# Base Load Power Hub (BLPH)

## EQUIPMENT MANUFACTURER RECORD BOOK
## Document Number: 1723002197-QC-DB-00048

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# Base Load Power Hub (BLPH)

## EQUIPMENT MANUFACTURER RECORD BOOK (FINAL DOSSIER) - INDEX
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1. Design Dossier

1.1. Data Sheet

1.1.1.SG-100D1 EQUIPMENT DATA SHEETS INCLUDING MSDS and WEIGHT DATA SHEET, Doc. No. 1723002197-EL-DS-00034

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# Base Load Power Hub (BLPH)

## SG-100D1 EQUIPMENT DATA SHEET INCLUDING MSDS AND WEIGHT DATA SHEET

Document Number: 1723002197-EL-DS-00034

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| Luca Maestri | 14/11/2024 |

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# 1 MEDIUM VOLTAGE SWITCHGEAR DATA SHEET

| | **Environmental data** | |
|---|---|---|
| 1 | ***AMBIENT*** | MARINE - OFFSHORE |
| 2 | ***INSTALLATION*** | INDOOR |
| 3 | ***AMBIENT AIR TEMPERATURE - DELAY AVERAGE MAXIMUM*** | 35°C |
| 4 | ***AMBIENT AIR MINIMUM/MAXIMUM TEMPERATURE*** | -8,4 ÷ +40°C |
| 5 | ***RELATIVE HUMIDITY AVERAGE*** | 95% |
| 6 | ***RELATIVE HUMIDITY MAXIMUM*** | - |
| 7 | ***POLLUTION LEVEL DEGREE*** | VERY LIGHT |

| | **Mechanical Features** | |
|---|---|---|
| 1 | ***EXTERNAL DEGREE OF PROTECTION*** | IP3X |
| 2 | ***INTERNAL DEGREE OF PROTECTION*** | IP2X |
| 3 | ***EXTERNAL MECHANICAL IMPACT PROTECTION*** | IK10 |
| 4 | ***ACCESSIBILITY*** | FRONT AND REAR |
| 5 | ***TYPE DESIGNATION*** | LSC2B-PM |
| 6 | ***COLOUR PAINTING*** | RAL 7035 |
| 7 | ***SURFACE NOT PAINTED*** | ZINC PLATED OR TROPICALIZED |

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| | Switchgear Electrical Features | |
|---|---|---|
| 1 | ***RATED VOLTAGE (Ue)*** | 6,6 kV |
| 2 | ***RATED INSULATION VOLTAGE (Ur)*** | 7,2 kV |
| 3 | ***RATED FREQUENCY (fr)*** | 50 Hz |
| 4 | ***RATED POWER-FREQUENCY WITHSTAND VOLTAGE (Ud)*** | 20 kV |
| 5 | ***RATED LIGHTNING IMPULSE WITHSTAND VOLTAGE (Up)*** | 60 kV |
| 6 | ***RATED NORMAL CURRENT (Ir)*** | 630 A |
| 7 | ***RATED SHORT TIME WITHSTAND CURRENT (Ik)*** | 25 kA |
| 8 | ***RATED DURATION OF SHORT CIRCUIT (tk)*** | 1 s |
| 9 | ***RATED PEAK WITHSTAND CURRENT (Ipk)*** | 65 kA |
| 10 | ***INTERNAL ARC CLASSIFICATION IAC*** | 25 kA x 1 s |
| 11 | ***ACCESSIBILITY TYPE*** | AFLR |
| 12 | ***NUMBER OF PHASES*** | 3 |
| 13 | ***PHASES IDENTIFICATION*** | L1-L2-L3 |
| 14 | ***EARTHING CIRCUITS MAIN BUSBAR SECTION*** | >200mmq |
| 15 | ***REFERENCE STANDARDS*** | IEC 62271-200 |
| 16 | ***CLASS REFERENCE*** | not applicable |

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# 2 MEDIUM VOLTAGE CIRCUIT BRAKER DATASHEET

## 2.1 MEDIUM VOLTAGE CIRCUIT BRAKER DATASHEET (ON CUBICLE A1, A6)

**ABB VD4/P 12.06.25 P150 (on unit A6 and A1)**

**Additional Information**

- **Rated Voltage ($U_r$):** 12 kV
- **Rated Impulse Withstand Voltage ($U_{imp}$):** 75 kV
- **Power Frequency Withstand Voltage:** 28 kV
- **Rated Frequency (f):**50/60 Hz
- **Rated Current ($I_n$):** 630 A
- **Rated Short-time Withstand Current Low Voltage ($I_{cw}$):** for 3 s 25 kA
- **Rated Short-Circuit Making Capacity ($I_{cm}$):** 63 kA
- **Operating Sequence:** O-0,3S-CO-15S-CO

## 2.2 MEDIUM VOLTAGE CONTACTOR V-CONTACT DATASHEET (ON CUBICLE A3, A7, A2, A4)

**ABB VSC 7/P 3P 7,2kV 400A DOUBLE COMMAND (DCO)**

**Rated voltage [kV]:** 7.2

**Rated insulation voltage [kV]:** 7.2

**Withstand voltage at 50 Hz (1 min) [kV]:** 20

**Impulse withstand voltage [kVp]:** 60

**Rated frequency [Hz]:** 50-60

**Rated service current [A]** 400

**Number of operations (rated values)**

**Contactor DCO [op./hour]** 1200

## 2.3 MEDIUM VOLTAGE ENCLOSURE AND EARTHING SWITCH DATASHEET (ON CUBICLE A1, A2, A3, A4, A6, A7)

**ABB Power Cube PB1/E L600 12kV 400/630A 25kA-3s**

**Rated voltage [kV]** 12

**Rated insulation voltage [kV]** 12

**Withstand voltage (50 Hz) [kV]** 28

**Impulse withstand voltage [kV]** 75

**Rated frequency [Hz]** 50-60

**Rated normal current (40°C) [A]** 400(VSC) / 630 (C.B.)

**Rated short-time withstand current (3 s) [kA]** 25

**Electrical Specification of the earthing switch**

| | |
|---|---|
| **Short time withstand current / Short- circuit making capacity** | 25 kA (3s) |
| **Peak current** | 63 kA |

## 2.4 MEDIUM VOLTAGE ENCLOSURE AND EARTHING SWITCH DATASHEET (ON CUBICLE A5)

**ABB Power Cube PB1/RE L600 12kV 630A 25kA-3s (with withdrawable compartment for TV)**

**Rated voltage [kV]** 12

**Rated insulation voltage [kV]** 12

**Withstand voltage (50 Hz) [kV]** 28

**Impulse withstand voltage [kV]** 75

**Rated frequency [Hz]** 50-60

**Rated normal current (40°C) [A]** 630

**Rated short-time withstand current (3 s) [kA]** 25

**Electrical Specification of the earthing switch**

| | |
|---|---|
| **Short time withstand current / Short- circuit making capacity** | 25 kA (3s) |
| **Peak current** | 63 kA |

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# 3 MEDIUM VOLTAGE FUSES DATASHEET

## 3.1 MEDIUM VOLTAGE FUSE DATASHEET (ON CUBICLE A3 AND A7)

**ABB CEF 6/12kV 160A (on A3 and A7 cubicle)**

**Product Name:** CEF 6/12kV 160A 442/87mm S

**Standards:** IEC 60282-1, VDE 0670-T4, VDE 0670-T402

**Rated Voltage ($U_r$):** 12 kV

**Rated Frequency (f):** 50 Hz

**Rated Current ($I_n$):** 160 A

## 3.2 MEDIUM VOLTAGE FUSES DATASHEET (ON CUBICLE A2)

**ABB CEF 6/12kV 63A (on A2 cubicle)**

**Product Name:** CEF 6/12kV 63A 442/65mm S

**Standards:** IEC 60282-1, VDE 0670-T4, VDE 0670-T402

**Rated Voltage ($U_r$):** 12 kV

**Rated Frequency (f):** 50 Hz

**Rated Current ($I_n$):** 63 A

## 3.3 MEDIUM VOLTAGE FUSES DATASHEET (ON CUBICLE A4)

**ABB CMF 6/12kV 250A (on A4 cubicle)**

**Product Name:** CMF 6/12kV 250A 442/87mm S

**Standards:** IEC 60282-1

**Rated Voltage ($U_r$):** 7,2 kV

**Input Voltage Type:** AC

**Rated Frequency (f):** 50 Hz

**Rated Current ($I_n$):** 250 A

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# 4 MEASURE AND PROTECTION TRANSFORMERS DATASHEETS

## 4.1 VOLTAGE TRANSFORMER DATASHEET

**ABB *TJP4.3 (Custom realization for Crosswind project) (on cubicle A1, A2, A3, A5, A6, A7)***

| | |
|---|---|
| **Highest voltage for equipment** | 7,2 kV |
| **Power frequency test voltage, 1 min.** | 20 kV |
| **Lightning impulse test voltage** | 60 kV |

***6,6kV: √3/110: √3-110: √3-110:3***

| | |
|---|---|
| ***1° winding: (110:√3)*** | ***Cl. 0,5-3P - Pr. 20VA*** |
| ***2° winding: (110:√3)*** | ***Cl. 0,5-3P - Pr. 30VA*** |
| ***3° winding: (110:3)*** | ***Cl. 3P - Pr. 30VA*** |

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## 4.2 CURRENT TRANSFORMER DATASHEET

### 4.2.1 Current Transformer Datasheet ATB 10-BS

**Esitas Current Transformer ATB 10-BS**

**Operating Voltage Um (kV):** 7,2

**Rated power frequency withstand voltage (1minute) (kV):** 20

**Rated impulse test voltage (1,2/50 us) full vawe (kV):** 60

**Rated Frequency (Hz):** 50

**Rated short-time thermal current (Ith) (1s) (kA):** 25

**Rated dynamic current (Idyn) (kA):** 65

**Note:**

**Regarding electrical characteristics like:**

**Transformation Ratio, current, measure class, protection class, safety factor, burden etc.. refer to Single Linee Diagram (document number 1723002197-EL-DG-00010_04)**

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# 5 WEIGHT M.V. SWITCHBOARD SG-100D1

1) SWITCHBOARD SG-100D1 UNIT 1 - WEIGHT 1185 Kg

2) SWITCHBOARD SG-100D1 UNIT 2 - WEIGHT 980 Kg

3) SWITCHBOARD SG-100D1 UNIT 3 - WEIGHT 980 Kg

4) SWITCHBOARD SG-100D1 UNIT 4 - WEIGHT 730 Kg

5)

6) SWITCHBOARD SG-100D1 UNIT 5 - WEIGHT 640 Kg

7) SWITCHBOARD SG-100D1 UNIT 6 - WEIGHT 1020 Kg

8) SWITCHBOARD SG-100D1 UNIT 7 - WEIGHT 1180 Kg

**TOTAL WEIGHT 6715 Kg**

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1.1.2.SG-200N1 EQUIPMENT DATA SHEETS INCLUDING MSDS and WEIGHT DATA SHEET,
Doc. No. 1723002197-EL-DS-00035

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# Base Load Power Hub (BLPH)

## SG-200N1 EQUIPMENT DATA SHEET INCLUDING MSDS AND WEIGHT DATA SHEET

Document Number: 1723002197-EL-DS-00035

Document Class: 3

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# 1 LOW VOLTAGE SWITCHBOARD DATA SHEET

| | **Environmental data** | |
|---|---|---|
| 1 | ***AMBIENT*** | MARINE - OFFSHORE |
| 2 | ***INSTALLATION*** | INDOOR |
| 3 | ***AMBIENT AIR TEMPERATURE - DELAY AVERAGE MAXIMUM*** | 35°C |
| 4 | ***AMBIENT AIR MINIMUM/MAXIMUM TEMPERATURE*** | -8,4 ÷ +40°C |
| 5 | ***RELATIVE HUMIDITY AVERAGE*** | 95% |
| 6 | ***RELATIVE HUMIDITY MAXIMUM*** | - |
| 7 | ***POLLUTION LEVEL DEGREE*** | VERY LIGHT |

| | **Mechanical Features** | |
|---|---|---|
| 1 | ***EXTERNAL DEGREE OF PROTECTION*** | IP30 |
| 2 | ***INTERNAL DEGREE OF PROTECTION*** | IP20 |
| 3 | ***EXTERNAL MECHANICAL IMPACT PROTECTION*** | IK10 |
| 4 | ***ACCESSIBILITY*** | FRONT |
| 5 | ***TYPE DESIGNATION*** | LSC2B-PM |
| 6 | ***COLOUR PAINTING*** | RAL 7035 |
| 7 | ***SURFACE NOT PAINTED*** | ZINC PLATED OR TROPICALIZED |

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| | Switchgear Electrical Features | |
|---|---|---|
| 1 | ***RATED VOLTAGE (Ue)*** | 0,4/0,23 kV |
| 2 | ***NOMINAL VOLTAGE (Un)*** | 0,4/0,23 kV |
| | ***RATED INSULATION VOLTAGE (Ui)*** | 0,69 kV |
| 3 | ***RATED FREQUENCY (Fn)*** | 50 Hz |
| 4 | ***RATED IMPULSE WITHSTAND VOLTAGE (Uimp)*** | 4 kV |
| 5 | ***RATED LIGHTNING IMPULSE WITHSTAND VOLTAGE (Up)*** | 60 kV |
| 6 | ***RATED NORMAL CURRENT (Ir)*** | 2500 A |
| 7 | ***RATED SHORT TIME WITHSTAND CURRENT (Ik)*** | 50 kA |
| 8 | ***RATED DURATION OF SHORT CIRCUIT (tk)*** | 1 s |
| 9 | ***RATED PEAK WITHSTAND CURRENT (Ipk)*** | 105 kA |
| 10 | ***INTERNAL ARC CLASSIFICATION IAC (only A1 column)*** | 50 kA |
| 11 | ***ARCING CLASS (only A1 column)*** | 0,3 s |
| 12 | ***NUMBER OF PHASES*** | 3 ÷ 1 |
| 13 | ***PHASES IDENTIFICATION*** | L1-L2-L3-N |
| 14 | ***EARTHING CIRCUITS MAIN BUSBAR SECTION*** | >300mmq |
| 15 | ***REFERENCE STANDARDS*** | IEC 61439-2 |
| 16 | ***EARTHING SYSTEM*** | TN-S |
| 17 | ***NEUTRAL BUSBAR SIZING*** | 50% PHASE SECTION |

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# 2 LOW VOLTAGE CIRCUIT BRAKER DATASHEET

## 2.1 LOW VOLTAGE CIRCUIT BRAKER DATASHEET (INCOMING UNIT)

ABB E4.2N/MS 3200 4p F HR

Circuit Braker Siwtch-Disconnector SACE EMAX2 E4.2N/MS 3200 Four-pole

- **Product Main Type:** SACE Emax 2
- **Product Name:** Switch Disconnector
- **Current Type:** AC
- **Neutral Pole Current ([%Iu]):** 100 %
- **Number of Poles:** 4
- **Power Loss:** 743 W
- **Rated Impulse Withstand Voltage ($U_{imp}$):** 12 kV
- **Rated Insulation Voltage ($U_i$):** AC 1000 V
- **Rated Operational Voltage:** 690 V AC
- **Rated Short-time Withstand Current Low Voltage ($I_{cw}$):** for 1 s 66 kA
- **Rated Uninterrupted Current ($I_u$):** 3200 A
- **Rated Voltage ($U_r$):** 690 V
- **Short-Circuit Performance Level:** N
- **Standards:** IEC

*For type of trip unit (Ekip HI-Touch LSIG or Ekip DIP LSIG) refer to single line diagram (document number 1723002197-EL-DG-00011-Rev.04)

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## 2.2 LOW VOLTAGE CIRCUIT BRAKER DATASHEET (ELECTROLYSER AUXILIARY LOAD)

ABB E1.2C 1250 Ekip Hi-Touch LSIG 4p WMP

Moving part for Circuit Braker SACE E1.2C 1250 FIXED Four-pole with state release in AC EKIP/HI-TOUCH-LSIG fitted with: 4 Auxiliary contact and C.B. in position open-closed.

- **Product Main Type:** SACE Emax 2
- **Product Name:** Air Circuit Breaker
- **Current Type:** AC
- **Neutral Pole Current ([%Iu]):** 100 %
- **Number of Poles:** 4
- **Power Loss:** 244 W
- **Rated Impulse Withstand Voltage ($U_{imp}$):** acc. to IEC 60947-212 12 kV
- **Rated Insulation Voltage ($U_i$):** AC 1000 V
- **Rated Operational Voltage:** 690 V AC
- **Rated Short-time Withstand Current Low Voltage ($I_{cw}$):** for 1 s 42 kA
- **Rated Service Short-Circuit Breaking Capacity ($I_{cs}$):** (400 V AC) 50 kA
- **Rated Service Short-Circuit Breaking Capacity, in % of Icu ($I_{cs}$):**100 %
- **Rated Ultimate Short-Circuit Breaking Capacity ($I_{cu}$):** (400 V AC) 50 kA
- **Rated Uninterrupted Current ($I_u$):** 1250 A
- **Rated Voltage ($U_r$):** 690 V
- **Short-Circuit Performance Level:** C
- **Standards:** IEC

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## 2.3 LOW VOLTAGE CIRCUIT BRAKER (FEEDERS)

### 2.3.1 ABB XT2S 160 BREAKING PART 4p F F

Breaking part TMAX XT2S 160 Fixed Four-pole with Front Terminals

- **Product Main Type:** SACE Tmax XT
- **Product Name:** Moulded Case Circuit Breaker
- **Number of Poles:** 4
- **Opening Time:**
  - CB with SOR 15 ms
  - CB with UVR 15 ms
- **Rated Frequency (f):** 50 / 60 Hz
- **Rated Impulse Withstand Voltage ($U_{imp}$):** 8 kV
- **Rated Insulation Voltage ($U_i$):**1000 V
- **Rated Operational Voltage:**690 V AC
- **Rated Service Short-Circuit Breaking Capacity ($I_{cs}$):** (415 V AC) 50 kA
- **Rated Ultimate Short-Circuit Breaking Capacity ($I_{cu}$):** (415 V AC) 50 kA
- **Rated Uninterrupted Current ($I_u$):** 160 A
- **Rated Voltage ($U_r$):** 690 V
- **Short-Circuit Performance Level:** S
- **Standards:** IEC60947-2

* For nominal current and type of trip unit (Ekip HI-Touch LSIG or Ekip DIP LSIG) refer to single line diagram (document number 1723002197-EL-DG-00011-Rev.04)

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### 2.3.2 ABB XT4S 250 BREAKING PART 4p F F

Breaking part TMAX XT4S 250 Fixed Four-Pole With Front Terminals

- **Product Main Type:** SACE Tmax XT
- **Product Name:** Moulded Case Circuit Breaker
- **Number of Poles:** 4
- **Opening Time:**
  - CB with SOR 15 ms
  - CB with UVR 15 m
- **Rated Impulse Withstand Voltage ($U_{imp}$):** 8 kV
- **Rated Insulation Voltage ($U_i$):**1000 V
- **Rated Operational Voltage:** 690 V AC
- **Rated Service Short-Circuit Breaking Capacity ($I_{cs}$):** (415 V AC) 50 kA
- **Rated Ultimate Short-Circuit Breaking Capacity ($I_{cu}$):** (415 V AC) 50 kA
- **Rated Uninterrupted Current ($I_u$):** 250 A
- **Short-Circuit Performance Level:** S
- **Standards:** IEC 60947-2

* For nominal current and type of Trip unit (Ekip HI-Touch LSIG or Ekip DIP LSIG) refer to single line diagram (document number 1723002197-EL-DG-00011-Rev.04)

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### 2.3.3 ABB XT5S 400 BREAKING PART 4p F F

Breaking Part TMAX XT5S 400 Fixed Four-Pole With Front Terminals

- **Product Main Type:** SACE Tmax XT
- **Product Name:** Moulded Case Circuit Breaker
- **Number of Poles:** 4
- **Rated Impulse Withstand Voltage ($U_{imp}$):** 8 kV
- **Rated Insulation Voltage ($U_i$):** 1000 V
- **Rated Operational Voltage:** 690 V AC
- **Rated Service Short-Circuit Breaking Capacity ($I_{cs}$):** (415 V AC) 50 kA
- **Rated Short-time Withstand Current Low Voltage ($I_{cw}$):** 5 kA
- **Rated Ultimate Short-Circuit Breaking Capacity ($I_{cu}$):** (415 V AC) 50 kA
- **Rated Uninterrupted Current ($I_u$):** 400 A
- **Short-Circuit Performance Level:** S
- **Standards:** IEC60947-2

* For nominal current and type of trip unit (Ekip HI-Touch LSIG or Ekip DIP LSIG) refer to single line diagram (document number 1723002197-EL-DG-00011-Rev.04)

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## 3 WEIGHT L.V. SWITCHBOARD SG-200N1

1) SWITCHBOARD SG-200N1 UNIT A1 - WEIGHT ± 920 Kg

2) SWITCHBOARD SG-200N1 UNIT A2 - WEIGHT ± 500 Kg

3) SWITCHBOARD SG-200N1 UNIT A3 - WEIGHT ±7 00 Kg

4) SWITCHBOARD SG-200N1 UNIT A4 - WEIGHT ± 675 Kg

5) SWITCHBOARD SG-200N1 UNIT A5 - WEIGHT ± 675 Kg

6) SWITCHBOARD SG-200N1 UNIT A6 - WEIGHT ±645 Kg

7) SWITCHBOARD SG-200N1 UNIT A7 - WEIGHT ±645 Kg

TOTAL WEIGHT 4760 Kg ± 10%

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1.1.3.SG-200D2 EQUIPMENT DATA SHEETS INCLUDING MSDS and WEIGHT DATA SHEET,

Doc. No. 1723002197-EL-DS-00036

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# Base Load Power Hub (BLPH)

## SG-200D2 EQUIPMENT DATA SHEET INCLUDING MSDS AND WEIGHT DATA SHEET

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# 1 LOW VOLTAGE SWITCHBOARD DATA SHEET

| | **Environmental data** | |
|---|---|---|
| 1 | ***AMBIENT*** | MARINE - OFFSHORE |
| 2 | ***INSTALLATION*** | INDOOR |
| 3 | ***AMBIENT AIR TEMPERATURE - DELAY AVERAGE MAXIMUM*** | 35°C |
| 4 | ***AMBIENT AIR MINIMUM/MAXIMUM TEMPERATURE*** | -8,4 ÷ +40°C |
| 5 | ***RELATIVE HUMIDITY AVERAGE*** | 95% |
| 6 | ***RELATIVE HUMIDITY MAXIMUM*** | - |
| 7 | ***POLLUTION LEVEL DEGREE*** | VERY LIGHT |

| | **Mechanical Features** | |
|---|---|---|
| 1 | ***EXTERNAL DEGREE OF PROTECTION*** | IP30 |
| 2 | ***INTERNAL DEGREE OF PROTECTION*** | IP20 |
| 3 | ***EXTERNAL MECHANICAL IMPACT PROTECTION*** | IK10 |
| 4 | ***ACCESSIBILITY*** | FRONT |
| 5 | ***TYPE DESIGNATION*** | FORM: 3B (INCOMING)<br>FOMR: 3B (OUTGOING) |
| 6 | ***COLOUR PAINTING*** | RAL 7035 |
| 7 | ***SURFACE NOT PAINTED*** | ZINC PLATED OR TROPICALIZED |

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| | Switchgear Electrical Features | |
|---|---|---|
| 1 | ***RATED VOLTAGE (Ue)*** | 0,8 kV |
| 2 | ***NOMINAL VOLTAGE (Un)*** | 0,8 kV |
| 3 | ***RATED INSULATION VOLTAGE (Ui)*** | 1 kV |
| 4 | ***RATED FREQUENCY (Fn)*** | 50 Hz |
| 5 | ***RATED IMPULSE WITHSTAND (Uimp)*** | 4 kV |
| 6 | ***RATED NORMAL CURRENT (Ir)*** | 630 A @ 45°C |
| 7 | ***RATED SHORT TIME WITHSTAND CURRENT (Ik)*** | 30 kA |
| 8 | ***RATED DURATION OF SHORT CIRCUIT (tk)*** | 1 s |
| 9 | ***RATED PEAK WITHSTAND CURRENT (Ipk)*** | 63 kA |
| 10 | ***INTERNAL ARC CLASSIFICATION IAC*** | Not Applicable |
| 11 | ***ARCING CLASS*** | Not Applicable |
| 12 | ***NUMBER OF PHASES*** | 3 |
| 13 | ***PHASES IDENTIFICATION*** | L1-L2-L3 |
| 14 | ***EARTHING CIRCUITS MAIN BUSBAR SECTION*** | >300mmq |
| 15 | ***REFERENCE STANDARDS*** | IEC 61439-2 |
| 16 | ***EARTHING SYSTEM*** | TN-S |
| 17 | ***NEUTRAL BUSBAR SIZING*** | - |

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# 2 LOW VOLTAGE CIRCUIT BRAKER DATASHEET

ABB E1.2N/E9 1250 Ekip Hi-Touch LSIG 3p WMP

Moving part for Circuit Breaker SACE EMAX2 E1.2N 1250 Three-Pole with solid state release in AC EKIP/HI-TOUCH-LSIG R 1250 fitted with: 4 AUXILIARY CONTACT AND C. BREAKER IN POSITION OPEN-CLOSED 800V

- **Product Main Type:** SACE Emax 2
- **Product Name:** Air Circuit Breaker
- **Current Type:** AC
- **Number of Poles: 3**
- **Power Loss:** 244 W
- **Rated Current ($I_n$):** 1250 A
- **Rated Impulse Withstand Voltage ($U_{imp}$):** acc. to IEC 60947-2 12 kV
- **Rated Insulation Voltage ($U_i$):** AC 1000 V
- **Rated Operational Voltage:** 800 V AC
- **Rated Service Short-Circuit Breaking Capacity ($I_{cs}$): (800 V AC)** 35 kA
- **Rated Short-time Withstand Current Low Voltage ($I_{cw}$):** for 1 s 35 kA
- **Rated Ultimate Short-Circuit Breaking Capacity ($I_{cu}$):** (800 V AC) 35 kA
- **Rated Uninterrupted Current ($I_u$):**1250 A
- **Rated Voltage ($U_r$):** 800 V
- **Short-Circuit Performance Level:** N
- **Standards:** IEC

* For additional details refer to single line diagram (document number 1723002197-EL-DA-00008-Rev.04)

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# 3 WEIGHT L.V. SWITCHBOARD SG-200D2

1) SWITCHBOARD SG-200D2 UNIT CL01 - WEIGHT ±450Kg

**TOTAL WEIGHT 450Kg ± 10%**

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1.1.4.DP-200N1 EQUIPMENT DATA SHEETS INCLUDING MSDS and WEIGHT DATA SHEET,
Doc. No. 1723002197-EL-DS-00037

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# Base Load Power Hub (BLPH)

## DP-200N1 EQUIPMENT DATA SHEET INCLUDING MSDS AND WEIGHT DATA SHEET

Document Number: 1723002197-EL-DS-00037

Document Class: 3

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IMESA ELECTRICAL ENGINEERING IMESA Doc. 231115/SD/034

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# 1 LOW VOLTAGE SWITCHGEAR DATA SHEET

| | **Environmental data** | |
|---|---|---|
| 1 | ***AMBIENT*** | MARINE - OFFSHORE |
| 2 | ***INSTALLATION*** | INDOOR |
| 3 | ***AMBIENT AIR TEMPERATURE - DELAY AVERAGE MAXIMUM*** | 35°C |
| 4 | ***AMBIENT AIR MINIMUM/MAXIMUM TEMPERATURE*** | -8,4 ÷ +40°C |
| 5 | ***RELATIVE HUMIDITY AVERAGE*** | 95% |
| 6 | ***RELATIVE HUMIDITY MAXIMUM*** | - |
| 7 | ***POLLUTION LEVEL DEGREE*** | VERY LIGHT |

| | **Mechanical Features** | |
|---|---|---|
| 1 | ***EXTERNAL DEGREE OF PROTECTION*** | IP30 |
| 2 | ***INTERNAL DEGREE OF PROTECTION*** | IP20 |
| 3 | ***EXTERNAL MECHANICAL IMPACT PROTECTION*** | IK10 |
| 4 | ***ACCESSIBILITY*** | FRONT |
| 5 | ***TYPE DESIGNATION*** | FORM: 2B (OUTGOING) |
| 6 | ***COLOUR PAINTING*** | RAL 7035 |
| 7 | ***SURFACE NOT PAINTED*** | ZINC PLATED OR TROPICALIZED |

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| | Switchgear Electrical Features | |
|---|---|---|
| 1 | ***RATED VOLTAGE (Ue)*** | 0,4/0,23 kV |
| 2 | ***NOMINAL VOLTAGE (Un)*** | 0,4/0,23 kV |
| 3 | ***RATED INSULATION VOLTAGE (Ui)*** | 0,69 kV |
| 4 | ***RATED FREQUENCY (Fn)*** | 50 Hz |
| 5 | ***RATED IMPULSE WITHSTAND VOLTAGE (Uimp)*** | 4 kV |
| 6 | ***RATED NORMAL CURRENT (In)*** | 63 A |
| 7 | ***POWER SUPPLY SHORT CIRCUIT CURRENT (Ik)*** | 25 kA |
| 8 | ***RATED DURATION OF SHORT CIRCUIT (tk)*** | NA |
| 9 | ***CONDITIONATED PEAK WITHSTAND CURRENT (Ipk)*** | 17 kA |
| 10 | ***INTERNAL ARC CLASSIFICATION IAC*** | Not Applicable |
| 11 | ***ARCING CLASS*** | Not Applicable |
| 12 | ***NUMBER OF PHASES*** | 3 + N |
| 13 | ***PHASES IDENTIFICATION*** | L1-L2-L3-N |
| 14 | ***EARTHING CIRCUITS MAIN BUSBAR SECTION*** | >150mmq |
| 15 | ***REFERENCE STANDARDS*** | IEC 61439-2 |
| 16 | ***EARTHING SYSTEM*** | TN-S |
| 17 | ***NEUTRAL BUSBARS SIZING*** | 50% PHASE SECTION |

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# 2 LOW VOLTAGE CIRCUIT BRAKER DATASHEET

## 2.1 SACE TMAX XT MOULDED CASE CIRCUIT BRAKER (GENERAL INCOMING)

ABB XT2N 160 Ekip LSI In=63A 4p F F

Circuit Breaker TMAX XT2N 160 Fixed four-pole with front terminal and Solid-State Release in AC EKIP-LSI R 63 A

- **Product Main Type:** SACE Tmax XT
- **Product Name:** Moulded Case Circuit Breaker
- **Product Type:** Automatic Circuit Breaker
- **Current Type:** AC
- **Number of Poles:** 4
- **Opening Time:**
  - CB with SOR 15 ms
  - CB with UVR 15 ms
- **Rated Current ($I_n$):** 63 A
- **Rated Frequency (f):** 50/60 Hz
- **Rated Impulse Withstand Voltage ($U_{imp}$):** 8 kV
- **Rated Insulation Voltage ($U_i$):**1000 V AC
- **Rated Operational Voltage:** 690 V AC
- **Rated Service Short-Circuit Breaking Capacity ($I_{cs}$):** (415 V AC) 36 kA
- **Rated Ultimate Short-Circuit Breaking Capacity ($I_{cu}$):** (415 V AC) 36 kA
- **Rated Uninterrupted Current ($I_u$):** 160 A
- **Rated Voltage ($U_r$):** 690 V AC
- **Short-Circuit Performance Level:** N
- **Standards:** IEC60947-2

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## 2.2 MINIATURE CIRCUIT BRAKER

The MCBs S300P series assures protection in industrial installations against overload and short circuits. This product is manufactured according to international IEC and UL standards, for the markets where it is required.

- **Standards:** CSA 22.2 No. 235 IEC/EN 60898-1 IEC/EN 60947-2 UL 1077
- **Tripping Characteristic:** *
- **Rated Insulation Voltage ($U_i$):** acc. to IEC/EN 60664-1 500 V
- **Rated Impulse Withstand Voltage ($U_{imp}$):** 6 kV
- **Dielectric Test Voltage:** 50/60 Hz-1 min: 2 kV
- **Input Voltage Type:** AC/DC
- **Rated Current ($I_n$):** *
- **Rated Short-Circuit Capacity:**(AC) 25 kA
- **Rated Ultimate Short-Circuit Breaking Capacity ($I_{cu}$):** (400 V) 25 kA
- **Rated Frequency (f):** 50 / 60 Hz
- **Number of Protected Poles:** *
- **Number of Poles:** *
- **Overvoltage Category:** IV

* For Additional details refer to single line diagram (document number 1723002197-EL-DG-00013)

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## 2.3 RESIDUAL CURRENT DEVICE BLOCK

The RCD block DDA200 series is suitable for assembly with MCBs S200 series and S300P. It assures protection against the effects of sinusoidal alternating earth fault currents, protection, against indirect contacts and additional protection against direct (with sensitivity = 30 mA) contacts.

- **Standards:** IEC/EN 61009 Ann. G
- **Type of Residual Current:** Type AC
- **Rated Voltage ($U_r$):** 230/400 V
- **Rated Insulation Voltage ($U_i$):** 500 V
- **Rated Impulse Withstand Voltage ($U_{imp}$):** 4 kV
- **Rated Current ($I_n$):** 25 A
- **Rated Residual Current:** 30 mA
- **Leakage Current Type:** AC
- **Rated Frequency (f):**50 … 60 Hz
- **Number of Poles:** 2
- **Operating Characteristic:** Instantaneous

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# 3 WEIGHT L.V. SWITCHBOARD DP-200N1

1) SWITCHBOARD DP-200N1 UNIT 1 - WEIGHT ± 600Kg

**TOTAL WEIGHT 600Kg ±10%**

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1.2. General Arrangement

1.2.1.SG-100D1 GENERAL ARRANGEMENTS DWG & FOUNDATION LOAD CALCULATION INCLUDING COG,

Doc. No. 1723002197-EL-DA-00006

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# BASE LOAD POWER HUB (BLPH)

# "SG-100D1" HV SWBD 6,6kV

# GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Mocale | 12/09/2024 |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231151/SD/6

Item n° : PF1113279/4

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 08/08/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| 2 | 03/07/2024 | Flamminio | Santinelli | Santinelli | Accepted for Construction (AFC) |
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CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

| A3 | DRAWING NO. | SHEET | REV. |
|---|---|---|---|
| | 1723002197-EL-DA-00006 | 001 | 03 |

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00006 Rev. 03

# INDEX SHEETS

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
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| 001 | Cover / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 002 | Index / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 003 | Switchgear Characteristics / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 004 | Switchgear Characteristics / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 005 | Switchgear Name Plate / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 006 | Switchgear Lay-Out - Front View / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 007 | Switchgear Lay-Out - Bottom View / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 008 | Switchgear Lay-Out - Top View / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 009 | Switchgear Lay-Out - Baseframe View / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 010 | Switchgear Lay-Out - Rear View / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 011 | Switchgear Lay-Out - Typical Baseframe / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 012 | Switchgear Lay-Out - Typical Column Bottom / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 013 | Base Frame Fixing System / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 014 | Base Frame Fixing System / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 015 | Switchgear Center of Gravity / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 016 | Extraction Truck for Circuit Breaker/Contactor / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231151/SD/6
Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

SHEET 002

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00006 Rev. 03

| A | ENVIRONMENTAL DATA | |
|---|---|---|
| 1 | AMBIENT | MARINE - OFFSHORE |
| 2 | INSTALLATION | INDOOR |
| 3 | AMBIENT AIR TEMPERATURE - DELAY AVERAGE MAXIMUM | 35 °C |
| 4 | AMBIENT AIR MINIMUM/MAXIMUM TEMPERATURE | -8,4 ÷ +40 °C |
| 5 | RELATIVE HUMIDITY AVERAGE | 95 % |
| 6 | RELATIVE HUMIDITY MAXIMUM | - |
| 7 | POLLUTION LEVEL DEGREE | VERY LIGHT |

| B | SWITCHGEAR ELECTRICAL FEATURES | |
|---|---|---|
| 1 | RATED VOLTAGE (Ue) | 6,6 kV |
| 2 | RATED INSULATION VOLTAGE (Ur) | 7,2 kV |
| 3 | RATED FREQUENCY (fr) | 50 Hz |
| 4 | RATED POWER-FREQUENCY WITHSTAND VOLTAGE (Ud) | 20 kV |
| 5 | RATED LIGHTNING IMPULSE WITHSTAND VOLTAGE (Up) | 60 kV |
| 6 | RATED NORMAL CURRENT (Ir) | 630 A |
| 7 | RATED SHORT TIME WITHSTAND CURRENT (Ik) | 25 kA |
| 8 | RATED DURATION OF SHORT CIRCUIT (tk) | 1 s |
| 9 | RATED PEAK WITHSTAND CURRENT (Ipk) | 65 kA |
| 10 | INTERNAL ARC CLASSIFICATION IAC | 25 kA x 1 s |
| 11 | ACCESSIBILITY TYPE | AFLR |
| 12 | NUMBER OF PHASES | 3 |
| 13 | PHASES IDENTIFICATION | L1-L2-L3 |
| 14 | EARTHING CIRCUITS MAIN BUSBAR SECTION | >200mmq |
| 15 | REFERENCE STANDARDS | IEC 62271-200 |
| 16 | CLASS REFERENCE | not applicable |

| C | SWITCHGEAR MECHANICAL FEATURES | |
|---|---|---|
| 1 | EXTERNAL DEGREE OF PROTECTION | IP3X |
| 2 | INTERNAL DEGREE OF PROTECTION | IP2X |
| 3 | EXTERNAL MECHANICAL IMPACT PROTECTION | IK10 |
| 4 | ACCESSIBILITY | FRONT AND REAR |
| 5 | TYPE DESIGNATION | LSC2B-PM |
| 6 | POWER CABLES (INCOMING) | FROM THE TOP (by MCT) |
| 7 | POWER CABLES (OUTGOING) | FROM THE TOP (by MCT) |
| 8 | AUXILIARY CABLES | FROM THE TOP (by MCT) |
| 9 | BASE FRAMES | PROVIDED |
| 10 | MIMIC DIAGRAM (BLACK) | PROVIDED |
| 11 | BOTTOM CLOSING | UNDRILLED ALUMINIUM REMOVABLE PLATES |
| 12 | PAINTING COLOUR | RAL 7035 |
| 13 | PAINTING SPECIFICATION CYCLE | C3-MEDIUM, > 60µ (IMESA CYCLE "A") |
| 14 | SURFACE NOT PAINTED | ZINC PLATED OR TROPICALIZED |
| 15 | FRONT DOORS (AUXILIARY COMPARTMENT) | HINGED WITH KEY LOCKS |
| 16 | FRONT DOOR (C.B./CONTACTOR COMPARTMENT) | PADLOCKABLE LOCK |
| 17 | REAR PANELS | BOLTED |
| 18 | MINIMUM CLEARANCE | TO THE FRONT 1500 mm |
| 19 | | TO THE REAR 800 mm |
| 20 | | TO THE TOP 600 mm |
| 21 | | TO THE SIDE 800 mm |
| 22 | WEIGHTS | 7.400 kg ± 10% (ESTIMATED) |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231151/SD/6
Item n° : PF1113279/4

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Switchgear Characteristics

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

SHEET 003

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00006 Rev. 03

| D | BUSBAR SYSTEM | |
|---|---|---|
| 1 | MATERIALS | ELECTROLYTIC COPPER |
| 2 | BUSBAR SURFACE TREATMENT | not applicable |
| 3 | INSULATION BUSBARS | SHEATHED (only main bus-bars & upper connection of power devices) |
| 4 | JOINT AND CONNECTIONS TREATMENT | not applicable |
| 5 | INSULATION JOINTS | REMOVABLE SOLID DIELECTRIC PROTECTIONS |
| 6 | BULKHEADS FOR POWER BARS | YES |
| 7 | PHASES IDENTIFICATION | L1 (BROWN) |
| 8 | | L2 (BLACK) |
| 9 | | L3 (GREY) |
| 10 | | PE |
| 11 | MARKING OF PHASES | ADHESIVE LABELS PLACED ON BARS |

| E | POWER / AUXILIARY CIRCUITS CABLES | | |
|---|---|---|---|
| 1 | LOW VOLTAGE CABLE TYPE | | SH-W (MARINE APPROVAL) |
| 2 | INSULATION | | HLPE (600/1000 V) |
| | SIZE / COLOUR CODE | | |
| 3 | MEASURE & CONTROL & SIGNAL CIRCUITS | AC/DC CIRCUIT (Internal Heating / Motor Spring Charger / Internal Distribution) | ≥ 2,5 mmq / BLACK |
| 4 | | VT SECONDARY CIRCUIT | 1,5 mmq / BLACK |
| 5 | | CT SECONDARY CIRCUIT | 2,5 mmq / BLACK |
| 6 | | AC CIRCUIT | ≥ 1,5 mmq / BLACK |
| 7 | | DC CIRCUIT | ≥ 1,5 mmq / + RED - -WHITE |
| 8 | | GROUND CIRCUIT | YELLOW / GREEN |
| 9 | | PHASES IDENTIFICATION FOR AC POWER CIRCUIT TERMINATION WITH SHRINKABLE SHEATH | not applicable |
| 10 | | | not applicable |
| 11 | | | not applicable |

| F | TERMINAL BLOCKS | |
|---|---|---|
| 1 | TERMINAL BLOCK TYPE | SPRING CLAMP (CABUR HMM grey) |
| 2 | DISCONNECT/TEST TERMINAL BLOCK TYPE | SPRING CLAMP (CABUR HMM grey) |
| 3 | MATERIAL | POLYAMIDE |
| 4 | SIZE | ≥ 4mmq |

| G | AUXILIARY CIRCUIT VOLTAGE | |
|---|---|---|
| 1 | AUXILIARY COMMAND CIRCUITS | 110 Vdc (External Supply) |
| 2 | AUXILIARY SIGNALLING CIRCUITS | 110 Vdc (External Supply) |
| 3 | AUXILIARY PROTECTION CIRCUITS | 110 Vdc (External Supply) |
| 4 | SPRING CHARGING MOTOR C.B. | 110 Vdc (External Supply) |
| 5 | INTERNAL LIGHTINGS | 230 Vac (External Supply) |
| 6 | ANTICONDENSATION HEATER | 230 Vac (External Supply) |
| 7 | SPACE MOTOR HEATER (If Applicable) | 230 Vac (External Supply) |

| H | LABELS | |
|---|---|---|
| 1 | MATERIAL | TRAFFOLYTE |
| 2 | BACKGROUND | WHITE |
| 3 | LETTERS | BLACK |
| 4 | LANGUAGE | ENGLISH |
| 5 | WARNING LABEL LANGUAGE | ENGLISH |
| 6 | FIXING | SCREWED |
| 7 | MARKING DEVICES / WIRES | INDIPENDENT |
| 8 | AC CIRCUIT | SEQUENTIAL |
| 9 | DC CIRCUIT | SEQUENTIAL WITH PREFIX "+" OR "-" |

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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231151/SD/6

Item n° : PF1113279/4

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Switchgear Characteristics

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

SHEET 004

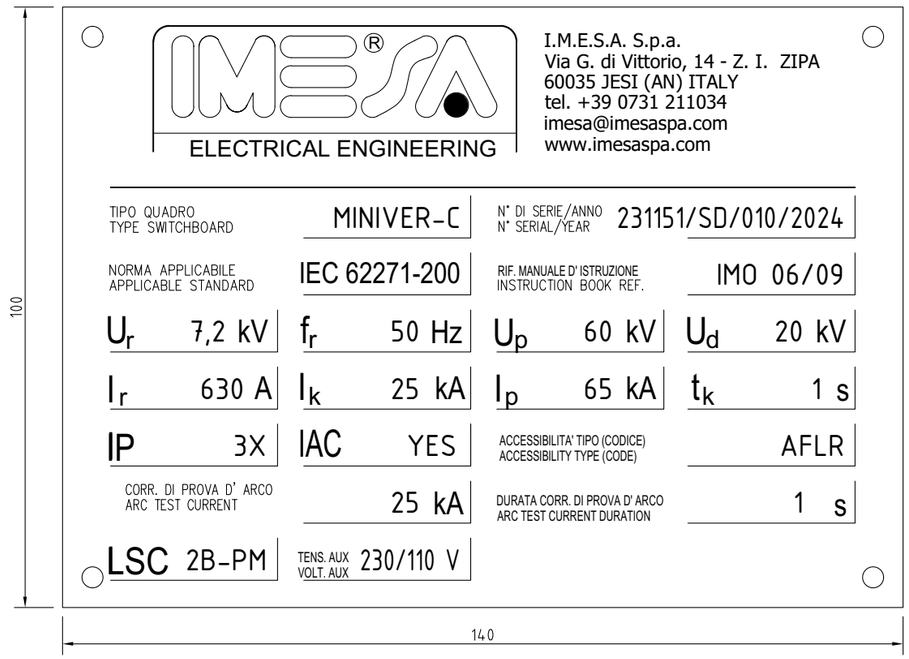
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00006 Rev. 03

# NAMEPLATE DATES

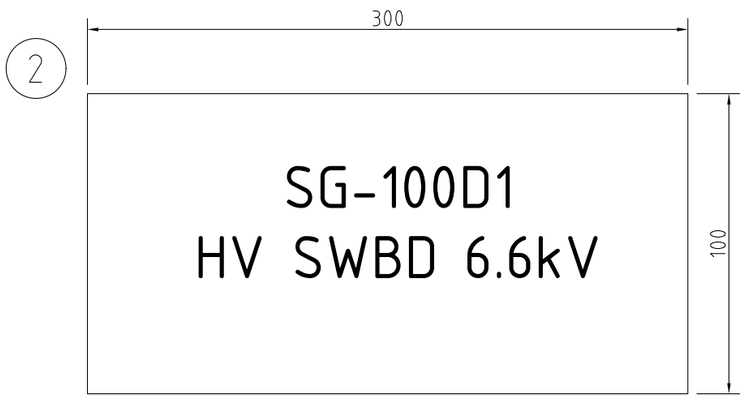
1




Material: Alloy

# SWITCHGEAR TAG PLATE

2




Material: Traffolyte

| | | | | | | | |
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| + | | | | | | | |
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DWG n° : 231151/SD/6
Item n° : PF1113279/4

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Switchgear Name Plate

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

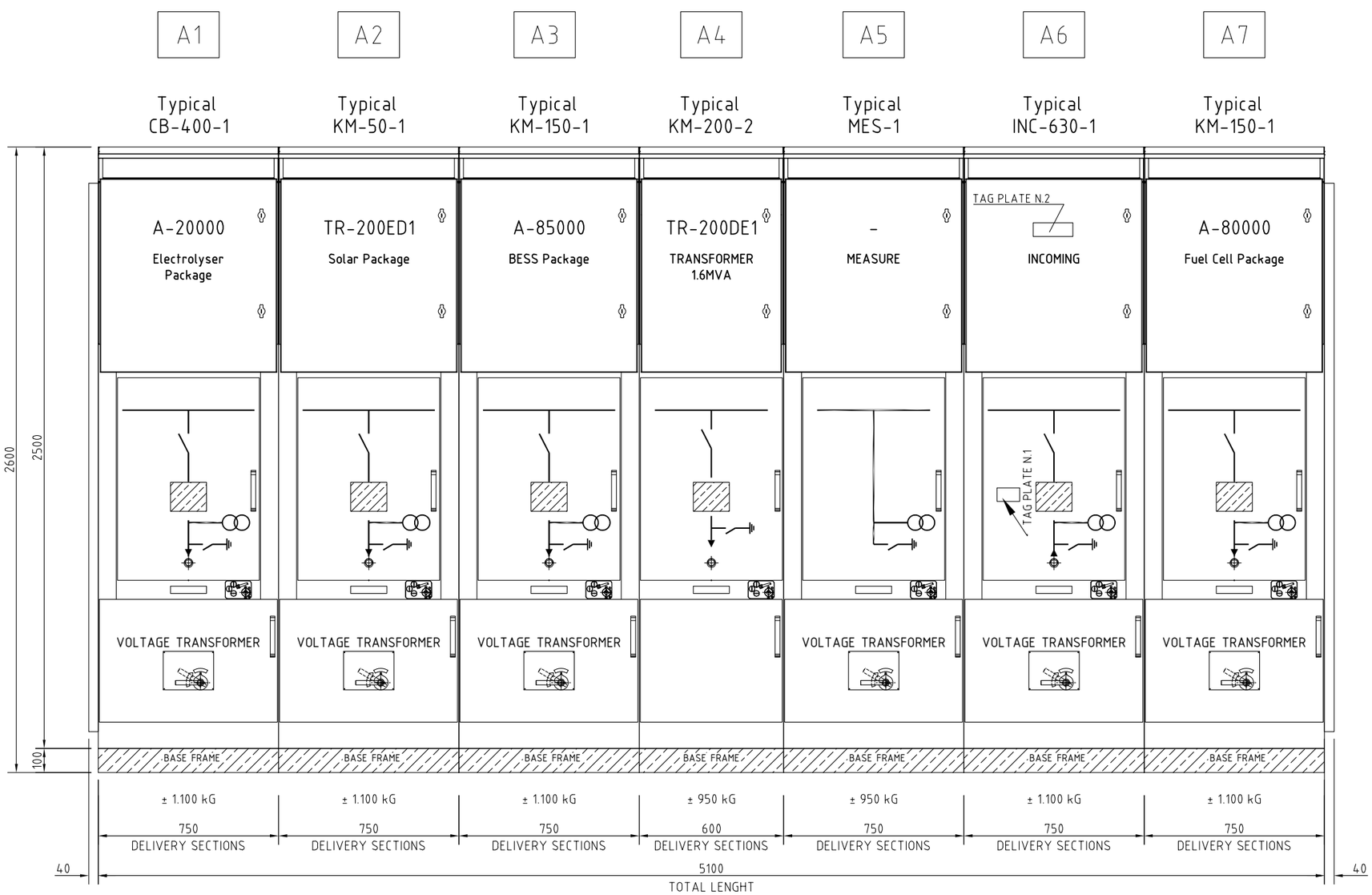
SHEET 005

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00006 Rev. 03

# FRONT VIEW




NOTE :

1. Measurement Tollerance + 0,25%
2. Weight Tollerance ± 10%
3. Mimic features - Colour : BLACK - Material : PLASTIC - Dimension : 10x3mm

scale 1/20

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/6
Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Front View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

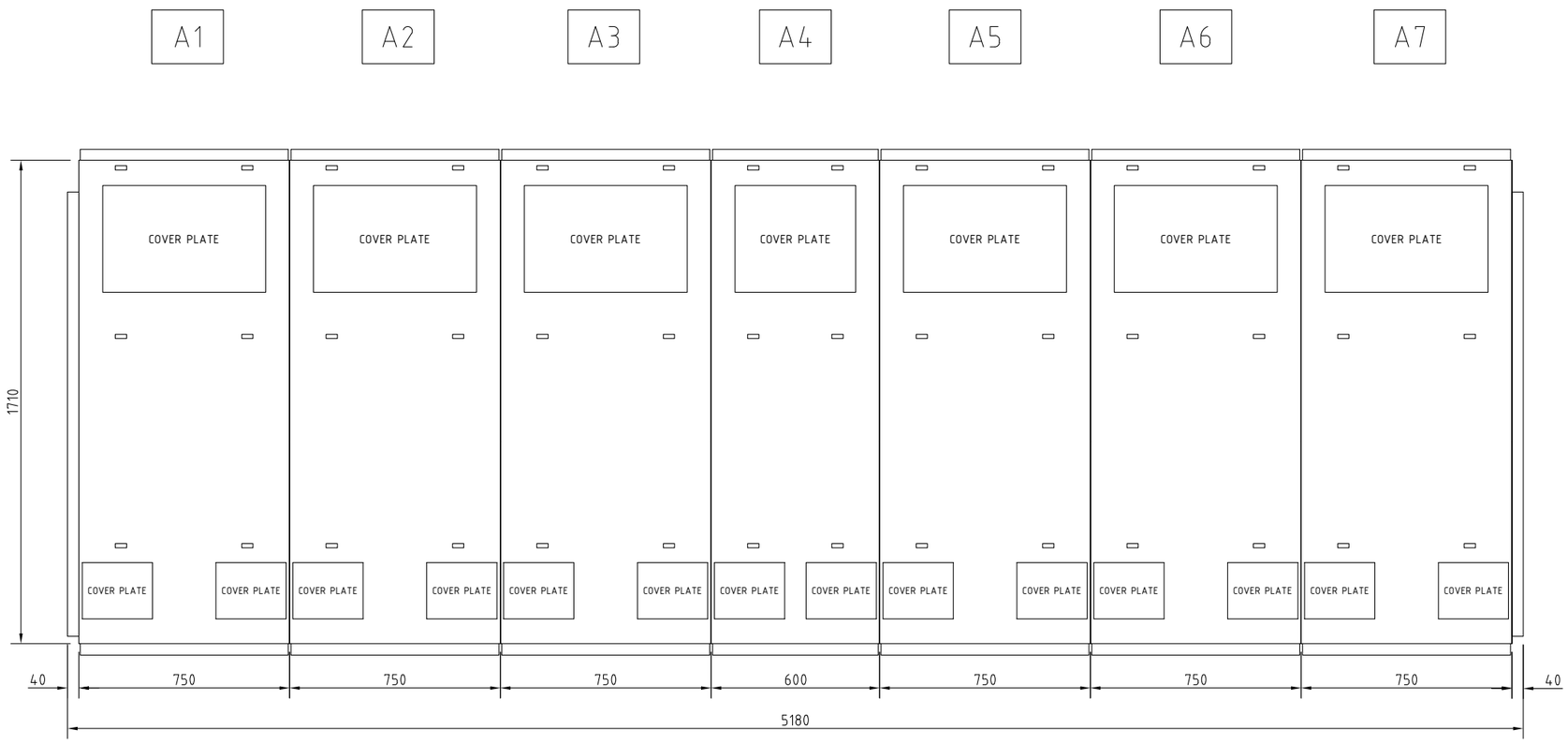
SHEET 006

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00006 Rev. 03

# BOTTOM VIEW




FRONT

NOTE :
1. Measurement Tollerance + 0,25%

scale 1/20

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
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DWG n° : 231151/SD/6
Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Bottom View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

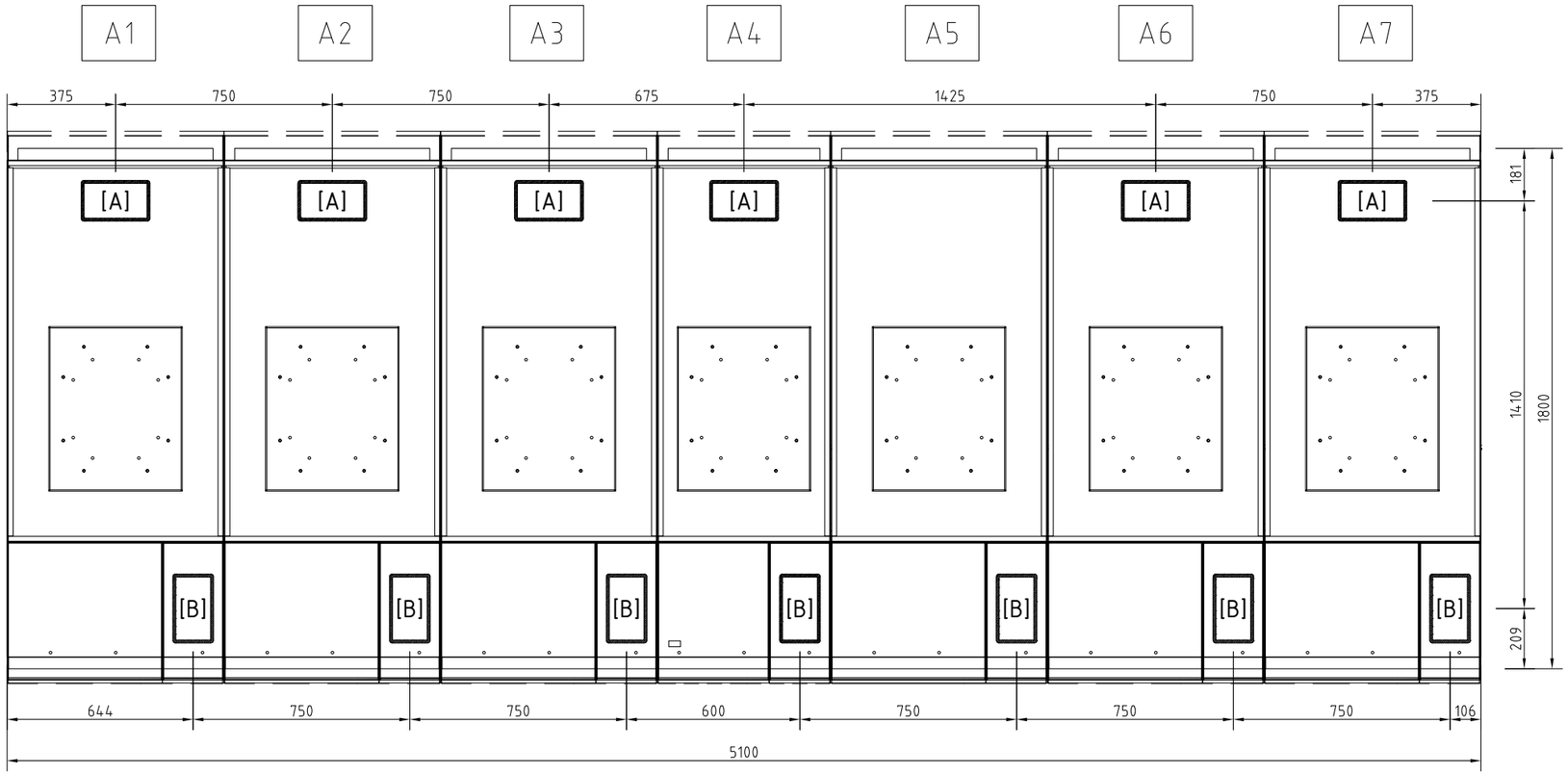
SHEET 007

REV. 03

F.to UNI A3: 420mmx297mm

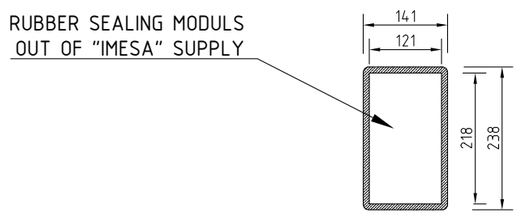
File Name : 1723002197-EL-DA-00006 Rev. 03

# TOP VIEW




FRONT

## "S6X1" MCT DETTAILS




NOTE :
1. Measurement Tollerance + 0,25%
2. [A] MCT for power cable - type S6x1
3. [B] MCT for auxialiary cable - - type S6x1

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231151/SD/6

Item n° : PF1113279/4

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Top View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

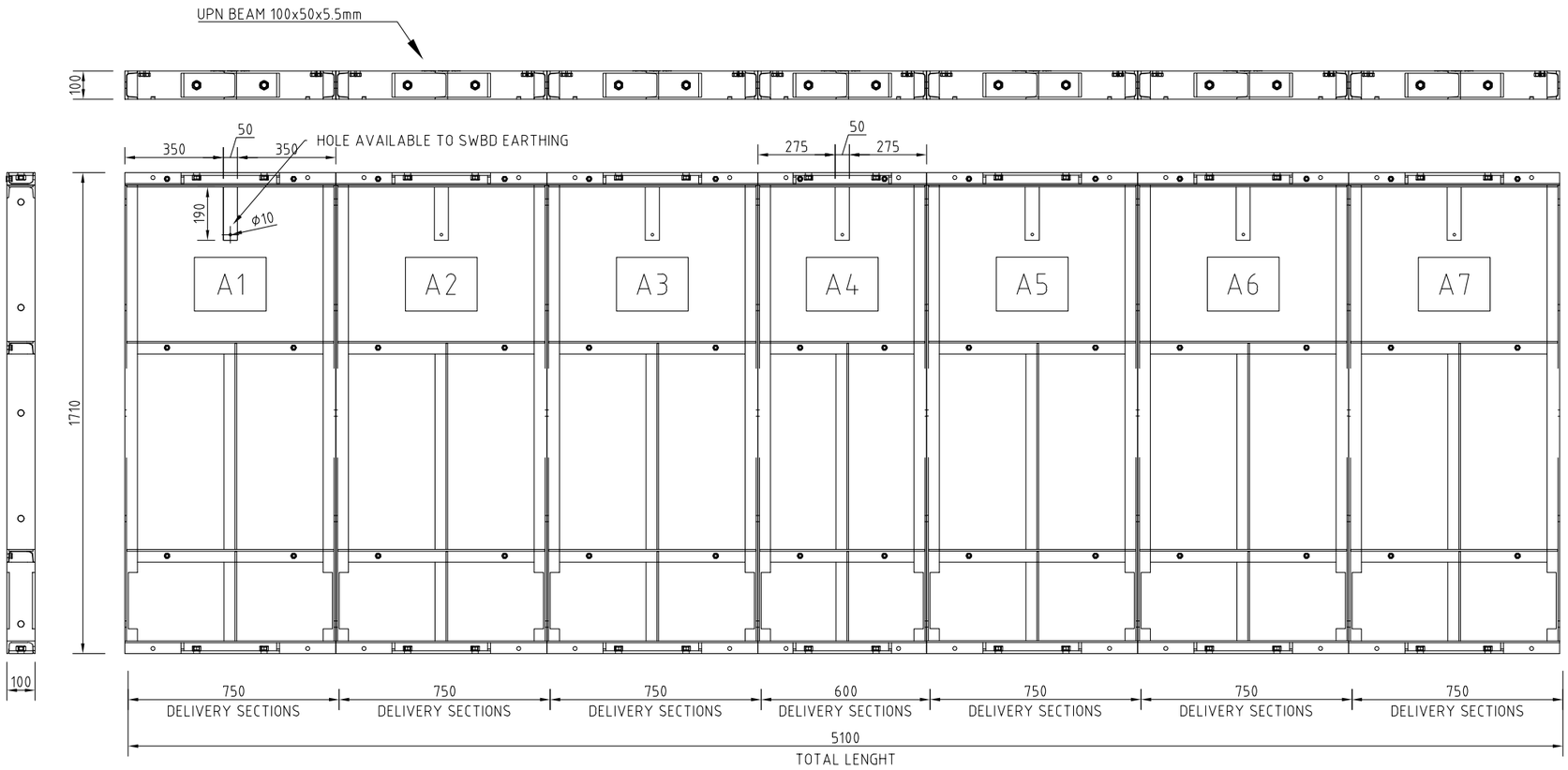
SHEET 008

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00006 Rev. 03

# BASEFRAME VIEW




NOTE :

1. Measurement Tollerance + 0,25%

scale 1/20

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|---|---|---|---|---|---|
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DWG n° : 231151/SD/6

Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Baseframe View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

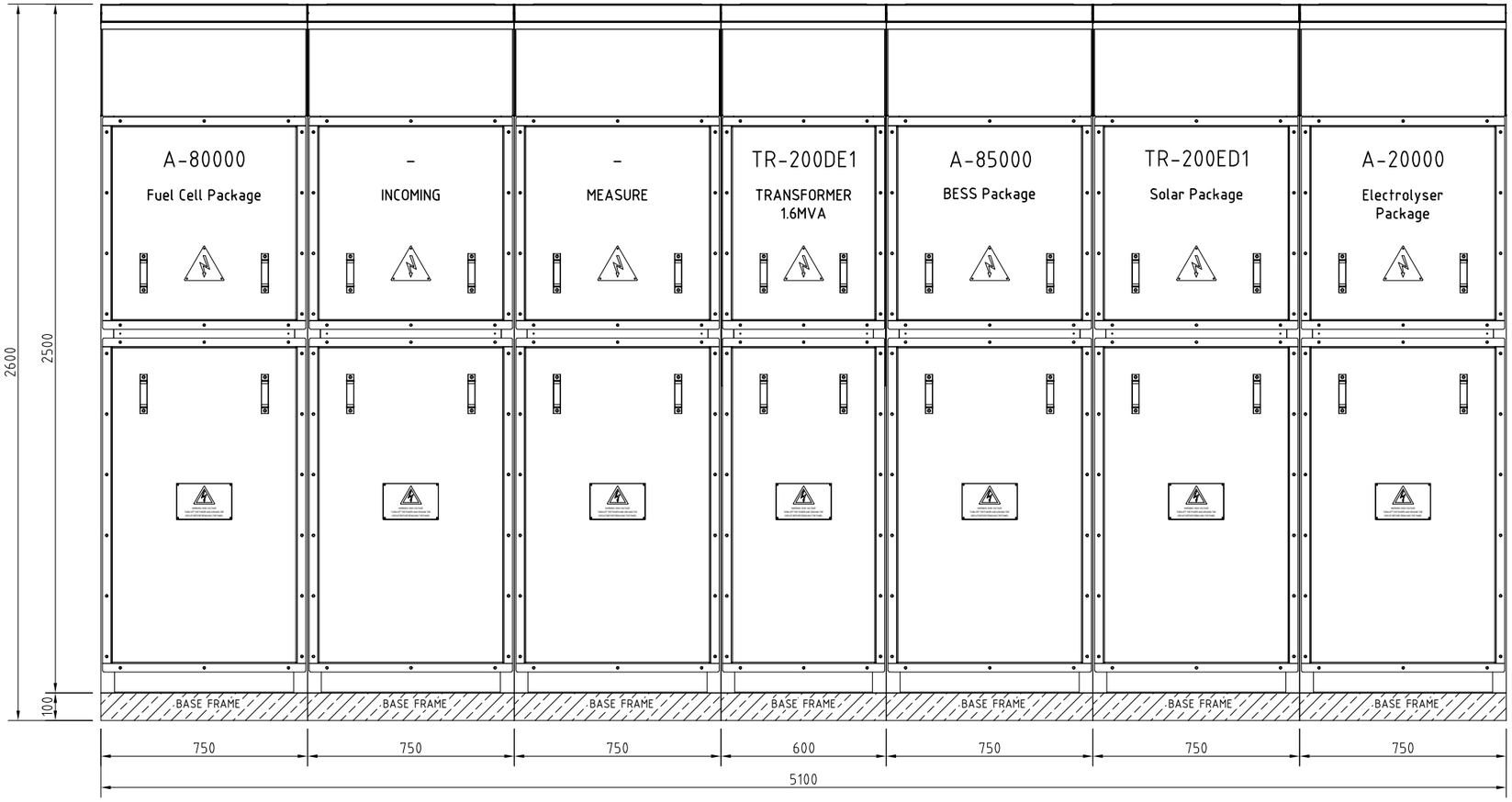
SHEET 009

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00006 Rev. 03

# REAR VIEW




NOTE :

1. Measurement Tollerance + 0,25%

scale 1/20

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/6

Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Rear View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

SHEET 010

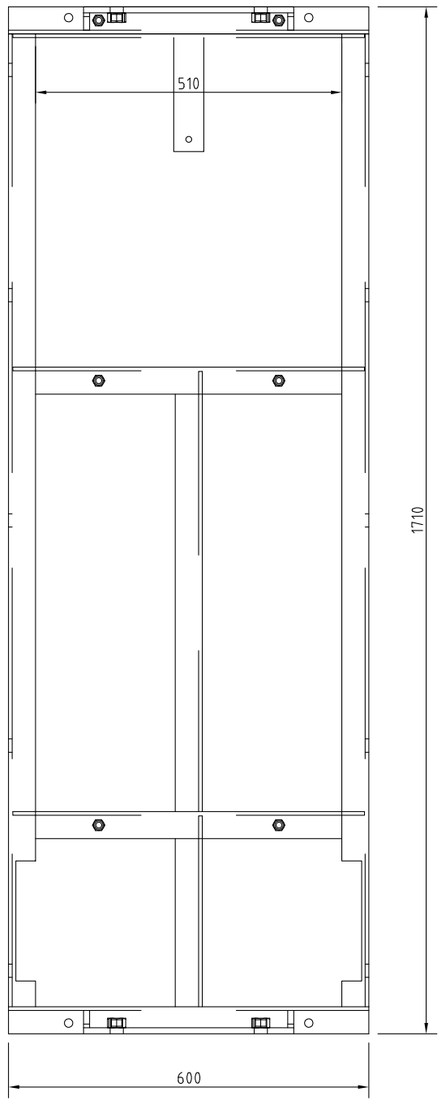
REV. 03

F.to UNI A3: 420mmx297mm

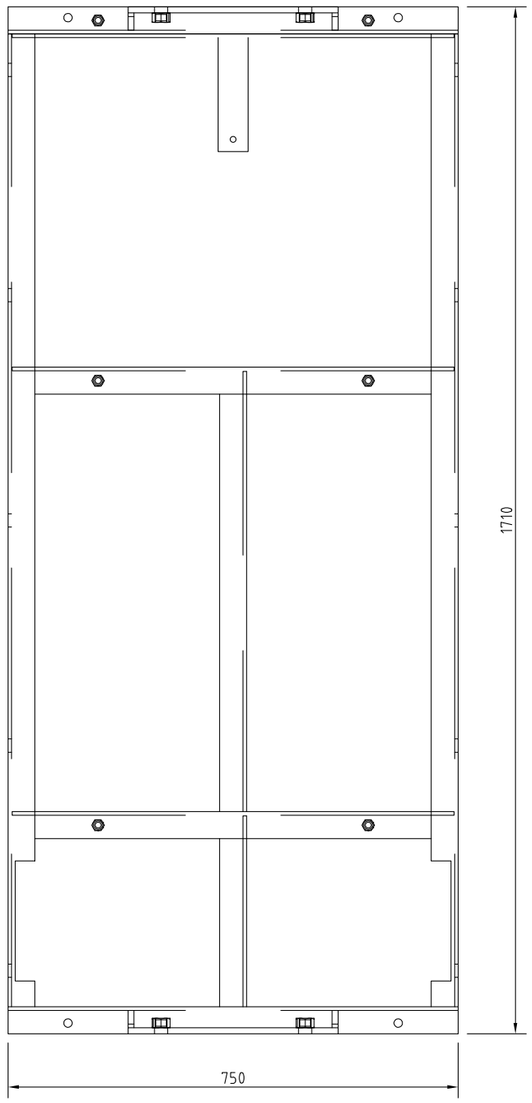
File Name : 1723002197-EL-DA-00006 Rev. 03

# TYPICAL BASE FRAME

TYPICAL BASE FRAME FOR COLUMNs
with width 600mm




TYPICAL BASE FRAME FOR COLUMNs
with width 750mm




NOTE :
1. Measurement Tollerance + 0,25%

scale 1/20

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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IMESA ELECTRICAL ENGINEERING
DWG n° : 231151/SD/6
Item n° : PF1113279/4

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Typical Baseframe

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

SHEET 011

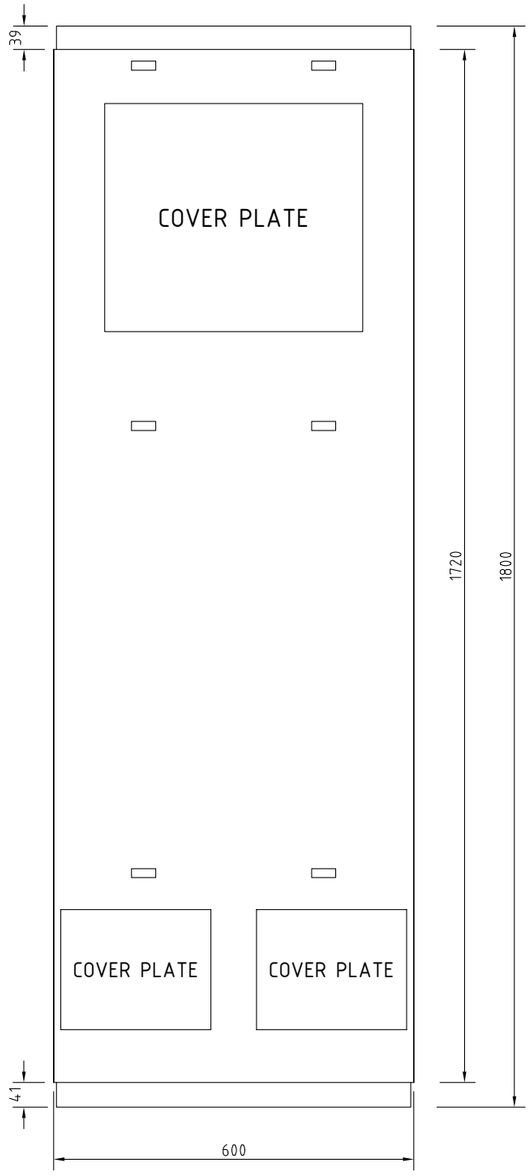
REV. 03

F.to UNI A3: 420mmx297mm

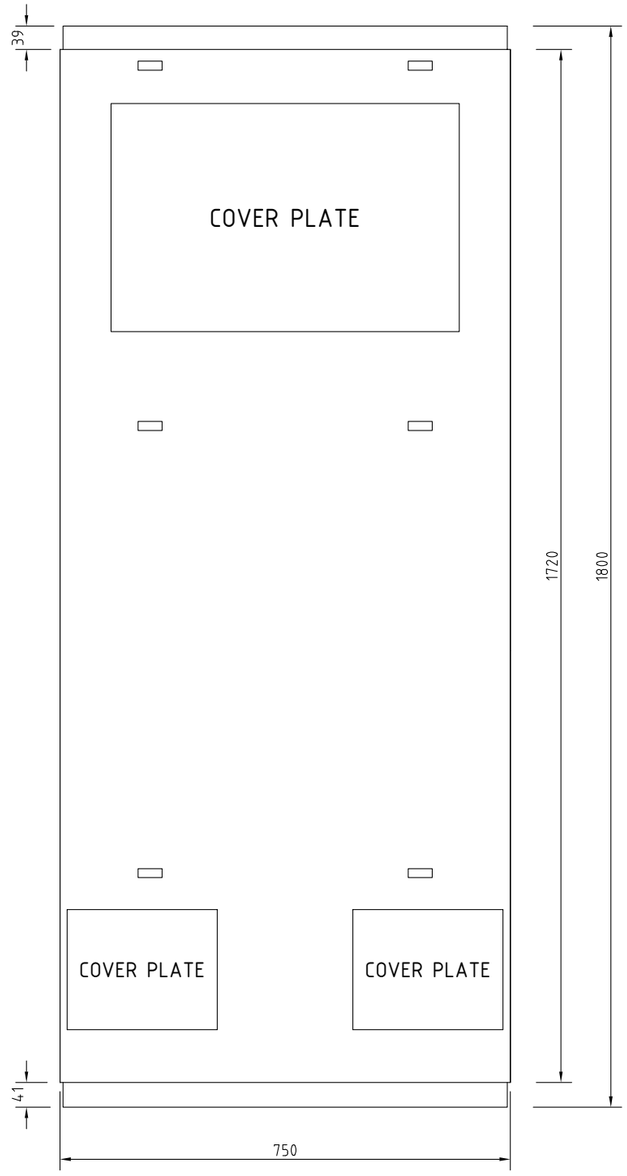
File Name : 1723002197-EL-DA-00006 Rev. 03

# TYPICAL COLUMNS BOTTOM VIEW

TYPICAL BASE FRAME FOR COLUMNs
with width 600mm




TYPICAL BASE FRAME FOR COLUMNs
with width 750mm




NOTE :
1. Measurement Tollerance + 0,25%

scale 1/20

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231151/SD/6
Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Typical Column Bottom

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

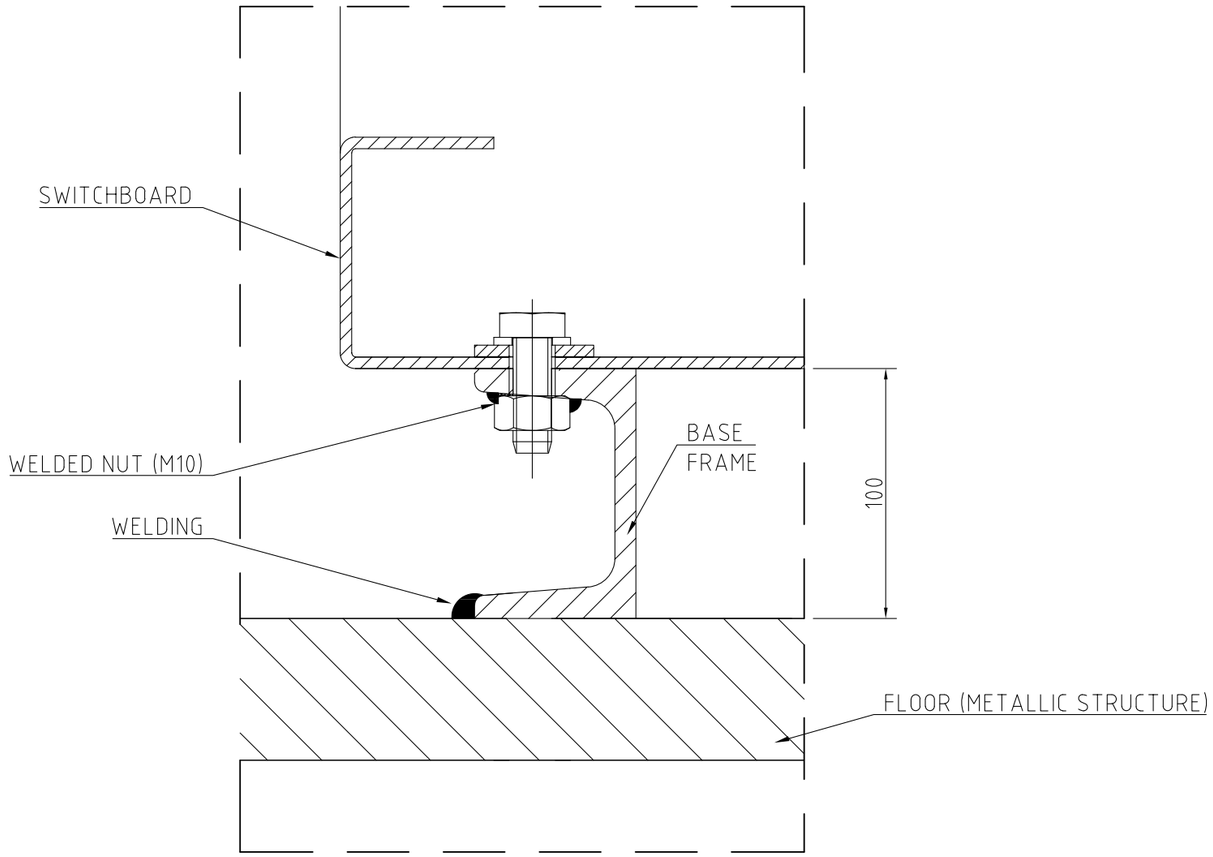
SHEET 012

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00006 Rev. 03

# BASE FRAME FIXING SYSTEM




NOTE :

1. Measurement Tollerance + 0,25%

scale 1/20

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231151/SD/6

Item n° : PF1113279/4

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Base Frame Fixing System

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

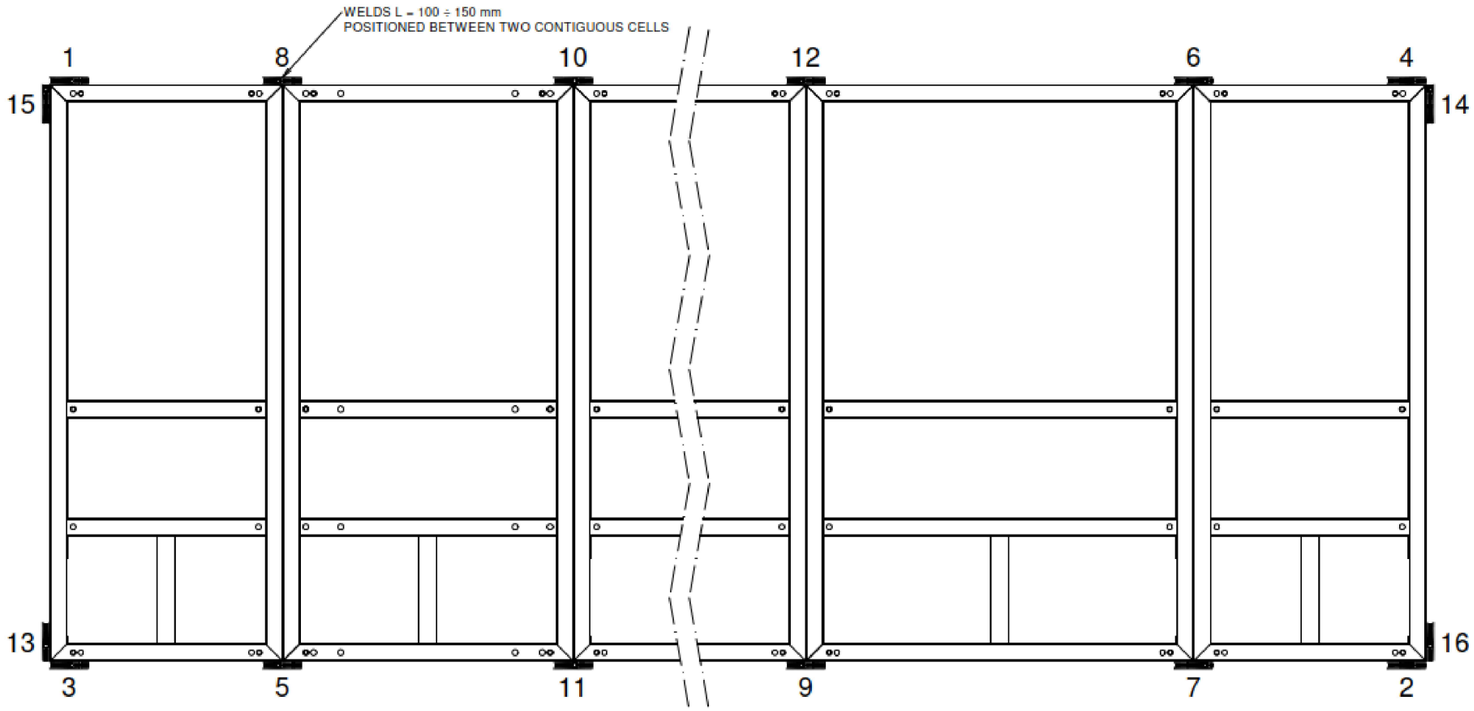
SHEET 013

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00006 Rev. 03

# BASE FRAME FIXING SYSTEM




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
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DWG n° : 231151/SD/6
Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Base Frame Fixing System

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

SHEET 014

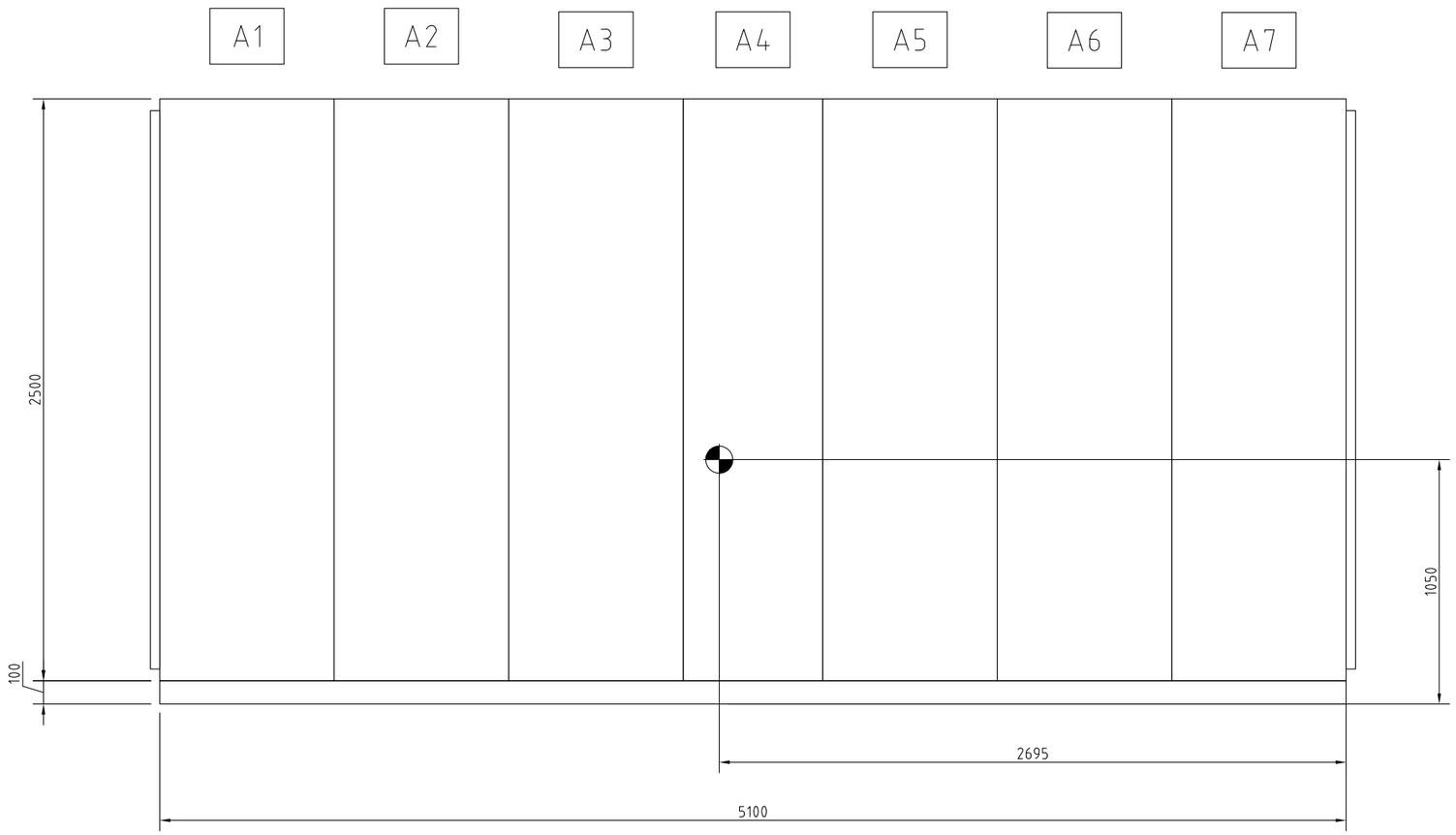
REV. 03

F.to UNI A3: 420mmx297mm

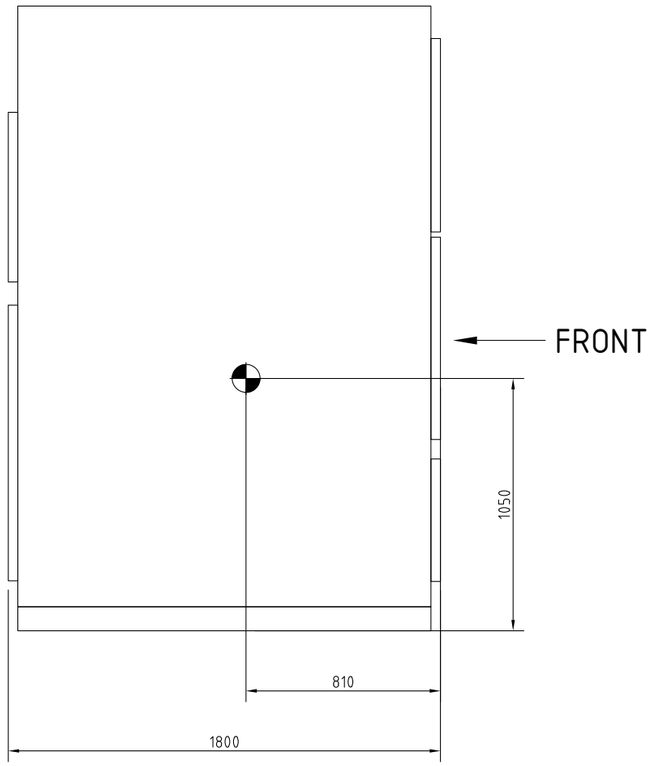
File Name : 1723002197-EL-DA-00006 Rev. 03

# CENTER OF GRAVITY

## FRONT VIEW




## SIDE VIEW




scale 1/25

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231151/SD/6

Item n° : PF1113279/4

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Switchgear Center of Gravity

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

SHEET 015

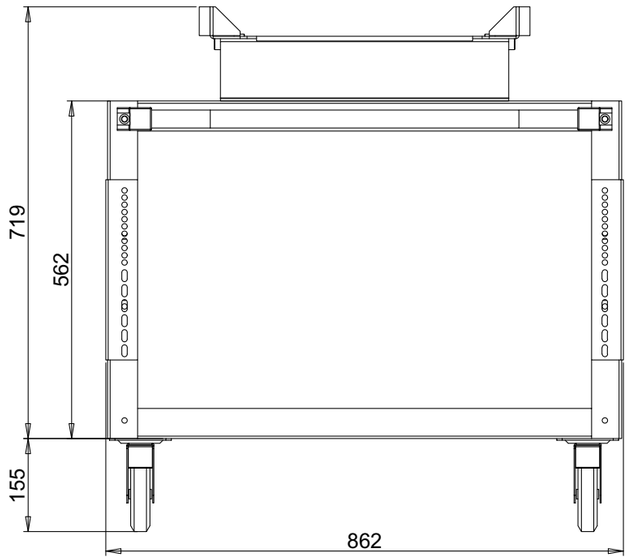
REV. 03

F.to UNI A3: 420mmx297mm

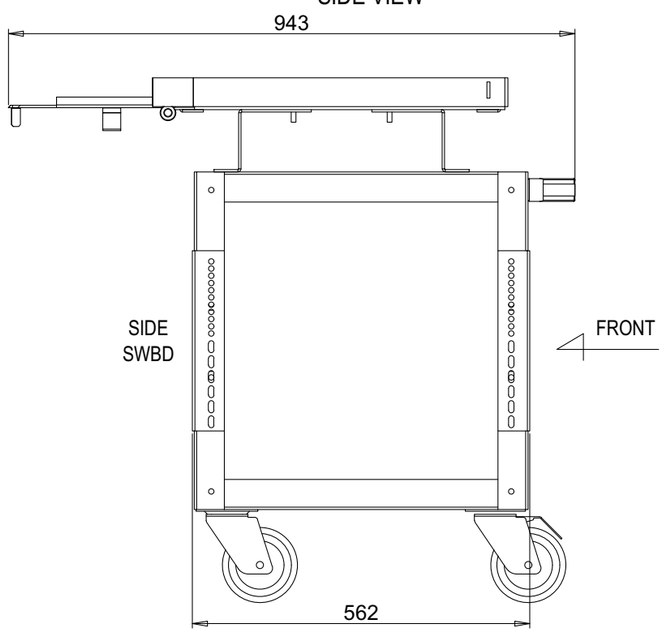
File Name : 1723002197-EL-DA-00006 Rev. 03

# EXTRACTION TRUCK FOR CIRCUIT BREAKER/CONTACTOR

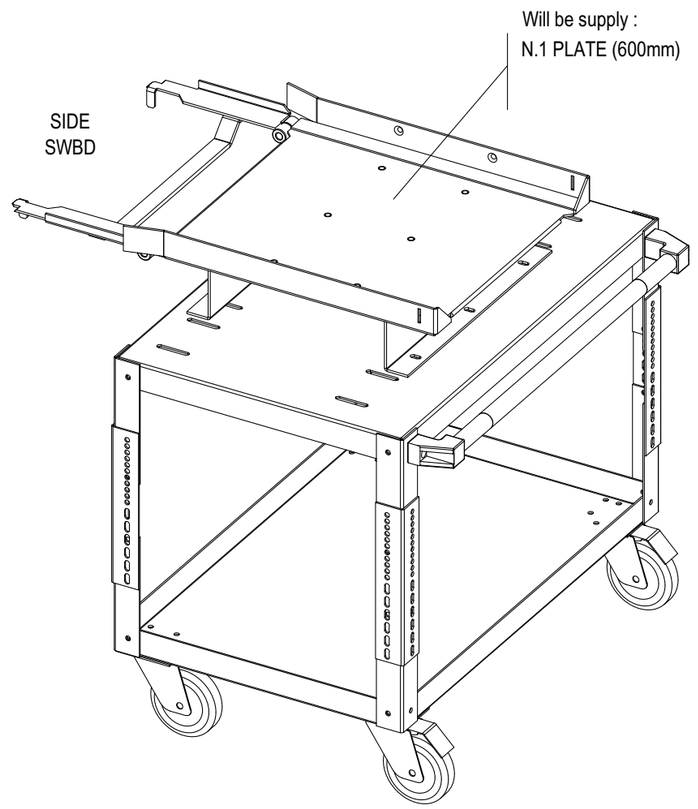
FRONT VIEW

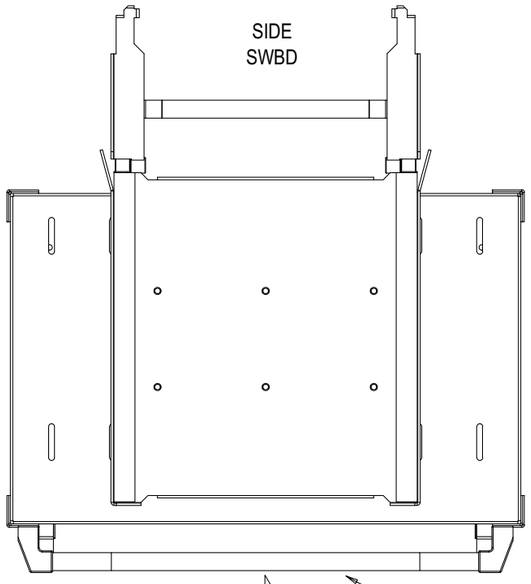



SIDE VIEW




ASSONOMETRIC VIEW




TOP VIEW

NOTE :
Measurement Tollerance + 0,25%

| | | | | | | |
|---|---|---|---|---|---|---|
| = | | | | | | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

DWG n° : 231151/SD/6
Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

GENERAL ARRANGEMENTS
Extraction Truck for Circuit Breaker/Contactor

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00006

SHEET 016

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00006 Rev. 03

1.2.2.SG-200N1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG,

Doc. No. 1723002197-EL-DA-00007

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# BASE LOAD POWER HUB (BLPH)

# "SG-200N1" LV SWBD 400/230V

# GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macula | 23/09/2024 |

IMESA ELECTRICAL ENGINEERING

DWG n°: 231298/SD/7

Item n°: PF1002983/26

CROSSWIND

ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

SHEET 001

REV. 03

File Name : 1723002197-EL-DA-00007 Rev. 03

F.to UNI A3: 420mmx297mm

# INDEX SHEETS

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 001 | Cover / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 002 | Index / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 003 | Switchgear Characteristics / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 004 | Switchgear Characteristics / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 005 | Switchgear Name Plate / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 006 | Switchgear Lay-Out - Front View / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 007 | Switchgear Lay-Out - Front View / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 008 | Switchgear Lay-Out - Top View / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 009 | Switchgear Lay-Out - Bottom View / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 010 | Switchgear Lay-Out - Base Frame View / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 011 | Switchgear Lay-Out - Side View / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 012 | Base Frame Fixing System / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |
| 013 | Center of Gravity Positioning / GENERAL ARRANGEMENTS | X | X | X | X | | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/7

Item n° : PF1002983/26

TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

SHEET 002

REV. 03

File Name : 1723002197-EL-DA-00007 Rev. 03

F.to UNI A3: 420mmx297mm

| A | ENVIRONMENTAL DATA | |
|---|---|---|
| 1 | AMBIENT | MARINE - OFFSHORE |
| 2 | INSTALLATION | INDOOR |
| 3 | AMBIENT AIR TEMPERATURE - DELAY AVERAGE MAXIMUM | 35 °C |
| 4 | AMBIENT AIR MINIMUM/MAXIMUM TEMPERATURE | -8,4 ÷ +40 °C |
| 5 | RELATIVE HUMIDITY AVERAGE | 95 % |
| 6 | RELATIVE HUMIDITY MAXIMUM | - |
| 7 | POLLUTION LEVEL DEGREE | VERY LIGHT |

| B | SWITCHGEAR ELECTRICAL FEATURES | |
|---|---|---|
| 1 | RATED VOLTAGE (Ue) | 0,4/0,23 kV |
| 2 | NOMINAL VOLTAGE (Un) | 0,4/0,23 kV |
| 3 | RATED INSULATION VOLTAGE (Ui) | 0,69 kV |
| 4 | RATED FREQUENCY (Fn) | 50 Hz |
| 5 | RATED IMPULSE WITHSTAND (Uimp) | 4 kV |
| 6 | RATED NORMAL CURRENT (In) | 2500 A |
| 7 | RATED SHORT TIME WITHSTAND CURRENT (Ik) | 50 kA |
| 8 | RATED DURATION OF SHORT CIRCUIT (tk) | 1 s |
| 9 | RATED PEAK WITHSTAND CURRENT (Ipk) | 105 kA |
| 10 | INTERNAL ARC CLASSIFICATION IAC (only A1 Column) | 50 kA |
| 11 | ARCING CLASS (only A1 Column) | 0,3 s |
| 12 | NUMBER OF PHASES | 3+1 |
| 13 | PHASES IDENTIFICATION | L1-L2-L3-N |
| 14 | EARTHING CIRCUITS MAIN BUSBAR SECTION | > 300mmq |
| 15 | REFERENCE STANDARDS | IEC 61439-2 |
| 16 | EARTHING SYSTEM | TN-S |
| 17 | NEUTRAL BUSBARS SIZING | 50% PHASE SECTION |

| C | SWITCHGEAR MECHANICAL FEATURES | |
|---|---|---|
| 1 | EXTERNAL DEGREE OF PROTECTION | IP30 |
| 2 | INTERNAL DEGREE OF PROTECTION | IP20 |
| 3 | EXTERNAL MECHANICAL IMPACT PROTECTION | IK10 |
| 4 | ACCESSIBILITY | FRONT |
| 5 | TYPE DESIGNATION | FORM : 4B (INCOMING)<br>FORM : 4B (OUTGOING) |
| 6 | POWER CABLES (INCOMING) | FROM THE TOP (by MCT) |
| 7 | POWER CABLES (OUTGOING) | FROM THE TOP (by MCT) |
| 8 | AUXILIARY CABLES | FROM THE TOP (by MCT) |
| 9 | BASE FRAMES | PROVIDED |
| 10 | MIMIC DIAGRAM (BLACK) | not applicable |
| 11 | BOTTOM CLOSING | UNDRILLED ALUMINIUM REMOVABLE PLATES |
| 12 | PAINTING COLOUR | RAL 7035 |
| 13 | PAINTING SPECIFICATION CYCLE | C3-MEDIUM, > 60µ (IMESA CYCLE "A") |
| 14 | SURFACE NOT PAINTED | ZINC PLATED OR TROPICALIZED |
| 15 | FRONT DOORS (AUXILIARY COMPARTMENT) | HINGED WITH KEY LOCKS |
| 16 | FRONT DOOR (C.B. COMPARTMENT) | HINGED WITH KEY LOCKS |
| 17 | REAR PANELS | BOLTED |
| 18 | MINIMUM CLEARANCE | TO THE FRONT 1200 mm |
| 19 | | TO THE REAR 100 mm |
| 20 | | TO THE TOP 200 mm |
| 21 | | TO THE SIDE 100 mm |
| 22 | WEIGHTS | 4.760 kg ± 10% |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/7

Item n° : PF1002983/26

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Switchgear Characteristics

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

SHEET 003

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00007 Rev. 03

| D | BUSBAR SYSTEM | |
|---|---|---|
| 1 | MATERIALS | ELECTROLYTIC COPPER |
| 2 | BUSBAR SURFACE TREATMENT | not applicable |
| 3 | INSULATION BUSBARS (if applicable) | SHEATHED |
| 4 | JOINT AND CONNECTIONS TREATMENT | not applicable |
| 5 | INSULATION JOINTS (if applicable) | REMOVABLE SOLID DIELECTRIC PROTECTIONS |
| 6 | BULKHEADS FOR POWER BARS (if applicable) | YES |
| 7 | PHASES IDENTIFICATION | L1 (BROWN) |
| 8 | | L2 (BLACK) |
| 9 | | L3 (GREY) |
| 10 | | N (BLUE) |
| 11 | | PE (YELLOW / GREEN) |
| 12 | MARKING OF PHASES | ADHESIVE LABELS PLACED ON BARS |

| E | POWER / AUXILIARY CIRCUITS CABLES | | |
|---|---|---|---|
| 1 | LOW VOLTAGE CABLE TYPE | | SH-W (MARINE APPROVAL) |
| 2 | INSULATION | | HLPE (600/1000 V) |
| | SIZE / COLOUR CODE | | |
| 3 | MEASURE & CONTROL & SIGNAL CIRCUITS | AC/DC CIRCUIT (Internal Heating / Motor Spring Charger / Internal Distribution) | ≥ 2,5 mmq / BLACK |
| 4 | | VT SECONDARY CIRCUIT | 1,5 mmq / BLACK |
| 5 | | CT SECONDARY CIRCUIT | 2,5 mmq / BLACK |
| 6 | | AC CIRCUIT | ≥ 1,5 mmq / BLACK |
| 7 | | DC CIRCUIT | ≥ 1,5 mmq / RED(+) WHITE (-) |
| 8 | | GROUND CIRCUIT | YELLOW / GREEN |
| 9 | | PHASES IDENTIFICATION FOR AC POWER CIRCUIT TERMINATION WITH SHRINKABLE SHEATH [cable insulation BLACK] | L1 (BROWN) |
| 10 | | | L2 (BLACK) |
| 11 | | | L3 (GREY) |

| F | TERMINAL BLOCKS | |
|---|---|---|
| 1 | TERMINAL BLOCK TYPE | SPRING CLAMP (CABUR HMM grey) |
| 2 | DISCONNECT/TEST TERMINAL BLOCK TYPE | SPRING CLAMP (CABUR HMM grey) |
| 3 | MATERIAL | POLYAMIDE |
| 4 | SIZE | ≥ 4mmq |

| G | AUXILIARY CIRCUIT VOLTAGE | |
|---|---|---|
| 1 | AUXILIARY COMMAND CIRCUITS | 230 Vac |
| 2 | AUXILIARY SIGNALLING CIRCUITS | 230 Vac |
| 3 | AUXILIARY PROTECTION CIRCUITS | 230 Vac |
| 4 | SPRING CHARGING MOTOR C.B. | 230 Vac |
| 5 | INTERNAL LIGHTINGS | 230 Vac |
| 6 | ANTICONDENSATION HEATER | 230 Vac |

| H | LABELS | |
|---|---|---|
| 1 | MATERIAL | TRAFFOLYTE |
| 2 | BACKGROUND | WHITE |
| 3 | LETTERS | BLACK |
| 4 | LANGUAGE | ENGLISH |
| 5 | WARNING LABEL LANGUAGE | ENGLISH |
| 6 | FIXING | SCREWED |
| 7 | MARKING DEVICES / WIRES | INDIPENDENT |
| 8 | AC CIRCUIT | SEQUENTIAL |
| 9 | DC CIRCUIT | SEQUENTIAL |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 28/08/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| 2 | 22/05/2024 | Flamminio | Santinelli | Santinelli | Accepted for Construction (AFC) |
| 1 | 28/03/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| 0 | 21/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/7

Item n° : PF1002983/26

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Switchgear Characteristics

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

SHEET 004

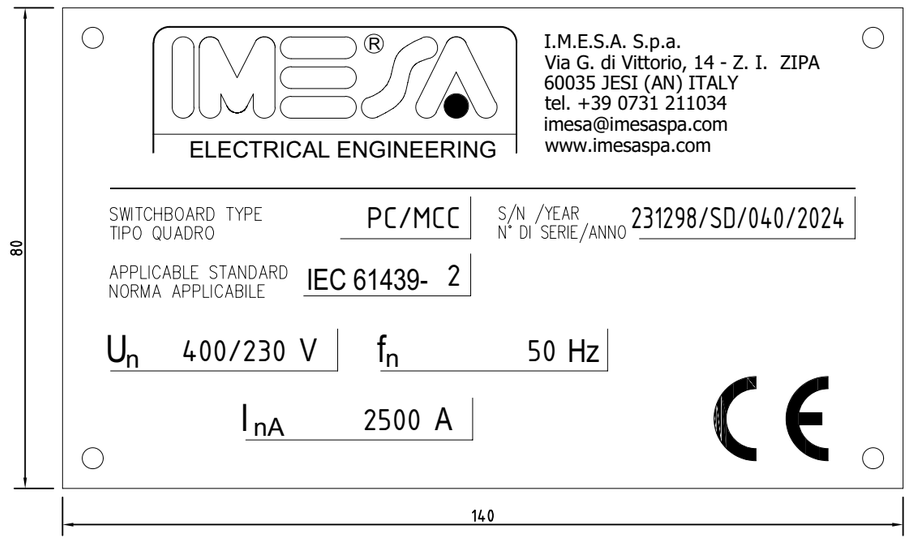
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00007 Rev. 03

# NAMEPLATE DATES

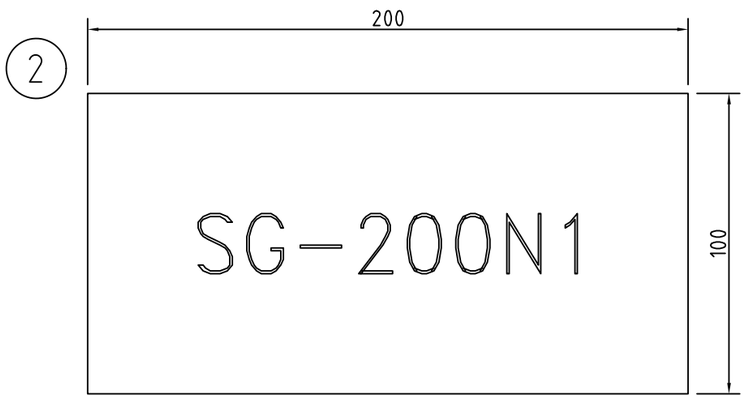
(1)




Material: Alloy

# SWITCHGEAR TAG PLATE

(2)




Material: Traffolyte

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 28/08/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| 2 | 22/05/2024 | Flamminio | Santinelli | Santinelli | Accepted for Construction (AFC) |
| 1 | 28/03/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| 0 | 21/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |

DWG n° : 231298/SD/7
Item n° : PF1002983/26

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Switchgear Name Plate

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

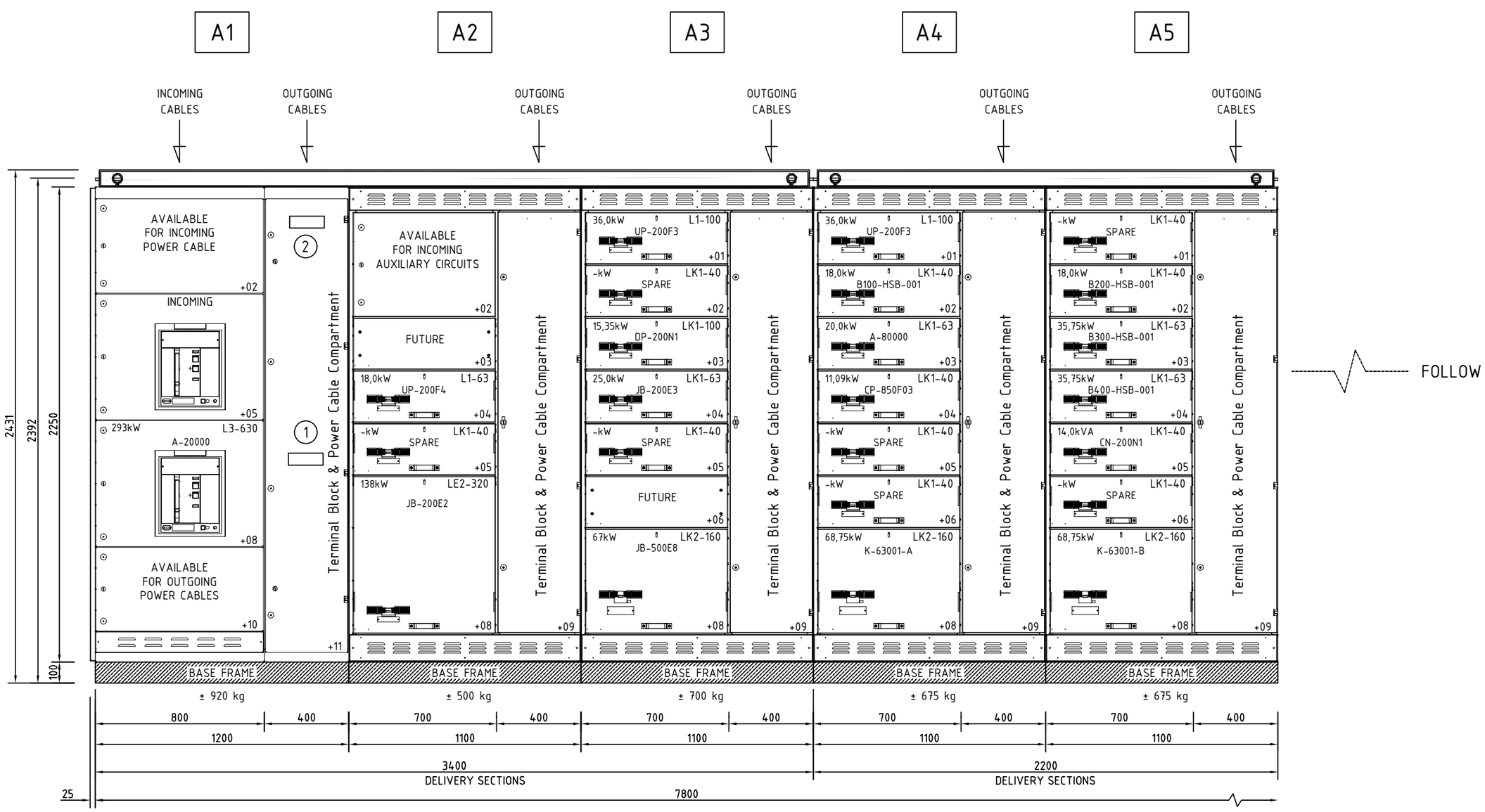
SHEET 005

REV. 03

File Name : 1723002197-EL-DA-00007 Rev. 03

F.to UNI A3: 420mmx297mm

# FRONT VIEW




NOTE :

1. Measurement Tollerance + 0,25%
2. Weight Tollerance ± 10%
3. Lifting Beam (Removable after Positioning)
4. Layout doors are represented in the Functional Diagrams

scale 1/20

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 28/08/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| 2 | 22/05/2024 | Flamminio | Santinelli | Santinelli | Accepted for Construction (AFC) |
| 1 | 28/03/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| 0 | 21/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |

DWG n° : 231298/SD/7
Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Front View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

SHEET 006

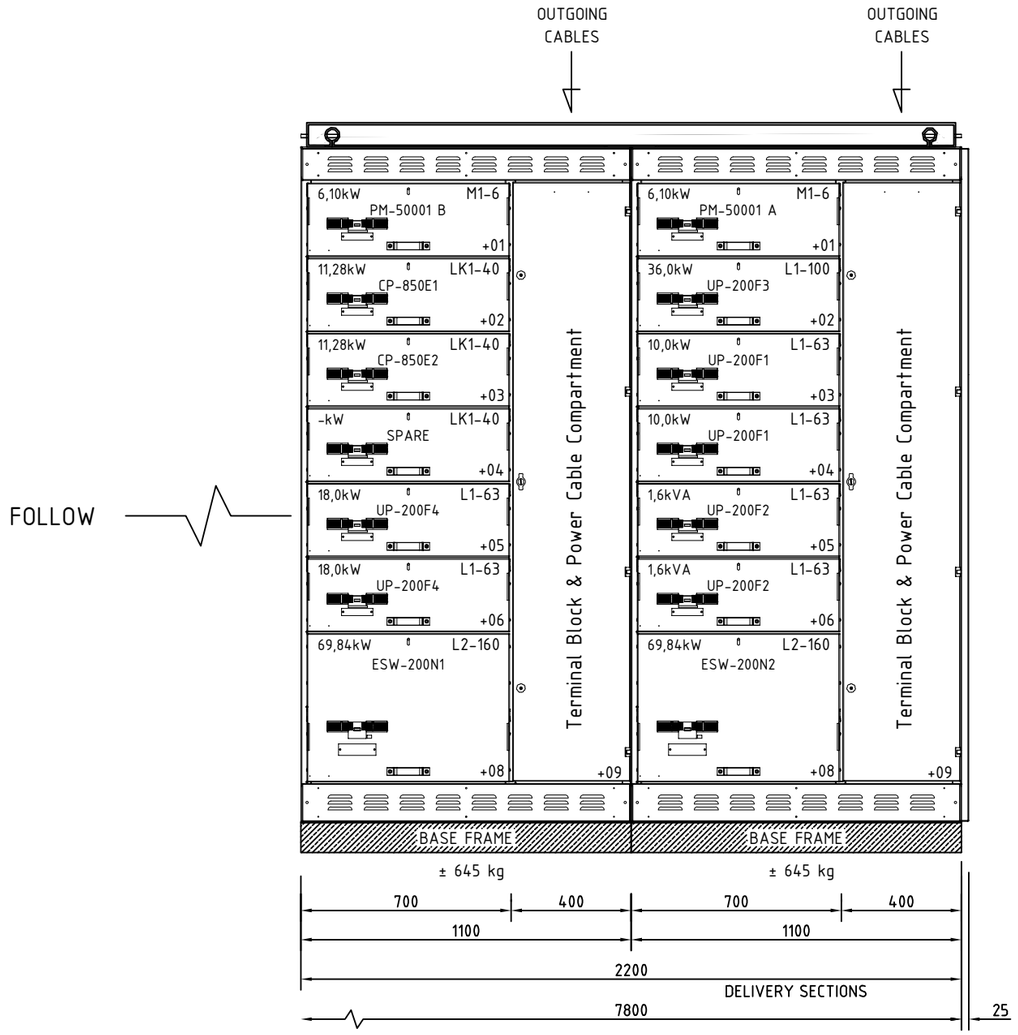
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00007 Rev. 03

# FRONT VIEW

A6 A7




FOLLOW

NOTE :

1. Measurement Tollerance + 0,25%
2. Weight Tollerance ± 10%
3. Lifting Beam (Removable after Positioning)
4. Layout doors are represented in the Functional Diagrams

scale 1/20

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 28/08/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| 2 | 22/05/2024 | Flamminio | Santinelli | Santinelli | Accepted for Construction (AFC) |
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| 0 | 21/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/7

Item n° : PF1002983/26

TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Front View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

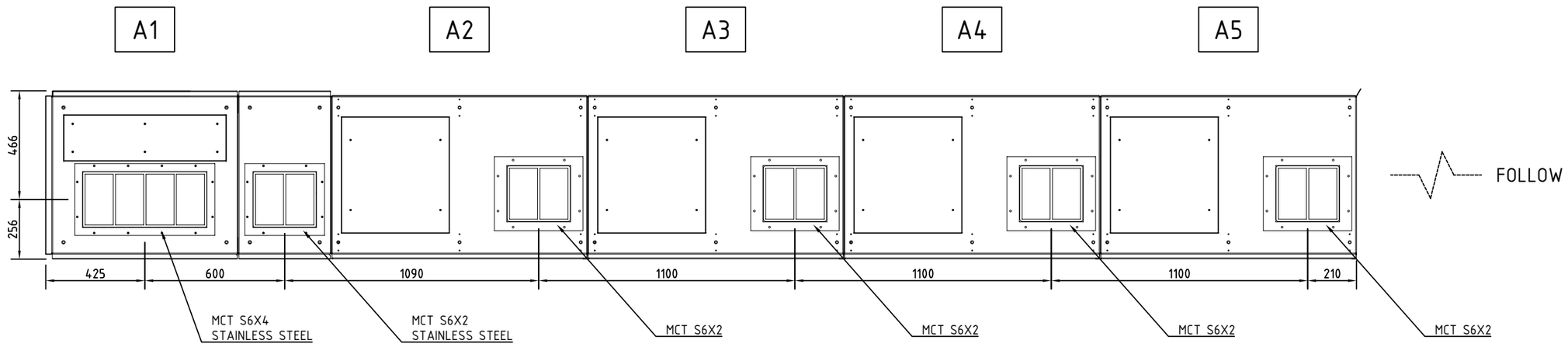
SHEET 007

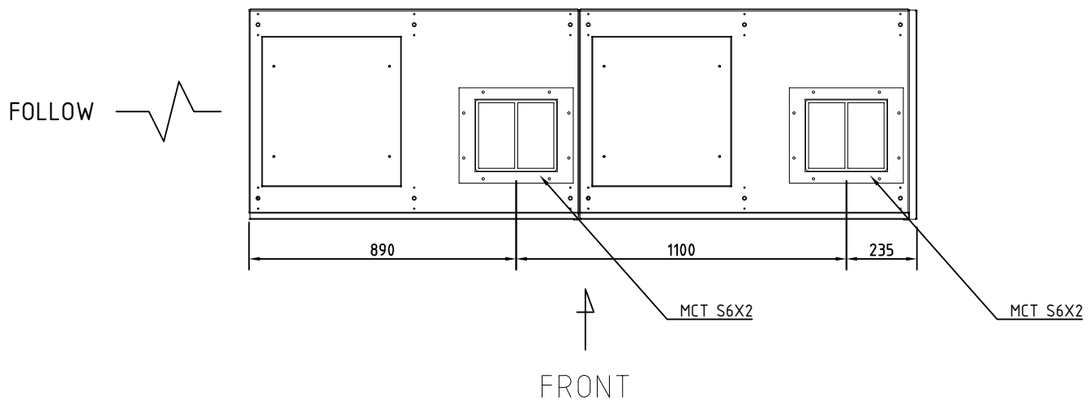
REV. 03

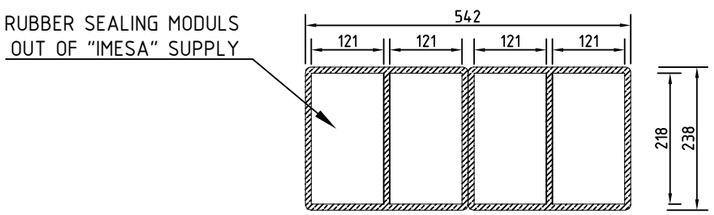
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00007 Rev. 03

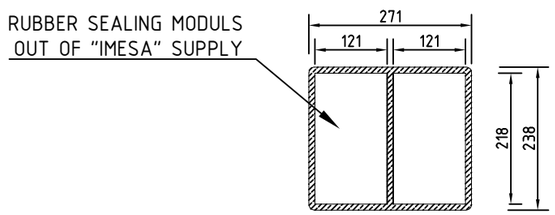
## TOP VIEW




"S6X4" MCT DETAILS




"S6X2" MCT DETAILS

scale 1/20

NOTE :
1. Measurement Tollerance + 0,25%

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 28/08/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| 2 | 22/05/2024 | Flamminio | Santinelli | Santinelli | Accepted for Construction (AFC) |
| 1 | 28/03/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| 0 | 21/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |

DWG n° : 231298/SD/7
Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Top View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

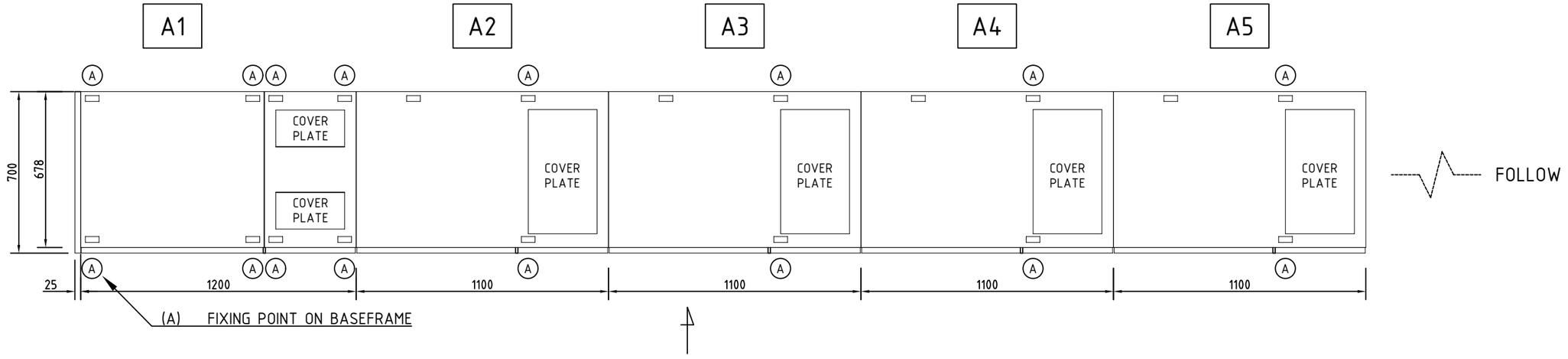
SHEET 008

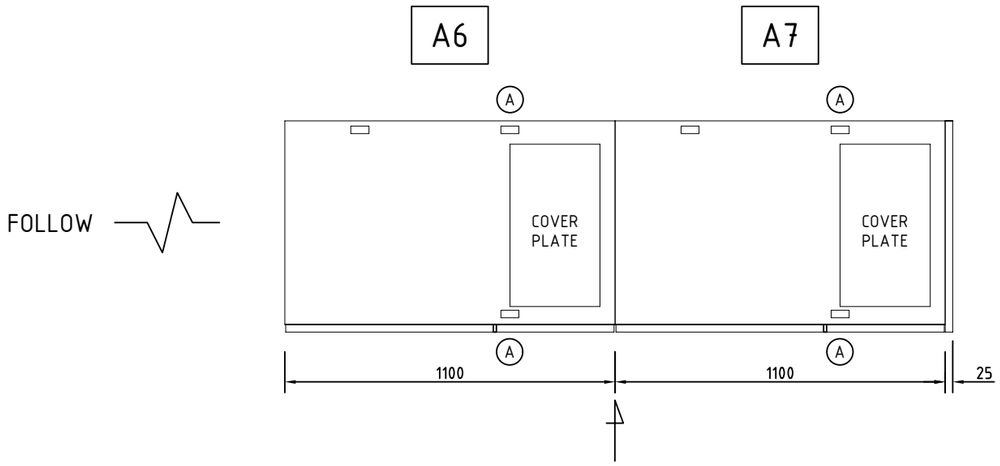
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00007 Rev. 03

# BOTTOM VIEW




NOTE :
1. Measurement Tollerance + 0,25%

scale 1/20

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 28/08/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| 2 | 22/05/2024 | Flamminio | Santinelli | Santinelli | Accepted for Construction (AFC) |
| 1 | 28/03/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| 0 | 21/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |

DWG n° : 231298/SD/7
Item n° : PF1002983/26

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"
GENERAL ARRANGEMENTS
Switchgear Lay-Out - Bottom View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

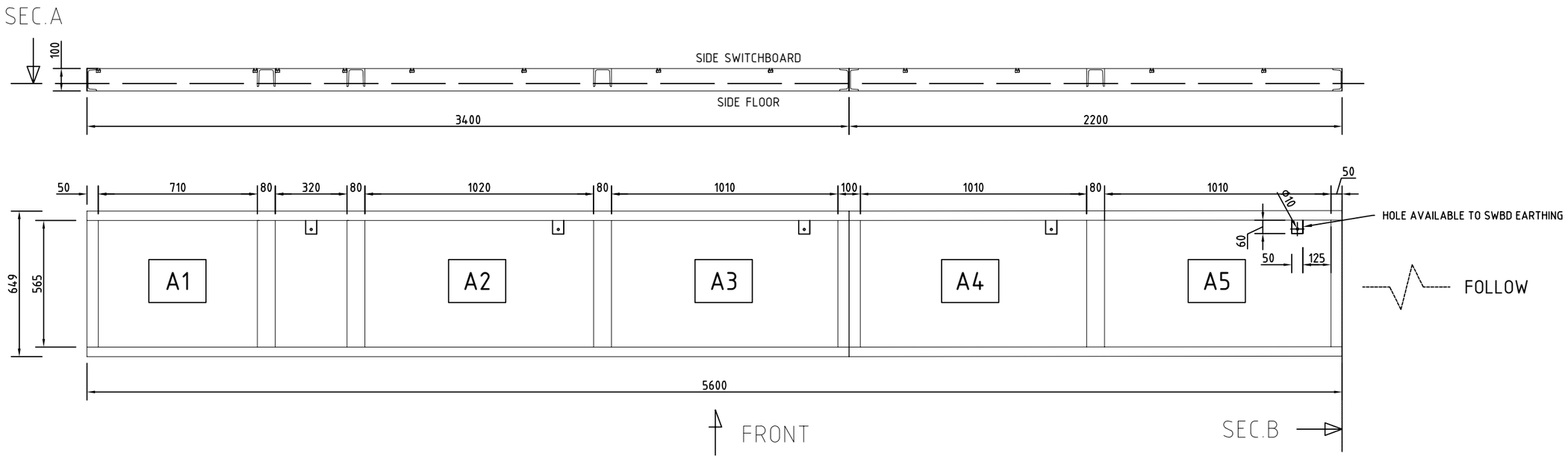
SHEET 009

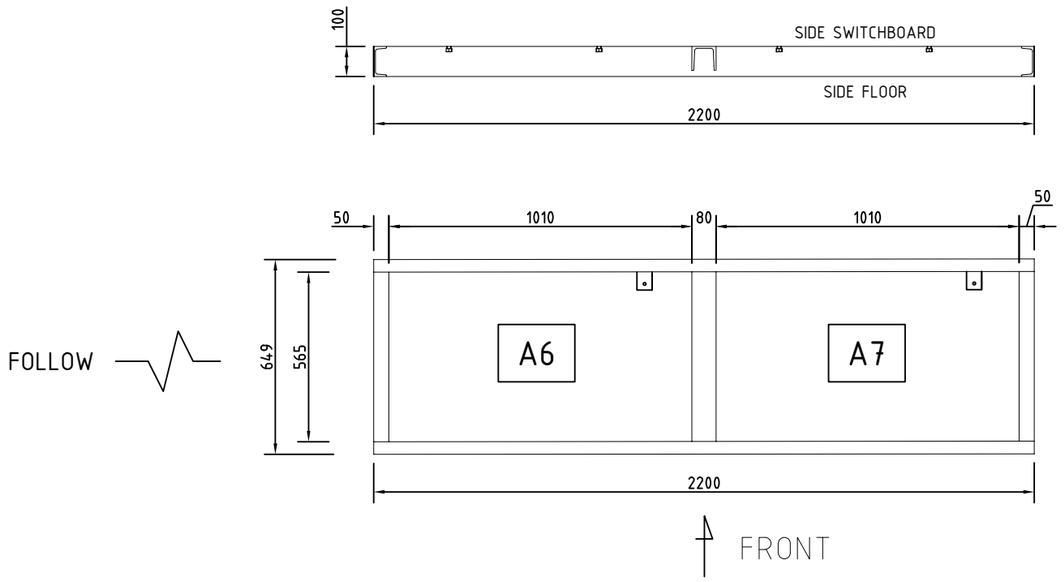
REV. 03

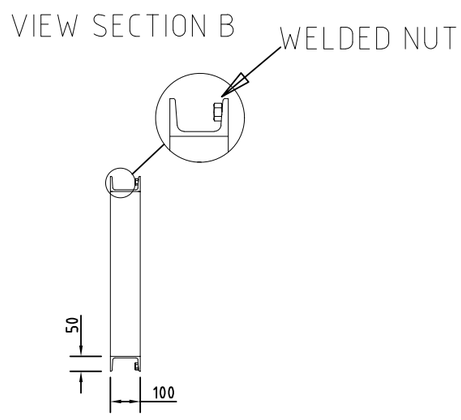
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00007 Rev. 03

# BASE FRAME VIEW




NOTE :
1. Measurement Tollerance + 0,25%

scale 1/20

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| + | | | | | | | |
| | 3 | 28/08/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| | 2 | 22/05/2024 | Flamminio | Santinelli | Santinelli | Accepted for Construction (AFC) |
| | 1 | 28/03/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| | 0 | 21/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/7

Item n° : PF1002983/26

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Base Frame View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

SHEET 010

REV. 03

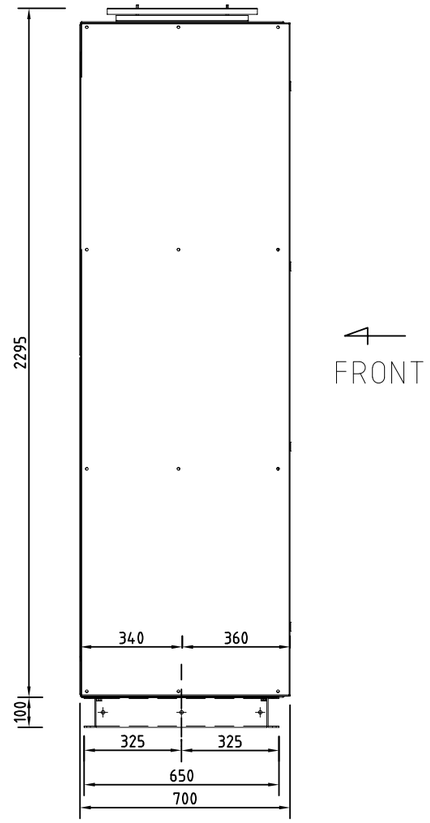
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00007 Rev. 03

1 2 3 4 5 6 7 8 9 10

A B C D E

# SIDE VIEW




NOTE :
1. Measurement Tollerance + 0,25%

scale 1/20

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| + | | | | | | | |
| 3 | 28/08/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) | | |
| 2 | 22/05/2024 | Flamminio | Santinelli | Santinelli | Accepted for Construction (AFC) | | |
| 1 | 28/03/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) | | |
| 0 | 21/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) | | |
| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | | |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/7

Item n° : PF1002983/26

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Side View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

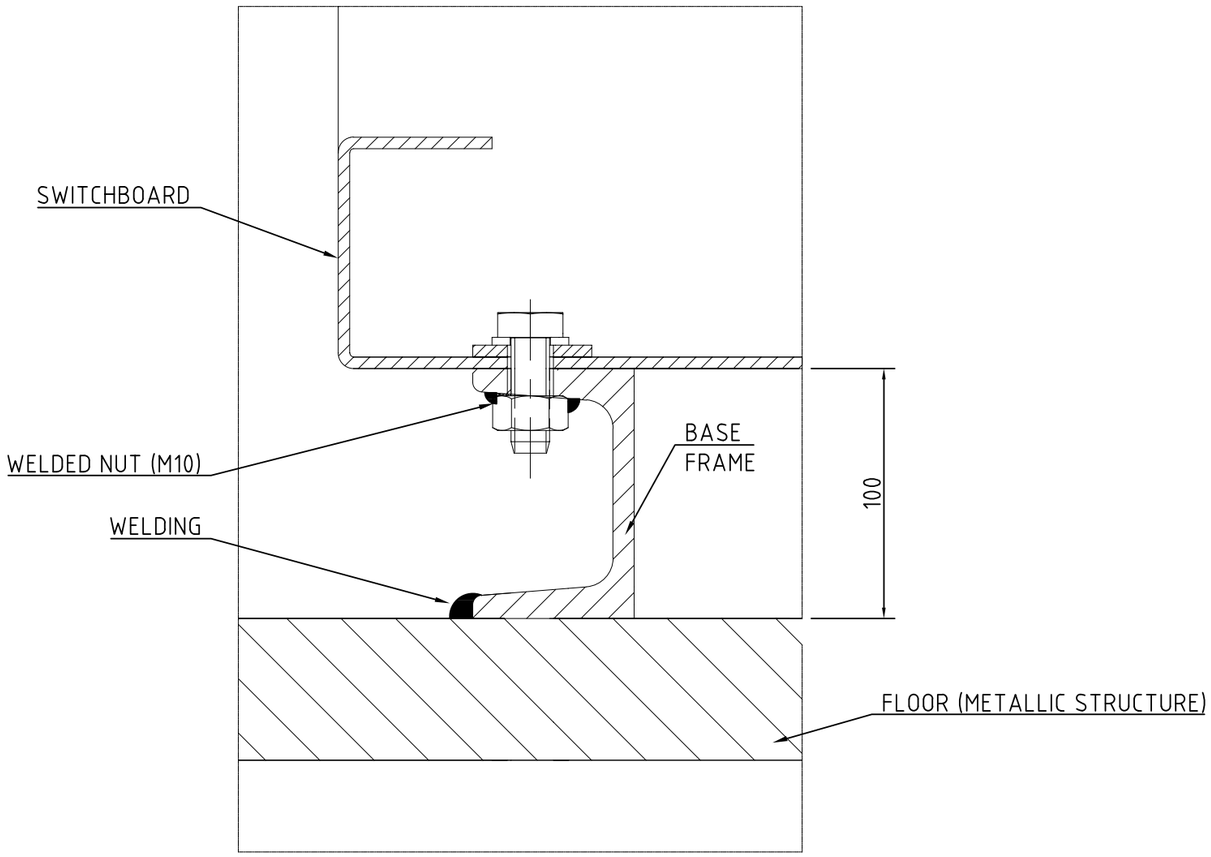
SHEET 011

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00007 Rev. 03

# BASE FRAME FIXING SYSTEM




NOTE :
1. Measurement Tollerance + 0,25%

scale 1/20

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 28/08/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| 2 | 22/05/2024 | Flamminio | Santinelli | Santinelli | Accepted for Construction (AFC) |
| 1 | 28/03/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| 0 | 21/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/7

Item n° : PF1002983/26

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Base Frame Fixing System

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

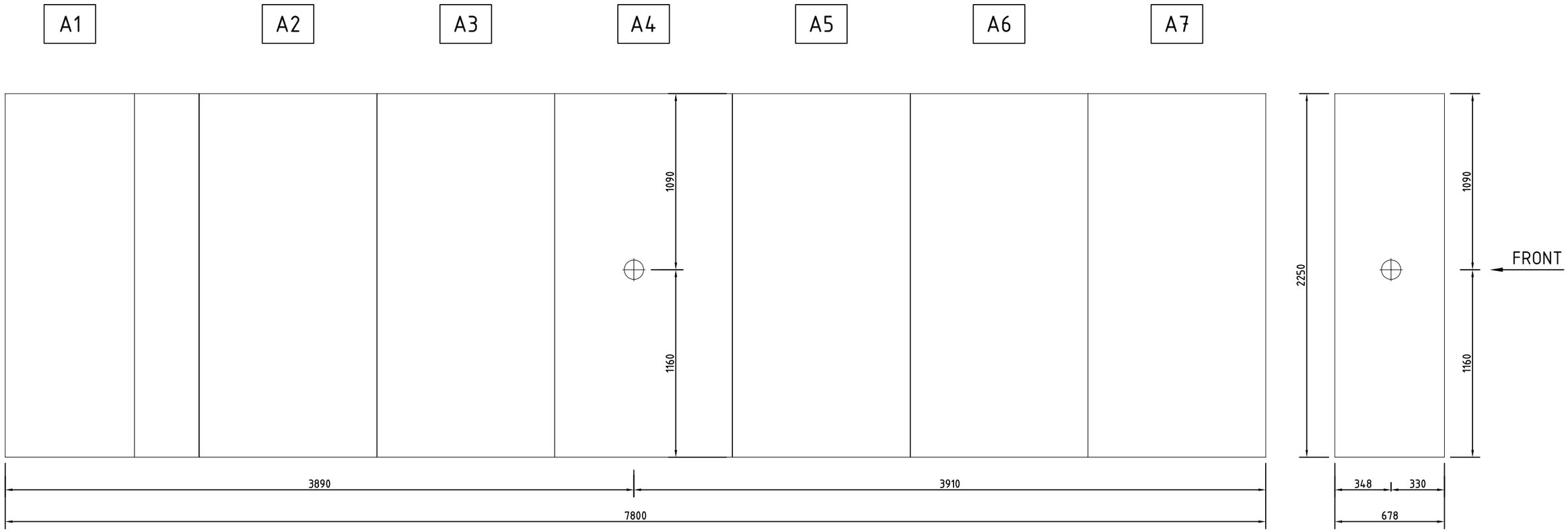
SHEET 012

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00007 Rev. 03

# CENTER OF GRAVITY POSITIONING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 28/08/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| 2 | 22/05/2024 | Flamminio | Santinelli | Santinelli | Accepted for Construction (AFC) |
| 1 | 28/03/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| 0 | 21/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/7

Item n° : PF1002983/26

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

GENERAL ARRANGEMENTS
Center of Gravity Positioning

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00007

SHEET 013

REV. 03

File Name : 1723002197-EL-DA-00007 Rev. 03

F.to UNI A3: 420mmx297mm

1.2.3.SG-200D2 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG,

Doc. No. 1723002197-EL-DA-00008

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# BASE LOAD POWER HUB (BLPH)

# "SG-200D2" LV SWBD 800V

# GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |
| *NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.* | |
| Sign | Date |
| Luca Macula | 25/09/2024 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 4 | 18/09/2024 | Rossi | Santinelli | Santinelli | As Built (ASB) |
| 3 | 08/07/2024 | Rossi | Santinelli | Santinelli | Accepted for Construction (AFC) |
| 2 | 22/05/2024 | Rossi | Santinelli | Santinelli | Issue for review (IFR) |
| 1 | 19/03/2024 | Rossi | Santinelli | Santinelli | Issue for review (IFR) |
| 0 | 09/02/2024 | Rossi | Santinelli | Santinelli | Issue for review (IFR) |

= 

+ 

DWG n° : 231298/SD/8

Item n° : PF1002669/3

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

GENERAL ARRANGEMENTS
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00008

SHEET 001

REV. 04

File Name : 1723002197-EL-DA-00008 Rev. 04

F.to UNI A3: 420mmx297mm

# INDEX SHEETS

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 001 | Cover / GENERAL ARRANGEMENTS | X | X | X | X | X | | | | | |
| 002 | Index / GENERAL ARRANGEMENTS | X | X | X | X | X | | | | | |
| 003 | Switchgear Characteristics / GENERAL ARRANGEMENTS | X | X | X | X | X | | | | | |
| 004 | Switchgear Characteristics / GENERAL ARRANGEMENTS | X | X | X | X | X | | | | | |
| 005 | Switchgear Name Plate / GENERAL ARRANGEMENTS | X | X | X | X | X | | | | | |
| 006 | Switchgear Lay-Out - Front View / GENERAL ARRANGEMENTS | X | X | X | X | X | | | | | |
| 007 | Switchgear Lay-Out - Laterals View / GENERAL ARRANGEMENTS | X | X | X | X | X | | | | | |
| 008 | Switchgear Lay-Out - Bottom View / GENERAL ARRANGEMENTS | X | X | X | X | X | | | | | |
| 009 | Base Frame Fixing System / GENERAL ARRANGEMENTS | X | X | X | X | X | | | | | |
| 010 | Center of Gravity Positioning / GENERAL ARRANGEMENTS | X | X | X | X | X | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/8

Item n° : PF1002669/3

TITLE : "SG-200D2"

GENERAL ARRANGEMENTS
Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00008

SHEET 002

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00008 Rev. 04

| A | ENVIRONMENTAL DATA | |
|---|---|---|
| 1 | AMBIENT | MARINE - OFFSHORE |
| 2 | INSTALLATION | INDOOR |
| 3 | AMBIENT AIR TEMPERATURE - DELAY AVERAGE MAXIMUM | 35 °C |
| 4 | AMBIENT AIR MINIMUM/MAXIMUM TEMPERATURE | -8,4 ÷ +40 °C |
| 5 | RELATIVE HUMIDITY AVERAGE | 95 % |
| 6 | RELATIVE HUMIDITY MAXIMUM | - |
| 7 | POLLUTION LEVEL DEGREE | VERY LIGHT |

| B | SWITCHGEAR ELECTRICAL FEATURES | |
|---|---|---|
| 1 | RATED VOLTAGE (Ue) | 0,8 kV |
| 2 | NOMINAL VOLTAGE (Un) | 0,8 kV |
| 3 | RATED INSULATION VOLTAGE (Ui) | 1 kV |
| 4 | RATED FREQUENCY (Fn) | 50 Hz |
| 5 | RATED IMPULSE WITHSTAND (Uimp) | 4 kV |
| 6 | RATED NORMAL CURRENT (In) | 630 A @45 °C |
| 7 | RATED SHORT TIME WITHSTAND CURRENT (Ik) | 30 kA |
| 8 | RATED DURATION OF SHORT CIRCUIT (tk) | 1 s |
| 9 | RATED PEAK WITHSTAND CURRENT (Ipk) | 63 kA |
| 10 | INTERNAL ARC CLASSIFICATION IAC | Not Applicable |
| 11 | ARCING CLASS | Not Applicable |
| 12 | NUMBER OF PHASES | 3 |
| 13 | PHASES IDENTIFICATION | L1-L2-L3 |
| 14 | EARTHING CIRCUITS MAIN BUSBAR SECTION | > 300mmq |
| 15 | REFERENCE STANDARDS | IEC 61439-2 |
| 16 | EARTHING SYSTEM | TN-S |
| 17 | NEUTRAL BUSBARS SIZING | - |

| C | SWITCHGEAR MECHANICAL FEATURES | |
|---|---|---|
| 1 | EXTERNAL DEGREE OF PROTECTION | IP30 |
| 2 | INTERNAL DEGREE OF PROTECTION | IP20 |
| 3 | EXTERNAL MECHANICAL IMPACT PROTECTION | IK10 |
| 4 | ACCESSIBILITY | FRONT |
| 5 | TYPE DESIGNATION | FORM : 3B (INCOMING)<br>FORM : 3B (OUTGOING) |
| 6 | POWER CABLES (INCOMING) | FROM THE TOP (by MCT) |
| 7 | POWER CABLES (OUTGOING) | FROM THE TOP (by MCT) |
| 8 | AUXILIARY CABLES | FROM THE TOP (by MCT) |
| 9 | BASE FRAMES | PROVIDED |
| 10 | MIMIC DIAGRAM (BLACK) | Not Applicable |
| 11 | BOTTOM CLOSING | Not Applicable |
| 12 | PAINTING COLOUR | RAL 7035 |
| 13 | PAINTING SPECIFICATION CYCLE | C3-MEDIUM, >60µ (IMESA CYCLE "A") |
| 14 | SURFACE NOT PAINTED | ZINC PLATED OR TROPICALIZED |
| 15 | FRONT DOORS (AUXILIARY COMPARTMENT) | HINGED WITH KEY LOCK |
| 16 | FRONT DOORS (CIRCUIT BREAKER) | HINGED WITH KEY LOCK |
| 17 | REAR/LATERAL PANELS | BOLTED |
| 18 | MINIMUM CLEARANCE | TO THE FRONT 1200 mm |
| 19 | | TO THE REAR 50 mm |
| 20 | | TO THE TOP 800 mm |
| 21 | | TO THE SIDE 1200 mm |
| 22 | WEIGHTS | 450 kg ± 10% |
| 23 | EXPANDABILITY | Not Applicable |

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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/8

Item n° : PF1002669/3

TITLE : "SG-200D2"

GENERAL ARRANGEMENTS
Switchgear Characteristics

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00008

SHEET 003

REV. 04

File Name : 1723002197-EL-DA-00008 Rev. 04

F.to UNI A3: 420mmx297mm

| D | BUSBAR SYSTEM | |
|---|---|---|
| 1 | MATERIALS | ELECTROLYTIC COPPER |
| 2 | BUSBAR SURFACE TREATMENT | not applicable |
| 3 | INSULATION BUSBARS (if Applicale) | SHEATHED |
| 4 | JOINT AND CONNECTIONS TREATMENT | Not Applicable |
| 5 | INSULATION JOINTS (if Applicable) | REMOVABLE SOLID DIELECTRIC PROTECTIONS |
| 6 | BULKHEADS FOR POWER BARS (if Applicable) | YES |
| 7 | PHASES IDENTIFICATION | L1 (BROWN) |
| 8 | | L2 (BLACK) |
| 9 | | L3 (GREY) |
| 10 | | PE |
| 12 | MARKING OF PHASES | ADHESIVE LABELS PLACED ON BARS |

| E | POWER / AUXILIARY CIRCUITS CABLES | | |
|---|---|---|---|
| 1 | LOW VOLTAGE CABLE TYPE | | Not Applicable |
| 2 | INSULATION | | Not Applicable |
| | SIZE / COLOUR CODE | | |
| 3 | MEASURE & CONTROL & SIGNAL CIRCUITS | AC/DC CIRCUIT (Internal Heating / Motor Spring Charger / Internal Distribution) | ≥ 2,5 mmq / BLACK |
| 4 | | VT SECONDARY CIRCUIT | 1,5 mmq / BLACK |
| 5 | | CT SECONDARY CIRCUIT | 2,5 mmq / BLACK |
| 6 | | AC CIRCUIT | ≥ 1,5 mmq / BLACK |
| 7 | | DC CIRCUIT | ≥ 1,5 mmq / RED(+) WHITE(-) |
| 8 | | GROUND CIRCUIT | YELLOW / GREEN |
| 9 | | PHASES IDENTIFICATION FOR AC POWER CIRCUIT TERMINATION WITH SHRINKABLE SHEATH | Not Applicable |
| 10 | | | Not Applicable |
| 11 | | | Not Applicable |

| F | TERMINAL BLOCKS | |
|---|---|---|
| 1 | TERMINAL BLOCK TYPE | SPRING CLAMP (CABUR HMM grey) |
| 2 | DISCONNECT/TEST TERMINAL BLOCK TYPE | SPRING CLAMP (CABUR HMM grey) |
| 3 | MATERIAL | POLYAMIDE |
| 4 | SIZE | ≥ 4mmq |

| G | AUXILIARY CIRCUIT VOLTAGE | |
|---|---|---|
| 1 | AUXILIARY COMMAND CIRCUITS | 230 Vac (Internal Supply) |
| 2 | AUXILIARY SIGNALLING CIRCUITS | 230 Vac (Internal Supply) |
| 3 | AUXILIARY CIRCUITS | 24 Vdc (Internal Supply) |
| 4 | SPRING CHARGING MOTOR C.B. | 230 Vac (Internal Supply) |
| 5 | INTERNAL LIGHTINGS | 230 Vac (Internal Supply) |
| 6 | ANTICONDENSATION HEATER | 230 Vac (Internal Supply) |

| H | LABELS | |
|---|---|---|
| 1 | MATERIAL | TRAFFOLYTE |
| 2 | BACKGROUND | WHITE |
| 3 | LETTERS | BLACK |
| 4 | LANGUAGE | ENGLISH |
| 5 | WARNING LABEL LANGUAGE | ENGLISH |
| 6 | FIXING | SCREWED |
| 7 | MARKING DEVICES / WIRES | INDIPENDENT |
| 8 | AC CIRCUIT | SEQUENTIAL |
| 9 | DC CIRCUIT | SEQUENTIAL |

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

GENERAL ARRANGEMENTS
Switchgear Characteristics

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00008

SHEET 004

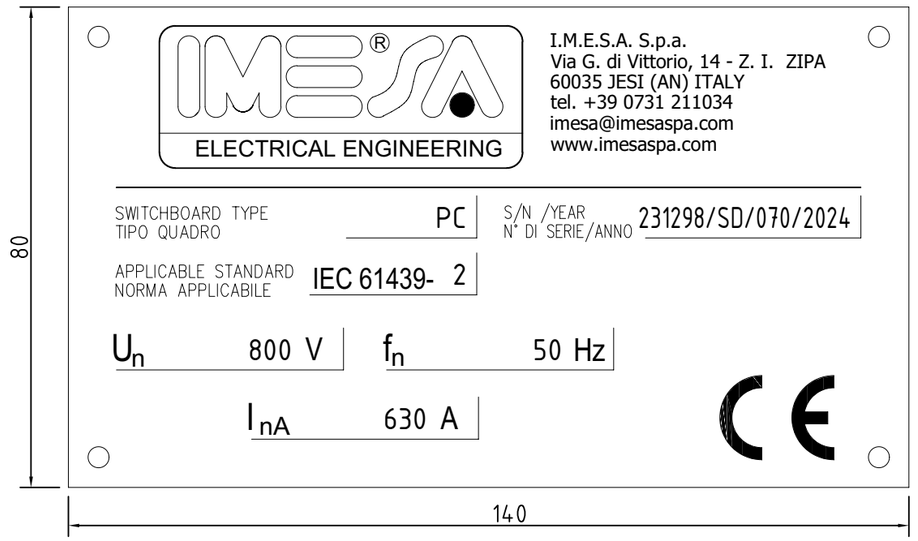
REV. 04

File Name : 1723002197-EL-DA-00008 Rev. 04

F.to UNI A3: 420mmx297mm

## NAMEPLATE DATES

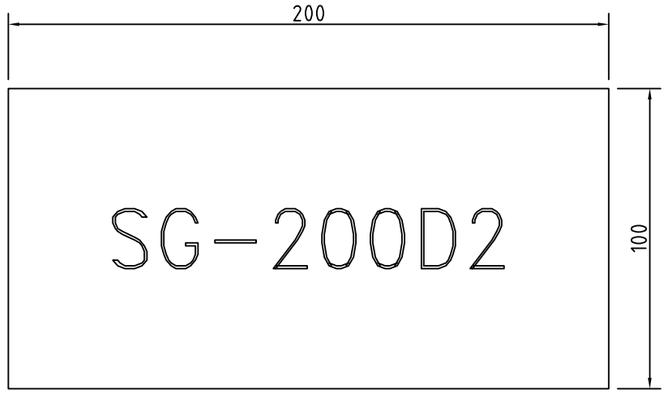
(1)




Material: Alloy

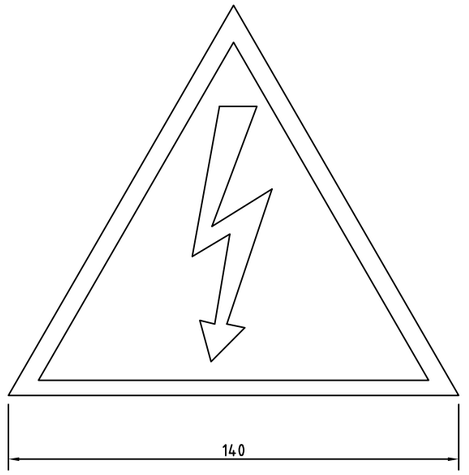
## SWITCHGEAR TAG PLATE

(2)




Material: Traffolyte

## WARNING LABEL




Material: Adhesive film

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DWG n°: 231298/SD/8
Item n°: PF1002669/3

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"
GENERAL ARRANGEMENTS
Switchgear Name Plate

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

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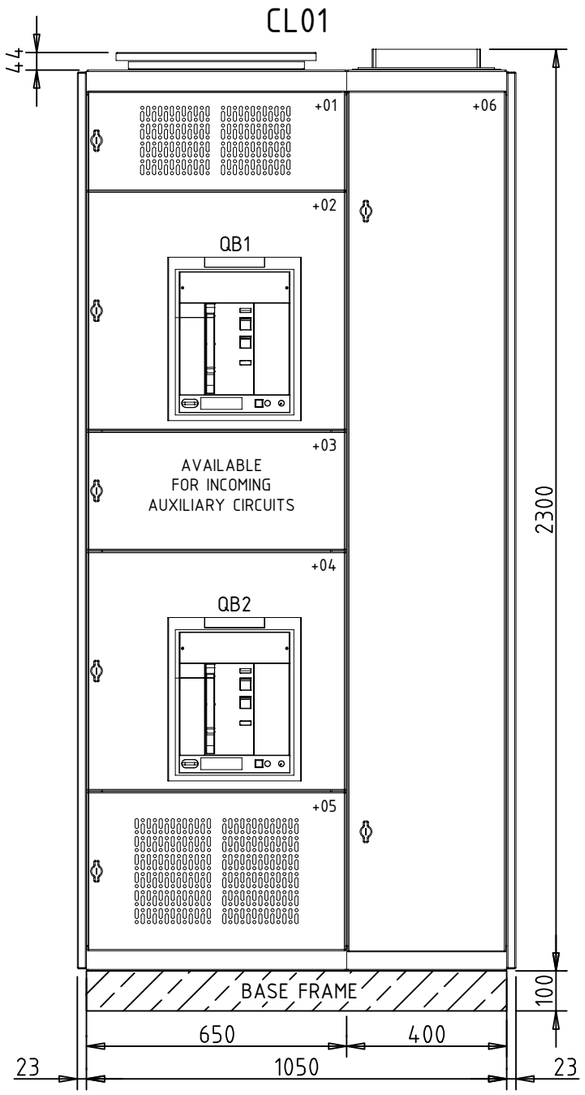
SHEET 005

REV. 04

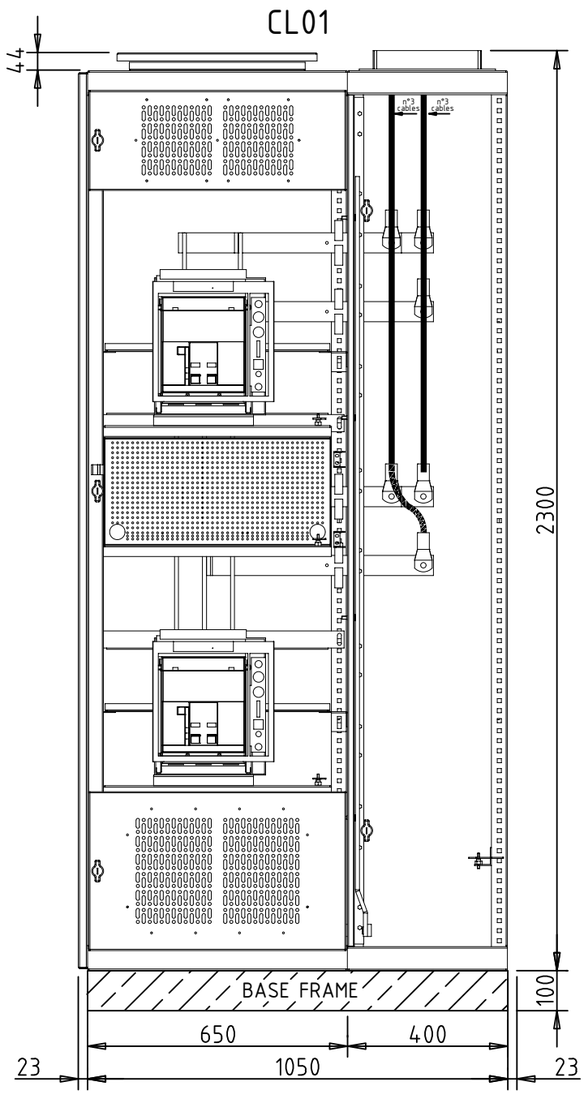
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00008 Rev. 04

## FRONT VIEW




## FRONT VIEW
(INTERNAL)




NOTE :
1. Measurement Tollerance + 0,25%
2. Weight Tollerance ± 10%

scale 1/15

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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/8

Item n° : PF1002669/3

TITLE : "SG-200D2"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Front View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00008

SHEET 006

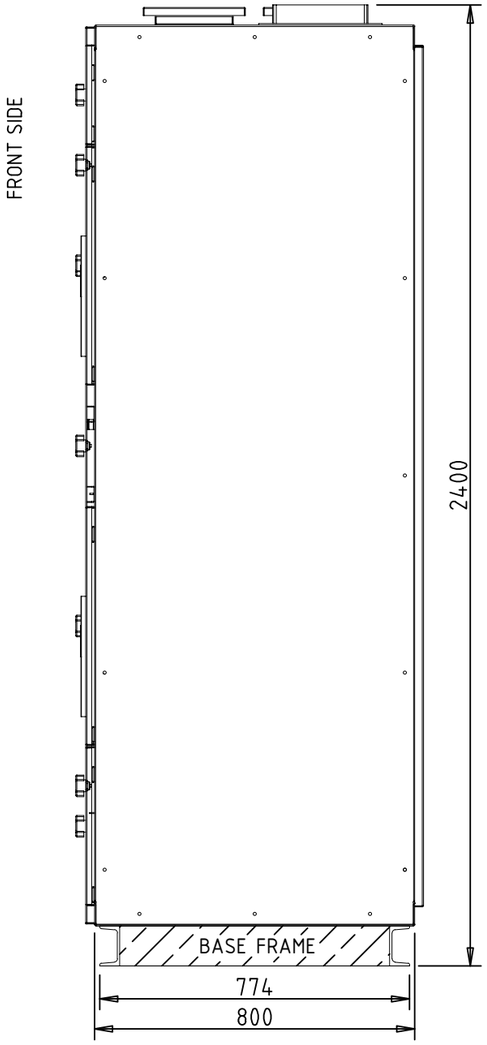
REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00008 Rev. 04

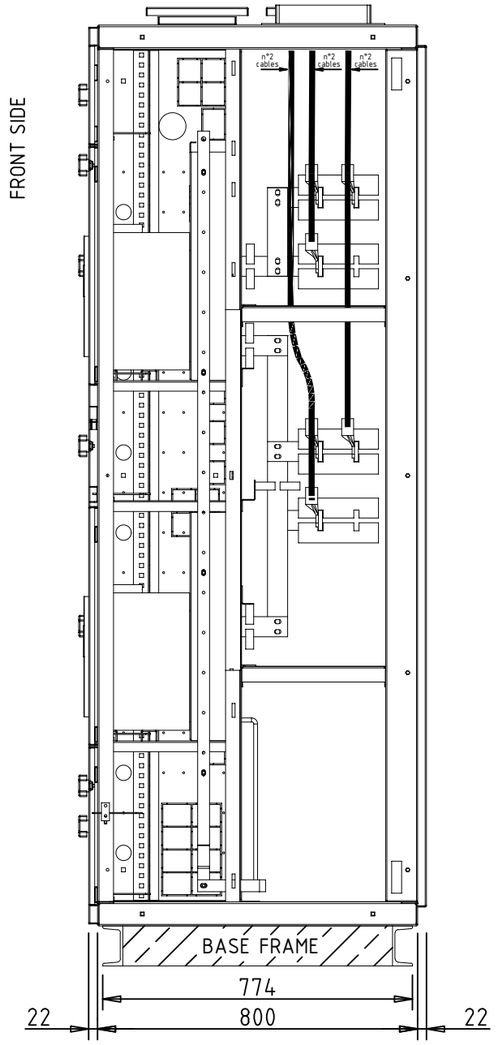
## LATERAL VIEW

CL01




## LATERAL VIEW
(W/O EXTERNAL PANEL)

CL01




NOTE :
1. Measurement Tollerance + 0,25%
2. Weight Tollerance ± 10%

scale 1/15

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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/8

Item n° : PF1002669/3

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Laterals View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

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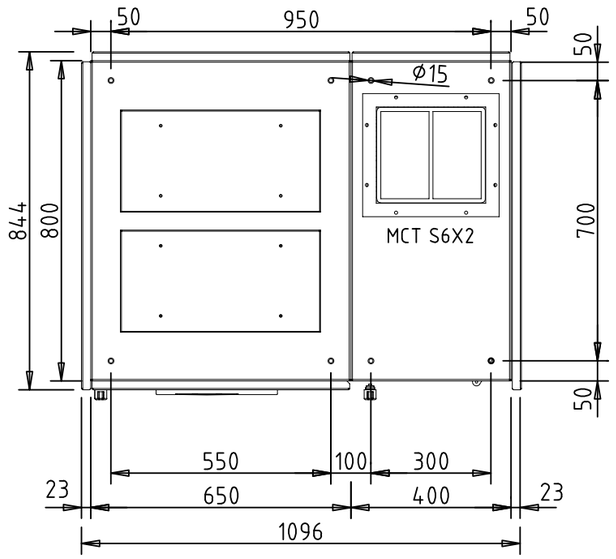
SHEET 007

REV. 04

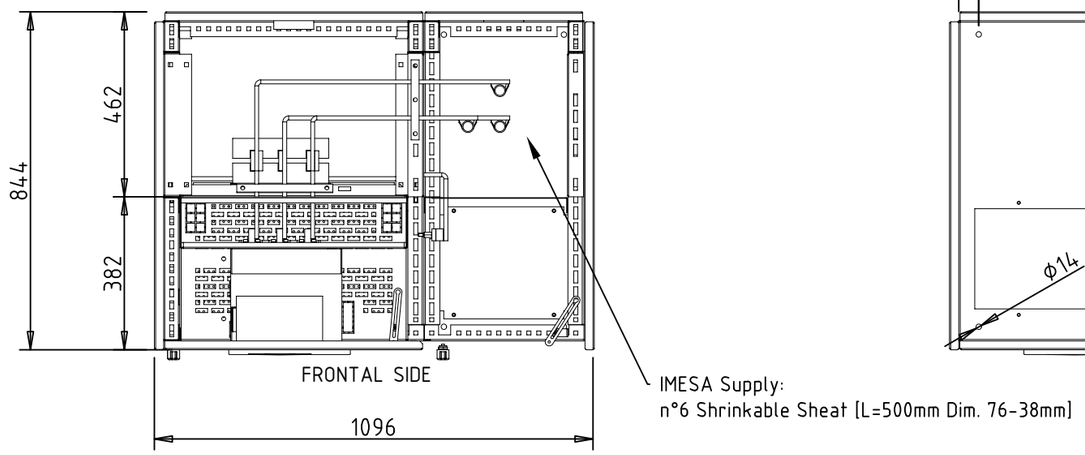
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00008 Rev. 04

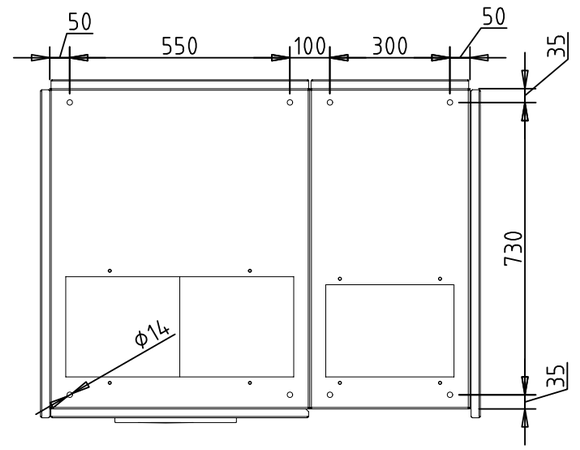
## TOP VIEW



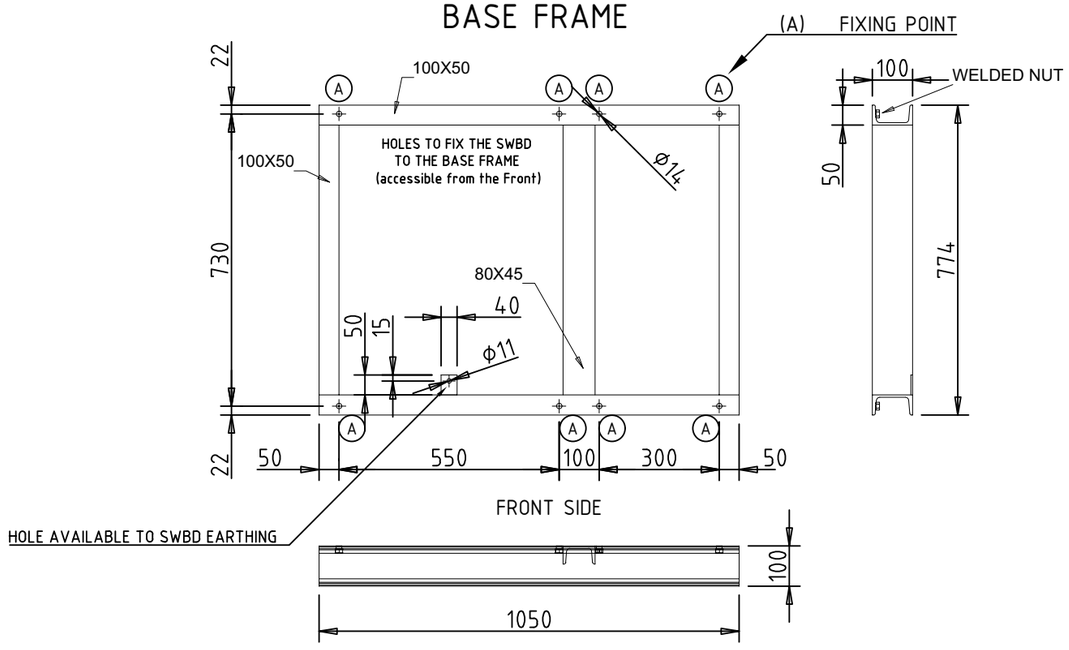

## TOP VIEW
(W/O EXTERNAL PANEL)



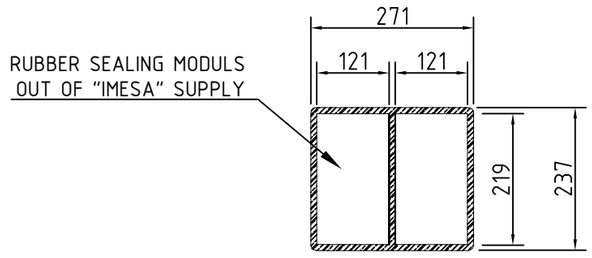

## BOTTOM VIEW




## BASE FRAME




## "S6X2" MCT DETAILS




NOTE :
1. Measurement Tollerance + 0,25%
2. Weight Tollerance ± 10%

scale 1/15

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IMESA ELECTRICAL ENGINEERING
DWG n° : 231298/SD/8
Item n° : PF1002669/3

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Bottom View

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

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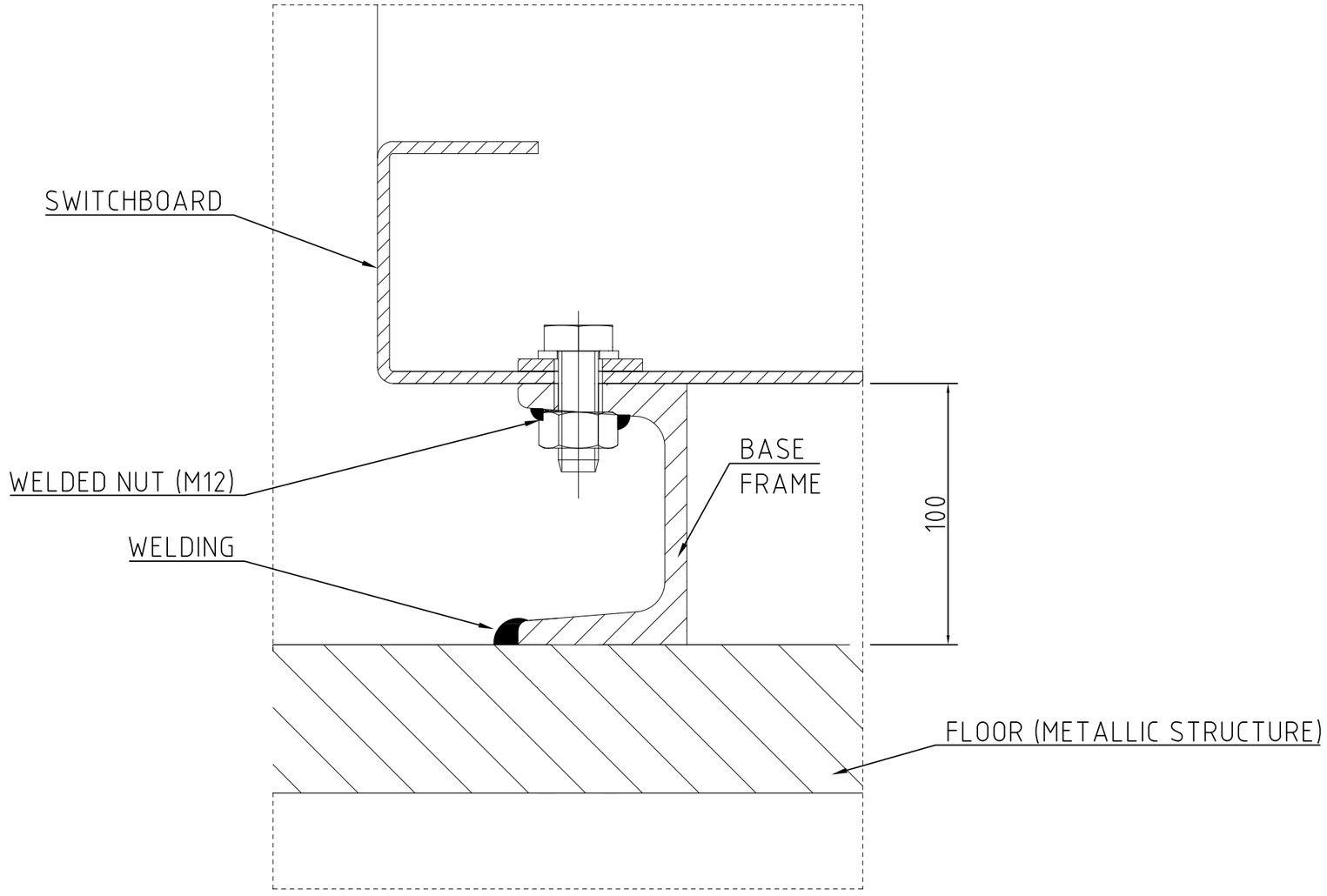
SHEET 008

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00008 Rev. 04

# BASE FRAME FIXING SYSTEM




NOTE :
1. Measurement Tollerance + 0,25%
2. Weight Tollerance ± 10%

scale 1/2

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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/8

Item n° : PF1002669/3

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

GENERAL ARRANGEMENTS
Base Frame Fixing System

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

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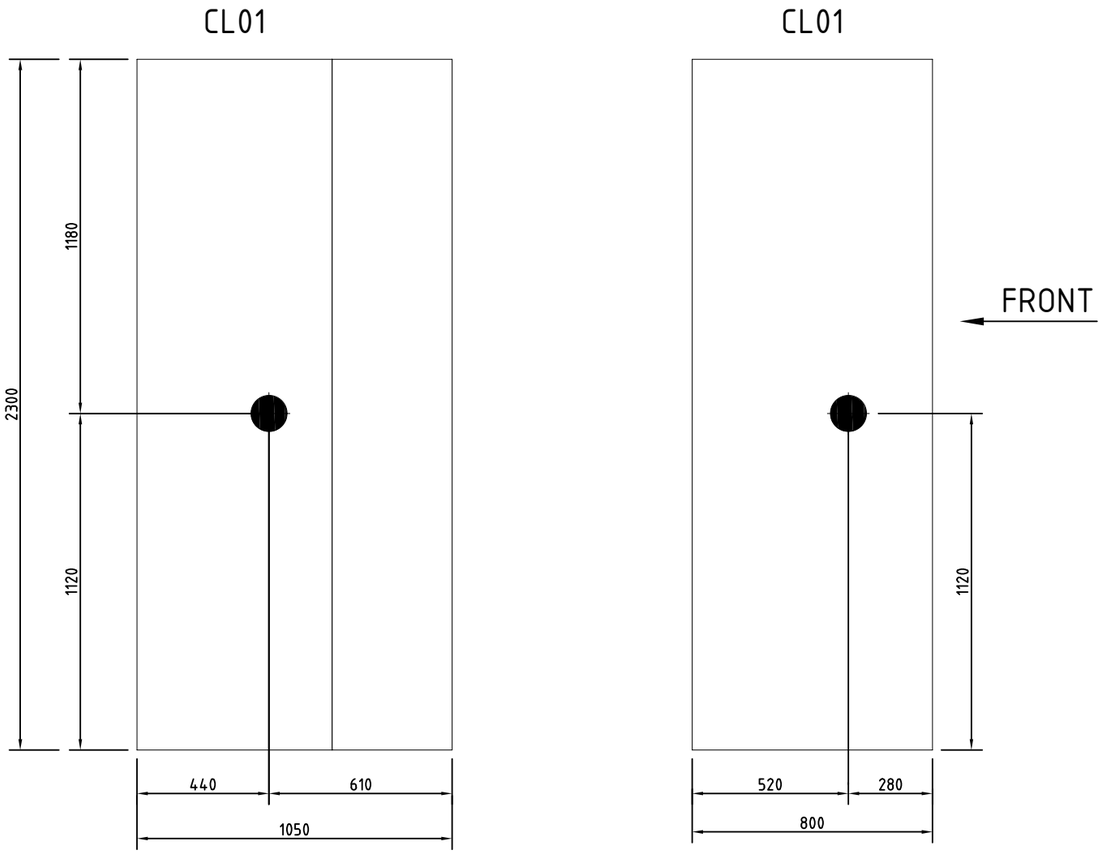
SHEET 009

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00008 Rev. 04

# CENTER OF GRAVITY POSITIONING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/8

Item n° : PF1002669/3

TITLE : "SG-200D2"

GENERAL ARRANGEMENTS
Center of Gravity Positioning

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00008

SHEET 010

REV. 04

File Name : 1723002197-EL-DA-00008 Rev. 04

F.to UNI A3: 420mmx297mm

1.2.4.DP-200N1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG,

Doc. No. 1723002197-EL-DA-00009

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# BASE LOAD POWER HUB (BLPH)

# "DP-200N1" LV SWBD 400/230V

# GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macula | 27/11/2024 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = 5 | 18/11/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| + 4 | 18/09/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
| 3 | 09/07/2024 | Flamminio | Santinelli | Santinelli | Accepted for construction (AFC) |
| 2 | 24/04/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| 1 | 22/03/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| 0 | 05/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/9

Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP–200N1"

GENERAL ARRANGEMENTS
Cover

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DA–00009

SHEET 001

REV. 05

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DA–00009 Rev. 05

# INDEX SHEETS

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 001 | Cover / GENERAL ARRANGEMENTS | X | X | X | X | X | X | | | | |
| 002 | Index / GENERAL ARRANGEMENTS | X | X | X | X | X | X | | | | |
| 003 | Switchgear Characteristics / GENERAL ARRANGEMENTS | X | X | X | X | X | X | | | | |
| 004 | Switchgear Characteristics / GENERAL ARRANGEMENTS | X | X | X | X | X | X | | | | |
| 005 | Switchgear Characteristics / GENERAL ARRANGEMENTS | X | X | X | X | X | X | | | | |
| 006 | Switchgear Nameplate Date and Switchgear Taglate / GENERAL ARRANGEMENTS | X | X | X | X | X | X | | | | |
| 007 | Switchgear Lay-Out - Front, Top, Bottom and Side View / GENERAL ARRANGEMENTS | X | X | X | X | X | X | | | | |
| 008 | Centre of Gravity Positioning / Base Frame Fixing System / GENERAL ARRANGEMENTS | X | X | X | X | X | X | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |

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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/9

Item n° : PF1002888/101

TITLE : "DP-200N1"

GENERAL ARRANGEMENTS
Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00009

SHEET 002

REV. 05

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00009 Rev. 05

| A | ENVIRONMENTAL DATA | |
|---|---|---|
| 1 | AMBIENT | MARINE - OFFSHORE |
| 2 | INSTALLATION | INDOOR |
| 3 | AMBIENT AIR TEMPERATURE - DELAY AVERAGE MAXIMUM | 35 °C |
| 4 | AMBIENT AIR MINIMUM/MAXIMUM TEMPERATURE | -8,4 ÷ +40 °C |
| 5 | RELATIVE HUMIDITY AVERAGE | 95 % |
| 6 | RELATIVE HUMIDITY MAXIMUM | - |
| 7 | POLLUTION LEVEL DEGREE | VERY LIGHT |

| B | SWITCHGEAR ELECTRICAL FEATURES | |
|---|---|---|
| 1 | RATED VOLTAGE (Ue) | 0,4/0,23 kV |
| 2 | NOMINAL VOLTAGE (Un) | 0,4/0,23 kV |
| 3 | RATED INSULATION VOLTAGE (Ui) | 0,69 kV |
| 4 | RATED FREQUENCY (Fn) | 50 Hz |
| 5 | RATED IMPULSE WITHSTAND (Uimp) | 4 kV |
| 6 | RATED NORMAL CURRENT (In) | 63 A |
| 7 | POWER SUPPLY SHORT CIRCUIT CURRENT (Ik) | 25 kA |
| 8 | RATED DURATION OF SHORT CIRCUIT (tk) | NA |
| 9 | CONDITIONATED PEAK WITHSTAND CURRENT (Ipk) | 17 kA |
| 10 | INTERNAL ARC CLASSIFICATION IAC | not applicable |
| 11 | ARCING CLASS | not applicable |
| 12 | NUMBER OF PHASES | 3+N |
| 13 | PHASES IDENTIFICATION | L1-L2-L3-N |
| 14 | EARTHING CIRCUITS MAIN BUSBAR SECTION | > 150mmq |
| 15 | REFERENCE STANDARDS | IEC 61439-2 |
| 16 | EARTHING SYSTEM | TN-S |
| 17 | NEUTRAL BUSBARS SIZING | 50% PHASE SECTION |

| C | SWITCHGEAR MECHANICAL FEATURES | |
|---|---|---|
| 1 | EXTERNAL DEGREE OF PROTECTION | IP30 |
| 2 | INTERNAL DEGREE OF PROTECTION | IP20 |
| 3 | EXTERNAL MECHANICAL IMPACT PROTECTION | IK10 |
| 4 | ACCESSIBILITY | FRONT |
| 5 | TYPE DESIGNATION | FORM : 2B (OUTGOING) |
| 6 | POWER CABLES (INCOMING) | FROM THE TOP (by MCT) |
| 7 | POWER CABLES (OUTGOING) | FROM THE TOP (by MCT) |
| 8 | AUXILIARY CABLES | FROM THE TOP (by MCT) |
| 9 | BASE FRAMES | PROVIDED |
| 10 | MIMIC DIAGRAM (BLACK) | not applicable |
| 11 | BOTTOM CLOSING | UNDRILLED ALUMINIUM REMOVABLE PLATES |
| 12 | PAINTING COLOUR | RAL 7035 |
| 13 | PAINTING SPECIFICATION CYCLE | C3-MEDIUM, > 60µ (IMESA CYCLE "A") |
| 14 | SURFACE NOT PAINTED | ZINC PLATED OR TROPICALIZED |
| 15 | FRONT DOORS (AUXILIARY COMPARTMENT) | HINGED WITH KEY LOCKS |
| 16 | FRONT DOOR (C.B./CONTACTOR COMPARTMENT) | HINGED WITH KEY LOCKS |
| 17 | REAR PANELS | BOLTED |
| 18 | MINIMUM CLEARANCE | TO THE FRONT 800 mm |
| 19 | | TO THE REAR 50 mm |
| 20 | | TO THE TOP 200 mm |
| 21 | | TO THE SIDE 100 mm |
| 22 | WEIGHTS | 360 kg ± 10% |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/9

Item n° : PF1002888/101

TITLE : "DP-200N1"

GENERAL ARRANGEMENTS
Switchgear Characteristics

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00009

SHEET 003

REV. 05

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00009 Rev. 05

| D | BUSBAR SYSTEM | |
|---|---|---|
| 1 | MATERIALS | ELECTROLYTIC COPPER |
| 2 | BUSBAR SURFACE TREATMENT | BARE |
| 3 | INSULATION BUSBARS (if applicable) | AIR INSULATION |
| 4 | JOINT AND CONNECTIONS TREATMENT | NONE |
| 5 | INSULATION JOINTS (if applicable) | NOT APPLICABLE |
| 6 | BULKHEADS FOR POWER BARS (if applicable) | NOT APPLICABLE |
| 7 | PHASES IDENTIFICATION | L1 (BROWN) |
| 8 | | L2 (BLACK) |
| 9 | | L3 (GREY) |
| 10 | | N (BLUE) |
| 11 | | PE (EARTH SYMBOL) |
| 12 | MARKING OF PHASES | ADHESIVE LABELS PLACED ON BARS |

| E | POWER / AUXILIARY CIRCUITS CABLES | | |
|---|---|---|---|
| 1 | LOW VOLTAGE CABLE TYPE | | SH-W (MARINE APPROVAL) |
| 2 | VOLTAGE INSULATION CABLE | | HLPE (600/1000 V) |
| 3 | COLOUR INSULATION CABLE | | BLACK (L1-L2-L3-N),<br>RED (+), WHITE (-);<br>YELLOW / GREEN (GROUND) |
| | SIZE / COLOUR CODE | | |
| 4 | POWER CIRCUIT | | ≥ 2,5 sqmm / BLACK |
| 5 | POWER CIRCUIT PHASES IDENTIFICATION WITH COLOURED SHRINKABLE TERMINATION SHEATH | | L1 (BROWN) |
| 6 | | | L2 (BLACK) |
| 7 | | | L3 (GREY) |
| 8 | | | N (BLUE) |
| 9 | | | PE (YELLOW / GREEN) |
| 10 | MEASURE & CONTROL & SIGNAL CIRCUITS | AC/DC CIRCUIT<br>(Internal Heating / Motor Spring Charger / Internal Distribution) | ≥ 2,5 mmq / BLACK |
| 11 | | VT SECONDARY CIRCUIT | 1,5 mmq / BLACK |
| 12 | | CT SECONDARY CIRCUIT | 2,5 mmq / BLACK |
| 13 | | AC CIRCUIT | ≥ 1,5 mmq / BLACK |
| 14 | | DC CIRCUIT | ≥ 1,5 mmq / RED (+) WHITE (-) |
| 15 | | GROUND CIRCUIT | YELLOW / GREEN |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n°: 231298/SD/9

Item n°: PF1002888/101

TITLE : "DP-200N1"

GENERAL ARRANGEMENTS
Switchgear Characteristics

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00009

SHEET 004

REV. 05

File Name : 1723002197-EL-DA-00009 Rev. 05

F.to UNI A3: 420mmx297mm

| F | TERMINAL BLOCKS | |
|---|---|---|
| 1 | POWER TERMINAL BLOCK TYPE | SCREW CLAMP<br>(CABUR CBD beige) |
| 2 | AUXILIARY TERMINAL BLOCK TYPE | SPRING CLAMP<br>(CABUR HMM grey) |
| 3 | DISCONNECT/TEST TERMINAL BLOCK TYPE<br>(if applicable) | SPRING CLAMP<br>(CABUR HMM grey) |
| 4 | MATERIAL | POLYAMIDE |
| 5 | POWER / AUXILIARY SIZE | ≥ 4mmq |

| G | AUXILIARY CIRCUIT VOLTAGE | |
|---|---|---|
| 1 | AUXILIARY COMMAND CIRCUITS | 230 Vac (External Supply) |
| 2 | INTERNAL LIGHTINGS | 230 Vac (External Supply) |
| 3 | ANTICONDENSATION HEATER | 230 Vac (External Supply) |

| H | LABELS | |
|---|---|---|
| 1 | MATERIAL | TRAFFOLYTE |
| 2 | BACKGROUND | WHITE |
| 3 | LETTERS | BLACK |
| 4 | LANGUAGE | ENGLISH |
| 5 | WARNING LABEL LANGUAGE | ENGLISH |
| 6 | FIXING | SCREWED |
| 7 | MARKING DEVICES / WIRES | INDIPENDENT |
| 8 | AC CIRCUIT | SEQUENTIAL |
| 9 | DC CIRCUIT | SEQUENTIAL WITH PREFIX "+" OR "-" |

CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/9

Item n° : PF1002888/101

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TITLE : "DP-200N1"

GENERAL ARRANGEMENTS
Switchgear Characteristics

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00009

SHEET 005

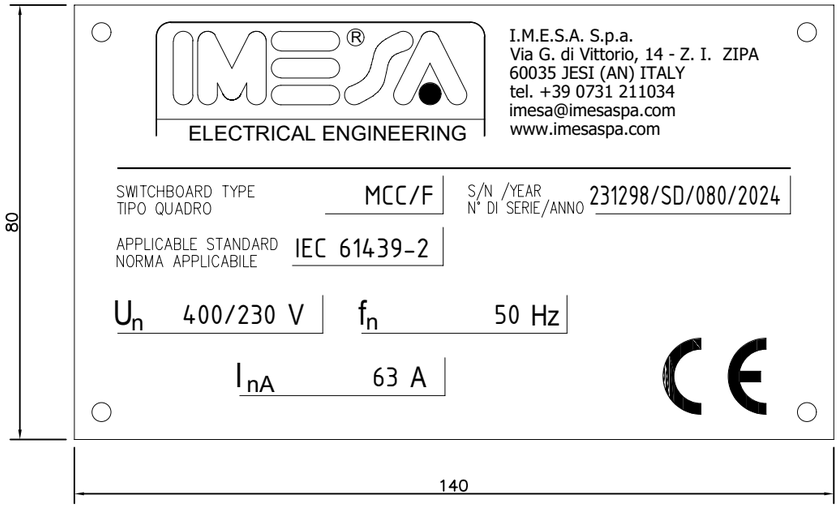
REV. 05

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00009 Rev. 05

## SWITCHGEAR NAMEPLATE DATES

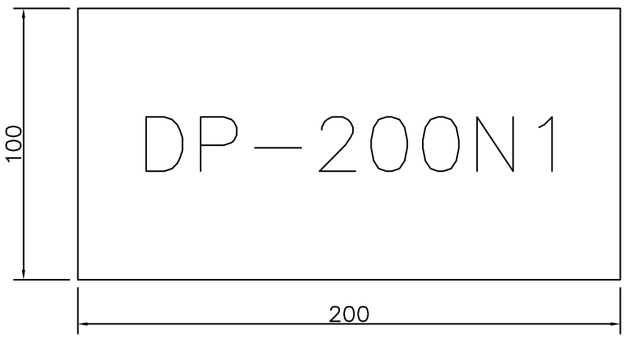
(1)




Material: Alloy

## SWITCHGEAR TAGPLATE

(2)




Material: Traffolyte

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | 18/11/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
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CROSSWIND

ROSETTI MARINO

DWG n° : 231298/SD/9

Item n° : PF1002888/101

TITLE : "DP–200N1"

GENERAL ARRANGEMENTS
Switchgear Nameplate Date and Switchgear Taglate

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

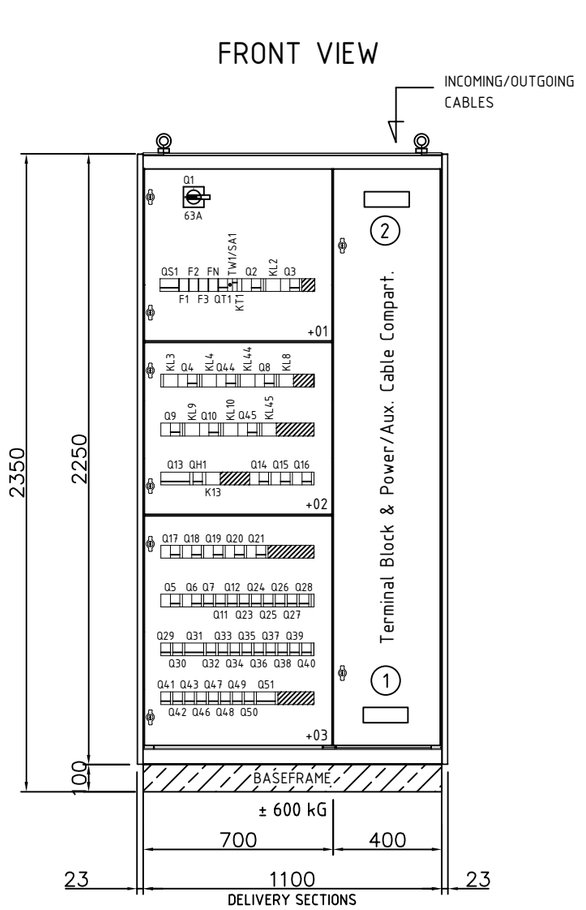
DRAWING NO. 1723002197–EL–DA–00009

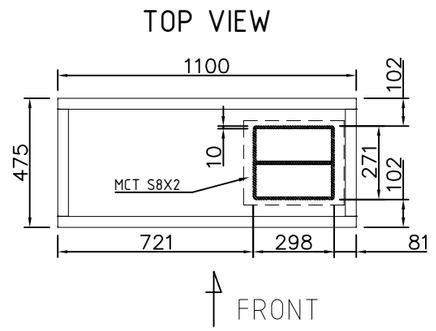
SHEET 006

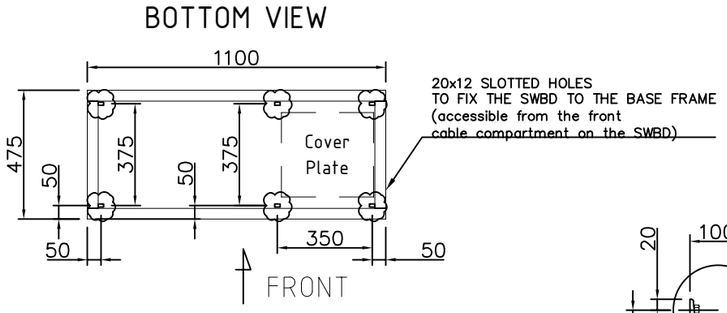
REV. 05

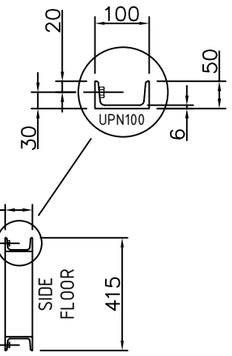
File Name : 1723002197–EL–DA–00009 Rev. 05

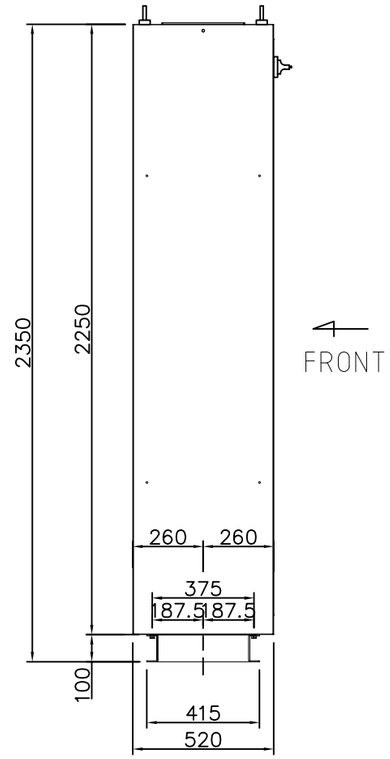
F.to UNI A3: 420mmx297mm

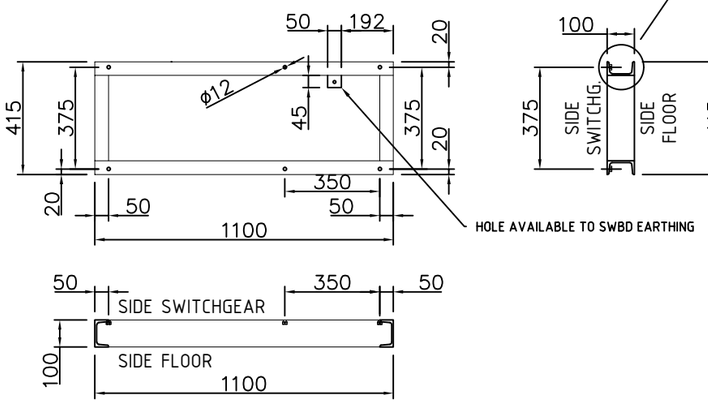


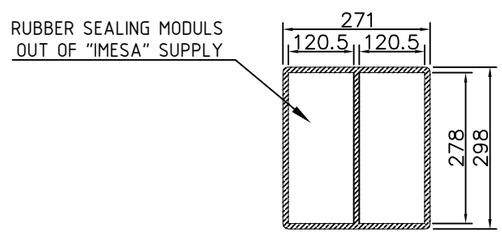




NOTE :
1. Measurement Tollerance + 0,25%
2. Weight Tollerance ± 10%

scale 1/20

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | 5 | 18/11/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
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| | 0 | 05/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/9

Item n° : PF1002888/101

TITLE : "DP–200N1"

GENERAL ARRANGEMENTS
Switchgear Lay-Out - Front, Top, Bottom and Side View

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DA–00009

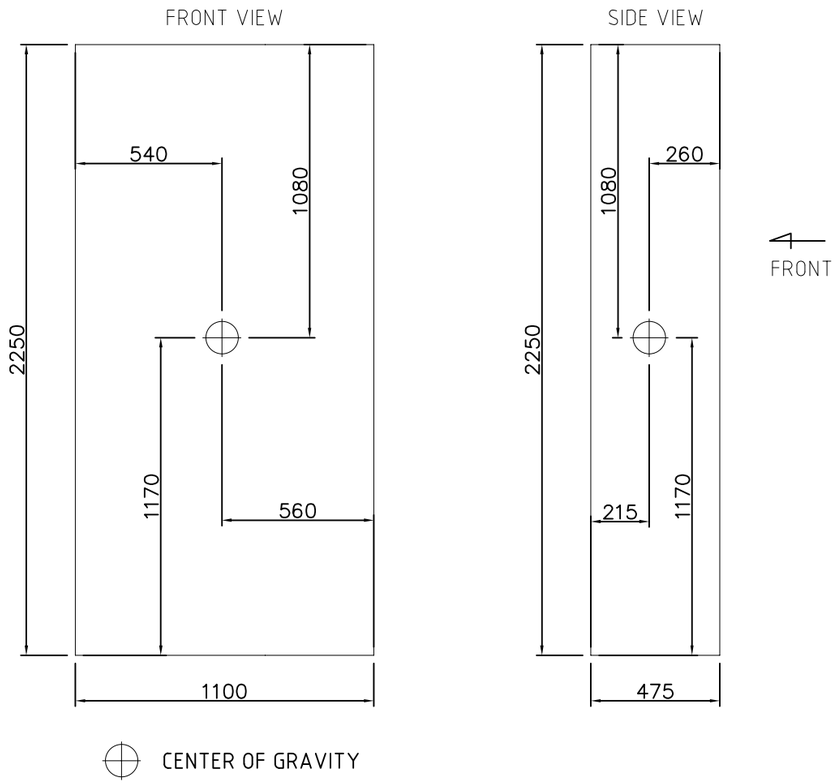
SHEET 007

REV. 05

F.to UNI A3: 420mmx297mm

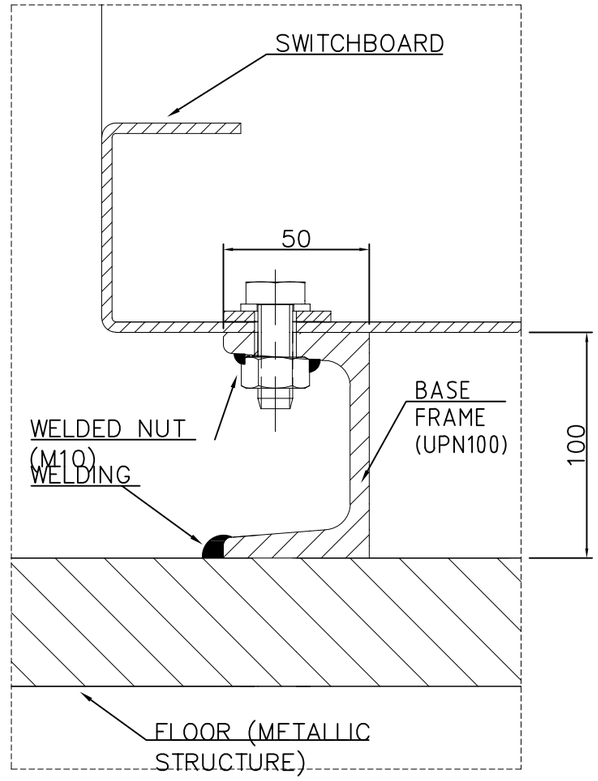
File Name : 1723002197–EL–DA–00009 Rev. 05

## CENTER OF GRAVITY POSITIONING




scale 1/20

## BASE FRAME FIXING SYSTEM




NOTE :

1. Measurement Tollerance + 0,25%

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | 5 | 18/11/2024 | Flamminio | Santinelli | Santinelli | As Built (ASB) |
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| | 0 | 05/02/2024 | Flamminio | Santinelli | Santinelli | Issued for review (IFR) |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/9

Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"

GENERAL ARRANGEMENTS
Centre of Gravity Positioning / Base Frame Fixing System

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DA-00009

SHEET 008

REV. 05

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DA-00009 Rev. 05

1.3. Single Line Diagram

1.3.1.SG-100D1 ELECTRICAL SINGLE LINE DIAGRAM,

Doc. No. 1723002197-EL-DG-00010

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# BASE LOAD POWER HUB (BLPH)

# "SG-100D1" HV SWBD 6,6kV

# ELECTRICAL
# SINGLE LINE DIAGRAM

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

***NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.***

| Sign | Date |
|---|---|
| Luca Macule | 12/09/2024 |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231151/SD/10

Item n° : PF1113279/4

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 4 | 08/08/2024 | Santinelli | Giulietti | Sigismondi | As-Built (ASB) |
| 3 | 26/06/2024 | Santinelli | Giulietti | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 07/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-100D1"

ELECTRICAL SINGLE LINE DIAGRAM
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00010

SHEET 001

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00010 Rev. 04

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| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/10

Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

ELECTRICAL SINGLE LINE DIAGRAM
Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00010

SHEET 002

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00010 Rev. 04

# ACRONIMUS LEGEND

| ITEM | DESCRIPTION |
|---|---|
| BB | ARC SENSOR PROTECTION ON MAIN BUS BARS |
| BGE | EARTHING SWITCH |
| C1 | VOLTAGE PRESENCE |
| CB | ARC SENSOR PROTECTION ON C.B. / CONTACTOR COMPARTMENT |
| CC | ARC SENSOR PROTECTION ON CABLE COMPARTMENT |
| DCO | DOUBLE COMMAND OPERATED CONTACTOR |
| DI3 | UNDERVOLTAGE CONTACTOR |
| DP1 | ALARM RELAY MODULE TEMPERATURE |
| E1 | INTERNAL LIGHT |
| E8 | RESISTOR FERRO-RESONANCE |
| EH1 | INTERNAL SPACE HEATER |
| Fn | MV FUSE |
| FP1 | PROTECTION RELAY |
| GS1 | DC/DC CONVERTER |
| HGR | THERMOSTAT |
| Kn | AUXILIARY RELAY |
| K1 | MV CONTACTOR |
| K86 | BLOCK RELAY |
| KT1 | DE-ENERGIZATION TIMER |
| LS | MICRO SWITCH ON AUXILIARY DOOR |
| MAS | MOTOR SPRING CHARGER |
| MBC | CLOSING COIL |
| MBO1 | OPENING COIL |
| MBU | UNDERVOLTAGE |
| ODn | VOLTAGE DISCHARGER |
| PU1 | MEASURING VOLTAGE INSTRUMENT |
| PTT | V.T. TRUCK |
| QM | MV CIRCUIT-BREAKER |
| QDn | M.C.B. CIRCUITS PROTECTION |

| ITEM | DESCRIPTION |
|---|---|
| QVn | M.C.B FOR V.T. PROTECTION |
| RLE1 | COIL FOR CONSET CLOSING CIRCUIT-BREAKER |
| RLE2 | COIL FOR UNLOCKING RACK-IN/OUT OPERATION |
| RLE3 | COIL FOR UNLOCKING OPERATION EARTHING |
| RLE4 | COIL FOR UNLOCKING ENCLOSURE DOOR OPERATION |
| SU1 | VOLTAGE SELECTOR |
| SWH... | ETHERNET SWITCH |
| TI-Ln | CURRENT TRANSFORMER |
| TO | OMOPOLAR RING CURRENT TRANSFORMER |
| TR1 | TEMPERATURE CONTROL DEVICE |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
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DWG n° : 231151/SD/10
Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

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ROSETTI MARINO

TITLE : "SG-100D1"

ELECTRICAL SINGLE LINE DIAGRAM
Acronyms Legend

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00010

SHEET 003

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00010 Rev. 04

# SINGLE LINE DIAGRAM
## "CB FEEDER"

LEGEND:

- Free key with opened Circuit Breaker (Circuit Breaker locked in open position)
- Free key with insolated Circuit Breaker or Contactor (Circuit Breaker or Contactor locked in isolated position)
- Free key with opened Earthing Switch (Earthing Switch locked in open position)
- Free key with closed Earthing Switch (Earthing Switch locked in close position)
- Mechanical interlock

| MAIN EQUIPMENT [Additional Features and Auxiliary Components will be inserted on Functional Diagram] | | | |
|---|---|---|---|
| Tag | Desciption Tag | Supplier | Type [Technical Features] |
| QM | Circuit Breaker | ABB | VD4/P [12KV - 630A - 25kA] |
| BGE | Earthing Switch | ABB | ST-E [12KV - 25kA] |
| FP1 | Protection Relay | ABB | REX640 |
| TI-L.. | Current Transformers | ESITAS | ATB 10-BS<br>7,2kV - 400/1 - 25kA<br>1°winding : Cl. 0,5+5P20 - Pr. 5VA |
| TU-L.. | Voltage Transformers + Fuses | ABB | TJP4.3 [7,2kV - 6,6kV:√3/110:√3-110:√3-110:3<br>1° winding : Cl. 0,5-3P - Pr. 20VA (110:√3)<br>2° winding : Cl. 0,5-3P - Pr. 30VA (110:√3)<br>3° winding : Cl. 3P - Pr. 30VA (110:3) |
| TO | Omopolar Ring Current Transformer (Internal Diameter 150mm) | ESITAS | KAP-150/250-55<br>1.2kV - 100/1A - 25kA<br>1° winding : Cl. 5P5 - Pr. 5VA |
| TR1 | Permanent Infrared Hotspot Detection | EXERTHERM | |
| OD.. | Voltage Discharger | DEHN | SBKW 9/DH I-0 [Ur=9kV-In=10kA] |
| C1 | Voltage Presence Indicator | ABB | VPIS [3÷24kV] |

| USER DETAILS | | | | | |
|---|---|---|---|---|---|
| Tag User | Desciption User | User Power | Current Transformer Ratio | Cable Size Formation | Tag Column |
| A-20000 | ELECTROLYSER PACKAGE | 3200 kVA | 400 / 1A | 3(1x120) mm² | A1 |

NOTE :

For ELECTROLYSER PAKAGE feeder interlocks and intertrips will be managed via serial link to EMCS

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231151/SD/10
Item n° : PF1113279/4

TITLE : "SG-100D1"

ELECTRICAL SINGLE LINE DIAGRAM
Column A1: Electrolyser Package A-20000

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00010 | SHEET 004 | REV. 04

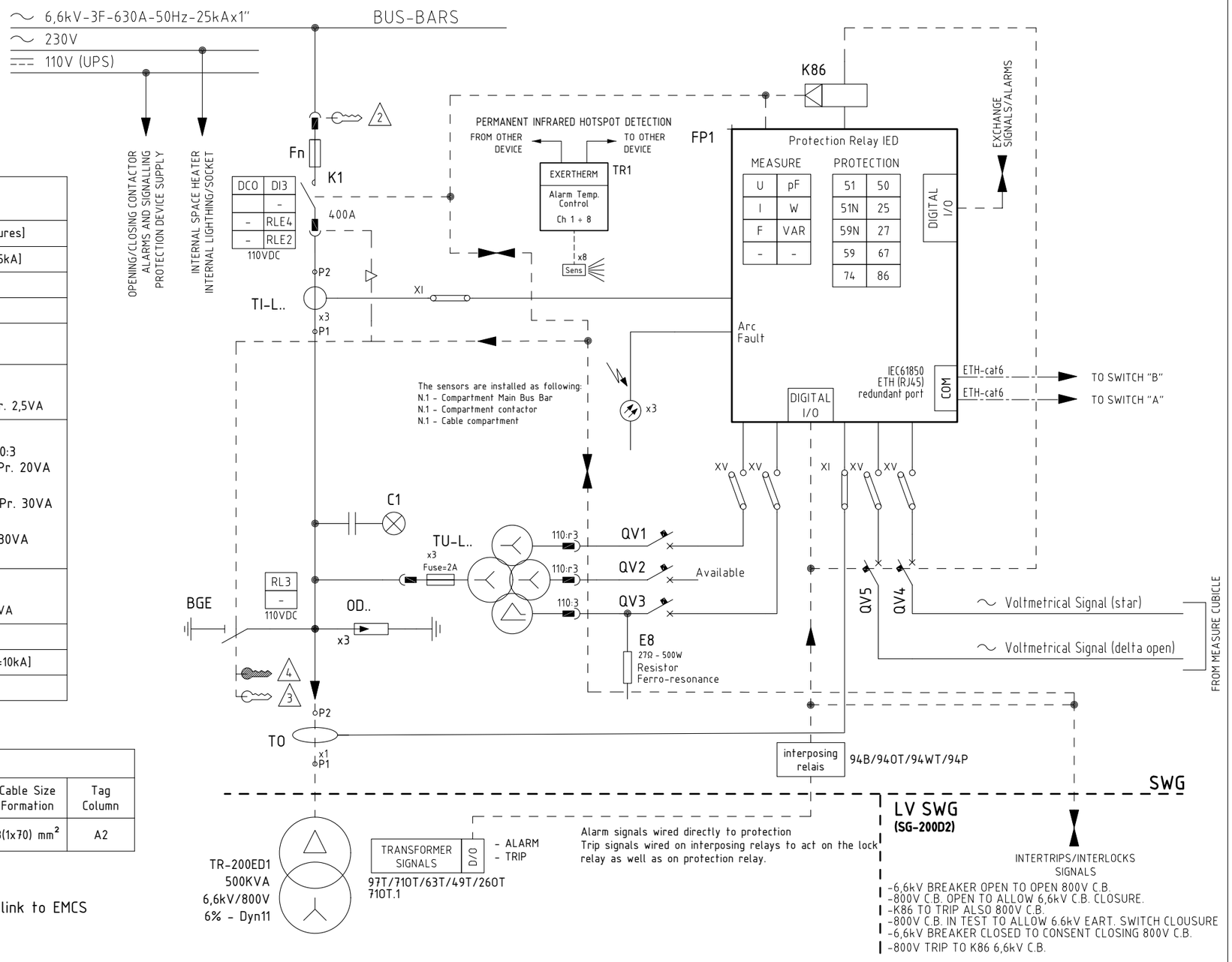
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00010 Rev. 04

LEGEND:

- Free key with opened Circuit Breaker (Circuit Breaker locked in open position)
- Free key with insolated Circuit Breaker or Contactor (Circuit Breaker or Contactor locked in isolated position)
- Free key with opened Earthing Switch (Earthing Switch locked in open position)
- Free key with closed Earthing Switch (Earthing Switch locked in close position)
- Mechanical interlock
- DCO — DOUBLE COMMAND OPERATED

# SINGLE LINE DIAGRAM
## "FEEDER with CONTACTOR"




## MAIN EQUIPMENT

[Additional Features and Auxiliary Components will be inserted on Functional Diagram]

| Tag | Desciption Tag | Supplier | Type [Technical Features] |
|---|---|---|---|
| K1 | Contactor | ABB | VSC7/P [7,2KV - 400A - 25kA] |
| Fn | Fuse for Contactor | ABB | CEF 63A |
| BGE | Earthing Switch | ABB | ST-E [12KV - 25kA] |
| FP1 | Protection Relay | ABB | REX640 |
| TI-L.. | Current Transformers | ESITAS | ATB 10-BS<br>7,2kV - 50/1 - 25kA<br>1°winding : Cl. 0,5+5P15 - Pr. 2,5VA |
| TU-L.. | Voltage Transformers + Fuses | ABB | TJP4.3 [7,2kV - 6,6kV:√3/110:√3-110:√3-110:3<br>1° winding : Cl. 0,5-3P - Pr. 20VA (110:√3)<br>2° winding : Cl. 0,5-3P - Pr. 30VA (110:√3)<br>3° winding : Cl. 3P - Pr. 30VA (110:3) |
| TO | Omopolar Ring Current Transformer (Internal Diameter 150mm) | ESITAS | KAP-150/250-55<br>1.2kV - 100/1A - 25kA<br>1° winding : Cl. 5P5 - Pr. 5VA |
| TR1 | Permanent Infrared Hotspot Detection | EXERTHERM | |
| OD.. | Voltage Discharger | DEHN | SBKW 9/DH I-0 [Ur=9kV-In=10kA] |
| C1 | Voltage Presence Indicator | ABB | VPIS [3÷24kV] |

## USER DETAILS

| Tag User | Desciption User | User Power | Current Transformer Ratio | Cable Size Formation | Tag Column |
|---|---|---|---|---|---|
| TR-200ED1 | SOLAR PACKAGE | 480KW | 50 / 1A | 3(1x70) mm² | A2 |

NOTE :

For SOLAR PACKAGE feeder interlocks and intertrips will be managed via serial link to EMCS

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|---|---|---|---|---|---|
| 4 | 08/08/2024 | Santinelli | Giulietti | Sigismondi | As-Built (ASB) |
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| 0 | 07/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/10
Item n° : PF1113279/4

TITLE : "SG-100D1"

ELECTRICAL SINGLE LINE DIAGRAM
Column A2 : Solar Package TR-200ED1

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00010

SHEET 005

REV. 04

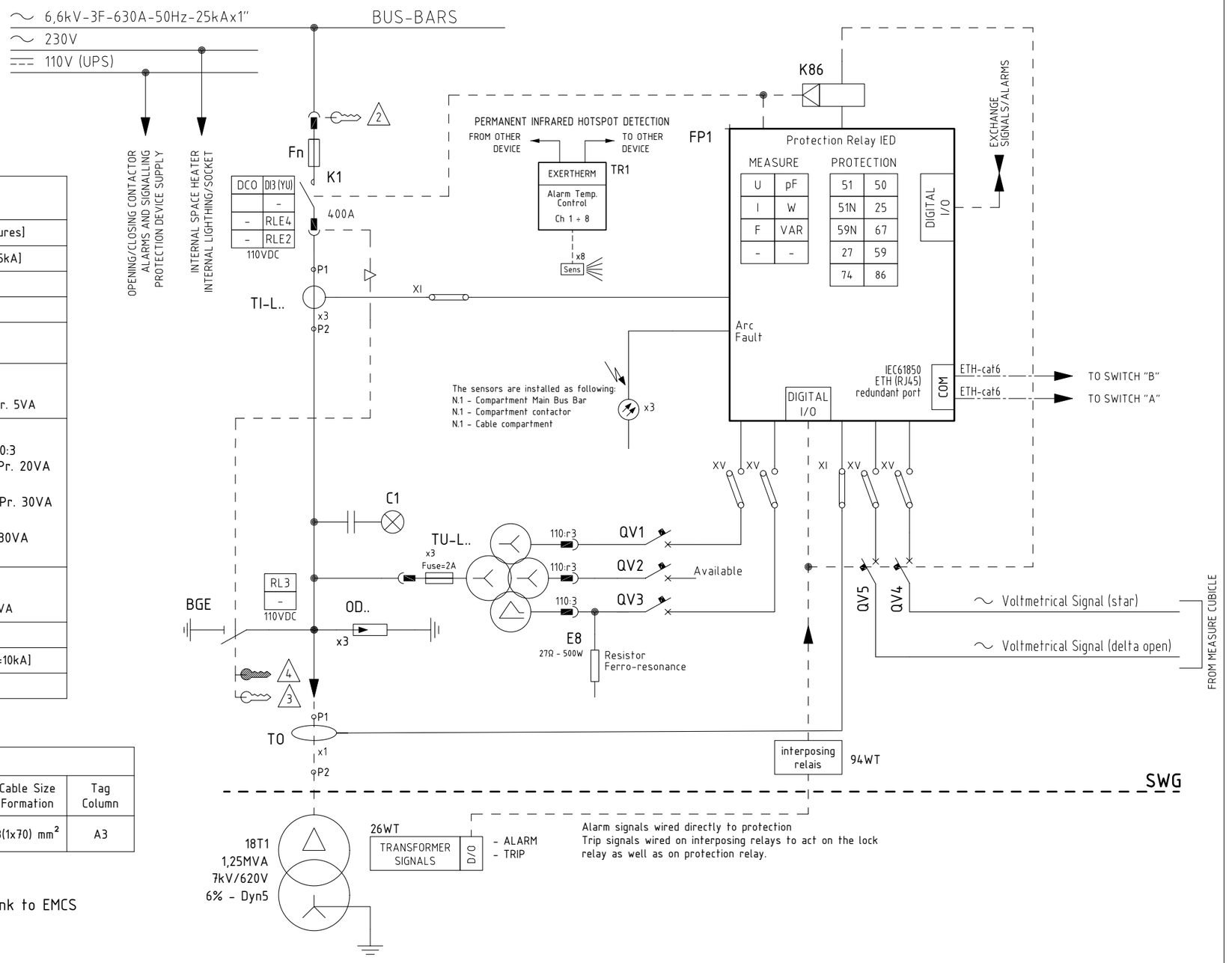
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00010 Rev. 04

LEGEND:

- Free key with opened Circuit Breaker (Circuit Breaker locked in open position)
- Free key with insolated Circuit Breaker or Contactor (Circuit Breaker or Contactor locked in isolated position)
- Free key with opened Earthing Switch (Earthing Switch locked in open position)
- Free key with closed Earthing Switch (Earthing Switch locked in close position)
- Mechanical interlock
- DCO DOUBLE COMMAND OPERATED

# SINGLE LINE DIAGRAM
# "FEEDER with CONTACTOR"




## MAIN EQUIPMENT

[Additional Features and Auxiliary Components will be inserted on Functional Diagram]

| Tag | Desciption Tag | Supplier | Type [Technical Features] |
|---|---|---|---|
| K1 | Contactor | ABB | VSC7/P [7,2KV - 400A - 25kA] |
| Fn | Fuse for Contactor | ABB | CEF 160A |
| BGE | Earthing Switch | ABB | ST-E [12KV - 25kA] |
| FP1 | Protection Relay | ABB | REX640 |
| TI-L.. | Current Transformers | ESITAS | ATB 10-BS<br>7,2kV - 150/1 - 25kA<br>1°winding : Cl. 0,5+5P20 - Pr. 5VA |
| TU-L.. | Voltage Transformers + Fuses | ABB | TJP4.3 [7,2kV - 6,6kV:√3/110:√3-110:√3-110:3<br>1° winding : Cl. 0,5-3P - Pr. 20VA (110:√3)<br>2° winding : Cl. 0,5-3P - Pr. 30VA (110:√3)<br>3° winding : Cl. 3P - Pr. 30VA (110:3) |
| TO | Omopolar Ring Current Transformer (Internal Diameter 150mm) | ESITAS | KAP-150/250-55<br>1.2kV - 100/1A - 25kA<br>1° winding : Cl. 5P5 - Pr. 5VA |
| TR1 | Permanent Infrared Hotspot Detection | EXERTHERM | |
| OD.. | Voltage Discharger | DEHN | SBKW 9/DH I-0 [Ur=9kV-In=10kA] |
| C1 | Voltage Presence Indicator | ABB | VPIS [3÷24kV] |

## USER DETAILS

| Tag User | Desciption User | User Power | Current Transformer Ratio | Cable Size Formation | Tag Column |
|---|---|---|---|---|---|
| A-85000 | BESS PACKAGE | 1000 kW | 150 / 1A | 3(1x70) mm² | A3 |

NOTE :

For BESS PACKAGE feeder interlocks and intertrips will be managed via serial link to EMCS

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DWG n° : 231151/SD/10
Item n° : PF1113279/4

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : "SG-100D1"

ELECTRICAL SINGLE LINE DIAGRAM
Column A3 : Bess Package A-85000

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00010

SHEET 006

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00010 Rev. 04

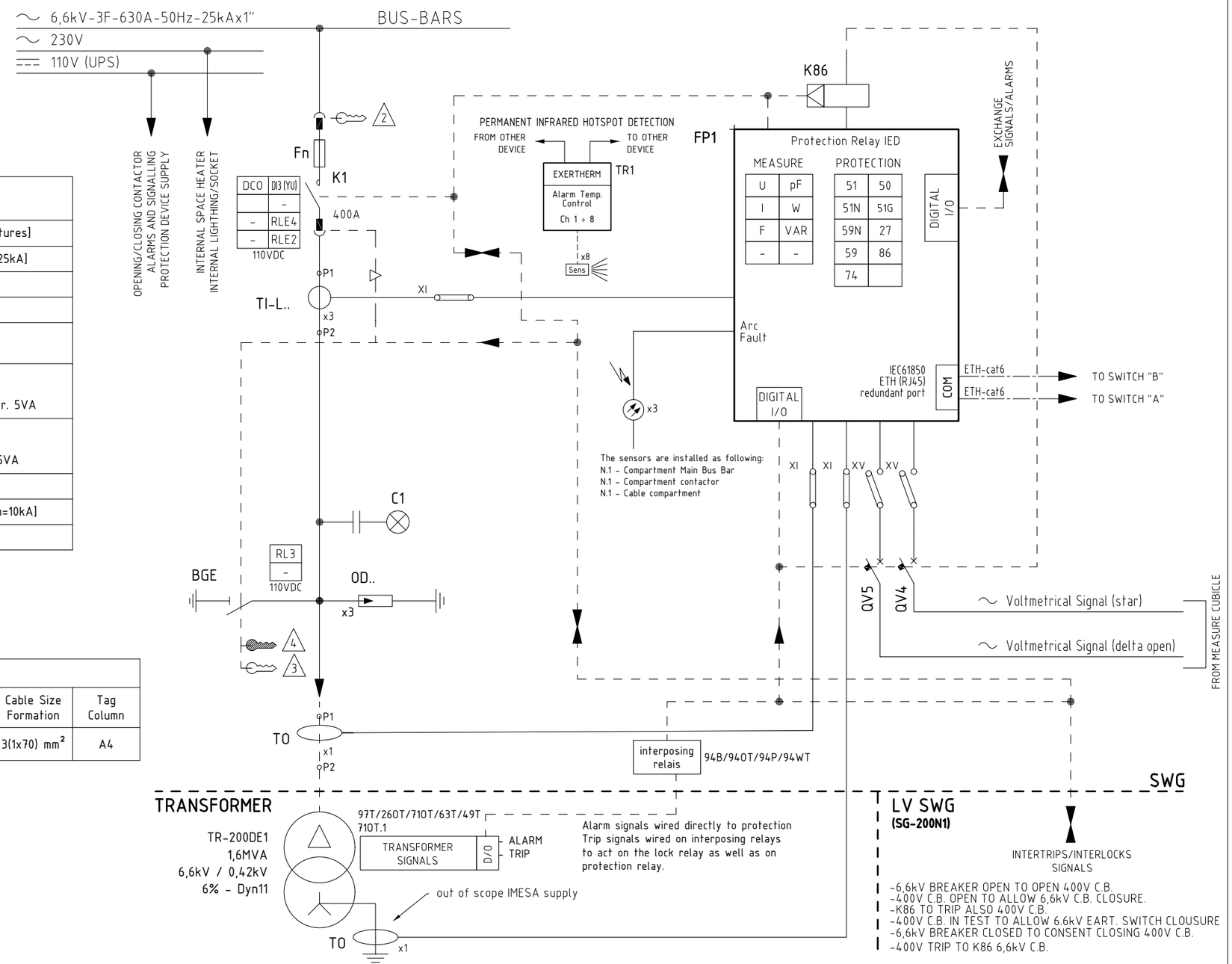
# SINGLE LINE DIAGRAM
# "TRANSFORMER"

LEGEND:

- Free key with opened Circuit Breaker (Circuit Breaker locked in open position)
- Free key with insolated Circuit Breaker or Contactor (Circuit Breaker or Contactor locked in isolated position)
- Free key with opened Earthing Switch (Earthing Switch locked in open position)
- Free key with closed Earthing Switch (Earthing Switch locked in close position)
- Mechanical interlock
- DCO DOUBLE COMMAND OPERATED

| MAIN EQUIPMENT [Additional Features and Auxiliary Components will be inserted on Functional Diagram] | | | |
|---|---|---|---|
| Tag | Desciption Tag | Supplier | Type [Technical Features] |
| K1 | Contactor | ABB | VSC7/P [7,2KV - 400A - 25kA] |
| Fk | Fuse for Contactor | ABB | CMF 250A |
| BGE | Earthing Switch | ABB | ST-E [12KV - 25kA] |
| FP1 | Protection Relay | ABB | REX640 |
| TI-L.. | Current Transformers | ESITAS | ATB 10-BS<br>7,2kV - 200/1 - 25kA<br>1°winding : Cl.0,5+5P20 - Pr. 5VA |
| TO | Omopolar Ring Current Transformer (Internal Diameter 150mm) | ESITAS | KAP-150/250-95<br>1.2kV - 100/1A - 25kA<br>1° winding : Cl. 5P5 - Pr. 5VA |
| TR1 | Permanent Infrared Hotspot Detection | EXERTHERM | |
| OD.. | Voltage Discharger | DEHN | SBKW 9/DH I-0 [Ur=9kV-In=10kA] |
| C1 | Voltage Presence Indicator | ABB | VPIS [3÷24kV] |

| USER DETAILS | | | | | |
|---|---|---|---|---|---|
| Tag User | Desciption User | User Power | Current Transformer Ratio | Cable Size Formation | Tag Column |
| TR-200DE1 | TRANSFORMER 1.6MVA | 1.6 MVA | 200 / 1A | 3(1x70) mm² | A4 |




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-100D1"

ELECTRICAL SINGLE LINE DIAGRAM
Column A4 : Auxiliary Transformer TR-200DE1

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00010 | SHEET 007 | REV. 04

F.to UNI A3: 420mmx297mm

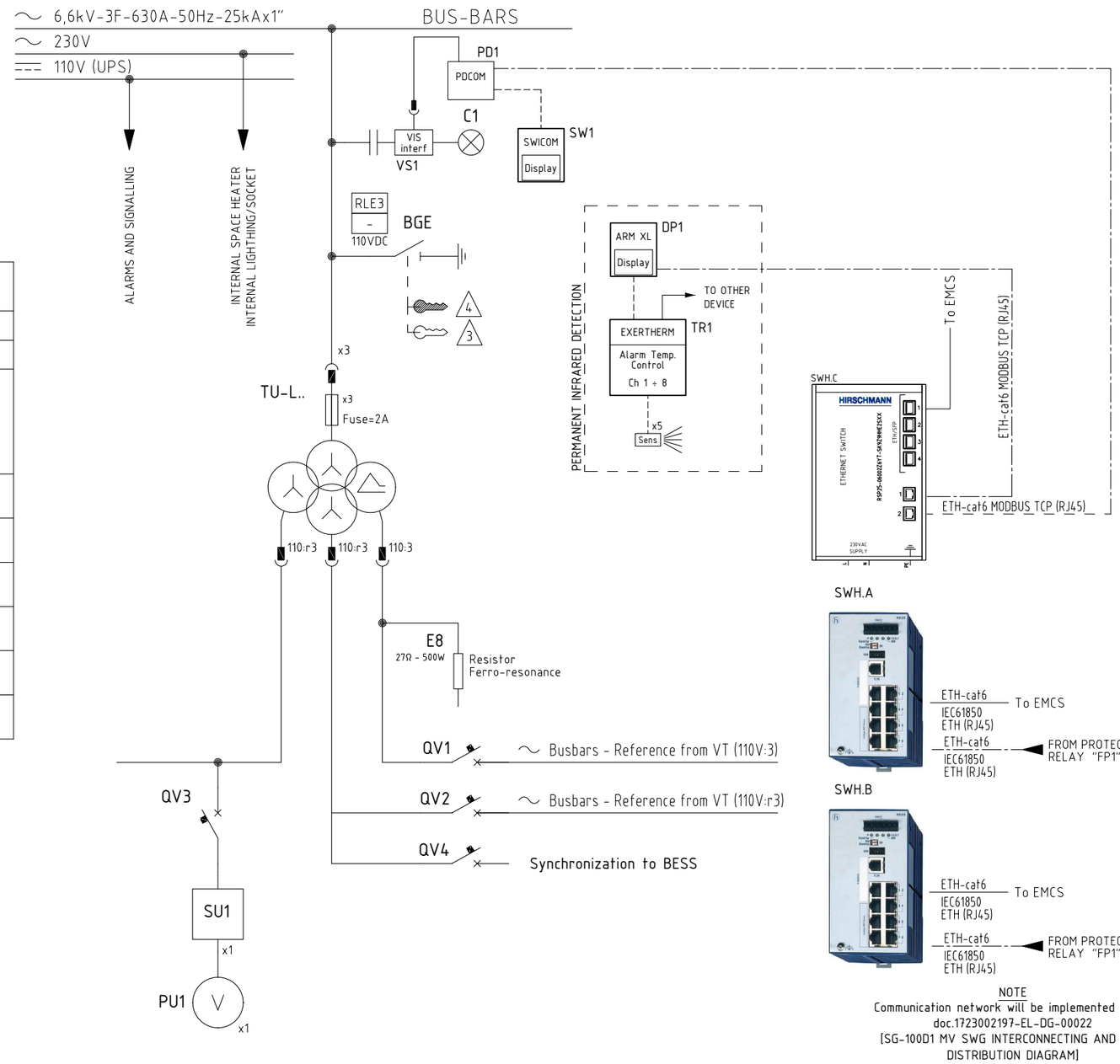
File Name : 1723002197-EL-DG-00010 Rev. 04

# SINGLE LINE DIAGRAM
# "MEASURING BUS BAR"

LEGEND:

Free key with opened Earthing Switch (Earthing Switch locked in open position)

Free key with closed Earthing Switch (Earthing Switch locked in close position)




NOTE
Communication network will be implemented inside doc.1723002197-EL-DG-00022 [SG-100D1 MV SWG INTERCONNECTING AND AUX DISTRIBUTION DIAGRAM]

## MAIN EQUIPMENT
[Additional Features and Auxiliary Components will be inserted on Functional Diagram]

| Tag | Desciption Tag | Supplier | Type [Technical Features] |
|---|---|---|---|
| BGE | Earthing Switch | ABB | ST-E [17,5KV - 31,5kA] |
| TU-L.. | Voltage Transformers + Fuses | ABB | TJP4.3 [7,2kV - 6,6kV:√3/110:√3-110:√3-110:3<br>1° winding : Cl. 0,5-3P - Pr. 20VA (110:√3)<br>2° winding : Cl. 0,5-3P - Pr. 30VA (110:√3)<br>3° winding : Cl. 3P - Pr. 30VA (110:3) |
| PU1 | Voltmeter | FRER | F96EVXYYYXC1 96x96 90° SCALE<br>0÷10kV on VT 6,6kV/110V |
| VS1+PD1 | Partial Discharge Condition Monitoring | ABB | PDCOM Interface + PDCOM |
| TR1+DP1 | Permanent Infrared Hotspot Detection | EXERTHERM | |
| SW1 | Monitoring Unit for Partial Discharge | ABB | SWICOM |
| SWH.n | Managed Ethernet Switch Device | ABB | AFS660 [n°3 SFP ports + n°8 RJ45 ports] |
| C1 | Voltage Presence Indicator | ABB | VPIS [3÷24kV] |

## USER DETAILS

| Tag User | Desciption User | User Power | Voltage Transformer Ratio | Cable Size Formation | Tag Column |
|---|---|---|---|---|---|
| - | MEASURING | N.A. | 6,6kV:√3<br>110:√3-110:√3-110:3 | - | A5 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231151/SD/10
Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING

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ROSETTI MARINO

TITLE : "SG-100D1"

ELECTRICAL SINGLE LINE DIAGRAM
Column A5 : Measure

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00010 | SHEET 008 | REV. 04

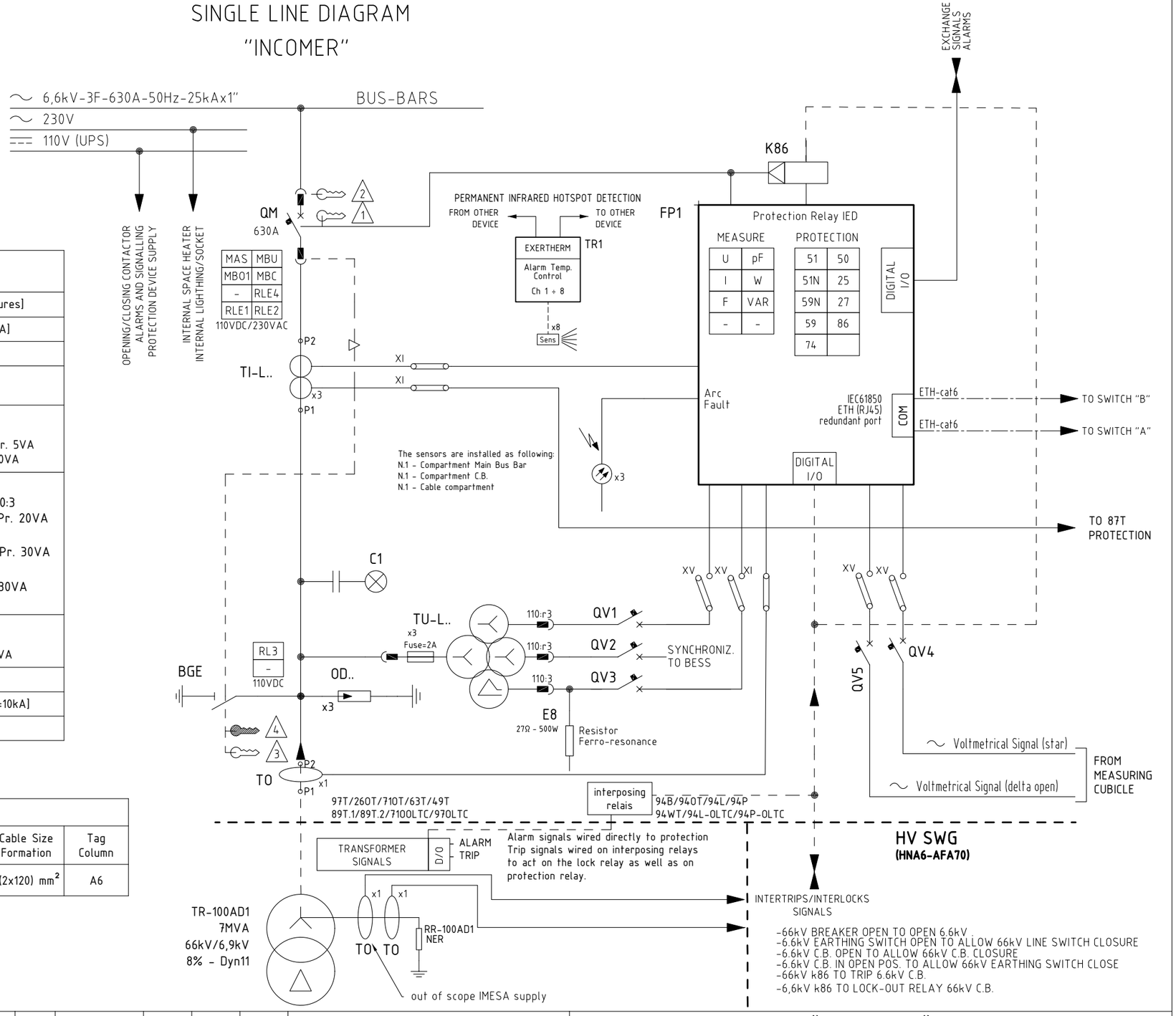
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00010 Rev. 04

# SINGLE LINE DIAGRAM
## "INCOMER"

LEGEND:

- Free key with opened Circuit Breaker (Circuit Breaker locked in open position)
- Free key with insolated Circuit Breaker or Contactor (Circuit Breaker or Contactor locked in isolated position)
- Free key with opened Earthing Switch (Earthing Switch locked in open position)
- Free key with closed Earthing Switch (Earthing Switch locked in close position)
- ▷ Mechanical interlock




### MAIN EQUIPMENT
[Additional Features and Auxiliary Components will be inserted on Functional Diagram]

| Tag | Desciption Tag | Supplier | Type [Technical Features] |
|---|---|---|---|
| QM | Circuit Breaker | ABB | VD4/P [12KV - 630A - 25kA] |
| BGE | Earthing Switch | ABB | ST-E [12KV - 25kA] |
| FP1 | Protection Relay | ABB | REX640 |
| TI-L.. | Current Transformers | ESITAS | ATB 10-BS<br>7,2kV - 600/1-1 - 25kA<br>1°winding : Cl. 0,5+5P20 - Pr. 5VA<br>2°winding : Cl. 5P25 - Pr. 10VA |
| TU-L.. | Voltage Transformers + Fuses | ABB | TJP4.3 [7,2kV - 6,6kV:√3/110:√3-110:√3-110:3<br>1° winding : Cl. 0,5-3P - Pr. 20VA (110:√3)<br>2° winding : Cl. 0,5-3P - Pr. 30VA (110:√3)<br>3° winding : Cl. 3P - Pr. 30VA (110:3) |
| TO | Omopolar Ring Current Transformer (Internal Diameter 150mm) | ESITAS | KAP-150/250-55<br>1.2kV - 100/1A - 25kA<br>1° winding : Cl. 5P5 - Pr. 5VA |
| TR1 | Permanent Infrared Hotspot Detection | EXERTHERM | |
| OD.. | Voltage Discharger | DEHN | SBKW 9/DH I-0 [Ur=9kV-In=10kA] |
| C1 | Voltage Presence Indicator | ABB | VPIS [3÷24kV] |

### USER DETAILS

| Tag User | Desciption User | User Power | Current Transformer Ratio | Cable Size Formation | Tag Column |
|---|---|---|---|---|---|
| TR-100AD1 | INCOMING | 7 MVA | 600 / 1A | 3(2x120) mm² | A6 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 4 | 08/08/2024 | Santinelli | Giulietti | Sigismondi | As-Built (ASB) |
| 3 | 26/06/2024 | Santinelli | Giulietti | Sigismondi | Accepted for Construction (AFC) |
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| 1 | 14/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 07/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/10
Item n° : PF1113279/4

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : "SG-100D1"

ELECTRICAL SINGLE LINE DIAGRAM
Column A6 : Incoming TR-100AD1

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00010

SHEET 009

REV. 04

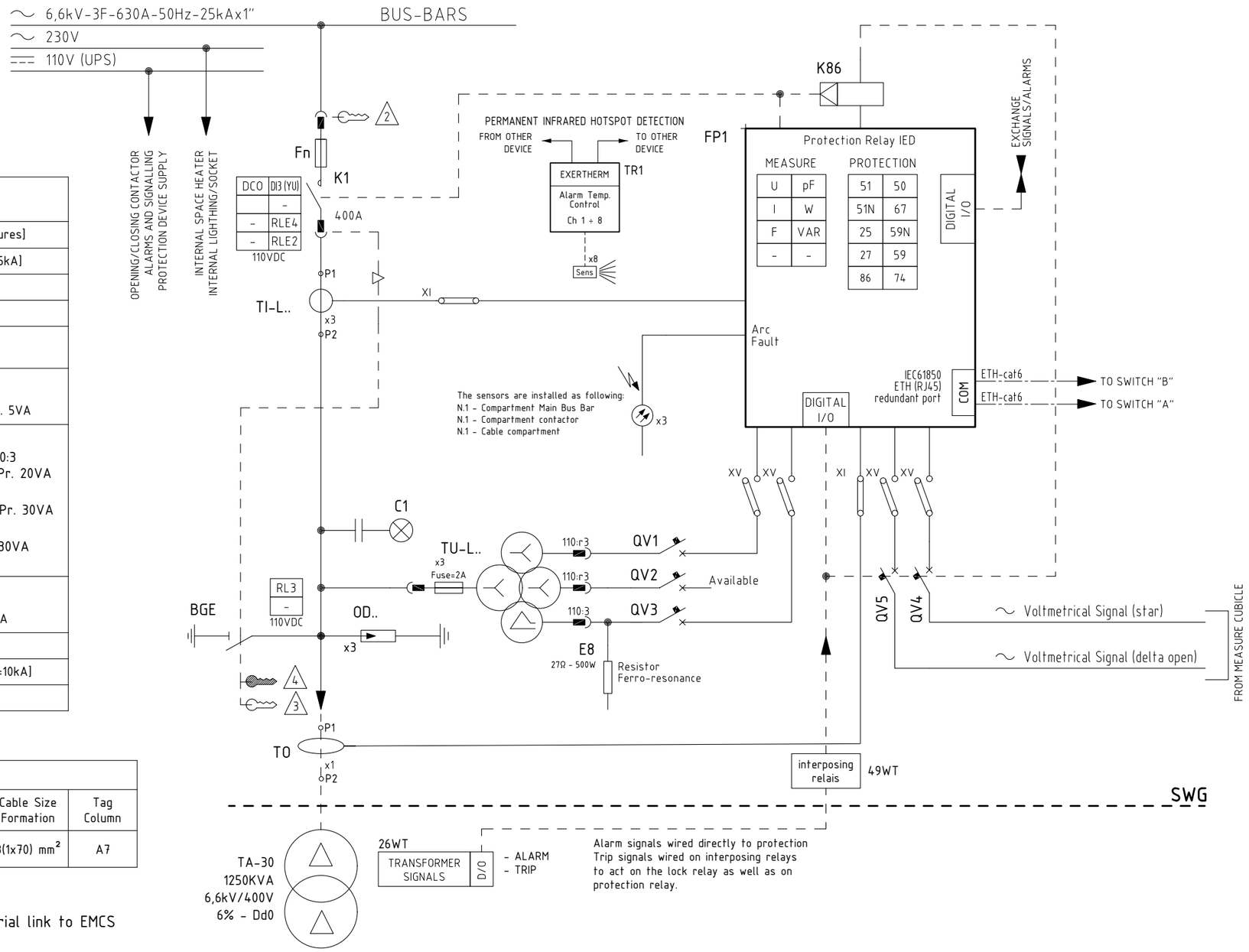
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00010 Rev. 04

LEGEND:

- 1 Free key with opened Circuit Breaker (Circuit Breaker locked in open position)
- 2 Free key with insolated Circuit Breaker or Contactor (Circuit Breaker or Contactor locked in isolated position)
- 3 Free key with opened Earthing Switch (Earthing Switch locked in open position)
- 4 Free key with closed Earthing Switch (Earthing Switch locked in close position)
- ▷ Mechanical interlock
- DCO DOUBLE COMMAND OPERATED

# SINGLE LINE DIAGRAM
## "FEEDER with CONTACTOR"




## MAIN EQUIPMENT

[Additional Features and Auxiliary Components will be inserted on Functional Diagram]

| Tag | Desciption Tag | Supplier | Type [Technical Features] |
|---|---|---|---|
| K1 | Contactor | ABB | VSC7/P [7,2KV - 400A - 25kA] |
| Fn | Fuse for Contactor | ABB | CEF 160A |
| BGE | Earthing Switch | ABB | ST-E [12KV - 25kA] |
| FP1 | Protection Relay | ABB | REX640 |
| TI-L.. | Current Transformers | ESITAS | ATB 10-BS<br>7,2kV - 150/1 - 25kA<br>1°winding : Cl.0,5+5P20 - Pr. 5VA |
| TU-L.. | Voltage Transformers + Fuses | ABB | TJP4.3 [7,2kV - 6,6kV:√3/110:√3-110:√3-110:3<br>1° winding : Cl. 0,5-3P - Pr. 20VA (110:√3)<br>2° winding : Cl. 0,5-3P - Pr. 30VA (110:√3)<br>3° winding : Cl. 3P - Pr. 30VA (110:3) |
| TO | Omopolar Ring Current Transformer (Internal Diameter 150mm) | ESITAS | KAP-150/250-55<br>1.2kV - 100/1A - 25kA<br>1° winding : Cl.5P5 - Pr. 5VA |
| TR1 | Permanent Infrared Hotspot Detection | EXERTHERM | |
| OD.. | Voltage Discharger | DEHN | SBKW 9/DH I-0 [Ur=9kV-In=10kA] |
| C1 | Voltage Presence Indicator | ABB | VPIS [3÷24kV] |

## USER DETAILS

| Tag User | Desciption User | User Power | Current Transformer Ratio | Cable Size Formation | Tag Column |
|---|---|---|---|---|---|
| A-80000 | FUEL CELL PACKAGE | 1000 kW | 150 / 1A | 3(1x70) mm² | A7 |

NOTE :

For FUEL CELL PACKAGE feeder interlocks and intertrips will be managed via serial link to EMCS

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231151/SD/10
Item n° : PF1113279/4

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE : "SG-100D1"

ELECTRICAL SINGLE LINE DIAGRAM
Column A7 : Fuel Cell Package A-80000

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00010

SHEET 010

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00010 Rev. 04

1.3.2.SG-200N1 ELECTRICAL SINGLE LINE DIAGRAM,

Doc. No. 1723002197-EL-DG-00011

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# BASE LOAD POWER HUB (BLPH)

# "SG-200N1" LV SWBD 400/230V

# ELECTRICAL
# SINGLE LINE DIAGRAM

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macerola | 25/09/2024 |

DWG n° : 231298/SD/11

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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TITLE : "SG-200N1"
SINGLE LINE DIAGRAM
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00011 | SHEET 001 | REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00011 Rev. 04

# INDEX SHEETS

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 001 | Cover | X | X | X | X | X | | | | | |
| 002 | Index | X | X | X | X | X | | | | | |
| 003 | Graphical Symbols | X | X | X | X | X | | | | | |
| 004 | Graphical Symbols | X | X | X | X | X | | | | | |
| 005 | Single Line Drawing | X | X | X | X | X | | | | | |
| 006 | Single Line Drawing | X | X | X | X | X | | | | | |
| 007 | Single Line Drawing | X | X | X | X | X | | | | | |
| 008 | Single Line Drawing | X | X | X | X | X | | | | | |
| 009 | Single Line Drawing | X | X | X | X | X | | | | | |
| 010 | Single Line Drawing | X | X | X | X | X | | | | | |
| 011 | Single Line Drawing | X | X | X | X | X | | | | | |
| 012 | Single Line Drawing | X | X | X | X | X | | | | | |
| 013 | Single Line Drawing | X | X | X | X | X | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
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| | | | | | | | | | | | |

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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/11

Item n° : PF1002983/26

TITLE : "SG-200N1"

SINGLE LINE DIAGRAM

Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

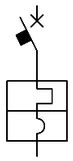
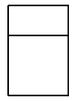
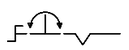
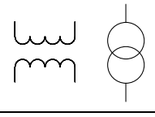
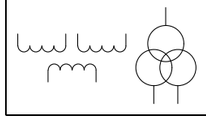
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SHEET 002

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00011 Rev. 04

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|  | **CIRCUIT BREAKER WITH AUTOMATIC RELEASE** |  | **CAPACITOR (GENERAL SYMBOL)** |  | **BISTABLE RELAY** |  | **CHANGE-OVER BREAK BEFORE MAKE CONTACT** |
|  | **CIRCUIT BREAKER WITH AUTOMATIC RELEASE AND BUILT-IN THERMOMAGNETIC RELEASE** |  | **CAPACITIVE VOLTAGE DIVIDER** |  | **COIL OF A MECHANICALLY LATCHED RELAY** |  | **DELAYED ACTION (IN THE DIRECTION OF MOVEMENT FROM THE ARC TOWARDS ITS CENTRE)** |
| | |  | **CURRENT TRANSFORMER** |  | **INDICATOR, ELECTROMECHANICAL ELEMENT** |  | POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT |
|  | **SWITCH DISCONNECTOR** |  | RING CURRENT TRANSFORMER |  | **LAMP (GENERAL SYMBOL)** |  | **POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT** |
|  | **CONTACTOR** |  | **INDICATING INSTRUMENT GENERAL SYMBOL** |  | **SEMICONDUCTOR DIODE** |  | POSITION SWITCH (LIMIT SWITCH), BREAK CONTACT |
|  | **LOCK WITH FREE KEY WHEN THE DEVICE IS IN OPEN POSITION** |  | **INTEGRATING INSTRUMENT (GENERAL SYMBOL)** |  | **LED** |  | **OPERATED BY TURNING** |
|  | **LOCK WITH FREE KEY WHEN THE DEVICE IS IN CLOSE POSITION** |  | **DISCONNECTING FUSE, NOT WITH LIVE CIRCUIT AND WITH MECHANICAL LINKAGE (STRIKER FUSE))** |   | **TRANSDUCER OF ALTERNATING CURRENT MEASURE INTO DIRECT CURRENT SIGNAL** |  | **THREE HELD POSITIONS TURNING SWITCH** |
|  | **PLUG AND SOCKET (MALE AND FEMALE)** |  | **OPERATING DEVICE (GENERAL SYMBOL)** |  | **EARTH, GROUND (GENERAL SYMBOL)** |  | **THREE POSITIONS TURNING SWITCH, WITH SPRING THROWBACK TO THE CENTRAL POSITION** |
|  | **VOLTAGE TRANSFORMER WITH TWO WINDINGS** |  | **COIL OF A TIME DELAYED OPERATING RELAY** |  | **MAKE CONTACT** |  | MECHANICAL INTERLOCK BETWEEN TWO DEVICES |
|  | **VOLTAGE TRANSFORMER WITH THREE WINDINGS** |  | **COIL OF A TIME DELAYED RELEASING RELAY** |  | **BREAK CONTACT** | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/11

Item n° : PF1002983/26

TITLE : "SG-200N1"

SINGLE LINE DIAGRAM

Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

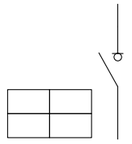
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SHEET 003

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00011 Rev. 04

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|  | RESISTOR (GENERAL SYMBOL) |  | AMPEROMETRIC TEST SOCKET | | | | |
|  | THERMISTOR (GENERAL SYMBOL) |  | 3 PHASES LINE | | | | |
|  | HEATING ELEMENT |  | 3 PHASES + NEUTRAL | | | | |
|  | INTERCONNECTION TERMINAL |  | SINGLE PHASE + NEUTRAL | | | | |
|  | WITHDRAWABLE TERMINAL SHORT-CIRCUITABLE ON C.T. SECONDARY CIRCUITS |  | CIRCUIT BREAKER SWITCH-DISCONNECTOR | | | | |
|  | WITHDRAWABLE TERMINAL FOR V.T. SECONDARY CIRCUITS | | | | | | |
|  | SWITCHBOARD TERMINAL | M | MOTOR FOR LOADING SPRINGS | | | | |
|  | ON - OFF SWITCH | YC | CLOSING COIL | | | | |
|  | SURGE ARRESTER | YO | OPENING COIL | | | | |
|  | VOLTMETRIC TEST SOCKET | YU | UNDERVOLTAGE COIL | | | | |

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Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"
SINGLE LINE DIAGRAM
Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

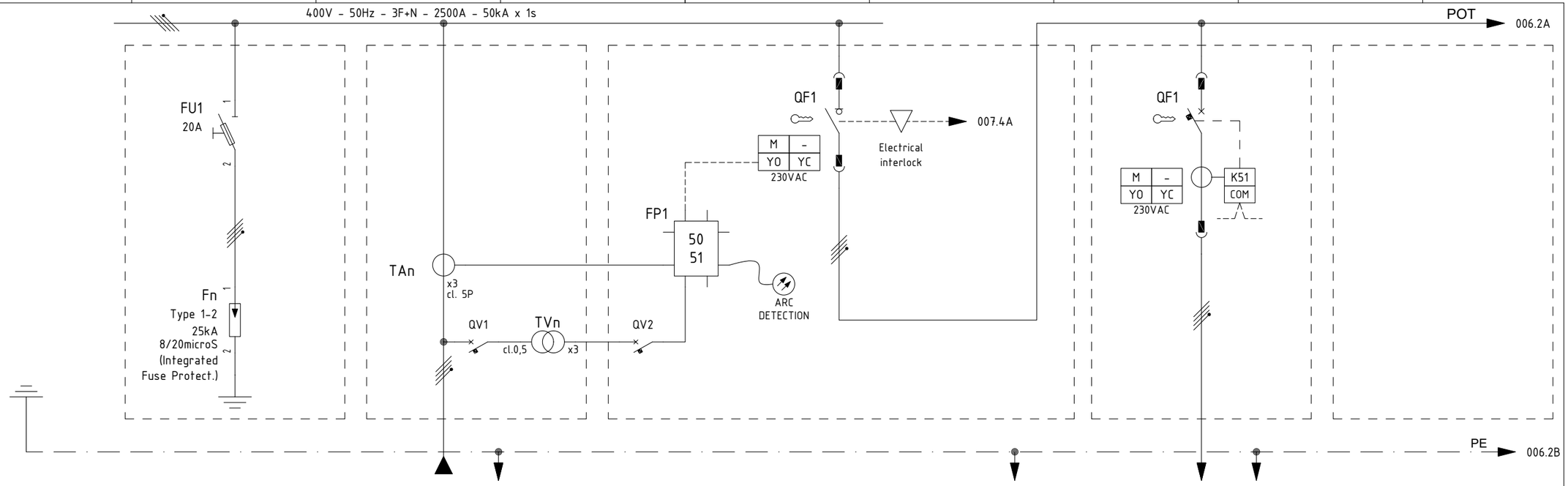
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SHEET 004

REV. 04

File Name : 1723002197-EL-DG-00011 Rev. 04

F.to UNI A3: 420mmx297mm




| ITEM | | | 1 | - | - | - | A-20000 | |
|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | SURGE ARRESTER | - | INCOMING TRASFORMER | ELECTROLYSER AUXILIARY LOAD | |
| COLUMN/CUBICLE | | | 3 | - | A1 / +02 | A1 / +05 | A1 / +08 | |
| RATED POWER \| RATED CURRENT | | | 4/5 | - \| - | - \| - | - \| - | 293 kW \| 497 A | |
| TYPICAL FUNCTIONAL | | | 6 | - | - | - | L3-630 | |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | - | - | E4.2N/MS-3200 4P | E1.2C-1250 4P | |
| | VERSION | | 8 | - | - | WITHDRAWABLE | WITHDRAWABLE | |
| | TRIP UNITS | | 9 | - | - | - | EKIP HI TOUCH LSIG = 630 | |
| | Icu | KA | 10 | - | - | 66 kA (1s) | 50 kA | |
| OVERLOAD | L | Range A | 11 | - | - | - | (0.4 ÷ 1) x In | |
| | | Range t | 12 | - | - | - | t=k/I^2 | |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | - | - | - | (0.6 ÷ 10) x In [EXCLUDABLE] | |
| | | Range t | 14 | - | - | - | t=k / t=k/I² | |
| INST. SHORT-CIRCUIT | I | Range A | 15 | - | - | - | (1.5 ÷ 15) x In | |
| | | Range t | 16 | - | - | - | instantaneous | |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | - | - | (0.1 ÷ 1) x In (EXCLUDABLE) | |
| | | Range t | 18 | - | - | - | t=k / t=k/I^2 | |
| CONTACTOR (ABB) | | | 19 | - | - | - | - | |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | |
| SURGE ARRESTER (DEHN) | | | 21 | DVCI 1 255 FM (961205) | - | - | - | |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | |
| FUSE HOLDER (ITALWEBER) | | | 23 | Fuses 20A gG | - | - | - | |
| INDIRECT PROTECTION (ABB) | | | 24 | - | - | REF615-(version F) HBFFAEFCNDCABBA11G | - | |
| VOLTMETER | | | 25 | - | - | - | - | |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | TAR1052K5N01V_18 - 2500/1A | - | - | |
| | PERFORMANCE/CLASS | | 27 | - | 5VA / 5P20 | - | - | |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | TTV020400VC1 - 400r3/110r3V | - | - | |
| | PERFORMANCE/CLASS | | 29 | - | 20VA / 0.5 | - | - | |
| LOCK-OUT RELAY (-) | | | 30 | - | - | - | - | |
| POWER CONDUCTOR | | mmq | 31 | - | - | - | 1 x 150 + [4 x (1 x 300)] | |

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DWG n° : 231298/SD/11

Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

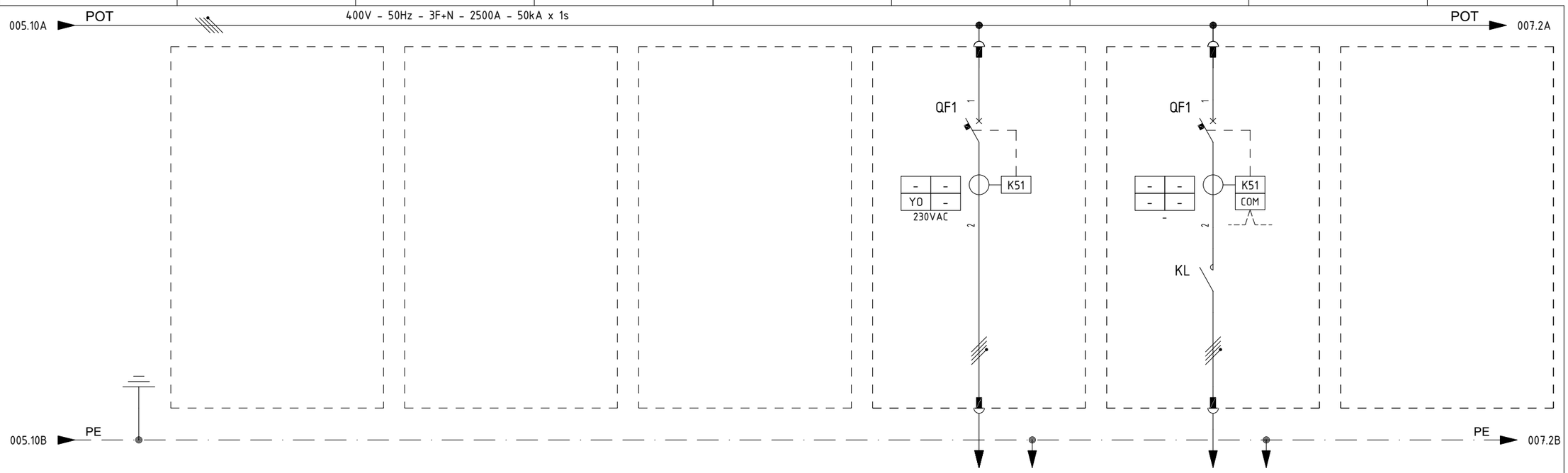
DRAWING NO. 1723002197-EL-DG-00011

SHEET 005

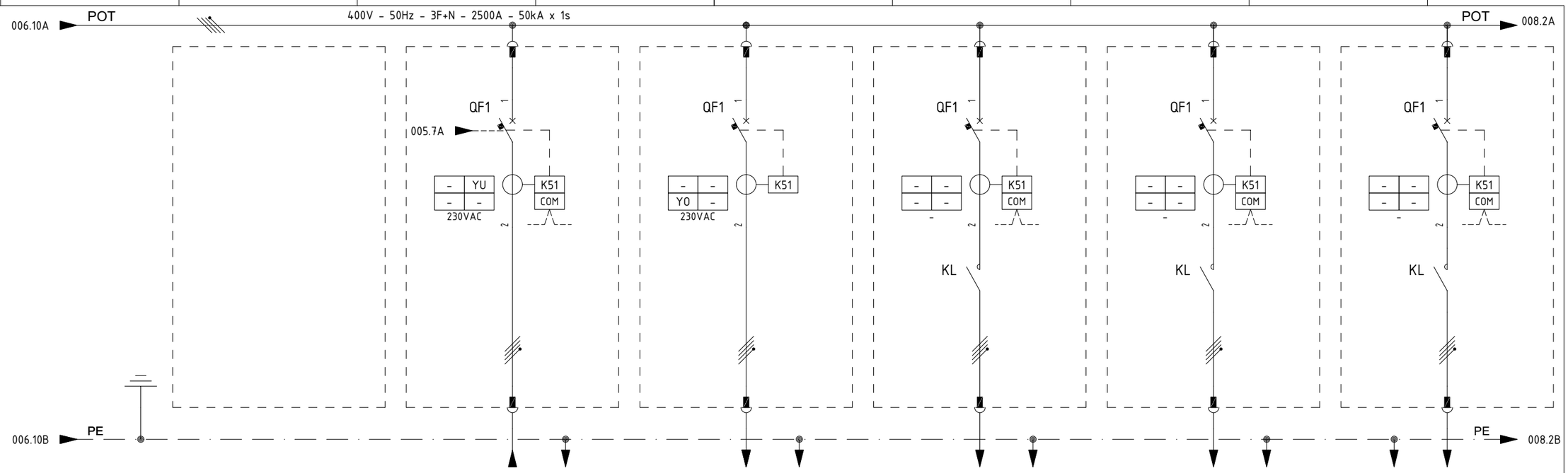
REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00011 Rev. 04


005.10A
POT
400V - 50Hz - 3F+N - 2500A - 50kA x 1s
POT
007.2A
QF1
K51
YO
230VAC
QF1
K51
COM
KL
005.10B
PE
PE
007.2B

| | | |




| ITEM | | | 1 | JB-200E2 | UP-200F3 | SPARE | DP-200N1 | JB-200E3 |
|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | TEMPORARY GENERATOR / MOBILE BATTERY PACK | AC UPS PAS - 30 MIN UP-200F3 - LINE A | SPARE | DB - LIGHTING & SMALL POWER - BoP | CRANE |
| COLUMN/CUBICLE | | | 3 | A2 / +08 | A3 / +01 | A3 / +02 | A3 / +03 | A3 / +04 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 138 kW \| 210 A | 36.0 kW \| 57.8 A | - kW \| - A | 15.35 kW \| 23.7 A | 25 kW \| 37.8 A |
| TYPICAL FUNCTIONAL | | | 6 | LE2-320 | L1-100 | LK1-40 | LK1-100 | LK1-63 |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | XT5S - 400 | XT2S - 160 | XT2S - 160 | XT2S - 160 | XT2S - 160 |
| | VERSION | | 8 | 4P - FIXED | 4P - FIXED | 4P - FIXED | 4P - FIXED | 4P - FIXED |
| | TRIP UNITS | | 9 | EKIP HI TOUCH LSIG (In = 320A) | EKIP DIP LSIG (In = 100A) | EKIP HI TOUCH LSIG (In = 40A) | EKIP HI TOUCH LSIG (In = 100A) | EKIP HI TOUCH LSIG (In = 63A) |
| | Icu | KA | 10 | 50 kA | 50 kA | 50 kA | 50 kA | 50 kA |
| OVERLOAD | L | Range A | 11 | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In |
| | | Range t | 12 | $k/I^2$ | $k/I^2$ | $k/I^2$ | $k/I^2$ | $k/I^2$ |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | (0.6 - 10) x In | (1 - 10) x In | (0.6 - 10) x In | (0.6 - 10) x In | (0.6 - 10) x In |
| | | Range t | 14 | 0.05 - 0.4 sec / $k/I^2$ | 0.05 - 0.4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ |
| INST. SHORT-CIRCUIT | I | Range A | 15 | (1.5 - 15) x In | (1 - 10) x In | (1.5 - 15) x In | (1.5 - 15) x In | (1.5 - 15) x In |
| | | Range t | 16 | instantaneous | <= 0.02 sec | instantaneous | instantaneous | instantaneous |
| EARTH FAULT PROTECTION | G | Range A | 17 | (0.1 - 1) x In | (0.2 - 1) x In | (0.1 - 1) x In | (0.1 - 1) x In | (0.1 - 1) x In |
| | | Range t | 18 | t=k / t=k/I^2 | 0.1 - 0.8 sec | t=k / t=k/I^2 | t=k / t=k/I^2 | t=k / t=k/I^2 |
| CONTACTOR (ABB) | | | 19 | - | - | AF40-40-00-13 (70A-AC1); 100-250VAC/DC | AF80-40-00-13 (70A-AC1); 100-250VAC/DC | AF52-40-00-13 (100A-AC1); 100-250VAC/DC |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | - |
| SURGE ARRESTER (DEHN) | | | 21 | - | - | - | - | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | - |
| FUSE HOLDER (ITALWEBER) | | | 23 | - | - | - | - | - |
| INDIRECT PROTECTION (ABB) | | | 24 | - | - | - | - | - |
| VOLTMETER | | | 25 | - | - | - | - | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | - |
| LOCK-OUT RELAY (-) | | | 30 | - | - | - | - | - |
| POWER CONDUCTOR | | mmq | 31 | 5 x (1 x 95) | 4G35 | - | 5G50 | 5G16 |

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DWG n° : 231298/SD/11

Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 4 | 28/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 08/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 2 | 03/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 28/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 15/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

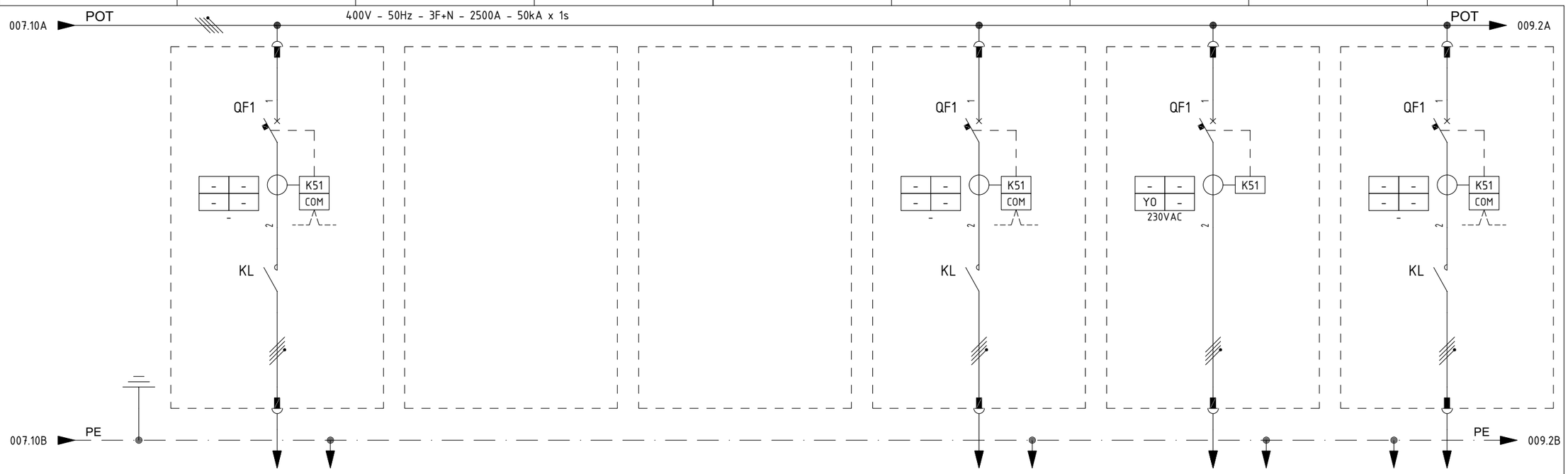
DRAWING NO. 1723002197-EL-DG-00011

SHEET 007

REV. 04

File Name : 1723002197-EL-DG-00011 Rev. 04

F.to UNI A3: 420mmx297mm




| ITEM | | | 1 | SPARE | - | | JB-500E8 | UP-200F3 | B100-HSB-001 |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | SPARE | FUTURE | | WATER PACKAGE | AC UPS PAS - 30 MIN UP-200F3 - LINE B | HVAC PANELS HV ROOM |
| COLUMN/CUBICLE | | | 3 | A3 / +05 | A3 / +06 | | A3 / +08 | A4 / +01 | A4 / +02 |
| RATED POWER \| RATED CURRENT | | | 4/5 | - kW \| - A | - \| - | | 67 kW \| 107.00 A | 36.0 kW \| 57.8 A | 18 kW \| 34.1 A |
| TYPICAL FUNCTIONAL | | | 6 | LK1-40 | | | LK2-160 | L1-100 | LK1-40 |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | XT2S - 160 | | | XT4S - 250 | XT2S - 160 | XT2S - 160 |
| | VERSION | | 8 | 4P - FIXED | | | 4P - FIXED | 4P - FIXED | 4P - FIXED |
| | TRIP UNITS | | 9 | EKIP HI TOUCH LSIG (In = 40A) | | | EKIP HI TOUCH LSIG (In = 160A) | EKIP DIP LSIG (In = 100A) | EKIP HI TOUCH LSIG (In = 40A) |
| | Icu | KA | 10 | 50 kA | | | 50 kA | 50 kA | 50 kA |
| OVERLOAD | L | Range A | 11 | (0.4 - 1) x In | | | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In |
| | | Range t | 12 | $k/I^2$ | | | $k/I^2$ | $k/I^2$ | $k/I^2$ |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | (0.6 - 10) x In | | | (0.6 - 10) x In | (1 - 10) x In | (0.6 - 10) x In |
| | | Range t | 14 | 0.05 - 0,4 sec / $k/I^2$ | | | 0.05 - 0.4 sec / $k/I^2$ | 0.05 - 0.4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ |
| INST. SHORT-CIRCUIT | I | Range A | 15 | (1.5 - 15) x In | | | (1.5 - 15) x In | (1 - 10) x In | (1.5 - 15) x In |
| | | Range t | 16 | instantaneous | | | instantaneous | <= 0.02 sec | instantaneous |
| EARTH FAULT PROTECTION | G | Range A | 17 | (0.1 - 1) x In | | | (0.1 - 1) x In | (0.2 - 1) x In | (0.1 - 1) x In |
| | | Range t | 18 | t=k / t=k/I^2 | | | t=k / t=k/I^2 | 0.1 - 0.8 sec | t=k / t=k/I^2 |
| CONTACTOR (ABB) | | | 19 | AF40-40-00-13 (70A-AC1); 100-250VAC/DC | | | AF190-40-11-13 (275A-AC1); 100-250 VAC/DC | - | AF40-40-00-13 (70A-AC1); 100-250VAC/DC |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | | | - | - | - |
| SURGE ARRESTER (DEHN) | | | 21 | - | | | - | - | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | | | - | - | - |
| FUSE HOLDER (ITALWEBER) | | | 23 | - | | | - | - | - |
| INDIRECT PROTECTION (ABB) | | | 24 | - | | | - | - | - |
| VOLTMETER | | | 25 | - | | | - | - | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | | | - | - | - |
| | PERFORMANCE/CLASS | | 27 | - | | | - | - | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | | | - | - | - |
| | PERFORMANCE/CLASS | | 29 | - | | | - | - | - |
| LOCK-OUT RELAY (-) | | | 30 | - | | | - | - | - |
| POWER CONDUCTOR | | mmq | 31 | - | | | 5G70 | 4G35 | 5G16 |

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DWG n° : 231298/SD/11

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 4 | 28/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 08/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 2 | 03/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 28/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 15/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

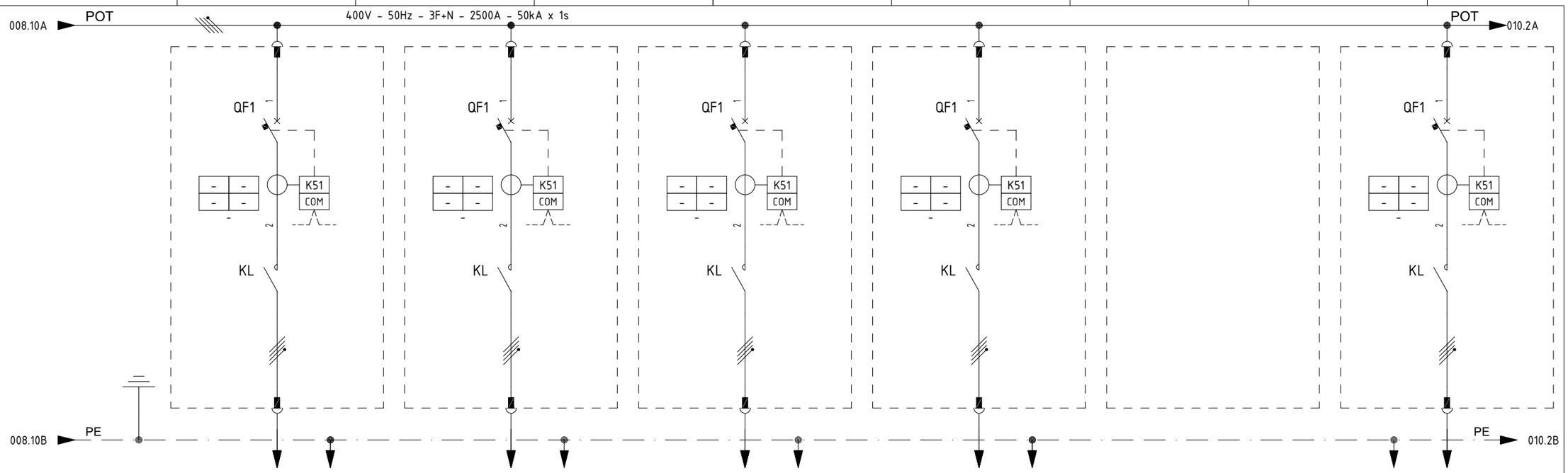
DRAWING NO. 1723002197-EL-DG-00011

SHEET 008

REV. 04

File Name : 1723002197-EL-DG-00011 Rev. 04

F.to UNI A3: 420mmx297mm




| ITEM | | | 1 | A-80000 | CP-850F03 | SPARE | SPARE | | K-63001-A |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | FUEL CELL AUXILIARY LOAD | BESS PCS CABINET | SPARE | SPARE | | INSTRUMENTS AIR PACKAGE 01A |
| COLUMN/CUBICLE | | | 3 | A4 / +03 | A4 / +04 | A4 / +05 | A4 / +06 | | A4 / +08 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 20 kW \| 32.84 A | 11,09 kW \| 17.42 A | - kW \| - A | - kW \| - A | | 68.75 kW \| 111.24 A |
| TYPICAL FUNCTIONAL | | | 6 | LK1-63 | LK1-40 | LK1-40 | LK1-40 | | LK2-160 |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | XT2S - 160 | XT2S - 160 | XT2S - 160 | XT2S - 160 | | XT4S - 250 |
| | VERSION | | 8 | 4P - FIXED | 4P - FIXED | 4P - FIXED | 4P - FIXED | | 4P - FIXED |
| | TRIP UNITS | | 9 | EKIP HI TOUCH LSIG (In = 63A) | EKIP HI TOUCH LSIG (In = 40A) | EKIP HI TOUCH LSIG (In = 40A) | EKIP HI TOUCH LSIG (In = 40A) | | EKIP HI TOUCH LSIG (In = 160A) |
| | Icu KA | | 10 | 50 kA | 50 kA | 50 kA | 50 kA | | 50 kA |
| OVERLOAD | L | Range A | 11 | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In | | (0.4 - 1) x In |
| | | Range t | 12 | $k/I^2$ | $k/I^2$ | $k/I^2$ | $k/I^2$ | | $k/I^2$ |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | (0.6 - 10) x In | (0.6 - 10) x In | (0.6 - 10) x In | (0.6 - 10) x In | | (0.6 - 10) x In |
| | | Range t | 14 | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ | | 0.05 - 0.4 sec / $k/I^2$ |
| INST. SHORT-CIRCUIT | I | Range A | 15 | (1.5 - 15) x In | (1.5 - 15) x In | (1.5 - 15) x In | (1.5 - 15) x In | | (1.5 - 15) x In |
| | | Range t | 16 | instantaneous | instantaneous | instantaneous | instantaneous | | instantaneous |
| EARTH FAULT PROTECTION | G | Range A | 17 | (0.1 - 1) x In | (0.1 - 1) x In | (0.1 - 1) x In | (0.1 - 1) x In | | (0.1 - 1) x In |
| | | Range t | 18 | t=k / t=k/I^2 | t=k / t=k/I^2 | t=k / t=k/I^2 | t=k / t=k/I^2 | | t=k / t=k/I^2 |
| CONTACTOR (ABB) | | | 19 | AF52-40-00-13 (100A-AC1); 100-250VAC/DC | AF40-40-00-13 (70A-AC1); 100-250VAC/DC | AF40-40-00-13 (70A-AC1); 100-250VAC/DC | AF40-40-00-13 (70A-AC1); 100-250VAC/DC | | AF190-40-11-13 (275A-AC1); 100-250 VAC/DC |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | | - |
| SURGE ARRESTER (DEHN) | | | 21 | - | - | - | - | | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | | - |
| FUSE HOLDER (ITALWEBER) | | | 23 | - | - | - | - | | - |
| INDIRECT PROTECTION (ABB) | | | 24 | - | - | - | - | | - |
| VOLTMETER | | | 25 | - | - | - | - | | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | | - |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | | - |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | | - |
| LOCK-OUT RELAY (-) | | | 30 | - | - | - | - | | - |
| POWER CONDUCTOR | | mmq | 31 | 5G16 | 4 x 10 | - | - | | 5G70 |

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DWG n° : 231298/SD/11

Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 4 | 28/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 08/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 2 | 03/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 28/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 15/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

# SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

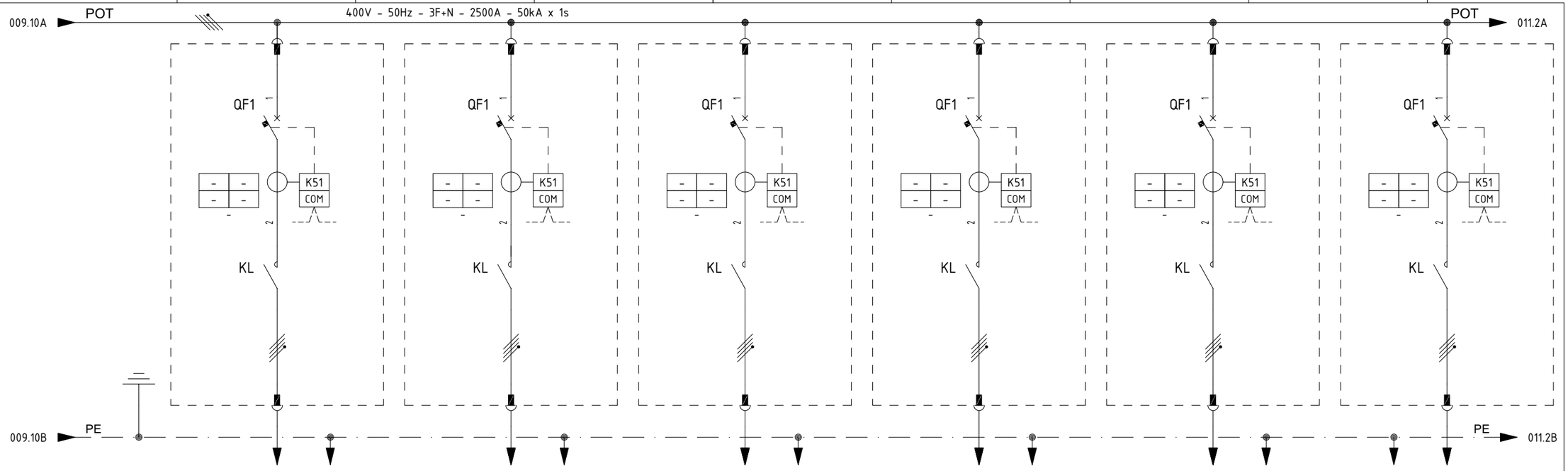
DRAWING NO. 1723002197-EL-DG-00011

SHEET 009

REV. 04

File Name : 1723002197-EL-DG-00011 Rev. 04

F.to UNI A3: 420mmx297mm




| ITEM | | | 1 | SPARE | B200-HSB-001 | B300-HSB-001 | B400-HSB-001 | CN-200N1 | SPARE |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | SPARE | HVAC PANELS - LV ROOM | HVAC PANELS - UPS ROOM | HVAC PANELS - ITER | IMPRESSED CURR. CATHODIC PROTECTION (ICCP) SYSTEM | SPARE |
| COLUMN/CUBICLE | | | 3 | A5 / +01 | A5 / +02 | A5 / +03 | A5 / +04 | A5 / +05 | A5 / +06 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 15 kW \| 24.0 A | 18 kW \| 34.1 A | 35,75 kW \| 61 A | 35,75 kW \| 61 A | 14 kVA \| 23.8 A | - kW \| - A |
| TYPICAL FUNCTIONAL | | | 6 | LK1-40 | LK1-40 | LK1-63 | LK1-63 | LK1-40 | LK1-40 |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | XT2S - 160 | XT2S - 160 | XT2S - 160 | XT2S - 160 | XT2S - 160 | XT2S - 160 |
| | VERSION | | 8 | 4P - FIXED | 4P - FIXED | 4P - FIXED | 4P - FIXED | 4P - FIXED | 4P - FIXED |
| | TRIP UNITS | | 9 | EKIP HI TOUCH LSIG (In = 40A) | EKIP HI TOUCH LSIG (In = 40A) | EKIP HI TOUCH LSIG (In = 63A) | EKIP HI TOUCH LSIG (In = 63A) | EKIP HI TOUCH LSIG (In = 40A) | EKIP HI TOUCH LSIG (In = 40A) |
| | Icu | KA | 10 | 50 kA | 50 kA | 50 kA | 50 kA | 50 kA | 50 kA |
| OVERLOAD | L | Range A | 11 | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In |
| | | Range t | 12 | $k/I^2$ | $k/I^2$ | $k/I^2$ | $k/I^2$ | $k/I^2$ | $k/I^2$ |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | (0.6 - 10) x In | (0.6 - 10) x In | (0.6 - 10) x In | (0.6 - 10) x In | (0.6 - 10) x In | (0.6 - 10) x In |
| | | Range t | 14 | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ |
| INST. SHORT-CIRCUIT | I | Range A | 15 | (1.5 - 15) x In | (1.5 - 15) x In | (1.5 - 15) x In | (1.5 - 15) x In | (1.5 - 15) x In | (1.5 - 15) x In |
| | | Range t | 16 | instantaneous | instantaneous | instantaneous | instantaneous | instantaneous | instantaneous |
| EARTH FAULT PROTECTION | G | Range A | 17 | (0.1 - 1) x In | (0.1 - 1) x In | (0.1 - 1) x In | (0.1 - 1) x In | (0.1 - 1) x In | (0.1 - 1) x In |
| | | Range t | 18 | t=k / t=k/I^2 | t=k / t=k/I^2 | t=k / t=k/I^2 | t=k / t=k/I^2 | t=k / t=k/I^2 | t=k / t=k/I^2 |
| CONTACTOR (ABB) | | | 19 | AF40-40-00-13 (70A-AC1); 100-250VAC/DC | AF40-40-00-13 (70A-AC1); 100-250VAC/DC | AF52-40-00-13 (100A-AC1); 100-250VAC/DC | AF52-40-00-13 (100A-AC1); 100-250VAC/DC | AF40-40-00-13 (70A-AC1); 100-250VAC/DC | AF40-40-00-13 (70A-AC1); 100-250VAC/DC |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | - | - |
| SURGE ARRESTER (DEHN) | | | 21 | - | - | - | - | - | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | - | - |
| FUSE HOLDER (ITALWEBER) | | | 23 | - | - | - | - | - | - |
| INDIRECT PROTECTION (ABB) | | | 24 | - | - | - | - | - | - |
| VOLTMETER | | | 25 | - | - | - | - | - | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | - | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | - | - |
| LOCK-OUT RELAY (-) | | | 30 | - | - | - | - | - | - |
| POWER CONDUCTOR | | mmq | 31 | - | 5G16 | 5G16 | 5G16 | 5G16 | - |

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DWG n° : 231298/SD/11

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 4 | 28/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 08/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 2 | 03/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 28/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 15/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

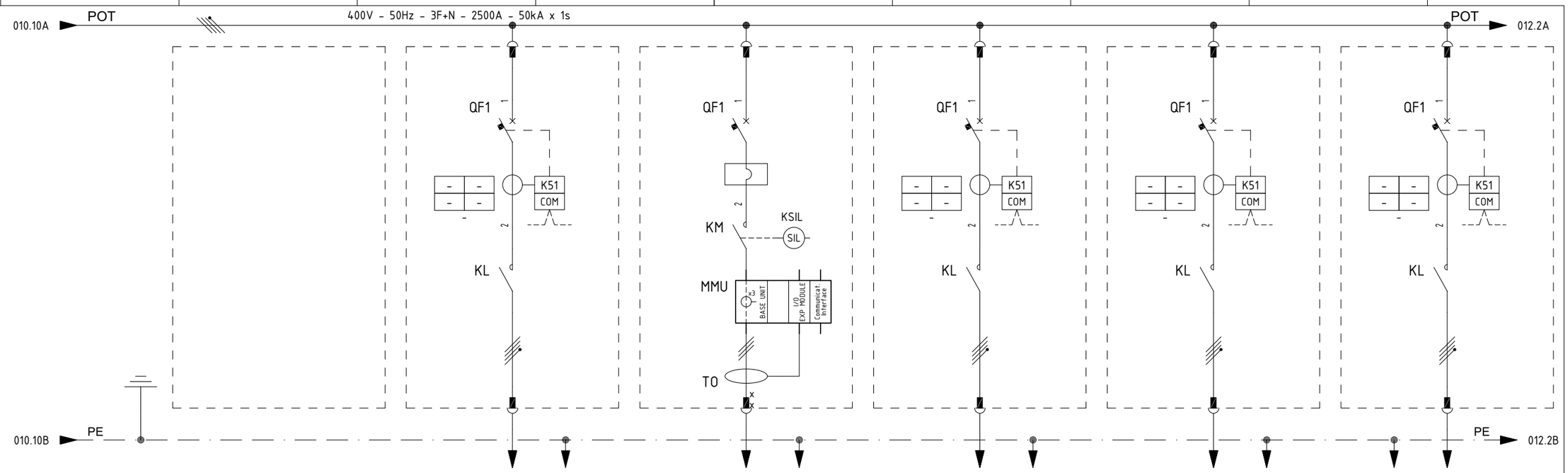
DRAWING NO. 1723002197-EL-DG-00011

SHEET 010

REV. 04

File Name : 1723002197-EL-DG-00011 Rev. 04

F.to UNI A3: 420mmx297mm




| ITEM | | | | K-63001-B | PM-50001 B | CP-850E1 | CP-850E2 | - |
|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | INSTRUMENTS AIR PACKAGE 01B | SEA WATER PUMP B | BESS LV1 CABINET (+DISTR 1) | BESS LV2 CABINET (+DISTR 2) | SPARE |
| COLUMN/CUBICLE | | | 3 | A5 / +08 | A6 / +01 | A6 / +02 | A6 / +03 | A6 / +04 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 68.75 kW \| 111.24 A | 6.1 kW \| 11.0 A | 11.28 kW \| 18.09 A | 11.28 kW \| 18.09 A | - kW \| - A |
| TYPICAL FUNCTIONAL | | | 6 | LK2-160 | M1-6 | LK1-40 | LK1-40 | LK1-40 |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | XT4S - 250 | XT2S - 160 | XT2S - 160 | XT2S - 160 | XT2S - 160 |
| | VERSION | | 8 | 4P - FIXED | 3P - FIXED | 4P - FIXED | 4P - FIXED | 4P - FIXED |
| | TRIP UNITS | | 9 | EKIP HI TOUCH LSIG (In = 160A) | MA (In = 20A) | EKIP HI TOUCH LSIG (In = 40A) | EKIP HI TOUCH LSIG (In = 40A) | EKIP HI TOUCH LSIG (In = 40A) |
| | Icu KA | | 10 | 50 kA | - | 50 kA | 50 kA | 50 kA |
| OVERLOAD | L | Range A | 11 | (0.4 - 1) x In | - | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In |
| | | Range t | 12 | $k/I^2$ | - | $k/I^2$ | $k/I^2$ | $k/I^2$ |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | (0.6 - 10) x In | - | (0.6 - 10) x In | (0.6 - 10) x In | (0.6 - 10) x In |
| | | Range t | 14 | 0.05 - 0.4 sec / $k/I^2$ | - | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ | 0.05 - 0,4 sec / $k/I^2$ |
| INST. SHORT-CIRCUIT | I | Range A | 15 | (1.5 - 15) x In | (6 - 14) x I | (1.5 - 15) x In | (1.5 - 15) x In | (1.5 - 15) x In |
| | | Range t | 16 | instantaneous | <= 0.02 sec | instantaneous | instantaneous | instantaneous |
| EARTH FAULT PROTECTION | G | Range A | 17 | (0.1 - 1) x In | - | (0.1 - 1) x In | (0.1 - 1) x In | (0.1 - 1) x In |
| | | Range t | 18 | t=k / t=k/I^2 | - | t=k / t=k/I^2 | t=k / t=k/I^2 | t=k / t=k/I^2 |
| CONTACTOR (ABB) | | | 19 | AF190-40-11-13 (275A-AC1); 100-250 VAC/DC | AF38-30-00-13 (18.5 kW - AC3) - 100-250Vac/dc | AF40-40-00-13 (70A-AC1); 100-250VAC/DC | AF40-40-00-13 (70A-AC1); 100-250VAC/DC | AF40-40-00-13 (70A-AC1); 100-250VAC/DC |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | UMC100.3 UC (0.24 - 63A) | - | - | - |
| SURGE ARRESTER (DEHN) | | | 21 | - | - | - | - | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | - |
| FUSE HOLDER (ITALWEBER) | | | 23 | - | - | - | - | - |
| INDIRECT PROTECTION (ABB) | | | 24 | - | - | - | - | - |
| VOLTMETER | | | 25 | - | - | - | - | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | - |
| LOCK-OUT RELAY (-) | | | 30 | - | - | - | - | - |
| POWER CONDUCTOR mmq | | | 31 | 5G70 | 4G4 | 4 x (1 x 10) | 4 x (1 x 10) | - |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 4 | 28/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 08/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 15/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231298/SD/11

Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

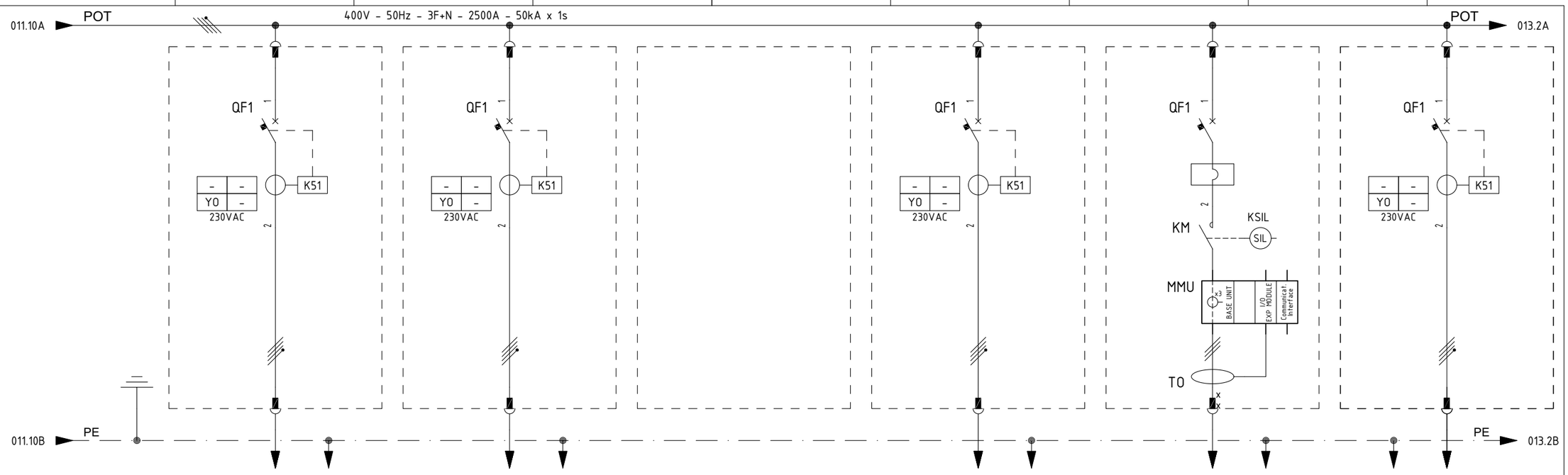
DRAWING NO. 1723002197-EL-DG-00011

SHEET 011

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00011 Rev. 04




| ITEM | | | 1 | UP-200F4 | UP-200F4 | | ESW-200N1 | PM-50001 A | UP-200F3 |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | AC UPS F&G - 8 H<br>UP-200F4 - LINE A | AC UPS F&G - 8h<br>UP-200F4 - LINE B | | WELDING SOCKETS<br>(TOP DECK) | SEA WATER PUMP A | AC UPS PAS - 30 min.<br>UP-200F3 - BYPASS |
| COLUMN/CUBICLE | | | 3 | A6 / +05 | A6 / +06 | | A6 / +08 | A7 / +01 | A7 / +02 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 18 kW \| 28.9 A | 18 kW \| 28.9 A | | 69.84 kW \| 126.15 A | 6.1 kW \| 11.0 A | 36 kW \| 57.8 A |
| TYPICAL FUNCTIONAL | | | 6 | L1-63 | L1-63 | | L2-160 | M1-6 | L1-100 |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | XT2S - 160 | XT2S - 160 | | XT4S - 250 | XT2S - 160 | XT2S - 160 |
| | VERSION | | 8 | 4P - FIXED | 4P - FIXED | | 4P - FIXED | 3P - FIXED | 4P - FIXED |
| | TRIP UNITS | | 9 | EKIP DIP LSIG (In = 63A) | EKIP DIP LSIG (In = 63A) | | EKIP DIP LSIG (In = 160A) | MA (In = 20A) | EKIP DIP LSIG (In = 100A) |
| | Icu | KA | 10 | 50 kA | 50kA | | 50kA | - | 50 kA |
| OVERLOAD | L | Range A | 11 | (0.4 - 1) x In | (0.4 - 1) x In | | (0.4 - 1) x In | - | (0.4 - 1) x In |
| | | Range t | 12 | $k/I^2$ | $k/I^2$ | | $k/I^2$ | - | $k/I^2$ |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | (1 - 10) x In | (1 - 10) x In | | (1 - 10) x In | - | (1 - 10) x In |
| | | Range t | 14 | 0.05 - 0.4 sec / $k/I^2$ | 0.05 - 0.4 sec / $k/I^2$ | | 0.05 - 0.4 sec / $k/I^2$ | - | 0.05 - 0.4 sec / $k/I^2$ |
| INST. SHORT-CIRCUIT | I | Range A | 15 | (1 - 10) x In | (1 - 10) x In | | (1 - 10) x In | (6 - 14) x I | (1 - 10) x In |
| | | Range t | 16 | <= 0.02 sec | <= 0.02 sec | | <= 0.02 sec | <= 0.02 sec | <= 0.02 sec |
| EARTH FAULT PROTECTION | G | Range A | 17 | (0.2 - 1) x In | (0.2 - 1) x In | | (0.2 - 1) x In | - | (0.2 - 1) x In |
| | | Range t | 18 | 0.1 - 0.8 sec | 0.1 - 0.8 sec | | 0.1 - 0.8 sec | - | 0.1 - 0.8 sec |
| CONTACTOR (ABB) | | | 19 | - | - | | - | AF38-30-00-13 (18.5 kW - AC3) - 100-250Vac/dc | - |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | | - | UMC100.3 UC (0.24 - 63A) | - |
| SURGE ARRESTER (DEHN) | | | 21 | - | - | | - | - | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | | - | - | - |
| FUSE HOLDER (ITALWEBER) | | | 23 | - | - | | - | - | - |
| INDIRECT PROTECTION (ABB) | | | 24 | - | - | | - | - | - |
| VOLTMETER | | | 25 | - | - | | - | - | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | | - | - | - |
| | PERFORMANCE/CLASS | | 27 | - | - | | - | - | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | | - | - | - |
| | PERFORMANCE/CLASS | | 29 | - | - | | - | - | - |
| LOCK-OUT RELAY (-) | | | 30 | - | - | | - | - | - |
| POWER CONDUCTOR | | mmq | 31 | 4G35 | 4G35 | | 5G50 | 4G4 | 4G35 |

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DWG n° : 231298/SD/11

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 4 | 28/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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TITLE : "SG-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

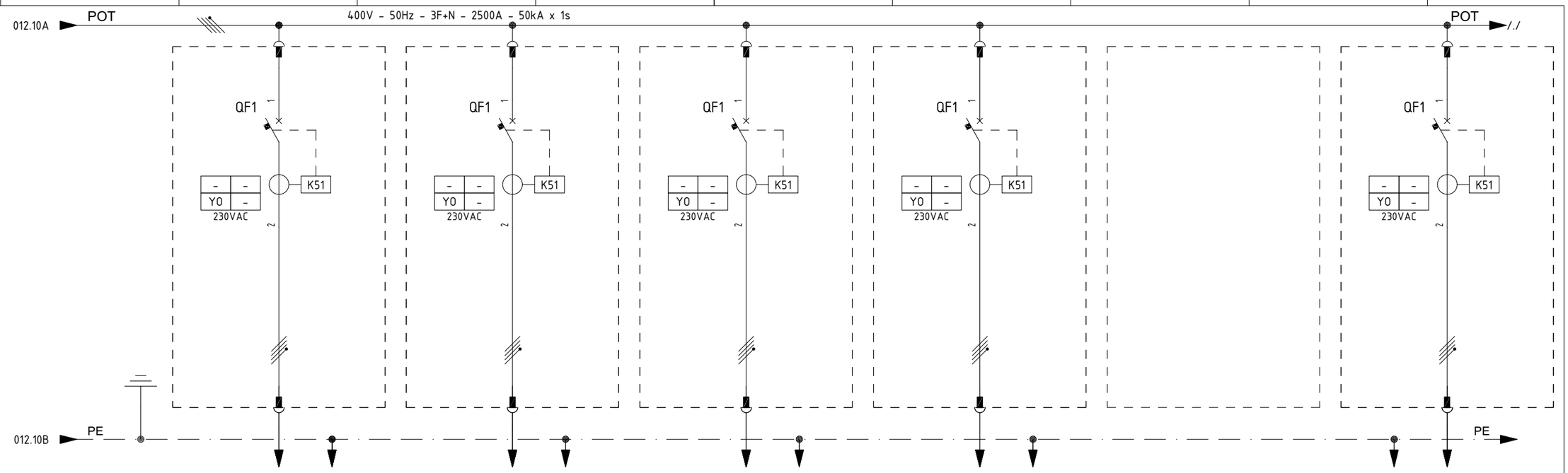
DRAWING NO. 1723002197-EL-DG-00011

SHEET 012

REV. 04

File Name : 1723002197-EL-DG-00011 Rev. 04

F.to UNI A3: 420mmx297mm




| ITEM | | | 1 | UP-200F1 | UP-200F1 | UP-200F2 | UP-200F2 | | ESW-200N2 |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | DC BATTERY SYSTEM SWTG CONTROL - FEEDER A | DC BATTERY SYSTEM SWTG CONTROL - FEEDER B | NAVAID SYSTEM FEEDER A | NAVAID SYSTEM FEEDER B | | WELDING SOCKETS (LOWER DECK) |
| COLUMN/CUBICLE | | | 3 | A7 / +03 | A7 / +04 | A7 / +05 | A7 / +06 | | A7 / +08 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 10 kW \| 16 A | 10 kW \| 16 A | 1.6 kVA \| 7 A | 1.6 kVA \| 7 A | | 69.84 kW \| 126.15 A |
| TYPICAL FUNCTIONAL | | | 6 | L1-63 | L1-63 | L1-63 | L1-63 | | L2-160 |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | XT2S - 160 | XT2S - 160 | XT2S - 160 | XT2S - 160 | | XT4S - 250 |
| | VERSION | | 8 | 4P - FIXED | 4P - FIXED | 4P - FIXED | 4P - FIXED | | 4P - FIXED |
| | TRIP UNITS | | 9 | EKIP DIP LSIG (In = 63A) | EKIP DIP LSIG (In = 63A) | EKIP DIP LSIG (In = 63A) | EKIP DIP LSIG (In = 63A) | | EKIP DIP LSIG (In = 160A) |
| | Icu | KA | 10 | 50kA | 50kA | 50kA | 50kA | | 50kA |
| OVERLOAD | L | Range A | 11 | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In | (0.4 - 1) x In | | (0.4 - 1) x In |
| | | Range t | 12 | $k/I^2$ | $k/I^2$ | $k/I^2$ | $k/I^2$ | | $k/I^2$ |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | (1 - 10) x In | (1 - 10) x In | (1 - 10) x In | (1 - 10) x In | | (1 - 10) x In |
| | | Range t | 14 | 0.05 - 0.4 sec / $k/I^2$ | 0.05 - 0.4 sec / $k/I^2$ | 0.05 - 0.4 sec / $k/I^2$ | 0.05 - 0.4 sec / $k/I^2$ | | 0.05 - 0.4 sec / $k/I^2$ |
| INST. SHORT-CIRCUIT | I | Range A | 15 | (1 - 10) x In | (1 - 10) x In | (1 - 10) x In | (1 - 10) x In | | (1 - 10) x In |
| | | Range t | 16 | <= 0.02 sec | <= 0.02 sec | <= 0.02 sec | <= 0.02 sec | | <= 0.02 sec |
| EARTH FAULT PROTECTION | G | Range A | 17 | (0.2 - 1) x In | (0.2 - 1) x In | (0.2 - 1) x In | (0.2 - 1) x In | | (0.2 - 1) x In |
| | | Range t | 18 | 0.1 - 0.8 sec | 0.1 - 0.8 sec | 0.1 - 0.8 sec | 0.1 - 0.8 sec | | 0.1 - 0.8 sec |
| CONTACTOR (ABB) | | | 19 | - | - | - | - | | - |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | | - |
| SURGE ARRESTER (DEHN) | | | 21 | - | - | - | - | | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | | - |
| FUSE HOLDER (ITALWEBER) | | | 23 | - | - | - | - | | - |
| INDIRECT PROTECTION (ABB) | | | 24 | - | - | - | - | | - |
| VOLTMETER | | | 25 | - | - | - | - | | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | | - |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | | - |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | | - |
| LOCK-OUT RELAY (-) | | | 30 | - | - | - | - | | - |
| POWER CONDUCTOR | | mmq | 31 | 4G16 | 4G16 | 3G16 | 3G16 | | 5G50 |

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DWG n° : 231298/SD/11

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 4 | 28/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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| 0 | 15/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00011

SHEET 013

REV. 04

File Name : 1723002197-EL-DG-00011 Rev. 04

F.to UNI A3: 420mmx297mm

1.3.3.SG-200D2 ELECTRICAL SINGLE LINE DIAGRAM,

Doc. No. 1723002197-EL-DG-00012

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# BASE LOAD POWER HUB (BLPH)

# "SG-200D2" LV SWBD 800V

# ELECTRICAL
# SINGLE LINE DIAGRAM

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macula | 25/09/2024 |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/12

Item n° : PF1002669/3

CROSSWIND

ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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| 1 | 19/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 15/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200D2"
SINGLE LINE DIAGRAM
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00012

SHEET 001

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00012 Rev. 04

# INDEX SHEETS

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 001 | Cover | X | X | X | X | X | | | | | | | | | | | | | | | | | |
| 002 | Index | X | X | X | X | X | | | | | | | | | | | | | | | | | |
| 003 | Graphical Symbols | X | X | X | X | X | | | | | | | | | | | | | | | | | |
| 004 | Graphical Symbols | X | X | X | X | X | | | | | | | | | | | | | | | | | |
| 005 | Single Line Drawing | X | X | X | X | X | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| + | 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) | |
| DWG n° : 231298/SD/12 | 3 | 08/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| Item n° : PF1002669/3 | 2 | 22/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) | |
| | 1 | 19/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) | |
| | 0 | 15/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

SINGLE LINE DIAGRAM

Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

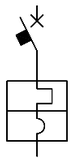
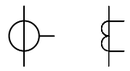
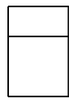
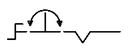
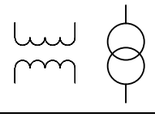
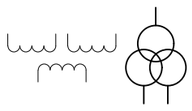
DRAWING NO. 1723002197-EL-DG-00012

SHEET 002

REV. 04

File Name : 1723002197-EL-DG-00012 Rev. 04

F.to UNI A3: 420mmx297mm

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|  | **CIRCUIT BREAKER WITH AUTOMATIC RELEASE** |  | **CAPACITOR (GENERAL SYMBOL)** |  | **BISTABLE RELAY** |  | **CHANGE-OVER BREAK BEFORE MAKE CONTACT** |
|  | **CIRCUIT BREAKER WITH AUTOMATIC RELEASE AND BUILT-IN THERMOMAGNETIC RELEASE** |  | **CAPACITIVE VOLTAGE DIVIDER** |  | **COIL OF A MECHANICALLY LATCHED RELAY** |  | **DELAYED ACTION (IN THE DIRECTION OF MOVEMENT FROM THE ARC TOWARDS ITS CENTRE)** |
| | |  | **CURRENT TRANSFORMER** |  | **INDICATOR, ELECTROMECHANICAL ELEMENT** |  | POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT |
|  | **SWITCH DISCONNECTOR** |  | RING CURRENT TRANSFORMER |  | **LAMP (GENERAL SYMBOL)** |  | **POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT** |
|  | **CONTACTOR** |  | **INDICATING INSTRUMENT GENERAL SYMBOL** |  | **SEMICONDUCTOR DIODE** |  | POSITION SWITCH (LIMIT SWITCH), BREAK CONTACT |
|  | **LOCK WITH FREE KEY WHEN THE DEVICE IS IN OPEN POSITION** |  | **INTEGRATING INSTRUMENT (GENERAL SYMBOL)** |  | **LED** |  | **OPERATED BY TURNING** |
|  | **LOCK WITH FREE KEY WHEN THE DEVICE IS IN CLOSE POSITION** |  | **DISCONNECTING FUSE, NOT WITH LIVE CIRCUIT AND WITH MECHANICAL LINKAGE (STRIKER FUSE))** |   | **TRANSDUCER OF ALTERNATING CURRENT MEASURE INTO DIRECT CURRENT SIGNAL** |  | **THREE HELD POSITIONS TURNING SWITCH** |
|  | **PLUG AND SOCKET (MALE AND FEMALE)** |  | **OPERATING DEVICE (GENERAL SYMBOL)** |  | **EARTH, GROUND (GENERAL SYMBOL)** |  | **THREE POSITIONS TURNING SWITCH, WITH SPRING THROWBACK TO THE CENTRAL POSITION** |
|  | **VOLTAGE TRANSFORMER WITH TWO WINDINGS** |  | **COIL OF A TIME DELAYED OPERATING RELAY** |  | **MAKE CONTACT** |  | MECHANICAL INTERLOCK BETWEEN TWO DEVICES |
|  | **VOLTAGE TRANSFORMER WITH THREE WINDINGS** |  | **COIL OF A TIME DELAYED RELEASING RELAY** |  | **BREAK CONTACT** | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/12

Item n° : PF1002669/3

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

SINGLE LINE DIAGRAM

Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00012

SHEET 003

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00012 Rev. 04

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | RESISTOR (GENERAL SYMBOL) | | AMPEROMETRIC TEST SOCKET | | | | |
| | THERMISTOR (GENERAL SYMBOL) | | 3 PHASES LINE | | | | |
| | HEATING ELEMENT | | 3 PHASES + NEUTRAL | | | | |
| | INTERCONNECTION TERMINAL | | SINGLE PHASE + NEUTRAL | | | | |
| | WITHDRAWABLE TERMINAL SHORT-CIRCUITABLE ON C.T. SECONDARY CIRCUITS | | CIRCUIT BREAKER SWITCH-DISCONNECTOR | | | | |
| | WITHDRAWABLE TERMINAL FOR V.T. SECONDARY CIRCUITS | | | | | | |
| | SWITCHBOARD TERMINAL | M | MOTOR FOR LOADING SPRINGS | | | | |
| | ON - OFF SWITCH | YC | CLOSING COIL | | | | |
| | SURGE ARRESTER | YO | OPENING COIL | | | | |
| | VOLTMETRIC TEST SOCKET | YU | UNDERVOLTAGE COIL | | | | |

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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/12

Item n° : PF1002669/3

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

SINGLE LINE DIAGRAM

Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

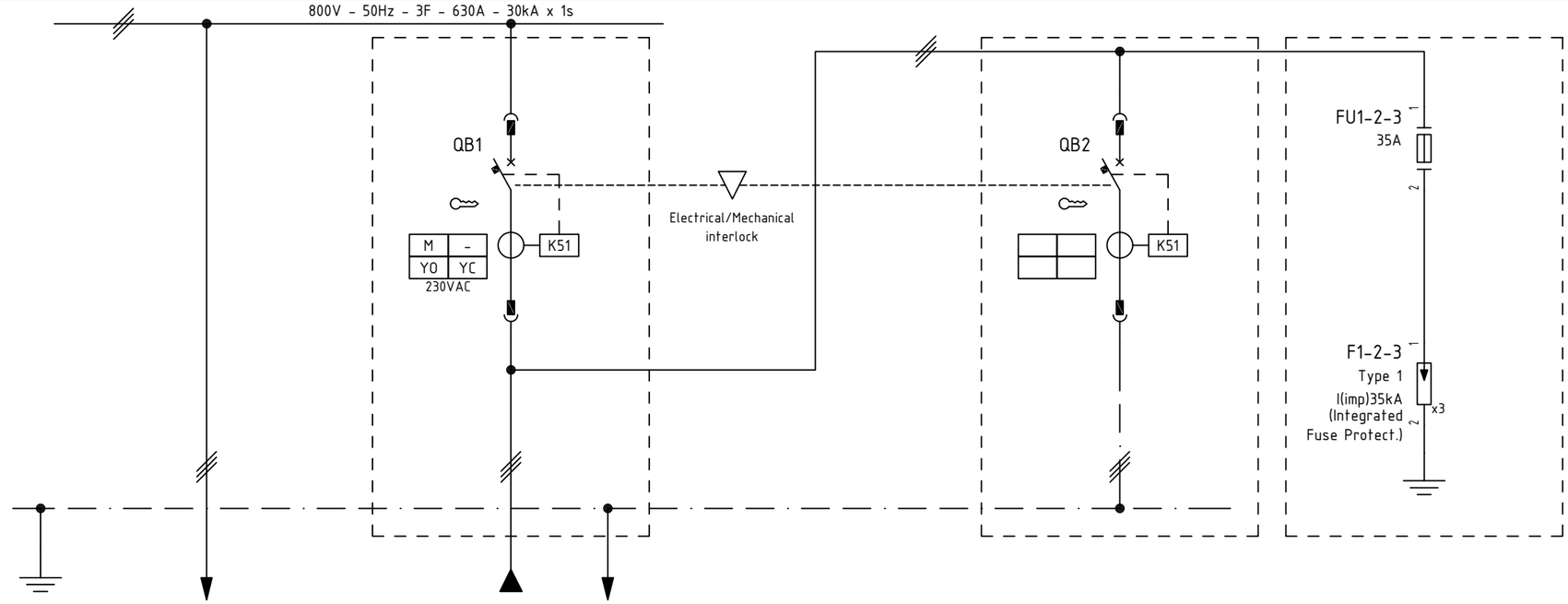
DRAWING NO. 1723002197-EL-DG-00012

SHEET 004

REV. 04

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00012 Rev. 04




| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ITEM | | | 1 | - | - | | - | - | | | |
| UTILITY | | | 2 | OUTGOING | INCOMING FROM SOLAR FARM | | EARTHING SWITCH | SURGE ARRESTER | | | |
| COLUMN/CUBICLE | | | 3 | CL01 / 06 | CL01 / 02 | | CL01 / 04 | CL01 / 06 | | | |
| RATED POWER \| RATED CURRENT | | | 4/5 | - \| - | - \| - | | - \| - | - \| - | | | |
| TYPICAL FUNCTIONAL | | | 6 | - | - | | - | - | | | |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | - | E1.2N/E9-1250 3P | | E1.2N/E9-1250 3P | - | | | |
| | VERSION | | 8 | - | WITHDRAWABLE | | WITHDRAWABLE | - | | | |
| | TRIP UNITS | | 9 | - | Ekip Hi Touch LSIG = 1250A | | Ekip Touch LSIG = 1250A (with Rating Plug L=OFF) | - | | | |
| | Icu | KA | 10 | - | 35KA | | 35KA | - | | | |
| OVERLOAD | L | Range A | 11 | - | 0.4 ÷ 1 In | | 0.4 ÷ 1 In [EXCLUDABLE] | - | | | |
| | | Range t | 12 | - | t=k/I^2 | | t=k/I^2 | - | | | |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | - | 0.6 ÷ 10 In | | 0.6 ÷ 10 In [EXCLUDABLE] | - | | | |
| | | Range t | 14 | - | t=k / t=k/I^2 | | t=k / t=k/I^2 | - | | | |
| INST. SHORT-CIRCUIT | I | Range A | 15 | - | 1.5 ÷ 15 In | | 1.5 ÷ 15 In [EXCLUDABLE] | - | | | |
| | | Range t | 16 | - | instantaneous | | instantaneous | - | | | |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | 0.1 ÷ 1 In | | - | - | | | |
| | | Range t | 18 | - | t=k / t=k/I^2 | | - | - | | | |
| CONTACTOR (ABB) | | | 19 | - | - | | - | - | | | |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | | - | - | | | |
| SURGE ARRESTERS (DEHN) | | | 21 | - | - | | - | DBM 1 CI 440 FM (961146) | | | |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | | - | - | | | |
| FUSE HOLDER (ITALWEBER) | | | 23 | - | - | | - | Fuses NH-00 35A gG / 800V | | | |
| INSULATION SYSTEM (BENDER) | | | 24 | - | - | | - | - | | | |
| VOLTMETER | | | 25 | - | - | | - | - | | | |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | | - | - | | | |
| | PERFORMANCE/CLASS | | 27 | - | - | | - | - | | | |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | | - | - | | | |
| | PERFORMANCE/CLASS | | 29 | - | - | | - | - | | | |
| LOCK-OUT RELAY (-) | | | 30 | - | - | | - | - | | | |
| POWER CONDUCTOR | | mmq | 31 | 3x(1x300) | 3x(1x300) | | - | - | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/12

Item n° : PF1002669/3

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00012

SHEET 005

REV. 04

File Name : 1723002197-EL-DG-00012 Rev. 04

F.to UNI A3: 420mmx297mm

1.3.4.DP-200N1 ELECTRICAL SINGLE LINE DIAGRAM,

Doc. No. 1723002197-EL-DG-00013

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# BASE LOAD POWER HUB (BLPH)

# "DP-200N1" LV SWBD 400/230V

# ELECTRICAL
# SINGLE LINE DIAGRAM

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Andrea Sgadoni | 12/03/2025 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
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| 5 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twilight Switch TW1 |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/13

Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"
SINGLE LINE DIAGRAM
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00013

SHEET 001

REV. 05

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00013 Rev. 05

# INDEX SHEETS

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 001 | Cover | | | | | | | | | | |
| 002 | Index | | | | | | | | | | |
| 003 | Graphical Symbols | | | | | | | | | | |
| 004 | Graphical Symbols | | | | | | | | | | |
| 005 | Single Line Drawing | | | | | | | | | | |
| 006 | Single Line Drawing | | | | | | | | | | |
| 007 | Single Line Drawing | | | | | | | | | | |
| 008 | Single Line Drawing | | | | | | | | | | |
| 009 | Single Line Drawing | | | | | | | | | | |
| 010 | Single Line Drawing | | | | | | | | | | |
| 011 | Single Line Drawing | | | | | | | | | | |
| 012 | Single Line Drawing | | | | | | | | | | |
| 013 | Single Line Drawing | | | | | | | | | | |
| 014 | Single Line Drawing | | | | | | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/13

Item n° : PF1002888/101

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

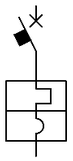
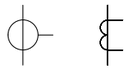
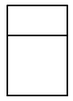
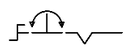
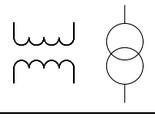
DRAWING NO. 1723002197-EL-DG-00013

SHEET 002

REV. 05

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00013 Rev. 05

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|  | **CIRCUIT BREAKER WITH AUTOMATIC RELEASE** |  | **CAPACITOR (GENERAL SYMBOL)** |  | **BISTABLE RELAY** |  | **CHANGE-OVER BREAK BEFORE MAKE CONTACT** |
|  | **CIRCUIT BREAKER WITH AUTOMATIC RELEASE AND BUILT-IN THERMOMAGNETIC RELEASE** |  | **CAPACITIVE VOLTAGE DIVIDER** |  | **COIL OF A MECHANICALLY LATCHED RELAY** |  | **DELAYED ACTION (IN THE DIRECTION OF MOVEMENT FROM THE ARC TOWARDS ITS CENTRE)** |
| | |  | **CURRENT TRANSFORMER** |  | **INDICATOR, ELECTROMECHANICAL ELEMENT** |  | POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT |
|  | **SWITCH DISCONNECTOR** |  | RING CURRENT TRANSFORMER |  | **LAMP (GENERAL SYMBOL)** |  | **POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT** |
|  | **CONTACTOR** |  | **INDICATING INSTRUMENT GENERAL SYMBOL** |  | **SEMICONDUCTOR DIODE** |  | POSITION SWITCH (LIMIT SWITCH), BREAK CONTACT |
|  | **LOCK WITH FREE KEY WHEN THE DEVICE IS IN OPEN POSITION** |  | **INTEGRATING INSTRUMENT (GENERAL SYMBOL)** |  | **LED** |  | **OPERATED BY TURNING** |
|  | **LOCK WITH FREE KEY WHEN THE DEVICE IS IN CLOSE POSITION** |  | **DISCONNECTING FUSE, NOT WITH LIVE CIRCUIT AND WITH MECHANICAL LINKAGE (STRIKER FUSE))** |   | **TRANSDUCER OF ALTERNATING CURRENT MEASURE INTO DIRECT CURRENT SIGNAL** |  | **THREE HELD POSITIONS TURNING SWITCH** |
|  | **PLUG AND SOCKET (MALE AND FEMALE)** |  | **OPERATING DEVICE (GENERAL SYMBOL)** |  | **EARTH, GROUND (GENERAL SYMBOL)** |  | **THREE POSITIONS TURNING SWITCH, WITH SPRING THROWBACK TO THE CENTRAL POSITION** |
|  | **VOLTAGE TRANSFORMER WITH TWO WINDINGS** |  | **COIL OF A TIME DELAYED OPERATING RELAY** |  | **MAKE CONTACT** |  | MECHANICAL INTERLOCK BETWEEN TWO DEVICES |
|  | **VOLTAGE TRANSFORMER WITH THREE WINDINGS** |  | **COIL OF A TIME DELAYED RELEASING RELAY** |  | **BREAK CONTACT** |  | RESISTOR (GENERAL SYMBOL) |

| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/13

Item n° : PF1002888/101

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00013

SHEET 003

REV. 05

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00013 Rev. 05

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|  | THERMISTOR (GENERAL SYMBOL) |  | 3 PHASE + NEUTRAL LINE | | | | |
|  | HEATING ELEMENT |  | SINGLE PHASE + NEUTRAL LINE | | | | |
|  | INTERCONNECTION TERMINAL | | | | | | |
|  | WITHDRAWABLE TERMINAL SHORT-CIRCUITABLE ON C.T. SECONDARY CIRCUITS | | | | | | |
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|  | SWITCHBOARD TERMINAL | | | | | | |
|  | ON - OFF SWITCH | | | | | | |
|  | SURGE ARRESTER | | | | | | |
|  | VOLTMETRIC TEST SOCKET | | | | | | |
|  | AMPEROMETRIC TEST SOCKET | | | | | | |

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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/13

Item n° : PF1002888/101

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

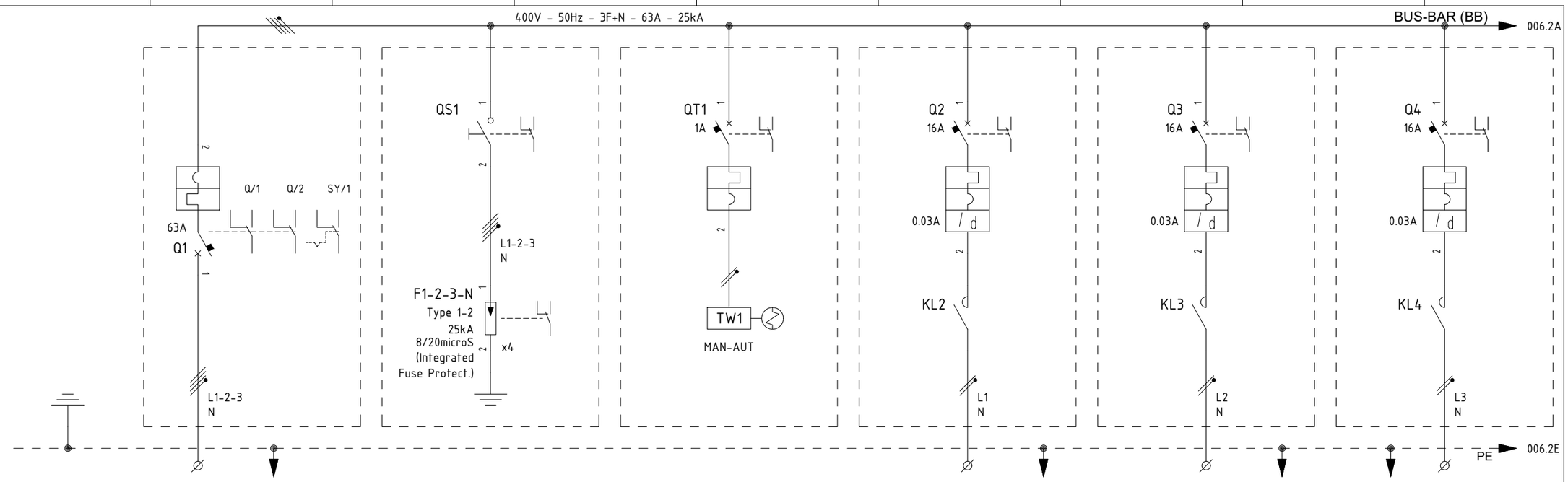
DRAWING NO. 1723002197-EL-DG-00013

SHEET 004

REV. 05

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00013 Rev. 05




| ITEM | | | 1 | - | | | | EJB-200N1-02-L1-01 | | EJB-200N1-03-L2-01 | | EJB-200N1-04-L3-01 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | GENERAL INCOMING | | SURGE ARRESTER | | TWILIGHT SWICTH AND AUXILIARY | | NORMAL LIGHTING UPPER DECK | | NORMAL LIGHTING LOWER DECK | | NORMAL LIGHTING STAIRS | |
| CUBICLE | | | 3 | +01 | | +01 | | +01 | | +01 | | +02 | | +02 | |
| RATED POWER | RATED CURRENT | | 4/5 | 34.8 KW | 63 A | / | / | / | / | 1.5 KW | 6.86 A | 1 KW | 4.58 A | 0.2 KW | 0.92 A |
| TYPICAL FUNCTIONAL | | | 6 | - | | - | | - | | - | | - | | - | |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | XT2N-160 4P | | E204/100R | | S302P-C1 | | S302P-C16 + DDA202 AC-25/0.03 | | S302P-C16 + DDA202 AC-25/0.03 | | S302P-C16 + DDA202 AC-25/0.03 | |
| | VERSION | | 8 | FIXED | | 4P / MINIATURE | | 2P / MINIATURE | | 2P / MINIATURE | | 2P / MINIATURE | | 2P / MINIAUTURE | |
| | TRIP UNITS | | 9 | Ekip Dip LSI = 63A | | In=100A | | In=1A - Curve C | | In=16A - Curve C / Id=0.03A Class AC | | In=16A - Curve C / Id=0.03A Class AC | | In=16A - Curve C / Id=0.03A Class AC | |
| | Icu | KA | 10 | 36KA | | - | | 25kA | | 25kA | | 25kA | | 25kA | |
| OVERLOAD | L | Range A | 11 | 0,4 ÷1 In | | - | | - | | - | | - | | - | |
| | | Range t | 12 | t=k/I^2 | | - | | - | | - | | - | | - | |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | 1 ÷10 In | | - | | - | | - | | - | | - | |
| | | Range t | 14 | t=k / t=k/I^2 | | - | | - | | - | | - | | - | |
| INST. SHORT-CIRCUIT | I | Range A | 15 | 1 ÷10 In | | - | | - | | - | | - | | - | |
| | | Range t | 16 | instantaneous | | - | | - | | - | | - | | - | |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | | - | | - | | - | | - | | - | |
| | | Range t | 18 | - | | - | | - | | - | | - | | - | |
| CONTACTOR (ABB) | | | 19 | - | | - | | - | | ESB40-20N-06; 2x22A AC3; Vaux=230Vdc/ac | | ESB40-20N-06; 2x22A AC3; Vaux=230Vdc/ac | | ESB40-20N-06; 2x22A AC3; Vaux=230Vdc/ac | |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | | - | | - | | - | | - | | - | |
| SURGE ARRESTERS (DHENN) | | | 21 | - | | DVCI 1 255 FM (961 205) | | - | | - | | - | | - | |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | | - | | - | | - | | - | | - | |
| FUSE HOLDER (ABB) | | | 23 | - | | - | | - | | - | | - | | - | |
| TWILIGHT SWITCH (FINDER) | | | 24 | - | | - | | 11.31.0.230.0000 (1-100 LUX); Vaux=110-230Vac/dc | | - | | - | | - | |
| VOLTMETER (FRER) | | | 25 | - | | - | | - | | - | | - | | - | |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | | - | | - | | - | | - | | - | |
| | PERFORMANCE/CLASS | | 27 | - | | - | | - | | - | | - | | - | |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | | - | | - | | - | | - | | - | |
| | PERFORMANCE/CLASS | | 29 | - | | - | | - | | - | | - | | - | |
| POWER TERM. BLOCK (CABUR) | | Type/mm² | 30 | SCREW / 16 | | - | | - | | SCREW / 4 | | SCREW / 4 | | SCREW / 4 | |
| POWER CONDUCTOR | | mm² | 31 | 5G16 | | - | | - | | 3G4 | | 3G4 | | 3G4 | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 5 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twilight Switch TW1 |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 2 | 24/04/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 15/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/13

Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

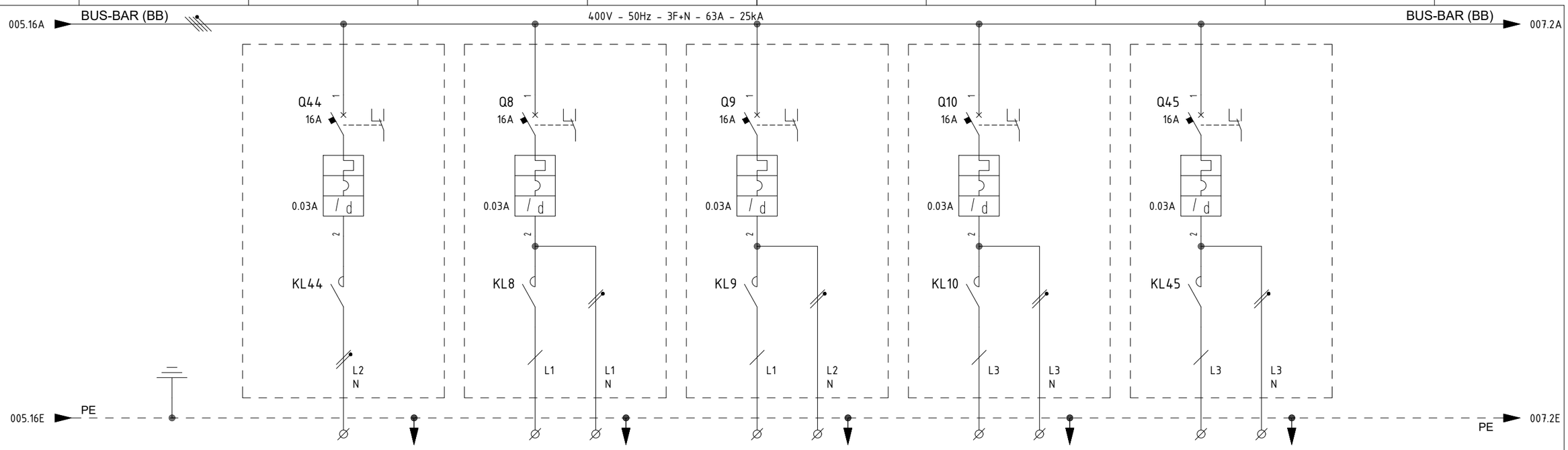
DRAWING NO. 1723002197-EL-DG-00013

SHEET 005

REV. 05

File Name : 1723002197-EL-DG-00013 Rev. 05

F.to UNI A3: 420mmx297mm




| ITEM | | | 1 | - | EJB-200N1-08-L1-01 | EJB-200N1-09-L2-01 | EJB-200N1-10-L3-01 | - | |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | NORMAL LIGHTING - SPARE | EMERGENCY LIGHTING UPPER DECK | EMERGENCY LIGHTING LOWER DECK | EMERGENCY LIGHTING STAIRS | EMERGENCY LIGHTING - SPARE | |
| CUBICLE | | | 3 | +02 | +02 | +02 | +02 | +02 | |
| RATED POWER | RATED CURRENT | | 4/5 | 1 KW / 4.58 A | 1.5 KW / 6.86 A | 1.5 KW / 6.86 A | 0.30 KW / 1.37 A | 1.5 KW / 6.86 A | |
| TYPICAL FUNCTIONAL | | | 6 | - | - | - | - | - | |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | S302P-C16 + DDA202 AC-25/0.03 | S302P-D16 + DDA202 AC-25/0.03 | S302P-D16 + DDA202 AC-25/0.03 | S302P-D16 + DDA202 AC-25/0.03 | S302P-D16 + DDA202 AC-25/0.03 | |
| | VERSION | | 8 | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | |
| | TRIP UNITS | | 9 | In=16A - Curve C / Id=0.03A Class AC | In=16A - Curve D / Id=0.03A Class AC | In=16A - Curve D / Id=0.03A Class AC | In=16A - Curve D / Id=0.03A Class AC | In=16A - Curve D / Id=0.03A Class AC | |
| | Icu | KA | 10 | 25KA | 25KA | 25KA | 25KA | 25KA | |
| OVERLOAD | L | Range A | 11 | - | - | - | - | - | |
| | | Range t | 12 | - | - | - | - | - | |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | - | - | - | - | - | |
| | | Range t | 14 | - | - | - | - | - | |
| INST. SHORT-CIRCUIT | I | Range A | 15 | - | - | - | - | - | |
| | | Range t | 16 | - | - | - | - | - | |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | - | - | - | - | |
| | | Range t | 18 | - | - | - | - | - | |
| CONTACTOR (ABB) | | | 19 | ESB40-20N-06; 2x22A AC3; Vaux=230Vdc/ac | ESB40-20N-06; 2x22A AC3; Vaux=230Vdc/ac | ESB40-20N-06; 2x22A AC3; Vaux=230Vdc/ac | ESB40-20N-06; 2x22A AC3; Vaux=230Vdc/ac | ESB40-20N-06; 2x22A AC3; Vaux=230Vdc/ac | |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | - | |
| SURGE ARRESTERS (DHENN) | | | 21 | - | - | - | - | - | |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | - | |
| FUSE HOLDER (ABB) | | | 23 | - | - | - | - | - | |
| TWILIGHT SWITCH (FINDER) | | | 24 | - | - | - | - | - | |
| VOLTMETER (FRER) | | | 25 | - | - | - | - | - | |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | - | |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | - | |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | - | |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | - | |
| POWER TERM. BLOCK (CABUR) | | Type/mm² | 30 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 4 | |
| POWER CONDUCTOR | | mm² | 31 | - | 4G4_E | 4G4_E | 4G4_E | - | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 5 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twilight Switch TW1 |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 2 | 24/04/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 15/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/13

Item n° : PF1002888/101

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

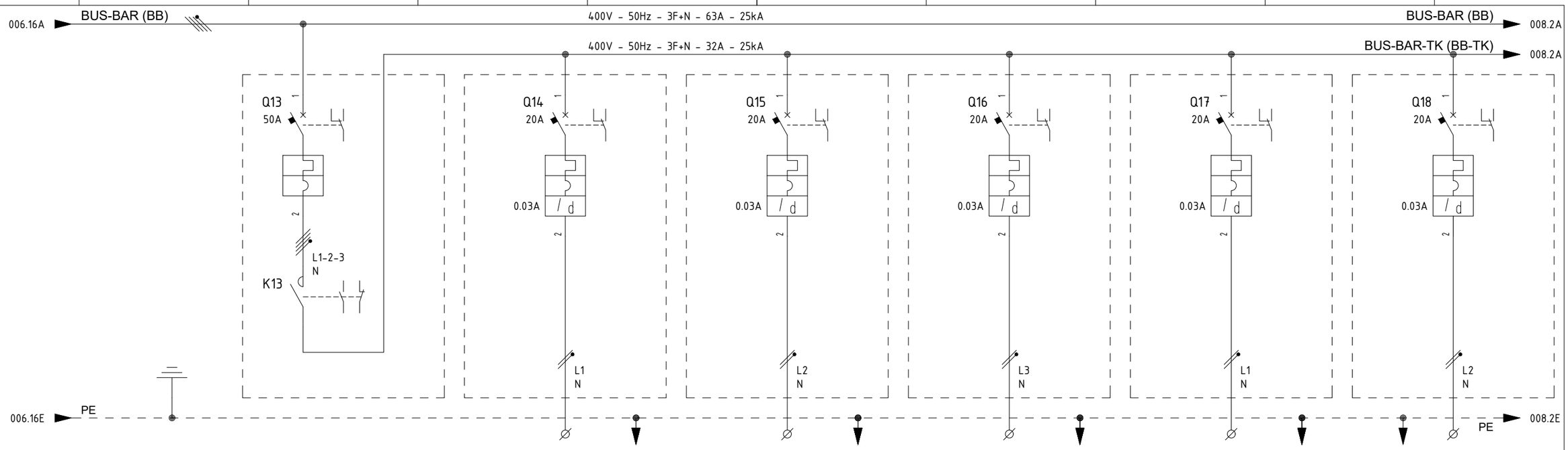
DRAWING NO. 1723002197-EL-DG-00013

SHEET 006

REV. 05

File Name : 1723002197-EL-DG-00013 Rev. 05

F.to UNI A3: 420mmx297mm




| ITEM | | | 1 | - | ETB-200N1-14-L1-01 | ETB-200N1-15-L2-01 | ETB-200N1-16-L3-01 | ETB-200N1-17-L1-01 | ETB-200N1-18-L2-01 |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | TRACE HEATING MAIN C.B. | TRACE HEATING - PROCESS LINES - FEEDER 1 (SWS LINES) | TRACE HEATING - PROCESS LINES - FEEDER 2 (CI LINES) | TRACE HEATING - PROCESS LINES - FEEDER 3 (DM LINE) | TRACE HEATING - PROCESS LINES - FEEDER 4 (WW LINES) | TRACE HEATING - PROCESS LINES - FEEDER 5 (VASSEL KO DRUM) |
| CUBICLE | | | 3 | +02 | +02 | +02 | +02 | +03 | +03 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 34.6 KW \| 50 A | 3.5 KW \| 15.22 A | 3.5 KW \| 15.22 A | 3.5 KW \| 15.22 A | 3.5 KW \| 15.22 A | 3.5 KW \| 15.22 A |
| TYPICAL FUNCTIONAL | | | 6 | - | - | - | - | - | - |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | S804C-C50 | S302P-C20 + DDA202 AC-25/0.03 | S302P-C20 + DDA202 AC-25/0.03 | S302P-C20 + DDA202 AC-25/0.03 | S302P-C20 + DDA202 AC-25/0.03 | S302P-C20 + DDA202 AC-25/0.03 |
| | VERSION | | 8 | 4P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE |
| | TRIP UNITS | | 9 | In=50A - curve C | In=20A - Curve C / Id=0.03A Class AC | In=20A - Curve C / Id=0.03A Class AC | In=20A - Curve C / Id=0.03A Class AC | In=20A - Curve C / Id=0.03A Class AC | In=20A - Curve C / Id=0.03A Class AC |
| | Icu | KA | 10 | 25kA | 25kA | 25kA | 25kA | 25kA | 25kA |
| OVERLOAD | L | Range A | 11 | - | - | - | - | - | - |
| | | Range t | 12 | - | - | - | - | - | - |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | - | - | - | - | - | - |
| | | Range t | 14 | - | - | - | - | - | - |
| INST. SHORT-CIRCUIT | I | Range A | 15 | - | - | - | - | - | - |
| | | Range t | 16 | - | - | - | - | - | - |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | - | - | - | - | - |
| | | Range t | 18 | - | - | - | - | - | - |
| CONTACTOR (ABB) | | | 19 | ESB63-40N-06; 4x63A AC1; Vaux=230Vdc/ac | - | - | - | - | - |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | - | - |
| SURGE ARRESTERS (DHENN) | | | 21 | - | - | - | - | - | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | - | - |
| FUSE HOLDER (ABB) | | | 23 | - | - | - | - | - | - |
| TWILIGHT SWITCH (FINDER) | | | 24 | - | - | - | - | - | - |
| VOLTMETER (FRER) | | | 25 | - | - | - | - | - | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | - | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | - | - |
| POWER TERM. BLOCK (CABUR) | | Type/mm² | 30 | - | SCREW / 6 | SCREW / 6 | SCREW / 6 | SCREW / 6 | SCREW / 6 |
| POWER CONDUCTOR | | mm² | 31 | - | 3G6 | 3G6 | 3G6 | 3G6 | 3G6 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 5 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twilight Switch TW1 |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 2 | 24/04/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 15/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/13

Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

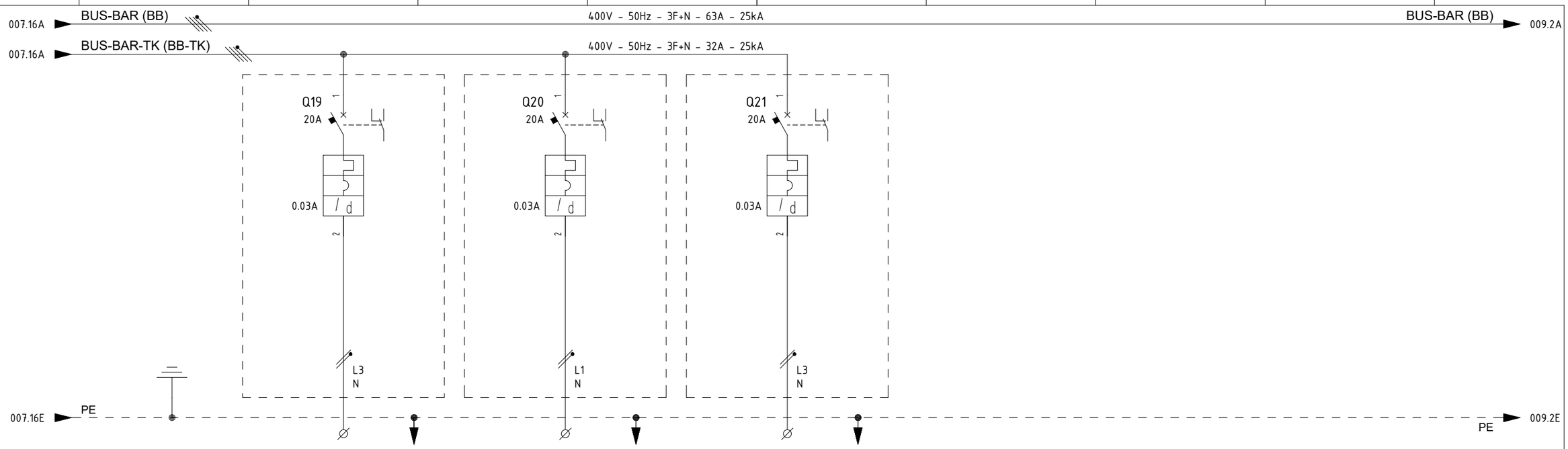
DRAWING NO. 1723002197-EL-DG-00013

SHEET 007

REV. 05

File Name : 1723002197-EL-DG-00013 Rev. 05

F.to UNI A3: 420mmx297mm




| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ITEM | | | 1 | ETB-200N1-19-L3-01 | | ETB-200N1-20-L1-01 | | - | | | | | | | | | | | |
| UTILITY | | | 2 | TRACE HEATING - PROCESS LINES - FEEDER 6 (H2 VENT) | | TRACE HEATING - PROCESS LINES - FEEDER 7 (SEA WATER PUMPS) | | TRACE HEATING - SPARE | | | | | | | | | | | |
| CUBICLE | | | 3 | +03 | | +03 | | +03 | | | | | | | | | | | |
| RATED POWER \| RATED CURRENT | | | 4/5 | 2.5 KW | 10.87 A | 2.5 KW | 10.87 A | 3.5 KW | 15.22 A | | | | | | | | | | |
| TYPICAL FUNCTIONAL | | | 6 | - | | - | | - | | | | | | | | | | | |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | S302P-C20 + DDA202 AC-25/0.03 | | S302P-C20 + DDA202 AC-25/0.03 | | S302P-C20 + DDA202 AC-25/0.03 | | | | | | | | | | | |
| | VERSION | | 8 | 2P / MINIATURE | | 2P / MINIATURE | | 2P / MINIATURE | | | | | | | | | | | |
| | TRIP UNITS | | 9 | In=20A - Curve C / Id=0.03A Class AC | | In=20A - Curve C / Id=0.03A Class AC | | In=20A - Curve C / Id=0.03A Class AC | | | | | | | | | | | |
| | Icu | KA | 10 | 25kA | | 25kA | | 25kA | | | | | | | | | | | |
| OVERLOAD | L | Range A | 11 | - | | - | | - | | | | | | | | | | | |
| | | Range t | 12 | - | | - | | - | | | | | | | | | | | |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | - | | - | | - | | | | | | | | | | | |
| | | Range t | 14 | - | | - | | - | | | | | | | | | | | |
| INST. SHORT-CIRCUIT | I | Range A | 15 | - | | - | | - | | | | | | | | | | | |
| | | Range t | 16 | - | | - | | - | | | | | | | | | | | |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | | - | | - | | | | | | | | | | | |
| | | Range t | 18 | - | | - | | - | | | | | | | | | | | |
| CONTACTOR (ABB) | | | 19 | - | | - | | - | | | | | | | | | | | |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | | - | | - | | | | | | | | | | | |
| SURGE ARRESTERS (DHENN) | | | 21 | - | | - | | - | | | | | | | | | | | |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | | - | | - | | | | | | | | | | | |
| FUSE HOLDER (ABB) | | | 23 | - | | - | | - | | | | | | | | | | | |
| TWILIGHT SWITCH (FINDER) | | | 24 | - | | - | | - | | | | | | | | | | | |
| VOLTMETER (FRER) | | | 25 | - | | - | | - | | | | | | | | | | | |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | | - | | - | | | | | | | | | | | |
| | PERFORMANCE/CLASS | | 27 | - | | - | | - | | | | | | | | | | | |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | | - | | - | | | | | | | | | | | |
| | PERFORMANCE/CLASS | | 29 | - | | - | | - | | | | | | | | | | | |
| POWER TERM. BLOCK (CABUR) | | Type/mm² | 30 | SCREW / 6 | | SCREW / 6 | | SCREW / 6 | | | | | | | | | | | |
| POWER CONDUCTOR | | mm² | 31 | 3G6 | | 3G6 | | - | | | | | | | | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 5 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twilight Switch TW1 |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 2 | 24/04/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 15/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/13

Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

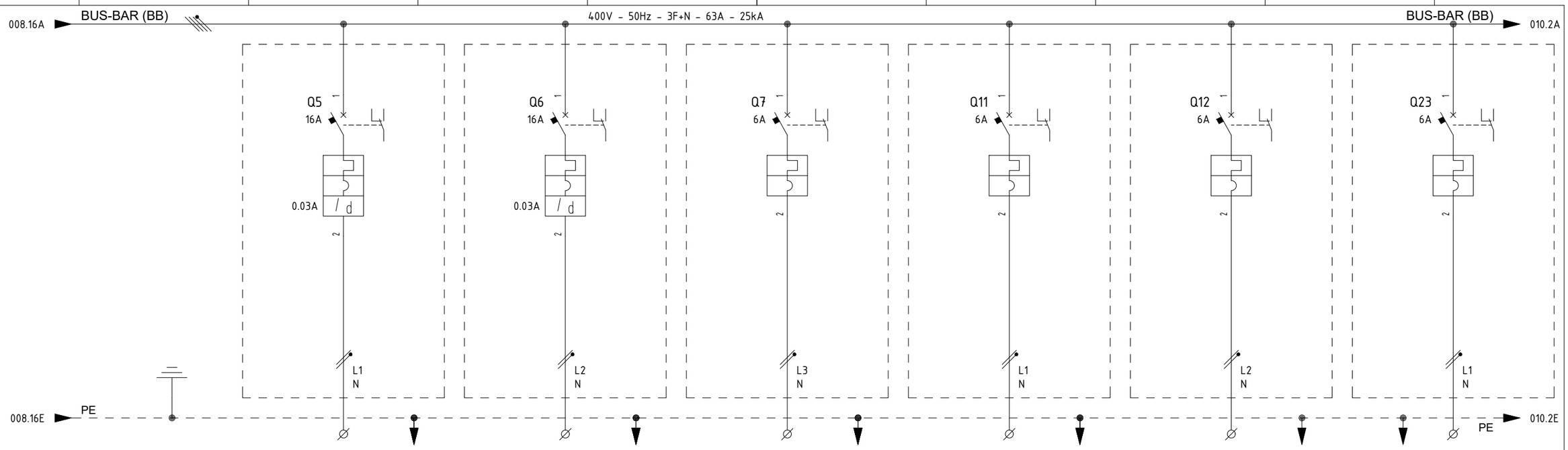
DRAWING NO. 1723002197-EL-DG-00013

SHEET 008

REV. 05

File Name : 1723002197-EL-DG-00013 Rev. 05

F.to UNI A3: 420mmx297mm




| ITEM | | | 1 | ESO-200N1-05-L1-01 | ESO-200N1-06-L2-01 | - | ESH-200N1-11-L1-01 | ESH-200N1-12-L2-01 | B400-SIS-001 |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | SMALL POWER SOCKET (UPPER DECK) | SMALL POWER SOCKET (LOWER DECK) | SPARE | SPACE HEATERS JB - WIND FARM SUBSEA CABLE | SPACE HEATERS JB - SOLAR SUBSEA CABLE | SIS-CONTROLLER AND I/O CABINET - AUXILIARY |
| CUBICLE | | | 3 | +03 | +03 | +03 | +03 | +03 | +03 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 3 KW \| 14.49 A | 3 KW \| 14.49 A | 0.726 KW \| 3.95 A | 0.25 KW \| 1.14 A | 0.25 KW \| 1.14 A | 0.5 KW \| 2.72 A |
| TYPICAL FUNCTIONAL | | | 6 | - | - | - | - | - | - |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | S302P-C16 + DDA202 AC-25/0.03 | S302P-C16 + DDA202 AC-25/0.03 | S302P-C6 | S302P-C6 | S302P-C6 | S302P-C6 |
| | VERSION | | 8 | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE |
| | TRIP UNITS | | 9 | In=16A - Curve C / Id=0.03A Class AC | In=16A - Curve C / Id=0.03A Class AC | In=6A - Curve C | In=6A - Curve C | In=6A - Curve C | In=6A - Curve C |
| | Icu | KA | 10 | 25kA | 25kA | 25kA | 25kA | 25kA | 25kA |
| OVERLOAD | L | Range A | 11 | - | - | - | - | - | - |
| | | Range t | 12 | - | - | - | - | - | - |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | - | - | - | - | - | - |
| | | Range t | 14 | - | - | - | - | - | - |
| INST. SHORT-CIRCUIT | I | Range A | 15 | - | - | - | - | - | - |
| | | Range t | 16 | - | - | - | - | - | - |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | - | - | - | - | - |
| | | Range t | 18 | - | - | - | - | - | - |
| CONTACTOR (ABB) | | | 19 | - | - | - | - | - | - |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | - | - |
| SURGE ARRESTERS (DHENN) | | | 21 | - | - | - | - | - | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | - | - |
| FUSE HOLDER (ABB) | | | 23 | - | - | - | - | - | - |
| TWILIGHT SWITCH (FINDER) | | | 24 | - | - | - | - | - | - |
| VOLTMETER (FRER) | | | 25 | - | - | - | - | - | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | - | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | - | - |
| POWER TERM. BLOCK (CABUR) | | Type/mm² | 30 | SCREW / 10 | SCREW / 10 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 4 |
| POWER CONDUCTOR | | mm² | 31 | 3G10 | 3G10 | 3G2.5 | 3G2.5 | 3G2.5 | 3G2.5 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 5 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twilight Switch TW1 |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 2 | 24/04/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 15/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/13

Item n° : PF1002888/101

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

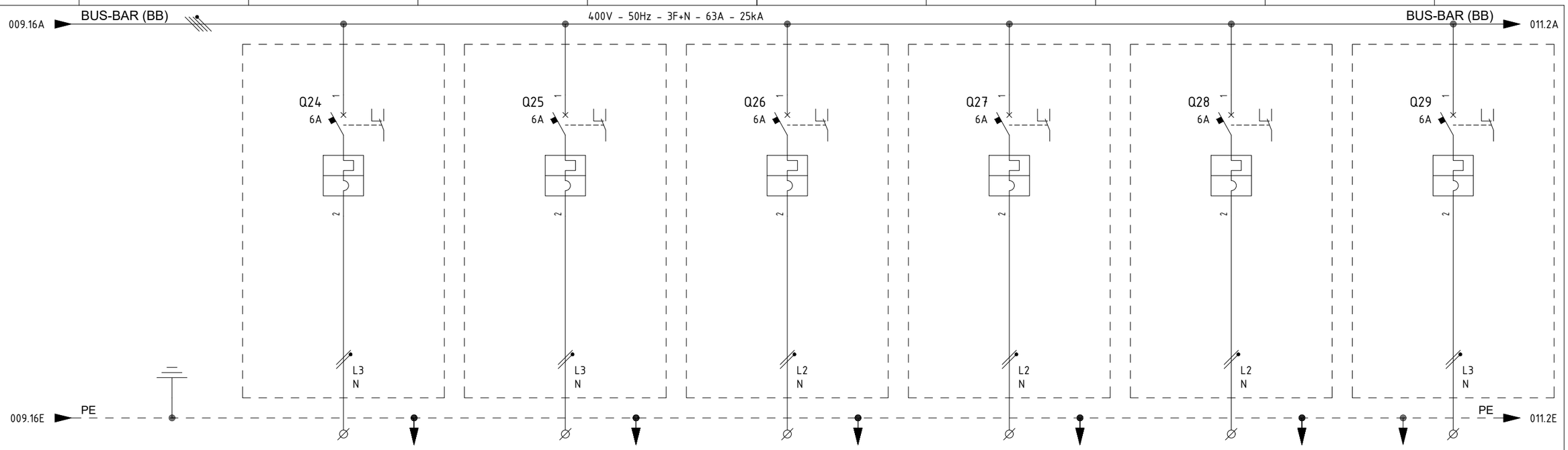
DRAWING NO. 1723002197-EL-DG-00013

SHEET 009

REV. 05

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00013 Rev. 05




| ITEM | | | 1 | B400-PCS-001 | B400-EMCS-001 | B400-FGS-001 | B400-NET-001 | B400-SRV-001 | CP-630E1 |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | PCS-CONTROLLER AND I/O CABINET - AUXILIARY | EMCS-CONTROLLER AND I/O CABINET - AUXILIARY | FGS FIRE & GAS PANEL - AUXILIARY | SYSTEM SERVER / NETWORK CABINET - AUXILIARY | SERVER CABINET ITER - AUXILIARY | UCP - INSTRUMENT AIR PACKAGE -A-63000 - AUXILIARY |
| CUBICLE | | | 3 | +03 | +03 | +03 | +03 | +03 | +03 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 0.5 KW \| 2.72 A | 0.5 KW \| 2.72 A | 0.8 KW \| 4.35 A | 0.5 KW \| 2.72 A | 0.5 KW \| 2.72 A | 0.5 KW \| 2.72 A |
| TYPICAL FUNCTIONAL | | | 6 | - | - | - | - | - | - |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | S302P-C6 | S302P-C6 | S302P-C6 | S302P-C6 | S302P-C6 | S302P-C6 |
| | VERSION | | 8 | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE |
| | TRIP UNITS | | 9 | In=6A - Curve C | In=6A - Curve C | In=6A - Curve C | In=6A - Curve C | In=6A - Curve C | In=6A - Curve C |
| | Icu | KA | 10 | 25kA | 25kA | 25kA | 25kA | 25kA | 25kA |
| OVERLOAD | L | Range A | 11 | - | - | - | - | - | - |
| | | Range t | 12 | - | - | - | - | - | - |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | - | - | - | - | - | - |
| | | Range t | 14 | - | - | - | - | - | - |
| INST. SHORT-CIRCUIT | I | Range A | 15 | - | - | - | - | - | - |
| | | Range t | 16 | - | - | - | - | - | - |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | - | - | - | - | - |
| | | Range t | 18 | - | - | - | - | - | - |
| CONTACTOR (ABB) | | | 19 | - | - | - | - | - | - |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | - | - |
| SURGE ARRESTERS (DHENN) | | | 21 | - | - | - | - | - | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | - | - |
| FUSE HOLDER (ABB) | | | 23 | - | - | - | - | - | - |
| TWILIGHT SWITCH (FINDER) | | | 24 | - | - | - | - | - | - |
| VOLTMETER (FRER) | | | 25 | - | - | - | - | - | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | - | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | - | - |
| POWER TERM. BLOCK (CABUR) | | Type/mm² | 30 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 4 |
| POWER CONDUCTOR | | mm² | 31 | 3G2.5 | 3G2.5 | 3G2.5 | 3G2.5 | 3G2.5 | 3G2.5 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 5 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twilight Switch TW1 |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 2 | 24/04/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 15/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/13

Item n° : PF1002888/101

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

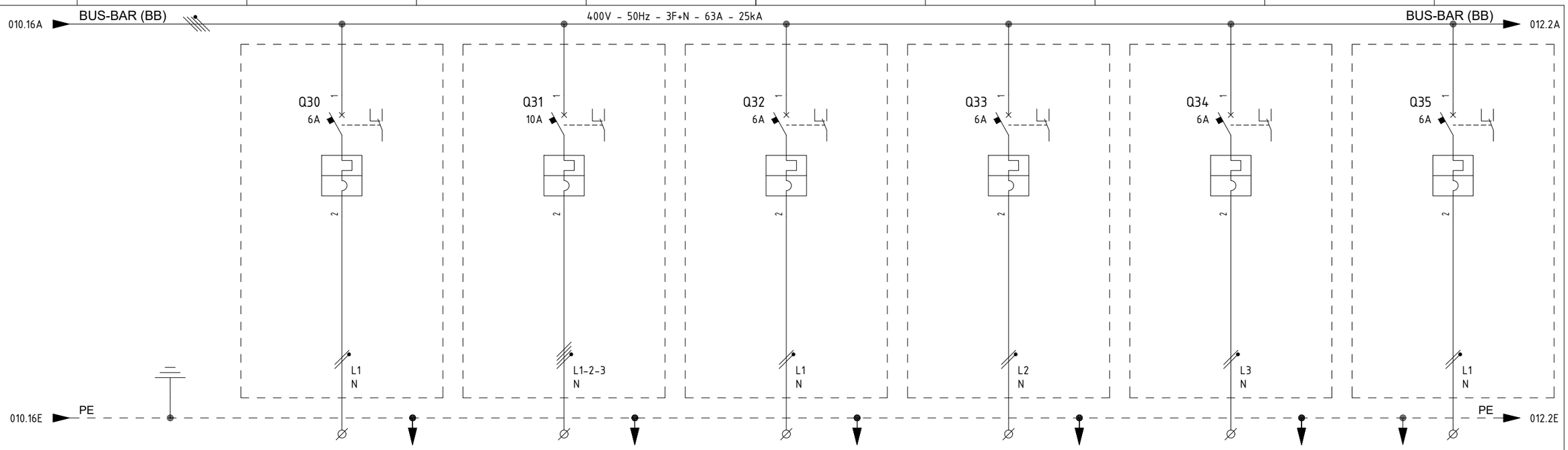
DRAWING NO. 1723002197-EL-DG-00013

SHEET 010

REV. 05

File Name : 1723002197-EL-DG-00013 Rev. 05

F.to UNI A3: 420mmx297mm




| ITEM | | | 1 | CP-640F1 | CP-100E2 | CP-100E3 | CP-100E4 | RR-100D1 | CP-200E1 |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | UCP - N2 PACKAGE - AUXILIARY | AUXILIARY TRAFO OLTC | AUXILIARY TRAFO AVR | AUXILIARY TRAFO 7MVA | AUXILIARY NER | AUXILIARY TRAFO 1.6MVA |
| CUBICLE | | | 3 | +03 | +03 | +03 | +03 | +03 | +03 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 0.5 KW \| 2.72 A | 1 KW \| 1.81 A | 0.3 KW \| 1.63 A | 0.5 KW \| 2.72 A | 0.3 KW \| 1.63 A | 0.5 KW \| 2.72 A |
| TYPICAL FUNCTIONAL | | | 6 | - | - | - | - | - | - |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | S302P-C6 | S304P-C10 | S302P-C6 | S302P-C6 | S302P-C6 | S302P-C6 |
| | VERSION | | 8 | 2P / MINIATURE | 4P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE |
| | TRIP UNITS | | 9 | In=6A - Curve C | In=10A - Curve C | In=6A - Curve C | In=6A - Curve C | In=6A - Curve C | In=6A - Curve C |
| | Icu | KA | 10 | 25kA | 25kA | 25kA | 25kA | 25kA | 25kA |
| OVERLOAD | L | Range A | 11 | - | - | - | - | - | - |
| | | Range t | 12 | - | - | - | - | - | - |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | - | - | - | - | - | - |
| | | Range t | 14 | - | - | - | - | - | - |
| INST. SHORT-CIRCUIT | I | Range A | 15 | - | - | - | - | - | - |
| | | Range t | 16 | - | - | - | - | - | - |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | - | - | - | - | - |
| | | Range t | 18 | - | - | - | - | - | - |
| CONTACTOR (ABB) | | | 19 | - | - | - | - | - | - |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | - | - |
| SURGE ARRESTERS (DHENN) | | | 21 | - | - | - | - | - | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | - | - |
| FUSE HOLDER (ABB) | | | 23 | - | - | - | - | - | - |
| TWILIGHT SWITCH (FINDER) | | | 24 | - | - | - | - | - | - |
| VOLTMETER (FRER) | | | 25 | - | - | - | - | - | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | - | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | - | - |
| POWER TERM. BLOCK (CABUR) | | Type/mm² | 30 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 4 |
| POWER CONDUCTOR | | mm² | 31 | 3G2.5 | 5G4 | 3G2.5 | 3G2.5 | 3G2.5 | 3G2.5 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 5 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twilight Switch TW1 |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 2 | 24/04/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 15/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/13

Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

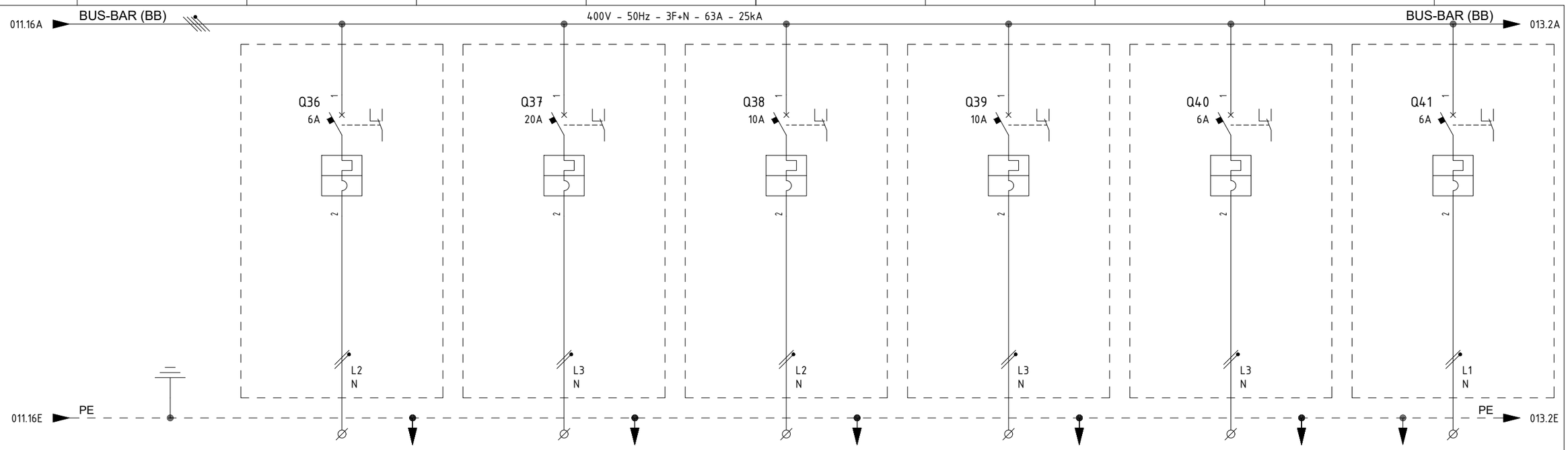
DRAWING NO. 1723002197-EL-DG-00013

SHEET 011

REV. 05

File Name : 1723002197-EL-DG-00013 Rev. 05

F.to UNI A3: 420mmx297mm




| ITEM | | | 1 | CP-200E2 | CP-100E1 | SG-100D1 | SG-200N1 | SG-200D2 | UP-200F3 |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | AUXILIARY TRAFO SOLARE 0.5MVA | AUXILIARY GIS | AUXILIARY 6.6KV SWITCHBOARD | AUXILIARY LV SWITCHBOARD | AUXILIARY LV SWITCHBOARD 800/460V | AC UPS PAS AUXILIARY |
| CUBICLE | | | 3 | +03 | +03 | +03 | +03 | +03 | +03 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 0.5 KW \| 2.72 A | 3 KW \| 16.3 A | 1 KW \| 5.43 A | 1 KW \| 5.43 A | 0.5 KW \| 2.72 A | 0.2 KW \| 0.82 A |
| TYPICAL FUNCTIONAL | | | 6 | - | - | - | - | - | - |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | S302P-C6 | S302P-C20 | S302P-C10 | S302P-C10 | S302P-C6 | S302P-C6 |
| | VERSION | | 8 | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE |
| | TRIP UNITS | | 9 | In=6A - Curve C | In=20A - Curve C | In=10A - Curve C | In=10A - Curve C | In=6A - Curve C | In=6A - Curve C |
| | Icu | KA | 10 | 25kA | 25kA | 25kA | 25kA | 25kA | 25kA |
| OVERLOAD | L | Range A | 11 | - | - | - | - | - | - |
| | | Range t | 12 | - | - | - | - | - | - |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | - | - | - | - | - | - |
| | | Range t | 14 | - | - | - | - | - | - |
| INST. SHORT-CIRCUIT | I | Range A | 15 | - | - | - | - | - | - |
| | | Range t | 16 | - | - | - | - | - | - |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | - | - | - | - | - |
| | | Range t | 18 | - | - | - | - | - | - |
| CONTACTOR (ABB) | | | 19 | - | - | - | - | - | - |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | - | - |
| SURGE ARRESTERS (DHENN) | | | 21 | - | - | - | - | - | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | - | - |
| FUSE HOLDER (ABB) | | | 23 | - | - | - | - | - | - |
| TWILIGHT SWITCH (FINDER) | | | 24 | - | - | - | - | - | - |
| VOLTMETER (FRER) | | | 25 | - | - | - | - | - | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | - | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | - | - |
| POWER TERM. BLOCK (CABUR) | | Type/mm² | 30 | SCREW / 4 | SCREW / 6 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 4 |
| POWER CONDUCTOR | | mm² | 31 | 3G2.5 | 3G6 | 3G2.5 | 3G2.5 | 3G2.5 | 3G2.5 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 5 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twilight Switch TW1 |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 2 | 24/04/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 15/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/13

Item n° : PF1002888/101

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

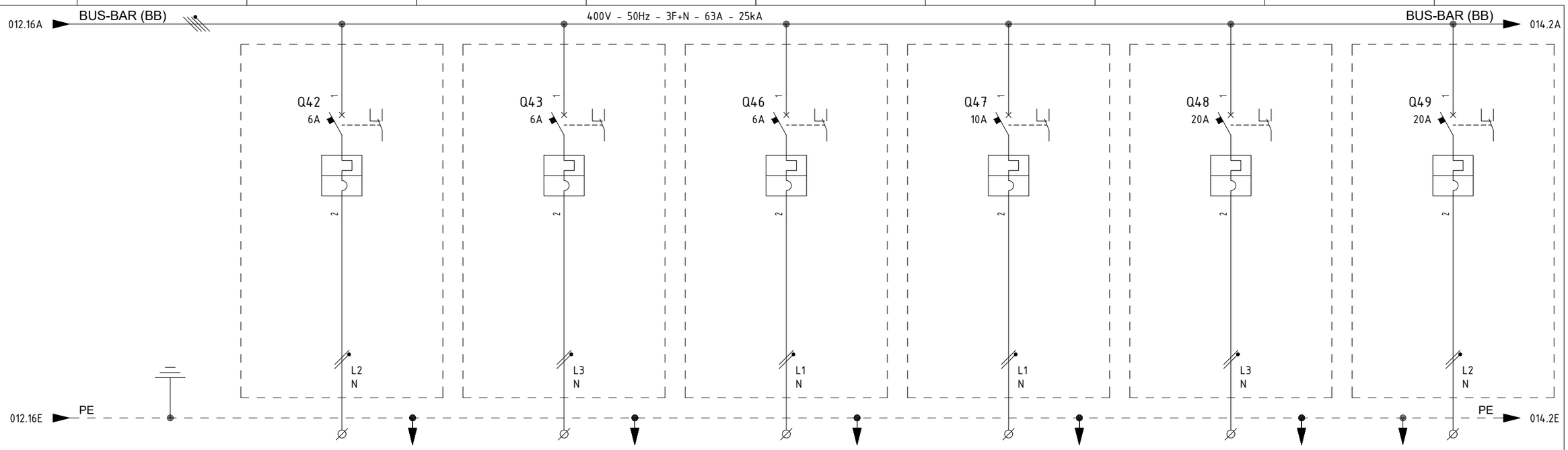
DRAWING NO. 1723002197-EL-DG-00013

SHEET 012

REV. 05

File Name : 1723002197-EL-DG-00013 Rev. 05

F.to UNI A3: 420mmx297mm




| ITEM | | | 1 | UP-200F4 | UP-200F1 | - | - | - | - |
|---|---|---|---|---|---|---|---|---|---|
| UTILITY | | | 2 | AC UPS F&G AUXILIARY | DC BATTERY SYSTEM AUXILIARY | INS CABINET - SPARE AUXILIARY | SPARE | SPARE | SPARE |
| CUBICLE | | | 3 | +03 | +03 | +03 | +03 | +03 | +03 |
| RATED POWER \| RATED CURRENT | | | 4/5 | 0.2 KW \| 0.82 A | 0.2 KW \| 0.82 A | 0.5 KW \| 2.72 A | 1 KW \| 5.43 A | 3 KW \| 16.3 A | 3 KW \| 16.3 A |
| TYPICAL FUNCTIONAL | | | 6 | - | - | - | - | - | - |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | S302P-C6 | S302P-C6 | S302P-C6 | S302P-C10 | S302P-C20 | S302P-C20 |
| | VERSION | | 8 | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE | 2P / MINIATURE |
| | TRIP UNITS | | 9 | In=6A - Curve C | In=6A - Curve C | In=6A - Curve C | In=10A - Curve C | In=20A - Curve C | In=20A - Curve C |
| | Icu | KA | 10 | 25kA | 25kA | 25kA | 25kA | 25kA | 25kA |
| OVERLOAD | L | Range A | 11 | - | - | - | - | - | - |
| | | Range t | 12 | - | - | - | - | - | - |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | - | - | - | - | - | - |
| | | Range t | 14 | - | - | - | - | - | - |
| INST. SHORT-CIRCUIT | I | Range A | 15 | - | - | - | - | - | - |
| | | Range t | 16 | - | - | - | - | - | - |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | - | - | - | - | - |
| | | Range t | 18 | - | - | - | - | - | - |
| CONTACTOR (ABB) | | | 19 | - | - | - | - | - | - |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | - | - | - | - | - |
| SURGE ARRESTERS (DHENN) | | | 21 | - | - | - | - | - | - |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | - | - | - | - | - |
| FUSE HOLDER (ABB) | | | 23 | - | - | - | - | - | - |
| TWILIGHT SWITCH (FINDER) | | | 24 | - | - | - | - | - | - |
| VOLTMETER (FRER) | | | 25 | - | - | - | - | - | - |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 27 | - | - | - | - | - | - |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | - | - | - | - | - |
| | PERFORMANCE/CLASS | | 29 | - | - | - | - | - | - |
| POWER TERM. BLOCK (CABUR) | | Type/mm² | 30 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 4 | SCREW / 6 | SCREW / 6 |
| POWER CONDUCTOR | | mm² | 31 | 3G2.5 | 3G2.5 | 3G2.5 | - | - | - |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 5 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twilight Switch TW1 |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/13

Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

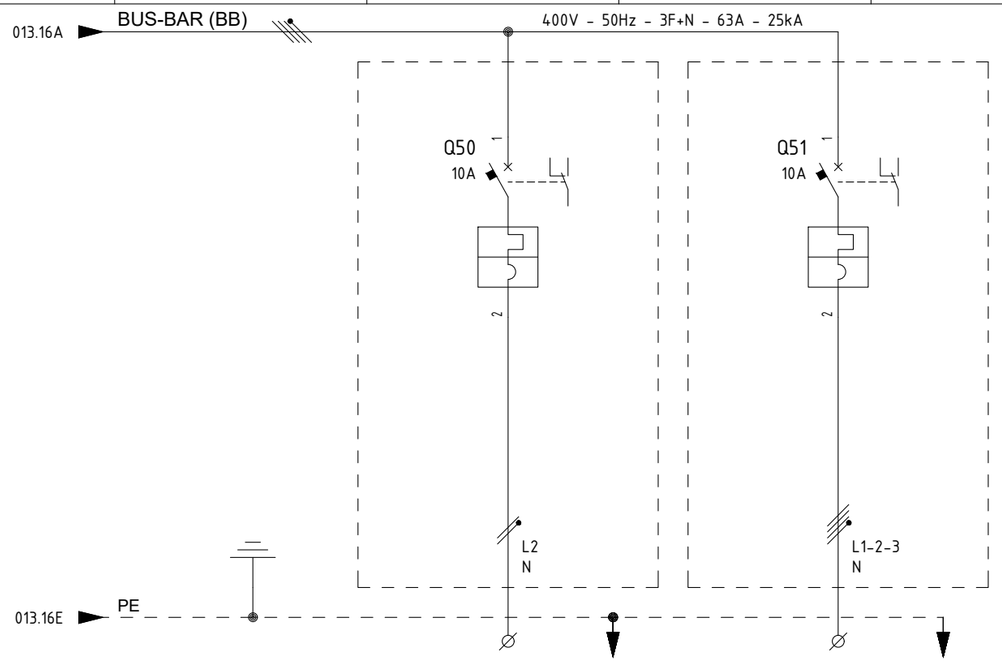
DRAWING NO. 1723002197-EL-DG-00013

SHEET 013

REV. 05

File Name : 1723002197-EL-DG-00013 Rev. 05

F.to UNI A3: 420mmx297mm




| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ITEM | | | 1 | - | | - | | | | | | | | | | | | | |
| UTILITY | | | 2 | SPARE | | SPARE | | | | | | | | | | | | | |
| CUBICLE | | | 3 | +03 | | +03 | | | | | | | | | | | | | |
| RATED POWER | RATED CURRENT | | 4/5 | 1 KW | 5.43 A | 3 KW | 5.42 A | | | | | | | | | | | | |
| TYPICAL FUNCTIONAL | | | 6 | - | | - | | | | | | | | | | | | | |
| CIRCUIT BREAKER (ABB) | TYPE | | 7 | S302P-C10 | | S304P-C10 | | | | | | | | | | | | | |
| | VERSION | | 8 | 2P / MINIATURE | | 4P / MINIATURE | | | | | | | | | | | | | |
| | TRIP UNITS | | 9 | In=10A - Curve C | | In=10A - Curve C | | | | | | | | | | | | | |
| | Icu | KA | 10 | 25kA | | 25kA | | | | | | | | | | | | | |
| OVERLOAD | L | Range A | 11 | - | | - | | | | | | | | | | | | | |
| | | Range t | 12 | - | | - | | | | | | | | | | | | | |
| SEL. SHORT-CIRCUIT | S | Range A | 13 | - | | - | | | | | | | | | | | | | |
| | | Range t | 14 | - | | - | | | | | | | | | | | | | |
| INST. SHORT-CIRCUIT | I | Range A | 15 | - | | - | | | | | | | | | | | | | |
| | | Range t | 16 | - | | - | | | | | | | | | | | | | |
| EARTH FAULT PROTECTION | G | Range A | 17 | - | | - | | | | | | | | | | | | | |
| | | Range t | 18 | - | | - | | | | | | | | | | | | | |
| CONTACTOR (ABB) | | | 19 | - | | - | | | | | | | | | | | | | |
| THERMAL OVERLOAD RELAY (ABB) | | | 20 | - | | - | | | | | | | | | | | | | |
| SURGE ARRESTERS (DHENN) | | | 21 | - | | - | | | | | | | | | | | | | |
| TOROIDAL CURRENT TRANSFORMER (FRER) | | | 22 | - | | - | | | | | | | | | | | | | |
| FUSE HOLDER (ABB) | | | 23 | - | | - | | | | | | | | | | | | | |
| TWILIGHT SWITCH (FINDER) | | | 24 | - | | - | | | | | | | | | | | | | |
| VOLTMETER (FRER) | | | 25 | - | | - | | | | | | | | | | | | | |
| CURRENT TRANSFORMER FOR MEASURE (FRER) | TYPE | | 26 | - | | - | | | | | | | | | | | | | |
| | PERFORMANCE/CLASS | | 27 | - | | - | | | | | | | | | | | | | |
| VOLTAGE TRANSFORMER FOR MEASURE (FRER) | TYPE | | 28 | - | | - | | | | | | | | | | | | | |
| | PERFORMANCE/CLASS | | 29 | - | | - | | | | | | | | | | | | | |
| POWER TERM. BLOCK (CABUR) | | Type/mm² | 30 | SCREW / 4 | | SCREW / 4 | | | | | | | | | | | | | |
| POWER CONDUCTOR | | mm² | 31 | - | | - | | | | | | | | | | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 5 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twilight Switch TW1 |
| 4 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 3 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 2 | 24/04/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 1 | 15/03/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/13

Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"

SINGLE LINE DIAGRAM

Single Line Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00013

SHEET 014

REV. 05

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00013 Rev. 05

1.4. Functional Diagram

1.4.1.SG-100D1 HV SWG FUNCTIONAL DIAGRAM - INCOMING FEEDER (including Terminals and BOM) , Doc. No. 1723002197-EL-DG-00015

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# "SG-100D1" HV SWBD 6,6kV (UNIT A6)

# FUNCTIONAL DIAGRAM

# INCOMING FEEDER TR-100AD1

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macula | 12/09/2024 |

= + A6

DWG n° : 231151/SD/15

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-100D1 – FUNCTIONAL INCOMING FEEDER TR-100AD1

Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# INDEX

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
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| 1 | Cover | | | | | | | | | |
| 2 | Sheets Index | | | | | | | | | |
| 3 | Legend | | | | | | | | | |
| 4 | Door Layout | | | | | | | | | |
| 5 | Protection Display REX640 | | | | | | | | | |
| 6 | Selector Switch Diagram | | | | | | | | | |
| 7 | Power Diagram | | | | | | | | | |
| 8 | Power Diagram | | | | | | | | | |
| 9 | Power Diagram | | | | | | | | | |
| 10 | Power Diagram | | | | | | | | | |
| 11 | 110Vdc / 24Vdc Distribution Voltage | | | | | | | | | |
| 12 | Composition Relay REX640 | | | | | | | | | |
| 13 | 230Vac Distribution Voltage | | | | | | | | | |
| 14 | 110V Protection/Measure Distribution Voltage | | | | | | | | | |
| 15 | 110V Protection/Measure Distribution Voltage | | | | | | | | | |
| 16 | "REX640"' Protection Wiring | | | | | | | | | |
| 17 | "REX640"' Protection Wiring | | | | | | | | | |
| 18 | "REX640"' Protection Wiring | | | | | | | | | |
| 19 | Extherm Device | | | | | | | | | |
| 20 | Command Circuit | | | | | | | | | |
| 21 | Command Circuit | | | | | | | | | |
| 22 | Command Circuit | | | | | | | | | |
| 23 | Command Circuit | | | | | | | | | |
| 24 | "REX640" Protection Wiring - Digital Input | | | | | | | | | |
| 25 | "REX640" Protection Wiring - Digital Input | | | | | | | | | |
| 26 | "REX640" Protection Wiring - Digital Input | | | | | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| 27 | Availables Signals | | | | | | | | | |
| 28 | Available Signals | | | | | | | | | |
| 29 | Terminal strips | | | | | | | | | |
| 30 | Terminal strips | | | | | | | | | |
| 31 | Terminal strips | | | | | | | | | |
| 32 | Terminal strips | | | | | | | | | |
| 33 | Terminal strips | | | | | | | | | |
| 34 | Terminal strips | | | | | | | | | |
| 35 | Bill of Materials | | | | | | | | | |
| 36 | Bill of Materials | | | | | | | | | |
| 37 | Bill of Materials | | | | | | | | | |

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DWG n° : 231151/SD/15
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Sheets Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00015 | SHEET 2 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# ACRONIMUS LEGEND

| ITEM | DESCRIPTION |
|---|---|
| BB | ARC SENSOR PROTECTION ON MAIN BUS BARS |
| BGE | EARTHING SWITCH |
| C1 | VOLTAGE PRESENCE |
| CB | ARC SENSOR PROTECTION ON C.B. / CONTACTOR COMPARTMENT |
| CC | ARC SENSOR PROTECTION ON CABLE COMPARTMENT |
| DCO | DOUBLE COMMAND OPERATED CONTACTOR |
| DI3 | UNDERVOLTAGE CONTACTOR |
| DP1 | ALARM RELAY MODULE TEMPERATURE |
| E1 | INTERNAL LIGHT |
| E8 | RESISTOR FERRO-RESONANCE |
| EH1 | INTERNAL SPACE HEATER |
| Fn | MV FUSE |
| FP1 | PROTECTION RELAY |
| GS1 | DC/DC CONVERTER |
| HGR | THERMOSTAT |
| Kn | AUXILIARY RELAY |
| K1 | MV CONTACTOR |
| K86 | BLOCK RELAY |
| KT1 | DE-ENERGIZATION TIMER |
| LS | MICRO SWITCH ON AUXILIARY DOOR |
| MAS | MOTOR SPRING CHARGER |
| MBC | CLOSING COIL |
| MBO1 | OPENING COIL |
| MBU | UNDERVOLTAGE |
| ODn | VOLTAGE DISCHARGER |
| PU1 | MEASURING VOLTAGE INSTRUMENT |

| ITEM | DESCRIPTION |
|---|---|
| PTT | V.T. TRUCK |
| QM | MV CIRCUIT-BREAKER |
| QDn | M.C.B. CIRCUITS PROTECTION |
| QVn | M.C.B FOR V.T. PROTECTION |
| RLE1 | COIL FOR CONSET CLOSING CIRCUIT-BREAKER |
| RLE2 | COIL FOR UNLOCKING RACK-IN/OUT OPERATION |
| RLE3 | COIL FOR UNLOCKING OPERATION EARTHING |
| RLE4 | COIL FOR UNLOCKING ENCLOSURE DOOR OPERATION |
| SU1 | VOLTAGE SELECTOR |
| SWH... | ETHERNET SWITCH |
| TI-Ln | CURRENT TRANSFORMER |
| TO | OMOPOLAR RING CURRENT TRANSFORMER |
| TR1 | TEMPERATURE CONTROL DEVICE |

FUNCTIONAL OF THE PROTECTION RELAY OUTPUT CONTACTS:

SLOT "G":
RF = WATCHDOG RELAY
S01 = EARTHING SWITCH UNLOCKING
S02 = C.B. or CONTACTOR READY TO CLOSE
SS01 = BREAKER FAILURE
POSP1 = CLOSING COMMAND
S03 = C.B. or CONTACTOR TRUCK UNLOCKED
PODP1 = OPENING COMMAND
SLOT "B"
S01 = TRIP PROTECTION TO LOCKOUT RELAY
S02 = EARTHING SWITCH CLOSED
S04 = RESET LOKOUT RELAY
SLOT "D":
SP01 = TRIP ARC DETECTOR ON OPENING COMMAND
SP02 = TRIP ARC DETECTOR TO 66kV SWICHB.
SP03 = TRIP ARC DETECTOR ON LOCKOUT RELAY

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DWG n° : 231151/SD/15
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Legend

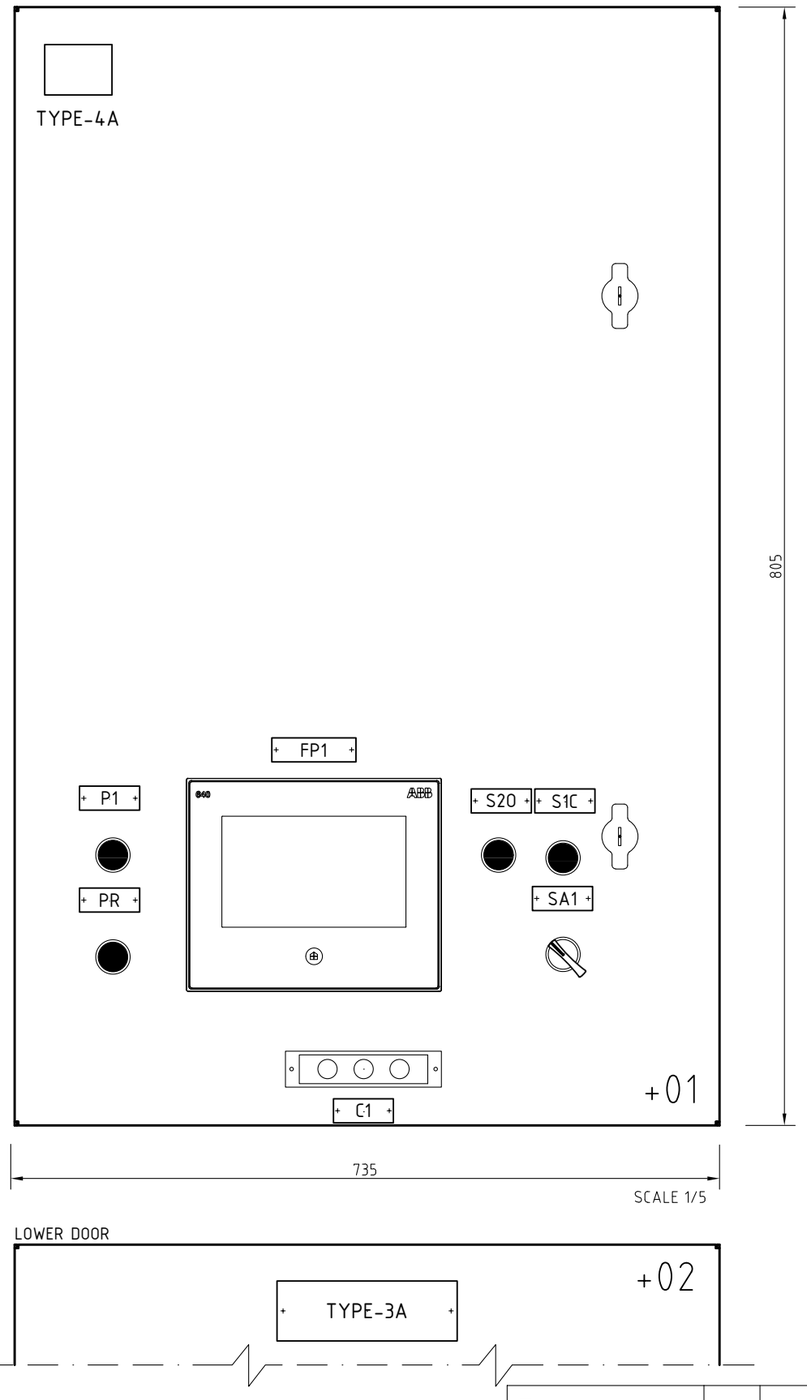
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00015 | SHEET 3 | REV. 03

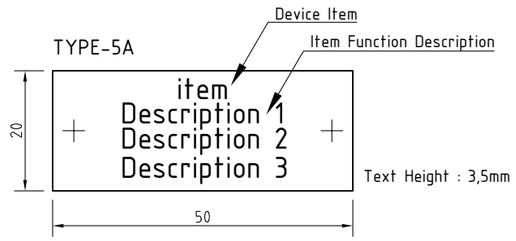
F.to UNI A3: 420mmx297mm

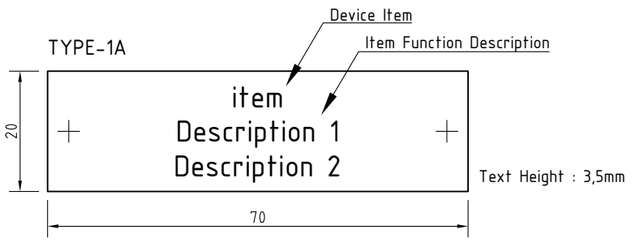
File Name : 1723002197-EL-DG-00015 Rev.03

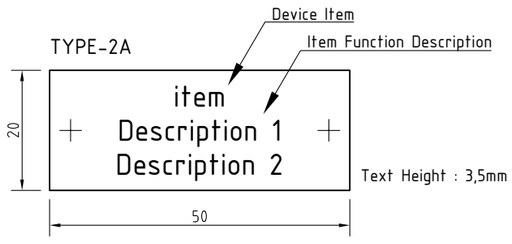
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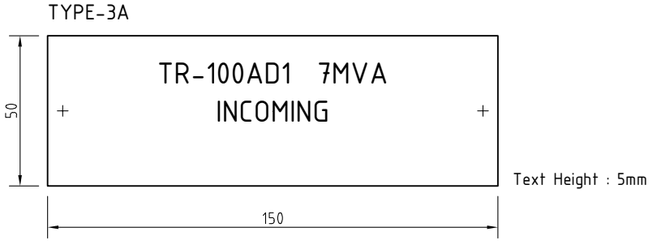


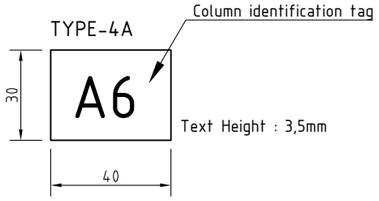

| DEVICES name plate | | | | | |
|---|---|---|---|---|---|
| ITEM | COMPONENT | DESCRIPTION 1 | DESCRIPTION 2 | DESCRIPTION 3 | NOTE |
| FP1 | PROTECTION RELAY | PROTECTION RELAY | | | TYPE-1A |
| S2.O | PUSH BUTTON | OPEN | COMMAND | C.B. | TYPE-5A |
| S1.C | PUSH BUTTON | CLOSE | COMMAND | C.B. | TYPE-5A |
| SA1 | SELECTOR SWITCH | LOCAL / REMOTE | | | TYPE-2A |
| PR | LIGHT PUSH BUTTON | RESET | LOCK-OUT | TRIP LOCK-OUT | TYPE-5A |
| C1 | PILOT LIGHT | VOLTAGE | PRESENCE | | TYPE-2A |
| P1 | PUSH BUTTON | TRUCK-DOOR | EARTHING | ENABLING | TYPE-5A |




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/15
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Door Layout

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

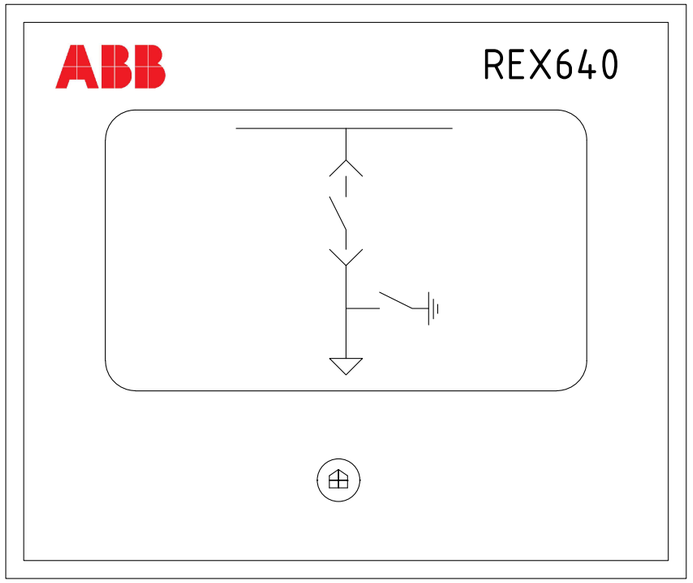
SHEET 4

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# PROTECTION DISPLAY




## LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE C.B." AND "OPEN C.B." NOT ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED

| LEDs PAGE 1 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/27-2/59-1/59-2 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | CONTACTOR READY (TCS) | - | GREEN | OK = TCS OK (CONTACTOR READY) |
| LED-3 | SYNCHRO CHECK | | GREEN | OK = SYNCHRONISM |
| LED-4 | CONTACTOR READY TO CLOSE | - | GREEN | OK = CONTACTOR READY TO CLOSE |
| LED-5 | 50-1/51-1/67-1/67-2 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/59N-1/59N-2 - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = CONTACTOR TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | EMERGENCY OPENING BY SIS (ESD) | RED | - | ALARM = ESD TRIPPED |

| LEDs PAGE 2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | - | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | | | | |
| LED-15 | | | | |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n°: 231151/SD/15

Item n°: PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

Protection Display REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

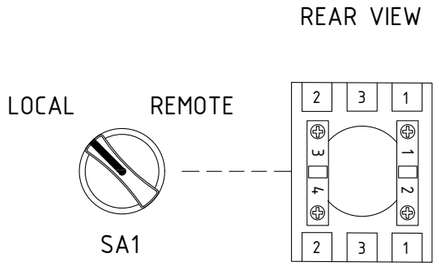
SHEET 5

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# SELECTORS SWITCH DIAGRAM




## NOTES

THE DIAGRAM INDICATES THE FOLLOWING CONDITIONS:
-INSERTED CIRCUIT BREAKER IN OPEN POSITION
-DE-ENERGIZED CIRCUITS
-DSCHARGED CLOSING SPRINGS
-EARTHING SWITCH OPEN

THE AUXILIARY CIRCUITS WILL HAVE THE FOLLOWING CHARACTERISTICS:
-110+ / 24+ 1,5mmq RED TYPE CABLE SH-W
-110- / 24- 1,5mmq WHITE TYPE CABLE SH-W
-AUXILIARY CONTACTS TO TERMINAL STRIP 1,5mmq BLACK TYPE CABLE SH-W
-230Vac 1,5mmq BLACK TYPE SH-W
-VOLTMETRICAL CIRCUITS 1,5mmq BLACK TYPE CABLE SH-W
-AMMETRICAL CIRCUIT 2,5mmq BLACK TYPE CABLE SH-W

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/15

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

Selector Switch Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

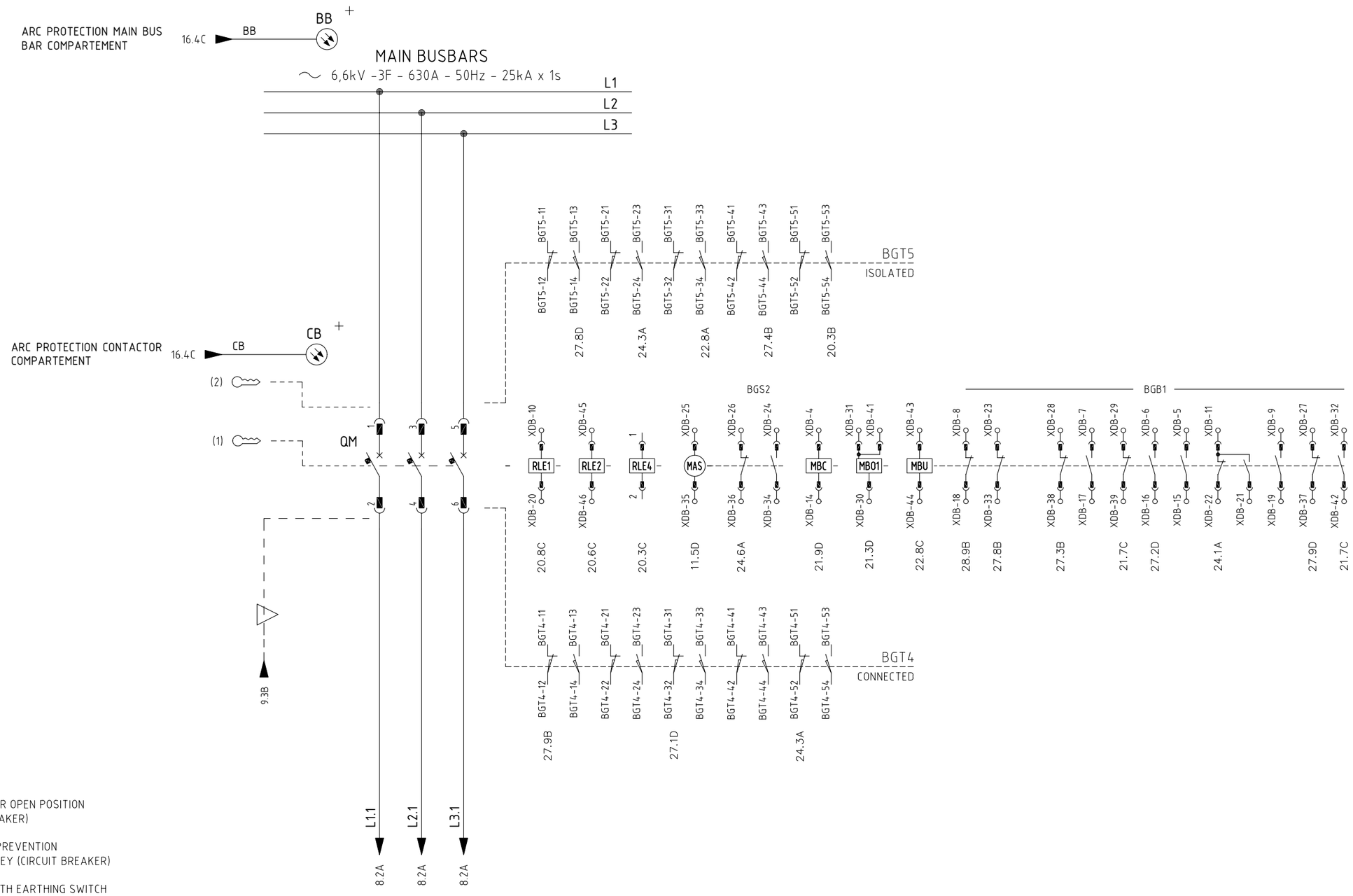
DRAWING NO. 1723002197-EL-DG-00015

SHEET 6

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

=
+A6
DWG n° : 231151/SD/15
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

EH-QMG-x
CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

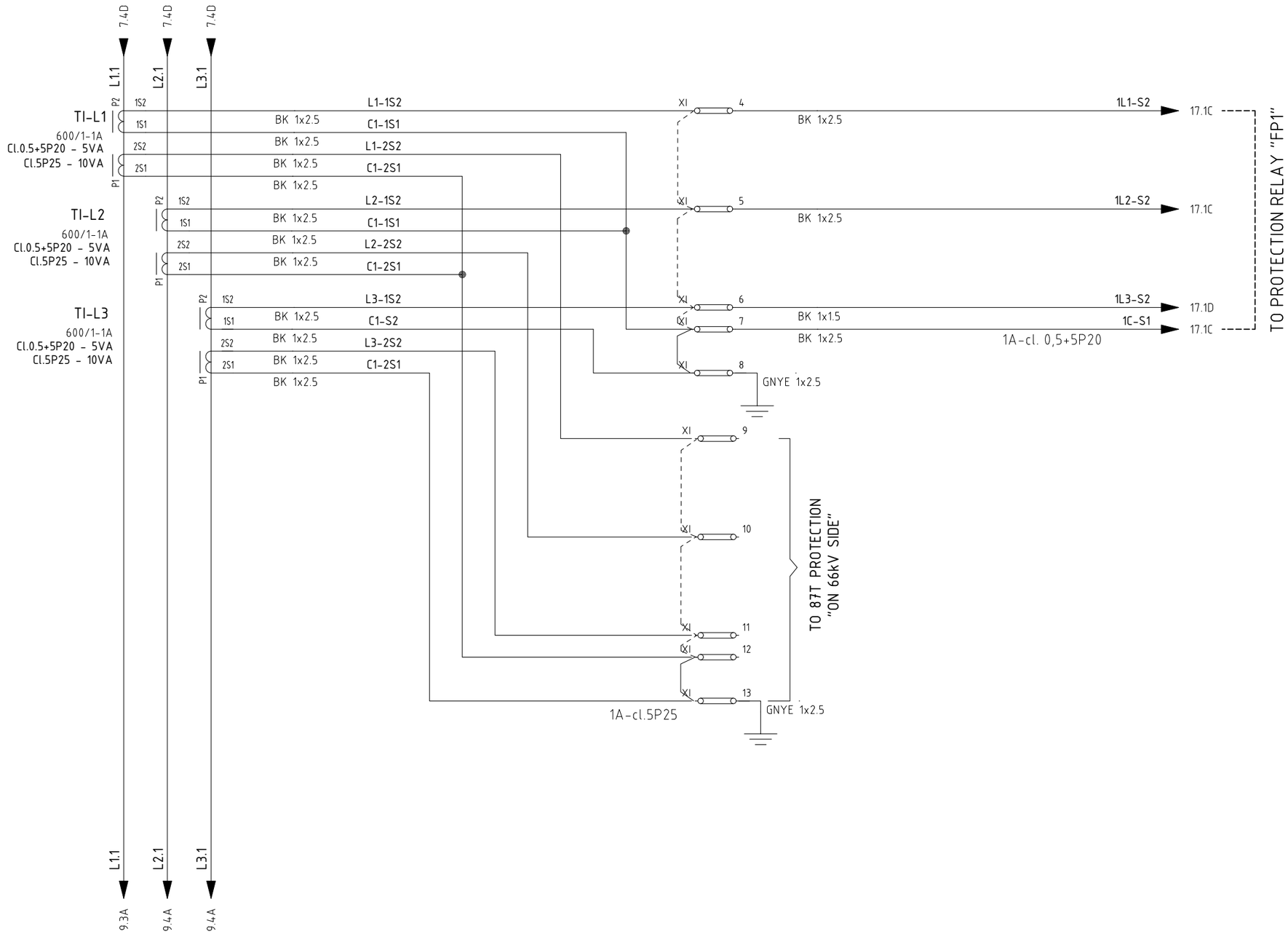
DRAWING NO. 1723002197-EL-DG-00015

SHEET 7

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + A6 | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/15
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

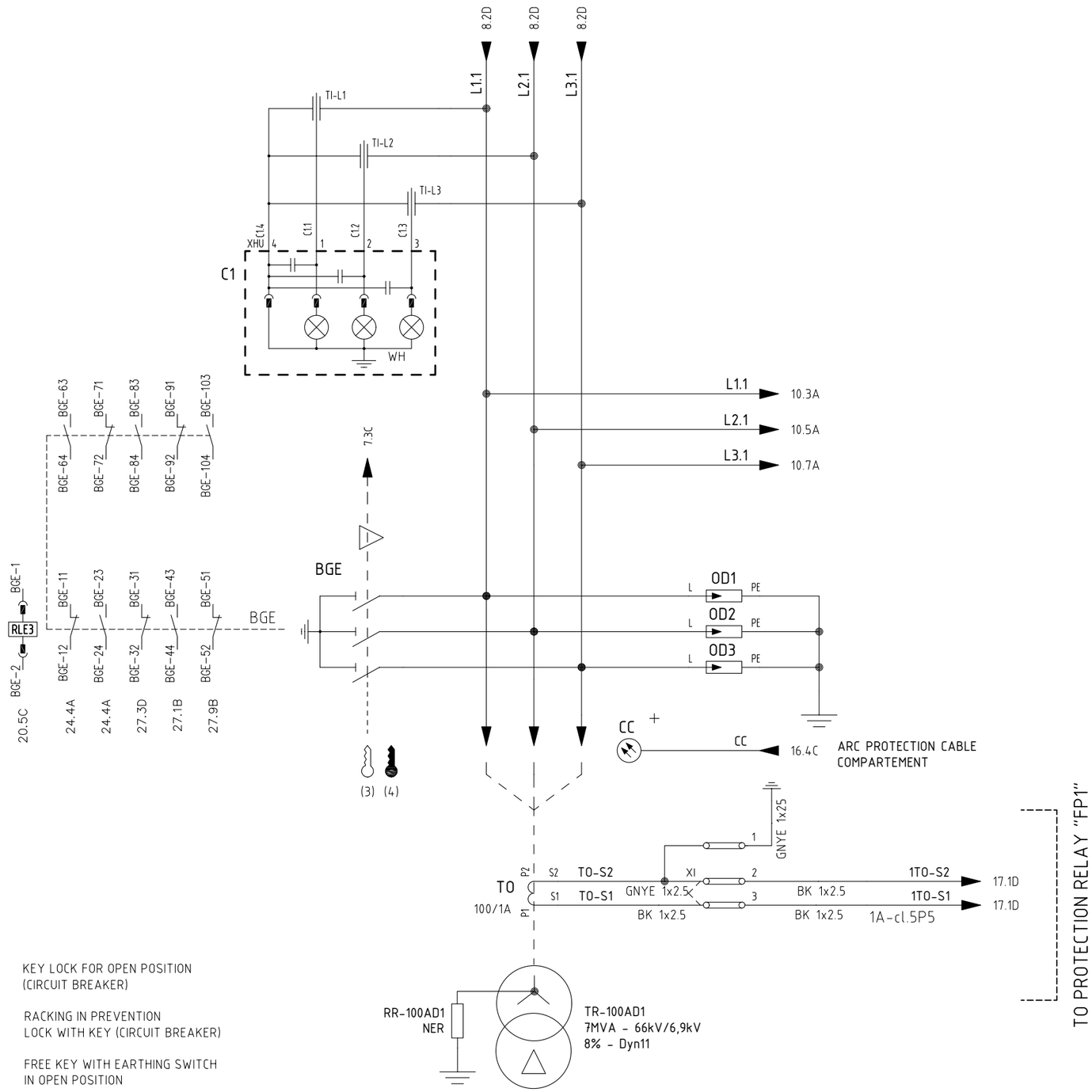
DRAWING NO. 1723002197-EL-DG-00015

SHEET 8

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03




(1) KEY LOCK FOR OPEN POSITION (CIRCUIT BREAKER)

(2) RACKING IN PREVENTION LOCK WITH KEY (CIRCUIT BREAKER)

(3) FREE KEY WITH EARTHING SWITCH IN OPEN POSITION

(4) FREE KEY WITH EARTHING SWITCH IN CLOSED POSITION

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= +A6

DWG n° : 231151/SD/15

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

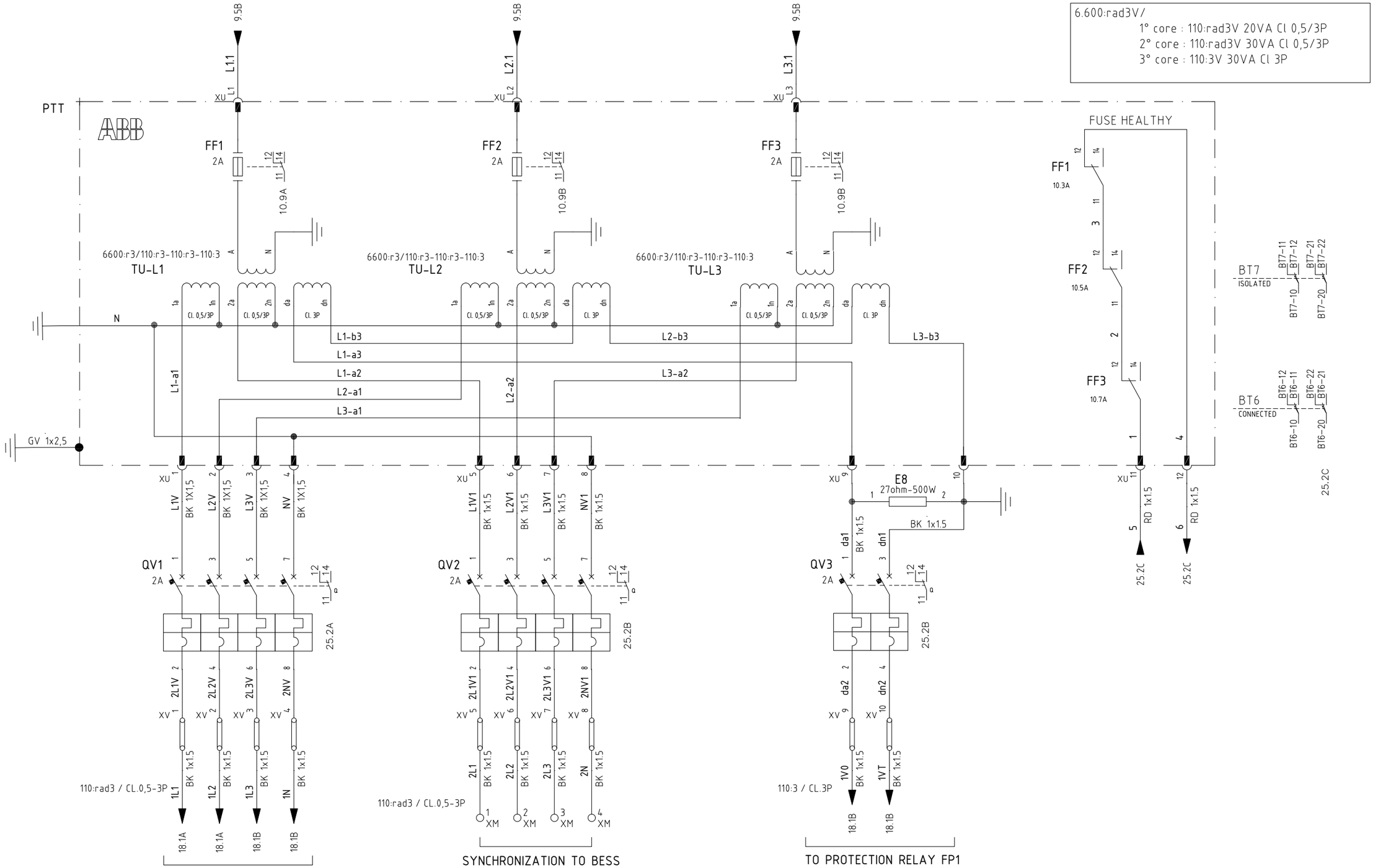
DRAWING NO. 1723002197-EL-DG-00015

SHEET 9

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03




| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

=
+A6

DWG n° : 231151/SD/15

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 1.0

REV. 03

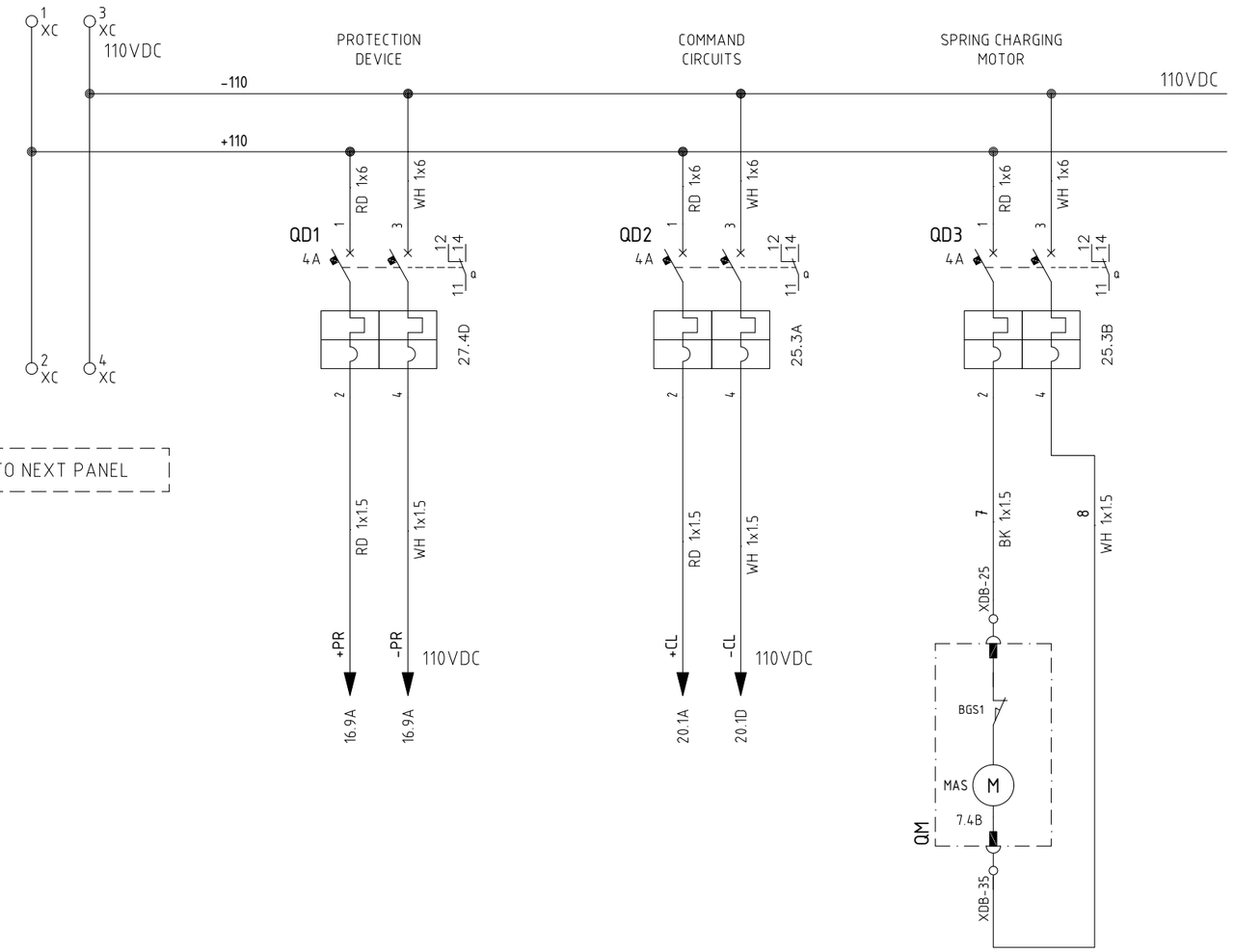
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

## 110VDC DISTRIBUTION VOLTAGE

110Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL

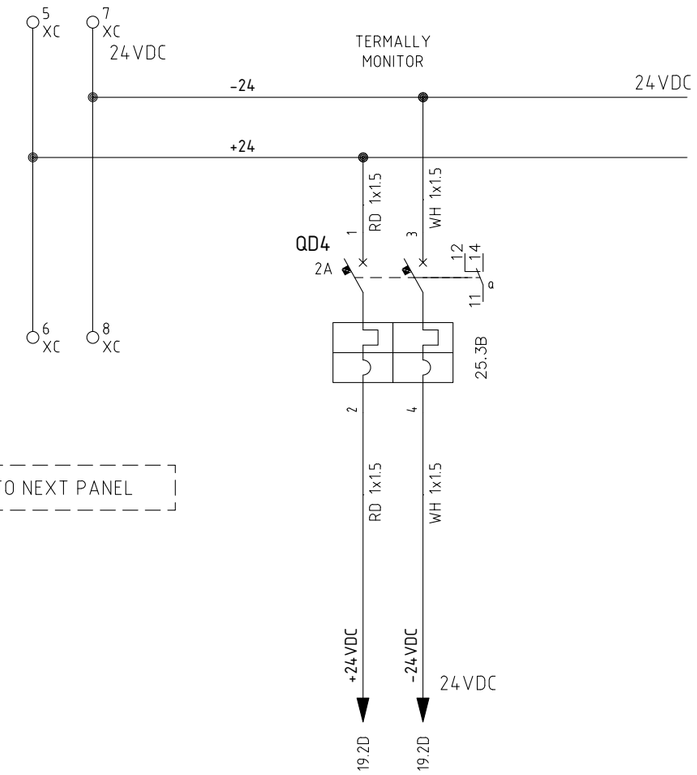



TO NEXT PANEL

## 24VDC DISTRIBUTION VOLTAGE

24Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= +A6

DWG n° : 231151/SD/15

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

110Vdc / 24Vdc Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 1.1

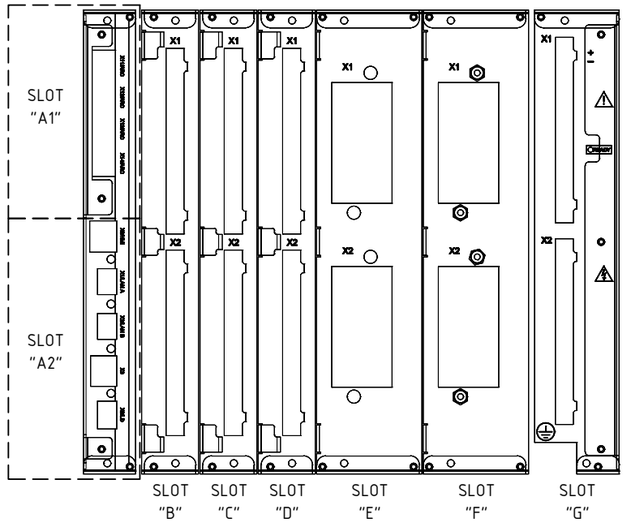
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# COMPOSITION RELAY REX640

## RACK VIEW




REX640B10NN+COM1+ARC1+BIO1+BIO1+BIO2+AIM1+AIM1+PSM3+MCT1+SCT1+CMP2+LNG1+PCL4

| LEGEND | | |
|---|---|---|
| SLOT | Module Type | Description Module |
| A1 | ARC1001 | n° 4 x ARC sensor inputs |
| A2 | COM1001 | n° 1 x RJ-45 (LHMI port) + n° 3 x RJ-45 + n° 1 x SFP100M LC |
| B | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| C | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| D | BIO1002 | n° 9 Binary Input + n° 6 x SPO + n° 2 x SPO(TCS) |
| E | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| F | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| G | PSM1003 | 77...150 VDC, n° 3 x PO (TCS) + n° 2 x PO + n° 3 x SO + n° 2 x SSO |
| | PO = Power Output<br>SO = Signal Output<br>SPO = Static Power Output<br>SSO = Static Signal Output | |

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+A6

DWG n° : 231151/SD/15
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Composition Relay REX640

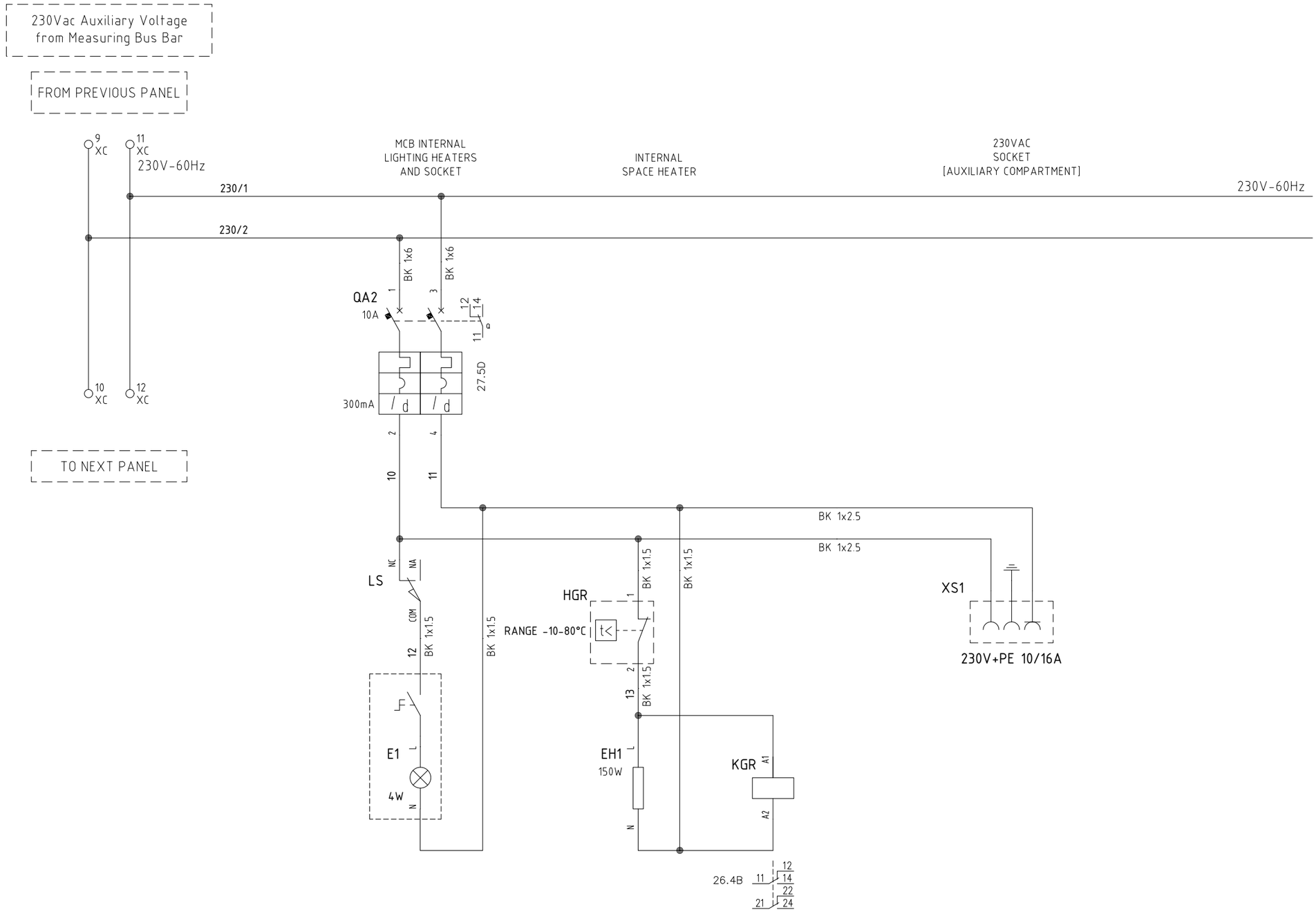
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00015 | SHEET 12 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# 230VAC DISTRIBUTION VOLTAGE




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+ A6

DWG n° : 231151/SD/15

Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

230Vac Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 1,3

REV. 03

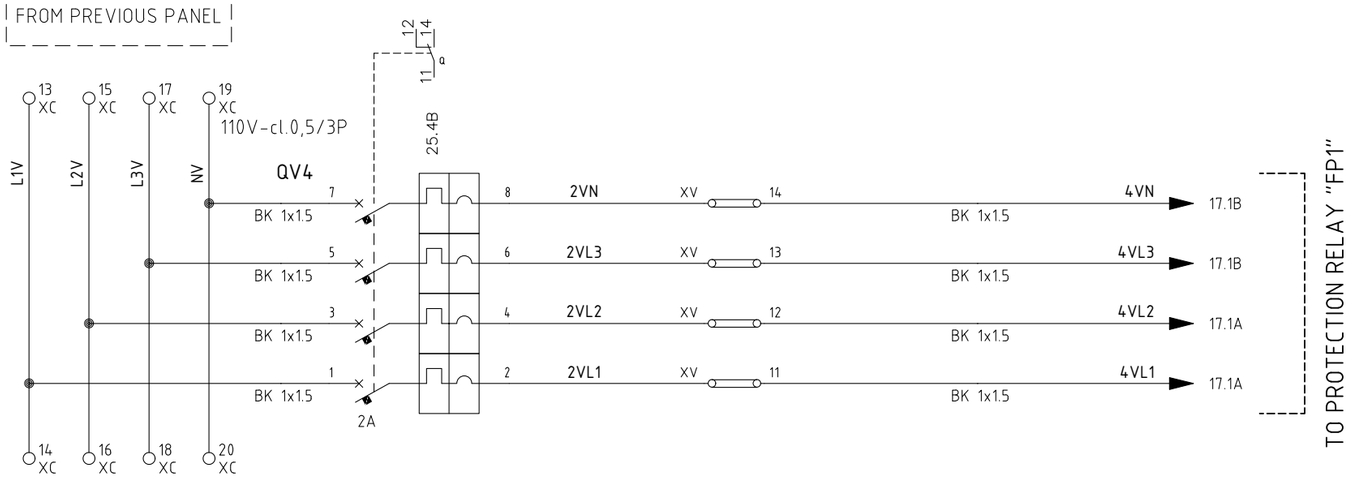
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# 110V: 1,73 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:√3V VOLTMETRIC LINE - STAR
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= + A6

DWG n° : 231151/SD/15

Item n° : PF1113279

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 14

REV. 03

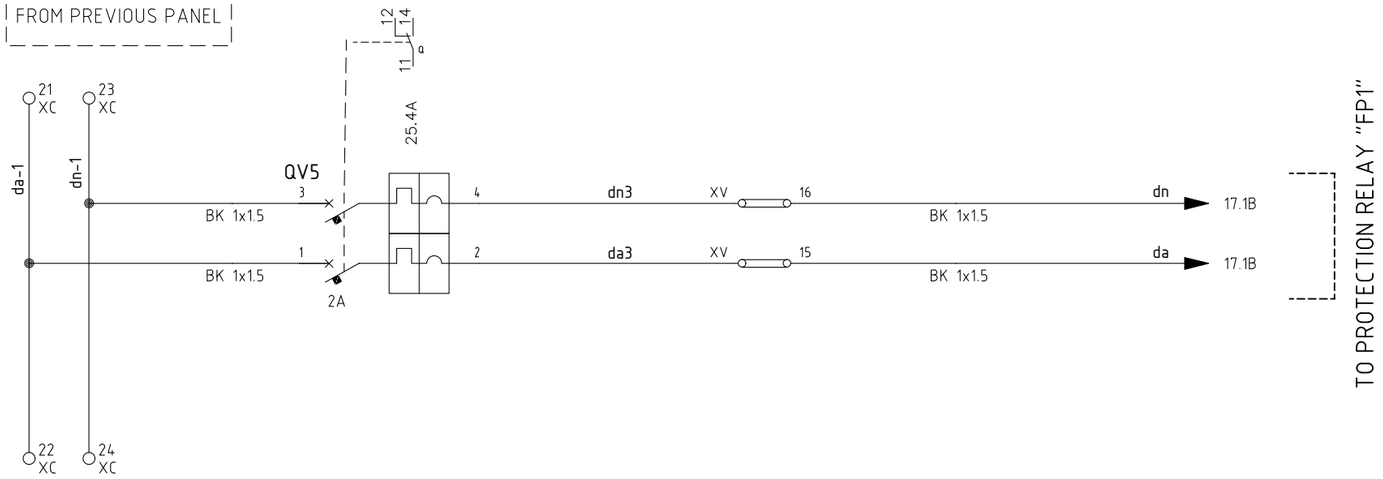
File Name : 1723002197-EL-DG-00015 Rev.03

F.to UNI A3: 420mmx297mm

# 110V:3 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:3V VOLTMETRIC LINE -
DELTA OPEN
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO PROTECTION RELAY "FP1"

TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + A6 | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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DWG n° : 231151/SD/15
Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 15

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# "REX640" PROTECTION WIRING

FP1

PSM1003
COM1001
slot G

X1
X1-1 (+)
Uaux
X1-2 (-)
GND
1x6 GNYE

11.2D +PR → +PR 24.1A
11.3D -PR → -PR 24.1D
110VDC

RD 1x1.5
WH 1x1.5

PROTECTION FUNCTION

| | |
|---|---|
| 51 | 50 |
| 51N | 25 |
| 59N | 86 |
| 74 | 27 |
| 59 | |
| | |
| | |
| | |

ETH PORT (IEC61850)
X1 X2 X3 X0

FP1-A6/A PATCH CORD CAT 6 RJ45 — FROM MEASURE CUBICLE A5
FP1-A6/B PATCH CORD CAT 6 RJ45 — FROM MEASURE CUBICLE A5
ETH.1 PATCH CORD CAT 7 RJ45

LHMI
Local HMI
[7" color Touch screen]
X1.1
X3 (+ / -)
GNYE 1x6

ARC1001
slot A1

ARC DETECTOR SENSOR
X11 BB → 7.3A BUS BAR COMPARTEMENT
X12 CB → 7.3B C.B. COMPARTEMENT
X13 CC → 9.5C CABLE COMPARTEMENT
X14

arc detectors

REX640

FP1

PSM1003

RF SO1 SO2 SSO1 SSO2 POSP1 POSP2 SO3 PODP1 PODP2 PODP3

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| X1-4 | X1-5 | X1-7 | X1-8 | X1-9 | X1-11 | X1-13 | X1-15 | X1-17 | X2-2 | X2-3 |
| X1-3 | | X1-6 | | X1-10 | X1-12 | X1-14 | X1-16 | X1-18 | X2-1 | |
| 22.9A | | 20.5C | | 27.6D | 27.6B | | 21.9B | | 20.6B | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| X2-6 | X2-4 | X2-7 | | X2-11 | X2-9 | X2-12 | | X2-16 | X2-14 | X2-17 |
| X2-5 | | X2-8 | TCS1 | X2-10 | | X2-13 | TCS2 | X2-15 | | X2-18 | TCS3 |
| 21.7B | | | | | | | | | | |

slot G

REX640

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| + A6 | | | | | | | |
| DWG n° : 231151/SD/15 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) | |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
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| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
"REX640"' Protection Wiring

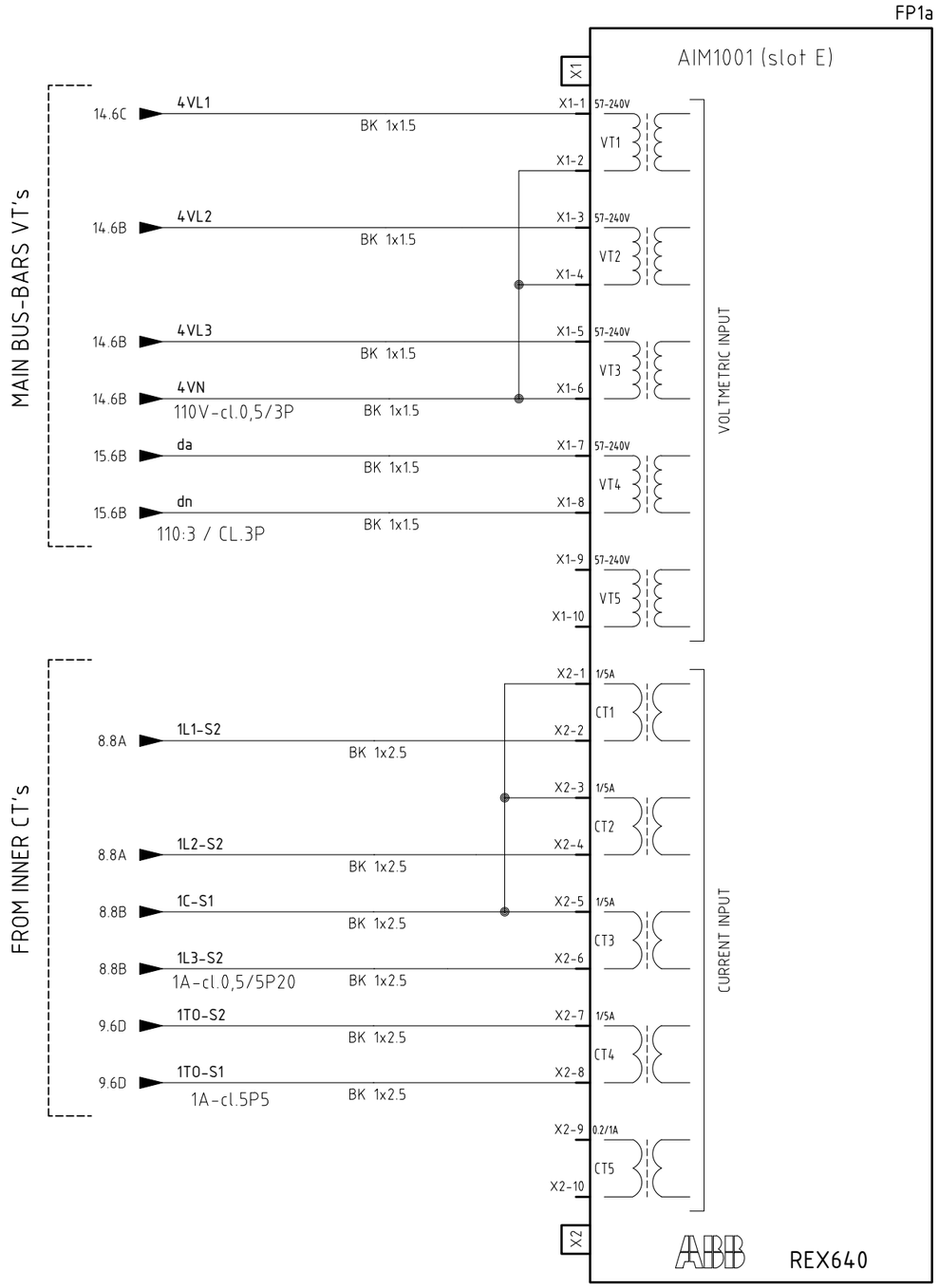
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00015
SHEET 16
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# "REX640" PROTECTION WIRING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
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+A6
DWG n° : 231151/SD/15
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

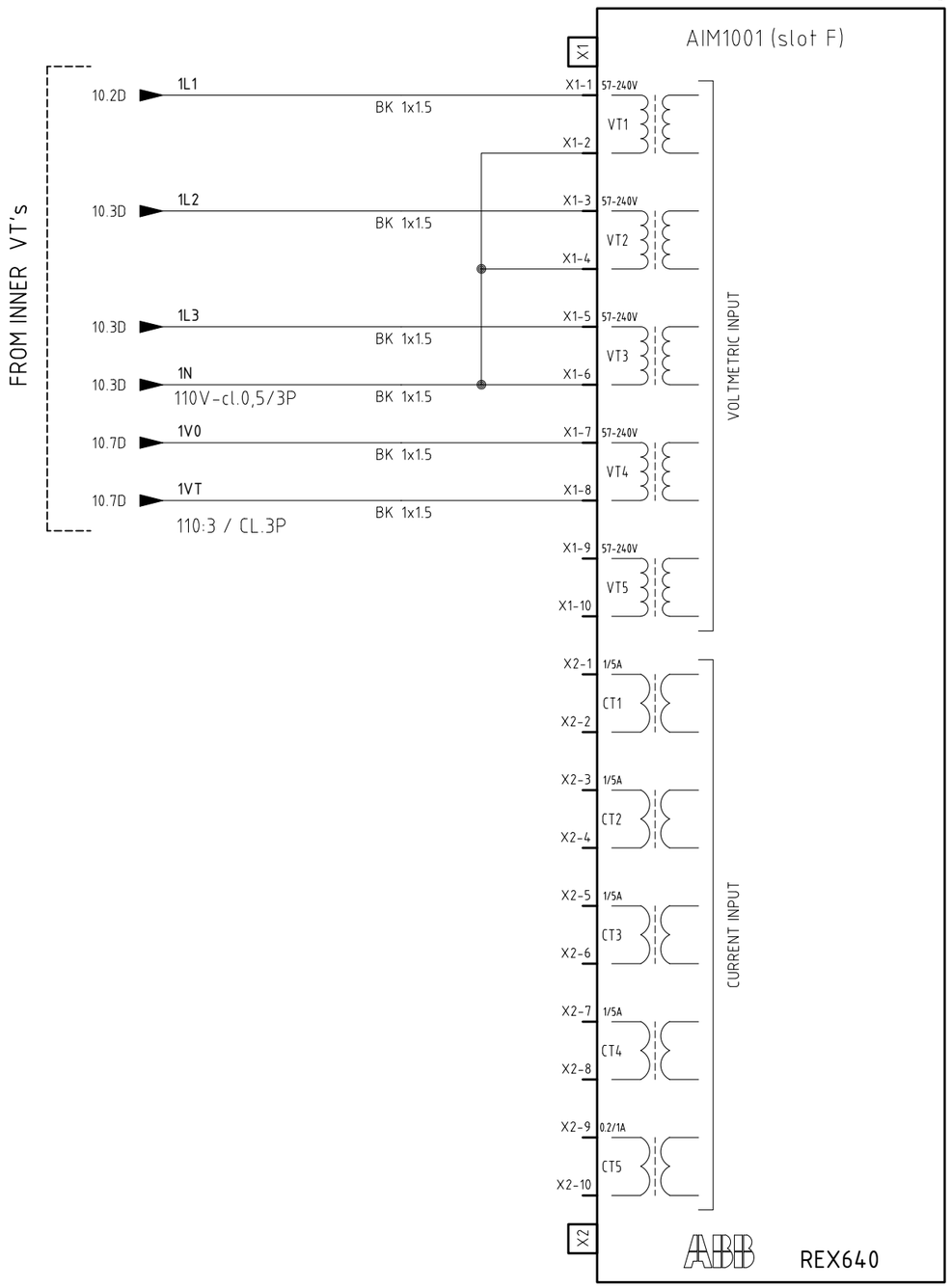
SHEET 17

REV. 03

File Name : 1723002197-EL-DG-00015 Rev.03

F.to UNI A3: 420mmx297mm

# "REX640" PROTECTION WIRING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
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= + A6

DWG n° : 231151/SD/15

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

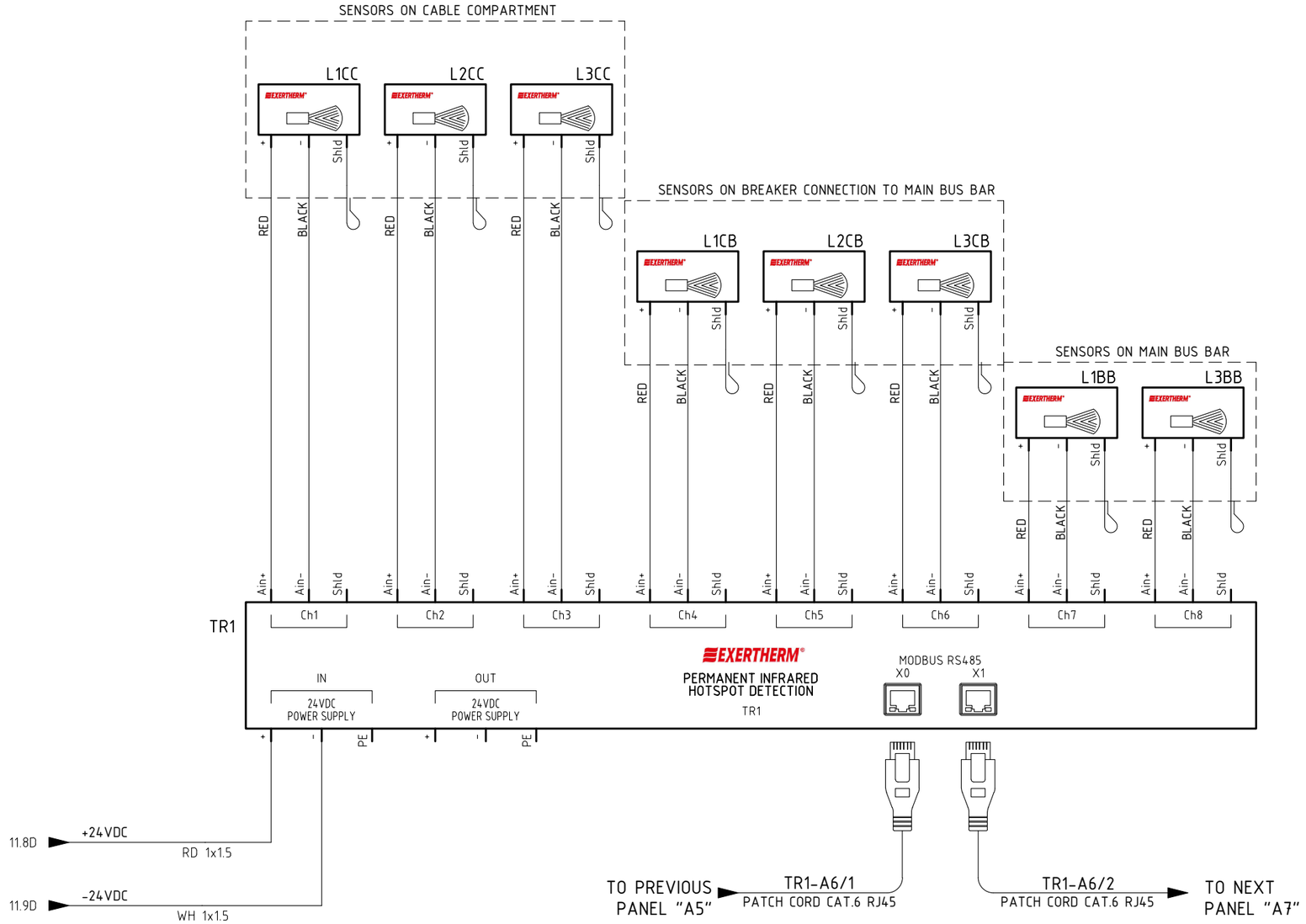
DRAWING NO. 1723002197-EL-DG-00015

SHEET 18

REV. 03

File Name : 1723002197-EL-DG-00015 Rev.03

F.to UNI A3: 420mmx297mm




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= + A6

DWG n° : 231151/SD/15

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

Extherm Device

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 19

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# COMMAND CIRCUITS

ENABLING C.B. TRUCK ENCLOSURE DOOR AND EARTHING SWITCH

UNLOCKING CIRCUIT BRAKER ENCLOSURE DOOR

ENABLING EARTHING SWITCH COMMAND

ENABLING RACK-IN AND RACK-OUT CIRCUIT BRAKER [LOCKING MAGNET]

ENABLING CIRCUIT BREAKER [LOCKING MAGNET]

11.4D +CL 110VDC (CL) — RD 1x1.5 — +CL 21.1A

P1 BK E 13 14

KT1 20.2D 16 18 30" 15

21 RD 1x1.5

QM ISOLATED BGT5 7.4B BGT5-53 BGT5-54

5 XM 6 XM

FP1 16.3A X2-2 X2-3 S03 REX640 X2 Slot G X2-1

KIRF 22.9D 22 24 21

22 RD 1x1.5

FP1 16.3A X1-7 X1-8 23 S01 REX640 X1 Slot G X1-6

24 RD 1x1.5

25 RD 1x1.5

7 XM 8 XM

26 RD 1x1.5

27 RD 1x1.5

9 XM 10 XM

28 RD 1x1.5

RD 1x1.5 (1) — QM RLE4 7.4B (2)

BGE RLE3 9.3C BGE-1 BGE-2

QM RLE2 7.4B XDB-45 XDB-46

QM BGT3 RLE1 7.4B XDB-10 XDB-20

20 RD 1x1.5

KT1 A1 B1 30" A2

11.4D -CL — WH 1x1.5 — -CL 21.1E

20.3A 15 16 18

24.9A 25 26 28

| | | | | | | |
|---|---|---|---|---|---|---|
| = | | | | | | |
| + A6 | | | | | | |
| DWG n° : 231151/SD/15 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

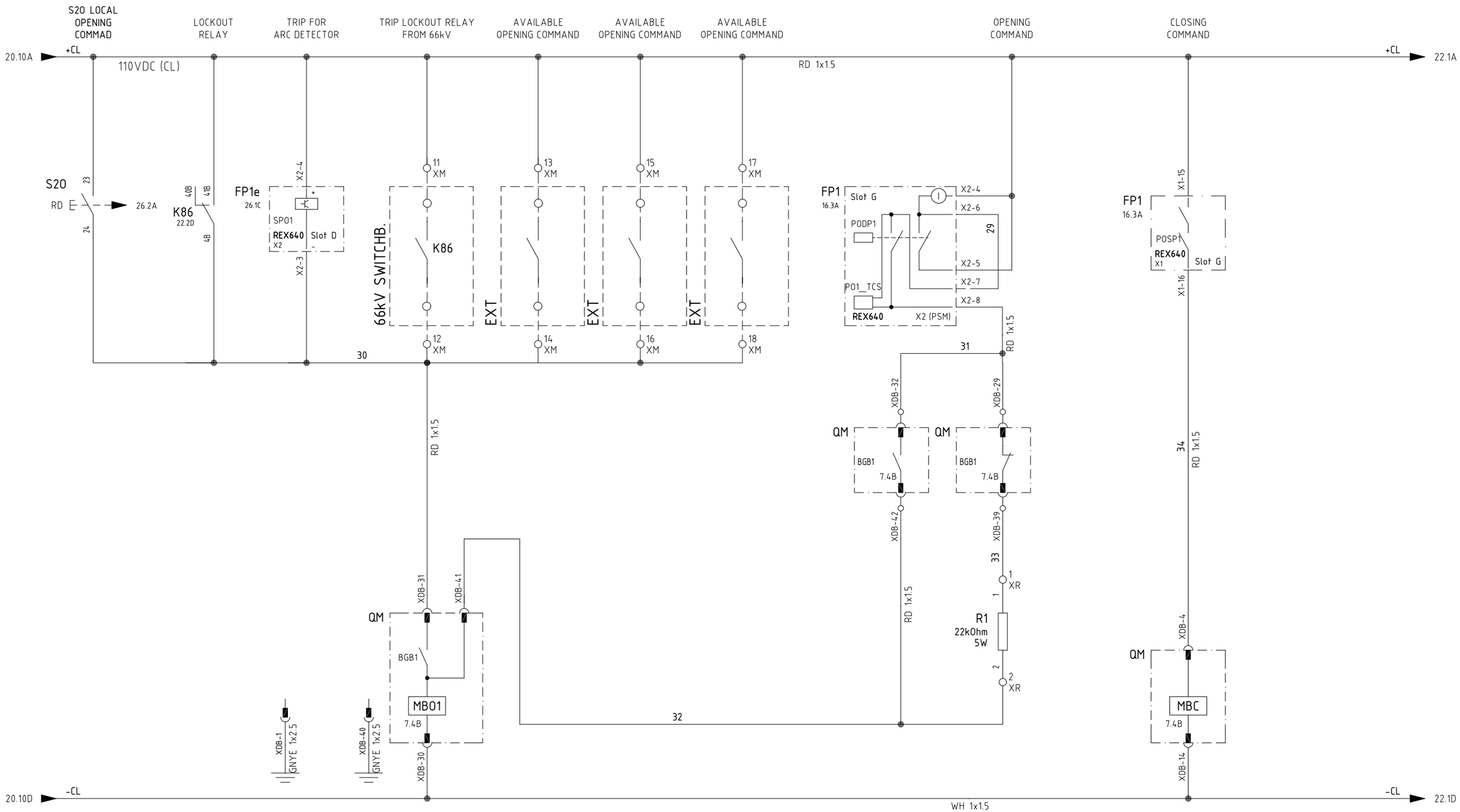
SHEET 20

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# CLOSING/OPENING COMMAND CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= +A6
DWG n°: 231151/SD/15
Item n°: PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

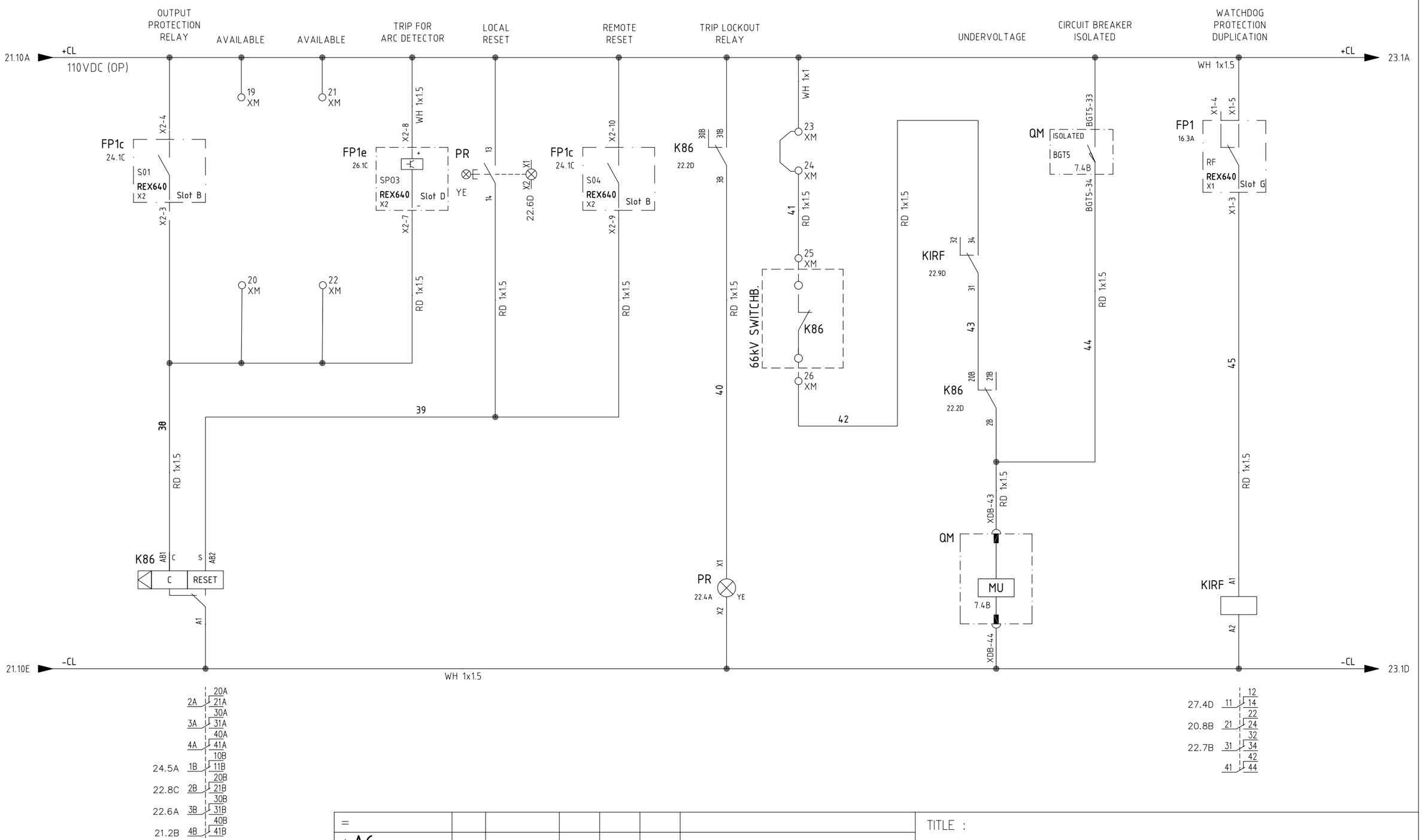
TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS
A3
DRAWING NO. 1723002197-EL-DG-00015
SHEET 21
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# COMMAND CIRCUITS




| | | | | | | |
|---|---|---|---|---|---|---|
| = | | | | | | |
| + A6 | | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) | |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

DWG n° : 231151/SD/15
Item n° : PF1113279

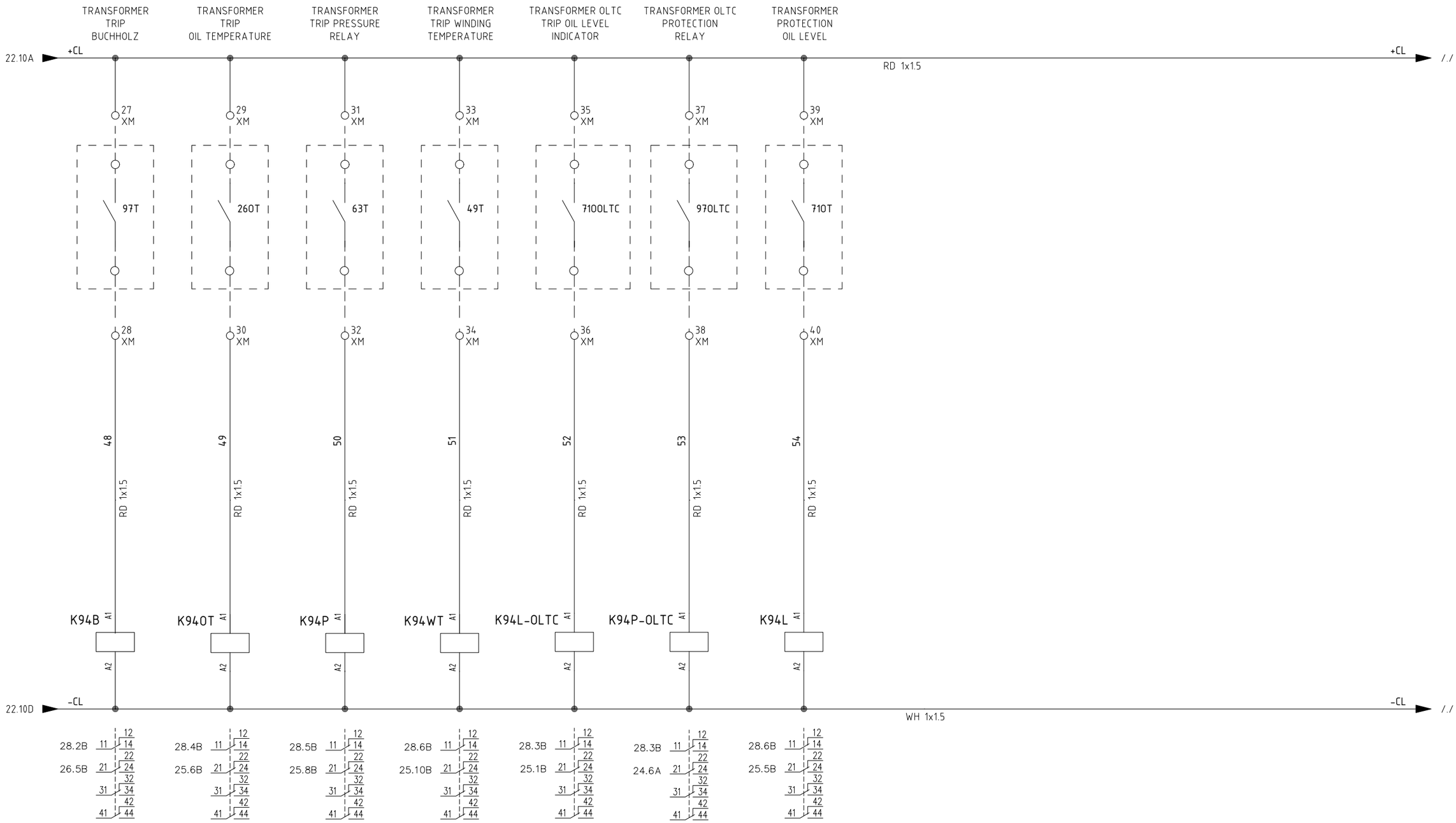
TITLE :
SG-100D1 – FUNCTIONAL INCOMING FEEDER TR-100AD1
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS
A3
DRAWING NO. 1723002197-EL-DG-00015
SHEET 22
REV. 03

CROSSWIND
IMESA ELECTRICAL ENGINEERING
ROSETTI MARINO

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| + A6 | | | | | | | |
| DWG n° : 231151/SD/15 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) | |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 23

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT

C.B. CLOSED | C.B. OPENED | CIRCUIT BREAKER SERVICE POSITION | CIRCUIT BREAKER TEST POSITION | EARTH SWITCH OPENED | EARTH SWITCH CLOSED | K86 RELAY TRIPPED | C.B. SPRING DISCHARGE | TRANSFORMER PROTECTION RELAY OLTC | SELECTOR IN LOCAL POSITION | SELECTOR IN REMOTE POSITION | EXTERNAL CLOSING INTERLOCK | FROM 66kV M.V. SWBD CB OPENED (OPENING COMMAND) | UNLOCKING EARHTING SWITCH/ TRUCK C.B.

16.10A +PR 110VDC (PR) — XDB-11 — RD 1x1.5 — +PR 25.1A

QM BGB1/2 7.4B — XDB-21 / XDB-22 — 50 / 51 — X1-1 / X1-2

QM CONNECTED BGT4 7.4B — BGT4-51 / BGT4-52 — 52 — X1-3

QM ISOLATED BGT5 7.4B — BGT5-23 / BGT5-24 — 53 — X1-5

BGE - 9.3C — BGE-11 / BGE-12 — 54 — X1-6

BGE - 9.3C — BGE-23 / BGE-24 — 55 — X1-7

K86 22.2D — 10B / 11B / 1B — 56 — X1-9

QM BGS2 7.4B — XDB-26 / XDB-36 — 57 — X1-10

K94P-OLTC 23.5D — 22 / 24 / 21 — 58 — X1-11

SA1 — 11 / 12 — 59 — X1-13

SA1 — 23 / 24 — 60 — X1-14

41 XM / 42 XM — 61 — X1-15

66kV M.V.SWITCHBOARD C.B. OPENED — 43 XM / 44 XM — 62 — X1-17

KT1 20.2D — 26 / 28 / 30" / 25 — 63 — X2-1

FP1c BIO1001 SLOT B — BI1 BI2 BI3 BI4 BI5 BI6 BI7 BI8 BI9 BI10 BI11 BI12 BI13 BI14 — REX640

X1-4 X1-8 X1-12 X1-16 X1-18 X2-2

16.10A -PR — WH 1x1.5 — -PR 25.1E

FP1c BIO1001 SLOT B — SO1 SO2 SO3 SO4 SO5 SO6 SO7 SO8 — X2-4 X2-6 X2-8 X2-10 X2-12 X2-14 X2-16 X2-18 / X2-3 X2-5 X2-7 X2-9 X2-11 X2-13 X2-15 X2-17 — REX640

22.2A 27.7D 22.5A 28.7B

= + A6

DWG n° : 231151/SD/15

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00015 | SHEET 24 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT

TRANSFORMER TRIP OIL LEVEL INDICATOR OLTC | VT HEALTY CIRCUIT | EARTING SWITCH OPEN (FROM MEASURING UNIT) | CLOSED AUXILIARY CIRCUIT MCB's | CLOSED AUXILIARY V.T. SECONDARY MCB's | TRANSFORMER ALARM MEMBRANE CONTROL | TRANSFORMER TRIP OIL LEVEL | TRANSFORMER ALARM OIL TEMPERATURE | TRANSFORMER TRIP OIL TEMPERATURE | TRANSFORMER ALARM OIL LEVEL | TRANSFORMER SELF DEHYDRATING BREATHER ALARM | TRANSFORMER TRIP OIL PRESSURE | TRANSFORMER ALARM WINDING TEMPERATURE | TRANSFORMER TRIP WINDING TEMPERATURE

24.10A +PR 110VDC (PR) — RD 1x1.5 — +PR 26.1A

QV1 10.2C · QV2 10.4C · QV3 10.7C · QV4 14.2C · QV5 15.2B · QD2 11.4B · QD3 11.5B · QD4 11.8B

K94L-OLTC 23.4D · PTT 10.2A (BI6-22, BI6-21) · 10.9C 5 · 10.9C 6

25 XC · 35 XC · KA1 · 36 XC · 26 XC

45 XM · 89T.1 · 46 XM

K94L 23.6D · 47 XM · 260T · 48 XM

K94OT 23.2D · 97802 · 49 XM · 710T · 50 XM

51 XM · 89T.2 · 52 XM

K94P 23.3D · 97803 · 53 XM · 49T · 54 XM

K94WT 23.4D · 97804

64 · 65 · 66 · 67 · 68 · 69 · 69A · 70 · 71 · 72 · 73 · 74 · 75 · 76 · 77 · 78 · 79 · 80 · 81 — RD 1x1.5

X1-1 · X1-2 · X1-3 · X1-5 · X1-6 · X1-7 · X1-9 · X1-10 · X1-11 · X1-13 · X1-14 · X1-15 · X1-17 · X2-1

FP1d BIO1001 SLOT C — ABB REX640 — BI1 · BI2 · BI3 · BI4 · BI5 · BI6 · BI7 · BI8 · BI9 · BI10 · BI11 · BI12 · BI13 · BI14

X1-4 · X1-8 · X1-12 · X1-16 · X1-18 · X2-2

24.10D -PR — WH 1x1.5 — -PR 26.1D

| | | | | | | |
|---|---|---|---|---|---|---|
| = | | | | | | |
| + A6 | | | | | | |
| DWG n° : 231151/SD/15 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
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| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING · CROSSWIND · ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
"REX640" Protection Wiring - Digital Input

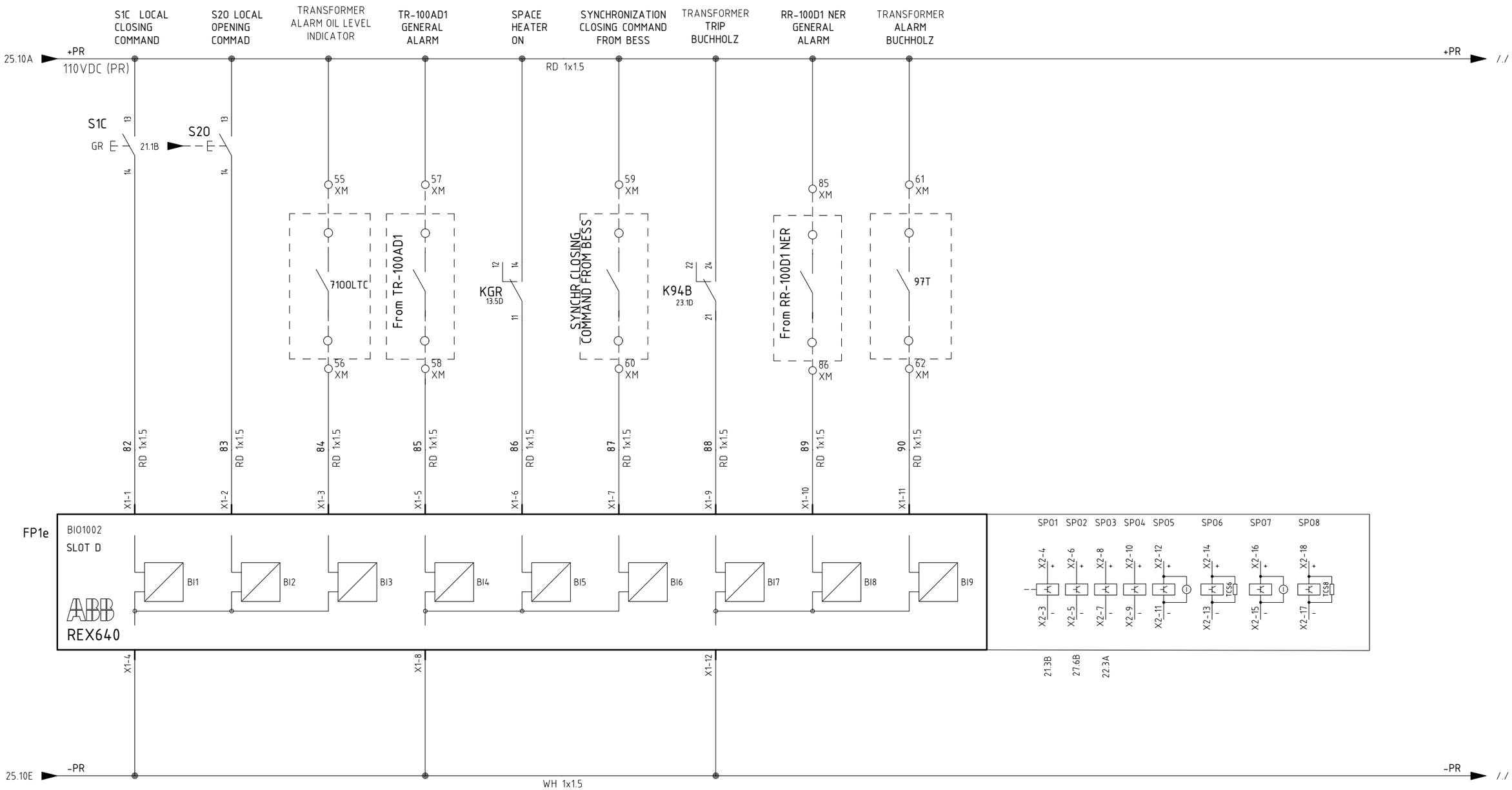
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00015 | SHEET 25 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT




| | | | | | | |
|---|---|---|---|---|---|---|
| = | | | | | | |
| + A6 | | | | | | |
| DWG n° : 231151/SD/15 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

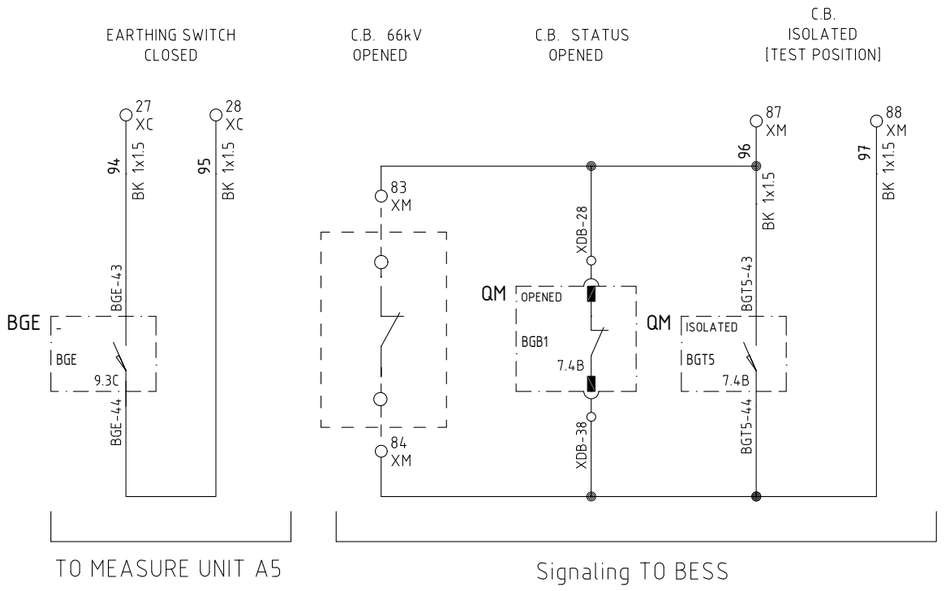
SHEET 26

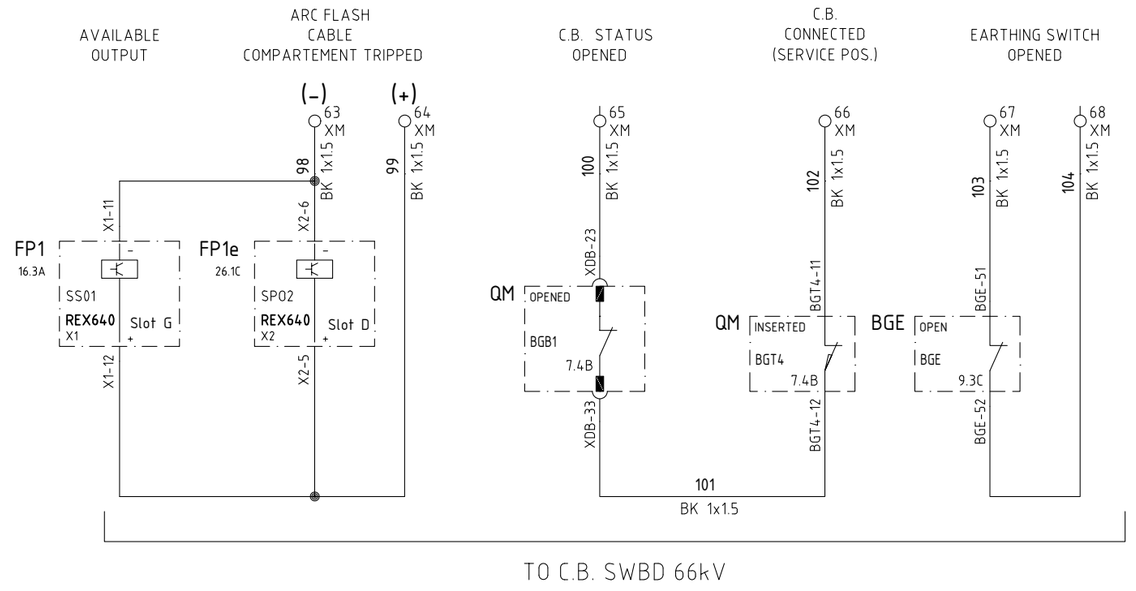
REV. 03

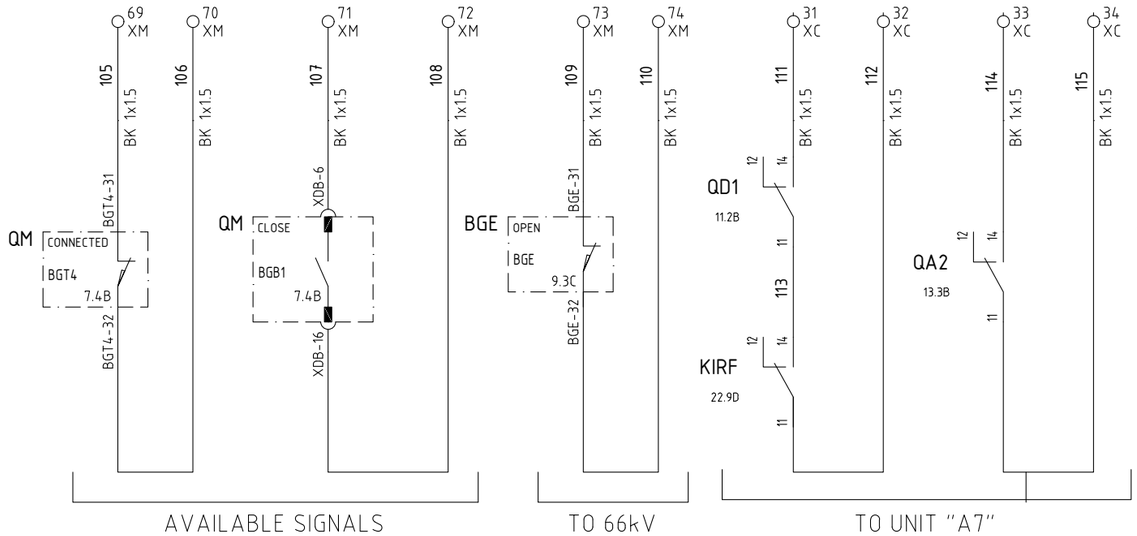
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

# AVAILABLE SIGNALS

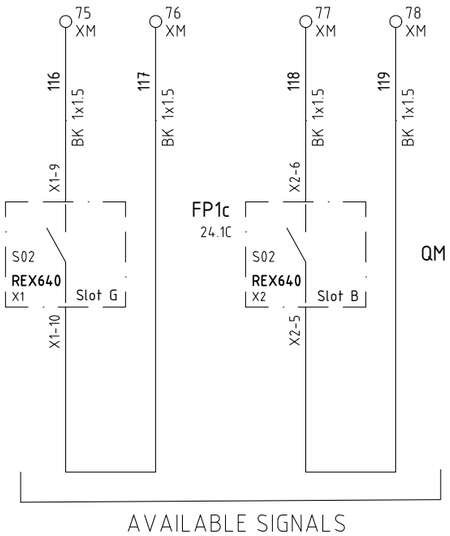


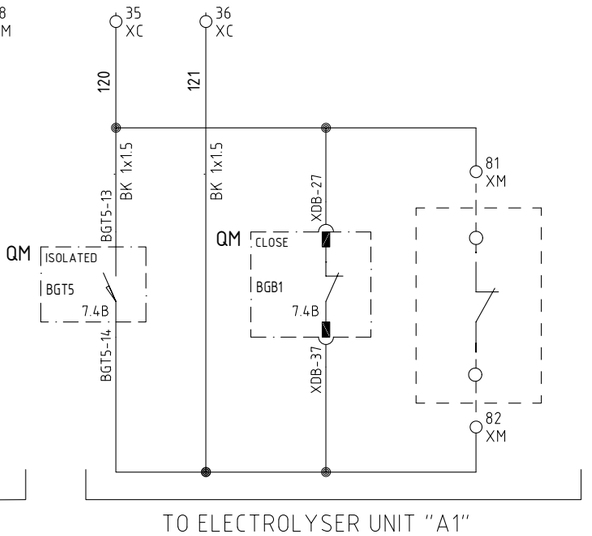










| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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+ A6
DWG n° : 231151/SD/15
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

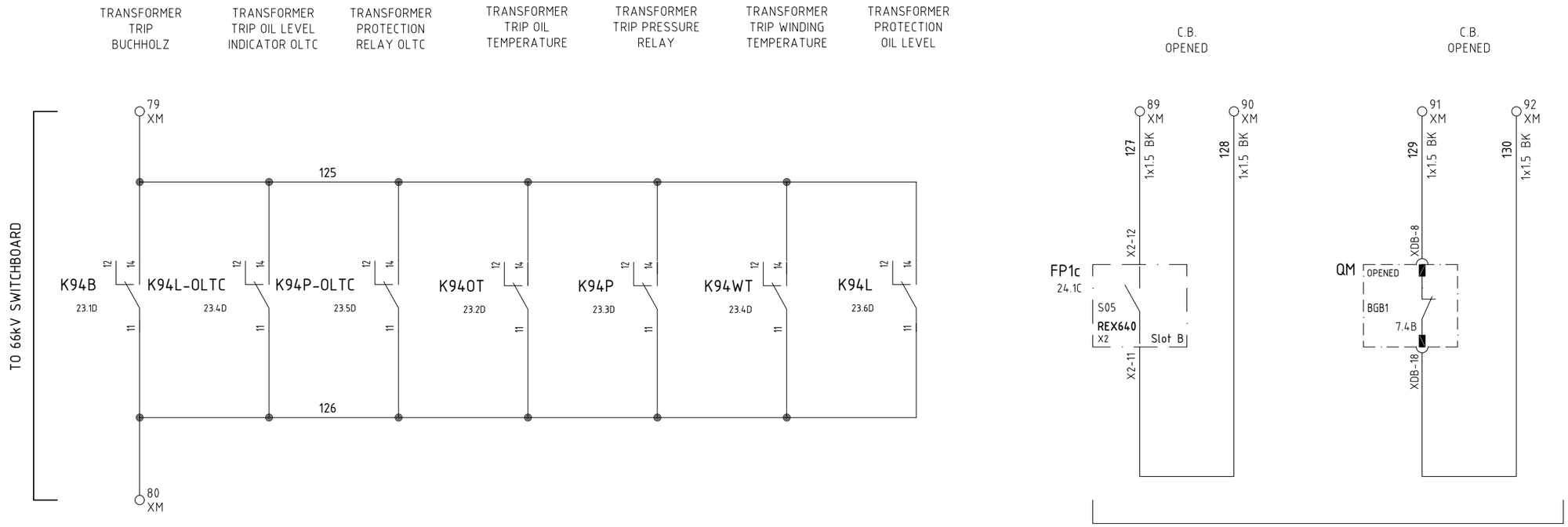
TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Availables Signals

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00015
SHEET 27
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + A6 | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/15
Item n° : PF1113279

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Available Signals

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 28

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

TYP - INCOMING
XI
Ammeter Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 2 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 3 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 4 | 8.5A | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 5 | 8.5A | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 6 | 8.5B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 7 | 8.5B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 8 | 8.5B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 9 | 8.5B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 10 | 8.5C | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 11 | 8.5C | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 12 | 8.5C | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 13 | 8.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |

TYP - INCOMING
XV
Voltmetric Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 10.2D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 2 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 3 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 4 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 5 | 10.4D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 6 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 7 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 8 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 9 | 10.7D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 10 | 10.7D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 11 | 14.4C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 12 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 13 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 14 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 15 | 15.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 16 | 15.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |

TYP - INCOMING
XR

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 21.7D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 2 | 21.7D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

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DWG n° : 231151/SD/15
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND
ROSETTI MARINO
IMESA ELECTRICAL ENGINEERING

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Terminal strips

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00015
SHEET 29
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

TYP - INCOMING

XC

Interconnection Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 11.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 2 | 11.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 3 | 11.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 4 | 11.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 5 | 11.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 6 | 11.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 7 | 11.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 8 | 11.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 9 | 13.1A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 10 | 13.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 11 | 13.2A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 12 | 13.2B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 13 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 14.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 14.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 21 | 15.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 15.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 15.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 15.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 25 | 25.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 27.1A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 27.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 27.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 27.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 27.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 27.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 27.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 27.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 37 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/15

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

Terminal strips

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 3.0

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

TYP - INCOMING

XC

Interconnection Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 38 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/15

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

Terminal strips

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 31

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

TYP - INCOMING

XM

Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 10.4E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 2 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 3 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 4 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 5 | 20.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 6 | 20.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 7 | 20.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 8 | 20.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 9 | 20.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 10 | 20.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 11 | 21.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 12 | 21.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 13 | 21.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 21.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 21.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 21.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 21.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 21.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 22.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 22.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 21 | 22.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 22.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 22.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 22.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 25 | 22.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 22.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 23.1A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 23.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 23.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 23.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 23.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 23.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 23.4A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 23.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 23.4A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 23.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 37 | 23.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 38 | 23.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 39 | 23.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 40 | 23.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/15

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :

SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1

Terminal strips

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00015

SHEET 3.2

REV. 03

File Name : 1723002197-EL-DG-00015 Rev.03

F.to UNI A3: 420mmx297mm

TYP - INCOMING
XM
Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 41 | 24.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 42 | 24.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 43 | 24.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 44 | 24.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 45 | 25.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 46 | 25.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 47 | 25.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 48 | 25.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 49 | 25.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 50 | 25.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 51 | 25.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 52 | 25.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 53 | 25.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 54 | 25.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 55 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 56 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 57 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 58 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 59 | 26.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 60 | 26.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 61 | 26.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 62 | 26.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 63 | 27.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 64 | 27.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 65 | 27.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 66 | 27.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 67 | 27.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 68 | 27.10A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 69 | 27.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 70 | 27.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 71 | 27.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 72 | 27.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 73 | 27.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 74 | 27.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 75 | 27.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 76 | 27.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 77 | 27.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 78 | 27.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 79 | 28.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 80 | 28.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 81 | 27.9D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/15
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Terminal strips

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00015 | SHEET 33 | REV. 03

File Name : 1723002197-EL-DG-00015 Rev.03

F.to UNI A3: 420mmx297mm

TYP - INCOMING

XM

Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 82 | 27.9D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 83 | 27.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 84 | 27.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 85 | 26.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 86 | 26.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 87 | 27.4A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 88 | 27.4A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 89 | 28.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 90 | 28.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 91 | 28.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 92 | 28.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 93 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 94 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| BGE | 9 | 1VCF599700R0131 | 1 | EARTHING SWITCH ST-E 17.31 150 | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | 1VCF599504R0063 | 1 | KEY LOCKS ON EARTHING SWITCH | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | 1VCF599700R0290 | 1 | EARTHING SWITCH OPERATING LEVER | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | 1VCF599505R0002 | 1 | 10 AUX CONTACTS FOR EARTHING SWITCH | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| C1 | 9 | 43931118 | 1 | VPIS 3,3÷36KV - DEVICE SIGNALLING VOLTAGE PRESENT KIT | ELECTRONSYSTEM | A6 | INCOMING FEEDER TR-100AD1 |
| CB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| CC | 9 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| E1 | 13 | 74041 | 1 | LED LAMP 4W 4000K 313x30x22 | Beghelli | A6 | INCOMING FEEDER TR-100AD1 |
| E8 | 10 | 1VCF501000R0001 | 1 | RESISTOR TR318 27R/J 27ohm 500W L=2,5M | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| EH1 | 13 | R1R150230 | 1 | SPACE HEATER SKR 150W ALIM. 220VCA | Torresan | A6 | INCOMING FEEDER TR-100AD1 |
| FF1 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| FF2 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| FF3 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| FP1 | 16 | 1VCF698331R0001 | 1 | REX640B10NN+AIM1+AIM1+ARC1+BIO1+BIO1+BI+O2+CMP2+COM1+LNG1+MCT1+PCL4+PSM3+SCT | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| HGR | 13 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | A6 | INCOMING FEEDER TR-100AD1 |
| K86 | 22 | RMBE13-C110T | 1 | MONOSTABLE RELAY 110VDC 7SC-5A TROP. | Amra | A6 | INCOMING FEEDER TR-100AD1 |
| | | PAVM321 | 1 | SOCKET WITH SCREW TO RELAY TYPE PAVM321 | Amra | A6 | INCOMING FEEDER TR-100AD1 |
| K94B | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| K94L | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| K94L-OLTC | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| K94OT | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| K94P | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| K94P-OLTC | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| K94WT | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| KGR | 13 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 552 0 | 1 | CR-M230AC2L SUPPLY 230VAC 2C/O 250V/6A LED | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| KIRF | 22 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A6 | INCOMING FEEDER TR-100AD1 |

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DWG n° : 231151/SD/15

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00015 | SHEET 35 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| KIRF | 22 | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| KT1 | 20 | H3DKM2ACDC24240 | 1 | MULTIFUNCTION TIMER RELAY Vaux=24÷240Vac/dc - 2SC | Omron | A6 | INCOMING FEEDER TR-100AD1 |
| L1C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A6 | INCOMING FEEDER TR-100AD1 |
| L1I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A6 | INCOMING FEEDER TR-100AD1 |
| L1MS | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A6 | INCOMING FEEDER TR-100AD1 |
| L2C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A6 | INCOMING FEEDER TR-100AD1 |
| L2I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A6 | INCOMING FEEDER TR-100AD1 |
| L3C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A6 | INCOMING FEEDER TR-100AD1 |
| L3I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A6 | INCOMING FEEDER TR-100AD1 |
| L3MS | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A6 | INCOMING FEEDER TR-100AD1 |
| LS | 13 | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | A6 | INCOMING FEEDER TR-100AD1 |
| | | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | A6 | INCOMING FEEDER TR-100AD1 |
| OD1 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A6 | INCOMING FEEDER TR-100AD1 |
| OD2 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A6 | INCOMING FEEDER TR-100AD1 |
| OD3 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A6 | INCOMING FEEDER TR-100AD1 |
| P1 | 20 | KW 080 2 | 1 | MP1-10B BLACK PUSH BUTTON UNSTABLE | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| PR | 22 | KW 101 6 | 1 | YELLOW LIGHT PUSH BUTTON | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | KV 022 5 | 1 | MLBL-05W YELLOW LED BLOCK INTEGRATED 110÷130VAC | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| PTT | 10 | 1VCF498412R0100 | 1 | TV/F COMPARTMENT 12/17kV IP4X L=590mm OUTLET ON THE BACK WITH N°3 VT + N°14 MAIN CONTACTS + N°2+2 SERVICE/ISOLATED POSITION CONTACTS | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | 1VCF499800R0302 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR TV/F | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| QA2 | 13 | B427917 | 1 | DDA202 AC 25A 300MA RCD BLOCK 2P | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | S550284 | 1 | S202M C10 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| QD1 | 11 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| QD2 | 11 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | a563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| QD3 | 11 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| QD4 | 11 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| QM | 7 | 1VCF337121R1141 | 1 | VACUUM CIRCUIT BREAKER VD4/P 3P 12KV 630A 25KA WITHDRAWABLE 12.06.25 P150 | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | 1VCF339700R0882 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR CIRCUIT-BREAKER | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | 1VCF339700R1885 | 1 | VD4 FOR POWERCUBE | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | 1VCF349700R4881 | 1 | WIRING WITH AFUMEX N07G9-K CABLE | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | 1VCF339701R2909 | 1 | FIRST OPENING COIL IST. 110Vdc (MB01) | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | 1VCF339800R6913 | 1 | CLOSING COIL 110..127 Vac/dc (MBC) | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| QV1 | 10 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A6 | INCOMING FEEDER TR-100AD1 |

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DWG n° : 231151/SD/15
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00015 | SHEET 3.6 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| QV2 | 10 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| QV3 | 10 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| QV4 | 14 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| QV5 | 15 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| R1 | 21 | 01062220 | 1 | RESISTANCE 22kOhm 5W | | A6 | INCOMING FEEDER TR-100AD1 |
| S1C | 26 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | KW 076 0 | 1 | MP1-10G PUSH BUTTON GREEN WITH BLACK RING | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| S2O | 21 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | EO 570 5 | 2 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | KW 075 2 | 1 | MP1-10R PUSH BUTTON RED WITH BLACK RING | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| SA1 | 24 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | EO 571 3 | 1 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| | | KW 329 3 | 1 | M2SS2-10B HANDLE SELECTOR 2P 90° BLACK RING BLACK | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| TI-L1 | 8 | ATB-10-BS_011 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 600/1-1A cl.0,5-5P20 (5VA) - cl.5P20 (10VA)- 25kA | ESITAS | A6 | INCOMING FEEDER TR-100AD1 |
| TI-L2 | 8 | ATB-10-BS_011 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 600/1-1A cl.0,5-5P20 (5VA) - cl.5P20 (10VA)- 25kA | ESITAS | A6 | INCOMING FEEDER TR-100AD1 |
| TI-L3 | 8 | ATB-10-BS_011 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 600/1-1A cl.0,5-5P20 (5VA) - cl.5P20 (10VA)- 25kA | ESITAS | A6 | INCOMING FEEDER TR-100AD1 |
| TO | 9 | KAP-150/250-95 | 1 | CURRENT TRANSFORMER 0,72/3/-kV 100/1 50Hz | ESITAS | A6 | INCOMING FEEDER TR-100AD1 |
| TR1 | 19 | 800208 | 1 | MODBUS DATACARD 8 CHANNELS | Exertherm | A6 | INCOMING FEEDER TR-100AD1 |
| TU-L1 | 10 | TJP4.3_002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| TU-L2 | 10 | TJP4.3_002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| TU-L3 | 10 | TJP4.3_002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| XC | | HM320GR | 12 | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) | Cabur | A6 | INCOMING FEEDER TR-100AD1 |
| | | HM250GR | 26 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A6 | INCOMING FEEDER TR-100AD1 |
| | | HM251GR | 2 | HMT.4/PT/GR End section - Grey | Cabur | A6 | INCOMING FEEDER TR-100AD1 |
| | | HM321GR | 3 | HMT.6/PT/GR End section - Grey | Cabur | A6 | INCOMING FEEDER TR-100AD1 |
| XI | | HB220GR | 13 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur | A6 | INCOMING FEEDER TR-100AD1 |
| | | HB201GR | 3 | HSCB.6/PT/GR End section - Grey | Cabur | A6 | INCOMING FEEDER TR-100AD1 |
| XM | | HM250GR | 94 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A6 | INCOMING FEEDER TR-100AD1 |
| | | HM251GR | 2 | HMT.4/PT/GR End section - Grey | Cabur | A6 | INCOMING FEEDER TR-100AD1 |
| XR | | HM250GR | 2 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A6 | INCOMING FEEDER TR-100AD1 |
| | | HM251GR | 1 | HMT.4/PT/GR End section - Grey | Cabur | A6 | INCOMING FEEDER TR-100AD1 |
| XS1 | 13 | E 9447 7 | 1 | SOCKET | ABB | A6 | INCOMING FEEDER TR-100AD1 |
| XV | | HB210GR | 16 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type | Cabur | A6 | INCOMING FEEDER TR-100AD1 |
| | | HB201GR | 5 | HSCB.6/PT/GR End section - Grey | Cabur | A6 | INCOMING FEEDER TR-100AD1 |

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DWG n° : 231151/SD/15
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As - Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 - FUNCTIONAL INCOMING FEEDER TR-100AD1
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00015 | SHEET 3.7 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00015 Rev.03

1.4.2.SG-100D1 HV SWG FUNCTIONAL DIAGRAM - BUS BAR METERING (including Terminals and BOM) , Doc. No. 1723002197-EL-DG-00016

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# "SG-100D1" HV SWBD 6,6kV (UNIT A5)

# FUNCTIONAL DIAGRAM

# BUS BAR METERING

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Maccioni | 12/09/2024 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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DWG n° : 231151/SD/16

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 – FUNCTIONAL BUS BAR METERING

Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00016

SHEET 1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

# INDEX

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| 24 | Bill of Materials | | | | | | | | | | | | | | | | | | | | |
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DWG n° : 231151/SD/16
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Sheets Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00016 | SHEET 2 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

# ACRONIMUS LEGEND

| ITEM | DESCRIPTION |
|---|---|
| BB | ARC SENSOR PROTECTION ON MAIN BUS BARS |
| BGE | EARTHING SWITCH |
| C1 | VOLTAGE PRESENCE |
| CB | ARC SENSOR PROTECTION ON C.B. / CONTACTOR COMPARTMENT |
| CC | ARC SENSOR PROTECTION ON CABLE COMPARTMENT |
| DCO | DOUBLE COMMAND OPERATED CONTACTOR |
| DI3 | UNDERVOLTAGE CONTACTOR |
| DP1 | ALARM RELAY MODULE TEMPERATURE |
| E1 | INTERNAL LIGHT |
| E8 | RESISTOR FERRO-RESONANCE |
| EH1 | INTERNAL SPACE HEATER |
| Fn | MV FUSE |
| FP1 | PROTECTION RELAY |
| GS1 | DC/DC CONVERTER |
| HGR | THERMOSTAT |
| Kn | AUXILIARY RELAY |
| K1 | MV CONTACTOR |
| K86 | BLOCK RELAY |
| KT1 | DE-ENERGIZATION TIMER |
| LS | MICRO SWITCH ON AUXILIARY DOOR |
| MAS | MOTOR SPRING CHARGER |
| MBC | CLOSING COIL |
| MBO1 | OPENING COIL |
| MBU | UNDERVOLTAGE |
| ODn | VOLTAGE DISCHARGER |
| PU1 | MEASURING VOLTAGE INSTRUMENT |
| PTT | V.T. TRUCK |
| QM | MV CIRCUIT-BREAKER |

| ITEM | DESCRIPTION |
|---|---|
| QDn | M.C.B. CIRCUITS PROTECTION |
| QVn | M.C.B FOR V.T. PROTECTION |
| RLE1 | COIL FOR CONSET CLOSING CIRCUIT-BREAKER |
| RLE2 | COIL FOR UNLOCKING RACK-IN/OUT OPERATION |
| RLE3 | COIL FOR UNLOCKING OPERATION EARTHING |
| RLE4 | COIL FOR UNLOCKING ENCLOSURE DOOR OPERATION |
| SU1 | VOLTAGE SELECTOR |
| SWH... | ETHERNET SWITCH |
| TI-Ln | CURRENT TRANSFORMER |
| TO | OMOPOLAR RING CURRENT TRANSFORMER |
| TR1 | TEMPERATURE CONTROL DEVICE |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231151/SD/16
Item n° : PF1113279

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Legend

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

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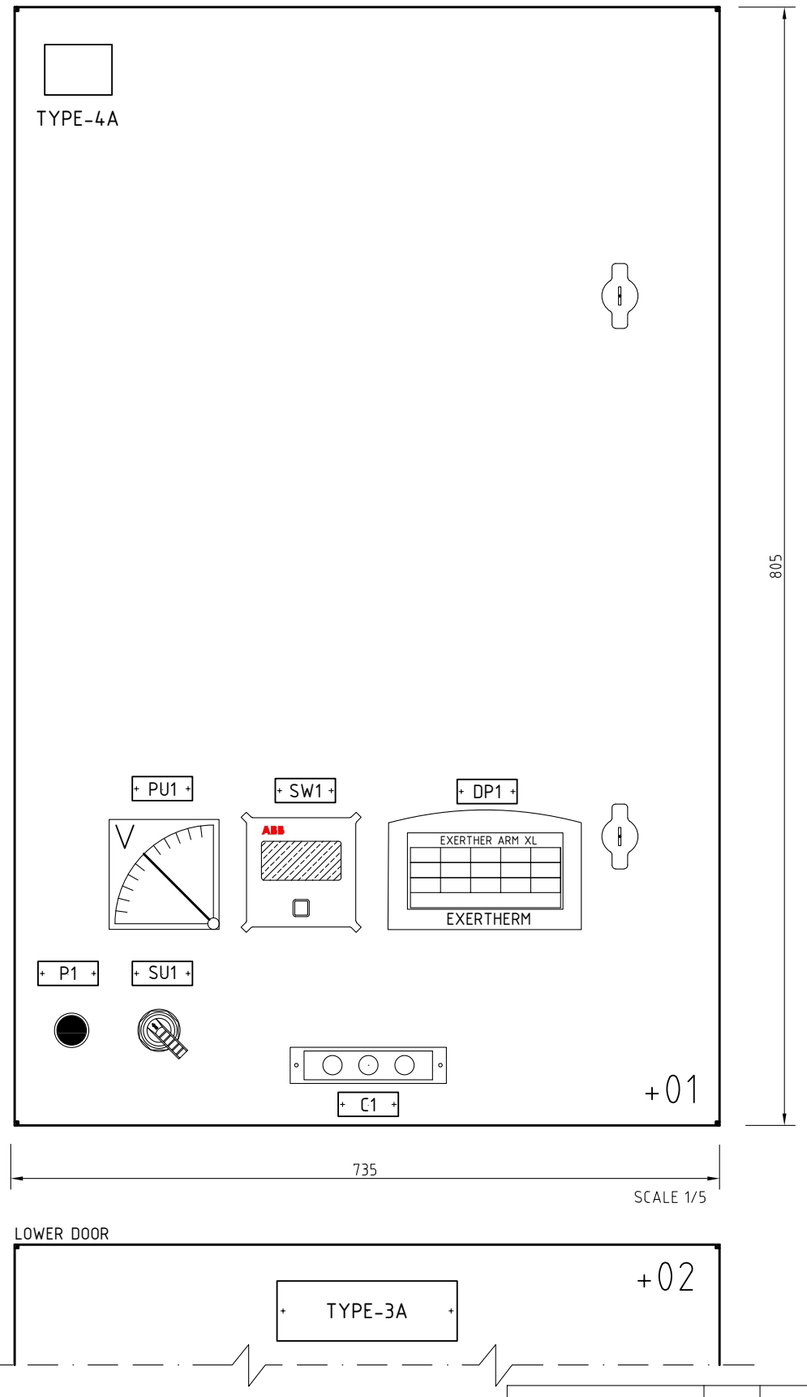
SHEET 3

REV. 03

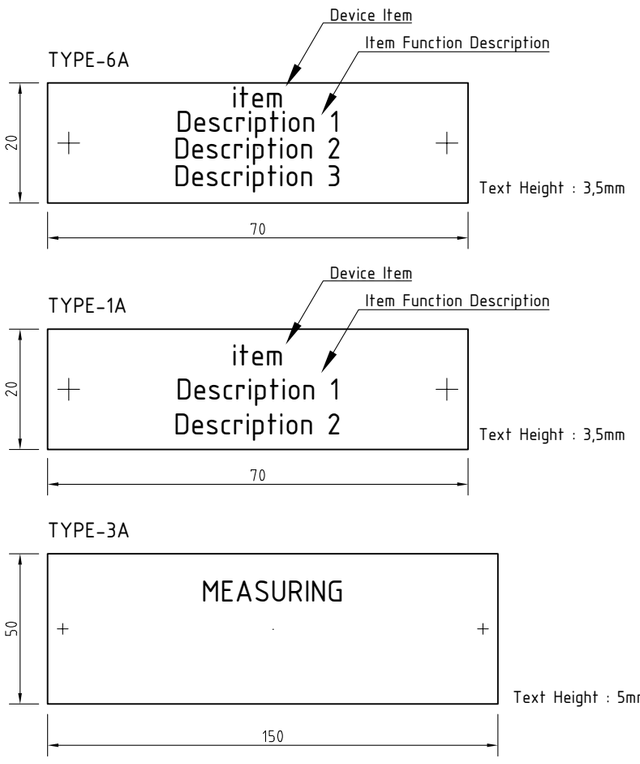
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# DOOR LAY-OUT




| DEVICES name plate | | | | | |
|---|---|---|---|---|---|
| ITEM | COMPONENT | DESCRIPTION 1 | DESCRIPTION 2 | DESCRIPTION 3 | NOTE |
| C1 | PILOT LIGHT | VOLTAGE | PRESENCE | | TYPE-2A |
| P1 | PUSHBUTTON | EARTHING SWITCH | SWITCH | ENABLING | TYPE-5A |
| SU1 | SWITCH | VOLMETRIC | SWITCH | | TYPE-2A |
| PU1 | ANALOG INSTRUMENT | BUS-BARS | VOLTAGE | | TYPE-1A |
| SW1 | SWICOM | PARTIAL DISCHARGE | MONITORING DISPLAY | | TYPE-1A |
| DP1 | ARM XL | INFRARED | TEMPERATURE | DETECTION DISPLAY | TYPE-6A |




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DWG n° : 231151/SD/16
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Door Layout

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

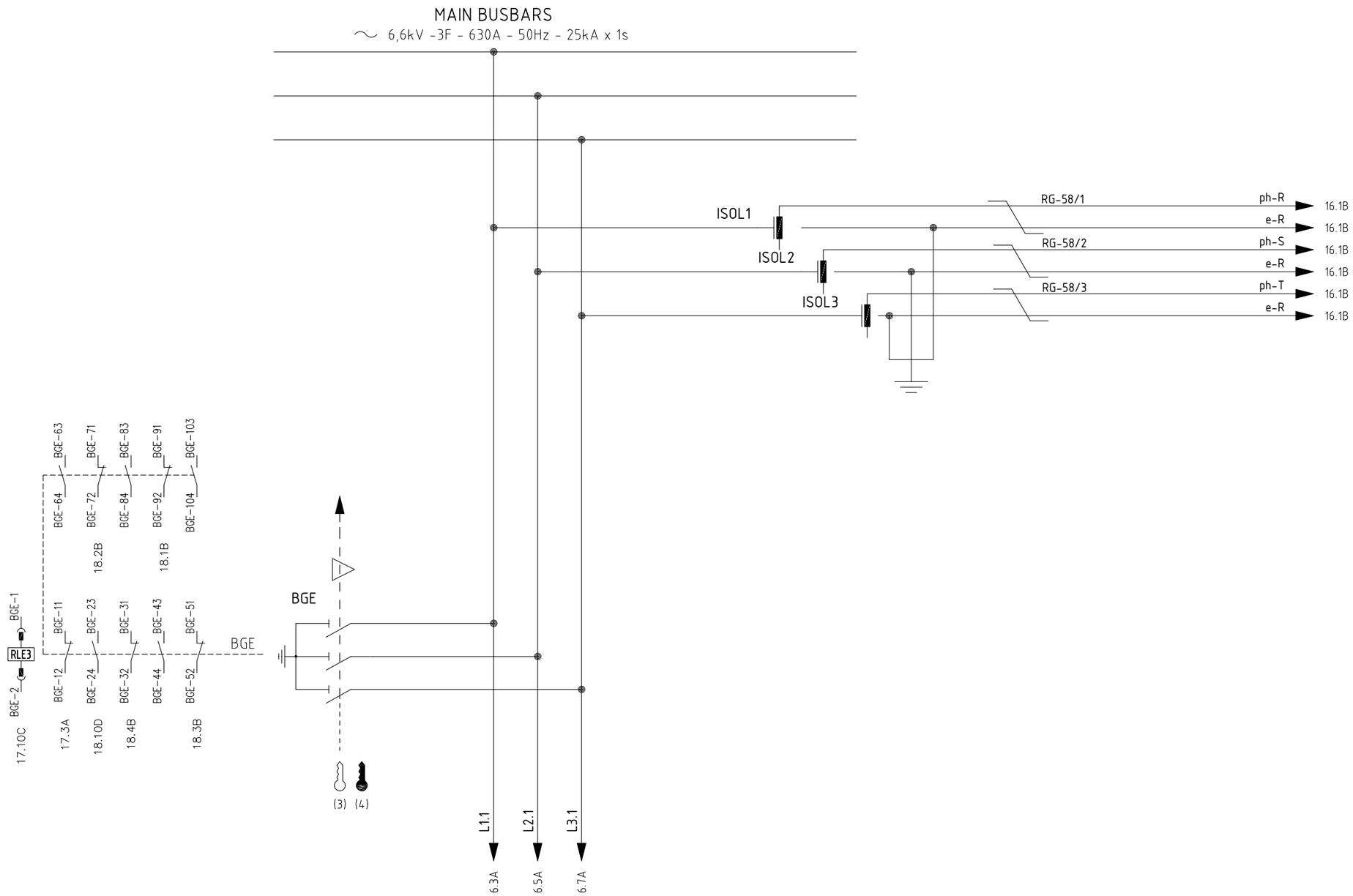
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SHEET 4

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03




(3) FREE KEY WITH EARTHING SWITCH IN OPEN POSITION

(4) FREE KEY WITH EARTHING SWITCH IN CLOSED POSITION

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Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

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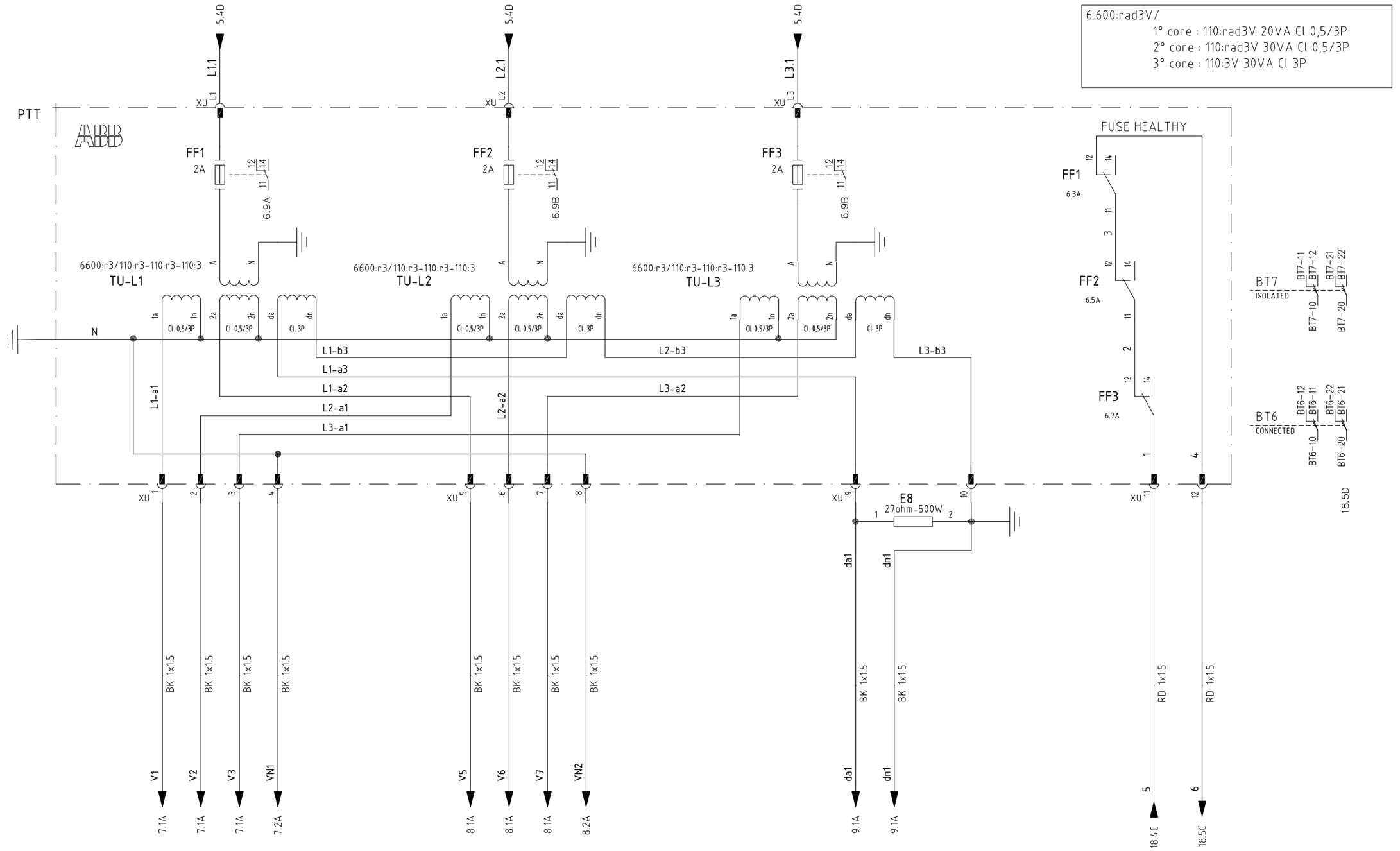
DRAWING NO. 1723002197-EL-DG-00016

SHEET 5

REV. 03

File Name : 1723002197-EL-DG-00016 Rev.03

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IMESA ELECTRICAL ENGINEERING

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ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Power Diagram

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SCALE : NTS

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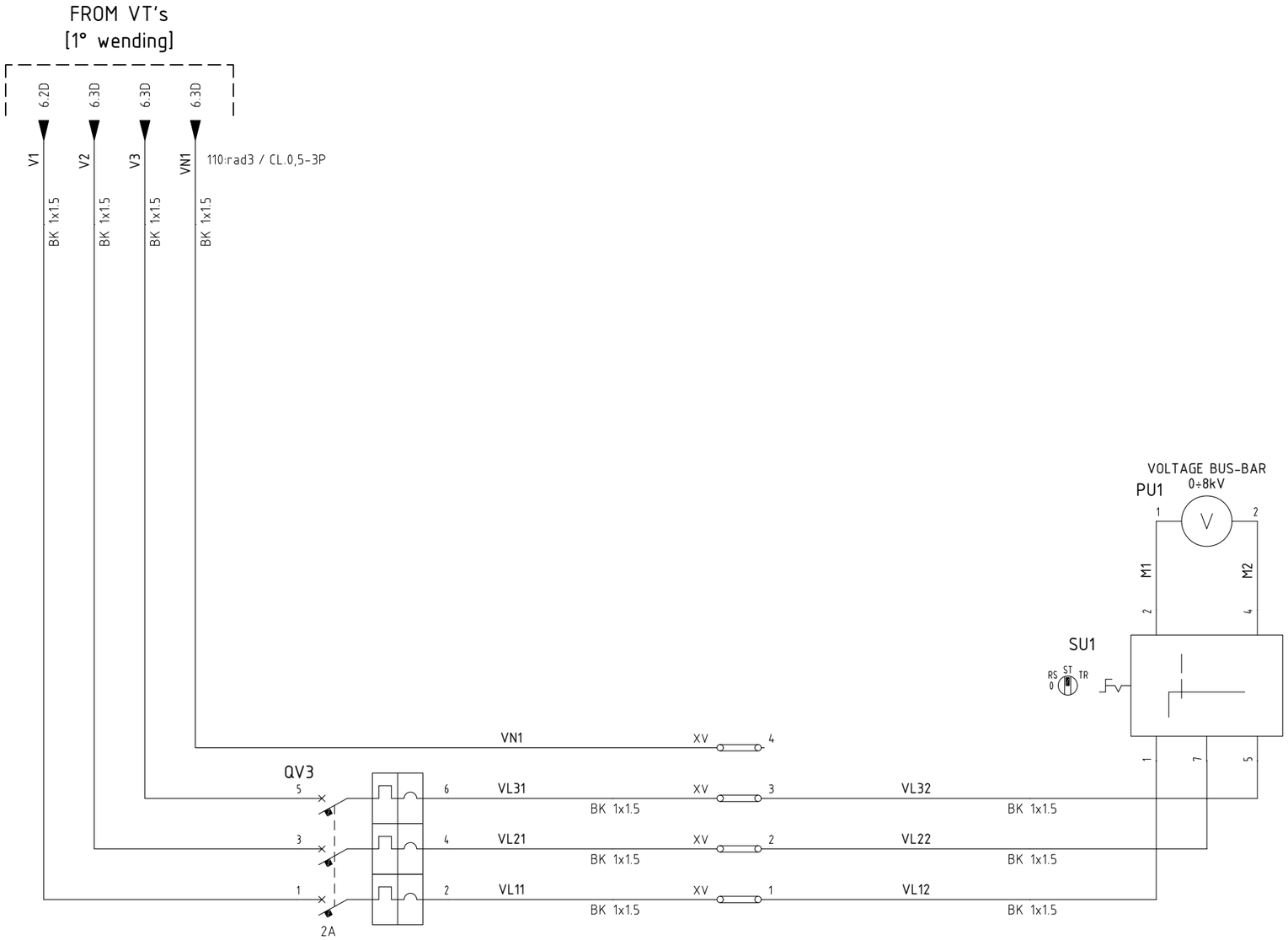
SHEET 6

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

# 110V:rad3 TO VOLTAGE INDICATOR




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DWG n° : 231151/SD/16
Item n° : PF1113279

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00016

SHEET 7

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

# 110V: rad3 DISTRIBUTION from MEASURE CUBICLE

FROM VT's
[2° wending]

V5 6.4D — V6 6.5D — V7 6.5D — VN2 6.5D

110:rad3 / CL.0,5-3P

BK 1x1.5

18.4D 11 12 14

QV5
3 — 4 VN31 — 1x1.5 BK — XV — 15 VN32 — 1x1.5 BK — 15 XM
1 — 2 V31 — 1x1.5 BK — XV — 16 V32 — 1x1.5 BK — 16 XM
2A

AVR TO TAP CHANGER TRANSFORMER

18.4D 11 12 14

QV2
7 — 8 VN21 — BK 1x1.5 — XV — 8 — NV — BK 1x1.5
5 — 6 V71 — BK 1x1.5 — XV — 7 — L3V — BK 1x1.5
3 — 4 V61 — BK 1x1.5 — XV — 6 — L2V — BK 1x1.5
1 — 2 V51 — BK 1x1.5 — XV — 5 — L1V — BK 1x1.5
2A

18.1D 11 12 14

QV4
7 — 8 VN22 — BK 1x1.5 — XV — 11 VN23 — BK 1x1.5 — 11 XM
5 — 6 V72 — BK 1x1.5 — XV — 12 V73 — BK 1x1.5 — 12 XM
3 — 4 V62 — BK 1x1.5 — XV — 13 V63 — BK 1x1.5 — 13 XM
1 — 2 V52 — BK 1x1.5 — XV — 14 V53 — BK 1x1.5 — 14 XM
2A

SYNCHRONIZER TO THE BESS

110:√3V VOLTMETRIC LINE - STAR
(FOR PROTECTION/MEASURE)

TO NEXT PANEL

110V-cl.0,5/3P

13 XC — 15 XC — 17 XC — 19 XC
14 XC — 16 XC — 18 XC — 20 XC

TO NEXT PANEL

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ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

110V Protection/Measure Distribution Voltage

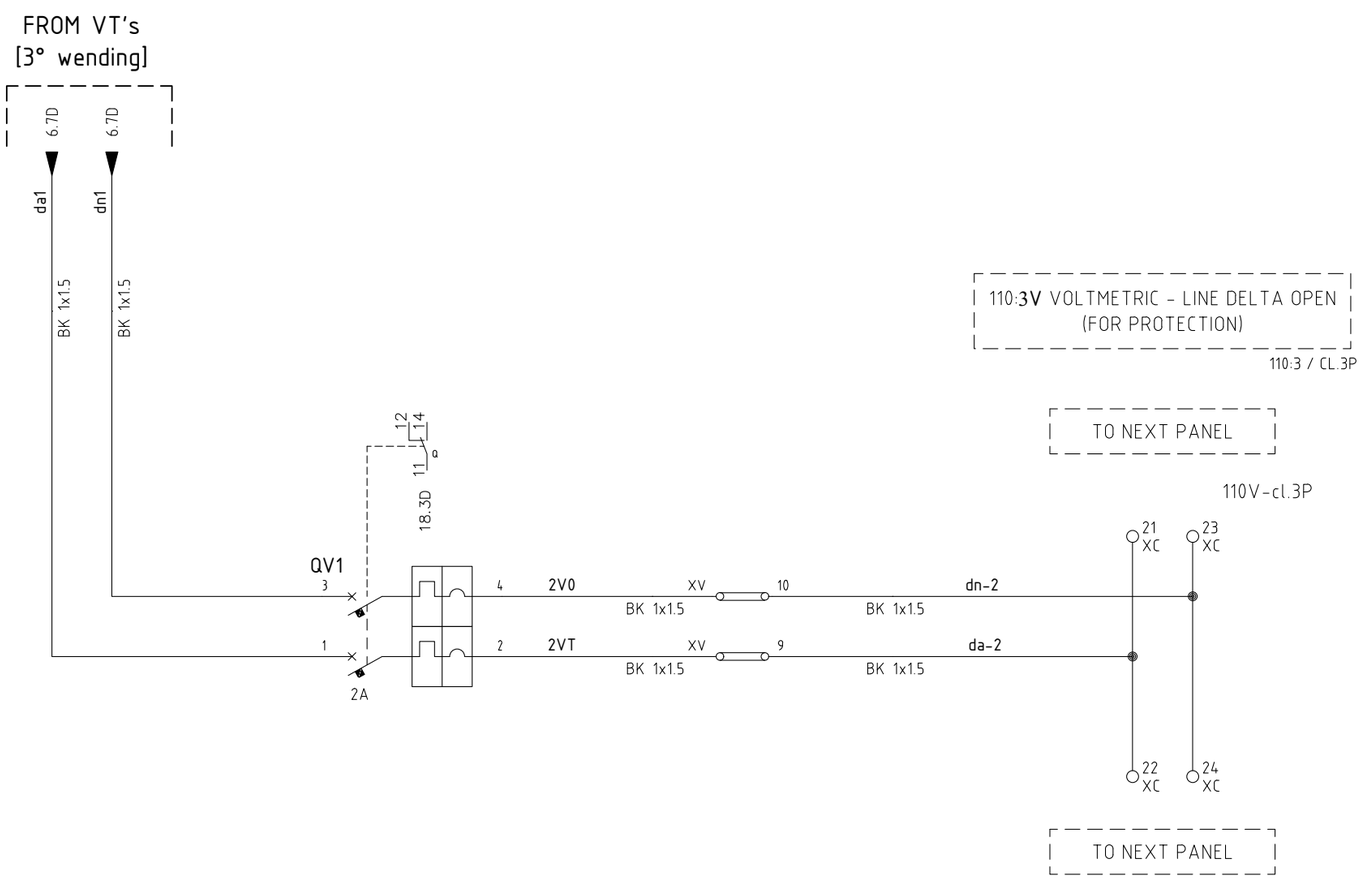
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A3 | DRAWING NO. 1723002197-EL-DG-00016 | SHEET 8 | REV. 03

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# 110V:3 DISTRIBUTION VOLTAGE TO MEASURE CUBICLE




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IMESA ELECTRICAL ENGINEERING

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TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00016

SHEET 9

REV. 03

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File Name : 1723002197-EL-DG-00016 Rev.03

# 230VAC DISTRIBUTION VOLTAGE

230Vac Auxiliary Voltage
from DP-200N1-Q38

TO NEXT PANEL

MCB INTERNAL LIGHTING HEATERS AND SOCKET

INTERNAL SPACE HEATER

230VAC SOCKET [AUXILIARY COMPARTMENT]

230VAC AUXILIARY HEALTLY

230V-50Hz

QA1
5 XM — 230VN1 — BK 1x6 — 3
6 XM — 230VN2 — BK 1x6 — 1
32A
4 — 230/1 — BK 1x6
2 — 230/2 — BK 1x6

9 XC, 11 XC, 10 XC, 12 XC

BK 1x6 (x2)

QA2
10A
1, 3
12, 14
11
18.7D
300mA

2, 4
10, 11

BK 1x1.5 (x2)

K230 A1 / A2

18.3D 11 12 14 22 21 24 32 31 34 42 41 44

BK 1x2.5
BK 1x2.5

LS NC NA COM 12 BK 1x1.5

HGR 1 1x1.5 BK
RANGE -10-80°C
2 13 BK 1x1.5

XS1
230V+PE 10/16A

E1 L N 4W

EH1 L N 150W
1x1.5 BK
1x1.5 BK

KGR A1 A2
1x1.5 BK
18.6D 11 12 14 42 41 44

TO NEXT PANEL

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

230Vac Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00016

SHEET 10

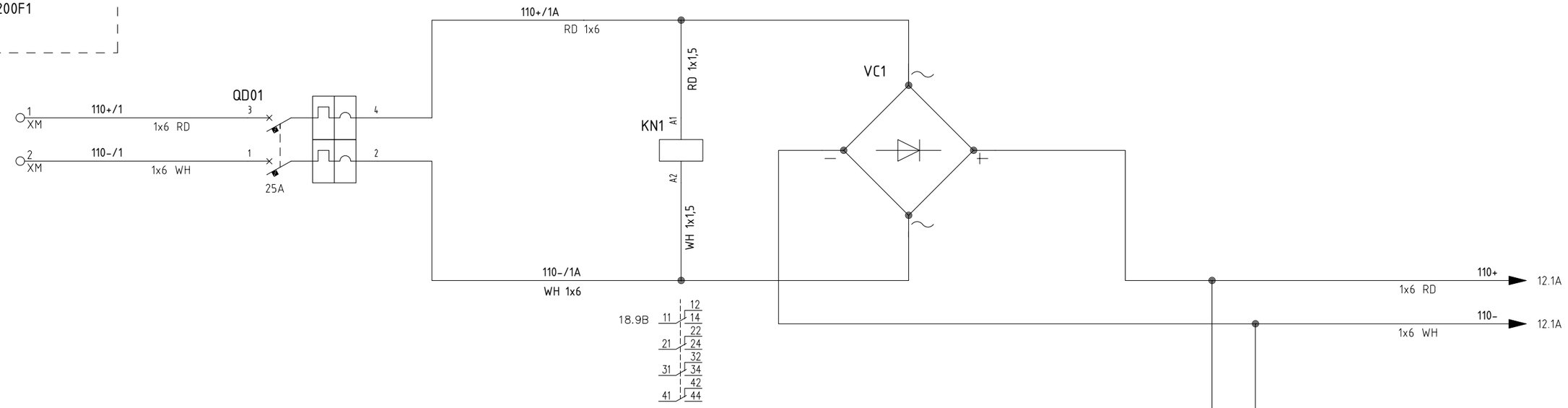
REV. 03

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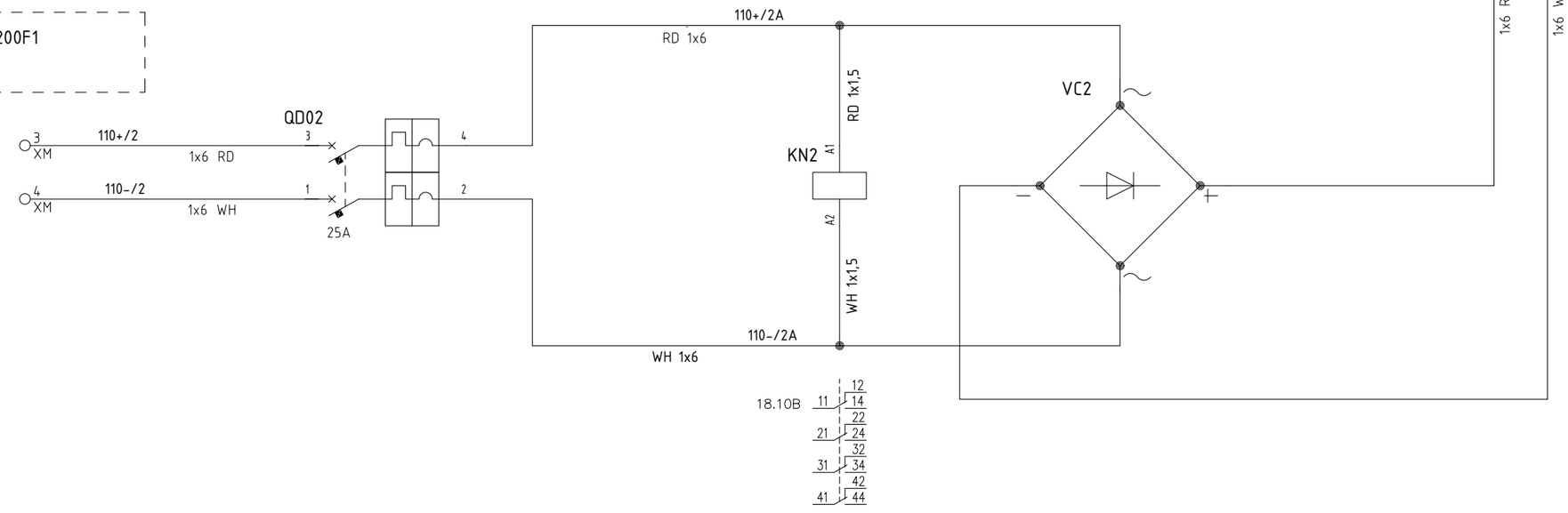
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# 110VDC DISTRIBUTION VOLTAGE

+DP-200F1
-Q12




+DP-200F1
-Q13




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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

110Vdc Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

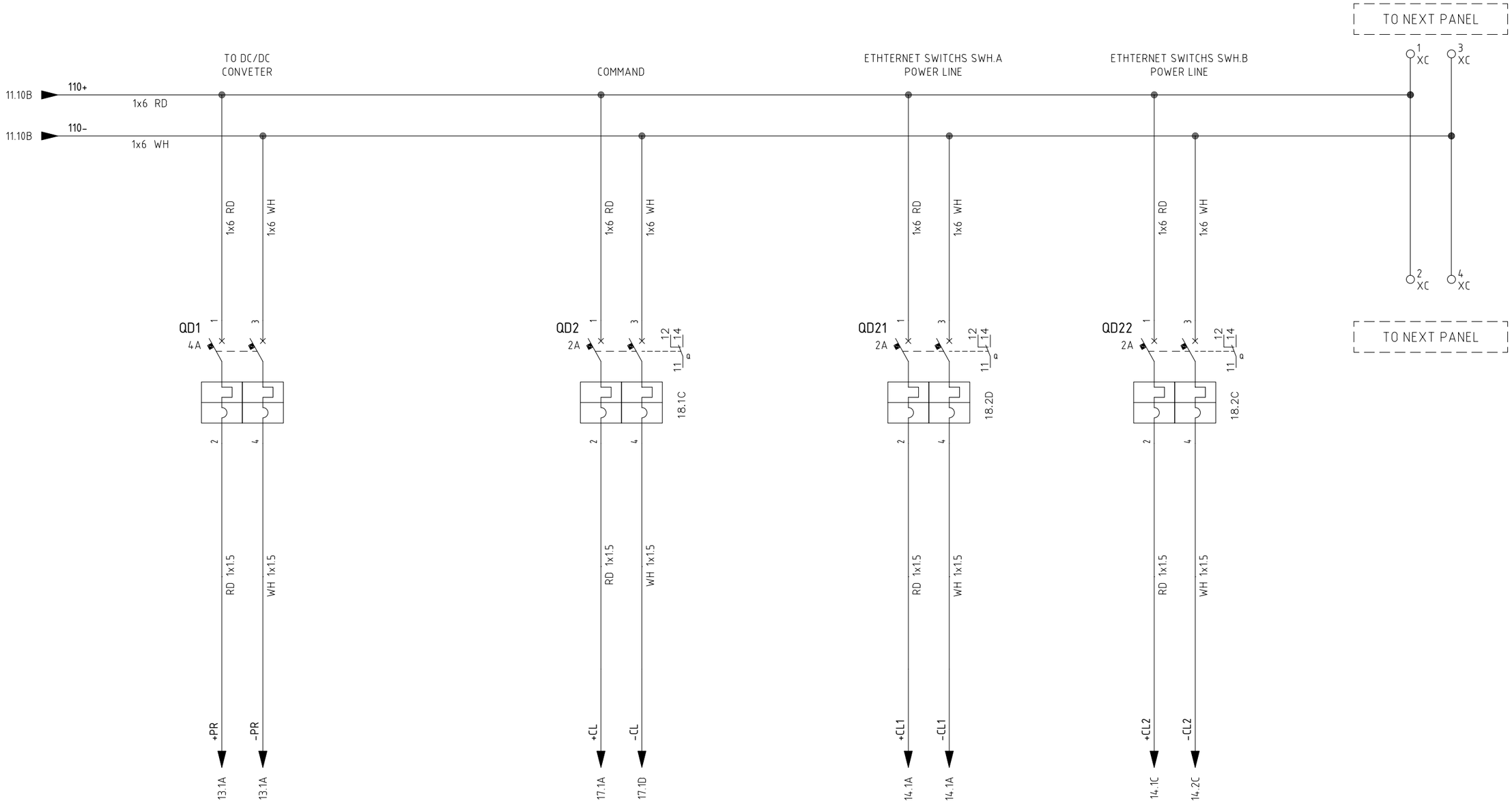
DRAWING NO. 1723002197-EL-DG-00016

SHEET 1.1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 27/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/16

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

110Vdc/24Vdc Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

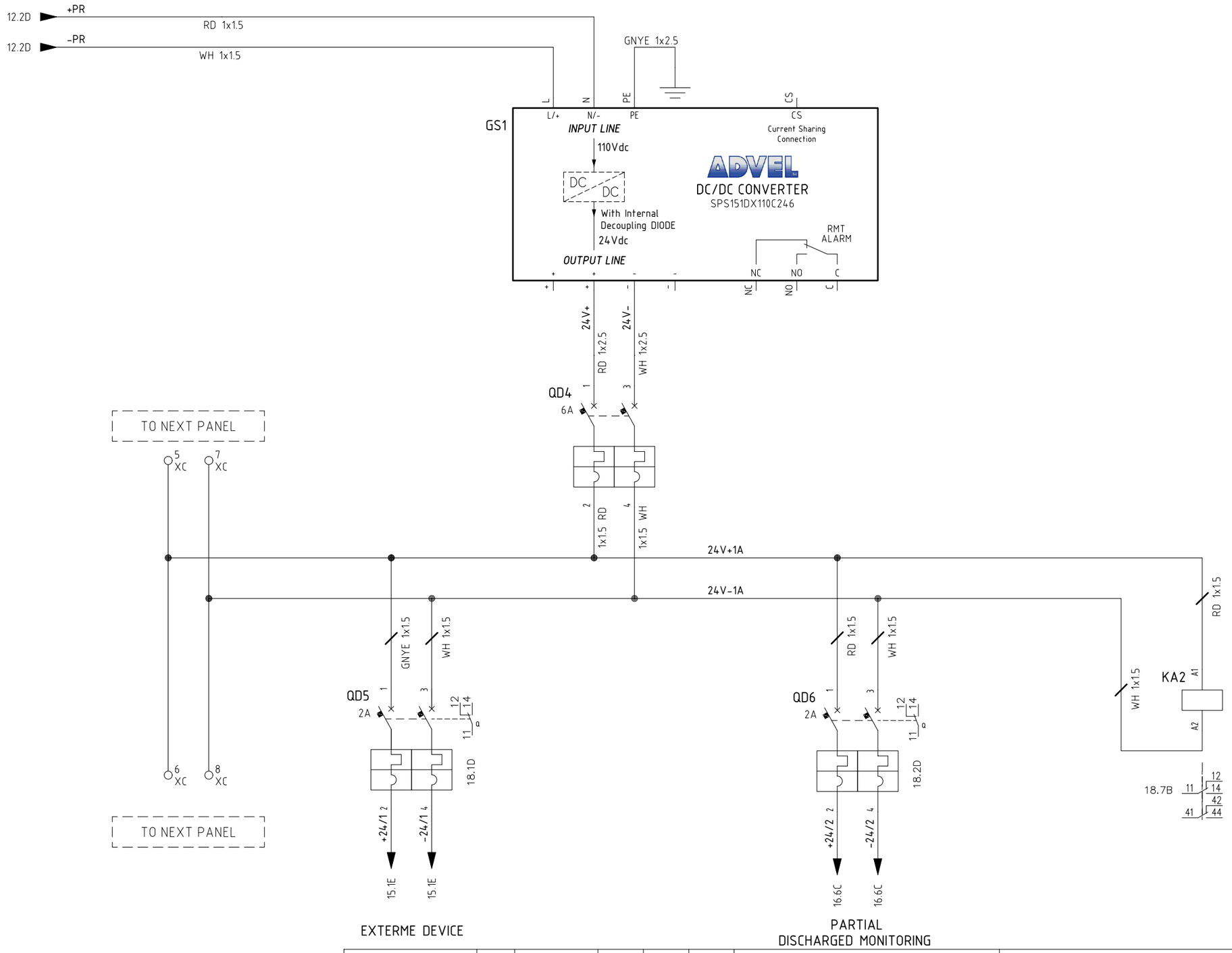
DRAWING NO. 1723002197-EL-DG-00016

SHEET 12

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03




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|---|---|---|---|---|---|---|---|
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| +A5 | | | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | | |
| 2 | 27/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | | |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | | |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | | |
| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | | |

DWG n° : 231151/SD/16
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

24Vdc Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

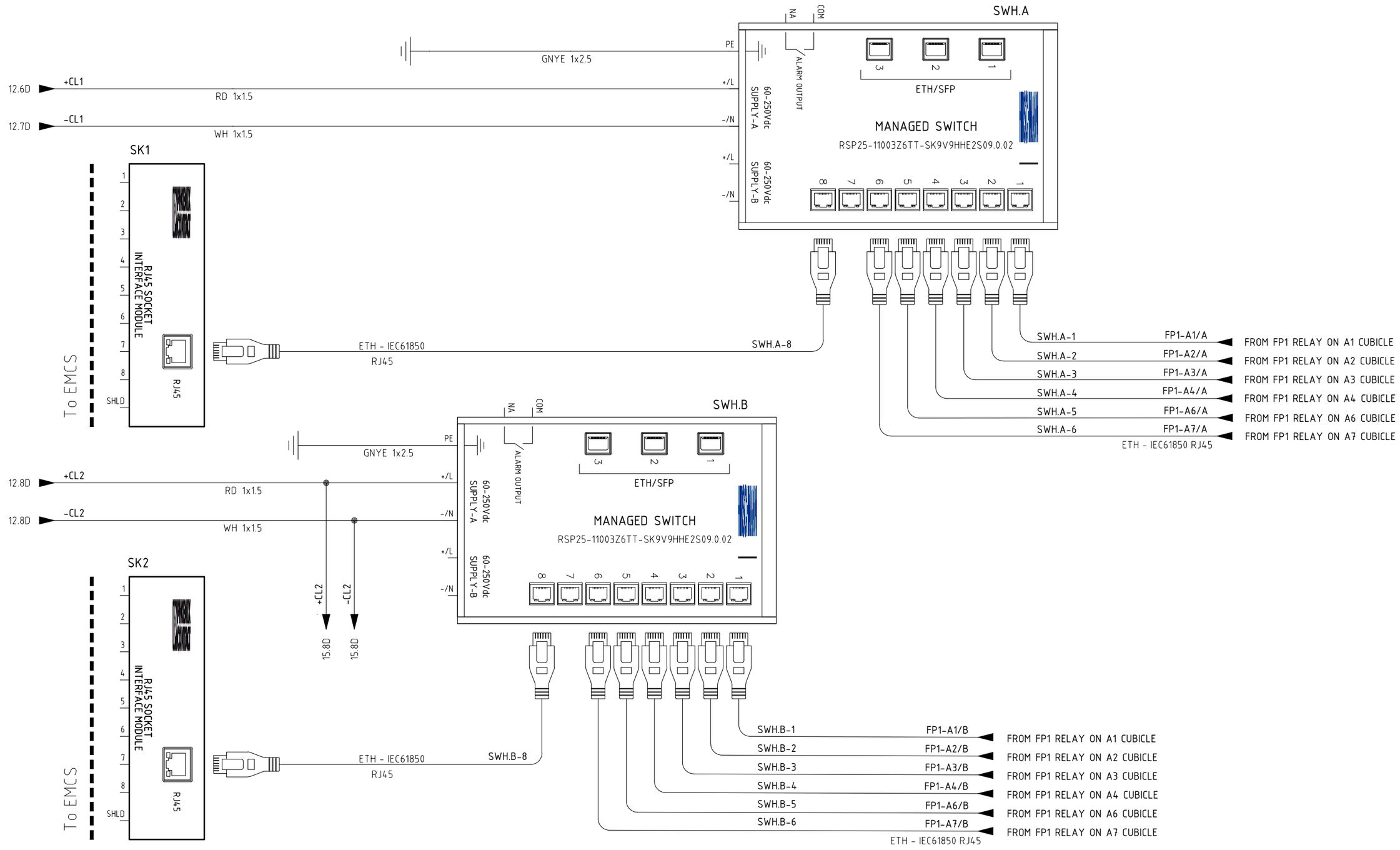
DRAWING NO. 1723002197-EL-DG-00016

SHEET 1.3

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 27/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/16
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Switchs

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

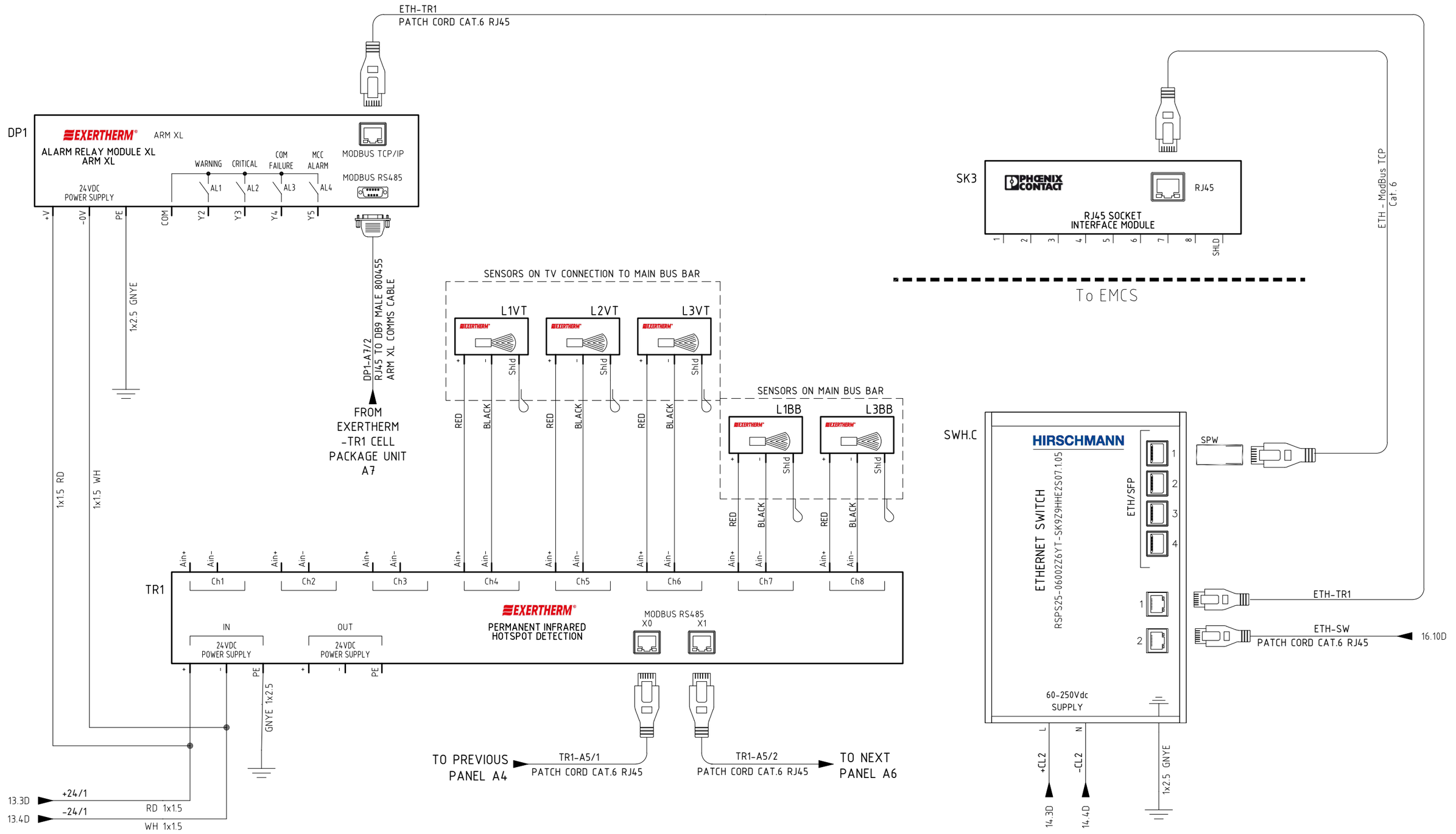
DRAWING NO. 1723002197-EL-DG-00016

SHEET 14

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03




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| = | | | | | | | |
| +A5 | | | | | | | |
| DWG n° : 231151/SD/16 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| Item n° : PF1113279 | 2 | 27/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Extherm Device

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

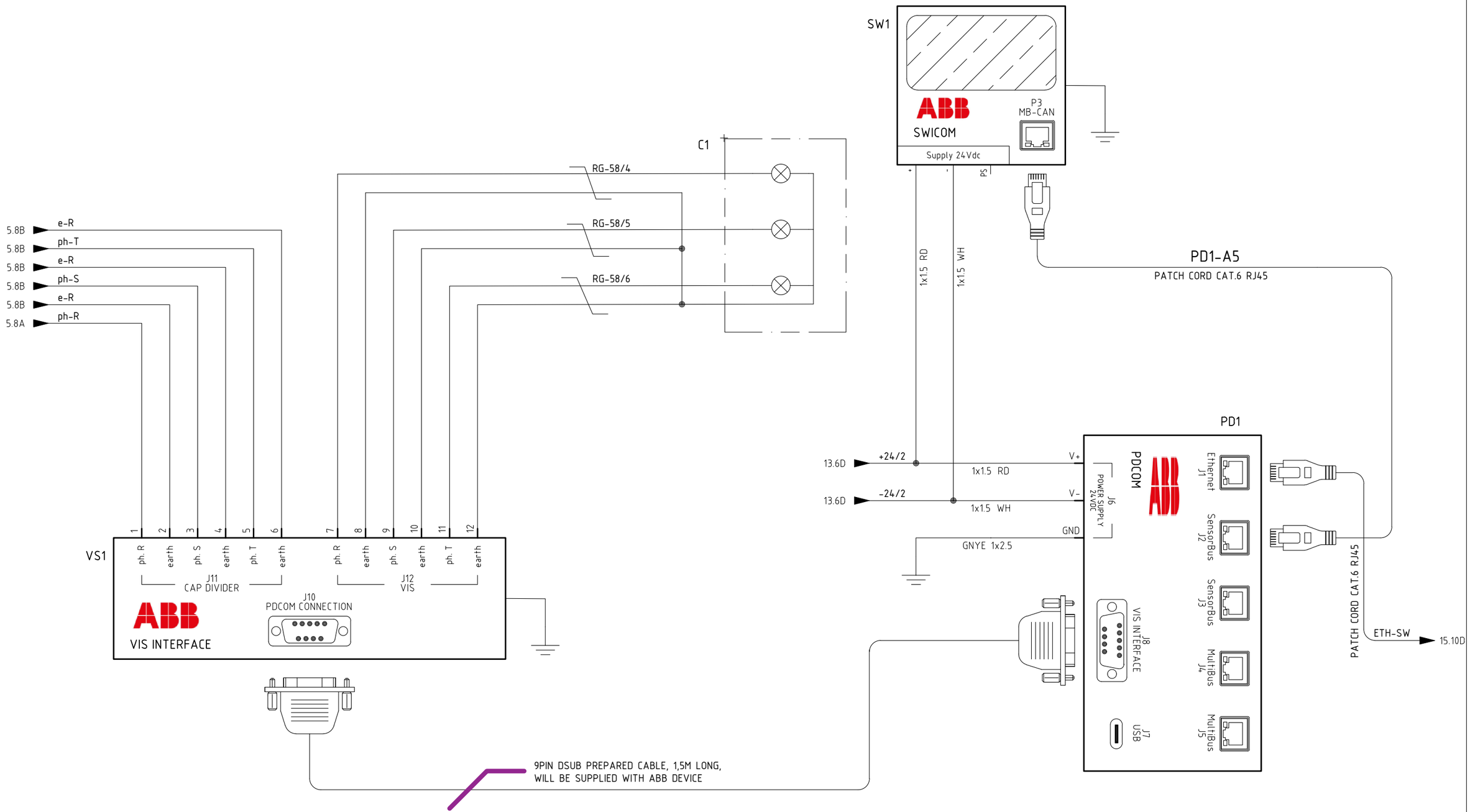
DRAWING NO. 1723002197-EL-DG-00016

SHEET 15

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 27/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A5
DWG n° : 231151/SD/16
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Partial discharge monitoring PDCOM

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00016

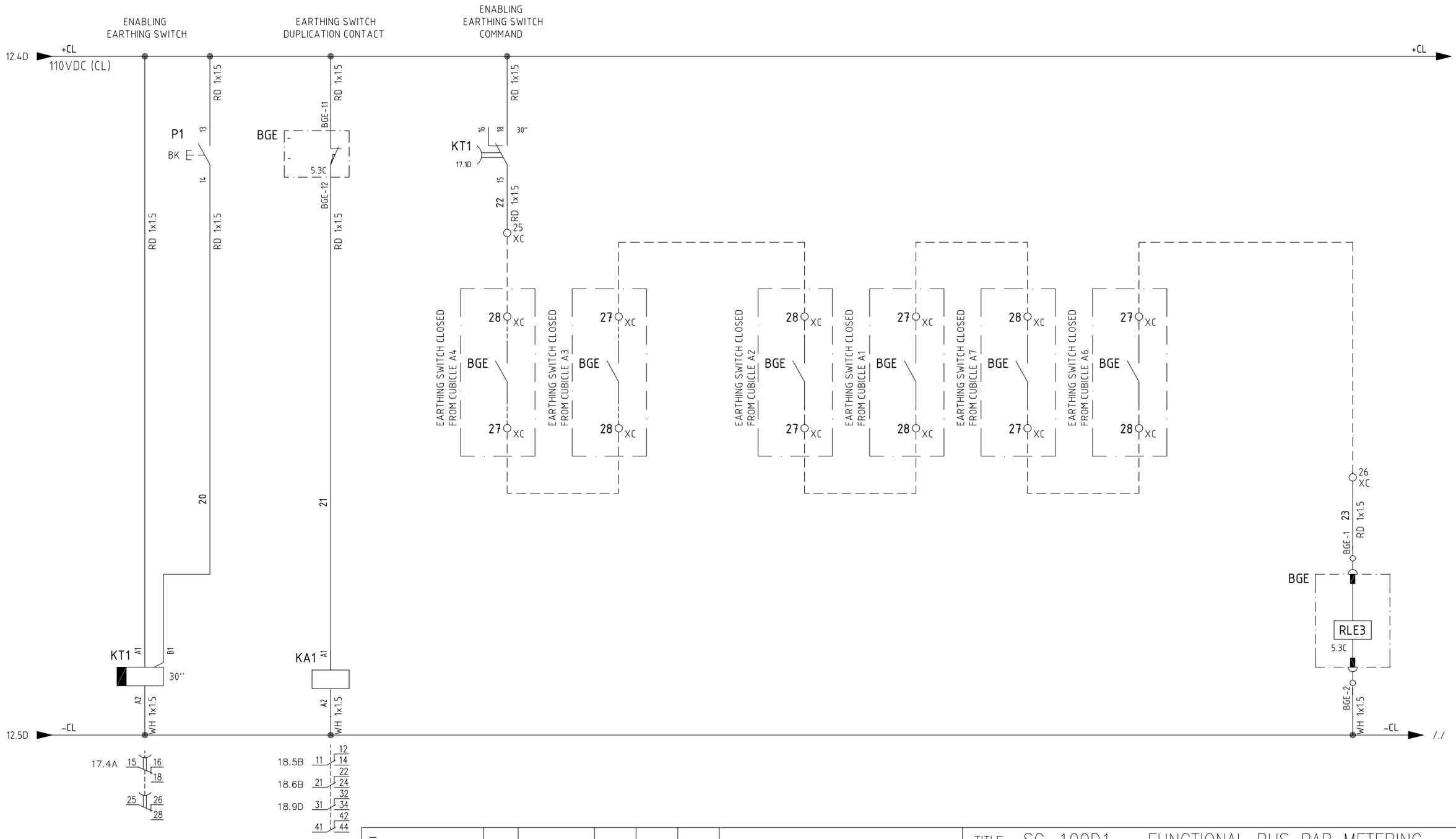
SHEET 1.6

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

# COMMAND CIRCUITS




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|---|---|---|---|---|---|---|
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| +A5 | | | | | | |
| DWG n° : 231151/SD/16 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| Item n° : PF1113279 | 2 | 27/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00016

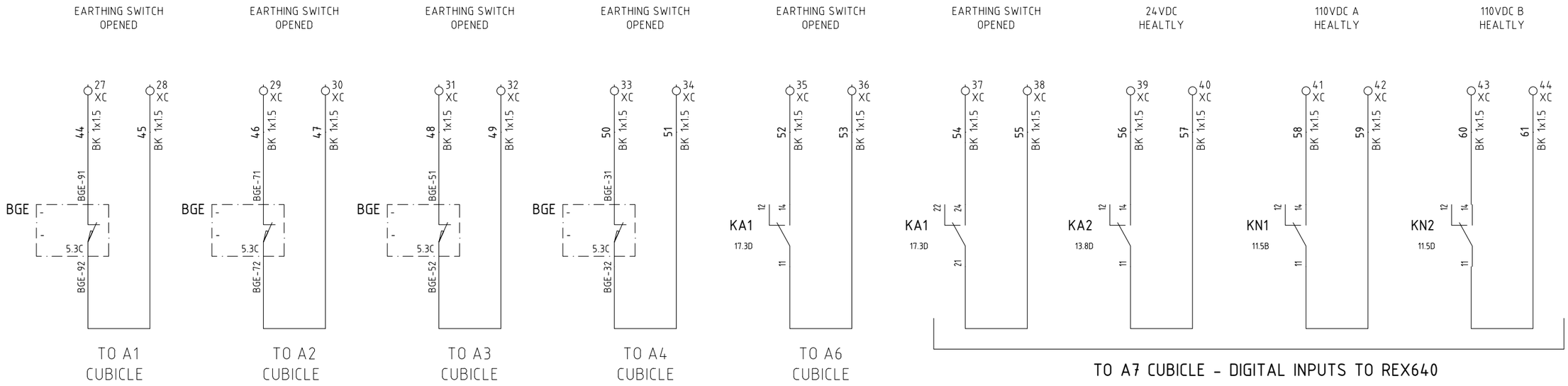
SHEET 17

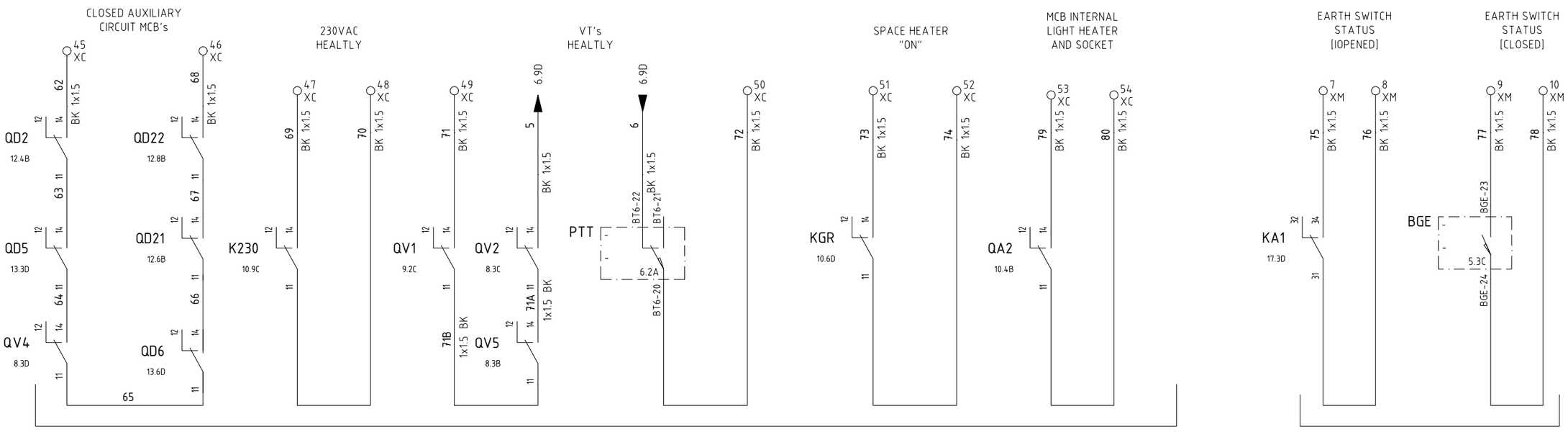
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

# AVAILABLE SIGNALS




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|---|---|---|---|---|---|---|---|
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| +A5 | | | | | | | |
| DWG n° : 231151/SD/16 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| Item n° : PF1113279 | 2 | 27/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Availables Signals

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00016

SHEET 18

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

TYP - METERING
XC
Interconnection Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 12.9A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 2 | 12.9B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 3 | 12.10A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 4 | 12.10B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 5 | 13.2C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 6 | 13.2D | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 7 | 13.2C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 8 | 13.2D | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 9 | 10.10A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 10 | 10.10B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 11 | 10.10A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 12 | 10.10B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 13 | 8.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 8.7D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 8.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 8.7D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 8.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 8.7D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 8.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 8.7D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 21 | 9.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 9.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 9.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 9.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 25 | 17.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 17.10C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 18.1A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 18.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 18.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 18.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 18.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 18.4A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 18.4A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 18.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 18.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 18.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

TYP - METERING
XC
Interconnection Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 37 | 18.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 38 | 18.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 39 | 18.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 40 | 18.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 41 | 18.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 42 | 18.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 43 | 18.10A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 44 | 18.10A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 45 | 18.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 46 | 18.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 47 | 18.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 48 | 18.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 49 | 18.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 50 | 18.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 51 | 18.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 52 | 18.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 53 | 18.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 54 | 18.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

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DWG n° : 231151/SD/16
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 27/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Terminal Strips

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00016 | SHEET 19 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

TYP - METERING

XM

Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 11.1B | 10 | HM330GR | Cabur | HMM.10/GR Feed-through Terminal Block - Grey (10 mmq) |
| 2 | 11.1B | 10 | HM330GR | Cabur | HMM.10/GR Feed-through Terminal Block - Grey (10 mmq) |
| | | | HM331GR | Cabur | HMT.10/PT/GR End section - Grey |
| 3 | 11.1C | 10 | HM330GR | Cabur | HMM.10/GR Feed-through Terminal Block - Grey (10 mmq) |
| 4 | 11.1D | 10 | HM330GR | Cabur | HMM.10/GR Feed-through Terminal Block - Grey (10 mmq) |
| | | | HM331GR | Cabur | HMT.10/PT/GR End section - Grey |
| 5 | 10.1A | 10 | HM330GR | Cabur | HMM.10/GR Feed-through Terminal Block - Grey (10 mmq) |
| 6 | 10.1B | 10 | HM330GR | Cabur | HMM.10/GR Feed-through Terminal Block - Grey (10 mmq) |
| | | | HM331GR | Cabur | HMT.10/PT/GR End section - Grey |
| 7 | 18.9C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 8 | 18.9C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 9 | 18.10C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 10 | 18.10C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 11 | 8.6D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 12 | 8.6D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 13 | 8.6D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 8.6D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 8.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 8.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| +A5 | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 27/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/16

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Terminal strips

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00016

SHEET 20

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

TYP - METERING

XV

Voltmetric Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 1 | 7.4D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 2 | 7.4D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 3 | 7.4D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 4 | 7.4C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 5 | 8.5C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 6 | 8.5C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 7 | 8.5C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 8 | 8.5C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 9 | 9.4C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 10 | 9.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 11 | 8.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 12 | 8.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 13 | 8.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 14 | 8.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 15 | 8.5B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 16 | 8.5B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |

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DWG n° : 231151/SD/16

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 27/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Terminal strip

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00016

SHEET 21

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BGE | 5 | 1VCF599700R0131 | 1 | EARTHING SWITCH ST-E 17.31 150 | ABB | A5 | BUS BAR METERING |
| | | 1VCF599505R0001 | 1 | 5 AUX CONTACTS FOR EARTHING SWITCH | ABB | A5 | BUS BAR METERING |
| | | 1VCF599504R0063 | 1 | KEY LOCKS ON EARTHING SWITCH | ABB | A5 | BUS BAR METERING |
| | | 1VCF599700R0290 | 1 | EARTHING SWITCH OPERATING LEVER | ABB | A5 | BUS BAR METERING |
| C1 | 16 | 43931118 | 1 | VPIS 3,3÷36KV - DEVICE SIGNALLING VOLTAGE PRESENT KIT | ELECTRONSYSTEM | A5 | BUS BAR METERING |
| DP1 | 15 | 900451 | 1 | Alarm Relay Module XL (ARM XL) - 4.3" Touchscreen Display | Exertherm | A5 | BUS BAR METERING |
| E1 | 10 | 74041 | 1 | LED LAMP 4W 4000K 313x30x22 | Beghelli | A5 | BUS BAR METERING |
| E8 | 6 | 1VCF501000R0001 | 1 | RESISTOR TR318 27R/J 27ohm 500W L=2,5M | ABB | A5 | BUS BAR METERING |
| EH1 | 10 | R1R150230 | 1 | SPACE HEATER SKR 150W ALIM. 220VCA | Torresan | A5 | BUS BAR METERING |
| FF1 | 6 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A5 | BUS BAR METERING |
| FF2 | 6 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A5 | BUS BAR METERING |
| FF3 | 6 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A5 | BUS BAR METERING |
| GS1 | 13 | SPS151DX110C246 | 1 | DC/DC CONVERTER 110VDC/24VDC 150W SPS151DX110C246 | ADVEL | A5 | BUS BAR METERING |
| HGR | 10 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | A5 | BUS BAR METERING |
| K230 | 10 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A5 | BUS BAR METERING |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A5 | BUS BAR METERING |
| | | ER 552 0 | 1 | CR-M230AC2L AUXILIARY RELAY 230VAC WITH 4 CONTACTS | ABB | A5 | BUS BAR METERING |
| KA1 | 17 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A5 | BUS BAR METERING |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A5 | BUS BAR METERING |
| | | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A5 | BUS BAR METERING |
| KA2 | 13 | ER 545 4 | 1 | CR-M024DC2L AUXILIRY RELAY 24VDC WITH 2 CONTACTS | ABB | A5 | BUS BAR METERING |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A5 | BUS BAR METERING |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A5 | BUS BAR METERING |
| KGR | 10 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A5 | BUS BAR METERING |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A5 | BUS BAR METERING |
| | | ER 552 0 | 1 | CR-M230AC2L AUXILIARY RELAY 230VAC | ABB | A5 | BUS BAR METERING |
| KN1 | 11 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A5 | BUS BAR METERING |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A5 | BUS BAR METERING |
| | | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A5 | BUS BAR METERING |
| KN2 | 11 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A5 | BUS BAR METERING |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A5 | BUS BAR METERING |
| | | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A5 | BUS BAR METERING |
| KT1 | 17 | H3DKM2ACDC24240 | 1 | MULTIFUNCTION TIMER RELAY Vaux=24÷240Vac/dc - 2SC | Omron | A5 | BUS BAR METERING |
| L1I | 15 | 801100 | 1 | IR.06-EM.SC Sensor, ΔT, ABS Housing, 10mtr Cable | Exertherm | A5 | BUS BAR METERING |
| L1MS | 15 | 801100 | 1 | IR.06-EM.SC Sensor, ΔT, ABS Housing, 10mtr Cable | Exertherm | A5 | BUS BAR METERING |
| L2I | 15 | 801100 | 1 | IR.06-EM.SC Sensor, ΔT, ABS Housing, 10mtr Cable | Exertherm | A5 | BUS BAR METERING |
| L3I | 15 | 801100 | 1 | IR.06-EM.SC Sensor, ΔT, ABS Housing, 10mtr Cable | Exertherm | A5 | BUS BAR METERING |
| L3MS | 15 | 801100 | 1 | IR.06-EM.SC Sensor, ΔT, ABS Housing, 10mtr Cable | Exertherm | A5 | BUS BAR METERING |
| LS | 10 | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | A5 | BUS BAR METERING |
| | | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | A5 | BUS BAR METERING |
| P1 | 17 | KW 080 2 | 1 | MP1-10B BLACK PUSH BUTTON UNSTABLE | ABB | A5 | BUS BAR METERING |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A5 | BUS BAR METERING |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A5 | BUS BAR METERING |
| PD1 | 16 | 1VC123000074Q02 | 1 | PDCOM | ABB | A5 | BUS BAR METERING |

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DWG n° : 231151/SD/16

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 27/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00016 | SHEET 22 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| PTT | 6 | 1VCF498412R0100 | 1 | TV/F COMPARTMENT 12/17kV IP4X L=590mm OUTLET ON THE BACK WITH N°3 VT + N°14 MAIN CONTACTS + N°2+2 SERVICE/ISOLATED POSITION CONTACTS | ABB | A5 | BUS BAR METERING |
| | | 1VCF499800R0302 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR TV/F | ABB | A5 | BUS BAR METERING |
| PU1 | 7 | F96EVXYYYXC1 | 1 | VOLTMETER 96x96 90° SCALE 0÷8kV ON TV 6,6kV/110V | FRER | A5 | BUS BAR METERING |
| QA1 | 10 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A5 | BUS BAR METERING |
| | | S600613 | 1 | M.C.B. S202 M - D32A | ABB | A5 | BUS BAR METERING |
| QA2 | 10 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A5 | BUS BAR METERING |
| | | S550284 | 1 | S202M C10 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| | | B427917 | 1 | DDA202 AC 25A 300MA RCD BLOCK 2P | ABB | A5 | BUS BAR METERING |
| QD1 | 12 | S600422 | 1 | S202M D 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| QD01 | 11 | S600545 | 1 | S202M D25 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| QD2 | 12 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| | | B427917 | 1 | DDA202 AC 25A 300MA RCD BLOCK 2P | ABB | A5 | BUS BAR METERING |
| QD02 | 11 | S600545 | 1 | S202M D25 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| QD4 | 13 | S600446 | 1 | S202M D 6 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| QD5 | 13 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A5 | BUS BAR METERING |
| | | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| QD6 | 13 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A5 | BUS BAR METERING |
| | | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| QD21 | 12 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| QD22 | 12 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| QV1 | 9 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A5 | BUS BAR METERING |
| QV2 | 8 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A5 | BUS BAR METERING |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A5 | BUS BAR METERING |
| QV3 | 7 | S550383 | 1 | S203M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 3P | ABB | A5 | BUS BAR METERING |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT | ABB | A5 | BUS BAR METERING |
| QV4 | 8 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A5 | BUS BAR METERING |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A5 | BUS BAR METERING |
| QV5 | 8 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A5 | BUS BAR METERING |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A5 | BUS BAR METERING |
| SK1 | 14 | 2900682 | 1 | UMK-RJ45/S/8PTDA Modul VARIOFACE | Phoenix Contact | A5 | BUS BAR METERING |
| SK2 | 14 | 2900682 | 1 | UMK-RJ45/S/8PTDA Modul VARIOFACE | Phoenix Contact | A5 | BUS BAR METERING |
| SK3 | 15 | 2900682 | 1 | UMK-RJ45/S/8PTDA Modul VARIOFACE | Phoenix Contact | A5 | BUS BAR METERING |
| SPW | 15 | M-FAST SFP-TX/RJ45 | 1 | SFP TX Fast Ethernet Transceiver with RJ45 | HIRSCHMANN | A5 | BUS BAR METERING |
| SU1 | 7 | CA10-A004-600-FT2 | 1 | VOLTMETER SWITCH PH-PH 4 POSITION | KRAUS & NAIMER | A5 | BUS BAR METERING |
| SW1 | 16 | 1VCF681000R0101 | 1 | SWICOM INTERFACE TO ETHERNET SWTCH | ABB | A5 | BUS BAR METERING |
| SWH.A | 14 | RSP25-11003Z6TT-SK9V9HHE2S09.0.02 | 1 | Managed Industrial Switch for DIN Rail, fanless design Fast Ethernet Type - Enhanced (PRP, Fast MRP, HSR, NAT with L3 type) - 8 x RJ45 | HIRSCHMANN | A5 | BUS BAR METERING |
| SWH.B | 14 | RSP25-11003Z6TT-SK9V9HHE2S09.0.02 | 1 | Managed Industrial Switch for DIN Rail, fanless design Fast Ethernet Type - Enhanced (PRP, Fast MRP, HSR, NAT with L3 type) - 8 x RJ45 | HIRSCHMANN | A5 | BUS BAR METERING |
| SWH.C | 15 | RSPS25-06002Z6YT-SK9Z9HHE2S07.1.05 | 1 | Managed Industrial Switch for DIN Rail, fanless design Fast Ethernet Type - Enhanced (PRP, Fast MRP, HSR, NAT with L3 type) - 2 x RJ45; 4 x SFP - V=48V÷320VDC -88÷265VAC) | HIRSCHMANN | A5 | BUS BAR METERING |

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DWG n° : 231151/SD/16

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00016 | SHEET 23 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| TR1 | 15 | 800208 | 1 | MODBUS DATACARD 8 CHANNELS | Exertherm | A5 | BUS BAR METERING |
| TU-L1 | 6 | TJP4.3_002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A5 | BUS BAR METERING |
| TU-L2 | 6 | TJP4.3_002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A5 | BUS BAR METERING |
| TU-L3 | 6 | TJP4.3_002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A5 | BUS BAR METERING |
| VC1 | 11 | KBPC5006 | 1 | SILICON BRIDGE RECTIFIER 400-600V 50A | GENERIC | A5 | BUS BAR METERING |
| VC2 | 11 | KBPC5006 | 1 | SILICON BRIDGE RECTIFIER 400-600V 50A | GENERIC | A5 | BUS BAR METERING |
| VS1 | 16 | 1VCF681000R0104 | 1 | INTERFACE BETWEEN PDCOM AND CAPACITIVE ISOLATORS | ABB | A5 | BUS BAR METERING |
| XC | | HM250GR | 42 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A5 | BUS BAR METERING |
| | | HM320GR | 12 | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) | Cabur | A5 | BUS BAR METERING |
| | | HM251GR | 3 | HMT.4/PT/GR End section - Grey | Cabur | A5 | BUS BAR METERING |
| | | HM321GR | 3 | HMT.6/PT/GR End section - Grey | Cabur | A5 | BUS BAR METERING |
| XM | | HM250GR | 10 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A5 | BUS BAR METERING |
| | | HM330GR | 6 | HMM.10/GR Feed-through Terminal Block - Grey (10 mmq) | Cabur | A5 | BUS BAR METERING |
| | | HM251GR | 2 | HMT.4/PT/GR End section - Grey | Cabur | A5 | BUS BAR METERING |
| | | HM331GR | 3 | HMT.10/PT/GR End section - Grey | Cabur | A5 | BUS BAR METERING |
| XS1 | 10 | E 9447 7 | 1 | SOCKET | ABB | A5 | BUS BAR METERING |
| XV | | HB210GR | 16 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type | Cabur | A5 | BUS BAR METERING |
| | | HB201GR | 6 | HSCB.6/PT/GR End section - Grey | Cabur | A5 | BUS BAR METERING |

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DWG n° : 231151/SD/16

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-100D1 - FUNCTIONAL BUS BAR METERING

Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00016

SHEET 24

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00016 Rev.03

1.4.3.SG-100D1 HV SWG FUNCTIONAL DIAGRAM - BESS FEEDER (including Terminals and BOM),
Doc. No. 1723002197-EL-DG-00017

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# "SG-100D1" HV SWBD 6,6kV (UNIT A3)

# FUNCTIONAL DIAGRAM

# BESS FEEDER A-85000

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |
| *NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.* | |
| Sign | Date |
| Luca Maestri | 12/09/2024 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| +A3 | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/17

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 – FUNCTIONAL BESS FEEDER A-85000

Cover

| CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | | SCALE : NTS | |
|---|---|---|---|
| A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 1 | REV. 03 |

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# INDEX

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| 15 | 110V Protection/Measure Distribution Voltage | | | | | | | | | |
| 16 | "REX640"' Protection Wiring | | | | | | | | | |
| 17 | "REX640"' Protection Wiring | | | | | | | | | |
| 18 | "REX640"' Protection Wiring | | | | | | | | | |
| 19 | Extherm Device | | | | | | | | | |
| 20 | Command Circuit | | | | | | | | | |
| 21 | Command Circuit | | | | | | | | | |
| 22 | Command Circuit | | | | | | | | | |
| 23 | "REX640" Protection Wiring - Digital Input | | | | | | | | | |
| 24 | "REX640" Protection Wiring - Digital Input | | | | | | | | | |
| 25 | "REX640" Protection Wiring - Digital Input | | | | | | | | | |
| 26 | Emergency Opening by "SIS" | | | | | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| 27 | Availables Signals | | | | | | | | | |
| 28 | Terminal stripes | | | | | | | | | |
| 29 | Terminal stripes | | | | | | | | | |
| 30 | Terminal stripes | | | | | | | | | |
| 31 | Terminal stripes | | | | | | | | | |
| 32 | Bill of Materials | | | | | | | | | |
| 33 | Bill of Materials | | | | | | | | | |
| 34 | Bill of Materials | | | | | | | | | |

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DWG n° : 231151/SD/17
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Sheets Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 2 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

## ACRONIMUS LEGEND

| ITEM | DESCRIPTION |
|---|---|
| BB | ARC SENSOR PROTECTION ON MAIN BUS BARS |
| BGE | EARTHING SWITCH |
| C1 | VOLTAGE PRESENCE |
| CB | ARC SENSOR PROTECTION ON C.B. / CONTACTOR COMPARTMENT |
| CC | ARC SENSOR PROTECTION ON CABLE COMPARTMENT |
| DCO | DOUBLE COMMAND OPERATED CONTACTOR |
| DI3 | UNDERVOLTAGE CONTACTOR |
| DP1 | ALARM RELAY MODULE TEMPERATURE |
| E1 | INTERNAL LIGHT |
| E8 | RESISTOR FERRO-RESONANCE |
| EH1 | INTERNAL SPACE HEATER |
| Fn | MV FUSE |
| FP1 | PROTECTION RELAY |
| GS1 | DC/DC CONVERTER |
| HGR | THERMOSTAT |
| Kn | AUXILIARY RELAY |
| K1 | MV CONTACTOR |
| K86 | BLOCK RELAY |
| KT1 | DE-ENERGIZATION TIMER |
| LS | MICRO SWITCH ON AUXILIARY DOOR |
| MAS | MOTOR SPRING CHARGER |
| MBC | CLOSING COIL |
| MBO1 | OPENING COIL |
| MBU | UNDERVOLTAGE |
| ODn | VOLTAGE DISCHARGER |
| PU1 | MEASURING VOLTAGE INSTRUMENT |

| ITEM | DESCRIPTION |
|---|---|
| PTT | V.T. TRUCK |
| QM | MV CIRCUIT-BREAKER |
| QDn | M.C.B. CIRCUITS PROTECTION |
| QVn | M.C.B FOR V.T. PROTECTION |
| RLE1 | COIL FOR CONSET CLOSING CIRCUIT-BREAKER |
| RLE2 | COIL FOR UNLOCKING RACK-IN/OUT OPERATION |
| RLE3 | COIL FOR UNLOCKING OPERATION EARTHING |
| RLE4 | COIL FOR UNLOCKING ENCLOSURE DOOR OPERATION |
| SU1 | VOLTAGE SELECTOR |
| SWH... | ETHERNET SWITCH |
| TI-Ln | CURRENT TRANSFORMER |
| TO | OMOPOLAR RING CURRENT TRANSFORMER |
| TR1 | TEMPERATURE CONTROL DEVICE |

FUNCTIONAL OF THE PROTECTION RELAY OUTPUT CONTACTS:

SLOT "G":
RF = WATCHDOG RELAY
S01 = EARTHING SWITCH UNLOCKING
S02 = C.B. or CONTACTOR READY TO CLOSE
POSP1 = CLOSING COMMAND
S03 = C.B. or CONTACTOR TRUCK UNLOCKED
PODP1 = OPENING COMMAND
SLOT "B":
S01 = TRIP PROTECTION TO LOCKOUT RELAY
S02 = EARTHING SWITCH CLOSED
S03 = AVAILABLE OUTPUT (ON TERMINAL STRIP)
S04 = RESET LOCKOUT RELAY
SLOT "D":
SP01 = TRIP ARC DETECTOR

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DWG n° : 231151/SD/17
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Legend

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

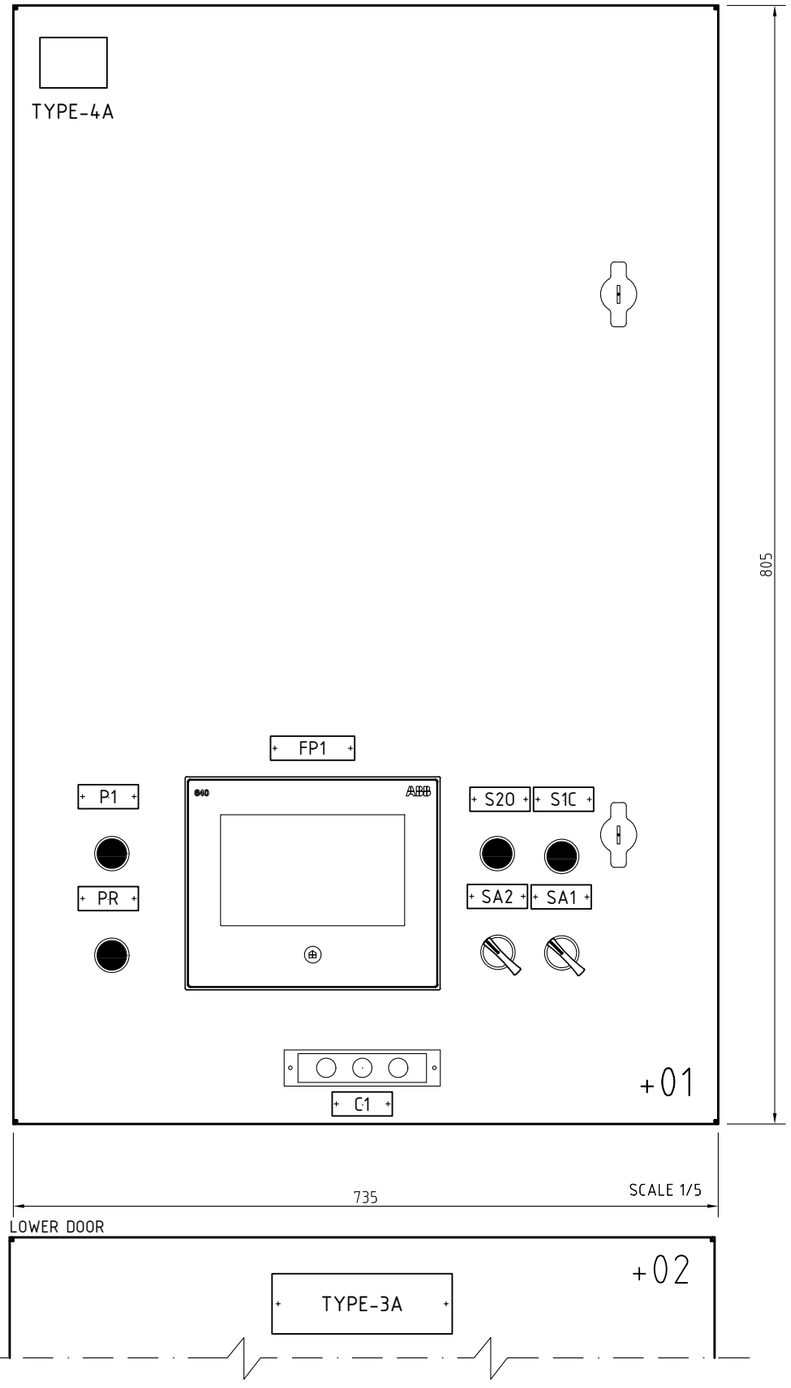
A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 3 | REV. 03

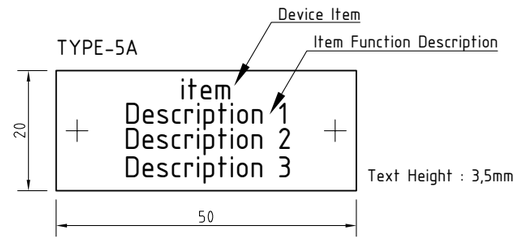
F.to UNI A3: 420mmx297mm

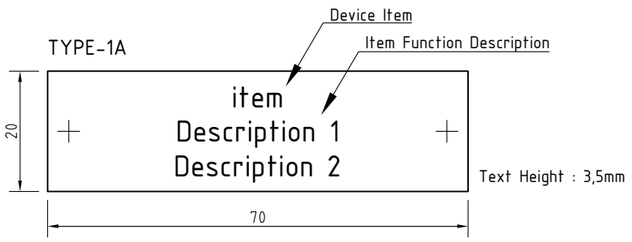
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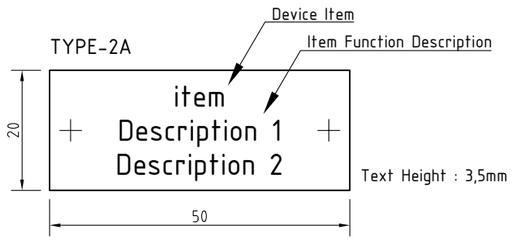
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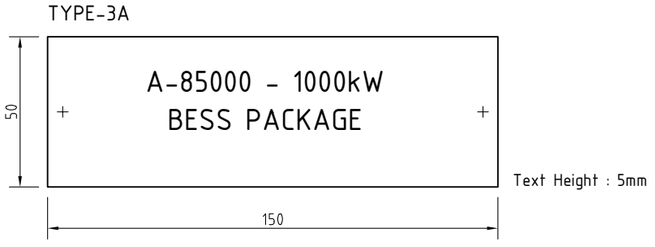
| DEVICES name plate | | | | | |
|---|---|---|---|---|---|
| ITEM | COMPONENT | DESCRIPTION 1 | DESCRIPTION 2 | DESCRIPTION 3 | NOTE |
| FP1 | PROTECTION RELAY | PROTECTION RELAY | | | TYPE-1A |
| S2.0 | PUSH BUTTON | OPEN | COMMAND | CONTACTOR | TYPE-5A |
| S1.C | PUSH BUTTON | CLOSE | COMMAND | CONTACTOR | TYPE-5A |
| SA1 | SELECTOR SWITCH | LOCAL / REMOTE | | | TYPE-2A |
| SA2 | SELECTOE SWITCH | OVERRIDE ESD | OFF - ON | | |
| PR | LIGHT PUSH BUTTON | RESET | LOCK-OUT | TRIP LOCK-OUT | TYPE-5A |
| C1 | PILOT LIGHT | VOLTAGE | PRESENCE | | TYPE-2A |
| P1 | PUSH BUTTON | TRUCK-DOOR | ENABLING | ENABLING | TYPE-5A |

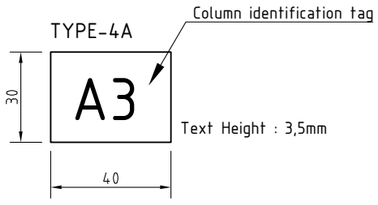



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| +A3 | | | | | |
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DWG n° : 231151/SD/17
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 – FUNCTIONAL BESS FEEDER A-85000
Door Layout

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00017

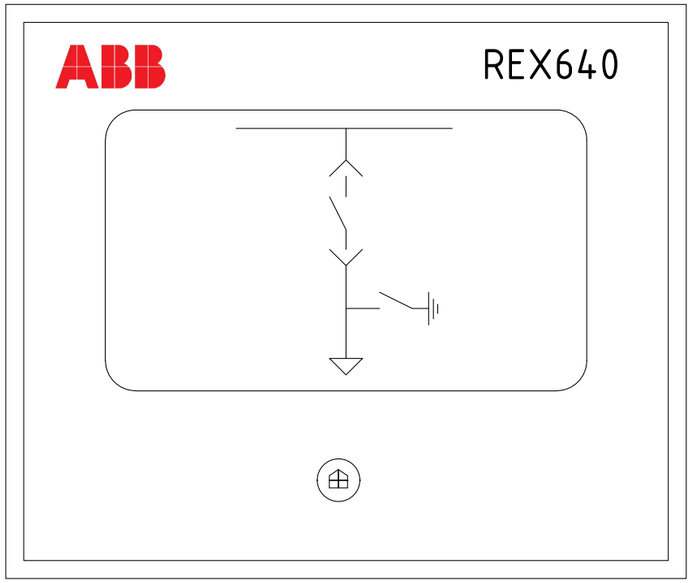
SHEET 4

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# PROTECTION DISPLAY




## LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE CONTACTOR " AND "OPEN CONTACTOR" NOT ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED

| LEDs PAGE 1 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/27-2/59-1/59-2 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | CONTACTOR READY (TCS) | - | GREEN | OK = TCS OK (CONTACTOR READY) |
| LED-3 | SYNCHRO CHECK | | GREEN | OK = SYNCHRONISM |
| LED-4 | CONTACTOR READY TO CLOSE | - | GREEN | OK = CONTACTOR READY TO CLOSE |
| LED-5 | 50-1/51-1/67-1/67-2 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/59N-1/59N-2 - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = CONTACTOR TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | EMERGENCY OPENING BY SIS (ESD) | RED | - | ALARM = ESD TRIPPED |

| LEDs PAGE 2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | - | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | FUSES TRIP | RED | | ALARM = FUSES TRIP |
| LED-15 | TRIP FROM L.V. | RED | | ALARM = L.V. TRIP |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

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DWG n° : 231151/SD/17
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Protection Display REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

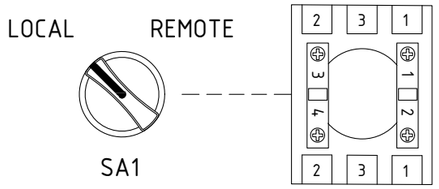
A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 5 | REV. 03

F.to UNI A3: 420mmx297mm

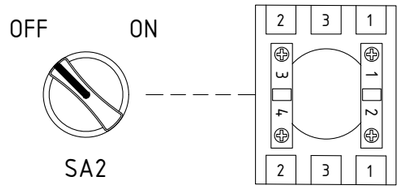
File Name : 1723002197-EL-DG-00017 Rev.03

# SELECTORS SWITCH DIAGRAM

REAR VIEW




REAR VIEW




## NOTES

THE DIAGRAM INDICATES THE FOLLOWING CONDITIONS:
-INSERTED CONTACTOR IN OPEN POSITION
-DE-ENERGIZED CIRCUITS
-EARTHING SWITCH OPEN

THE AUXILIARY CIRCUITS WILL HAVE THE FOLLOWING CHARACTERISTICS:
-110+ / 24+ 1,5mmq RED TYPE CABLE SH-W
-110- / 24- 1,5mmq WHITE TYPE CABLE SH-W
-AUXILIARY CONTACTS TO TERMINAL STRIP 1,5mmq BLACK TYPE CABLE SH-W
-230Vac 1,5mmq BLACK TYPE SH-W
-VOLTMETRICAL CIRCUITS 1,5mmq BLACK TYPE CABLE SH-W
-AMMETRICAL CIRCUIT 2,5mmq BLACK TYPE CABLE SH-W

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Selector Switch Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

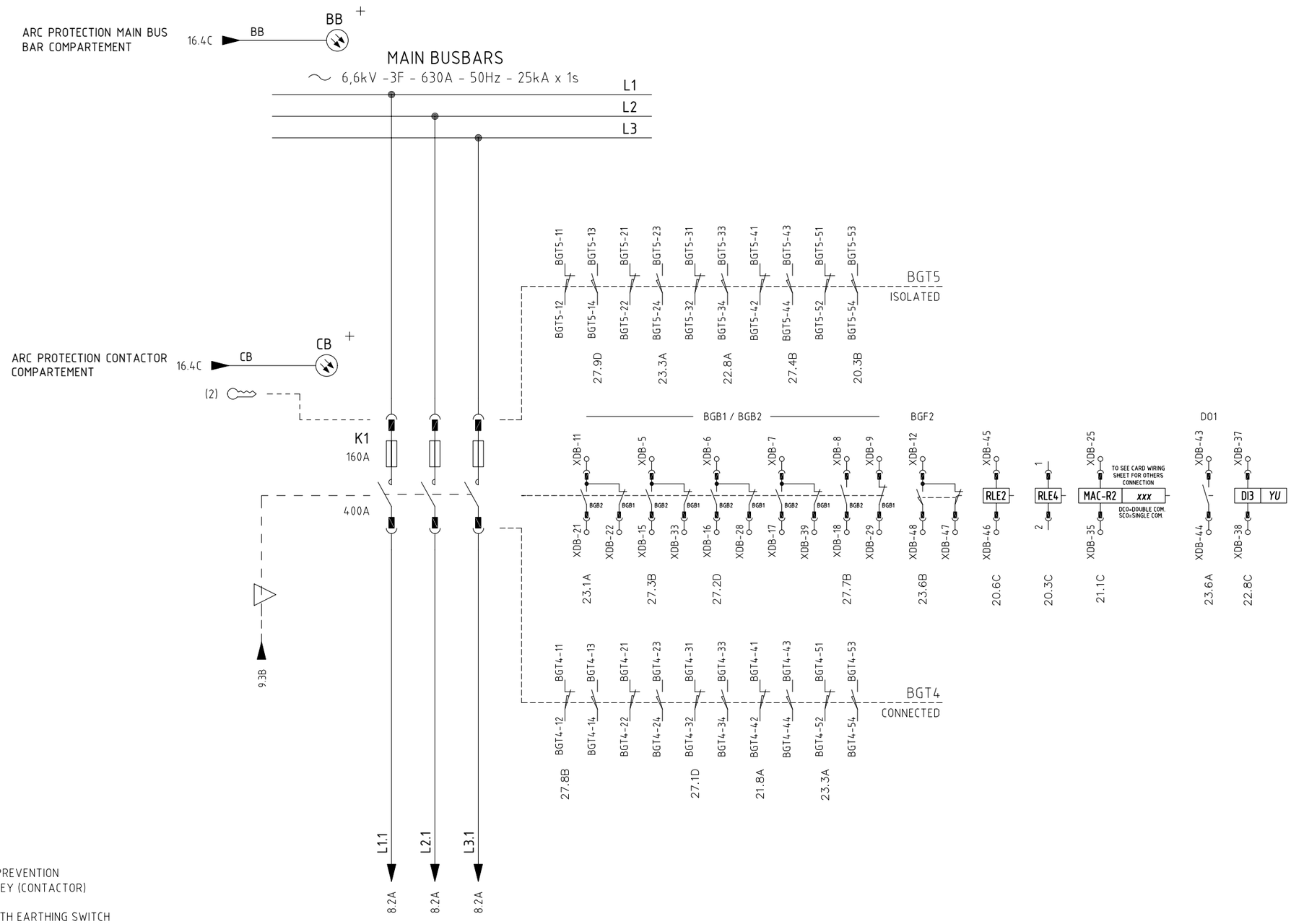
DRAWING NO. 1723002197-EL-DG-00017

SHEET 6

REV. 03

F.to UNI A3: 420mmx297mm

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(2) RACKING IN PREVENTION LOCK WITH KEY (CONTACTOR)

(3) FREE KEY WITH EARTHING SWITCH IN OPEN POSITION

(4) FREE KEY WITH EARTHING SWITCH IN CLOSED POSITION

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL BESS FEEDER A-85000

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

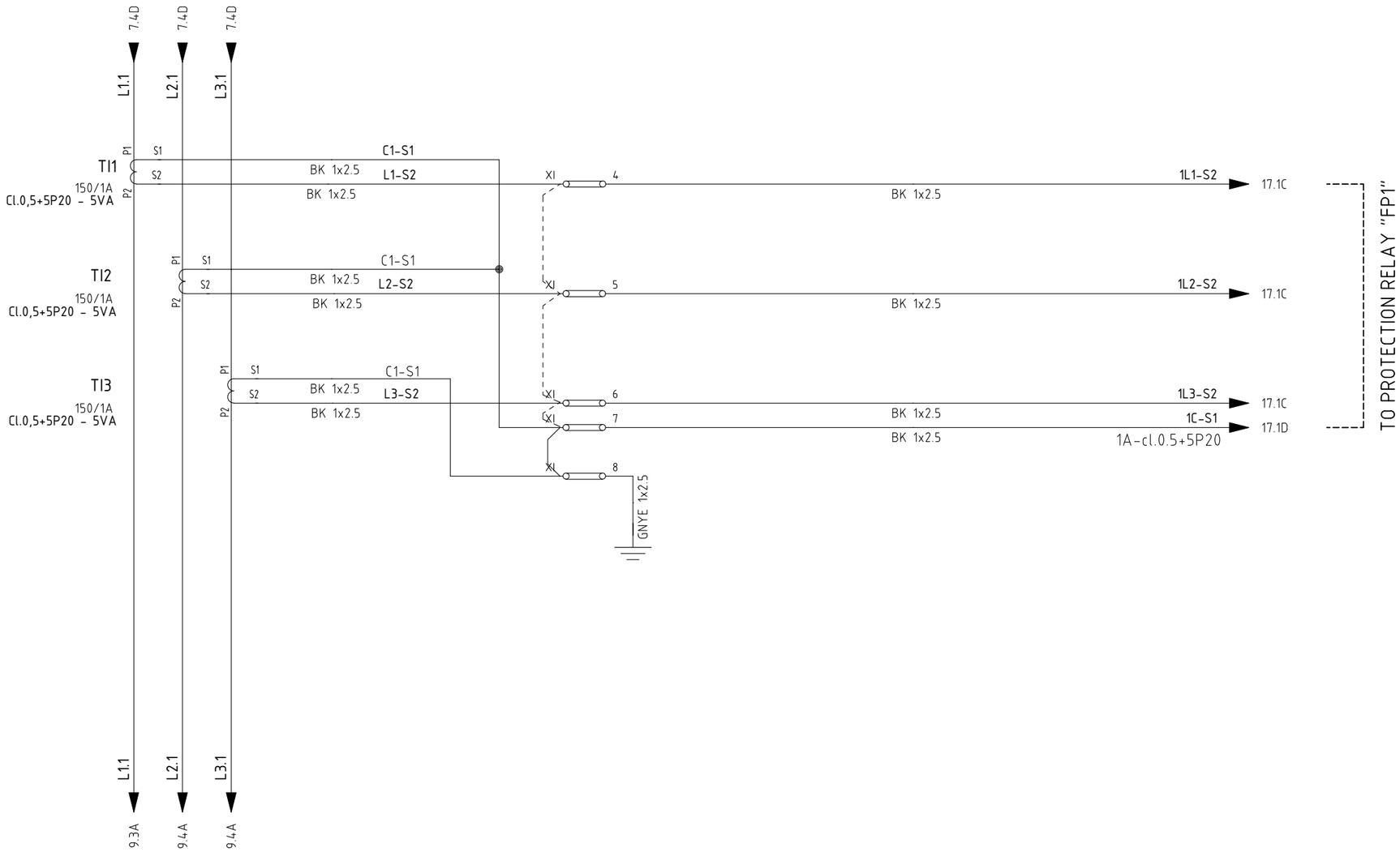
DRAWING NO. 1723002197-EL-DG-00017

SHEET 7

REV. 03

F.to UNI A3: 420mmx297mm

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DWG n° : 231151/SD/17
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

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TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

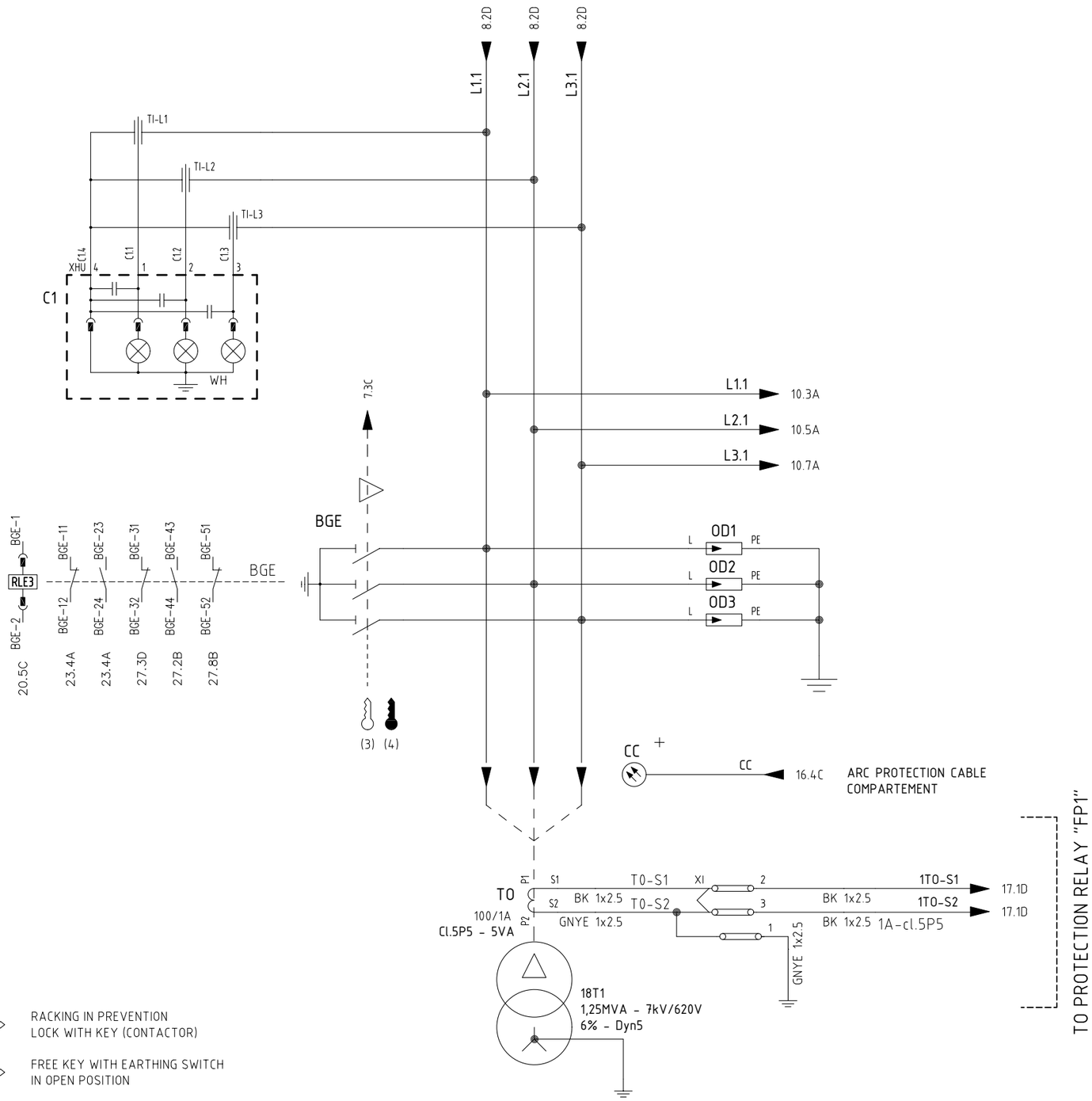
DRAWING NO. 1723002197-EL-DG-00017

SHEET 8

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03




(2) RACKING IN PREVENTION LOCK WITH KEY (CONTACTOR)

(3) FREE KEY WITH EARTHING SWITCH IN OPEN POSITION

(4) FREE KEY WITH EARTHING SWITCH IN CLOSED POSITION

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL BESS FEEDER A-85000

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

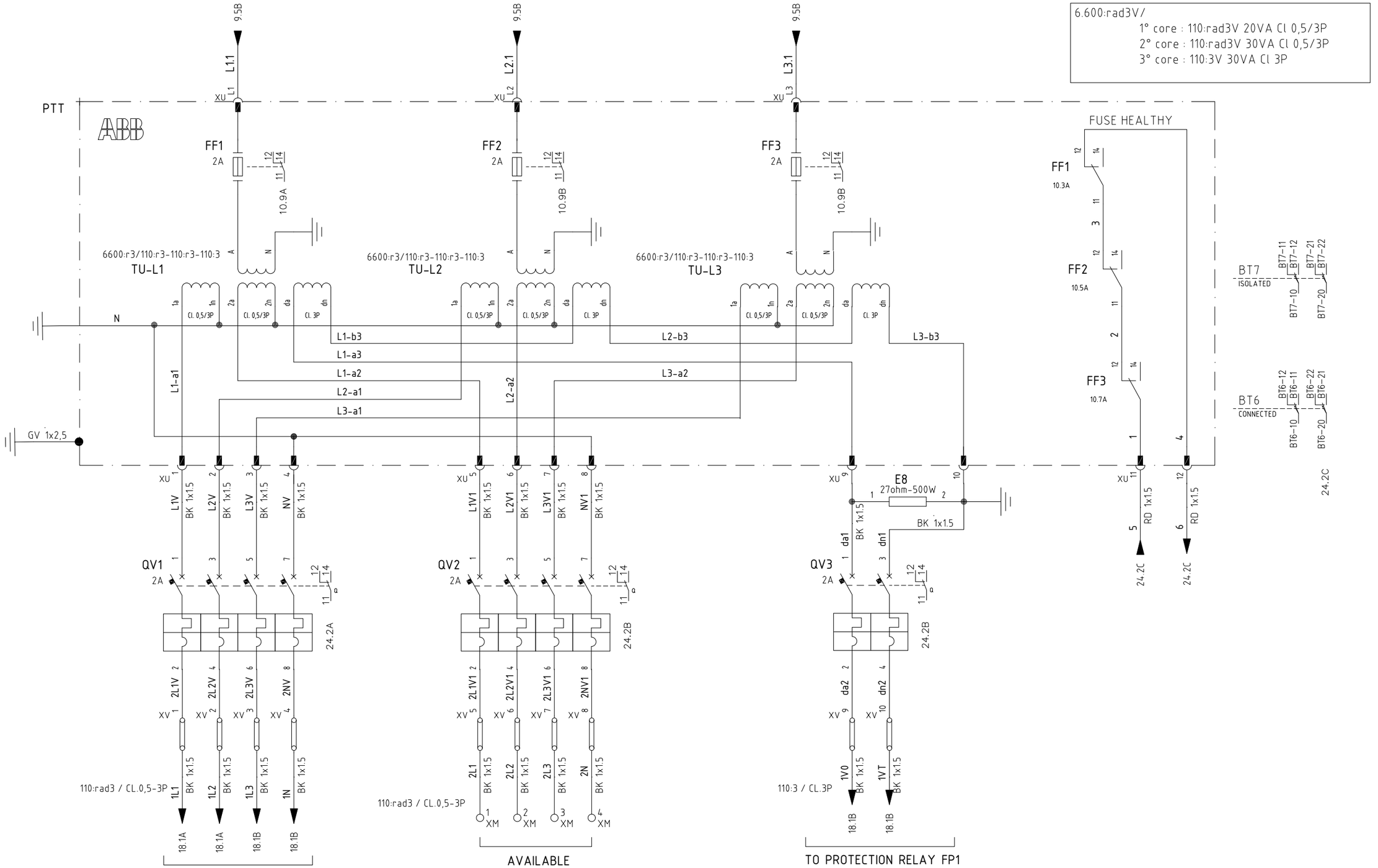
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SHEET 9

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03




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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 – FUNCTIONAL BESS FEEDER A-85000

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00017

SHEET 1.0

REV. 03

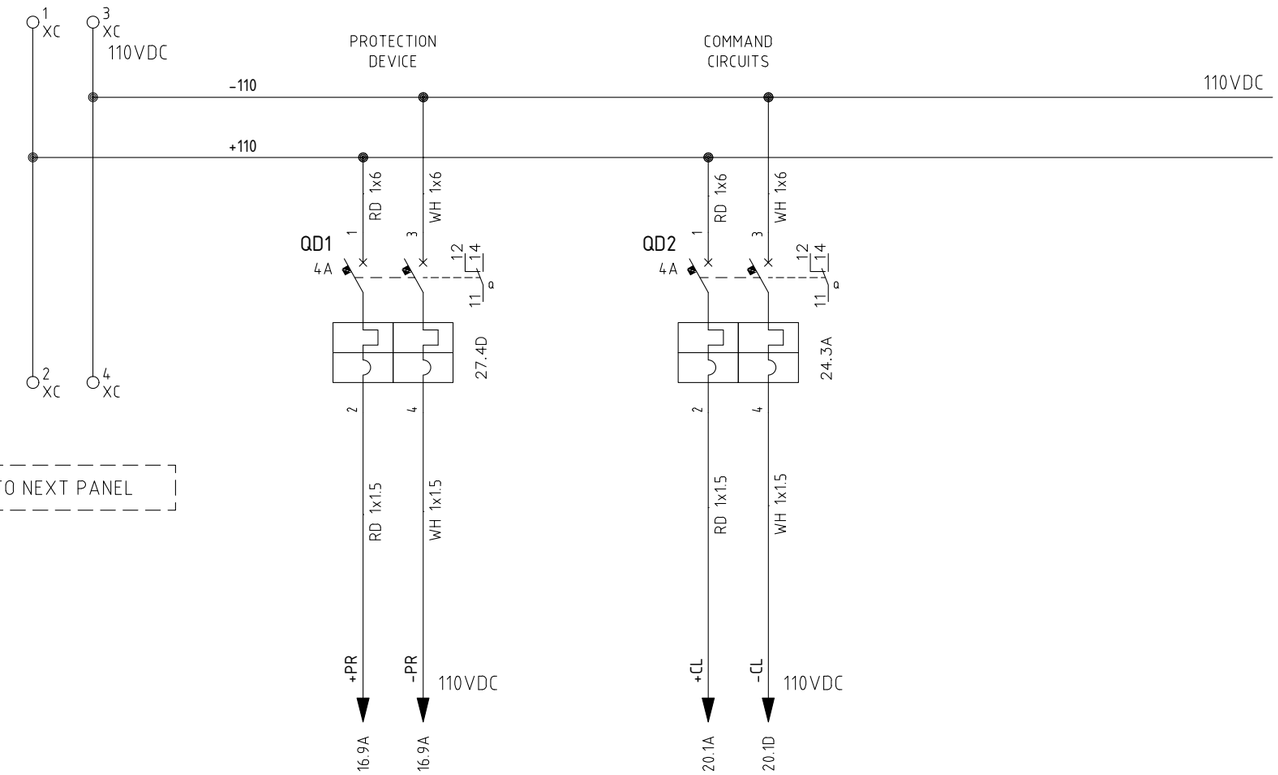
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

## 110VDC DISTRIBUTION VOLTAGE

110Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL

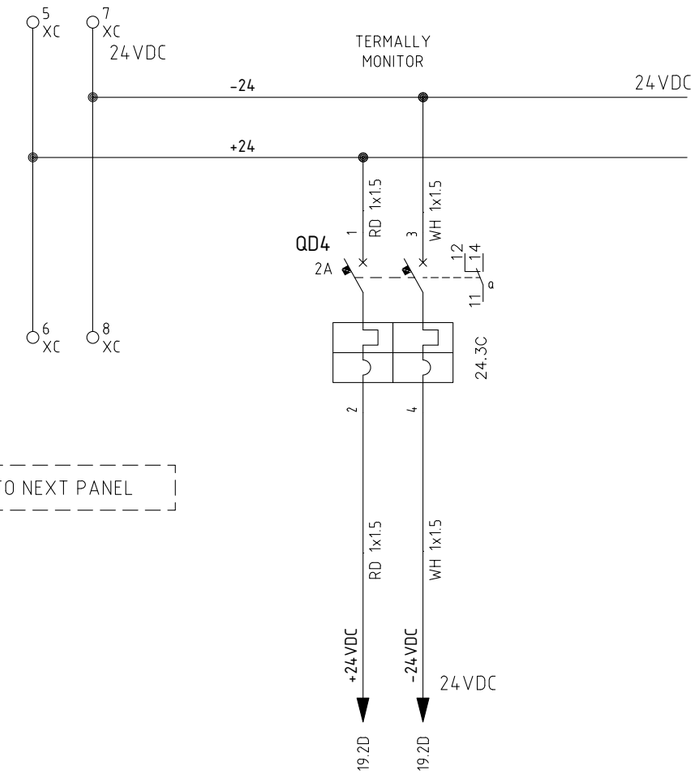



TO NEXT PANEL

## 24VDC DISTRIBUTION VOLTAGE

24Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= +A3

DWG n° : 231151/SD/17

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL BESS FEEDER A-85000

110Vdc / 24Vdc Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00017

SHEET 1.1

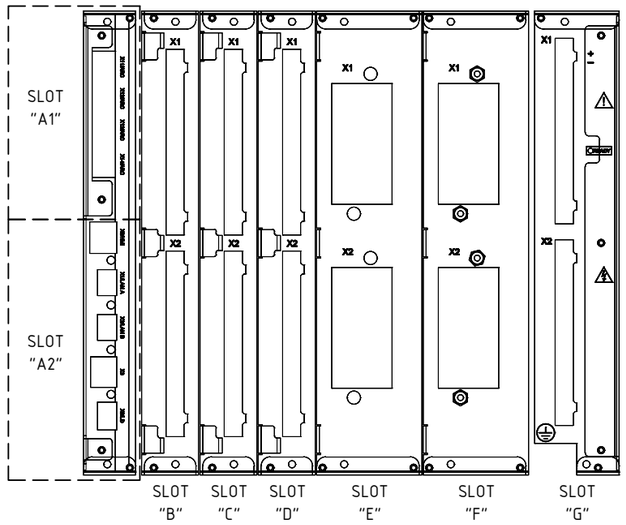
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# COMPOSITION RELAY REX640

## RACK VIEW




REX640B10NN+COM1+ARC1+BIO1+BIO1+BIO2+AIM1+AIM1+PSM3+MCT1+SCT1+CMP2+LNG1+PCL4

LEGEND

| SLOT | Module Type | Description Module |
|---|---|---|
| A1 | ARC1001 | n° 4 x ARC sensor inputs |
| A2 | COM1001 | n° 1 x RJ-45 (LHMI port) + n° 3 x RJ-45 + n° 1 x SFP100M LC |
| B | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| C | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| D | BIO1002 | n° 9 Binary Input + n° 6 x SPO + n° 2 x SPO(TCS) |
| E | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| F | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| G | PSM1003 | 77...150 VDC, n° 3 x PO (TCS) + n° 2 x PO + n° 3 x SO + n° 2 x SSO |
| | PO = Power Output<br>SO = Signal Output<br>SPO = Static Power Output<br>SSO = Static Signal Output | |

=
+A3

DWG n° : 231151/SD/17
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Composition Relay REX640

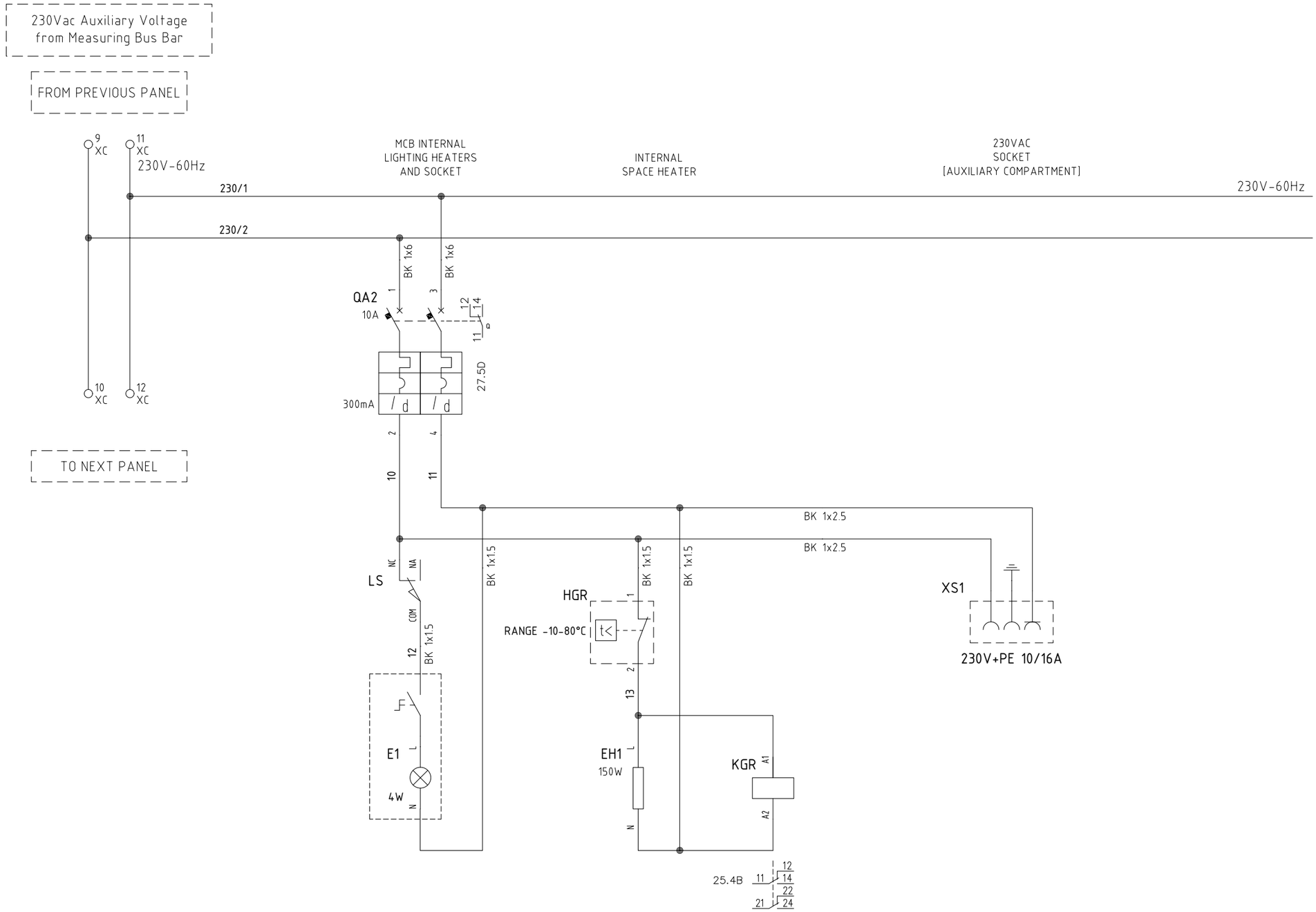
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 12 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# 230VAC DISTRIBUTION VOLTAGE




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| +A3 | | | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | | |

DWG n° : 231151/SD/17
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
230Vac Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 13 | REV. 03

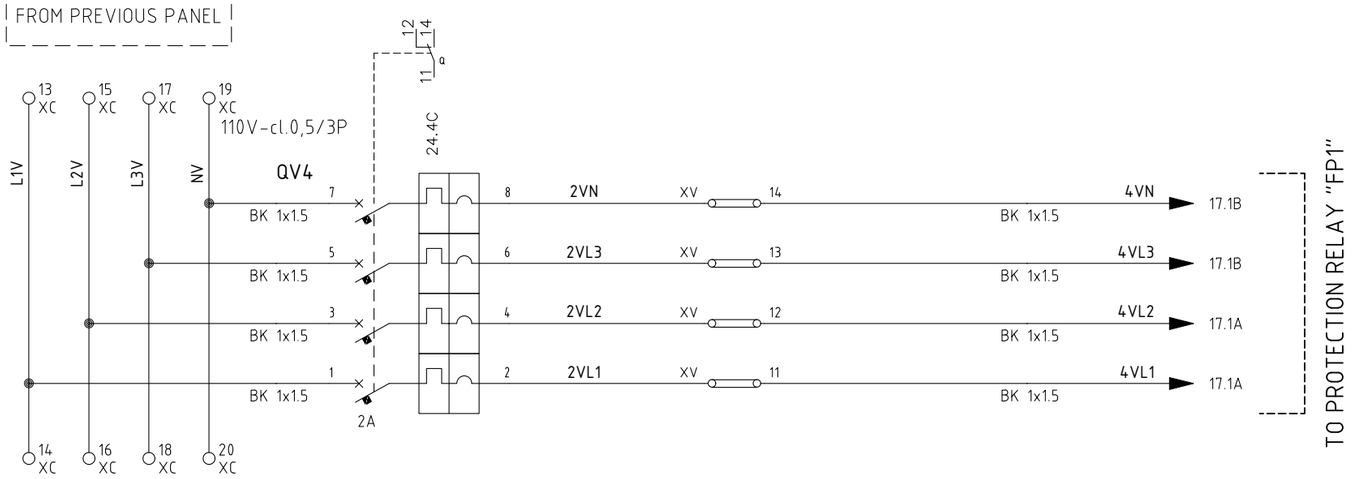
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# 110V: 1,73 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:√3V VOLTMETRIC LINE - STAR
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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= +A3
DWG n° : 231151/SD/17
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 14 | REV. 03

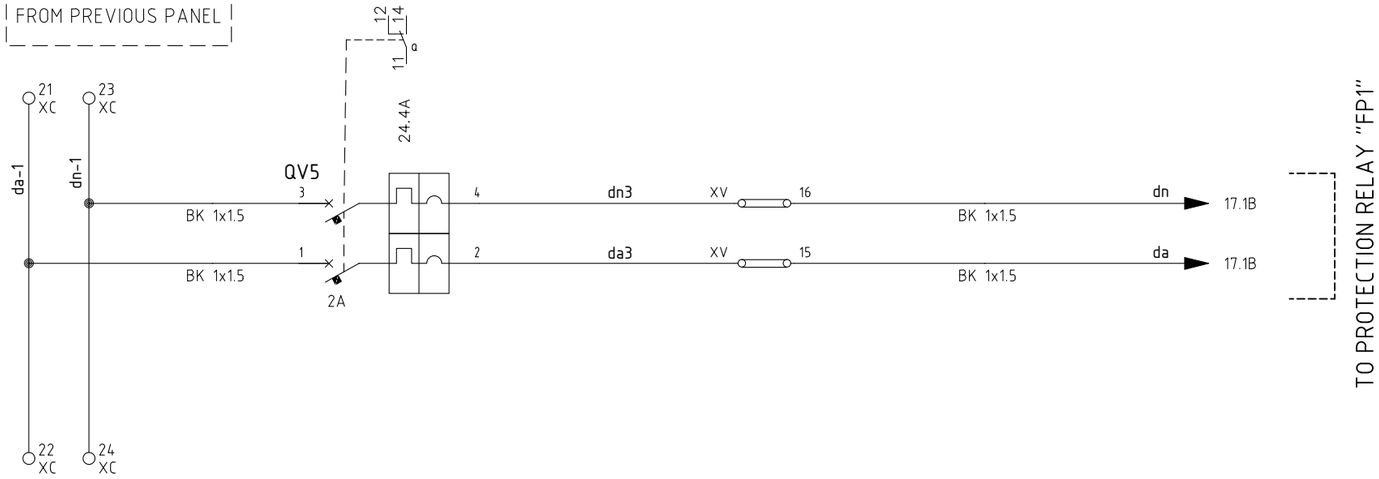
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# 110V:3 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:3V VOLTMETRIC LINE -
DELTA OPEN
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO PROTECTION RELAY "FP1"

TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| +A3 | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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DWG n° : 231151/SD/17
Item n° : PF1113279

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 15 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# "REX640" PROTECTION WIRING

FP1

PSM1003
COM1001
slot G

X1

X1-1 (+) — RD 1x1.5 — 11.2D +PR → +PR 23.1A
X1-2 (Uaux −) — WH 1x1.5 — 11.3D −PR → −PR 23.1D
110VDC

GND — 1x6 GNYE

PROTECTION FUNCTION

| | |
|---|---|
| 51 | 50 |
| 51N | 25 |
| 59N | 67 |
| 27 | 86 |
| 74 | 59 |
| | |
| | |
| | |

ETH PORT (IEC61850)

X1 — PATCH CORD cat.6 RJ45 — FP1-A3/A — FROM MEASURE CUBICLE A5
X2
X3 — PATCH CORD cat.6 RJ45 — FP1-A3/B — FROM MEASURE CUBICLE A5
X0 — PATCH CORD cat.7 RJ45 — ETH.1

LHMI
Local HMI
[7" color Touch screen]
640 ABB
X1.1
X3 (+ / −)
GNYE 1x6

ARC1001
slot A1

ARC DETECTOR SENSOR

| | | | | |
|---|---|---|---|---|
| X11 | BB | 7.3A | BUS BAR COMPARTEMENT | arc detectors |
| X12 | CB | 7.3B | C.B. COMPARTEMENT | |
| X13 | CC | 9.5D | CABLE COMPARTEMENT | |
| X14 | | | | |

REX640

FP1

PSM1003

| RF | SO1 | SO2 | SSO1 | SSO2 | POSP1 | POSP2 | SO3 | PODP1 | PODP2 | PODP3 |
|---|---|---|---|---|---|---|---|---|---|---|
| X1-4 / X1-3 | X1-5 / X1-7 | X1-8 / X1-6 | X1-9 / X1-10 | X1-11 / X1-12 | X1-13 / X1-14 | X1-15 / X1-16 | X1-17 / X1-18 | X2-2 / X2-1 | X2-3 / X2-5 | X2-6 / X2-8 |
| 22.9A | 20.5C | 27.6D | | | 21.10B | | 20.6B | 21.9B | | |

slot G

REX640

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| +A3 | | | | | | | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | | |

DWG n° : 231151/SD/17
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 – FUNCTIONAL BESS FEEDER A-85000
"REX640"' Protection Wiring

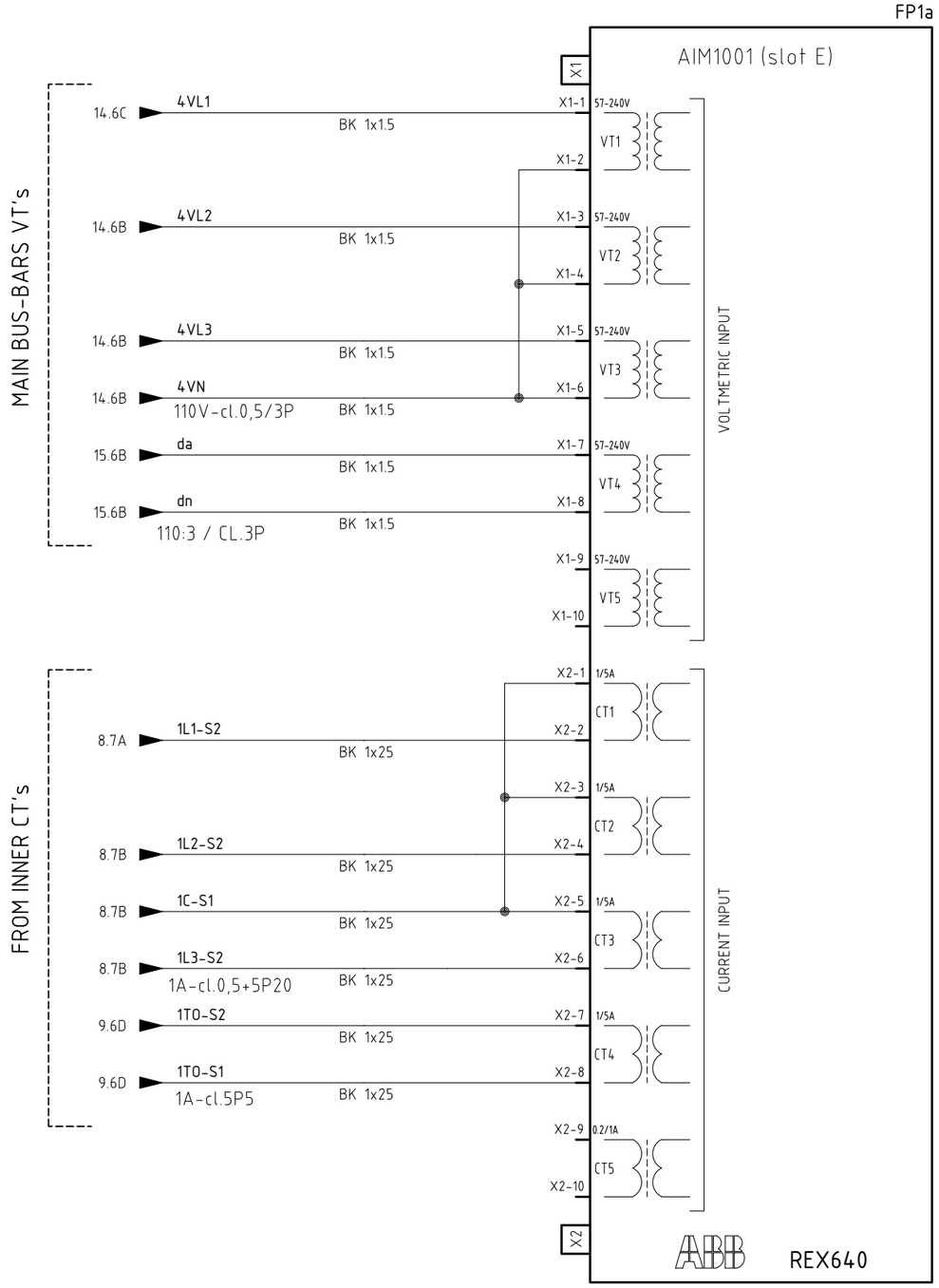
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00017
SHEET 16
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# "REX640" PROTECTION WIRING




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+A3
DWG n° : 231151/SD/17
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
"REX640"' Protection Wiring

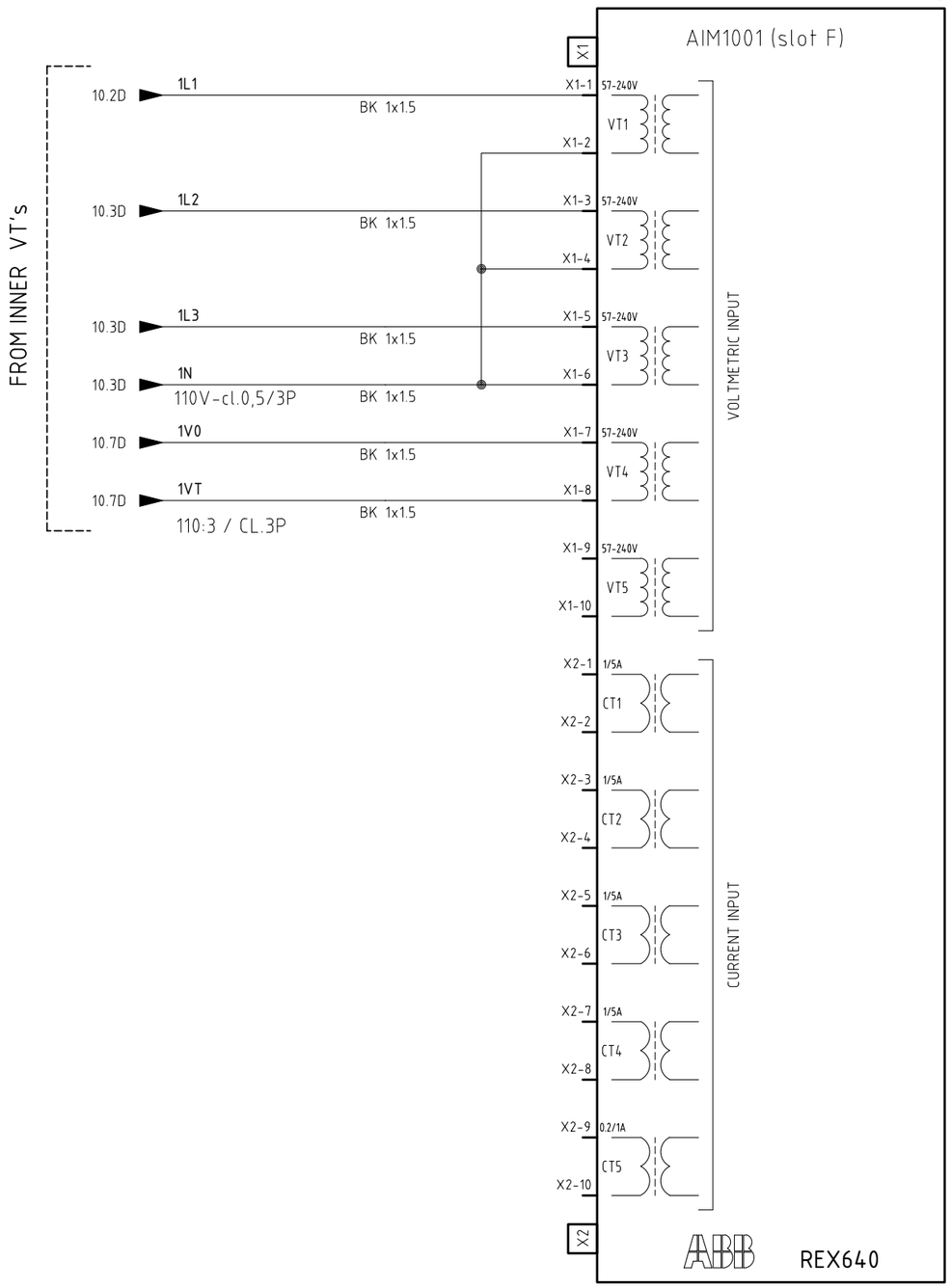
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00017
SHEET 1.7
REV. 03

File Name : 1723002197-EL-DG-00017 Rev.03

F.to UNI A3: 420mmx297mm

# "REX640" PROTECTION WIRING




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+A3

DWG n° : 231151/SD/17

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL BESS FEEDER A-85000

"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

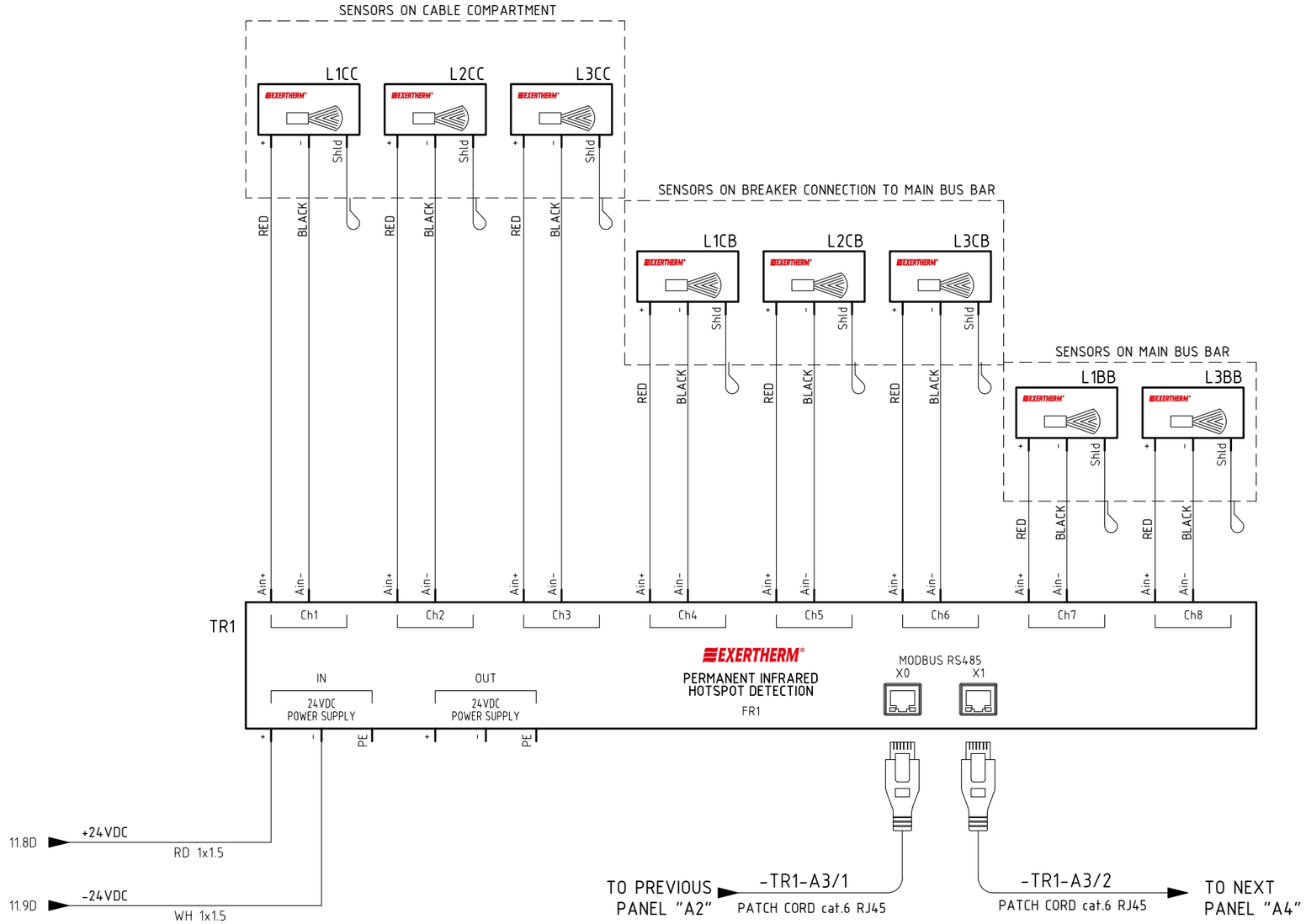
DRAWING NO. 1723002197-EL-DG-00017

SHEET 18

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03




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+A3

DWG n° : 231151/SD/17

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL BESS FEEDER A-85000

Extherm Device

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00017

SHEET 19

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# COMMAND CIRCUITS

ENABLING CONTACTOR TRUCK ENCLOSURE DOOR AND EARTHING SWITCH

UNLOCKING CONTACTOR ENCLOSURE DOOR

ENABLING EARTHING SWITCH COMMAND

ENABLING RACK-IN AND RACK-OUT CONTACTOR [LOCKING MAGNET]

11.4D +CL 110VDC (CL)

+CL 21.1A

RD 1x1.5

P1 BK 13 14

KT1 20.2D 16 18 15 30"

21 RD 1x1.5

K1 ISOLATED BGT5 7.4B BGT5-53 BGT5-54

5 XM 6 XM

FP1 16.3A S01 REX640 X1 Slot G X1-7 X1-8 23 X1-6 24 RD 1x1.5

FP1 16.3A S03 REX640 X2 Slot G X2-2 X2-3 X2-1 25 RD 1x1.5

7 XM 8 XM

RD 1x1.5 20

22 RD 1x1.5

26 RD 1x1.5 XDB-45

BGE-1 BGE-2

K1 RLE4 7.4B 1 2

BGE RLE3 9.3C

K1 RLE2 7.4B XDB-46

KT1 A1 B1 A2 30"

11.4D -CL

-CL 21.1E

WH 1x1.5

20.3A 15 16 18

23.9A 25 26 28

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= +A3

DWG n° : 231151/SD/17

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL BESS FEEDER A-85000

Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00017

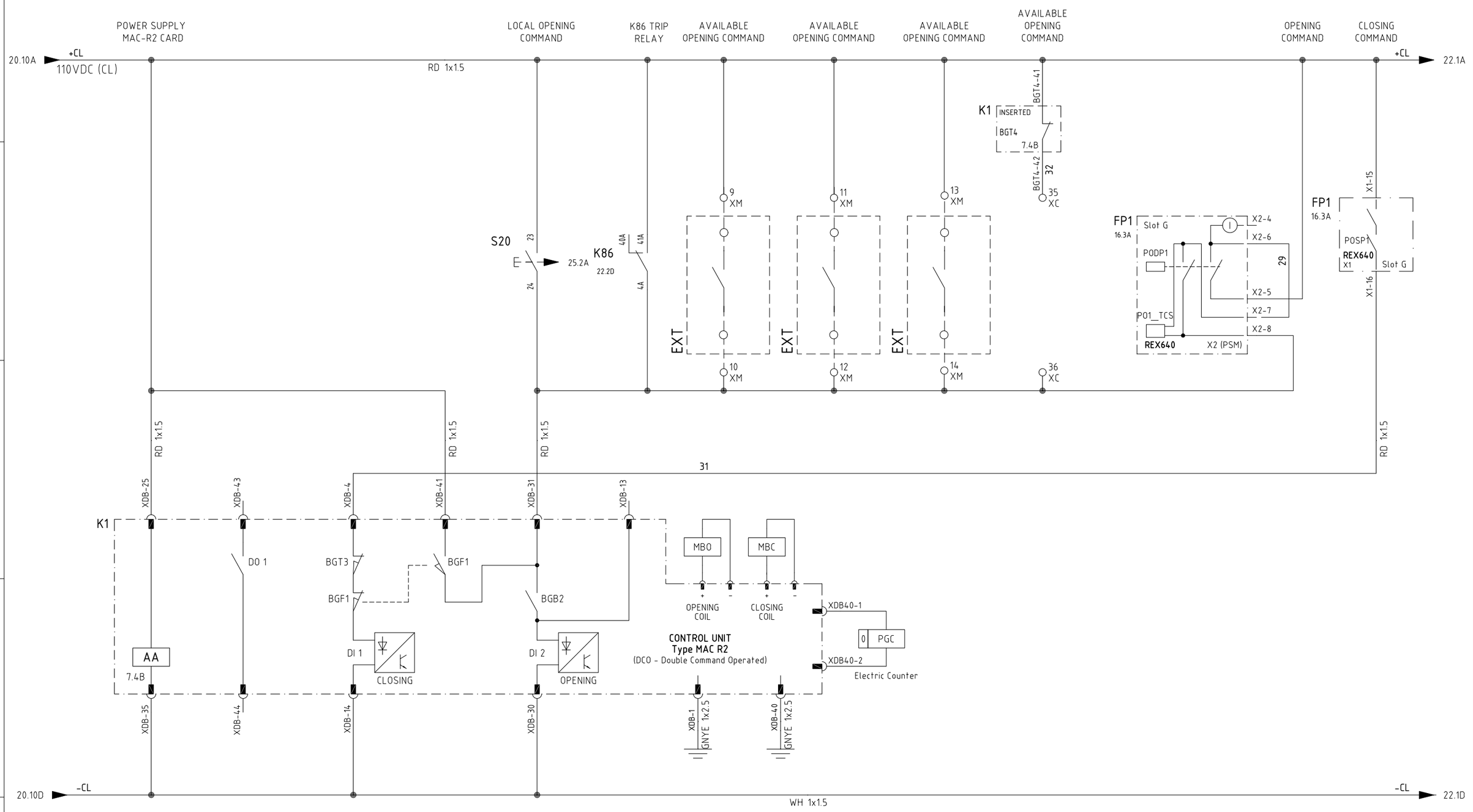
SHEET 20

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# CLOSING/OPENING COMMAND CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| +A3 | | | | | |
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DWG n° : 231151/SD/17
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL BESS FEEDER A-85000

Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00017

SHEET 21

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# COMMAND CIRCUITS

OUTPUT PROTECTION RELAY | AVAILABLE | AVAILABLE | TRANSFORMER TRIP WINDING TEMPERATURE | LOCAL RESET | REMOTE RESET | TRIP LOCK-OUT RELAY | SELECTOR SWITCH OF OVERRIDE | EMERGENCY OPENING BY SIS | UNDERVOLTAGE | CONTACTOR ISOLATED | WATCHDOG PROTECTION DUPLICATION | TRANSFORMER TRIP WINDING TEMPERATURE

21.10A +CL 110VDC (OP)

RD 1x1.5

15 XM

17 XM

FP1c 23.1C X2-4 S01 REX640 X2 Slot B X2-3

K94WT 22.10D 12 14 11

PR 13 14 X1 X2 22.5D

FP1c 23.1C X2-10 S04 REX640 X1 Slot B X2-9

K86 22.2D 40B 41B 4B

SA2 OFF ON 23 24 25.7B

KSIL 26.5B 13 14

20 XM 19 XM

KIRF 22.9D 22 24 21 39 40

K1 ISOLATED BGT5 7.4B BGT5-33 BGT5-34

FP1 16.3A X1-4 X1-5 RF REX640 X1 Slot G X1-3

+CL /./

65 XM 49T 66 XM

16 XM 18 XM

35 36 37 38 41 42 46

RD 1x1.5

K86 B1 C S B2 C RESET 1

PR 22.4A X1 X2

K86 22.2D 30B 31B 3B

XDB-37 XDB-38

K1 DI 3 7.4B OPENING

KIRF A1 A2

K94WT A1 A2

21.10E -CL

WH 1x1.5

-CL /./

20A 2A 21A 30A 3A 31A 40A 21.5B 4A 41A 10B 27.6B 1B 11B 20B 23.5A 2B 21B 30B 22.8B 3B 31B 40B 22.5B 4B 41B

27.4D 11 12 14 22

22.8A 21 24 32

31 34 42

41 44

22.3A 11 12 14 22

24.10B 21 24 32

31 34 42

41 44

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

= +A3

DWG n° : 231151/SD/17

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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TITLE :

SG-100D1 – FUNCTIONAL BESS FEEDER A-85000

Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00017

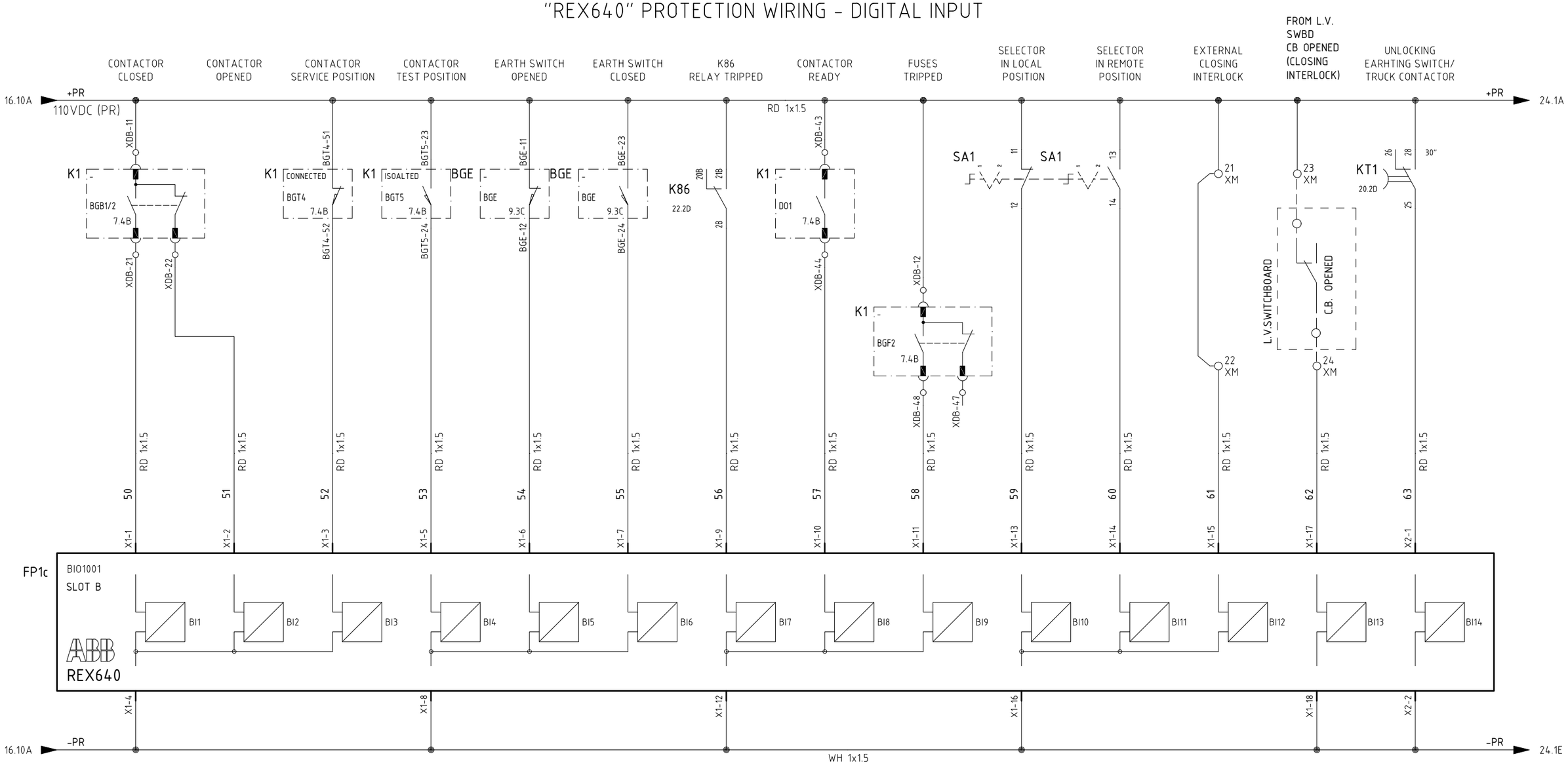
SHEET 22

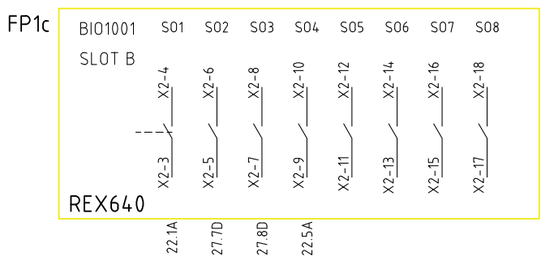
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/17

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL BESS FEEDER A-85000

"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00017

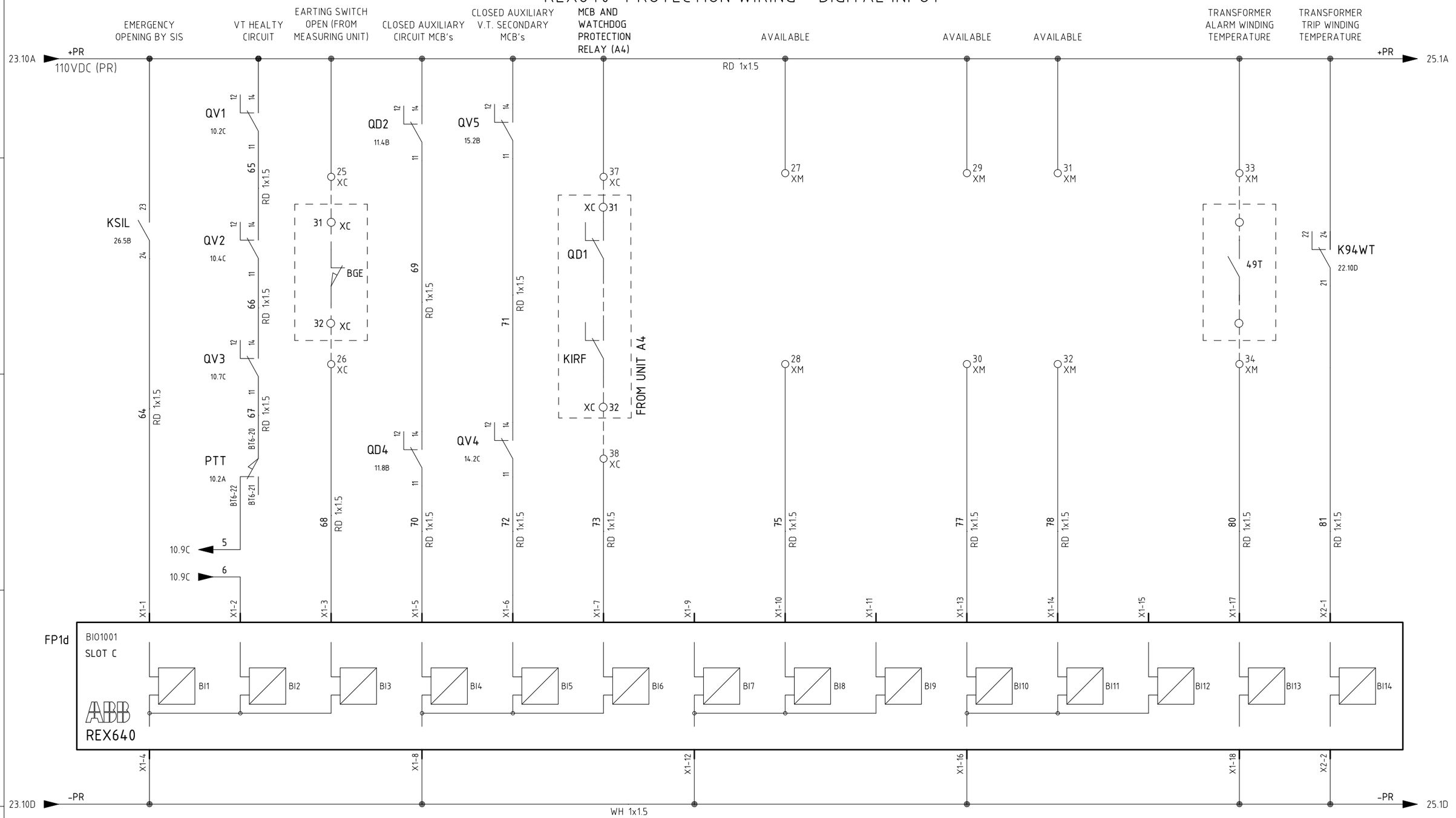
SHEET 23

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT




| | | | | | | | |
|---|---|---|---|---|---|---|---|
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| +A3 | | | | | | | |
| DWG n° : 231151/SD/17 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL BESS FEEDER A-85000

"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00017

SHEET 24

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT

S1C LOCAL CLOSING COMMAND
S20 LOCAL OPENING COMMAD
FROM L.V. SWBD CB TEST POSITION
FROM L.V. SWBD TRIPPED
SPACE HEATER ON
AVAILABLE REMOTE OPENING COMMAND
AVAILABLE REMOTE OPENING COMMAND
MCB AND WATCHDOG PROTECTION RELAY (A2)
SELECTOR SWITCH OF OVERRIDE (SIL ENABLED)

24.10A +PR 110VDC (PR)

RD 1x1.5

+PR /./

S1C GR 13 14
S20 21.4B RD 13 14

L.V.SWITCHBOARD C.B. IN TEST POSITION 35 XM 36 XM
L.V.SWITCHBOARD TRIP 37 XM 38 XM
KGR 13.5D 12 14 11
39 XM 40 XM
41 XM 42 XM
QD1 KIRF FROM UNIT A2 29 XC XC 31 XC 32 30 XC
22.6A SA2 OFF ON 11 12

82 RD 1x1.5 X1-1
83 RD 1x1.5 X1-2
84 RD 1x1.5 X1-3
85 RD 1x1.5 X1-5
86 RD 1x1.5 X1-6
87 RD 1x1.5 X1-7
88 RD 1x1.5 X1-9
89 RD 1x1.5 X1-10
90 RD 1x1.5 X1-11

FP1e
BIO1002
SLOT D
ABB
REX640
BI1 BI2 BI3 BI4 BI5 BI6 BI7 BI8 BI9

X1-4 X1-8 X1-12

SP01 SP02 SP03 SP04 SP05 SP06 SP07 SP08
X2-4 X2-6 X2-8 X2-10 X2-12 X2-14 X2-16 X2-18
X2-3 X2-5 X2-7 X2-9 X2-11 X2-13 X2-15 X2-17
TCS6 TCS8

27.5B

24.10E -PR

WH 1x1.5

-PR /./

| | | | | | | |
|---|---|---|---|---|---|---|
| = | | | | | | |
| +A3 | | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

DWG n° : 231151/SD/17
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
"REX640" Protection Wiring - Digital Input

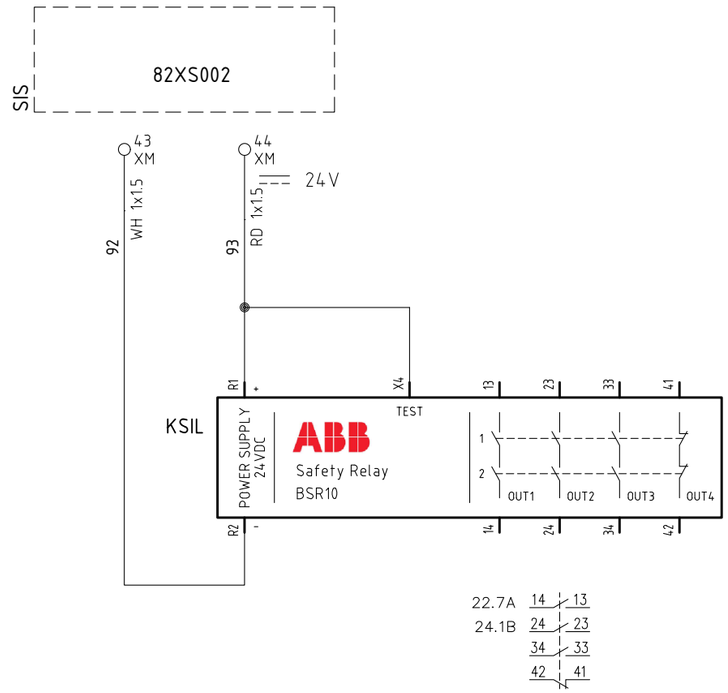
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00017
SHEET 25
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# EMERGENCY OPENING BY "SIS"




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A3
DWG n° : 231151/SD/17
Item n° : PF1113279

CROSSWIND
IMESA ELECTRICAL ENGINEERING
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Emergency Opening by "SIS"

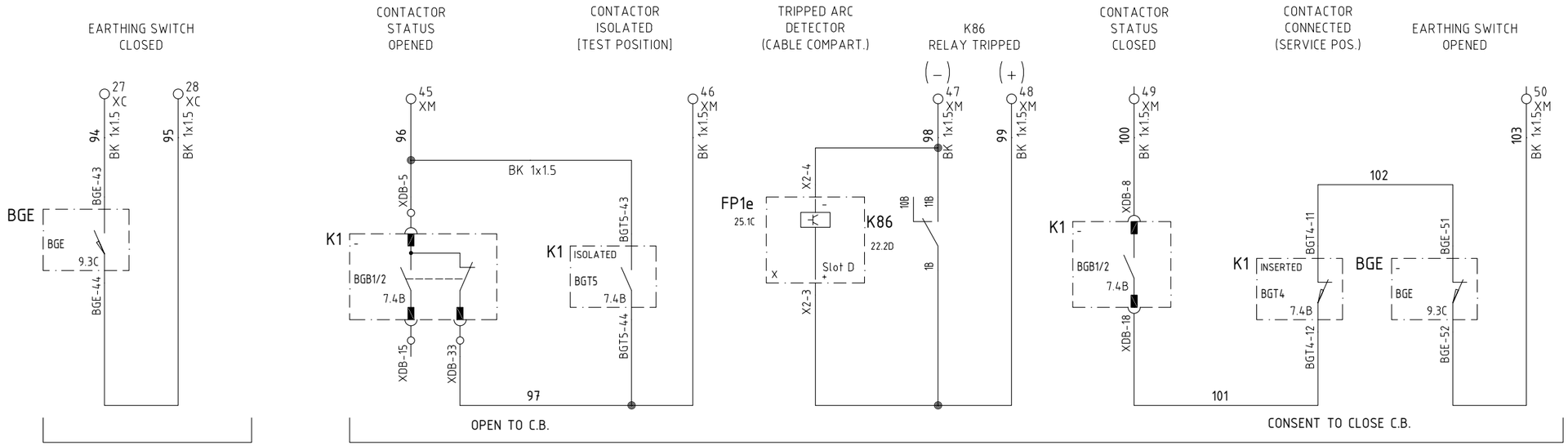
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

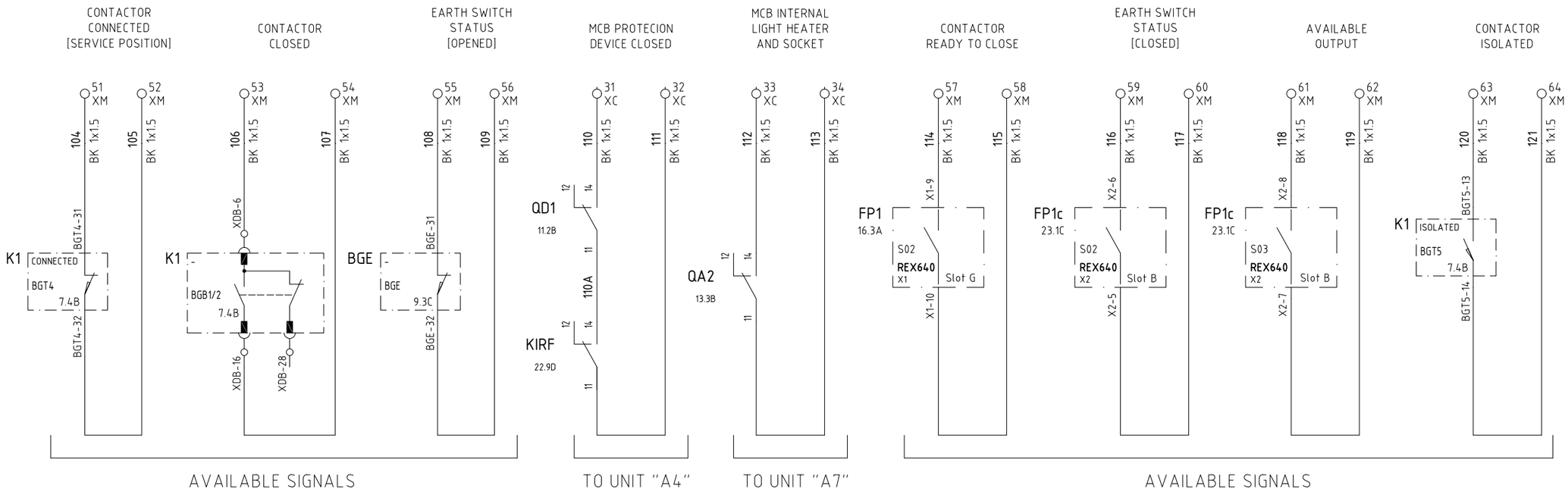
A3
DRAWING NO. 1723002197-EL-DG-00017
SHEET 26
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

# AVAILABLE SIGNALS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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DWG n° : 231151/SD/17
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Availables Signals

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00017
SHEET 27
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

TYP - BESS
XI
Ammeter Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 2 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 3 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HL201GR | Cabur | HLD.2/PT/GR End section - Grey |
| 4 | 8.4A | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 5 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 6 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 7 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 8 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HL201GR | Cabur | HLD.2/PT/GR End section - Grey |

TYP - BESS
XV
Voltmetric Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 10.2D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 2 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 3 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 4 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 5 | 10.4D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 6 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 7 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 8 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 9 | 10.7D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 10 | 10.7D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 11 | 14.4C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 12 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 13 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 14 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 15 | 15.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 16 | 15.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |

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DWG n° : 231151/SD/17
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00017
SHEET 28
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

TYP - BESS
XC
Interconnection Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 11.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 2 | 11.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 3 | 11.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 4 | 11.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 5 | 11.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 6 | 11.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 7 | 11.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 8 | 11.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 9 | 13.1A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 10 | 13.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 11 | 13.2A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 12 | 13.2B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 13 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 14.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 14.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 21 | 15.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 15.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 15.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 15.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 25 | 24.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 24.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 27.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 27.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 25.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 25.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 27.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 27.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 27.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 27.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 21.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 21.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

TYP - BESS
XC
Interconnection Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 37 | 24.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 38 | 24.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/17
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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CROSSWIND
ROSETTI MARINO
IMESA ELECTRICAL ENGINEERING

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00017
SHEET 29
REV. 03

File Name : 1723002197-EL-DG-00017 Rev.03

F.to UNI A3: 420mmx297mm

TYP - BESS

XM

Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 10.4E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 2 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 3 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 4 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 5 | 20.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 6 | 20.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 7 | 20.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 8 | 20.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 9 | 21.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 10 | 21.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 11 | 21.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 12 | 21.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 13 | 21.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 21.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 22.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 22.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 22.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 22.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 22.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 22.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 21 | 23.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 23.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 23.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 23.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 25 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 24.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 24.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 24.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 24.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 24.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 24.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 24.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 24.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 37 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 38 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 39 | 25.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 40 | 25.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/17

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL BESS FEEDER A-85000

Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00017

SHEET 30

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

TYP - BESS
XM
Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 41 | 25.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 42 | 25.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 43 | 26.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 44 | 26.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 45 | 27.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 46 | 27.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 47 | 27.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 48 | 27.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 49 | 27.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 50 | 27.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 51 | 27.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 52 | 27.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 53 | 27.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 54 | 27.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 55 | 27.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 56 | 27.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 57 | 27.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 58 | 27.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 59 | 27.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 60 | 27.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 61 | 27.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 62 | 27.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 63 | 27.9C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 64 | 27.9C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 65 | 22.10A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 66 | 22.10B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 67 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 68 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 69 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 70 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 71 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 72 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 73 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 74 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 75 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 76 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

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DWG n° : 231151/SD/17
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 31 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A3 | BESS FEEDER A-85000 |
| BGE | 9 | 1VCF599700R0131 | 1 | EARTHING SWITCH ST-E 17.31 150 | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF599505R0001 | 1 | 5 AUX CONTACTS FOR EARTHING SWITCH | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF599504R0063 | 1 | KEY LOCKS ON EARTHING SWITCH | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF599700R0290 | 1 | EARTHING SWITCH OPERATING LEVER | ABB | A3 | BESS FEEDER A-85000 |
| C1 | 9 | 43911082 | 1 | VPIS - DEVICE SIGNALLING VOLTAGE PRESENT KIT | ELECTRONSYSTEM | A3 | BESS FEEDER A-85000 |
| CB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A3 | BESS FEEDER A-85000 |
| CC | 9 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A3 | BESS FEEDER A-85000 |
| E1 | 13 | 74041 | 1 | LED LAMP 4W 4000K 313x30x22 | Beghelli | A3 | BESS FEEDER A-85000 |
| E8 | 10 | 1VCF501000R0001 | 1 | RESISTOR TR318 27R/J 27ohm 500W L=2,5M | ABB | A3 | BESS FEEDER A-85000 |
| EH1 | 13 | R1R150230 | 1 | SPACE HEATER SKR 150W ALIM. 220VCA | Torresan | A3 | BESS FEEDER A-85000 |
| FF1 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A3 | BESS FEEDER A-85000 |
| FF2 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A3 | BESS FEEDER A-85000 |
| FF3 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A3 | BESS FEEDER A-85000 |
| FP1 | 16 | 1VCF698331R0001 | 1 | REX640B10NN+AIM1+AIM1+ARC1+BIO1+BIO1+BI+O2+CMP2+COM1+LNG1+MCT1+PCL4+PSM3+SCT1 | ABB | A3 | BESS FEEDER A-85000 |
| HGR | 13 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | A3 | BESS FEEDER A-85000 |
| K1 | 7 | 1VCF305661R3200 | 1 | VACUUM CONTACTOR VSC7/P 3P 7,2KV 400A DOUBLE COMMAND (DCO) | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF309500R3881 | 1 | VACUUM CONTACTOR FITTED FOR DIN E=442mm FUSES | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF309500R0882 | 1 | NAMEPLATE IN ENGLISH LANGUAGE | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF309500R1881 | 1 | VACUUM CONTACTOR FOR UNIGEAR/UNISEC | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF309503R0881 | 1 | MAC-R2 ELECTRONIC CONTROL MODULE TYPE STANDARD | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF309503R1881 | 1 | VACUUM CONTACTOR CONFORMS TO THE IRC 62271-106 STANDARDS | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF309588R0909 | 1 | POWER SUPPLY VOLTAGE OF MAC-R2 ELECTRONIC CONTROL MODULE 110VDC | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF309500R0100 | 1 | OPERATIONS COUNTER FOR VSC/P VERSIONE FOR SHIPPINGS REGISTER | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF349700R0407 | 1 | MECHANICAL INTERLOCK WITH DOOR | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF339700R0291 | 1 | POSITION CONTACTS FOR VD4 | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF339700R1909 | 1 | LOCKING MAGNET ON THE TRUCK 110Vdc (RLE2) | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF309503R0251 | 1 | KIT FOR FUSES DIAMETER 87mm | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF309500R0192 | 1 | LIFTING TOOL FOR SHIPPINGS REGISTERS VERSION | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF597111R0140 | 1 | POWER CUBE PB1/E L600 12kV 400A 31.5KA 3S | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF599700R0882 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR POWERCUBE | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF599700R5886 | 1 | PB FOR VSC | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF599700R4882 | 1 | PAINTED DOOR | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF599504R0042 | 1 | LOCK TO PREVENT RACKING-IN WITH EARTHING SWITCH | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF599700R0162 | 1 | 58 POLES CONNECTOR + ATOXIC WIRING L=0.8mt | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF599505R0111 | 1 | FAIL-SAFE SHUTTER ELEMENTS | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF579700R0909 | 1 | ELECTROMECHANICAL ISOLATING INTERLOCK CIRCUIT-BREAKER/DOOR 110Vdc (RLE4) | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF599700R0280 | 1 | INTERLOCK FOR DOOR EARTHING SWITCH | ABB | A3 | BESS FEEDER A-85000 |
| | | 1YMB711238M4812 | 1 | BACK UP CURRENT LIMINTING FUSE LINK 6/12kV 160A 442x65mm - CEF | ABB | A3 | BESS FEEDER A-85000 |
| K86 | 22 | RMBE13-C110T | 1 | BISTABLE RELAY 110VDC 7SC-5A TROP. | Amra | A3 | BESS FEEDER A-85000 |
| | | PAVM321 | 1 | SOCKET WITH SCREW TO RELAY TYPE PAVM321 | Amra | A3 | BESS FEEDER A-85000 |
| K94WT | 22 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A3 | BESS FEEDER A-85000 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A3 | BESS FEEDER A-85000 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A3 | BESS FEEDER A-85000 |

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DWG n° : 231151/SD/17
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 32 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| KGR | 13 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A3 | BESS FEEDER A-85000 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A3 | BESS FEEDER A-85000 |
| | | ER 552 0 | 1 | CR-M230AC2L SUPPLY 230VAC 2C/O 250V/6A LED | ABB | A3 | BESS FEEDER A-85000 |
| KIRF | 22 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A3 | BESS FEEDER A-85000 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A3 | BESS FEEDER A-85000 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A3 | BESS FEEDER A-85000 |
| KSIL | 26 | 2TLA010040R0000 | 1 | BSR10 Vaux=24VDC SAFETY RELAY | ABB | A3 | BESS FEEDER A-85000 |
| KT1 | 20 | H3DKM2ACDC24240 | 1 | MULTIFUNCTION TIMER RELAY Vaux=24÷240Vac/dc - 2SC | Omron | A3 | BESS FEEDER A-85000 |
| L1C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A3 | BESS FEEDER A-85000 |
| L1I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A3 | BESS FEEDER A-85000 |
| L1MS | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A3 | BESS FEEDER A-85000 |
| L2C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A3 | BESS FEEDER A-85000 |
| L2I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A3 | BESS FEEDER A-85000 |
| L3C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A3 | BESS FEEDER A-85000 |
| L3I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A3 | BESS FEEDER A-85000 |
| L3MS | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A3 | BESS FEEDER A-85000 |
| LS | 13 | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | A3 | BESS FEEDER A-85000 |
| | | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | A3 | BESS FEEDER A-85000 |
| OD1 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A3 | BESS FEEDER A-85000 |
| OD2 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A3 | BESS FEEDER A-85000 |
| OD3 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A3 | BESS FEEDER A-85000 |
| P1 | 20 | KW 080 2 | 1 | MP1-10B BLACK PUSH BUTTON UNSTABLE | ABB | A3 | BESS FEEDER A-85000 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A3 | BESS FEEDER A-85000 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A3 | BESS FEEDER A-85000 |
| PR | 22 | KW 101 6 | 1 | YELLOW LIGHT PUSH BUTTON | ABB | A3 | BESS FEEDER A-85000 |
| | | KV 022 5 | 1 | MLBL-05W YELLOW LED BLOCK INTEGRATED 110÷130VAC | ABB | A3 | BESS FEEDER A-85000 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A3 | BESS FEEDER A-85000 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A3 | BESS FEEDER A-85000 |
| PTT | 10 | 1VCF498412R0100 | 1 | TV/F COMPARTMENT 12/17kV IP4X L=590mm OUTLET ON THE BACK WITH N°3 VT + N°14 MAIN CONTACTS + N°2+2 SERVICE/ISOLATED POSITION CONTACTS | ABB | A3 | BESS FEEDER A-85000 |
| | | 1VCF499800R0302 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR TV/F | ABB | A3 | BESS FEEDER A-85000 |
| QA2 | 13 | B427917 | 1 | DDA202 AC 25A 300MA BLOCCO DIFFERENZIALE 2P | ABB | A3 | BESS FEEDER A-85000 |
| | | A563819 | 1 | S2-CS/H6R CONTATTO DI SEGNALAZIONE/AUX 1SC | ABB | A3 | BESS FEEDER A-85000 |
| | | S550284 | 1 | S202M C10 INTERRUTTORE AUTOMATICO 10KA 2P | ABB | A3 | BESS FEEDER A-85000 |
| QD1 | 11 | A563819 | 1 | S2-CS/H6R CONTATTO DI SEGNALAZIONE/AUX 1SC | ABB | A3 | BESS FEEDER A-85000 |
| | | S550253 | 1 | S202M C 4 INTERRUTTORE AUTOMATICO 10KA 2P | ABB | A3 | BESS FEEDER A-85000 |
| QD2 | 11 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A3 | BESS FEEDER A-85000 |
| | | a563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT | ABB | A3 | BESS FEEDER A-85000 |
| QD4 | 11 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A3 | BESS FEEDER A-85000 |
| | | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A3 | BESS FEEDER A-85000 |
| QV1 | 10 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A3 | BESS FEEDER A-85000 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A3 | BESS FEEDER A-85000 |
| QV2 | 10 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A3 | BESS FEEDER A-85000 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A3 | BESS FEEDER A-85000 |

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DWG n° : 231151/SD/17

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL BESS FEEDER A-85000

Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 33 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| QV3 | 10 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A3 | BESS FEEDER A-85000 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A3 | BESS FEEDER A-85000 |
| QV4 | 14 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A3 | BESS FEEDER A-85000 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A3 | BESS FEEDER A-85000 |
| QV5 | 15 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A3 | BESS FEEDER A-85000 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A3 | BESS FEEDER A-85000 |
| S1C | 25 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A3 | BESS FEEDER A-85000 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A3 | BESS FEEDER A-85000 |
| | | KW 076 0 | 1 | MP1-10G PUSH BUTTON GREEN WITH BLACK RING | ABB | A3 | BESS FEEDER A-85000 |
| S2O | 25 | KW 075 2 | 1 | MP1-10R PUSH BUTTON RED WITH BLACK RING | ABB | A3 | BESS FEEDER A-85000 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A3 | BESS FEEDER A-85000 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A3 | BESS FEEDER A-85000 |
| SA1 | 23 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A3 | BESS FEEDER A-85000 |
| | | EO 571 3 | 1 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | A3 | BESS FEEDER A-85000 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A3 | BESS FEEDER A-85000 |
| | | KW 329 3 | 1 | M2SS2-10B HANDLE SELECTOR 2P 90° BLACK RING BLACK | ABB | A3 | BESS FEEDER A-85000 |
| SA2 | 22 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A3 | BESS FEEDER A-85000 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A3 | BESS FEEDER A-85000 |
| | | EO 571 3 | 1 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | A3 | BESS FEEDER A-85000 |
| | | KW 329 3 | 1 | M2SS2-10B HANDLE SELECTOR 2P 90° BLACK RING BLACK | ABB | A3 | BESS FEEDER A-85000 |
| TI1 | 8 | ATB-10-BS__014 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 150/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A3 | BESS FEEDER A-85000 |
| TI2 | 8 | ATB-10-BS__014 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 150/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A3 | BESS FEEDER A-85000 |
| TI3 | 8 | ATB-10-BS__014 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 150/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A3 | BESS FEEDER A-85000 |
| TO | 9 | KAP-150/250-55 | 1 | CURRENT TRANSFORMER 0,72/3/-kV 100/1 50Hz | ESITAS | A3 | BESS FEEDER A-85000 |
| TR1 | 19 | 800208 | 1 | MODBUS DATACARD 8 CHANNELS | Exertherm | A3 | BESS FEEDER A-85000 |
| TU-L1 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A3 | BESS FEEDER A-85000 |
| TU-L2 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A3 | BESS FEEDER A-85000 |
| TU-L3 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A3 | BESS FEEDER A-85000 |
| XC | | HM320GR | 12 | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) | Cabur | A3 | BESS FEEDER A-85000 |
| | | HM250GR | 26 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A3 | BESS FEEDER A-85000 |
| | | HM251GR | 2 | HMT.4/PT/GR End section - Grey | Cabur | A3 | BESS FEEDER A-85000 |
| | | HM321GR | 3 | HMT.6/PT/GR End section - Grey | Cabur | A3 | BESS FEEDER A-85000 |
| XI | | HB220GR | 8 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur | A3 | BESS FEEDER A-85000 |
| | | HL201GR | 2 | HLD.2/PT/GR End section - Grey | Cabur | A3 | BESS FEEDER A-85000 |
| XM | | HM250GR | 76 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A3 | BESS FEEDER A-85000 |
| | | HM251GR | 2 | HMT.4/PT/GR End section - Grey | Cabur | A3 | BESS FEEDER A-85000 |
| XS1 | 13 | E 9447 7 | 1 | SOCKET | ABB | A3 | BESS FEEDER A-85000 |
| XV | | HB210GR | 16 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type | Cabur | A3 | BESS FEEDER A-85000 |
| | | HB201GR | 5 | HSCB.6/PT/GR End section - Grey | Cabur | A3 | BESS FEEDER A-85000 |

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DWG n° : 231151/SD/17
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL BESS FEEDER A-85000
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00017 | SHEET 3.4 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00017 Rev.03

1.4.4.SG-100D1 HV SWG FUNCTIONAL DIAGRAM - ELECTROLYSER FEEDER (including Terminals and BOM) ,

Doc. No. 1723002197-EL-DG-00018

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# "SG-100D1" HV SWBD 6,6kV (UNIT A1)

# FUNCTIONAL DIAGRAM

# ELECTROLYSER FEEDER A-20000

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Maeule | 12/09/2024 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/18

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 – FUNCTIONAL ELECTROLYSER FEEDER A-2000

Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

SHEET 1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

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| 3 | Legend | | | | | | | | | |
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| 26 | "REX640" Protection Wiring - Digital Input | | | | | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
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| 29 | Terminal strips | | | | | | | | | |
| 30 | Terminal strips | | | | | | | | | |
| 31 | Terminal strips | | | | | | | | | |
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DWG n° : 231151/SD/18
Item n° : PF1113279

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
Sheets Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 2 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# ACRONIMUS LEGEND

| ITEM | DESCRIPTION |
|---|---|
| BB | ARC SENSOR PROTECTION ON MAIN BUS BARS |
| BGE | EARTHING SWITCH |
| C1 | VOLTAGE PRESENCE |
| CB | ARC SENSOR PROTECTION ON C.B. / CONTACTOR COMPARTMENT |
| CC | ARC SENSOR PROTECTION ON CABLE COMPARTMENT |
| DCO | DOUBLE COMMAND OPERATED CONTACTOR |
| DI3 | UNDERVOLTAGE CONTACTOR |
| DP1 | ALARM RELAY MODULE TEMPERATURE |
| E1 | INTERNAL LIGHT |
| E8 | RESISTOR FERRO-RESONANCE |
| EH1 | INTERNAL SPACE HEATER |
| Fn | MV FUSE |
| FP1 | PROTECTION RELAY |
| GS1 | DC/DC CONVERTER |
| HGR | THERMOSTAT |
| Kn | AUXILIARY RELAY |
| K1 | MV CONTACTOR |
| K86 | BLOCK RELAY |
| KT1 | DE-ENERGIZATION TIMER |
| LS | MICRO SWITCH ON AUXILIARY DOOR |
| MAS | MOTOR SPRING CHARGER |
| MBC | CLOSING COIL |
| MBO1 | OPENING COIL |
| MBU | UNDERVOLTAGE |
| ODn | VOLTAGE DISCHARGER |
| PU1 | MEASURING VOLTAGE INSTRUMENT |

| ITEM | DESCRIPTION |
|---|---|
| PTT | V.T. TRUCK |
| QM | MV CIRCUIT-BREAKER |
| QDn | M.C.B. CIRCUITS PROTECTION |
| QVn | M.C.B FOR V.T. PROTECTION |
| RLE1 | COIL FOR CONSET CLOSING CIRCUIT-BREAKER |
| RLE2 | COIL FOR UNLOCKING RACK-IN/OUT OPERATION |
| RLE3 | COIL FOR UNLOCKING OPERATION EARTHING |
| RLE4 | COIL FOR UNLOCKING ENCLOSURE DOOR OPERATION |
| SU1 | VOLTAGE SELECTOR |
| SWH... | ETHERNET SWITCH |
| TI-Ln | CURRENT TRANSFORMER |
| TO | OMOPOLAR RING CURRENT TRANSFORMER |
| TR1 | TEMPERATURE CONTROL DEVICE |

FUNCTIONAL OF THE PROTECTION RELAY OUTPUT CONTACTS:

SLOT "G":
RF = WATCHDOG RELAY
S01 = EARTHING SWITCH UNLOCKING
S02 = C.B. or CONTACTOR READY TO CLOSE
SS01 = BREAKER FAILURE
POSP1 = CLOSING COMMAND
S03 = C.B. or CONTACTOR TRUCK UNLOCKED
PODP1 = OPENING COMMAND
SLOT "B"
S01 = TRIP PROTECTION TO LOCKOUT RELAY
S02 = EARTHING SWITCH CLOSED
S03 = AVAILABLE OUTPUT (ON TERMINAL STRIP)
S04 = RESET LOKOUT RELAY
SLOT "D":
SP01 = TRIP ARC DETECTOR ON OPENING COMMAND
SP03 = TRIP ARC DETECTOR ON LOCKOUT RELAY

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DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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TITLE :
SG-100D1 – FUNCTIONAL ELECTROLYSER FEEDER A-2000
Legend

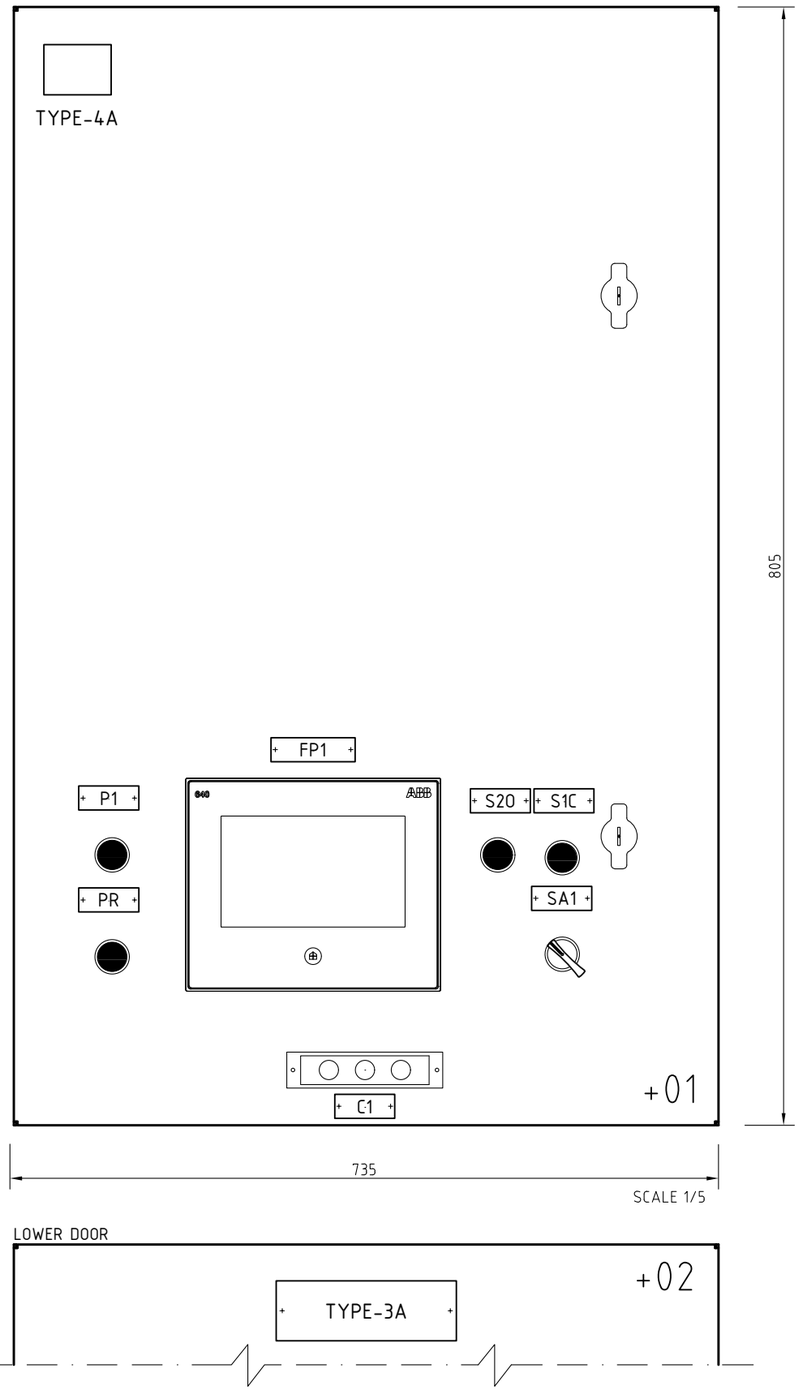
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 3 | REV. 03

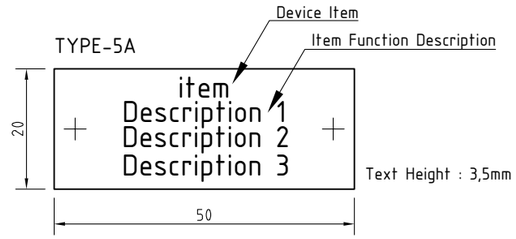
F.to UNI A3: 420mmx297mm

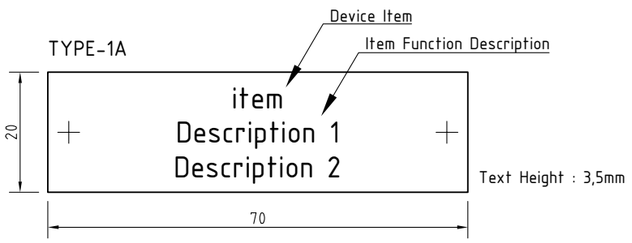
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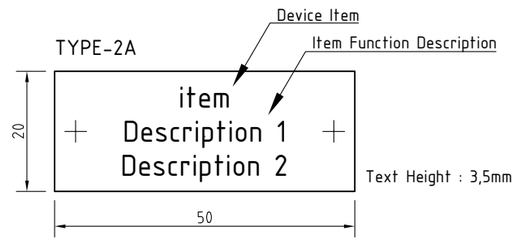
# DOOR LAY-OUT

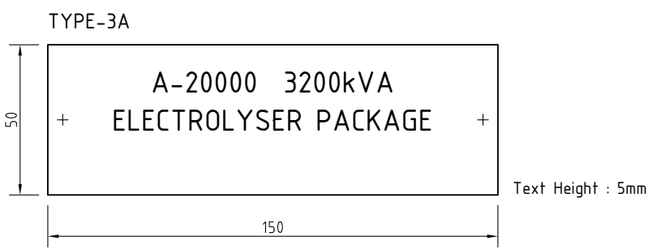


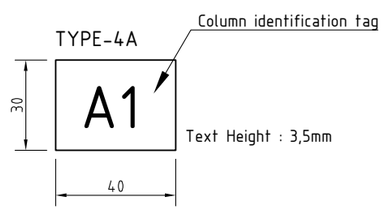

| DEVICES name plate | | | | | |
|---|---|---|---|---|---|
| ITEM | COMPONENT | DESCRIPTION 1 | DESCRIPTION 2 | DESCRIPTION 3 | NOTE |
| FP1 | PROTECTION RELAY | PROTECTION RELAY | | | TYPE-1A |
| S2.O | PUSH BUTTON | OPEN | COMMAND | C.B. | TYPE-5A |
| S1.C | PUSH BUTTON | CLOSE | COMMAND | C.B. | TYPE-5A |
| SA1 | SELECTOR SWITCH | LOCAL / REMOTE | | | TYPE-2A |
| PR | LIGHT PUSH BUTTON | RESET | LOCK-OUT | TRIP LOCK-OUT | TYPE-5A |
| C1 | PILOT LIGHT | VOLTAGE | PRESENCE | | TYPE-2A |
| P1 | PUSH BUTTON | TRUCK-DOOR | ENABLING | ENABLING | TYPE-5A |




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| DWG n° : 231151/SD/18 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| Item n° : PF1113279 | 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

TITLE :
SG-100D1 – FUNCTIONAL ELECTROLYSER FEEDER A-2000
Door Layout

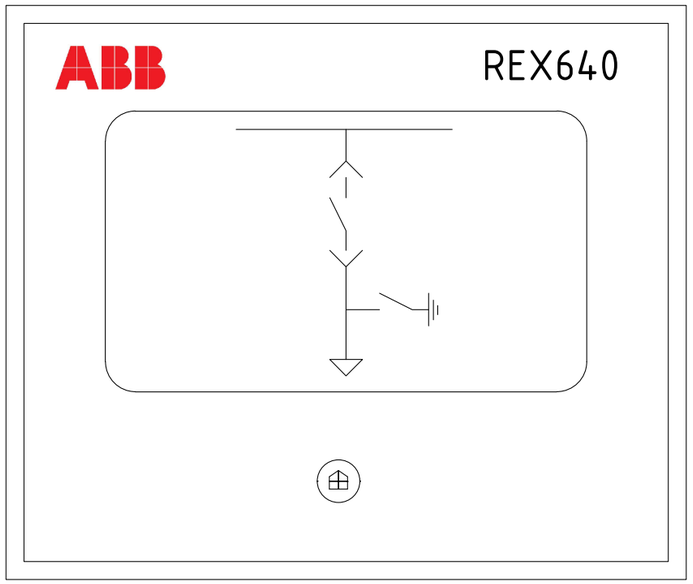
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 4 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# PROTECTION DISPLAY




## LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE C.B." AND "OPEN C.B." NOT ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED

| LEDs PAGE 1 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/27-2/59-1/59-2 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | CONTACTOR READY (TCS) | - | GREEN | OK = TCS OK (CONTACTOR READY) |
| LED-3 | SYNCHRO CHECK | | GREEN | OK = SYNCHRONISM |
| LED-4 | CONTACTOR READY TO CLOSE | - | GREEN | OK = CONTACTOR READY TO CLOSE |
| LED-5 | 50-1/51-1/67-1/67-2 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/59N-1/59N-2 - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = CONTACTOR TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | EMERGENCY OPENING BY SIS (ESD) | RED | - | ALARM = ESD TRIPPED |

| LEDs PAGE2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | | | | |
| LED-15 | TRIP FROM L.V. | RED | | ALARM = L.V. TRIP |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
Protection Display REX640

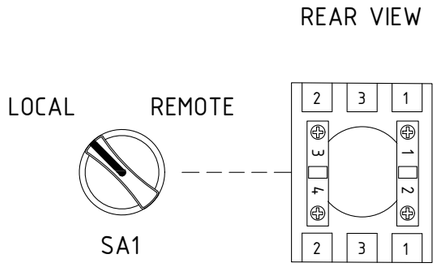
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 5 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# SELECTORS SWITCH DIAGRAM




## NOTES

THE DIAGRAM INDICATES THE FOLLOWING CONDITIONS:
-INSERTED CIRCUIT BREAKER IN OPEN POSITION
-DE-ENERGIZED CIRCUITS
-DSCHARGED CLOSING SPRINGS
-EARTHING SWITCH OPEN

THE AUXILIARY CIRCUITS WILL HAVE THE FOLLOWING CHARACTERISTICS:
-110+ / 24+ 1,5mmq RED TYPE CABLE SH-W
-110- / 24- 1,5mmq WHITE TYPE CABLE SH-W
-AUXILIARY CONTACTS TO TERMINAL STRIP 1,5mmq BLACK TYPE CABLE SH-W
-230Vac 1,5mmq BLACK TYPE SH-W
-VOLTMETRICAL CIRCUITS 1,5mmq BLACK TYPE CABLE SH-W
-AMMETRICAL CIRCUIT 2,5mmq BLACK TYPE CABLE SH-W

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A1
DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

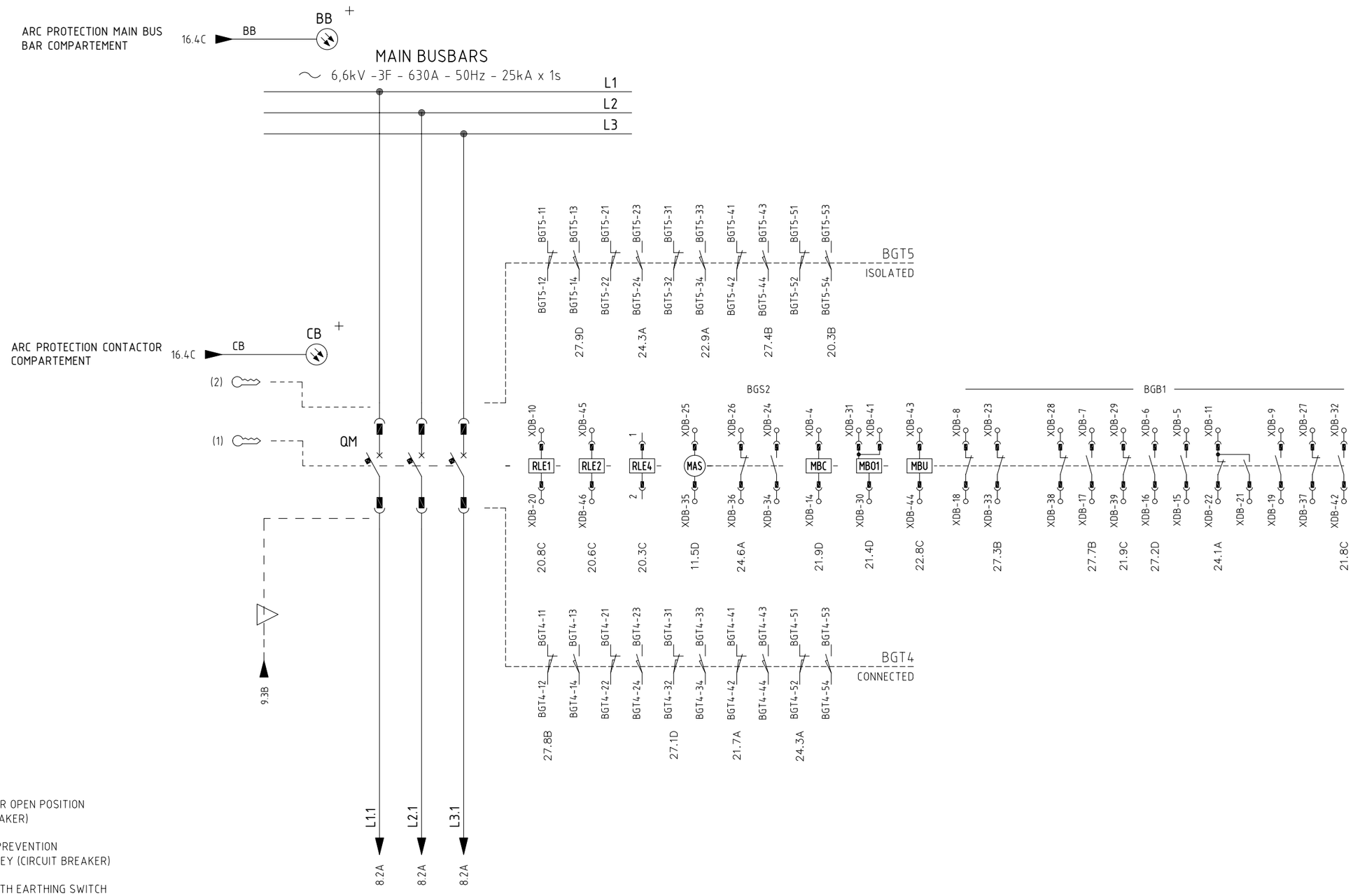
TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
Selector Switch Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 6 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03




(1) KEY LOCK FOR OPEN POSITION (CIRCUIT BREAKER)

(2) RACKING IN PREVENTION LOCK WITH KEY (CIRCUIT BREAKER)

(3) FREE KEY WITH EARTHING SWITCH IN OPEN POSITION

(4) FREE KEY WITH EARTHING SWITCH IN CLOSED POSITION

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/18

Item n° : PF1113279

EH-QMG-x

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

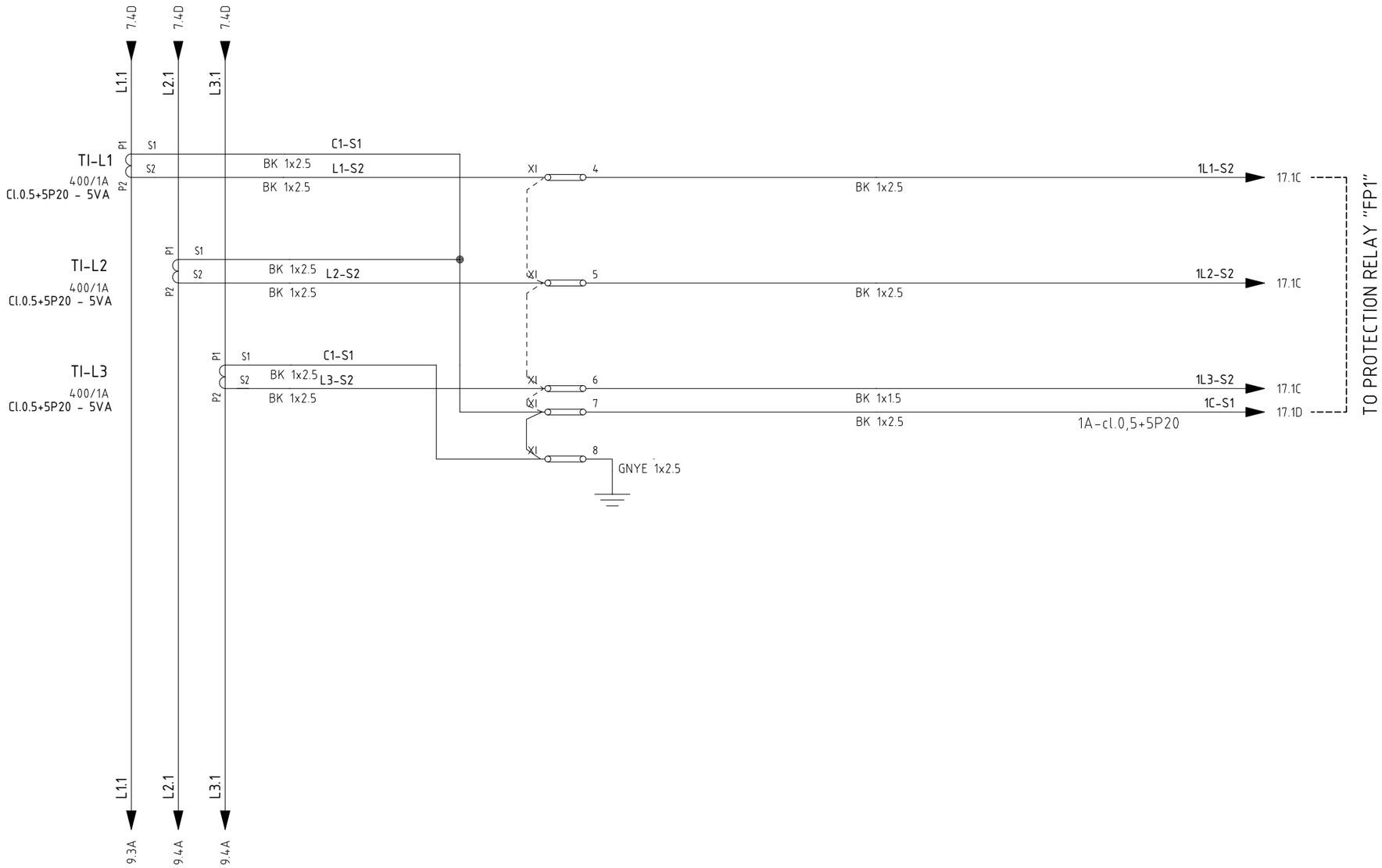
DRAWING NO. 1723002197-EL-DG-00018

SHEET 7

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

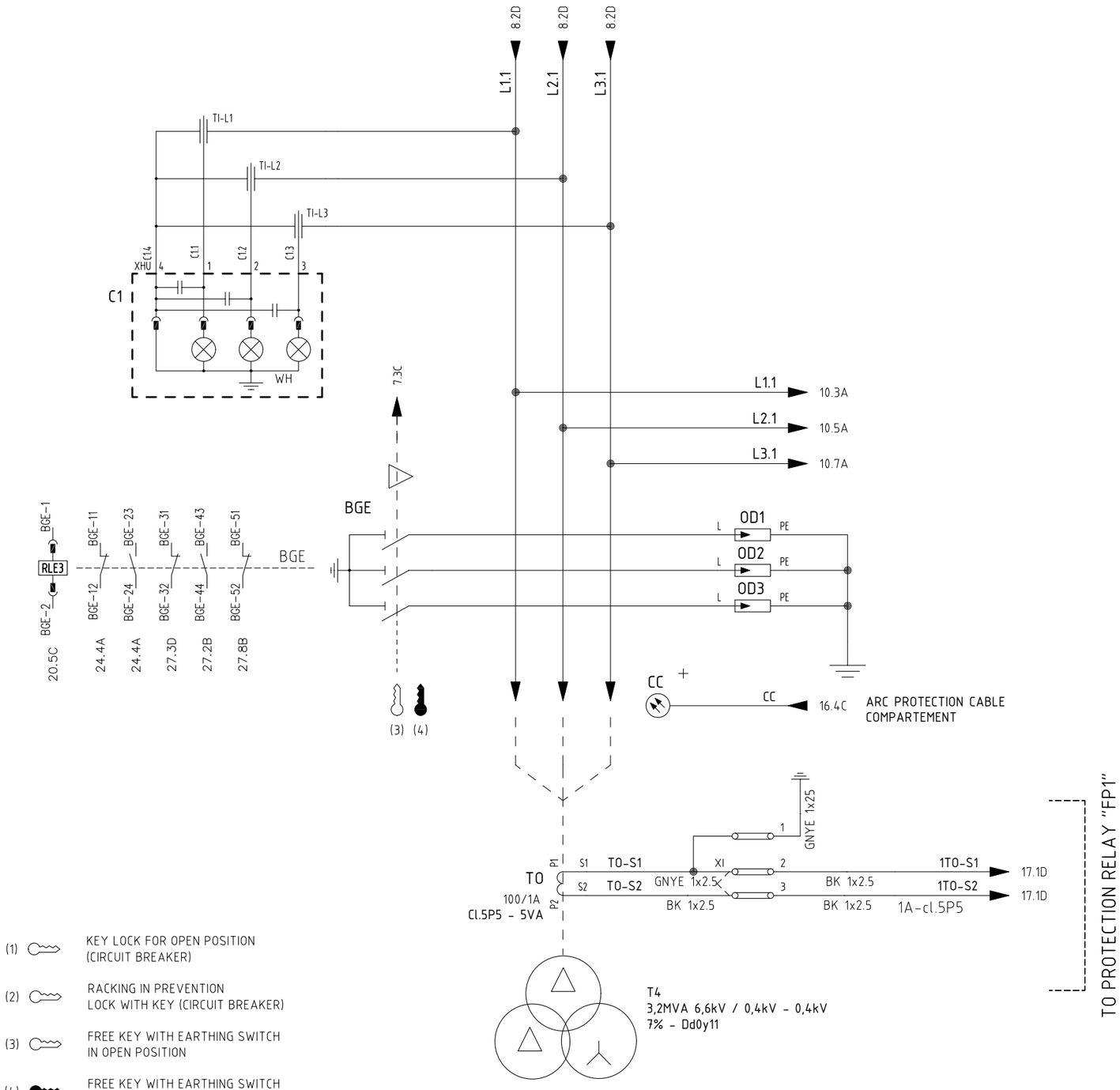
DRAWING NO. 1723002197-EL-DG-00018

SHEET 8

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03




(1) KEY LOCK FOR OPEN POSITION (CIRCUIT BREAKER)

(2) RACKING IN PREVENTION LOCK WITH KEY (CIRCUIT BREAKER)

(3) FREE KEY WITH EARTHING SWITCH IN OPEN POSITION

(4) FREE KEY WITH EARTHING SWITCH IN CLOSED POSITION

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231151/SD/18

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

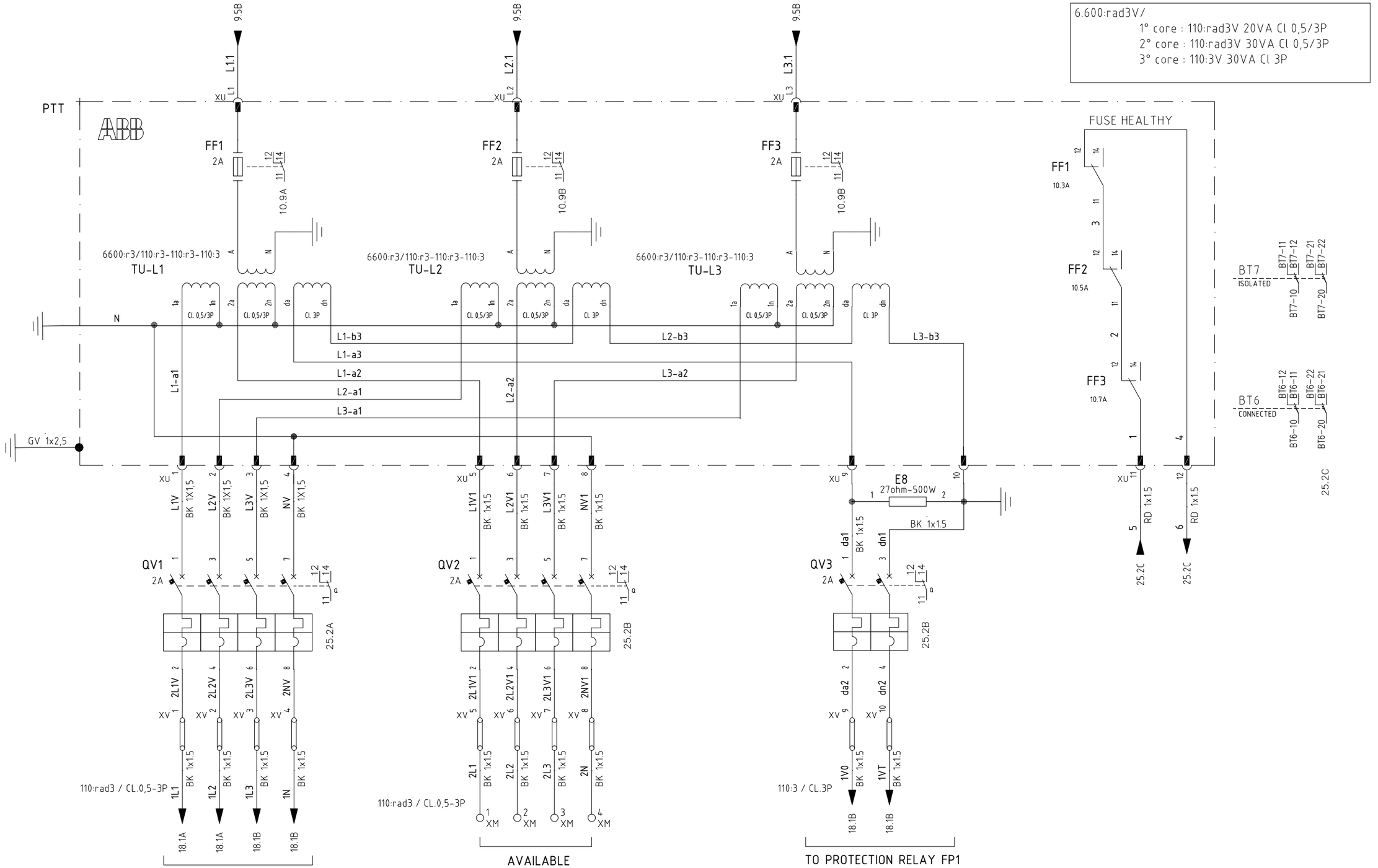
DRAWING NO. 1723002197-EL-DG-00018

SHEET 9

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

=
+A1

DWG n° : 231151/SD/18

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 – FUNCTIONAL ELECTROLYSER FEEDER A-2000

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

SHEET 1.0

REV. 03

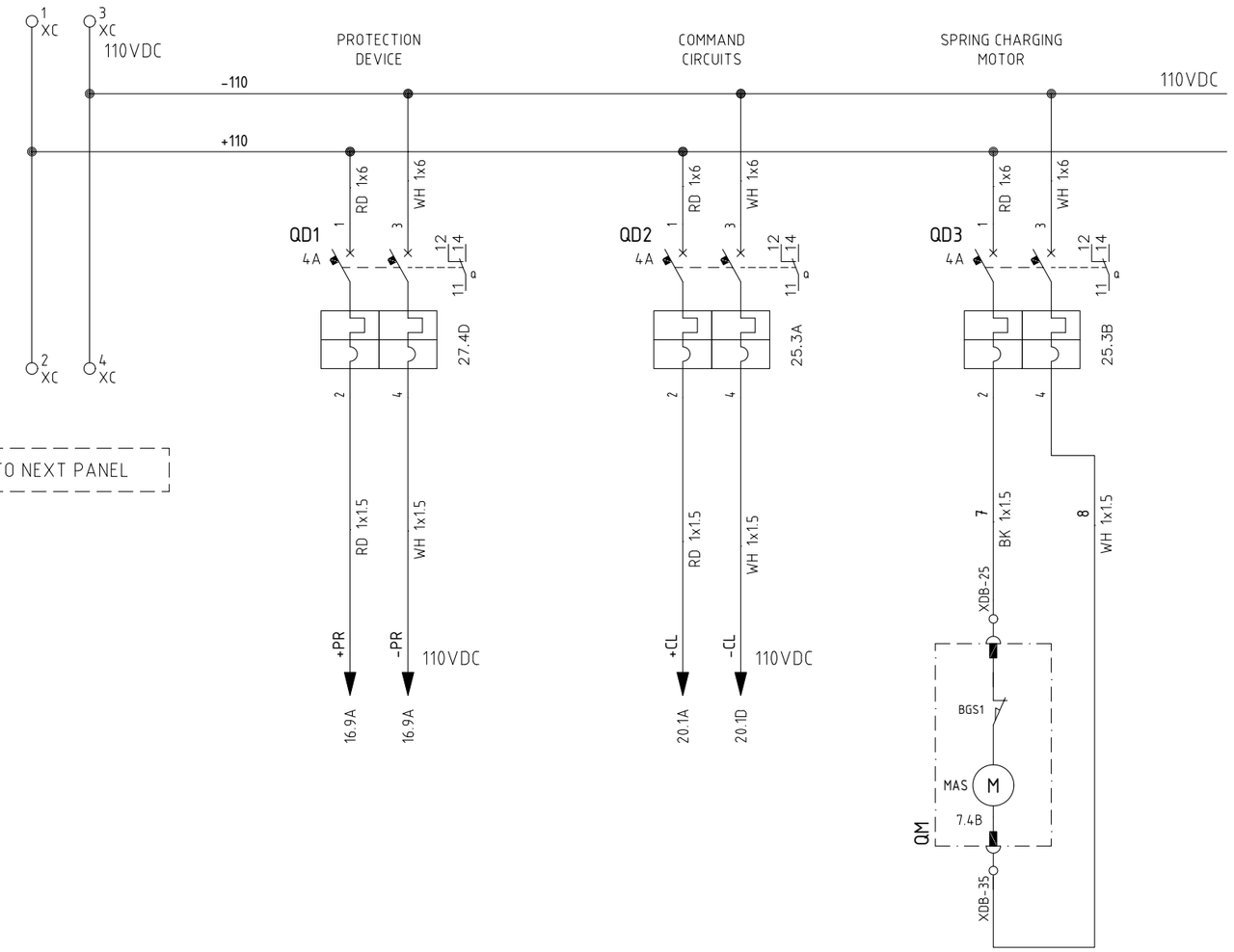
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

## 110VDC DISTRIBUTION VOLTAGE

110Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL

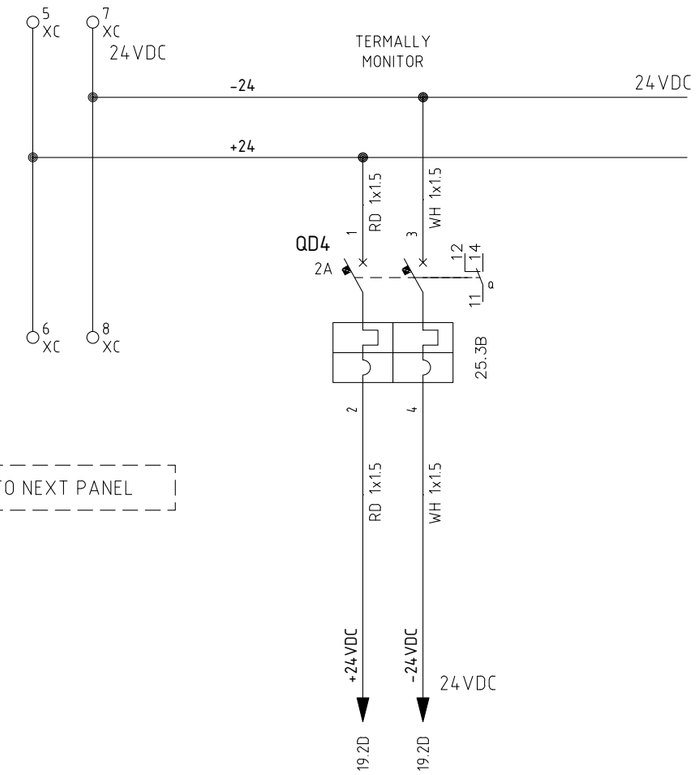



TO NEXT PANEL

## 24VDC DISTRIBUTION VOLTAGE

24Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A1
DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
110Vdc / 24Vdc Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

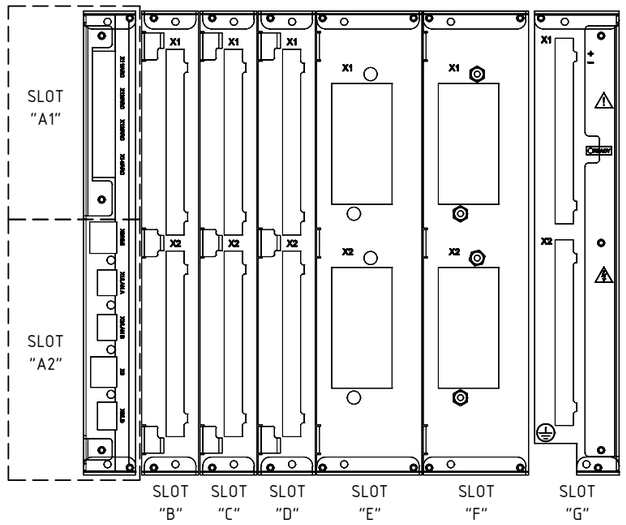
A3
DRAWING NO. 1723002197-EL-DG-00018
SHEET 1.1
REV. 03

File Name : 1723002197-EL-DG-00018 Rev.03

F.to UNI A3: 420mmx297mm

# COMPOSITION RELAY REX640

## RACK VIEW




REX640B10NN+COM1+ARC1+BIO1+BIO1+BIO2+AIM1+AIM1+PSM3+MCT1+SCT1+CMP2+LNG1+PCL4

| LEGEND | | |
|---|---|---|
| SLOT | Module Type | Description Module |
| A1 | ARC1001 | n° 4 x ARC sensor inputs |
| A2 | COM1001 | n° 1 x RJ-45 (LHMI port) + n° 3 x RJ-45 + n° 1 x SFP100M LC |
| B | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| C | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| D | BIO1002 | n° 9 Binary Input + n° 6 x SPO + n° 2 x SPO(TCS) |
| E | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| F | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| G | PSM1003 | 77...150 VDC, n° 3 x PO (TCS) + n° 2 x PO + n° 3 x SO + n° 2 x SSO |
| | PO = Power Output<br>SO = Signal Output<br>SPO = Static Power Output<br>SSO = Static Signal Output | |

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+A1

DWG n° : 231151/SD/18
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
Composition Relay REX640

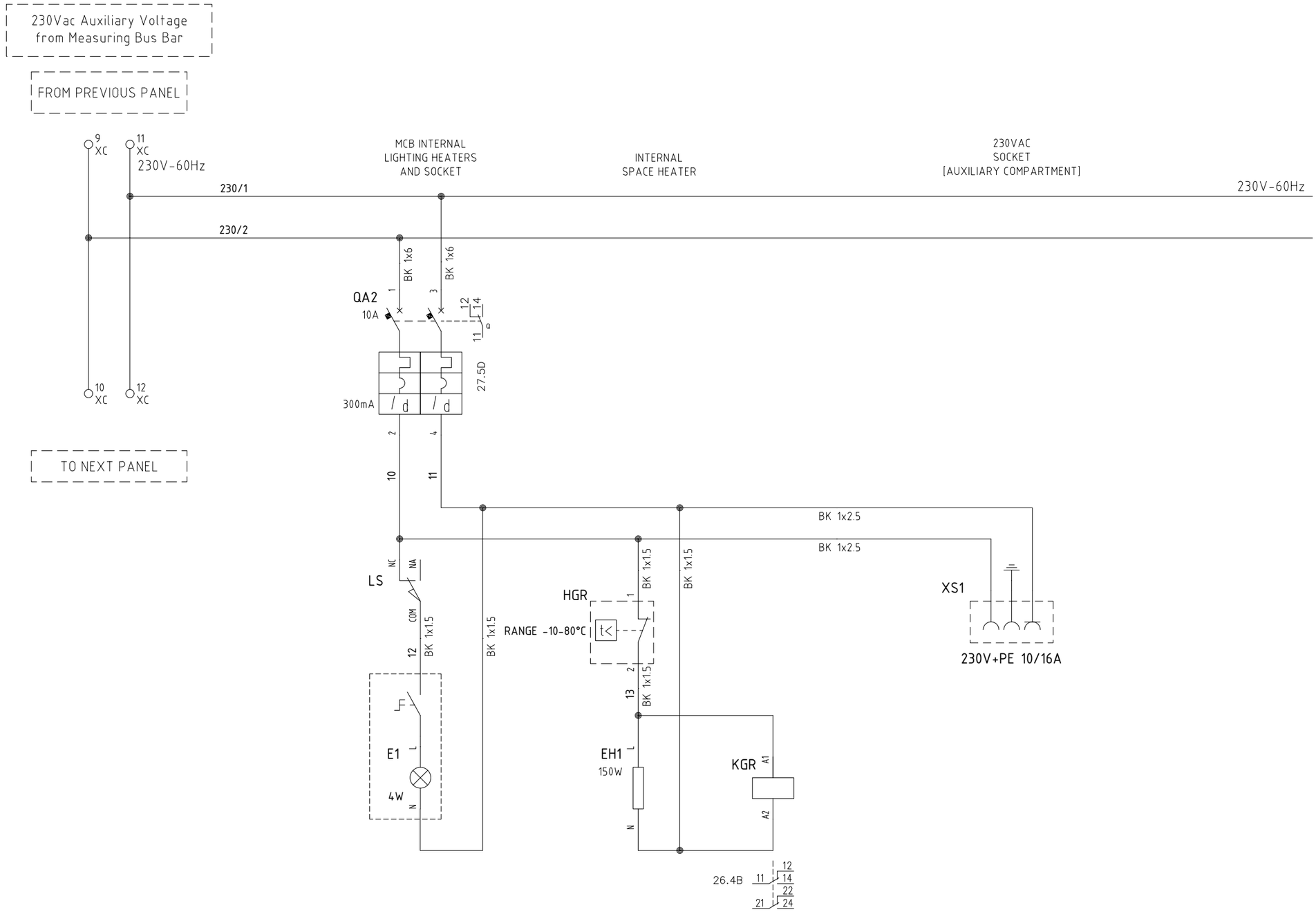
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 12 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# 230VAC DISTRIBUTION VOLTAGE




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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+A1

DWG n° : 231151/SD/18

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000

230Vac Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

SHEET 13

REV. 03

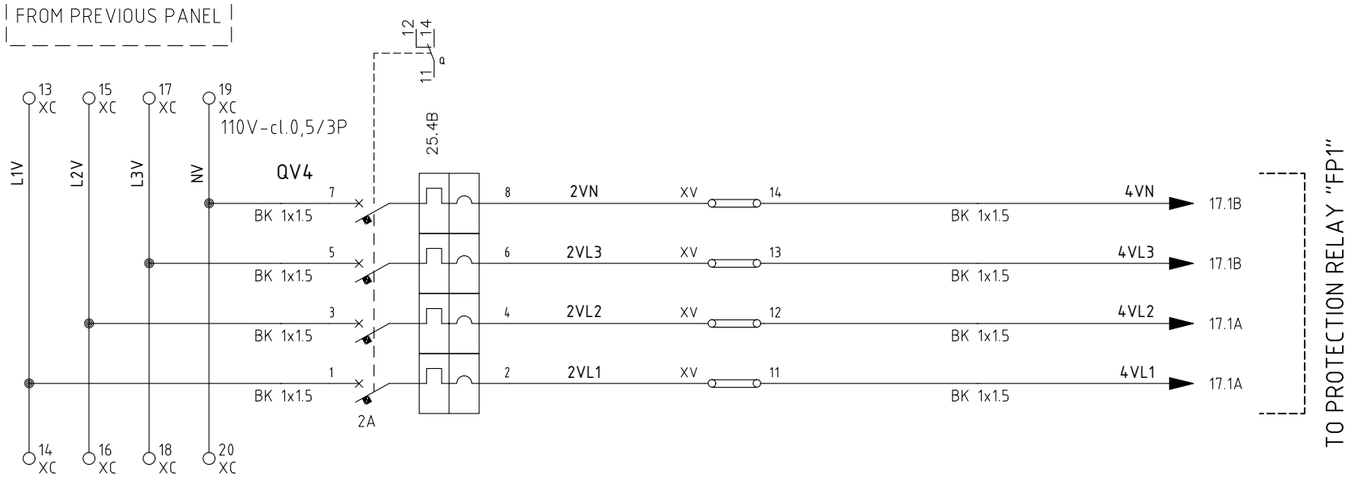
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# 110V: 1,73 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:√3V VOLTMETRIC LINE - STAR
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO PROTECTION RELAY "FP1"

TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= +A1
DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00018
SHEET 14
REV. 03

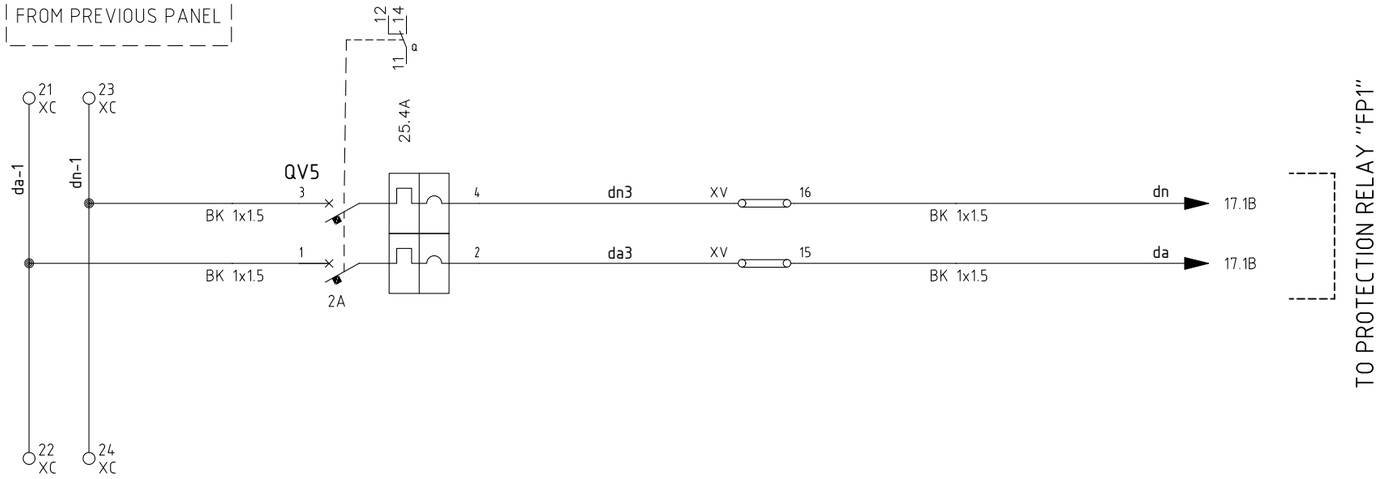
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# 110V:3 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:3V VOLTMETRIC LINE -
DELTA OPEN
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO PROTECTION RELAY "FP1"

TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
110V Protection/Measure Distribution Voltage

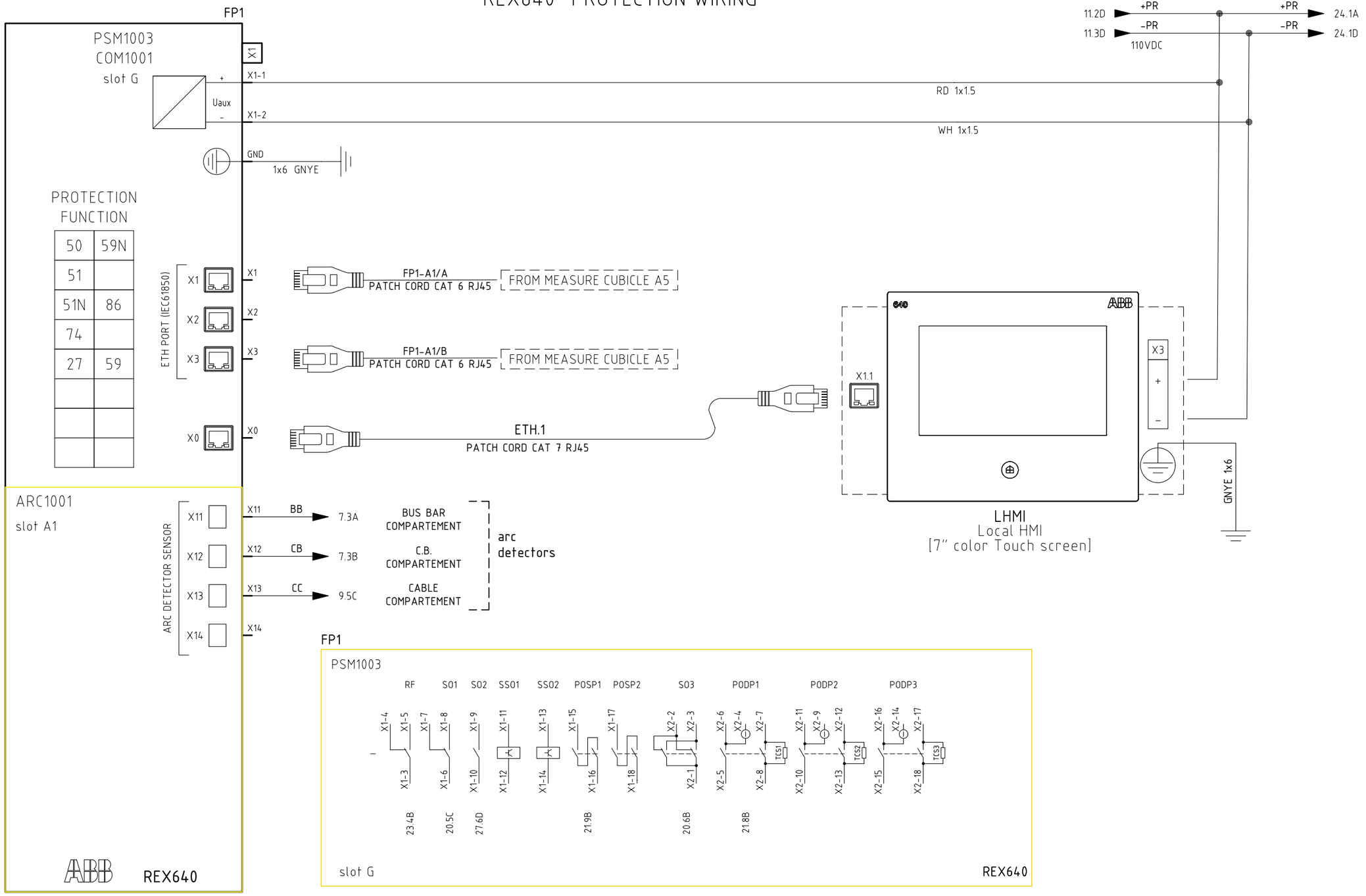
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 15 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# "REX640" PROTECTION WIRING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

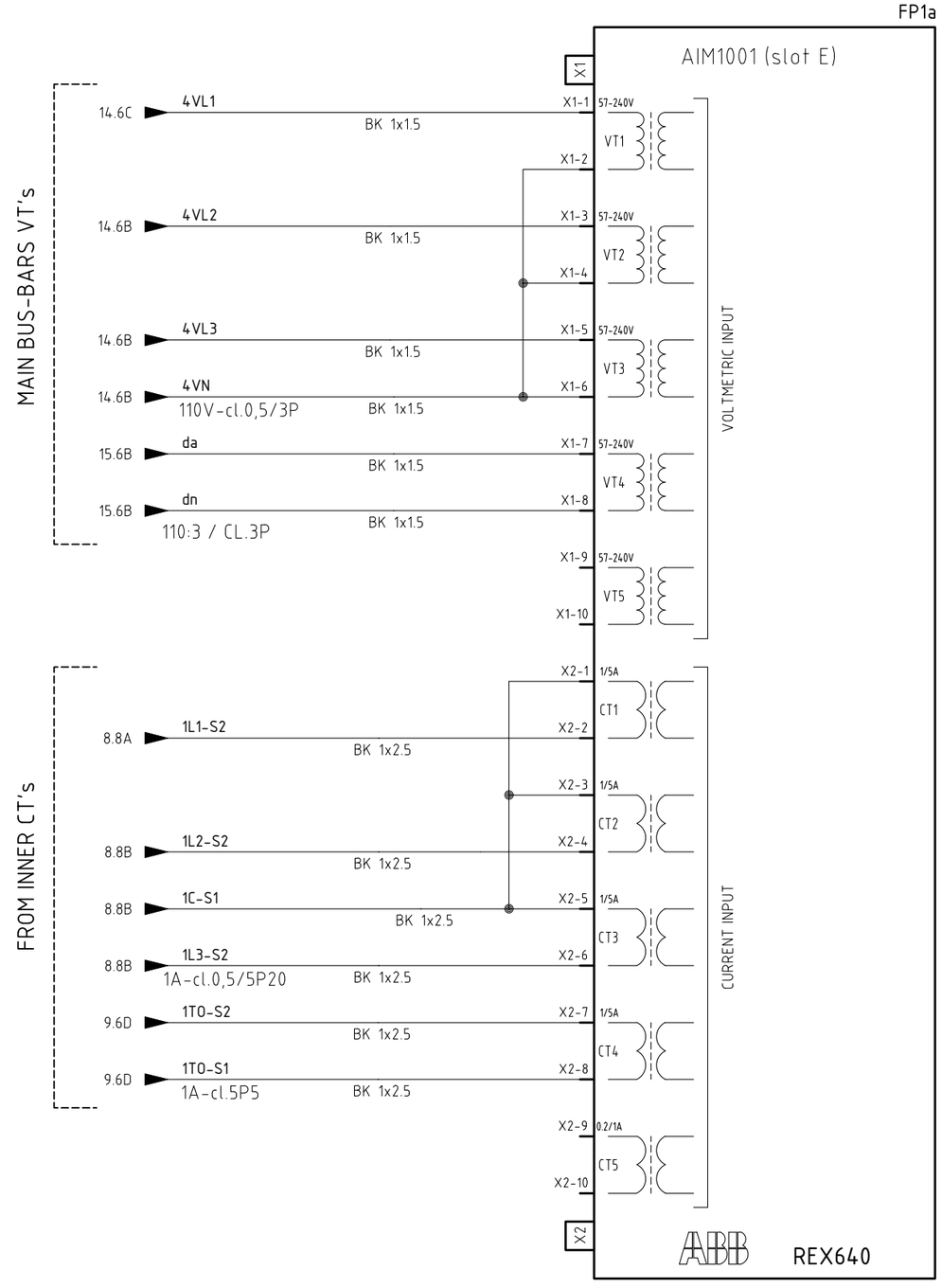
SHEET 16

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# "REX640" PROTECTION WIRING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

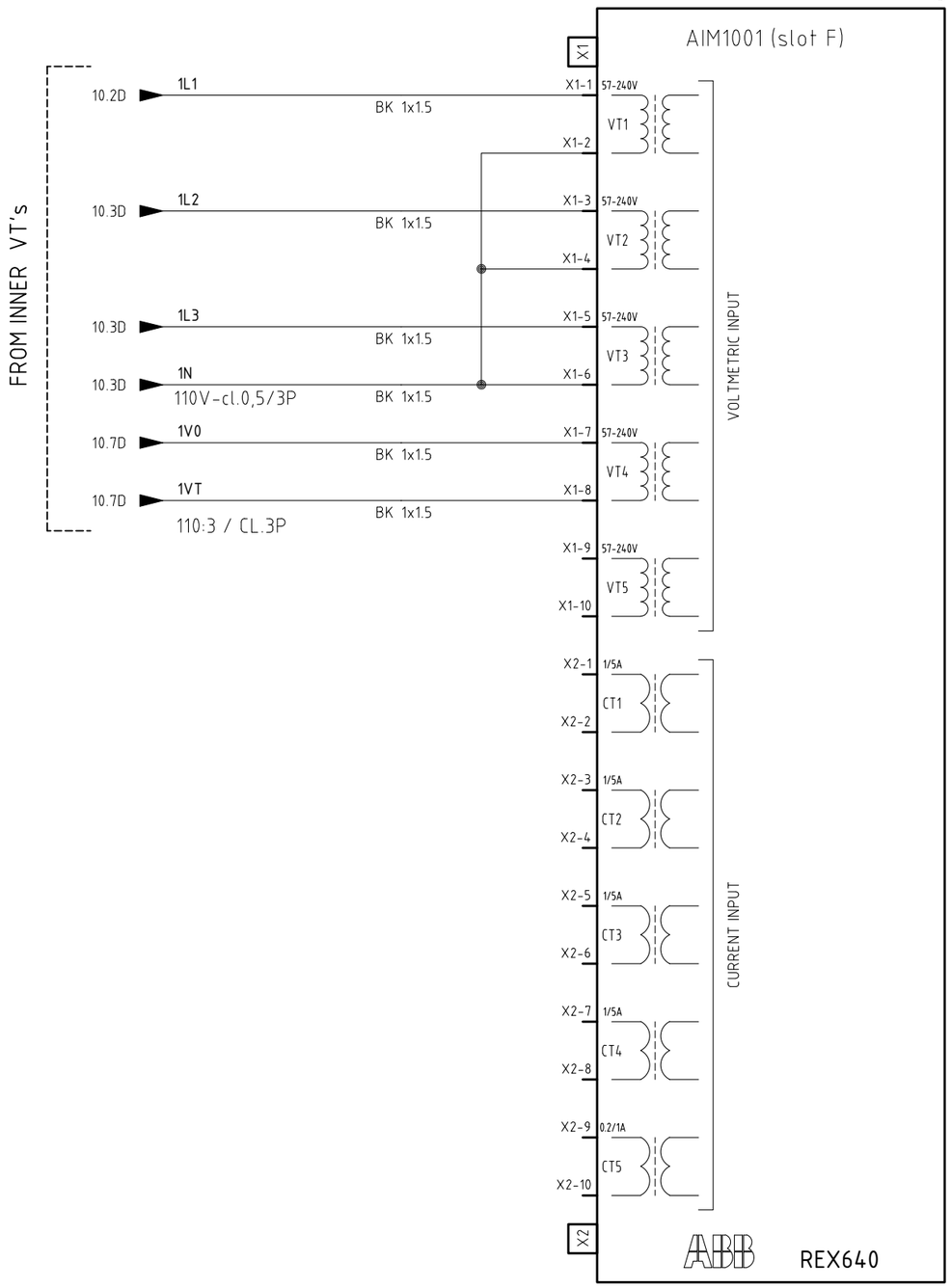
SHEET 1.7

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# "REX640" PROTECTION WIRING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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+A1
DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

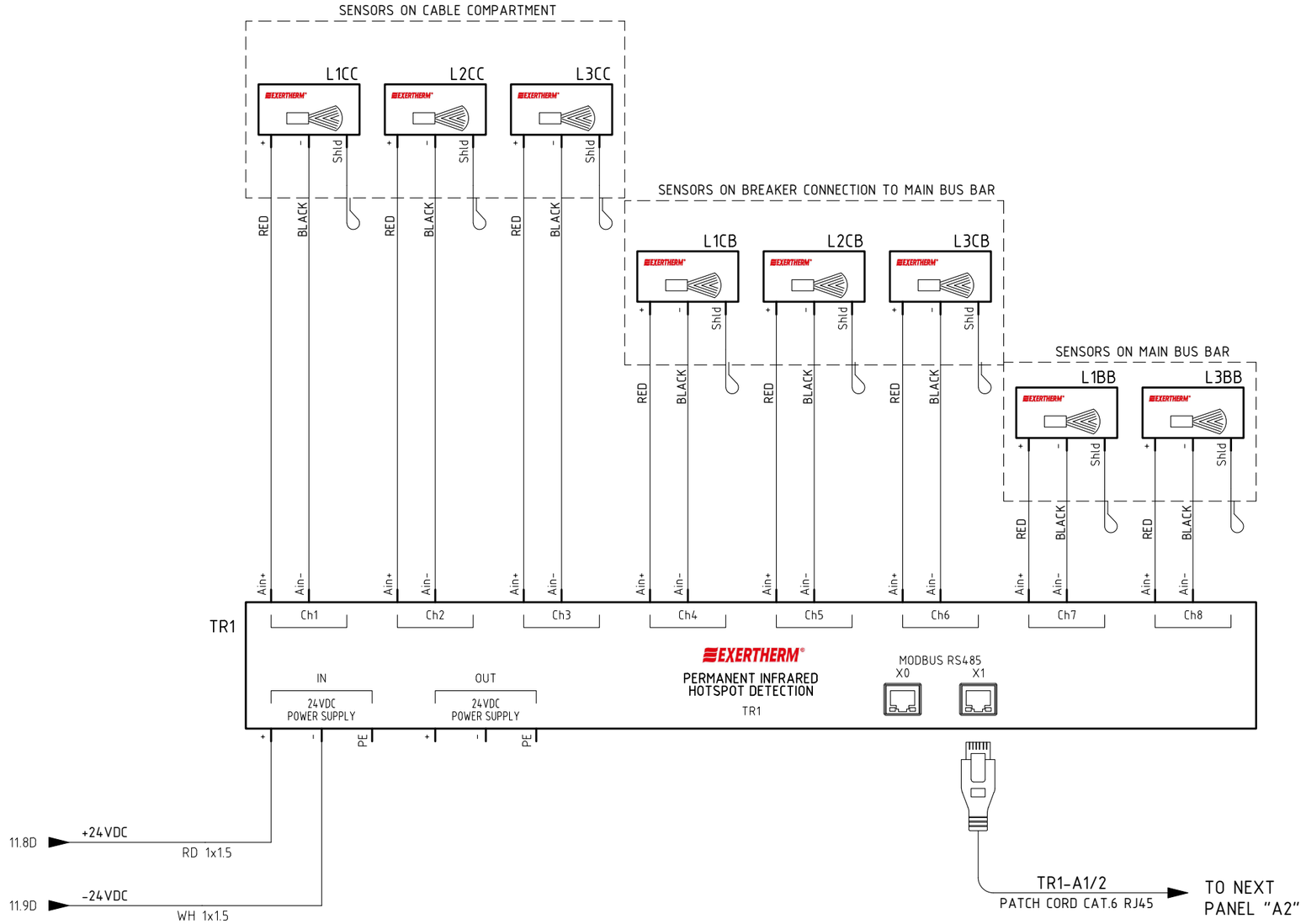
TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00018
SHEET 18
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A1

DWG n° : 231151/SD/18

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000

Extherm Device

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

SHEET 19

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# COMMAND CIRCUITS

ENABLING C.B. TRUCK ENCLOSURE DOOR AND EARTHING SWITCH

UNLOCKING CIRCUIT BRAKER ENCLOSURE DOOR

ENABLING EARTHING SWITCH COMMAND

ENABLING RACK-IN AND RACK-OUT CIRCUIT BRAKER [LOCKING MAGNET]

ENABLING CIRCUIT BREAKER [LOCKING MAGNET]

11.4D +CL 110VDC (CL) — RD 1x1.5 — +CL 21.1A

P1 BK E 13 14

KT1 20.2D 16 18 30'' 15

21 RD 1x1.5

QM ISOLATED BGT5 7.4B BGT5-53 BGT5-54

5 XM 6 XM

FP1 16.3A X1-7 X1-8 23 S01 REX640 X1 Slot G X1-6 24 RD 1x1.5 BGE-1

FP1 16.3A X2-2 X2-3 S03 REX640 X2 Slot G X2-1 25 7 XM 8 XM 26 RD 1x1.5 XDB-45

KIRF 23.4D 22 24 21 27 RD 1x1.5 9 XM 10 XM 28 XDB-10

KT1 A1 B1 30'' A2 — 20 RD 1x1.5

QM 1 RD 1x1.5 2 RLE4 7.4B

BGE BGE-2 RLE3 9.3C

QM XDB-46 RLE2 7.4B

QM XDB-20 BGT3 RLE1 7.4B

11.4D -CL — WH 1x1.5 — -CL 21.1E

20.3A 15 16 18

24.9A 25 26 28

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/18

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 – FUNCTIONAL ELECTROLYSER FEEDER A-2000

Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

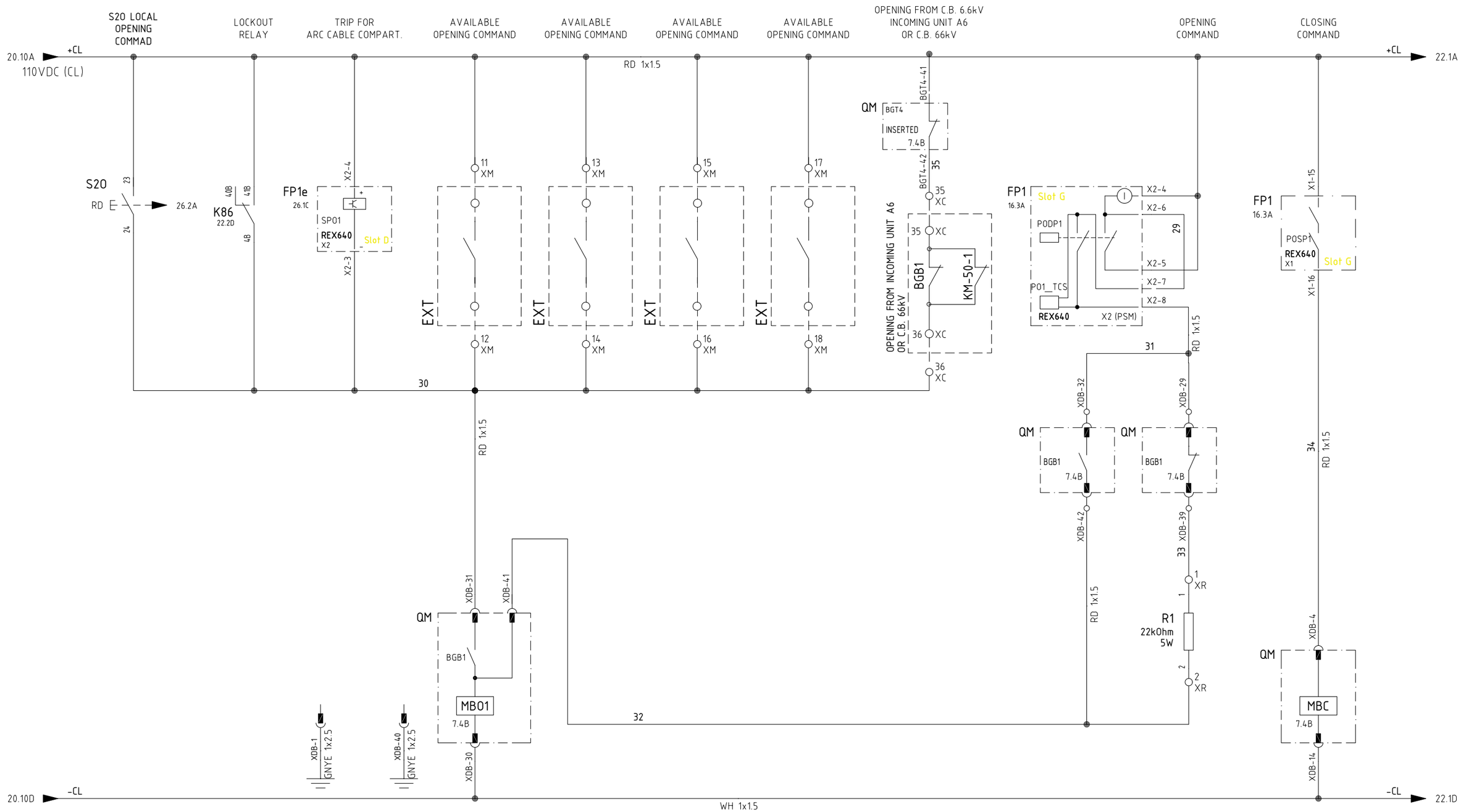
SHEET 20

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# CLOSING/OPENING COMMAND CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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+A1
DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 – FUNCTIONAL ELECTROLYSER FEEDER A-2000
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

SHEET 21

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# COMMAND CIRCUITS

OUTPUT PROTECTION RELAY | AVAILABLE | AVAILABLE | TRIP FOR ARC CABLE COMPART. | TRASFORMER TRIP OIL TEMPERATURE | TRANSFORMER TRIP PRESSURE RELAY | TRANSFORMER TRIP WINDING TEMPERATURE | LOCAL RESET | REMOTE RESET | TRIP LOCKOUT RELAY | UNDERVOLTAGE | CIRCUIT BREAKER ISOLATED

21.10A +CL 110VDC (OP) → +CL 23.1A

FP1c 24.1C — S01 REX640 X2 Slot B — X2-4 / X2-3

19 XM — 21 XM — 20 XM — 22 XM

FP1e 26.1C — SP03 REX640 X2 Slot D — X2-8 / X2-7 — WH 1x1.5

K940T 23.5D — K94P 23.6D — K94WT 23.7D — 12 / 14 / 11 — WH 1x1 / RD 1x1.5

PR YE — 13 / 14 — X1 / X2 — 22.7D

FP1c 24.1C — S04 REX640 X2 Slot B — X2-10 / X2-9 — RD 1x1.5

K86 22.2D — 30B / 31B / 38 — 40

23 XM — 24 XM — WH 1x1

QM ISOLATED / BGT5 7.4B — BGT5-33 / BGT5-34

KIRF 23.4D — 32 / 34 / 41 / 31 / 42

K86 22.2D — 20B / 21B / 2B

43 — RD 1x1.5 — XDB-43 — XDB-44

QM — MU 7.4B

38 — RD 1x1.5 — 39

K86 A81 C S A82 — C RESET — A1

PR 22.6A YE — X1 / X2

21.10E -CL → -CL 23.1D — RD 1x1.5

20A
2A 21A
30A
3A 31A
40A
27.6B 4A 41A
10B
24.5A 1B 11B
20B
22.8B 2B 21B
30B
22.7A 3B 31B
40B
21.2B 4B 41B

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

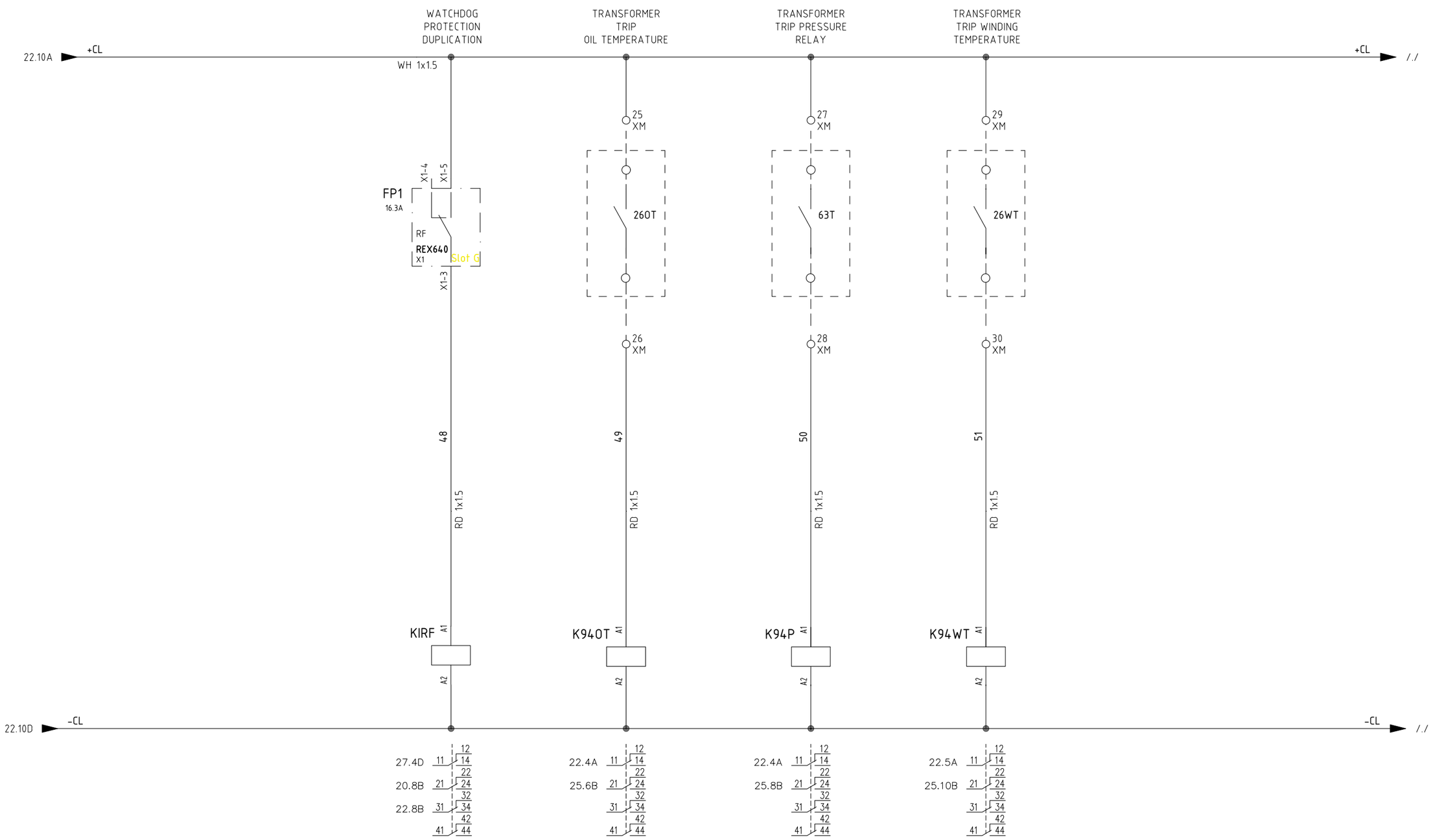
TITLE :
SG-100D1 – FUNCTIONAL ELECTROLYSER FEEDER A-2000
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 22 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A1
DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
Command Circuit

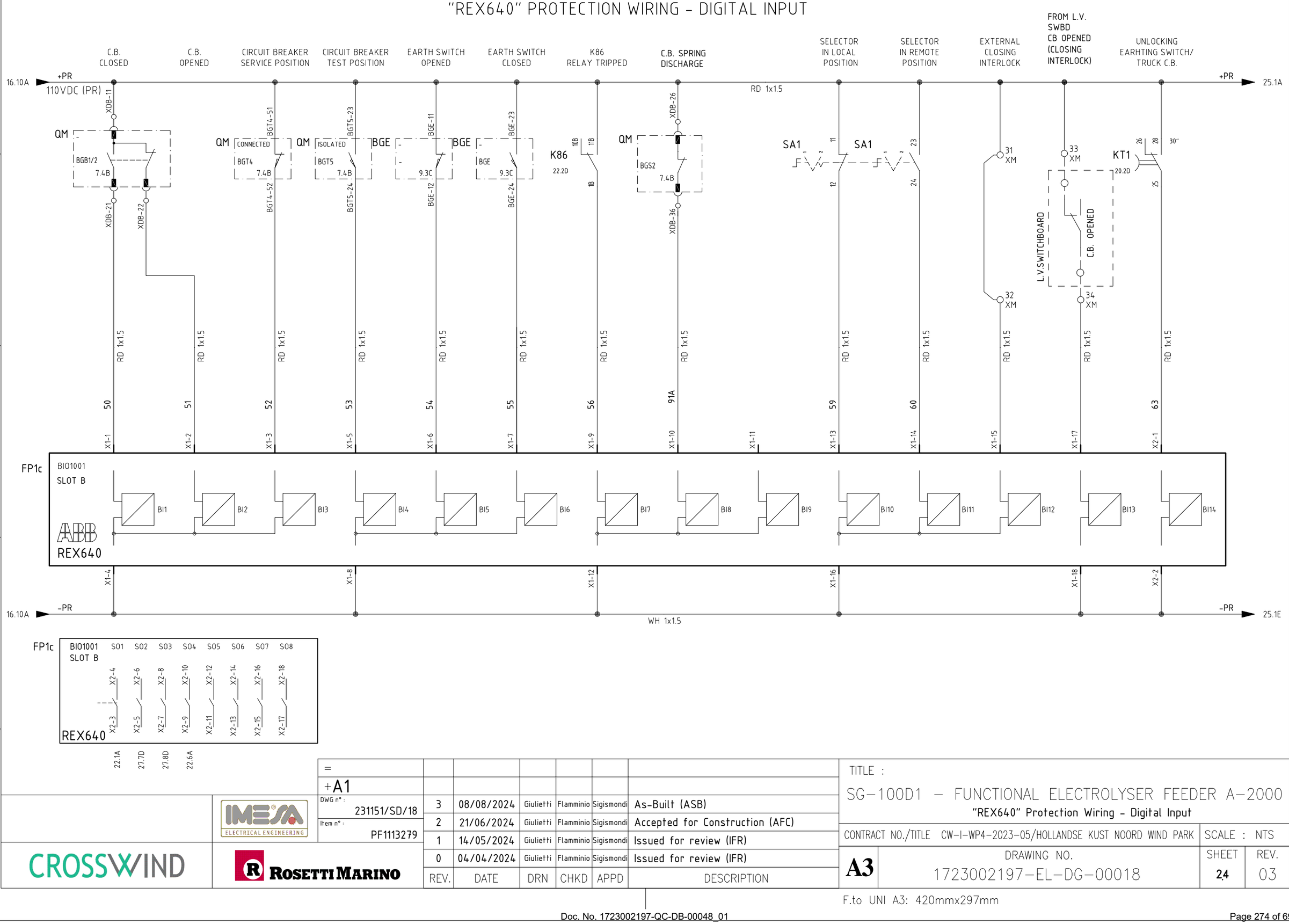
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00018
SHEET 23
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

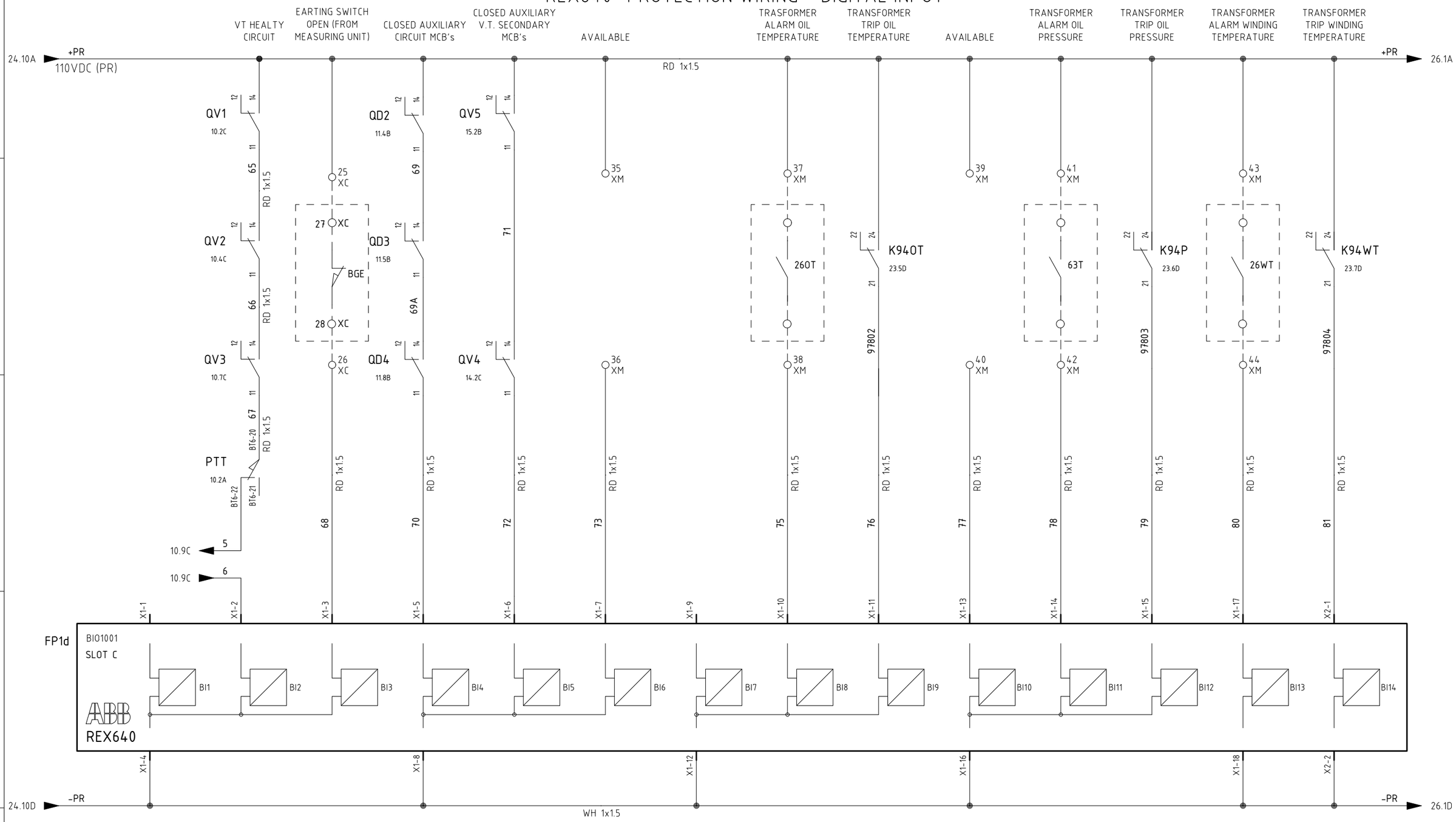
SHEET 24

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT




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|---|---|---|---|---|---|---|
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| DWG n° : 231151/SD/18 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| Item n° : PF1113279 | 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
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| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000

"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

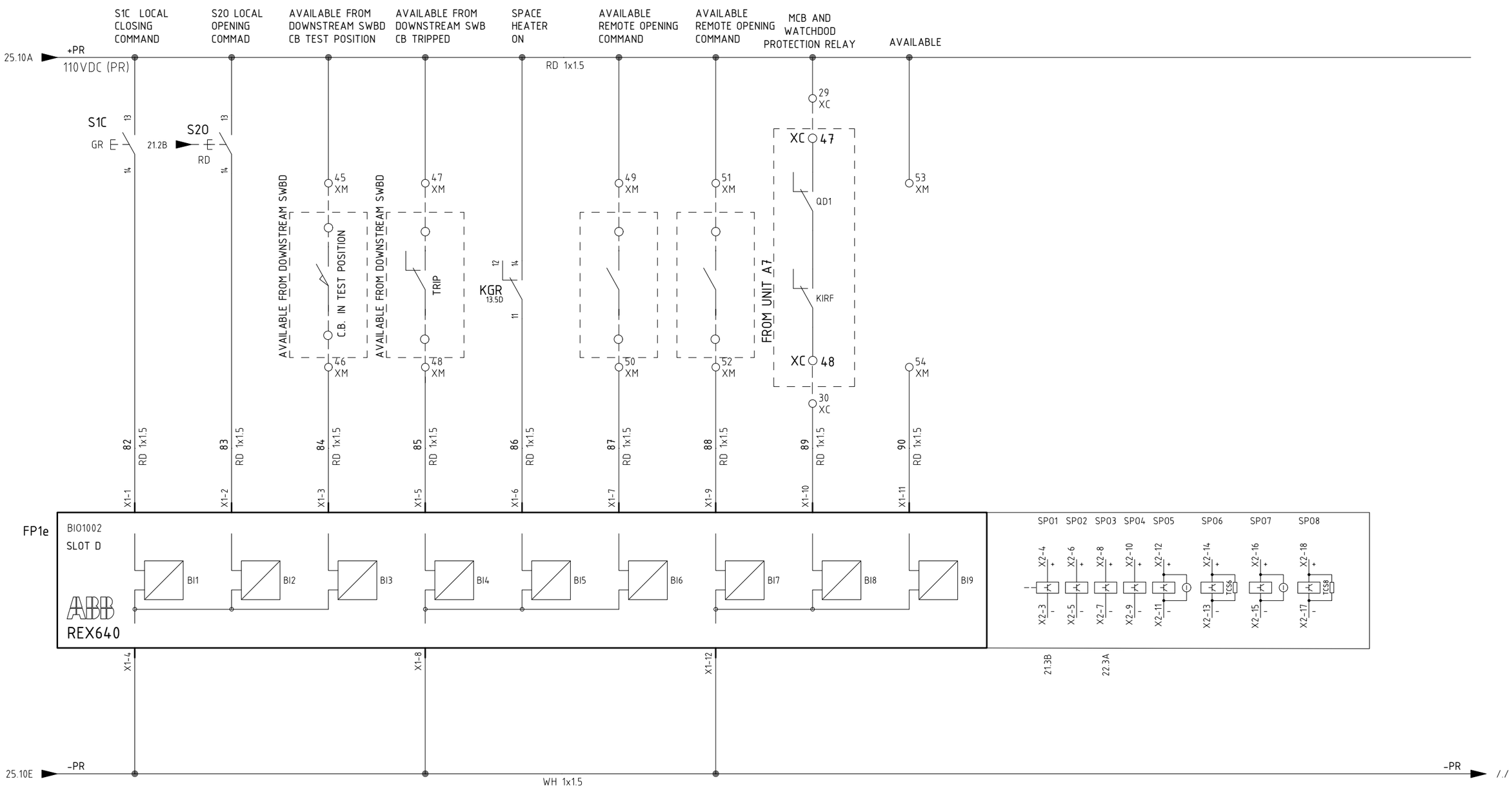
SHEET 25

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT




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|---|---|---|---|---|---|---|
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| DWG n° : 231151/SD/18 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| Item n° : PF1113279 | 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

TITLE :

SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000

"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

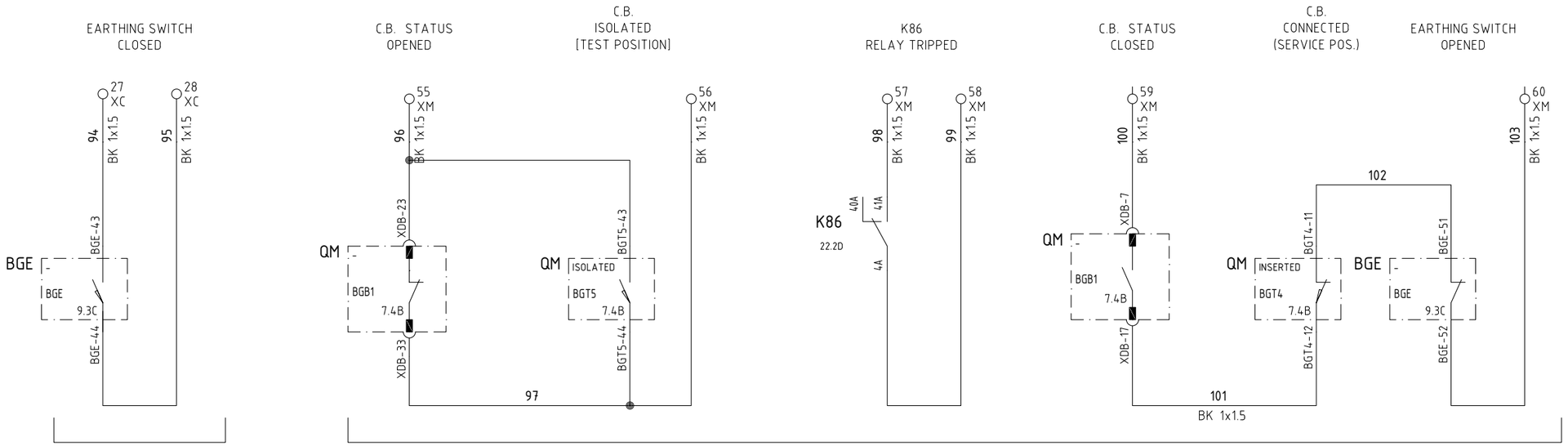
SHEET 26

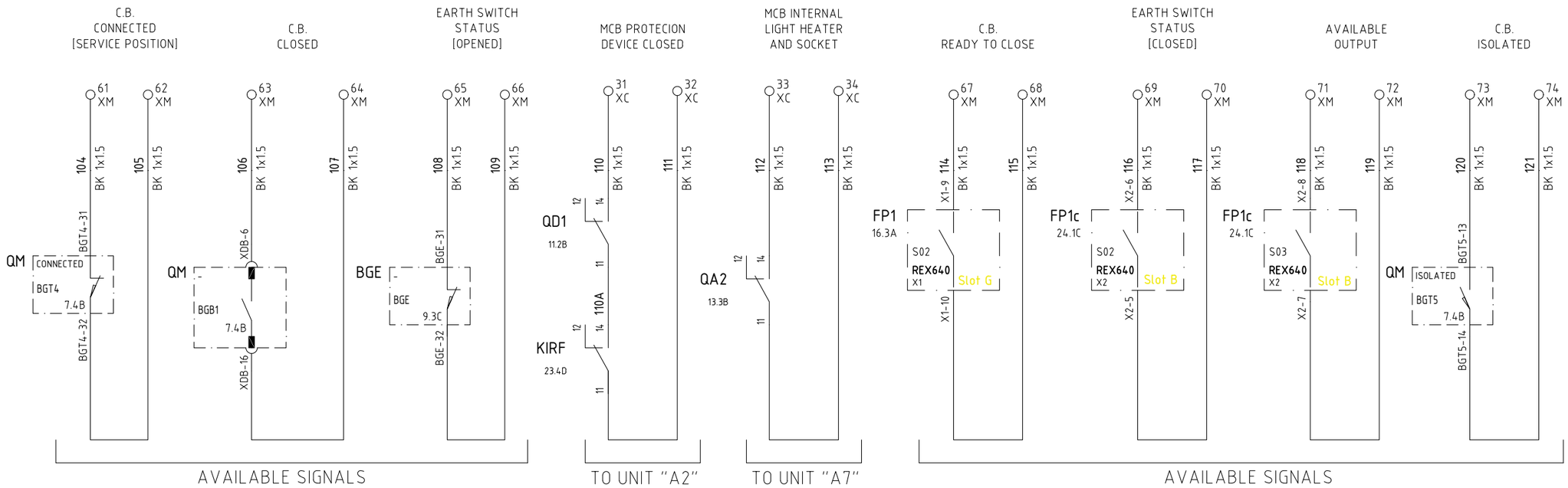
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

# AVAILABLE SIGNALS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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DWG n°: 231151/SD/18

Item n°: PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000

Availables Signals

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

SHEET 27

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

TYP - ELECTROLYSER
XI
Ammeter Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 2 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 3 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 4 | 8.4A | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 5 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 6 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 7 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 8 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |

TYP - ELECTROLYSER
XR

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 21.9D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 2 | 21.9D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

TYP - ELECTROLYSER
XV
Voltmetric Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 10.2D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 2 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 3 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 4 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 5 | 10.4D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 6 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 7 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 8 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 9 | 10.7D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 10 | 10.7D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 11 | 14.4C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 12 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 13 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 14 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 15 | 15.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 16 | 15.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |

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DWG n° : 231151/SD/18
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
Terminal strips

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 28 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

TYP - ELECTROLYSER

XC

Interconnection Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 11.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 2 | 11.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 3 | 11.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 4 | 11.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 5 | 11.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 6 | 11.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 7 | 11.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 8 | 11.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 9 | 13.1A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 10 | 13.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 11 | 13.2A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 12 | 13.2B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 13 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 14.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 14.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 21 | 15.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 15.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 15.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 15.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 25 | 25.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 27.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 27.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 26.6A | 4 | CBI04 | Cabur | CBC.4(EX)I Feed-through terminal |
| 30 | 26.6C | 4 | CBI04 | Cabur | CBC.4(EX)I Feed-through terminal |
| 31 | 27.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 27.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 27.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 27.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 21.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 21.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/18

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :

SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000

Terminal strips

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

SHEET 29

REV. 03

File Name : 1723002197-EL-DG-00018 Rev.03

F.to UNI A3: 420mmx297mm

TYP - ELECTROLYSER

XM

Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 10.4E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 2 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 3 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 4 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 5 | 20.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 6 | 20.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 7 | 20.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 8 | 20.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 9 | 20.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 10 | 20.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 11 | 21.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 12 | 21.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 13 | 21.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 21.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 21.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 21.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 21.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 21.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 22.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 22.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 21 | 22.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 22.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 22.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 22.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 25 | 23.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 23.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 23.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 23.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 23.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 23.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 24.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 24.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 24.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 24.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 25.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 25.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 37 | 25.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 38 | 25.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 39 | 25.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 40 | 25.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/18

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :

SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000

Terminal strips

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

SHEET 3.0

REV. 03

File Name : 1723002197-EL-DG-00018 Rev.03

F.to UNI A3: 420mmx297mm

TYP - ELECTROLYSER
XM
Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 41 | 25.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 42 | 25.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 43 | 25.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 44 | 25.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 45 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 46 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 47 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 48 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 49 | 26.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 50 | 26.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 51 | 26.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 52 | 26.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 53 | 26.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 54 | 26.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 55 | 27.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 56 | 27.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 57 | 27.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 58 | 27.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 59 | 27.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 60 | 27.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 61 | 27.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 62 | 27.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 63 | 27.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 64 | 27.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 65 | 27.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 66 | 27.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 67 | 27.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 68 | 27.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 69 | 27.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 70 | 27.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 71 | 27.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 72 | 27.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 73 | 27.9C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 74 | 27.9C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 75 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 76 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 77 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 78 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 79 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 80 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 81 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/18
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
Terminal strips

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 31 | REV. 03

File Name : 1723002197-EL-DG-00018 Rev.03

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A1 | ELECTROLYSER PACKAGE |
| BGE | 9 | 1VCF599700R0131 | 1 | EARTHING SWITCH ST-E 17.31 150 | ABB | A1 | ELECTROLYSER PACKAGE |
| | | 1VCF599505R0001 | 1 | 5 AUX CONTACTS FOR EARTHING SWITCH | ABB | A1 | ELECTROLYSER PACKAGE |
| | | 1VCF599504R0063 | 1 | KEY LOCKS ON EARTHING SWITCH | ABB | A1 | ELECTROLYSER PACKAGE |
| | | 1VCF599700R0290 | 1 | EARTHING SWITCH OPERATING LEVER | ABB | A1 | ELECTROLYSER PACKAGE |
| C1 | 9 | 43931118 | 1 | VPIS 3,3÷36KV - DEVICE SIGNALLING VOLTAGE PRESENT KIT | ELECTRONSYSTEM | A1 | ELECTROLYSER PACKAGE |
| CB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A1 | ELECTROLYSER PACKAGE |
| CC | 9 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A1 | ELECTROLYSER PACKAGE |
| E1 | 13 | 74041 | 1 | LED LAMP 4W 4000K 313x30x22 | Beghelli | A1 | ELECTROLYSER PACKAGE |
| E8 | 10 | 1VCF501000R0001 | 1 | RESISTOR TR318 27R/J 27ohm 500W L=2,5M | ABB | A1 | ELECTROLYSER PACKAGE |
| EH1 | 13 | R1R150230 | 1 | SPACE HEATER SKR 150W ALIM. 220VCA | Torresan | A1 | ELECTROLYSER PACKAGE |
| FF1 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A1 | ELECTROLYSER PACKAGE |
| FF2 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A1 | ELECTROLYSER PACKAGE |
| FF3 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A1 | ELECTROLYSER PACKAGE |
| FP1 | 16 | 1VCF698331R0001 | 1 | REX640B10NN+AIM1+AIM1+ARC1+BIO1+BIO1+BI+O2+CMP2+COM1+LNG1+MCT1+PCL4+PSM3+SCT | ABB | A1 | ELECTROLYSER PACKAGE |
| HGR | 13 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | A1 | ELECTROLYSER PACKAGE |
| K940T | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A1 | ELECTROLYSER PACKAGE |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A1 | ELECTROLYSER PACKAGE |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A1 | ELECTROLYSER PACKAGE |
| K94P | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A1 | ELECTROLYSER PACKAGE |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A1 | ELECTROLYSER PACKAGE |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A1 | ELECTROLYSER PACKAGE |
| K94WT | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A1 | ELECTROLYSER PACKAGE |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A1 | ELECTROLYSER PACKAGE |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A1 | ELECTROLYSER PACKAGE |
| KGR | 13 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A1 | ELECTROLYSER PACKAGE |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A1 | ELECTROLYSER PACKAGE |
| | | Copia di ER 552 0 | 1 | CR-M230AC2L SUPPLY 230VAC 2C/O 250V/6A LED | ABB | A1 | ELECTROLYSER PACKAGE |
| KIRF | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A1 | ELECTROLYSER PACKAGE |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A1 | ELECTROLYSER PACKAGE |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A1 | ELECTROLYSER PACKAGE |
| KT1 | 20 | H3DKM2ACDC24240 | 1 | MULTIFUNCTION TIMER RELAY Vaux=24÷240Vac/dc - 2SC | Omron | A1 | ELECTROLYSER PACKAGE |
| L1C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A1 | ELECTROLYSER PACKAGE |
| L1I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A1 | ELECTROLYSER PACKAGE |
| L1MS | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A1 | ELECTROLYSER PACKAGE |
| L2C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A1 | ELECTROLYSER PACKAGE |
| L2I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A1 | ELECTROLYSER PACKAGE |
| L3C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A1 | ELECTROLYSER PACKAGE |
| L3I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A1 | ELECTROLYSER PACKAGE |
| L3MS | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A1 | ELECTROLYSER PACKAGE |
| LS | 13 | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | A1 | ELECTROLYSER PACKAGE |
| | | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | A1 | ELECTROLYSER PACKAGE |
| OD1 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A1 | ELECTROLYSER PACKAGE |
| OD2 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A1 | ELECTROLYSER PACKAGE |

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DWG n° : 231151/SD/18

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000

Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00018

SHEET 32

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| OD3 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A1 | ELECTROLYSER PACKAGE |
| P1 | 20 | KW 080 2 | 1 | MP1-10B BLACK PUSH BUTTON UNSTABLE | ABB | A1 | ELECTROLYSER PACKAGE |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A1 | ELECTROLYSER PACKAGE |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A1 | ELECTROLYSER PACKAGE |
| PTT | 10 | 1VCF498412R0100 | 1 | TV/F COMPARTMENT 12/17kV IP4X L=590mm OUTLET ON THE BACK WITH N°3 VT + N°14 MAIN CONTACTS + N°2+2 SERVICE/ISOLATED POSITION CONTACTS | ABB | A1 | ELECTROLYSER PACKAGE |
| | | 1VCF499800R0302 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR TV/F | ABB | A1 | ELECTROLYSER PACKAGE |
| QA2 | 13 | B427917 | 1 | DDA202 AC 25A 300MA RCD BLOCK 2P | ABB | A1 | ELECTROLYSER PACKAGE |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A1 | ELECTROLYSER PACKAGE |
| | | S550284 | 1 | S202M C10 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A1 | ELECTROLYSER PACKAGE |
| QD1 | 11 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A1 | ELECTROLYSER PACKAGE |
| | | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A1 | ELECTROLYSER PACKAGE |
| QD2 | 11 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A1 | ELECTROLYSER PACKAGE |
| | | a563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A1 | ELECTROLYSER PACKAGE |
| QD3 | 11 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A1 | ELECTROLYSER PACKAGE |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A1 | ELECTROLYSER PACKAGE |
| QD4 | 11 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A1 | ELECTROLYSER PACKAGE |
| | | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A1 | ELECTROLYSER PACKAGE |
| QM | 7 | 1VCF337121R1141 | 1 | VACUUM CIRCUIT BREAKER VD4/P 3P 12KV 630A 25KA WITHDRAWABLE 12.06.25 P150 | ABB | A1 | ELECTROLYSER PACKAGE |
| | | 1VCF339700R0882 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR CIRCUIT-BREAKER | ABB | A1 | ELECTROLYSER PACKAGE |
| | | 1VCF339700R1885 | 1 | VD4 FOR POWERCUBE | ABB | A1 | ELECTROLYSER PACKAGE |
| | | 1VCF349700R4881 | 1 | WIRING WITH AFUMEX N07G9-K CABLE | ABB | A1 | ELECTROLYSER PACKAGE |
| | | 1VCF339701R2909 | 1 | FIRST OPENING COIL IST. 110Vdc (MB01) | ABB | A1 | ELECTROLYSER PACKAGE |
| | | 1VCF339800R6913 | 1 | CLOSING COIL 110..127 Vac/dc (MBC) | ABB | A1 | ELECTROLYSER PACKAGE |
| QV1 | 10 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A1 | ELECTROLYSER PACKAGE |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A1 | ELECTROLYSER PACKAGE |
| QV2 | 10 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A1 | ELECTROLYSER PACKAGE |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A1 | ELECTROLYSER PACKAGE |
| QV3 | 10 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A1 | ELECTROLYSER PACKAGE |
| | | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A1 | ELECTROLYSER PACKAGE |
| QV4 | 14 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A1 | ELECTROLYSER PACKAGE |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A1 | ELECTROLYSER PACKAGE |
| QV5 | 15 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A1 | ELECTROLYSER PACKAGE |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A1 | ELECTROLYSER PACKAGE |
| R1 | 21 | 01062220 | 1 | RESISTANCE 22kOhm 5W | | A1 | ELECTROLYSER PACKAGE |
| S1C | 26 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A1 | ELECTROLYSER PACKAGE |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A1 | ELECTROLYSER PACKAGE |
| | | KW 076 0 | 1 | MP1-10G PUSH BUTTON GREEN WITH BLACK RING | ABB | A1 | ELECTROLYSER PACKAGE |
| S2O | 26 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A1 | ELECTROLYSER PACKAGE |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A1 | ELECTROLYSER PACKAGE |
| | | KW 075 2 | 1 | MP1-10R PUSH BUTTON RED WITH BLACK RING | ABB | A1 | ELECTROLYSER PACKAGE |
| SA1 | 24 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A1 | ELECTROLYSER PACKAGE |
| | | EO 571 3 | 1 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | A1 | ELECTROLYSER PACKAGE |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A1 | ELECTROLYSER PACKAGE |

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DWG n° : 231151/SD/18
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 – FUNCTIONAL ELECTROLYSER FEEDER A-2000
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 33 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| SA1 | 24 | KW 329 3 | 1 | M2SS2-10B HANDLE SELECTOR 2P 90° BLACK RING BLACK | ABB | A1 | ELECTROLYSER PACKAGE |
| TI-L1 | 8 | ATB-10-BS__012 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 400/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A1 | ELECTROLYSER PACKAGE |
| TI-L2 | 8 | ATB-10-BS__012 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 400/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A1 | ELECTROLYSER PACKAGE |
| TI-L3 | 8 | ATB-10-BS__012 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 400/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A1 | ELECTROLYSER PACKAGE |
| TO | 9 | KAP-150/250-95 | 1 | CURRENT TRANSFORMER 0,72/3/-kV 100/1 50Hz | ESITAS | A1 | ELECTROLYSER PACKAGE |
| TR1 | 19 | 800208 | 1 | MODBUS DATACARD 8 CHANNELS | Exertherm | A1 | ELECTROLYSER PACKAGE |
| TU-L1 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A1 | ELECTROLYSER PACKAGE |
| TU-L2 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A1 | ELECTROLYSER PACKAGE |
| TU-L3 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A1 | ELECTROLYSER PACKAGE |
| XC | | HM320GR | 12 | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) | Cabur | A1 | ELECTROLYSER PACKAGE |
| | | HM250GR | 22 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A1 | ELECTROLYSER PACKAGE |
| | | CBI04 | 2 | CBC.4(EX)I Feed-through terminal | Cabur | A1 | ELECTROLYSER PACKAGE |
| | | HM251GR | 3 | HMT.4/PT/GR End section - Grey | Cabur | A1 | ELECTROLYSER PACKAGE |
| | | HM321GR | 3 | HMT.6/PT/GR End section - Grey | Cabur | A1 | ELECTROLYSER PACKAGE |
| XI | | HB220GR | 8 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur | A1 | ELECTROLYSER PACKAGE |
| | | HB201GR | 2 | HSCB.6/PT/GR End section - Grey | Cabur | A1 | ELECTROLYSER PACKAGE |
| XM | | HM250GR | 81 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A1 | ELECTROLYSER PACKAGE |
| | | HM251GR | 1 | HMT.4/PT/GR End section - Grey | Cabur | A1 | ELECTROLYSER PACKAGE |
| XR | | HM250GR | 2 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A1 | ELECTROLYSER PACKAGE |
| | | HM251GR | 1 | HMT.4/PT/GR End section - Grey | Cabur | A1 | ELECTROLYSER PACKAGE |
| XS1 | 13 | E 9447 7 | 1 | SOCKET | ABB | A1 | ELECTROLYSER PACKAGE |
| XV | | HB210GR | 16 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type | Cabur | A1 | ELECTROLYSER PACKAGE |
| | | HB201GR | 5 | HSCB.6/PT/GR End section - Grey | Cabur | A1 | ELECTROLYSER PACKAGE |

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DWG n° : 231151/SD/18
Item n° : PF1113279

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TITLE :
SG-100D1 - FUNCTIONAL ELECTROLYSER FEEDER A-2000
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00018 | SHEET 3.4 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00018 Rev.03

1.4.5.SG-100D1 HV SWG FUNCTIONAL DIAGRAM - FUEL CELL FEEDER (including Terminals and BOM) , Doc. No. 1723002197-EL-DG-00019

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# "SG-100D1" HV SWBD 6,6kV (UNIT A7)

# FUNCTIONAL DIAGRAM

# FUEL CELL FEEDER A-80000

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macula | 12/09/2024 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/19
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 – FUNCTIONAL FUEL CELL FEEDER A-80000
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# INDEX

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| 2 | Sheets Index | | | | | | | | | |
| 3 | Legend | | | | | | | | | |
| 4 | Door Layout | | | | | | | | | |
| 5 | Protection Display REX640 | | | | | | | | | |
| 6 | Selector Switch Diagram | | | | | | | | | |
| 7 | Power Diagram | | | | | | | | | |
| 8 | Power Diagram | | | | | | | | | |
| 9 | Power Diagram | | | | | | | | | |
| 10 | Power Diagram | | | | | | | | | |
| 11 | 110Vdc / 24Vdc Distribution Voltage | | | | | | | | | |
| 12 | Composition Relay REX640 | | | | | | | | | |
| 13 | 230Vac Distribution Voltage | | | | | | | | | |
| 14 | 110V Protection/Measure Distribution Voltage | | | | | | | | | |
| 15 | 110V Protection/Measure Distribution Voltage | | | | | | | | | |
| 16 | "REX640"' Protection Wiring | | | | | | | | | |
| 17 | "REX640"' Protection Wiring | | | | | | | | | |
| 18 | "REX640"' Protection Wiring | | | | | | | | | |
| 19 | Extherm Device | | | | | | | | | |
| 20 | Command Circuit | | | | | | | | | |
| 21 | Command Circuit | | | | | | | | | |
| 22 | Command Circuit | | | | | | | | | |
| 23 | "REX640" Protection Wiring - Digital Input | | | | | | | | | |
| 24 | "REX640" Protection Wiring - Digital Input | | | | | | | | | |
| 25 | "REX640" Protection Wiring - Digital Input | | | | | | | | | |
| 26 | Emergency Opening by "SIS" | | | | | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| 27 | 230Vac Auxiliary General Healtly | | | | | | | | | |
| 28 | Availables Signals | | | | | | | | | |
| 29 | Terminal strip | | | | | | | | | |
| 30 | Terminal strip | | | | | | | | | |
| 31 | Terminal strip | | | | | | | | | |
| 32 | Terminal strip | | | | | | | | | |
| 33 | Terminal strip | | | | | | | | | |
| 34 | Bill of Materials | | | | | | | | | |
| 35 | Bill of Materials | | | | | | | | | |
| 36 | Bill of Materials | | | | | | | | | |

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DWG n° : 231151/SD/19
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

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TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Sheets Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00019 | SHEET 2 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

| ITEM | DESCRIPTION |
|---|---|
| BB | ARC SENSOR PROTECTION ON MAIN BUS BARS |
| BGE | EARTHING SWITCH |
| C1 | VOLTAGE PRESENCE |
| CB | ARC SENSOR PROTECTION ON C.B. / CONTACTOR COMPARTMENT |
| CC | ARC SENSOR PROTECTION ON CABLE COMPARTMENT |
| DCO | DOUBLE COMMAND OPERATED CONTACTOR |
| DI3 | UNDERVOLTAGE CONTACTOR |
| DP1 | ALARM RELAY MODULE TEMPERATURE |
| E1 | INTERNAL LIGHT |
| E8 | RESISTOR FERRO-RESONANCE |
| EH1 | INTERNAL SPACE HEATER |
| Fn | MV FUSE |
| FP1 | PROTECTION RELAY |
| GS1 | DC/DC CONVERTER |
| HGR | THERMOSTAT |
| Kn | AUXILIARY RELAY |
| K1 | MV CONTACTOR |
| K86 | BLOCK RELAY |
| KT1 | DE-ENERGIZATION TIMER |
| LS | MICRO SWITCH ON AUXILIARY DOOR |
| MAS | MOTOR SPRING CHARGER |
| MBC | CLOSING COIL |
| MBO1 | OPENING COIL |
| MBU | UNDERVOLTAGE |
| ODn | VOLTAGE DISCHARGER |
| PU1 | MEASURING VOLTAGE INSTRUMENT |

| ITEM | DESCRIPTION |
|---|---|
| PTT | V.T. TRUCK |
| QM | MV CIRCUIT-BREAKER |
| QDn | M.C.B. CIRCUITS PROTECTION |
| QVn | M.C.B FOR V.T. PROTECTION |
| RLE1 | COIL FOR CONSET CLOSING CIRCUIT-BREAKER |
| RLE2 | COIL FOR UNLOCKING RACK-IN/OUT OPERATION |
| RLE3 | COIL FOR UNLOCKING OPERATION EARTHING |
| RLE4 | COIL FOR UNLOCKING ENCLOSURE DOOR OPERATION |
| SU1 | VOLTAGE SELECTOR |
| SWH... | ETHERNET SWITCH |
| TI-Ln | CURRENT TRANSFORMER |
| TO | OMOPOLAR RING CURRENT TRANSFORMER |
| TR1 | TEMPERATURE CONTROL DEVICE |

FUNCTIONAL OF THE PROTECTION RELAY OUTPUT CONTACTS:

SLOT "G":
RF = WATCHDOG RELAY
S01 = EARTHING SWITCH UNLOCKING
S02 = C.B. or CONTACTOR READY TO CLOSE
POSP1 = CLOSING COMMAND
S03 = C.B. or CONTACTOR TRUCK UNLOCKED
PODP1 = OPENING COMMAND
SLOT "B":
S01 = TRIP PROTECTION TO LOCKOUT RELAY
S02 = EARTHING SWITCH CLOSED
S03 = AVAILABLE OUTPUT (ON TERMINAL STRIP)
S04 = RESET LOCKOUT RELAY

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DWG n° : 231151/SD/19
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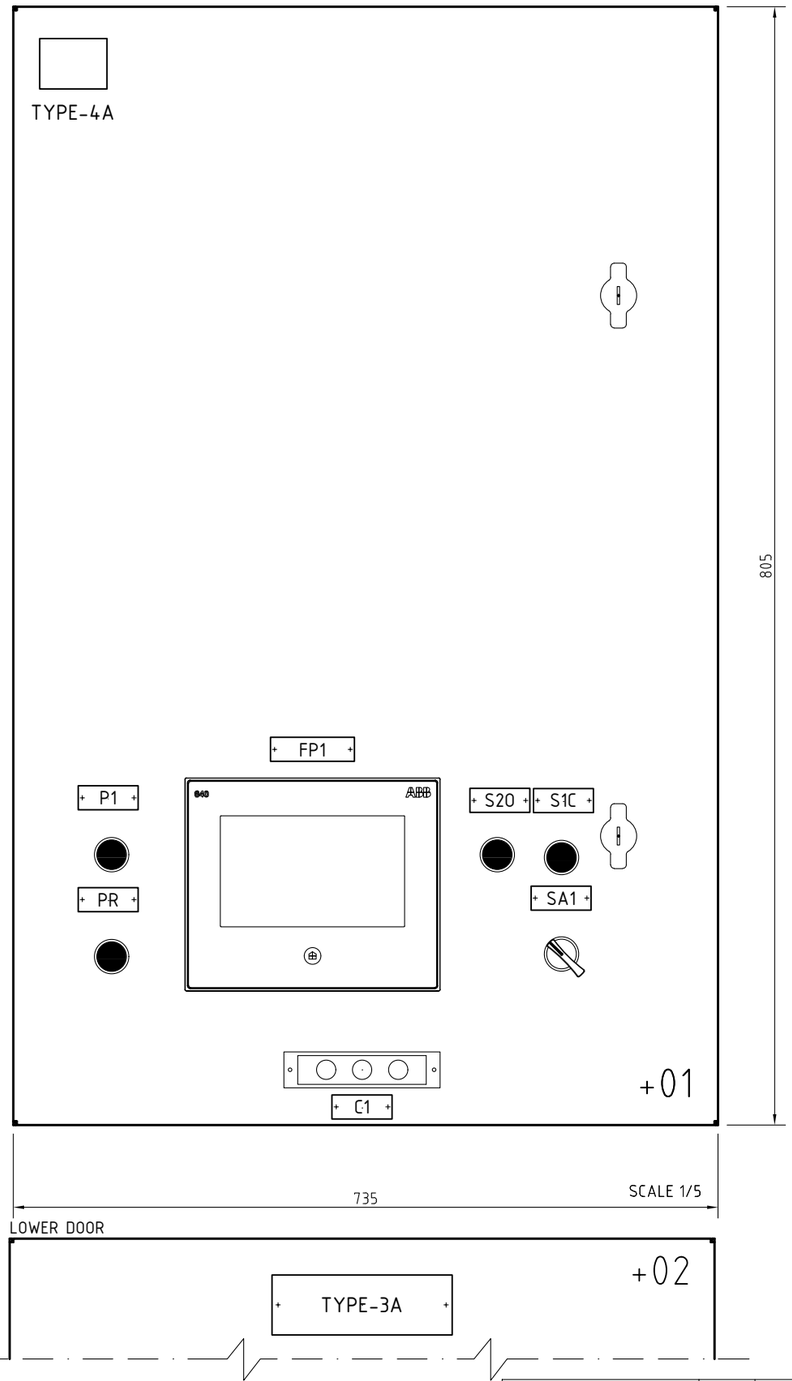
TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Legend

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

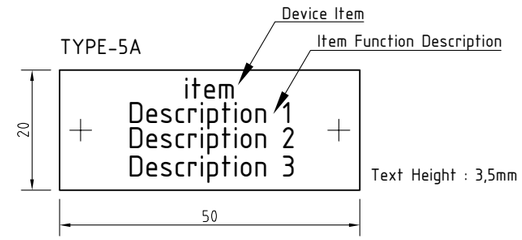
A3 | DRAWING NO. 1723002197-EL-DG-00019 | SHEET 3 | REV. 03

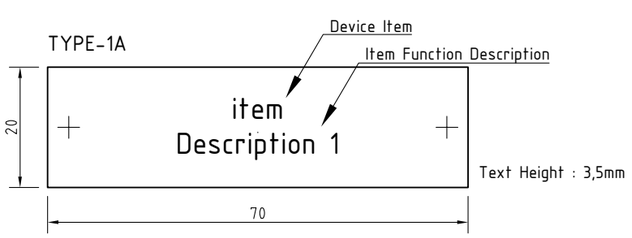
F.to UNI A3: 420mmx297mm

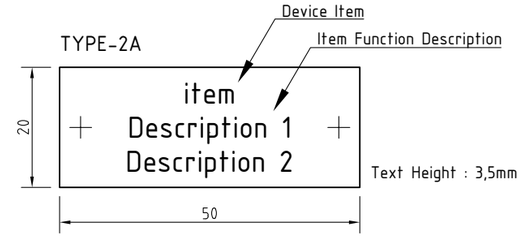
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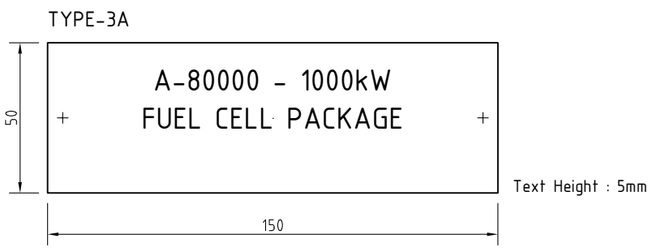


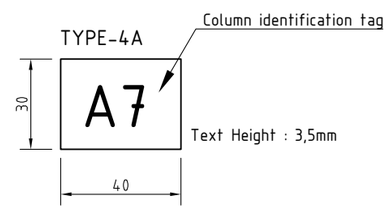

| DEVICES name plate | | | | | |
|---|---|---|---|---|---|
| ITEM | COMPONENT | DESCRIPTION 1 | DESCRIPTION 2 | DESCRIPTION 3 | NOTE |
| FP1 | PROTECTION RELAY | PROTECTION RELAY | | | TYPE-1A |
| S2.O | PUSH BUTTON | OPEN | COMMAND | CONTACTOR | TYPE-5A |
| S1.C | PUSH BUTTON | CLOSE | COMMAND | CONTACTOR | TYPE-5A |
| SA1 | SELECTOR SWITCH | LOCAL / REMOTE | | | TYPE-2A |
| PR | LIGHT PUSH BUTTON | RESET | LOCK-OUT | TRIP LOCK-OUT | TYPE-5A |
| C1 | PILOT LIGHT | VOLTAGE | PRESENCE | | TYPE-2A |
| P1 | PUSH BUTTON | TRUCK-DOOR | ENABLING | ENABLING | TYPE-5A |




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Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Door Layout

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

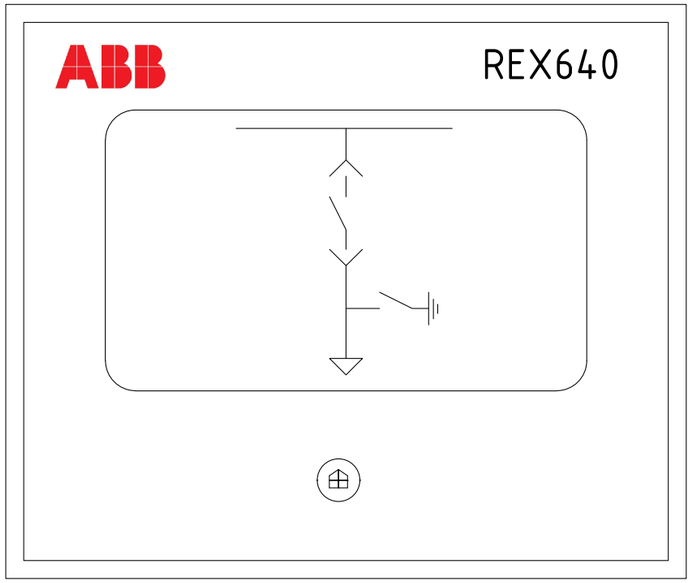
SHEET 4

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# PROTECTION DISPLAY




## LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE CONTACTOR " AND "OPEN CONTACTOR" NOT ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED

| LEDs PAGE 1 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/27-2/59-1/59-2 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | CONTACTOR READY (TCS) | - | GREEN | OK = TCS OK (CONTACTOR READY) |
| LED-3 | SYNCHRO CHECK | | GREEN | OK = SYNCHRONISM |
| LED-4 | CONTACTOR READY TO CLOSE | - | GREEN | OK = CONTACTOR READY TO CLOSE |
| LED-5 | 50-1/51-1/67-1/67-2 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/59N-1/59N-2 - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = CONTACTOR TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | EMERGENCY OPENING BY SIS (ESD) | RED | - | ALARM = ESD TRIPPED |

| LEDs PAGE 2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | - | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | FUSES TRIP | RED | | ALARM = FUSES TRIP |
| LED-15 | TRIP FROM L.V. | RED | | ALARM = L.V. TRIP |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

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+A7

DWG n° : 231151/SD/19
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Protection Display REX640

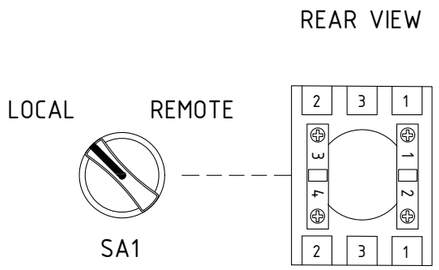
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00019 | SHEET 5 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# SELECTORS SWITCH DIAGRAM




## NOTES

THE DIAGRAM INDICATES THE FOLLOWING CONDITIONS:
-INSERTED CONTACTOR IN OPEN POSITION
-DE-ENERGIZED CIRCUITS
-EARTHING SWITCH OPEN

THE AUXILIARY CIRCUITS WILL HAVE THE FOLLOWING CHARACTERISTICS:
-110+ / 24+ 1,5mmq RED TYPE CABLE SH-W
-110- / 24- 1,5mmq WHITE TYPE CABLE SH-W
-AUXILIARY CONTACTS TO TERMINAL STRIP 1,5mmq BLACK TYPE CABLE SH-W
-230Vac 1,5mmq BLACK TYPE SH-W
-VOLTMETRICAL CIRCUITS 1,5mmq BLACK TYPE CABLE SH-W
-AMMETRICAL CIRCUIT 2,5mmq BLACK TYPE CABLE SH-W

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+A7
DWG n° : 231151/SD/19
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

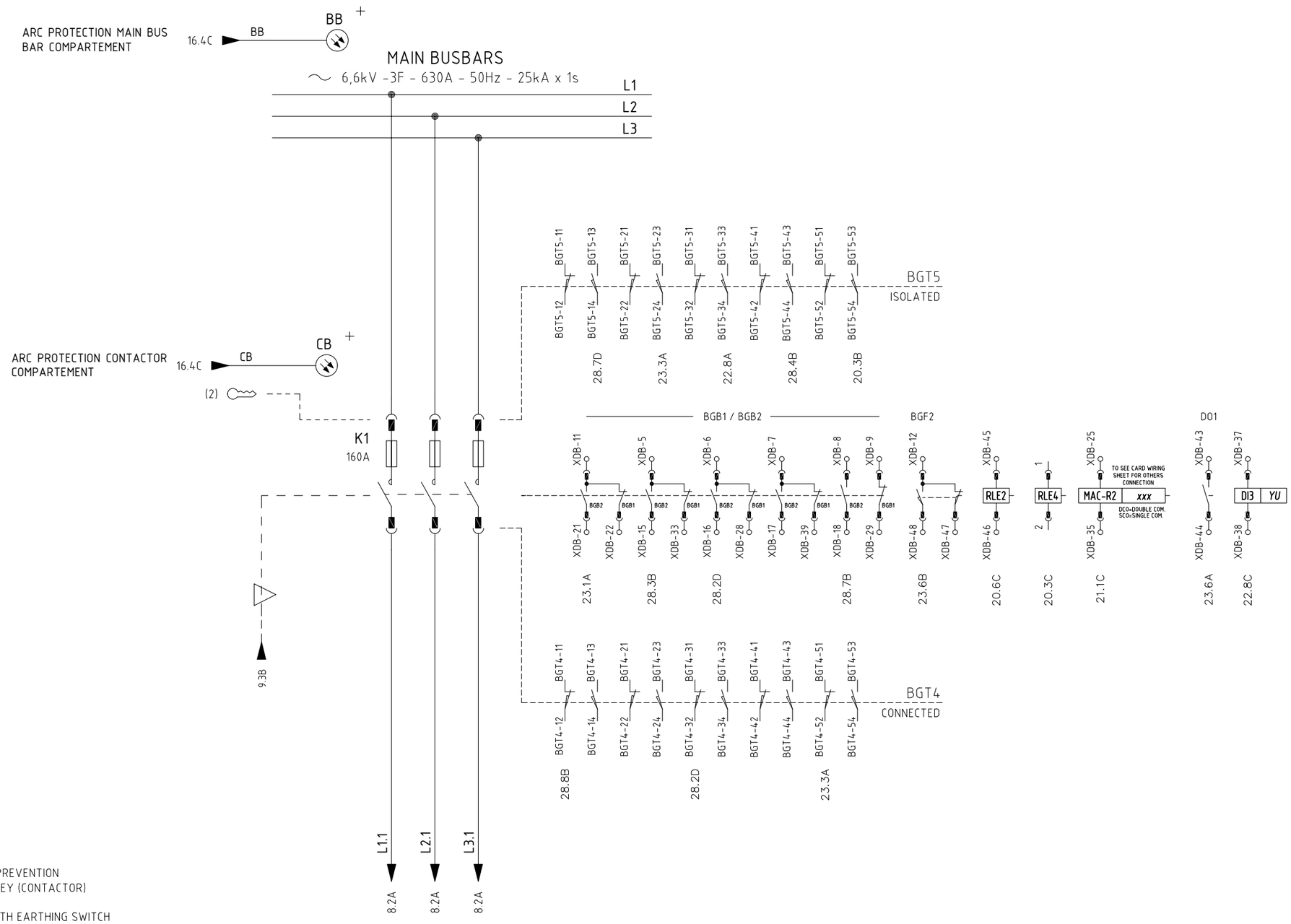
TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Selector Switch Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00019 | SHEET 6 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03




(2) RACKING IN PREVENTION LOCK WITH KEY (CONTACTOR)

(3) FREE KEY WITH EARTHING SWITCH IN OPEN POSITION

(4) FREE KEY WITH EARTHING SWITCH IN CLOSED POSITION

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/19

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

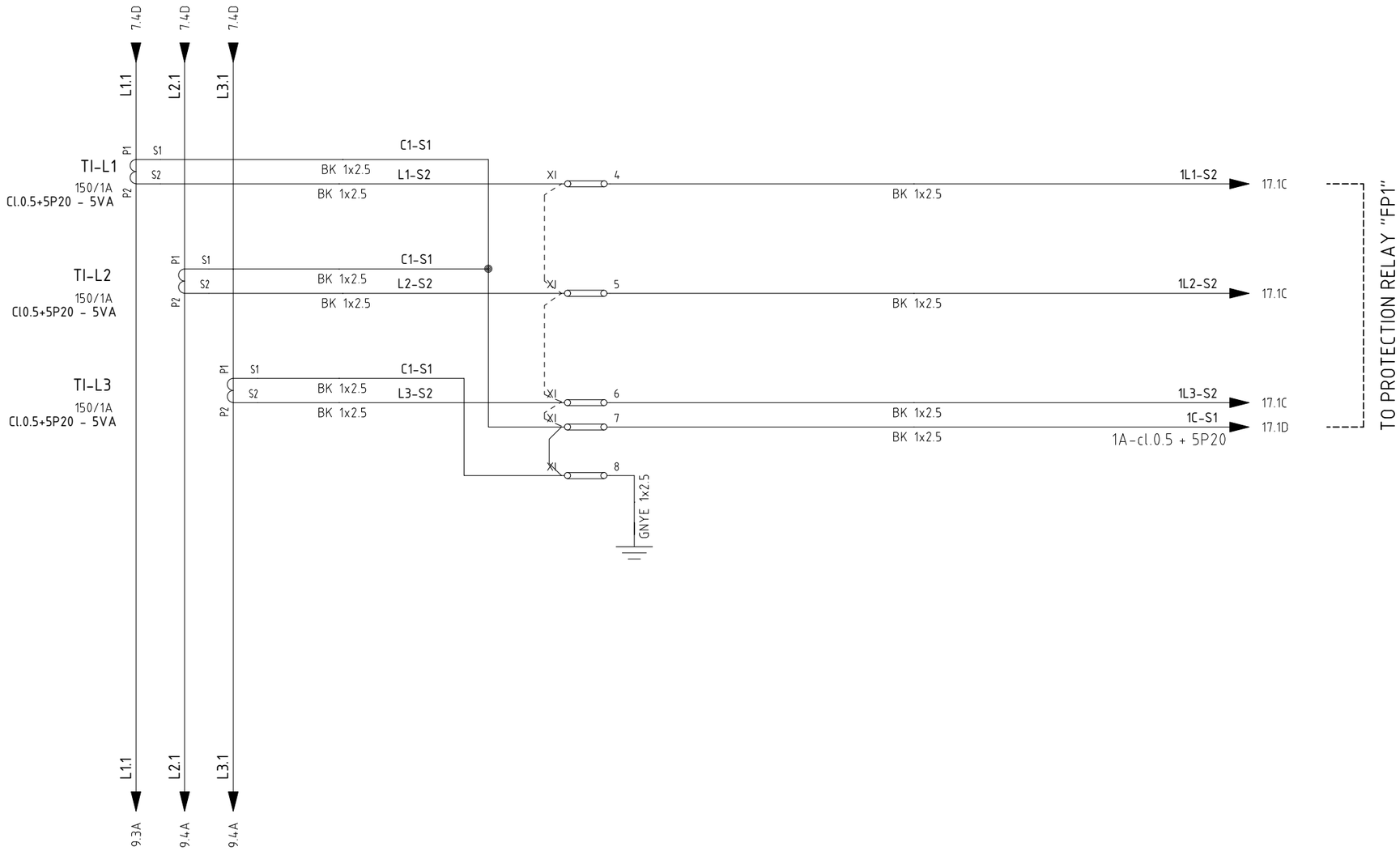
DRAWING NO. 1723002197-EL-DG-00019

SHEET 7

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03




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|---|---|---|---|---|---|---|---|
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| +A7 | | | | | | | |
| | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

DWG n° : 231151/SD/19
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

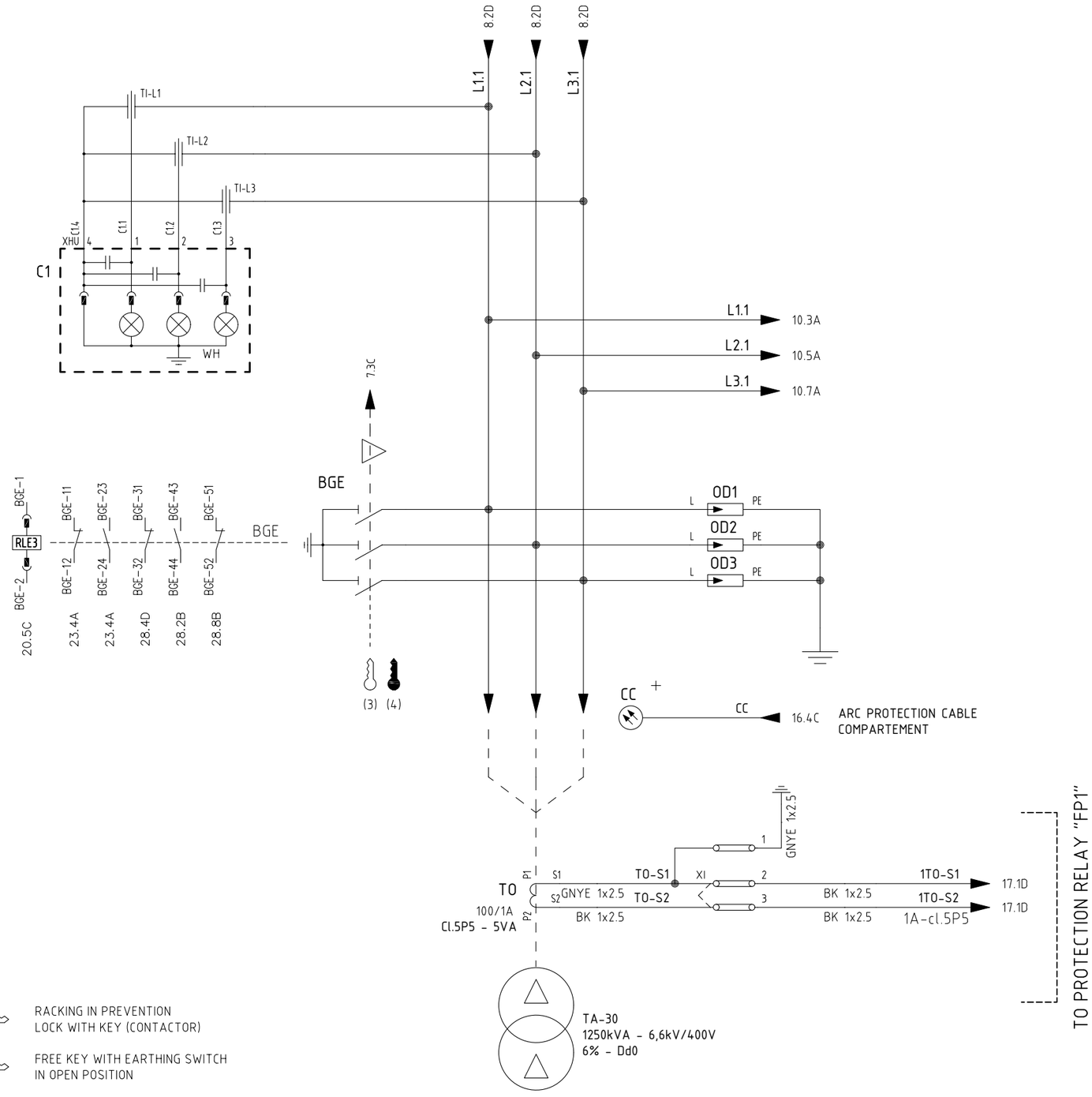
DRAWING NO. 1723002197-EL-DG-00019

SHEET 8

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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DWG n° : 231151/SD/19
Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

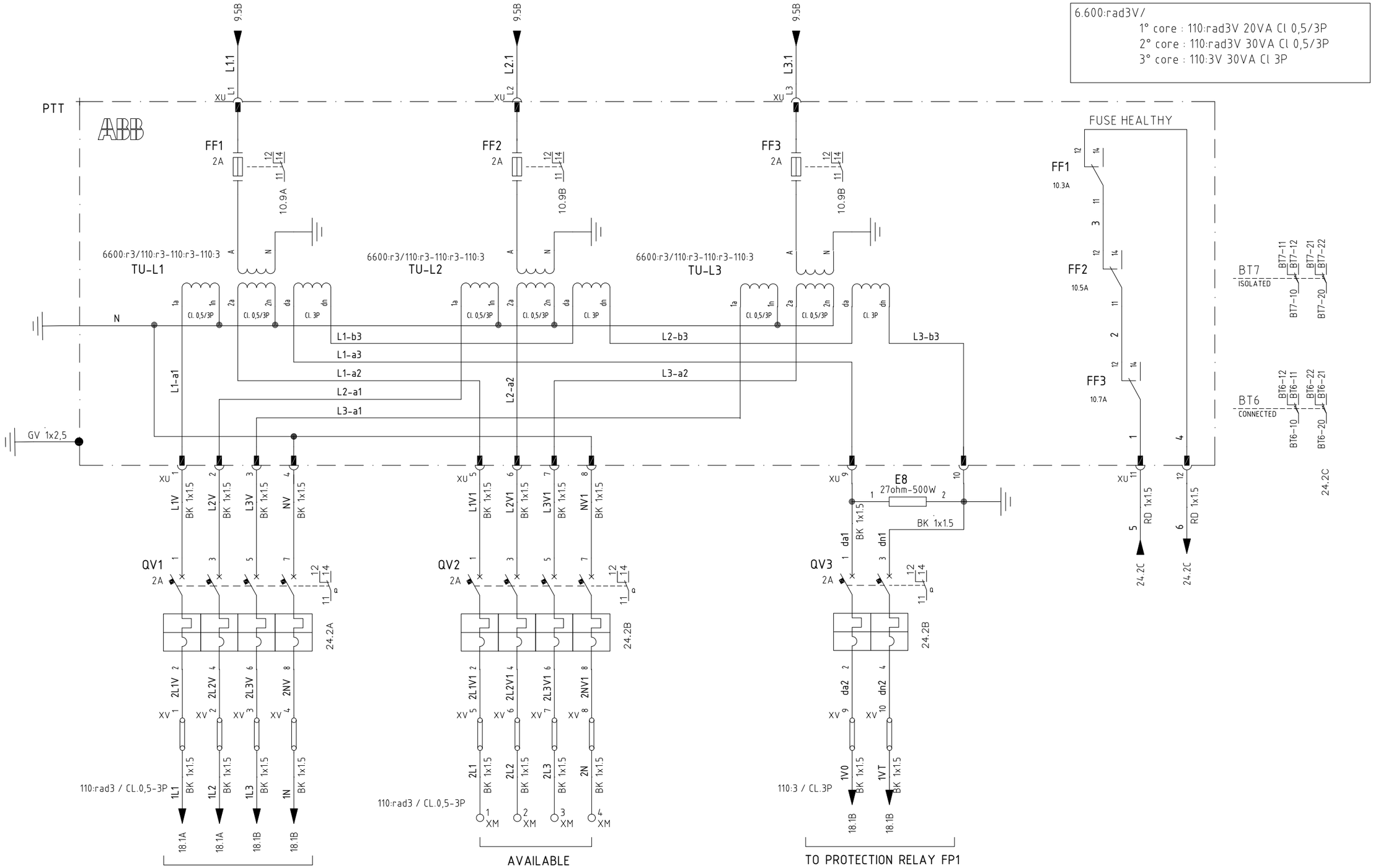
DRAWING NO. 1723002197-EL-DG-00019

SHEET 9

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/19

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 – FUNCTIONAL FUEL CELL FEEDER A-80000

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 1.0

REV. 03

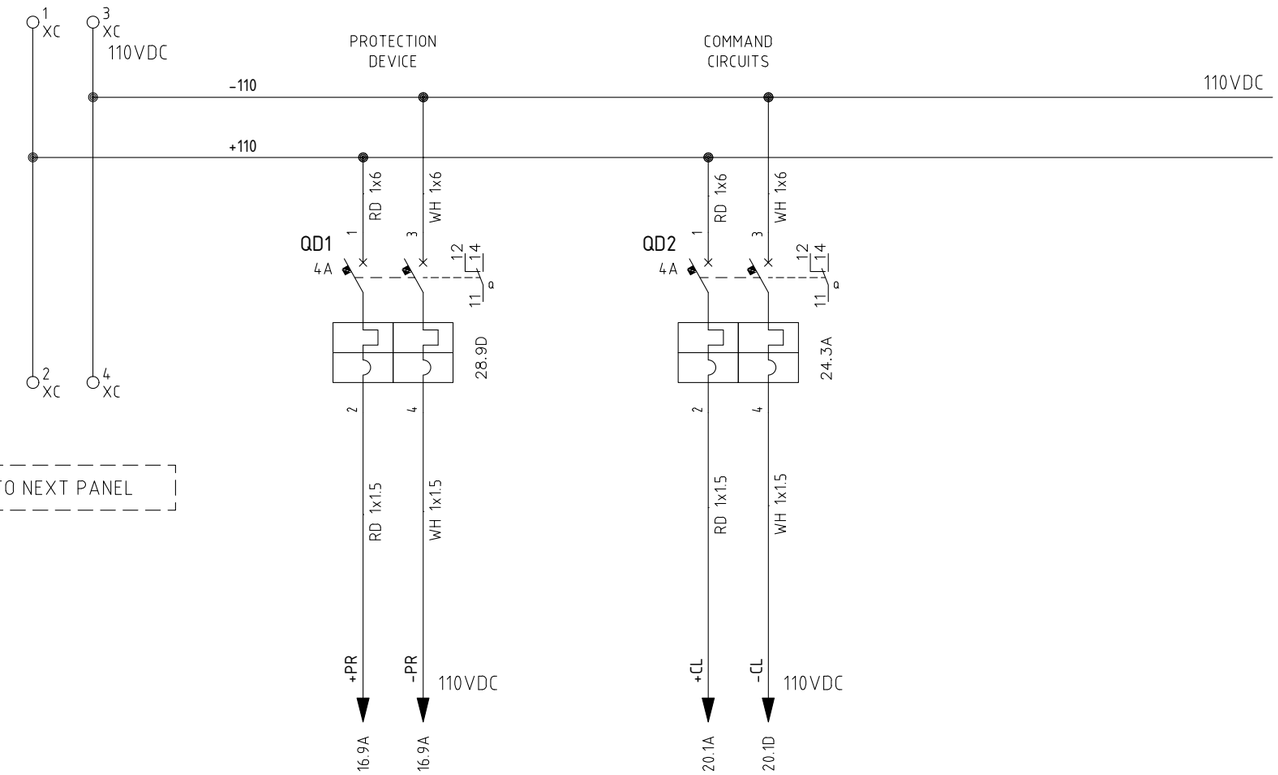
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

## 110VDC DISTRIBUTION VOLTAGE

110Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL

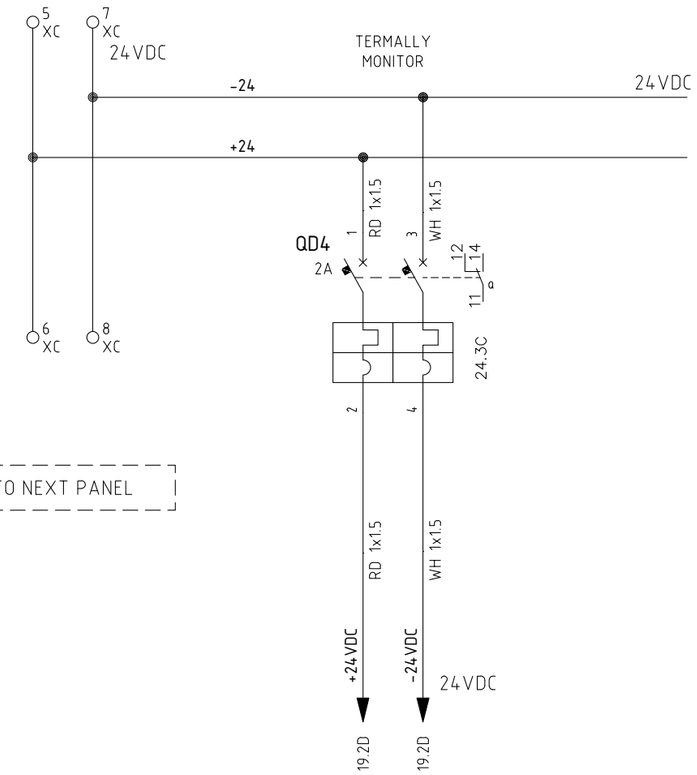



TO NEXT PANEL

## 24VDC DISTRIBUTION VOLTAGE

24Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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+A7
DWG n° : 231151/SD/19
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
110Vdc / 24Vdc Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 1.1

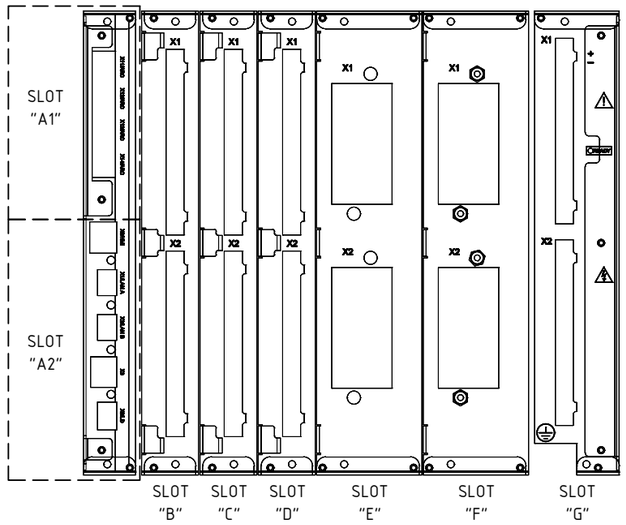
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# COMPOSITION RELAY REX640

## RACK VIEW




REX640B10NN+COM1+ARC1+BIO1+BIO1+BIO2+AIM1+AIM1+PSM3+MCT1+SCT1+CMP2+LNG1+PCL4

| LEGEND | | |
|---|---|---|
| SLOT | Module Type | Description Module |
| A1 | ARC1001 | n° 4 x ARC sensor inputs |
| A2 | COM1001 | n° 1 x RJ-45 (LHMI port) + n° 3 x RJ-45 + n° 1 x SFP100M LC |
| B | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| C | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| D | BIO1002 | n° 9 Binary Input + n° 6 x SPO + n° 2 x SPO(TCS) |
| E | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| F | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| G | PSM1003 | 77...150 VDC, n° 3 x PO (TCS) + n° 2 x PO + n° 3 x SO + n° 2 x SSO |
| | PO = Power Output<br>SO = Signal Output<br>SPO = Static Power Output<br>SSO = Static Signal Output | |

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+A7

DWG n° : 231151/SD/19
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Composition Relay REX640

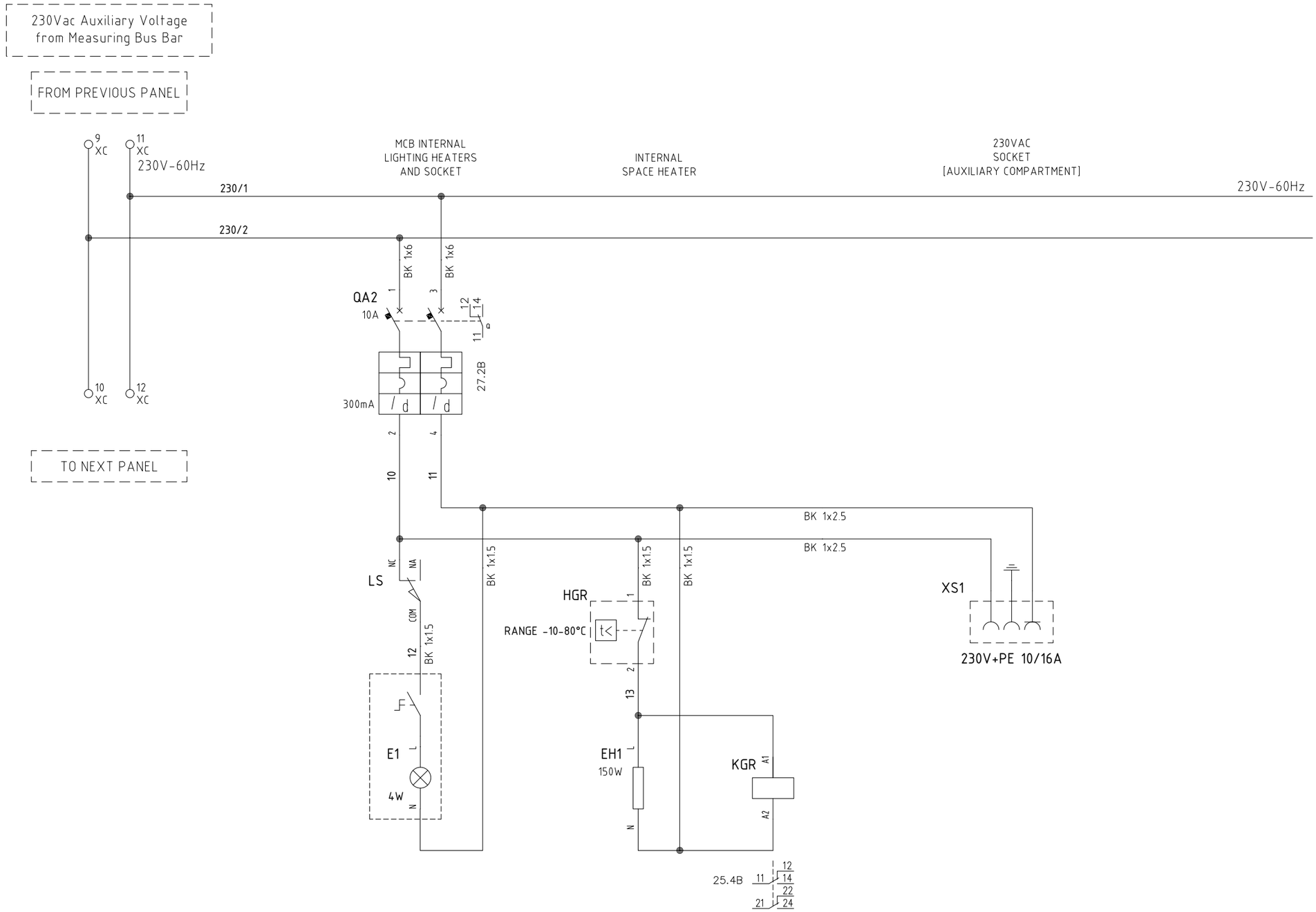
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00019 | SHEET 12 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# 230VAC DISTRIBUTION VOLTAGE




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| +A7 | | | | | | | |
| | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

DWG n° : 231151/SD/19
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
230Vac Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 13

REV. 03

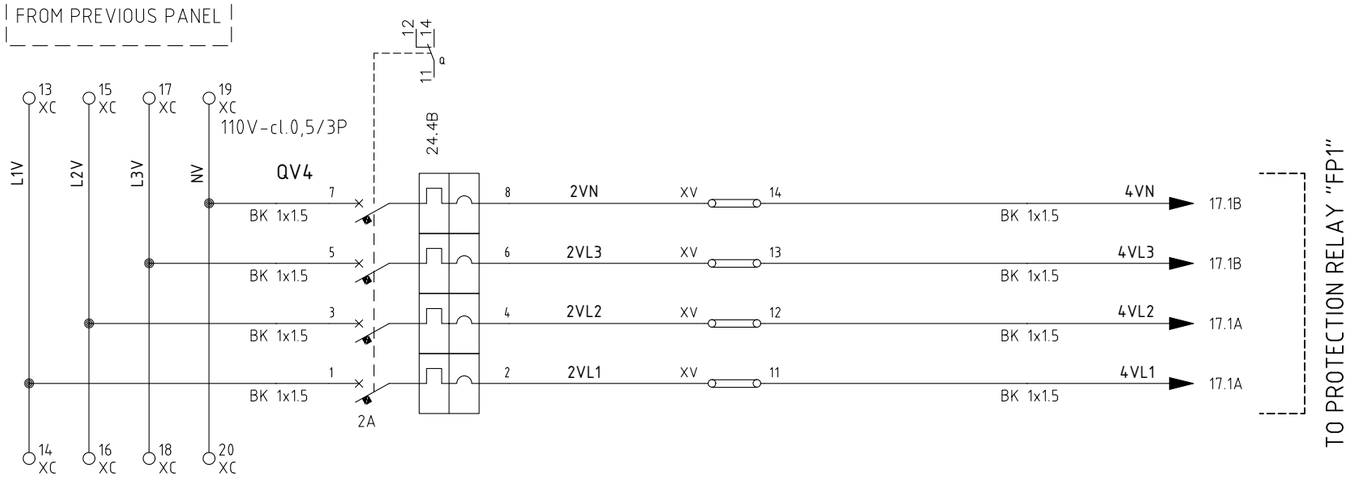
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# 110V: 1,73 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:√3V VOLTMETRIC LINE - STAR
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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= +A7
DWG n° : 231151/SD/19
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00019 | SHEET 14 | REV. 03

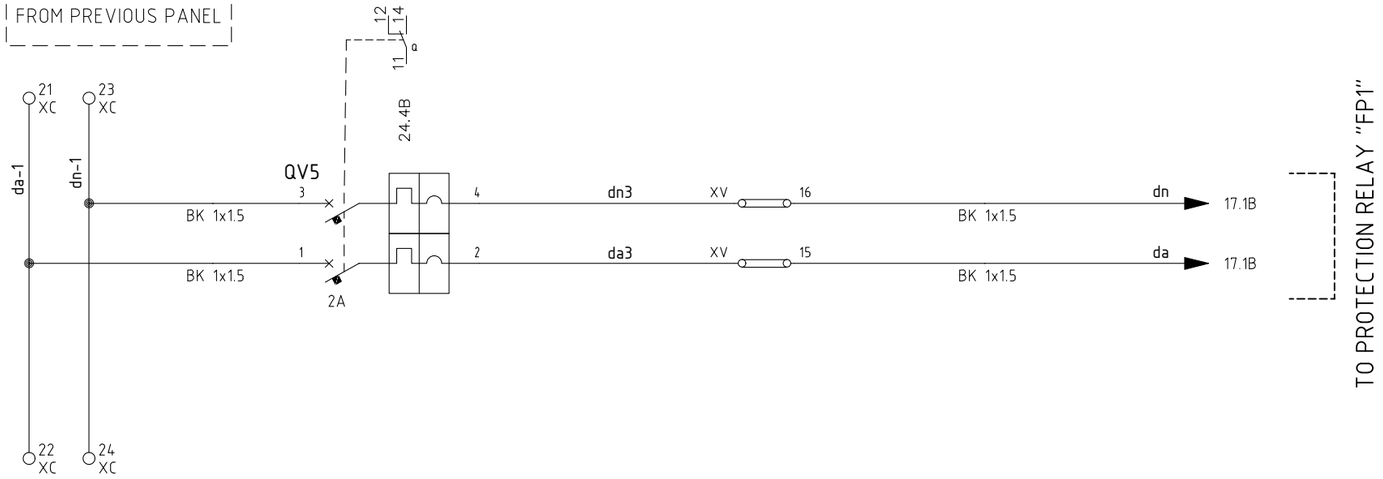
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# 110V:3 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:3V VOLTMETRIC LINE -
DELTA OPEN
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO PROTECTION RELAY "FP1"

TO NEXT PANEL

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| +A7 | | | | | | | |
| | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

DWG n° : 231151/SD/19
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 15

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# "REX640" PROTECTION WIRING

FP1

PSM1003
COM1001
slot G

X1

X1-1 (+) Uaux (-) X1-2

GND — 1x6 GNYE

11.2D +PR → +PR → 23.1A
11.3D -PR → -PR → 23.1D
110VDC

RD 1x1.5
WH 1x1.5

PROTECTION FUNCTION

| | |
|---|---|
| 51 | 50 |
| 51N | 67 |
| 25 | 59N |
| 27 | 59 |
| 74 | 86 |
| | |
| | |
| | |

ETH PORT (IEC61850)

X1 — PATCH CORD cat.6 RJ45 — FP1-A7/A — FROM MEASURE CUBICLE A5
X2
X3 — PATCH CORD cat.6 RJ45 — FP1-A7/B — FROM MEASURE CUBICLE A5
X0 — PATCH CORD cat.7 RJ45 — ETH.1

ARC1001
slot A1

ARC DETECTOR SENSOR

| | | | | |
|---|---|---|---|---|
| X11 | BB | 7.3A | BUS BAR COMPARTEMENT | arc detectors |
| X12 | CB | 7.3B | C.B. COMPARTEMENT | |
| X13 | CC | 9.5C | CABLE COMPARTEMENT | |
| X14 | | | | |

REX640

640 ABB
X1.1
X3 (+ / -)
GNYE 1x6

LHMI
Local HMI
[7" color Touch screen]

FP1

PSM1003
slot G
REX 640

| RF | SO1 | SO2 | SS01 | SS02 | POSP1 | POSP2 | SO3 | PODP1 | PODP2 | PODP3 |
|---|---|---|---|---|---|---|---|---|---|---|
| X1-4 | X1-7 | X1-9 | X1-11 | X1-13 | X1-15 | X1-17 | X2-2 | X2-6 | X2-11 | X2-16 |
| X1-5 | X1-8 | X1-10 | X1-12 | X1-14 | X1-16 | X1-18 | X2-3 | X2-4 | X2-9 | X2-14 |
| X1-3 | X1-6 | | | | | | X2-1 | X2-5 | X2-12 | X2-17 |
| | | | | | | | | X2-7 | X2-10 | X2-15 |
| | | | | | | | | X2-8 | X2-13 | X2-18 |
| | | | | | | | | TCS1 | TCS2 | TCS3 |
| 22.9A | 20.5C | 28.4D | | | 21.10B | | 20.6B | 21.8B | | |

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+A7
DWG n° : 231151/SD/19
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 – FUNCTIONAL FUEL CELL FEEDER A-80000
"REX640"' Protection Wiring

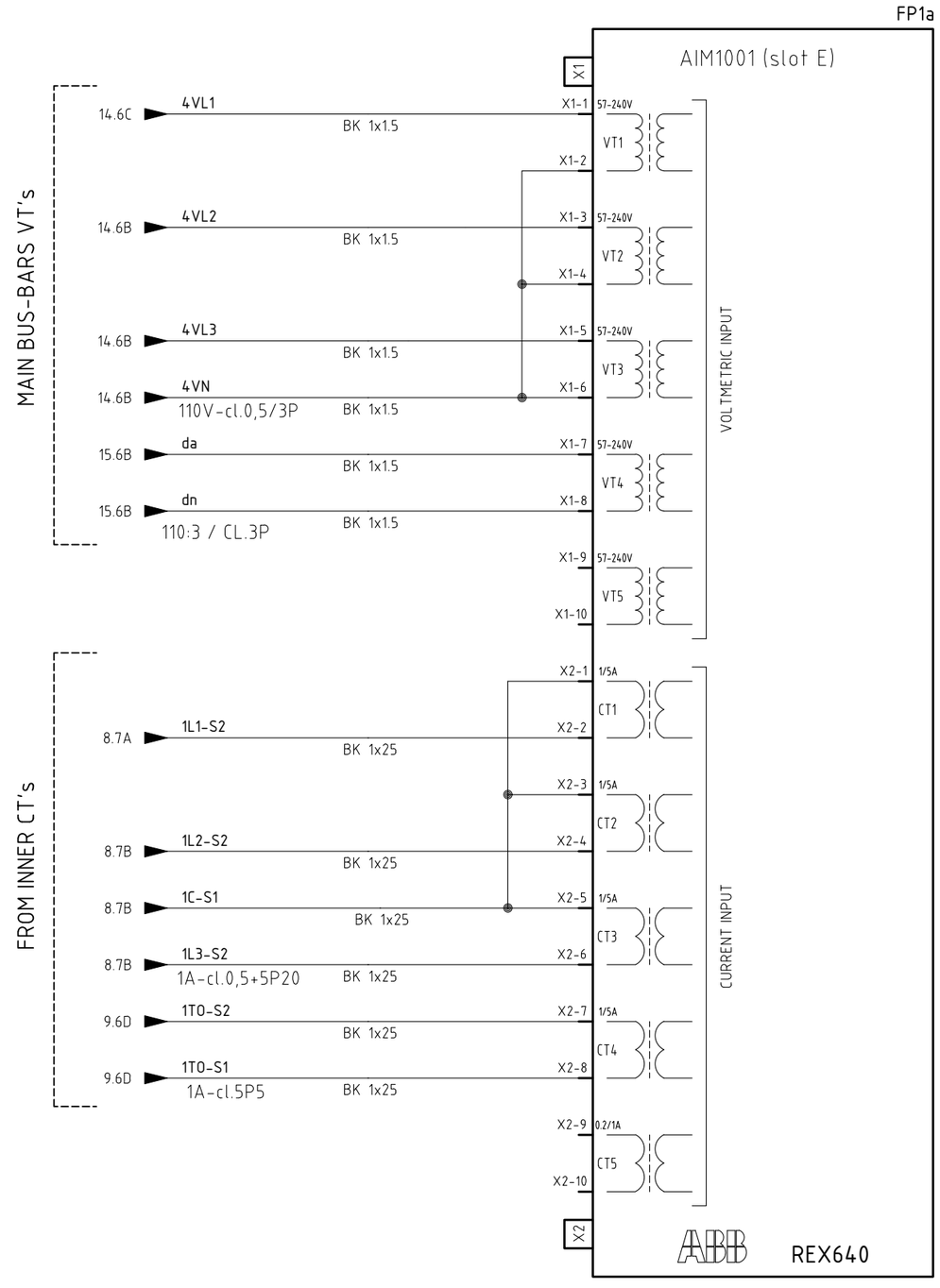
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00019
SHEET 16
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# "REX640" PROTECTION WIRING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A7
DWG n° : 231151/SD/19
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

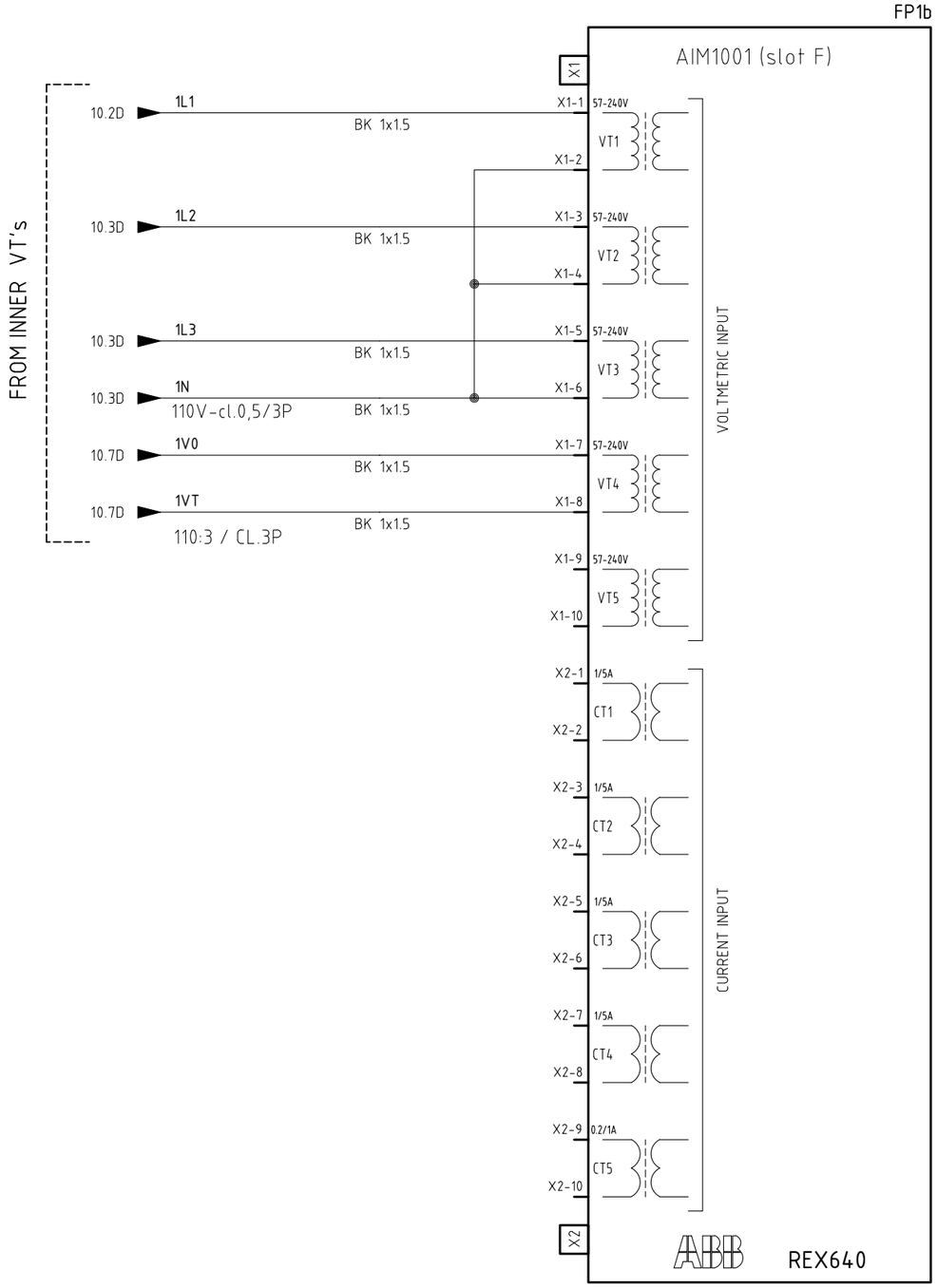
SHEET 1.7

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# "REX640" PROTECTION WIRING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A7
DWG n° : 231151/SD/19
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

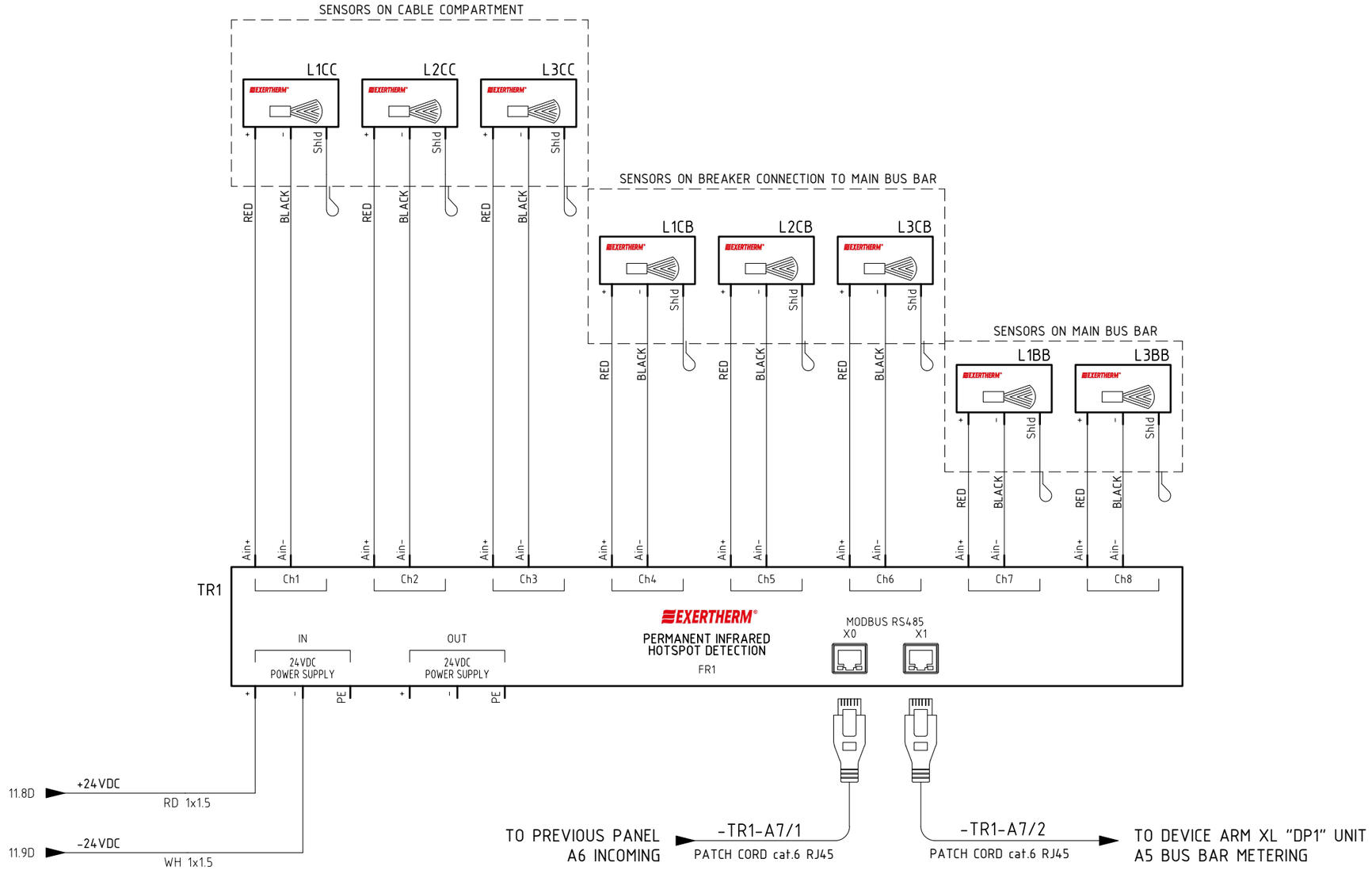
TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00019
SHEET 18
REV. 03

File Name : 1723002197-EL-DG-00019 Rev.03

F.to UNI A3: 420mmx297mm




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= +A7

DWG n° : 231151/SD/19

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

Extherm Device

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 19

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# COMMAND CIRCUITS

ENABLING CONTACTOR TRUCK ENCLOSURE DOOR AND EARTHING SWITCH

UNLOCKING CONTACTOR ENCLOSURE DOOR

ENABLING EARTHING SWITCH COMMAND

ENABLING RACK-IN AND RACK-OUT CONTACTOR [LOCKING MAGNET]

11.4D +CL 110VDC (CL)

+CL 21.1A

RD 1x1.5

P1 BK 13 14

KT1 20.2D 16 18 15 30"

21 RD 1x1.5

K1 ISOLATED BGT5 7.4B BGT5-53 BGT5-54

5 XM 6 XM

FP1 16.3A S03 REX640 X2 Slot G X2-2 X2-3 X2-1

25 7 XM 8 XM

FP1 16.3A S01 REX640 X1 Slot G X1-7 X1-8 X1-6

23 24 RD 1x1.5 BGE-1

26 RD 1x1.5 XDB-45

RD 1x1.5 20

RD 1x1.5 22

K1 RLE4 7.4B 1 2

BGE RLE3 9.3C BGE-2

K1 RLE2 7.4B XDB-46

KT1 A1 B1 30" A2

11.4D -CL

-CL 21.1E

WH 1x1.5

20.3A 15 16 18

23.9A 25 26 28

| | | | | | | |
|---|---|---|---|---|---|---|
| = | | | | | | |
| +A7 | | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

DWG n° : 231151/SD/19

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

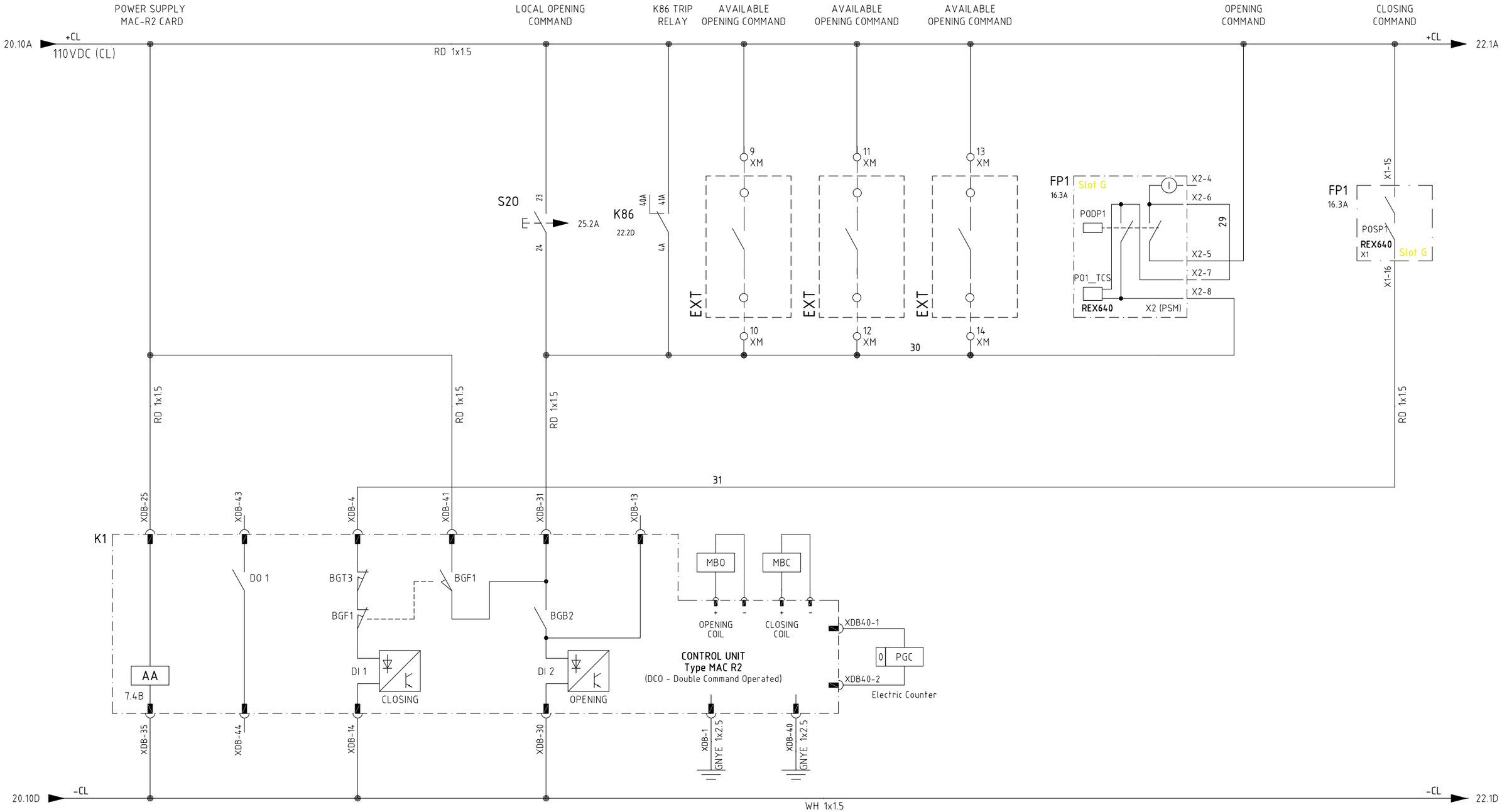
SHEET 20

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# CLOSING/OPENING COMMAND CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A7
DWG n° : 231151/SD/19
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

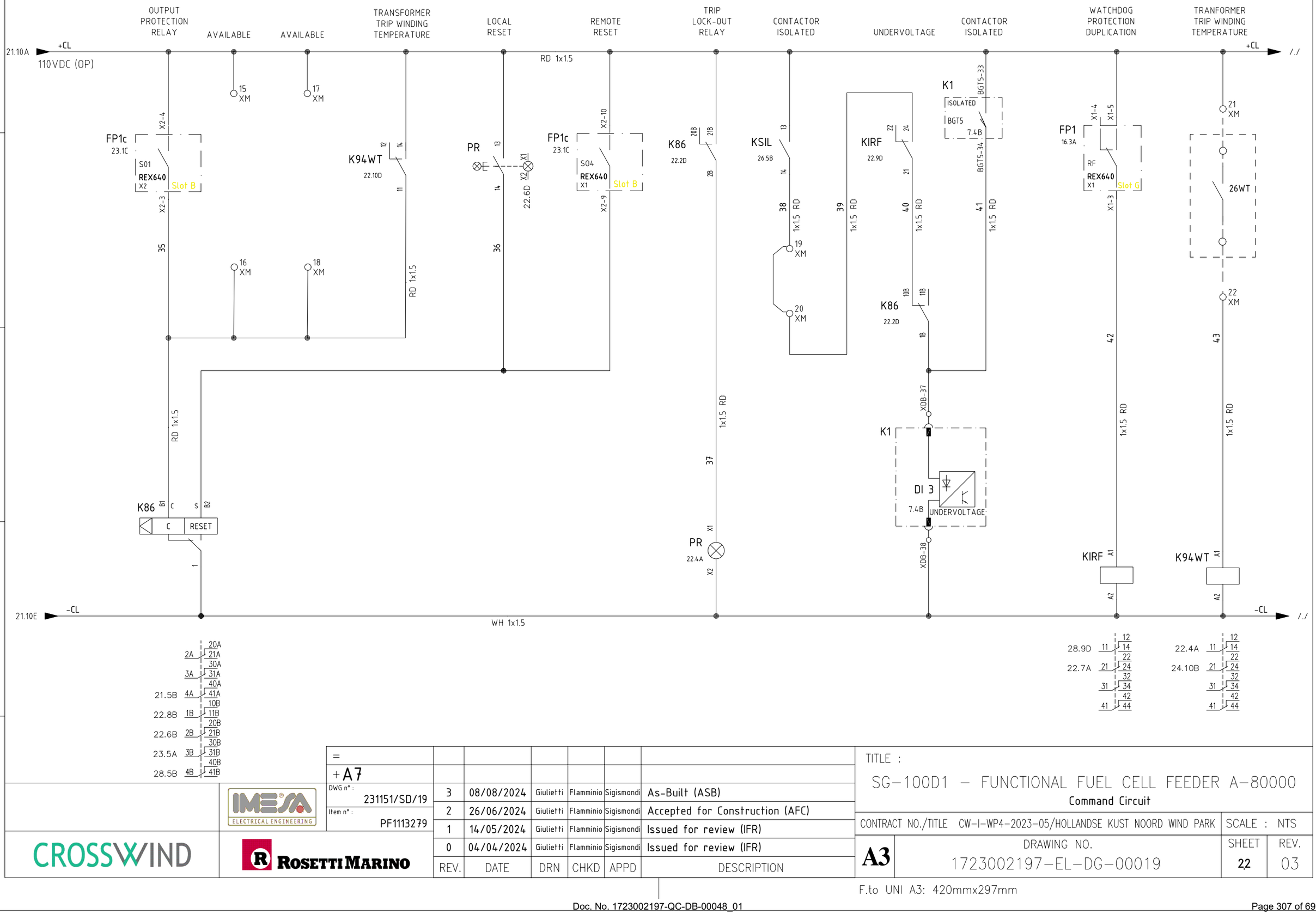
SHEET 21

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# COMMAND CIRCUITS




| | | | | | | |
|---|---|---|---|---|---|---|
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| +A7 | | | | | | |
| DWG n° : 231151/SD/19 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 – FUNCTIONAL FUEL CELL FEEDER A-80000

Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 22

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT

CONTACTOR CLOSED | CONTACTOR OPENED | CONTACTOR SERVICE POSITION | CONTACTOR TEST POSITION | EARTH SWITCH OPENED | EARTH SWITCH CLOSED | K86 RELAY TRIPPED | CONTACTOR READY | FUSES TRIPPED | SELECTOR IN LOCAL POSITION | SELECTOR IN REMOTE POSITION | EXTERNAL CLOSING INTERLOCK | FROM L.V. SWBD CB OPENED (CLOSING INTERLOCK) | UNLOCKING EARHTING SWITCH/ TRUCK CONTACTOR

16.10A +PR 110VDC (PR) — RD 1x1.5 — +PR 24.1A

XDB-11 | K1 BGB1/2 7.4B | XDB-21 | XDB-22

K1 CONNECTED BGT4 7.4B | BGT4-51 | BGT4-52

K1 ISOALTED BGT5 7.4B | BGT5-23 | BGT5-24

BGE BGE 9.3C | BGE-11 | BGE-12

BGE BGE 9.3C | BGE-23 | BGE-24

K86 22.2D | 30B | 31B | 3B

K1 D01 7.4B | XDB-43 | XDB-44

K1 BGF2 7.4B | XDB-12 | XDB-48 | XDB-47

SA1 | 11 | 12 | SA1 | 13 | 14

23 XM | 24 XM

L.V.SWITCHBOARD C.B. OPENED | 25 XM | 26 XM

KT1 20.2D | 26 | 28 | 30" | 25

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
| RD 1x1.5 | RD 1x1.5 | RD 1x1.5 | RD 1x1.5 | RD 1x1.5 | RD 1x1.5 | RD 1x1.5 | RD 1x1.5 | RD 1x1.5 | RD 1x1.5 | RD 1x1.5 | RD 1x1.5 | RD 1x1.5 | RD 1x1.5 |
| X1-1 | X1-2 | X1-3 | X1-5 | X1-6 | X1-7 | X1-9 | X1-10 | X1-11 | X1-13 | X1-14 | X1-15 | X1-17 | X2-1 |

FP1c BIO1001 SLOT B — REX640

BI1 | BI2 | BI3 | BI4 | BI5 | BI6 | BI7 | BI8 | BI9 | BI10 | BI11 | BI12 | BI13 | BI14

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X1-4 | | | X1-8 | | | X1-12 | | | X1-16 | | | X1-18 | X2-2 |

16.10A -PR — WH 1x1.5 — -PR 24.1E

FP1c BIO1001 SLOT B — REX640

| SO1 | SO2 | SO3 | SO4 | SO5 | SO6 | SO7 | SO8 |
|---|---|---|---|---|---|---|---|
| X2-4 | X2-6 | X2-8 | X2-10 | X2-12 | X2-14 | X2-16 | X2-18 |
| X2-3 | X2-5 | X2-7 | X2-9 | X2-11 | X2-13 | X2-15 | X2-17 |
| 22.2A | 28.5D | 28.6D | 22.5A | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= | +A7 | DWG n°: 231151/SD/19 | Item n°: PF1113279

IMESA ELECTRICAL ENGINEERING | CROSSWIND | ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00019 | SHEET 23 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT

FROM MEASURE UNIT A5

EMERGENCY OPENING BY SIS | VT HEALTY CIRCUIT | EARTING SWITCH OPEN (FROM MEASURING UNIT) | CLOSED AUXILIARY CIRCUIT MCB's | CLOSED AUXILIARY V.T. SECONDARY MCB's | CLOSED AUXILIARY CIRCUIT MCB's | VT HEALTY CIRCUIT | UPS 110VDC SUPPLY A "ON" | UPS 110VDC SUPPLY B "ON" | 230VAC SUPPLY "ON" | 24VDC SUPPLY "ON" | SPACE HEATER ON | TRANSFORMER ALARM WINDING TEMPERATURE | TRANSFORMER TRIP WINDING TEMPERATURE

23.10A +PR 110VDC (PR) — RD 1x1.5 — +PR 25.1A

KSIL 26.5B — QV1 10.2C — QV2 10.4C — QV3 10.7C — PTT 10.2A — QD2 11.4B — QD4 11.8B — QV5 15.2B — QV4 14.2C — QD2 — QD5 — QD6 — QD21 — QD22 — QV1 — QV2 — FF1 — FF2 — FF3 — PTT — KA1 — KN1 — KN2 — K230 — KA2 — KGR — 26WT — K94WT 22.10D

10.9C 5 — 10.9C 6

FP1d BIO1001 SLOT C — ABB REX640 — BI1 BI2 BI3 BI4 BI5 BI6 BI7 BI8 BI9 BI10 BI11 BI12 BI13 BI14

23.10D -PR — WH 1x1.5 — -PR 25.1D

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| DWG n° : 231151/SD/19 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
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| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING — CROSSWIND — ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
"REX640" Protection Wiring - Digital Input

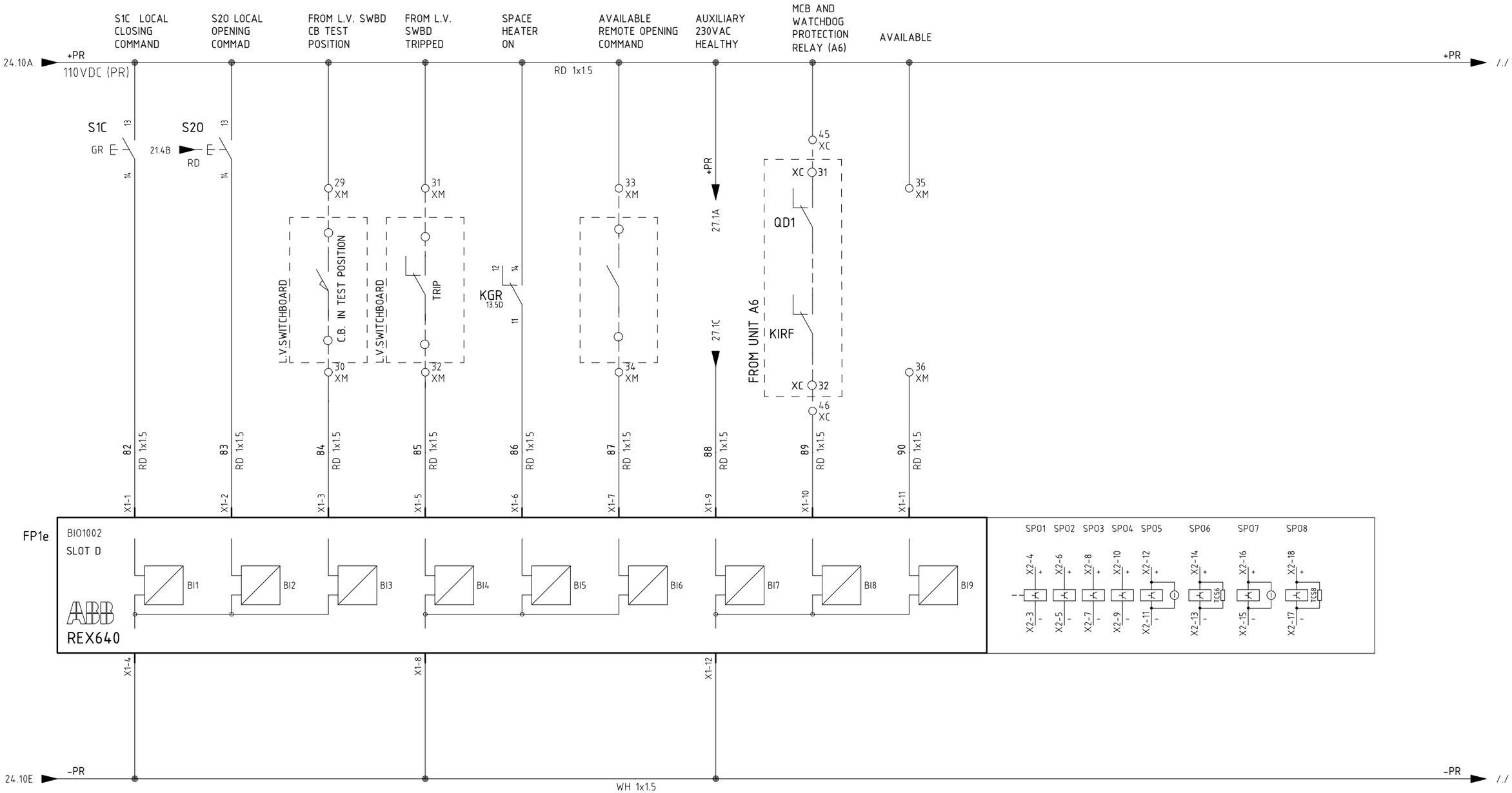
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00019 | SHEET 24 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT




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|---|---|---|---|---|---|---|
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| +A7 | | | | | | |
| DWG n° : 231151/SD/19 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
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| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

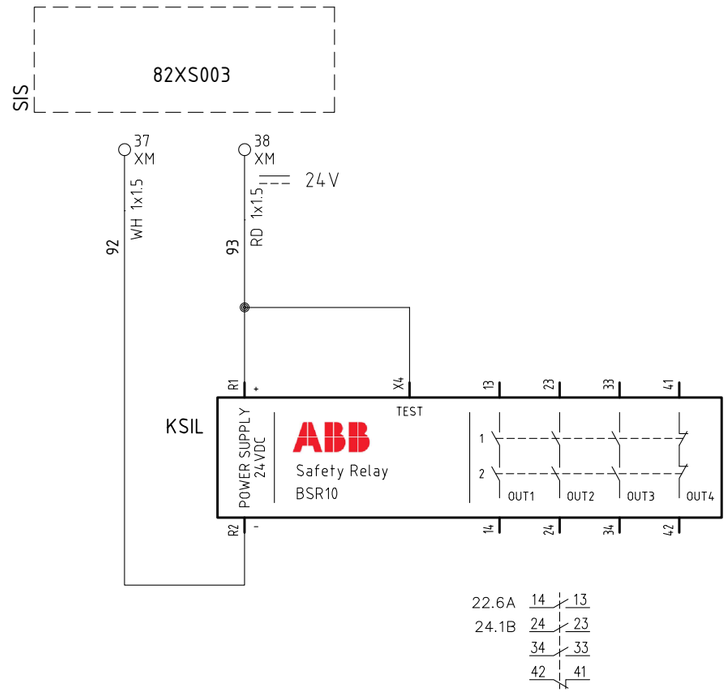
SHEET 25

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# EMERGENCY OPENING BY "SIS"




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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+A7
DWG n° : 231151/SD/19
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Emergency Opening by "SIS"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

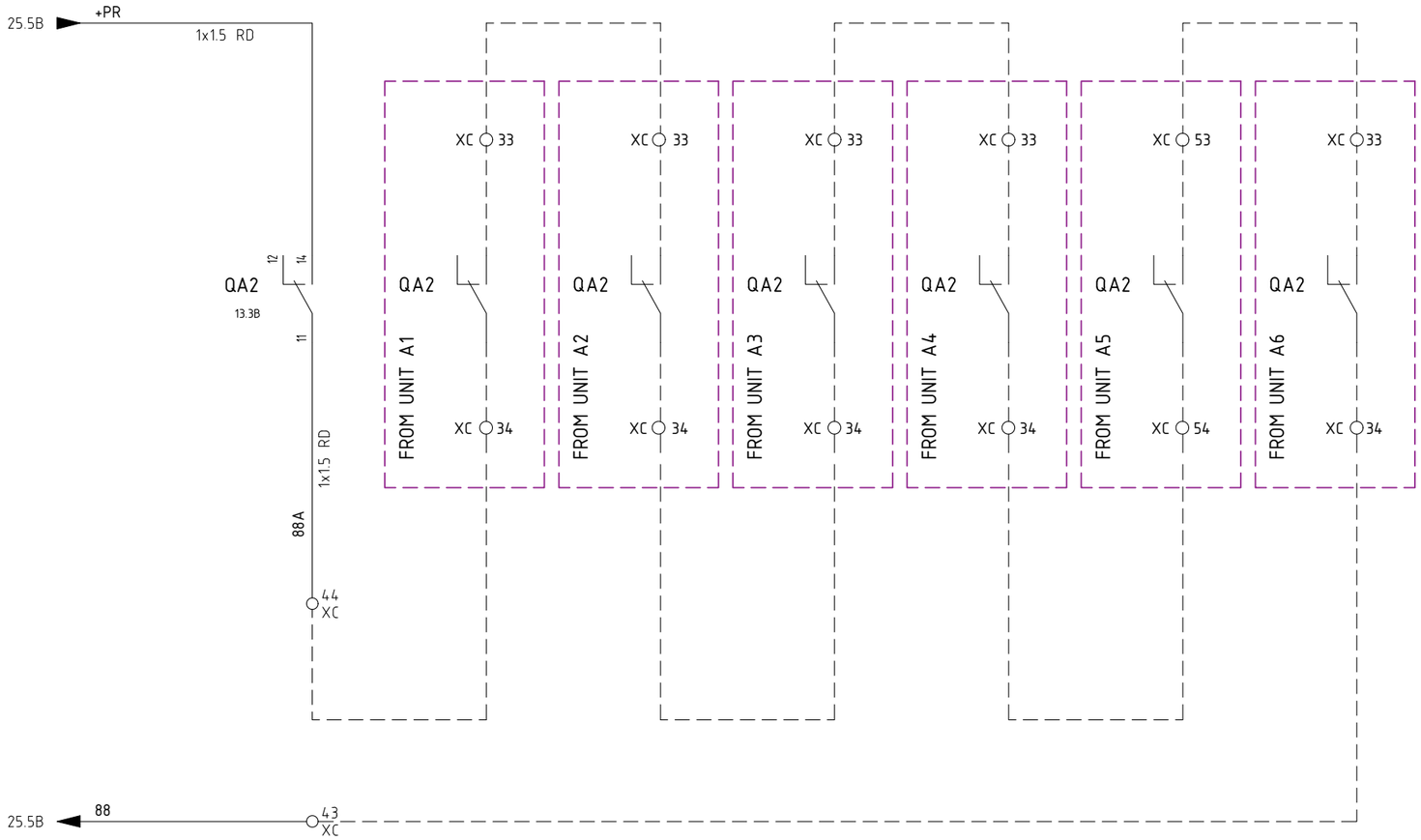
DRAWING NO. 1723002197-EL-DG-00019

SHEET 26

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A7

DWG n° : 231151/SD/19

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

230Vac Auxiliary General Healtly

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

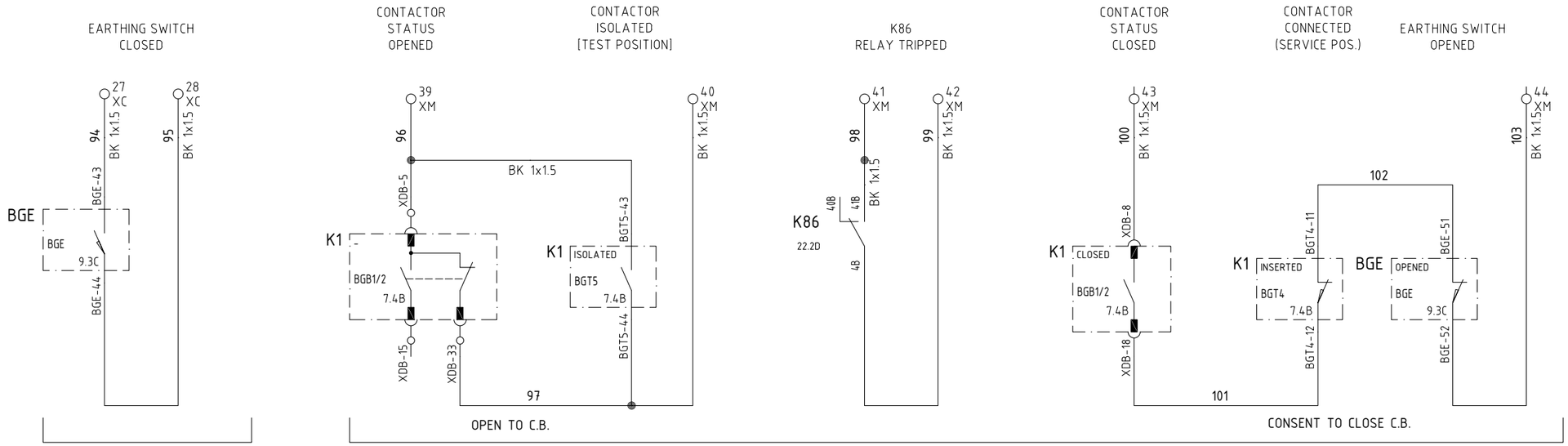
SHEET 27

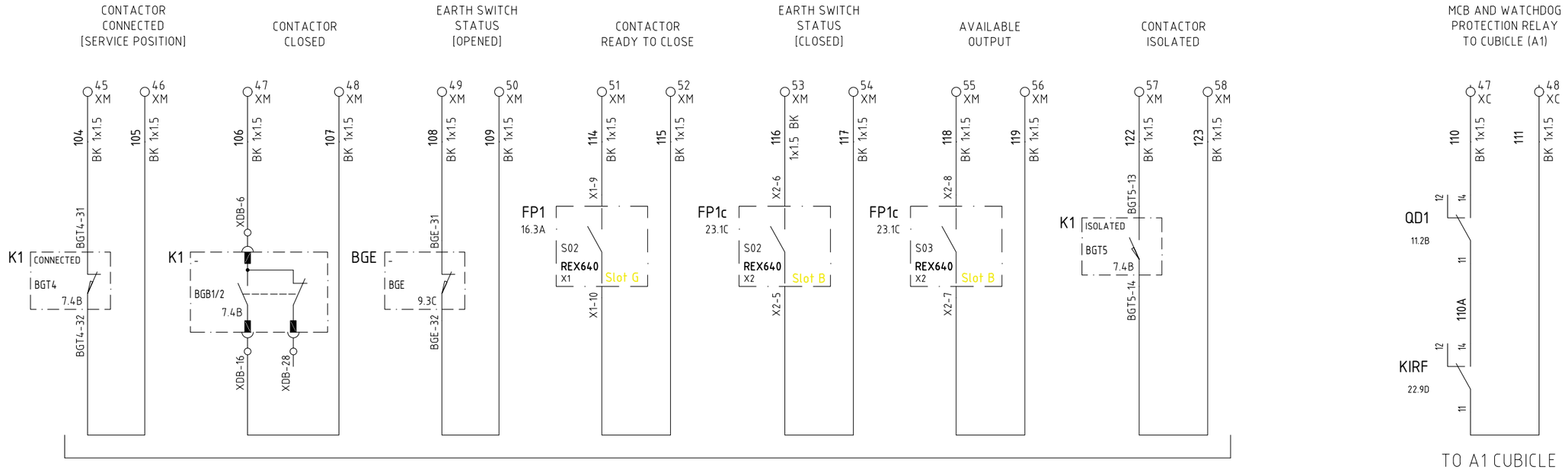
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

# AVAILABLE SIGNALS




AVAILABLE SIGNALS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
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| +A7 | | | | | | | |
| DWG n° : 231151/SD/19 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
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| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

Availables Signals

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 28

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

TYP - FUEL

XI

Ammeter Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 2 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 3 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HL201GR | Cabur | HLD.2/PT/GR End section - Grey |
| 4 | 8.4A | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 5 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 6 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 7 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 8 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HL201GR | Cabur | HLD.2/PT/GR End section - Grey |

TYP - FUEL

XV

Voltmetric Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 10.2D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 2 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 3 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 4 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 5 | 10.4D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 6 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 7 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 8 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 9 | 10.7D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 10 | 10.7D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 11 | 14.4C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 12 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 13 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 14 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 15 | 15.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 16 | 15.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |

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DWG n° : 231151/SD/19

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

Terminal strip

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 29

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

TYP - FUEL

XC

Interconnection Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 11.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 2 | 11.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 3 | 11.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 4 | 11.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 5 | 11.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 6 | 11.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 7 | 11.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 8 | 11.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 9 | 13.1A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 10 | 13.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 11 | 13.2A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 12 | 13.2B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 13 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 14.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 14.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 21 | 15.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 15.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 15.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 15.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 25 | 24.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 24.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 28.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 28.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 24.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 24.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 24.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 24.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 24.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 24.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 24.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 24.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/19

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

Terminal strip

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 3.0

REV. 03

File Name : 1723002197-EL-DG-00019 Rev.03

F.to UNI A3: 420mmx297mm

TYP - FUEL

XC

Interconnection Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 37 | 24.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 38 | 24.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 39 | 24.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 40 | 24.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 41 | 24.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 42 | 24.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 43 | 27.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 44 | 27.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 45 | 25.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 46 | 25.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 47 | 28.9C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 48 | 28.10C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/19

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

Terminal strip

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 31

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

TYP - FUEL

XM

Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 10.4E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 2 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 3 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 4 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 5 | 20.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 6 | 20.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 7 | 20.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 8 | 20.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 9 | 21.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 10 | 21.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 11 | 21.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 12 | 21.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 13 | 21.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 21.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 22.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 22.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 22.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 22.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 22.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 22.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 21 | 22.10A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 22.10B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 23.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 23.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 25 | 23.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 23.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 24.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 24.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 25.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 25.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 25.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 25.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 37 | 26.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 38 | 26.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 39 | 28.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 40 | 28.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/19

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

Terminal strip

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 3.2

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

TYP - FUEL

XM

Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 41 | 28.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 42 | 28.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 43 | 28.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 44 | 28.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 45 | 28.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 46 | 28.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 47 | 28.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 48 | 28.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 49 | 28.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 50 | 28.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 51 | 28.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 52 | 28.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 53 | 28.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 54 | 28.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 55 | 28.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 56 | 28.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 57 | 28.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 58 | 28.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 59 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 60 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 61 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 62 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 63 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 64 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 65 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 66 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 67 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 68 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

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DWG n° : 231151/SD/19

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

Terminal strip

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00019

SHEET 33

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A7 | FUEL CELL FEEDER A-80000 |
| BGE | 9 | 1VCF599700R0131 | 1 | EARTHING SWITCH ST-E 17.31 150 | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF599505R0001 | 1 | 5 AUX CONTACTS FOR EARTHING SWITCH | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF599504R0063 | 1 | KEY LOCKS ON EARTHING SWITCH | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF599700R0290 | 1 | EARTHING SWITCH OPERATING LEVER | ABB | A7 | FUEL CELL FEEDER A-80000 |
| C1 | 9 | 43931118 | 1 | VPIS 3,3÷36KV - DEVICE SIGNALLING VOLTAGE PRESENT KIT | ELECTRONSYSTEM | A7 | FUEL CELL FEEDER A-80000 |
| CB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A7 | FUEL CELL FEEDER A-80000 |
| CC | 9 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A7 | FUEL CELL FEEDER A-80000 |
| E1 | 13 | 74041 | 1 | LED LAMP 4W 4000K 313x30x22 | Beghelli | A7 | FUEL CELL FEEDER A-80000 |
| E8 | 10 | 1VCF501000R0001 | 1 | RESISTOR TR318 27R/J 27ohm 500W L=2,5M | ABB | A7 | FUEL CELL FEEDER A-80000 |
| EH1 | 13 | R1R150230 | 1 | SPACE HEATER SKR 150W ALIM. 220VCA | Torresan | A7 | FUEL CELL FEEDER A-80000 |
| FF1 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A7 | FUEL CELL FEEDER A-80000 |
| FF2 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A7 | FUEL CELL FEEDER A-80000 |
| FF3 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A7 | FUEL CELL FEEDER A-80000 |
| FP1 | 16 | 1VCF698331R0001 | 1 | REX640B10NN+AIM1+AIM1+ARC1+BIO1+BIO1+BI+O2+CMP2+COM1+LNG1+MCT1+PCL4+PSM3+SCT | ABB | A7 | FUEL CELL FEEDER A-80000 |
| HGR | 13 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | A7 | FUEL CELL FEEDER A-80000 |
| K1 | 7 | 1VCF305661R3200 | 1 | VACUUM CONTACTOR VSC7/P 3P 7,2KV 400A DOUBLE COMMAND (DCO) | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF309500R3881 | 1 | VACUUM CONTACTOR FITTED FOR DIN E=442mm FUSES | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF309500R0882 | 1 | NAMEPLATE IN ENGLISH LANGUAGE | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF309500R1881 | 1 | VACUUM CONTACTOR FOR UNIGEAR/UNISEC | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF309503R0881 | 1 | MAC-R2 ELECTRONIC CONTROL MODULE TYPE STANDARD | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF309503R1881 | 1 | VACUUM CONTACTOR CONFORMS TO THE IRC 62271-106 STANDARDS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF309588R0909 | 1 | POWER SUPPLY VOLTAGE OF MAC-R2 ELECTRONIC CONTROL MODULE 110VDC | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF309500R0100 | 1 | OPERATIONS COUNTER FOR VSC/P VERSIONE FOR SHIPPINGS REGISTER | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF349700R0407 | 1 | MECHANICAL INTERLOCK WITH DOOR | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF339700R0291 | 1 | POSITION CONTACTS FOR VD4 | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF339700R1909 | 1 | LOCKING MAGNET ON THE TRUCK 110Vdc (RLE2) | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF309503R0251 | 1 | KIT FOR FUSES DIAMETER 87mm | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF309500R0192 | 1 | LIFTING TOOL FOR SHIPPINGS REGISTERS VERSION | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF597111R0140 | 1 | POWER CUBE PB1/E L600 12kV 400A 31.5KA 3S | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF599700R0882 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR POWERCUBE | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF599700R5886 | 1 | PB FOR VSC | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF599700R4882 | 1 | PAINTED DOOR | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF599504R0042 | 1 | LOCK TO PREVENT RACKING-IN WITH EARTHING SWITCH | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF599700R0162 | 1 | 58 POLES CONNECTOR + ATOXIC WIRING L=0.8mt | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF599505R0111 | 1 | FAIL-SAFE SHUTTER ELEMENTS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF579700R0909 | 1 | ELECTROMECHANICAL ISOLATING INTERLOCK CIRCUIT-BREAKER/DOOR 110Vdc (RLE4) | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF599700R0280 | 1 | INTERLOCK FOR DOOR EARTHING SWITCH | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1YMB711238M4812 | 1 | BACK UP CURRENT LIMITING FUSE LINK 6/12kV 160A 442x65mm - CEF | ABB | A7 | FUEL CELL FEEDER A-80000 |
| K86 | 22 | RMBE13-C110T | 1 | BISTABLE RELAY 110VDC 7SC-5A TROP. | Amra | A7 | FUEL CELL FEEDER A-80000 |
| | | PAVM321 | 1 | SOCKET WITH SCREW TO RELAY TYPE PAVM321 | Amra | A7 | FUEL CELL FEEDER A-80000 |
| K94WT | 22 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A7 | FUEL CELL FEEDER A-80000 |

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DWG n° : 231151/SD/19
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00019 | SHEET 34 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| KGR | 13 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | ER 552 0 | 1 | CR-M230AC2L SUPPLY 230VAC 2C/O 250V/6A LED | ABB | A7 | FUEL CELL FEEDER A-80000 |
| KIRF | 22 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A7 | FUEL CELL FEEDER A-80000 |
| KSIL | 26 | 2TLA010040R0000 | 1 | BSR10 Vaux=24VDC SAFETY RELAY | ABB | A7 | FUEL CELL FEEDER A-80000 |
| KT1 | 20 | H3DKM2ACDC24240 | 1 | MULTIFUNCTION TIMER RELAY Vaux=24÷240Vac/dc - 2SC | Omron | A7 | FUEL CELL FEEDER A-80000 |
| L1C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A7 | FUEL CELL FEEDER A-80000 |
| L1I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A7 | FUEL CELL FEEDER A-80000 |
| L1MS | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A7 | FUEL CELL FEEDER A-80000 |
| L2C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A7 | FUEL CELL FEEDER A-80000 |
| L2I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A7 | FUEL CELL FEEDER A-80000 |
| L3C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A7 | FUEL CELL FEEDER A-80000 |
| L3I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A7 | FUEL CELL FEEDER A-80000 |
| L3MS | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A7 | FUEL CELL FEEDER A-80000 |
| LS | 13 | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | A7 | FUEL CELL FEEDER A-80000 |
| | | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | A7 | FUEL CELL FEEDER A-80000 |
| OD1 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A7 | FUEL CELL FEEDER A-80000 |
| OD2 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A7 | FUEL CELL FEEDER A-80000 |
| OD3 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A7 | FUEL CELL FEEDER A-80000 |
| P1 | 20 | KW 080 2 | 1 | MP1-10B BLACK PUSH BUTTON UNSTABLE | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| PR | 22 | KW 101 6 | 1 | YELLOW LIGHT PUSH BUTTON | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | KV 022 5 | 1 | MLBL-05W YELLOW LED BLOCK INTEGRATED 110÷130VAC | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| PTT | 10 | 1VCF498412R0100 | 1 | TV/F COMPARTMENT 12/17kV IP4X L=590mm OUTLET ON THE BACK WITH N°3 VT + N°14 MAIN CONTACTS + N°2+2 SERVICE/ISOLATED POSITION CONTACTS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | 1VCF499800R0302 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR TV/F | ABB | A7 | FUEL CELL FEEDER A-80000 |
| QA2 | 13 | B427917 | 1 | DDA202 AC 25A 300MA BLOCCO DIFFERENZIALE 2P | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | A563819 | 1 | S2-CS/H6R CONTATTO DI SEGNALAZIONE/AUX 1SC | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | S550284 | 1 | S202M C10 INTERRUTTORE AUTOMATICO 10KA 2P | ABB | A7 | FUEL CELL FEEDER A-80000 |
| QD1 | 11 | A563819 | 1 | S2-CS/H6R CONTATTO DI SEGNALAZIONE/AUX 1SC | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | S550253 | 1 | S202M C 4 INTERRUTTORE AUTOMATICO 10KA 2P | ABB | A7 | FUEL CELL FEEDER A-80000 |
| QD2 | 11 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | a563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT | ABB | A7 | FUEL CELL FEEDER A-80000 |
| QD4 | 11 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A7 | FUEL CELL FEEDER A-80000 |
| QV1 | 10 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A7 | FUEL CELL FEEDER A-80000 |
| QV2 | 10 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A7 | FUEL CELL FEEDER A-80000 |

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DWG n° : 231151/SD/19

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000

Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00019 | SHEET 35 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| QV3 | 10 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A7 | FUEL CELL FEEDER A-80000 |
| QV4 | 14 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A7 | FUEL CELL FEEDER A-80000 |
| QV5 | 15 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A7 | FUEL CELL FEEDER A-80000 |
| S1C | 25 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | KW 076 0 | 1 | MP1-10G PUSH BUTTON GREEN WITH BLACK RING | ABB | A7 | FUEL CELL FEEDER A-80000 |
| S2O | 25 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | EO 570 5 | 2 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | KW 075 2 | 1 | MP1-10R PUSH BUTTON RED WITH BLACK RING | ABB | A7 | FUEL CELL FEEDER A-80000 |
| SA1 | 23 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | EO 571 3 | 1 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A7 | FUEL CELL FEEDER A-80000 |
| | | KW 329 3 | 1 | M2SS2-10B HANDLE SELECTOR 2P 90° BLACK RING BLACK | ABB | A7 | FUEL CELL FEEDER A-80000 |
| TI-L1 | 8 | ATB-10-BS__014 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 150/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A7 | FUEL CELL FEEDER A-80000 |
| TI-L2 | 8 | ATB-10-BS__014 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 150/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A7 | FUEL CELL FEEDER A-80000 |
| TI-L3 | 8 | ATB-10-BS__014 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 150/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A7 | FUEL CELL FEEDER A-80000 |
| TO | 9 | KAP-150/250-55 | 1 | CURRENT TRANSFORMER 0,72/3/-kV 100/1 50Hz | ESITAS | A7 | FUEL CELL FEEDER A-80000 |
| TR1 | 19 | 800208 | 1 | MODBUS DATACARD 8 CHANNELS | Exertherm | A7 | FUEL CELL FEEDER A-80000 |
| TU-L1 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A7 | FUEL CELL FEEDER A-80000 |
| TU-L2 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A7 | FUEL CELL FEEDER A-80000 |
| TU-L3 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A7 | FUEL CELL FEEDER A-80000 |
| XC | | HM320GR | 12 | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) | Cabur | A7 | FUEL CELL FEEDER A-80000 |
| | | HM250GR | 36 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A7 | FUEL CELL FEEDER A-80000 |
| | | HM251GR | 3 | HMT.4/PT/GR End section - Grey | Cabur | A7 | FUEL CELL FEEDER A-80000 |
| | | HM321GR | 3 | HMT.6/PT/GR End section - Grey | Cabur | A7 | FUEL CELL FEEDER A-80000 |
| XI | | HB220GR | 8 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur | A7 | FUEL CELL FEEDER A-80000 |
| | | HL201GR | 2 | HLD.2/PT/GR End section - Grey | Cabur | A7 | FUEL CELL FEEDER A-80000 |
| XM | | HM250GR | 68 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A7 | FUEL CELL FEEDER A-80000 |
| | | HM251GR | 2 | HMT.4/PT/GR End section - Grey | Cabur | A7 | FUEL CELL FEEDER A-80000 |
| XS1 | 13 | E 9447 7 | 1 | SOCKET | ABB | A7 | FUEL CELL FEEDER A-80000 |
| XV | | HB210GR | 16 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type | Cabur | A7 | FUEL CELL FEEDER A-80000 |
| | | HB201GR | 5 | HSCB.6/PT/GR End section - Grey | Cabur | A7 | FUEL CELL FEEDER A-80000 |

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DWG n° : 231151/SD/19
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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TITLE :
SG-100D1 - FUNCTIONAL FUEL CELL FEEDER A-80000
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00019 | SHEET 3.6 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00019 Rev.03

1.4.6.SG-100D1 HV SWG FUNCTIONAL DIAGRAM - TRANSFORMER FEEDER TR200ED1 (including Terminals and BOM) ,

Doc. No. 1723002197-EL-DG-00020

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# "SG-100D1" HV SWBD 6,6kV (UNIT A2)

# FUNCTIONAL DIAGRAM

# TRANSFORMER FEEDER TR-200ED1

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macula | 12/09/2024 |

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| DWG n° : 231151/SD/20 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| Item n° : PF1113279 | 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 – FUNCTIONAL TRANSF FEEDER TR-200ED1

Cover

| CONTRACT NO./TITLE | SCALE : |
|---|---|
| CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | NTS |

| | DRAWING NO. | SHEET | REV. |
|---|---|---|---|
| A3 | 1723002197-EL-DG-00020 | 1 | 03 |

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

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| 17 | "REX640"' Protection Wiring | | | | | | | | | |
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| 19 | Extherm Device | | | | | | | | | |
| 20 | Command Circuit | | | | | | | | | |
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| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
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| 27 | Emergency Opening by "SIS" | | | | | | | | | |
| 28 | Availables Signals | | | | | | | | | |
| 29 | Terminal stripes | | | | | | | | | |
| 30 | Terminal stripes | | | | | | | | | |
| 31 | Terminal stripes | | | | | | | | | |
| 32 | Terminal stripes | | | | | | | | | |
| 33 | Terminal stripes | | | | | | | | | |
| 34 | Bill of Materials | | | | | | | | | |
| 35 | Bill of Materials | | | | | | | | | |
| 36 | Bill of Materials | | | | | | | | | |
| 37 | Bill of Materials | | | | | | | | | |

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DWG n° : 231151/SD/20

Item n° : PF1113279

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TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1

Sheets Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

SHEET 2

REV. 03

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# ACRONIMUS LEGEND

| ITEM | DESCRIPTION |
|---|---|
| BB | ARC SENSOR PROTECTION ON MAIN BUS BARS |
| BGE | EARTHING SWITCH |
| C1 | VOLTAGE PRESENCE |
| CB | ARC SENSOR PROTECTION ON C.B. / CONTACTOR COMPARTMENT |
| CC | ARC SENSOR PROTECTION ON CABLE COMPARTMENT |
| DCO | DOUBLE COMMAND OPERATED CONTACTOR |
| DI3 | UNDERVOLTAGE CONTACTOR |
| DP1 | ALARM RELAY MODULE TEMPERATURE |
| E1 | INTERNAL LIGHT |
| E8 | RESISTOR FERRO-RESONANCE |
| EH1 | INTERNAL SPACE HEATER |
| Fn | MV FUSE |
| FP1 | PROTECTION RELAY |
| GS1 | DC/DC CONVERTER |
| HGR | THERMOSTAT |
| Kn | AUXILIARY RELAY |
| K1 | MV CONTACTOR |
| K86 | BLOCK RELAY |
| KT1 | DE-ENERGIZATION TIMER |
| LS | MICRO SWITCH ON AUXILIARY DOOR |
| MAS | MOTOR SPRING CHARGER |
| MBC | CLOSING COIL |
| MBO1 | OPENING COIL |
| MBU | UNDERVOLTAGE |
| ODn | VOLTAGE DISCHARGER |
| PU1 | MEASURING VOLTAGE INSTRUMENT |

| ITEM | DESCRIPTION |
|---|---|
| PTT | V.T. TRUCK |
| QM | MV CIRCUIT-BREAKER |
| QDn | M.C.B. CIRCUITS PROTECTION |
| QVn | M.C.B FOR V.T. PROTECTION |
| RLE1 | COIL FOR CONSET CLOSING CIRCUIT-BREAKER |
| RLE2 | COIL FOR UNLOCKING RACK-IN/OUT OPERATION |
| RLE3 | COIL FOR UNLOCKING OPERATION EARTHING |
| RLE4 | COIL FOR UNLOCKING ENCLOSURE DOOR OPERATION |
| SU1 | VOLTAGE SELECTOR |
| SWH... | ETHERNET SWITCH |
| TI-Ln | CURRENT TRANSFORMER |
| TO | OMOPOLAR RING CURRENT TRANSFORMER |
| TR1 | TEMPERATURE CONTROL DEVICE |

FUNCTIONAL OF THE PROTECTION RELAY OUTPUT CONTACTS:

SLOT "G":
RF = WATCHDOG RELAY
S01 = EARTHING SWITCH UNLOCKING
S02 = C.B. or CONTACTOR READY TO CLOSE
POSP1 = CLOSING COMMAND
S03 = C.B. or CONTACTOR TRUCK UNLOCKED
PODP1 = OPENING COMMAND
SLOT "B":
S01 = TRIP PROTECTION TO LOCKOUT RELAY
S02 = EARTHING SWITCH CLOSED
S03 = AVAILABLE OUTPUT (ON TERMINAL STRIP)
S04 = RESET LOCKOUT RELAY

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Item n° : PF1113279

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ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Legend

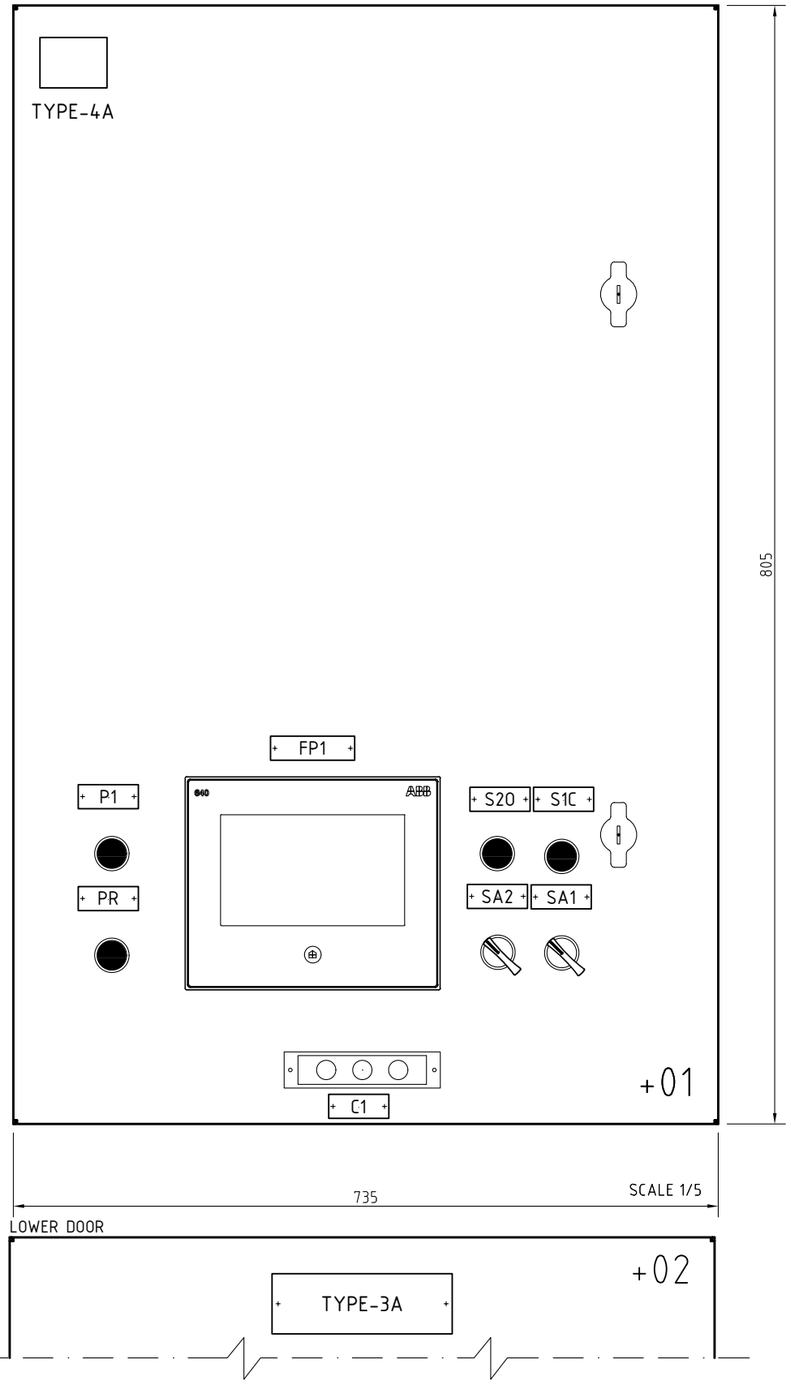
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A3 | DRAWING NO. 1723002197-EL-DG-00020 | SHEET 3 | REV. 03

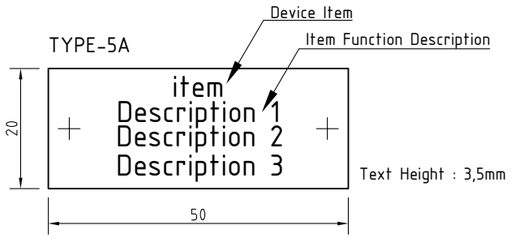
F.to UNI A3: 420mmx297mm

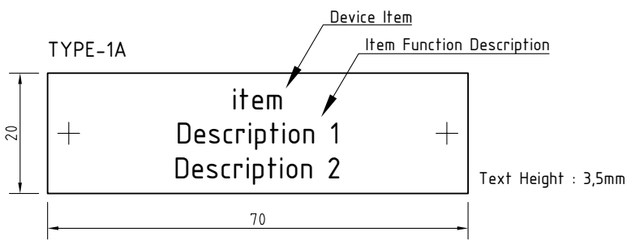
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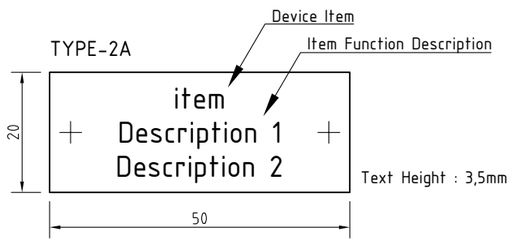
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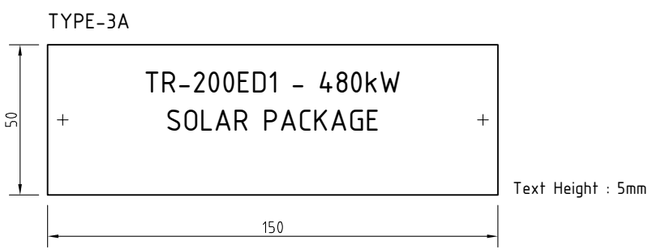


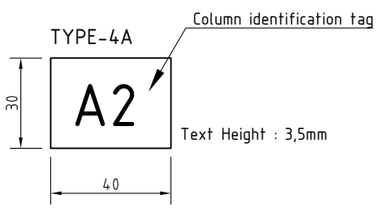

| DEVICES name plate | | | | | |
|---|---|---|---|---|---|
| ITEM | COMPONENT | DESCRIPTION 1 | DESCRIPTION 2 | DESCRIPTION 3 | NOTE |
| FP1 | PROTECTION RELAY | PROTECTION RELAY | | | TYPE-1A |
| S2.0 | PUSH BUTTON | OPEN | COMMAND | CONTACTOR | TYPE-5A |
| S1.C | PUSH BUTTON | CLOSE | COMMAND | CONTACTOR | TYPE-5A |
| SA1 | SELECTOR SWITCH | LOCAL / REMOTE | | | TYPE-2A |
| SA2 | SELECTOR SWITCH | OVERRIDE ESD | OFF - ON | | TYPE-2A |
| PR | LIGHT PUSH BUTTON | RESET | LOCK-OUT | TRIP LOCK-OUT | TYPE-5A |
| C1 | PILOT LIGHT | VOLTAGE | PRESENCE | | TYPE-2A |
| P1 | PUSH BUTTON | TRUCK-DOOR | ENABLING | ENABLING | TYPE-5A |




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DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

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ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Door Layout

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

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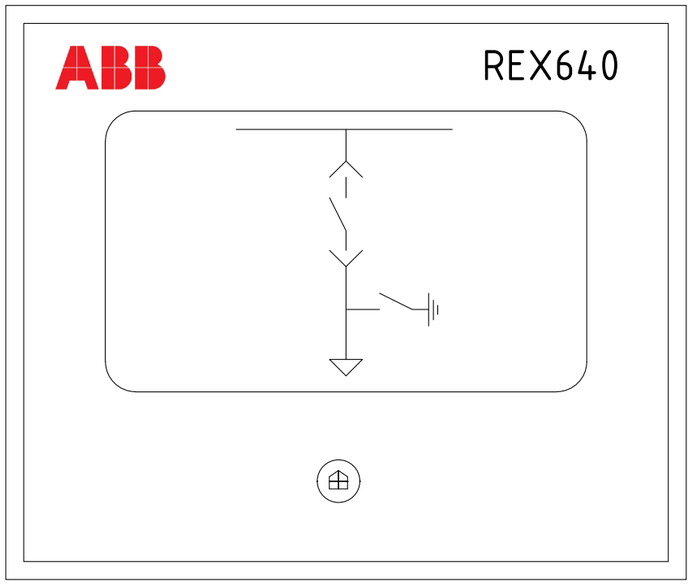
SHEET 4

REV. 03

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File Name : 1723002197-EL-DG-00020 Rev.03

# PROTECTION DISPLAY




## LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE CONTACTOR " AND "OPEN CONTACTOR" NOT ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED

| LEDs PAGE 1 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/27-2/59-1/59-2 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | CONTACTOR READY (TCS) | - | GREEN | OK = TCS OK (CONTACTOR READY) |
| LED-3 | SYNCHRO CHECK | | GREEN | OK = SYNCHRONISM |
| LED-4 | CONTACTOR READY TO CLOSE | - | GREEN | OK = CONTACTOR READY TO CLOSE |
| LED-5 | 50-1/51-1/67-1/67-2 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/59N-1/59N-2 - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = CONTACTOR TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | EMERGENCY OPENING BY SIS (ESD) | RED | - | ALARM = ESD TRIPPED |

| LEDs PAGE 2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | - | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | FUSES TRIP | RED | | ALARM = FUSES TRIP |
| LED-15 | TRIP FROM L.V. | RED | | ALARM = L.V. TRIP |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
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ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Protection Display REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

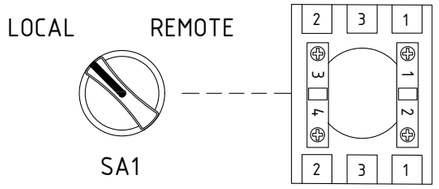
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F.to UNI A3: 420mmx297mm

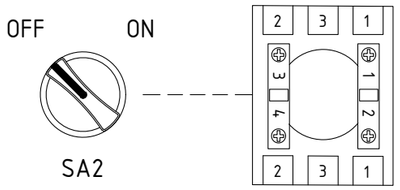
File Name : 1723002197-EL-DG-00020 Rev.03

# SELECTORS SWITCH DIAGRAM

REAR VIEW




REAR VIEW




## NOTES

THE DIAGRAM INDICATES THE FOLLOWING CONDITIONS:
-INSERTED CONTACTOR IN OPEN POSITION
-DE-ENERGIZED CIRCUITS
-EARTHING SWITCH OPEN

THE AUXILIARY CIRCUITS WILL HAVE THE FOLLOWING CHARACTERISTICS:
-110+ / 24+ 1,5mmq RED TYPE CABLE SH-W
-110- / 24- 1,5mmq WHITE TYPE CABLE SH-W
-AUXILIARY CONTACTS TO TERMINAL STRIP 1,5mmq BLACK TYPE CABLE SH-W
-230Vac 1,5mmq BLACK TYPE SH-W
-VOLTMETRICAL CIRCUITS 1,5mmq BLACK TYPE CABLE SH-W
-AMMETRICAL CIRCUIT 2,5mmq BLACK TYPE CABLE SH-W

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Selector Switch Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

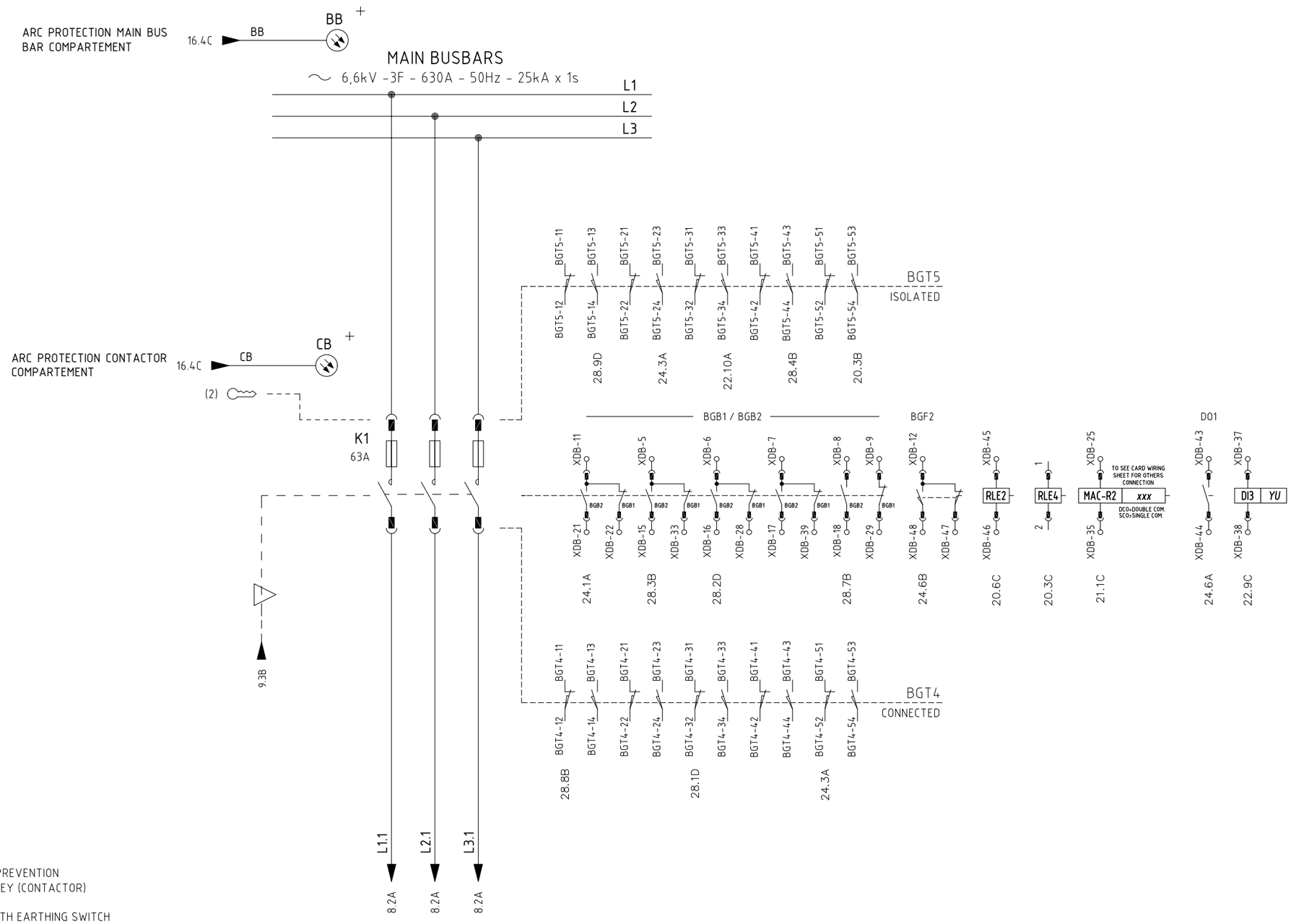
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SHEET 6

REV. 03

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Item n° : PF1113279

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CROSSWIND
ROSETTI MARINO

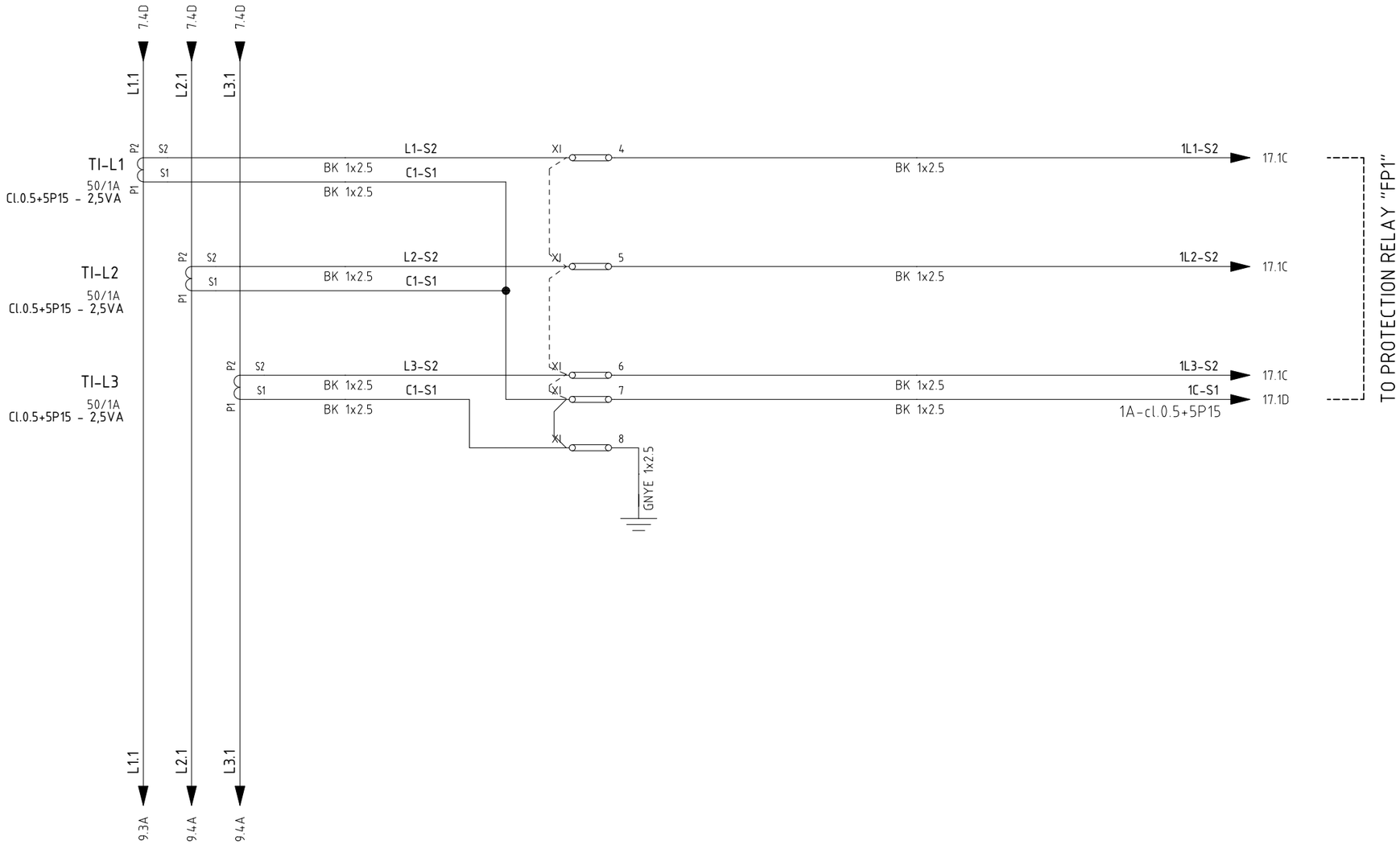
TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00020
SHEET 7
REV. 03

F.to UNI A3: 420mmx297mm

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CROSSWIND
ROSETTI MARINO

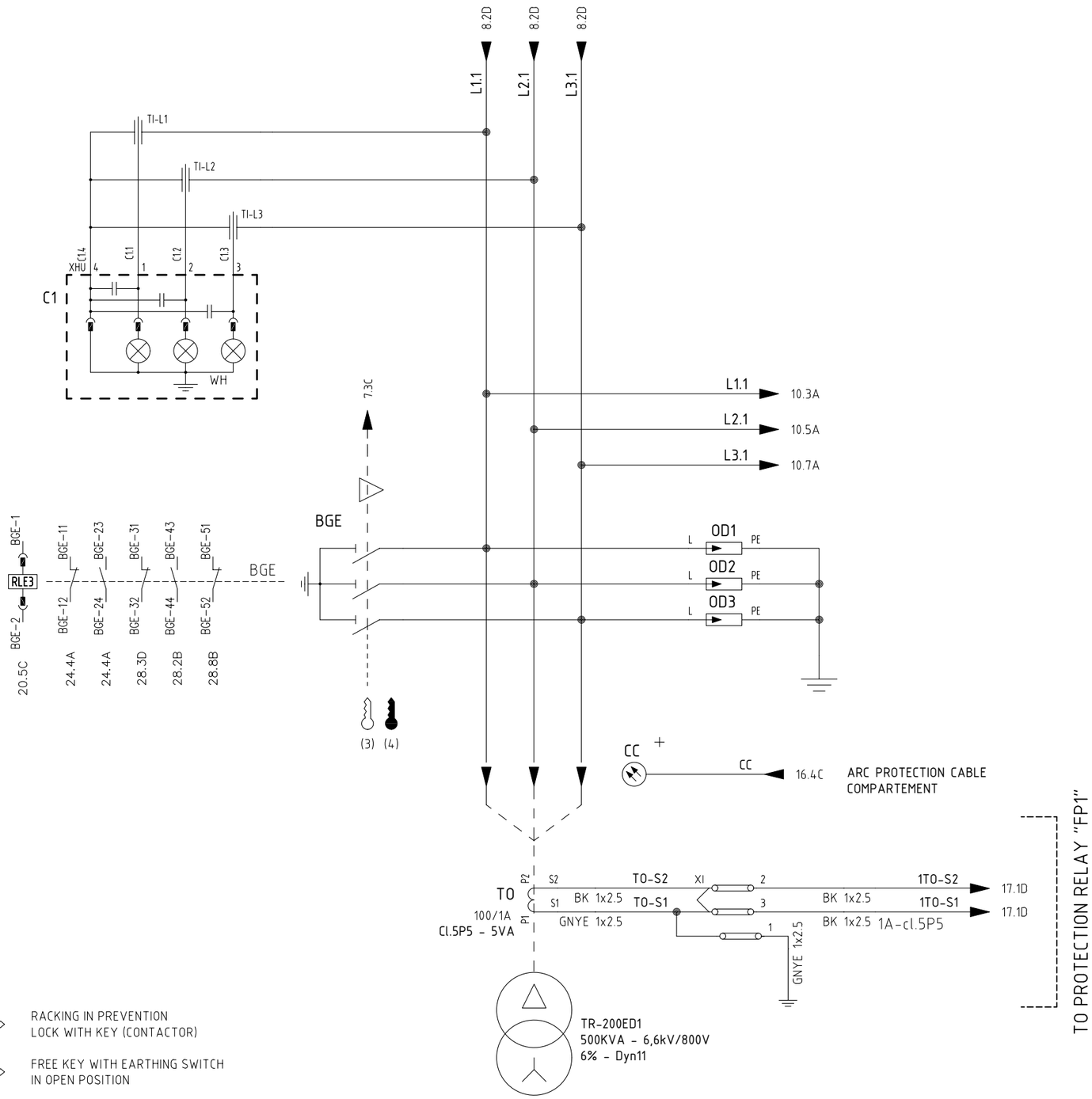
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SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Power Diagram

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SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00020
SHEET 8
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03




(2) RACKING IN PREVENTION LOCK WITH KEY (CONTACTOR)

(3) FREE KEY WITH EARTHING SWITCH IN OPEN POSITION

(4) FREE KEY WITH EARTHING SWITCH IN CLOSED POSITION

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

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TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

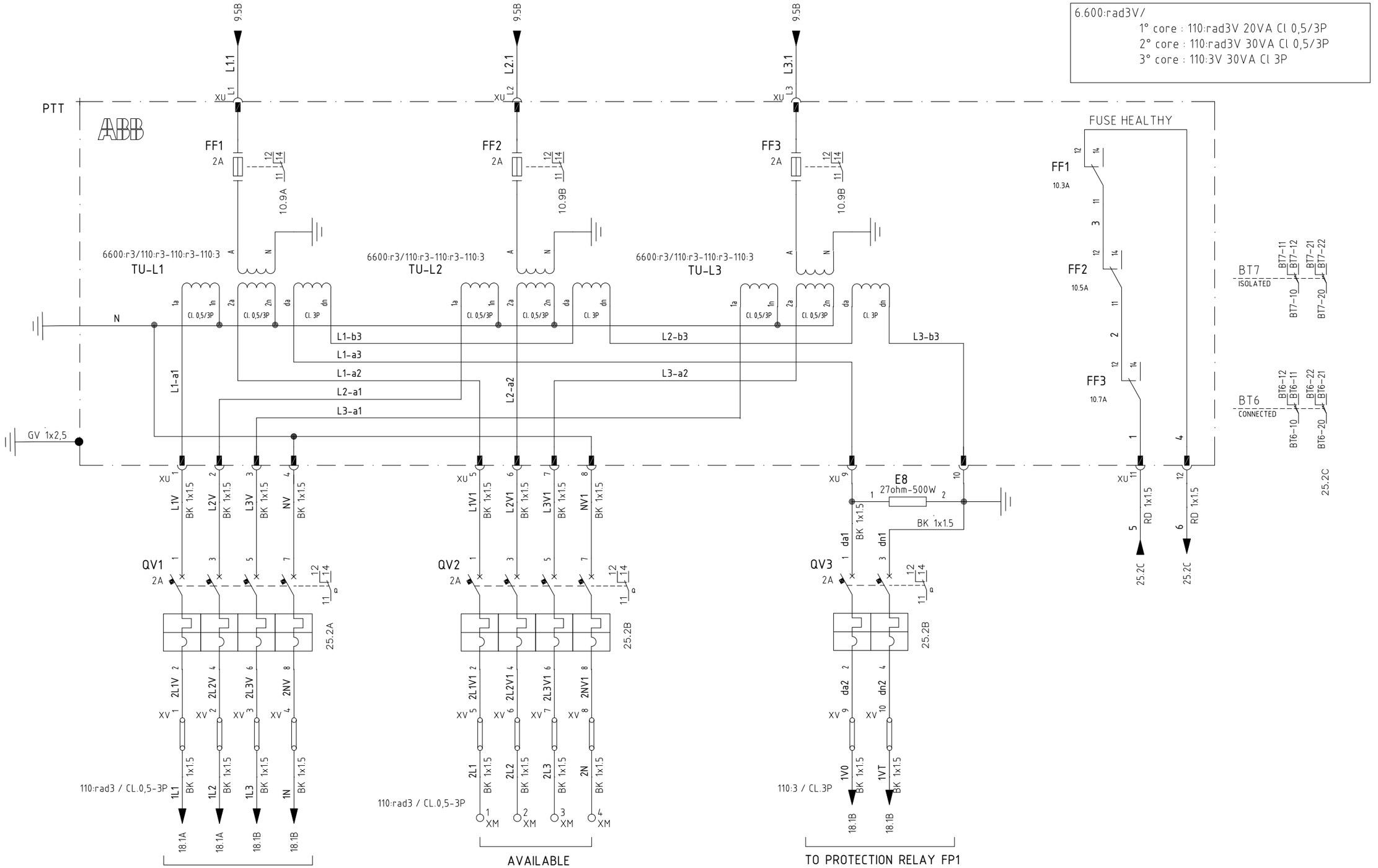
DRAWING NO. 1723002197-EL-DG-00020

SHEET 9

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A2

DWG n° : 231151/SD/20

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 – FUNCTIONAL TRANSF FEEDER TR-200ED1

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

SHEET 1.0

REV. 03

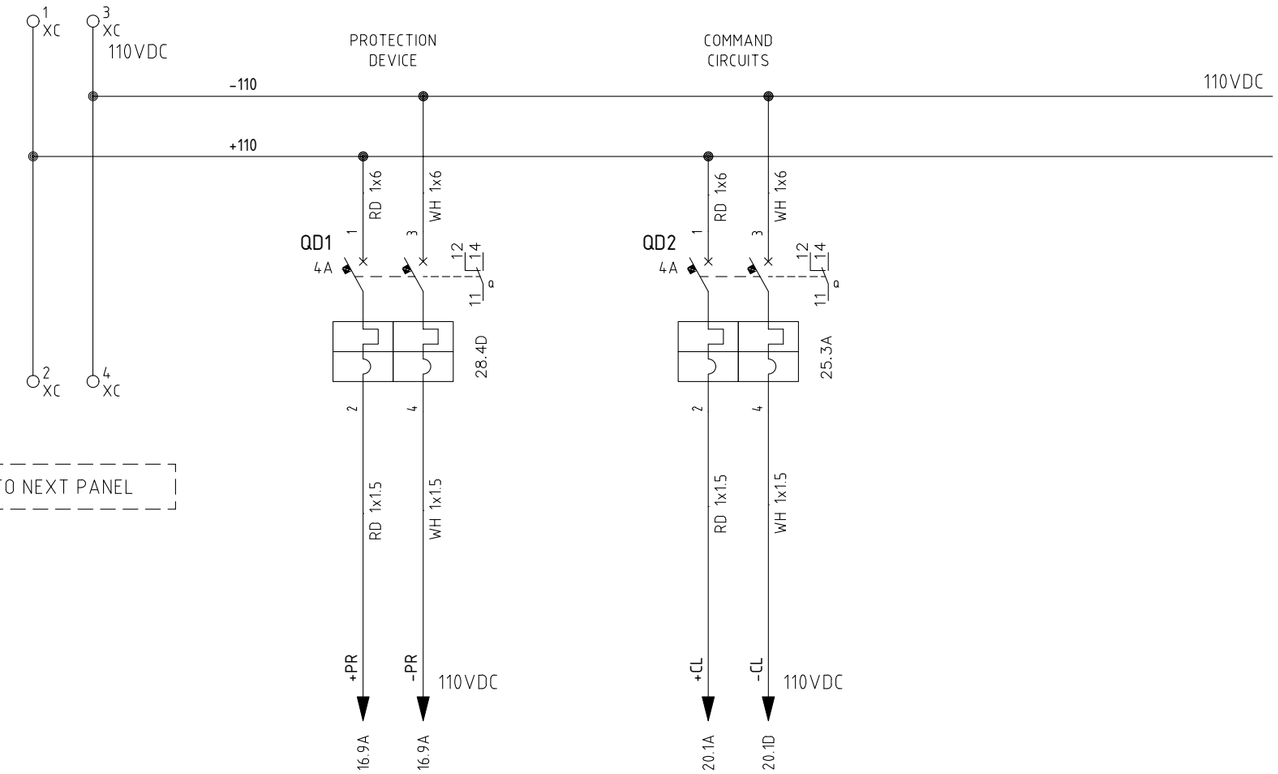
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

## 110VDC DISTRIBUTION VOLTAGE

110Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL

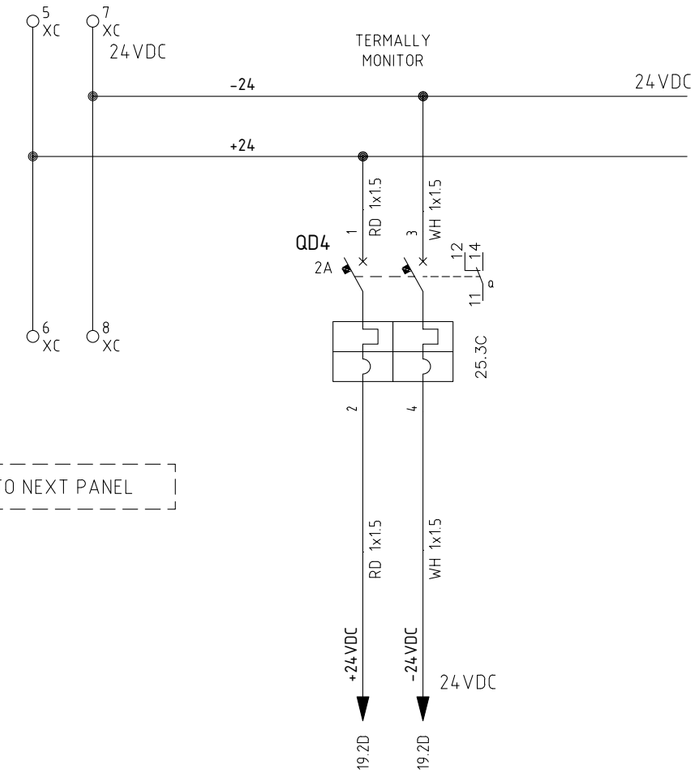



TO NEXT PANEL

## 24VDC DISTRIBUTION VOLTAGE

24Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

=
+A2
DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
110Vdc / 24Vdc Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

SHEET 1.1

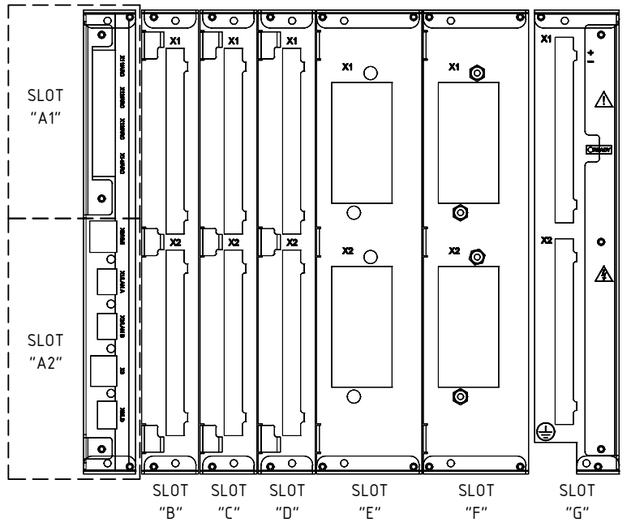
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# COMPOSITION RELAY REX640

## RACK VIEW




REX640B10NN+COM1+ARC1+BIO1+BIO1+BIO2+AIM1+AIM1+PSM3+MCT1+SCT1+CMP2+LNG1+PCL4

| LEGEND | | |
|---|---|---|
| SLOT | Module Type | Description Module |
| A1 | ARC1001 | n° 4 x ARC sensor inputs |
| A2 | COM1001 | n° 1 x RJ-45 (LHMI port) + n° 3 x RJ-45 + n° 1 x SFP100M LC |
| B | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| C | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| D | BIO1002 | n° 9 Binary Input + n° 6 x SPO + n° 2 x SPO(TCS) |
| E | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| F | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| G | PSM1003 | 77...150 VDC, n° 3 x PO (TCS) + n° 2 x PO + n° 3 x SO + n° 2 x SSO |
| | PO = Power Output<br>SO = Signal Output<br>SPO = Static Power Output<br>SSO = Static Signal Output | |

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+A2

DWG n° : 231151/SD/20
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Composition Relay REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00020 | SHEET 12 | REV. 03

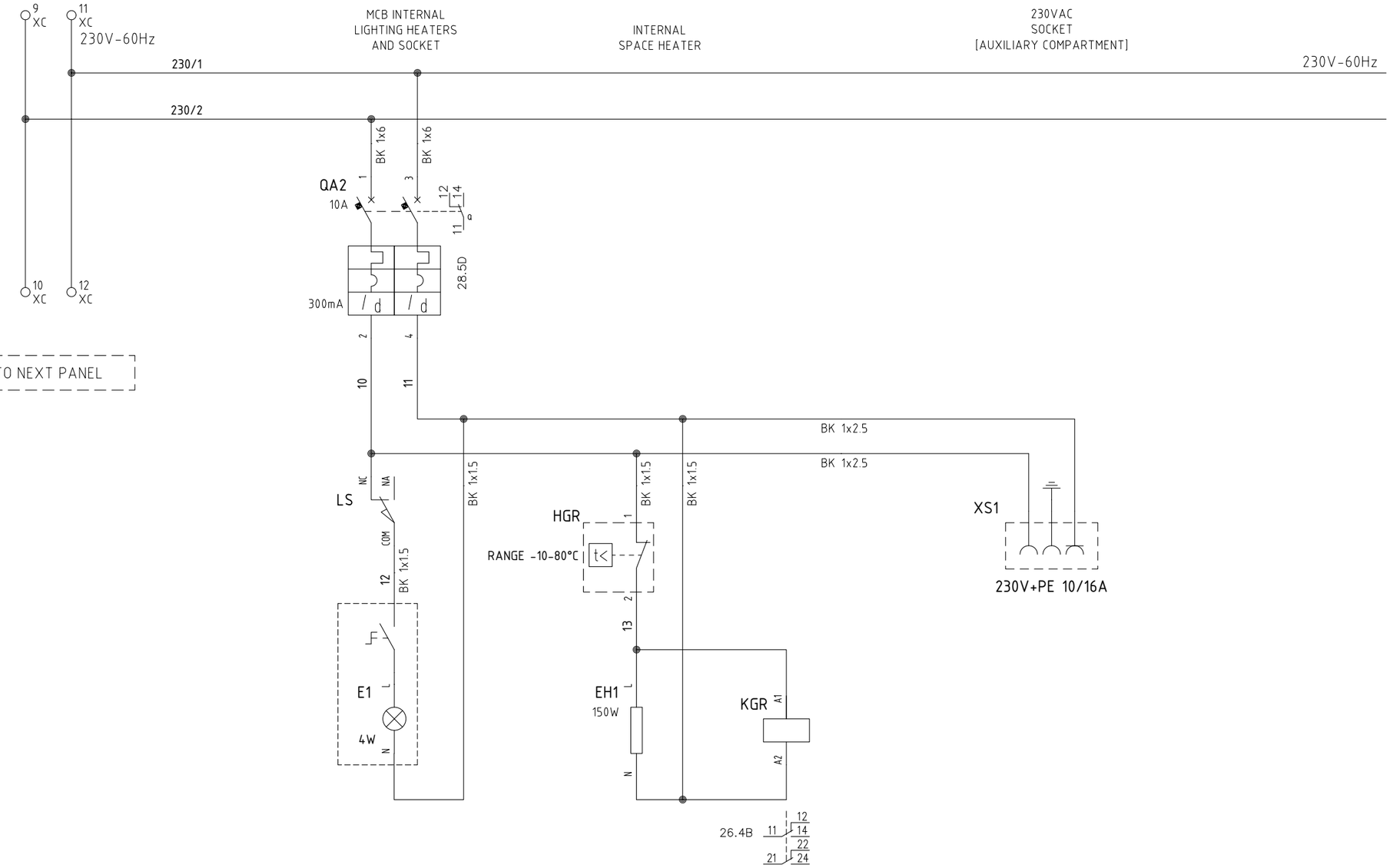
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# 230VAC DISTRIBUTION VOLTAGE

230Vac Auxiliary Voltage
from Measuring Bus Bar

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

=
+A2
DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
230Vac Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00020
SHEET 1.3
REV. 03

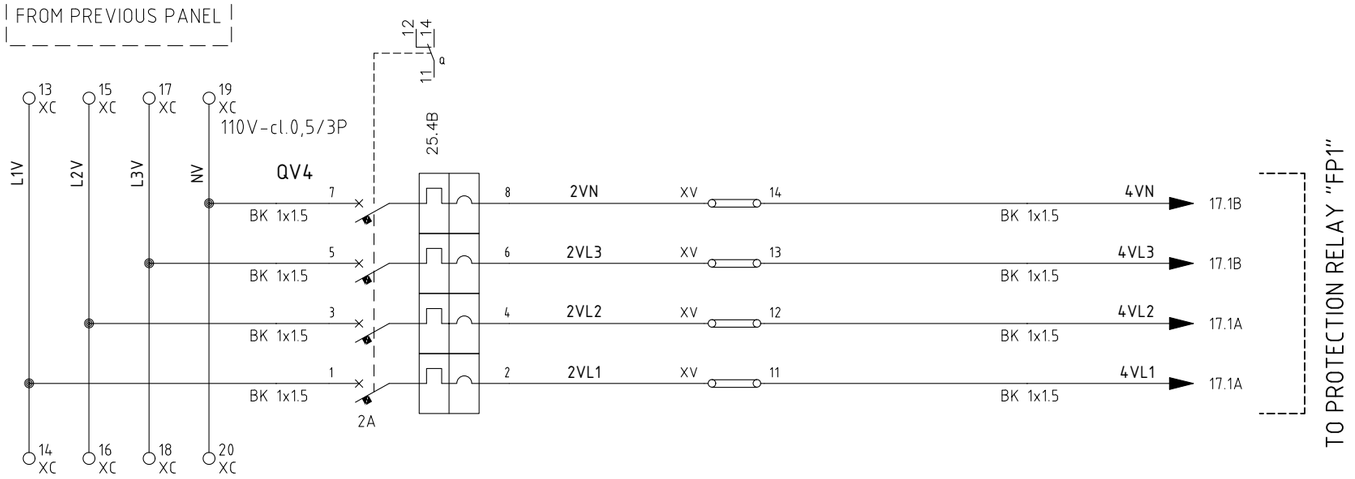
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# 110V: 1,73 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:√3V VOLTMETRIC LINE - STAR
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= +A2

DWG n° : 231151/SD/20

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

SHEET 14

REV. 03

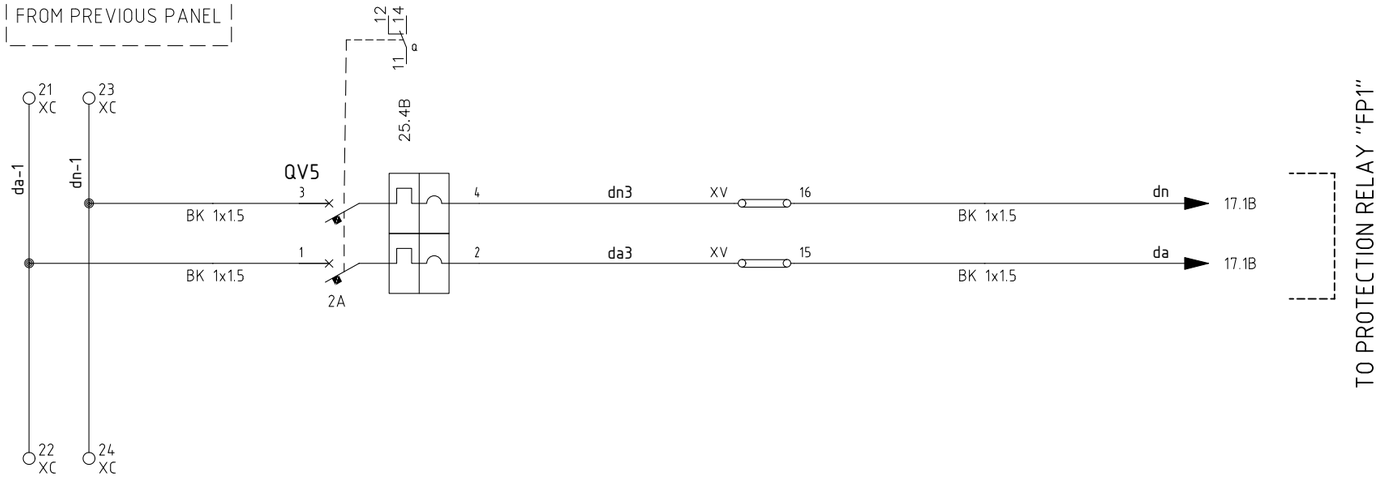
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# 110V:3 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:3V VOLTMETRIC LINE -
DELTA OPEN
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO PROTECTION RELAY "FP1"

TO NEXT PANEL

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| +A2 | | | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | | |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | | |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | | |
| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | | |

DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

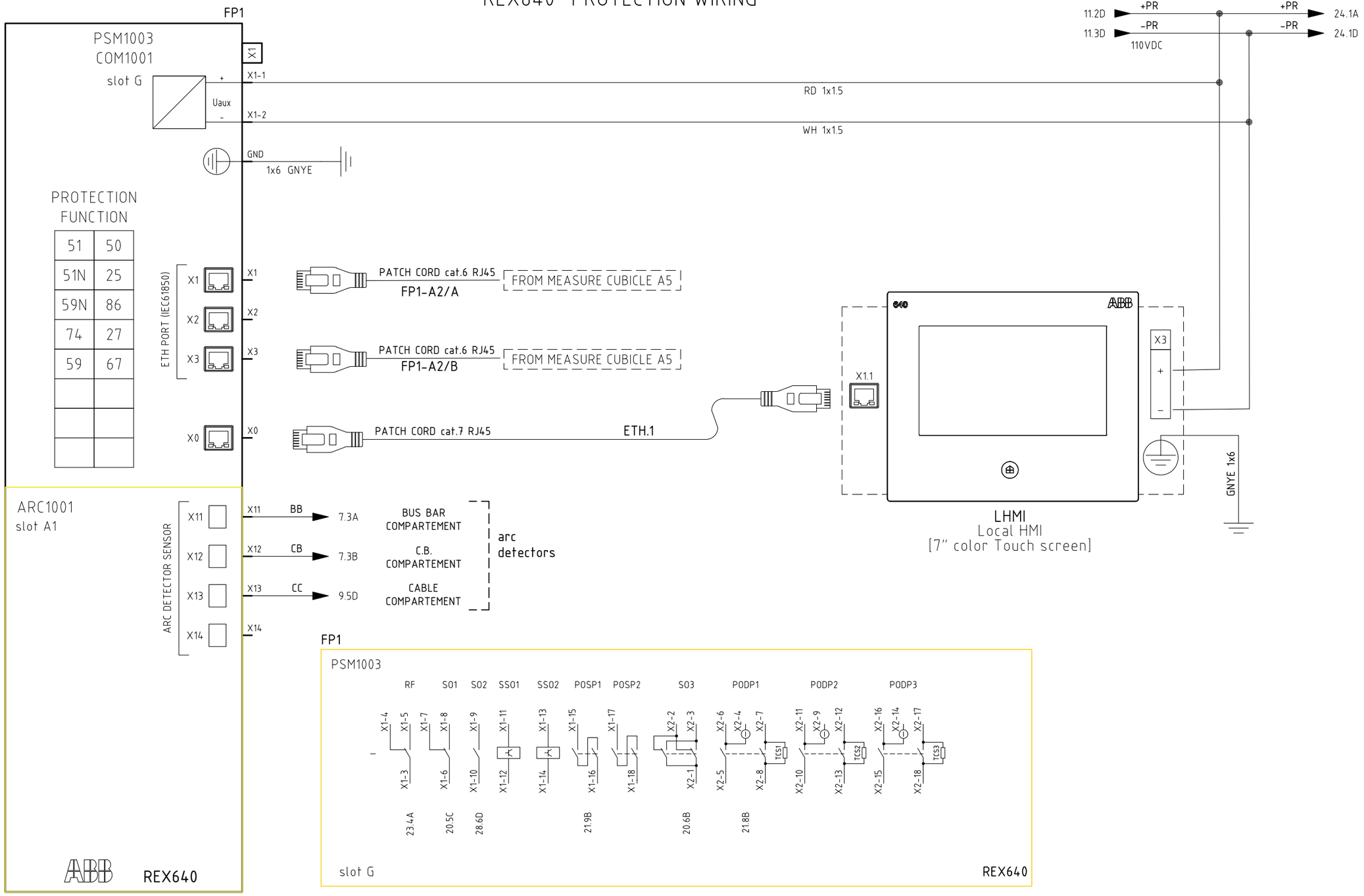
SHEET 15

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# "REX640" PROTECTION WIRING




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| +A2 | | | | | | | |
| | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| | 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

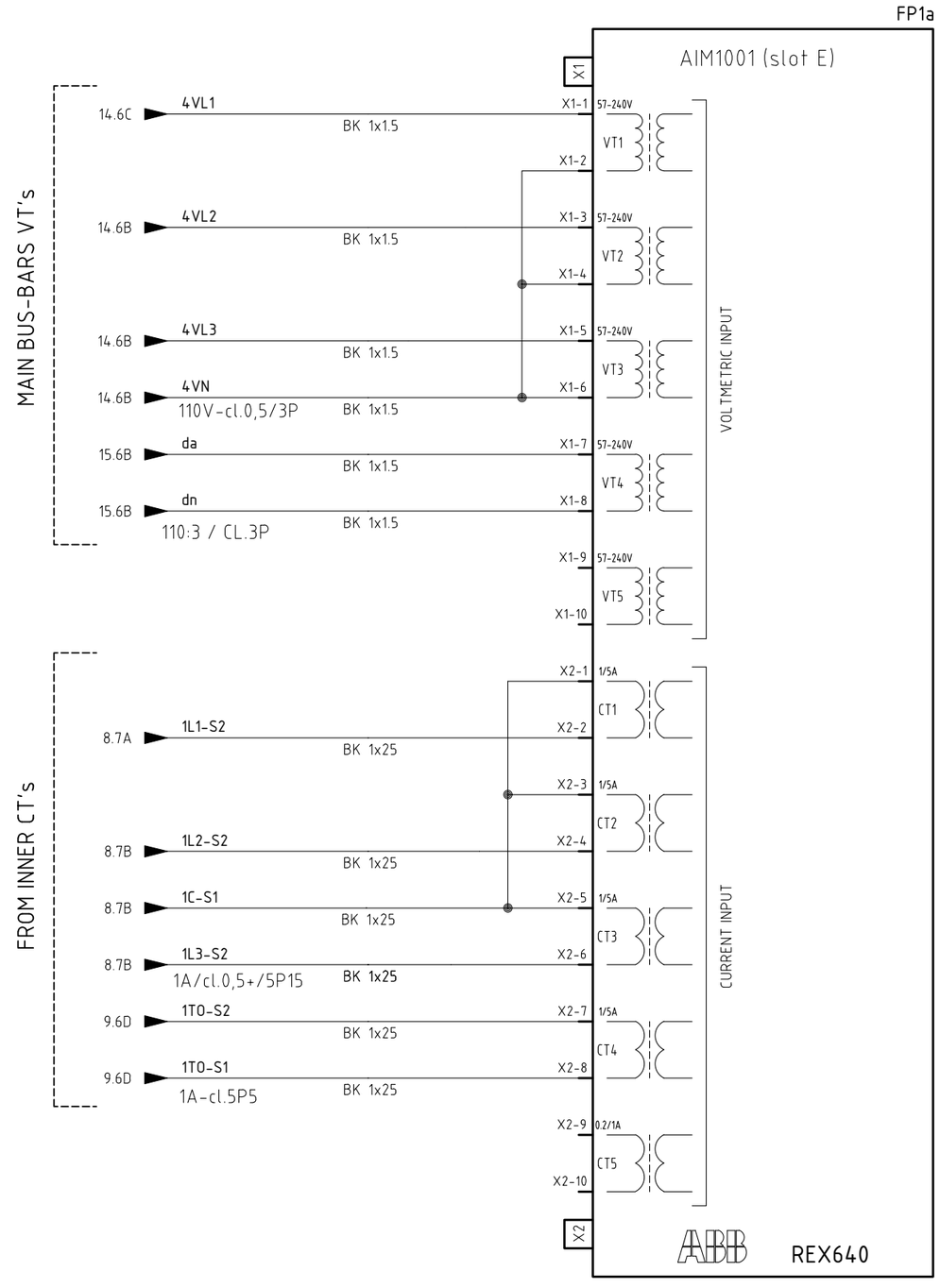
SHEET 16

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# "REX640" PROTECTION WIRING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A2
DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

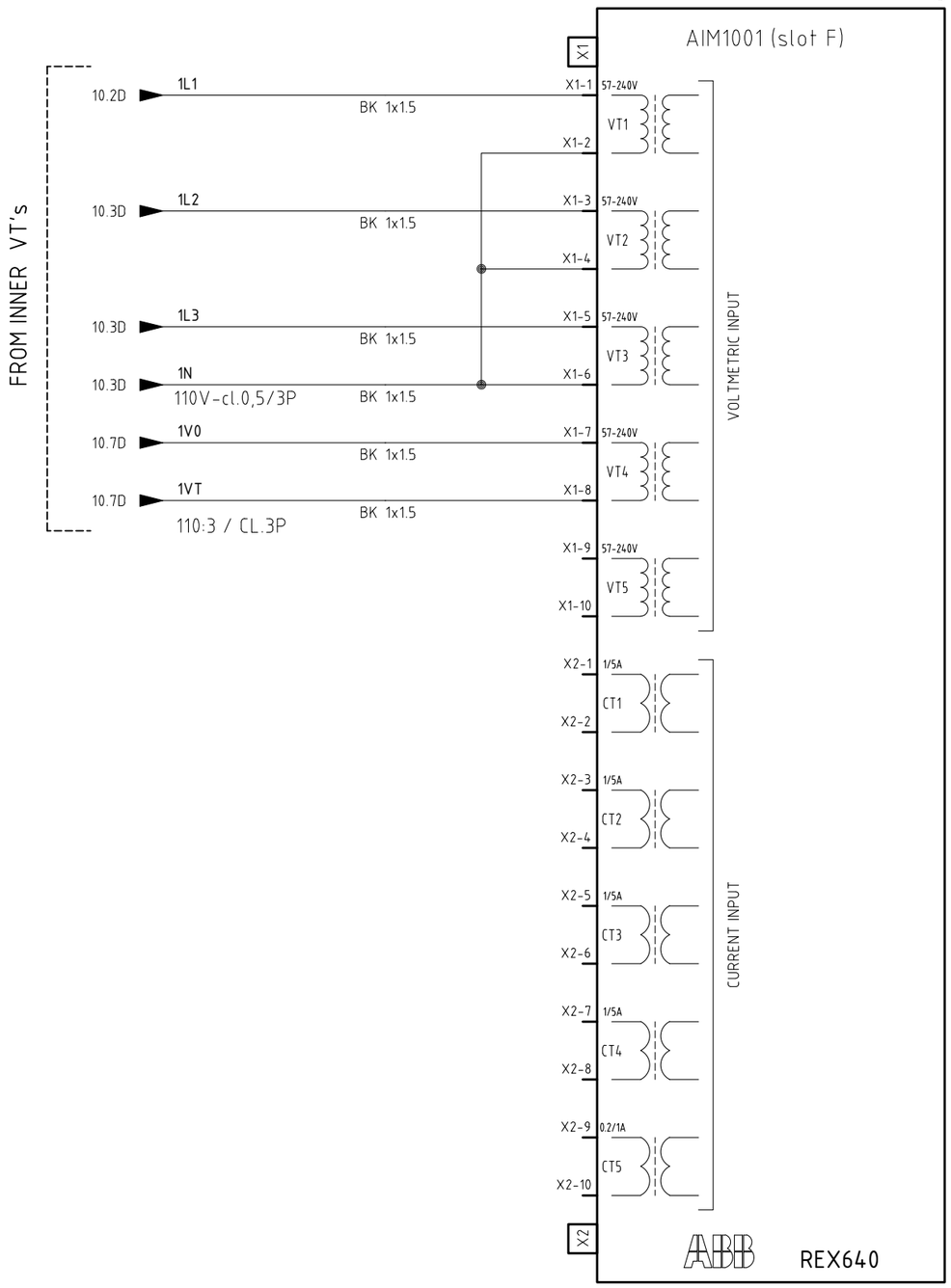
SHEET 1.7

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# "REX640" PROTECTION WIRING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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+A2
DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

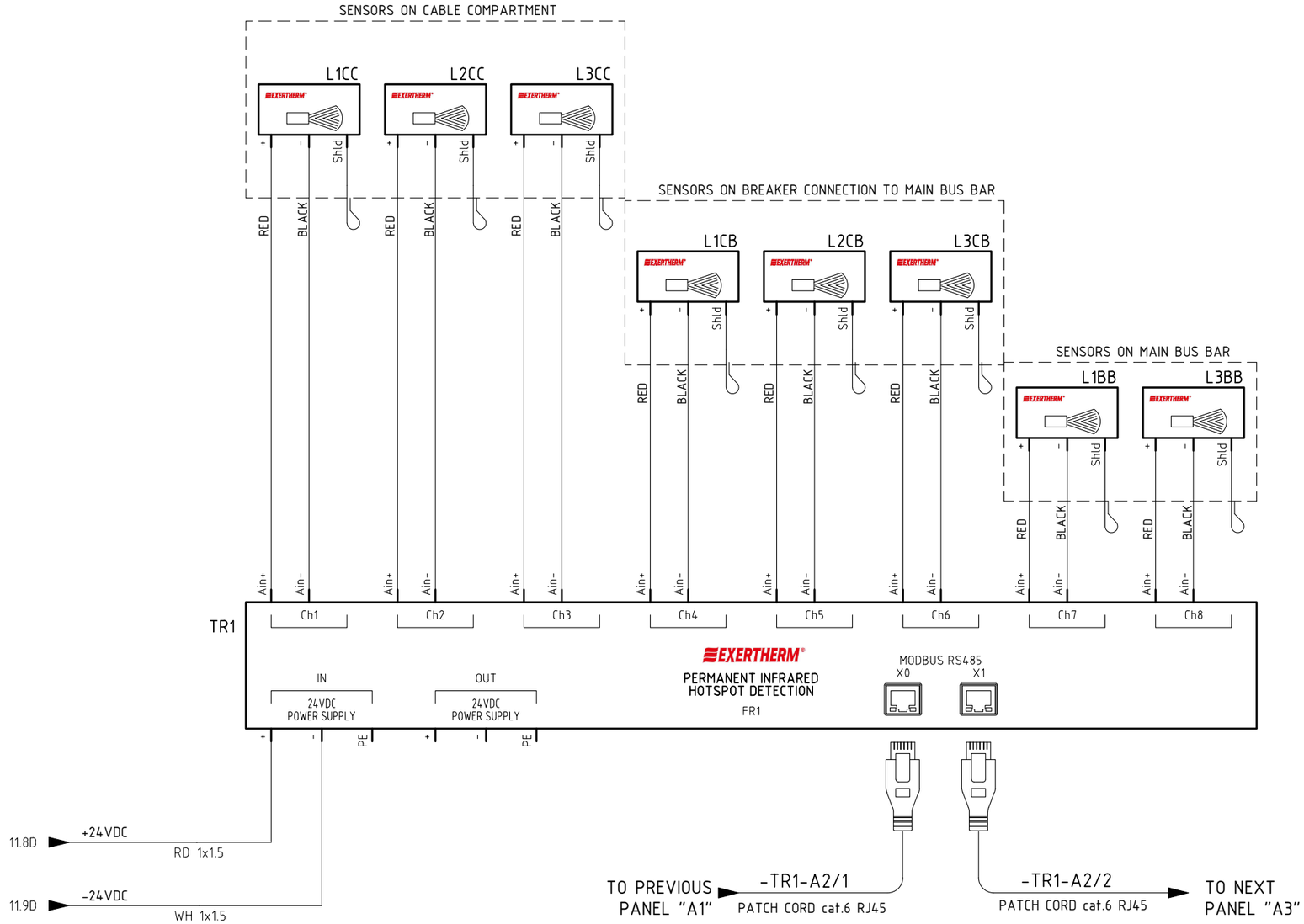
TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00020
SHEET 18
REV. 03

File Name : 1723002197-EL-DG-00020 Rev.03

F.to UNI A3: 420mmx297mm




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|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| +A2 | | | | | | | |
| DWG n° : 231151/SD/20 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| Item n° : PF1113279 | 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1

Extherm Device

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

SHEET 1.9

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# COMMAND CIRCUITS

ENABLING CONTACTOR TRUCK ENCLOSURE DOOR AND EARTHING SWITCH

UNLOCKING CONTACTOR ENCLOSURE DOOR

ENABLING EARTHING SWITCH COMMAND

ENABLING RACK-IN AND RACK-OUT CONTACTOR [LOCKING MAGNET]

11.4D +CL 110VDC (CL)

+CL 21.1A

RD 1x1.5

P1 BK E 13 14

KT1 20.2D 16 18 30'' 15

21 RD 1x1.5

K1 ISOLATED BGT5 7.4B BGT5-53 BGT5-54

5 XM 6 XM

FP1 16.3A S03 REX640 X2 Slot G X2-2 X2-3 X2-1

25 RD 1x1.5

7 XM 8 XM

FP1 16.3A S01 REX640 X1 Slot G X1-7 X1-8 23 X1-6

24 RD 1x1.5 BGE-1

22 RD 1x1.5

20 RD 1x1.5

26 RD 1x1.5 XDB-45

K1 1 2 RLE4 7.4B

BGE RLE3 9.3C BGE-2

K1 RLE2 7.4B XDB-46

KT1 A1 B1 30'' A2

11.4D -CL

-CL 21.1E

WH 1x1.5

20.3A 15 16 18

24.9A 25 26 28

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A2

DWG n° : 231151/SD/20

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1

Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

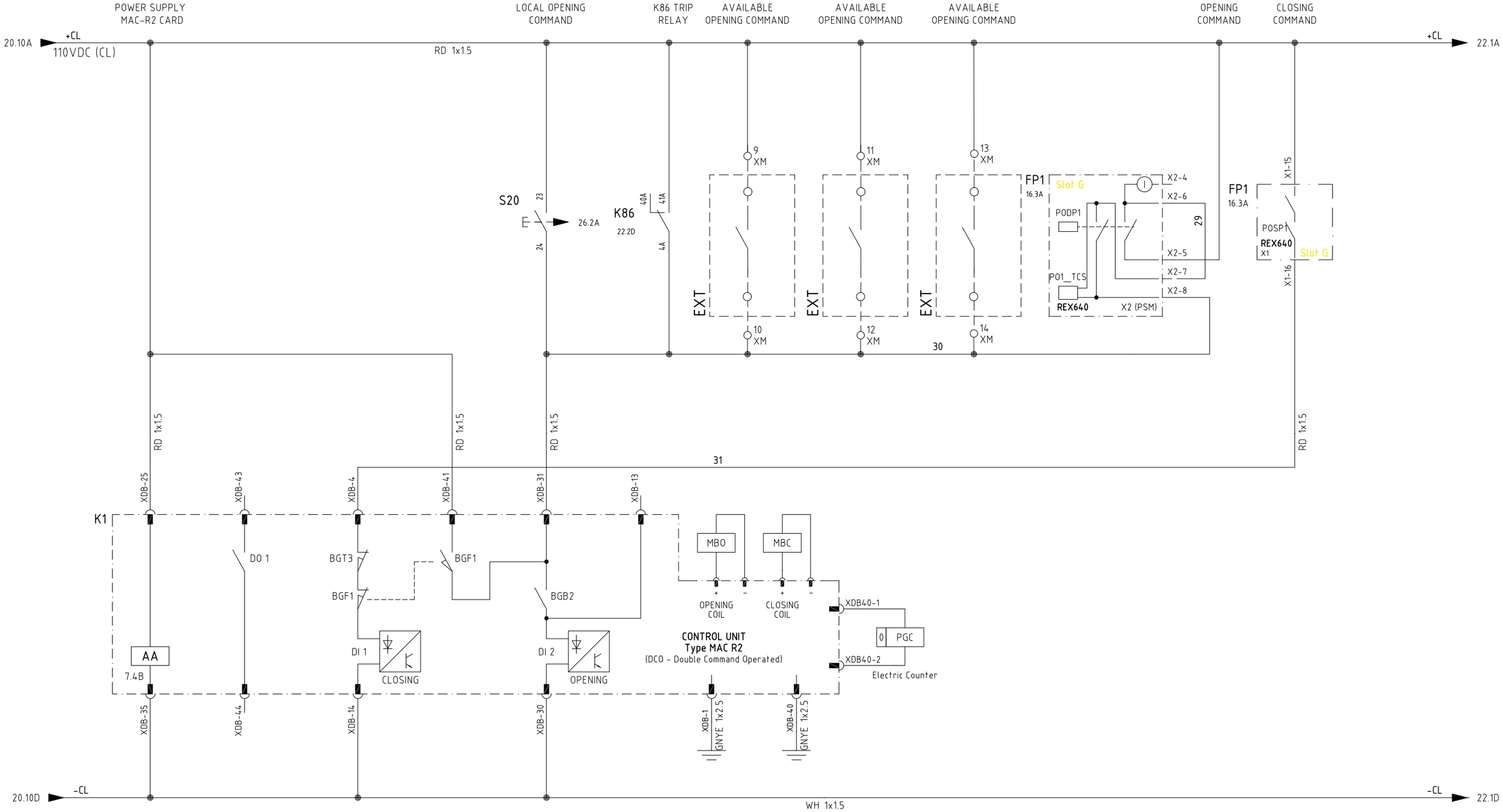
SHEET 20

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# CLOSING/OPENING COMMAND CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| +A2 | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

SHEET 21

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# COMMAND CIRCUITS

OUTPUT PROTECTION RELAY
AVAILABLE
AVAILABLE
TRANSFORME TRIP BUCHHOLZ
TRANSFORMER TRIP OIL TEMPERATURE
TRANSFORMER TRIP PRESSURE RELAY
TRANSFORMER TRIP WINDING TEMPERATURE
LOCAL RESET
REMOTE RESET
TRIP LOCK-OUT RELAY
SELECTOR SWITCH OF OVERRIDE
EMERGENCY OPENING BY SIS
UNDERVOLTAGE
CONTACTOR ISOLATED

21.10A +CL 110VDC (OP)

FP1c 24.1C S01 REX640 X2 Slot B X2-4 X2-3
15 XM
17 XM
16 XM
18 XM
35
K94B 23.5D
K940T 23.6D
K94P 23.7D
K94WT 23.8D
RD 1x1.5
PR 22.7D X1 X2
36
FP1c 24.1C S04 REX640 X1 Slot B X2-10 X2-9
K86 22.2D
40B 41B 48
SA2 OFF ON 23 24
KSIL 26.7B 27.5B 13 14
RD 1x1.5
38
20 XM
19 XM
KIRF 23.4D 39 22 24 21 40
K86 22.2D 30B 31B 38
K1 BGT5-33 ISOLATED BGT5 7.4B BGT5-34 41
+CL 23.1A

K86 B1 C S B2 C RESET 1

XDB-37
K1 DI 3 7.4B OPENING
XDB-38

PR 22.5A X1 X2
37

21.10E -CL WH 1x1.5 -CL 23.1D

2A 20A 21A
3A 30A 31A
21.5B 4A 40A 41A
28.6B 1B 10B 11B
24.5A 2B 20B 21B
22.9B 3B 30B 31B
22.7B 4B 40B 41B

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= +A2
DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

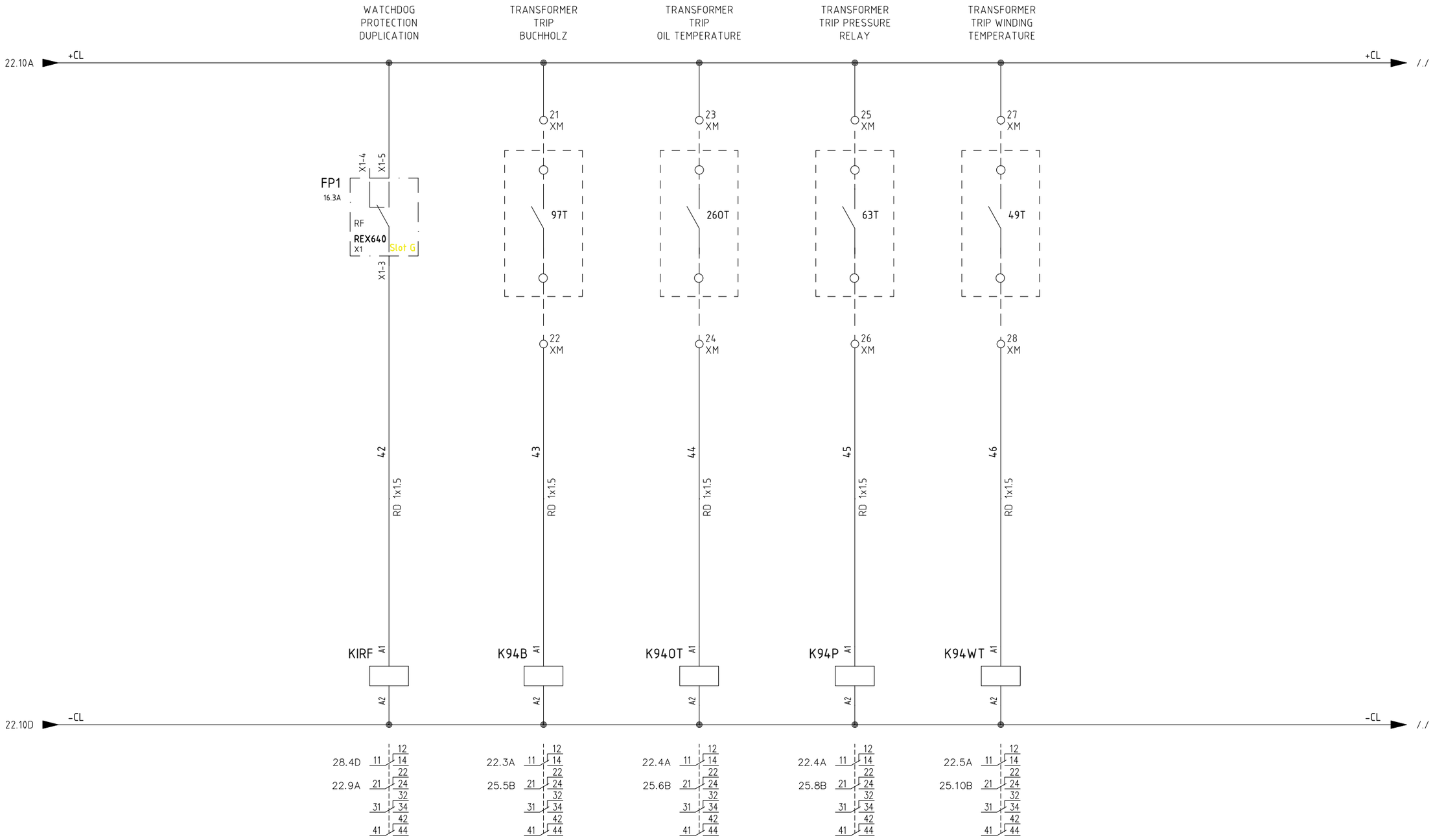
TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS
A3
DRAWING NO. 1723002197-EL-DG-00020
SHEET 22
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# COMMAND CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A2
DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 – FUNCTIONAL TRANSF FEEDER TR-200ED1
Command Circuit

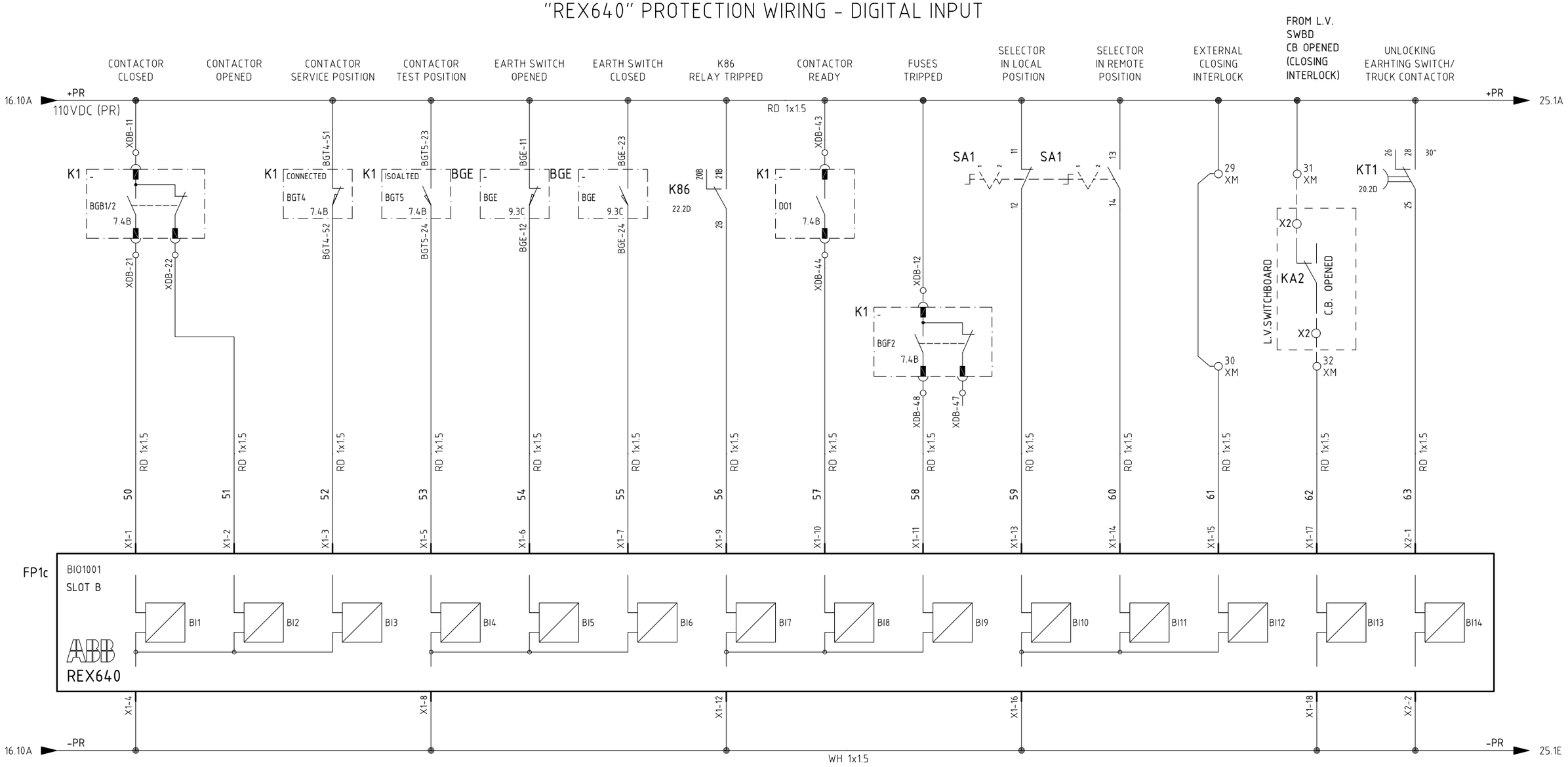
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

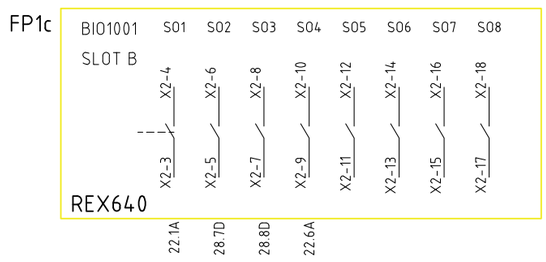
A3
DRAWING NO. 1723002197-EL-DG-00020
SHEET 23
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A2
DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

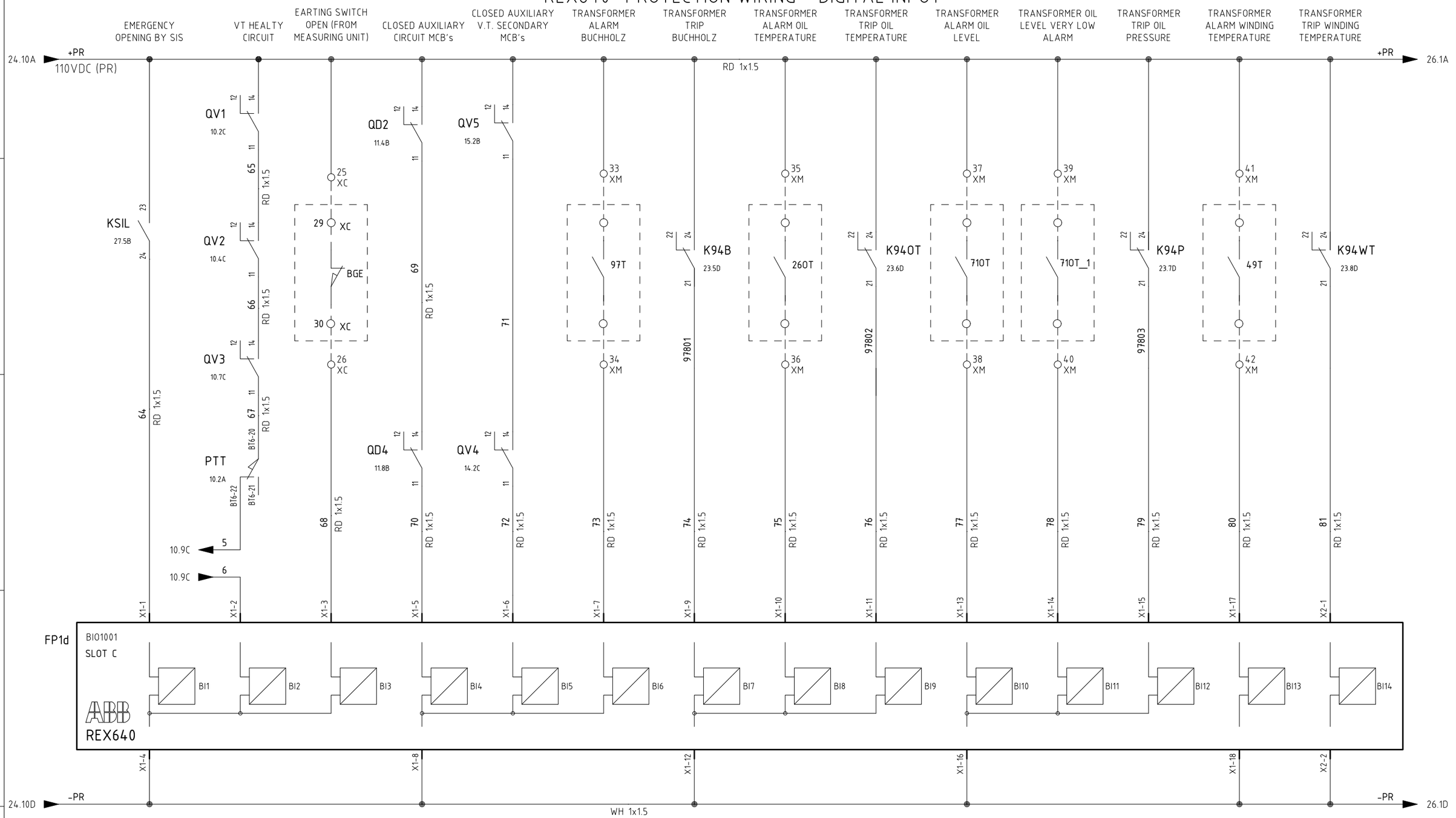
SHEET 24

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n°: 231151/SD/20

Item n°: PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1

"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

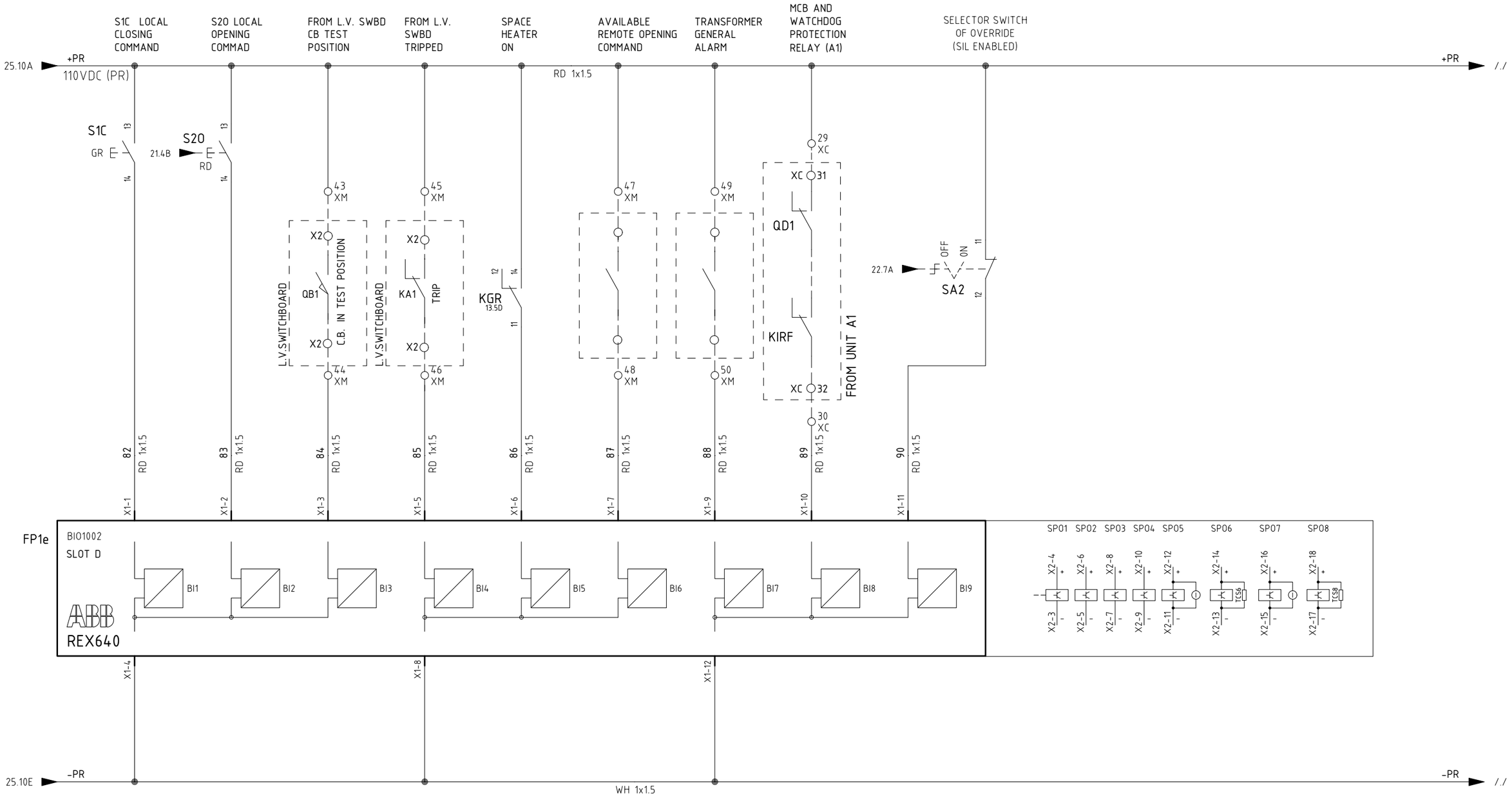
SHEET 25

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT




| | | | | | | |
|---|---|---|---|---|---|---|
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| +A2 | | | | | | |
| DWG n° : 231151/SD/20 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| Item n° : PF1113279 | 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1

"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

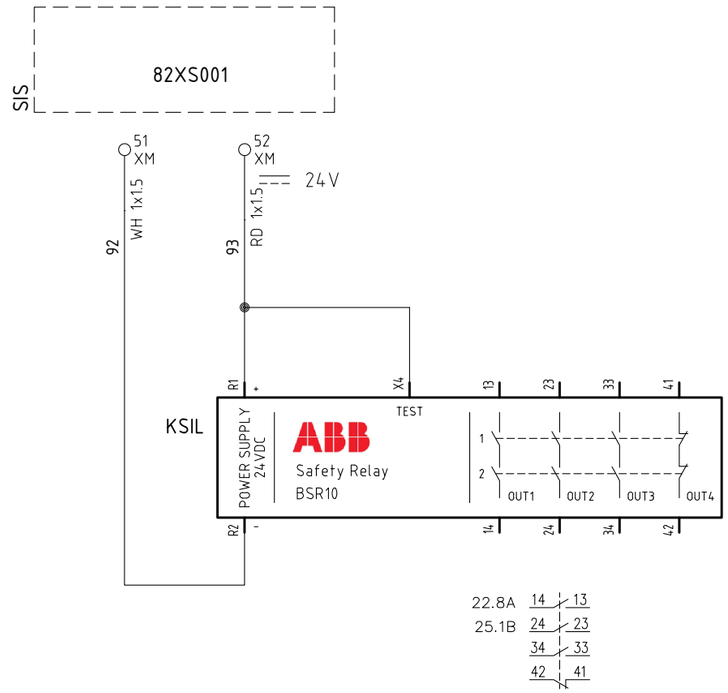
SHEET 26

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# EMERGENCY OPENING BY "SIS"




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A2
DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Emergency Opening by "SIS"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

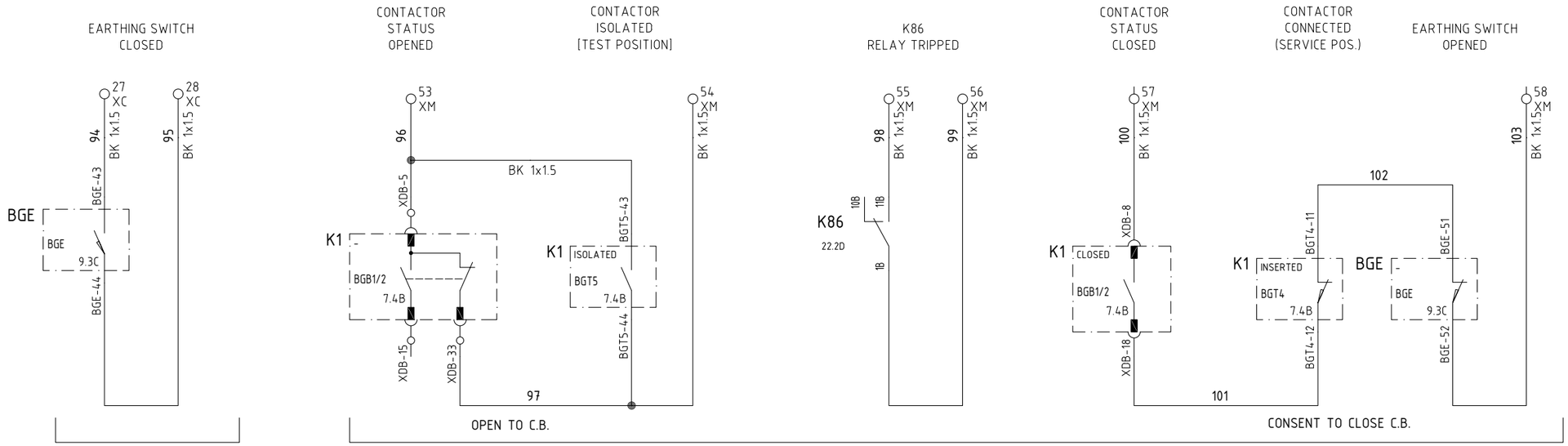
SHEET 27

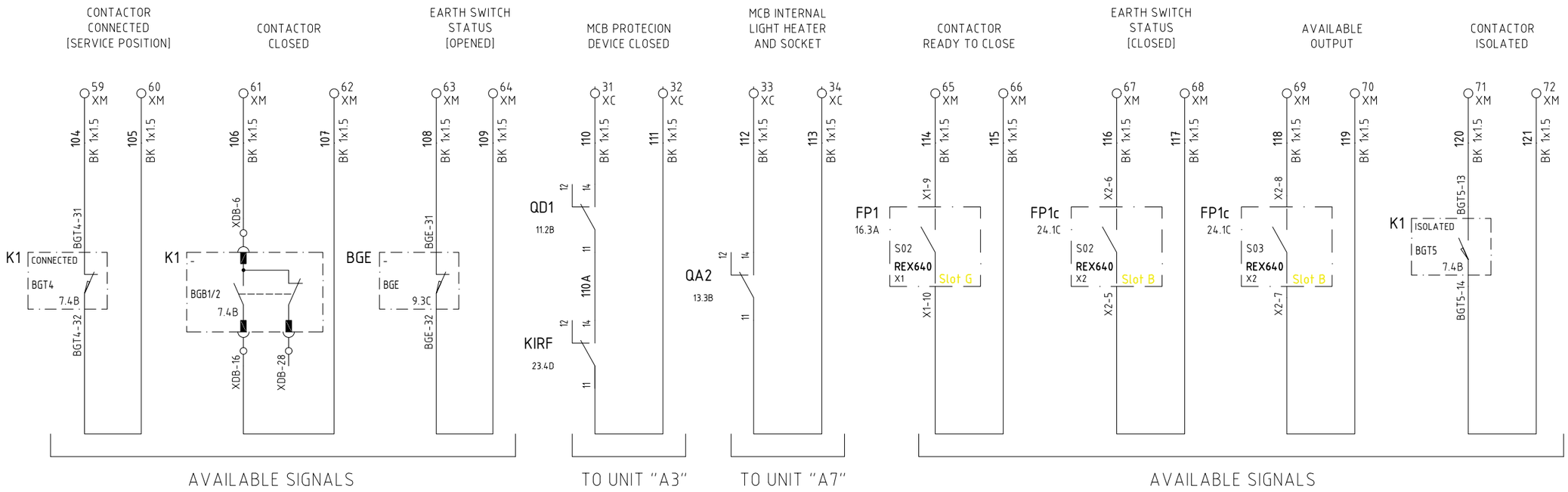
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

# AVAILABLE SIGNALS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231151/SD/20
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Availables Signals

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

SHEET 28

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

TYP - TR200ED1

XI

Ammeter Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 2 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 3 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HL201GR | Cabur | HLD.2/PT/GR End section - Grey |
| 4 | 8.4A | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 5 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 6 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 7 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 8 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HL201GR | Cabur | HLD.2/PT/GR End section - Grey |

TYP - TR200ED1

XV

Voltmetric Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 10.2D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 2 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 3 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 4 | 10.3D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 5 | 10.4D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 6 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 7 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 8 | 10.5D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 9 | 10.7D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 10 | 10.7D | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 11 | 14.4C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 12 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 13 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 14 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 15 | 15.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 16 | 15.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/20

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1

Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

SHEET 29

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

TYP - TR200ED1

XC

Interconnection Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 11.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 2 | 11.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 3 | 11.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 4 | 11.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 5 | 11.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 6 | 11.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 7 | 11.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 8 | 11.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 9 | 13.1A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 10 | 13.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 11 | 13.2A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 12 | 13.2B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 13 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 14.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 14.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 21 | 15.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 15.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 15.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 15.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 25 | 25.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 28.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 28.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 26.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 26.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 28.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 28.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 28.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 28.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

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DWG n° : 231151/SD/20

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

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ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1

Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

SHEET 3.0

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

TYP - TR200ED1

XM

Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 10.4E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 2 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 3 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 4 | 10.5E | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 5 | 20.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 6 | 20.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 7 | 20.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 8 | 20.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 9 | 21.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 10 | 21.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 11 | 21.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 12 | 21.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 13 | 21.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 21.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 22.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 22.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 22.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 22.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 22.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 22.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 21 | 23.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 23.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 23.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 23.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 25 | 23.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 23.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 23.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 23.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 24.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 24.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 24.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 24.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 25.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 25.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 25.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 25.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 37 | 25.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 38 | 25.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 39 | 25.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 40 | 25.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/20

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1

Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

SHEET 31

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

TYP - TR200ED1
XM
Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 41 | 25.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 42 | 25.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 43 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 44 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 45 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 46 | 26.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 47 | 26.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 48 | 26.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 49 | 26.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 50 | 26.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 51 | 27.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 52 | 27.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 53 | 28.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 54 | 28.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 55 | 28.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 56 | 28.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 57 | 28.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 58 | 28.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 59 | 28.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 60 | 28.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 61 | 28.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 62 | 28.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 63 | 28.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 64 | 28.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 65 | 28.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 66 | 28.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 67 | 28.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 68 | 28.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 69 | 28.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 70 | 28.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 71 | 28.9C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 72 | 28.9C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 73 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 74 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 75 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 76 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 77 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 78 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 79 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 80 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 81 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/20
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND
IMESA ELECTRICAL ENGINEERING
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS
A3
DRAWING NO. 1723002197-EL-DG-00020
SHEET 32
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

TYP - TR200ED1

XM

Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 82 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| +A2 | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/20

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1

Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00020

SHEET 33

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| BGE | 9 | 1VCF599700R0131 | 1 | EARTHING SWITCH ST-E 17.31 150 | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF599505R0001 | 1 | 5 AUX CONTACTS FOR EARTHING SWITCH | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF599504R0063 | 1 | KEY LOCKS ON EARTHING SWITCH | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF599700R0290 | 1 | EARTHING SWITCH OPERATING LEVER | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| C1 | 9 | 43931118 | 1 | VPIS 3,3÷36KV - DEVICE SIGNALLING VOLTAGE PRESENT KIT | ELECTRONSYSTEM | A2 | TRANSFORMER FEEDER TR-200ED1 |
| CB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| CC | 9 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| E1 | 13 | 74041 | 1 | LED LAMP 4W 4000K 313x30x22 | Beghelli | A2 | TRANSFORMER FEEDER TR-200ED1 |
| E8 | 10 | 1VCF501000R0001 | 1 | RESISTOR TR318 27R/J 27ohm 500W L=2,5M | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| EH1 | 13 | R1R150230 | 1 | SPACE HEATER SKR 150W ALIM. 220VCA | Torresan | A2 | TRANSFORMER FEEDER TR-200ED1 |
| FF1 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| FF2 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| FF3 | 10 | 1YMB751209M1502 | 1 | FUSE-LINKS FOR VOLTAGE TRANSFORMER PROTECTION 6/12kV 2A 192x53mm - CEF-VT | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| FP1 | 16 | 1VCF698331R0001 | 1 | REX640B10NN+AIM1+AIM1+ARC1+BIO1+BIO1+BI+O2+CMP2+COM1+LNG1+MCT1+PCL4+PSM3+SCT | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| HGR | 13 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | A2 | TRANSFORMER FEEDER TR-200ED1 |
| K1 | 7 | 1VCF305661R3200 | 1 | VACUUM CONTACTOR VSC7/P 3P 7,2KV 400A DOUBLE COMMAND (DCO) | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF309500R3881 | 1 | VACUUM CONTACTOR FITTED FOR DIN E=442mm FUSES | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF309500R0882 | 1 | NAMEPLATE IN ENGLISH LANGUAGE | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF309500R1881 | 1 | VACUUM CONTACTOR FOR UNIGEAR/UNISEC | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF309503R0881 | 1 | MAC-R2 ELECTRONIC CONTROL MODULE TYPE STANDARD | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF309503R1881 | 1 | VACUUM CONTACTOR CONFORMS TO THE IRC 62271-106 STANDARDS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF309588R0909 | 1 | POWER SUPPLY VOLTAGE OF MAC-R2 ELECTRONIC CONTROL MODULE 110VDC | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF309500R0100 | 1 | OPERATIONS COUNTER FOR VSC/P VERSIONE FOR SHIPPINGS REGISTER | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF349700R0407 | 1 | MECHANICAL INTERLOCK WITH DOOR | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF339700R0291 | 1 | POSITION CONTACTS FOR VD4 | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF339700R1909 | 1 | LOCKING MAGNET ON THE TRUCK 110Vdc (RLE2) | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF309503R0251 | 1 | KIT FOR FUSES DIAMETER 87mm | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF309500R0192 | 1 | LIFTING TOOL FOR SHIPPINGS REGISTERS VERSION | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF597111R0140 | 1 | POWER CUBE PB1/E L600 12kV 400A 31.5KA 3S | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF599700R0882 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR POWERCUBE | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF599700R5886 | 1 | PB FOR VSC | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF599700R4882 | 1 | PAINTED DOOR | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF599504R0042 | 1 | LOCK TO PREVENT RACKING-IN WITH EARTHING SWITCH | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF599700R0162 | 1 | 58 POLES CONNECTOR + ATOXIC WIRING L=0.8mt | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF599505R0111 | 1 | FAIL-SAFE SHUTTER ELEMENTS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF579700R0909 | 1 | ELECTROMECHANICAL ISOLATING INTERLOCK CIRCUIT-BREAKER/DOOR 110Vdc (RLE4) | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF599700R0280 | 1 | INTERLOCK FOR DOOR EARTHING SWITCH | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1YMB711229M4612 | 1 | BACK UP CURRENT LIMITING FUSE LINK 6/12kV 63A 442x65mm - CEF | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| K86 | 22 | RMBE13-C110T | 1 | BISTABLE RELAY 110VDC 7SC-5A TROP. | Amra | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | PAVM321 | 1 | SOCKET WITH SCREW TO RELAY TYPE PAVM321 | Amra | A2 | TRANSFORMER FEEDER TR-200ED1 |
| K94B | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |

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DWG n° : 231151/SD/20
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 21/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00020 | SHEET 34 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| K940T | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| K94P | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| K94WT | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| KGR | 13 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 552 0 | 1 | CR-M230AC2L SUPPLY 230VAC 2C/O 250V/6A LED | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| KIRF | 23 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| KSIL | 27 | 2TLA010040R0000 | 1 | BSR10 Vaux=24VDC SAFETY RELAY | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| KT1 | 20 | H3DKM2ACDC24240 | 1 | MULTIFUNCTION TIMER RELAY Vaux=24÷240Vac/dc - 2SC | Omron | A2 | TRANSFORMER FEEDER TR-200ED1 |
| L1C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A2 | TRANSFORMER FEEDER TR-200ED1 |
| L1I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A2 | TRANSFORMER FEEDER TR-200ED1 |
| L1MS | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A2 | TRANSFORMER FEEDER TR-200ED1 |
| L2C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A2 | TRANSFORMER FEEDER TR-200ED1 |
| L2I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A2 | TRANSFORMER FEEDER TR-200ED1 |
| L3C | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A2 | TRANSFORMER FEEDER TR-200ED1 |
| L3I | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A2 | TRANSFORMER FEEDER TR-200ED1 |
| L3MS | 19 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A2 | TRANSFORMER FEEDER TR-200ED1 |
| LS | 13 | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | A2 | TRANSFORMER FEEDER TR-200ED1 |
| OD1 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A2 | TRANSFORMER FEEDER TR-200ED1 |
| OD2 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A2 | TRANSFORMER FEEDER TR-200ED1 |
| OD3 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A2 | TRANSFORMER FEEDER TR-200ED1 |
| P1 | 20 | KW 080 2 | 1 | MP1-10B BLACK PUSH BUTTON UNSTABLE | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| PR | 22 | KW 101 6 | 1 | YELLOW LIGHT PUSH BUTTON | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | KV 022 5 | 1 | MLBL-05W YELLOW LED BLOCK INTEGRATED 110÷130VAC | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| PTT | 10 | 1VCF498412R0100 | 1 | TV/F COMPARTMENT 12/17kV IP4X L=590mm OUTLET ON THE BACK WITH N°3 VT + N°14 MAIN CONTACTS + N°2+2 SERVICE/ISOLATED POSITION CONTACTS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | 1VCF499800R0302 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR TV/F | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| QA2 | 13 | B427917 | 1 | DDA202 AC 25A 300MA BLOCCO DIFFERENZIALE 2P | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | A563819 | 1 | S2-CS/H6R CONTATTO DI SEGNALAZIONE/AUX 1SC | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | S550284 | 1 | S202M C10 INTERRUTTORE AUTOMATICO 10KA 2P | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| QD1 | 11 | A563819 | 1 | S2-CS/H6R CONTATTO DI SEGNALAZIONE/AUX 1SC | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |

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DWG n° : 231151/SD/20
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00020 | SHEET 35 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| QD1 | 11 | S550253 | 1 | S202M C 4 INTERRUTTORE AUTOMATICO 10KA 2P | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| QD2 | 11 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | a563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| QD4 | 11 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| QV1 | 10 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| QV2 | 10 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| QV3 | 10 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| QV4 | 14 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| QV5 | 15 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| S1C | 26 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | KW 076 0 | 1 | MP1-10G PUSH BUTTON GREEN WITH BLACK RING | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| S2O | 26 | KW 075 2 | 1 | MP1-10R PUSH BUTTON RED WITH BLACK RING | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| SA1 | 24 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | EO 571 3 | 1 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | KW 329 3 | 1 | M2SS2-10B HANDLE SELECTOR 2P 90° BLACK RING BLACK | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| SA2 | 22 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | EO 571 3 | 1 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | KW 329 3 | 1 | M2SS2-10B HANDLE SELECTOR 2P 90° BLACK RING BLACK | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| TI-L1 | 8 | ATB-10-BS__013 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 50/1A cl.0,5-5P15 (2,5VA)- 25kA | ESITAS | A2 | TRANSFORMER FEEDER TR-200ED1 |
| TI-L2 | 8 | ATB-10-BS__013 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 50/1A cl.0,5-5P15 (2,5VA)- 25kA | ESITAS | A2 | TRANSFORMER FEEDER TR-200ED1 |
| TI-L3 | 8 | ATB-10-BS__013 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 50/1A cl.0,5-5P15 (2,5VA)- 25kA | ESITAS | A2 | TRANSFORMER FEEDER TR-200ED1 |
| TO | 9 | KAP-150/250-55 | 1 | CURRENT TRANSFORMER 0,72/3/-kV 100/1 50Hz | ESITAS | A2 | TRANSFORMER FEEDER TR-200ED1 |
| TR1 | 19 | 800208 | 1 | MODBUS DATACARD 8 CHANNELS | Exertherm | A2 | TRANSFORMER FEEDER TR-200ED1 |
| TU-L1 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| TU-L2 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| TU-L3 | 10 | TJP4.3__002 | 1 | VT ON RESIN 7,2KV 50-60Hz 6600:r3/110:r3-110:r3-110:3 Cl.0,5-3P Pr.20VA, Cl.0,5-3P Pr.30VA, Cl.3P Pr.30VA | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| XC | | HM320GR | 12 | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) | Cabur | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | HM250GR | 22 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | HM251GR | 3 | HMT.4/PT/GR End section - Grey | Cabur | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | HM321GR | 3 | HMT.6/PT/GR End section - Grey | Cabur | A2 | TRANSFORMER FEEDER TR-200ED1 |

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DWG n° : 231151/SD/20

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1

Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00020 | SHEET 36 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| XI | | HB220GR | 8 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | HL201GR | 2 | HLD.2/PT/GR End section - Grey | Cabur | A2 | TRANSFORMER FEEDER TR-200ED1 |
| XM | | HM250GR | 82 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | HM251GR | 2 | HMT.4/PT/GR End section - Grey | Cabur | A2 | TRANSFORMER FEEDER TR-200ED1 |
| XS1 | 13 | E 9447 7 | 1 | SOCKET | ABB | A2 | TRANSFORMER FEEDER TR-200ED1 |
| XV | | HB210GR | 16 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type | Cabur | A2 | TRANSFORMER FEEDER TR-200ED1 |
| | | HB201GR | 5 | HSCB.6/PT/GR End section - Grey | Cabur | A2 | TRANSFORMER FEEDER TR-200ED1 |

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SG-100D1 - FUNCTIONAL TRANSF FEEDER TR-200ED1
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00020 | SHEET 37 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00020 Rev.03

1.4.7.SG-100D1 HV SWG FUNCTIONAL DIAGRAM - TRANSFORMER FEEDER TR200DE1 (including Terminals and BOM) ,

Doc. No. 1723002197-EL-DG-00021

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# "SG-100D1" HV SWBD 6,6kV (UNIT A4)

# FUNCTIONAL DIAGRAM

# TRANSFORMER FEEDER TR200DE1

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

***NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.***

| Sign | Date |
|---|---|
| Luca Macuk | 12/09/2024 |

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DWG n° : 231151/SD/21

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

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TITLE :
SG-100D1 – FUNCTIONAL TRANSF FEEDER TR200DE1

Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# INDEX

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|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cover | X | X | X | X | | | | | |
| 2 | Sheets Index | X | X | X | X | | | | | |
| 3 | Legend | X | X | X | X | | | | | |
| 4 | Door Layout | X | X | X | X | | | | | |
| 5 | Protection Display REX640 | X | X | X | X | | | | | |
| 6 | Selector Switch Diagram | X | X | X | X | | | | | |
| 7 | Power Diagram | X | X | X | X | | | | | |
| 8 | Power Diagram | X | X | X | X | | | | | |
| 9 | Power Diagram | X | X | X | X | | | | | |
| 10 | 110Vdc / 24Vdc Distribution Voltage | X | X | X | X | | | | | |
| 11 | Composition Relay REX640 | X | X | X | X | | | | | |
| 12 | 230Vac Distribution Voltage | X | X | X | X | | | | | |
| 13 | 110V Protection/Measure Distribution Voltage | X | X | X | X | | | | | |
| 14 | 110V Protection/Measure Distribution Voltage | X | X | X | X | | | | | |
| 15 | "REX640"' Protection Wiring | X | X | X | X | | | | | |
| 16 | "REX640"' Protection Wiring | X | X | X | X | | | | | |
| 17 | "REX640"' Protection Wiring | X | X | X | X | | | | | |
| 18 | Extherm Device | X | X | X | X | | | | | |
| 19 | Command Circuit | X | X | X | X | | | | | |
| 20 | Command Circuit | X | X | X | X | | | | | |
| 21 | Command Circuit | X | X | X | X | | | | | |
| 22 | Command Circuit | X | X | X | X | | | | | |
| 23 | "REX640" Protection Wiring - Digital Input | X | X | X | X | | | | | |
| 24 | "REX640" Protection Wiring - Digital Input | X | X | X | X | | | | | |
| 25 | "REX640" Protection Wiring - Digital Input | X | X | X | X | | | | | |
| 26 | Availables Signals | X | X | X | X | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| 27 | Terminal stripes | X | X | X | X | | | | | |
| 28 | Terminal stripes | X | X | X | X | | | | | |
| 29 | Terminal stripes | X | X | X | X | | | | | |
| 30 | Terminal stripes | X | X | X | X | | | | | |
| 31 | Bill of Materials | X | X | X | X | | | | | |
| 32 | Bill of Materials | X | X | X | X | | | | | |
| 33 | Bill of Materials | X | X | X | X | | | | | |

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DWG n° : 231151/SD/21
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TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Sheets Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00021 | SHEET 2 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# ACRONIMUS LEGEND

| ITEM | DESCRIPTION |
|---|---|
| BB | ARC SENSOR PROTECTION ON MAIN BUS BARS |
| BGE | EARTHING SWITCH |
| C1 | VOLTAGE PRESENCE |
| CB | ARC SENSOR PROTECTION ON C.B. / CONTACTOR COMPARTMENT |
| CC | ARC SENSOR PROTECTION ON CABLE COMPARTMENT |
| DCO | DOUBLE COMMAND OPERATED CONTACTOR |
| DI3 | UNDERVOLTAGE CONTACTOR |
| DP1 | ALARM RELAY MODULE TEMPERATURE |
| E1 | INTERNAL LIGHT |
| E8 | RESISTOR FERRO-RESONANCE |
| EH1 | INTERNAL SPACE HEATER |
| Fn | MV FUSE |
| FP1 | PROTECTION RELAY |
| GS1 | DC/DC CONVERTER |
| HGR | THERMOSTAT |
| Kn | AUXILIARY RELAY |
| K1 | MV CONTACTOR |
| K86 | BLOCK RELAY |
| KT1 | DE-ENERGIZATION TIMER |
| LS | MICRO SWITCH ON AUXILIARY DOOR |
| MAS | MOTOR SPRING CHARGER |
| MBC | CLOSING COIL |
| MBO1 | OPENING COIL |
| MBU | UNDERVOLTAGE |
| ODn | VOLTAGE DISCHARGER |
| PU1 | MEASURING VOLTAGE INSTRUMENT |
| PTT | V.T. TRUCK |
| QM | MV CIRCUIT-BREAKER |

| ITEM | DESCRIPTION |
|---|---|
| QDn | M.C.B. CIRCUITS PROTECTION |
| QVn | M.C.B FOR V.T. PROTECTION |
| RLE1 | COIL FOR CONSET CLOSING CIRCUIT-BREAKER |
| RLE2 | COIL FOR UNLOCKING RACK-IN/OUT OPERATION |
| RLE3 | COIL FOR UNLOCKING OPERATION EARTHING |
| RLE4 | COIL FOR UNLOCKING ENCLOSURE DOOR OPERATION |
| SU1 | VOLTAGE SELECTOR |
| SWH... | ETHERNET SWITCH |
| TI-Ln | CURRENT TRANSFORMER |
| TO | OMOPOLAR RING CURRENT TRANSFORMER |
| TR1 | TEMPERATURE CONTROL DEVICE |

FUNCTIONAL OF THE PROTECTION RELAY OUTPUT CONTACTS:

SLOT "G":
RF = WATCHDOG RELAY
S01 = EARTHING SWITCH UNLOCKING
S02 = C.B. or CONTACTOR READY TO CLOSE
POSP1 = CLOSING COMMAND
S03 = C.B. or CONTACTOR TRUCK UNLOCKED
PODP1 = OPENING COMMAND
SLOT "B":
S01 = TRIP PROTECTION TO LOCKOUT RELAY
S02 = EARTHING SWITCH CLOSED
S03 = AVAILABLE OUTPUT (ON TERMINAL STRIP)
S04 = RESET LOCKOUT RELAY

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DWG n° : 231151/SD/21
Item n° : PF1113279

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TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
Legend

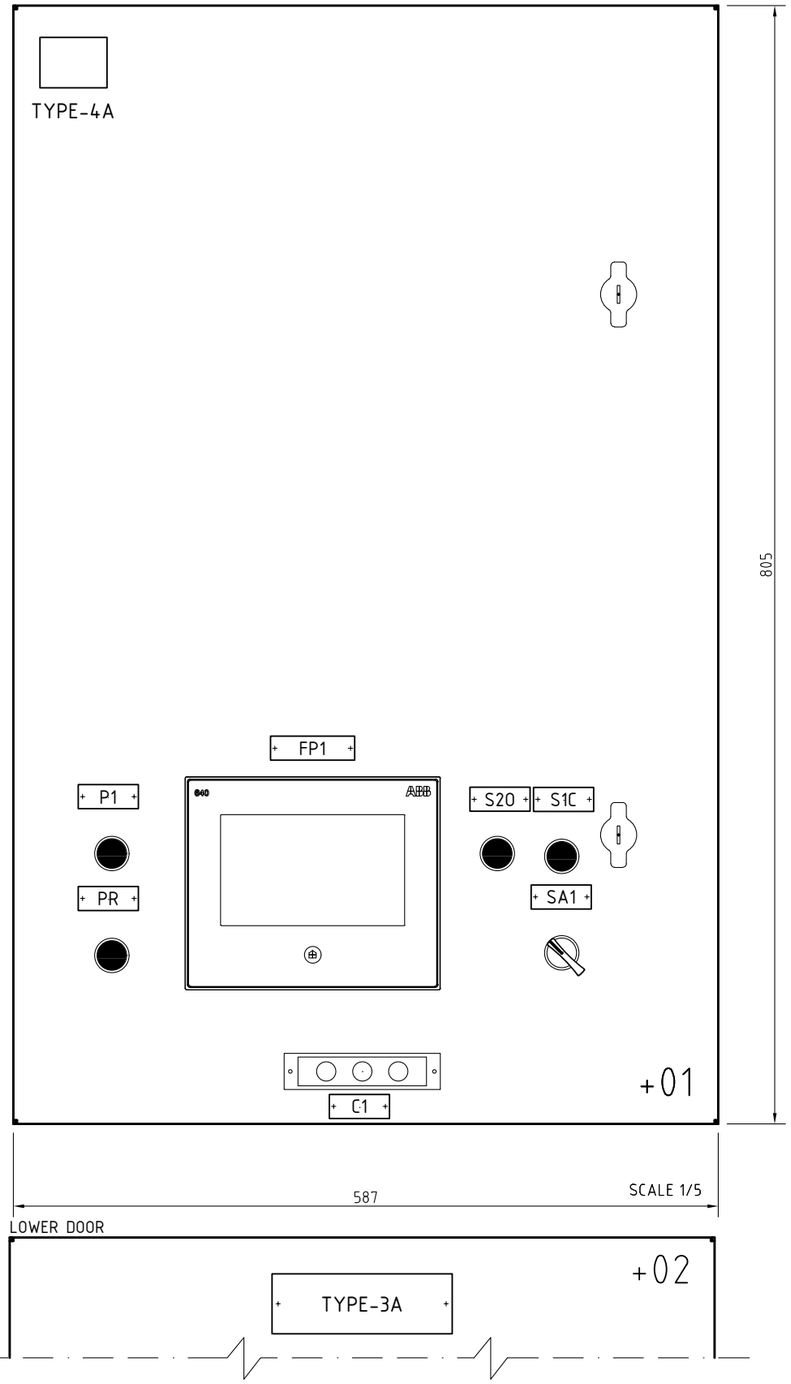
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00021 | SHEET 3 | REV. 03

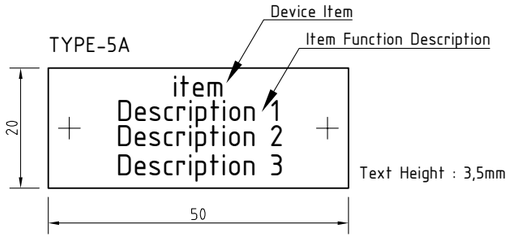
File Name : 1723002197-EL-DG-00021 Rev.03

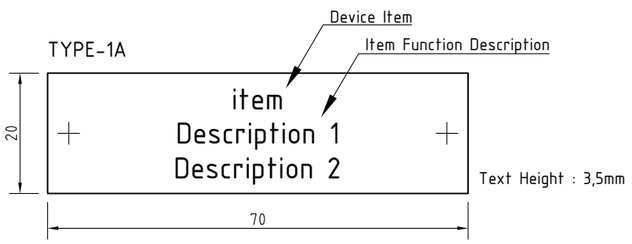
F.to UNI A3: 420mmx297mm

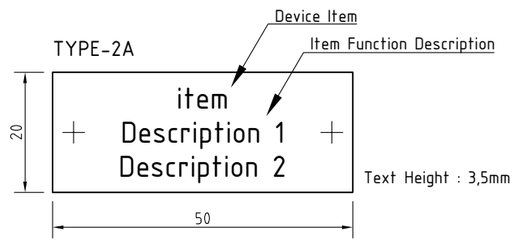
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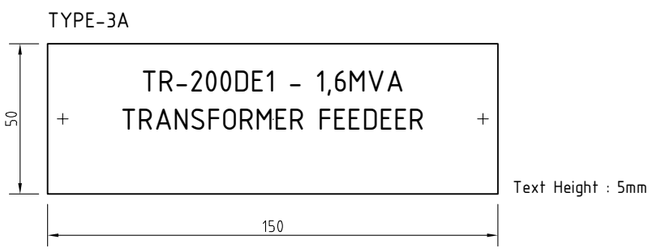


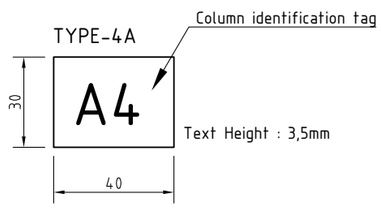

| DEVICES name plate | | | | | |
|---|---|---|---|---|---|
| ITEM | COMPONENT | DESCRIPTION 1 | DESCRIPTION 2 | DESCRIPTION 3 | NOTE |
| FP1 | PROTECTION RELAY | PROTECTION RELAY | | | TYPE-1A |
| S2.O | PUSH BUTTON | OPEN | COMMAND | CONTACTOR | TYPE-5A |
| S1.C | PUSH BUTTON | CLOSE | COMMAND | CONTACTOR | TYPE-5A |
| SA1 | SELECTOR SWITCH | LOCAL / REMOTE | | | TYPE-2A |
| PR | LIGHT PUSH BUTTON | RESET | LOCK-OUT | TRIP LOCK-OUT | TYPE-5A |
| C1 | PILOT LIGHT | VOLTAGE | PRESENCE | | TYPE-2A |
| P1 | PUSH BUTTON | TRUCK-DOOR | EARTHING | ENABLING | TYPE-5A |




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= +A4

DWG n° : 231151/SD/21

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Door Layout

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

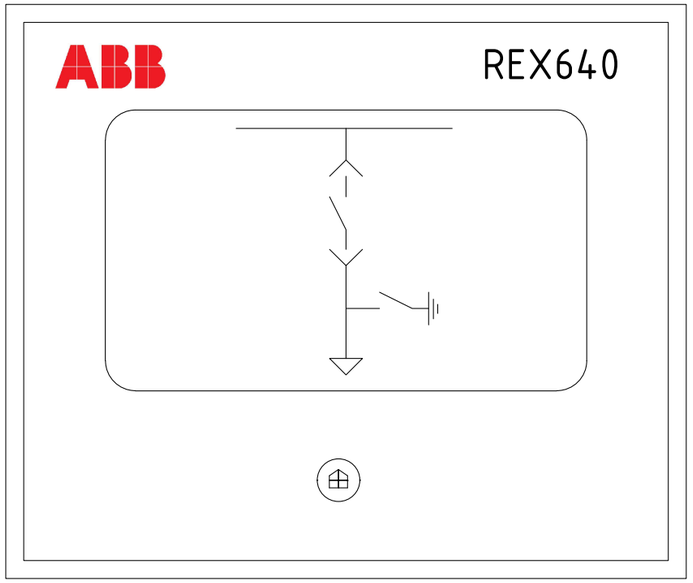
SHEET 4

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# PROTECTION DISPLAY




## LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE CONTACTOR " AND "OPEN CONTACTOR" NOT ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED

| LEDs PAGE 1 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/27-2/59-1/59-2 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | CONTACTOR READY (TCS) | - | GREEN | OK = TCS OK (CONTACTOR READY) |
| LED-3 | SYNCHRO CHECK | | GREEN | OK = SYNCHRONISM |
| LED-4 | CONTACTOR READY TO CLOSE | - | GREEN | OK = CONTACTOR READY TO CLOSE |
| LED-5 | 50-1/51-1/67-1/67-2 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/59N-1/59N-2 - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = CONTACTOR TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | EMERGENCY OPENING BY SIS (ESD) | RED | - | ALARM = ESD TRIPPED |

| LEDs PAGE 2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | - | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | FUSES TRIP | RED | | ALARM = FUSES TRIP |
| LED-15 | TRIP FROM L.V. | RED | | ALARM = L.V. TRIP |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/21

Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
Protection Display REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 5

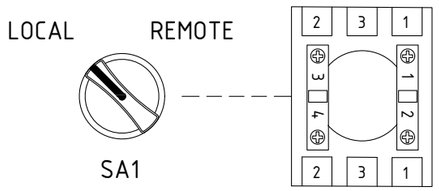
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# SELECTORS SWITCH DIAGRAM

REAR VIEW




## NOTES

THE DIAGRAM INDICATES THE FOLLOWING CONDITIONS:
-INSERTED CONTACTOR IN OPEN POSITION
-DE-ENERGIZED CIRCUITS
-EARTHING SWITCH OPEN

THE AUXILIARY CIRCUITS WILL HAVE THE FOLLOWING CHARACTERISTICS:
-110+ / 24+ 1,5mmq RED TYPE CABLE SH-W
-110- / 24- 1,5mmq WHITE TYPE CABLE SH-W
-AUXILIARY CONTACTS TO TERMINAL STRIP 1,5mmq BLACK TYPE CABLE SH-W
-230Vac 1,5mmq BLACK TYPE SH-W
-VOLTMETRICAL CIRCUITS 1,5mmq BLACK TYPE CABLE SH-W
-AMMETRICAL CIRCUIT 2,5mmq BLACK TYPE CABLE SH-W

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+A4
DWG n° : 231151/SD/21
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

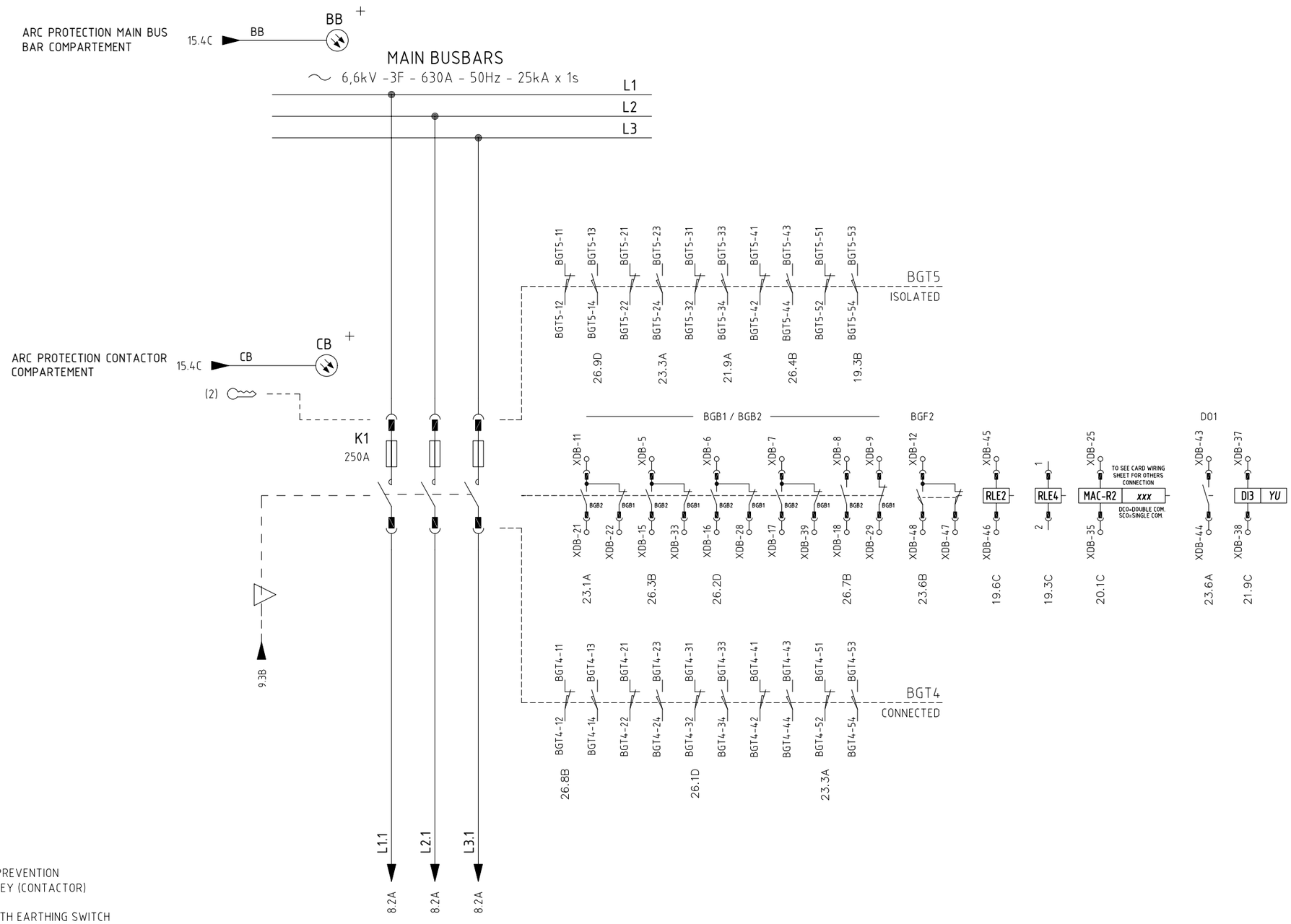
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SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
Selector Switch Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00021
SHEET 6
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03




(2) RACKING IN PREVENTION LOCK WITH KEY (CONTACTOR)

(3) FREE KEY WITH EARTHING SWITCH IN OPEN POSITION

(4) FREE KEY WITH EARTHING SWITCH IN CLOSED POSITION

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/21

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

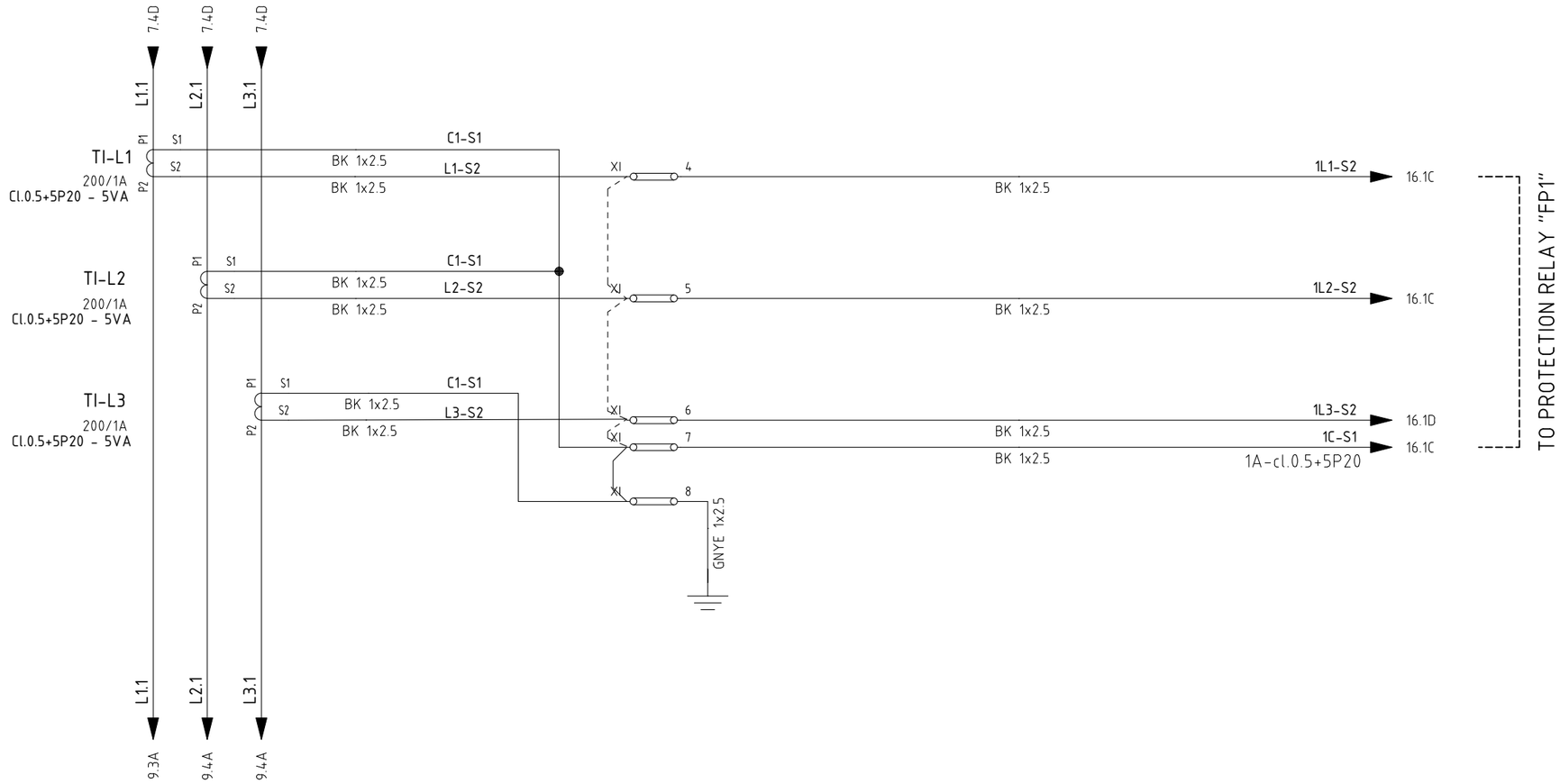
DRAWING NO. 1723002197-EL-DG-00021

SHEET 7

REV. 03

File Name : 1723002197-EL-DG-00021 Rev.03

F.to UNI A3: 420mmx297mm




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = +A4 | | | | | | | |
| DWG n° : 231151/SD/21 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
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| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

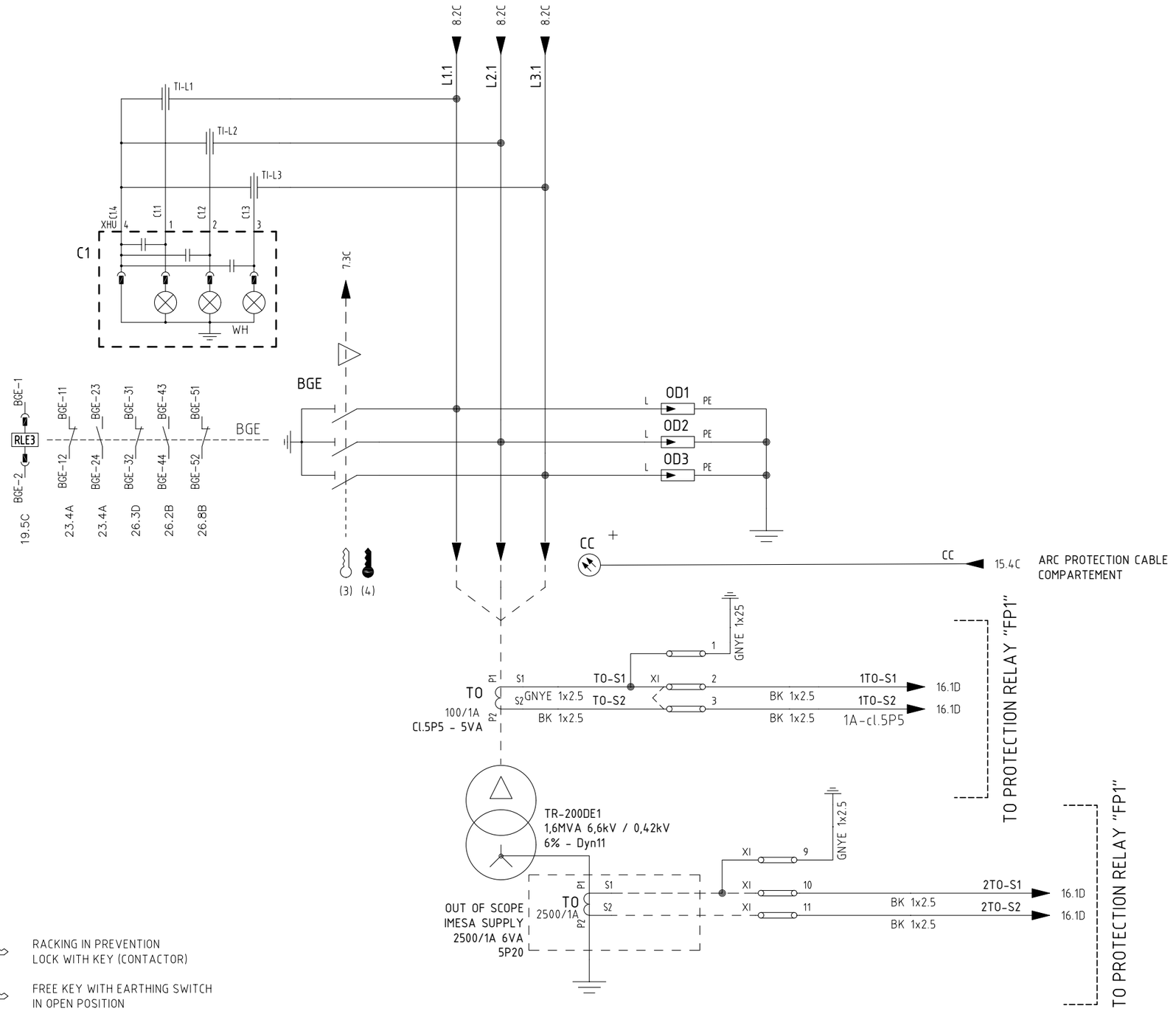
DRAWING NO. 1723002197-EL-DG-00021

SHEET 8

REV. 03

File Name : 1723002197-EL-DG-00021 Rev.03

F.to UNI A3: 420mmx297mm




(2) RACKING IN PREVENTION LOCK WITH KEY (CONTACTOR)

(3) FREE KEY WITH EARTHING SWITCH IN OPEN POSITION

(4) FREE KEY WITH EARTHING SWITCH IN CLOSED POSITION

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231151/SD/21

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 9

REV. 03

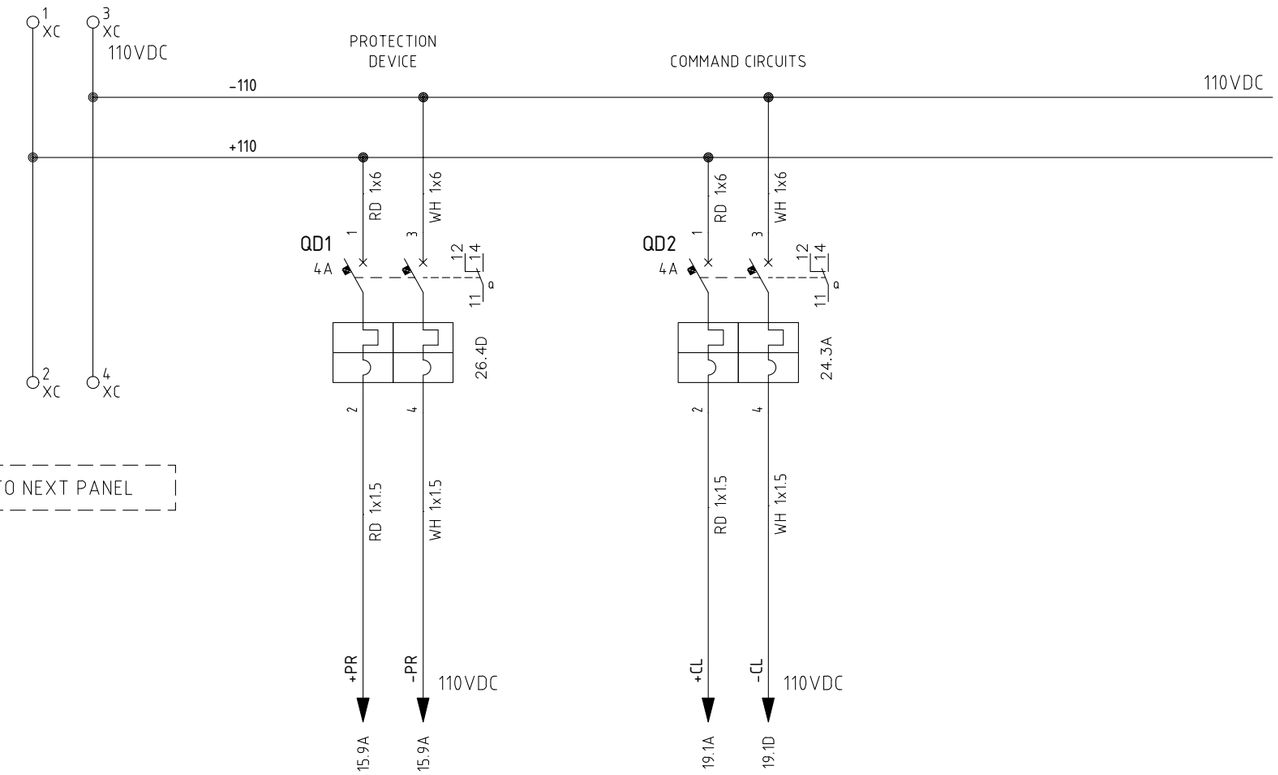
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

## 110VDC DISTRIBUTION VOLTAGE

110Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL

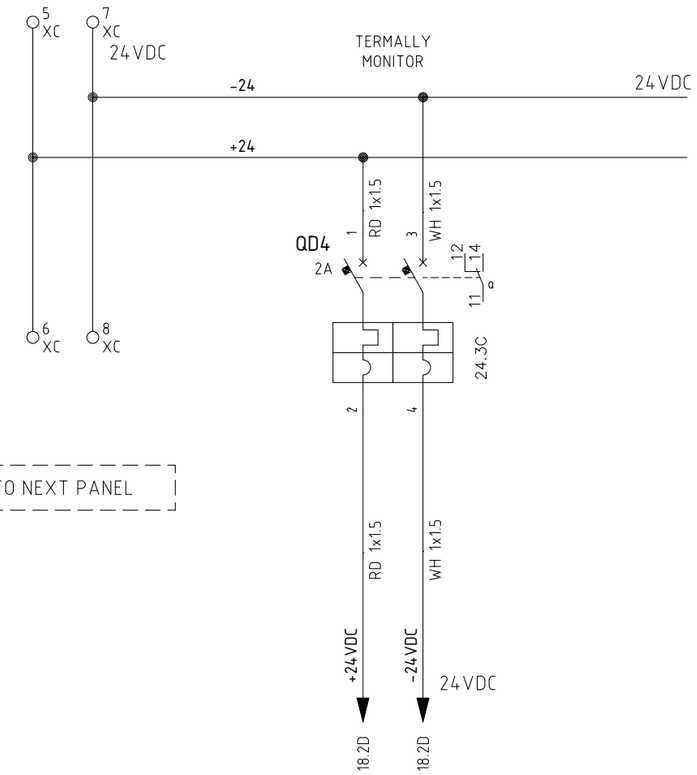



TO NEXT PANEL

## 24VDC DISTRIBUTION VOLTAGE

24Vdc Auxiliary Voltage
from Measuring Bus Bar Unit

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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+A4
DWG n° : 231151/SD/21
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
110Vdc / 24Vdc Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 10

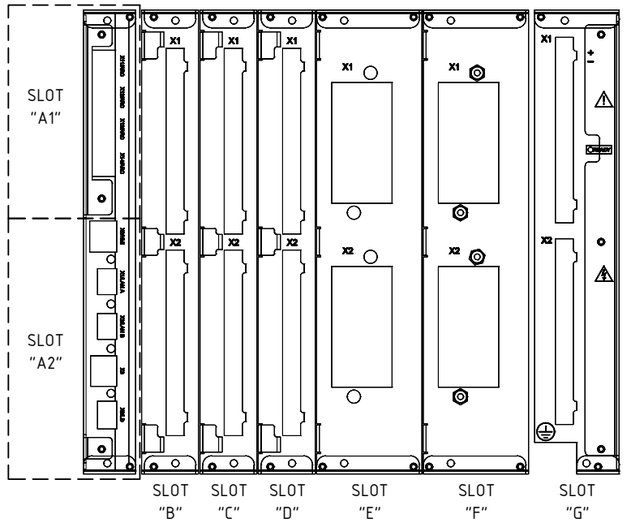
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# COMPOSITION RELAY REX640

## RACK VIEW




REX640B10NN+COM1+ARC1+BIO1+BIO1+BIO2+AIM1+AIM1+PSM3+MCT1+SCT1+CMP2+LNG1+PCL4

LEGEND

| SLOT | Module Type | Description Module |
|---|---|---|
| A1 | ARC1001 | n° 4 x ARC sensor inputs |
| A2 | COM1001 | n° 1 x RJ-45 (LHMI port) + n° 3 x RJ-45 + n° 1 x SFP100M LC |
| B | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| C | BIO1001 | n° 14 Binary Input + n° 8 x SO |
| D | BIO1002 | n° 9 Binary Input + n° 6 x SPO + n° 2 x SPO(TCS) |
| E | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| F | AIM1001 | n° 4 x CT + n° 1 x CT (sensitive, for residual current only) + n° 5 x VT |
| G | PSM1003 | 77...150 VDC, n° 3 x PO (TCS) + n° 2 x PO + n° 3 x SO + n° 2 x SSO |
| | PO = Power Output<br>SO = Signal Output<br>SPO = Static Power Output<br>SSO = Static Signal Output | |

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+A4

DWG n° : 231151/SD/21

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
Composition Relay REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

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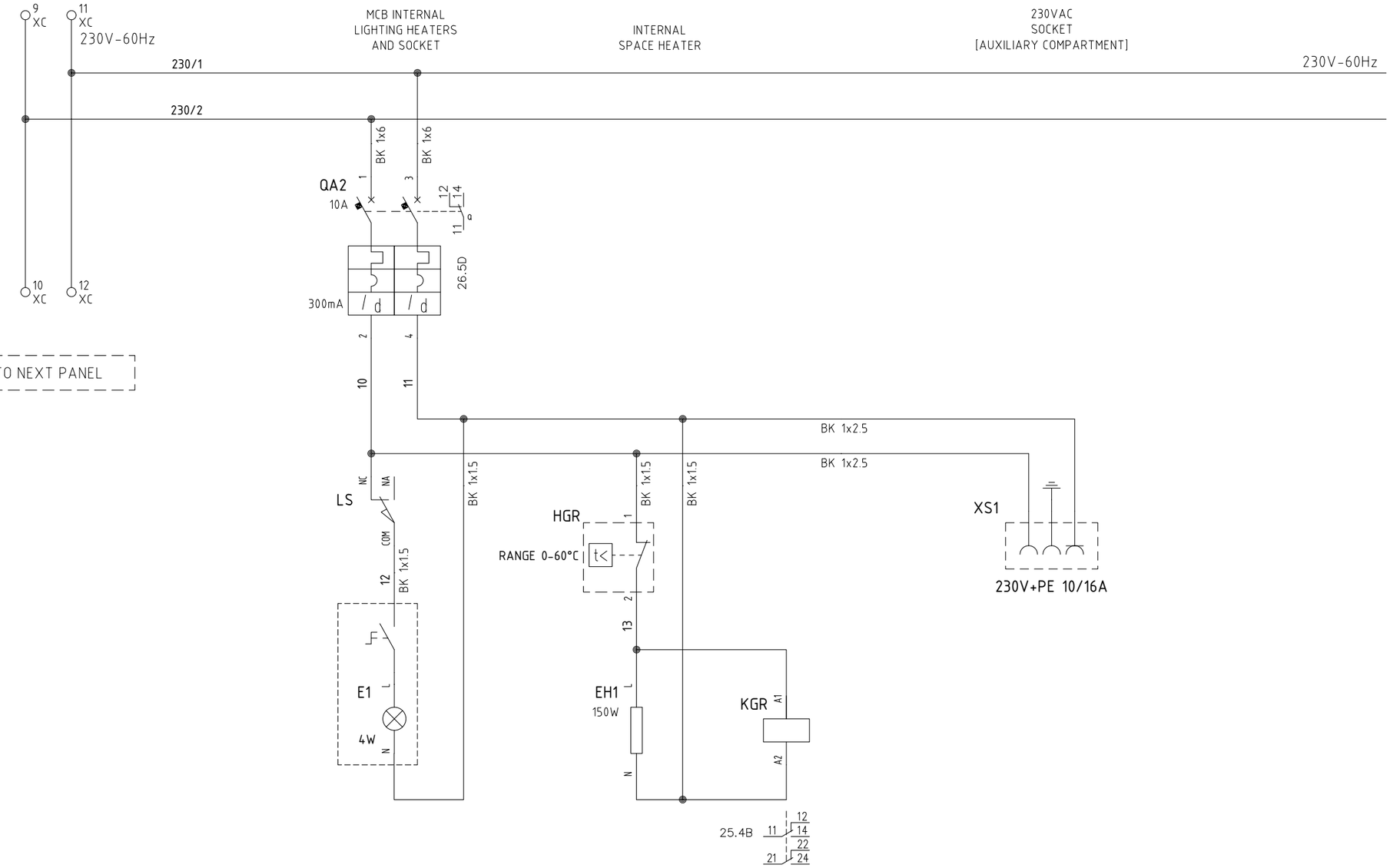
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# 230VAC DISTRIBUTION VOLTAGE

230Vac Auxiliary Voltage
from Measuring Bus Bar

FROM PREVIOUS PANEL




TO NEXT PANEL

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | = | | | | | |
| | | +A4 | | | | | |
| | IMESA ELECTRICAL ENGINEERING | DWG n° : 231151/SD/21 | 3 | 08/08/2024 | Giulietti | Flamminio Sigismondi | As-Built (ASB) |
| | | Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio Sigismondi | Accepted for Construction (AFC) |
| | | | 1 | 14/05/2024 | Giulietti | Flamminio Sigismondi | Issued for review (IFR) |
| CROSSWIND | ROSETTI MARINO | | 0 | 04/04/2024 | Giulietti | Flamminio Sigismondi | Issued for review (IFR) |
| | | | REV. | DATE | DRN | CHKD APPD | DESCRIPTION |

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
230Vac Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00021 | SHEET 12 | REV. 03

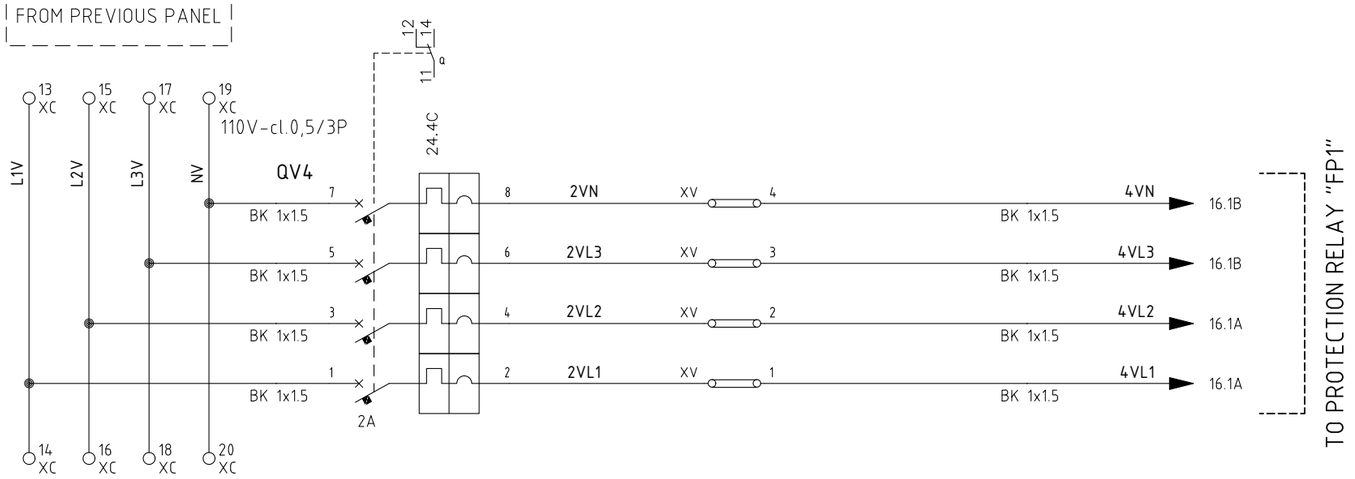
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# 110V: 1,73 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:√3V VOLTMETRIC LINE - STAR
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO NEXT PANEL

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A4
DWG n° : 231151/SD/21
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00021
SHEET 1,3
REV. 03

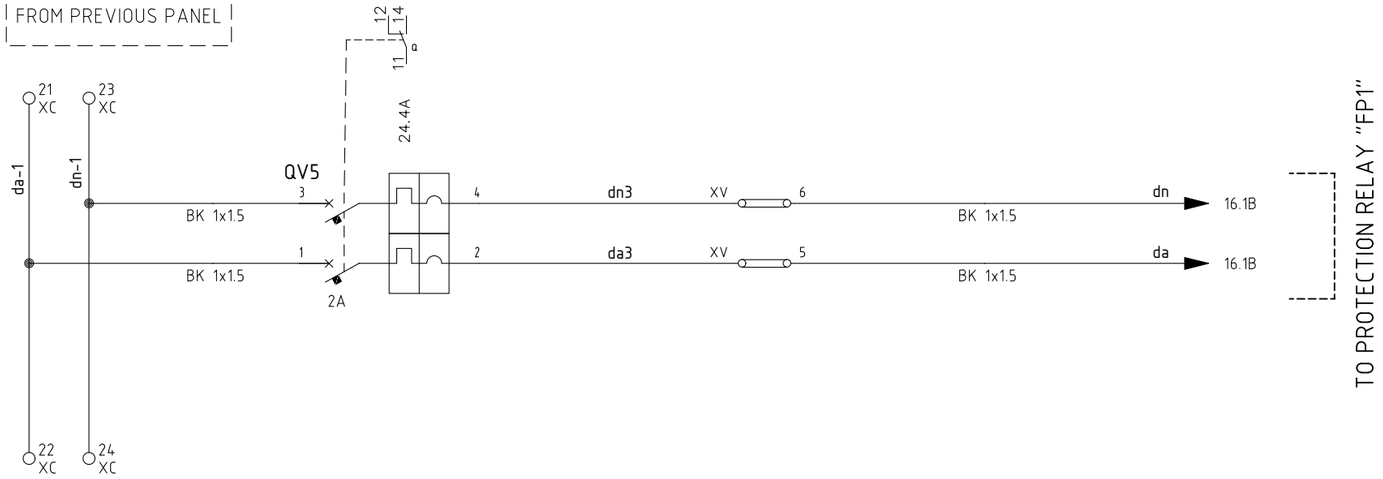
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# 110V:3 DISTRIBUTION VOLTAGE VT'S FROM MAIN BUS BAR

MAIN BUS BAR
110:3V VOLTMETRIC LINE -
DELTA OPEN
(FOR PROTECTION/MEASURE)

FROM PREVIOUS PANEL




TO PROTECTION RELAY "FP1"

TO NEXT PANEL

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| +A4 | | | | | | | |
| DWG n° : 231151/SD/21 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
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| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
110V Protection/Measure Distribution Voltage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 14

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# "REX640" PROTECTION WIRING

FP1

PSM1002
COM1001
slot G

X1
X1-1 (+)
X1-2 (-)
Uaux
GND
1x6 GNYE

10.2D +PR → +PR → 23.1A
10.3D -PR → -PR → 23.1D
110VDC

RD 1x1.5
WH 1x1.5

PROTECTION FUNCTION

| | |
|---|---|
| 51 | 50 |
| 51N | 74 |
| 86 | 51G |
| 59N | 27 |
| 59 | |
| | |
| | |
| | |

ETH PORT (IEC61850)
X1 — PATCH CORD cat.6 RJ45 — FP1-A4/A — FROM MEASURE CUBICLE A5
X2
X3 — PATCH CORD cat.6 RJ45 — FP1-A4/B — FROM MEASURE CUBICLE A5
X0 — PATCH CORD cat.7 RJ45 — ETH.1

LHMI
Local HMI
[7" color Touch screen]
X1.1
X3
GNYE 1x6

ARC1001
slot A1

ARC DETECTOR SENSOR
X11 — BB → 7.3A — BUS BAR COMPARTEMENT
X12 — CB → 7.3B — C.B. COMPARTEMENT
X13 — CC → 9.6C — CABLE COMPARTEMENT
X14
arc detectors

ABB REX640

FP1

PSM1003

RF SO1 SO2 SSO1 SSO2 POSP1 POSP2 SO3 PODP1 PODP2 PODP3

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| X1-4 | X1-5 | X1-7 | X1-8 | X1-9 | X1-11 | X1-13 | X1-15 | X1-17 | X2-2 | X2-3 |
| X1-3 | | X1-6 | | X1-10 | X1-12 | X1-14 | X1-16 | X1-18 | X2-1 | |
| 22.4B | | 19.5C | | 26.6D | | | 20.9B | | 19.6B | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| X2-6 | X2-4 | X2-7 | | X2-11 | X2-9 | X2-12 | | X2-16 | X2-14 | X2-17 |
| X2-5 | | X2-8 | TCS1 | X2-10 | | X2-13 | TCS2 | X2-15 | | X2-18 | TCS3 |
| 20.8B | | | | | | | | | | |

slot G
REX640

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| +A4 | | | | | | | |
| DWG n° : 231151/SD/21 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
"REX640"' Protection Wiring

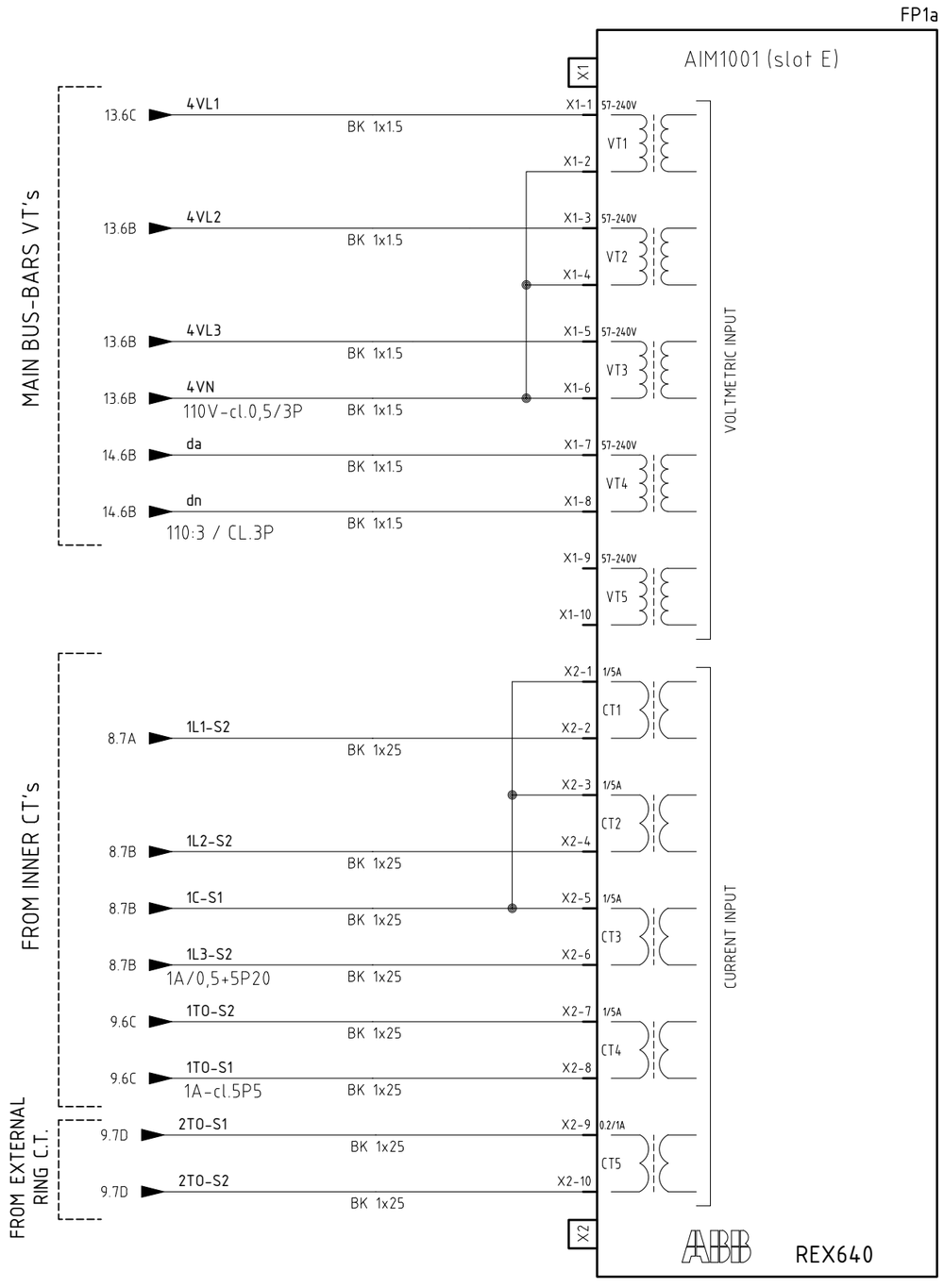
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00021
SHEET 15
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# "REX640" PROTECTION WIRING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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+A4
DWG n° : 231151/SD/21
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

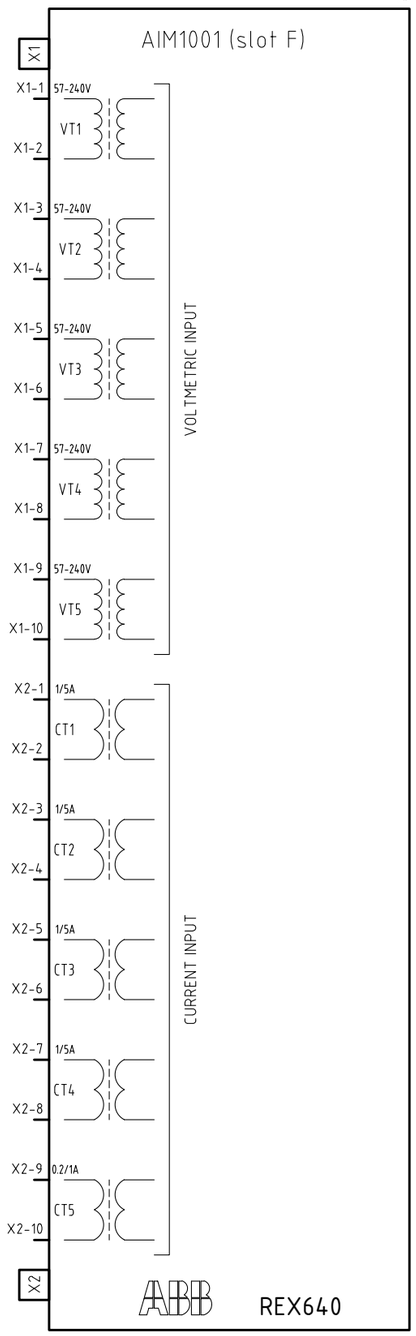
SHEET 1.6

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# "REX640" PROTECTION WIRING




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | = | | | | | |
| | | +A4 | | | | | |
| | IMESA ELECTRICAL ENGINEERING | DWG n° : 231151/SD/21 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| | | Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| CROSSWIND | ROSETTI MARINO | | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

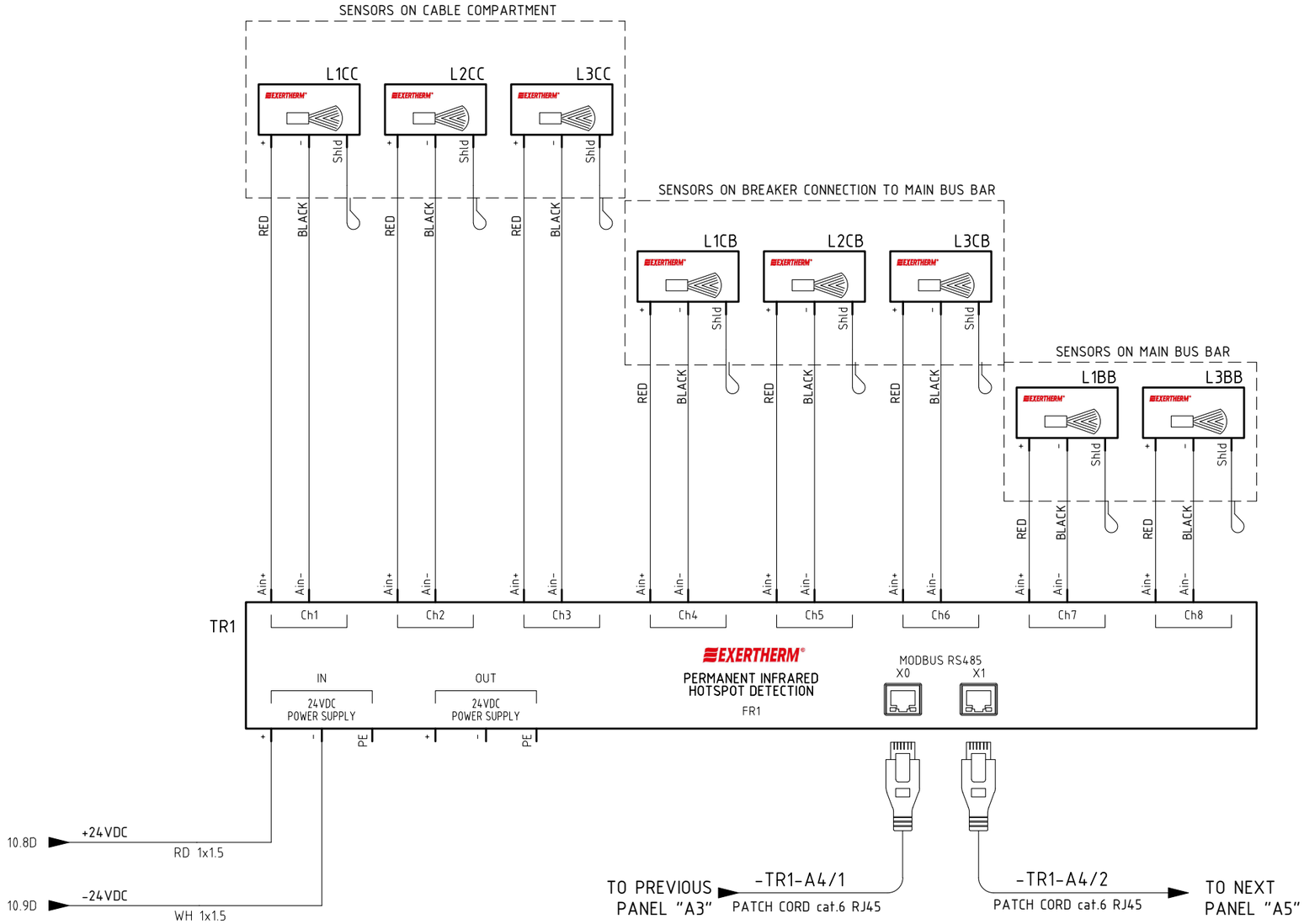
TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
"REX640"' Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

| A3 | DRAWING NO. | SHEET | REV. |
|---|---|---|---|
| | 1723002197-EL-DG-00021 | 1.7 | 03 |

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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+A4

DWG n° : 231151/SD/21

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Extherm Device

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 18

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# COMMAND CIRCUITS

ENABLING CONTACTOR TRUCK ENCLOSURE DOOR AND EARTHING SWITCH

UNLOCKING CONTACTOR ENCLOSURE DOOR

ENABLING EARTHING SWITCH COMMAND

ENABLING RACK-IN AND RACK-OUT CONTACTOR [LOCKING MAGNET]

10.4D +CL 110VDC (CL) — RD 1x1.5 — +CL 20.1A

P1 BK 13 14 — RD 1x1.5 — 20

KT1 19.2D 16 18 30" 15 — 21 RD 1x1.5

K1 ISOLATED BGT5 7.4B BGT5-53 BGT5-54 — 1 XM 2 XM — 22 RD 1x1.5 — K1 RLE4 7.4B 1 2

FP1 15.3A S01 REX640 X1 Slot G X1-7 X1-8 X1-6 — 23 — 24 RD 1x1.5 — BGE-1 BGE-2 — BGE RLE3 9.3B

FP1 15.3A S03 REX640 X2 Slot G X2-2 X2-3 X2-1 — 24 — 3 XM 4 XM — 25 RD 1x1.5 XDB-45 XDB-46 — K1 RLE2 7.4B

KT1 A1 B1 30" A2

10.4D -CL — WH 1x1.5 — -CL 20.1E

19.3A 15 16 18

23.9A 25 26 28

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | | |

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+A4

DWG n° : 231151/SD/21

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 19

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# CLOSING/OPENING COMMAND CIRCUITS

POWER SUPPLY MAC-R2 CARD

19.10A +CL 110VDC (CL)

RD 1x1.5

LOCAL OPENING COMMAND

S20 23 24 25.2A

K86 TRIP RELAY

K86 21.2D 40A 41A 4A

AVAILABLE OPENING COMMAND

AVAILABLE OPENING COMMAND

AVAILABLE OPENING COMMAND

5 XM 6 XM EXT

7 XM 8 XM EXT

9 XM 10 XM EXT

30

OPENING COMMAND

FP1 15.3A Slot G

PODP1

PO1_TCS

REX640 X2 (PSM)

X2-4 X2-6 X2-5 X2-7 X2-8 29

CLOSING COMMAND

FP1 15.3A X1-15 X1-16

POSP1

REX640 X1 Slot G

+CL 21.1A

RD 1x1.5

31

XDB-25 XDB-43 XDB-4 XDB-41 XDB-31 XDB-13

K1

DO 1

BGT3 BGF1 BGF1 BGB2

MBO MBC

OPENING COIL CLOSING COIL

XDB40-1 XDB40-2 PGC Electric Counter

AA 7.4B

DI 1 CLOSING

DI 2 OPENING

CONTROL UNIT
Type MAC R2
(DCO - Double Command Operated)

XDB-35 XDB-44 XDB-14 XDB-30 XDB-1 GNYE 1x2.5 XDB-40 GNYE 1x2.5

19.10D -CL

WH 1x1.5

-CL 21.1D

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DWG n° : 231151/SD/21

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 20

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# COMMAND CIRCUITS

OUTPUT PROTECTION RELAY
AVAILABLE
AVAILABLE
TRANSFORMER TRIP BUCHHOLZ
TRANSFORMER TRIP OIL TEMPERATURE
TRANSFORMER TRIP PRESSURE RELAY
TRANSFORMER TRIP WINDING TEMPERATURE
LOCAL RESET
REMOTE RESET
TRIP LOCK-OUT RELAY
UNDERVOLTAGE
CONTACTOR ISOLATED

20.10A +CL 110VDC (OP)

RD 1x1.5

+CL 22.2A

11 XM
13 XM
12 XM
14 XM
15 XM
16 XM

FP1c 23.1C X2-4 S01 REX640 X2 Slot B X2-3
K94B 22.5D
K94OT 22.5D
K94P 22.6D
K94WT 22.7D
PR 21.7D X2 X1
FP1c 23.1C X2-10 S04 REX640 X1 Slot B X2-9
K86 21.2D 40B 41B 48
K1 ISOLATED BGT5 7.4B BGT5-33 BGT5-34
KIRF 22.4D 22 24 38 39 21
K86 21.2D 30B 31B 3B
K1 DI 3 7.4B OPENING XDB-37 XDB-38

35 RD 1x1.5
36
37 RD 1x1.5
40 RD 1x1.5

K86 B1 C S B2 C RESET 1

PR 21.5A X1 X2

20.10E -CL WH 1x1.5 -CL 22.1D

26.9B 2A 20A 21A 30A
3A 31A 40A
20.5B 4A 41A 10B
26.6B 1B 11B 20B
23.5A 2B 21B 30B
21.9B 3B 31B 40B
21.7B 4B 41B

KM-50-1

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+A4
DWG n°: 231151/SD/21
Item n°: PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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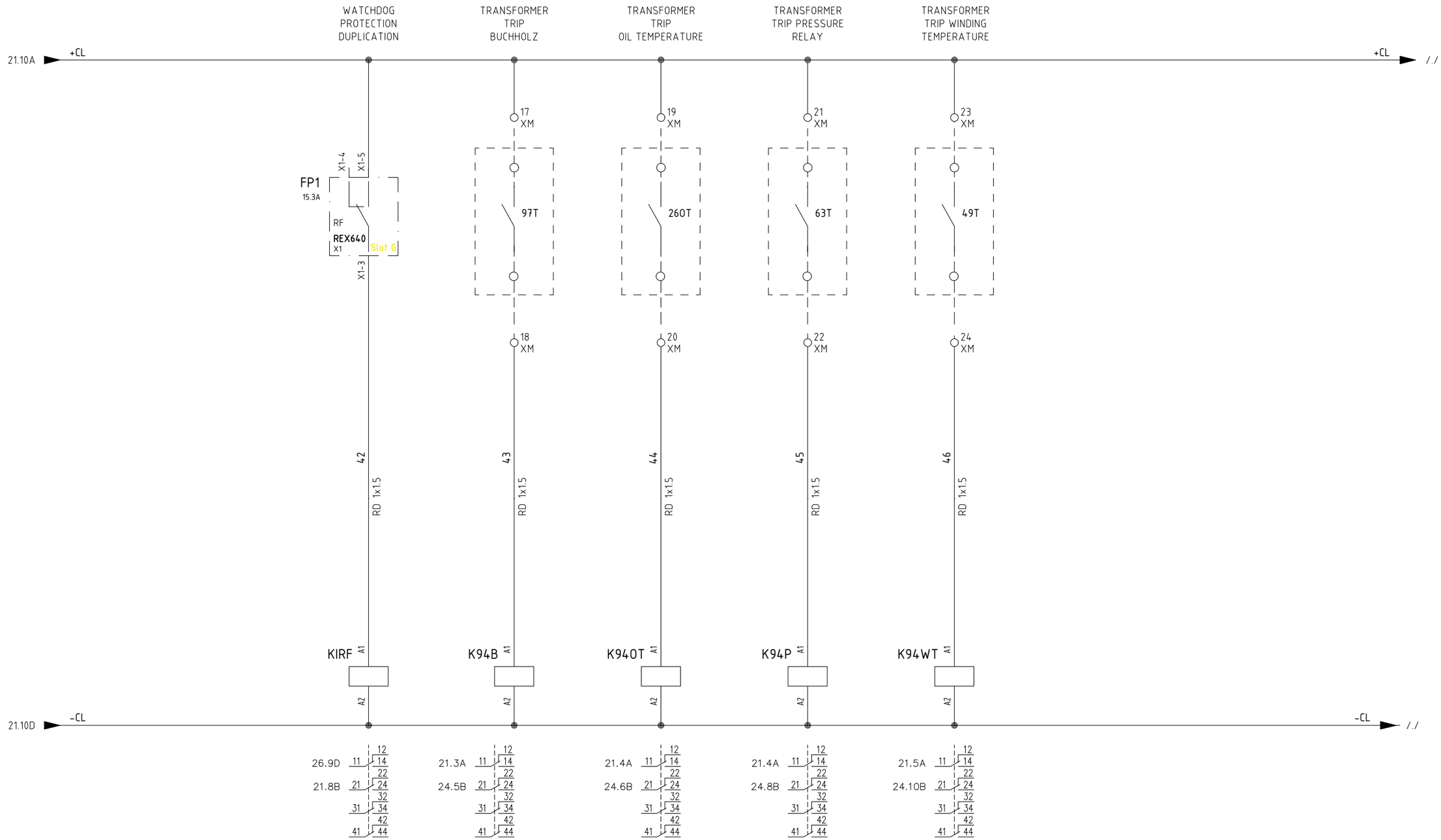
TITLE :
SG-100D1 – FUNCTIONAL TRANSF FEEDER TR200DE1
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00021
SHEET 21
REV. 03

File Name : 1723002197-EL-DG-00021 Rev.03

F.to UNI A3: 420mmx297mm




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|---|---|---|---|---|---|---|---|---|
| = | | | | | | | | |
| +A4 | | | | | | | | |
| DWG n° : 231151/SD/21 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | TITLE : SG-100D1 – FUNCTIONAL TRANSF FEEDER TR200DE1 | |
| Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | Command Circuit | |
| | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | A3 DRAWING NO. 1723002197-EL-DG-00021 | SHEET 22 / REV. 03 |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT

CONTACTOR CLOSED | CONTACTOR OPENED | CONTACTOR SERVICE POSITION | CONTACTOR TEST POSITION | EARTH SWITCH OPENED | EARTH SWITCH CLOSED | K86 RELAY TRIPPED | CONTACTOR READY | FUSES TRIPPED | SELECTOR IN LOCAL POSITION | SELECTOR IN REMOTE POSITION | EXTERNAL CLOSING INTERLOCK | FROM L.V. SWBD CB OPENED (CLOSING INTERLOCK) | UNLOCKING EARHTING SWITCH/ TRUCK CONTACTOR

15.10A +PR 110VDC (PR) — RD 1x1.5 — +PR 24.1A

XDB-11 | XDB-21 | XDB-22 | BGT4-51 | BGT4-52 | BGT5-23 | BGT5-24 | BGE-11 | BGE-12 | BGE-23 | BGE-24 | 20B | 21B | XDB-43 | XDB-44 | XDB-12 | XDB-48 | XDB-47

K1 BGB1/2 7.4B

K1 CONNECTED BGT4 7.4B

K1 ISOALTED BGT5 7.4B

BGE BGE 9.3B

BGE BGE 9.3B

K86 21.2D

K1 D01 7.4B

K1 BGF2 7.4B

SA1 11 12 SA1 13 14

25 XM 26 XM

L.V.SWITCHBOARD C.B. OPENED 27 XM 28 XM

KT1 19.2D 26 28 30" 25

50 51 52 53 54 55 56 57 58 59 60 61 62 63

RD 1x1.5

X1-1 X1-2 X1-3 X1-5 X1-6 X1-7 X1-9 X1-10 X1-11 X1-13 X1-14 X1-15 X1-17 X2-1

FP1c BIO1001 SLOT B

BI1 BI2 BI3 BI4 BI5 BI6 BI7 BI8 BI9 BI10 BI11 BI12 BI13 BI14

ABB REX640

X1-4 X1-8 X1-12 X1-16 X1-18 X2-2

15.10A -PR — WH 1x1.5 — -PR 24.1E

FP1c BIO1001 SLOT B

S01 S02 S03 S04 S05 S06 S07 S08

X2-4 X2-6 X2-8 X2-10 X2-12 X2-14 X2-16 X2-18

X2-3 X2-5 X2-7 X2-9 X2-11 X2-13 X2-15 X2-17

REX640

21.1A 26.7D 26.8D 21.6A

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+A4
DWG n° : 231151/SD/21
Item n° : PF1113279

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 23

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT

EARTING SWITCH OPEN (FROM MEASURING UNIT) | CLOSED AUXILIARY CIRCUIT MCB's | CLOSED AUXILIARY V.T. SECONDARY MCB's | TRANSFORMER ALARM BUCHHOLZ | TRANSFORMER TRIP BUCHHOLZ | TRANSFORMER ALARM OIL TEMPERATURE | TRANSFORMER TRIP OIL TEMPERATURE | TRANSFORMER ALARM OIL LEVEL | TRANSFORMER OIL LEVEL VERY LOW ALARM | TRANSFORMER TRIP OIL PRESSURE | TRANSFORMER ALARM WINDING TEMPERATURE | TRANSFORMER TRIP WINDING TEMPERATURE

23.10A +PR 110VDC (PR) — RD 1x1.5 — +PR 25.1A

QD2 10.4B — QV5 14.2B — QD4 10.8B — QV4 13.2C

25 XC — 33 XC — BGE — 34 XC — 26 XC

69 RD 1x1.5 — 71 RD 1x1.5 — 68 RD 1x1.5 — 70 RD 1x1.5 — 72 RD 1x1.5 — 73 RD 1x1.5 — 74 RD 1x1.5 — 75 RD 1x1.5 — 76 RD 1x1.5 — 77 RD 1x1.5 — 78 RD 1x1.5 — 79 RD 1x1.5 — 80 RD 1x1.5 — 81 RD 1x1.5

29 XM — 97T — 30 XM

97801 — K94B 22.5D — 31 XM — 260T — 32 XM

97802 — K94OT 22.5D — 33 XM — 710T — 34 XM

35 XM — 710T_1 — 36 XM

97803 — K94P 22.6D — 37 XM — 49T — 38 XM

97804 — K94WT 22.7D

FP1d
BIO1001
SLOT C
ABB
REX640

X1-1 X1-2 X1-3 X1-5 X1-6 X1-7 X1-9 X1-10 X1-11 X1-13 X1-14 X1-15 X1-17 X2-1

BI1 BI2 BI3 BI4 BI5 BI6 BI7 BI8 BI9 BI10 BI11 BI12 BI13 BI14

X1-4 X1-8 X1-12 X1-16 X1-18 X2-2

23.10D -PR — WH 1x1.5 — -PR 25.1D

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+A4
DWG n° : 231151/SD/21
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
"REX640" Protection Wiring - Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00021 | SHEET 24 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# "REX640" PROTECTION WIRING - DIGITAL INPUT

S1C LOCAL CLOSING COMMAND
S20 LOCAL OPENING COMMAD
FROM L.V. SWBD CB TEST POSITION
FROM L.V. SWBD TRIPPED
SPACE HEATER ON
AVAILABLE REMOTE OPENING COMMAND
TRANSFORMER GENERAL ALARM
MCB AND WATCHDOD PROTECTION RELAY
AVAILABLE

24.10A +PR 110VDC (PR) — RD 1x1.5 — +PR /.//

S1C GR 13 14 — 20.4B — S20 RD 13 14

39 XM — X2 — QB1 — C.B. IN TEST POSITION — X2 — 40 XM — L.V.SWITCHBOARD
41 XM — X2 — KA1 — TRIP — X2 — 42 XM — L.V.SWITCHBOARD
KGR 12.5D 12 14 11
43 XM — 44 XM
45 XM — 46 XM
29 XC — XC 31 — QD1 — KIRF — XC 32 — 30 XC — FROM UNIT A3
47 XM — 48 XM

82 RD 1x1.5 X1-1
83 RD 1x1.5 X1-2
84 RD 1x1.5 X1-3
85 RD 1x1.5 X1-5
86 RD 1x1.5 X1-6
87 RD 1x1.5 X1-7
88 RD 1x1.5 X1-9
89 RD 1x1.5 X1-10
90 RD 1x1.5 X1-11

FP1e
BIO1002
SLOT D
ABB
REX640
BI1 BI2 BI3 BI4 BI5 BI6 BI7 BI8 BI9

X1-4 X1-8 X1-12

SP01 SP02 SP03 SP04 SP05 SP06 SP07 SP08
X2-4 X2-6 X2-8 X2-10 X2-12 X2-14 X2-16 X2-18
X2-3 X2-5 X2-7 X2-9 X2-11 X2-13 X2-15 X2-17
TCS6 TCS8

24.10E -PR — WH 1x1.5 — -PR /.//

| | | | | | | | |
|---|---|---|---|---|---|---|---|
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| | +A4 | | | | | | |
| | DWG n° : 231151/SD/21 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| | Item n° : PF1113279 | 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| CROSSWIND | ROSETTI MARINO | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1
"REX640" Protection Wiring - Digital Input

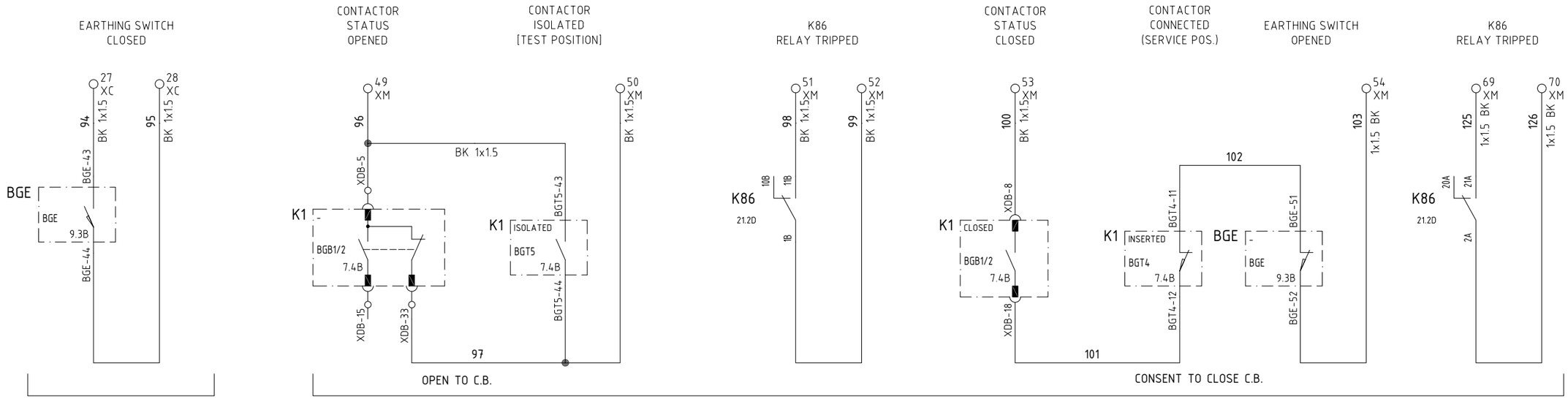
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

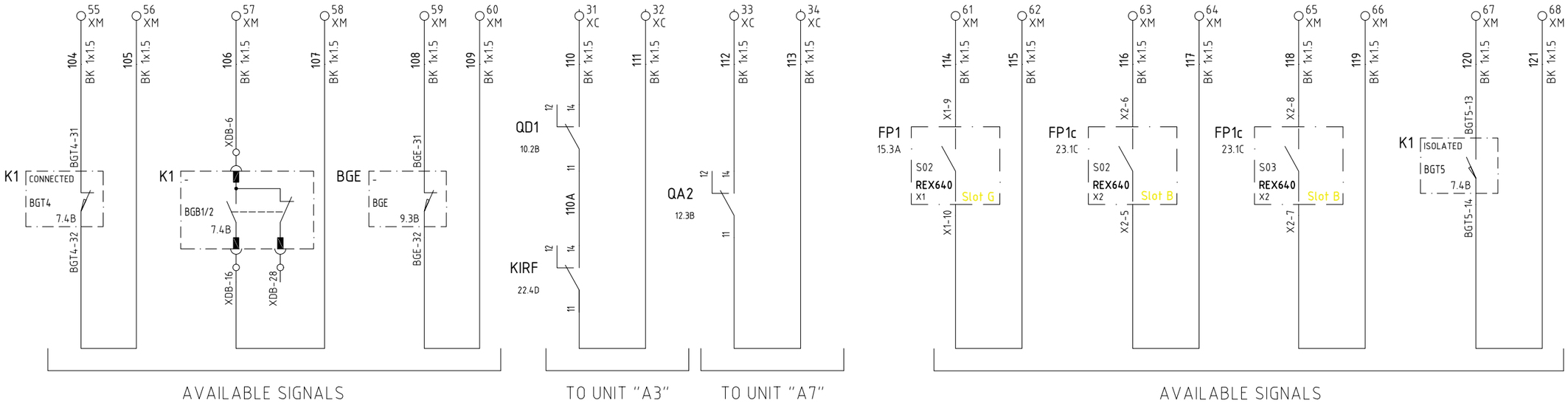
A3 | DRAWING NO. 1723002197-EL-DG-00021 | SHEET 25 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

# AVAILABLE SIGNALS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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DWG n° : 231151/SD/21

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Availables Signals

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 2.6

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

TYP - TR200DE1

XI

Ammeter Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 9.5C | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 2 | 9.5C | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 3 | 9.5C | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 4 | 8.4A | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 5 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 6 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 7 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 8 | 8.4B | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 9 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 10 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| 11 | 9.5D | 6 | HB220GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |

TYP - TR200DE1

XV

Voltmetric Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 13.4C | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 2 | 13.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 3 | 13.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 4 | 13.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |
| 5 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| 6 | 14.4B | 6 | HB210GR | Cabur | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type |
| | | | HB201GR | Cabur | HSCB.6/PT/GR End section - Grey |

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DWG n° : 231151/SD/21

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 27

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

TYP - TR200DE1

XC

Interconnection Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 10.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 2 | 10.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 3 | 10.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 4 | 10.1C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 5 | 10.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 6 | 10.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 7 | 10.7B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 8 | 10.7C | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 9 | 12.1A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 10 | 12.1B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 11 | 12.2A | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| 12 | 12.2B | 6 | HM320GR | Cabur | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| 13 | 13.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 13.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 13.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 13.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 13.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 13.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 13.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 13.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 21 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 14.1B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 14.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |
| 25 | 24.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 24.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 26.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 26.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 25.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 25.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 26.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 26.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 26.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 26.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM321GR | Cabur | HMT.6/PT/GR End section - Grey |

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DWG n° : 231151/SD/21

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 28

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

TYP - TR200DE1

XM

Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 1 | 19.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 2 | 19.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 3 | 19.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 4 | 19.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 5 | 20.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 6 | 20.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 7 | 20.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 8 | 20.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 9 | 20.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 10 | 20.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 11 | 21.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 12 | 21.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 13 | 21.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 21.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 21.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 21.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 22.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 22.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 22.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 22.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 21 | 22.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 22.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 22.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 22.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 25 | 23.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 23.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 23.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 23.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 24.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 24.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 24.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 24.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 24.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 24.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 24.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 24.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 37 | 24.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 38 | 24.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 39 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 40 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 41 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

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DWG n° : 231151/SD/21

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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TITLE :

SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 29

REV. 03

File Name : 1723002197-EL-DG-00021 Rev.03

F.to UNI A3: 420mmx297mm

TYP - TR200DE1

XM

Interface Terminals

| NumM | Fg. | Sez. | Tipo | Costruttore | Descrizione |
|---|---|---|---|---|---|
| 42 | 25.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 43 | 25.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 44 | 25.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 45 | 25.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 46 | 25.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 47 | 25.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 48 | 25.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 49 | 26.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 50 | 26.5A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 51 | 26.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 52 | 26.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 53 | 26.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 54 | 26.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 55 | 26.1C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 56 | 26.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 57 | 26.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 58 | 26.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 59 | 26.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 60 | 26.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 61 | 26.6C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 62 | 26.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 63 | 26.7C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 64 | 26.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 65 | 26.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 66 | 26.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 67 | 26.9C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 68 | 26.9C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 69 | 26.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 70 | 26.10A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 71 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 72 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 73 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 74 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 75 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 76 | | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |

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DWG n° : 231151/SD/21

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 14/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Terminal stripes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 3.0

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| BGE | 9 | 1VCF599700R0131 | 1 | EARTHING SWITCH ST-E 17.31 150 | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF599505R0001 | 1 | 5 AUX CONTACTS FOR EARTHING SWITCH | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF599504R0063 | 1 | KEY LOCKS ON EARTHING SWITCH | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF599700R0290 | 1 | EARTHING SWITCH OPERATING LEVER | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| C1 | 9 | 43931118 | 1 | VPIS 3,3÷36KV - DEVICE SIGNALLING VOLTAGE PRESENT KIT | ELECTRONSYSTEM | A4 | TRANSFORMER FEEDER TR-200DE1 |
| CB | 7 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| CC | 9 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| E1 | 12 | 74041 | 1 | LED LAMP 4W 4000K 313x30x22 | Beghelli | A4 | TRANSFORMER FEEDER TR-200DE1 |
| EH1 | 12 | R1R150230 | 1 | SPACE HEATER SKR 150W ALIM. 220VCA | Torresan | A4 | TRANSFORMER FEEDER TR-200DE1 |
| FP1 | 15 | 1VCF698331R0001 | 1 | REX640B10NN+AIM1+AIM1+ARC1+BIO1+BIO1+BI+O2+CMP2+COM1+LNG1+MCT1+PCL4+PSM3+SCT | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| HGR | 12 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | A4 | TRANSFORMER FEEDER TR-200DE1 |
| K1 | 7 | 1VCF305661R3200 | 1 | VACUUM CONTACTOR VSC7/P 3P 7,2KV 400A DOUBLE COMMAND (DCO) | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF309500R3881 | 1 | VACUUM CONTACTOR FITTED FOR DIN E=442mm FUSES | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF309500R0882 | 1 | NAMEPLATE IN ENGLISH LANGUAGE | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF309500R1881 | 1 | VACUUM CONTACTOR FOR UNIGEAR/UNISEC | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF309503R0881 | 1 | MAC-R2 ELECTRONIC CONTROL MODULE TYPE STANDARD | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF309503R1881 | 1 | VACUUM CONTACTOR CONFORMS TO THE IRC 62271-106 STANDARDS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF309588R0909 | 1 | POWER SUPPLY VOLTAGE OF MAC-R2 ELECTRONIC CONTROL MODULE 110VDC | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF309500R0100 | 1 | OPERATIONS COUNTER FOR VSC/P VERSIONE FOR SHIPPINGS REGISTER | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF349700R0407 | 1 | MECHANICAL INTERLOCK WITH DOOR | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF339700R0291 | 1 | POSITION CONTACTS FOR VD4 | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF339700R1909 | 1 | LOCKING MAGNET ON THE TRUCK 110Vdc (RLE2) | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF309503R0251 | 1 | KIT FOR FUSES DIAMETER 87mm | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF309500R0192 | 1 | LIFTING TOOL FOR SHIPPINGS REGISTERS VERSION | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF597111R0140 | 1 | POWER CUBE PB1/E L600 12kV 400A 31.5KA 3S | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF599700R0882 | 1 | NAMEPLATE IN ENGLISH LANGUAGE FOR POWERCUBE | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF599700R5886 | 1 | PB FOR VSC | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF599700R4882 | 1 | PAINTED DOOR | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF599504R0042 | 1 | LOCK TO PREVENT RACKING-IN WITH EARTHING SWITCH | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF599700R0162 | 1 | 58 POLES CONNECTOR + ATOXIC WIRING L=0.8mt | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF599505R0111 | 1 | FAIL-SAFE SHUTTER ELEMENTS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF579700R0909 | 1 | ELECTROMECHANICAL ISOLATING INTERLOCK CIRCUIT-BREAKER/DOOR 110Vdc (RLE4) | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1VCF599700R0280 | 1 | INTERLOCK FOR DOOR EARTHING SWITCH | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | 1YMB760741M4811 | 1 | FUSE LINK FOR MOTOR PROTECTION 7,2kV 250A 442x65mm - CMF | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| K86 | 21 | RMBE13-C110T | 1 | BISTABLE RELAY 110VDC 7SC-5A TROP. | Amra | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | PAVM321 | 1 | SOCKET WITH SCREW TO RELAY TYPE PAVM321 | Amra | A4 | TRANSFORMER FEEDER TR-200DE1 |
| K94B | 22 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| K94OT | 22 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| K94P | 22 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |

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DWG n° : 231151/SD/21

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00021 | SHEET 31 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| K94P | 22 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| K94WT | 22 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| KGR | 12 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | ER 552 0 | 1 | CR-M230AC2L SUPPLY 230VAC 2C/O 250V/6A LED | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| KIRF | 22 | ER 589 2 | 1 | CR-M110DC4L SUPPLY 110VDC 4C/O 250V/6A LED | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| KT1 | 19 | H3DKM2ACDC24240 | 1 | MULTIFUNCTION TIMER RELAY Vaux=24÷240Vac/dc - 2SC | Omron | A4 | TRANSFORMER FEEDER TR-200DE1 |
| L1C | 18 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A4 | TRANSFORMER FEEDER TR-200DE1 |
| L1I | 18 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A4 | TRANSFORMER FEEDER TR-200DE1 |
| L1MS | 18 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A4 | TRANSFORMER FEEDER TR-200DE1 |
| L2C | 18 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A4 | TRANSFORMER FEEDER TR-200DE1 |
| L2I | 18 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A4 | TRANSFORMER FEEDER TR-200DE1 |
| L3C | 18 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A4 | TRANSFORMER FEEDER TR-200DE1 |
| L3I | 18 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A4 | TRANSFORMER FEEDER TR-200DE1 |
| L3MS | 18 | 801100 | 1 | IR SENSOR 10m CABLE | EXERTHERM | A4 | TRANSFORMER FEEDER TR-200DE1 |
| LS | 12 | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | A4 | TRANSFORMER FEEDER TR-200DE1 |
| OD1 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A4 | TRANSFORMER FEEDER TR-200DE1 |
| OD2 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A4 | TRANSFORMER FEEDER TR-200DE1 |
| OD3 | 9 | 990003 | 1 | MEDIUM VOLTAGE DISCHARGE DMI-9-10-1-L Ur=9kV | DEHN | A4 | TRANSFORMER FEEDER TR-200DE1 |
| P1 | 19 | KW 080 2 | 1 | MP1-10B BLACK PUSH BUTTON UNSTABLE | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| PR | 21 | KW 101 6 | 1 | YELLOW LIGHT PUSH BUTTON | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | KV 022 5 | 1 | MLBL-05W YELLOW LED BLOCK INTEGRATED 110÷130VAC | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| QA2 | 12 | B427917 | 1 | DDA202 AC 25A 300MA BLOCCO DIFFERENZIALE 2P | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | A563819 | 1 | S2-CS/H6R CONTATTO DI SEGNALAZIONE/AUX 1SC | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | S550284 | 1 | S202M C10 INTERRUTTORE AUTOMATICO 10KA 2P | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| QD1 | 10 | A563819 | 1 | S2-CS/H6R CONTATTO DI SEGNALAZIONE/AUX 1SC | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | S550253 | 1 | S202M C 4 INTERRUTTORE AUTOMATICO 10KA 2P | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| QD2 | 10 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| QD4 | 10 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| QV4 | 13 | S550680 | 1 | S204M C 2 AUTOMATIC CIRCUIT-BREAKER 10KA 4P | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| QV5 | 14 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |

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DWG n° : 231151/SD/21
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00021 | SHEET 32 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| QV5 | 14 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| S1C | 25 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | KW 076 0 | 1 | MP1-10G PUSH BUTTON GREEN WITH BLACK RING | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| S2O | 25 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | KW 075 2 | 1 | MP1-10R PUSH BUTTON RED WITH BLACK RING | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| SA1 | 23 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | EO 571 3 | 1 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | KW 329 3 | 1 | M2SS2-10B HANDLE SELECTOR 2P 90° BLACK RING BLACK | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| TI-L1 | 8 | ATB-10-BS__015 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 200/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A4 | TRANSFORMER FEEDER TR-200DE1 |
| TI-L2 | 8 | ATB-10-BS__015 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 200/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A4 | TRANSFORMER FEEDER TR-200DE1 |
| TI-L3 | 8 | ATB-10-BS__015 | 1 | CURRENT TRANSFORMER 7,2kV 50Hz 200/1A cl.0,5-5P20 (5VA)- 25kA | ESITAS | A4 | TRANSFORMER FEEDER TR-200DE1 |
| TO | 9 | KAP-150/250-55 | 1 | CURRENT TRANSFORMER 0,72/3/-kV 100/1 50Hz | ESITAS | A4 | TRANSFORMER FEEDER TR-200DE1 |
| TR1 | 18 | 800208 | 1 | MODBUS DATACARD 8 CHANNELS | Exertherm | A4 | TRANSFORMER FEEDER TR-200DE1 |
| XC | | HM320GR | 12 | HMM.6/GR Feed-through Terminal Block - Grey (6 mmq) | Cabur | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | HM250GR | 22 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | HM251GR | 3 | HMT.4/PT/GR End section - Grey | Cabur | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | HM321GR | 3 | HMT.6/PT/GR End section - Grey | Cabur | A4 | TRANSFORMER FEEDER TR-200DE1 |
| XI | | HB220GR | 11 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | HB201GR | 3 | HSCB.6/PT/GR End section - Grey | Cabur | A4 | TRANSFORMER FEEDER TR-200DE1 |
| XM | | HM250GR | 76 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | HM251GR | 1 | HMT.4/PT/GR End section - Grey | Cabur | A4 | TRANSFORMER FEEDER TR-200DE1 |
| XS1 | 12 | E 9447 7 | 1 | SOCKET | ABB | A4 | TRANSFORMER FEEDER TR-200DE1 |
| XV | | HB210GR | 6 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type | Cabur | A4 | TRANSFORMER FEEDER TR-200DE1 |
| | | HB201GR | 2 | HSCB.6/PT/GR End section - Grey | Cabur | A4 | TRANSFORMER FEEDER TR-200DE1 |

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DWG n° : 231151/SD/21

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 26/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - FUNCTIONAL TRANSF FEEDER TR200DE1

Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00021

SHEET 33

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00021 Rev.03

1.4.8.SG-100D1 HV SWG INTERCONNECTING AND AUX DISTRIBUTION DIAGRAM (including BOM) ,
Doc. No. 1723002197-EL-DG-00022

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# "SG-100D1" MV SWBD 6,6kV

# INTERCONNECTING

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macuke | 12/09/2024 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 28/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/22
Item n° : PF1113279

TITLE : SG–100D1 – INTERCONNECTING

Cover

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197–EL–DG–00022 | SHEET 1 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00022 Rev.03

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| 7 | Network architecture IEC 61850 | | | | | | | | | | | | | | | | | | | | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231151/SD/22

Item n° : PF1113279

TITLE : SG-100D1 - INTERCONNECTING

Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00022

SHEET 2

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00022 Rev.03

| TABLE OF REFERENCES | | |
|---|---|---|
| Document nr. Client | Document nr. Supplier | Document title |
| 1723002197-EL-DA-00006 | 231151/SD/6 | SG-100D1 GENERAL ARRANGEMENTS |
| 1723002197-EL-DG-00010 | 231151/SD/10 | SG-100D1 ELECTRICAL SINGLE LINE DIAGRAM |
| 1723002197-EL-DG-00015 | 231151/SD/15 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - INCOMING FEEDER |
| 1723002197-EL-DG-00016 | 231151/SD/16 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - BUS BAR METERING |
| 1723002197-EL-DG-00017 | 231151/SD/17 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - BESS FEEDER |
| 1723002197-EL-DG-00018 | 231151/SD/18 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - ELECTROLYSER FEEDER |
| 1723002197-EL-DG-00019 | 231151/SD/19 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - FUEL CELL FEEDER |
| 1723002197-EL-DG-00020 | 231151/SD/20 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - TRANSFORMER FEEDER TR200ED1 |
| 1723002197-EL-DG-00021 | 231151/SD/21 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - TRANSFORMER FEEDER TR200DE1 |
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NOTE: To better understand this document you have to use in conjuction with the documents listed on the table above

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231151/SD/22

Item n° : PF1113279

TITLE : SG-100D1 - INTERCONNECTING

Table of reference documents

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00022

SHEET 3

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00022 Rev.03

| | ELECTROLYSER "A1" | SOLAR "A2" | BESS PACKAGE "A3" | TRANSF. 1,6MVA TR-200DE1 "A4" | VT BUS BARS "A5" | INCOMING "A6" | FUEL CELL "A7" |
|---|---|---|---|---|---|---|---|
| V.aux 110Vdc | 1 XC XC-2/A1 — 2 XC XC-2/A1 | XC-1/A2 1 XC — RD 1x6 — 2 XC XC-2/A2 | XC-1/A3 1 XC — 2 XC XC-2/A3 | XC-1/A4 1 XC — RD 1x6 — 2 XC XC-2/A4 | XC-1/A5 1 XC — RD 1x6 — 2 XC XC-2/A5 | XC-1/A6 1 XC — 2 XC XC-2/A6 | XC-1/A7 1 XC — RD 1x6 — 2 XC |
| | 3 XC XC-4/A1 — 4 XC XC-4/A1 | XC-3/A2 3 XC — WH 1x6 — 4 XC XC-4/A2 | XC-3/A3 3 XC — 4 XC XC-4/A3 | XC-3/A4 3 XC — WH 1x6 — 4 XC XC-4/A4 | XC-3/A5 3 XC — WH 1x6 — 4 XC XC-4/A5 | XC-3/A6 3 XC — 4 XC XC-4/A6 | XC-3/A7 3 XC — WH 1x6 — 4 XC |
| V.aux 24Vdc | 5 XC XC-6/A1 — 6 XC XC-6/A1 | XC-5/A2 5 XC — RD 1x1,5 — 6 XC XC-6/A2 | XC-5/A3 5 XC — 6 XC XC-6/A3 | XC-5/A4 5 XC — RD 1x1,5 — 6 XC XC-6/A4 | XC-5/A5 5 XC — RD 1x1,5 — 6 XC XC-6/A5 | XC-5/A6 5 XC — 6 XC XC-6/A6 | XC-5/A7 5 XC — RD 1x1,5 — 6 XC |
| | 7 XC XC-8/A1 — 8 XC XC-8/A1 | XC-7/A2 7 XC — WH 1x1,5 — 8 XC XC-8/A2 | XC-7/A3 7 XC — 8 XC XC-8/A3 | XC-7/A4 7 XC — WH 1x1,5 — 8 XC XC-8/A4 | XC-7/A5 7 XC — WH 1x1,5 — 8 XC XC-8/A5 | XC-7/A6 7 XC — 8 XC XC-8/A6 | XC-7/A7 7 XC — WH 1x1,5 — 8 XC |
| V.aux 230Vac | 9 XC XC-10/A1 — 10 XC XC-10/A1 | XC-9/A2 9 XC — BK 1x6 — 10 XC XC-10/A2 | XC-9/A3 9 XC — 10 XC XC-10/A3 | XC-9/A4 9 XC — BK 1x6 — 10 XC XC-10/A4 | XC-9/A5 9 XC — BK 1x6 — 10 XC XC-10/A5 | XC-9/A6 9 XC — 10 XC XC-10/A6 | XC-9/A7 9 XC — BK 1x6 — 10 XC |
| | 11 XC XC-12/A1 — 12 XC XC-12/A1 | XC-11/A2 11 XC — BK 1x6 — 12 XC XC-12/A2 | XC-11/A3 11 XC — 12 XC XC-12/A3 | XC-11/A4 11 XC — BK 1x6 — 12 XC XC-12/A4 | XC-11/A5 11 XC — BK 1x6 — 12 XC XC-12/A5 | XC-11/A6 11 XC — 12 XC XC-12/A6 | XC-11/A7 11 XC — BK 1x6 — 12 XC |
| VOLTMETRICAL LINE FROM MAIN BUS BAR 110:1,73Vac | 13 XC XC-14/A1 — 14 XC XC-14/A1 | XC-13/A2 13 XC — BK 1x1.5 — 14 XC XC-14/A2 | XC-13/A3 13 XC — 14 XC XC-14/A3 | XC-13/A4 13 XC — BK 1x1.5 — 14 XC XC-14/A4 | XC-13/A5 13 XC — BK 1x1.5 — 14 XC XC-14/A5 | XC-13/A6 13 XC — 14 XC XC-14/A6 | XC-13/A7 13 XC — BK 1x1.5 — 14 XC |
| | 15 XC XC-16/A1 — 16 XC XC-16/A1 | XC-15/A2 15 XC — BK 1x1.5 — 16 XC XC-16/A2 | XC-15/A3 15 XC — 16 XC XC-16/A3 | XC-15/A4 15 XC — BK 1x1.5 — 16 XC XC-16/A4 | XC-15/A5 15 XC — BK 1x1.5 — 16 XC XC-16/A5 | XC-15/A6 15 XC — 16 XC XC-16/A6 | XC-15/A7 15 XC — BK 1x1.5 — 16 XC |
| | 17 XC XC-18/A1 — 18 XC XC-18/A1 | XC-17/A2 17 XC — BK 1x1.5 — 18 XC XC-18/A2 | XC-17/A3 17 XC — 18 XC XC-18/A3 | XC-17/A4 17 XC — BK 1x1.5 — 18 XC XC-18/A4 | XC-17/A5 17 XC — BK 1x1.5 — 18 XC XC-18/A5 | XC-17/A6 17 XC — 18 XC XC-18/A6 | XC-17/A7 17 XC — BK 1x1.5 — 18 XC |
| | 19 XC XC-20/A1 — 20 XC XC-20/A1 | XC-19/A2 19 XC — BK 1x1.5 — 20 XC XC-20/A2 | XC-19/A3 19 XC — 20 XC XC-20/A3 | XC-19/A4 19 XC — BK 1x1.5 — 20 XC XC-20/A4 | XC-19/A5 19 XC — BK 1x1.5 — 20 XC XC-20/A5 | XC-19/A6 19 XC — 20 XC XC-20/A6 | XC-19/A7 19 XC — BK 1x1.5 — 20 XC |
| VOLTMETRICAL LINE FROM MAIN BUS BAR 110:3Vac | 21 XC XC-22/A1 — 22 XC XC-22/A1 | XC-21/A2 21 XC — BK 1x1.5 — 22 XC XC-22/A2 | XC-21/A3 21 XC — 22 XC XC-22/A3 | XC-21/A4 21 XC — BK 1x1.5 — 22 XC XC-22/A4 | XC-21/A5 21 XC — BK 1x1.5 — 22 XC XC-22/A5 | XC-21/A6 21 XC — 22 XC XC-22/A6 | XC-21/A7 21 XC — BK 1x1.5 — 22 XC |
| | 23 XC XC-24/A1 — 24 XC XC-24/A1 | XC-23/A2 23 XC — BK 1x1.5 — 24 XC XC-24/A2 | XC-23/A3 23 XC — 24 XC XC-24/A3 | XC-23/A4 23 XC — BK 1x1.5 — 24 XC XC-24/A4 | XC-23/A5 23 XC — BK 1x1.5 — 24 XC XC-24/A5 | XC-23/A6 23 XC — 24 XC XC-24/A6 | XC-23/A7 23 XC — BK 1x1.5 — 24 XC |
| EARTH.SWITCH OPEN (VT BUS BARS UNIT) | 25 XC XC-25/A1 — BK 1x1.5 — XC-27/A5 27 XC | | | | | | |
| | 26 XC XC-26/A1 — BK 1x1.5 — XC-28/A5 28 XC | | | | | | |
| | | 25 XC XC-25/A2 — BK 1x1.5 — XC-29/A5 29 XC | | | | | |
| | | 26 XC XC-26/A2 — BK 1x1.5 — XC-30/A5 30 XC | | | | | |
| | | | 25 XC XC-25/A3 — BK 1x1.5 — XC-31/A5 31 XC | | | | |
| | | | 26 XC XC-26/A3 — BK 1x1.5 — XC-32/A5 32 XC | | | | |

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DWG n° : 231151/SD/22
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 – INTERCONNECTING

Intercolumn Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00022

SHEET 4

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00022 Rev.03

| | ELECTROLYSER "A1" | SOLAR "A2" | BESS PACKAGE "A3" | TRANSF. 1,6MVA TR-200DE1 "A4" | VT BUS BARS "A5" | INCOMING "A6" | FUEL CELL "A7" |
|---|---|---|---|---|---|---|---|
| EARTH.SWITCH OPEN (FROM VT BUS BARS UNIT) | | | | 25 XC — XC-25/A4 | XC-33/A5 — 33 XC (BK 1x1.5) | | |
| | | | | 26 XC — XC-26/A4 | XC-34/A5 — 34 XC (BK 1x1.5) | | |
| | | | | | 35 XC — XC-35/A5 | XC-25/A6 — 25 XC (BK 1x1.5) | |
| | | | | | 36 XC — XC-36/A5 | XC-26/A6 — 26 XC (BK 1x1.5) | |
| | | | | | 37 XC — XC-37/A5 | | XC-25/A7 — 25 XC (BK 1x1.5) |
| | | | | | 38 XC — XC-38/A5 | | XC-26/A7 — 26 XC (BK 1x1.5) |
| ENABLING COMMAND EARTHING SWITCH VT BUS BARS UNIT | 28 XC — XC-28/A1 | XC-27/A2 — 27 XC (BK 1x1.5) | 28 XC — XC-28/A2 | XC-27/A3 — 27 XC (BK 1x1.5) | 28 XC — XC-28/A3 | XC-27/A4 — 27 XC (BK 1x1.5) | 28 XC — XC-28/A4 |
| | XC-25/A5 — 25 XC (BK 1x1.5) | | 26 XC — XC-26/A5 | XC-27/A6 — 27 XC (BK 1x1.5) | | 28 XC — XC-28/A6 | XC-27/A7 — 27 XC (BK 1x1.5) |
| | 27 XC — XC-27/A1 (BK 1x1.5) | | | | | | XC-28/A7 — 28 XC (BK 1x1.5) |
| SIGNALS FROM VT BUS BARS UNIT TO CELL PAKAGE UNIT | | | | | 45 XC — XC-45/A5 | | XC-29/A7 — 29 XC (BK 1x1.5) |
| | | | | | 46 XC — XC-46/A5 | | XC-30/A7 — 30 XC (BK 1x1.5) |
| | | | | | 49 XC — XC-49/A5 | | XC-31/A7 — 31 XC (BK 1x1.5) |
| | | | | | 50 XC — XC-50/A5 | | XC-32/A7 — 32 XC (BK 1x1.5) |
| | | | | | 41 XC — XC-41/A5 | | XC-33/A7 — 33 XC (BK 1x1.5) |
| | | | | | 42 XC — XC-42/A5 | | XC-34/A7 — 34 XC (BK 1x1.5) |
| | | | | | 43 XC — XC-43/A5 | | XC-35/A7 — 35 XC (BK 1x1.5) |
| | | | | | 44 XC — XC-44/A5 | | XC-36/A7 — 36 XC (BK 1x1.5) |
| | | | | | 47 XC — XC-47/A5 | | XC-37/A7 — 37 XC (BK 1x1.5) |
| | | | | | 48 XC — XC-48/A5 | | XC-38/A7 — 38 XC (BK 1x1.5) |
| | | | | | 39 XC — XC-39/A5 | | XC-39/A7 — 39 XC (BK 1x1.5) |
| | | | | | 40 XC — XC-40/A5 | | XC-40/A7 — 40 XC (BK 1x1.5) |
| | | | | | 51 XC — XC-51/A5 | | XC-41/A7 — 41 XC (BK 1x1.5) |
| | | | | | 52 XC — XC-52/A5 | | XC-42/A7 — 42 XC (BK 1x1.5) |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231151/SD/22

Item n° : PF1113279

TITLE : SG-100D1 - INTERCONNECTING

Intercolumn Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00022

SHEET 5

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00022 Rev.03

| | ELECTROLYSER "A1" | SOLAR "A2" | BESS PACKAGE "A3" | TRANSF. 1,6MVA TR-200DE1 "A4" | VT BUS BARS "A5" | INCOMING "A6" | FUEL CELL "A7" |
|---|---|---|---|---|---|---|---|
| PROTECTION RELAY HEALTHY | 29 XC-29/A1 XC BK 1x1.5 | | | | | | XC-47/A7 BK 1x1.5 47 XC |
| | 30 XC-30/A1 XC BK 1x1.5 | | | | | | XC-48/A7 BK 1x1.5 48 XC |
| | 31 XC-31/A1 XC BK 1x1.5 | XC-29/A2 29 XC | | | | | |
| | 32 XC-32/A1 XC BK 1x1.5 | XC-30/A2 30 XC | | | | | |
| | | 31 XC-31/A2 XC BK 1x1.5 | XC-29/A3 29 XC | | | | |
| | | 32 XC-32/A2 XC BK 1x1.5 | XC-30/A3 30 XC | | | | |
| | | | 31 XC-31/A3 XC BK 1x1.5 | XC-29/A4 29 XC | | | |
| | | | 32 XC-32/A3 XC BK 1x1.5 | XC-30/A4 30 XC | | | |
| | | | 37 XC-37/A3 XC BK 1x1.5 | XC-31/A4 31 XC | | | |
| | | | 38 XC-38/A3 XC BK 1x1.5 | XC-32/A4 32 XC | | | |
| | | | | | | 31 XC-31/A6 XC BK 1x1.5 | XC-45/A7 45 XC |
| | | | | | | 32 XC-32/A6 XC BK 1x1.5 | XC-46/A7 46 XC |
| 230Vac AUXILIARY SUPPLY HEALTHY | 33 XC-33/A1 XC BK 1x1.5 | XC-33/A2 BK 1x1.5 34 XC | 34 XC-34/A2 XC BK 1x1.5 | XC-34/A3 34 XC | 33 XC-33/A3 XC BK 1x1.5 | XC-33/A4 33 XC | 34 XC-34/A4 XC BK 1x1.5 |
| | 34 XC-34/A1 XC BK 1x1.5 | | | | | | XC-44/A7 44 XC |
| OPENING COMMAND FROM INCOMING | 35 XC-35/A1 XC BK 1x1.5 | | | | | | XC-35/A6 35 XC |
| | 36 XC-36/A1 XC BK 1x1.5 | | | | | | XC-36/A6 36 XC |

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IMESA ELECTRICAL ENGINEERING

DWG n° : 231151/SD/22

Item n° : PF1113279

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - INTERCONNECTING

Intercolumn Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

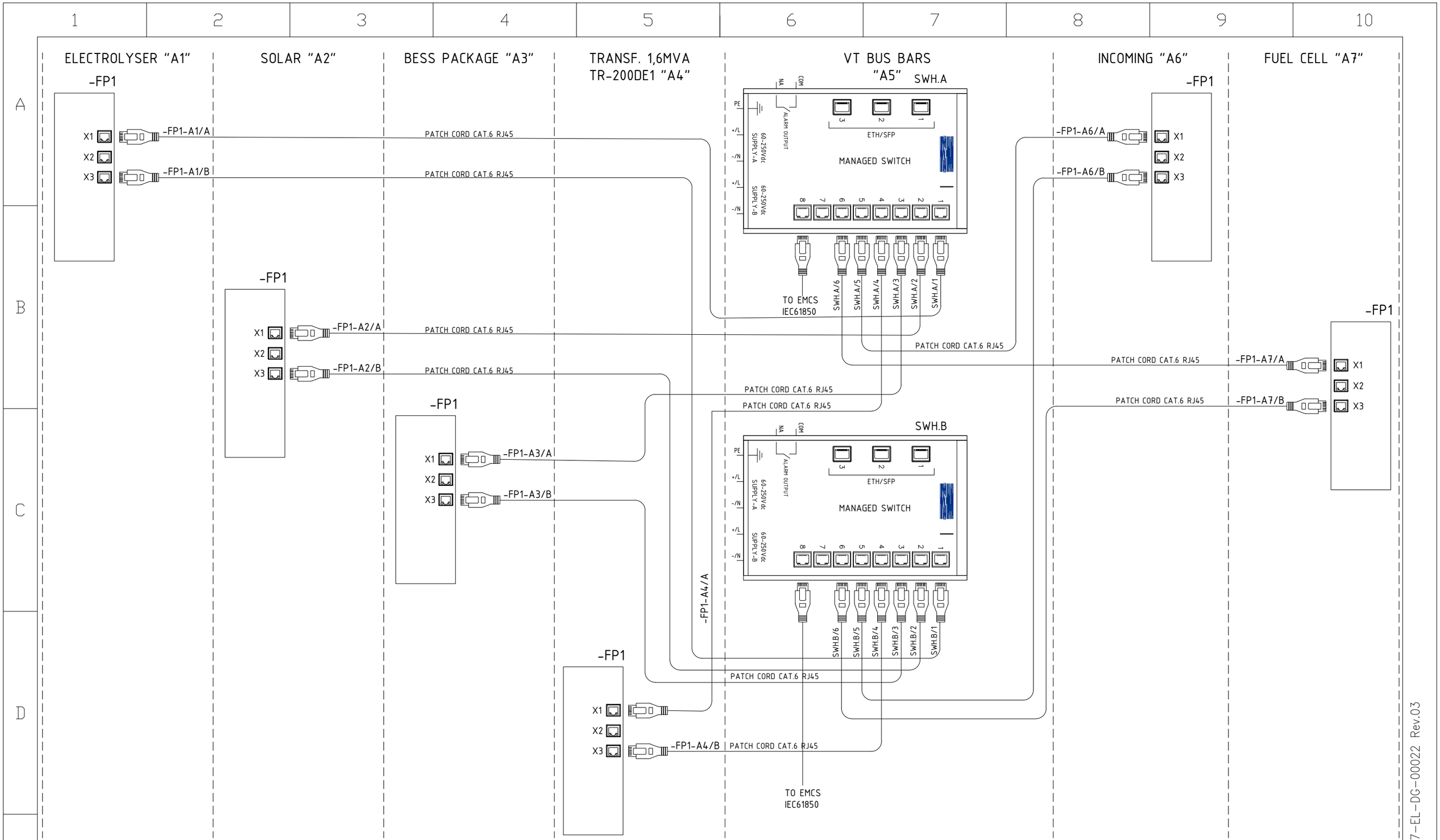
DRAWING NO. 1723002197-EL-DG-00022

SHEET 6

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00022 Rev.03




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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231151/SD/22

Item n° : PF1113279

TITLE : SG-100D1 - INTERCONNECTING

Network architecture IEC 61850

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

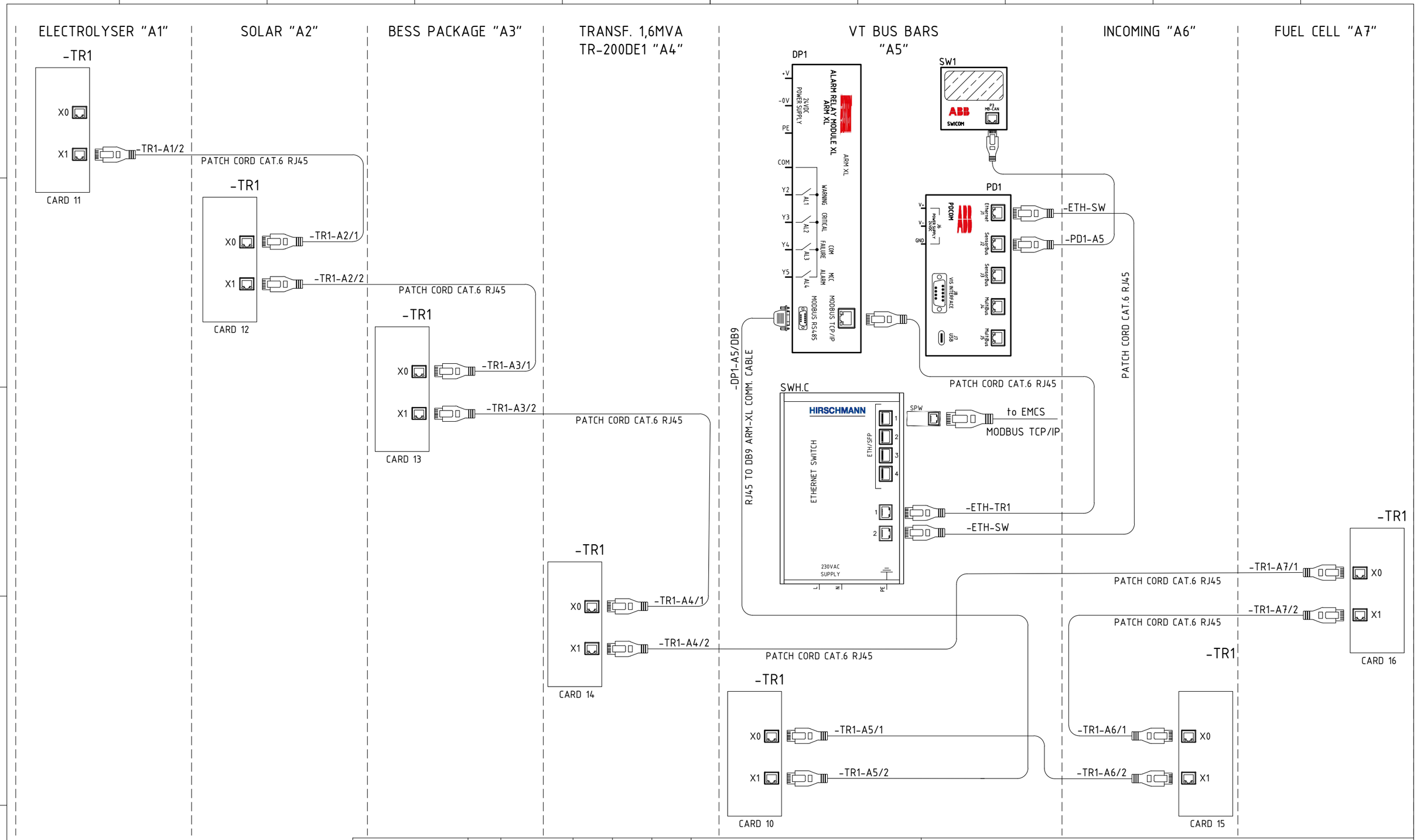
DRAWING NO. 1723002197-EL-DG-00022

SHEET 7

REV. 03

File Name : 1723002197-EL-DG-00022 Rev.03

F.to UNI A3: 420mmx297mm




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 28/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 1 | 23/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/22
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 - INTERCONNECTING

Network architecture Modbus TCP/IP

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00022

SHEET 8

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00022 Rev.03

1.4.9.SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - INCOMINGS, INTERCONNECTING AND AUX DISTRIBUTION,

Doc. No. 1723002197-EL-DG-00030

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# BASE LOAD POWER HUB (BLPH)

# "SG-200N1" LV SWBD 400/230V

# ELECTRICAL FUNCTIONAL DIAGRAM

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macerle | 28/10/2024 |

IMESA ELECTRICAL ENGINEERING

DWG n°: 231298/SD/30

Item n°: PF1002983/30

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1 FUNCTIONAL DIAGRAM Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 001

REV. 02

CROSSWIND

ROSETTI MARINO

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

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| 002 | Index | | | | | | | | | | |
| 003 | Index | | | | | | | | | | |
| 004 | Graphical Symbols | | | | | | | | | | |
| 005 | Graphical Symbols | | | | | | | | | | |
| 006 | General Note | | | | | | | | | | |
| 007 | Selector Switch | | | | | | | | | | |
| 008 | Door Layout | | | | | | | | | | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| = | | | | | |
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| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/30

Item n° : PF1002983/30

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 002

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/30

Item n° : PF1002983/30

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

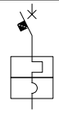
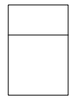
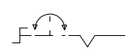
SHEET 003

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# SYMBOLS LEGEND

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|   | CIRCUIT BREAKER WITH AUTOMATIC RELEASE |  | CAPACITIVE VOLTAGE DIVIDER |  | COIL OF A MECHANICALLY LATCHED RELAY |  | DELAYED ACTION (IN THE DIRECTION OF MOVEMENT FROM THE ARC TOWARDS ITS CENTRE) |
|  | CIRCUIT BREAKER WITH AUTOMATIC RELEASE AND BUILT-IN THERMOMAGNETIC RELEASE |  | CURRENT TRANSFORMER |  | INDICATOR, ELECTROMECHANICAL ELEMENT |  | POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT |
|  | SWITCH DISCONNECTOR |  | CURRENT TRANSFORMER WITH TWO CORES AND TWO SECONDARY WINDINGS |  | LAMP (GENERAL SYMBOL) |  | POSITION SWITCH (LIMIT SWITCH), BREAK CONTACT |
|  | CONTACTOR |  | INDICATING INSTRUMENT GENERAL SYMBOL |  | SEMICONDUCTOR DIODE |  | OPERATED BY PUSHING |
|  | LOCK WITH FREE KEY WHEN THE DEVICE IS IN OPEN POSITION |  | INTEGRATING INSTRUMENT (GENERAL SYMBOL) |  | LED |  | OPERATED BY TURNING |
|  | LOCK WITH FREE KEY WHEN THE DEVICE IS IN CLOSE POSITION |  | DISCONNECTING FUSE, NOT WITH LIVE CIRCUIT AND WITH MECHANICAL LINKAGE (STRIKER FUSE) |   | TRANSDUCER OF ALTERNATING CURRENT MEASURE INTO DIRECT CURRENT SIGNAL |  | THREE HELD POSITIONS TURNING SWITCH |
|  | PLUG AND SOCKET (MALE AND FEMALE) |  | OPERATING DEVICE (GENERAL SYMBOL) |  | EARTH, GROUND (GENERAL SYMBOL) |  | THREE POSITIONS TURNING SWITCH, WITH SPRING THROWBACK TO THE CENTRAL POSITION |
|  | VOLTAGE TRANSFORMER WITH TWO WINDINGS |  | COIL OF A TIME DELAYED OPERATING RELAY |  | MAKE CONTACT |  | MECHANICAL, PNEUMATIC OR HYDRAULIC CONNECTION |
|  | VOLTAGE TRANSFORMER WITH THREE WINDINGS |  | COIL OF A TIME DELAYED RELEASING RELAY |  | BREAK CONTACT |  | MECHANICAL INTERLOCK BETWEEN TWO DEVICES |
|  | CAPACITOR (GENERAL SYMBOL) |  | BISTABLE RELAY |  | CHANGE-OVER BREAK BEFORE MAKE CONTACT |  | RESISTOR (GENERAL SYMBOL) |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n°: 231298/SD/30
Item n°: PF1002983/30

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 004

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# SYMBOLS LEGEND

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|  | HEATING ELEMENT | | | | | | |
|  | CONNECTION OF CONDUCTORS | | | | | | |
|  | WITHDRAWABLE TERMINAL (SHORT-CIRCUITABLE ONLY ON C.T. SECONDARY CIRCUITS) | | | | | | |
|  | SWITCHBOARD TERMINAL | | | | | | |
| | | | | | | | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231298/SD/30
Item n° : PF1002983/30

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 005

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# GENERAL NOTES

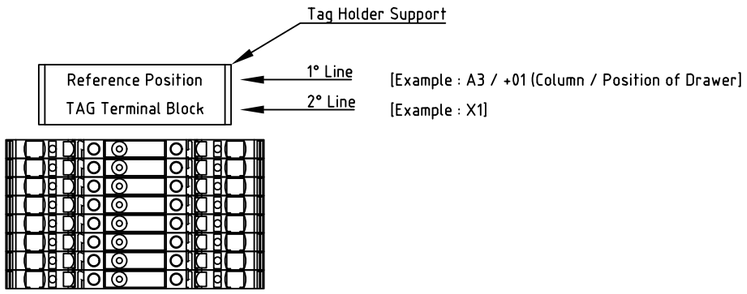
THE DIAGRAM INDICATES THE FOLLOWING CONDITIONS :

- CIRCUIT-BREAKER IN OPEN POSITION
- DE-ENERGIZED CIRCUITS
- DRAWER INSERTED

THE AUXILIARY CIRCUITS WILL HAVE THE FOLLOWING CHARACTERISTICS :

- 24VDC (+) 1,5mmq RED TYPE CABLE SH-W
- 24vdc (-) 1,5mmq WHITE TYPE CABLE SH-W
- AUXILIARY CONTACTS TO TERMINAL STRIP 1,5mmq BLACK TYPE CABLE SH-W
- 230Vac 1,5mmq BLACK TYPE SH-W
- VOLTMETRICAL CIRCUITS 1,5mmq BLACK TYPE CABLE SH-W
- AMMETRICAL CIRCUIT 2,5mmq BLACK TYPE CABLE SH-W

MARKING DETAIL OF TERMINAL BLOCKS :




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| | | | | | |
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DWG n° : 231298/SD/30
Item n° : PF1002983/30

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
General Note

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

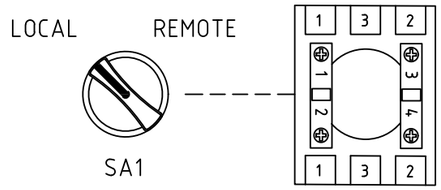
SHEET 006

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# SELECTORS SWITCH DIAGRAMS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/30

Item n° : PF1002983/30

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Selector Switch

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 007

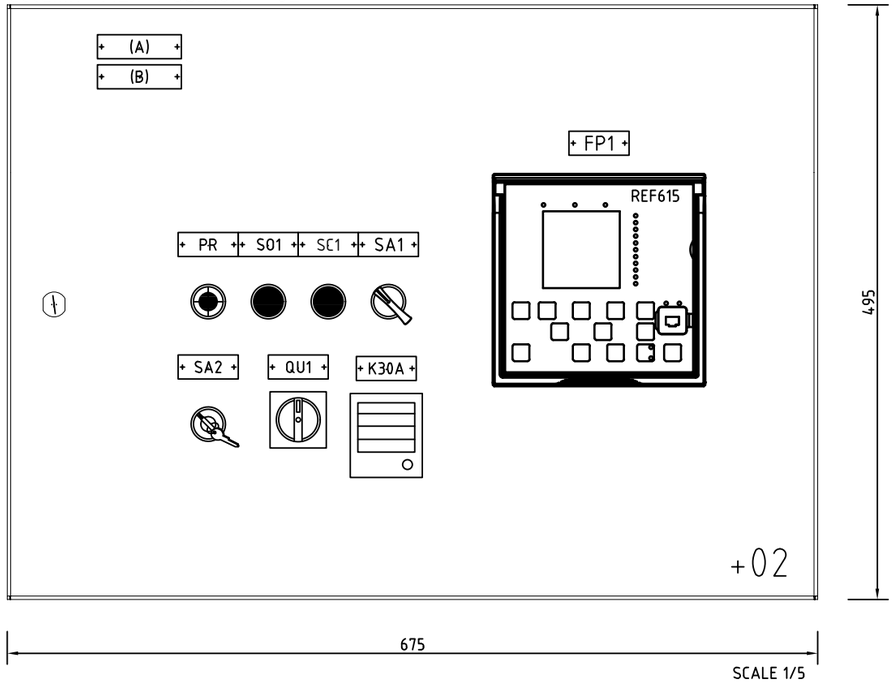
REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

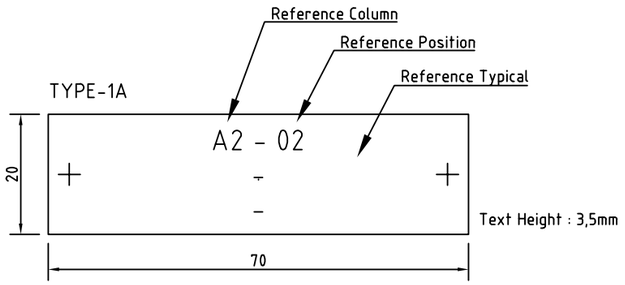
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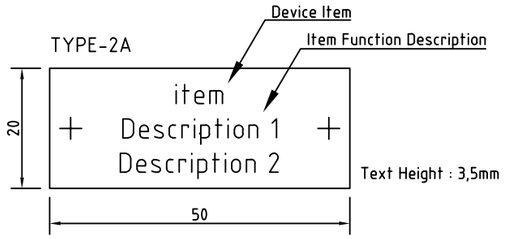
Column : A2 - Position : +02

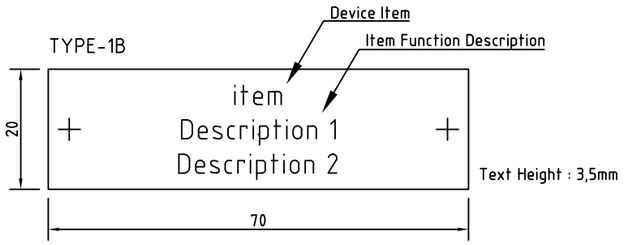



SCALE 1/5

| DEVICES name plate | | | | |
|---|---|---|---|---|
| ITEM | COMPONENT | DESCRIPTION 1 | DESCRIPTION 2 | NOTE |
| FP1 | PROTECTION RELAY | PROTECTION RELAY | INCOMING TRANSFORMER | TYPE-2A |
| SC1 | PUSH BUTTON | CLOSE COMMAND | CIRCUIT BREAKER | TYPE-2A |
| SO1 | PUSH BUTTON | OPEN COMMAND | CIRCUIT BREAKER | TYPE-2A |
| SA1 | SELECTOR SWITCH | LOCAL - REMOTE | SWITCH | TYPE-2A |
| SA2 | SELECTOR SWITCH | NORMAL - MAINTENANCE | SWITCH | TYPE-2A |
| PR | LIGHT PUSH BUTTON | RESET LOCK-OUT | TRIP LOCK-OUT | TYPE-2A |
| K30A | FLAG RELAY | LOSS 230VAC | AUXILIARY VOLTAGE | TYPE-2A |
| QU1 | SWITCH | AUXILIARY VOLTAGE | SWITCH | TYPE-2A |




NOTE :

A) IDENTIFICATION name plate (type-1A) , with :
- Drawer position [Column / Position inside SWB]
- Typical name [reference applicability typical used, where applicable]

B) USER name plate (type-1B), with :
- Item User [to see SLD diagrams, where applicable]
- User Description [to see SLD diagrams, where applicable]

| | |
|---|---|
| = | SG-200N1 |
| + | A2/+02 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Door Layout

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

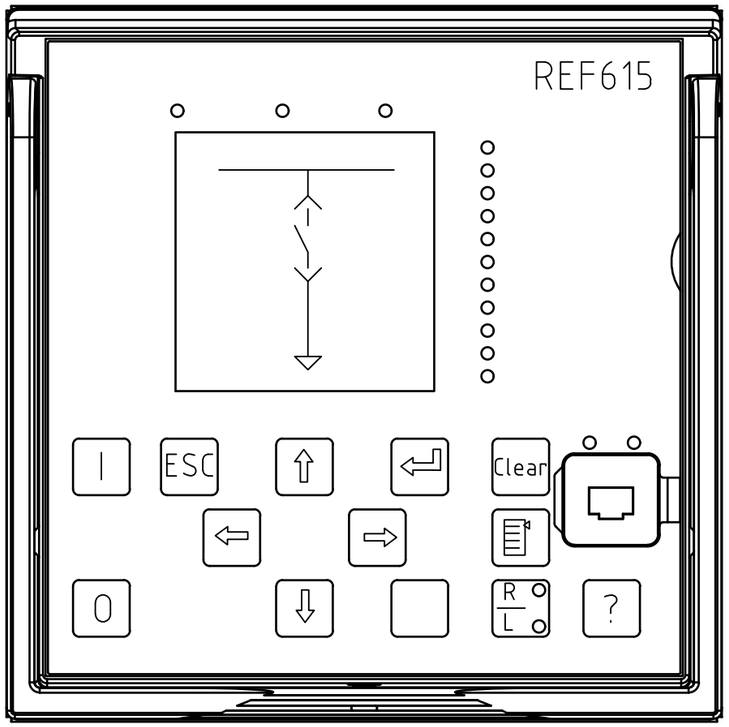
SHEET 008

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# PROTECTION DISPLAY




STATUS INDICATOR LEDs

| | |
|---|---|
| READY LED | OFF = AUXILIARY SUPPLY VOLTAGE IS DISCONNECTED<br>ON = NORMAL OPERATION<br>FLASHING = INTERNAL FAULT HAS OCCURED (WATCH DOG) |
| START LED | OFF = NORMAL OPERATION<br>ON = A PROTECTION FUNCTION HAS STARTED<br>FLASHING = A PROTECTION FUNCTION IS BLOCKED |
| TRIP LED | OFF = NORMAL OPERATION<br>ON = A PROTECTION FUNCTION HAS TRIPPED<br>FLASHING = INTERNAL FAULT HAS OCCURED (WATCH DOG) |
| n°11<br>ALARM LEDs | To Function to see Logical Functional Drawings |

NOTE :

1. Circuit-Breaker status and its position will be shown on mimic on protection dispaly
2. Close/Open and Remote/Local push-buttons on Protection relay are disabled

| LED | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | SPRING MOTOR DISCHARGED | RED | - | ALARM = SPRING NOT CHARGED |
| LED-2 | TCS | - | GREEN | ALARM = TRIP CIRCUIT YO ON FAULT |
| LED-3 | MCB's CLOSED | - | GREEN | ALARM = MCB's OPENED |
| LED-4 | 50/51 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-5 | C.B. READY | - | GREEN | ALARM = C.B. NOT READY FOR CLOSE |
| LED-6 | LOCKOUT TRIPPED FROM M.V.S. UNIT A4 | RED | - | ALARM - LOCKOUT TRIPPED |
| LED-7 | UPSTREAM C.B. CLOSED & INSERTED | - | GREEN | OK = UPSTREAM CIRCUIT CLOSED & INSERTED |
| LED-8 | | | | |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM - TRIP ARC DETECTION |
| LED-10 | | | | |
| LED-11 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A2/+02 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | | | | | | |
| | | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Protection Display REF615

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 009

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

## INPUTS

| X110 | | |
|---|---|---|
| 1 | BI1 | C.B. CLOSED |
| 2 | | |
| 3 | BI2 | C.B. OPENED |
| 4 | | |
| 5 | BI3 | C.B. RACKED-IN |
| 6 | | |
| 7 | BI4 | C.B. RACKED-OUT |
| 6 | | |
| 8 | BI5 | C.B. TEST POSITION |
| 9 | | |
| 10 | BI6 | C.B. SPRINGS DISCAHRGED |
| 9 | | |
| 11 | BI7 | LOCAL OPENING COMMAND |
| 12 | | |
| 13 | BI8 | LOCAL CLOSING COMMAND |
| 12 | | |

## INPUTS

| X–120 | | |
|---|---|---|
| 1 | BI1 | LOCKOUT REALY |
| 2 | | |
| 3 | BI2 | C.B.OPENED OR ISOLATED |
| 2 | | |
| 4 | BI3 | LOCKOUT REALY |
| 2 | | |
| 5 | BI4 | C.B. CLOSED, INSERTED AND E.S. OPENED. |
| 6 | | |

FROM M.V.S. SG-100D1 UNIT A4

## INPUTS

| X–130 | | |
|---|---|---|
| 1 | BI1 | MCB's CLOSED |
| 2 | | |
| 3 | BI2 | SELECTOR IN MAINTENANCE POSITION |
| 4 | | |
| 5 | BI3 | SELECTOR IN LOCAL POSITION |
| 6 | | |
| 7 | BI4 | TCS ALARM |
| 8 | | |

## ARC MODULE

| | | |
|---|---|---|
| LIGHT SENSOR INPUT 1 | X13 | ARC "BUS BARS COMPARTEMENTS" "BB" |
| LIGHT SENSOR INPUT 2 | X14 | ARC "C.B. COMPARTEMENT." "CB" |
| LIGHT SENSOR INPUT 3 | X15 | ARC "CABLE COMPARTEMENT" "CC" |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

= SG-200N1
+ A2/+02
DWG n° : 231298/SD/30
Item n° : PF1002983/30

CROSSWIND

ROSETTI MARINO

TITLE : SG–200N1
FUNCTIONAL DIAGRAM
Digital Input REF615

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00030

SHEET 010

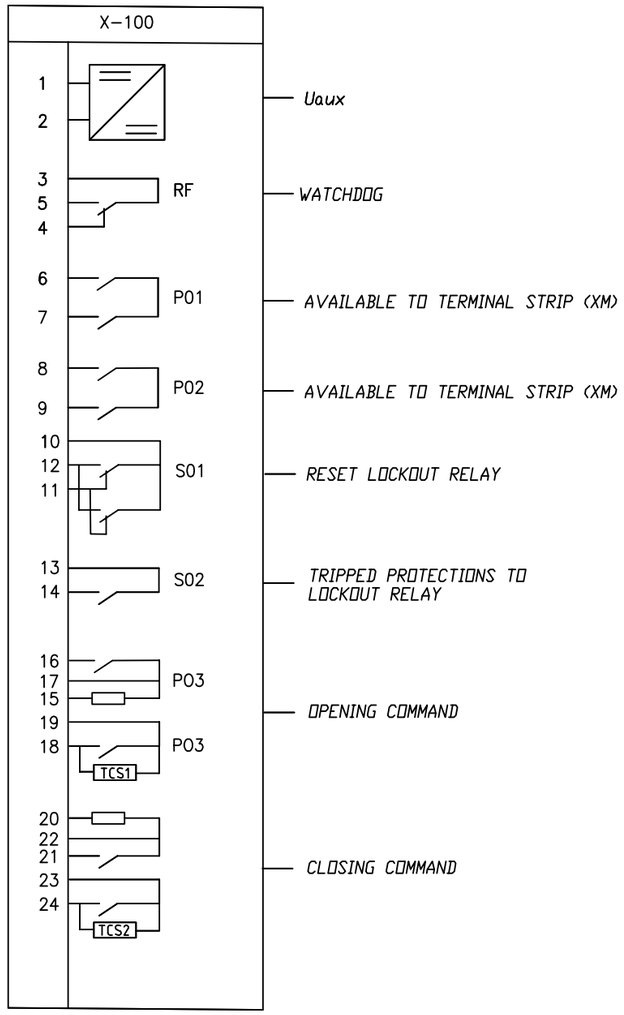
REV. 02

File Name : 1723002197–EL–DG–00030 Rev.02

F.to UNI A3: 420mmx297mm

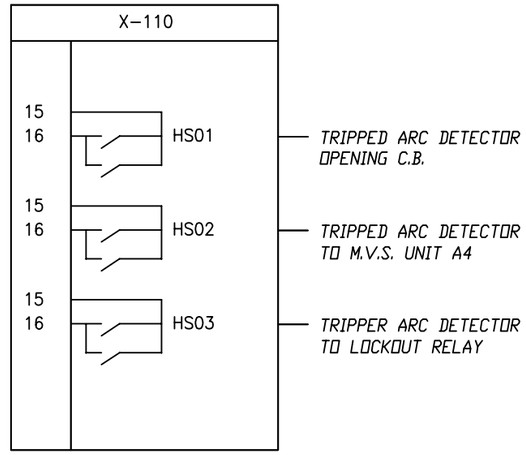
OUTPUT

X–100




OUTPUT

X–110




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A2/+02 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG–200N1

FUNCTIONAL DIAGRAM
Digital Output REF615

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00030

SHEET 011

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00030 Rev.02

INPUTS

PROTECTIONS REF615 (FP1)

OUTPUTS

50-1 3I>>> DPHHPDOC1 (0 / 1 / Start)

50 3I>>> DPHLPDOC2 (BLOCK / 0 / 1 / Start)

TO EMCS IEC 61850 — ISLAND CONDITION

64 Io> DEFLPDEF1 (0 / 1 / Start)

51 3I> DPHLPTOC1 (0 / 1 / Start)

50 3I>>> PHIPTOC1 (BLOCK / 0 / 1 / Start)

TO EMCS IEC 61850 — SWBD ON MAINTENACE

SA2 SELECTOR IN MAINTENANCE POSITION (0 / 1)

CHANGE SETTING PARAMETERS

X130-3 — 1 — SG_2_ACT — When selected, will be active 2nd Setting of Protections

ONLY "LIGHT"

50L/50NL ARC ARCSARC1 (0 / 1 / Start) — ARC "MAIN BUS BAR" "BB"

ONLY "LIGHT"

50L/50NL ARC ARCSARC2 (0 / 1 / Start) — ARC "C.B. COMPARTMENT" "CB"

ONLY "LIGHT"

50L/50NL ARC ARCSARC3 (0 / 1 / Start) — ARC "CABLE COMPARTEMENT" "CC"

≥1

t=0,5" &

TO EMCS IEC 61850 — 50-PROTECTION OPERATED

TO EMCS IEC 61850 — 51-PROTECTION OPERATED

LED-4 (RED)

RESET K86 014.5A

PROTECTION 013.6B

TO EMCS IEC 61850 — INTERTRIP SEND (TO M.V. SWITCHB.)

X100-S02

K86 TRIPPED PROTECTION (0 / 1)

X110-HS01 — FP1 – HS01 ARC DETECTOR OPENING C.B. (0 / 1)

X110-HS02 — FP1 – HS02 ARC DETECTOR TO MV.S. UNIT A4 (0 / 1)

X110-HS03 — FP1 – HS03 ARC DETECTOR LOCKOUT RELAY (0 / 1)

TO M.V.S. UNIT A4 — 0 / 1 — TRIPPED ARC PROTECTION

LED-9 (RED)

014.6A K86

ARC 013.6C

| | |
|---|---|
| = | SG-200N1 |
| + | A2/+02 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

Logic Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 012

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

1 2 3 4 5 6 7 8 9 10

A B C D E

# INPUTS

# REF615 CONTACTOR COMMANDS

# OUTPUTS

S20 LOCAL OPENING COMMAND (0/1) → X110-11

QG1 – S75I C.B. SERVICE (0/1) → X110-5

QG1 – S75E C.B. TEST (0/1) → X110-8

IEC 61850 – EMCS OPENING (0/1)

FROM M.V.S. UNIT 4 LOCKOUT RELAY (0/1) → X120-4

FROM M.V.S. UNIT 4 C.B. OPENED OR ISOLATED (0/1) → X120-3

IEC 61850 – EMCS CLOSING (0/1)

SA1 SELECTOR IN LOCAL POSITION (0/1) → X130-5

S1C LOCAL CLOSING COMMAND (0/1) → X110-13

LED-6 (RED)

K86-MV → 014.6C

TEST → 013.5D

INSERT. → 014.3D

INSERT. → 014.4C

CONNECTED

012.9B ← PROTECTION

014.5A ← K86

012.7E ← ARC

LOCAL OPENING

REMOTE OPENING

OPENING → 014.4C

X100-P03 → QG1 0 C.B. OPENING 1

TO EMCS IEC 61850 *RESET LOCKOUT RELAY* → X100-SO1 → FP1 0 RESET LOCKOUT RELAY 1

REMOTE → 014.6B

TO EMCS IEC 61850 *SELECTOR IN REMOTE POSITION*

REMOTE CLOSING

LOCAL CLOSING

014.6A ← READY

X100-P04 → QG1 0 C.B. CLOSING 1

LOCAL

TO EMCS IEC 61850 *SELECTOR IN LOCAL POSITION*

LOCAL CLOSING

TEST LOCAL CLOSING

013.3B ← TEST

TEST → 014.2C

| | |
|---|---|
| = | SG-200N1 |
| + | A2/+02 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

Logic Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 013

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# INPUTS

# REF615 CONTACTOR COMMANDS

# OUTPUTS

K86
RELAY TRIPPED 0/1

FROM M.V.S.UNIT 4
C.B.CLOSED INSER. 0
E.S.OPENED 1

UB1
TCS ALARM 0/1

QG1 – S33M
C.B. DISCHARGED 0/1

QG1
C.B. OPENED 0/1

QD2–QD3–QV1.A–QV2.A
CLOSED AUXILIARY V.T. SECONDARY MCB's 0/1

QG1
C.B. CLOSED 0/1

X120-1
X120-5
X130-7
X110-10
X110-3
X130-1
X110-1

TO EMCS IEC 61850
*K86 TRIPPED*

K86 → 012.6E
K86 → 013.6B
K86 → 012.4B

LED-7 (GREEN)
LED-1 (RED)
LED-3 (GREEN)
LED-5 (GREEN)
LED-2 (GREEN)

t=10"

&

TCS-EXT → 014.6C

013.6E TEST
013.5A INSERT.
013.7B OPENING
014.9C TCS
C.B. OPENED
014.6D WATCHDOG

TO EMCS IEC 61850
*C.B. OPENED OR IN TEST POS.*

TO EMCS IEC 61850
*MCB's CLOSED*

013.5A INSERT.

TO EMCS IEC 61850
*C.B. CLOSED AND INSERTED*

READY → 013.6C
013.4C REMOTE

TO EMCS IEC 61850
*C.B. READY TO CLOSE*

G_S02-X1

XM
0 CIRCUIT BREAKER READY TO CLOSE
1

TCS → 014.4C

014.3B TCS-EXT
013.3B K86-MV

NOT

TO EMCS IEC 61850
*TSC YO COIL SUPERVISION*

014.4D WATCHDOG

WATCHDOG 0/1

TO EMCS IEC 61850
*WATCHDOG PROTECTION RELAY*

X100-IRF

KIRF
0 WATCHDOG
1

| | |
|---|---|
| = | SG-200N1 |
| + | A2/+02 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG–200N1
FUNCTIONAL DIAGRAM
Logic Diagram

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00030

SHEET 014

REV. 02

File Name : 1723002197–EL–DG–00030 Rev.02

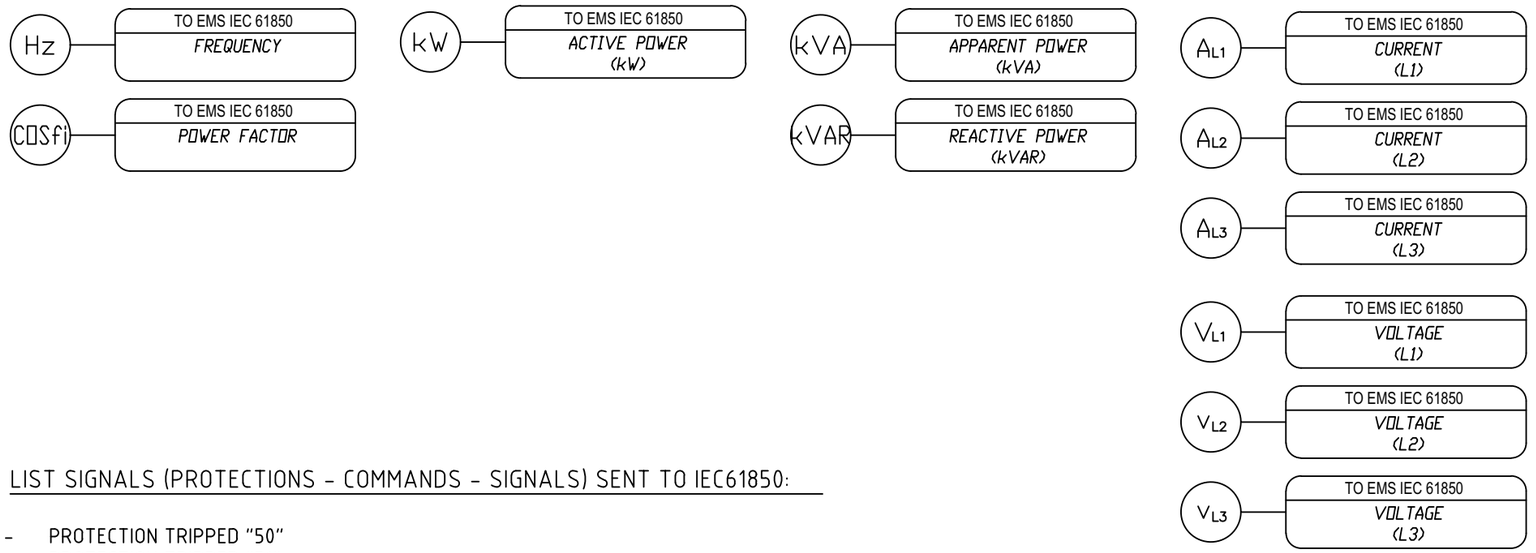
F.to UNI A3: 420mmx297mm

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|

INPUTS

REF615 SIGNALS MEASURES AND COMMAND AVAILABLE TO IEC61850

OUTPUTS




LIST SIGNALS (PROTECTIONS - COMMANDS - SIGNALS) SENT TO IEC61850:

- PROTECTION TRIPPED "50"
- PROTECTION TRIPPED "51"
- SELECTOR SWITCH IN LOCAL POSITION
- SELECTOR SWITCH IN REMOTE POSITION
- WATCHDOG PROTECTION RELAY
- K86 TRIPPED
- INTERTRIP SEND TO M.V. SWITCH.
- C.B. CLOSED AND INSERTED
- C.B. OPENED OR ISOLATED
- MCB'S CLOSED
- TCS (YO COIL SUPERVISION)
- C.B. READY TO CLOSE
- OPENING COMMAND
- CLOSING COMMAND

| | |
|---|---|
| = | SG-200N1 |
| + | A2/+02 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Signals to IEC61850

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 015

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

"INCOMING TRANSFORMER"

INCOMING FROM
HV SWBD "SG-100D1"

TR-200DE1
1,6MVA
6.6 / 0.42kV
zcc%=6%
Dyn 11

out of scope
IMESA supply

TO P1 S1 S2 P2

51G PROTECTIVE FUNCTION
ON 6,6kV side

PE (ext)

VENDOR
SWBD supplier

BATTERY LIMIT

PE (swbd)

400V - 50Hz - 2500A - 50kA

L1-A
L2-A
L3-A
N-A

017.1A
017.2A
017.2A
017.2A

LENS Optical Fiber for
Internal Arc Survey
[on Incoming Busbars Compartement]

021.5C CC CC +

AUXILIARY VOLTAGE SWITCH

QU1

QU2

QU3

L3-A
N-A

1x4 BK

16A

Pos.1 = Incoming from
Temporary Generator

Pos.2 = Incoming from
Transformer

1 0 2

Close
on "Pos.2"

Close
on "Pos.1"

220/1
1x4 BK
019.1A

220/2
1x4 BK
019.1B

DISTRIBUTION
AUXILIARY VOLTAGE

from
TEMPORARY GENERATOR
drawer placed on
"CLA2 / +08"

018.9A L3
018.9A N

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/30
Item n° : PF1002983/30

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

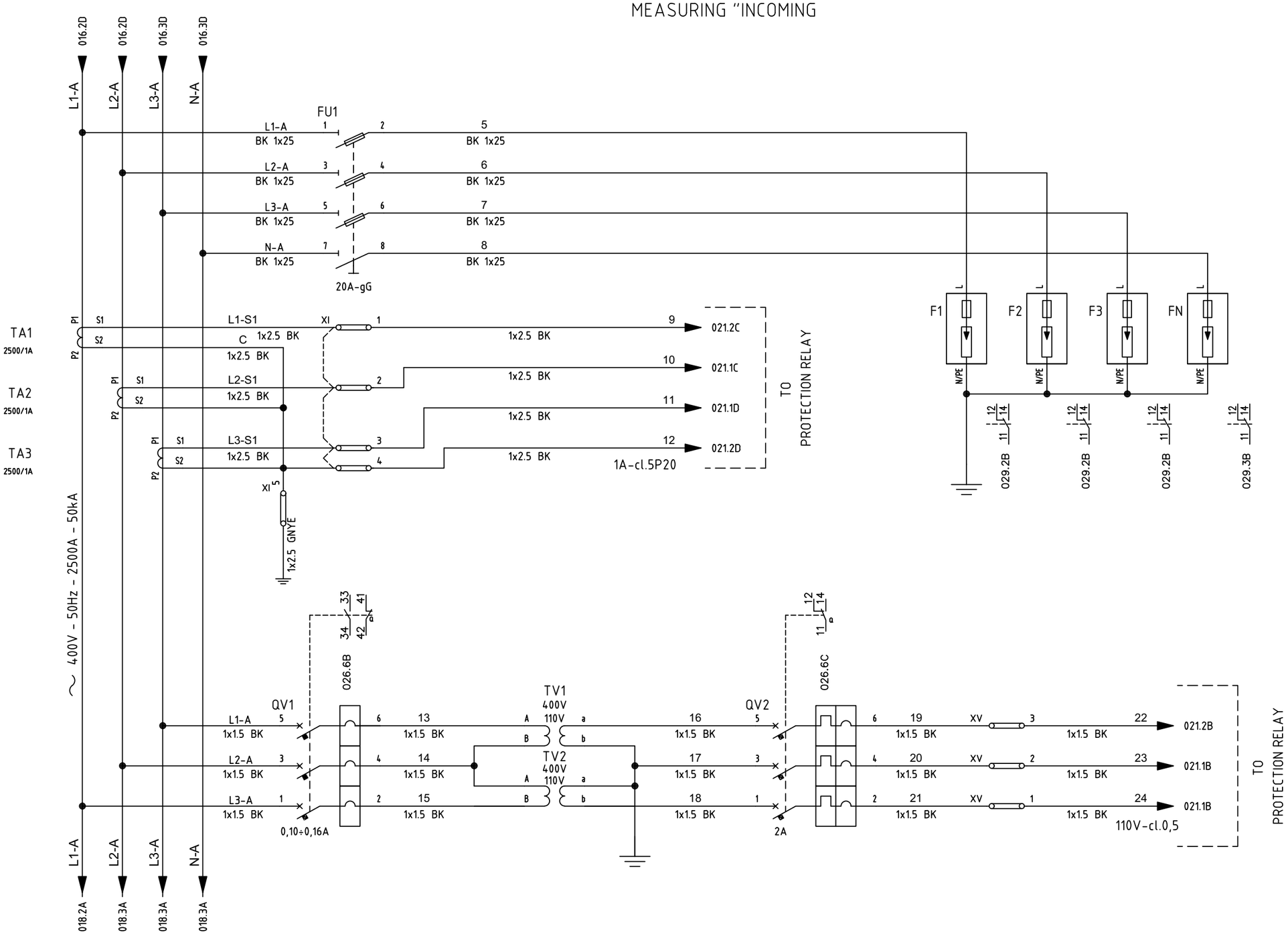
SHEET 016

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

MEASURING "INCOMING




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/30

Item n° : PF1002983/30

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 017

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# CIRCUIT BREAKER

TEMPORARY GENERATOR/
MOBILE BATTERY PACK

L1 L2 L3 N

L3 → 016.5D
N → 016.5D
to AUXILIARY VOLTAGE SWITCH

A2 / +08

ONLY FOR REPRESENTATION
FOR DETTAILS TO SEE RELEVANT
DOCUMENT N°1723002197-EL-DG-00031

017.1D L1-A
017.2D L2-A
017.2D L3-A
017.2D N-A

~ 400V - 50Hz - 2500A - 50kA

Emax E2÷6

| | | | | | INSERTED | TEST | ISOLATED |
|---|---|---|---|---|---|---|---|
| S75I | 101-102 / 101-104 | 111-112 / 111-114 | 151-152 / 151-154 | 161-162 / 161-164 | X | | |
| S75T | 121-122 / 121-124 | 171-172 / 171-174 | | | X | X | X |
| S75E | 131-132 / 131-134 | 141-142 / 141-144 | 181-182 / 181-184 | 191-192 / 191-194 | X | X | X |

S75I/1 S75I/2 S75T/1 S75E/1 S75E/2

101 023.9A | 111 018.6D | 121 023.8A | 131 025.4A | 141 023.9A

Q/1 Q/2 Q/3 Q/4 S33M RTC

11 022.9B | 21 025.2A | 31 023.7A | 41 018.7D | U2 019.2C | 35 025.6A | 45 | C2 022.2D | C12 022.5D

QF1 3200A

LENS Optical Fiber for
Internal Arc Survey
[on Circuit-Breaker Compartement]

021.5C CB CB +

(1) KEY LOCK FOR OPEN POSITION (CIRCUIT-BREAKER)

(2) RACKIING-IN/RACKING-OUT PREVENTION LOCK WITH KEY (CIRCUIT-BREAKER)

QA1

QF1 018.7B YU D1 D2

Q/1 Q/2 D1 YU D2 018.7B

11 X1 12 X1

#W1 4x1.5

5 X2 6 X2

25 1x1.5 BK

QF1 018.2B S75I 111 112 114

QF1 018.2B Q 41 42 44

26 1x1.5 BK

LENS Optical Fiber for
Internal Arc Survey
[on Main Busbars Compartement]

021.5C BB BB +

~ 400V - 50Hz - 2500A - 50kA

~ MAIN BUS BARS

L1-AA → 038.1A
L2-AA → 038.1A
L3-AA → 038.1A
N-AA → 038.1A

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Power Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

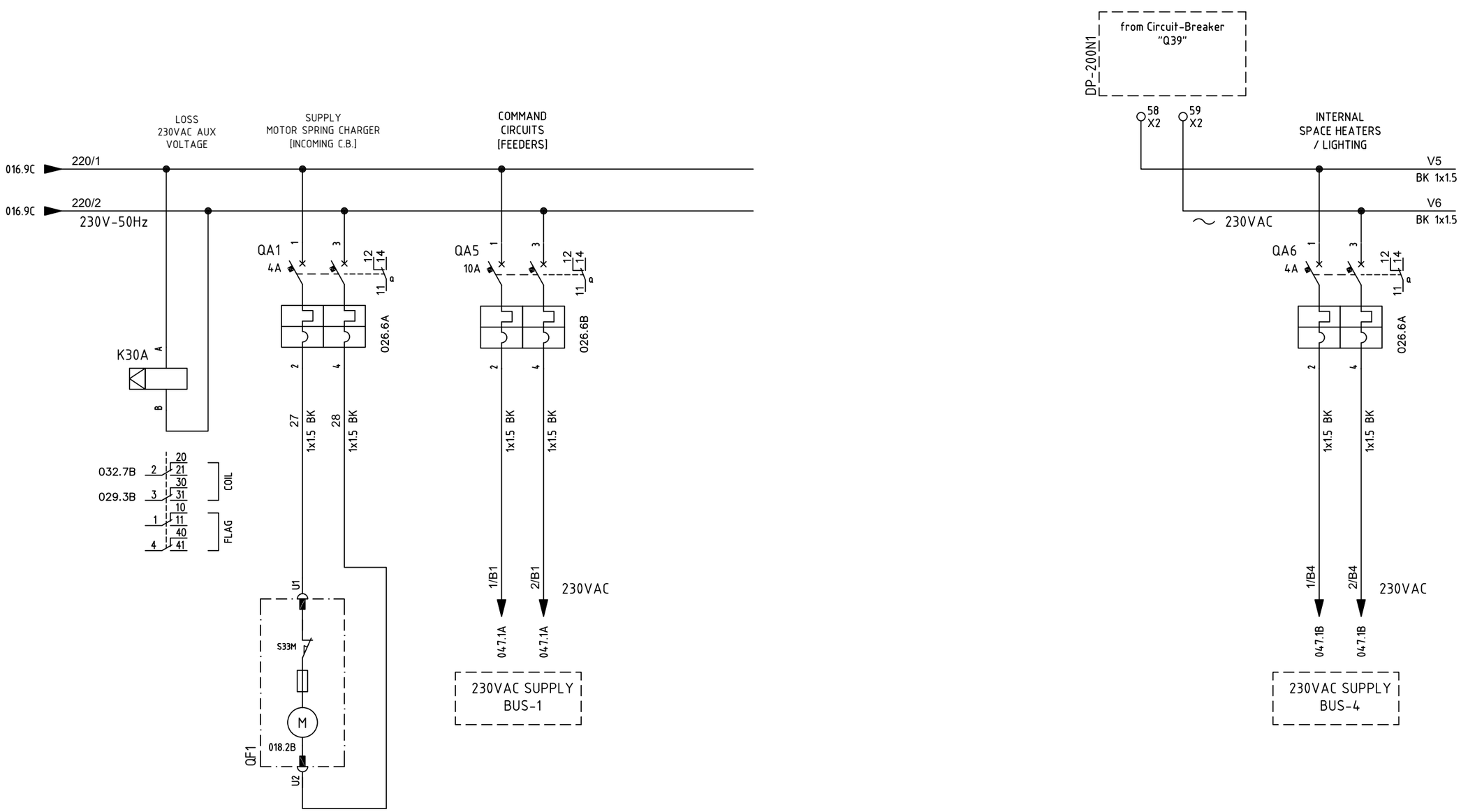
SHEET 018

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# SUPPLY AUXILIARY CIRCUITS




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A2/+02 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | | | | | | |
| | | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

230Vac/24Vdc Distribution Volatage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

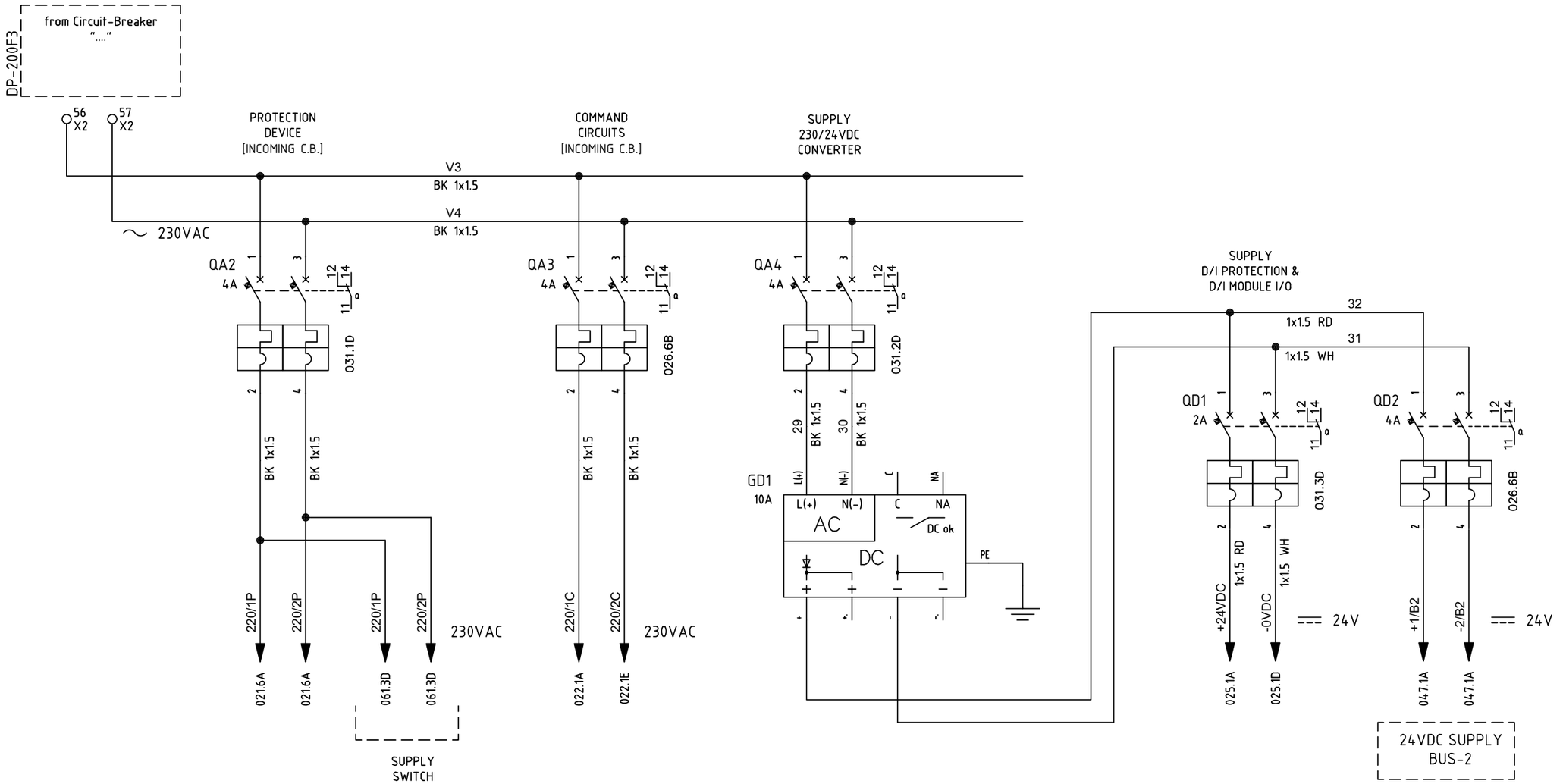
SHEET 019

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# SUPPLY AUXILIARY CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/30

Item n° : PF1002983/30

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

230Vac/24Vdc Distribution Volatage

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

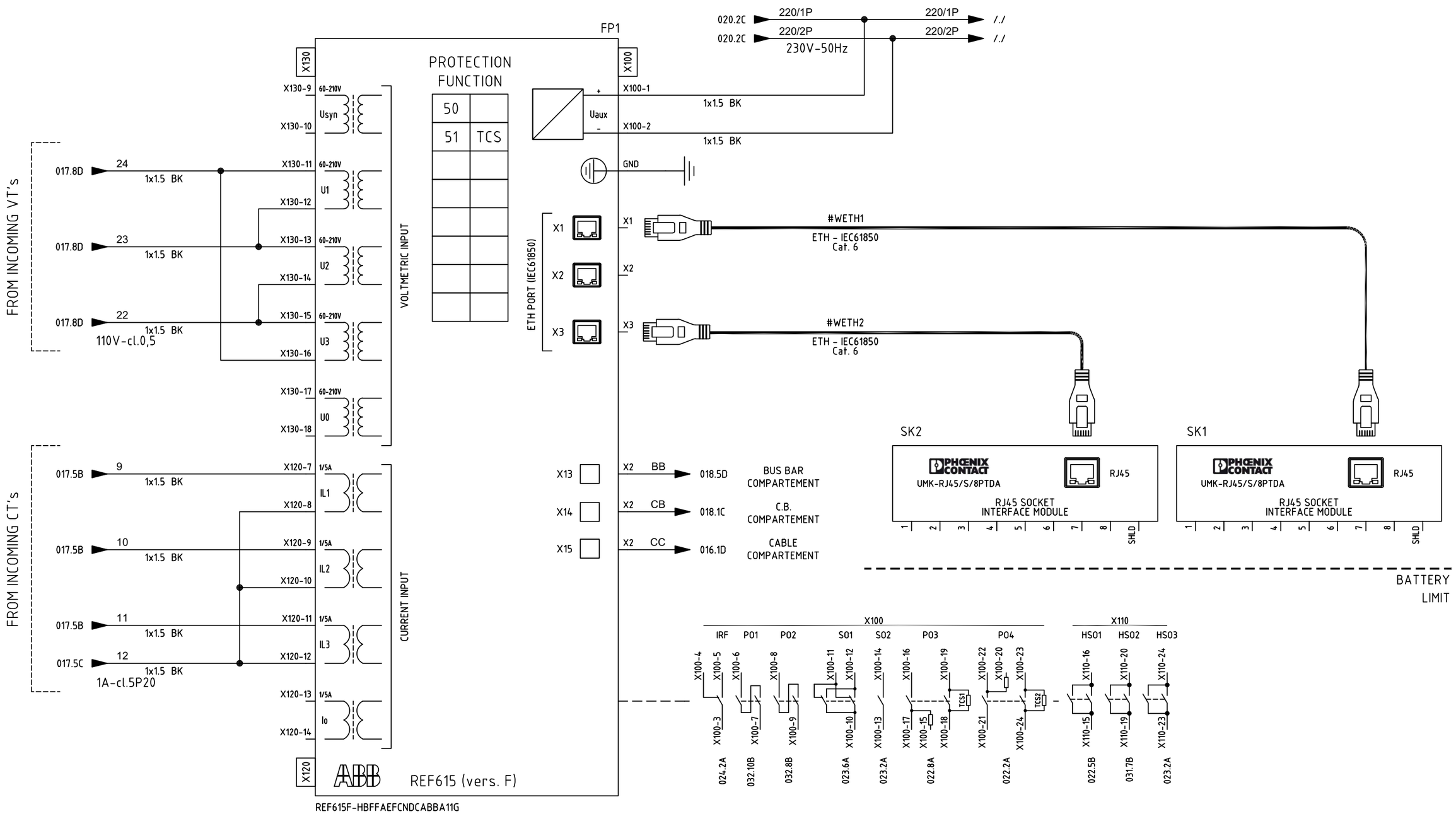
SHEET 020

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# "REF615" PROTECTION WIRING




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A2/+02 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | | | | | | |
| | | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
REF615 Protection Wiring

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 021

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# COMMAND CIRCUITS

CLOSING COMMAND | LOCAL OPENING COMMAND | LOCKOUT RELAY | WATCHDOG PROTECTION | OPENING BY ARC PROTECTION | LOCKOUT RELAY | AVAILABLE | OPENING BY -PROTECTION TRIPPED -OPENING COMMAND EMS | TCS CONTROL UNIT

020.4C 220/1C 230V-50Hz — 220/1C 023.1A

FP1 021.3A PO4 — X100-21, X100-22, X100-20, X100-23, X100-24, TCS2, REF615, X100

34 1x1.5 BK — X2 1 — X2 2 — 35 — X2 3 — #W1 4x1.5

A2 / +08 — X1 13 — QF1 018.7B (22, 24, 21) DRAWER ON TEST OR RACKED-OUT — X1 14

#W1 4x1.5 — X2 4 — 36 BK 1x1.5 — C1 — QF1 — YC 018.2B — C2

S01 RD E 23, 14, 13, 24, 025.7A

K86 023.3D 41B, 41B, 4B

KA05 024.2D 12, 14, 11

FP1 021.3A X110-16, HS01, REF615 X110, X110-15 — 37 1x1.5 BK

SG-100D1 (UNIT A4) — K86 — 7 X2, 69 XM, 70 XM, 8 X2

EXT — 9 X2, 10 X2

FP1 021.3A PO3 — X100-16, X100-17, X100-15, X100-19, X100-18, TCS1, REF615, X100

39 1x1.5 BK — 11 — QF1 018.2B Q — 14, 12

QF1 — C11 — YO 018.2B — C12

UB1 — LATCH=OFF, 120ohm=OFF, ADDR=, COM=OFF, Tmax/XT=OFF — L(+), N(-), W3, W4, Power Supply 24÷250VDC/AC, Local BUS, YO-YC TEST UNIT, YO/YC Control Unit, KT1-KT2=ALARM, KT3-KT2=OK, V1, V2, KT1, KT3, KT2

KT3 KT1 KT2 — 026.9A

020.4C 220/2C — 220/2C 023.1D

| | | | | | | |
|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | |
| + | A2/+02 | | | | | |
| DWG n° : | 231298/SD/30 | | | | | |
| Item n° : | PF1002983/30 | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) | |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING — CROSSWIND — ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Command Circuit

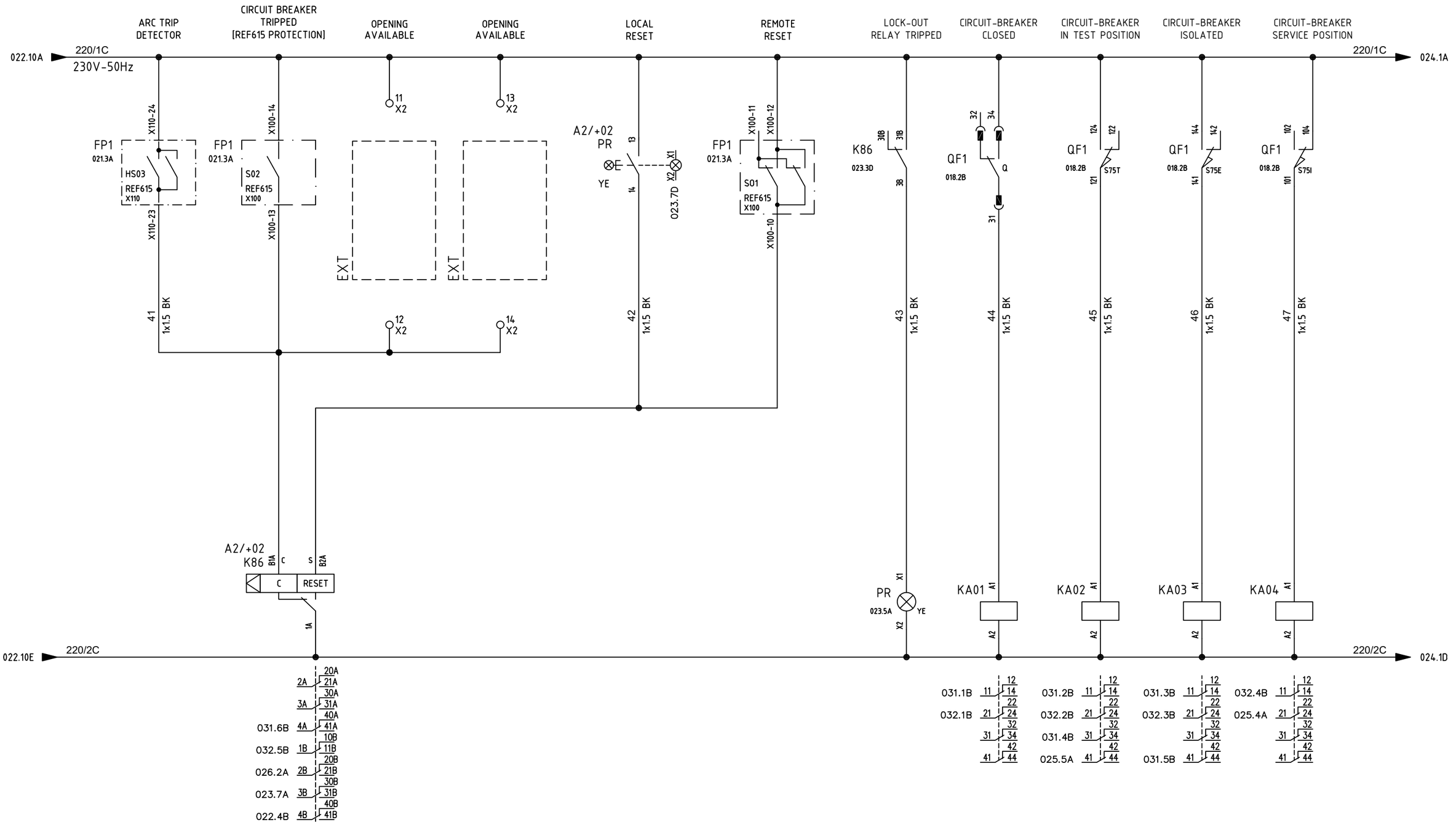
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00030 | SHEET 022 | REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# COMMAND CIRCUITS




| | |
|---|---|
| = | SG-200N1 |
| + | A2/+02 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

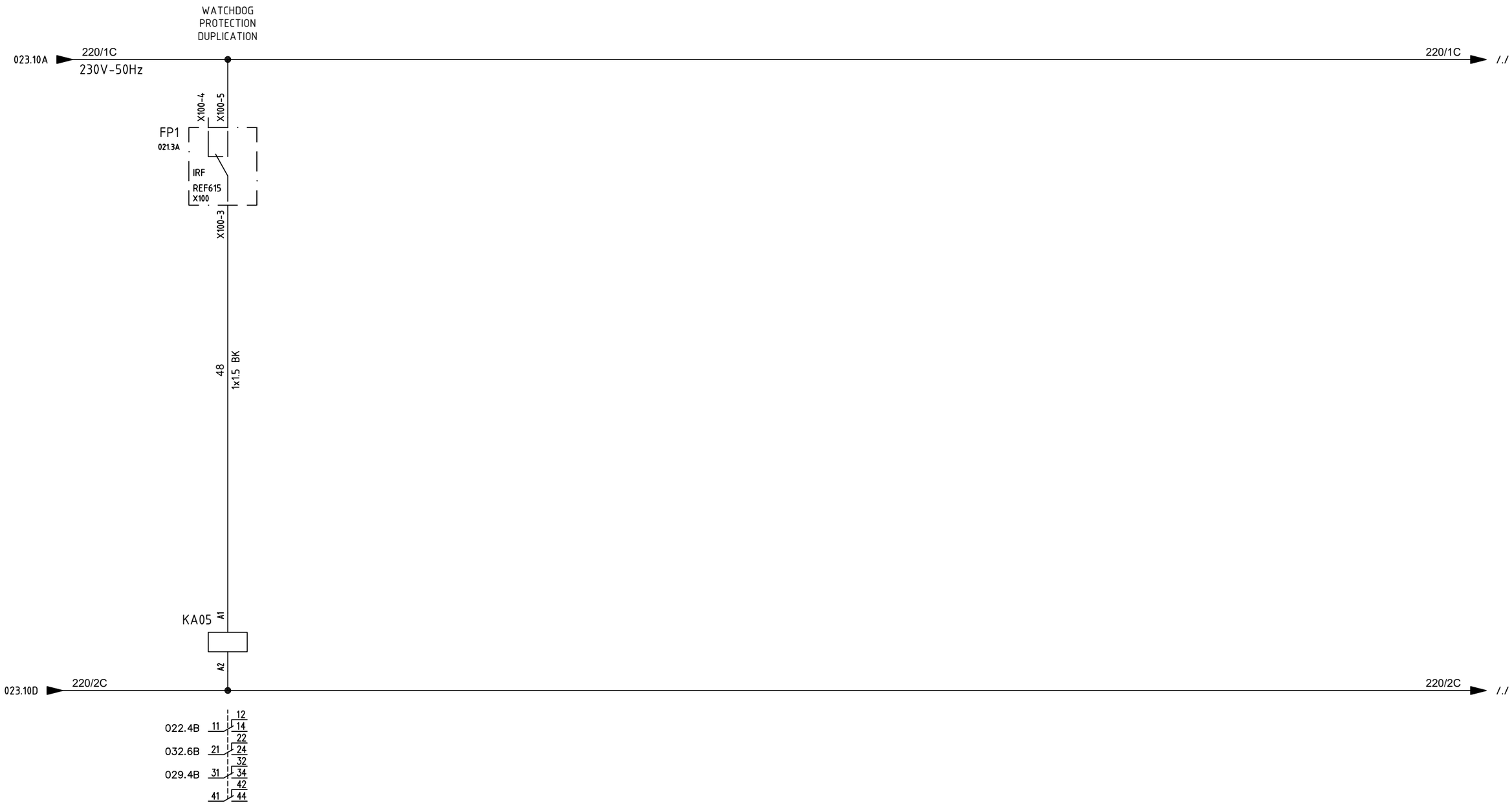
SHEET 023

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# COMMAND CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Command Circuit

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

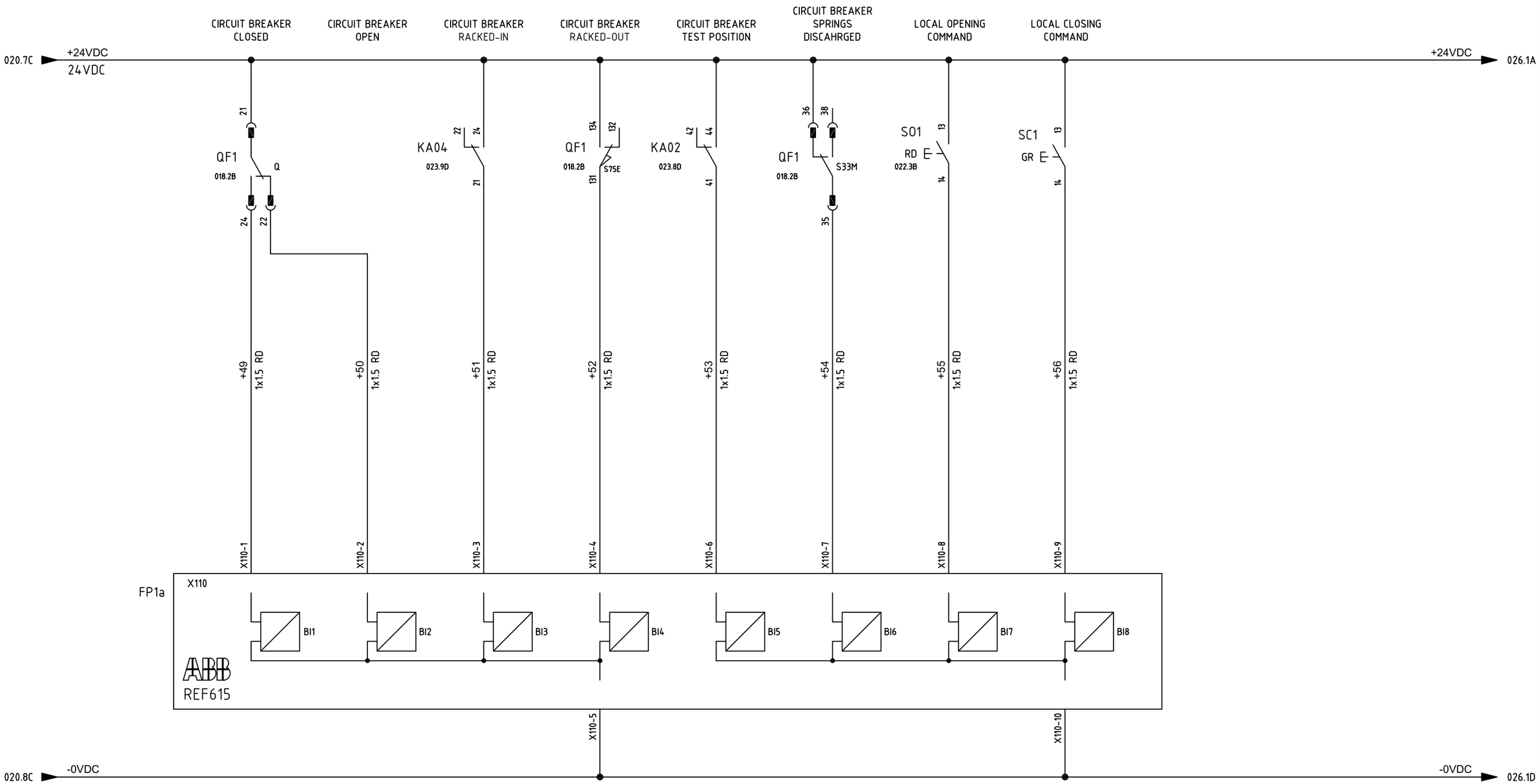
SHEET 024

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# "REF615" PROTECTION WIRING - DIGITAL INPUT




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A2/+02 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | | | | | | |
| | | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
REF615 Protection Wiring Digital Input

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 025

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# "REF615" PROTECTION WIRING - DIGITAL INPUT

025.10A +24VDC 24VDC

LOCKOUT RELAY — K86 023.3D — 20B 21B 2B

C.B. OPENED OR ISOLATED — 15 X2 — 49 XM — K1 — K1 BGT5 — 50 XM — 16 X2

LOCKOUT RELAY — 17 X2 — 51 XM — K86 — 52 XM — 18 X2

C.B. CLOSED,INSERTED AND E.S. OPENED — 19 X2 — 53 XM — K1 — K1 BGT4 — BGE — 54 XM — 20 X2

SG-100D1 (UNIT A4)

+57 1x1.5 BK — X120-1

+58 1x1.5 BK — X120-3

+59 1x1.5 BK — X120-4

+60 1x1.5 BK — X120-5

FP1b — X120 — BI1 BI2 BI3 BI4 — ABB REF615 — X120-2 X120-6

MCB'S CLOSED — QA1 019.2B — QA3 020.4B — QA5 019.4B — +61 +62 1x1.5 BK

+63 1x1.5 BK

QA6 019.8B — QD2 020.9B — +64 +66 1x1.5 BK

QV1 017.3D — +63 1x1.5 BK

QV2 017.6D — +67 1x1.5 BK — X130-1

SELECTOR IN MAINTENANCE POSITION — SA2 NOR MAIN — 3 23 24 — 4 — 031.8B — CLOSE ON "MAIN" — +69A RD 1x1.5 — X130-3

SELECTOR IN LOCAL POSITION — SA1 LOC REM — 11 — 12 — CLOSE ON "LOC" — +69 1x1.5 BK — X130-5

TCS ALARM — UB1 022.9C — KT3 KT1 KT2 — +70 1x1.5 BK — X130-7

FP1c — X130 — BI1 BI2 BI3 BI4 — ABB REF615 — X130-2 X130-4 X130-6 X130-8

025.10D -0VDC

+24VDC 027.1C

-0VDC 027.1C

| | | | | | | |
|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | |
| + | A2/+02 | | | | | |
| DWG n° : | 231298/SD/30 | | | | | |
| Item n° : | PF1002983/30 | | | | | |
| | | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING — CROSSWIND — ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
REF615 Protection Wiring Digital Input

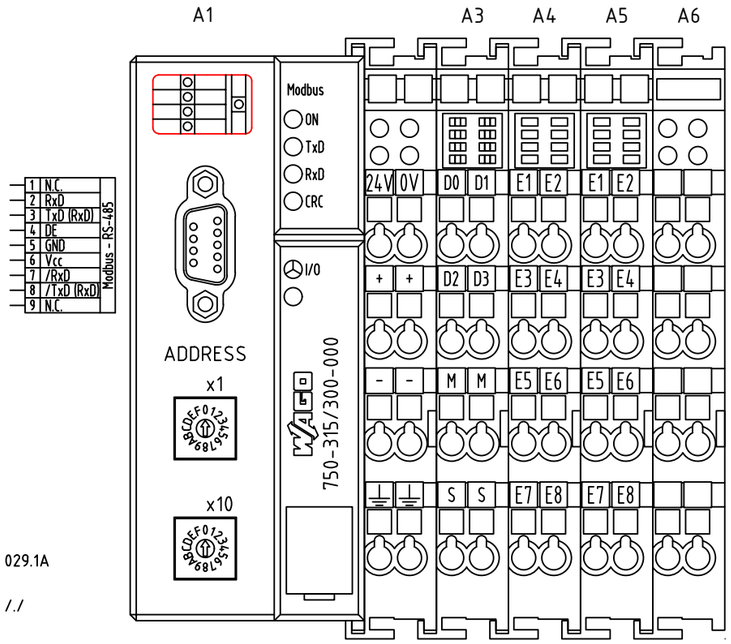
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK — SCALE : NTS

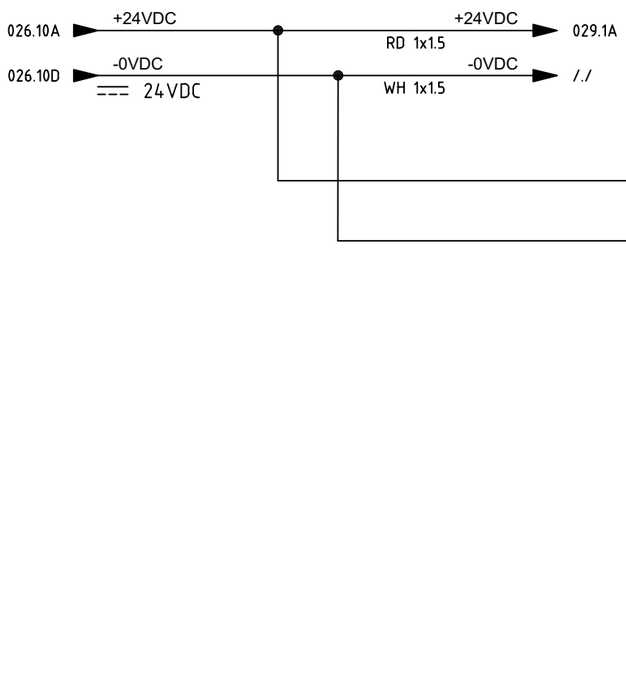
A3 — DRAWING NO. 1723002197-EL-DG-00030 — SHEET 026 — REV. 02

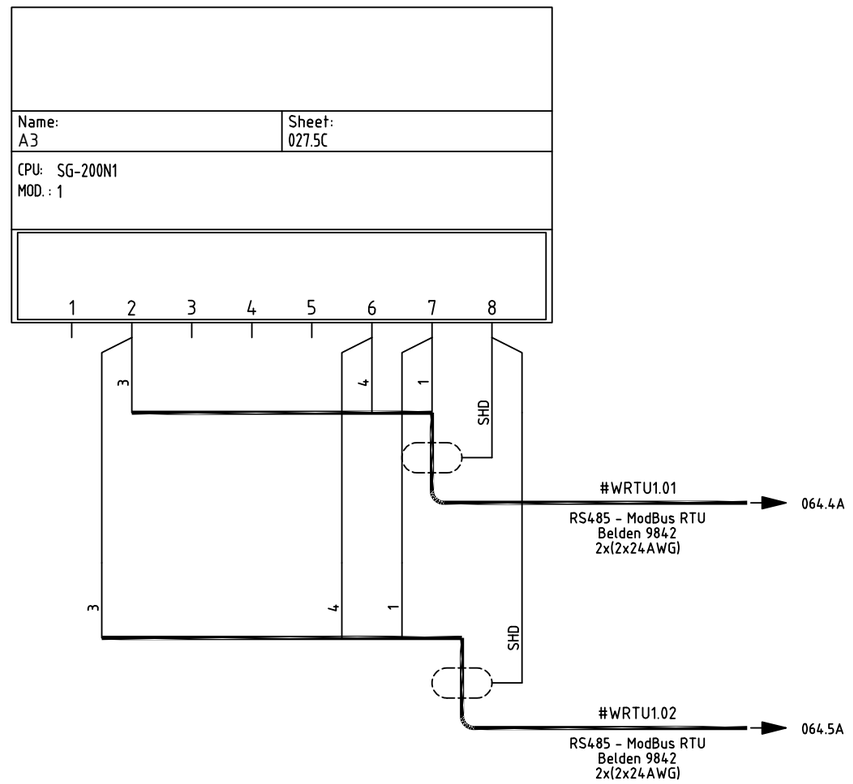
File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# MODULE I/O CONNECTION




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/30

Item n° : PF1002983/30

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Module I/O Connection

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 027

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# MODULE I/O CONNECTION

| Quadro: A2/+02 | Gruppo Funzione: | Sigla: A4 | | | | | |
|---|---|---|---|---|---|---|---|
| CPU: SG-200N1 | Rack: 01 | Slot: 2 | | | | | |
| Pin | Descrizione Pin | Indirizzo | Commento1 | Commento2 | Commento3 | Commento4 | Foglio |
| 1 [E1] | DI 1 | E0.0 | SG-200N1 | SURGE ARRESTER | FAULT | | 029 |
| 5 [E2] | DI 2 | E0.1 | SG-200N1 | LOSS 230VAC | AUXILIARY | VOLTAGE | 029 |
| 2 [E3] | DI 3 | E0.2 | SG-200N1 | WATCHDOG | PROTECTION | | 029 |
| 6 [E4] | DI 4 | E0.3 | SG-200N1 | MOTOR FEEDER | FAULT LOOP | [BUS-3] | 029 |
| 3 [E5] | DI 5 | E0.4 | SG-200N1 | AVAILABLE | | | 029 |
| 7 [E6] | DI 6 | E0.5 | SG-200N1 | AVAILABLE | | | 029 |
| 4 [E7] | DI 7 | E0.6 | SG-200D2 | MCBs | HEALTHY | | 029 |
| 8 [E8] | DI 8 | E0.7 | SG-200D2 | AVAILABLE | | | 029 |

| Quadro: A2/+02 | Gruppo Funzione: | Sigla: A5 | | | | | |
|---|---|---|---|---|---|---|---|
| CPU: SG-200N1 | Rack: 01 | Slot: 3 | | | | | |
| Pin | Descrizione Pin | Indirizzo | Commento1 | Commento2 | Commento3 | Commento4 | Foglio |
| 1 [E1] | DI 1 | E1.0 | DP-200N1 | SURGE ARRESTER | FAULT | | 030 |
| 5 [E2] | DI 2 | E1.1 | DP-200N1 | NORMAL AND EMERGENCY | LIGHTING | ON AUTOMATIC | 030 |
| 2 [E3] | DI 3 | E1.2 | DP-200N1 | NORMAL AND EMERGENCY | LIGHTING | ACTIVATED | 030 |
| 6 [E4] | DI 4 | E1.3 | DP-200N1 | NORMAL AND EMERGENCY | CIRCUIT-BREAKERS | CLOSED | 030 |
| 3 [E5] | DI 5 | E1.4 | DP-200N1 | TRACE HEATINGS | ACTIVATED | | 030 |
| 7 [E6] | DI 6 | E1.5 | DP-200N1 | TRACE HEATINGS | CIRCUIT-BREAKERS | CLOSED | 030 |
| 4 [E7] | DI 7 | E1.6 | DP-200N1 | MAIN AND UTILITIES | CIRCUIT-BREAKERS | CLOSED | 030 |
| 8 [E8] | DI 8 | E1.7 | DP-200N1 | AVAILABLE | | | 030 |

| Quadro: A2/+02 | Gruppo Funzione: | Sigla: A3 | | | | | |
|---|---|---|---|---|---|---|---|
| CPU: SG-200N1 | Rack: 01 | Slot: 1 | | | | | |
| Pin | Descrizione Pin | Indirizzo | Commento1 | Commento2 | Commento3 | Commento4 | Foglio |
| 1 | RTS (RS-232) / Z (RS-485/422) | | | | | | 027 |
| 2 | CTS (RS-232) / B (RS-485/422) | | | | | | |
| 3 | Common (Ground) | | | | | | |
| 4 | Shield (screen) | | | | | | |
| 5 | TxD (RS-232) / Y (RS-485/422) | | | | | | |
| 6 | RxD (RS-232) / A (RS-485/422) | | | | | | |
| 7 | Common (Ground) | | | | | | |
| 8 | Shield (screen) | | | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n°: 231298/SD/30
Item n°: PF1002983/30

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Module I/O Connection

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

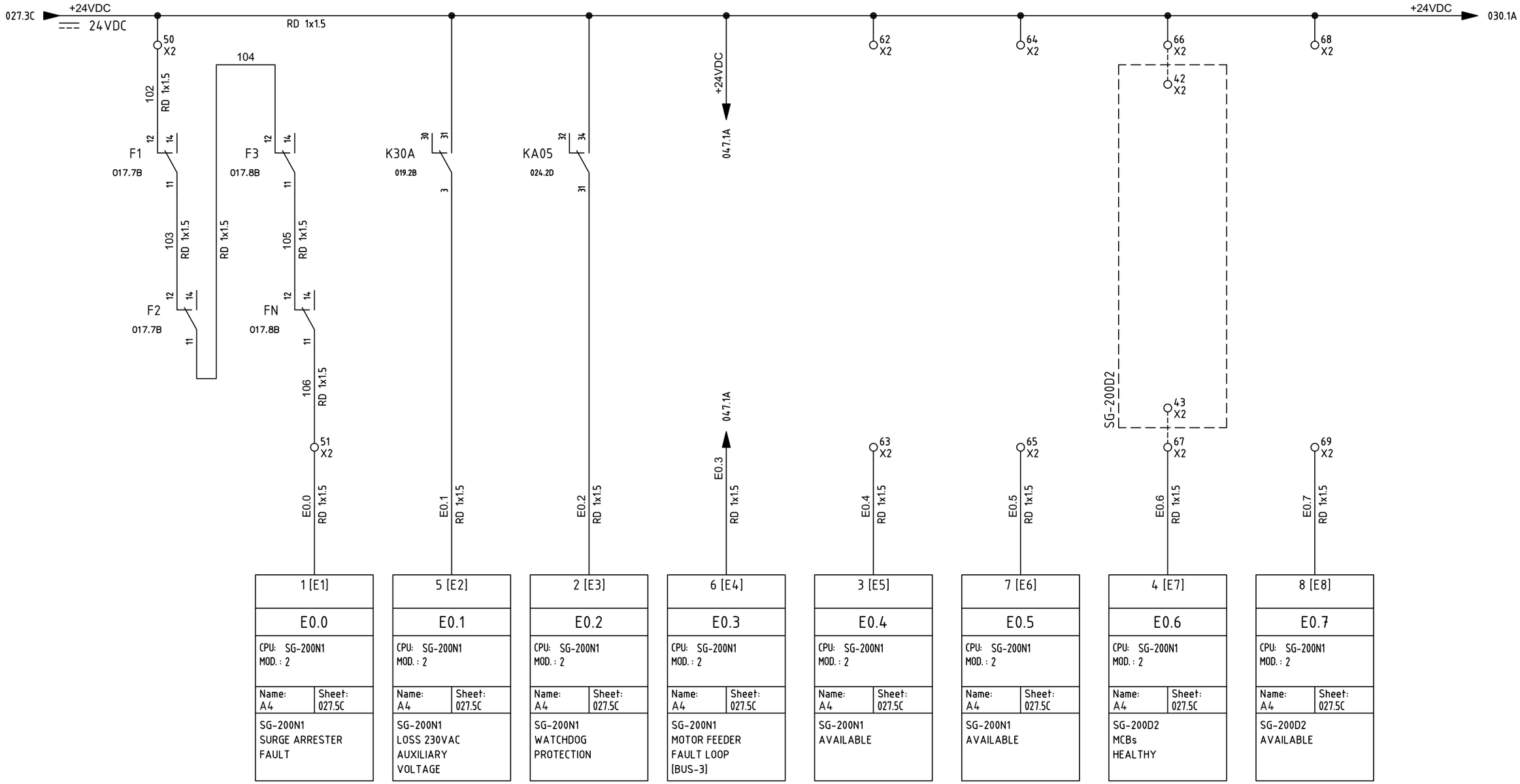
SHEET 028

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# MODULE I/O CONNECTION




| 1 [E1] | 5 [E2] | 2 [E3] | 6 [E4] | 3 [E5] | 7 [E6] | 4 [E7] | 8 [E8] |
|---|---|---|---|---|---|---|---|
| E0.0 | E0.1 | E0.2 | E0.3 | E0.4 | E0.5 | E0.6 | E0.7 |
| CPU: SG-200N1<br>MOD. : 2 | CPU: SG-200N1<br>MOD. : 2 | CPU: SG-200N1<br>MOD. : 2 | CPU: SG-200N1<br>MOD. : 2 | CPU: SG-200N1<br>MOD. : 2 | CPU: SG-200N1<br>MOD. : 2 | CPU: SG-200N1<br>MOD. : 2 | CPU: SG-200N1<br>MOD. : 2 |
| Name: A4 / Sheet: 027.5C | Name: A4 / Sheet: 027.5C | Name: A4 / Sheet: 027.5C | Name: A4 / Sheet: 027.5C | Name: A4 / Sheet: 027.5C | Name: A4 / Sheet: 027.5C | Name: A4 / Sheet: 027.5C | Name: A4 / Sheet: 027.5C |
| SG-200N1<br>SURGE ARRESTER<br>FAULT | SG-200N1<br>LOSS 230VAC<br>AUXILIARY<br>VOLTAGE | SG-200N1<br>WATCHDOG<br>PROTECTION | SG-200N1<br>MOTOR FEEDER<br>FAULT LOOP<br>[BUS-3] | SG-200N1<br>AVAILABLE | SG-200N1<br>AVAILABLE | SG-200D2<br>MCBs<br>HEALTHY | SG-200D2<br>AVAILABLE |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Module I/O Connection

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

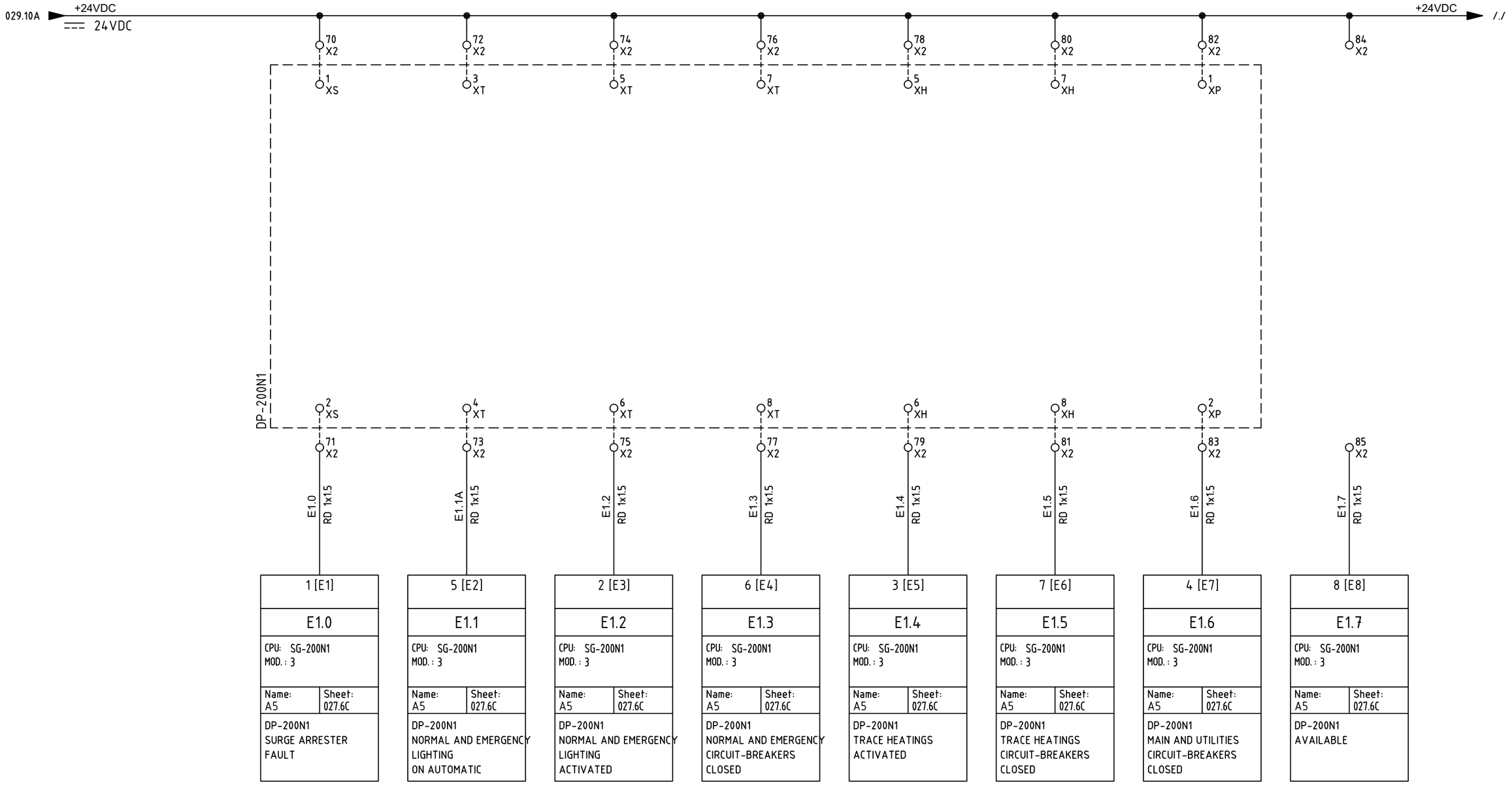
SHEET 029

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# MODULE I/O CONNECTION




| 1 [E1] | 5 [E2] | 2 [E3] | 6 [E4] | 3 [E5] | 7 [E6] | 4 [E7] | 8 [E8] |
|---|---|---|---|---|---|---|---|
| E1.0 | E1.1 | E1.2 | E1.3 | E1.4 | E1.5 | E1.6 | E1.7 |
| CPU: SG-200N1<br>MOD.: 3 | CPU: SG-200N1<br>MOD.: 3 | CPU: SG-200N1<br>MOD.: 3 | CPU: SG-200N1<br>MOD.: 3 | CPU: SG-200N1<br>MOD.: 3 | CPU: SG-200N1<br>MOD.: 3 | CPU: SG-200N1<br>MOD.: 3 | CPU: SG-200N1<br>MOD.: 3 |
| Name: A5 / Sheet: 027.6C | Name: A5 / Sheet: 027.6C | Name: A5 / Sheet: 027.6C | Name: A5 / Sheet: 027.6C | Name: A5 / Sheet: 027.6C | Name: A5 / Sheet: 027.6C | Name: A5 / Sheet: 027.6C | Name: A5 / Sheet: 027.6C |
| DP-200N1<br>SURGE ARRESTER<br>FAULT | DP-200N1<br>NORMAL AND EMERGENCY<br>LIGHTING<br>ON AUTOMATIC | DP-200N1<br>NORMAL AND EMERGENCY<br>LIGHTING<br>ACTIVATED | DP-200N1<br>NORMAL AND EMERGENCY<br>CIRCUIT-BREAKERS<br>CLOSED | DP-200N1<br>TRACE HEATINGS<br>ACTIVATED | DP-200N1<br>TRACE HEATINGS<br>CIRCUIT-BREAKERS<br>CLOSED | DP-200N1<br>MAIN AND UTILITIES<br>CIRCUIT-BREAKERS<br>CLOSED | DP-200N1<br>AVAILABLE |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n°: 231298/SD/30

Item n°: PF1002983/30

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Module I/O Connection

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

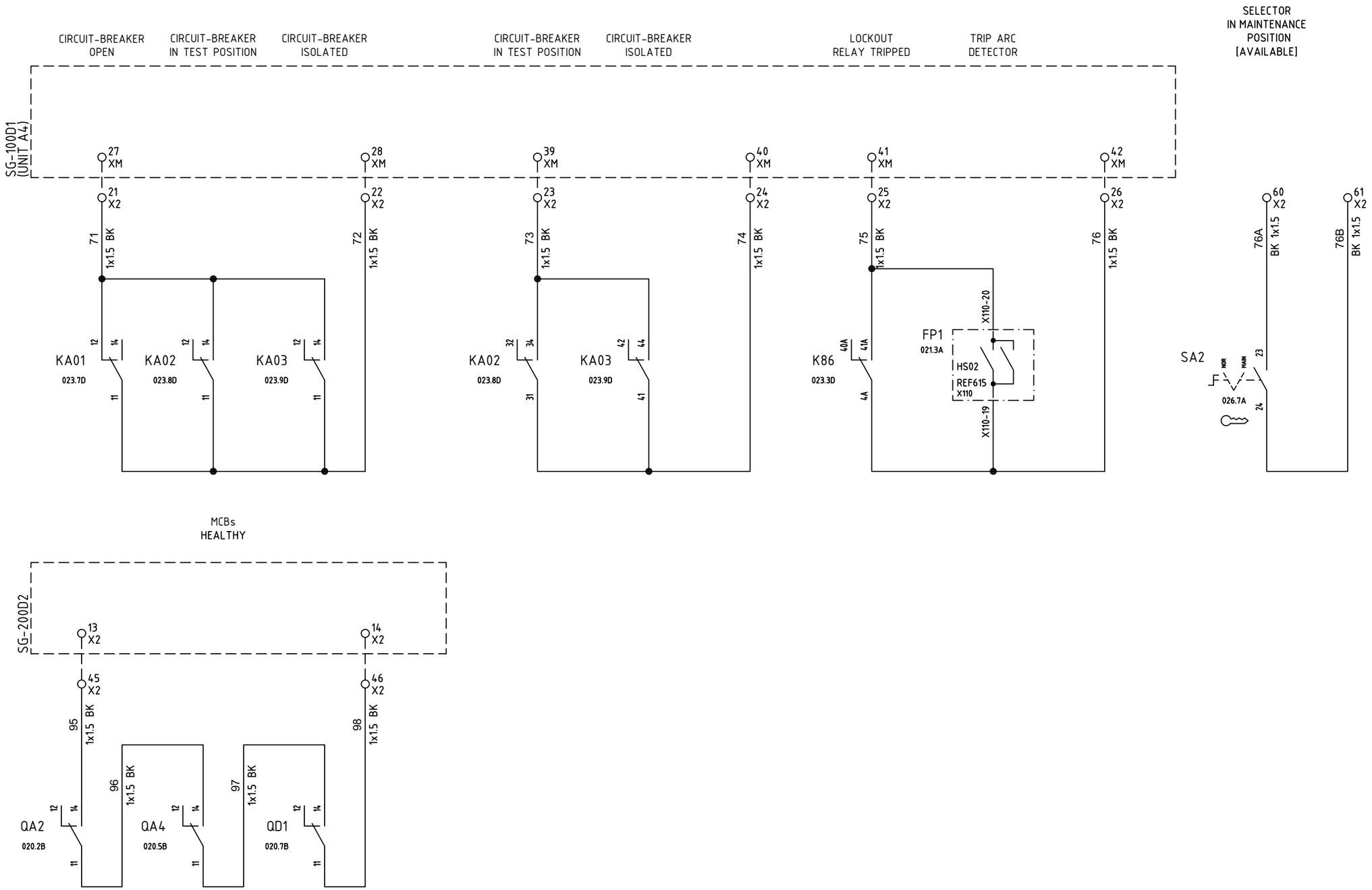
SHEET 030

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# AVAILABLE SIGNALS




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A2/+02 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Available Signals

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

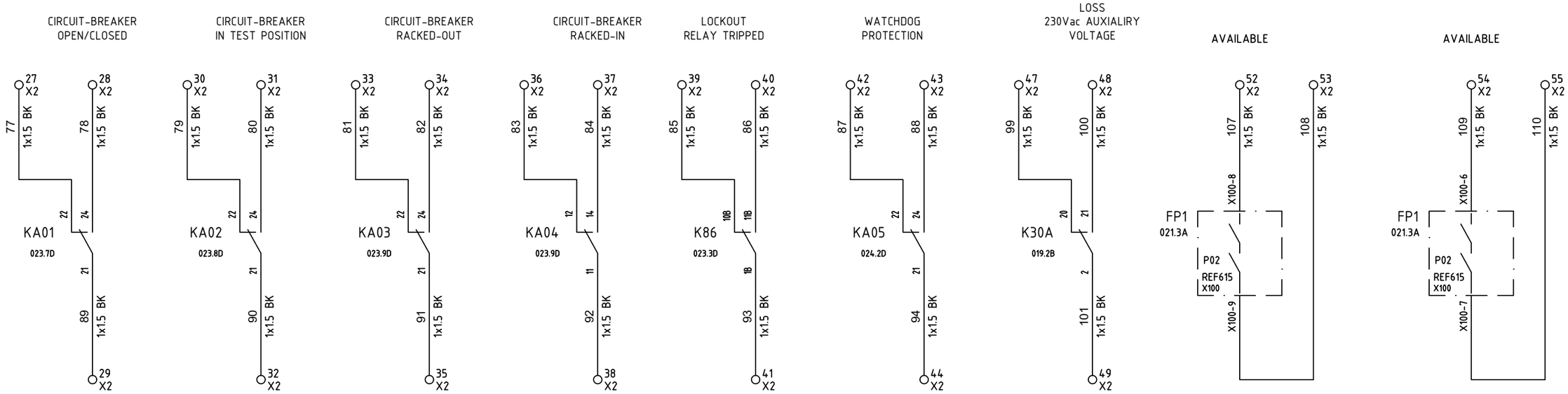
SHEET 031

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# AVAILABLE SIGNALS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Available Signals

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 032

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

SG-200N1 - A2/+02
XI

| NumM | Sheet | Sec. | Type | Terminal Description | Manufacturer |
|---|---|---|---|---|---|
| | | | BT005 | BTU End bracket | Cabur |
| 1 | 017.3B | 6 | HB220GR | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur |
| 2 | 017.3B | 6 | HB220GR | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur |
| 3 | 017.3C | 6 | HB220GR | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur |
| 4 | 017.3C | 6 | HB220GR | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur |
| 5 | 017.3C | 6 | HB220GR | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur |
| | | | HL201GR | HLD.2/PT/GR End section - Grey | Cabur |
| | | | BT005 | BTU End bracket | Cabur |

SG-200N1 - A2/+02
XV

| NumM | Sheet | Sec. | Type | Terminal Description | Manufacturer |
|---|---|---|---|---|---|
| | | | BT005 | BTU End bracket | Cabur |
| 1 | 017.7D | 6 | HB210GR | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type | Cabur |
| 2 | 017.7D | 6 | HB210GR | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type | Cabur |
| 3 | 017.7D | 6 | HB210GR | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type | Cabur |
| | | | HB201GR | HSCB.6/PT/GR End section - Grey | Cabur |
| | | | BT005 | BTU End bracket | Cabur |

= SG-200N1
\+ A2/+02
DWG n° : 231298/SD/30
Item n° : PF1002983/30

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Terminal Blocks

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 033

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

SG-200N1 - A2/+02
X2

| NumM | Sheet | Sec. | Type | Terminal Description | Manufacturer |
|---|---|---|---|---|---|
| | | | BT005 | BTU BLOCCHETTO TERMINALE | Cabur |
| 1 | 022.2B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 2 | 022.2B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 3 | 022.2C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 4 | 022.2D | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 5 | 018.7C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 6 | 018.7C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 7 | 022.6A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 8 | 022.6B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 9 | 022.7A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 10 | 022.7B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 11 | 023.3A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 12 | 023.3B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 13 | 023.4A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 14 | 023.4B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 15 | 026.3A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 16 | 026.3C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 17 | 026.4A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 18 | 026.4C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 19 | 026.4A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 20 | 026.4C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 21 | 031.1B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 22 | 031.3B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 23 | 031.4B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 24 | 031.5B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 25 | 031.6B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 26 | 031.7B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 27 | 032.1A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 28 | 032.1A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 29 | 032.1B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 30 | 032.2A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 31 | 032.2A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 32 | 032.2B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 33 | 032.3A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 34 | 032.3A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 35 | 032.3B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 36 | 032.4A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |

SG-200N1 - A2/+02
X2

| NumM | Sheet | Sec. | Type | Terminal Description | Manufacturer |
|---|---|---|---|---|---|
| 37 | 032.4A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 38 | 032.4B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 39 | 032.5A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 40 | 032.5A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 41 | 032.5B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 42 | 032.6A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 43 | 032.6A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 44 | 032.6B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 45 | 031.1D | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 46 | 031.3D | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 47 | 032.7A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 48 | 032.7A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 49 | 032.7B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 50 | 029.2A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 51 | 029.3C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 52 | 032.8A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 53 | 032.9A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 54 | 032.10A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 55 | 032.10A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 56 | 020.1A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 57 | 020.1A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 58 | 019.7A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 59 | 019.8A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 60 | 031.8B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 61 | 031.9B | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 62 | 029.6A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 63 | 029.6C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 64 | 029.7A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 65 | 029.7C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 66 | 029.8A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 67 | 029.8C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 68 | 029.9A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 69 | 029.9C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 70 | 030.3A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 71 | 030.3C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 72 | 030.4A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 73 | 030.4C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |

= SG-200N1
\+ A2/+02

DWG n° : 231298/SD/30
Item n° : PF1002983/30

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Terminal Blocks

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00030 | SHEET 034 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

SG-200N1 - A2/+02

X2

| NumM | Sheet | Sec. | Type | Terminal Description | Manufacturer |
|---|---|---|---|---|---|
| 74 | 030.4A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 75 | 030.4C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 76 | 030.5A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 77 | 030.5C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 78 | 030.6A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 79 | 030.6C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 80 | 030.7A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 81 | 030.7C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 82 | 030.8A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 83 | 030.8C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 84 | 030.9A | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| 85 | 030.9C | 4 | HM250GR | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur |
| | | | HM251GR | HMT.4/PT/GR Piastrina terminale grigia | Cabur |
| | | | BT005 | BTU BLOCCHETTO TERMINALE | Cabur |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30

Item n° : PF1002983/30

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

Terminal Blocks

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

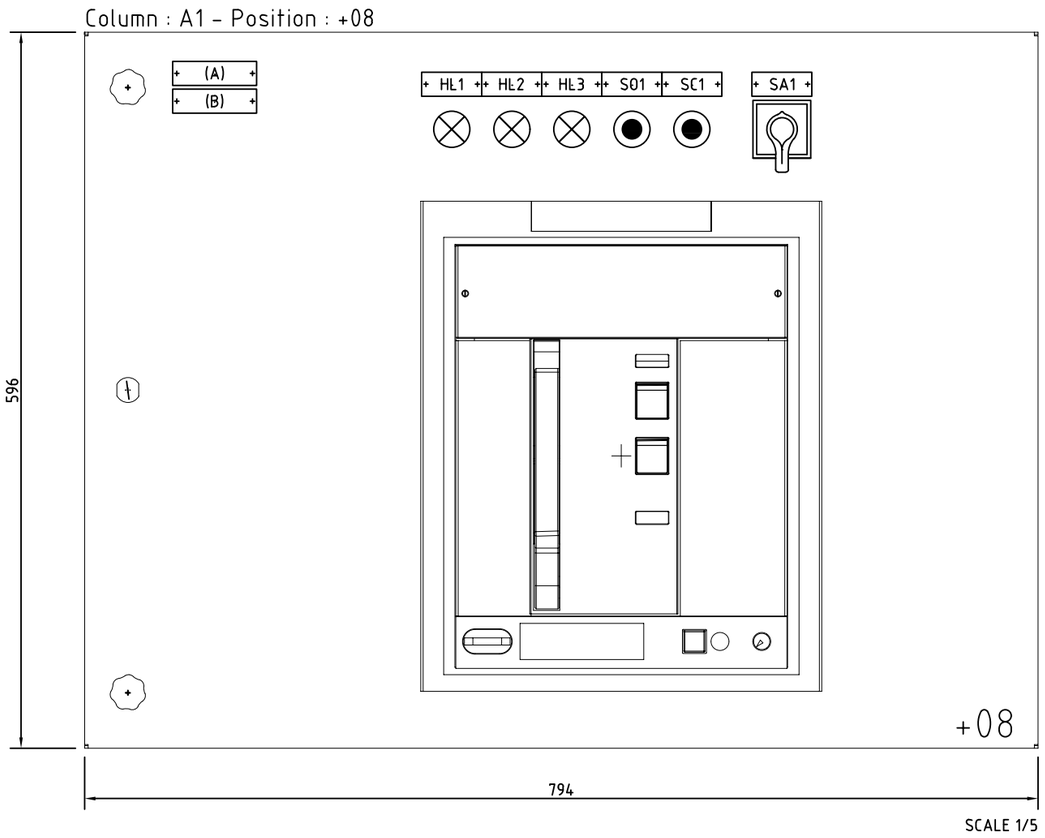
SHEET 035

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# FUNCTIONAL DIAGRAM - "A-20000 ELECTROLYSER AUXILIARY LOAD" [L3-630]

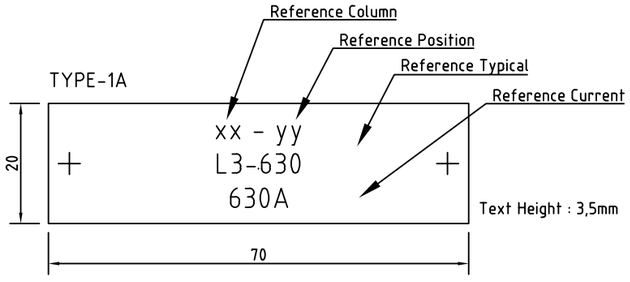


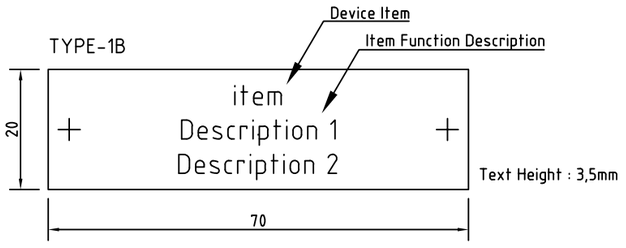

NOTE :

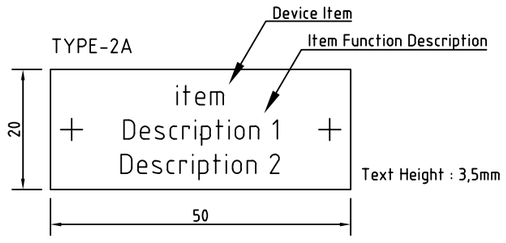
A) IDENTIFICATION name plate (type-1A) , with :
- Drawer position [Column / Position inside SWB]
- Typical name [reference applicability typical used]
- Power [reference applicability typical used]

B) USER name plate (type-1B), with :
- Item User [to see SLD diagrams]
- User Description [to see SLD diagrams]

| DEVICES name plate | | | | |
|---|---|---|---|---|
| ITEM | COMPONENT | DESCRIPTION 1 | DESCRIPTION 2 | NOTE |
| HL1 | PILOT LIGHT | CIRCUIT BREAKER | CLOSED | TYPE-2A |
| HL2 | PILOT LIGHT | CIRCUIT BREAKER | OPENED | TYPE-2A |
| HL3 | PILOT LIGHT | CIRCUIT BREAKER | TRIPPED | TYPE-2A |
| S01 | PUSH BUTTON | CIRCUIT BREAKER | OPENING COMMAND | TYPE-2A |
| SC1 | PUSH BUTTON | CIRCUIT BREAKER | CLOSING COMMAND | TYPE-2A |
| SA1 | PUSH BUTTON | SELECTOR | LOCAL / REMOTE | TYPE-2A |




| | |
|---|---|
| = | SG-200N1 |
| + | A1/+08 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
A-2000 / Electrolyser Auxiliry Load [L3-630]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

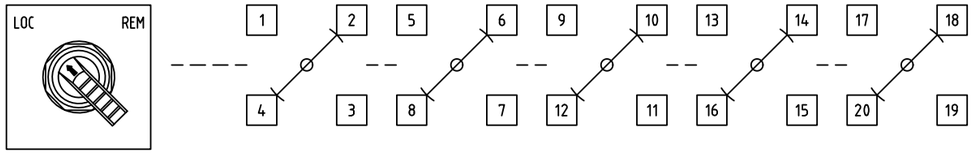
SHEET 036

REV. 02

F.to UNI A3: 420mmx297mm

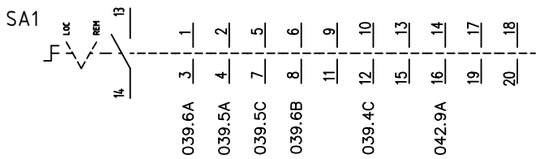
File Name : 1723002197-EL-DG-00030 Rev.02

# FUNCTIONAL DIAGRAM - "A-20000 ELECTROLYSER AUXILIARY LOAD" [L3-630]




Control Mode Switch

NOTE:
1. Square plate
2. Fixed position




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A1/+08 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
A-2000 / Electrolyser Auxiliry Load [L3-630]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 037

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# FUNCTIONAL DIAGRAM - "A-20000 ELECTROLYSER AUXILIARY LOAD" [L3-630]

MAIN BUS BARS
400V - 50Hz - 2500A - 50kA

018.10D L1-AA
018.10D L2-AA
018.10E L3-AA
018.10E N-AA

Emax E1

| | | | INSERTED | TEST | ISOLATED |
|---|---|---|---|---|---|
| S75E | 101-102 / 101-104 | 111-112 / 111-114 | X | X | |
| | | | | | X |
| S75T | 121-122 / 121-124 | 131-132 / 131-134 | X | | X |
| | | | | X | |
| S75I | 141-142 / 141-144 | 151-152 / 151-154 | | X | X |
| | | | X | | |

S75E/1 S75E/2 S75T/1 S75T/2 S75I/1 S75I/2
102 104 112 114 122 124 132 134 144 142 154 152
101 111 121 131 141 151
040.5A 039.5B 039.6C 040.6A

Q/1 Q/2 Q/3 Q/4 S33M RTC S51
12 14 22 24 32 34 42 44 U1 36 38 46 48 96 98 C1 C3 C11 C13 K1
11 21 31 41 U2 35 45 95 C2 C12 K2
040.2A 043.2B 042.4A 038.8C 040.4A 039.5C 039.3C

QF1
630A
(1)
K51 Ekip Hi-Touch
(2)

A-20000
ELECTROLYSER AUXILIARY LOAD

BUS-1
(Command/Signal Circuit)
P
LE3-bus1
048.6A
1 2 3 4 X1
230V-50Hz
200 201

SUPPLY MOTOR SPRING CHARGER C.B.
COMMAND CIRCUITS

QA1 4A
1 3 12 14 Q 11
042.6A
2 4
202 1x1.5 BK
203 1x1.5 BK
U1
BGS1
MAS M
038.2B
QF1
U2

QA2 4A
1 3 12 14 Q 11
042.6B
2 4
204 1x1.5 BK
205 1x1.5 BK
230V-50Hz
039.1A
039.1E

(1) KEY LOCK FOR OPEN POSITION (CIRCUIT-BREAKER)

(2) RACKIING-IN/RACKING-OUT PREVENTION LOCK WITH KEY (CIRCUIT-BREAKER)

| | |
|---|---|
| = | SG-200N1 |
| + | A1/+08 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND
IMESA ELECTRICAL ENGINEERING
ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
A-2000 / Electrolyser Auxialiry Load [L3-630]

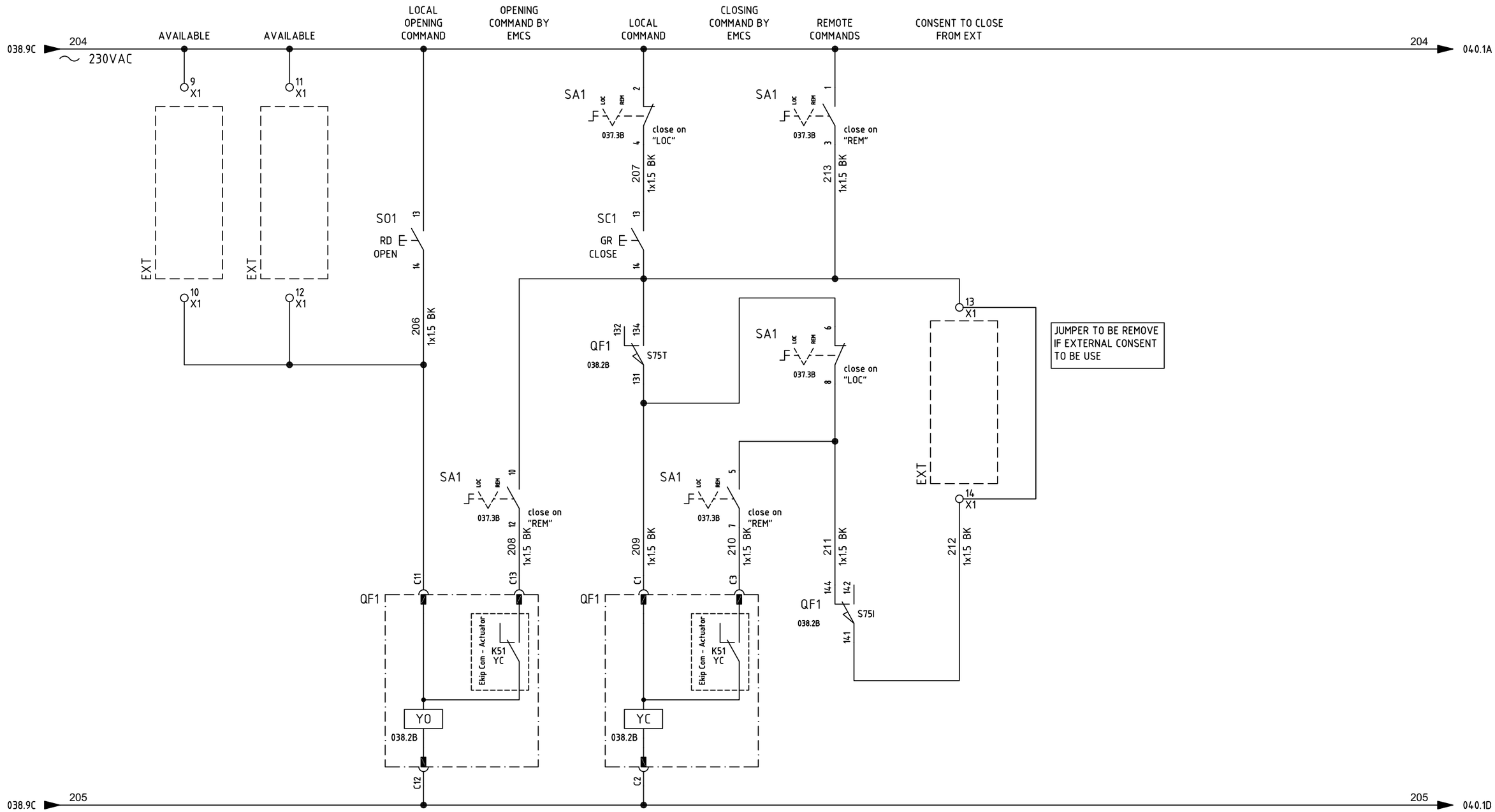
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00030
SHEET 038
REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# FUNCTIONAL DIAGRAM - "A-20000 ELECTROLYSER AUXILIARY LOAD" [L3-630]




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A1/+08 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | | | | | | |
| | | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
A-2000 / Electrolyser Auxiliry Load [L3-630]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

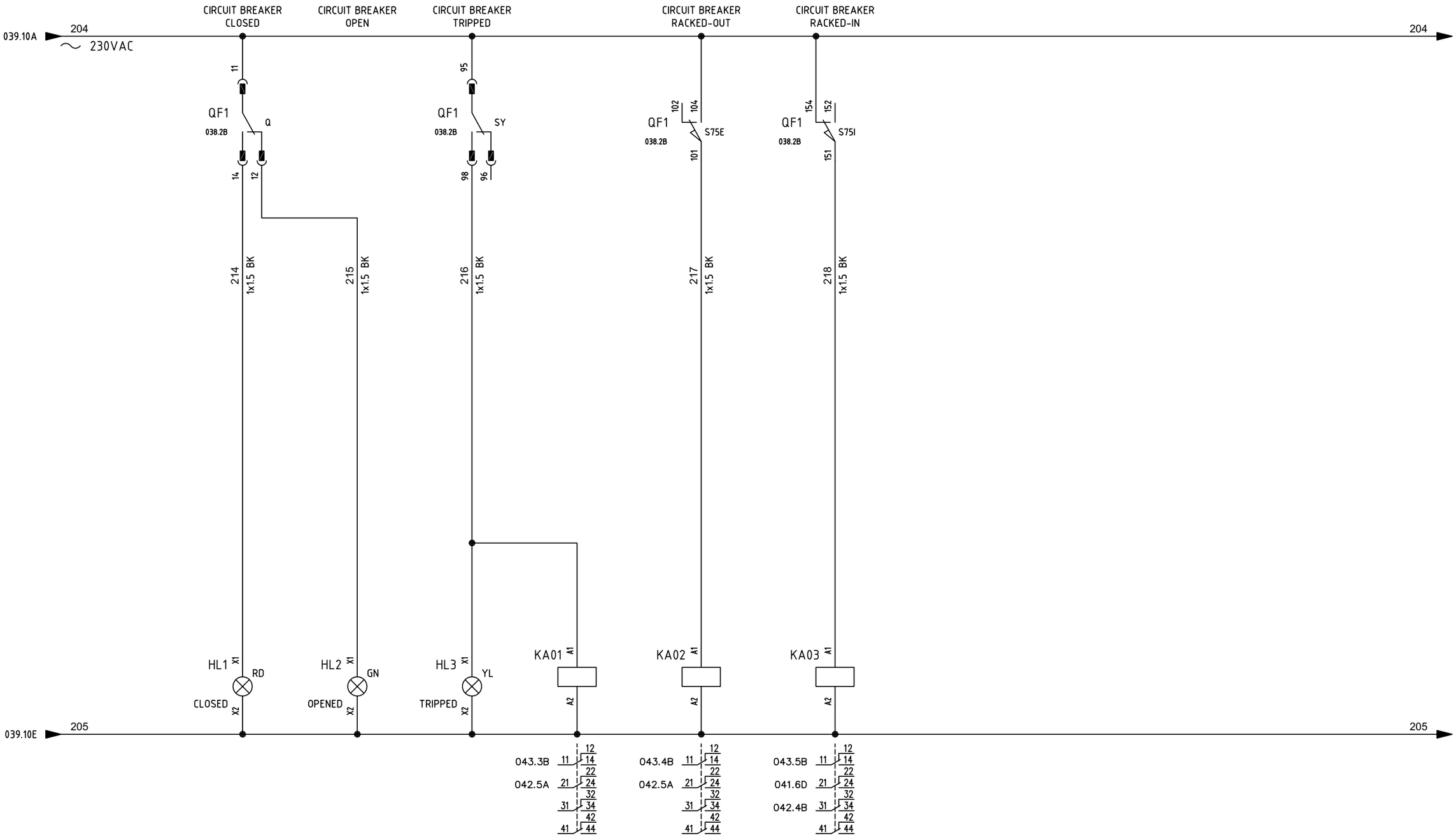
SHEET 039

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# FUNCTIONAL DIAGRAM - "A-20000 ELECTROLYSER AUXILIARY LOAD" [L3-630]




| | |
|---|---|
| = | SG-200N1 |
| + | A1/+08 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
A-2000 / Electrolyser Auxiliry Load [L3-630]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

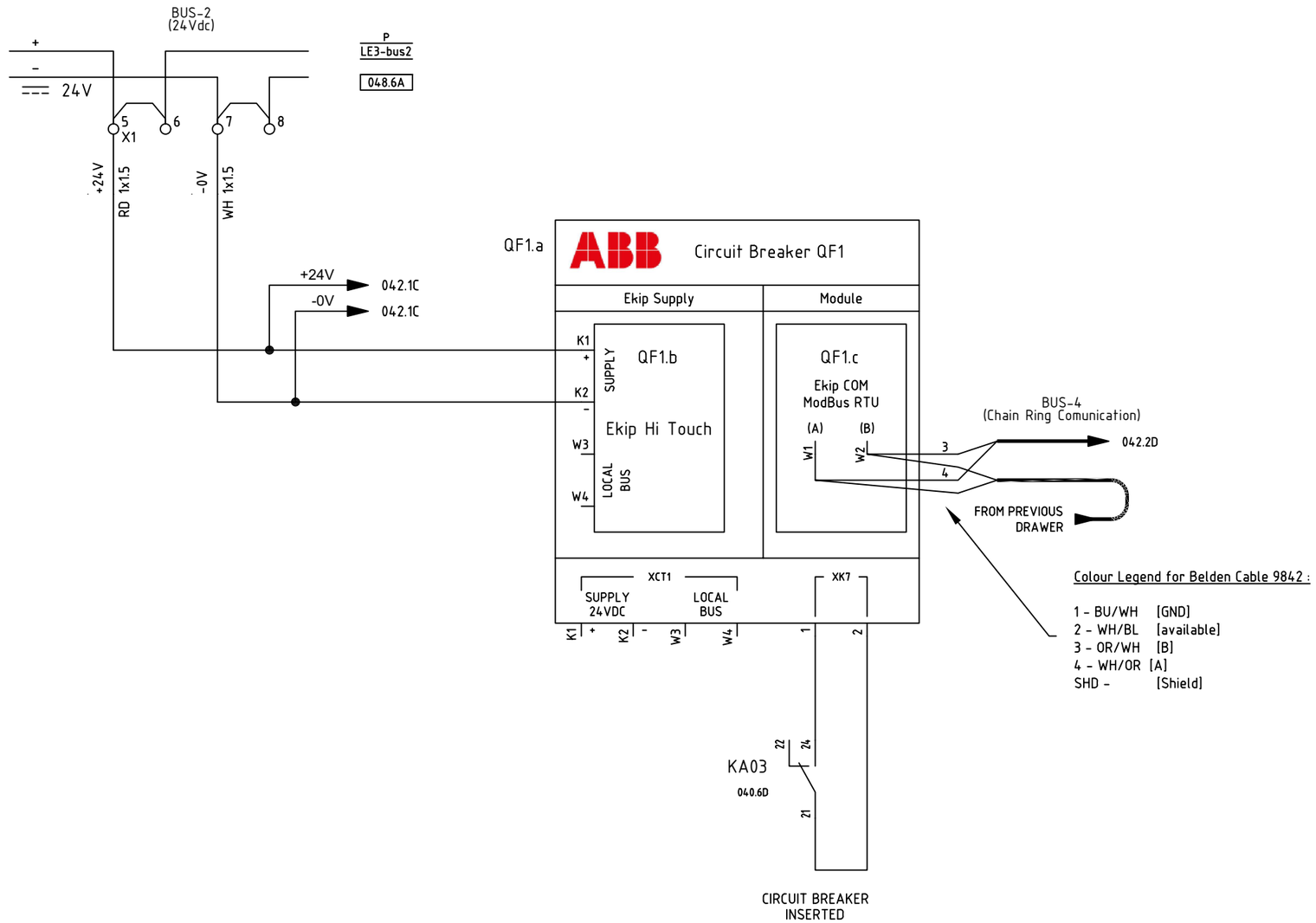
SHEET 040

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# FUNCTIONAL DIAGRAM - "A-20000 ELECTROLYSER AUXILIARY LOAD" [L3-630]




| | |
|---|---|
| = | SG-200N1 |
| + | A1/+08 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
A-2000 / Electrolyser Auxiliry Load [L3-630]

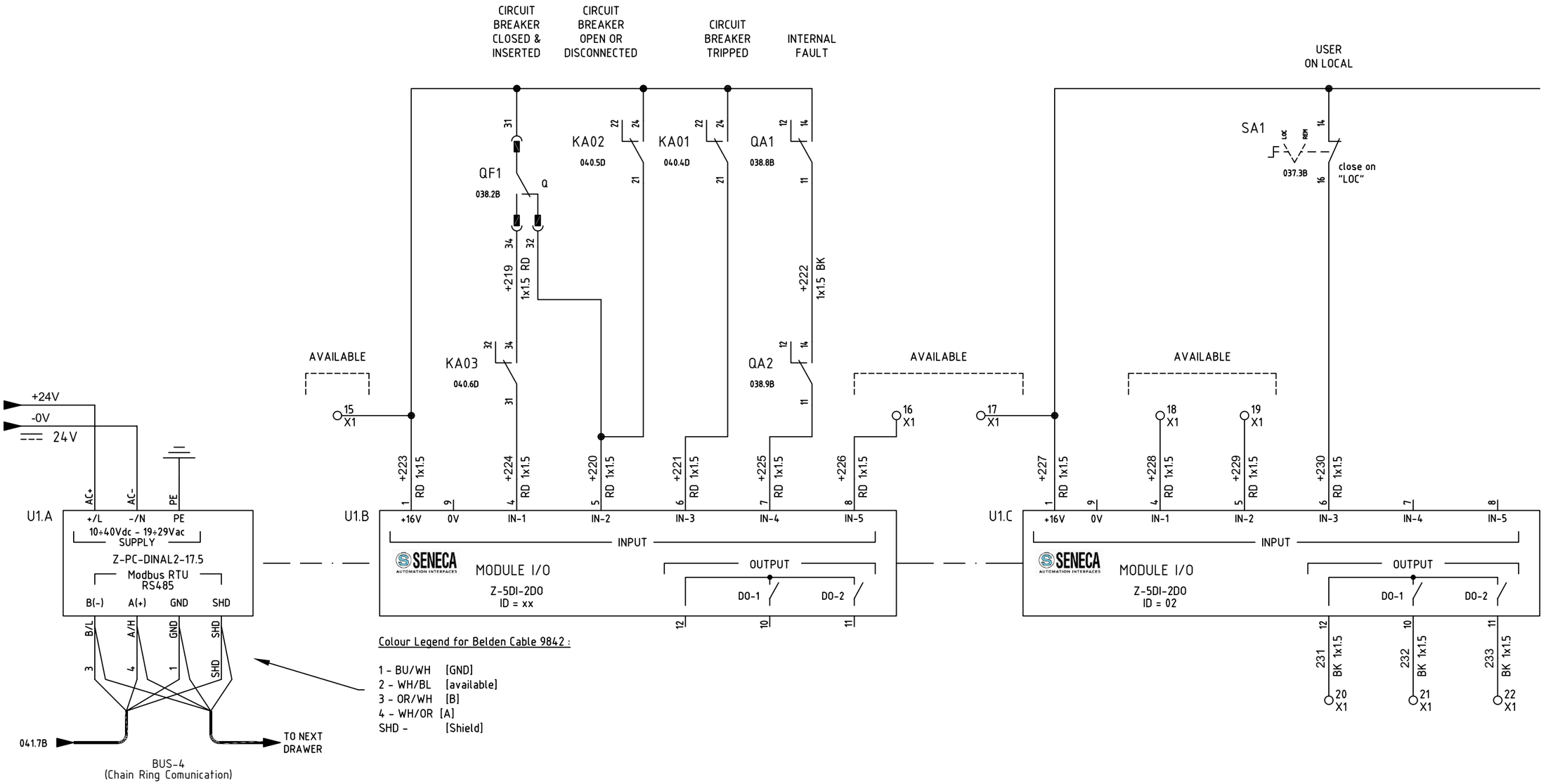
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00030 | SHEET 041 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# FUNCTIONAL DIAGRAM - "A-20000 ELECTROLYSER AUXILIARY LOAD" [L3-630]




Colour Legend for Belden Cable 9842 :

1 - BU/WH [GND]
2 - WH/BL [available]
3 - OR/WH [B]
4 - WH/OR [A]
SHD - [Shield]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A1/+08 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
A-2000 / Electrolyser Auxiliry Load [L3-630]

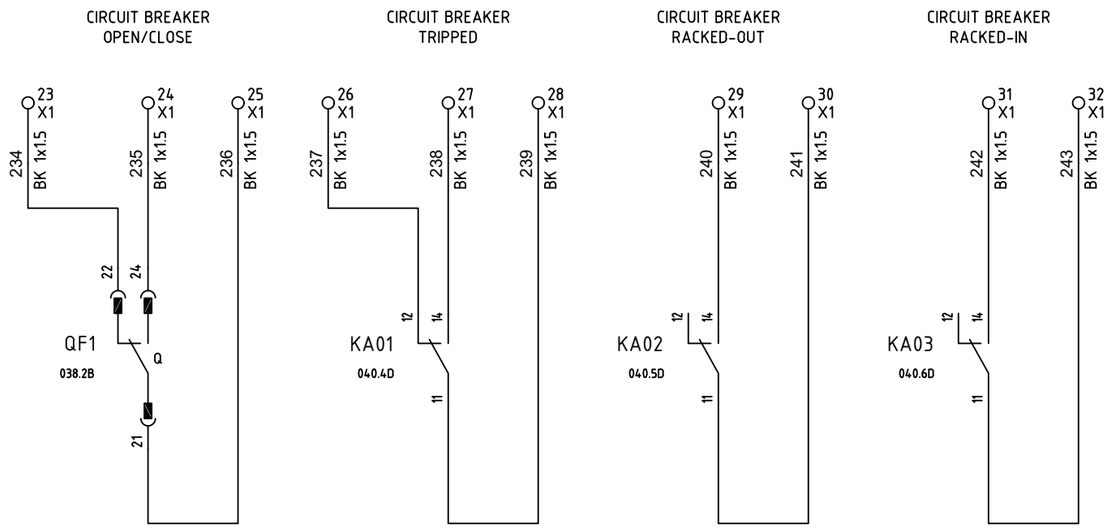
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00030 | SHEET 042 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# FUNCTIONAL DIAGRAM - "A-20000 ELECTROLYSER AUXILIARY LOAD" [L3-630]




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A1/+08 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
A-2000 / Electrolyser Auxiliry Load [L3-630]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 043

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

SG-200N1 - A1/+08

X1

| NumM | Sheet | Sec. | Type | Terminal Description | Manufacturer |
|---|---|---|---|---|---|
| | | | BT003 | BT/3 End bracket | Cabur |
| 1 | 038.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 2 | 038.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| | | | HD101GR | HMD/PT/GR End section - Grey | Cabur |
| 3 | 038.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 4 | 038.7A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 5 | 041.3A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 6 | 041.3A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 7 | 041.3A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 8 | 041.3A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 9 | 039.2A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 10 | 039.2B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 11 | 039.3A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 12 | 039.2B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 13 | 039.7B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 14 | 039.7C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 15 | 042.3C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 16 | 042.6C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 17 | 042.7C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 18 | 042.8C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 19 | 042.8C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 20 | 042.9D | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 21 | 042.9D | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 22 | 042.10D | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 23 | 043.1A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 24 | 043.2A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 25 | 043.2A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 26 | 043.3A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 27 | 043.3A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 28 | 043.4A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 29 | 043.4A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 30 | 043.5A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 31 | 043.5A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 32 | 043.6A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| | | | HD201GR | HMD.1/PT/GR End section - Grey | Cabur |
| | | | BT003 | BT/3 End bracket | Cabur |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30

Item n° : PF1002983/30

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

A-2000 / Electrolyser Auxiliry Load [L3-630]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 044

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| HL1 | 040 | EO 562 2 | 1 | ML1-100R RED LAMP | ABB | SG-200N1 | A1/+08 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | SG-200N1 | A1/+08 |
| | | KV 035 7 | 1 | MLBL-07R RED LED BLOCK INTEGRATED 230VAC | ABB | SG-200N1 | A1/+08 |
| HL2 | 040 | EO 563 0 | 1 | ML1-100G GREEN LAMP | ABB | SG-200N1 | A1/+08 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | SG-200N1 | A1/+08 |
| | | KV 036 5 | 1 | MLBL-07G GREEN LED BLOCK INTEGRATED 230VAC | ABB | SG-200N1 | A1/+08 |
| HL3 | 040 | EO 564 8 | 1 | ML1-100Y YELLOW LAMP | ABB | SG-200N1 | A1/+08 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | SG-200N1 | A1/+08 |
| | | KV 037 3 | 1 | MLBL-07Y YELLOW LED BLOCK INTEGRATED 230VAC | ABB | SG-200N1 | A1/+08 |
| KA01 | 040 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | SG-200N1 | A1/+08 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | SG-200N1 | A1/+08 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | SG-200N1 | A1/+08 |
| KA02 | 040 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | SG-200N1 | A1/+08 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | SG-200N1 | A1/+08 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | SG-200N1 | A1/+08 |
| KA03 | 040 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | SG-200N1 | A1/+08 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | SG-200N1 | A1/+08 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | SG-200N1 | A1/+08 |
| QA1 | 038 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | SG-200N1 | A1/+08 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | SG-200N1 | A1/+08 |
| QA2 | 038 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | SG-200N1 | A1/+08 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | SG-200N1 | A1/+08 |
| QF1 | 038 | 1SDA072819R1 | 1 | E1.2C 1250 Ekip Hi-Touch LSIG In=1000A 4p MP | ABB | SG-200N1 | A1/+08 |
| | | 1SDA073908R1 | 1 | E1.2 W FP 250÷1600A 4P FIXED PART HR-HR | ABB | SG-200N1 | A1/+08 |
| | | 1SDA073762R1 | 1 | AUP 6 CONTACT AUX INS/TEST/EST TO E1.2 | ABB | SG-200N1 | A1/+08 |
| | | 1SDA073687R1 | 1 | CLOSING COIL YC 220÷240VAC/DC TO E1.2÷E6.2 | ABB | SG-200N1 | A1/+08 |
| | | 1SDA073711R1 | 1 | MOTOR SPRING CHARGER 220÷250Vac/dc TO E1.2 | ABB | SG-200N1 | A1/+08 |
| | | 1SDA073770R1 | 1 | RTC 250V E1.2 | ABB | SG-200N1 | A1/+08 |
| | | 1SDA074166R1 | 2 | Module Ekip Actuator Emax E1.2÷E6.2÷XT7÷XT7M | ABB | SG-200N1 | A1/+08 |
| | | 1SDA073782R1 | 1 | KLC-D BLOCK KEY ON OPEN POSITION TO E1.2 | ABB | SG-200N1 | A1/+08 |
| | | 1SDA073822R1 | 1 | KLP-D INSERTED/ISOLATED KEY BLOCK TO E1.2 | ABB | SG-200N1 | A1/+08 |
| | | 1SDA073854R1 | 1 | PBC PUSHBOTTOM COVER OP/CL FOR E1.2 | ABB | SG-200N1 | A1/+08 |
| | | 1SDA074173R1 | 1 | MODUL EKIP SUPPLY 24÷48VDC | ABB | SG-200N1 | A1/+08 |
| | | 1SDA074150R1 | 1 | Module Ekip Com Modbus RTU Emax E1.2÷E6.2 | ABB | SG-200N1 | A1/+08 |
| | | 1SDA112845R1 | 1 | RATING PLUG In=630A E1.2÷-E6.2 | ABB | SG-200N1 | A1/+08 |
| SA1 | 037 | R601-205__02-W002 | 1 | SWITCH R16 2/5 - 2 STAY POSITION | Cometric | SG-200N1 | A1/+08 |
| | | Q4820030 | 1 | Frontplate 48x48mm (LOC-REM) | Cometric | SG-200N1 | A1/+08 |
| SC1 | 039 | KW 076 0 | 1 | MP1-10G PUSH BUTTON GREEN WITH BLACK RING | ABB | SG-200N1 | A1/+08 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | SG-200N1 | A1/+08 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | SG-200N1 | A1/+08 |
| SO1 | 039 | KW 075 2 | 1 | MP1-10R PUSH BUTTON RED WITH BLACK RING | ABB | SG-200N1 | A1/+08 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | SG-200N1 | A1/+08 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | SG-200N1 | A1/+08 |
| U1.A | 042 | Z-PC-DINAL2-17.5 | 1 | DIN RAIL 2SLOT WITH HEAD FOR "Z-5DI-2DO" | SENECA | SG-200N1 | A1/+08 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
A-2000 / Electrolyser Auxiliry Load [L3-630]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 045

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| U1.B | 042 | Z-5DI-2DO | 1 | I/O MODUL 5DI+2DO modbus RS485 Vaux=10÷40Vdc 19÷28Vac | SENECA | SG-200N1 | A1/+08 |
| U1.C | 042 | Z-5DI-2DO | 1 | I/O MODUL 5DI+2DO modbus RS485 Vaux=10÷40Vdc 19÷28Vac | SENECA | SG-200N1 | A1/+08 |
| X1 | | HD400GR__ | 24 | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur | SG-200N1 | A1/+08 |
| | | HD100GR__ | 8 | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur | SG-200N1 | A1/+08 |
| | | BT003 | 2 | BT/3 End bracket | Cabur | SG-200N1 | A1/+08 |
| | | HD101GR | 1 | HMD/PT/GR End section - Grey | Cabur | SG-200N1 | A1/+08 |
| | | HD201GR | 1 | HMD.1/PT/GR End section - Grey | Cabur | SG-200N1 | A1/+08 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
A-2000 / Electrolyser Auxiliry Load [L3-630]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 046

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

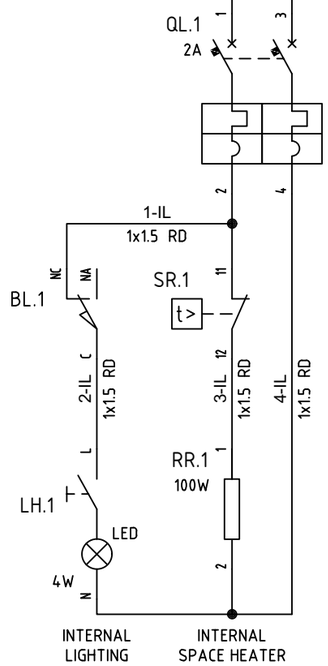
# DISTRIBUTION AUX VOLTAGE COLUMNS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 019.4C | 1/B1 | 1 | 230V-50Hz [Bus-1] (Command/Signal Circuit) | | | | | 1/B1 | 049.1A |
| 019.4C | 2/B1 | 2 | | | | | | 2/B1 | 049.1A |
| 020.9C | +1/B2 | 3 | 24VDC [Bus-2] (Comunication) | | | | | +1/B2 | 049.1A |
| 020.9C | -2/B2 | 4 | | | | | | -2/B2 | 049.1A |
| 029.5A | +24VDC | 5 | 24VDC [Bus-3] (Fault Loop) | | | | | +1/B3 | 049.1A |
| 029.5C | E0.3 | 6 | | | | | | +2/B3 | 049.1A |
| 019.8C | 1/B4 | 7 | 230V-50Hz [Bus-4] (Internal Lighting/Heater) | | | | | 1/B4 | 049.1B |
| 019.9C | 2/B4 | 8 | | | | | | 2/B4 | 049.1B |
| | | 9 | Available | | | | | 1/B5 | 049.1B |
| | | 10 | | | | | | 2/B5 | 049.1B |
| | | 11 | Available | | | | | 1/B6 | 049.1B |
| | | 12 | | | | | | 2/B6 | 049.1B |

1/B1 → 048.2A; 2/B1 → 048.2A — BUS-1
SUPPLY DISTRIBUTION
230Vac
Command/Signal Circuit

+1/B2 → 048.2A; -2/B2 → 048.2A — BUS-2
SUPPLY DISTRIBUTION
24Vdc
Comunication

+3/B3 → 048.2B; +4/B3 → 048.2B — BUS-3
Fault Loop




| | |
|---|---|
| = | SG-200N1 |
| + | A1 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Distribution Aux Voltage Columns [A1]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

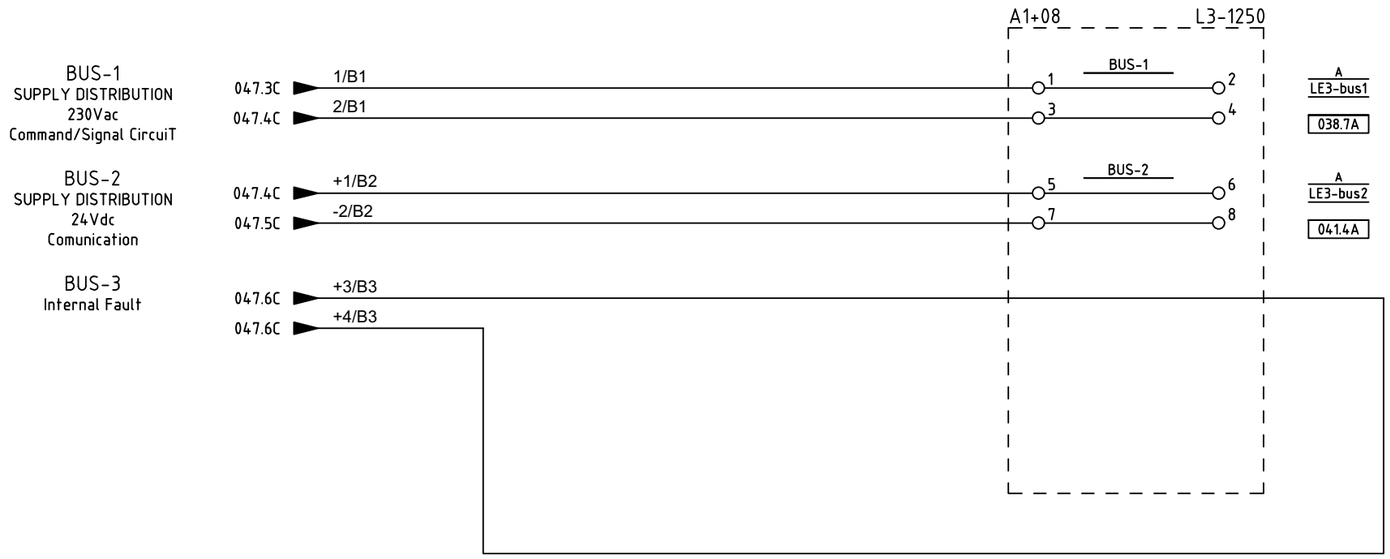
A3 | DRAWING NO. 1723002197-EL-DG-00030 | SHEET 047 | REV. 02

CROSSWIND
IMESA ELECTRICAL ENGINEERING
ROSETTI MARINO

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# DISTRIBUTION AUX VOLTAGE COLUMNS




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A1 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Distribution Aux Voltage Columns [A1]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 048

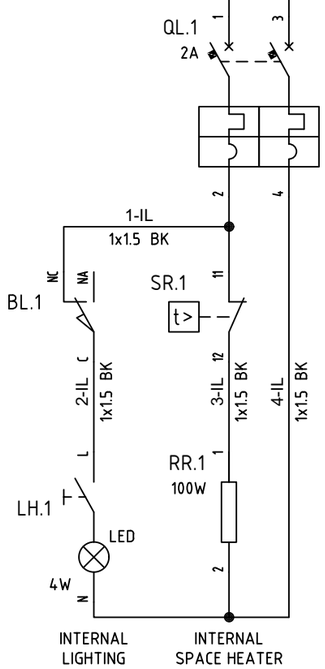
REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# DISTRIBUTION AUX VOLTAGE COLUMNS

| | | | | | |
|---|---|---|---|---|---|
| 047.10A | 1/B1 | 1 | 230V-50Hz [Bus-1] (Command/Signal Circuit) | 1/B1 | 051.1A |
| 047.10A | 2/B1 | 2 | | 2/B1 | 051.1A |
| 047.10A | +1/B2 | 3 | 24VDC [Bus-2] (Comunication) | +1/B2 | 051.1A |
| 047.10A | -2/B2 | 4 | | -2/B2 | 051.1A |
| 047.10A | +1/B3 | 5 | 24VDC [Bus-3] (Fault Loop) | +1/B3 | 051.1A |
| 047.10A | +2/B3 | 6 | | +2/B3 | 051.1A |
| 047.10B | 1/B4 | 7 | 230V-50Hz [Bus-4] (Internal Lighting/Heater) | 1/B4 | 051.1B |
| 047.10B | 2/B4 | 8 | | 2/B4 | 051.1B |
| 047.10B | 1/B5 | 9 | Available | 1/B5 | 051.1B |
| 047.10B | 2/B5 | 10 | | 2/B5 | 051.1B |
| 047.10B | 1/B6 | 11 | Available | 1/B6 | 051.1B |
| 047.10B | 2/B6 | 12 | | 2/B6 | 051.1B |




1/B1 2/B1 → 050.2A 050.2A

BUS-1
SUPPLY DISTRIBUTION
230Vac
Command/Signal Circuit

+1/B2 -2/B2 → 050.2A 050.2A

BUS-2
SUPPLY DISTRIBUTION
24Vdc
Comunication

+3/B3 +4/B3 → 050.2B 050.2B

BUS-3
Fault Loop

+1/B2 -2/B2 → 063.1A 063.1A

SUPPLY
ModBus converter

| | |
|---|---|
| = | SG-200N1 |
| + | A2 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Distribution Aux Voltage Columns [A2]

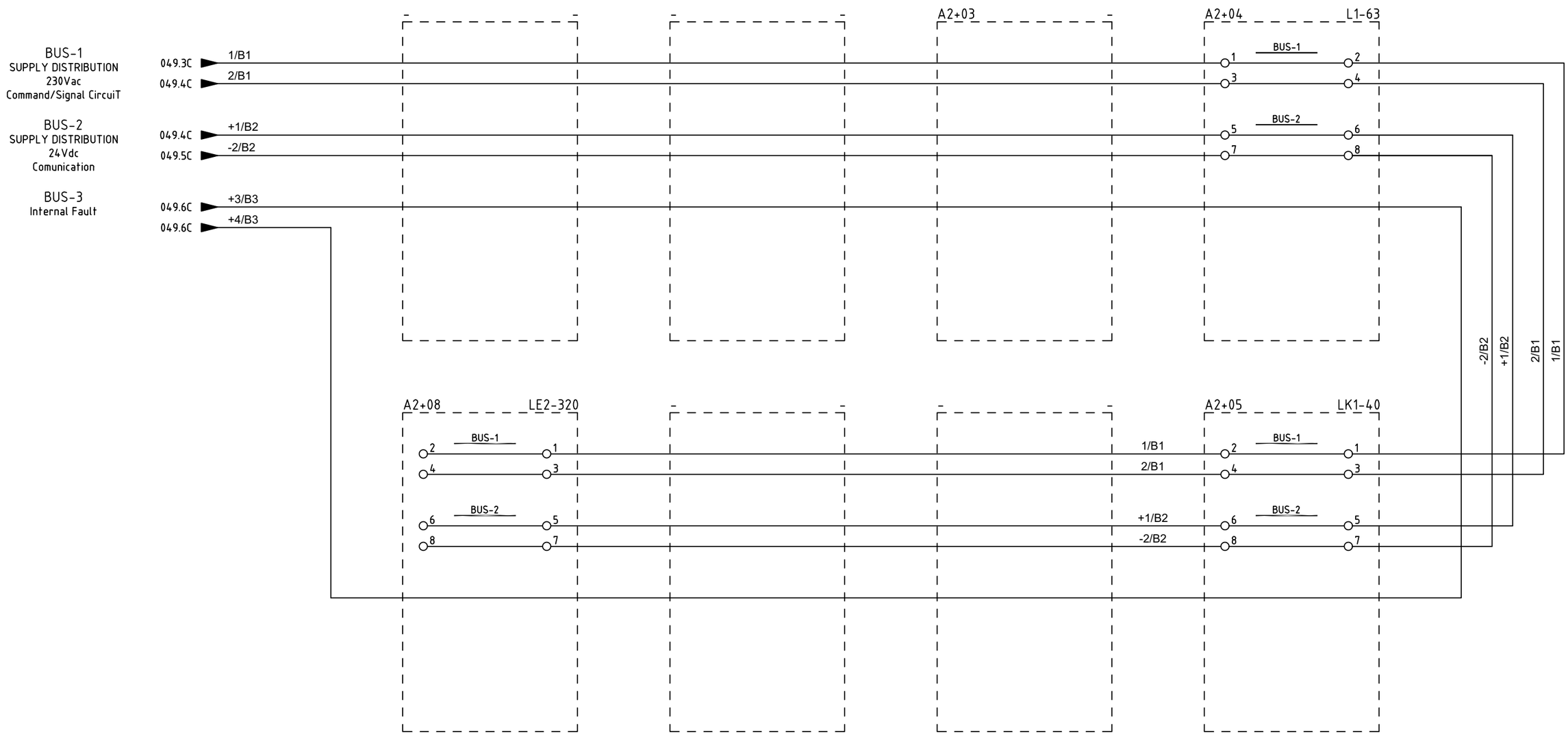
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00030 | SHEET 049 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# DISTRIBUTION AUX VOLTAGE COLUMNS




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A2 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

Distribution Aux Voltage Columns [A2]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 050

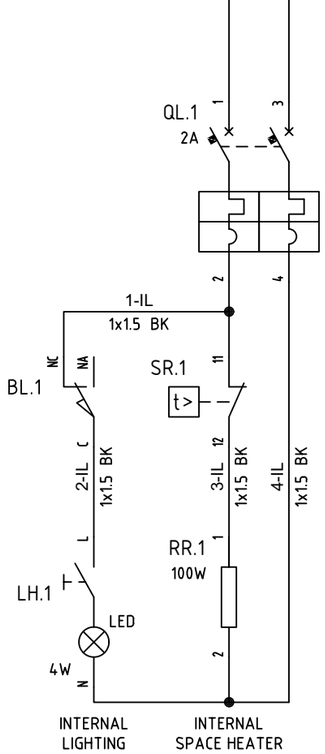
REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# DISTRIBUTION AUX VOLTAGE COLUMNS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 049.10A | 1/B1 | 1 | 230V-50Hz [Bus-1] (Command/Signal Circuit) | | | | | 1/B1 | 053.1A |
| 049.10A | 2/B1 | 2 | | | | | | 2/B1 | 053.1A |
| 049.10A | +1/B2 | 3 | 24VDC [Bus-2] (Comunication) | | | | | +1/B2 | 053.1A |
| 049.10A | -2/B2 | 4 | | | | | | -2/B2 | 053.1A |
| 049.10A | +1/B3 | 5 | 24VDC [Bus-3] (Fault Loop) | | | | | +1/B3 | 053.1A |
| 049.10A | +2/B3 | 6 | | | | | | +2/B3 | 053.1A |
| 049.10B | 1/B4 | 7 | 230V-50Hz [Bus-4] (Internal Lighting/Heater) | | | | | 1/B4 | 053.1B |
| 049.10B | 2/B4 | 8 | | | | | | 2/B4 | 053.1B |
| 049.10B | 1/B5 | 9 | Available | | | | | 1/B5 | 053.1B |
| 049.10B | 2/B5 | 10 | | | | | | 2/B5 | 053.1B |
| 049.10B | 1/B6 | 11 | Available | | | | | 1/B6 | 053.1B |
| 049.10B | 2/B6 | 12 | | | | | | 2/B6 | 053.1B |




1/B1 → 052.2A — BUS-1 SUPPLY DISTRIBUTION 230Vac Command/Signal Circuit

2/B1 → 052.2A — BUS-1 SUPPLY DISTRIBUTION 230Vac Command/Signal Circuit

+1/B2 → 052.2A — BUS-2 SUPPLY DISTRIBUTION 24Vdc Comunication

-2/B2 → 052.2A — BUS-2 SUPPLY DISTRIBUTION 24Vdc Comunication

+3/B3 → 052.2B — BUS-3 Fault Loop

+4/B3 → 052.2B — BUS-3 Fault Loop

| | |
|---|---|
| = | SG-200N1 |
| + | A3 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Distribution Aux Voltage Columns [A3]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

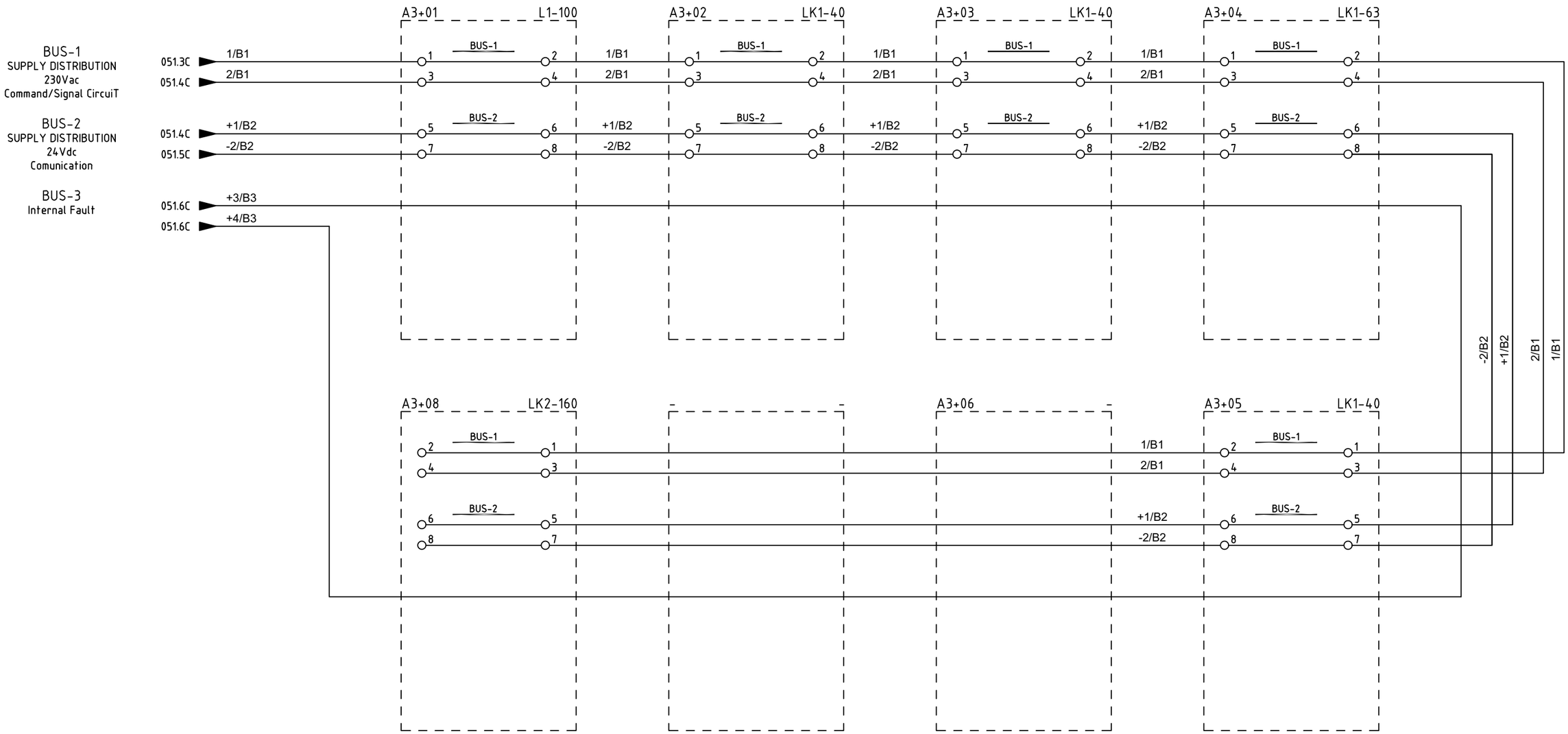
SHEET 051

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# DISTRIBUTION AUX VOLTAGE COLUMNS




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A3 | | | | | | |
| DWG n°: | 231298/SD/30 | | | | | | |
| Item n°: | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

Distribution Aux Voltage Columns [A3]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

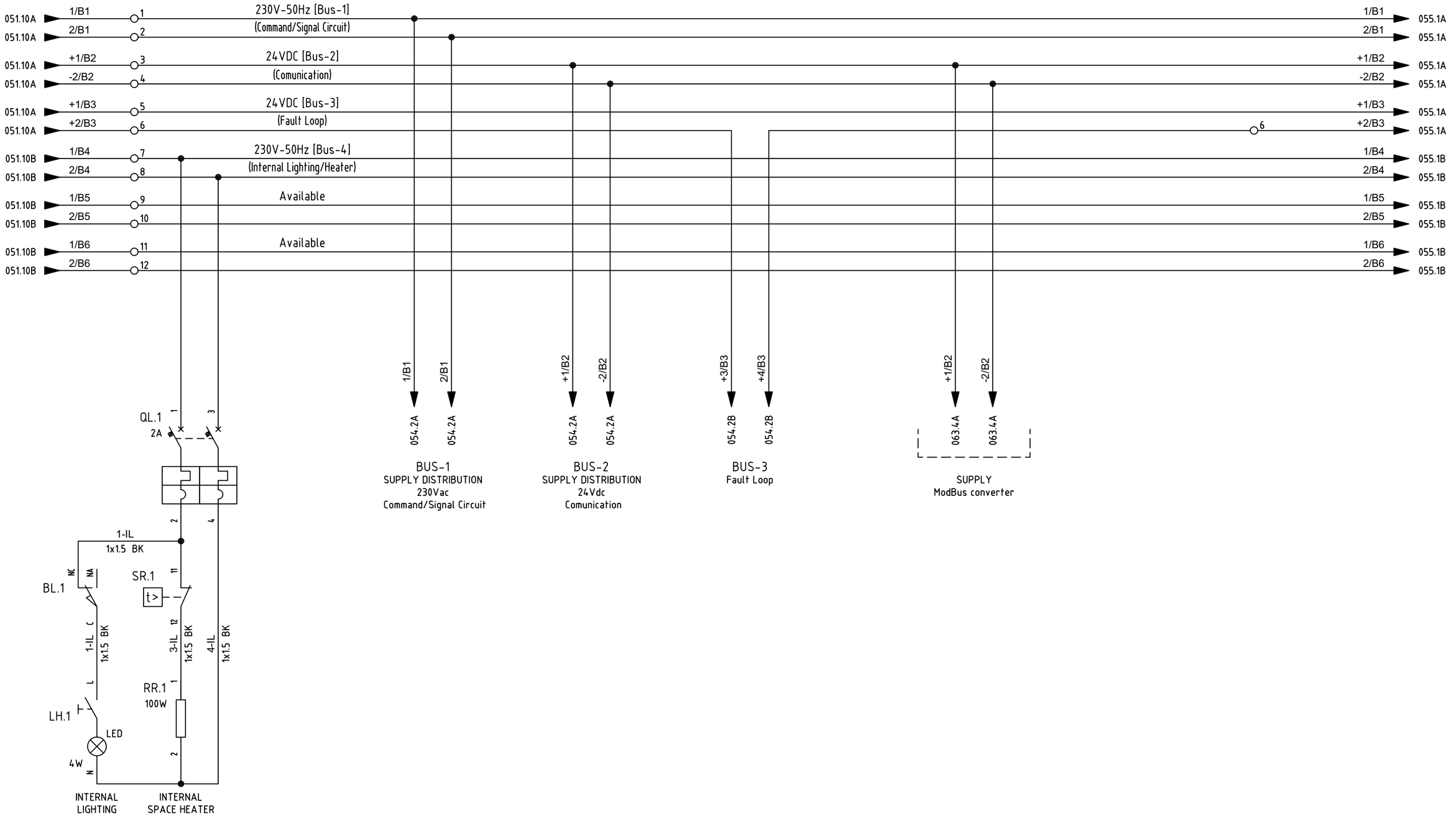
SHEET 052

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# DISTRIBUTION AUX VOLTAGE COLUMNS




| | | | | | | |
|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | |
| + | A4 | | | | | |
| DWG n° : | 231298/SD/30 | | | | | |
| Item n° : | PF1002983/30 | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) | |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Distribution Aux Voltage Columns [A4]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 053

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

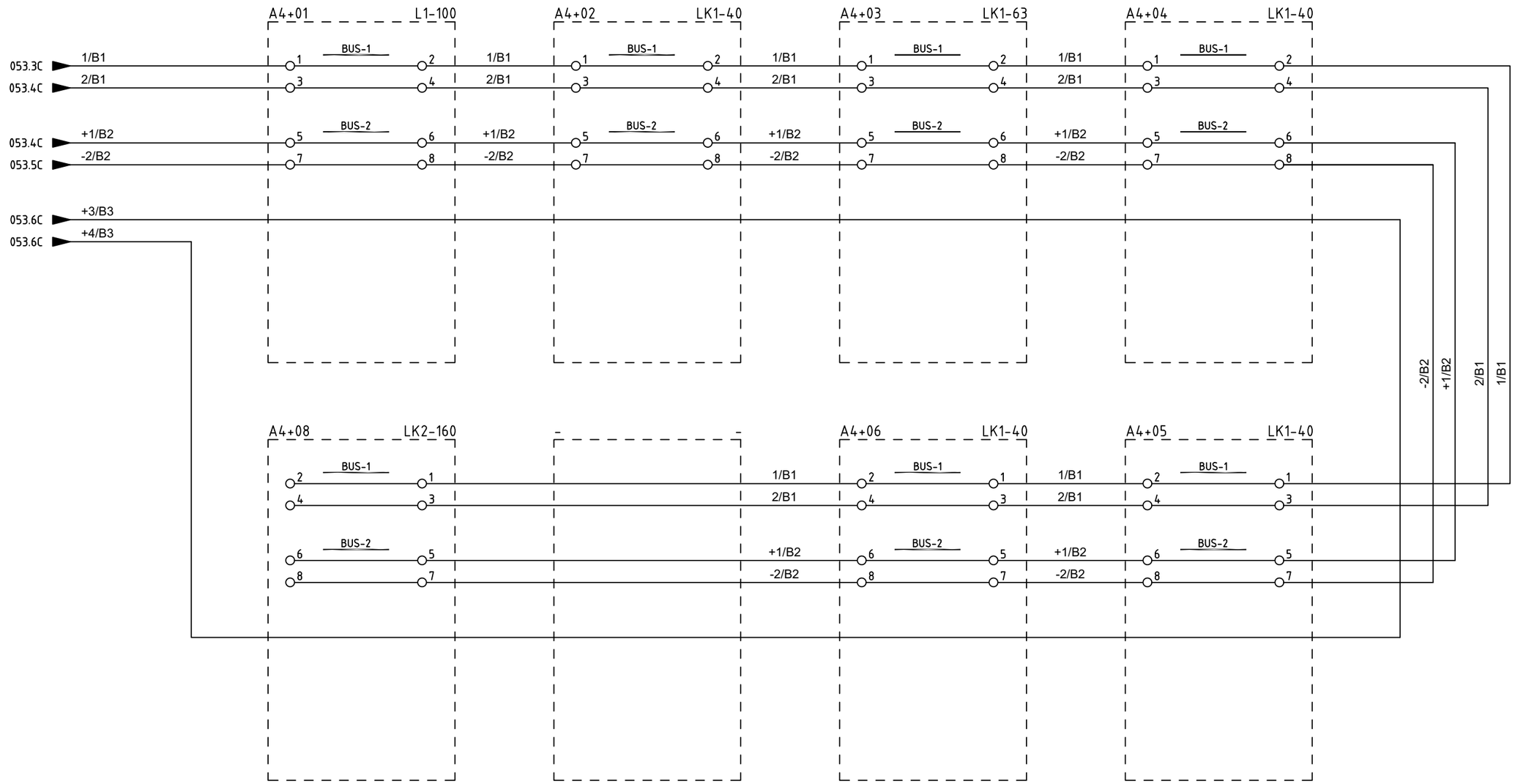
F.to UNI A3: 420mmx297mm

# DISTRIBUTION AUX VOLTAGE COLUMNS

BUS-1
SUPPLY DISTRIBUTION
230Vac
Command/Signal CircuiT

BUS-2
SUPPLY DISTRIBUTION
24Vdc
Comunication

BUS-3
Internal Fault




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A4 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Distribution Aux Voltage Columns [A4]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 054

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# DISTRIBUTION AUX VOLTAGE COLUMNS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 053.10A | 1/B1 | 1 | 230V-50Hz [Bus-1] (Command/Signal Circuit) | | | | | 1/B1 | 057.1A |
| 053.10A | 2/B1 | 2 | | | | | | 2/B1 | 057.1A |
| 053.10A | +1/B2 | 3 | 24VDC [Bus-2] (Comunication) | | | | | +1/B2 | 057.1A |
| 053.10A | -2/B2 | 4 | | | | | | -2/B2 | 057.1A |
| 053.10A | +1/B3 | 5 | 24VDC [Bus-3] (Fault Loop) | | | | | +1/B3 | 057.1A |
| 053.10A | +2/B3 | 6 | | | | | | +2/B3 | 057.1A |
| 053.10B | 1/B4 | 7 | 230V-50Hz [Bus-4] (Internal Lighting/Heater) | | | | | 1/B4 | 057.1B |
| 053.10B | 2/B4 | 8 | | | | | | 2/B4 | 057.1B |
| 053.10B | 1/B5 | 9 | Available | | | | | 1/B5 | 057.1B |
| 053.10B | 2/B5 | 10 | | | | | | 2/B5 | 057.1B |
| 053.10B | 1/B6 | 11 | Available | | | | | 1/B6 | 057.1B |
| 053.10B | 2/B6 | 12 | | | | | | 2/B6 | 057.1B |

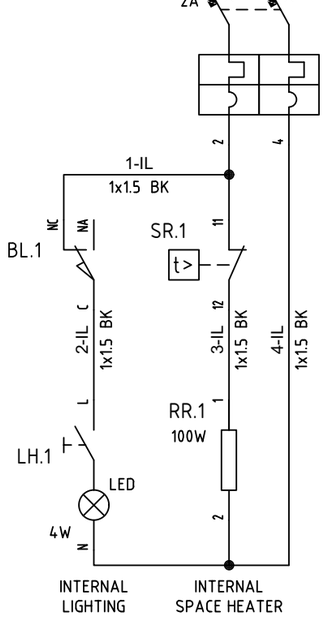
6

1/B1 → 056.2A
2/B1 → 056.2A
+1/B2 → 056.2A
-2/B2 → 056.2A
+3/B3 → 056.2B
+4/B3 → 056.2B

**BUS-1**
SUPPLY DISTRIBUTION
230Vac
Command/Signal Circuit

**BUS-2**
SUPPLY DISTRIBUTION
24Vdc
Comunication

**BUS-3**
Fault Loop




| | |
|---|---|
| = | SG-200N1 |
| + | A5 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Distribution Aux Voltage Columns [A5]

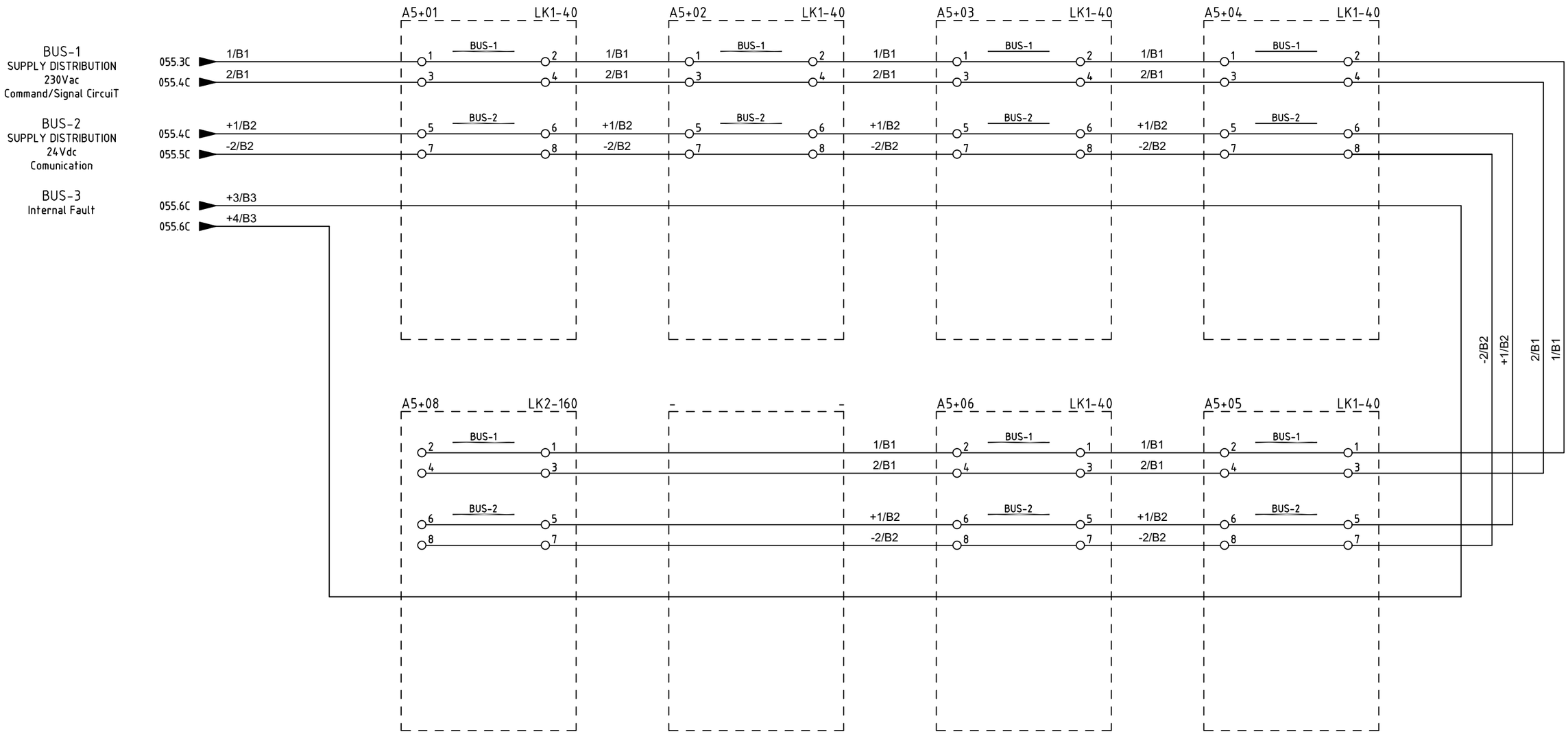
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

| A3 | DRAWING NO. | SHEET | REV. |
|---|---|---|---|
| | 1723002197-EL-DG-00030 | 055 | 02 |

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# DISTRIBUTION AUX VOLTAGE COLUMNS




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A5 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

Distribution Aux Voltage Columns [A5]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

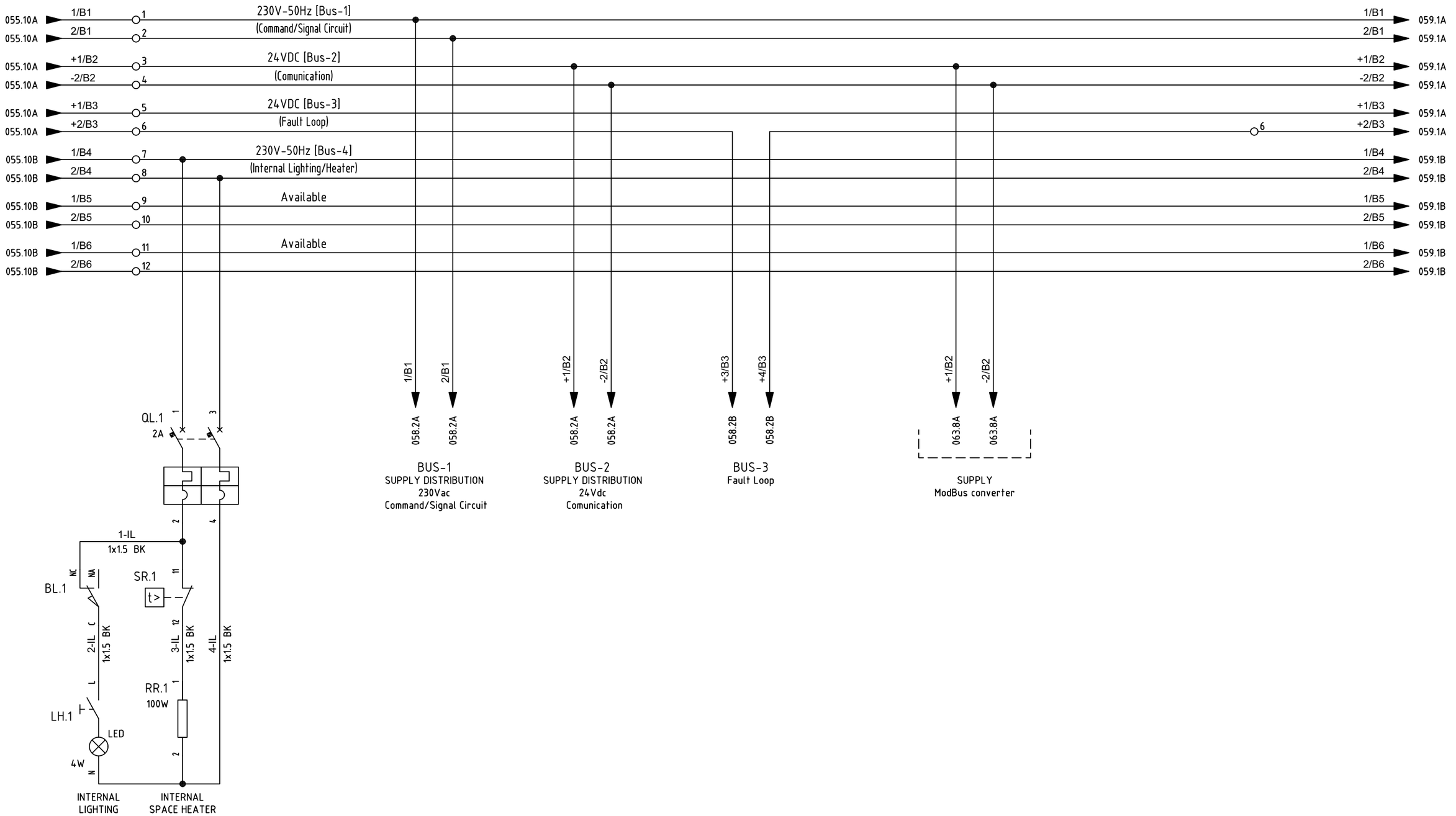
SHEET 056

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# DISTRIBUTION AUX VOLTAGE COLUMNS




| | | | | | | |
|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | |
| + | A6 | | | | | |
| DWG n° : | 231298/SD/30 | | | | | |
| Item n° : | PF1002983/30 | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) | |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) | |
| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

Distribution Aux Voltage Columns [A6]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

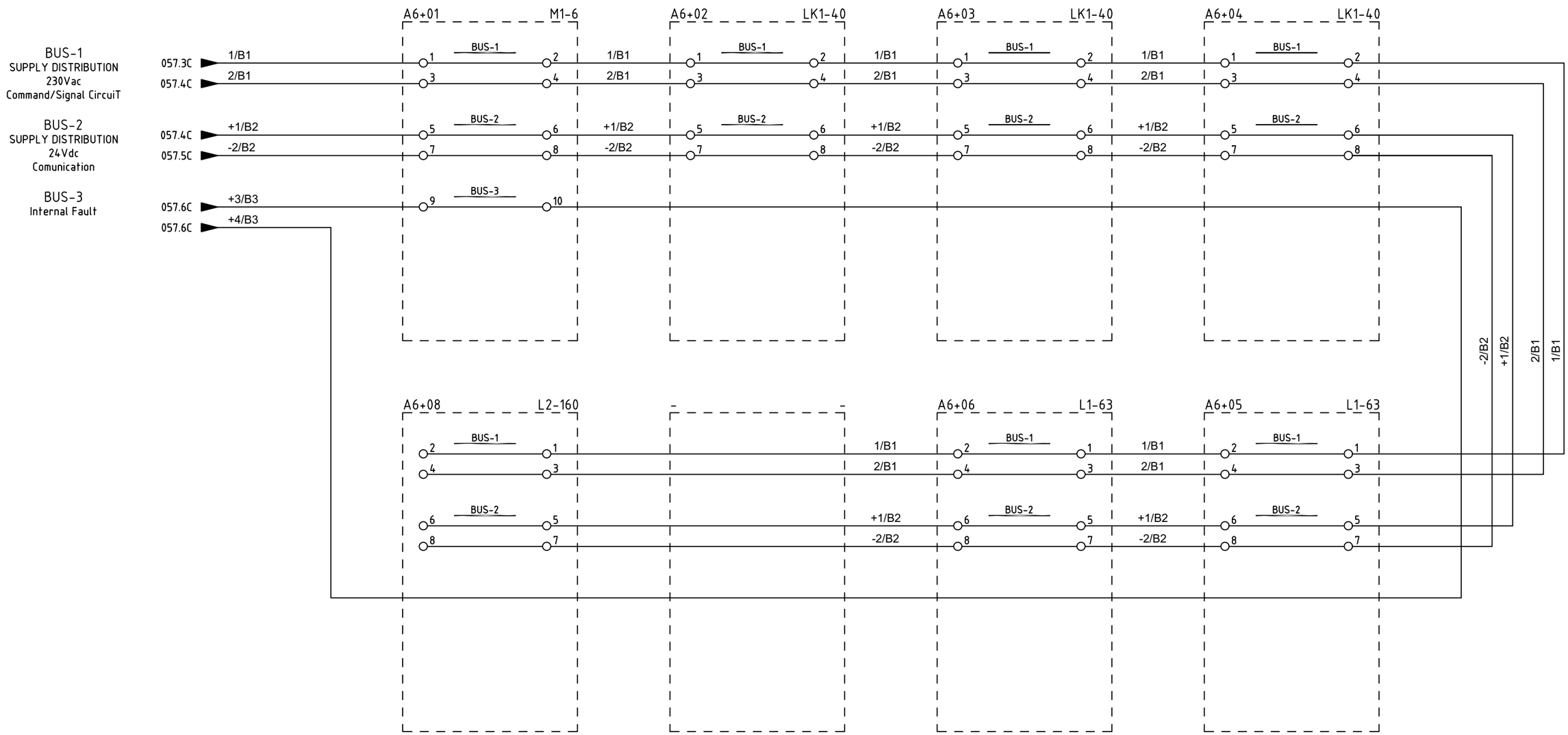
SHEET 057

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# DISTRIBUTION AUX VOLTAGE COLUMNS




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A6 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

Distribution Aux Voltage Columns [A6]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

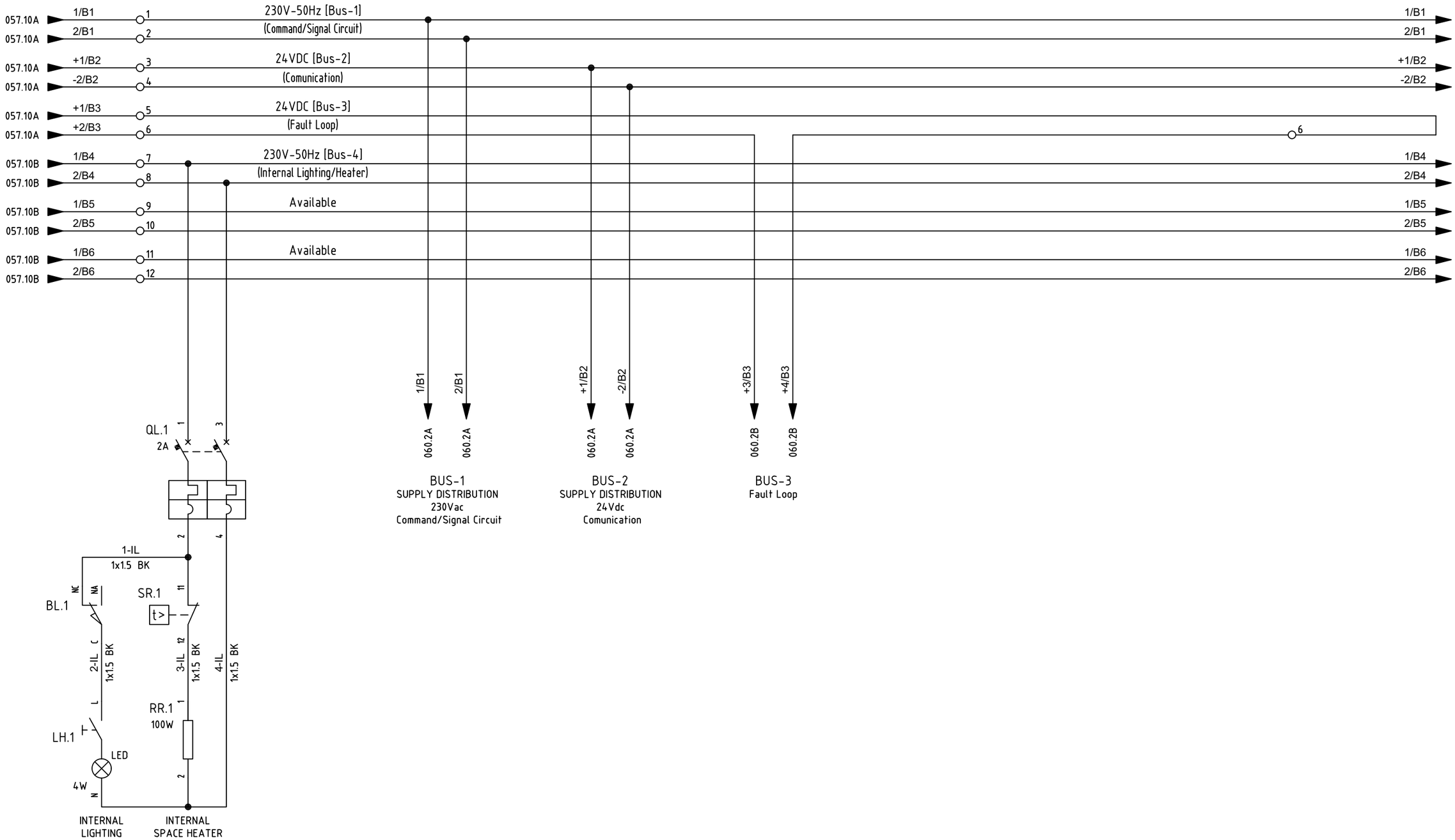
SHEET 058

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# DISTRIBUTION AUX VOLTAGE COLUMNS




| | |
|---|---|
| = | SG-200N1 |
| + | A7 |
| DWG n° : | 231298/SD/30 |
| Item n° : | PF1002983/30 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Distribution Aux Voltage Columns [A7]

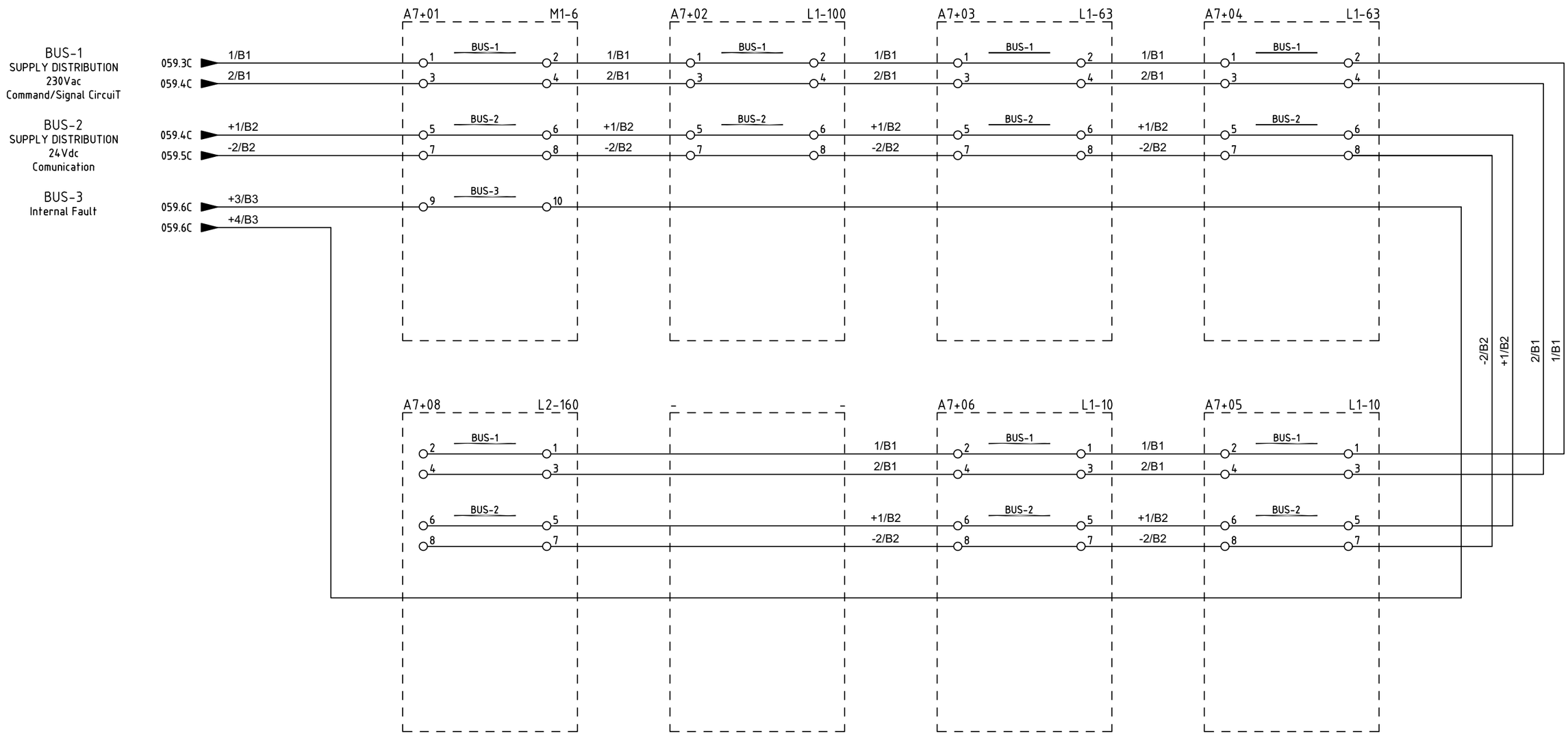
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00030 | SHEET 059 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# DISTRIBUTION AUX VOLTAGE COLUMNS




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A7 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1

FUNCTIONAL DIAGRAM

Distribution Aux Voltage Columns [A7]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

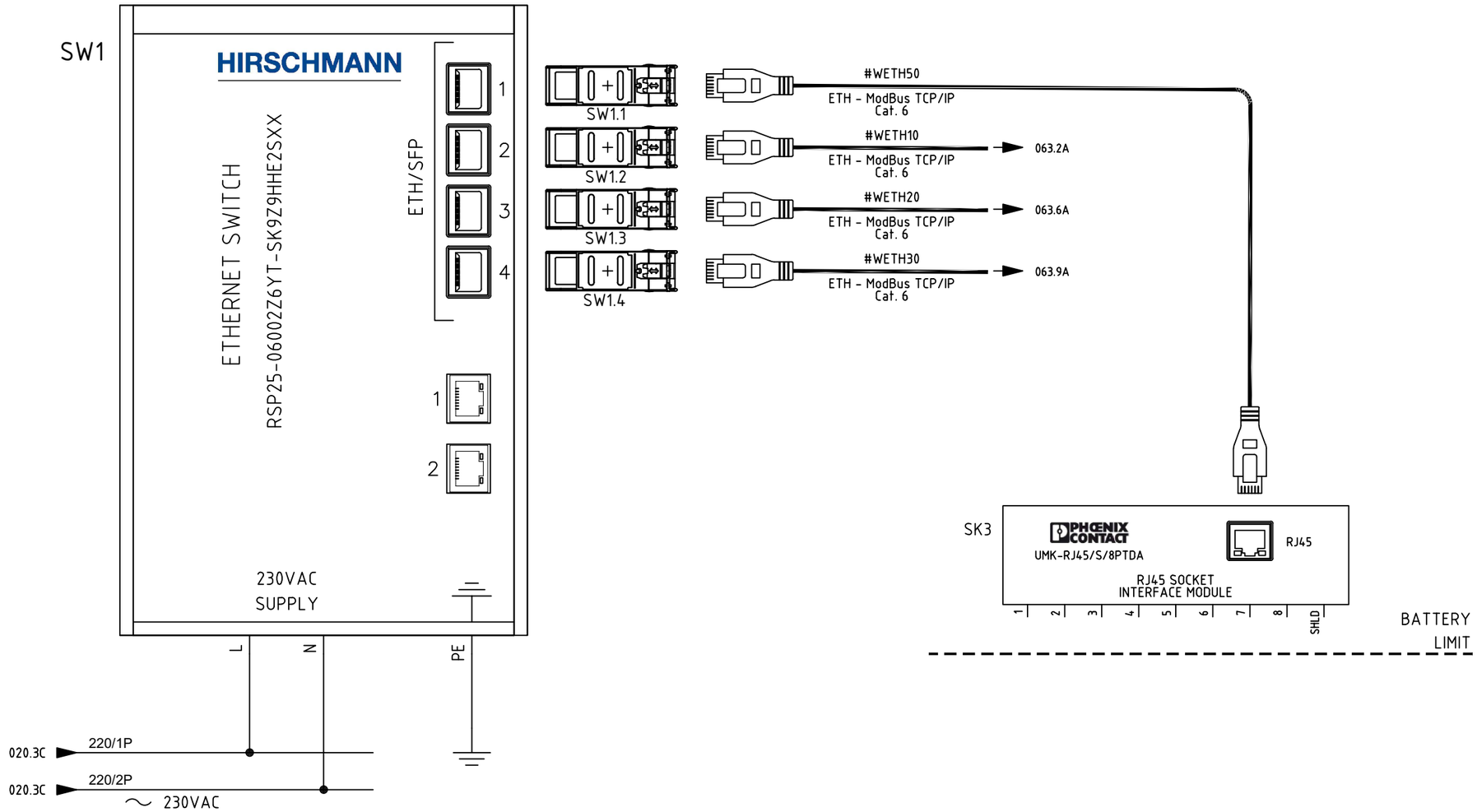
SHEET 060

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# SWITCH CONNECTION




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | SG-200N1 | | | | | | |
| + | A2/+09 | | | | | | |
| DWG n° : | 231298/SD/30 | | | | | | |
| Item n° : | PF1002983/30 | | | | | | |
| | | 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Switch Connection

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 061

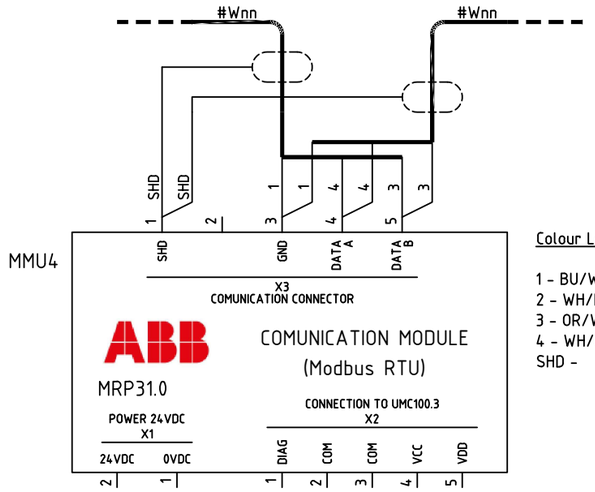
REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# Modbus RTU Chain Network - Connection Typies

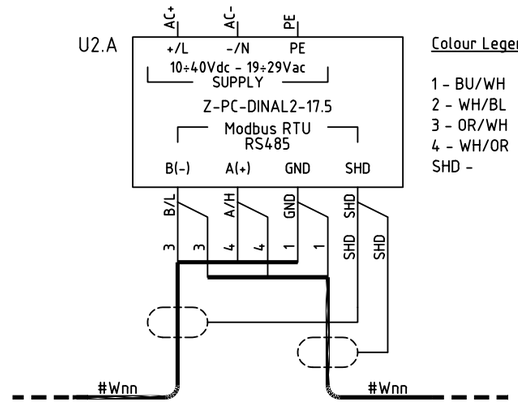
## CONNECTION TYPE- A




Colour Legend for Belden Cable 9842 :

1 - BU/WH [GND]
2 - WH/BL [available]
3 - OR/WH [B]
4 - WH/OR [A]
SHD - [Shield]

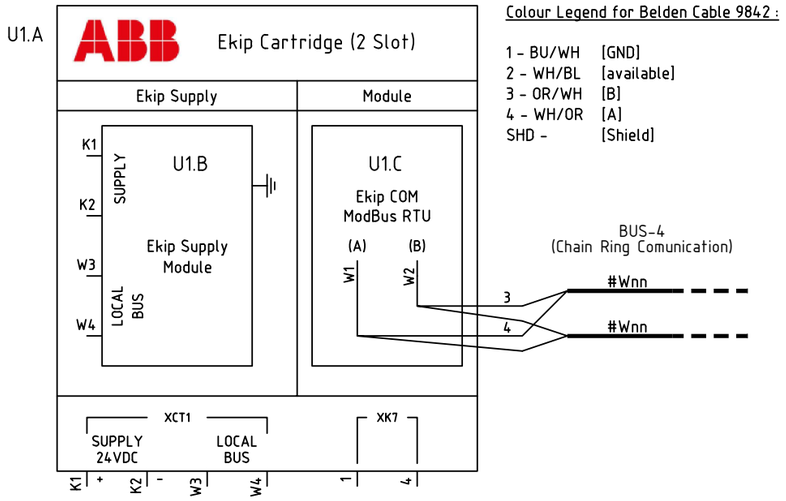
## CONNECTION TYPE- B




Colour Legend for Belden Cable 9842 :

1 - BU/WH [GND]
2 - WH/BL [available]
3 - OR/WH [B]
4 - WH/OR [A]
SHD - [Shield]

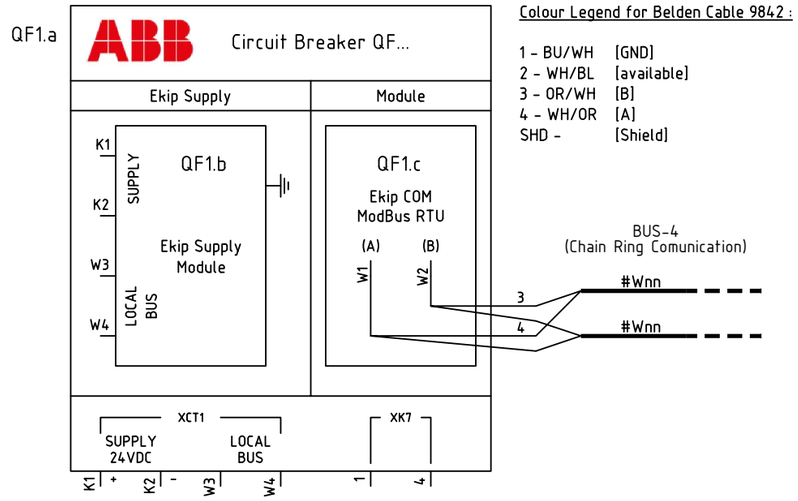
## CONNECTION TYPE- C




Colour Legend for Belden Cable 9842 :

1 - BU/WH [GND]
2 - WH/BL [available]
3 - OR/WH [B]
4 - WH/OR [A]
SHD - [Shield]

## CONNECTION TYPE- D




Colour Legend for Belden Cable 9842 :

1 - BU/WH [GND]
2 - WH/BL [available]
3 - OR/WH [B]
4 - WH/OR [A]
SHD - [Shield]

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Modbus RTU Chain Network - Connections Typies

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

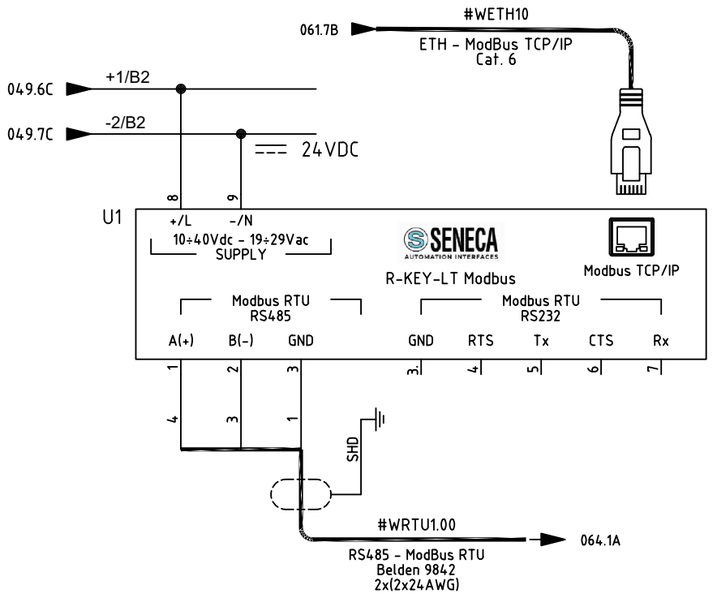
SHEET 062

REV. 02

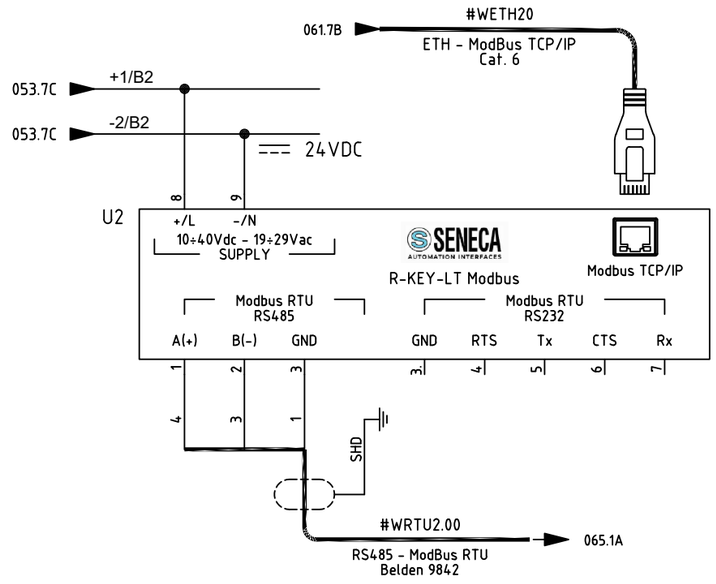
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

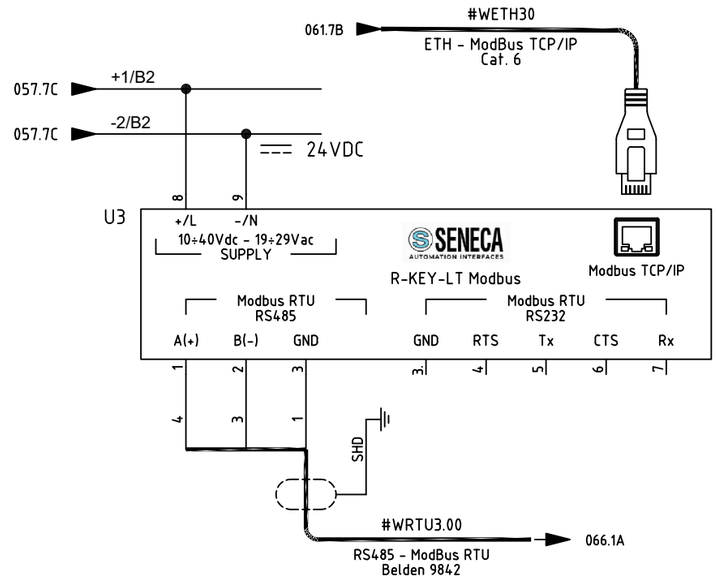
# Modbus RTU Chain Network




SECTION 1 - Modbus RTU Chain Network [A1+A2+A3]




SECTION 2 - Modbus RTU Chain Network [A4+A5]




SECTION 3 - Modbus RTU Chain Network [A6+A7]

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Modbus RTU Chain Network

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

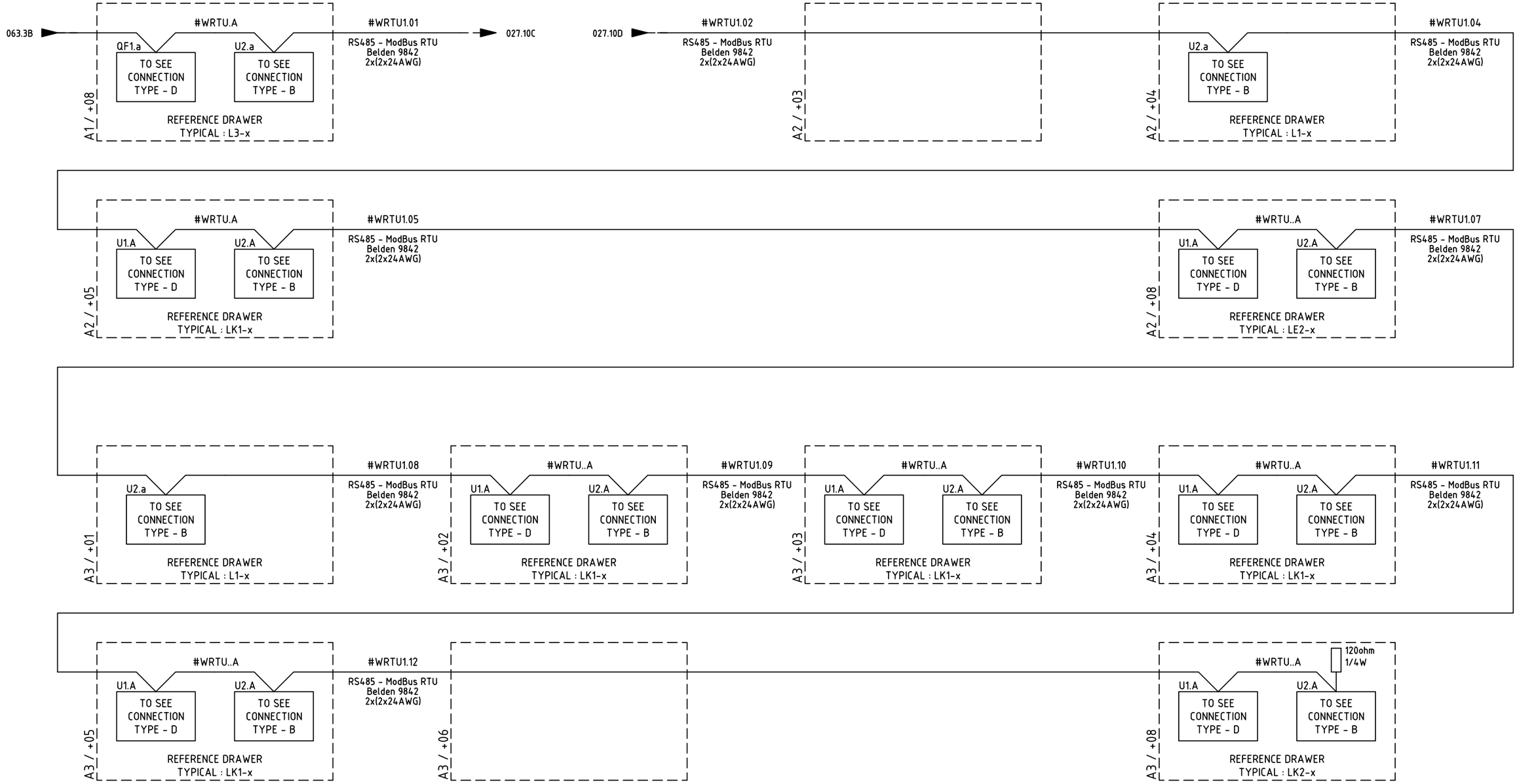
SHEET 063

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

# SECTION 1 - Modbus RTU Chain Network [A1+A2+A3]




NOTE :
For Connection type refer to sheet
"Modbus RTU Chain Network - Connection Typies"

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Modbus RTU Chain Network [A1+A2+A3]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

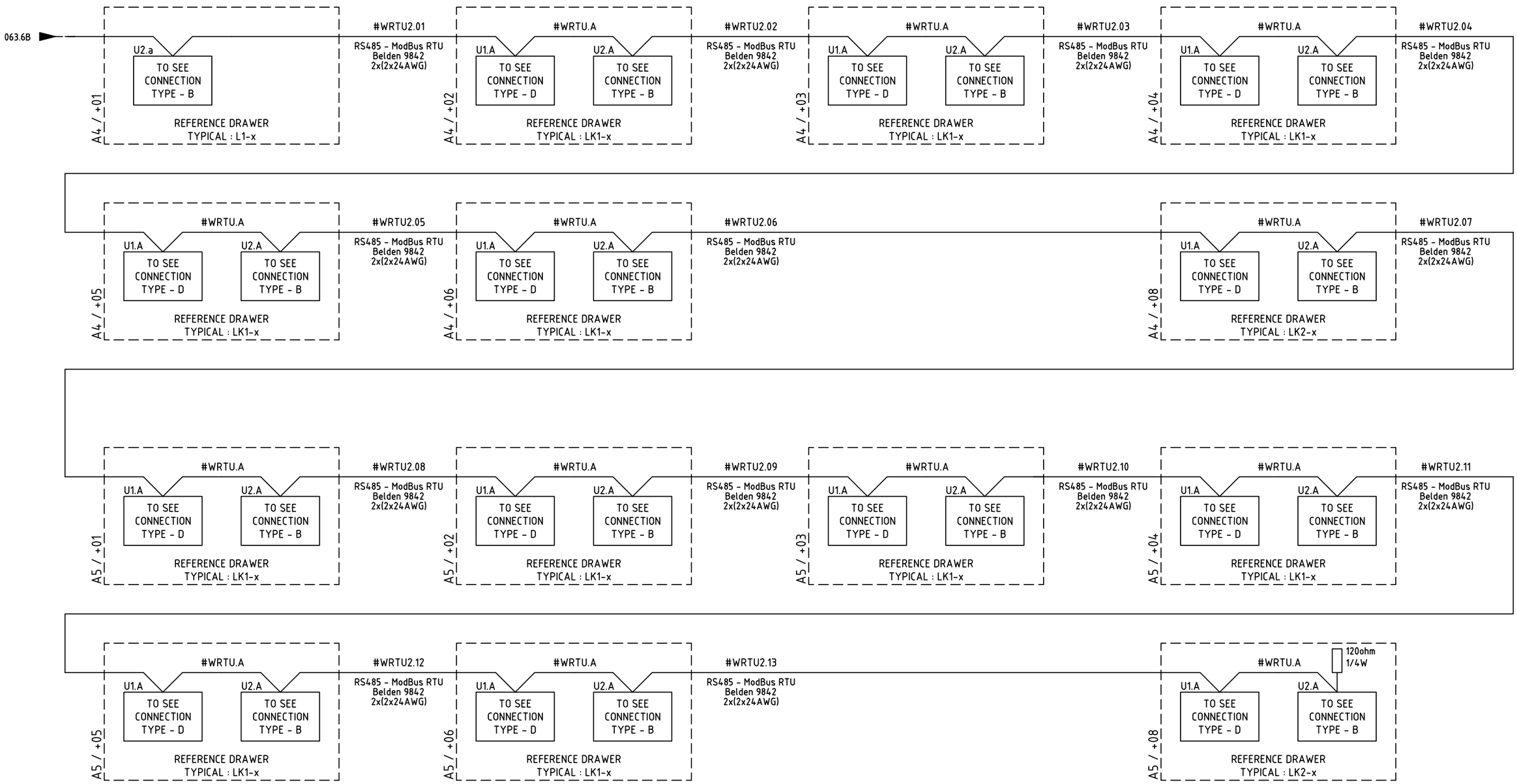
SHEET 064

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# SECTION 2 - Modbus RTU Chain Network [A4+A5]




NOTE :
For Connection type refer to sheet
"Modbus RTU Chain Network - Connection Typies"

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231298/SD/30
Item n° : PF1002983/30

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Modbus RTU Chain Network [A4+A5]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

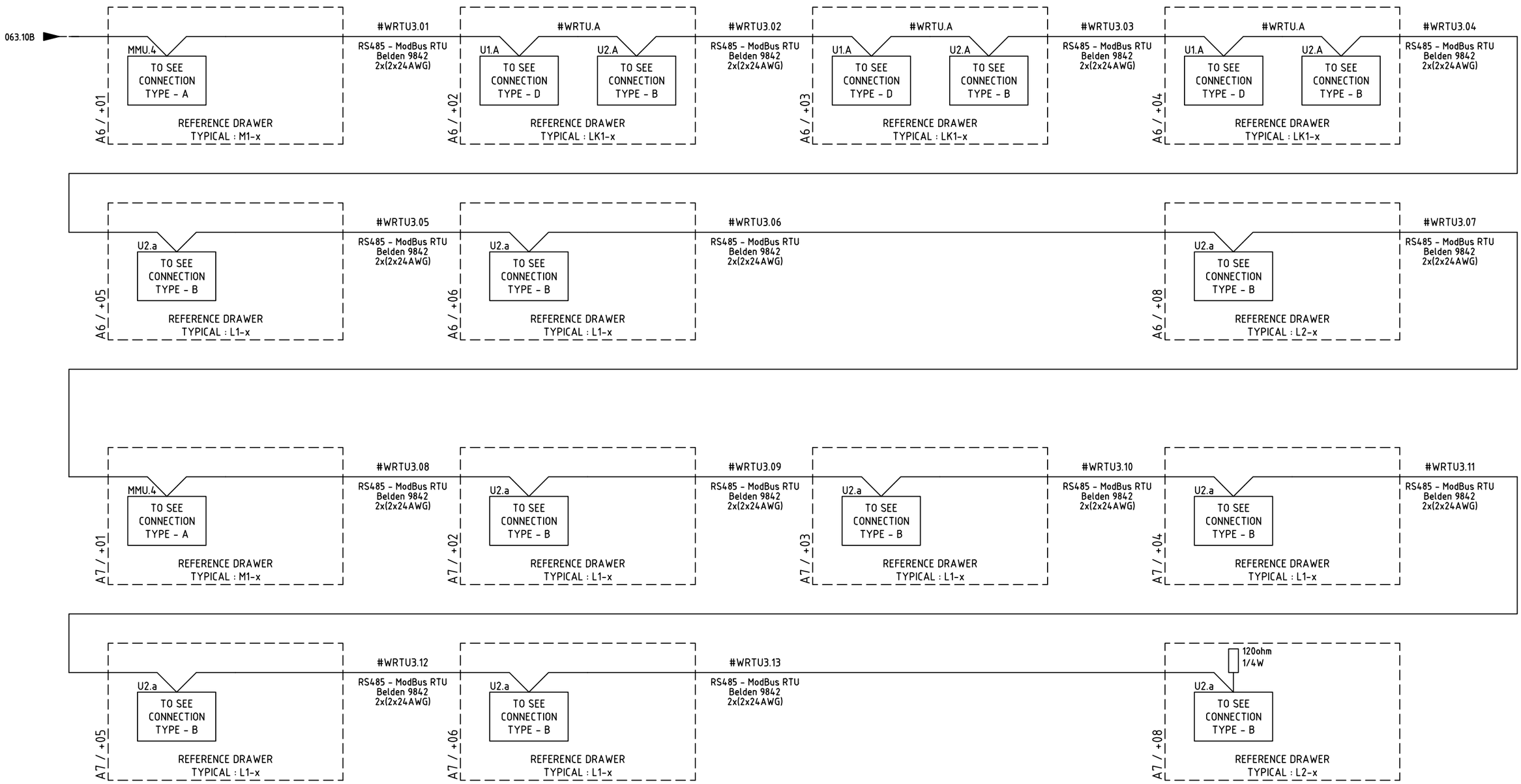
SHEET 065

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

# SECTION 3 - Modbus RTU Chain Network [A6+A7]




NOTE :
For Connection type refer to sheet
"Modbus RTU Chain Network - Connection Typies"

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Modbus RTU Chain Network [A6+A7]

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 066

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| QF1 | 018 | 1SDA0735541R1 | 1 | E4.2N/MS In=3200A 4p W MP | ABB | SG-200N1 | A1/+05 |
| | | 1SDA073914R1 | 1 | E4.2 W FP 3200 4P FIXED PART HR-HR | ABB | SG-200N1 | A1/+05 |
| | | 1SDA073764R1 | 1 | AUP 5 CONTACT AUX INS/TEST/EST TO E2.2÷E6.2 - LEFT SIDE | ABB | SG-200N1 | A1/+05 |
| | | 1SDA073674R1 | 1 | OPENING COIL YO 220÷240VAC/DC TO E12÷E6.2 | ABB | SG-200N1 | A1/+05 |
| | | 1SDA073687R1 | 1 | CLOSING COIL YC 220÷240VAC/DC TO E1.2÷E6.2 | ABB | SG-200N1 | A1/+05 |
| | | 1SDA073725R1 | 1 | MOTOR SPRING CHARGER 220÷250Vac/dc TO E2.2÷E6.2 | ABB | SG-200N1 | A1/+05 |
| | | 1SDA073773R1 | 1 | RTC 250V E2.2...E6.2 | ABB | SG-200N1 | A1/+05 |
| | | 1SDA073806R1 | 1 | KLP-D KEY BLOCK ON POSITION DRAWN-IN/TEST/DRAWN-OUT TO E2.2÷E6.2 | ABB | SG-200N1 | A1/+05 |
| | | 1SDA073858R1 | 1 | PBC OPEN AND CLOSE PUSHBOTTON COVER PROTECTION TO E2.2÷E6.2 | ABB | SG-200N1 | A1/+05 |
| | | 1SDA073791R1 | 1 | KLC-D BLOCK KEY ON OPEN POSITION TO E2.2÷E6.2 | ABB | SG-200N1 | A1/+05 |
| TA1 | 017 | TAR1052K5N01V18 | 1 | MEASURE CT BUSBAR PASSING 105x55 2500/1A Cl.5P20 Pr.5VA | FRER | SG-200N1 | A1/+05 |
| TA2 | 017 | TAR1052K5N01V18 | 1 | MEASURE CT BUSBAR PASSING 105x55 2500/1A Cl.5P20 Pr.5VA | FRER | SG-200N1 | A1/+05 |
| TA3 | 017 | TAR1052K5N01V18 | 1 | MEASURE CT BUSBAR PASSING 105x55 2500/1A Cl.5P20 Pr.5VA | FRER | SG-200N1 | A1/+05 |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/30

Item n° : PF1002983/30

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 067

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BL.1 | 047 | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | SG-200N1 | A1/+09 |
| | | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | SG-200N1 | A1/+09 |
| LH.1 | 047 | BEG74041 | 1 | LAMP 4W 220-240V 50-60HZ COD.74041 - RGL P LED 4W 313MM 4000K | Beghelli | SG-200N1 | A1/+09 |
| QL.1 | 047 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | SG-200N1 | A1/+09 |
| RR.1 | 047 | R1R100230 | 1 | SPACE HEATER SKR 100W ALIM. 220VCA | Torresan | SG-200N1 | A1/+09 |
| SR.1 | 047 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | SG-200N1 | A1/+09 |
| XCL | | HM210GR | 13 | HMM.4/1+2/GR Feed-through Terminal Block - Grey 1 input and 2 outputs (4 mmq) - Spring type | Cabur | SG-200N1 | A1/+09 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 068

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| A1 | 027 | 750-315/300-000 | 1 | Accoppiatore fieldbus MODBUS, RS-485, 115,2 kBd | Wago | SG-200N1 | A2/+02 |
| A3 | 027 | 750-652 | 1 | Interfaccia seriale RS 232 C / RS 485 configurabile | Wago | SG-200N1 | A2/+02 |
| A4 | 027 | 750-430 | 1 | Modulo 8 ingressi digitali 24 V DC 3.0ms | Wago | SG-200N1 | A2/+02 |
| A5 | 027 | 750-430 | 1 | Modulo 8 ingressi digitali 24 V DC 3.0ms | Wago | SG-200N1 | A2/+02 |
| A6 | 027 | 750-600 | 1 | Modulo terminatore | Wago | SG-200N1 | A2/+02 |
| BB | 018 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | SG-200N1 | A2/+02 |
| CB | 018 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | SG-200N1 | A2/+02 |
| CC | 016 | 1VCF698000R0012 | 1 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M | ABB | SG-200N1 | A2/+02 |
| F1 | 017 | 961205 | 1 | LV SURGE ARRESTER DVCI 1 255 FM Uc=255V Tipo 1+Tipo 2 / Classe I + Classe II | DEHN | SG-200N1 | A2/+02 |
| | | 900417 | 1 | WIRING SYSTEM 4POLES TYPE EB149 | DEHN | SG-200N1 | A2/+02 |
| F2 | 017 | 961205 | 1 | LV SURGE ARRESTER DVCI 1 255 FM Uc=255V Tipo 1+Tipo 2 / Classe I + Classe II | DEHN | SG-200N1 | A2/+02 |
| F3 | 017 | 961205 | 1 | LV SURGE ARRESTER DVCI 1 255 FM Uc=255V Tipo 1+Tipo 2 / Classe I + Classe II | DEHN | SG-200N1 | A2/+02 |
| FN | 017 | 961205 | 1 | LV SURGE ARRESTER DVCI 1 255 FM Uc=255V Tipo 1+Tipo 2 / Classe I + Classe II | DEHN | SG-200N1 | A2/+02 |
| FP1 | 021 | REF615F-HBFFAEFCNDCABBA11G | 1 | MULTIFUNCTION RELAY REF615F (vers. F) 4I+5U 16BI+6BO+3HSO IEC61850+MODBUS (3xRJ45-ETH) 45÷250VDC/100÷240VAC | ABB | SG-200N1 | A2/+02 |
| FU1 | 017 | M204733 | 1 | E 93N/32 FUSE HOLDER E 90 3P+N, 32A | ABB | SG-200N1 | A2/+02 |
| | | M277323 | 4 | E 9F10 GG20 FUSIBILE GG 10,3X38, 20A, 500VC | ABB | SG-200N1 | A2/+02 |
| GD1 | 020 | XCSL1240W024VAA | 1 | CSL1-2400W/024V/AA Switching power supply Easy Power 1-phase 85...264 Vac / 24 Vdc 10 A | Cabur | SG-200N1 | A2/+02 |
| K30A | 019 | A4RCND230VCA | 1 | DE-ENERGITATION FLAG RELAY Vaux=230VAC 2SC (Coil) + 2sc (Flag) | Torresan | SG-200N1 | A2/+02 |
| K86 | 023 | RMBE13-A230T | 1 | MONOSTABLE RELAY 230VAC 7SC-5A TROP. | Amra | SG-200N1 | A2/+02 |
| | | PAVM321 | 1 | SOCKET WITH SCREW TO RELAY TYPE PAVM321 | Amra | SG-200N1 | A2/+02 |
| KA01 | 023 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | SG-200N1 | A2/+02 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | SG-200N1 | A2/+02 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | SG-200N1 | A2/+02 |
| KA02 | 023 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | SG-200N1 | A2/+02 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | SG-200N1 | A2/+02 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | SG-200N1 | A2/+02 |
| KA03 | 023 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | SG-200N1 | A2/+02 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | SG-200N1 | A2/+02 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | SG-200N1 | A2/+02 |
| KA04 | 023 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | SG-200N1 | A2/+02 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | SG-200N1 | A2/+02 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | SG-200N1 | A2/+02 |
| KA05 | 024 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | SG-200N1 | A2/+02 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | SG-200N1 | A2/+02 |
| | | ER 728 6 | 1 | CR-MH1 METAL RETAINING JUMPER | ABB | SG-200N1 | A2/+02 |
| PR | 023 | KW 101 6 | 1 | MP1-11Y P. INSTABLE LIGHT. YELLOW BLACK RING | ABB | SG-200N1 | A2/+02 |
| | | KV 037 3 | 1 | MLBL-07Y YELLOW LED BLOCK INTEGRATED 230VAC | ABB | SG-200N1 | A2/+02 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | SG-200N1 | A2/+02 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | SG-200N1 | A2/+02 |
| QA1 | 019 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | SG-200N1 | A2/+02 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | SG-200N1 | A2/+02 |
| QA2 | 020 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | SG-200N1 | A2/+02 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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DWG n° : 231298/SD/30
Item n° : PF1002983/30

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 069

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| QA2 | 020 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | SG-200N1 | A2/+02 |
| QA3 | 020 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | SG-200N1 | A2/+02 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | SG-200N1 | A2/+02 |
| QA4 | 020 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | SG-200N1 | A2/+02 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | SG-200N1 | A2/+02 |
| QA5 | 019 | S550284 | 1 | S202M C10 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | SG-200N1 | A2/+02 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | SG-200N1 | A2/+02 |
| QA6 | 019 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | SG-200N1 | A2/+02 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | SG-200N1 | A2/+02 |
| QD1 | 020 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | SG-200N1 | A2/+02 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | SG-200N1 | A2/+02 |
| QD2 | 020 | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | SG-200N1 | A2/+02 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | SG-200N1 | A2/+02 |
| QU1 | 016 | EE 230 7 | 1 | OT16F3C SWITCH 3P 1-0-2 16A | ABB | SG-200N1 | A2/+02 |
| | | EE 629 0 | 1 | OHBS2AJE011 SQUARE BLACK HANDLE 1-0-2 | ABB | SG-200N1 | A2/+02 |
| | | EE 324 8 | 1 | OXS6X180 SHAFT 180MM | ABB | SG-200N1 | A2/+02 |
| QU2 | 016 | M200883 | 1 | E 92/32 FUSE HOLDER E 90 2P, 32A | ABB | SG-200N1 | A2/+02 |
| | | M277543 | 2 | E 9F10 GG16 FUSE GG 10,3X38, 16A, 500VC | ABB | SG-200N1 | A2/+02 |
| QU3 | 016 | M200883 | 1 | E 92/32 FUSE HOLDER E 90 2P, 32A | ABB | SG-200N1 | A2/+02 |
| | | M277543 | 2 | E 9F10 GG16 FUSE GG 10,3X38, 16A, 500VC | ABB | SG-200N1 | A2/+02 |
| QV1 | 017 | MO1320V16 | 1 | MO132-0,16A MAGNETIC MOTOR STARTER | ABB | SG-200N1 | A2/+02 |
| | | EP 096 0 | 2 | HK1-11 AUX LATERLA CONTACT 1NA+1NC FOR MS116/132 | ABB | SG-200N1 | A2/+02 |
| QV2 | 017 | S550383 | 1 | S203M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 3P | ABB | SG-200N1 | A2/+02 |
| | | A563819 | 2 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | SG-200N1 | A2/+02 |
| SA1 | 026 | KW 329 3 | 1 | M2SS2-10B SEL. 2P 90. NERO GH. NERA | ABB | SG-200N1 | A2/+02 |
| | | EO 570 5 | 2 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | SG-200N1 | A2/+02 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | SG-200N1 | A2/+02 |
| | | EO 571 3 | 1 | MCB-01 CONTATTO NC PER PULSANTI | ABB | SG-200N1 | A2/+02 |
| SA2 | 026 | KW 416 8 | 1 | M2SSK2-101 SELECTOR WITH KEY 2P (0-1) (KEY REMOVABLE ON "0") | ABB | SG-200N1 | A2/+02 |
| | | EO 570 5 | 2 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | SG-200N1 | A2/+02 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | SG-200N1 | A2/+02 |
| SC1 | 025 | KW 076 0 | 1 | MP1-10G PUSH BUTTON GREEN WITH BLACK RING | ABB | SG-200N1 | A2/+02 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | SG-200N1 | A2/+02 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | SG-200N1 | A2/+02 |
| SK1 | 021 | 2900682 | 1 | UMK-RJ45/S/8PTDA Modul VARIOFACE | Phoenix Contact | SG-200N1 | A2/+02 |
| SK2 | 021 | 2900682 | 1 | UMK-RJ45/S/8PTDA Modul VARIOFACE | Phoenix Contact | SG-200N1 | A2/+02 |
| SK3 | 061 | 2900682 | 1 | UMK-RJ45/S/8PTDA Modul VARIOFACE | Phoenix Contact | SG-200N1 | A2/+02 |
| SO1 | 022 | KW 075 2 | 1 | MP1-10R PUSH BUTTON RED WITH BLACK RING | ABB | SG-200N1 | A2/+02 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | SG-200N1 | A2/+02 |
| | | EO 570 5 | 2 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | SG-200N1 | A2/+02 |
| SW1 | 061 | RSPS25-06002Z6YT-SK9Z9HHE2SXX.X | 1 | Managed Industrial Switch for DIN Rail, fanless design Fast Ethernet Type - Enhanced (PRP, Fast MRP, HSR, NAT with L3 type) - 2 x RJ45; 4 x SFP - V=48V÷320VDC -88÷265VAC) | HIRSCHMANN | SG-200N1 | A2/+02 |
| SW1.1 | 061 | M-FAST SFP-TX/RJ45 | 1 | SFP TX Fast Ethernet Transceiver with RJ45 | HIRSCHMANN | SG-200N1 | A2/+02 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/30

Item n° : PF1002983/30

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 070

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| SW1.2 | 061 | M-FAST SFP-TX/RJ45 | 1 | SFP TX Fast Ethernet Transceiver with RJ45 | HIRSCHMANN | SG-200N1 | A2/+02 |
| SW1.3 | 061 | M-FAST SFP-TX/RJ45 | 1 | SFP TX Fast Ethernet Transceiver with RJ45 | HIRSCHMANN | SG-200N1 | A2/+02 |
| SW1.4 | 061 | M-FAST SFP-TX/RJ45 | 1 | SFP TX Fast Ethernet Transceiver with RJ45 | HIRSCHMANN | SG-200N1 | A2/+02 |
| TV1 | 017 | 9SBMCTV | 1 | TERMINAL COVER FOR VT (n°2 pz) | FRER | SG-200N1 | A2/+02 |
| | | TTV010400XC0_1 | 1 | Voltage Transformer 400V/110V - cl.0,5 10VA - TROP | FRER | SG-200N1 | A2/+02 |
| TV2 | 017 | 9SBMCTV | 1 | TERMINAL COVER FOR VT (n°2 pz) | FRER | SG-200N1 | A2/+02 |
| | | TTV010400XC0_1 | 1 | Voltage Transformer 400V/110V - cl.0,5 10VA - TROP | FRER | SG-200N1 | A2/+02 |
| UB1 | 022 | 1SDA082751R1 | 1 | YO/YC TEST UNIT TmaxT/XT-X1-Emax-Emax2 Vaux=24÷250Vac/dc | ABB | SG-200N1 | A2/+02 |
| X2 | | HM250GR | 85 | HMM.4/GR Morsetto passante grigio (4 mmq) - a molla | Cabur | SG-200N1 | A2/+02 |
| | | BT005 | 2 | BTU End bracket | Cabur | SG-200N1 | A2/+02 |
| | | HM251GR | 1 | HMT.4/PT/GR End section - Grey | Cabur | SG-200N1 | A2/+02 |
| XI | | HB220GR | 5 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - spring type | Cabur | SG-200N1 | A2/+02 |
| | | BT005 | 2 | BTU End bracket | Cabur | SG-200N1 | A2/+02 |
| | | HL201GR | 1 | HLD.2/PT/GR End section - Grey | Cabur | SG-200N1 | A2/+02 |
| XV | | HB210GR | 3 | HSCB.6/GR Disconnect by slide link Terminal Block - Grey (6 mmq) - Spring type | Cabur | SG-200N1 | A2/+02 |
| | | BT005 | 2 | BTU End bracket | Cabur | SG-200N1 | A2/+02 |
| | | HB201GR | 1 | HSCB.6/PT/GR End section - Grey | Cabur | SG-200N1 | A2/+02 |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/30

Item n° : PF1002983/30

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 071

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| X1 | | HM250GR | 4 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | SG-200N1 | A2/+08 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 072

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BL.1 | 049 | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | SG-200N1 | A2/+09 |
| | | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | SG-200N1 | A2/+09 |
| LH.1 | 049 | BEG74041 | 1 | LAMP 4W 220-240V 50-60HZ COD.74041 - RGL P LED 4W 313MM 4000K | Beghelli | SG-200N1 | A2/+09 |
| QL.1 | 049 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | SG-200N1 | A2/+09 |
| RR.1 | 049 | R1R100230 | 1 | SPACE HEATER SKR 100W ALIM. 220VCA | Torresan | SG-200N1 | A2/+09 |
| SR.1 | 049 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | SG-200N1 | A2/+09 |
| U1 | 063 | R-KEY-LT | 1 | GATEWAY CONVERTER MODBUS RTU/MODBUS TCP/IP Vaux=24Vdc | SENECA | SG-200N1 | A2/+09 |
| XCL | | HM210GR | 13 | HMM.4/1+2/GR Feed-through Terminal Block - Grey 1 input and 2 outputs (4 mmq) - Spring type | Cabur | SG-200N1 | A2/+09 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

CROSSWIND

ROSETTI MARINO

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 073

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BL.1 | 051 | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | SG-200N1 | A3/+09 |
| | | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | SG-200N1 | A3/+09 |
| LH.1 | 051 | BEG74041 | 1 | LAMP 4W 220-240V 50-60HZ COD.74041 - RGL P LED 4W 313MM 4000K | Beghelli | SG-200N1 | A3/+09 |
| QL.1 | 051 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | SG-200N1 | A3/+09 |
| RR.1 | 051 | R1R100230 | 1 | SPACE HEATER SKR 100W ALIM. 220VCA | Torresan | SG-200N1 | A3/+09 |
| SR.1 | 051 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | SG-200N1 | A3/+09 |
| XCL | | HM210GR | 13 | HMM.4/1+2/GR Feed-through Terminal Block - Grey 1 input and 2 outputs (4 mmq) - Spring type | Cabur | SG-200N1 | A3/+09 |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/30

Item n° : PF1002983/30

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 074

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BL.1 | 053 | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | SG-200N1 | A4/+09 |
| | | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | SG-200N1 | A4/+09 |
| LH.1 | 053 | BEG74041 | 1 | LAMP 4W 220-240V 50-60HZ COD.74041 - RGL P LED 4W 313MM 4000K | Beghelli | SG-200N1 | A4/+09 |
| QL.1 | 053 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | SG-200N1 | A4/+09 |
| RR.1 | 053 | R1R100230 | 1 | SPACE HEATER SKR 100W ALIM. 220VCA | Torresan | SG-200N1 | A4/+09 |
| SR.1 | 053 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | SG-200N1 | A4/+09 |
| U2 | 063 | R-KEY-LT | 1 | GATEWAY CONVERTER MODBUS RTU/MODBUS TCP/IP Vaux=24Vdc | SENECA | SG-200N1 | A4/+09 |
| XCL | | HM210GR | 13 | HMM.4/1+2/GR Feed-through Terminal Block - Grey 1 input and 2 outputs (4 mmq) - Spring type | Cabur | SG-200N1 | A4/+09 |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/30

Item n° : PF1002983/30

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 075

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BL.1 | 055 | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | SG-200N1 | A5/+09 |
| | | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | SG-200N1 | A5/+09 |
| LH.1 | 055 | BEG74041 | 1 | LAMP 4W 220-240V 50-60HZ COD.74041 - RGL P LED 4W 313MM 4000K | Beghelli | SG-200N1 | A5/+09 |
| QL.1 | 055 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | SG-200N1 | A5/+09 |
| RR.1 | 055 | R1R100230 | 1 | SPACE HEATER SKR 100W ALIM. 220VCA | Torresan | SG-200N1 | A5/+09 |
| SR.1 | 055 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | SG-200N1 | A5/+09 |
| XCL | | HM210GR | 13 | HMM.4/1+2/GR Feed-through Terminal Block - Grey 1 input and 2 outputs (4 mmq) - Spring type | Cabur | SG-200N1 | A5/+09 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/30
Item n° : PF1002983/30

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 076

REV. 02

File Name : 1723002197-EL-DG-00030 Rev.02

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BL.1 | 057 | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | SG-200N1 | A6/+09 |
| | | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | SG-200N1 | A6/+09 |
| LH.1 | 057 | BEG74041 | 1 | LAMP 4W 220-240V 50-60HZ COD.74041 - RGL P LED 4W 313MM 4000K | Beghelli | SG-200N1 | A6/+09 |
| QL.1 | 057 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | SG-200N1 | A6/+09 |
| RR.1 | 057 | R1R100230 | 1 | SPACE HEATER SKR 100W ALIM. 220VCA | Torresan | SG-200N1 | A6/+09 |
| SR.1 | 057 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | SG-200N1 | A6/+09 |
| U3 | 063 | R-KEY-LT | 1 | GATEWAY CONVERTER MODBUS RTU/MODBUS TCP/IP Vaux=24Vdc | SENECA | SG-200N1 | A6/+09 |
| XCL | | HM210GR | 13 | HMM.4/1+2/GR Feed-through Terminal Block - Grey 1 input and 2 outputs (4 mmq) - Spring type | Cabur | SG-200N1 | A6/+09 |

CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/30

Item n° : PF1002983/30

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 077

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| BL.1 | 059 | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | SG-200N1 | A7/+09 |
| | | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | SG-200N1 | A7/+09 |
| LH.1 | 059 | BEG74041 | 1 | LAMP 4W 220-240V 50-60HZ COD.74041 - RGL P LED 4W 313MM 4000K | Beghelli | SG-200N1 | A7/+09 |
| QL.1 | 059 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | SG-200N1 | A7/+09 |
| RR.1 | 059 | R1R100230 | 1 | SPACE HEATER SKR 100W ALIM. 220VCA | Torresan | SG-200N1 | A7/+09 |
| SR.1 | 059 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | SG-200N1 | A7/+09 |
| XCL | | HM210GR | 13 | HMM.4/1+2/GR Feed-through Terminal Block - Grey 1 input and 2 outputs (4 mmq) - Spring type | Cabur | SG-200N1 | A7/+09 |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/30

Item n° : PF1002983/30

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 28/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 08/07/2024 | Giulietti | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 10/06/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : SG-200N1
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00030

SHEET 078

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00030 Rev.02

1.4.10. SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS,

Doc. No. 1723002197-EL-DG-00031

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# BASE LOAD POWER HUB (BLPH)

# "SG-200N1" LV SWBD 400/230V

# ELECTRICAL
# LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Moceri | 23/09/2024 |

DWG n° : 231298/SD/31

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 001 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

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| 002 | Index | X | X | X | | | | | | | |
| 003 | Index | X | X | X | | | | | | | |
| 004 | Graphical Symbols | X | X | X | | | | | | | |
| 005 | Graphical Symbols | X | X | X | | | | | | | |
| 006 | General Notes | X | X | X | | | | | | | |
| 007 | Door Front Lay-Out - Typical "M1-n" | X | X | X | | | | | | | |
| 008 | Users Legend - Typical "M1-n" | X | X | X | | | | | | | |
| 009 | Functional Drawing - Typical "M1-n" | X | X | X | | | | | | | |
| 010 | Functional Drawing - Typical "M1-n" | X | X | X | | | | | | | |
| 011 | Functional Drawing - Typical "M1-n" | X | X | X | | | | | | | |
| 012 | Functional Drawing - Typical "M1-n" | X | X | X | | | | | | | |
| 013 | Functional Drawing - Typical "M1-n" | X | X | X | | | | | | | |
| 014 | Functional Drawing - Typical "M1-n" | X | X | X | | | | | | | |
| 015 | Functional Drawing - Typical "M1-n" | X | X | X | | | | | | | |
| 016 | UMC100 Internal Function Logic - Typical "M1-n" | X | X | X | | | | | | | |
| 017 | UMC100 Internal Function Logic - Typical "M1-n" | X | X | X | | | | | | | |
| 018 | UMC100 Internal Function Logic - Typical "M1-n" | X | X | X | | | | | | | |
| 019 | UMC100 Internal Function Logic - Typical "M1-n" | X | X | X | | | | | | | |
| 020 | Functional Drawing - Typical "M1-n" | X | X | X | | | | | | | |
| 021 | Functional Drawing - Typical "M1-n" | X | X | X | | | | | | | |
| 022 | Functional Drawing - Typical "M1-n" | X | X | X | | | | | | | |
| 023 | Door Front Lay-Out - Typical "L1-n" & "L2-n" | X | X | X | | | | | | | |
| 024 | Door Front Lay-Out - Typical "L1-n" & "L2-n" | X | X | X | | | | | | | |
| 025 | Users Legend - Typical "L1-n" & "L2-n" | X | X | X | | | | | | | |
| 026 | Items Acronym - Typical "L1-n" & "L2-n" | X | X | X | | | | | | | |
| 027 | Functional Drawing - Typical "L1-n" & "L2-n" | X | X | X | | | | | | | |
| 028 | Functional Drawing - Typical "L1-n" & "L2-n" | X | X | X | | | | | | | |
| 029 | Functional Drawing - Typical "L1-n" & "L2-n" | X | X | X | | | | | | | |
| 030 | Functional Drawing - Typical "L1-n" & "L2-n" | X | X | X | | | | | | | |
| 031 | Functional Drawing - Typical "L1-n" & "L2-n" | X | X | X | | | | | | | |
| 032 | Functional Drawing - Typical "L1-n" & "L2-n" | X | X | X | | | | | | | |
| 033 | Functional Drawing - Typical "L1-n" & "L2-n" | X | X | X | | | | | | | |
| 034 | Door Front Lay-Out - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 035 | Door Front Lay-Out - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 036 | Users Legend - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 037 | Items Acronym - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 038 | Functional Drawing - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 039 | Functional Drawing - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 040 | Functional Drawing - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 041 | Functional Drawing - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 042 | Functional Drawing - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 043 | Functional Drawing - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 044 | Functional Drawing - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 045 | Functional Drawing - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 046 | Functional Drawing - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 047 | Functional Drawing - Typical "LK1-n" & "LK2-n" | X | X | X | | | | | | | |
| 048 | Door Front Lay-Out - Typical "LE2-320" | X | X | X | | | | | | | |
| 049 | Users Legend - Typical "LE2-320" | X | X | X | | | | | | | |
| 050 | Functional Drawing - Typical "LE2-320" | X | X | X | | | | | | | |
| 051 | Functional Drawing - Typical "LE2-320" | X | X | X | | | | | | | |
| 052 | Functional Drawing - Typical "LE2-320" | X | X | X | | | | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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DWG n° : 231298/SD/31
Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 002

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# INDEX SHEETS

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 053 | Functional Drawing - Typical "LE2-320" | X | X | X | | | | | | | | | | | | | | | | | | | |
| 054 | Functional Drawing - Typical "LE2-320" | X | X | X | | | | | | | | | | | | | | | | | | | |
| 055 | Functional Drawing - Typical "LE2-320" | X | X | X | | | | | | | | | | | | | | | | | | | |
| 056 | Functional Drawing - Typical "LE2-320" | X | X | X | | | | | | | | | | | | | | | | | | | |

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

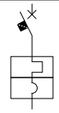
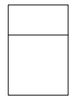
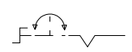
SHEET 003

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# SYMBOLS LEGEND

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|   | CIRCUIT BREAKER WITH AUTOMATIC RELEASE |  | CAPACITIVE VOLTAGE DIVIDER |  | COIL OF A MECHANICALLY LATCHED RELAY |  | DELAYED ACTION (IN THE DIRECTION OF MOVEMENT FROM THE ARC TOWARDS ITS CENTRE) |
|  | CIRCUIT BREAKER WITH AUTOMATIC RELEASE AND BUILT-IN THERMOMAGNETIC RELEASE |  | CURRENT TRANSFORMER |  | INDICATOR, ELECTROMECHANICAL ELEMENT |  | POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT |
|  | SWITCH DISCONNECTOR |  | CURRENT TRANSFORMER WITH TWO CORES AND TWO SECONDARY WINDINGS |  | LAMP (GENERAL SYMBOL) |  | POSITION SWITCH (LIMIT SWITCH), BREAK CONTACT |
|  | CONTACTOR |  | INDICATING INSTRUMENT GENERAL SYMBOL |  | SEMICONDUCTOR DIODE |  | OPERATED BY PUSHING |
|  | LOCK WITH FREE KEY WHEN THE DEVICE IS IN OPEN POSITION |  | INTEGRATING INSTRUMENT (GENERAL SYMBOL) |  | LED |  | OPERATED BY TURNING |
|  | LOCK WITH FREE KEY WHEN THE DEVICE IS IN CLOSE POSITION |  | DISCONNECTING FUSE, NOT WITH LIVE CIRCUIT AND WITH MECHANICAL LINKAGE (STRIKER FUSE) |   | TRANSDUCER OF ALTERNATING CURRENT MEASURE INTO DIRECT CURRENT SIGNAL |  | THREE HELD POSITIONS TURNING SWITCH |
|  | PLUG AND SOCKET (MALE AND FEMALE) |  | OPERATING DEVICE (GENERAL SYMBOL) |  | EARTH, GROUND (GENERAL SYMBOL) |  | THREE POSITIONS TURNING SWITCH, WITH SPRING THROWBACK TO THE CENTRAL POSITION |
|  | VOLTAGE TRANSFORMER WITH TWO WINDINGS |  | COIL OF A TIME DELAYED OPERATING RELAY |  | MAKE CONTACT |  | MECHANICAL, PNEUMATIC OR HYDRAULIC CONNECTION |
|  | VOLTAGE TRANSFORMER WITH THREE WINDINGS |  | COIL OF A TIME DELAYED RELEASING RELAY |  | BREAK CONTACT |  | MECHANICAL INTERLOCK BETWEEN TWO DEVICES |
|  | CAPACITOR (GENERAL SYMBOL) |  | BISTABLE RELAY |  | CHANGE-OVER BREAK BEFORE MAKE CONTACT |  | RESISTOR (GENERAL SYMBOL) |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231298/SD/31
Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 004 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# SYMBOLS LEGEND

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|  | HEATING ELEMENT | | | | | | |
|  | CONNECTION OF CONDUCTORS | | | | | | |
|  | WITHDRAWABLE TERMINAL (SHORT-CIRCUITABLE ONLY ON C.T. SECONDARY CIRCUITS) | | | | | | |
|  | SWITCHBOARD TERMINAL | | | | | | |
| | | | | | | | |
| | | | | | | | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231298/SD/31
Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 005

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# GENERAL NOTES

THE DIAGRAM INDICATES THE FOLLOWING CONDITIONS :

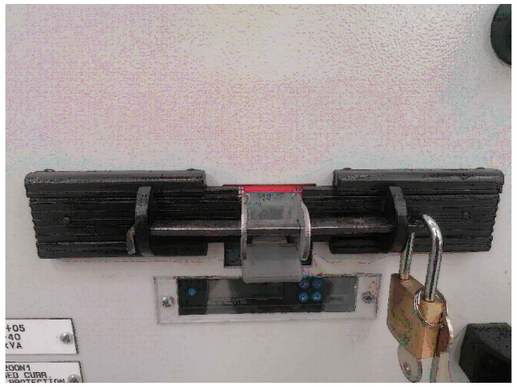
- CIRCUIT-BREAKER IN OPEN POSITION
- DE-ENERGIZED CIRCUITS
- DRAWER INSERTED

THE AUXILIARY CIRCUITS WILL HAVE THE FOLLOWING CHARACTERISTICS :

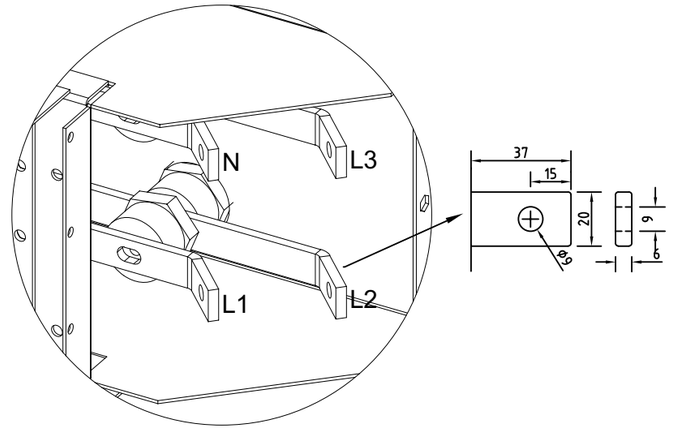
- 24VDC (+) 1,5mmq RED TYPE CABLE SH-W
- 24vdc (-) 1,5mmq WHITE TYPE CABLE SH-W
- AUXILIARY CONTACTS TO TERMINAL STRIP 1,5mmq BLACK TYPE CABLE SH-W
- 230Vac 1,5mmq BLACK TYPE SH-W
- VOLTMETRICAL CIRCUITS 1,5mmq BLACK TYPE CABLE SH-W
- AMMETRICAL CIRCUIT 2,5mmq BLACK TYPE CABLE SH-W

ACCESSORIES REMOVABLE DRAWERS :

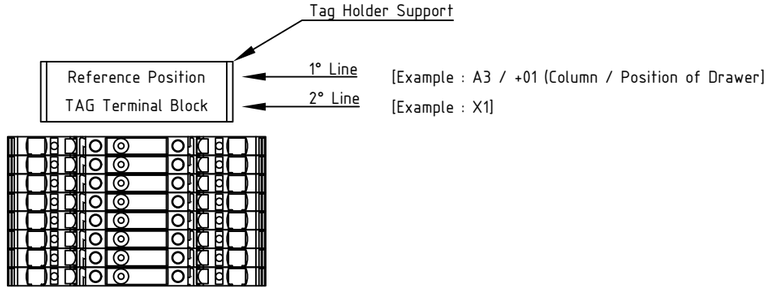
- THROUGH THE ACCESSORY (LEVER + PADLOCK) SHOWN IN THE PHOTO IT WILL BE POSSIBLE TO LOCK THE CIRCUIT-BREAKER OF THE WITHDRAWABLE DRAWER IN THE OPEN POSITION



DETAIL OF CABLE ATTACHMENT ON CU BARS FOR WITHDRAWABLE DRAWERS :




MARKING DETAIL OF TERMINAL BLOCKS :




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231298/SD/31
Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
General Notes

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 006

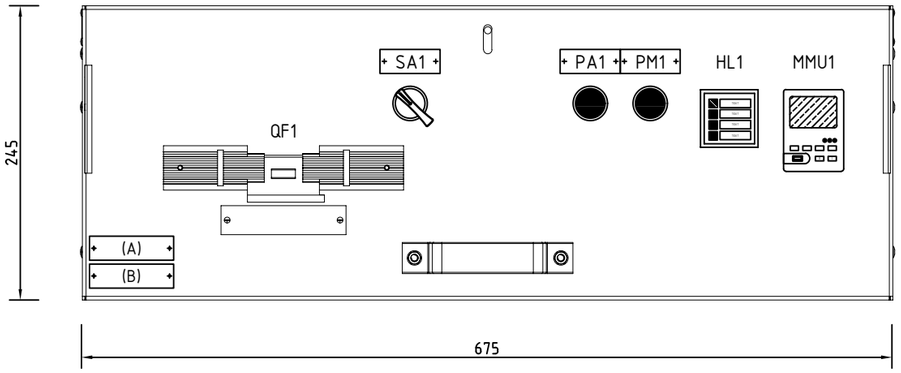
REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# DOOR FRONT LAY-OUT

## TYPICAL : MOTOR FEEDER (M1)

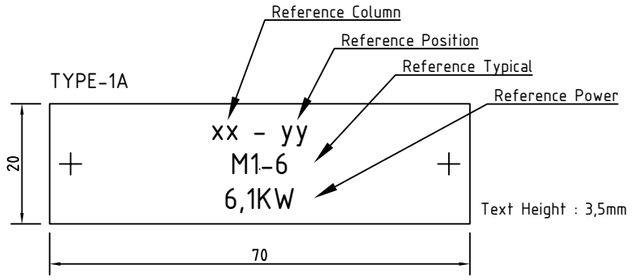


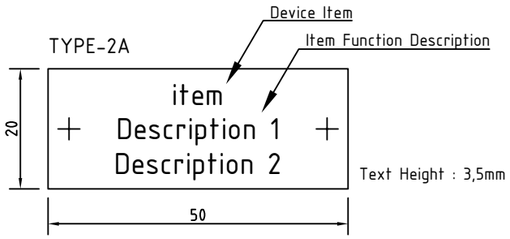

NOTE :

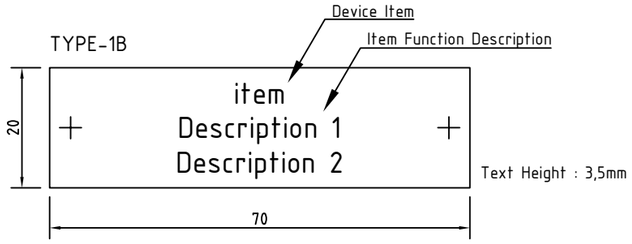
A) IDENTIFICATION name plate (type-1A) , with :
- Drawer position [Column / Position inside SWB]
- Typical name [reference applicability typical used]
- Power [reference applicability typical used]

B) USER name plate (type-1B), with :
- Item User [to see SLD diagrams]
- User Description [to see SLD diagrams]

| DEVICES name plate | | | |
|---|---|---|---|
| ITEM | DESCRIPTION 1 | DESCRIPTION 2 | NOTE |
| MMU1 | Unit Motor Control HMI | | NO plate |
| QF1 | Circuit Breaker | | NO plate |
| SA1 | LOC-REM | SELECTOR | Type-2A |
| PA1 | STOP | MOTOR | Type-2A |
| PM1 | RUN | MOTOR | Type-2A |
| HL1 | Multiled | Signalling | NO plate |




| | |
|---|---|
| = | TYPICAL |
| + | M1 |
| DWG n° : | 231298/SD/31 |
| Item n° : | PF1002983/26 |

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TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Door Front Lay-Out - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 007 | REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm

# USERS LEGEND

## TYPICAL : MOTOR FEEDER (M1)

| TYPICAL APPLICABILITY | | | | | |
|---|---|---|---|---|---|
| ITEM | ITEM TAG | DESCRIPTION TAG | REFERENCE POSITION (written on name name plate "type-1A) | REFERENCE POWER (written on name name plate "type-1A) | REFERENCE TYPICAL (written on name name plate "type-1A) |
| 1 | PM-50001A | SEA WATER PUMP A | A6 / +01 | 6,1 kW | M1-6 |
| 2 | PM-50001B | SEA WATER PUMP B | A7 / +01 | 6,1 kW | M1-6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | M1 | | | | | | |
| DWG n° : | 231298/SD/31 | | | | | | |
| Item n° : | PF1002983/26 | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Users Legend - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

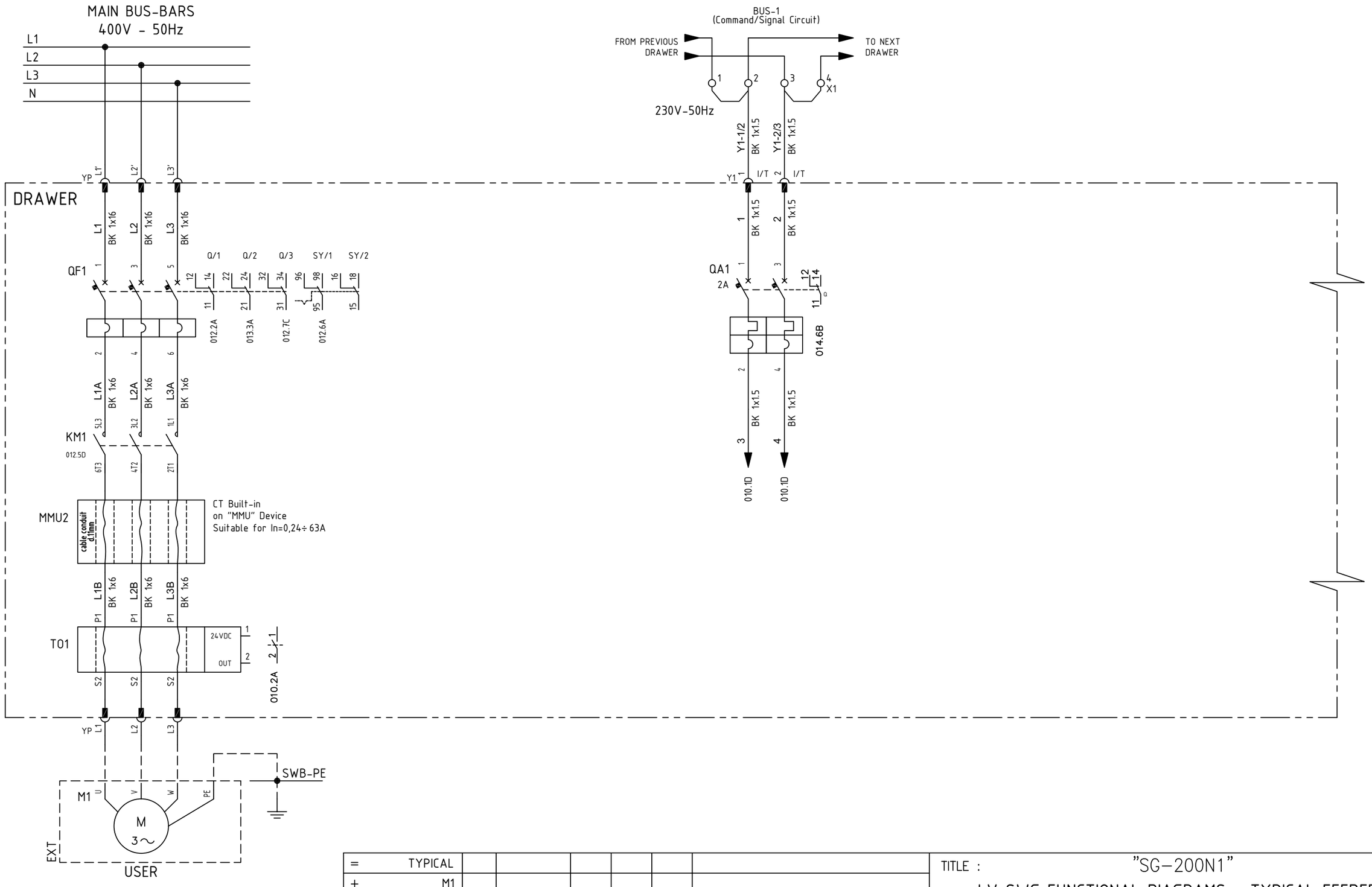
DRAWING NO. 1723002197-EL-DG-00031

SHEET 008

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | M1 | | | | | | |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

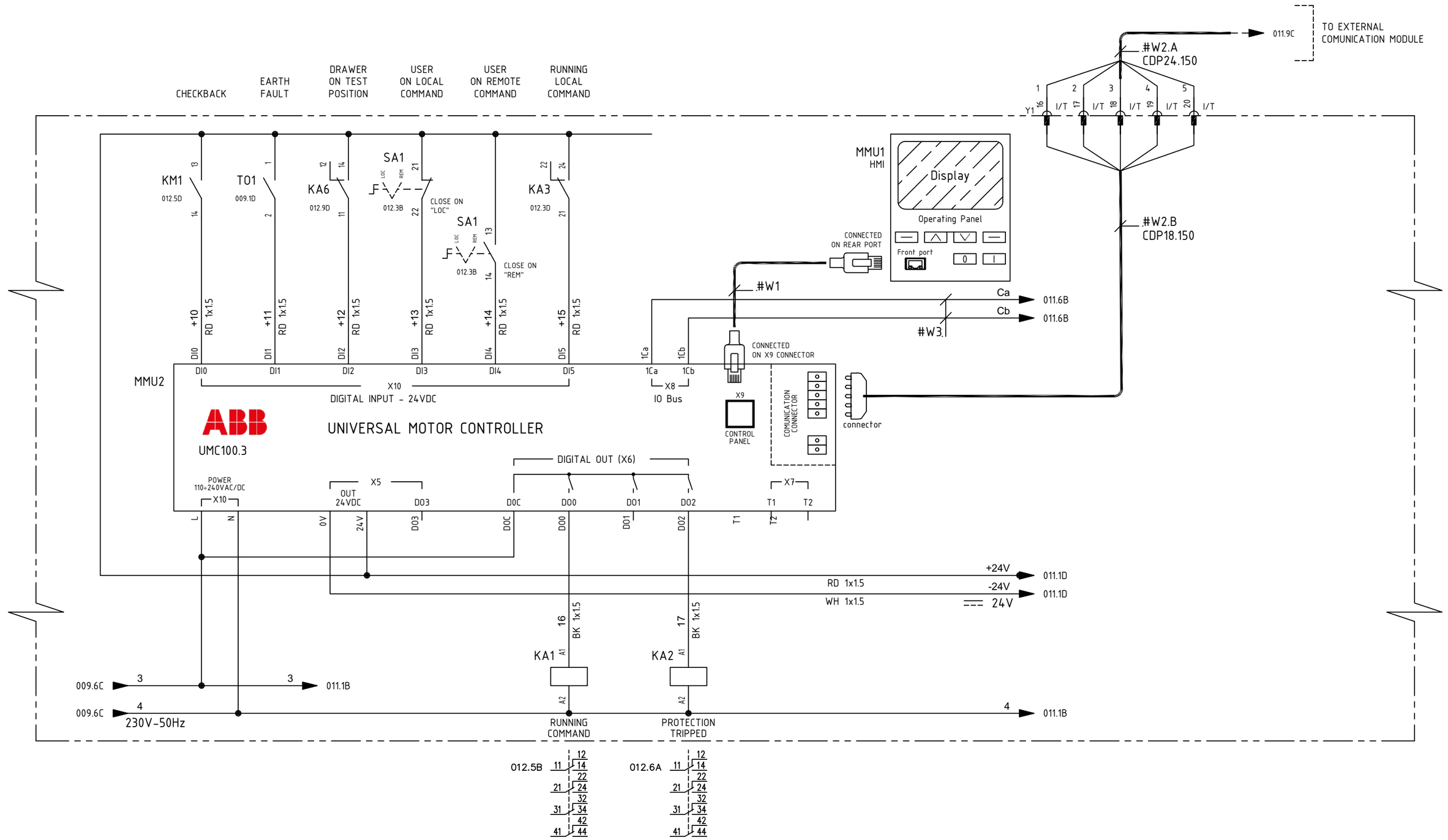
DRAWING NO. 1723002197-EL-DG-00031

SHEET 009

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




| | | | | | | |
|---|---|---|---|---|---|---|
| = TYPICAL | | | | | | |
| + M1 | | | | | | |
| DWG n° : 231298/SD/31 | | | | | | |
| Item n° : PF1002983/26 | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

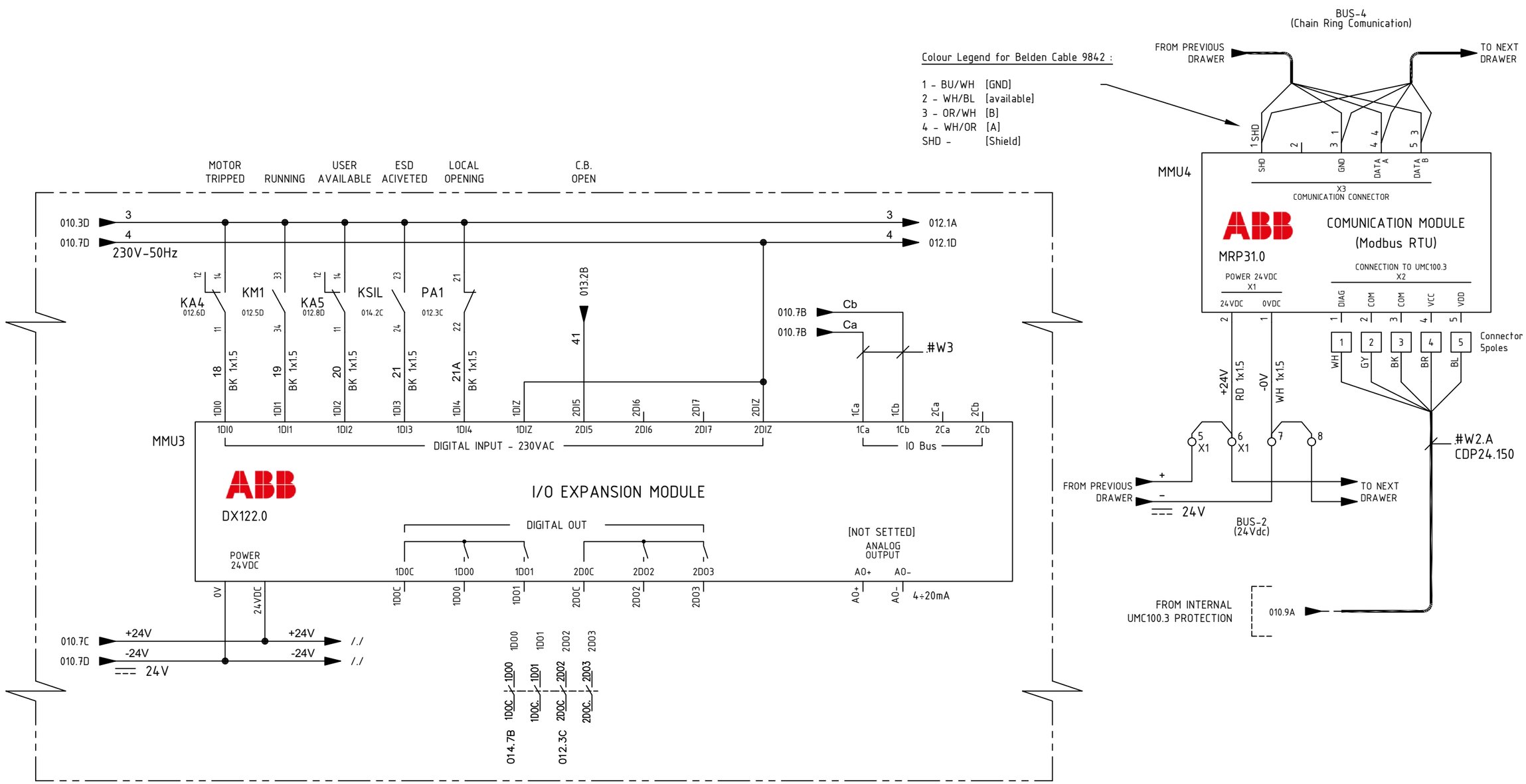
DRAWING NO. 1723002197-EL-DG-00031

SHEET 010

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




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| = | TYPICAL | | | | | | |
| + | M1 | | | | | | |
| DWG n° : | 231298/SD/31 | | | | | | |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

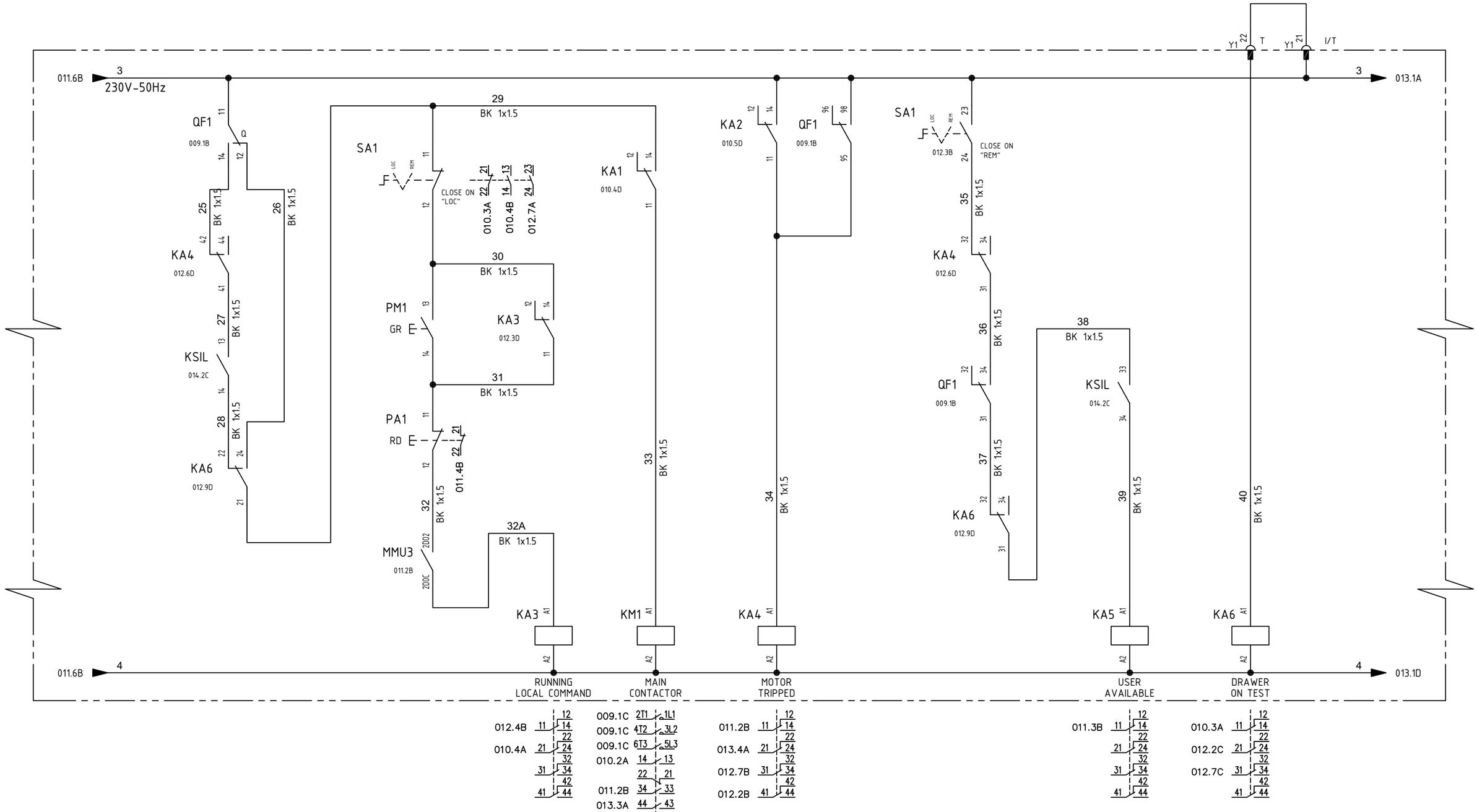
DRAWING NO. 1723002197-EL-DG-00031

SHEET 011

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




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|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | M1 | | | | | | |
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| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

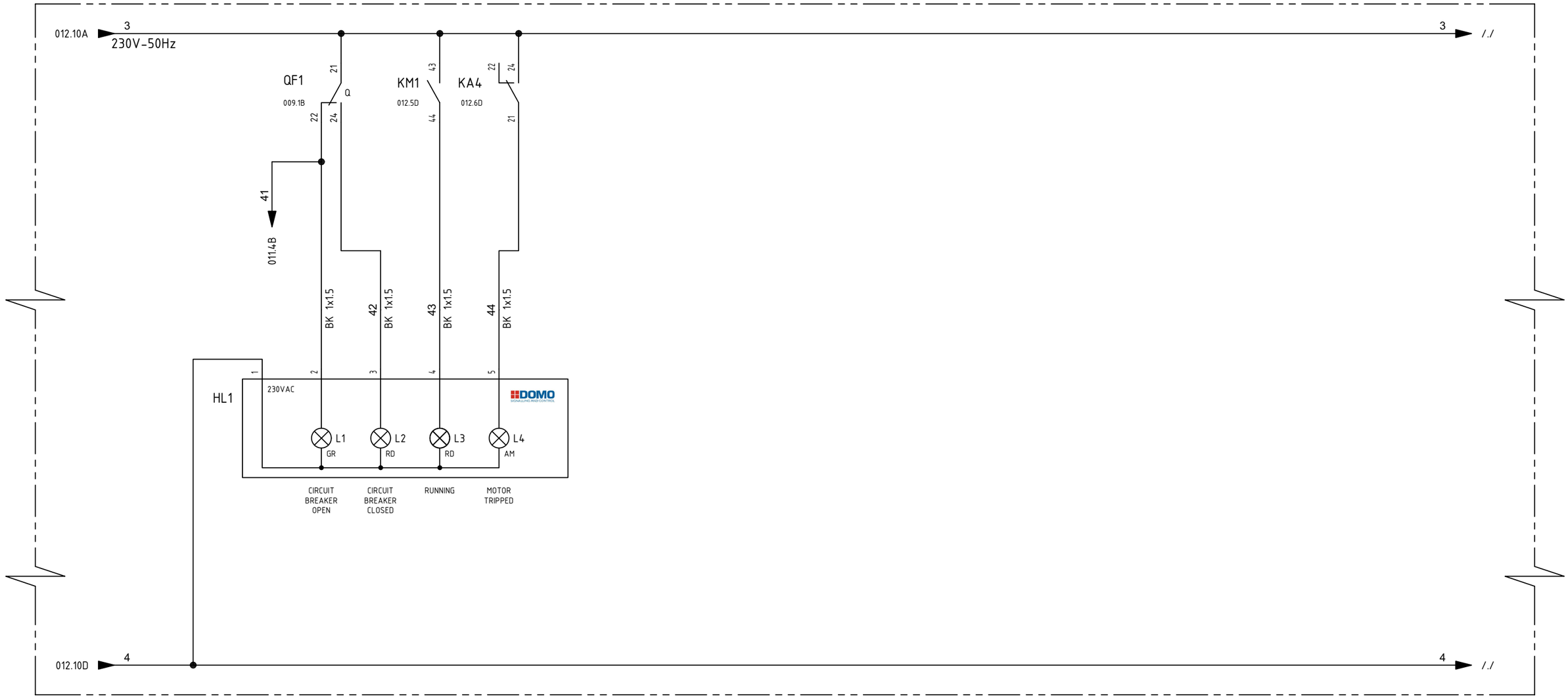
DRAWING NO. 1723002197-EL-DG-00031

SHEET 012

REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm




| | |
|---|---|
| = | TYPICAL |
| + | M1 |
| DWG n° : | 231298/SD/31 |
| Item n° : | PF1002983/26 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 013

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

ONLY FOR REPRESENTATION
FOR DETTAILS TO SEE RELEVANT
DOCUMENT N°1723002197-EL-DG-00030

SIS

BUS-3
(Internal Fault loop)

FROM PREVIOUS DRAWER

TO NEXT DRAWER

AVAILABLE

AVAILABLE

11 X1 — Y1-5/11 BK 1x1.5 — Y1 5 I/T

12 X1 — Y1-6/12 BK 1x1.5 — Y1 6 I/T

9 X1 — Y1-3/9 BK 1x1.5 — Y1 3 I/T

10 X1 — Y1-4/10 BK 1x1.5 — Y1 4 I/T

13 X1 — Y1-8/13 BK 1x1.5 — Y1 8 I/T

14 X1 — Y19/14 BK 1x1.5 — Y1 9 I/T

15 X1 — Y1-10/15 BK 1x1.5 — Y1 10 I/T

16 X1 — Y1-11/16 BK 1x1.5 — Y1 11 I/T

24V

-45 WH 1x1.5

+46 RD 1x1.5

+47 RD 1x1.5

+48 RD 1x1.5

49 BK 1x1.5

50 BK 1x1.5

QA1
009.6B
12
14
11

MMU3
011.2B
1000
100C

KSIL
POWER SUPPLY 24VDC
R1 + X4 TEST R2 -
ABB
Safety Relay
BSR10
13 23 33 41
1 2
OUT1 OUT2 OUT3 OUT4
14 24 34 42

012.2B 14 / 13
011.3B 24 / 23
012.8C 34 / 33
42 / 41

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | M1 | | | | | | |
| DWG n° : | 231298/SD/31 | | | | | | |
| Item n° : | PF1002983/26 | | | | | | |
| | | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 014

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

AUXILIARY SOCKET

136450/001 (PF – 1 pcs) + 136458/005 (PM – 1 pcs)

| N° PIN | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUMP | | | ● | ● | | | | | | | | | | | | | | | | | | |
| RACKED-OUT | | | ✕ | ✕ | | | | | | | | | | | | | | | | | | |
| TEST | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| RACKED-IN | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | |
| PIN USED | 009.6A | 009.6A | 014.6B | 014.6B | 014.2B | 014.2B | | 014.7B | 014.8B | 014.9B | 014.9B | | | | | 010.8A | 010.8A | 010.8A | 010.8A | 010.9A | 012.9A | 012.9A |




← FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN RACKED-OUT POSITION

← FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN TEST POSITION

← FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN RACKED-IN POSITION

← CROS-REFERENCE USED PIN

TYPICAL - M1 - Y1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = TYPICAL | | | | | | | |
| + M1 | | | | | | | |
| DWG n° : 231298/SD/31 | | | | | | | |
| Item n° : PF1002983/26 | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) | |
| | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
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| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 015

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# UMC100 INTERNAL FUNCTION LOGIC

INPUT | INTERNAL LOGIC | OUTPUT

-KA3 LOCAL COMMAND RUNNIG (0/1) — DI5

-KA5 USER AVAILABLE (0/1) — 1DI2

to Modbus RTU: 0 USER AVAILABLE / 1

GREEN led

017.5D → CHCBK (1)

&

≥1

KM → 017.3D

DO0 → -KA1 MAIN RUNNING COMMAND (0/1)

-QF1 CIRCUIT-BREAKER OPEN (0/1) — 2DI5

-KA6 DRAWER ON TEST POSITION (0/1) — DI2

-PA1 OPEN PUSH-BOTTOM (0/1) — 1DI4

-SA1 SELECTOR IN "REMOTE" POSITION (0/1) — DI4

from Modbus RTU: RUN COMMAND (0/1)

from Modbus RTU: STOP COMMAND (0/1)

RED led

SET / RESET / Q / $\overline{Q}$

ModBus RTU command

to Modbus RTU: 0 -SA1 ON "LOCAL" POSITION / 1

-SA1 SELECTOR IN "LOCAL" POSITION (0/1) — DI3

2DO2 → -MMU3 LOCAL CONSENT TO CLOSE (0/1)

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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CROSSWIND — IMESA ELECTRICAL ENGINEERING — ROSETTI MARINO

DWG n° : 231298/SD/31

Item n° : PF1002983/26

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

UMC100 Internal Function Logic - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

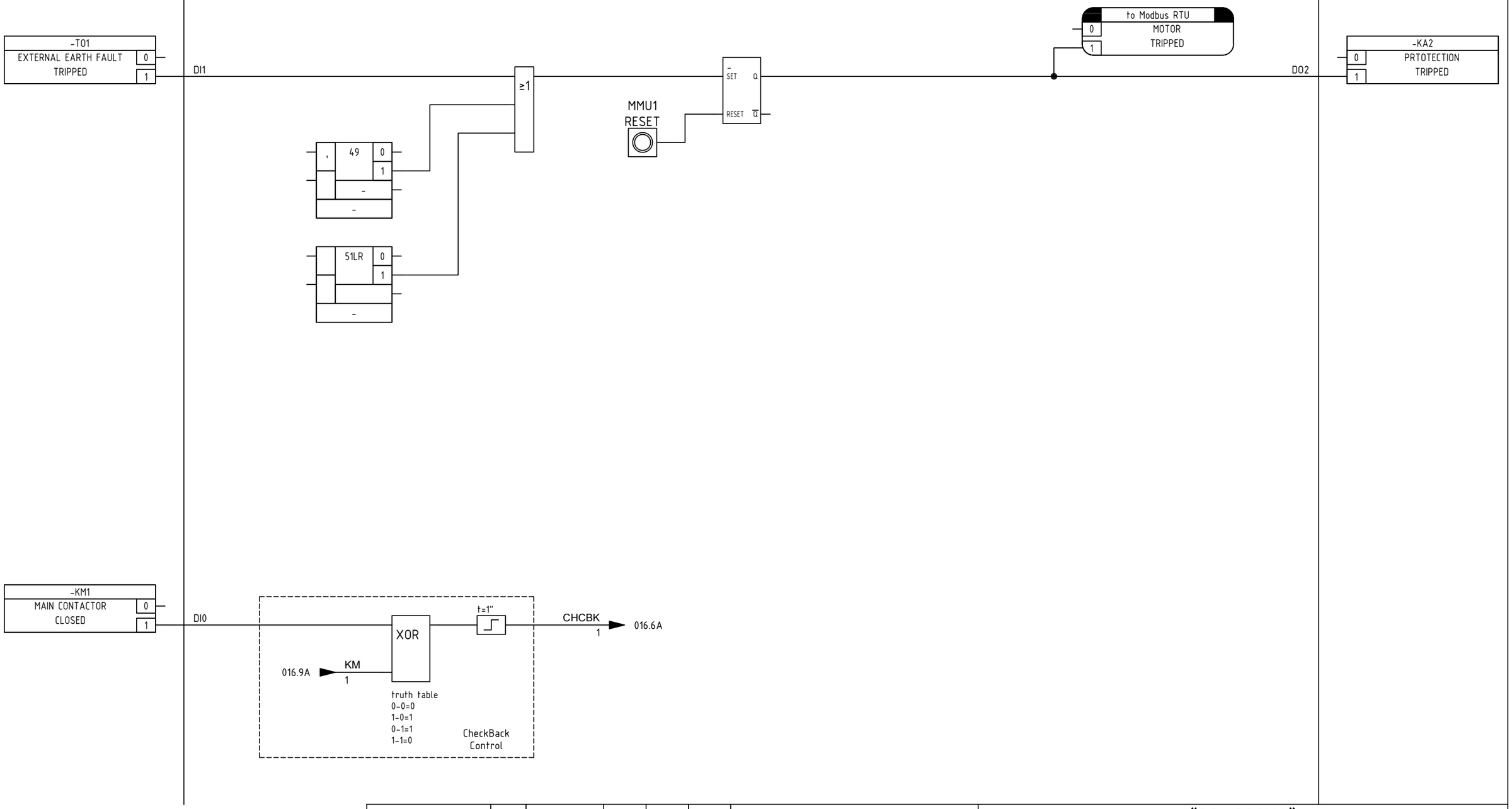
A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 016 | REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm

# UMC100 INTERNAL FUNCTION LOGIC

INPUT | INTERNAL LOGIC | OUTPUT




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

= 
+ 

DWG n° : 231298/SD/31
Item n° : PF1002983/26

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
UMC100 Internal Function Logic - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

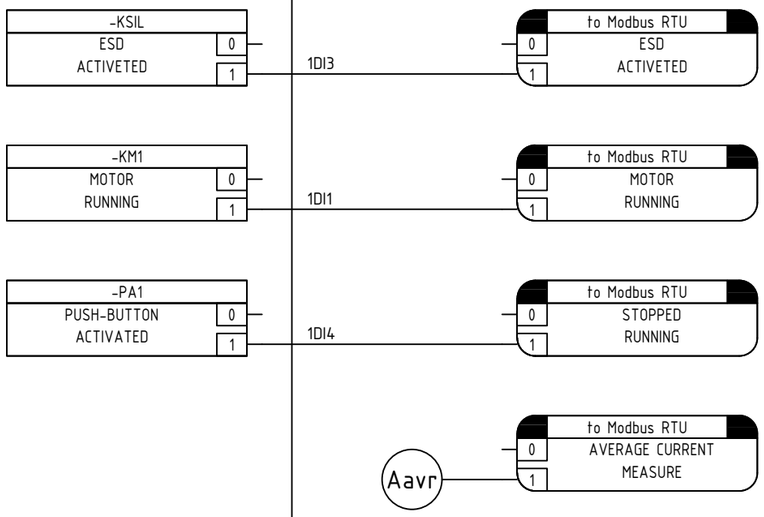
A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 017 | REV. 02

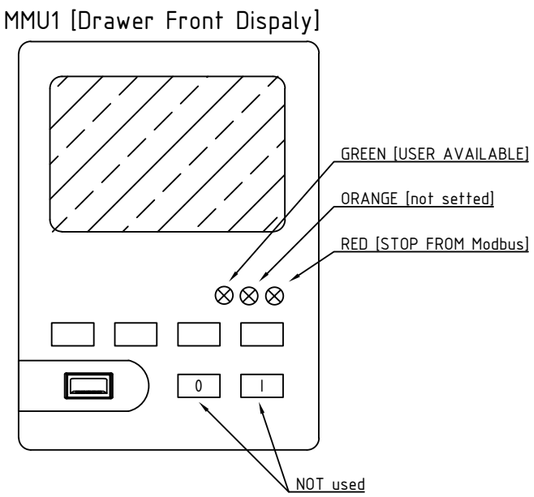
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# UMC100 INTERNAL FUNCTION LOGIC

INPUT | INTERNAL LOGIC | OUTPUT




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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DWG n° : 231298/SD/31
Item n° : PF1002983/26

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

UMC100 Internal Function Logic - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 018 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10

A

B

C

D

E

# UMC100 INTERNAL FUNCTION LOGIC

INPUT | INTERNAL LOGIC | OUTPUT

## AVAILABLE SHEET

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| | | | | | |
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/31

Item n° : PF1002983/26

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

UMC100 Internal Function Logic - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 019 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

TYPICAL - M1

X1

| NumM | Fg. | Sez. | Tipo | Descrizione | Costruttore |
|---|---|---|---|---|---|
| | | | BT003 | BT/3 End bracket | Cabur |
| 1 | 009.5A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 2 | 009.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 3 | 009.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 4 | 009.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 5 | 011.8C | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 6 | 011.8C | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 7 | 011.9C | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 8 | 011.9C | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| | | | HD101GR | HMD/PT/GR End section - Grey | Cabur |
| 9 | 014.6A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 10 | 014.6A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 11 | 014.2A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 12 | 014.2A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 13 | 014.7A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 14 | 014.8A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 15 | 014.9A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 16 | 014.9A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| | | | HD201GR | HMD.1/PT/GR End section - Grey | Cabur |
| | | | BT003 | BT/3 End bracket | Cabur |

= TYPICAL

\+ M1

DWG n° : 231298/SD/31

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 020

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| HL1 | 013 | ML22/484L230STLTTR | 1 | MULTILED 48x48 - 4 LED - Vaux=230Vac/dc + LAMP TEST + TROP | DOMO | | TYPICAL M1 |
| KA1 | 010 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | | TYPICAL M1 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | | TYPICAL M1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | | TYPICAL M1 |
| KA2 | 010 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | | TYPICAL M1 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | | TYPICAL M1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | | TYPICAL M1 |
| KA3 | 012 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | | TYPICAL M1 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | | TYPICAL M1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | | TYPICAL M1 |
| KA4 | 012 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | | TYPICAL M1 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | | TYPICAL M1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | | TYPICAL M1 |
| KA5 | 012 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | | TYPICAL M1 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | | TYPICAL M1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | | TYPICAL M1 |
| KA6 | 012 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | | TYPICAL M1 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | | TYPICAL M1 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | | TYPICAL M1 |
| KM1 | 012 | AF38300013 | 1 | AF38-30-00-13 CONTACTOR 3P 38A 100-250V AC/DC | ABB | | TYPICAL M1 |
| | | CA431E | 1 | CA4-31E CONTACTS BLOCK AUX 3NA+1NC FRONT | ABB | | TYPICAL M1 |
| KSIL | 014 | 2TLA010040R0000 | 1 | BSR10 Vaux=24VDC SAFETY RELAY | ABB | | TYPICAL M1 |
| MMU1 | 010 | 1SAJ590000R0103 | 1 | UMC100-PAN - CONTROL PANEL FOR UMC100 | ABB | | TYPICAL M1 |
| | | 1SAJ510003R0002 | 1 | UMCPAN-CAB.070 - 0.7mt ext. cable with door mounting set | ABB | | TYPICAL M1 |
| MMU2 | 010 | 1SAJ530000R1100 | 1 | UMC100.3 UC - UNIVERSAL MOTOR CONTROLLER Vaux=110-240VAC/DC | ABB | | TYPICAL M1 |
| | | 1SAJ691000R0001 | 1 | UMCIO-CAB.030 - Connection cable UMC100-I/O module, lenght 0.3mt | ABB | | TYPICAL M1 |
| MMU3 | 011 | 1SAJ622000R0102 | 1 | DX122.0 - I/O module for UMC100, 110-230 VAC digital input | ABB | | TYPICAL M1 |
| MMU4 | 011 | 1SAJ929600R0001 | 1 | SMK3.0 - Adapter for separate mounting of a communication interface; terminal block for 24 V DC supply included | ABB | | TYPICAL M1 |
| | | 1SAJ251000R0001 | 1 | MRP31.0 - Modbus RTU communication interface; terminal block for fieldbus connection included | ABB | | TYPICAL M1 |
| | | 1SAJ929240R0015 | 1 | CDP24.150 - Cable from SMK3.0 to drawer's outside, length 1.5 mt | ABB | | TYPICAL M1 |
| PA1 | 012 | KW 075 2 | 1 | MP1-10R PUSH BUTTON RED WITH BLACK RING | ABB | | TYPICAL M1 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | | TYPICAL M1 |
| | | EO 571 3 | 2 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | | TYPICAL M1 |
| PM1 | 012 | KW 076 0 | 1 | MP1-10G PUSH BUTTON GREEN WITH BLACK RING | ABB | | TYPICAL M1 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | | TYPICAL M1 |
| | | EO 570 5 | 2 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | | TYPICAL M1 |
| QA1 | 009 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | | TYPICAL M1 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | | TYPICAL M1 |
| QF1 | 009 | XT2S20MA3 | 1 | XT2S 160 MA 20 Im=120...280 3p F F | ABB | | TYPICAL M1 |
| | | 1SDA066436R1 | 1 | AUX-C 3Q+2SY 250Vac/dc XT2-XT4 F/P | ABB | | TYPICAL M1 |
| SA1 | 012 | KW 329 3 | 1 | M2SS2-10B HANDLE SELECTOR 2P 90° BLACK RING BLACK | ABB | | TYPICAL M1 |

= TYPICAL
+ M1

DWG n° : 231298/SD/31
Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 021 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| SA1 | 012 | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | | TYPICAL M1 |
| | | EO 570 5 | 2 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | | TYPICAL M1 |
| | | EO 571 3 | 2 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | | TYPICAL M1 |
| T01 | 009 | 1SAJ929200R0035 | 1 | CEM11-FBP.35 Earth fault monitor UMC100.3 | ABB | | TYPICAL M1 |
| X1 | | HD100GR_ | 8 | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur | | TYPICAL M1 |
| | | HD400GR_ | 8 | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur | | TYPICAL M1 |
| | | BT003 | 2 | BT/3 End bracket | Cabur | | TYPICAL M1 |
| | | HD101GR | 1 | HMD/PT/GR End section - Grey | Cabur | | TYPICAL M1 |
| | | HD201GR | 1 | HMD.1/PT/GR End section - Grey | Cabur | | TYPICAL M1 |

= TYPICAL
\+ M1

DWG n° : 231298/SD/31
Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
Functional Drawing - Typical "M1-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

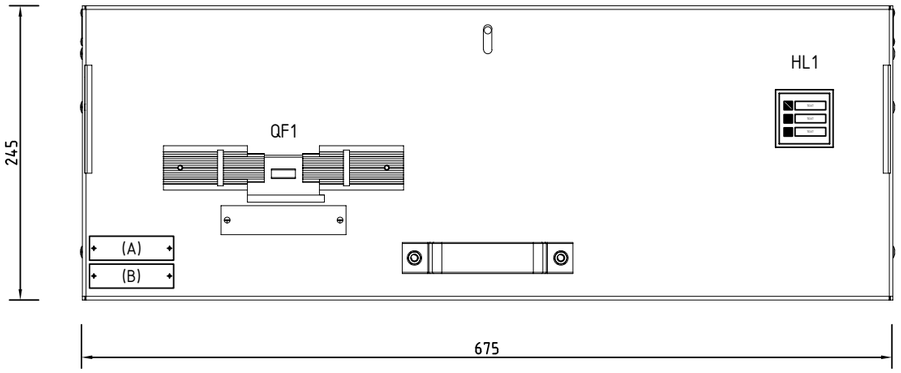
A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 022 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# DOOR FRONT LAY-OUT

## TYPICAL : LINE FEEDER "L1-n"

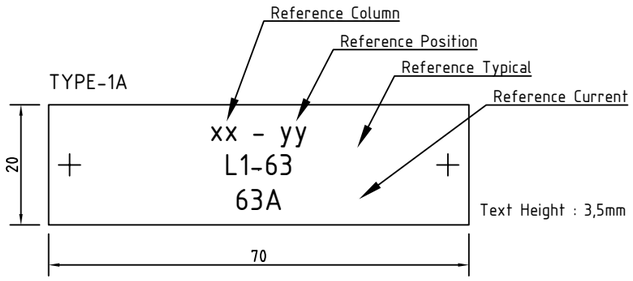


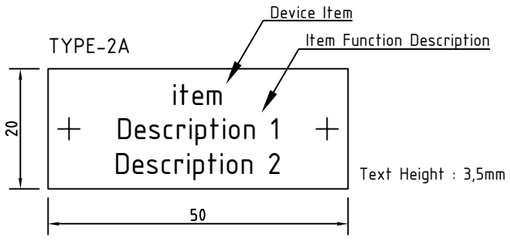

NOTE :

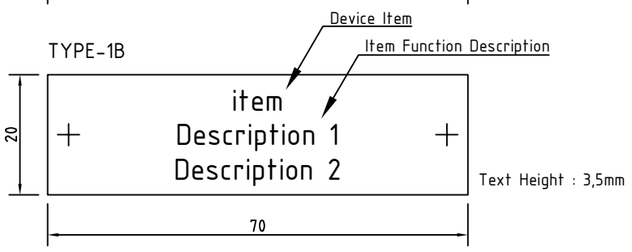
A) IDENTIFICATION name plate (type-1A) , with :
- Drawer position [Column / Position inside SWB]
- Typical name [reference applicability typical used]
- Power [reference applicability typical used]

B) USER name plate (type-1B), with :
- Item User [to see SLD diagrams]
- User Description [to see SLD diagrams]

| DEVICES name plate | | | |
|---|---|---|---|
| ITEM | DESCRIPTION 1 | DESCRIPTION 2 | NOTE |
| QF1 | Circuit Breaker | Signalling | NO plate |
| HL1 | Multiled | Signalling | NO plate |




| | |
|---|---|
| = | TYPICAL |
| + | L-x |

DWG n° : 231298/SD/31

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Door Front Lay-Out - Typical "L1-n" & "L2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

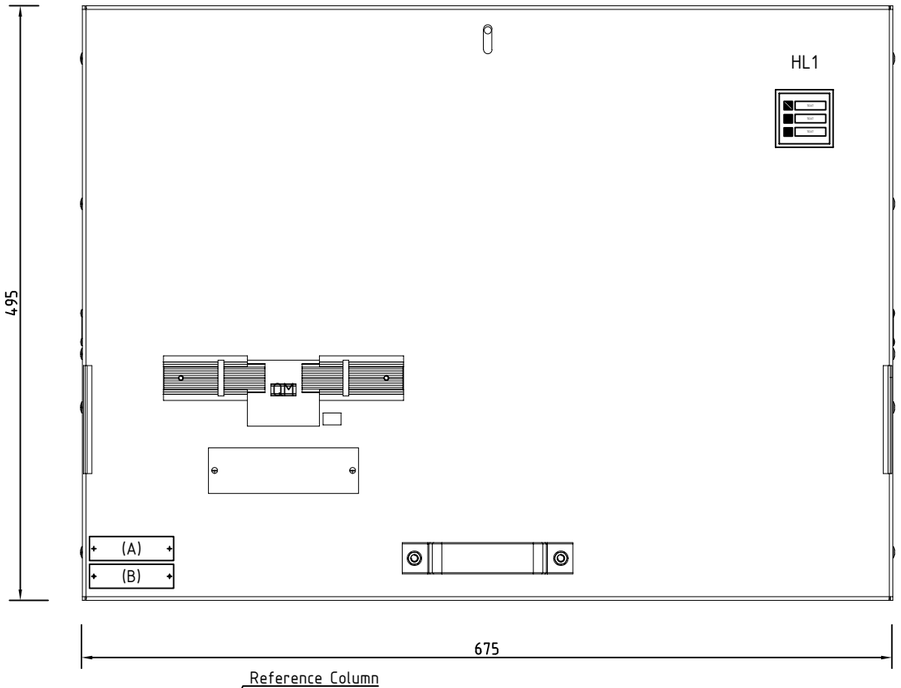
A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 023 | REV. 02

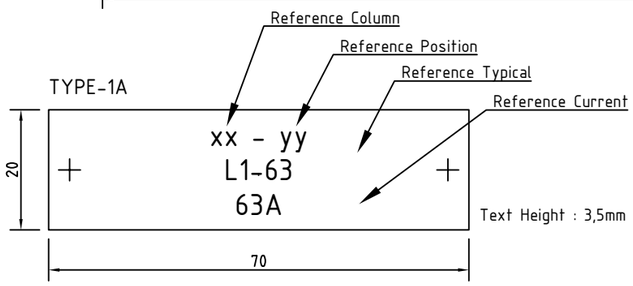
File Name : 1723002197-EL-DG-00031 Rev. 02

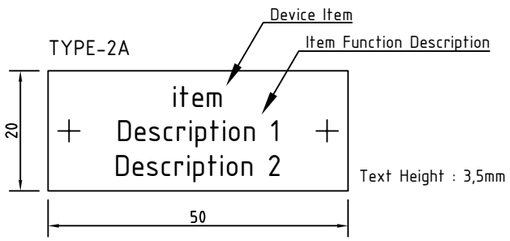
F.to UNI A3: 420mmx297mm

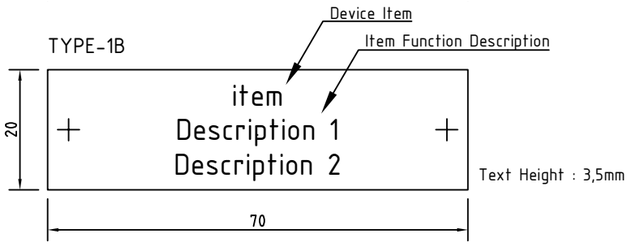
# DOOR FRONT LAY-OUT

TYPICAL : LINE FEEDER "L2-n"




NOTE :

A) IDENTIFICATION name plate (type-1A) , with :
- Drawer position [Column / Position inside SWB]
- Typical name [reference applicability typical used]
- Power [reference applicability typical used]

B) USER name plate (type-1B), with :
- Item User [to see SLD diagrams]
- User Description [to see SLD diagrams]

## DEVICES name plate

| ITEM | DESCRIPTION 1 | DESCRIPTION 2 | NOTE |
|---|---|---|---|
| QF1 | Circuit Breaker | Signalling | NO plate |
| HL1 | Multiled | Signalling | NO plate |

| | |
|---|---|
| = | TYPICAL |
| + | L-x |
| DWG n° : | 231298/SD/31 |
| Item n° : | PF1002983/26 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Door Front Lay-Out - Typical "L1-n" & "L2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 024 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# USERS LEGEND

## TYPICAL : LINE FEEDER "L1-n" & "L2-n"

| TYPICAL APPLICABILITY | | | | | |
|---|---|---|---|---|---|
| ITEM | ITEM TAG | DESCRIPTION TAG | REFERENCE POSITION (written on name name plate "type-1A) | REFERENCE NOMINAL CURRENT C.B. TRIP UNIT (written on name name plate "type-1A) | REFERENCE TYPICAL (written on name name plate "type-1A) |
| 1 | UP-200F4 | AC UPS F&G - 8H UP-200F4 - BYPASS | A2 / +04 | 63A | L1-63 |
| 2 | UP-200F3 | AC UPS PAS - 30 MIN UP-200F3 - LINE A | A3 / +01 | 100A | L1-100 |
| 3 | UP-200F3 | AC UPS PAS - 30 MIN UP-200F3 - LINE B | A4 / +01 | 100A | L1-100 |
| 4 | UP-200F4 | AC UPS F&G - 8H UP-200F4 - LINE A | A6 / +05 | 63A | L1-63 |
| 5 | UP-200F4 | AC UPS F&G - 8H UP-200F4 - LINE B | A6 / +06 | 63A | L1-63 |
| 6 | ESW-200N1 | WELDING SOCKETS (TOP DECK) | A6 / +08 | 160A | L2-160 |
| 7 | UP-200F3 | AC UPS PAS - 30 MIN UP-200F3 (BYPASS) | A7 / +02 | 100A | L1-100 |
| 8 | UP-200F1 | DC BATTERY SYSTEM SWTG CONTROL - FEEDER A | A7 / +03 | 63A | L1-63 |
| 9 | UP-200F1 | DC BATTERY SYSTEM SWTG CONTROL - FEEDER B | A7 / +04 | 63A | L1-63 |
| 10 | UP-200F2 | NAVAID SYSTEM FEEDER A | A7 / +05 | 63A | L1-63 |
| 11 | UP-200F2 | NAVAID SYSTEM FEEDER B | A7 / +06 | 63A | L1-63 |
| 12 | ESW-200N2 | WELDING SOCKETS (LOWER DECK) | A7 / +08 | 160A | L2-160 |

= TYPICAL
+ L-x

DWG n° : 231298/SD/31
Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
Users Legend - Typical "L1-n" & "L2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 025

REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm

# ITEMS ACRONYM

## TYPICAL : LINE FEEDER "L1-n" & "L2-n"

Composition of Typical :

L-x = Common Parts
L1-"nn" or L2-"nn"= Specific Parts

Example for Composition of L1-63:
- to take "L-x" plus "L1-63"

Example for Composition of L2-160:
- to take "L-x" plus "L2-160"

| | ACRONYM ITEMS [Comun parts] | ACRONYM ITEMS [Specific parts] | | | | |
|---|---|---|---|---|---|---|
| | L-x | L1-40 [In=40A] [Current Trip Unit] | L1-63 [In=63A] [Current Trip Unit] | L1-100 [In=100A] [Current Trip Unit] | L2-160 [In=160A] [Current Trip Unit] | |
| ASSOCIATED TYPICAL | This Item include all devices that are comun for both "Specific Parts" Items | This Items include only devices that are detail for "Specific Parts" Items | | | | |
| L1-40 | X | X | | | | |
| L1-63 | X | | X | | | |
| L1-100 | X | | | X | | |
| L2-160 | X | | | | X | |

| | | | | | | |
|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | |
| + | L-x | | | | | |
| DWG n° : | 231298/SD/31 | | | | | |
| Item n° : | PF1002983/26 | | | | | |
| | | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
Items Acronym - Typical "L1-n" & "L2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 026 | REV. 02

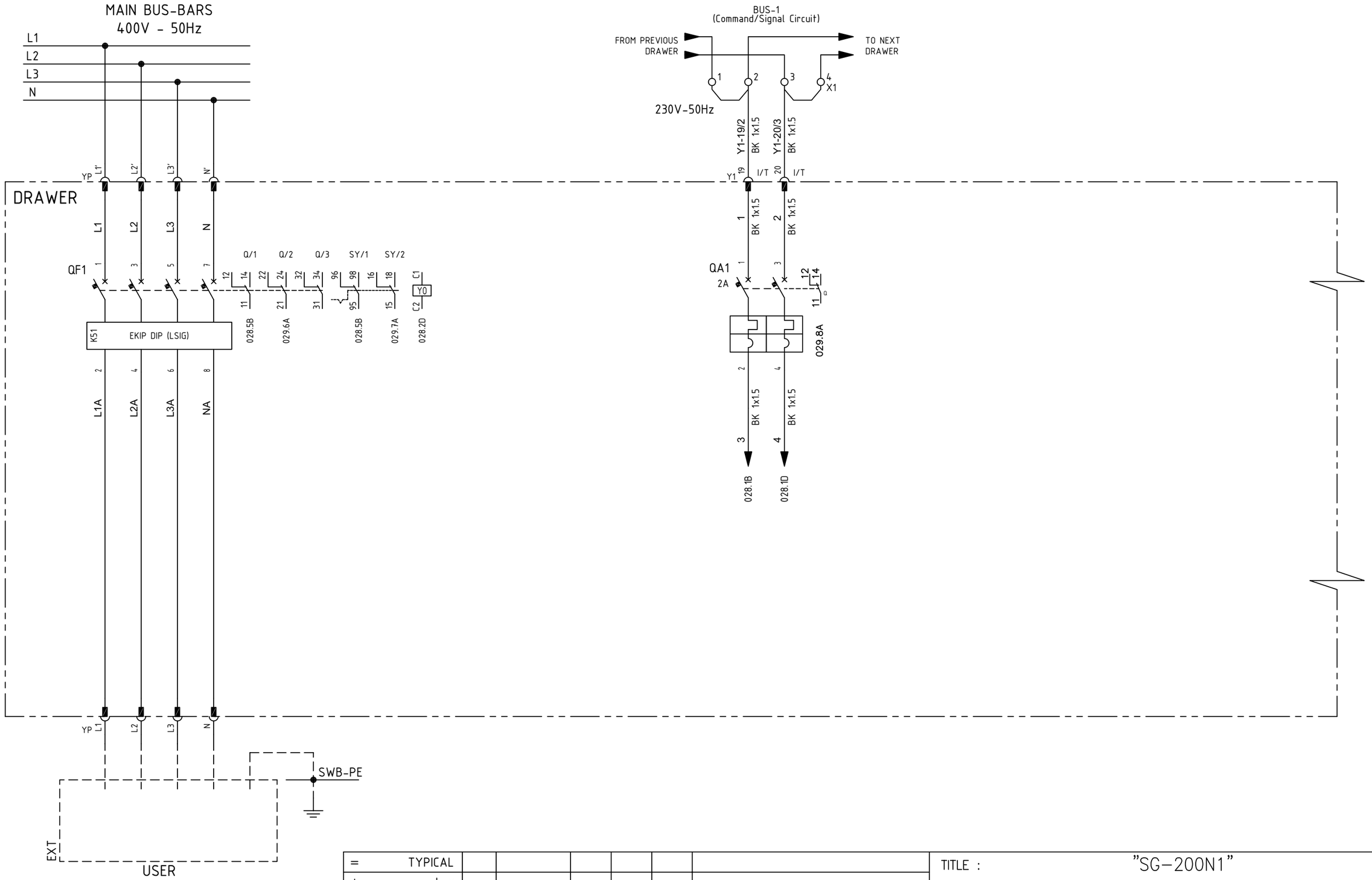
CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




| | | | | | | |
|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | |
| + | L-x | | | | | |
| DWG n° : | 231298/SD/31 | | | | | |
| Item n° : | PF1002983/26 | | | | | |
| | | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "L1-n" & "L2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

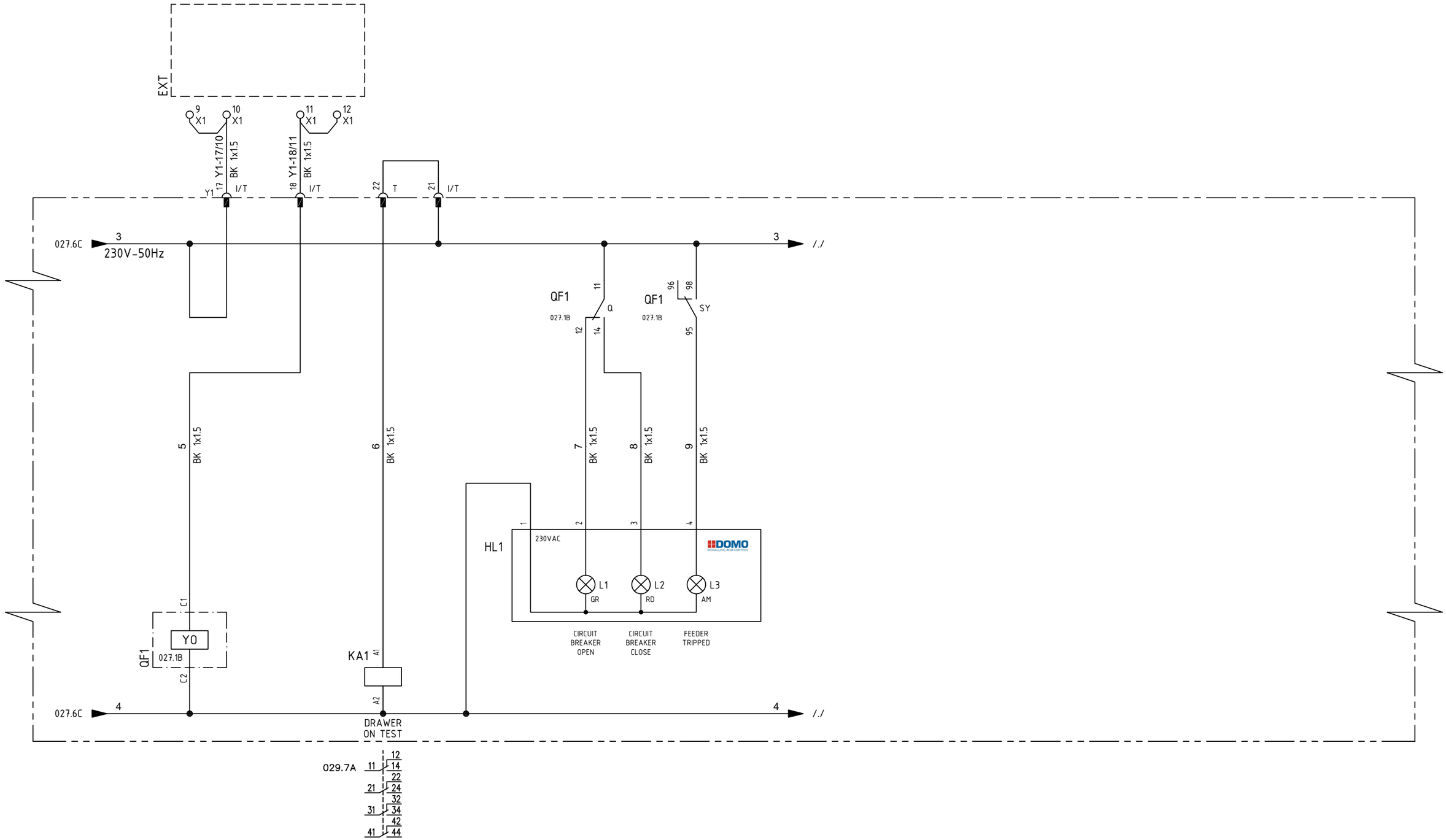
DRAWING NO. 1723002197-EL-DG-00031

SHEET 027

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = TYPICAL | | | | | | | |
| + L-x | | | | | | | |
| DWG n° : 231298/SD/31 | | | | | | | |
| Item n° : PF1002983/26 | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) | |
| | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "L1-n" & "L2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

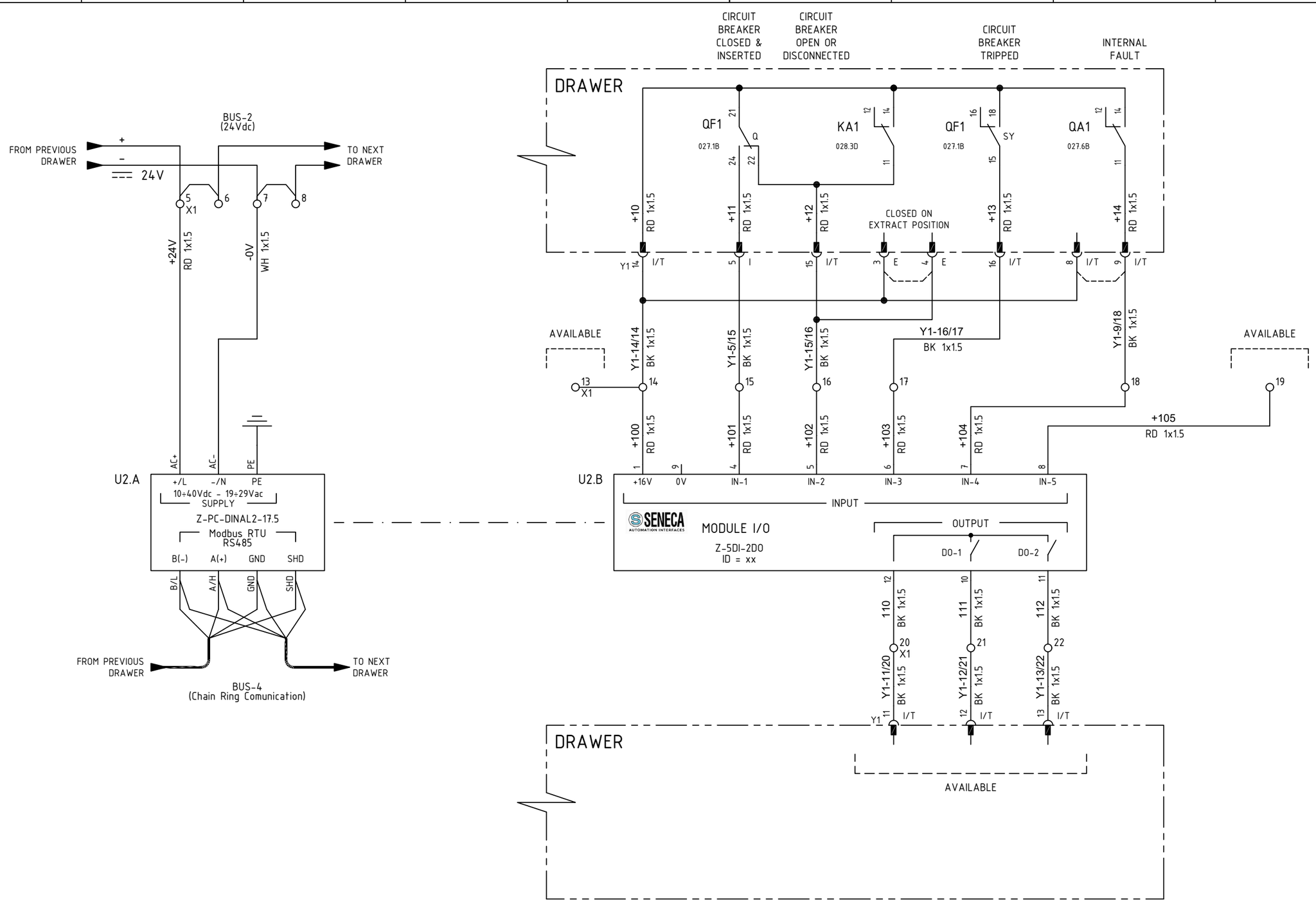
DRAWING NO. 1723002197-EL-DG-00031

SHEET 028

REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | L-x | | | | | | |
| DWG n° : | 231298/SD/31 | | | | | | |
| Item n° : | PF1002983/26 | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "L1-n" & "L2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

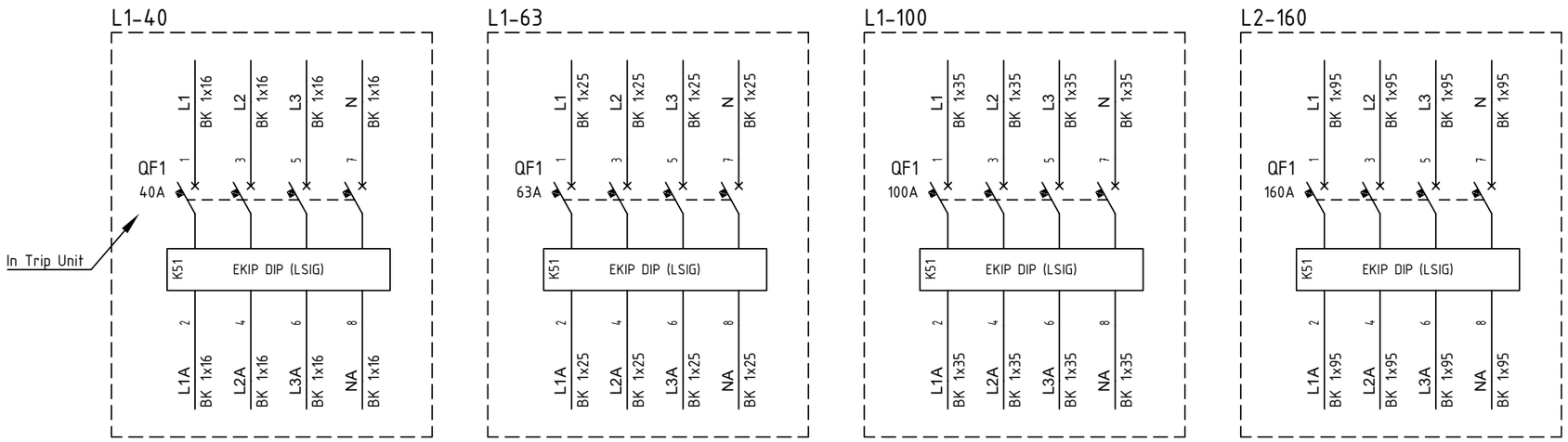
A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 029 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# SPECIFIC PARTS

## TYPICAL : LINE FEEDER "L1-n" & "L2-n"




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = TYPICAL | | | | | | | |
| + L-x | | | | | | | |
| DWG n° : 231298/SD/31 | | | | | | | |
| Item n° : PF1002983/26 | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) | |
| | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) | |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "L1-n" & "L2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 030 | REV. 02

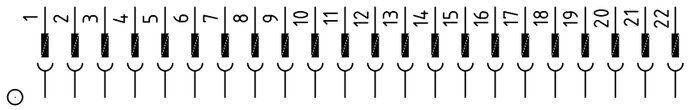
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

TYPICAL - L-x - Y1

AUXILIARY SOCKET
136450/001 (PF – 1 pcs) + 136458/004 (PM – 1 pcs)

| N° PIN | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUMP | | | ● | ● | | | | ● | ● | | | | | | | | | | | | | |
| RACKED-OUT | | | X | X | | | | X | X | | | | | | | | | | | | | |
| TEST | | | | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| RACKED-IN | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | |
| PIN USED | | | 029.6B | 029.7B | 029.6B | | | 029.8B | 029.8B | | 029.7D | 029.7D | 029.8D | 029.5B | 029.6B | 029.7B | 028.2B | 028.3B | 027.6A | 027.6A | 028.4B | 028.3B |




← FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN RACKED-OUT POSITION

← FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN TEST POSITION

← FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN RACKED-IN POSITION

← CROS-REFERENCE USED PIN

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

= TYPICAL
+ L-x

DWG n° : 231298/SD/31
Item n° : PF1002983/26

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
Functional Drawing - Typical "L1-n" & "L2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 031 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

TYPICAL - L-x

X1

| NumM | Fg. | Sez. | Tipo | Descrizione | Costruttore |
|---|---|---|---|---|---|
| | | | BT003 | BT/3 End bracket | Cabur |
| 1 | 027.5A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 2 | 027.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 3 | 027.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 4 | 027.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 5 | 029.2A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 6 | 029.2A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 7 | 029.2A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 8 | 029.3A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| | | | HD101GR | HMD/PT/GR End section - Grey | Cabur |
| 9 | 028.2A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 10 | 028.2A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 11 | 028.3A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 12 | 028.3A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 13 | 029.4B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 14 | 029.5B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 15 | 029.6B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 16 | 029.6B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 17 | 029.7B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 18 | 029.8B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 19 | 029.9B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 20 | 029.7D | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 21 | 029.7D | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 22 | 029.8D | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| | | | HD201GR | HMD.1/PT/GR End section - Grey | Cabur |
| | | | BT003 | BT/3 End bracket | Cabur |

= TYPICAL

\+ L-x

DWG n° : 231298/SD/31

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "L1-n" & "L2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 032

REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| HL1 | 028 | ML22/483L230STLTTR | 1 | MULTILED 48x48 - 3 LED - Vaux=230Vac/dc + LAMP TEST + TROP | DOMO | TYPICAL L-x |
| KA1 | 028 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | TYPICAL L-x |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | TYPICAL L-x |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | TYPICAL L-x |
| QA1 | 027 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | TYPICAL L-x |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | TYPICAL L-x |
| U2.A | 029 | Z-PC-DINAL2-17.5 | 1 | DIN RAIL 2SLOT WITH HEAD FOR "Z-5DI-2DO" | SENECA | TYPICAL L-x |
| U2.B | 029 | Z-5DI-2DO | 1 | I/O MODUL 5DI+2DO modbus RS485 Vaux=10÷40Vdc 19÷28Vac | SENECA | TYPICAL L-x |
| X1 | | HD100GR__ | 8 | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur | TYPICAL L-x |
| | | HD400GR__ | 14 | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur | TYPICAL L-x |
| | | BT003 | 2 | BT/3 End bracket | Cabur | TYPICAL L-x |
| | | HD101GR | 1 | HMD/PT/GR End section - Grey | Cabur | TYPICAL L-x |
| | | HD201GR | 1 | HMD.1/PT/GR End section - Grey | Cabur | TYPICAL L-x |

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| QF1 | 030 | XT2S40LSIG4 | 1 | XT2S 160 Ekip LSIG In=40A 4p F F | ABB | TYPICAL L1-40 |
| | | 1SDA066436R1 | 1 | AUX-C 3Q+2SY 250Vac/dc XT2-XT4 F/P | ABB | TYPICAL L1-40 |
| | | 1SDA066325R1 | 1 | SOR-C XT1..XT4 F/P 220-240Vac-220-250Vdc | ABB | TYPICAL L1-40 |

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| QF1 | 030 | XT2S63LSIG4 | 1 | XT2S 160 Ekip LSIG In=63A 4p F F | ABB | TYPICAL L1-63 |
| | | 1SDA066436R1 | 1 | AUX-C 3Q+2SY 250Vac/dc XT2-XT4 F/P | ABB | TYPICAL L1-63 |
| | | 1SDA066325R1 | 1 | SOR-C XT1..XT4 F/P 220-240Vac-220-250Vdc | ABB | TYPICAL L1-63 |

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| QF1 | 030 | XT2S100LSIG4 | 1 | XT2S 160 Ekip LSIG In=100A 4p F F | ABB | TYPICAL L1-100 |
| | | 1SDA066436R1 | 1 | AUX-C 3Q+2SY 250Vac/dc XT2-XT4 F/P | ABB | TYPICAL L1-100 |
| | | 1SDA066325R1 | 1 | SOR-C XT1..XT4 F/P 220-240Vac-220-250Vdc | ABB | TYPICAL L1-100 |

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| QF1 | 030 | 1SDA068179R1 | 1 | XT4S 250 BREAKING PART 4p F F | ABB | TYPICAL L2-160 |
| | | 1SDA067536R1 | 1 | SG.EL.Ekip LSIG In=160A XT4 4p | ABB | TYPICAL L2-160 |
| | | 1SDA066436R1 | 1 | AUX-C 3Q+2SY 250Vac/dc XT2-XT4 F/P | ABB | TYPICAL L2-160 |
| | | 1SDA066325R1 | 1 | SOR-C XT1..XT4 F/P 220-240Vac-220-250Vdc | ABB | TYPICAL L2-160 |

= TYPICAL
\+ L-x

DWG n° : 231298/SD/31
Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "L1-n" & "L2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

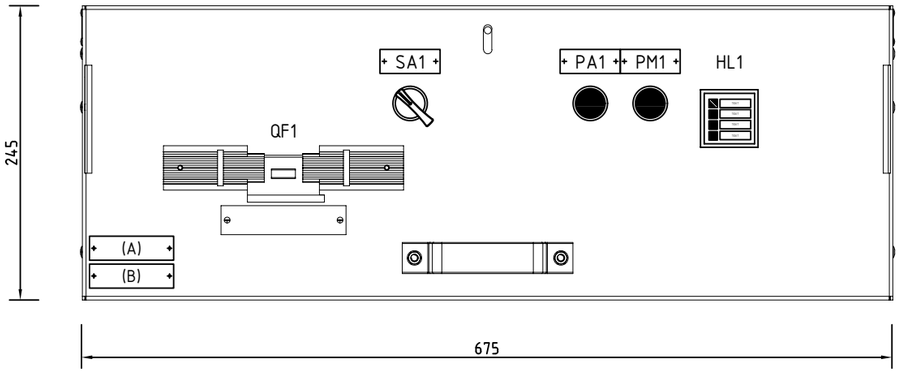
A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 033 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# DOOR FRONT LAY-OUT

## TYPICAL : LINE FEEDER "LK1-n"

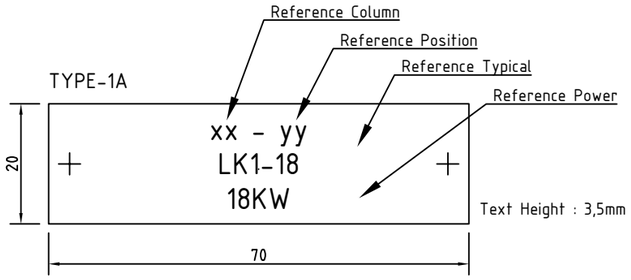


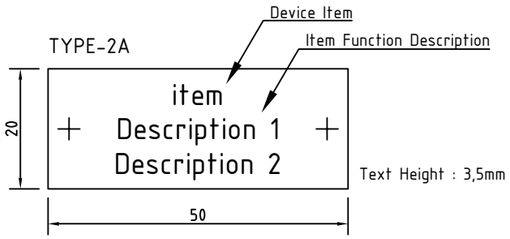

NOTE :

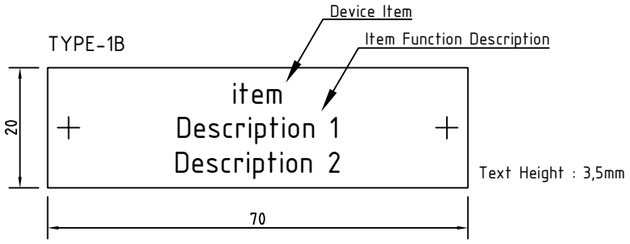
A) IDENTIFICATION name plate (type-1A) , with :
- Drawer position [Column / Position inside SWB]
- Typical name [reference applicability typical used]
- Power [reference applicability typical used]

B) USER name plate (type-1B), with :
- Item User [to see SLD diagrams]
- User Description [to see SLD diagrams]

| DEVICES name plate | | | |
|---|---|---|---|
| ITEM | DESCRIPTION 1 | DESCRIPTION 2 | NOTE |
| QF1 | Circuit Breaker | | NO plate |
| SA1 | LOC-REM | SELECTOR | Type-2A |
| PA1 | STOP | MOTOR | Type-2A |
| PM1 | RUN | MOTOR | Type-2A |
| HL1 | Multiled | Signalling | NO plate |




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | LK-x | | | | | | |
| DWG n° : | 231298/SD/31 | | | | | | |
| Item n° : | PF1002983/26 | | | | | | |
| | | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Door Front Lay-Out - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

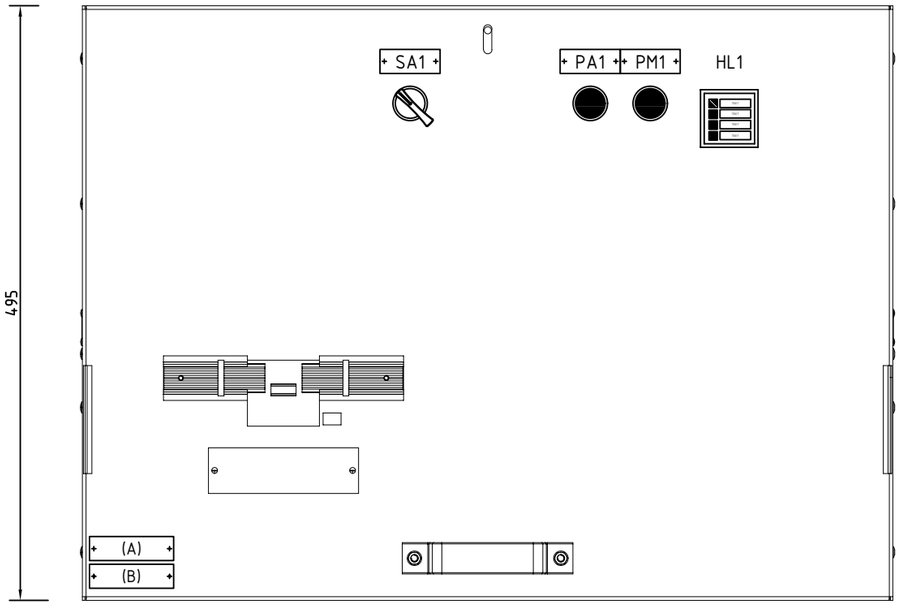
A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 034 | REV. 02

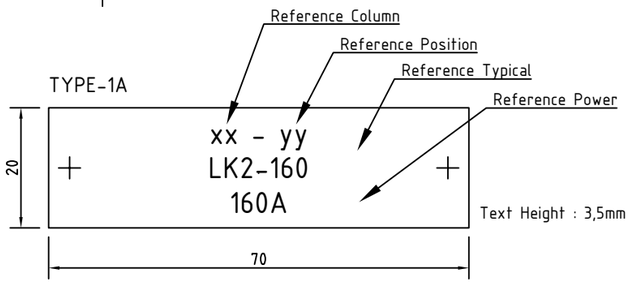
F.to UNI A3: 420mmx297mm

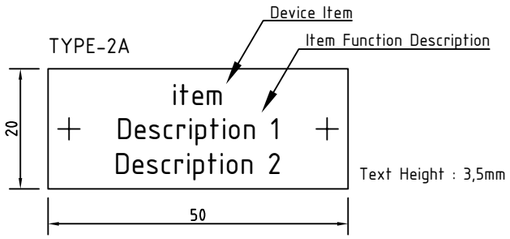
File Name : 1723002197-EL-DG-00031 Rev. 02

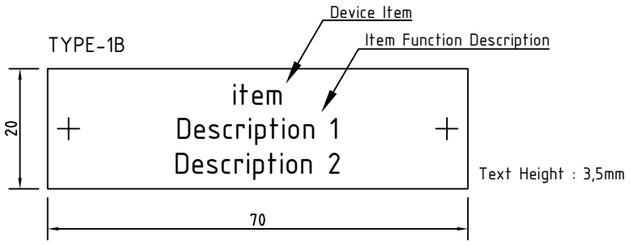
# DOOR FRONT LAY-OUT

## TYPICAL : LINE FEEDER "LK2-n"




NOTE :

A) IDENTIFICATION name plate (type-1A) , with :
- Drawer position [Column / Position inside SWB]
- Typical name [reference applicability typical used]
- Power [reference applicability typical used]

B) USER name plate (type-1B), with :
- Item User [to see SLD diagrams]
- User Description [to see SLD diagrams]

| DEVICES name plate | | | |
|---|---|---|---|
| ITEM | DESCRIPTION 1 | DESCRIPTION 2 | NOTE |
| QF1 | Circuit Breaker | | NO plate |
| SA1 | LOC-REM | SELECTOR | Type-2A |
| PA1 | STOP | MOTOR | Type-2A |
| PM1 | RUN | MOTOR | Type-2A |
| HL1 | Multiled | Signalling | NO plate |

| | |
|---|---|
| = | TYPICAL |
| + | LK-x |

DWG n° : 231298/SD/31
Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Door Front Lay-Out - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 035 | REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm

# USERS LEGEND

## TYPICAL : LINE FEEDER "LK1-n" "LK2-n"

| TYPICAL APPLICABILITY | | | | | |
|---|---|---|---|---|---|
| ITEM | ITEM TAG | DESCRIPTION TAG | REFERENCE POSITION (written on name name plate "type-1A) | REFERENCE NOMINAL CURRENT C.B. TRIP UNIT (written on name name plate "type-1A) | REFERENCE TYPICAL (written on name name plate "type-1A) |
| 1 | SPARE | SPARE | A2 / +05 | 40A | LK1-40 |
| 2 | SPARE | SPARE | A3 / +02 | 40A | LK1-40 |
| 3 | DP-200N1 | DB-LIGHTING & SMALL POWER BoP | A3 / +03 | 100A | LK1-100 |
| 4 | JB-200E3 | CRANE | A3 / +04 | 63A | LK1-63 |
| 5 | SPARE | SPARE | A3 / +05 | 40A | LK1-40 |
| 6 | JB-500E8 | WATER PACKAGE | A3 / +08 | 160A | LK2-160 |
| 7 | B100-HSB-001 | HVAC PANELS HV ROOM | A4 / +02 | 40A | LK1-40 |
| 8 | A-80000 | FUELL CELL AUXIALIRY LOAD | A4 / +03 | 63A | LK1-63 |
| 9 | CP-850F03 | BESS PCS CABINET | A4 / +04 | 40A | LK1-40 |
| 10 | SPARE | SPARE | A4 / +05 | 40A | LK1-40 |
| 11 | SPARE | SPARE | A4 / +06 | 40A | LK1-40 |
| 12 | K-63001-A | INSTRUMENTS AIR PACKAGE 01A | A4 / +08 | 160A | LK2-160 |
| 13 | SPARE | SPARE | A5 / +01 | 40A | LK1-40 |
| 14 | B200-HSB-001 | HVAC PANELS - LV ROOM | A5 / +02 | 40A | LK1-40 |
| 15 | B300-HSB-001 | HVAC PANELS - UPS ROOM | A5 / +03 | 63A | LK1-63 |
| 16 | B400-HSB-001 | HVAC PANELS - ITER | A5 / +04 | 63A | LK1-63 |
| 17 | CN-200N1 | IMPRESSED CURR. CATHODIC PROTECTION (ICCP) SYSTEM | A5 / +05 | 40A | LK1-40 |
| 18 | SPARE | SPARE | A5 / +06 | 40A | LK1-40 |
| 19 | K-63001-B | INSTRUMENTS AIR PACKAGE 01B | A5 / +08 | 160A | LK2-160 |
| 20 | CP-850E1 | BESS LV1 CABINAT (+DISTR 1) | A6 / +02 | 40A | LK1-40 |
| 21 | CP-850E2 | BESS LV2 CABINAT (+DISTR 2) | A6 / +03 | 40A | LK1-40 |
| 22 | SPARE | SPARE | A6 / +04 | 40A | LK1-40 |

= TYPICAL
+ LK-x

DWG n° : 231298/SD/31
Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Users Legend - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 036

REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm

# ITEMS ACRONYM

## TYPICAL : LINE FEEDER "LK1-n" "LK2-n"

Composition of Typical :

LK-x = Common Parts
LK1-"nn" or LK2-"nn"= Specific Parts

Example for Composition of LK1-63:
- to take "LK-x" plus "LK1-63"

Example for Composition of LK2-160:
- to take "LK-x" plus "LK2-160"

| | ACRONYM ITEMS [Comun parts] | ACRONYM ITEMS [Specific parts] | | | | | |
|---|---|---|---|---|---|---|---|
| | LK-x | LK1-40 [In=40A] [Current Trip Unit] | LK1-63 [In=63A] [Current Trip Unit] | LK1-100 [In=100A] [Current Trip Unit] | LK2-160 [In=160A] [Current Trip Unit] | | |
| ASSOCIATED TYPICAL | This Item include all devices that are comun for both "Specific Parts" Items | This Items include only devices that are detail for "Specific Parts" Items | | | | | |
| LK1-40 | X | X | | | | | |
| LK1-63 | X | | X | | | | |
| LK1-100 | X | | | X | | | |
| LK2-160 | X | | | | X | | |
| - | | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | |
| + | LK-x | | | | | |
| DWG n° : 231298/SD/31 | | | | | | |
| Item n° : PF1002983/26 | | | | | | |
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) | |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) | |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) | |
| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

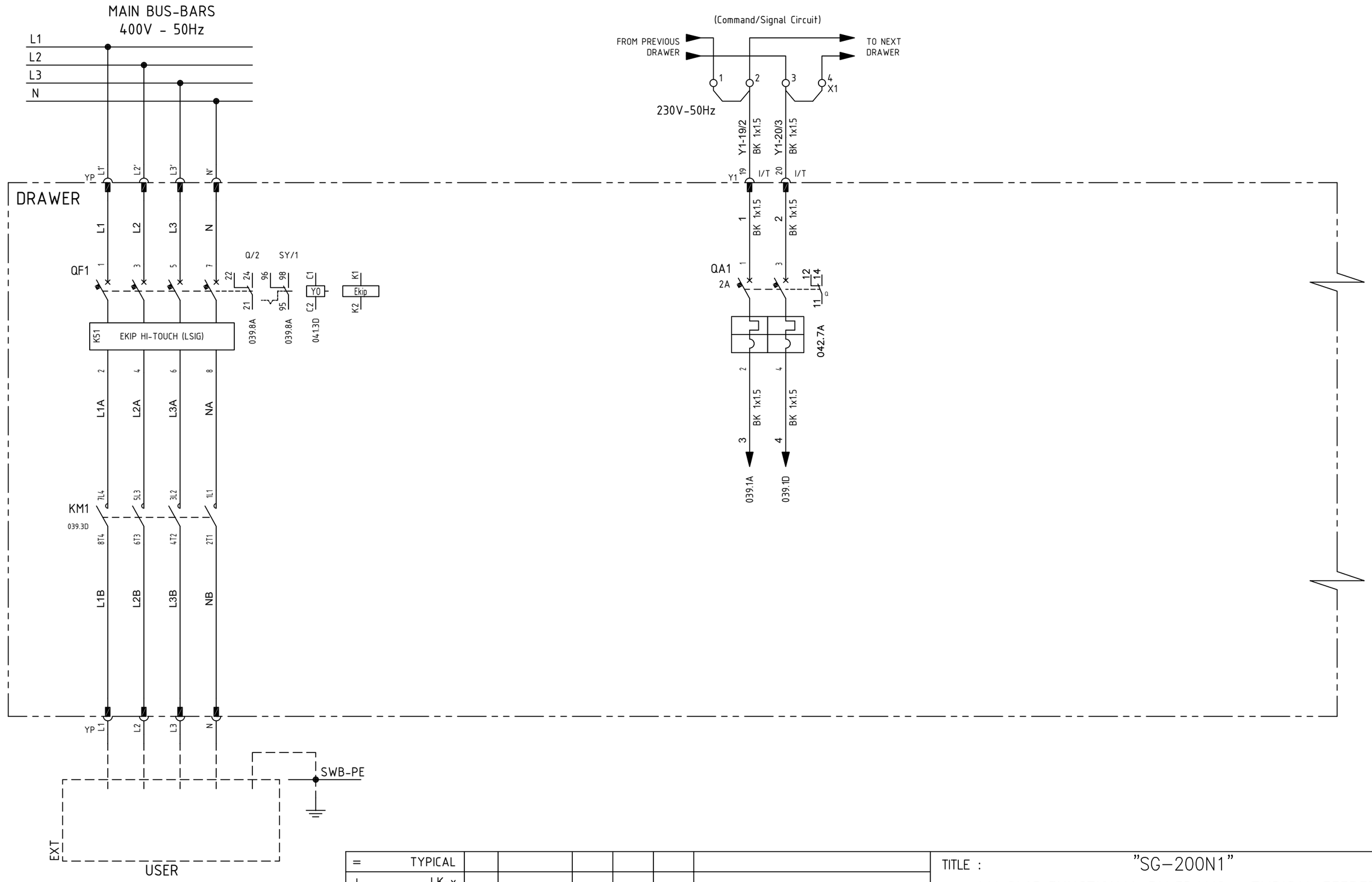
TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
Items Acronym - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 037 | REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm




| | |
|---|---|
| = | TYPICAL |
| + | LK-x |

DWG n° : 231298/SD/31

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

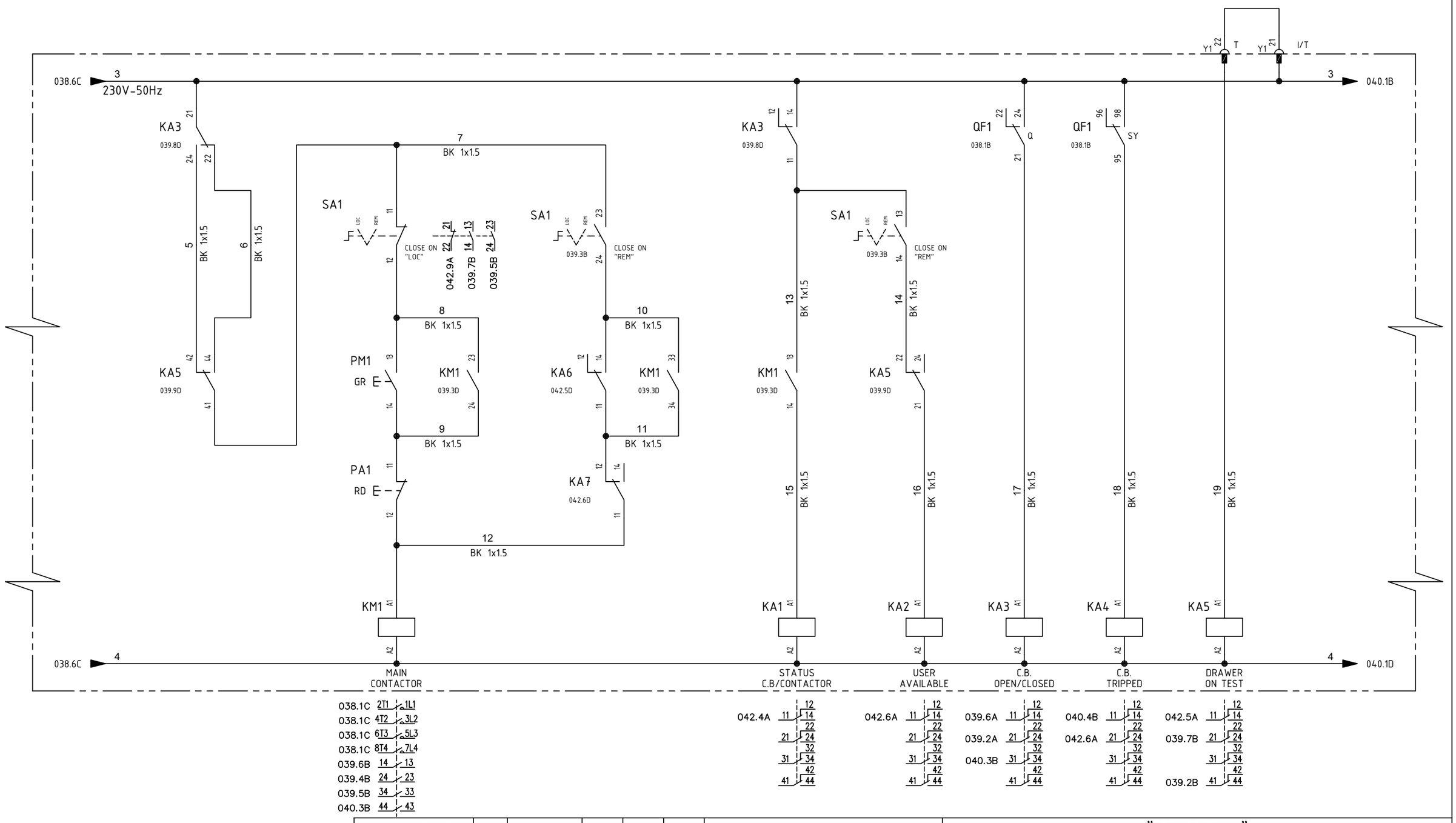
DRAWING NO. 1723002197-EL-DG-00031

SHEET 038

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




| | |
|---|---|
| = | TYPICAL |
| + | LK-x |

DWG n° : 231298/SD/31

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

# LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

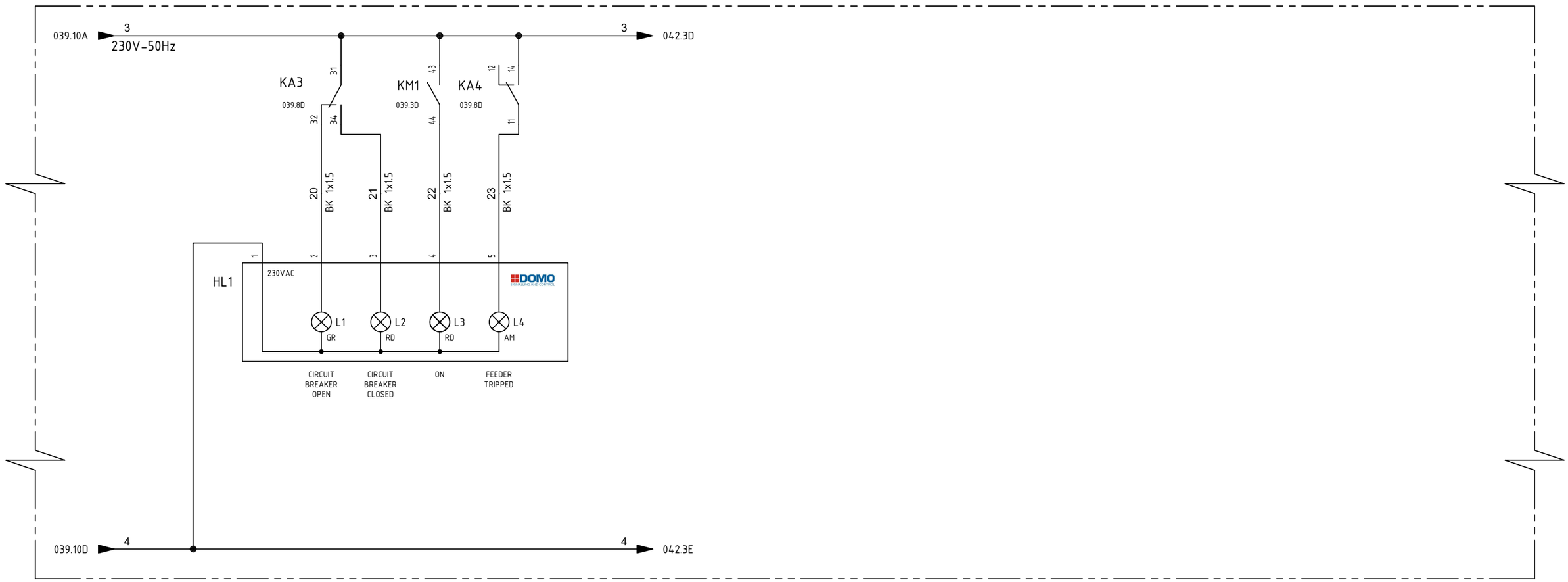
DRAWING NO. 1723002197-EL-DG-00031

SHEET 039

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | LK-x | | | | | | |
| DWG n° : | 231298/SD/31 | | | | | | |
| Item n° : | PF1002983/26 | | | | | | |
| | | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

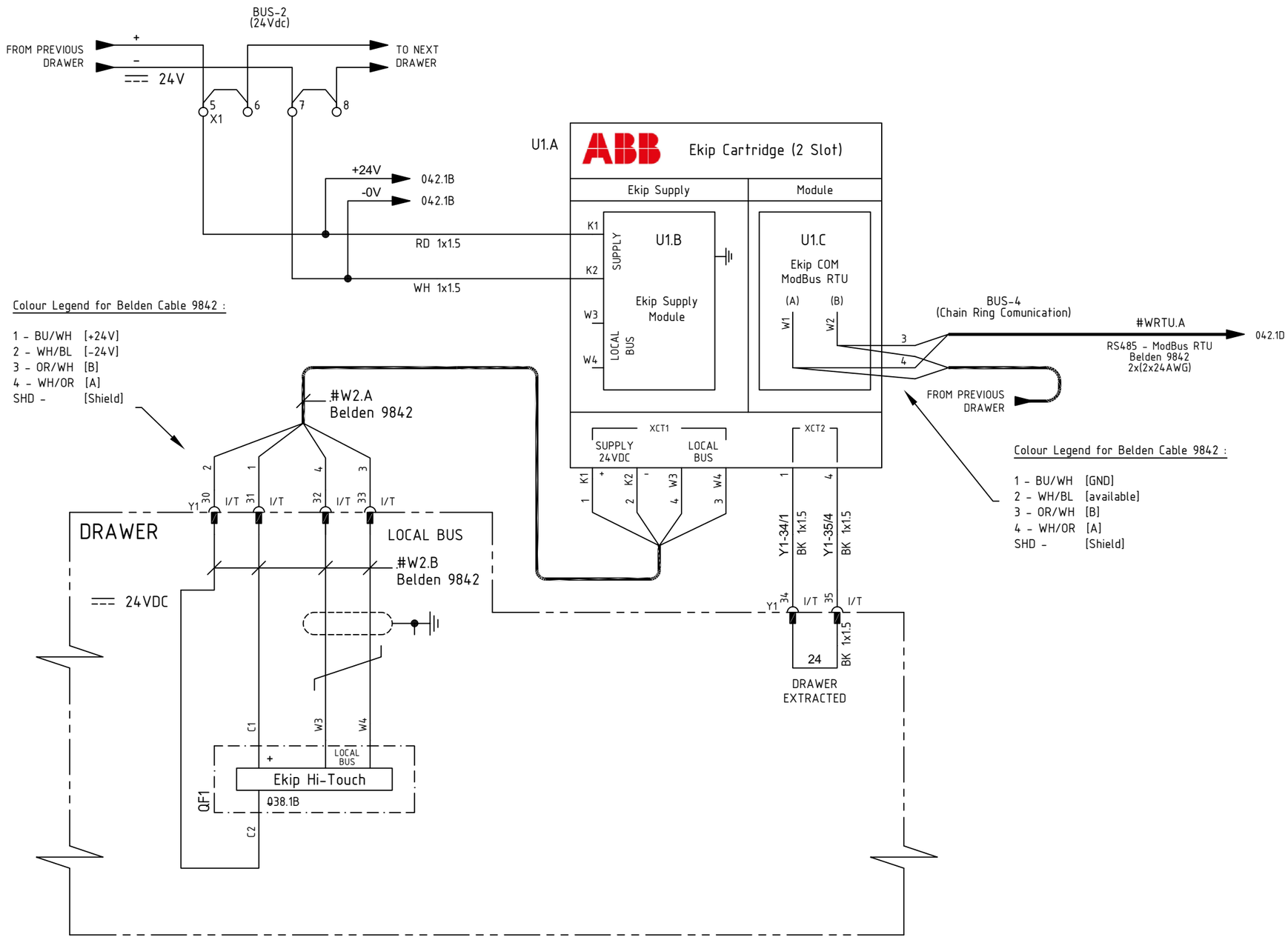
DRAWING NO. 1723002197-EL-DG-00031

SHEET 040

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | LK-x | | | | | | |
| DWG n° : 231298/SD/31 | | | | | | | |
| Item n° : PF1002983/26 | | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

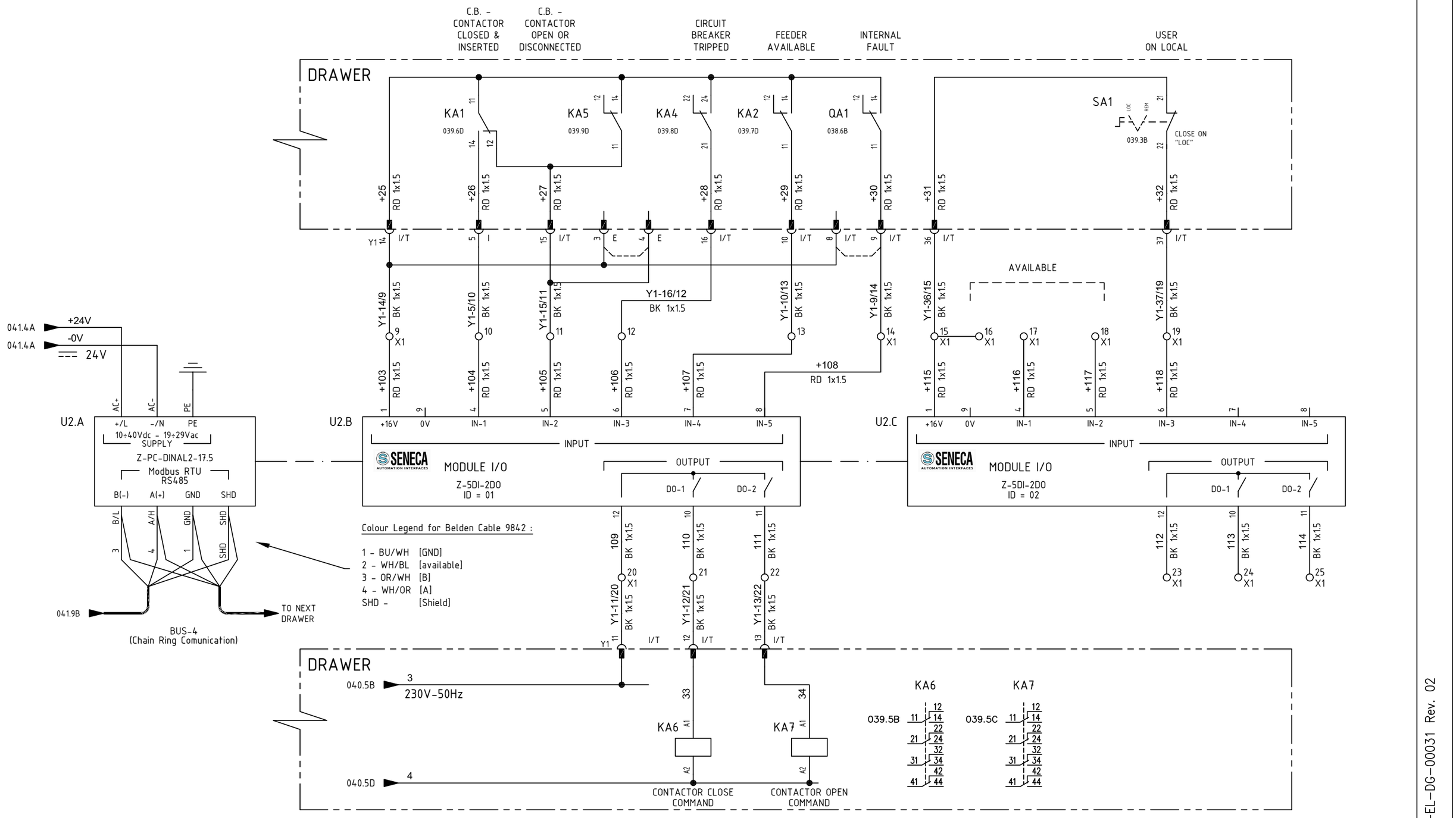
DRAWING NO. 1723002197-EL-DG-00031

SHEET 041

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | LK-x | | | | | | |
| DWG n° : 231298/SD/31 | | | | | | | |
| Item n° : PF1002983/26 | | | | | | | |
| | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 042

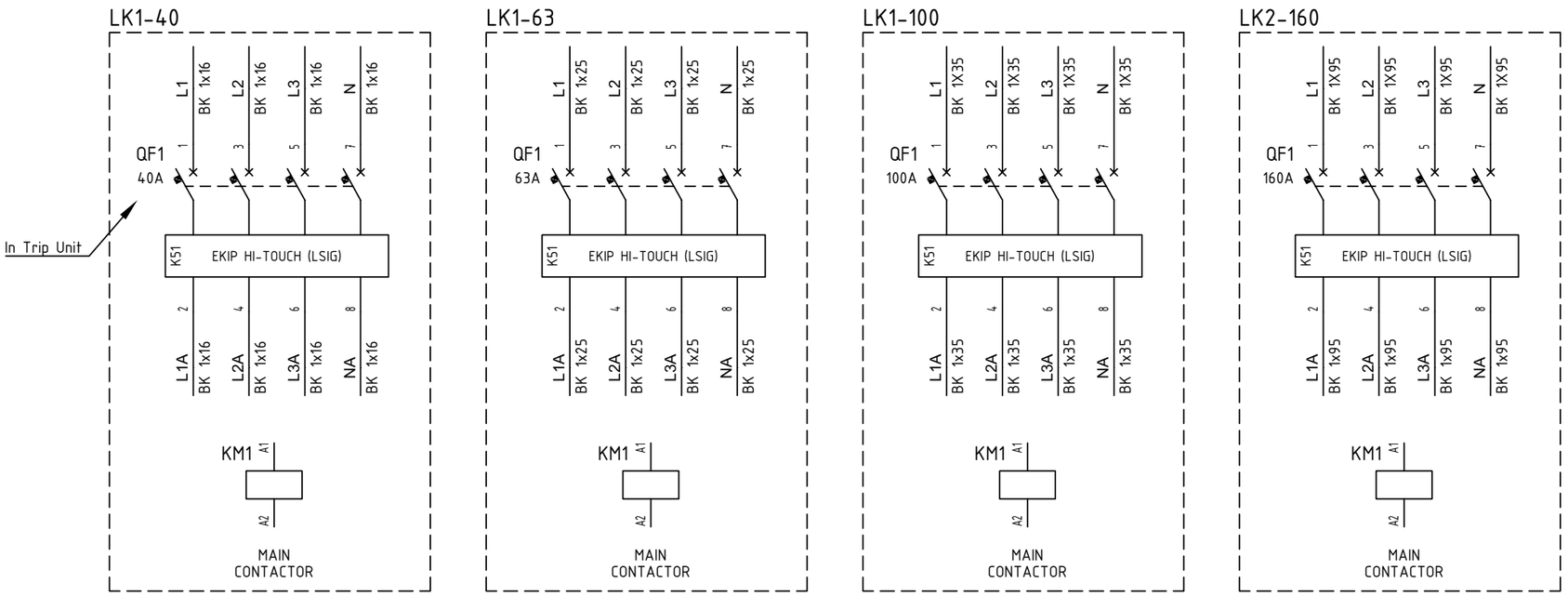
REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm

# SPECIFIC PARTS

## TYPICAL : LINE FEEDER "LK1-n" "LK2-n"




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | TYPICAL | | | | |
| + | LK-x | | | | |
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/31
Item n° : PF1002983/26

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
Functional Drawing - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 043 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# TYPICAL - LK-x - Y1

AUXILIARY SOCKET
136450/001 (PF – 2 pcs) + 136458/004 (PM – 2 pcs)

| N° PIN | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUMP | | | ● | ● | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RACKED-OUT | | | X | X | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TEST | | | | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| RACKED-IN | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | |
| PIN USED | | | 042.5B | 042.5B | 042.4B | | | 042.6B | 042.7B | 042.6B | 042.5D | 042.5D | 042.6D | 042.3B | 042.4B | 042.6B | | | 038.6A | 038.6A | 039.9A | 039.9A | | | | | | | | | 041.3C | 041.3C | 041.4C | 041.4C | 041.6C | 041.7C | 042.7B | 042.9B | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |

- FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN RACKED-OUT POSITION
- FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN TEST POSITION
- FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN RACKED-IN POSITION
- CROS-REFERENCE USED PIN

| | |
|---|---|
| = | TYPICAL |
| + | LK-x |
| DWG n° : | 231298/SD/31 |
| Item n° : | PF1002983/26 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 044

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

TYPICAL - LK-x

X1

| NumM | Fg. | Sez. | Tipo | Descrizione | Costruttore |
|---|---|---|---|---|---|
| | | | BT003 | BT/3 End bracket | Cabur |
| 1 | 038.5A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 2 | 038.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 3 | 038.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 4 | 038.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 5 | 041.3A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 6 | 041.3A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 7 | 041.4A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 8 | 041.4A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| | | | HD101GR | HMD/PT/GR End section - Grey | Cabur |
| 9 | 042.3B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 10 | 042.4B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 11 | 042.4B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 12 | 042.5B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 13 | 042.6B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 14 | 042.7B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 15 | 042.7B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 16 | 042.7B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 17 | 042.8B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 18 | 042.8B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 19 | 042.9B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 20 | 042.5C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 21 | 042.5C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 22 | 042.6C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 23 | 042.9C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 24 | 042.9C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 25 | 042.10C | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| | | | HD201GR | HMD.1/PT/GR End section - Grey | Cabur |
| | | | BT003 | BT/3 End bracket | Cabur |

= TYPICAL

\+ LK-x

DWG n° : 231298/SD/31

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 045

REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| HL1 | 040 | ML22/484L230STLTTR | 1 | MULTILED 48x48 - 4 LED - Vaux=230Vac/dc + LAMP TEST + TROP | DOMO | TYPICAL LK-x |
| KA1 | 039 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | TYPICAL LK-x |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | TYPICAL LK-x |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | TYPICAL LK-x |
| KA2 | 039 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | TYPICAL LK-x |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | TYPICAL LK-x |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | TYPICAL LK-x |
| KA3 | 039 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | TYPICAL LK-x |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | TYPICAL LK-x |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | TYPICAL LK-x |
| KA4 | 039 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | TYPICAL LK-x |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | TYPICAL LK-x |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | TYPICAL LK-x |
| KA5 | 039 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | TYPICAL LK-x |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | TYPICAL LK-x |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | TYPICAL LK-x |
| KA6 | 042 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | TYPICAL LK-x |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | TYPICAL LK-x |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | TYPICAL LK-x |
| KA7 | 042 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | TYPICAL LK-x |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | TYPICAL LK-x |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | TYPICAL LK-x |
| PA1 | 039 | KW 075 2 | 1 | MP1-10R PUSH BUTTON RED WITH BLACK RING | ABB | TYPICAL LK-x |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | TYPICAL LK-x |
| | | EO 571 3 | 2 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | TYPICAL LK-x |
| PM1 | 039 | KW 076 0 | 1 | MP1-10G PUSH BUTTON GREEN WITH BLACK RING | ABB | TYPICAL LK-x |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | TYPICAL LK-x |
| | | EO 570 5 | 2 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | TYPICAL LK-x |
| QA1 | 038 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | TYPICAL LK-x |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | TYPICAL LK-x |
| SA1 | 039 | KW 329 3 | 1 | M2SS2-10B HANDLE SELECTOR 2P 90° BLACK RING BLACK | ABB | TYPICAL LK-x |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | TYPICAL LK-x |
| | | EO 570 5 | 2 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | TYPICAL LK-x |
| | | EO 571 3 | 2 | MCB-01 CONTACT NC FOR PUSHBUTTOM | ABB | TYPICAL LK-x |
| U1.2 | 041 | 1SDA074173R1 | 1 | MODUL EKIP SUPPLY 24÷48VDC | ABB | TYPICAL LK-x |
| U1.3 | 041 | 1SDA105166R1 | 1 | Module Ekip Com Modbus RS485 Tmax XT | ABB | TYPICAL LK-x |
| U1.A | 041 | 1SDA105203R1 | 1 | EKIP CARTRIDGE 2SLOT FOR XT2-XT4-XT5 | ABB | TYPICAL LK-x |
| U2.A | 042 | Z-PC-DINAL2-17.5 | 1 | DIN RAIL 2SLOT WITH HEAD FOR "Z-5DI-2DO" | SENECA | TYPICAL LK-x |
| U2.B | 042 | Z-5DI-2DO | 1 | I/O MODUL 5DI+2DO modbus RS485 Vaux=10÷40Vdc 19÷28Vac | SENECA | TYPICAL LK-x |
| U2.C | 042 | Z-5DI-2DO | 1 | I/O MODUL 5DI+2DO modbus RS485 Vaux=10÷40Vdc 19÷28Vac | SENECA | TYPICAL LK-x |
| X1 | | HD100GR__ | 8 | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur | TYPICAL LK-x |
| | | HD400GR__ | 17 | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur | TYPICAL LK-x |
| | | BT003 | 2 | BT/3 End bracket | Cabur | TYPICAL LK-x |
| | | HD101GR | 1 | HMD/PT/GR End section - Grey | Cabur | TYPICAL LK-x |

= TYPICAL
+ LK-x

DWG n° : 231298/SD/31
Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 046 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| X1 | | HD201GR | 1 | HMD.1/PT/GR End section - Grey | Cabur | TYPICAL LK-x |

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| KM1 | 043 | AF40400013 | 1 | AF40-40-00-13 CONTACTOR 4P 40A 100-250VAC/DC | ABB | TYPICAL LK1-40 |
| | | CA440E | 1 | CA4-40E AUXILIARY FRONT CONTACT 4NO | ABB | TYPICAL LK1-40 |
| QF1 | 043 | 1SDA068169R1 | 1 | XT2S 160 BREAKING PART 4p F F | ABB | TYPICAL LK1-40 |
| | | 1SDA100162R1 | 1 | ELECTRONIC TRIP RELEASE Ekip Hi-Touch LSIG In=40A XT2 4p | ABB | TYPICAL LK1-40 |
| | | 1SDA066431R1 | 1 | AUX-C 1Q+1SY 250Vac/dc XT1..XT5 F/P | ABB | TYPICAL LK1-40 |

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| KM1 | 043 | AF52400013 | 1 | AF52-30-00-13 CONTACTOR 4P 53A(AC3) 100-250VAC/DC | ABB | TYPICAL LK1-63 |
| | | CA440E | 1 | CA4-40E AUXILIARY FRONT CONTACT 4NO | ABB | TYPICAL LK1-63 |
| QF1 | 043 | 1SDA068169R1 | 1 | XT2S 160 BREAKING PART 4p F F | ABB | TYPICAL LK1-63 |
| | | 1SDA100163R1 | 1 | ELECTRONIC TRIP RELEASE Ekip Hi-Touch LSIG In=63A XT2 4p | ABB | TYPICAL LK1-63 |
| | | 1SDA066431R1 | 1 | AUX-C 1Q+1SY 250Vac/dc XT1..XT5 F/P | ABB | TYPICAL LK1-63 |

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| KM1 | 043 | AF80400013 | 1 | AF80-30-00-13 CONTACTOR 4P 80A(AC3) 100-250VAC/DC | ABB | TYPICAL LK1-100 |
| | | CA440E | 1 | CA4-40E AUXILIARY FRONT CONTACT 4NO | ABB | TYPICAL LK1-100 |
| QF1 | 043 | 1SDA068169R1 | 1 | XT2S 160 BREAKING PART 4p F F | ABB | TYPICAL LK1-100 |
| | | 1SDA100164R1 | 1 | ELECTRONIC TRIP RELEASE Ekip Hi-Touch LSIG In=100A XT2 4p | ABB | TYPICAL LK1-100 |
| | | 1SDA066431R1 | 1 | AUX-C 1Q+1SY 250Vac/dc XT1..XT5 F/P | ABB | TYPICAL LK1-100 |

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| KM1 | 043 | AF190401113 | 1 | AF190-40-11-13 CONT 4P 190A AC3 100-250VAC/DC | ABB | TYPICAL LK2-160 |
| | | CAL1911 | 1 | CAL19-11 CONTATTO AUSILIARIO 1NA+1NC PER AF116÷AF370 | ABB | TYPICAL LK2-160 |
| | | CAL1911B | 2 | CAL19-11B AUXILIARY CONTACT 1NA+1NC PER AF116÷AF370 | ABB | TYPICAL LK2-160 |
| QF1 | 043 | 1SDA068179R1 | 1 | XT4S 250 BREAKING PART 4p F F | ABB | TYPICAL LK2-160 |
| | | 1SDA100334R1 | 1 | ELECTRONIC TRIP RELEASE Ekip Hi-Touch LSIG In=160A XT4 4p | ABB | TYPICAL LK2-160 |
| | | 1SDA066431R1 | 1 | AUX-C 1Q+1SY 250Vac/dc XT1..XT5 F/P | ABB | TYPICAL LK2-160 |

= TYPICAL
+ LK-x

DWG n° : 231298/SD/31
Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LK1-n" & "LK2-n"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

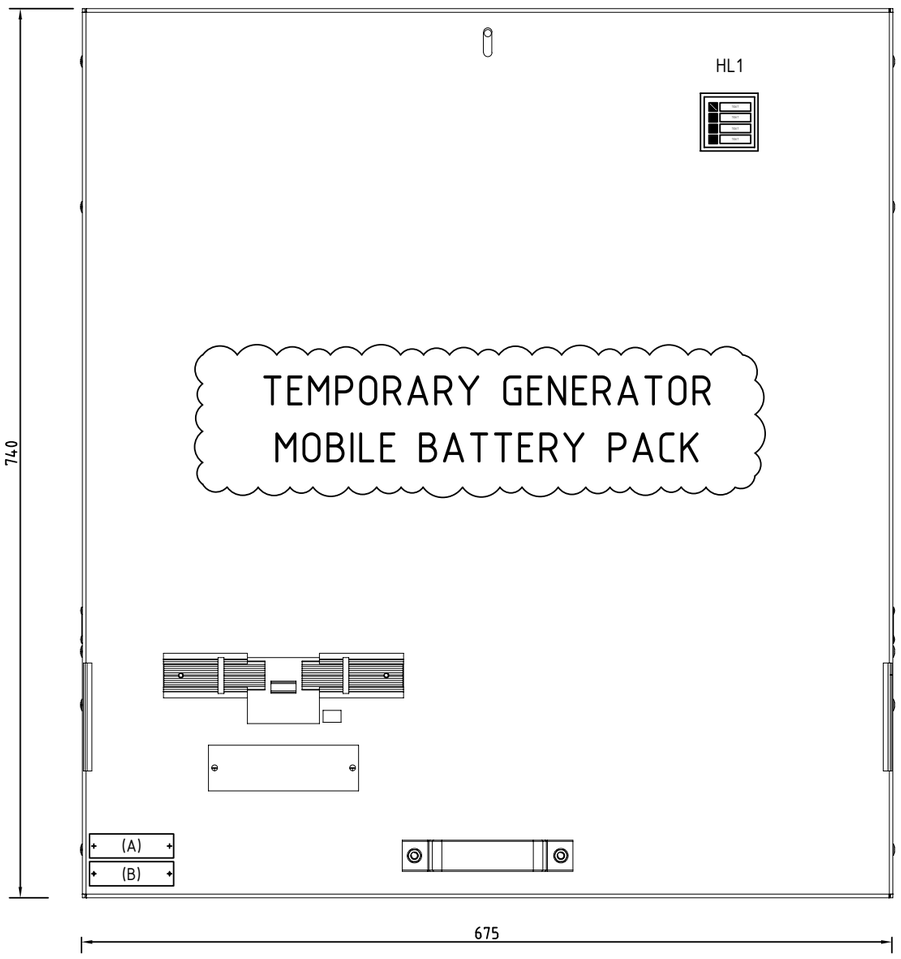
A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 047 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

# DOOR FRONT LAY-OUT

TYPICAL : LINE FEEDER "LE2-320"

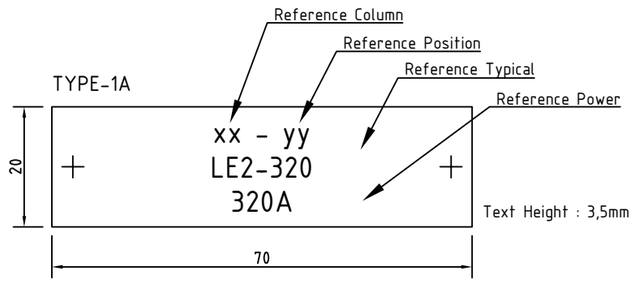


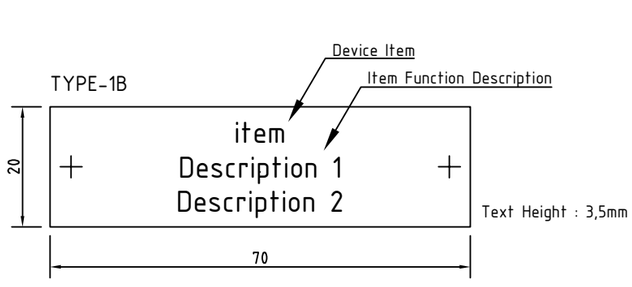

NOTE :

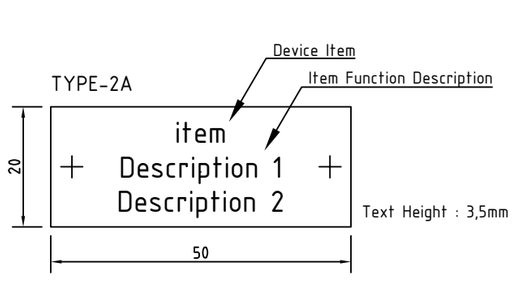
A) IDENTIFICATION name plate (type-1A) , with :
- Drawer position [Column / Position inside SWB]
- Typical name [reference applicability typical used]
- Power [reference applicability typical used]

B) USER name plate (type-1B), with :
- Item User [to see SLD diagrams]
- User Description [to see SLD diagrams]

| DEVICES name plate | | | |
|---|---|---|---|
| ITEM | DESCRIPTION 1 | DESCRIPTION 2 | NOTE |
| QF1 | Circuit Breaker | | NO plate |
| HL1 | Multiled | Signalling | NO plate |




| = | TYPICAL |
|---|---|
| + | LE2-250 |

DWG n° : 231298/SD/31

Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Door Front Lay-Out - Typical "LE2-320"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 048

REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm

# USERS LEGEND

## TYPICAL : LINE FEEDER "LE2-320"

| TYPICAL APPLICABILITY | | | | | |
|---|---|---|---|---|---|
| ITEM | ITEM TAG | DESCRIPTION TAG | REFERENCE POSITION (written on name name plate "type-1A) | REFERENCE POWER (written on name name plate "type-1A) | REFERENCE TYPICAL (written on name name plate "type-1A) |
| 1 | JB-200E2 | TEMPORARY GENERATOR / MOBILE BATTERY PACK | A2 / +08 | 138 kW | LE2-320 |

| | |
|---|---|
| = | TYPICAL |
| + | LE2-250 |
| DWG n° : | 231298/SD/31 |
| Item n° : | PF1002983/26 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Users Legend - Typical "LE2-320"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

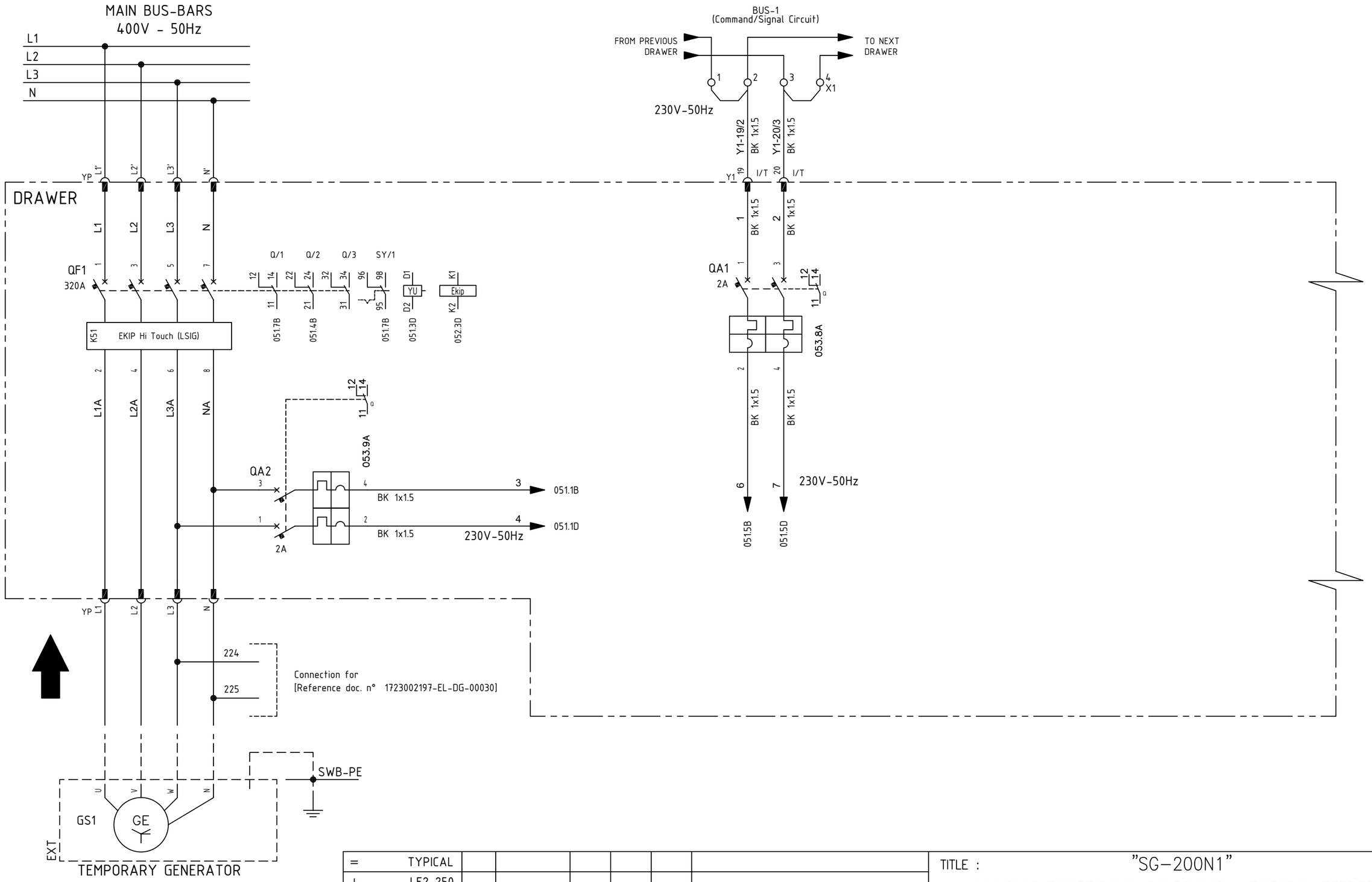
DRAWING NO. 1723002197-EL-DG-00031

SHEET 049

REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | LE2-250 | | | | | | |
| DWG n° : | 231298/SD/31 | | | | | | |
| Item n° : | PF1002983/26 | | | | | | |
| | | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LE2-320"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

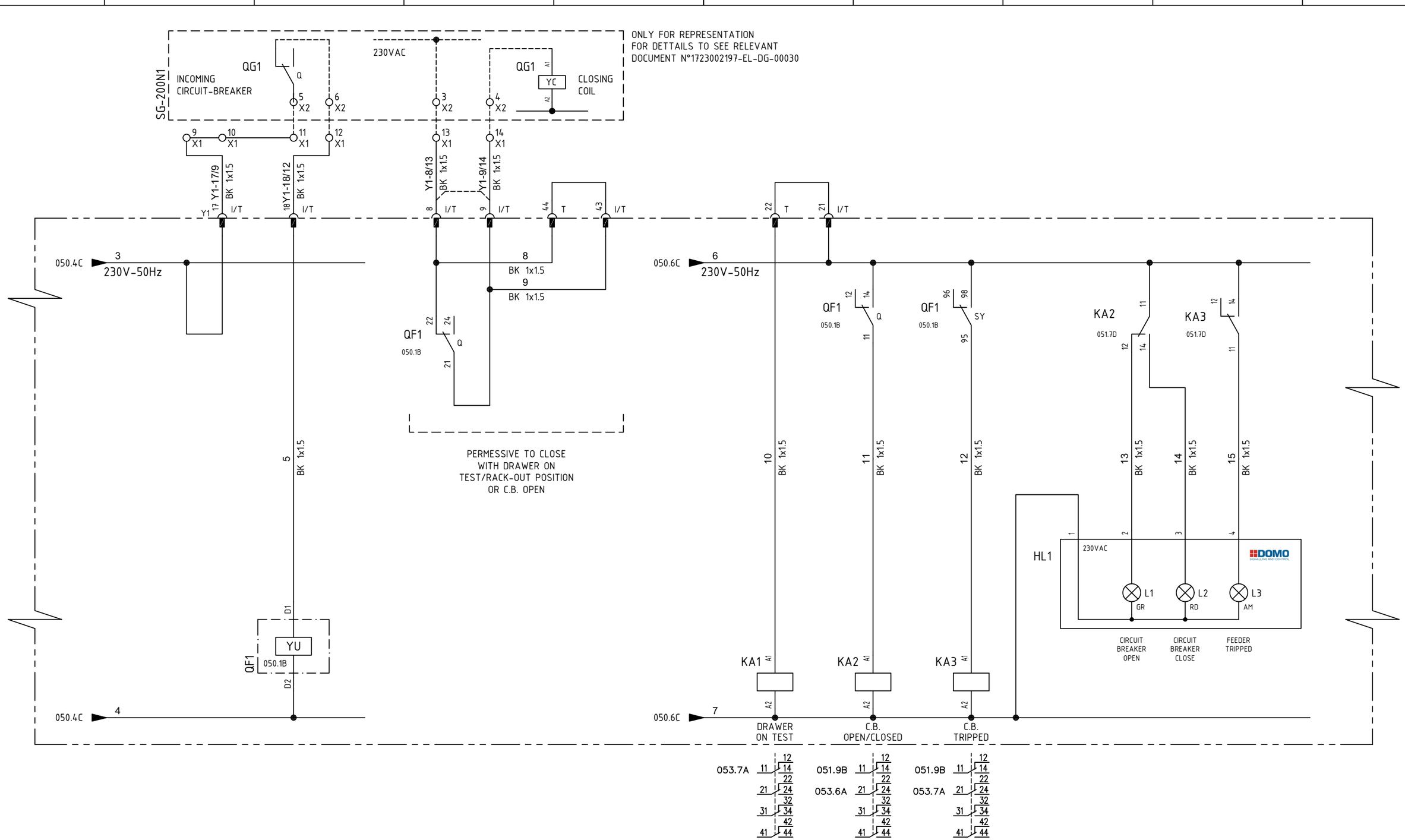
DRAWING NO. 1723002197-EL-DG-00031

SHEET 050

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | LE2-250 | | | | | | |
| DWG n° : | 231298/SD/31 | | | | | | |
| Item n° : | PF1002983/26 | | | | | | |
| | | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LE2-320"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

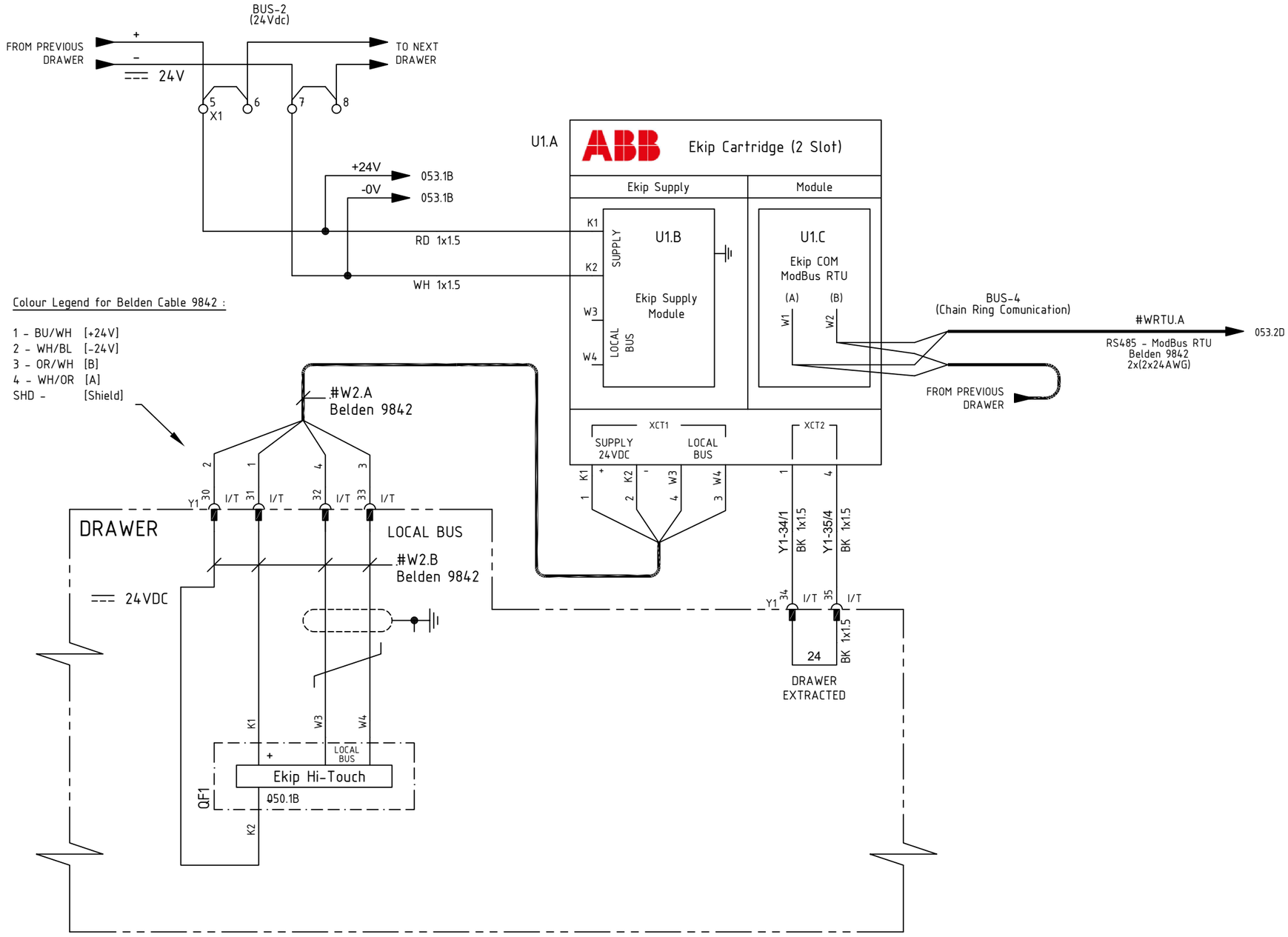
DRAWING NO. 1723002197-EL-DG-00031

SHEET 051

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | LE2-250 | | | | | | |
| DWG n° : | 231298/SD/31 | | | | | | |
| Item n° : | PF1002983/26 | | | | | | |
| | | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LE2-320"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

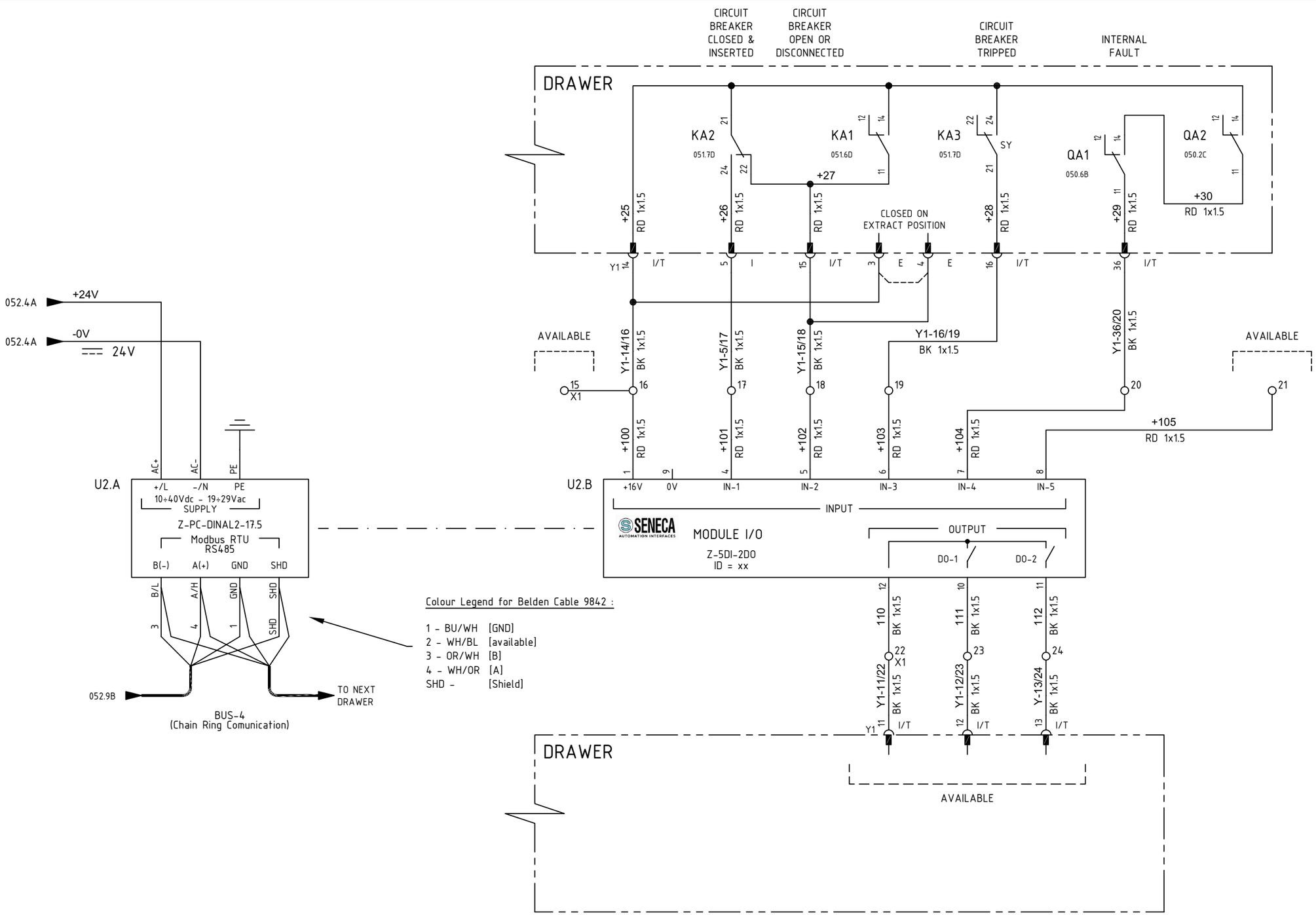
DRAWING NO. 1723002197-EL-DG-00031

SHEET 052

REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | LE2-250 | | | | | | |
| DWG n° : | 231298/SD/31 | | | | | | |
| Item n° : | PF1002983/26 | | | | | | |
| | | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LE2-320"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00031

SHEET 053

REV. 02

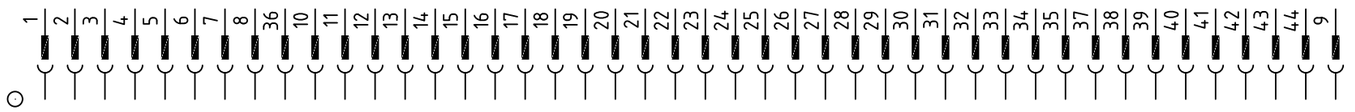
File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm

# TYPICAL - LE2-320 - Y1

AUXILIARY SOCKET
136450/001 (PF – 2 pcs) + 136458/004 (PM – 2 pcs)

| N° PIN | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUMP | | | ● | ● | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RACKED-OUT | | | ✕ | ✕ | | | | ✕ | ✕ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TEST | | | | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| RACKED-IN | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | |
| PIN USED | | | 053.6B | 053.7B | 053.6B | | | 051.4B | 053.8B | | 053.7D | 053.7D | 053.8D | 053.5B | 053.6B | 053.7B | 051.2B | 051.3B | 050.6A | 050.6A | 051.6B | 051.6B | | | | | | | | 052.3C | 052.3C | 052.4C | 052.4C | 052.6C | 052.7C | | | | | | | 051.5B | 051.4B | 051.4B |




← FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN RACKED-OUT POSITION
← FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN TEST POSITION
← FIELD WHIT "X" - CONTACT CLOSE WHEN DRAWER IS IN RACKED-IN POSITION

← CROS-REFERENCE USED PIN

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | TYPICAL | | | | |
| + | LE2-250 | | | | |
| 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/31
Item n° : PF1002983/26

CROSSWIND
IMESA ELECTRICAL ENGINEERING
ROSETTI MARINO

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
Functional Drawing - Typical "LE2-320"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 054 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

TYPICAL - LE2-320

X1

| NumM | Fg. | Sez. | Tipo | Descrizione | Costruttore |
|---|---|---|---|---|---|
| | | | BT003 | BT/3 End bracket | Cabur |
| 1 | 050.5A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 2 | 050.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 3 | 050.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 4 | 050.6A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 5 | 052.3A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 6 | 052.3A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 7 | 052.4A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 8 | 052.4A | 2.5 | HD100GR__ | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| | | | HD101GR | HMD/PT/GR End section - Grey | Cabur |
| 9 | 051.2A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 10 | 051.2A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 11 | 051.3A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 12 | 051.3A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 13 | 051.4A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 14 | 051.4A | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 15 | 053.4B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 16 | 053.5B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 17 | 053.6B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 18 | 053.6B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 19 | 053.7B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 20 | 053.8B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 21 | 053.9B | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 22 | 053.7D | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 23 | 053.7D | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| 24 | 053.8D | 2.5 | HD400GR__ | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur |
| | | | HD201GR | HMD.1/PT/GR End section - Grey | Cabur |
| | | | BT003 | BT/3 End bracket | Cabur |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | TYPICAL | | | | | | |
| + | LE2-250 | | | | | | |
| DWG n° : | 231298/SD/31 | | | | | | |
| Item n° : | PF1002983/26 | 2 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| | | 1 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| | | 0 | 09/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| | | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200N1"

LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS

Functional Drawing - Typical "LE2-320"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 055 | REV. 02

File Name : 1723002197-EL-DG-00031 Rev. 02

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.ta/Q.ty | Descrizione/Description | Costruttore/Manufacturer | Quadro (descrizione) |
|---|---|---|---|---|---|---|
| GS1 | 050 | | 1 | Generatore sincrono trifase indotto collegato a stella e neutro accessibile | | TYPICAL LE2-320 |
| HL1 | 051 | ML22/483L230STLTTR | 1 | MULTILED 48x48 - 3 LED - Vaux=230Vac/dc + LAMP TEST + TROP | DOMO | TYPICAL LE2-320 |
| KA1 | 051 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | TYPICAL LE2-320 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | TYPICAL LE2-320 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | TYPICAL LE2-320 |
| KA2 | 051 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | TYPICAL LE2-320 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | TYPICAL LE2-320 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | TYPICAL LE2-320 |
| KA3 | 051 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | TYPICAL LE2-320 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | TYPICAL LE2-320 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | TYPICAL LE2-320 |
| QA1 | 050 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | TYPICAL LE2-320 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | TYPICAL LE2-320 |
| QA2 | 050 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | TYPICAL LE2-320 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | TYPICAL LE2-320 |
| QF1 | 050 | 1SDA100556R1 | 1 | XT5S 400 BREAKING PART 4p F F | ABB | TYPICAL LE2-320 |
| | | 1SDA100692R1 | 1 | ELECTRONIC TRIP RELEASE Ekip Hi-Touch LSIG In=320A XT5 4p | ABB | TYPICAL LE2-320 |
| | | 1SDA066434R1 | 1 | AUX-C 3Q+1SY 250Vac/dc XT2..XT6 F/P | ABB | TYPICAL LE2-320 |
| | | 1SDA104958R1 | 1 | YU-C XT5 F/R 220-240Vac-220-250Vdc | ABB | TYPICAL LE2-320 |
| U1.2 | 052 | 1SDA074173R1 | 1 | MODUL EKIP SUPPLY 24÷48VDC | ABB | TYPICAL LE2-320 |
| U1.3 | 052 | 1SDA105166R1 | 1 | Module Ekip Com Modbus RS485 Tmax XT | ABB | TYPICAL LE2-320 |
| U1.A | 052 | 1SDA105203R1 | 1 | EKIP CARTRIDGE 2SLOT FOR XT2-XT4-XT5 | ABB | TYPICAL LE2-320 |
| U2.A | 053 | Z-PC-DINAL2-17.5 | 1 | DIN RAIL 2SLOT WITH HEAD FOR "Z-5DI-2DO" | SENECA | TYPICAL LE2-320 |
| U2.B | 053 | Z-5DI-2DO | 1 | I/O MODUL 5DI+2DO modbus RS485 Vaux=10÷40Vdc 19÷28Vac | SENECA | TYPICAL LE2-320 |
| X1 | | HD100GR_ | 8 | HMD.2/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur | TYPICAL LE2-320 |
| | | HD400GR_ | 16 | HMD.2N/GR Two-level feed-through Terminal Block - Grey (2.5 mmq) - Spring type | Cabur | TYPICAL LE2-320 |
| | | BT003 | 2 | BT/3 End bracket | Cabur | TYPICAL LE2-320 |
| | | HD101GR | 1 | HMD/PT/GR End section - Grey | Cabur | TYPICAL LE2-320 |
| | | HD201GR | 1 | HMD.1/PT/GR End section - Grey | Cabur | TYPICAL LE2-320 |

= TYPICAL
+ LE2-250
DWG n° : 231298/SD/31
Item n° : PF1002983/26

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE : "SG-200N1"
LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS
Functional Drawing - Typical "LE2-320"

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00031 | SHEET 056 | REV. 02

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00031 Rev. 02

1.4.11. SG-200D2 FUNCTIONAL DIAGRAM,

Doc. No. 1723002197-EL-DG-00032

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# BASE LOAD POWER HUB (BLPH)

# "SG-200D2" LV SWBD 800V

# ELECTRICAL FUNCTIONAL DIAGRAM

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Maeule | 23/09/2024 |

IMESA ELECTRICAL ENGINEERING

DWG n°: 231298/SD/32

Item n°: PF1002669/3

CROSSWIND

ROSETTI MARINO

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
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TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

SHEET 001

REV. 03

File Name : 1723002197-EL-DG-00032 Rev. 03

F.to UNI A3: 420mmx297mm

# INDEX SHEETS

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 001 | Cover | X | X | X | X | | | | | | |
| 002 | Index | X | X | X | X | | | | | | |
| 003 | Graphical Symbols | X | X | X | X | | | | | | |
| 004 | Graphical Symbols | X | X | X | X | | | | | | |
| 005 | Door Layout | X | X | X | X | | | | | | |
| 006 | Selector Switch Diagram | X | X | X | X | | | | | | |
| 007 | Functional Drawing | X | X | X | X | | | | | | |
| 008 | Functional Drawing | X | X | X | X | | | | | | |
| 009 | Functional Drawing | X | X | X | X | | | | | | |
| 010 | Functional Drawing | X | X | X | X | | | | | | |
| 011 | Functional Drawing | X | X | X | X | | | | | | |
| 012 | Functional Drawing | X | X | X | X | | | | | | |
| 013 | Functional Drawing | X | X | X | X | | | | | | |
| 014 | Functional Drawing | X | X | X | X | | | | | | |
| 015 | Functional Drawing | X | X | X | X | | | | | | |
| 016 | Functional Drawing | X | X | X | X | | | | | | |
| 017 | Functional Drawing | X | X | X | X | | | | | | |
| 018 | Functional Drawing | X | X | X | X | | | | | | |
| 019 | Functional Drawing | X | X | X | X | | | | | | |
| 020 | Functional Drawing | X | X | X | X | | | | | | |
| 021 | Terminal Block | X | X | X | X | | | | | | |
| 022 | Bill of Materials | X | X | X | X | | | | | | |
| 023 | Bill of Materials | X | X | X | X | | | | | | |
| 024 | Bill of Materials | X | X | X | X | | | | | | |
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| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/32

Item n° : PF1002669/3

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

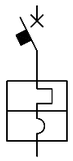
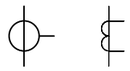
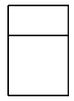
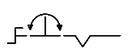
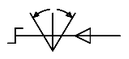
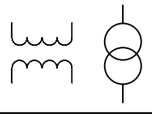
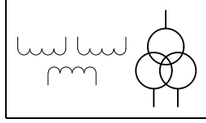
DRAWING NO. 1723002197-EL-DG-00032

SHEET 002

REV. 03

File Name : 1723002197-EL-DG-00032 Rev. 03

F.to UNI A3: 420mmx297mm

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|  | **CIRCUIT BREAKER WITH AUTOMATIC RELEASE** |  | **CAPACITOR (GENERAL SYMBOL)** |  | **BISTABLE RELAY** |  | **CHANGE-OVER BREAK BEFORE MAKE CONTACT** |
|  | **CIRCUIT BREAKER WITH AUTOMATIC RELEASE AND BUILT-IN THERMOMAGNETIC RELEASE** |  | **CAPACITIVE VOLTAGE DIVIDER** |  | **COIL OF A MECHANICALLY LATCHED RELAY** |  | **DELAYED ACTION (IN THE DIRECTION OF MOVEMENT FROM THE ARC TOWARDS ITS CENTRE)** |
| | |  | **CURRENT TRANSFORMER** |  | **INDICATOR, ELECTROMECHANICAL ELEMENT** |  | POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT |
|  | **SWITCH DISCONNECTOR** |  | RING CURRENT TRANSFORMER |  | **LAMP (GENERAL SYMBOL)** |  | **POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT** |
|  | **CONTACTOR** |  | **INDICATING INSTRUMENT GENERAL SYMBOL** |  | **SEMICONDUCTOR DIODE** |  | POSITION SWITCH (LIMIT SWITCH), BREAK CONTACT |
|  | **LOCK WITH FREE KEY WHEN THE DEVICE IS IN OPEN POSITION** |  | **INTEGRATING INSTRUMENT (GENERAL SYMBOL)** |  | **LED** |  | **OPERATED BY TURNING** |
|  | **LOCK WITH FREE KEY WHEN THE DEVICE IS IN CLOSE POSITION** |  | **DISCONNECTING FUSE, NOT WITH LIVE CIRCUIT AND WITH MECHANICAL LINKAGE (STRIKER FUSE))** |   | **TRANSDUCER OF ALTERNATING CURRENT MEASURE INTO DIRECT CURRENT SIGNAL** |  | **THREE HELD POSITIONS TURNING SWITCH** |
|  | **PLUG AND SOCKET (MALE AND FEMALE)** |  | **OPERATING DEVICE (GENERAL SYMBOL)** |  | **EARTH, GROUND (GENERAL SYMBOL)** |  | **THREE POSITIONS TURNING SWITCH, WITH SPRING THROWBACK TO THE CENTRAL POSITION** |
|  | **VOLTAGE TRANSFORMER WITH TWO WINDINGS** |  | **COIL OF A TIME DELAYED OPERATING RELAY** |  | **MAKE CONTACT** |  | MECHANICAL INTERLOCK BETWEEN TWO DEVICES |
|  | **VOLTAGE TRANSFORMER WITH THREE WINDINGS** |  | **COIL OF A TIME DELAYED RELEASING RELAY** |  | **BREAK CONTACT** | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n°: 231298/SD/32

Item n°: PF1002669/3

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

SHEET 003

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00032 Rev. 03

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | RESISTOR (GENERAL SYMBOL) | | AMPEROMETRIC TEST SOCKET | | | | |
| | THERMISTOR (GENERAL SYMBOL) | | 3 PHASES LINE | | | | |
| | HEATING ELEMENT | | | | | | |
| | INTERCONNECTION TERMINAL | | | | | | |
| | WITHDRAWABLE TERMINAL SHORT-CIRCUITABLE ON C.T. SECONDARY CIRCUITS | | | | | | |
| | WITHDRAWABLE TERMINAL FOR V.T. SECONDARY CIRCUITS | | | | | | |
| | SWITCHBOARD TERMINAL | | | | | | |
| | ON - OFF SWITCH | | | | | | |
| | SURGE ARRESTER | | | | | | |
| | VOLTMETRIC TEST SOCKET | | | | | | |

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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/32

Item n° : PF1002669/3

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

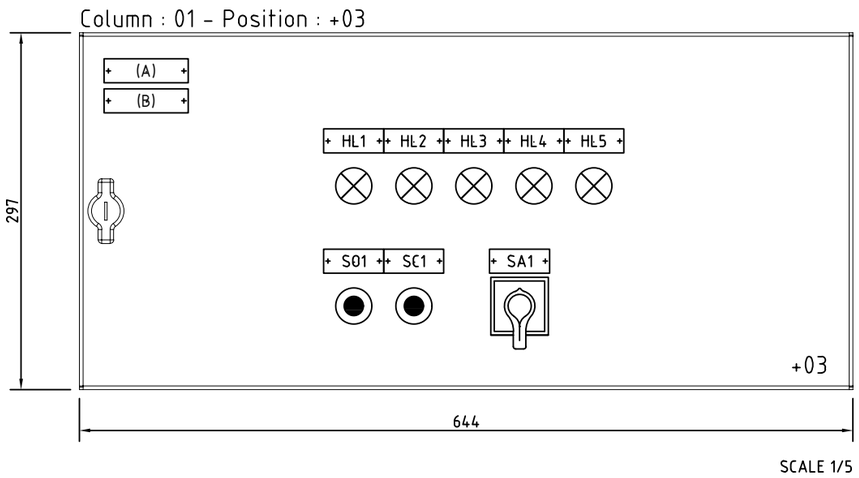
SHEET 004

REV. 03

F.to UNI A3: 420mmx297mm

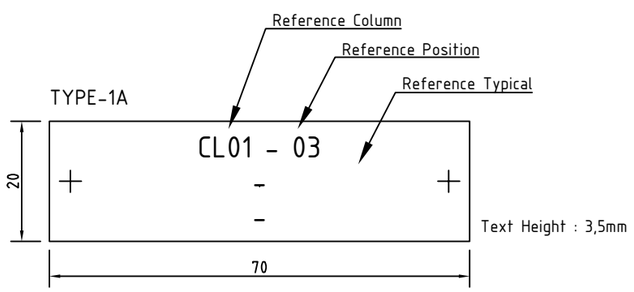
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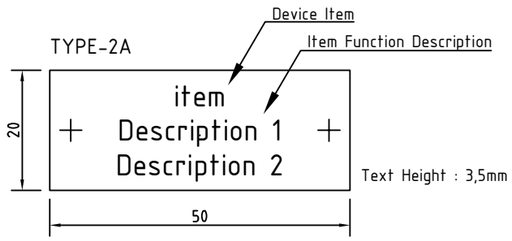
# DOOR LAYOUT




SCALE 1/5

| DEVICES name plate | | | | |
|---|---|---|---|---|
| ITEM | COMPONENT | DESCRIPTION 1 | DESCRIPTION 2 | NOTE |
| HL1 | PILOT LIGHT | QB1 - CIRCUIT BREAKER | CLOSED | TYPE-2A |
| HL2 | PILOT LIGHT | QB1 - CIRCUIT BREAKER | OPENED | TYPE-2A |
| HL3 | PILOT LIGHT | QB1 - CIRCUIT BREAKER | TRIPPED | TYPE-2A |
| HL4 | PILOT LIGHT | QB2 - CIRCUIT BREAKER | OPENED | TYPE-2A |
| HL5 | PILOT LIGHT | QB2 - CIRCUIT BREAKER | CLOSED | TYPE-2A |
| S01 | PUSH BUTTON | QB1 - CIRCUIT BREAKER | OPENING COMMAND | TYPE-2A |
| SC1 | PUSH BUTTON | QB1 - CIRCUIT BREAKER | CLOSING COMMAND | TYPE-2A |
| SA1 | SELECTOR SWITCH | SELECTOR | LOCAL / REMOTE | TYPE-2A |




NOTE :

A) IDENTIFICATION name plate (type-1A) , with :
- Drawer position [Column / Position inside SWB]
- Typical name [reference applicability typical used, where applicable]

B) USER name plate (type-1B), with :
- Item User [to see SLD diagrams, where applicable]
- User Description [to see SLD diagrams, where applicable]

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/32

Item n° : PF1002669/3

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Door Layout

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

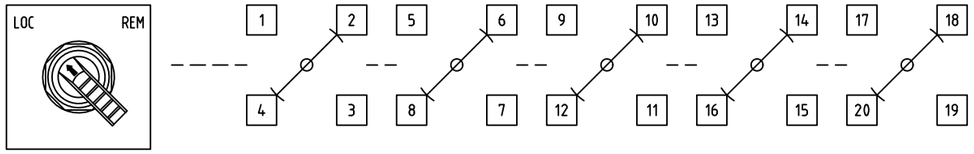
SHEET 005

REV. 03

F.to UNI A3: 420mmx297mm

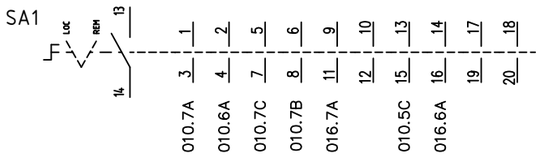
File Name : 1723002197-EL-DG-00032 Rev. 03

# SELECTORS SWITCH DIAGRAM




Control Mode Switch

NOTE:
1. Square plate
2. Fixed position




## NOTES

THE DIAGRAM INDICATES THE FOLLOWING CONDITIONS:

- INSERTED CIRCUIT BREAKER IN OPEN POSITION
- DE-ENERGIZED CIRCUITS
- DSCHARGED CLOSING SPRINGS

THE AUXILIARY CIRCUITS WILL HAVE THE FOLLOWING CHARACTERISTICS:

- 24+ 1,5mmq RED TYPE CABLE SH-W
- 24- 1,5mmq WHITE TYPE CABLE SH-W
- AUXILIARY CONTACTS TO TERMINAL STRIP 1,5mmq BLACK TYPE CABLE SH-W
- 230Vac 1,5mmq BLACK TYPE SH-W
- VOLTMETRICAL CIRCUITS 1,5mmq BLACK TYPE CABLE SH-W
- AMMETRICAL CIRCUIT 2,5mmq BLACK TYPE CABLE SH-W

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n°: 231298/SD/32

Item n°: PF1002669/3

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 22/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Selector Switch Diagram

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

SHEET 006

REV. 03

File Name : 1723002197-EL-DG-00032 Rev. 03

F.to UNI A3: 420mmx297mm

# POWER DISTRIBUTION

800V - 50Hz - 630A - 30kA x 1s

L1 008.1A
L2 008.1A
L3 008.1A

Emax E1

| | | | INSERTED | TEST | ISOLATED |
|---|---|---|---|---|---|
| S75E | 101-102 / 101-104 | 111-112 / 111-114 | X | X | X |
| S75T | 121-122 / 121-124 | 131-132 / 131-134 | X | X | X |
| S75I | 141-142 / 141-144 | 151-152 / 151-154 | X | X | X |

S75E/1 S75E/2 S75T/1 S75T/2 S75I/1 S75I/2
102 104 112 114 122 124 132 134 144 142 154 152
101 111 121 131 141 151
011.7A 016.2A 011.6A 010.6B 010.7D 011.6A

QB1
1250A
(1)
K51 Ekip Hi-Touch
Q/1 Q/2 Q/3 Q/4 S51 S33M
12 14 22 24 32 34 42 44 96 98 U1 36 38 C11 C13 C1 C3
11 21 31 41 95 U2 35 Y0 C12 YC C2
011.2A 020.2D 011.5A 020.3B 011.3A 008.4C 010.4C 010.6C

Electrical/Mechanical interlock

S75E/1 S75E/2 S75T/1 S75T/2 S75I/1 S75I/2
102 104 112 114 122 124 132 134 144 142 154 152
101 111 121 131 141 151
016.4A 010.9B 016.5A

QB2
1250A
(1)
K51 Ekip Touch
Q/1 Q/2 Q/3 Q/4
12 14 22 24 32 34 42 44
11 21 31 41
010.8B 020.5D 011.8A 012.2A

NOTE:
All function protection will be sett in OFF

FU1 1 2 L1S BN 1x16
FU2 1 2 L2S BK 1x16
FU3 1 2 L3S GY 1x16
35A-gG

F1 F2 F3 F4
L N/PE
12 14 11
017.4A 017.4A 017.5A
PE GNYE 1x16 017.6A

SFL1 SFL2 SFL3
INCOMING FROM SOLAR FARM

L1 L2 L3
OUTGOING

(1) KEY LOCK FOR OPEN POSITION (CIRCUIT-BREAKER)

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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DWG n°: 231298/SD/32
Item n°: PF1002669/3

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

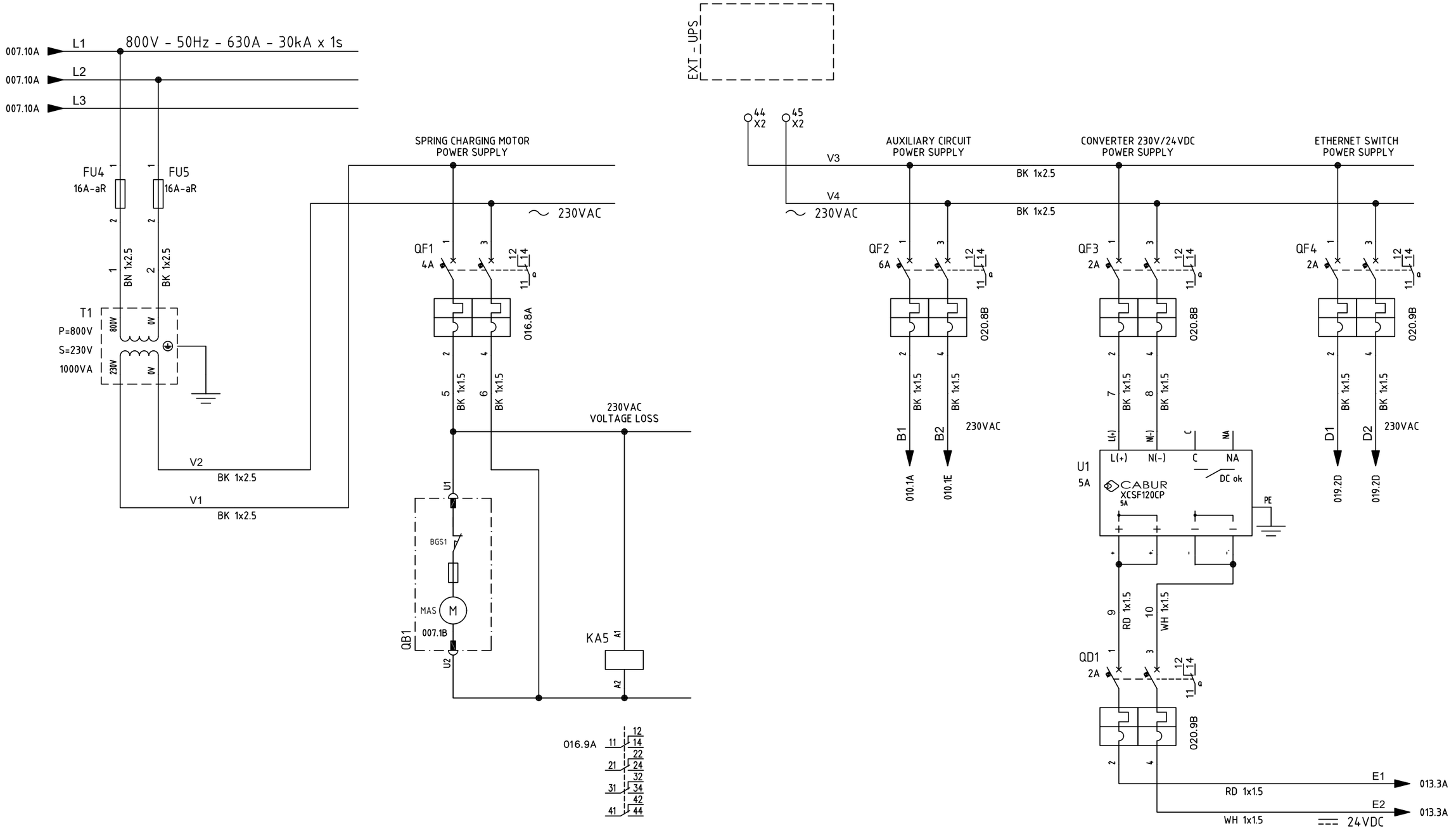
TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS
A3
DRAWING NO. 1723002197-EL-DG-00032
SHEET 007
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00032 Rev. 03

# SUPPLY AUXILIARY CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/32

Item n° : PF1002669/3

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

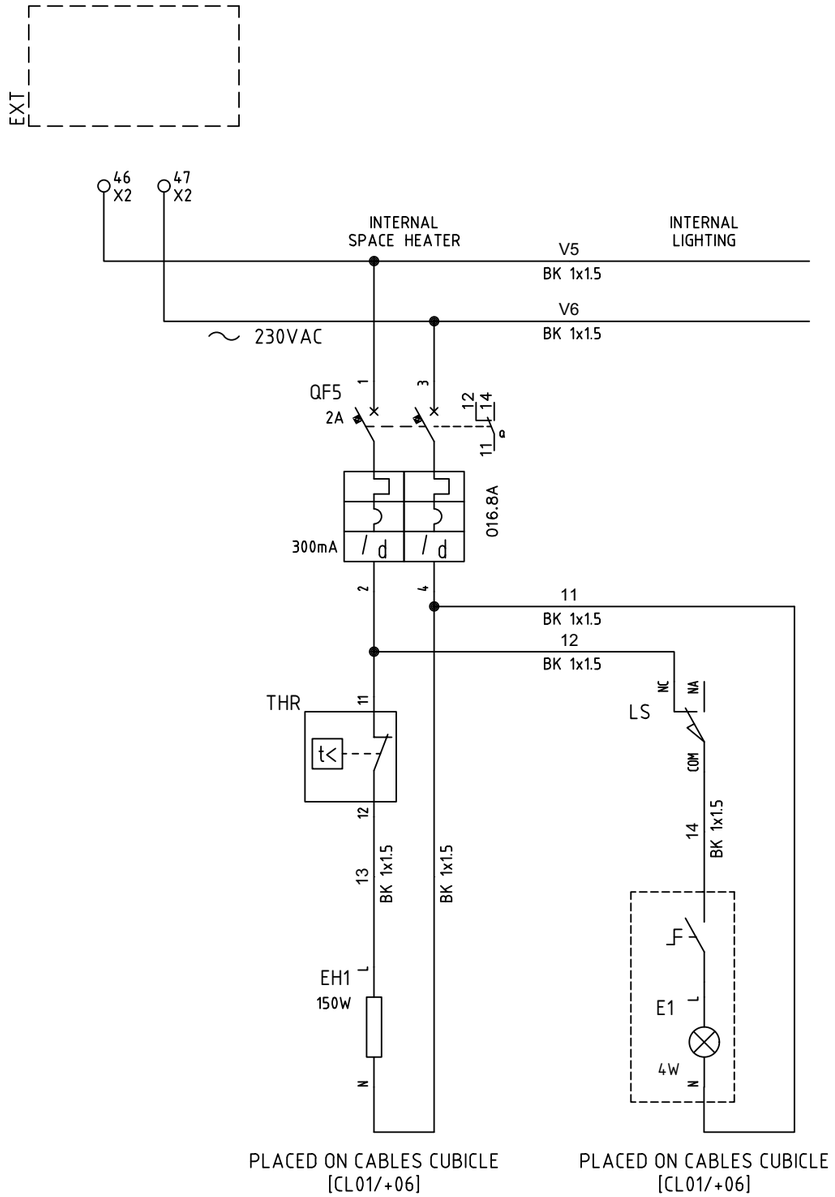
SHEET 008

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00032 Rev. 03

# SUPPLY AUXILIARY CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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DWG n° : 231298/SD/32
Item n° : PF1002669/3

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

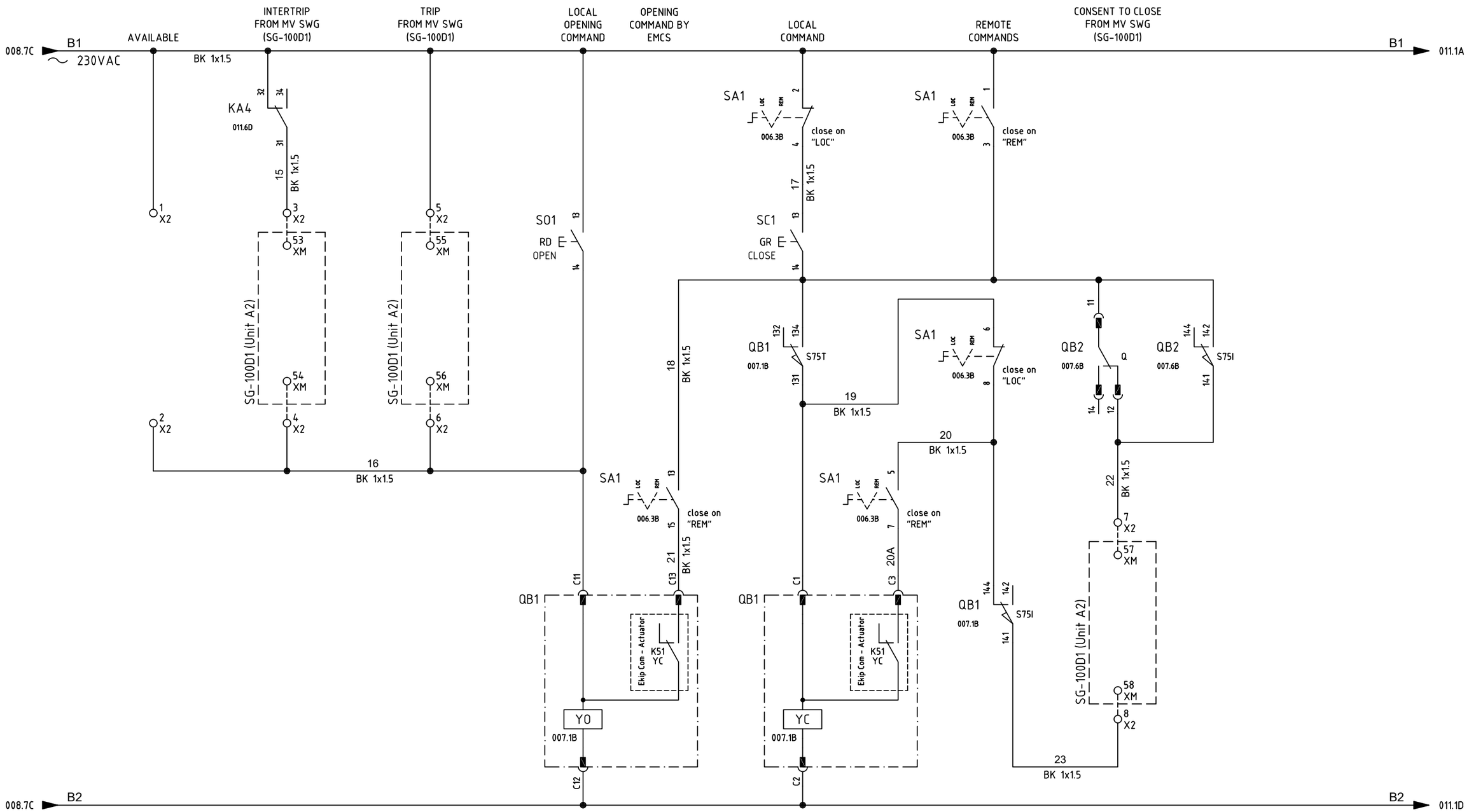
SHEET 009

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00032 Rev. 03

# "QB1" CIRCUIT BREAKER - COMMAND CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n°: 231298/SD/32
Item n°: PF1002669/3

TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

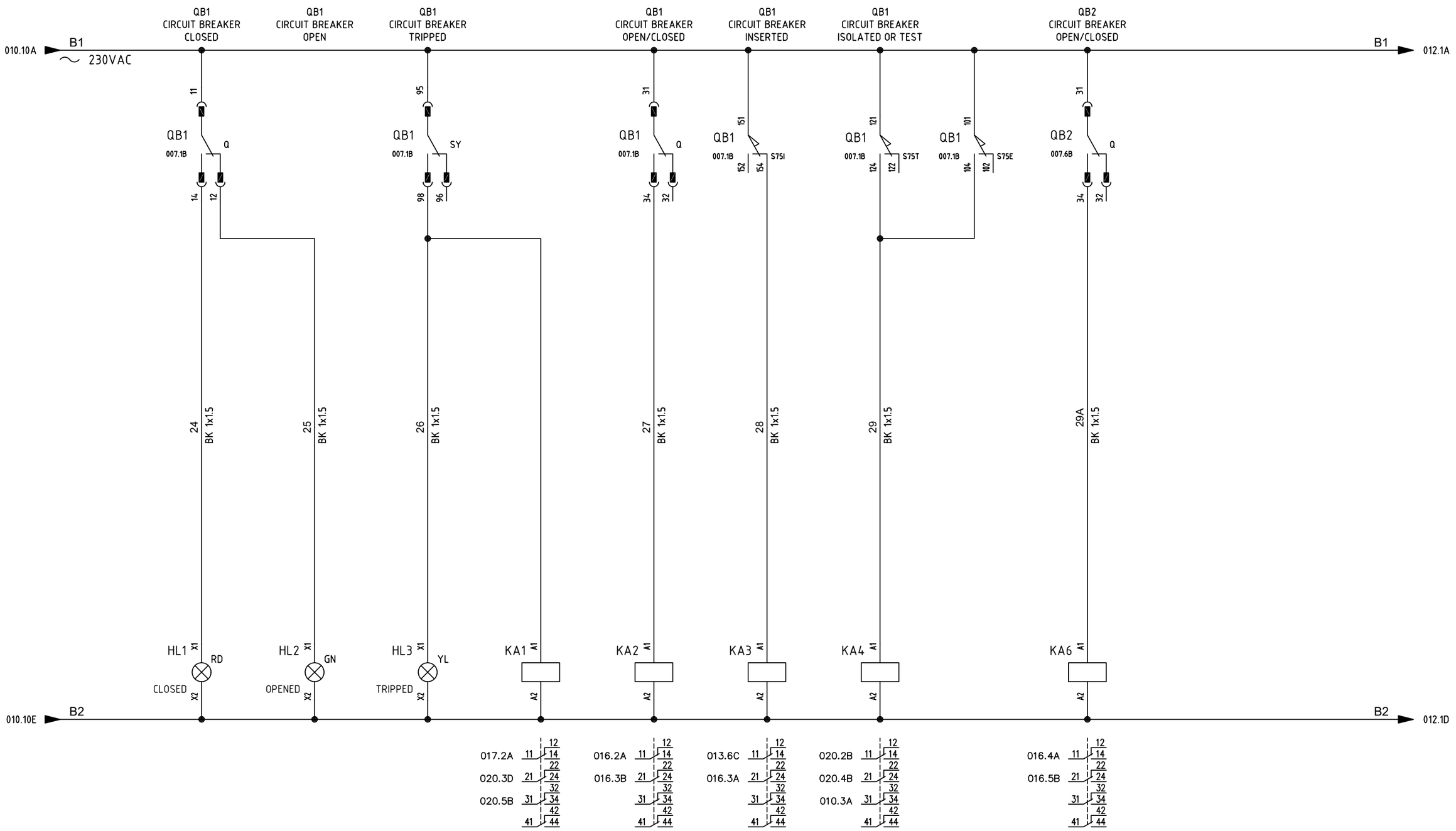
SHEET 010

REV. 03

File Name : 1723002197-EL-DG-00032 Rev. 03

F.to UNI A3: 420mmx297mm

# "QB1" CIRCUIT BREAKER - SIGNALLING CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 22/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n°: 231298/SD/32
Item n°: PF1002669/3

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

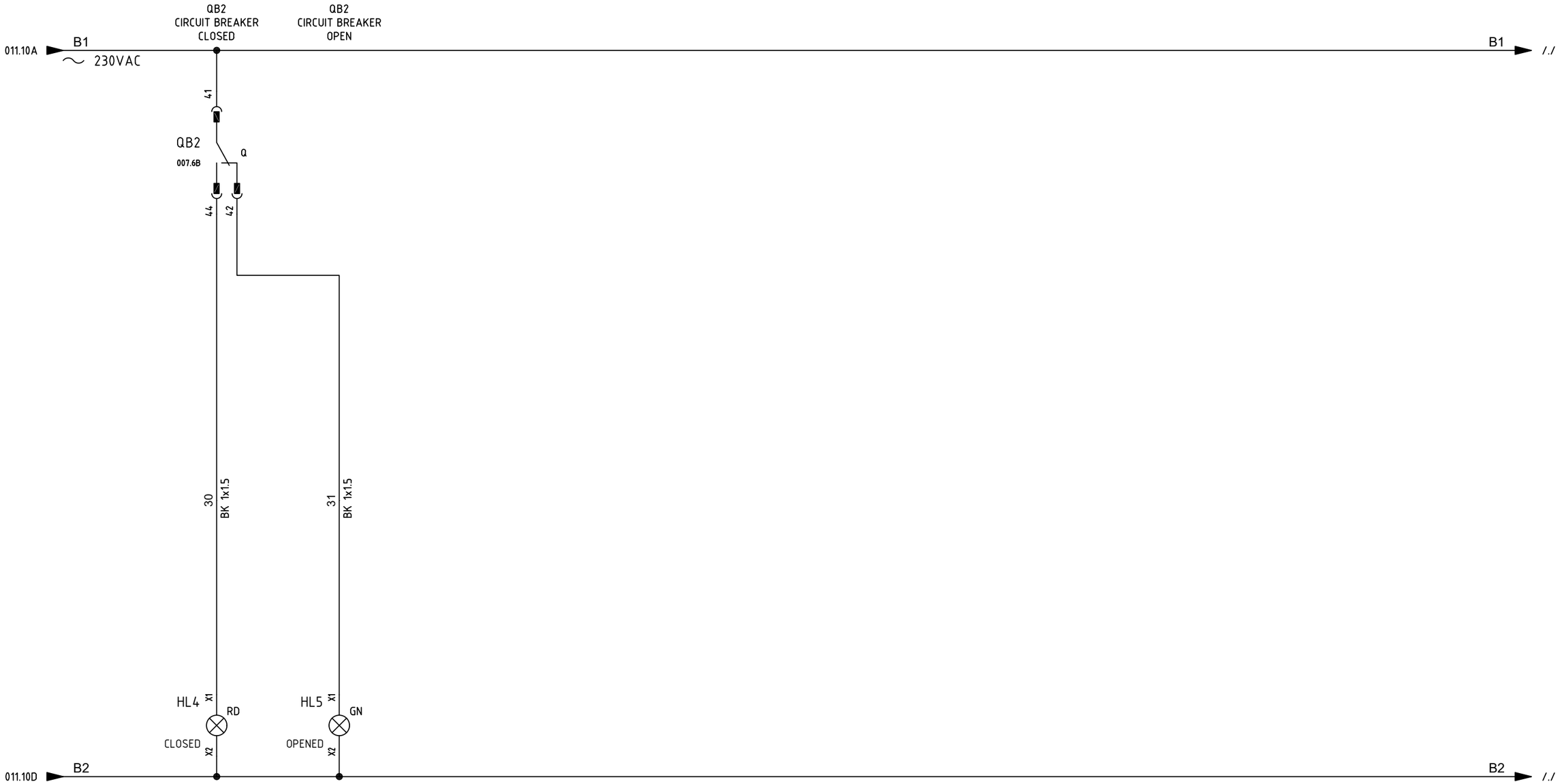
SHEET 011

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00032 Rev. 03

# "QB2" CIRCUIT BREAKER - SIGNALLING CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n°: 231298/SD/32
Item n°: PF1002669/3

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

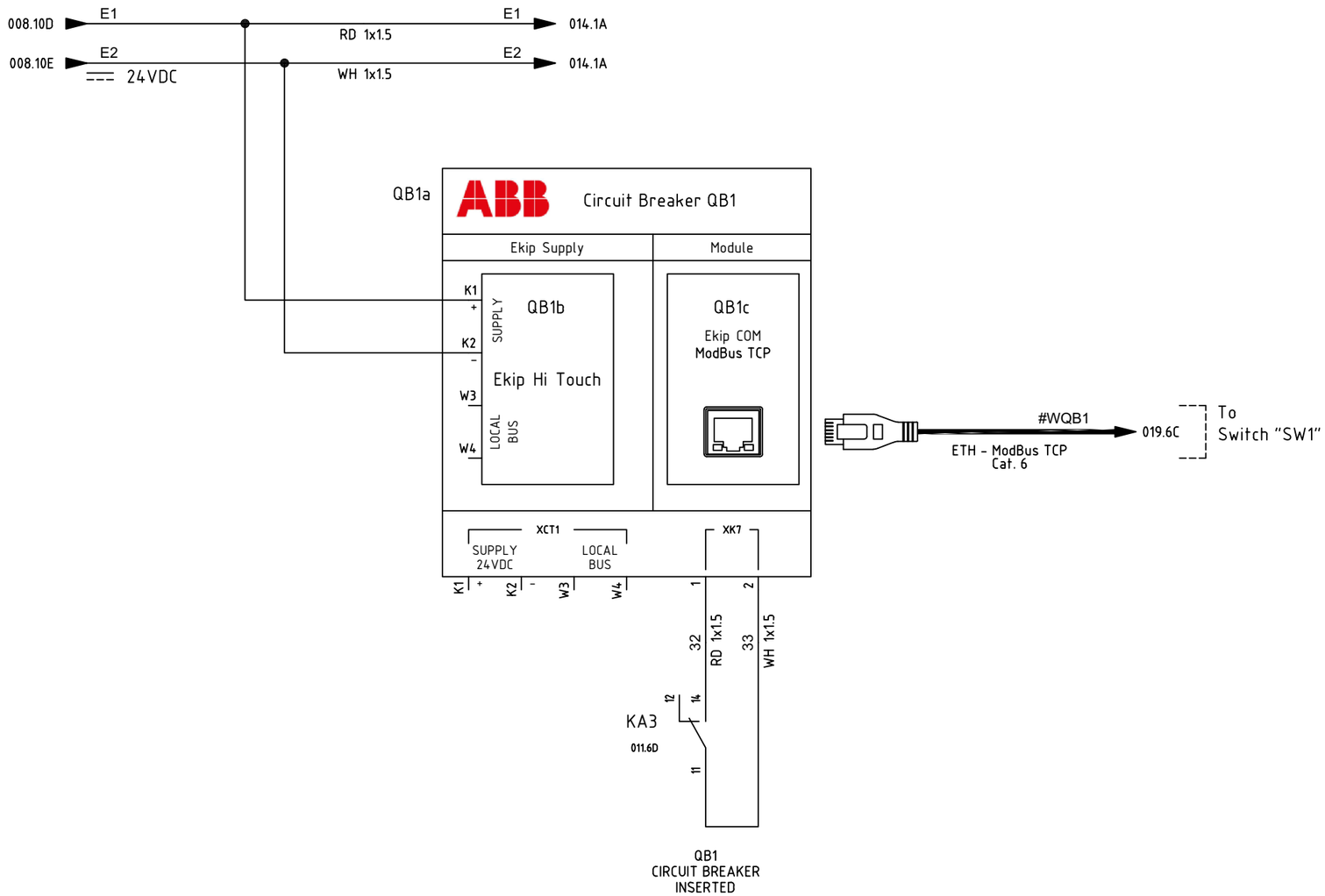
SHEET 012

REV. 03

File Name : 1723002197-EL-DG-00032 Rev. 03

F.to UNI A3: 420mmx297mm

# "QB1" CIRCUIT BREAKER - COMUNICATION CIRCUITS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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| 1 | 22/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/32
Item n° : PF1002669/3

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

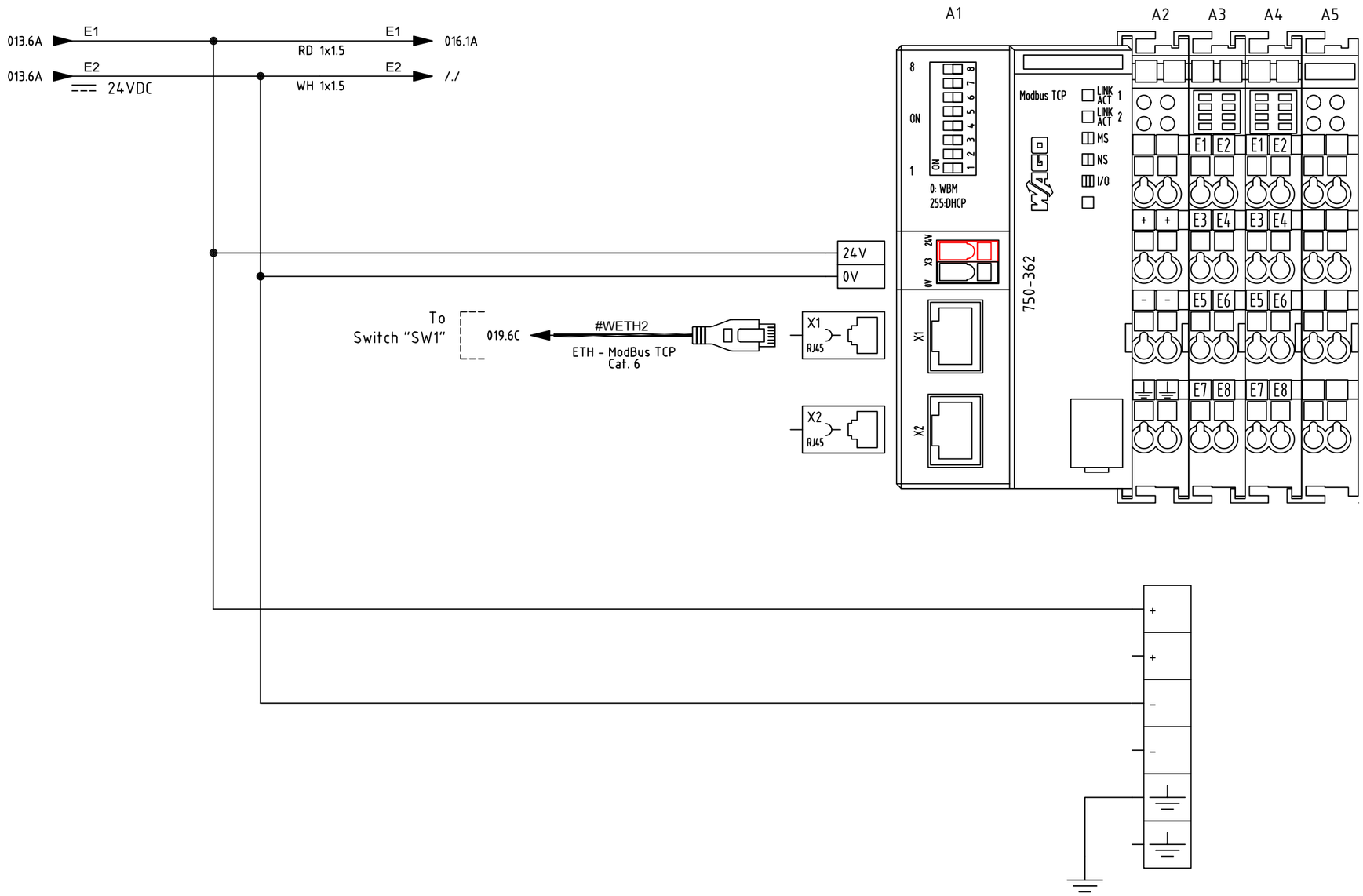
SHEET 013

REV. 03

File Name : 1723002197-EL-DG-00032 Rev. 03

F.to UNI A3: 420mmx297mm

# MODULE I/O CONNECTION




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

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DWG n° : 231298/SD/32

Item n° : PF1002669/3

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

SHEET 014

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00032 Rev. 03

# MODULE I/O CONNECTION

| Quadro: SG-200D2 | Gruppo Funzione: | Sigla: A3 | | | | | |
|---|---|---|---|---|---|---|---|
| CPU: SG-200D2 | Rack: A1 | Slot: 2 | | | | | |
| Pin | Descrizione Pin | Indirizzo | Commento1 | Commento2 | Commento3 | Commento4 | Foglio |
| 1 [E1] | DI 1 | E0.0 | SG-200D2 | QB1 | DISCONNECTED | OR OPEN | 016 |
| 5 [E2] | DI 2 | E0.1 | SG-200D2 | QB1 | CONNECTED | AND CLOSED | 016 |
| 2 [E3] | DI 3 | E0.2 | SG-200D2 | QB2 | DISCONNECTED | OR OPEN | 016 |
| 6 [E4] | DI 4 | E0.3 | SG-200D2 | QB2 | CONNECTED | AND CLOSED | 016 |
| 3 [E5] | DI 5 | E0.4 | SG-200D2 | SA1 | ON LOCAL | POSITION | 016 |
| 7 [E6] | DI 6 | E0.5 | SG-200D2 | SA1 | ON REMOTE | POSITION | 016 |
| 4 [E7] | DI 7 | E0.6 | SG-200D2 | MCBs/VOLTAGE LOSS | ALARM | | 016 |
| 8 [E8] | DI 8 | E0.7 | SG-200D2 | COMMUN | FAILURE | | 017 |

| Quadro: SG-200D2 | Gruppo Funzione: | Sigla: A4 | | | | | |
|---|---|---|---|---|---|---|---|
| CPU: SG-200D2 | Rack: A1 | Slot: 3 | | | | | |
| Pin | Descrizione Pin | Indirizzo | Commento1 | Commento2 | Commento3 | Commento4 | Foglio |
| 1 [E1] | DI 1 | E1.0 | SG-200D2 | SURGE ARRESTER | FAULT | | 017 |
| 5 [E2] | DI 2 | E1.1 | SG-200N1 | MCBs | CLOSED | | 017 |
| 2 [E3] | DI 3 | E1.2 | | AVAILABLE | | | 017 |
| 6 [E4] | DI 4 | E1.3 | | AVAILABLE | | | 017 |
| 3 [E5] | DI 5 | E1.4 | | AVAILABLE | | | 017 |
| 7 [E6] | DI 6 | E1.5 | | AVAILABLE | | | 018 |
| 4 [E7] | DI 7 | E1.6 | | AVAILABLE | | | 018 |
| 8 [E8] | DI 8 | E1.7 | | AVAILABLE | | | 018 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/32

Item n° : PF1002669/3

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

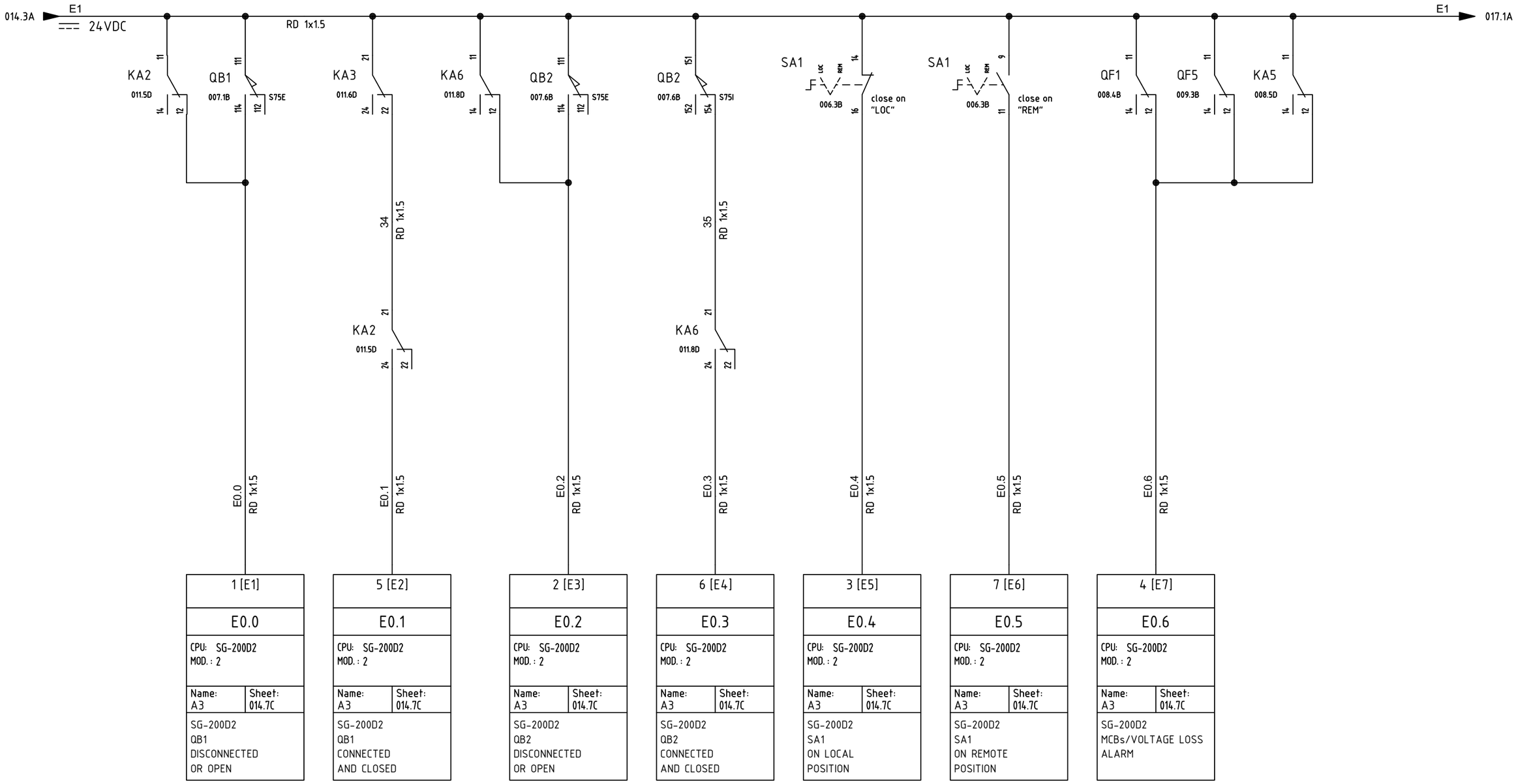
SHEET 015

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00032 Rev. 03

# MODULE I/O CONNECTION




| 1 [E1] | 5 [E2] | 2 [E3] | 6 [E4] | 3 [E5] | 7 [E6] | 4 [E7] |
|---|---|---|---|---|---|---|
| E0.0 | E0.1 | E0.2 | E0.3 | E0.4 | E0.5 | E0.6 |
| CPU: SG-200D2<br>MOD. : 2 | CPU: SG-200D2<br>MOD. : 2 | CPU: SG-200D2<br>MOD. : 2 | CPU: SG-200D2<br>MOD. : 2 | CPU: SG-200D2<br>MOD. : 2 | CPU: SG-200D2<br>MOD. : 2 | CPU: SG-200D2<br>MOD. : 2 |
| Name: A3 / Sheet: 014.7C | Name: A3 / Sheet: 014.7C | Name: A3 / Sheet: 014.7C | Name: A3 / Sheet: 014.7C | Name: A3 / Sheet: 014.7C | Name: A3 / Sheet: 014.7C | Name: A3 / Sheet: 014.7C |
| SG-200D2<br>QB1<br>DISCONNECTED<br>OR OPEN | SG-200D2<br>QB1<br>CONNECTED<br>AND CLOSED | SG-200D2<br>QB2<br>DISCONNECTED<br>OR OPEN | SG-200D2<br>QB2<br>CONNECTED<br>AND CLOSED | SG-200D2<br>SA1<br>ON LOCAL<br>POSITION | SG-200D2<br>SA1<br>ON REMOTE<br>POSITION | SG-200D2<br>MCBs/VOLTAGE LOSS<br>ALARM |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/32

Item n° : PF1002669/3

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

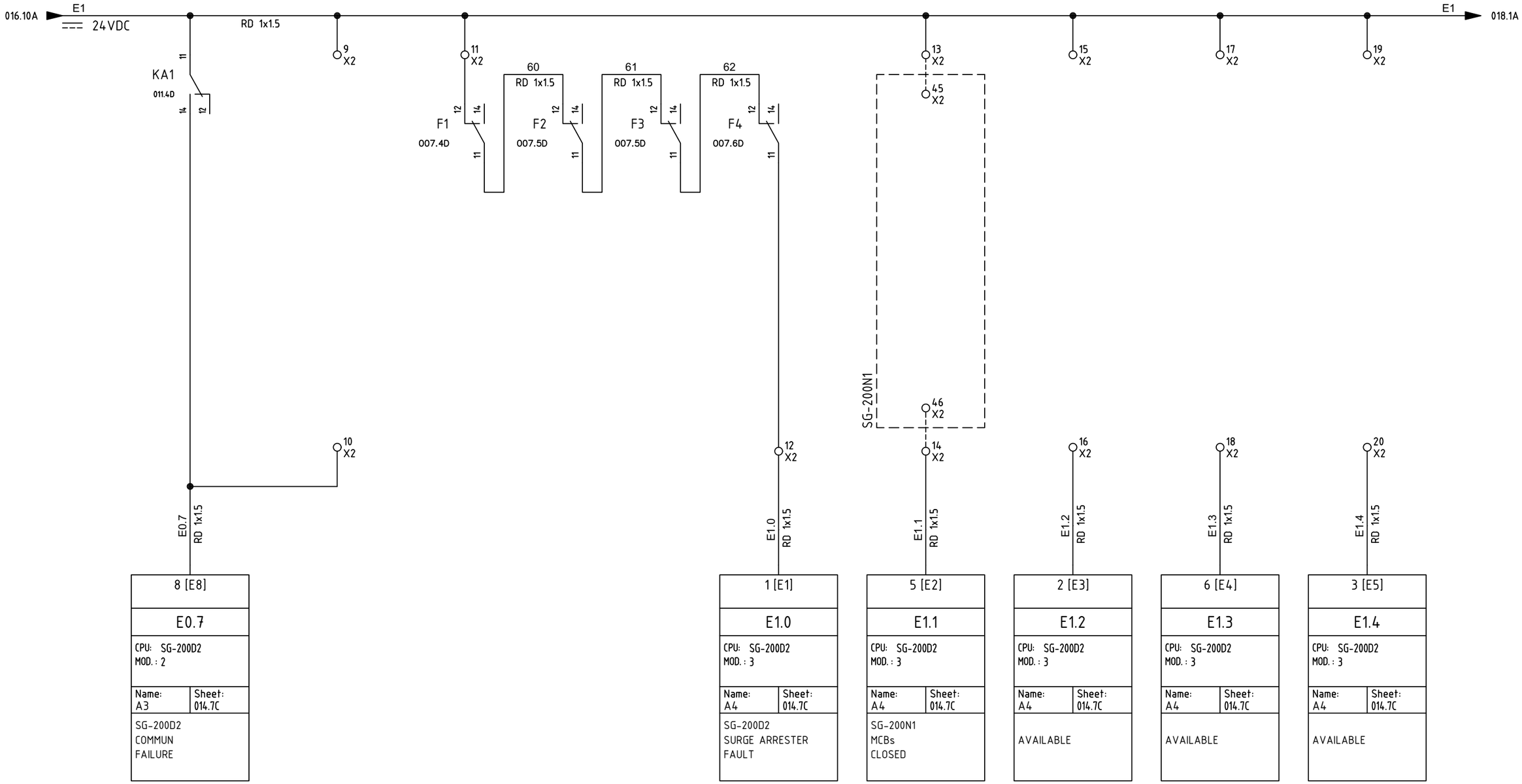
SHEET 016

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00032 Rev. 03

# MODULE I/O CONNECTION




| 8 [E8] |
|---|
| E0.7 |
| CPU: SG-200D2<br>MOD. : 2 |
| Name: A3 / Sheet: 014.7C |
| SG-200D2<br>COMMUN<br>FAILURE |

| 1 [E1] |
|---|
| E1.0 |
| CPU: SG-200D2<br>MOD. : 3 |
| Name: A4 / Sheet: 014.7C |
| SG-200D2<br>SURGE ARRESTER<br>FAULT |

| 5 [E2] |
|---|
| E1.1 |
| CPU: SG-200D2<br>MOD. : 3 |
| Name: A4 / Sheet: 014.7C |
| SG-200N1<br>MCBs<br>CLOSED |

| 2 [E3] |
|---|
| E1.2 |
| CPU: SG-200D2<br>MOD. : 3 |
| Name: A4 / Sheet: 014.7C |
| AVAILABLE |

| 6 [E4] |
|---|
| E1.3 |
| CPU: SG-200D2<br>MOD. : 3 |
| Name: A4 / Sheet: 014.7C |
| AVAILABLE |

| 3 [E5] |
|---|
| E1.4 |
| CPU: SG-200D2<br>MOD. : 3 |
| Name: A4 / Sheet: 014.7C |
| AVAILABLE |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 22/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/32

Item n° : PF1002669/3

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

SHEET 017

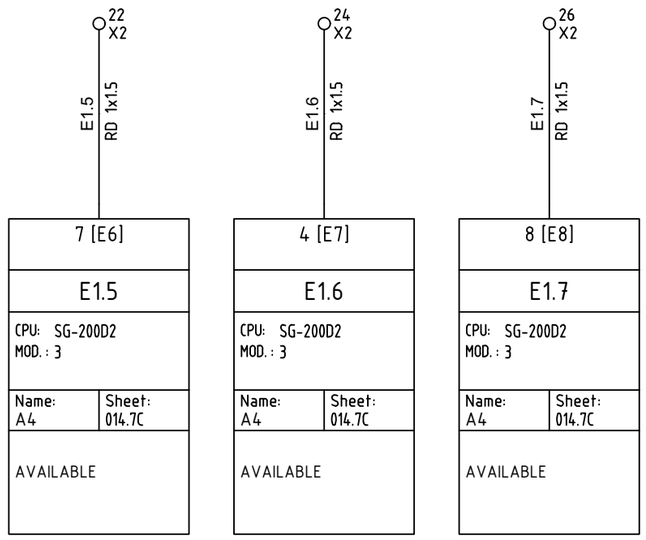
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00032 Rev. 03

# MODULE I/O CONNECTION




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 22/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n°: 231298/SD/32
Item n°: PF1002669/3

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

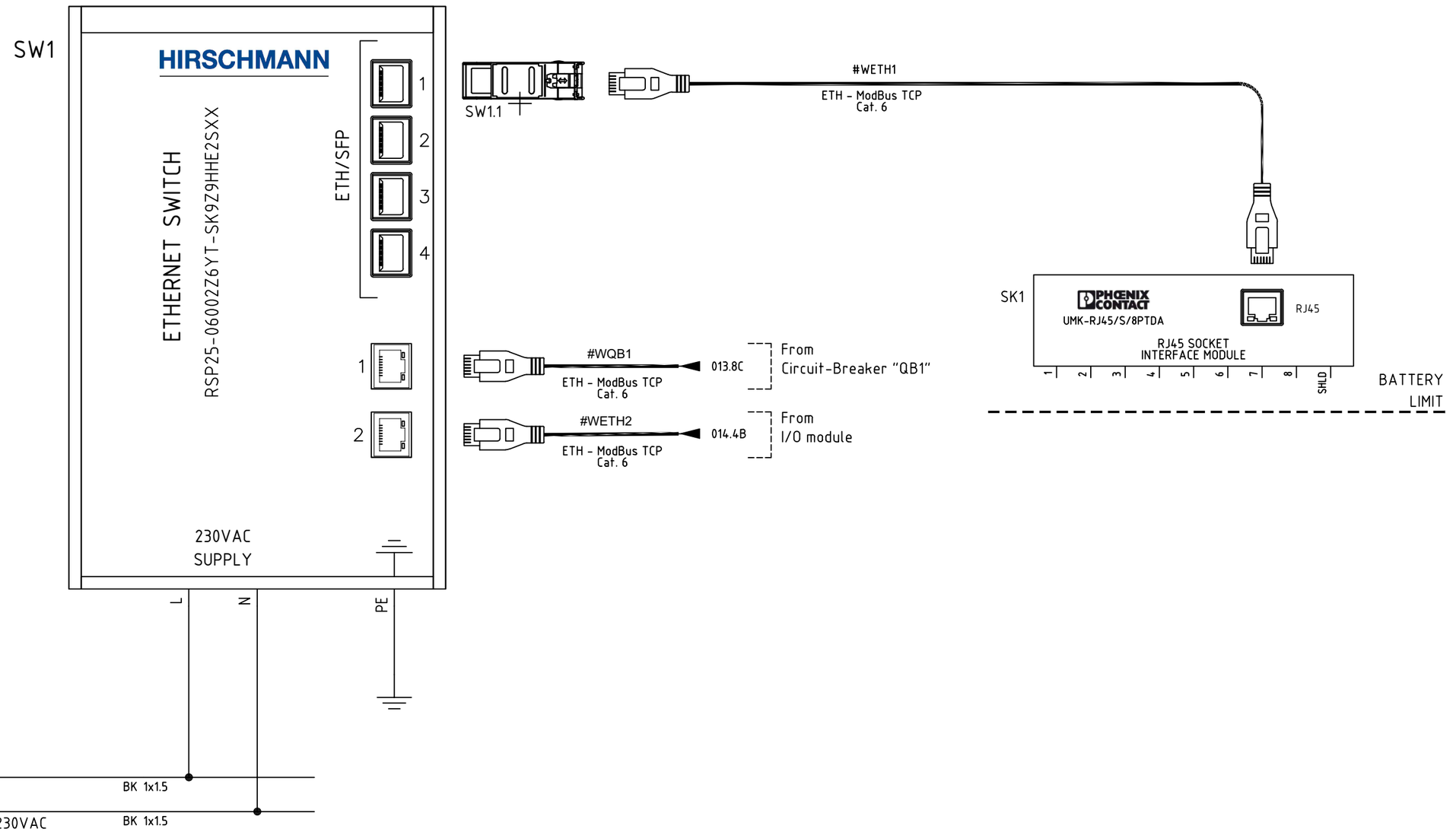
SHEET 018

REV. 03

File Name : 1723002197-EL-DG-00032 Rev. 03

F.to UNI A3: 420mmx297mm

# SWITCH CONNECTION




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 22/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/32
Item n° : PF1002669/3

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

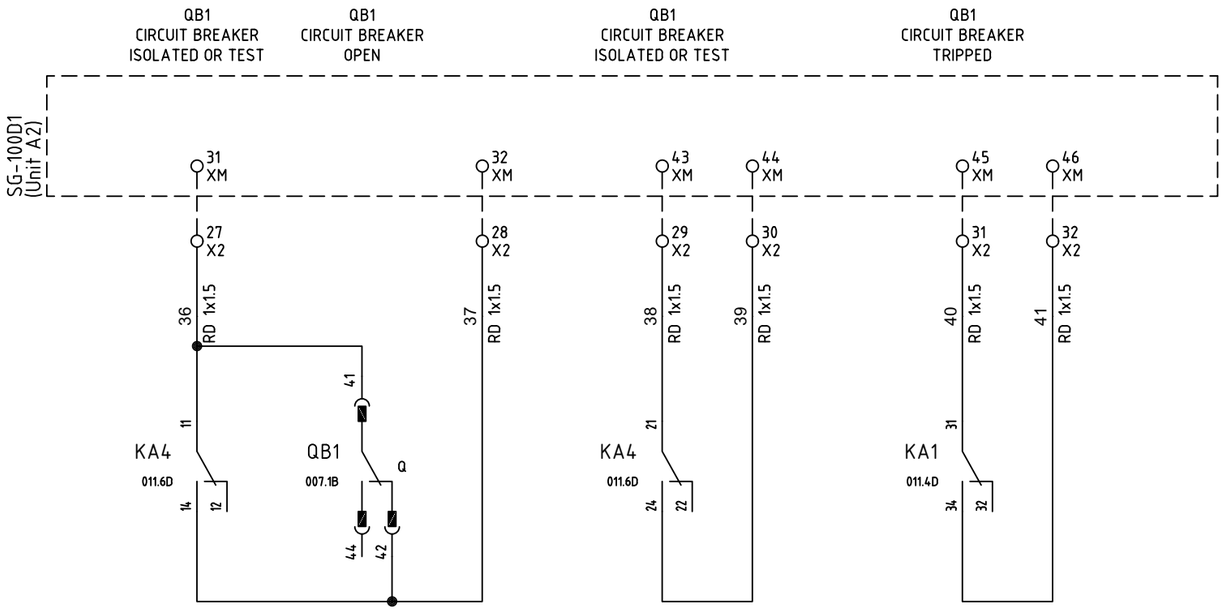
SHEET 019

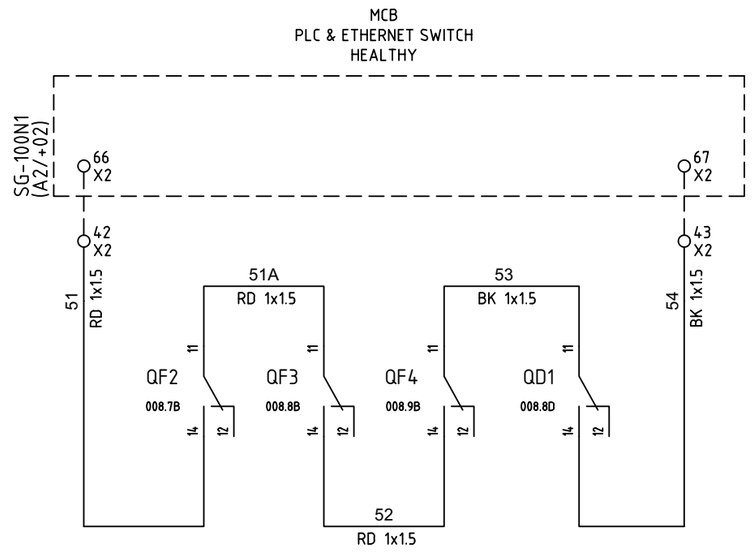
REV. 03

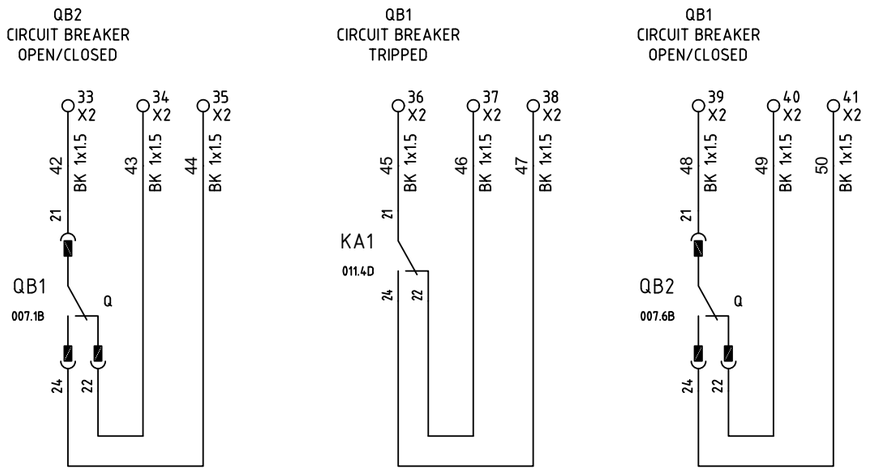
File Name : 1723002197-EL-DG-00032 Rev. 03

F.to UNI A3: 420mmx297mm

# AVAILABLE SIGNALS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 22/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/32

Item n° : PF1002669/3

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

SHEET 020

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00032 Rev. 03

FUN - SG-200D2
X2

| NumM | Sheet | Sec. | Type | Manufacturer | Terminal Description |
|---|---|---|---|---|---|
| | | | BT003 | Cabur | BT/3 End bracket |
| 1 | 010.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 2 | 010.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 3 | 010.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 4 | 010.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 5 | 010.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 6 | 010.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 7 | 010.8C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 8 | 010.8D | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 9 | 017.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 10 | 017.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 11 | 017.4A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 12 | 017.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 13 | 017.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 14 | 017.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 15 | 017.7A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 16 | 017.7B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 17 | 017.8A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 18 | 017.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 19 | 017.9A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 20 | 017.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 21 | 018.2A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 22 | 018.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 23 | 018.3A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 24 | 018.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 25 | 018.4A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 26 | 018.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 27 | 020.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 28 | 020.3B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 29 | 020.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 30 | 020.4B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 31 | 020.5B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 32 | 020.6B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 33 | 020.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 34 | 020.2C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 35 | 020.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 36 | 020.3C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |

FUN - SG-200D2
X2

| NumM | Sheet | Sec. | Type | Manufacturer | Terminal Description |
|---|---|---|---|---|---|
| 37 | 020.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 38 | 020.4C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 39 | 020.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 40 | 020.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 41 | 020.5C | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 42 | 020.8B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 43 | 020.9B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 44 | 008.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 45 | 008.6A | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 46 | 009.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| 47 | 009.2B | 4 | HM250GR | Cabur | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type |
| | | | HM251GR | Cabur | HMT.4/PT/GR End section - Grey |
| | | | BT003 | Cabur | BT/3 End bracket |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
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| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/32
Item n° : PF1002669/3

TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Terminal Block

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

SHEET 021

REV. 03

File Name : 1723002197-EL-DG-00032 Rev. 03

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| A1 | 014 | 750-362 | 1 | Accoppiatore fieldbus ETHERNET, 4ª generazione 24VDC | Wago | FUN | SG-200D2 |
| A2 | 014 | 750-602 | 1 | Alimentazione del potenziale 24 V DC / passiva | Wago | FUN | SG-200D2 |
| A3 | 014 | 750-430 | 1 | Modulo 8 ingressi digitali 24 V DC 3.0ms | Wago | FUN | SG-200D2 |
| A4 | 014 | 750-430 | 1 | Modulo 8 ingressi digitali 24 V DC 3.0ms | Wago | FUN | SG-200D2 |
| A5 | 014 | 750-600 | 1 | Modulo terminatore | Wago | FUN | SG-200D2 |
| E1 | 009 | BEG74041 | 1 | LAMP 4W 220-240V 50-60HZ COD.74041 - RGL P LED 4W 313MM 4000K | Beghelli | FUN | SG-200D2 |
| EH1 | 009 | R1R150230 | 1 | SPACE HEATER SKR 150W ALIM. 220VCA | Torresan | FUN | SG-200D2 |
| F1 | 007 | 961146 | 1 | SURGE ARRESTER LOW VOLTAGE DBM 1 CI 440 FM Uc=440V Tipo 1 / Classe I | DEHN | FUN | SG-200D2 |
| | | 900461 | 1 | WIRING SYSTEM 3POLES TYPE EB1310 | DEHN | FUN | SG-200D2 |
| F2 | 007 | 961146 | 1 | SURGE ARRESTER LOW VOLTAGE DBM 1 CI 440 FM Uc=440V Tipo 1 / Classe I | DEHN | FUN | SG-200D2 |
| F3 | 007 | 961146 | 1 | SURGE ARRESTER LOW VOLTAGE DBM 1 CI 440 FM Uc=440V Tipo 1 / Classe I | DEHN | FUN | SG-200D2 |
| F4 | 007 | 961146 | 1 | SURGE ARRESTER LOW VOLTAGE DBM 1 CI 440 FM Uc=440V Tipo 1 / Classe I | DEHN | FUN | SG-200D2 |
| FU1 | 007 | 2640014P | 1 | PK-0/1000 Fuseholders for fuses In=160A up to 1000V DC/AC | Italweber | FUN | SG-200D2 |
| | | 1505036 | 1 | Fusible NH-0 35A gG 500V | Italweber | FUN | SG-200D2 |
| FU2 | 007 | 2640014P | 1 | PK-0/1000 Fuseholders for fuses In=160A up to 1000V DC/AC | Italweber | FUN | SG-200D2 |
| | | 1505036 | 1 | Fusible NH-0 35A gG 500V | Italweber | FUN | SG-200D2 |
| FU3 | 007 | 2640014P | 1 | PK-0/1000 Fuseholders for fuses In=160A up to 1000V DC/AC | Italweber | FUN | SG-200D2 |
| | | 1505036 | 1 | Fusible NH-0 35A gG 500V | Italweber | FUN | SG-200D2 |
| FU4 | 008 | 2640014P | 1 | PK-0/1000 Fuseholders for fuses In=160A up to 1000V DC/AC | Italweber | FUN | SG-200D2 |
| | | 1544016M | 1 | Fuse NH-0 16A aR 1000V | Italweber | FUN | SG-200D2 |
| FU5 | 008 | 2640014P | 1 | PK-0/1000 Fuseholders for fuses In=160A up to 1000V DC/AC | Italweber | FUN | SG-200D2 |
| | | 1544016M | 1 | Fuse NH-0 16A aR 1000V | Italweber | FUN | SG-200D2 |
| HL1 | 011 | EO 562 2 | 1 | ML1-100R RED LAMP | ABB | FUN | SG-200D2 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | FUN | SG-200D2 |
| | | KV 035 7 | 1 | MLBL-07R RED LED BLOCK INTEGRATED 230VAC | ABB | FUN | SG-200D2 |
| HL2 | 011 | EO 563 0 | 1 | ML1-100G GREEN LAMP | ABB | FUN | SG-200D2 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | FUN | SG-200D2 |
| | | KV 036 5 | 1 | MLBL-07G GREEN LED BLOCK INTEGRATED 230VAC | ABB | FUN | SG-200D2 |
| HL3 | 011 | EO 564 8 | 1 | ML1-100Y YELLOW LAMP | ABB | FUN | SG-200D2 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | FUN | SG-200D2 |
| | | KV 037 3 | 1 | MLBL-07Y YELLOW LED BLOCK INTEGRATED 230VAC | ABB | FUN | SG-200D2 |
| HL4 | 012 | EO 562 2 | 1 | ML1-100R RED LAMP | ABB | FUN | SG-200D2 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | FUN | SG-200D2 |
| | | KV 035 7 | 1 | MLBL-07R RED LED BLOCK INTEGRATED 230VAC | ABB | FUN | SG-200D2 |
| HL5 | 012 | EO 563 0 | 1 | ML1-100G GREEN LAMP | ABB | FUN | SG-200D2 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | FUN | SG-200D2 |
| | | KV 036 5 | 1 | MLBL-07G GREEN LED BLOCK INTEGRATED 230VAC | ABB | FUN | SG-200D2 |
| KA1 | 011 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | FUN | SG-200D2 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | FUN | SG-200D2 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | FUN | SG-200D2 |
| KA2 | 011 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | FUN | SG-200D2 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | FUN | SG-200D2 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | FUN | SG-200D2 |
| KA3 | 011 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | FUN | SG-200D2 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
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DWG n° : 231298/SD/32
Item n° : PF1002669/3

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

SHEET 022

REV. 03

File Name : 1723002197-EL-DG-00032 Rev. 03

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| KA3 | 011 | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | FUN | SG-200D2 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | FUN | SG-200D2 |
| KA4 | 011 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | FUN | SG-200D2 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | FUN | SG-200D2 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | FUN | SG-200D2 |
| KA5 | 008 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | FUN | SG-200D2 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | FUN | SG-200D2 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | FUN | SG-200D2 |
| KA6 | 011 | ER 592 6 | 1 | CR-M230AC4L SUPPLY 230VAC 4C/O 250V/6A LED | ABB | FUN | SG-200D2 |
| | | ER 686 6 | 1 | CR-M4SS SOCKET STANDARD X 2/4 C/O(CR-M) | ABB | FUN | SG-200D2 |
| | | ER 609 8 | 1 | CR-MH HOLDER FOR CR-M RELAY | ABB | FUN | SG-200D2 |
| LS | 009 | Z15GW2-1-1453270 | 1 | MICROSWITCH 1sc | Omron | FUN | SG-200D2 |
| | | APB-PG | 1 | COVER TO MICRO-SWITCH | Omron | FUN | SG-200D2 |
| QB1 | 007 | 1SDA073782R1 | 1 | KLC-D BLOCK KEY ON OPEN POSITION TO E1.2 | ABB | FUN | SG-200D2 |
| | | 1SDA073822R1 | 1 | KLP-D INSERTED/ISOLATED KEY BLOCK TO E1.2 | ABB | FUN | SG-200D2 |
| | | 1SDA073885R1 | 1 | MECHANICAL INTERLOCKING CABLE TO TYPE A VERTICAL TO E1.2÷E6.2 | ABB | FUN | SG-200D2 |
| | | 1SDA073896R1 | 1 | SUPPORT FOR MECHANICAL INTERLOCK OF FIXED PART FOR E1.2 TYPE A | ABB | FUN | SG-200D2 |
| | | 1SDA073674R1 | 1 | OPENING COIL YO 220÷240VAC/DC TO E12÷E6.2 | ABB | FUN | SG-200D2 |
| | | 1SDA073687R1 | 1 | CLOSING COIL YC 220÷240VAC/DC TO E1.2÷E6.2 | ABB | FUN | SG-200D2 |
| | | 1SDA073711R1 | 1 | MOTOR SPRING CHARGER 220÷250Vac/dc TO E1.2 | ABB | FUN | SG-200D2 |
| | | 1SDA073907R1 | 1 | E1.2 W FP 1600 3P FIXED PART HR-HR | ABB | FUN | SG-200D2 |
| | | 1SDA073762R1 | 1 | AUP 6 CONTACT AUX INS/TEST/EST TO E1.2 | ABB | FUN | SG-200D2 |
| | | 1SDA074151R1 | 1 | Module Ekip Com Modbus TCP Emax E1.2÷E6.2 | ABB | FUN | SG-200D2 |
| | | 1SDA074173R1 | 1 | MODUL EKIP SUPPLY 24÷48VDC | ABB | FUN | SG-200D2 |
| | | 1SDA073855R1 | 1 | PBC Prot. Pushbutt.AP/CH D=4mm E1.2-XT7M | ABB | FUN | SG-200D2 |
| | | 1SDA104297R1 | 1 | E1.2N/E9 1250 3P Ekip Hi-Touch-LSIG In=1250A WITHDRAWABLE MOBIL PART | ABB | FUN | SG-200D2 |
| | | 1SDA074166R1 | 2 | Module Ekip Actuator Emax E1.2÷E6.2÷XT7÷XT7M | ABB | FUN | SG-200D2 |
| | | 1SDA073906R1 | 1 | AUXILIARY TERMINALS CONNECTION (10PC) | ABB | FUN | SG-200D2 |
| | | 1SDA073838R1 | 1 | ADDITIONAL BLOCK ISOALTED FOR E1 | ABB | FUN | SG-200D2 |
| QB2 | 007 | 1SDA073782R1 | 1 | KLC-D BLOCK KEY ON OPEN POSITION TO E1.2 | ABB | FUN | SG-200D2 |
| | | 1SDA073822R1 | 1 | KLP-D INSERTED/ISOLATED KEY BLOCK TO E1.2 | ABB | FUN | SG-200D2 |
| | | 1SDA073896R1 | 1 | SUPPORT FOR MECHANICAL INTERLOCK OF FIXED PART FOR E1.2 TYPE A | ABB | FUN | SG-200D2 |
| | | 1SDA074280R1 | 1 | RATING PLUG 1250A FUNCTION L (OFF) TO EKIP RELEASE TO E1.2..E6.2 INSTALLED | ABB | FUN | SG-200D2 |
| | | 1SDA073907R1 | 1 | E1.2 W FP 1600 3P FIXED PART HR-HR | ABB | FUN | SG-200D2 |
| | | 1SDA073762R1 | 1 | AUP 6 CONTACT AUX INS/TEST/EST TO E1.2 | ABB | FUN | SG-200D2 |
| | | 1SDA073855R1 | 1 | PBC Prot. Pushbutt.AP/CH D=4mm E1.2-XT7M | ABB | FUN | SG-200D2 |
| | | 1SDA104296R1 | 1 | E1.2N/E9 1250 3P Ekip Touch-LSIG In=1250A WITHDRAWABLE MOBIL PART | ABB | FUN | SG-200D2 |
| | | 1SDA073906R1 | 1 | AUXILIARY TERMINALS CONNECTION (10PC) | ABB | FUN | SG-200D2 |
| | | 1SDA073885R1 | 1 | MECHANICAL INTERLOCKING CABLE TO TYPE A VERTICAL TO E1.2÷E6.2 | ABB | FUN | SG-200D2 |
| | | 1SDA073838R1 | 1 | ADDITIONAL BLOCK ISOALTED FOR E1 | ABB | FUN | SG-200D2 |
| QD1 | 008 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | FUN | SG-200D2 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | FUN | SG-200D2 |
| QF1 | 008 | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | FUN | SG-200D2 |
| | | S550253 | 1 | S202M C 4 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | FUN | SG-200D2 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| 3 | 18/09/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 10/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for Construction (AFC) |
| 1 | 22/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 08/02/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/32

Item n° : PF1002669/3

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"

FUNCTIONAL DIAGRAM

Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

SHEET 023

REV. 03

File Name : 1723002197-EL-DG-00032 Rev. 03

F.to UNI A3: 420mmx297mm

| Nome/Item | Fg/Sh | Tipo/Type | Q.tà | Descrizione/Description | Costruttore/Manufacturer | Ubicazione (descrizione) | Quadro (descrizione) |
|---|---|---|---|---|---|---|---|
| QF2 | 008 | S550260 | 1 | S202M C 6 AUTOMATIC CIRCUIT-BREAKER 10KA 2P | ABB | FUN | SG-200D2 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | FUN | SG-200D2 |
| QF3 | 008 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | FUN | SG-200D2 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | FUN | SG-200D2 |
| QF4 | 008 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | FUN | SG-200D2 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | FUN | SG-200D2 |
| QF5 | 009 | S550239 | 1 | S202M C 2 AUTOMATIC CIRCUIT BREAKER 10KA 2P | ABB | FUN | SG-200D2 |
| | | B427960 | 1 | DDA202 A 25A 300MA RCD BLOCK 2P | ABB | FUN | SG-200D2 |
| | | A563819 | 1 | S2-CS/H6R AUXILIARY STATE CONTACT 1CO | ABB | FUN | SG-200D2 |
| SA1 | 006 | R601-205_02-W002 | 1 | SWITCH R16 2/5 - 2 STAY POSITION | Cometric | FUN | SG-200D2 |
| | | Q4820030 | 1 | Frontplate 48x48mm (LOC-REM) | Cometric | FUN | SG-200D2 |
| SC1 | 010 | KW 076 0 | 1 | MP1-10G PUSH BUTTON GREEN WITH BLACK RING | ABB | FUN | SG-200D2 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | FUN | SG-200D2 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | FUN | SG-200D2 |
| SK1 | 019 | 2900682 | 1 | UMK-RJ45/S/8PTDA Modul VARIOFACE | Phoenix Contact | FUN | SG-200D2 |
| SO1 | 010 | KW 075 2 | 1 | MP1-10R PUSH BUTTON RED WITH BLACK RING | ABB | FUN | SG-200D2 |
| | | EO 569 7 | 1 | MCBH-00 FIXING SUPPORT 3 CONTACTS | ABB | FUN | SG-200D2 |
| | | EO 570 5 | 1 | MCB-10 CONTACT NO FOR PUSHBUTTONS | ABB | FUN | SG-200D2 |
| SW1 | 019 | RSPS25-06002Z6YT-SK9Z9HHE2SXX.X | 1 | Managed Industrial Switch for DIN Rail, fanless design Fast Ethernet Type - Enhanced (PRP, Fast MRP, HSR, NAT with L3 type) - 2 x RJ45; 4 x SFP - V=48V÷320VDC -88÷265VAC) | HIRSCHMANN | FUN | SG-200D2 |
| SW1.1 | 019 | M-FAST SFP-TX/RJ45 | 1 | SFP TX Fast Ethernet Transceiver with RJ45 | HIRSCHMANN | FUN | SG-200D2 |
| T1 | 008 | F14XXX_01 | 1 | Moofase Transformer 50Hz 800/230Vac 50Hz P=1000VA ? tropicalized | L.E.F. | FUN | SG-200D2 |
| THR | 009 | TRT-10A230V-NC | 1 | Regolable Thermostat -10÷80°C 1NC IP20 DIN Mounting | Fandis | FUN | SG-200D2 |
| U1 | 008 | XCSF120CP | 1 | CSF120CP Switching power supply Cool Power 1-phase 90...264 Vac & 100...345 Vdc / 24 Vdc 5 A redundant version | Cabur | FUN | SG-200D2 |
| X2 | | HM250GR | 47 | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur | FUN | SG-200D2 |
| | | BT003 | 2 | BT/3 End bracket | Cabur | FUN | SG-200D2 |
| | | HM251GR | 1 | HMT.4/PT/GR End section - Grey | Cabur | FUN | SG-200D2 |

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DWG n° : 231298/SD/32
Item n° : PF1002669/3

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "SG-200D2"
FUNCTIONAL DIAGRAM
Bill of Materials

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00032

SHEET 024

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00032 Rev. 03

1.4.12. DP-200N1 FUNCTIONAL DIAGRAM,

Doc. No. 1723002197-EL-DG-00033

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# BASE LOAD POWER HUB (BLPH)

# "DP-200N1" LV SWBD 400/230V

# FUNCTIONAL DIAGRAMS

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Andrea Santarelli | 12/03/2025 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231298/SD/33
Item n° : PF1002888/101

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 1

REV. 03

File Name : 1723002197-EL-DG-00033 Rev. 03

F.to UNI A3: 420mmx297mm

# INDEX SHEETS

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 001 | Cover | | | | | | | | | | |
| 002 | Index | | | | | | | | | | |
| 003 | Graphical Symbols | | | | | | | | | | |
| 004 | Graphical Symbols | | | | | | | | | | |
| 005 | Functional Drawing | | | | | | | | | | |
| 006 | Functional Drawing | | | | | | | | | | |
| 007 | Functional Drawing | | | | | | | | | | |
| 008 | Functional Drawing | | | | | | | | | | |
| 009 | Functional Drawing | | | | | | | | | | |
| 010 | Functional Drawing | | | | | | | | | | |
| 011 | Functional Drawing | | | | | | | | | | |
| 012 | Functional Drawing | | | | | | | | | | |
| 013 | Functional Drawing | | | | | | | | | | |
| 014 | Functional Drawing | | | | | | | | | | |
| 015 | Functional Drawing | | | | | | | | | | |
| 016 | Functional Drawing | | | | | | | | | | |
| 017 | Functional Drawing | | | | | | | | | | |
| 018 | Functional Drawing | | | | | | | | | | |
| 019 | Functional Drawing | | | | | | | | | | |
| 020 | Power Teminal Block | | | | | | | | | | |
| 021 | Power Teminal Block | | | | | | | | | | |
| 022 | Auxiliary Terminal Blocks | | | | | | | | | | |
| 023 | Material List | | | | | | | | | | |
| 024 | Material List | | | | | | | | | | |
| 025 | Material List | | | | | | | | | | |
| 026 | Material List | | | | | | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/33

Item n° : PF1002888/101

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TITLE : "DP-200N1"

LV SWBD FUNCTIONAL DIAGRAMS

Index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

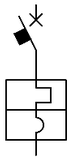
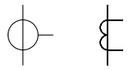
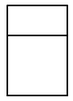
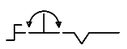
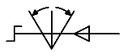
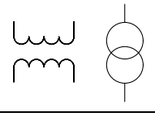
DRAWING NO. 1723002197-EL-DG-00033

SHEET 2

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|  | **CIRCUIT BREAKER WITH AUTOMATIC RELEASE** |  | **CAPACITOR (GENERAL SYMBOL)** |  | **BISTABLE RELAY** |  | **CHANGE-OVER BREAK BEFORE MAKE CONTACT** |
|  | **CIRCUIT BREAKER WITH AUTOMATIC RELEASE AND BUILT-IN THERMOMAGNETIC RELEASE** |  | **CAPACITIVE VOLTAGE DIVIDER** |  | **COIL OF A MECHANICALLY LATCHED RELAY** |  | **DELAYED ACTION (IN THE DIRECTION OF MOVEMENT FROM THE ARC TOWARDS ITS CENTRE)** |
| | |  | **CURRENT TRANSFORMER** |  | **INDICATOR, ELECTROMECHANICAL ELEMENT** |  | POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT |
|  | **SWITCH DISCONNECTOR** |  | RING CURRENT TRANSFORMER |  | **LAMP (GENERAL SYMBOL)** |  | **POSITION SWITCH (LIMIT SWITCH), MAKE CONTACT** |
|  | **CONTACTOR** |  | **INDICATING INSTRUMENT GENERAL SYMBOL** |  | **SEMICONDUCTOR DIODE** |  | POSITION SWITCH (LIMIT SWITCH), BREAK CONTACT |
|  | **LOCK WITH FREE KEY WHEN THE DEVICE IS IN OPEN POSITION** |  | **INTEGRATING INSTRUMENT (GENERAL SYMBOL)** |  | **LED** |  | **OPERATED BY TURNING** |
|  | **LOCK WITH FREE KEY WHEN THE DEVICE IS IN CLOSE POSITION** |  | **DISCONNECTING FUSE, NOT WITH LIVE CIRCUIT AND WITH MECHANICAL LINKAGE (STRIKER FUSE))** |   | **TRANSDUCER OF ALTERNATING CURRENT MEASURE INTO DIRECT CURRENT SIGNAL** |  | **THREE HELD POSITIONS TURNING SWITCH** |
|  | **PLUG AND SOCKET (MALE AND FEMALE)** |  | **OPERATING DEVICE (GENERAL SYMBOL)** |  | **EARTH, GROUND (GENERAL SYMBOL)** |  | **THREE POSITIONS TURNING SWITCH, WITH SPRING THROWBACK TO THE CENTRAL POSITION** |
|  | **VOLTAGE TRANSFORMER WITH TWO WINDINGS** |  | **COIL OF A TIME DELAYED OPERATING RELAY** |  | **MAKE CONTACT** |  | MECHANICAL INTERLOCK BETWEEN TWO DEVICES |
|  | **VOLTAGE TRANSFORMER WITH THREE WINDINGS** |  | **COIL OF A TIME DELAYED RELEASING RELAY** |  | **BREAK CONTACT** | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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CROSSWIND

ROSETTI MARINO

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/33

Item n° : PF1002888/101

TITLE : "DP-200N1"

LV SWBD FUNCTIONAL DIAGRAMS

Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 3

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03

| GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION | GRAPHICAL SYMBOLS | DESCRIPTION |
|---|---|---|---|---|---|---|---|
|  | RESISTOR (GENERAL SYMBOL) |  | AMPEROMETRIC TEST SOCKET | | | | |
|  | THERMISTOR (GENERAL SYMBOL) |  | 3 PHASES LINE + N | | | | |
|  | HEATING ELEMENT |  | 1 PHASES LINE + N | | | | |
|  | INTERCONNECTION TERMINAL | | | | | | |
|  | WITHDRAWABLE TERMINAL SHORT-CIRCUITABLE ON C.T. SECONDARY CIRCUITS | | | | | | |
|  | WITHDRAWABLE TERMINAL FOR V.T. SECONDARY CIRCUITS | | | | | | |
|  | SWITCHBOARD TERMINAL | | | | | | |
|  | ON - OFF SWITCH | | | | | | |
|  | SURGE ARRESTER | | | | | | |
|  | VOLTMETRIC TEST SOCKET | | | | | | |

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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Graphical Symbols

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

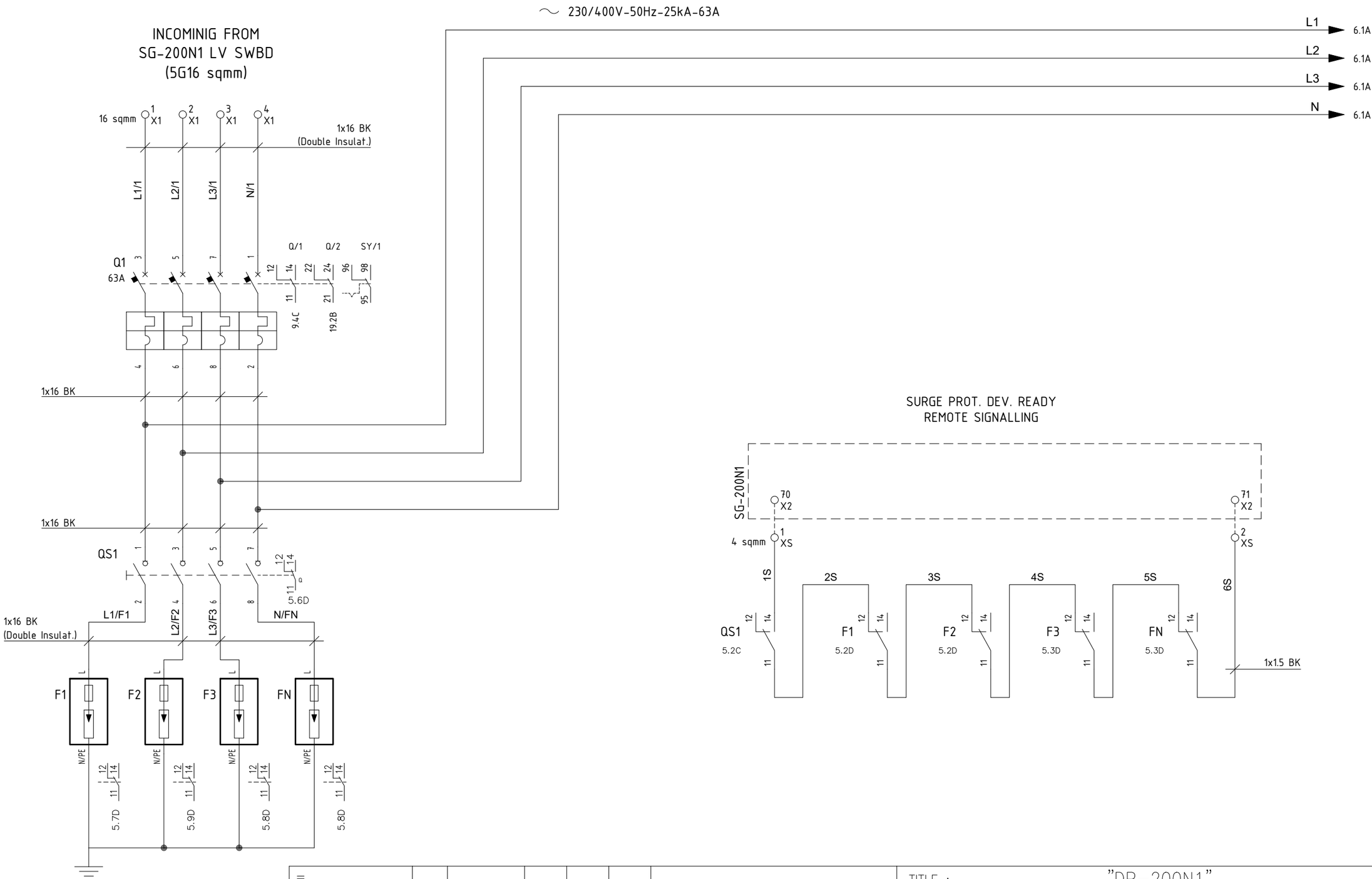
DRAWING NO. 1723002197-EL-DG-00033

SHEET 4

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03




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Item n° : PF1002888/101

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"

LV SWBD FUNCTIONAL DIAGRAMS

Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 5

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03

# NORMAL AND EMERGENCY LIGHTING FUNCTIONAL DIAGRAM

~ 230/400V-50Hz-25kA-63A

5.10A L1 — L1 7.1A
5.10A L2 — L2 7.1A
5.10A L3 — L3 7.1A
5.10A N — N 7.1A

1L1/T1 1N/T1
QT1 1A
6.7C
1x1.5 BK
FT
1x1.5 BK
NT

TWLIGHT SWITCH
AUTOM. OPERATION (UNMANNED)
MANUAL OPERATION (MANNED)
AUTOM. OPER. SIGNAL. (UNMANNED)
LIGHTING POWER ON COMMAND

SA1 UNMANNED MANNED
SA1 SELECTOR DRAWED IN POSIT. 1
SA1
KT1 6.4D
KT1 6.4D
1T 2T 3T 4T 5T 6T
4 sqmm 1 XT 2 XT 3 XT 4 XT
72 X2 73 X2
SG-200N1
TW1 (1-100 LUX) POWER SUPPLY
EXTERNAL SENSOR (IP66); MAX. TOTAL LENGHT OF THE CONNECTION: 50m
KT1 A1 A2
7T
KL2 KL3 KL4 KL44 KL8 KL9 KL10 KL45 A1 A2

6.6B 6.6B
7.2C 7.3C 7.5C 7.6C 7.8C 8.2C 8.3C 8.5C
6.7B 6.8B 6.8B 6.9B 6.7B 6.8B 6.8B 6.9B

LIGHTINGS ON REMOTE SIGNALLING

74 X2 — 5 XT
15T KL2 16T KL3 17T KL4 18T KL44
6.6D 6.6D 6.7D 6.7D
1x1.5 BK
19T
KL8 20T KL9 21T KL10 22T KL45 23T
6.8D 6.8D 6.9D 6.9D
6 XT — 75 X2
4 sqmm

LIGHTINGS UTILITIES PROT. BREAKERS CLOSED REMOTE SIGNALLING

SG-200N1
76 X2 — 7 XT
30T QT1 31T Q2 32T Q3 33T Q4 34T
6.2A 7.2B 7.3B 7.5B
Q10 Q9 Q8 Q44 38T
8.3B 37T 8.2B 36T 7.8B 35T 7.6B
1x1.5 BK
Q45 39T
8.5B
8 XT — 77 X2
4 sqmm
SG-200N1

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twiligh Switch TW1 |
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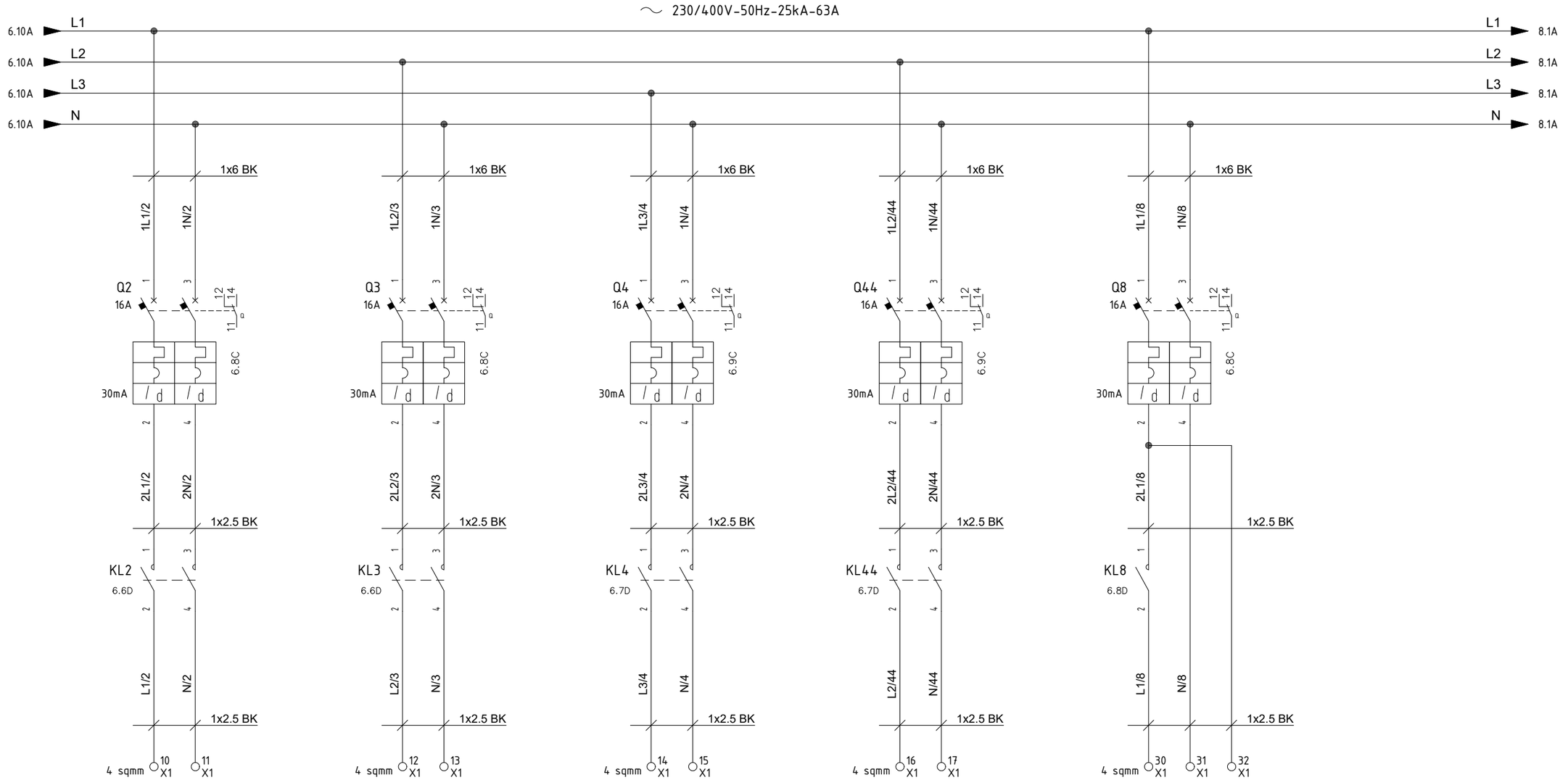
CROSSWIND
IMESA ELECTRICAL ENGINEERING
ROSETTI MARINO

DWG n° : 231298/SD/33
Item n° : PF1002888/101

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS
A3
DRAWING NO. 1723002197-EL-DG-00033
SHEET 6
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03




EJB-200N1-02-L1-01
Normal Lighting Upper Deck - Circuit No. 1
(3G4 sqmm)

EJB-200N1-03-L2-01
Normal Lighting Lower Deck - Circuit No. 1
(3G4 sqmm)

EJB-200N1-04-L3-01
Normal Lighting stairs
(3G4 sqmm)

Spare
Normal Lighting - Spare

EJB-200N1-08-L1-01
Emergency Lighting Upper Deck - Circuit No. 1
(4G4 sqmm _E)

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DWG n° : 231298/SD/33
Item n° : PF1002888/101

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

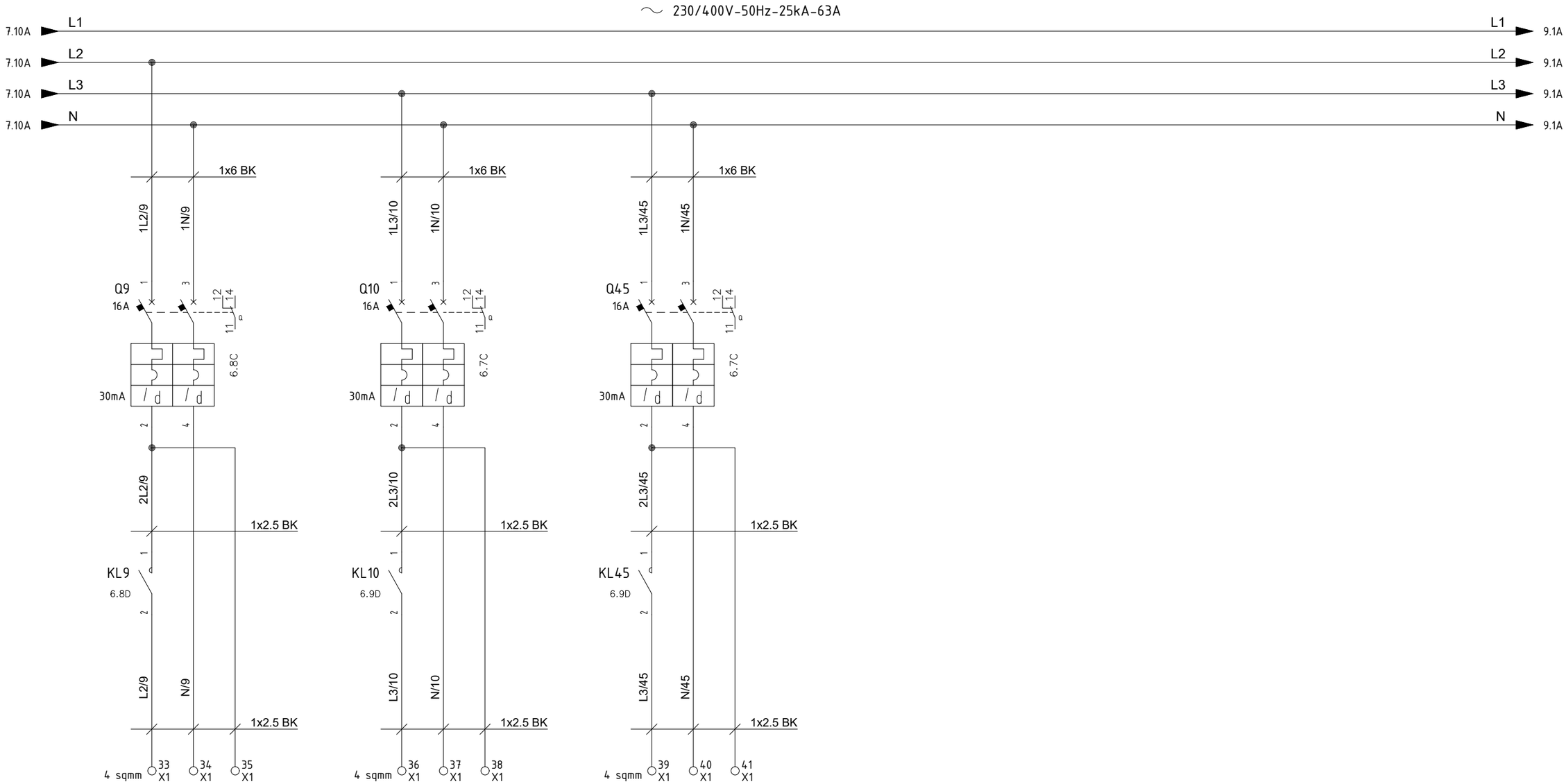
TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00033 | SHEET 7 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03




EJB-200N1-09-L2-01
Emergency Lighting Lower Deck - Circuit No. 1
(4G4 sqmm _E)

EJB-200N1-10-L3-01
Emergency Lighting stairs
(4G4 sqmm _E)

Spare
Emergency Lighting - SPARE

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| = | | | | | |
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Item n° : PF1002888/101

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 8

REV. 03

File Name : 1723002197-EL-DG-00033 Rev. 03

F.to UNI A3: 420mmx297mm

# TRACE HEATINGS FUNCTIONAL DIAGRAM

~ 230/400V-50Hz-25kA-63A

8.10A L1 → L1 10.1A
8.10A L2 → L2 10.1A
8.10A L3 → L3 10.1A
8.10A N → N 10.1A

1L1/13 1L2/13 1L3/13 1N/13 — 1x16 BK
Q13 50A
9.5C

TRACE HEATINGS POWER ON COMMANND
TRACE HEATINGS SPARE EXTERNAL TRIP
1 XH — 2 2H — 3 XH — 4 XH
Remote Ambient Termostat
1H — 1x1.5 BK — 3H
K13 A1 / A2
9.2C 2-1 / 4-3 / 6-5 / 8-7
9.3C 34-33 / 22-21
9.5C
QH1 1A
4H — 1x1.5 BK

2L1/13 2L2/13 2L3/13 2N/13 — 1x16 BK
K13 9.6B — 1x16 BK

TRACE HEATINGS ON REM. SIGNALLING
5H — 4 sqmm — 5 XH
6H — 6 XH
SG-200N1 78 X2 / 79 X2

TRACE HEATINGS UTILITIES PROT. BREAKERS CLOSED REM. SIGNALLING
SG-200N1 80 X2 — 7 XH — 10H
Q1 — 5.2B — 11H
Q13 — 9.2B — 12H
QH1 — 9.2B — 13H
Q14 — 9.8B — 1x1.5 BK
14H
Q15 — 10.1B — 15H
Q16 — 10.3B — 16H
Q17 — 10.4B — 17H
Q18 — 10.6B
18H
Q19 — 10.7B — 19H
Q20 — 10.9B — 20H
Q21 — 11.1B — 21H
8 XH — 4 sqmm — 81 X2 — SG-200N1

~ 230/400V-50Hz-25kA-50A

L1/13 → 10.1B
L2/13 → 10.1B
L3/13 → 10.1B
N/13 → 10.1B

1L1/14 1N/14 — 1x4 BK
Q14 20A
9.6C
30mA
L1/14 N/14 — 1x4 BK
6 sqmm — 50 X1 / 51 X1

ETB-200N1-14-L1-01
Trace Heating - Process Lines - Feeeder 1
(SWS Lines)
(3G6 sqmm)

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CROSSWIND
IMESA ELECTRICAL ENGINEERING
ROSETTI MARINO

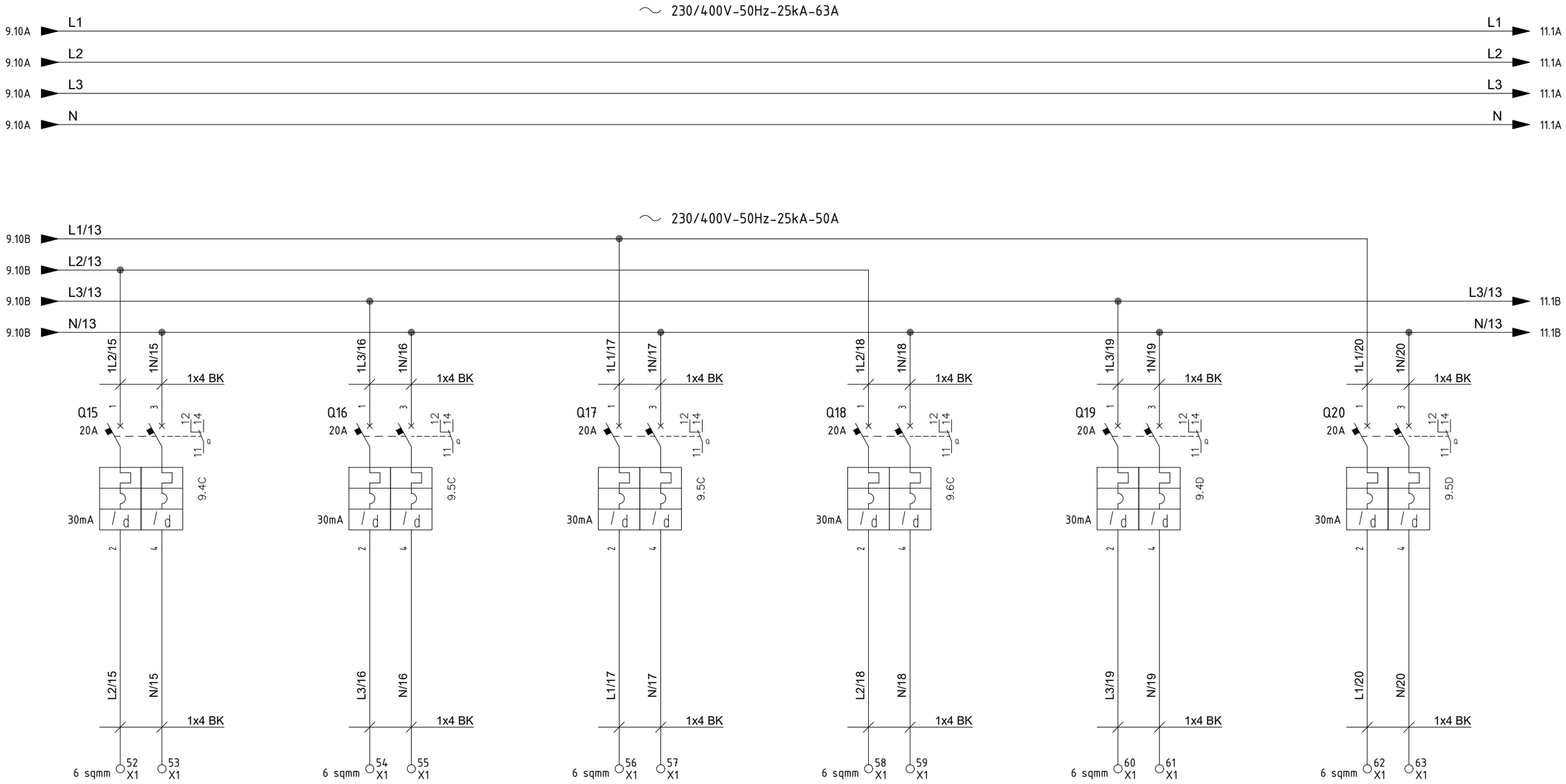
DWG n° : 231298/SD/33
Item n° : PF1002888/101

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS
A3
DRAWING NO. 1723002197-EL-DG-00033
SHEET 9
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03




ETB-200N1-15-L2-01
Trace Heating - Process
Lines - Feeeder 2
(CI Lines)
(3G6 sqmm)

ETB-200N1-16-L3-01
Trace Heating - Process
Lines - Feeeder 3
(DM Line)
(3G6 sqmm)

ETB-200N1-17-L1-01
Trace Heating - Process
Lines - Feeeder 4
(WW Lines)
(3G6 sqmm)

ETB-200N1-18-L2-01
Trace Heating - Process
Lines - Feeeder 5
(Vassel Ko Drum)
(3G6 sqmm)

ETB-200N1-19-L3-01
Trace Heating - Process
Lines - Feeeder 6
(H2 Vent)
(3G6 sqmm)

ETB-200N1-20-L1-01
Trace Heating - Process -
Lines - Feeeder 7
(Sea Water Pumps)
(3G6 sqmm)

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/33
Item n° : PF1002888/101

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 1.0

REV. 03

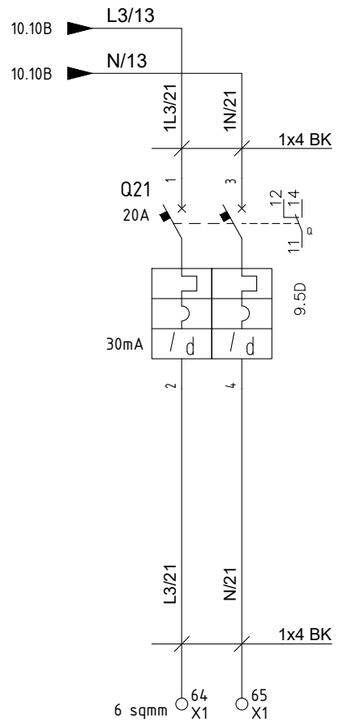
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03

~ 230/400V-50Hz-25kA-63A

10.10A L1 → L1 12.1A
10.10A L2 → L2 12.1A
10.10A L3 → L3 12.1A
10.10A N → N 12.1A

~ 230/400V-50Hz-25kA-50A




Spare
Trace Heating -
SPARE

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/33
Item n° : PF1002888/101

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

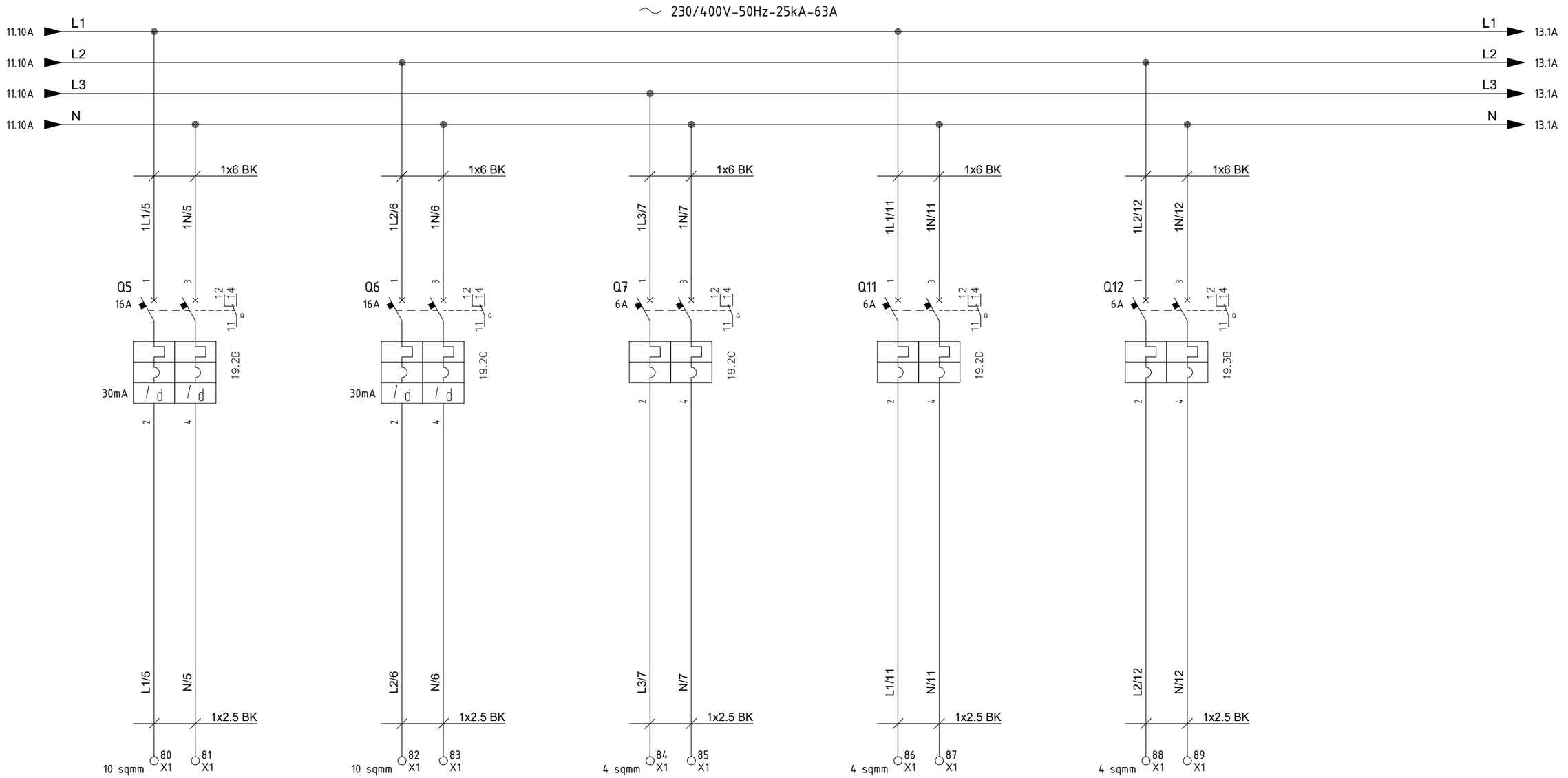
DRAWING NO. 1723002197-EL-DG-00033

SHEET 1.1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03




ESO-200N1-05-L1-01
Small Power Socket
(Upper Deck)
3G10 sqmm

ESO-200N1-06-L2-01
Small Power Socket
(Lower Deck)
3G10 sqmm

Spare

ESH-200N1-11-L1-01
Space heater JB - Wind
farm subsea cable
(3G2.5 sqmm)

ESH-200N1-12-L2-01
Space heater JB - Solar
subsea cable
(3G2.5 sqmm)

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231298/SD/33
Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

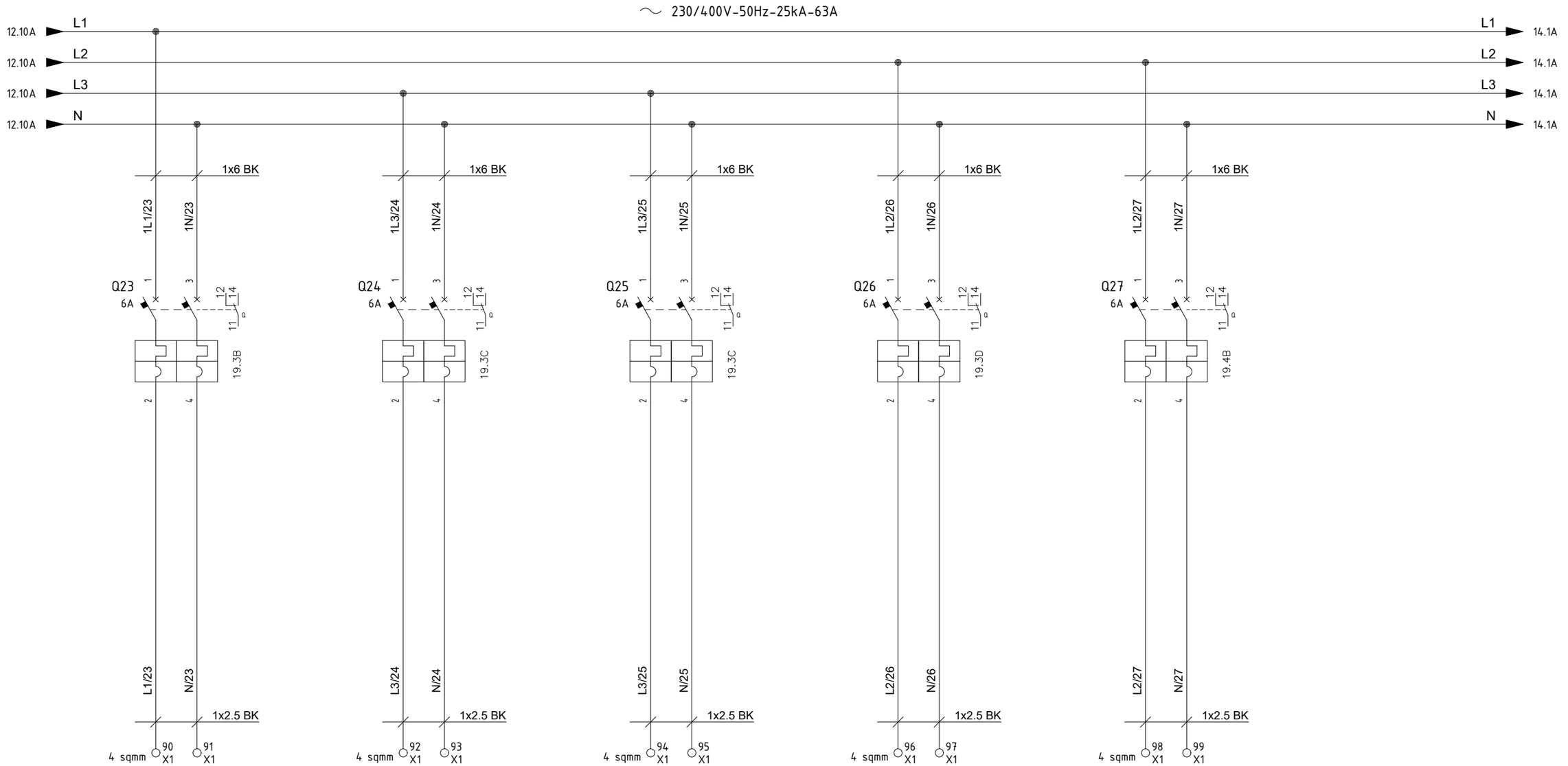
DRAWING NO. 1723002197-EL-DG-00033

SHEET 12

REV. 03

File Name : 1723002197-EL-DG-00033 Rev. 03

F.to UNI A3: 420mmx297mm




B400-SIS-001
SIS - Controller and I/O Cabinet - Auxiliary
(3G2.5 sqmm)

B400-PCS-001
PCS - Controller and I/O Cabinet - Auxiliary
(3G2.5 sqmm)

B400-EMCS-001
EMCS - Controller and I/O Cabinet - Auxiliary
(3G2.5 sqmm)

B400-FGS-001
FGS Fire & Gas Panel - Auxiliary
(3G2.5 sqmm)

B400-NET-001
System Server / Network Cabinet - Auxiliary
(3G2.5 sqmm)

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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/33
Item n° : PF1002888/101

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

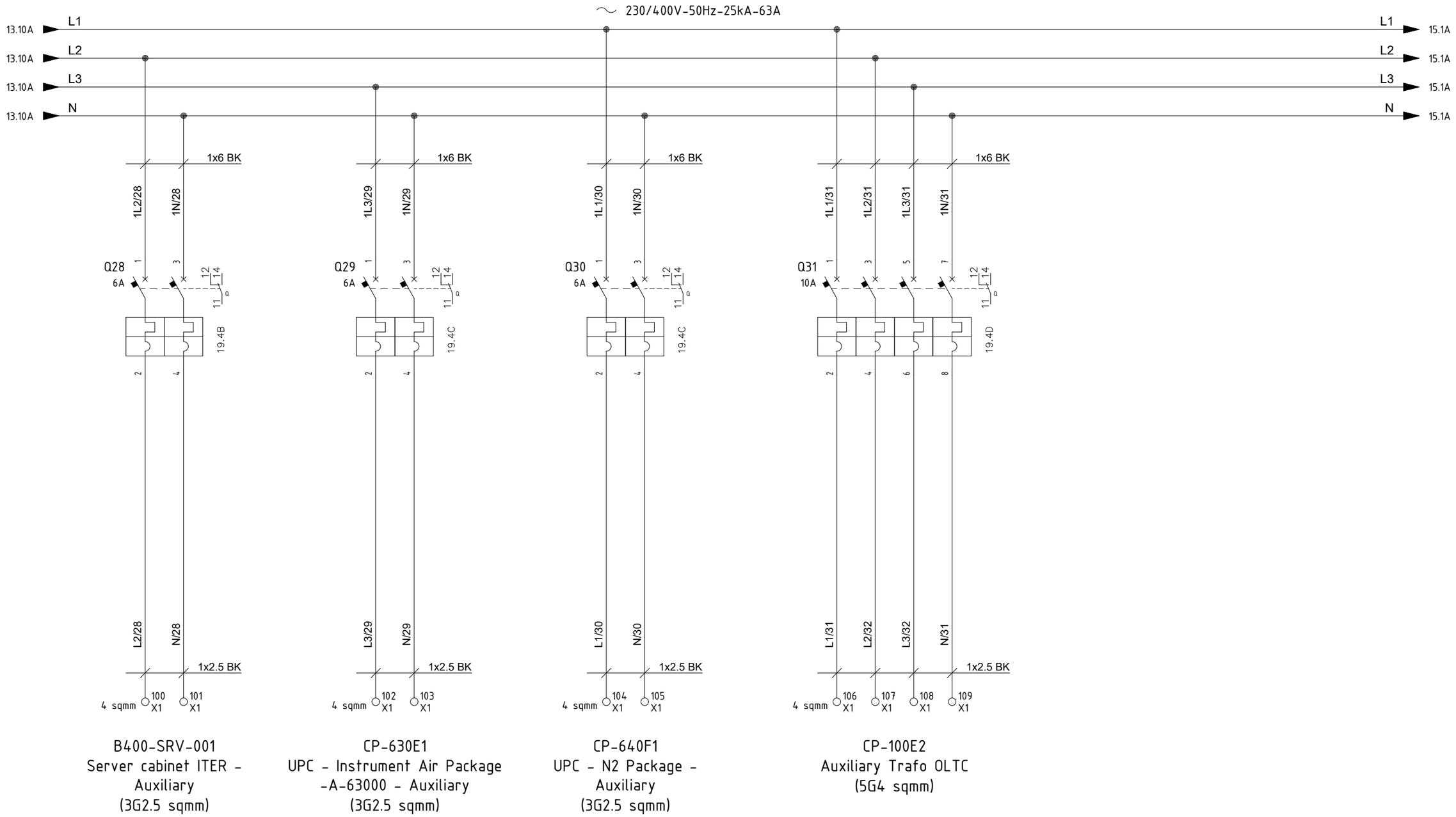
DRAWING NO. 1723002197-EL-DG-00033

SHEET 13

REV. 03

File Name : 1723002197-EL-DG-00033 Rev. 03

F.to UNI A3: 420mmx297mm




B400-SRV-001
Server cabinet ITER - Auxiliary
(3G2.5 sqmm)

CP-630E1
UPC - Instrument Air Package -A-63000 - Auxiliary
(3G2.5 sqmm)

CP-640F1
UPC - N2 Package - Auxiliary
(3G2.5 sqmm)

CP-100E2
Auxiliary Trafo OLTC
(5G4 sqmm)

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

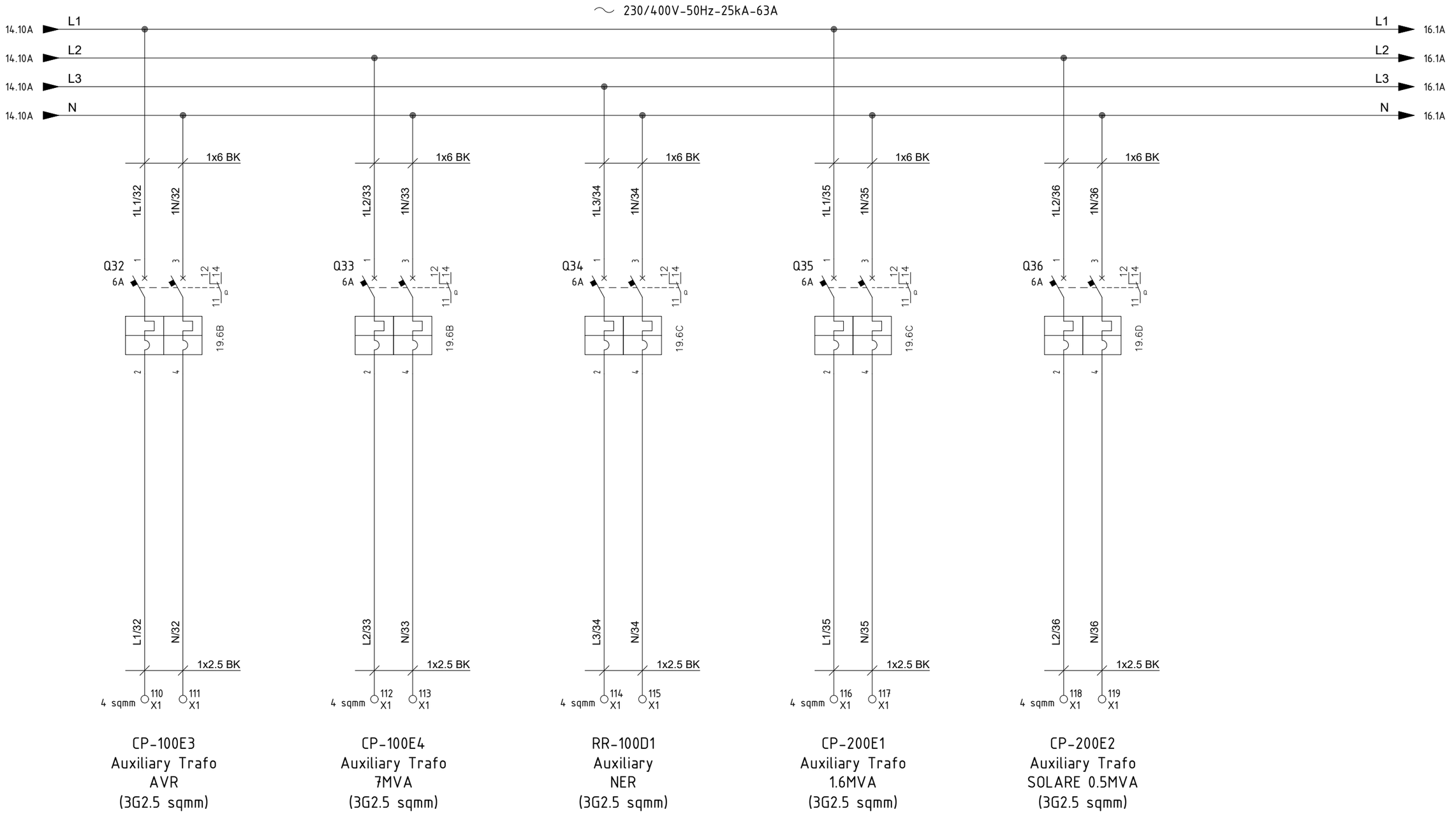
DRAWING NO. 1723002197-EL-DG-00033

SHEET 1.4

REV. 03

File Name : 1723002197-EL-DG-00033 Rev. 03

F.to UNI A3: 420mmx297mm




CP-100E3
Auxiliary Trafo
AVR
(3G2.5 sqmm)

CP-100E4
Auxiliary Trafo
7MVA
(3G2.5 sqmm)

RR-100D1
Auxiliary
NER
(3G2.5 sqmm)

CP-200E1
Auxiliary Trafo
1.6MVA
(3G2.5 sqmm)

CP-200E2
Auxiliary Trafo
SOLARE 0.5MVA
(3G2.5 sqmm)

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DWG n° : 231298/SD/33
Item n° : PF1002888/101

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

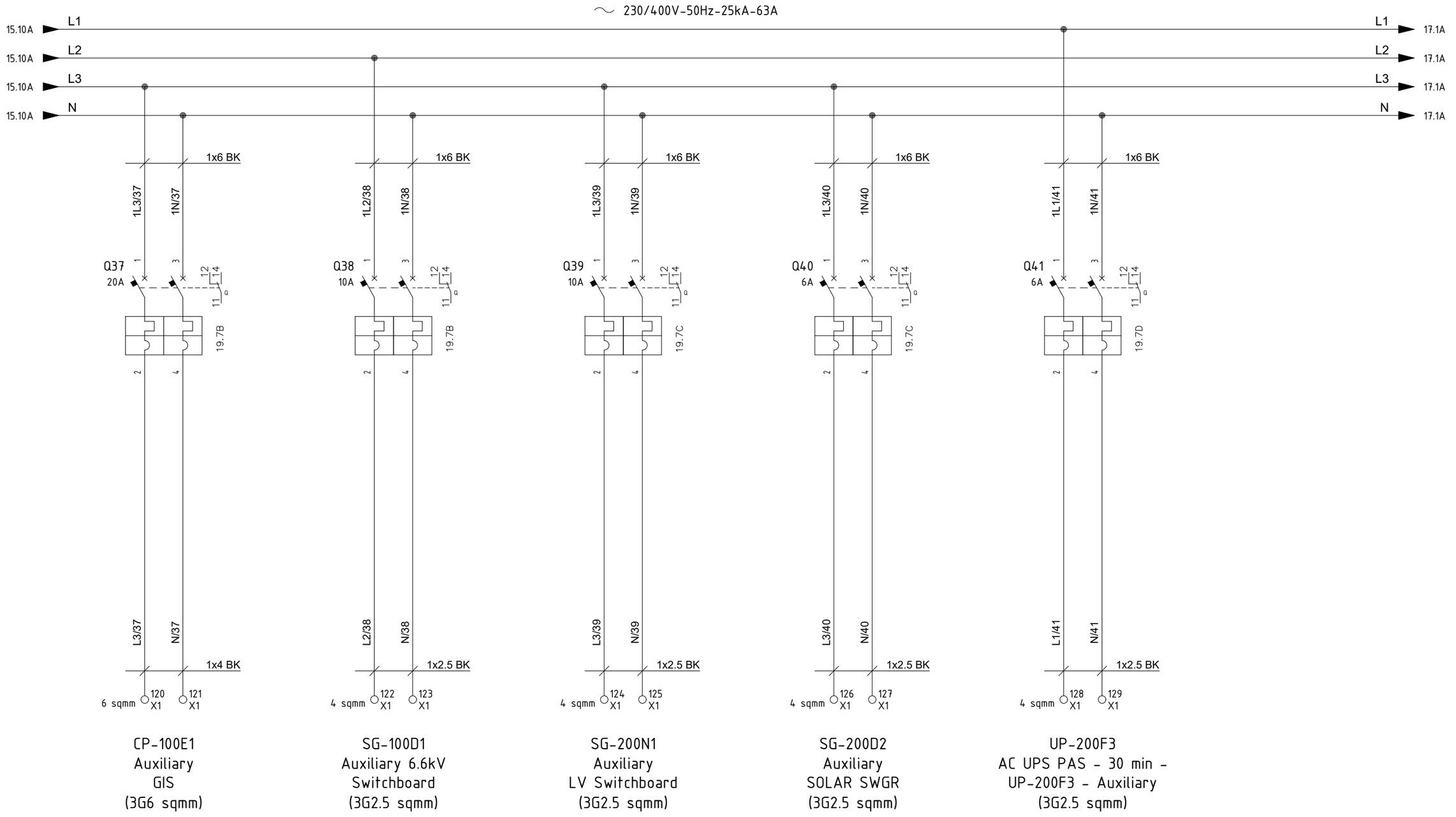
DRAWING NO. 1723002197-EL-DG-00033

SHEET 15

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03




CP-100E1
Auxiliary
GIS
(3G6 sqmm)

SG-100D1
Auxiliary 6.6kV
Switchboard
(3G2.5 sqmm)

SG-200N1
Auxiliary
LV Switchboard
(3G2.5 sqmm)

SG-200D2
Auxiliary
SOLAR SWGR
(3G2.5 sqmm)

UP-200F3
AC UPS PAS - 30 min -
UP-200F3 - Auxiliary
(3G2.5 sqmm)

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231298/SD/33
Item n° : PF1002888/101

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

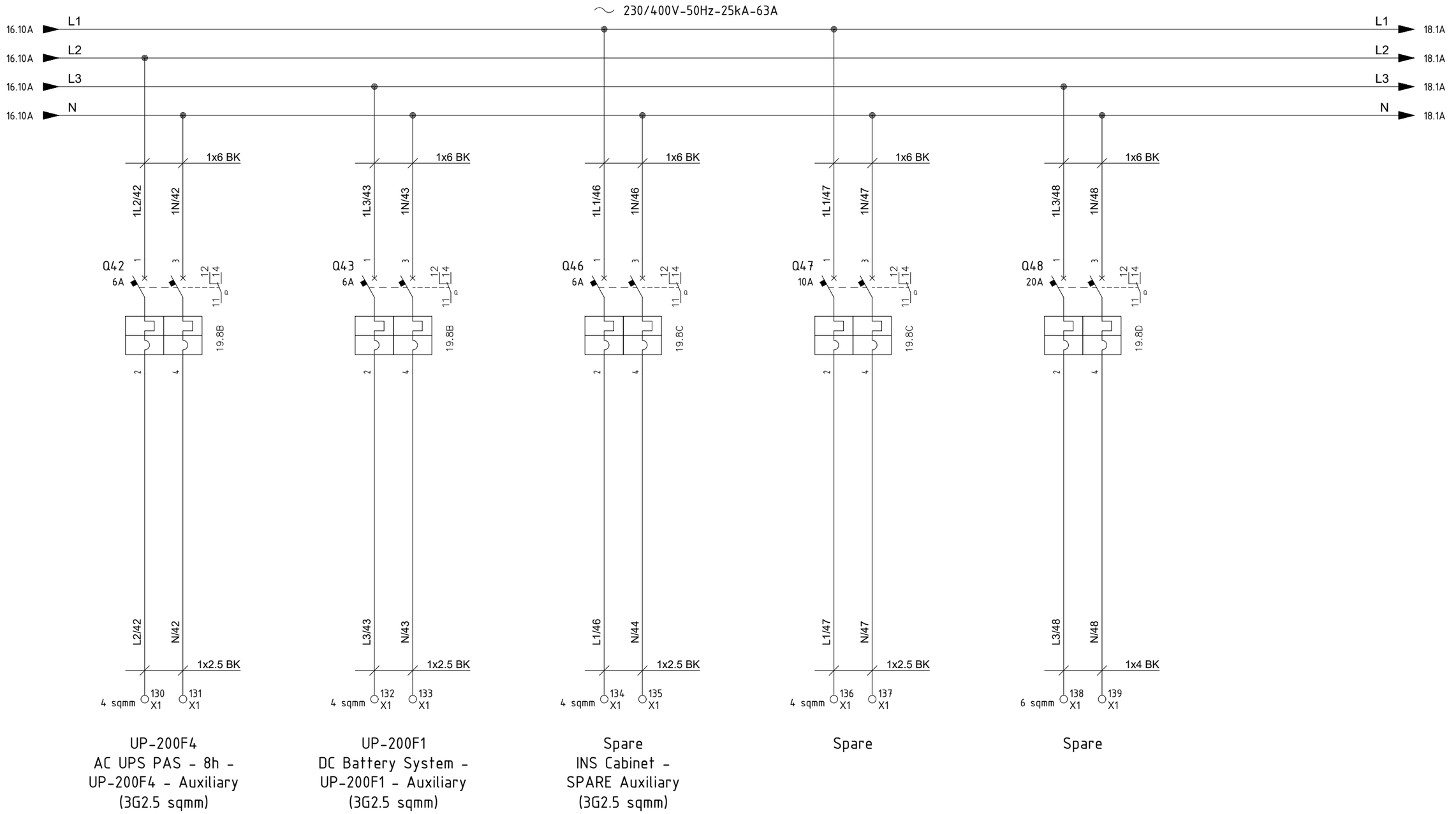
DRAWING NO. 1723002197-EL-DG-00033

SHEET 1.6

REV. 03

File Name : 1723002197-EL-DG-00033 Rev. 03

F.to UNI A3: 420mmx297mm




UP-200F4
AC UPS PAS - 8h -
UP-200F4 - Auxiliary
(3G2.5 sqmm)

UP-200F1
DC Battery System -
UP-200F1 - Auxiliary
(3G2.5 sqmm)

Spare
INS Cabinet -
SPARE Auxiliary
(3G2.5 sqmm)

Spare

Spare

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
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| 2 | 19/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 0 | 29/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/33
Item n° : PF1002888/101

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

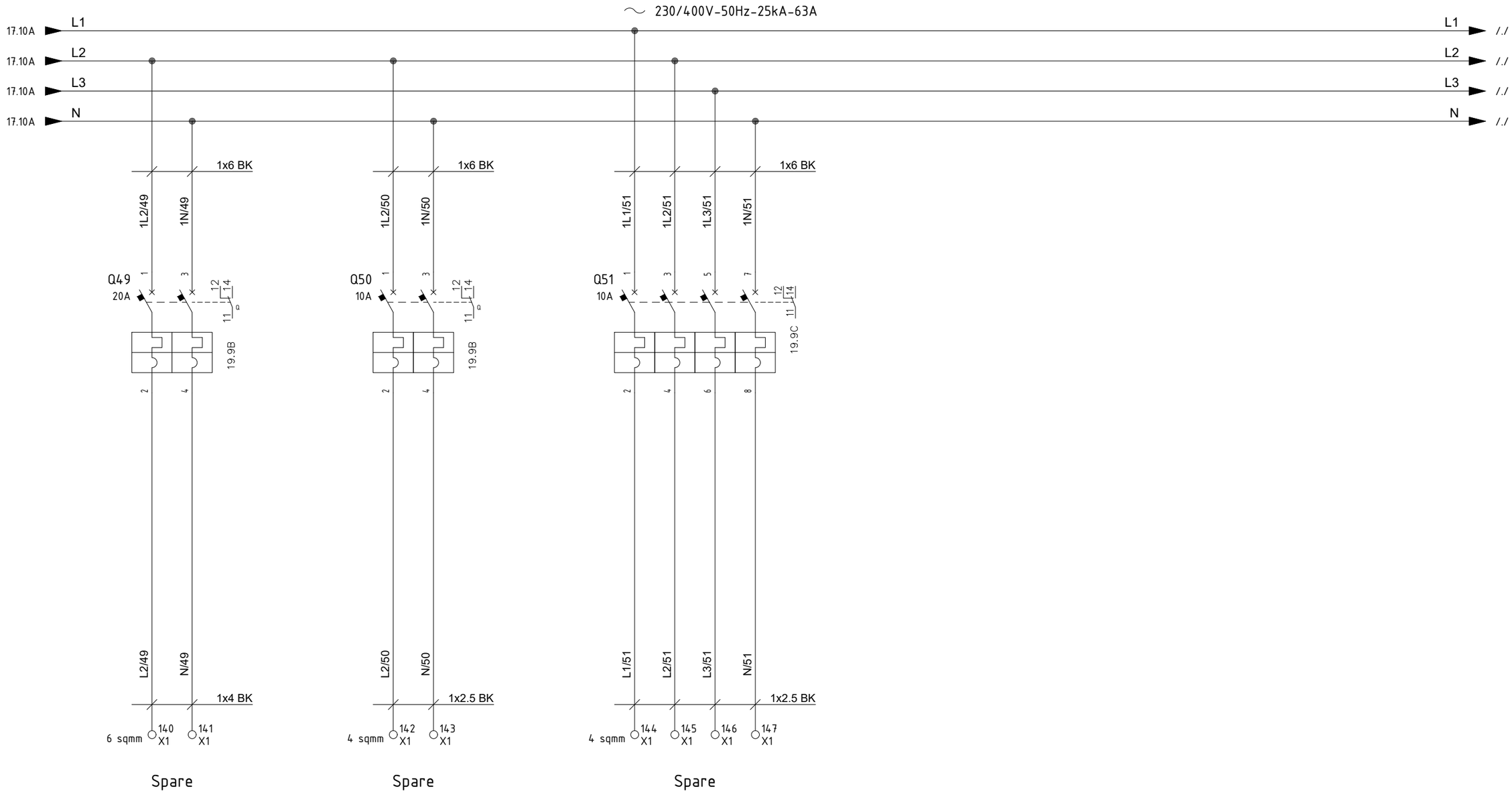
DRAWING NO. 1723002197-EL-DG-00033

SHEET 17

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twiligh Switch TW1 |
| 2 | 19/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 0 | 29/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/33
Item n° : PF1002888/101

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

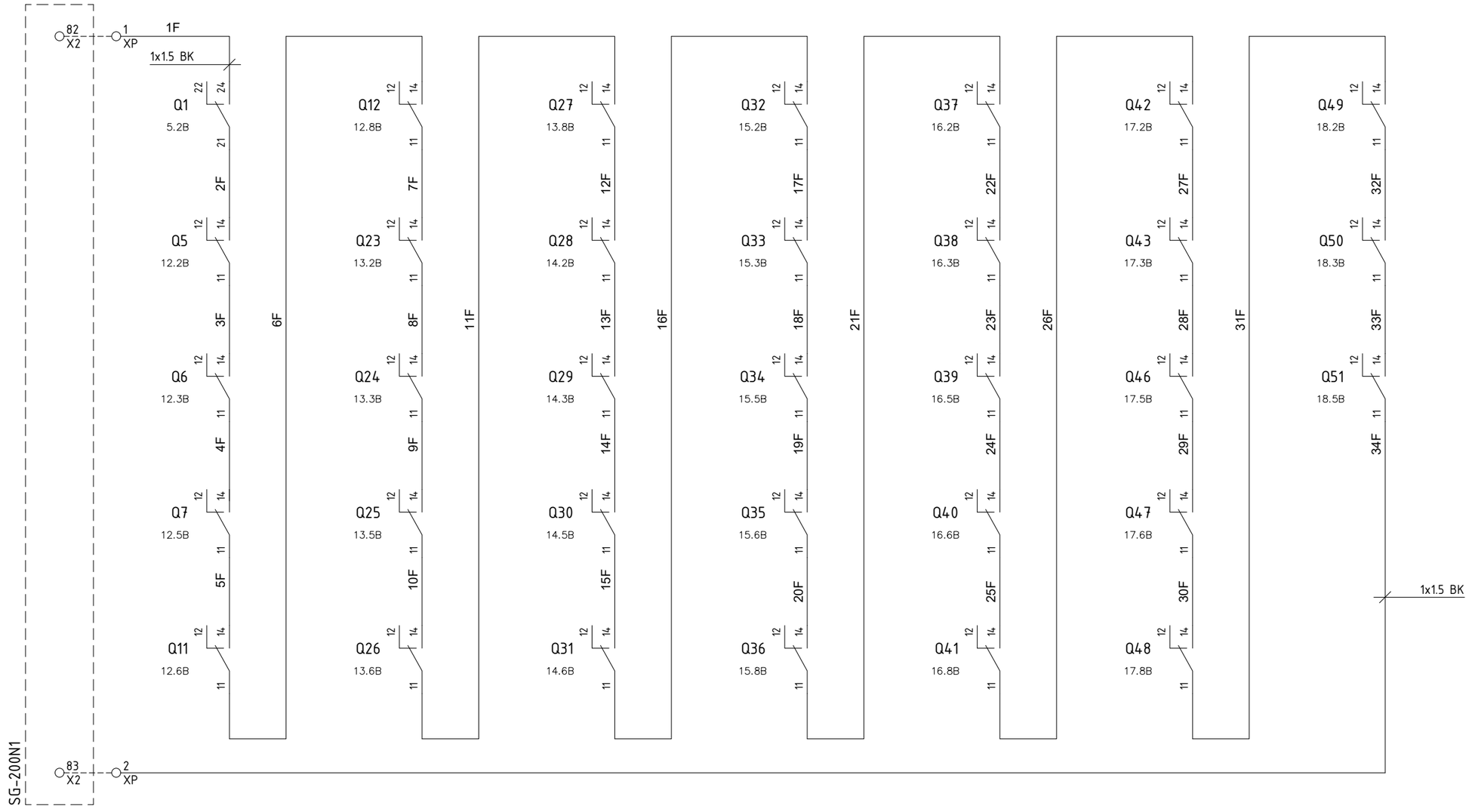
SHEET 18

REV. 03

File Name : 1723002197-EL-DG-00033 Rev. 03

F.to UNI A3: 420mmx297mm

# MAIN AND UTILITIES PROTECTION BREAKERS CLOSED REMOTE SIGNALLING
# (EXCLUDING: SURGE ARRESTERS SWITCH, LIGHTING UTILITIES PROT. BREAKERS, TRACE HEATING MAIN PROT. BREAKER AND RELATIVE SINGLE UTILITIES PROT. BREAKERS)




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twiligh Switch TW1 |
| 2 | 19/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 0 | 29/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/33

Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"

LV SWBD FUNCTIONAL DIAGRAMS

Functional Drawing

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 19

REV. 03

File Name : 1723002197-EL-DG-00033 Rev. 03

F.to UNI A3: 420mmx297mm

DP-200N1 - DP-200N1
X1
POWER UTILITY BLOCK

| NumM | Fg. | Sez. | Tipo | Descrizione | Costruttore |
|---|---|---|---|---|---|
| 1 | 005.2A | 16 | CB510 | CBD.16 Feed-through terminal ATEX CQ403 | Cabur |
| 2 | 005.2A | 16 | CB510 | CBD.16 Feed-through terminal ATEX CQ403 | Cabur |
| 3 | 005.2A | 16 | CB510 | CBD.16 Feed-through terminal ATEX CQ403 | Cabur |
| 4 | 005.3A | 16 | CB510 | CBD.16 Feed-through terminal ATEX CQ403 | Cabur |
| 10 | 007.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 11 | 007.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 12 | 007.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 13 | 007.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 14 | 007.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 15 | 007.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 16 | 007.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 17 | 007.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 30 | 007.8D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 31 | 007.8D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 32 | 007.8D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 33 | 008.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 34 | 008.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 35 | 008.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 36 | 008.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 37 | 008.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 38 | 008.4D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 39 | 008.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 40 | 008.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 41 | 008.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 50 | 009.8D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 51 | 009.9D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 52 | 010.1D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 53 | 010.2D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 54 | 010.3D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 55 | 010.3D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 56 | 010.4D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 57 | 010.5D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 58 | 010.6D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 59 | 010.6D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 60 | 010.7D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 61 | 010.8D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |

DP-200N1 - DP-200N1
X1
POWER UTILITY BLOCK

| NumM | Fg. | Sez. | Tipo | Descrizione | Costruttore |
|---|---|---|---|---|---|
| 62 | 010.9D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 63 | 010.9D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 64 | 011.1D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 65 | 011.2D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 80 | 012.2D | 10 | CB440 | CBD.10 Feed-through terminal ATEX CQ403 | Cabur |
| 81 | 012.2D | 10 | CB440 | CBD.10 Feed-through terminal ATEX CQ403 | Cabur |
| 82 | 012.3D | 10 | CB440 | CBD.10 Feed-through terminal ATEX CQ403 | Cabur |
| 83 | 012.3D | 10 | CB440 | CBD.10 Feed-through terminal ATEX CQ403 | Cabur |
| 84 | 012.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 85 | 012.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 86 | 012.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 87 | 012.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 88 | 012.8D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 89 | 012.8D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 90 | 013.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 91 | 013.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 92 | 013.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 93 | 013.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 94 | 013.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 95 | 013.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 96 | 013.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 97 | 013.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 98 | 013.8D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 99 | 013.8D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 100 | 014.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 101 | 014.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 102 | 014.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 103 | 014.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 104 | 014.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 105 | 014.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 106 | 014.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 107 | 014.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 108 | 014.7D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 109 | 014.7D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 110 | 015.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 111 | 015.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twiligh Switch TW1 |
| 2 | 19/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 0 | 29/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/33
Item n° : PF1002888/101

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Power Teminal Block

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00033 | SHEET 20 | REV. 03

File Name : 1723002197-EL-DG-00033 Rev. 03

F.to UNI A3: 420mmx297mm

DP-200N1 - DP-200N1

X1

POWER UTILITY BLOCK

| NumM | Fg. | Sez. | Tipo | Descrizione | Costruttore |
|---|---|---|---|---|---|
| 112 | 015.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 113 | 015.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 114 | 015.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 115 | 015.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 116 | 015.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 117 | 015.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 118 | 015.8D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 119 | 015.8D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 120 | 016.2D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 121 | 016.2D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 122 | 016.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 123 | 016.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 124 | 016.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 125 | 016.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 126 | 016.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 127 | 016.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 128 | 016.8D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 129 | 016.8D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 130 | 017.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 131 | 017.2D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 132 | 017.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 133 | 017.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 134 | 017.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 135 | 017.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 136 | 017.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 137 | 017.6D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 138 | 017.8D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 139 | 017.8D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 140 | 018.2D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 141 | 018.2D | 6 | CB340 | CBD.6 Feed-through terminal ATEX CQ403 | Cabur |
| 142 | 018.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 143 | 018.3D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 144 | 018.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 145 | 018.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 146 | 018.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |
| 147 | 018.5D | 4 | CB240 | CBD.4 Feed-through terminal ATEX CQ403 | Cabur |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twiligh Switch TW1 |
| 2 | 19/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 0 | 29/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/33

Item n° : PF1002888/101

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"

LV SWBD FUNCTIONAL DIAGRAMS

Power Teminal Block

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 21

REV. 03

File Name : 1723002197-EL-DG-00033 Rev. 03

F.to UNI A3: 420mmx297mm

DP-200N1 - DP-200N1
XS
SURGE ARRESTER AUX. BLOCK

| NumM | Fg. | Sez. | Tipo | Descrizione | Costruttore |
|---|---|---|---|---|---|
| 1 | 5.6C | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 2 | 5.9D | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |

DP-200N1 - DP-200N1
XP
POWER UTILITY READY BLOCK

| NumM | Fg. | Sez. | Tipo | Descrizione | Costruttore |
|---|---|---|---|---|---|
| 1 | 19.2A | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 2 | 19.9D | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |

DP-200N1 - DP-200N1
XT
NORM. & EMERG. LIGHTING AUX. BLOCK

| NumM | Fg. | Sez. | Tipo | Descrizione | Costruttore |
|---|---|---|---|---|---|
| 1 | 6.3D | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 2 | 6.3D | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 3 | 6.4C | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 4 | 6.5C | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 5 | 6.7B | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 6 | 6.10B | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 7 | 6.7C | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 8 | 6.10C | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |

DP-200N1 - DP-200N1
XH
TRACE HEATING AUX. BLOCK

| NumM | Fg. | Sez. | Tipo | Descrizione | Costruttore |
|---|---|---|---|---|---|
| 1 | 9.4B | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 2 | 9.5B | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 3 | 9.5B | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 4 | 9.6B | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 5 | 9.3D | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 6 | 9.3D | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 7 | 9.4C | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |
| 8 | 9.6D | 4 | HM250GR | HMM.4/GR Feed-through Terminal Block - Grey (4 mmq) - spring type | Cabur |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

DWG n° : 231298/SD/33
Item n° : PF1002888/101

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twiligh Switch TW1 |
| 2 | 19/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 0 | 29/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Auxiliary Terminal Blocks

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 22

REV. 03

File Name : 1723002197-EL-DG-00033 Rev. 03

F.to UNI A3: 420mmx297mm

| Nome/Item | Tipo/Type | Descrizione/Description | Costruttore/Manufacturer | Fg/Sh | Q.ta/Q.ty |
|---|---|---|---|---|---|
| F1 | 961205 | LV SURGE ARRESTER DVCI 1 255 FM Uc=255V Tipo 1+Tipo 2 / Classe I + Classe II | DEHN | 5 | 1 |
| F2 | 961205 | LV SURGE ARRESTER DVCI 1 255 FM Uc=255V Tipo 1+Tipo 2 / Classe I + Classe II | DEHN | 5 | 1 |
| F3 | 961205 | LV SURGE ARRESTER DVCI 1 255 FM Uc=255V Tipo 1+Tipo 2 / Classe I + Classe II | DEHN | 5 | 1 |
| FN | 961205 | LV SURGE ARRESTER DVCI 1 255 FM Uc=255V Tipo 1+Tipo 2 / Classe I + Classe II | DEHN | 5 | 1 |
| K13 | ESB6340N06 | ESB 63-40N-06 230V AC/DC MODULAR CONTACTOR | ABB | 9 | 1 |
| | EH0411N | EH04-11N AUXILIARY CONTACTS 1NO+1NC | ABB | | 1 |
| KL2 | ESB4020N06 | ESB40-20-N06 230V AC/DC MODULAR CONTACTOR | ABB | 6 | 1 |
| | EH0411N | EH04-11N CONTATTI AUSILIARI 1NA+1NC | ABB | | 1 |
| KL3 | ESB4020N06 | ESB40-20-N06 230V AC/DC MODULAR CONTACTOR | ABB | 6 | 1 |
| | EH0411N | EH04-11N CONTATTI AUSILIARI 1NA+1NC | ABB | | 1 |
| KL4 | ESB4020N06 | ESB40-20-N06 230V AC/DC MODULAR CONTACTOR | ABB | 6 | 1 |
| | EH0411N | EH04-11N CONTATTI AUSILIARI 1NA+1NC | ABB | | 1 |
| KL8 | ESB4020N06 | ESB40-20-N06 230V AC/DC MODULAR CONTACTOR | ABB | 6 | 1 |
| | EH0411N | EH04-11N CONTATTI AUSILIARI 1NA+1NC | ABB | | 1 |
| KL9 | ESB4020N06 | ESB40-20-N06 230V AC/DC MODULAR CONTACTOR | ABB | 6 | 1 |
| | EH0411N | EH04-11N CONTATTI AUSILIARI 1NA+1NC | ABB | | 1 |
| KL10 | ESB4020N06 | ESB40-20-N06 230V AC/DC MODULAR CONTACTOR | ABB | 6 | 1 |
| | EH0411N | EH04-11N CONTATTI AUSILIARI 1NA+1NC | ABB | | 1 |
| KL44 | ESB4020N06 | ESB40-20-N06 230V AC/DC MODULAR CONTACTOR | ABB | 6 | 1 |
| | EH0411N | EH04-11N CONTATTI AUSILIARI 1NA+1NC | ABB | | 1 |
| KL45 | ESB4020N06 | ESB40-20-N06 230V AC/DC MODULAR CONTACTOR | ABB | 6 | 1 |
| | EH0411N | EH04-11N CONTATTI AUSILIARI 1NA+1NC | ABB | | 1 |
| KT1 | ESB1620N06 | ESB16-20-N06 230VAC/DC MODULAR CONTACTOR | ABB | 6 | 1 |
| Q1 | XT2N63LSI4 | XT2N 160 Ekip LSI In=63A 4p F F | ABB | 5 | 1 |
| | 1SDA066433R1 | AUX-C 2Q+1SY 250Vac/dc XT1..XT4 F/P | ABB | | 1 |
| Q2 | S302PC16 | S302P C16 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 7 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q3 | S302PC16 | S302P C16 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 7 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q4 | S302PC16 | S302P C16 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 7 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q5 | S302PC16 | S302P C16 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 12 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q6 | S302PC16 | S302P C16 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 12 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q7 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 12 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twiligh Switch TW1 |
| 2 | 19/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 0 | 29/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/33
Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Material List

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 23

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03

| Nome/Item | Tipo/Type | Descrizione/Description | Costruttore/Manufacturer | Fg/Sh | Q.ta/Q.ty |
|---|---|---|---|---|---|
| Q8 | S302PD16 | S302P D16 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 7 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q9 | S302PD16 | S302P D16 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 8 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q10 | S302PD16 | S302P D16 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 8 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q11 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 12 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q12 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 12 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q13 | S120471 | S804N-C50 AUTOMATIC CIRCUIT-BREAKER 36KA 4P | ABB | 9 | 1 |
| | A120680 | S800-AUX AUSILIARY CONTACT | ABB | | 1 |
| Q14 | S302PC20 | S302P C20 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 9 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q15 | S302PC20 | S302P C20 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 10 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q16 | S302PC20 | S302P C20 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 10 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q17 | S302PC20 | S302P C20 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 10 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q18 | S302PC20 | S302P C20 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 10 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q19 | S302PC20 | S302P C20 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 10 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q20 | S302PC20 | S302P C20 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 10 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q21 | S302PC20 | S302P C20 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 11 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q23 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 13 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q24 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 13 | 1 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twiligh Switch TW1 |
| 2 | 19/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 0 | 29/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231298/SD/33

Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"

LV SWBD FUNCTIONAL DIAGRAMS

Material List

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 24

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03

| Nome/Item | Tipo/Type | Descrizione/Description | Costruttore/Manufacturer | Fg/Sh | Q.ta/Q.ty |
|---|---|---|---|---|---|
| Q24 | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | 13 | 1 |
| Q25 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 13 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q26 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 13 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q27 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 13 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q28 | S302PC6 | S302P C 6 INTERRUTTORE AUTOMATICO 25KA 2P | ABB | 14 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q29 | S302PC6 | S302P C 6 INTERRUTTORE AUTOMATICO 25KA 2P | ABB | 14 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q30 | S302PC6 | S302P C 6 INTERRUTTORE AUTOMATICO 25KA 2P | ABB | 14 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q31 | S304PC10 | S304P C10 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 14 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q32 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 15 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q33 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 15 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q34 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 15 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q35 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 15 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q36 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 15 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q37 | S302PC20 | S302P C20 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 16 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q38 | S302PC10 | S302P C10 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 16 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q39 | S302PC10 | S302P C10 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 16 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q40 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 16 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q41 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 16 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q42 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 17 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q43 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 17 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q44 | S302PC16 | S302P C16 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 7 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| + | | | | | |
| 3 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twiligh Switch TW1 |
| 2 | 19/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 0 | 29/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/33
Item n° : PF1002888/101

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Material List

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 25

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03

| Nome/Item | Tipo/Type | Descrizione/Description | Costruttore/Manufacturer | Fg/Sh | Q.ta/Q.ty |
|---|---|---|---|---|---|
| Q45 | S302PD16 | S302P D16 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 8 | 1 |
| | B427911 | DDA202 AC 25A 30MA RCD BLOCK 2P | ABB | | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q46 | S302PC6 | S302P C 6 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 17 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q47 | S302PC10 | S302P C10 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 17 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q48 | S302PC20 | S302P C20 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 17 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q49 | S302PC20 | S302P C20 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 18 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q50 | S302PC10 | S302P C10 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 18 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| Q51 | S304PC10 | S304P C10 AUTOMATIC CIRCUIT-BRAKER 25KA 2P | ABB | 18 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| QH1 | S302PC1 | S302P C 1 AUTOMATIC CIRCUIT-BREAKER 25KA 2P | ABB | 9 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| QS1 | M646307 | E204/100R INTERRUTTORE-SEZIONATORE 4P 100A | ABB | 5 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| QT1 | S302PC1 | S302P C 1 INTERRUTTORE AUTOMATICO 25KA 2P | ABB | 6 | 1 |
| | A563826 | S2-CH6R AUXILIARY CONTACT 1CO | ABB | | 1 |
| SA1 | M093878 | E218-16-22 SWITCH 2NO+2NC 16A | ABB | 6 | 1 |
| TW1 | 11.31.0.230.0000 | TWILIGHT SWITCH (1-100 LUX) 110-230VAC/DC + EXTERNAL SENSOR (IP66) 011.03 | Finder | 6 | 1 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + | | | | | |
| 3 | 12/03/2025 | Santinelli | Flamminio | Sigismondi | Replaced Twiligh Switch TW1 |
| 2 | 19/08/2024 | Santinelli | Flamminio | Sigismondi | As Built (ASB) |
| 1 | 05/07/2024 | Santinelli | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 0 | 29/05/2024 | Santinelli | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231298/SD/33
Item n° : PF1002888/101

CROSSWIND

ROSETTI MARINO

TITLE : "DP-200N1"
LV SWBD FUNCTIONAL DIAGRAMS
Material List

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00033

SHEET 26

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00033 Rev. 03

1.5. Logic Diagram

1.5.1.SG-100D1 HV SWG LOGIC DIAGRAM - INCOMING FEEDER,

Doc. No. 1723002197-EL-DG-00023

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# "SG-100D1" HV SWBD 6,6kV (UNIT A6)

# LOGICAL DIAGRAM

# INCOMING FEEDER TR-100AD1

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macula | 12/09/2024 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| + A6 | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 28/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 1 | 21/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

DWG n° : 231151/SD/23

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 – LOGICAL INCOMING FEEDER TR-100AD1

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00023

SHEET 1

REV. 03

F.to UNI A3: 420mmx297mm

Cover

File Name : 1723002197-EL-DG-00023 Rev.03

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| 4 | Input Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 5 | Output Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
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| 9 | C.B. Commands | | | | | | | | | | | | | | | | | | | | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 28/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 1 | 21/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A6

DWG n° : 231151/SD/23
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL INCOMING FEEDER TR-100AD1

Sheets index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

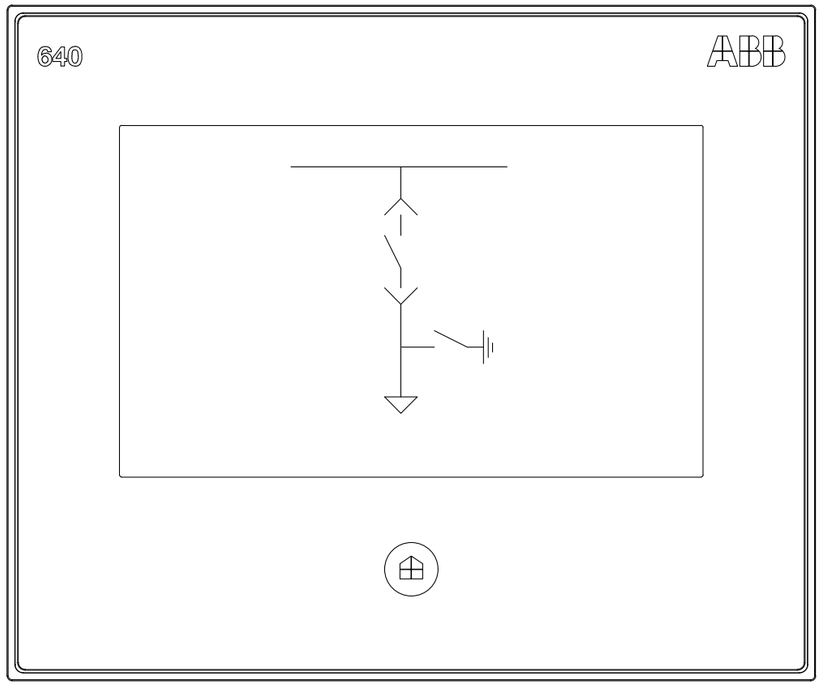
DRAWING NO. 1723002197-EL-DG-00023

SHEET 2

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00023 Rev.03




LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE C.B." AND "OPEN C.B." NON ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED
- ONLY PUSH BUTTON "RESET" ARC PROTECTION WILL BE ENABLED

| LED | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/27-2/59-1/59-2 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | C.B. READY (TCS) | - | GREEN | OK = TCS OK (C.B. READY) |
| LED-3 | SYNCHRO CHECK | - | GREEN | OK = SYNCHRONISM |
| LED-4 | C.B. READY TO CLOSE | - | GREEN | OK = C.B. READY TO CLOSE |
| LED-5 | 50-1/51-1 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/59N-1/59N-2 - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = CONTACTOR TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | SPRING DISCHARGED | RED | - | ALARM = C.B. SPRING DISCHARGED |

| LEDs PAGE 2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | - | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | | | | |
| LED-15 | | | | |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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+A6
DWG n° : 231151/SD/23
Item n° : PF1113279

CROSSWIND
IMESA ELECTRICAL ENGINEERING
ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL INCOMING FEEDER TR-100AD1
Input Protection Relay REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS
A3
DRAWING NO. 1723002197-EL-DG-00023
SHEET 3
REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00023 Rev.03

## INPUTS

| B–X1 | | |
|---|---|---|
| 1 | BI1 | C.B. CLOSED |
| 4 | | |
| 2 | BI2 | C.B. OPENED |
| 4 | | |
| 3 | BI3 | C.B. SERVICE POSITION |
| 4 | | |
| 5 | BI4 | C.B. TEST POSITION |
| 8 | | |
| 6 | BI5 | EARTH SWITCH OPENED |
| 8 | | |
| 7 | BI6 | EARTH SWITCH CLOSED |
| 8 | | |
| 9 | BI7 | RELAY TRIPPED |
| 12 | | |
| 10 | BI8 | C.B. SPRING DISCHARGED |
| 12 | | |
| 11 | BI9 | PROTECTION RELAY TRANSFORMER |
| 12 | | |
| 13 | BI10 | SELECTOR IN LOCAL POSITION |
| 16 | | |
| 14 | BI11 | SELECTOR IN REMOTE POSITION |
| 16 | | |
| 15 | BI12 | EXTERNAL CLOSING INTERLOCK |
| 16 | | |
| 17 | BI13 | CIRC.BREAKER OPENED (FROM 66kV SWITCHBOARD) |
| 18 | | |
| B–X2 | | |
| 1 | BI14 | UNLOCKING EARTHING SWITCH / TRUCK C.B. |
| 2 | | |

## INPUTS

| C–X1 | | |
|---|---|---|
| 1 | BI1 | TRANSF.TRIP OIL LEVEL INDICATOR |
| 4 | | |
| 2 | BI2 | V.T. HEALTY CIRCUIT |
| 4 | | |
| 3 | BI3 | EARTHING SWITCH OPEN (FROM MEASURING UNIT) |
| 4 | | |
| 5 | BI4 | CLOSED AUXILIARY CIRCUIT MCB's |
| 8 | | |
| 6 | BI5 | CLOSED AUXILIARY V.T. SECONDARY MCB's |
| 8 | | |
| 7 | BI6 | TRANSF. ALARM MEMBRANE CONTROL |
| 8 | | |
| 9 | BI7 | TRANSF. TRIP OIL LEVEL |
| 12 | | |
| 10 | BI8 | TRANSF. ALARM OIL TEMPERATURE |
| 12 | | |
| 11 | BI9 | TRANSF. TRIP OIL TEMPERATURE |
| 12 | | |
| 13 | BI10 | TRANSF. ALARM OIL LEVEL |
| 16 | | |
| 14 | BI11 | TRANSF. SELF DEHY-DRATING BREATHER ALARM |
| 16 | | |
| 15 | BI12 | TRANSF. TRIP OIL PRESSURE |
| 16 | | |
| 17 | BI13 | TRANSF. ALARM WINDING TEMPERATURE |
| 18 | | |
| B–X2 | | |
| 1 | BI14 | TRANSF. TRIP WINDING TEMPERATURE |
| 2 | | |

## INPUTS

| D–X1 | | |
|---|---|---|
| 1 | BI1 | LOCAL CLOSING COMMAND |
| 4 | | |
| 2 | BI2 | LOCAL OPENING COMMAND |
| 4 | | |
| 3 | BI3 | TRANSF. ALARM OIL LEVEL |
| 4 | | |
| 5 | BI4 | TR-100AD1 GENERAL ALARM |
| 8 | | |
| 6 | BI5 | SPACE HEATER "ON" |
| 8 | | |
| 7 | BI6 | SYNCHRONIZATION CLOSING COMMAND FROM BESS |
| 8 | | |
| 9 | BI7 | TRANSF. TRIP BUCHHOLZ |
| 12 | | |
| 10 | BI8 | RR-100D1 NER GENERAL ALARM |
| 12 | | |
| 11 | BI9 | TRANSF. ALARM BUCHHOLZ |
| 12 | | |

## ARC MODULE

| | | |
|---|---|---|
| LIGHT SENSOR INPUT 1 | Slot A1 X11 | ARC "MAIN BUS BAR" "BB" |
| LIGHT SENSOR INPUT 2 | Slot A1 X12 | ARC "C.B. COMPART." "CB" |
| LIGHT SENSOR INPUT 3 | Slot A1 X13 | ARC "CABLE COMPARTEMENT" "CC" |
| LIGHT SENSOR INPUT 4 | Slot A1 X14 | |

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DWG n° : 231151/SD/23
Item n° : PF1113279

CROSSWIND
IMESA ELECTRICAL ENGINEERING
ROSETTI MARINO

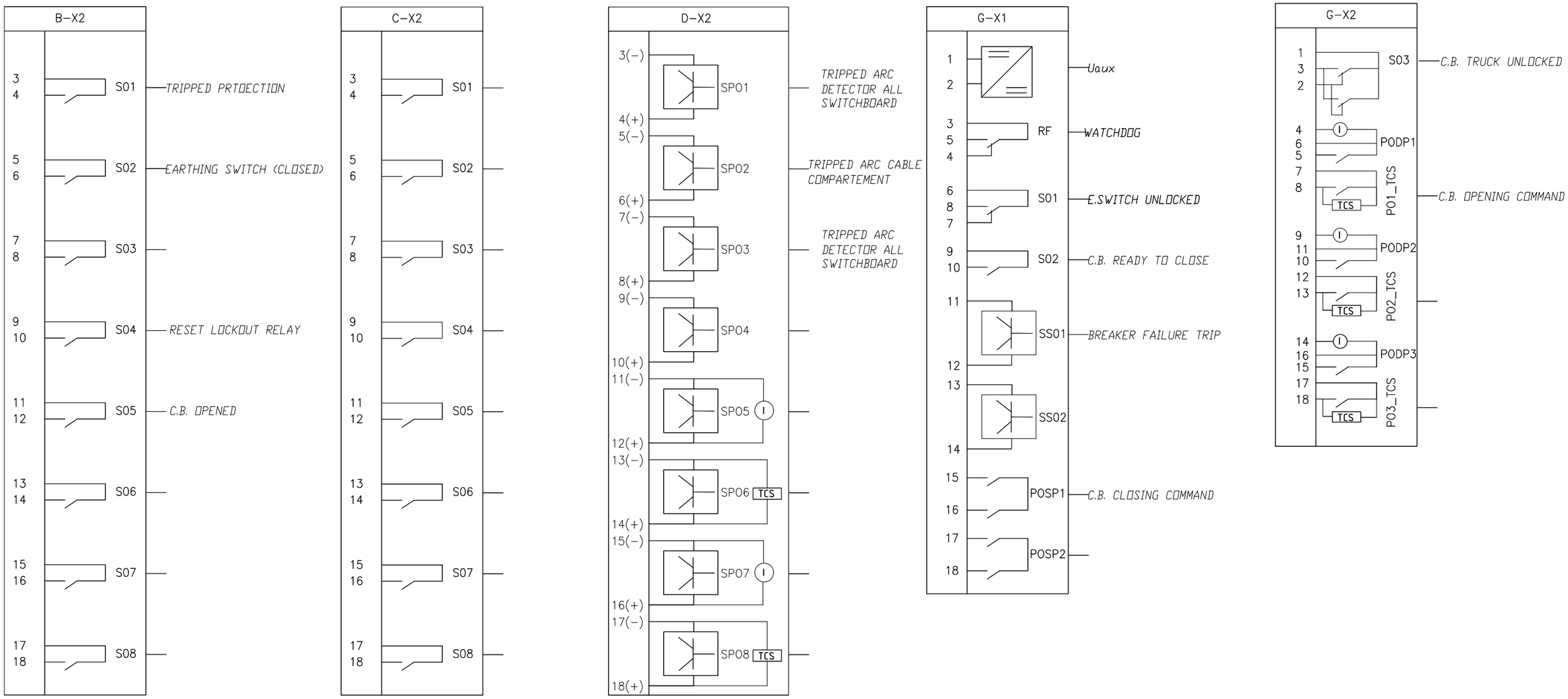
TITLE :
SG–100D1 – LOGICAL INCOMING FEEDER TR–100AD1
Input Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197–EL–DG–00023 | SHEET 4 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00023 Rev.03




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DWG n° : 231151/SD/23
Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :
SG–100D1 – LOGICAL INCOMING FEEDER TR–100AD1
Output Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00023

SHEET 5

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00023 Rev.03

# INPUTS

# PROTECTIONS REX640 (FP1)

# OUTPUTS

50-1 / 3I>>> / PHIPTOC1 (0 / 1 / Start)

TO EMCS IEC 61850 — *50-1 -PROTECTION OPERATED*

51-1 / 3I> / PHLPTOC1 (0 / 1 / Start)

TO EMCS IEC 61850 — *51-1 -PROTECTION OPERATED*

TO EMCS IEC 61850 — *51N PROTECTION OPERATED*

51N / Io> / EFLPTOC1 (0 / 1 / Start)

59N-2 / Vo> / ROVPTOV2 (0 / 1 / Start)

TO EMCS IEC 61850 — *59N-2 PROTECTION OPERATED*

t=0,5" &

RESET K86 → 9.5A

K86 → 7.5B

59N → 7.9A

LED-5 (RED)

LED-6 (RED)

PROTECTION → 8.6B

59 / 3U> / VMMXU2 (0 / 1 / Start)

Vn=0.9 t=1sec. (main bus bars)

TO EMCS IEC 61850 — *LIVE VOLTAGE ON THE MAIN BUS-BARS*

TO EMCS IEC 61850 — *INTERTRIP SEND (TO 66kV MSBD. SWITCHB.)*

B_S01-X2 → K86 (0 TRIPPED PROTECTION / 1)

D_SP02-X2 → FP1e "XM" (0 TRIPPED ARC CABLE COMPART. TO 66kV / 1)

INCOMING VOLTAGE

MAIN BUS BAR VOLTAGE

25 / SYNC / SECRSYN (0 / 1 / Start)

SYNCH OK → LED-3 (RED)

SYNCH OK → 7.4D

ONLY "LIGHT"

50L/50NL / ARC / ARCSARC1 (0 / 1 / Start) — ARC "MAIN BUS BAR" "BB"

ONLY "LIGHT"

50L/50NL / ARC / ARCSARC2 (0 / 1 / Start) — ARC "C.B. COMPART." "CB"

ONLY "LIGHT"

50L/50NL / ARC / ARCSARC3 (0 / 1 / Start) — ARC "CABLE COMPARTEMENT" "CC"

**GOOSE FROM FEEDERS:**

TRIPPED ARC PROTECTION FOR:

- ARC DETECTED ON MAIN BUS BAR (FROM ALL UNITS)
- ARC DETECTED ON C.B. / CONTACTOR COMPARTEMENT (FROM ALL UNITS)
- ARC DETECTED ON CABLE COMPARTEMENT (ONLY CONTACTOR UNIT)

t=1" ARC TRIP → 11.5D

ARC → 8.6B

D_SP01-X2 → FP1e "MB01" (0 TRIPPED ARC DETECTOR ALL SWITCH / 1)

D_SP03-X2 → FP1e "K86" (0 TRIPPED ARC DETECTOR ALL SWITCH / 1)

LED-9 (RED)

9.6A K86

TO EMCS IEC 61850 — *TRIPPED ARC CABLE COMPARTMENT (TO 66kV MSBD. SWITCHB.)*

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DWG n°: 231151/SD/23

Item n°: PF1113279

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TITLE :

SG-100D1 - LOGICAL INCOMING FEEDER TR-100AD1

Protections REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00023

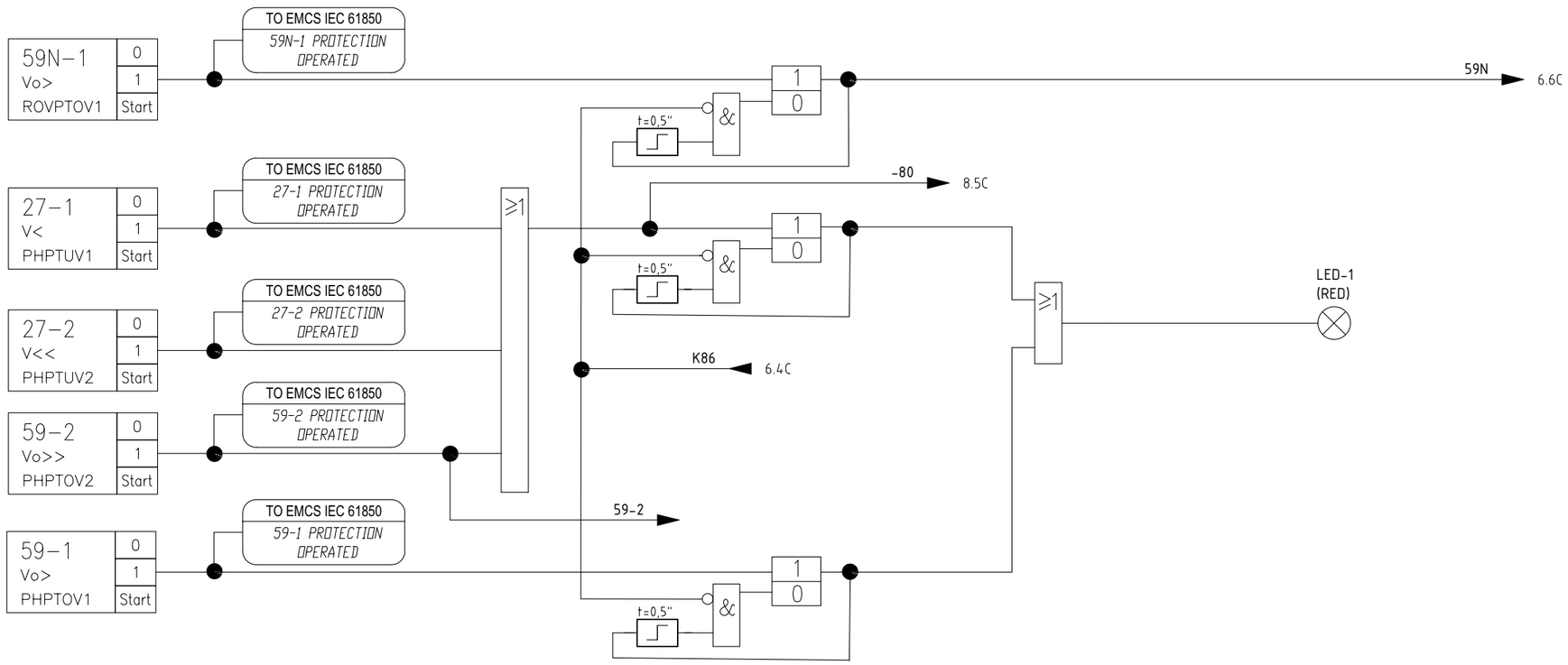
SHEET 6

REV. 03

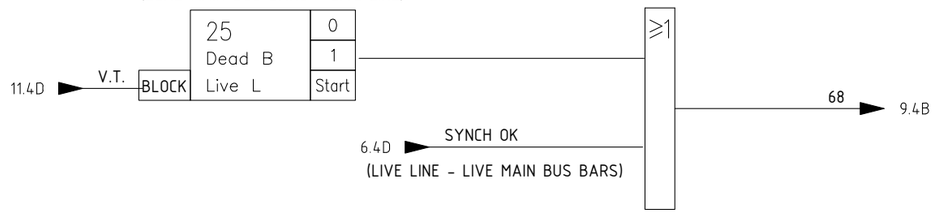
F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00023 Rev.03

| INPUTS | PROTECTIONS REX640 (FP1) | OUTPUTS |
|---|---|---|




(DEAD MAIN BUS BARS - LIVE LINE)




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/23
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL INCOMING FEEDER TR-100AD1
C.B. Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00023

SHEET 7

REV. 03

File Name : 1723002197-EL-DG-00023 Rev.03

F.to UNI A3: 420mmx297mm

# INPUTS

# REX640 C.B. COMMANDS

# OUTPUTS

S20 LOCAL OPENING COMMAND 0/1 → D-X1-2

K1 – BGT4 C.B. SERVICE 0/1 → B-X1-3

K1 – BGT5 C.B. TEST 0/1 → B-X1-5

XM SYNCHRONIZ. CLOSING COMMAND FROM BESS 0/1 → D-X1-7

XM FROM 66kV M.V.SWBD C.B. OPENED 0/1 → B-X1-17

IEC 61850 – EMCS OPENING 0/1

IEC 61850 – EMCS CLOSING 0/1

SA1 SELECTOR IN REMOTE POSITION 0/1 → B-X1-14

SA1 SELECTOR IN LOCAL POSITION 0/1 → B-X1-13

S1C LOCAL CLOSING COMMAND 0/1 → D-X1-1

KGR SPACE HEATER "ON" 0/1 → D-X1-6

LED-12 (RED)

TEST → 8.5D

REMOTE

REMOTE → 9.7B

LOCAL → 11.4B

TO EMCS IEC 61850 *SELECTOR IN REMOTE POSITION*

TO EMCS IEC 61850 *SELECTOR IN LOCAL POSITION*

INSERT. → 9.3D

INSERT. → 9.4C

INSERT.

INSERT.

-83 → 9.6D

-83 → 11.3C

INSERT.

7.6B → -80

LOCAL OPENING

REMOTE OPENING

6.9B → PROTECTION

9.5A → K86

6.8D → ARC

UNDERVOLTAGE

≥1

OPENING → 9.4C

G_PODP1-X2 → K1 0/1 C.B. OPENING

TO EMCS IEC 61850 *RESET LOCKOUT RELAY* → B_S04-X2 → FP1c 0/1 RESET LOCKOUT RELAY

SYNCHRONIZ. CLOSING FROM BESS

REMOTE CLOSING FROM IEC61850

LOCAL CLOSING

9.6B → READY

TEST LOCAL CLOSING

≥1

G_POSP1-X1 → K1 0/1 C.B. CLOSING

LOCAL CLOSING

8.3B → TEST

TEST → 11.3C

&

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DWG n° : 231151/SD/23

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG–100D1 – LOGICAL INCOMING FEEDER TR–100AD1

C.B. Commands

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00023

SHEET 8

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00023 Rev.03

# INPUTS

# REX640 C.B. COMMANDS

# OUTPUTS

K86 RELAY TRIPPED 0/1 — B-X1-9

XM EXTERNAL CLOSING INTERLOCK 0/1 — B-X1-15

QM "BGS2" C.B. DISCHARGED 0/1 — B-X1-10

BGE EARTHING SWITCH OPENED 0/1 — B-X1-6

BGE EARTHING SWITCH CLOSED 0/1 — B-X1-7

QM C.B. OPENED 0/1 — B-X1-2

QD2 – QD3 – QD4 CLOSED AUXILIARY CIRCUIT MCB's 0/1 — C-X1-5

QV4 – QV5 CLOSED AUXILIARY V.T. SECONDARY MCB's 0/1 — C-X1-6

QM C.B. CLOSED 0/1 — B-X1-1

TO EMCS IEC 61850: *K86 TRIPPED*

K86 → 6.7D

K86 → 8.6B

K86 → 6.5C

LED-11 (RED)

t=12"

7.5C → 68

LED-4 (GREEN)

READY → 8.6C

8.4C → REMOTE

TO EMCS IEC 61850: *C.B. READY TO CLOSE*

G_S02-X1 → XM 0/1 C.B. READY TO CLOSE

E.S. OPEN → 11.4B

E.S. OPENED

11.8D → TCS

8.5B → INSERT.

E.S. CLOSED → 9.8C

9.3C → E.S. CLOSED

B_S02-X2 → XM 0/1 E.SWITCH CLOSED

C.B. OPEN → 11.5D

C.B. OPEN → 11.4B

8.7B → OPENING

C.B. OPENED

G_SS01-X1 → XM 0/1 AVAILABLE

B_S04-X2 → XM 0/1 C.B. OPENED

TO EMCS IEC 61850: *MCB's CLOSED*

11.4D → V.T.

8.5B → -83 C.B. 66kV OPEN

GOOSE: *DEACTIVATION OF PROTECTION FUNCTIONS ON UNITS 2,3,4,7*

8.5A → INSERT.

C.B. CLD&INS

TO EMCS IEC 61850: *C.B CLOSED AND INSERTED*

C.B. CLD&INS

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DWG n° : 231151/SD/23

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG-100D1 – LOGICAL INCOMING FEEDER TR-100AD1

C.B. Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00023

SHEET 9

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00023 Rev.03

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

| | | |
|---|---|---|
| K94P–OLTC TRANSF.TRIPPED PROTEC. RELAY TRANSF. | 0/1 | B-X1-11 |
| 26OT TRANSF. ALARM OIL TEMPERATURE | 0/1 | C-X1-10 |
| K94OT TRANSF.TRIPPED OIL TEMPERATURE | 0/1 | C-X1-11 |
| 89T.1 TRANSF.ALARM MEMBRANE CONTROL | 0/1 | C-X1-7 |
| 89T.2 TRANSF. SELFDRATING BREATHER ALARM | 0/1 | C-X1-14 |
| K94P TRANSF.TRIPPED OIL PRESSURE | 0/1 | C-X1-15 |
| 49T TRANSF.ALARM WINDING TEMPERATURE | 0/1 | C-X1-17 |
| K94WT TRANSF.TRIPPED WINDING TEMPERATURE | 0/1 | C-X2-1 |
| 97T TRANSF. ALARM BUCHHOLZ | 0/1 | D-X1-11 |
| K94B TRANSF. TRIPPED BUCHHOLZ | 0/1 | D-X1-9 |
| 71OT TRANSF. ALARM OIL LEVEL | 0/1 | C-X1-13 |
| K94L TRANSF. TRIPPED OIL LEVEL | 0/1 | C-X1-9 |
| 71OLTC TRANSF. ALARM OIL LEVEL INDICATOR | 0/1 | D-X1-3 |
| K94L–OLTC TRANSF. TRIPPED OIL LEVEL INDICATOR | 0/1 | C-X1-1 |

| | |
|---|---|
| TO EMCS IEC 61850 | TRIPPED PROTECTION RELAY TRANSF. |
| TO EMCS IEC 61850 | ALARM OIL TEMPERATURE |
| TO EMCS IEC 61850 | TRIPPED OIL TEMPERATURE |
| TO EMCS IEC 61850 | ALARM MEMBRANE CONTROL |
| TO EMCS IEC 61850 | SELF DEHYDRATING BREATHER ALARM |
| TO EMCS IEC 61850 | TRIPPED OIL PRESSURE |
| TO EMCS IEC 61850 | ALARM WINDING TEMPERATURE |
| TO EMCS IEC 61850 | TRIPPED WINDING TEMPERATURE |
| TO EMCS IEC 61850 | ALARM BUCHHOLZ |
| TO EMCS IEC 61850 | TRIPPED BUCHHOLZ |
| TO EMCS IEC 61850 | ALARM OIL LEVEL |
| TO EMCS IEC 61850 | TRIPPED OIL LEVEL |
| TO EMCS IEC 61850 | ALARM OIL LEVEL INDICATOR |
| TO EMCS IEC 61850 | TRIPPED OIL LEVEL INDICATOR |

≥1

LED-13 (RED)

WATCHDOG 0/1 → TO EMCS IEC 61850 WATCHDOG PROTECTION RELAY → G_RF-X1 → KIRF 0/1 WATCHDOG

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CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00023

SHEET 10

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00023 Rev.03

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

BGE
EART.SWITCH OPENED FROM MEASURING UNIT 0 1

C-X1-3

KT1
UNLOCKING E.SWITCH/C.B. TRUCK 0 1

B-X2-1

XM
TR-100AD1 GENERAL ALARM 0 1

D-X1-5

XM
PR-100D1 NER GENERAL ALARM 0 1

D-X1-10

QV1/2/3-PTT-FF1/2/3
VT HEALTY CIRCUIT 0 1

C-X1-2

≥1

TO EMCS IEC 61850
*C.B OPENED OR ISOLATED*

&

9.3C C.B. OPEN

9.4B E.S. OPEN

8.4D LOCAL

&

8.5C -83 66kV Switchboard C.B. INCOMING OPENED

8.6E TEST

TO EMCS IEC 61850
*TR-100AD1 GENERAL ALARM*

TO EMCS IEC 61850
*PR-100D1 NER GENERAL ALARM*

V.T. 7.2C

V.T. 9.5D

TO EMCS IEC 61850
*VT HEALTY CIRCUIT*

&

9.3C C.B. OPEN

6.9C ARC TRIP

T.C.S.
TCS1
TCSSCBR
ALARM

TO EMCS IEC 61850
*TSC MB01 COIL SUPERVISION*

NOT

TCS 9.4C

LED-2 (GREEN)

B_S05-X2

XM
0 C.B. OPENED
1

LED-8 (GREEN)

G_S03-X2

RLE2
0 C.B. TRUCK UNLOCKED
1

LED-10 (RED)

*GOOSE*

LED-7 (GREEN)

G_S01-X1

RLE3
0 EARTHING SWITCH UNLOCKED
1

**GOOSE TO ALL FEEDERS:**

TRIPPED ARC PROTECTION FOR:
- ARC DETECTED ON MAIN BUS BAR (FROM ALL UNITS)
- ARC DETECTED ON C.B. / CONTACTOR COMPARTEMENT (FROM ALL UNITS)
- ARC DETECTED ON CABLE COMPARTEMENT (ONLY CONTACTOR UNIT AND INCOMING)

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| 2 | 28/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for construction (AFC) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

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+A6
DWG n° : 231151/SD/23
Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL INCOMING FEEDER TR-100AD1
C.B. Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00023

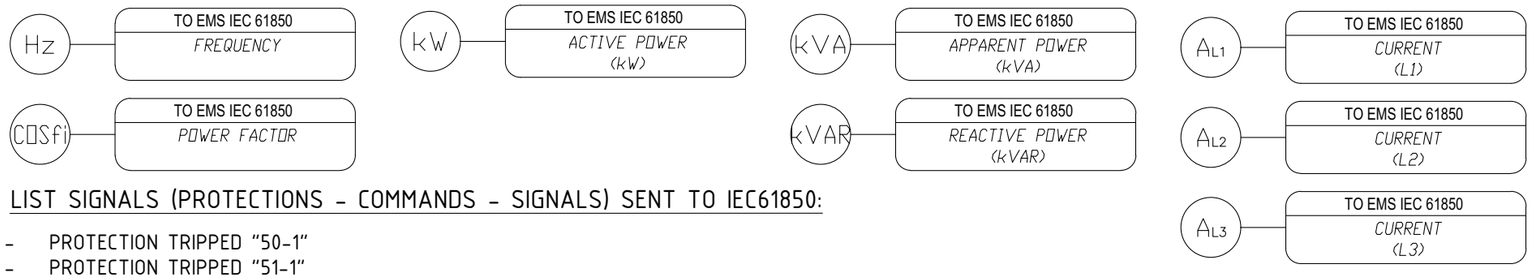
SHEET 1.1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00023 Rev.03

| INPUTS | REX640 SIGNALS MEASURES AND COMMAND AVAILABLE TO IEC61850 | OUTPUTS |
|---|---|---|




LIST SIGNALS (PROTECTIONS - COMMANDS - SIGNALS) SENT TO IEC61850:

- PROTECTION TRIPPED "50-1"
- PROTECTION TRIPPED "51-1"
- PROTECTION TRIPPED "51N"
- SYNCHRO "OK"
- PROTECTION TRIPPED "59N-1"
- PROTECTION TRIPPED "59N-2"
- PROTECTION TRIPPED "27-1"
- PROTECTION TRIPPED "27-2"
- PROTECTION TRIPPED "59-1"
- PROTECTION TRIPPED "59-2"
- SELECTOR SWITCH IN LOCAL POSITION
- SELECTOR SWITCH IN REMOTE POSITION
- TRANSFORMER PROTECTION TRIPPED "OIL TEMPERATURE"
- TRANSFORMER PROTECTION ALARM "OIL TEMPERATURE"
- TRANSFORMER PROTECTION TRIPPED "OIL PRESSURE"
- TRANSFORMER PROTECTION SELF DEHYDRATING BREATHER ALARM
- TRANSFORMER PROTECTION TRIPPED "WINDING TEMPERATURE"
- TRANSFORMER PROTECTION ALARM "WINDING TEMPERATURE"
- TRANSFORMER PROTECTION ALARM BUCHHOLZ
- TRANSFORMER PROTECTION TRIPPED BUCHHOLZ
- TRANSFORMER PROTECTION RELAY OLTC
- TRANSFORMER PROTECTION ALARM LEVEL OIL
- TRANSFORMER PROTECTION TRIPPED LEVEL OIL
- TRANSFORMER PROTECTION ALARM OIL LEVEL INDICATOR
- TRANSFORMER PROTECTION TRIPPED OIL LEVEL INDICATOR
- TRANSFORMER PROTECTION ALARM MEMBRANE CONTROL
- WATCHDOG PROTECTION RELAY
- V.T. HEALTLY CIRCUIT
- INTERTRIP SEND TO 66kV SWITCHB.
- K86 TRIPPED
- C.B. CLOSED AND INSERTED
- C.B. OPENED OR ISOLATED
- MCB'S CLOSED
- C.B. READY (TCS)
- C.B. READY TO CLOSE
- OPENING COMMAND
- CLOSING COMMAND
- LIVE VOLTAGE 6.6kV ON THE MAIN BUS-BARS
- TRIPPED ARC CABLE COMPARTMENTE TO 66kV SWITCHBOARD
- TR-100AD1 GENERAL ALAM
- RR-100D1 NER GENERAL ALARM

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231151/SD/23

Item n° : PF1113279

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL INCOMING FEEDER TR-100AD1

Measures

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00023

SHEET 12

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00023 Rev.03

1.5.2.SG-100D1 HV SWG LOGIC DIAGRAM - BESS FEEDER,

Doc. No. 1723002197-EL-DG-00025

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# "SG-100D1" HV SWBD 6,6kV (UNIT A3)

# LOGICAL DIAGRAM

# BESS FEEDER A-85000

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |
| *NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.* | |
| Sign | Date |
| Luca Macuke | 12/09/2024 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| **2** | **28/06/2024** | **Giulietti** | **Flamminio** | **Sigismondi** | **Accepted for construction (AFC)** |
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DWG n° : 231151/SD/25

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL BESS FEEDER A-85000
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00025

SHEET 1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00025 Rev.03

# INDEX

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cover | | | | | | | | | | | | | | | | | | | | |
| 2 | Sheets index | | | | | | | | | | | | | | | | | | | | |
| 3 | Input Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 4 | Input Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 5 | Output Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 6 | Protections REX640 | | | | | | | | | | | | | | | | | | | | |
| 7 | Protections REX640 | | | | | | | | | | | | | | | | | | | | |
| 8 | Contactor Commands | | | | | | | | | | | | | | | | | | | | |
| 9 | Contactor Commands | | | | | | | | | | | | | | | | | | | | |
| 10 | Contactor Commands | | | | | | | | | | | | | | | | | | | | |
| 11 | Contactor Commands | | | | | | | | | | | | | | | | | | | | |
| 12 | Measures | | | | | | | | | | | | | | | | | | | | |
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DWG n° : 231151/SD/25

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - LOGICAL BESS FEEDER A-85000

Sheets index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

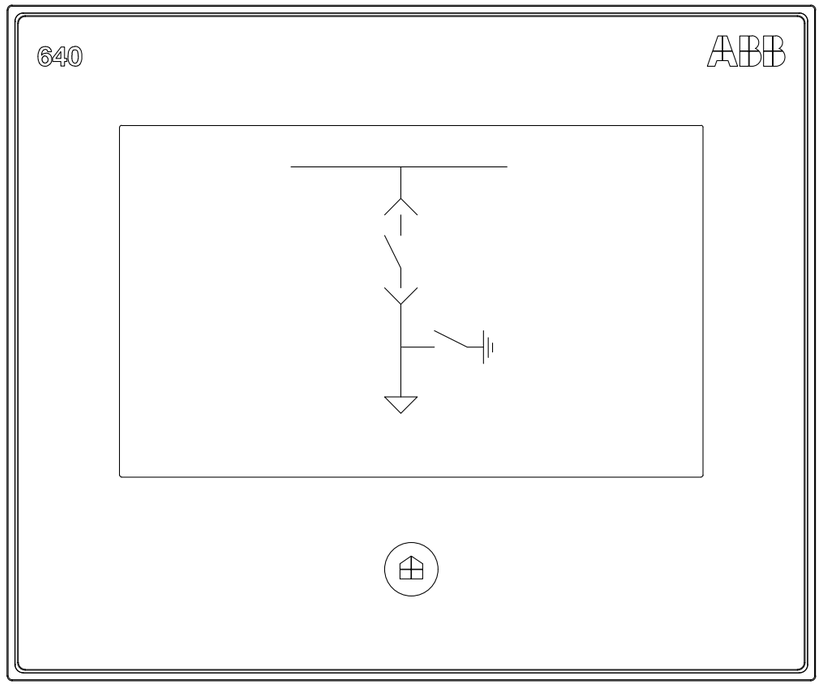
DRAWING NO. 1723002197-EL-DG-00025

SHEET 2

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00025 Rev.03




LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE C.B." AND "OPEN C.B." NON ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED
- ONLY PUSH BUTTON "RESET" ARC PROTECTION WILL BE ENABLED

| LEDs PAGE 1 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/27-2/59-1/59-2 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | CONTACTOR READY (TCS) | - | GREEN | OK = TCS OK (CONTACTOR READY) |
| LED-3 | SYNCHRO CHECK | | GREEN | OK = SYNCHRONISM |
| LED-4 | CONTACTOR READY TO CLOSE | - | GREEN | OK = CONTACTOR READY TO CLOSE |
| LED-5 | 50-1/51-1/67-1/67-2 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/59N-1/59N-2 - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = CONTACTOR TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | EMERGENCY OPENING BY SIS (ESD) | RED | - | ALARM = ESD TRIPPED |

| LEDs PAGE 2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | - | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | FUSES TRIP | RED | | ALARM = FUSES TRIP |
| LED-15 | TRIP FROM L.V. | RED | | ALARM = L.V. TRIP |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| +A3 | | | | | |
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DWG n° : 231151/SD/25
Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL BESS FEEDER A-85000
Input Protection Relay REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00025

SHEET 3

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00025 Rev.03

## INPUTS

| B–X1 | | |
|---|---|---|
| 1 / 4 | BI1 | CONTACTOR CLOSED |
| 2 / 4 | BI2 | CONTACTOR OPENED |
| 3 / 4 | BI3 | CONTACTOR SERVICE POSITION |
| 5 / 8 | BI4 | CONTACTOR TEST POSITION |
| 6 / 8 | BI5 | EARTH SWITCH OPENED |
| 7 / 8 | BI6 | EARTH SWITCH CLOSED |
| 9 / 12 | BI7 | RELAY TRIPPED |
| 10 / 12 | BI8 | CONTACTOR READY |
| 11 / 12 | BI9 | FUSES TRIPPED |
| 13 / 16 | BI10 | SELECTOR IN LOCAL POSITION |
| 14 / 16 | BI11 | SELECTOR IN REMOTE POSITION |
| 15 / 16 | BI12 | EXTERNAL CLOSING INTERLOCK |
| 17 / 18 | BI13 | CIRC.BREAKER OPENED (FROM L.V. SWITCHBOARD) |
| B–X2 | | |
| 1 / 2 | BI14 | UNLOCKING EARTHING SWITCH / TRUCK CONTACTOR |

## INPUTS

| C–X1 | | |
|---|---|---|
| 1 / 4 | BI1 | EMERGENCY OPENING BY SIS |
| 2 / 4 | BI2 | V.T. HEALTY CIRCUIT |
| 3 / 4 | BI3 | EARTHING SWITCH OPEN (FROM MEASURING UNIT) |
| 5 / 8 | BI4 | CLOSED AUXILIARY CIRCUIT MCB's |
| 6 / 8 | BI5 | CLOSED AUXILIARY V.T. SECONDARY MCB's |
| 7 / 8 | BI6 | AVAILABLE |
| 9 / 12 | BI7 | |
| 10 / 12 | BI8 | AVAILABLE |
| 11 / 12 | BI9 | |
| 13 / 16 | BI10 | AVAILABLE |
| 14 / 16 | BI11 | AVAILABLE |
| 15 / 16 | BI12 | |
| 17 / 18 | BI13 | TRANSF. ALARM WINDING TEMPERATURE |
| B–X2 | | |
| 1 / 2 | BI14 | TRANSF. TRIP WINDING TEMPERATURE |

## INPUTS

| D–X1 | | |
|---|---|---|
| 1 / 4 | BI1 | LOCAL CLOSING COMMAND |
| 2 / 4 | BI2 | LOCAL OPENING COMMAND |
| 3 / 4 | BI3 | CIRC.BREAKER IN TEST POSITION (FROM L.V. SWITCHBOARD) |
| 5 / 8 | BI4 | CIRC.BREAKER TRIPPED (FROM L.V. SWITCHBOARD) |
| 6 / 8 | BI5 | SPACE HEATER "ON" |
| 7 / 8 | BI6 | AVAILABLE REMOTE OPENING COMMNAD |
| 9 / 12 | BI7 | AVAILABLE REMOTE OPENING COMMNAD |
| 10 / 12 | BI8 | MCB AND WATCHDOG PROTECTION. RELAY HEALTH (FROM UNIT A1) |
| 11 / 12 | BI9 | SELECTOR SWITCH OF OVERRIDE (SIL ENABLED) |

## ARC MODULE

| | | |
|---|---|---|
| LIGHT SENSOR INPUT 1 | Slot A1 X11 | ARC "MAIN BUS BAR" "BB" |
| LIGHT SENSOR INPUT 2 | Slot A1 X12 | ARC "CONTACTOR COMPART." "CB" |
| LIGHT SENSOR INPUT 3 | Slot A1 X13 | ARC "CABLE COMPARTEMENT" "CC" |
| LIGHT SENSOR INPUT 4 | Slot A1 X14 | |

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DWG n° : 231151/SD/25
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG–100D1 – LOGICAL BESS FEEDER A–85000
Input Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

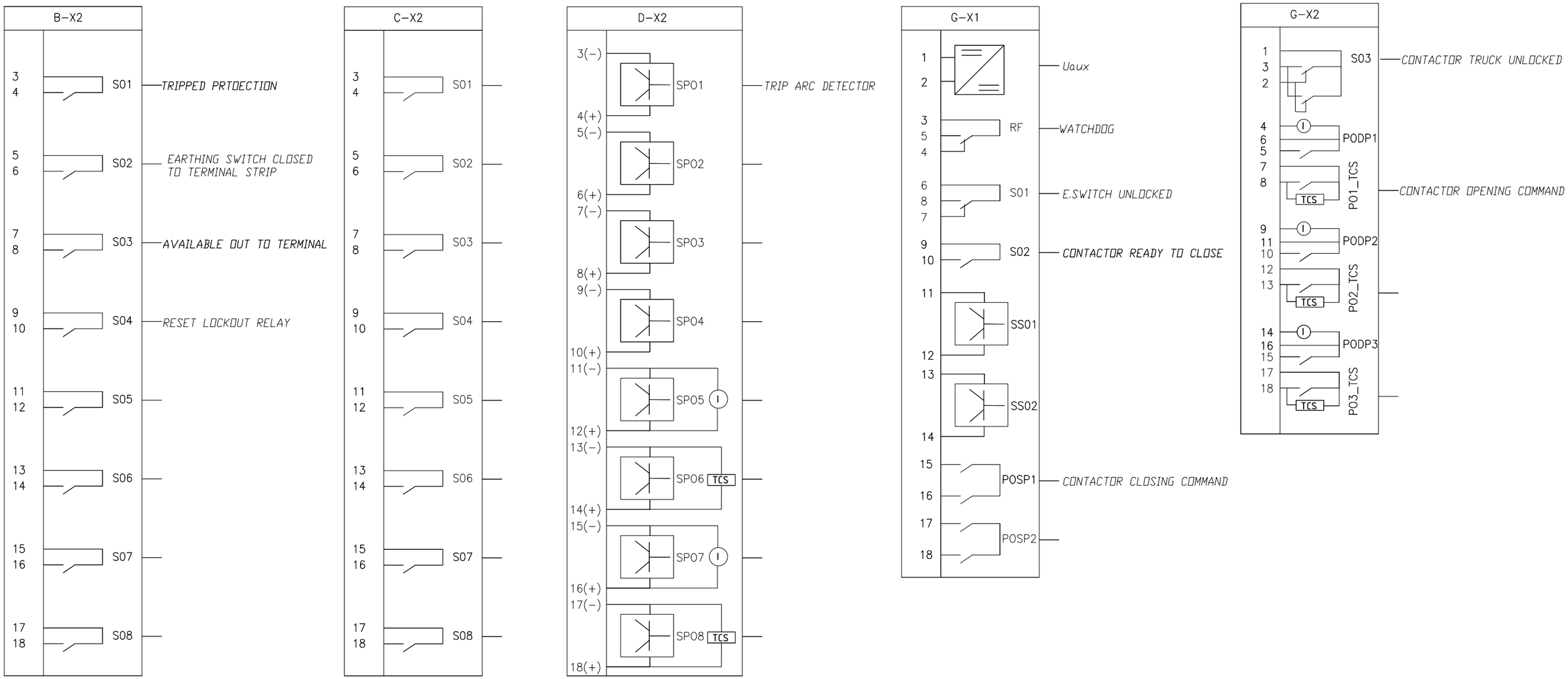
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SHEET 4

REV. 03

File Name : 1723002197–EL–DG–00025 Rev.03

F.to UNI A3: 420mmx297mm




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231151/SD/25
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG–100D1 – LOGICAL BESS FEEDER A–85000
Output Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00025

SHEET 5

REV. 03

File Name : 1723002197–EL–DG–00025 Rev.03

F.to UNI A3: 420mmx297mm

# INPUTS

# PROTECTIONS REX640 (FP1)

# OUTPUTS

50-1 / 3I>>> / PHIPTOC1 — 0 / 1 / Start
TO EMCS IEC 61850: 50-1 -PROTECTION OPERATED
51-1 / 3I> / PHLPTOC1 — 0 / 1 / Start
TO EMCS IEC 61850: 51-1 -PROTECTION OPERATED
51N / Io> / EFLPTOC1 — 0 / 1 / Start
TO EMCS IEC 61850: 51N PROTECTION OPERATED
59N-2 / Vo> / ROVPTOV2 — 0 / 1 / Start
TO EMCS IEC 61850: 59N-2 PROTECTION OPERATED
LED-15 (RED)
KA1: TRIP PROTECTION FROM LOW VOLTAGE — 0 / 1
D-X1-5
INCOMING VOLTAGE
MAIN BUS BAR VOLTAGE
U3P2 25 SYNC U3P1 SECRSYN — 0 / 1 / Start
SYNCH OK
LED-3 (RED)
SYNCH OK → 7.4C
TO EMCS IEC 61850: 25 SYNCHRO OK
ONLY "LIGHT"
50L/50NL ARC ARCSARC1 — 0 / 1 / Start
ARC "MAIN BUS BAR" "BB"
ONLY "LIGHT"
50L/50NL ARC ARCSARC2 — 0 / 1 / Start
ARC "CONTACTOR COMPART." "CB"
ONLY "LIGHT"
50L/50NL ARC ARCSARC3 — 0 / 1 / Start
ARC "CABLE COMPARTEMENT" "CC"
7.6D → 67
t=0,5"
RESET
K86 → 9.5A
K86 → 7.5B
59N → 7.8A
LED-5 (RED)
LED-6 (RED)
PROTECTION → 8.6B
TO EMCS IEC 61850: INTERTRIP SEND (TO L.V. SWITCHB.)
B_X2-S01
K86: 0 TRIPPED PROTECTION / 1
7.5B → 59-2
10.8B → TRIPPED TRASF.
9.4B → FUSE
D_X2-S01
FP1e: 0 TRIPPED ARC CABLE COMPARTMENT / 1
GOOSE FROM INCOMINGS: UNIT :A6
TRIPPED ARC PROTECTION FOR:
- ARC DETECTED ON MAIN BUS BAR (FROM ALL UNITS)
- ARC DETECTED ON C.B. / CONTACTOR COMPARTEMENT (FROM ALL UNITS)
- ARC DETECTED ON CABLE COMPARTEMENT (ONLY CONTACTOR UNIT)
GOOSE TO INCOMINGS: UNIT :A6
0 TRIPPED ARC PROTECTION 1
LED-9 (RED)
9.6A → K86 ARC
8.6C

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n°: 231151/SD/25
Item n°: PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL BESS FEEDER A-85000
Protections REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS
A3
DRAWING NO. 1723002197-EL-DG-00025
SHEET 6
REV. 03

File Name : 1723002197-EL-DG-00025 Rev.03

F.to UNI A3: 420mmx297mm

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|

# INPUTS

# PROTECTIONS REX640 (FP1)

# OUTPUTS

TO EMCS IEC 61850
59N-1 PROTECTION OPERATED

59N-1 | Vo> | ROVPTOV1 | 0 | 1 | Start

t=0,5"

59N → 6.6C

TO EMCS IEC 61850
27-1 PROTECTION OPERATED

27-1 | V< | PHPTUV1 | 0 | 1 | Start

-80 → 8.5C

TO EMCS IEC 61850
27-2 PROTECTION OPERATED

27-2 | V<< | PHPTUV2 | 0 | 1 | Start

K86 → 6.4C

TO EMCS IEC 61850
59-2 PROTECTION OPERATED

59-2 | Vo>> | PHPTOV2 | 0 | 1 | Start

59-2 → 6.6C

TO EMCS IEC 61850
59-1 PROTECTION OPERATED

59-1 | Vo> | PHPTOV1 | 0 | 1 | Start

LED-1 (RED)

(DEAD LINE - LIVE MAIN BUS BARS)

10.4C → V.T. → BLOCK | 25 Dead L Live B | 0 | 1 | Start

68 → 9.4C

6.4D → SYNCH OK
(LIVE LINE - LIVE MAIN BUS BARS)

TO EMCS IEC 61850
67-1 -PROTECTION OPERATED

GOOSE (from unit A6)
FUNCTIONS BLOCKED WITH 6.6kV and 66kV C.BREAKERS CLOSED

BLOCK | 67-1 | 3I> -> | DPHLPDOC1 | 0 | 1 | Start

67 → 6.3A

BLOCK | 67-2 | 3I>> -> | DPHLPDOC2 | 0 | 1 | Start

TO EMCS IEC 61850
67-2 -PROTECTION OPERATED

| | | | | | | | |
|---|---|---|---|---|---|---|---|
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| +A3 | | | | | | | |
| | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
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| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

DWG n° : 231151/SD/25

Item n° : PF1113279

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL BESS FEEDER A-85000
Protections REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00025 | SHEET 7 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00025 Rev.03

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

S20 LOCAL OPENING COMMAND 0/1 — D-X1-2

K1 – BGT4 CONTACTOR SERVICE 0/1 — B-X1-3

K1 – BGT5 CONTACTOR TEST 0/1 — B-X1-5

XM REMOTE AVAILABLE OPENING COMMAND 0/1 — D-X1-7

XM REMOTE AVAILABLE OPENING COMMAND 0/1 — D-X1-9

SA1 SELECTOR IN REMOTE POSITION 0/1 — B-X1-14

SA1 SELECTOR IN LOCAL POSITION 0/1 — B-X1-13

S1C LOCAL CLOSING COMMAND 0/1 — D-X1-1

KGR SPACE HEATER "ON" 0/1 — D-X1-6

LED-12 (RED)

IEC 61850 – EMCS OPENING 0/1

IEC 61850 – EMCS CLOSING 0/1

TEST → 8.5D

INSERT. → 9.3D

INSERT. → 9.4C

INSERT

INSERT

7.6A → -80

REMOTE → 9.7B

TO EMCS IEC 61850 *SELECTOR IN REMOTE POSITION*

LOCAL → 11.4B

TO EMCS IEC 61850 *SELECTOR IN LOCAL POSITION*

LOCAL OPENING

REMOTE OPENING

6.9B → PROTECTION

9.5A → K86

UNDERVOLTAGE

6.6E → ARC

OPENING → 9.4C

REMOTE CLOSING

LOCAL CLOSING

9.6B → READY

LOCAL CLOSING

8.3B → TEST

TEST → 11.3C

TEST LOCAL CLOSING

G_PODP1-X2 → K1 CONTACTOR OPENING 0/1

G_POSP1-X1 → K1 CONTACTOR CLOSING 0/1

TO EMCS IEC 61850 *RESET LOCKOUT RELAY* — B_S04-X2 → FP1c RESET LOCKOUT RELAY 0/1

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/25

Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : SG–100D1 – LOGICAL BESS FEEDER A–85000

Contactor Commands

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00025

SHEET 8

REV. 03

File Name : 1723002197–EL–DG–00025 Rev.03

F.to UNI A3: 420mmx297mm

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

**K86** — RELAY TRIPPED (0/1) → B-X1-9

**XM** — EXTERNAL CLOSING INTERLOCK (0/1) → B-X1-15

**XM** — FROM L.V.SWDB C.B.OPENED (0/1) → B-X1-17

**DO1** — CONTACTOR READY (TCS) (0/1) → B-X1-10

**BGF2** — FUSE TRIPPED (0/1) → B-X1-11

**BGE** — EARTHING SWITCH OPENED (0/1) → B-X1-6

**BGE** — EARTHING SWITCH CLOSED (0/1) → B-X1-7

**K1** — CONTACTOR OPENED (0/1) → B-X1-2

**QD2 – QD4** — CLOSED AUXILIARY CIRCUIT MCB's (0/1) → C-X1-5

**QV4 – QV5** — CLOSED AUXILIARY V.T. SECONDARY MCB's (0/1) → C-X1-6

**KSIL** — EMERGENCY OPENING BY SIS (0/1) → C-X1-1

**K1** — CONTACTOR CLOSED (0/1) → B-X1-1

B-X1-9 → TO EMCS IEC 61850 *K86 TRIPPED*

K86 → 6.6D

K86 → 8.6B

K86 → 6.4C

B-X1-10 → LED-2 (GREEN) → TO EMCS IEC 61850 *CONTACTOR READY (TCS)*

B-X1-11 → LED-14 (RED) → FUSE → 6.6D

B-X1-6 → & → E.S. OPEN → 11.4B → E.S. OPENED

B-X1-7 → & → E.S. CLOSED → 9.8C

B-X1-2 → CONT.OPEN → 11.4B → CONTACTOR OPENED

C-X1-5 → &

C-X1-6 → & → TO EMCS IEC 61850 *MCB's CLOSED*

C-X1-1 → LED-11 (RED)

B-X1-1 → 8.5A INSERT. → & → TO EMCS IEC 61850 *CONTACTOR CLOSED AND INSERTED*

7.5C → 68

8.5B → INSERT.

8.7B → OPENING

&

READY → 8.6C

LED-4 (GREEN)

&

8.4C → REMOTE

TO EMCS IEC 61850 *CONTACTOR READY TO CLOSE*

G_S02-X1 → **XM** 0/1 CONTACTOR READY TO CLOSE

9.3C → E.S. CLOSED → B_S02-X2 → **XM** 0/1 E.SWITCH CLOSED

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DWG n°: 231151/SD/25

Item n°: PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG–100D1 – LOGICAL BESS FEEDER A–85000

Contactor Commands

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00025

SHEET 9

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00025 Rev.03

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|

## INPUTS

## REX640 CONTACTOR COMMANDS

## OUTPUTS

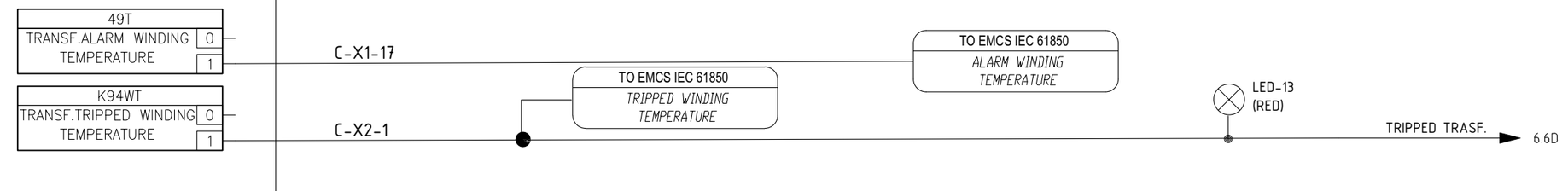
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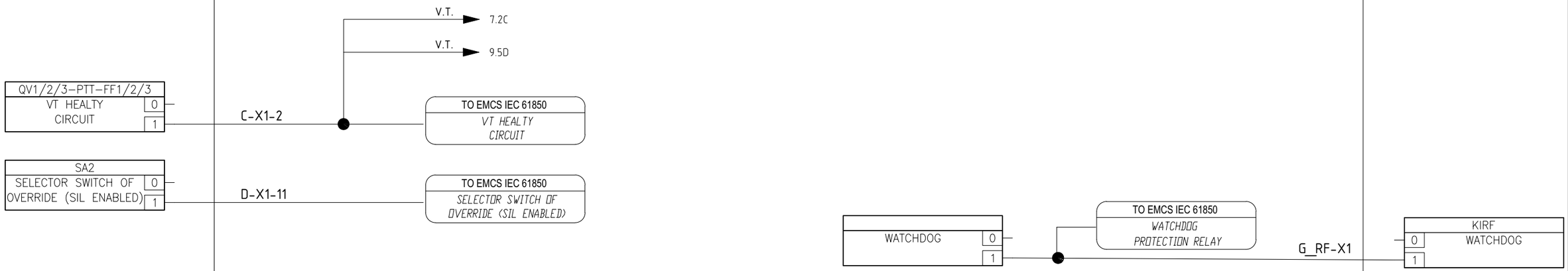
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DWG n° : 231151/SD/25

Item n° : PF1113279

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - LOGICAL BESS FEEDER A-85000

Contactor Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00025

SHEET 10

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00025 Rev.03

1 2 3 4 5 6 7 8 9 10

A B C D E

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

BGE
EART.SWITCH OPENED FROM MEASURING UNIT 0 1
C-X1-3

KT1
UNLOCKING E.SWITCH/CONT. TRUCK 0 1
B-X2-1

QB1
LOW VOLTAGE CIR.BREAK IN TEST POSITION 0 1
D-X1-3

QD1 – KIRF (UNIT A2)
MCB AND WATCHDOG PROTEC. RELAY HEALTHY 0 1
D-X1-10

QD1 – KIRF (UNIT A4)
MCB AND WATCHDOG PROTEC. RELAY HEALTHY 0 1
C-X1-7

≥1

TO EMCS IEC 61850
*CONTACTOR OPENED OR ISOLATED*

&

9.3C CONT.OPEN

9.4B E.S. OPEN

8.4D LOCAL

8.6E TEST

&

LED-8 (GREEN)

G_S03-X2

RLE2
0 CONTACTOR TRUCK UNLOCKED
1

LED-7 (GREEN)

G_S01-X1

RLE3
0 EARTHING SWITCH UNLOCKED
1

TO EMCS IEC 61850
*PROTECTION RELAY UNIT 2 HEALTHY*

TO EMCS IEC 61850
*PROTECTION RELAY UNIT 4 HEALTHY*

*GOOSE*

LED-10 (RED)

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|---|---|---|---|---|---|---|
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Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

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ROSETTI MARINO

TITLE :
SG-100D1 – LOGICAL BESS FEEDER A-85000
Contactor Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

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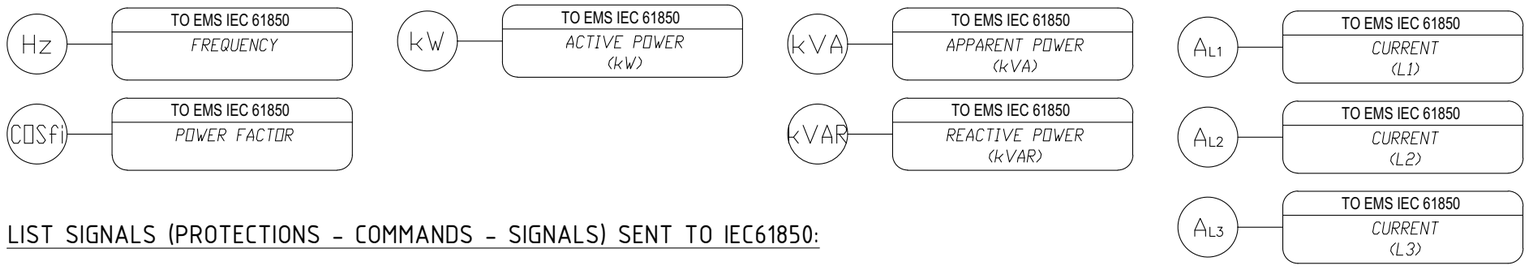
SHEET 1.1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00025 Rev.03

| INPUTS | REX640 SIGNALS MEASURES AND COMMAND AVAILABLE TO IEC61850 | OUTPUTS |
|---|---|---|




LIST SIGNALS (PROTECTIONS - COMMANDS - SIGNALS) SENT TO IEC61850:

- PROTECTION TRIPPED "50-1"
- PROTECTION TRIPPED "51-1"
- PROTECTION TRIPPED "51N"
- SYNCHRO "OK"
- PROTECTION TRIPPED "59N-1"
- PROTECTION TRIPPED "59N-2"
- PROTECTION TRIPPED "27-1"
- PROTECTION TRIPPED "27-2"
- PROTECTION TRIPPED "59-1"
- PROTECTION TRIPPED "59-2"
- PROTECTION TRIPPED "67-1"
- PROTECTION TRIPPED "67-2"
- SELECTOR SWITCH IN LOCAL POSITION
- SELECTOR SWITCH IN REMOTE POSITION
- TRANSFORMER PROTECTION TRIPPED "WINDING TEMPERATURE"
- TRANSFORMER PROTECTION ALARM "WINDING TEMPERATURE"
- WATCHDOG PROTECTION RELAY
- V.T. HEALTLY CIRCUIT
- INTERTRIP SEND TO L.V.SWITCHB.
- K86 TRIPPED
- CONTACTOR CLOSED AND INSERTED
- CONTACTOR OPENED OR ISOLATED
- MCB'S CLOSED
- CONTACTOR READY (TCS)
- CONTACTOR READY TO CLOSE
- OPENING COMMAND
- CLOSING COMMAND
- PROTECTION RELAY UNIT 2 HEALTHY
- PROTECTION RELAY UNIT 4 HEALTHY
- SELECTOR SWITCH OF OVERRIDE (SIL ENABLED)

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| +A3 | | | | | |
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DWG n° : 231151/SD/25
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL BESS FEEDER A-85000
Measures

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00025 | SHEET 12 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00025 Rev.03

1.5.3.SG-100D1 HV SWG LOGIC DIAGRAM - ELECTROLYSER FEEDER,

Doc. No. 1723002197-EL-DG-00026

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# "SG-100D1" HV SWBD 6,6kV (UNIT A1)

# LOGICAL DIAGRAM

# ELECTROLYSER FEEDER A-20000

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macuta | 12/09/2024 |

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DWG n° : 231151/SD/26

Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE : SG-100D1 – LOGICAL ELECTROLYSER FEEDER A-20000

Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00026

SHEET 1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00026 Rev.03

# INDEX

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cover | | | | | | | | | | | | | | | | | | | | |
| 2 | Sheets index | | | | | | | | | | | | | | | | | | | | |
| 3 | Input Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 4 | Input Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 5 | Output Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 6 | Protections REX640 | | | | | | | | | | | | | | | | | | | | |
| 7 | Protections REX640 | | | | | | | | | | | | | | | | | | | | |
| 8 | C.B. Commands | | | | | | | | | | | | | | | | | | | | |
| 9 | C.B. Commands | | | | | | | | | | | | | | | | | | | | |
| 10 | C.B. Commands | | | | | | | | | | | | | | | | | | | | |
| 11 | C.B. Commands | | | | | | | | | | | | | | | | | | | | |
| 12 | Measures | | | | | | | | | | | | | | | | | | | | |
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DWG n° : 231151/SD/26

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL ELECTROLYSER FEEDER A-20000

Sheets index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

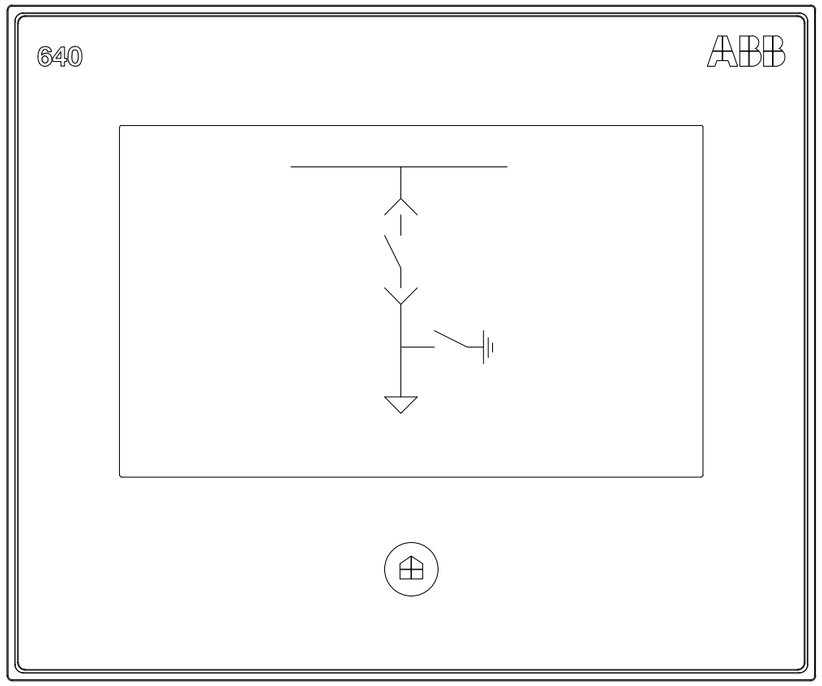
DRAWING NO. 1723002197-EL-DG-00026

SHEET 2

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00026 Rev.03




| LEDs PAGE1 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/59-1 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | C.B. READY (TCS) | - | GREEN | OK = TCS OK (C.B. READY) |
| LED-3 | | | | |
| LED-4 | C.B. READY TO CLOSE | - | GREEN | OK = C.B. READY TO CLOSE |
| LED-5 | 50-1/51-1 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/59N - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = C.B. TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | SPRING DISCHARGED | RED | - | ALARM = C.B. SPRING DISCHARGED |

| LEDs PAGE2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | | | | |
| LED-15 | TRIP FROM L.V. | RED | | ALARM = L.V. TRIP |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

## LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE C.B." AND "OPEN C.B." NON ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED
- ONLY PUSH BUTTON "RESET" ARC PROTECTION WILL BE ENABLED

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DWG n° : 231151/SD/26

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL ELECTROLYSER FEEDER A-20000
Input Protection Relay REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00026

SHEET 3

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00026 Rev.03

## INPUTS

| B–X1 | | |
|---|---|---|
| 1 | BI1 | C.B. CLOSED |
| 4 | | |
| 2 | BI2 | C.B. OPENED |
| 4 | | |
| 3 | BI3 | C.B. SERVICE POSITION |
| 4 | | |
| 5 | BI4 | C.B. TEST POSITION |
| 8 | | |
| 6 | BI5 | EARTH SWITCH OPENED |
| 8 | | |
| 7 | BI6 | EARTH SWITCH CLOSED |
| 8 | | |
| 9 | BI7 | RELAY TRIPPED |
| 12 | | |
| 10 | BI8 | C.B. SPRING DISCHARGED |
| 12 | | |
| 11 | BI9 | |
| 12 | | |
| 13 | BI10 | SELECTOR IN LOCAL POSITION |
| 16 | | |
| 14 | BI11 | SELECTOR IN REMOTE POSITION |
| 16 | | |
| 15 | BI12 | EXTERNAL CLOSING INTERLOCK |
| 16 | | |
| 17 | BI13 | CIRC.BREAKER OPENED (FROM L.V. SWITCHBOARD) |
| 18 | | |
| B–X2 | | |
| 1 | BI14 | UNLOCKING EARTHING SWITCH / TRUCK C.B. |
| 2 | | |

## INPUTS

| C–X1 | | |
|---|---|---|
| 1 | BI1 | |
| 4 | | |
| 2 | BI2 | V.T. HEALTY CIRCUIT |
| 4 | | |
| 3 | BI3 | EARTHING SWITCH OPEN (FROM MEASURING UNIT) |
| 4 | | |
| 5 | BI4 | CLOSED AUXILIARY CIRCUIT MCB's |
| 8 | | |
| 6 | BI5 | CLOSED AUXILIARY V.T. SECONDARY MCB's |
| 8 | | |
| 7 | BI6 | AVAILABLE |
| 8 | | |
| 9 | BI7 | |
| 12 | | |
| 10 | BI8 | TRANSF.ALARM OIL TEMPERATURE |
| 12 | | |
| 11 | BI9 | TRANSF.TRIP OIL TEMPERATURE |
| 12 | | |
| 13 | BI10 | AVAILABLE |
| 16 | | |
| 14 | BI11 | TRANSF.ALARM OIL PRESSURE |
| 16 | | |
| 15 | BI12 | TRANSF.TRIP OIL PRESSURE |
| 16 | | |
| 17 | BI13 | TRANSF. ALARM WINDING TEMPERATURE |
| 18 | | |
| B–X2 | | |
| 1 | BI14 | TRANSF. TRIP WINDING TEMPERATURE |
| 2 | | |

## INPUTS

| D–X1 | | |
|---|---|---|
| 1 | BI1 | LOCAL CLOSING COMMAND |
| 4 | | |
| 2 | BI2 | LOCAL OPENING COMMAND |
| 4 | | |
| 3 | BI3 | CIRC.BREAKER IN TEST POSITION (AVAILABLE FROM L.V. SWITCHBOARD) |
| 4 | | |
| 5 | BI4 | CIRC.BREAKER TRIPPED (AVAILABLE FROM L.V. SWITCHBOARD) |
| 8 | | |
| 6 | BI5 | SPACE HEATER "ON" |
| 8 | | |
| 7 | BI6 | AVAILABLE REMOTE OPENING COMMNAD |
| 8 | | |
| 9 | BI7 | AVAILABLE REMOTE OPENING COMMNAD |
| 12 | | |
| 10 | BI8 | MCB AND WATCHDOG PROTECTION. RELAY HEALTH (FROM UNIT A7) |
| 12 | | |
| 11 | BI9 | |
| 12 | | |

## ARC MODULE

| | | |
|---|---|---|
| LIGHT SENSOR INPUT 1 | Slot A1 X11 | ARC "MAIN BUS BAR" "BB" |
| LIGHT SENSOR INPUT 2 | Slot A1 X12 | ARC "C.B. COMPART." "CB" |
| LIGHT SENSOR INPUT 3 | Slot A1 X13 | ARC "CABLE COMPARTEMENT" "CC" |
| LIGHT SENSOR INPUT 4 | Slot A1 X14 | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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+A1
DWG n° : 231151/SD/26
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

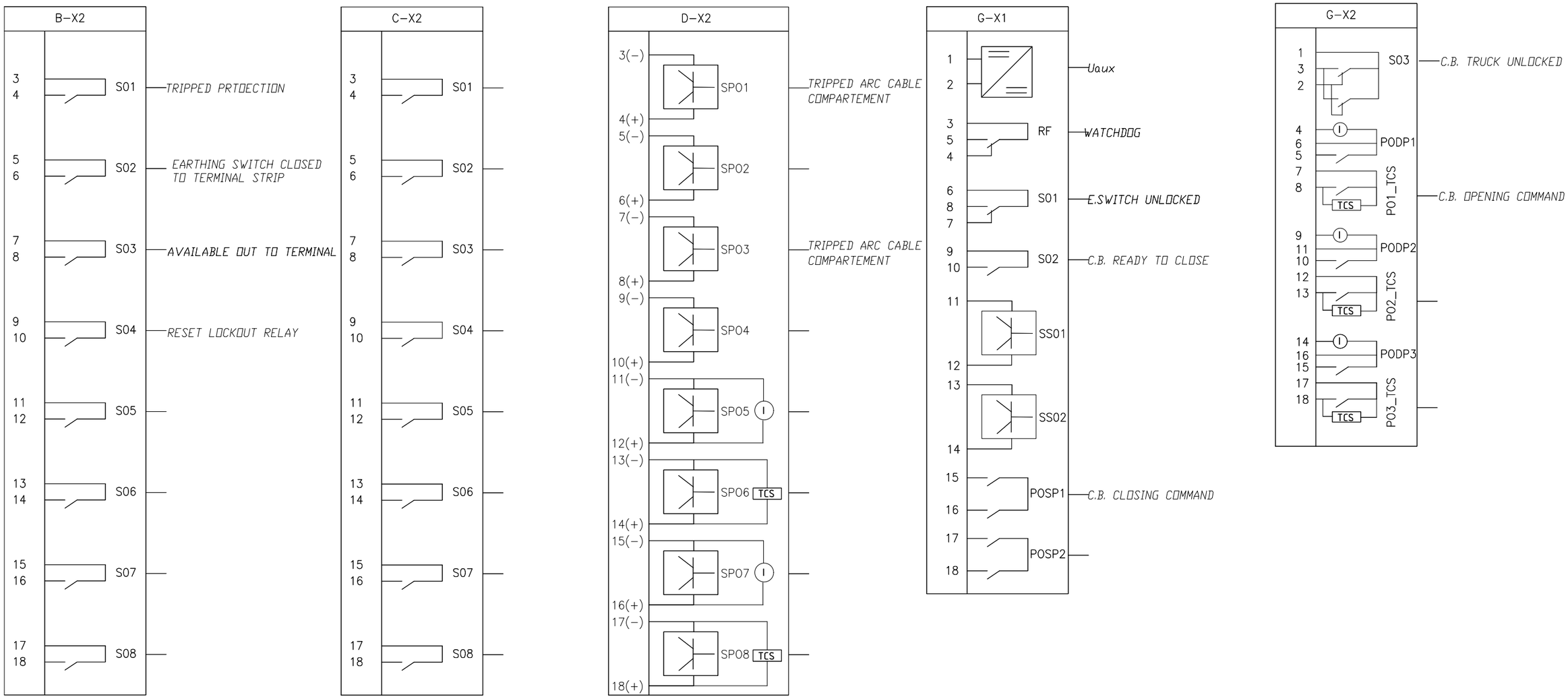
TITLE :
SG–100D1 – LOGICAL ELECTROLYSER FEEDER A–20000
Input Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197–EL–DG–00026
SHEET 4
REV. 03

File Name : 1723002197–EL–DG–00026 Rev.03

F.to UNI A3: 420mmx297mm




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| = | | | | | |
| +A1 | | | | | |
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DWG n° : 231151/SD/26
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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :
SG–100D1 – LOGICAL ELECTROLYSER FEEDER A–20000
Output Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00026

SHEET 5

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00026 Rev.03

# INPUTS

# PROTECTIONS REX640 (FP1)

# OUTPUTS

TO EMCS IEC 61850
*50-PROTECTION OPERATED*

50-1 / 3I>>> / PHIPTOC1 — 0 / 1 / Start

51-1 / 3I> / PHLPTOC1 — 0 / 1 / Start

TO EMCS IEC 61850
*51-PROTECTION OPERATED*

TO EMCS IEC 61850
*51N-PROTECTION OPERATED*

51N / Io> / EFLPTOC1 — 0 / 1 / Start

59N / Vo> / ROVPTOV1 — 0 / 1 / Start

TO EMCS IEC 61850
*59N-PROTECTION OPERATED*

LED-15 (RED)

AVAILABLE
TRIP PROTECTION FROM LOW VOLTAGE — 0 / 1

D-X1-5

LED-5 (RED)

t=0,5" &

1 / 0

LED-6 (RED)

RESET K86 9.5A

PROTECTION 8.6B

TO EMCS IEC 61850
*INTERTRIP SEND (TO L.V. SWITCHB.)*

B_X2-S01

K86
0 TRIPPED PROTECTION
1

FP1e "MB01"
0 TRIPPED ARC CABLE COMPART.
1

D_SP01-X2

10.8B TRIPPED TRASF.

FP1e "K86"
0 TRIPPED ARC CABLE COMPART.
1

D_SP03-X2

ONLY "LIGHT"
50L/50NL ARC ARCSARC1 — 0 / 1 / Start
ARC "MAIN BUS BAR" "BB"

ONLY "LIGHT"
50L/50NL ARC ARCSARC2 — 0 / 1 / Start
ARC "C.B. COMPART." "CB"

ONLY "LIGHT"
50L/50NL ARC ARCSARC3 — 0 / 1 / Start
ARC "CABLE COMPARTEMENT" "CC" -ARC CC 6.7D

GOOSE FROM INCOMINGS:
UNIT :A6

TRIPPED ARC PROTECTION FOR:
- ARC DETECTED ON MAIN BUS BAR (FROM ALL UNITS)
- ARC DETECTED ON C.B. / CONTACTOR COMPARTEMENT (FROM ALL UNITS)
- ARC DETECTED ON CABLE COMPARTEMENT (ONLY CONTACTOR UNIT)

t=0,5"

6.4E -ARC CC

9.5A K86

LED-9 (RED)

GOOSE TO INCOMINGS:
UNIT :A6
0 TRIPPED ARC PROTECTION
1

ARC 8.6B

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| = | | | | | | | |
| +A1 | | | | | | | |
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IMESA ELECTRICAL ENGINEERING

DWG n° : 231151/SD/26

Item n° : PF1113279

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 – LOGICAL ELECTROLYSER FEEDER A-20000

Protections REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00026

SHEET 6

REV. 03

F.to UNI A3: 420mmx297mm

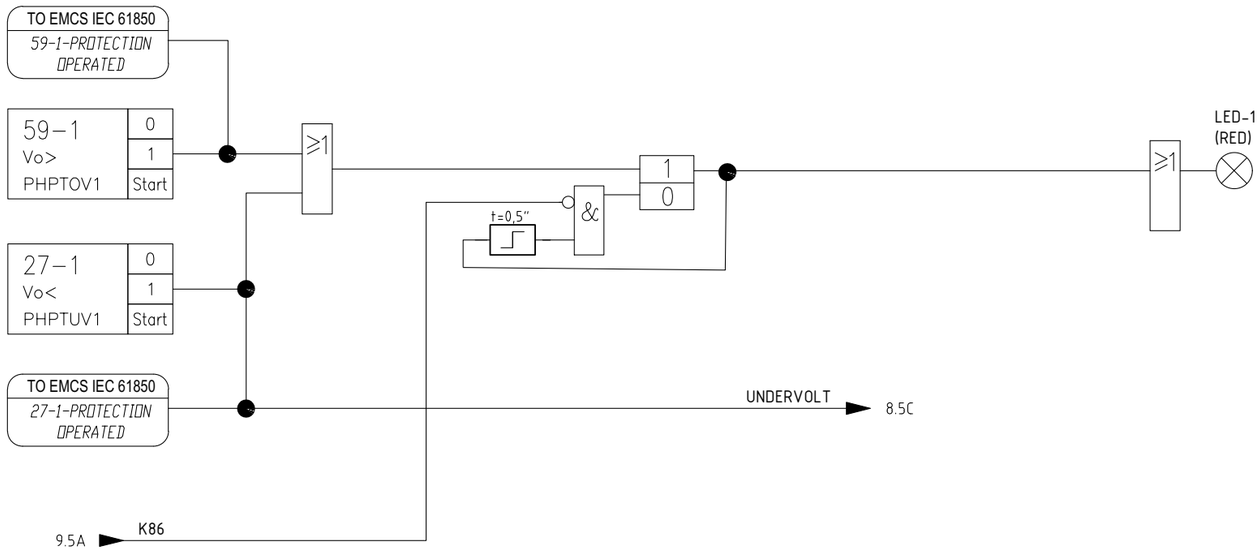
File Name : 1723002197-EL-DG-00026 Rev.03

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|

## INPUTS

## PROTECTIONS REX640 (FP1)

## OUTPUTS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| +A1 | | | | | |
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CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL ELECTROLYSER FEEDER A-20000
Protections REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00026

SHEET 7

REV. 03

File Name : 1723002197-EL-DG-00026 Rev.03

F.to UNI A3: 420mmx297mm

# INPUTS

# REX640 C.B. COMMANDS

# OUTPUTS

S20 LOCAL OPENING COMMAND (0/1) — D-X1-2

K1 – BGT4 C.B. SERVICE (0/1) — B-X1-3

K1 – BGT5 C.B. TEST (0/1) — B-X1-5

XM REMOTE AVAILABLE OPENING COMMAND (0/1) — D-X1-7

XM REMOTE AVAILABLE OPENING COMMAND (0/1) — D-X1-9

SA1 SELECTOR IN REMOTE POSITION (0/1) — B-X1-14

SA1 SELECTOR IN LOCAL POSITION (0/1) — B-X1-13

S1C LOCAL CLOSING COMMAND (0/1) — D-X1-1

KGR SPACE HEATER "ON" (0/1) — D-X1-6

IEC 61850 – EMCS OPENING (0/1)

IEC 61850 – EMCS CLOSING (0/1)

TEST → 8.5D

INSERT. → 9.3D

INSERT. → 9.4C

INSERTED

INSERTED

7.5B UNDERVOLT

UNDERVOLTAGE

6.9B PROTECTION

9.5A K86

6.6E ARC

LOCAL OPENING

REMOTE OPENING

OPENING → 9.4C

G_PODP1-X2 → K1 C.B. OPENING (0/1)

TO EMCS IEC 61850 *RESET LOCKOUT RELAY* — B_S04-X2 → FP1c RESET LOCKOUT RELAY (0/1)

REMOTE

REMOTE → 9.7B

TO EMCS IEC 61850 *SELECTOR IN REMOTE POSITION*

LOCAL → 11.4B

LOCAL

TO EMCS IEC 61850 *SELECTOR IN LOCAL POSITION*

REMOTE CLOSING

LOCAL CLOSING

9.6B READY

LOCAL CLOSING

8.3B TEST

TEST LOCAL CLOSING

G_POSP1-X1 → K1 C.B. CLOSING (0/1)

TEST → 11.3C

LED-12 (RED)

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+A1

DWG n° : 231151/SD/26

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG–100D1 – LOGICAL ELECTROLYSER FEEDER A–20000

C.B. Commands

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00026

SHEET 8

REV. 03

File Name : 1723002197–EL–DG–00026 Rev.03

F.to UNI A3: 420mmx297mm

# INPUTS

# REX640 C.B. COMMANDS

# OUTPUTS

K86 RELAY TRIPPED (0/1) — B-X1-9

XM EXTERNAL CLOSING INTERLOCK (0/1) — B-X1-15

XM FROM L.V.SWBD C.B. OPENED (0/1) — B-X1-17

QM "BGS2" C.B. DISCHARGED (0/1) — B-X1-10

BGE EARTHING SWITCH OPENED (0/1) — B-X1-6

BGE EARTHING SWITCH CLOSED (0/1) — B-X1-7

QM C.B. OPENED (0/1) — B-X1-2

QD2 – QD3 – QD4 CLOSED AUXILIARY CIRCUIT MCB's (0/1) — C-X1-5

QV4 – QV5 CLOSED AUXILIARY V.T. SECONDARY MCB's (0/1) — C-X1-6

QM C.B. CLOSED (0/1) — B-X1-1

TO EMCS IEC 61850: *K86 TRIPPED*

K86 → 6.7D, 8.6B, 6.4C, 7.2C

LED-11 (RED)

t=12"

LED-4 (GREEN)

READY → 8.6C

8.4C REMOTE

TO EMCS IEC 61850: *C.B. TO CLOSE*

G_S02-X1 — XM 0/1 C.B. READY TO CLOSE

E.S. OPEN → 11.4B

E.S. OPENED

E.S. CLOSED → 9.8C

9.3C E.S. CLOSED — B_S02-X2 — XM 0/1 E.SWITCH CLOSED

10.9C TCS

8.5B INSERT.

8.7B OPENING

C.B. OPEN → 11.4B

C.B. OPENED

TO EMCS IEC 61850: *MCB's CLOSED*

10.4C V.T.

8.5A INSERT.

TO EMCS IEC 61850: *C.B CLOSED AND INSERTED*

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

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C.B. Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00026

SHEET 9

REV. 03

File Name : 1723002197-EL-DG-00026 Rev.03

F.to UNI A3: 420mmx297mm

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

26OT
TRANSF.ALARM OIL TEMPERATURE 0 1

K94OT
TRANSF.TRIPPED OIL TEMPERATURE 0 1

63T
TRANSF.ALARM OIL PRESSURE 0 1

K94P
TRANSF.TRIPPED OIL PRESSURE 0 1

26WT
TRANSF.ALARM WINDING TEMPERATURE 0 1

K94WT
TRANSF.TRIPPED WINDING TEMPERATURE 0 1

QV1/2/3-PTT-FF1/2/3
VT HEALTY CIRCUIT 0 1

C-X1-10

C-X1-11

C-X1-14

C-X1-15

C-X1-17

C-X2-1

C-X1-2

TO EMCS IEC 61850
ALARM OIL TEMPERATURE

TO EMCS IEC 61850
TRIPPED OIL TEMPERATURE

TO EMCS IEC 61850
ALARM OIL PRESSURE

TO EMCS IEC 61850
TRIPPED OIL PRESSURE

TO EMCS IEC 61850
ALARM WINDING TEMPERATURE

TO EMCS IEC 61850
TRIPPED WINDING TEMPERATURE

TO EMCS IEC 61850
VT HEALTY CIRCUIT

≥1

LED-13 (RED)

TRIPPED TRASF.

6.6C

V.T. 9.5D

T.C.S.
TCS1
TCSSCBR
ALARM

TO EMCS IEC 61850
TSC
MB01 COIL SUPERVISION

NOT

TCS 9.4C

LED-2 (GREEN)

WATCHDOG 0 1

TO EMCS IEC 61850
WATCHDOG PROTECTION RELAY

G_RF-X1

KIRF
0 WATCHDOG
1

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C.B. Commands

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A3

DRAWING NO. 1723002197-EL-DG-00026

SHEET 10

REV. 03

File Name : 1723002197-EL-DG-00026 Rev.03

F.to UNI A3: 420mmx297mm

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

BGE
EART.SWITCH OPENED FROM MEASURING UNIT 0 1

C-X1-3

KT1
UNLOCKING E.SWITCH/C.B. TRUCK 0 1

B-X2-1

QB1
LOW VOLTAGE CIR.BREAK IN TEST POS. (AVAILAB.) 0 1

D-X1-3

QD1 – KIRF (UNIT A7)
MCB AND WATCHDOG PROTEC. RELAY HEALTHY 0 1

D-X1-10

≥1

&

&

9.3C C.B. OPEN

9.4B E.S. OPEN

8.4D LOCAL

8.6E TEST

TO EMCS IEC 61850
*C.B OPENED OR ISOLATED*

LED-8
(GREEN)

G_S03-X2

RLE2
0 C.B. TRUCK UNLOCKED

LED-7
(GREEN)

G_S01-X1

RLE3
0 EARTHING SWITCH UNLOCKED

*GOOSE*

LED-10
(RED)

TO EMCS IEC 61850
*PROTECTION RELAY UNIT 7 HEALTHY*

| | | | | | | |
|---|---|---|---|---|---|---|
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C.B. Commands

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SCALE : NTS

A3

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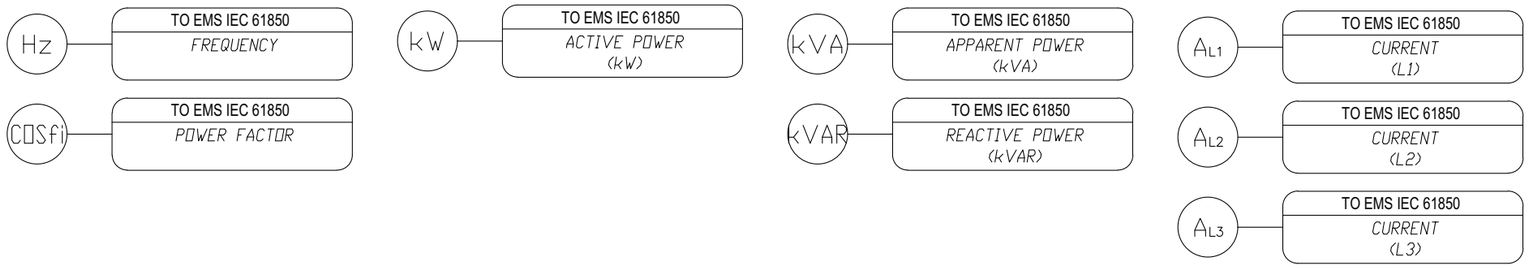
SHEET 1.1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00026 Rev.03

| INPUTS | REX640 SIGNALS MEASURES AND COMMAND AVAILABLE TO IEC61850 | OUTPUTS |
|---|---|---|




LIST SIGNALS (PROTECTIONS - COMMANDS - SIGNALS) SENT TO IEC61850:

- PROTECTION TRIPPED "50-1"
- PROTECTION TRIPPED "51-1"
- PROTECTION TRIPPED "51N"
- PROTECTION TRIPPED "59N"
- PROTECTION TRIPPED "27-1"
- PROTECTION TRIPPED "59-1"
- SELECTOR SWITCH IN LOCAL POSITION
- SELECTOR SWITCH IN REMOTE POSITION
- TRANSFORMER PROTECTION TRIPPED "OIL TEMPERATURE"
- TRANSFORMER PROTECTION ALARM "OIL TEMPERATURE"
- TRANSFORMER PROTECTION TRIPPED "OIL PRESSURE"
- TRANSFORMER PROTECTION ALARM "OIL PRESSURE"
- TRANSFORMER PROTECTION TRIPPED "WINDING TEMPERATURE"
- TRANSFORMER PROTECTION ALARM "WINDING TEMPERATURE"
- WATCHDOG PROTECTION RELAY
- V.T. HEALTLY CIRCUIT
- INTERTRIP SEND TO L.V.SWITCHB.
- K86 TRIPPED
- C.B. CLOSED AND INSERTED
- C.B. OPENED OR ISOLATED
- MCB'S CLOSED
- C.B. READY (TCS)
- C.B. READY TO CLOSE
- OPENING COMMAND
- CLOSING COMMAND
- PROTECTION RELAY UNIT 7 HEALTHY

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+A1

DWG n° : 231151/SD/26
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TITLE :
SG-100D1 - LOGICAL ELECTROLYSER FEEDER A-20000
Measures

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00026 | SHEET 12 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00026 Rev.03

1.5.4.SG-100D1 HV SWG LOGIC DIAGRAM - FUEL CELL FEEDER,

Doc. No. 1723002197-EL-DG-00027

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# "SG-100D1" HV SWBD 6,6kV (UNIT A7)

# LOGICAL DIAGRAM

# FUELL CELL A-80000

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

***NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.***

| Sign | Date |
|---|---|
| Luca Mocule | 12/09/2024 |

| | | | | | | |
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| +A7 | | | | | | |
| DWG n° : 231151/SD/27 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| Item n° : PF1113279 | 2 | 28/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for construction (AFC) |
| | 1 | 21/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 – LOGICAL FUEL CELL A-80000
Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00027 | SHEET 1 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00027 Rev.03

# INDEX

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| 2 | Sheets index | | | | | | | | | |
| 3 | Input Protection Relay REX640 | | | | | | | | | |
| 4 | Input Protection Relay REX640 | | | | | | | | | |
| 5 | Output Protection Relay REX640 | | | | | | | | | |
| 6 | Protections REX640 | | | | | | | | | |
| 7 | Protections REX640 | | | | | | | | | |
| 8 | Contactor Commands | | | | | | | | | |
| 9 | Contactor Commands | | | | | | | | | |
| 10 | Contactor Commands | | | | | | | | | |
| 11 | Contactor Commands | | | | | | | | | |
| 12 | Measures | | | | | | | | | |

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
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DWG n° : 231151/SD/27

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

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TITLE :

SG-100D1 - LOGICAL FUEL CELL A-80000

Sheets index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

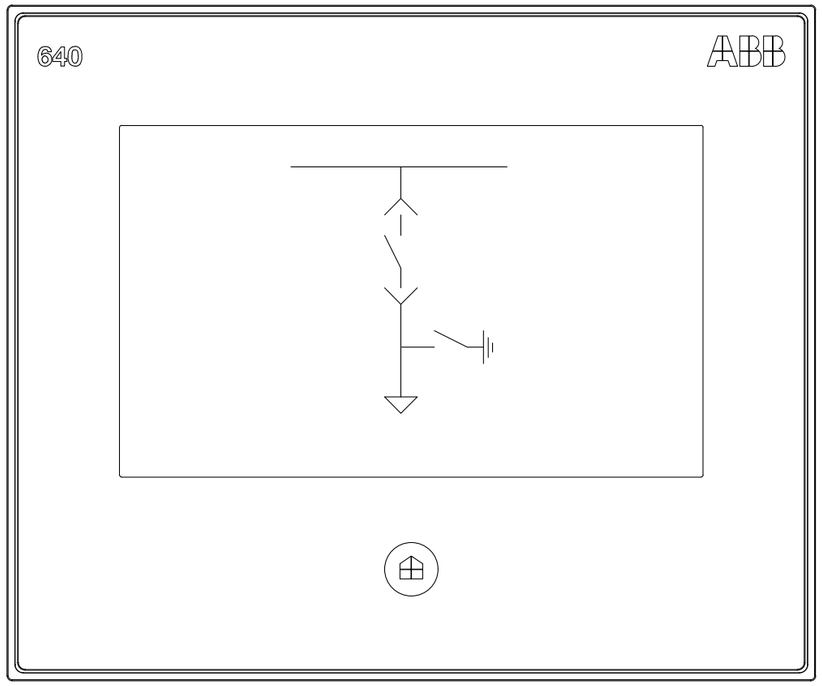
DRAWING NO. 1723002197-EL-DG-00027

SHEET 2

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00027 Rev.03




LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE C.B." AND "OPEN C.B." NON ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED
- ONLY PUSH BUTTON "RESET" ARC PROTECTION WILL BE ENABLED

| LEDs PAGE 1 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/27-2/59-1/59-2 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | CONTACTOR READY (TCS) | - | GREEN | OK = TCS OK (CONTACTOR READY) |
| LED-3 | SYNCHRO CHECK | | GREEN | OK = SYNCHRONISM |
| LED-4 | CONTACTOR READY TO CLOSE | - | GREEN | OK = CONTACTOR READY TO CLOSE |
| LED-5 | 50-1/51-1/67-1/67-2 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/59N-1/59N-2 - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = CONTACTOR TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | EMERGENCY OPENING BY SIS (ESD) | RED | - | ALARM = ESD TRIPPED |

| LEDs PAGE 2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | - | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | FUSES TRIP | RED | | ALARM = FUSES TRIP |
| LED-15 | TRIP FROM L.V. | RED | | ALARM = L.V. TRIP |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| = | | | | | |
| +A7 | | | | | |
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DWG n° : 231151/SD/27
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL FUEL CELL A-80000
Input Protection Relay REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00027 | SHEET 3 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00027 Rev.03

## INPUTS

| B–X1 | | |
|---|---|---|
| 1 / 4 | BI1 | CONTACTOR CLOSED |
| 2 / 4 | BI2 | CONTACTOR OPENED |
| 3 / 4 | BI3 | CONTACTOR SERVICE POSITION |
| 5 / 8 | BI4 | CONTACTOR TEST POSITION |
| 6 / 8 | BI5 | EARTH SWITCH OPENED |
| 7 / 8 | BI6 | EARTH SWITCH CLOSED |
| 9 / 12 | BI7 | RELAY TRIPPED |
| 10 / 12 | BI8 | CONTACTOR READY |
| 11 / 12 | BI9 | FUSES TRIPPED |
| 13 / 16 | BI10 | SELECTOR IN LOCAL POSITION |
| 14 / 16 | BI11 | SELECTOR IN REMOTE POSITION |
| 15 / 16 | BI12 | EXTERNAL CLOSING INTERLOCK |
| 17 / 18 | BI13 | CIRC.BREAKER OPENED (FROM L.V. SWITCHBOARD) |
| B–X2 | | |
| 1 / 2 | BI14 | UNLOCKING EARTHING SWITCH / TRUCK CONTACTOR |

## INPUTS

| C–X1 | | |
|---|---|---|
| 1 / 4 | BI1 | EMERGENCY OPENING BY SIS |
| 2 / 4 | BI2 | V.T. HEALTY CIRCUIT |
| 3 / 4 | BI3 | EARTHING SWITCH OPEN (FROM MEASURING UNIT) |
| 5 / 8 | BI4 | CLOSED AUXILIARY CIRCUIT MCB's |
| 6 / 8 | BI5 | CLOSED AUXILIARY V.T. SECONDARY MCB's |
| 7 / 8 | BI6 | CLOSED AUXILIARY CIRCUIT MCB's |
| 9 / 12 | BI7 | V.T. HEALTY CIRCUIT |
| 10 / 12 | BI8 | UPS 110VDC SUPPLY A "ON" |
| 11 / 12 | BI9 | UPS 110VDC SUPPLY B "ON" |
| 13 / 16 | BI10 | 230VAC SUPPLY "ON" |
| 14 / 16 | BI11 | 24VDC SUPPLY "ON" |
| 15 / 16 | BI12 | SPACE HEATER ON |
| 17 / 18 | BI13 | TRANSF. ALARM WINDING TEMPERATURE |
| B–X2 | | |
| 1 / 2 | BI14 | TRANSF. TRIP WINDING TEMPERATURE |

FORM MEASURE UNIT A5

## INPUTS

| D–X1 | | |
|---|---|---|
| 1 / 4 | BI1 | LOCAL CLOSING COMMAND |
| 2 / 4 | BI2 | LOCAL OPENING COMMAND |
| 3 / 4 | BI3 | CIRC.BREAKER IN TEST POSITION (FROM L.V. SWITCHBOARD) |
| 5 / 8 | BI4 | CIRC.BREAKER TRIPPED (FROM L.V. SWITCHBOARD) |
| 6 / 8 | BI5 | SPACE HEATER "ON" |
| 7 / 8 | BI6 | AVAILABLE REMOTE OPENING COMMNAD |
| 9 / 12 | BI7 | AUXILIARY 230VAC HEALTLTY |
| 10 / 12 | BI8 | MCB AND WATCHDOG PROTECTION. RELAY HEALTH (FROM UNIT A6) |
| 11 / 12 | BI9 | AVAILABLE |

## ARC MODULE

| | | |
|---|---|---|
| LIGHT SENSOR INPUT 1 | Slot A1 X11 | ARC "MAIN BUS BAR" "BB" |
| LIGHT SENSOR INPUT 2 | Slot A1 X12 | ARC "CONTACTOR COMPART." "CB" |
| LIGHT SENSOR INPUT 3 | Slot A1 X13 | ARC "CABLE COMPARTEMENT" "CC" |
| LIGHT SENSOR INPUT 4 | Slot A1 X14 | |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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DWG n° : 231151/SD/27
Item n° : PF1113279

CROSSWIND
IMESA ELECTRICAL ENGINEERING
ROSETTI MARINO

TITLE :
SG–100D1 – LOGICAL FUEL CELL A–80000
Input Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197–EL–DG–00027 | SHEET 4 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00027 Rev.03

## OUTPUT

B–X2

| | | | |
|---|---|---|---|
| 3 4 | S01 | TRIPPED PRTOECTION | |
| 5 6 | S02 | EARTHING SWITCH CLOSED TO TERMINAL STRIP | |
| 7 8 | S03 | AVAILABLE OUT TO TERMINAL | |
| 9 10 | S04 | RESET LOCKOUT RELAY | |
| 11 12 | S05 | | |
| 13 14 | S06 | | |
| 15 16 | S07 | | |
| 17 18 | S08 | | |

## OUTPUT

C–X2

| | | |
|---|---|---|
| 3 4 | S01 | |
| 5 6 | S02 | |
| 7 8 | S03 | |
| 9 10 | S04 | |
| 11 12 | S05 | |
| 13 14 | S06 | |
| 15 16 | S07 | |
| 17 18 | S08 | |

## OUTPUT

D–X2

| | | |
|---|---|---|
| 3(–) | SP01 | |
| 4(+) 5(–) | SP02 | |
| 6(+) 7(–) | SP03 | |
| 8(+) 9(–) | SP04 | |
| 10(+) 11(–) | SP05 (I) | |
| 12(+) 13(–) | SP06 TCS | |
| 14(+) 15(–) | SP07 (I) | |
| 16(+) 17(–) | SP08 TCS | |
| 18(+) | | |

## OUTPUT

G–X1

| | | |
|---|---|---|
| 1 2 | | Uaux |
| 3 5 4 | RF | WATCHDOG |
| 6 8 7 | S01 | E.SWITCH UNLOCKED |
| 9 10 | S02 | CONTACTOR READY TO CLOSE |
| 11 12 | SS01 | |
| 13 14 | SS02 | |
| 15 16 | POSP1 | CONTACTOR CLOSING COMMAND |
| 17 18 | POSP2 | |

## OUTPUT

G–X2

| | | |
|---|---|---|
| 1 3 2 | S03 | CONTACTOR TRUCK UNLOCKED |
| 4 6 5 | (I) PODP1 | |
| 7 8 | TCS P01_TCS | CONTACTOR OPENING COMMAND |
| 9 11 10 | (I) PODP2 | |
| 12 13 | TCS P02_TCS | |
| 14 16 15 | (I) PODP3 | |
| 17 18 | TCS P03_TCS | |

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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :

SG–100D1 – LOGICAL FUEL CELL A–80000

Output Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00027

SHEET 5

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00027 Rev.03

# INPUTS

# PROTECTIONS REX640 (FP1)

# OUTPUTS

50-1 / 3I>>> / PHIPTOC1 (0 / 1 / Start)
TO EMCS IEC 61850: 50-1 -PROTECTION OPERATED
51-1 / 3I> / PHLPTOC1 (0 / 1 / Start)
TO EMCS IEC 61850: 51-1 -PROTECTION OPERATED
51N / Io> / EFLPTOC1 (0 / 1 / Start)
TO EMCS IEC 61850: 51N PROTECTION OPERATED
59N-2 / Vo> / ROVPTOV2 (0 / 1 / Start)
TO EMCS IEC 61850: 59N-2 PROTECTION OPERATED
7.6D
67
t=0,5"
RESET
K86
9.5A
K86
7.5B
59N
7.8A
LED-5 (RED)
LED-6 (RED)
LED-15 (RED)
PROTECTION
8.6B
TO EMCS IEC 61850: INTERTRIP SEND (TO L.V. SWITCHB.)
B_X2-S01
K86: 0 TRIPPED PROTECTION / 1 PROTECTION

KA1: TRIP PROTECTION FROM LOW VOLTAGE (0 / 1)
D-X1-5

INCOMING VOLTAGE
MAIN BUS BAR VOLTAGE
U3P2 25 SYNC U3P1 SECRSYN (0 / 1 / Start)
SYNCH OK
LED-3 (RED)
SYNCH OK
7.4C
TO EMCS IEC 61850: 25 SYNCHRO OK

7.5B 59-2
10.6C TRIPPED TRASF.
9.4B FUSE

ONLY "LIGHT"
50L/50NL ARC ARCSARC1 (0 / 1 / Start)
ARC "MAIN BUS BAR" "BB"
ONLY "LIGHT"
50L/50NL ARC ARCSARC2 (0 / 1 / Start)
ARC "CONTACTOR COMPART." "CB"
ONLY "LIGHT"
50L/50NL ARC ARCSARC3 (0 / 1 / Start)
ARC "CABLE COMPARTEMENT" "CC"

GOOSE FROM INCOMINGS:
UNIT :A6
TRIPPED ARC PROTECTION FOR:
- ARC DETECTED ON MAIN BUS BAR (FROM ALL UNITS)
- ARC DETECTED ON C.B. / CONTACTOR COMPARTEMENT (FROM ALL UNITS)
- ARC DETECTED ON CABLE COMPARTEMENT (ONLY CONTACTOR UNIT)

t=0,5"
LED-9 (RED)
9.5A K86 ARC
8.6C

GOOSE TO INCOMINGS:
UNIT :A6
0 TRIPPED ARC PROTECTION
1

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Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL FUEL CELL A-80000
Protections REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS
A3
DRAWING NO. 1723002197-EL-DG-00027
SHEET 6
REV. 03

F.to UNI A3: 420mmx297mm

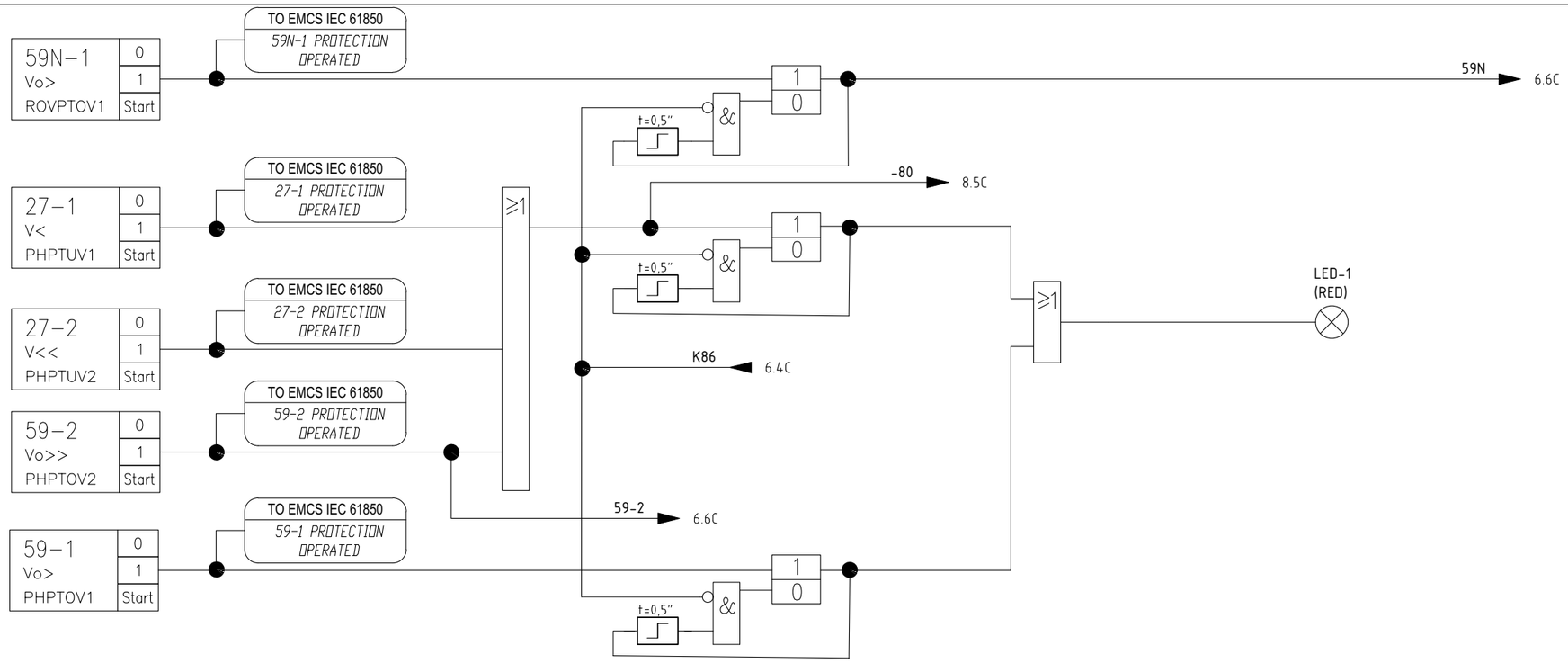
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| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|

## INPUTS

## PROTECTIONS REX640 (FP1)

## OUTPUTS




| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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CROSSWIND

ROSETTI MARINO

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SG-100D1 - LOGICAL FUEL CELL A-80000
Protections REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00027

SHEET 7

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00027 Rev.03

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

S20 LOCAL OPENING COMMAND 0/1 → D-X1-2

K1 – BGT4 CONTACTOR SERVICE 0/1 → B-X1-3

K1 – BGT5 CONTACTOR TEST 0/1 → B-X1-5

XM REMOTE AVAILABLE OPENING COMMAND 0/1 → D-X1-7

QA2 AUXILIARY 230VAC HEALTLY (ALL SWITCH.) 0/1 → D-X1-9

SA1 SELECTOR IN REMOTE POSITION 0/1 → B-X1-14

SA1 SELECTOR IN LOCAL POSITION 0/1 → B-X1-13

S1C LOCAL CLOSING COMMAND 0/1 → D-X1-1

KGR SPACE HEATER "ON" 0/1 → D-X1-6

KGR SPACE HEATER ON FROM MEASURE UNIT A5 0/1 → C-X1-15

IEC 61850 – EMCS OPENING 0/1

IEC 61850 – EMCS CLOSING 0/1

TO EMCS IEC 61850: *AUXIL 230Vac HEALTY (ALL SWITCH)*

TO EMCS IEC 61850: *SELECTOR IN REMOTE POSITION*

TO EMCS IEC 61850: *SELECTOR IN LOCAL POSITION*

TO EMCS IEC 61850: *RESET LOCKOUT RELAY*

TEST → 8.5D

INSERT. → 9.3D

INSERT. → 9.4C

INSERT.

INSERT.

INSERT.

REMOTE → 9.7B

LOCAL → 11.4B

LOCAL

REMOTE

LOCAL OPENING

REMOTE OPENING

6.9B PROTECTION

9.5A K86

UNDERVOLTAGE

7.6A -80

6.6E ARC

OPENING → 9.4C

G_PODP1-X2 → K1 0/1 CONTACTOR OPENING

B_S04-X2 → FP1c 0/1 RESET LOCKOUT RELAY

REMOTE CLOSING

LOCAL CLOSING

9.6B READY

TEST LOCAL CLOSING

LOCAL CLOSING

8.3B TEST

TEST → 11.3C

G_POSP1-X1 → K1 0/1 CONTACTOR CLOSING

LED-12 (RED)

| | | | | | | |
|---|---|---|---|---|---|---|
| = | | | | | | |
| +A7 | | | | | | |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG–100D1 – LOGICAL FUEL CELL A–80000

Contactor Commands

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00027

SHEET 8

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00027 Rev.03

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

K86 RELAY TRIPPED (0/1) — B-X1-9

XM EXTERNAL CLOSING INTERLOCK (0/1) — B-X1-15

XM FROM L.V.SWDB C.B.OPENED (0/1) — B-X1-17

DO1 CONTACTOR READY (TCS) (0/1) — B-X1-10

BGF2 FUSE TRIPPED (0/1) — B-X1-11

BGE EARTHING SWITCH OPENED (0/1) — B-X1-6

BGE EARTHING SWITCH CLOSED (0/1) — B-X1-7

K1 CONTACTOR OPENED (0/1) — B-X1-2

QD2 – QD4 CLOSED AUXILIARY CIRCUIT MCB's (0/1) — C-X1-5

QV4 – QV5 CLOSED AUXILIARY V.T. SECONDARY MCB's (0/1) — C-X1-6

KSIL EMERGENCY OPENING BY SIS (0/1) — C-X1-1

K1 CONTACTOR CLOSED (0/1) — B-X1-1

TO EMCS IEC 61850 *K86 TRIPPED*

K86 → 6.6D

K86 → 8.6B

K86 → 6.4C

LED-2 (GREEN)

TO EMCS IEC 61850 *CONTACTOR READY (TCS)*

LED-14 (RED)

FUSE → 6.6D

E.S. OPEN → 11.4B

E.S. CLOSED → 9.8C

7.5C → 68

8.5B → INSERT.

8.7B → OPENING

CONT.OPEN → 11.4B

CONTACTOR OPENED

TO EMCS IEC 61850 *MCB's CLOSED*

LED-11 (RED)

8.5A → INSERT.

TO EMCS IEC 61850 *CONTACTOR CLOSED AND INSERTED*

10.4C → V.T.

READY → 8.6C

LED-4 (GREEN)

8.4C → REMOTE

TO EMCS IEC 61850 *CONTACTOR READY TO CLOSE*

G_S02-X1 — XM 0/1 CONTACTOR READY TO CLOSE

9.3C → E.S. CLOSED — B_S02-X2 — XM 0/1 E.SWITCH CLOSED

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|---|---|---|---|---|---|---|
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| DWG n°: 231151/SD/27 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As Built (ASB) |
| Item n°: PF1113279 | 2 | 28/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for construction (AFC) |
| | 1 | 21/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 – LOGICAL FUEL CELL A-80000

Contactor Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00027

SHEET 9

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00027 Rev.03

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

| | | |
|---|---|---|
| XC CLOSED AUX. CIRCUIT MCB's | 0/1 | C-X1-7 |
| XC VT HEALTY CIRCUIT | 0/1 | C-X1-9 |
| XC UPS 110VDC SUPPLY A "ON" | 0/1 | C-X1-10 |
| XC UPS 110VDC SUPPLY B "ON" | 0/1 | C-X1-11 |
| XC 230VAC SUPPLY "ON" | 0/1 | C-X1-13 |
| XC 24VDC SUPPLY "ON" | 0/1 | C-X1-14 |
| 49T TRANSF.ALARM WINDING TEMPERATURE | 0/1 | C-X1-17 |
| K94WT TRANSF.TRIPPED WINDING TEMPERATURE | 0/1 | C-X2-1 |
| QV1/2/3-PTT-FF1/2/3 VT HEALTY CIRCUIT | 0/1 | C-X1-2 |

TO EMCS IEC 61850 — *CLOSED AUX. CIRCUIT MCB's*

TO EMCS IEC 61850 — *VT HEALTY CIRCUIT*

TO EMCS IEC 61850 — *UPS 110VDC SUPPLY A "ON"*

TO EMCS IEC 61850 — *UPS 110VDC SUPPLY B "ON"*

TO EMCS IEC 61850 — *230VCA SUPPLY "ON"*

TO EMCS IEC 61850 — *24VDC SUPPLY "ON"*

FROM MEASURE UNIT A5

TO EMCS IEC 61850 — *ALARM WINDING TEMPERATURE*

TO EMCS IEC 61850 — *TRIPPED WINDING TEMPERATURE*

LED-13 (RED)

TRIPPED TRASF. → 6.6D

V.T. → 7.2C

V.T. → 9.5D

TO EMCS IEC 61850 — *VT HEALTY CIRCUIT*

WATCHDOG 0/1

TO EMCS IEC 61850 — *WATCHDOG PROTECTION RELAY*

G_RF-X1

KIRF 0/1 WATCHDOG

| | | | | | | |
|---|---|---|---|---|---|---|
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DWG n° : 231151/SD/27

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 – LOGICAL FUEL CELL A-80000

Contactor Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

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DRAWING NO. 1723002197-EL-DG-00027

SHEET 10

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00027 Rev.03

1 2 3 4 5 6 7 8 9 10

A B C D E

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

BGE
EART.SWITCH OPENED FROM MEASURING UNIT 0 1

C-X1-3

TO EMCS IEC 61850
*EARTHING SWITCH OPENED FROM MEASURE UNIT*

KT1
UNLOCKING E.SWITCH/CONT. TRUCK 0 1

B-X2-1

QB1
LOW VOLTAGE CIR.BREAK IN TEST POSITION 0 1

D-X1-3

QD1 – KIRF (UNIT A6)
MCB AND WATCHDOG PROTEC. RELAY HEALTHY 0 1

D-X1-10

TO EMCS IEC 61850
*PROTECTION RELAY UNIT 6 HEALTHY*

≥1

&

&

9.3C CONT.OPEN

9.4B E.S. OPEN

8.4D LOCAL

8.6E TEST

TO EMCS IEC 61850
*CONTACTOR OPENED OR ISOLATED*

LED-8 (GREEN)

G_S03-X2

RLE2
0 CONTACTOR TRUCK UNLOCKED
1

LED-7 (GREEN)

G_S01-X1

RLE3
0 EARTHING SWITCH UNLOCKED
1

*GOOSE*

LED-10 (RED)

| | | | | | | |
|---|---|---|---|---|---|---|
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 – LOGICAL FUEL CELL A-80000
Contactor Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

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DRAWING NO. 1723002197-EL-DG-00027

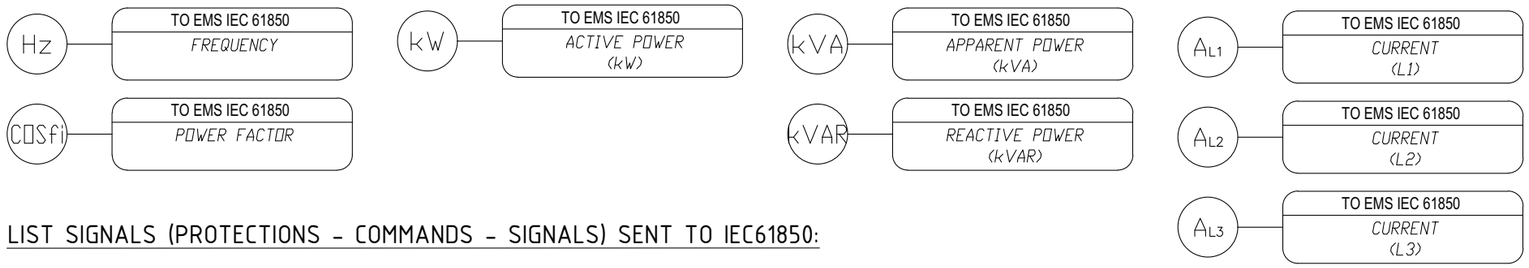
SHEET 1.1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00027 Rev.03

| INPUTS | REX640 SIGNALS MEASURES AND COMMAND AVAILABLE TO IEC61850 | OUTPUTS |
|---|---|---|




LIST SIGNALS (PROTECTIONS - COMMANDS - SIGNALS) SENT TO IEC61850:

- PROTECTION TRIPPED "50-1"
- PROTECTION TRIPPED "51-1"
- PROTECTION TRIPPED "51N"
- SYNCHRO "OK"
- PROTECTION TRIPPED "59N-1"
- PROTECTION TRIPPED "59N-2"
- PROTECTION TRIPPED "27-1"
- PROTECTION TRIPPED "27-2"
- PROTECTION TRIPPED "59-1"
- PROTECTION TRIPPED "59-2"
- PROTECTION TRIPPED "67-1"
- PROTECTION TRIPPED "67-2"
- SELECTOR SWITCH IN LOCAL POSITION
- SELECTOR SWITCH IN REMOTE POSITION
- TRANSFORMER PROTECTION TRIPPED "WINDING TEMPERATURE"
- TRANSFORMER PROTECTION ALARM "WINDING TEMPERATURE"
- WATCHDOG PROTECTION RELAY
- V.T. HEALTLY CIRCUIT
- INTERTRIP SEND TO L.V.SWITCHB.
- K86 TRIPPED
- CONTACTOR CLOSED AND INSERTED
- CONTACTOR OPENED OR ISOLATED
- MCB'S CLOSED
- CONTACTOR READY (TCS)
- CONTACTOR READY TO CLOSE
- OPENING COMMAND
- CLOSING COMMAND
- PROTECTION RELAY UNIT 3 HEALTHY
- AUXILIARY 230VAC HEALTHY (ALL SWITCHBOARD)

- MCB'S CLOSED (FROM MEASURE UNIT A5)
- V.T. HEALTLY CIRCUIT (FROM MEASURE UNIT A5)
- UPS 110VDC A SUPPLY "ON" (FROM MEASURE UNIT A5)
- UPS 110VDC B SUPPLY "ON" (FROM MEASURE UNIT A5)
- 230VAC SUPPLY "ON" (FROM MEASURE UNIT A5)
- 24VDC SUPPLY "ON" (FROM MEASURE UNIT A5)
- EARTHING SWITCH OPENED (FROM MEASURE UNIT A5)

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DWG n° : 231151/SD/27
Item n° : PF1113279

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TITLE :
SG-100D1 - LOGICAL FUEL CELL A-80000
Measures

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00027 | SHEET 12 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00027 Rev.03

1.5.5.SG-100D1 HV SWG LOGIC DIAGRAM - TRANSFORMER FEEDER TR200ED1,

Doc. No. 1723002197-EL-DG-00028

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# "SG-100D1" HV SWBD 6,6kV (UNIT A2)

# LOGICAL DIAGRAM

# TRANSFORMER FEEDER TR-200ED1

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macule | 12/09/2024 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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DWG n° : 231151/SD/28

Item n° : PF1113279

TITLE : SG-100D1 – LOGICAL TRANSF FEEDER TR-200ED1

Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00028

SHEET 1

REV. 03

File Name : 1723002197-EL-DG-00028 Rev.03

F.to UNI A3: 420mmx297mm

# INDEX

| Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Sheet | Description | Revision 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cover | | | | | | | | | | | | | | | | | | | | |
| 2 | Sheets index | | | | | | | | | | | | | | | | | | | | |
| 3 | Input Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 4 | Input Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 5 | Output Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 6 | Protections REX640 | | | | | | | | | | | | | | | | | | | | |
| 7 | Protections REX640 | | | | | | | | | | | | | | | | | | | | |
| 8 | Contactor Commands | | | | | | | | | | | | | | | | | | | | |
| 9 | Contactor Commands | | | | | | | | | | | | | | | | | | | | |
| 10 | Contactor Commands | | | | | | | | | | | | | | | | | | | | |
| 11 | Contactor Commands | | | | | | | | | | | | | | | | | | | | |
| 12 | Measures | | | | | | | | | | | | | | | | | | | | |
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DWG n° : 231151/SD/28

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - LOGICAL TRANSF FEEDER TR-200ED1

Sheets index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

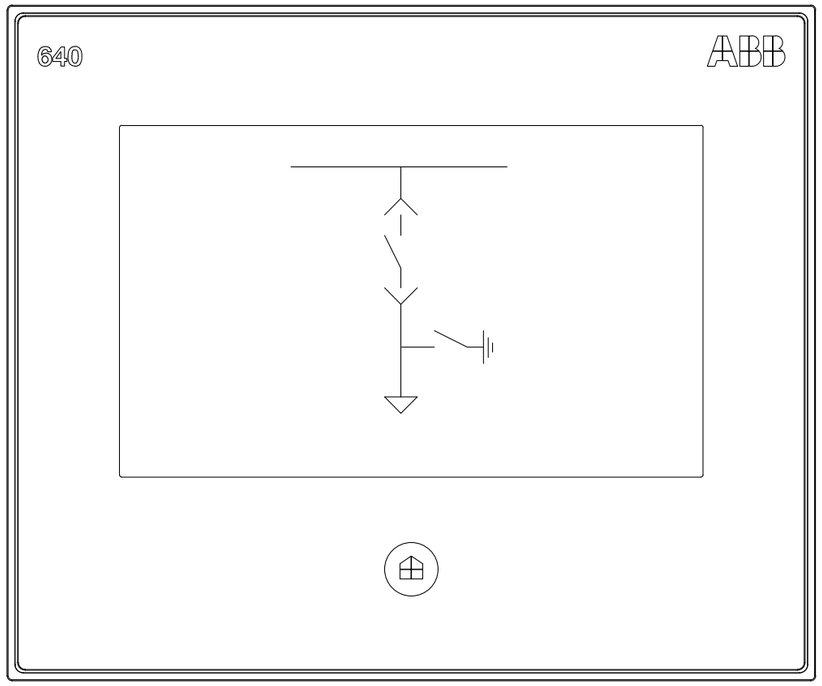
DRAWING NO. 1723002197-EL-DG-00028

SHEET 2

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00028 Rev.03




LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE C.B." AND "OPEN C.B." NON ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED
- ONLY PUSH BUTTON "RESET" ARC PROTECTION WILL BE ENABLED

| LEDs PAGE 1 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/27-2/59-1/59-2 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | CONTACTOR READY (TCS) | - | GREEN | OK = TCS OK (CONTACTOR READY) |
| LED-3 | SYNCHRO CHECK | | GREEN | OK = SYNCHRONISM |
| LED-4 | CONTACTOR READY TO CLOSE | - | GREEN | OK = CONTACTOR READY TO CLOSE |
| LED-5 | 50-1/51-1/67-1/67-2 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/59N-1/59N-2 - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = CONTACTOR TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | EMERGENCY OPENING BY SIS (ESD) | RED | - | ALARM = ESD TRIPPED |

| LEDs PAGE 2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | - | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | FUSES TRIP | RED | | ALARM = FUSES TRIP |
| LED-15 | TRIP FROM L.V. | RED | | ALARM = L.V. TRIP |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

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DWG n° : 231151/SD/28
Item n° : PF1113279

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TITLE :
SG-100D1 - LOGICAL TRANSF FEEDER TR-200ED1
Input Protection Relay REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00028 | SHEET 3 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00028 Rev.03

## INPUTS

| B–X1 | | |
|---|---|---|
| 1 | BI1 | CONTACTOR CLOSED |
| 4 | | |
| 2 | BI2 | CONTACTOR OPENED |
| 4 | | |
| 3 | BI3 | CONTACTOR SERVICE POSITION |
| 4 | | |
| 5 | BI4 | CONTACTOR TEST POSITION |
| 8 | | |
| 6 | BI5 | EARTH SWITCH OPENED |
| 8 | | |
| 7 | BI6 | EARTH SWITCH CLOSED |
| 8 | | |
| 9 | BI7 | RELAY TRIPPED |
| 12 | | |
| 10 | BI8 | CONTACTOR READY |
| 12 | | |
| 11 | BI9 | FUSES TRIPPED |
| 12 | | |
| 13 | BI10 | SELECTOR IN LOCAL POSITION |
| 16 | | |
| 14 | BI11 | SELECTOR IN REMOTE POSITION |
| 16 | | |
| 15 | BI12 | EXTERNAL CLOSING INTERLOCK |
| 16 | | |
| 17 | BI13 | CIRC.BREAKER OPENED (FROM L.V. SWITCHBOARD) |
| 18 | | |
| | | |
| B–X2 | | |
| 1 | BI14 | UNLOCKING EARTHING SWITCH / TRUCK CONTACTOR |
| 2 | | |

## INPUTS

| C–X1 | | |
|---|---|---|
| 1 | BI1 | EMERGENCY OPENING BY SIS |
| 4 | | |
| 2 | BI2 | V.T. HEALTY CIRCUIT |
| 4 | | |
| 3 | BI3 | EARTHING SWITCH OPEN (FROM MEASURING UNIT) |
| 4 | | |
| 5 | BI4 | CLOSED AUXILIARY CIRCUIT MCB's |
| 8 | | |
| 6 | BI5 | CLOSED AUXILIARY V.T. SECONDARY MCB's |
| 8 | | |
| 7 | BI6 | TRANSF. ALAM BUCHHOLZ |
| 8 | | |
| 9 | BI7 | ALARM TRIP BUCHHOLZ |
| 12 | | |
| 10 | BI8 | TRANSF. ALARM OIL TEMPERATURE |
| 12 | | |
| 11 | BI9 | TRANSF. TRIP OIL TEMPERATURE |
| 12 | | |
| 13 | BI10 | TRANSF.ALARM OIL LEVEL |
| 16 | | |
| 14 | BI11 | TRANSF. OIL LEVEL VERY LOW ALARM |
| 16 | | |
| 15 | BI12 | TRANSF. TRIP OIL PRESSURE |
| 16 | | |
| 17 | BI13 | TRANSF. ALARM WINDING TEMPERATURE |
| 18 | | |
| | | |
| B–X2 | | |
| 1 | BI14 | TRANSF. TRIP WINDING TEMPERATURE |
| 2 | | |

## INPUTS

| D–X1 | | |
|---|---|---|
| 1 | BI1 | LOCAL CLOSING COMMAND |
| 4 | | |
| 2 | BI2 | LOCAL OPENING COMMAND |
| 4 | | |
| 3 | BI3 | CIRC.BREAKER IN TEST POSITION (FROM L.V. SWITCHBOARD) |
| 4 | | |
| 5 | BI4 | CIRC.BREAKER TRIPPED (FROM L.V. SWITCHBOARD) |
| 8 | | |
| 6 | BI5 | SPACE HEATER "ON" |
| 8 | | |
| 7 | BI6 | AVAILABLE REMOTE OPENING COMMNAD |
| 8 | | |
| 9 | BI7 | TRANSF. GENERAL ALARM |
| 12 | | |
| 10 | BI8 | MCB AND WATCHDOG PROTECTION. RELAY HEALTH (FROM UNIT A1) |
| 12 | | |
| 11 | BI9 | SELECTOR SWITCH OF OVERRIDE (SIL ENABLED) |
| 12 | | |

## ARC MODULE

| | | |
|---|---|---|
| LIGHT SENSOR INPUT 1 | Slot A1 X11 | ARC "MAIN BUS BAR" "BB" |
| LIGHT SENSOR INPUT 2 | Slot A1 X12 | ARC "CONTACTOR COMPART." "CB" |
| LIGHT SENSOR INPUT 3 | Slot A1 X13 | ARC "CABLE COMPARTEMENT" "CC" |
| LIGHT SENSOR INPUT 4 | Slot A1 X14 | |

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DWG n° : 231151/SD/28
Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :
SG–100D1 – LOGICAL TRANSF FEEDER TR–200ED1
Input Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00028

SHEET 4

REV. 03

File Name : 1723002197–EL–DG–00028 Rev.03

F.to UNI A3: 420mmx297mm

## OUTPUT

B–X2

| | | | |
|---|---|---|---|
| 3 4 | S01 | TRIPPED PRTOECTION | |
| 5 6 | S02 | EARTHING SWITCH CLOSED TO TERMINAL STRIP | |
| 7 8 | S03 | AVAILABLE OUT TO TERMINAL | |
| 9 10 | S04 | RESET LOCKOUT RELAY | |
| 11 12 | S05 | | |
| 13 14 | S06 | | |
| 15 16 | S07 | | |
| 17 18 | S08 | | |

## OUTPUT

C–X2

| | | |
|---|---|---|
| 3 4 | S01 | |
| 5 6 | S02 | |
| 7 8 | S03 | |
| 9 10 | S04 | |
| 11 12 | S05 | |
| 13 14 | S06 | |
| 15 16 | S07 | |
| 17 18 | S08 | |

## OUTPUT

D–X2

| | | |
|---|---|---|
| 3(–) | SP01 | |
| 4(+) 5(–) | SP02 | |
| 6(+) 7(–) | SP03 | |
| 8(+) 9(–) | SP04 | |
| 10(+) 11(–) | SP05 (I) | |
| 12(+) 13(–) | SP06 TCS | |
| 14(+) 15(–) | SP07 (I) | |
| 16(+) 17(–) | SP08 TCS | |
| 18(+) | | |

## OUTPUT

G–X1

| | | |
|---|---|---|
| 1 2 | | Uaux |
| 3 5 4 | RF | WATCHDOG |
| 6 8 7 | S01 | E.SWITCH UNLOCKED |
| 9 10 | S02 | CONTACTOR READY TO CLOSE |
| 11 12 | SS01 | |
| 13 14 | SS02 | |
| 15 16 | POSP1 | CONTACTOR CLOSING COMMAND |
| 17 18 | POSP2 | |

## OUTPUT

G–X2

| | | |
|---|---|---|
| 1 3 2 | S03 | CONTACTOR TRUCK UNLOCKED |
| 4 6 5 | (I) PODP1 | |
| 7 8 | TCS P01_TCS | CONTACTOR OPENING COMMAND |
| 9 11 10 | (I) PODP2 | |
| 12 13 | TCS P02_TCS | |
| 14 16 15 | (I) PODP3 | |
| 17 18 | TCS P03_TCS | |

| | | | | | | |
|---|---|---|---|---|---|---|
| = | | | | | | |
| +A7 | | | | | | |
| 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) | |
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| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION | |

DWG n°: 231151/SD/28
Item n°: PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG–100D1 – LOGICAL TRANSF FEEDER TR–200ED1
Output Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00028

SHEET 5

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00028 Rev.03

# INPUTS

# PROTECTIONS REX640 (FP1)

# OUTPUTS

7.6D 67

50-1 / 3I>>> / PHIPTOC1 — 0 / 1 / Start

TO EMCS IEC 61850 — *50-1 -PROTECTION OPERATED*

51-1 / 3I> / PHLPTOC1 — 0 / 1 / Start

TO EMCS IEC 61850 — *51-1 -PROTECTION OPERATED*

TO EMCS IEC 61850 — *51N PROTECTION OPERATED*

51N / Io> / EFLPTOC1 — 0 / 1 / Start

59N-2 / Vo> / ROVPTOV2 — 0 / 1 / Start

TO EMCS IEC 61850 — *59N-2 PROTECTION OPERATED*

t=0,5"

RESET

K86 9.5A

K86 7.5B

59N 7.8A

LED-5 (RED)

LED-6 (RED)

PROTECTION 8.6B

TO EMCS IEC 61850 — *INTERTRIP SEND (TO L.V. SWITCHB.)*

B_X2-S01

K86 — 0 TRIPPED PROTECTION / 1

KA1 — TRIP PROTECTION FROM LOW VOLTAGE — 0 / 1

D-X1-5

INCOMING VOLTAGE

MAIN BUS BAR VOLTAGE

U3P2 25 SYNC U3P1 SECRSYN — 0 / 1 / Start

SYNCH OK

LED-3 (RED)

SYNCH OK 7.4C

TO EMCS IEC 61850 — *25 SYNCHRO OK*

LED-15 (RED)

7.5B 59-2

10.8B TRIPPED TRASF.

9.4B FUSE

ONLY "LIGHT"

50L/50NL ARC ARCSARC1 — 0 / 1 / Start — ARC "MAIN BUS BAR" "BB"

ONLY "LIGHT"

50L/50NL ARC ARCSARC2 — 0 / 1 / Start — ARC "CONTACTOR COMPART." "CB"

ONLY "LIGHT"

50L/50NL ARC ARCSARC3 — 0 / 1 / Start — ARC "CABLE COMPARTEMENT" "CC"

GOOSE FROM INCOMINGS: UNIT :A6

TRIPPED ARC PROTECTION FOR:
- ARC DETECTED ON MAIN BUS BAR (FROM ALL UNITS)
- ARC DETECTED ON C.B. / CONTACTOR COMPARTEMENT (FROM ALL UNITS)
- ARC DETECTED ON CABLE COMPARTEMENT (ONLY CONTACTOR UNIT)

t=0,5"

LED-9 (RED)

9.6A K86 ARC

8.6C

GOOSE TO INCOMINGS: UNIT :A6

0 TRIPPED ARC PROTECTION / 1

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+A7

DWG n° : 231151/SD/28

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG-100D1 - LOGICAL TRANSF FEEDER TR-200ED1

Protections REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00028

SHEET 6

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00028 Rev.03

INPUTS

PROTECTIONS REX640 (FP1)

OUTPUTS

59N-1 Vo> ROVPTOV1 (0 / 1 / Start)
TO EMCS IEC 61850 — 59N-1 PROTECTION OPERATED
59N — 6.6C

27-1 V< PHPTUV1 (0 / 1 / Start)
TO EMCS IEC 61850 — 27-1 PROTECTION OPERATED

27-2 V<< PHPTUV2 (0 / 1 / Start)
TO EMCS IEC 61850 — 27-2 PROTECTION OPERATED

59-2 Vo>> PHPTOV2 (0 / 1 / Start)
TO EMCS IEC 61850 — 59-2 PROTECTION OPERATED
59-2 — 6.6C

59-1 Vo> PHPTOV1 (0 / 1 / Start)
TO EMCS IEC 61850 — 59-1 PROTECTION OPERATED

≥1 — -80 — 8.5C

K86 — 6.4C

≥1 — LED-1 (RED)

t=0,5" — &

(DEAD LINE - LIVE MAIN BUS BARS)
25 Dead L Live B (0 / 1 / Start), BLOCK ← 10.4D V.T.
≥1 — 68 — 9.4C

6.4D SYNCH OK (LIVE LINE - LIVE MAIN BUS BARS)

GOOSE (from unit A6)
FUNCTIONS BLOCKED WITH 6.6kV and 66kV C.BREAKERS CLOSED

67-1 31> -> DPHLPDOC1 (0 / 1 / Start), BLOCK
TO EMCS IEC 61850 — 67-1 -PROTECTION OPERATED

67-2 31>> -> DPHLPDOC2 (0 / 1 / Start), BLOCK
TO EMCS IEC 61850 — 67-2 -PROTECTION OPERATED

≥1 — 67 — 6.3A

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+A7
DWG n°: 231151/SD/28
Item n°: PF1113279

IMESA ELECTRICAL ENGINEERING
CROSSWIND
ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL TRANSF FEEDER TR-200ED1
Protections REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK
SCALE : NTS

A3
DRAWING NO. 1723002197-EL-DG-00028
SHEET 7
REV. 03

File Name : 1723002197-EL-DG-00028 Rev.03

F.to UNI A3: 420mmx297mm

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

S20 LOCAL OPENING COMMAND 0/1 — D-X1-2

K1 – BGT4 CONTACTOR SERVICE 0/1 — B-X1-3

K1 – BGT5 CONTACTOR TEST 0/1 — B-X1-5

XM REMOTE AVAILABLE OPENING COMMAND 0/1 — D-X1-7

IEC 61850 – EMCS OPENING 0/1

SA1 SELECTOR IN REMOTE POSITION 0/1 — B-X1-14

SA1 SELECTOR IN LOCAL POSITION 0/1 — B-X1-13

IEC 61850 – EMCS CLOSING 0/1

S1C LOCAL CLOSING COMMAND 0/1 — D-X1-1

KGR SPACE HEATER "ON" 0/1 — D-X1-6

LED-12 (RED)

TEST → 8.5D

INSERT. → 9.3D

INSERT. → 9.4C

INSERT.

INSERT.

INSERT.

7.6A –80

LOCAL → 11.4B

REMOTE → 9.7B

TO EMCS IEC 61850 *SELECTOR IN REMOTE POSITION*

TO EMCS IEC 61850 *SELECTOR IN LOCAL POSITION*

LOCAL OPENING

REMOTE OPENING

6.9B PROTECTION

9.5A K86

UNDERVOLTAGE

6.6E ARC

REMOTE CLOSING

LOCAL CLOSING

9.6B READY

LOCAL CLOSING

8.3B TEST

TEST → 11.3C

TEST LOCAL CLOSING

OPENING → 9.4C

G_PODP1-X2 → K1 0/1 CONTACTOR OPENING

TO EMCS IEC 61850 *RESET LOCKOUT RELAY* — B_S04-X2 → FP1c 0/1 RESET LOCKOUT RELAY

G_POSP1-X1 → K1 0/1 CONTACTOR CLOSING

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DWG n° : 231151/SD/28

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE : SG–100D1 – LOGICAL TRANSF FEEDER TR–200ED1

Contactor Commands

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00028

SHEET 8

REV. 03

File Name : 1723002197–EL–DG–00028 Rev.03

F.to UNI A3: 420mmx297mm

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

K86 RELAY TRIPPED (0/1) — B-X1-9

XM EXTERNAL CLOSING INTERLOCK (0/1) — B-X1-15

XM FROM L.V.SWDB C.B.OPENED (0/1) — B-X1-17

DO1 CONTACTOR READY (TCS) (0/1) — B-X1-10

BGF2 FUSE TRIPPED (0/1) — B-X1-11

BGE EARTHING SWITCH OPENED (0/1) — B-X1-6

BGE EARTHING SWITCH CLOSED (0/1) — B-X1-7

K1 CONTACTOR OPENED (0/1) — B-X1-2

QD2 – QD4 CLOSED AUXILIARY CIRCUIT MCB's (0/1) — C-X1-5

QV4 – QV5 CLOSED AUXILIARY V.T. SECONDARY MCB's (0/1) — C-X1-6

KSIL EMERGENCY OPENING BY SIS (0/1) — C-X1-1

K1 CONTACTOR CLOSED (0/1) — B-X1-1

TO EMCS IEC 61850 — K86 TRIPPED

K86 → 6.6D

K86 → 8.6B

K86 → 6.4C

LED-2 (GREEN)

TO EMCS IEC 61850 — CONTACTOR READY (TCS)

LED-11 (RED)

FUSE → 6.6D

E.S. OPEN → 11.4B

E.S. CLOSED → 9.8C

7.5C → 68

8.5B → INSERT.

8.7B → OPENING

CONT.OPEN → 11.4B

CONTACTOR OPENED

MCB's CLOSED

LED-11 (RED)

8.5A → INSERT.

TO EMCS IEC 61850 — CONTACTOR CLOSED AND INSERTED

10.4D → V.T.

READY → 8.6C

LED-4 (GREEN)

8.4C → REMOTE

TO EMCS IEC 61850 — CONTACTOR READY TO CLOSE

G_S02-X1 — XM 0/1 CONTACTOR READY TO CLOSE

9.3C → E.S. CLOSED — B_S02-X2 — XM 0/1 E.SWITCH CLOSED

| | | | | | | |
|---|---|---|---|---|---|---|
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| +A7 | | | | | | |
| DWG n° : 231151/SD/28 | 3 | 08/08/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| Item n° : PF1113279 | 2 | 28/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for construction (AFC) |
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :

SG–100D1 – LOGICAL TRANSF FEEDER TR–200ED1

Contactor Commands

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00028

SHEET 9

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00028 Rev.03

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

| | | |
|---|---|---|
| 97T TRANSF.ALARM BUCHHOLZ | 0 / 1 | C-X1-7 |
| K94B TRANSF.TRIPPED BUCHHOLZ | 0 / 1 | C-X1-9 |
| 26OT TRANSF.ALARM OIL TEMPERATURE | 0 / 1 | C-X1-10 |
| K94OT TRANSF.TRIPPED OIL TEMPERATURE | 0 / 1 | C-X1-11 |
| 71OT TRANSF.ALARM OIL LEVEL | 0 / 1 | C-X1-13 |
| 71OT_1 TRANSF.OIL LEVEL VERY LOW ALARM | 0 / 1 | C-X1-14 |
| K94P TRANSF.TRIPPED OIL PRESSURE | 0 / 1 | C-X1-15 |
| 49T TRANSF.ALARM WINDING TEMPERATURE | 0 / 1 | C-X1-17 |
| K94WT TRANSF.TRIPPED WINDING TEMPERATURE | 0 / 1 | C-X2-1 |
| XM TRANSFORMER GENERAL ALARM | 0 / 1 | D-X1-9 |
| QV1/2/3-PTT-FF1/2/3 VT HEALTY CIRCUIT | 0 / 1 | C-X1-2 |
| SA2 SELECTOR SWITCH OF OVERRIDE (SIL ENABLED) | 0 / 1 | D-X1-11 |

- C-X1-7 → TO EMCS IEC 61850: *ALARM BUCHHOLZ*
- C-X1-9 → TO EMCS IEC 61850: *TRIPPED BUCHHOLZ*
- C-X1-10 → TO EMCS IEC 61850: *ALARM OIL TEMPERATURE*
- C-X1-11 → TO EMCS IEC 61850: *TRIPPED OIL TEMPERATURE*
- C-X1-13 → TO EMCS IEC 61850: *ALARM OIL LEVEL*
- C-X1-14 → TO EMCS IEC 61850: *OIL LEVEL VERY LOW ALARM*
- C-X1-15 → TO EMCS IEC 61850: *TRIPPED OIL PRESSURE*
- C-X1-17 → TO EMCS IEC 61850: *ALARM WINDING TEMPERATURE*
- C-X2-1 → TO EMCS IEC 61850: *TRIPPED WINDING TEMPERATURE*
- D-X1-9 → TO EMCS IEC 61850: *TRANSFORMER GENERAL ALARM*
- C-X1-2 → TO EMCS IEC 61850: *VT HEALTY CIRCUIT*
- D-X1-11 → TO EMCS IEC 61850: *SELECTOR SWITCH OF OVERRIDE (SIL ENABLED)*

≥1

LED-13 (RED)

TRIPPED TRASF. → 6.6D

V.T. → 7.2C

V.T. → 9.5D

WATCHDOG (0 / 1) → TO EMCS IEC 61850: *WATCHDOG PROTECTION RELAY* → G_RF-X1 → KIRF 0 WATCHDOG 1

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DWG n° : 231151/SD/28

Item n° : PF1113279

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :

SG-100D1 - LOGICAL TRANSF FEEDER TR-200ED1

Contactor Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00028

SHEET 10

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00028 Rev.03

1 2 3 4 5 6 7 8 9 10

A B C D E

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

BGE
EART.SWITCH OPENED FROM MEASURING UNIT 0 1
C-X1-3

KT1
UNLOCKING E.SWITCH/CONT. TRUCK 0 1
B-X2-1

QB1
LOW VOLTAGE CIR.BREAK IN TEST POSITION 0 1
D-X1-3

QD1 – KIRF (UNIT A1)
MCB AND WATCHDOG PROTEC. RELAY HEALTHY 0 1
D-X1-10

≥1

TO EMCS IEC 61850
CONTACTOR OPENED OR ISOLATED

&

9.3C CONT.OPEN

9.4B E.S. OPEN

8.4D LOCAL

8.6E TEST

LED-8 (GREEN)

G_S03-X2

RLE2
0 CONTACTOR TRUCK UNLOCKED
1

LED-7 (GREEN)

G_S01-X1

RLE3
0 EARTHING SWITCH UNLOCKED
1

TO EMCS IEC 61850
PROTECTION RELAY UNIT 1 HEALTHY

GOOSE

LED-10 (RED)

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+A7
DWG n° : 231151/SD/28
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

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SG-100D1 – LOGICAL TRANSF FEEDER TR-200ED1
Contactor Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00028

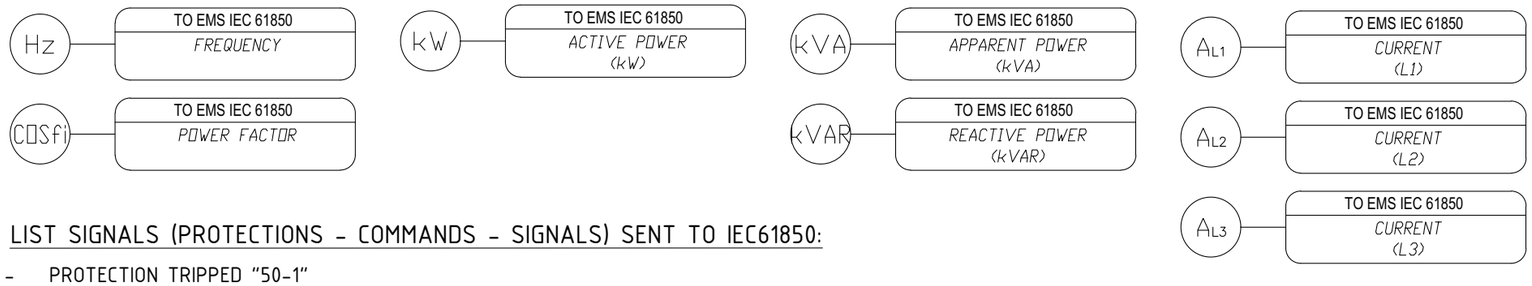
SHEET 1.1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00028 Rev.03

| INPUTS | REX640 SIGNALS MEASURES AND COMMAND AVAILABLE TO IEC61850 | OUTPUTS |
|---|---|---|




LIST SIGNALS (PROTECTIONS - COMMANDS - SIGNALS) SENT TO IEC61850:

- PROTECTION TRIPPED "50-1"
- PROTECTION TRIPPED "51-1"
- PROTECTION TRIPPED "51N"
- SYNCHRO "OK"
- PROTECTION TRIPPED "59N-1"
- PROTECTION TRIPPED "59N-2"
- PROTECTION TRIPPED "27-1"
- PROTECTION TRIPPED "27-2"
- PROTECTION TRIPPED "59-1"
- PROTECTION TRIPPED "59-2"
- PROTECTION TRIPPED "67-1"
- PROTECTION TRIPPED "67-2"
- SELECTOR SWITCH IN LOCAL POSITION
- SELECTOR SWITCH IN REMOTE POSITION
- TRANSFORMER PROTECTION TRIPPED "BUCHHOLZ"
- TRANSFORMER PROTECTION ALARM "BUCHHOLZ"
- TRANSFORMER PROTECTION TRIPPED "OIL TEMPERATURE"
- TRANSFORMER PROTECTION ALARM "OIL TEMPERATURE"
- TRANSFORMER PROTECTION ALARM "OIL LEVEL"
- TRANSFORMER PROTECTION TRIPPED "OIL PRESSURE"
- TRANSFORMER PROTECTION ALARM "OIL LEVEL VERY LOW"
- TRANSFORMER PROTECTION TRIPPED "WINDING TEMPERATURE"
- TRANSFORMER PROTECTION ALARM "WINDING TEMPERATURE"
- TRANSFORMER GENERAL ALARM
- WATCHDOG PROTECTION RELAY
- V.T. HEALTLY CIRCUIT
- INTERTRIP SEND TO L.V.SWITCHB.
- K86 TRIPPED
- CONTACTOR CLOSED AND INSERTED
- CONTACTOR OPENED OR ISOLATED
- MCB'S CLOSED
- CONTACTOR READY (TCS)
- CONTACTOR READY TO CLOSE
- OPENING COMMAND
- CLOSING COMMAND
- PROTECTION RELAY UNIT 1 HEALTHY
- SELECTOR SWITCH OF OVERRIDE (SIL ENABLED)

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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| +A7 | | | | | |
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DWG n° : 231151/SD/28
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL TRANSF FEEDER TR-200ED1
Measures

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00028

SHEET 12

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00028 Rev.03

1.5.6.SG-100D1 HV SWG LOGIC DIAGRAM - TRANSFORMER FEEDER TR200DE1,

Doc. No. 1723002197-EL-DG-00029

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# "SG-100D1" HV SWBD 6,6kV (UNIT A4)

# LOGICAL DIAGRAM

# TRANSFORMER FEEDER TR-200DE1

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Mocule | 12/09/2024 |

CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

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DWG n° : 231151/SD/29

Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 22/07/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | **28/06/2024** | **Giulietti** | **Flamminio** | **Sigismondi** | **Accepted for construction (AFC)** |
| 1 | 21/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :

SG-100D1 – LOGICAL TRANSF FEEDER TR-200DE1

Cover

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00029

SHEET 1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00029 Rev.03

# INDEX

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| 1 | Cover | | | | | | | | | | | | | | | | | | | | |
| 2 | Sheets index | | | | | | | | | | | | | | | | | | | | |
| 3 | Input Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 4 | Input Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 5 | Output Protection Relay REX640 | | | | | | | | | | | | | | | | | | | | |
| 6 | Protections REX640 | | | | | | | | | | | | | | | | | | | | |
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| 12 | Measures | | | | | | | | | | | | | | | | | | | | |
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DWG n° : 231151/SD/29

Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL TRANSF FEEDER TR-200DE1
Sheets index

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

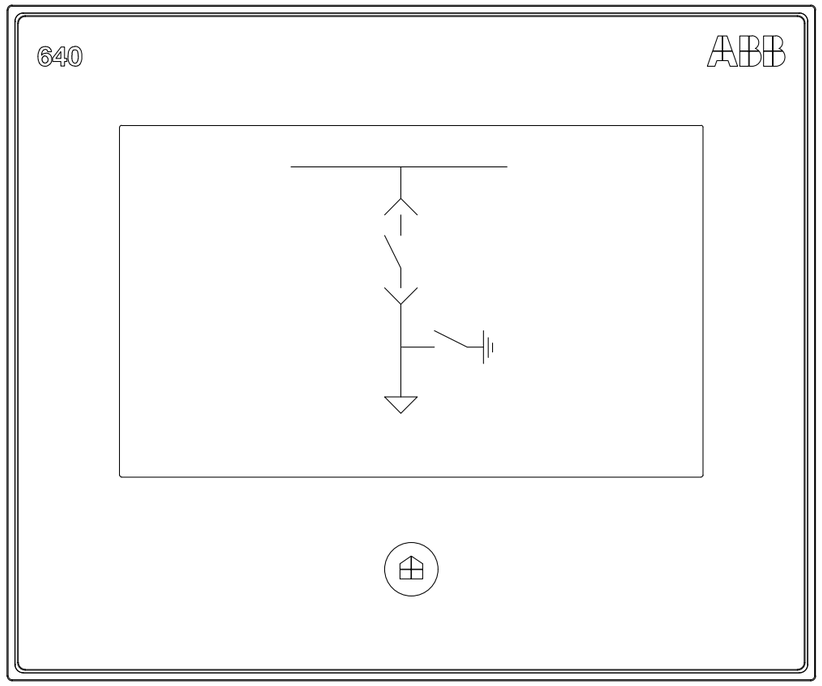
DRAWING NO. 1723002197-EL-DG-00029

SHEET 2

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00029 Rev.03




| LEDs PAGE 1 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-1 | 27-1/59-1 - VOLTAGE PROTECTION | RED | - | ALARM = OVER/UNDER VOLTAGE PROTECTION |
| LED-2 | CONTACTOR READY (TCS) | - | GREEN | OK = TCS OK (CONTACTOR READY) |
| LED-3 | | | | |
| LED-4 | CONTACTOR READY TO CLOSE | - | GREEN | OK = CONTACTOR READY TO CLOSE |
| LED-5 | 50/50-1/50-2/51/51-1 - TRIPPED | RED | - | ALARM = OVERCURRENT PROTECTION TRIPPED |
| LED-6 | 51N/51G/59N-1/59N-2 - TRIPPED | RED | - | ALARM = EARTH PROTECTION TRIPPED |
| LED-7 | EARTHING SWITCH UNLOCKED | - | GREEN | OK = EARTHING SWITCH UNLOCKED |
| LED-8 | RACK-IN/OUT ENABLED | - | GREEN | OK = CONTACTOR TRUCK UNLOCKED |
| LED-9 | ARC PROTECTION TRIPPED | RED | - | ALARM = TRIP ARC PROTECTION |
| LED-10 | GOOSE ALARM | RED | - | ALARM = GOOSE FAULT |
| LED-11 | | | | |

| LEDs PAGE 2 | | | | |
|---|---|---|---|---|
| Item | NAME PLATE | COLOUR | | Note |
| | | ALARM | OK | |
| LED-12 | SPACE HEATER "ON" | RED | - | ALARM = SPACE HEATER "ON" |
| LED-13 | TRANSF. PROTECTIONS | RED | | ALARM = PROTECTIONS TRIP |
| LED-14 | FUSES TRIP | RED | | ALARM = FUSES TRIP |
| LED-15 | TRIP FROM L.V. | RED | | ALARM = L.V. TRIP |
| LED-16 | | | | |
| LED-17 | | | | |
| LED-18 | | | | |
| LED-19 | | | | |
| LED-20 | | | | |
| LED-21 | | | | |
| LED-22 | | | | |

## LHMI - TOUCH DISPLAY

- COMMANDS "CLOSE C.B." AND "OPEN C.B." NON ENABLED
- PUSH BUTTON "REMOTE / LOCAL" NOT ENABLED
- ONLY PUSH BUTTON "RESET" ARC PROTECTION WILL BE ENABLED

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DWG n° : 231151/SD/29
Item n° : PF1113279

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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL TRANSF FEEDER TR-200DE1
Input Protection Relay REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00029

SHEET 3

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00029 Rev.03

## INPUTS

| B–X1 | | |
|---|---|---|
| 1 / 4 | BI1 | CONTACTOR CLOSED |
| 2 / 4 | BI2 | CONTACTOR OPENED |
| 3 / 4 | BI3 | CONTACTOR SERVICE POSITION |
| 5 / 8 | BI4 | CONTACTOR TEST POSITION |
| 6 / 8 | BI5 | EARTH SWITCH OPENED |
| 7 / 8 | BI6 | EARTH SWITCH CLOSED |
| 9 / 12 | BI7 | RELAY TRIPPED |
| 10 / 12 | BI8 | CONTACTOR READY |
| 11 / 12 | BI9 | FUSES TRIPPED |
| 13 / 16 | BI10 | SELECTOR IN LOCAL POSITION |
| 14 / 16 | BI11 | SELECTOR IN REMOTE POSITION |
| 15 / 16 | BI12 | EXTERNAL CLOSING INTERLOCK |
| 17 / 18 | BI13 | CIRC.BREAKER OPENED (FROM L.V. SWITCHBOARD) |
| B–X2 | | |
| 1 / 2 | BI14 | UNLOCKING EARTHING SWITCH / TRUCK CONTACTOR |

## INPUTS

| C–X1 | | |
|---|---|---|
| 1 / 4 | BI1 | |
| 2 / 4 | BI2 | |
| 3 / 4 | BI3 | EARTHING SWITCH OPEN (FROM MEASURING UNIT) |
| 5 / 8 | BI4 | CLOSED AUXILIARY CIRCUIT MCB's |
| 6 / 8 | BI5 | CLOSED AUXILIARY V.T. SECONDARY MCB's |
| 7 / 8 | BI6 | TRANSF.ALAM BUCHHOLZ |
| 9 / 12 | BI7 | TRANSF.TRIP BUCHHOLZ |
| 10 / 12 | BI8 | TRANSF.ALARM OIL TEMPERATURE |
| 11 / 12 | BI9 | TRANSF.TRIP OIL TEMPERATURE |
| 13 / 16 | BI10 | TRANSF.ALARM OIL LEVEL |
| 14 / 16 | BI11 | TRANSF. OIL LEVEL VERY LOW ALARM |
| 15 / 16 | BI12 | TRANSF.TRIP OIL PRESSURE |
| 17 / 18 | BI13 | TRANSF.ALARM WINDING TEMPERATURE |
| B–X2 | | |
| 1 / 2 | BI14 | TRANSF.TRIP WINDING TEMPERATURE |

## INPUTS

| D–X1 | | |
|---|---|---|
| 1 / 4 | BI1 | LOCAL CLOSING COMMAND |
| 2 / 4 | BI2 | LOCAL OPENING COMMAND |
| 3 / 4 | BI3 | CIRC.BREAKER IN TEST POSITION (FROM L.V. SWITCHBOARD) |
| 5 / 8 | BI4 | CIRC.BREAKER TRIPPED (FROM L.V. SWITCHBOARD) |
| 6 / 8 | BI5 | SPACE HEATER "ON" |
| 7 / 8 | BI6 | AVAILABLE REMOTE OPENING COMMNAD |
| 9 / 12 | BI7 | TRANSF. GENERAL ALARM |
| 10 / 12 | BI8 | MCB AND WATCHDOG PROTECTION. RELAY HEALTH (FROM UNIT A3) |
| 11 / 12 | BI9 | |

## ARC MODULE

| | | |
|---|---|---|
| LIGHT SENSOR INPUT 1 | Slot A1 X11 | ARC "MAIN BUS BAR" "BB" |
| LIGHT SENSOR INPUT 2 | Slot A1 X12 | ARC "CONTACTOR COMPART." "CB" |
| LIGHT SENSOR INPUT 3 | Slot A1 X13 | ARC "CABLE COMPARTEMENT" "CC" |
| LIGHT SENSOR INPUT 4 | Slot A1 X14 | |

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DWG n° : 231151/SD/29
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG–100D1 – LOGICAL TRANSF FEEDER TR–200DE1
Input Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

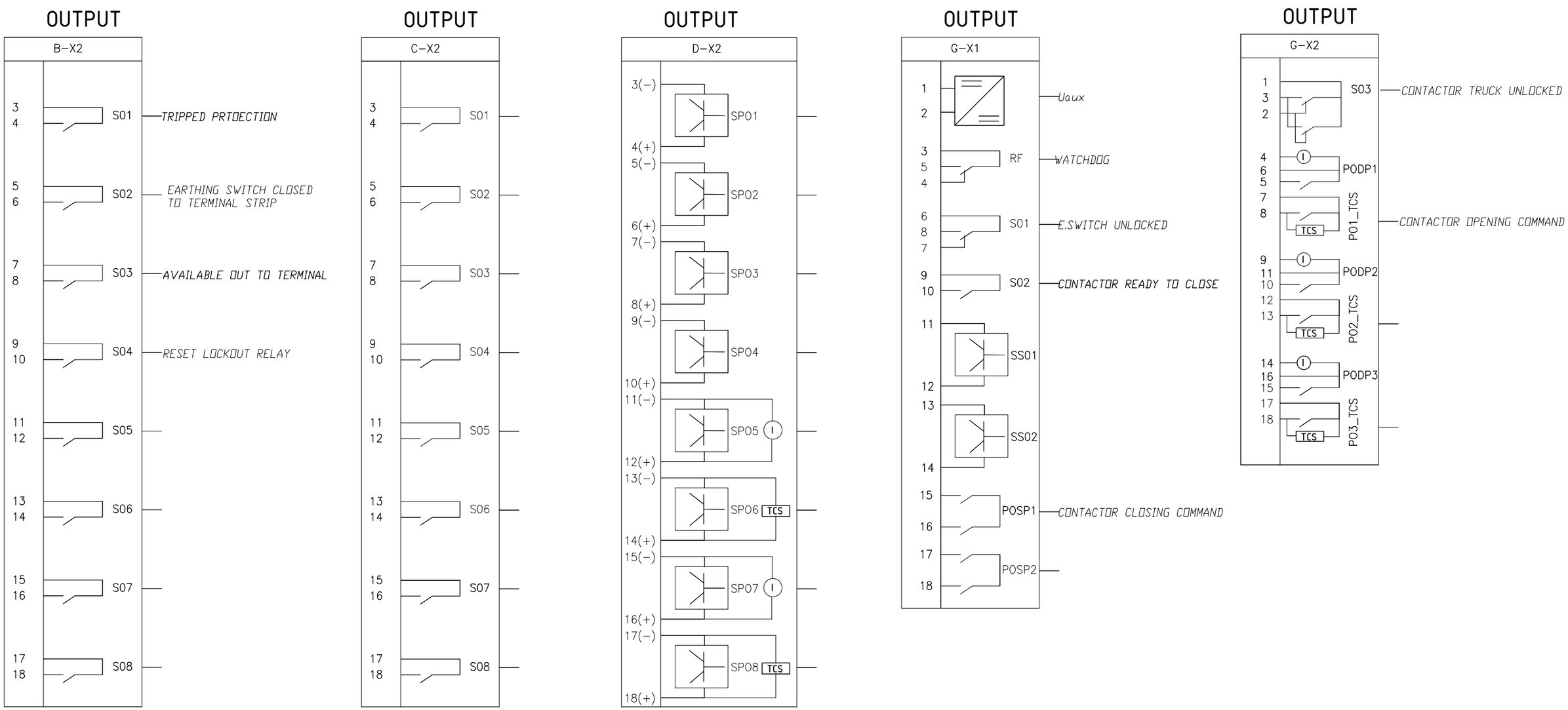
DRAWING NO. 1723002197–EL–DG–00029

SHEET 4

REV. 03

File Name : 1723002197–EL–DG–00029 Rev.03

F.to UNI A3: 420mmx297mm




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Output Protection Relay REX640

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00029

SHEET 5

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00029 Rev.03

# INPUTS

# PROTECTIONS REX640 (FP1)

# OUTPUTS

TO EMCS IEC 61850
*51G -PROTECTION OPERATED*

51G
Io>>
EFHPTOC1
0 / 1 / Start

7.6D ▶ 67

50-1
3I>>>
PHHPTOC1
0 / 1 / Start

TO EMCS IEC 61850
*50-1 -PROTECTION OPERATED*

51-1
3I>
PHLPTOC1
0 / 1 / Start

TO EMCS IEC 61850
*51-1 -PROTECTION OPERATED*

TO EMCS IEC 61850
*51N PROTECTION OPERATED*

51N
Io>
EFLPTOC1
0 / 1 / Start

59N-2
Vo>
ROVPTOV2
0 / 1 / Start

TO EMCS IEC 61850
*59N-2 PROTECTION OPERATED*

KA1
TRIP PROTECTION FROM LOW VOLTAGE
0 / 1

D-X1-5

LED-15 (RED)

t=0,5"

RESET
K86 ▶ 9.5A
K86 ▶ 7.5B

59N ▶ 7.8A

LED-5 (RED)

LED-6 (RED)

PROTECTION ▶ 8.6B

TO EMCS IEC 61850
*INTERTRIP SEND (TO L.V. SWITCHB.)*

B_X2-S01

K86
TRIPPED PROTECTION
0 / 1

10.8B ▶ TRIPPED TRASF.

9.4B ▶ FUSE

ONLY "LIGHT"
50L/50NL
ARC
ARCSARC1
0 / 1 / Start
ARC "MAIN BUS BAR" "BB"

ONLY "LIGHT"
50L/50NL
ARC
ARCSARC2
0 / 1 / Start
ARC "CONTACTOR COMPART." "CB"

ONLY "LIGHT"
50L/50NL
ARC
ARCSARC3
0 / 1 / Start
ARC "CABLE COMPARTEMENT" "CC"

GOOSE FROM INCOMINGS:
UNIT :A6

TRIPPED ARC PROTECTION FOR:
- ARC DETECTED ON MAIN BUS BAR (FROM ALL UNITS)
- ARC DETECTED ON C.B. / CONTACTOR COMPARTEMENT (FROM ALL UNITS)
- ARC DETECTED ON CABLE COMPARTEMENT (ONLY CONTACTOR UNIT)

LED-9 (RED)

9.6A ▶ K86 ARC

8.6C ▶

GOOSE TO INCOMINGS:
UNIT :A6

0 / 1 — TRIPPED ARC PROTECTION

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
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IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 - LOGICAL TRANSF FEEDER TR-200DE1
Protections REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00029

SHEET 6

REV. 03

F.to UNI A3: 420mmx297mm

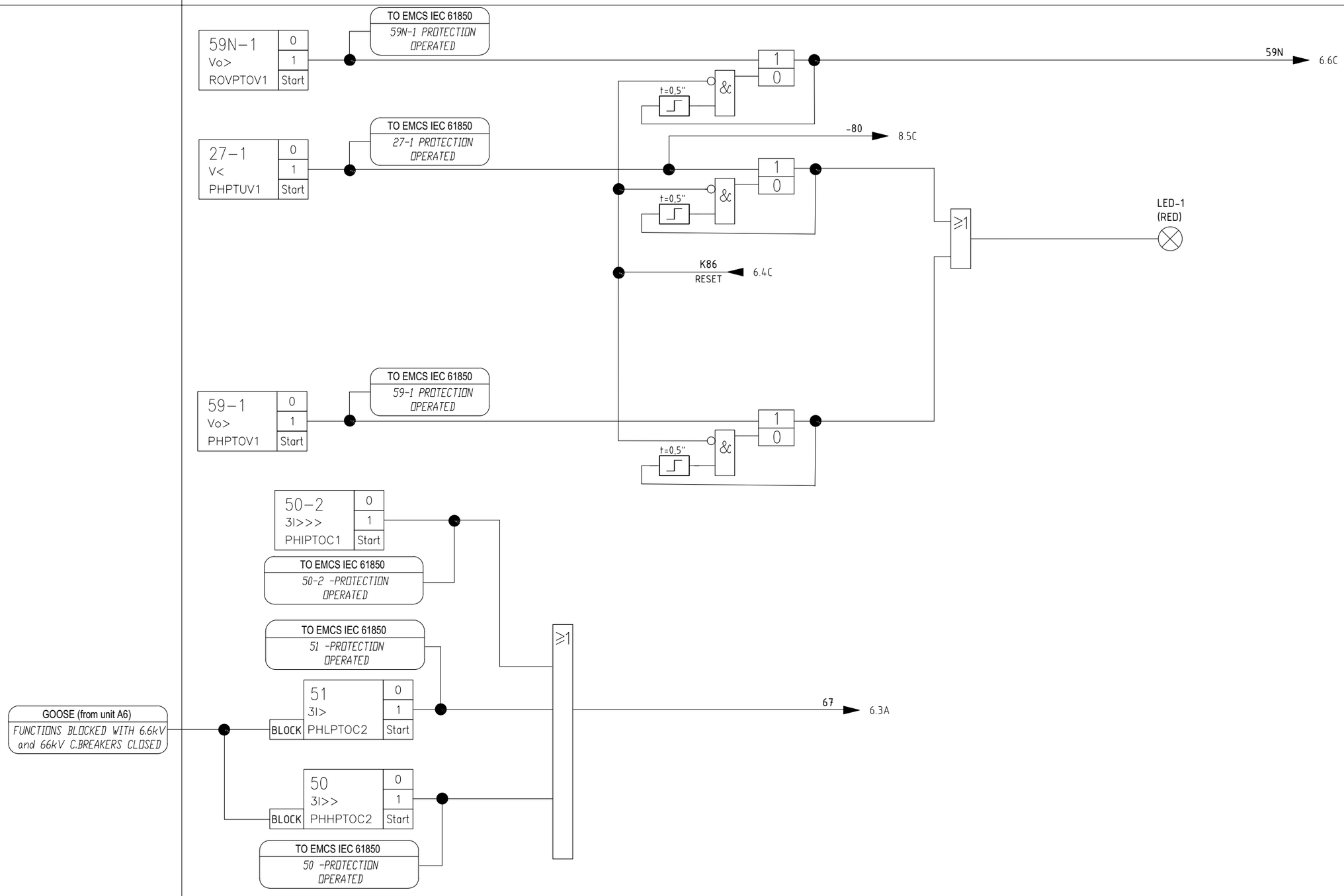
File Name : 1723002197-EL-DG-00029 Rev.03

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|

## INPUTS

## PROTECTIONS REX640 (FP1)

## OUTPUTS




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Protections REX640

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00029 | SHEET 7 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00029 Rev.03

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

S20 LOCAL OPENING COMMAND 0/1 — D-X1-2

K1 – BGT4 CONTACTOR SERVICE 0/1 — B-X1-3

K1 – BGT5 CONTACTOR TEST 0/1 — B-X1-5

XM REMOTE AVAILABLE OPENING COMMAND 0/1 — D-X1-7

SA1 SELECTOR IN REMOTE POSITION 0/1 — B-X1-14

SA1 SELECTOR IN LOCAL POSITION 0/1 — B-X1-13

S1C LOCAL CLOSING COMMAND 0/1 — D-X1-1

KGR SPACE HEATER "ON" 0/1 — D-X1-6

LED-12 (RED)

IEC 61850 – EMCS OPENING 0/1

IEC 61850 – EMCS CLOSING 0/1

TEST → 8.5D

INSERT. → 9.3D

INSERT. → 9.4C

INSERT.

INSERT.

INSERT.

7.6A → -80

LOCAL → 11.4B

REMOTE → 9.7B

TO EMCS IEC 61850 *SELECTOR IN REMOTE POSITION*

TO EMCS IEC 61850 *SELECTOR IN LOCAL POSITION*

LOCAL OPENING

REMOTE OPENING

6.9B → PROTECTION

9.5A → K86

UNDERVOLTAGE

6.6E → ARC

REMOTE CLOSING

LOCAL CLOSING

9.6B → READY

LOCAL CLOSING

8.3B → TEST

TEST → 11.3C

TEST LOCAL CLOSING

OPENING → 9.4C

G_PODP1-X2 → K1 0/1 CONTACTOR OPENING

TO EMCS IEC 61850 *RESET LOCKOUT RELAY* — B_S04-X2 → FP1c 0/1 RESET LOCKOUT RELAY

G_POSP1-X1 → K1 0/1 CONTACTOR CLOSING

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SG–100D1 – LOGICAL TRANSF FEEDER TR–200DE1

Contactor Commands

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

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A3

DRAWING NO. 1723002197–EL–DG–00029

SHEET 8

REV. 03

File Name : 1723002197–EL–DG–00029 Rev.03

F.to UNI A3: 420mmx297mm

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

K86 RELAY TRIPPED 0/1 — B-X1-9

XM EXTERNAL CLOSING INTERLOCK 0/1 — B-X1-15

XM FROM L.V.SWDB C.B.OPENED 0/1 — B-X1-17

DO1 CONTACTOR READY (TCS) 0/1 — B-X1-10

BGF2 FUSE TRIPPED 0/1 — B-X1-11

BGE EARTHING SWITCH OPENED 0/1 — B-X1-6

BGE EARTHING SWITCH CLOSED 0/1 — B-X1-7

K1 CONTACTOR OPENED 0/1 — B-X1-2

QD2 – QD4 CLOSED AUXILIARY CIRCUIT MCB's 0/1 — C-X1-5

QV4 – QV5 CLOSED AUXILIARY V.T. SECONDARY MCB's 0/1 — C-X1-6

K1 CONTACTOR CLOSED 0/1 — B-X1-1

TO EMCS IEC 61850 *K86 TRIPPED*

K86 → 6.6D

K86 → 8.6B

K86 → 6.4C

LED-2 (GREEN)

TO EMCS IEC 61850 *CONTACTOR READY (TCS)*

LED-14 (RED)

FUSE → 6.6D

E.S. OPEN → 11.4B

E.S. OPENED

E.S. CLOSED → 9.8C

CONT.OPEN → 11.4B

CONTACTOR OPENED

8.5A INSERT.

TO EMCS IEC 61850 *CONTACTOR CLOSED AND INSERTED*

8.5B INSERT.

8.7B OPENING

READY → 8.6C

LED-4 (GREEN)

8.4C REMOTE

TO EMCS IEC 61850 *CONTACTOR READY TO CLOSE*

G_S02-X1 — XM 0/1 CONTACTOR READY TO CLOSE

9.3C E.S. CLOSED — B_S02-X2 — XM 0/1 E.SWITCH CLOSED

TO EMCS IEC 61850 *MCB's CLOSED*

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CROSSWIND

IMESA ELECTRICAL ENGINEERING

ROSETTI MARINO

TITLE :

SG–100D1 – LOGICAL TRANSF FEEDER TR–200DE1

Contactor Commands

CONTRACT NO./TITLE CW–I–WP4–2023–05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197–EL–DG–00029

SHEET 9

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197–EL–DG–00029 Rev.03

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

| | | |
|---|---|---|
| 97T TRANSF.ALARM BUCHHOLZ | 0 | |
| | 1 | C-X1-7 → TO EMCS IEC 61850 *ALARM BUCHHOLZ* |
| K94B TRANSF.TRIPPED BUCHHOLZ | 0 | |
| | 1 | C-X1-9 → TO EMCS IEC 61850 *TRIPPED BUCHHOLZ* |
| 26OT TRANSF.ALARM OIL TEMPERATURE | 0 | |
| | 1 | C-X1-10 → TO EMCS IEC 61850 *ALARM OIL TEMPERATURE* |
| K94OT TRANSF.TRIPPED OIL TEMPERATURE | 0 | |
| | 1 | C-X1-11 → TO EMCS IEC 61850 *TRIPPED OIL TEMPERATURE* |
| 71OT TRANSF.ALARM OIL LEVEL | 0 | |
| | 1 | C-X1-13 → TO EMCS IEC 61850 *ALARM OIL LEVEL* |
| 71OT_1 TRANSF. OIL LEVEL VERY LOW ALARM | 0 | |
| | 1 | C-X1-14 → TO EMCS IEC 61850 *OIL LEVEL VERY LOW ALARM* |
| K94P TRANSF.TRIPPED OIL PRESSURE | 0 | |
| | 1 | C-X1-15 → TO EMCS IEC 61850 *TRIPPED OIL PRESSURE* |
| 49T TRANSF.ALARM WINDING TEMPERATURE | 0 | |
| | 1 | C-X1-17 → TO EMCS IEC 61850 *ALARM WINDING TEMPERATURE* |
| K94WT TRANSF.TRIPPED WINDING TEMPERATURE | 0 | |
| | 1 | C-X2-1 → TO EMCS IEC 61850 *TRIPPED WINDING TEMPERATURE* |
| XM TRANSFORMER GENERAL ALARM | 0 | |
| | 1 | D-X1-9 → TO EMCS IEC 61850 *TRANSFORMER GENERAL ALARM* |

≥1

LED-13 (RED) → TRIPPED TRASF. → 6.6D

| | | |
|---|---|---|
| WATCHDOG | 0 | |
| | 1 | TO EMCS IEC 61850 *WATCHDOG PROTECTION RELAY* → G_RF-X1 → KIRF 1 WATCHDOG 0 |

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | 22/07/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| 2 | 28/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for construction (AFC) |
| 1 | 21/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

=
+A4
DWG n° : 231151/SD/29
Item n° : PF1113279

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 – LOGICAL TRANSF FEEDER TR-200DE1
Contactor Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00029

SHEET 10

REV. 03

File Name : 1723002197-EL-DG-00029 Rev.03

F.to UNI A3: 420mmx297mm

# INPUTS

# REX640 CONTACTOR COMMANDS

# OUTPUTS

BGE
EART.SWITCH OPENED FROM MEASURING UNIT 0/1

C-X1-3

KT1
UNLOCKING E.SWITCH/CONT. TRUCK 0/1

B-X2-1

QB1
LOW VOLTAGE CIR.BREAK IN TEST POSITION 0/1

D-X1-3

QD1 – KIRF (UNIT A3)
MCB AND WATCHDOG PROTEC. RELAY HEALTHY 0/1

D-X1-10

≥1

&

&

9.3C CONT.OPEN

9.4B E.S. OPEN

8.4D LOCAL

8.6E TEST

TO EMCS IEC 61850
*CONTACTOR OPENED OR ISOLATED*

LED-8 (GREEN)

G_S03-X2

RLE2
0 CONTACTOR TRUCK UNLOCKED

LED-7 (GREEN)

G_S01-X1

RLE3
0 EARTHING SWITCH UNLOCKED

TO EMCS IEC 61850
*PROTECTION RELAY UNIT 3 HEALTHY*

*GOOSE*

LED-10 (RED)

| | | | | | | |
|---|---|---|---|---|---|---|
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| DWG n° : 231151/SD/29 | 3 | 22/07/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
| Item n° : PF1113279 | 2 | 28/06/2024 | Giulietti | Flamminio | Sigismondi | Accepted for construction (AFC) |
| | 1 | 21/05/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |
| | REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |

IMESA ELECTRICAL ENGINEERING

CROSSWIND

ROSETTI MARINO

TITLE :
SG-100D1 – LOGICAL TRANSF FEEDER TR-200DE1
Contactor Commands

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1723002197-EL-DG-00029

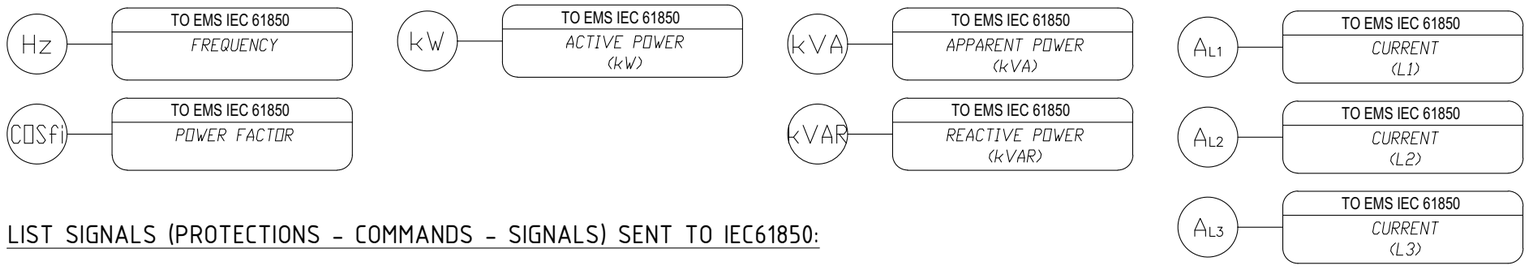
SHEET 1.1

REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00029 Rev.03

| INPUTS | REX640 SIGNALS MEASURES AND COMMAND AVAILABLE TO IEC61850 | OUTPUTS |
|---|---|---|




LIST SIGNALS (PROTECTIONS - COMMANDS - SIGNALS) SENT TO IEC61850:

- PROTECTION TRIPPED "50"
- PROTECTION TRIPPED "50-1"
- PROTECTION TRIPPED "50-2"
- PROTECTION TRIPPED "51"
- PROTECTION TRIPPED "51-1"
- PROTECTION TRIPPED "51N"
- PROTECTION TRIPPED "51G"
- PROTECTION TRIPPED "59N-1"
- PROTECTION TRIPPED "59N-2"
- PROTECTION TRIPPED "27-1"
- PROTECTION TRIPPED "59-1"
- SELECTOR SWITCH IN LOCAL POSITION
- SELECTOR SWITCH IN REMOTE POSITION
- TRANSFORMER PROTECTION TRIPPED "BUCHHOLZ"
- TRANSFORMER PROTECTION ALARM "BUCHHOLZ"
- TRANSFORMER PROTECTION TRIPPED "OIL TEMPERATURE"
- TRANSFORMER PROTECTION ALARM "OIL TEMPERATURE"
- TRASNFORMER PROTECTION ALARM "OIL LEVEL"
- TRANSFORMER PROTECTION TRIPPED "OIL PRESSURE"
- TRANSFORMER PROTECTION ALARM "OIL LEVEL VERY LOW"
- TRANSFORMER PROTECTION TRIPPED "WINDING TEMPERATURE"
- TRANSFORMER PROTECTION ALARM "WINDING TEMPERATURE"
- TRANSFORMER GENERAL ALARM
- WATCHDOG PROTECTION RELAY
- INTERTRIP SEND TO L.V.SWITCHB.
- K86 TRIPPED
- CONTACTOR CLOSED AND INSERTED
- CONTACTOR OPENED OR ISOLATED
- MCB'S CLOSED
- CONTACTOR READY (TCS)
- CONTACTOR READY TO CLOSE
- OPENING COMMAND
- CLOSING COMMAND
- PROTECTION RELAY UNIT 3 HEALTHY
- RESET LOCKOUT RELAY

=
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DWG n° : 231151/SD/29
Item n° : PF1113279

| REV. | DATE | DRN | CHKD | APPD | DESCRIPTION |
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| 3 | 22/07/2024 | Giulietti | Flamminio | Sigismondi | As-Built (ASB) |
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| 0 | 04/04/2024 | Giulietti | Flamminio | Sigismondi | Issued for review (IFR) |

TITLE :
SG-100D1 - LOGICAL TRANSF FEEDER TR-200DE1
Measures

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE : NTS

A3 | DRAWING NO. 1723002197-EL-DG-00029 | SHEET 12 | REV. 03

F.to UNI A3: 420mmx297mm

File Name : 1723002197-EL-DG-00029 Rev.03

1.6. Calculation

1.6.1.SG-100D1 CURRENT and VOLTAGE TRANSFORMER SIZING CALCULATION and CHARACTERISTIC, Doc. No. 1723002197-EL-CAL-00014

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# Base Load Power Hub (BLPH)

## SG-100D1 - CURRENT and VOLTAGE TRANSFORMER SIZING CALCULATION and FUSE RATING

Document Number: 1723002197-EL-CAL-00014

| ROSETTI MARINO | |
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| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
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| *NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.* | |
| Sign | Date |
| Luca Moceri | 01/08/2024 |

Document Class: 3

| Rev. | Date | Description | Prepared | Reviewed | Approved |
|---|---|---|---|---|---|
| 3 | 30/07/2024 | Issue for Information (IFI) | Gambirasio | Flamminio | Sigismondi |
| 2 | 01/07/2024 | Issue for Information (IFI) | Gambirasio | Flamminio | Sigismondi |
| 1 | 03/04/2024 | Issue for Information (IFI) | Gambirasio | Flamminio | Sigismondi |
| 0 | 15/03/2024 | Issue for Information (IFI) | Gambirasio | Flamminio | Sigismondi |

IMESA ELECTRICAL ENGINEERING IMESA Doc. 231115/SD/14

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| 2 | Issue for Information (IFI) |
| 3 | Issue for Information (IFI) |
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1- CT's and VTs calculation table……..……...…….4

2- MV fuses rating calculation……..……..…….6



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**ROSETTI MARINO**
**CROSSWIND**

**CURRENT & VOLTAGE TRANSFORMER SIZING**

**SWB: SG-100D1**

$I_{sc}$ [kA]= **25**
$U_n$ [kV]= **6.6**
$f_n$ [Hz]= **50**

Document number: 22403-IMG-05-T

| REV.: | DATE | DESCRIPTION |
|---|---|---|
| 00 | 15/03/2024 | First issue |
| 01 | 29/03/2024 | General revision |

SELECTY



| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USER ID | $I_n$ [A] | | TYPE OF EQUIP. | PROT. FUNCT. | $I_{1n}$/ $V_{1n}$ [A/kV] | $I_{2n}$/ $V_{2n}$ [A/V] | $S_n$ [VA] / Vk [V] | CLASS | Fl /Fs Ft Iμ @Vk | $R_{CT}$ max at 75° [Ω] | RELAY/INSTRUM. BURDEN [VA] | Rr/Istr. [Ω] | WIRING Type 2/4/6W | WIRING L [m] | WIRING S [mm²] | WIRING $R_c$ [Ω] | LOADING RESISTOR [VA] | REAL LOAD [VA] | TOTAL LOAD % | CALCULATED F'l / F's $V_k$ / $S_n$ | | REQUIRED F'l / F's $V_k$ / $S_{real}$ | | ACCEPT. |
| **7 MVA INCOMER** | 585.7 | | ABB REX640 | 50/51 | 600 | 1 | 5 VA | 5P | 20 | 5.24 | 0.02 | 0.020 | 6 | 4.0 | 2.5 | 0.0685 | | 0.09 | 2% | Fl | 38.4 | F'l> | 20.0 | OK |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | ABB REX640 | 50G | 100 | 1 | 5 VA | 5P | 5 | 1.00 | 0.02 | 0.020 | 2 | 4.0 | 2.5 | 0.0685 | | 0.09 | 2% | Fl | 27.6 | F'l> | 20.0 | OK |
| | | | ABB REX640 | | 6.6:√3 | 0.11:√3 | 20 VA | Cl. 05+3P | 1.9 / 8h | | 0.05 | | | | | | | | | $S_n$ | 20.0 | $S_n$> | 0.1 | OK |
| | | | Available | | 6.6:√3 | 0.11:√3 | 30 VA | Cl. 05+3P | 1.9 / 8h | | | | | | | | | | | $S_n$ | 30.0 | $S_n$> | | |
| | | | Available | | 6.6:√3 | 0.11:3 | 30 VA | 3P | 1.9 / 8h | | | | | | | | | | | $S_n$ | 30.0 | $S_n$> | 0.0 | OK |
| **Measuring busbar** | | | TBD | | 6.6:√3 | 0.11:√3 | 20 VA | Cl. 05+3P | 1.9 / 8h | | 0.25 | | | | | | | | | $S_n$ | 20.0 | $S_n$> | 0.3 | OK |
| | | | TBD | | 6.6:√3 | 0.11:√3 | 30 VA | Cl. 05+3P | 1.9 / 8h | | 1.00 | | | | | | | | | $S_n$ | 30.0 | $S_n$> | 1.0 | OK |
| | | | TBD | | 6.6:√3 | 0.11:3 | 30 VA | 3P | 1.9 / 8h | | | | | | | | | | | $S_n$ | 30.0 | $S_n$> | 0.0 | OK |
| **1.25 MVA BESS** | 109.3 | | ABB REX640 | 67 | 150 | 1 | 5 VA | 5P | 20 | 1.45 | 0.02 | 0.020 | 6 | 4.0 | 2.5 | 0.0685 | | 0.09 | 2% | Fl | 83.7 | F'l> | 20.0 | OK |
| | | | ABB REX640 | 67G | 100 | 1 | 5 VA | 5P | 5 | 1.00 | 0.02 | 0.020 | 2 | 4.0 | 2.5 | 0.0685 | | 0.09 | 2% | Fl | 27.6 | F'l> | 20.0 | OK |
| | | | ABB REX640 | | 6.6:√3 | 0.11:√3 | 20 VA | Cl. 05+3P | 1.9 / 8h | | 0.05 | | | | | | | | | $S_n$ | 20.0 | $S_n$> | 0.1 | OK |
| | | | Available | | 6.6:√3 | 0.11:√3 | 30 VA | Cl. 05+3P | 1.9 / 8h | | | | | | | | | | | $S_n$ | 30.0 | $S_n$> | | |
| | | | Available | | 6.6:√3 | 0.11:3 | 30 VA | 3P | 1.9 / 8h | | | | | | | | | | | $S_n$ | 30.0 | $S_n$> | 0.0 | OK |
| **1.25 MVA FUEL CELL** | 109.3 | | ABB REX640 | 67 | 150 | 1 | 5 VA | 5P | 20 | 1.45 | 0.02 | 0.020 | 6 | 4.0 | 2.5 | 0.0685 | | 0.09 | 2% | Fl | 83.7 | F'l> | 20.0 | OK |
| | | | ABB REX640 | 67G | 100 | 1 | 5 VA | 5P | 5 | 1.00 | 0.02 | 0.020 | 2 | 4.0 | 2.5 | 0.0685 | | 0.09 | 2% | Fl | 27.6 | F'l> | 20.0 | OK |
| | | | ABB REX640 | | 6.6:√3 | 0.11:√3 | 20 VA | Cl. 05+3P | 1.9 / 8h | | 0.05 | | | | | | | | | $S_n$ | 20.0 | $S_n$> | 0.1 | OK |
| | | | Available | | 6.6:√3 | 0.11:√3 | 30 VA | Cl. 05+3P | 1.9 / 8h | | 1.00 | | | | | | | | | $S_n$ | 30.0 | $S_n$> | 1.0 | OK |
| | | | Available | | 6.6:√3 | 0.11:3 | 30 VA | 3P | 1.9 / 8h | | | | | | | | | | | $S_n$ | 30.0 | $S_n$> | 0.0 | OK |
| **0.5 MVA SOLAR** | 43.7 | | ABB REX640 | 67 | 50 | 1 | 2.5 VA | 5P | 15 | 0.53 | 0.02 | 0.020 | 6 | 4.0 | 2.5 | 0.0685 | | 0.09 | 4% | Fl | 73.9 | F'l> | 20.0 | OK |
| | | | ABB REX640 | 67G | 100 | 1 | 5 VA | 5P | 5 | 1.00 | 0.02 | 0.020 | 2 | 4.0 | 2.5 | 0.0685 | | 0.09 | 2% | Fl | 27.6 | F'l> | 20.0 | OK |
| | | | ABB REX640 | | 6.6:√3 | 0.11:√3 | 20 VA | Cl. 05+3P | 1.9 / 8h | | 0.05 | | | | | | | | | $S_n$ | 20.0 | $S_n$> | 0.1 | OK |
| | | | Available | | 6.6:√3 | 0.11:√3 | 30 VA | Cl. 05+3P | 1.9 / 8h | | | | | | | | | | | $S_n$ | 30.0 | $S_n$> | | |
| | | | Available | | 6.6:√3 | 0.11:3 | 30 VA | 3P | 1.9 / 8h | | | | | | | | | | | $S_n$ | 30.0 | $S_n$> | 0.0 | OK |
| **1.6 MVA Transformer feeder** | 140.0 | | ABB REX640 | 50/51 | 200 | 1 | 5 VA | 5P | 20 | 1.90 | 0.02 | 0.020 | 6 | 4.0 | 2.5 | 0.0685 | | 0.09 | 2% | Fl | 69.5 | F'l> | 20.0 | OK |
| | | | ABB REX640 | 50G | 100 | 1 | 5 VA | 5P | 5 | 1.00 | 0.02 | 0.020 | 2 | 4.0 | 2.5 | 0.0685 | | 0.09 | 2% | Fl | 27.6 | F'l> | 20.0 | OK |
| | | | ABB REX640 | 51G | 2500 | 1 | 6 VA | 5P | 20 | 19.61 | 0.02 | 0.020 | 2 | 4.0 | 2.5 | 0.0685 | | 0.09 | 1% | Fl | 26.0 | F'l> | 20.0 | OK |

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**ROSETTI MARINO**
**CROSSWIND**

**CURRENT & VOLTAGE TRANSFORMER SIZING**

**SWB: SG-100D1**

$I_{sc}$ [kA]= 25
$U_n$ [kV]= 6.6
$f_n$ [Hz]= 50

Document number: 22403-IMG-05-T

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| REV.: | DATE | DESCRIPTION |
|---|---|---|
| 00 | 15/03/2024 | First issue |
| 01 | 29/03/2024 | General revision |

Page A02

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USER ID | $I_n$ [A] | | TYPE OF EQUIP. | PROT. FUNCT. | $I_{1n}$/ $V_{1n}$ [A/kV] | $I_{2n}$/ $V_{2n}$ [A/V] | $S_n$ [VA] / Vk [V] | CLASS | Fl /Fs Ft Iμ @Vk | $R_{CT}$ max at 75° [Ω] | RELAY/INSTRUM. BURDEN [VA] | Rr/Istr. [Ω] | WIRING Type 2/4/6W | L [m] | S [mm²] | $R_c$ [Ω] | LOADING RESISTOR [VA] | REAL LOAD [VA] | TOTAL LOAD % | CALCULATED Fl / Fs $V_k$ / $S_n$ | | REQUIRED Fl / Fs $V_k$ / $S_{real}$ | | ACCEPT. |
| | 279.9 | | ABB REX640 | 50/51 | 400 | 1 | 5 VA | 5P | 20 | 3.60 | 0.02 | 0.020 | 6 | 4.0 | 2.5 | 0.0685 | | 0.09 | 2% | Fl | 46.6 | Fl> | 20.0 | OK |
| | | | ABB REX640 | 50G | 100 | 1 | 5 VA | 5P | 5 | 1.00 | 0.02 | 0.020 | 2 | 4.0 | 2.5 | 0.0685 | | 0.09 | 2% | Fl | 27.6 | Fl> | 20.0 | OK |
| ELECTROLYSER PACKAGE | | | ABB REX640 | | 6.6:√3 | 0.11:√3 | 20 VA | Cl. 05+3P | 1.9 / 8h | | 0.05 | | | | | | | | | $S_n$ | 20.0 | $S_n$> | 0.1 | OK |
| | | | Available | | 6.6:√3 | 0.11:√3 | 30 VA | Cl. 05+3P | 1.9 / 8h | | | | | | | | | | | $S_n$ | 30.0 | $S_n$> | | |
| | | | Available | | 6.6:√3 | 0.11:3 | 30 VA | 3P | 1.9 / 8h | | | | | | | | | | | $S_n$ | 30.0 | $S_n$> | 0.0 | OK |

Note: GREEN = in green are highlighted the estimated values / parameters

MV fuses rating calculation

ROSETTI MARINO

CROSSWIND

SWB: SG-100D1

Document number 22403-IMG-05-F

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| | | | | | | | | | Fuse Time current characteristics | | | | | Requirements | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sn [kVA] | Vn [kV] | In [A] | Zcc [%] | FUSE | | | | @100ms | @1s | @10s | @15s | @2s | Min @100ms | Min @1s | Min @10s | Min @15s | Max @2s | |
| TR FEEDER | 1600 | 6.6 | 140.0 | 6% | ABB | CMF | 250A | | 4000 | 2500 | 1500 | 1400 | 2100 | 1680 | 840 | 420 | 280 | 2333 | OK |
| BESS | 1250 | 6.6 | 109.3 | 6% | ABB | CEF | 160A | | 1700 | 1050 | 690 | 620 | 900 | 1312 | 656 | 328 | 219 | 1822 | OK |
| FUEL CELL | 1250 | 6.6 | 109.3 | 6% | ABB | CEF | 160A | | 1700 | 1050 | 690 | 620 | 900 | 1312 | 656 | 328 | 219 | 1822 | OK |
| SOLAR | 500 | 6.6 | 43.7 | 6% | ABB | CEF | 63A | | 650 | 400 | 220 | 210 | 350 | 525 | 262 | 131 | 87 | 729 | OK |

1.6.2.HEAT DISSIPATION CALCULATIONS,

Doc. No. 1723002197-EL-CAL-00049

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# Base Load Power Hub (BLPH)

## HEAT DISSIPATION CALCULATIONS

## Document Number: 1723002197-EL-CAL-00049

## Document Class: 3

ROSETTI MARINO

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| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
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| 4 | APPROVAL NOT REQUIRED |

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| Sign | Date |
|---|---|
| Luca Moeurle | 23/09/2024 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| 1 | 28/08/2024 | Issue for Information (IFI) | L. Rossi | Flamminio | Sigismondi |
| 0 | 13/03/2024 | Issue for Information (IFI) | L. Rossi | Flamminio | Sigismondi |
| Rev. | Date | Description | Prepared | Reviewed | Approved |

IMESA ELECTRICAL ENGINEERING IMESA Doc. 231115/SD/49

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| 0 | Issue for Information (IFI) |
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3- SG-200D2.....7
4- DP-200N1.....8

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## "SG-100D1"

| 6,6KV - 50Hz - 630A | | | | | | | Correction - k | Corrected - W | L (mt) used | n° pcs | Power Heat (W) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bus-Bars Distribution MV (1//40X10) | In (A)= | 885 | Ib (A)= | 630 | MAX Bus-Bar Heat Power (W/m) | 52,99 | 1,00 | 53,0 | 5,00 | 1 | 264,93 |
| | | | | | | | Correction - k | Corrected - W | | n° Feeders | Power Heat (W) |
| Feeder Electrolyser Package (3200kVA) | In (A)= | 630 | Ib (A)= | 280 | MAX Feeder Heat Power (W)= | 193,79 | 1,00 | 193,8 | | 1 | 193,79 |
| Feeder Solar Package (500kVA) | In (A)= | 400 | Ib (A)= | 44 | MAX Feeder Heat Power (W)= | 159,31 | 1,00 | 159,3 | | 1 | 159,31 |
| Feeder Bess Package (1250kVA) | In (A)= | 400 | Ib (A)= | 110 | MAX Feeder Heat Power (W)= | 176,30 | 1,00 | 176,3 | | 1 | 176,30 |
| Feeder TRF (1600kVA) | In (A)= | 400 | Ib (A)= | 140 | MAX Feeder Heat Power (W)= | 33,30 | 1,00 | 33,3 | | 1 | 33,30 |
| Bus Bars Measure | In (A)= | 0 | Ib (A)= | 0 | MAX Feeder Heat Power (W)= | 150,00 | 1,00 | 150,0 | | 1 | 150,00 |
| Incomer 630 | In (A)= | 630 | Ib (A)= | 630 | MAX Feeder Heat Power (W)= | 355,76 | 1,00 | 355,8 | | 1 | 355,76 |
| Feeder Fuel Cell Package (1250kVA) | In (A)= | 400 | Ib (A)= | 110 | MAX Feeder Heat Power (W)= | 176,30 | 1,00 | 176,3 | | 1 | 176,30 |

| | |
|---|---|
| SWBD Max Heat Power (W) = | 1.509,69 |
| "K" contemporaneity | 1,00 |
| SWBD Heat Power (W) = | 1.509,69 |

## "SG-200N1"

| 400/230V - 50Hz - 2500A | | | | | | | Correction - k | Corrected - W | L (mt) used | n° pcs | Power Heat (W) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bus-Bars Distribution LV (2//80X15) | In (A)= | 2646 | Ib (A)= | 2500 | MAX Bus-Bar Heat Power (W/m)= | 139,06 | 0,60 | 83,4 | 8,90 | 1 | 742,59 |
| Bus-Bars Distribution LV (1//60X6) | In (A)= | 900 | Ib (A)= | 300 | MAX Bus-Bar Heat Power (W/m)= | 13,35 | 0,60 | 8,0 | 12,00 | 1 | 96,12 |
| | | | | | | | Correction - k | Corrected - W | | n° Feeders | Power Heat (W) |
| Incomer Transformer | In (A)= | 3200 | Ib (A)= | 2500 | MAX Feeder Heat Power (W)= | 620,37 | 1,00 | 620,4 | | 1 | 620,37 |
| BESS PCS Cabinet | In (A)= | 40 | Ib (A)= | 17,41 | MAX Feeder Heat Power (W)= | 6,93 | 1,00 | 6,9 | | 1 | 6,93 |
| Fuel Cell Auxiliary Load | In (A)= | 63 | Ib (A)= | 32,84 | MAX Feeder Heat Power (W)= | 13,75 | 1,00 | 13,7 | | 1 | 13,75 |
| Electrolyser Auxiliary Load | In (A)= | 630 | Ib (A)= | 497 | MAX Feeder Heat Power (W)= | 67,45 | 1,00 | 67,5 | | 1 | 67,45 |
| BESS LV1 Cabinet (+DISTR 1) | In (A)= | 40 | Ib (A)= | 18,12 | MAX Feeder Heat Power (W)= | 7,30 | 1,00 | 7,3 | | 1 | 7,30 |
| BESS LV2 Cabinet (+DISTR 2) | In (A)= | 40 | Ib (A)= | 18,12 | MAX Feeder Heat Power (W)= | 7,30 | 1,00 | 7,3 | | 1 | 7,30 |
| Water Package | In (A)= | 160 | Ib (A)= | 107 | MAX Feeder Heat Power (W)= | 47,77 | 1,00 | 47,8 | | 1 | 47,77 |
| Instrument Air Package 01A | In (A)= | 160 | Ib (A)= | 112,24 | MAX Feeder Heat Power (W)= | 52,31 | 1,00 | 52,3 | | 1 | 52,31 |
| Instrument Air Package 01B | In (A)= | 160 | Ib (A)= | 112,24 | MAX Feeder Heat Power (W)= | 52,31 | 1,00 | 52,3 | | 1 | 52,31 |
| Crane | In (A)= | 63 | Ib (A)= | 40,14 | MAX Feeder Heat Power (W)= | 16,81 | 1,00 | 16,8 | | 1 | 16,81 |
| Welding Sockets (Top Deck) | In (A)= | 160 | Ib (A)= | 126,15 | MAX Feeder Heat Power (W)= | 57,00 | 1,00 | 57,0 | | 1 | 57,00 |
| Welding Sockets (Lower Deck) | In (A)= | 160 | Ib (A)= | 126,15 | MAX Feeder Heat Power (W)= | 57,00 | 1,00 | 57,0 | | 1 | 57,00 |
| HVAC panels - HV/MV Room | In (A)= | 40 | Ib (A)= | 34,1 | MAX Feeder Heat Power (W)= | 19,49 | 1,00 | 19,5 | | 1 | 19,49 |
| HVAC panels - LV Room | In (A)= | 40 | Ib (A)= | 34,1 | MAX Feeder Heat Power (W)= | 16,99 | 1,00 | 17,0 | | 1 | 16,99 |
| HVAC panels - UPS Room | In (A)= | 63 | Ib (A)= | 61 | MAX Feeder Heat Power (W)= | 41,31 | 1,00 | 41,3 | | 1 | 41,31 |
| HVAC panels - ITER | In (A)= | 63 | Ib (A)= | 61 | MAX Feeder Heat Power (W)= | 41,31 | 1,00 | 41,3 | | 1 | 41,31 |
| Impressed Current Cathodic Protection (ICCP) System | In (A)= | 40 | Ib (A)= | 23,8 | MAX Feeder Heat Power (W)= | 10,78 | 1,00 | 10,8 | | 1 | 10,78 |
| AC UPS PAS - 30min - UP-200F3 - Line A | In (A)= | 100 | Ib (A)= | 65 | MAX Feeder Heat Power (W)= | 25,10 | 1,00 | 25,1 | | 1 | 25,10 |
| AC UPS PAS - 30min - UP-200F3 - Line B | In (A)= | 100 | Ib (A)= | 65 | MAX Feeder Heat Power (W)= | 25,10 | 1,00 | 25,1 | | 1 | 25,10 |

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## "SG-200N1"

| 400/230V - 50Hz - 2500A | | | | | | | Correction - k | Corrected - W | L (mt) used | n° pcs | Power Heat (W) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AC UPS PAS - 30min - UP-200F3 - Bypass | In (A)= | 100 | Ib (A)= | 65,1 | MAX Feeder Heat Power (W)= | 25,17 | 1,00 | 25,2 | | 1 | 25,17 |
| AC UPS F&G - 8h - UP-200F4 - Line A | In (A)= | 63 | Ib (A)= | 32,5 | MAX Feeder Heat Power (W)= | 9,03 | 1,00 | 9,0 | | 1 | 9,03 |
| AC UPS F&G - 8h - UP-200F4 - Line B | In (A)= | 63 | Ib (A)= | 32,5 | MAX Feeder Heat Power (W)= | 9,03 | 1,00 | 9,0 | | 1 | 9,03 |
| AC UPS F&G - 8h - UP-200F4 - Bypass | In (A)= | 63 | Ib (A)= | 32,5 | MAX Feeder Heat Power (W)= | 9,03 | 1,00 | 9,0 | | 1 | 9,03 |
| DC Battery System - Switchgears Control - Feeder A | In (A)= | 63 | Ib (A)= | 16 | MAX Feeder Heat Power (W)= | 2,19 | 1,00 | 2,2 | | 1 | 2,19 |
| DC Battery System - Switchgears Control - Feeder B | In (A)= | 63 | Ib (A)= | 16 | MAX Feeder Heat Power (W)= | 2,19 | 1,00 | 2,2 | | 1 | 2,19 |
| Navaid System - Feeder A | In (A)= | 63 | Ib (A)= | 7 | MAX Feeder Heat Power (W)= | 0,42 | 1,00 | 0,4 | | 1 | 0,42 |
| Navaid System - Feeder B | In (A)= | 63 | Ib (A)= | 7 | MAX Feeder Heat Power (W)= | 0,42 | 1,00 | 0,4 | | 1 | 0,42 |
| DB - Lighting & Small Power - BoP | In (A)= | 100 | Ib (A)= | 24 | MAX Feeder Heat Power (W)= | 6,79 | 1,00 | 6,8 | | 1 | 6,79 |
| SEA WATER PUMP A | In (A)= | 20 | Ib (A)= | 12 | MAX Feeder Heat Power (W)= | 18,39 | 1,00 | 18,4 | | 1 | 18,39 |
| SEA WATER PUMP B | In (A)= | 20 | Ib (A)= | 12 | MAX Feeder Heat Power (W)= | 18,39 | 1,00 | 18,4 | | 1 | 18,39 |
| SPARE (40A) | In (A)= | 40 | Ib (A)= | 40 | MAX Feeder Heat Power (W)= | 25,88 | 1,00 | 25,9 | | 8 | 207,01 |

| | |
|---|---|
| SWBD Max Heat Power (W) = | 2.333,12 |
| "K" contemporaneity | 1,00 |
| SWBD Heat Power (W) = | 2.333,12 |

## "SG-200D2"

**800/460V - 50Hz - 630A**

| | | | | | | | Correction - k | Corrected - W | L (mt) used | n° pcs | Power Heat (W) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Incoming / Outgoimg Cables [300mmq]** | In (A)= | **635** | Ib (A)= | **630** | MAX Bus-Bar Heat Power (W/m) | **76,32** | **1,00** | **76,3** | **1,90** | 1 | **145,02** |
| | | | | | | | **Correction - k** | **Corrected - W** | | **n° Feeders** | **Power Heat (W)** |
| **Incoming from Solar Farm** | In (A)= | **1250** | Ib (A)= | **630** | MAX Feeder Heat Power (W)= | **143,37** | **1,00** | **143,4** | | 1 | **143,37** |

| | |
|---|---|
| **SWBD Max Heat Power (W) =** | **288,38** |
| **"K" contemporaneity** | **1,00** |
| **SWBD Heat Power (W) =** | **288,38** |

## "DP-200N1"

**400/230V - 50Hz - 63A**

| | | | | | | | Correction - k | Corrected - W | L (mt) used | n° pcs | Power Heat (W) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bus-Bars Distribution STQ (1//20X5) | In (A)= | 340 | Ib (A)= | 63 | MAX Bus-Bar Heat Power (W/m) | 2,12 | 1,00 | 2,1 | 2,00 | 1 | 4,24 |
| | | | | | | | Correction - k | Corrected - W | | n° Feeders | Power Heat (W) |
| Incoming [XT2N-160, EkipDip(In=63A)-LSI] | In (A)= | 63 | Ib (A)= | 63 | MAX Feeder Heat Power (W)= | 19,51 | 1,00 | 19,5 | | 1 | 19,51 |
| MCB + Contactor Feeder [4P-50A] | In (A)= | 50 | Ib (A)= | 50 | MAX Feeder Heat Power (W)= | 35,02 | 1,00 | 35,0 | | 1 | 35,02 |
| MCB Feeder [4P-10A] | In (A)= | 10 | Ib (A)= | 10 | MAX Feeder Heat Power (W)= | 9,29 | 1,00 | 9,3 | | 2 | 18,58 |
| MCB Feeder [2P-20A] | In (A)= | 20 | Ib (A)= | 20 | MAX Feeder Heat Power (W)= | 12,52 | 1,00 | 12,5 | | 3 | 37,56 |
| MCB Feeder [2P-10A] | In (A)= | 10 | Ib (A)= | 10 | MAX Feeder Heat Power (W)= | 6,19 | 1,00 | 6,2 | | 4 | 24,77 |
| MCB Feeder [2P-6A] | In (A)= | 6 | Ib (A)= | 6 | MAX Feeder Heat Power (W)= | 2,95 | 1,00 | 2,9 | | 21 | 61,93 |
| RCBO Feeder [2P-20A] | In (A)= | 20 | Ib (A)= | 20 | MAX Feeder Heat Power (W)= | 13,80 | 1,00 | 13,8 | | 8 | 110,40 |
| RCBO Feeder [2P-16A] | In (A)= | 16 | Ib (A)= | 16 | MAX Feeder Heat Power (W)= | 12,39 | 1,00 | 12,4 | | 2 | 24,78 |
| RCBO + Contactor Feeder [2P-16A] | In (A)= | 16 | Ib (A)= | 16 | MAX Feeder Heat Power (W)= | 13,35 | 1,00 | 13,4 | | 8 | 106,81 |

| | |
|---|---|
| SWBD Max Heat Power (W) = | 443,58 |
| "K" contemporaneity | 0,31 |
| SWBD Heat Power (W) = | 137,51 |

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1.7. I/O List

1.7.1.SG-100D1 IO LIST (HARDWARE - SOFTWARE),

Doc.No. 1723002197-EL-LIS-00041

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Base Load Power Hub (BLPH)

# SG-100D1 I/O LIST
# HV Switchgear

Document Number: 1723002197-EL-LIS-00041

Document Class:2

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

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| Sign | Date |
|---|---|
| Luca Mascia | 20/12/2024 |

| Rev. | Date | Description | Prepared | Reviewed | Approved |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| 02 | 28/11/2024 | As Built (ASB) | Giulietti | Santinelli | Mastri |
| 01 | 09/08/2024 | Accepted for Costruction (AFC) | Giulietti | Santinelli | Mastri |
| 00 | 08/07/2024 | Issue for Review (IFR) | Giulietti | Santinelli | Mastri |

IMESA ELECTRICAL ENGINEERING

IMESA Doc. n. 231115/SD/41

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Revision / Change Log

| Rev. | Description |
|---|---|
| 00 | Issue or Review (IFR) |
| 01 | Accepted for Costruction (AFC) |
| 02 | As Built (ASB) |
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| ITEM | SWITCHGEAR TAG | VOLTAGE | TAG NAME | FEEDER CUBICLE No | SIGNAL_DESCRIPTION | TYPE ANALOG/DIGITAL | RELAY MODEL | UNIT | SCALE FACTOR | IEC61850 ITEM TAG | TECHNICAL KEY | | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| **ELECTROLYSER FEEDER A-20000 "A1"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | PROTECTION TRIPPED "50-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHIPTOC1.ST.Op.general | SG100D1A1 | | 1=failure |
| 2 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | PROTECTION TRIPPED "51-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHLPTOC1.ST.Op.general | SG100D1A1 | | 1=failure |
| 3 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | PROTECTION TRIPPED "51N" | DIGITAL | REX640 | N.A. | N.A. | LD0.EFLPTOC1.ST.Op.general | SG100D1A1 | | 1=failure |
| 4 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | PROTECTION TRIPPED "59N" | DIGITAL | REX640 | N.A. | N.A. | LD0.ROVPTOV1.ST.Op.general | SG100D1A1 | | 1=failure |
| 5 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | PROTECTION TRIPPED "27-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTUV1.ST.Op.general | SG100D1A1 | | 1=failure |
| 6 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | PROTECTION TRIPPED "59-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTOV1.ST.Op.general | SG100D1A1 | | 1=failure |
| 7 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | SELECTOR SWITCH IN LOCAL POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO6.stVal | SG100D1A1 | | 1=local |
| 8 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | SELECTOR SWITCH IN REMOTE POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO7.stVal | SG100D1A1 | | 1=remote |
| 9 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Line Current (L1) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsA.cVal.mag.f | SG100D1A1 | | |
| 10 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Line Current (L2) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsB.cVal.mag.f | SG100D1A1 | | |
| 11 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Line Current (L3) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsC.cVal.mag.f | SG100D1A1 | | |
| 12 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Line Volts (L1-L2) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsAB.cVal.mag.f | SG100D1A1 | | |
| 13 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Line Volts (L2-L3) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsBC.cVal.mag.f | SG100D1A1 | | |
| 14 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Line Volts (L3-L1) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsCA.cVal.mag.f | SG100D1A1 | | |
| 15 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Frequency | ANALOG | REX640 | Hz | 1 | LD0.FMMXU1.Hz.mag.f | SG100D1A1 | | |
| 16 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | APPARENT POWER (kVA) | ANALOG | REX640 | kVA | 1 | LD0.PEMMXU1.TotVA.mag.f | SG100D1A1 | | |
| 17 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | REAL POWER (kW) | ANALOG | REX640 | kW | 1 | LD0.PEMMXU1.TotW.mag.f | SG100D1A1 | | |
| 18 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | REACTIVE POWER (kVAR) | ANALOG | REX640 | kVAR | 1 | LD0.PEMMXU1.TotVAr.mag.f | SG100D1A1 | | |
| 19 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | POWER FACTOR | ANALOG | REX640 | COSfi | 1 | LD0.PEMMXU1.TotPF.mag.f | SG100D1A1 | | |
| 20 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | TRANSFORMER PROTECTION TRIPPED "OIL TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind9.stVal | SG100D1A1 | | 1=failure |
| 21 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | TRANSFORMER PROTECTION ALARM "OIL TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind8.stVal | SG100D1A1 | | 1=failure |
| 22 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | TRANSFORMER PROTECTION TRIPPED "OIL PRESSURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind12.stVal | SG100D1A1 | | 1=failure |
| 23 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | TRANSFORMER PROTECTION ALARM "OIL PRESSURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind11.stVal | SG100D1A1 | | 1=failure |
| 24 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | TRANSF. PROTECTION TRIPPED "WINDING TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind14.stVal | SG100D1A1 | | 1=failure |
| 25 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | TRANSF. PROTECTION ALARM "WINDING TEMPERATURE | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind13.stVal | SG100D1A1 | | 1=failure |
| 26 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | WATCHDOG PROTECTION RELAY | DIGITAL | REX640 | N.A. | N.A. | LD0.LPHD1.PhyHealth.stVal | SG100D1A1 | | 1=watchdog "OK" |
| 27 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | V.T. HEALTLY CIRCUIT | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind2.stVal | SG100D1A1 | | 1=healtly V.T. |
| 28 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | INTERTRIP SEND TO L.V. SWITCHBOARD | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO4.stVal | SG100D1A1 | | 1=Intertrip |
| 29 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | K86 TRIPPED | DIGITAL | REX640 | N.A. | N.A. | LD0.SBBIGGIO1.ST.Ind7.stVal | SG100D1A1 | | 1=failure K86 |
| 30 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | C.B. CLOSED AND INSERTED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO8.stVal | SG100D1A1 | | 1=C.B. closed |
| 31 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | C.B. OPENED OR ISOLATED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO2.stVal | SG100D1A1 | | 1=C.B. opened |
| 32 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | MCB'S CLOSED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO3.stVal | SG100D1A1 | | 1=MCB's closed |
| 33 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | C.B. READY (TCS) | DIGITAL | REX640 | N.A. | N.A. | LD0.TCSSCBR1.ST.CircAlm.stVal | SG100D1A1 | | 0=C.B. ready, 1=TCS Alarm |
| 34 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | C.B. READY TO CLOSE | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO1.stVal | SG100D1A1 | | 1=C.B.ready to close |
| 35 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | OPENING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO2.stVal | SG100D1A1 | | 1=open command |
| 36 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | CLOSING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO1.stVal | SG100D1A1 | | 1=close command |
| 37 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | K86 RESET COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO3.stVal | SG100D1A1 | | 1=reset command |
| 38 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | PROTECTION RELAY UNIT 7 HEALTHY | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind8.stVal | SG100D1A1 | | 1= Relay unit 7 Healthy |
| | | | | | | | | | | | | | |
| **TRANSFORMER FEEDER TR-200ED1 "A2"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION TRIPPED "50-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHIPTOC1.ST.Op.general | SG100D1A2 | | 1=failure |
| 2 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION TRIPPED "51-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHLPTOC1.ST.Op.general | SG100D1A2 | | 1=failure |
| 3 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION TRIPPED "51N" | DIGITAL | REX640 | N.A. | N.A. | LD0.EFLPTOC1.ST.Op.general | SG100D1A2 | | 1=failure |
| 4 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | SYNCHRO "OK" | DIGITAL | REX640 | N.A. | N.A. | LD0.LEDGGIO1.ST.Ind3.stVal | SG100D1A2 | | 1=failure |
| 5 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION TRIPPED "59N-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.ROVPTOV1.ST.Op.general | SG100D1A2 | | 1=failure |
| 6 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION TRIPPED "59N-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.ROVPTOV2.ST.Op.general | SG100D1A2 | | 1=failure |
| 7 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION TRIPPED "27-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTUV1.ST.Op.general | SG100D1A2 | | 1=failure |
| 8 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION TRIPPED "27-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTUV2.ST.Op.general | SG100D1A2 | | 1=failure |
| 9 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION TRIPPED "59-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTOV1.ST.Op.general | SG100D1A2 | | 1=failure |
| 10 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION TRIPPED "59-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTOV2.ST.Op.general | SG100D1A2 | | 1=failure |
| 11 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION TRIPPED "67-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.DPHLPTOC1.Op.general | SG100D1A2 | | 1=failure |
| 12 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION TRIPPED "67-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.DPHLPTOC2.Op.general | SG100D1A2 | | 1=failure |
| 13 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | SELECTOR SWITCH IN LOCAL POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO6.stVal | SG100D1A2 | | 1=local |
| 14 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | SELECTOR SWITCH IN REMOTE POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO7.stVal | SG100D1A2 | | 1=remote |
| 15 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Line Current (L1) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsA.cVal.mag.f | SG100D1A2 | | |
| 16 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Line Current (L2) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsB.cVal.mag.f | SG100D1A2 | | |
| 17 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Line Current (L3) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsC.cVal.mag.f | SG100D1A2 | | |
| 18 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Line Volts (L1-L2) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsAB.cVal.mag.f | SG100D1A2 | | |
| 19 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Line Volts (L2-L3) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsBC.cVal.mag.f | SG100D1A2 | | |
| 20 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Line Volts (L3-L1) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsCA.cVal.mag.f | SG100D1A2 | | |
| 21 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Frequency | ANALOG | REX640 | Hz | 1 | LD0.FMMXU1.Hz.mag.f | SG100D1A2 | | |
| 22 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | APPARENT POWER (kVA) | ANALOG | REX640 | kVA | 1 | LD0.PEMMXU1.TotVA.mag.f | SG100D1A2 | | |
| 23 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | REAL POWER (kW) | ANALOG | REX640 | kW | 1 | LD0.PEMMXU1.TotW.mag.f | SG100D1A2 | | |
| 24 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | REACTIVE POWER (kVAR) | ANALOG | REX640 | kVAR | 1 | LD0.PEMMXU1.TotVAr.mag.f | SG100D1A2 | | |
| 25 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | POWER FACTOR | ANALOG | REX640 | COSfi | 1 | LD0.PEMMXU1.TotPF.mag.f | SG100D1A2 | | |
| 26 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | TRANSFORMER PROTECTION TRIPPED "BUCHHOLZ" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind7.stVal | SG100D1A2 | | 1=failure |
| 27 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | TRANSFORMER PROTECTION ALARM "BUCHHOLZ" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind6.stVal | SG100D1A2 | | 1=failure |
| 28 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | TRANSFORMER PROTECTION TRIPPED "OIL TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind9.stVal | SG100D1A2 | | 1=failure |
| 29 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | TRANSFORMER PROTECTION ALARM "OIL TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind8.stVal | SG100D1A2 | | 1=failure |
| 30 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | TRANSFORMER PROTECTION TRIP "OIL PRESSURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind12.stVal | SG100D1A2 | | 1=failure |
| 31 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | TRANSF. OIL LEVEL VERY LOW ALARM | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind11.stVal | SG100D1A2 | | 1=failure |
| 32 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | TRANSF. PROTECTION TRIPPED "WINDING TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind14.stVal | SG100D1A2 | | 1=failure |
| 33 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | TRANSF. PROTECTION ALARM "WINDING TEMPERATURE | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind13.stVal | SG100D1A2 | | 1=failure |
| 34 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | TRANSF. GENERAL ALARM | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind7.stVal | SG100D1A2 | | 1=failure |
| 35 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | WATCHDOG PROTECTION RELAY | DIGITAL | REX640 | N.A. | N.A. | LD0.LPHD1.PhyHealth.stVal | SG100D1A2 | | 1=watchdog "OK" |
| 36 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | V.T. HEALTLY CIRCUIT | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind2.stVal | SG100D1A2 | | 1=healtly V.T. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 37 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | INTERTRIP SEND TO L.V. SWITCHBOARD | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO4.stVal | SG100D1A2 | | 1=Intertrip |
| 38 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | K86 TRIPPED | DIGITAL | REX640 | N.A. | N.A. | LD0.SBBIGGIO1.ST.Ind7.stVal | SG100D1A2 | | 1=failure K86 |
| 39 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Contactor CLOSED AND INSERTED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO8.stVal | SG100D1A2 | | 1=Contactor closed |
| 40 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Contactor OPENED OR ISOLATED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO2.stVal | SG100D1A2 | | 1=Contactor opened |
| 41 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | MCB'S CLOSED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO3.stVal | SG100D1A2 | | 1=MCB's closed |
| 42 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Contactor READY (TCS) | DIGITAL | REX640 | N.A. | N.A. | LD0.TCSSCBR1.ST.CircAlm.stVal | SG100D1A2 | | 0=C.B. ready, 1=TCS Alarm |
| 43 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Contactor READY TO CLOSE | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO1.stVal | SG100D1A2 | | 1=Contac. ready to close |
| 44 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | OPENING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO2.stVal | SG100D1A2 | | 1=open command |
| 45 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | CLOSING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO1.stVal | SG100D1A2 | | 1=close command |
| 46 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | K86 RESET COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO3.stVal | SG100D1A2 | | 1=reset command |
| 47 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | PROTECTION RELAY UNIT 1 HEALTHY | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind8.stVal | SG100D1A2 | | 1= Relay unit 1 Healthy |
| 48 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | SELECTOR SWITCH OF OVERRIDE IN OFF (SIL ENABLED) | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind9.stVal | SG100D1A2 | | 1=SIL enabled |
| | | | | | | | | | | | | | |
| **BESS FEEDER A-85000 "A3"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION TRIPPED "50-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHIPTOC1.ST.Op.general | SG100D1A3 | | 1=failure |
| 2 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION TRIPPED "51-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHLPTOC1.ST.Op.general | SG100D1A3 | | 1=failure |
| 3 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION TRIPPED "51N" | DIGITAL | REX640 | N.A. | N.A. | LD0.EFLPTOC1.ST.Op.general | SG100D1A3 | | 1=failure |
| 4 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | SYNCHRO "OK" | DIGITAL | REX640 | N.A. | N.A. | LD0.LEDGGIO1.ST.Ind3.stVal | SG100D1A3 | | 1=syncho |
| 5 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION TRIPPED "59N-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.ROVPTOV1.ST.Op.general | SG100D1A3 | | 1=failure |
| 6 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION TRIPPED "59N-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.ROVPTOV2.ST.Op.general | SG100D1A3 | | 1=failure |
| 7 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION TRIPPED "27-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTUV1.ST.Op.general | SG100D1A3 | | 1=failure |
| 8 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION TRIPPED "27-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTUV2.ST.Op.general | SG100D1A3 | | 1=failure |
| 9 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION TRIPPED "59-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTOV1.ST.Op.general | SG100D1A3 | | 1=failure |
| 10 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION TRIPPED "59-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTOV2.ST.Op.general | SG100D1A3 | | 1=failure |
| 11 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION TRIPPED "67-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.DPHLPTOC1.Op.general | SG100D1A3 | | 1=failure |
| 12 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION TRIPPED "67-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.DPHLPTOC2.Op.general | SG100D1A3 | | 1=failure |
| 13 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | SELECTOR SWITCH IN LOCAL POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO6.stVal | SG100D1A3 | | 1=local |
| 14 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | SELECTOR SWITCH IN REMOTE POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO7.stVal | SG100D1A3 | | 1=remote |
| 15 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Line Current (L1) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsA.cVal.mag.f | SG100D1A3 | | |
| 16 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Line Current (L2) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsB.cVal.mag.f | SG100D1A3 | | |
| 17 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Line Current (L3) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsC.cVal.mag.f | SG100D1A3 | | |
| 18 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Line Volts (L1-L2) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsAB.cVal.mag.f | SG100D1A3 | | |
| 19 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Line Volts (L2-L3) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsBC.cVal.mag.f | SG100D1A3 | | |
| 20 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Line Volts (L3-L1) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsCA.cVal.mag.f | SG100D1A3 | | |
| 21 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Frequency | ANALOG | REX640 | Hz | 1 | LD0.FMMXU1.Hz.mag.f | SG100D1A3 | | |
| 22 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | APPARENT POWER (kVA) | ANALOG | REX640 | kVA | 1 | LD0.PEMMXU1.TotVA.mag.f | SG100D1A3 | | |
| 23 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | REAL POWER (kW) | ANALOG | REX640 | kW | 1 | LD0.PEMMXU1.TotW.mag.f | SG100D1A3 | | |
| 24 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | REACTIVE POWER (kVAR) | ANALOG | REX640 | kVAR | 1 | LD0.PEMMXU1.TotVAr.mag.f | SG100D1A3 | | |
| 25 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | POWER FACTOR | ANALOG | REX640 | COSfi | 1 | LD0.PEMMXU1.TotPF.mag.f | SG100D1A3 | | |
| 26 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | TRANSF. PROTECTION TRIPPED "WINDING TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind14.stVal | SG100D1A3 | | 1=failure |
| 27 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | TRANSF. PROTECTION ALARM "WINDING TEMPERATURE | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind13.stVal | SG100D1A3 | | 1=failure |
| 28 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | WATCHDOG PROTECTION RELAY | DIGITAL | REX640 | N.A. | N.A. | LD0.LPHD1.PhyHealth.stVal | SG100D1A3 | | 1=watchdog "OK" |
| 29 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | V.T. HEALTLY CIRCUIT | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind2.stVal | SG100D1A3 | | 1=healtly V.T. |
| 30 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | INTERTRIP SEND TO L.V. SWITCHBOARD | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO4.stVal | SG100D1A3 | | 1=Intertrip |
| 31 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | K86 TRIPPED | DIGITAL | REX640 | N.A. | N.A. | LD0.SBBIGGIO1.ST.Ind7.stVal | SG100D1A3 | | 1=failure K86 |
| 32 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Contactor CLOSED AND INSERTED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO8.stVal | SG100D1A3 | | 1=Contactor closed |
| 33 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Contactor OPENED OR ISOLATED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO2.stVal | SG100D1A3 | | 1=Contactor opened |
| 34 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | MCB'S CLOSED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO3.stVal | SG100D1A3 | | 1=MCB's closed |
| 35 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Contactor READY (TCS) | DIGITAL | REX640 | N.A. | N.A. | LD0.TCSSCBR1.ST.CircAlm.stVal | SG100D1A3 | | 0=C.B. ready, 1=TCS Alarm |
| 36 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Contactor READY TO CLOSE | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO1.stVal | SG100D1A3 | | 1=Contac. ready to close |
| 37 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | OPENING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO2.stVal | SG100D1A3 | | 1=open command |
| 38 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | CLOSING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO1.stVal | SG100D1A3 | | 1=close command |
| 39 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | K86 RESET COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO3.stVal | SG100D1A3 | | 1=reset command |
| 40 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION RELAY UNIT 2 HEALTHY | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind8.stVal | SG100D1A3 | | 1= Relay unit 2 Healthy |
| 41 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | PROTECTION RELAY UNIT 4 HEALTHY | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind6.stVal | SG100D1A3 | | 1= Relay unit 4 Healthy |
| 42 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | SELECTOR SWITCH OF OVERRIDE (SIL ENABLED) | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind9.stVal | SG100D1A3 | | 1=SIL enabled |
| | | | | | | | | | | | | | |
| **TRANSFORMER FEEDER TR-200DE1 "A4"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED "50" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHHPTOC2.ST.Op.general | SG100D1A4 | | 1=failure |
| 2 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED "50-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHHPTOC1.ST.Op.general | SG100D1A4 | | 1=failure |
| 3 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED "50-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHIPTOC1.ST.Op.general | SG100D1A4 | | 1=failure |
| 4 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED "51" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHLPTOC2.ST.Op.general | SG100D1A4 | | 1=failure |
| 5 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED "51-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHLPTOC1.ST.Op.general | SG100D1A4 | | 1=failure |
| 6 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED "51N" | DIGITAL | REX640 | N.A. | N.A. | LD0.EFLPTOC1.ST.Op.general | SG100D1A4 | | 1=failure |
| 7 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED "51G" | DIGITAL | REX640 | N.A. | N.A. | LD0.EFHPTOC1.ST.Op.general | SG100D1A4 | | 1=failure |
| 8 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED "59N-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.ROVPTOV1.ST.Op.general | SG100D1A4 | | 1=failure |
| 9 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED "59N-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.ROVPTOV2.ST.Op.general | SG100D1A4 | | 1=failure |
| 10 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED "27-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTUV1.ST.Op.general | SG100D1A4 | | 1=failure |
| 11 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED "59-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTOV1.ST.Op.general | SG100D1A4 | | 1=failure |
| 12 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | SELECTOR SWITCH IN LOCAL POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO6.stVal | SG100D1A4 | | 1=local |
| 13 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | SELECTOR SWITCH IN REMOTE POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO7.stVal | SG100D1A4 | | 1=remote |
| 14 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Line Current (L1) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsA.cVal.mag.f | SG100D1A4 | | |
| 15 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Line Current (L2) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsB.cVal.mag.f | SG100D1A4 | | |
| 16 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Line Current (L3) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsC.cVal.mag.f | SG100D1A4 | | |
| 17 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | VOLTAGE MAIN BUS BAR (L1-I2) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsAB.cVal.mag.f | SG100D1A4 | | |
| 18 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | VOLTAGE MAIN BUS BAR (L2-L3) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsBC.cVal.mag.f | SG100D1A4 | | |
| 19 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | VOLTAGE MAIN BUS BAR (L3-L1) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsCA.cVal.mag.f | SG100D1A4 | | |
| 20 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Frequency | ANALOG | REX640 | Hz | 1 | LD0.FMMXU1.Hz.mag.f | SG100D1A4 | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | APPARENT POWER (kVA) | ANALOG | REX640 | kVA | 1 | LD0.PEMMXU1.TotVA.mag.f | SG100D1A4 | | |
| 22 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | REAL POWER (kW) | ANALOG | REX640 | kW | 1 | LD0.PEMMXU1.TotW.mag.f | SG100D1A4 | | |
| 23 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | REACTIVE POWER (kVAR) | ANALOG | REX640 | kVAR | 1 | LD0.PEMMXU1.TotVAr.mag.f | SG100D1A4 | | |
| 24 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | POWER FACTOR | ANALOG | REX640 | COSfi | 1 | LD0.PEMMXU1.TotPF.mag.f | SG100D1A4 | | |
| 25 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | TRANSFORMER PROTECTION TRIPPED "BUCHHOLZ" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind7.stVal | SG100D1A4 | | 1=failure |
| 26 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | TRANSFORMER PROTECTION ALARM "BUCHHOLZ" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind6.stVal | SG100D1A4 | | 1=failure |
| 27 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | TRANSFORMER PROTECTION TRIPPED "OIL TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind9.stVal | SG100D1A4 | | 1=failure |
| 28 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | TRANSFORMER PROTECTION ALARM "OIL TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind8.stVal | SG100D1A4 | | 1=failure |
| 29 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION TRIPPED ALARM "OIL LEVEL" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind10.stVal | SG100D1A4 | | 1=failure |
| 30 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | TRANSFORMER PROTECTION TRIPPED "OIL PRESSURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind12.stVal | SG100D1A4 | | 1=failure |
| 31 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | TRANSF. PROTECTION TRIPPED "WINDING TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind14.stVal | SG100D1A4 | | 1=failure |
| 32 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | TRANSF. PROTECTION ALARM "WINDING TEMPERATURE | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind13.stVal | SG100D1A4 | | 1=failure |
| 33 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | TRANSF. OIL LEVEL VERY LOW ALARM | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind11.stVal | SG100D1A4 | | 1=failure |
| 34 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | TRANSFORMER GENERAL ALARM | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind7.stVal | SG100D1A4 | | 1=failure |
| 35 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | WATCHDOG PROTECTION RELAY | DIGITAL | REX640 | N.A. | N.A. | LD0.LPHD1.PhyHealth.stVal | SG100D1A4 | | 1=watchdog "OK" |
| 36 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | INTERTRIP SEND TO L.V. SWITCHBOARD | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO4.stVal | SG100D1A4 | | 1=Intertrip |
| 37 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | K86 TRIPPED | DIGITAL | REX640 | N.A. | N.A. | LD0.SBBIGGIO1.ST.Ind7.stVal | SG100D1A4 | | 1=failure K86 |
| 38 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Contactor CLOSED AND INSERTED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO8.stVal | SG100D1A4 | | 1=Contactor closed |
| 39 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Contactor OPENED OR ISOLATED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO2.stVal | SG100D1A4 | | 1=Contactor opened |
| 40 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | MCB'S CLOSED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO3.stVal | SG100D1A4 | | 1=MCB's closed |
| 41 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Contactor READY (TCS) | DIGITAL | REX640 | N.A. | N.A. | LD0.TCSSCBR1.ST.CircAlm.stVal | SG100D1A4 | | 0=C.B. ready, 1=TCS Alarm |
| 42 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Contactor READY TO CLOSE | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO1.stVal | SG100D1A4 | | 1=Contac. ready to close |
| 43 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | OPENING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO2.stVal | SG100D1A4 | | 1=open command |
| 44 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | CLOSING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO1.stVal | SG100D1A4 | | 1=close command |
| 45 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | K86 RESET COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO3.stVal | SG100D1A4 | | 1=reset command |
| 46 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | PROTECTION RELAY UNIT 3 HEALTHY | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind8.stVal | SG100D1A4 | | 1= Relay unit 3 Healthy |
| 47 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | SELECTOR SWITCH OF OVERRIDE (SIL ENABLED) | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind9.stVal | SG100D1A4 | | 1=SIL enabled |
| | | | | | | | | | | | | | |
| **INCOMING FEEDER TR-100AD1 "A6"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | PROTECTION TRIPPED "50-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHIPTOC1.ST.Op.general | SG100D1A6 | | 1=failure |
| 2 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | PROTECTION TRIPPED "51-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHLPTOC1.ST.Op.general | SG100D1A6 | | 1=failure |
| 3 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | PROTECTION TRIPPED "51N" | DIGITAL | REX640 | N.A. | N.A. | LD0.EFLPTOC1.ST.Op.general | SG100D1A6 | | 1=failure |
| 4 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | SYNCHRO "OK" | DIGITAL | REX640 | N.A. | N.A. | LD0.LEDGGIO1.ST.Ind3.stVal | SG100D1A6 | | 1=failure |
| 5 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | PROTECTION TRIPPED "59N-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.ROVPTOV1.ST.Op.general | SG100D1A6 | | 1=failure |
| 6 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | PROTECTION TRIPPED "59N-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.ROVPTOV2.ST.Op.general | SG100D1A6 | | 1=failure |
| 7 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | PROTECTION TRIPPED "27-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTUV1.ST.Op.general | SG100D1A6 | | 1=failure |
| 8 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | PROTECTION TRIPPED "27-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTUV2.ST.Op.general | SG100D1A6 | | 1=failure |
| 9 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | PROTECTION TRIPPED "59-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTOV1.ST.Op.general | SG100D1A6 | | 1=failure |
| 10 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | PROTECTION TRIPPED "59-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTOV2.ST.Op.general | SG100D1A6 | | 1=failure |
| 11 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | SELECTOR SWITCH IN LOCAL POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO6.stVal | SG100D1A6 | | 1=local |
| 12 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | SELECTOR SWITCH IN REMOTE POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO7.stVal | SG100D1A6 | | 1=remote |
| 13 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Line Current (L1) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsA.cVal.mag.f | SG100D1A6 | | |
| 14 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Line Current (L2) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsB.cVal.mag.f | SG100D1A6 | | |
| 15 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Line Current (L3) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsC.cVal.mag.f | SG100D1A6 | | |
| 16 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Line Volts (L1-I2) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsAB.cVal.mag.f | SG100D1A6 | | |
| 17 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Line Volts (L2-L3) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsBC.cVal.mag.f | SG100D1A6 | | |
| 18 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Line Volts (L3-L1) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsCA.cVal.mag.f | SG100D1A6 | | |
| 19 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Frequency | ANALOG | REX640 | Hz | 1 | LD0.FMMXU1.Hz.mag.f | SG100D1A6 | | |
| 20 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | APPARENT POWER (kVA) | ANALOG | REX640 | kVA | 1 | LD0.PEMMXU1.TotVA.mag.f | SG100D1A6 | | |
| 21 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | REAL POWER (kW) | ANALOG | REX640 | kW | 1 | LD0.PEMMXU1.TotW.mag.f | SG100D1A6 | | |
| 22 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | REACTIVE POWER (kVAR) | ANALOG | REX640 | kVAR | 1 | LD0.PEMMXU1.TotVAr.mag.f | SG100D1A6 | | |
| 23 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | POWER FACTOR | ANALOG | REX640 | COSfi | 1 | LD0.PEMMXU1.TotPF.mag.f | SG100D1A6 | | |
| 24 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSFORMER PROTECTION TRIPPED "OIL TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind9.stVal | SG100D1A6 | | 1=failure |
| 25 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSFORMER PROTECTION ALARM "OIL TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind8.stVal | SG100D1A6 | | 1=failure |
| 26 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSFORMER PROTECTION TRIPPED "OIL PRESSURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind12.stVal | SG100D1A6 | | 1=failure |
| 27 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSF. PROT. SELF DEHYDRATING BREATHER ALARM | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind11.stVal | SG100D1A6 | | 1=failure |
| 28 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSF. PROTECTION TRIPPED "WINDING TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind14.stVal | SG100D1A6 | | 1=failure |
| 29 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSF. PROTECTION ALARM "WINDING TEMPERATURE | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind13.stVal | SG100D1A6 | | 1=failure |
| 30 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSFORMER PROTECTION ALARM BUCHHOLZ | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind7.stVal | SG100D1A6 | | 1=failure |
| 31 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSFORMER PROTECTION TRIPPED BUCHHOLZ | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind9.stVal | SG100D1A6 | | 1=failure |
| 32 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSFORMER OLTC PROTECTION RELAY | DIGITAL | REX640 | N.A. | N.A. | LD0.SBBIGGIO1.ST.Ind9.stVal | SG100D1A6 | | 1=failure |
| 33 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSFORMER PROTECTION ALARM LEVEL OIL | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.Ind10.stVal | SG100D1A6 | | 1=failure |
| 34 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSFORMER PROTECTION TRIPPED LEVEL OIL | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind7.stVal | SG100D1A6 | | 1=failure |
| 35 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSFORMER PROTECTION ALARM OIL LEVEL INDICATOR | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind3.stVal | SG100D1A6 | | 1=failure |
| 36 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSF. OLTC PROTECTION TRIPPED OIL LEVEL INDICATOR | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind1.stVal | SG100D1A6 | | 1=failure |
| 37 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRANSFORMER PROTECTION ALARM MEMBRANE CONTROL | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind6.stVal | SG100D1A6 | | 1=failure |
| 38 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | WATCHDOG PROTECTION RELAY | DIGITAL | REX640 | N.A. | N.A. | LD0.LPHD1.PhyHealth.stVal | SG100D1A6 | | 1=watchdog "OK" |
| 39 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | V.T. HEALTLY CIRCUIT | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind2.stVal | SG100D1A6 | | 1=healtly V.T. |
| 40 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | INTERTRIP SEND TO 66kV SWITCHB. | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO4.stVal | SG100D1A6 | | 1=Intertrip |
| 41 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | K86 TRIPPED | DIGITAL | REX640 | N.A. | N.A. | LD0.SBBIGGIO1.ST.Ind7.stVal | SG100D1A6 | | 1=failure K86 |
| 42 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | C.B. CLOSED AND INSERTED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO8.stVal | SG100D1A6 | | 1=C.B. closed |
| 43 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | C.B. OPENED OR ISOLATED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO2.stVal | SG100D1A6 | | 1=C.B. opened |
| 44 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | MCB'S CLOSED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO5.stVal | SG100D1A6 | | 1=MCB's closed |
| 45 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | C.B. READY (TCS) | DIGITAL | REX640 | N.A. | N.A. | LD0.TCSSCBR1.ST.CircAlm.stVal | SG100D1A6 | | 0=C.B. ready, 1=TCS Alarm |
| 46 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | C.B. READY TO CLOSE | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO1.stVal | SG100D1A6 | | 1=C.B.ready to close |
| 47 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | OPENING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO2.stVal | SG100D1A6 | | 1=open command |
| 48 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | CLOSING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO1.stVal | SG100D1A6 | | 1=close command |
| 49 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | K86 RESET COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO3.stVal | SG100D1A6 | | 1=reset command |
| 50 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | LIVE VOLTAGE 6.6kV ON THE MAIN BUS-BARS | DIGITAL | REX640 | N.A. | N.A. | LD0.VMMXU2.ST.HiWrn.stVal | SG100D1A6 | | 1= voltage 6,6kV on the bars alive |
| 50 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TRIPPED ARC CABLE COMPARTEMENT | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBOGGIO1.ST.SPCSO2.stVal | SG100D1A6 | | 1=failure ARC Cable comp. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | TR-100AD1 GENERAL ALAM | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind4.stVal | SG100D1A6 | | 1=failure |
| 52 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | RR-100D1 NER GENERAL ALARM | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind8.stVal | SG100D1A6 | | 1=failure |
| | | | | | | | | | | | | | |
| **FUEL CELL A-80000 "A7"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION TRIPPED "50-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHIPTOC1.ST.Op.general | SG100D1A6 | | 1=failure |
| 2 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION TRIPPED "51-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHLPTOC1.ST.Op.general | SG100D1A6 | | 1=failure |
| 3 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION TRIPPED "51N" | DIGITAL | REX640 | N.A. | N.A. | LD0.EFLPTOC1.ST.Op.general | SG100D1A6 | | 1=failure |
| 4 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | SYNCHRO "OK" | DIGITAL | REX640 | N.A. | N.A. | LD0.LEDGGIO1.ST.Ind3.stVal | SG100D1A6 | | 1=failure |
| 5 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION TRIPPED "59N-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.ROVPTOV1.ST.Op.general | SG100D1A6 | | 1=failure |
| 6 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION TRIPPED "59N-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.ROVPTOV2.ST.Op.general | SG100D1A6 | | 1=failure |
| 7 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION TRIPPED "27-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTUV1.ST.Op.general | SG100D1A6 | | 1=failure |
| 8 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION TRIPPED "27-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTUV2.ST.Op.general | SG100D1A6 | | 1=failure |
| 9 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION TRIPPED "59-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTOV1.ST.Op.general | SG100D1A6 | | 1=failure |
| 10 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION TRIPPED "59-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.PHPTOV2.ST.Op.general | SG100D1A6 | | 1=failure |
| 11 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION TRIPPED "67-1" | DIGITAL | REX640 | N.A. | N.A. | LD0.DPHLPTOC1.Op.general | SG100D1A6 | | 1=failure |
| 12 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION TRIPPED "67-2" | DIGITAL | REX640 | N.A. | N.A. | LD0.DPHLPTOC2.Op.general | SG100D1A6 | | 1=failure |
| 13 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | SELECTOR SWITCH IN LOCAL POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO6.stVal | SG100D1A6 | | 1=local |
| 14 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | SELECTOR SWITCH IN REMOTE POSITION | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO7.stVal | SG100D1A6 | | 1=remote |
| 15 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Line Current (L1) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsA.cVal.mag.f | SG100D1A6 | | |
| 16 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Line Current (L2) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsB.cVal.mag.f | SG100D1A6 | | |
| 17 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Line Current (L3) | ANALOG | REX640 | A | 1 | LD0.CMMXU1.A.phsC.cVal.mag.f | SG100D1A6 | | |
| 18 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Line Volts (L1-I2) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsAB.cVal.mag.f | SG100D1A6 | | |
| 19 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Line Volts (L2-L3) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsBC.cVal.mag.f | SG100D1A6 | | |
| 20 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Line Volts (L3-L1) | ANALOG | REX640 | kV | 1 | LD0.VMMXU1.PPV.phsCA.cVal.mag.f | SG100D1A6 | | |
| 21 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Frequency | ANALOG | REX640 | Hz | 1 | LD0.FMMXU1.Hz.mag.f | SG100D1A6 | | |
| 22 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | APPARENT POWER (kVA) | ANALOG | REX640 | kVA | 1 | LD0.PEMMXU1.TotVA.mag.f | SG100D1A6 | | |
| 23 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | REAL POWER (kW) | ANALOG | REX640 | kW | 1 | LD0.PEMMXU1.TotW.mag.f | SG100D1A6 | | |
| 24 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | REACTIVE POWER (kVAR) | ANALOG | REX640 | kVAR | 1 | LD0.PEMMXU1.TotVAr.mag.f | SG100D1A6 | | |
| 25 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | POWER FACTOR | ANALOG | REX640 | COSfi | 1 | LD0.PEMMXU1.TotPF.mag.f | SG100D1A6 | | |
| 26 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | TRANSF. PROTECTION TRIPPED "WINDING TEMPERATURE" | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind14.stVal | SG100D1A6 | | 1=failure |
| 27 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | TRANSF. PROTECTION ALARM "WINDING TEMPERATURE | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind13.stVal | SG100D1A6 | | 1=failure |
| 28 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | WATCHDOG PROTECTION RELAY | DIGITAL | REX640 | N.A. | N.A. | LD0.LPHD1.PhyHealth.stVal | SG100D1A6 | | 1=watchdog "OK" |
| 29 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | V.T. HEALTLY CIRCUIT | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind2.stVal | SG100D1A6 | | 1=healtly V.T. |
| 30 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | INTERTRIP SEND TO L.V. SWITCHBOARD | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO4.stVal | SG100D1A6 | | 1=Intertrip |
| 31 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | K86 TRIPPED | DIGITAL | REX640 | N.A. | N.A. | LD0.SBBIGGIO1.ST.Ind7.stVal | SG100D1A6 | | 1=failure K86 |
| 32 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Contactor CLOSED AND INSERTED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC1.ST.SPCSO8.stVal | SG100D1A6 | | 1=Contactor closed |
| 33 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Contactor OPENED OR ISOLATED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO2.stVal | SG100D1A6 | | 1=Contactor opened |
| 34 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | MCB'S CLOSED | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO3.stVal | SG100D1A6 | | 1=MCB's closed |
| 35 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Contactor READY (TCS) | DIGITAL | REX640 | N.A. | N.A. | LD0.TCSSCBR1.ST.CircAlm.stVal | SG100D1A6 | | 0=C.B. ready, 1=TCS Alarm |
| 36 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Contactor READY TO CLOSE | DIGITAL | REX640 | N.A. | N.A. | LD0.MVGAPC2.ST.SPCSO1.stVal | SG100D1A6 | | 1=Contac. ready to close |
| 37 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | OPENING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO2.stVal | SG100D1A6 | | 1=open command |
| 38 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | CLOSING COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO1.stVal | SG100D1A6 | | 1=close command |
| 39 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | K86 RESET COMMAND | DIGITAL | REX640 | N.A. | N.A. | LD0.SPCGAPC1.SPCSO3.stVal | SG100D1A6 | | 1=reset command |
| 40 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | PROTECTION RELAY UNIT 6 HEALTHY | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind8.stVal | SG100D1A6 | | 1= Relay unit 6 Healthy |
| 41 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | AUXILIARY 230VAC HEALTHY (ALL SWITCHBOARD) | DIGITAL | REX640 | N.A. | N.A. | LD0.SDBIGGIO1.ST.Ind7.stVal | SG100D1A6 | | 1=auxiliary 230Vac ON |
| 42 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | MCB'S CLOSED (FROM MEASURE UNIT A5) | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind6.stVal | SG100D1A6 | | 1=MCB's closed (A5) |
| 43 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | V.T. HEALTLY CIRCUIT (FROM MEASURE UNIT A5) | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind7.stVal | SG100D1A6 | | 1=healty V.T. (A5) |
| 44 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | UPS 110VDC A SUPPLY "ON" (FROM MEASURE UNIT A5) | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind8.stVal | SG100D1A6 | | 1=auxiliary 110Vdc ON "A" (A5) |
| 45 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | UPS 110VDC B SUPPLY "ON" (FROM MEASURE UNIT A5) | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind9.stVal | SG100D1A6 | | 1=auxiliary 110Vdc ON "B" (A5) |
| 46 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | 230VAC SUPPLY "ON" (FROM MEASURE UNIT A5) | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind10.stVal | SG100D1A6 | | 1=auxiliary 230Vac "ON" (A5) |
| 47 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | 24VDC SUPPLY "ON" (FROM MEASURE UNIT A5) | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind11.stVal | SG100D1A6 | | 1=auxiliary 24Vd "ON" (A5) |
| 48 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | EARTHING SWITCH OPENED (FROM MEASURE UNIT A5) | DIGITAL | REX640 | N.A. | N.A. | LD0.SCBIGGIO1.ST.Ind3.stVal | SG100D1A6 | | 1=earthing switch open (A5) |

| ITEM | SWITCHGEAR TAG | VOLTAGE | TAG NAME | FEEDER CUBICLE No | SIGNAL_DESCRIPTION | DATA CARD | TCP REGISTER | TYPE ANALOG/DIGITAL | UNIT | SCALE FACTOR | Warning Alarm [°C] | Critical Alarm [°C] | DATA CARD SENSOR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| **ELECTROLYSER FEEDER A-20000 "A1"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Phase L1 - Temperature Detection - Main Bus Bar | 11 | 40117 | Analog | ΔT | 1 | 20 | 30 | Channel 1 |
| 2 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Phase L3 - Temperature Detection - Main Bus Bar | 11 | 40118 | Analog | ΔT | 1 | 20 | 30 | Channel 2 |
| 3 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Phase L1 - Temperature Detection - C.B. Compart. | 11 | 40119 | Analog | ΔT | 1 | 20 | 30 | Channel 3 |
| 4 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Phase L2 - Temperature Detection - C.B. Compart. | 11 | 40120 | Analog | ΔT | 1 | 20 | 30 | Channel 4 |
| 5 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Phase L3 - Temperature Detection - C.B. Compart. | 11 | 40121 | Analog | ΔT | 1 | 20 | 30 | Channel 5 |
| 6 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Phase L1 - Temperature Detection - Cabel Compart. | 11 | 40122 | Analog | ΔT | 1 | 20 | 30 | Channel 6 |
| 7 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Phase L2 - Temperature Detection - Cabel Compart. | 11 | 40123 | Analog | ΔT | 1 | 20 | 30 | Channel 7 |
| 8 | SG100D1 | 6.6kV | ELECTROLYSER FEEDER A-20000 | A1 | Phase L3 - Temperature Detection - Cabel Compart. | 11 | 40124 | Analog | ΔT | 1 | 20 | 30 | Channel 8 |
| | | | | | | | | | | | | | |
| **TRANSFORMER FEEDER TR-200ED1 "A2"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Phase L1 - Temperature Detection - Main Bus Bar | 12 | 40125 | Analog | ΔT | 1 | 20 | 30 | Channel 1 |
| 2 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Phase L3 - Temperature Detection - Main Bus Bar | 12 | 40126 | Analog | ΔT | 1 | 20 | 30 | Channel 2 |
| 3 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Phase L1 - Temperature Detection - C.B. Compart. | 12 | 40127 | Analog | ΔT | 1 | 20 | 30 | Channel 3 |
| 4 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Phase L2 - Temperature Detection - C.B. Compart. | 12 | 40128 | Analog | ΔT | 1 | 20 | 30 | Channel 4 |
| 5 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Phase L3 - Temperature Detection - C.B. Compart. | 12 | 40129 | Analog | ΔT | 1 | 20 | 30 | Channel 5 |
| 6 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Phase L1 - Temperature Detection - Cabel Compart. | 12 | 40130 | Analog | ΔT | 1 | 20 | 30 | Channel 6 |
| 7 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Phase L2 - Temperature Detection - Cabel Compart. | 12 | 40131 | Analog | ΔT | 1 | 20 | 30 | Channel 7 |
| 8 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A2 | Phase L3 - Temperature Detection - Cabel Compart. | 12 | 40132 | Analog | ΔT | 1 | 20 | 30 | Channel 8 |
| | | | | | | | | | | | | | |
| **BESS FEEDER A-85000 "A3"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Phase L1 - Temperature Detection - Main Bus Bar | 13 | 40133 | Analog | ΔT | 1 | 20 | 30 | Channel 1 |
| 2 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Phase L3 - Temperature Detection - Main Bus Bar | 13 | 40134 | Analog | ΔT | 1 | 20 | 30 | Channel 2 |
| 3 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Phase L1 - Temperature Detection - C.B. Compart. | 13 | 40135 | Analog | ΔT | 1 | 20 | 30 | Channel 3 |
| 4 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Phase L2 - Temperature Detection - C.B. Compart. | 13 | 40136 | Analog | ΔT | 1 | 20 | 30 | Channel 4 |
| 5 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Phase L3 - Temperature Detection - C.B. Compart. | 13 | 40137 | Analog | ΔT | 1 | 20 | 30 | Channel 5 |
| 6 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Phase L1 - Temperature Detection - Cabel Compart. | 13 | 40138 | Analog | ΔT | 1 | 20 | 30 | Channel 6 |
| 7 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Phase L2 - Temperature Detection - Cabel Compart. | 13 | 40139 | Analog | ΔT | 1 | 20 | 30 | Channel 7 |
| 8 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A3 | Phase L3 - Temperature Detection - Cabel Compart. | 13 | 40140 | Analog | ΔT | 1 | 20 | 30 | Channel 8 |
| | | | | | | | | | | | | | |
| **TRANSFORMER FEEDER TR-200DE1 "A4"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Phase L1 - Temperature Detection - Main Bus Bar | 14 | 40141 | Analog | ΔT | 1 | 20 | 30 | Channel 1 |
| 2 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Phase L3 - Temperature Detection - Main Bus Bar | 14 | 40142 | Analog | ΔT | 1 | 20 | 30 | Channel 2 |
| 3 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Phase L1 - Temperature Detection - C.B. Compart. | 14 | 40143 | Analog | ΔT | 1 | 20 | 30 | Channel 3 |
| 4 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Phase L2 - Temperature Detection - C.B. Compart. | 14 | 40144 | Analog | ΔT | 1 | 20 | 30 | Channel 4 |
| 5 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Phase L3 - Temperature Detection - C.B. Compart. | 14 | 40145 | Analog | ΔT | 1 | 20 | 30 | Channel 5 |
| 6 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Phase L1 - Temperature Detection - Cabel Compart. | 14 | 40146 | Analog | ΔT | 1 | 20 | 30 | Channel 6 |
| 7 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Phase L2 - Temperature Detection - Cabel Compart. | 14 | 40147 | Analog | ΔT | 1 | 20 | 30 | Channel 7 |
| 8 | SG100D1 | 6.6kV | TRANSFORMER FEEDER TR-200ED1 | A4 | Phase L3 - Temperature Detection - Cabel Compart. | 14 | 40148 | Analog | ΔT | 1 | 20 | 30 | Channel 8 |
| | | | | | | | | | | | | | |

| ITEM | SWITCHGEAR TAG | VOLTAGE | TAG NAME | FEEDER CUBICLE No | SIGNAL_DESCRIPTION | DATA CARD | TCP REGISTER | TYPE ANALOG/DIGITAL | UNIT | SCALE FACTOR | Warning Alarm [°C] | Critical Alarm [°C] | DATA CARD SENSOR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MEASURING BUS BAR "A5"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | MEASURING BUS BAR | A5 | Phase L1 - Temperature Detection - Main Bus Bar | 10 | 40109 | Analog | ΔT | 1 | 20 | 30 | Channel 4 |
| 2 | SG100D1 | 6.6kV | MEASURING BUS BAR | A5 | Phase L3 - Temperature Detection - Main Bus Bar | 10 | 40110 | Analog | ΔT | 1 | 20 | 30 | Channel 5 |
| 3 | SG100D1 | 6.6kV | MEASURING BUS BAR | A5 | Phase L1 -Temperature Detection - T.V. Compartment | 10 | 40111 | Analog | ΔT | 1 | 20 | 30 | Channel 6 |
| 4 | SG100D1 | 6.6kV | MEASURING BUS BAR | A5 | Phase L2 -Temperature Detection - T.V. Compartment | 10 | 40112 | Analog | ΔT | 1 | 20 | 30 | Channel 7 |
| 5 | SG100D1 | 6.6kV | MEASURING BUS BAR | A5 | Phase L3 -Temperature Detection - T.V. Compartment | 10 | 40113 | Analog | ΔT | 1 | 20 | 30 | Channel 8 |
| | | | | | | | | | | | | | |
| **INCOMING FEEDER TR-100AD1 "A6"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Phase L1 - Temperature Detection - Main Bus Bar | 15 | 40149 | Analog | ΔT | 1 | 20 | 30 | Channel 1 |
| 2 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Phase L3 - Temperature Detection - Main Bus Bar | 15 | 40150 | Analog | ΔT | 1 | 20 | 30 | Channel 2 |
| 3 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Phase L1 - Temperature Detection - C.B. Compart. | 15 | 40151 | Analog | ΔT | 1 | 20 | 30 | Channel 3 |
| 4 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Phase L2 - Temperature Detection - C.B. Compart. | 15 | 40152 | Analog | ΔT | 1 | 20 | 30 | Channel 4 |
| 5 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Phase L3 - Temperature Detection - C.B. Compart. | 15 | 40153 | Analog | ΔT | 1 | 20 | 30 | Channel 5 |
| 6 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Phase L1 - Temperature Detection - Cabel Compart. | 15 | 40154 | Analog | ΔT | 1 | 20 | 30 | Channel 6 |
| 7 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Phase L2 - Temperature Detection - Cabel Compart. | 15 | 40155 | Analog | ΔT | 1 | 20 | 30 | Channel 7 |
| 8 | SG100D1 | 6.6kV | INCOMING FEEDER TR-100AD1 | A6 | Phase L3 - Temperature Detection - Cabel Compart. | 15 | 40156 | Analog | ΔT | 1 | 20 | 30 | Channel 8 |
| | | | | | | | | | | | | | |
| **FUEL CELL A-80000 "A7"** | | | | | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Phase L1 - Temperature Detection - Main Bus Bar | 16 | 40157 | Analog | ΔT | 1 | 20 | 30 | Channel 1 |
| 2 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Phase L3 - Temperature Detection - Main Bus Bar | 16 | 40158 | Analog | ΔT | 1 | 20 | 30 | Channel 2 |
| 3 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Phase L1 - Temperature Detection - C.B. Compart. | 16 | 40159 | Analog | ΔT | 1 | 20 | 30 | Channel 3 |
| 4 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Phase L2 - Temperature Detection - C.B. Compart. | 16 | 40160 | Analog | ΔT | 1 | 20 | 30 | Channel 4 |
| 5 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Phase L3 - Temperature Detection - C.B. Compart. | 16 | 40161 | Analog | ΔT | 1 | 20 | 30 | Channel 5 |
| 6 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Phase L1 - Temperature Detection - Cabel Compart. | 16 | 40162 | Analog | ΔT | 1 | 20 | 30 | Channel 6 |
| 7 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Phase L2 - Temperature Detection - Cabel Compart. | 16 | 40163 | Analog | ΔT | 1 | 20 | 30 | Channel 7 |
| 8 | SG100D1 | 6.6kV | FUEL CELL A-80000 | A7 | Phase L3 - Temperature Detection - Cabel Compart. | 16 | 40164 | Analog | ΔT | 1 | 20 | 30 | Channel 8 |

| ITEM | SWITCHGEAR TAG | VOLTAGE | TAG NAME | DEVICE | SIGNAL_DESCRIPTION | TYPE ANALOG/DIGITAL | RELAY/DEVICE MODEL | UNIT | SCALE FACTOR | BITOFFS | MODBUS RTU Register | MODBUS RTU Data Type | MODBUS RTU Function Code | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **PD phase A calculated ( for customer)** | | | | | | | | | |
| 1 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: PD presence likelihood, value | SW-AI | SWICOM | A5 | 1 | | 1088 | U16 | | Value range 0...100 |
| 2 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Discharge strength (normalized), value | SW-AI | SWICOM | A5 | 100 | | 1089 | U16 | | Value range 0.00...100.00 |
| 3 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Pulse rate (Q50 pulse rate 1), value | SW-AI | SWICOM | A5 | 1 | | 1090 | U16 | | Value range [Hz] |
| 4 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Discharge variability, value | SW-AI | SWICOM | A5 | 100 | | 1091 | U16 | | Value range 0.00...100.00 |
| 5 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Discharge increase, value | SW-AI | SWICOM | A5 | 100 | | 1092 | U16 | | Value range -100.00...100.00 |
| | | | | | **PD phase B calculated ( for customer)** | | | | | | | | | |
| 6 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: PD presence likelihood, value | SW-AI | SWICOM | A5 | 1 | | 1093 | U16 | | Value range 0...100 |
| 7 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Discharge strength (normalized), value | SW-AI | SWICOM | A5 | 100 | | 1094 | U16 | | Value range 0.00...100.00 |
| 8 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Pulse rate (Q50 pulse rate 1), value | SW-AI | SWICOM | A5 | 1 | | 1095 | U16 | | Value range [Hz] |
| 9 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Discharge variability, value | SW-AI | SWICOM | A5 | 100 | | 1096 | U16 | | Value range 0.00...100.00 |
| 10 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Discharge increase, value | SW-AI | SWICOM | A5 | 100 | | 1097 | U16 | | Value range -100.00...100.00 |
| | | | | | **PD phase C calculated ( for customer)** | | | | | | | | | |
| 11 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: PD presence likelihood, value | SW-AI | SWICOM | A5 | 1 | | 1098 | U16 | | Value range 0...100 |
| 12 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Discharge strength (normalized), value | SW-AI | SWICOM | A5 | 100 | | 1099 | U16 | | Value range 0.00...100.00 |
| 13 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Pulse rate (Q50 pulse rate 1), value | SW-AI | SWICOM | A5 | 1 | | 1100 | U16 | | Value range [Hz] |
| 14 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Discharge variability, value | SW-AI | SWICOM | A5 | 100 | | 1101 | U16 | | Value range 0.00...100.00 |
| 15 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PDCOM measurements calculated: Discharge increase, value | SW-AI | SWICOM | A5 | 100 | | 1102 | U16 | | Value range -100.00...100.00 |
| | | | | | **PD outputs antenna 1 (A - B)** | | | | | | | | | |
| 16 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Warning-free time (1 week) is under warning level, value | SW-DI | SWICOM | A5 | | 608 | 1958.00 | | | |
| 17 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Alarm-free time (1 week) is under alarm level, value | SW-DI | SWICOM | A5 | | 609 | 1958.01 | | | |
| 18 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Warning-free time (1 month) is under warning level, value | SW-DI | SWICOM | A5 | | 610 | 1958.02 | | | |
| 19 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Alarm-free time (1 month) is under alarm level, value | SW-DI | SWICOM | A5 | | 611 | 1958.03 | | | |
| | | | | | **PD outputs antenna 2 (A - B)** | | | | | | | | | |
| 20 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Warning-free time (1 week) is under warning level, value | SW-DI | SWICOM | A5 | | 612 | 1958.04 | | | |
| 21 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Alarm-free time (1 week) is under alarm level, value | SW-DI | SWICOM | A5 | | 613 | 1958.05 | | | |
| 22 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Warning-free time (1 month) is under warning level, value | SW-DI | SWICOM | A5 | | 614 | 1958.06 | | | |
| 23 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Alarm-free time (1 month) is under alarm level, value | SW-DI | SWICOM | A5 | | 615 | 1958.07 | | | |
| | | | | | **PD outputs antenna 3 (A - B)** | | | | | | | | | |
| 24 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Warning-free time (1 week) is under warning level, value | SW-DI | SWICOM | A5 | | 616 | 1958.08 | | | |
| 25 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Alarm-free time (1 week) is under alarm level, value | SW-DI | SWICOM | A5 | | 617 | 1958.09 | | | |
| 26 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Warning-free time (1 month) is under warning level, value | SW-DI | SWICOM | A5 | | 618 | 1958.10 | | | |
| 27 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD Alarm-free time (1 month) is under alarm level, value | SW-DI | SWICOM | A5 | | 619 | 1958.11 | | | |
| | | | | | **PD outputs antenna 1 (A - B)** | | | | | | | | | |
| 28 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD has reached warning level, value | SW-DI | SWICOM | A5 | | 542 | 1953.14 | | | |
| 29 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD has reached alarm level, value | SW-DI | SWICOM | A5 | | 543 | 1953.15 | | | |
| | | | | | **PD outputs antenna 2 (A - B)** | | | | | | | | | |
| 30 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD has reached warning level, value | SW-DI | SWICOM | A5 | | 544 | 1954.00 | | | |
| 31 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD has reached alarm level, value | SW-DI | SWICOM | A5 | | 545 | 1954.01 | | | |
| | | | | | **PD outputs antenna 3 (A - B)** | | | | | | | | | |
| 32 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD has reached warning level, value | SW-DI | SWICOM | A5 | | 546 | 1954.02 | | | |
| 33 | SG100D1 | 6.6kV | MEASURING BUS BAR | SW1 | PD has reached alarm level, value | SW-DI | SWICOM | A5 | | 547 | 1954.03 | | | |

1.7.2.SG-200N1 IO LIST (HARDWARE - SOFTWARE),

Doc.No. 1723002197-EL-LIS-00042

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Base Load Power Hub (BLPH)

# SG-200N1 I/O LIST
# (HARDWARE – SOFTWARE)

Document Number: 1723002197-EL-LIS-00042

Document Class:2

ROSETTI MARINO

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| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
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| 02 | 18/09/2024 | As Built (ASB) | Flamminio | Santinelli | Mastri |
| 01 | 09/08/2024 | Accepted for Costruction (AFC) | Flamminio | Santinelli | Mastri |
| 00 | 10/07/2024 | Issue for Review (IFR) | Flamminio | Santinelli | Mastri |

IMESA ELECTRICAL ENGINEERING

IMESA Doc. n. 231115/SD/43

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Revision / Change Log

| Rev. | Description |
|---|---|
| 00 | Issue or Review (IFR) |
| 01 | Accepted for Costruction (AFC) |
| 02 | As Built (ASB) |
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| ITEM | SWITCHGEAR TAG | VOLTAGE | TAG NAME | DEVICE | SIGNAL_DESCRIPTION | TYPE ANALOG/DIGITAL | RELAY/DEVICE MODEL | UNIT | SCALE FACTOR | MODBUS RTU Register | MODBUS RTU Data Type | MODBUS RTU Function Code | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SG200N1 | 0.4/0,23kV | COMMON | A1 | SG-200N1 - SURGE ARRESTER FAULT | SW-DI | Module I/O | | | 1 | BIT | | 0=failure |
| 2 | SG200N1 | 0.4/0,23kV | COMMON | A1 | SG-200N1 - LOSS 230VAC AUXILIARY VOLTAGE | SW-DI | Module I/O | | | 2 | BIT | | 1=alarm |
| 3 | SG200N1 | 0.4/0,23kV | COMMON | A1 | SG-200N1 - "FP1" WATCHDOG PROTECTION | SW-DI | Module I/O | | | 3 | BIT | | 0=failure |
| 4 | SG200N1 | 0.4/0,23kV | COMMON | A1 | SG-200N1 - MOTOR FEEDER FAULT LOOP [BUS-3] | SW-DI | Module I/O | | | 4 | BIT | | 0=failure |
| 5 | SG200N1 | 0.4/0,23kV | COMMON | A1 | *available* | SW-DI | Module I/O | | | 5 | BIT | | |
| 6 | SG200N1 | 0.4/0,23kV | COMMON | A1 | *available* | SW-DI | Module I/O | | | 6 | BIT | | |
| 7 | SG200N1 | 0.4/0,23kV | COMMON | A1 | SG-200D2 - MCBs HEALTY | SW-DI | Module I/O | | | 7 | BIT | | 0=alarm |
| 8 | SG200N1 | 0.4/0,23kV | COMMON | A1 | *available* | SW-DI | Module I/O | | | 8 | BIT | | |
| 9 | SG200N1 | 0.4/0,23kV | COMMON | A1 | DP-200N1 - SURGE ARRESTER FAULT | SW-DI | Module I/O | | | 9 | BIT | | 0=failure |
| 10 | SG200N1 | 0.4/0,23kV | COMMON | A1 | DP-200N1 - NORMAL AND EMERGENCY LIGHTING ON AUTOMATIC | SW-DI | Module I/O | | | 10 | BIT | | 1=automatic |
| 11 | SG200N1 | 0.4/0,23kV | COMMON | A1 | DP-200N1 - NORMAL AND EMERGENCY LIGHTING ACTIVATED | SW-DI | Module I/O | | | 11 | BIT | | 1=activated |
| 12 | SG200N1 | 0.4/0,23kV | COMMON | A1 | DP-200N1 - NORMAL AND EMERGENCY CIRCUIT-BREAKER CLOSED | SW-DI | Module I/O | | | 12 | BIT | | 1=close |
| 13 | SG200N1 | 0.4/0,23kV | COMMON | A1 | DP-200N1 - TRACE HEATINGS ACTIVATED | SW-DI | Module I/O | | | 13 | BIT | | 1=activated |
| 14 | SG200N1 | 0.4/0,23kV | COMMON | A1 | DP-200N1 - TRACE HEATINGS CIRCUIT-BREAKER CLOSED | SW-DI | Module I/O | | | 14 | BIT | | 1=close |
| 15 | SG200N1 | 0.4/0,23kV | COMMON | A1 | DP-200N1 - MAIN AND UTILITIES CIRCUIT-BREAKERS CLOSED | SW-DI | Module I/O | | | 15 | BIT | | 1=close |
| 16 | SG200N1 | 0.4/0,23kV | COMMON | A1 | *available* | SW-DI | Module I/O | | | 16 | BIT | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| 1 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - PROTECTION TRIPPED "L" | SW-DI | Ekip Hi-Touch | | | 50.0 | BOOL | 04 | 1=tripped |
| 2 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - PROTECTION TRIPPED "S" | SW-DI | Ekip Hi-Touch | | | 50.1 | BOOL | 04 | 1=tripped |
| 3 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - PROTECTION TRIPPED "I" | SW-DI | Ekip Hi-Touch | | | 50.2 | BOOL | 04 | 1=tripped |
| 4 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - PROTECTION TRIPPED "G" | SW-DI | Ekip Hi-Touch | | | 50.3 | BOOL | 04 | 1=tripped |
| 5 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - OPEN | SW-DI | Ekip Hi-Touch | | | 40.6 | BOOL | 04 | 1=open |
| 6 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - CLOSED | SW-DI | Ekip Hi-Touch | | | 40.0 | BOOL | 04 | 1=closed |
| 7 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - CONNECTED | SW-DI | Ekip Hi-Touch | | | 40.1 | BOOL | 04 | 1=connected |
| 8 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - ISOLATED | SW-DI | Ekip Hi-Touch | | | 40.1 | BOOL | 04 | 0=isolated |
| 9 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - TEST | SW-DI | Ekip Hi-Touch | | | 40.2 | BOOL | 04 | 1=test |
| 10 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - TRIP UNIT DISCONNECTED | SW-DI | Ekip Hi-Touch | | | 40.15 | BOOL | 04 | 1=Failure |
| 11 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - CLOSE COMMAND | SW-DO | Ekip Hi-Touch | | | 0.8 | E32 | 16 | 1=close command |
| 12 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | CIRCUIT-BRAKER - OPEN COMMAND | SW-DO | Ekip Hi-Touch | | | 0.7 | E32 | 16 | 1=open command |
| 13 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | MEASURE - CURRENT "L1" | SW-AI | Ekip Hi-Touch | A | 0,1 | 100÷101 | U32 | 04 | |
| 14 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | MEASURE - CURRENT "L2" | SW-AI | Ekip Hi-Touch | A | 0,1 | 102÷103 | U32 | 04 | |
| 15 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | MEASURE - CURRENT "L3" | SW-AI | Ekip Hi-Touch | A | 0,1 | 104÷105 | U32 | 04 | |
| 16 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | MEASURE - VOLTAGE "L1-L2" | SW-AI | Ekip Hi-Touch | V | 0,1 | 154 | U16 | 04 | |
| 17 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | MEASURE - VOLTAGE "L2-L3" | SW-AI | Ekip Hi-Touch | V | 0,1 | 155 | U16 | 04 | |
| 18 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | MEASURE - VOLTAGE "L3-L1" | SW-AI | Ekip Hi-Touch | V | 0,1 | 156 | U16 | 04 | |
| 19 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | MEASURE - FREQUENCY | SW-AI | Ekip Hi-Touch | Hz | 0,01 | 254 | U16 | 04 | |
| 20 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | MEASURE - APPARENT POWER | SW-AI | Ekip Hi-Touch | kVA | 0,1 | 222÷223 | S32 | 04 | |
| 21 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | MEASURE - REAL POWER | SW-AI | Ekip Hi-Touch | kW | 0,1 | 206÷207 | S32 | 04 | |
| 22 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | MEASURE - REACTIVE POWER | SW-AI | Ekip Hi-Touch | kVAR | 0,1 | 214÷215 | S32 | 04 | |
| 23 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | QF1 | MEASURE - POWER FACTOR | SW-AI | Ekip Hi-Touch | COSfi | 0,001 | 253 | S16 | 04 | |
| 24 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | U1B | CIRCUIT-BRAKER - CLOSED AND INSERTED | SW-DI | Module I/O | | | 40015.0 | BOOL | 3 | 1=close |
| 25 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | U1B | CIRCUIT-BRAKER - OPEN OR DISCONNECTED | SW-DI | Module I/O | | | 40015.1 | BOOL | 3 | 1=open |
| 26 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | U1B | CIRCUIT-BRAKER - TRIPPED | SW-DI | Module I/O | | | 40015.2 | BOOL | 3 | 1=tripped |
| 27 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | U1B | *available* | SW-DI | Module I/O | | | 40015.3 | BOOL | 3 | |
| 28 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | U1B | *available* | SW-DI | Module I/O | | | 40015.4 | BOOL | 3 | |
| 29 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | U1C | *available* | SW-DI | Module I/O | | | 40015.0 | BOOL | 3 | |
| 30 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | U1C | *available* | SW-DI | Module I/O | | | 40015.1 | BOOL | 3 | |
| 31 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | U1C | SA1 ON "LOCAL" POSITION | SW-DI | Module I/O | | | 40015.2 | BOOL | 3 | 1=local |
| 32 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | U1C | *available* | SW-DI | Module I/O | | | 40015.3 | BOOL | 3 | |
| 33 | SG200N1 | 0.4/0,23kV | A-20000 ELECTROLYSER AUXILIARY LOAD (typ L3-630) | U1C | *available* | SW-DI | Module I/O | | | 40015.4 | BOOL | 3 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

| ITEM | SWITCHGEAR TAG | VOLTAGE | TAG NAME | DEVICE | SIGNAL_DESCRIPTION | TYPE ANALOG/DIGITAL | RELAY/DEVICE MODEL | UNIT | SCALE FACTOR | MODBUS RTU Register | MODBUS RTU Data Type | MODBUS RTU Function Code | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| | | | | | | Column | Position | Item TAG | Description TAG | | | | |
| | | | | | **(L1-n ÷ L2-n)** Signals valid for following USERS : | A2 | +04 | UP-200F4 | AC UPS F&G - 8H UP-200F4 - BYPASS | | | | |
| | | | | | | A3 | +01 | UP-200F3 | AC UPS PAS - 30 MIN UP-200F3 - LINE A | | | | |
| | | | | | | A4 | +01 | UP-200F3 | AC UPS PAS - 30 MIN UP-200F3 - LINE B | | | | |
| | | | | | | A6 | +05 | UP-200F4 | AC UPS F&G - 8H UP-200F4 - LINE A | | | | |
| | | | | | | A6 | +06 | UP-200F4 | AC UPS F&G - 8H UP-200F4 - LINE B | | | | |
| | | | | | | A6 | +08 | ESW-200N1 | WELDING SOCKETS (TOP DECK) | | | | |
| | | | | | | A7 | +02 | UP-200F3 | AC UPS PAS - 30 MIN UP-200F3 (BYPASS) | | | | |
| | | | | | | A7 | +03 | UP-200F1 | DC BATTERY SYSTEM SWTG CONTROL - FEEDER A | | | | |
| | | | | | | A7 | +04 | UP-200F1 | DC BATTERY SYSTEM SWTG CONTROL - FEEDER B | | | | |
| | | | | | | A7 | +05 | UP-200F2 | NAVAID SYSTEM FEEDER A | | | | |
| | | | | | | A7 | +06 | UP-200F2 | NAVAID SYSTEM FEEDER B | | | | |
| | | | | | | A7 | +08 | ESW-200N2 | WELDING SOCKETS (LOWER DECK) | | | | |
| | | | | | | | | | | | | | |
| 1 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ L1-n ÷ L2-n) | U2.B | CIRCUIT-BRAKER - CLOSED AND INSERTED | SW-DI | Module I/O | | | 40015.0 | BOOL | 3 | 1=close |
| 2 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ L1-n ÷ L2-n) | U2.B | CIRCUIT-BRAKER - OPEN OR DISCONNECTED | SW-DI | Module I/O | | | 40015.1 | BOOL | 3 | 1=open |
| 3 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ L1-n ÷ L2-n) | U2.B | CIRCUIT-BRAKER - TRIPPED | SW-DI | Module I/O | | | 40015.2 | BOOL | 3 | 1=tripped |
| 4 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ L1-n ÷ L2-n) | U2.B | INTERNAL FAULT | SW-DI | Module I/O | | | 40015.3 | BOOL | 3 | 0=fault |
| 5 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ L1-n ÷ L2-n) | U2.B | *available* | SW-DI | Module I/O | | | 40015.4 | BOOL | 3 | |
| 6 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ L1-n ÷ L2-n) | U2.B | *available* | SW-DO | Module I/O | | | 40016.0 | BOOL | 3 | |
| 7 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ L1-n ÷ L2-n) | U2.B | *available* | SW-DO | Module I/O | | | 40016.1 | BOOL | 3 | |
| | | | | | | | | | | | | | |

| ITEM | SWITCHGEAR TAG | VOLTAGE | TAG NAME | DEVICE | SIGNAL_DESCRIPTION | TYPE ANALOG/DIGITAL | RELAY/DEVICE MODEL | UNIT | SCALE FACTOR | MODBUS RTU Register | MODBUS RTU Data Type | MODBUS RTU Function Code | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| | | | | | | Column | Position | Item TAG | Description TAG | | | | |
| | | | | | **(LK1-n ÷ LK2-n)** Signals valid for following USERS : | **A2** | **+05** | SPARE | SPARE | | | | |
| | | | | | | **A3** | **+02** | SPARE | SPARE | | | | |
| | | | | | | **A3** | **+03** | DP-200N1 | DB-LIGHTING & SMALL POWER BoP | | | | |
| | | | | | | **A3** | **+04** | JB-200E3 | CRANE | | | | |
| | | | | | | **A3** | **+05** | SPARE | SPARE | | | | |
| | | | | | | **A3** | **+08** | JB-500E8 | WATER PACKAGE | | | | |
| | | | | | | **A4** | **+02** | B100-HSB-001 | HVAC PANELS HV ROOM | | | | |
| | | | | | | **A4** | **+03** | A-80000 | FUELL CELL AUXIALIRY LOAD | | | | |
| | | | | | | **A4** | **+04** | CP-850F03 | BESS PCS CABINET | | | | |
| | | | | | | **A4** | **+05** | SPARE | SPARE | | | | |
| | | | | | | **A4** | **+06** | SPARE | SPARE | | | | |
| | | | | | | **A4** | **+08** | K-63001-A | INSTRUMENTS AIR PACKAGE 01A | | | | |
| | | | | | | **A5** | **+01** | SPARE | SPARE | | | | |
| | | | | | | **A5** | **+02** | B200-HSB-001 | HVAC PANELS - LV ROOM | | | | |
| | | | | | | **A5** | **+03** | B300-HSB-001 | HVAC PANELS - UPS ROOM | | | | |
| | | | | | | **A5** | **+04** | B400-HSB-001 | HVAC PANELS - ITER | | | | |
| | | | | | | **A5** | **+05** | CN-200N1 | IMPRESSED CURR. CATHODIC PROTECTION (ICCP) SYSTEM | | | | |
| | | | | | | **A5** | **+06** | SPARE | SPARE | | | | |
| | | | | | | **A5** | **+08** | K-63001-B | INSTRUMENTS AIR PACKAGE 01B | | | | |
| | | | | | | **A6** | **+02** | CP-850E1 | BESS LV1 CABINAT (+DISTR 1) | | | | |
| | | | | | | **A6** | **+03** | CP-850E2 | BESS LV2 CABINAT (+DISTR 2) | | | | |
| | | | | | | **A6** | **+04** | SPARE | SPARE | | | | |
| | | | | | | | | | | | | | |
| 1 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | CIRCUIT-BRAKER - PROTECTION TRIPPED "L" | SW-DI | Ekip Hi-Touch | | | 50.0 | BOOL | 04 | |
| 2 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | CIRCUIT-BRAKER - PROTECTION TRIPPED "S" | SW-DI | Ekip Hi-Touch | | | 50.1 | BOOL | 04 | |
| 3 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | CIRCUIT-BRAKER - PROTECTION TRIPPED "I" | SW-DI | Ekip Hi-Touch | | | 50.2 | BOOL | 04 | |
| 4 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | CIRCUIT-BRAKER - PROTECTION TRIPPED "G" | SW-DI | Ekip Hi-Touch | | | 50.3 | BOOL | 04 | |
| 5 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | CIRCUIT-BRAKER - OPEN | SW-DI | Ekip Hi-Touch | | | 40.6 | BOOL | 04 | |
| 6 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | CIRCUIT-BRAKER - CLOSED | SW-DI | Ekip Hi-Touch | | | 40.0 | BOOL | 04 | |
| 7 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | CIRCUIT-BRAKER - TRIP UNIT DISCONNECTED | SW-DI | Ekip Hi-Touch | | | 40.15 | BOOL | 04 | |
| 8 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | MEASURE - CURRENT "L1" | SW-AI | Ekip Hi-Touch | A | 0,1 | 100÷101 | U32 | 04 | |
| 9 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | MEASURE - CURRENT "L2" | SW-AI | Ekip Hi-Touch | A | 0,1 | 102÷103 | U32 | 04 | |
| 10 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | MEASURE - CURRENT "L3" | SW-AI | Ekip Hi-Touch | A | 0,1 | 104÷105 | U32 | 04 | |
| 11 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | MEASURE - VOLTAGE "L1-L2" | SW-AI | Ekip Hi-Touch | V | 0,1 | 154 | U16 | 04 | |
| 12 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | MEASURE - VOLTAGE "L2-L3" | SW-AI | Ekip Hi-Touch | V | 0,1 | 155 | U16 | 04 | |
| 13 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | MEASURE - VOLTAGE "L3-L1" | SW-AI | Ekip Hi-Touch | V | 0,1 | 156 | U16 | 04 | |
| 14 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | MEASURE - FREQUENCY | SW-AI | Ekip Hi-Touch | Hz | 0,01 | 254 | U16 | 04 | |
| 15 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | MEASURE - APPARENT POWER | SW-AI | Ekip Hi-Touch | kVA | 0,1 | 222÷223 | S32 | 04 | |
| 16 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | MEASURE - REAL POWER | SW-AI | Ekip Hi-Touch | kW | 0,1 | 206÷207 | S32 | 04 | |
| 17 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | MEASURE - REACTIVE POWER | SW-AI | Ekip Hi-Touch | kVAR | 0,1 | 214÷215 | S32 | 04 | |
| 18 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U1.A | MEASURE - POWER FACTOR | SW-AI | Ekip Hi-Touch | COSfi | 0,001 | 253 | S16 | 04 | |
| 19 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.B | CIRCUIT-BRAKER - CLOSED AND INSERTED | SW-DI | Module I/O | | | 40015.0 | BOOL | 3 | 1=close |
| 20 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.B | CIRCUIT-BRAKER - OPEN OR DISCONNECTED | SW-DI | Module I/O | | | 40015.1 | BOOL | 3 | 1=open |
| 21 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.B | CIRCUIT-BRAKER - TRIPPED | SW-DI | Module I/O | | | 40015.2 | BOOL | 3 | 1=tripped |
| 22 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.B | FEEDER AVAILABLE | SW-DI | Module I/O | | | 40015.3 | BOOL | 3 | 1=available |
| 23 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.B | INTERNAL FAULT | SW-DI | Module I/O | | | 40015.4 | BOOL | 3 | 0=fault |
| 24 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.B | CONTACTOR CLOSING COMAND | SW-DO | Module I/O | | | 40016.0 | BOOL | 3 | 1=closing |
| 25 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.B | CONTACTOR OPENING COMAND | SW-DO | Module I/O | | | 40016.1 | BOOL | 3 | 1=opening |
| 26 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.C | *available* | SW-DI | Module I/O | | | 40015.0 | BOOL | 3 | |
| 27 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.C | *available* | SW-DI | Module I/O | | | 40015.1 | BOOL | 3 | |
| 28 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.C | SA1 ON "LOCAL" POSITION | SW-DI | Module I/O | | | 40015.2 | BOOL | 3 | 1=local |
| 29 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.C | *available* | SW-DI | Module I/O | | | 40015.3 | BOOL | 3 | |
| 30 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.C | *available* | SW-DI | Module I/O | | | 40015.4 | BOOL | 3 | |
| 31 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.C | *available* | SW-DO | Module I/O | | | 40016.0 | BOOL | 3 | |
| 32 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LK1-n ÷ LK2-n) | U2.C | *available* | SW-DO | Module I/O | | | 40016.1 | BOOL | 3 | |
| | | | | | | | | | | | | | |

| ITEM | SWITCHGEAR TAG | VOLTAGE | TAG NAME | DEVICE | SIGNAL_DESCRIPTION | TYPE ANALOG/DIGITAL | RELAY/DEVICE MODEL | UNIT | SCALE FACTOR | MODBUS RTU Register | MODBUS RTU Data Type | MODBUS RTU Function Code | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| | | | | | | Column | Position | Item TAG | | Description TAG | | | |
| | | | | | **(LE2-320)** | A2 | +08 | JB-200E2 | TEMPORARY GENERATOR / MOBILE BATTERY PACK | | | | |
| | | | | | Signals valid for following USERS : | | | | | | | | |
| 1 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U1.A | MEASURE - CURRENT "L1" | SW-AI | Ekip Hi-Touch | A | 0,1 | 100÷101 | U32 | 04 | |
| 2 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U1.A | MEASURE - CURRENT "L2" | SW-AI | Ekip Hi-Touch | A | 0,1 | 102÷103 | U32 | 04 | |
| 3 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U1.A | MEASURE - CURRENT "L3" | SW-AI | Ekip Hi-Touch | A | 0,1 | 104÷105 | U32 | 04 | |
| 4 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U1.A | MEASURE - VOLTAGE "L1-L2" | SW-AI | Ekip Hi-Touch | V | 0,1 | 154 | U16 | 04 | |
| 5 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U1.A | MEASURE - VOLTAGE "L2-L3" | SW-AI | Ekip Hi-Touch | V | 0,1 | 155 | U16 | 04 | |
| 6 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U1.A | MEASURE - VOLTAGE "L3-L1" | SW-AI | Ekip Hi-Touch | V | 0,1 | 156 | U16 | 04 | |
| 7 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U1.A | MEASURE - FREQUENCY | SW-AI | Ekip Hi-Touch | Hz | 0,01 | 254 | U16 | 04 | |
| 8 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U1.A | MEASURE - APPARENT POWER | SW-AI | Ekip Hi-Touch | kVA | 0,1 | 222÷223 | S32 | 04 | |
| 9 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U1.A | MEASURE - REAL POWER | SW-AI | Ekip Hi-Touch | kW | 0,1 | 206÷207 | S32 | 04 | |
| 10 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U1.A | MEASURE - REACTIVE POWER | SW-AI | Ekip Hi-Touch | kVAR | 0,1 | 214÷215 | S32 | 04 | |
| 11 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U1.A | MEASURE - POWER FACTOR | SW-AI | Ekip Hi-Touch | COSfi | 0,001 | 253 | S16 | 04 | |
| 12 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U2.B | CIRCUIT-BRAKER - CLOSED AND INSERTED | SW-DI | Module I/O | | | 40015.0 | BOOL | 3 | 1=close |
| 13 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U2.B | CIRCUIT-BRAKER - OPEN OR DISCONNECTED | SW-DI | Module I/O | | | 40015.1 | BOOL | 3 | 1=open |
| 14 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U2.B | CIRCUIT-BRAKER - TRIPPED | SW-DI | Module I/O | | | 40015.2 | BOOL | 3 | 1=tripped |
| 15 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U2.B | FEEDER AVAILABLE | SW-DI | Module I/O | | | 40015.3 | BOOL | 3 | 1=available |
| 16 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U2.B | INTERNAL FAULT | SW-DI | Module I/O | | | 40015.4 | BOOL | 3 | 0=fault |
| 17 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U2.B | *available* | SW-DO | Module I/O | | | 40016.0 | BOOL | 3 | 1=closing |
| 18 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ LE2-320) | U2.B | *available* | SW-DO | Module I/O | | | 40016.1 | BOOL | 3 | 1=opening |

| ITEM | SWITCHGEAR TAG | VOLTAGE | TAG NAME | DEVICE | SIGNAL_DESCRIPTION | TYPE ANALOG/DIGITAL | RELAY/DEVICE MODEL | UNIT | SCALE FACTOR | MODBUS RTU Register | MODBUS RTU Data Type | MODBUS RTU Function Code | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Column | Position | Item TAG | Description TAG | | | | |
| | | | | | **(M1-6)** | A6 | +01 | PM-50001A | SEA WATER PUMP A | | | | |
| | | | | | | A7 | +01 | PM-50001B | SEA WATER PUMP B | | | | |
| | | | | | Signals valid for following USERS : | | | | | | | | |
| 1 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ M1-6) | MMU4 | MEASURE - CURRENT (average) | SW-AI | MRP31.0 | A | 0,001 | 512 | U16 | 3 | |
| 2 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ M1-6) | MMU4 | SA1 ON "LOCAL" POSITION | SW-DI | MRP31.0 | | | 1 | BIT | 2 | 1=local |
| 3 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ M1-6) | MMU4 | MOTOR RUNNING | SW-DI | MRP31.0 | | | 2 | BIT | 2 | 1=running |
| 4 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ M1-6) | MMU4 | MOTOR TRIPPED | SW-DI | MRP31.0 | | | 3 | BIT | 2 | 1=tripped |
| 5 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ M1-6) | MMU4 | USER AVAILABLE | SW-DI | MRP31.0 | | | 4 | BIT | 2 | 1=available |
| 6 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ M1-6) | MMU4 | ESD ACTIVETED | SW-DI | MRP31.0 | | | 5 | BIT | 2 | 0=activeted |
| 7 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ M1-6) | MMU4 | MOTOR STOPPED BY PA1 (PUSH BUTTON ACTIVETED) | SW-DI | MRP31.0 | | | 6 | BIT | 2 | 0=activeted |
| 8 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ M1-6) | MMU4 | MOTOR RUN COMMAND | SW-DO | MRP31.0 | | | 256 | | 15 | 1=run |
| 9 | SG200N1 | 0.4/0,23kV | miscellaneous USERS (typ M1-6) | MMU4 | MOTOR STOP COMMAND | SW-DO | MRP31.0 | | | 257 | | 15 | 1=stop |

| ITEM | SWITCHGEAR TAG | VOLTAGE | TAG NAME | DEVICE | SIGNAL_DESCRIPTION | TYPE ANALOG/DIGITAL | RELAY/DEVICE MODEL | UNIT | SCALE FACTOR | IEC61850 ITEM TAG | IEC61850 Technical Key | Note | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | CIRCUIT-BRAKER - PROTECTION TRIPPED "50" | SW-DI | REF615 | | | LD0.DPHLPDOC2.ST.Op.general | SG200N1FP1 | 1=tripped | |
| 2 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | CIRCUIT-BRAKER - PROTECTION TRIPPED "51" | SW-DI | REF615 | | | LD0.DPHLPDOC1.ST.Op.general | SG200N1FP1 | 1=tripped | |
| 3 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | CIRCUIT-BRAKER - FUNCTION TRIPPED "74TCS" | SW-DI | REF615 | | | LD0.XAGGIO130.Ind4.stVal | SG200N1FP1 | 1=tripped | |
| 4 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | CIRCUIT-BRAKER - FUNCTION TRIPPED "86" | SW-DI | REF615 | | | LD0.XAGGIO120.Ind1.stVal | SG200N1FP1 | 1=tripped | |
| 5 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | CIRCUIT-BRAKER - READY TO CLOSE | SW-DI | REF615 | | | LD0.MVGAPC2.ST.SPCSO1.stVal | SG200N1FP1 | 1=ready | |
| 6 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | CIRCUIT-BRAKER - OPEN OR TEST POSITION | SW-DI | REF615 | | | LD0.MVGAPC2.ST.SPCSO2.stVal | SG200N1FP1 | 1=open | |
| 7 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | CIRCUIT-BRAKER - CLOSED AND INSERTED | SW-DI | REF615 | | | LD0.MVGAPC1.ST.SPCSO8.stVal | SG200N1FP1 | 1=closed | |
| 8 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | CIRCUIT-BRAKER - WATCHDOG | SW-DI | REF615 | | | LD0.LPHD1.PhyHealth.stVal | SG200N1FP1 | 0=Failure | |
| 9 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MCBs ALARM | SW-DI | REF615 | | | LD0.XAGGIO130.Ind1.stVal | SG200N1FP1 | 0=alarm | |
| 10 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | SA1 ON "LOCAL" POSITION | SW-DI | REF615 | | | LD0.MVGAPC1.ST.SPCSO6.stVal | SG200N1FP1 | 1=local | |
| 11 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | SA1 ON "REMOTE" POSITION | SW-DI | REF615 | | | LD0.MVGAPC1.ST.SPCSO7.stVal | SG200N1FP1 | 1=remote | |
| 12 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | SA2 ON "MAINTENANCE" POSITION | SW-DI | REF615 | | | LD0.XAGGIO130.Ind2.stVal | SG200N1FP1 | 1=maintenance | |
| 13 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | INTERTRIP TO MV SWBD | SW-DI | REF615 | | | LD0.MVGAPC1.ST.SPCSO4.stVal | SG200N1FP1 | 1=tripped | |
| 14 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | CIRCUIT-BRAKER - CLOSE COMMAND | SW-DO | REF615 | | | LD0.SPCGAPC1.SPCSO1.stVal | SG200N1FP1 | 1=close command | |
| 15 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | CIRCUIT-BRAKER - OPEN COMMAND | SW-DO | REF615 | | | LD0.SPCGAPC1.SPCSO2.stVal | SG200N1FP1 | 1=open command | |
| 16 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | K86 RESET COMMAND | SW-DO | REF615 | | | LD0.SPCGAPC1.SPCSO3.stVal | SG200N1FP1 | 1=reset command | |
| 17 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MEASURE - CURRENT "L1" | SW-AI | REF615 | A | 1 | LD0.CMMXU1.A.phsA.cVal.mag.f | SG200N1FP1 | | |
| 18 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MEASURE - CURRENT "L2" | SW-AI | REF615 | A | 1 | LD0.CMMXU1.A.phsB.cVal.mag.f | SG200N1FP1 | | |
| 19 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MEASURE - CURRENT "L3" | SW-AI | REF615 | A | 1 | LD0.CMMXU1.A.phsC.cVal.mag.f | SG200N1FP1 | | |
| 20 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MEASURE - VOLTAGE "L1-L2" | SW-AI | REF615 | kV | 1 | LD0.VMMXU1.PPV.phsAB.cVal.mag.f | SG200N1FP1 | | |
| 21 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MEASURE - VOLTAGE "L2-L3" | SW-AI | REF615 | kV | 1 | LD0.VMMXU1.PPV.phsBC.cVal.mag.f | SG200N1FP1 | | |
| 22 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MEASURE - VOLTAGE "L3-L1" | SW-AI | REF615 | kV | 1 | LD0.VMMXU1.PPV.phsCA.cVal.mag.f | SG200N1FP1 | | |
| 23 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MEASURE - FREQUENCY | SW-AI | REF615 | Hz | 1 | LD0.FMMXU1.Hz.mag.f | SG200N1FP1 | | |
| 24 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MEASURE - APPARENT POWER | SW-AI | REF615 | kVA | 1 | LD0.PEMMXU1.TotVA.mag.f | SG200N1FP1 | | |
| 25 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MEASURE - REAL POWER | SW-AI | REF615 | kW | 1 | LD0.PEMMXU1.TotW.mag.f | SG200N1FP1 | | |
| 26 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MEASURE - REACTIVE POWER | SW-AI | REF615 | kVAR | 1 | LD0.PEMMXU1.TotVAr.mag.f | SG200N1FP1 | | |
| 27 | SG200N1 | 0.4/0,23kV | INCOMING | FP1 | MEASURE - POWER FACTOR | SW-AI | REF615 | COSfi | 1 | LD0.PEMMXU1.TotPF.mag.f | SG200N1FP1 | | |
| | | | | | | | | | | | | | |
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# Devices Modbus RTU Adress

## 1° Modbus RING

**Column : A1**

| Position User | TYP | CARTRIDGE (U1.A) MRP31.0 (MMU4) Ekip Touch (QF1) | SENECA (U2.B) | SENECA (U2.C) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| **08** | L3-630 | 1 | 2 | 3 |

**Column : A2**

| Position User | TYP | CARTRIDGE (U1.A) MRP31.0 (MMU4) Ekip Touch (QF1) | SENECA (U2.B) | SENECA (U2.C) | WAGO (A1) |
|---|---|---|---|---|---|
| **01** | | | | | |
| **02** | INCOMING | | | | 4 |
| **03** | FUTURE | | | | |
| **04** | L1-63 | - | 8 | - | - |
| **05** | LK1-40 | 46 | 11 | 12 | - |
| **06** | | | | | |
| **07** | | | | | |
| **08** | LE2-320 | 13 | 14 | - | - |

**Column : A3**

| Position User | TYP | CARTRIDGE (U1.A) MRP31.0 (MMU4) Ekip Touch (QF1) | SENECA (U2.B) | SENECA (U2.C) |
|---|---|---|---|---|
| **01** | L1-100 | - | 23 | - |
| **02** | LK1-40 | 25 | 26 | 27 |
| **03** | LK1-100 | 28 | 29 | 30 |
| **04** | LK1-63 | 31 | 32 | 33 |
| **05** | LK1-40 | 34 | 35 | 36 |
| **06** | FUTURE | | | |
| **07** | | | | |
| **08** | LK2-160 | 40 | 41 | 42 |

## 2° Modbus RING

**Column : A4**

| Position User | TYP | CARTRIDGE (U1.A) MRP31.0 (MMU4) Ekip Touch (QF1) | SENECA (U2.B) | SENECA (U2.C) |
|---|---|---|---|---|
| **01** | L1-100 | - | 2 | - |
| **02** | LK1-40 | 4 | 5 | 6 |
| **03** | LK1-63 | 7 | 8 | 9 |
| **04** | LK1-40 | 10 | 11 | 12 |
| **05** | LK1-40 | 13 | 14 | 15 |
| **06** | LK1-40 | 16 | 17 | 18 |
| **07** | | | | |
| **08** | LK2-160 | 19 | 20 | 21 |

**Column : A5**

| Position User | TYP | CARTRIDGE (U1.A) MRP31.0 (MMU4) Ekip Touch (QF1) | SENECA (U2.B) | SENECA (U2.C) |
|---|---|---|---|---|
| **01** | LK1-40 | 25 | 26 | 27 |
| **02** | LK1-40 | 28 | 29 | 30 |
| **03** | LK1-63 | 31 | 32 | 33 |
| **04** | LK1-63 | 34 | 35 | 36 |
| **05** | LK1-40 | 37 | 38 | 39 |
| **06** | LK1-40 | 40 | 41 | 42 |
| **07** | | | | |
| **08** | LK2-160 | 43 | 44 | 45 |

## 3° Modbus RING

**Column : A6**

| Position User | TYP | CARTRIDGE (U1.A) MRP31.0 (MMU4) Ekip Touch (QF1) | SENECA (U2.B) | SENECA (U2.C) |
|---|---|---|---|---|
| **01** | M1-6 | 1 | - | - |
| **02** | LK1-40 | 4 | 5 | 6 |
| **03** | LK1-40 | 7 | 8 | 9 |
| **04** | LK1-40 | 10 | 11 | 12 |
| **05** | L1-63 | - | 14 | - |
| **06** | L1-63 | - | 17 | - |
| **07** | | | | |
| **08** | L2-160 | - | 20 | - |

**Column : A7**

| Position User | TYP | CARTRIDGE (U1.A) MRP31.0 (MMU4) Ekip Touch (QF1) | SENECA (U2.B) | SENECA (U2.C) |
|---|---|---|---|---|
| **01** | M1-6 | 25 | - | - |
| **02** | L1-100 | - | 29 | - |
| **03** | L1-63 | - | 32 | - |
| **04** | L1-63 | - | 35 | - |
| **05** | L1-63 | - | 38 | - |
| **06** | L1-63 | - | 41 | - |
| **07** | | | | |
| **08** | L2-160 | - | 44 | - |

1.7.3.SG-200D2 IO LIST (HARDWARE - SOFTWARE),

Doc.No. 1723002197-EL-LIS-00043

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Base Load Power Hub (BLPH)

# SG-200D2 I/O LIST
# Lv Switchgear

Document Number: 1723002197-EL-LIS-00043

Document Class:2

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| ITEM | SWITCHGEAR TAG | VOLTAGE | TAG NAME | DEVICE | SIGNAL_DESCRIPTION | TYPE ANALOG/DIGITAL | RELAY/DEVICE MODEL | UNIT | SCALE FACTOR | MODBUS TCP/IP Register | MODBUS TCP/IP Data Type | MODBUS TCP/IP Function Code | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - PROTECTION TRIPPED "L" | SW-DI | Ekip Hi-Touch | | | 50.0 | BOOL | 04 | 1=tripped |
| 2 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - PROTECTION TRIPPED "S" | SW-DI | Ekip Hi-Touch | | | 50.1 | BOOL | 04 | 1=tripped |
| 3 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - PROTECTION TRIPPED "I" | SW-DI | Ekip Hi-Touch | | | 50.2 | BOOL | 04 | 1=tripped |
| 4 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - PROTECTION TRIPPED "G" | SW-DI | Ekip Hi-Touch | | | 50.3 | BOOL | 04 | 1=tripped |
| 5 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - TRIPPED (COMMON) | SW-DI | Ekip Hi-Touch | | | 40.3 | BOOL | 04 | 1=tripped |
| 6 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - OPEN | SW-DI | Ekip Hi-Touch | | | 40.6 | BOOL | 04 | 1=open |
| 7 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - CLOSED | SW-DI | Ekip Hi-Touch | | | 40.0 | BOOL | 04 | 1=closed |
| 8 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - CONNECTED | SW-DI | Ekip Hi-Touch | | | 40.1 | BOOL | 04 | 1=connected |
| 9 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - ISOLATED | SW-DI | Ekip Hi-Touch | | | 40.1 | BOOL | 04 | 0=isolated |
| 10 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - TEST | SW-DI | Ekip Hi-Touch | | | 40.2 | BOOL | 04 | 1=test |
| 11 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - TRIP UNIT DISCONNECTED | SW-DI | Ekip Hi-Touch | | | 40.15 | BOOL | 04 | 1=Failure |
| 12 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - CLOSE COMMAND | SW-DO | Ekip Hi-Touch | | | 0.8 | E32 | 16 | 1=close command |
| 13 | SG200D2 | 0.8kV | INCOMING | QB1 | CIRCUIT-BRAKER - OPEN COMMAND | SW-DO | Ekip Hi-Touch | | | 0.7 | E32 | 16 | 1=open command |
| 14 | SG200D2 | 0.8kV | INCOMING | QB1 | MEASURE - CURRENT "L1" | SW-AI | Ekip Hi-Touch | A | 0,1 | 100÷101 | U32 | 04 | |
| 15 | SG200D2 | 0.8kV | INCOMING | QB1 | MEASURE - CURRENT "L2" | SW-AI | Ekip Hi-Touch | A | 0,1 | 102÷103 | U32 | 04 | |
| 16 | SG200D2 | 0.8kV | INCOMING | QB1 | MEASURE - CURRENT "L3" | SW-AI | Ekip Hi-Touch | A | 0,1 | 104÷105 | U32 | 04 | |
| 17 | SG200D2 | 0.8kV | INCOMING | QB1 | MEASURE - VOLTAGE "L1-L2" | SW-AI | Ekip Hi-Touch | V | 0,1 | 154 | U16 | 04 | |
| 18 | SG200D2 | 0.8kV | INCOMING | QB1 | MEASURE - VOLTAGE "L2-L3" | SW-AI | Ekip Hi-Touch | V | 0,1 | 155 | U16 | 04 | |
| 19 | SG200D2 | 0.8kV | INCOMING | QB1 | MEASURE - VOLTAGE "L3-L1" | SW-AI | Ekip Hi-Touch | V | 0,1 | 156 | U16 | 04 | |
| 20 | SG200D2 | 0.8kV | INCOMING | QB1 | MEASURE - FREQUENCY | SW-AI | Ekip Hi-Touch | Hz | 0,01 | 254 | U16 | 04 | |
| 21 | SG200D2 | 0.8kV | INCOMING | QB1 | MEASURE - APPARENT POWER | SW-AI | Ekip Hi-Touch | kVA | 0,1 | 222÷223 | S32 | 04 | |
| 22 | SG200D2 | 0.8kV | INCOMING | QB1 | MEASURE - REAL POWER | SW-AI | Ekip Hi-Touch | kW | 0,1 | 206÷207 | S32 | 04 | |
| 23 | SG200D2 | 0.8kV | INCOMING | QB1 | MEASURE - REACTIVE POWER | SW-AI | Ekip Hi-Touch | kVAR | 0,1 | 214÷215 | S32 | 04 | |
| 24 | SG200D2 | 0.8kV | INCOMING | QB1 | MEASURE - POWER FACTOR | SW-AI | Ekip Hi-Touch | COSfi | 0,001 | 253 | S16 | 04 | |
| 25 | SG200D2 | 0.8kV | COMMON | A1 | QB1 - DISCONNECTED OR OPEN | SW-DI | Module I/O | | | 1 | BIT | | 1=open |
| 26 | SG200D2 | 0.8kV | COMMON | A1 | QB1 - CONNECTED AND CLOSED | SW-DI | Module I/O | | | 2 | BIT | | 1=closed |
| 27 | SG200D2 | 0.8kV | COMMON | A1 | QB2 - DISCONNECTED OR OPEN | SW-DI | Module I/O | | | 3 | BIT | | 1=open |
| 28 | SG200D2 | 0.8kV | COMMON | A1 | QB2 - CONNECTED AND CLOSED | SW-DI | Module I/O | | | 4 | BIT | | 1=closed |
| 29 | SG200D2 | 0.8kV | COMMON | A1 | SA1 ON "LOCAL" POSITION | SW-DI | Module I/O | | | 5 | BIT | | 1=local |
| 30 | SG200D2 | 0.8kV | COMMON | A1 | SA1 ON "REMOTE" POSITION | SW-DI | Module I/O | | | 6 | BIT | | 1=remote |
| 31 | SG200D2 | 0.8kV | COMMON | A1 | MCBs ALARM | SW-DI | Module I/O | | | 7 | BIT | | 1=alarm |
| 32 | SG200D2 | 0.8kV | COMMON | A1 | COMMON FAILURE | SW-DI | Module I/O | | | 8 | BIT | | 1=failure |
| 33 | SG200D2 | 0.8kV | COMMON | A1 | SURGE ARRESTER FAULT | SW-DI | Module I/O | | | 9 | BIT | | 0=failure |
| 34 | SG200D2 | 0.8kV | COMMON | A1 | SG-200N1 - MCBs FAILURE | SW-DI | Module I/O | | | 10 | BIT | | 1=failure |
| 35 | SG200D2 | 0.8kV | COMMON | A1 | *available* | SW-DI | Module I/O | | | 11 | BIT | | |
| 36 | SG200D2 | 0.8kV | COMMON | A1 | *available* | SW-DI | Module I/O | | | 12 | BIT | | |
| 37 | SG200D2 | 0.8kV | COMMON | A1 | *available* | SW-DI | Module I/O | | | 13 | BIT | | |
| 38 | SG200D2 | 0.8kV | COMMON | A1 | *available* | SW-DI | Module I/O | | | 14 | BIT | | |
| 39 | SG200D2 | 0.8kV | COMMON | A1 | *available* | SW-DI | Module I/O | | | 15 | BIT | | |
| 40 | SG200D2 | 0.8kV | COMMON | A1 | *available* | SW-DI | Module I/O | | | 16 | BIT | | |

1.8. Consumption List,

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# 1 AUXIALIRY CIRCUITS CONSUPTION FOR SWG "SG-100D1"

## 1.1 TABLE 1 (110VDC FROM UNINTERRUPTIBLE POWER SUPPLY)

| POS. | SWITCHGEAR SG-100D1 – CONTINUOS ABSORPTION ON 110VDC SUPPLY | | | |
|---|---|---|---|---|
| | DESCRIPTION | CONSUPTION | DEVICE QUANTITY | TOTAL W |
| 1 | IR SENSOR TEMPERATURE MONITORING "TR1" | 0,4W | 7 | 2,8W |
| 2 | EXERTHERM DISPLAY "DP1" | 7W | 1 | 7W |
| 3 | PROTECTION RELAY (REX640) "FP1" | 25W | 6 | 150W |
| 4 | UNDERVOLTAGE RELAY -MBU (ON VD4 C.B.) | 5W<br>(200W for 100ms) | 2 | 10W |
| 5 | OPENING / CLOSING -MB01 /- MBC (ON VD4 C.B.) | 5W<br>(200W for 100ms) | 2 | 10W |
| 6 | CLOSING SPRING CHARGE MOTOR "MAS" (ON VD4 C.B.) | 200W for 5s<br>500W for 0,2s | 2 | |
| 7 | LOCKING MAGNET -RLE1 (ON VD4 C.B.) | 5W | 2 | 10W |
| 8 | UNDERVOLTAGE RELAY (ON VSC CONTACTOR.) | 5W | 4 | 20W |
| 9 | CONTACTOR COMMAND (ON VSC CONTACTOR) | 5W<br>(Inrush current 42A for 2ms) | 4 | 20W |
| 10 | PARTIAL DISCHARGE MONITORIG SYSTEM "PD1" | 35W | 1 | 35W |
| 11 | AUXILIARY RELAY "K.." | 0.9W | 15 (EXTIMATED) | 13,5W |
| 12 | ETHERNET SWITCH "SWH.A – SWH.B" | 19W | 2 | 38W |

1. **Total 316W x 1,2 = 380W (continuous load)**
2. **Total 380W + 200W = 580W x 5sec.**
3. **Total 380W + 500W = 880W x 0,2sec. (peak load)**

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## 1.2 TABLE 2 (230VAC FROM NORMAL POWER SUPPLY)

| POS. | SWITCHGEAR SG-100D1 - CONTINUOS ABSORPTION ON 230VAC SUPPLY | | | |
|---|---|---|---|---|
| | DESCRIPTION | CONSUPTION | DEVICE QUANTITY | TOTAL W |
| 1 | CUBICLE HEATING RESISTOR | 150W | 7 | 1050W |
| 2 | CUBICLE AUXILIARY LIGHT | 8W | 7 | 56W |
| 3 | AUXILIARY SOCKET | 1000W | - | 1000W |

1. **Total 1100W x 1,2 = 1320W (max power)**

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# 2 AUXIALIRY CIRCUITS CONSUPTION FOR SWG "DP-200N1"

## 2.1 TABLE 1 (110VDC FROM UNINTERRUPTIBLE POWER SUPPLY)

**An external auxiliary supply is NOT necessary for this SWG**

## 2.2 TABLE 2 (230VAC FROM NORMAL POWER SUPPLY)

**An external auxiliary supply is NOT necessary for this SWG**

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# 3 AUXIALIRY CIRCUITS CONSUPTION FOR SWG "SG-200D2"

## 3.1 TABLE 3 (230VAC FROM UNINTERRUPTIBLE POWER SUPPLY)

| POS. | SWITCHGEAR SG-200D2 - CONTINUOS ABSORPTION ON 230VAC SUPPLY | | | |
|---|---|---|---|---|
| | DESCRIPTION | CONSUPTION | DEVICE QUANTITY | TOTAL W |
| 1 | ETHERNET SWITCH (SW1) | 20W | 1 | 20W |
| 2 | POWER SUPPLY 230VAC/24VDC (U1) | 15W | 1 | 15W |
| 3 | OPENING / CLOSING -YO /-YC (EMAX C.B..) | 5W<br>(300W for 70ms) | 1 | 5W |
| 4 | AUXILIARY RELAY "K.." | 0.9W | 5<br>(EXTIMATED) | 4,5W |
| | | | | |
| | | | | |

1. **Total 45W x 1,2 = 55W (max power)**
2. **Total 55W + 300W = 355W x 0,07sec. (peak load)**

## 3.2 TABLE 2 (230VAC FROM NORMAL POWER SUPPLY)

| POS. | SWITCHGEAR SG-200D2 - CONTINUOS ABSORPTION ON 230VAC SUPPLY | | | |
|---|---|---|---|---|
| | DESCRIPTION | CONSUPTION | DEVICE QUANTITY | TOTAL W |
| 1 | CUBICLE HEATING RESISTOR | 150W | 1 | 150W |
| 2 | CUBICLE AUXILIARY LIGHT | 4W | 1 | 4W |
| 3 | | | | |

1. **Total 154W x 1,2 = 185W (max power)**

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# 4 AUXIALIRY CIRCUITS CONSUPTION FOR SWG "SG-200N1"

## 4.1 TABLE 3 (230VAC FROM UNINTERRUPTIBLE POWER SUPPLY)

| POS. | SWITCHGEAR SG-200N1 - CONTINUOS ABSORPTION ON 230VAC SUPPLY | | | |
|---|---|---|---|---|
| | DESCRIPTION | CONSUPTION | DEVICE QUANTITY | TOTAL W |
| 1 | ETHERNET SWITCH (SW1) | 20W | 1 | 20W |
| 2 | POWER SUPPLY 230VAC/24VDC (GD1) | 180W | 1 | 180W |
| 3 | OPENING / CLOSING -YO /-YC (EMAX C.B..) | 5W<br>(300W for 70ms) | 1 | 5W |
| 4 | AUXILIARY RELAY "K.." | 0.9W | 5<br>(EXTIMATED) | 4,5W |
| 5 | PROTECTION RELAY (REF615) "FP1" | 25W | 1 | 25W |
| 6 | UNIT TEST YO (EMAX C.B.) "UB1" | 5W | 1 | 5W |

1. **Total 240W x 1,2 = 290W (max power)**
2. **Total 290W + 300W = 590W x 0,07sec. (peak load)**

## 4.2 TABLE 2 (230VAC FROM NORMAL POWER SUPPLY)

| POS. | SWITCHGEAR SG-200N1 - CONTINUOS ABSORPTION ON 230VAC SUPPLY | | | |
|---|---|---|---|---|
| | DESCRIPTION | CONSUPTION | DEVICE QUANTITY | TOTAL W |
| 1 | CUBICLE HEATING RESISTOR | 100W | 7 | 700W |
| 2 | CUBICLE AUXILIARY LIGHT | 4W | 7 | 28W |
| 3 | | | | |

1. **Total 728W x 1,2 = 875W (max power)**

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1.9. Data Table,

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# Base Load Power Hub (BLPH)

## DATA TABLE

umber: 1723002197-EL-LIS-00051

Document Class: 2

ROSETTI MARINO

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| Sign | Date |
|---|---|
| Luca Moscuto | 03/12/2024 |

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| | | | | | |
| 1 | 26/11/2024 | Accepted For Construction (AFC) | Giulietti | Flamminio | Santinelli |
| 0 | 19/09/2024 | Issue for Review (IFR) | Giulietti | Flamminio | Santinelli |
| Rev. | Date | Description | Prepared | Reviewed | Approved |

IMESA ELECTRICAL ENGINEERING IMESA Doc. 231115/SD/051

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*File:* 1723002197-EL-LIS-00051 Rev.011

## Revision / Change Log

| Rev. | Description |
|---|---|
| 00 | Issue for Review (IFR) |
| 01 | Accepted For Construction (AFC) |
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| Tag Number | Tag Description | Physical Class Name | Location | System/SubSystem Code | Purchase Order Number | Vendor Company Name | Manufacturer Company Name | Model Number | Equipment Manufacturer Serial Number | Model Part No | Hazardous Area Equip Relevant | Hazardous Area Certificate Standard | Hazardous Area Certifying Authority | Hazardous Area Certificate Number | Atex Classification | Explosion Protection Examination Certificate Document Number | Layout Drawing | Datasheet | Assembly/Dimensional Drawing | General Arrangement | Operating & Maintenance Manual | Wiring Diagram | Spare Parts List | Lubricant Document Reference | Criticality | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SG-100D1 | | | | | 1723002197 | IMESA spa | IMESA spa | MINIVER-C | 231151/SD/010/2024 | NOT APPLICABLE | | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | 1723002197-EL-DA-00006 | 1723002197-EL-DS-00034 | 1723002197-EL-DA-00006 | 1723002197-EL-DA-00006 | 1723002197-EL-MAN-00054 | 1723002197-EL-DG-00015<br>1723002197-EL-DG-00016<br>1723002197-EL-DG-00017<br>1723002197-EL-DG-00018<br>1723002197-EL-DG-00019<br>1723002197-EL-DG-00020<br>1723002197-EL-DG-00021<br>1723002197-EL-DG-00022 | 1723002197-COM-LIS-00052 | NOT APPLICABLE | 2 | |
| SG-200N1 | | | | | 1723002197 | IMESA spa | IMESA spa | PC/MCC | 231298/SD/040/2024 | NOT APPLICABLE | | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | 1723002197-EL-DA-00007 | 1723002197-EL-DS-00035 | 1723002197-EL-DA-00007 | 1723002197-EL-DA-00007 | 1723002197-EL-MAN-00054 | 1723002197-EL-DG-00030<br>1723002197-EL-DG-00031 | 1723002197-COM-LIS-00052 | NOT APPLICABLE | 2 | |
| SG-200D2 | | | | | 1723002197 | IMESA spa | IMESA spa | PC | 231298/SD/070/2024 | NOT APPLICABLE | | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | 1723002197-EL-DA-00008 | 1723002197-EL-DS-00036 | 1723002197-EL-DA-00008 | 1723002197-EL-DA-00008 | 1723002197-EL-MAN-00054 | 1723002197-EL-DG-00032 | 1723002197-COM-LIS-00052 | NOT APPLICABLE | 3 | |
| DP-200N1 | | | | | 1723002197 | IMESA spa | IMESA spa | MCC/F | 231298/SD/080/2024 | NOT APPLICABLE | | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | NOT APPLICABLE | 1723002197-EL-DA-00009 | 1723002197-EL-DS-00037 | 1723002197-EL-DA-00009 | 1723002197-EL-DA-00009 | 1723002197-EL-MAN-00054 | 1723002197-EL-DG-00033 | 1723002197-COM-LIS-00052 | NOT APPLICABLE | 3 | |

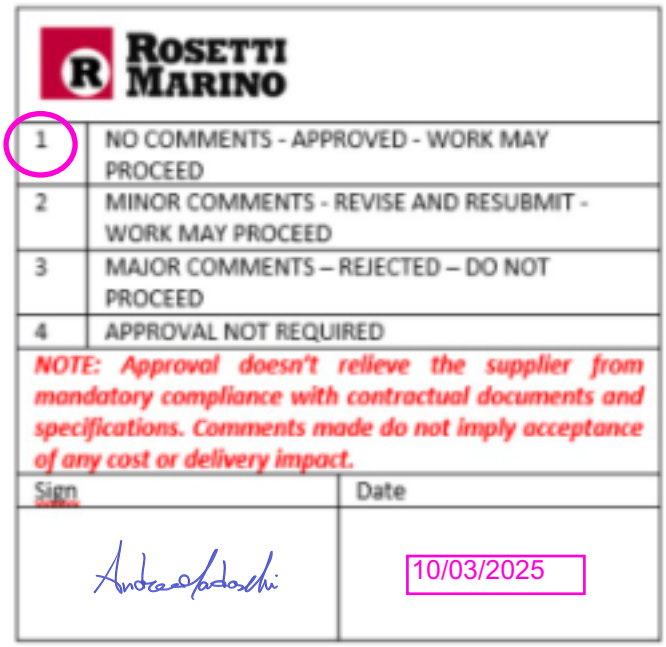
1.10. Protection Relays

1.10.1. PROTECTION SETTING REPORT,

Doc.No. 1723002197-EL-RE-00038

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# Base Load Power Hub (BLPH)


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| Sign | Date |
|---|---|
| Andrea Spadoni | 10/03/2025 |

ETTING REPORT

723002197-EL-RE-00038

nt Class: 3

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| 02 | 10/03/2025 | Issue for Information (IFI) | Giulietti | Flamminio | Santinelli |
| 01 | 21/02/2025 | Issue for Information (IFI) | Giulietti | Flamminio | Santinelli |
| 00 | 16/10/2024 | Issue for Information (IFI) | Giulietti | Flamminio | Santinelli |
| Rev. | Date | Description | Prepared | Reviewed | Approved |

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| 01 | Issue for Information (IFI) |
| 02 | Issue for Information (IFI) |
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# Sheets Index

1 high Voltage Switchgear "SG-100D1" ..... 4

2 Low Voltage Switchgear "SG-200N1" ..... 5

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# 1 HIGH VOLTAGE SWITCHGEAR "SG-100D1"

**Column A1**

To See Attachment Protection Report : "SG-100D1_6,6kV_A1_Electrolyser Feeder A-20000"

**Column A2**

To See Attachment Protection Report : "SG-100D1_6,6kV_A2_Transformer Feeder TR-200ED1"

**Column A3**

To See Attachment Protection Report : "SG-100D1_6,6kV_A3_BESS Feeder A-85000"

**Column A4**

To See Attachment Protection Report : "SG-100D1_6,6kV_A4_Transformer Feeder TR-200DE1"

**Column A6**

To See Attachment Protection Report : "SG-100D1_6,6kV_A6_Incoming Feeder TR-100AD1"

**Column A7**

To See Attachment Protection Report : "SG-100D1_6,6kV_A7_Fuell Cell A-80000"

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# 2 LOW VOLTAGE SWITCHGEAR "SG-200N1"

**Column A1 (Incoming)**

To See Attachment Protection Report : "SG-200N1_400V_A1_Incoming Trasformer"

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*Settings*

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| REX640_A1 | | | | | | |
| IED Configuration | | | | | | |
| HW Configuration | | | | | | |
| Slot B (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot C (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot D (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| POSITION | | intermediate | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| TRIG 1 | | False | | | | |
| TRIG 2 | | False | | | | |
| TRIG 3 | | False | | | | |
| TRIG 4 | | False | | | | |
| TRIG 5 | | False | | | | |
| TRIG 6 | | False | | | | |
| TRIG 7 | | False | | | | |
| TRIG 8 | | False | | | | |
| TRIG 9 | | False | | | | |
| TRIG 10 | | False | | | | |
| TRIG 11 | | False | | | | |
| TRIG 12 | | False | | | | |
| TRIG 13 | | False | | | | |
| TRIG 14 | | False | | | | |
| TRIG 15 | | False | | | | |
| TRIG 16 | | False | | | | |
| Measurements | | | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| S-kVA:1 | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P-kW:1 | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q-kVAr:1 | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF:1 | | 0,00 | | -1,00 | 1,00 | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| IL1-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL2-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL3-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Io-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESVMMXU1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Uo(1) | | | | | | |
| Uo-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| U12-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| UL1-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL2-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL3-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| U12-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| UL1-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL2-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL3-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| f-Hz:1 | | 50,00 | Hz | 35,00 | 75,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| NgSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| PsSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| ZrSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| NgSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| PsSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| ZrSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| Disturbance records | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Number of recordings | | 0 | | 0 | 100 | |
| Rem. amount of rec. | | 0 | | 0 | 100 | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| Trig recording | | Cancel | | | | |
| Time to trigger | | 0 | s | 0 | 604800 | |
| Configuration | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| General | | | | | | |
| Operation | | on | | | | |
| Record length | | 50 | cycles | 10 | 500 | |
| Pre-trg length | | 50 | % | 0 | 100 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Overwrite | | | | |
| Exclusion time | | 0 | ms | 0 | 1000000 | |
| Storage rate | | 32 samples / cycle | | | | |
| Periodic trig time | | 0 | s | 0 | 604800 | |
| Stor. mode periodic | | Waveform | | | | |
| Stor. mode manual | | Waveform | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Operation | | on | | | | |
| Select timeout | | 30000 | ms | 10000 | 300000 | |
| Pulse length | | 200 | ms | 10 | 60000 | |
| Operation counter | | 0 | | 0 | 99999 | |
| Control model | | sbo-with-enhanced-security | | | | |
| Adaptive pulse | | True | | | | |
| Event delay | | 200 | ms | 0 | 10000 | |
| Operation timeout | | 500 | ms | 10 | 6000000 | |
| Interlocking Pls Len | | 2 | s | 1 | 10 | |
| Identification | | CBXCBR1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| General: 0 | | | | | | |
| Control | | | | | | |
| General | | | | | | |
| LR control | | Binary input | | | | |
| Station authority | | L,R | | | | |
| Control mode | | On | | | | |
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | DCSXSWI1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | ESSXSWI1 switch position | | | 255 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| System | | | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| Rated frequency | | 50Hz | | | | |
| Phase rotation | | ABC | | | | |
| Blocking mode | | Freeze timer | | | | |
| Bay name | | REX640_A1 | | | 20 characters | |
| IDMT Sat point | | 50 | I/I> | 10 | 50 | |
| Frequency adaptivity | | Disable | | | | |
| SMV Max Delay | | 3/3 ms | | | | |
| Test mode selection | | Local | | | | |
| HMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Backlight brightness | | 100 | % | 1 | 100 | |
| Enable USB access | | No | | | | |
| Enable HMI service port | | Yes | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| Rate Limiter: 1 | | | | | | |
| Rate Limiter | | | | | | |
| Rate limiter | | | | | | |
| Rate limit ctrl | | False | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Redundancy | | | | | | |
| Redundant mode | | None | | | | |
| Filter | | | | | | |
| Filter mode A_B | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit A_B | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit A_B | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit A_B | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Port modes | | | | | | |
| Port mode X1 | | On | | | | |
| Filter | | | | | | |
| Filter mode X1 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X1 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X1 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X1 | | 8,000 | | 0,512 | 90,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Port modes | | | | | | |
| Port mode X2 | | On | | | | |
| Filter | | | | | | |
| Filter mode X2 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X2 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X2 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X2 | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Port modes | | | | | | |
| Port mode X3 | | On | | | | |
| Filter | | | | | | |
| Filter mode X3 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X3 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X3 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X3 | | 8,000 | | 0,512 | 90,000 | |
| Network1: 1 | | | | | | |
| Network1 | | | | | | |
| Network1 address | | | | | | |
| IP address | | 192.168.10.5 | | | | |
| Subnet mask | | 255.255.255.224 | | | | |
| Default gateway | | 192.168.10.30 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| Network2: 2 | | | | | | |
| Network2 | | | | | | |
| Network2 address | | | | | | |
| Enable | | False | | | | |
| IP address | | 192.168.3.10 | | | | |
| Subnet mask | | 255.255.255.0 | | | | |
| Default gateway | | 0.0.0.0 | | | 16 characters | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| HMI: 1 | | | | | | |
| HMI | | | | | | |
| HMI address | | | | | | |
| IP address | | 192.168.0.254 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Protocols | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| GOOSE | | | | | | |
| Change det. interval | | 500 | ms | 50 | 1000 | |
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| MMS | | | | | | |
| Unit mode | | Nominal | | | | |
| Network1 | | | | | | |
| MMS | | On | | | | |
| HMI port | | | | | | |
| MMS | | On | | | | |
| FTPLPRT1: 1 | | | | | | |
| FTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| FTP | | Secure | | | | |
| HMI port | | | | | | |
| FTP | | Secure | | | | |
| HTTPLPRT1: 1 | | | | | | |
| HTTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| HTTPS | | On | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Network1 | | | | | | |
| Modbus | | On | | | | |
| MBSLPRT2: 2 | | | | | | |
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 400,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | False | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 100,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | False | | | | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Voltage input type | | Voltage trafo | | | | |
| Primary voltage | | 6,600 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 416 | |
| Division ratio | | 10000 | | 1000 | 20000 | |
| VT connection | | Wye | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (3UB): 2 | | | | | | |
| Voltage (3UB) | | | | | | |
| Voltage input type | | Voltage trafo | | | | |
| Primary voltage | | 6,600 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 416 | |
| Division ratio | | 10000 | | 1000 | 20000 | |
| VT connection | | Wye | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (Uo): 1 | | | | | | |
| Voltage (Uo) | | | | | | |
| Primary voltage | | 3,810 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 240 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (UoB): 2 | | | | | | |
| Voltage (UoB) | | | | | | |
| Primary voltage | | 3,810 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 240 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| A high high limit | | 1,40 | xIn | 0,00 | 40,00 | |
| A high limit | | 1,20 | xIn | 0,00 | 40,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A low low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A deadband | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| A Hi high limit res | | 0,20 | xIn | 0,00 | 40,00 | |
| A high limit res | | 0,05 | xIn | 0,00 | 40,00 | |
| A deadband res | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| V Hi high limit res | | 0,20 | xUn | 0,00 | 4,00 | |
| V high limit res | | 0,05 | xUn | 0,00 | 4,00 | |
| V deadband res | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 3 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,20 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Off delay time | | 0 | ms | 0 | 1800000 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| Operation | | on | | | | |
| F high high limit | | 60,00 | Hz | 35,00 | 75,00 | |
| F high limit | | 55,00 | Hz | 35,00 | 75,00 | |
| F low limit | | 45,00 | Hz | 35,00 | 75,00 | |
| F low low limit | | 40,00 | Hz | 35,00 | 75,00 | |
| F deadband | | 1000 | | 100 | 100000 | |
| Def frequency Sel | | Nominal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Operation | | on | | | | |
| Power unit Mult | | k | | | | |
| Energy unit Mult | | k | | | | |
| Active power Dir | | Forward | | | | |
| Reactive power Dir | | Forward | | | | |
| Power deadband | | 10000 | | 1000 | 10000 | |
| Forward Wh Initial | | 0 | | 0 | 999999999 | |
| Reverse Wh Initial | | 0 | | 0 | 999999999 | |
| Forward VArh Initial | | 0 | | 0 | 999999999 | |
| Reverse VArh Initial | | 0 | | 0 | 999999999 | |
| Measurement mode | | PhsA, PhsB, PhsC | | | | |
| Pulse quantity | | 100000 | Wh/VArh | 1 | 10000000 | |
| Pulse on time | | 1,000 | s | 0,050 | 60,000 | |
| Pulse off time | | 0,500 | s | 0,050 | 60,000 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq A Hi high Lim | | 1,40 | xIn | 0,00 | 40,00 | |
| Ps Seq A high limit | | 1,20 | xIn | 0,00 | 40,00 | |
| Ps Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A deadband | | 2500 | | 100 | 100000 | |
| Ng Seq A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Ng Seq A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Ng Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A deadband | | 2500 | | 100 | 100000 | |
| Zro A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Zro A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Zro A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A deadband | | 2500 | | 100 | 100000 | |
| Ps Seq A on delay time | | 0 | ms | 0 | 1800000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Ps Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Zro A on delay time | | 0 | ms | 0 | 1800000 | |
| Zro A off delay time | | 0 | ms | 0 | 1800000 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq V Hi high Lim | | 1,40 | xUn | 0,00 | 4,00 | |
| Ps Seq V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| Ps Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V deadband | | 10000 | | 100 | 100000 | |
| Ng Seq V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Ng Seq V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Ng Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V deadband | | 10000 | | 100 | 100000 | |
| Zro V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Zro V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Zro V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V deadband | | 10000 | | 100 | 100000 | |
| Ps Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ps Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Zro V on delay time | | 0 | ms | 0 | 1800000 | |
| Zro V off delay time | | 0 | ms | 0 | 1800000 | |
| Demand metering: 0 | | | | | | |
| Demand metering | | | | | | |
| Demand interval | | 1 minute | | | | |
| A demand Av mode | | Linear | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Operation | | on | | | | |
| Trip pulse time | | 250 | ms | 20 | 60000 | |
| Trip output mode | | Non-latched | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Operation | | on | | | | |
| Acc stop current | | 10,00 | A | 5,00 | 500,00 | |
| Open alarm time | | 40 | ms | 0 | 200 | |
| Close alarm time | | 40 | ms | 0 | 200 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Opening time Cor | | 10 | ms | -100 | 100 | |
| Closing time Cor | | 10 | ms | -100 | 100 | |
| Spring charge time | | 15 | s | 0 | 60 | |
| Counter initial Val | | 0 | | 0 | 99999 | |
| Alarm Op number | | 200 | | 0 | 99999 | |
| Lockout Op number | | 300 | | 0 | 99999 | |
| Current exponent | | 2,00 | | 0,00 | 5,00 | |
| Difference Cor time | | 5 | ms | -10 | 10 | |
| Alm Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| LO Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| Ini Acc currents Pwr | | 0,00 | | 0,00 | 20000,00 | |
| Initial CB Rmn life | | 5000 | | 0 | 99999 | |
| Rated Op current | | 1000,00 | A | 100,00 | 6300,00 | |
| Rated fault current | | 5000,00 | A | 500,00 | 99999,00 | |
| Op number rated | | 10000 | | 1 | 99999 | |
| Op number fault | | 1000 | | 1 | 10000 | |
| Life alarm level | | 500 | | 0 | 99999 | |
| Pressure alarm time | | 10 | ms | 0 | 60000 | |
| Pres lockout time | | 10 | ms | 0 | 60000 | |
| Inactive Alm days | | 2000 | | 0 | 9999 | |
| Ini inactive days | | 0 | | 0 | 9999 | |
| Inactive Alm hours | | 0 | h | 0 | 23 | |
| Travel time Clc mode | | From Pos to Pos | | | | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Operation | | on | | | | |
| Operate delay time | | 3000 | ms | 1000 | 300000 | |
| Reset delay time | | 1000 | ms | 1000 | 60000 | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Operation | | on | | | | |
| Start value | | 0,05 | xIn | 0,05 | 0,50 | |
| Max operate current | | 1,50 | xIn | 1,00 | 5,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Operation | | off | | | | |
| Neg Seq current Lev | | 0,03 | xIn | 0,03 | 0,20 | |
| Neg Seq voltage Lev | | 0,10 | xUn | 0,03 | 0,20 | |
| Change rate enable | | False | | | | |
| Min Op voltage delta | | 0,50 | xUn | 0,01 | 1,00 | |
| Min Op current delta | | 0,10 | xIn | 0,01 | 1,00 | |
| Enable seal in | | False | | | | |
| Current dead Lin Val | | 0,05 | xIn | 0,05 | 1,00 | |
| Disturbance recorder | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| A1RADR: 1 | | | | | | |
| A1RADR | | | | | | |
| Analog channel 1 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 1 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 2 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 2 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 3 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 3 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 4 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 4 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 5 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 5 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 6 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 6 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 7 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 7 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 8 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 8 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 9 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 9 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 10 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 10 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 11 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 11 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 12 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 12 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| A2RADR: 13 | | | | | | |
| A2RADR | | | | | | |
| Analog channel 13 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 13 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 14 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 14 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 15 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 15 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 16 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 16 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 17 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 17 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 18 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 18 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 19 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 19 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 20 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 20 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 21 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 21 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 22 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 22 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 23 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 23 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 24 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 24 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| B1RBDR: 1 | | | | | | |
| B1RBDR | | | | | | |
| Binary channel 1 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 1 input | | | 64 characters | |
| Binary channel 2 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 2 input | | | 64 characters | |
| Binary channel 3 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 3 input | | | 64 characters | |
| Binary channel 4 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 4 input | | | 64 characters | |
| Binary channel 5 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 5 input | | | 64 characters | |
| Binary channel 6 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 6 input | | | 64 characters | |
| Binary channel 7 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 7 input | | | 64 characters | |
| Binary channel 8 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 8 input | | | 64 characters | |
| Binary channel 9 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 9 input | | | 64 characters | |
| Binary channel 10 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 10 input | | | 64 characters | |
| Binary channel 11 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 11 input | | | 64 characters | |
| Binary channel 12 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 12 input | | | 64 characters | |
| Binary channel 13 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 13 input | | | 64 characters | |
| Binary channel 14 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 14 input | | | 64 characters | |
| Binary channel 15 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 15 input | | | 64 characters | |
| Binary channel 16 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 16 input | | | 64 characters | |
| Binary channel 17 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 17 input | | | 64 characters | |
| Binary channel 18 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 18 input | | | 64 characters | |
| Binary channel 19 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 19 input | | | 64 characters | |
| Binary channel 20 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 20 input | | | 64 characters | |
| Binary channel 21 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 21 input | | | 64 characters | |
| Binary channel 22 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 22 input | | | 64 characters | |
| Binary channel 23 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 23 input | | | 64 characters | |
| Binary channel 24 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 24 input | | | 64 characters | |
| Binary channel 25 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 25 input | | | 64 characters | |
| Binary channel 26 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 26 input | | | 64 characters | |
| Binary channel 27 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 27 input | | | 64 characters | |
| Binary channel 28 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 28 input | | | 64 characters | |
| Binary channel 29 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 29 input | | | 64 characters | |
| Binary channel 30 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 30 input | | | 64 characters | |
| Binary channel 31 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 31 input | | | 64 characters | |
| Binary channel 32 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 32 input | | | 64 characters | |
| B2RBDR: 33 | | | | | | |
| B2RBDR | | | | | | |
| Binary channel 33 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 33 input | | | 64 characters | |
| Binary channel 34 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 34 input | | | 64 characters | |
| Binary channel 35 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 35 input | | | 64 characters | |
| Binary channel 36 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 36 input | | | 64 characters | |
| Binary channel 37 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 37 input | | | 64 characters | |
| Binary channel 38 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 38 input | | | 64 characters | |
| Binary channel 39 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 39 input | | | 64 characters | |
| Binary channel 40 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 40 input | | | 64 characters | |
| Binary channel 41 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 41 input | | | 64 characters | |
| Binary channel 42 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 42 input | | | 64 characters | |
| Binary channel 43 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 43 input | | | 64 characters | |
| Binary channel 44 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 44 input | | | 64 characters | |
| Binary channel 45 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 45 input | | | 64 characters | |
| Binary channel 46 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 46 input | | | 64 characters | |
| Binary channel 47 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 47 input | | | 64 characters | |
| Binary channel 48 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 48 input | | | 64 characters | |
| Binary channel 49 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 49 input | | | 64 characters | |
| Binary channel 50 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 50 input | | | 64 characters | |
| Binary channel 51 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 51 input | | | 64 characters | |
| Binary channel 52 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 52 input | | | 64 characters | |
| Binary channel 53 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 53 input | | | 64 characters | |
| Binary channel 54 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 54 input | | | 64 characters | |
| Binary channel 55 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 55 input | | | 64 characters | |
| Binary channel 56 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 56 input | | | 64 characters | |
| Binary channel 57 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 57 input | | | 64 characters | |
| Binary channel 58 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 58 input | | | 64 characters | |
| Binary channel 59 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 59 input | | | 64 characters | |
| Binary channel 60 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 60 input | | | 64 characters | |
| Binary channel 61 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 61 input | | | 64 characters | |
| Binary channel 62 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 62 input | | | 64 characters | |
| Binary channel 63 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 63 input | | | 64 characters | |
| Binary channel 64 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 64 input | | | 64 characters | |
| Fault record | | | | | | |
| FLTRFRC1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| FLTRFRC1 | | | | | | |
| Operation | | on | | | | |
| Trig mode | | From operate | | | | |
| A measurement mode | | DFT | | | | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Operation | | on | | | | |
| Mem. warning level | | 0 | % | 0 | 100 | |
| Mem. alarm level | | 0 | % | 0 | 100 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Off delay time 1 | | 500 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Off delay time 1 | | 0 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Pulse time 1 | | 150 | ms | 0 | 3600000 | |
| Pulse time 2 | | 150 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Pulse time 1 | | 0 | ms | 0 | 3600000 | |
| Pulse time 2 | | 0 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| General | | | | | | |
| Loc Rem restriction | | False | | | | |
| Output 1 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM CLOSE CMD (DIRECT) | | | 64 characters | |
| Output 2 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM OPEN CMD (DIRECT) | | | 64 characters | |
| Output 3 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | RESET ALARMS | | | 64 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Output 4 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 4 | | | 64 characters | |
| Output 5 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 5 | | | 64 characters | |
| Output 6 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 6 | | | 64 characters | |
| Output 7 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 7 | | | 64 characters | |
| Output 8 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 8 | | | 64 characters | |
| Output 9 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 9 | | | 64 characters | |
| Output 10 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 10 | | | 64 characters | |
| Output 11 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 11 | | | 64 characters | |
| Output 12 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 12 | | | 64 characters | |
| Output 13 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | SPCGAPC1 Output 13 | | | 64 characters | |
| Output 14 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 14 | | | 64 characters | |
| Output 15 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | EMERGENCY | | | 64 characters | |
| Output 16 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 16 | | | 64 characters | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC1 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC1 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC1 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC1 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC1 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC1 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC1 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC1 Q8 | | | 20 characters | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC2 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC2 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC2 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC2 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC2 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC2 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC2 Q7 | | | 20 characters | |
| Output 8 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC2 Q8 | | | 20 characters | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC3 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC3 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC3 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC3 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC3 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC3 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC3 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC3 Q8 | | | 20 characters | |
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC4 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC4 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC4 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC4 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC4 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC4 Q6 | | | 20 characters | |
| Output 7 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC4 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC4 Q8 | | | 20 characters | |
| General: 0 | | | | | | |
| General | | | | | | |
| Software reset | | Cancel | | | | |
| HMI: 0 | | | | | | |
| HMI | | | | | | |
| FB naming convention | | IEC61850 | | | | |
| Backlight timeout | | 3 | min | 1 | 60 | |
| Web HMI mode | | On | | | | |
| HMI timeout | | 15 | min | 1 | 60 | |
| SLD symbol format | | IEC | | | | |
| Setting visibility | | Advanced | | | | |
| User defined name | | Disabled | | | | |
| Time: 0 | | | | | | |
| Time | | | | | | |
| System time | | | | | | |
| Time format | | 24H:MM:SS:MS | | | | |
| Date format | | DD.MM.YYYY | | | | |
| Date | | 0 | | | 20 characters | |
| Time | | 0 | | | 20 characters | |
| Local time offset | | 0 | min | -840 | 840 | |
| Daylight saving time | | | | | | |
| DST in use | | True | | | | |
| DST on time (hours) | | 2 | h | 0 | 23 | |
| DST on time (minutes) | | 0 | min | 0 | 59 | |
| DST on date (day) | | 1 | | 1 | 31 | |
| DST on date (month) | | May | | | | |
| DST on day (weekday) | | reserved | | | | |
| DST off time (hours) | | 2 | h | 0 | 23 | |
| DST off time (minutes) | | 0 | min | 0 | 59 | |
| DST off date (day) | | 25 | | 1 | 31 | |
| DST off date (month) | | September | | | | |
| DST off day (weekday) | | reserved | | | | |
| DST offset | | 60 | min | -720 | 720 | |
| SNTP | | | | | | |
| IP SNTP primary | | 192.168.2.166 | | | | |
| IP SNTP secondary | | 192.168.2.165 | | | | |
| Synchronization | | | | | | |
| Synch source | | SNTP | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PTP Profile | | IEEE C37.238-2011 | | | | |
| PTP domain ID | | 0 | | 0 | 255 | |
| PTP priority 1 | | 128 | | 0 | 255 | |
| PTP priority 2 | | 128 | | 0 | 255 | |
| PTP Slave-only | | False | | | | |
| Time master mode | | Master with finite holdover | | | | |
| Clear clock list | | False | | | | |
| Time Syn Src Tmm | | 3 | min | 1 | 65535 | |
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |
| SG operation mode | | Operator | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LHMI | | | | | | |
| Close delay mode | | Not in use | | | | |
| Close delay | | 60 | s | 5 | 900 | |
| Breaker operation | | After confirmation | | | | |
| Programmable LEDs: 1 | | | | | | |
| Programmable LEDs | | | | | | |
| General | | | | | | |
| Alarm colour | | Red | | | | |
| LED 1 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 27/59 Voltage Protection | | | 64 characters | |
| LED 2 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Trip Coil Supervision | | | 64 characters | |
| LED 3 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 4 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | CB Ready to close | | | 64 characters | |
| LED 5 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 50/51 Current Protection | | | 64 characters | |
| LED 6 | | | | | | |
| Alarm mode | | Follow-S | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | 51N/59N Earth Fault Protection | | | 64 characters | |
| LED 7 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Earthing Switch Unlocked | | | 64 characters | |
| LED 8 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | CB Truck Unlocked | | | 64 characters | |
| LED 9 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Arc Protection Trip | | | 64 characters | |
| LED 10 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | GOOSE Alarm | | | 64 characters | |
| LED 11 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | CB Spring | | | 64 characters | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| LED 12 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Space Heater ON | | | 64 characters | |
| LED 13 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Transformer Protections | | | 64 characters | |
| LED 14 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 15 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Trip from LV | | | 64 characters | |
| LED 16 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 17 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 18 | | | | | | |
| Alarm mode | | Follow-S | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | - | | | 64 characters | |
| LED 19 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 20 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 21 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 22 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| I/O modules: 0 | | | | | | |
| I/O modules | | | | | | |
| Common settings | | | | | | |
| Slot specific threshold | | False | | | | |
| Slot specific hysteresis | | False | | | | |
| Input threshold voltage | | 16 | Vdc | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input osc. level | | 30 | events/s | 2 | 50 | |
| Input osc. hyst | | 10 | events/s | 2 | 50 | |
| User Activity log: 0 | | | | | | |
| User Activity log | | | | | | |
| Server Settings 1 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address | | 192.168.2.5 | | | | |
| Server Settings 2 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address2 | | 192.168.2.6 | | | | |
| Authorization: 1 | | | | | | |
| Authorization | | | | | | |
| Security | | | | | | |
| Remote Update | | Disable | | | | |
| Passwords | | | | | | |
| Remote override | | True | | | | |
| Local override | | True | | | | |
| CAM | | | | | | |
| Clear AD userlist | | False | | | | |
| Network1 | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| HTTPS write access | | On | | | | |
| HMI | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |
| Monitoring | | | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CHLIV_A | | False | | | | |
| REDCHLIV_B | | False | | | | |
| Link statuses | | | | | | |
| LNKLIV_A | | False | | | | |
| REDLNKLIV_B | | False | | | | |
| Diagnostics | | | | | | |
| A_B | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CH1LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK1LIV | | False | | | | |
| Diagnostics | | | | | | |
| X1 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Activity | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| CH2LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK2LIV | | False | | | | |
| Diagnostics | | | | | | |
| X2 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Activity | | | | | | |
| CH3LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK3LIV | | False | | | | |
| Diagnostics | | | | | | |
| X3 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| HMILCCH1: 1 | | | | | | |
| HMILCCH1 | | | | | | |
| Activity | | | | | | |
| HMICHLIV | | False | | | | |
| Link statuses | | | | | | |
| HMILNKLIV | | Down | | | | |
| SCHLCCH6: 6 | | | | | | |
| SCHLCCH6 | | | | | | |
| Activity | | | | | | |
| CH6LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK6LIV | | False | | | | |
| Diagnostics | | | | | | |
| X6 | | | | | | |
| Temperature | | 0,0 | °C | -128,0 | 128,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage | | 0,000 | V | 0,000 | 6,550 | |
| Bias current | | 0,0 | mA | 0,0 | 131,0 | |
| TX power | | 0,000 | mW | 0,000 | 6,550 | |
| RX power | | 0,000 | mW | 0,000 | 6,550 | |
| XCVR detected | | False | | | | |
| RX power alarm | | False | | | | |
| TX power alarm | | False | | | | |
| Voltage alarm | | False | | | | |
| Temperature alarm | | False | | | | |
| Part name | | 0 | | | 20 characters | |
| Protocols | | | | | | |
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| CHLIV | | False | | | | |
| Successful conn. | | 0 | | 0 | 10000000 | |
| Failed conn. | | 0 | | 0 | 10000000 | |
| Concludes | | 0 | | 0 | 10000000 | |
| Sent aborts | | 0 | | 0 | 10000000 | |
| Recv. aborts | | 0 | | 0 | 10000000 | |
| Sent rejects | | 0 | | 0 | 10000000 | |
| Recv. requests | | 0 | | 0 | 10000000 | |
| Failed requests | | 0 | | 0 | 10000000 | |
| Reads | | 0 | | 0 | 10000000 | |
| Failed reads | | 0 | | 0 | 10000000 | |
| Writes | | 0 | | 0 | 10000000 | |
| Failed writes | | 0 | | 0 | 10000000 | |
| Reports | | 0 | | 0 | 10000000 | |
| Active conn. | | 0 | | 0 | 10000000 | |
| Reset counters | | False | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT2: 2 | | | | | | |
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| STATUS | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| MEM_WARN | | False | | | | |
| MEM_ALARM | | False | | | | |
| I/O status | | | | | | |
| Binary input values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| TCS Input 1 | | False | | | | |
| TCS Input 2 | | False | | | | |
| Binary output values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Output 9 | | False | | | | |
| Output 10 | | False | | | | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (Uo): 1 | | | | | | |
| Voltage (Uo) | | | | | | |
| URES_ALARM | | False | | | | |
| URES_WARNING | | False | | | | |
| Voltage (UoB): 2 | | | | | | |
| Voltage (UoB) | | | | | | |
| URES_ALARM | | False | | | | |
| URES_WARNING | | False | | | | |
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (3UB): 2 | | | | | | |
| Voltage (3UB) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| I_INST_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_A | | normal | | | | |
| I_INST_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_B | | normal | | | | |
| I_INST_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_C | | normal | | | | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I_INST_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_RES | | normal | | | | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U_INST_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_RES | | normal | | | | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Inputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Outputs | | | | | | |
| I2_HIGH_AL | | False | | | | |
| I2_HIGH_WARN | | False | | | | |
| I1_HIGH_AL | | False | | | | |
| I1_HIGH_WARN | | False | | | | |
| I1_LOW_WARN | | False | | | | |
| I1_LOW_AL | | False | | | | |
| I0_HIGH_AL | | False | | | | |
| I0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I2_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I2_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_RANGE | | normal | | | | |
| I1_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I1_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_RANGE | | normal | | | | |
| I0_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I0_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_RANGE | | normal | | | | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| U2_HIGH_AL | | False | | | | |
| U2_HIGH_WARN | | False | | | | |
| U1_HIGH_AL | | False | | | | |
| U1_HIGH_WARN | | False | | | | |
| U1_LOW_WARN | | False | | | | |
| U1_LOW_AL | | False | | | | |
| U0_HIGH_AL | | False | | | | |
| U0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U2_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U2_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_RANGE | | normal | | | | |
| U1_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U1_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_RANGE | | normal | | | | |
| U0_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U0_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_RANGE | | normal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Inputs | | | | | | |
| RSTACM | | False | | | | |
| Monitored data | | | | | | |
| S_INST | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DB | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DMD | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P_INST | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DB | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DMD | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q_INST | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DB | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DMD | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF_INST | | 0,00 | | -1,00 | 1,00 | |
| PF_DB | | 0,00 | | -1,00 | 1,00 | |
| PF_DMD | | 0,00 | | -1,00 | 1,00 | |
| EA_RV_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_RV_ACM | | 0 | kVArh | 0 | 999999999 | |
| EA_FWD_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_FWD_ACM | | 0 | kVArh | 0 | 999999999 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| Monitored data | | | | | | |
| F_INST | | 50,00 | Hz | 35,00 | 75,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| F_DB | | 50,00 | Hz | 35,00 | 75,00 | |
| F_RANGE | | normal | | | | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| IN9 | | False | | | | |
| IN10 | | False | | | | |
| IN11 | | False | | | | |
| IN12 | | False | | | | |
| IN13 | | False | | | | |
| IN14 | | False | | | | |
| IN15 | | False | | | | |
| IN16 | | False | | | | |
| Outputs | | | | | | |
| O1 | | False | | | | |
| O2 | | False | | | | |
| O3 | | False | | | | |
| O4 | | False | | | | |
| O5 | | False | | | | |
| O6 | | False | | | | |
| O7 | | False | | | | |
| O8 | | False | | | | |
| O9 | | False | | | | |
| O10 | | False | | | | |
| O11 | | False | | | | |
| O12 | | False | | | | |
| O13 | | False | | | | |
| O14 | | False | | | | |
| O15 | | False | | | | |
| O16 | | False | | | | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Inputs | | | | | | |
| ENA_OPEN | | True | | | | |
| ENA_CLOSE | | True | | | | |
| BLK_OPEN | | False | | | | |
| BLK_CLOSE | | False | | | | |
| SYNC_OK | | True | | | | |
| SYNC_BYPASS | | False | | | | |
| ITL_BYPASS | | False | | | | |
| Outputs | | | | | | |
| SELECTED | | False | | | | |
| EXE_OP | | False | | | | |
| EXE_CL | | False | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| OPEN_ENAD | | False | | | | |
| CLOSE_ENAD | | False | | | | |
| CTL_ITL_BLKD | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Outputs | | | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| Current protection | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| BLK2H | | False | | | | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Voltage protection | | | | | | |
| 59N; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| START | | False | | | | |
| POSCLOSE | | False | | | | |
| CB_FAULT | | False | | | | |
| Outputs | | | | | | |
| CB_FAULT_AL | | False | | | | |
| TRBU | | False | | | | |
| TRRET | | False | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| OPERATE | | False | | | | |
| RST_LKOUT | | False | | | | |
| Outputs | | | | | | |
| TRIP | | False | | | | |
| CL_LKOUT | | False | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| POSOPEN | | False | | | | |
| POSCLOSE | | False | | | | |
| OPEN_CB_EXE | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| CLOSE_CB_EXE | | False | | | | |
| PRES_ALM_IN | | False | | | | |
| PRES_LO_IN | | False | | | | |
| RST_IPOW | | False | | | | |
| RST_CB_WEAR | | False | | | | |
| RST_TRV_T | | False | | | | |
| RST_SPR_T | | False | | | | |
| Outputs | | | | | | |
| TRV_T_OP_ALM | | False | | | | |
| TRV_T_CL_ALM | | False | | | | |
| SPR_CHR_ALM | | False | | | | |
| OPR_ALM | | False | | | | |
| OPR_LO | | False | | | | |
| IPOW_ALM | | False | | | | |
| IPOW_LO | | False | | | | |
| CB_LIFE_ALM | | False | | | | |
| MON_ALM | | False | | | | |
| PRES_ALM | | False | | | | |
| PRES_LO | | False | | | | |
| OPENPOS | | False | | | | |
| INVALIDPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| Monitored data | | | | | | |
| T_TRV_OP | | 0 | ms | 0 | 60000 | |
| T_TRV_CL | | 0 | ms | 0 | 60000 | |
| T_SPR_CHR | | 0,00 | s | 0,00 | 99,99 | |
| NO_OPR | | 0 | | 0 | 99999 | |
| INA_DAYS | | 0 | | 0 | 9999 | |
| CB_LIFE_A | | 0 | | -99999 | 99999 | |
| CB_LIFE_B | | 0 | | -99999 | 99999 | |
| CB_LIFE_C | | 0 | | -99999 | 99999 | |
| IPOW_A | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_B | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_C | | 0,000 | | 0,000 | 30000,000 | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| FAIL | | False | | | | |
| ALARM | | False | | | | |
| Monitored data | | | | | | |
| IDIFF | | 0,00 | xIn | 0,00 | 40,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| CB_CLOSED | | False | | | | |
| DISCON_OPEN | | False | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| FUSEF_3PH | | False | | | | |
| FUSEF_U | | False | | | | |
| Communication | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| Monitoring | | | | | | |
| Reset counters | | False | | | | |
| Received msgs | | 0 | | 0 | 10000000 | |
| Transmitted msgs | | 0 | | 0 | 10000000 | |
| State changes | | 0 | | 0 | 10000000 | |
| SeqNum changes | | 0 | | 0 | 10000000 | |
| Test msgs | | 0 | | 0 | 10000000 | |
| State warnings | | 0 | | 0 | 10000000 | |
| Seq. warnings | | 0 | | 0 | 10000000 | |
| Recv. timeouts | | 0 | | 0 | 10000000 | |
| ConfRev errors | | 0 | | 0 | 10000000 | |
| NdsComm errors | | 0 | | 0 | 10000000 | |
| Dataset errors | | 0 | | 0 | 10000000 | |
| Replay Prot warnings | | 0 | | 0 | 10000000 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| FB status | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>>>(1) | | on | | | | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>(1) | | on | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Current protection | | | | | | |
| 3I2f>(1) | | on | | | | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Current protection | | | | | | |
| Io>(1) | | on | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U>(1) | | on | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 3U<(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U<(1) | | on | | | | |
| 59N; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Voltage protection | | | | | | |
| Uo>(1) | | on | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Other protection | | | | | | |
| 3I>/Io>BF(1) | | on | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Other protection | | | | | | |
| ARC(1) | | on | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Other protection | | | | | | |
| ARC(2) | | on | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Other protection | | | | | | |
| ARC(3) | | on | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Trip logic | | | | | | |
| Master Trip(1) | | on | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Condition monitoring | | | | | | |
| CBCM(1) | | on | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Supervision | | | | | | |
| TCS(1) | | on | | | | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Supervision | | | | | | |
| MCS 3I(1) | | on | | | | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Supervision | | | | | | |
| FUSEF(1) | | on | | | | |
| Recorded data | | | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 3I(1) | | | | | | |
| Max demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand IL1 | | 0 | | | 34 characters | |
| Time max demand IL2 | | 0 | | | 34 characters | |
| Time max demand IL3 | | 0 | | | 34 characters | |
| Time min demand IL1 | | 0 | | | 34 characters | |
| Time min demand IL2 | | 0 | | | 34 characters | |
| Time min demand IL3 | | 0 | | | 34 characters | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Max demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand Io | | 0 | | | 34 characters | |
| Time min demand Io | | 0 | | | 34 characters | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Max demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Min demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Max demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Min demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Max demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Min demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Time max dmd S | | 0 | | | 34 characters | |
| Time min dmd S | | 0 | | | 34 characters | |
| Time max dmd P | | 0 | | | 34 characters | |
| Time min dmd P | | 0 | | | 34 characters | |
| Time max dmd Q | | 0 | | | 34 characters | |
| Time min dmd Q | | 0 | | | 34 characters | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault record | | | | | | |
| Fault number | | 0 | | 0 | 999999 | |
| Time and date | | 0 | | | 34 characters | |
| Protection (rec. set 1) | | None | | | | |
| Protection (rec. set 2) | | None | | | | |
| Start duration | | 0,00 | % | 0,00 | 100,00 | |
| Operate time | | 0,000 | s | 0,000 | 999999,999 | |
| Breaker clear time | | 0,000 | s | 0,000 | 3,000 | |
| Fault distance | | 0,00 | pu | 0,00 | 3000,00 | |
| Fault resistance | | 0,00 | ohm | 0,00 | 3000,00 | |
| Fault reactance | | 0,00 | ohm | 0,00 | 3000,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Active group | | 1 | | 1 | 6 | |
| Shot pointer | | 1 | | 1 | 7 | |
| Max diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Diff current Io:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Bias current Io:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Current Io-Calc:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Voltage UL1:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL12:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL23:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL31:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| PTTR thermal level | | 0,00 | | 0,00 | 99,99 | |
| I2/I1>(1) rat. I2/I1 | | 0,00 | % | 0,00 | 999,99 | |
| Frequency:1 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:1 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:2 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:2 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:3 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:3 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Conductance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Susceptance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Angle Uo:1 - Io:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:1- IL1:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:1 - IL2:1 | | 0,00 | deg | -180,00 | 180,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Angle U12:1 - IL3:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:2 - Io:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:2 - IL1:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:2 - IL2:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:2 - IL3:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:3 - Io:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:3 - IL1:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:3 - IL2:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:3 - IL3:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Control command | | | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LR state | | Remote | | | | |
| Detached LHMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| CONNECTION | | False | | | | |
| Service port IP address | | 0 | | | 20 characters | |
| Main unit port IP address | | 0 | | | 20 characters | |
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |
| Outputs | | | | | | |
| SG_LOGIC_SEL | | False | | | | |
| SG_1_ACT | | False | | | | |
| SG_2_ACT | | False | | | | |
| SG_3_ACT | | False | | | | |
| SG_4_ACT | | False | | | | |
| SG_5_ACT | | False | | | | |
| SG_6_ACT | | False | | | | |
| Programmable LEDs: 1 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 1 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 2 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 3 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 4 | | | | | | |
| OK | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 5 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 6 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 7 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 8 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 9 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 10 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 11 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 1 | | None | | | | |
| Programmable LED 2 | | None | | | | |
| Programmable LED 3 | | None | | | | |
| Programmable LED 4 | | None | | | | |
| Programmable LED 5 | | None | | | | |
| Programmable LED 6 | | None | | | | |
| Programmable LED 7 | | None | | | | |
| Programmable LED 8 | | None | | | | |
| Programmable LED 9 | | None | | | | |
| Programmable LED 10 | | None | | | | |
| Programmable LED 11 | | None | | | | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 12 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 13 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 14 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 15 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 16 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 17 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 18 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 19 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 20 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 21 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 22 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 12 | | None | | | | |
| Programmable LED 13 | | None | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Programmable LED 14 | | None | | | | |
| Programmable LED 15 | | None | | | | |
| Programmable LED 16 | | None | | | | |
| Programmable LED 17 | | None | | | | |
| Programmable LED 18 | | None | | | | |
| Programmable LED 19 | | None | | | | |
| Programmable LED 20 | | None | | | | |
| Programmable LED 21 | | None | | | | |
| Programmable LED 22 | | None | | | | |
| IED status: 1 | | | | | | |
| IED status | | | | | | |
| CAM | | | | | | |
| UAM mode | | Local | | | | |
| CAM server1 | | Offline | | | | |
| CAM server2 | | Offline | | | | |
| Replication | | N.A. | | | | |
| Last update | | 0 | | | 34 characters | |
| PKI | | | | | | |
| CA Server Status | | Offline | | | | |
| Time synchronization | | | | | | |
| PTP P2P delay X1 | | 0 | ns | -2147483648 | 2147483647 | |
| PTP P2P delay X2 | | 0 | ns | -2147483648 | 2147483647 | |
| PTP P2P delay X3 | | 0 | ns | -2147483648 | 2147483647 | |
| Self-supervision | | | | | | |
| Warning | | All ok | | | | |
| Internal Fault | | All ok | | | | |
| Boot up time | | 0 | | | 34 characters | |
| Boot up reason | | None | | | | |
| Device state | | on | | | | |
| Composition changes | | | | | | |
| No of comp. changes | | 0 | | 0 | 100000 | |
| Setting changes | | | | | | |
| Setting changes | | 0 | | 0 | 20000 | |
| Setting time | | 0 | | | 34 characters | |
| SMV accuracy | | | | | | |
| SMV Synch accuracy | | InternalClock | | | | |
| Local synch accuracy | | 0 | us | 0 | 1000000000 | |
| Max Dev synch Acc | | 0 | us | 0 | 1000000000 | |
| Information | | | | | | |
| HW modules | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Article number | | 2RCA034506A0001 | | | 20 characters | |
| SW version | | 0x105 | | | 20 characters | |
| HW revision | | G | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Serial number | | 1VH341247124 | | | 20 characters | |
| Manufacturing date | | 24.2.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 24.2.2024 00:00:00.000 | | | 34 characters | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Article number | | 2RCA034506A0001 | | | 20 characters | |
| SW version | | 0x105 | | | 20 characters | |
| HW revision | | G | | | 20 characters | |
| Serial number | | 1VH341254410 | | | 20 characters | |
| Manufacturing date | | 17.4.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 17.4.2024 00:00:00.000 | | | 34 characters | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Article number | | 2RCA034536A0001 | | | 20 characters | |
| SW version | | 0x105 | | | 20 characters | |
| HW revision | | F | | | 20 characters | |
| Serial number | | 1VH341253310 | | | 20 characters | |
| Manufacturing date | | 26.4.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 26.4.2024 00:00:00.000 | | | 34 characters | |
| Slot E (AIM): 1 | | | | | | |
| Slot E (AIM) | | | | | | |
| Article number | | 2RCA034442A0001 | | | 20 characters | |
| SW version | | 0x104 | | | 20 characters | |
| HW revision | | H | | | 20 characters | |
| Serial number | | 1VH341244788 | | | 20 characters | |
| Manufacturing date | | 11.2.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 11.2.2024 00:00:00.000 | | | 34 characters | |
| Slot F (AIM): 1 | | | | | | |
| Slot F (AIM) | | | | | | |
| Article number | | 2RCA034442A0001 | | | 20 characters | |
| SW version | | 0x104 | | | 20 characters | |
| HW revision | | H | | | 20 characters | |
| Serial number | | 1VH341244337 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Manufacturing date | | 9.2.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 9.2.2024 00:00:00.000 | | | 34 characters | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Article number | | 2RCA034470A0001 | | | 20 characters | |
| SW version | | 0x101 | | | 20 characters | |
| HW revision | | H | | | 20 characters | |
| Serial number | | 1VH341219358 | | | 20 characters | |
| Manufacturing date | | 3.10.2023 00:00:00.000 | | | 34 characters | |
| Test date | | 3.10.2023 00:00:00.000 | | | 34 characters | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Detached LHMI | | | | | | |
| Article number | | 2RCA033008A0001 | | | 20 characters | |
| Application version | | 22-12-12-18:25 | | | 20 characters | |
| Firmware version | | 20230131222023 | | | 20 characters | |
| HW revision | | V | | | 20 characters | |
| Serial number | | 1VHR51024462 | | | 20 characters | |
| Manufacturing date | | 16.5.2024 01:00:00.000 | | | 34 characters | |
| Test date | | 16.5.2024 01:00:00.000 | | | 34 characters | |
| Service port MAC address | | 00:21:C1:34:82:AF | | | 20 characters | |
| Main unit port MAC address | | 00:21:C1:34:82:B0 | | | 20 characters | |
| Slot A1 (ARC): 1 | | | | | | |
| Slot A1 (ARC) | | | | | | |
| Article number | | 2RCA032261A0001 | | | 20 characters | |
| SW version | | 0x107 | | | 20 characters | |
| HW revision | | G | | | 20 characters | |
| Serial number | | 1VH341251233 | | | 20 characters | |
| Manufacturing date | | 28.3.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 28.3.2024 00:00:00.000 | | | 34 characters | |
| Slot A2 (COM): 1 | | | | | | |
| Slot A2 (COM) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Article number | | 2RCA034478A0001 | | | 20 characters | |
| SW version | | 0x11D | | | 20 characters | |
| HW revision | | L | | | 20 characters | |
| Serial number | | 1VH341254193 | | | 20 characters | |
| Manufacturing date | | 15.4.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 15.4.2024 00:00:00.000 | | | 34 characters | |
| Product identifiers: 0 | | | | | | |
| Product identifiers | | | | | | |
| Type | | REX640 | | | 20 characters | |
| Product version | | 1 | | | 64 characters | |
| Serial number | | 1VHR81041858 | | | 20 characters | |
| Production date | | 10.5.2024 01:00:00.000 | | | 34 characters | |
| SW version | | 1.3.3 | | | 20 characters | |
| SW date | | 11.3.2024 13:07:00.000 | | | 34 characters | |
| SW number | | 2RCA057448D | | | 20 characters | |
| Interface level | | 0 | | | 64 characters | |
| Order code | | REX640_1AC2 | | | 20 characters | |
| Site identifiers: 0 | | | | | | |
| Site identifiers | | | | | | |
| Customer name | | 0 | | | 20 characters | |
| Street | | 0 | | | 20 characters | |
| House number | | 0 | | | 20 characters | |
| ZIP/Postal code | | 0 | | | 20 characters | |
| City/Province | | 0 | | | 20 characters | |
| State | | 0 | | | 20 characters | |
| Country | | 0 | | | 20 characters | |
| System identifiers: 0 | | | | | | |
| System identifiers | | | | | | |
| Technical key | | AA1L1Q01A1 | | | 20 characters | |
| IEC 61850 version | | Edition 2.1 | | | 24 characters | |
| Engineering model | | ABB | | | | |
| HW modules: 0 | | | | | | |
| HW modules | | | | | | |
| Main board | | | | | | |
| Article number | | 2RCA036414A0001 | | | 20 characters | |
| SW version | | 0x5402 | | | 20 characters | |
| HW revision | | J | | | 20 characters | |
| Serial number | | 1VH341253729 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Manufacturing date | | 12.4.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 12.4.2024 00:00:00.000 | | | 34 characters | |
| Clear | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Disturbance records | | Cancel | | | | |
| Clear: 0 | | | | | | |
| Clear | | | | | | |
| Indications and LEDs | | Cancel | | | | |
| Programmable LEDs | | Cancel | | | | |
| Events | | Cancel | | | | |
| Metering records | | Cancel | | | | |
| Power quality data | | Cancel | | | | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault records | | Cancel | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Load Profile record | | Cancel | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Master Trip(1) | | Cancel | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| CBCM(1) acc.energy | | Cancel | | | | |
| CBCM(1) rem.life | | Cancel | | | | |
| CBCM(1) travel times | | Cancel | | | | |
| CBCM(1) spr.charge t | | Cancel | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| P,E(1) acc.energy | | Cancel | | | | |
| Application Configuration | | | | | | |
| General | | | | | | |
| Settings | | | | | | |
| Setting group | | | | | | |
| Protection: 0 | | | | | | |
| Setting group | | | | | | |
| Active group | | 1 | | 1 | 6 | |
| Protection | | | | | | |
| Settings | | | | | | |
| Current protection | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 6,50 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 6,50 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 6,50 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 6,50 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 6,50 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 6,50 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 300000 | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Minimum operate time | | 50 | ms | 20 | 60000 | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 50000,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 6,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,75 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,200 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| settingGroup 2 | | | | | | |
| Start value | | 0,75 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,200 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,75 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,200 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,75 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,200 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,75 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,200 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,75 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,200 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Operation | | off | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 2 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 3 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 4 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 5 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 6 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage protection | | | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Enable block value | | False | | | | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 59N; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Operation | | off | | | | |
| Current value | | 0,300 | xIn | 0,050 | 2,000 | |
| Current value Res | | 0,30 | xIn | 0,05 | 2,00 | |
| CB failure trip mode | | 1 out of 3 | | | | |
| CB failure mode | | Current | | | | |
| CB fail retrip mode | | Off | | | | |
| Retrip time | | 120 | ms | 0 | 60000 | |
| CB failure delay | | 240 | ms | 0 | 60000 | |
| CB fault delay | | 5000 | ms | 0 | 60000 | |
| Measurement mode | | Peak-to-Peak | | | | |
| Trip pulse time | | 200 | ms | 0 | 60000 | |
| Start latching mode | | Rising edge | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |

*Settings*

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| REX640_A2 | | | | | | |
| IED Configuration | | | | | | |
| HW Configuration | | | | | | |
| Slot B (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot C (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot D (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| POSITION | | intermediate | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| TRIG 1 | | False | | | | |
| TRIG 2 | | False | | | | |
| TRIG 3 | | False | | | | |
| TRIG 4 | | False | | | | |
| TRIG 5 | | False | | | | |
| TRIG 6 | | False | | | | |
| TRIG 7 | | False | | | | |
| TRIG 8 | | False | | | | |
| TRIG 9 | | False | | | | |
| TRIG 10 | | False | | | | |
| TRIG 11 | | False | | | | |
| TRIG 12 | | False | | | | |
| TRIG 13 | | False | | | | |
| TRIG 14 | | False | | | | |
| TRIG 15 | | False | | | | |
| TRIG 16 | | False | | | | |
| Measurements | | | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| S-kVA:1 | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P-kW:1 | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q-kVAr:1 | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF:1 | | 0,00 | | -1,00 | 1,00 | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| IL1-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL2-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL3-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Io-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESVMMXU1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Uo(1) | | | | | | |
| Uo-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| U12-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| UL1-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL2-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL3-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| U12-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| UL1-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL2-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL3-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| f-Hz:1 | | 50,00 | Hz | 35,00 | 75,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| NgSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| PsSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| ZrSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| NgSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| PsSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| ZrSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| Disturbance records | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Number of recordings | | 0 | | 0 | 100 | |
| Rem. amount of rec. | | 0 | | 0 | 100 | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| Trig recording | | Cancel | | | | |
| Time to trigger | | 0 | s | 0 | 604800 | |
| Configuration | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| General | | | | | | |
| Operation | | on | | | | |
| Record length | | 50 | cycles | 10 | 500 | |
| Pre-trg length | | 50 | % | 0 | 100 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Overwrite | | | | |
| Exclusion time | | 0 | ms | 0 | 1000000 | |
| Storage rate | | 32 samples / cycle | | | | |
| Periodic trig time | | 0 | s | 0 | 604800 | |
| Stor. mode periodic | | Waveform | | | | |
| Stor. mode manual | | Waveform | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Operation | | on | | | | |
| Select timeout | | 30000 | ms | 10000 | 300000 | |
| Pulse length | | 200 | ms | 10 | 60000 | |
| Operation counter | | 0 | | 0 | 99999 | |
| Control model | | sbo-with-enhanced-security | | | | |
| Adaptive pulse | | True | | | | |
| Event delay | | 200 | ms | 0 | 10000 | |
| Operation timeout | | 500 | ms | 10 | 6000000 | |
| Interlocking Pls Len | | 2 | s | 1 | 10 | |
| Identification | | CBXCBR1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| General: 0 | | | | | | |
| Control | | | | | | |
| General | | | | | | |
| LR control | | Binary input | | | | |
| Station authority | | L,R | | | | |
| Control mode | | On | | | | |
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | DCSXSWI1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | ESSXSWI1 switch position | | | 255 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| System | | | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| Rated frequency | | 50Hz | | | | |
| Phase rotation | | ABC | | | | |
| Blocking mode | | Freeze timer | | | | |
| Bay name | | REX640_A2 | | | 20 characters | |
| IDMT Sat point | | 50 | I/I> | 10 | 50 | |
| Frequency adaptivity | | Disable | | | | |
| SMV Max Delay | | 3/3 ms | | | | |
| Test mode selection | | Local | | | | |
| HMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Backlight brightness | | 100 | % | 1 | 100 | |
| Enable USB access | | No | | | | |
| Enable HMI service port | | Yes | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| Rate Limiter: 1 | | | | | | |
| Rate Limiter | | | | | | |
| Rate limiter | | | | | | |
| Rate limit ctrl | | False | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Redundancy | | | | | | |
| Redundant mode | | None | | | | |
| Filter | | | | | | |
| Filter mode A_B | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit A_B | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit A_B | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit A_B | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Port modes | | | | | | |
| Port mode X1 | | On | | | | |
| Filter | | | | | | |
| Filter mode X1 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X1 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X1 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X1 | | 8,000 | | 0,512 | 90,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Port modes | | | | | | |
| Port mode X2 | | On | | | | |
| Filter | | | | | | |
| Filter mode X2 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X2 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X2 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X2 | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Port modes | | | | | | |
| Port mode X3 | | On | | | | |
| Filter | | | | | | |
| Filter mode X3 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X3 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X3 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X3 | | 8,000 | | 0,512 | 90,000 | |
| Network1: 1 | | | | | | |
| Network1 | | | | | | |
| Network1 address | | | | | | |
| IP address | | 192.168.10.6 | | | | |
| Subnet mask | | 255.255.255.224 | | | | |
| Default gateway | | 192.168.10.30 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| Network2: 2 | | | | | | |
| Network2 | | | | | | |
| Network2 address | | | | | | |
| Enable | | False | | | | |
| IP address | | 192.168.3.10 | | | | |
| Subnet mask | | 255.255.255.0 | | | | |
| Default gateway | | 0.0.0.0 | | | 16 characters | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| HMI: 1 | | | | | | |
| HMI | | | | | | |
| HMI address | | | | | | |
| IP address | | 192.168.0.254 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Protocols | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| GOOSE | | | | | | |
| Change det. interval | | 500 | ms | 50 | 1000 | |
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| MMS | | | | | | |
| Unit mode | | Nominal | | | | |
| Network1 | | | | | | |
| MMS | | On | | | | |
| HMI port | | | | | | |
| MMS | | On | | | | |
| FTPLPRT1: 1 | | | | | | |
| FTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| FTP | | Secure | | | | |
| HMI port | | | | | | |
| FTP | | Secure | | | | |
| HTTPLPRT1: 1 | | | | | | |
| HTTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| HTTPS | | On | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Network1 | | | | | | |
| Modbus | | On | | | | |
| MBSLPRT2: 2 | | | | | | |
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 50,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | True | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 100,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | False | | | | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Voltage input type | | Voltage trafo | | | | |
| Primary voltage | | 6,600 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 416 | |
| Division ratio | | 10000 | | 1000 | 20000 | |
| VT connection | | Wye | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (3UB): 2 | | | | | | |
| Voltage (3UB) | | | | | | |
| Voltage input type | | Voltage trafo | | | | |
| Primary voltage | | 6,600 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 416 | |
| Division ratio | | 10000 | | 1000 | 20000 | |
| VT connection | | Wye | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (Uo): 1 | | | | | | |
| Voltage (Uo) | | | | | | |
| Primary voltage | | 3,810 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 240 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (UoB): 2 | | | | | | |
| Voltage (UoB) | | | | | | |
| Primary voltage | | 3,810 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 240 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| A high high limit | | 1,40 | xIn | 0,00 | 40,00 | |
| A high limit | | 1,20 | xIn | 0,00 | 40,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A low low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A deadband | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| A Hi high limit res | | 0,20 | xIn | 0,00 | 40,00 | |
| A high limit res | | 0,05 | xIn | 0,00 | 40,00 | |
| A deadband res | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| V Hi high limit res | | 0,20 | xUn | 0,00 | 4,00 | |
| V high limit res | | 0,05 | xUn | 0,00 | 4,00 | |
| V deadband res | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 3 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,20 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Off delay time | | 0 | ms | 0 | 1800000 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| Operation | | on | | | | |
| F high high limit | | 60,00 | Hz | 35,00 | 75,00 | |
| F high limit | | 55,00 | Hz | 35,00 | 75,00 | |
| F low limit | | 45,00 | Hz | 35,00 | 75,00 | |
| F low low limit | | 40,00 | Hz | 35,00 | 75,00 | |
| F deadband | | 1000 | | 100 | 100000 | |
| Def frequency Sel | | Nominal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Operation | | on | | | | |
| Power unit Mult | | k | | | | |
| Energy unit Mult | | k | | | | |
| Active power Dir | | Forward | | | | |
| Reactive power Dir | | Forward | | | | |
| Power deadband | | 10000 | | 1000 | 10000 | |
| Forward Wh Initial | | 0 | | 0 | 999999999 | |
| Reverse Wh Initial | | 0 | | 0 | 999999999 | |
| Forward VArh Initial | | 0 | | 0 | 999999999 | |
| Reverse VArh Initial | | 0 | | 0 | 999999999 | |
| Measurement mode | | PhsA, PhsB, PhsC | | | | |
| Pulse quantity | | 100000 | Wh/VArh | 1 | 10000000 | |
| Pulse on time | | 1,000 | s | 0,050 | 60,000 | |
| Pulse off time | | 0,500 | s | 0,050 | 60,000 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq A Hi high Lim | | 1,40 | xIn | 0,00 | 40,00 | |
| Ps Seq A high limit | | 1,20 | xIn | 0,00 | 40,00 | |
| Ps Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A deadband | | 2500 | | 100 | 100000 | |
| Ng Seq A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Ng Seq A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Ng Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A deadband | | 2500 | | 100 | 100000 | |
| Zro A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Zro A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Zro A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A deadband | | 2500 | | 100 | 100000 | |
| Ps Seq A on delay time | | 0 | ms | 0 | 1800000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Ps Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Zro A on delay time | | 0 | ms | 0 | 1800000 | |
| Zro A off delay time | | 0 | ms | 0 | 1800000 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq V Hi high Lim | | 1,40 | xUn | 0,00 | 4,00 | |
| Ps Seq V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| Ps Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V deadband | | 10000 | | 100 | 100000 | |
| Ng Seq V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Ng Seq V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Ng Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V deadband | | 10000 | | 100 | 100000 | |
| Zro V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Zro V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Zro V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V deadband | | 10000 | | 100 | 100000 | |
| Ps Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ps Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Zro V on delay time | | 0 | ms | 0 | 1800000 | |
| Zro V off delay time | | 0 | ms | 0 | 1800000 | |
| Demand metering: 0 | | | | | | |
| Demand metering | | | | | | |
| Demand interval | | 1 minute | | | | |
| A demand Av mode | | Linear | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Operation | | on | | | | |
| Trip pulse time | | 250 | ms | 20 | 60000 | |
| Trip output mode | | Non-latched | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Operation | | on | | | | |
| Acc stop current | | 10,00 | A | 5,00 | 500,00 | |
| Open alarm time | | 40 | ms | 0 | 200 | |
| Close alarm time | | 40 | ms | 0 | 200 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Opening time Cor | | 10 | ms | -100 | 100 | |
| Closing time Cor | | 10 | ms | -100 | 100 | |
| Spring charge time | | 15 | s | 0 | 60 | |
| Counter initial Val | | 0 | | 0 | 99999 | |
| Alarm Op number | | 200 | | 0 | 99999 | |
| Lockout Op number | | 300 | | 0 | 99999 | |
| Current exponent | | 2,00 | | 0,00 | 5,00 | |
| Difference Cor time | | 5 | ms | -10 | 10 | |
| Alm Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| LO Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| Ini Acc currents Pwr | | 0,00 | | 0,00 | 20000,00 | |
| Initial CB Rmn life | | 5000 | | 0 | 99999 | |
| Rated Op current | | 1000,00 | A | 100,00 | 6300,00 | |
| Rated fault current | | 5000,00 | A | 500,00 | 99999,00 | |
| Op number rated | | 10000 | | 1 | 99999 | |
| Op number fault | | 1000 | | 1 | 10000 | |
| Life alarm level | | 500 | | 0 | 99999 | |
| Pressure alarm time | | 10 | ms | 0 | 60000 | |
| Pres lockout time | | 10 | ms | 0 | 60000 | |
| Inactive Alm days | | 2000 | | 0 | 9999 | |
| Ini inactive days | | 0 | | 0 | 9999 | |
| Inactive Alm hours | | 0 | h | 0 | 23 | |
| Travel time Clc mode | | From Pos to Pos | | | | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Operation | | off | | | | |
| Operate delay time | | 3000 | ms | 1000 | 300000 | |
| Reset delay time | | 1000 | ms | 1000 | 60000 | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Operation | | on | | | | |
| Start value | | 0,05 | xIn | 0,05 | 0,50 | |
| Max operate current | | 1,50 | xIn | 1,00 | 5,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Operation | | off | | | | |
| Neg Seq current Lev | | 0,03 | xIn | 0,03 | 0,20 | |
| Neg Seq voltage Lev | | 0,10 | xUn | 0,03 | 0,20 | |
| Change rate enable | | False | | | | |
| Min Op voltage delta | | 0,50 | xUn | 0,01 | 1,00 | |
| Min Op current delta | | 0,10 | xIn | 0,01 | 1,00 | |
| Enable seal in | | False | | | | |
| Current dead Lin Val | | 0,05 | xIn | 0,05 | 1,00 | |
| Disturbance recorder | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| A1RADR: 1 | | | | | | |
| A1RADR | | | | | | |
| Analog channel 1 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 1 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 2 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 2 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 3 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 3 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 4 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 4 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 5 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 5 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 6 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 6 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 7 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 7 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 8 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 8 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 9 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 9 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 10 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 10 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 11 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 11 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 12 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 12 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| A2RADR: 13 | | | | | | |
| A2RADR | | | | | | |
| Analog channel 13 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 13 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 14 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 14 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 15 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 15 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 16 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 16 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 17 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 17 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 18 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 18 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 19 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 19 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 20 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 20 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 21 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 21 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 22 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 22 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 23 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 23 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 24 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 24 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| B1RBDR: 1 | | | | | | |
| B1RBDR | | | | | | |
| Binary channel 1 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 1 input | | | 64 characters | |
| Binary channel 2 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 2 input | | | 64 characters | |
| Binary channel 3 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 3 input | | | 64 characters | |
| Binary channel 4 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 4 input | | | 64 characters | |
| Binary channel 5 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 5 input | | | 64 characters | |
| Binary channel 6 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 6 input | | | 64 characters | |
| Binary channel 7 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 7 input | | | 64 characters | |
| Binary channel 8 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 8 input | | | 64 characters | |
| Binary channel 9 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 9 input | | | 64 characters | |
| Binary channel 10 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 10 input | | | 64 characters | |
| Binary channel 11 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 11 input | | | 64 characters | |
| Binary channel 12 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 12 input | | | 64 characters | |
| Binary channel 13 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 13 input | | | 64 characters | |
| Binary channel 14 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 14 input | | | 64 characters | |
| Binary channel 15 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 15 input | | | 64 characters | |
| Binary channel 16 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 16 input | | | 64 characters | |
| Binary channel 17 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 17 input | | | 64 characters | |
| Binary channel 18 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 18 input | | | 64 characters | |
| Binary channel 19 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 19 input | | | 64 characters | |
| Binary channel 20 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 20 input | | | 64 characters | |
| Binary channel 21 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 21 input | | | 64 characters | |
| Binary channel 22 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 22 input | | | 64 characters | |
| Binary channel 23 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 23 input | | | 64 characters | |
| Binary channel 24 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 24 input | | | 64 characters | |
| Binary channel 25 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 25 input | | | 64 characters | |
| Binary channel 26 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 26 input | | | 64 characters | |
| Binary channel 27 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 27 input | | | 64 characters | |
| Binary channel 28 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 28 input | | | 64 characters | |
| Binary channel 29 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 29 input | | | 64 characters | |
| Binary channel 30 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 30 input | | | 64 characters | |
| Binary channel 31 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 31 input | | | 64 characters | |
| Binary channel 32 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 32 input | | | 64 characters | |
| B2RBDR: 33 | | | | | | |
| B2RBDR | | | | | | |
| Binary channel 33 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 33 input | | | 64 characters | |
| Binary channel 34 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 34 input | | | 64 characters | |
| Binary channel 35 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 35 input | | | 64 characters | |
| Binary channel 36 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 36 input | | | 64 characters | |
| Binary channel 37 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 37 input | | | 64 characters | |
| Binary channel 38 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 38 input | | | 64 characters | |
| Binary channel 39 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 39 input | | | 64 characters | |
| Binary channel 40 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 40 input | | | 64 characters | |
| Binary channel 41 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 41 input | | | 64 characters | |
| Binary channel 42 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 42 input | | | 64 characters | |
| Binary channel 43 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 43 input | | | 64 characters | |
| Binary channel 44 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 44 input | | | 64 characters | |
| Binary channel 45 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 45 input | | | 64 characters | |
| Binary channel 46 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 46 input | | | 64 characters | |
| Binary channel 47 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 47 input | | | 64 characters | |
| Binary channel 48 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 48 input | | | 64 characters | |
| Binary channel 49 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 49 input | | | 64 characters | |
| Binary channel 50 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 50 input | | | 64 characters | |
| Binary channel 51 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 51 input | | | 64 characters | |
| Binary channel 52 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 52 input | | | 64 characters | |
| Binary channel 53 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 53 input | | | 64 characters | |
| Binary channel 54 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 54 input | | | 64 characters | |
| Binary channel 55 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 55 input | | | 64 characters | |
| Binary channel 56 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 56 input | | | 64 characters | |
| Binary channel 57 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 57 input | | | 64 characters | |
| Binary channel 58 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 58 input | | | 64 characters | |
| Binary channel 59 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 59 input | | | 64 characters | |
| Binary channel 60 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 60 input | | | 64 characters | |
| Binary channel 61 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 61 input | | | 64 characters | |
| Binary channel 62 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 62 input | | | 64 characters | |
| Binary channel 63 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 63 input | | | 64 characters | |
| Binary channel 64 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 64 input | | | 64 characters | |
| Fault record | | | | | | |
| FLTRFRC1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| FLTRFRC1 | | | | | | |
| Operation | | on | | | | |
| Trig mode | | From operate | | | | |
| A measurement mode | | DFT | | | | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Operation | | on | | | | |
| Mem. warning level | | 0 | % | 0 | 100 | |
| Mem. alarm level | | 0 | % | 0 | 100 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Off delay time 1 | | 500 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Off delay time 1 | | 0 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Pulse time 1 | | 150 | ms | 0 | 3600000 | |
| Pulse time 2 | | 150 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Pulse time 1 | | 0 | ms | 0 | 3600000 | |
| Pulse time 2 | | 0 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| General | | | | | | |
| Loc Rem restriction | | False | | | | |
| Output 1 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM CLOSE CMD (DIRECT) | | | 64 characters | |
| Output 2 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM OPEN CMD (DIRECT) | | | 64 characters | |
| Output 3 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | RESET ALARMS | | | 64 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Output 4 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 4 | | | 64 characters | |
| Output 5 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 5 | | | 64 characters | |
| Output 6 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 6 | | | 64 characters | |
| Output 7 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 7 | | | 64 characters | |
| Output 8 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 8 | | | 64 characters | |
| Output 9 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 9 | | | 64 characters | |
| Output 10 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 10 | | | 64 characters | |
| Output 11 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 11 | | | 64 characters | |
| Output 12 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 12 | | | 64 characters | |
| Output 13 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | SPCGAPC1 Output 13 | | | 64 characters | |
| Output 14 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 14 | | | 64 characters | |
| Output 15 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | EMERGENCY | | | 64 characters | |
| Output 16 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 16 | | | 64 characters | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC1 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC1 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC1 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC1 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC1 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC1 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC1 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC1 Q8 | | | 20 characters | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC2 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC2 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC2 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC2 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC2 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC2 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC2 Q7 | | | 20 characters | |
| Output 8 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC2 Q8 | | | 20 characters | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC3 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC3 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC3 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC3 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC3 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC3 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC3 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC3 Q8 | | | 20 characters | |
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC4 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC4 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC4 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC4 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC4 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC4 Q6 | | | 20 characters | |
| Output 7 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC4 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC4 Q8 | | | 20 characters | |
| General: 0 | | | | | | |
| General | | | | | | |
| Software reset | | Cancel | | | | |
| HMI: 0 | | | | | | |
| HMI | | | | | | |
| FB naming convention | | IEC61850 | | | | |
| Backlight timeout | | 3 | min | 1 | 60 | |
| Web HMI mode | | On | | | | |
| HMI timeout | | 15 | min | 1 | 60 | |
| SLD symbol format | | IEC | | | | |
| Setting visibility | | Advanced | | | | |
| User defined name | | Disabled | | | | |
| Time: 0 | | | | | | |
| Time | | | | | | |
| System time | | | | | | |
| Time format | | 24H:MM:SS:MS | | | | |
| Date format | | DD.MM.YYYY | | | | |
| Date | | 0 | | | 20 characters | |
| Time | | 0 | | | 20 characters | |
| Local time offset | | 0 | min | -840 | 840 | |
| Daylight saving time | | | | | | |
| DST in use | | True | | | | |
| DST on time (hours) | | 2 | h | 0 | 23 | |
| DST on time (minutes) | | 0 | min | 0 | 59 | |
| DST on date (day) | | 1 | | 1 | 31 | |
| DST on date (month) | | May | | | | |
| DST on day (weekday) | | reserved | | | | |
| DST off time (hours) | | 2 | h | 0 | 23 | |
| DST off time (minutes) | | 0 | min | 0 | 59 | |
| DST off date (day) | | 25 | | 1 | 31 | |
| DST off date (month) | | September | | | | |
| DST off day (weekday) | | reserved | | | | |
| DST offset | | 60 | min | -720 | 720 | |
| SNTP | | | | | | |
| IP SNTP primary | | 192.168.2.166 | | | | |
| IP SNTP secondary | | 192.168.2.165 | | | | |
| Synchronization | | | | | | |
| Synch source | | SNTP | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PTP Profile | | IEEE C37.238-2011 | | | | |
| PTP domain ID | | 0 | | 0 | 255 | |
| PTP priority 1 | | 128 | | 0 | 255 | |
| PTP priority 2 | | 128 | | 0 | 255 | |
| PTP Slave-only | | False | | | | |
| Time master mode | | Master with finite holdover | | | | |
| Clear clock list | | False | | | | |
| Time Syn Src Tmm | | 3 | min | 1 | 65535 | |
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |
| SG operation mode | | Operator | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LHMI | | | | | | |
| Close delay mode | | Not in use | | | | |
| Close delay | | 60 | s | 5 | 900 | |
| Breaker operation | | After confirmation | | | | |
| Programmable LEDs: 1 | | | | | | |
| Programmable LEDs | | | | | | |
| General | | | | | | |
| Alarm colour | | Red | | | | |
| LED 1 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 27/59 Voltage Protection | | | 64 characters | |
| LED 2 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Ready | | | 64 characters | |
| LED 3 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Synchrocheck | | | 64 characters | |
| LED 4 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Ready to close | | | 64 characters | |
| LED 5 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 50/51 Current Protection | | | 64 characters | |
| LED 6 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Alarm mode | | Follow-S | | | | |
| Description | | 51N/59N Earth Fault Protection | | | 64 characters | |
| LED 7 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Earthing Switch Unlocked | | | 64 characters | |
| LED 8 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Truck Unlocked | | | 64 characters | |
| LED 9 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Arc Protection Trip | | | 64 characters | |
| LED 10 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | GOOSE Alarm | | | 64 characters | |
| LED 11 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Emergency Open by SIS | | | 64 characters | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| LED 12 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Space Heater ON | | | 64 characters | |
| LED 13 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Transformer Protections | | | 64 characters | |
| LED 14 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Fuses Trip | | | 64 characters | |
| LED 15 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Trip from LV | | | 64 characters | |
| LED 16 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 17 | | | | | | |
| Alarm mode | | Follow-S | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | - | | | 64 characters | |
| LED 18 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 19 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 20 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 21 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 22 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| I/O modules: 0 | | | | | | |
| I/O modules | | | | | | |
| Common settings | | | | | | |
| Slot specific threshold | | False | | | | |
| Slot specific hysteresis | | False | | | | |
| Input threshold voltage | | 16 | Vdc | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input osc. level | | 30 | events/s | 2 | 50 | |
| Input osc. hyst | | 10 | events/s | 2 | 50 | |
| User Activity log: 0 | | | | | | |
| User Activity log | | | | | | |
| Server Settings 1 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address | | 192.168.2.5 | | | | |
| Server Settings 2 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address2 | | 192.168.2.6 | | | | |
| Authorization: 1 | | | | | | |
| Authorization | | | | | | |
| Security | | | | | | |
| Remote Update | | Disable | | | | |
| Passwords | | | | | | |
| Remote override | | True | | | | |
| Local override | | True | | | | |
| CAM | | | | | | |
| Clear AD userlist | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Network1 | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |
| HTTPS write access | | On | | | | |
| HMI | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |
| Monitoring | | | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CHLIV_A | | False | | | | |
| REDCHLIV_B | | False | | | | |
| Link statuses | | | | | | |
| LNKLIV_A | | False | | | | |
| REDLNKLIV_B | | False | | | | |
| Diagnostics | | | | | | |
| A_B | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CH1LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK1LIV | | False | | | | |
| Diagnostics | | | | | | |
| X1 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Activity | | | | | | |
| CH2LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK2LIV | | False | | | | |
| Diagnostics | | | | | | |
| X2 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Activity | | | | | | |
| CH3LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK3LIV | | False | | | | |
| Diagnostics | | | | | | |
| X3 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| HMILCCH1: 1 | | | | | | |
| HMILCCH1 | | | | | | |
| Activity | | | | | | |
| HMICHLIV | | False | | | | |
| Link statuses | | | | | | |
| HMILNKLIV | | Down | | | | |
| SCHLCCH6: 6 | | | | | | |
| SCHLCCH6 | | | | | | |
| Activity | | | | | | |
| CH6LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK6LIV | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Diagnostics | | | | | | |
| X6 | | | | | | |
| Temperature | | 0,0 | °C | -128,0 | 128,0 | |
| Voltage | | 0,000 | V | 0,000 | 6,550 | |
| Bias current | | 0,0 | mA | 0,0 | 131,0 | |
| TX power | | 0,000 | mW | 0,000 | 6,550 | |
| RX power | | 0,000 | mW | 0,000 | 6,550 | |
| XCVR detected | | False | | | | |
| RX power alarm | | False | | | | |
| TX power alarm | | False | | | | |
| Voltage alarm | | False | | | | |
| Temperature alarm | | False | | | | |
| Part name | | 0 | | | 20 characters | |
| Protocols | | | | | | |
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| CHLIV | | False | | | | |
| Successful conn. | | 0 | | 0 | 10000000 | |
| Failed conn. | | 0 | | 0 | 10000000 | |
| Concludes | | 0 | | 0 | 10000000 | |
| Sent aborts | | 0 | | 0 | 10000000 | |
| Recv. aborts | | 0 | | 0 | 10000000 | |
| Sent rejects | | 0 | | 0 | 10000000 | |
| Recv. requests | | 0 | | 0 | 10000000 | |
| Failed requests | | 0 | | 0 | 10000000 | |
| Reads | | 0 | | 0 | 10000000 | |
| Failed reads | | 0 | | 0 | 10000000 | |
| Writes | | 0 | | 0 | 10000000 | |
| Failed writes | | 0 | | 0 | 10000000 | |
| Reports | | 0 | | 0 | 10000000 | |
| Active conn. | | 0 | | 0 | 10000000 | |
| Reset counters | | False | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT2: 2 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| MEM_WARN | | False | | | | |
| MEM_ALARM | | False | | | | |
| I/O status | | | | | | |
| Binary input values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Slot D (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| TCS Input 1 | | False | | | | |
| TCS Input 2 | | False | | | | |
| Binary output values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Output 1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Output 9 | | False | | | | |
| Output 10 | | False | | | | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (Uo): 1 | | | | | | |
| Voltage (Uo) | | | | | | |
| URES_ALARM | | False | | | | |
| URES_WARNING | | False | | | | |
| Voltage (UoB): 2 | | | | | | |
| Voltage (UoB) | | | | | | |
| URES_ALARM | | False | | | | |
| URES_WARNING | | False | | | | |
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (3UB): 2 | | | | | | |
| Voltage (3UB) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| I_INST_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_A | | normal | | | | |
| I_INST_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_B | | normal | | | | |
| I_INST_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_C | | normal | | | | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I_INST_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_RES | | normal | | | | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U_INST_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_RES | | normal | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Outputs | | | | | | |
| I2_HIGH_AL | | False | | | | |
| I2_HIGH_WARN | | False | | | | |
| I1_HIGH_AL | | False | | | | |
| I1_HIGH_WARN | | False | | | | |
| I1_LOW_WARN | | False | | | | |
| I1_LOW_AL | | False | | | | |
| I0_HIGH_AL | | False | | | | |
| I0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I2_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I2_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_RANGE | | normal | | | | |
| I1_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I1_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_RANGE | | normal | | | | |
| I0_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I0_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_RANGE | | normal | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Outputs | | | | | | |
| U2_HIGH_AL | | False | | | | |
| U2_HIGH_WARN | | False | | | | |
| U1_HIGH_AL | | False | | | | |
| U1_HIGH_WARN | | False | | | | |
| U1_LOW_WARN | | False | | | | |
| U1_LOW_AL | | False | | | | |
| U0_HIGH_AL | | False | | | | |
| U0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U2_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U2_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_RANGE | | normal | | | | |
| U1_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U1_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_RANGE | | normal | | | | |
| U0_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U0_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_RANGE | | normal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Inputs | | | | | | |
| RSTACM | | False | | | | |
| Monitored data | | | | | | |
| S_INST | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DB | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DMD | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P_INST | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DB | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DMD | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q_INST | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DB | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DMD | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF_INST | | 0,00 | | -1,00 | 1,00 | |
| PF_DB | | 0,00 | | -1,00 | 1,00 | |
| PF_DMD | | 0,00 | | -1,00 | 1,00 | |
| EA_RV_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_RV_ACM | | 0 | kVArh | 0 | 999999999 | |
| EA_FWD_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_FWD_ACM | | 0 | kVArh | 0 | 999999999 | |
| FMMXU1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| f(1) | | | | | | |
| Monitored data | | | | | | |
| F_INST | | 50,00 | Hz | 35,00 | 75,00 | |
| F_DB | | 50,00 | Hz | 35,00 | 75,00 | |
| F_RANGE | | normal | | | | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| IN9 | | False | | | | |
| IN10 | | False | | | | |
| IN11 | | False | | | | |
| IN12 | | False | | | | |
| IN13 | | False | | | | |
| IN14 | | False | | | | |
| IN15 | | False | | | | |
| IN16 | | False | | | | |
| Outputs | | | | | | |
| O1 | | False | | | | |
| O2 | | False | | | | |
| O3 | | False | | | | |
| O4 | | False | | | | |
| O5 | | False | | | | |
| O6 | | False | | | | |
| O7 | | False | | | | |
| O8 | | False | | | | |
| O9 | | False | | | | |
| O10 | | False | | | | |
| O11 | | False | | | | |
| O12 | | False | | | | |
| O13 | | False | | | | |
| O14 | | False | | | | |
| O15 | | False | | | | |
| O16 | | False | | | | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Inputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Inputs | | | | | | |
| ENA_OPEN | | True | | | | |
| ENA_CLOSE | | True | | | | |
| BLK_OPEN | | False | | | | |
| BLK_CLOSE | | False | | | | |
| SYNC_OK | | True | | | | |
| SYNC_BYPASS | | False | | | | |
| ITL_BYPASS | | False | | | | |
| Outputs | | | | | | |
| SELECTED | | False | | | | |
| EXE_OP | | False | | | | |
| EXE_CL | | False | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| OPEN_ENAD | | False | | | | |
| CLOSE_ENAD | | False | | | | |
| CTL_ITL_BLKD | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Outputs | | | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Outputs | | | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| CL_COMMAND | | False | | | | |
| BYPASS | | False | | | | |
| Outputs | | | | | | |
| SYNC_INPRO | | False | | | | |
| SYNC_OK | | False | | | | |
| CL_FAIL_AL | | False | | | | |
| CMD_FAIL_AL | | False | | | | |
| LLDB | | False | | | | |
| LLLB | | False | | | | |
| DLLB | | False | | | | |
| DLDB | | False | | | | |
| Monitored data | | | | | | |
| ENERG_STATE | | Unknown | | | | |
| U_DIFF_MEAS | | 0,00 | xUn | -3,00 | 3,00 | |
| FR_DIFF_MEAS | | 0,000 | xFn | -1,500 | 1,500 | |
| PH_DIFF_MEAS | | 0,00 | deg | -180,00 | 180,00 | |
| U_DIFF_SYNC | | False | | | | |
| PH_DIF_SYNC | | False | | | | |
| FR_DIFF_SYNC | | False | | | | |
| Current protection | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 67-1; DPHLPDOC1: 1 | | | | | | |
| 3I>->(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| NON_DIR | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| FAULT_DIR | | unknown | | | | |
| DIRECTION | | unknown | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| DIR_A | | unknown | | | | |
| DIR_B | | unknown | | | | |
| DIR_C | | unknown | | | | |
| ANGLE_A | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_B | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_C | | 0,00 | deg | -180,00 | 180,00 | |
| VMEM_USED | | False | | | | |
| 67-2; DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| NON_DIR | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| FAULT_DIR | | unknown | | | | |
| DIRECTION | | unknown | | | | |
| Monitored data | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| DIR_A | | unknown | | | | |
| DIR_B | | unknown | | | | |
| DIR_C | | unknown | | | | |
| ANGLE_A | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_B | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_C | | 0,00 | deg | -180,00 | 180,00 | |
| VMEM_USED | | False | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| BLK2H | | False | | | | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Voltage protection | | | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Inputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59-2; PHPTOV2: 2 | | | | | | |
| 3U>(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| START | | False | | | | |
| POSCLOSE | | False | | | | |
| CB_FAULT | | False | | | | |
| Outputs | | | | | | |
| CB_FAULT_AL | | False | | | | |
| TRBU | | False | | | | |
| TRRET | | False | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ARC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| OPERATE | | False | | | | |
| RST_LKOUT | | False | | | | |
| Outputs | | | | | | |
| TRIP | | False | | | | |
| CL_LKOUT | | False | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| POSOPEN | | False | | | | |
| POSCLOSE | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OPEN_CB_EXE | | False | | | | |
| CLOSE_CB_EXE | | False | | | | |
| PRES_ALM_IN | | False | | | | |
| PRES_LO_IN | | False | | | | |
| RST_IPOW | | False | | | | |
| RST_CB_WEAR | | False | | | | |
| RST_TRV_T | | False | | | | |
| RST_SPR_T | | False | | | | |
| Outputs | | | | | | |
| TRV_T_OP_ALM | | False | | | | |
| TRV_T_CL_ALM | | False | | | | |
| SPR_CHR_ALM | | False | | | | |
| OPR_ALM | | False | | | | |
| OPR_LO | | False | | | | |
| IPOW_ALM | | False | | | | |
| IPOW_LO | | False | | | | |
| CB_LIFE_ALM | | False | | | | |
| MON_ALM | | False | | | | |
| PRES_ALM | | False | | | | |
| PRES_LO | | False | | | | |
| OPENPOS | | False | | | | |
| INVALIDPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| Monitored data | | | | | | |
| T_TRV_OP | | 0 | ms | 0 | 60000 | |
| T_TRV_CL | | 0 | ms | 0 | 60000 | |
| T_SPR_CHR | | 0,00 | s | 0,00 | 99,99 | |
| NO_OPR | | 0 | | 0 | 99999 | |
| INA_DAYS | | 0 | | 0 | 9999 | |
| CB_LIFE_A | | 0 | | -99999 | 99999 | |
| CB_LIFE_B | | 0 | | -99999 | 99999 | |
| CB_LIFE_C | | 0 | | -99999 | 99999 | |
| IPOW_A | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_B | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_C | | 0,000 | | 0,000 | 30000,000 | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| FAIL | | False | | | | |
| ALARM | | False | | | | |
| Monitored data | | | | | | |
| IDIFF | | 0,00 | xIn | 0,00 | 40,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| CB_CLOSED | | False | | | | |
| DISCON_OPEN | | False | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| FUSEF_3PH | | False | | | | |
| FUSEF_U | | False | | | | |
| Communication | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| Monitoring | | | | | | |
| Reset counters | | False | | | | |
| Received msgs | | 0 | | 0 | 10000000 | |
| Transmitted msgs | | 0 | | 0 | 10000000 | |
| State changes | | 0 | | 0 | 10000000 | |
| SeqNum changes | | 0 | | 0 | 10000000 | |
| Test msgs | | 0 | | 0 | 10000000 | |
| State warnings | | 0 | | 0 | 10000000 | |
| Seq. warnings | | 0 | | 0 | 10000000 | |
| Recv. timeouts | | 0 | | 0 | 10000000 | |
| ConfRev errors | | 0 | | 0 | 10000000 | |
| NdsComm errors | | 0 | | 0 | 10000000 | |
| Dataset errors | | 0 | | 0 | 10000000 | |
| Replay Prot warnings | | 0 | | 0 | 10000000 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| FB status | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>>>(1) | | on | | | | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>(1) | | on | | | | |
| 67-1; DPHLPDOC1: 1 | | | | | | |
| 3I>->(1) | | | | | | |
| Current protection | | | | | | |
| 3I>->(1) | | on | | | | |
| 67-2; DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| Current protection | | | | | | |
| 3I>->(2) | | on | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Current protection | | | | | | |
| 3I2f>(1) | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Current protection | | | | | | |
| Io>(1) | | on | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U>(1) | | on | | | | |
| 59-2; PHPTOV2: 2 | | | | | | |
| 3U>(2) | | | | | | |
| Voltage protection | | | | | | |
| 3U>(2) | | on | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U<(1) | | on | | | | |
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Voltage protection | | | | | | |
| 3U<(2) | | on | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Voltage protection | | | | | | |
| Uo>(1) | | on | | | | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Voltage protection | | | | | | |
| Uo>(2) | | on | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Other protection | | | | | | |
| 3I>/Io>BF(1) | | on | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Other protection | | | | | | |
| ARC(1) | | on | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Other protection | | | | | | |
| ARC(2) | | on | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Other protection | | | | | | |
| ARC(3) | | on | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Control | | | | | | |
| SYNC(1) | | on | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Trip logic | | | | | | |
| Master Trip(1) | | on | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Condition monitoring | | | | | | |
| CBCM(1) | | on | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Supervision | | | | | | |
| TCS(1) | | on | | | | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Supervision | | | | | | |
| MCS 3I(1) | | on | | | | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Supervision | | | | | | |
| FUSEF(1) | | on | | | | |
| Recorded data | | | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Max demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand IL1 | | 0 | | | 34 characters | |
| Time max demand IL2 | | 0 | | | 34 characters | |
| Time max demand IL3 | | 0 | | | 34 characters | |
| Time min demand IL1 | | 0 | | | 34 characters | |
| Time min demand IL2 | | 0 | | | 34 characters | |
| Time min demand IL3 | | 0 | | | 34 characters | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Max demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand Io | | 0 | | | 34 characters | |
| Time min demand Io | | 0 | | | 34 characters | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Max demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Min demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Max demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Min demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Max demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Min demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Time max dmd S | | 0 | | | 34 characters | |
| Time min dmd S | | 0 | | | 34 characters | |
| Time max dmd P | | 0 | | | 34 characters | |
| Time min dmd P | | 0 | | | 34 characters | |
| Time max dmd Q | | 0 | | | 34 characters | |
| Time min dmd Q | | 0 | | | 34 characters | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault record | | | | | | |
| Fault number | | 0 | | 0 | 999999 | |
| Time and date | | 0 | | | 34 characters | |
| Protection (rec. set 1) | | None | | | | |
| Protection (rec. set 2) | | None | | | | |
| Start duration | | 0,00 | % | 0,00 | 100,00 | |
| Operate time | | 0,000 | s | 0,000 | 999999,999 | |
| Breaker clear time | | 0,000 | s | 0,000 | 3,000 | |
| Fault distance | | 0,00 | pu | 0,00 | 3000,00 | |
| Fault resistance | | 0,00 | ohm | 0,00 | 3000,00 | |
| Fault reactance | | 0,00 | ohm | 0,00 | 3000,00 | |
| Active group | | 1 | | 1 | 6 | |
| Shot pointer | | 1 | | 1 | 7 | |
| Max diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Diff current Io:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Bias current Io:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Voltage UL1:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage Ps-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL12:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL23:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL31:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| PTTR thermal level | | 0,00 | | 0,00 | 99,99 | |
| I2/I1>(1) rat. I2/I1 | | 0,00 | % | 0,00 | 999,99 | |
| Frequency:1 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:1 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:2 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:2 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:3 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:3 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Conductance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Susceptance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Angle Uo:1 - Io:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:1- IL1:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:1 - IL2:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:1 - IL3:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:2 - Io:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:2 - IL1:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:2 - IL2:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:2 - IL3:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:3 - Io:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:3 - IL1:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:3 - IL2:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:3 - IL3:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Control command | | | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LR state | | Remote | | | | |
| Detached LHMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| CONNECTION | | False | | | | |
| Service port IP address | | 0 | | | 20 characters | |
| Main unit port IP address | | 0 | | | 20 characters | |
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| SG_LOGIC_SEL | | False | | | | |
| SG_1_ACT | | False | | | | |
| SG_2_ACT | | False | | | | |
| SG_3_ACT | | False | | | | |
| SG_4_ACT | | False | | | | |
| SG_5_ACT | | False | | | | |
| SG_6_ACT | | False | | | | |
| Programmable LEDs: 1 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 1 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 2 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 3 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 4 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 5 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 6 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 7 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 8 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 9 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| RESET | | False | | | | |
| LED 10 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 11 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 1 | | None | | | | |
| Programmable LED 2 | | None | | | | |
| Programmable LED 3 | | None | | | | |
| Programmable LED 4 | | None | | | | |
| Programmable LED 5 | | None | | | | |
| Programmable LED 6 | | None | | | | |
| Programmable LED 7 | | None | | | | |
| Programmable LED 8 | | None | | | | |
| Programmable LED 9 | | None | | | | |
| Programmable LED 10 | | None | | | | |
| Programmable LED 11 | | None | | | | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 12 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 13 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 14 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 15 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 16 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 17 | | | | | | |
| OK | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 18 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 19 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 20 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 21 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 22 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 12 | | None | | | | |
| Programmable LED 13 | | None | | | | |
| Programmable LED 14 | | None | | | | |
| Programmable LED 15 | | None | | | | |
| Programmable LED 16 | | None | | | | |
| Programmable LED 17 | | None | | | | |
| Programmable LED 18 | | None | | | | |
| Programmable LED 19 | | None | | | | |
| Programmable LED 20 | | None | | | | |
| Programmable LED 21 | | None | | | | |
| Programmable LED 22 | | None | | | | |
| IED status: 1 | | | | | | |
| IED status | | | | | | |
| CAM | | | | | | |
| UAM mode | | Local | | | | |
| CAM server1 | | Offline | | | | |
| CAM server2 | | Offline | | | | |
| Replication | | N.A. | | | | |
| Last update | | 0 | | | 34 characters | |
| PKI | | | | | | |
| CA Server Status | | Offline | | | | |
| Time synchronization | | | | | | |
| PTP P2P delay X1 | | 0 | ns | -2147483648 | 2147483647 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PTP P2P delay X2 | | 0 | ns | -2147483648 | 2147483647 | |
| PTP P2P delay X3 | | 0 | ns | -2147483648 | 2147483647 | |
| Self-supervision | | | | | | |
| Warning | | All ok | | | | |
| Internal Fault | | All ok | | | | |
| Boot up time | | 0 | | | 34 characters | |
| Boot up reason | | None | | | | |
| Device state | | on | | | | |
| Composition changes | | | | | | |
| No of comp. changes | | 0 | | 0 | 100000 | |
| Setting changes | | | | | | |
| Setting changes | | 0 | | 0 | 20000 | |
| Setting time | | 0 | | | 34 characters | |
| SMV accuracy | | | | | | |
| SMV Synch accuracy | | InternalClock | | | | |
| Local synch accuracy | | 0 | us | 0 | 1000000000 | |
| Max Dev synch Acc | | 0 | us | 0 | 1000000000 | |
| Information | | | | | | |
| HW modules | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot E (AIM): 1 | | | | | | |
| Slot E (AIM) | | | | | | |
| Article number | | 0 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot F (AIM): 1 | | | | | | |
| Slot F (AIM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | - | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | - | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Detached LHMI | | | | | | |
| Article number | | 0 | | | 20 characters | |
| Application version | | 0 | | | 20 characters | |
| Firmware version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Service port MAC address | | 0 | | | 20 characters | |
| Main unit port MAC address | | 0 | | | 20 characters | |
| Slot A1 (ARC): 1 | | | | | | |
| Slot A1 (ARC) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot A2 (COM): 1 | | | | | | |
| Slot A2 (COM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Product identifiers: 0 | | | | | | |
| Product identifiers | | | | | | |
| Type | | REX640 | | | 20 characters | |
| Product version | | 0 | | | 64 characters | |
| Serial number | | 1XXXXXXXXXXX | | | 20 characters | |
| Production date | | 0 | | | 34 characters | |
| SW version | | X.X | | | 20 characters | |
| SW date | | 0 | | | 34 characters | |
| SW number | | 2RCA057448A | | | 20 characters | |
| Interface level | | 0 | | | 64 characters | |
| Order code | | XXXXXXXXXXXXXXXXX | | | 20 characters | |
| Site identifiers: 0 | | | | | | |
| Site identifiers | | | | | | |
| Customer name | | 0 | | | 20 characters | |
| Street | | 0 | | | 20 characters | |
| House number | | 0 | | | 20 characters | |
| ZIP/Postal code | | 0 | | | 20 characters | |
| City/Province | | 0 | | | 20 characters | |
| State | | 0 | | | 20 characters | |
| Country | | 0 | | | 20 characters | |
| System identifiers: 0 | | | | | | |
| System identifiers | | | | | | |
| Technical key | | TIGER | | | 20 characters | |
| IEC 61850 version | | Edition 2 | | | 24 characters | |
| Engineering model | | ABB | | | | |
| HW modules: 0 | | | | | | |
| HW modules | | | | | | |
| Main board | | | | | | |
| Article number | | 2RAAXXXXXX | | | 20 characters | |
| SW version | | A | | | 20 characters | |
| HW revision | | X | | | 20 characters | |
| Serial number | | 1XXXXXXXXXXX | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Clear | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Disturbance records | | Cancel | | | | |
| Clear: 0 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Clear | | | | | | |
| Indications and LEDs | | Cancel | | | | |
| Programmable LEDs | | Cancel | | | | |
| Events | | Cancel | | | | |
| Metering records | | Cancel | | | | |
| Power quality data | | Cancel | | | | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault records | | Cancel | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Load Profile record | | Cancel | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Master Trip(1) | | Cancel | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| CBCM(1) acc.energy | | Cancel | | | | |
| CBCM(1) rem.life | | Cancel | | | | |
| CBCM(1) travel times | | Cancel | | | | |
| CBCM(1) spr.charge t | | Cancel | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| P,E(1) acc.energy | | Cancel | | | | |
| Application Configuration | | | | | | |
| General | | | | | | |
| Settings | | | | | | |
| Setting group | | | | | | |
| Protection: 0 | | | | | | |
| Setting group | | | | | | |
| Active group | | 1 | | 1 | 6 | |
| Protection | | | | | | |
| Settings | | | | | | |
| Current protection | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 4,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 4,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 4,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 4,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 4,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 4,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Minimum operate time | | 250 | ms | 20 | 60000 | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 50000,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 6,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,20 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,20 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 3 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,20 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,20 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,20 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| 67-1; DPHLPDOC1: 1 | | | | | | |
| 3I>->(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| Allow Non Dir | | False | | | | |
| Min operate current | | 0,010 | xIn | 0,010 | 1,000 | |
| Min operate voltage | | 0,010 | xUn | 0,010 | 1,000 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| 67-2; DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| Allow Non Dir | | False | | | | |
| Min operate current | | 0,010 | xIn | 0,010 | 1,000 | |
| Min operate voltage | | 0,010 | xUn | 0,010 | 1,000 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Operation | | off | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 2 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 3 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 4 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 5 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 6 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage protection | | | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 59-2; PHPTOV2: 2 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 3U>(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operating curve type | | IEC Def. Time | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage block value | | 0,20 | xUn | 0,05 | 1,00 | |
| Enable block value | | True | | | | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| settingGroup 6 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage block value | | 0,20 | xUn | 0,05 | 1,00 | |
| Enable block value | | True | | | | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 4 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Operation | | off | | | | |
| Current value | | 0,300 | xIn | 0,050 | 2,000 | |
| Current value Res | | 0,30 | xIn | 0,05 | 2,00 | |
| CB failure trip mode | | 1 out of 3 | | | | |
| CB failure mode | | Current | | | | |
| CB fail retrip mode | | Off | | | | |
| Retrip time | | 120 | ms | 0 | 60000 | |
| CB failure delay | | 240 | ms | 0 | 60000 | |
| CB fault delay | | 5000 | ms | 0 | 60000 | |
| Measurement mode | | Peak-to-Peak | | | | |
| Trip pulse time | | 200 | ms | 0 | 60000 | |
| Start latching mode | | Rising edge | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Control | | | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |
| Operation | | on | | | | |
| Synchro check mode | | Asynchronous | | | | |
| Control mode | | Continuous | | | | |
| Dead line value | | 0,1 | xUn | 0,1 | 0,8 | |
| Live line value | | 0,5 | xUn | 0,2 | 1,0 | |
| Dead bus value | | 0,1 | xUn | 0,1 | 0,8 | |
| Live bus value | | 0,5 | xUn | 0,2 | 1,0 | |
| Max energizing V | | 1,11 | xUn | 0,50 | 1,15 | |
| Phase shift | | 0 | deg | -180 | 180 | |
| Minimum Syn time | | 10000 | ms | 0 | 60000 | |
| Energizing time | | 100 | ms | 100 | 60000 | |
| Closing time of CB | | 50 | ms | 40 | 250 | |
| Voltage source switch | | False | | | | |
| settingGroup 1 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 2 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 3 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 4 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 5 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 6 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |

*Settings*

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| REX640_A3 | | | | | | |
| IED Configuration | | | | | | |
| HW Configuration | | | | | | |
| Slot B (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot C (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot D (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| POSITION | | intermediate | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| TRIG 1 | | False | | | | |
| TRIG 2 | | False | | | | |
| TRIG 3 | | False | | | | |
| TRIG 4 | | False | | | | |
| TRIG 5 | | False | | | | |
| TRIG 6 | | False | | | | |
| TRIG 7 | | False | | | | |
| TRIG 8 | | False | | | | |
| TRIG 9 | | False | | | | |
| TRIG 10 | | False | | | | |
| TRIG 11 | | False | | | | |
| TRIG 12 | | False | | | | |
| TRIG 13 | | False | | | | |
| TRIG 14 | | False | | | | |
| TRIG 15 | | False | | | | |
| TRIG 16 | | False | | | | |
| Measurements | | | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| S-kVA:1 | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P-kW:1 | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q-kVAr:1 | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF:1 | | 0,00 | | -1,00 | 1,00 | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| IL1-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL2-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL3-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Io-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESVMMXU1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Uo(1) | | | | | | |
| Uo-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| U12-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| UL1-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL2-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL3-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| U12-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| UL1-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL2-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL3-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| f-Hz:1 | | 50,00 | Hz | 35,00 | 75,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| NgSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| PsSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| ZrSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| NgSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| PsSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| ZrSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| Disturbance records | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Number of recordings | | 0 | | 0 | 100 | |
| Rem. amount of rec. | | 0 | | 0 | 100 | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| Trig recording | | Cancel | | | | |
| Time to trigger | | 0 | s | 0 | 604800 | |
| Configuration | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| General | | | | | | |
| Operation | | on | | | | |
| Record length | | 50 | cycles | 10 | 500 | |
| Pre-trg length | | 50 | % | 0 | 100 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Overwrite | | | | |
| Exclusion time | | 0 | ms | 0 | 1000000 | |
| Storage rate | | 32 samples / cycle | | | | |
| Periodic trig time | | 0 | s | 0 | 604800 | |
| Stor. mode periodic | | Waveform | | | | |
| Stor. mode manual | | Waveform | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Operation | | on | | | | |
| Select timeout | | 30000 | ms | 10000 | 300000 | |
| Pulse length | | 200 | ms | 10 | 60000 | |
| Operation counter | | 0 | | 0 | 99999 | |
| Control model | | sbo-with-enhanced-security | | | | |
| Adaptive pulse | | True | | | | |
| Event delay | | 200 | ms | 0 | 10000 | |
| Operation timeout | | 500 | ms | 10 | 6000000 | |
| Interlocking Pls Len | | 2 | s | 1 | 10 | |
| Identification | | CBXCBR1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| General: 0 | | | | | | |
| Control | | | | | | |
| General | | | | | | |
| LR control | | Binary input | | | | |
| Station authority | | L,R | | | | |
| Control mode | | On | | | | |
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | DCSXSWI1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | ESSXSWI1 switch position | | | 255 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| System | | | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| Rated frequency | | 50Hz | | | | |
| Phase rotation | | ABC | | | | |
| Blocking mode | | Freeze timer | | | | |
| Bay name | | REX640_A3 | | | 20 characters | |
| IDMT Sat point | | 50 | I/I> | 10 | 50 | |
| Frequency adaptivity | | Disable | | | | |
| SMV Max Delay | | 3/3 ms | | | | |
| Test mode selection | | Local | | | | |
| HMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Backlight brightness | | 100 | % | 1 | 100 | |
| Enable USB access | | No | | | | |
| Enable HMI service port | | Yes | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| Rate Limiter: 1 | | | | | | |
| Rate Limiter | | | | | | |
| Rate limiter | | | | | | |
| Rate limit ctrl | | False | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Redundancy | | | | | | |
| Redundant mode | | None | | | | |
| Filter | | | | | | |
| Filter mode A_B | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit A_B | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit A_B | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit A_B | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Port modes | | | | | | |
| Port mode X1 | | On | | | | |
| Filter | | | | | | |
| Filter mode X1 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X1 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X1 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X1 | | 8,000 | | 0,512 | 90,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Port modes | | | | | | |
| Port mode X2 | | On | | | | |
| Filter | | | | | | |
| Filter mode X2 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X2 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X2 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X2 | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Port modes | | | | | | |
| Port mode X3 | | On | | | | |
| Filter | | | | | | |
| Filter mode X3 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X3 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X3 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X3 | | 8,000 | | 0,512 | 90,000 | |
| Network1: 1 | | | | | | |
| Network1 | | | | | | |
| Network1 address | | | | | | |
| IP address | | 192.168.10.7 | | | | |
| Subnet mask | | 255.255.255.224 | | | | |
| Default gateway | | 192.168.10.30 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| Network2: 2 | | | | | | |
| Network2 | | | | | | |
| Network2 address | | | | | | |
| Enable | | False | | | | |
| IP address | | 192.168.3.10 | | | | |
| Subnet mask | | 255.255.255.0 | | | | |
| Default gateway | | 0.0.0.0 | | | 16 characters | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| HMI: 1 | | | | | | |
| HMI | | | | | | |
| HMI address | | | | | | |
| IP address | | 192.168.0.254 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Protocols | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| GOOSE | | | | | | |
| Change det. interval | | 500 | ms | 50 | 1000 | |
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| MMS | | | | | | |
| Unit mode | | Nominal | | | | |
| Network1 | | | | | | |
| MMS | | On | | | | |
| HMI port | | | | | | |
| MMS | | On | | | | |
| FTPLPRT1: 1 | | | | | | |
| FTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| FTP | | Secure | | | | |
| HMI port | | | | | | |
| FTP | | Secure | | | | |
| HTTPLPRT1: 1 | | | | | | |
| HTTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| HTTPS | | On | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Network1 | | | | | | |
| Modbus | | On | | | | |
| MBSLPRT2: 2 | | | | | | |
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 150,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | True | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 100,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | False | | | | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Voltage input type | | Voltage trafo | | | | |
| Primary voltage | | 6,600 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 416 | |
| Division ratio | | 10000 | | 1000 | 20000 | |
| VT connection | | Wye | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (3UB): 2 | | | | | | |
| Voltage (3UB) | | | | | | |
| Voltage input type | | Voltage trafo | | | | |
| Primary voltage | | 6,600 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 416 | |
| Division ratio | | 10000 | | 1000 | 20000 | |
| VT connection | | Wye | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (Uo): 1 | | | | | | |
| Voltage (Uo) | | | | | | |
| Primary voltage | | 3,810 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 240 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (UoB): 2 | | | | | | |
| Voltage (UoB) | | | | | | |
| Primary voltage | | 3,810 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 240 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| A high high limit | | 1,40 | xIn | 0,00 | 40,00 | |
| A high limit | | 1,20 | xIn | 0,00 | 40,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A low low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A deadband | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| A Hi high limit res | | 0,20 | xIn | 0,00 | 40,00 | |
| A high limit res | | 0,05 | xIn | 0,00 | 40,00 | |
| A deadband res | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| V Hi high limit res | | 0,20 | xUn | 0,00 | 4,00 | |
| V high limit res | | 0,05 | xUn | 0,00 | 4,00 | |
| V deadband res | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 3 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,20 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Off delay time | | 0 | ms | 0 | 1800000 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| Operation | | on | | | | |
| F high high limit | | 60,00 | Hz | 35,00 | 75,00 | |
| F high limit | | 55,00 | Hz | 35,00 | 75,00 | |
| F low limit | | 45,00 | Hz | 35,00 | 75,00 | |
| F low low limit | | 40,00 | Hz | 35,00 | 75,00 | |
| F deadband | | 1000 | | 100 | 100000 | |
| Def frequency Sel | | Nominal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Operation | | on | | | | |
| Power unit Mult | | k | | | | |
| Energy unit Mult | | k | | | | |
| Active power Dir | | Forward | | | | |
| Reactive power Dir | | Forward | | | | |
| Power deadband | | 10000 | | 1000 | 10000 | |
| Forward Wh Initial | | 0 | | 0 | 999999999 | |
| Reverse Wh Initial | | 0 | | 0 | 999999999 | |
| Forward VArh Initial | | 0 | | 0 | 999999999 | |
| Reverse VArh Initial | | 0 | | 0 | 999999999 | |
| Measurement mode | | PhsA, PhsB, PhsC | | | | |
| Pulse quantity | | 100000 | Wh/VArh | 1 | 10000000 | |
| Pulse on time | | 1,000 | s | 0,050 | 60,000 | |
| Pulse off time | | 0,500 | s | 0,050 | 60,000 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq A Hi high Lim | | 1,40 | xIn | 0,00 | 40,00 | |
| Ps Seq A high limit | | 1,20 | xIn | 0,00 | 40,00 | |
| Ps Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A deadband | | 2500 | | 100 | 100000 | |
| Ng Seq A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Ng Seq A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Ng Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A deadband | | 2500 | | 100 | 100000 | |
| Zro A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Zro A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Zro A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A deadband | | 2500 | | 100 | 100000 | |
| Ps Seq A on delay time | | 0 | ms | 0 | 1800000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Ps Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Zro A on delay time | | 0 | ms | 0 | 1800000 | |
| Zro A off delay time | | 0 | ms | 0 | 1800000 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq V Hi high Lim | | 1,40 | xUn | 0,00 | 4,00 | |
| Ps Seq V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| Ps Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V deadband | | 10000 | | 100 | 100000 | |
| Ng Seq V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Ng Seq V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Ng Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V deadband | | 10000 | | 100 | 100000 | |
| Zro V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Zro V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Zro V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V deadband | | 10000 | | 100 | 100000 | |
| Ps Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ps Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Zro V on delay time | | 0 | ms | 0 | 1800000 | |
| Zro V off delay time | | 0 | ms | 0 | 1800000 | |
| Demand metering: 0 | | | | | | |
| Demand metering | | | | | | |
| Demand interval | | 1 minute | | | | |
| A demand Av mode | | Linear | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Operation | | on | | | | |
| Trip pulse time | | 250 | ms | 20 | 60000 | |
| Trip output mode | | Non-latched | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Operation | | on | | | | |
| Acc stop current | | 10,00 | A | 5,00 | 500,00 | |
| Open alarm time | | 40 | ms | 0 | 200 | |
| Close alarm time | | 40 | ms | 0 | 200 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Opening time Cor | | 10 | ms | -100 | 100 | |
| Closing time Cor | | 10 | ms | -100 | 100 | |
| Spring charge time | | 15 | s | 0 | 60 | |
| Counter initial Val | | 0 | | 0 | 99999 | |
| Alarm Op number | | 200 | | 0 | 99999 | |
| Lockout Op number | | 300 | | 0 | 99999 | |
| Current exponent | | 2,00 | | 0,00 | 5,00 | |
| Difference Cor time | | 5 | ms | -10 | 10 | |
| Alm Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| LO Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| Ini Acc currents Pwr | | 0,00 | | 0,00 | 20000,00 | |
| Initial CB Rmn life | | 5000 | | 0 | 99999 | |
| Rated Op current | | 1000,00 | A | 100,00 | 6300,00 | |
| Rated fault current | | 5000,00 | A | 500,00 | 99999,00 | |
| Op number rated | | 10000 | | 1 | 99999 | |
| Op number fault | | 1000 | | 1 | 10000 | |
| Life alarm level | | 500 | | 0 | 99999 | |
| Pressure alarm time | | 10 | ms | 0 | 60000 | |
| Pres lockout time | | 10 | ms | 0 | 60000 | |
| Inactive Alm days | | 2000 | | 0 | 9999 | |
| Ini inactive days | | 0 | | 0 | 9999 | |
| Inactive Alm hours | | 0 | h | 0 | 23 | |
| Travel time Clc mode | | From Pos to Pos | | | | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Operation | | off | | | | |
| Operate delay time | | 3000 | ms | 1000 | 300000 | |
| Reset delay time | | 1000 | ms | 1000 | 60000 | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Operation | | on | | | | |
| Start value | | 0,05 | xIn | 0,05 | 0,50 | |
| Max operate current | | 1,50 | xIn | 1,00 | 5,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Operation | | off | | | | |
| Neg Seq current Lev | | 0,03 | xIn | 0,03 | 0,20 | |
| Neg Seq voltage Lev | | 0,10 | xUn | 0,03 | 0,20 | |
| Change rate enable | | False | | | | |
| Min Op voltage delta | | 0,50 | xUn | 0,01 | 1,00 | |
| Min Op current delta | | 0,10 | xIn | 0,01 | 1,00 | |
| Enable seal in | | False | | | | |
| Current dead Lin Val | | 0,05 | xIn | 0,05 | 1,00 | |
| Disturbance recorder | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| A1RADR: 1 | | | | | | |
| A1RADR | | | | | | |
| Analog channel 1 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 1 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 2 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 2 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 3 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 3 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 4 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 4 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 5 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 5 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 6 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 6 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 7 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 7 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 8 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 8 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 9 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 9 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 10 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 10 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 11 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 11 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 12 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 12 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| A2RADR: 13 | | | | | | |
| A2RADR | | | | | | |
| Analog channel 13 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 13 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 14 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 14 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 15 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 15 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 16 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 16 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 17 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 17 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 18 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 18 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 19 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 19 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 20 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 20 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 21 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 21 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 22 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 22 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 23 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 23 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 24 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 24 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| B1RBDR: 1 | | | | | | |
| B1RBDR | | | | | | |
| Binary channel 1 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 1 input | | | 64 characters | |
| Binary channel 2 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 2 input | | | 64 characters | |
| Binary channel 3 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 3 input | | | 64 characters | |
| Binary channel 4 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 4 input | | | 64 characters | |
| Binary channel 5 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 5 input | | | 64 characters | |
| Binary channel 6 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 6 input | | | 64 characters | |
| Binary channel 7 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 7 input | | | 64 characters | |
| Binary channel 8 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 8 input | | | 64 characters | |
| Binary channel 9 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 9 input | | | 64 characters | |
| Binary channel 10 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 10 input | | | 64 characters | |
| Binary channel 11 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 11 input | | | 64 characters | |
| Binary channel 12 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 12 input | | | 64 characters | |
| Binary channel 13 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 13 input | | | 64 characters | |
| Binary channel 14 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 14 input | | | 64 characters | |
| Binary channel 15 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 15 input | | | 64 characters | |
| Binary channel 16 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 16 input | | | 64 characters | |
| Binary channel 17 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 17 input | | | 64 characters | |
| Binary channel 18 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 18 input | | | 64 characters | |
| Binary channel 19 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 19 input | | | 64 characters | |
| Binary channel 20 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 20 input | | | 64 characters | |
| Binary channel 21 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 21 input | | | 64 characters | |
| Binary channel 22 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 22 input | | | 64 characters | |
| Binary channel 23 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 23 input | | | 64 characters | |
| Binary channel 24 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 24 input | | | 64 characters | |
| Binary channel 25 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 25 input | | | 64 characters | |
| Binary channel 26 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 26 input | | | 64 characters | |
| Binary channel 27 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 27 input | | | 64 characters | |
| Binary channel 28 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 28 input | | | 64 characters | |
| Binary channel 29 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 29 input | | | 64 characters | |
| Binary channel 30 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 30 input | | | 64 characters | |
| Binary channel 31 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 31 input | | | 64 characters | |
| Binary channel 32 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 32 input | | | 64 characters | |
| B2RBDR: 33 | | | | | | |
| B2RBDR | | | | | | |
| Binary channel 33 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 33 input | | | 64 characters | |
| Binary channel 34 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 34 input | | | 64 characters | |
| Binary channel 35 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 35 input | | | 64 characters | |
| Binary channel 36 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 36 input | | | 64 characters | |
| Binary channel 37 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 37 input | | | 64 characters | |
| Binary channel 38 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 38 input | | | 64 characters | |
| Binary channel 39 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 39 input | | | 64 characters | |
| Binary channel 40 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 40 input | | | 64 characters | |
| Binary channel 41 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 41 input | | | 64 characters | |
| Binary channel 42 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 42 input | | | 64 characters | |
| Binary channel 43 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 43 input | | | 64 characters | |
| Binary channel 44 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 44 input | | | 64 characters | |
| Binary channel 45 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 45 input | | | 64 characters | |
| Binary channel 46 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 46 input | | | 64 characters | |
| Binary channel 47 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 47 input | | | 64 characters | |
| Binary channel 48 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 48 input | | | 64 characters | |
| Binary channel 49 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 49 input | | | 64 characters | |
| Binary channel 50 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 50 input | | | 64 characters | |
| Binary channel 51 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 51 input | | | 64 characters | |
| Binary channel 52 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 52 input | | | 64 characters | |
| Binary channel 53 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 53 input | | | 64 characters | |
| Binary channel 54 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 54 input | | | 64 characters | |
| Binary channel 55 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 55 input | | | 64 characters | |
| Binary channel 56 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 56 input | | | 64 characters | |
| Binary channel 57 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 57 input | | | 64 characters | |
| Binary channel 58 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 58 input | | | 64 characters | |
| Binary channel 59 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 59 input | | | 64 characters | |
| Binary channel 60 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 60 input | | | 64 characters | |
| Binary channel 61 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 61 input | | | 64 characters | |
| Binary channel 62 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 62 input | | | 64 characters | |
| Binary channel 63 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 63 input | | | 64 characters | |
| Binary channel 64 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 64 input | | | 64 characters | |
| Fault record | | | | | | |
| FLTRFRC1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| FLTRFRC1 | | | | | | |
| Operation | | on | | | | |
| Trig mode | | From operate | | | | |
| A measurement mode | | DFT | | | | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Operation | | on | | | | |
| Mem. warning level | | 0 | % | 0 | 100 | |
| Mem. alarm level | | 0 | % | 0 | 100 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Off delay time 1 | | 500 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Off delay time 1 | | 0 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Pulse time 1 | | 150 | ms | 0 | 3600000 | |
| Pulse time 2 | | 150 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Pulse time 1 | | 0 | ms | 0 | 3600000 | |
| Pulse time 2 | | 0 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| General | | | | | | |
| Loc Rem restriction | | False | | | | |
| Output 1 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM CLOSE CMD (DIRECT) | | | 64 characters | |
| Output 2 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM OPEN CMD (DIRECT) | | | 64 characters | |
| Output 3 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | RESET ALARMS | | | 64 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Output 4 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 4 | | | 64 characters | |
| Output 5 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 5 | | | 64 characters | |
| Output 6 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 6 | | | 64 characters | |
| Output 7 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 7 | | | 64 characters | |
| Output 8 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 8 | | | 64 characters | |
| Output 9 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 9 | | | 64 characters | |
| Output 10 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 10 | | | 64 characters | |
| Output 11 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 11 | | | 64 characters | |
| Output 12 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 12 | | | 64 characters | |
| Output 13 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | SPCGAPC1 Output 13 | | | 64 characters | |
| Output 14 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 14 | | | 64 characters | |
| Output 15 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | EMERGENCY | | | 64 characters | |
| Output 16 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 16 | | | 64 characters | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC1 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC1 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC1 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC1 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC1 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC1 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC1 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC1 Q8 | | | 20 characters | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC2 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC2 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC2 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC2 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC2 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC2 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC2 Q7 | | | 20 characters | |
| Output 8 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC2 Q8 | | | 20 characters | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC3 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC3 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC3 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC3 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC3 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC3 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC3 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC3 Q8 | | | 20 characters | |
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC4 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC4 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC4 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC4 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC4 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC4 Q6 | | | 20 characters | |
| Output 7 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC4 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC4 Q8 | | | 20 characters | |
| General: 0 | | | | | | |
| General | | | | | | |
| Software reset | | Cancel | | | | |
| HMI: 0 | | | | | | |
| HMI | | | | | | |
| FB naming convention | | IEC61850 | | | | |
| Backlight timeout | | 3 | min | 1 | 60 | |
| Web HMI mode | | On | | | | |
| HMI timeout | | 15 | min | 1 | 60 | |
| SLD symbol format | | IEC | | | | |
| Setting visibility | | Advanced | | | | |
| User defined name | | Disabled | | | | |
| Time: 0 | | | | | | |
| Time | | | | | | |
| System time | | | | | | |
| Time format | | 24H:MM:SS:MS | | | | |
| Date format | | DD.MM.YYYY | | | | |
| Date | | 0 | | | 20 characters | |
| Time | | 0 | | | 20 characters | |
| Local time offset | | 0 | min | -840 | 840 | |
| Daylight saving time | | | | | | |
| DST in use | | True | | | | |
| DST on time (hours) | | 2 | h | 0 | 23 | |
| DST on time (minutes) | | 0 | min | 0 | 59 | |
| DST on date (day) | | 1 | | 1 | 31 | |
| DST on date (month) | | May | | | | |
| DST on day (weekday) | | reserved | | | | |
| DST off time (hours) | | 2 | h | 0 | 23 | |
| DST off time (minutes) | | 0 | min | 0 | 59 | |
| DST off date (day) | | 25 | | 1 | 31 | |
| DST off date (month) | | September | | | | |
| DST off day (weekday) | | reserved | | | | |
| DST offset | | 60 | min | -720 | 720 | |
| SNTP | | | | | | |
| IP SNTP primary | | 192.168.2.166 | | | | |
| IP SNTP secondary | | 192.168.2.165 | | | | |
| Synchronization | | | | | | |
| Synch source | | SNTP | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PTP Profile | | IEEE C37.238-2011 | | | | |
| PTP domain ID | | 0 | | 0 | 255 | |
| PTP priority 1 | | 128 | | 0 | 255 | |
| PTP priority 2 | | 128 | | 0 | 255 | |
| PTP Slave-only | | False | | | | |
| Time master mode | | Master with finite holdover | | | | |
| Clear clock list | | False | | | | |
| Time Syn Src Tmm | | 3 | min | 1 | 65535 | |
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |
| SG operation mode | | Operator | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LHMI | | | | | | |
| Close delay mode | | Not in use | | | | |
| Close delay | | 60 | s | 5 | 900 | |
| Breaker operation | | After confirmation | | | | |
| Programmable LEDs: 1 | | | | | | |
| Programmable LEDs | | | | | | |
| General | | | | | | |
| Alarm colour | | Red | | | | |
| LED 1 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 27/59 Voltage Protection | | | 64 characters | |
| LED 2 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Ready | | | 64 characters | |
| LED 3 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Synchrocheck | | | 64 characters | |
| LED 4 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Ready to close | | | 64 characters | |
| LED 5 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 50/51 Current Protection | | | 64 characters | |
| LED 6 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Alarm mode | | Follow-S | | | | |
| Description | | 51N/59N Earth Fault Protection | | | 64 characters | |
| LED 7 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Earthing Switch Unlocked | | | 64 characters | |
| LED 8 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Truck Unlocked | | | 64 characters | |
| LED 9 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Arc Protection Trip | | | 64 characters | |
| LED 10 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | GOOSE Alarm | | | 64 characters | |
| LED 11 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Emergency Open by SIS | | | 64 characters | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| LED 12 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Space Heater ON | | | 64 characters | |
| LED 13 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Transformer Protections | | | 64 characters | |
| LED 14 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Fuses Trip | | | 64 characters | |
| LED 15 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Trip from LV | | | 64 characters | |
| LED 16 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 17 | | | | | | |
| Alarm mode | | Follow-S | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | - | | | 64 characters | |
| LED 18 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 19 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 20 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 21 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 22 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| I/O modules: 0 | | | | | | |
| I/O modules | | | | | | |
| Common settings | | | | | | |
| Slot specific threshold | | False | | | | |
| Slot specific hysteresis | | False | | | | |
| Input threshold voltage | | 16 | Vdc | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input osc. level | | 30 | events/s | 2 | 50 | |
| Input osc. hyst | | 10 | events/s | 2 | 50 | |
| User Activity log: 0 | | | | | | |
| User Activity log | | | | | | |
| Server Settings 1 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address | | 192.168.2.5 | | | | |
| Server Settings 2 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address2 | | 192.168.2.6 | | | | |
| Authorization: 1 | | | | | | |
| Authorization | | | | | | |
| Security | | | | | | |
| Remote Update | | Disable | | | | |
| Passwords | | | | | | |
| Remote override | | True | | | | |
| Local override | | True | | | | |
| CAM | | | | | | |
| Clear AD userlist | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Network1 | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |
| HTTPS write access | | On | | | | |
| HMI | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |
| Monitoring | | | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CHLIV_A | | False | | | | |
| REDCHLIV_B | | False | | | | |
| Link statuses | | | | | | |
| LNKLIV_A | | False | | | | |
| REDLNKLIV_B | | False | | | | |
| Diagnostics | | | | | | |
| A_B | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CH1LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK1LIV | | False | | | | |
| Diagnostics | | | | | | |
| X1 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Activity | | | | | | |
| CH2LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK2LIV | | False | | | | |
| Diagnostics | | | | | | |
| X2 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Activity | | | | | | |
| CH3LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK3LIV | | False | | | | |
| Diagnostics | | | | | | |
| X3 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| HMILCCH1: 1 | | | | | | |
| HMILCCH1 | | | | | | |
| Activity | | | | | | |
| HMICHLIV | | False | | | | |
| Link statuses | | | | | | |
| HMILNKLIV | | Down | | | | |
| SCHLCCH6: 6 | | | | | | |
| SCHLCCH6 | | | | | | |
| Activity | | | | | | |
| CH6LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK6LIV | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Diagnostics | | | | | | |
| X6 | | | | | | |
| Temperature | | 0,0 | °C | -128,0 | 128,0 | |
| Voltage | | 0,000 | V | 0,000 | 6,550 | |
| Bias current | | 0,0 | mA | 0,0 | 131,0 | |
| TX power | | 0,000 | mW | 0,000 | 6,550 | |
| RX power | | 0,000 | mW | 0,000 | 6,550 | |
| XCVR detected | | False | | | | |
| RX power alarm | | False | | | | |
| TX power alarm | | False | | | | |
| Voltage alarm | | False | | | | |
| Temperature alarm | | False | | | | |
| Part name | | 0 | | | 20 characters | |
| Protocols | | | | | | |
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| CHLIV | | False | | | | |
| Successful conn. | | 0 | | 0 | 10000000 | |
| Failed conn. | | 0 | | 0 | 10000000 | |
| Concludes | | 0 | | 0 | 10000000 | |
| Sent aborts | | 0 | | 0 | 10000000 | |
| Recv. aborts | | 0 | | 0 | 10000000 | |
| Sent rejects | | 0 | | 0 | 10000000 | |
| Recv. requests | | 0 | | 0 | 10000000 | |
| Failed requests | | 0 | | 0 | 10000000 | |
| Reads | | 0 | | 0 | 10000000 | |
| Failed reads | | 0 | | 0 | 10000000 | |
| Writes | | 0 | | 0 | 10000000 | |
| Failed writes | | 0 | | 0 | 10000000 | |
| Reports | | 0 | | 0 | 10000000 | |
| Active conn. | | 0 | | 0 | 10000000 | |
| Reset counters | | False | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT2: 2 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| MEM_WARN | | False | | | | |
| MEM_ALARM | | False | | | | |
| I/O status | | | | | | |
| Binary input values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Slot D (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| TCS Input 1 | | False | | | | |
| TCS Input 2 | | False | | | | |
| Binary output values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Output 1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Output 9 | | False | | | | |
| Output 10 | | False | | | | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (Uo): 1 | | | | | | |
| Voltage (Uo) | | | | | | |
| URES_ALARM | | False | | | | |
| URES_WARNING | | False | | | | |
| Voltage (UoB): 2 | | | | | | |
| Voltage (UoB) | | | | | | |
| URES_ALARM | | False | | | | |
| URES_WARNING | | False | | | | |
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (3UB): 2 | | | | | | |
| Voltage (3UB) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| I_INST_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_A | | normal | | | | |
| I_INST_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_B | | normal | | | | |
| I_INST_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_C | | normal | | | | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I_INST_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_RES | | normal | | | | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U_INST_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_RES | | normal | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Outputs | | | | | | |
| I2_HIGH_AL | | False | | | | |
| I2_HIGH_WARN | | False | | | | |
| I1_HIGH_AL | | False | | | | |
| I1_HIGH_WARN | | False | | | | |
| I1_LOW_WARN | | False | | | | |
| I1_LOW_AL | | False | | | | |
| I0_HIGH_AL | | False | | | | |
| I0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I2_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I2_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_RANGE | | normal | | | | |
| I1_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I1_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_RANGE | | normal | | | | |
| I0_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I0_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_RANGE | | normal | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Outputs | | | | | | |
| U2_HIGH_AL | | False | | | | |
| U2_HIGH_WARN | | False | | | | |
| U1_HIGH_AL | | False | | | | |
| U1_HIGH_WARN | | False | | | | |
| U1_LOW_WARN | | False | | | | |
| U1_LOW_AL | | False | | | | |
| U0_HIGH_AL | | False | | | | |
| U0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U2_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U2_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_RANGE | | normal | | | | |
| U1_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U1_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_RANGE | | normal | | | | |
| U0_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U0_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_RANGE | | normal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Inputs | | | | | | |
| RSTACM | | False | | | | |
| Monitored data | | | | | | |
| S_INST | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DB | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DMD | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P_INST | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DB | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DMD | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q_INST | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DB | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DMD | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF_INST | | 0,00 | | -1,00 | 1,00 | |
| PF_DB | | 0,00 | | -1,00 | 1,00 | |
| PF_DMD | | 0,00 | | -1,00 | 1,00 | |
| EA_RV_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_RV_ACM | | 0 | kVArh | 0 | 999999999 | |
| EA_FWD_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_FWD_ACM | | 0 | kVArh | 0 | 999999999 | |
| FMMXU1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| f(1) | | | | | | |
| Monitored data | | | | | | |
| F_INST | | 50,00 | Hz | 35,00 | 75,00 | |
| F_DB | | 50,00 | Hz | 35,00 | 75,00 | |
| F_RANGE | | normal | | | | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| IN9 | | False | | | | |
| IN10 | | False | | | | |
| IN11 | | False | | | | |
| IN12 | | False | | | | |
| IN13 | | False | | | | |
| IN14 | | False | | | | |
| IN15 | | False | | | | |
| IN16 | | False | | | | |
| Outputs | | | | | | |
| O1 | | False | | | | |
| O2 | | False | | | | |
| O3 | | False | | | | |
| O4 | | False | | | | |
| O5 | | False | | | | |
| O6 | | False | | | | |
| O7 | | False | | | | |
| O8 | | False | | | | |
| O9 | | False | | | | |
| O10 | | False | | | | |
| O11 | | False | | | | |
| O12 | | False | | | | |
| O13 | | False | | | | |
| O14 | | False | | | | |
| O15 | | False | | | | |
| O16 | | False | | | | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Inputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Inputs | | | | | | |
| ENA_OPEN | | True | | | | |
| ENA_CLOSE | | True | | | | |
| BLK_OPEN | | False | | | | |
| BLK_CLOSE | | False | | | | |
| SYNC_OK | | True | | | | |
| SYNC_BYPASS | | False | | | | |
| ITL_BYPASS | | False | | | | |
| Outputs | | | | | | |
| SELECTED | | False | | | | |
| EXE_OP | | False | | | | |
| EXE_CL | | False | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| OPEN_ENAD | | False | | | | |
| CLOSE_ENAD | | False | | | | |
| CTL_ITL_BLKD | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Outputs | | | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Outputs | | | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| CL_COMMAND | | False | | | | |
| BYPASS | | False | | | | |
| Outputs | | | | | | |
| SYNC_INPRO | | False | | | | |
| SYNC_OK | | False | | | | |
| CL_FAIL_AL | | False | | | | |
| CMD_FAIL_AL | | False | | | | |
| LLDB | | False | | | | |
| LLLB | | False | | | | |
| DLLB | | False | | | | |
| DLDB | | False | | | | |
| Monitored data | | | | | | |
| ENERG_STATE | | Unknown | | | | |
| U_DIFF_MEAS | | 0,00 | xUn | -3,00 | 3,00 | |
| FR_DIFF_MEAS | | 0,000 | xFn | -1,500 | 1,500 | |
| PH_DIFF_MEAS | | 0,00 | deg | -180,00 | 180,00 | |
| U_DIFF_SYNC | | False | | | | |
| PH_DIF_SYNC | | False | | | | |
| FR_DIFF_SYNC | | False | | | | |
| Current protection | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 67-1; DPHLPDOC1: 1 | | | | | | |
| 3I>->(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| NON_DIR | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| FAULT_DIR | | unknown | | | | |
| DIRECTION | | unknown | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| DIR_A | | unknown | | | | |
| DIR_B | | unknown | | | | |
| DIR_C | | unknown | | | | |
| ANGLE_A | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_B | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_C | | 0,00 | deg | -180,00 | 180,00 | |
| VMEM_USED | | False | | | | |
| 67-2; DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| NON_DIR | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| FAULT_DIR | | unknown | | | | |
| DIRECTION | | unknown | | | | |
| Monitored data | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| DIR_A | | unknown | | | | |
| DIR_B | | unknown | | | | |
| DIR_C | | unknown | | | | |
| ANGLE_A | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_B | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_C | | 0,00 | deg | -180,00 | 180,00 | |
| VMEM_USED | | False | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| BLK2H | | False | | | | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Voltage protection | | | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Inputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59-2; PHPTOV2: 2 | | | | | | |
| 3U>(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| START | | False | | | | |
| POSCLOSE | | False | | | | |
| CB_FAULT | | False | | | | |
| Outputs | | | | | | |
| CB_FAULT_AL | | False | | | | |
| TRBU | | False | | | | |
| TRRET | | False | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ARC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| OPERATE | | False | | | | |
| RST_LKOUT | | False | | | | |
| Outputs | | | | | | |
| TRIP | | False | | | | |
| CL_LKOUT | | False | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| POSOPEN | | False | | | | |
| POSCLOSE | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OPEN_CB_EXE | | False | | | | |
| CLOSE_CB_EXE | | False | | | | |
| PRES_ALM_IN | | False | | | | |
| PRES_LO_IN | | False | | | | |
| RST_IPOW | | False | | | | |
| RST_CB_WEAR | | False | | | | |
| RST_TRV_T | | False | | | | |
| RST_SPR_T | | False | | | | |
| Outputs | | | | | | |
| TRV_T_OP_ALM | | False | | | | |
| TRV_T_CL_ALM | | False | | | | |
| SPR_CHR_ALM | | False | | | | |
| OPR_ALM | | False | | | | |
| OPR_LO | | False | | | | |
| IPOW_ALM | | False | | | | |
| IPOW_LO | | False | | | | |
| CB_LIFE_ALM | | False | | | | |
| MON_ALM | | False | | | | |
| PRES_ALM | | False | | | | |
| PRES_LO | | False | | | | |
| OPENPOS | | False | | | | |
| INVALIDPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| Monitored data | | | | | | |
| T_TRV_OP | | 0 | ms | 0 | 60000 | |
| T_TRV_CL | | 0 | ms | 0 | 60000 | |
| T_SPR_CHR | | 0,00 | s | 0,00 | 99,99 | |
| NO_OPR | | 0 | | 0 | 99999 | |
| INA_DAYS | | 0 | | 0 | 9999 | |
| CB_LIFE_A | | 0 | | -99999 | 99999 | |
| CB_LIFE_B | | 0 | | -99999 | 99999 | |
| CB_LIFE_C | | 0 | | -99999 | 99999 | |
| IPOW_A | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_B | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_C | | 0,000 | | 0,000 | 30000,000 | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| FAIL | | False | | | | |
| ALARM | | False | | | | |
| Monitored data | | | | | | |
| IDIFF | | 0,00 | xIn | 0,00 | 40,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| CB_CLOSED | | False | | | | |
| DISCON_OPEN | | False | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| FUSEF_3PH | | False | | | | |
| FUSEF_U | | False | | | | |
| Communication | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| Monitoring | | | | | | |
| Reset counters | | False | | | | |
| Received msgs | | 0 | | 0 | 10000000 | |
| Transmitted msgs | | 0 | | 0 | 10000000 | |
| State changes | | 0 | | 0 | 10000000 | |
| SeqNum changes | | 0 | | 0 | 10000000 | |
| Test msgs | | 0 | | 0 | 10000000 | |
| State warnings | | 0 | | 0 | 10000000 | |
| Seq. warnings | | 0 | | 0 | 10000000 | |
| Recv. timeouts | | 0 | | 0 | 10000000 | |
| ConfRev errors | | 0 | | 0 | 10000000 | |
| NdsComm errors | | 0 | | 0 | 10000000 | |
| Dataset errors | | 0 | | 0 | 10000000 | |
| Replay Prot warnings | | 0 | | 0 | 10000000 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| FB status | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>>>(1) | | on | | | | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>(1) | | on | | | | |
| 67-1; DPHLPDOC1: 1 | | | | | | |
| 3I>->(1) | | | | | | |
| Current protection | | | | | | |
| 3I>->(1) | | on | | | | |
| 67-2; DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| Current protection | | | | | | |
| 3I>->(2) | | on | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Current protection | | | | | | |
| 3I2f>(1) | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Current protection | | | | | | |
| Io>(1) | | on | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U>(1) | | on | | | | |
| 59-2; PHPTOV2: 2 | | | | | | |
| 3U>(2) | | | | | | |
| Voltage protection | | | | | | |
| 3U>(2) | | on | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U<(1) | | on | | | | |
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Voltage protection | | | | | | |
| 3U<(2) | | on | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Voltage protection | | | | | | |
| Uo>(1) | | on | | | | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Voltage protection | | | | | | |
| Uo>(2) | | on | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Other protection | | | | | | |
| 3I>/Io>BF(1) | | on | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Other protection | | | | | | |
| ARC(1) | | on | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Other protection | | | | | | |
| ARC(2) | | on | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Other protection | | | | | | |
| ARC(3) | | on | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Control | | | | | | |
| SYNC(1) | | on | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Trip logic | | | | | | |
| Master Trip(1) | | on | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Condition monitoring | | | | | | |
| CBCM(1) | | on | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Supervision | | | | | | |
| TCS(1) | | on | | | | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Supervision | | | | | | |
| MCS 3I(1) | | on | | | | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Supervision | | | | | | |
| FUSEF(1) | | on | | | | |
| Recorded data | | | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Max demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand IL1 | | 0 | | | 34 characters | |
| Time max demand IL2 | | 0 | | | 34 characters | |
| Time max demand IL3 | | 0 | | | 34 characters | |
| Time min demand IL1 | | 0 | | | 34 characters | |
| Time min demand IL2 | | 0 | | | 34 characters | |
| Time min demand IL3 | | 0 | | | 34 characters | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Max demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand Io | | 0 | | | 34 characters | |
| Time min demand Io | | 0 | | | 34 characters | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Max demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Min demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Max demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Min demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Max demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Min demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Time max dmd S | | 0 | | | 34 characters | |
| Time min dmd S | | 0 | | | 34 characters | |
| Time max dmd P | | 0 | | | 34 characters | |
| Time min dmd P | | 0 | | | 34 characters | |
| Time max dmd Q | | 0 | | | 34 characters | |
| Time min dmd Q | | 0 | | | 34 characters | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault record | | | | | | |
| Fault number | | 0 | | 0 | 999999 | |
| Time and date | | 0 | | | 34 characters | |
| Protection (rec. set 1) | | None | | | | |
| Protection (rec. set 2) | | None | | | | |
| Start duration | | 0,00 | % | 0,00 | 100,00 | |
| Operate time | | 0,000 | s | 0,000 | 999999,999 | |
| Breaker clear time | | 0,000 | s | 0,000 | 3,000 | |
| Fault distance | | 0,00 | pu | 0,00 | 3000,00 | |
| Fault resistance | | 0,00 | ohm | 0,00 | 3000,00 | |
| Fault reactance | | 0,00 | ohm | 0,00 | 3000,00 | |
| Active group | | 1 | | 1 | 6 | |
| Shot pointer | | 1 | | 1 | 7 | |
| Max diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Diff current Io:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Bias current Io:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Voltage UL1:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage Ps-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL12:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL23:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL31:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| PTTR thermal level | | 0,00 | | 0,00 | 99,99 | |
| I2/I1>(1) rat. I2/I1 | | 0,00 | % | 0,00 | 999,99 | |
| Frequency:1 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:1 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:2 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:2 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:3 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:3 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Conductance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Susceptance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Angle Uo:1 - Io:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:1- IL1:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:1 - IL2:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:1 - IL3:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:2 - Io:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:2 - IL1:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:2 - IL2:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:2 - IL3:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:3 - Io:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:3 - IL1:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:3 - IL2:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:3 - IL3:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Control command | | | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LR state | | Remote | | | | |
| Detached LHMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| CONNECTION | | False | | | | |
| Service port IP address | | 0 | | | 20 characters | |
| Main unit port IP address | | 0 | | | 20 characters | |
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| SG_LOGIC_SEL | | False | | | | |
| SG_1_ACT | | False | | | | |
| SG_2_ACT | | False | | | | |
| SG_3_ACT | | False | | | | |
| SG_4_ACT | | False | | | | |
| SG_5_ACT | | False | | | | |
| SG_6_ACT | | False | | | | |
| Programmable LEDs: 1 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 1 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 2 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 3 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 4 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 5 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 6 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 7 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 8 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 9 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| RESET | | False | | | | |
| LED 10 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 11 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 1 | | None | | | | |
| Programmable LED 2 | | None | | | | |
| Programmable LED 3 | | None | | | | |
| Programmable LED 4 | | None | | | | |
| Programmable LED 5 | | None | | | | |
| Programmable LED 6 | | None | | | | |
| Programmable LED 7 | | None | | | | |
| Programmable LED 8 | | None | | | | |
| Programmable LED 9 | | None | | | | |
| Programmable LED 10 | | None | | | | |
| Programmable LED 11 | | None | | | | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 12 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 13 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 14 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 15 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 16 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 17 | | | | | | |
| OK | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 18 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 19 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 20 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 21 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 22 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 12 | | None | | | | |
| Programmable LED 13 | | None | | | | |
| Programmable LED 14 | | None | | | | |
| Programmable LED 15 | | None | | | | |
| Programmable LED 16 | | None | | | | |
| Programmable LED 17 | | None | | | | |
| Programmable LED 18 | | None | | | | |
| Programmable LED 19 | | None | | | | |
| Programmable LED 20 | | None | | | | |
| Programmable LED 21 | | None | | | | |
| Programmable LED 22 | | None | | | | |
| IED status: 1 | | | | | | |
| IED status | | | | | | |
| CAM | | | | | | |
| UAM mode | | Local | | | | |
| CAM server1 | | Offline | | | | |
| CAM server2 | | Offline | | | | |
| Replication | | N.A. | | | | |
| Last update | | 0 | | | 34 characters | |
| PKI | | | | | | |
| CA Server Status | | Offline | | | | |
| Time synchronization | | | | | | |
| PTP P2P delay X1 | | 0 | ns | -2147483648 | 2147483647 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PTP P2P delay X2 | | 0 | ns | -2147483648 | 2147483647 | |
| PTP P2P delay X3 | | 0 | ns | -2147483648 | 2147483647 | |
| Self-supervision | | | | | | |
| Warning | | All ok | | | | |
| Internal Fault | | All ok | | | | |
| Boot up time | | 0 | | | 34 characters | |
| Boot up reason | | None | | | | |
| Device state | | on | | | | |
| Composition changes | | | | | | |
| No of comp. changes | | 0 | | 0 | 100000 | |
| Setting changes | | | | | | |
| Setting changes | | 0 | | 0 | 20000 | |
| Setting time | | 0 | | | 34 characters | |
| SMV accuracy | | | | | | |
| SMV Synch accuracy | | InternalClock | | | | |
| Local synch accuracy | | 0 | us | 0 | 1000000000 | |
| Max Dev synch Acc | | 0 | us | 0 | 1000000000 | |
| Information | | | | | | |
| HW modules | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot E (AIM): 1 | | | | | | |
| Slot E (AIM) | | | | | | |
| Article number | | 0 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot F (AIM): 1 | | | | | | |
| Slot F (AIM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | - | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | - | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Detached LHMI | | | | | | |
| Article number | | 0 | | | 20 characters | |
| Application version | | 0 | | | 20 characters | |
| Firmware version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Service port MAC address | | 0 | | | 20 characters | |
| Main unit port MAC address | | 0 | | | 20 characters | |
| Slot A1 (ARC): 1 | | | | | | |
| Slot A1 (ARC) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot A2 (COM): 1 | | | | | | |
| Slot A2 (COM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Product identifiers: 0 | | | | | | |
| Product identifiers | | | | | | |
| Type | | REX640 | | | 20 characters | |
| Product version | | 0 | | | 64 characters | |
| Serial number | | 1XXXXXXXXXXX | | | 20 characters | |
| Production date | | 0 | | | 34 characters | |
| SW version | | X.X | | | 20 characters | |
| SW date | | 0 | | | 34 characters | |
| SW number | | 2RCA057448A | | | 20 characters | |
| Interface level | | 0 | | | 64 characters | |
| Order code | | XXXXXXXXXXXXXXXXX | | | 20 characters | |
| Site identifiers: 0 | | | | | | |
| Site identifiers | | | | | | |
| Customer name | | 0 | | | 20 characters | |
| Street | | 0 | | | 20 characters | |
| House number | | 0 | | | 20 characters | |
| ZIP/Postal code | | 0 | | | 20 characters | |
| City/Province | | 0 | | | 20 characters | |
| State | | 0 | | | 20 characters | |
| Country | | 0 | | | 20 characters | |
| System identifiers: 0 | | | | | | |
| System identifiers | | | | | | |
| Technical key | | TIGER | | | 20 characters | |
| IEC 61850 version | | Edition 2 | | | 24 characters | |
| Engineering model | | ABB | | | | |
| HW modules: 0 | | | | | | |
| HW modules | | | | | | |
| Main board | | | | | | |
| Article number | | 2RAAXXXXXX | | | 20 characters | |
| SW version | | A | | | 20 characters | |
| HW revision | | X | | | 20 characters | |
| Serial number | | 1XXXXXXXXXXX | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Clear | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Disturbance records | | Cancel | | | | |
| Clear: 0 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Clear | | | | | | |
| Indications and LEDs | | Cancel | | | | |
| Programmable LEDs | | Cancel | | | | |
| Events | | Cancel | | | | |
| Metering records | | Cancel | | | | |
| Power quality data | | Cancel | | | | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault records | | Cancel | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Load Profile record | | Cancel | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Master Trip(1) | | Cancel | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| CBCM(1) acc.energy | | Cancel | | | | |
| CBCM(1) rem.life | | Cancel | | | | |
| CBCM(1) travel times | | Cancel | | | | |
| CBCM(1) spr.charge t | | Cancel | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| P,E(1) acc.energy | | Cancel | | | | |
| Application Configuration | | | | | | |
| General | | | | | | |
| Settings | | | | | | |
| Setting group | | | | | | |
| Protection: 0 | | | | | | |
| Setting group | | | | | | |
| Active group | | 1 | | 1 | 6 | |
| Protection | | | | | | |
| Settings | | | | | | |
| Current protection | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Minimum operate time | | 250 | ms | 20 | 60000 | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 50000,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 6,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| 67-1; DPHLPDOC1: 1 | | | | | | |
| 3I>->(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| Allow Non Dir | | False | | | | |
| Min operate current | | 0,010 | xIn | 0,010 | 1,000 | |
| Min operate voltage | | 0,010 | xUn | 0,010 | 1,000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 900 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 900 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 900 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 900 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 900 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 900 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| 67-2; DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| Allow Non Dir | | False | | | | |
| Min operate current | | 0,010 | xIn | 0,010 | 1,000 | |
| Min operate voltage | | 0,010 | xUn | 0,010 | 1,000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Operation | | off | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 2 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 3 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 4 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 5 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 6 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage protection | | | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 59-2; PHPTOV2: 2 | | | | | | |
| 3U>(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage block value | | 0,20 | xUn | 0,05 | 1,00 | |
| Enable block value | | True | | | | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage block value | | 0,20 | xUn | 0,05 | 1,00 | |
| Enable block value | | True | | | | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 6 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Operation | | off | | | | |
| Current value | | 0,300 | xIn | 0,050 | 2,000 | |
| Current value Res | | 0,30 | xIn | 0,05 | 2,00 | |
| CB failure trip mode | | 1 out of 3 | | | | |
| CB failure mode | | Current | | | | |
| CB fail retrip mode | | Off | | | | |
| Retrip time | | 120 | ms | 0 | 60000 | |
| CB failure delay | | 240 | ms | 0 | 60000 | |
| CB fault delay | | 5000 | ms | 0 | 60000 | |
| Measurement mode | | Peak-to-Peak | | | | |
| Trip pulse time | | 200 | ms | 0 | 60000 | |
| Start latching mode | | Rising edge | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ARC(2) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Control | | | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |
| Operation | | on | | | | |
| Synchro check mode | | Asynchronous | | | | |
| Control mode | | Continuous | | | | |
| Dead line value | | 0,1 | xUn | 0,1 | 0,8 | |
| Live line value | | 0,5 | xUn | 0,2 | 1,0 | |
| Dead bus value | | 0,1 | xUn | 0,1 | 0,8 | |
| Live bus value | | 0,5 | xUn | 0,2 | 1,0 | |
| Max energizing V | | 1,11 | xUn | 0,50 | 1,15 | |
| Phase shift | | 0 | deg | -180 | 180 | |
| Minimum Syn time | | 10000 | ms | 0 | 60000 | |
| Energizing time | | 100 | ms | 100 | 60000 | |
| Closing time of CB | | 50 | ms | 40 | 250 | |
| Voltage source switch | | False | | | | |
| settingGroup 1 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 2 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 3 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 4 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| settingGroup 5 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 6 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |

*Settings*

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| REX640_A4 | | | | | | |
| IED Configuration | | | | | | |
| HW Configuration | | | | | | |
| Slot B (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot C (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot D (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| POSITION | | intermediate | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| TRIG 1 | | False | | | | |
| TRIG 2 | | False | | | | |
| TRIG 3 | | False | | | | |
| TRIG 4 | | False | | | | |
| TRIG 5 | | False | | | | |
| TRIG 6 | | False | | | | |
| TRIG 7 | | False | | | | |
| TRIG 8 | | False | | | | |
| TRIG 9 | | False | | | | |
| TRIG 10 | | False | | | | |
| TRIG 11 | | False | | | | |
| TRIG 12 | | False | | | | |
| TRIG 13 | | False | | | | |
| TRIG 14 | | False | | | | |
| TRIG 15 | | False | | | | |
| TRIG 16 | | False | | | | |
| Measurements | | | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| S-kVA:1 | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P-kW:1 | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q-kVAr:1 | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF:1 | | 0,00 | | -1,00 | 1,00 | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| IL1-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL2-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL3-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Io-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESCMMXU2: 2 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Io(2) | | | | | | |
| Io-A:2 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Uo-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| U12-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| UL1-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL2-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL3-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| f-Hz:1 | | 50,00 | Hz | 35,00 | 75,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| NgSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| PsSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| ZrSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| NgSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| PsSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| ZrSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| Disturbance records | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Number of recordings | | 0 | | 0 | 100 | |
| Rem. amount of rec. | | 0 | | 0 | 100 | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| Trig recording | | Cancel | | | | |
| Time to trigger | | 0 | s | 0 | 604800 | |
| Configuration | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| General | | | | | | |
| Operation | | on | | | | |
| Record length | | 50 | cycles | 10 | 500 | |
| Pre-trg length | | 50 | % | 0 | 100 | |
| Operation mode | | Overwrite | | | | |
| Exclusion time | | 0 | ms | 0 | 1000000 | |
| Storage rate | | 32 samples / cycle | | | | |
| Periodic trig time | | 0 | s | 0 | 604800 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Stor. mode periodic | | Waveform | | | | |
| Stor. mode manual | | Waveform | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Operation | | on | | | | |
| Select timeout | | 30000 | ms | 10000 | 300000 | |
| Pulse length | | 200 | ms | 10 | 60000 | |
| Operation counter | | 0 | | 0 | 99999 | |
| Control model | | sbo-with-enhanced-security | | | | |
| Adaptive pulse | | True | | | | |
| Event delay | | 200 | ms | 0 | 10000 | |
| Operation timeout | | 500 | ms | 10 | 6000000 | |
| Interlocking Pls Len | | 2 | s | 1 | 10 | |
| Identification | | CBXCBR1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| General: 0 | | | | | | |
| Control | | | | | | |
| General | | | | | | |
| LR control | | Binary input | | | | |
| Station authority | | L,R | | | | |
| Control mode | | On | | | | |
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | DCSXSWI1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | ESSXSWI1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| System | | | | | | |
| Control: 0 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Control | | | | | | |
| Rated frequency | | 50Hz | | | | |
| Phase rotation | | ABC | | | | |
| Blocking mode | | Freeze timer | | | | |
| Bay name | | REX640_A4 | | | 20 characters | |
| IDMT Sat point | | 50 | I/I> | 10 | 50 | |
| Frequency adaptivity | | Disable | | | | |
| SMV Max Delay | | 3/3 ms | | | | |
| Test mode selection | | Local | | | | |
| HMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Backlight brightness | | 100 | % | 1 | 100 | |
| Enable USB access | | No | | | | |
| Enable HMI service port | | Yes | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| Rate Limiter: 1 | | | | | | |
| Rate Limiter | | | | | | |
| Rate limiter | | | | | | |
| Rate limit ctrl | | False | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Redundancy | | | | | | |
| Redundant mode | | None | | | | |
| Filter | | | | | | |
| Filter mode A_B | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit A_B | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit A_B | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit A_B | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Port modes | | | | | | |
| Port mode X1 | | On | | | | |
| Filter | | | | | | |
| Filter mode X1 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X1 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X1 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X1 | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Port modes | | | | | | |
| Port mode X2 | | On | | | | |
| Filter | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Filter mode X2 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X2 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X2 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X2 | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Port modes | | | | | | |
| Port mode X3 | | On | | | | |
| Filter | | | | | | |
| Filter mode X3 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X3 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X3 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X3 | | 8,000 | | 0,512 | 90,000 | |
| Network1: 1 | | | | | | |
| Network1 | | | | | | |
| Network1 address | | | | | | |
| IP address | | 192.168.10.8 | | | | |
| Subnet mask | | 255.255.255.224 | | | | |
| Default gateway | | 192.168.10.30 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| Network2: 2 | | | | | | |
| Network2 | | | | | | |
| Network2 address | | | | | | |
| Enable | | False | | | | |
| IP address | | 192.168.3.10 | | | | |
| Subnet mask | | 255.255.255.0 | | | | |
| Default gateway | | 0.0.0.0 | | | 16 characters | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| HMI: 1 | | | | | | |
| HMI | | | | | | |
| HMI address | | | | | | |
| IP address | | 192.168.0.254 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| Protocols | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| GOOSE | | | | | | |
| Change det. interval | | 500 | ms | 50 | 1000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| MMS | | | | | | |
| Unit mode | | Nominal | | | | |
| Network1 | | | | | | |
| MMS | | On | | | | |
| HMI port | | | | | | |
| MMS | | On | | | | |
| FTPLPRT1: 1 | | | | | | |
| FTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| FTP | | Secure | | | | |
| HMI port | | | | | | |
| FTP | | Secure | | | | |
| HTTPLPRT1: 1 | | | | | | |
| HTTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| HTTPS | | On | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Network1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Modbus | | On | | | | |
| MBSLPRT2: 2 | | | | | | |
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 200,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | False | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 100,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | False | | | | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Current (IoB): 2 | | | | | | |
| Current (IoB) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 2500,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Reverse polarity | | False | | | | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Voltage input type | | Voltage trafo | | | | |
| Primary voltage | | 6,600 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 416 | |
| Division ratio | | 10000 | | 1000 | 20000 | |
| VT connection | | Wye | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (Uo): 1 | | | | | | |
| Voltage (Uo) | | | | | | |
| Primary voltage | | 3,810 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 240 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| A high high limit | | 1,40 | xIn | 0,00 | 40,00 | |
| A high limit | | 1,20 | xIn | 0,00 | 40,00 | |
| A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A low low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A deadband | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| A Hi high limit res | | 0,20 | xIn | 0,00 | 40,00 | |
| A high limit res | | 0,05 | xIn | 0,00 | 40,00 | |
| A deadband res | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESCMMXU2: 2 | | | | | | |
| Io(2) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| A Hi high limit res | | 0,20 | xIn | 0,00 | 40,00 | |
| A high limit res | | 0,05 | xIn | 0,00 | 40,00 | |
| A deadband res | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| V Hi high limit res | | 0,20 | xUn | 0,00 | 4,00 | |
| V high limit res | | 0,05 | xUn | 0,00 | 4,00 | |
| V deadband res | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 3 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,20 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| Operation | | on | | | | |
| F high high limit | | 60,00 | Hz | 35,00 | 75,00 | |
| F high limit | | 55,00 | Hz | 35,00 | 75,00 | |
| F low limit | | 45,00 | Hz | 35,00 | 75,00 | |
| F low low limit | | 40,00 | Hz | 35,00 | 75,00 | |
| F deadband | | 1000 | | 100 | 100000 | |
| Def frequency Sel | | Nominal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Operation | | on | | | | |
| Power unit Mult | | k | | | | |
| Energy unit Mult | | k | | | | |
| Active power Dir | | Forward | | | | |
| Reactive power Dir | | Forward | | | | |
| Power deadband | | 10000 | | 1000 | 10000 | |
| Forward Wh Initial | | 0 | | 0 | 999999999 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Reverse Wh Initial | | 0 | | 0 | 999999999 | |
| Forward VArh Initial | | 0 | | 0 | 999999999 | |
| Reverse VArh Initial | | 0 | | 0 | 999999999 | |
| Measurement mode | | PhsA, PhsB, PhsC | | | | |
| Pulse quantity | | 100000 | Wh/VArh | 1 | 10000000 | |
| Pulse on time | | 1,000 | s | 0,050 | 60,000 | |
| Pulse off time | | 0,500 | s | 0,050 | 60,000 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq A Hi high Lim | | 1,40 | xIn | 0,00 | 40,00 | |
| Ps Seq A high limit | | 1,20 | xIn | 0,00 | 40,00 | |
| Ps Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A deadband | | 2500 | | 100 | 100000 | |
| Ng Seq A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Ng Seq A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Ng Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A deadband | | 2500 | | 100 | 100000 | |
| Zro A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Zro A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Zro A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A deadband | | 2500 | | 100 | 100000 | |
| Ps Seq A on delay time | | 0 | ms | 0 | 1800000 | |
| Ps Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Zro A on delay time | | 0 | ms | 0 | 1800000 | |
| Zro A off delay time | | 0 | ms | 0 | 1800000 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq V Hi high Lim | | 1,40 | xUn | 0,00 | 4,00 | |
| Ps Seq V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| Ps Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V deadband | | 10000 | | 100 | 100000 | |
| Ng Seq V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Ng Seq V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Ng Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V deadband | | 10000 | | 100 | 100000 | |
| Zro V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Zro V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Zro V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V deadband | | 10000 | | 100 | 100000 | |
| Ps Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ps Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Zro V on delay time | | 0 | ms | 0 | 1800000 | |
| Zro V off delay time | | 0 | ms | 0 | 1800000 | |
| Demand metering: 0 | | | | | | |
| Demand metering | | | | | | |
| Demand interval | | 1 minute | | | | |
| A demand Av mode | | Linear | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Operation | | on | | | | |
| Trip pulse time | | 250 | ms | 20 | 60000 | |
| Trip output mode | | Non-latched | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Operation | | on | | | | |
| Acc stop current | | 10,00 | A | 5,00 | 500,00 | |
| Open alarm time | | 40 | ms | 0 | 200 | |
| Close alarm time | | 40 | ms | 0 | 200 | |
| Opening time Cor | | 10 | ms | -100 | 100 | |
| Closing time Cor | | 10 | ms | -100 | 100 | |
| Spring charge time | | 15 | s | 0 | 60 | |
| Counter initial Val | | 0 | | 0 | 99999 | |
| Alarm Op number | | 200 | | 0 | 99999 | |
| Lockout Op number | | 300 | | 0 | 99999 | |
| Current exponent | | 2,00 | | 0,00 | 5,00 | |
| Difference Cor time | | 5 | ms | -10 | 10 | |
| Alm Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| LO Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| Ini Acc currents Pwr | | 0,00 | | 0,00 | 20000,00 | |
| Initial CB Rmn life | | 5000 | | 0 | 99999 | |
| Rated Op current | | 1000,00 | A | 100,00 | 6300,00 | |
| Rated fault current | | 5000,00 | A | 500,00 | 99999,00 | |
| Op number rated | | 10000 | | 1 | 99999 | |
| Op number fault | | 1000 | | 1 | 10000 | |
| Life alarm level | | 500 | | 0 | 99999 | |
| Pressure alarm time | | 10 | ms | 0 | 60000 | |
| Pres lockout time | | 10 | ms | 0 | 60000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Inactive Alm days | | 2000 | | 0 | 9999 | |
| Ini inactive days | | 0 | | 0 | 9999 | |
| Inactive Alm hours | | 0 | h | 0 | 23 | |
| Travel time Clc mode | | From Pos to Pos | | | | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Operation | | off | | | | |
| Operate delay time | | 3000 | ms | 1000 | 300000 | |
| Reset delay time | | 1000 | ms | 1000 | 60000 | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Operation | | on | | | | |
| Start value | | 0,05 | xIn | 0,05 | 0,50 | |
| Max operate current | | 1,50 | xIn | 1,00 | 5,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Operation | | off | | | | |
| Neg Seq current Lev | | 0,03 | xIn | 0,03 | 0,20 | |
| Neg Seq voltage Lev | | 0,10 | xUn | 0,03 | 0,20 | |
| Change rate enable | | False | | | | |
| Min Op voltage delta | | 0,50 | xUn | 0,01 | 1,00 | |
| Min Op current delta | | 0,10 | xIn | 0,01 | 1,00 | |
| Enable seal in | | False | | | | |
| Current dead Lin Val | | 0,05 | xIn | 0,05 | 1,00 | |
| Disturbance recorder | | | | | | |
| A1RADR: 1 | | | | | | |
| A1RADR | | | | | | |
| Analog channel 1 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 1 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 2 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 2 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 3 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 3 input | | | 64 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 4 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 4 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 5 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 5 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 6 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 6 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 7 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 7 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 8 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 8 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 9 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 9 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 10 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 10 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 11 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 11 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 12 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 12 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| A2RADR: 13 | | | | | | |
| A2RADR | | | | | | |
| Analog channel 13 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 13 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 14 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 14 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 15 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 15 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 16 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 16 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 17 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 17 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 18 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 18 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 19 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 19 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 20 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 20 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 21 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 21 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 22 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 22 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 23 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 23 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 24 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 24 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| B1RBDR: 1 | | | | | | |
| B1RBDR | | | | | | |
| Binary channel 1 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 1 input | | | 64 characters | |
| Binary channel 2 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 2 input | | | 64 characters | |
| Binary channel 3 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 3 input | | | 64 characters | |
| Binary channel 4 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 4 input | | | 64 characters | |
| Binary channel 5 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 5 input | | | 64 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Binary channel 6 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 6 input | | | 64 characters | |
| Binary channel 7 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 7 input | | | 64 characters | |
| Binary channel 8 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 8 input | | | 64 characters | |
| Binary channel 9 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 9 input | | | 64 characters | |
| Binary channel 10 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 10 input | | | 64 characters | |
| Binary channel 11 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 11 input | | | 64 characters | |
| Binary channel 12 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 12 input | | | 64 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Binary channel 13 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 13 input | | | 64 characters | |
| Binary channel 14 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 14 input | | | 64 characters | |
| Binary channel 15 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 15 input | | | 64 characters | |
| Binary channel 16 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 16 input | | | 64 characters | |
| Binary channel 17 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 17 input | | | 64 characters | |
| Binary channel 18 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 18 input | | | 64 characters | |
| Binary channel 19 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 19 input | | | 64 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Binary channel 20 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 20 input | | | 64 characters | |
| Binary channel 21 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 21 input | | | 64 characters | |
| Binary channel 22 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 22 input | | | 64 characters | |
| Binary channel 23 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 23 input | | | 64 characters | |
| Binary channel 24 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 24 input | | | 64 characters | |
| Binary channel 25 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 25 input | | | 64 characters | |
| Binary channel 26 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 26 input | | | 64 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Binary channel 27 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 27 input | | | 64 characters | |
| Binary channel 28 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 28 input | | | 64 characters | |
| Binary channel 29 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 29 input | | | 64 characters | |
| Binary channel 30 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 30 input | | | 64 characters | |
| Binary channel 31 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 31 input | | | 64 characters | |
| Binary channel 32 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 32 input | | | 64 characters | |
| B2RBDR: 33 | | | | | | |
| B2RBDR | | | | | | |
| Binary channel 33 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 33 input | | | 64 characters | |
| Binary channel 34 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 34 input | | | 64 characters | |
| Binary channel 35 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 35 input | | | 64 characters | |
| Binary channel 36 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 36 input | | | 64 characters | |
| Binary channel 37 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 37 input | | | 64 characters | |
| Binary channel 38 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 38 input | | | 64 characters | |
| Binary channel 39 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 39 input | | | 64 characters | |
| Binary channel 40 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 40 input | | | 64 characters | |
| Binary channel 41 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 41 input | | | 64 characters | |
| Binary channel 42 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 42 input | | | 64 characters | |
| Binary channel 43 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 43 input | | | 64 characters | |
| Binary channel 44 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 44 input | | | 64 characters | |
| Binary channel 45 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 45 input | | | 64 characters | |
| Binary channel 46 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 46 input | | | 64 characters | |
| Binary channel 47 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 47 input | | | 64 characters | |
| Binary channel 48 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 48 input | | | 64 characters | |
| Binary channel 49 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 49 input | | | 64 characters | |
| Binary channel 50 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 50 input | | | 64 characters | |
| Binary channel 51 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 51 input | | | 64 characters | |
| Binary channel 52 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 52 input | | | 64 characters | |
| Binary channel 53 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 53 input | | | 64 characters | |
| Binary channel 54 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 54 input | | | 64 characters | |
| Binary channel 55 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 55 input | | | 64 characters | |
| Binary channel 56 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 56 input | | | 64 characters | |
| Binary channel 57 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 57 input | | | 64 characters | |
| Binary channel 58 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 58 input | | | 64 characters | |
| Binary channel 59 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 59 input | | | 64 characters | |
| Binary channel 60 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 60 input | | | 64 characters | |
| Binary channel 61 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 61 input | | | 64 characters | |
| Binary channel 62 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 62 input | | | 64 characters | |
| Binary channel 63 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 63 input | | | 64 characters | |
| Binary channel 64 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 64 input | | | 64 characters | |
| Fault record | | | | | | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Operation | | on | | | | |
| Trig mode | | From operate | | | | |
| A measurement mode | | DFT | | | | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Operation | | on | | | | |
| Mem. warning level | | 0 | % | 0 | 100 | |
| Mem. alarm level | | 0 | % | 0 | 100 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TONGAPC2: 2 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| TON(2) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Off delay time 1 | | 500 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Off delay time 1 | | 0 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Pulse time 1 | | 150 | ms | 0 | 3600000 | |
| Pulse time 2 | | 150 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Pulse time 1 | | 0 | ms | 0 | 3600000 | |
| Pulse time 2 | | 0 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| General | | | | | | |
| Loc Rem restriction | | False | | | | |
| Output 1 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM CLOSE CMD (DIRECT) | | | 64 characters | |
| Output 2 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM OPEN CMD (DIRECT) | | | 64 characters | |
| Output 3 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | RESET ALARMS | | | 64 characters | |
| Output 4 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 4 | | | 64 characters | |
| Output 5 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 5 | | | 64 characters | |
| Output 6 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 6 | | | 64 characters | |
| Output 7 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 7 | | | 64 characters | |
| Output 8 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | SPCGAPC1 Output 8 | | | 64 characters | |
| Output 9 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 9 | | | 64 characters | |
| Output 10 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 10 | | | 64 characters | |
| Output 11 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 11 | | | 64 characters | |
| Output 12 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 12 | | | 64 characters | |
| Output 13 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 13 | | | 64 characters | |
| Output 14 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 14 | | | 64 characters | |
| Output 15 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | EMERGENCY | | | 64 characters | |
| Output 16 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 16 | | | 64 characters | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC1 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC1 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC1 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC1 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC1 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC1 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC1 Q7 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Output 8 | | | | | | |
| Description | | MVGAPC1 Q8 | | | 20 characters | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC2 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC2 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC2 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC2 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC2 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC2 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC2 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC2 Q8 | | | 20 characters | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC3 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC3 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC3 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC3 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC3 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC3 Q6 | | | 20 characters | |
| Output 7 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC3 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC3 Q8 | | | 20 characters | |
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC4 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC4 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC4 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC4 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC4 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC4 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC4 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC4 Q8 | | | 20 characters | |
| General: 0 | | | | | | |
| General | | | | | | |
| Software reset | | Cancel | | | | |
| HMI: 0 | | | | | | |
| HMI | | | | | | |
| FB naming convention | | IEC61850 | | | | |
| Backlight timeout | | 3 | min | 1 | 60 | |
| Web HMI mode | | On | | | | |
| HMI timeout | | 15 | min | 1 | 60 | |
| SLD symbol format | | IEC | | | | |
| Setting visibility | | Advanced | | | | |
| User defined name | | Disabled | | | | |
| Time: 0 | | | | | | |
| Time | | | | | | |
| System time | | | | | | |
| Time format | | 24H:MM:SS: MS | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Date format | | DD.MM.YYYY | | | | |
| Date | | 0 | | | 20 characters | |
| Time | | 0 | | | 20 characters | |
| Local time offset | | 0 | min | -840 | 840 | |
| Daylight saving time | | | | | | |
| DST in use | | True | | | | |
| DST on time (hours) | | 2 | h | 0 | 23 | |
| DST on time (minutes) | | 0 | min | 0 | 59 | |
| DST on date (day) | | 1 | | 1 | 31 | |
| DST on date (month) | | May | | | | |
| DST on day (weekday) | | reserved | | | | |
| DST off time (hours) | | 2 | h | 0 | 23 | |
| DST off time (minutes) | | 0 | min | 0 | 59 | |
| DST off date (day) | | 25 | | 1 | 31 | |
| DST off date (month) | | September | | | | |
| DST off day (weekday) | | reserved | | | | |
| DST offset | | 60 | min | -720 | 720 | |
| SNTP | | | | | | |
| IP SNTP primary | | 192.168.2.166 | | | | |
| IP SNTP secondary | | 192.168.2.165 | | | | |
| Synchronization | | | | | | |
| Synch source | | SNTP | | | | |
| PTP Profile | | IEEE C37.238-2011 | | | | |
| PTP domain ID | | 0 | | 0 | 255 | |
| PTP priority 1 | | 128 | | 0 | 255 | |
| PTP priority 2 | | 128 | | 0 | 255 | |
| PTP Slave-only | | False | | | | |
| Time master mode | | Master with finite holdover | | | | |
| Clear clock list | | False | | | | |
| Time Syn Src Tmm | | 3 | min | 1 | 65535 | |
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |
| SG operation mode | | Operator | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LHMI | | | | | | |
| Close delay mode | | Not in use | | | | |
| Close delay | | 60 | s | 5 | 900 | |
| Breaker operation | | After confirmation | | | | |
| Programmable LEDs: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Programmable LEDs | | | | | | |
| General | | | | | | |
| Alarm colour | | Red | | | | |
| LED 1 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 27/59 Voltage Protection | | | 64 characters | |
| LED 2 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Ready | | | 64 characters | |
| LED 3 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 4 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Ready to close | | | 64 characters | |
| LED 5 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 50/51 Current Protection | | | 64 characters | |
| LED 6 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 51N/59N Earth Fault Protection | | | 64 characters | |
| LED 7 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Earthing Switch Unlocked | | | 64 characters | |
| LED 8 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Truck Unlocked | | | 64 characters | |
| LED 9 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Arc Protection Trip | | | 64 characters | |
| LED 10 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | GOOSE Alarm | | | 64 characters | |
| LED 11 | | | | | | |
| Alarm mode | | Follow-S | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | - | | | 64 characters | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| LED 12 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Space Heater ON | | | 64 characters | |
| LED 13 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Transformer Protections | | | 64 characters | |
| LED 14 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Fuses Trip | | | 64 characters | |
| LED 15 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Trip from LV | | | 64 characters | |
| LED 16 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 17 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 18 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 19 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 20 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 21 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 22 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| I/O modules: 0 | | | | | | |
| I/O modules | | | | | | |
| Common settings | | | | | | |
| Slot specific threshold | | False | | | | |
| Slot specific hysteresis | | False | | | | |
| Input threshold voltage | | 16 | Vdc | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input osc. level | | 30 | events/s | 2 | 50 | |
| Input osc. hyst | | 10 | events/s | 2 | 50 | |
| User Activity log: 0 | | | | | | |
| User Activity log | | | | | | |
| Server Settings 1 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address | | 192.168.2.5 | | | | |
| Server Settings 2 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address2 | | 192.168.2.6 | | | | |
| Authorization: 1 | | | | | | |
| Authorization | | | | | | |
| Security | | | | | | |
| Remote Update | | Disable | | | | |
| Passwords | | | | | | |
| Remote override | | True | | | | |
| Local override | | True | | | | |
| CAM | | | | | | |
| Clear AD userlist | | False | | | | |
| Network1 | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |
| HTTPS write access | | On | | | | |
| HMI | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |
| Monitoring | | | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CHLIV_A | | False | | | | |
| REDCHLIV_B | | False | | | | |
| Link statuses | | | | | | |
| LNKLIV_A | | False | | | | |
| REDLNKLIV_B | | False | | | | |
| Diagnostics | | | | | | |
| A_B | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CH1LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK1LIV | | False | | | | |
| Diagnostics | | | | | | |
| X1 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Activity | | | | | | |
| CH2LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK2LIV | | False | | | | |
| Diagnostics | | | | | | |
| X2 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Activity | | | | | | |
| CH3LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK3LIV | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Diagnostics | | | | | | |
| X3 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| HMILCCH1: 1 | | | | | | |
| HMILCCH1 | | | | | | |
| Activity | | | | | | |
| HMICHLIV | | False | | | | |
| Link statuses | | | | | | |
| HMILNKLIV | | Down | | | | |
| SCHLCCH6: 6 | | | | | | |
| SCHLCCH6 | | | | | | |
| Activity | | | | | | |
| CH6LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK6LIV | | False | | | | |
| Diagnostics | | | | | | |
| X6 | | | | | | |
| Temperature | | 0,0 | °C | -128,0 | 128,0 | |
| Voltage | | 0,000 | V | 0,000 | 6,550 | |
| Bias current | | 0,0 | mA | 0,0 | 131,0 | |
| TX power | | 0,000 | mW | 0,000 | 6,550 | |
| RX power | | 0,000 | mW | 0,000 | 6,550 | |
| XCVR detected | | False | | | | |
| RX power alarm | | False | | | | |
| TX power alarm | | False | | | | |
| Voltage alarm | | False | | | | |
| Temperature alarm | | False | | | | |
| Part name | | 0 | | | 20 characters | |
| Protocols | | | | | | |
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| CHLIV | | False | | | | |
| Successful conn. | | 0 | | 0 | 10000000 | |
| Failed conn. | | 0 | | 0 | 10000000 | |
| Concludes | | 0 | | 0 | 10000000 | |
| Sent aborts | | 0 | | 0 | 10000000 | |
| Recv. aborts | | 0 | | 0 | 10000000 | |
| Sent rejects | | 0 | | 0 | 10000000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Recv. requests | | 0 | | 0 | 10000000 | |
| Failed requests | | 0 | | 0 | 10000000 | |
| Reads | | 0 | | 0 | 10000000 | |
| Failed reads | | 0 | | 0 | 10000000 | |
| Writes | | 0 | | 0 | 10000000 | |
| Failed writes | | 0 | | 0 | 10000000 | |
| Reports | | 0 | | 0 | 10000000 | |
| Active conn. | | 0 | | 0 | 10000000 | |
| Reset counters | | False | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT2: 2 | | | | | | |
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| MEM_WARN | | False | | | | |
| MEM_ALARM | | False | | | | |
| I/O status | | | | | | |
| Binary input values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| TCS Input 1 | | False | | | | |
| TCS Input 2 | | False | | | | |
| Binary output values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Output 9 | | False | | | | |
| Output 10 | | False | | | | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Current (IoB): 2 | | | | | | |
| Current (IoB) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (Uo): 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage (Uo) | | | | | | |
| URES_ALARM | | False | | | | |
| URES_WARNING | | False | | | | |
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| I_INST_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_A | | normal | | | | |
| I_INST_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_B | | normal | | | | |
| I_INST_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_C | | normal | | | | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I_INST_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| I_DB_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_RES | | normal | | | | |
| RESCMMXU2: 2 | | | | | | |
| Io(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I_INST_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_RES | | normal | | | | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U_INST_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_RES | | normal | | | | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Outputs | | | | | | |
| I2_HIGH_AL | | False | | | | |
| I2_HIGH_WARN | | False | | | | |
| I1_HIGH_AL | | False | | | | |
| I1_HIGH_WARN | | False | | | | |
| I1_LOW_WARN | | False | | | | |
| I1_LOW_AL | | False | | | | |
| I0_HIGH_AL | | False | | | | |
| I0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I2_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I2_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_RANGE | | normal | | | | |
| I1_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I1_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_RANGE | | normal | | | | |
| I0_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I0_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_RANGE | | normal | | | | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Outputs | | | | | | |
| U2_HIGH_AL | | False | | | | |
| U2_HIGH_WARN | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| U1_HIGH_AL | | False | | | | |
| U1_HIGH_WARN | | False | | | | |
| U1_LOW_WARN | | False | | | | |
| U1_LOW_AL | | False | | | | |
| U0_HIGH_AL | | False | | | | |
| U0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U2_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U2_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_RANGE | | normal | | | | |
| U1_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U1_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_RANGE | | normal | | | | |
| U0_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U0_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_RANGE | | normal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Inputs | | | | | | |
| RSTACM | | False | | | | |
| Monitored data | | | | | | |
| S_INST | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DB | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DMD | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P_INST | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DB | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DMD | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q_INST | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DB | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DMD | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF_INST | | 0,00 | | -1,00 | 1,00 | |
| PF_DB | | 0,00 | | -1,00 | 1,00 | |
| PF_DMD | | 0,00 | | -1,00 | 1,00 | |
| EA_RV_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_RV_ACM | | 0 | kVArh | 0 | 999999999 | |
| EA_FWD_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_FWD_ACM | | 0 | kVArh | 0 | 999999999 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| Monitored data | | | | | | |
| F_INST | | 50,00 | Hz | 35,00 | 75,00 | |
| F_DB | | 50,00 | Hz | 35,00 | 75,00 | |
| F_RANGE | | normal | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| IN9 | | False | | | | |
| IN10 | | False | | | | |
| IN11 | | False | | | | |
| IN12 | | False | | | | |
| IN13 | | False | | | | |
| IN14 | | False | | | | |
| IN15 | | False | | | | |
| IN16 | | False | | | | |
| Outputs | | | | | | |
| O1 | | False | | | | |
| O2 | | False | | | | |
| O3 | | False | | | | |
| O4 | | False | | | | |
| O5 | | False | | | | |
| O6 | | False | | | | |
| O7 | | False | | | | |
| O8 | | False | | | | |
| O9 | | False | | | | |
| O10 | | False | | | | |
| O11 | | False | | | | |
| O12 | | False | | | | |
| O13 | | False | | | | |
| O14 | | False | | | | |
| O15 | | False | | | | |
| O16 | | False | | | | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Inputs | | | | | | |
| ENA_OPEN | | True | | | | |
| ENA_CLOSE | | True | | | | |
| BLK_OPEN | | False | | | | |
| BLK_CLOSE | | False | | | | |
| SYNC_OK | | True | | | | |
| SYNC_BYPASS | | False | | | | |
| ITL_BYPASS | | False | | | | |
| Outputs | | | | | | |
| SELECTED | | False | | | | |
| EXE_OP | | False | | | | |
| EXE_CL | | False | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| OPEN_ENAD | | False | | | | |
| CLOSE_ENAD | | False | | | | |
| CTL_ITL_BLKD | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Outputs | | | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Outputs | | | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| Current protection | | | | | | |
| 50-2; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 50-1; PHHPTOC1: 1 | | | | | | |
| 3I>>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 50; PHHPTOC2: 2 | | | | | | |
| 3I>>(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 51; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 51; PHLPTOC2: 2 | | | | | | |
| 3I>(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| BLK2H | | False | | | | |
| 51G; EFHPTOC1: 1 | | | | | | |
| Io>>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Voltage protection | | | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Inputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| START | | False | | | | |
| POSCLOSE | | False | | | | |
| CB_FAULT | | False | | | | |
| Outputs | | | | | | |
| CB_FAULT_AL | | False | | | | |
| TRBU | | False | | | | |
| TRRET | | False | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ARC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| OPERATE | | False | | | | |
| RST_LKOUT | | False | | | | |
| Outputs | | | | | | |
| TRIP | | False | | | | |
| CL_LKOUT | | False | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| POSOPEN | | False | | | | |
| POSCLOSE | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OPEN_CB_EXE | | False | | | | |
| CLOSE_CB_EXE | | False | | | | |
| PRES_ALM_IN | | False | | | | |
| PRES_LO_IN | | False | | | | |
| RST_IPOW | | False | | | | |
| RST_CB_WEAR | | False | | | | |
| RST_TRV_T | | False | | | | |
| RST_SPR_T | | False | | | | |
| Outputs | | | | | | |
| TRV_T_OP_ALM | | False | | | | |
| TRV_T_CL_ALM | | False | | | | |
| SPR_CHR_ALM | | False | | | | |
| OPR_ALM | | False | | | | |
| OPR_LO | | False | | | | |
| IPOW_ALM | | False | | | | |
| IPOW_LO | | False | | | | |
| CB_LIFE_ALM | | False | | | | |
| MON_ALM | | False | | | | |
| PRES_ALM | | False | | | | |
| PRES_LO | | False | | | | |
| OPENPOS | | False | | | | |
| INVALIDPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| Monitored data | | | | | | |
| T_TRV_OP | | 0 | ms | 0 | 60000 | |
| T_TRV_CL | | 0 | ms | 0 | 60000 | |
| T_SPR_CHR | | 0,00 | s | 0,00 | 99,99 | |
| NO_OPR | | 0 | | 0 | 99999 | |
| INA_DAYS | | 0 | | 0 | 9999 | |
| CB_LIFE_A | | 0 | | -99999 | 99999 | |
| CB_LIFE_B | | 0 | | -99999 | 99999 | |
| CB_LIFE_C | | 0 | | -99999 | 99999 | |
| IPOW_A | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_B | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_C | | 0,000 | | 0,000 | 30000,000 | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| FAIL | | False | | | | |
| ALARM | | False | | | | |
| Monitored data | | | | | | |
| IDIFF | | 0,00 | xIn | 0,00 | 40,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| CB_CLOSED | | False | | | | |
| DISCON_OPEN | | False | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| FUSEF_3PH | | False | | | | |
| FUSEF_U | | False | | | | |
| Communication | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| Monitoring | | | | | | |
| Reset counters | | False | | | | |
| Received msgs | | 0 | | 0 | 10000000 | |
| Transmitted msgs | | 0 | | 0 | 10000000 | |
| State changes | | 0 | | 0 | 10000000 | |
| SeqNum changes | | 0 | | 0 | 10000000 | |
| Test msgs | | 0 | | 0 | 10000000 | |
| State warnings | | 0 | | 0 | 10000000 | |
| Seq. warnings | | 0 | | 0 | 10000000 | |
| Recv. timeouts | | 0 | | 0 | 10000000 | |
| ConfRev errors | | 0 | | 0 | 10000000 | |
| NdsComm errors | | 0 | | 0 | 10000000 | |
| Dataset errors | | 0 | | 0 | 10000000 | |
| Replay Prot warnings | | 0 | | 0 | 10000000 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| FB status | | | | | | |
| 50-2; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>>>(1) | | on | | | | |
| 50-1; PHHPTOC1: 1 | | | | | | |
| 3I>>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>>(1) | | on | | | | |
| 50; PHHPTOC2: 2 | | | | | | |
| 3I>>(2) | | | | | | |
| Current protection | | | | | | |
| 3I>>(2) | | on | | | | |
| 51; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>(1) | | on | | | | |
| 51; PHLPTOC2: 2 | | | | | | |
| 3I>(2) | | | | | | |
| Current protection | | | | | | |
| 3I>(2) | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Current protection | | | | | | |
| 3I2f>(1) | | on | | | | |
| 51G; EFHPTOC1: 1 | | | | | | |
| Io>>(1) | | | | | | |
| Current protection | | | | | | |
| Io>>(1) | | on | | | | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Current protection | | | | | | |
| Io>(1) | | on | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U>(1) | | on | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U<(1) | | on | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Voltage protection | | | | | | |
| Uo>(1) | | on | | | | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Voltage protection | | | | | | |
| Uo>(2) | | on | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Other protection | | | | | | |
| 3I>/Io>BF(1) | | on | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Other protection | | | | | | |
| ARC(1) | | on | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Other protection | | | | | | |
| ARC(2) | | on | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Other protection | | | | | | |
| ARC(3) | | on | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Trip logic | | | | | | |
| Master Trip(1) | | on | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Condition monitoring | | | | | | |
| CBCM(1) | | on | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Supervision | | | | | | |
| TCS(1) | | on | | | | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Supervision | | | | | | |
| MCS 3I(1) | | on | | | | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Supervision | | | | | | |
| FUSEF(1) | | on | | | | |
| Recorded data | | | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Max demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand IL1 | | 0 | | | 34 characters | |
| Time max demand IL2 | | 0 | | | 34 characters | |
| Time max demand IL3 | | 0 | | | 34 characters | |
| Time min demand IL1 | | 0 | | | 34 characters | |
| Time min demand IL2 | | 0 | | | 34 characters | |
| Time min demand IL3 | | 0 | | | 34 characters | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Max demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand Io | | 0 | | | 34 characters | |
| Time min demand Io | | 0 | | | 34 characters | |
| RESCMMXU2: 2 | | | | | | |
| Io(2) | | | | | | |
| Max demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand Io | | 0 | | | 34 characters | |
| Time min demand Io | | 0 | | | 34 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Max demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Min demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Max demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Min demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Max demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Min demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Time max dmd S | | 0 | | | 34 characters | |
| Time min dmd S | | 0 | | | 34 characters | |
| Time max dmd P | | 0 | | | 34 characters | |
| Time min dmd P | | 0 | | | 34 characters | |
| Time max dmd Q | | 0 | | | 34 characters | |
| Time min dmd Q | | 0 | | | 34 characters | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault record | | | | | | |
| Fault number | | 0 | | 0 | 999999 | |
| Time and date | | 0 | | | 34 characters | |
| Protection (rec. set 1) | | None | | | | |
| Protection (rec. set 2) | | None | | | | |
| Start duration | | 0,00 | % | 0,00 | 100,00 | |
| Operate time | | 0,000 | s | 0,000 | 999999,999 | |
| Breaker clear time | | 0,000 | s | 0,000 | 3,000 | |
| Fault distance | | 0,00 | pu | 0,00 | 3000,00 | |
| Fault resistance | | 0,00 | ohm | 0,00 | 3000,00 | |
| Fault reactance | | 0,00 | ohm | 0,00 | 3000,00 | |
| Active group | | 1 | | 1 | 6 | |
| Shot pointer | | 1 | | 1 | 7 | |
| Max diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Diff current Io:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Bias current Io:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Max current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Voltage UL1:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:2 | | 0,000 | xUn | 0,000 | 4,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage Uo:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL12:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL23:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL31:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| PTTR thermal level | | 0,00 | | 0,00 | 99,99 | |
| I2/I1>(1) rat. I2/I1 | | 0,00 | % | 0,00 | 999,99 | |
| Frequency:1 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:1 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:2 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:2 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:3 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:3 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Conductance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Susceptance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Angle Uo:1 - Io:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:1- IL1:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:1 - IL2:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:1 - IL3:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:2 - Io:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:2 - IL1:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:2 - IL2:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:2 - IL3:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:3 - Io:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:3 - IL1:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:3 - IL2:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:3 - IL3:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Control command | | | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LR state | | Remote | | | | |
| Detached LHMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| CONNECTION | | False | | | | |
| Service port IP address | | 0 | | | 20 characters | |
| Main unit port IP address | | 0 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |
| Outputs | | | | | | |
| SG_LOGIC_SEL | | False | | | | |
| SG_1_ACT | | False | | | | |
| SG_2_ACT | | False | | | | |
| SG_3_ACT | | False | | | | |
| SG_4_ACT | | False | | | | |
| SG_5_ACT | | False | | | | |
| SG_6_ACT | | False | | | | |
| Programmable LEDs: 1 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 1 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 2 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 3 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 4 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 5 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 6 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 7 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 8 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 9 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 10 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 11 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 1 | | None | | | | |
| Programmable LED 2 | | None | | | | |
| Programmable LED 3 | | None | | | | |
| Programmable LED 4 | | None | | | | |
| Programmable LED 5 | | None | | | | |
| Programmable LED 6 | | None | | | | |
| Programmable LED 7 | | None | | | | |
| Programmable LED 8 | | None | | | | |
| Programmable LED 9 | | None | | | | |
| Programmable LED 10 | | None | | | | |
| Programmable LED 11 | | None | | | | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 12 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 13 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 14 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 15 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 16 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| LED 17 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 18 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 19 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 20 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 21 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 22 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 12 | | None | | | | |
| Programmable LED 13 | | None | | | | |
| Programmable LED 14 | | None | | | | |
| Programmable LED 15 | | None | | | | |
| Programmable LED 16 | | None | | | | |
| Programmable LED 17 | | None | | | | |
| Programmable LED 18 | | None | | | | |
| Programmable LED 19 | | None | | | | |
| Programmable LED 20 | | None | | | | |
| Programmable LED 21 | | None | | | | |
| Programmable LED 22 | | None | | | | |
| IED status: 1 | | | | | | |
| IED status | | | | | | |
| CAM | | | | | | |
| UAM mode | | Local | | | | |
| CAM server1 | | Offline | | | | |
| CAM server2 | | Offline | | | | |
| Replication | | N.A. | | | | |
| Last update | | 0 | | | 34 characters | |
| PKI | | | | | | |
| CA Server Status | | Offline | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Time synchronization | | | | | | |
| PTP P2P delay X1 | | 0 | ns | -2147483648 | 2147483647 | |
| PTP P2P delay X2 | | 0 | ns | -2147483648 | 2147483647 | |
| PTP P2P delay X3 | | 0 | ns | -2147483648 | 2147483647 | |
| Self-supervision | | | | | | |
| Warning | | All ok | | | | |
| Internal Fault | | All ok | | | | |
| Boot up time | | 0 | | | 34 characters | |
| Boot up reason | | None | | | | |
| Device state | | on | | | | |
| Composition changes | | | | | | |
| No of comp. changes | | 0 | | 0 | 100000 | |
| Setting changes | | | | | | |
| Setting changes | | 0 | | 0 | 20000 | |
| Setting time | | 0 | | | 34 characters | |
| SMV accuracy | | | | | | |
| SMV Synch accuracy | | InternalClock | | | | |
| Local synch accuracy | | 0 | us | 0 | 1000000000 | |
| Max Dev synch Acc | | 0 | us | 0 | 1000000000 | |
| Information | | | | | | |
| HW modules | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Article number | | 2RCA034506 A0001 | | | 20 characters | |
| SW version | | 0x105 | | | 20 characters | |
| HW revision | | G | | | 20 characters | |
| Serial number | | 1VH341247127 | | | 20 characters | |
| Manufacturing date | | 24.2.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 24.2.2024 00:00:00.000 | | | 34 characters | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Article number | | 2RCA034506 A0001 | | | 20 characters | |
| SW version | | 0x105 | | | 20 characters | |
| HW revision | | G | | | 20 characters | |
| Serial number | | 1VH341247119 | | | 20 characters | |
| Manufacturing date | | 24.2.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 24.2.2024 00:00:00.000 | | | 34 characters | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Article number | | 2RCA034536 A0001 | | | 20 characters | |
| SW version | | 0x105 | | | 20 characters | |
| HW revision | | F | | | 20 characters | |
| Serial number | | 1VH341253356 | | | 20 characters | |
| Manufacturing date | | 26.4.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 26.4.2024 00:00:00.000 | | | 34 characters | |
| Slot E (AIM): 1 | | | | | | |
| Slot E (AIM) | | | | | | |
| Article number | | 2RCA034442 A0001 | | | 20 characters | |
| SW version | | 0x104 | | | 20 characters | |
| HW revision | | H | | | 20 characters | |
| Serial number | | 1VH341244843 | | | 20 characters | |
| Manufacturing date | | 11.2.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 11.2.2024 00:00:00.000 | | | 34 characters | |
| Slot F (AIM): 1 | | | | | | |
| Slot F (AIM) | | | | | | |
| Article number | | 2RCA034442 A0001 | | | 20 characters | |
| SW version | | 0x104 | | | 20 characters | |
| HW revision | | H | | | 20 characters | |
| Serial number | | 1VH341244839 | | | 20 characters | |
| Manufacturing date | | 11.2.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 11.2.2024 00:00:00.000 | | | 34 characters | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Article number | | 2RCA034470 A0001 | | | 20 characters | |
| SW version | | 0x101 | | | 20 characters | |
| HW revision | | H | | | 20 characters | |
| Serial number | | 1VH341219400 | | | 20 characters | |
| Manufacturing date | | 3.10.2023 00:00:00.000 | | | 34 characters | |
| Test date | | 3.10.2023 00:00:00.000 | | | 34 characters | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Detached LHMI | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Article number | | 2RCA033008A0001 | | | 20 characters | |
| Application version | | 22-12-12-18:25 | | | 20 characters | |
| Firmware version | | 20230131222023 | | | 20 characters | |
| HW revision | | V | | | 20 characters | |
| Serial number | | 1VHR51024465 | | | 20 characters | |
| Manufacturing date | | 16.5.2024 01:00:00.000 | | | 34 characters | |
| Test date | | 16.5.2024 01:00:00.000 | | | 34 characters | |
| Service port MAC address | | 00:21:C1:34:82:A9 | | | 20 characters | |
| Main unit port MAC address | | 00:21:C1:34:82:AA | | | 20 characters | |
| Slot A1 (ARC): 1 | | | | | | |
| Slot A1 (ARC) | | | | | | |
| Article number | | 2RCA032261A0001 | | | 20 characters | |
| SW version | | 0x107 | | | 20 characters | |
| HW revision | | G | | | 20 characters | |
| Serial number | | 1VH341251261 | | | 20 characters | |
| Manufacturing date | | 28.3.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 28.3.2024 00:00:00.000 | | | 34 characters | |
| Slot A2 (COM): 1 | | | | | | |
| Slot A2 (COM) | | | | | | |
| Article number | | 2RCA034478A0001 | | | 20 characters | |
| SW version | | 0x11D | | | 20 characters | |
| HW revision | | L | | | 20 characters | |
| Serial number | | 1VH341254202 | | | 20 characters | |
| Manufacturing date | | 15.4.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 15.4.2024 00:00:00.000 | | | 34 characters | |
| Product identifiers: 0 | | | | | | |
| Product identifiers | | | | | | |
| Type | | REX640 | | | 20 characters | |
| Product version | | 1 | | | 64 characters | |
| Serial number | | 1VHR81041856 | | | 20 characters | |
| Production date | | 10.5.2024 01:00:00.000 | | | 34 characters | |
| SW version | | 1.3.3 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SW date | | 11.3.2024 13:07:00.000 | | | 34 characters | |
| SW number | | 2RCA057448 D | | | 20 characters | |
| Interface level | | 0 | | | 64 characters | |
| Order code | | REX640_1A C2 | | | 20 characters | |
| Site identifiers: 0 | | | | | | |
| Site identifiers | | | | | | |
| Customer name | | 0 | | | 20 characters | |
| Street | | 0 | | | 20 characters | |
| House number | | 0 | | | 20 characters | |
| ZIP/Postal code | | 0 | | | 20 characters | |
| City/Province | | 0 | | | 20 characters | |
| State | | 0 | | | 20 characters | |
| Country | | 0 | | | 20 characters | |
| System identifiers: 0 | | | | | | |
| System identifiers | | | | | | |
| Technical key | | AA1L1Q04A1 | | | 20 characters | |
| IEC 61850 version | | Edition 2.1 | | | 24 characters | |
| Engineering model | | ABB | | | | |
| HW modules: 0 | | | | | | |
| HW modules | | | | | | |
| Main board | | | | | | |
| Article number | | 2RCA036414 A0001 | | | 20 characters | |
| SW version | | 0x5402 | | | 20 characters | |
| HW revision | | J | | | 20 characters | |
| Serial number | | 1VH3412537 21 | | | 20 characters | |
| Manufacturing date | | 12.4.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 12.4.2024 00:00:00.000 | | | 34 characters | |
| Clear | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Disturbance records | | Cancel | | | | |
| Clear: 0 | | | | | | |
| Clear | | | | | | |
| Indications and LEDs | | Cancel | | | | |
| Programmable LEDs | | Cancel | | | | |
| Events | | Cancel | | | | |
| Metering records | | Cancel | | | | |
| Power quality data | | Cancel | | | | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Fault records | | Cancel | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Load Profile record | | Cancel | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Master Trip(1) | | Cancel | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| CBCM(1) acc.energy | | Cancel | | | | |
| CBCM(1) rem.life | | Cancel | | | | |
| CBCM(1) travel times | | Cancel | | | | |
| CBCM(1) spr.charge t | | Cancel | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| P,E(1) acc.energy | | Cancel | | | | |
| Application Configuration | | | | | | |
| General | | | | | | |
| Settings | | | | | | |
| Setting group | | | | | | |
| Protection: 0 | | | | | | |
| Setting group | | | | | | |
| Active group | | 1 | | 1 | 6 | |
| Protection | | | | | | |
| Settings | | | | | | |
| Current protection | | | | | | |
| 50-2; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Operation | | off | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 12,60 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 350 | ms | 20 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 12,60 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 350 | ms | 20 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 12,60 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 350 | ms | 20 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 12,60 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operate delay time | | 350 | ms | 20 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 12,60 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 350 | ms | 20 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 12,60 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 350 | ms | 20 | 300000 | |
| 50-1; PHHPTOC1: 1 | | | | | | |
| 3I>>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 2,65 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 2,65 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 2,65 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 2,65 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 2,65 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 2,65 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 50; PHHPTOC2: 2 | | | | | | |
| 3I>>(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 2,10 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 50 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 2,10 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 50 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 2,10 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 50 | ms | 40 | 300000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 2,10 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 50 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 2,10 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 50 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 2,10 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 50 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 51; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Minimum operate time | | 500 | ms | 20 | 60000 | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 50000,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 6,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,00 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| 51; PHLPTOC2: 2 | | | | | | |
| 3I>(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 50000,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 6,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,52 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,52 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,52 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,52 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,52 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,52 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Operation | | off | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 2 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 3 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 4 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 5 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 6 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| 51G; EFHPTOC1: 1 | | | | | | |
| Io>>(1) | | | | | | |
| Operation | | on | | | | |
| Minimum operate time | | 100 | ms | 20 | 60000 | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,180 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,180 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| settingGroup 3 | | | | | | |
| Start value | | 0,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,180 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,180 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,180 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,180 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage protection | | | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Enable block value | | False | | | | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Operation | | off | | | | |
| Current value | | 0,300 | xIn | 0,050 | 2,000 | |
| Current value Res | | 0,30 | xIn | 0,05 | 2,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| CB failure trip mode | | 1 out of 3 | | | | |
| CB failure mode | | Current | | | | |
| CB fail retrip mode | | Off | | | | |
| Retrip time | | 120 | ms | 0 | 60000 | |
| CB failure delay | | 240 | ms | 0 | 60000 | |
| CB fault delay | | 5000 | ms | 0 | 60000 | |
| Measurement mode | | Peak-to-Peak | | | | |
| Trip pulse time | | 200 | ms | 0 | 60000 | |
| Start latching mode | | Rising edge | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Light only | | | | |

*Settings*

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| REX640_A6 | | | | | | |
| IED Configuration | | | | | | |
| HW Configuration | | | | | | |
| Slot B (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot C (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot D (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| POSITION | | intermediate | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| TRIG 1 | | False | | | | |
| TRIG 2 | | False | | | | |
| TRIG 3 | | False | | | | |
| TRIG 4 | | False | | | | |
| TRIG 5 | | False | | | | |
| TRIG 6 | | False | | | | |
| TRIG 7 | | False | | | | |
| TRIG 8 | | False | | | | |
| TRIG 9 | | False | | | | |
| TRIG 10 | | False | | | | |
| TRIG 11 | | False | | | | |
| TRIG 12 | | False | | | | |
| TRIG 13 | | False | | | | |
| TRIG 14 | | False | | | | |
| TRIG 15 | | False | | | | |
| TRIG 16 | | False | | | | |
| Measurements | | | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| S-kVA:1 | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P-kW:1 | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q-kVAr:1 | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF:1 | | 0,00 | | -1,00 | 1,00 | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| IL1-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL2-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL3-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Io-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESVMMXU1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Uo(1) | | | | | | |
| Uo-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| U12-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| UL1-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL2-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL3-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| U12-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| UL1-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL2-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL3-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| f-Hz:1 | | 50,00 | Hz | 35,00 | 75,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| NgSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| PsSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| ZrSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| NgSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| PsSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| ZrSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| Disturbance records | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Number of recordings | | 0 | | 0 | 100 | |
| Rem. amount of rec. | | 0 | | 0 | 100 | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| Trig recording | | Cancel | | | | |
| Time to trigger | | 0 | s | 0 | 604800 | |
| Configuration | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| General | | | | | | |
| Operation | | on | | | | |
| Record length | | 50 | cycles | 10 | 500 | |
| Pre-trg length | | 50 | % | 0 | 100 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Overwrite | | | | |
| Exclusion time | | 0 | ms | 0 | 1000000 | |
| Storage rate | | 32 samples / cycle | | | | |
| Periodic trig time | | 0 | s | 0 | 604800 | |
| Stor. mode periodic | | Waveform | | | | |
| Stor. mode manual | | Waveform | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Operation | | on | | | | |
| Select timeout | | 30000 | ms | 10000 | 300000 | |
| Pulse length | | 200 | ms | 10 | 60000 | |
| Operation counter | | 0 | | 0 | 99999 | |
| Control model | | sbo-with-enhanced-security | | | | |
| Adaptive pulse | | True | | | | |
| Event delay | | 200 | ms | 0 | 10000 | |
| Operation timeout | | 500 | ms | 10 | 6000000 | |
| Interlocking Pls Len | | 2 | s | 1 | 10 | |
| Identification | | CBXCBR1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| General: 0 | | | | | | |
| Control | | | | | | |
| General | | | | | | |
| LR control | | Binary input | | | | |
| Station authority | | L,R | | | | |
| Control mode | | On | | | | |
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | DCSXSWI1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | ESSXSWI1 switch position | | | 255 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| System | | | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| Rated frequency | | 50Hz | | | | |
| Phase rotation | | ABC | | | | |
| Blocking mode | | Freeze timer | | | | |
| Bay name | | REX640_A6 | | | 20 characters | |
| IDMT Sat point | | 50 | I/I> | 10 | 50 | |
| Frequency adaptivity | | Disable | | | | |
| SMV Max Delay | | 3/3 ms | | | | |
| Test mode selection | | Local | | | | |
| HMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Backlight brightness | | 100 | % | 1 | 100 | |
| Enable USB access | | No | | | | |
| Enable HMI service port | | Yes | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| Rate Limiter: 1 | | | | | | |
| Rate Limiter | | | | | | |
| Rate limiter | | | | | | |
| Rate limit ctrl | | False | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Redundancy | | | | | | |
| Redundant mode | | None | | | | |
| Filter | | | | | | |
| Filter mode A_B | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit A_B | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit A_B | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit A_B | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Port modes | | | | | | |
| Port mode X1 | | On | | | | |
| Filter | | | | | | |
| Filter mode X1 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X1 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X1 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X1 | | 8,000 | | 0,512 | 90,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Port modes | | | | | | |
| Port mode X2 | | On | | | | |
| Filter | | | | | | |
| Filter mode X2 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X2 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X2 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X2 | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Port modes | | | | | | |
| Port mode X3 | | On | | | | |
| Filter | | | | | | |
| Filter mode X3 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X3 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X3 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X3 | | 8,000 | | 0,512 | 90,000 | |
| Network1: 1 | | | | | | |
| Network1 | | | | | | |
| Network1 address | | | | | | |
| IP address | | 192.168.10.9 | | | | |
| Subnet mask | | 255.255.255.224 | | | | |
| Default gateway | | 192.168.10.30 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| Network2: 2 | | | | | | |
| Network2 | | | | | | |
| Network2 address | | | | | | |
| Enable | | False | | | | |
| IP address | | 192.168.3.10 | | | | |
| Subnet mask | | 255.255.255.0 | | | | |
| Default gateway | | 0.0.0.0 | | | 16 characters | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| HMI: 1 | | | | | | |
| HMI | | | | | | |
| HMI address | | | | | | |
| IP address | | 192.168.0.254 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Protocols | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| GOOSE | | | | | | |
| Change det. interval | | 500 | ms | 50 | 1000 | |
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| MMS | | | | | | |
| Unit mode | | Nominal | | | | |
| Network1 | | | | | | |
| MMS | | On | | | | |
| HMI port | | | | | | |
| MMS | | On | | | | |
| FTPLPRT1: 1 | | | | | | |
| FTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| FTP | | Secure | | | | |
| HMI port | | | | | | |
| FTP | | Secure | | | | |
| HTTPLPRT1: 1 | | | | | | |
| HTTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| HTTPS | | On | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Network1 | | | | | | |
| Modbus | | On | | | | |
| MBSLPRT2: 2 | | | | | | |
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 600,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | False | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 100,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | False | | | | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Voltage input type | | Voltage trafo | | | | |
| Primary voltage | | 6,600 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 416 | |
| Division ratio | | 10000 | | 1000 | 20000 | |
| VT connection | | Wye | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (3UB): 2 | | | | | | |
| Voltage (3UB) | | | | | | |
| Voltage input type | | Voltage trafo | | | | |
| Primary voltage | | 6,600 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 416 | |
| Division ratio | | 10000 | | 1000 | 20000 | |
| VT connection | | Wye | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (Uo): 1 | | | | | | |
| Voltage (Uo) | | | | | | |
| Primary voltage | | 3,810 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 240 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (UoB): 2 | | | | | | |
| Voltage (UoB) | | | | | | |
| Primary voltage | | 3,810 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 240 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| A high high limit | | 1,40 | xIn | 0,00 | 40,00 | |
| A high limit | | 1,20 | xIn | 0,00 | 40,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A low low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A deadband | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| A Hi high limit res | | 0,20 | xIn | 0,00 | 40,00 | |
| A high limit res | | 0,05 | xIn | 0,00 | 40,00 | |
| A deadband res | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| V Hi high limit res | | 0,20 | xUn | 0,00 | 4,00 | |
| V high limit res | | 0,05 | xUn | 0,00 | 4,00 | |
| V deadband res | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 3 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,20 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 0,90 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Off delay time | | 0 | ms | 0 | 1800000 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| Operation | | on | | | | |
| F high high limit | | 60,00 | Hz | 35,00 | 75,00 | |
| F high limit | | 55,00 | Hz | 35,00 | 75,00 | |
| F low limit | | 45,00 | Hz | 35,00 | 75,00 | |
| F low low limit | | 40,00 | Hz | 35,00 | 75,00 | |
| F deadband | | 1000 | | 100 | 100000 | |
| Def frequency Sel | | Nominal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Operation | | on | | | | |
| Power unit Mult | | k | | | | |
| Energy unit Mult | | k | | | | |
| Active power Dir | | Forward | | | | |
| Reactive power Dir | | Forward | | | | |
| Power deadband | | 10000 | | 1000 | 10000 | |
| Forward Wh Initial | | 0 | | 0 | 999999999 | |
| Reverse Wh Initial | | 0 | | 0 | 999999999 | |
| Forward VArh Initial | | 0 | | 0 | 999999999 | |
| Reverse VArh Initial | | 0 | | 0 | 999999999 | |
| Measurement mode | | PhsA, PhsB, PhsC | | | | |
| Pulse quantity | | 100000 | Wh/VArh | 1 | 10000000 | |
| Pulse on time | | 1,000 | s | 0,050 | 60,000 | |
| Pulse off time | | 0,500 | s | 0,050 | 60,000 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq A Hi high Lim | | 1,40 | xIn | 0,00 | 40,00 | |
| Ps Seq A high limit | | 1,20 | xIn | 0,00 | 40,00 | |
| Ps Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A deadband | | 2500 | | 100 | 100000 | |
| Ng Seq A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Ng Seq A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Ng Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A deadband | | 2500 | | 100 | 100000 | |
| Zro A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Zro A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Zro A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A deadband | | 2500 | | 100 | 100000 | |
| Ps Seq A on delay time | | 0 | ms | 0 | 1800000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Ps Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Zro A on delay time | | 0 | ms | 0 | 1800000 | |
| Zro A off delay time | | 0 | ms | 0 | 1800000 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq V Hi high Lim | | 1,40 | xUn | 0,00 | 4,00 | |
| Ps Seq V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| Ps Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V deadband | | 10000 | | 100 | 100000 | |
| Ng Seq V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Ng Seq V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Ng Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V deadband | | 10000 | | 100 | 100000 | |
| Zro V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Zro V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Zro V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V deadband | | 10000 | | 100 | 100000 | |
| Ps Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ps Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Zro V on delay time | | 0 | ms | 0 | 1800000 | |
| Zro V off delay time | | 0 | ms | 0 | 1800000 | |
| Demand metering: 0 | | | | | | |
| Demand metering | | | | | | |
| Demand interval | | 1 minute | | | | |
| A demand Av mode | | Linear | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Operation | | on | | | | |
| Trip pulse time | | 250 | ms | 20 | 60000 | |
| Trip output mode | | Non-latched | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Operation | | on | | | | |
| Acc stop current | | 10,00 | A | 5,00 | 500,00 | |
| Open alarm time | | 40 | ms | 0 | 200 | |
| Close alarm time | | 40 | ms | 0 | 200 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Opening time Cor | | 10 | ms | -100 | 100 | |
| Closing time Cor | | 10 | ms | -100 | 100 | |
| Spring charge time | | 15 | s | 0 | 60 | |
| Counter initial Val | | 0 | | 0 | 99999 | |
| Alarm Op number | | 200 | | 0 | 99999 | |
| Lockout Op number | | 300 | | 0 | 99999 | |
| Current exponent | | 2,00 | | 0,00 | 5,00 | |
| Difference Cor time | | 5 | ms | -10 | 10 | |
| Alm Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| LO Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| Ini Acc currents Pwr | | 0,00 | | 0,00 | 20000,00 | |
| Initial CB Rmn life | | 5000 | | 0 | 99999 | |
| Rated Op current | | 1000,00 | A | 100,00 | 6300,00 | |
| Rated fault current | | 5000,00 | A | 500,00 | 99999,00 | |
| Op number rated | | 10000 | | 1 | 99999 | |
| Op number fault | | 1000 | | 1 | 10000 | |
| Life alarm level | | 500 | | 0 | 99999 | |
| Pressure alarm time | | 10 | ms | 0 | 60000 | |
| Pres lockout time | | 10 | ms | 0 | 60000 | |
| Inactive Alm days | | 2000 | | 0 | 9999 | |
| Ini inactive days | | 0 | | 0 | 9999 | |
| Inactive Alm hours | | 0 | h | 0 | 23 | |
| Travel time Clc mode | | From Pos to Pos | | | | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Operation | | on | | | | |
| Operate delay time | | 3000 | ms | 1000 | 300000 | |
| Reset delay time | | 1000 | ms | 1000 | 60000 | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Operation | | on | | | | |
| Start value | | 0,05 | xIn | 0,05 | 0,50 | |
| Max operate current | | 1,50 | xIn | 1,00 | 5,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Operation | | off | | | | |
| Neg Seq current Lev | | 0,03 | xIn | 0,03 | 0,20 | |
| Neg Seq voltage Lev | | 0,10 | xUn | 0,03 | 0,20 | |
| Change rate enable | | False | | | | |
| Min Op voltage delta | | 0,50 | xUn | 0,01 | 1,00 | |
| Min Op current delta | | 0,10 | xIn | 0,01 | 1,00 | |
| Enable seal in | | False | | | | |
| Current dead Lin Val | | 0,05 | xIn | 0,05 | 1,00 | |
| Disturbance recorder | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| A1RADR: 1 | | | | | | |
| A1RADR | | | | | | |
| Analog channel 1 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 1 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 2 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 2 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 3 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 3 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 4 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 4 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 5 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 5 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 6 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 6 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 7 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 7 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 8 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 8 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 9 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 9 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 10 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 10 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 11 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 11 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 12 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 12 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| A2RADR: 13 | | | | | | |
| A2RADR | | | | | | |
| Analog channel 13 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 13 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 14 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 14 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 15 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 15 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 16 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 16 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 17 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 17 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 18 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 18 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 19 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 19 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 20 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 20 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 21 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 21 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 22 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 22 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 23 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 23 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 24 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 24 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| B1RBDR: 1 | | | | | | |
| B1RBDR | | | | | | |
| Binary channel 1 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 1 input | | | 64 characters | |
| Binary channel 2 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 2 input | | | 64 characters | |
| Binary channel 3 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 3 input | | | 64 characters | |
| Binary channel 4 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 4 input | | | 64 characters | |
| Binary channel 5 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 5 input | | | 64 characters | |
| Binary channel 6 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 6 input | | | 64 characters | |
| Binary channel 7 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 7 input | | | 64 characters | |
| Binary channel 8 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 8 input | | | 64 characters | |
| Binary channel 9 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 9 input | | | 64 characters | |
| Binary channel 10 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 10 input | | | 64 characters | |
| Binary channel 11 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 11 input | | | 64 characters | |
| Binary channel 12 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 12 input | | | 64 characters | |
| Binary channel 13 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 13 input | | | 64 characters | |
| Binary channel 14 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 14 input | | | 64 characters | |
| Binary channel 15 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 15 input | | | 64 characters | |
| Binary channel 16 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 16 input | | | 64 characters | |
| Binary channel 17 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 17 input | | | 64 characters | |
| Binary channel 18 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 18 input | | | 64 characters | |
| Binary channel 19 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 19 input | | | 64 characters | |
| Binary channel 20 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 20 input | | | 64 characters | |
| Binary channel 21 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 21 input | | | 64 characters | |
| Binary channel 22 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 22 input | | | 64 characters | |
| Binary channel 23 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 23 input | | | 64 characters | |
| Binary channel 24 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 24 input | | | 64 characters | |
| Binary channel 25 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 25 input | | | 64 characters | |
| Binary channel 26 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 26 input | | | 64 characters | |
| Binary channel 27 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 27 input | | | 64 characters | |
| Binary channel 28 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 28 input | | | 64 characters | |
| Binary channel 29 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 29 input | | | 64 characters | |
| Binary channel 30 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 30 input | | | 64 characters | |
| Binary channel 31 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 31 input | | | 64 characters | |
| Binary channel 32 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 32 input | | | 64 characters | |
| B2RBDR: 33 | | | | | | |
| B2RBDR | | | | | | |
| Binary channel 33 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 33 input | | | 64 characters | |
| Binary channel 34 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 34 input | | | 64 characters | |
| Binary channel 35 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 35 input | | | 64 characters | |
| Binary channel 36 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 36 input | | | 64 characters | |
| Binary channel 37 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 37 input | | | 64 characters | |
| Binary channel 38 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 38 input | | | 64 characters | |
| Binary channel 39 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 39 input | | | 64 characters | |
| Binary channel 40 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 40 input | | | 64 characters | |
| Binary channel 41 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 41 input | | | 64 characters | |
| Binary channel 42 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 42 input | | | 64 characters | |
| Binary channel 43 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 43 input | | | 64 characters | |
| Binary channel 44 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 44 input | | | 64 characters | |
| Binary channel 45 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 45 input | | | 64 characters | |
| Binary channel 46 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 46 input | | | 64 characters | |
| Binary channel 47 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 47 input | | | 64 characters | |
| Binary channel 48 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 48 input | | | 64 characters | |
| Binary channel 49 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 49 input | | | 64 characters | |
| Binary channel 50 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 50 input | | | 64 characters | |
| Binary channel 51 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 51 input | | | 64 characters | |
| Binary channel 52 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 52 input | | | 64 characters | |
| Binary channel 53 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 53 input | | | 64 characters | |
| Binary channel 54 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 54 input | | | 64 characters | |
| Binary channel 55 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 55 input | | | 64 characters | |
| Binary channel 56 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 56 input | | | 64 characters | |
| Binary channel 57 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 57 input | | | 64 characters | |
| Binary channel 58 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 58 input | | | 64 characters | |
| Binary channel 59 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 59 input | | | 64 characters | |
| Binary channel 60 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 60 input | | | 64 characters | |
| Binary channel 61 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 61 input | | | 64 characters | |
| Binary channel 62 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 62 input | | | 64 characters | |
| Binary channel 63 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 63 input | | | 64 characters | |
| Binary channel 64 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 64 input | | | 64 characters | |
| Fault record | | | | | | |
| FLTRFRC1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| FLTRFRC1 | | | | | | |
| Operation | | on | | | | |
| Trig mode | | From operate | | | | |
| A measurement mode | | DFT | | | | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Operation | | on | | | | |
| Mem. warning level | | 0 | % | 0 | 100 | |
| Mem. alarm level | | 0 | % | 0 | 100 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Off delay time 1 | | 1000 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Off delay time 1 | | 0 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Pulse time 1 | | 150 | ms | 0 | 3600000 | |
| Pulse time 2 | | 150 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Pulse time 1 | | 0 | ms | 0 | 3600000 | |
| Pulse time 2 | | 0 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| General | | | | | | |
| Loc Rem restriction | | False | | | | |
| Output 1 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM CLOSE CMD (DIRECT) | | | 64 characters | |
| Output 2 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM OPEN CMD (DIRECT) | | | 64 characters | |
| Output 3 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | RESET ALARMS | | | 64 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Output 4 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 4 | | | 64 characters | |
| Output 5 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 5 | | | 64 characters | |
| Output 6 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 6 | | | 64 characters | |
| Output 7 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 7 | | | 64 characters | |
| Output 8 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 8 | | | 64 characters | |
| Output 9 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 9 | | | 64 characters | |
| Output 10 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 10 | | | 64 characters | |
| Output 11 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 11 | | | 64 characters | |
| Output 12 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 12 | | | 64 characters | |
| Output 13 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | SPCGAPC1 Output 13 | | | 64 characters | |
| Output 14 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 14 | | | 64 characters | |
| Output 15 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | EMERGENCY | | | 64 characters | |
| Output 16 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 16 | | | 64 characters | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC1 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC1 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC1 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC1 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC1 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC1 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC1 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC1 Q8 | | | 20 characters | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC2 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC2 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC2 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC2 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC2 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC2 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC2 Q7 | | | 20 characters | |
| Output 8 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC2 Q8 | | | 20 characters | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC3 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC3 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC3 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC3 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC3 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC3 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC3 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC3 Q8 | | | 20 characters | |
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC4 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC4 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC4 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC4 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC4 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC4 Q6 | | | 20 characters | |
| Output 7 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC4 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC4 Q8 | | | 20 characters | |
| General: 0 | | | | | | |
| General | | | | | | |
| Software reset | | Cancel | | | | |
| HMI: 0 | | | | | | |
| HMI | | | | | | |
| FB naming convention | | IEC61850 | | | | |
| Backlight timeout | | 3 | min | 1 | 60 | |
| Web HMI mode | | On | | | | |
| HMI timeout | | 15 | min | 1 | 60 | |
| SLD symbol format | | IEC | | | | |
| Setting visibility | | Advanced | | | | |
| User defined name | | Disabled | | | | |
| Time: 0 | | | | | | |
| Time | | | | | | |
| System time | | | | | | |
| Time format | | 24H:MM:SS:MS | | | | |
| Date format | | DD.MM.YYYY | | | | |
| Date | | 0 | | | 20 characters | |
| Time | | 0 | | | 20 characters | |
| Local time offset | | 0 | min | -840 | 840 | |
| Daylight saving time | | | | | | |
| DST in use | | True | | | | |
| DST on time (hours) | | 2 | h | 0 | 23 | |
| DST on time (minutes) | | 0 | min | 0 | 59 | |
| DST on date (day) | | 1 | | 1 | 31 | |
| DST on date (month) | | May | | | | |
| DST on day (weekday) | | reserved | | | | |
| DST off time (hours) | | 2 | h | 0 | 23 | |
| DST off time (minutes) | | 0 | min | 0 | 59 | |
| DST off date (day) | | 25 | | 1 | 31 | |
| DST off date (month) | | September | | | | |
| DST off day (weekday) | | reserved | | | | |
| DST offset | | 60 | min | -720 | 720 | |
| SNTP | | | | | | |
| IP SNTP primary | | 192.168.2.166 | | | | |
| IP SNTP secondary | | 192.168.2.165 | | | | |
| Synchronization | | | | | | |
| Synch source | | SNTP | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PTP Profile | | IEEE C37.238-2011 | | | | |
| PTP domain ID | | 0 | | 0 | 255 | |
| PTP priority 1 | | 128 | | 0 | 255 | |
| PTP priority 2 | | 128 | | 0 | 255 | |
| PTP Slave-only | | False | | | | |
| Time master mode | | Master with finite holdover | | | | |
| Clear clock list | | False | | | | |
| Time Syn Src Tmm | | 3 | min | 1 | 65535 | |
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |
| SG operation mode | | Operator | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LHMI | | | | | | |
| Close delay mode | | Not in use | | | | |
| Close delay | | 60 | s | 5 | 900 | |
| Breaker operation | | After confirmation | | | | |
| Programmable LEDs: 1 | | | | | | |
| Programmable LEDs | | | | | | |
| General | | | | | | |
| Alarm colour | | Red | | | | |
| LED 1 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 27/59 Voltage Protection | | | 64 characters | |
| LED 2 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Trip Coil Supervision | | | 64 characters | |
| LED 3 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Synchrocheck | | | 64 characters | |
| LED 4 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | CB Ready to close | | | 64 characters | |
| LED 5 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 50/51 Current Protection | | | 64 characters | |
| LED 6 | | | | | | |
| Alarm mode | | Follow-S | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | 51N/59N Earth Fault Protection | | | 64 characters | |
| LED 7 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Earthing Switch Unlocked | | | 64 characters | |
| LED 8 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | CB Truck Unlocked | | | 64 characters | |
| LED 9 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Arc Protection Trip | | | 64 characters | |
| LED 10 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | GOOSE Alarm | | | 64 characters | |
| LED 11 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | CB Spring | | | 64 characters | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| LED 12 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Space Heater ON | | | 64 characters | |
| LED 13 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Transformer Protections | | | 64 characters | |
| LED 14 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 15 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 16 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 17 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 18 | | | | | | |
| Alarm mode | | Follow-S | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | - | | | 64 characters | |
| LED 19 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 20 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 21 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 22 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| I/O modules: 0 | | | | | | |
| I/O modules | | | | | | |
| Common settings | | | | | | |
| Slot specific threshold | | False | | | | |
| Slot specific hysteresis | | False | | | | |
| Input threshold voltage | | 16 | Vdc | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input osc. level | | 30 | events/s | 2 | 50 | |
| Input osc. hyst | | 10 | events/s | 2 | 50 | |
| User Activity log: 0 | | | | | | |
| User Activity log | | | | | | |
| Server Settings 1 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address | | 192.168.2.5 | | | | |
| Server Settings 2 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address2 | | 192.168.2.6 | | | | |
| Authorization: 1 | | | | | | |
| Authorization | | | | | | |
| Security | | | | | | |
| Remote Update | | Disable | | | | |
| Passwords | | | | | | |
| Remote override | | True | | | | |
| Local override | | True | | | | |
| CAM | | | | | | |
| Clear AD userlist | | False | | | | |
| Network1 | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| HTTPS write access | | On | | | | |
| HMI | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |
| Monitoring | | | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CHLIV_A | | False | | | | |
| REDCHLIV_B | | False | | | | |
| Link statuses | | | | | | |
| LNKLIV_A | | False | | | | |
| REDLNKLIV_B | | False | | | | |
| Diagnostics | | | | | | |
| A_B | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CH1LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK1LIV | | False | | | | |
| Diagnostics | | | | | | |
| X1 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Activity | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| CH2LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK2LIV | | False | | | | |
| Diagnostics | | | | | | |
| X2 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Activity | | | | | | |
| CH3LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK3LIV | | False | | | | |
| Diagnostics | | | | | | |
| X3 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| HMILCCH1: 1 | | | | | | |
| HMILCCH1 | | | | | | |
| Activity | | | | | | |
| HMICHLIV | | False | | | | |
| Link statuses | | | | | | |
| HMILNKLIV | | Down | | | | |
| SCHLCCH6: 6 | | | | | | |
| SCHLCCH6 | | | | | | |
| Activity | | | | | | |
| CH6LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK6LIV | | False | | | | |
| Diagnostics | | | | | | |
| X6 | | | | | | |
| Temperature | | 0,0 | °C | -128,0 | 128,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage | | 0,000 | V | 0,000 | 6,550 | |
| Bias current | | 0,0 | mA | 0,0 | 131,0 | |
| TX power | | 0,000 | mW | 0,000 | 6,550 | |
| RX power | | 0,000 | mW | 0,000 | 6,550 | |
| XCVR detected | | False | | | | |
| RX power alarm | | False | | | | |
| TX power alarm | | False | | | | |
| Voltage alarm | | False | | | | |
| Temperature alarm | | False | | | | |
| Part name | | 0 | | | 20 characters | |
| Protocols | | | | | | |
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| CHLIV | | False | | | | |
| Successful conn. | | 0 | | 0 | 10000000 | |
| Failed conn. | | 0 | | 0 | 10000000 | |
| Concludes | | 0 | | 0 | 10000000 | |
| Sent aborts | | 0 | | 0 | 10000000 | |
| Recv. aborts | | 0 | | 0 | 10000000 | |
| Sent rejects | | 0 | | 0 | 10000000 | |
| Recv. requests | | 0 | | 0 | 10000000 | |
| Failed requests | | 0 | | 0 | 10000000 | |
| Reads | | 0 | | 0 | 10000000 | |
| Failed reads | | 0 | | 0 | 10000000 | |
| Writes | | 0 | | 0 | 10000000 | |
| Failed writes | | 0 | | 0 | 10000000 | |
| Reports | | 0 | | 0 | 10000000 | |
| Active conn. | | 0 | | 0 | 10000000 | |
| Reset counters | | False | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT2: 2 | | | | | | |
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| STATUS | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| MEM_WARN | | False | | | | |
| MEM_ALARM | | False | | | | |
| I/O status | | | | | | |
| Binary input values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| TCS Input 1 | | False | | | | |
| TCS Input 2 | | False | | | | |
| Binary output values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Output 9 | | False | | | | |
| Output 10 | | False | | | | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (Uo): 1 | | | | | | |
| Voltage (Uo) | | | | | | |
| URES_ALARM | | False | | | | |
| URES_WARNING | | False | | | | |
| Voltage (UoB): 2 | | | | | | |
| Voltage (UoB) | | | | | | |
| URES_ALARM | | False | | | | |
| URES_WARNING | | False | | | | |
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (3UB): 2 | | | | | | |
| Voltage (3UB) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| I_INST_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_A | | normal | | | | |
| I_INST_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_B | | normal | | | | |
| I_INST_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_C | | normal | | | | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I_INST_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_RES | | normal | | | | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U_INST_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_RES | | normal | | | | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Inputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Outputs | | | | | | |
| I2_HIGH_AL | | False | | | | |
| I2_HIGH_WARN | | False | | | | |
| I1_HIGH_AL | | False | | | | |
| I1_HIGH_WARN | | False | | | | |
| I1_LOW_WARN | | False | | | | |
| I1_LOW_AL | | False | | | | |
| I0_HIGH_AL | | False | | | | |
| I0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I2_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I2_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_RANGE | | normal | | | | |
| I1_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I1_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_RANGE | | normal | | | | |
| I0_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I0_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_RANGE | | normal | | | | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| U2_HIGH_AL | | False | | | | |
| U2_HIGH_WARN | | False | | | | |
| U1_HIGH_AL | | False | | | | |
| U1_HIGH_WARN | | False | | | | |
| U1_LOW_WARN | | False | | | | |
| U1_LOW_AL | | False | | | | |
| U0_HIGH_AL | | False | | | | |
| U0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U2_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U2_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_RANGE | | normal | | | | |
| U1_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U1_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_RANGE | | normal | | | | |
| U0_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U0_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_RANGE | | normal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Inputs | | | | | | |
| RSTACM | | False | | | | |
| Monitored data | | | | | | |
| S_INST | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DB | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DMD | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P_INST | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DB | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DMD | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q_INST | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DB | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DMD | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF_INST | | 0,00 | | -1,00 | 1,00 | |
| PF_DB | | 0,00 | | -1,00 | 1,00 | |
| PF_DMD | | 0,00 | | -1,00 | 1,00 | |
| EA_RV_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_RV_ACM | | 0 | kVArh | 0 | 999999999 | |
| EA_FWD_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_FWD_ACM | | 0 | kVArh | 0 | 999999999 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| Monitored data | | | | | | |
| F_INST | | 50,00 | Hz | 35,00 | 75,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| F_DB | | 50,00 | Hz | 35,00 | 75,00 | |
| F_RANGE | | normal | | | | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| IN9 | | False | | | | |
| IN10 | | False | | | | |
| IN11 | | False | | | | |
| IN12 | | False | | | | |
| IN13 | | False | | | | |
| IN14 | | False | | | | |
| IN15 | | False | | | | |
| IN16 | | False | | | | |
| Outputs | | | | | | |
| O1 | | False | | | | |
| O2 | | False | | | | |
| O3 | | False | | | | |
| O4 | | False | | | | |
| O5 | | False | | | | |
| O6 | | False | | | | |
| O7 | | False | | | | |
| O8 | | False | | | | |
| O9 | | False | | | | |
| O10 | | False | | | | |
| O11 | | False | | | | |
| O12 | | False | | | | |
| O13 | | False | | | | |
| O14 | | False | | | | |
| O15 | | False | | | | |
| O16 | | False | | | | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Inputs | | | | | | |
| ENA_OPEN | | True | | | | |
| ENA_CLOSE | | True | | | | |
| BLK_OPEN | | False | | | | |
| BLK_CLOSE | | False | | | | |
| SYNC_OK | | True | | | | |
| SYNC_BYPASS | | False | | | | |
| ITL_BYPASS | | False | | | | |
| Outputs | | | | | | |
| SELECTED | | False | | | | |
| EXE_OP | | False | | | | |
| EXE_CL | | False | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| OPEN_ENAD | | False | | | | |
| CLOSE_ENAD | | False | | | | |
| CTL_ITL_BLKD | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Outputs | | | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| CL_COMMAND | | False | | | | |
| BYPASS | | False | | | | |
| Outputs | | | | | | |
| SYNC_INPRO | | False | | | | |
| SYNC_OK | | False | | | | |
| CL_FAIL_AL | | False | | | | |
| CMD_FAIL_AL | | False | | | | |
| LLDB | | False | | | | |
| LLLB | | False | | | | |
| DLLB | | False | | | | |
| DLDB | | False | | | | |
| Monitored data | | | | | | |
| ENERG_STATE | | Unknown | | | | |
| U_DIFF_MEAS | | 0,00 | xUn | -3,00 | 3,00 | |
| FR_DIFF_MEAS | | 0,000 | xFn | -1,500 | 1,500 | |
| PH_DIFF_MEAS | | 0,00 | deg | -180,00 | 180,00 | |
| U_DIFF_SYNC | | False | | | | |
| PH_DIF_SYNC | | False | | | | |
| FR_DIFF_SYNC | | False | | | | |
| Current protection | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| BLK2H | | False | | | | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Voltage protection | | | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59-2; PHPTOV2: 2 | | | | | | |
| 3U>(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| START | | False | | | | |
| POSCLOSE | | False | | | | |
| CB_FAULT | | False | | | | |
| Outputs | | | | | | |
| CB_FAULT_AL | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| TRBU | | False | | | | |
| TRRET | | False | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| OPERATE | | False | | | | |
| RST_LKOUT | | False | | | | |
| Outputs | | | | | | |
| TRIP | | False | | | | |
| CL_LKOUT | | False | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Inputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| BLOCK | | False | | | | |
| POSOPEN | | False | | | | |
| POSCLOSE | | False | | | | |
| OPEN_CB_EXE | | False | | | | |
| CLOSE_CB_EXE | | False | | | | |
| PRES_ALM_IN | | False | | | | |
| PRES_LO_IN | | False | | | | |
| RST_IPOW | | False | | | | |
| RST_CB_WEAR | | False | | | | |
| RST_TRV_T | | False | | | | |
| RST_SPR_T | | False | | | | |
| Outputs | | | | | | |
| TRV_T_OP_ALM | | False | | | | |
| TRV_T_CL_ALM | | False | | | | |
| SPR_CHR_ALM | | False | | | | |
| OPR_ALM | | False | | | | |
| OPR_LO | | False | | | | |
| IPOW_ALM | | False | | | | |
| IPOW_LO | | False | | | | |
| CB_LIFE_ALM | | False | | | | |
| MON_ALM | | False | | | | |
| PRES_ALM | | False | | | | |
| PRES_LO | | False | | | | |
| OPENPOS | | False | | | | |
| INVALIDPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| Monitored data | | | | | | |
| T_TRV_OP | | 0 | ms | 0 | 60000 | |
| T_TRV_CL | | 0 | ms | 0 | 60000 | |
| T_SPR_CHR | | 0,00 | s | 0,00 | 99,99 | |
| NO_OPR | | 0 | | 0 | 99999 | |
| INA_DAYS | | 0 | | 0 | 9999 | |
| CB_LIFE_A | | 0 | | -99999 | 99999 | |
| CB_LIFE_B | | 0 | | -99999 | 99999 | |
| CB_LIFE_C | | 0 | | -99999 | 99999 | |
| IPOW_A | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_B | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_C | | 0,000 | | 0,000 | 30000,000 | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| CCSPVC1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MCS 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| FAIL | | False | | | | |
| ALARM | | False | | | | |
| Monitored data | | | | | | |
| IDIFF | | 0,00 | xIn | 0,00 | 40,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| CB_CLOSED | | False | | | | |
| DISCON_OPEN | | False | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| FUSEF_3PH | | False | | | | |
| FUSEF_U | | False | | | | |
| Communication | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| Monitoring | | | | | | |
| Reset counters | | False | | | | |
| Received msgs | | 0 | | 0 | 10000000 | |
| Transmitted msgs | | 0 | | 0 | 10000000 | |
| State changes | | 0 | | 0 | 10000000 | |
| SeqNum changes | | 0 | | 0 | 10000000 | |
| Test msgs | | 0 | | 0 | 10000000 | |
| State warnings | | 0 | | 0 | 10000000 | |
| Seq. warnings | | 0 | | 0 | 10000000 | |
| Recv. timeouts | | 0 | | 0 | 10000000 | |
| ConfRev errors | | 0 | | 0 | 10000000 | |
| NdsComm errors | | 0 | | 0 | 10000000 | |
| Dataset errors | | 0 | | 0 | 10000000 | |
| Replay Prot warnings | | 0 | | 0 | 10000000 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC2: 2 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PT(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| FB status | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>>>(1) | | on | | | | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>(1) | | on | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Current protection | | | | | | |
| 3I2f>(1) | | on | | | | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Current protection | | | | | | |
| Io>(1) | | on | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 3U>(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U>(1) | | on | | | | |
| 59-2; PHPTOV2: 2 | | | | | | |
| 3U>(2) | | | | | | |
| Voltage protection | | | | | | |
| 3U>(2) | | on | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U<(1) | | on | | | | |
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Voltage protection | | | | | | |
| 3U<(2) | | on | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Voltage protection | | | | | | |
| Uo>(1) | | on | | | | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Voltage protection | | | | | | |
| Uo>(2) | | on | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Other protection | | | | | | |
| 3I>/Io>BF(1) | | on | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Other protection | | | | | | |
| ARC(1) | | on | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Other protection | | | | | | |
| ARC(2) | | on | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Other protection | | | | | | |
| ARC(3) | | on | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |
| Control | | | | | | |
| SYNC(1) | | on | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Trip logic | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Master Trip(1) | | on | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Condition monitoring | | | | | | |
| CBCM(1) | | on | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Supervision | | | | | | |
| TCS(1) | | on | | | | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Supervision | | | | | | |
| MCS 3I(1) | | on | | | | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Supervision | | | | | | |
| FUSEF(1) | | on | | | | |
| Recorded data | | | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Max demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand IL1 | | 0 | | | 34 characters | |
| Time max demand IL2 | | 0 | | | 34 characters | |
| Time max demand IL3 | | 0 | | | 34 characters | |
| Time min demand IL1 | | 0 | | | 34 characters | |
| Time min demand IL2 | | 0 | | | 34 characters | |
| Time min demand IL3 | | 0 | | | 34 characters | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Max demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand Io | | 0 | | | 34 characters | |
| Time min demand Io | | 0 | | | 34 characters | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Max demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Min demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Max demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Min demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Max demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Min demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Time max dmd S | | 0 | | | 34 characters | |
| Time min dmd S | | 0 | | | 34 characters | |
| Time max dmd P | | 0 | | | 34 characters | |
| Time min dmd P | | 0 | | | 34 characters | |
| Time max dmd Q | | 0 | | | 34 characters | |
| Time min dmd Q | | 0 | | | 34 characters | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault record | | | | | | |
| Fault number | | 0 | | 0 | 999999 | |
| Time and date | | 0 | | | 34 characters | |
| Protection (rec. set 1) | | None | | | | |
| Protection (rec. set 2) | | None | | | | |
| Start duration | | 0,00 | % | 0,00 | 100,00 | |
| Operate time | | 0,000 | s | 0,000 | 999999,999 | |
| Breaker clear time | | 0,000 | s | 0,000 | 3,000 | |
| Fault distance | | 0,00 | pu | 0,00 | 3000,00 | |
| Fault resistance | | 0,00 | ohm | 0,00 | 3000,00 | |
| Fault reactance | | 0,00 | ohm | 0,00 | 3000,00 | |
| Active group | | 1 | | 1 | 6 | |
| Shot pointer | | 1 | | 1 | 7 | |
| Max diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Diff current Io:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Bias current Io:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Current Ng-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Voltage UL1:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:3 | | 0,000 | xUn | 0,000 | 4,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage UL12:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL23:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL31:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| PTTR thermal level | | 0,00 | | 0,00 | 99,99 | |
| I2/I1>(1) rat. I2/I1 | | 0,00 | % | 0,00 | 999,99 | |
| Frequency:1 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:1 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:2 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:2 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:3 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:3 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Conductance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Susceptance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Angle Uo:1 - Io:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:1- IL1:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:1 - IL2:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:1 - IL3:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:2 - Io:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:2 - IL1:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:2 - IL2:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:2 - IL3:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:3 - Io:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:3 - IL1:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:3 - IL2:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:3 - IL3:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Control command | | | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LR state | | Remote | | | | |
| Detached LHMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| CONNECTION | | False | | | | |
| Service port IP address | | 0 | | | 20 characters | |
| Main unit port IP address | | 0 | | | 20 characters | |
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |
| Outputs | | | | | | |
| SG_LOGIC_SEL | | False | | | | |
| SG_1_ACT | | False | | | | |
| SG_2_ACT | | False | | | | |
| SG_3_ACT | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SG_4_ACT | | False | | | | |
| SG_5_ACT | | False | | | | |
| SG_6_ACT | | False | | | | |
| Programmable LEDs: 1 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 1 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 2 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 3 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 4 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 5 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 6 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 7 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 8 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 9 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 10 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| LED 11 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 1 | | None | | | | |
| Programmable LED 2 | | None | | | | |
| Programmable LED 3 | | None | | | | |
| Programmable LED 4 | | None | | | | |
| Programmable LED 5 | | None | | | | |
| Programmable LED 6 | | None | | | | |
| Programmable LED 7 | | None | | | | |
| Programmable LED 8 | | None | | | | |
| Programmable LED 9 | | None | | | | |
| Programmable LED 10 | | None | | | | |
| Programmable LED 11 | | None | | | | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 12 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 13 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 14 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 15 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 16 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 17 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 18 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| RESET | | False | | | | |
| LED 19 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 20 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 21 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 22 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 12 | | None | | | | |
| Programmable LED 13 | | None | | | | |
| Programmable LED 14 | | None | | | | |
| Programmable LED 15 | | None | | | | |
| Programmable LED 16 | | None | | | | |
| Programmable LED 17 | | None | | | | |
| Programmable LED 18 | | None | | | | |
| Programmable LED 19 | | None | | | | |
| Programmable LED 20 | | None | | | | |
| Programmable LED 21 | | None | | | | |
| Programmable LED 22 | | None | | | | |
| IED status: 1 | | | | | | |
| IED status | | | | | | |
| CAM | | | | | | |
| UAM mode | | Local | | | | |
| CAM server1 | | Offline | | | | |
| CAM server2 | | Offline | | | | |
| Replication | | N.A. | | | | |
| Last update | | 0 | | | 34 characters | |
| PKI | | | | | | |
| CA Server Status | | Offline | | | | |
| Time synchronization | | | | | | |
| PTP P2P delay X1 | | 0 | ns | -2147483648 | 2147483647 | |
| PTP P2P delay X2 | | 0 | ns | -2147483648 | 2147483647 | |
| PTP P2P delay X3 | | 0 | ns | -2147483648 | 2147483647 | |
| Self-supervision | | | | | | |
| Warning | | All ok | | | | |
| Internal Fault | | All ok | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Boot up time | | 0 | | | 34 characters | |
| Boot up reason | | None | | | | |
| Device state | | on | | | | |
| Composition changes | | | | | | |
| No of comp. changes | | 0 | | 0 | 100000 | |
| Setting changes | | | | | | |
| Setting changes | | 0 | | 0 | 20000 | |
| Setting time | | 0 | | | 34 characters | |
| SMV accuracy | | | | | | |
| SMV Synch accuracy | | InternalClock | | | | |
| Local synch accuracy | | 0 | us | 0 | 1000000000 | |
| Max Dev synch Acc | | 0 | us | 0 | 1000000000 | |
| Information | | | | | | |
| HW modules | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Article number | | 2RCA034506A0001 | | | 20 characters | |
| SW version | | 0x105 | | | 20 characters | |
| HW revision | | G | | | 20 characters | |
| Serial number | | 1VH341254400 | | | 20 characters | |
| Manufacturing date | | 17.4.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 17.4.2024 00:00:00.000 | | | 34 characters | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Article number | | 2RCA034506A0001 | | | 20 characters | |
| SW version | | 0x105 | | | 20 characters | |
| HW revision | | G | | | 20 characters | |
| Serial number | | 1VH341254641 | | | 20 characters | |
| Manufacturing date | | 16.4.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 16.4.2024 00:00:00.000 | | | 34 characters | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Article number | | 2RCA034536A0001 | | | 20 characters | |
| SW version | | 0x105 | | | 20 characters | |
| HW revision | | F | | | 20 characters | |
| Serial number | | 1VH341253320 | | | 20 characters | |
| Manufacturing date | | 26.4.2024 00:00:00.000 | | | 34 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Test date | | 26.4.2024 00:00:00.000 | | | 34 characters | |
| Slot E (AIM): 1 | | | | | | |
| Slot E (AIM) | | | | | | |
| Article number | | 2RCA034442 A0001 | | | 20 characters | |
| SW version | | 0x104 | | | 20 characters | |
| HW revision | | H | | | 20 characters | |
| Serial number | | 1VH341244340 | | | 20 characters | |
| Manufacturing date | | 9.2.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 9.2.2024 00:00:00.000 | | | 34 characters | |
| Slot F (AIM): 1 | | | | | | |
| Slot F (AIM) | | | | | | |
| Article number | | 2RCA034442 A0001 | | | 20 characters | |
| SW version | | 0x104 | | | 20 characters | |
| HW revision | | H | | | 20 characters | |
| Serial number | | 1VH341244339 | | | 20 characters | |
| Manufacturing date | | 9.2.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 9.2.2024 00:00:00.000 | | | 34 characters | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Article number | | 2RCA034470 A0001 | | | 20 characters | |
| SW version | | 0x101 | | | 20 characters | |
| HW revision | | H | | | 20 characters | |
| Serial number | | 1VH341219364 | | | 20 characters | |
| Manufacturing date | | 3.10.2023 00:00:00.000 | | | 34 characters | |
| Test date | | 3.10.2023 00:00:00.000 | | | 34 characters | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Detached LHMI | | | | | | |
| Article number | | 2RCA033008 A0001 | | | 20 characters | |
| Application version | | 22-12-12-18:25 | | | 20 characters | |
| Firmware version | | 20230131222023 | | | 20 characters | |
| HW revision | | V | | | 20 characters | |
| Serial number | | 1VHR51024461 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Manufacturing date | | 16.5.2024 01:00:00.000 | | | 34 characters | |
| Test date | | 16.5.2024 01:00:00.000 | | | 34 characters | |
| Service port MAC address | | 00:21:C1:34:82:99 | | | 20 characters | |
| Main unit port MAC address | | 00:21:C1:34:82:9A | | | 20 characters | |
| Slot A1 (ARC): 1 | | | | | | |
| Slot A1 (ARC) | | | | | | |
| Article number | | 2RCA032261A0001 | | | 20 characters | |
| SW version | | 0x107 | | | 20 characters | |
| HW revision | | G | | | 20 characters | |
| Serial number | | 1VH341251259 | | | 20 characters | |
| Manufacturing date | | 28.3.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 28.3.2024 00:00:00.000 | | | 34 characters | |
| Slot A2 (COM): 1 | | | | | | |
| Slot A2 (COM) | | | | | | |
| Article number | | 2RCA034478A0001 | | | 20 characters | |
| SW version | | 0x11D | | | 20 characters | |
| HW revision | | L | | | 20 characters | |
| Serial number | | 1VH341254247 | | | 20 characters | |
| Manufacturing date | | 16.4.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 16.4.2024 00:00:00.000 | | | 34 characters | |
| Product identifiers: 0 | | | | | | |
| Product identifiers | | | | | | |
| Type | | REX640 | | | 20 characters | |
| Product version | | 1 | | | 64 characters | |
| Serial number | | 1VHR81041859 | | | 20 characters | |
| Production date | | 10.5.2024 01:00:00.000 | | | 34 characters | |
| SW version | | 1.3.3 | | | 20 characters | |
| SW date | | 11.3.2024 13:07:00.000 | | | 34 characters | |
| SW number | | 2RCA057448D | | | 20 characters | |
| Interface level | | 0 | | | 64 characters | |
| Order code | | REX640_1AC2 | | | 20 characters | |
| Site identifiers: 0 | | | | | | |
| Site identifiers | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Customer name | | 0 | | | 20 characters | |
| Street | | 0 | | | 20 characters | |
| House number | | 0 | | | 20 characters | |
| ZIP/Postal code | | 0 | | | 20 characters | |
| City/Province | | 0 | | | 20 characters | |
| State | | 0 | | | 20 characters | |
| Country | | 0 | | | 20 characters | |
| System identifiers: 0 | | | | | | |
| System identifiers | | | | | | |
| Technical key | | AA1L1Q06A1 | | | 20 characters | |
| IEC 61850 version | | Edition 2.1 | | | 24 characters | |
| Engineering model | | ABB | | | | |
| HW modules: 0 | | | | | | |
| HW modules | | | | | | |
| Main board | | | | | | |
| Article number | | 2RCA036414A0001 | | | 20 characters | |
| SW version | | 0x5402 | | | 20 characters | |
| HW revision | | J | | | 20 characters | |
| Serial number | | 1VH341253728 | | | 20 characters | |
| Manufacturing date | | 12.4.2024 00:00:00.000 | | | 34 characters | |
| Test date | | 12.4.2024 00:00:00.000 | | | 34 characters | |
| Clear | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Disturbance records | | Cancel | | | | |
| Clear: 0 | | | | | | |
| Clear | | | | | | |
| Indications and LEDs | | Cancel | | | | |
| Programmable LEDs | | Cancel | | | | |
| Events | | Cancel | | | | |
| Metering records | | Cancel | | | | |
| Power quality data | | Cancel | | | | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault records | | Cancel | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Load Profile record | | Cancel | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Master Trip(1) | | Cancel | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| CBCM(1) acc.energy | | Cancel | | | | |
| CBCM(1) rem.life | | Cancel | | | | |
| CBCM(1) travel times | | Cancel | | | | |
| CBCM(1) spr.charge t | | Cancel | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| P,E(1) acc.energy | | Cancel | | | | |
| Application Configuration | | | | | | |
| General | | | | | | |
| Settings | | | | | | |
| Setting group | | | | | | |
| Protection: 0 | | | | | | |
| Setting group | | | | | | |
| Active group | | 1 | | 1 | 6 | |
| Protection | | | | | | |
| Settings | | | | | | |
| Current protection | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 5,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 550 | ms | 20 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 5,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 550 | ms | 20 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 5,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 550 | ms | 20 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 5,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 550 | ms | 20 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 5,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 550 | ms | 20 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 5,20 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 550 | ms | 20 | 300000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Minimum operate time | | 550 | ms | 20 | 60000 | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 50000,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 6,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,98 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,98 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,98 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,98 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,98 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,98 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,300 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Operation | | off | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 2 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 3 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 4 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 5 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 6 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 300 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 300 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 300 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 300 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 300 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 300 | ms | 40 | 300000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operating curve type | | IEC Def. Time | | | | |
| Voltage protection | | | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 59-2; PHPTOV2: 2 | | | | | | |
| 3U>(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 250 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 250 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 250 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 250 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 250 | ms | 40 | 300000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 250 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage block value | | 0,20 | xUn | 0,05 | 1,00 | |
| Enable block value | | True | | | | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2500 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2500 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2500 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2500 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| settingGroup 5 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2500 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2500 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage block value | | 0,20 | xUn | 0,05 | 1,00 | |
| Enable block value | | True | | | | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 400 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 400 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 400 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 400 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 400 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 400 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 750 | ms | 40 | 300000 | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 2 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1500 | ms | 40 | 300000 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Operation | | off | | | | |
| Current value | | 0,300 | xIn | 0,050 | 2,000 | |
| Current value Res | | 0,30 | xIn | 0,05 | 2,00 | |
| CB failure trip mode | | 1 out of 3 | | | | |
| CB failure mode | | Current | | | | |
| CB fail retrip mode | | Off | | | | |
| Retrip time | | 120 | ms | 0 | 60000 | |
| CB failure delay | | 240 | ms | 0 | 60000 | |
| CB fault delay | | 5000 | ms | 0 | 60000 | |
| Measurement mode | | Peak-to-Peak | | | | |
| Trip pulse time | | 200 | ms | 0 | 60000 | |
| Start latching mode | | Rising edge | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Control | | | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |
| Operation | | on | | | | |
| Synchro check mode | | Asynchronous | | | | |
| Control mode | | Continuous | | | | |
| Dead line value | | 0,1 | xUn | 0,1 | 0,8 | |
| Live line value | | 0,5 | xUn | 0,2 | 1,0 | |
| Dead bus value | | 0,1 | xUn | 0,1 | 0,8 | |
| Live bus value | | 0,5 | xUn | 0,2 | 1,0 | |
| Max energizing V | | 1,11 | xUn | 0,50 | 1,15 | |
| Phase shift | | 0 | deg | -180 | 180 | |
| Minimum Syn time | | 10000 | ms | 0 | 60000 | |
| Energizing time | | 100 | ms | 100 | 60000 | |
| Closing time of CB | | 50 | ms | 40 | 250 | |
| Voltage source switch | | False | | | | |
| settingGroup 1 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 2 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 3 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 4 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 5 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 6 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |

*Settings*

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| REX640_A7 | | | | | | |
| IED Configuration | | | | | | |
| HW Configuration | | | | | | |
| Slot B (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot C (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input 10 filter time | | 5 | ms | 5 | 1000 | |
| Input 11 filter time | | 5 | ms | 5 | 1000 | |
| Input 12 filter time | | 5 | ms | 5 | 1000 | |
| Input 13 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 filter time | | 5 | ms | 5 | 1000 | |
| Input 14 counter-mode | | False | | | | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input counter threshold voltage | | 24 | V | 16 | 176 | |
| Input counter threshold hysteresis | | 50 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Input 10 inversion | | False | | | | |
| Input 11 inversion | | False | | | | |
| Input 12 inversion | | False | | | | |
| Input 13 inversion | | False | | | | |
| Input 14 inversion | | False | | | | |
| Slot D (BIO) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input 9 filter time | | 5 | ms | 5 | 1000 | |
| Input threshold voltage | | 16 | V | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| Input 9 inversion | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| POSITION | | intermediate | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| TRIG 1 | | False | | | | |
| TRIG 2 | | False | | | | |
| TRIG 3 | | False | | | | |
| TRIG 4 | | False | | | | |
| TRIG 5 | | False | | | | |
| TRIG 6 | | False | | | | |
| TRIG 7 | | False | | | | |
| TRIG 8 | | False | | | | |
| TRIG 9 | | False | | | | |
| TRIG 10 | | False | | | | |
| TRIG 11 | | False | | | | |
| TRIG 12 | | False | | | | |
| TRIG 13 | | False | | | | |
| TRIG 14 | | False | | | | |
| TRIG 15 | | False | | | | |
| TRIG 16 | | False | | | | |
| Measurements | | | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| S-kVA:1 | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P-kW:1 | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q-kVAr:1 | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF:1 | | 0,00 | | -1,00 | 1,00 | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| IL1-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL2-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| IL3-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Io-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| RESVMMXU1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Uo(1) | | | | | | |
| Uo-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| U12-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| UL1-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL2-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL3-kV:1 | | 0,00 | xUn | 0,00 | 5,00 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| U12-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV:2 | | 0,00 | xUn | 0,00 | 4,00 | |
| UL1-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL2-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| UL3-kV:2 | | 0,00 | xUn | 0,00 | 5,00 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| f-Hz:1 | | 50,00 | Hz | 35,00 | 75,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| NgSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| PsSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| ZrSeq-A:1 | | 0,00 | xIn | 0,00 | 40,00 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| NgSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| PsSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| ZrSeq-kV:1 | | 0,00 | xUn | 0,00 | 4,00 | |
| Disturbance records | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Number of recordings | | 0 | | 0 | 100 | |
| Rem. amount of rec. | | 0 | | 0 | 100 | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| Trig recording | | Cancel | | | | |
| Time to trigger | | 0 | s | 0 | 604800 | |
| Configuration | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| General | | | | | | |
| Operation | | on | | | | |
| Record length | | 50 | cycles | 10 | 500 | |
| Pre-trg length | | 50 | % | 0 | 100 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Overwrite | | | | |
| Exclusion time | | 0 | ms | 0 | 1000000 | |
| Storage rate | | 32 samples / cycle | | | | |
| Periodic trig time | | 0 | s | 0 | 604800 | |
| Stor. mode periodic | | Waveform | | | | |
| Stor. mode manual | | Waveform | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Operation | | on | | | | |
| Select timeout | | 30000 | ms | 10000 | 300000 | |
| Pulse length | | 200 | ms | 10 | 60000 | |
| Operation counter | | 0 | | 0 | 99999 | |
| Control model | | sbo-with-enhanced-security | | | | |
| Adaptive pulse | | True | | | | |
| Event delay | | 200 | ms | 0 | 10000 | |
| Operation timeout | | 500 | ms | 10 | 6000000 | |
| Interlocking Pls Len | | 2 | s | 1 | 10 | |
| Identification | | CBXCBR1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| General: 0 | | | | | | |
| Control | | | | | | |
| General | | | | | | |
| LR control | | Binary input | | | | |
| Station authority | | L,R | | | | |
| Control mode | | On | | | | |
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | DCSXSWI1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | ESSXSWI1 switch position | | | 255 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| System | | | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| Rated frequency | | 50Hz | | | | |
| Phase rotation | | ABC | | | | |
| Blocking mode | | Freeze timer | | | | |
| Bay name | | REX640_A7 | | | 20 characters | |
| IDMT Sat point | | 50 | I/I> | 10 | 50 | |
| Frequency adaptivity | | Disable | | | | |
| SMV Max Delay | | 3/3 ms | | | | |
| Test mode selection | | Local | | | | |
| HMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Backlight brightness | | 100 | % | 1 | 100 | |
| Enable USB access | | No | | | | |
| Enable HMI service port | | Yes | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| Rate Limiter: 1 | | | | | | |
| Rate Limiter | | | | | | |
| Rate limiter | | | | | | |
| Rate limit ctrl | | False | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Redundancy | | | | | | |
| Redundant mode | | None | | | | |
| Filter | | | | | | |
| Filter mode A_B | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit A_B | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit A_B | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit A_B | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Port modes | | | | | | |
| Port mode X1 | | On | | | | |
| Filter | | | | | | |
| Filter mode X1 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X1 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X1 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X1 | | 8,000 | | 0,512 | 90,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Port modes | | | | | | |
| Port mode X2 | | On | | | | |
| Filter | | | | | | |
| Filter mode X2 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X2 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X2 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X2 | | 8,000 | | 0,512 | 90,000 | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Port modes | | | | | | |
| Port mode X3 | | On | | | | |
| Filter | | | | | | |
| Filter mode X3 | | Off | | | | |
| Rate limiter | | | | | | |
| GOOSE rate limit X3 | | 10,000 | | 0,512 | 90,000 | |
| SMV rate limit X3 | | 70,000 | | 0,512 | 90,000 | |
| Def. rate limit X3 | | 8,000 | | 0,512 | 90,000 | |
| Network1: 1 | | | | | | |
| Network1 | | | | | | |
| Network1 address | | | | | | |
| IP address | | 192.168.10.10 | | | | |
| Subnet mask | | 255.255.255.224 | | | | |
| Default gateway | | 192.168.10.30 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| Network2: 2 | | | | | | |
| Network2 | | | | | | |
| Network2 address | | | | | | |
| Enable | | False | | | | |
| IP address | | 192.168.3.10 | | | | |
| Subnet mask | | 255.255.255.0 | | | | |
| Default gateway | | 0.0.0.0 | | | 16 characters | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| HMI: 1 | | | | | | |
| HMI | | | | | | |
| HMI address | | | | | | |
| IP address | | 192.168.0.254 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Protocols | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| GOOSE | | | | | | |
| Change det. interval | | 500 | ms | 50 | 1000 | |
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| MMS | | | | | | |
| Unit mode | | Nominal | | | | |
| Network1 | | | | | | |
| MMS | | On | | | | |
| HMI port | | | | | | |
| MMS | | On | | | | |
| FTPLPRT1: 1 | | | | | | |
| FTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| FTP | | Secure | | | | |
| HMI port | | | | | | |
| FTP | | Secure | | | | |
| HTTPLPRT1: 1 | | | | | | |
| HTTPLPRT1 | | | | | | |
| Network1 | | | | | | |
| HTTPS | | On | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Network1 | | | | | | |
| Modbus | | On | | | | |
| MBSLPRT2: 2 | | | | | | |
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Prtl Customization | | 0 | | 0 | 2147483647 | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 150,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | True | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| Current input type | | Current trafo | | | | |
| Primary current | | 100,0 | A | 1,0 | 15000,0 | |
| Secondary current | | 1A | | | | |
| Rated secondary Val | | 3,000 | mV/Hz | 1,000 | 150,000 | |
| Reverse polarity | | False | | | | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Voltage input type | | Voltage trafo | | | | |
| Primary voltage | | 6,600 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 416 | |
| Division ratio | | 10000 | | 1000 | 20000 | |
| VT connection | | Wye | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (3UB): 2 | | | | | | |
| Voltage (3UB) | | | | | | |
| Voltage input type | | Voltage trafo | | | | |
| Primary voltage | | 6,600 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 416 | |
| Division ratio | | 10000 | | 1000 | 20000 | |
| VT connection | | Wye | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (Uo): 1 | | | | | | |
| Voltage (Uo) | | | | | | |
| Primary voltage | | 3,810 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 240 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (UoB): 2 | | | | | | |
| Voltage (UoB) | | | | | | |
| Primary voltage | | 3,810 | kV | 0,100 | 800,000 | |
| Secondary voltage | | 110 | V | 57 | 240 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| A high high limit | | 1,40 | xIn | 0,00 | 40,00 | |
| A high limit | | 1,20 | xIn | 0,00 | 40,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A low low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A deadband | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| A Hi high limit res | | 0,20 | xIn | 0,00 | 40,00 | |
| A high limit res | | 0,05 | xIn | 0,00 | 40,00 | |
| A deadband res | | 2500 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| V Hi high limit res | | 0,20 | xUn | 0,00 | 4,00 | |
| V high limit res | | 0,05 | xUn | 0,00 | 4,00 | |
| V deadband res | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 3 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,20 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |
| Off delay time | | 0 | ms | 0 | 1800000 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| On delay time | | 0 | ms | 0 | 1800000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Off delay time | | 0 | ms | 0 | 1800000 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| Operation | | on | | | | |
| F high high limit | | 60,00 | Hz | 35,00 | 75,00 | |
| F high limit | | 55,00 | Hz | 35,00 | 75,00 | |
| F low limit | | 45,00 | Hz | 35,00 | 75,00 | |
| F low low limit | | 40,00 | Hz | 35,00 | 75,00 | |
| F deadband | | 1000 | | 100 | 100000 | |
| Def frequency Sel | | Nominal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Operation | | on | | | | |
| Power unit Mult | | k | | | | |
| Energy unit Mult | | k | | | | |
| Active power Dir | | Forward | | | | |
| Reactive power Dir | | Forward | | | | |
| Power deadband | | 10000 | | 1000 | 10000 | |
| Forward Wh Initial | | 0 | | 0 | 999999999 | |
| Reverse Wh Initial | | 0 | | 0 | 999999999 | |
| Forward VArh Initial | | 0 | | 0 | 999999999 | |
| Reverse VArh Initial | | 0 | | 0 | 999999999 | |
| Measurement mode | | PhsA, PhsB, PhsC | | | | |
| Pulse quantity | | 100000 | Wh/VArh | 1 | 10000000 | |
| Pulse on time | | 1,000 | s | 0,050 | 60,000 | |
| Pulse off time | | 0,500 | s | 0,050 | 60,000 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq A Hi high Lim | | 1,40 | xIn | 0,00 | 40,00 | |
| Ps Seq A high limit | | 1,20 | xIn | 0,00 | 40,00 | |
| Ps Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A deadband | | 2500 | | 100 | 100000 | |
| Ng Seq A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Ng Seq A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Ng Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A deadband | | 2500 | | 100 | 100000 | |
| Zro A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Zro A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Zro A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A deadband | | 2500 | | 100 | 100000 | |
| Ps Seq A on delay time | | 0 | ms | 0 | 1800000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Ps Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq A off delay time | | 0 | ms | 0 | 1800000 | |
| Zro A on delay time | | 0 | ms | 0 | 1800000 | |
| Zro A off delay time | | 0 | ms | 0 | 1800000 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq V Hi high Lim | | 1,40 | xUn | 0,00 | 4,00 | |
| Ps Seq V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| Ps Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V deadband | | 10000 | | 100 | 100000 | |
| Ng Seq V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Ng Seq V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Ng Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V deadband | | 10000 | | 100 | 100000 | |
| Zro V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Zro V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Zro V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V deadband | | 10000 | | 100 | 100000 | |
| Ps Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ps Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V on delay time | | 0 | ms | 0 | 1800000 | |
| Ng Seq V off delay time | | 0 | ms | 0 | 1800000 | |
| Zro V on delay time | | 0 | ms | 0 | 1800000 | |
| Zro V off delay time | | 0 | ms | 0 | 1800000 | |
| Demand metering: 0 | | | | | | |
| Demand metering | | | | | | |
| Demand interval | | 1 minute | | | | |
| A demand Av mode | | Linear | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Operation | | on | | | | |
| Trip pulse time | | 250 | ms | 20 | 60000 | |
| Trip output mode | | Non-latched | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Operation | | on | | | | |
| Acc stop current | | 10,00 | A | 5,00 | 500,00 | |
| Open alarm time | | 40 | ms | 0 | 200 | |
| Close alarm time | | 40 | ms | 0 | 200 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Opening time Cor | | 10 | ms | -100 | 100 | |
| Closing time Cor | | 10 | ms | -100 | 100 | |
| Spring charge time | | 15 | s | 0 | 60 | |
| Counter initial Val | | 0 | | 0 | 99999 | |
| Alarm Op number | | 200 | | 0 | 99999 | |
| Lockout Op number | | 300 | | 0 | 99999 | |
| Current exponent | | 2,00 | | 0,00 | 5,00 | |
| Difference Cor time | | 5 | ms | -10 | 10 | |
| Alm Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| LO Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| Ini Acc currents Pwr | | 0,00 | | 0,00 | 20000,00 | |
| Initial CB Rmn life | | 5000 | | 0 | 99999 | |
| Rated Op current | | 1000,00 | A | 100,00 | 6300,00 | |
| Rated fault current | | 5000,00 | A | 500,00 | 99999,00 | |
| Op number rated | | 10000 | | 1 | 99999 | |
| Op number fault | | 1000 | | 1 | 10000 | |
| Life alarm level | | 500 | | 0 | 99999 | |
| Pressure alarm time | | 10 | ms | 0 | 60000 | |
| Pres lockout time | | 10 | ms | 0 | 60000 | |
| Inactive Alm days | | 2000 | | 0 | 9999 | |
| Ini inactive days | | 0 | | 0 | 9999 | |
| Inactive Alm hours | | 0 | h | 0 | 23 | |
| Travel time Clc mode | | From Pos to Pos | | | | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Operation | | off | | | | |
| Operate delay time | | 3000 | ms | 1000 | 300000 | |
| Reset delay time | | 1000 | ms | 1000 | 60000 | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Operation | | on | | | | |
| Start value | | 0,05 | xIn | 0,05 | 0,50 | |
| Max operate current | | 1,50 | xIn | 1,00 | 5,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Operation | | off | | | | |
| Neg Seq current Lev | | 0,03 | xIn | 0,03 | 0,20 | |
| Neg Seq voltage Lev | | 0,10 | xUn | 0,03 | 0,20 | |
| Change rate enable | | False | | | | |
| Min Op voltage delta | | 0,50 | xUn | 0,01 | 1,00 | |
| Min Op current delta | | 0,10 | xIn | 0,01 | 1,00 | |
| Enable seal in | | False | | | | |
| Current dead Lin Val | | 0,05 | xIn | 0,05 | 1,00 | |
| Disturbance recorder | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| A1RADR: 1 | | | | | | |
| A1RADR | | | | | | |
| Analog channel 1 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 1 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 2 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 2 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 3 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 3 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 4 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 4 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 5 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 5 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 6 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 6 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 7 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 7 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 8 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 8 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 9 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 9 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 10 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 10 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 11 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 11 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 12 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 12 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| A2RADR: 13 | | | | | | |
| A2RADR | | | | | | |
| Analog channel 13 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 13 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 14 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 14 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 15 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 15 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 16 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 16 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 17 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 17 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 18 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 18 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 19 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 19 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 20 | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Analog ch 20 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 21 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 21 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 22 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 22 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 23 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 23 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 24 | | | | | | |
| Operation | | on | | | | |
| Channel id text | | Analog ch 24 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| B1RBDR: 1 | | | | | | |
| B1RBDR | | | | | | |
| Binary channel 1 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 1 input | | | 64 characters | |
| Binary channel 2 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 2 input | | | 64 characters | |
| Binary channel 3 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 3 input | | | 64 characters | |
| Binary channel 4 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 4 input | | | 64 characters | |
| Binary channel 5 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 5 input | | | 64 characters | |
| Binary channel 6 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 6 input | | | 64 characters | |
| Binary channel 7 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 7 input | | | 64 characters | |
| Binary channel 8 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 8 input | | | 64 characters | |
| Binary channel 9 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 9 input | | | 64 characters | |
| Binary channel 10 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 10 input | | | 64 characters | |
| Binary channel 11 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 11 input | | | 64 characters | |
| Binary channel 12 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 12 input | | | 64 characters | |
| Binary channel 13 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 13 input | | | 64 characters | |
| Binary channel 14 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 14 input | | | 64 characters | |
| Binary channel 15 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 15 input | | | 64 characters | |
| Binary channel 16 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 16 input | | | 64 characters | |
| Binary channel 17 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 17 input | | | 64 characters | |
| Binary channel 18 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 18 input | | | 64 characters | |
| Binary channel 19 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 19 input | | | 64 characters | |
| Binary channel 20 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 20 input | | | 64 characters | |
| Binary channel 21 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 21 input | | | 64 characters | |
| Binary channel 22 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 22 input | | | 64 characters | |
| Binary channel 23 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 23 input | | | 64 characters | |
| Binary channel 24 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 24 input | | | 64 characters | |
| Binary channel 25 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 25 input | | | 64 characters | |
| Binary channel 26 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 26 input | | | 64 characters | |
| Binary channel 27 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 27 input | | | 64 characters | |
| Binary channel 28 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 28 input | | | 64 characters | |
| Binary channel 29 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 29 input | | | 64 characters | |
| Binary channel 30 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 30 input | | | 64 characters | |
| Binary channel 31 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 31 input | | | 64 characters | |
| Binary channel 32 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 32 input | | | 64 characters | |
| B2RBDR: 33 | | | | | | |
| B2RBDR | | | | | | |
| Binary channel 33 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 33 input | | | 64 characters | |
| Binary channel 34 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 34 input | | | 64 characters | |
| Binary channel 35 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 35 input | | | 64 characters | |
| Binary channel 36 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 36 input | | | 64 characters | |
| Binary channel 37 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 37 input | | | 64 characters | |
| Binary channel 38 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 38 input | | | 64 characters | |
| Binary channel 39 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 39 input | | | 64 characters | |
| Binary channel 40 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 40 input | | | 64 characters | |
| Binary channel 41 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 41 input | | | 64 characters | |
| Binary channel 42 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 42 input | | | 64 characters | |
| Binary channel 43 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 43 input | | | 64 characters | |
| Binary channel 44 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 44 input | | | 64 characters | |
| Binary channel 45 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 45 input | | | 64 characters | |
| Binary channel 46 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 46 input | | | 64 characters | |
| Binary channel 47 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 47 input | | | 64 characters | |
| Binary channel 48 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 48 input | | | 64 characters | |
| Binary channel 49 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 49 input | | | 64 characters | |
| Binary channel 50 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 50 input | | | 64 characters | |
| Binary channel 51 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 51 input | | | 64 characters | |
| Binary channel 52 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 52 input | | | 64 characters | |
| Binary channel 53 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 53 input | | | 64 characters | |
| Binary channel 54 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 54 input | | | 64 characters | |
| Binary channel 55 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 55 input | | | 64 characters | |
| Binary channel 56 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 56 input | | | 64 characters | |
| Binary channel 57 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 57 input | | | 64 characters | |
| Binary channel 58 | | | | | | |
| Operation | | off | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 58 input | | | 64 characters | |
| Binary channel 59 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 59 input | | | 64 characters | |
| Binary channel 60 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 60 input | | | 64 characters | |
| Binary channel 61 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 61 input | | | 64 characters | |
| Binary channel 62 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 62 input | | | 64 characters | |
| Binary channel 63 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 63 input | | | 64 characters | |
| Binary channel 64 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 64 input | | | 64 characters | |
| Fault record | | | | | | |
| FLTRFRC1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| FLTRFRC1 | | | | | | |
| Operation | | on | | | | |
| Trig mode | | From operate | | | | |
| A measurement mode | | DFT | | | | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Operation | | on | | | | |
| Mem. warning level | | 0 | % | 0 | 100 | |
| Mem. alarm level | | 0 | % | 0 | 100 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Off delay time 1 | | 500 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Off delay time 1 | | 0 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Pulse time 1 | | 150 | ms | 0 | 3600000 | |
| Pulse time 2 | | 150 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Pulse time 1 | | 0 | ms | 0 | 3600000 | |
| Pulse time 2 | | 0 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| General | | | | | | |
| Loc Rem restriction | | False | | | | |
| Output 1 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM CLOSE CMD (DIRECT) | | | 64 characters | |
| Output 2 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | REM OPEN CMD (DIRECT) | | | 64 characters | |
| Output 3 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | RESET ALARMS | | | 64 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Output 4 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 4 | | | 64 characters | |
| Output 5 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 5 | | | 64 characters | |
| Output 6 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 6 | | | 64 characters | |
| Output 7 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 7 | | | 64 characters | |
| Output 8 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 8 | | | 64 characters | |
| Output 9 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 9 | | | 64 characters | |
| Output 10 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 10 | | | 64 characters | |
| Output 11 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 11 | | | 64 characters | |
| Output 12 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 12 | | | 64 characters | |
| Output 13 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | SPCGAPC1 Output 13 | | | 64 characters | |
| Output 14 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 14 | | | 64 characters | |
| Output 15 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 150 | ms | 10 | 3600000 | |
| Description | | EMERGENCY | | | 64 characters | |
| Output 16 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC1 Output 16 | | | 64 characters | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC1 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC1 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC1 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC1 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC1 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC1 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC1 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC1 Q8 | | | 20 characters | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC2 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC2 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC2 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC2 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC2 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC2 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC2 Q7 | | | 20 characters | |
| Output 8 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC2 Q8 | | | 20 characters | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC3 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC3 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC3 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC3 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC3 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC3 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC3 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC3 Q8 | | | 20 characters | |
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC4 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC4 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC4 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC4 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC4 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC4 Q6 | | | 20 characters | |
| Output 7 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC4 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC4 Q8 | | | 20 characters | |
| General: 0 | | | | | | |
| General | | | | | | |
| Software reset | | Cancel | | | | |
| HMI: 0 | | | | | | |
| HMI | | | | | | |
| FB naming convention | | IEC61850 | | | | |
| Backlight timeout | | 3 | min | 1 | 60 | |
| Web HMI mode | | On | | | | |
| HMI timeout | | 15 | min | 1 | 60 | |
| SLD symbol format | | IEC | | | | |
| Setting visibility | | Advanced | | | | |
| User defined name | | Disabled | | | | |
| Time: 0 | | | | | | |
| Time | | | | | | |
| System time | | | | | | |
| Time format | | 24H:MM:SS:MS | | | | |
| Date format | | DD.MM.YYYY | | | | |
| Date | | 0 | | | 20 characters | |
| Time | | 0 | | | 20 characters | |
| Local time offset | | 0 | min | -840 | 840 | |
| Daylight saving time | | | | | | |
| DST in use | | True | | | | |
| DST on time (hours) | | 2 | h | 0 | 23 | |
| DST on time (minutes) | | 0 | min | 0 | 59 | |
| DST on date (day) | | 1 | | 1 | 31 | |
| DST on date (month) | | May | | | | |
| DST on day (weekday) | | reserved | | | | |
| DST off time (hours) | | 2 | h | 0 | 23 | |
| DST off time (minutes) | | 0 | min | 0 | 59 | |
| DST off date (day) | | 25 | | 1 | 31 | |
| DST off date (month) | | September | | | | |
| DST off day (weekday) | | reserved | | | | |
| DST offset | | 60 | min | -720 | 720 | |
| SNTP | | | | | | |
| IP SNTP primary | | 192.168.2.166 | | | | |
| IP SNTP secondary | | 192.168.2.165 | | | | |
| Synchronization | | | | | | |
| Synch source | | SNTP | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PTP Profile | | IEEE C37.238-2011 | | | | |
| PTP domain ID | | 0 | | 0 | 255 | |
| PTP priority 1 | | 128 | | 0 | 255 | |
| PTP priority 2 | | 128 | | 0 | 255 | |
| PTP Slave-only | | False | | | | |
| Time master mode | | Master with finite holdover | | | | |
| Clear clock list | | False | | | | |
| Time Syn Src Tmm | | 3 | min | 1 | 65535 | |
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |
| SG operation mode | | Operator | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LHMI | | | | | | |
| Close delay mode | | Not in use | | | | |
| Close delay | | 60 | s | 5 | 900 | |
| Breaker operation | | After confirmation | | | | |
| Programmable LEDs: 1 | | | | | | |
| Programmable LEDs | | | | | | |
| General | | | | | | |
| Alarm colour | | Red | | | | |
| LED 1 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 27/59 Voltage Protection | | | 64 characters | |
| LED 2 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Ready | | | 64 characters | |
| LED 3 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Synchrocheck | | | 64 characters | |
| LED 4 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Ready to close | | | 64 characters | |
| LED 5 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | 50/51 Current Protection | | | 64 characters | |
| LED 6 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Alarm mode | | Follow-S | | | | |
| Description | | 51N/59N Earth Fault Protection | | | 64 characters | |
| LED 7 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Earthing Switch Unlocked | | | 64 characters | |
| LED 8 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Truck Unlocked | | | 64 characters | |
| LED 9 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Arc Protection Trip | | | 64 characters | |
| LED 10 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | GOOSE Alarm | | | 64 characters | |
| LED 11 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Emergency Open by SIS | | | 64 characters | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| LED 12 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Space Heater ON | | | 64 characters | |
| LED 13 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Transformer Protections | | | 64 characters | |
| LED 14 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Contactor Fuses Trip | | | 64 characters | |
| LED 15 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Trip from LV | | | 64 characters | |
| LED 16 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 17 | | | | | | |
| Alarm mode | | Follow-S | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | - | | | 64 characters | |
| LED 18 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 19 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 20 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 21 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| LED 22 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | - | | | 64 characters | |
| I/O modules: 0 | | | | | | |
| I/O modules | | | | | | |
| Common settings | | | | | | |
| Slot specific threshold | | False | | | | |
| Slot specific hysteresis | | False | | | | |
| Input threshold voltage | | 16 | Vdc | 16 | 176 | |
| Input threshold hysteresis | | 10 | % | 10 | 50 | |
| Input osc. level | | 30 | events/s | 2 | 50 | |
| Input osc. hyst | | 10 | events/s | 2 | 50 | |
| User Activity log: 0 | | | | | | |
| User Activity log | | | | | | |
| Server Settings 1 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address | | 192.168.2.5 | | | | |
| Server Settings 2 | | | | | | |
| Enable | | Disable | | | | |
| Communication Type | | UDP | | | | |
| Communication Port | | 514 | | 1 | 7800 | |
| Server IP Address2 | | 192.168.2.6 | | | | |
| Authorization: 1 | | | | | | |
| Authorization | | | | | | |
| Security | | | | | | |
| Remote Update | | Disable | | | | |
| Passwords | | | | | | |
| Remote override | | True | | | | |
| Local override | | True | | | | |
| CAM | | | | | | |
| Clear AD userlist | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Network1 | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |
| HTTPS write access | | On | | | | |
| HMI | | | | | | |
| FTP write access | | On | | | | |
| MMS write access | | On | | | | |
| Monitoring | | | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| RCHLCCH1: 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CHLIV_A | | False | | | | |
| REDCHLIV_B | | False | | | | |
| Link statuses | | | | | | |
| LNKLIV_A | | False | | | | |
| REDLNKLIV_B | | False | | | | |
| Diagnostics | | | | | | |
| A_B | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH1: 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CH1LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK1LIV | | False | | | | |
| Diagnostics | | | | | | |
| X1 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SCHLCCH2: 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Activity | | | | | | |
| CH2LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK2LIV | | False | | | | |
| Diagnostics | | | | | | |
| X2 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| SCHLCCH3: 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Activity | | | | | | |
| CH3LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK3LIV | | False | | | | |
| Diagnostics | | | | | | |
| X3 | | | | | | |
| Reset counters | | False | | | | |
| GOOSE limit count | | 0 | | 0 | 1000000 | |
| SMV limit count | | 0 | | 0 | 1000000 | |
| Ucast limit count | | 0 | | 0 | 1000000 | |
| Def. limit count | | 0 | | 0 | 1000000 | |
| GOOSE limit alarm | | False | | | | |
| SMV limit alarm | | False | | | | |
| Ucast limit alarm | | False | | | | |
| Def. limit alarm | | False | | | | |
| HMILCCH1: 1 | | | | | | |
| HMILCCH1 | | | | | | |
| Activity | | | | | | |
| HMICHLIV | | False | | | | |
| Link statuses | | | | | | |
| HMILNKLIV | | Down | | | | |
| SCHLCCH6: 6 | | | | | | |
| SCHLCCH6 | | | | | | |
| Activity | | | | | | |
| CH6LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK6LIV | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Diagnostics | | | | | | |
| X6 | | | | | | |
| Temperature | | 0,0 | °C | -128,0 | 128,0 | |
| Voltage | | 0,000 | V | 0,000 | 6,550 | |
| Bias current | | 0,0 | mA | 0,0 | 131,0 | |
| TX power | | 0,000 | mW | 0,000 | 6,550 | |
| RX power | | 0,000 | mW | 0,000 | 6,550 | |
| XCVR detected | | False | | | | |
| RX power alarm | | False | | | | |
| TX power alarm | | False | | | | |
| Voltage alarm | | False | | | | |
| Temperature alarm | | False | | | | |
| Part name | | 0 | | | 20 characters | |
| Protocols | | | | | | |
| MMSLPRT1: 1 | | | | | | |
| MMS(1) | | | | | | |
| CHLIV | | False | | | | |
| Successful conn. | | 0 | | 0 | 10000000 | |
| Failed conn. | | 0 | | 0 | 10000000 | |
| Concludes | | 0 | | 0 | 10000000 | |
| Sent aborts | | 0 | | 0 | 10000000 | |
| Recv. aborts | | 0 | | 0 | 10000000 | |
| Sent rejects | | 0 | | 0 | 10000000 | |
| Recv. requests | | 0 | | 0 | 10000000 | |
| Failed requests | | 0 | | 0 | 10000000 | |
| Reads | | 0 | | 0 | 10000000 | |
| Failed reads | | 0 | | 0 | 10000000 | |
| Writes | | 0 | | 0 | 10000000 | |
| Failed writes | | 0 | | 0 | 10000000 | |
| Reports | | 0 | | 0 | 10000000 | |
| Active conn. | | 0 | | 0 | 10000000 | |
| Reset counters | | False | | | | |
| MBSLPRT1: 1 | | | | | | |
| MBSLPRT1 | | | | | | |
| Modbus (1) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT2: 2 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| MBSLPRT2 | | | | | | |
| Modbus (2) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT3: 3 | | | | | | |
| MBSLPRT3 | | | | | | |
| Modbus (3) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT4: 4 | | | | | | |
| MBSLPRT4 | | | | | | |
| Modbus (4) | | | | | | |
| STATUS | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MBSLPRT5: 5 | | | | | | |
| MBSLPRT5 | | | | | | |
| Modbus (5) | | | | | | |
| STATUS | | False | | | | |
| Reset counters | | False | | | | |
| Customization Mode | | Off/Normal | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| MEM_WARN | | False | | | | |
| MEM_ALARM | | False | | | | |
| I/O status | | | | | | |
| Binary input values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| Input 10 | | False | | | | |
| Input 11 | | False | | | | |
| Input 12 | | False | | | | |
| Input 13 | | False | | | | |
| Input 14 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Slot D (BIO) | | | | | | |
| Input 1 | | False | | | | |
| Input 2 | | False | | | | |
| Input 3 | | False | | | | |
| Input 4 | | False | | | | |
| Input 5 | | False | | | | |
| Input 6 | | False | | | | |
| Input 7 | | False | | | | |
| Input 8 | | False | | | | |
| Input 9 | | False | | | | |
| TCS Input 1 | | False | | | | |
| TCS Input 2 | | False | | | | |
| Binary output values | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Output 1 | | False | | | | |
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Output 1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Output 2 | | False | | | | |
| Output 3 | | False | | | | |
| Output 4 | | False | | | | |
| Output 5 | | False | | | | |
| Output 6 | | False | | | | |
| Output 7 | | False | | | | |
| Output 8 | | False | | | | |
| Output 9 | | False | | | | |
| Output 10 | | False | | | | |
| Analog inputs | | | | | | |
| Current (3I): 1 | | | | | | |
| Current (3I) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Current (Io): 1 | | | | | | |
| Current (Io) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (Uo): 1 | | | | | | |
| Voltage (Uo) | | | | | | |
| URES_ALARM | | False | | | | |
| URES_WARNING | | False | | | | |
| Voltage (UoB): 2 | | | | | | |
| Voltage (UoB) | | | | | | |
| URES_ALARM | | False | | | | |
| URES_WARNING | | False | | | | |
| Voltage (3U): 1 | | | | | | |
| Voltage (3U) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (3UB): 2 | | | | | | |
| Voltage (3UB) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| I_INST_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_A | | normal | | | | |
| I_INST_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_B | | normal | | | | |
| I_INST_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_C | | normal | | | | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I_INST_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_RES | | normal | | | | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U_INST_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_RES | | normal | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| VMMXU2: 2 | | | | | | |
| 3U(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Outputs | | | | | | |
| I2_HIGH_AL | | False | | | | |
| I2_HIGH_WARN | | False | | | | |
| I1_HIGH_AL | | False | | | | |
| I1_HIGH_WARN | | False | | | | |
| I1_LOW_WARN | | False | | | | |
| I1_LOW_AL | | False | | | | |
| I0_HIGH_AL | | False | | | | |
| I0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I2_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I2_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_RANGE | | normal | | | | |
| I1_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I1_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_RANGE | | normal | | | | |
| I0_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I0_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_RANGE | | normal | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Outputs | | | | | | |
| U2_HIGH_AL | | False | | | | |
| U2_HIGH_WARN | | False | | | | |
| U1_HIGH_AL | | False | | | | |
| U1_HIGH_WARN | | False | | | | |
| U1_LOW_WARN | | False | | | | |
| U1_LOW_AL | | False | | | | |
| U0_HIGH_AL | | False | | | | |
| U0_HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U2_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U2_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_RANGE | | normal | | | | |
| U1_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U1_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_RANGE | | normal | | | | |
| U0_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U0_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_RANGE | | normal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Inputs | | | | | | |
| RSTACM | | False | | | | |
| Monitored data | | | | | | |
| S_INST | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DB | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DMD | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P_INST | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DB | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DMD | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q_INST | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DB | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DMD | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF_INST | | 0,00 | | -1,00 | 1,00 | |
| PF_DB | | 0,00 | | -1,00 | 1,00 | |
| PF_DMD | | 0,00 | | -1,00 | 1,00 | |
| EA_RV_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_RV_ACM | | 0 | kVArh | 0 | 999999999 | |
| EA_FWD_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_FWD_ACM | | 0 | kVArh | 0 | 999999999 | |
| FMMXU1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| f(1) | | | | | | |
| Monitored data | | | | | | |
| F_INST | | 50,00 | Hz | 35,00 | 75,00 | |
| F_DB | | 50,00 | Hz | 35,00 | 75,00 | |
| F_RANGE | | normal | | | | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| IN9 | | False | | | | |
| IN10 | | False | | | | |
| IN11 | | False | | | | |
| IN12 | | False | | | | |
| IN13 | | False | | | | |
| IN14 | | False | | | | |
| IN15 | | False | | | | |
| IN16 | | False | | | | |
| Outputs | | | | | | |
| O1 | | False | | | | |
| O2 | | False | | | | |
| O3 | | False | | | | |
| O4 | | False | | | | |
| O5 | | False | | | | |
| O6 | | False | | | | |
| O7 | | False | | | | |
| O8 | | False | | | | |
| O9 | | False | | | | |
| O10 | | False | | | | |
| O11 | | False | | | | |
| O12 | | False | | | | |
| O13 | | False | | | | |
| O14 | | False | | | | |
| O15 | | False | | | | |
| O16 | | False | | | | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Inputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC3: 3 | | | | | | |
| MV(3) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC4: 4 | | | | | | |
| MV(4) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Inputs | | | | | | |
| ENA_OPEN | | True | | | | |
| ENA_CLOSE | | True | | | | |
| BLK_OPEN | | False | | | | |
| BLK_CLOSE | | False | | | | |
| SYNC_OK | | True | | | | |
| SYNC_BYPASS | | False | | | | |
| ITL_BYPASS | | False | | | | |
| Outputs | | | | | | |
| SELECTED | | False | | | | |
| EXE_OP | | False | | | | |
| EXE_CL | | False | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| OPEN_ENAD | | False | | | | |
| CLOSE_ENAD | | False | | | | |
| CTL_ITL_BLKD | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Outputs | | | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| ESSXSWI1: 1 | | | | | | |
| I<->O ES(1) | | | | | | |
| Outputs | | | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| CL_COMMAND | | False | | | | |
| BYPASS | | False | | | | |
| Outputs | | | | | | |
| SYNC_INPRO | | False | | | | |
| SYNC_OK | | False | | | | |
| CL_FAIL_AL | | False | | | | |
| CMD_FAIL_AL | | False | | | | |
| LLDB | | False | | | | |
| LLLB | | False | | | | |
| DLLB | | False | | | | |
| DLDB | | False | | | | |
| Monitored data | | | | | | |
| ENERG_STATE | | Unknown | | | | |
| U_DIFF_MEAS | | 0,00 | xUn | -3,00 | 3,00 | |
| FR_DIFF_MEAS | | 0,000 | xFn | -1,500 | 1,500 | |
| PH_DIFF_MEAS | | 0,00 | deg | -180,00 | 180,00 | |
| U_DIFF_SYNC | | False | | | | |
| PH_DIF_SYNC | | False | | | | |
| FR_DIFF_SYNC | | False | | | | |
| Current protection | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 67-1; DPHLPDOC1: 1 | | | | | | |
| 3I>->(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| NON_DIR | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| FAULT_DIR | | unknown | | | | |
| DIRECTION | | unknown | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| DIR_A | | unknown | | | | |
| DIR_B | | unknown | | | | |
| DIR_C | | unknown | | | | |
| ANGLE_A | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_B | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_C | | 0,00 | deg | -180,00 | 180,00 | |
| VMEM_USED | | False | | | | |
| 67-2; DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| NON_DIR | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| FAULT_DIR | | unknown | | | | |
| DIRECTION | | unknown | | | | |
| Monitored data | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| DIR_A | | unknown | | | | |
| DIR_B | | unknown | | | | |
| DIR_C | | unknown | | | | |
| ANGLE_A | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_B | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_C | | 0,00 | deg | -180,00 | 180,00 | |
| VMEM_USED | | False | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| BLK2H | | False | | | | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Voltage protection | | | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Inputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 59-2; PHPTOV2: 2 | | | | | | |
| 3U>(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| START | | False | | | | |
| POSCLOSE | | False | | | | |
| CB_FAULT | | False | | | | |
| Outputs | | | | | | |
| CB_FAULT_AL | | False | | | | |
| TRBU | | False | | | | |
| TRRET | | False | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ARC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ALARM | | False | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| OPERATE | | False | | | | |
| RST_LKOUT | | False | | | | |
| Outputs | | | | | | |
| TRIP | | False | | | | |
| CL_LKOUT | | False | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| POSOPEN | | False | | | | |
| POSCLOSE | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| OPEN_CB_EXE | | False | | | | |
| CLOSE_CB_EXE | | False | | | | |
| PRES_ALM_IN | | False | | | | |
| PRES_LO_IN | | False | | | | |
| RST_IPOW | | False | | | | |
| RST_CB_WEAR | | False | | | | |
| RST_TRV_T | | False | | | | |
| RST_SPR_T | | False | | | | |
| Outputs | | | | | | |
| TRV_T_OP_ALM | | False | | | | |
| TRV_T_CL_ALM | | False | | | | |
| SPR_CHR_ALM | | False | | | | |
| OPR_ALM | | False | | | | |
| OPR_LO | | False | | | | |
| IPOW_ALM | | False | | | | |
| IPOW_LO | | False | | | | |
| CB_LIFE_ALM | | False | | | | |
| MON_ALM | | False | | | | |
| PRES_ALM | | False | | | | |
| PRES_LO | | False | | | | |
| OPENPOS | | False | | | | |
| INVALIDPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| Monitored data | | | | | | |
| T_TRV_OP | | 0 | ms | 0 | 60000 | |
| T_TRV_CL | | 0 | ms | 0 | 60000 | |
| T_SPR_CHR | | 0,00 | s | 0,00 | 99,99 | |
| NO_OPR | | 0 | | 0 | 99999 | |
| INA_DAYS | | 0 | | 0 | 9999 | |
| CB_LIFE_A | | 0 | | -99999 | 99999 | |
| CB_LIFE_B | | 0 | | -99999 | 99999 | |
| CB_LIFE_C | | 0 | | -99999 | 99999 | |
| IPOW_A | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_B | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_C | | 0,000 | | 0,000 | 30000,000 | |
| Supervision | | | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| FAIL | | False | | | | |
| ALARM | | False | | | | |
| Monitored data | | | | | | |
| IDIFF | | 0,00 | xIn | 0,00 | 40,00 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| CB_CLOSED | | False | | | | |
| DISCON_OPEN | | False | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| FUSEF_3PH | | False | | | | |
| FUSEF_U | | False | | | | |
| Communication | | | | | | |
| GSELPRT1: 1 | | | | | | |
| GSE(1) | | | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| Monitoring | | | | | | |
| Reset counters | | False | | | | |
| Received msgs | | 0 | | 0 | 10000000 | |
| Transmitted msgs | | 0 | | 0 | 10000000 | |
| State changes | | 0 | | 0 | 10000000 | |
| SeqNum changes | | 0 | | 0 | 10000000 | |
| Test msgs | | 0 | | 0 | 10000000 | |
| State warnings | | 0 | | 0 | 10000000 | |
| Seq. warnings | | 0 | | 0 | 10000000 | |
| Recv. timeouts | | 0 | | 0 | 10000000 | |
| ConfRev errors | | 0 | | 0 | 10000000 | |
| NdsComm errors | | 0 | | 0 | 10000000 | |
| Dataset errors | | 0 | | 0 | 10000000 | |
| Replay Prot warnings | | 0 | | 0 | 10000000 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Monitored data | | | | | | |
| T_LEFT1 | | 0 | s | 0 | 3600 | |
| T_LEFT2 | | 0 | s | 0 | 3600 | |
| T_LEFT3 | | 0 | s | 0 | 3600 | |
| T_LEFT4 | | 0 | s | 0 | 3600 | |
| T_LEFT5 | | 0 | s | 0 | 3600 | |
| T_LEFT6 | | 0 | s | 0 | 3600 | |
| T_LEFT7 | | 0 | s | 0 | 3600 | |
| T_LEFT8 | | 0 | s | 0 | 3600 | |
| FB status | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>>>(1) | | on | | | | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Current protection | | | | | | |
| 3I>(1) | | on | | | | |
| 67-1; DPHLPDOC1: 1 | | | | | | |
| 3I>->(1) | | | | | | |
| Current protection | | | | | | |
| 3I>->(1) | | on | | | | |
| 67-2; DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| Current protection | | | | | | |
| 3I>->(2) | | on | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Current protection | | | | | | |
| 3I2f>(1) | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Current protection | | | | | | |
| Io>(1) | | on | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U>(1) | | on | | | | |
| 59-2; PHPTOV2: 2 | | | | | | |
| 3U>(2) | | | | | | |
| Voltage protection | | | | | | |
| 3U>(2) | | on | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Voltage protection | | | | | | |
| 3U<(1) | | on | | | | |
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Voltage protection | | | | | | |
| 3U<(2) | | on | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Voltage protection | | | | | | |
| Uo>(1) | | on | | | | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Voltage protection | | | | | | |
| Uo>(2) | | on | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Other protection | | | | | | |
| 3I>/Io>BF(1) | | on | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Other protection | | | | | | |
| ARC(1) | | on | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Other protection | | | | | | |
| ARC(2) | | on | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Other protection | | | | | | |
| ARC(3) | | on | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Control | | | | | | |
| SYNC(1) | | on | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Trip logic | | | | | | |
| Master Trip(1) | | on | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Condition monitoring | | | | | | |
| CBCM(1) | | on | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Supervision | | | | | | |
| TCS(1) | | on | | | | |
| CCSPVC1: 1 | | | | | | |
| MCS 3I(1) | | | | | | |
| Supervision | | | | | | |
| MCS 3I(1) | | on | | | | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Supervision | | | | | | |
| FUSEF(1) | | on | | | | |
| Recorded data | | | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Max demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand IL1 | | 0 | | | 34 characters | |
| Time max demand IL2 | | 0 | | | 34 characters | |
| Time max demand IL3 | | 0 | | | 34 characters | |
| Time min demand IL1 | | 0 | | | 34 characters | |
| Time min demand IL2 | | 0 | | | 34 characters | |
| Time min demand IL3 | | 0 | | | 34 characters | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Max demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand Io | | 0 | | | 34 characters | |
| Time min demand Io | | 0 | | | 34 characters | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Max demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Min demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Max demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Min demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Max demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Min demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Time max dmd S | | 0 | | | 34 characters | |
| Time min dmd S | | 0 | | | 34 characters | |
| Time max dmd P | | 0 | | | 34 characters | |
| Time min dmd P | | 0 | | | 34 characters | |
| Time max dmd Q | | 0 | | | 34 characters | |
| Time min dmd Q | | 0 | | | 34 characters | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault record | | | | | | |
| Fault number | | 0 | | 0 | 999999 | |
| Time and date | | 0 | | | 34 characters | |
| Protection (rec. set 1) | | None | | | | |
| Protection (rec. set 2) | | None | | | | |
| Start duration | | 0,00 | % | 0,00 | 100,00 | |
| Operate time | | 0,000 | s | 0,000 | 999999,999 | |
| Breaker clear time | | 0,000 | s | 0,000 | 3,000 | |
| Fault distance | | 0,00 | pu | 0,00 | 3000,00 | |
| Fault resistance | | 0,00 | ohm | 0,00 | 3000,00 | |
| Fault reactance | | 0,00 | ohm | 0,00 | 3000,00 | |
| Active group | | 1 | | 1 | 6 | |
| Shot pointer | | 1 | | 1 | 7 | |
| Max diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL1:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL2:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Diff current IL3:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Max bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL1:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL2:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Bias current IL3:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Diff current Io:1 | | 0,000 | pu | 0,000 | 80,000 | |
| Bias current Io:1 | | 0,000 | pu | 0,000 | 50,000 | |
| Max current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:1 | | 0,000 | xIn | 0,000 | 50,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Current IL2:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq:3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Voltage UL1:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage Ps-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL1:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL12:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL23:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL31:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq:3 | | 0,000 | xUn | 0,000 | 4,000 | |
| PTTR thermal level | | 0,00 | | 0,00 | 99,99 | |
| I2/I1>(1) rat. I2/I1 | | 0,00 | % | 0,00 | 999,99 | |
| Frequency:1 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:1 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:2 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:2 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Frequency:3 | | 50,00 | Hz | 0,00 | 80,00 | |
| Frequency gradient:3 | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Conductance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Susceptance Yo | | 0,00 | mS | -1000,00 | 1000,00 | |
| Angle Uo:1 - Io:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:1- IL1:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:1 - IL2:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:1 - IL3:1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:2 - Io:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:2 - IL1:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:2 - IL2:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:2 - IL3:2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle Uo:3 - Io:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23:3 - IL1:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31:3 - IL2:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12:3 - IL3:3 | | 0,00 | deg | -180,00 | 180,00 | |
| Control command | | | | | | |
| Control: 0 | | | | | | |
| Control | | | | | | |
| LR state | | Remote | | | | |
| Detached LHMI | | | | | | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| CONNECTION | | False | | | | |
| Service port IP address | | 0 | | | 20 characters | |
| Main unit port IP address | | 0 | | | 20 characters | |
| Setting group: 0 | | | | | | |
| Setting group | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Outputs | | | | | | |
| SG_LOGIC_SEL | | False | | | | |
| SG_1_ACT | | False | | | | |
| SG_2_ACT | | False | | | | |
| SG_3_ACT | | False | | | | |
| SG_4_ACT | | False | | | | |
| SG_5_ACT | | False | | | | |
| SG_6_ACT | | False | | | | |
| Programmable LEDs: 1 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 1 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 2 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 3 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 4 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 5 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 6 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 7 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 8 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 9 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| RESET | | False | | | | |
| LED 10 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 11 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 1 | | None | | | | |
| Programmable LED 2 | | None | | | | |
| Programmable LED 3 | | None | | | | |
| Programmable LED 4 | | None | | | | |
| Programmable LED 5 | | None | | | | |
| Programmable LED 6 | | None | | | | |
| Programmable LED 7 | | None | | | | |
| Programmable LED 8 | | None | | | | |
| Programmable LED 9 | | None | | | | |
| Programmable LED 10 | | None | | | | |
| Programmable LED 11 | | None | | | | |
| Programmable LEDs: 2 | | | | | | |
| Programmable LEDs | | | | | | |
| Inputs | | | | | | |
| LED 12 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 13 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 14 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 15 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 16 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 17 | | | | | | |
| OK | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 18 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 19 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 20 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 21 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 22 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| Monitored data | | | | | | |
| Programmable LED 12 | | None | | | | |
| Programmable LED 13 | | None | | | | |
| Programmable LED 14 | | None | | | | |
| Programmable LED 15 | | None | | | | |
| Programmable LED 16 | | None | | | | |
| Programmable LED 17 | | None | | | | |
| Programmable LED 18 | | None | | | | |
| Programmable LED 19 | | None | | | | |
| Programmable LED 20 | | None | | | | |
| Programmable LED 21 | | None | | | | |
| Programmable LED 22 | | None | | | | |
| IED status: 1 | | | | | | |
| IED status | | | | | | |
| CAM | | | | | | |
| UAM mode | | Local | | | | |
| CAM server1 | | Offline | | | | |
| CAM server2 | | Offline | | | | |
| Replication | | N.A. | | | | |
| Last update | | 0 | | | 34 characters | |
| PKI | | | | | | |
| CA Server Status | | Offline | | | | |
| Time synchronization | | | | | | |
| PTP P2P delay X1 | | 0 | ns | -2147483648 | 2147483647 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PTP P2P delay X2 | | 0 | ns | -2147483648 | 2147483647 | |
| PTP P2P delay X3 | | 0 | ns | -2147483648 | 2147483647 | |
| Self-supervision | | | | | | |
| Warning | | All ok | | | | |
| Internal Fault | | All ok | | | | |
| Boot up time | | 0 | | | 34 characters | |
| Boot up reason | | None | | | | |
| Device state | | on | | | | |
| Composition changes | | | | | | |
| No of comp. changes | | 0 | | 0 | 100000 | |
| Setting changes | | | | | | |
| Setting changes | | 0 | | 0 | 20000 | |
| Setting time | | 0 | | | 34 characters | |
| SMV accuracy | | | | | | |
| SMV Synch accuracy | | InternalClock | | | | |
| Local synch accuracy | | 0 | us | 0 | 1000000000 | |
| Max Dev synch Acc | | 0 | us | 0 | 1000000000 | |
| Information | | | | | | |
| HW modules | | | | | | |
| Slot B (BIO): 1 | | | | | | |
| Slot B (BIO) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot C (BIO): 1 | | | | | | |
| Slot C (BIO) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot D (BIO): 1 | | | | | | |
| Slot D (BIO) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot E (AIM): 1 | | | | | | |
| Slot E (AIM) | | | | | | |
| Article number | | 0 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot F (AIM): 1 | | | | | | |
| Slot F (AIM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | - | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot G (PSM): 1 | | | | | | |
| Slot G (PSM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | - | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| EIHMI1: 1 | | | | | | |
| EIHMI1 | | | | | | |
| Detached LHMI | | | | | | |
| Article number | | 0 | | | 20 characters | |
| Application version | | 0 | | | 20 characters | |
| Firmware version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Service port MAC address | | 0 | | | 20 characters | |
| Main unit port MAC address | | 0 | | | 20 characters | |
| Slot A1 (ARC): 1 | | | | | | |
| Slot A1 (ARC) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Slot A2 (COM): 1 | | | | | | |
| Slot A2 (COM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Product identifiers: 0 | | | | | | |
| Product identifiers | | | | | | |
| Type | | REX640 | | | 20 characters | |
| Product version | | 0 | | | 64 characters | |
| Serial number | | 1XXXXXXXXXXX | | | 20 characters | |
| Production date | | 0 | | | 34 characters | |
| SW version | | X.X | | | 20 characters | |
| SW date | | 0 | | | 34 characters | |
| SW number | | 2RCA057448A | | | 20 characters | |
| Interface level | | 0 | | | 64 characters | |
| Order code | | XXXXXXXXXXXXXXXXX | | | 20 characters | |
| Site identifiers: 0 | | | | | | |
| Site identifiers | | | | | | |
| Customer name | | 0 | | | 20 characters | |
| Street | | 0 | | | 20 characters | |
| House number | | 0 | | | 20 characters | |
| ZIP/Postal code | | 0 | | | 20 characters | |
| City/Province | | 0 | | | 20 characters | |
| State | | 0 | | | 20 characters | |
| Country | | 0 | | | 20 characters | |
| System identifiers: 0 | | | | | | |
| System identifiers | | | | | | |
| Technical key | | TIGER | | | 20 characters | |
| IEC 61850 version | | Edition 2 | | | 24 characters | |
| Engineering model | | ABB | | | | |
| HW modules: 0 | | | | | | |
| HW modules | | | | | | |
| Main board | | | | | | |
| Article number | | 2RAAXXXXXX | | | 20 characters | |
| SW version | | A | | | 20 characters | |
| HW revision | | X | | | 20 characters | |
| Serial number | | 1XXXXXXXXXXX | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Clear | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Disturbance records | | Cancel | | | | |
| Clear: 0 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Clear | | | | | | |
| Indications and LEDs | | Cancel | | | | |
| Programmable LEDs | | Cancel | | | | |
| Events | | Cancel | | | | |
| Metering records | | Cancel | | | | |
| Power quality data | | Cancel | | | | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault records | | Cancel | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Load Profile record | | Cancel | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Master Trip(1) | | Cancel | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| CBCM(1) acc.energy | | Cancel | | | | |
| CBCM(1) rem.life | | Cancel | | | | |
| CBCM(1) travel times | | Cancel | | | | |
| CBCM(1) spr.charge t | | Cancel | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| P,E(1) acc.energy | | Cancel | | | | |
| Application Configuration | | | | | | |
| General | | | | | | |
| Settings | | | | | | |
| Setting group | | | | | | |
| Protection: 0 | | | | | | |
| Setting group | | | | | | |
| Active group | | 1 | | 1 | 6 | |
| Protection | | | | | | |
| Settings | | | | | | |
| Current protection | | | | | | |
| 50-1; PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 3,00 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 250 | ms | 20 | 300000 | |
| 51-1; PHLPTOC1: 1 | | | | | | |
| 3I>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Minimum operate time | | 250 | ms | 20 | 60000 | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 50000,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 6,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,70 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,150 | | 0,025 | 15,000 | |
| Operate delay time | | 40 | ms | 40 | 300000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| 67-1; DPHLPDOC1: 1 | | | | | | |
| 3I>->(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| Allow Non Dir | | False | | | | |
| Min operate current | | 0,010 | xIn | 0,010 | 1,000 | |
| Min operate voltage | | 0,010 | xUn | 0,010 | 1,000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 700 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Reverse | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| 67-2; DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| Allow Non Dir | | False | | | | |
| Min operate current | | 0,010 | xIn | 0,010 | 1,000 | |
| Min operate voltage | | 0,010 | xUn | 0,010 | 1,000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,80 | xIn | 0,05 | 10,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Forward | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| 68; INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Operation | | off | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 2 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 3 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 4 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 5 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| settingGroup 6 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Min operate current | | 5 | %In | 5 | 500 | |
| 51N; EFLPTOC1: 1 | | | | | | |
| Io>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xIn | 0,010 | 10,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Voltage protection | | | | | | |
| 59-1; PHPTOV1: 1 | | | | | | |
| 3U>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,20 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 59-2; PHPTOV2: 2 | | | | | | |
| 3U>(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 1,30 | xUn | 0,05 | 1,60 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 100 | ms | 40 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 27-1; PHPTUV1: 1 | | | | | | |
| 3U<(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage block value | | 0,20 | xUn | 0,05 | 1,00 | |
| Enable block value | | True | | | | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,80 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 2000 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 27-2; PHPTUV2: 2 | | | | | | |
| 3U<(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Curve parameter A | | 1,000 | | 0,005 | 200,000 | |
| Curve parameter B | | 1,00 | | 0,50 | 100,00 | |
| Curve parameter C | | 0,0 | | 0,0 | 1,0 | |
| Curve parameter D | | 0,000 | | 0,000 | 60,000 | |
| Curve parameter E | | 1,000 | | 0,000 | 3,000 | |
| Voltage block value | | 0,20 | xUn | 0,05 | 1,00 | |
| Enable block value | | True | | | | |
| Voltage selection | | phase-to-phase | | | | |
| Relative hysteresis | | 4,0 | % | 1,0 | 5,0 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 2 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 3 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 4 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 5 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| settingGroup 6 | | | | | | |
| Start value | | 0,50 | xUn | 0,05 | 1,20 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Time multiplier | | 1,000 | | 0,025 | 15,000 | |
| Operate delay time | | 200 | ms | 20 | 300000 | |
| Operating curve type | | IEC Def. Time | | | | |
| 59N-1; ROVPTOV1: 1 | | | | | | |
| Uo>(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| settingGroup 6 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 500 | ms | 40 | 300000 | |
| 59N-2; ROVPTOV2: 2 | | | | | | |
| Uo>(2) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| settingGroup 1 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 2 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 3 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 4 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 5 | | | | | | |
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| settingGroup 6 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value | | 0,100 | xUn | 0,010 | 1,000 | |
| Operate delay time | | 1000 | ms | 40 | 300000 | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Operation | | off | | | | |
| Current value | | 0,300 | xIn | 0,050 | 2,000 | |
| Current value Res | | 0,30 | xIn | 0,05 | 2,00 | |
| CB failure trip mode | | 1 out of 3 | | | | |
| CB failure mode | | Current | | | | |
| CB fail retrip mode | | Off | | | | |
| Retrip time | | 120 | ms | 0 | 60000 | |
| CB failure delay | | 240 | ms | 0 | 60000 | |
| CB fault delay | | 5000 | ms | 0 | 60000 | |
| Measurement mode | | Peak-to-Peak | | | | |
| Trip pulse time | | 200 | ms | 0 | 60000 | |
| Start latching mode | | Rising edge | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ARC(2) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Operation | | on | | | | |
| Sensor supervision | | on | | | | |
| settingGroup 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Light only | | | | |
| settingGroup 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| settingGroup 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Control | | | | | | |
| 25; SECRSYN1: 1 | | | | | | |
| SYNC(1) | | | | | | |
| Operation | | on | | | | |
| Synchro check mode | | Asynchronous | | | | |
| Control mode | | Continuous | | | | |
| Dead line value | | 0,1 | xUn | 0,1 | 0,8 | |
| Live line value | | 0,5 | xUn | 0,2 | 1,0 | |
| Dead bus value | | 0,1 | xUn | 0,1 | 0,8 | |
| Live bus value | | 0,5 | xUn | 0,2 | 1,0 | |
| Max energizing V | | 1,11 | xUn | 0,50 | 1,15 | |
| Phase shift | | 0 | deg | -180 | 180 | |
| Minimum Syn time | | 10000 | ms | 0 | 60000 | |
| Energizing time | | 100 | ms | 100 | 60000 | |
| Closing time of CB | | 50 | ms | 40 | 250 | |
| Voltage source switch | | False | | | | |
| settingGroup 1 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 2 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 3 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 4 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| settingGroup 5 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |
| settingGroup 6 | | | | | | |
| Live dead mode | | Not Both Live | | | | |
| Difference voltage | | 0,05 | xUn | 0,01 | 0,50 | |
| Difference frequency | | 0,0100 | xFn | 0,0002 | 0,1000 | |
| Difference angle | | 5 | deg | 5 | 90 | |

*Settings*

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| REF615 | | | | | | |
| IED Configuration | | | | | | |
| HW Configuration | | | | | | |
| X110 (BIO-H)_110 | | | | | | |
| X110 (BIO-H) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input 5 filter time | | 5 | ms | 5 | 1000 | |
| Input 6 filter time | | 5 | ms | 5 | 1000 | |
| Input 7 filter time | | 5 | ms | 5 | 1000 | |
| Input 8 filter time | | 5 | ms | 5 | 1000 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Input 5 inversion | | False | | | | |
| Input 6 inversion | | False | | | | |
| Input 7 inversion | | False | | | | |
| Input 8 inversion | | False | | | | |
| X120 (AIM)_120 | | | | | | |
| X120 (AIM) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| X130 (AIM)_130 | | | | | | |
| X130 (AIM) | | | | | | |
| Input filtering | | | | | | |
| Input 1 filter time | | 5 | ms | 5 | 1000 | |
| Input 2 filter time | | 5 | ms | 5 | 1000 | |
| Input 3 filter time | | 5 | ms | 5 | 1000 | |
| Input 4 filter time | | 5 | ms | 5 | 1000 | |
| Input inversion | | | | | | |
| Input 1 inversion | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Input 2 inversion | | False | | | | |
| Input 3 inversion | | False | | | | |
| Input 4 inversion | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| POSITION | | intermediate | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| TRIG 1 | | False | | | | |
| TRIG 2 | | False | | | | |
| TRIG 3 | | False | | | | |
| TRIG 4 | | False | | | | |
| TRIG 5 | | False | | | | |
| TRIG 6 | | False | | | | |
| TRIG 7 | | False | | | | |
| TRIG 8 | | False | | | | |
| TRIG 9 | | False | | | | |
| TRIG 10 | | False | | | | |
| TRIG 11 | | False | | | | |
| TRIG 12 | | False | | | | |
| TRIG 13 | | False | | | | |
| TRIG 14 | | False | | | | |
| TRIG 15 | | False | | | | |
| TRIG 16 | | False | | | | |
| Measurements | | | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| S-kVA | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P-kW | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q-kVAr | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF | | 0,00 | | -1,00 | 1,00 | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| IL1-A | | 0,00 | xIn | 0,00 | 40,00 | |
| IL2-A | | 0,00 | xIn | 0,00 | 40,00 | |
| IL3-A | | 0,00 | xIn | 0,00 | 40,00 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Io-A | | 0,00 | xIn | 0,00 | 40,00 | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Uo-kV | | 0,00 | xUn | 0,00 | 4,00 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| U12-kV | | 0,00 | xUn | 0,00 | 4,00 | |
| U23-kV | | 0,00 | xUn | 0,00 | 4,00 | |
| U31-kV | | 0,00 | xUn | 0,00 | 4,00 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| f-Hz | | 50,00 | Hz | 35,00 | 75,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| NgSeq-A | | 0,00 | xIn | 0,00 | 40,00 | |
| PsSeq-A | | 0,00 | xIn | 0,00 | 40,00 | |
| ZroSeq-A | | 0,00 | xIn | 0,00 | 40,00 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| NgSeq-kV | | 0,00 | xUn | 0,00 | 4,00 | |
| PsSeq-kV | | 0,00 | xUn | 0,00 | 4,00 | |
| ZroSeq-kV | | 0,00 | xUn | 0,00 | 4,00 | |
| Disturbance records | | | | | | |
| Disturbance recorder(Disturbance recorder): 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Number of recordings | | 0 | | 0 | 100 | |
| Rem. amount of rec. | | 0 | | 0 | 100 | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| Trig recording | | Cancel | | | | |
| Time to trigger | | 0 | s | 0 | 604800 | |
| Configuration | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| General | | | | | | |
| Operation | | on | | | | |
| Record length | | 50 | cycles | 10 | 500 | |
| Pre-trg length | | 50 | % | 0 | 100 | |
| Operation mode | | Overwrite | | | | |
| Exclusion time | | 0 | ms | 0 | 1000000 | |
| Storage rate | | 32 samples / cycle | | | | |
| Periodic trig time | | 0 | s | 0 | 604800 | |
| Stor. mode periodic | | Waveform | | | | |
| Stor. mode manual | | Waveform | | | | |
| Channel settings | | | | | | |
| Analog channel 1 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | IL1 | | | | |
| Channel id text | | IL1 | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Storage mode | | Waveform | | | | |
| Analog channel 2 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | IL2 | | | | |
| Channel id text | | IL2 | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 3 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | IL3 | | | | |
| Channel id text | | IL3 | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 4 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | Io | | | | |
| Channel id text | | Io | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 5 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | Uo | | | | |
| Channel id text | | Uo | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 6 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | U1 | | | | |
| Channel id text | | U1 | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 7 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | U2 | | | | |
| Channel id text | | U2 | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 8 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | U3 | | | | |
| Channel id text | | U3 | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 9 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | Disabled | | | | |
| Channel id text | | Analog ch 9 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 10 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | Disabled | | | | |
| Channel id text | | Analog ch 10 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 11 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | Disabled | | | | |
| Channel id text | | Analog ch 11 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Analog channel 12 | | | | | | |
| Operation | | on | | | | |
| Channel selection | | Disabled | | | | |
| Channel id text | | Analog ch 12 input | | | 64 characters | |
| High trigger level | | 10,00 | | 0,00 | 60,00 | |
| Low trigger level | | 0,00 | | 0,00 | 2,00 | |
| Storage mode | | Waveform | | | | |
| Binary channel 1 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | CB CLOSED | | | 64 characters | |
| Binary channel 2 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | CB OPEN | | | 64 characters | |
| Binary channel 3 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 51.S1 START | | | 64 characters | |
| Binary channel 4 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 51.S1 TRIP | | | 64 characters | |
| Binary channel 5 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 51.S2 START | | | 64 characters | |
| Binary channel 6 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 51.S2 TRIP | | | 64 characters | |
| Binary channel 7 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 50.S3 START | | | 64 characters | |
| Binary channel 8 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | 50.S3 TRIP | | | 64 characters | |
| Binary channel 9 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 67N.NI START | | | 64 characters | |
| Binary channel 10 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 67N.NI TRIP | | | 64 characters | |
| Binary channel 11 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 51.S1 START | | | 64 characters | |
| Binary channel 12 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 51.S1 TRIP | | | 64 characters | |
| Binary channel 13 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 51N.S2 START | | | 64 characters | |
| Binary channel 14 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 51N.S2 TRIP | | | 64 characters | |
| Binary channel 15 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 15 input | | | 64 characters | |
| Binary channel 16 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | ARC CB | | | 64 characters | |
| Binary channel 17 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | ARC CABLE | | | 64 characters | |
| Binary channel 18 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | ARC BUSBAR | | | 64 characters | |
| Binary channel 19 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 19 input | | | 64 characters | |
| Binary channel 20 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 20 input | | | 64 characters | |
| Binary channel 21 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 27.1 TRIP | | | 64 characters | |
| Binary channel 22 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | 27.1 START | | | 64 characters | |
| Binary channel 23 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 27.1 TRIP | | | 64 characters | |
| Binary channel 24 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 27.2 START | | | 64 characters | |
| Binary channel 25 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 59.1 TRIP | | | 64 characters | |
| Binary channel 26 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 59.1 START | | | 64 characters | |
| Binary channel 27 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 59.2 TRIP | | | 64 characters | |
| Binary channel 28 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 59.2 START | | | 64 characters | |
| Binary channel 29 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | 59N.1 TRIP | | | 64 characters | |
| Binary channel 30 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 59N.1 START | | | 64 characters | |
| Binary channel 31 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 59N.2 TRIP | | | 64 characters | |
| Binary channel 32 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | 59N.2 START | | | 64 characters | |
| Binary channel 33 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 33 input | | | 64 characters | |
| Binary channel 34 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 34 input | | | 64 characters | |
| Binary channel 35 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 35 input | | | 64 characters | |
| Binary channel 36 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 36 input | | | 64 characters | |
| Binary channel 37 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 37 input | | | 64 characters | |
| Binary channel 38 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 38 input | | | 64 characters | |
| Binary channel 39 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 39 input | | | 64 characters | |
| Binary channel 40 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | PHIPTOC1_START | | | 64 characters | |
| Binary channel 41 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | PHIPTOC1_OPERATE | | | 64 characters | |
| Binary channel 42 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 42 input | | | 64 characters | |
| Binary channel 43 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 43 input | | | 64 characters | |
| Binary channel 44 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 44 input | | | 64 characters | |
| Binary channel 45 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 45 input | | | 64 characters | |
| Binary channel 46 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 46 input | | | 64 characters | |
| Binary channel 47 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 47 input | | | 64 characters | |
| Binary channel 48 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 48 input | | | 64 characters | |
| Binary channel 49 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Level trigger off | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 49 input | | | 64 characters | |
| Binary channel 50 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 50 input | | | 64 characters | |
| Binary channel 51 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 51 input | | | 64 characters | |
| Binary channel 52 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 52 input | | | 64 characters | |
| Binary channel 53 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 53 input | | | 64 characters | |
| Binary channel 54 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 54 input | | | 64 characters | |
| Binary channel 55 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 55 input | | | 64 characters | |
| Binary channel 56 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 56 input | | | 64 characters | |
| Binary channel 57 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 57 input | | | 64 characters | |
| Binary channel 58 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 58 input | | | 64 characters | |
| Binary channel 59 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 59 input | | | 64 characters | |
| Binary channel 60 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 60 input | | | 64 characters | |
| Binary channel 61 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 61 input | | | 64 characters | |
| Binary channel 62 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 62 input | | | 64 characters | |
| Binary channel 63 | | | | | | |
| Operation | | off | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |
| Channel id text | | Binary ch 63 input | | | 64 characters | |
| Binary channel 64 | | | | | | |
| Operation | | on | | | | |
| Level trigger mode | | Positive or Rising | | | | |
| Storage mode | | Waveform | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Channel id text | | Binary ch 64 input | | | 64 characters | |
| System | | | | | | |
| Control(Control): 0 | | | | | | |
| Control | | | | | | |
| Rated frequency | | 50Hz | | | | |
| Phase rotation | | ABC | | | | |
| Blocking mode | | Freeze timer | | | | |
| Bay name | | REF615 | | | 20 characters | |
| IDMT Sat point | | 50 | I/I> | 10 | 50 | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| Communication(Communication): 0 | | | | | | |
| Communication | | | | | | |
| Rear port(s) | | | | | | |
| IP address | | 192.168.10 .11 | | | | |
| Subnet mask | | 255.255.25 5.224 | | | | |
| Default gateway | | 192.168.10 .30 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| Front port | | | | | | |
| IP address | | 192.168.0. 254 | | | | |
| Mac address | | XX-XX-XX-XX-XX-XX | | | 18 characters | |
| SCHLCCH1(SCHLCCH1): 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Rear port(s) | | | | | | |
| Port 1 mode | | On | | | | |
| SCHLCCH2(SCHLCCH2): 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Rear port(s) | | | | | | |
| Port 2 mode | | On | | | | |
| SCHLCCH3(SCHLCCH3): 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Rear port(s) | | | | | | |
| Port 3 mode | | On | | | | |
| RCHLCCH1(RCHLCCH1): 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Redundancy | | | | | | |
| Redundant mode | | None | | | | |
| Modbus | | | | | | |
| Modbus(1)(Modbus(1)): 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Modbus(1) | | | | | | |
| MBS01 | | | | | | |
| Operation | | on | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| Start delay | | 4 | | 0 | 20 | |
| End delay | | 4 | | 0 | 20 | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Modbus(2): 2 | | | | | | |
| Modbus(2) | | | | | | |
| MBS02 | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| Start delay | | 4 | | 0 | 20 | |
| End delay | | 4 | | 0 | 20 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Modbus(3)(Modbus(3)): 3 | | | | | | |
| Modbus(3) | | | | | | |
| MBS03 | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| Start delay | | 4 | | 0 | 20 | |
| End delay | | 4 | | 0 | 20 | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Modbus(4): 4 | | | | | | |
| Modbus(4) | | | | | | |
| MBS04 | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| Start delay | | 4 | | 0 | 20 | |
| End delay | | 4 | | 0 | 20 | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| Modbus(5)(Modbus(5)): 5 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Modbus(5) | | | | | | |
| MBS05 | | | | | | |
| Operation | | off | | | | |
| Port | | Ethernet - TCP 1 | | | | |
| Mapping selection | | 1 | | 1 | 2 | |
| Address | | 1 | | 1 | 254 | |
| Link mode | | RTU | | | | |
| TCP port | | 502 | | 1 | 65535 | |
| Parity | | even | | | | |
| Start delay | | 4 | | 0 | 20 | |
| End delay | | 4 | | 0 | 20 | |
| CRC order | | Hi-Lo | | | | |
| Client IP | | 0.0.0.0 | | | | |
| Write authority | | Full access | | | | |
| Time format | | Local | | | | |
| Event ID selection | | Address | | | | |
| Event buffering | | Keep oldest | | | | |
| Event backoff | | 200 | | 1 | 500 | |
| ControlStructPWd 1 | | **** | | | 4 characters | |
| ControlStructPWd 2 | | **** | | | 4 characters | |
| ControlStructPWd 3 | | **** | | | 4 characters | |
| ControlStructPWd 4 | | **** | | | 4 characters | |
| ControlStructPWd 5 | | **** | | | 4 characters | |
| ControlStructPWd 6 | | **** | | | 4 characters | |
| ControlStructPWd 7 | | **** | | | 4 characters | |
| ControlStructPWd 8 | | **** | | | 4 characters | |
| MMSLPRT1(MMS): 1 | | | | | | |
| MMS | | | | | | |
| Unit mode | | Nominal | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Operation | | on | | | | |
| Trip pulse time | | 250 | ms | 20 | 60000 | |
| Trip output mode | | Non-latched | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation | | on | | | | |
| Select timeout | | 30000 | ms | 10000 | 300000 | |
| Pulse length | | 200 | ms | 10 | 60000 | |
| Operation counter | | 0 | | 0 | 10000 | |
| Control model | | sbo-with-enhanced-security | | | | |
| Adaptive pulse | | True | | | | |
| Event delay | | 200 | ms | 0 | 10000 | |
| Operation timeout | | 500 | ms | 10 | 60000 | |
| Identification | | CBXCBR1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| General(General): 0 | | | | | | |
| Control | | | | | | |
| General | | | | | | |
| LR control | | Binary input | | | | |
| Station authority | | L,R | | | | |
| Control mode | | On | | | | |
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Event delay | | 30000 | ms | 0 | 60000 | |
| Identification | | DCSXSWI1 switch position | | | 255 characters | |
| Vendor | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Model | | 0 | | | 20 characters | |
| HMI(HMI): 0 | | | | | | |
| HMI | | | | | | |
| FB naming convention | | IEC61850 | | | | |
| Default view | | SLD | | | | |
| Backlight timeout | | 3 | min | 1 | 60 | |
| Web HMI timeout | | 15 | min | 1 | 60 | |
| SLD symbol format | | IEC | | | | |
| Autoscroll delay | | 0 | s | 0 | 30 | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation | | on | | | | |
| Acc stop current | | 10,00 | A | 5,00 | 500,00 | |
| Open alarm time | | 40 | ms | 0 | 200 | |
| Close alarm time | | 40 | ms | 0 | 200 | |
| Opening time Cor | | 10 | ms | -100 | 100 | |
| Closing time Cor | | 10 | ms | -100 | 100 | |
| Spring charge time | | 15000 | ms | 0 | 60000 | |
| Counter initial Val | | 0 | | 0 | 99999 | |
| Alarm Op number | | 200 | | 0 | 99999 | |
| Lockout Op number | | 300 | | 0 | 99999 | |
| Current exponent | | 2,00 | | 0,00 | 2,00 | |
| Difference Cor time | | 5 | ms | -10 | 10 | |
| Alm Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| LO Acc currents Pwr | | 2500,00 | | 0,00 | 20000,00 | |
| Ini Acc currents Pwr | | 0,00 | | 0,00 | 20000,00 | |
| Directional Coef | | -1,50 | | -3,00 | -0,50 | |
| Initial CB Rmn life | | 5000 | | 0 | 99999 | |
| Rated Op current | | 1000,00 | A | 100,00 | 5000,00 | |
| Rated fault current | | 5000,00 | A | 500,00 | 75000,00 | |
| Op number rated | | 10000 | | 1 | 99999 | |
| Op number fault | | 1000 | | 1 | 10000 | |
| Life alarm level | | 500 | | 0 | 99999 | |
| Pressure alarm time | | 10 | ms | 0 | 60000 | |
| Pres lockout time | | 10 | ms | 0 | 60000 | |
| Inactive Alm days | | 2000 | | 0 | 9999 | |
| Ini inactive days | | 0 | | 0 | 9999 | |
| Inactive Alm hours | | 0 | h | 0 | 23 | |
| Travel time Clc mode | | From Pos to Pos | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Operation | | off | | | | |
| Operate delay time | | 3000 | ms | 20 | 300000 | |
| Reset delay time | | 1000 | ms | 20 | 60000 | |
| TCSSCBR2: 2 | | | | | | |
| TCS(2) | | | | | | |
| Operation | | off | | | | |
| Operate delay time | | 3000 | ms | 20 | 300000 | |
| Reset delay time | | 1000 | ms | 20 | 60000 | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Operation | | off | | | | |
| Neg Seq current Lev | | 0,03 | xIn | 0,03 | 0,20 | |
| Neg Seq voltage Lev | | 0,10 | xUn | 0,03 | 0,20 | |
| Current change rate | | 0,15 | xIn | 0,01 | 0,50 | |
| Voltage change rate | | 0,40 | xUn | 0,25 | 0,90 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Change rate enable | | False | | | | |
| Min Op voltage delta | | 0,50 | xUn | 0,01 | 1,00 | |
| Min Op current delta | | 0,10 | xIn | 0,01 | 1,00 | |
| Seal in voltage | | 0,50 | xUn | 0,01 | 1,00 | |
| Enable seal in | | False | | | | |
| Current dead Lin Val | | 0,05 | xIn | 0,05 | 1,00 | |
| MDSOPT1: 1 | | | | | | |
| OPTS(1) | | | | | | |
| Operation | | on | | | | |
| Warning value | | 8000 | h | 0 | 299999 | |
| Alarm value | | 10000 | h | 0 | 299999 | |
| Initial value | | 0 | h | 0 | 299999 | |
| Operating time hour | | 0 | h | 0 | 23 | |
| Operating time mode | | Immediate | | | | |
| Time(Time): 0 | | | | | | |
| Time | | | | | | |
| System time | | | | | | |
| Time format | | 24H:MM:SS:MS | | | | |
| Date format | | DD.MM.YYYY | | | | |
| Date | | 0 | | | 20 characters | |
| Time | | 0 | | | 20 characters | |
| Local time offset | | 0 | min | -840 | 840 | |
| Daylight saving time | | | | | | |
| DST in use | | True | | | | |
| DST on time (hours) | | 2 | h | 0 | 23 | |
| DST on time (minutes) | | 0 | min | 0 | 59 | |
| DST on date (day) | | 1 | | 1 | 31 | |
| DST on date (month) | | May | | | | |
| DST on day (weekday) | | reserved | | | | |
| DST off time (hours) | | 2 | h | 0 | 23 | |
| DST off time (minutes) | | 0 | min | 0 | 59 | |
| DST off date (day) | | 25 | | 1 | 31 | |
| DST off date (month) | | September | | | | |
| DST off day (weekday) | | reserved | | | | |
| DST offset | | 60 | min | -720 | 720 | |
| SNTP | | | | | | |
| IP SNTP primary | | 10.58.125.165 | | | | |
| IP SNTP secondary | | 192.168.2.165 | | | | |
| Synchronization | | | | | | |
| Synch source | | SNTP | | | | |
| PTP domain ID | | 0 | | 0 | 255 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PTP priority 1 | | 128 | | 0 | 255 | |
| PTP priority 2 | | 128 | | 0 | 255 | |
| PTP announce mode | | Basic IEEE1588 | | | | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Operation | | on | | | | |
| Quantity Sel 1 | | Disabled | | | | |
| Quantity Sel 2 | | Disabled | | | | |
| Quantity Sel 3 | | Disabled | | | | |
| Quantity Sel 4 | | Disabled | | | | |
| Quantity Sel 5 | | Disabled | | | | |
| Quantity Sel 6 | | Disabled | | | | |
| Quantity Sel 7 | | Disabled | | | | |
| Quantity Sel 8 | | Disabled | | | | |
| Quantity Sel 9 | | Disabled | | | | |
| Quantity Sel 10 | | Disabled | | | | |
| Quantity Sel 11 | | Disabled | | | | |
| Quantity Sel 12 | | Disabled | | | | |
| Mem. warning level | | 0 | % | 0 | 100 | |
| Mem. alarm level | | 0 | % | 0 | 100 | |
| Authorization(Authorization): 1 | | | | | | |
| Authorization | | | | | | |
| Security | | | | | | |
| Remote Update | | Disable | | | | |
| Authority logging | | None | | | | |
| Passwords | | | | | | |
| Remote override | | True | | | | |
| Remote viewer | | 0 | | | 20 characters | |
| Remote operator | | 0 | | | 20 characters | |
| Remote engineer | | 0 | | | 20 characters | |
| Remote administrator | | 0 | | | 20 characters | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| A high high limit | | 1,40 | xIn | 0,00 | 40,00 | |
| A high limit | | 1,20 | xIn | 0,00 | 40,00 | |
| A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| A low low limit | | 0,00 | xIn | 0,00 | 40,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| A deadband | | 2500 | | 100 | 100000 | |
| RESCMMXU1(In(1)): 1 | | | | | | |
| Io(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| A Hi high limit res | | 0,20 | xIn | 0,00 | 40,00 | |
| A high limit res | | 0,05 | xIn | 0,00 | 40,00 | |
| A deadband res | | 2500 | | 100 | 100000 | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| V Hi high limit res | | 0,20 | xUn | 0,00 | 4,00 | |
| V high limit res | | 0,05 | xUn | 0,00 | 4,00 | |
| V deadband res | | 10000 | | 100 | 100000 | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Operation | | on | | | | |
| Measurement mode | | DFT | | | | |
| Num of phases | | 1 out of 3 | | | | |
| V high high limit | | 1,40 | xUn | 0,00 | 4,00 | |
| V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V low low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| V deadband | | 10000 | | 100 | 100000 | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| Operation | | on | | | | |
| F high high limit | | 60,00 | Hz | 35,00 | 75,00 | |
| F high limit | | 55,00 | Hz | 35,00 | 75,00 | |
| F low limit | | 45,00 | Hz | 35,00 | 75,00 | |
| F low low limit | | 40,00 | Hz | 35,00 | 75,00 | |
| F deadband | | 1000 | | 100 | 100000 | |
| Def frequency Sel | | Nominal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Operation | | on | | | | |
| Power unit Mult | | Kilo | | | | |
| Energy unit Mult | | Kilo | | | | |
| Active power Dir | | Forward | | | | |
| Reactive power Dir | | Forward | | | | |
| Forward Wh Initial | | 0 | | 0 | 999999999 | |
| Reverse Wh Initial | | 0 | | 0 | 999999999 | |
| Forward VArh Initial | | 0 | | 0 | 999999999 | |
| Reverse VArh Initial | | 0 | | 0 | 999999999 | |
| CSMSQI1: 1 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| I1,I2,I0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq A Hi high Lim | | 1,40 | xIn | 0,00 | 40,00 | |
| Ps Seq A high limit | | 1,20 | xIn | 0,00 | 40,00 | |
| Ps Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ps Seq A deadband | | 2500 | | 100 | 100000 | |
| Ng Seq A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Ng Seq A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Ng Seq A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Ng Seq A deadband | | 2500 | | 100 | 100000 | |
| Zro A Hi high Lim | | 0,20 | xIn | 0,00 | 40,00 | |
| Zro A High limit | | 0,05 | xIn | 0,00 | 40,00 | |
| Zro A low limit | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A low low Lim | | 0,00 | xIn | 0,00 | 40,00 | |
| Zro A deadband | | 2500 | | 100 | 100000 | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Operation | | on | | | | |
| Ps Seq V Hi high Lim | | 1,40 | xUn | 0,00 | 4,00 | |
| Ps Seq V high limit | | 1,20 | xUn | 0,00 | 4,00 | |
| Ps Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ps Seq V deadband | | 10000 | | 100 | 100000 | |
| Ng Seq V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Ng Seq V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Ng Seq V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Ng Seq V deadband | | 10000 | | 100 | 100000 | |
| Zro V Hi high Lim | | 0,20 | xUn | 0,00 | 4,00 | |
| Zro V High limit | | 0,05 | xUn | 0,00 | 4,00 | |
| Zro V low limit | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V low low Lim | | 0,00 | xUn | 0,00 | 4,00 | |
| Zro V deadband | | 10000 | | 100 | 100000 | |
| Demand metering(Demand metering): 0 | | | | | | |
| Demand metering | | | | | | |
| Demand interval | | 1 minute | | | | |
| A demand Av mode | | Linear | | | | |
| General(General): 0 | | | | | | |
| General | | | | | | |
| Software reset | | Cancel | | | | |
| Setting group(Setting group): 0 | | | | | | |
| Setting group | | | | | | |
| SG operation mode | | Operator | | | | |
| Fault record | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Operation | | on | | | | |
| Trig mode | | From all faults | | | | |
| A measurement mode | | DFT | | | | |
| Control(Control): 0 | | | | | | |
| Control | | | | | | |
| LHMI | | | | | | |
| Close delay mode | | Not in use | | | | |
| Close delay | | 60 | s | 5 | 900 | |
| Generic timers | | | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| On delay time 1 | | 0 | ms | 0 | 3600000 | |
| On delay time 2 | | 0 | ms | 0 | 3600000 | |
| On delay time 3 | | 0 | ms | 0 | 3600000 | |
| On delay time 4 | | 0 | ms | 0 | 3600000 | |
| On delay time 5 | | 0 | ms | 0 | 3600000 | |
| On delay time 6 | | 0 | ms | 0 | 3600000 | |
| On delay time 7 | | 0 | ms | 0 | 3600000 | |
| On delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Off delay time 1 | | 0 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Off delay time 1 | | 0 | ms | 0 | 3600000 | |
| Off delay time 2 | | 0 | ms | 0 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Off delay time 3 | | 0 | ms | 0 | 3600000 | |
| Off delay time 4 | | 0 | ms | 0 | 3600000 | |
| Off delay time 5 | | 0 | ms | 0 | 3600000 | |
| Off delay time 6 | | 0 | ms | 0 | 3600000 | |
| Off delay time 7 | | 0 | ms | 0 | 3600000 | |
| Off delay time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Pulse time 1 | | 150 | ms | 0 | 3600000 | |
| Pulse time 2 | | 150 | ms | 0 | 3600000 | |
| Pulse time 3 | | 250 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Pulse time 1 | | 0 | ms | 0 | 3600000 | |
| Pulse time 2 | | 0 | ms | 0 | 3600000 | |
| Pulse time 3 | | 0 | ms | 0 | 3600000 | |
| Pulse time 4 | | 0 | ms | 0 | 3600000 | |
| Pulse time 5 | | 0 | ms | 0 | 3600000 | |
| Pulse time 6 | | 0 | ms | 0 | 3600000 | |
| Pulse time 7 | | 0 | ms | 0 | 3600000 | |
| Pulse time 8 | | 0 | ms | 0 | 3600000 | |
| I/O modules(I/O modules): 0 | | | | | | |
| I/O modules | | | | | | |
| Common settings | | | | | | |
| Threshold voltage | | 16 | Vdc | 16 | 176 | |
| Input osc. level | | 30 | events/s | 2 | 50 | |
| Input osc. hyst | | 10 | events/s | 2 | 50 | |
| Generic logic | | | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| General | | | | | | |
| Loc Rem restriction | | True | | | | |
| Output 1 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 100 | ms | 10 | 3600000 | |
| Description | | REM CLOSE CMD | | | 64 characters | |
| Output 2 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 100 | ms | 10 | 3600000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | REM OPEN CMD | | | 64 characters | |
| Output 3 | | | | | | |
| Operation mode | | Pulsed | | | | |
| Pulse length | | 100 | ms | 10 | 3600000 | |
| Description | | RESET | | | 64 characters | |
| Output 4 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 4 | | | 64 characters | |
| Output 5 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 5 | | | 64 characters | |
| Output 6 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 6 | | | 64 characters | |
| Output 7 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 7 | | | 64 characters | |
| Output 8 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 8 | | | 64 characters | |
| Output 9 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 9 | | | 64 characters | |
| Output 10 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 10 | | | 64 characters | |
| Output 11 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 11 | | | 64 characters | |
| Output 12 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 12 | | | 64 characters | |
| Output 13 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 13 | | | 64 characters | |
| Output 14 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 14 | | | 64 characters | |
| Output 15 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 15 | | | 64 characters | |
| Output 16 | | | | | | |
| Operation mode | | Off | | | | |
| Pulse length | | 1000 | ms | 10 | 3600000 | |
| Description | | SPCGAPC 1 Output 16 | | | 64 characters | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Reset Q1 | | Cancel | | | | |
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Reset Q1 | | Cancel | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Reset Q2 | | Cancel | | | | |
| Reset Q3 | | Cancel | | | | |
| Reset Q4 | | Cancel | | | | |
| Reset Q5 | | Cancel | | | | |
| Reset Q6 | | Cancel | | | | |
| Reset Q7 | | Cancel | | | | |
| Reset Q8 | | Cancel | | | | |
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC1 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC1 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC1 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC1 Q4 | | | 20 characters | |
| Output 5 | | | | | | |
| Description | | MVGAPC1 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC1 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC1 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC1 Q8 | | | 20 characters | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Output 1 | | | | | | |
| Description | | MVGAPC2 Q1 | | | 20 characters | |
| Output 2 | | | | | | |
| Description | | MVGAPC2 Q2 | | | 20 characters | |
| Output 3 | | | | | | |
| Description | | MVGAPC2 Q3 | | | 20 characters | |
| Output 4 | | | | | | |
| Description | | MVGAPC2 Q4 | | | 20 characters | |
| Output 5 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Description | | MVGAPC2 Q5 | | | 20 characters | |
| Output 6 | | | | | | |
| Description | | MVGAPC2 Q6 | | | 20 characters | |
| Output 7 | | | | | | |
| Description | | MVGAPC2 Q7 | | | 20 characters | |
| Output 8 | | | | | | |
| Description | | MVGAPC2 Q8 | | | 20 characters | |
| Analog inputs | | | | | | |
| Current (3I,CT)(Current (3I,CT)): 1 | | | | | | |
| Current (3I,CT) | | | | | | |
| Primary current | | 2500,0 | A | 1,0 | 6000,0 | |
| Secondary current | | 1A | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Reverse polarity | | False | | | | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (3U,VT)(Voltage (3U,VT)): 1 | | | | | | |
| Voltage (3U,VT) | | | | | | |
| Primary voltage | | 0,400 | kV | 0,100 | 440,000 | |
| Secondary voltage | | 110 | V | 60 | 210 | |
| VT connection | | Delta | | | | |
| Amplitude Corr A | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr B | | 1,0000 | | 0,9000 | 1,1000 | |
| Amplitude Corr C | | 1,0000 | | 0,9000 | 1,1000 | |
| Voltage input type | | Voltage trafo | | | | |
| Angle Corr A | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr B | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Angle Corr C | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Voltage (Uo,VT)(Voltage (Uo,VT)): 1 | | | | | | |
| Voltage (Uo,VT) | | | | | | |
| Primary voltage | | 0,230 | kV | 0,100 | 440,000 | |
| Secondary voltage | | 110 | V | 60 | 210 | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Current (Io,CT)(Current (Io,CT)): 1 | | | | | | |
| Current (Io,CT) | | | | | | |
| Primary current | | 100,0 | A | 1,0 | 6000,0 | |
| Secondary current | | 1A | | | | |
| Amplitude Corr | | 1,0000 | | 0,9000 | 1,1000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Reverse polarity | | False | | | | |
| Angle correction | | 0,0000 | deg | -8,0000 | 8,0000 | |
| Programmable LEDs(Programmable LEDs): 1 | | | | | | |
| Programmable LEDs | | | | | | |
| General | | | | | | |
| Alarm colour | | Red | | | | |
| LED 1 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Programmable LEDs LED 1 | | | 64 characters | |
| LED 2 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Programmable LEDs LED 2 | | | 64 characters | |
| LED 3 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Programmable LEDs LED 3 | | | 64 characters | |
| LED 4 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Programmable LEDs LED 4 | | | 64 characters | |
| LED 5 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Programmable LEDs LED 5 | | | 64 characters | |
| LED 6 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Programmable LEDs LED 6 | | | 64 characters | |
| LED 7 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Programmable LEDs LED 7 | | | 64 characters | |
| LED 8 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Programmable LEDs LED 8 | | | 64 characters | |
| LED 9 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Programmable LEDs LED 9 | | | 64 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| LED 10 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Programmable LEDs LED 10 | | | 64 characters | |
| LED 11 | | | | | | |
| Alarm mode | | Follow-S | | | | |
| Description | | Programmable LEDs LED 11 | | | 64 characters | |
| Monitoring | | | | | | |
| Communication | | | | | | |
| Ethernet | | | | | | |
| SCHLCCH1(SCHLCCH1): 1 | | | | | | |
| SCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CH1LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK1LIV | | False | | | | |
| SCHLCCH2(SCHLCCH2): 2 | | | | | | |
| SCHLCCH2 | | | | | | |
| Activity | | | | | | |
| CH2LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK2LIV | | False | | | | |
| SCHLCCH3(SCHLCCH3): 3 | | | | | | |
| SCHLCCH3 | | | | | | |
| Activity | | | | | | |
| CH3LIV | | False | | | | |
| Link statuses | | | | | | |
| LNK3LIV | | False | | | | |
| RCHLCCH1(RCHLCCH1): 1 | | | | | | |
| RCHLCCH1 | | | | | | |
| Activity | | | | | | |
| CHLIV_A | | False | | | | |
| REDCHLIV_B | | False | | | | |
| Link statuses | | | | | | |
| LNKLIV_A | | False | | | | |
| REDLNKLIV_B | | False | | | | |
| Modbus | | | | | | |
| Modbus(1)(Modbus(1)): 1 | | | | | | |
| Modbus(1) | | | | | | |
| MBS01 | | | | | | |
| Status | | False | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| Modbus(2): 2 | | | | | | |
| Modbus(2) | | | | | | |
| MBS02 | | | | | | |
| Status | | False | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| Modbus(3): 3 | | | | | | |
| Modbus(3) | | | | | | |
| MBS03 | | | | | | |
| Status | | False | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| Modbus(4): 4 | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Modbus(4) | | | | | | |
| MBS04 | | | | | | |
| Status | | False | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| Modbus(5): 5 | | | | | | |
| Modbus(5) | | | | | | |
| MBS05 | | | | | | |
| Status | | False | | | | |
| Reset counters | | False | | | | |
| Received frames | | -1 | | -1 | 2147483646 | |
| Transmitted frames | | -1 | | -1 | 2147483646 | |
| Transmitted exc A | | -1 | | -1 | 2147483646 | |
| Transmitted exc B | | -1 | | -1 | 2147483646 | |
| Checksum errors | | -1 | | -1 | 2147483646 | |
| CnReject no sockets | | -1 | | -1 | 2147483646 | |
| CnReject unregistered | | -1 | | -1 | 2147483646 | |
| MMSLPRT1(MMS): 1 | | | | | | |
| MMS | | | | | | |
| CHLIV | | False | | | | |
| Successful conn. | | 0 | | 0 | 10000000 | |
| Failed conn. | | 0 | | 0 | 10000000 | |
| Concludes | | 0 | | 0 | 10000000 | |
| Sent aborts | | 0 | | 0 | 10000000 | |
| Recv. aborts | | 0 | | 0 | 10000000 | |
| Sent rejects | | 0 | | 0 | 10000000 | |
| Recv. requests | | 0 | | 0 | 10000000 | |
| Failed requests | | 0 | | 0 | 10000000 | |
| Reads | | 0 | | 0 | 10000000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Failed reads | | 0 | | 0 | 10000000 | |
| Writes | | 0 | | 0 | 10000000 | |
| Failed writes | | 0 | | 0 | 10000000 | |
| Reports | | 0 | | 0 | 10000000 | |
| Active conn. | | 0 | | 0 | 10000000 | |
| Reset counters | | False | | | | |
| Load profile record | | | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Rec. memory used | | 0 | % | 0 | 100 | |
| MEM_WARN | | False | | | | |
| MEM_ALARM | | False | | | | |
| Setting group(Setting group): 0 | | | | | | |
| Setting group | | | | | | |
| Outputs | | | | | | |
| SG_LOGIC_SEL | | False | | | | |
| SG_1_ACT | | False | | | | |
| SG_2_ACT | | False | | | | |
| SG_3_ACT | | False | | | | |
| SG_4_ACT | | False | | | | |
| SG_5_ACT | | False | | | | |
| SG_6_ACT | | False | | | | |
| IED status(IED status): 0 | | | | | | |
| IED status | | | | | | |
| Self-supervision | | | | | | |
| Warning | | All ok | | | | |
| Internal Fault | | All ok | | | | |
| Boot up time | | 0 | | | 34 characters | |
| Composition changes | | | | | | |
| No of comp. changes | | 0 | | 0 | 100000 | |
| Setting changes | | | | | | |
| Setting changes | | 0 | | 0 | 20000 | |
| Setting time | | 0 | | | 34 characters | |
| Time synchronization | | | | | | |
| Synch source | | Not defined | | | | |
| Synch status | | Down | | | | |
| Synch accuracy | | 0 | | 0 | 128 | |
| IEEE 1588 | | | | | | |
| Grandmaster identity | | ---------- | | | 20 characters | |
| Grandmaster time Src | | Internal oscil. | | | | |
| Grandmaster accuracy | | more than 10 s | | | | |
| Programmable LEDs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Inputs | | | | | | |
| Programmable LEDs(Programmable LEDs): 1 | | | | | | |
| Programmable LEDs | | | | | | |
| LED 1 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 2 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 3 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 4 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 5 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 6 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 7 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 8 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 9 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 10 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |
| RESET | | False | | | | |
| LED 11 | | | | | | |
| OK | | False | | | | |
| ALARM | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| RESET | | False | | | | |
| Control command | | | | | | |
| Control(Control): 0 | | | | | | |
| Control | | | | | | |
| LR state | | Off | | | | |
| I/O status | | | | | | |
| Trip logic | | | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| OPERATE | | False | | | | |
| RST_LKOUT | | False | | | | |
| Outputs | | | | | | |
| TRIP | | False | | | | |
| CL_LKOUT | | False | | | | |
| Control | | | | | | |
| CBXCBR1: 1 | | | | | | |
| I<->O CB(1) | | | | | | |
| Inputs | | | | | | |
| ENA_OPEN | | True | | | | |
| ENA_CLOSE | | True | | | | |
| BLK_OPEN | | False | | | | |
| BLK_CLOSE | | False | | | | |
| SYNC_OK | | True | | | | |
| SYNC_ITL_BYP | | False | | | | |
| Outputs | | | | | | |
| SELECTED | | False | | | | |
| EXE_OP | | False | | | | |
| EXE_CL | | False | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| OPEN_ENAD | | False | | | | |
| CLOSE_ENAD | | False | | | | |
| Monitored data | | | | | | |
| POSITION | | intermediate | | | | |
| DCSXSWI1: 1 | | | | | | |
| I<->O DC(1) | | | | | | |
| Outputs | | | | | | |
| OPENPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| OKPOS | | False | | | | |
| Monitored data | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| POSITION | | intermediate | | | | |
| Condition monitoring | | | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| POSOPEN | | False | | | | |
| POSCLOSE | | False | | | | |
| OPEN_CB_EXE | | False | | | | |
| CLOSE_CB_EXE | | False | | | | |
| PRES_ALM_IN | | False | | | | |
| PRES_LO_IN | | False | | | | |
| SPR_CHR_ST | | False | | | | |
| SPR_CHR | | False | | | | |
| RST_IPOW | | False | | | | |
| RST_CB_WEAR | | False | | | | |
| RST_TRV_T | | False | | | | |
| RST_SPR_T | | False | | | | |
| Outputs | | | | | | |
| TRV_T_OP_ALM | | False | | | | |
| TRV_T_CL_ALM | | False | | | | |
| SPR_CHR_ALM | | False | | | | |
| OPR_ALM | | False | | | | |
| OPR_LO | | False | | | | |
| IPOW_ALM | | False | | | | |
| IPOW_LO | | False | | | | |
| CB_LIFE_ALM | | False | | | | |
| MON_ALM | | False | | | | |
| PRES_ALM | | False | | | | |
| PRES_LO | | False | | | | |
| OPENPOS | | False | | | | |
| INVALIDPOS | | False | | | | |
| CLOSEPOS | | False | | | | |
| Monitored data | | | | | | |
| T_TRV_OP | | 0 | ms | 0 | 60000 | |
| T_TRV_CL | | 0 | ms | 0 | 60000 | |
| T_SPR_CHR | | 0,00 | s | 0,00 | 99,99 | |
| NO_OPR | | 0 | | 0 | 99999 | |
| INA_DAYS | | 0 | | 0 | 9999 | |
| CB_LIFE_A | | 0 | | -99999 | 99999 | |
| CB_LIFE_B | | 0 | | -99999 | 99999 | |
| CB_LIFE_C | | 0 | | -99999 | 99999 | |
| IPOW_A | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_B | | 0,000 | | 0,000 | 30000,000 | |
| IPOW_C | | 0,000 | | 0,000 | 30000,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| TCSSCBR2(TCM(2)): 2 | | | | | | |
| TCS(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| CB_CLOSED | | False | | | | |
| DISCON_OPEN | | False | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| FUSEF_3PH | | False | | | | |
| FUSEF_U | | False | | | | |
| MDSOPT1: 1 | | | | | | |
| OPTS(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| POS_ACTIVE | | False | | | | |
| RESET | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Monitored data | | | | | | |
| OPR_TIME | | 0 | h | 0 | 299999 | |
| Generic logic | | | | | | |
| MVGAPC1: 1 | | | | | | |
| MV(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| MVGAPC2: 2 | | | | | | |
| MV(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SPCGAPC1: 1 | | | | | | |
| SPC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| IN9 | | False | | | | |
| IN10 | | False | | | | |
| IN11 | | False | | | | |
| IN12 | | False | | | | |
| IN13 | | False | | | | |
| IN14 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| IN15 | | False | | | | |
| IN16 | | False | | | | |
| Outputs | | | | | | |
| O1 | | False | | | | |
| O2 | | False | | | | |
| O3 | | False | | | | |
| O4 | | False | | | | |
| O5 | | False | | | | |
| O6 | | False | | | | |
| O7 | | False | | | | |
| O8 | | False | | | | |
| O9 | | False | | | | |
| O10 | | False | | | | |
| O11 | | False | | | | |
| O12 | | False | | | | |
| O13 | | False | | | | |
| O14 | | False | | | | |
| O15 | | False | | | | |
| O16 | | False | | | | |
| SRGAPC1: 1 | | | | | | |
| SR(1) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q8 | | False | | | | |
| SRGAPC2: 2 | | | | | | |
| SR(2) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| SRGAPC3: 3 | | | | | | |
| SR(3) | | | | | | |
| Inputs | | | | | | |
| S1 | | False | | | | |
| R1 | | False | | | | |
| S2 | | False | | | | |
| R2 | | False | | | | |
| S3 | | False | | | | |
| R3 | | False | | | | |
| S4 | | False | | | | |
| R4 | | False | | | | |
| S5 | | False | | | | |
| R5 | | False | | | | |
| S6 | | False | | | | |
| R6 | | False | | | | |
| S7 | | False | | | | |
| R7 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| S8 | | False | | | | |
| R8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Current protection | | | | | | |
| INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| BLK2H | | False | | | | |
| DEFLPDEF1: 1 | | | | | | |
| Io>->(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| RCA_CTL | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| FAULT_DIR | | unknown | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| DIRECTION | | unknown | | | | |
| ANGLE_RCA | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE | | 0,00 | deg | -180,00 | 180,00 | |
| I_OPER | | 0,00 | xIn | 0,00 | 40,00 | |
| PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| DPHHPDOC1: 1 | | | | | | |
| 3I>>->(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| NON_DIR | | False | | | | |
| Outputs | | | | | | |
| START | | False | | | | |
| OPERATE | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| FAULT_DIR | | unknown | | | | |
| DIRECTION | | unknown | | | | |
| DIR_A | | unknown | | | | |
| DIR_B | | unknown | | | | |
| DIR_C | | unknown | | | | |
| ANGLE_A | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_B | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_C | | 0,00 | deg | -180,00 | 180,00 | |
| VMEM_USED | | False | | | | |
| DPHLPDOC1: 1 | | | | | | |
| 3I>->(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| NON_DIR | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| FAULT_DIR | | unknown | | | | |
| DIRECTION | | unknown | | | | |
| DIR_A | | unknown | | | | |
| DIR_B | | unknown | | | | |
| DIR_C | | unknown | | | | |
| ANGLE_A | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_B | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_C | | 0,00 | deg | -180,00 | 180,00 | |
| VMEM_USED | | False | | | | |
| DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| ENA_MULT | | False | | | | |
| NON_DIR | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| START | | False | | | | |
| Monitored data | | | | | | |
| START_DUR | | 0,00 | % | 0,00 | 100,00 | |
| FAULT_DIR | | unknown | | | | |
| DIRECTION | | unknown | | | | |
| DIR_A | | unknown | | | | |
| DIR_B | | unknown | | | | |
| DIR_C | | unknown | | | | |
| ANGLE_A | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_B | | 0,00 | deg | -180,00 | 180,00 | |
| ANGLE_C | | 0,00 | deg | -180,00 | 180,00 | |
| VMEM_USED | | False | | | | |
| Binary input values | | | | | | |
| X130 (AIM)(X130 (AIM)): 130 | | | | | | |
| X130 (AIM) | | | | | | |
| X130-Input 1 | | False | | | | |
| X130-Input 2 | | False | | | | |
| X130-Input 3 | | False | | | | |
| X130-Input 4 | | False | | | | |
| X120 (AIM)(X120 (AIM)): 120 | | | | | | |
| X120 (AIM) | | | | | | |
| X120-Input 1 | | False | | | | |
| X120-Input 2 | | False | | | | |
| X120-Input 3 | | False | | | | |
| X120-Input 4 | | False | | | | |
| X110 (BIO-H)(X110 (BIO-H)): 110 | | | | | | |
| X110 (BIO-H) | | | | | | |
| X110-Input 1 | | False | | | | |
| X110-Input 2 | | False | | | | |
| X110-Input 3 | | False | | | | |
| X110-Input 4 | | False | | | | |
| X110-Input 5 | | False | | | | |
| X110-Input 6 | | False | | | | |
| X110-Input 7 | | False | | | | |
| X110-Input 8 | | False | | | | |
| Binary output values | | | | | | |
| X110 (BIO-H)(X110 (BIO-H)): 110 | | | | | | |
| X110 (BIO-H) | | | | | | |
| X110-HSO1 | | False | | | | |
| X110-HSO2 | | False | | | | |
| X110-HSO3 | | False | | | | |
| X100 (PSM)(X100 (PSM)): 100 | | | | | | |
| X100 (PSM) | | | | | | |
| X100-PO1 | | False | | | | |
| X100-PO2 | | False | | | | |
| X100-SO1 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| X100-SO2 | | False | | | | |
| X100-PO3 | | False | | | | |
| X100-PO4 | | False | | | | |
| Communication | | | | | | |
| GSELPRT1(GSE): 1 | | | | | | |
| GSE | | | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| Monitoring | | | | | | |
| Reset counters | | False | | | | |
| Received msgs | | 0 | | 0 | 10000000 | |
| Transmitted msgs | | 0 | | 0 | 10000000 | |
| State changes | | 0 | | 0 | 10000000 | |
| SeqNum changes | | 0 | | 0 | 10000000 | |
| Test msgs | | 0 | | 0 | 10000000 | |
| State warnings | | 0 | | 0 | 10000000 | |
| Seq. warnings | | 0 | | 0 | 10000000 | |
| Recv. timeouts | | 0 | | 0 | 10000000 | |
| ConfRev errors | | 0 | | 0 | 10000000 | |
| NdsComm errors | | 0 | | 0 | 10000000 | |
| Dataset errors | | 0 | | 0 | 10000000 | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| I_INST_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_A | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_A | | normal | | | | |
| I_INST_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_B | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_B | | normal | | | | |
| I_INST_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_C | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_C | | 0,00 | xIn | 0,00 | 40,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| I_RANGE_C | | normal | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Inputs | | | | | | |
| RSTACM | | False | | | | |
| Monitored data | | | | | | |
| S_INST | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DB | | 0,0 | kVA | -999999,9 | 999999,9 | |
| S_DMD | | 0,0 | kVA | -999999,9 | 999999,9 | |
| P_INST | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DB | | 0,0 | kW | -999999,9 | 999999,9 | |
| P_DMD | | 0,0 | kW | -999999,9 | 999999,9 | |
| Q_INST | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DB | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Q_DMD | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| PF_INST | | 0,00 | | -1,00 | 1,00 | |
| PF_DB | | 0,00 | | -1,00 | 1,00 | |
| PF_DMD | | 0,00 | | -1,00 | 1,00 | |
| EA_RV_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_RV_ACM | | 0 | kVArh | 0 | 999999999 | |
| EA_FWD_ACM | | 0 | kWh | 0 | 999999999 | |
| ER_FWD_ACM | | 0 | kVArh | 0 | 999999999 | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| I_INST_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| I_DB_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_DMD_RES | | 0,00 | xIn | 0,00 | 40,00 | |
| I_RANGE_RES | | normal | | | | |
| RESVMMXU1: 1 | | | | | | |
| Uo(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| Monitored data | | | | | | |
| U_INST_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_RES | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_RES | | 0,00 | xUn | 0,00 | 4,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| U_DMD_RES | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_RES | | normal | | | | |
| VMMXU1: 1 | | | | | | |
| 3U(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| Outputs | | | | | | |
| HIGH_ALARM | | False | | | | |
| HIGH_WARN | | False | | | | |
| LOW_WARN | | False | | | | |
| LOW_ALARM | | False | | | | |
| Monitored data | | | | | | |
| U_INST_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_AB | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_AB | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_AB | | normal | | | | |
| U_INST_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_BC | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_BC | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_BC | | normal | | | | |
| U_INST_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_ANGL_CA | | 0,00 | deg | -180,00 | 180,00 | |
| U_DB_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_DMD_CA | | 0,00 | xUn | 0,00 | 4,00 | |
| U_RANGE_CA | | normal | | | | |
| U_INST_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_A | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_A | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_B | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_B | | 0,00 | xUn | 0,00 | 5,00 | |
| U_INST_C | | 0,00 | xUn | 0,00 | 5,00 | |
| U_ANGL_C | | 0,00 | deg | -180,00 | 180,00 | |
| U_DMD_C | | 0,00 | xUn | 0,00 | 5,00 | |
| CSMSQI1: 1 | | | | | | |
| I1,I2,I0(1) | | | | | | |
| Monitored data | | | | | | |
| I2_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I2_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I2_RANGE | | normal | | | | |
| I1_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I1_DB | | 0,00 | xIn | 0,00 | 40,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| I1_RANGE | | normal | | | | |
| I0_INST | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| I0_DB | | 0,00 | xIn | 0,00 | 40,00 | |
| I0_RANGE | | normal | | | | |
| VSMSQI1: 1 | | | | | | |
| U1,U2,U0(1) | | | | | | |
| Monitored data | | | | | | |
| U2_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U2_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U2_RANGE | | normal | | | | |
| U1_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U1_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U1_RANGE | | normal | | | | |
| U0_INST | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_ANGL | | 0,00 | deg | -180,00 | 180,00 | |
| U0_DB | | 0,00 | xUn | 0,00 | 4,00 | |
| U0_RANGE | | normal | | | | |
| FMMXU1: 1 | | | | | | |
| f(1) | | | | | | |
| Monitored data | | | | | | |
| F_INST | | 50,00 | Hz | 35,00 | 75,00 | |
| F_DB | | 50,00 | Hz | 35,00 | 75,00 | |
| F_RANGE | | normal | | | | |
| Other protection | | | | | | |
| CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| START | | False | | | | |
| POSCLOSE | | False | | | | |
| CB_FAULT | | False | | | | |
| Outputs | | | | | | |
| CB_FAULT_AL | | False | | | | |
| TRBU | | False | | | | |
| TRRET | | False | | | | |
| ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ARC_FLT_DET | | False | | | | |
| ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Inputs | | | | | | |
| BLOCK | | False | | | | |
| REM_FLT_ARC | | False | | | | |
| OPR_MODE | | False | | | | |
| Outputs | | | | | | |
| OPERATE | | False | | | | |
| ARC_FLT_DET | | False | | | | |
| Generic timers | | | | | | |
| PTGAPC1: 1 | | | | | | |
| PT(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| PTGAPC2: 2 | | | | | | |
| PT(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| TOFGAPC1: 1 | | | | | | |
| TOF(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| TOFGAPC2: 2 | | | | | | |
| TOF(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| TONGAPC1: 1 | | | | | | |
| TON(1) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| TONGAPC2: 2 | | | | | | |
| TON(2) | | | | | | |
| Inputs | | | | | | |
| IN1 | | False | | | | |
| IN2 | | False | | | | |
| IN3 | | False | | | | |
| IN4 | | False | | | | |
| IN5 | | False | | | | |
| IN6 | | False | | | | |
| IN7 | | False | | | | |
| IN8 | | False | | | | |
| Outputs | | | | | | |
| Q1 | | False | | | | |
| Q2 | | False | | | | |
| Q3 | | False | | | | |
| Q4 | | False | | | | |
| Q5 | | False | | | | |
| Q6 | | False | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Q7 | | False | | | | |
| Q8 | | False | | | | |
| Analog inputs | | | | | | |
| Current (3I,CT)(Current (3I,CT)): 1 | | | | | | |
| Current (3I,CT) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Current (Io,CT)(Current (Io,CT)): 1 | | | | | | |
| Current (Io,CT) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (Uo,VT)(Voltage (Uo,VT)): 1 | | | | | | |
| Voltage (Uo,VT) | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| Voltage (3U,VT)(Voltage (3U,VT)): 1 | | | | | | |
| Voltage (3U,VT) | | | | | | |
| Inputs | | | | | | |
| MINCB_OPEN | | False | | | | |
| Outputs | | | | | | |
| ALARM | | False | | | | |
| WARNING | | False | | | | |
| FB status | | | | | | |
| INRPHAR1: 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| 3I2f>(1) | | on | | | | |
| DEFLPDEF1: 1 | | | | | | |
| Io>->(1) | | | | | | |
| Io>->(1) | | on | | | | |
| PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| 3I>>>(1) | | on | | | | |
| DPHHPDOC1: 1 | | | | | | |
| 3I>>->(1) | | | | | | |
| 3I>>->(1) | | on | | | | |
| DPHLPDOC1: 1 | | | | | | |
| 3I>->(1) | | | | | | |
| 3I>->(1) | | on | | | | |
| DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| 3I>->(2) | | on | | | | |
| CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| 3I>/Io>BF(1) | | on | | | | |
| ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| ARC(1) | | on | | | | |
| ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| ARC(2) | | on | | | | |
| ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| ARC(3) | | on | | | | |
| TRPPTRC1: 1 | | | | | | |
| Master Trip(1) | | | | | | |
| Master Trip(1) | | on | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| CBCM(1) | | on | | | | |
| TCSSCBR1: 1 | | | | | | |
| TCS(1) | | | | | | |
| TCS(1) | | on | | | | |
| TCSSCBR2: 2 | | | | | | |
| TCS(2) | | | | | | |
| TCS(2) | | on | | | | |
| SEQSPVC1: 1 | | | | | | |
| FUSEF(1) | | | | | | |
| FUSEF(1) | | on | | | | |
| MDSOPT1: 1 | | | | | | |
| OPTS(1) | | | | | | |
| OPTS(1) | | on | | | | |
| Recorded data | | | | | | |
| Measurements | | | | | | |
| CMMXU1: 1 | | | | | | |
| 3I(1) | | | | | | |
| Max demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Max demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL1 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL2 | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand IL3 | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand IL1 | | 0 | | | 34 characters | |
| Time max demand IL2 | | 0 | | | 34 characters | |
| Time max demand IL3 | | 0 | | | 34 characters | |
| Time min demand IL1 | | 0 | | | 34 characters | |
| Time min demand IL2 | | 0 | | | 34 characters | |
| Time min demand IL3 | | 0 | | | 34 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| Max demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Min demand S | | 0,0 | kVA | -999999,9 | 999999,9 | |
| Max demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Min demand P | | 0,0 | kW | -999999,9 | 999999,9 | |
| Max demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Min demand Q | | 0,0 | kVAr | -999999,9 | 999999,9 | |
| Time max dmd S | | 0 | | | 34 characters | |
| Time min dmd S | | 0 | | | 34 characters | |
| Time max dmd P | | 0 | | | 34 characters | |
| Time min dmd P | | 0 | | | 34 characters | |
| Time max dmd Q | | 0 | | | 34 characters | |
| Time min dmd Q | | 0 | | | 34 characters | |
| RESCMMXU1: 1 | | | | | | |
| Io(1) | | | | | | |
| Max demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Min demand Io | | 0,00 | xIn | 0,00 | 40,00 | |
| Time max demand Io | | 0 | | | 34 characters | |
| Time min demand Io | | 0 | | | 34 characters | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault record | | | | | | |
| Fault number | | 0 | | 0 | 999999 | |
| Time and date | | 0 | | | 34 characters | |
| Protection | | Unknown | | | | |
| Start duration | | 0,00 | % | 0,00 | 100,00 | |
| Operate time | | 0,000 | s | 0,000 | 999999,999 | |
| Breaker clear time | | 0,000 | s | 0,000 | 3,000 | |
| Active group | | 1 | | 1 | 6 | |
| Shot pointer | | 1 | | 1 | 7 | |
| Max current IL1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current IL3 | | 0,000 | xIn | 0,000 | 50,000 | |
| Max current Io | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL1 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL2 | | 0,000 | xIn | 0,000 | 50,000 | |
| Current IL3 | | 0,000 | xIn | 0,000 | 50,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Current Io | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Io-Calc | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ps-Seq | | 0,000 | xIn | 0,000 | 50,000 | |
| Current Ng-Seq | | 0,000 | xIn | 0,000 | 50,000 | |
| Voltage UL1 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL2 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage UL3 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U12 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U23 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage U31 | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Uo | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Zro-Seq | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ps-Seq | | 0,000 | xUn | 0,000 | 4,000 | |
| Voltage Ng-Seq | | 0,000 | xUn | 0,000 | 4,000 | |
| PTTR thermal level | | 0,00 | | 0,00 | 99,99 | |
| I2/I1>(1) rat. I2/I1 | | 0,00 | % | 0,00 | 999,99 | |
| Frequency | | 50,00 | Hz | 30,00 | 80,00 | |
| Frequency gradient | | 0,00 | Hz/s | -10,00 | 10,00 | |
| Angle Uo - Io | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U23 - IL1 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U31 - IL2 | | 0,00 | deg | -180,00 | 180,00 | |
| Angle U12 - IL3 | | 0,00 | deg | -180,00 | 180,00 | |
| Information | | | | | | |
| Product identifiers(Product identifiers): 0 | | | | | | |
| Product identifiers | | | | | | |
| Type | | REF615 | | | 20 characters | |
| Product version | | 5.0 FP1 | | | 64 characters | |
| Serial number | | 1XXXXXXXXXXX | | | 20 characters | |
| Order code | | XXXXXXXXXXXXXXXX | | | 20 characters | |
| Production date | | 0 | | | 34 characters | |
| Configuration name | | FE06 | | | 20 characters | |
| SW version | | X.X | | | 20 characters | |
| SW date | | 0 | | | 34 characters | |
| SW number | | 2RCA035017E | | | 20 characters | |
| HW revision | | X | | | 20 characters | |
| Site identifiers(Site identifiers): 0 | | | | | | |
| Site identifiers | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Customer name | | 0 | | | 20 characters | |
| Street | | 0 | | | 20 characters | |
| House number | | 0 | | | 20 characters | |
| ZIP/Postal code | | 0 | | | 20 characters | |
| City/Province | | 0 | | | 20 characters | |
| State | | 0 | | | 20 characters | |
| Country | | 0 | | | 20 characters | |
| System identifiers(System identifiers): 0 | | | | | | |
| System identifiers | | | | | | |
| Technical key | | TIGER | | | 20 characters | |
| IEC 61850 version | | Edition 2 | | | 24 characters | |
| HW modules(HW modules): 0 | | | | | | |
| HW modules | | | | | | |
| Main board | | | | | | |
| Article number | | 2RAAXXXXXX | | | 20 characters | |
| SW version | | A | | | 20 characters | |
| HW revision | | X | | | 20 characters | |
| Serial number | | 1XXXXXXXXXXX | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| LHMI | | | | | | |
| Article number | | 2RAAXXXXXX | | | 20 characters | |
| SW version | | A | | | 20 characters | |
| HW revision | | X | | | 20 characters | |
| Serial number | | 1XXXXXXXXXXX | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| HW modules | | | | | | |
| X110 (BIO-H)(X110 (BIO-H)): 110 | | | | | | |
| X110 (BIO-H) | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Article number | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| X100 (PSM)(X100 (PSM)): 100 | | | | | | |
| X100 (PSM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| X130 (AIM)(X130 (AIM)): 130 | | | | | | |
| X130 (AIM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| X120 (AIM)(X120 (AIM)): 120 | | | | | | |
| X120 (AIM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| X000 (COM)(X000 (COM)): 90 | | | | | | |
| X000 (COM) | | | | | | |
| Article number | | 0 | | | 20 characters | |
| SW version | | - | | | 20 characters | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| HW revision | | 0 | | | 20 characters | |
| Serial number | | 0 | | | 20 characters | |
| Manufacturing date | | 0 | | | 34 characters | |
| Test date | | 0 | | | 34 characters | |
| Clear | | | | | | |
| Disturbance recorder: 0 | | | | | | |
| Disturbance recorder | | | | | | |
| Disturbance records | | Cancel | | | | |
| Clear(Clear): 0 | | | | | | |
| Clear | | | | | | |
| Indications and LEDs | | Cancel | | | | |
| Programmable LEDs | | Cancel | | | | |
| Events | | Cancel | | | | |
| Metering records | | Cancel | | | | |
| Power quality data | | Cancel | | | | |
| FLTRFRC1: 1 | | | | | | |
| FLTRFRC1 | | | | | | |
| Fault records | | Cancel | | | | |
| LDPRLRC1: 1 | | | | | | |
| LDPRLRC1 | | | | | | |
| Load Profile record | | Cancel | | | | |
| SSCBR1: 1 | | | | | | |
| CBCM(1) | | | | | | |
| CBCM(1) acc.energy | | Cancel | | | | |
| CBCM(1) rem.life | | Cancel | | | | |
| CBCM(1) travel times | | Cancel | | | | |
| CBCM(1) spr.charge t | | Cancel | | | | |
| PEMMXU1: 1 | | | | | | |
| P,E(1) | | | | | | |
| P,E(1) acc.energy | | Cancel | | | | |
| MDSOPT1: 1 | | | | | | |
| OPTS(1) | | | | | | |
| OPTS(1) operation t | | Cancel | | | | |
| Application Configuration | | | | | | |
| General | | | | | | |
| Settings | | | | | | |
| Setting group | | | | | | |
| Protection: 0 | | | | | | |
| Setting group | | | | | | |
| Active group | | 1 | | 1 | 6 | |
| Protection | | | | | | |
| Settings | | | | | | |
| Current protection | | | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 68; INRPHAR1(68(1)): 1 | | | | | | |
| 3I2f>(1) | | | | | | |
| Operation | | off | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Setting Group 1 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Setting Group 2 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Setting Group 3 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Setting Group 4 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Setting Group 5 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| Setting Group 6 | | | | | | |
| Start value | | 20 | % | 5 | 100 | |
| Operate delay time | | 20 | ms | 20 | 60000 | |
| 64; DEFLPDEF1: 1 | | | | | | |
| Io>->(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Minimum operate time | | 50 | ms | 50 | 60000 | |
| Allow Non Dir | | True | | | | |
| Measurement mode | | DFT | | | | |
| Min operate current | | 0,005 | xIn | 0,005 | 1,000 | |
| Min operate voltage | | 0,01 | xUn | 0,01 | 1,00 | |
| Correction angle | | 0,0 | deg | 0,0 | 10,0 | |
| Pol reversal | | False | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| Io signal Sel | | Calculated Io | | | | |
| Uo signal Sel | | Calculated Uo | | | | |
| Pol quantity | | Zero seq. volt. | | | | |
| Setting Group 1 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 5,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 0,12 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 1000 | ms | 50 | 200000 | |
| Operation mode | | Phase angle | | | | |
| Characteristic angle | | -90 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 180 | |
| Max reverse angle | | 80 | deg | 0 | 180 | |
| Min forward angle | | 80 | deg | 0 | 180 | |
| Min reverse angle | | 80 | deg | 0 | 180 | |
| Voltage start value | | 0,010 | xUn | 0,010 | 1,000 | |
| Enable voltage limit | | False | | | | |
| Setting Group 2 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 5,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 0,12 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 1000 | ms | 50 | 200000 | |
| Operation mode | | Phase angle | | | | |
| Characteristic angle | | -90 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 180 | |
| Max reverse angle | | 80 | deg | 0 | 180 | |
| Min forward angle | | 80 | deg | 0 | 180 | |
| Min reverse angle | | 80 | deg | 0 | 180 | |
| Voltage start value | | 0,010 | xUn | 0,010 | 1,000 | |
| Enable voltage limit | | False | | | | |
| Setting Group 3 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 5,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 0,12 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 1000 | ms | 50 | 200000 | |
| Operation mode | | Phase angle | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Characteristic angle | | -90 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 180 | |
| Max reverse angle | | 80 | deg | 0 | 180 | |
| Min forward angle | | 80 | deg | 0 | 180 | |
| Min reverse angle | | 80 | deg | 0 | 180 | |
| Voltage start value | | 0,010 | xUn | 0,010 | 1,000 | |
| Enable voltage limit | | False | | | | |
| Setting Group 4 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 5,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 0,12 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 1000 | ms | 50 | 200000 | |
| Operation mode | | Phase angle | | | | |
| Characteristic angle | | -90 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 180 | |
| Max reverse angle | | 80 | deg | 0 | 180 | |
| Min forward angle | | 80 | deg | 0 | 180 | |
| Min reverse angle | | 80 | deg | 0 | 180 | |
| Voltage start value | | 0,010 | xUn | 0,010 | 1,000 | |
| Enable voltage limit | | False | | | | |
| Setting Group 5 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 5,000 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 0,12 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 1000 | ms | 50 | 200000 | |
| Operation mode | | Phase angle | | | | |
| Characteristic angle | | -90 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 180 | |
| Max reverse angle | | 80 | deg | 0 | 180 | |
| Min forward angle | | 80 | deg | 0 | 180 | |
| Min reverse angle | | 80 | deg | 0 | 180 | |
| Voltage start value | | 0,010 | xUn | 0,010 | 1,000 | |
| Enable voltage limit | | False | | | | |
| Setting Group 6 | | | | | | |
| Start value | | 0,150 | xIn | 0,010 | 5,000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 0,12 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Norm. inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 1000 | ms | 50 | 200000 | |
| Operation mode | | Phase angle | | | | |
| Characteristic angle | | -90 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 180 | |
| Max reverse angle | | 80 | deg | 0 | 180 | |
| Min forward angle | | 80 | deg | 0 | 180 | |
| Min reverse angle | | 80 | deg | 0 | 180 | |
| Voltage start value | | 0,010 | xUn | 0,010 | 1,000 | |
| Enable voltage limit | | False | | | | |
| PHIPTOC1: 1 | | | | | | |
| 3I>>>(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Setting Group 1 | | | | | | |
| Start value | | 2,30 | xIn | 1,00 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 200000 | |
| Setting Group 2 | | | | | | |
| Start value | | 2,30 | xIn | 1,00 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 200000 | |
| Setting Group 3 | | | | | | |
| Start value | | 2,30 | xIn | 1,00 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 200000 | |
| Setting Group 4 | | | | | | |
| Start value | | 2,30 | xIn | 1,00 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 200000 | |
| Setting Group 5 | | | | | | |
| Start value | | 2,30 | xIn | 1,00 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 200000 | |
| Setting Group 6 | | | | | | |
| Start value | | 2,30 | xIn | 1,00 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Operate delay time | | 50 | ms | 20 | 200000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| 50-1; DPHHPDOC1: 1 | | | | | | |
| 3I>>->(1) | | | | | | |
| Operation | | on | | | | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Minimum operate time | | 20 | ms | 20 | 60000 | |
| Allow Non Dir | | True | | | | |
| Measurement mode | | DFT | | | | |
| Min operate current | | 0,01 | xIn | 0,01 | 1,00 | |
| Min operate voltage | | 0,01 | xUn | 0,01 | 1,00 | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| Num of start phases | | 1 out of 3 | | | | |
| Setting Group 1 | | | | | | |
| Start value | | 2,30 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 2 | | | | | | |
| Start value | | 2,30 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 3 | | | | | | |
| Start value | | 2,30 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 4 | | | | | | |
| Start value | | 2,30 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 5 | | | | | | |
| Start value | | 2,30 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Characteristic angle | | 60 | deg | -179 | 180 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 6 | | | | | | |
| Start value | | 2,30 | xIn | 0,10 | 40,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Directional mode | | Non-directional | | | | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Pol quantity | | Cross pol | | | | |
| 51; DPHLPDOC1(67-1(1)): 1 | | | | | | |
| 3I>->(1) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |
| Minimum operate time | | 300 | ms | 20 | 60000 | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| Allow Non Dir | | True | | | | |
| Min operate current | | 0,01 | xIn | 0,01 | 1,00 | |
| Min operate voltage | | 0,01 | xUn | 0,01 | 1,00 | |
| Setting Group 1 | | | | | | |
| Start value | | 0,88 | xIn | 0,05 | 5,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,25 | | 0,05 | 15,00 | |
| Operate delay time | | 16000 | ms | 40 | 200000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 2 | | | | | | |
| Start value | | 0,88 | xIn | 0,05 | 5,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,25 | | 0,05 | 15,00 | |
| Operate delay time | | 16000 | ms | 40 | 200000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 3 | | | | | | |
| Start value | | 0,88 | xIn | 0,05 | 5,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,25 | | 0,05 | 15,00 | |
| Operate delay time | | 16000 | ms | 40 | 200000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 4 | | | | | | |
| Start value | | 0,88 | xIn | 0,05 | 5,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,25 | | 0,05 | 15,00 | |
| Operate delay time | | 16000 | ms | 40 | 200000 | |
| Operating curve type | | IEC inv. | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 5 | | | | | | |
| Start value | | 0,88 | xIn | 0,05 | 5,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,25 | | 0,05 | 15,00 | |
| Operate delay time | | 16000 | ms | 40 | 200000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 6 | | | | | | |
| Start value | | 0,88 | xIn | 0,05 | 5,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 0,25 | | 0,05 | 15,00 | |
| Operate delay time | | 16000 | ms | 40 | 200000 | |
| Operating curve type | | IEC inv. | | | | |
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| 50; DPHLPDOC2: 2 | | | | | | |
| 3I>->(2) | | | | | | |
| Operation | | on | | | | |
| Num of start phases | | 1 out of 3 | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Minimum operate time | | 20 | ms | 20 | 60000 | |
| Reset delay time | | 20 | ms | 0 | 60000 | |
| Measurement mode | | DFT | | | | |
| Curve parameter A | | 28,2000 | | 0,0086 | 120,0000 | |
| Curve parameter B | | 0,1217 | | 0,0000 | 0,7120 | |
| Curve parameter C | | 2,00 | | 0,02 | 2,00 | |
| Curve parameter D | | 29,10 | | 0,46 | 30,00 | |
| Curve parameter E | | 1,0 | | 0,0 | 1,0 | |
| Allow Non Dir | | True | | | | |
| Min operate current | | 0,01 | xIn | 0,01 | 1,00 | |
| Min operate voltage | | 0,01 | xUn | 0,01 | 1,00 | |
| Setting Group 1 | | | | | | |
| Start value | | 0,55 | xIn | 0,05 | 5,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 2 | | | | | | |
| Start value | | 0,55 | xIn | 0,05 | 5,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 3 | | | | | | |
| Start value | | 0,55 | xIn | 0,05 | 5,00 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 4 | | | | | | |
| Start value | | 0,55 | xIn | 0,05 | 5,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 5 | | | | | | |
| Start value | | 0,55 | xIn | 0,05 | 5,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| Setting Group 6 | | | | | | |
| Start value | | 0,55 | xIn | 0,05 | 5,00 | |
| Start value Mult | | 1,0 | | 0,8 | 10,0 | |
| Time multiplier | | 1,00 | | 0,05 | 15,00 | |
| Operate delay time | | 300 | ms | 40 | 200000 | |
| Operating curve type | | IEC Def. Time | | | | |
| Type of reset curve | | Immediate | | | | |
| Voltage Mem time | | 40 | ms | 0 | 3000 | |
| Directional mode | | Non-directional | | | | |
| Characteristic angle | | 60 | deg | -179 | 180 | |
| Max forward angle | | 80 | deg | 0 | 90 | |
| Max reverse angle | | 80 | deg | 0 | 90 | |
| Min forward angle | | 80 | deg | 0 | 90 | |
| Min reverse angle | | 80 | deg | 0 | 90 | |
| Pol quantity | | Cross pol | | | | |
| Other protection | | | | | | |
| BF; CCBRBRF1: 1 | | | | | | |
| 3I>/Io>BF(1) | | | | | | |
| Operation | | off | | | | |
| Current value | | 0,30 | xIn | 0,05 | 2,00 | |
| Current value Res | | 0,30 | xIn | 0,05 | 2,00 | |
| CB failure trip mode | | 1 out of 4 | | | | |
| CB failure mode | | Both | | | | |
| CB fail retrip mode | | Off | | | | |
| Retrip time | | 120 | ms | 0 | 60000 | |
| CB failure delay | | 240 | ms | 0 | 60000 | |
| CB fault delay | | 5000 | ms | 0 | 60000 | |
| Measurement mode | | Peak-to-Peak | | | | |
| Trip pulse time | | 150 | ms | 0 | 60000 | |
| Start latching mode | | Rising edge | | | | |
| ARC BUSBAR; ARCSARC1: 11 | | | | | | |
| ARC(1) | | | | | | |
| Operation | | on | | | | |
| Setting Group 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Setting Group 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CB; ARCSARC2: 21 | | | | | | |
| ARC(2) | | | | | | |
| Operation | | on | | | | |
| Setting Group 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| ARC CABLE; ARCSARC3: 31 | | | | | | |
| ARC(3) | | | | | | |
| Operation | | on | | | | |

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max | Format |
|---|---|---|---|---|---|---|
| Setting Group 1 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 2 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 3 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 4 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 5 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |
| Setting Group 6 | | | | | | |
| Phase start value | | 2,50 | xIn | 0,50 | 40,00 | |
| Ground start value | | 0,20 | xIn | 0,05 | 8,00 | |
| Operation mode | | Light only | | | | |

1.10.2. SG-100D1 PROTECTION CONFIGURATION (INCLUDING IO CONFIGURATION) (CID File and PCM600),

Doc.No. 1723002197-EL-SO-00039

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# Base Load Power Hub (BLPH)

## SG-100D1 PROTECTION CONFIGURATION (INCLUDING IO CONFIGURATION) (CID FILE AND PCM600)

lumber: 1723002197-EL-SO-00039

Document Class: 3

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Mocenti | 23/09/2024 |

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| 0 | 19/09/2024 | Issue for Information (IFI) | Giulietti | Flamminio | Santinelli |
| Rev. | Date | Description | Prepared | Reviewed | Approved |

IMESA ELECTRICAL ENGINEERING IMESA Doc. 231151/SD/039

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*File:* 1723002197-EL-SO-00039 Rev.00.docx

## Revision / Change Log

| Rev. | Description |
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# Attached files list

1. 1723002197-EL-SO-00039_Rev.00_CID.zip [file CID]
2. IMESA_Rosetti_CrossWind_Rev.0_2024-09-18_PCM600.apcmp [file PCM600]

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1.10.3. SG-200N1 PROTECTION CONFIGURATION (INCLUDING IO CONFIGURATION) (CID File and PCM600),

Doc.No. 1723002197-EL-SO-00040

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# Base Load Power Hub (BLPH)

## SG-200N1 PROTECTION CONFIGURATION (INCLUDING IO CONFIGURATION) (CID FILE AND PCM600)

mber: 1723002197-EL-SO-00040

Document Class: 3

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| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

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| Sign | Date |
|---|---|
| Luca Maceri | 23/09/2024 |

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| 0 | 19/09/2024 | Issue for Information (IFI) | Giulietti | Flamminio | Santinelli |
| Rev. | Date | Description | Prepared | Reviewed | Approved |

IMESA ELECTRICAL ENGINEERING IMESA Doc. 231298/SD/040

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## Revision / Change Log

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1. 1723002197-EL-SO-00040_Rev.00_CID.zip [file CID]
2. IMESA_Rosetti_CrossWind_Rev.0_2024-09-18_PCM600.apcmp [file PCM600]

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## 1.11. Spare Parts & Special Tools

### 1.11.1. SPARE PART INDEX REGISTER (COMMISSIONING AND OPERATION), Doc.No. 1723002197-COM-LIS-00052

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# Base Load Power Hub (BLPH)

## SPARE PART INDEX REGISTER
## (COMMISSIONING AND OPERATION)

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

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| Sign | Date |
|---|---|
| Luca Maestri | 03/09/2024 |

mber: 1723002197-COM-LIS-00052

Document Class: 3

| Rev. | Date | Description | Prepared | Reviewed | Approved |
|---|---|---|---|---|---|
| 3 | 08/08/2024 | Issue for Information (IFI) | Del Federico | Flamminio | Santinelli |
| 2 | 01/08/2024 | Issue for Information (IFI) | Del Federico | Flamminio | Santinelli |
| 1 | 24/07/2024 | Issue for Information (IFI) | Del Federico | Flamminio | Santinelli |
| 0 | 24/04/2024 | Issue for Information (IFI) | Giulietti | Flamminio | Santinelli |

IMESA ELECTRICAL ENGINEERING IMESA Doc. 231115/SD/052

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| 01 | Issue for Information (IFI) |
| 02 | Issue for Information (IFI) |
| 03 | Issue for Information (IFI) |
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ROSETTI MARINO

# SPARE PARTS LIST

CROSSWIND

| | |
|---|---|
| Document Title | **SPARE PART INDEX REGISTER (COMMISSIONING AND OPERATION)** |
| The document relates to | **HOLLANDSE KUST NOORD WIND PARK Project - Base Load Power Hub (BLPH)** |
| Project ID | **123A90** — Doc. n° **1723002197-COM-LIS-00052** — Rev. **Issued for review** — Rev. Date **08-Aug-24** — Status **IFR** — Class **3** |
| Contract | **CW-I-WP4-2023-05** |

The equipment consists of the following units/components

| | | | | | |
|---|---|---|---|---|---|
| 1 | Tag no. | SG-10.01 1 | SG-20.N 1 | SG-20.02 | DP-20.N 1 |
| 2 | Tag description | HV SWBD 6.6kV | LV SWBD 400/230V | LV SWBD 400/230V | LV SWBD 400/230V |
| 3 | Manufacturer model/type no. | Minivar PC | PC/MCC | PC | MCC/F |
| 4 | Manufacturer serial no. | 231115/10/010/2024 | 231128/10/040/2024 | 231128/10/070/2024 | 231128/10/080/2024 |
| 5 | No. of units | 1 | 1 | 1 | 1 |

Supplier: IMESA S.p.A — PO Number: 1723002197_123A90 — PO description: HV and LV Switchgears — Contact name: Mr. Damiano Santinelli

Address: via G. di Vittorio, 14 — IESI - (AN) — ITALY — Supplier telephone no: +39 0731 211034 — Contact mobile no: +39 0731 649242

E-mail: spareparts@imesaspa.com; damiano.santinelli@imesaspa.com — WEBSITE

General Information:

**MATERIALS DATA**

| Item Number | Total number of identical spares installed | Description of recommended spare parts | Parts/drawing ref. | | | Material | Corrosion Type (if applicable) | Corrosion Reference (if applicable) | Shelf life (years) | Weight (net) | Weight (gross) | Volume | HS Code | ECSS Code | % US Content | Country of origin | Supplier part no. | Manufacturer part no. | Manufacturername | Commissioning spares | 2 Years spares | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Project Datasheet no. | Project Detail dwg. no. | Item ref. | | | | | | | | | | | | | | | Quantity ordered | Quantity ordered | |
| | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 1 | 6,00 | REX640 GENERAL PURPOSE CODE | | | | | | | | | | | | | | | | MP02000001VCF698331R0001 | 1VCF698331R0001 | ABB PT | | | |
| 2 | 6,00 | ACCESSORY FOR REX640 - 2RCA033008A0001 - SCHERMO A COLORI TOUCH | | | | | | | | | | | | | | | | MP02000001VCF698331R0002 | 1VCF698331R0002 | ABB PT | | | |
| 3 | 6,00 | ACCESSORY FOR REX640 - 1MRS120549-3 - LHMI CABLE 3mt | | | | | | | | | | | | | | | | MP02000001VCF698331R0012 | 1VCF698331R0012 | ABB PT | | | |
| 4 | 3,00 | UMK-RJ45/5/8PTDA VARIOFACE MODULE | | | | | | | | | | | | | | | | MP02000002900682 | 2900682 | PHOENIX CONTACT spa | | | |
| 5 | 5,00 | BSR10 SENTRY RELAY SIL3 24Vcc 1NA+1NC COD. A1004000 | | | | | | | | | | | | | | | | MP02000027LA01004OR0000 | A1004000 | ABB SACE SPA | | | |
| 6 | 6,00 | VOLTAGE PRESENCE SIGNALING DEVICE VPS 3LED dis.43911082 | | | | | | | | | | | | | | | | MP02000043911082 | VPIS1082 | ELECTRONSYSTEM MD srl | | | |
| 7 | 1,00 | VOLTAGE PRESENCE SIGNALING DEVICE VPIS1118 3,3-36KV dis.43931118 | | | | | | | | | | | | | | | | MP02000043931118 | VPIS1118 | ELECTRONSYSTEM MD srl | | | |
| 8 | 2,00 | PATCH CORD CAT.6 UTP WHITE L=1mt ART. 6U-010WH | | | | | | | | | | | | | | | | MP02000006U010WH | 6U010WH | SECURNET srl | | | |
| 9 | 6,00 | PATCH CORD CAT.6 UTP YELLOW L=5mt ART. 6U-050-YE | | | | | | | | | | | | | | | | MP02000006U050YE | 6U050YE | SECURNET srl | | | |
| 10 | 1,00 | PATCH CORD CAT.6 UTP YELLOW L=7,5mt | | | | | | | | | | | | | | | | MP02000006U075YE | 6U075YE | SECURNET srl | | | |
| 11 | 7,00 | MODBUS DATACARD, 8-CHANNEL, EM SENSOR INPUT, RS485 MODBUS RTU OUTPUT | | | | | | | | | | | | | | | | MP02000000800208 | 800208 | QM Group Ltd | | | |
| 12 | 1,00 | CONFIGURATION & COMMISSIONING KIT 800447 | | | | | | | | | | | | | | | | MP02000000800447 | 800447 | QM Group Ltd | | | |
| 13 | 53,00 | IR SENSOR EM-10-SC-801100-CABLE-L=10MT | | | | | | | | | | | | | | | | MP02000000801100 | 801100 | QM Group Ltd | | | |
| 14 | 1,00 | ARM-XL PANEL - 10X8 CH 4.3" TOUCHSCREEN DISPLAY | | | | | | | | | | | | | | | | MP02000000900451 | 900451 | QM Group Ltd | | | |
| 15 | 1,00 | M-FAST SFP-TX/RJ45 OPTICAL FIBER TRANSCEIVER 100MBIT/S | | | | | | | | | | | | | | | | MP02000000942098001 | 942098001 | ABB PT | | | |
| 16 | 21,00 | SURGE DISCHARGE INV 10KA CL 1 DMI-9-10-1-L | | | | | | | | | | | | | | | | MP02000000990003 | 990003 | DEHN ITALIA spa | | 2 | |
| 17 | 122,00 | S2C-S/H 6R SINGNALINC CONTACT/AUX | | | | | | | | | | | | | | | | MP02000000A563819 | A563819 | ABB SACE SPA | | 7 | |
| 18 | 7,00 | RCD MOULE AC TYPE 2P 25A DDA202-25-300mA/AC | | | | | | | | | | | | | | | | MP02000000B427917 | B427917 | ABB SACE SPA | | 1 | |
| 19 | 15,00 | REGLETTE LED 4W 220-240V 50-60HZ COD.74041 - RGL P LED 4W 313mm 4000K I | | | | | | | | | | | | | | | | MP02000000BEG74041 | 74041 | BEGHELLI srl | 1 | | |
| 20 | 1,00 | VOLMETRICAL SWITCH 3Teri-FF CA1D-A004-600-FT2 + SD F776 + SDC-E251 | | | | | | | | | | | | | | | | MP02000000CA1DA004600FT2 | CA1DA004600FT2 | KRAUS & NAIMER | | | |
| 21 | 18,00 | MICROSWITCH D2VW-5L2-1 WITH LONG LEVER/ROT. OMRON | | | | | | | | | | | | | | | | MP02000000D2VW5L21 | D2VW-5L2-1 | OMRON ELECTRONICS spA | | 1 | |
| 22 | 144,00 | FEED THROUGH TERMINAL BLOCK DAS.4 DOUBLE LEVEL 4mmq GREY | | | | | | | | | | | | | | | | MP02000000DS100GR | DS100GR | CABUR spa | | 8 | |
| 23 | 6,00 | TERMINAL PLATE GREY DAS/PT/GR | | | | | | | | | | | | | | | | MP02000000DS101GR | DS101GR | CABUR spa | | 1 | |
| 24 | 7,00 | M1173 SCOKET ITALIAN STANDARD 2P+T WITH PROTECTION 250V | | | | | | | | | | | | | | | | MP02000000EA0447 | EA0447 | ABB SACE SPA | | | |
| 25 | 40,00 | CONTACT BLOCK HOLDER MCBH-00 3 SLOT | | | | | | | | | | | | | | | | MP02000000EOS697 | EOS697 | ABB SACE SPA | 6 | | |
| 26 | 146,00 | MCB-10 1NO CONTACT BLOCK | | | | | | | | | | | | | | | | MP02000000EOS705 | EOS705 | ABB SACE SPA | 6 | | |
| 27 | 106,00 | MCB-01 1NC CONTACT BLOCK | | | | | | | | | | | | | | | | MP02000000EOS713 | EOS713 | ABB SACE SPA | | 6 | |
| 28 | 1,00 | CR-M024DC2L RELAY, CR-M 24VCC 2SC +LED | | | | | | | | | | | | | | | | MP02000000ERS454 | 1SVR405611R1100 | ABB SACE SPA | | | |
| 29 | 8,00 | CR-M230AC2L RELAY230V AC 2C/O CONTACTS NA/NC 250V/12A | | | | | | | | | | | | | | | | MP02000000ERS520 | ERS520 | ABB SACE SPA | | | |
| 30 | 29,00 | CR-M110DC4L RELAY CR-M 110VDC 4C/O CONTACTS +LED | | | | | | | | | | | | | | | | MP02000000ERS892 | ERS892 | ABB SACE SPA | 3 | | |
| 31 | 233,00 | STANDARD SOCKET CR-M4SS FOR RELAY WITH 2/4 C/O CONTACTS | | | | | | | | | | | | | | | | MP02000000FN6866 | 1SVR405651R3000 | ABB SACE SPA | | | |
| 32 | 75,00 | RETAIN METAL SPRING CR-MH1 ER7286 | | | | | | | | | | | | | | | | MP02000000ER7286 | ER7286 | ABB SACE SPA | | | |
| 33 | 7,00 | H3DK-M2 MULTIFUNC. RELAY WITH TIMER . aux:24-230VCA/CC 2SC.T | | | | | | | | | | | | | | | | MP02000000H3DKM2 | H3DKM2ACDC242 | OMRON ELECTRONICS spA | | | |
| 34 | 47,00 | END PLATE GREY HSCB/6/PT/GR | | | | | | | | | | | | | | | | MP02000000HB201GR | HB201GR | CABUR spa | | | |
| 35 | 7,00 | SHORT CIRCUIT PLATE 2 POLES. RED. HSCB/6/PO/2 | | | | | | | | | | | | | | | | MP02000000HB203 | HB203 | CABUR spa | | | |
| 36 | 7,00 | SHORT CIRCUIT PLASTE 4 POLES. RED. HSCB/6/PO/4 | | | | | | | | | | | | | | | | MP02000000HB204 | HB204 | CABUR spa | | | |
| 37 | 99,00 | TERMINAL BLOCK - VOLTMETRIC- HSCB.6/DD/GR SPRING CLAMP | | | | | | | | | | | | | | | | MP02000000HB210GR | HB210GR | CABUR spa | | | |
| 38 | 60,00 | TERMINAL BLOCK - AMMETRICAL- HSCB.6/CD/GR SPRING CLAMP | | | | | | | | | | | | | | | | MP02000000HB220GR | HB220GR | CABUR spa | | | |
| 39 | 735,00 | FEED THROUGH TERMINAL BLOCK HMM.4/GR SPRING CLAMP | | | | | | | | | | | | | | | | MP02000000HM250GR | HM250GR | CABUR spa | 40 | | |
| 40 | 56,00 | END PLATE GRAY HMT.4/PT/GR | | | | | | | | | | | | | | | | MP02000000HM251GR | HM251GR | CABUR spa | | | |
| 41 | 84,00 | FEED THROUGH TERMINAL BLOCK HMM.6 SPRING CLAMP | | | | | | | | | | | | | | | | MP02000000HM320GR | HM320GR | CABUR spa | | | |
| 42 | 21,00 | END PLATE HMT.6/PT GRIGIA | | | | | | | | | | | | | | | | MP02000000HM321GR | HM321GR | CABUR spa | | | |
| 43 | 6,00 | FEED THROUGH TERMINAL BLOCK HMM.10 SPRING CLAMP | | | | | | | | | | | | | | | | MP02000000HM330GR | HM330GR | CABUR spa | | | |
| 44 | 2,00 | END PLATE GRAY HMM.10PT | | | | | | | | | | | | | | | | MP02000000HM331GR | HM331GR | CABUR spa | | | |
| 45 | 6,00 | TO-0.22/2.4V 50HZ 100/1A SPS-SVA DWG-SDR9-00-44 Ø150MM | | | | | | | | | | | | | | | | MP02000000KAP150250S5 | KAP150250S5 | ESITAS ELEKTRİK SANAYİ | | | |
| 46 | 3,00 | RECTIFIER BRIDGE KBPC 50A 600V - KBPCS006 | | | | | | | | | | | | | | | | MP02000000KBPCS006 | KBPCS006 | GENERIC | | | |
| 47 | 6,00 | MLBL-04Y LED BLOCK WITH YELLOW LED 110-130VAC | | | | | | | | | | | | | | | | MP02000000KV0225 | KV0225 | ABB SACE SPA | | | |
| 48 | 6,00 | MLBL-05Y LED BLOCK WITH YELLOW LED 110-130VDC | | | | | | | | | | | | | | | | MP02000000KV0274 | KV0274 | ABB SACE SPA | | | |
| 49 | 33,00 | MP1-10R RED PUSH BUTTON WITH PLASTIC RING. D22 | | | | | | | | | | | | | | | | MP02000000KW0752 | KW0752 | ABB SACE SPA | 2 | | |
| 50 | 33,00 | MP1-10G GREEN PUSH BUTTON WITH PLASTIC RING.D22 | | | | | | | | | | | | | | | | MP02000000KW0760 | KW0760 | ABB SACE SPA | 2 | | |
| 51 | 7,00 | MP1-10B BLACK PUSH BUTTON WITH PLASTIC RING.D22 | | | | | | | | | | | | | | | | MP02000000KW0802 | KW0802 | ABB SACE SPA | | | |
| 52 | 7,00 | MP1-11Y YELLOW PUSH BUTTON WITH PLASTIC RING - ILLUMINATED D22 | | | | | | | | | | | | | | | | MP02000000KW1016 | KW1016 | ABB SACE SPA | | | |
| 53 | 34,00 | M2SS2-10B 90 DEG. 2P POS. SELECTOR BLACK WITH LEVER AND BLACK RING. D22 | | | | | | | | | | | | | | | | MP02000000KW3293 | 1SFA611201R1006 | ABB SACE SPA | 2 | | |
| 54 | 7,00 | PAVM321 DIN SOCKET FOR SCREW TERMINAL BLOCK | | | | | | | | | | | | | | | | MP02000000PAVM321 | PAVM321 | A.M.R.A. spA | | | |
| 55 | 42,00 | PLUG-IN CROSS CONNECTION PTC/5/02 2 POLES | | | | | | | | | | | | | | | | MP02000000PTC0502 | PTC0502 | CABUR spa | | | |
| 56 | 42,00 | PLUG-IN CROSS CONNECTION PTC/8/02 3 POLES | | | | | | | | | | | | | | | | MP02000000PTC0802 | PTC0802 | CABUR spa | | | |
| 57 | 8,00 | ANTICONDENSATE RESISTOR 5KR 150W SUPPLY 220-240VCA | | | | | | | | | | | | | | | | MP02000000R1R150230 | R1R150230 | TORRESAN P. srl COSTRUZIONI EL | | | |
| 58 | 6,00 | RMBE13-C110T BISTABILE 110VCC 7SC.UN.-M TROPICALIZED | | | | | | | | | | | | | | | | MP02000000RMBE13C110T | RMBE13C110T | A.M.R.A. spA | | 1 | |
| 59 | 2,00 | RSP52S-S60026YT-SKP2HHE25SXX.X RSPS RAIL SWITCH POWER SMART CONFIG. | | | | | | | | | | | | | | | | MP02000000RSP52S060026YT | RSP52S060026YT | HIRSCHMANN | | | |
| 60 | 27,00 | MCB 2P 2A-C S202M-C2 | | | | | | | | | | | | | | | | MP02000000SS50239 | S550239 | ABB SACE SPA | | 2 | |
| 61 | 22,00 | MCB 2P 4A-C S202M-C4 | | | | | | | | | | | | | | | | MP02000000SS50253 | S550253 | ABB SACE SPA | | 2 | |
| 62 | 8,00 | MCB 2P 10A-C S202M-C10 | | | | | | | | | | | | | | | | MP02000000SS50284 | S550284 | ABB SACE SPA | | 1 | |
| 63 | 2,00 | MCB 3P 2A-C S203M-C2 | | | | | | | | | | | | | | | | MP02000000SS50383 | S550383 | ABB SACE SPA | | 1 | |
| 64 | 18,00 | MCB 4P 2A-C S204M-C2 | | | | | | | | | | | | | | | | MP02000000SS50680 | S550680 | ABB SACE SPA | | 1 | |
| 65 | 1,00 | MCB 2P 4A-D S202M-D4 | | | | | | | | | | | | | | | | MP02000000S600422 | S600422 | ABB SACE SPA | | 1 | |
| 66 | 1,00 | MCB 2P 6A-D S202M-D6 | | | | | | | | | | | | | | | | MP02000000S600446 | S600446 | ABB SACE SPA | | 1 | |
| 67 | 2,00 | MCB 2P 25A-D S202M-D25 | | | | | | | | | | | | | | | | MP02000000S600545 | S600545 | ABB SACE SPA | | 1 | |
| 68 | 1,00 | MCB 2P 32A-D S202M-D32 | | | | | | | | | | | | | | | | MP02000000S600613 | S600613 | ABB SACE SPA | | 1 | |
| 69 | 1,00 | DC/DC CONVERTER IN=110VDC OUT=24VDC 150W 6A MOD. SPS115DX-110C-24-6 | | | | | | | | | | | | | | | | MP02000000SPS115DX110C246 | SPS115DX110C246 | ADVEL SRL | | | |
| 70 | 15,00 | TRT-10A ADJUSTABLE THERMOSTAT -10° A +80° 1NC IP20 EN50022/35 | | | | | | | | | | | | | | | | MP02000001TRT10A230VNC | TRT10A230VNC | FANDIS | | | |
| 71 | 3,00 | CMF 7.2KV 250A 442/87MM STRIKER BIN 1YMB760741M4811 59014360023289 | | | | | | | | | | | | | | | | MP02000021VCF501000R0002 | 000021VCF501000R0002 | ABB PT | | 3 | |
| 72 | 2,00 | RSP25-11003Z6TT-SK9VIHHE2SXX SWITCH HIRSCHMANN | | | | | | | | | | | | | | | | MP02000021VCF698390R0397 | 2-1VCF698390R0397 | HIRSCHMANN | | | |
| 73 | 1,00 | VOLTAGE INDICATOR 96X96 90° CA.D=8KV ON TV 6600/110V TROP. SHP VERSION | | | | | | | | | | | | | | | | MP02000021F66EVXYYXCL | 2-F66EVXYYXCL | FBER Srl | | | |
| 74 | 6,00 | FUSIBLE CEF 6/12KV 160A 442/87MM S 1YMB711238M4812 | | | | | | | | | | | | | | | | MP02000081VCF501000R0002 | 8-1VCF501000R0002 | ABB PT | | 3 | |
| 75 | 3,00 | FUSIBLE CEF 6/12KV 63A 442/65MM S 1YMB711229M4612 | | | | | | | | | | | | | | | | MP02000091VCF501000R0002 | 9-1VCF501000R0002 | ABB PT | | 3 | |
| 76 | 3,00 | FUSIBLE CEF 6/12KV 200A 442/87MM S 1YMB711239M4812 | | | | | | | | | | | | | | | | MP02000101VCF501000R0002 | 10-1VCF501000R0002 | ABB PT | | | |
| 77 | 6,00 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=7M 1MRS120534-7 | | | | | | | | | | | | | | | | MP02000171VCF698000R0012 | 000171VCF698000R0012 | ABB PT | | | |
| 78 | 12,00 | OPTICAL FIBER CABLE PRE-MANUFACT. LENS L=5M 1MRS120534-5 | | | | | | | | | | | | | | | | MP02000201VCF698000R0012 | 000201VCF698000R0012 | ABB PT | | | |
| 79 | 3,00 | TA ATB10-85 7,2/20/60KV 60HZ 600/1-1 5VA-0,5/5P20 10VA-5P20 SEC.P1 SIDE | | | | | | | | | | | | | | | | MP02000035ATB1085 | 35-ATB1085 | ESITAS ELEKTRİK SANAYİ | | | |
| 80 | 3,00 | TA ATB10-85 7,2/20/60KV 60HZ 400/1 0,5/5P20-5VA SEC.P2 SIDE | | | | | | | | | | | | | | | | MP02000036ATB1085 | 36-ATB1085 | ESITAS ELEKTRİK SANAYİ | | | |

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## FOR 6.6kV SWITCHGEAR SG-100D1

N.2 LEVER FOR INSERTION / EXTRACTION VD4 CIRCUIT BREAKERS AND VSC CONTACTOR



N.1 LIFTING TRUCK TO INSERTION / EXTRACTION VD4 CIRCUIT BREAKERS



N.2 EARTHING SWITCH OPERATING LEVER



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N.6 LEVER FOR INSERTION / EXTRACTION VOLTAGE TRANSFORMER (INTEGRATED IN THE VOLTAGE TRANSFORMER COMPARTMENTS)



N.3 FUSE EXTRACTION HOOK FROM VSC CONTACTOR BODY



N.6 VOLTAGE TRANSFORMER GUIDES (INTEGRATED IN THE VOLTAGE TRANSFORMER COMPARTMENTS)



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N.1 RACK



N.1 COUPLE OF METAL PLATE TO LIFT VSC WITH CRANE/FORKLIFT




N.1 COUPLE OF BRACKETS TO LIFT VD4 WITH CRANE/FORKLIFT




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N.2 LEVER FOR MECHANICAL OPENING OF VSC CONTACTOR



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## FOR LOW VOLTAGE SWITCHGEAR

N.4 LEVER FOR INSERTION / EXTRACTION EMAX CIRCUIT BRAKER (INSIDE CIRCUIT BRAKER BODY)



N.5 EXTRACTION LEVER FOR DRAWER ON MCC CABINET



N.1 RACK



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N.1 MANUAL FORKLIFT TRUCK FOR LOW VOLTAGE CIRCUIT BRAKER AND DRAWERS

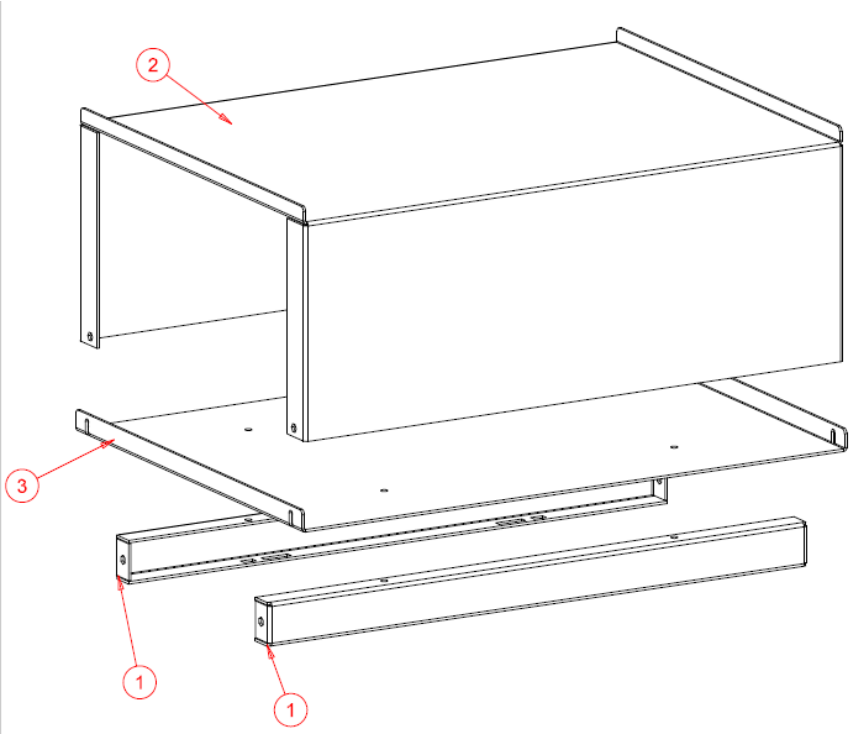



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N.1 ADAPTAPTION KIT FOR MCCE DRAWERS AND CIRCUIT BRAKERS (only for ABB EMAX SERIES E1-E2-E4 MODELS) EXTRACTION.




Bubbles legend

1 *two Crossbars*: have to fix on forks of forklift truck.

3 *Adaptation plate*: to use in conjunction with Crossbars (1) for extraction of MCC drawers and Emax Circuit Brakers.

2 *Adaptation plate*: to use in conjunction with Crossbars (1) and Plate (3) only for extraction of the uppest MCC drawer.

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## 1.12. INSTALLATION OPERATING AND MAINTENANCE MANUAL

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# Base Load Power Hub (BLPH)

## HV INSTALLATION OPERATING AND MAINTENANCE MANUAL

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## INTRODUCTION

It is important to always refer, in addition to this manual, also to the technical documentation issued by IMESA for the specific project supply (general arrangement drawings, single-line electrical diagrams, schematic diagrams, etc.).

**WARNING**



**IMESA disclaims all liability in the following cases:**

- ✓ **inadequate maintenance and non-compliance with the instructions contained in this manual;**
- ✓ **Interventions by inadequately trained and instructed personnel;**
- ✓ **failure to comply with the safety provisions**;

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# 1 CHECKS ON RECEIPT

The switchboard is split into shipping sub-sections, consisting of each vertical unit.

Each section is packaged by air ball protective sheets and additional protections at fragile parts (reinforced polystyrene covers at relay, instrument, lamps etc.)

The switchboard is shipped complete with removable parts (HV circuit breakers, HV contactors, voltage transformers) inserted in the respective cells. On the panels the earthing switches are in closed position, while the HV circuit breakers are in open and disconnected position.

Upon receipt, it is necessary to unpack and check compartments and accessories, as indicated in the technical documents provided before delivery of the switchboard.

If there are damages or faults detected on the switchboard or on the internal equipment, once the material is unpacked, immediately inform our logistic dept.

Claims regarding defects, shall include the serial number and the year of manufacturing, indicated on the nameplate of the switchboard.

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## 2 STORAGE

If the switchboard is to be temporarily stored, our workshop (upon request) will provide suitable packaging for the specified storage conditions.

Upon receipt, the panel shall be in any case unpacked and thoroughly subjected to visual inspection, as indicated at par. 1, and then repacked using the packaging material originally provided.

The switchboard must be stored in a dry, non-dusty and non-corrosive environment, as well as not subjected to extreme temperature fluctuations.

When the switchboard is not immediately installed at receipt, to store it in a well-ventilated environment, covering the same with a tarpaulin or with waterproof sheets (such as polyethylene). Anti-condensation heaters are to be and regularly used to avoid build-up of humidity.

It is also recommended to place at least one bag of desiccant salts in each compartment; to be replaced every six months.

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# 3 HANDLING THE SWITCHBOARD

Each unit is attached to a wooden platform. For handling, it is recommended to use an overhead travelling crane or a mobile crane. Alternatively, use rollers or forklift trucks. The weight and dimensions of the various sections are indicated in the shipping documents and on the general arrangement drawings.

**SAFETY PRECAUTIONS**



- **While handling the panels, it is recommended to pay extreme caution**
- **To handle the modules containing the removable equipment (HV circuit breakers, HV contactors, voltage transformers trucks), it is essential to use the appropriate lifting eyebolts or the flanges at the baseframe, in the case of lifting from the bottom, when it is advised in the General Arrangement drawings.**

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### 3.1 UNPACKING

- Remove the packing material
- Open the door of the units and loosen the screws that secure the module to the support platform
- Lift the module with the crane following the instructions below
- Insert the support shims
- With the crane, lower the unit onto the support shims

Only use a rocker arm lifting system of the type shown in the figure (fig. 1).

After unpacking the unit, lift it with the crane using the appropriate eyebolts (1) (fig. 1) and the ropes equipped with safety carabiners, following this procedure:

- Grip the lifting eyebolts by the handle (3);
- Insert the attachment hooks (5) into the slots (4) on the sides of the unit and marked with self-adhesive labels;
- Push the eyebolts against the unit and slide them upwards until the coupling hooks (5) strike the upper limit of the slot (4);
- Thoroughly tighten the positioning screw (6);
- Attach the lifting rope carabiners to the unit eyebolts and lift.

After installation, remove the eyebolts by operating in the reverse sequence.

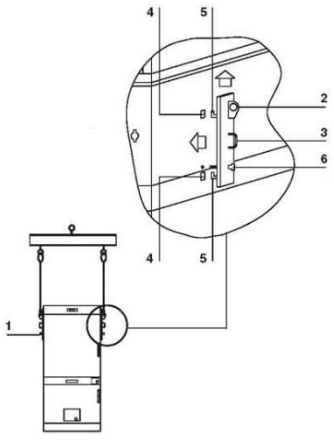



***fig. 1 – Handling the unit***

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### 3.2 HANDLING WITH ROLLERS

The floor on which the rollers slide must be levelled. Move the module avoiding shocks that could tip it over.

Lift the unit by means of an overhead travelling crane, a mobile crane or jacks (fig. 1). Remove the wooden platform by loosening the screws that secure it to the base of the switchboard. Place a sturdy sheet metal plate between the rollers and the base of the units and place the unit on the sliding rollers (fig. 2).

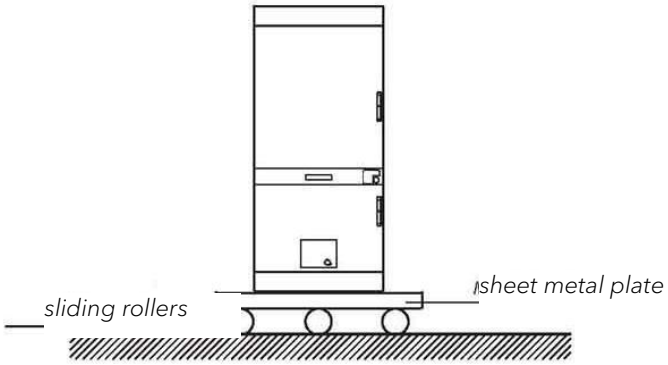



***fig. 2 – Handling with rollers***

### 3.3 HANDLING WITH PALLET TRUCKS OR FORKLIFT TRUCKS

The floor on which the pallet trucks or forklift trucks run must be levelled. Move the unit avoiding shocks that could tip it over.

To obtain greater stability, lift the unit only enough to allow it to be moved. Also check the flatness of the forks (fig. 3).



***fig. 3 – Handling with pallet trucks***

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# 4 DESCRIPTION

## 4.1 LAYOUT AND CHARACTERISTICS OF THE SINGLE PANEL UNITS

Normal operations at the switchboard are carried out from the front of the units with all the doors closed.

Only maintenance and the replacement of faulty parts do require opening of doors and panels.

The switchboards units provide accessibility to power connection compartment and busbars compartment from the rear side.

Each vertical panel is composed of the following segregated compartments:

- Instrument unit (A)
- Switch unit (B)
- Line unit (C)
- Distribution busbars unit (D)
- Voltage transformer unit (E)

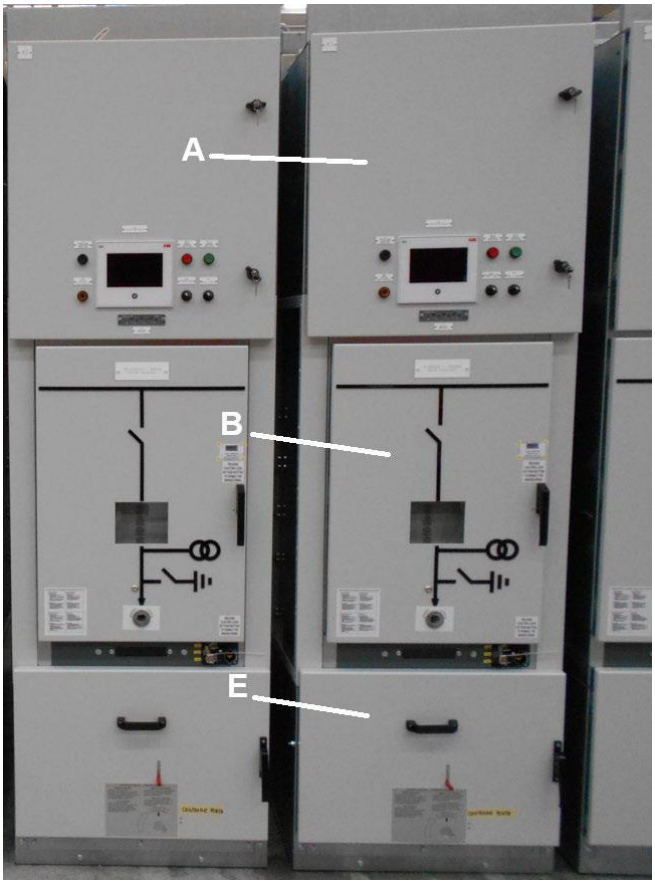



***fig. 5 – Front of the switchboard***

**A Switch compartment details**

**1** Voltage presence indicating device
**2** HV circuit breaker / HV contactor
**3** Shutters to segregate the switch unit from main poles terminations
**4** Lower and upper isolating blocks of the main poles
**5** Earthing switch
**6** Compartment door

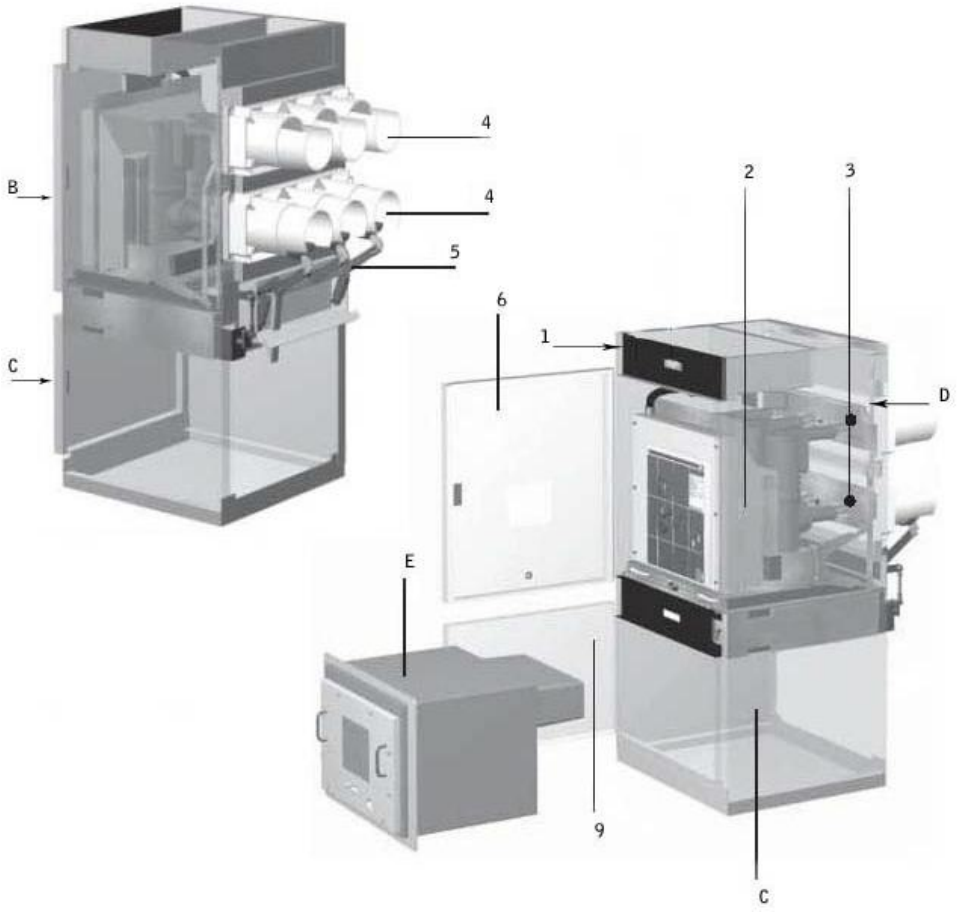



***fig. 6 – Typical section***

## 4.2 MAIN COMPARTMENTS AND APPLIANCES

### 4.2.1 Switching and interrupting devices

The SWBD units are equipped with the following switching and interrupting devices:

- HV vacuum circuit breakers
- HV vacuum contactors

The above appliances, are in withdrawable and removable execution, fitted on a specific truck that allows for the following operating conditions of the equipment, with regard to the position into the compartment:

**RACKED-IN:** main and auxiliary circuits connected

**RACKED-OUT:**

- partially disconnected, with main circuits disconnected and auxiliary circuits connected (connecting plug inserted)
- totally disconnected, with main and auxiliary circuits disconnected (connector plug racked out)

**REMOVED:** main and auxiliary circuits disconnected and appliance removed from the panel.

In the racked-in and racked-out condition, the appliances remain in the compartment while the door is closed. The appliances are visible through the inspection window of the door.

The main appliances are equipped with key locks, located at the front crossbar. Those key locks allow for the safety interlocks design for the specific application of the unit.

At the front door of the switch unit, it is provided the slot for racking-in/racking-out manoeuvres, by means of the dedicated crank (operations allowed with front door closed). A mechanical interlock prevents the breaker trolley from moving forward/backward in the compartment, in case the main breaker/contactor or the earthing switch is closed. Vice versa, in case the breaker trolley is in an intermediate position, between racked-out and racked-in status, the mechanical interlock prevents the switch from closing. Also a locking magnet is fitted on the trolley, which, if de-energised, prevents the trolley from manoeuvring (electrical interlock). The connecting plug, provided for the connection of the auxiliary circuits of the main switching device (breaker or contactor) comes out from the front protection of the appliance.

The upper part of the switch unit is fitted with the lever mechanisms for activation of the auxiliary contacts of the main appliance, for indication of its relevant position (racked-in/racked-out).

The slides for operating the HV poles segregating shutters are fixed to the sides of the appliances. Please, refer to the instruction manuals of that equipment for further details.

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### 4.2.2 Earthing switch

The earthing switch is located at the rear of the unit (fig. 7, item 1); while the manoeuvring mechanism and relevant key locks are located at the front side (fig. 8).

The safe position of the earthing switch is indicated by means of the graphic symbols at the operating position (fig. 8, item 2). The actual corresponding position of the earthing switch is indicated by the yellow arrow marked on the manoeuvring shaft (fig. 8, item 5). It is also allowed to check once more the actual position of the earthing knives by means of the relevant visual indicator (fig. 7, item 3), which is located inside the power cable connection compartment and visible through the inspection window provided at the front side (fig. 9, item 1).

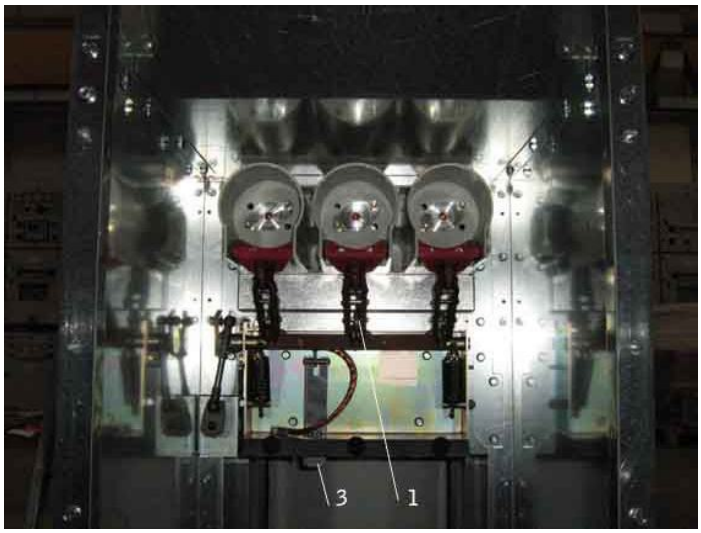



***fig.7 – Earthing switch (unit rear side)***




***fig.8 – Manoeuvring and key locking set of theearthing switch (unit front side)***

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### 4.2.3 Unit Compartments

#### *4.2.3.1 HV Circuit breaker / HV fused-Contactor compartment*

The metallic structure is equipped with a front door and has external manoeuvring and control devices on the front side (fig. 9). Racking-in / racking-out operations of the appliances must be carried out with doors closed only.

In the lower area of the front side it is located the earthing switch manoeuvring set, which includes (fig. 10):

- the slot for the manoeuvring lever of the earthing switch (item 10)
- the actuator (9) to lift the covering shutter (item 11) of the earthing switch maneuver slot
- key lock at open earthing switch (item 8)
- key lock at closed earthing switch (item 12)

In the upper part of the panels, voltage presence indicating lamps are provided at the door of the upper LV compartment.

The door is fitted with (fig. 9):

- closing-opening handle (item 5);
- inspection window to check the position of the main appliance (item 3);
- slot for the crank to rack-in/rack-out the main appliance, while the front door remains closed (item 2).

The following parts are instead housed into the compartment itself (fig. 11):

- guiding rails for the main appliance trolley (item 15)
- shutters for segregation of the main poles (item 18) and moving mechanisms of the shutters (item 16)
- socket for the main appliance aux. circuits' plug connector (item 22)
- mechanical block to prevent removal of the auxiliary circuits plug connector, when the main appliance is in closed position (item 23)
- mechanisms with limit-switches, indicating the main appliance's complete racked-in position (item 21)
- mechanisms with limit-switches, indicating the main appliance's complete racked-out position (item 24)
- mechanical block that prevents the main appliance from being racked-in, if the earthing switch is closed; as well as preventing the earthing switch from being closed, if the main appliance is racked-in (item 27)
- space heater location (item 25), in case requested
- location for the key lock to prevent racking-in of earthing trolley with upper loops (item 19), when requested
- location for the key lock to prevent racking-in of earthing trolley with lower loops (item 20), when requested
- Interlock to prevent insertion of main appliances of wrong size (item 22; included in the socket).

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At the back side of the compartment are provided the insulating blocks for the power connections to the main poles (fig. 12, item 14).

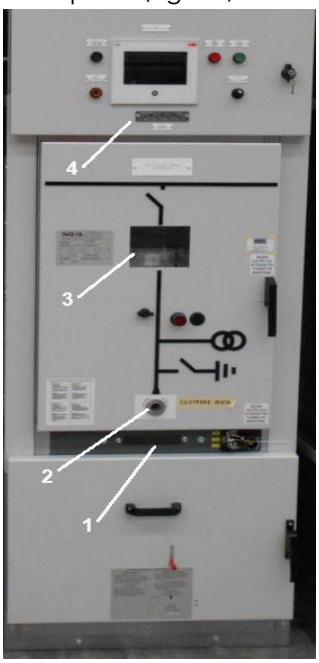



***fig. 9 – Front of the switchboard (detail)***




***fig. 10 – Manoeuvring and key locking set of the earthing switch (unit front side)***




***fig. 11 – Switch unit interior view (detail)***

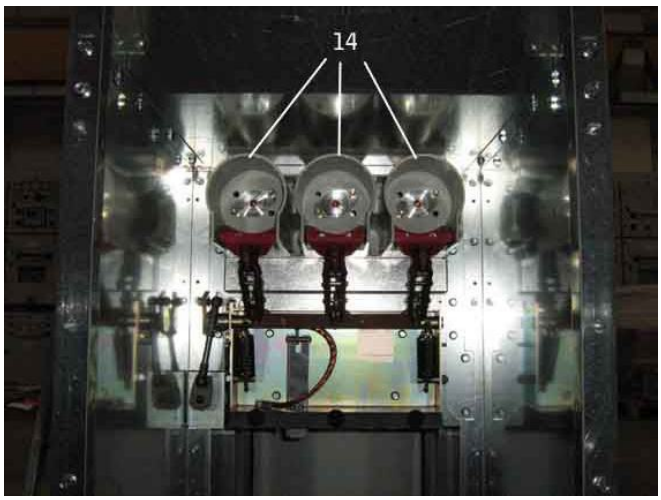



***fig. 12 – Switch unit rear view (main poles isolating blocks)***

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#### *4.2.3.2 Line compartment*

From the line compartment it is possible to reach the earthing switch auxiliary contacts.

#### *4.2.3.3 Power Cables connection compartment*

Before accessing to the terminations of the power cables, make sure that the earthing switch position indicator (fig. 7, item 3), visible through the inspection window (fig. 9, item 1), as well as the shaft indication, visible from the manoeuvring set of the earthing switch (fig. 8, item 5), is confirming successful closure.

#### *4.2.3.4 Voltage transformers compartment and withdrawable trolley*

The voltage transformers compartment (fig. 13) consists of a casing (fig. 15) containing a withdrawable trolley (fig. 16), where are installed the voltage measuring transformers (fig. 16, item 53) and the relevant protective fuses at the primary circuit (within the VT resin block itself).
The withdrawable trolley (fig. 16) is completely removable from the compartment, which allows for safe replacement of the primary circuit fuses. A dedicated metal damper (fig. 14, item 57) prevents direct contact to the medium voltage terminals, when the trolley is removed from the compartment.

The main features of the voltage measuring compartment are:

- voltage transformers are mounted on a trolley, that can be positioned in fully disconnected position, while remaining within the inside compartment space (complete operation with front door closed);
- voltage transformers with built-in fuses are being disconnected by means of the control handle, located at the front door of the compartment
- once disconnected the main circuit of the voltage transformers, the relevant auxiliary circuits are also disconnected, at the same time
- the metal shutter, segregating the compartment from the MV circuits of the switchboard, is automatically activated by the relevant movement of the transformers trolley
- the primary circuit fuses can be replaced once removed the VTs trolley from the compartment, after opening the front door and having already disconnected the transformer trolley
- the transformers can be replaced only when the trolley is removed from the compartment
- the electrical aux. contacts, signalling VTs racked-in and racked-out position, can be supplied on request.

The voltage transformers trolley can take the following positions, with relation to the compartment:

**RACKED-IN:** main and auxiliary circuits of the transformers are connected

**RACKED-OUT:** main and auxiliary circuits of the transformers are disconnected; the transformer trolley remains inside the compartment.

**REMOVED:** main and auxiliary circuits of the transformers are disconnected; the transformer trolley is removed from the compartment

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The resin insulated Voltage transformers, provided for measurement to the instrumentation and protections relays, have the performance and accuracy class required by the calculations carried out in the engineering phase. The auxiliary circuits of the transformers are connected by sliding contacts (58) (fig. 14).

The following components are fitted in the transformer compartment:

**Voltage transformer compartment:**

- Door (41) (fig. 13);
- manoeuvring sequence plate indication (42) (fig. 13);
- manoeuvring seat for insertion of the lever to rack-in/rack-out the transformer trolley (43) (fig. 13);
- trolley guides (55) (fig. 14);
- metal damper (57) for segregation of the sectioning contacts inside the monoblocks and activation mechanisms of the shutters (56) (fig. 14);
- sliding contacts of the transformer auxiliary circuits (58) (fig. 14);
- inserted transformer trolley signalling contacts (60) (fig. 14);
- disconnected transformer trolley signalling contacts (61) (fig. 14).

**Voltage transformer trolley:**

- Door closing latch actuator (45) (fig. 15); manoeuvre seat of the insertion/disconnection lever (46) (fig. 15);
- door closing latch release pin (47) (fig. 15);
- door locking screws (48) (fig. 15);
- voltage transformers (53) (fig. 16);
- additional right and left guides (52) (fig. 16).

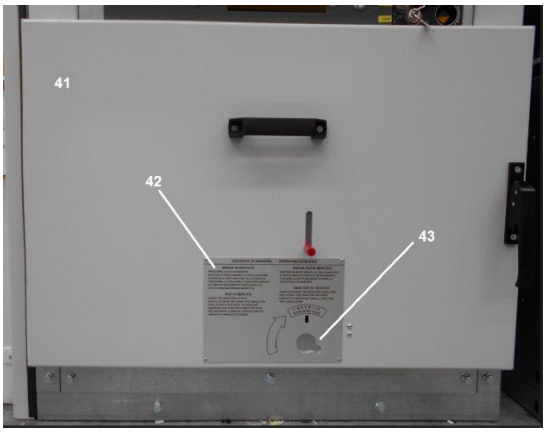



***fig.13 – Voltage transformer compartment (front door closed and withdrawing lever)***

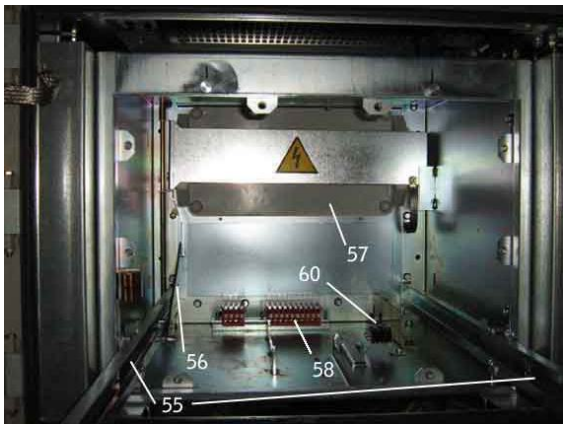



***fig. 14 – voltage transformers compartment (internal view)***

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***fig.15 – Voltage transformer compartment (front door open)***




***fig.16 – Voltage transformers on the withdrawable trolley***

*4.2.3.5 LV Compartment*

The LV compartment, positioned above the C.B. compartment, contains all the low voltage components (see fig. 17).
In particular, the LV compartment unit houses:

- the terminal block and the cables (inserted in specific ducts) for the connections between the compartments and for connection of the auxiliary cables
- the field control cables terminal blocks
- switch and compartment auxiliary accessories (measuring instruments, protection relays, control and signalling devices, fuses, low voltage switches, etc.)
- the auxiliary switch position contacts (on/off) (on request)

The unit is partitioned by a plate with the relative cable glands for accessing to the upper distribution duct.



***fig.17 – Low voltage compartment***

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*4.2.3.6 Distribution busbar unit*

The distribution busbars unit (see fig.18) houses the main busbars system, fitted on the through-terminals of the switch unit.

Segregation with respect to the line unit is ensured by removable sheet metal plates.



***fig.18 – Distribution busbar compartment***

## 4.3 DUCTS FOR GAS VENTING DUE TO OVERPRESSURE CAUSED BY INTERNAL ARCS

The electric arc that can spread inside a panel represents a danger for users who access, transit or stop near the switchboard.

The possibilities of developing an internal arc are extremely remote; however, if this happens, all configurations of the switchboard panels have been designed with appropriate technical solutions.

The hot gases and overpressure generated by the arc fault are conveyed towards the top, into the internal exhaust duct and finally released in the room, preventing direct impact and injuries to the operators.

## 4.4 INTERLOCKS

The manoeuvres must be carried out with the normal operating force (not exceeding 200 N) using only the appropriate levers. If the manoeuvres are prevented, do not force the mechanical interlocks and check the correctness of the manoeuvres themselves.
The blocks can be operated with a maximum force of 400 N, using the appropriate manoeuvring tools.

The locks used in the switchboard units are mechanical and electrical, with microswitches that give continuity or interrupt the circuits. The mechanical locks are divided into:

- force locks
- impediment locks
- electromechanical locks
- safety locks (padlocks/keys)

The locks provided are those indicated in the following table:

| Description of the blocks | Appliances (1) | Appliances compartment |
|---|---|---|
| Electrical lock that prevents the devices from closing when the trolley is not in the inserted and disconnected positions. | Yes | |
| Mechanical lock that, in the closed position, prevents insertion and extraction of the devices. | Yes | |
| Mechanical lock that prevents the devices from closing when the trolley is not in the inserted and disconnected positions. | Yes | |
| A block that prevents the insertion of an appliance into a compartment designed for an appliance of a different type or size. The lock is located in the connector. | Yes<br>(fig. 19 - det. 4) | Yes<br>(fig. 19 - det. 4) |
| Locking electromagnet on the trolley of the appliances which, in the absence of voltage, prevents insertion or extraction. | Yes<br>(fig. 27a - det. 43) | |
| Electromechanical lock that prevents the door from opening if the appliances are not in the disconnected position. | | On request<br>(fig. 21 - det. 8) |
| Mechanical lock that prevents insertion of the appliances if the door is open. | On request | On request<br>(fig. 27 - det. 17) |
| Mechanical interlock with earthing switch: when the earthing switch is closed, the appliances cannot be inserted;<br>with devices inserted or in the intermediate positions between inserted and disconnected, it is not possible to close the earthing switch. | Yes<br>(fig. 26 - det. 14)<br><br>Yes<br>(fig. 26 - det. 60)<br>(fig. 27a – det. 12) | Yes<br><br>Yes |
| Mechanical lock that prevents manual opening of the dampers if the appliances are removed. (Fail-Safe). | On request<br>(fig. 20n - det. 3) | On request<br>(fig. 26 - det. 3) |
| Key lock with earthing switch open. It can only be operated with the earthing switch open. The key can only be pulled out when the block is active. | | On request<br>(fig. 22 - det. 33) |
| Key lock with earthing switch closed. It can only be operated when the appliances are disconnected and the earthing switch is closed. The key can only be pulled out when the block is active. | | On request (fig. 22 - det. 34) |
| Lock that blocks the dampers in the closed position. | | On request (fig. 23 - det. 52) |

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| | | |
|---|---|---|
| Mechanical lock that prevents extraction of the connector of the auxiliary circuits when the devices are inserted and during insertion and extraction. | | Yes (fig. 19 - det. 5) |
| Electromechanical lock for earthing switch, which, with the coil de-energised, prevents opening and closing of the earthing switch. | | On request (fig. 24 - det. 53) |
| Door lock with earthing switch open. | | |




***fig. 19 – Internal view***




***fig. 20 – Internal view***

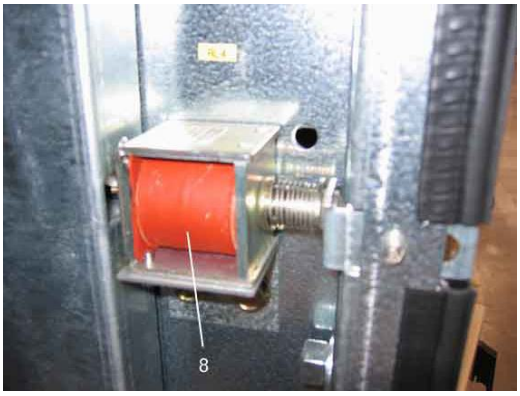



***fig. 21 – Internal view***




***fig. 22 – Internal view***

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***fig. 23 – Internal view***

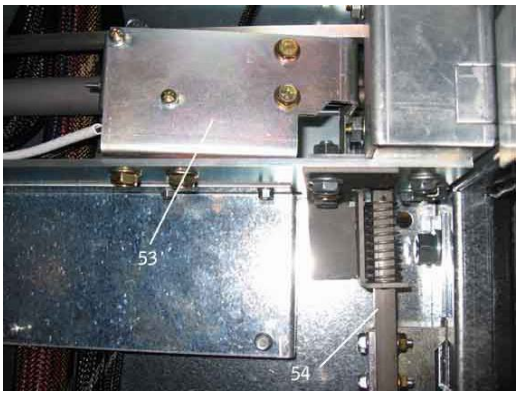



***fig. 24 – Internal view***



***fig. 25 – Internal view***




***fig. 26 – Internal view***




***fig. 27 – Internal view***

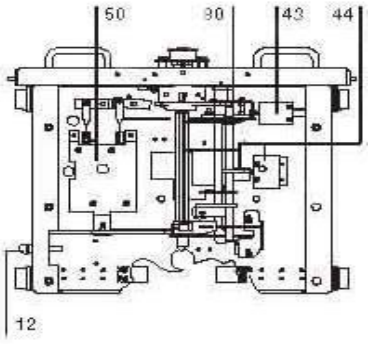



***fig. 27a – Internal view***

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## 4.5 REFERENCE STANDARDS

- IEC 62271-1 for HV general appliances
- IEC 62271-200 for HV switchboards
- IEC 62271-102 for earthing switches
- IEC 60071-2 for insulation coordination
- IEC 62271-100 for HV circuit breakers
- IEC 62271-106 for HV contactors
- IEC 60271-103 for HV switches and switch-disconnectors
- IEC EN 60529 protection degrees classification of casings

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# 5 INSTALLATION

Correct installation is paramount. The manufacturer's instructions must be carefully studied and followed as well as: the G.A. drawings (including overviews, front and sectional views, layout of the holes on the slab and the fixing points of the panel), and electrical diagrams.

## 5.1 INSTALLATION CONDITIONS

The panels are intended to be used under operating conditions of temperature and humidity considered normal in accordance with the provisions of sect.2.1 of IEC 62271-200.

## 5.2 PLACE INSTALLATION

When positioning the switchboard, leave a minimum clearance on the front (at least 1500 mm) and on the back and on the sides (at least 800 mm). Please, refer to the General Arrangement Drawings, for better details.

The space on the front of the panel must be sufficient to allow opening of the doors, removal and insertion of the circuit breakers and their transfer to other compartments or away from the room.

**SAFETY PRECAUTIONS**



The safety provisions provided for in the Emergency and Evacuation Plan must be respected to allow free passage to the emergency exits.

## 5.3 FOUNDATIONS AND FIXING PLAN

The floor or foundation must be strong enough to withstand the weight of the module without bending.

The foundation must be well prepared before installation, in accordance with the instructions of the project documents. Considering that permissible tolerances and corrections are minimal, the panel must be installed on a perfectly smooth and horizontal surface.

**PRECAUTIONS**



- **clean the area provided for the installation of the fixing surface**
- **visibly trace on the slab the perimeter of all the compartments constituting the panel, taking into account the minimum distances from the walls and from any obstacles present in the room**

For welding of the switchboard's baseframe to the deck, please refer to Annex 1.

- position and align the base frame on the floor

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- secure the base frame to the floor by means of welding beads with a length of 8-10 cm, which must be carried out with a step of approximately 20-25 cm along the entire perimeter of the frame, respecting the sequence shown in the annexed drawing (ann.1)

## 5.4 INSTALLING THE COMPARTMENTS

To ensure that the panel has been installed correctly, check that:

- the compartments are firmly fixed to the baseframe and correctly aligned
- the front of the panel is perfectly vertical
- the sections (and/or compartments) of the panel have been coupled and all the ground busbars and auxiliary connections have been completed
- the ground busbar of the panel has been connected to the earthing system.
- the power connections with the utilities and the auxiliary connections of the control circuits have been made.

The compartments must be fixed to the floor starting from the centre of the switchboard and gradually adding the side compartments.

The table below indicates the tightening torques to be applied to the nuts and screws to fix and connect the compartments and the distribution busbar.

| Screw Type | Tightening Torque (Nm) | | |
|---|---|---|---|
| | Minimum | Nominal | Maximum |
| M 5 | 4.5 | **5** | 5.5 |
| M 6 | 8 | **9** | 10 |
| M 8 | 19 | **22** | 25 |
| M 10 | 40 | **45** | 50 |
| M 12 | 68 | **75** | 83 |
| M 14 | 100 | **115** | 130 |
| M 16 | 160 | **185** | 200 |

In the case of hardware other than that mentioned above, apply a tightening torque corresponding to the strength class of the fixing device in question.

### 5.4.1 Positioning the compartments

- Lift the compartment units and deposit them on the baseframe
- Secure the central compartment to the baseframe

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- Make sure that the side compartments are positioned correctly, joining them to the central compartment and securing them to the baseframe.

### 5.4.2 Joining the compartments

Secure the outer sheet metal plates at the appropriate points by means of nuts and screws (to determine the exact position of the fixing points, refer to the position of the screws of the joint compartments from our workshop).

### 5.4.3 Connecting the main distribution busbars

The distribution busbars are connected between the compartments by means of standardised elements; all the necessary components are contained in the supplied hardware bag.

It may be necessary to remove the unit segregation plates to reach the connection points.

Before assembling the main distribution busbars, thoroughly clean the contact area with a clean cloth soaked in alcohol or in a suitable solvent. Rub with neutral grease.

The tightening torque of the nuts and screws is indicated in the table in paragraph.5.4.

IMPORTANT! If the surfaces are made of silver, it may stain under certain environmental conditions, without however damaging the resistance of the contacts. Never use any type of file (as it may damage the silver coating of the bar couplings). If it is necessary to use similar tools, remember to restore the silver coating of the bars.

### 5.4.4 Connecting the earthing busbar

Usually, all the compartments of the panel are equipped with a 250 $mm^2$ bare ground busbar.

The ground busbar must be connected to the coupling joints of the panel compartment units, after having removed any traces of oxidation from the contact area of the distribution busbars with an emery cloth.

Secure the ground busbar using the screws, the flat washers, the spring washers and the corresponding nuts.

### 5.4.5 Connecting the auxiliary circuits

After fixing and coupling the electrical cabinet compartments, couple the auxiliary connections.

The wires of the auxiliary connections, equipped with terminals and detached from the terminal board of the compartment to which they must be connected, are curled up and positioned near the compartment.

To ensure correct identification of the terminals to which they are connected, the wires are provided with a tagged ring.

To be followed interpanel wring diagrams.

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## 5.5 INSTALLING THE COMPARTMENTS

### 5.5.1 External connection – earthing

The ground busbar extends longitudinally in the lower section at the back of the panel.

The holes at its ends are provided for connection to the system earthing system.

Screws and bolts must be tightened at the specified torque to prevent loosening due to vibrations during operation.

The connection to the earthing network of the system must be carried out at the two ends of the switchboard.

This connection must be as short as possible and must not be inserted into metal pipes.

### 5.5.2 External connections – power circuits

The output terminations of the line unit are arranged for connection by means of lugs.

Pay particular attention to the correct position and direction of the cycle of the phases and to all the connections to ensure parallelism of the two systems, as well as the correct direction of rotation of the motors supplied, in order to ensure the regular insertion of the measuring and protection instruments.

If the terminations are installed inside the panel, take appropriate precautions to avoid sudden changes in direction, angles and sharp edges that could damage or destroy the insulation.

Pay particular attention also to the bending radius of the cable.

Provide adequate mechanical and electrical distances between the cables, the live busbars and the sheet metal plate. The input cables of the different units must be fixed in such a way as to prevent tugging or stress on the terminals.

The cable supports must be arranged and fixed on the structure of the panel in order to resist the electrodynamic stresses due to the short circuits.

The connection of each cable must be fixed separately, to facilitate maintenance or replacement.

### 5.5.3 External connections – auxiliary circuits

To connect the auxiliary circuits, refer to the diagram of each compartment.

Each compartment is arranged, through a suitable output terminal board, to receive connection wires coming from the outside.

These terminal blocks are equipped with cage-clamps terminals, suitable for connecting wires even without lugs.

The panels are provided with upper cable entry, with conduit for the auxiliary cables.

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## 5.6 PROTECTION FROM POLLUTANTS

If the panel is installed in a polluted environment, silicone spray grease must be applied to the live parts.

During the installation phase, this operation can only be necessary if the grease applied in the factory has been removed during the operations.

The grease application points are indicated in the maintenance chapter

## 5.7 PAINTING

Any damage to the external painting of the panel, scratches or peeling caused during installation operations, can be repaired as indicated in the chapter on maintenance.

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# 6 COMMISSIONIG

## 6.1 GENERAL RECOMMEDATIONS



Operations related to the commissioning of IMESA panels must be carried out by qualified personnel who have a detailed knowledge of the equipment and of the system.

- If the manoeuvres are prevented, do not force the mechanical interlocks; check the correct sequence of the manoeuvres being carried out.
- Before opening the front door of each compartment, always check the correct position of the earthing switch (closed) through the external mechanical signalling and the position of the blades through the inspection window.
- Only power the panel with the appliances open and the doors closed.
- Before commissioning the panel, carry out the following checks; at the end of the operations, check that everything is restored to its original condition.
- In case of negative verification, do not put the panel into service and if necessary, contact IMESA.

Before commissioning the panel, carry out the checks shown in the following table.

| Object of the check | Operation and Controls | Notes |
|---|---|---|
| Compartments | Visually inspect the inside and outside, ensuring there is no obvious damage: remove any foreign bodies (such as tools or test connections that may have been forgotten during installation).<br>Carefully clean the insulating parts, removing any traces of moisture.<br>Remove dust or dirt from air intake grilles and vent ducts | |
| Main circit connections | Check that bolted connections of the HV and earthing circuits (at busbars, CBs poles, CTs, VTs, etc. ) are suitably tighten. No disalignment is expected at the marks provided over the bolt, during torque wrench tightening at the factory. In case found, to torque wrench again the connection (see par. 5.4).<br>Torque wrench all the bolted joints of the shipping sections, which have been coupled at site, according to the values indicated at par. 5.4.<br>After tightening, each bolt is to be marked to indicated its relative position against the fixed part (as already done for the torque wrench tightening provided at the factory). | |

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| Object of the check | Operation and Controls | Notes |
|---|---|---|
| Grounding bars and relevant branch connections | Check that bolted connections of the earthing circuits are suitably tighten.<br>In case found loose connections, to torque wrench it again (see par. 5.4). | Check the efficiency of the earthing according to the accident-prevention regulations. |
| Insulation | Measure the insulation resistance of the power circuits (phase to ground) by 2500 V or 5000 V d.c. and the insulation resistance of the auxiliary circuits by 500 V d.c. by means of Megger testing device.<br>The measured value must be >1000 MΩ for power circuits and >2 MΩ for auxiliary circuits. | The insulation resistance value may be affected by environmental conditions.<br>The panel must not be put into service if the insulation resistance is very low, for example less than 50 MΩ.<br>If the low value of the insulation resistance is attributable to the humidity of the environment, use temporary heaters to resolve the problem. |
| Switches and contactors | Perform on each appliance the operations prescribed by the relevant instructions before commissioning.<br>Check the presence of the manoeuvring devices and accessories provided for normal operation.<br>Insert the appliances into the relevant units and connect the plugs of the auxiliary circuits.<br>Close the doors of the units and bring the appliances to the "inserted" position. | The spare keys of each safety lock must be stored in a place not accessible to the operating personnel.<br>The operations are indicated in the instructions of each switch |
| Auxiliary circuits | According to the functional diagram of the panel, check the functionality and the service sequence of the automation and of all the auxiliary relays. | Before performing this check, verify the calibrations of all the relays installed in the panel. |

In the case of particular system configurations, it is possible that the tests shown in the table must be integrated with others to be established by the system technical manager.

Check that the secondary winding of the current transformers is grounded and connected with the relative amperometric circuit of protection and/or measurement, then eliminate (if envisaged) any short-circuit connections.

If the secondary winding of the voltage transformers must be connected with equipment external to the panel, the following conditions must be verified, to avoid overloads or short circuits of the voltage transformers themselves:

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- Check that the total self-consumption of the powered equipment does not exceed the performance of the voltage transformer.
- Check that there are no incorrect connections in the measuring circuit (possibly even temporary) and in any case not in accordance with the functional diagram of the panel and if other system units (power supply panel, sub-panels, control or manoeuvring benches, etc.).
- Check that only one of the secondary windings of the voltage transformers is earthed. This verification is particularly important on the power supply side of the devices that can be connected to each.

other by means of a connector. The system configuration described above is in fact used in cases where it is necessary to place in parallel several power supply circuits.
At the end of the preliminary tests, perform the following operations:

- Open and disconnect all the trolleys (switches and contactors).
- Remove any test connections.

It is advisable to manually load all the closing springs of the switches before powering the auxiliary circuits to avoid excessive current absorption as a result of the simultaneous starting of the gearmotors.

Also, remember to:

- Close all the doors of the switch and measuring cells.
- Check the presence of the internal metal segregations (when provided) and the external closing panels.
- Verify that the various mechanical and electrical interlocks (possibly switched off to carry out the commissioning tests with the panel not live) have been restored.
- Power the auxiliary circuits and the power circuit.
- Close (compatible with the needs of the system) the switches and contactors, making sure that each relative function takes place regularly.
- Check the correct operation of the measuring instruments.

**Instructions for operation of the devices and sequence of operations on the units**

Do not remove the cover panels of the switch. If necessary, during the opening and closing operations of the appliance, maintain an adequate safety distance to avoid contact with moving parts. The manoeuvres must be carried out with the normal operating force (not exceeding 200 N) using only the appropriate levers (see below). If they are prevented, check the correct manoeuvring sequence.

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Manoeuvring accessories and devices:




***fig.28 – Manoeuvring accessories***

**Legend**

1. Ground disconnectors manoeuvre lever
2. Switch spring load lever
3. Switch insertion/extraction lever
4. Voltage transformer trolley insertion/extraction lever
5. Additional guides for insertion/extraction of the voltage transformer trolley
6. Manoeuvring lever protrusion

If manoeuvres are carried out with the appliance removed from the panel, pay the utmost attention to the moving parts. The appliance must only be inserted into the unit in the open position. Insertion and extraction must be gradual to avoid impacts that can deform the mechanical interlocks.

## 6.2 RACKING-IN THE SWITCHES (HV CBS, CONTACTORS)

### 6.2.1 Switching from the removed position to the "disconnected" position of the switch:

- lift the device and place on the handling trolley (1)
- open the door of the switch compartment
- align the trolley with the panel (fig. 29)
- insert the coupling bracket (4) and lock the wheels (fig. 30)
- detach the switch from the trolley by simultaneously moving the two handles (5) (fig. 31) towards the median axis of the switch and at the same time progressively push the handles of the switch towards the bottom of the module, until the switch locks with the handles (5) (fig. 32) that click sideways, sliding into the slots (6) (fig. 30)
- release the wheels of the trolley, lift the coupling bracket (4) (fig. 30) and move the trolley away from the panel.

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Make sure the handles are clicked sideways (horizontal trolley locks inserted in the casing)

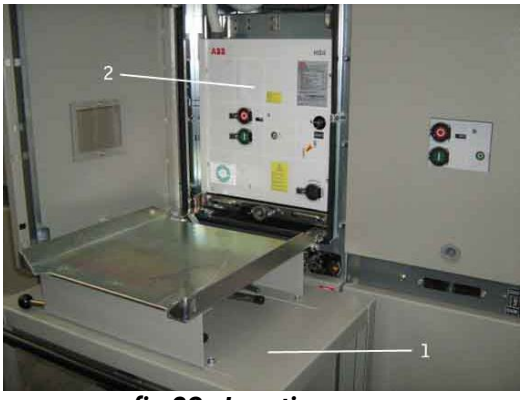



***fig.29 – Insertion***




***fig.30 – Insertion***




***fig.31 – Insertion***




***fig.32 – Insertion***

6.2.2 Switching from the "disconnected" position to the "test" position (connection of the auxiliary circuits).

- Insert and attach the mobile connector (fig. 33) into the fixed socket of the casing (fig. 34).

Make sure that the lever (3) is fully pressed against the connector (1) (fig. 34)



***fig.33 – Connecting the auxiliary circuits***

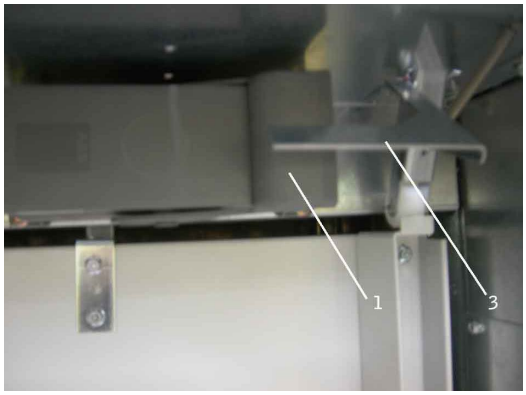
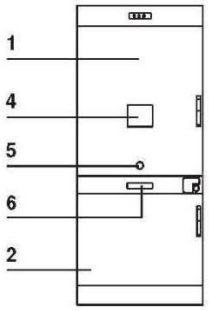



***fig.34 – Connecting the auxiliary circuits***

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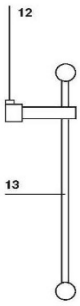
6.2.3 Switching from the "test" position to the "inserted" position (with the earthing switch closed) (fig. 35).

- Close the door of the switch compartment (1) by pushing the handle down
- close the line compartment door (2) by pushing the handle down ensure that:
  - the earthing switch locking magnet (where provided) is energized.
  - the key lock (8) is trapped into the lock.
- insert the manoeuvre lever (13) in the seat of the earthing switch, making the projection (12) line up with one of the two slots (11)
- open the earthing switch by turning the manoeuvre lever (13) anticlockwise
- remove the manoeuvre lever (13) from the earthing switch seat
- check on the manoeuvre shaft (11) and through the inspection window (6), that the earthing switch is open (indicator in position "O").
- close the cover of the earthing switch manoeuvre seat, turning the actuator (10) clockwise; this operation releases the switch and activates a lock that prevents insertion of the manoeuvre lever in the earthing switch
- check that the locking magnet is powered on the switch trolley and check that the key lock that prevents insertion (where provided) is trapped into the lock.
- insert the trolley/switch insertion lever (3) (fig.28) fully into the corresponding coupling (5 – fig.35b) and turn it clockwise until the switch is fully inserted.
- check through the inspection window (4) that the switch is in inserted position.










***35a*** ***35b*** ***35c***

***fig.35 – Handling for the earthing switch.***

## 6.3 RACKING-OUT THE SWITCHES (HV CBS, CONTACTORS)

### 6.3.1 **Switch from the "inserted" position to the "disconnected under test" position (with the switch open)**

- check through the inspection window (6 – fig.35a) that the earthing switch is open (indicator in position "O" at (11 – fig. 35a)
- insert the trolley/switch insertion/extraction lever (3) (fig. 28) fully into the corresponding coupling (5-fig. 35) and turn it anticlockwise until the switch stops.
- open the cover of the earthing switch manoeuvre seat by turning the actuator anti-clockwise (10-fig.35).
- Insert the manoeuvre lever (13 -fig.35c) in the seat of the earthing switch, making the projection (12) line up with one of the two slots (11 – fig.35b).
- close the earthing switch by turning the manoeuvre lever clockwise
- remove the manoeuvre lever (13) from the earthing switch seat
- check on the manoeuvre seat (fig. 10) and through the inspection window (6 - fig.35a) (for units without forced ventilation) that the position indicator of the earthing switch is in position "I", indicating closure of the same
- open the door of the switch compartment (1) by lifting the handle upwards.

### 6.3.2 **Switching from the "disconnected under test" position to the "disconnected" position (disconnection of the auxiliary circuits).**

- release the mobile connector and remove it from the fixed socket of the casing (fig. 33, 34).

### 6.3.3 **Switching from the "disconnected " position to the "racked-out" position.**

- bring the trolley closer to the panel (fig. 29)
- insert the coupling bracket (4) (fig. 30) and lock the wheels
- simultaneously move the two handles (5) (fig. 31) towards the median axis of the switch and at the same time progressively pull the handles of the switch outwards on the trolley
- release the handles and continue the extraction until the switch locks with the handles that click sideways, locking the switch on the trolley
- release the wheels and lift the coupling bracket (4) (fig. 30)
- lift the coupling bracket (4) (fig. 30) and move the trolley away from the panel.

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## 6.4 VOLTAGE TRANSFORMER COMPARTMENT

### 6.4.1 Inserting the trolley into the compartment.

- open the door of the unit by lifting the handle upwards
- insert the additional left and right guides into the side slots (52) fig. 40
- lift the front of the voltage transformer trolley and insert the front wheels into the additional guides (fig. 36)
- push the trolley towards the bottom, lift the rear and insert the rear wheels into the slots of the additional guides
- push the trolley towards the bottom until it locks (fig. 37)
- remove the additional left and right guides
- attach the door (fig. 38) and insert the earthing connection of the door
- tighten the door retaining screws (fig. 39)
- move the pin to the left, releasing the engagement hole of the manoeuvre lever
- turn the door closing latch lever (45) clockwise (fig.39)
- close the compartment door by pushing the handle downwards.
- Insert the manoeuvre lever (fig. 41) into the seat making the lever's projection line up with the slot
- rotate the lever clockwise and push hard towards until it is fully engaged
- from the inserted position, turn the lever anticlockwise, until the indexes line up and the manoeuvre lever remains engaged (fig. 42)
- check that, by pulling the door handle upwards, the door does not open.

### 6.4.2 Trolley racking-out manoeuvre

- Turn the lever clockwise (fig. 42) and pull hard the trolley backward until it clicks into racked-out position
- remove the manoeuvre lever from the seat, aligning the projection of the lever with the slot
- open the door by pushing the handle upwards. In this condition, the voltage transformer trolley is disconnected and grounded and the auxiliary circuits of the disconnected transformers are connected.
- open the door of the unit by lifting the handle upwards
- move the pin to the right to be able to release the closing latch of the front door of the voltage transformer trolley (fig. 48)
- turn the door lock latch actuator anti-clockwise (fig. 38)
- loosen the door retaining screws (fig. 39)
- remove the door
- insert the additional left and right guides in the slots (52) (fig. 40)
- pull the trolley outwards until it locks
- lift the rear of the trolley and remove the rear wheels from the additional guides (fig. 36)
- lift the front of the voltage transformer trolley and remove the front wheels from the additional guides (fig. 35)

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- remove the additional left and right guides (52) (fig. 40)
- close the compartment door by pushing the handle downwards.



***Fig.36 – Insertion/Extraction of the voltage transformers (1)***



***fig.37 – Insertion/Extraction of the voltage transformers (3)***



***fig.38 – Insertion/Extraction of the voltage transformers***




***fig.39 – Voltage transformer compartment***




***fig.40 – Voltage transformers (2)***



***fig-41 - Commissioning/decommissioning***

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***fig-42 - Commissioning/decommissioning***

## 6.5 DISABLING THE DOOR LOCK OF THE APPLIANCE UNIT

Operation only to be carried out in the event of an emergency by personnel who have an adequate knowledge of the equipment and the system.

When the door lock of the appliance compartment is present and it is necessary to unlock the door of the panel, by overtaking the safety locks, loosen the screw (1), push the lever (2) and open the door by shifting the handle upwards (fig. 50).




***fig.50 – Front door***

## 6.6 EARTHING SWITCH

Check that the key safety lock on the earthing switch is released and the electromechanical lock of the earthing switch (where present) is energized. The earthing switch can only be operated with the HV CB or Contactor in the racked-out position. Once started, the manoeuvres must be completed.

### 6.6.1 Earthing switch closing

- Check that the CB or Contactor is in the racked-out position
- open the cover of the earthing switch manoeuvre seat by turning the actuator (10 – fig.43) anticlockwise; the earthing switch manoeuvre seat is released
- insert the manoeuvre lever (13 – fig.43) in the seat of the earthing switch by matching the projection (12) with one of the two slots (11- fig.43)
- close the earthing switch by turning the manoeuvre lever (13) clockwise
- remove the manoeuvre lever
- check on the manoeuvre seat (11 – fig.43) (indicator in the "earthing" position) and, through the inspection window (fig. 9-1), that the earthing switch is closed.

### 6.6.2 Earthing switch opening

Insert the manoeuvre lever (13) (fig. 43) in the seat of the earthing switch making the projection (12) line up with one of the two slots (11);

- open the earthing switch by turning the manoeuvre lever (13) anticlockwise
- remove the manoeuvre lever (13) from the earthing switch seat
- check on the manoeuvre seat (11 – fig.43) (indicator in position "O") and, through the inspection window (fig. 9-1), that the earthing switch is open
- close the cover of the earthing switch manoeuvre seat, turning the actuator (10 – fig.43) clockwise; this operation releases the switch and activates a lock that prevents insertion of the manoeuvre lever in the earthing switch.




***fig.43 – Handling for the earthing switch***

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## 6.7 REPLACEMENT OF VOLATAGE TRANSFORMER FUSES

All the operations described below must be carried out by personnel who have sufficient qualification and detailed knowledge of the equipment. Check that the rated current of the fuses to be installed corresponds to the value indicated on the fuse holder plate.

**Procedure**

- remove the VTs trolley from the compartment, by following instructions at par. 6.4.2
- turn the fuse contact ring nut clockwise (fig.44) and remove it
- remove the fuse and replace it
- insert the ring nut and rotate it anticlockwise
- racking-in the VTs trolley, by following instructions at par. 6.4.1



***fig-44 - Commissioning/decommissioning***

# 7 MAINTENANCE

**Safety precautions**



**Before carrying out any maintenance on the panel or on the installed equipment, it is necessary to:**

- ✓ **remove voltage**
- ✓ **earth the main circuits**

Use equipment and apparatus that complies with the current safety regulations

⇒ The personnel performing maintenance must be adequately trained and instructed

Use voltage detectors

Use barriers and hazard warning signs

## 7.1 GENERAL INFORMATION

Electrical equipment is sensitive to environmental conditions and can be easily damaged by abnormal operating conditions.

Water, dust, heat, low temperatures, humidity, corrosive atmosphere, chemical residues, fumes, vibrations and other conditions can affect the performance and durability of electrical equipment.

Such conditions, if neglected, will result in premature system faults.

Repair costs can be avoided by observing the manufacturer's recommendations for application and maintenance. The most important rules to follow are:

- keep clean
- keep dry
- tighten bolts and connections
- prevent excessive friction of the mechanical parts.

Paragraph 7.2 provides instructions for the maintenance of the various parts of the panel, excluding the devices for which reference is made to the relative instruction manuals.

## 7.2 MAINTENACE ACTIVITY

**Metallic structure**

Metallic structure means the set of components of the load-bearing construction, complete with removable panels, vertical and horizontal segregation metal sheets, hinges, doors and locks. These parts are generally painted, with the exception of certain parts that can be galvanised or chrome-plated with an electrolytic process.

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**Painted parts**

Typically, the frame is finished with an epoxy-based paint coating, at least 60 microns thick.

**Retouching**

Obtain the material necessary for any retouching that may be necessary after installation, following the instructions of the paint manufacturer.

If they are not available, proceed as follows:

- clean the part to be retouched with damp abrasive paper and smooth the edges of the damaged area
- prepare the quantity of paint needed for the repair, adding 30% by weight of catalyst to the paint
- perform a test retouch on a piece of sheet metal. Any scratches of the brush can be reduced by making the paint more fluid with the addition of solvent. The product prepared by this method can be stored in a normal refrigerator for approximately 24 hours, after which it will solidify.

**Cleaning**

Clean the painted parts with a solution of soap and water or, in the most difficult cases, with a common thinner for paints. In this case, it is in any case advisable to carry out a test on a surface that is not visible and check that the thinner does not remove the paint layer.

**Galvanised components**

Clean the galvanised and passivated parts (iridescent yellow) with a dry cloth.

Any oil or grease can be removed with an alcohol damp cloth. To restore shine to the surface, repeat the previous operation.

All parts are protected with a minimum zinc thickness of 12 microns, however, in the presence of reagents such as sea moisture, the metal could rust on corners, holes and edges, where the coating is thinner. If this happens, remove the rust with abrasive paper or a metal brush, rub the residues of oil or grease, clean thoroughly and apply a galvanising product to the area.

**Hinges**

They are lubricated at our workshops during assembly. If necessary, lubricate them again.

**Locks**

The type of lock used depends on the degree and type of protection required. The locks are of the knob type, with or without a key.

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The moving parts do not require lubrication.

**Mechanical drives**

Mechanical drives are all the mechanical components of a compartment suitable for carrying out manoeuvres, locks and to act as safety devices. Force locks, stop locks and safety locks are considered mechanical drives. These devices are normally galvanised with an electrolytic process.

The moving parts are lubricated and tested during assembly of the panel.

**PRECAUTION**

- Mechanical locks should not be ignored, but correctly used in order to avoid creating dangerous situations.
- Knowledge of the blocking process is essential, before using any mechanical block, so that all situations can be verified.
- When operation is prevented, before forcing the mechanical lock, test the mechanical operation sequence.

The mechanical interlocks must be placed in the final locked or unlocked positions without stopping in the intermediate positions. To achieve this, check the distances and adjustments by precisely following the instructions.

The mechanical interlocks must be tested several times to ensure that their movement is free, also checking the pressure necessary to carry out the operations.

Check the correspondence of the position of the mechanical interlock with the position of the controlled component and with the blocked equipment.

If excessive effort is observed in the device's operation, it means that the device is prevented in its movement by the presence of dust or by a modification of the adjustment of the mechanism itself.

To test the device, proceed as follows:

- remove the moving part, clean it and, if necessary, lubricate all parts subjected to movement or friction
- test the efficiency of the operating device and, if necessary, clean and lubricate the parts subjected to movement or friction
- test the efficiency of all the devices that compose the drive: pins, levers, pins, screws, nuts and washers, etc., and if necessary clean and lubricate
- adjust the device, checking the force required for movement.

If during these tests an altered component has been noticed and it is not possible to change it, report the observation on the maintenance sheet and in the service book, indicate the anomaly with a sign on the compartment and inform the operating personnel.

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**Blocks**

For the force, stop and safety locks of the switch trolleys, contactor trolleys, special trolleys and containers see the related installation, operation and maintenance instructions.

**Force blocks**

They are all those devices whose action is based on the actuating force and which may be damaged by the application of a force exceeding normal resistance.

These devices are mechanical locks and control manoeuvres.

**Stop blocks**

These are all devices whose action is based on interference that prevents the manoeuvre device from entering the control part seat and therefore from being controlled.

**Safety blocks**

They are all those devices that prevent access to a unit or compartment if a certain operation has not been performed before that allows the operator to reach the affected area without danger.

The application of excessive force will result in breakage of the stop device. These blocks are, for example, the door locking devices that prevent opening of the door of the line cell if the earthing switch is not closed.

## 7.3 MAINTANANCE SCHEDULE

The maintenance activity can be divided into two parts: **preventive** and **extraordinary** maintenance.

**PREVENTIVE MAINTENANCE**: activity aimed at preventing faults/disruptions, limiting degradation and maintaining optimal operating conditions of the switchboard.

**EXTRAORDINARY MAINTENANCE**: activity carried out following a fault or for an intervention not included in the preventive maintenance.

### 7.3.1 Preventive maintenance and functional checks

The frequency of preventive maintenance essentially depends on the service conditions in which the switchboard operates; in fact, the performance and duration of electrical equipment can be influenced by operating and environmental conditions.

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In the presence of certain particular operating conditions (defined by the IEC EN 62271-200 Standard) early faults can occur if maintenance is not properly managed.

At present, no technical standard regulates the preventive maintenance of electrical equipment and, in principle, reference is made to the condition of defectiveness and therefore of danger to safety.



**Any defects must be removed immediately.**

**In the event of danger to persons, property or to the environment, defective equipment must be taken out of service to prevent its use.**

Instructions are provided below regarding the operations to be carried out on the various parts of the panel excluding the electrical equipment for which reference is made to the relevant product instruction manuals.

Maintenance intervals shall be shortened if the system or equipment is installed in an environment with particular operating conditions.

### Maintenance schedule

| Part Subject to Inspection | Frequency | Activity to be performed | Solution |
|---|---|---|---|
| Metallic structure | 12 months | Presence of dirt or scratches | Cleaning and retouching |
| Painted or galvanised parts | 24 months | Presence of dirt, grease and/or rust | Clean and/or remove rust |
| Hinges, locks | | Presence of dirt | Cleaning |
| Mechanical drives | 12 months | Presence of dust or rust | Clean and remove rust |
| Force blocks | | Additional pressure required for manoeuvring | Check the blocking sequence |
| Stop blocks<br>Safety blocks | | Incorrect adjustment | Adjust the tie rods |
| Disconnecting contacts | 12 months | Silver coating blackening | Wipe with a cloth soaked in alcohol and protect the areas with petroleum jelly |

| Part Subject to Inspection | Frequency | Activity to be performed | Solution |
|---|---|---|---|
| Fixed contacts | 24 months | Blackening of silver surfaces in environments with the presence of H2S, SO2 and salt environment | Wipe with a cloth soaked in alcohol and protect the areas with silicone grease spray |
| Switch trolley<br>Contactor trolley<br>Special trolley | 12 months | See the relevant installation, operation and maintenance instructions | Perform the recommended maintenance |
| Earthing connection components<br>Connections to the earthing system | 12 months | Traces of discharges or presence of black smoke | Clean with thinner<br>Rub the oxidation traces with emery cloth<br>Tighten the screws |
| Auxiliary circuits connections | 12 months | Loose screws | Tighten the screws |
| External connections<br>Power circuits | 12 months | Traces of discharges or presence of black smoke | Clean with thinner<br>Remove the oxidation traces with emery cloth |
| External connections<br>Power circuits | 12 months | Check that bolted connections of the HV and earthing circuits (at busbars, CBs poles, CTs, VTs, etc. ) are suitably tighten. | No disalignment is expected at the marks provided over the bolt, during torque wrench tightening at the factory. In case found, to torque wrench again the connection (see par. 5.4). |
| Check the insulation resistance<br>Power circuits<br>Auxiliary circuits | 12 months | Insufficient insulation resistance (see comments) | Identify the point of failure |

**Comments**

Measure the insulation resistance with the same methods indicated for commissioning. The measured values must not be very different from those measured at the time of commissioning. If the insulation level is very low, perform a voltage test. It is advisable to measure the insulation resistance before and after the voltage test to facilitate identification of the failure point in the event of a decrease in the insulation resistance.

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## Functional checks

| PART INSPECTED | FREQUENCY | PROBLEM | SOLUTION |
|---|---|---|---|
| Control circuit<br>Power supplies<br>Local controls<br>Remote controls | 12 months | Absence of power supply<br>Contactors don't open or close | Check the power supply circuit.<br>Check with the functional diagram the efficiency of the control devices (buttons, consent contacts, fuses or protection switches, auxiliary relay contacts, terminals, cables, etc.). |
| Automatisms | 12 months | Work sequence of one or more functions does not take place | Check the circuit with the functional diagram and intervene accordingly |
| Indicators | 12 months | Failure to power on | Check the power supply circuit.<br>Check the lights and replace them if necessary |
| Measuring devices | 12 months | Irregular or absent indications | Check the efficiency of the measuring circuit including current and/or voltage transformers and any measuring transducers.<br>Check the functionality of the measuring instruments with test instruments. |
| Protections | 12 months | Irregular or absent indications | Check the efficiency of the measuring circuit including current and/or voltage transformers.<br>Check the functionality of the protection relays with test instruments. |
| Service circuits<br>Sockets | 12 months | Absent or delayed intervention | Check the power supply circuit.<br>Check the power supply and trip circuits of the protection relays |

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| PART INSPECTED | FREQUENCY | PROBLEM | SOLUTION |
|---|---|---|---|
| Mechanical interlocking devices | 12 months | Malfunction of the mechanical<br>locking devices | Check the adjustments |

### 7.3.2 Extraordinary maintenance

If scheduled maintenance is carried out periodically and according to the procedures described above, no functional faults should occur (except in the case of electrical or mechanical wear and tear of the equipment), as declared by the manufacturer.

The most common problem that can occur is usually the indicator lights.

| Anomaly | Causes | Solution |
|---|---|---|
| Noise in metal structures | Incorrect fixing of:<br>segregation plates external panels | Check the fixing of metal sheets and panels |
| Unit overheating | Insufficient ventilation caused by:<br>• obstructed ducts<br>• obstructed slots | Eliminate the obstructions |
| | High ambient temperature | Reduce the ambient temperature |
| | Incorrect tightening torque:<br>• joints of the distribution busbars<br>• shunts<br>• connections of power circuits | Check the tightening torque of joints, shunts and terminals |
| | Disconnecting contacts | Check the pressure of the disconnection contacts, clean and lubricate |
| | Utility overload | Reduce the utility overhead |
| Condensation | Insufficient ventilation | See "Heating the units" |
| Non-functioning or malfunction of the equipment | • Switches and contactors<br>• Various components<br>• Automatisms<br>• Indicators | Read the installation, operation and maintenance instructions.<br>Search for possible causes by consulting the functional diagram of the panel.<br>Auxiliary power supply outside the permissible tolerance limits.<br>Replace the faulty components or restore power. |

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| Anomaly | Causes | Solution |
|---|---|---|
| Delayed opening of switches or contactors | • Intervention of the power fuse<br>• Intervention of the voltage transformer fuse<br>• No auxiliary power supply<br>• Overheating<br>• Incorrect coordination of the protections<br>• Faulty protections | Identify the cause and replace the fuses<br>Restore the auxiliary power supply.<br>Check the pressure of the disconnecting contacts, clean and lubricate.<br>Check the calibration of the protections based on the selectivity diagrams.<br>Replace or repair the protection. |

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# 8 DISPOSAL



**The panel must be disposed of in accordance with the legal provisions on environmental protection of the country of installation of the panel**.

The following materials may be used in the frame:

Metals:

- Steel sheet metal (stainless steel, galvanised, painted,...)
- bare copper, silver plated, tin plated
- aluminium

Plastic:

- PVC (insulation of cables, busbars, duct, ...)
- Polycarbonate

Rubber materials

- gaskets

The components of the compartments are recyclable as mixed metal scrap.

For the equipment, follow the instructions in the relevant manufacturer's instruction manuals

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# 9 ATTACHMENTS

9.1 ANNEX 1

9.2 TECHNICAL MANUAL CIRCUIT BREAKER

9.3 INSTALLATION AND MAINTENANCE INSTRUCTIONS FOR POWR CUBE ENCLOSURE FOR C.B. AND CONTACTOR - ABB

9.4 TECHNICAL MANUAL PROTECTION RELAY REX640 – ABB

9.5 TECHNICAL MANUAL PERMANENT INFRARED TEMPERATURE DETECTION SYSTEM – EXERTHERM

9.6 CATOLOGUE INSTANTANEOUS BISTABLE RELAYS – AMRA

9.7 CATALOGUE M.V. FUSES FOR CONTACTOR – ABB

9.8 DATA SHEET DISCHARGE TYPE DMI-9-10-1-L – DHEN

9.9 INSTRUCTIONS MANUAL FOR M.V. CONTACTOR TYPE VSC – ABB

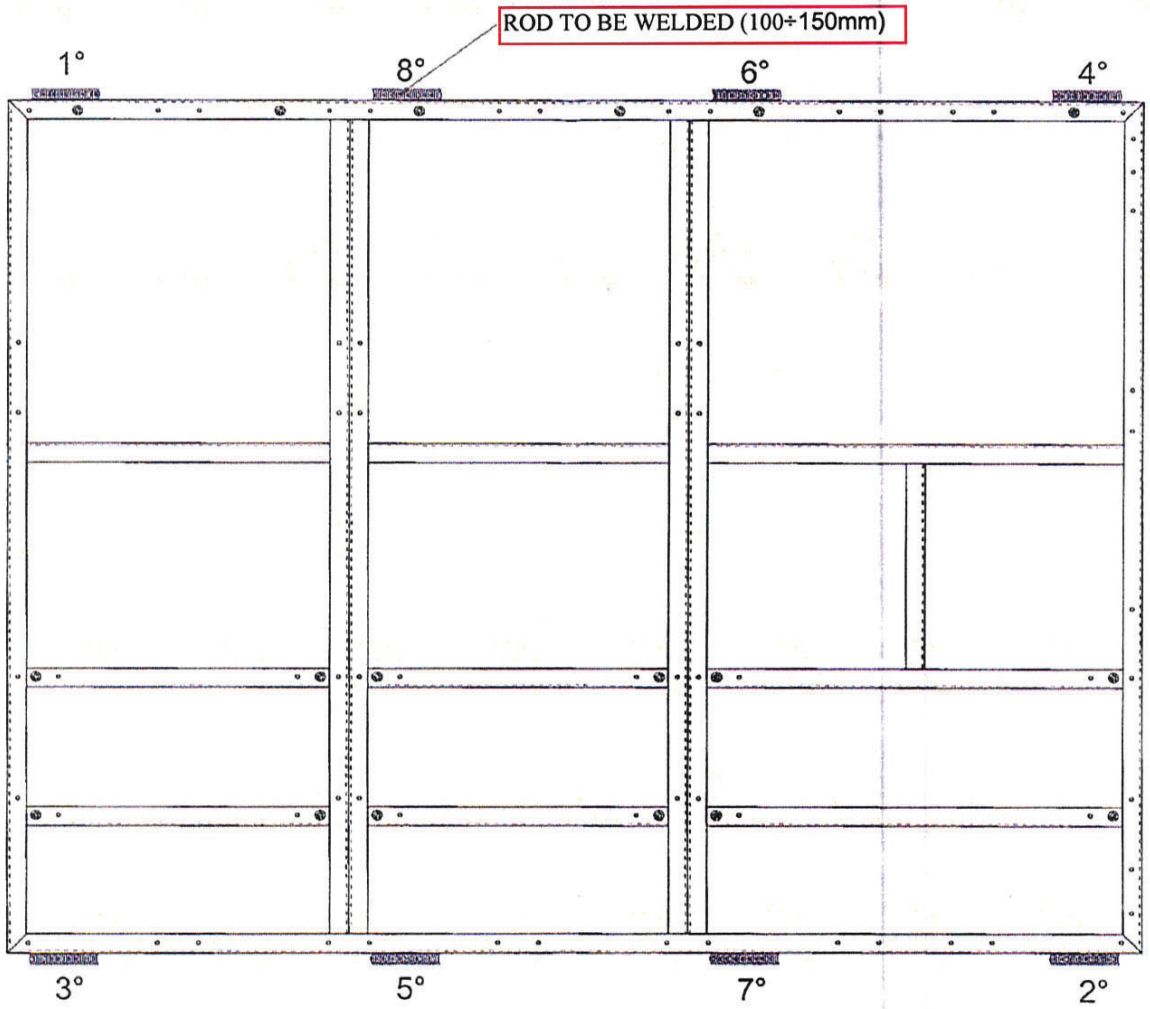
9.10 CATALOGUE VOLTAGE TRANSFORMER TYPE TJP4.3 – ABB

9.11 PARTIAL DISCHARGE MONITORING SYSTEM PDCOM – ABB

9.12 CATALOGUE CURRENT TRANSFORMER TYPE ATB, KAP - ESISTAS

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ANNEX 1




Please, follow the welding sequence

| | | | | | |
|---|---|---|---|---|---|
| TOLLERANZE GENERALI UNI-ISO 2768<br>TOLL. COORD. PUNZONAT. C.N. JS 11<br>TOLL. FILETTI 6g - 6H UNI 5541-65 | | | Numero Disegno : | Revisione Disegno : 0 | Stato Superfici : 3,2 ( √ ) |
| Trattamento Termico : | | | Finitura : | | |
| DIM.LINEARI E ANGOLARI | C | CLASS. | Materiale : | | Peso : Kg <,> |
| TOLL.GEOMETRICHE | L | | Descrizione : SALDATURA CONTROBASAMENTO A PAVIMENTO | Dis. : Garnali 20/09/2010<br>Contr. : Pandolfi 20/09/2010 | Superficie $dm^2$ <,><br>Scala : 1:10 |
| IMEA ELECTRICAL ENGINEERING<br>Ci riserviamo tutti i diritti connessi con il presente documento a sua divulga di riproduzione, utilizzazio e vendetta accessibile a terzi in assenza di nostra previa autorizzazione. | | | Codice : | | Revisione : |
| Sottofamiglia : . | | | Gruppo / Sottogruppo : / | | |

DISTRIBUTION SOLUTIONS

# VD4

## Installation and service instructions
## 12 ... 40.5 kV - 630 ... 3150 A - 16 ... 50 kA




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# I. For your safety!

- **Make sure that the installation room (spaces, divisions and ambient) is suitable for the electrical apparatus.**
- **Check that all the installation, putting into service and maintenance operations are carried out by qualified personnel with suitable knowledge of the apparatus.**
- **Make sure that the standard and legal prescriptions are complied with during installation, putting into service and maintenance, so that installations according to the rules of good working practice and safety in the work place are constructed.**
- **Strictly follow the information given in this instruction manual.**
- **Check that the rated performance of the apparatus is not exceeded during service.**
- **Check that the personnel operating the apparatus have this instruction manual to hand as well as the necessary information for correct intervention.**
- **Pay special attention to the danger notes indicated in the manual by the following symbol:**

**Responsible behaviour safeguards your own and others' safety!**
**For any requests, please contact the ABB Assistance Service.**

# II. Introduction

This publication contains the information needed to install medium voltage VD4 circuit breakers and put them into service.
For correct use of the product, please read it carefully.
Like all the apparatus we manufacture, the VD4 circuit breakers are designed for different installation configurations.
However, this apparatus allows further technical-construction modifications (at the customer's request) to adapt to special installation requirements.
Consequently, the information given below may sometimes not contain instructions concerning special configurations.
Apart from this manual, it is therefore always necessary to consult the latest technical documentation (electric circuit and wiring diagrams, assembly and installation drawings, any protection coordination studies, etc.), especially regarding any variants requested in relation to the standardised configurations.
Only use original spare parts for maintenance operations.
For further information, please also see the technical catalogue of the circuit breaker and the spare parts catalogue.



**All the installation, putting into service, running and maintenance operations must be carried out by skilled personnel with in-depth knowledge of the apparatus.**

# III. Environmental protection programme

The VD4 circuit breakers are manufactured in accordance with the ISO 14000 Standards (Guidelines for environmental management).
The production processes are carried out in compliance with the Standards for environmental protection in terms of reduction in energy consumption as well as in raw materials and production of waste materials. All this is thanks to the medium voltage apparatus manufacturing facility environmental management system.

# 1. Packing and transport

The circuit breaker is shipped in special packing, in the open position and with the spring discharged. Each piece of apparatus is protected by a plastic cover to prevent any infiltration of water during the loading and unloading stages and to keep the dust off during storage.

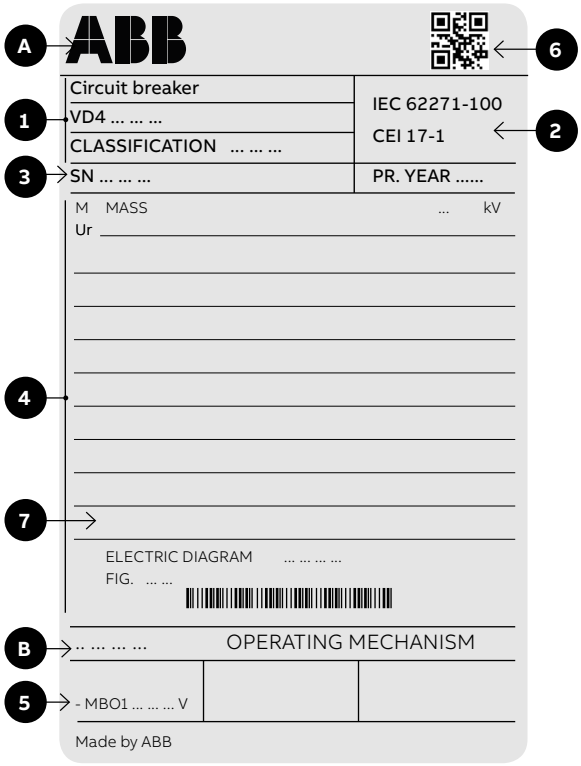
# 2. Checking on receipt

**Before carrying out any operation, always make sure that the operating mechanism spring is discharged and that the apparatus is in the open position.**

On receipt, check the state of the apparatus, integrity of the packing and correspondence with the nameplate data (see fig. 1) with what is specified in the order confirmation and in the accompanying shipping note.
Also make sure that all the materials described in the shipping note are included in the supply.
Should any damage or irregularity be noted in the supply on unpacking, notify ABB (directly or through the agent or supplier) as soon as possible and in any case within five days of receipt.
The apparatus is only supplied with the accessories specified at the time of ordering and validated in the order confirmation sent by ABB.

The accompanying documents inserted in the shipping packing are:
- instruction manual (this document)
- test certification
- identification label
- copy of the shipping documents
- electric wiring diagram.

Other documents which are sent prior to shipment of the apparatus are:
- order confirmation
- original shipping advice note
- any drawings or documents referring to special configurations/conditions.




Caption
A Circuit breaker rating plate
B Operating mechanism rating plate
1 Type of apparatus
2 Symbols of compliance with Standards
3 Serial number
4 Circuit breaker characteristics
5 Characteristics of the operating mechanism auxiliaries
6 QR code
7 CMU power supply (VD4 evo only)

Fig. 1

# 3. Storage

When a period of storage is foreseen, our workshops can (on request) provide suitable packing for the specified storage conditions.
On receipt the apparatus must be carefully unpacked and checked as described in Checking on receipt (chap. 2).
If immediate installation is not possible, the packing must be replaced, using the original material supplied.
Insert packets of special hygroscopic substances inside the packing, with at least one standard packet for piece of apparatus.
Should the original packing not be available and immediate installation is not possible, store in a covered, well-ventilated, dry, dust-free, non-corrosive ambient, away from any easily flammable materials and at a temperature between – 5 °C and + 45 °C.
In any case, avoid any accidental impacts or positioning which stresses the structure of the apparatus.

# 4. Handling

Before carrying out any operations, always make sure that the operating mechanism spring is discharged and that the apparatus is in the open position.
To lift and handle the circuit breaker, proceed as follows (fig. 2):

- use a special lifting tool (1) (not supplied) fitted with ropes with safety hooks (2);
- insert the hooks (2) in the supports (3) fixed to the frame of the circuit breaker and lift. Put the hooks (2) into the support holes (3) according to the type of apparatus (see table);
- on completion of the operation (and in any case before putting into service) unhook the lifting tool (1) and dismantle the supports (3) from the frame.

During handling, take great care not to stress the insulating parts and the terminals of the circuit breaker.

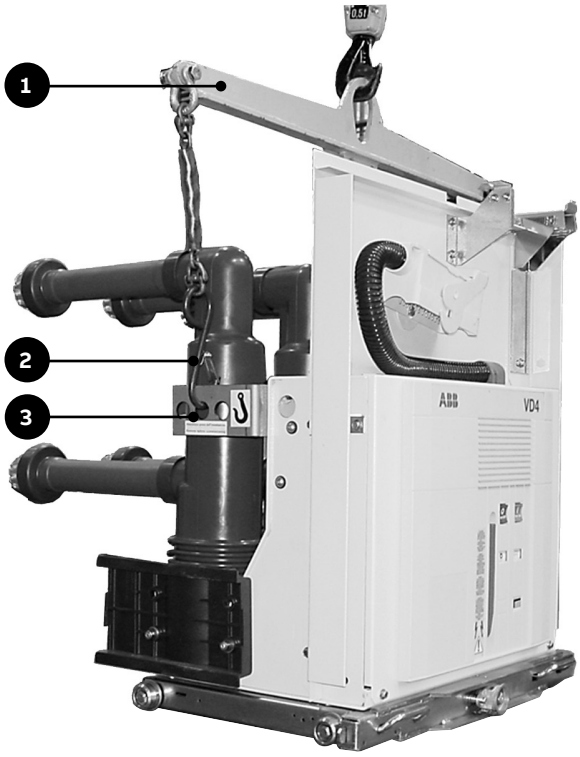



Fig. 2

**The apparatus must not be handled by putting lifting devices directly under the apparatus itself.**
**Should it be necessary to use this technique, put the circuit breaker onto a pallet or a sturdy supporting surface (see fig. 3).**
**In any case, it is always advisable to carry out lifting using the supports (3).**

| Version | Pole centre distance | Rated current | Hole |
|---|---|---|---|
| Fixed | 150-210 mm | up to 1250 A | A |
| Fixed | 275 mm | from 1600 to 3150 A | A |
| Fixed | 210 mm | from 1600 to 2000 A | A |
| Fixed | 210-275 mm | up to 4000 A | C |
| Withdrawable | 150 mm | up to 1250 A | A |
| Withdrawable | 210 mm | from 1600 to 2500 A | B |
| Withdrawable | 275 mm | up to 1250 A | B |
| Withdrawable | 275 mm | from 1600 to 3150 A | C |
| Withdrawable | 210 mm | up to 1250 A | C |
| Withdrawable | 210-275 mm | up to 4000 A | C |

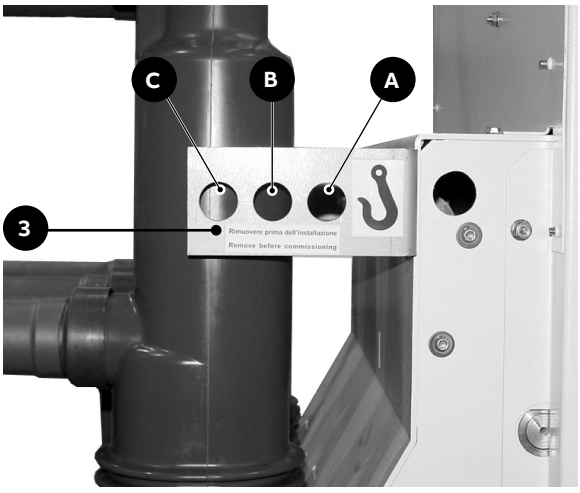



Fig. 2a Lifting support

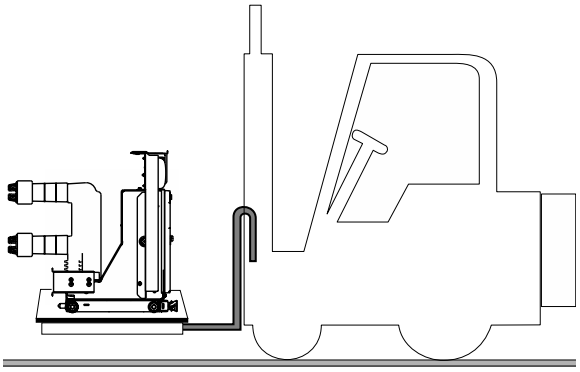


Fig. 3

# 5. Description

## 5.1. General

The VD4 are vacuum circuit breaker for indoor installation.
For the electrical performances, please refer to the corresponding technical catalogue code 1VCP000001.
For special installation requirements, please contact ABB.
The following versions are available:

- fixed
- withdrawable for UniGear ZS1 switchgear and PowerCube modules.

## 5.2. Reference Standards

The VD4 circuit breakers conform to the IEC 62271-100, CEI - VDE - BS Standards are equivalent to IEC Standards due to harmonization with IEC.
Some ratings are qualified also according to ANSI/ IEEE standards.

## 5.3. EL operating mechanism

VD4 circuit breakers are equipped with modular EL spring operating mechanisms. The operating mechanism is designed to cover the whole range of performances as shown in the following table:

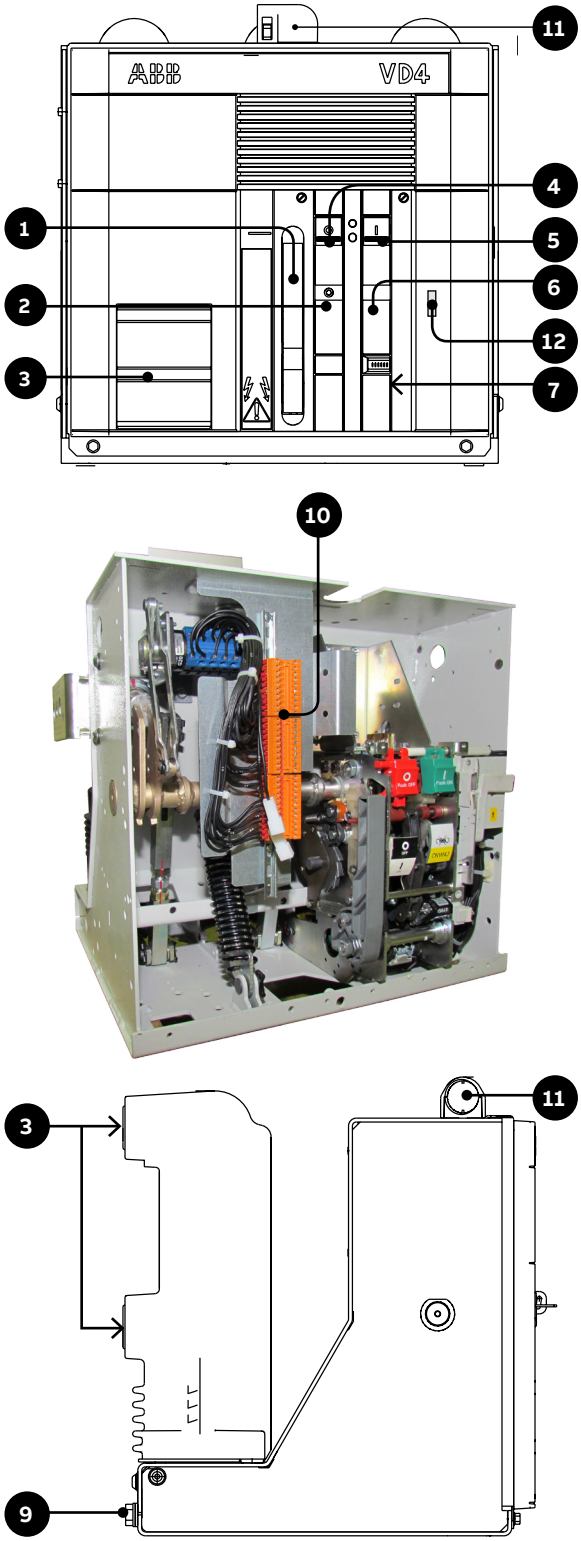
| Type of operating mechanism | Rated short-circuit current |
|---|---|
| EL1 - EL2 | Up to 31.5 kA |
| EL3 - EL3 | Up to 40 kA - 24 kV, 31.5 kA |
| EL3 - EL3-S | 40.5 kV up to 31.5 kA<br>40 kA up to 17.5 kV |
| EL1 TWIN | Up to 50 kA (rated current up to 2000 A) |
| EL2 TWIN | Up to 50 kA (rated current ≥ 2500 A) |

## 5.4. VD4 evo

VD4 evo availablen with digital capabilities and sensors.

## 5.5. Fixed circuit breakers

The fixed circuit breaker (fig. 4) is the basic version complete with structure and front protection screen. The fixing holes are made in the lower part of the structure.
For the electrical connections of the circuit breaker auxiliary circuits, the terminal box (10) is available (also see par. 7.8.1.).
The earthing screw is placed in the rear part of the circuit breaker. For further details please see the caption to figure 4.




Caption
1 Lever for manual closing spring charging
2 Signalling device for circuit breaker open/closed
3 Rating plate
4 Opening pushbutton
5 Closing pushbutton
6 Signalling device for closing spring charged/discharged
7 Operation counter
8 Terminals
9 Earthing screw
10 Delivery terminal box
11 Cabling connection
12 Mechanical override of the undervoltage release (on request)

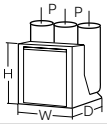
Fig. 4

# 5. Description

### 5.5.1. General characteristics of fixed circuit breakers

**General characteristics of fixed circuit breakers (12 kV)**




| Circuit breaker | | VD4 12 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | | |
| Rated voltage | Ur [kV] | 12 (2) | | | | | | |
| Rated insulation voltage | Us [kV] | 12 | | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | | | | | |
| Impulse withstand voltage | Up [kV] | 75 | | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | | |
| Rated normal current (40 °C) | Ir [A] | 630 | 630 | 630 | 1250 | 1250 | 1250 | 1250 (5) |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 | 25 | 25 | 25 | 25 | 25 | – |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | – |
| | | – | – | – | – | – | – | 40 (5) |
| | | – | – | – | – | | – | – |
| | | – | – | – | – | – | – | – |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 | 25 | 25 | 25 | 25 | 25 | – |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | – |
| | | – | – | – | – | – | – | 40 (5) |
| | | – | – | – | – | – | – | – |
| | | – | – | – | – | – | – | – |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 | 40 | – |
| | | 50 | 50 | 50 | 50 | 50 | 50 | – |
| | | 63 | 63 | 63 | 63 | 63 | 63 | – |
| | | 80 | 80 | 80 | 80 | 80 | 80 | – |
| | | – | – | – | – | – | – | 104 (5) |
| | | – | – | – | – | – | – | – |
| | | – | – | – | – | – | – | – |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | | | | | | |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | – | – | – | – |
| Opening time | [ms] | 33 ... 60 | | | | | | |
| Arcing time | [ms] | 10 ... 15 | | | | | | |
| Total breaking time | [ms] | 43 ... 75 | | | | | | |
| Closing time | [ms] | 30 ... 60 | | | | | | |
| Maximum overall dimensions   | H [mm] | 461 | 461 | 461 | 461 | 461 | 461 | 589 |
| | W [mm] | 450 | 570 | 700 | 450 | 570 | 700 | 450 |
| | D [mm] | 424 | 424 | 424 | 424 | 424 | 424 | 424 |
| | Pole distance P [mm] | 150 | 210 | 275 | 150 | 210 | 275 | 150 |
| Weight | [kg] | 73 | 75 | 79 | 73 | 75 | 79 | 81 |
| Standardised table of dimensions | TN | 7405(1) | 7406(1) | – | 7405(1) | 7406(1) | – | 2RDA043108 |
| | 1VCD | – | – | 000051(1) | – | – | 000051(1) | |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | | |

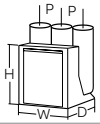
(1) Poles in polyamide
(2) Available in 10 kV voltage version in accordance with GOST standards up to 50 kA
(3) Up to 4000 A with forced ventilation
(4) On request, the closing spring can be loaded by means of a removable crank handle outside operating mechanism (instead of linear loading by a lever built into the front of operating mechanism)
(5) Available in VD4 evo only
*) Consult ABB for the 4000 A version with natural ventilation

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **VD4 12** | | | | | | | | |
| • | | | | | | | | |
| 12 (2) | | | | | | | | |
| 12 | | | | | | | | |
| 28 | | | | | | | | |
| 75 | | | | | | | | |
| 50-60 | | | | | | | | |
| 1250 | 1250 | 1250 | 1250 | 1250 | 1600 | 1600 | 1600 | 1600 |
| – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | 20 | 20 | 20 | – |
| – | – | – | – | – | 25 | 25 | 25 | – |
| – | – | – | – | – | 31.5 | 31.5 | 31.5 | – |
| 40 | 40 | – | – | – | – | – | – | 40 |
| – | – | 50 | 50 | – | – | – | – | – |
| – | – | – | – | 63 | – | – | – | – |
| – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | 20 | 20 | 20 | – |
| – | – | – | – | – | 25 | 25 | 25 | – |
| – | – | – | – | – | 31.5 | 31.5 | 31.5 | – |
| 40 | 40 | – | – | – | – | – | – | 40 |
| – | – | 50 | 50 | – | – | – | – | – |
| – | – | – | – | 63 | – | – | – | – |
| – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | 50 | 50 | 50 | – |
| – | – | – | – | – | 63 | 63 | 63 | – |
| – | – | – | – | – | 80 | 80 | 80 | – |
| 100 | 100 | – | – | – | – | – | – | 100 |
| – | – | 125 | 125 | – | – | – | – | – |
| – | – | – | – | 158 | – | – | – | – |
| • | | | | | | | | |
| – | – | – | – | – | – | – | – | – |
| 33 ... 60 | | | | ≤45 | 33 ... 60 | | | |
| 10 ... 15 | | | | ≤15 | 10 ... 15 | | | |
| 43 ... 75 | | | | ≤60 | 43 ... 75 | | | |
| 30 ... 60 | | | | approx. 60 | 30 ... 60 | | | |
| 589 | 589 | 610 | 610 | 677.5 | 599 | 599 | 599 | 589 |
| 570 | 700 | 600 | 750 | 750 | 450 | 570 | 700 | 570 |
| 424 | 424 | 459 | 459 | 459 | 424 | 424 | 424 | 424 |
| 210 | 275 | 210 | 275 | 275 | 150 | 210 | 275 | 210 |
| 84 | 84 | 146 | 158 | 265 | 93 | 98 | 105 | 84 |
| – | – | – | – | – | – | 7407 (1) | 7408 (1) | – |
| 003282(1) | 003285(1) | 003440 | 003441 | GCEM370562 | 000050 | – | – | 003282(1) |
| - 5 ... + 40 | | | | | | | | |
| • | | | | | | | | |
| • | | | | | | | | |

# 5. Description

### General characteristics of fixed circuit breakers (12 kV)




| Circuit breaker | | VD4 12 | | | | | |
|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | |
| Rated voltage | Ur [kV] | 12 (2) | | | | | |
| Rated insulation voltage | Us [kV] | 12 | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | | | | |
| Impulse withstand voltage | Up [kV] | 75 | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | |
| Rated normal current (40 °C) | Ir [A] | 1600 | 1600 | 1600 | 1600 | 2000 | 2000 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | – | – | – | – | – | – |
| | | – | – | – | – | 20 | 20 |
| | | – | – | – | – | 25 | 25 |
| | | – | – | – | – | 31.5 | 31.5 |
| | | 40 | – | – | – | 40 | 40 |
| | | – | 50 | 50 | – | – | – |
| | | – | – | – | 63 | – | – |
| Rated short-time withstand current (3s) | Ik [kA] | – | – | – | – | – | – |
| | | – | – | – | – | 20 | 20 |
| | | – | – | – | – | 25 | 25 |
| | | – | – | – | – | 31.5 | 31.5 |
| | | 40 | – | – | – | 40 | 40 |
| | | – | 50 | 50 | – | – | – |
| | | – | – | – | 63 | – | – |
| Making capacity | Ip [kA] | – | – | – | – | – | – |
| | | – | – | – | – | 50 | 50 |
| | | – | – | – | – | 63 | 63 |
| | | – | – | – | – | 80 | 80 |
| | | 100 | – | – | – | 100 | 100 |
| | | – | 125 | 125 | – | – | – |
| | | – | – | – | 158 | – | – |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | – | • | • |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | • | – | – |
| Opening time | [ms] | 33...60 | | | ≤45 | 33...60 | |
| Arcing time | [ms] | 10...15 | | | ≤15 | 10...15 | |
| Total breaking time | [ms] | 43...75 | | | ≤60 | 43...75 | |
| Closing time | [ms] | 30...60 | | | approx. 60 | 30...60 | |
| Maximum overall dimensions   | H [mm] | 589 | 610 | 610 | 677.5 | 599 | 599 |
| | W [mm] | 700 | 600 | 750 | 750 | 570 | 700 |
| | D [mm] | 424 | 459 | 459 | 459 | 424 | 424 |
| | Pole distance P [mm] | 275 | 210 | 275 | 265 | 210 | 275 |
| Weight | [kg] | 84 | 146 | 158 | 265 | 98 | 105 |
| Standardised table of dimensions | TN | – | – | – | – | 7407 (1) | 7408 (1) |
| | 1VCD | 003285(1) | 003440 | 003441 | GCEM370562 | – | – |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | |

(1) Poles in polyamide
(2) Available in 10 kV voltage version in accordance with GOST standards up to 50 kA
(3) Up to 4000 A with forced ventilation
(4) On request, the closing spring can be loaded by means of a removable crank handle outside operating mechanism (instead of linear loading by a lever built into the front of operating mechanism)
*) Consult ABB for the 4000 A version with natural ventilation

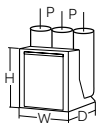
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **VD4 12** | | | | | | | | |
| • | | | | | | | | |
| 12 (2) | | | | | | | | |
| 12 | | | | | | | | |
| 28 | | | | | | | | |
| 75 | | | | | | | | |
| 50-60 | | | | | | | | |
| 2000 | 2000 | 2000 | 2500 | 2500 | 2500 | 2500 | 3150 (3) | 3150 (3) |
| – | – | – | – | – | – | – | – | – |
| – | – | – | 20 | 20 | – | – | 20 | – |
| – | – | – | 25 | 25 | – | – | 25 | – |
| – | – | – | 31.5 | 31.5 | – | – | 31.5 | – |
| – | – | – | 40 | 40 | – | – | 40 | – |
| 50 | 50 | – | – | – | 50 | – | – | 50 |
| – | – | 63 | – | – | – | 63 | | |
| – | – | – | – | – | – | – | – | – |
| – | – | – | 20 | 20 | – | – | 20 | – |
| – | – | – | 25 | 25 | – | – | 25 | – |
| – | – | – | 31.5 | 31.5 | – | – | 31.5 | – |
| – | – | – | 40 | 40 | – | – | 40 | – |
| 50 | 50 | – | – | – | 50 | – | – | 50 |
| – | – | 63 | – | – | – | 63 | – | – |
| – | – | – | – | – | – | – | – | – |
| – | – | – | 50 | 50 | – | – | 50 | – |
| – | – | – | 63 | 63 | – | – | 63 | – |
| – | – | – | 80 | 80 | – | – | 80 | – |
| – | – | – | 100 | 100 | – | – | 100 | – |
| 125 | 125 | – | – | – | 125 | – | – | 125 |
| – | – | 158 | – | – | – | 158 | – | – |
| • | • | – | • | • | • | – | • | • |
| – | – | • | – | – | – | • | – | – |
| | | ≤45 | 33...60 | | | ≤45 | 33...60 | |
| | | ≤15 | 10...15 | | | ≤15 | 10...15 | |
| | | ≤60 | 43...75 | | | ≤60 | 43...75 | |
| | | approx. 60 | 30...60 | | | approx. 60 | 30...60 | |
| 610 | 610 | 677.5 | 599 | 599 | 610 | 677.5 | 635 | 636 |
| 600 | 750 | 750 | 570 | 700 | 750 | 750 | 700 | 750 |
| 459 | 459 | 459 | 424 | 424 | 459 | 459 | 424 | 459 |
| 210 | 275 | 275 | 210 | 275 | 275 | 275 | 275 | 275 |
| 146 | 158 | 265 | 98 | 105 | 163 | 265 | 140 | 177 |
| – | – | – | 7407 (1) | 7408 (1) | – | – | – | – |
| 003440 | 003441 | GCEM370562 | – | – | 003441 | GCEM370562 | 000149 (1) | 003443 |
| - 5 ... + 40 | | | | | | | | |
| • | | | | | | | | |
| • | | | | | | | | |



# 5. Description

**General characteristics of fixed circuit breakers (15kV)**

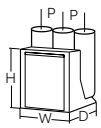



| Circuit breaker | | | VD4/N 15 | | VD4 15 | |
|---|---|---|---|---|---|---|
| Standard | | IEEE C37.04 | • | | • | |
| Rated voltage | | [kV] | 15 | | 15 | |
| Rated frequency | | [Hz] | 60 | | 50/60 | |
| Short-circuit breaking current Isc | | [kA] | 31.5 | | 40 | |
| Rated current Ir | | [A] | 1200 | 2000 | 1200 | 2000 |
| Short-time withstand current | | [A] | 31.5 | | 40 | |
| Short circuit withstand | | [A] | 3 | | 2 | |
| Close and latch capability | | [kA] | 82 | | 104 | |
| Operation sequence | | [O - 0,3 s - CO - 3 min - CO] | • | | • | |
| % DC component | | [%] | 40 | | 30 | |
| Interrupting time | | [ms] | 50 | | 50 | |
| Closing time | | [ms] | 30...60 | | 30…60 | |
| Mechanical endurance class | | [M2] | 10k | | 10k | |
| Lightning impulse withstand voltage Up | | [kV] | 95 | | 95 | |
| Power frequency withstand voltage Ud | | [kV] | 36 | | 36 | |
| Operating temperature | | [°C] | -5…+40 | | -20…+40 | |
| Maximum overall dimensions   | Height | [mm] | 461 | 599 | 599 | |
| | Width | [mm] | 450 | 570 | 570 | |
| | Depth | [mm] | 424 | 424 | 424 | |
| | Pole distance | [mm] | 150 | 210 | 210 | |
| Standard table of dimensions | | TN | 7407 | 7405 | 7407 | |
| Weight | | [kg] | 73 | 80 | 75 | |

# 5. Description

### General characteristics of fixed circuit breakers (17.5 kV)




| Circuit breaker | | | VD4 17 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | | • | | | | | | | | | | |
| | VDE 0671; CEI EN 62271-100 File 7642 | | • | | | | | | | | | | |
| Rated voltage | | Ur [kV] | 17.5 | | | | | | | | | | |
| Rated insulation voltage | | Us [kV] | 17.5 | | | | | | | | | | |
| Withstand voltage at 50 Hz | | Ud (1 min) [kV] | 38 | | | | | | | | | | |
| Impulse withstand voltage | | Up [kV] | 95 | | | | | | | | | | |
| Rated frequency | | fr [Hz] | 50-60 | | | | | | | | | | |
| Rated normal current (40 °C) | | Ir [A] | 630 | 630 | 630 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 (2) |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | | Isc [kA] | 16 | 16 | 16 | 16 | 16 | 16 | - | - | - | - | - |
| | | | 20 | 20 | 20 | 20 | 20 | 20 | - | - | - | - | - |
| | | | 25 | 25 | 25 | 25 | 25 | 25 | - | - | - | - | - |
| | | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | - | - | - | - | - |
| | | | - | - | - | - | - | - | 40 | 40 | - | - | 40 (2) |
| | | | - | - | - | - | - | - | - | - | 50 | 50 | - |
| Rated short-time withstand current (3s) | | Ik [kA] | 16 | 16 | 16 | 16 | 16 | 16 | - | - | - | - | - |
| | | | 20 | 20 | 20 | 20 | 20 | 20 | - | - | - | - | - |
| | | | 25 | 25 | 25 | 25 | 25 | 25 | - | - | - | - | - |
| | | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | - | - | - | - | - |
| | | | - | - | - | - | - | - | 40 | 40 | - | - | 40 (2) |
| | | | - | - | - | - | - | - | - | - | 50 | 50 | - |
| Making capacity | | Ip [kA] | 40 | 40 | 40 | 40 | 40 | 40 | - | - | - | - | - |
| | | | 50 | 50 | 50 | 50 | 50 | 50 | - | - | - | - | - |
| | | | 63 | 63 | 63 | 63 | 63 | 63 | - | - | - | - | - |
| | | | 80 | 80 | 80 | 80 | 80 | 80 | - | - | - | - | - |
| | | | - | - | - | - | - | - | 100 | 100 | - | - | 104 (2) |
| | | | - | - | - | - | - | - | - | - | 125 | 125 | - |
| Operation sequence | | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • | • | • | • | • |
| Opening time | | [ms] | 33 ... 60 | | | | | | | | | | |
| Arcing time | | [ms] | 10 ... 15 | | | | | | | | | | |
| Total breaking time | | [ms] | 43 ... 75 | | | | | | | | | | |
| Closing time | | [ms] | 30 ... 60 | | | | | | | | | | |
| Maximum overall dimensions   | | H [mm] | 461 | 461 | 461 | 461 | 461 | 461 | 589 | 589 | 610 | 610 | 589 |
| | | W [mm] | 450 | 570 | 700 | 450 | 570 | 700 | 570 | 700 | 600 | 750 | 450 |
| | | D [mm] | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 459 | 459 | 424 |
| | | Pole distance P [mm] | 150 | 210 | 275 | 150 | 210 | 275 | 210 | 275 | 210 | 275 | 150 |
| Weight | | [kg] | 73 | 75 | 79 | 73 | 75 | 79 | 84 | 84 | 146 | 158 | 81 |
| Standardised table of dimensions | | TN | 7405 (1) | 7406 (1) | - | 7405 (1) | 7406 (1) | - | - | - | - | - | 2RDA043108 |
| | | 1VCD | - | - | 000051 (1) | - | - | 000051 (1) | 003282 (1) | 003285 (1) | 003440 | 003441 | |
| Operating temperature | | [°C] | - 5 ... + 40 | | | | | | | | | | |
| Tropicalization | | IEC: 60068-2-30, 60721-2-1 | • | | | | | | | | | | |
| Electromagnetic compatibility | | IEC: 62271 | • | | | | | | | | | | |

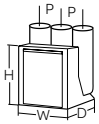
(1) Poles in polyamide
(2) Available in VD4 evo only

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VD4 17** | | | | | | | | | | | | | | |
| • | | | | | | | | | | | | | | |
| • | | | | | | | | | | | | | | |
| 17.5 | | | | | | | | | | | | | | |
| 17.5 | | | | | | | | | | | | | | |
| 38 | | | | | | | | | | | | | | |
| 95 | | | | | | | | | | | | | | |
| 50-60 | | | | | | | | | | | | | | |
| 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 2000 | 2000 | 2000 | 2000 | 2500 | 2500 | 2500 | 3150 | 3150 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 20 | 20 | - | - | - | - | 20 | 20 | - | - | 20 | 20 | - | 20 | - |
| 25 | 25 | - | - | - | - | 25 | 25 | - | - | 25 | 25 | - | 25 | - |
| 31.5 | 31.5 | - | - | - | - | 31.5 | 31.5 | - | - | 31.5 | 31.5 | - | 31.5 | - |
| - | - | 40 | 40 | - | - | 40 | 40 | - | - | - | 40 | - | 40 | - |
| - | - | - | - | 50 | 50 | - | - | 50 | 50 | - | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 20 | 20 | - | - | - | - | 20 | 20 | - | - | 20 | 20 | - | 20 | - |
| 25 | 25 | - | - | - | - | 25 | 25 | - | - | 25 | 25 | - | 25 | - |
| 31.5 | 31.5 | - | - | - | - | 31.5 | 31.5 | - | - | 31.5 | 31.5 | - | 31.5 | - |
| - | - | 40 | 40 | - | - | 40 | 40 | - | - | - | 40 | - | 40 | - |
| - | - | - | - | 50 | 50 | - | - | 50 | 50 | - | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 50 | 50 | - | - | - | - | 50 | 50 | - | - | 50 | 50 | - | 50 | - |
| 63 | 63 | - | - | - | - | 63 | 63 | - | - | 63 | 63 | - | 63 | - |
| 80 | 80 | - | - | - | - | 80 | 80 | - | - | 80 | 80 | - | 80 | - |
| - | - | 100 | 100 | - | - | 100 | 100 | - | - | - | 100 | - | 100 | - |
| - | - | - | - | 125 | 125 | - | - | 125 | 125 | - | - | 125 | - | 125 |
| • | • | • | • | • | • | • | • | • | • | • | • | • | • | - |
| 33 ... 60 | | | | | | | | | | | | | | |
| 10 ... 15 | | | | | | | | | | | | | | |
| 43 ... 75 | | | | | | | | | | | | | | |
| 30 ... 60 | | | | | | | | | | | | | | |
| 599 | 599 | 589 | 589 | 610 | 610 | 599 | 599 | 610 | 610 | 599 | 599 | 610 | 635 | 636 |
| 570 | 700 | 570 | 700 | 600 | 750 | 570 | 700 | 600 | 750 | 570 | 700 | 750 | 700 | 750 |
| 424 | 424 | 424 | 424 | 459 | 459 | 424 | 424 | 459 | 459 | 424 | 424 | 459 | 424 | 459 |
| 210 | 275 | 210 | 275 | 210 | 275 | 210 | 275 | 210 | 275 | 210 | 275 | 275 | 275 | 275 |
| 98 | 105 | 84 | 84 | 146 | 158 | 98 | 105 | 146 | 158 | 98 | 105 | 163 | 140 | 177 |
| 7407 (1) | 7408 (1) | - | - | - | - | 7407 (1) | 7408 (1) | - | - | 7407 (1) | 7408 (1) | - | - | - |
| - | - | 003282 (1) | 003285 (1) | 003440 | 003441 | - | - | 003440 | 003441 | - | - | 003441 | 000149 (1) | 003443 |
| - 5 ... + 40 | | | | | | | | | | | | | | |
| • | | | | | | | | | | | | | | |
| • | | | | | | | | | | | | | | |

# 5. Description

### General characteristics of fixed circuit breakers (24 kV)

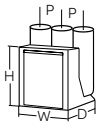



| Circuit breaker | | | VD4 24 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | | • | | | | | | |
| | VDE 0671; CEI EN 62271-100 File 7642 | | • | | | | | | |
| Rated voltage | | Ur [kV] | 24 | | | | | | |
| Rated insulation voltage | | Us [kV] | 24 | | | | | | |
| Withstand voltage at 50 Hz | | Ud (1 min) [kV] | 50 | | | | | | |
| Impulse withstand voltage | | Up [kV] | 125 | | | | | | |
| Rated frequency | | fr [Hz] | 50-60 | | | | | | |
| Rated normal current (40 °C) | | Ir [A] | 630 | 630 | 1250 | 1250 | 1600 | 2000 | 2500 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | | Isc [kA] | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| | | | – | – | 31.5 | – | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | | Ik [kA] | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| | | | – | – | 31.5 | – | 31.5 | 31.5 | 31.5 |
| Making capacity | | Ip [kA] | 40 | 40 | 40 | 40 | 40 | 40 | – |
| | | | 50 | 50 | 50 | 50 | 50 | 50 | – |
| | | | 63 | 63 | 63 | 63 | 63 | 63 | 63 |
| | | | – | – | 80 | – | 80 | 80 | 80 |
| Operation sequence | | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • |
| Opening time | | [ms] | 33 ... 60 | | | | | | |
| Arcing time | | [ms] | 10 ... 15 | | | | | | |
| Total breaking time | | [ms] | 43 ... 75 | | | | | | |
| Closing time | | [ms] | 30 ... 60 | | | | | | |
| Maximum overall dimensions   | | H [mm] | 631 | 631 | 631 | 631 | 642 | 642 | 642 |
| | | W [mm] | 570 | 700 | 570 | 700 | 700 | 700 | 700 |
| | | D [mm] | 424 | 424 | 424 | 424 | 424 | 424 | 424 |
| | | Pole distance P [mm] | 210 | 275 | 210 | 275 | 275 | 275 | 275 |
| Weight | | [kg] | 100 | 104 | 100/106 (1) | 104 | 110 | 110 | 110 |
| Standardised table of dimensions | | TN | 7409 | 7410 | 7409 | 7410 | 7411 | 7411 | 7411 |
| | | 1VCD | – | – | 000172 (1) | – | – | – | – |
| Operating temperature | | [°C] | - 5 ... + 40 | | | | | | |
| Tropicalization | | IEC: 60068-2-30, 60721-2-1 | • | | | | | | |
| Electromagnetic compatibility | | IEC: 62271-1 | • | | | | | | |

(1) 31.5 kA version.

## General characteristics of fixed circuit breakers (36 kV)

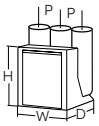



| Circuit breaker | | VD4 36 | | | |
|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | |
| Rated voltage | Ur [kV] | 36 | | | |
| Rated insulation voltage | Us [kV] | 36 | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 70 | | | |
| Impulse withstand voltage | Up [kV] | 170 | | | |
| Rated frequency | fr [Hz] | 50 | | | |
| Rated normal current (40 °C) | Ir [A] | 1250 | 1600 | 2000 | 2500 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 |
| | | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • |
| Opening time | [ms] | 35 ... 60 | | | |
| Arcing time | [ms] | 5 ... 15 | | | |
| Total breaking time | [ms] | 40 ... 75 | | | |
| Closing time | [ms] | 50 ... 65 | | | |
| Maximum overall dimensions   | H [mm] | 884 | 884 | 884 | 884 |
| | W [mm] | 796 | 796 | 796 | 796 |
| | D [mm] | 501 | 501 | 501 | 501 |
| | Pole distance P [mm] | 275 | 275 | 275 | 275 |
| Weight | [kg] | 170 | 170 | 170 | 210 |
| Standardised table of dimensions | TN | 1VYN300901-RF | 1VYN300901-RF | 1VYN300901-RF | 1VYN300901-RF |
| Operating temperature | [°C] | - 5 ... + 40 | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | |

# 5. Description

**General characteristics of fixed circuit breakers (40.5 kV)**



| **Circuit breaker** | | **VD4 40.5** | | |
|---|---|---|---|---|
| Standards | IEC 62271-100 | • (1) | | |
| Rated voltage | Ur [kV] | 40.5 | | |
| Rated insulation voltage | Us [kV] | 40.5 | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 95 | | |
| Impulse withstand voltage | Up [kV] | 190 | | |
| Rated frequency | fr [Hz] | 50 | | |
| Rated normal current (40 °C) | Ir [A] | 1250 | 1600 | 2000 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 20 | 20 | 20 |
| | | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 20 | 20 | 20 |
| | | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 50 | 50 | 50 |
| | | 63 | 63 | 63 |
| | | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 3 min - CO] | • | • | • |
| Opening time | [ms] | 35 ... 60 | 35 ... 60 | 35 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 45 ... 75 | 45 ... 75 | 45 ... 75 |
| Closing time | [ms] | 50 ... 65 | 50 ... 65 | 50 ... 65 |
| Maximum overall dimensions   | H [mm] | 884 | 884 | 884 |
| | W [mm] | 796 | 796 | 796 |
| | D [mm] | 501 | 501 | 501 |
| | Pole distance P [mm] | 275 | 275 | 275 |
| Weight | [kg] | 170 | 170 | 170 |
| Standardised table of dimensions | TN | 2RDA043326A001 | 2RDA043326A001 | 2RDA043326A001 |
| Operating temperature | [°C] | - 20 ... + 40 | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | |

(1) GOST version available on request.

### 5.5.2. Types of circuit breakers available in the fixed version

#### VD4 fixed circuit breaker without bottom and top terminals (12 kV)

| Ur | Isc | Rated uninterrupted current (40°C) [A] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H=461 | | | H=589 | | H=599 | | | H=610 | | H=636 | H=589 | |
| | | D=424 | | | D=424 | | D=424 | | | D=459 | | D=459 | D=424 | |
| kV | kA | u/l=205 | | | u/l=310 | | u/l=310 | | | u/l=310 | | u/l=310 | u/l=310 | Circuit breaker type |
| | | l/g=217.5 | | | l/g=238 | | l/g=237.5 | | | l/g=237 | | l/g=237 | l/g=237.5 | |
| | | P=150 | P=210 | P=275 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | P=150 | |
| | | W=450 | W=570 | W=700 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | W=450 | |
| 12 | 16 | 630 | | | | | | | | | | | | VD4 12.06.16 p150 |
| | 20 | 630 | | | | | | | | | | | | VD4 12.06.20 p150 |
| | 25 | 630 | | | | | | | | | | | | VD4 12.06.25 p150 |
| | 31.5 | 630 | | | | | | | | | | | | VD4 12.06.32 p150 |
| | 16 | 1250 | | | | | | | | | | | | VD4 12.12.16 p150 |
| | 20 | 1250 | | | | | | | | | | | | VD4 12.12.20 p150 |
| | 25 | 1250 | | | | | | | | | | | | VD4 12.12.25 p150 |
| | 31.5 | 1250 | | | | | | | | | | | | VD4 12.12.32 p150 |
| | 40 | | | | | | | | | | | | 1250 | VD4 12.12.40 p150 |
| | 20 | | | | | | 1600 | | | | | | | VD4 12.16.20 p150 |
| | 25 | | | | | | 1600 | | | | | | | VD4 12.16.25 p150 |
| | 31.5 | | | | | | 1600 | | | | | | | VD4 12.16.32 p150 |
| | 16 | | 630 | | | | | | | | | | | VD4 12.06.16 p210 |
| | 20 | | 630 | | | | | | | | | | | VD4 12.06.20 p210 |
| | 25 | | 630 | | | | | | | | | | | VD4 12.06.25 p210 |
| | 31.5 | | 630 | | | | | | | | | | | VD4 12.06.32 p210 |
| | 16 | | 1250 | | | | | | | | | | | VD4 12.12.16 p210 |
| | 20 | | 1250 | | | | | | | | | | | VD4 12.12.20 p210 |
| | 25 | | 1250 | | | | | | | | | | | VD4 12.12.25 p210 |
| | 31.5 | | 1250 | | | | | | | | | | | VD4 12.12.32 p210 |
| | 40 | | | | 1250 | | | | | | | | | VD4 12.12.40 p210 |
| | 50 | | | | | | | | | 1250 | | | | VD4 12.12.50 p210 |
| | 20 | | | | | | | 1600 | | | | | | VD4 12.16.20 p210 |
| | 25 | | | | | | | 1600 | | | | | | VD4 12.16.25 p210 |
| | 31.5 | | | | | | | 1600 | | | | | | VD4 12.16.32 p210 |
| | 40 | | | | 1600 | | | | | | | | | VD4 12.16.40 p210 |
| | 50 | | | | | | | | | 1600 | | | | VD4 12.16.50 p210 |
| | 20 | | | | | | | 2000 | | | | | | VD4 12.20.20 p210 |
| | 25 | | | | | | | 2000 | | | | | | VD4 12.20.25 p210 |
| | 31.5 | | | | | | | 2000 | | | | | | VD4 12.20.32 p210 |
| | 40 | | | | | | | 2000 | | | | | | VD4 12.20.40 p210 |
| | 50 | | | | | | | | | 2000 | | | | VD4 12.20.50 p210 |
| | 20 | | | | | | | 2500 | | | | | | VD4 12.25.20 p210 |
| | 25 | | | | | | | 2500 | | | | | | VD4 12.25.25 p210 |
| | 31.5 | | | | | | | 2500 | | | | | | VD4 12.25.32 p210 |
| | 40 | | | | | | | 2500 | | | | | | VD4 12.25.40 p210 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.

# 5. Description

### VD4 fixed circuit breaker without bottom and top terminals (12 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H=461 | | | H=589 | | H=599 | | | H=610 | | H=636 | |
| | | D=424 | | | D=424 | | D=424 | | | D=459 | | D=459 | |
| kV | kA | u/l=205 | | | u/l=310 | | u/l=310 | | | u/l=310 | | u/l=310 | Circuit breaker type |
| | | l/g=217.5 | | | l/g=238 | | l/g=237.5 | | | l/g=237 | | l/g=237 | |
| | | P=150 | P=210 | P=275 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | |
| | | W=450 | W=570 | W=700 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | |
| 12 | 16 | | | 630 | | | | | | | | | VD4 12.06.16 p275 |
| | 20 | | | 630 | | | | | | | | | VD4 12.06.20 p275 |
| | 25 | | | 630 | | | | | | | | | VD4 12.06.25 p275 |
| | 31.5 | | | 630 | | | | | | | | | VD4 12.06.32 p275 |
| | 16 | | | 1250 | | | | | | | | | VD4 12.12.16 p275 |
| | 20 | | | 1250 | | | | | | | | | VD4 12.12.20 p275 |
| | 25 | | | 1250 | | | | | | | | | VD4 12.12.25 p275 |
| | 31.5 | | | 1250 | | | | | | | | | VD4 12.12.32 p275 |
| | 40 | | | | | 1250 | | | | | | | VD4 12.12.40 p275 |
| | 50 | | | | | | | | | | 1250 | | VD4 12.12.50 p275 |
| | 20 | | | | | | | | 1600 | | | | VD4 12.16.20 p275 |
| | 25 | | | | | | | | 1600 | | | | VD4 12.16.25 p275 |
| | 31.5 | | | | | | | | 1600 | | | | VD4 12.16.32 p275 |
| | 40 | | | | | 1600 | | | | | | | VD4 12.16.40 p275 |
| | 50 | | | | | | | | | | 1600 | | VD4 12.16.50 p275 |
| | 20 | | | | | | | | 2000 | | | | VD4 12.20.20 p275 |
| | 25 | | | | | | | | 2000 | | | | VD4 12.20.25 p275 |
| | 31.5 | | | | | | | | 2000 | | | | VD4 12.20.32 p275 |
| | 40 | | | | | | | | 2000 | | | | VD4 12.20.40 p275 |
| | 50 | | | | | | | | | | 2000 | | VD4 12.20.50 p275 |
| | 20 | | | | | | | | 2500 | | | | VD4 12.25.20 p275 |
| | 25 | | | | | | | | 2500 | | | | VD4 12.25.25 p275 |
| | 31.5 | | | | | | | | 2500 | | | | VD4 12.25.32 p275 |
| | 40 | | | | | | | | 2500 | | | | VD4 12.25.40 p275 |
| | 50 | | | | | | | | | | 2500 | | VD4 12.25.50 p275 |
| | 20 | | | | | | | | | | | 3150 (1) | VD4 12.32.20 p275 |
| | 25 | | | | | | | | | | | 3150 (1) | VD4 12.32.25 p275 |
| | 31.5 | | | | | | | | | | | 3150 (1) | VD4 12.32.32 p275 |
| | 40 | | | | | | | | | | | 3150 (1) | VD4 12.32.40 p275 |
| | 50 | | | | | | | | | | | 3150 (1) | VD4 12.32.50 p275 |

### VD4 fixed circuit breaker without bottom and top terminals (15 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | |
|---|---|---|---|---|
| | | H=461 | H=599 | |
| | | D=424 | D=424 | |
| kV | kA | u/l=205 | u/l=310 | Circuit breaker type |
| | | l/g=217.5 | l/g=237.5 | |
| | | P=150 | P=210 | |
| | | W=450 | W=570 | |
| 15 | 31.5 | 1200 | | VD4/N 15.12.32 p150 |
| | 40 | | 1200 | VD4 15.12.40 p210 |
| | 31.5 | | 2000 | VD4/N 15.20.32 p210 |
| | 40 | | 2000 | VD4 15.20.40 p210 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.
(1) Up to 4000 A with forced ventilation

## VD4 fixed circuit breaker without bottom and top terminals (17.5 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H=461 | | | H=589 | | H=599 | | | H=610 | | H=635 | H=589 | |
| | | D=424 | | | D=424 | | D=424 | | | D=459 | | D=459 | D=424 | |
| kV | kA | u/l=205 | | | u/l=310 | | u/l=310 | | | u/l=310 | | u/l=310 | u/l=310 | Circuit breaker type |
| | | l/g=217.5 | | | l/g=238 | | l/g=237.5 | | | l/g=237 | | l/g=237.5 | l/g=237.5 | |
| | | P=150 | P=210 | P=275 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | P=150 | |
| | | W=450 | W=570 | W=700 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | W=450 | |
| | 16 | 630 | | | | | | | | | | | | VD4 17.06.16 p150 |
| | 20 | 630 | | | | | | | | | | | | VD4 17.06.20 p150 |
| | 25 | 630 | | | | | | | | | | | | VD4 17.06.25 p150 |
| | 31.5 | 630 | | | | | | | | | | | | VD4 17.06.32 p150 |
| | 16 | 1250 | | | | | | | | | | | | VD4 17.12.16 p150 |
| | 20 | 1250 | | | | | | | | | | | | VD4 17.12.20 p150 |
| | 25 | 1250 | | | | | | | | | | | | VD4 17.12.25 p150 |
| | 31.5 | 1250 | | | | | | | | | | | | VD4 17.12.32 p150 |
| | 40 | | | | | | | | | | | | 1250 | VD4 17.12.40 p150 |
| | 16 | | 630 | | | | | | | | | | | VD4 17.06.16 p210 |
| | 20 | | 630 | | | | | | | | | | | VD4 17.06.20 p210 |
| | 25 | | 630 | | | | | | | | | | | VD4 17.06.25 p210 |
| | 31.5 | | 630 | | | | | | | | | | | VD4 17.06.32 p210 |
| | 16 | | 1250 | | | | | | | | | | | VD4 17.12.16 p210 |
| **17.5** | 20 | | 1250 | | | | | | | | | | | VD4 17.12.20 p210 |
| | 25 | | 1250 | | | | | | | | | | | VD4 17.12.25 p210 |
| | 31.5 | | 1250 | | | | | | | | | | | VD4 17.12.32 p210 |
| | 40 | | | | 1250 | | | | | | | | | VD4 17.12.40 p210 |
| | 50 | | | | | | | | | 1250 | | | | VD4 17.12.50 p210 |
| | 20 | | | | | | | 1600 | | | | | | VD4 17.16.20 p210 |
| | 25 | | | | | | | 1600 | | | | | | VD4 17.16.25 p210 |
| | 31.5 | | | | | | | 1600 | | | | | | VD4 17.16.32 p210 |
| | 40 | | | | 1600 | | | | | | | | | VD4 17.16.40 p210 |
| | 50 | | | | | | | | | 1600 | | | | VD4 17.16.50 p210 |
| | 20 | | | | | | | 2000 | | | | | | VD4 17.20.20 p210 |
| | 25 | | | | | | | 2000 | | | | | | VD4 17.20.25 p210 |
| | 31.5 | | | | | | | 2000 | | | | | | VD4 17.20.32 p210 |
| | 40 | | | | | | | 2000 | | | | | | VD4 17.20.40 p210 |
| | 50 | | | | | | | | | 2000 | | | | VD4 17.20.50 p210 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.

# 5. Description

**VD4 fixed circuit breaker without bottom and top terminals (17.5 kV)**

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | | | | | | Circuit breaker type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H=461 | | | H=589 | | H=599 | | | H=610 | | H=635 | |
| | | D=424 | | | D=424 | | D=424 | | | D=459 | | D=459 | |
| kV | kA | u/l=205 | | | u/l=310 | | u/l=310 | | | u/l=310 | | u/l=310 | |
| | | l/g=217.5 | | | l/g=238 | | l/g=237.5 | | | l/g=237 | | l/g=237.5 | |
| | | P=150 | P=210 | P=275 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | |
| | | W=450 | W=570 | W=700 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | |
| 17.5 | 16 | | | 630 | | | | | | | | | VD4 17.06.16 p275 |
| | 20 | | | 630 | | | | | | | | | VD4 17.06.20 p275 |
| | 25 | | | 630 | | | | | | | | | VD4 17.06.25 p275 |
| | 31.5 | | | 630 | | | | | | | | | VD4 17.06.32 p275 |
| | 16 | | | 1250 | | | | | | | | | VD4 17.12.16 p275 |
| | 20 | | | 1250 | | | | | | | | | VD4 17.12.20 p275 |
| | 25 | | | 1250 | | | | | | | | | VD4 17.12.25 p275 |
| | 31.5 | | | 1250 | | | | | | | | | VD4 17.12.32 p275 |
| | 40 | | | | | 1250 | | | | | | | VD4 17.12.40 p275 |
| | 50 | | | | | | | | | | 1250 | | VD4 17.12.50 p275 |
| | 20 | | | | | | | | 1600 | | | | VD4 17.16.20 p275 |
| | 25 | | | | | | | | 1600 | | | | VD4 17.16.25 p275 |
| | 31.5 | | | | | | | | 1600 | | | | VD4 17.16.32 p275 |
| | 40 | | | | | 1600 | | | | | | | VD4 17.16.40 p275 |
| | 50 | | | | | | | | | | 1600 | | VD4 17.16.50 p275 |
| | 20 | | | | | | | | 2000 | | | | VD4 17.20.20 p275 |
| | 25 | | | | | | | | 2000 | | | | VD4 17.20.25 p275 |
| | 31.5 | | | | | | | | 2000 | | | | VD4 17.20.32 p275 |
| | 40 | | | | | | | | 2000 | | | | VD4 17.20.40 p275 |
| | 50 | | | | | | | | | | 2000 | | VD4 17.20.50 p275 |
| | 20 | | | | | | | | 2500 | | | | VD4 17.25.20 p275 |
| | 25 | | | | | | | | 2500 | | | | VD4 17.25.25 p275 |
| | 31.5 | | | | | | | | 2500 | | | | VD4 17.25.32 p275 |
| | 40 | | | | | | | | 2500 | | | | VD4 17.25.40 p275 |
| | 50 | | | | | | | | | | 2500 | | VD4 17.25.50 p275 |
| | 20 | | | | | | | | | | | 3150 (1) | VD4 17.32.20 p275 |
| | 25 | | | | | | | | | | | 3150 (1) | VD4 17.32.25 p275 |
| | 31.5 | | | | | | | | | | | 3150 (1) | VD4 17.32.32 p275 |
| | 40 | | | | | | | | | | | 3150 (1) | VD4 17.32.40 p275 |
| | 50 | | | | | | | | | | | 3150 (1) | VD4 17.32.50 p275 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.
(1) Up to 4000 A with forced ventilation

## VD4 fixed circuit breaker without bottom and top terminals (24 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | |
|---|---|---|---|---|---|
| | | H=631 | | H=642 | |
| | | D=424 | | D=424 | |
| | | u/l=310 | | u/l=310 | |
| kV | kA | l/g=282.5 | | l/g=282.5 | Circuit breaker type |
| | | P=210 | P=275 | P=275 | |
| | | W=570 | W=700 | W=700 | |
| | 16 | 630 | | | VD4 24.06.16 p210 |
| | 20 | 630 | | | VD4 24.06.20 p210 |
| | 25 | 630 | | | VD4 24.06.25 p210 |
| | 16 | 1250 | | | VD4 24.12.16 p210 |
| | 20 | 1250 | | | VD4 24.12.20 p210 |
| | 25 | 1250 | | | VD4 24.12.25 p210 |
| | 31.5 | 1250 | | | VD4 24.12.32 p210 |
| | 16 | | 630 | | VD4 24.06.16 p275 |
| | 20 | | 630 | | VD4 24.06.20 p275 |
| | 25 | | 630 | | VD4 24.06.25 p275 |
| | 16 | | 1250 | | VD4 24.12.16 p275 |
| 24 | 20 | | 1250 | | VD4 24.12.20 p275 |
| | 25 | | 1250 | | VD4 24.12.25 p275 |
| | 16 | | | 1600 | VD4 24.16.16 p275 |
| | 20 | | | 1600 | VD4 24.16.20 p275 |
| | 25 | | | 1600 | VD4 24.16.25 p275 |
| | 31.5 | | | 1600 | VD4 24.16.32 p275 |
| | 16 | | | 2000 | VD4 24.20.16 p275 |
| | 20 | | | 2000 | VD4 24.20.20 p275 |
| | 25 | | | 2000 | VD4 24.20.25 p275 |
| | 31.5 | | | 2000 | VD4 24.20.32 p275 |
| | 25 | | | 2500 | VD4 24.25.25 p275 |
| | 31.5 | | | 2500 | VD4 24.25.32 p275 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.

# 5. Description

### VD4 fixed circuit breaker without bottom and top terminals (36-40.5 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | Circuit breaker type |
|---|---|---|---|---|---|---|
| | | H = 884 | | | | |
| | | W = 796 | | | | |
| | | D = 501 | | | | |
| kV | kA | u/l = 328 | | | | |
| | | l/g = 428.5 | | | | |
| | | P = 275 | | | | |
| 36 | 20 | 1250 A | | | | VD4 36.12.20 p275 |
| | 25 | 1250 A | | | | VD4 36.12.25 p275 |
| | 31.5 | 1250 A | | | | VD4 36.12.32 p275 |
| | 20 | | 1600 A | | | VD4 36.16.20 p275 |
| | 25 | | 1600 A | | | VD4 36.16.25 p275 |
| | 31.5 | | 1600 A | | | VD4 36.16.32 p275 |
| | 20 | | | 2000 A | | VD4 36.20.20 p275 |
| | 25 | | | 2000 A | | VD4 36.20.25 p275 |
| | 31.5 | | | 2000 A | | VD4 36.20.32 p275 |
| | 20 | | | | 2500 A | VD4 36.25.20 p275 |
| | 25 | | | | 2500 A | VD4 36.25.25 p275 |
| | 31.5 | | | | 2500 A | VD4 36.25.32 p275 |
| 40.5 | 20 | 1250 A | | | | VD4 40.12.20 p275 |
| | 25 | 1250 A | | | | VD4 40.12.25 p275 |
| | 31.5 | 1250 A | | | | VD4 40.12.32 p275 |
| | 20 | | 1600 A | | | VD4 40.16.20 p275 |
| | 25 | | 1600 A | | | VD4 40.16.25 p275 |
| | 31.5 | | 1600 A | | | VD4 40.16.32 p275 |
| | 20 | | | 2000 A | | VD4 40.20.20 p275 |
| | 25 | | | 2000 A | | VD4 40.20.25 p275 |
| | 31.5 | | | 2000 A | | VD4 40.20.32 p275 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.

**5.5.3. Standard fittings for fixed circuit breakers**

The basic versions of the fixed circuit breakers are three-pole and fitted with:

- EL type manual operating mechanism
- mechanical signalling device for closing spring charged/ discharged
- mechanical signalling device for circuit breaker open/closed
- closing pushbutton, opening pushbutton and operation counter
- set of ten circuit breaker open/closed auxiliary contacts

  Note: with the set of ten auxiliary contacts supplied as standard and the maximum number of electrical applications possible, three make contacts (signalling circuit breaker open) and five break contacts (signalling circuit breaker closed) are available.

- lever for manual closing spring charging




VD4 evo - up to 17 kV




VD4 - up to 24 kV




VD4 - 36 kV

## 5.6. Withdrawable circuit breakers

The withdrawable circuit breakers up to 24 kV are available for UniGear ZS1 and UniSec switchgear, PowerCube modules (see fig. 5a) and for ZS8.4 switchgear (see fig. 5b).
The 36 kV circuit breakers are available for ZS2 switchgear.
They consist of a truck on which the supporting structure of the circuit breaker is fixed.

**Circuit breakers for UniGear ZS1 and UniSec switchgear and for PowerCube modules (fig. 5a)**

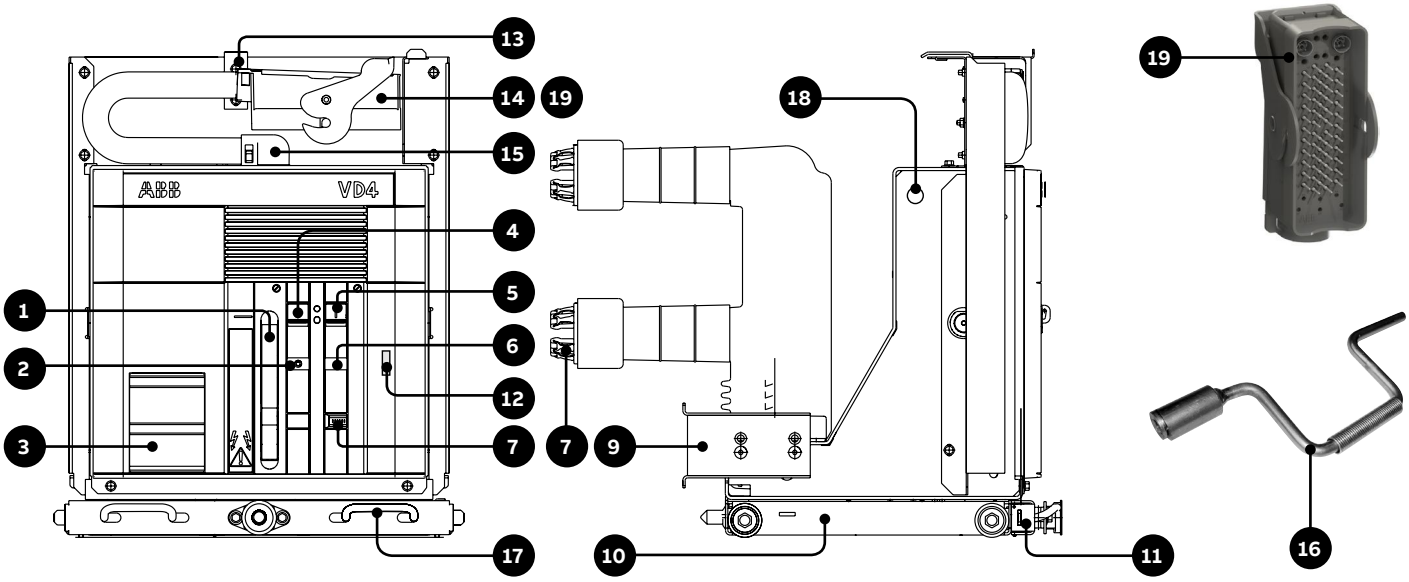
The cord with the connector (14) (plug) for connection of the operating mechanism electrical accessories comes out of the connection (15).
The strikers for operating the contacts (connected/ isolated) placed in the switchgear are fixed in the top part of the circuit breaker.
The shutter actuator (9) (roller (18) for UniSec version) are provided for operating the segregation shutters of the medium voltage contacts of the enclosure or of the switchgear are fixed on the sides of the circuit breaker.
The crosspiece with the handles (17) for hooking up the circuit breaker for the racking-in/out operations by means of the special operating lever (16) is mounted on the front part of the circuit breaker truck.
The circuit breaker is completed with the isolating contacts (8).

# 5. Description

The withdrawable circuit breaker is fitted with special locks on the front crosspiece, which allow hooking up into the corresponding couplings of the switchgear.
The locks can only be activated by the handles with the truck fully resting against the crosspiece.
The operating lever (16) must be fully inserted (also see par. 7.5.). A lock prevents the truck from advancing into the enclosure or fixed part when the earthing switch is closed.
Another lock prevents racking-in and racking-out with the circuit breaker closed. With the truck in an intermediate position between isolated and connected, a further lock prevents circuit breaker closing (either mechanical or electrical).
A locking magnet is also mounted on the truck which, when de-energised, prevents the truck racking-in operation.

On request, an interlock is available which prevents racking-in of the circuit breaker with the door open, and door opening with the circuit breaker closed.
The lever for loading the closing spring (1) in the manual mode is built into the operating mechanism. The spring is loaded by repeatedly lowering the lever with linear movements until the yellow indicator (6) appears to show that loading is complete.
The spring can only be loaded with the switchgear door open.
Comply with the instructions in the UniGear switchgear manual for the operations that can be performed with the door open.

Note: on request, the closing spring loading device for withdrawable circuit breakers for UniGear switchgear can be supplied with the lever outside the operating mechanism and a rotary loading movement. This device is part of the standard equipment for VD4/ZS8 withdrawable circuit breakers only (see detail 1 of Fig. 5b on the next page). This rotary loading device allows the closing spring to be loaded with the switchgear door closed.




Caption
1 Lever for manually charging the closing spring
2 Signalling device for circuit breaker open/closed
3 Rating plate
4 Opening pushbutton
5 Closing pushbutton
6 Signalling device for closing spring charged/discharged
7 Operation counter
8 Isolating contacts
9 Slide for operating the switchgear shutters (UniGear ZS1, PowerCube, ZS8.4)
10 Truck
11 Locks for hooking into the fixed part
12 Mechanical override of the undervoltage release (on request)
13 Strikers for activating the contacts placed in the enclosure
14 Connector (plug)
15 Cabling connection
16 Operating lever for circuit breaker racking-in/out
17 Handles for activating the locks (11)
18 Shutters actuator (for UniSec version only)
19 Connector (plug) with two Harting connectors - VD4 evo only

Fig. 5a

**Circuit breakers for ZS8.4 switchgear (fig. 5b)**
The socket (13) takes the connector (plug) placed in the switchgear.
The slides (9) for operating the segregation shutters of the medium voltage contacts of the switchgear are fixed on the sides of the circuit breaker.
The crosspiece with the handles (17) for hooking up the circuit breaker for the racking-in/out operations by means of the special operating lever (16) is mounted on the front part of the circuit breaker truck.
The circuit breaker is completed with the isolating contacts (8).
The withdrawable circuit breaker is fitted with special locks, described below (see fig. 5c - 5d).

**1) Prevention of traverse with circuit breaker closed**

With the circuit breaker closed, the feeler pin (16 - fig. 5c) prevents the shutter sliding (19 - fig. 5c) and therefore insertion of the lever (20 - fig. 5c) for traverse of the apparatus.

**2) Prevention of traverse with socket-plug disconnected**

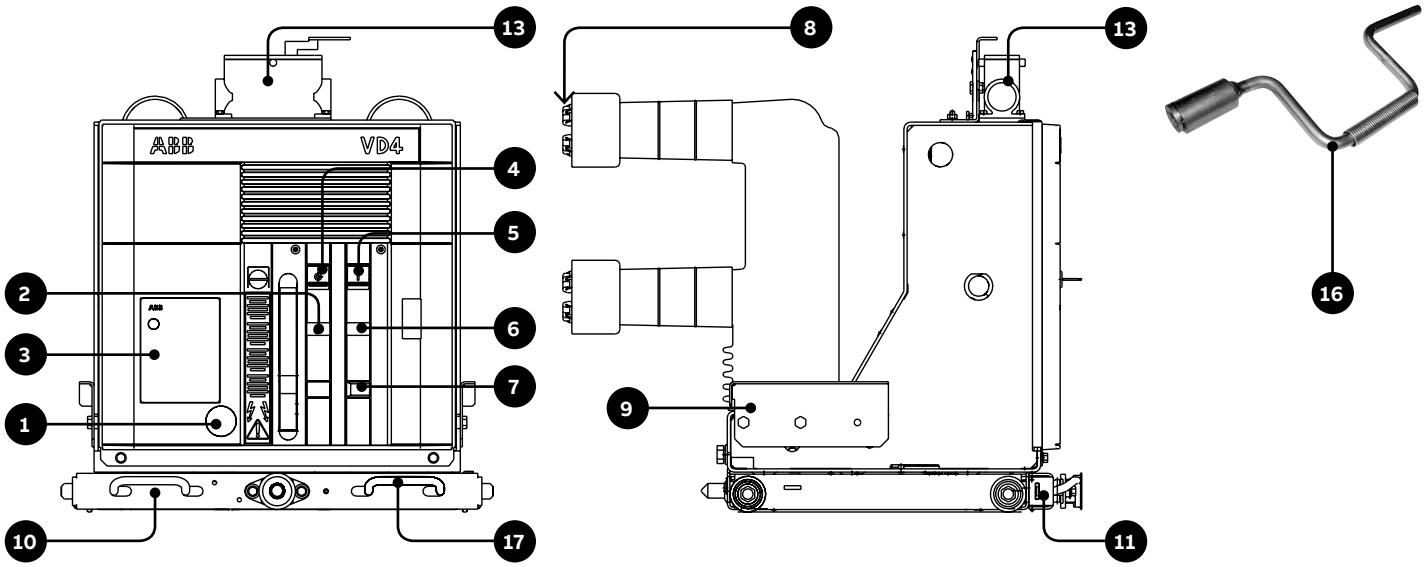
When the plug is not inserted in the socket (13), the stem (21 - fig. 5c) prevents the plate (22 - fig. 5c) lifting and traverse of the apparatus.

**3) Prevention of switchgear door closing with socketplug disconnected (*)**

When the plug is not inserted in the socket (13), the feeler pin (23 - fig. 5d) prevents door closing.

**4) Prevention of circuit breaker racking-out with the socket-plug connected (*)**

When the plug is inserted in the socket (13), the lock bolt (29 - fig. 5d) hits the pin (30 - fig. 5d) preventing the apparatus from being racked out of the switchgear.




Caption
1 Coupling for the manual closing spring charging lever (*)
2 Signalling device for circuit breaker open/closed
3 Rating plate
4 Opening pushbutton
5 Closing pushbutton
6 Signalling device for closing spring charged/discharged
7 Operation counter
8 Isolating contacts
9 Slide for operating the switchgear shutters
10 Truck
11 Locks for hooking into the fixed part
13 Connector (plug)
16 Operating lever for circuit breaker racking-in/out (a special version is provided for VD4/ZS8 Preussen Elektra EON circuit breakers)
17 Handles for activating the locks (11)
(*) Only VD4/ZS8 Preussen - Elektra EON version.

Fig. 5b

# 5. Description

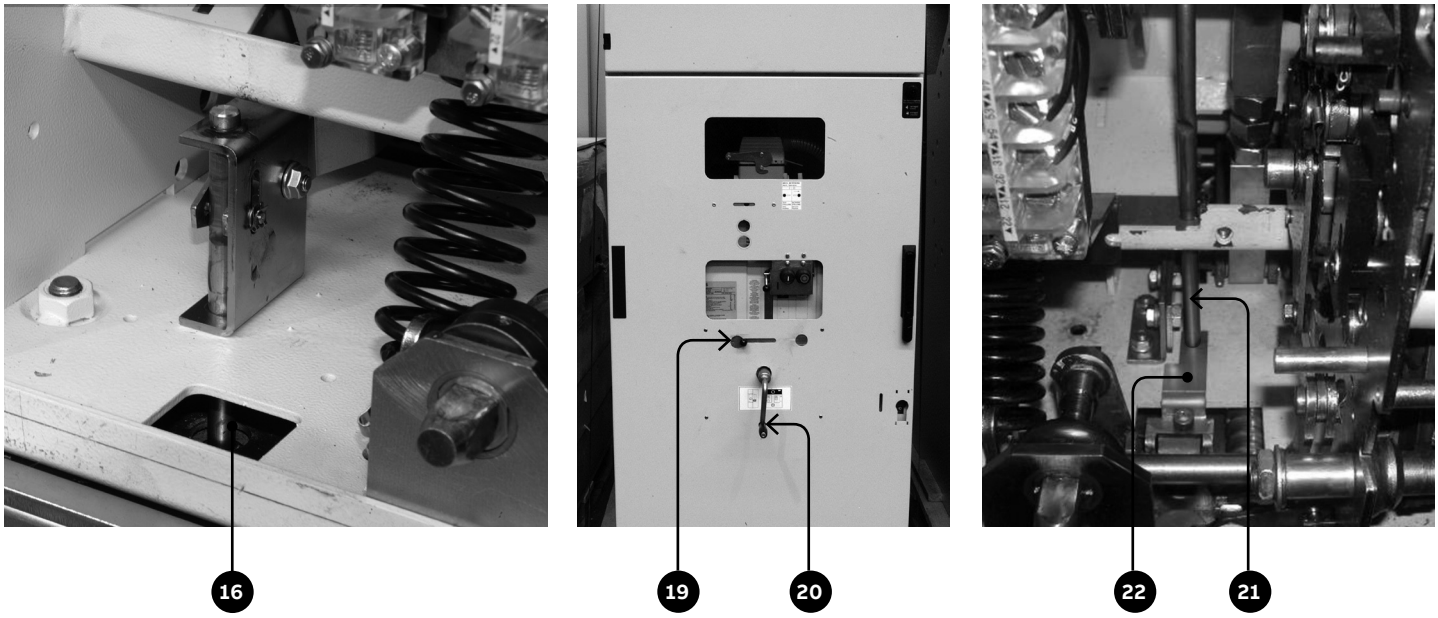



Fig. 5c

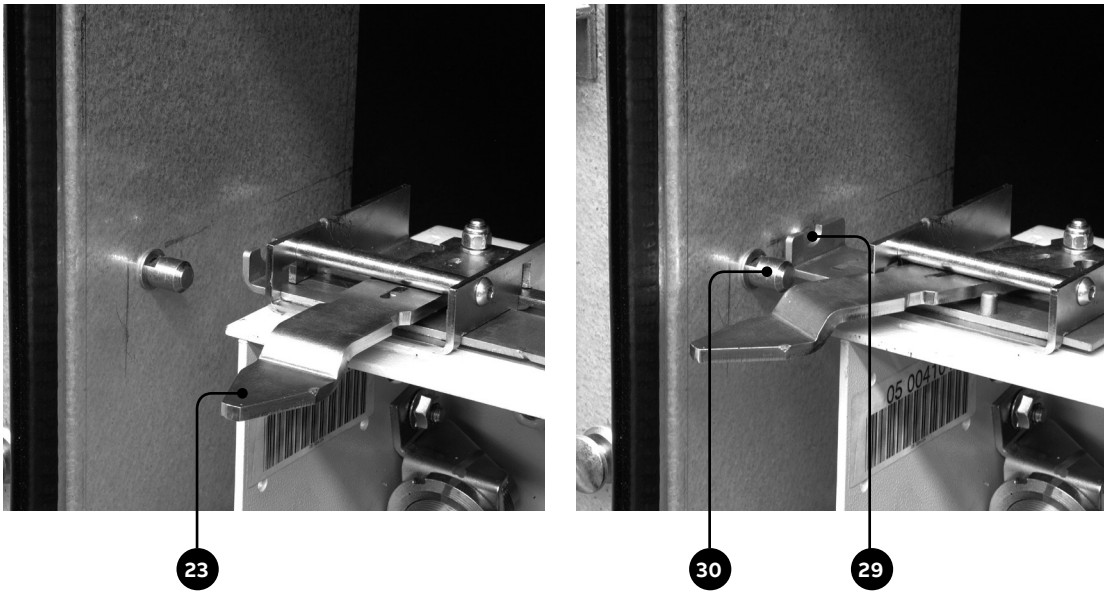


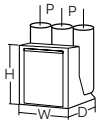

Fig. 5d

# 5. Description

### 5.6.1. General characteristics of withdrawable circuit breakers for UniGear ZS1 switchgear




**General characteristics of withdrawable circuit breakers for UniGear ZS1 switchgear (12 kV)**

| **Circuit breaker** | | **VD4/P 12** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | | | |
| Rated voltage | Ur [kV] | 12 | | | | | | | |
| Rated insulation voltage | Us [kV] | 12 | | | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | | | | | | |
| Impulse withstand voltage | Up [kV] | 75 | | | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | | | |
| Rated normal current (40 °C) (1) | Ir [A] | 630 | 1250 | 1250 (4) | 1250 | 1250 | 1250 | 1600 | 1600 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | - | - | - | - | - | - |
| | | 20 | 20 | - | - | - | - | 20 | 20 |
| | | 25 | 25 | - | - | - | - | 25 | 25 |
| | | 31.5 | 31.5 | - | - | - | - | 31.5 | 31.5 |
| | | - | - | 40 (4) | 40 | 40 | - | - | - |
| | | - | - | - | - | - | 50 | - | - |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | - | - | - | - | - | - |
| | | 20 | 20 | - | - | - | - | 20 | 20 |
| | | 25 | 25 | - | - | - | - | 25 | 25 |
| | | 31.5 | 31.5 | - | - | - | - | 31.5 | 31.5 |
| | | - | - | 40 (4) | 40 | 40 | - | - | - |
| | | - | - | - | - | - | 50 | - | - |
| Making capacity | Ip [kA] | 40 | 40 | - | - | - | - | - | - |
| | | 50 | 50 | - | - | - | - | 50 | 50 |
| | | 63 | 63 | - | - | - | - | 63 | 63 |
| | | 80 | 80 | - | - | - | - | 80 | 80 |
| | | - | - | 104 (4) | 100 | 100 | - | - | - |
| | | - | - | - | - | - | 125 | - | - |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • | • |
| Opening time | [ms] | 33 ... 60 | | | | | | | |
| Arcing time | [ms] | 10 ... 15 | | | | | | | |
| Total breaking time | [ms] | 43 ... 75 | | | | | | | |
| Closing time | [ms] | 30 ... 60 | | | | | | | |
| Maximum overall dimensions   | H [mm] | 628 | 628 | 693 | 691 | 691 | 691 | 691 | 691 |
| | W [mm] | 503 | 503 | 503 | 653 | 853 | 681 | 653 | 853 |
| | D [mm] | 662 | 662 | 651 | 641 | 642 | 643 | 642 | 642 |
| | Pole distance P [mm] | 150 | 150 | 150 | 210 | 275 | 210 | 210 | 275 |
| Weight | [kg] | 116 | 116 | 111 | 174 | 176 | 180 | 160 | 166 |
| Standardised table of dimensions | TN | 7412 (3) | 7412 (3) | 2RDA040163 | - | - | - | 7415 (3) | 7416 (3) |
| | 1VCD | - | - | | 003284 (3) | 003286 (3) | 003444 | - | - |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | | | |

(1) Rated current guaranteed with circuit breaker installed in UniGear ZS1 switchgear and with 40 °C ambient temperature.
(2) Up to 4000 A with forced ventilation
(3) Poles in polyamide
(4) Available in VD4 evo only

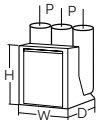
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **VD4/P 12** | | | | | | | | | | | |
| • | | | | | | | | | | | |
| 12 | | | | | | | | | | | |
| 12 | | | | | | | | | | | |
| 28 | | | | | | | | | | | |
| 75 | | | | | | | | | | | |
| 50-60 | | | | | | | | | | | |
| 1600 | 1600 | 1600 | 1600 | 2000 | 2000 | 2000 | 2000 | 2500 | 2500 | 3150 (²) | 3150 (²) |
| – | – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | 20 | 20 | – | – | 20 | – | 20 | – |
| – | – | – | – | 25 | 25 | – | – | 25 | – | 25 | – |
| – | – | – | – | 31.5 | 31.5 | – | – | 31.5 | – | 31.5 | – |
| 40 | 40 | – | – | 40 | 40 | – | – | 40 | – | 40 | – |
| – | – | 50 | 50 | – | – | 50 | 50 | – | 50 | – | 50 |
| – | – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | 20 | 20 | – | – | 20 | – | 20 | – |
| – | – | – | – | 25 | 25 | – | – | 25 | – | 25 | – |
| – | – | – | – | 31.5 | 31.5 | – | – | 31.5 | – | 31.5 | – |
| 40 | 40 | – | – | 40 | 40 | – | – | 40 | – | 40 | – |
| – | – | 50 | 50 | – | – | 50 | 50 | – | 50 | – | 50 |
| – | – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | 50 | 50 | – | – | 50 | – | 50 | – |
| – | – | – | – | 63 | 63 | – | – | 63 | – | 63 | – |
| – | – | – | – | 80 | 80 | – | – | 80 | – | 80 | – |
| 100 | 100 | – | – | 100 | 100 | – | – | 100 | – | 100 | – |
| – | – | 125 | 125 | – | – | 125 | 125 | – | 125 | – | 125 |
| • | • | • | • | • | • | • | • | • | • | • | • |
| 33 ... 60 | | | | | | | | | | | |
| 10 ... 15 | | | | | | | | | | | |
| 43 ... 75 | | | | | | | | | | | |
| 30 ... 60 | | | | | | | | | | | |
| 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 730 | 742 |
| 653 | 853 | 681 | 853 | 653 | 853 | 681 | 853 | 853 | 853 | 853 | 853 |
| 641 | 642 | 643 | 643 | 642 | 642 | 643 | 643 | 640 | 643 | 640 | 643 |
| 210 | 275 | 210 | 275 | 210 | 275 | 210 | 275 | 275 | 275 | 275 | 275 |
| 174 | 176 | 180 | 193 | 160 | 166 | 190 | 205 | 186 | 225 | 221 | 240 |
| – | – | – | – | 7415 (³) | 7416 (³) | – | – | 7417 (³) | – | – | – |
| 003284 (³) | 003286 (³) | 003444 | 003445 | – | – | 003444 | 003445 | – | 003446 | 000153 (³) | 003447 |
| - 5 ... + 40 | | | | | | | | | | | |
| • | | | | | | | | | | | |
| • | | | | | | | | | | | |


ABB

# 5. Description

**General characteristics of withdrawable circuit breakers for OeM switchgear (15kV)**

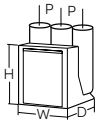



| Circuit breaker | | OeM panel | VD4/N/P 15 | |
|---|---|---|---|---|
| Standard | | IEEE C37.04 | • | |
| Rated voltage | | [kV] | 15 | |
| Rated frequency | | [Hz] | 60 | |
| Short-circuit breaking current Isc | | [kA] | 31.5 | |
| Rated current Ir | | [A] | 1200 | 2000 |
| Short-time withstand current | | [A] | 31.5 | |
| Short circuit withstand | | [A] | 3 | |
| Close and latch capability | | [kA] | 82 | |
| Operation sequence | | [O - 0,3 s - CO - 3 min - CO] | • | |
| % DC component | | [%] | 40 | |
| Interrupting time | | [ms] | 50 | |
| Closing time | | [ms] | 30…60 | |
| Mechanical endurance class | | [M2] | 10k | |
| Lightning impulse withstand voltage Up | | [kV] | 95 | |
| Power frequency withstand voltage Ud | | [kV] | 36 | |
| Operating temperature | | [°C] | -5…+40 | |
| Maximum overall dimensions   | Height | [mm] | 632 | 691 |
| | Width | [mm] | 503 | 653 |
| | Depth | [mm] | 664 | 642 |
| | Pole distance | [mm] | 150 | 210 |
| Standard table of dimensions | | TN | 7412 | 7415 |
| Weight | | [kg] | 116 | 160 |

# 5. Description

**General characteristics of withdrawable circuit breakers for UniGear ZS1 switchgear (17.5 kV)**




| Circuit breaker | | | VD4/P 17 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Standards | | IEC 62271-100 | • | | | | | | |
| Rated voltage | | Ur [kV] | 17.5 | | | | | | |
| Rated insulation voltage | | Us [kV] | 17.5 | | | | | | |
| Withstand voltage at 50 Hz | | Ud (1 min) [kV] | 38 | | | | | | |
| Impulse withstand voltage | | Up [kV] | 95 | | | | | | |
| Rated frequency | | fr [Hz] | 50-60 | | | | | | |
| Rated normal current (40 °C) (1) | | Ir [A] | 630 | 1250 | 1250 (4) | 1250 | 1250 | 1250 | 1600 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | | Isc [kA] | 16 | 16 | - | - | - | - | - |
| | | | 20 | 20 | - | - | - | - | 20 |
| | | | 25 | 25 | - | - | - | - | 25 |
| | | | 31.5 | 31.5 | - | - | - | - | 31.5 |
| | | | - | - | 40 (4) | 40 | 40 | - | - |
| | | | - | - | - | - | - | 50 | - |
| Rated short-time withstand current (3s) | | Ik [kA] | 16 | 16 | - | - | - | - | - |
| | | | 20 | 20 | - | - | - | - | 20 |
| | | | 25 | 25 | - | - | - | - | 25 |
| | | | 31.5 | 31.5 | - | - | - | - | 31.5 |
| | | | - | - | 40 (4) | 40 | 40 | - | - |
| | | | - | - | - | - | - | 50 | - |
| Making capacity | | Ip [kA] | 40 | 40 | - | - | - | - | - |
| | | | 50 | 50 | - | - | - | - | 50 |
| | | | 63 | 63 | - | - | - | - | 63 |
| | | | 80 | 80 | - | - | - | - | 80 |
| | | | - | - | 104 (4) | 100 | 100 | - | - |
| | | | - | - | - | - | - | 125 | - |
| Operation sequence | | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • |
| Opening time | | [ms] | 33 ... 60 | | | | | | |
| Arcing time | | [ms] | 10 ... 15 | | | | | | |
| Total breaking time | | [ms] | 43 ... 75 | | | | | | |
| Closing time | | [ms] | 30 ... 60 | | | | | | |
| Maximum overall dimensions |  | H [mm] | 632 | 632 | 693 | 691 | 691 | 691 | 691 |
| | | W [mm] | 503 | 503 | 503 | 653 | 853 | 681 | 653 |
| | | D [mm] | 664 | 664 | 651 | 641 | 642 | 643 | 642 |
| | | Pole distance P [mm] | 150 | 150 | 150 | 210 | 275 | 210 | 210 |
| Weight | | [kg] | 116 | 116 | 111 | 174 | 176 | 180 | 160 |
| Standardised table of dimensions | | TN | 7412 (3) | 7412 (3) | 2RDA040163- | | - | - | 7415 (3) |
| | | 1VCD | - | - | - | 003284 (3) | 003286 (3) | 003444 | - |
| Operating temperature | | [°C] | - 5 ... + 40 | | | | | | |
| Tropicalization | | IEC: 60068-2-30, 60721-2-1 | • | | | | | | |
| Electromagnetic compatibility | | IEC: 62271-1 | • | | | | | | |

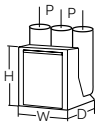
(1) Rated current guaranteed with circuit breaker installed in UniGear ZS1 switchgear and with 40 °C ambient temperature.
(2) Up to 4000 A with forced ventilation.
(3) Poles in polyamide
(4) Available in VD4 evo only

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VD4/P 17** | | | | | | | | | | | | |
| • | | | | | | | | | | | | |
| 17.5 | | | | | | | | | | | | |
| 17.5 | | | | | | | | | | | | |
| 38 | | | | | | | | | | | | |
| 95 | | | | | | | | | | | | |
| 50-60 | | | | | | | | | | | | |
| 1600 | 1600 | 1600 | 1600 | 1600 | 2000 | 2000 | 2000 | 2000 | 2500 | 2500 | 3150 (²) | 3150 (²) |
| - | – | – | – | – | – | – | – | – | – | – | – | – |
| 20 | – | – | – | – | 20 | 20 | – | – | 20 | – | 20 | – |
| 25 | – | – | – | – | 25 | 25 | – | – | 25 | – | 25 | – |
| 31.5 | – | – | – | – | 31.5 | 31.5 | – | – | 31.5 | – | 31.5 | – |
| - | 40 | 40 | – | – | 40 | 40 | – | – | 40 | – | 40 | – |
| - | – | – | 50 | 50 | – | – | 50 | 50 | – | 50 | – | 50 |
| - | – | – | – | – | – | – | – | – | – | – | – | – |
| 20 | – | – | – | – | 20 | 20 | – | – | 20 | – | 20 | – |
| 25 | – | – | – | – | 25 | 25 | – | – | 25 | – | 25 | – |
| 31.5 | – | – | – | – | 31.5 | 31.5 | – | – | 31.5 | – | 31.5 | – |
| - | 40 | 40 | – | – | 40 | 40 | – | – | 40 | – | 40 | – |
| - | – | – | 50 | 50 | – | – | 50 | 50 | – | 50 | – | 50 |
| - | – | – | – | – | – | – | – | – | – | – | – | – |
| 50 | – | – | – | – | 50 | 50 | – | – | 50 | – | 50 | – |
| 63 | – | – | – | – | 63 | 63 | – | – | 63 | – | 63 | – |
| 80 | – | – | – | – | 80 | 80 | – | – | 80 | – | 80 | – |
| - | 100 | 100 | – | – | 100 | 100 | – | – | 100 | – | 100 | – |
| - | – | – | 125 | 125 | – | – | 125 | 125 | – | 125 | – | 125 |
| • | • | • | • | • | • | • | • | • | • | • | • | • |
| 33 ... 60 | | | | | | | | | | | | |
| 10 ... 15 | | | | | | | | | | | | |
| 43 ... 75 | | | | | | | | | | | | |
| 30 ... 60 | | | | | | | | | | | | |
| 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 730 | 742 |
| 853 | 653 | 853 | 681 | 853 | 653 | 853 | 681 | 853 | 853 | 853 | 853 | 853 |
| 642 | 641 | 642 | 643 | 643 | 642 | 642 | 643 | 643 | 640 | 643 | 640 | 643 |
| 275 | 210 | 275 | 210 | 275 | 210 | 275 | 210 | 275 | 275 | 275 | 275 | 275 |
| 166 | 174 | 176 | 180 | 193 | 160 | 166 | 190 | 205 | 186 | 225 | 221 | 240 |
| 7416 (³) | – | – | – | – | 7415 (³) | 7416 (³) | – | – | 7417 (³) | – | – | – |
| - | 003284 (³) | 003286 (³) | 003444 | 003445 | – | – | 003444 | 003445 | – | 003446 | 000153 (³) | 003447 |
| - 5 ... + 40 | | | | | | | | | | | | |
| • | | | | | | | | | | | | |
| • | | | | | | | | | | | | |

# 5. Description

**General characteristics of withdrawable circuit breakers for UniGear ZS1 switchgear (24 kV)**

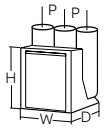



| **Circuit breaker** | | **VD4/P 24** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | | | |
| Rated voltage | Ur [kV] | 24 | | | | | | | |
| Rated insulation voltage | Us [kV] | 24 | | | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 50 | | | | | | | |
| Impulse withstand voltage | Up [kV] | 125 | | | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | | | |
| Rated normal current (40 °C) (1) | Ir [A] | 630 | 630 | 1250 | 1250 | 1600 | 2000 | 2500 (2) | 3150 (3) |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | – |
| | | – | – | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | – |
| | | – | – | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 | 40 | 40 | – |
| | | 50 | 50 | 50 | 50 | 50 | 50 | 50 | – |
| | | 63 | 63 | 63 | 63 | 63 | 63 | 63 | – |
| | | – | – | 80 | 80 | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • | • |
| Opening time | [ms] | 33 ... 60 | | | | | | | |
| Arcing time | [ms] | 10 ... 15 | | | | | | | |
| Total breaking time | [ms] | 43 ... 75 | | | | | | | |
| Closing time | [ms] | 30 ... 60 | | | | | | | |
| Maximum overall dimensions   | H [mm] | 794 | 794 | 794 | 794 | 838 | 838 | 838 | 838 |
| | W [mm] | 653 | 853 | 653 | 853 | 853 | 853 | 853 | 853 |
| | D [mm] | 802 | 802 | 802 | 802 | 790 | 790 | 790 | 790 |
| | Pole distance P [mm] | 210 | 275 | 210 | 275 | 275 | 275 | 275 | 275 |
| Weight | [kg] | 140 | 148 | 140/146 (4) | 148 | 228 | 228 | 228 | 277 |
| Standardised table of dimensions | TN | 7413 | 7414 | 7413 | 7414 | 7418 | 7418 | 7418 | – |
| | 1VCD | – | – | 000173 (4) | | – | – | – | 000177 |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | | | |

(1) Rated current guaranteed with circuit breaker installed in UniGear ZS1 switchgear and with 40 °C ambient temperature.
(2) 2300 A rated current guaranteed with natural ventilation; 2500 A rated current guaranteed with forced ventilation.
(3) 2700 A rated current guaranteed with natural ventilation; 3150 A rated current guaranteed with forced ventilation.
(4) 31.5 kA version.

## Withdrawable circuit breakers for UniGear ZS2 switchgear (36 kV)



| Circuit breaker | | VD4/W 36 | | | | |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | |
| Rated voltage | Ur [kV] | 36 | | | | |
| Rated insulation voltage | Us [kV] | 36 | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 70 | | | | |
| Impulse withstand voltage | Up [kV] | 170 | | | | |
| Rated frequency | fr [Hz] | 50 | | | | |
| Rated normal current (40 °C) | Ir [A] | 1250 | 1600 | 2000 | 2500 (1) | 3150 (2) |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 |
| | | 80 | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| Opening time | [ms] | 35 ... 60 | | | | |
| Arcing time | [ms] | 10 ... 15 | | | | |
| Total breaking time | [ms] | 45 ... 75 | | | | |
| Closing time | [ms] | 50 ... 65 | | | | |
| Maximum overall dimensions   | H [mm] | 974 | 974 | 974 | 974 | 974 |
| | W [mm] | 880 | 880 | 880 | 880 | 880 |
| | D [mm] | 789 | 789 | 789 | 789 | 789 |
| | Pole distance P [mm] | 275 | 275 | 275 | 275 | 275 |
| Weight | [kg] | 230 | 245 | 275 | 275/315 | 315 |
| Standardised table of dimensions | TN | 1VYN300901-KG | 1VYN300901-RA | 1VYN300901-RA | 1VYN300901-RA (1) 1VYN300901-RB | 1VYN300901-RB |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

(1) 2500 A with forced ventilation and tulip contacts diameter 79 mm (TN 1VYN300901-RA).
(2) 3150 A with forced ventilation.

# 5. Description

### 5.6.2. Types of withdrawable circuit breakers available for UniGear ZS1 switchgear

**VD4 withdrawable circuit breaker (12 kV)**

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | W=650 | W=800 | W=1000 | W=1000 | W=1000 | W=650 | |
| | | P=150 | P=210 | P=275 | P=275 | P=275 | P=150 | |
| kV | kA | u/l=205 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | Circuit breaker type |
| | | ø=35 | ø=79 | ø=79 | ø=109 | ø=109 | ø=45 | |
| | 16 | 630 | | | | | | VD4/P 12.06.16 p150 |
| | 20 | 630 | | | | | | VD4/P 12.06.20 p150 |
| | 25 | 630 | | | | | | VD4/P 12.06.25 p150 |
| | 31.5 | 630 | | | | | | VD4/P 12.06.32 p150 |
| | 16 | 1250 | | | | | | VD4/P 12.12.16 p150 |
| | 20 | 1250 | | | | | | VD4/P 12.12.20 p150 |
| | 25 | 1250 | | | | | | VD4/P 12.12.25 p150 |
| | 31.5 | 1250 | | | | | | VD4/P 12.12.32 p150 |
| | 40 | | | | | | 1250 | VD4/P 12.12.40 p150 |
| | 40 | | 1250 | | | | | VD4/P 12.12.40 p210 |
| | 50 | | 1250 | | | | | VD4/P 12.12.50 p210 |
| | 20 | | 1600 | | | | | VD4/P 12.16.20 p210 |
| | 25 | | 1600 | | | | | VD4/P 12.16.25 p210 |
| | 31.5 | | 1600 | | | | | VD4/P 12.16.32 p210 |
| | 40 | | 1600 | | | | | VD4/P 12.16.40 p210 |
| | 50 | | 1600 | | | | | VD4/P 12.16.50 p210 |
| | 20 | | 2000 | | | | | VD4/P 12.20.20 p210 |
| | 25 | | 2000 | | | | | VD4/P 12.20.25 p210 |
| | 31.5 | | 2000 | | | | | VD4/P 12.20.32 p210 |
| | 40 | | 2000 | | | | | VD4/P 12.20.40 p210 |
| | 50 | | 2000 | | | | | VD4/P 12.20.50 p210 |
| 12 | 40 | | | 1250 | | | | VD4/P 12.12.40 p275 |
| | 20 | | | 1600 | | | | VD4/P 12.16.20 p275 |
| | 25 | | | 1600 | | | | VD4/P 12.16.25 p275 |
| | 31.5 | | | 1600 | | | | VD4/P 12.16.32 p275 |
| | 40 | | | 1600 | | | | VD4/P 12.16.40 p275 |
| | 50 | | | 1600 | | | | VD4/P 12.16.50 p275 |
| | 20 | | | 2000 | | | | VD4/P 12.20.20 p275 |
| | 25 | | | 2000 | | | | VD4/P 12.20.25 p275 |
| | 31.5 | | | 2000 | | | | VD4/P 12.20.32 p275 |
| | 40 | | | 2000 | | | | VD4/P 12.20.40 p275 |
| | 50 | | | 2000 | | | | VD4/P 12.20.50 p275 |
| | 20 | | | | 2500 | | | VD4/P 12.25.20 p275 |
| | 25 | | | | 2500 | | | VD4/P 12.25.25 p275 |
| | 31.5 | | | | 2500 | | | VD4/P 12.25.32 p275 |
| | 40 | | | | 2500 | | | VD4/P 12.25.40 p275 |
| | 50 | | | | 2500 | | | VD4/P 12.25.50 p275 |
| | 20 | | | | | 3150 (1) | | VD4/P 12.32.20 p275 |
| | 25 | | | | | 3150 (1) | | VD4/P 12.32.25 p275 |
| | 31.5 | | | | | 3150 (1) | | VD4/P 12.32.32 p275 |
| | 40 | | | | | 3150 (1) | | VD4/P 12.32.40 p275 |
| | 50 | | | | | 3150 (1) | | VD4/P 12.32.50 p275 |

W = Width of the switchgear..
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) Up to 4000 A rated current guaranteed with forced ventilation.

## VD4 withdrawable circuit breaker (17.5 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | W=650 | W=800 | W=1000 | W=1000 | W=1000 | W=650 | |
| | | P=150 | P=210 | P=275 | P=275 | P=275 | P=150 | |
| kV | kA | u/l=205 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | Circuit breaker type |
| | | ø=35 | ø=79 | ø=79 | ø=109 | ø=109 | ø=45 | |
| 17.5 | 16 | 630 | | | | | | VD4/P 17.06.16 p150 |
| | 20 | 630 | | | | | | VD4/P 17.06.20 p150 |
| | 25 | 630 | | | | | | VD4/P 17.06.25 p150 |
| | 31.5 | 630 | | | | | | VD4/P 17.06.32 p150 |
| | 16 | 1250 | | | | | | VD4/P 17.12.16 p150 |
| | 20 | 1250 | | | | | | VD4/P 17.12.20 p150 |
| | 25 | 1250 | | | | | | VD4/P 17.12.25 p150 |
| | 31.5 | 1250 | | | | | | VD4/P 17.12.32 p150 |
| | 40 | | | | | | 1250 | VD4/P 17.12.40 p150 |
| | 40 | | 1250 | | | | | VD4/P 17.12.40 p210 |
| | 50 | | 1250 | | | | | VD4/P 17.12.50 p210 |
| | 20 | | 1600 | | | | | VD4/P 17.16.20 p210 |
| | 25 | | 1600 | | | | | VD4/P 17.16.25 p210 |
| | 31.5 | | 1600 | | | | | VD4/P 17.16.32 p210 |
| | 40 | | 1600 | | | | | VD4/P 17.16.40 p210 |
| | 50 | | 1600 | | | | | VD4/P 17.16.50 p210 |
| | 20 | | 2000 | | | | | VD4/P 17.20.20 p210 |
| | 25 | | 2000 | | | | | VD4/P 17.20.25 p210 |
| | 31.5 | | 2000 | | | | | VD4/P 17.20.32 p210 |
| | 40 | | 2000 | | | | | VD4/P 17.20.40 p210 |
| | 50 | | 2000 | | | | | VD4/P 17.20.50 p210 |
| | 40 | | | 1250 | | | | VD4/P 17.12.40 p275 |
| | 20 | | | 1600 | | | | VD4/P 17.16.20 p275 |
| | 25 | | | 1600 | | | | VD4/P 17.16.25 p275 |
| | 31.5 | | | 1600 | | | | VD4/P 17.16.32 p275 |
| | 40 | | | 1600 | | | | VD4/P 17.16.40 p275 |
| | 50 | | | 1600 | | | | VD4/P 17.16.50 p275 |
| | 20 | | | 2000 | | | | VD4/P 17.20.20 p275 |
| | 25 | | | 2000 | | | | VD4/P 17.20.25 p275 |
| | 31.5 | | | 2000 | | | | VD4/P 17.20.32 p275 |
| | 40 | | | 2000 | | | | VD4/P 17.20.40 p275 |
| | 50 | | | 2000 | | | | VD4/P 17.20.50 p275 |
| | 20 | | | | 2500 | | | VD4/P 17.25.20 p275 |
| | 25 | | | | 2500 | | | VD4/P 17.25.25 p275 |
| | 31.5 | | | | 2500 | | | VD4/P 17.25.32 p275 |
| | 40 | | | | 2500 | | | VD4/P 17.25.40 p275 |
| | 50 | | | | 2500 | | | VD4/P 17.25.50 p275 |
| | 20 | | | | | 3150 (1) | | VD4/P 17.32.20 p275 |
| | 25 | | | | | 3150 (1) | | VD4/P 17.32.25 p275 |
| | 31.5 | | | | | 3150 (1) | | VD4/P 17.32.32 p275 |
| | 40 | | | | | 3150 (1) | | VD4/P 17.32.40 p275 |
| | 50 | | | | | 3150 (1) | | VD4/P 17.32.50 p275 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) Up to 4000 A rated current guaranteed with forced ventilation

# 5. Description

### VD4 withdrawable circuit breaker (24 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | |
|---|---|---|---|---|---|---|
| | | W=800 | W=1000 | W=1000 | W=1000 | |
| | | P=210 | P=275 | P=275 | P=275 | |
| **kV** | **kA** | u/l=310 | u/l=310 | u/l=310 | u/l=310 | **Circuit breaker type** |
| | | ø=35 | ø=35 | ø=79 | ø=109 | |
| | 16 | 630 | | | | VD4/P 24.06.16 p210 |
| | 20 | 630 | | | | VD4/P 24.06.20 p210 |
| | 25 | 630 | | | | VD4/P 24.06.25 p210 |
| | 16 | 1250 | | | | VD4/P 24.12.16 p210 |
| | 20 | 1250 | | | | VD4/P 24.12.20 p210 |
| | 25 | 1250 | | | | VD4/P 24.12.25 p210 |
| | 31.5 | 1250 | | | | VD4/P 24.12.32 p210 |
| | 16 | | 630 | | | VD4/P 24.06.16 p275 |
| | 20 | | 630 | | | VD4/P 24.06.20 p275 |
| | 25 | | 630 | | | VD4/P 24.06.25 p275 |
| | 16 | | 1250 | | | VD4/P 24.12.16 p275 |
| | 20 | | 1250 | | | VD4/P 24.12.20 p275 |
| | 25 | | 1250 | | | VD4/P 24.12.25 p275 |
| **24** | 31.5 | | 1250 | | | VD4/P 24.12.32 p275 |
| | 16 | | | 1600 | | VD4/P 24.16.16 p275 |
| | 20 | | | 1600 | | VD4/P 24.16.20 p275 |
| | 25 | | | 1600 | | VD4/P 24.16.25 p275 |
| | 31.5 | | | 1600 | | VD4/P 24.16.32 p275 |
| | 16 | | | 2000 | | VD4/P 24.20.16 p275 |
| | 20 | | | 2000 | | VD4/P 24.20.20 p275 |
| | 25 | | | 2000 | | VD4/P 24.20.25 p275 |
| | 31.5 | | | 2000 | | VD4/P 24.20.32 p275 |
| | 16 | | | 2300 (1) | | VD4/P 24.25.16 p275 |
| | 20 | | | 2300 (1) | | VD4/P 24.25.20 p275 |
| | 25 | | | 2300 (1) | | VD4/P 24.25.25 p275 |
| | 31.5 | | | 2300 (1) | | VD4/P 24.25.32 p275 |
| | 31.5 | | | | 2700 (2) | VD4/P 24.32.32 p275 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) 2500 A rated current guaranteed with forced ventilation.
(2) 3150 A rated current guaranteed with forced ventilation.

### VD4 withdrawable circuit breaker (36 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | |
|---|---|---|---|
| **kV** | **kA** | H = 951 - W = 788 - D = 778 - u/l = 380 - l/g = 399 - P = 275 | **Circuit breaker type** |
| | 20 | 1250 A | VD4/W 36.12.20 p275 |
| | 25 | 1250 A | VD4/W 36.12.25 p275 |
| | 31.5 | 1250 A | VD4/W 36.12.32 p275 |
| | 20 | 1600 A | VD4/W 36.16.20 p275 |
| | 25 | 1600 A | VD4/W 36.16.25 p275 |
| | 31.5 | 1600 A | VD4/W 36.16.32 p275 |
| | 20 | 2000 A | VD4/W 36.20.20 p275 |
| **36** | 25 | 2000 A | VD4/W 36.20.25 p275 |
| | 31.5 | 2000 A | VD4/W 36.20.32 p275 |
| | 20 | 2500 A (1) | VD4/W 36.25.20 p275 |
| | 25 | 2500 A (1) | VD4/W 36.25.25 p275 |
| | 31.5 | 2500 A (1) | VD4/W 36.25.32 p275 |
| | 20 | 3150 A (2) | VD4/W 36.32.20 p275 |
| | 25 | 3150 A (2) | VD4/W 36.32.25 p275 |
| | 31.5 | 3150 A (2) | VD4/W 36.32.32 p275 |

H = Height of the circuit breaker.
W = Width of the switchgear.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.
(1) 2500 A rated current guaranteed with forced ventilation and tulip contacts diameter 79 mm (TN 1VYN300901-RA).
(2) 3150 A rated current guaranteed with forced ventilation.

### 5.6.3. Standard fittings of withdrawable circuit breakers for UniGear ZS1 switchgear (up to 24 kV) - UniGear ZS2 and PowerCube modules (VD4 36 kV)

The basic versions of the withdrawable circuit breakers are three-pole and fitted with:

- EL type manual operating mechanism
- mechanical signalling device for closing spring charged/discharged
- mechanical signalling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten auxiliary circuit breaker open/closed contacts

  Note: with the set of ten auxiliary contacts supplied as standard and the maximum number of electrical applications possible, three make contacts (signalling circuit breaker open) and four break contacts (signalling circuit breaker closed) are available.
- lever for manually charging the closing spring
- isolating contacts
- cord with connector (plug only) for auxiliary circuits, withstriker pin which does not allow connection of the plugin the socket if the rated current of the circuit breaker isdifferent from the rated current of the panel
- racking-in/out lever (the quantity must be defined according to the number of pieces of apparatus ordered)
- locking electromagnet in the truck. This prevents the circuit breaker from being racked into the panel with auxiliary circuits not connected (plug not inserted in the socket).




VD4 with poles in polyamide




VD4 - 36 kV




VD4 - up to 24 kV



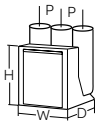

VD4 evo - up to 17 kV

# 5. Description

### 5.6.4. General characteristics of withdrawable circuit breakers for PowerCube modules

**General characteristics of withdrawable circuit breakers for PowerCube modules (12 kV)**




| Circuit breaker | | VD4/P 12 | | VD4/W 12 | | VD4/P 12 | |
|---|---|---|---|---|---|---|---|
| | PowerCube module | PB1 | | PB2 | | PB2 | |
| Standards | IEC 62271-100 | • | | • | | • | |
| Rated voltage | Ur [kV] | 12 | | 12 | | 12 | |
| Rated insulation voltage | Us [kV] | 12 | | 12 | | 12 | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | 28 | | 28 | |
| Impulse withstand voltage | Up [kV] | 75 | | 75 | | 75 | |
| Rated frequency | fr [Hz] | 50-60 | | 50-60 | | 50-60 | |
| Rated normal current (40 °C) (1) | Ir [A] | 630 | 1250 | 630 | 1250 | 1250 | 1250 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | 16 | 16 | - | - |
| | | 20 | 20 | 20 | 20 | - | - |
| | | 25 | 25 | 25 | 25 | - | - |
| | | 31.5 | 31.5 | 31.5 | 31.5 | - | - |
| | | - | - | - | - | 40 | - |
| | | - | - | - | - | - | 50 |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | - | - |
| | | 20 | 20 | 20 | 20 | - | - |
| | | 25 | 25 | 25 | 25 | - | - |
| | | 31.5 | 31.5 | 31.5 | 31.5 | - | - |
| | | - | - | - | - | 40 | - |
| | | - | - | - | - | - | 50 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | - | - |
| | | 50 | 50 | 50 | 50 | - | - |
| | | 63 | 63 | 63 | 63 | - | - |
| | | 80 | 80 | 80 | 80 | - | - |
| | | - | - | - | - | 100 | - |
| | | - | - | - | - | - | 125 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | | • | | • | |
| Opening time | [ms] | 33 ... 60 | | 33 ... 60 | | 33 ... 60 | |
| Arcing time | [ms] | 10 ... 15 | | 10 ... 15 | | 10 ... 15 | |
| Total breaking time | [ms] | 43 ... 75 | | 43 ... 75 | | 43 ... 75 | |
| Closing time | [ms] | 30 ... 60 | | 30 ... 60 | | 30 ... 60 | |
| Maximum overall dimensions   | H [mm] | 628 | 628 | 691 | 691 | 691 | 691 |
| | W [mm] | 503 | 503 | 653 | 853 | 653 | 681 |
| | D [mm] | 662 | 662 | 642 | 642 | 641 | 643 |
| | Pole distance P [mm] | 150 | 150 | 210 | 210 | 210 | 210 |
| Weight | [kg] | 116 | 116 | 135 | 135 | 174 | 180 |
| Standardised table of dimensions | TN | 7412 (3) | 7412 (3) | 7420 (3) | 7420 (3) | - | - |
| | 1VCD | - | - | - | - | 003284 (3) | 003444 |
| Operating temperature | [°C] | - 5 ... + 40 | | - 5 ... + 40 | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | • | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | • | | | |

(1) Rated current guaranteed with circuit breaker installed in PowerCube enclosure and with 40 °C ambient temperature
(2) Up to 4000 A with forced ventilation.
(3) Poles in polyamide

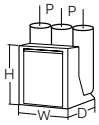
| VD4/P 12 | | | | | | | VD4/W 12 | |
|---|---|---|---|---|---|---|---|---|
| PB2 | | | | | PB3 | | PB3 | |
| • | | | | | • | | • | |
| 12 | | | | | 12 | | 12 | |
| 12 | | | | | 12 | | 12 | |
| 28 | | | | | 28 | | 28 | |
| 75 | | | | | 75 | | 75 | |
| 50-60 | | | | | 50-60 | | 50-60 | |
| 1600 | 1600 | 1600 | 2000 | 2000 | 2500 | 2500 | 3150 (²) | 3150 (²) |
| - | - | - | - | - | - | - | - | - |
| 20 | - | - | 20 | - | 20 | - | 20 | - |
| 25 | - | - | 25 | - | 25 | - | 25 | - |
| 31.5 | - | - | 31.5 | - | 31.5 | - | 31.5 | - |
| - | 40 | - | 40 | - | 40 | - | 40 | - |
| - | - | 50 | - | 50 | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - |
| 20 | - | - | 20 | - | 20 | - | 20 | - |
| 25 | - | - | 25 | - | 25 | - | 25 | - |
| 31.5 | - | - | 31.5 | - | 31.5 | - | 31.5 | - |
| - | 40 | - | 40 | - | 40 | - | 40 | - |
| - | - | 50 | - | 50 | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - |
| 50 | - | - | 50 | - | 50 | - | 50 | - |
| 63 | - | - | 63 | - | 63 | - | 63 | - |
| 80 | - | - | 80 | - | 80 | - | 80 | - |
| - | 100 | - | 100 | - | 100 | - | 100 | - |
| - | - | 125 | - | 125 | - | 125 | - | 125 |
| • | | | | | • | | • | |
| 33 ... 60 | | | | | 33 ... 60 | | 33 ... 60 | |
| 10 ... 15 | | | | | 10 ... 15 | | 10 ... 15 | |
| 43 ... 75 | | | | | 43 ... 75 | | 43 ... 75 | |
| 30 ... 60 | | | | | 30 ... 60 | | 30 ... 60 | |
| 691 | 691 | 691 | 690 | 691 | 691 | 691 | 730 | 691 |
| 653 | 653 | 681 | 653 | 681 | 853 | 853 | 853 | 853 |
| 642 | 641 | 643 | 642 | 643 | 640 | 643 | 640 | 643 |
| 210 | 210 | 210 | 210 | 210 | 275 | 275 | 275 | 275 |
| 160 | 174 | 180 | 160 | 190 | 186 | 225 | 221 | 240 |
| 7415 (³) | - | - | 7415 (³) | - | 7417 (³) | - | - | - |
| - | 003284 (³) | 003444 | - | 003444 | - | 003445 | 000152 (³) | 003596 |
| - 5 ... + 40 | | | | | - 5 ... + 40 | | - 5 ... + 40 | |
| • | | | | | • | | • | |
| • | | | | | • | | • | |


ABB

# 5. Description

**General characteristics of withrawable circuit breakers for PowerCube modules (15kV)**

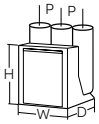



| Circuit breaker | | | VD4/P 15 | |
|---|---|---|---|---|
| | PowerCube module | | PB2/E & PB2/FL | |
| Standard | IEEE C37.04 | | • | |
| Rated voltage | | [kV] | 15 | |
| Rated frequency | | [Hz] | 50/60 | |
| Short-circuit breaking current Isc | | [kA] | 40 | |
| Rated current Ir | | [A] | 1200 | 2000 |
| Short-time withstand current | | [A] | 40 | |
| Short circuit withstand | | [A] | 2 | |
| Close and latch capability | | [kA] | 104 | |
| Operation sequence | [O - 0,3 s - CO - 3 min - CO] | | • | |
| % DC component | | [%] | 30 | |
| Interrupting time | | [ms] | 50 | |
| Closing time | | [ms] | 30…60 | |
| Mechanical endurance class | | [M2] | 10k | |
| Lightning impulse withstand voltage Up | | [kV] | 95 | |
| Power frequency withstand voltage Ud | | [kV] | 36 | |
| Operating temperature | | [°C] | -20…+40 | |
| Maximum overall dimensions   | Height | [mm] | 691 | |
| | Width | [mm] | 653 | |
| | Depth | [mm] | 642 | |
| | Pole distance | [mm] | 210 | |
| Standard table of dimensions | | TN | 7415 | |
| Weight | | [kg] | 160 | |

# 5. Description

**General characteristics of withdrawable circuit breakers for PowerCube modules (17.5 kV)**




| Circuit breaker | | VD4/P 17 | | VD4/W 17 | | VD4/P 17 | |
|---|---|---|---|---|---|---|---|
| | PowerCube module | PB1 | | PB2 | | PB2 | |
| Standards | IEC 62271-100 | • | | • | | • | |
| Rated voltage | Ur [kV] | 17.5 | | 17.5 | | 17.5 | |
| Rated insulation voltage | Us [kV] | 17.5 | | 17.5 | | 17.5 | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 38 | | 38 | | 38 | |
| Impulse withstand voltage | Up [kV] | 95 | | 95 | | 95 | |
| Rated frequency | fr [Hz] | 50-60 | | 50-60 | | 50-60 | |
| Rated normal current (40 °C)(1) | Ir [A] | 630 | 1250 | 630 | 1250 | 1250 | 1250 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | 16 | 16 | - | - |
| | | 20 | 20 | 20 | 20 | - | - |
| | | 25 | 25 | 25 | 25 | - | - |
| | | 31.5 | 31.5 | 31.5 | 31.5 | - | - |
| | | - | - | - | - | 40 | - |
| | | - | - | - | - | - | 50 |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | - | - |
| | | 20 | 20 | 20 | 20 | - | - |
| | | 25 | 25 | 25 | 25 | - | - |
| | | 31.5 | 31.5 | 31.5 | 31.5 | - | - |
| | | - | - | - | - | 40 | - |
| | | - | - | - | - | - | 50 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | - | - |
| | | 50 | 50 | 50 | 50 | - | - |
| | | 63 | 63 | 63 | 63 | - | - |
| | | 80 | 80 | 80 | 80 | - | - |
| | | - | - | - | - | 100 | - |
| | | - | - | - | - | - | 125 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | | • | | | |
| Opening time | [ms] | 33 ... 60 | | 33 ... 60 | | | |
| Arcing time | [ms] | 10 ... 15 | | 10 ... 15 | | | |
| Total breaking time | [ms] | 43 ... 75 | | 43 ... 75 | | | |
| Closing time | [ms] | 30 ... 60 | | 30 ... 60 | | | |
| Maximum overall dimensions   | H [mm] | 628 | 628 | 691 | 691 | 691 | 691 |
| | W [mm] | 503 | 503 | 653 | 653 | 653 | 681 |
| | D [mm] | 662 | 662 | 642 | 642 | 641 | 643 |
| | Pole distance P [mm] | 150 | 150 | 210 | 210 | 210 | 210 |
| Weight | [kg] | 116 | 116 | 135 | 135 | 174 | 180 |
| Standardised table of dimensions | TN | 7412 (3) | 7412 (3) | 7420 (3) | 7420 (3) | - | - |
| | 1VCD | - | - | - | - | 003284 (3) | 003444 |
| Operating temperature | [°C] | - 5 ... + 40 | | - 5 ... + 40 | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | • | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | • | | | |

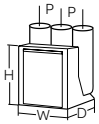
(1) Rated current guaranteed with circuit breaker installed in PowerCube enclosure and with 40 °C ambient temperature.
(2) Up to 4000 A with forced ventilation.
(3) Poles in polyamide.

| VD4/P 17 | | | | | | | VD4/W 17 | |
|---|---|---|---|---|---|---|---|---|
| PB2 | | | | | PB3 | | PB3 | |
| • | | | | | • | | • | |
| 17.5 | | | | | 17.5 | | 17.5 | |
| 17.5 | | | | | 17.5 | | 17.5 | |
| 38 | | | | | 38 | | 38 | |
| 95 | | | | | 95 | | 95 | |
| 50-60 | | | | | 50-60 | | 50-60 | |
| 1600 | 1600 | 1600 | 2000 | 2000 | 2500 | 2500 | 3150 (²) | 3150 (²) |
| - | - | - | - | - | - | - | - | - |
| 20 | - | - | 20 | - | 20 | - | 20 | - |
| 25 | - | - | 25 | - | 25 | - | 25 | - |
| 31.5 | - | - | 31.5 | - | 31.5 | - | 31.5 | - |
| - | 40 | - | 40 | - | 40 | - | 40 | - |
| - | - | 50 | - | 50 | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - |
| 20 | - | - | 20 | - | 20 | - | 20 | - |
| 25 | - | - | 25 | - | 25 | - | 25 | - |
| 31.5 | - | - | 31.5 | - | 31.5 | - | 31.5 | - |
| - | 40 | - | 40 | - | 40 | - | 40 | - |
| - | - | 50 | - | 50 | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - |
| 50 | - | - | 50 | - | 50 | - | 50 | - |
| 63 | - | - | 63 | - | 63 | - | 63 | - |
| 80 | - | - | 80 | - | 80 | - | 80 | - |
| - | 100 | - | 100 | - | 100 | - | 100 | - |
| - | - | 125 | - | 125 | - | 125 | - | 125 |
| • | | | | | • | | • | |
| 33 … 60 | | | | | 33 … 60 | | 33 … 60 | |
| 10 … 15 | | | | | 10 … 15 | | 10 … 15 | |
| 43 … 75 | | | | | 43 … 75 | | 43 … 75 | |
| 30 … 60 | | | | | 30 … 60 | | 30 … 60 | |
| 691 | 691 | 691 | 690 | 691 | 691 | 691 | 730 | 691 |
| 653 | 653 | 681 | 653 | 681 | 853 | 853 | 853 | 853 |
| 642 | 641 | 643 | 642 | 643 | 640 | 643 | 640 | 643 |
| 210 | 210 | 210 | 210 | 210 | 275 | 275 | 275 | 275 |
| 160 | 174 | 180 | 160 | 190 | 186 | 225 | 221 | 240 |
| 7415 (³) | - | - | 7415 (³) | - | 7417 (³) | - | - | - |
| - | 003284 (³) | 003444 | - | 003444 | - | 003445 | 000152 (³) | 003596 |
| - 5 … + 40 | | | | | - 5 … + 40 | | - 5 … + 40 | |
| • | | | | | • | | • | |
| • | | | | | • | | • | |

# 5. Description

**General characteristics of withdrawable circuit breakers for PowerCube modules (24 kV)**




| **Circuit breaker** | | **VD4/P 24** | | | | |
|---|---|---|---|---|---|---|
| | **PowerCube module** | **PB4** | | **PB5** | | |
| Standards | IEC 62271-100 | • | | • | | |
| Rated voltage | Ur [kV] | 24 | | 24 | | |
| Rated insulation voltage | Us [kV] | 24 | | 24 | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 50 | | 50 | | |
| Impulse withstand voltage | Up [kV] | 125 | | 125 | | |
| Rated frequency | fr [Hz] | 50-60 | | 50-60 | | |
| Rated normal current (40 °C) (1) | Ir [A] | 630 | 1250 | 1600 | 2000 | 2500 (2) |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 |
| | | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 |
| | | – | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| Opening time | [ms] | 33 ... 60 | | 33 ... 60 | | |
| Arcing time | [ms] | 10 ... 15 | | 10 ... 15 | | |
| Total breaking time | [ms] | 43 ... 75 | | 43 ... 75 | | |
| Total breaking time | [ms] | 30 ... 60 | | 30 ... 60 | | |
| Maximum overall dimensions   | H [mm] | 794 | 794 | 838 | 838 | 838 |
| | W [mm] | 653 | 653 | 853 | 853 | 853 |
| | D [mm] | 802 | 802 | 790 | 790 | 790 |
| | Pole distance P [mm] | 210 | 210 | 275 | 275 | 275 |
| Weight | [kg] | 140 | 140/146 (3) | 228 | 228 | 228 |
| Standardised table of dimensions | TN | 7413 | 7413 | 7418 | 7418 | 7418 |
| | 1VCD | – | 000173 (3) | – | – | – |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

(1) Rated current guaranteed with circuit breaker installed in PowerCube enclosure and with 40 °C ambient temperature.
(2) 2300 A rated uninterrupted current guaranteed with natural ventilation; 2500 A rated current guaranteed with forced ventilation.
(3) 31.5 kA version.

### 5.6.5. Types of withdrawable circuit breakers available for PowerCube modules

#### VD4 withdrawable circuit breaker (12 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | |
|---|---|---|---|---|---|---|---|
| | | W=650 | W=800 | W=1000 | W=1000 | W=1000 | |
| kV | kA | P=150 | P=210 | P=275 | P=275 | P=275 | Circuit breaker type |
| | | u/l=205 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | |
| | | ø=35 | ø=79 | ø=79 | ø=109 | ø=109 | |
| 12 | 16 | 630 | | | | | VD4/P 12.06.16 p150 |
| | 20 | 630 | | | | | VD4/P 12.06.20 p150 |
| | 25 | 630 | | | | | VD4/P 12.06.25 p150 |
| | 31.5 | 630 | | | | | VD4/P 12.06.32 p150 |
| | 16 | 1250 | | | | | VD4/P 12.12.16 p150 |
| | 20 | 1250 | | | | | VD4/P 12.12.20 p150 |
| | 25 | 1250 | | | | | VD4/P 12.12.25 p150 |
| | 31.5 | 1250 | | | | | VD4/P 12.12.32 p150 |
| | 16 | | 630 | | | | VD4/W 12.06.16 p210 |
| | 20 | | 630 | | | | VD4/W 12.06.20 p210 |
| | 25 | | 630 | | | | VD4/W 12.06.25 p210 |
| | 31.5 | | 630 | | | | VD4/W 12.06.32 p210 |
| | 16 | | 1250 | | | | VD4/W 12.12.16 p210 |
| | 20 | | 1250 | | | | VD4/W 12.12.20 p210 |
| | 25 | | 1250 | | | | VD4/W 12.12.25 p210 |
| | 31.5 | | 1250 | | | | VD4/W 12.12.32 p210 |
| | 40 | | 1250 | | | | VD4/P 12.12.40 p210 |
| | 50 | | 1250 | | | | VD4/P 12.12.50 p210 |
| | 20 | | | 1600 | | | VD4/P 12.16.20 p210 |
| | 25 | | | 1600 | | | VD4/P 12.16.25 p210 |
| | 31.5 | | | 1600 | | | VD4/P 12.16.32 p210 |
| | 40 | | | 1600 | | | VD4/P 12.16.40 p210 |
| | 50 | | | 1600 | | | VD4/P 12.16.50 p210 |
| | 20 | | | 2000 | | | VD4/P 12.20.20 p210 |
| | 25 | | | 2000 | | | VD4/P 12.20.25 p210 |
| | 31.5 | | | 2000 | | | VD4/P 12.20.32 p210 |
| | 40 | | | 2000 | | | VD4/P 12.20.40 p210 |
| | 50 | | | 2000 | | | VD4/P 12.20.50 p210 |
| | 20 | | | | 2500 | | VD4/P 12.25.20 p275 |
| | 25 | | | | 2500 | | VD4/P 12.25.25 p275 |
| | 31.5 | | | | 2500 | | VD4/P 12.25.32 p275 |
| | 40 | | | | 2500 | | VD4/P 12.25.40 p275 |
| | 50 | | | | 2500 | | VD4/P 12.25.50 p275 |
| | 20 | | | | | 3150 (1) | VD4/W 12.32.20 p275 |
| | 25 | | | | | 3150 (1) | VD4/W 12.32.25 p275 |
| | 31.5 | | | | | 3150 (1) | VD4/W 12.32.32 p275 |
| | 40 | | | | | 3150 (1) | VD4/W 12.32.40 p275 |
| | 50 | | | | | 3150 (1) | VD4/W 12.32.50 p275 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) Up to 4000 A rated current guaranteed with forced ventilation. Available on request.

# 5. Description

### VD4 withdrawable circuit breakers (15kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | Circuit breaker type |
|---|---|---|---|---|
| | | W=650 | W=800 | |
| | | P=150 | P=210 | |
| kV | kA | u/l=205 | u/l=310 | |
| | | Ø=35 | Ø=79 | |
| 15 | 31.5 | 1200 | | VD4/N/P 15.12.32 p150 |
| | 40 | | 1200 | VD4/P 15.12.40 p210 |
| | 31.5 | | 2000 | VD4/N/P 15.20.32 p210 |
| | 40 | | 2000 | VD4/P 15.20.40 p210 |

### VD4 withdrawable circuit breaker (17.5 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | Circuit breaker type |
|---|---|---|---|---|---|---|---|
| | | W=650 | W=800 | W=1000 | W=1000 | W=1000 | |
| | | P=150 | P=210 | P=275 | P=275 | P=275 | |
| kV | kA | u/l=205 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | |
| | | ø=35 | ø=79 | ø=79 | ø=109 | ø=109 | |
| 17.5 | 16 | 630 | | | | | VD4/P 17.06.16 p150 |
| | 20 | 630 | | | | | VD4/P 17.06.20 p150 |
| | 25 | 630 | | | | | VD4/P 17.06.25 p150 |
| | 31.5 | 630 | | | | | VD4/P 17.06.32 p150 |
| | 16 | 1250 | | | | | VD4/P 17.12.16 p150 |
| | 20 | 1250 | | | | | VD4/P 17.12.20 p150 |
| | 25 | 1250 | | | | | VD4/P 17.12.25 p150 |
| | 31.5 | 1250 | | | | | VD4/P 17.12.32 p150 |
| | 16 | | 630 | | | | VD4/W 17.06.16 p210 |
| | 20 | | 630 | | | | VD4/W 17.06.20 p210 |
| | 25 | | 630 | | | | VD4/W 17.06.25 p210 |
| | 31.5 | | 630 | | | | VD4/W 17.06.32 p210 |
| | 16 | | 1250 | | | | VD4/W 17.12.16 p210 |
| | 20 | | 1250 | | | | VD4/W 17.12.20 p210 |
| | 25 | | 1250 | | | | VD4/W 17.12.25 p210 |
| | 31.5 | | 1250 | | | | VD4/W 17.12.32 p210 |
| | 40 | | 1250 | | | | VD4/P 17.12.40 p210 |
| | 50 | | 1250 | | | | VD4/P 17.12.50 p210 |
| | 20 | | | 1600 | | | VD4/P 17.16.20 p210 |
| | 25 | | | 1600 | | | VD4/P 17.16.25 p210 |
| | 31.5 | | | 1600 | | | VD4/P 17.16.32 p210 |
| | 40 | | | 1600 | | | VD4/P 17.16.40 p210 |
| | 50 | | | 1600 | | | VD4/P 17.16.50 p210 |
| | 20 | | | 2000 | | | VD4/P 17.20.20 p210 |
| | 25 | | | 2000 | | | VD4/P 17.20.25 p210 |
| | 31.5 | | | 2000 | | | VD4/P 17.20.32 p210 |
| | 40 | | | 2000 | | | VD4/P 17.20.40 p210 |
| | 50 | | | 2000 | | | VD4/P 17.20.50 p210 |
| | 20 | | | | 2500 | | VD4/P 17.25.20 p275 |
| | 25 | | | | 2500 | | VD4/P 17.25.25 p275 |
| | 31.5 | | | | 2500 | | VD4/P 17.25.32 p275 |
| | 40 | | | | 2500 | | VD4/P 17.25.40 p275 |
| | 50 | | | | 2500 | | VD4/P 17.25.50 p275 |
| | 20 | | | | | 3150 (1) | VD4/W 17.32.20 p275 |
| | 25 | | | | | 3150 (1) | VD4/W 17.32.25 p275 |
| | 31.5 | | | | | 3150 (1) | VD4/W 17.32.32 p275 |
| | 40 | | | | | 3150 (1) | VD4/W 17.32.40 p275 |
| | 50 | | | | | 3150 (1) | VD4/W 17.32.50 p275 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) Up to 4000 A rated current guaranteed with forced ventilation. Available on request.

## VD4 withdrawable circuit breaker (24 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | Circuit breaker type |
|---|---|---|---|---|
| | | W=800 | W=1000 | |
| kV | kA | P=210 | P=275 | |
| | | u/l=310 | u/l=310 | |
| | | ø=35 | ø=79 | |
| | 16 | 630 | | VD4/P 24.06.16 p210 |
| | 20 | 630 | | VD4/P 24.06.20 p210 |
| | 25 | 630 | | VD4/P 24.06.25 p210 |
| | 16 | 1250 | | VD4/P 24.12.16 p210 |
| | 20 | 1250 | | VD4/P 24.12.20 p210 |
| | 25 | 1250 | | VD4/P 24.12.25 p210 |
| | 31.5 | 1250 | | VD4/P 24.12.32 p210 |
| | 16 | | 1600 | VD4/P 24.16.16 p275 |
| | 20 | | 1600 | VD4/P 24.16.20 p275 |
| 24 | 25 | | 1600 | VD4/P 24.16.25 p275 |
| | 31.5 | | 1600 | VD4/P 24.16.32 p275 |
| | 16 | | 2000 | VD4/P 24.20.16 p275 |
| | 20 | | 2000 | VD4/P 24.20.20 p275 |
| | 25 | | 2000 | VD4/P 24.20.25 p275 |
| | 31.5 | | 2000 | VD4/P 24.20.32 p275 |
| | 16 | | 2300 (1) | VD4/P 24.25.16 p275 |
| | 20 | | 2300 (1) | VD4/P 24.25.20 p275 |
| | 25 | | 2300 (1) | VD4/P 24.25.25 p275 |
| | 31.5 | | 2300 (1) | VD4/P 24.25.32 p275 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) Up to 2500 A rated current guaranteed with forced ventilation.

### Standard fittings of withdrawable circuit breakers for PowerCube modules

The basic versions of the withdrawable circuit breakers are always three-pole and fitted with:

- EL type manual operating mechanism
- mechanical signalling device for closing springs charged/discharged
- mechanical signalling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten circuit breaker open/closed auxiliary contacts
  Note: with the group of ten auxiliary contacts supplied as standard and the maximum number of electrical applications, three break contacts (signalling circuit breaker open) and four make contacts (signalling circuit breaker closed) are available.
- lever built into operating mechanism for linear loading of closing spring
- isolating contacts
- cord with connector (plug only) for auxiliary circuits, with striker pin which does not allow the plug to be inserted into the socket if the rated current of the circuit breaker is different from the rated current of the panel
- racking-in/out lever (the quantity must be defined according to the number of pieces of apparatus ordered)
- electromagnet lock in the truck. Prevents the circuit breaker from being racked into the panel when the auxiliary circuits are not connected (plug not in socket)
- door interlock (compulsory for ABB switchgear); this device prevents racking the circuit breaker into the switchgear when the switchgear door is open.



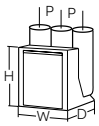

VD4 with poles in polyamide



# 5. Description

### 5.6.6. General characteristics of withdrawable circuit breakers for ZS8.4 switchgear




| Circuit breaker | | VD4/Z8 | | | | | |
|---|---|---|---|---|---|---|---|
| | Panel without partitions | • | | | | | |
| | Panel with partitions | - | | | | | |
| | Preussen Elektra - EON (2) | - | | | | | |
| | Width [kV] | 650 | 650 | 650 | 650 | 800 | 800 |
| | Depth [kV] | 1000 | 1000 | 1000 | 1000 | 1200 | 1200 |
| Standards | IEC 62271-100 | • | | | | | |
| | VDE 0671 | • | | | | | |
| Rated voltage | Ur [kV] | 12 | 12 | 17.5 | 17.5 | 24 | 24 |
| Rated insulation voltage | Us [kV] | 12 | 12 | 17.5 | 17.5 | 24 | 24 |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | 28 | 38 | 38 | 50 | 50 |
| Impulse withstand voltage | Up [kV] | 75 | 75 | 95 | 95 | 125 | 125 |
| Rated frequency | fr [Hz] | 50-60 | | | | | |
| Rated normal current (40 °C) (1) | Ir [A] | 630 | 1250 | 630 | 1250 | 630 | 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | - | - | - | - | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 | 25 |
| Rated short-time withstand current (3 s) | Ik [kA] | - | - | - | - | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 | 25 |
| Making capacity | Ip [kA] | - | - | - | - | 40 | 40 |
| | | 50 | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 | 63 |
| Operation sequence | [O-0.3s-CO-15s-CO] | • | | | | | |
| Opening time | [ms] | 33...60 | | | | | |
| Arcing time | [ms] | 10...15 | | | | | |
| Total breaking time | [ms] | 43...75 | | | | | |
| Closing time | [ms] | 60...80 | | | | | |
| Maximum overall dimensions   | H [mm] | 579 | 579 | 579 | 579 | 680 | 680 |
| | W [mm] | 503 | 503 | 503 | 503 | 653 | 653 |
| | D [mm] | 548 | 548 | 548 | 548 | 646 | 646 |
| | Pole distance P [mm] | 150 | 150 | 150 | 150 | 210 | 210 |
| Weight | [kg] | 116 | 116 | 116 | 116 | 140 | 140 |
| Standardised table of dimensions | 1VCD | 000092 | 000137 | 000137 | 000137 | 000089 | 000138 |
| Operating temperature | [°C] | – 5 ... + 40 | | | | | |
| Tropicalisation | IEC 60068-2-30 | • | | | | | |
| | IEC 60721-2-1 | • | | | | | |
| Electromagnetic compatibility | IEC 62271-1 | • | | | | | |

(1) Rated current guaranteed with circuit breaker installed in switchgear with 40 °C ambient temperature.
(2) Special type with device for charging the closing spring by means of a rotary handle outside the operating mechanism.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **VD4/ZT8** | | | | | | **VD4/ZS8** | | | |
| - | | | | | | - | | | |
| • | | | | | | - | | | |
| - | | | | | | • | | | |
| 650 | 650 | 650 | 650 | 800 | 800 | 650 | 650 | 800 | 800 |
| 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| • | | | | | | • | | | |
| • | | | | | | • | | | |
| 12 | 12 | 17.5 | 17.5 | 24 | 24 | 12 | 12 | 24 | 24 |
| 12 | 12 | 17.5 | 17.5 | 24 | 24 | 12 | 12 | 24 | 24 |
| 28 | 28 | 38 | 38 | 50 | 50 | 28 | 28 | 50 | 50 |
| 75 | 75 | 95 | 95 | 125 | 125 | 75 | 75 | 125 | 125 |
| 50-60 | | | | | | 50-60 | | | |
| 630 | 1250 | 630 | 1250 | 630 | 1250 | 630 | 1250 | 630 | 1250 |
| - | - | - | - | 16 | 16 | - | - | 16 | 16 |
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| - | - | - | - | 16 | 16 | - | - | 16 | 16 |
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| - | - | - | - | 40 | 40 | - | - | 40 | 40 |
| 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 |
| • | | | | | | • | | | |
| 33…60 | | | | | | 40…60 | | | |
| 10…15 | | | | | | 10…15 | | | |
| 43…75 | | | | | | 50…75 | | | |
| 60…80 | | | | | | 60…80 | | | |
| 579 | 579 | 579 | 579 | 680 | 680 | 579 | 579 | 680 | 680 |
| 503 | 503 | 503 | 503 | 653 | 653 | 503 | 503 | 653 | 653 |
| 638 | 638 | 638 | 638 | 646 | 646 | 638 | 638 | 646 | 646 |
| 150 | 150 | 150 | 150 | 210 | 210 | 150 | 150 | 210 | 210 |
| 116 | 116 | 116 | 116 | 140 | 140 | 116 | 116 | 140 | 140 |
| 000093 | 000134 | 000134 | 000134 | 000090 | 000136 | 000091 | 000133 | 000088 | 000135 |
| – 5 … + 40 | | | | | | – 5 … + 40 | | | |
| • | | | | | | • | | | |
| • | | | | | | • | | | |
| • | | | | | | • | | | |

# 5. Description

### 5.6.7. General characteristics of withdrawable circuit breakers for ZS8.4 switchgear

**VD4/ZS8 - VD4/ZT8 - VD4/Z8 withdrawable circuit breaker for ZS8.4 switchgear**

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | Circuit breaker type |
|---|---|---|---|---|---|---|---|---|
| | | Panel without partition | | Panel with partition | | Special panel EON | | |
| | | W = 650 | W = 800 | W = 650 | W = 800 | W = 650 | W = 800 | |
| kV | kA | P = 150 | P = 210 | P = 150 | P = 210 | P = 150 | P = 210 | |
| | | u/l = 205 | u/l = 310 | u/l = 205 | u/l = 310 | u/l = 205 | u/l = 310 | |
| | | ø = 35 | ø = 35 | ø = 35 | ø = 35 | ø = 35 | ø = 35 | |
| 12 | 20 | 630 | | | | | | VD4/Z8 12.06.20 p150 |
| | 25 | 630 | | | | | | VD4/Z8 12.06.25 p150 |
| | 20 | 1250 | | | | | | VD4/Z8 12.12.20 p150 |
| | 25 | 1250 | | | | | | VD4/Z8 12.12.25 p150 |
| | 20 | | | 630 | | | | VD4/ZT8 12.06.20 p150 |
| | 25 | | | 630 | | | | VD4/ZT8 12.06.25 p150 |
| | 20 | | | 1250 | | | | VD4/ZT8 12.12.20 p150 |
| | 25 | | | 1250 | | | | VD4/ZT8 12.12.25 p150 |
| | 20 | | | | | 630 | | VD4/ZS8 12.06.20 p150 |
| | 25 | | | | | 630 | | VD4/ZS8 12.06.25 p150 |
| | 20 | | | | | 1250 | | VD4/ZS8 12.12.20 p150 |
| | 25 | | | | | 1250 | | VD4/ZS8 12.12.25 p150 |
| 17.5 | 20 | 630 | | | | | | VD4/Z8 17.06.20 p150 |
| | 25 | 630 | | | | | | VD4/Z8 17.06.25 p150 |
| | 20 | 1250 | | | | | | VD4/Z8 17.12.20 p150 |
| | 25 | 1250 | | | | | | VD4/Z8 17.12.25 p150 |
| | 20 | | | 630 | | | | VD4/ZT8 17.06.20 p150 |
| | 25 | | | 630 | | | | VD4/ZT8 17.06.25 p150 |
| | 20 | | | 1250 | | | | VD4/ZT8 17.12.20 p150 |
| | 25 | | | 1250 | | | | VD4/ZT8 17.12.25 p150 |
| 24 | 16 | | 630 | | | | | VD4/Z8 24.06.16 p210 |
| | 20 | | 630 | | | | | VD4/Z8 24.06.20 p210 |
| | 25 | | 630 | | | | | VD4/Z8 24.06.25 p210 |
| | 16 | | 1250 | | | | | VD4/Z8 24.12.16 p210 |
| | 20 | | 1250 | | | | | VD4/Z8 24.12.20 p210 |
| | 25 | | 1250 | | | | | VD4/Z8 24.12.25 p210 |
| | 16 | | | | 630 | | | VD4/ZT8 24.06.16 p210 |
| | 20 | | | | 630 | | | VD4/ZT8 24.06.20 p210 |
| | 25 | | | | 630 | | | VD4/ZT8 24.06.25 p210 |
| | 16 | | | | 1250 | | | VD4/ZT8 24.12.16 p210 |
| | 20 | | | | 1250 | | | VD4/ZT8 24.12.20 p210 |
| | 25 | | | | 1250 | | | VD4/ZT8 24.12.25 p210 |
| | 16 | | | | | | 630 | VD4/ZS8 24.06.16 p210 |
| | 20 | | | | | | 630 | VD4/ZS8 24.06.20 p210 |
| | 25 | | | | | | 630 | VD4/ZS8 24.06.25 p210 |
| | 16 | | | | | | 1250 | VD4/ZS8 24.12.16 p210 |
| | 20 | | | | | | 1250 | VD4/ZS8 24.12.20 p210 |
| | 25 | | | | | | 1250 | VD4/ZS8 24.12.25 p210 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
Ø = Diameter of the isolating contact.

### 5.6.8. Standard fittings for withdrawable circuit breakers for ZS8.4 switchgear

The basic versions of the withdrawable circuit breakers are always three-pole and fitted with:

- EL type manual operating mechanism
- mechanical signalling device for closing spring charged/ discharged
- mechanical signalling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten auxiliary circuit breaker open/closed contacts

  Note: with the set of ten auxiliary contacts supplied as standard and the maximum number of electrical applications possible, three make contacts (signalling circuit breaker open) and four break contacts (signalling circuit breaker closed) are available.
- lever for manually charging the closing springs incorporatedin the operating mechanism for VD4/ Z8 and VD4/ZT8,external with rotary movement for VD4/ZS8
- isolating contacts
- cord with connector (only plug) for auxiliary circuits, withstriker pin which does not allow connection of the plugin the socket if the rated current of the circuit breaker isdifferent from the rated current of the panel
- racking-in/out lever (the quantity must be defined accordingto the number of pieces of apparatus ordered)

### 5.6.9. VD4/ZS8 (Preussen Elektra-EON version)

- Device for recharging the closing spring, with door closed, by means of removable rotary handle and outside the operating mechanism and the switchgear
- 64-pin Harting socket with mechanical interlock which prevents traverse of the circuit breaker when the plug is not inserted in the socket
- Interlock with the door which prevents insertion of the spring charging lever when the circuit breaker is closed
- Interlock with the door and the 64-pin Harting socket which prevents door closure when the plug is not inserted in the socket.

### 5.6.10. VD4/Z8 - VD4/ZT8

- Harting 64-pin socket with mechanical interlock which prevents traverse of the circuit breaker when the plug is not inserted in the socket.

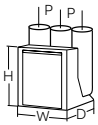



Caption
1) Device for spring charging with rotary handle
2) Harting 64-pin socket with mechanical interlock which prevents traverse when the socket is not inserted
3) Door-socket-spring charging device interlock (only VD4/ZS8 version)

# 5. Description

### 5.6.11. General characteristics of withdrawable circuit breakers for UniSwitch switchgear and UniMix (24 kV) switchgear




| Circuit breaker | | VD4/SEC | VD4/P 12 | | VD4/P 17 | |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | • | | • | |
| Rated voltage | Ur [kV] | 24 | 12 | | 17.5 | |
| Rated insulation voltage | Us [kV] | 24 | 12 | | 17.5 | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 50 | 28 | | 38 | |
| Impulse withstand voltage | Up [kV] | 125 | 75 | | 95 | |
| Rated frequency | fr [Hz] | 50-60 | 50-60 | | 50-60 | |
| Rated normal current (40 °C) (1) | Ir [A] | 630 - 1250 | 630 | 1250 | 630 | 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| Rated short-time withstand current (3 s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 |
| | | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | | 33 ... 60 | |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | | 10 ... 15 | |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | | 43 ... 75 | |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | | 30 ... 60 | |
| Maximum overall dimensions   | H [mm] | 743 | 628 | 628 | 632 | 632 |
| | W [mm] | 653 | 503 | 503 | 503 | 503 |
| | D [mm] | 742 | 662 | 662 | 664 | 664 |
| | Pole distance P [mm] | 210 | 150 | 150 | 150 | 150 |
| Weight | [kg] | 133 | 116 | 116 | 116 | 116 |
| Standardised table of dimensions | 1VCD | 000190 | 7412 (2) | 7412 (2) | 7412 (2) | 7412 (2) |
| Operating temperature | [°C] | - 5 ... + 40 | - 5 ... + 40 | | - 5 ... + 40 | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | • | • | • | • |
| Electromagnetic compatibility | IEC 62271 | • | • | • | • | • |

(1) Rated current guaranteed with circuit breaker installed in switchgear with 40 °C ambient temperature.
(2) Poles in polyamide.

**Withdrawable circuit breakers for UniSec switchgear**

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | Circuit breaker type |
|---|---|---|---|---|---|
| | | P=150 | P=150 | P=210 | |
| kV | kA | u/l=205 | u/l=205 | u/l=310 | |
| | | ø=35 | ø=35 | ø=79 | |
| 12 | 16 | 630 | | | VD4/P 12.06.16 p150 |
| | 20 | 630 | | | VD4/P 12.06.20 p150 |
| | 25 | 630 | | | VD4/P 12.06.25 p150 |
| | 16 | 1250 | | | VD4/P 12.12.16 p150 |
| | 20 | 1250 | | | VD4/P 12.12.20 p150 |
| | 25 | 1250 | | | VD4/P 12.12.25 p150 |
| 17 | 16 | | 630 | | VD4/P 17.06.16 p150 |
| | 20 | | 630 | | VD4/P 17.06.20 p150 |
| | 25 | | 630 | | VD4/P 17.06.25 p150 |
| | 16 | | 1250 | | VD4/P 17.12.16 p150 |
| | 20 | | 1250 | | VD4/P 17.12.20 p150 |
| | 25 | | 1250 | | VD4/P 17.12.25 p150 |
| 24 | 16 | | | 630 | VD4/SEC 24.06.16 p210 |
| | 20 | | | 630 | VD4/SEC 24.06.20 p210 |
| | 25 | | | 630 | VD4/SEC 24.06.25 p210 |
| | 16 | | | 1250 | VD4/SEC 24.12.16 p210 |
| | 20 | | | 1250 | VD4/SEC 24.12.20 p210 |
| | 25 | | | 1250 | VD4/SEC 24.12.25 p210 |

P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
Ø = Diameter of the isolating contact.

### 5.6.12. Standard fittings of withdrawable circuit breakers for UniSec

The basic versions of the withdrawable circuit breakers are three-pole and fitted with:

- EL type manual operating mechanism
- mechanical signalling device for closing springs charged/discharged
- mechanical signalling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten circuit breaker open/closed auxiliary contacts

Note: with the group of ten auxiliary contacts supplied as standard and the maximum number of electrical applications, three break contacts (signalling circuit breaker open) and four make contacts (signalling circuit breaker closed) are available.

- lever built into operating mechanism for linear loading of closing spring
- isolating contacts
- cord with connector (plug only) for auxiliary circuits, with striker pin which does not allow the plug to be inserted into the socket if the rated current of the circuit breaker is different from the rated current of the panel
- racking-in/out lever (the quantity must be defined according to the number of pieces of apparatus ordered)

# 5. Description

## 5.7. Characteristics of the electrical accessories

**The accessories identified with the same number are alternative to each other.**

### 1 Shunt opening release (-MBO1)

Allows opening command of apparatus to be enabled by remote control.
This release is suitable for both instantaneous and permanent duty. However, an auxiliary contact -BGB1 de-energizes it after circuit breaker has opened. In the case of instantaneous service, the current impulse must last at least 100 ms.
This release can be controlled by the following devices: coil continuity control (CCC), opening circuit supervision (TCS)(*) or the ABB STU functionality control device (see accessory 21, supplied on request).

| Characteristics | |
|---|---|
| Un | 24-30-48-60-110...132-220...250 V DC |
| Un | 48-60-110...127-220...250 V AC 50-60 Hz |
| Operating limits | 65 ... 120% Un |
| Inrush power (Ps) | 60...100 W / VA |
| Continuous power consumption (Pc) | 1.5 W |
| Electronics self-consumption (no coil supplied); value independent of voltage applied | 1.5 mA |
| Opening time | 33...60 ms |
| Insulation voltage | 2000 V 50 Hz (for 1 min) |

(*) The minimum current that the relay with TCS function (used for monitoring coil continuity) detects as a condition denoting that the trip circuit is operating correctly (specified for each relay in the relative manual), must be sensibly higher than the current consumption of the actual coil (~1.5 mA).
If this fails to occur, always add, in parallel to the TCS, a circuit able to absorb sufficient current to compensate the gap while preventing the total current in the TCS circuit from rising above the maximum threshold (Itcs < 10 mA for High Voltage coils - from 110V to 250V, and Itcs < 50 mA for Low Voltage coils from 24 V to 60 V).
A simple resistor can be sized for the purpose, depending on the parameters of the TCS and the auxiliary voltage range used.

### 2 Additional shunt opening release (-MBO2)

Similarly to shunt opening release -MBO1, this allows the opening command of the apparatus to be transmitted by remote control. It can be powered by the same circuit as main shunt opening release -MBO1 or by a circuit that is completely separate from release -MBO1.
This release is suitable for both instantaneous and permanent duty. However, an auxiliary contact -BGB1 de-energizes it after the circuit breaker has opened.
To guarantee the release action, the current impulse must last at least 100 ms.
Continuity functionality can be checked with a continuity control device (CCC), opening circuit supervision (TCS)(*) or the STU functionality control device (see accessory 21, supplied on request).
-MBO2 has the same electrical and operating characteristics as release -MBO1.






### 3 Opening solenoid (-MO3)

The opening solenoid (-MO3) is a special release with demagnetisation to be combined with an overcurrent protection relay of the self-supplied type.
It is located in the operating mechanism (in the left side piece) and is not alternative to the additional shunt opening release (-MO2).
It is not available for 40 and 50 kA circuit breakers.
Should the application of this accessory be required, specify the request at the time of order since subsequent application by the customer is not possible.

Note: for combination with the protection relays, please ask for the document: Data sheet 1VCD600854.

The opening solenoid (-MBO3) is available in two versions:

- For DC (release by discharging energy stored in protection relay against overcurrent of the self-supplied type)
- For AC (release by means of the energy supplied by an adder transformer on the secondaries of the protection current transformers (the TA is at customer's charge)

(*) The minimum current that the relay with TCS function (used for monitoring coil continuity) detects as a condition denoting that the trip circuit is operating correctly (specified for each relay in the relative manual), must be sensibly higher than the current consumption of the actual coil (~1.5 mA).
If this fails to occur, always add, in parallel to the TCS, a circuit able to absorb sufficient current to compensate the gap while preventing the total current in the TCS circuit from rising above the maximum threshold (Itcs < 10 mA for High Voltage coils - from 110V to 250V, and Itcs < 50 mA for Low Voltage coils from 24 V to 60 V).
A simple resistor can be sized for the purpose, depending on the parameters of the TCS and the auxiliary voltage range used.

### 4 Shunt closing release (-MC)

Allows closing command of apparatus to be transmitted by remote control.
This release is suitable for both instantaneous and permanent duty. An auxiliary contact that de-energizes it after the circuit breaker has closed is not envisaged.
The permanently supplied release provides the electrical anti-pumping function with both electrical opening and re-closing commands maintained. To guarantee the closing action, the current impulse must last at least 100 ms.
If there is the same supply voltage for shunt closing release -MBC and under-voltage release -MBU and the circuit breaker must close automatically when auxiliary voltage returns, there must be a delay of at least 50 ms between under-voltage release energizing and energizing of the shunt closing release to allow the closing operation to take place.Continuity functionality can be checked with a continuity control device (CCC), opening circuit supervision (TCS)(*) or the STU functionality control device (see accessory 21, supplied on request).

| Characteristics | |
|---|---|
| Un | 24-30-48-60-110...132-220...250 V DC |
| Un | 48-60-110...127-220...250 V AC 50-60 Hz |
| Operating limits | 65 ... 120% Un |
| Inrush power (Ps) | 60...100 W / VA |
| Continuous power consumption (Pc) | 1.5 W |
| Electronics self-consumption (no coil supplied); value independent of voltage applied | 1.5 mA |
| Opening time | 33...60 ms |
| Insulation voltage | 2000 V 50/60 Hz (for 1 min) |





# 5. Description

### 5 Undervoltage release (-MBU)

The undervoltage release opens the circuit breaker when there is a sensible reduction or lack of the voltage that powers it. The circuit breaker can only close when the release is energized (the closing lock is obtained mechanically).
It can be used for remote release (by means of a pushbutton of the normally closed type), for locking on automatic closing/opening in the absence of voltage in the auxiliary circuits. Supplied by means of the secondary output of a voltage transformer, it provides locking upon automatic closing/opening in the absence of voltage in the Medium Voltage main circuit.
If there is the same supply voltage for shunt closing release -MBC and under-voltage release -MBU and the circuit breaker must close automatically when auxiliary voltage returns, there must be a delay of at least 50 ms between under-voltage release energizing and energizing of the shunt closing release to allow the closing operation to take place.

The undervoltage release is available in the following versions:

**5A** Undervoltage release (with supply shunted from a transformer on the supply side of the circuit breaker or from an auxiliary power supply, regardless of the state in which the circuit breaker is to be found).

**5B** Undervoltage release with -KFT electronic time-lag device (0.5 - 1 - 1.5 - 2 - 3 s) (with power supply as indicated for 5A); this device is supplied with a 0.5 s setting (the adjustments are described in the Circuit diagrams chapter)

| Characteristics | |
|---|---|
| Un | 24-30-48-60-110...132-220...250 V DC |
| Un | 48-60-110...127-220...250 V AC 50-60 Hz |
| Operating limits | – circuit breaker opening: 35-70% Un |
| | – circuit breaker closing: 85-110% Un |
| Inrush power (Ps) | 150 W / VA |
| Continuous power consumption (Pc) | 1.55 W |
| Electronics self-consumption (no coil supplied); value independent of voltage applied | 1.5 mA |
| Opening time | 60...80 ms |
| Insulation voltage | 2000 V 50/60 Hz (for 1 min) |

Note
As an alternative to the undervoltage release, an additional shunt opening release (-MBO4) with the same electrical and operating specifications as shunt opening release (-MBO1) can be installed on request (only for circuit breakers 12..17.5 kV up to 40 kA and 24 kV up to 31.5 kA).
Warning! Since installation of the additional shunt opening release (-MBO4) requires a special mounting plate for releases, ask for application (-MBO4) when ordering and not after delivery.



### 5a Electronic time delay device (-KFT)

The electronic time delay device must be mounted externally in relation to the circuit breaker. It allows release trip delay with established and adjustable times.
The use of the undervoltage release is recommended in order to prevent trips when the power supply network of the release may be subject to cuts or voltage drops of short duration.
If it is not supplied, circuit breaker closing is disabled.
The time delay device must be combined with an undervoltage release for d.c.
Rated voltage of the undervoltage release must be within the selected range of working of the time-delay device.

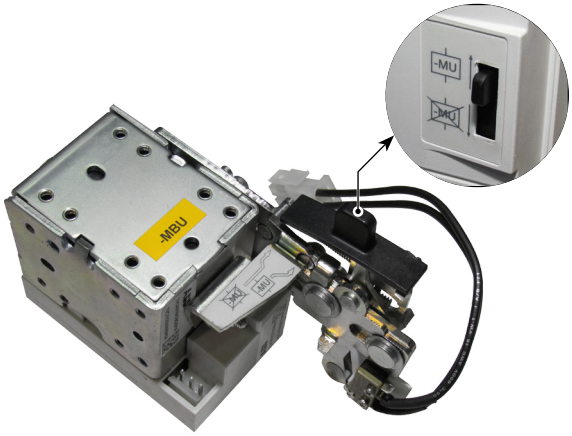
| Characteristics of the time-delay device | |
|---|---|
| Un | 24...30 - 48 - 60 - 110...127 - 220...250 V– |
| Un | 48 - 60 - 110...127 - 220...240 - V~ 50/60 Hz |
| Adjustable opening time (release + time delay device): 0.5-1-1.5-2-3 s | |

### 6 Undervoltage release mechanical override

This is a mechanical device which allows the undervoltage release trip to be temporarily excluded.
It is always fitted with electrical signalling.

**Should the application of this accessory be required, specify the request at the time of order since subsequent application by the customer is not possible.**



# 5. Description

### 7a Auxiliary contacts of the circuit breaker (-BGB1) for 12 to 24 kV versions

Electrical signalling of circuit breaker open/closed can be obtained with a group of 10, 16 or 20 auxiliary contacts for the fixed version and 10 or 16 auxiliary contacts for the withdrawable version. The standard equipment comprises 10 auxiliary contacts.

**Note**

The following are available using the standard group of ten auxiliary contacts and the maximum number of electrical accessories:

- for fixed circuit breakers: three closing contacts "a" for signalling circuit breaker open and five opening contacts "b" for signalling circuit breaker closed;
- for withdrawable circuit breakers: three closing contacts "a" for signalling circuit breaker open and four opening contacts "b" for signalling circuit breaker closed;

Circuit breakers in the fixed version are available with two finishing accessories (to be specified when ordering):

- non-wired auxiliary contacts; wiring to the terminals of the contacts is at the customer's charge (photo below left; the terminal box to which the other electrical accessories are wired is at the top); ask for instructions 1VCD601204 (available in the main languages) which describe how to remove, wire auxiliary contacts more easily and fit auxiliary contacts unit back into its housing;
- auxiliary contacts already wired to the terminal box (see photo at top right).

Consult circuit diagrams 1VCD400151 for fixed circuit breakers and 1VCD400155 for withdrawable circuit breakers.

**Note:** The main shunt opening release and/or the additional shunt opening release use 1 and/or 2 closing contacts "a", thereby reducing the number of auxiliary contacts available. Always check the maximum number of contacts available with non-standard equipment.

The new diagrams are interchangeable with the existing ones, with the following exceptions:

- diagram 1VCD400151 (substitutes 1VCD400046 and 1VCD400099)
- fig. 34 on the previous diagrams is represented by fig. 31 + fig. 32 on the new diagram;
- fig. 33 and fig. 35 on the previous diagrams are not available with the new layout
- diagram 1VCD400155 (substitutes 1VCD400047)







Auxiliary contacts –BGB1 conform to the following standards/regulations/directives:

- IEC 62271-100
- IEEE C37.54
- EN 61373 cat.1 class B / impact and vibration test
- Germanish Loyd regulation / vibrations envisaged by the shipping registers
- UL 508
- EN 60947 (DC-21A DC-22A DC-23A AC-21A)
- RoHS Directive

| General characteristics | |
|---|---|
| Insulation voltage to standard VDE 0110, Group C | 660 V AC<br>800 V DC |
| Rated voltage | 24 V ... 660 V |
| Test voltage | 2 kV for 1 min |
| Maximum rated current | 10 A - 50/60 Hz |
| Breaking capacity | Class 1 (IEC 62271-1) |
| Number of contacts | 5 |
| Groups of contacts | 10 / 16 / 20 |
| Contact travel | 90° |
| Actuating force | 0.66 Nm |
| Resistance | <6.5 mΩ |
| Storage temperature | –30 °C ... +120 °C |
| Operating temperature | –20 °C ... +70 °C<br>(-30° ref. ANSI 37.09) |
| Contact overtemperature | 10 K |
| Mechanical life | 30.000 mechanical operations |
| Protection class | IP20 |
| Cable section | 1 mm² |

| Electrical characteristics (according to IEC 60947) | | |
|---|---|---|
| Rated current Un | | Breaking capacity (10000 interruptions) |
| 220 V AC | Cosφ = 0.70 | 20 A |
| 220 V DC | Cosφ = 0.45 | 10 A |
| 24 V DC | 1 ms | 12 A |
| | 15 ms | 9 A |
| | 50 ms | 6 A |
| 60 V DC | 1 ms | 10 A |
| | 15 ms | 6 A |
| | 50 ms | 4.6 A |
| 110 V DC | 1 ms | 7 A |
| | 15 ms | 4.5 A |
| | 50 ms | 3.5 A |
| 220 V DC | 1 ms | 2 A |
| | 15 ms | 1.7 A |
| | 50 ms | 1.5 A |
| 250 V DC | 1 ms | 2 A |
| | 15 ms | 1.4 A |
| | 50 ms | 1.2 A |

| Electrical characteristics (according to IEC 62271-100 class 1) | |
|---|---|
| Rated current Un | Breaking capacity |
| 24 V DC 20 ms | 18.8 A |
| 60 V DC 20 ms | 7.4 A |
| 110 V DC 20 ms | 4.2 A |
| 250 V DC 20 ms | 1.8 A |

# 5. Description

### 7b Auxiliary contacts of the circuit breaker (-BGB1, -BGB2, -BGB3 ) for 36 kV version

As an alternative to the standard 10 contacts, electrical signaling of circuit breaker open/closed can be obtained with a group of 15 auxiliary contacts.
Consult the following circuit diagrams for VD4 36 kV series with “7b” auxiliary contacts:

- for fixed circuit breakers: 1VCD400236
- for withdrawable circuit breakers: 1VCD400237

**Note**

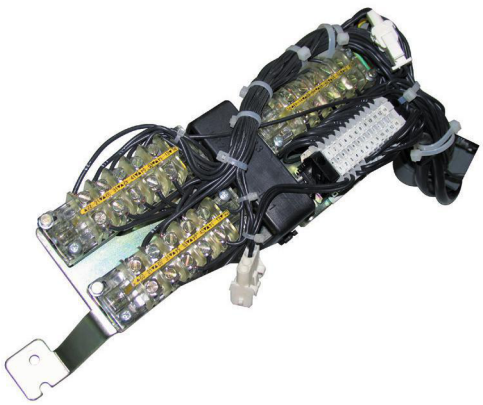
The following are available with the standard group of ten contacts and maximum electrical applications:
- three make contacts (circuit breaker open signal) and five break contacts (circuit breaker closed signal), and five break contacts (circuit breaker closed signal) for fixed circuit breakers, four break contacts (circuit breaker closed signal) for withdrawable circuit breakers.

Depending on the electrical applications required, the following are available with the group of 15 auxiliary circuits:

- for fixed circuit breakers: thirteen auxiliary contacts comprising the numbers of break contacts and make contacts established by the required wiring configuration;
- for withdrawable circuit breakers, since the plug of the auxiliary circuits has a limited number of pins: five make contacts (circuit breaker open signal) and five break contacts (circuit breaker closed signal).

| General characteristics | |
|---|---|
| Insulation voltage to standard VDE 0110, Group C | 660 V AC<br>800 V DC |
| Rated voltage | 24 V ... 660 V AC |
| Test voltage | 2 kV 50 Hz (for 1 min) |
| Maximum rated current | 10 A |
| Number of contacts | 5 |
| Contact travel | 6 mm ... 7 mm |
| Actuating force | 26 N |
| Resistance | 3 mΩ |
| Storage temperature | –20 °C ... +120 °C |
| Operating temperature | –20 °C ... +70 °C |
| Contact overtemperature | 20 K |
| Number of cycles | 30.000 |
| Unlimited breaking capacity if used with 10 A fuse in series | |

| Electrical characteristics | | | |
|---|---|---|---|
| Un | | Rated current | Breaking capacity |
| 220 V AC | Cosφ = 0.7 | 2.5 A | 25 A |
| 380 V AC | Cosφ = 0.7 | 1.5 A | 15 A |
| 500 V AC | Cosφ = 0.7 | 1.5 A | 15 A |
| 660 V AC | Cosφ= 0.7 | 1.2 A | 12 A |
| 24 V DC | 1 ms | 10 A | 12 A |
| | 15 ms | 10 A | 12 A |
| | 50 ms | 8 A | 10 A |
| | 200 ms | 6 A | 7.7 A |
| 60 V DC | 1 ms | 8 A | 10 A |
| | 15 ms | 6 A | 8 A |
| | 50 ms | 5 A | 6 A |
| | 200 ms | 4 A | 5.4 A |
| 110 V DC | 1 ms | 6 A | 8 A |
| | 15 ms | 4 A | 5 A |
| | 50 ms | 2 A | 4.6 A |
| | 200 ms | 1 A | 2.2 A |
| 220 V DC | 1 ms | 1.5 A | 2 A |
| | 15 ms | 1 A | 1.4 A |
| | 50 ms | 0.75 A | 1.2 A |
| | 200 ms | 0.5 A | 1 A |



### 8 Transient contact (-BGB4)

This contact closes momentarily (duration > 30 ms) on circuit breaker opening controlled remotely with a shunt opening release.
The indication is not provided when opening is manual and local. In fact, a contact (–BGB11) is activated by the manual pushbutton and cuts off the transient contact closure (–BGB4).
The transient contact is activated directly from the main operating shaft when the indication is provided only on actual opening of the main circuit breaker contacts.

### 9 Position contact (-BGT3)

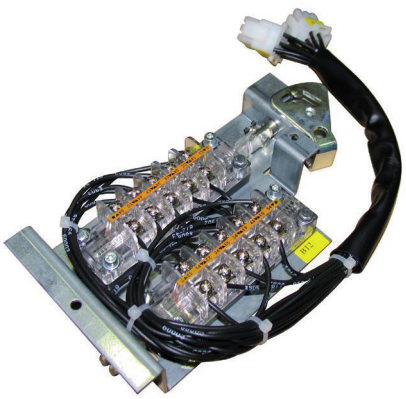
This contact is used, together with the locking magnet in the operating mechanism **(-RLE1)** to prevent remote closing during traverse into the unit.
It is only supplied for the withdrawable version circuit breakers for UniGear ZS1 switchgear and PowerCube modules.
It cannot be supplied when the transmitted contacts are requested in the truck **(-BGT1; -BGT2)**.




### 10 Transmitted contacts in the truck (-BGT1; -BGT2)

Transmitted contacts of the withdrawable circuit breaker (installed in the circuit breaker truck - only for VD4/P withdrawable circuit breaker).
These contacts are either in addition or as an alternative to the position contacts (for signalling circuit breaker racked out) located in the unit. They also carry out the function of the position contact **(-BGT3)**.
Contacts -BGT1 and BGT2 have the same general and electrical characteristics as auxiliary contacts "7b. -BGB1, -BGB2, -BGB3".



# 5. Description

### 11 Motor operator (-MAS)

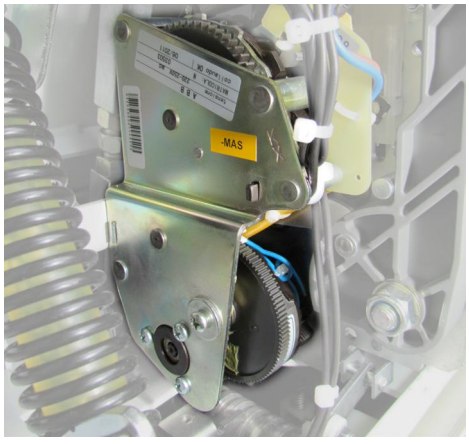
This carries out automatic charging of the circuit breaker operating mechanism closing spring. After circuit breaker closing, the geared motor immediately recharges the closing springs.
In the case of a power cut or during maintenance work, the closing spring can be charged manually in any case (by means of the special crank handle incorporated in the operating mechanism).

| **Characteristics** | | |
|---|---|---|
| Un | 24...30 - 48...60 - 110...130 - 220...250 V– | |
| Un | 100...130 - 220...250 V~ 50/60 Hz | |
| Operating limits | 85 ... 110% Un | |
| Power on inrush (Ps) | ≤ 40 kA | 50 kA |
| | DC = 600 W; AC = 600 VA | DC = 900 W; AC = 900 VA |
| Rated power (Pn) | DC = 200 W; AC = 200 VA | DC = 350 W; AC = 350 VA |
| Inrush duration | 0.2 s | 0.2 s |
| Charging time | 6-7 s | 6-7 s |
| Insulating voltage | 2000 V 50/60 Hz (for 1 min) | 2000 V 50 Hz (for 1 min) |

### 12 Contact for signalling closing spring charged/ discharged (-BGS2)

This consists of a microswitch which allows remote signalling of the state of the circuit breaker operating mechanism closing pring.
The following signals are possible:
- contact open: signalling spring charged
- contact closed: signalling spring discharged.

The two signals must be used for circuits which have the same power supply voltage.






# Protections and locks

Various mechanical and electromechanical locking and protection devices are available.

**13 Opening and closing pushbutton protection**

The protection only allows the opening and closing pushbuttons to be operated using a special tool.

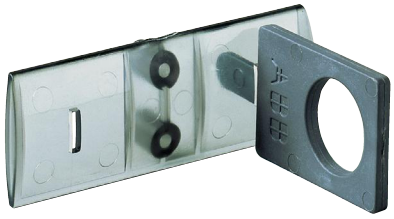
**14 Opening and closing pushbutton padlock**

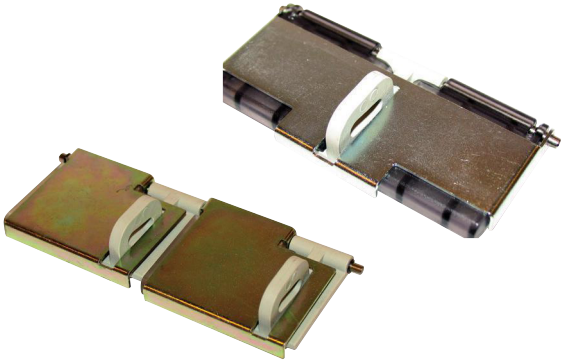
The device allows the opening and closing pushbuttons to be locked using a maximum of three padlocks (not supplied): ø 4 mm. Also prevents closing using remote control.
This lock is available in two versions:

**14A** Possibility of padlocking both the pushbuttons without distinction

**14B** Separate padlocking of the opening and/or closing pushbutton.

N.B. Lock 14A prevents closure by remote control; lock 14B does not prevent closure by remote control.





# 5. Description

**15 Key lock in open position**

The lock is activated by a special circular lock. Different keys (for a single circuit breaker) are available, or the same keys (for several circuit breakers).
To activate the lock, keep the opening pushbutton pressed down, turn the key and remove it.
With the key removed, the opening pushbutton automatically remains in the pressed position preventing local manual closing and remote electrical closing.

**16 Locking magnet on the operating mechanism (-RLE1)**

Only allows activation of the command with the electromagnet supplied.
The locking electromagnet in the operating mechanism has the same electrical characteristics as shunt closing release -MBC.






### 17 Locking magnet on the truck (-RLE2)

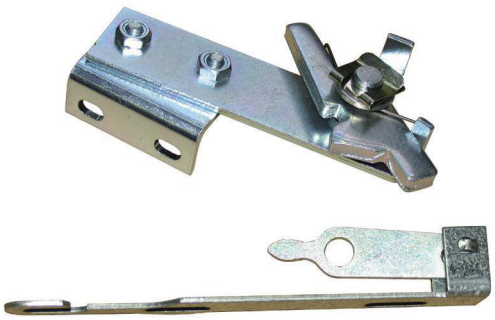
Compulsory accessory for the withdrawable versions for UniGear ZS1 switchgear and PowerCube modules, to prevent circuit breaker racking into the switchgear with the auxiliary circuit plug disconnected.
The plug also makes the anti-insertion lock for a different rated current. Special striker pins do not allow insertion of the plug in the socket if the rated current of the circuit breaker is lower than the rated current of the panel.
**Note: a specific version for the circuit breakers of ZS8.4 switchgear is available on request. This accessory is not available when the motor-operated truck is required.**

| Characteristics | |
|---|---|
| Un | 24 - 30 - 48 - 60 - 110 - 125 - 127 - 132 - 220 - 240 V– |
| Un | 24 - 30 - 48 - 60 - 110 - 125 - 127 - 220 - 230 ... 240 V~ 50/60 Hz |
| Operating limits | 85 ... 110% Un |
| Power on inrush (Ps) | d.c. 250 W; a.c. = 250 VA |
| Continuous power (Pc) | d.c. = 5 W; a.c. = 5 VA |
| Inrush duration | 150 ms |
| Insulating voltage | 2000 V 50/60 Hz (for 1 min) |

### 18 Interlock for fixed circuit breaker

Device for fixed circuit breakers which are converted into withdrawable ones by the customer. It allows a mechanical lock to be made, by the customer, which prevents racking-out/in with the circuit breaker closed and prevents circuit breaker closing during translation.
**Note: The device must be requested when ordering since it must be assembled and tested in the factory.**



# 5. Description

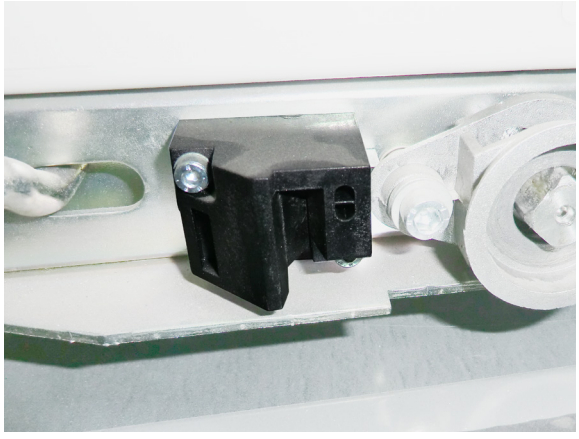
### 19 Mechanical interlock with the door

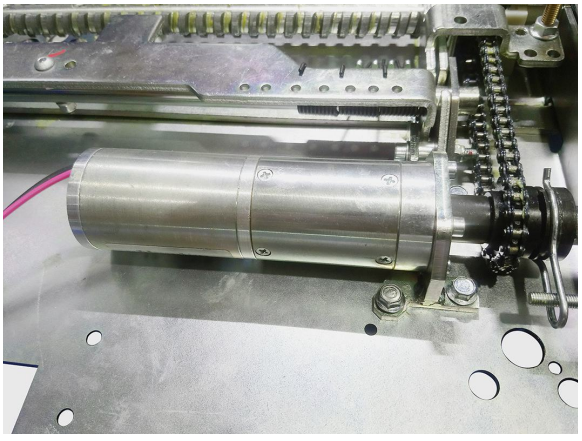
This device prevents circuit breaker racking-in when the switchgear door is open. It is only provided for circuit breakers used in switchgear UniGear ZS1 and PowerCube modules, fitted with a special actuator on the door.

### 20 Motorised truck (-MAT)

It allows racking-in and racking-out of the circuit breaker in the switchgear to be carried out remotely, (only for circuit breaker in withdrawable version for UniGear ZS1 and ZS8.4 switchgear and PowerCube modules).
The motor version with clutch is supplied as standard, so that racking-in/ out can be performed in an emergency if the truck motor fails to operate.

| **Characteristics** | |
|---|---|
| Un | 24 - 30 - 48 - 60 - 110 - 220 V– |
| Operating limits | 85 ... 110% Un |
| Nominal power (Pn) | 40 W |





## 21 STU Shunt Test Unit

Due to the particular construction of these releases, checking the functionality of the shunt closing (-MBC) and opening (-MBO1, -MBO2) releases is not possible with dedicated relays (e.g. TCS Test Control Supervision, CCC Control Coil Continuity) or with the REF control and protection unit. The only device able to carry out a check of the functionality is the STU device. Please contact us if you want to carry out this control with devices other than STU.
This device can be combined with the shunt opening release **(-MBO1; -MBO2)** or with the shunt closing release **(-MBC)** to check functionality and continuity.

The control/monitoring Shunt Test Unit allows the continuity of releases with a rated operating voltage between 24 V and 250 V (AC and DC) to be checked, as well as the functionality of the electronic circuit of the release.
Checking continuity is carried out cyclically with an interval of 20 seconds between one test and the next.
The unit has optical signals by means of LEDs on the front. In particular the following information is indicated:

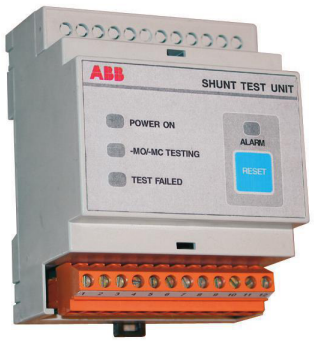
- POWER ON: power supply present
- (-MO) TESTING: test being carried out
- TEST FAILED: signal following a failed test or in the absence of auxiliary power supply
- ALARM: signal after three failed tests.

Two relays and a changeover are also available on board the unit, which allow remote signalling of the following two events:

- failure of a test (resetting is carried out automatically when the alarm stops)
- failure of three tests (resetting is only carried out by means of the manual - RESET – from the front of the unit).

There is also a manual - RESET – button on the front of the unit.

| Characteristics | |
|---|---|
| Un | 24 ... 250 V AC/DC |
| Maximum interrupted current | 6 A |
| Maximum interrupted voltage | 250 V AC |




## 22 Digital accessories for VD4 evo CMU

The CMU is an embedded unit with Monitor & Diagnostic capabilities. It also embeds sensors for basic breaker monitoring features. It can be ordered stand alone or in combination with a range of Sensors from ABB sensors portfolio, depending on the monitoring needs (see next section).
For more details please see the CMU datasheet 2RDA044111 6 CMU Dashboard Manual 2RDA044113.

| Parameter | Unit | Min Value | Max Value |
|---|---|---|---|
| AUX Rated voltage | AC (V) | 85 | 250 |
| Working temperature range | °C | -20 | +55 |
| Storage temperature | °C | -30 | +80 |



# 5. Description

### 23 Monitor & Diagnostic Sensors

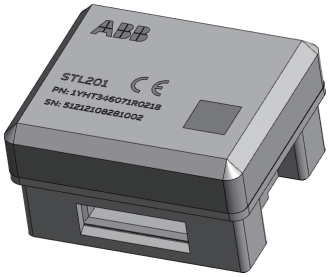
**23a STA201 Primary contacts thermal monitoring**
The STA201 sensors embedded in the primary contact arms allow direct measurement of the temperature in one of the most critical points of the circuit breaker. The measurement is shared through wireless to the concentrator unit for Monitor & Diagnostic features.
For installation or replacements please consult dedicated device documentation.



**23b SMA201 Smart Angle sensor**
The SMA201 sensor is assembled on the breaker kinematic chain to allow direct measurement of the most important characteristic of a proper Opening or Closing operation. The measurement is shared to with the concentrator unit for Monitor & Diagnostic features.
For installation or replacements please consult dedicated device documentation.



**23c STE201/STL201 Cables/BusBars thermal monitoring**
The STE201/STL201 Temperature monitoring devices are key components in ABB's switchgear and apparatus monitoring & diagnostic solutions. The devices are battery-free, self-powered smart temperature sensors, using wireless communication technology for connecting to ABB's monitoring and diagnostics data concentrators. The sensor devices can be installed directly on high-voltage parts, inside medium-voltage switchgear.
For installation or replacements please consult dedicated device documentation.

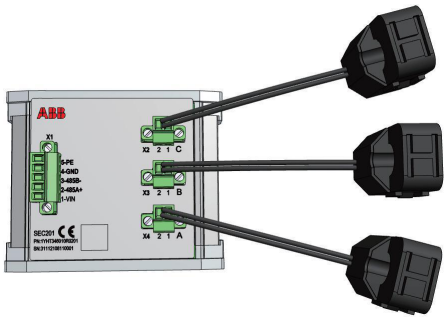



**23d THS01 Environmental monitoring**
The THS01 senors allows the monitoring of the circuit breaker at room parameters for monitor and diagnostic purposes.
For installation or replacements please consult dedicated device documentation.



**23e SEC201 Primary Current Sensor**

The SEC201 sensor allows the measurement of primary currents for monitor and diagnostic of the circuit breaker from the current transformer secondary circuit. It allows electrical life monitoring and in combination with the thermal sensors enables advanced thermal monitoring and diagnostic features.
For installation or replacements please consult dedicated device documentation.




**24 Digital upgrade KIT**

It is available a complete kit to upgrade a VD4 evo with Digital feature for monitor and diagnostic.
It includes the necessary connectors, concentrator unit CMU, and a flexible selection of ABB sensors.
Please contact your sales representative for more information.
Please contact ABB for more details based on your needs.

**25 Serial Hub**

The Serial communication hub is automatically delivered when more than one sensor with serial communication embedded in the CB has been ordered.
To be purchased separately in case of sensors upgrade after the ordering of the circuit breaker.

# 6. Instructions for operating the circuit breaker

## 6.1. Safety indications

**The VD4 circuit breakers guarantee a minimum IP2X degree of protection when installed in the following conditions:**

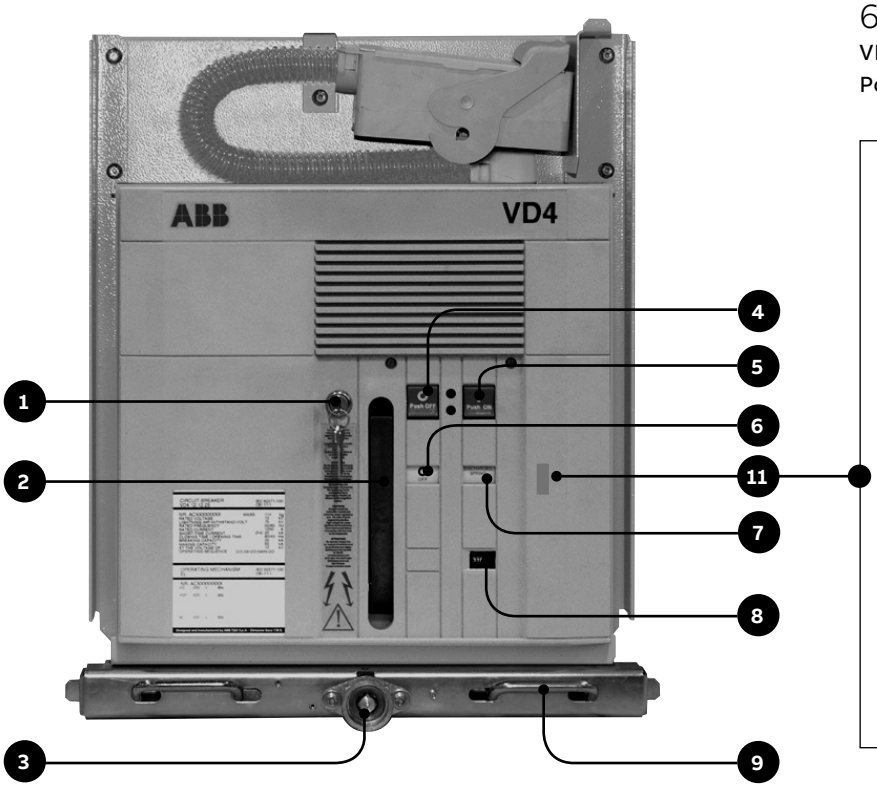
- **fixed circuit breaker, installed behind a protective metal net**
- **withdrawable circuit breaker, installed in switchgear.**

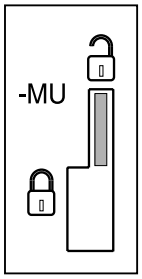
**Under these conditions the operator is totally guaranteed against accidental contact with moving parts.**
**Should mechanical operations be carried out on the circuit breaker outside of the switchgear, take great care of the moving parts.**

**If the operations are prevented, do not force the mechanical interlocks and check that the operating sequence is correct.**
**Racking the circuit breaker in and out of the switchgear must be done gradually to avoid shocks which may deform the mechanical interlocks.**
**Due to safety reasons, the circuit breaker has to be treated as "switched on" if the switching position cannot be clearly determined.**
**In this case all high voltage connections to the circuit breaker have to be de-energized and zero potential on the primary side of the circuit breaker has to be confirmed prior to commissioning, operation, maintenance or repair work.**

## 6.2. Switching and signalling parts

VD4 circuit breakers for UniGear switchgear and PowerCube modules (fig. 6a)




**Mechanical override of the undervoltage release (on request)**

Undervoltage release enabled. The circuit breaker can only be closed if the undervoltage release is supplied with power.

Undervoltage release disabled. The circuit breaker can also be closed if the undervoltage release is not supplied with power.

Caption
1 Key lock (if provided) (*)
2 Lever for manually charging the closing spring (except version VD4/ZS8 - see figure 6b)
3 Coupling lever for racking-out operation (withdrawable circuit breakers only)
4 Opening pushbutton
5 Closing pushbutton
6 Signalling device for circuit breaker open/closed
7 Signalling device for closing springs charged/discharged
8 Operation counter.
9 Handles for operating the truck locks (only for withdrawable circuit breakers)
10 Operating lever for circuit breaker racking-in/out (there is a special version for VD4/ZS8)
11 Mechanical undervoltage release override (on request).
(*) Warning! To activate the key lock: open the circuit breaker, keep the opening pushbutton depressed, then turn the key and remove it from the housing.

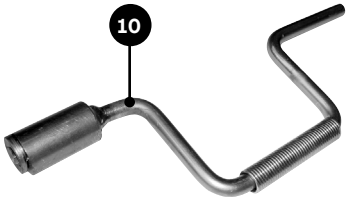



Fig. 6a

## 6.3. Circuit breaker closing and opening operations

Circuit breaker operation can be either manual or electrical (fig. 6 - fig. 7).

**a1) Manual closing spring charging for VD4 circuit breakers for UniGear switchgear and PowerCube modules (fig. 7a)**

Repeatedly activate the charging lever (2) (maximum rotation angle of the lever: about 90°) until the yellow indicator (7) appears.
The maximum forces which can normally be applied to the lever are < 150 N for the EL1operating mechanism, < 200 N for the EL2 operating mechanism and < 250 N for EL3 operating mechanism.
EL1 Twin and EL2 Twin type operating mechanisms are provided for circuit breakers with 50 kA breaking capacity.
For manual charging, the additional lever (1) should be inserted fully, as indicated in fig. 7c. In this way, the maximum force to be applied is < 200 N. For the type of operating mechanism, please refer to the rating plate in fig. 1.

**a2) Closing spring loading in the manual mode for withdrawable VD4 circuit breakers for UniGear switchgear equipped with a hand-operated rotaryc loading device for the closing spring (refer to fig. 6b for indicative details)**

Rotate the charging lever (2) (rotate about 12 times) until the yellow indicator (7) appears. The maximum force which can normally be applied to the lever is < 150 N for the EL1 operating mechanism and < 230 N for the EL3 operating mechanism.
The operation can be carried out with the door either open or closed and the circuit breaker either withdrawn or connected.
WARNING (fig. 6b): Fit the hand-operated loading lever of the closing spring (2b) into its housing (2a). Turn the lever clockwise (about 12 times) until the yellow indicator (7) appears to show that loading is complete. Once this happens, the lever will continue for half a turn without loading (without exercising any force), after which it will lock owing to a sudden load increase. Do not exercise force or try to continue loading as this will damage the device.

**VD4 circuit breakers for ZS8.4 switchgear (fig. 6b)**

**a3) Manual closing spring charging for VD4 circuit breakers (fig. 7b)**

Ruotare la leva di carica (2) fino alla comparsa del
Rotate the charging lever (2) until the yellow indicator (7) appears. The maximum force which can normally be applied to the lever is < 150 N for the EL1 operating mechanism and < 230 N for the EL3 operating mechanism.
The operation can be carried out with the door either open or closed and the circuit breaker either withdrawn or connected.

WARNING (fig. 6b): Fit the hand-operated loading lever of the closing spring (2b) into its housing (2a). Turn the lever clockwise (about 12 times) until the yellow indicator (7) appears to show that loading is complete. Once this happens, the lever will continue for half a turn without loading (without exercising any force), after which it will lock owing to a sudden load increase. Do not exercise force or try to continue loading as this will damage the device.

**b) Electrical spring charging operation**

On request, the circuit breaker can be fitted with the following accessories for electrical operation:
- geared motor for automatic closing spring charging
- shunt closing release
- shunt opening release.

The geared motor automatically recharges the spring after each closing operation until the yellow indicator (7) appears. If the power is cut off during charging, the geared motor stops and automatically starts recharging the springs again when the power returns.
In any case, it is always possible to complete the charging operation manually.

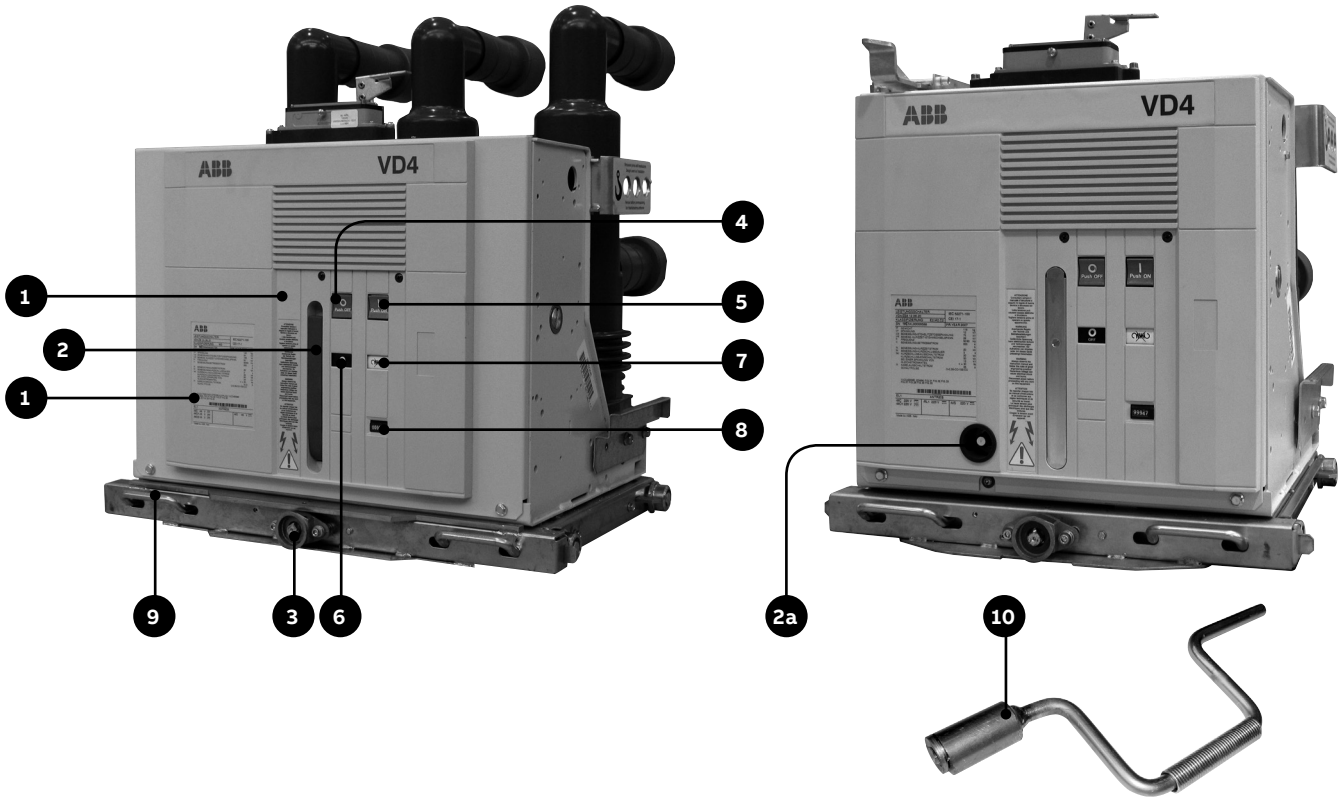
**c) Circuit breaker closing**

The operation can only be carried out with the closing spring completely charged.
For manual closing, press the pushbutton (5 - fig. 6b).
When there is a shunt closing release, the operation can also be carried out remotely by means of a special control circuit. Closing having taken place is indicated by the signalling device (6 - fig. 6b).

**d) Circuit breaker opening**

The operation can only be carried out with the closing spring completely charged.
For manual closing, press the pushbutton (5 - fig. 6b).
When there is a shunt closing release, the operation can also be carried out remotely by means of a special control circuit.
Closing having taken place is indicated by the signalling device (6 - fig. 6b).

# 6. Instructions for operating the circuit breaker




Caption
1 Key lock (if provided)
2 Lever for manually charging the closing spring
2a Coupling for manual closing spring charging (when lever 2 is not provided)
2b Lever for manual closing spring charging for rotary charging device
3 Coupling for racking-out operation lever (only for withdrawable circuit breakers)
4 Opening pushbutton
5 Closing pushbutton
6 Signalling device for circuit breaker open/closed
7 Signalling device for closing spring charged/discharged
8 Operation counter.
9 Handles for operating the truck locks (only for withdrawable circuit breakers)
10 Operating lever for circuit breaker racking-in/out.

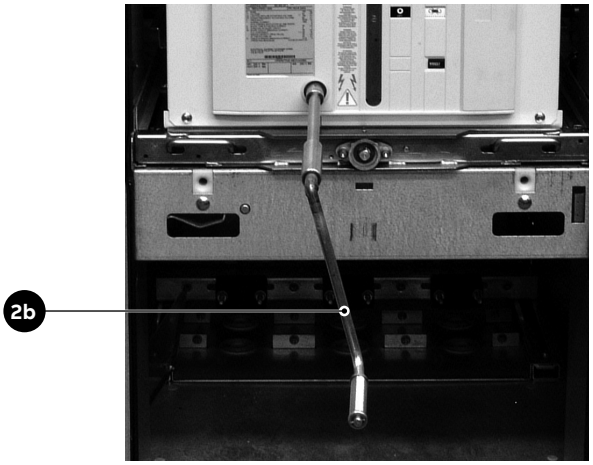



Fig. 6b

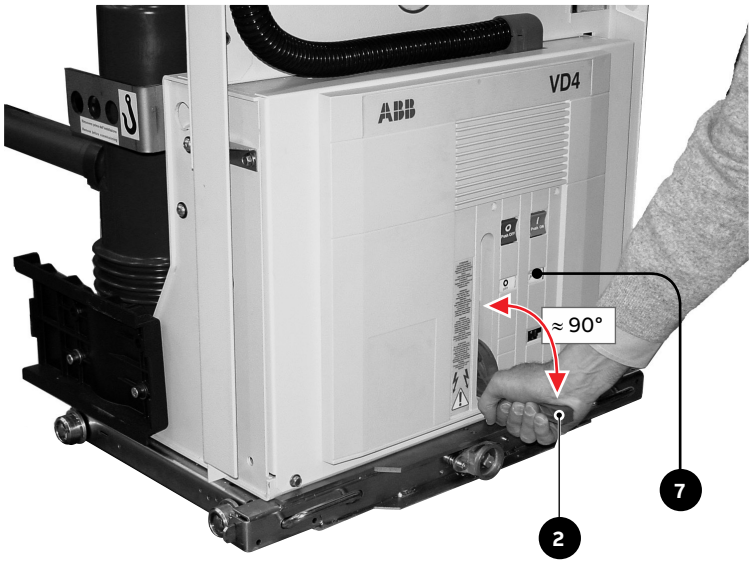



Fig. 7a

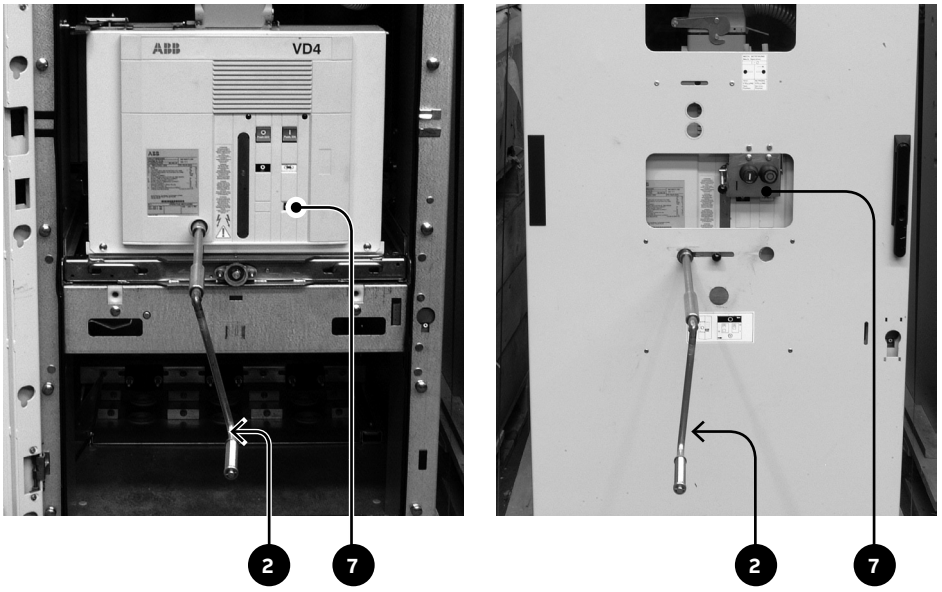



Fig. 7b

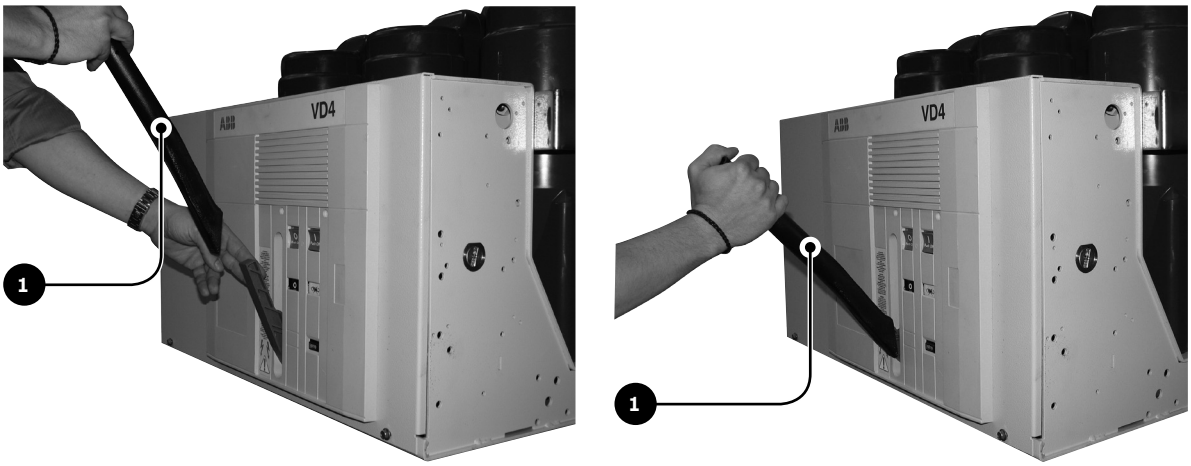



Fig. 7c

6.4 Detailed instruction of sensors and CMU Usage is in 2RDA044113 &2RDA044114. only for VD4 evo

# 7. Installation

## 7.1. General

**Correct installation is of primary importance. The manufacturer's instructions must be carefully studied and followed. It is good practice to use gloves for handling the pieces during installation.**

## 7.2. Installation and operating conditions

The following Standards must be taken into particular consideration during installation and service:

- IEC 62271-1/DIN VDE 0101
- VDE 0105: Electrical installation service
- DIN VDE 0141: Earthing systems for installations with rated voltage above 1 kV
- All the accident prevention regulations in force in the relative countries.

### 7.2.1. Normal conditions

Follow the recommendations in the IEC 62271-1 and 62271- 100 Standards. In more detail:

| **Ambient temperature** | |
|---|---|
| Maximum | + 40 °C |
| Average maximum over 24 hours | + 35 °C |
| Minimum (according to class – 5), apparatus for indoor installation | – 5° |

| **Humidity** |
|---|
| The average value of the relative humidity, measured for a period longer than 24 hours, must not exceed the 95%. |
| The average value of the pressure of the water vapour, measured for a period longer than 24 hours, must not exceed 2.2 kPa. |
| The average value of the relative humidity, measured for a period longer than 1 month, must not exceed the 90%. |
| The average value of the pressure of the water vapour, measured for a period longer than 1 month, must not exceed 1.8 kPa. |

| **Altitude** |
|---|
| ≤ 1000 m above sea level. |

### 7.2.2. Special conditions

| Installations over 1000 m a.s.l. |
|---|
| Possible within the limits permitted by reduction of the dielectric resistance of the air. |

| **Increase in the ambient temperature** |
|---|
| Reduction in the rated current. |
| Encourage heat dissipation with appropriate additional ventilation. |

| **Climate** |
|---|
| To avoid the risk of corrosion or other damage in areas: |
| • with a high level of humidity, and/or |
| • with rapid and big temperature variations, take appropriate steps (for example, by using suitable electric heaters) to prevent condensation phenomena. |

For special installation requirements or other operating conditions, please contact ABB.

**The areas involved by the passage of power conductors or auxiliary circuit conductors must be protected against access of any animals which might cause damage or disservices.**

### 7.2.3. Trip curves

The following graphs show the number of closing-opening cycles (No.) allowed, of the vacuum interrupters, according to the breaking capacity (Ia).

Caption (Figs. 8...)
No. Number of closing-opening cycles allowed for the vacuum interrupters.
Ia: Breaking capacity of the vacuum interrupters.

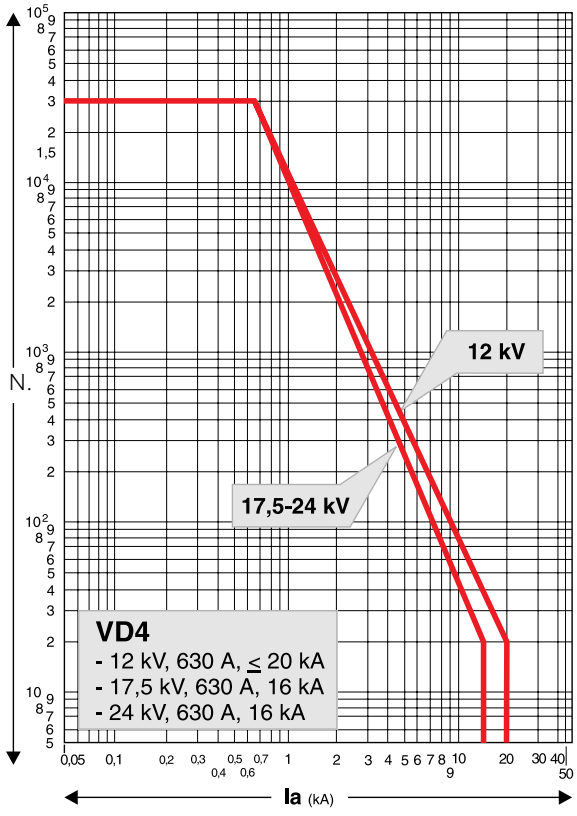



Fig. 8a

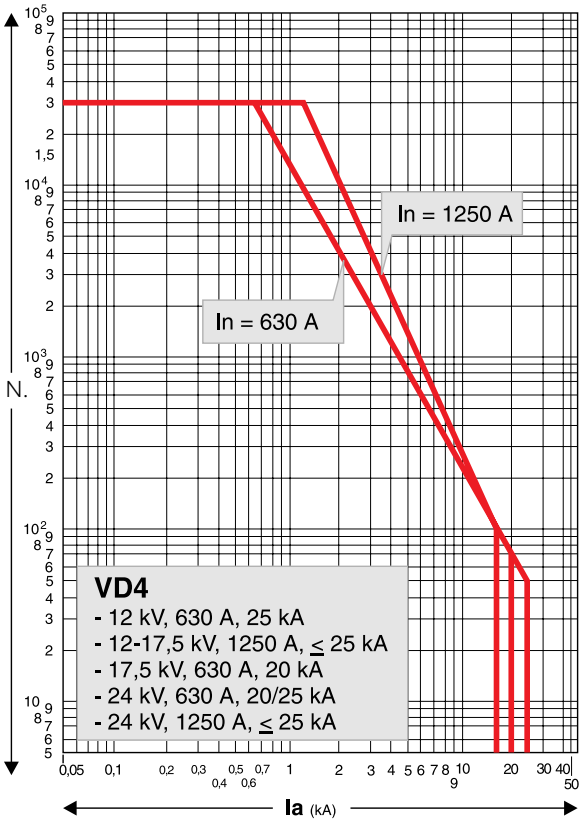



Fig. 8b

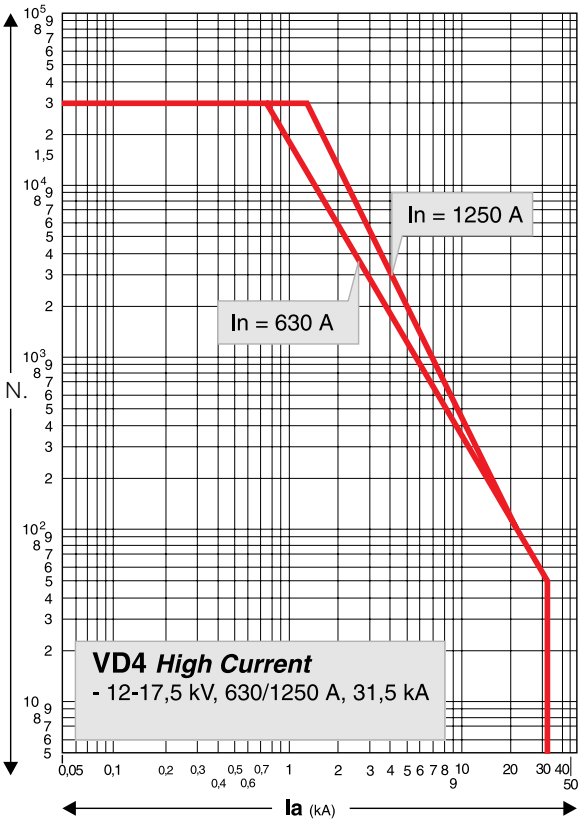



Fig. 8c

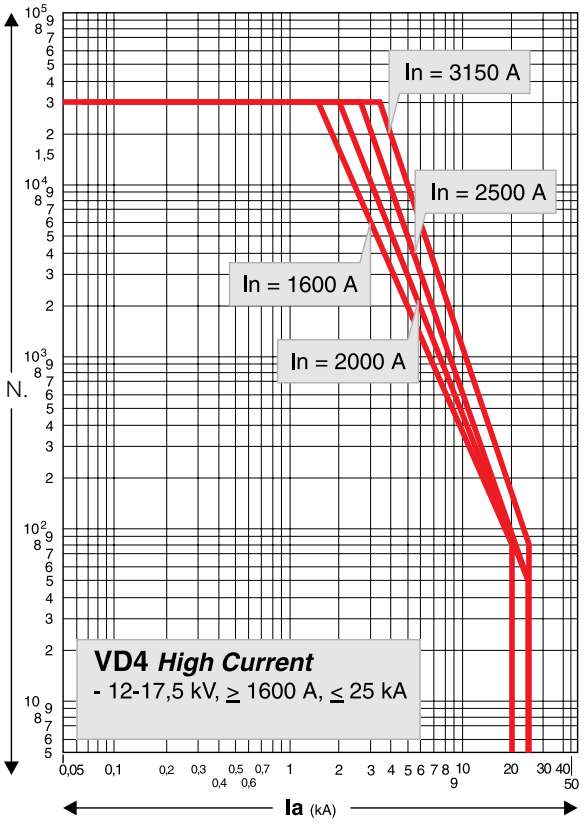



Fig. 8d

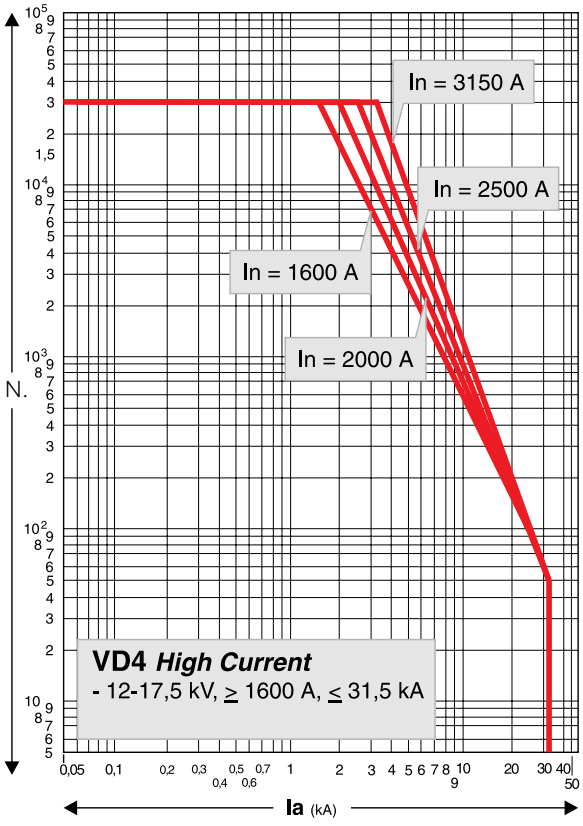



Fig. 8e

# 7. Installation

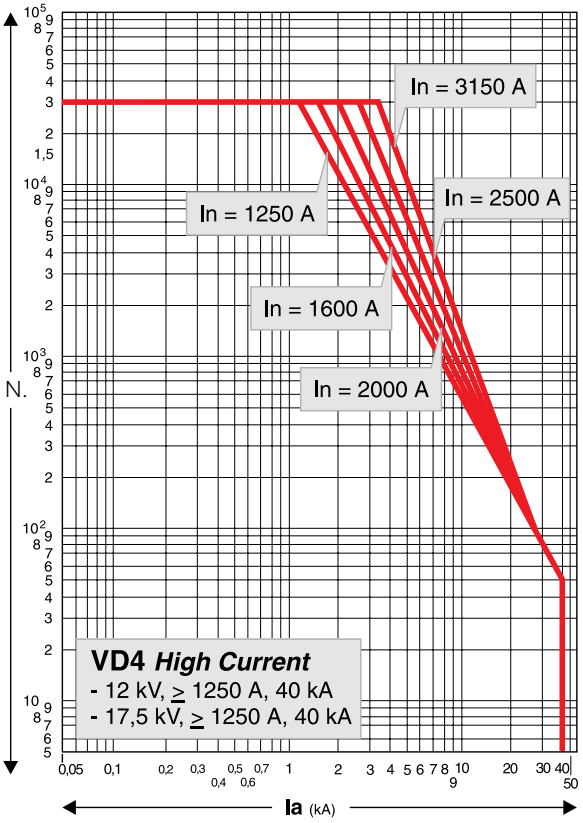



Fig. 8f

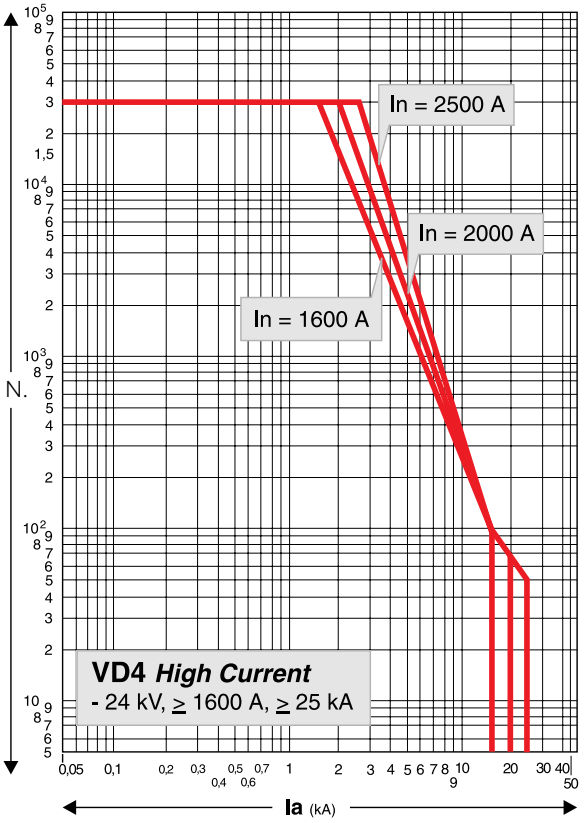



Fig. 8g

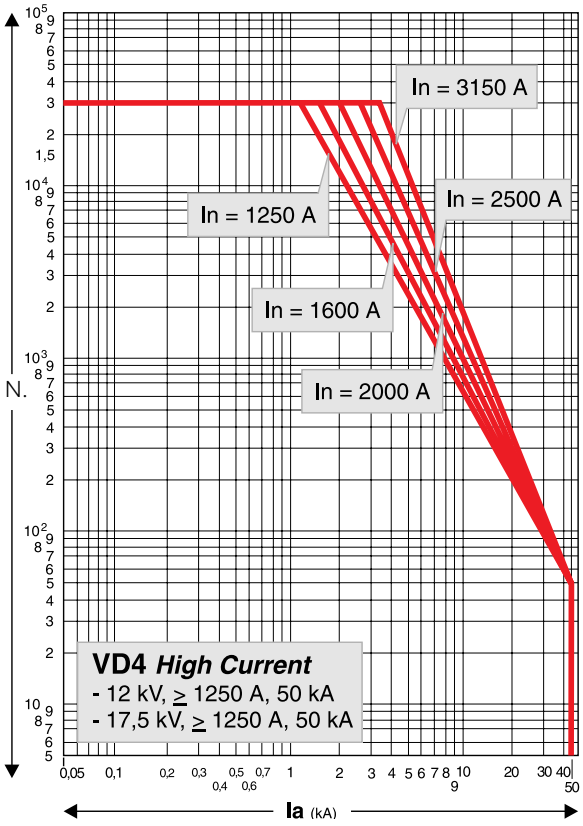



Fig. 8h

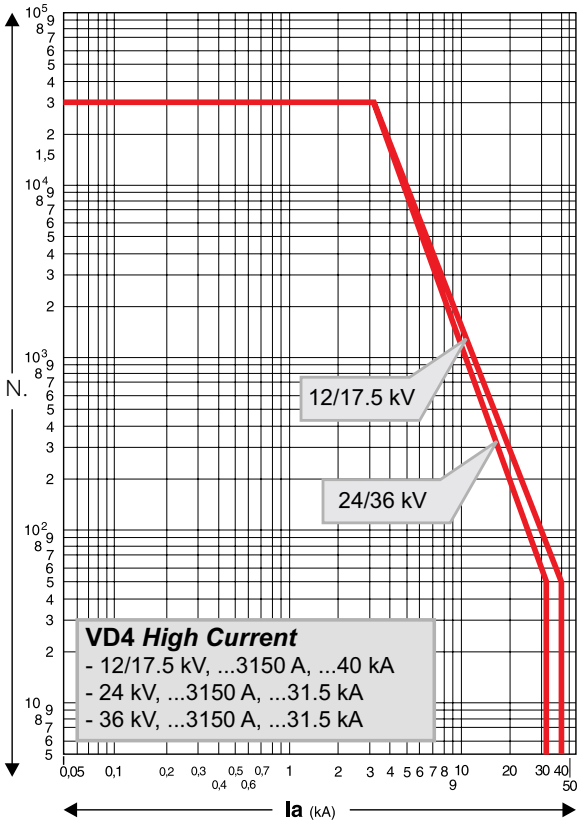



Fig. 8i

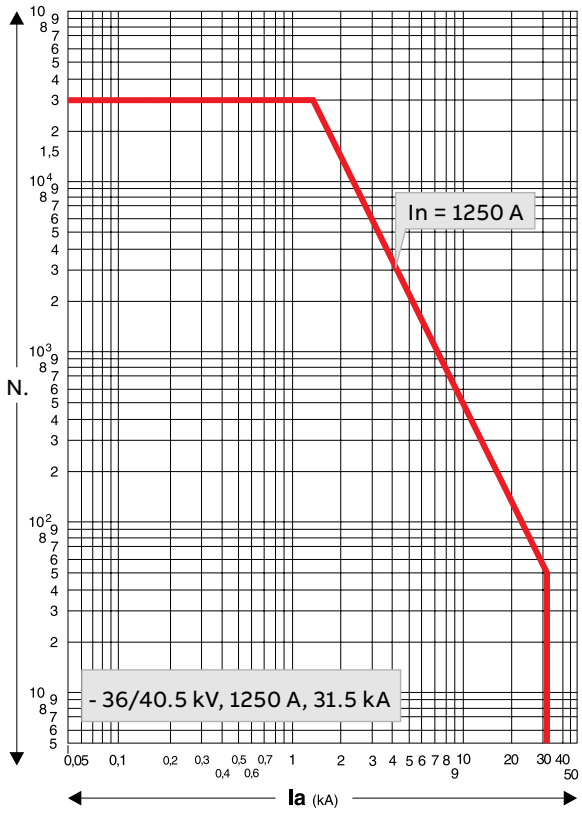



Fig. 8l

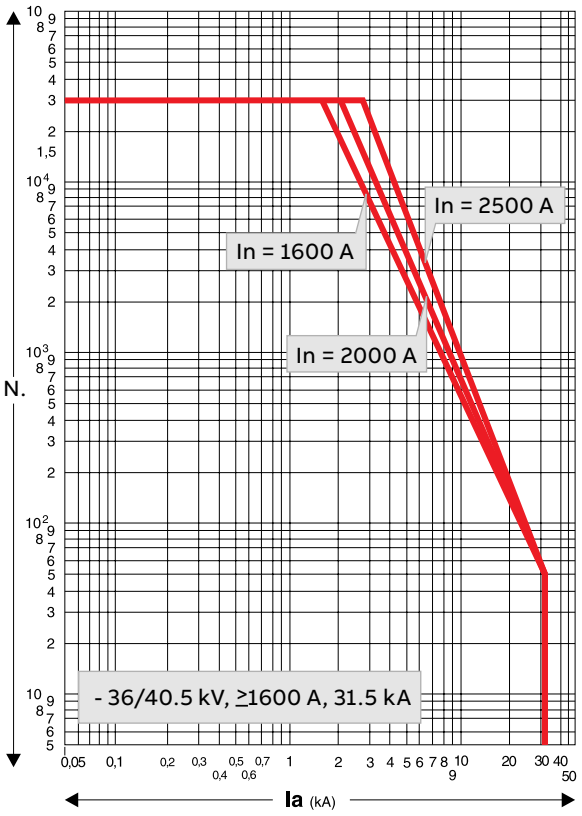



Fig. 8m

**Breaking curves for vacuum interrupters embedded in thermoplastic poles for VD4 High Current:**

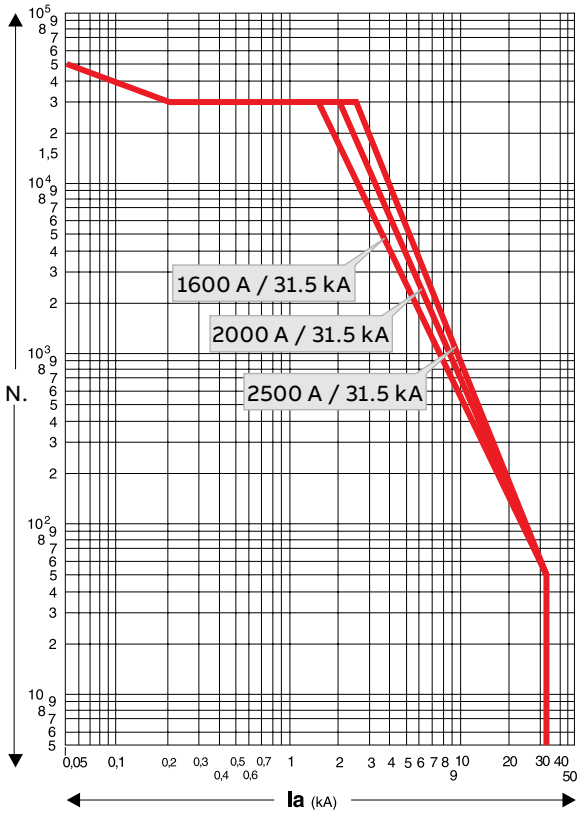



Fig. 8n

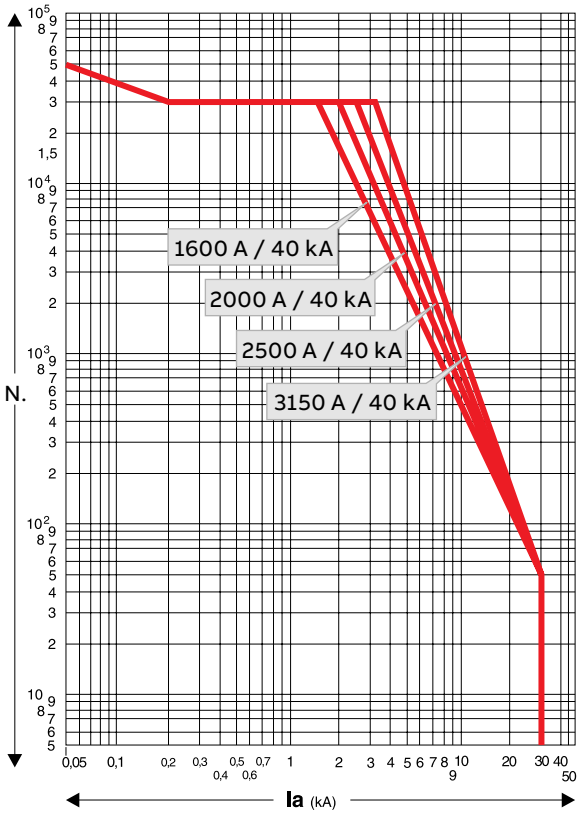



Fig. 8o

# 7. Installation

## 7.3. Preliminary operations

- Clean the insulating parts with clean dry cloths.
- Check that the top and bottom terminals are clean and free of any deformation caused by shocks received during transport or storage.

## 7.4. Installation of fixed circuit breakers

The circuit breaker can be mounted directly on supporting frames to be provided by the customer, or on a special supporting truck (available on request).
The circuit breaker, with supporting truck, must be suitably fixed to the floor of its own compartment by the customer.
The floor surface in correspondence with the truck wheels must be carefully levelled.
A minimum degree of protection (IP2X) must be guaranteed from the front towards live parts.

### 7.4.1. Mounting the circuit breaker on a truck made by other manufacturers

The VD4 circuit breakers which are not installed on ABB trucks, but on trucks made by the customer, must be fitted with one or two additional auxiliary contacts (activated by the mechanical lock and by the circuit breaker release device) to carry out the function of interrupting the shunt closing release circuit (-MBC) during traverse from isolated and vice versa.
In ABB trucks, this function is carried out by the -BGT1 and -BGT2 auxiliary contacts which cut of the release power supply during and before activation of the mechanical lock of the screw truck racking-in device. This means that the shunt closing release power supply can only by applied at the end of activation of the mechanical lock. In this way it is certain that no electrical impulse can activate the shunt closing release with the circuit breaker in an intermediate position.

## 7.5. Installation of withdrawable circuit breaker

The withdrawable circuit breakers are preset for use in UniGear ZS1, UniGear ZS2, UniSec switchgear and PowerCube modules.
For racking-in/racking-out of the switchgear, fully insert the lever (1) (fig. 9) in the appropriate seat (2) and work it clockwise for racking-in, and anti-clockwise for racking-out, until the limit switch positions are reached.
Circuit breaker racking-in/-out must be carried out gradually to avoid shocks which may deform the mechanical interlocks and the limit switches.
The torque normally required to carry out racking-in and racking-out is <25 Nm.
This value must not be exceeded. If operations are prevented or difficult, do not force them and check that the operating sequence is correct.

Note
To complete the racking-in/out operation, about 20 rotations of the lever are required for circuit breakers up to 17.5 kV, and about 30 rotations for 24 kV circuit breakers.

When the circuit breaker has reached the isolated for test/ isolated position, it can be considered racked into the switchgear and, at the same time, earthed by means of the truck wheels.
Withdrawable circuit breakers of the same version, and therefore with the same dimensions, are interchangeable.
However, when, for example, different electrical accessory fittings are provided, a different code for the plug of the auxiliary circuits does not allow incorrect combinations between panels and circuit breakers.
For the circuit breaker installation operations, also refer to the technical documentation of the above-mentioned switchgear.



- **The racking-in/-out operations must always be carried out with the circuit breaker open.**
- **When putting into service for the first time, it is advisable to charge the circuit breaker operating mechanisms manually so as not to overload the auxiliary power suply circuit.**

### 7.5.1. Circuit breakers with withdrawable motorized truck

Carry out the racking-in/racking-out test of the motorized truck in the same way as for a manual truck, following the instructions below:

- Rack the circuit breaker into the switchgear in the open and isolated position, with the power supply to the motor circuit cut off and with the enclosure door closed.
- Insert the manual racking-in lever (1) in the special coupling (2) Fig. 9, and take the motorized truck to about half its run between the isolated for test and the connected position. The torque needed to carry out truck handling is < 25 Nm.
- In the case of accidental inversion of the truck motor power supply polarity, this operation allows a possible error in direction to be dealt with without any damage. Verification checks:
  a) motor rotation clockwise during circuit breaker racking-in.
  b) motor rotation anticlockwise during circuit breaker racking-out.
- Remove the manual lever (1) from the coupling (2) Fig. 9
- Supply the truck motor circuit.
- Activate the control for the electrical racking-in operation. When racking-in has taken place, check correct changeover of the relative auxiliary contact.
- On completion, activate the control for the electrical racking-out operation. When racking-out has taken place, check correct changeover of the relative auxiliary contact.
- In the case of a motor fault during a racking-in or rackingout operation, in an emergency the truck can be taken to the end of its run manually, after first cutting off the power supply to the motor power supply circuit and then, using the manual lever, work in the same way as with the manual truck.

Note
The clutch has to mechanically disconnect the motor to operate the truck by manual lever in the right way. To do it, perform one turn by manual lever in the opposite direction compared to the last motorized truck movement, before to operate by manual lever in the needed direction.

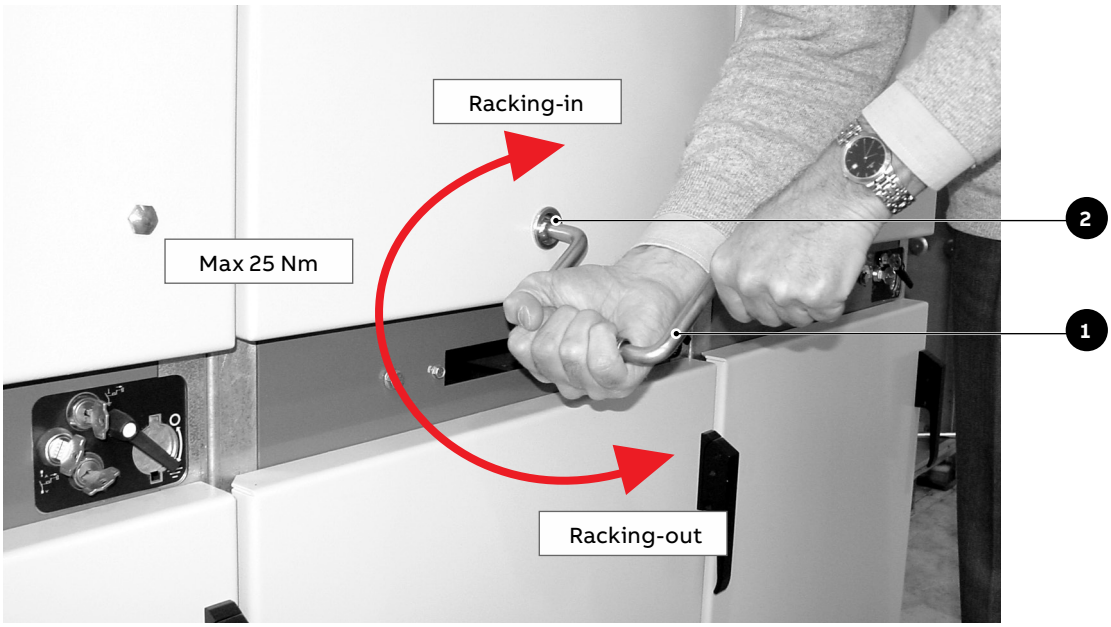



Fig. 9

# 7. Installation

## 7.6. Power circuit connections of fixed circuit breakers

### 7.6.1. General recommendations

- Select the cross-section of the conductors according to the service current and the short-circuit current of the installation.
- Prepare special pole insulators, near the terminals of the fixed circuit breaker or of the enclosure, sized according to the electrodynamic forces deriving from the short-circuit current of the installation.

### 7.6.2. Assembly of the connections

- Check that the contact surfaces of the connections are flat, and are free of any burrs, traces of oxidation or deformation caused by drilling or impacts received.
- According to the conductor material and the surface treatment used, carry out the operations indicated in table T1 on the contact surface of the conductor.

**Assembly procedure**

- Put the connections in contact with the circuit breaker terminals, taking care to avoid mechanical stresses (traction / compression) on, for example, the conducting busbars on the terminals.
- Interpose a spring washer and a flat washer between the head of the bolt and the connection.
- It is advisable to use bolts according to DIN class 8.8 Standards, also referring to what is indicated in table T2.
- In the case of cable connections, strictly follow the manufacturer's instructions to make the terminals.

**T1**

| **Bare copper** |
|---|
| • Clean with a fine file or emery cloth. |
| • Tighten fully and cover the contact surfaces with 5RX Moly type grease |

| **Copper or silver-plated aluminium** |
|---|
| • Clean with a rough dry cloth. |
| • Only in the case of obstinate traces of oxidation, clean with a very fine grain emery cloth taking care not to remove the surface layer. |
| • If necessary, restore the surface treatment. |

| **Bare aluminium** |
|---|
| • Clean with a metal brush or emery cloth. |
| • Cover the contact surfaces again immediately with neutral grease |
| • Insert the copper-aluminium bimetal with surfaces shined (copper side in contact with the terminal; aluminium side in contact with the connection) between the aluminium connection and the copper terminal. |

**T2**

| **Bolt** | **Recommended tightening torque (1)** | |
|---|---|---|
| | Without lubricant | With lubricant (2) |
| M6 | 10.5 Nm | 4.5 Nm |
| M8 | 26 Nm | 10 Nm |
| M10 | 50 Nm | 20 Nm |
| M12 | 86 Nm | 40 Nm |
| M16 | 200 Nm | 80 Nm |

(1) The nominal tightening torque is based on a friction coefficient of the thread of 0.14 (distributed value the thread is subjected to which, in some cases, is not negligible). The nominal tightening torque with lubricant is according to the DIN 43673 Standards.

(2) Oil or grease. The thread and surfaces in contact with the lubricated heads. Take into account the deviations from the general Standards table (for example, for systems in contact or terminals) as foreseen in the specific technical documentation. The thread and surfaces in contact with the heads of bolts must be slightly oiled or greased, so as to obtain a correct nominal tightening torque.

## 7.7. Earthing

For the fixed version circuit breaker, carry out earthing by means of the special screw marked with the relative symbol.
Clean and degrease the area around the screw to a diameter of about 30 mm and, on completion of assembly, cover the joint again with Vaseline grease.
Use a conductor (busbar or braid) with a cross-section conforming to the Standards in force.

## 7.8. Connection of the auxiliary circuits

Note: the minimum cross-section of the wires used for the auxiliary circuits must not be less than the one used for the internal cabling. Furthermore, they must be insulated for 3 kV of test.

### 7.8.1. Fixed circuit breaker

The customer can choose between two types of auxiliary circuit connections in the circuit breaker. The first type is supplied as the standard version. In this case, the auxiliary contacts must be disassembled from the structure of the circuit breaker, since their terminals cannot be directly accessed (fig. 10) (consult the installation manual). Part of the wiring is made during the production phase for the second type. This means that the customer can wire up by directly accessing the terminal boxes in the front part of the circuit breaker. In this case, the wiring operation is much faster and immediate.

To prevent the cabling wires outside the circuit breaker (carried out by the customer) from accidentally coming into contact with moving parts and therefore undergoing damage to the insulation, it is recommended to fix the wires as shown in fig. 10a.
In both types of connection, the wires must pass through connection (2) while outside the circuit breaker, the cables must be screened by an appropriate sort of metallic protection (tube, duct, ...), which must be earthed.

### 7.8.2. Withdrawable circuit breakers

The auxiliary circuits of withdrawable circuit breakers are fully cabled in the factory as far as the connector (fig. 11).
For the external connections, refer to the electric wiring diagram of the switchgear.

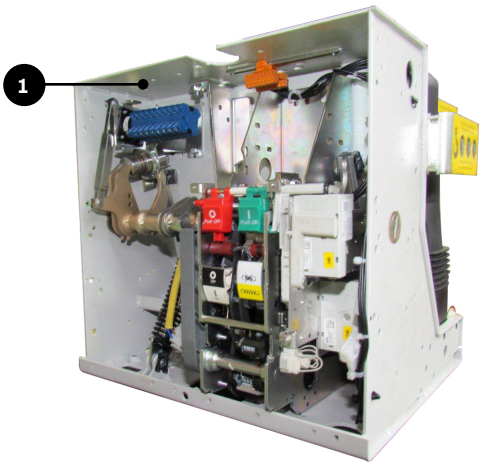



Fig. 10

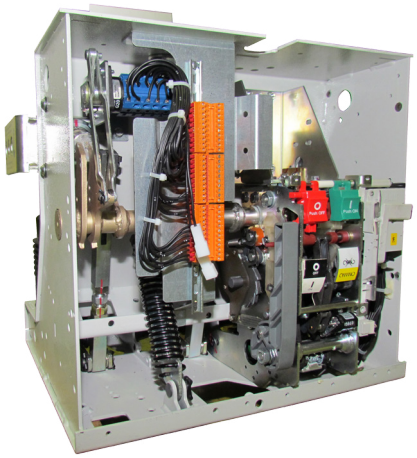


Fig. 10a

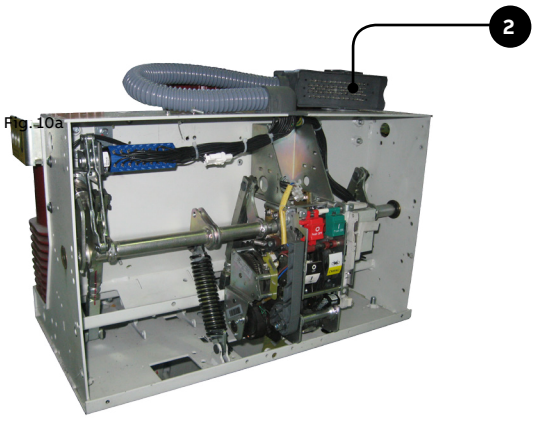



Fig. 10a

Fig. 11

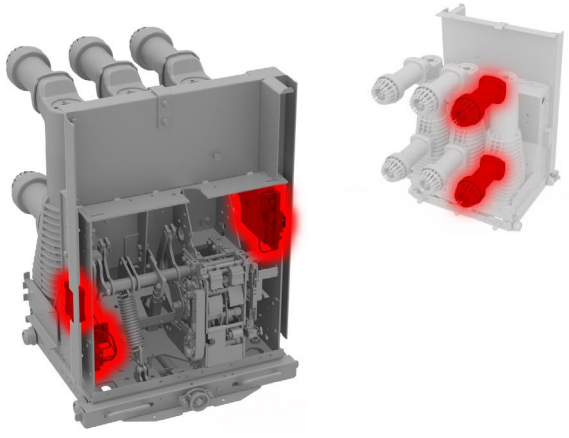


Fig. 12 VD4 evo with sensors

# 7. Installation

## 7.9. Sensors installation

Please refer to manual 2RDA044114 for sensor configuration.

### 7.9.1. Installation of CMU

Detailed instructions for installing CMU are available in 1VCD601733R0001

### 7.9.2. Installation of Serial Hub

Detailed instructions for installing Serial Hub are available in 1VCD601734R0001

### 7.9.3. Installation of Temperature Sensor

Detailed instructions for installing Temperature Sensor are available in 1VCD601730R0001

### 7.9.4. Installation of Angle Sensor

Detailed instructions for installing Angle Sensor are available in 1VCD601731R0001

# 8. Putting into service

## 8.1. General procedures



**All the operations regarding putting into service must be carried out by ABB personnel or by suitably qualified customer personnel with in-depth knowledge of the apparatus and of the installation.**
**Should the operations be prevented, do not force the mechanical interlocks and check that the operating sequence is correct.**
**The operating forces which can be applied for racking-in withdrawable circuit breakers are indicated in paragraph 7.5.**

Before putting the circuit breaker into service, carry out the following operations:

- check tightness of the power connections to the circuit breaker terminals;
- establish the setting of the primary electronic overcurrent release (if provided);
- check that the value of the power supply voltage of the auxiliary circuits is between 85% and 110% of the rated voltage of the electrical accessories;
- check that no foreign bodies, such as bits of packing, have got into the moving parts;
- check that there is a sufficient exchange of air in the installation place to avoid overtemperatures;
- also carry out the checks indicated in table T3.

**Detailed instruction for putting sensors and CMU into service are available in 2RDA044114**

# 8. Putting into service

**T3**

| ITEM | INSPECTED | PROCEDURE | POSITIVE CHECK |
|---|---|---|---|
| **1** | Insulation resistance. | **Medium voltage circuit** | |
| | | With a 2500 V megger, measure the insulation resistance between the phases and the exposed conductive part of the circuit. | The insulation resistance should be at least 50 Mohm and in any case constant over time. |
| | | **Auxiliary circuits** | |
| | | With a 500 V megger (if the apparatus installed allows this), measure the insulation resistance between the auxiliary circuits and the exposed conductive part. | The insulation resistance should be a few Mohm and in any case constant over time. |
| **2** | Auxiliary circuits. | Check that the connections to the control circuit are correct: proceed at the relative power supply. | Operations and signals normal. |
| **3** | Manual operating mechanism. | Carry out a few closing and opening operations (see cap. 6).<br>N.B. Supply the undervoltage release and the locking magnet on the operating mechanism at the relative rated voltage (if provided). | The operations and relative signals take place normally. |
| **4** | Motor operator (if provided). | Supply the spring charging geared motor at the relative rated voltage. | The spring is charged normally.<br>The signals are normal.<br>With the spring charged, the geared motor stops. |
| | | Carry out a few closing and opening operations.N.B. Supply the undervoltage release and the locking magnet on the operating mechanism at the relative rated voltage (if provided). | The geared motor recharges the spring after each closing operation. |
| **5** | Undervoltage release (if provided). | Supply the undervoltage release at the relative rated voltage and carry out the circuit breaker closing operation. | The circuit breaker closes normally.<br>The signals are normal. |
| | | Cut off power to the release. | The circuit breaker opens.<br>The signalling changes over. |
| **6** | Shunt opening release and additional shunt opening release (if provided). | Close the circuit breaker and supply the shunt opening release at the relative rated voltage. | The circuit breaker opens normally.<br>The signals are normal. |
| **7** | Shunt closing release (if provided). | Open the circuit breaker and supply the shunt closing release at the relative rated voltage. | The circuit breaker opens normally.<br>The signals are normal |
| **8** | Key lock (if provided). | Open the circuit breaker, keep the opening pushbutton depressed, then turn the key and remove it from the housing.<br>Attempt the circuit breaker closing operation. | Neither manual nor electrical closing takes place. |
| | | Put the key back in and turn it 90°.<br>Carry out the closing operation. | Both electrical and manual closing take place normally; in this position the key cannot be removed. |
| **9** | Locking electromagnet (-RLE1) (if provided). | With the circuit breaker open, spring charged and locking electromagnet not supplied, attempt circuit breaker closing both manually and electrically. | Closing is not possible. |
| **10** | Auxiliary contacts in the operating mechanism. | Insert the auxiliary contacts in suitable signalling circuits.<br>Carry out a few closing and opening operations. | Signals take place normally. |
| **11** | Locking electromagnet on the truck circuit breaker (-RLE2) (if provided). | With the circuit breaker open, in the isolated for test position and the locking electromagnet not supplied, attempt racking-in of the circuit breaker. | Racking-in is not possible. |
| | | Supply the locking electromagnet and carry out the racking-in operation. | Racking-in takes place correctly. |
| **12** | Auxiliary transmitted contacts for signalling circuit breaker racked-in, isolated (UniGear switchgear or PowerCube modules). | Insert the auxiliary contacts in suitable signalling circuits.<br>With the circuit breaker racked into the enclosure, carry out a few traverse operations from the isolated for test position to the connected position.<br>Take the circuit breaker to the racked-out position. | The signals due to the relative operations take place normally. |
| **13** | CMU and Sensors | Perform 5O & 5C to check if the CMU and Sensors are communicating. | Curves on dashboard as per the standard. |

# 9. Maintenance

The maintenance operations are aimed at keeping the apparatus in good working condition for as long as possible.
In accordance with what is specified in the IEC 61208 / DIN 31 051 Standards, the following operations must be carried out.

| | |
|---|---|
| Inspection: | Finding out the actual conditions |
| Overhauling: | Measures to be taken to maintain the specific conditions |
| Repairs: | Measures to be taken to restore the specific conditions. |

## 9.1. General

ABB Advises you to refer to the SWAPs maintenance program to get a customized maintenance plan according to your specific environmental and operational conditions. Use the QR code below to access the SWAPs webpage and related creation tool.

Vacuum interruption does not produce any harmful effects even when there are frequent interruptions at the rated and short-circuit current.
The interventions during service and their aim are determined by the ambient conditions, by the sequence of operations and by the short-circuit interruptions.

Note
Respect the following Standards for maintenance work:
the relative specifications given in the chapter on “Standards and Specifications”;
– work safety regulations in the chapter on “Putting into service and operations”;
– standards and specifications of the country where the apparatus is installed.

The maintenance operations must only be carried out by trained personnel and who follow all the safety regulations.
Furthermore, it is advisable to call on ABB personnel, at least in cases for checking the performances in service and for repairs.
Cut the power supply off and put the apparatus under safe conditions during the maintenance operations.



**Before carrying out any operations, check that the circuit breaker is open, with the spring discharged and that it is not supplied (medium voltage circuit and auxiliary circuits).**

### 9.1.1. Operating life expectancy

The operating life expectancy for the VD4 circuit breakers is as follows:

- vacuum interrupters: up to 30.000 operations, according to their type (see par. 7.2.3. Trip curves);
- switching device, actuator and transmission system: up to 30.000 operations, under normal operating conditions, according to the type of circuit breaker and with regular
- with operations correctly executed it is possible to carry outup to 1000 racking-out/in operations (as prescribed in theIEC 60271-200 Standards);
- with operations correctly executed it is possible to carry out up to 500 racking-out/in operations (as prescribed in the IEEE/ANSI C37.20.2 Standards);
- the data regarding the operating life are basically applicable to all the components which cannot be directly affected by operator activity. The manually operated components (moving parts of isolatable parts, etc.) can vary their behaviour.

# 9. Maintenance

## 9.2. Inspections and functionality tests

### 9.2.1. Interruption devices in general

- Check the conditions of the interruption devices with regular inspections.
- Inspection at fixed intervals can be avoided when the apparatus is permanently under the control of qualified personnel.
- The checks must, first of all, include visual inspection to check for any contamination, traces of corrosion or electrical discharge phenomena.
- Carry out more frequent inspections when there are unusual operating conditions (including severe climatic conditions) and in the case of environmental pollution (e.g. high level of contamination or an atmosphere with aggressive agents).
- Visual inspection of the isolating contacts. It is recommended to turn the contact system alternately in order to keep the internal surface of the contact areas clean. The contact areas must be cleaned when there are signs of overheating (discoloured surface) (also see Repairs).



- In the case of abnormal conditions, take suitable overhauling measures (see Overhauling par.).

### 9.2.2. Stored energy operating mechanism

Carry out the functional test of the operating mechanism after 5.000 operations or during ordinary maintenance operations as specified in par. 9.2.1. and service the release devices at least every 5 years (see par. 9.3.2.).
Before doing the test, open the circuit breaker and carry out the following operations:

- in the case of withdrawable circuit breakers, take the circuit breaker to the isolated for test position
- in the case of fixed circuit breakers: cut off the power supply to the medium voltage circuit.

Note
Insulate the work area and make it safe, following the safety regulations specified in the IEC/DIN VDE Standards.

**Functional test**

- With the circuit breaker not connected to the load, carry out a few opening and closing operations.
- If foreseen, cut the power supply to the spring charging motor off. Discharge the spring by closing and opening the circuit breaker by means of the closing and opening pushbuttons.
- Visually inspect the lubrication conditions of the tulip isolating contacts, of the sliding surfaces, etc.
- Check correct electrical and mechanical operation of the various devices, with particular attention to the interlocks.
- The screws and nuts are tightened in the factory and correct tightening is marked with a collared sign. No further tightening operations are foreseen during the operating life of the circuit breaker. However, following any maintenance interventions, should it be necessary to re-tighten the screws or nuts, it is recommended to always replace the screws and nuts and to keep to the values indicated in fig. 12.

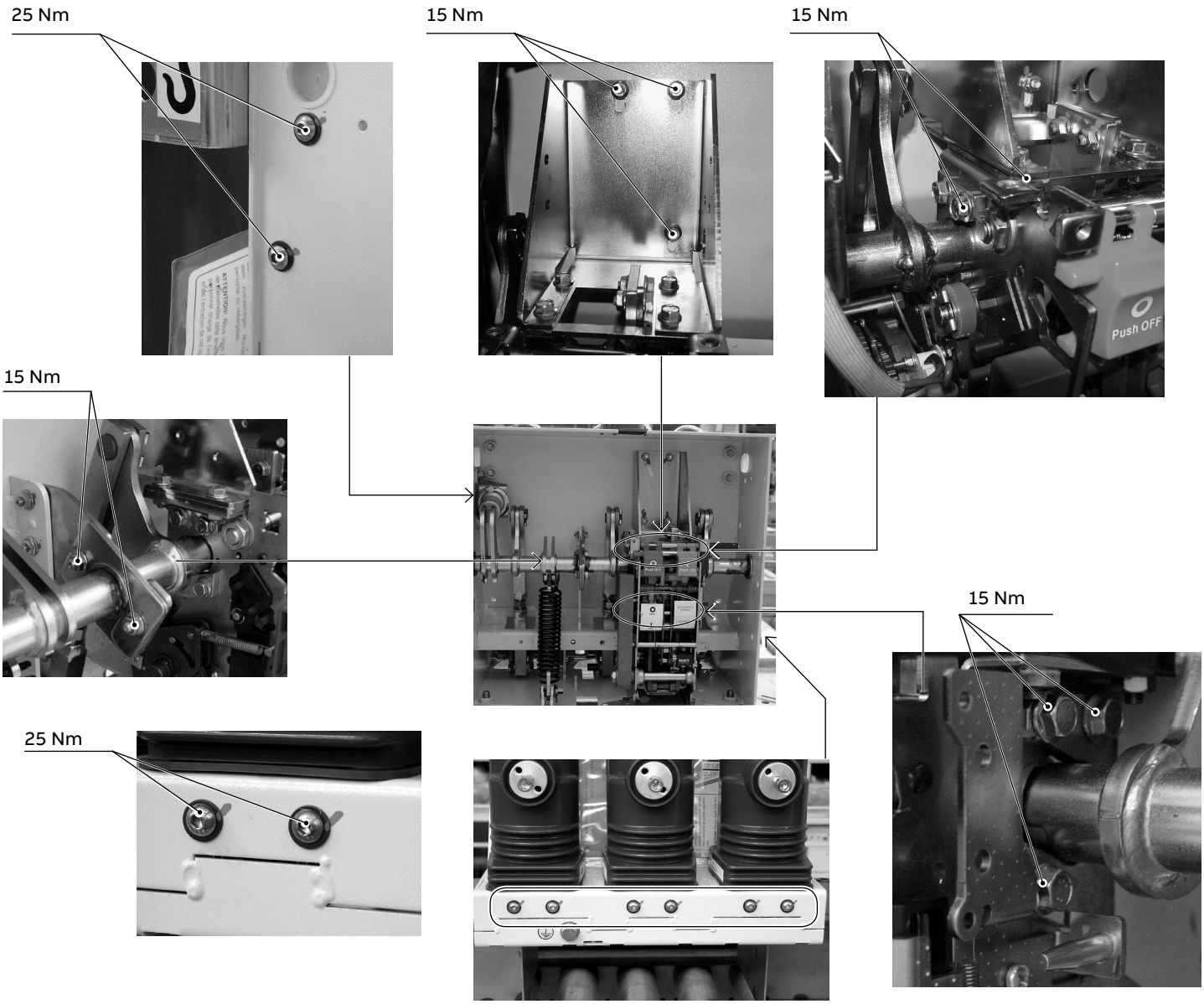
### 9.2.3. Circuit breaker pole

No other check except what has already been specified in par. 9.2.1. is necessary.

### 9.2.4. Withdrawable assembly (truck and circuit-breaker)

Visually inspect the components, especially those which may be damaged by incorrect operations (also see table in chap. 8).
Visually inspect the isolating contacts and that all the contact elements are clean, especially in cases where signs of overheating are found (also see par. 9.4.).
Visually inspect and carry out the functional tests of the locks, checking their correct operation and activation without abnormal force – maximum 25 N (also see table in chap. 8).

**Checking tightness of the screws**




**EL Twin actuator - 50 kA**

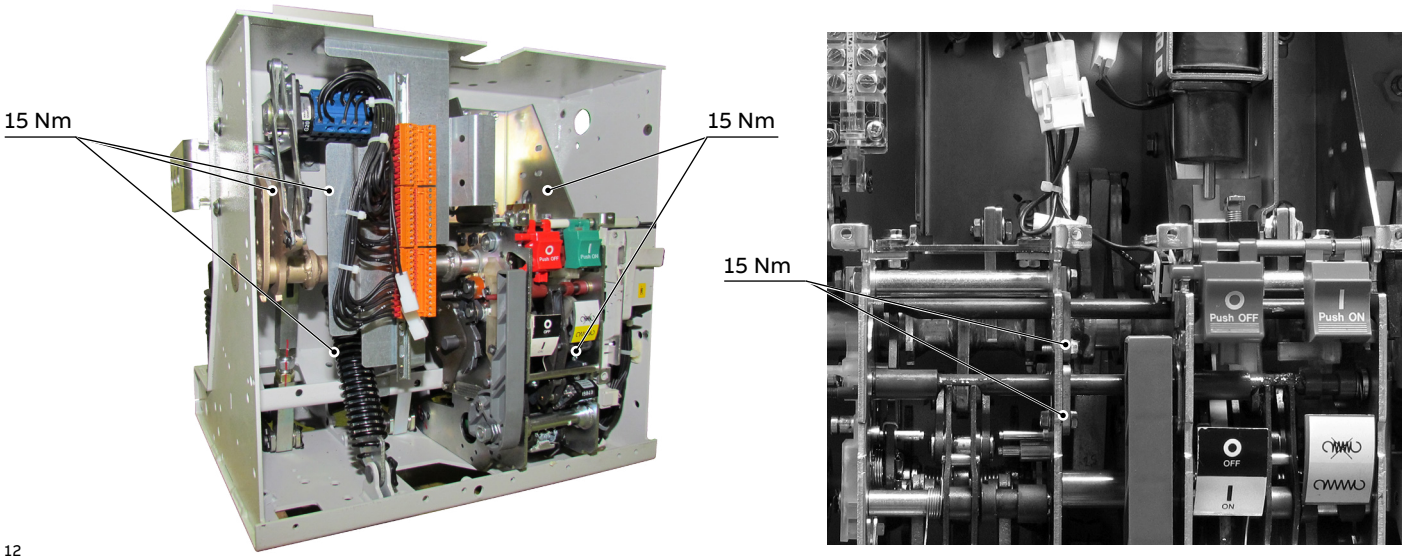



Fig. 12

# 9. Maintenance

## 9.3. Overhauling

### 9.3.1. Interruption devices in general

Should it have been necessary to clean the devices during the inspections, according to what is specified in par. 9.2.1., use the following procedure:

- insulate the work ar ea and make it safe, following the safety regulations specified in the IEC/DIN VDE Standards;
- general cleaning of the surfaces:
  - dry and eliminate light deposits of dirt with a soft dry cloth;
  - more resistant deposits of dirt can be removed using slightly alkaline domestic type detergent or Rivolta BWR 210 type detergent;
- cleaning insulating surfaces and conductive parts.

After cleaning, rinse thoroughly with clean water and dry carefully.

Note
Only use detergents without halogens and never 1.1.1-trichloroethane, trichloroethylene or carbon tetrachloride!

### 9.3.2. Tripping device: actuator and transmission system

**Circuit breakers up to 17.5 kV, 1250 A, 31.5 kA and up to 24 kV, 2500 A, 25 kA**

To ensure correct operation of the circuit breaker, inspection and maintenance of the tripping devices is recommended every 10.000 operations. For this purpose, please contact the ABB Service office.
Complete replacement of the actuator, shock absorber and of the other transmission system parts (shaft, main levers, safety rings, etc.) must be carried out after 30.000 operations.

**IEEE circuit breakers 15kV up to 2000A, 40kA**

To ensure correct operation of the circuit breaker, inspection and maintenance of the tripping devices must be carried out every 2.000 operations. For this purpose, please contact the ABB Service office.
Replacement of spring charging motor (-MAS) must be carried out every 5.000 operations.
Complete replacement of the shock absorber and of the other parts of the transmission system (shaft, main levers, safety rings, etc.) must be carried out every 10.000 operations.

**Circuit breakers up to 17.5 kV, 40 kA and 24 kV, 31.5 kA**

To ensure correct operation of the circuit breaker, inspection and maintenance of the tripping devices is recommended every 5.000 operations. For this purpose, please contact the ABB Service office.
Complete replacement of the actuator must be carried out every 10.000 operations.
Complete replacement of the shock absorber and of the other transmission system parts (shaft, main levers, safety rings, etc.) must be carried out after 30.000 operations.

**Circuit breakers up to 17.5 kV, 3150 A , 40 kA and 36/40.5 kV**

To ensure correct operation of the circuit breaker, inspection and maintenance of the tripping devices must be carried out every 5.000 operations. For this purpose, please contact the ABB Service office.
Complete replacement of the shock absorber and of the other part of the transmission system (shaft, main levers, safety rings, etc.) must be carried out after 10.000 operations.

**Circuit breakers up to 17.5 kV, 50 kA and EL twin actuator**

To ensure correct operation of the circuit breaker, inspection and maintenance of the tripping devices must be carried out every 5.000 operations. For this purpose, please contact ABB Service.
Complete replacement of the shock-absorber and of the other parts of the transmission system (shaft, main levers, safety rings, etc.) must be carried out every 10.000 operations.

Note
Dismantling and replacement of the operating mechanism (trip box) can only be carried out by ABB personnel or by skilled and specially trained personnel, particularly for the necessary adjustments.

**Details regarding overhauling**

- When foreseen, cut of the power supply to the spring charging motor and manually discharge the operating mechanism spring by closing and opening the circuit breaker.
- Replace the parts subjected to mechanical str ess or stress due to particular environmental conditions, (contact and ABB service centre).
- Consult maintenance instruction manual 1VCP000558 for further details.

Note
These operations can only be carried out by ABB personnel or by skilled and specially trained personnel.

### 9.3.3. Circuit breaker pole

The circuit breaker pole and relative vacuum interrupter are maintenance-free until the maximum number of electrical operations for the type of interrupter is reached (see par. 7.2.3. Trip curves). The operating life of the vacuum interrupter is defined by the sum of the ultimate currents corresponding to the specific type of interrupter in accordance with what is indicated in the graphs of par. 7.2.3. Trip curves: when the sum of the ultimate currents is reached, the whole pole must be replaced.

Note
Dismantling and replacement of the pole can only be carried out by ABB personnel or by skilled and specially trained personnel, particularly for the necessary adjustments.

To carry out the interrupter test without dismantling the circuit breaker pole, use:

- the VIDAR vacuum tester, made by the company Programma Electric GmbH, Bad Homberg v.d.H.

To check vacuum tightness of the interrupter, the following test values must be set on the VIDAR tester:

| Rated voltage of the circuit breaker | d.c. test voltage |
|---|---|
| 12 kV | 40 kV |
| 17.5 kV | 40 kV |
| 24 kV - 36 kV - 40.5 kV | 60 kV |

CMU and Sensors The expected life expectancy for CMU and sensors is 10 years. After 10 years please get in touch with ABB Service for the replacement. For VD4 evo customers can replace the sensors themselves without any intervention from ABB Service.
Detailed instructions for installing the sensors is available .Please see section.7 -Installation for more details.
ABB shall provide the software updates from time to time.

The test must always be carried out with the circuit breaker open with the contacts at the nominal distance.



**Procedure for testing the degree of vacuum of the interrupter of the circuit breaker poles:**

- **turn the power supply off and make the working area safe by following the safety regulations specified in the IEC/ DIN VDE Standards;**
- **open the circuit breaker;**
- **earth a terminal of each circuit breaker pole;**
- **connect the earth terminal of the VIDAR tester to the circuit breaker structure;**
- **connect the high voltage terminal of the VIDAR tester to the terminal of the circuit breaker pole not connected to earth (L1 phase) and carry out the test. Repeat the test for phases L2 and L3.**

Note
The tester connection cables can produce an indication due to the capacitive effect. In this case the cables must not be removed.

## 9.4. Repairs

Replacement of spare parts and accessories must only be carried out by ABB personnel or suitably qualified and specially trained personnel.
Always work with the circuit breaker open and locked so that it cannot be closed again, with the work area insulated and made safe.
The operating mechanism spring must be discharged.
All power supply sources must be disconnected and made safe against any reclosing during removal and installation work.



**Should maintenance be carried out by the customer's personnel, responsibility for the interventions remains with the customer.**
**The replacement of parts not included in the "List of spare parts/accessories" (par. 12.1.) must only be carried out by ABB personnel. In particular:**

- **complete pole with bushings/ connections**
- **actuator and transmission system**
- **closing spring set**
- **opening spring**
- **shock-absorber.**

# 10. Application of the X-ray emission Standards

One of the physical properties of vacuum insulation is the possibility of X-ray emission when the interrupter contacts are open.
The specific tests carried out at the PTB laboratories (Physikalisch-Technische Bundesanstalt, in Brunswick - Germany) show that local emission at a distance of 10 cm from the interrupter or pole surface, does not exceed 1 μSv/h.

**It follows that:**

- at the rated service voltage the use of vacuum interrupters is absolutely safe;
- application of the withstand voltage at power frequency, according to the IEC 62271-100 and VDE 0670 Standards, is safe;
- application of a voltage higher than the withstand voltage at power frequency or of a test voltage in direct current, specified in the IEC and VDE Standards, cannot be used;
- limitation of the above-mentioned local phenomena, with interrupters with open contacts, depends on keeping the specific distance between the contacts.
  This condition is intrinsically guaranteed by correct operation of the operating mechanism and by the adjustments of the transmission system.

# 11. Spare parts and accessories



**All assembly operations of spare parts/ accessories must be carried out following the instructions enclosed with the spare parts, by ABB personnel or by suitably qualified customer personnel with in-depth knowledge of the apparatus (IEC 60694) and of all the Standards aimed at carrying out these interventions in safe conditions. Should the maintenance be carried out by the customer's personnel, responsibility for the interventions remains with the customer. Before carrying out any operation, always make sure that the circuit breaker is open, the spring discharged and that it is not energised (medium voltage circuit and auxiliary circuits).**

To order circuit breaker spare parts/accessories, refer to the ordering sales codes indicated in the technical catalogue and always state the following:
- type of circuit breaker
- rated voltage of the circuit breaker
- rated normal current of the circuit breaker
- breaking capacity of the circuit breaker
- serial number of the circuit breaker
- rated voltage of any electrical spare parts.

For availability and to order spare parts, please contact our Service office.

## 11.1. List of spare parts

- Shunt opening release
- Additional shunt opening release
- Undervoltage release
- Contact for signalling undervoltage release energised/deenergised
- Time delay device for undervoltage release
- Mechanical override for undervoltage release
- Shunt closing release
- Spring charging geared motor with electrical signalling of spring charged
- Contact signalling protection circuit breaker of the geared motor open/closed
- Contact signalling closing spring charged/ discharged
- Transient contact with momentary closing during circuit breaker opening
- Circuit breaker auxiliary contacts
- Locking electromagnet on the operating mechanism
- Position contact of the withdrawable truck
- Contacts signalling connected/isolated
- Opening solenoid
- Key lock in open position
- Isolation interlock with the door
- Protection for opening pushbutton
- Protection for closing pushbutton
- Locking electromagnet on the withdrawable truck
- Set of six tulip contacts
- CMU (for VD4 evo only)
- Temperature sensor with Smart Arm (for VD4 evo only)
- Angle sensor (for VD4 evo only)

# 12. Electric circuit diagrams

The standard VD4 circuit breaker electric circuit diagrams are as follows:

Free standing version:
- 1VCD400151: Fixed circuit breakers
- 1VCD400152: Fixed circuit breakers with 64-pole connector
- 1VCD400153: Fixed circuit breakers with 58-pole connector
- 1VCD400154: Fixed circuit breakers with truck

Withdrawable version
- 1VCD400155: Withdrawable circuit breakers
- 1VCD400156: Withdrawable motorized circuit breakers
- 1VCD400158 Withdrawable circuit breakers for ZS8.4 switchgear VD4/ZS8, ZT8 and Z8 with circuit breaker
- 1VCD400159: Withdrawable circuit breakers for ZS8.4 switchgear with VD4/ZS8, ZT8 and Z8 circuit breaker with motorized truck

50kA version
- 1VCD400166: Fixed circuit breakers 50 kA
- 1VCD400167: Withdrawable circuit breakers 50 kA
- 1VCD400168: Withdrawable circuit breakers 50 kA with motorized truck.

Each circuit breaker is always provided with the standard electric diagram or with a specific diagram in the case of a circuit breaker with non-standard cabling.

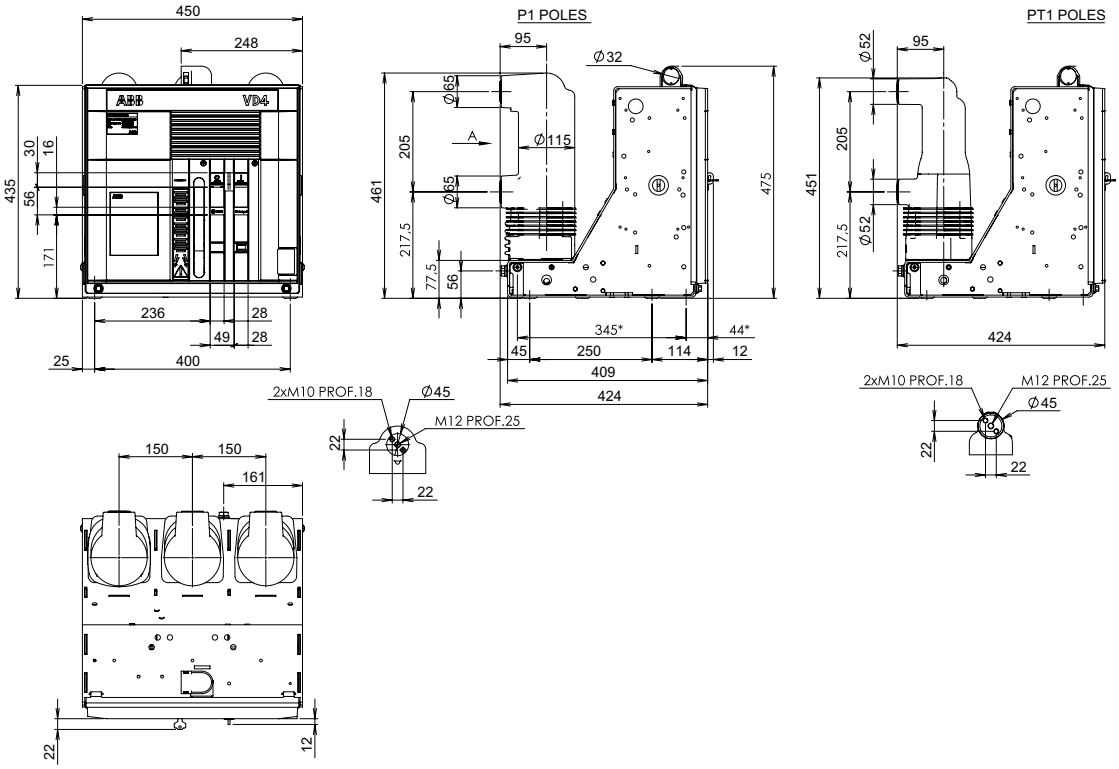
Free standing version VD4 evo 40 kA:
- 1VCD400316: Fixed circuit breakers

Withdrawable version VD4 evo 40 kA:
- 1VCD400311: Withdrawable circuit breakers
- 1VCD400312: Withdrawable motorized circuit breakers

# 13. Overall dimensions

### Fixed circuit breakers

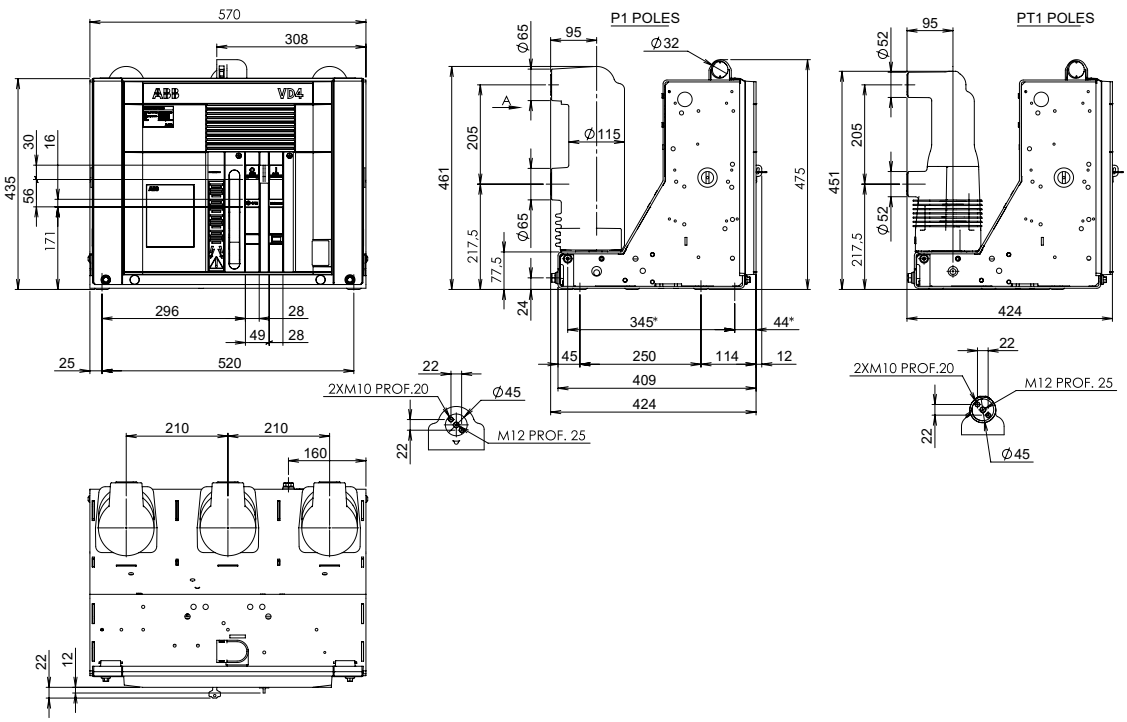
| VD4 | | |
|---|---|---|
| TN | 7405 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1200 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




(*) Fixing interchangeability with previous series (345 x 400).

### Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 7406 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

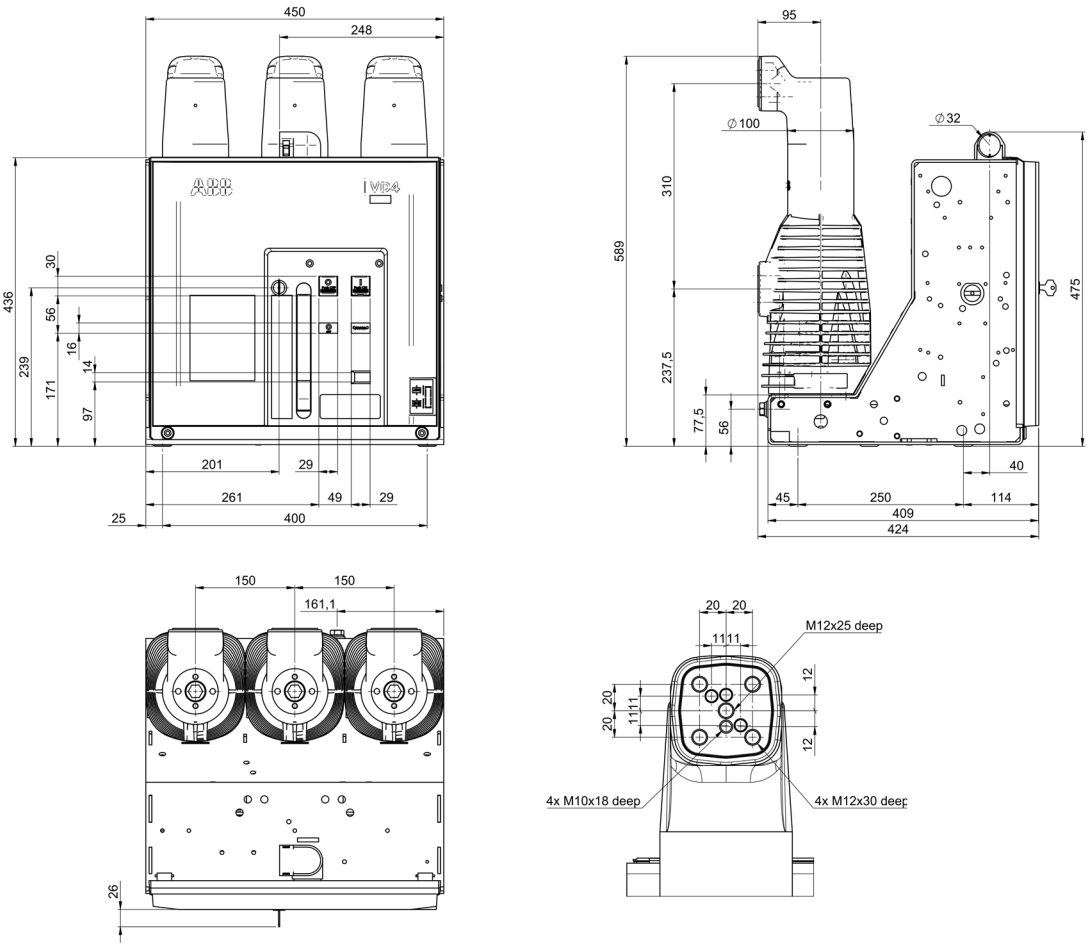



(*) Fixing interchangeability with previous series (345 x 520).

# 13. Overall dimensions

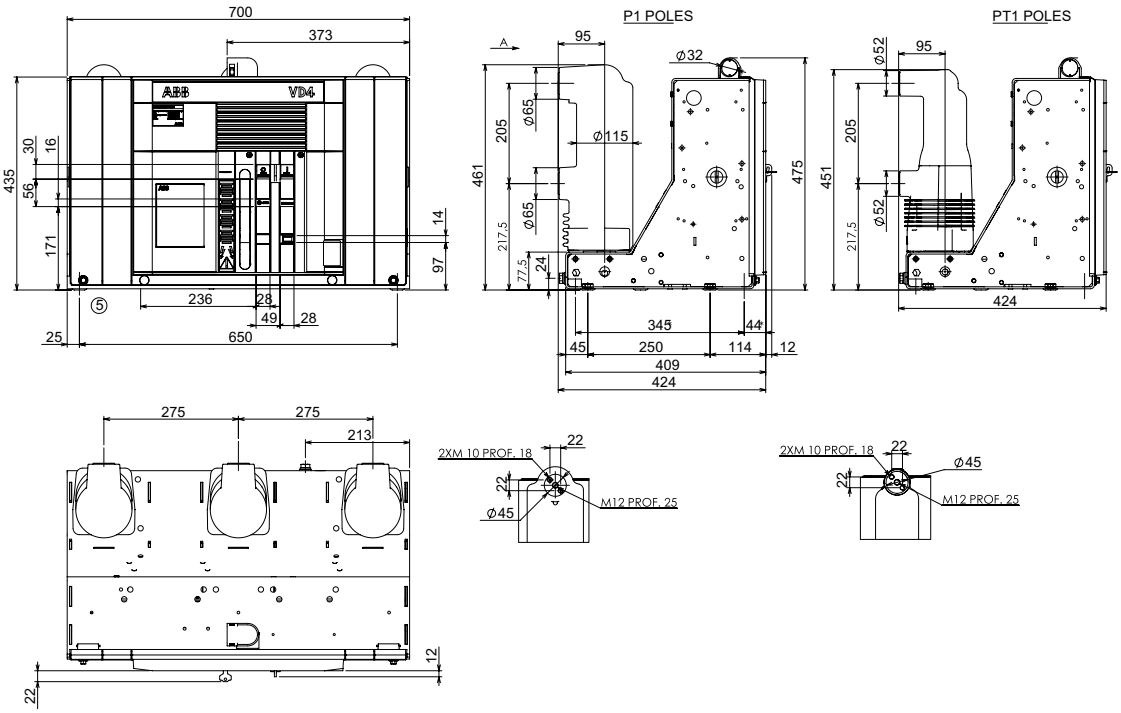
### Fixed circuit breakers

| **VD4** | | |
|---|---|---|
| TN | 2RDA043108 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



## Fixed circuit breakers

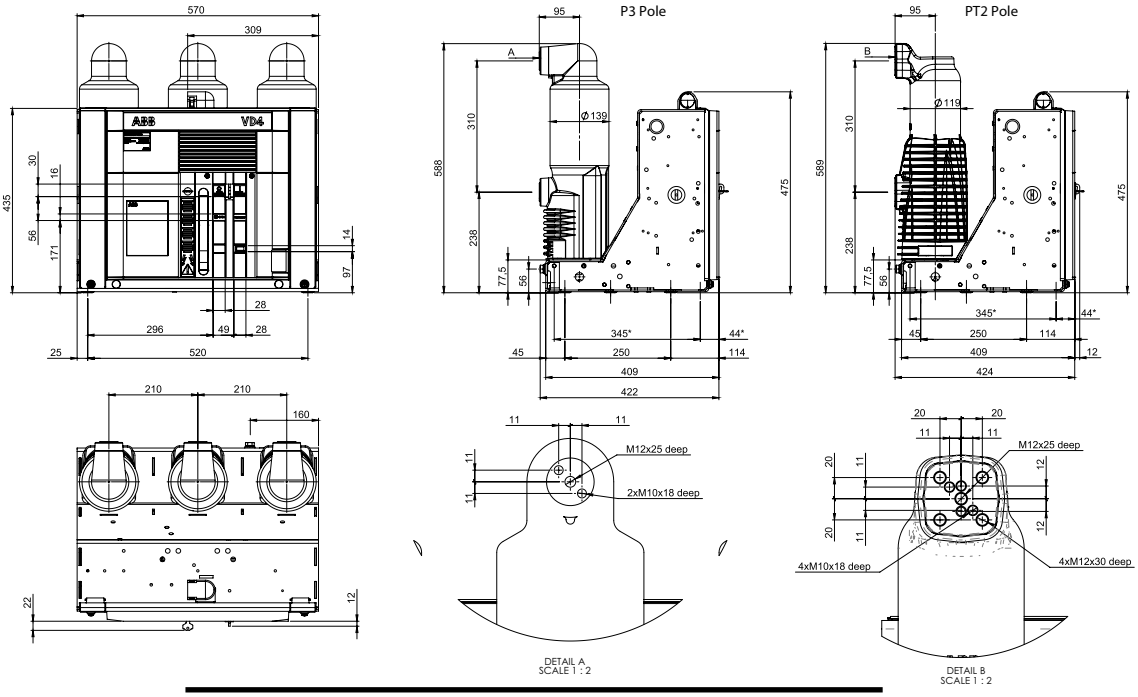
| VD4 | | |
|---|---|---|
| TN | 1VCD000051 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




(*) Fixing interchangeability with previous series (345 x 650).

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003282 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |



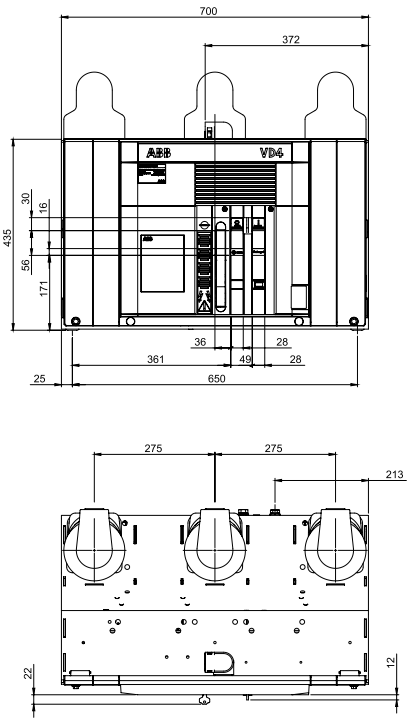

| Type | Pole | Ur | Ir | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p210 | P3 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |
| VD4 p210 | PT2 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |

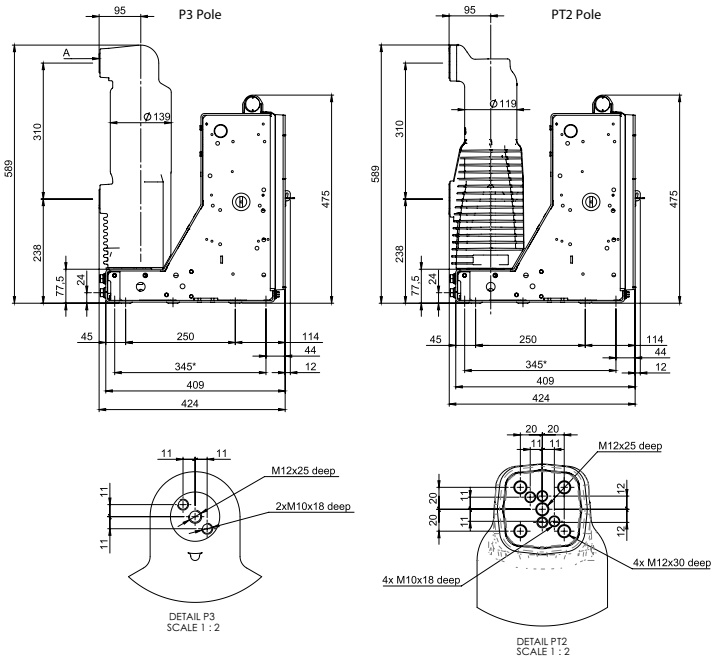
(*) Fixing interchangeability with previous series (345 x 650).

# 13. Overall dimensions

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003285 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |



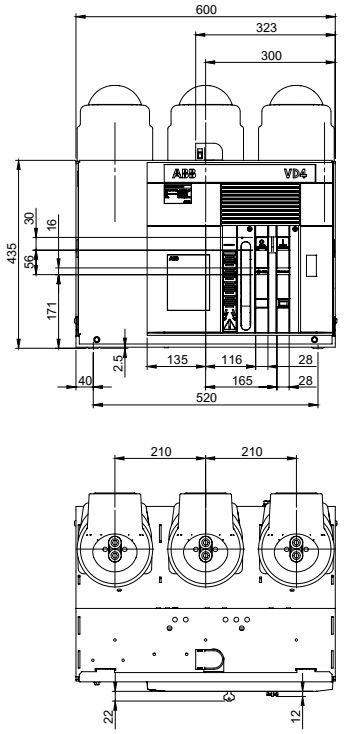



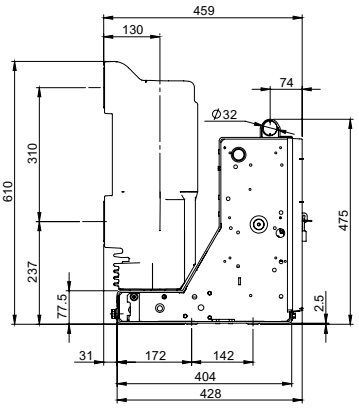

| Type | Pole | Ur | Ir | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p275 | P3 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |
| VD4 p275 | PT2 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |

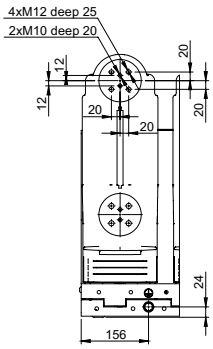
(*) Fixing interchangeability with previous series (345 x 650).

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003440 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| Isc | 50 | kA |

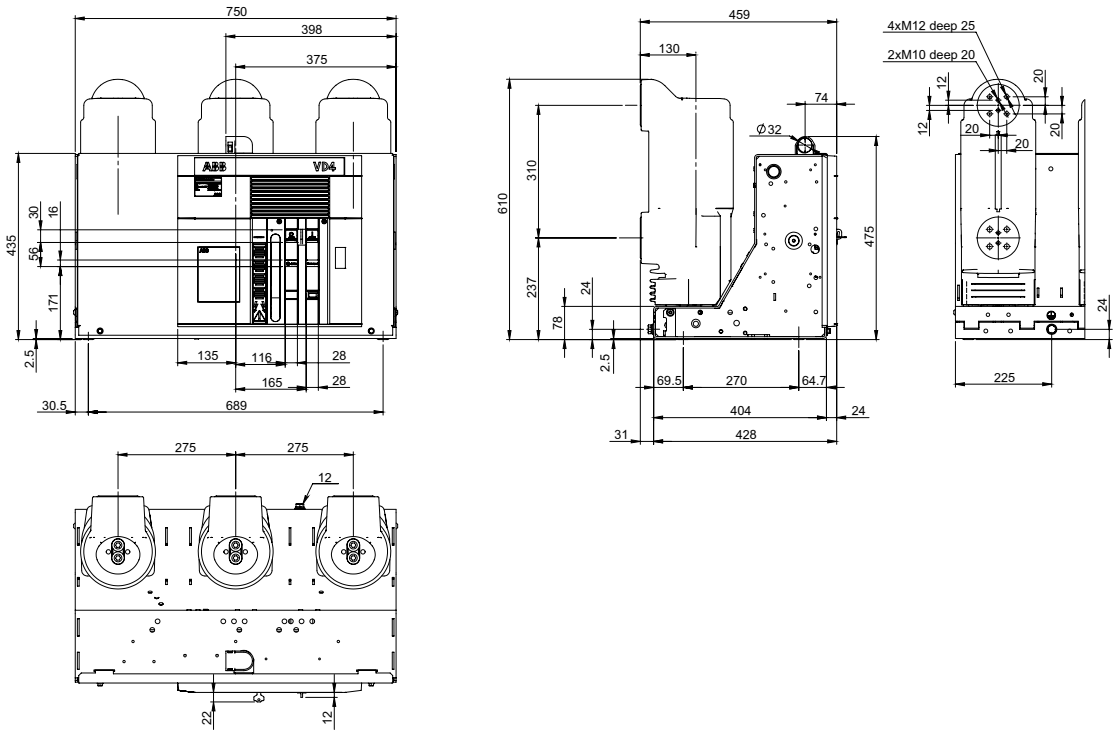


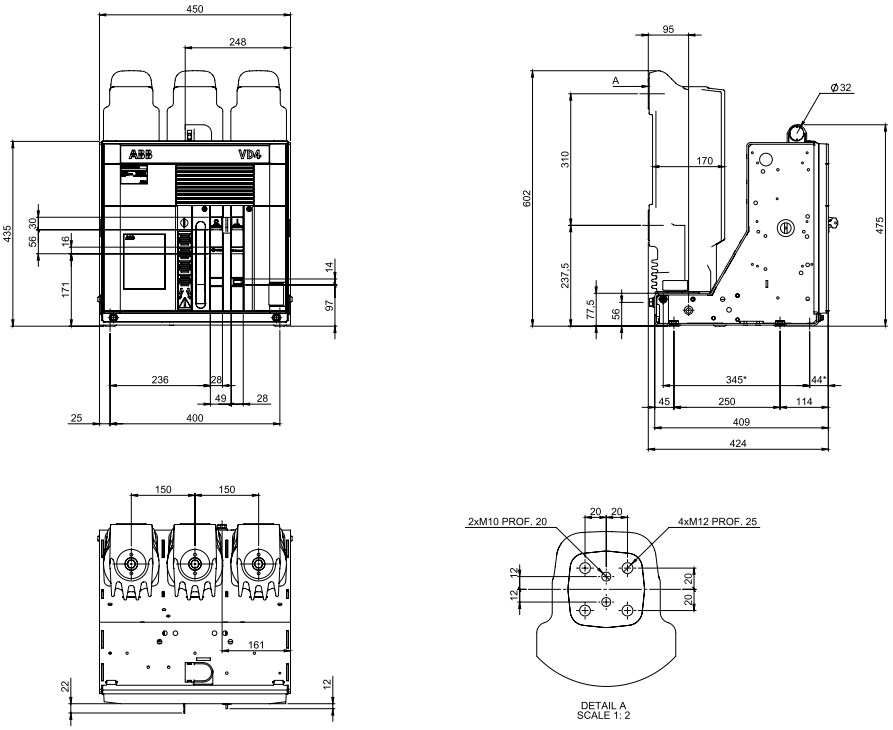
## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003441 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 50 | kA |




## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD000050 | |
| Ur | 12 | kV |
| Ir | 1600 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




(*) Fixing interchangeability with previous series (345 x 400).

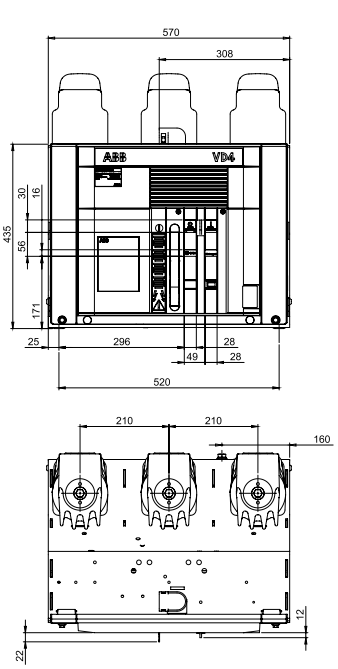
# 13. Overall dimensions

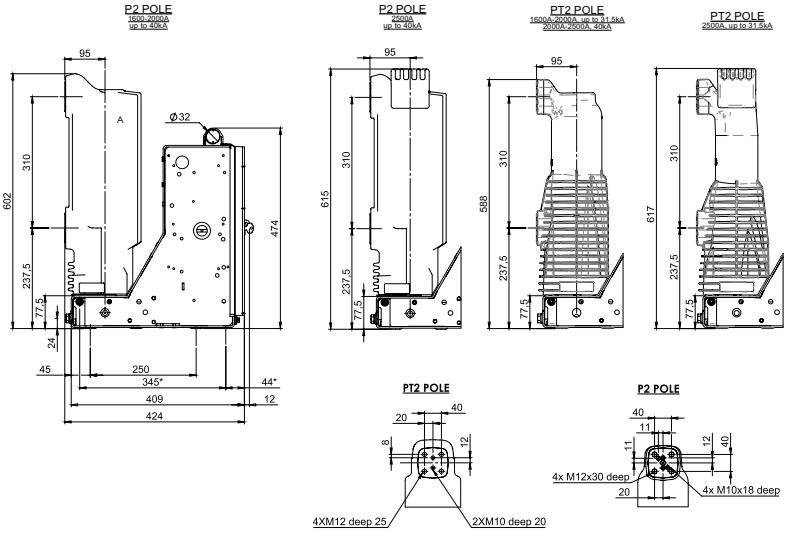
### Fixed circuit breakers

| **VD4** | | |
|---|---|---|
| TN | 7407 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 1200 | A |
| | 1600 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| **VD4** | | |
|---|---|---|
| TN | 7407 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 1200 | A |
| | 2000 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |

| **VD4** | | |
|---|---|---|
| TN | 7407 | |
| Ur | 12 | kV |
| Ir | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



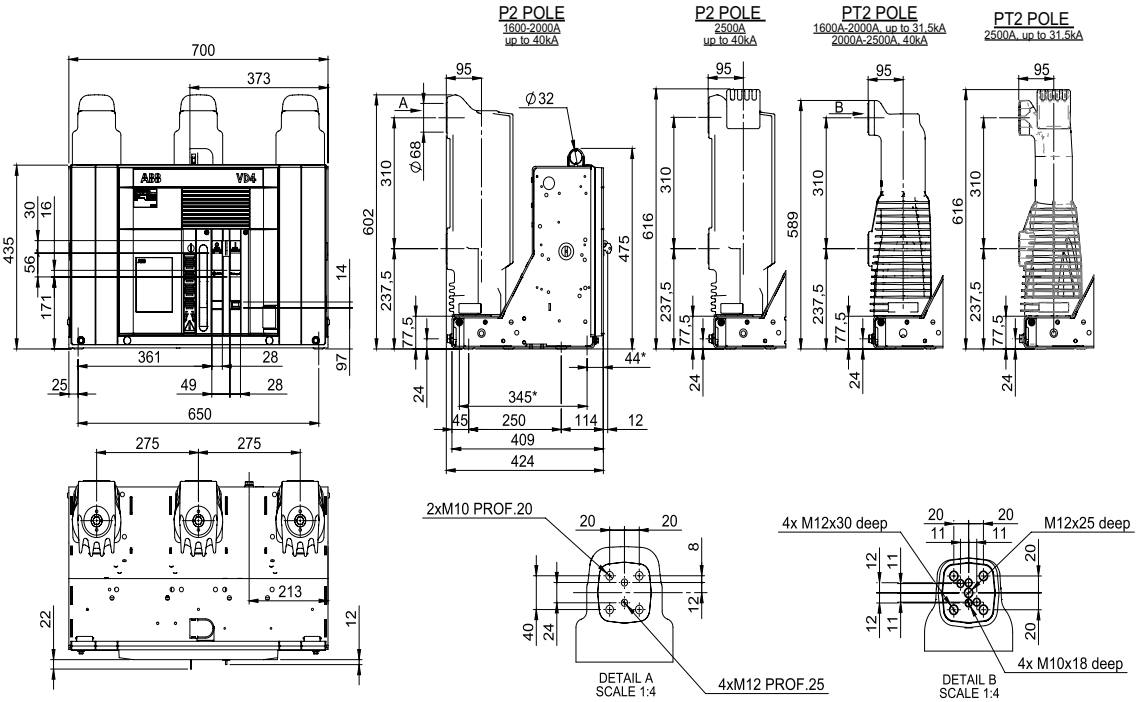

| Type | Pole | Un | In | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p.210 | P2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | free standing version |
| | | 12-17.5kV | 2000A | 40kA | EL3 | |
| | | 12kV | 2500A | 40kA | EL3 | |
| | | 15kV | 2000A | 31,5kA | EL3 | |
| VD4 12/**/**/G p.210 | | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | |
| VD4 p.210 | P2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |
| | | 12-17.5kV | 2000A | 40kA | EL3S | |
| | | 12kV | 2500A | 40kA | EL3S | |
| | PT2 | 15kV | 1200A-2000A | 40kA | EL3S | |
| VD4 12/**/**/G p.210 | | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |

(*) Fixing interchangeability with previous series (345 x 650).

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 7408 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4 | | |
|---|---|---|
| TN | 7408 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2000 | A |
| | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



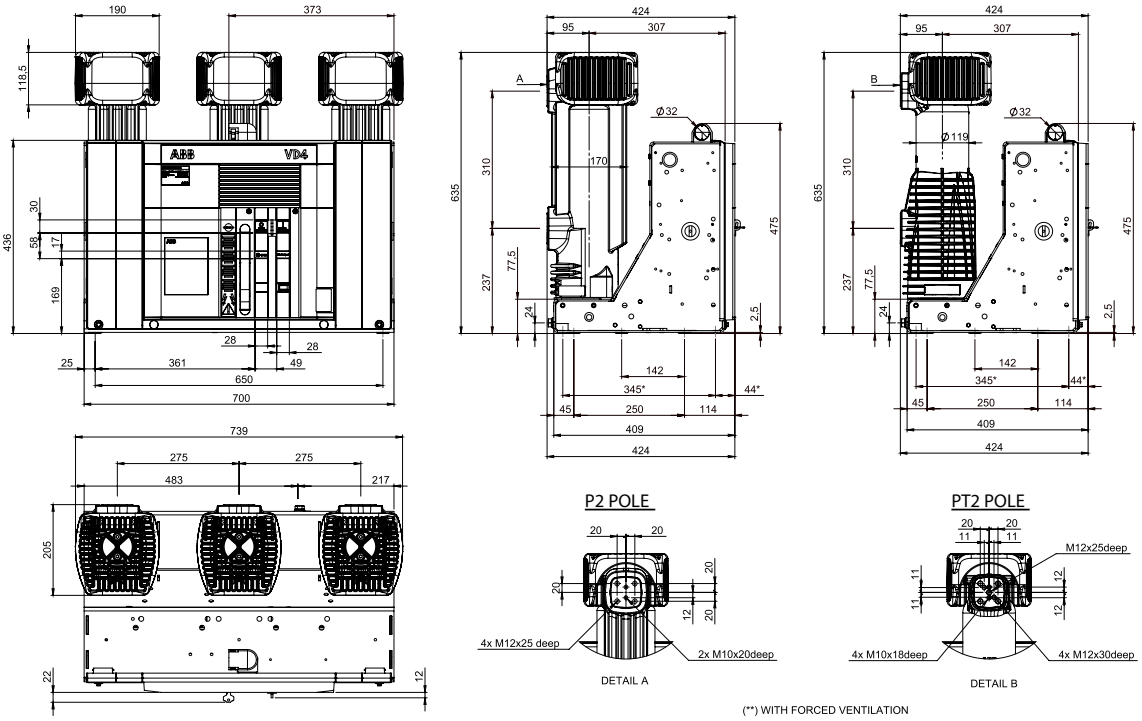

| Type | Poles | Un | In | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p.275 | P2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | free standing version |
| | | 12-17.5kV | 2000-2500A | 40kA | EL3 | |
| VD4 12/**/**/G p.275 | P2 | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | |
| | | 12kV | 2000-2500A | 40kA | EL3 | |
| VD4 p.275 | PT2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |
| | | 12-17.5kV | 2000-2500A | 40kA | EL3S | |
| VD4 12/**/**/G p.275 | PT2 | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |
| | | 12kV | 2000-2500A | 40kA | EL3S | |

(*) Fixing interchangeability with previous series (345 x 650).

# 13. Overall dimensions

## Fixed circuit breakers

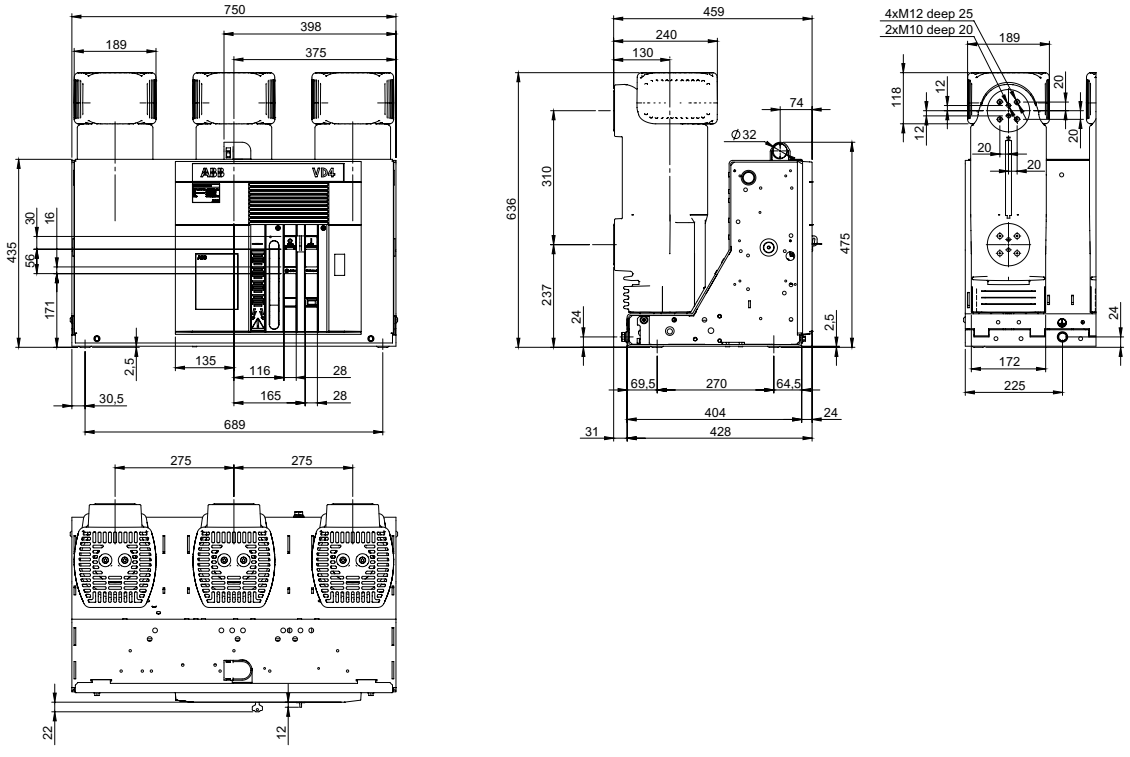
| VD4 | | |
|---|---|---|
| TN | 1VCD000149 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |




(*) Fixing interchangeability with previous series (345 x 650).

## Fixed circuit breakers

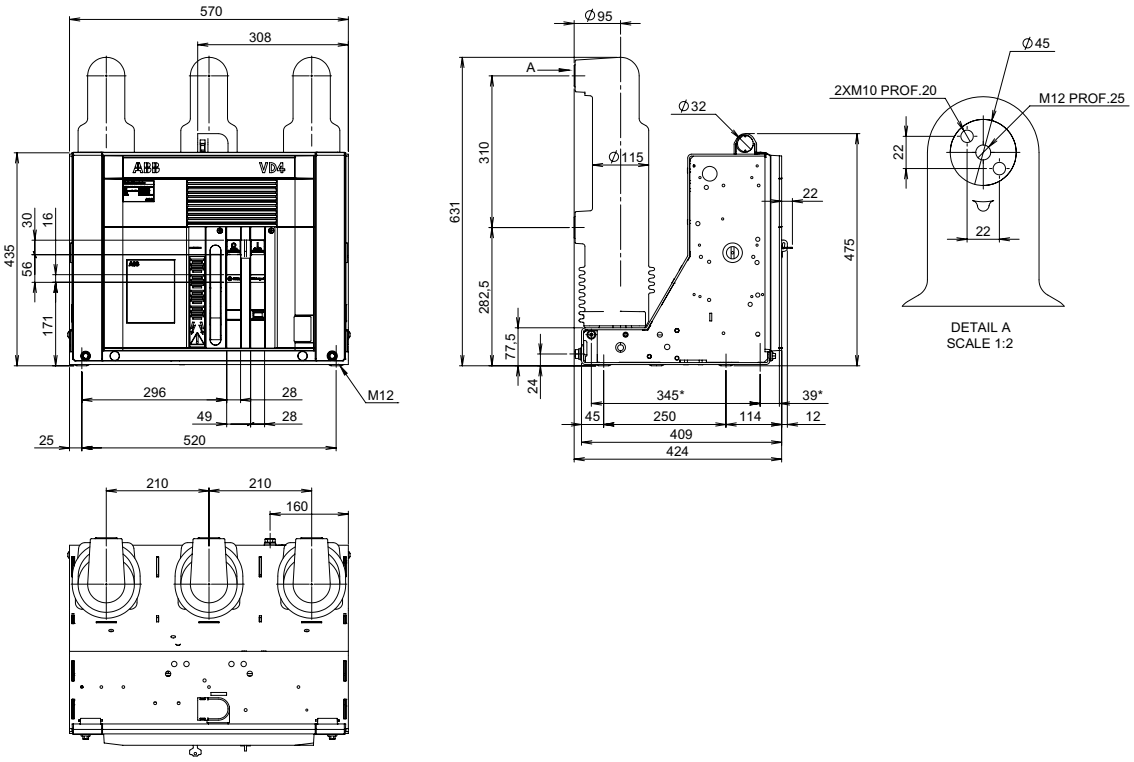
| VD4 | | |
|---|---|---|
| TN | 1VCD003443 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 50 | kA |




(*) 4000 A with forced ventilation.

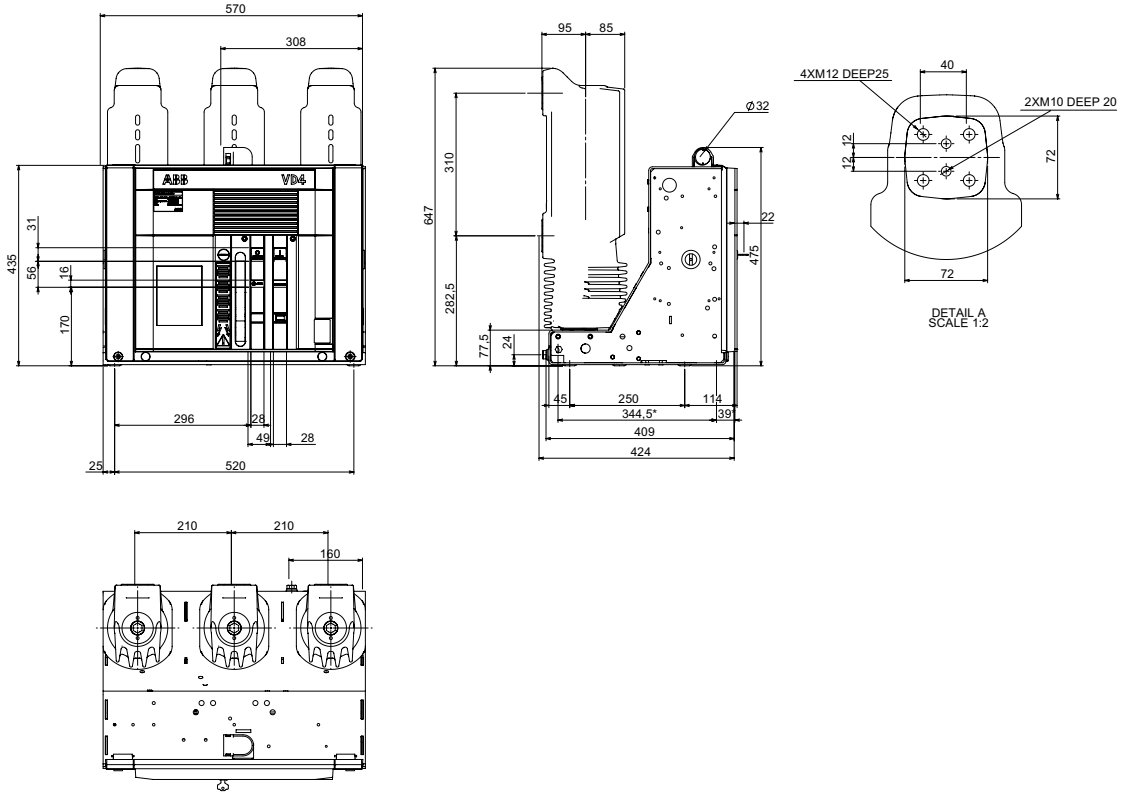
## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 7409 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |




## Fixed circuit breakers

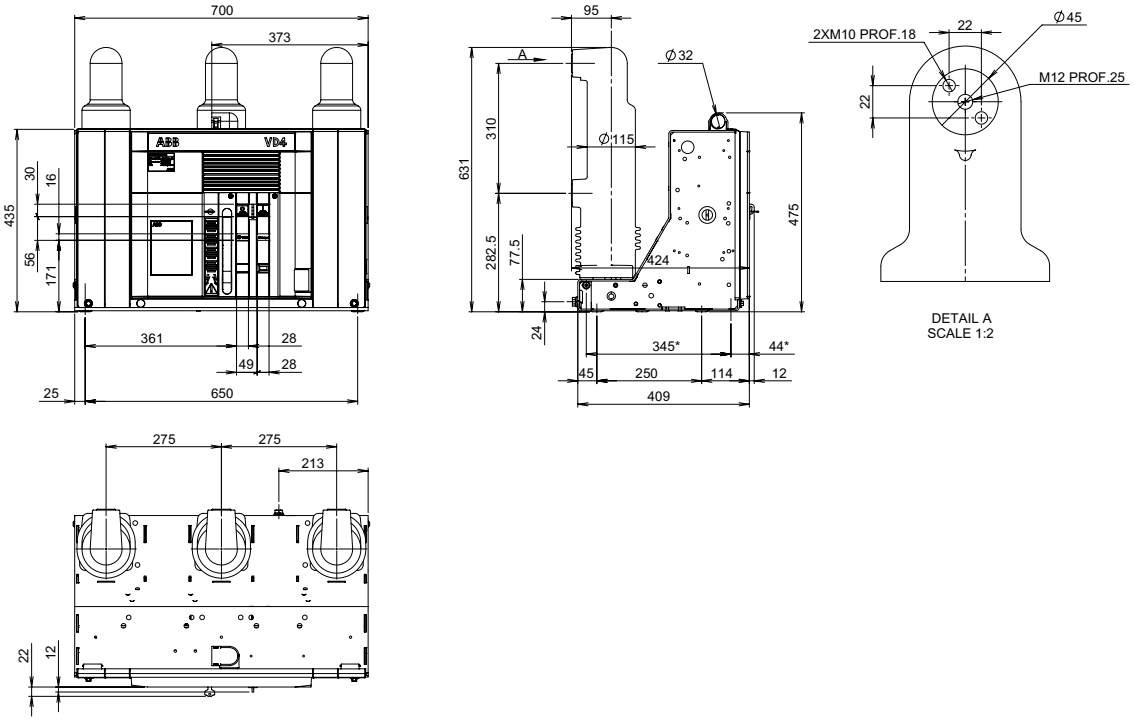
| VD4 | | |
|---|---|---|
| TN | 1VCD000172 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 31,5 | kA |



# 13. Overall dimensions

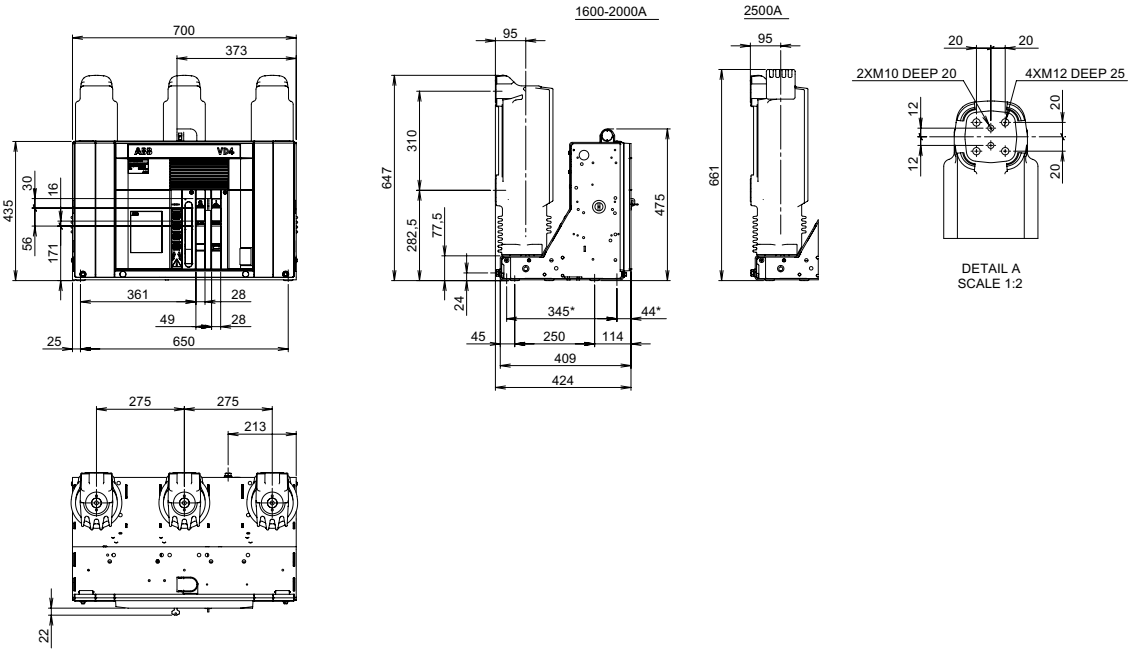
### Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 7410 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |




### Fixed circuit breakers

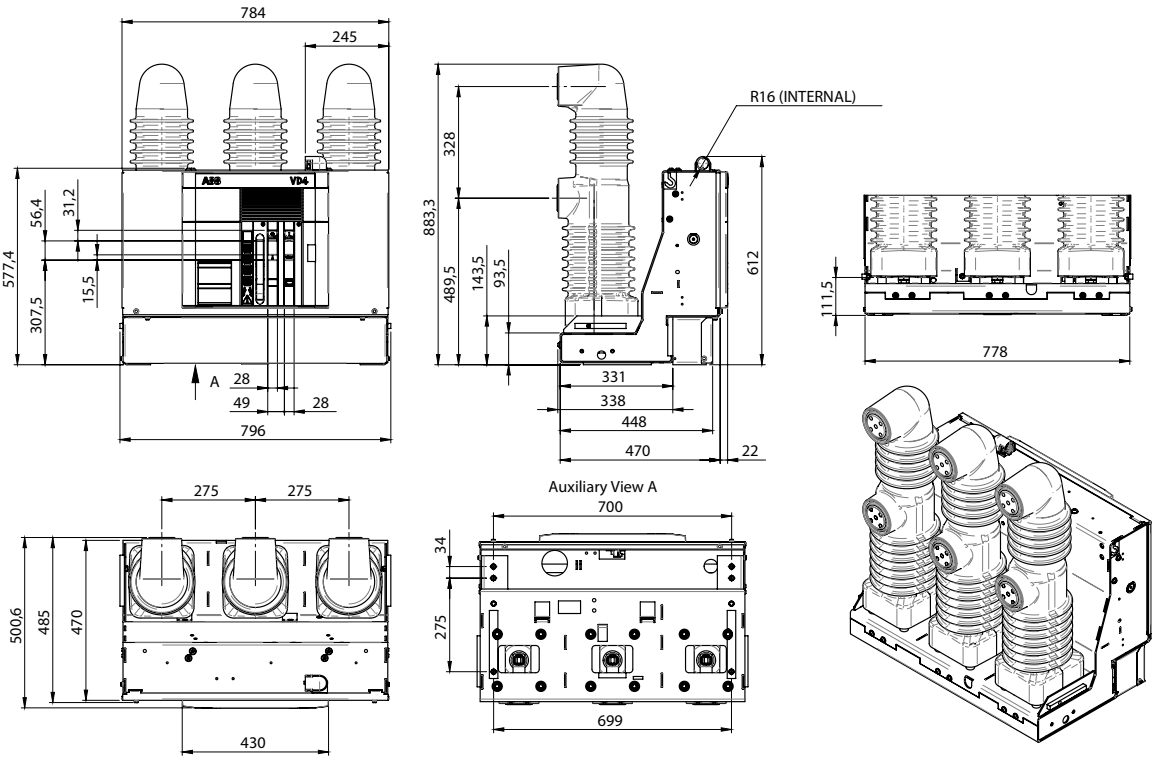
| VD4 | | |
|---|---|---|
| TN | 7411 | |
| Ur | 24 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |



## Fixed circuit breakers

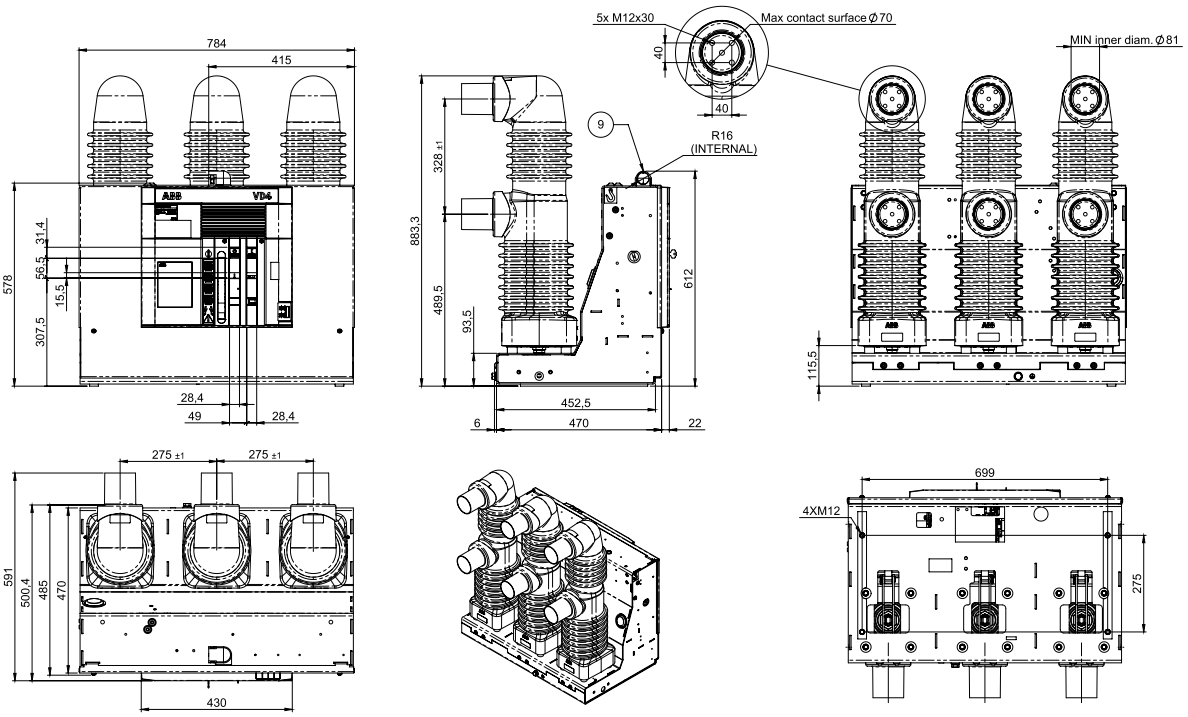
| VD4 | | |
|---|---|---|
| TN | 1VYN300901-RF | |
| Ur | 36 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4 | | |
|---|---|---|
| TN | 1VYN300901-RF | |
| Ur | 38 | kV |
| Ir | 1200 | A |
| | 2000 | A |
| Isc | 31.5 | kA |




## Fixed circuit breakers

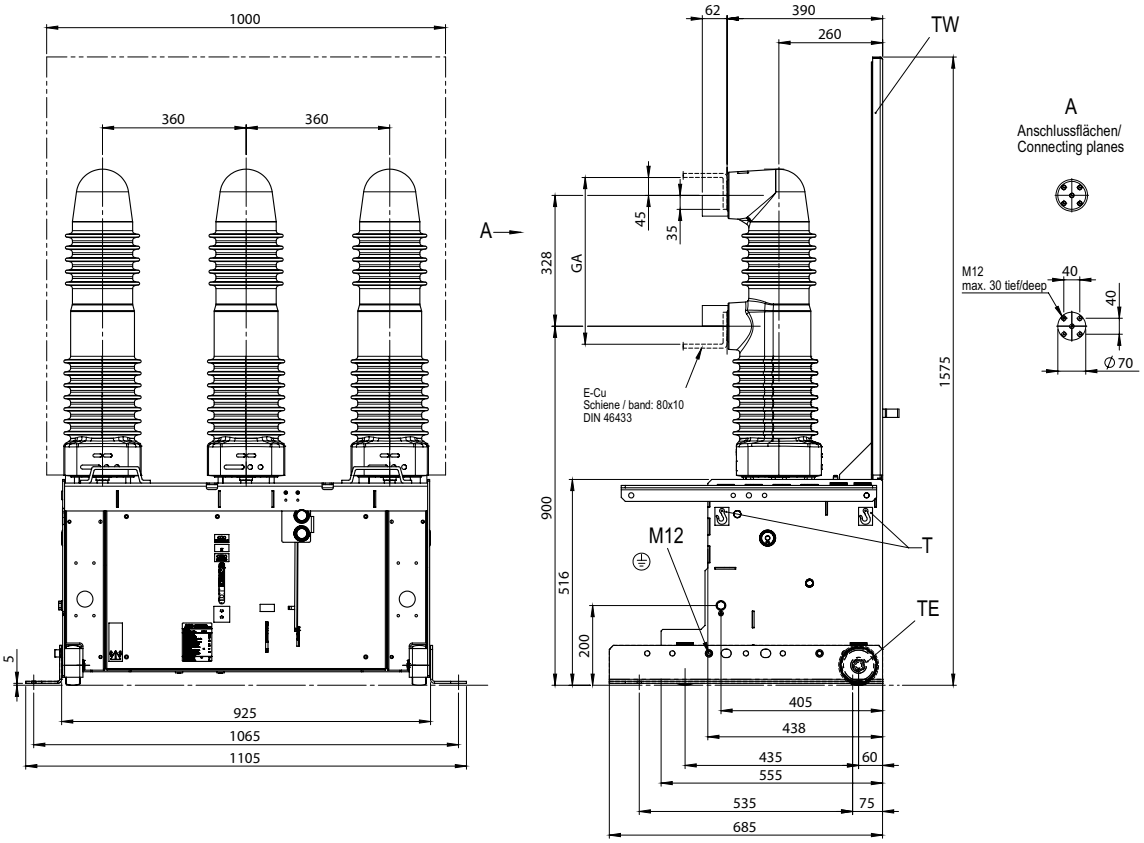
| VD4 | | |
|---|---|---|
| TN | 2RDA043326A | |
| Ur | 40.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| Isc | 31.5 | kA |



# 13. Overall dimensions

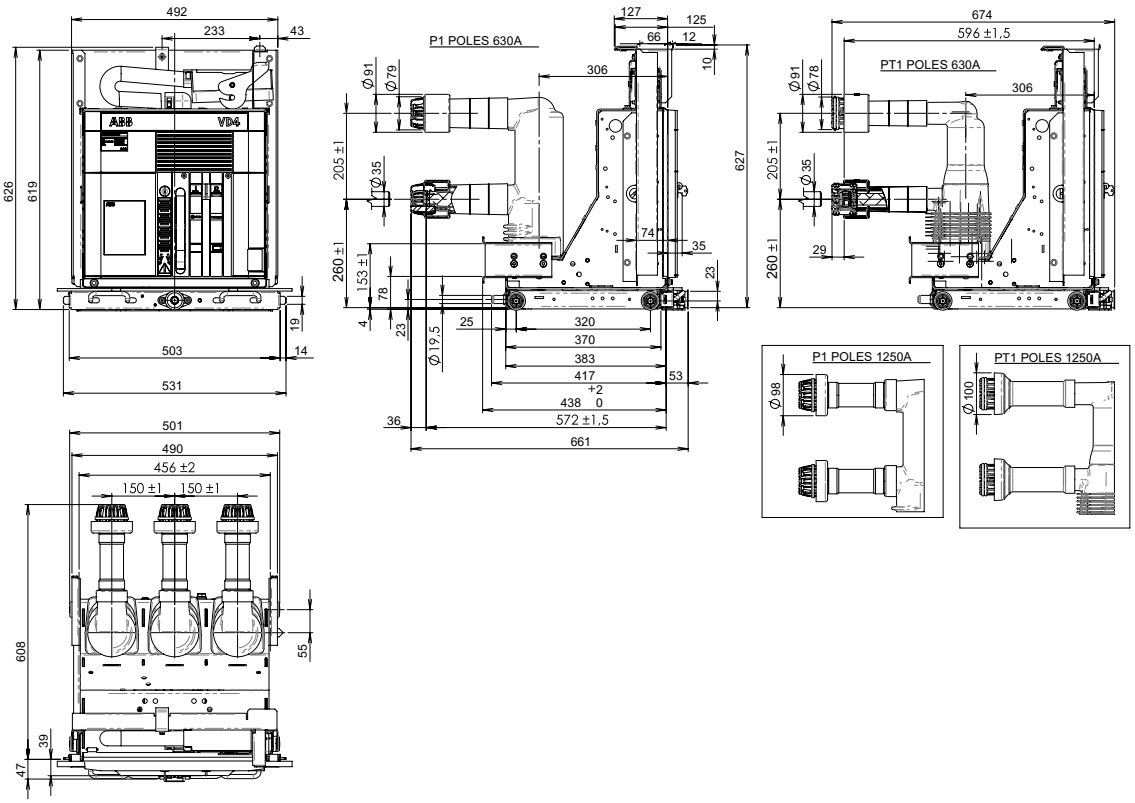
### Fixed circuit breakers

| **VD4** | | |
|---|---|---|
| TN | GCEM700198 | |
| Ur | 36-40.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



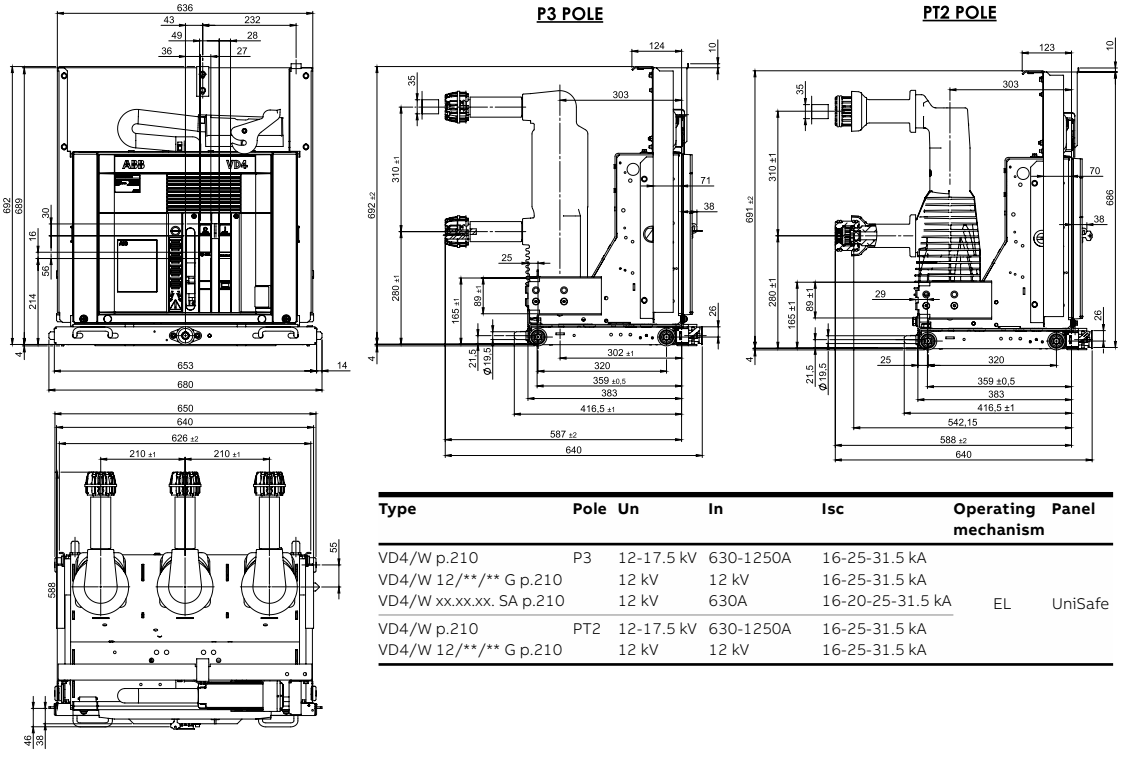
## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB1 modules

| VD4/P | | |
|---|---|---|
| TN | 7412 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1200 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




## Withdrawable circuit breakers for PowerCube PB2 modules

| VD4/W | | |
|---|---|---|
| TN | 7420 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

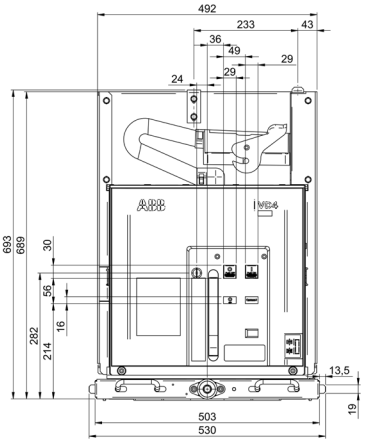


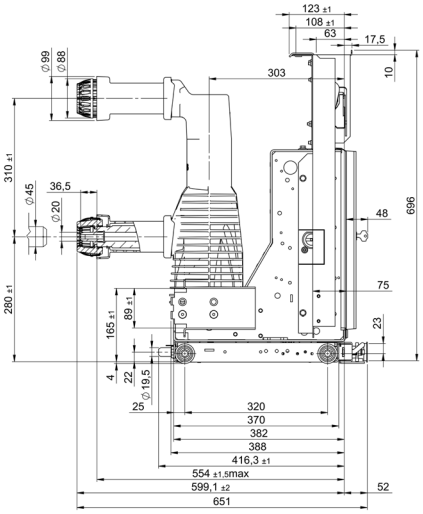

| Type | Pole | Un | In | Isc | Operating mechanism | Panel |
|---|---|---|---|---|---|---|
| VD4/W p.210 | P3 | 12-17.5 kV | 630-1250A | 16-25-31.5 kA | | |
| VD4/W 12/**/** G p.210 | | 12 kV | 12 kV | 16-25-31.5 kA | | |
| VD4/W xx.xx.xx. SA p.210 | | 12 kV | 630A | 16-20-25-31.5 kA | EL | UniSafe |
| VD4/W p.210 | PT2 | 12-17.5 kV | 630-1250A | 16-25-31.5 kA | | |
| VD4/W 12/**/** G p.210 | | 12 kV | 12 kV | 16-25-31.5 kA | | |

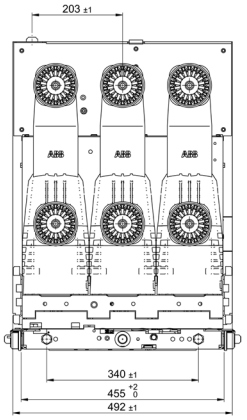
# 13. Overall dimensions

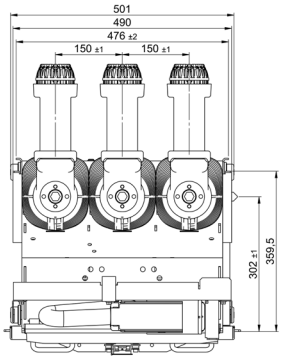
**Withdrawable circuit breakers for UniGear ZS1 switchgear**

| **VD4** | | |
|---|---|---|
| TN | 2RDA040163 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



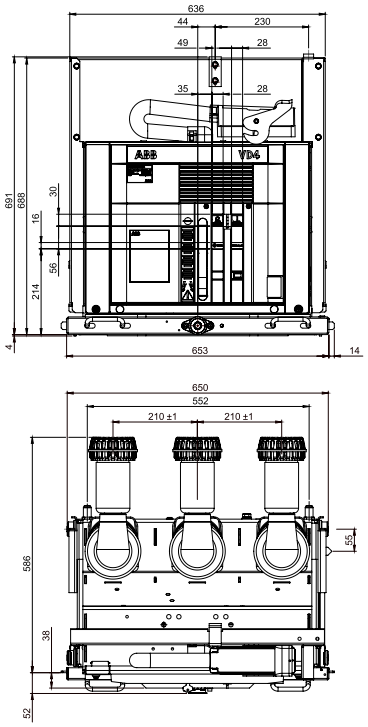



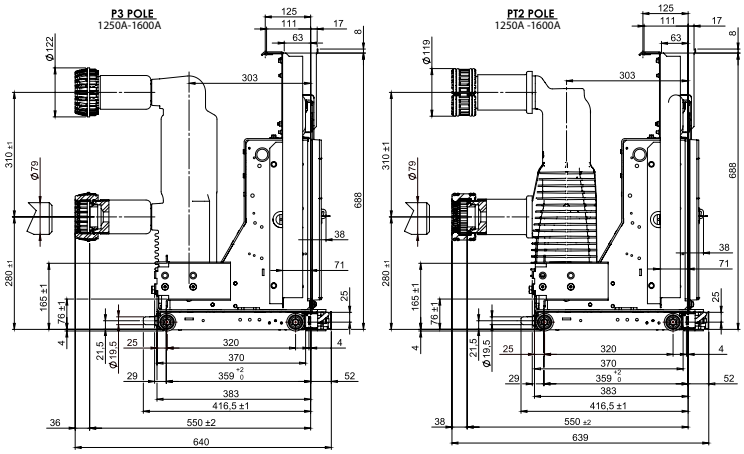



## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB2 modules

| VD4/P | | |
|---|---|---|
| TN | 1VCD003284 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |

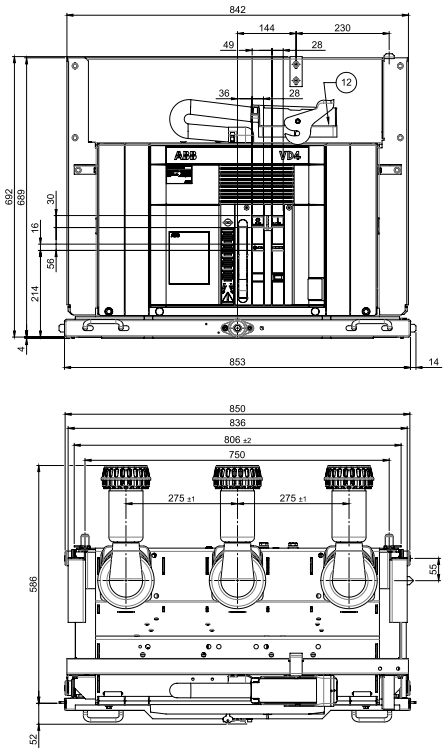


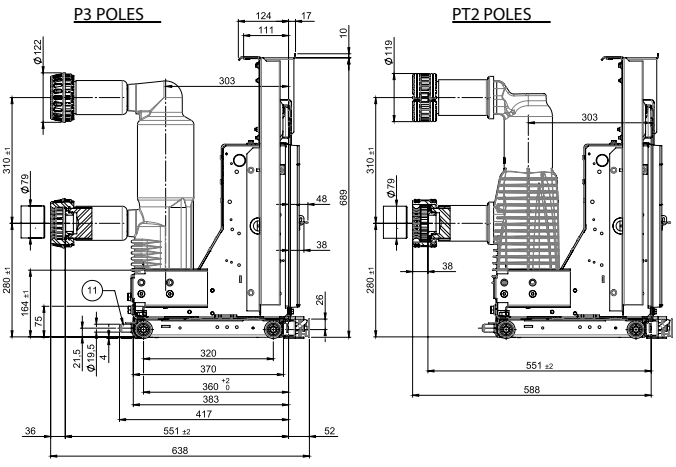




| C.B. type | Ur | Ir | Isc | Pole | Operating mechanism | Enclosure | Cubicle |
|---|---|---|---|---|---|---|---|
| VD4/P p.210 | 12-17.5 kV | 1250-1600 A | 40 kA | P3 | EL | – | UniGear |
| VD4/P p.210 | 12-17.5 kV | 1600 A | 40 kA | | | PowerCube PB2 | – |
| VD4/P p.210 | 12-17.5 kV | 1250-1600 A | 40 kA | PT2 | EL | – | UniGear |
| VD4/P p.210 | 12-17.5 kV | 1600 A | 40 kA | | | PowerCube PB2 | – |

## Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD003286 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |



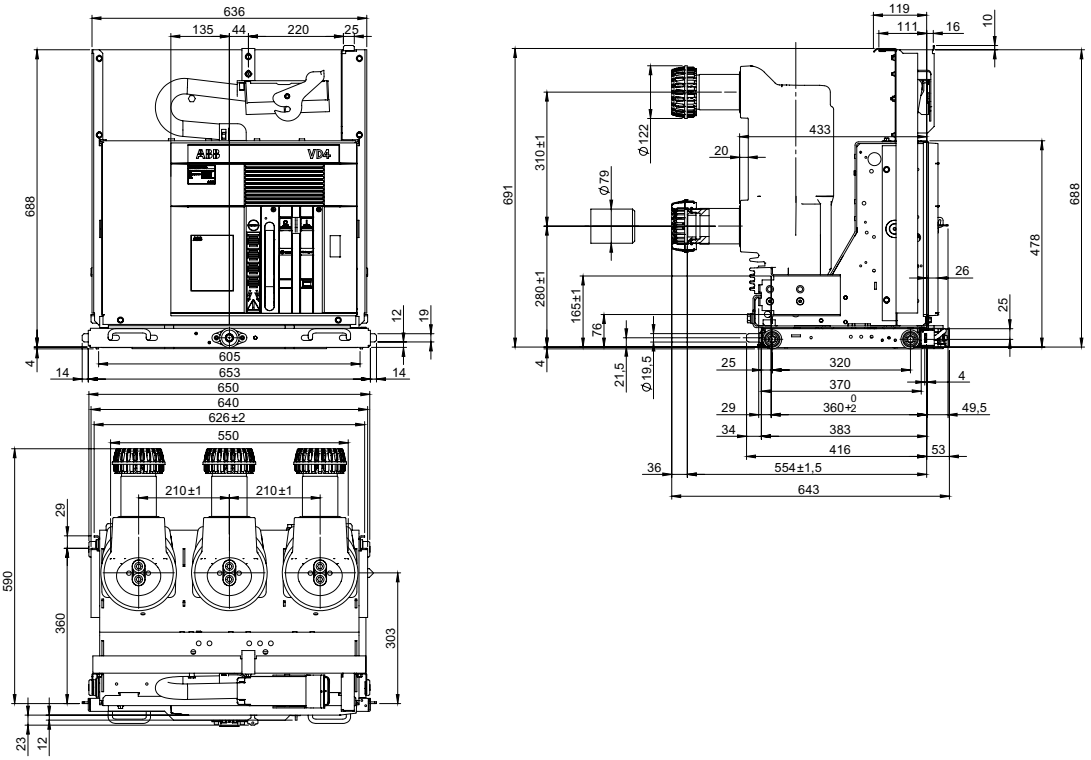




| C.B. type | Ur | Ir | Isc | Pole | Operating mechanism | Cubicle |
|---|---|---|---|---|---|---|
| VD4 p.275 | 12-17.5 kV | 1250-1600 | 40 kA | P | EL | UniGear ZS1 |
| VD4 p.275 | 12-17.5 kV | 1250-1600 A | 40 kA | PT2 | EL | UniGear ZS1 |

# 13. Overall dimensions

### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB2 modules

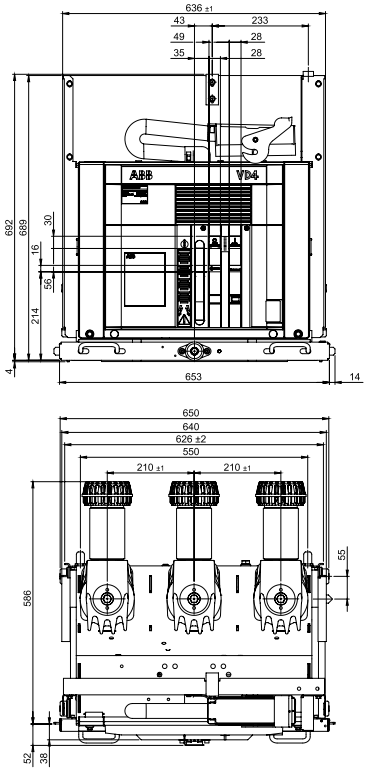
| VD4/P | | |
|---|---|---|
| TN | 1VCD 003444 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| Isc | 50 | kA |

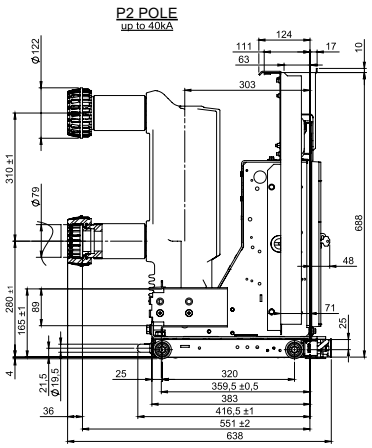


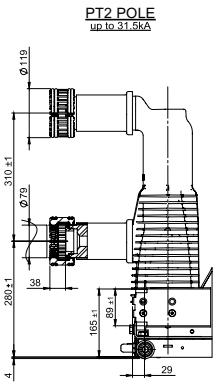

### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB2 modules

| VD4/P | | |
|---|---|---|
| TN | 7415 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4/P | | |
|---|---|---|
| TN | 7415 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 1200 | A |
| | 2000 | A |
| Isc | 40 | kA |



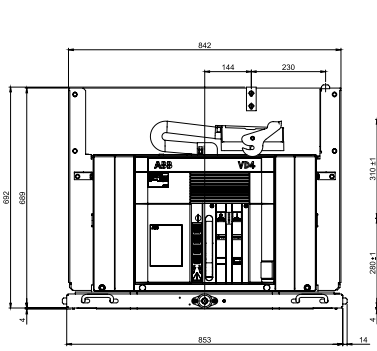



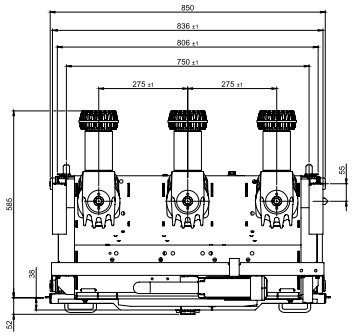

| Type | Un | In | Isc | Pole | O.M. | Enclosure | Cubide |
|---|---|---|---|---|---|---|---|
| VD4/P p.210 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | P2 | EL | CBE2-CBF2 PowerBloc-PowerCube PB2 | UniGear UniGear ZS1 |
| | 12-17.5kV | 2000A | 40kA | | | | UniGear |
| VD4/P 12/**/**/G p.210 | 12kV | 1600A-2000A | 20-25-31.5kA | | | | UniGear UniGear ZS1 |
| VD4/P XX.XX. XX.SA p.210 | 12-17.5kV | 1600A | 20-25kA | P2 | EL | PowerCube PB2 | UniGear |
| | | 2000A | 20-25-31.5kA | | | | |
| VD4/P p.210 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | PT2 | EL | PowerCube PB2 | UniGear |
| | | 2000A | 40kA | | | | |
| VD4/P 12/**/**/G p.210 | 12kV | 1600A-2000A | 20-25-31.5kA | | | | |
| VD4/P p.210 | 15kV | 1200A-2000A | 40kA | PT2 | EL | PowerCube **PB2/E-PB2/FL** | |
| **VD4/N/P** p.210 | 15kV | 2000A | 31.5kA | P2 | EL | | OeM panel |

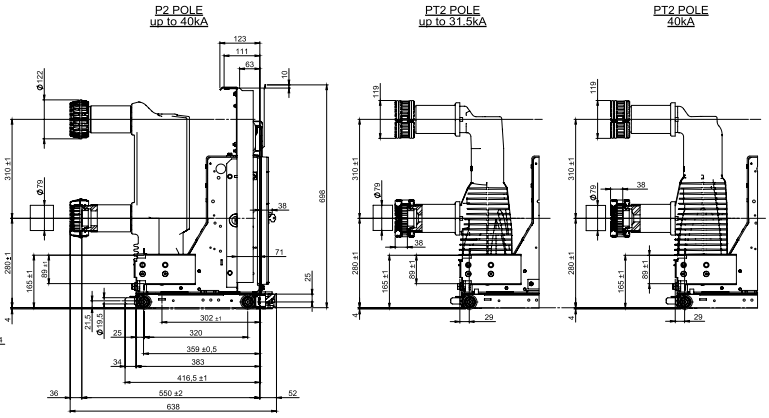
## Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 7416 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4/P | | |
|---|---|---|
| TN | 7416 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2000 | A |
| Isc | 40 | kA |



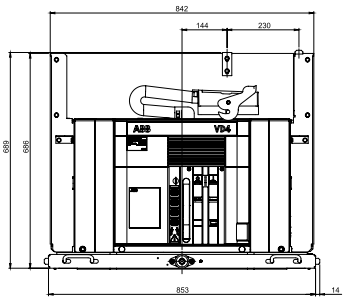



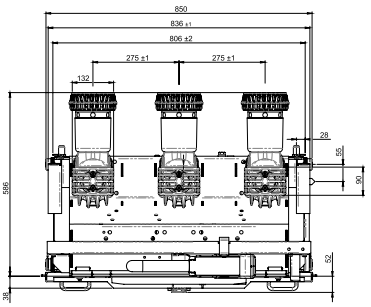



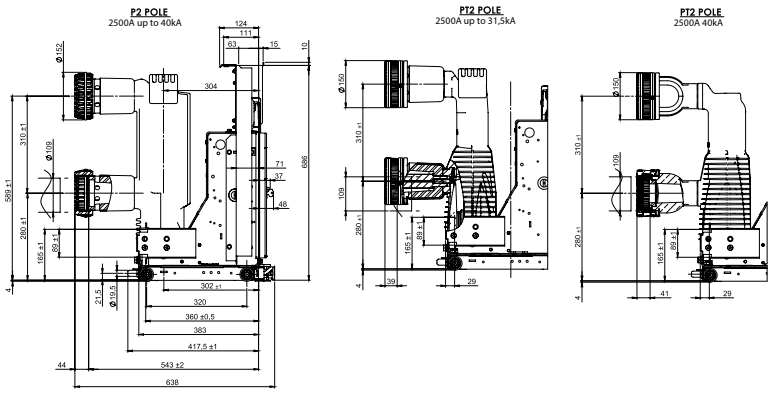

| Type | Un | In | Isc | Pole | O.M. | Enclosure | Cubide |
|---|---|---|---|---|---|---|---|
| VD4/P p.275 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | P2 | EL | PowerBloc CBF3 PowerCube | UniGear ZS1 |
| VD4/P 12/**/**/G p.275 | 12kV | 1600A-2000A | 20-25-31.5kA | | | | |
| VD4/P p.275 | 12-17.5kV | 2000A | 40kA | | | PowerBloc CBF3 | |
| VD4/P p.275 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | P2 | EL | PowerBloc PowerCube | UniGear ZS1 |
| VD4/P 12/**/**/G p.275 | 12kV | 1600A-2000A | 20-25-31.5kA | | | | |
| VD4/P p.275 | 12-17.5kV | 2000A | 40kA | | | | |
| VD4/P XX.XX.XX.SA p.210 | 12kV | 1600A | 20-25kA | PT2 | EL | PowerCube PB2 | UniGear |
| | | 2000A | 20-25-31.5kA | | | | |
| | 17.5kV | 1600A | 20-25kA | | | | |
| | | 2000A | 20-25-31.5kA | | | | |

## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB3 modules

| VD4/P | | |
|---|---|---|
| TN | 7417 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



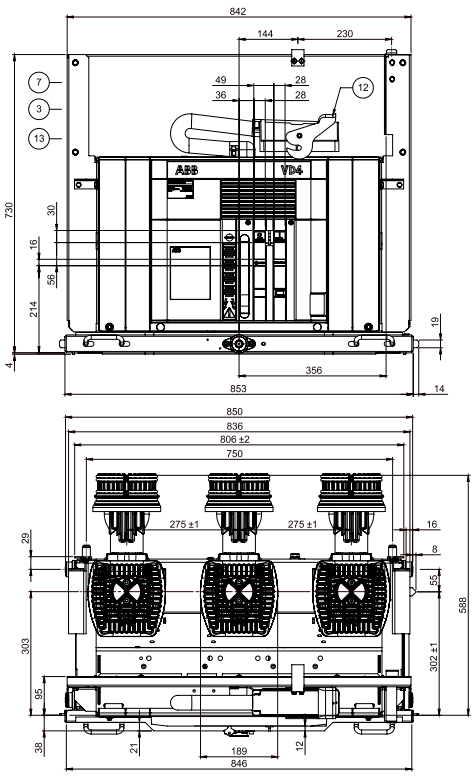



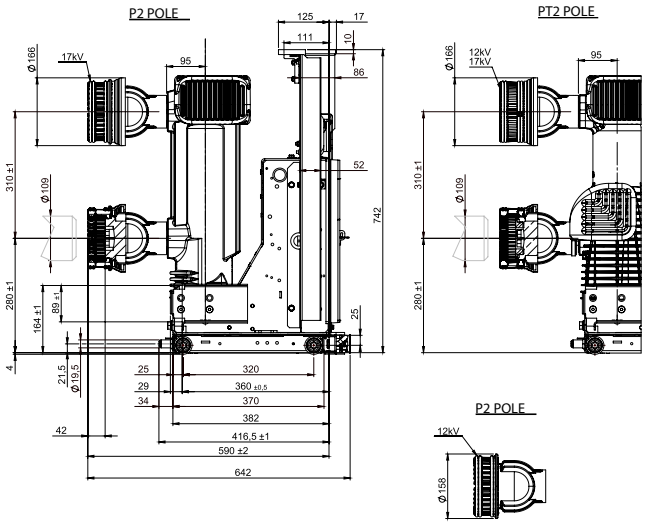

| Type | Un | In | Isc | Pole | O.M. | Enclosure | Cubide |
|---|---|---|---|---|---|---|---|
| VD4/P p.275 | 12-17.5kV | 2500A | 20-25-31.5-40kA | P2 | EL | PowerBloc CBF3 PowerCube | UniGear ZS1 UniSafe |
| VD4/P 12/**/**/G p.275 | 12kV | 2500A | 20-25-31.5kA | | | | |
| VD4/P XX.XX.XX.SA p.210 | 12-17.5kV | 2500A | 40kA | | | PowerCube | |
| VD4/P p.275 | 12-17.5kV | 2500A | 20-25-31.5kA | P2 | EL | PowerCube | UniGear ZS1 UniSafe |
| VD4/P 12/**/**/G p.275 | 12kV | 2500A | 20-25-31.5kA | | | | |
| VD4/P p.275 | 12-17.5kV | 2500A | 40kA | | | | |

# 13. Overall dimensions

### Withdrawable circuit breakers for PowerCube PB3 modules

| VD4/W | | |
|---|---|---|
| TN | 1VCD000152 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |





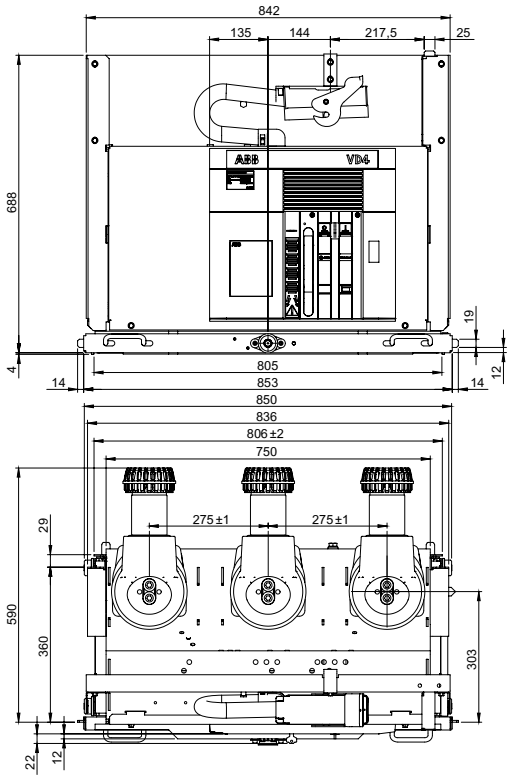


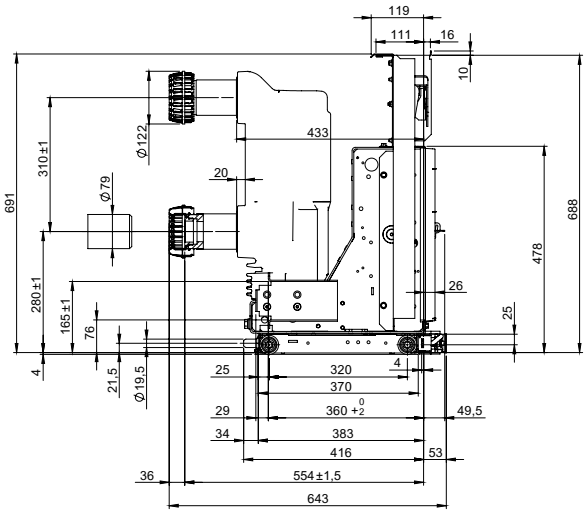
| C.B. type | Pole | Ur | Ir | Isc | Oper. mech. | Cubicle |
|---|---|---|---|---|---|---|
| VD4/W p.275 | P2 | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | PowerCube PB3 |
| VD4/W p.275 | PT2 | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | PowerCube PB3 |

(*) 4000 A con ventilazione forzata.

### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB3 modules

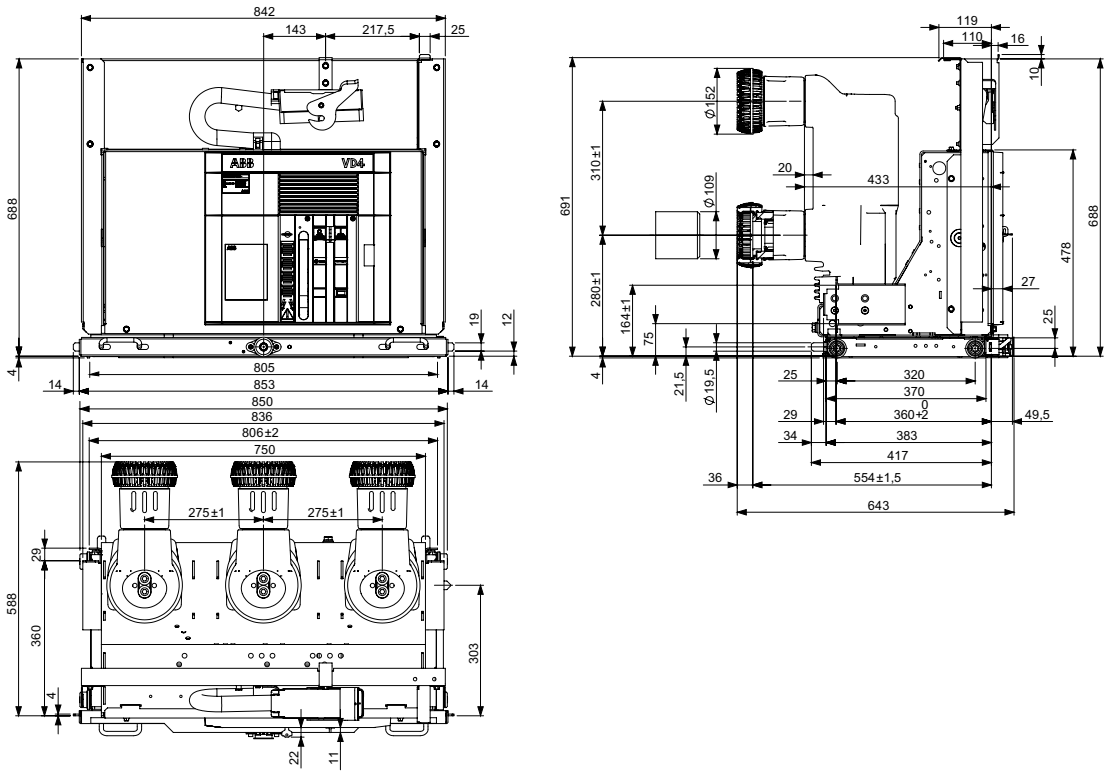
| VD4/P | | |
|---|---|---|
| TN | 1VCD003445 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| Isc | 50 | kA |



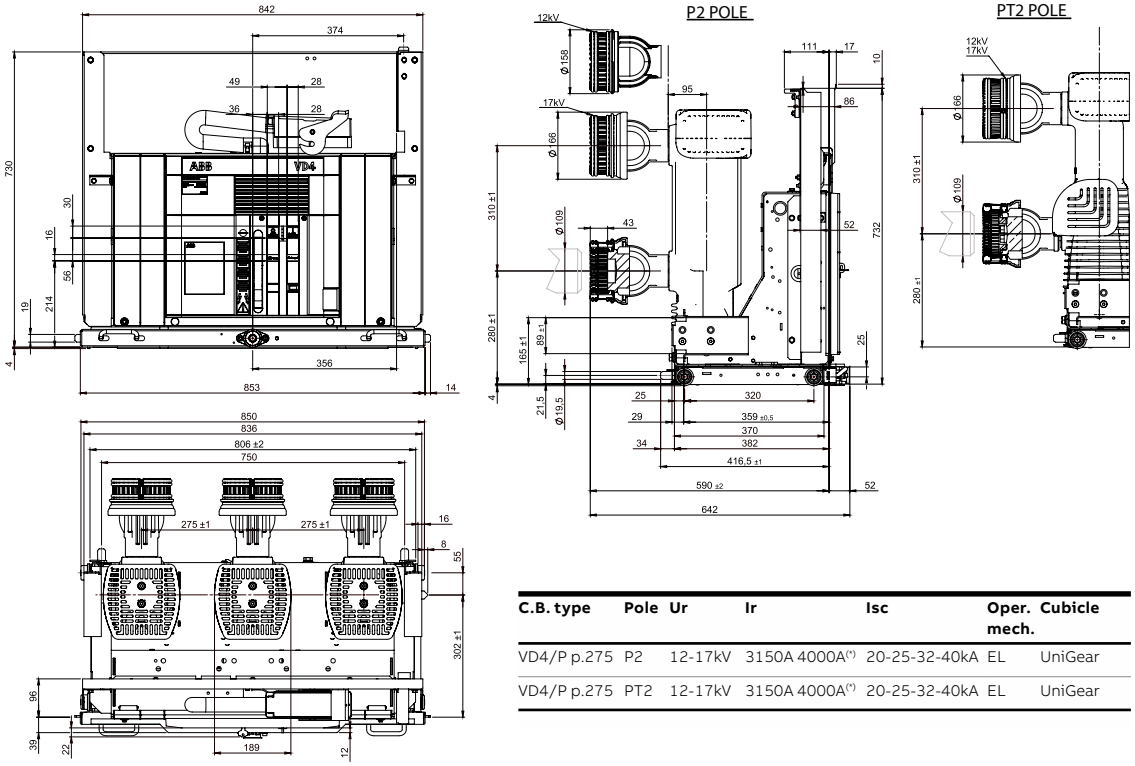
## Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD003446 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2500 | A |
| Isc | 50 | kA |




## Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD000153 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 40 | kA |



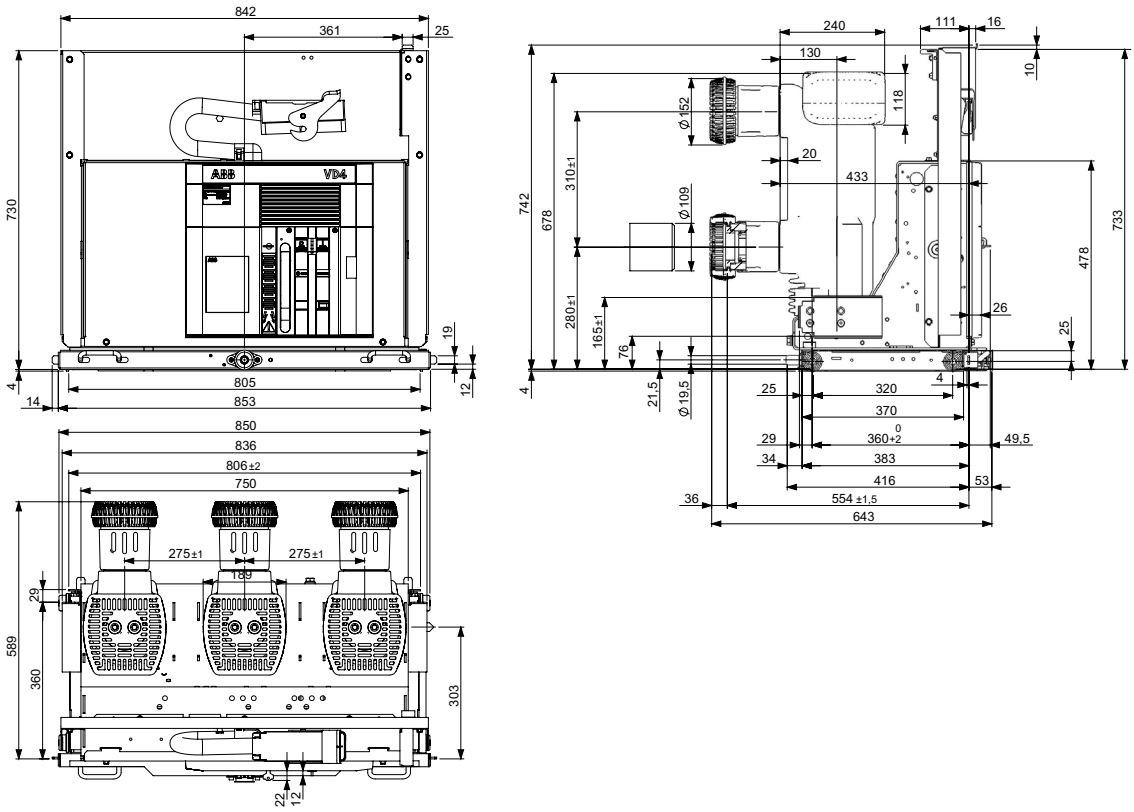

| C.B. type | Pole | Ur | Ir | Isc | Oper. mech. | Cubicle |
|---|---|---|---|---|---|---|
| VD4/P p.275 | P2 | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | UniGear |
| VD4/P p.275 | PT2 | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | UniGear |

(*) 4000 A with forced ventilation.

# 13. Overall dimensions

### Withdrawable circuit breakers for UniGear ZS1 switchgear

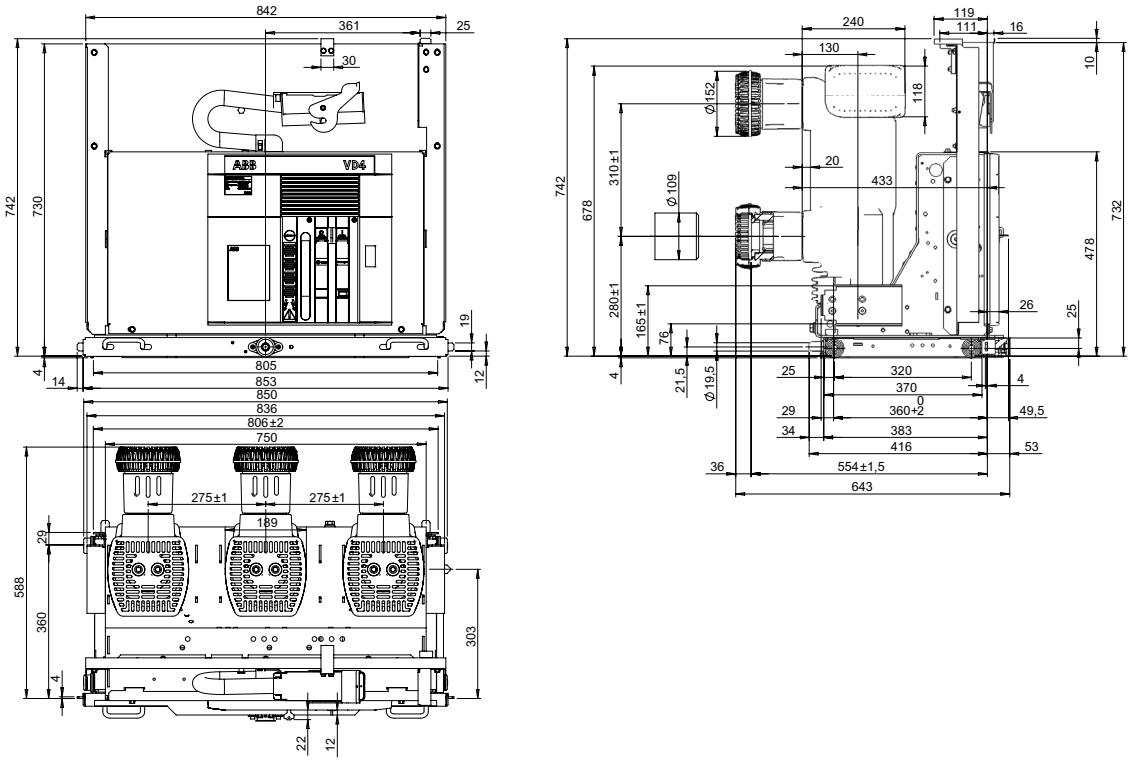
| VD4/P | | |
|---|---|---|
| TN | 1VCD003447 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 50 | kA |




(*) 4000 A with forced ventilation.

### Withdrawable circuit breakers for PowerCube PB3 modules

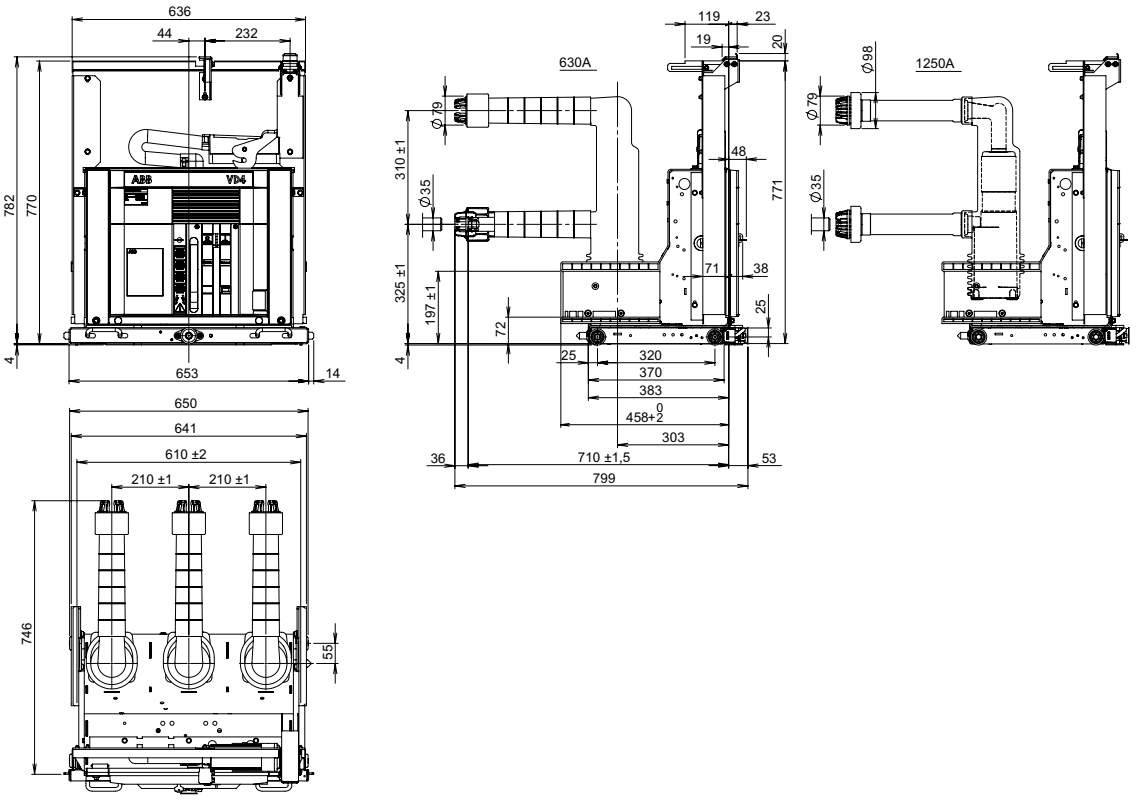
| VD4/W | | |
|---|---|---|
| TN | 1VCD003596 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 50 | kA |




(*) 4000 A with forced ventilation.

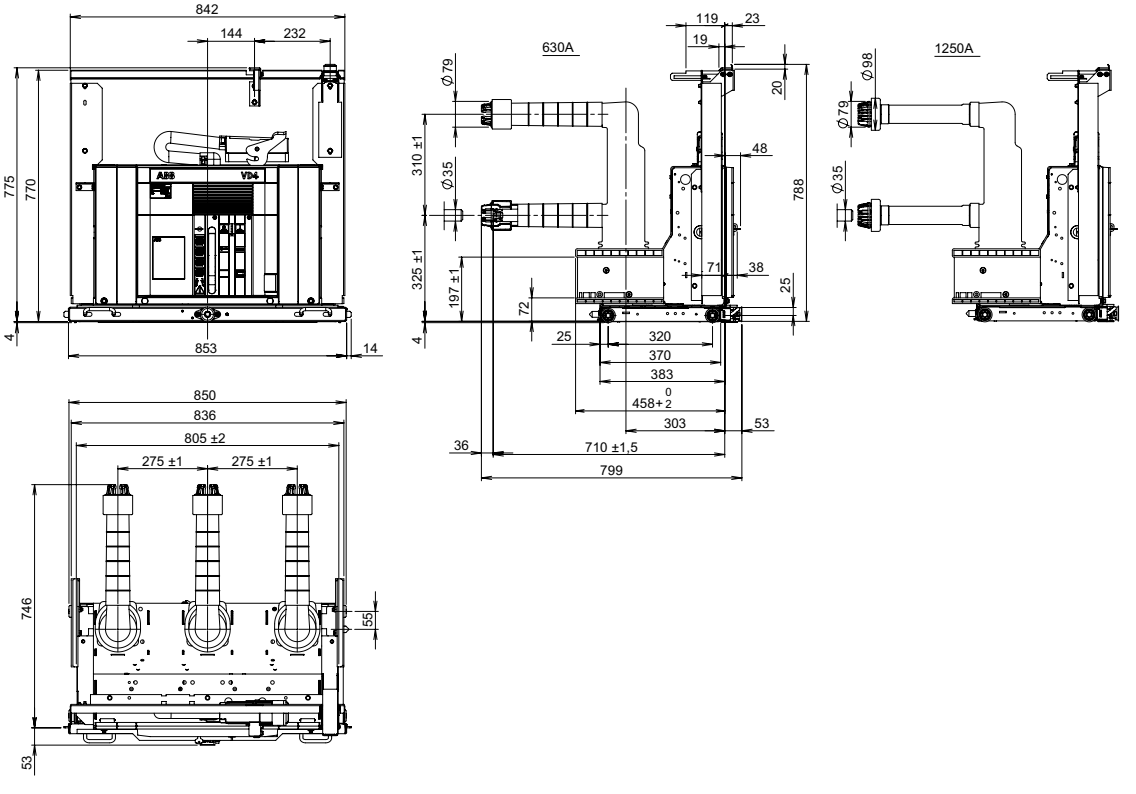
## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB4 modules

| VD4/P | | |
|---|---|---|
| TN | 7413 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |




## Withdrawable circuit breakers for UniGear ZS1 switchgear

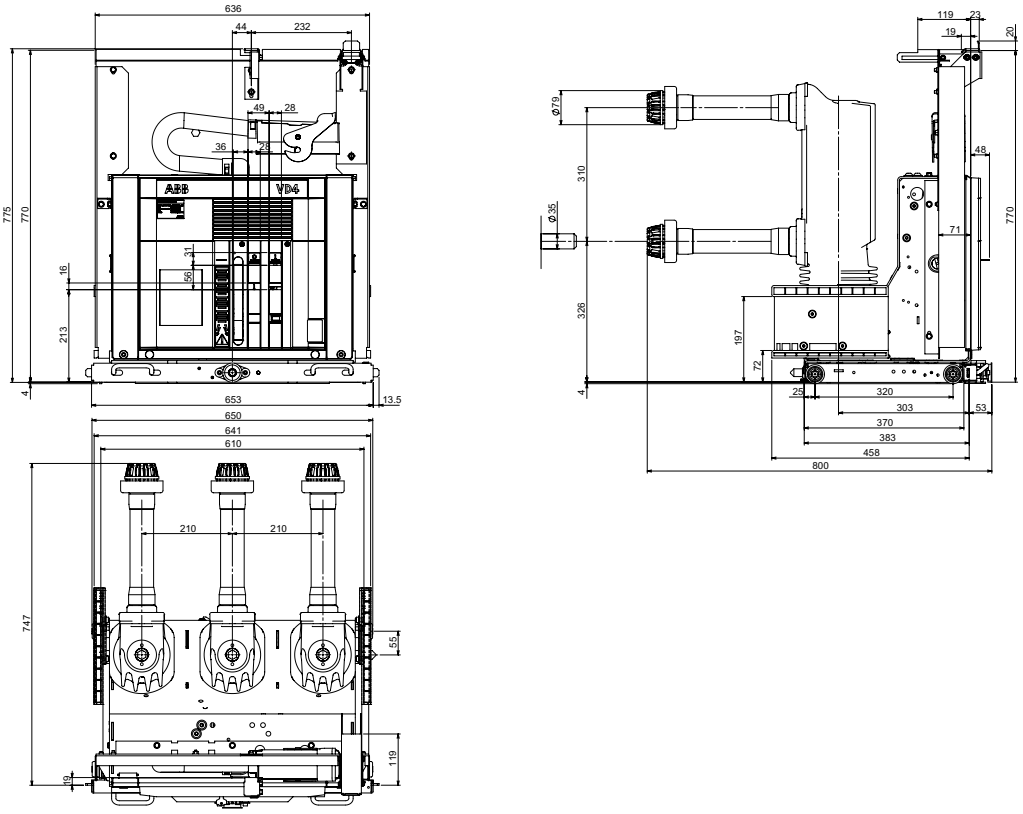
| VD4/P | | |
|---|---|---|
| TN | 7414 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |



# 13. Overall dimensions

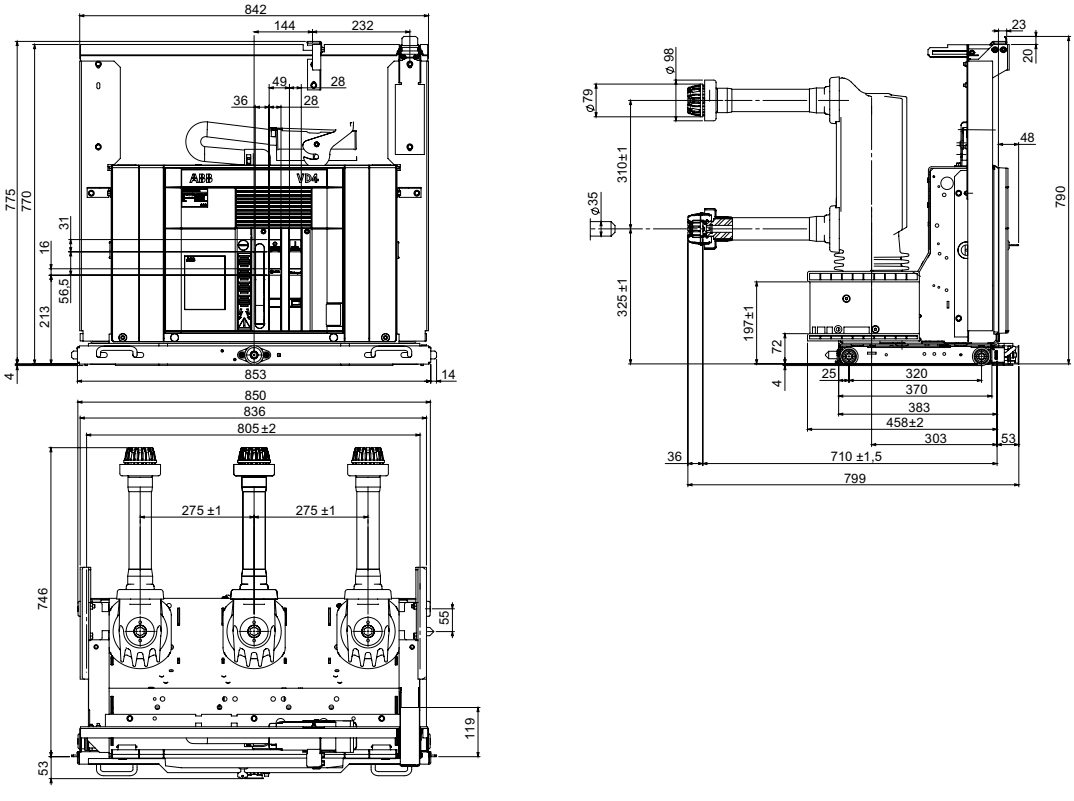
### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB4 modules

| VD4/P | | |
|---|---|---|
| TN | 1VCD000173 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| Isc | 31.5 | kA |



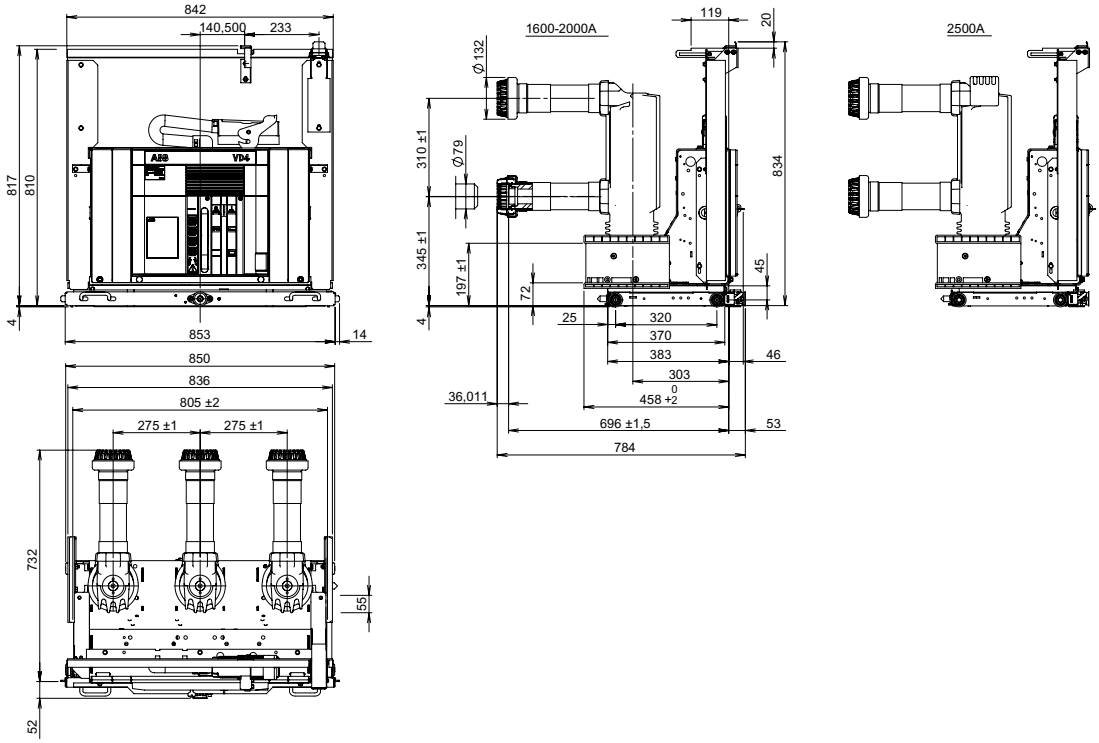

### Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD000174 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| Isc | 31.5 | kA |



## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB5 modules

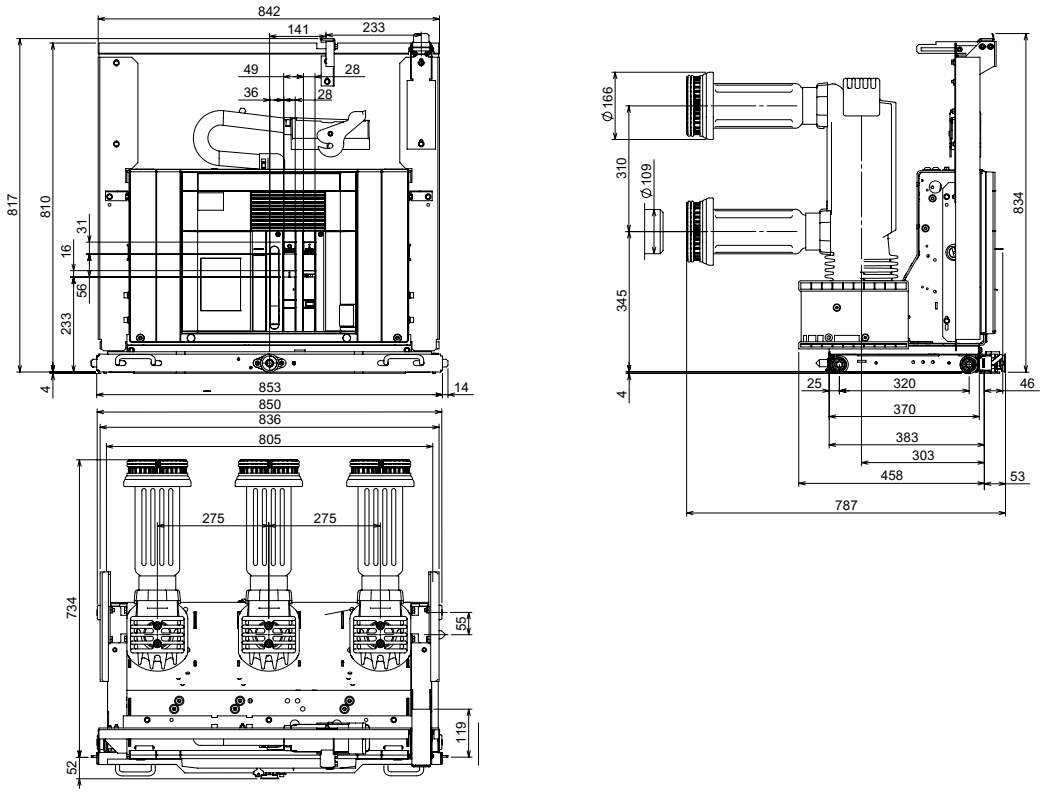
| VD4/P | | |
|---|---|---|
| TN | 7418 | |
| Ur | 24 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| | 2500 | A (1) |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




(1) The rated uninterrupted current of 2300 A is guaranteed with natural ventilation. The rated uninterrupted current of 2500 A is guaranteed with forced ventilation.

## Withdrawable circuit breakers for UniGear ZS1 switchgear

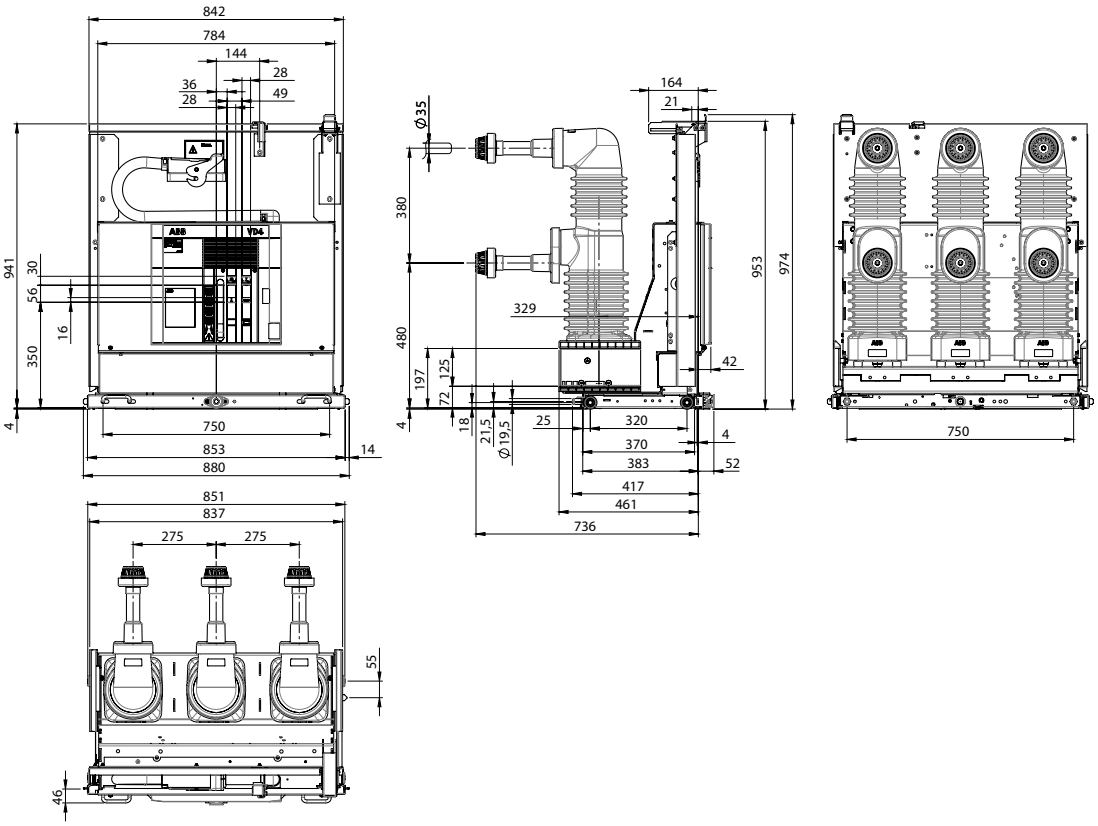
| VD4/P | | |
|---|---|---|
| TN | 1VCD000177 | |
| Ur | 24 | kV |
| | 3150 | A |
| Isc | 31.5 | kA |



# 13. Overall dimensions

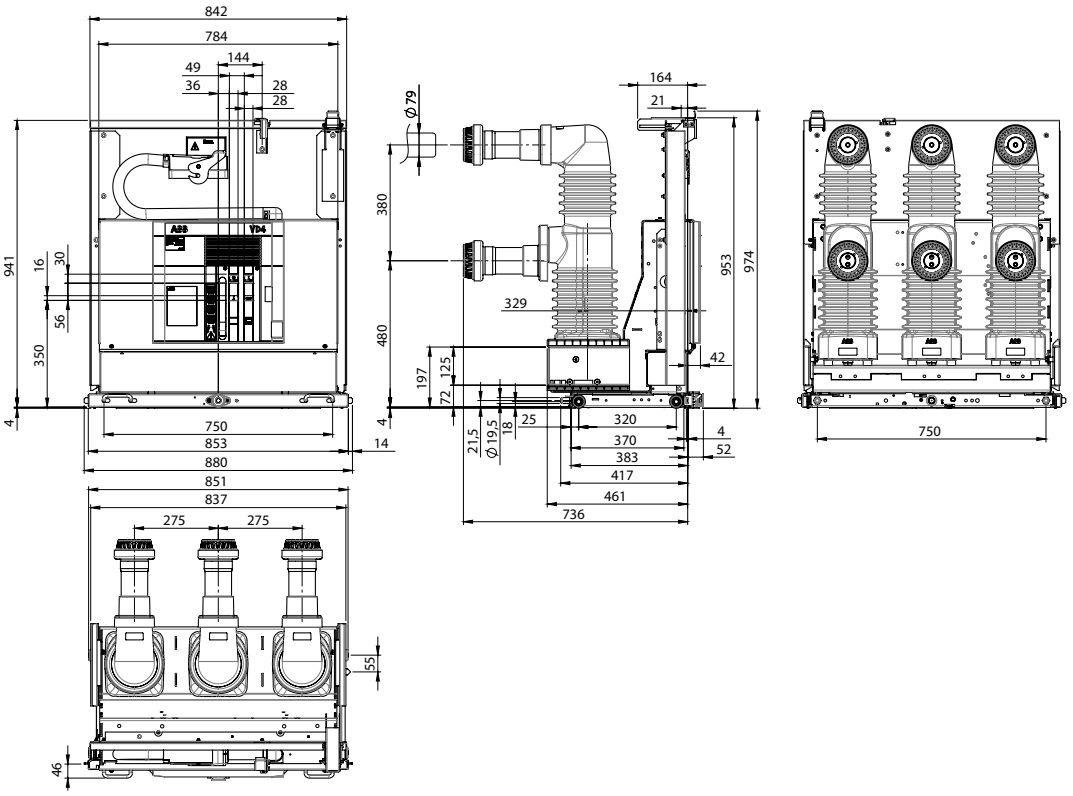
### Withdrawable circuit breakers for UniGear ZS2 switchgear

| VD4/W | | |
|---|---|---|
| TN | 1VYN300901-KG | |
| Ur | 36 | kV |
| Ir | 1250 | A |
| | 20 | kA |
| Isc | 25 | kA |
| | 31.5 | kA |




### Withdrawable circuit breakers for UniGear ZS2 switchgear

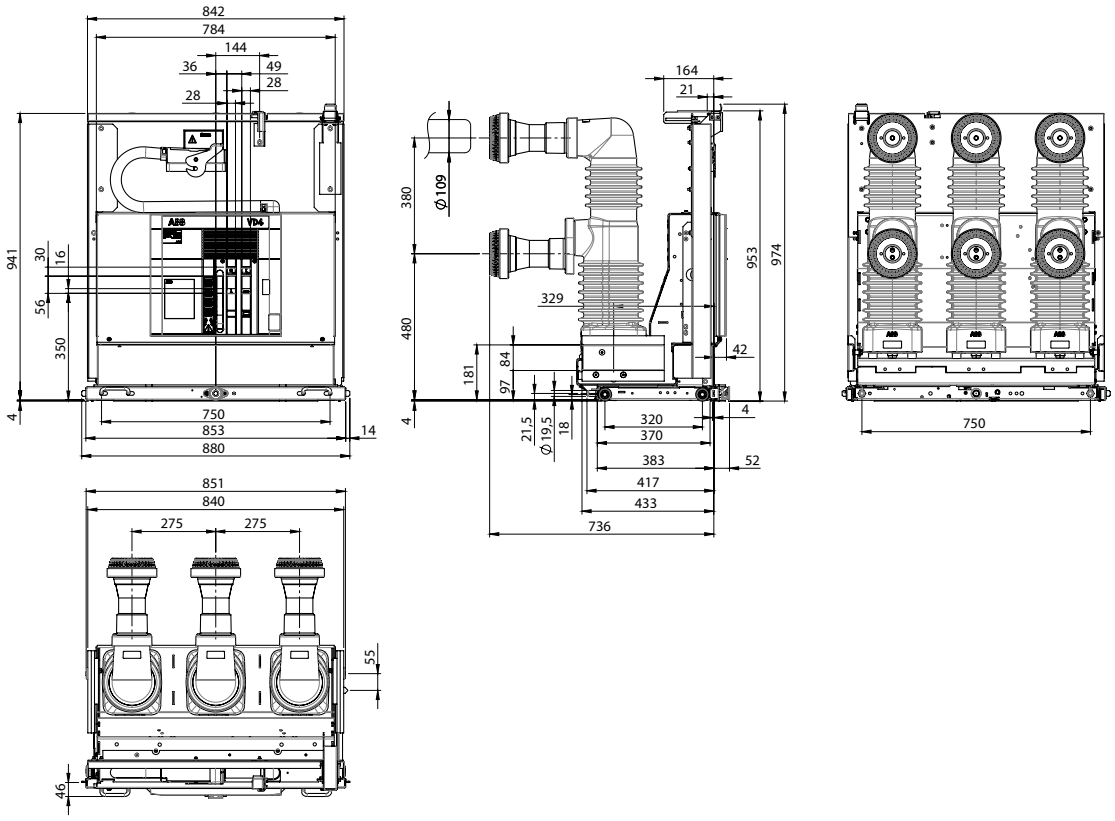
| VD4/W | | |
|---|---|---|
| TN | 1VYN300901RA | |
| Ur | 36 | kV |
| | 1600 | A |
| Ir | 2000 | A |
| | 2500 | A (*) |
| | 20 | kA |
| Isc | 25 | kA |
| | 31.5 | kA |




(1) The rated uninterrupted current of 2300 A is guaranteed with natural ventilation. The rated uninterrupted current of 2500 A is guaranteed with forced ventilation.

## Withdrawable circuit breakers for UniGear ZS2 switchgear

| VD4/W | | |
|---|---|---|
| TN | 1VYN300901RB | |
| Ur | 36 | kV |
| Ir | 2500 | A (*) |
| | 20 | kA |
| Isc | 25 | kA |
| | 31.5 | kA |

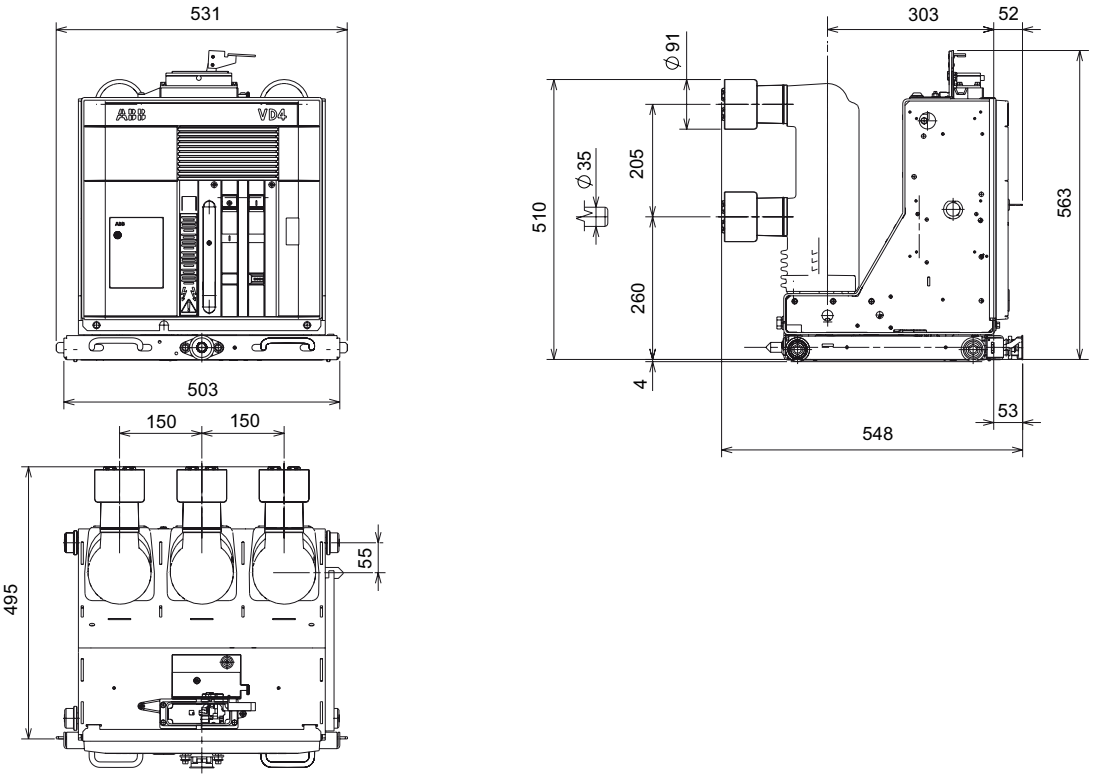



(*) The rated uninterrupted current of 3150 A is guaranteed with forced ventilation.

# 13. Overall dimensions

### Withdrawable circuit breakers for ZS8.4 switchgear

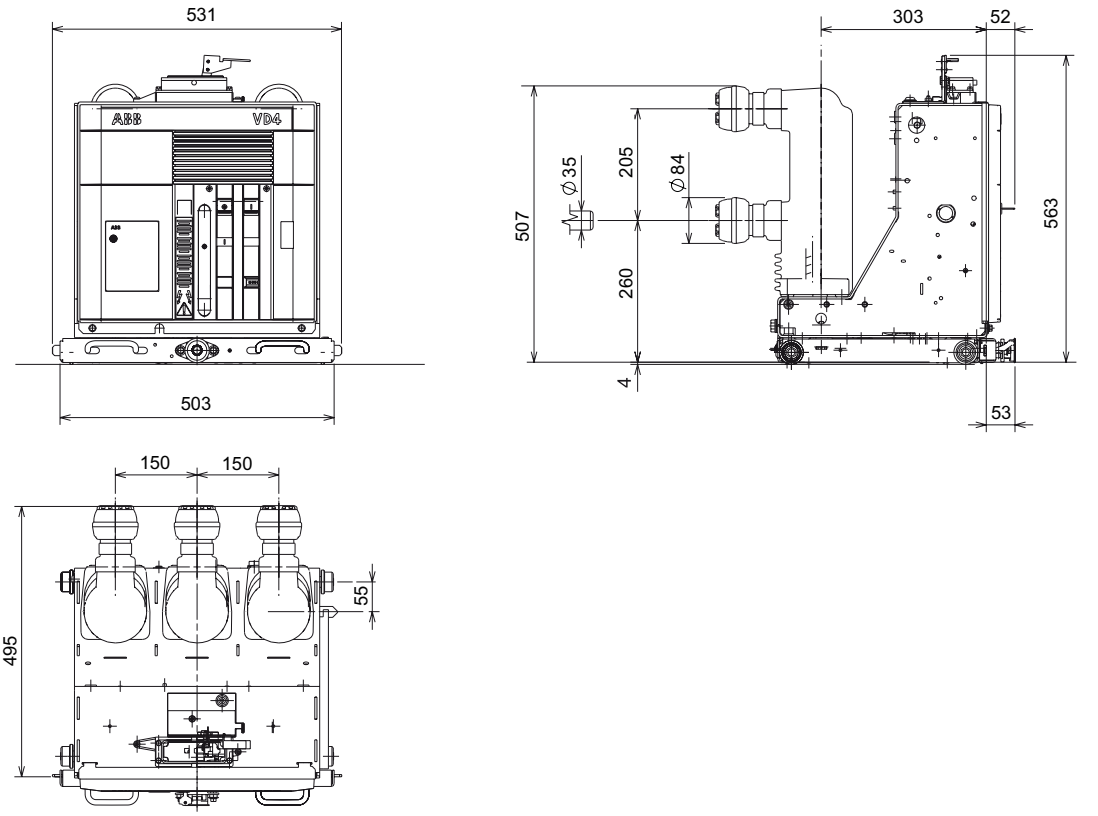
| VD4/Z8 | | |
|---|---|---|
| TN | 1VCD000092 | |
| Ur | 12 | kV |
| Ir | 630 | A |
| Isc | 20 | kA |
| | 25 | kA |




### Withdrawable circuit breakers for ZS8.4 switchgear

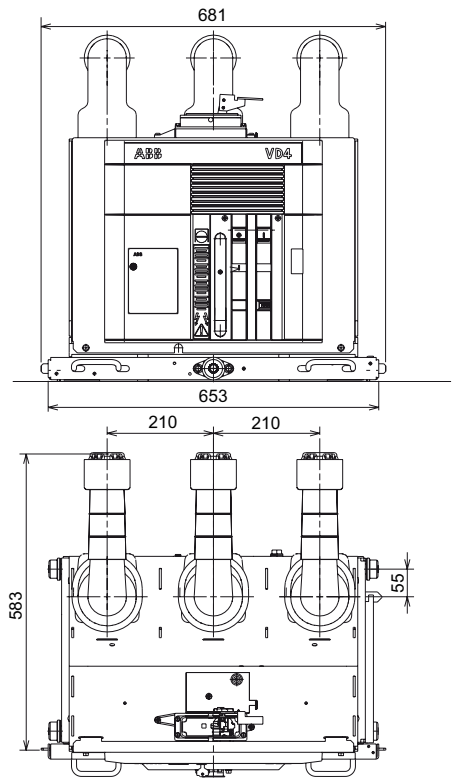
| VD4/Z8 | | |
|---|---|---|
| TN | 1VCD000137 | |
| Ur | 12 | kV |
| Ir | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |

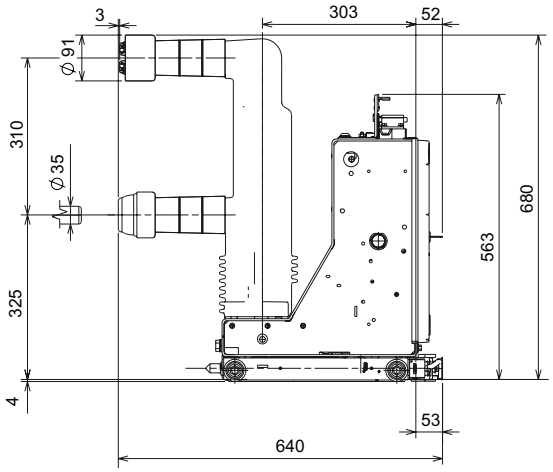
| | | |
|---|---|---|
| TN | 1VCD000137 | |
| Ur | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |



### Withdrawable circuit breakers for ZS8.4 switchgear

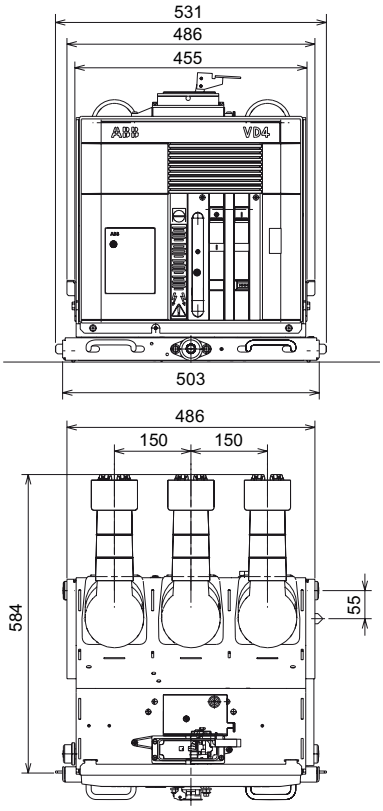
| VD4/Z8 | | |
|---|---|---|
| TN | 1VCD000089 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |

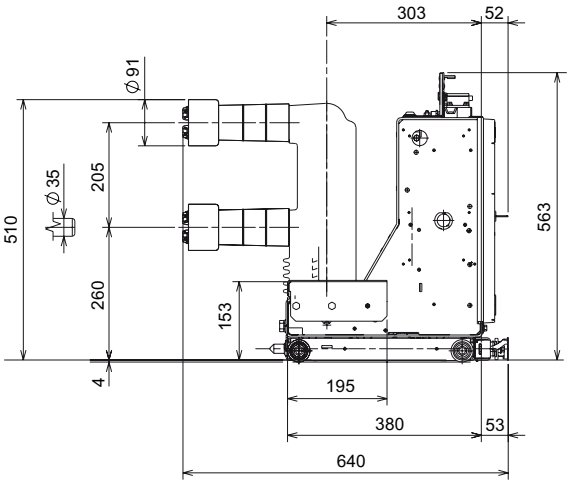



### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/ZT8 | | |
|---|---|---|
| TN | 1VCD000093 | |
| Ur | 12 | kV |
| Ir | 630 | A |
| Isc | 20 | kA |
| | 25 | kA |

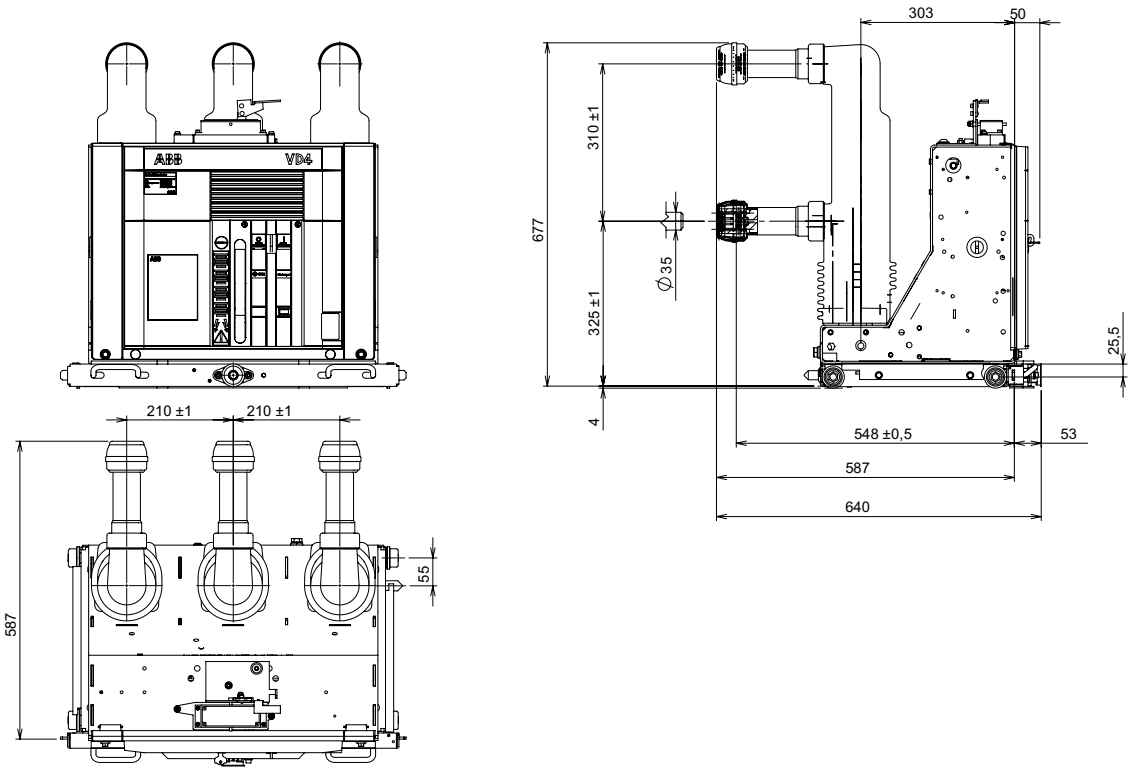


# 13. Overall dimensions

### Withdrawable circuit breakers for ZS8.4 switchgear

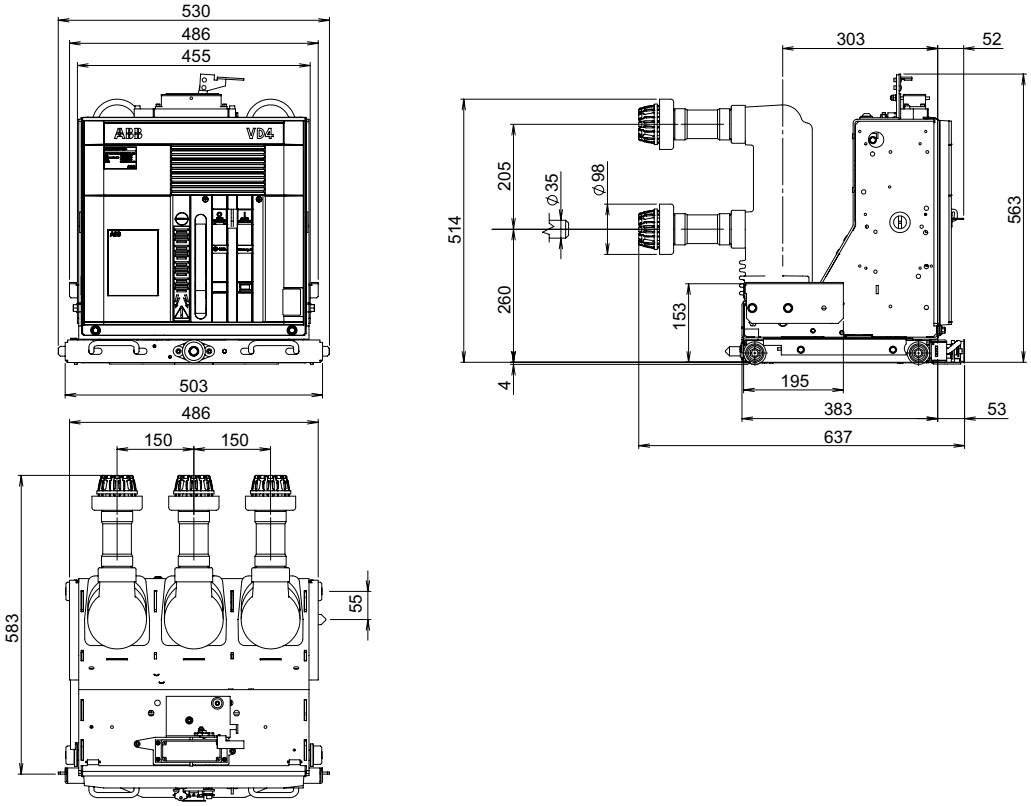
| **VD4/Z8** | | |
|---|---|---|
| TN | 1VCD000138 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |




### Withdrawable circuit breakers for ZS8.4 switchgear

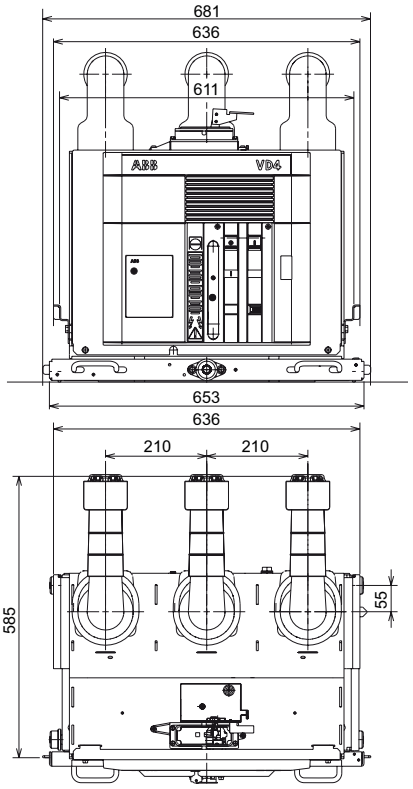
| **VD4/ZT8** | | |
|---|---|---|
| TN | 1VCD000134 | |
| Ur | 12 | kV |
| Ir | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |

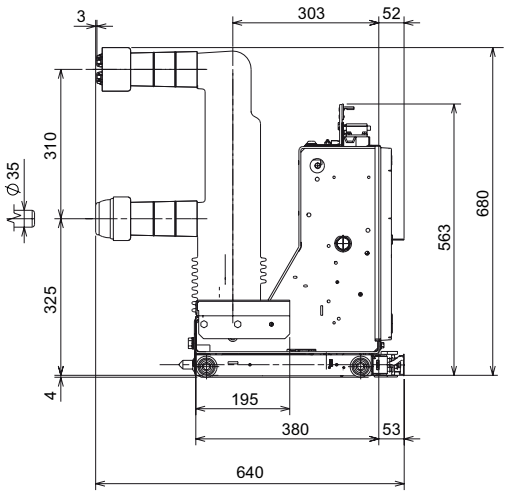
| **VD4/ZT8** | | |
|---|---|---|
| TN | 1VCD000134 | |
| Ur | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |



### Withdrawable circuit breakers for ZS8.4 switchgear

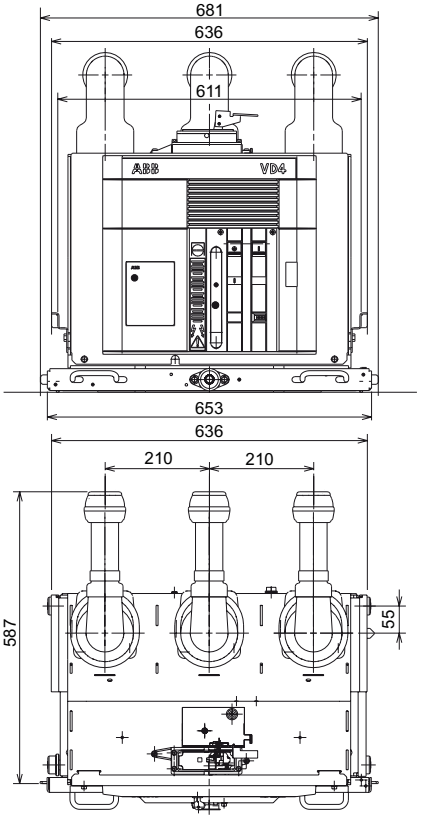
| VD4/ZT8 | | |
|---|---|---|
| TN | 1VCD000090 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 16 | kA |
| Isc | 20 | kA |
| | 25 | kA |

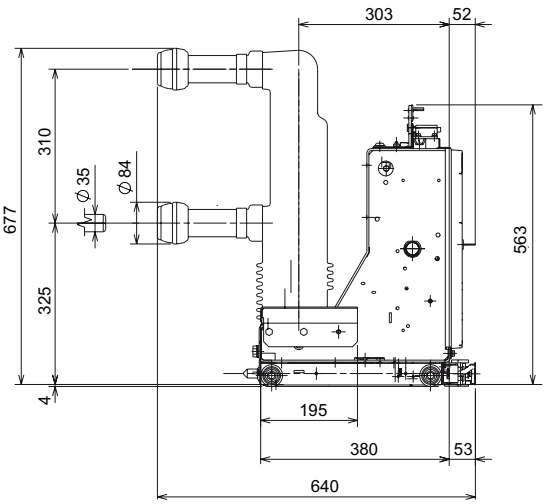



### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/ZT8 | | |
|---|---|---|
| **TN** | 1VCD000136 | |
| **Ur** | 24 | kV |
| **Ir** | 1250 | A |
| | 16 | kA |
| **Isc** | 20 | kA |
| | 25 | kA |

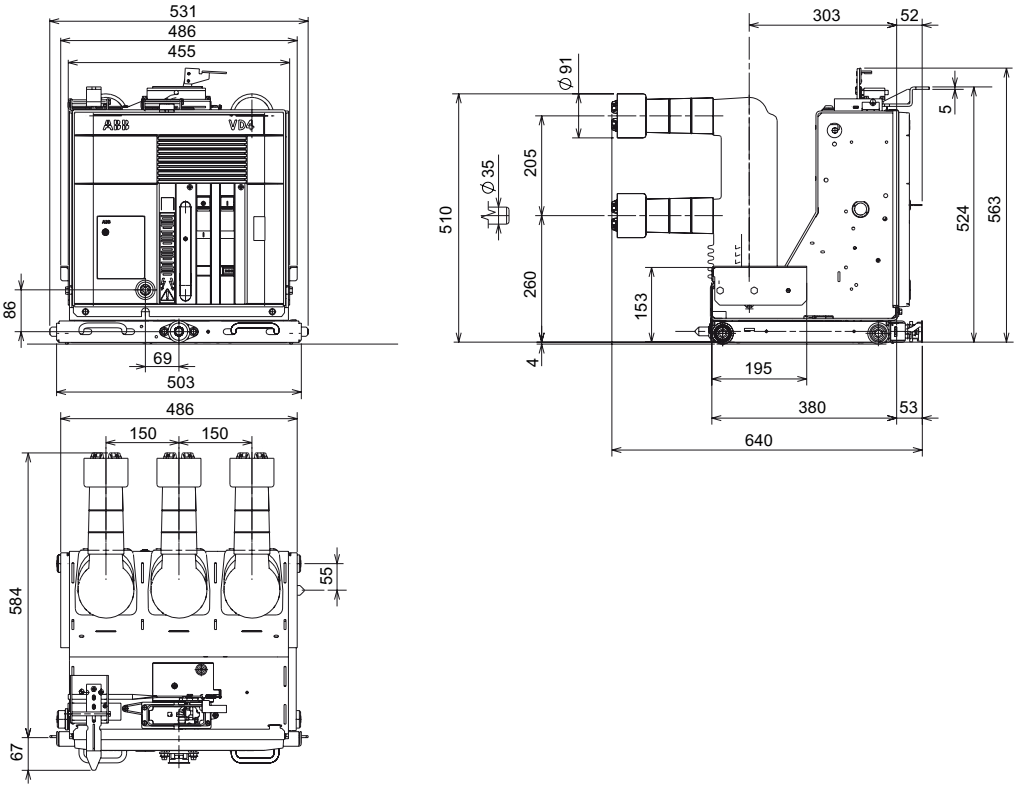


# 13. Overall dimensions

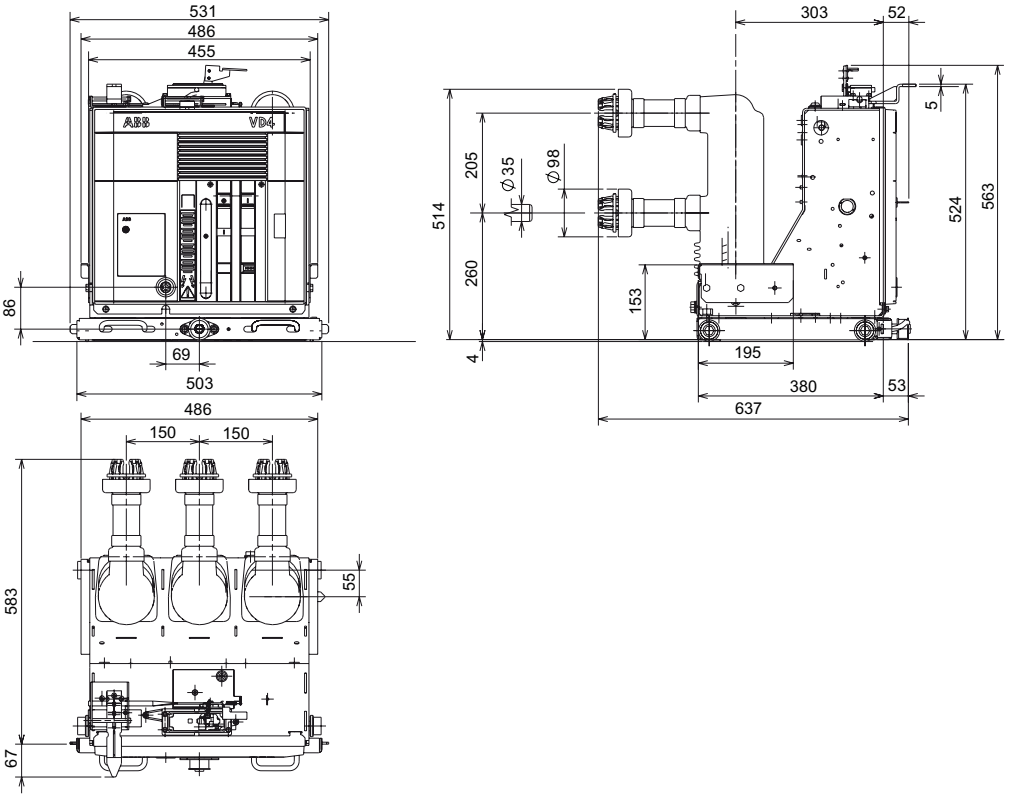
### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000091 | |
| Ur | 12 | kV |
| Ir | 630 | A |
| Isc | 20 | kA |
| | 25 | kA |



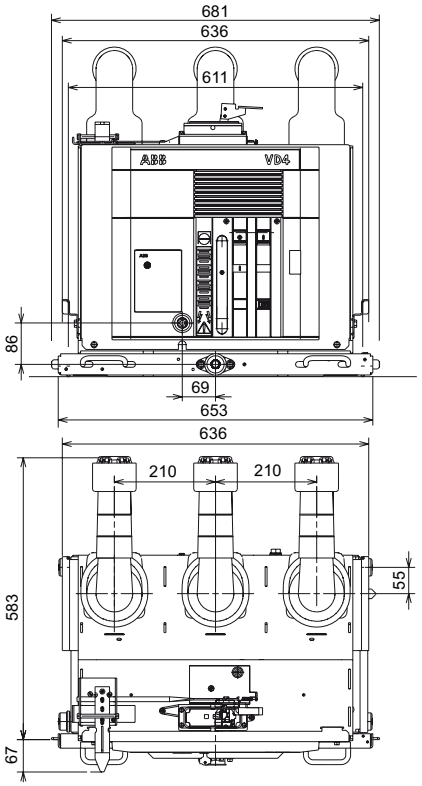

### Withdrawable circuit breakers for ZS8.4 switchgear

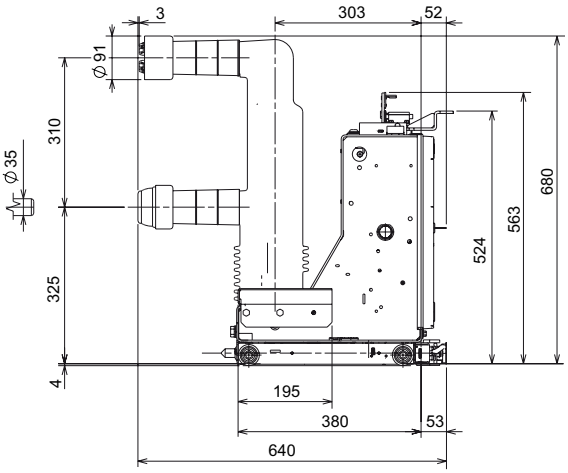
| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000133 | |
| Ur | 12 | kV |
| Ir | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |



### Withdrawable circuit breakers for ZS8.4 switchgear

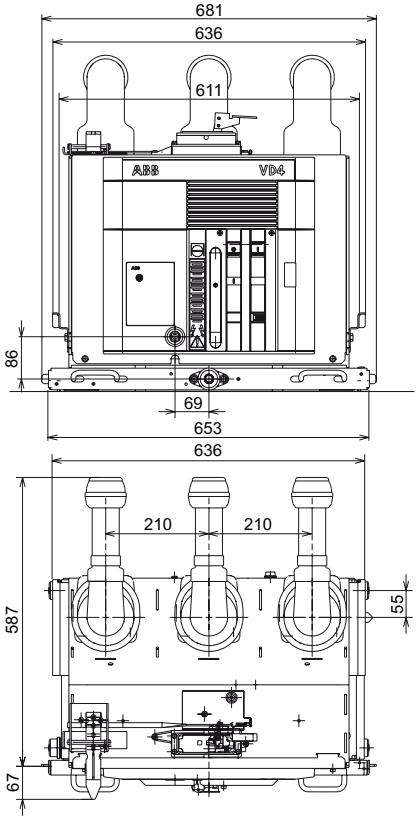
| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000088 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 16 | kA |
| Isc | 20 | kA |
| | 25 | kA |

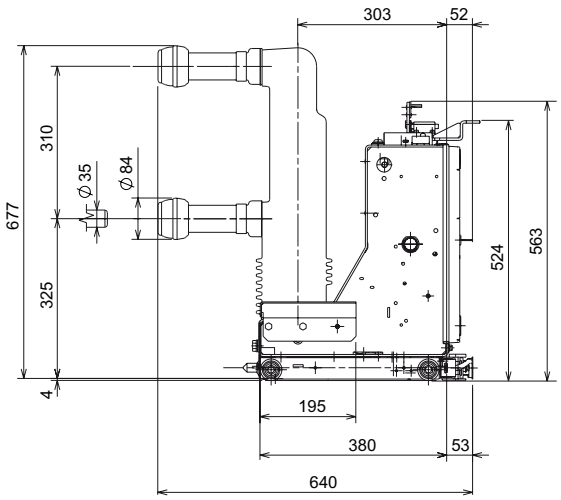



### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000135 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| | 16 | kA |
| Isc | 20 | kA |
| | 25 | kA |

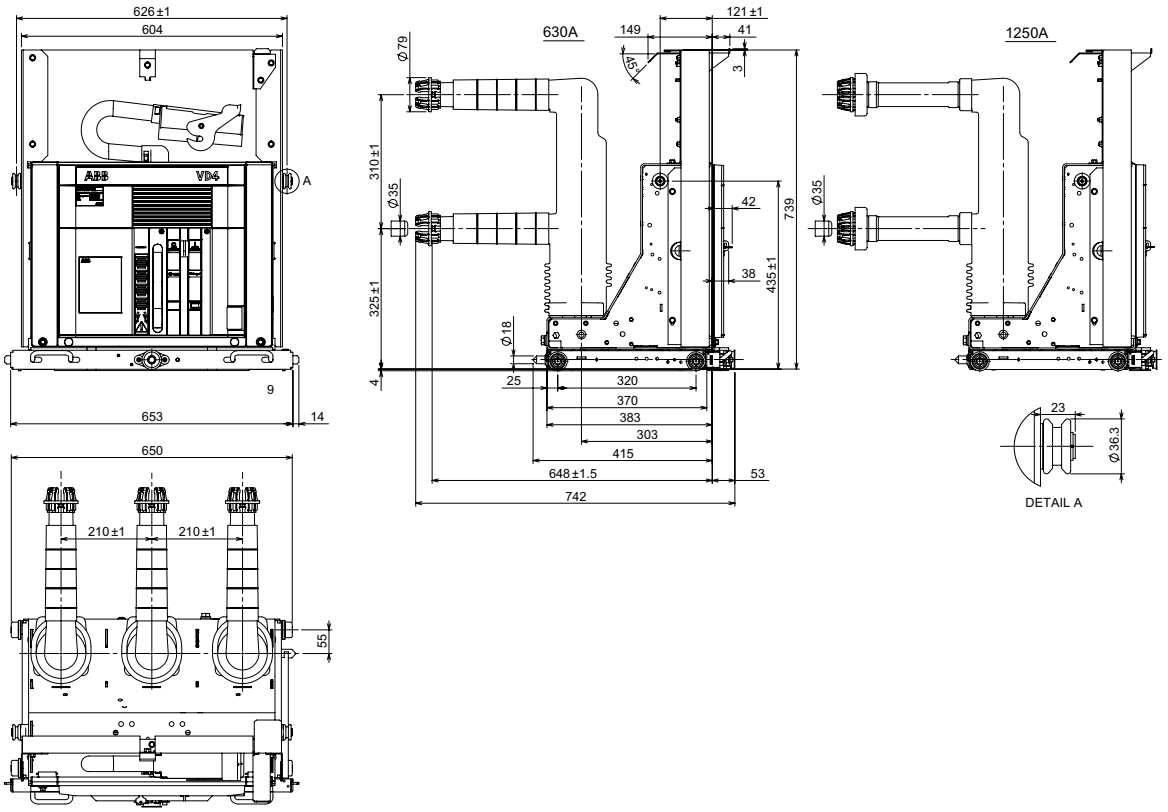


# 13. Overall dimensions

**Withdrawable circuit breakers for UniSec (WBC and WBS) switchgear**

| VD4/Sec | | |
|---|---|---|
| TN | 1VCD000190 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |



# 14. Product quality and environmental protection

The apparatus are produced in compliance with the requirements of international standards for the quality management system and environmental management system. In these fields, the excellent level is proved by quality certificates according to ISO 9001 and by the EMS according to ISO 14 001.

## End of life of product

The ABB company is committed to complying with the relevant legal and other requirements for environment protection according to the ISO 14 001 standard.
The duty of company is to facilitate subsequent recycling or disposal at the end of product life. During disposal of the product, it is always necessary to act in accordance with local legal requirements in force.

## Methods of disposal

Disposal can either be carried out thermally in an incineration plant or by storing on a waste site.

| Raw material | Recommended method of disposal |
|---|---|
| Metal material (Fe, Cu, Al, Ag, Zn, W, others) | Separation and recycling |
| Thermoplasts | Recycling or disposal |
| Epoxy resin | Separation of metal material and the disposal of rest |
| Rubber | Disposal |
| Oil as dielectric (transformer oil) | Draining from equipment and further recycling or disposal |
| Packing material – wood | Recycling or disposal |

# Notes

# Notes

More product information:
abb.com/mediumvoltage
Your contact center:
abb.com/contactcenters
More service information:
abb.com/service

The data and illustrations are not binding. We reserve the right to make changes without notice in the course of technical development of the product.

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6447654/001 - Rev. AB, en - Instruction Manual - 2022.09 (VD4 up to 12 ... 40.5 kA) (gs)

**Medium voltage products**

# PowerCube PB
# Installation and maintenance instructions

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Power and productivity
for a better world™

# For your safety!

- Make sure that the room is suitable for the installation of electrical apparatus.
- Make sure that all the installation, putting into service and maintenance operations are carried out by skilled personnel with in-depth knowledge of the apparatus.
- Make sure that all the installation, service and maintenance operations comply with standard and legal requirements for constructing the installations in accordance with the regulations for safety in the workplace.
- Strictly follow this instruction manual.
- Make sure that the ratings are not exceeded while the apparatus is in service.
- Pay the utmost attention to the notes shown in the manual by the following symbol:



- Make sure that the personnel working on the apparatus have this manual to hand and all the information required for correct intervention.



Responsible behaviour safeguards your own and others' safety!

For any requests, place contact the ABB Assistance Service.

# Introduction

The instructions in this manual refer to standardised PowerCube type medium voltage modules.
The instructions applicable to both the PowerCube PB/M modules and to the PowerCube PB/E enclosures will refer to these as PowerCube “Units”.
For correct use of the apparatus, please read the manual carefully.
PowerCube modules are designed for a large number of installation configurations.
However, they do allow further technical and constructional modifications to satisfy special installation requirements.
Consequently, the information given below may sometimes not contain instructions concerning special configurations requested by the customer.
Apart from to the manual, it is therefore always necessary to consult the latest technical documentation (circuit and wiring diagrams, foundation plans, any protection coordination studies, etc.), especially regarding any variants requested in relation to the standardised configurations.
For maintenance use only original spare parts. For any further information, refer to Technical Catalogue 1VCP000091.
For instructions regarding the apparatus (circuit-breakers, contactors ...), refer to the relative instruction booklets.

# 1. Packing and transport

**Follow the symbols and instructions shown on the packing carefully**

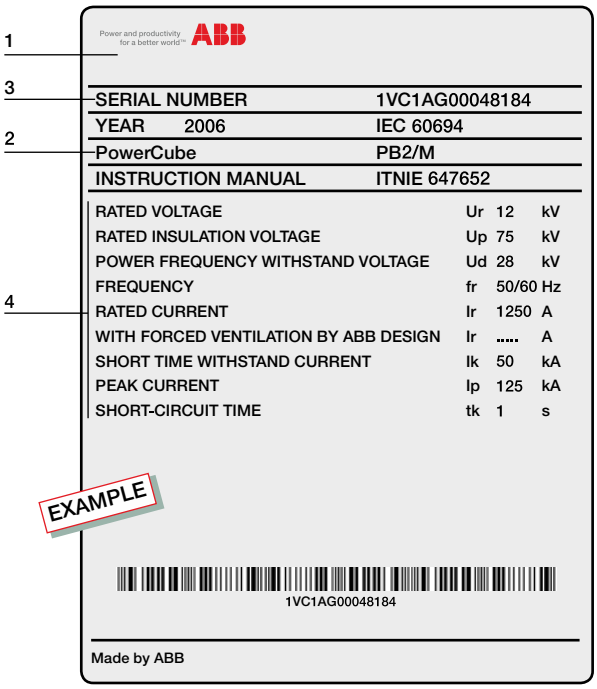
The PowerCube modules are shipped complete with trucks (voltage transformers) inserted in the relative compartments, except where otherwise agree with
the customer.
Each module is packed according to the shipping and storage requirements of the customer.
Each module is protected by a plastic cover to prevent any water entering during the loading and unloading stages and to keep it free of dust during storage.
The vehicle to be used to transport must have a loading platform not higher than 1.5 m from the ground so as to come within the maximum height of 4 metres. The loading platform must be slip-proof with a high friction coefficient.
The modules must be placed on the transport vehicle platform back-to-back and transversely, placing materials between them suitable for absorbing any compression and to avoid any direct contact between the surfaces of the various groups.
Special longitudinal members must be placed on the platform to space each module and prevent it moving either longitudinally or transversely.
The modules must be anchored to the structure of the vehicle with ropes, so that there is not deformation and to prevent tilting on bends or in the case of sudden stops.
The transport vehicle must also have a tarpaulin cover over the whole load.
The resting points of the lifting means must have a specific capacity to ensure proper weight distribution.
To unload the modules, there must be an area at the same level and with dimensions not less than 3 x 2 m in front of the access to the warehouse or switchboard room.
See paragraph 4 for handling.
Small differences in level can be compensated with temporary structures made using wooden boards.
Unloading must be carried out with the utmost care using suitable lifting equipment.
Special attention must be paid and the specific risks analysed for working in areas with live overhead lines.

# 2. Control on receipt

- **While handling the unit do not put stress on the insulating parts.**
- **Before performing any operation make sure that the operating device springs are discharged and the apparatus is in the open position.**

On receipt, immediately check the packing and the state of the apparatus.
Open the packing as shown in para. 4., taking care not to damage its materials. Check that no damage has occurred during transport and make sure that the nameplate data (fig. 1) corresponds to what is specified in the ABB order acknowledgement and in the shipping note.
Should any damage or irregularity be found in the supply, immediately notify ABB (directly, through the agent or the supplier) and the carrier who delivered the goods.
Notification of any irregularity, even after receipt, must indicate the module serial number shown on the nameplate located on the module itself.
The modules are only supplied complete with the accessories specified at the time of ordering and confirmed in the order acknowledgement sent by ABB.
The documents enclosed in the shipping packing are:
– adhesive labels showing the addressee and product type;
– this instruction manual;
– the test report;
– the electrical diagram.

## 2.1. Nameplate data




Caption
1 Trade mark
2 Enclosure type
3 Serial number
4 Electrical characteristics
5 Standards

**Fig. 1**

# 3. Storage

- **Please contact ABB in case of special storage conditions.**
- **If the gas pressure of the circuit-breaker (due to the altitude) has been reduced for shipping purposes, the nominal value the SF6 level must be restored (see para. 12.2.2) with SF6 gas in compliance with CEI 10-7 and IEC 60376 Standards.**
- **Gas recovery must be carried out either by our personnel or suitably qualified customer personnel with in-depth knowledge of the apparatus.**

If the apparatus has to be stored before installation, on request suitable packing for the conditions specified can be provided.
On receipt, the module must be unpacked and checked as described in “Control on receipt” (chapter 2), and then put back in the packing again using the original materials.
PowerCube modules must be stored in a dry, dust-free, non-corrosive place, at a temperature ranging from – 5 °C to + 45 °C without significant changes. If this is not possible, store the modules in a well-ventilated room, cover them with tarpaulins or waterproof sheets (e.g.: polyethylene) and supply the anti-condensation heaters to prevent any condensation.
The package contains dehydrating bags that must be replaced every six months.
For special requirements, please contact us.

# 4. Handling

## 4.1. Modules/enclosures

Each unit is usually fixed onto a wooden platform.
Handling should preferably be carried out by means of bridge or mobile cranes. Otherwise, use rollers or fork lift trucks.
Weights and dimensions of the various sections are indicated in the shipping documents and on the plant drawings.

### 4.1.1. Handling

**To handle the modules containing the apparatus (circuit-breaker, contactor or service truck), it is compulsory to use the proper lifting eyebolts.**

#### 4.1.1.1. Handling with bridge or mobile crane and unpacking

**Handling the wood packing**

Lifting by means of a crane must be carried out using the circular slings (1) (fig. 2).
The slings must be inserted according to the lifting symbols marked on the crate.
Weight and lifting opening angle must be taken into account when choosing the circular slings.

**Unpacking**

– Remove the nails and crate lid and sides;
– open the door of the units and loosen the screws fixing the module to the pallet (if present);
– lift the module by means of the crane following the instructions below;
– slide the pallet out from under the unit;
– position the unloading shims;
– lower the unit onto the shims using the crane.

**Only use a suitable balance lifting system of the type shown in the picture.**

After unpacking it, lift the unit by means of a crane, using the special eyebolts (1) (fig. 3) and the ropes fitted with safety spring catches, following this procedure:
– take hold of the lifting eyebolts by the handle (3);
– insert the hooking irons (5) in the slots (4) made on the side of the unit and marked with self-adhesive labels;
– push the lifting bolts against the module and make them slide upwards until the hooking irons (5) hit the top of the slot (4);
– fully tighten the positioning screw (6);
– hook the rope spring catches to the unit eyebolts and lift.
After installation, remove the eyebolts used for lifting by proceeding in reverse order.

**Handling the unit in the wooden crate**

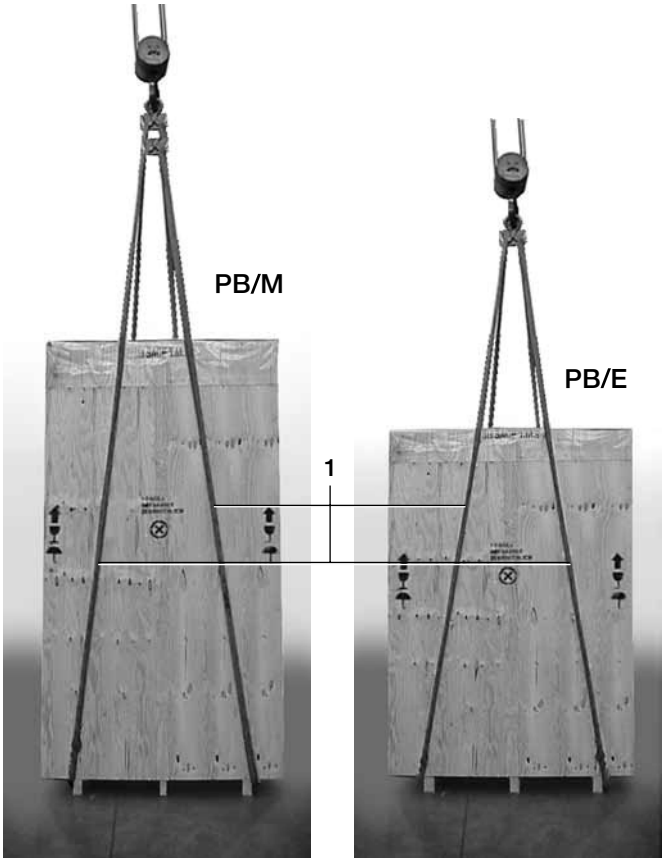



Fig. 2

**Module handling**

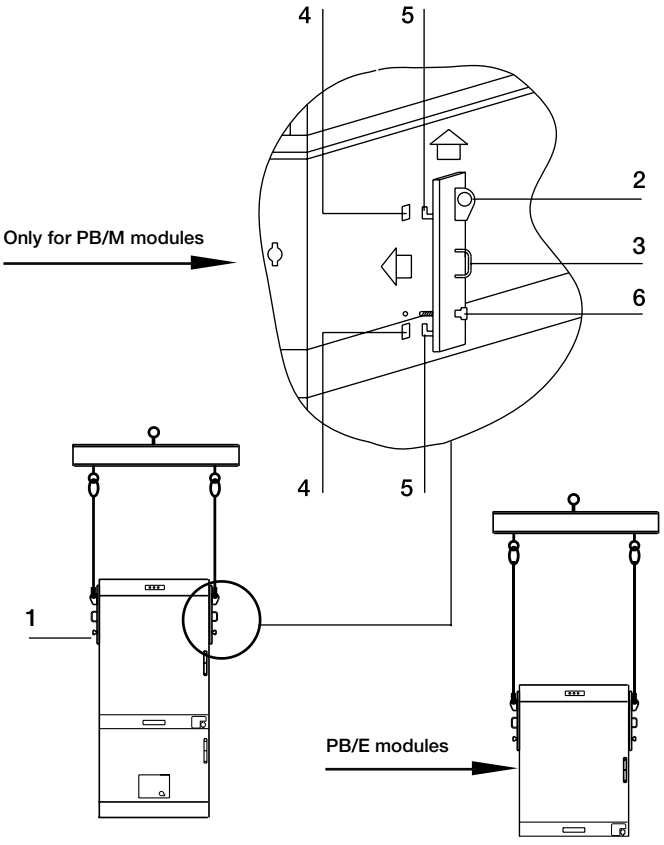



Fig. 3

#### 4.1.1.2. Handling by means of rollers

- **The floor on which the rollers slide must be completely level.**
- **Move the module, avoiding any bumps which might turn it over.**

Lift the unit by means of a bridge or mobile crane or using jacks (fig. 3).
Remove the wooden pallet, loosening the screws fixing it to the switchboard section base.
Put a sturdy metal sheet between the rollers and the base of the units and place the unit on the sliding rollers (fig. 4).

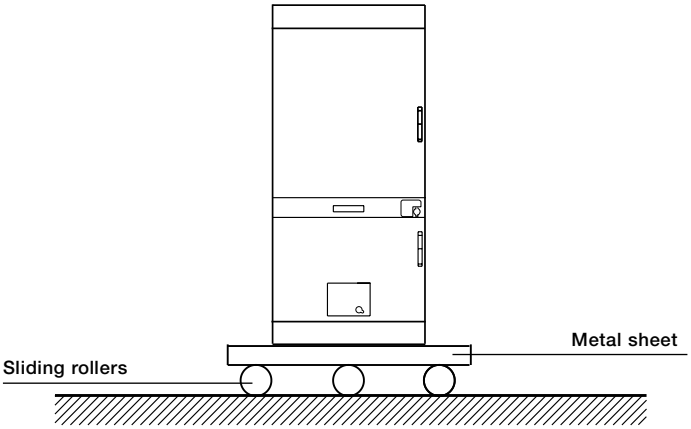



**Fig. 4**

#### 4.1.1.3. Handling by means of transpallets or fork lift trucks

- **The floor on which the transpallets or fork lift trucks run must be completely**
- **Move the unit, avoiding any bumps which might turn it over.**

For greater stability, only lift the unit enough to allow handling.
Also check levelness of the forks.

**Lifting a unit packed in a wooden crate.**



## 4.2. Apparatus

The apparatus can be handled by means of cranes, fork lift trucks or using the special truck provided by ABB.
For each apparatus follow the instructions given in the relative booklet.

**Unit handling.**

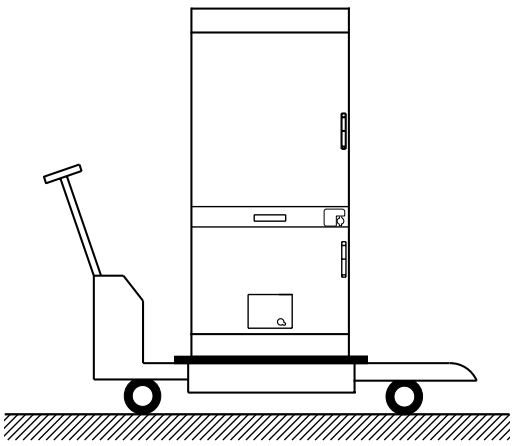


**Fig. 5**

# 5. Description

## 5.1. Unit construction features

The PowerCube units allow MV metal-clad switchboards with metal enclosure to be built, suitable for indoor installation.
The PowerCube units are pre-assembled and tested in the factory.
The PowerCube units are suitable for all primary distribution requirements with service voltages up to 24 kV and can take on different configurations according to customer requests.
For the instructions regarding the apparatus please refer to the relative manuals.
All normal service operations are carried out from the front of the unit with the doors closed. The doors on the front only need to be opened for maintenance operations and replacement of spare parts.

The circuit-breaker unit can be fitted with withdrawable circuit-breakers or contactors.
The switchgears built up with Power Cube units can be installed against walls since they are fully accessible from the front for the operations, maintenance and installation operations.
The PowerCube units allow arc-proof switchboards to be constructed in compliance with the prescriptions of the IEC 62271 - App. AA Standards, class of access (A) criteria (1 - 5).

The PowerCube units are designed with the following degrees of protection:

| | |
|---|---|
| Degree of protection with doors open | IP2X |
| Degree of protection on the external enclosure | IP4X |

Each unit (fig. 6) is divided internally into a circuit-breaker compartment and a feeder compartment.

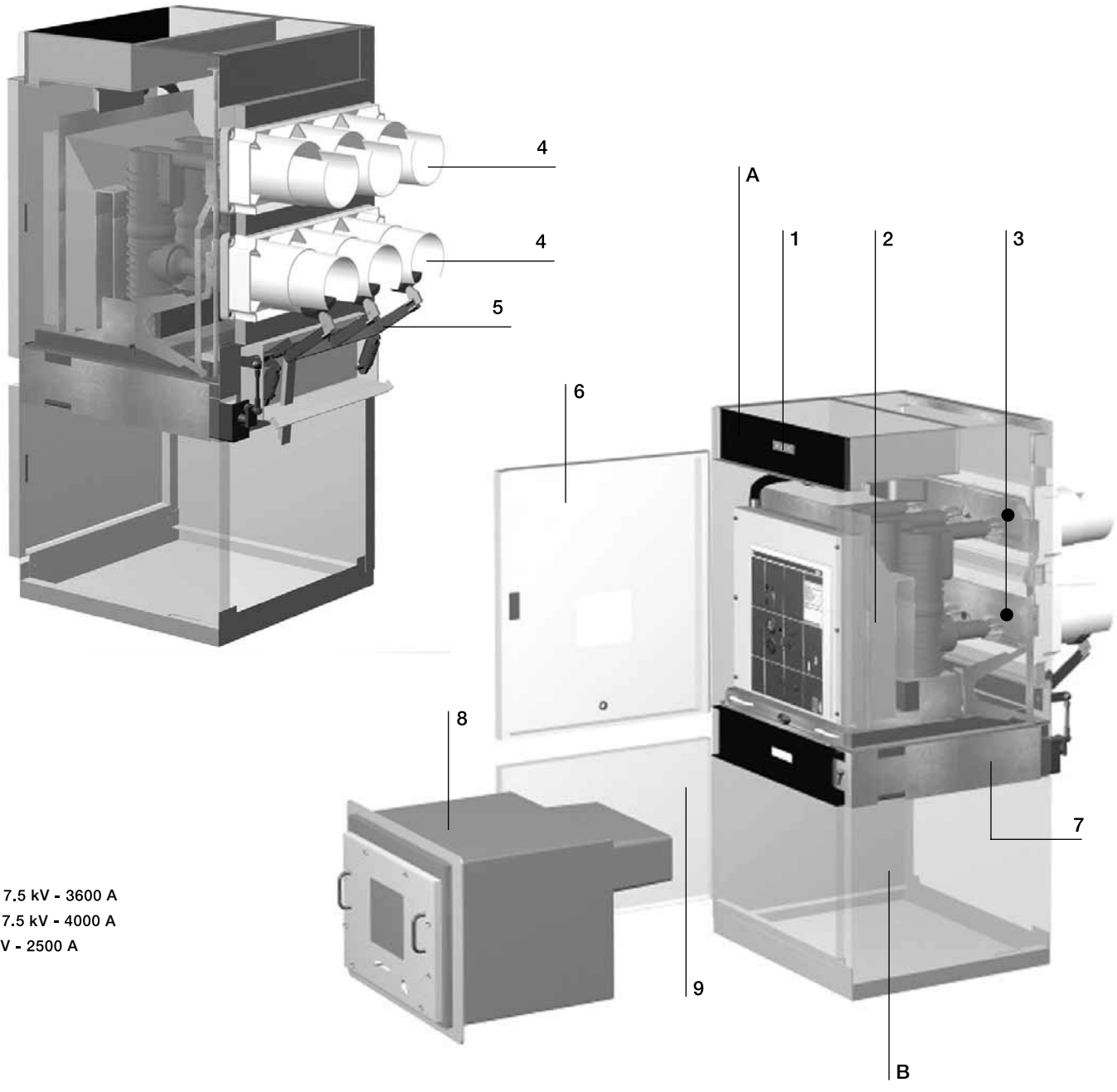
**A Circuit-breaker compartment**

1 Voltage signalling device (on request for PB/M only)
2 Circuit-breaker/contactor
3 Shutters
4 Lower and upper monoblocks
5 Earthing switch (on request)
6 Door
7 Fan (*)

**B Feeder compartment (PB/M-PB/RM)**

8 VT compartment on request (non available PB1/M - PB1/RM)
9 Door.

**Standard cross-section**

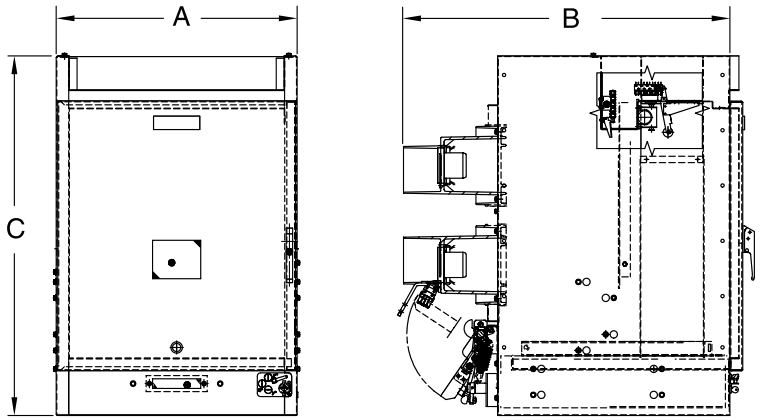



**(*)12/17.5 kV - 3600 A**
**12/17.5 kV - 4000 A**
**24 kV - 2500 A**

**Fig. 6**

# 5.2. Dimensions and weights

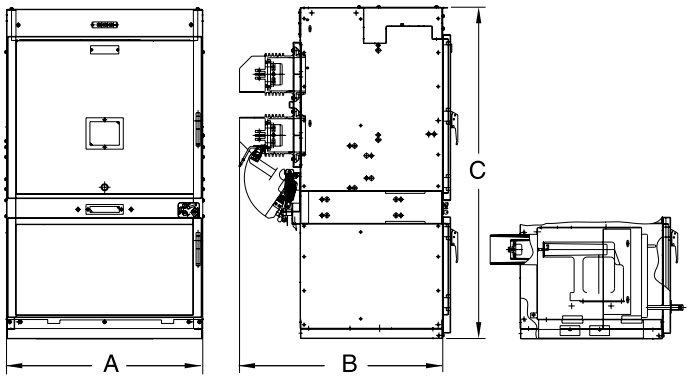
## PB/E



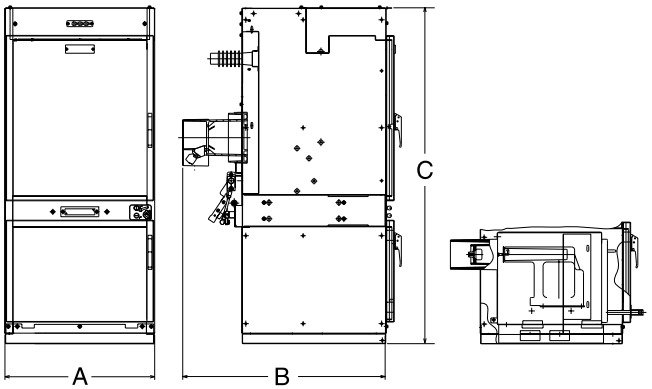

| Unit | Rated voltage [kV] | Rated current [A] | Isc Icw [kV] | Table of dimensions | A [mm] | B [mm] | C [mm] | Weight [kg] (1) |
|---|---|---|---|---|---|---|---|---|
| PB1/E | 12 | 630 - 1250 | 31.5 | 1VCD003369 | 600 | 1016 | 1120 | 180 |
| | 17.5 | 630 - 1250 | 31.5 | 1VCD003369 | 600 | 1016 | 1120 | |
| PB2/E | 12 | 630...2000 | 31.5 | 1VCD003370 | 750 | 1016 | 1120 | 200...240 |
| | 12 | 1250...2000 | 40-50 | 1VCD003370 | 750 | 1016 | 1120 | |
| | 17,5 | 630...2000 | 31.5 | 1VCD003370 | 750 | 1016 | 1120 | |
| | 17.5 | 1250...2000 | 40-50 | 1VCD003370 | 750 | 1016 | 1120 | |
| PB3/E | 12-17.5 | 2500 | 31.5 | 1VCD003371 | 1000 | 1030 | 1120 | 300 |
| | 12-17.5 | 3150 | 31.5 | 1VCD003372 | 1000 | 1030 | 1120 | 320 |
| | 12-17.5 | 3600...4000 | 31.5 | 1VCD003373 | 1000 | 1030 | 1120 | 350...380 |
| | 12-17.5 | 2500 | 40-50 | 1VCD003371 | 1000 | 1030 | 1120 | 300 |
| | 12-17.5 | 3150 | 40-50 | 1VCD003372 | 1000 | 1030 | 1120 | 320 |
| | 12-17.5 | 3600 - 4000 | 40-50 | 1VCD003373 | 1000 | 1030 | 1120 | 350...380 |
| PB4/E | 24 | 630 - 1250 | 31.5 | 1VCD003374 | 750 | 1246 | 1230 | 250 |
| PB5/E | 24 | 1600 - 2000 | 31.5 | 1VCD003376 | 1000 | 1246 | 1230 | 310 |
| | 24 | 2500 | 31.5 | 1VCD003376 | 1000 | 1246 | 1230 | 340 |
| PB1/RE | 17.5 | NOT APPLICABLE | 31.5 | 1VCD003377 | 600 | 1016 (2) | 1120 | 165 |
| PB2/RE | 17.5 | | 31.5 | 1VCD003378 | 750 | 1016 (2) | 1120 | 165...215 |
| | 17.5 | | 40-50 | 1VCD003378 | 750 | 1016 (2) | 1120 | 165...215 |
| PB3/RE | 12-17.5 | | 31.5 | 1VCD003379 | 1000 | 1030 (2) | 1120 | 270 |
| | 12-17.5 | | 40-50 | 1VCD003379 | 1000 | 1030 (2) | 1120 | 270 |
| PB4/RE | 24 | | 31.5 | 1VCD003380 | 750 | 1310 (2) | 1230 | 215 |
| PB5/RE | 24 | | 31.5 | 1VCD003381 | 1000 | 1246 (2) | 1230 | 250 |

(1) Weight without earthing switch.
(2) Dimension with earthing switch.

## PB/M




## PR/M




| Unit | Rated voltage [kV] | Rated current [A] | Isc Icw [kV] | Table of dimensions | A [mm] | B [mm] | C [mm] | Weight [kg] (1) |
|---|---|---|---|---|---|---|---|---|
| PB1/M | 12 | 630 - 1250 | 31.5 | 1VCD000023 | 600 | 1016 | 1680 | |
| | 17.5 | 630 - 1250 | 31.5 | 1VCD000028 | 600 | 1016 | 1680 | 200 |
| PB2/M | 12 | 630...2000 | 31.5 | 1VCD000024 | 750 | 1016 | 1680 | |
| | 12 | 1250...2000 | 40-50 | 1VCD000027 | 750 | 1016 | 1680 | |
| | 17.5 | 630...2000 | 31.5 | 1VCD000029 | 750 | 1016 | 1680 | 220...260 |
| | 17.5 | 1250...2000 | 40-50 | 1VCD000030 | 750 | 1016 | 1680 | |
| PB3/M | 12-17.5 | 2500 | 31.5 | 1VCD000025 | 1000 | 1030 | 1680 | 320 |
| | 12-17.5 | 3150 | 31.5 | 1VCD000026 | 1000 | 1030 | 1680 | 344 |
| | 12-17.5 | 3600...4000 | 31.5 | 1VCD000043 | 1000 | 1030 | 1680 | 370...400 |
| | 12-17.5 | 2500 | 40-50 | 1VCD000037 | 1000 | 1030 | 1680 | 320 |
| | 12-17.5 | 3150 | 40-50 | 1VCD000038 | 1000 | 1030 | 1680 | 344 |
| | 12-17.5 | 3600 - 4000 | 40-50 | 1VCD000039 | 1000 | 1030 | 1680 | 370...400 |
| PB4/M | 24 | 630 - 1250 | 31.5 | 1VCD000031 | 750 | 1310 | 1745 | 270 |
| PB5/M | 24 | 1600 - 2000 | 31.5 | 1VCD000032 | 1000 | 1246 | 1745 | 330 |
| | 24 | 2500 | 31.5 | 1VCD000044 | 1000 | 1246 | 1745 | 360 |

| Unit | Rated voltage [kV] | Rated current [A] | Isc Icw [kV] | Table of dimensions | A [mm] | B [mm] | C [mm] | Weight [kg] (1) |
|---|---|---|---|---|---|---|---|---|
| PB1/RM | 17.5 | NOT APPLICABLE | 31.5 | 1VCD000033 | 600 | 1016 | 1745 | 185 |
| PB2/RM | 12 | | 31.5 | 1VCD000034 | 750 | 1016 | 1745 | 185...235 |
| | 17,5 | | 40-50 | 1VCD000040 | 750 | 1016 | 1745 | 185...235 |
| PB3/RM | 12-17.5 | | 31.5 | 1VCD000041 | 1000 | 1030 | 1680 | 290 |
| | 12-17.5 | | 40-50 | 1VCD000042 | 1000 | 1030 | 1680 | 290 |
| PB4/RM | 24 | | 31.5 | 1VCD000035 | 750 | 1310 | 1745 | 270 |
| PB5/RM | 24 | | 31.5 | 1VCD000036 | 1000 | 1246 | 1745 | 270 |

(1) Weight without earthing switch and without VT compartment.
(2) Dimension with earthing switch.

# 5.3. Possibility of combining PowerCube units with ABB apparatus

**Table 1 - VD4 withdrawable circuit-breakers for PowerCube type PB units (*)**
**Rated current of the VD4 circuit-breakers (A - 40 °C)**



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12-17.5 | 16 | 16 | 630 | | | | | | VD4/P 12.06.16 p150 | VD4/P 17.06.16 p150 | PB 1/E PB 1/M |
| | 20 | 20 | 630 | | | | | | VD4/P 12.06.20 p150 | VD4/P 17.06.20 p150 | |
| | 25 | 25 | 630 | | | | | | VD4/P 12.06.25 p150 | VD4/P 17.06.25 p150 | |
| | 31.5 | 31.5 | 630 | | | | | | VD4/P 12.06.32 p150 | VD4/P 17.06.32 p150 | |
| | 16 | 16 | 1250 | | | | | | VD4/P 12.12.16 p150 | VD4/P 17.12.16 p150 | |
| | 20 | 20 | 1250 | | | | | | VD4/P 12.12.20 p150 | VD4/P 17.12.20 p150 | |
| | 25 | 25 | 1250 | | | | | | VD4/P 12.12.25 p150 | VD4/P 17.12.25 p150 | |
| | 31.5 | 31.5 | 1250 | | | | | | VD4/P 12.12.32 p150 | VD4/P 17.12.32 p150 | |
| | 16 | 16 | | 630 | | | | | VD4/W 12.06.16 p210 | VD4/W 17.06.16 p210 | |
| | 20 | 20 | | 630 | | | | | VD4/W 12.06.20 p210 | VD4/W 17.06.20 p210 | |
| | 25 | 25 | | 630 | | | | | VD4/W 12.06.25 p210 | VD4/W 17.06.25 p210 | |
| | 31.5 | 31.5 | | 630 | | | | | VD4/W 12.06.32 p210 | VD4/W 17.06.32 p210 | |
| | 16 | 16 | | 1250 | | | | | VD4/W 12.12.16 p210 | VD4/W 17.12.16 p210 | |
| | 20 | 20 | | 1250 | | | | | VD4/W 12.12.20 p210 | VD4/W 17.12.20 p210 | |
| | 25 | 25 | | 1250 | | | | | VD4/W 12.12.25 p210 | VD4/W 17.12.25 p210 | |
| | 31.5 | 31.5 | | 1250 | | | | | VD4/W 12.12.32 p210 | VD4/W 17.12.32 p210 | |
| | 40 | 40 | | 1250 | | | | | – | – | |
| | 50 | 50 | | 1250 | | | | | – | – | |
| | 40 | 40 | | | 1250 | | | | VD4/P 12.12.40 p210 (3) | VD4/P 17.12.40 p210 (3) | PB 2/E PB 2/M |
| | 50 | 50 | | | 1250 | | | | VD4/P 12.12.50 p210 (3) | VD4/P 17.12.50 p210 (3) | |
| | 20 | 20 | | | 1600 | | | | VD4/P 12.16.20 p210 | VD4/P 17.16.20 p210 | |
| | 25 | 25 | | | 1600 | | | | VD4/P 12.16.25 p210 | VD4/P 17.16.25 p210 | |
| | 31.5 | 31.5 | | | 1600 | | | | VD4/P 12.16.32 p210 | VD4/P 17.16.32 p210 | |
| | 40 | 40 | | | 1600 | | | | VD4/P 12.16.40 p210 (3) | VD4/P 17.16.40 p210 (3) | |
| | 50 | 50 | | | 1600 | | | | VD4/P 12.16.50 p210 (3) | VD4/P 17.16.50 p210 (3) | |
| | 20 | 20 | | | 2000 | | | | VD4/P 12.20.20 p210 | VD4/P 17.20.20 p210 | |
| | 25 | 25 | | | 2000 | | | | VD4/P 12.20.25 p210 | VD4/P 17.20.25 p210 | |
| | 31.5 | 31.5 | | | 2000 | | | | VD4/P 12.20.32 p210 | VD4/P 17.20.32 p210 | |
| | 40 | 40 | | | 2000 | | | | VD4/P 12.20.40 p210 (3) | VD4/P 17.20.40 p210 (3) | |
| | 50 | 50 | | | 2000 | | | | VD4/P 12.20.50 p210 (3) | VD4/P 17.20.50 p210 (3) | |
| | 20 | 20 | | | | 2500 | | | VD4/P 12.25.20 p275 | VD4/P 17.25.20 p275 | |
| | 25 | 25 | | | | 2500 | | | VD4/P 12.25.25 p275 | VD4/P 17.25.25 p275 | |
| | 31.5 | 31.5 | | | | 2500 | | | VD4/P 12.25.32 p275 | VD4/P 17.25.32 p275 | |
| | 40 | 40 | | | | 2500 | | | VD4/P 12.25.40 p275 (3) | VD4/P 17.25.40 p275 (3) | |
| | 50 | 50 | | | | 2500 | | | VD4/P 12.25.50 p275 (3) | VD4/P 17.25.50 p275 (3) | |
| | 31.5 | 31.5 | | | | 3150 | | | VD4/P 12.32.32 p275 (3) | VD4/P 17.32.32 p275 (3) | |
| | 40 | 40 | | | | 3150 | | | VD4/W 12.32.40 p275 (3) | VD4/W 17.32.40 p275 (3) | PB 3/E PB 3/M |
| | 50 | 50 | | | | 3150 | | | VD4/P 12.32.50 p275 (3) | VD4/P 17.32.50 p275 (3) | |
| | 31.5 | 31.5 | | | | 3600 (1) | | | VD4/P 12.32.32 p275 (3) | VD4/P 17.32.32 p275 (3) | |
| | 40 | 40 | | | | 3600 (1) | | | VD4/W 12.32.40 p275 (3) | VD4/W 17.32.40 p275 (3) | |
| | 50 | 50 | | | | 3600 (1) | | | VD4/P 12.32.50 p275 (3) | VD4/P 17.32.50 p275 (3) | |
| | 31.5 | 31.5 | | | | 4000 (1) | | | VD4/P 12.32.32 p275 (3) | VD4/P 17.32.32 p275 (3) | |
| | 40 | 40 | | | | 4000 (1) | | | VD4/W 12.32.40 p275 (3) | VD4/W 17.32.40 p275 (3) | |
| | 50 | 50 | | | | 4000 (1) | | | VD4/P 12.32.50 p275 (3) | VD4/P 17.32.50 p275 (3) | |



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 16 | | | | | 630 | | VD4/P 24.06.16 p210 | – | |
| | 20 | 20 | | | | | 630 | | VD4/P 24.06.20 p210 | – | |
| | 25 | 25 | | | | | 630 | | VD4/P 24.06.25 p210 | – | PB 4/E |
| | 16 | 16 | | | | | 1250 | | VD4/P 24.12.16 p210 | – | PB 4/M |
| | 20 | 20 | | | | | 1250 | | VD4/P 24.12.20 p210 | – | |
| | 25 | 25 | | | | | 1250 | | VD4/P 24.12.25 p210 | – | |
| | 16 | 16 | | | | | | 1600 | VD4/P 24.16.16 p275 | – | |
| 24 | 20 | 20 | | | | | | 1600 | VD4/P 24.16.20 p275 | – | |
| | 25 | 25 | | | | | | 1600 | VD4/P 24.16.25 p275 | – | |
| | 16 | 16 | | | | | | 2000 | VD4/P 24.20.16 p275 | – | |
| | 20 | 20 | | | | | | 2000 | VD4/P 24.20.20 p275 | – | PB 5/E |
| | 25 | 25 | | | | | | 2000 | VD4/P 24.20.25 p275 | – | PB 5/M |
| | 16 | 16 | | | | | | 2500 (2) | VD4/P 24.25.16 p275 | – | |
| | 20 | 20 | | | | | | 2500 (2) | VD4/P 24.25.20 p275 | – | |
| | 25 | 25 | | | | | | 2500 (2) | VD4/P 24.25.25 p275 | – | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monbloc.
(*) The PowerCube units are not prepared for application of the “motorised truck” for VD4 circuit-breakers
(1) 3600 A with fan pre-installed in the PB3 units. For 4000 A it is necessary to install another fan in the back of the switchgear (by the customer).
(2) 2500 A with fan pre-installed in the PB5 units.
(3) Please ask ABB for availability.

## Table 2 - Withdrawable HD4 circuit-breakers for PowerCube type PB units

### Rated current of the HD4 circuit-breakers (A - 40 °C)



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12-17.5 | 16 | 16 | 630 | | | | | | HD4/W 12.06.16 p150 | HD4/W 17.06.16 p150 | PB 1/E<br>PB 1/M |
| | 25 | 25 | 630 | | | | | | HD4/W 12.06.25 p150 | HD4/W 17.06.25 p150 | |
| | 31.5 | 31.5 | 630 | | | | | | HD4/W 12.06.32 p150 | HD4/W 17.06.32 p150 | |
| | 16 | 16 | 1250 | | | | | | HD4/W 12.12.16 p150 | HD4/W 17.12.16 p150 | |
| | 25 | 25 | 1250 | | | | | | HD4/W 12.12.25 p150 | HD4/W 17.12.25 p150 | |
| | 31.5 | 31.5 | 1250 | | | | | | HD4/W 12.12.32 p150 | HD4/W 17.12.32 p150 | |
| | 16 | 16 | | 630 | | | | | HD4/W 12.06.16 p210 | HD4/W 17.06.16 p210 | PB 2/E<br>PB 2/M |
| | 25 | 25 | | 630 | | | | | HD4/W 12.06.25 p210 | HD4/W 17.06.25 p210 | |
| | 31.5 | 31.5 | | 630 | | | | | HD4/W 12.06.32 p210 | HD4/W 17.06.32 p210 | |
| | 16 | 16 | | 1250 | | | | | HD4/W 12.12.16 p210 | HD4/W 17.12.16 p210 | |
| | 25 | 25 | | 1250 | | | | | HD4/W 12.12.25 p210 | HD4/W 17.12.25 p210 | |
| | 31.5 | 31.5 | | 1250 | | | | | HD4/W 12.12.32 p210 | HD4/W 17.12.32 p210 | |
| | 40 | 40 | | 1250 | | | | | HD4/W 12.12.40 p210 | HD4/W 17.12.40 p210 | |
| | 50 | 50 | | 1250 | | | | | HD4/W 12.12.50 p210 | HD4/W 17.12.50 p210 | |
| | 40 | 40 | | | 1250 | | | | – | – | |
| | 50 | 50 | | | 1250 | | | | – | – | |
| | 16 | 16 | | | 1600 | | | | HD4/W 12.16.16 p210 | HD4/W 17.16.16 p210 | |
| | 25 | 25 | | | 1600 | | | | HD4/W 12.16.25 p210 | HD4/W 17.16.25 p210 | |
| | 31.5 | 31.5 | | | 1600 | | | | HD4/W 12.16.32 p210 | HD4/W 17.16.32 p210 | |
| | 40 | 40 | | | 1600 | | | | HD4/P 12.16.40 p210 | HD4/P 17.16.40 p210 | |
| | 50 | 50 | | | 1600 | | | | HD4/P 12.16.50 p210 | HD4/P 17.16.50 p210 | |
| | 16 | 16 | | | 2000 | | | | HD4/W 12.20.16 p210 | HD4/W 17.20.16 p210 | |
| | 25 | 25 | | | 2000 | | | | HD4/W 12.20.25 p210 | HD4/W 17.20.25 p210 | |
| | 31.5 | 31.5 | | | 2000 | | | | HD4/W 12.20.32 p210 | HD4/W 17.20.32 p210 | |
| | 40 | 40 | | | 2000 | | | | HD4/P 12.20.40 p210 | HD4/P 17.20.40 p210 | |
| | 50 | 50 | | | 2000 | | | | HD4/P 12.20.50 p210 | HD4/P 17.20.50 p210 | |
| | 25 | 25 | | | | 2500 | | | HD4/P 12.25.25 p275 | HD4/P 17.25.25 p275 | PB 3/E<br>PB 3/M |
| | 31.5 | 31.5 | | | | 2500 | | | HD4/P 12.25.32 p275 | HD4/P 17.25.32 p275 | |
| | 40 | 40 | | | | 2500 | | | HD4/P 12.25.40 p275 | HD4/P 17.25.40 p275 | |
| | 50 | 50 | | | | 2500 | | | HD4/P 12.25.50 p275 | HD4/P 17.25.50 p275 | |
| | 31.5 | 31.5 | | | | 3150 | | | HD4/W 12.32.32 p275 | HD4/W 17.32.32 p275 | |
| | 40 | 40 | | | | 3150 | | | HD4/W 12.32.40 p275 | HD4/W 17.32.40 p275 | |
| | 50 | 50 | | | | 3150 | | | HD4/W 12.32.50 p275 | HD4/W 17.32.50 p275 | |
| | 31.5 | 31.5 | | | | 3600 (1) | | | HD4/W 12.32.32 p275 | HD4/W 17.32.32 p275 | |
| | 40 | 40 | | | | 3600 (1) | | | HD4/W 12.32.40 p275 | HD4/W 17.32.40 p275 | |
| | 50 | 50 | | | | 3600 (1) | | | HD4/W 12.32.50 p275 | HD4/W 17.32.50 p275 | |
| | 31.5 | 31.5 | | | | 4000 (1) | | | HD4/W 12.32.32 p275 | HD4/W 17.32.32 p275 | |
| | 40 | 40 | | | | 4000 (1) | | | HD4/W 12.32.40 p275 | HD4/W 17.32.40 p275 | |
| | 50 | 50 | | | | 4000 (1) | | | HD4/W 12.32.50 p275 | HD4/W 17.32.50 p275 | |



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 16 | | | | | 630 | | HD4/W 24.06.16 p210 | – | |
| | 20 | 20 | | | | | 630 | | HD4/W 24.06.20 p210 | – | |
| | 25 | 25 | | | | | 630 | | HD4/W 24.06.25 p210 | – | |
| | 16 | 16 | | | | | 1250 | | HD4/W 24.12.16 p210 | – | PB 4/E PB 4/M |
| | 20 | 20 | | | | | 1250 | | HD4/W 24.12.20 p210 | – | |
| | 25 | 25 | | | | | 1250 | | HD4/W 24.12.25 p210 | – | |
| | 31.5 | 31.5 | | | | | 1250 (3) | | HD4/P 24.12.32 p275 | – | |
| | 16 | 16 | | | | | | 1600 | HD4/P 24.16.16 p275 | – | |
| | 20 | 20 | | | | | | 1600 | HD4/P 24.16.20 p275 | – | |
| 24 | 25 | 25 | | | | | | 1600 | HD4/P 24.16.25 p275 | – | |
| | 31.5 | 31.5 | | | | | | 1600 (3) | HD4/P 24.16.32 p275 | – | |
| | 16 | 16 | | | | | | 2000 | HD4/P 24.20.16 p275 | – | |
| | 20 | 20 | | | | | | 2000 | HD4/P 24.20.20 p275 | – | PB 5/E PB 5/M |
| | 25 | 25 | | | | | | 2000 | HD4/P 24.20.25 p275 | – | |
| | 31.5 | 31.5 | | | | | | 2000 (3) | HD4/P 24.20.32 p275 | – | |
| | 16 | 16 | | | | | | 2500 (2) | HD4/P 24.25.16 p275 | – | |
| | 20 | 20 | | | | | | 2500 (2) | HD4/P 24.25.20 p275 | – | |
| | 25 | 25 | | | | | | 2500 (2) | HD4/P 24.25.25 p275 | – | |
| | 31.5 | 31.5 | | | | | | 2500 (2)(3) | HD4/P 24.25.32 p275 | – | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monbloc.
(1) 3600 A with fan pre-installed in the PB3 modules. For 4000 A it is necessary to install another fan in the back of the switchgear (by the customer).
(2) 2500 A with fan pre-installed in the PB5 modules.
(3) Please ask ABB for availability. Not available for PB/M.

## Table 3 - Withdrawable VM1 circuit-breakers for PowerCube type PB units

### Rated current of the VM1 circuit-breakers (A - 40 °C)



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12-17.5 | 16 | 16 | 630 | | | | | | VM1/P 12.06.16 p150 | VM1/P 17.06.16 p150 | PB 1/E PB 1/M |
| | 20 | 20 | 630 | | | | | | VM1/P 12.06.20 p150 | VM1/P 17.06.20 p150 | |
| | 25 | 25 | 630 | | | | | | VM1/P 12.06.25 p150 | VM1/P 17.06.25 p150 | |
| | 31.5 | 31.5 | 630 | | | | | | VM1/P 12.06.32 p150 | VM1/P 17.06.32 p150 | |
| | 16 | 16 | 1250 | | | | | | VM1/P 12.12.16 p150 | VM1/P 17.12.16 p150 | |
| | 20 | 20 | 1250 | | | | | | VM1/P 12.12.20 p150 | VM1/P 17.12.20 p150 | |
| | 25 | 25 | 1250 | | | | | | VM1/P 12.12.25 p150 | VM1/P 17.12.25 p150 | |
| | 31.5 | 31.5 | 1250 | | | | | | VM1/P 12.12.32 p150 | VM1/P 17.12.32 p150 | |
| | 16 | 16 | | 630 | | | | | VM1/W 12.06.16 p210 | VM1/W 17.06.16 p210 | PB 2/E PB 2/M |
| | 20 | 20 | | 630 | | | | | VM1/W 12.06.20 p210 | VM1/W 17.06.20 p210 | |
| | 25 | 25 | | 630 | | | | | VM1/W 12.06.25 p210 | VM1/W 17.06.25 p210 | |
| | 31.5 | 31.5 | | 630 | | | | | VM1/W 12.06.32 p210 | VM1/W 17.06.32 p210 | |
| | 16 | 16 | | 1250 | | | | | VM1/W 12.12.16 p210 | VM1/W 17.12.16 p210 | |
| | 20 | 20 | | 1250 | | | | | VM1/W 12.12.20 p210 | VM1/W 17.12.20 p210 | |
| | 25 | 25 | | 1250 | | | | | VM1/W 12.12.25 p210 | VM1/W 17.12.25 p210 | |
| | 31.5 | 31.5 | | 1250 | | | | | VM1/W 12.12.32 p210 | VM1/W 17.12.32 p210 | |
| | 40 | 40 | | 1250 | | | | | – | – | |
| | 50 | 50 | | 1250 | | | | | – | – | |
| | 40 | 40 | | | 1250 | | | | – | – | |
| | 50 | 50 | | | 1250 | | | | – | – | |
| | 20 | 20 | | | 1600 | | | | VM1/P 12.16.20 p210 | VM1/P 17.16.20 p210 | |
| | 25 | 25 | | | 1600 | | | | VM1/P 12.16.25 p210 | VM1/P 17.16.25 p210 | |
| | 31.5 | 31.5 | | | 1600 | | | | VM1/P 12.16.32 p210 | VM1/P 17.16.32 p210 | |
| | 40 | 40 | | | 1600 | | | | – | – | |
| | 50 | 50 | | | 1600 | | | | – | – | |
| | 20 | 20 | | | 2000 | | | | VM1/P 12.20.20 p210 | VM1/P 17.20.20 p210 | |
| | 25 | 25 | | | 2000 | | | | VM1/P 12.20.25 p210 | VM1/P 17.20.25 p210 | |
| | 31.5 | 31.5 | | | 2000 | | | | VM1/P 12.20.32 p210 | VM1/P 17.20.32 p210 | |
| | 40 | 40 | | | 2000 | | | | – | – | |
| | 50 | 50 | | | 2000 | | | | – | – | |
| | 20 | 20 | | | | 2500 | | | VM1/P 12.25.20 p275 | VM1/P 17.25.20 p275 | PB 3/E PB 3/M |
| | 25 | 25 | | | | 2500 | | | VM1/P 12.25.25 p275 | VM1/P 17.25.25 p275 | |
| | 31.5 | 31.5 | | | | 2500 | | | VM1/P 12.25.32 p275 | VM1/P 17.25.32 p275 | |
| | 40 | 40 | | | | 2500 | | | – | – | |
| | 50 | 50 | | | | 2500 | | | – | – | |
| | 31.5 | 31.5 | | | | 3150 | | | – | – | |
| | 40 | 40 | | | | 3150 | | | – | – | |
| | 50 | 50 | | | | 3150 | | | – | – | |
| | 31.5 | 31.5 | | | | 3600 (1) | | | – | – | |
| | 40 | 40 | | | | 3600 (1) | | | – | – | |
| | 50 | 50 | | | | 3600 (1) | | | – | – | |
| | 31.5 | 31.5 | | | | 4000 (1) | | | – | – | |
| | 40 | 40 | | | | 4000 (1) | | | – | – | |
| | 50 | 50 | | | | 4000 (1) | | | – | – | |



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 16 | | | | | 630 | | VM1/P 24.06.16 p210 | – | |
| | 20 | 20 | | | | | 630 | | VM1/P 24.06.20 p210 | – | |
| | 25 | 25 | | | | | 630 | | VM1/P 24.06.25 p210 | – | PB 4/E |
| | 16 | 16 | | | | | 1250 | | VM1/P 24.12.16 p210 | – | PB 4/M |
| | 20 | 20 | | | | | 1250 | | VM1/P 24.12.20 p210 | – | |
| | 25 | 25 | | | | | 1250 | | VM1/P 24.12.25 p210 | – | |
| | 16 | 16 | | | | | | 1600 | VM1/P 24.16.16 p275 | – | |
| 24 | 20 | 20 | | | | | | 1600 | VM1/P 24.16.20 p275 | – | |
| | 25 | 25 | | | | | | 1600 | VM1/P 24.16.25 p275 | – | |
| | 16 | 16 | | | | | | 2000 | VM1/P 24.20.16 p275 | – | |
| | 20 | 20 | | | | | | 2000 | VM1/P 24.20.20 p275 | – | PB 5/E |
| | 25 | 25 | | | | | | 2000 | VM1/P 24.20.25 p275 | – | PB 5/M |
| | 16 | 16 | | | | | | 2500 (2) | VM1/P 24.25.16 p275 (3) | – | |
| | 20 | 20 | | | | | | 2500 (2) | VM1/P 24.25.20 p275 (3) | – | |
| | 25 | 25 | | | | | | 2500 (2) | VM1/P 24.25.25 p275 (3) | – | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monbloc.
(1) 3600 A with fan pre-installed in the PB3 units. For 4000 A it is necessary to install another fan in the back of the switchgear (by the customer).
(2) 2500 A with fan pre-installed in the PB5 units.
(3) Please ask ABB for availability.

## Table 4 - Withdrawable eVM1 circuit-breakers for PowerCube type PB units



| | | | Rated current of the eVM1 circuit-breakers inserted in the PowerCube units (40°C) [A] | | | | | | Withdrawable eVM1 for PowerCube unit | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| kV | Isc [kA] 3s | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker type | Circuit-breaker type | PowerCube |
| 7.2 | 16 | 16 | 630 | | | | | | eVM1/P 12.06.16 p150 | eVM1/P 17.06.16 p150 | PB1/E PB1/M |
| | 20 | 20 | 630 | | | | | | eVM1/P 12.06.20 p150 | eVM1/P 17.06.20 p150 | |
| | 25 | 25 | 630 | | | | | | eVM1/P 12.06.25 p150 | eVM1/P 17.06.25 p150 | |
| | 31.5 | 31.5 | 630 | | | | | | eVM1/P 12.06.32 p150 | eVM1/P 17.06.32 p150 | |
| 12 | 16 | 16 | 1250 | | | | | | eVM1/P 12.12.16 p150 | eVM1/P 17.12.16 p150 | |
| | 20 | 20 | 1250 | | | | | | eVM1/P 12.12.20 p150 | eVM1/P 17.12.20 p150 | |
| | 25 | 25 | 1250 | | | | | | eVM1/P 12.12.25 p150 | eVM1/P 17.12.25 p150 | |
| | 31.5 | 31.5 | 1250 | | | | | | eVM1/P 12.12.32 p150 | eVM1/P 17.12.32 p150 | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monobloc.
* Please contact us for availability.

## Table 5 - Withdrawable Vmax circuit-breakers for PowerCube type PB units



| | | | Rated current of the circuit-breakers Vmax inserted in the PowerCube units (40°C) [A] | | | | | | Withdrawable Vmax for PowerCube units | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| kV | Isc [kA] 3s | Icw [kA] | W=600 p=150 ul=205 H=260 ø=35 | W=750 p=210 ul=310 H=280 ø=35 | W=750 p=210 ul=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 ul=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker type | Circuit-breaker type | PowerCube |
| 7.2 | 16 | 16 | 630 | | | | | | Vmax/W 12.06.16 p150 | Vmax/W 17.06.16 p150 * | PB1/E PB1/M |
| | 20 | 20 | 630 | | | | | | Vmax/W 12.06.20 p150 | Vmax/W 17.06.20 p150 * | |
| | 25 | 25 | 630 | | | | | | Vmax/W 12.06.25 p150 | Vmax/W 17.06.25 p150 * | |
| | 31.5 | 31.5 | 630 | | | | | | Vmax/W 12.06.32 p150 | Vmax/W 17.06.32 p150 * | |
| 12 | 16 | 16 | 1250 | | | | | | Vmax/W 12.12.16 p150 | Vmax/W 17.12.16 p150 * | |
| | 20 | 20 | 1250 | | | | | | Vmax/W 12.12.20 p150 | Vmax/W 17.12.20 p150 * | |
| | 25 | 25 | 1250 | | | | | | Vmax/W 12.12.25 p150 | Vmax/W 17.12.25 p150 * | |
| | 31.5 | 31.5 | 1250 | | | | | | Vmax/W 12.12.32 p150 | Vmax/W 17.12.32 p150 * | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monobloc.
* Please contact us for availability.

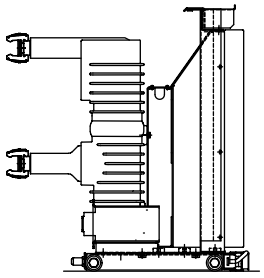
## Table 6 - V-Contact withdrawable contactors for PowerCube type PB units



| | | | Rated current of the V-Contact contactors (A - 40 °C) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| kV | Isc [kA] ([3]) | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Contactor | PowerCube |
| 7.2 | 16 | 6 | 400 ([4]) | | | | | | V7/W VSC7/P | PB 1/E PB 1/M |
| | 20 | 6 | 400 ([4]) | | | | | | | |
| | 25 | 6 | 400 ([4]) | | | | | | | |
| | 31.5 | 6 | 400 ([4]) | | | | | | | |
| 12 | 16 | 6 | 400 ([4]) | | | | | | V12/W VSC12/P | |
| | 20 | 6 | 400 ([4]) | | | | | | | |
| | 25 | 6 | 400 ([4]) | | | | | | | |
| | 31.5 | 6 | 400 ([4]) | | | | | | | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monobloc.
(1) 3600 A with fan pre-installed in the PB3 modules. For 4000 A it is necessary to install another fan in the back of the switchgear (by the customer).
(2) 2500 A with fan pre-installed in the PB5 modules.
(3) Guaranteed using suitable fuses.
(4) The rated current is subject to derating according to the rated current of the fuses.

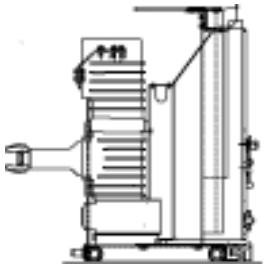
## Table 7 – Isolating trucks for PowerCube type PB units



| kV | Isc [kA] | Icw [kA] | Rated current of the isolating trucks (A - 40 °C) W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Isolating truck | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|
| 12-17.5 | 16 | 16 | ...1250 | | | | | | S-HD4/W 17.12.32 p150 | PB 1/E PB 1/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 16 | 16 | | ...1250 | | | | | S-HD4/W 17.12.32 p210 | PB 2/E PB 2/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | S-HD4/W 17.12.50 p210 | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | ...2000 | | | | S-HD4/W 17.20.32 p210 | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | S-HD4/P 17.20.50 p210 | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | | ...2500 | | | S-HD4/P 17.25.50 p275 | PB 3/E PB 3/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | | ...3150 | | | S-HD4/P 17.32.50 p275 | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| | 31.5 | 31.5 | | | | ...3600 (1) | | | S-HD4/P 17.32.50 p275 | |
| | 40 | 40 | | | | ...3600 (1) | | | | |
| | 50 | 50 | | | | | | | | |
| | 31.5 | 31.5 | | | | ...4000 (1) | | | S-HD4/P 17.32.50 p275 | |
| | 40 | 40 | | | | ...4000 (1) | | | | |
| | 50 | 50 | | | | | | | | |
| 24 | 16 | 16 | | | | | ...1250 | | S-HD4/W 24.12.25 p210 | PB 4/E PB 4/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2000 | S-HD4/P 24.20.25 p275 | PB 5/E PB 5/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2500 (2) | S-HD4/P 24.25.25 p275 | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monobloc.
(1) 3600 A with fan pre-installed in the PB3 modules. For 4000 A it is necessary to install another fan in the back of the switchgear (by the customer).
(2) 2500 A with fan pre-installed in the PB5 modules.
(3) Guaranteed using suitable fuses.
(4) The rated current is subject to derating according to the rated current of the fuses.

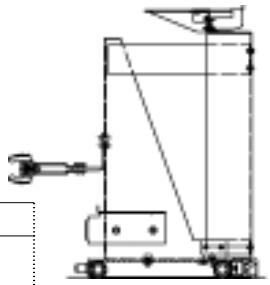
## Table 8 – Earthing trucks with making capacity for PowerCube type PB units



| | | | Rated current of the earthing trucks (A - 40 °C) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Earthing truck (1) | PowerCube |
| 12-17.5 | 16 | 16 | ...1250 | | | | | | | |
| | 20 | 20 | | | | | | | EM-U/W 17.12.32 p150 | PB 1/E PB 1/M |
| | 25 | 25 | | | | | | | EM-L/W 17.12.32 p150 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 16 | 16 | | ...1250 | | | | | | |
| | 20 | 20 | | | | | | | EM-L/W 17.12.32 p210 | |
| | 25 | 25 | | | | | | | EM-U/W 17.12.32 p210 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | EM-L/W 17.12.50 p210 (2) | |
| | 50 | 50 | | | | | | | EM-U/W 17.12.50 p210 (2) | PB 2/E PB 2/M |
| | 16 | 16 | | | ...2000 | | | | | |
| | 20 | 20 | | | | | | | EM-L/W 17.20.32 p210 | |
| | 25 | 25 | | | | | | | EM-U/W 17.20.32 p210 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | EM-L/P 17.20.50 p210 | |
| | 50 | 50 | | | | | | | EM-U/P 17.20.50 p210 | |
| | 16 | 16 | | | | ...2500 | | | | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | EM-L/P 17.25.50 p275 | |
| | 31.5 | 31.5 | | | | | | | EM-U/P 17.25.50 p275 | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | PB 3/E PB 3/M |
| | 16 | 16 | | | | ....3150 | | | | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | EM-L/P 17.32.50 p275 | |
| | 31.5 | 31.5 | | | | | | | EM-U/P 17.32.50 p275 | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| 24 | 16 | 16 | | | | | ...1250 | | EM-L/W 24.12.25 p210 | |
| | 20 | 20 | | | | | | | EM-U/W 24.12.25 p210 | PB 4/E PB 4/M |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2000 | EM-L/P 24.20.25 p275 | |
| | 20 | 20 | | | | | | | EM-U/P 24.20.25 p275 | |
| | 25 | 25 | | | | | | | EM-L/P 24.25.25 p275 | |
| | 16 | 16 | | | | | | ...2500 (2) | EM-U/P 24.25.25 p275 | PB 5/E |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube type PB unit monobloc.
(1) - EM-L... = Earthing truck with making capacity with bottom bushings (for cable earthing).
- EM-U... = Earthing truck with making capacity with top bushings (for earthing the busbar system).
(2) Ask ABB.

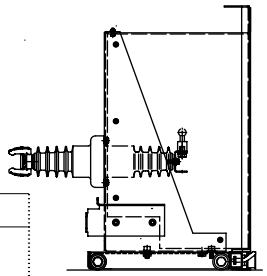
## Table 9 - Earthing trucks without making capacity for PowerCube type PB units



| | | | Rated current of the earthing trucks (A - 40 °C) | | | | | | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|
| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Earthing truck (1) | |
| 12-17.5 | 16 | 16 | ...1250 | | | | | | | PB 1/E PB 1/M |
| | 20 | 20 | | | | | | | E-U/W 17.12.32 p150 | |
| | 25 | 25 | | | | | | | E-L/W 17.12.32 p150 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 16 | 16 | | ...1250 | | | | | | PB 2/E PB 2/M |
| | 20 | 20 | | | | | | | E-L/W 17.12.32 p210 | |
| | 25 | 25 | | | | | | | E-U/W 17.12.32 p210 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | E-L/W 17.12.50 p210 (2) | |
| | 50 | 50 | | | | | | | E-U/W 17.12.50 p210 (2) | |
| | 16 | 16 | | | ...2000 | | | | | |
| | 20 | 20 | | | | | | | E-L/W 17.20.32 p210 | |
| | 25 | 25 | | | | | | | E-U/W 17.20.32 p210 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | E-L/P 17.20.50 p210 | |
| | 50 | 50 | | | | | | | E-U/P 17.20.50 p210 | |
| | 16 | 16 | | | | ...2500 | | | | PB 3/E PB 3/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | E-L/P 17.25.50 p275 | |
| | 31.5 | 31.5 | | | | | | | E-U/P 17.25.50 p275 | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | | ...3150 | | | | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | E-L/P 17.32.50 p275 | |
| | 31.5 | 31.5 | | | | | | | E-U/P 17.32.50 p275 | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| 24 | 16 | 16 | | | | | ...1250 | | E-L/W 24.12.25 p210 | PB 4/E PB 4/M |
| | 20 | 20 | | | | | | | E-U/W 24.12.25 p210 | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2000 | E-L/P 24.20.25 p275 | PB 5/E PB 5/M |
| | 20 | 20 | | | | | | | E-U/P 24.20.25 p275 | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2500 | E-L/P 24.25.25 p275 | |
| | 20 | 20 | | | | | | | E-U/P 24.25.25 p275 | |
| | 25 | 25 | | | | | | | | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monobloc.
(1) - EM-L... = Earthing truck without making capacity with bottom bushings (for cable earthing).
- EM-U... = Earthing truck without making capacity with top bushings (for earthing the busbar system).
(2) Ask ABB..

## Table 10 – Cable testing trucks for PowerCube type PB units



| | | | Rated current of the cable testing trucks (A - 40 °C) | | | | | | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|
| kV | Isc [kA] | Icw (kAx3s) | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Cable testing truck | |
| 12-17.5 | 16 | 16 | ...1250 | | | | | | T/W 17.12 p150 | PB 1/E PB 1/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 16 | 16 | | ...1250 | | | | | T/W 17.12 p210 | PB 2/E PB 2/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | T/W 17.12 p210 (1) | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | ...2000 | | | | T/P 17.20 p210 | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | T/P 17.20 p210 | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | | 2500 | | | T/P 17.32 p275 | PB 3/E PB 3/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | | 3150 | | | | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| 24 | 16 | 16 | | | | | ...1250 | | T/W 24.12 p210 | PB 4/E PB 4/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2000 | T/W 24.20 p275 | PB 5/E PB 5/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2500 (1) | T/P 24.25 p275 | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth
Ø = Diameter of the contacts in the PowerCube unit monobloc.
(1) Ask ABB.

**Table 11 - PowerCube type PB units without apparatus**

| Enclosure characteristics | | | | Configuration | | | | |
|---|---|---|---|---|---|---|---|---|
| Rated voltage [kV] | Width (mm) | Rated current (A) | Isc [kA] (1) | Icw (kA x 3s/1s) (1) | Bus riser or direct incoming feeder with earthing switch | Bus riser or direct incoming feeder | Measuring (2) | Measuring (2) |
| 12-17.5 | 600 | 1250 | 31.5 | 31.5 | PB1/RE - PB1/RM | PB1/RE - PB1/RM | PB1/RE - PB1/RM | PB1/RE - PB1/RM |
| | 750 | 2000 | 31.5 | 31.5 | PB2/RE - PB2/RM | PB2/RE - PB2/RM | PB2/RE - PB2/RM | PB2/RE - PB2/RM |
| | 750 | 2000 | 40-50 | 40-50 | PB2/RE - PB2/RM | PB2/RE - PB2/RM | PB2/RE - PB2/RM | PB2/RE - PB2/RM |
| | 1000 | 4000 | 31.5 | 31.5 | PB3/RE - PB3/RM | PB3/RE - PB3/RM | PB3/RE - PB3/RM | PB3/RE - PB3/RM |
| | 1000 | 4000 | 40-50 | 40-50 | PB3/RE - PB3/RM | PB3/RE - PB3/RM | PB3/RE - PB3/RM | PB3/RE - PB3/RM |
| 24 | 750 | 1250 | 25 | 25 | PB4/RE - PB4/RM | PB4/RE - PB4/RM | PB4/RE - PB4/RM | PB4/RE - PB4/RM |
| | 1000 | 2500 | 25 | 25 | PB5/RE - PB5/RM | PB5/RE - PB5/RM | PB5/RE - PB5/RM | PB5/RE - PB5/RM |

(1) On earthing switch, if provided.
(2) For units PB/RE end for PB1/RM, the VT compartment is not available. Construction at customer care.

## 5.4. Main components

### 5.4.1. Switchgear

PowerCube units can be equipped with the following switchgear:
– HD4 series SF6 circuit-breaker;
– VD4 and VM1 series vacuum circuit-breaker;
– V-Contact series vacuum contactor;
– operational trucks.
The apparatus is always the withdrawable version, mounted on a truck that allows the following positions in relation to the compartment:

CONNECTED: – main and auxiliary circuits connected;
ISOLATED: – partially isolated with main circuits disconnected and auxiliary circuits (plug connector connected);
– totally isolated with main and auxiliary circuits disconnected, (plug connector withdrawn);
WITHDRAWN: – main and auxiliary circuits disconnected and apparatus racked out of the switchboard.

In the connected and isolated positions the apparatus remains in the unit with the door closed is visible through switchboard inspection window.
The apparatus is equipped with special locks, located on the front crosspiece which allow their hooking into the corresponding slots of the unit. The front hooking crosspiece also allows the connecting/isolating operation, with the door closed, by means of the special operating lever.
A lock prevents truck insertion into the switchboard (for example when the earthing switch is closed).
If the truck is in the indefinite position (between connected and isolated), the lock prevents both mechanical and electrical circuit-breaker closing.
The truck is equipped with a locking magnet which, if deenergised, prevents its operation.
The connector (plug) for connection of the operating mechanism electrical accessories comes out of the front protection of the apparatus.
The strikers for actuating the contacts (connected/isolated) located in the switchboard are fixed in the upper part of the apparatus.
The slides for activating the segregation shutters of the medium voltage contacts are placed on the sides of the apparatus.
Please refer to the relative instruction booklet for further details.

### 5.4.2. Earthing switch

The earthing switch (1) (fig. 8) with making capacity is placed in the rear part whereas the front houses the operating mechanism (2).
The switch position is indicated in the flange of the operating seat (2).



**The certain position of the earthing switch is indicated by the graphic symbols at the operating seat (2). The position of the earthing switch is indicated by the yellow arrow made directly on the operating shaft (5).**
**For enclosures up to 17 kV and rated current up to 3150 A, or enclosures of 24 kV and rated currents up to 2000 A, the position of the earthing switch can be checked either by means of the indicator (3), located inside the enclosure and visible through the inspection window (4) positioned on the bottom front part of the unit.**

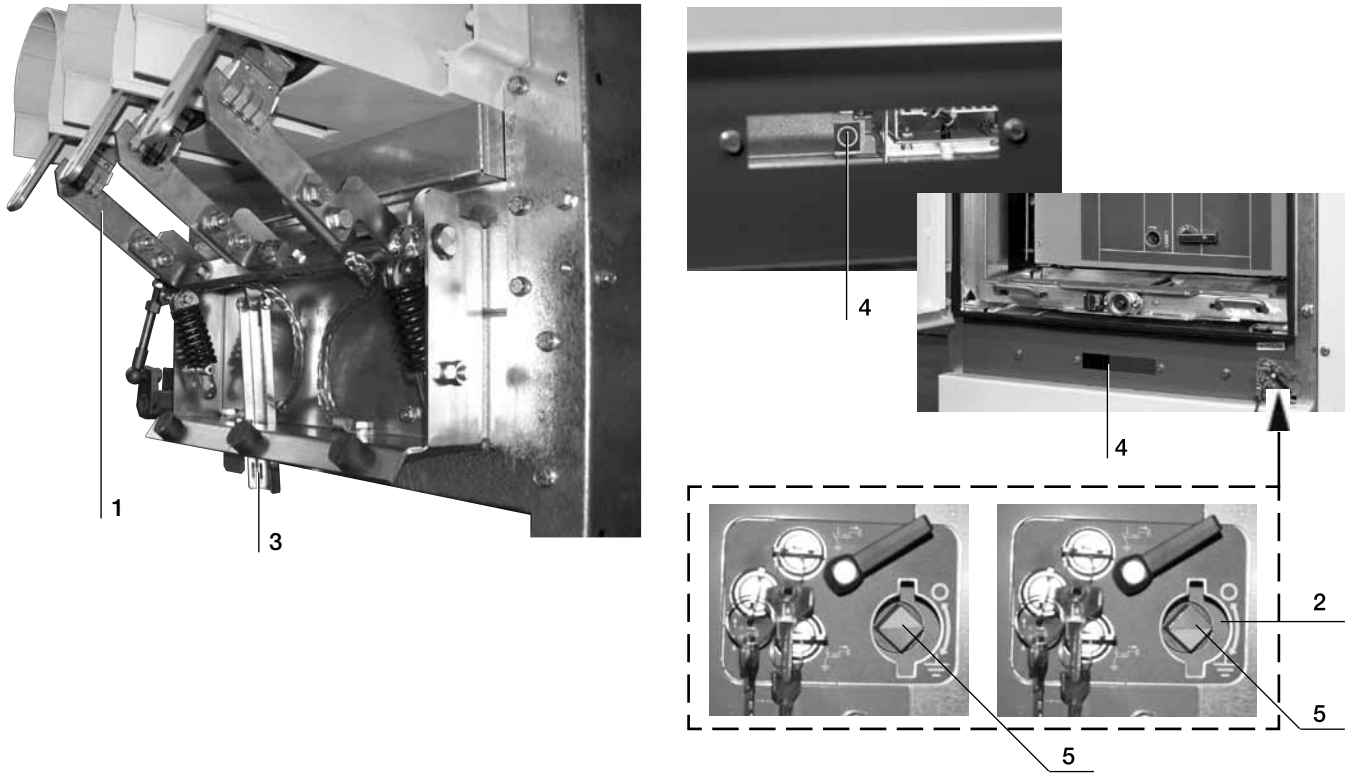



Fig. 8

### 5.4.3. Module units

#### 5.4.3.1. Circuit-breaker and/or contactor unit

The parallelepiped metal structure is fitted with a front door and operating and control mechanisms on the external front side (fig. 9).
The apparatus must only be isolated and connected with the door closed.
The earthing switch control panel on the lower front part is fitted with:
– the earthing switch operating mechanism seat (10);
– the actuator (9) for operating the shutter (11) of the earthing switch operating mechanism seat;
– key lock with earthing switch open (8);
– key lock with earthing switch closed (12);
– key lock for preventing apparatus racking in (7).
The voltage indicator lamps (4) are mounted in the upper part of the unit (for PB/M only).
The door is fitted with:
– an opening-closing handle (5);
– an inspection window to see the apparatus position (3);
– a coupling (2) for the removable lever for apparatus racking in/ out with the door closed;
– screw for emergency unlock of the door lock (6).

The compartment houses the following components:
– truck guides (15);
– segregating shutters (18) of the fixed isolating contacts inside the monoblocks and the shutter operating mechanisms (16);
– socket for the mobile connector (22);
– mechanical lock (23) for preventing racking out of the auxiliary circuit connector when the circuit-breaker is connected;
– microswitch kinematics (21) for signalling circuit-breaker connected position;
– microswitch kinematics (24) for signalling the apparatus isolated position;
– mechanical lock for preventing either circuit-breaker racking in when the earthing switch is closed or earthing switch closing if the circuit-breaker is connected (27);
– on request, anti-condensation heater (25);
– on request, key lock for the earthing truck fitted with upper bushings (19);
– on request, earthing truck fitted with lower bushings (20);
– lock for preventing insertion of apparatus of different size than foreseen for the compartment (22).
The insulating monoblocks (14) for the power connections are on the rear of the compartment.

### 5.4.3.2. Feeder unit (PB/M-PB/RM units)

The feeder unit contains the earthing switch and relative auxiliary contacts. It allows access to the cable area working from the front.
The live components can be segregated by means of (fig. 10) earthing switch interlock (22) - in this case the door can only be opened when the earthing switch is closed.

**Before accessing the cable terminals, make sure that the earthing switch position indicators (3) fig. 8, visible through the inspection window (4) and (5) fig. 8, visible from the operating seat of the earthing switch, confirm that closing has taken place.**

### 5.4.3.3. VT unit and withdrawable truck (PB/M-PB/RM units)

The voltage transformer unit (fig. 11) consists of an enclosure (fig. 11d) where a withdrawable truck is inserted (fig. 11f), with the transformers on board (53) (fig. 11f) and the relative protection fuses.

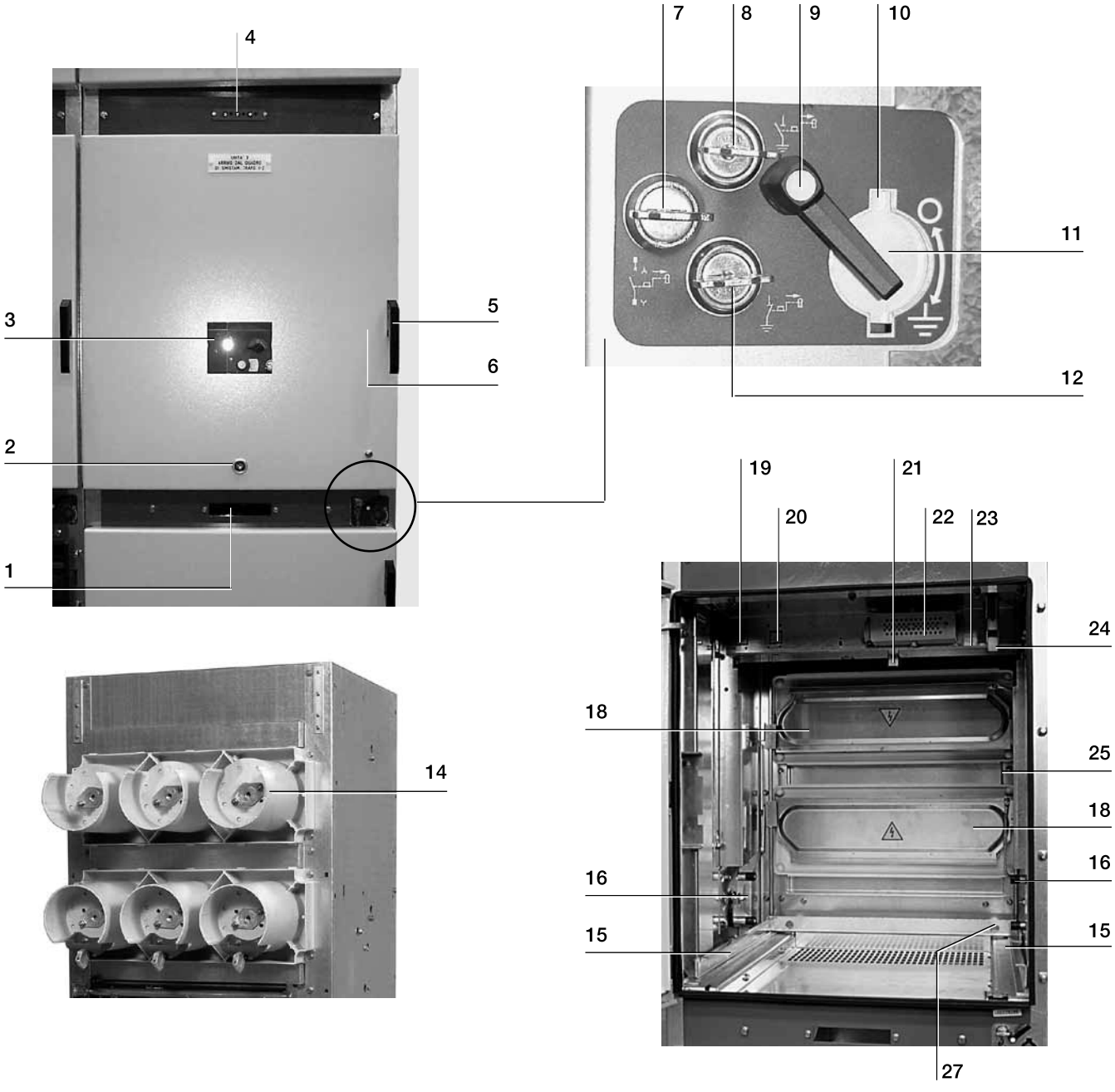



**Fig. 9**

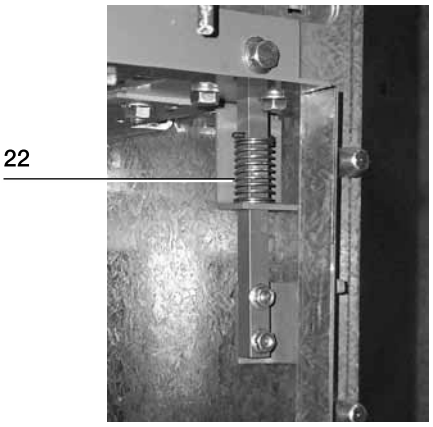



**Fig. 10**

The withdrawable truck (fig. 11f) can be fully withdrawn from the unit and allows safe fuse replacement.
A special metallic shutter (57) (fig. 11b) prevents contact with the medium voltage terminals when the truck is withdrawn.
The main measurement compartment features are:
– VTs mounted on a withdrawable truck inside the unit
– isolation of the VTs and relative fuses is by means of an operating handle outside the compartment;
– when the VTs are isolated the VT auxiliary circuits are also isolated automatically;
– travel of the VT truck automatically operates the metallic shutter;
– the fuses can be replaced opening the door, after VT isolation and its withdrawal from the compartment;
– the VTs can be replaced only after the truck is withdrawn from the compartment;
– on request, electrical signalling of VT inserted and withdrawn can be supplied.

The VT truck can take up the following positions:

| | |
|---|---|
| INSERTED: | VT main and auxiliary circuits connected; |
| ISOLATED: | VT main and auxiliary circuits disconnected. The VT truck remains inside the compartment. |
| WITHDRAWN: | VT main and auxiliary circuits disconnected: VT truck withdrawn. |

The voltage transformers insulated in resin for supplying power to instruments and protection devices, have the performances and precision classes normally provided by instrument transformer manufacturers. VT auxiliary circuits are connected by means of sliding contacts (58) (fig. 11c).
The cable area of wall-standing switchboards can be accessed by withdrawing the whole measurement compartment.

The following components are mounted in the VT compartment:

**VT Compartment:**

– door (41) (fig. 11a);
– operation sequence plate (42) (fig. 11a);
– operating seat of lever for VT truck racking in/out (43) (fig. 11a);
– truck guides (55) (fig. 11b);
– metallic shutter (57) (fig. 11b) for segregating the isolating contacts inside the monoblocks and segregation actuating kinematics (56) (fig. 11b);
– sliding contacts of the VT auxiliary circuits (58) (fig. 11c);
– contacts for signalling VT truck inserted (60) (fig. 11c);
– contacts for signalling VT truck isolated (61) (fig. 11c).

**VT truck:**

– actuator of the door closing bolt (45) (fig. 11d);
– operating seat of the racking in/out lever (46) (fig. 11d);
– pin for unlocking the door closing bolt (47) (fig. 11d);
– door closing screws (48) (fig. 11d);
– door locking bolt (50) (fig. 11e);
– pin plate for releasing the door closing bolt (49) (fig. 11e);
– voltage transformers (VTs) (53) (fig. 11f);
– left and right supplementary guides (52) (fig. 11f).

VT compartment

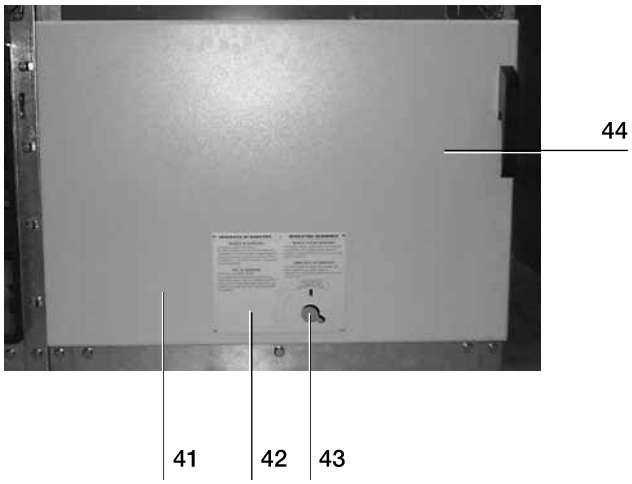



Fig. 11a

VT compartment (internal view)

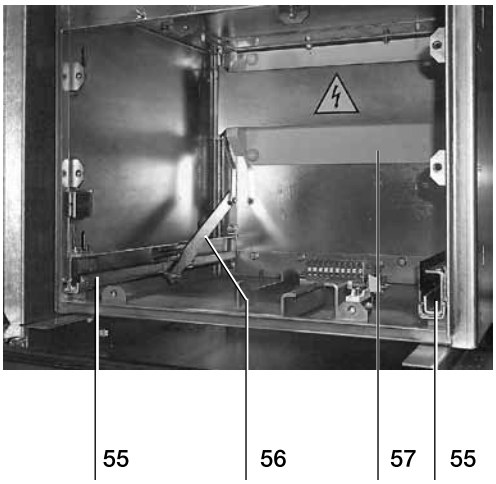



Fig. 11b

VT compartment (internal view)

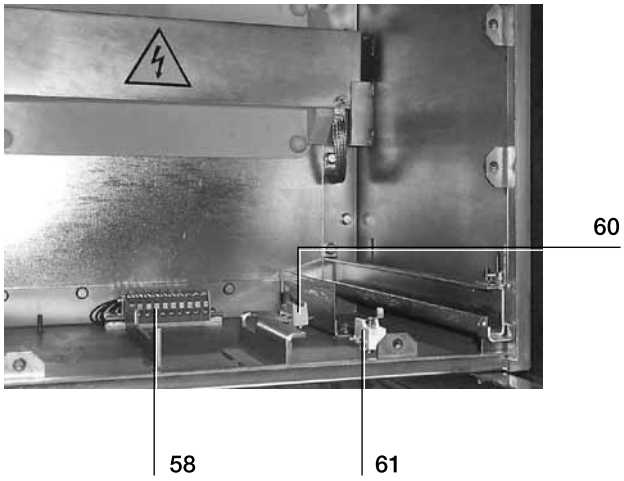



Fig.11c

VT truck

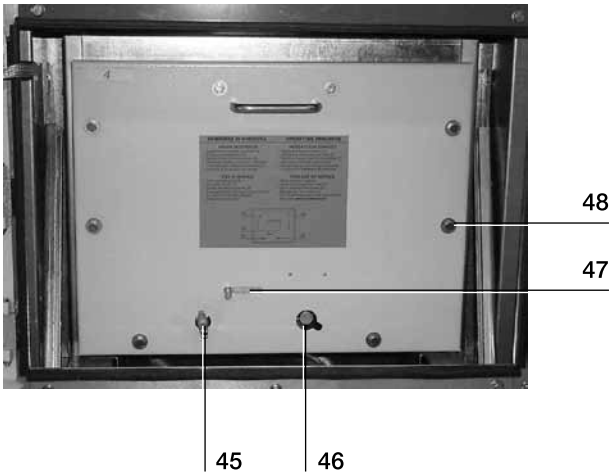



Fig. 11d

VT truck door

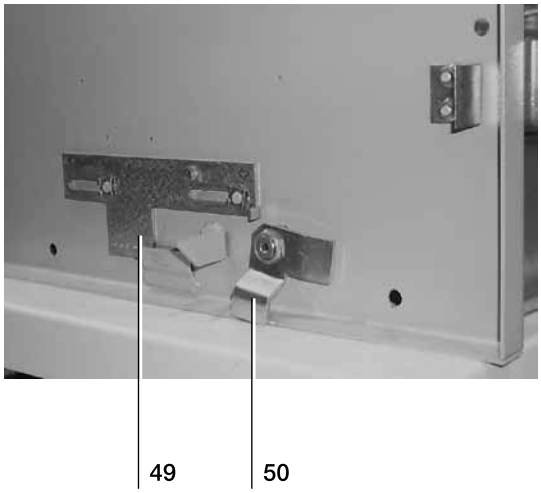



Fig.11e

VT truck

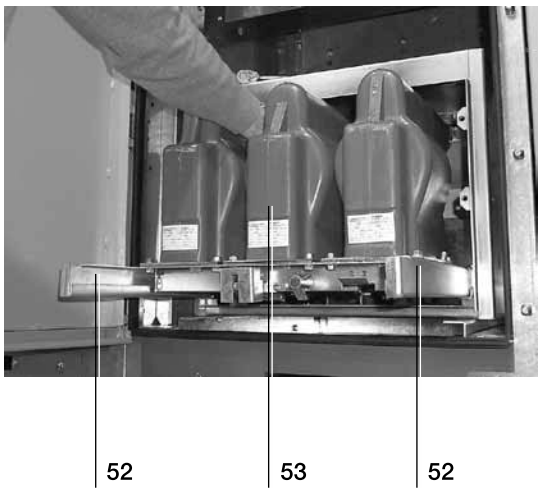



Fig. 11f

### 5.4.3.4. Voltage indicator and phase concordance device

- **Just indication of the device is not sufficient to prove that the system is out of service.**
- **Before accessing the indicator connections, make sure that the relative line is disconnected and the cables earthed.**

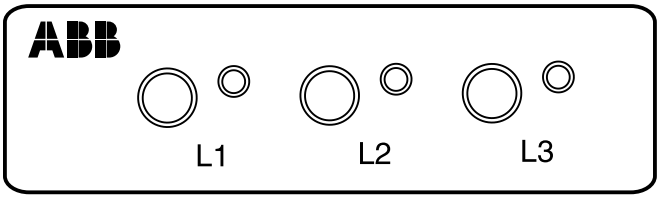
#### Voltage indicator

The voltage indicator (fig. 12) consists of capacitive dividers made of capacitors incorporated in insulators or in the CTs. They are connected to a device containing the signalling lamps and the bushings for checking phase concordance. The presence of voltage is indicated by the lamps either flashing or lit continuously.

#### Phase concordance checking device (on request)

The device consists of electronic apparatus with which phase concordance can be checked using the voltage indicator. The instructions are included in the kit.

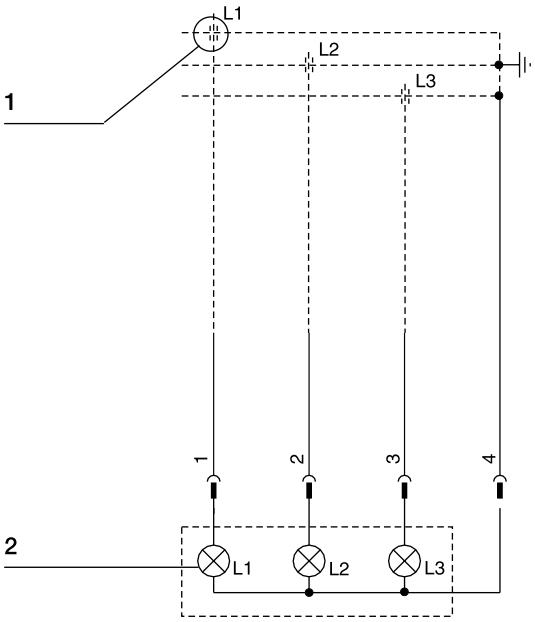
**Voltage indicator**




**Phase concordance checking device**



**Electrical diagram**




Caption

1 Capacitive socket shunted either from the insulator or from the current transformers with capacitive socket.

2 Voltage indicator lamps.

**Fig. 12**

## 5.5. Interlocks/locks

- **The operations must be carried out using normal operating force (not more than 200 N) only using the special levers.**
  **Should the operations be prevented, do not force the mechanical interlocks and check that the operations are correct.**
- **The locks can be activated with a maximum force of 400 N, using the special operating tools.**

The locks used in the PowerCube units are mechanical and electrical with microswitches for circuit continuity or interruption.
The mechanical locks are divided into:
– force locks;
– prevention locks;
– electromechanical locks;
– safety locks (padlocks/keys).
PowerCube modules can be equipped with the locks shown in the following table.

| Lock description | Apparatus (1) | Apparatus compartment | Feeder compartment PB/M-PB/RM | compartment PB/M-PB/RM |
|---|---|---|---|---|
| Electric lock to prevent apparatus closing when the truck is not in the connected/isolated position. | ■ (fig. 13r - det. 44) | | | |
| Mechanical lock to prevent apparatus racking in/out in the closed position. | ■ | | | |
| Mechanical lock which prevents closing the apparatus when the truck is not in the racked-in and isolated positions. | ■ (not available for VM1 and eVM1) | | | |
| Lock to prevent racking-in apparatus in an enclosure preset for another type or size of apparatus. The lock is located in the connector. | ■ (fig. 13a - det. 4) | ■ (fig. 13a - det. 4) | | |
| Locking electromagnet on the apparatus truck to prevent racking-in/out without power. | ■ (fig. 13r - det. 43) | | | |
| Electromechanical lock to prevent door opening if the apparatus is not in the isolated position. | | □ (fig. 13c - det. 8) | | |
| Mechanical lock to prevent apparatus racking-in with the door open. | □ (fig. 13q - det. 17) | □ (fig. 13d - det. 17) | | ■ (fig. 13m - det. 61) |
| Mechanical interlock with earthing switch:<br>– the apparatus cannot be inserted when the earthing switch is closed;<br>– the earthing switch cannot be closed when the apparatus is inserted or in the intermediate positions between connected and isolated. | ■ (fig. 13n - det. 12) (fig. 13r - det. 12)<br>■ (fig. 13n - det. 60) | ■ (fig. 13b - det. 12)<br>■ (fig. 13b - det. 12) | | |
| Mechanical lock to prevent the manual opening of the shutters when the apparatus is withdrawn. (Fail-Safe). | □ (fig. 13n - det. 3) (fig. 13o - det. 3) | □ (fig. 13b - det. 3) | | ■ (fig. 11b - det. 56) |
| Key lock to prevent apparatus insertion. Only when the apparatus is in the isolated position can the lock be operated and the key released thus preventing apparatus insertion. | □ (fig.13n - det. 12) (fig. 13r - det. 12) | □ (fig. 13e - det. 35) | | |
| Key lock with open earthing switch. It can only be operated when the earthing switch is open. The key can only be withdrawn with the lock activated. | | □ (fig. 13e - det. 33) | | |
| Key lock with closed earthing switch. It can only be operated when the apparatus is isolated and the earthing switch is closed. The key can only be removed with the lock activated. | | □ (fig. 13e - det. 34) | | |
| Padlock on the shutters in the closed position. | | □ (fig. 13g - det. 52) | | |
| Key lock to prevent placing the earthing truck in the switchboard. | | □ (fig. 13a - det. 19) | | |
| Mechanical lock to prevent the racking out of the auxiliarycircuit connector when the apparatus is connected and during apparatus racking in/out. | | ■ (fig. 13a - det. 20) | | |
| Padlock for the door handles. | | □ (fig. 13h) | | |
| Earthing switch electromechanical lock to prevent earthing switch opening and closing once the coil (BED) is deenergised. | | □ (fig. 13i - det. 53) | | |
| Door lock with earthing switch open. | | | ■ (fig. 13f - det. 22) | |
| Padlock lock to prevent manual apparatus closing. | □ (fig. 13s) | | | |

(1) HD4, VD4, V-Contact.
■ Standard
□ On request

### 5.5.1. Locks in the apparatus compartment (circuit-breaker, contactor, VT compartment)

**Positions of the locks with reference to the figures.**

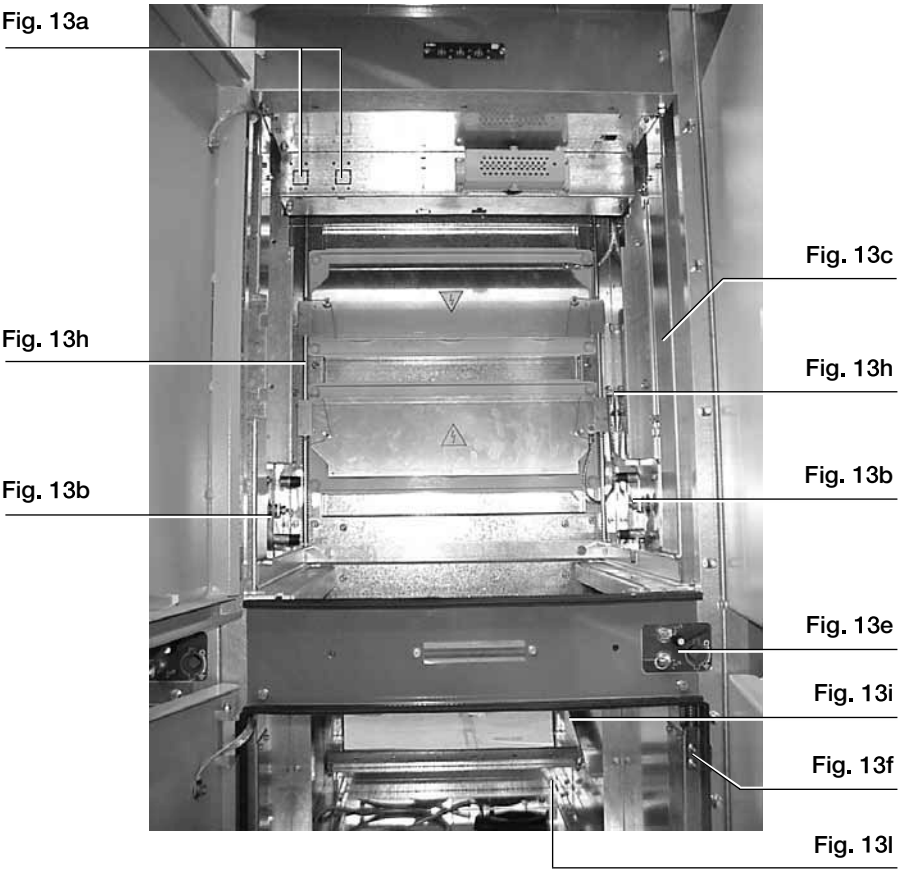



**Fig. 13**

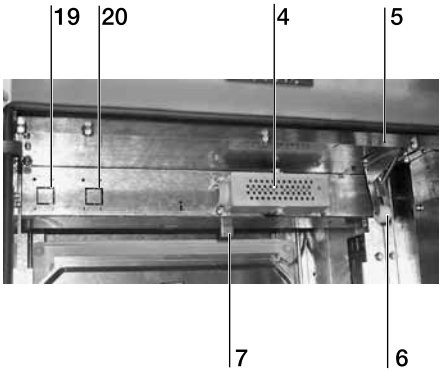



Fig. 13a

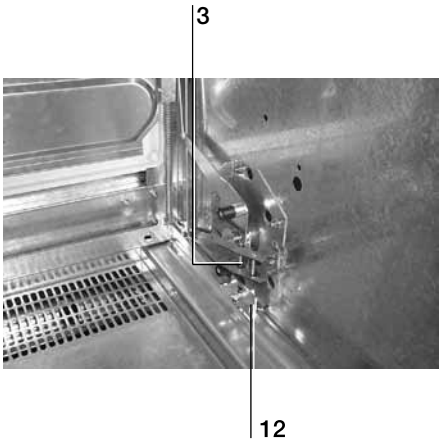



Fig. 13b

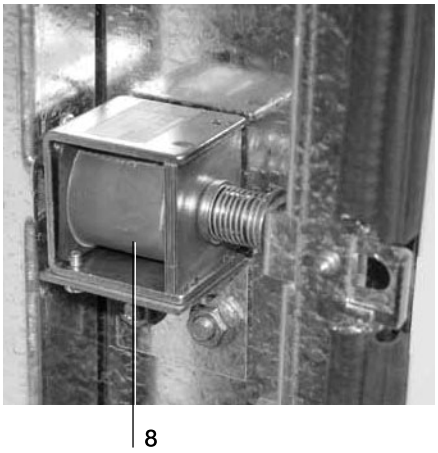



Fig. 13c

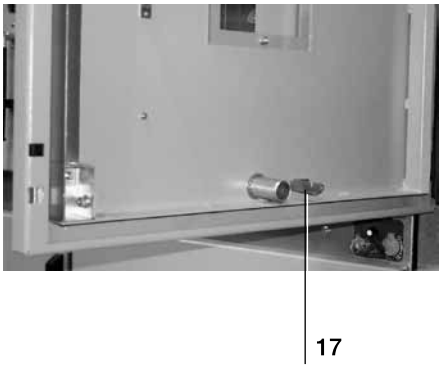



Fig. 13d

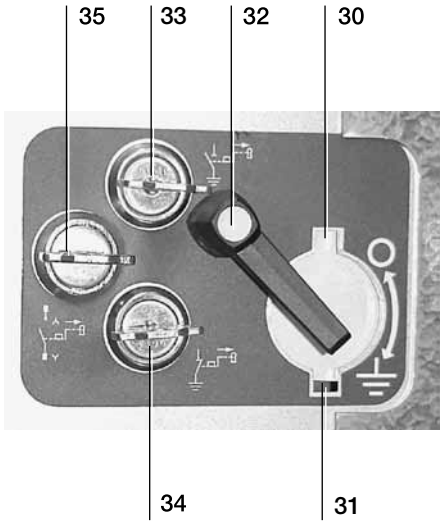



Fig. 13e

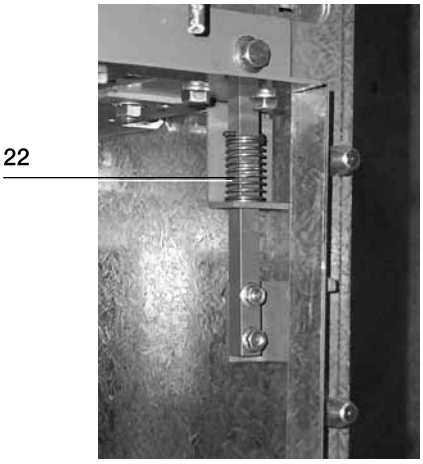



Fig. 13f

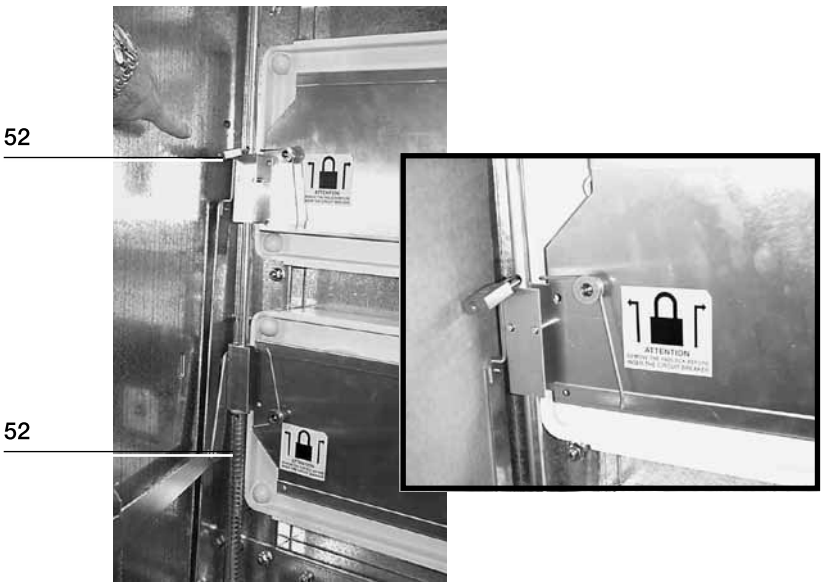



Fig. 13g



Fig. 13h

VT compartment door.

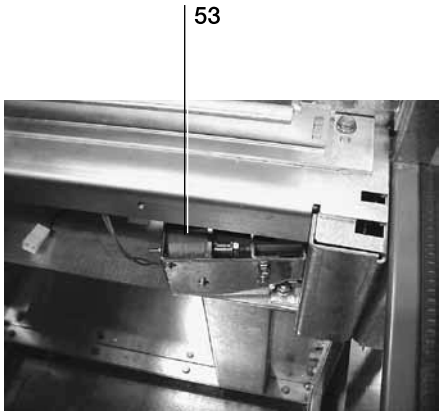



Fig. 13i

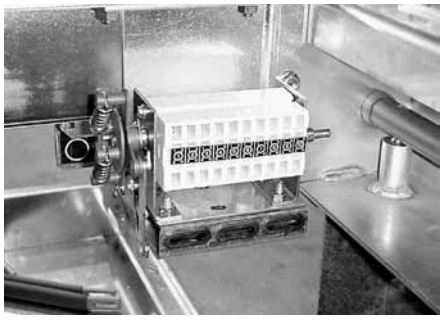


Fig. 13l

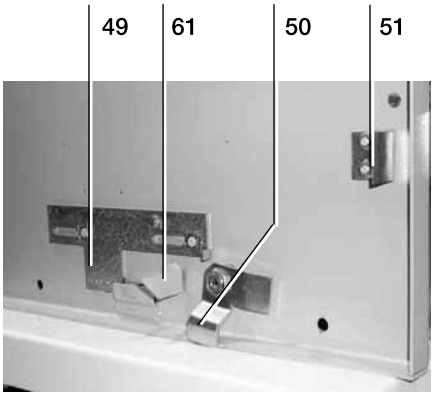



Fig. 13m

Apparatus locks

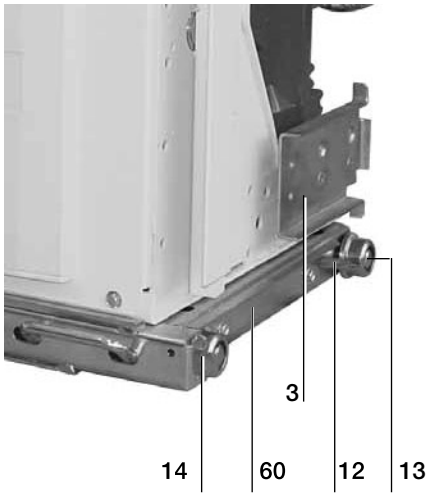



Fig. 13n

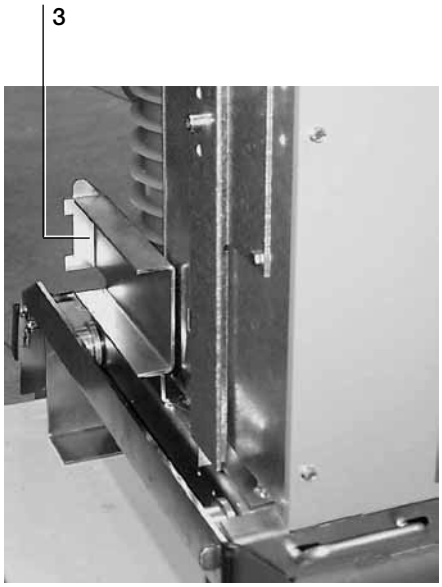



Fig. 13o

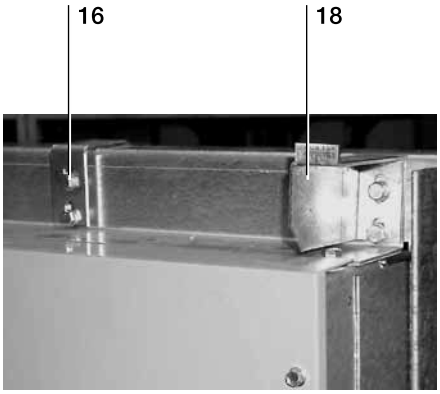



Fig. 13p

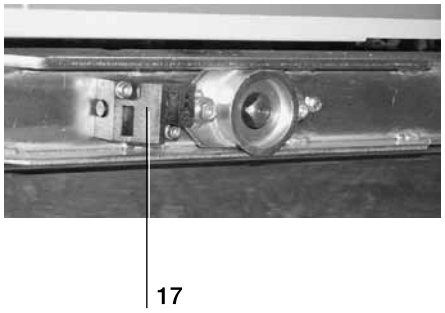



Fig. 13q

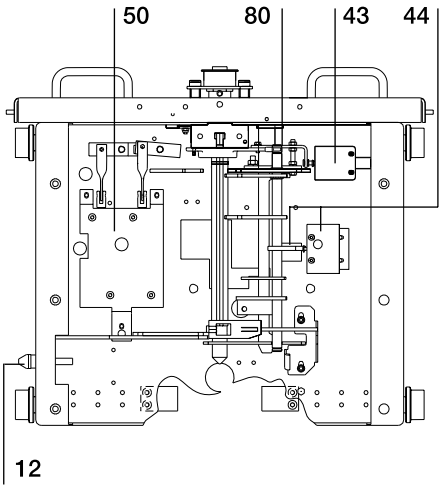



Fig. 13r



Fig. 13s

**Coding the plug-socket connector of the auxiliary circuits**

Coding the plug-socket connector of the auxiliary circuits allows the apparatus to be electrically combined with its panel.
For example, it only allows apparatus with different rated current to be combined with the panels they are destined for.
The operating mechanism cabling coding pins are inserted in the sockets, and must couple with the corresponding seats of the plug-socket connector.
Coding the plug-socket connector depends on the final configuration of the switchgear and must be carried out by the customer by closing the holes not used with the special plugs, according to the coding enclosed with this manual.

Socket references:
B1 - B2 - B3 - B4 - B5 - B6.

Plug references:
(B1) - (B2) - (B3) - (B4) - (B5) - (B6).

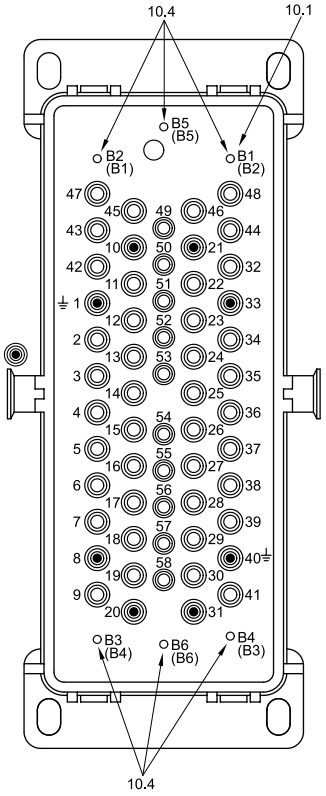



**Fig. 13t**

**Application of locks on plug-socket**

| Ir | Apparatus | Pole center line | Isc | Ø contacts | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|---|---|---|---|
| 400A | V-CONTACT | 150 | 31.5 kA | 35 | | | ■ | ■ | | |
| 630A | HD4-VD4-VM1 | | | | ■ | | | ■ | | |
| 1250A | HD4-VD4-VM1 | | | | ■ | | | | | |
| 1250A | HD4 isolating truck | | | | | ■ | | ■ | | |
| 1250A | HD4-VD4-VM1 | 210 | 31.5 kA | 35 | ■ | | | | | |
| 1250A | HD4 (UniSafe/PowerCube) | | 50 kA | 35 | ■ | | | | | |
| 1250A | VD4 | | 50 kA | 79 | | | ■ | ■ | ■ | |
| 1250A | HD4 isolating truck | | 31.5-50 kA | 79 | ■ | | | ■ | | |
| 1600A | HD4-VD4-VM1 | | | | | | | ■ | ■ | |
| 2000A | HD4-VD4-VM1 | | | | | | | | ■ | |
| 1250A | HD4 isolating truck | | | | | ■ | ■ | | | |
| 2500A | HD4-VD4-VM1 | 275 | 31.5-50 kA | 109 | | | | | | ■ |
| 2000A | HD4 isolating truck | | | | | | | | | ■ |
| 3150-3600-4000A | HD4-VD4 | | | | | | | | | |
| 2500A | HD4 isolating truck | | | | | | | | | |
| 2500A | HD4 (UniSafe) | 210 | 31.5 kA | 35 | | | | ■ | | ■ |
| 2500A | HD4 isolating truck (UniSafe) | | | | | | ■ | | | ■ |
| 1600A | HD4-HXB/P p210 | 210 | – | – | | | | | ■ | |
| The white boxes in the correspond with the assembly position of the rivets on the switchgear side socket. | | | | | B2 | B1 | B4 | B3 | B5 | B6 |

Pin position in the plug (apparatus)

Hole position in the socket (switchgear)

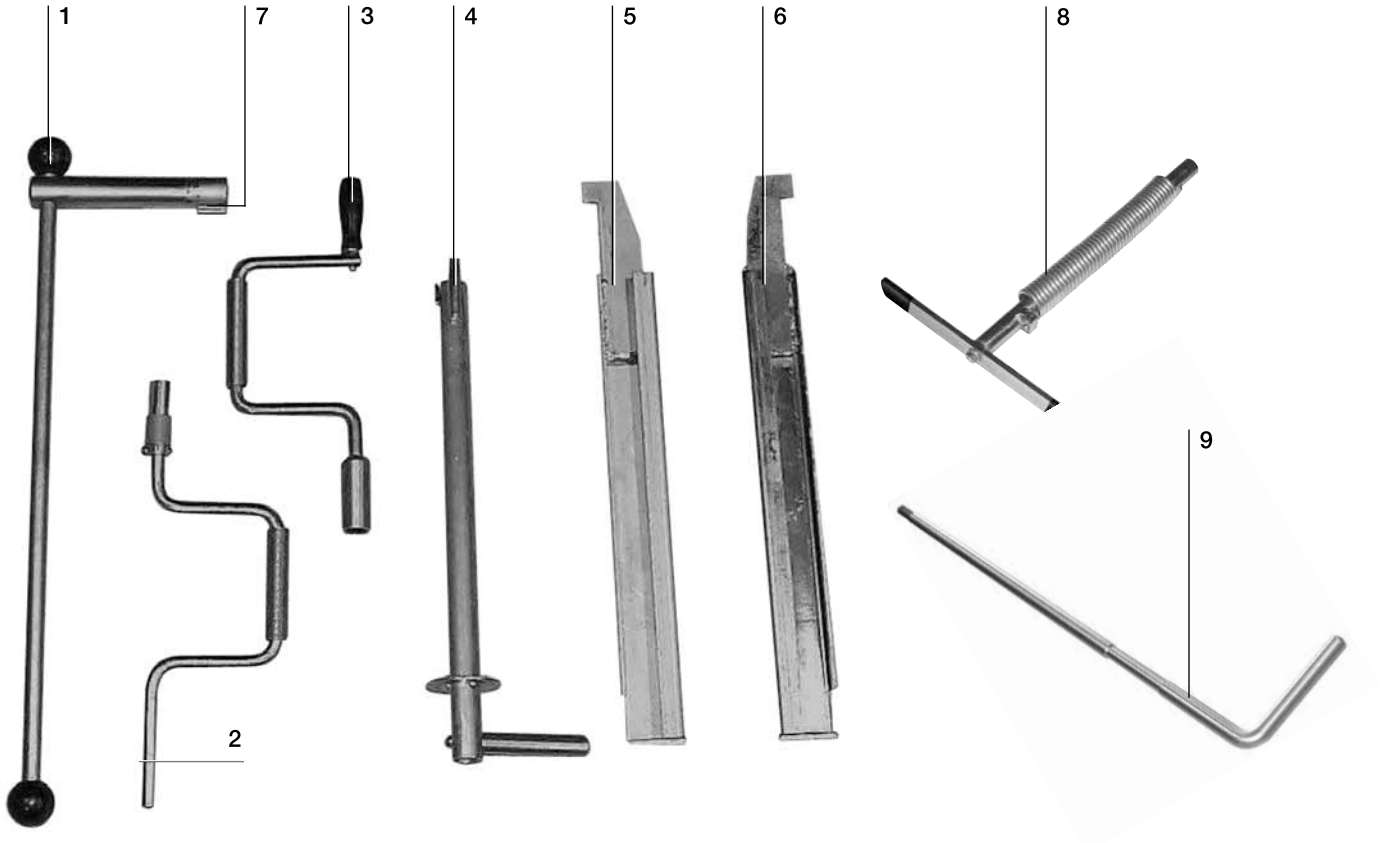
## 5.6. Reference Standards

| | |
|---|---|
| **IEC 60694** | for general application |
| **IEC 62271-200** | for the switchgear |
| **IEC 62271-102** | for the earthing switch |
| **IEC 60071-2** | coordination of insulation |
| **IEC 62271-100** | for the circuit-breakers |
| **IEC 60470** | for the contactor |
| **IEC 60265-1** | for the switch-disconnector |
| **CEI EN 60529** | degrees of protection for the housings Classification. |

# 6. Instructions for operating the apparatus and operation sequence of the units

- **Do not remove the circuit-breaker covering panels; if necessary, keep a safe distance during apparatus opening and closing operations to avoid any contact with moving parts.**
- **The operations must be carried out with normal activating force (not more than 200 Nm), only using the special tools (see para. 6.1). Should they be prevented, make sure that the operating sequence is correct.**

## 6.1. Operating accessories and devices




Caption

1 Earthing switch operating lever
2 Circuit-breaker charging-spring lever
3 Circuit-breaker racking in/out lever
4 VT truck racking in/out lever
5 Additional left guide for VT truck racking in/out
6 Additional right guide for VT truck racking in/out
7 Operating lever raised part
8 Emergency operating lever of VM1circuit-breakers
9 Emergency operating lever of VSC contactors

**Fig. 14**

## 6.2. Apparatus racking in/out

- **Should any operation be carried out while the apparatus is withdrawn from the switchboard, pay the utmost attention to the moving parts.**
- **The apparatus must be inserted into the unit only in the open position; its racking in/out must be gradual, so as to safeguard the mechanical interlocks against any deforming impact.**

### 6.2.1. Apparatus (circuit-breakers and contactors)

The following instructions refer to HD4 circuit-breakers but they are valid for VD4 circuit-breakers and V-Contact contactors as well.

**a) Racking in**

(1) Switching from circuit-breaker withdrawn to “isolated” position

– lift the apparatus (2) (fig. 15a) and place it on the handling truck (1) (fig. 15a), following the instructions in par. 4.2. “Circuit-breaker handling by means of truck”;
– open the door of the circuit-breaker compartment;
– draw the truck close to the switchboard (fig. 15a);
– insert the hooking bracket (4) (fig. 44b - c), and block the wheels (3) (fig. 15a);
– release the circuit-breaker from the truck by moving the handles (5) at the same time (fig. 15d) towards the circuitbreaker centre axis and at the same time gradually pushing the circuit-breaker handles towards the back of the module until the circuit-breaker locks with the handles (5) (fig. 15e) clicking laterally, inserting themselves into the slots (6) (fig. 15b);
– unlock the wheels (3) (fig. 15a), lift the hooking bracket (4) (fig. 15f) and remove the truck from the switchboard.

**Make sure that the handles have tripped sideways (horizontal locks of the truck inserted in the enclosure)**

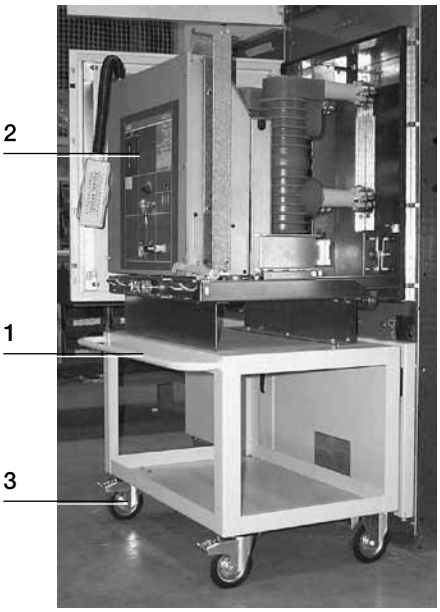



Fig. 15a

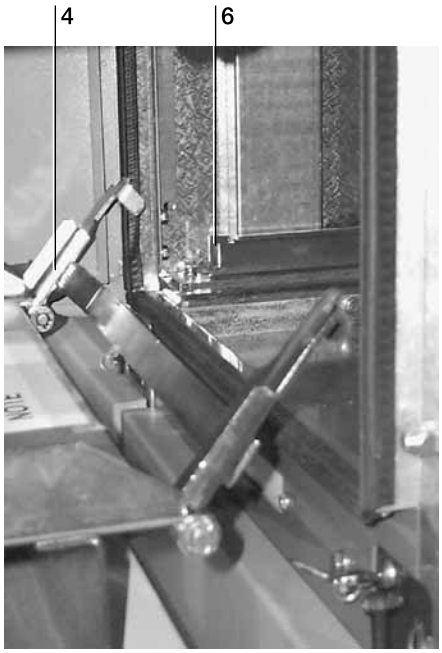



Fig. 15b

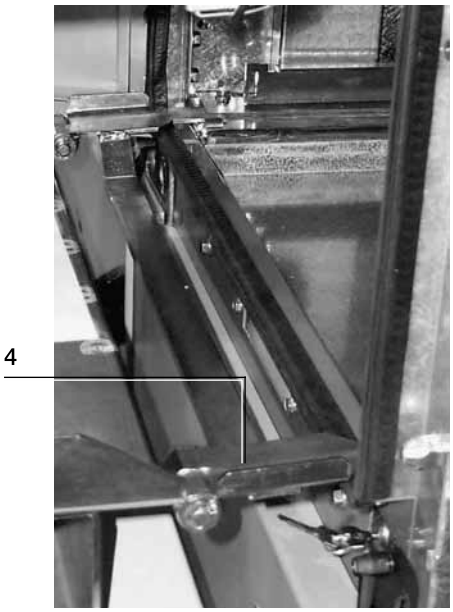



Fig. 15c

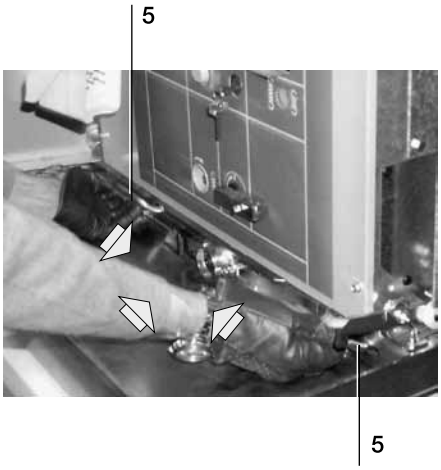



Fig. 15d

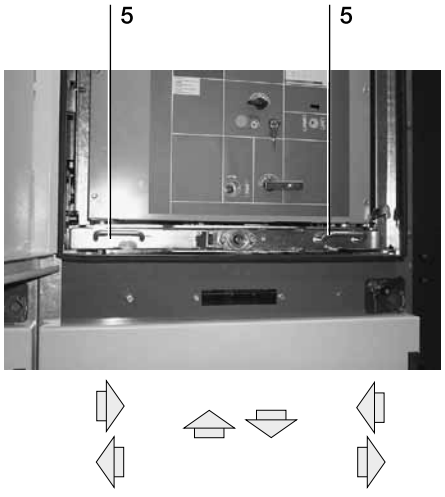



Fig. 15e

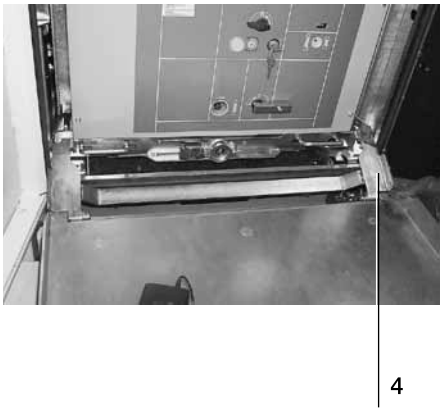



Fig. 15f

(2) Switching from “isolated” to “test” position (connection of auxiliary circuits).

– Insert and hook the mobile connector (1) (fig. 17) in the enclosure fixed socket (2) (fig. 16).

**Make sure that the lever (3) (fig. 17) is fully pushed against the connector (1) (fig. 17).**

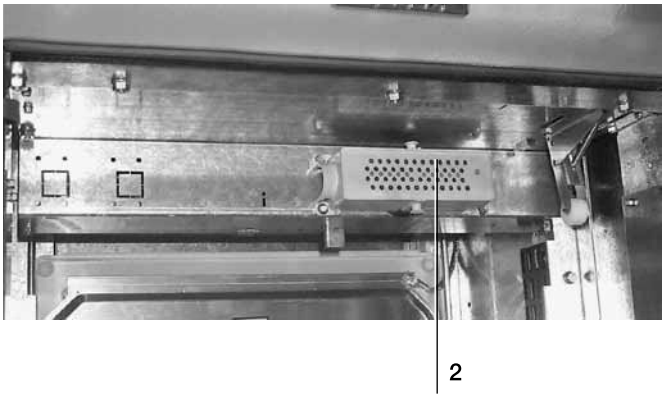



**Fig. 16**

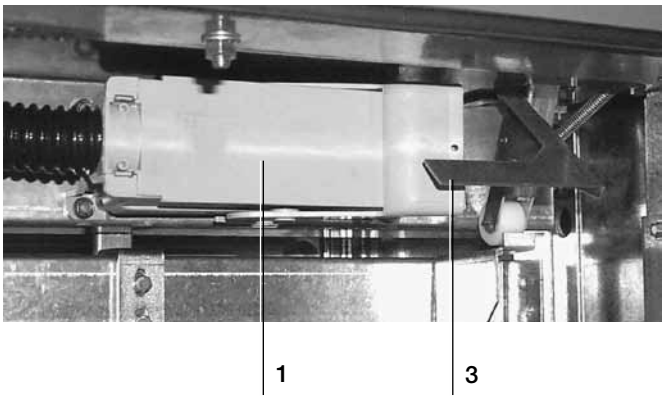



**Fig. 17**

(3) Switching from “test” to “connected” position (with earthing switch closed) (fig. 18)

– close the circuit-breaker compartment door (1) pushing the handle downwards;
– close the feeder compartment door (2) pushing the handle downwards;
– make sure that:
  • the locking electromagnet of the earthing switch is energised (if supplied);
  • the key locks (7-8-9) are disabled, if supplied;
– insert operating lever (13) into the seat of the earthing switch making the raised piece (12) coincide with one of the two slots (11);
– open the earthing switch, turning the operating lever anticlockwise (13);
– withdraw the operating lever (13) from the earthing switch seat;
– through the inspection window (6) and/or the operating seat (2 - fig. 8) for version without forced ventilation make sure that the earthing switch is open (indicator in the “O” position);

**Make sure that the feeder unit door (2) is locked (PB/M-PB/RM).**

– close the cover of the earthing switch seat by turning the actuator (10) clockwise; this operation unlocks the circuit-breaker and trips a lock for preventing insertion of the operating lever into the earthing switch;
– make sure that the locking magnet on the circuit-breaker truck (if supplied) is energised and check that the key lock for preventing insertion (if supplied) is disabled;
– fully insert the operating lever of the circuit-breaker/truck (3) (fig. 14) in the corresponding coupling (5) and turn it clockwise until the circuit-breaker is fully connected;
– through the inspection window (4) make sure that the circuitbreaker is connected.

**b) Racking out operation (only with circuit-breaker open)**

(1) Switching from “connected” to “isolated for test” position (with circuit-breaker open) (fig. 18)

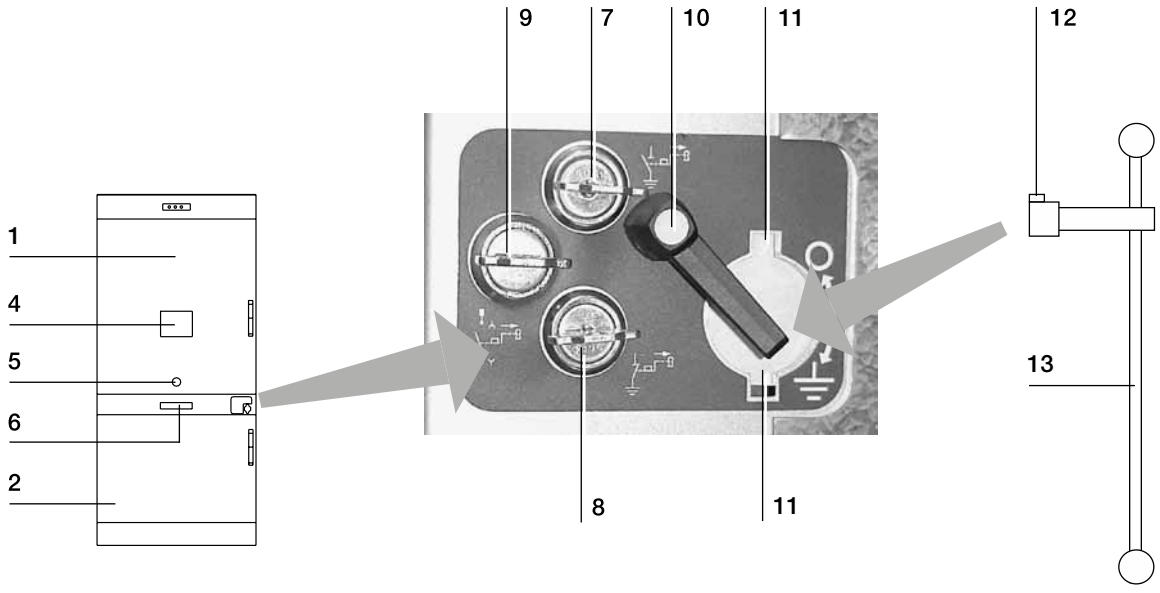
– through the inspection window (4) make sure that the earthing switch is open (indicator in the “O” position);
– fully insert the circuit-breaker truck/racking in/out lever (3) (fig. 14) in the relative coupling (5 - fig. 18) and turn it anticlockwise until the circuit-breaker stops;
– open the cover of the earthing switch operating seat by turning the actuator anticlockwise (10);
– insert the operating lever (13) in the earthing switch seat making the raised part (12) coincide with one of the two slots (11);
– close the earthing switch turning the operating lever clockwise;
– withdraw the operating lever (13) from the earthing switch seat;
– through the inspection window (6 - fig. 18) (for modules without forced ventilation) and the operating seat (2 - fig. 8) make sure that the earthing switch position indicator is in the “I” position showing closing;
– open the circuit-breaker compartment door (1) pulling the handle upwards.

(2) Switching from “isolated for test” to “isolated” position (auxiliary circuit disconnection)

– unlock the mobile connector (1) (fig. 17) and withdraw the latter from the enclosure fixed socket (2) (fig. 16);

(3) Switching from “isolated” to “withdrawn” position

– draw the truck close to the switchboard (fig. 15a);
– insert the hooking bracket (4) (fig. 15b-c) and block the wheels (3) (fig. 15a);
– move the two handles (5) (fig. 15d) at the same time towards the circuit-breaker centre and by means of the handles gradually pull the circuit-breaker outside on the truck;
– release the handles and continue withdrawal until the circuitbreaker stops (fig. 15a) and the handles trip sideways thus locking the circuit-breaker on the truck;
– unlock the wheels (3) (fig. 15a) and lift the hooking bracket (4) (fig. 15f);
– lift the hooking bracket (4) (fig. 15f) and remove the truck from the switchboard.




Caption of the earthing switch key locks

7 Lock with earthing switch open
8 lock with earthing switch closed
9 lock for preventing circuit-breaker insertion.

**Fig. 18**

### 6.2.2. VT unit (PB/M-PB/RM)

**Putting the VT truck in and out of service must be carried out with the door closed**

**a) Racking truck into the unit**

– open the unit door pulling the handle (3) (fig. 20m) upwards;
– insert the left and right additional guides (fig. 419a) in the lateral slots as in fig. 19b;
– lift the VT truck front part and insert the front wheels in the additional guides (fig. 19c);
– push the truck backwards, lift the rear part and insert the rear wheels in the additional guide slots (fig. 19d);
– push the truck backwards until it is blocked (fig. 19e);
– remove the left and right additional guides (fig. 19f);
– hook the door (fig. 20a) and insert the door earthing connection;
– tighten the door fixing screws (fig. 20b-fig. 20c);
– move the pin leftwards removing it from the slot of the operating lever (2) (fig. 20d);
– turn the lever of the door locking bolt clockwise (1) (fig. 20d);
– close the compartment door pushing the handle (3) (fig. 20e) downwards.

**b) Truck racking out operation (with compartment unit deenergised)**

– open the unit door pulling the handle upwards (3) (fig. 20e);
– move the pin rightwards to unlock the closing bolt of the VT truck front door (2) (fig. 20d);
– turn the actuator anticlockwise to lock the door bolt (1) (fig. 20d);
– loosen the door fixing screws (fig. 20b);
– remove the door (fig. 20a);
– insert through the inspection window (6) make sure that the earthing switch position indicator is in the “I” position showing closing; the left and right additional guides (fig. 19a) into the slots (fig. 19b);
– pull the truck outside until it is blocked;
– lift the truck rear part and remove the rear wheels from the additional guides (fig. 19c);
– pull the truck outside until it is blocked;
– lift the VT truck front part and remove the front wheels from the additional guides (fig. 19c);
– remove the left and right additional guides (fig. 19f);
– close the compartment door pushing the handle (3) downwards (fig. 20e).

**Note**

Use a lifting truck (fig. 20i), always positioning and moving the VT truck in the rotated position indicated in fig. 20m.

**Operation for racking the truck in/out of the unit**



Fig. 19a

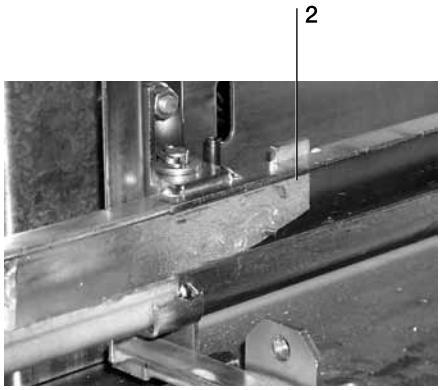



Fig. 19b



Fig. 19c

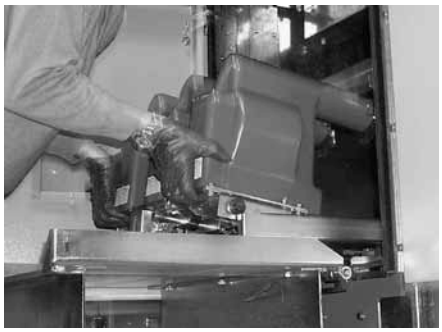


Fig. 19d

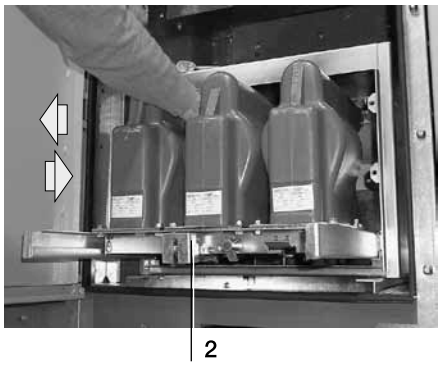



Fig. 19e

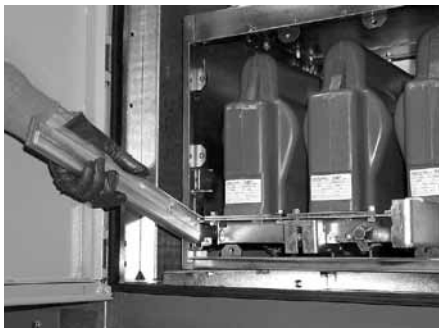


Fig. 19f

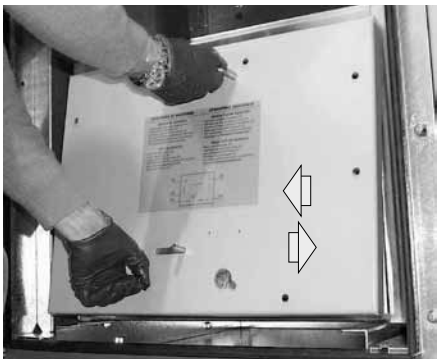


Fig. 20a

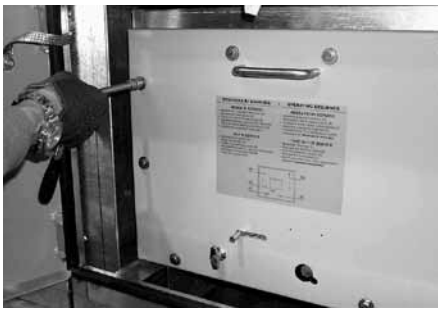


Fig. 20b

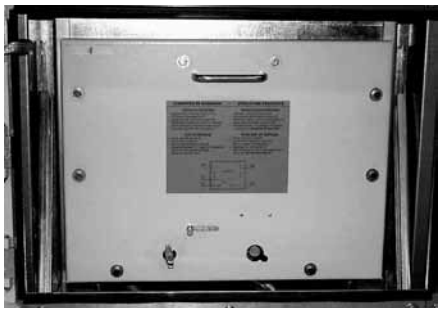


Fig. 20c

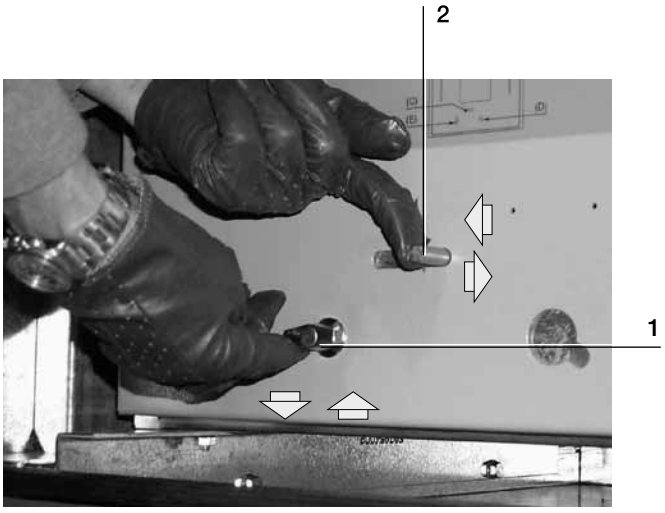



Fig. 20d




Fig. 20e



Fig. 20f



Fig. 20g



Fig. 20h



Fig. 20i



Fig.20l



Fig. 20m

## 6.3. Disabling the apparatus unit door lock

**Skilled personnel with suitable knowledge of the apparatus and installation must carry out this operation only in case of emergency.**

Should the door lock of the apparatus unit be activated and the switchboard door must be unlocked, loosen the screw (1), insert a 2-3 mm diameter rod in the hole, push the lever (2) and at the same time open the door, pulling the handle upwards.

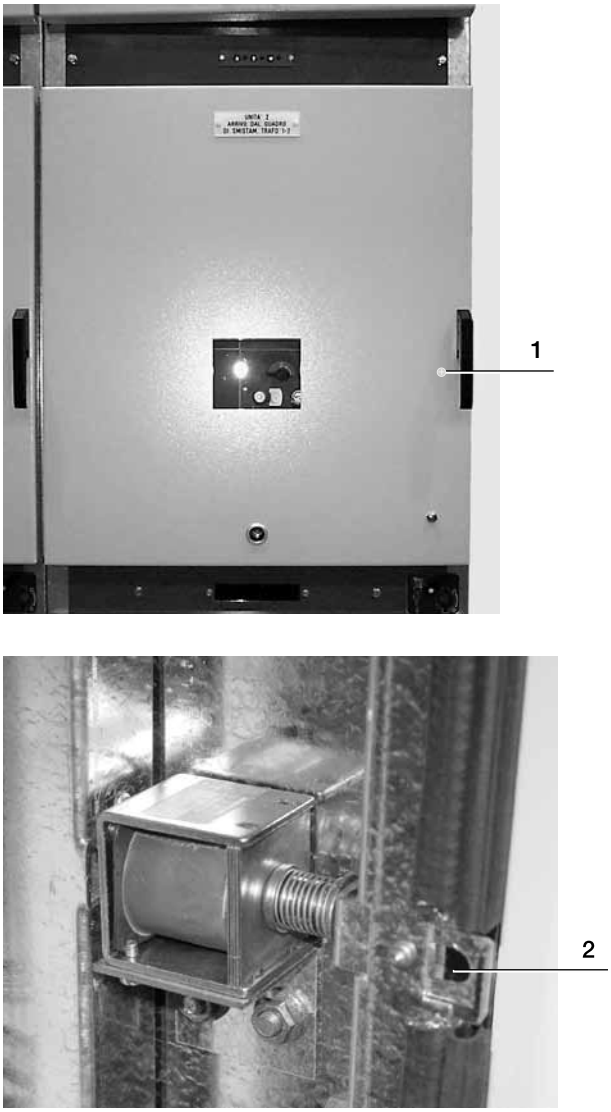



**Fig. 21**

## 6.4. Operating the apparatus

### 6.4.1. Earthing switch

- **Make sure that the earthing switch key locks (if supplied) are disabled and that the electromagnetic lock of the earthing switch (if supplied) is energised.**
- **The earthing switch can only be operated with the circuit-breaker in the isolated or withdrawn position.**
- **Once started, the operations must be completed.**

**Closing (fig. 22)**

– Make sure that the circuit-breaker is either in the isolated or withdrawn position;
– open the cover of the earthing switch operating seat by turning the operating actuator (10) anticlockwise; the earthing switch operating seat is freed;
– insert the operating lever (13) in the earthing switch seat making the raised part (12) coincide with one of the two slots (11);
– close the earthing switch by turning (13) the lever clockwise;
– remove the operating lever;
– check on the operating seat (5) and through the inspection window (6) (version without forced ventilation) that the earthing switch is closed (indicator in the "⏚" position).

**Opening**

– Insert the operating lever (13) in the earthing switch seat making the raised part (12) coincide with one of the two slots (11);
– open the earthing switch turning the operating lever anticlockwise (13);
– remove the operating lever (13) from the earthing switch seat;
– through the operation seat (5) and the inspection window (6) (version without forced ventilation) make sure that the earthing switch is open (indicator in the "O" position);
– close the cover of the earthing switch turning the actuator (10) clockwise; the circuit-breaker is thus unlocked while a lock for preventing operating lever insertion into the earthing switch is activated.

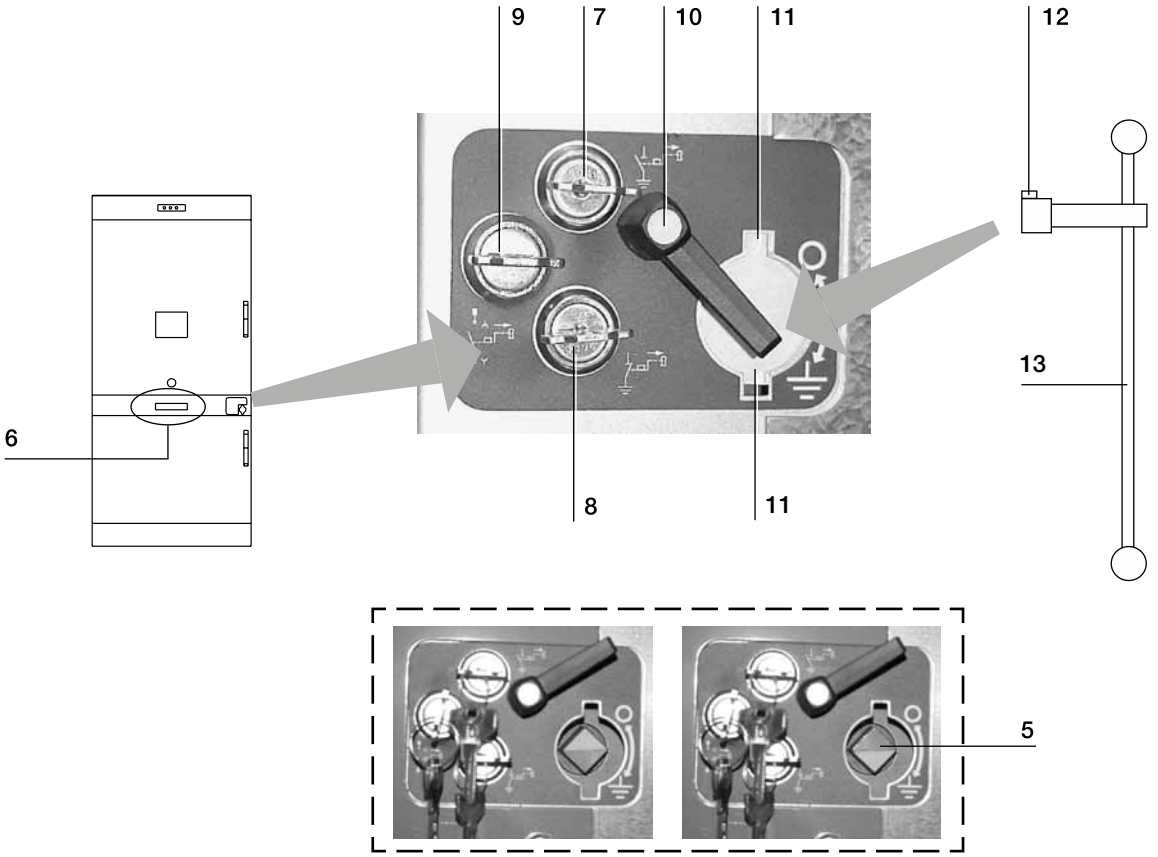
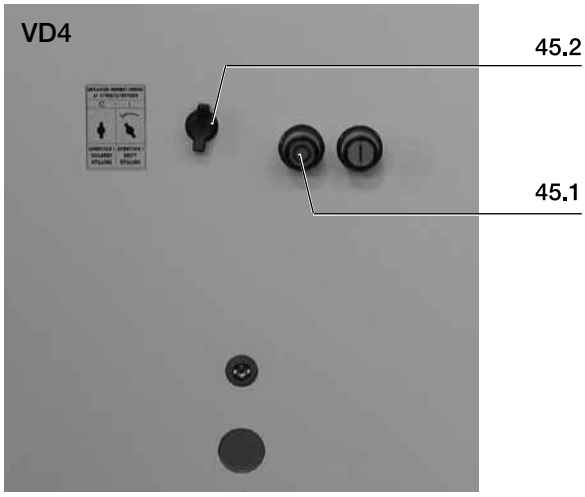
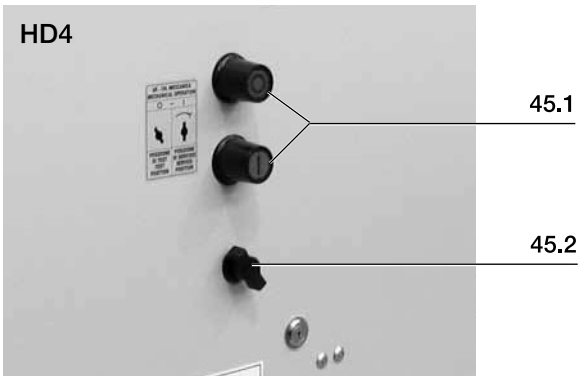



Fig. 22

### 6.4.2. Operation of HD4 - VD4 circuit-breakers with the door closed (application on request) (PB/E)

For operation of the apparatus, please also refer to the relative instruction manuals.
Pushbutton for circuit-breaker opening and closing operation with the door closed (on request). If the circuit-breaker is in the service position, the operation is carried out by rotating the knob 45.2 which takes the extension of operating rod 45.3 into position, allowing the operation by means of pressing the mechanical opening and closing pushbuttons (45.1).





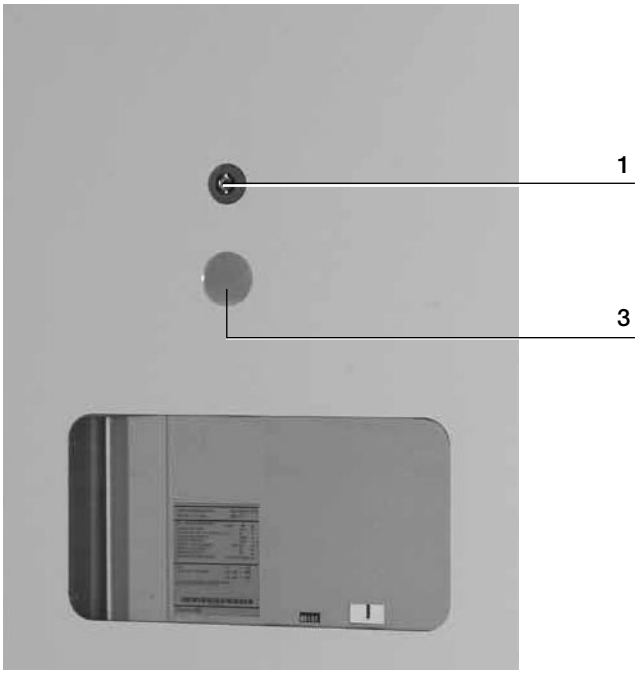

### 6.4.3. Emergency opening of VM1circuit-breakers with the door closed

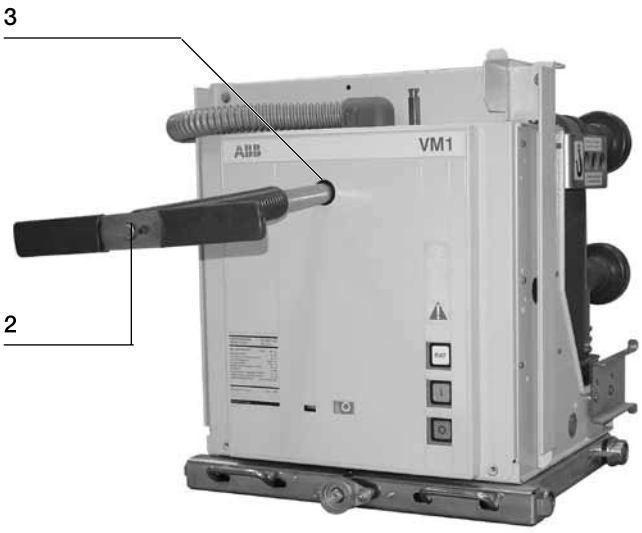
For operation of the apparatus, please also refer to the relative instruction manuals.

Opening due to fault on the auxiliary feeder:
– electrical opening is still possible within the first 200 s;
– after a period of 200 s, manual emergency opening is necessary.

Turn the small handle 1 to free the operating seat; insert operating lever 2 in the special opening so as to insert it in seat 3 and turn lever 2 until the apparatus opens.

Just before reaching the run end, a little resistance on the emergency shaft must be overcome.



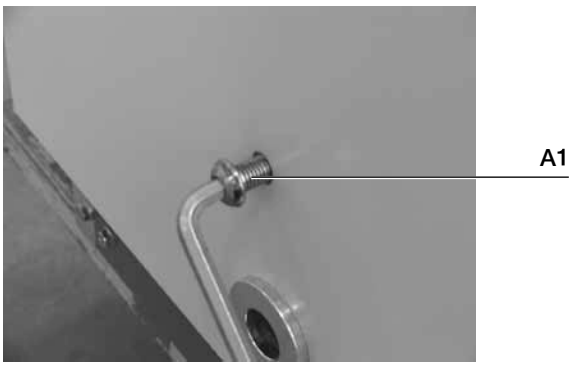

### 6.4.4. Emergency opening of VSC/P contactors with the door closed

For operation of the contactors, please also refer to the relative instruction manuals.

Unscrew screw A1 on the door using an 8 mm socket head wrench or the emergency operating lever of the contactor. Put the screw in a safe place and put the operating lever into the opening left by the screw (A1.1) inserting it in the special opening A2 on the contactor shield.

Turn the lever clockwise until the apparatus opens. Once opening has taken place, withdraw the lever and screw up the dome-headed screw on the door again.

**CAUTION!**
– Do not screw up the closing screw A1 – this would jeopardise the arc proofing of the door.









### 6.4.5. VT unit (PB/M-PB/RM)

**Putting the VT truck in and out of service must be performed with door closed.**

**a) Putting into service**

– Insert the operating lever (1) (fig. 23b) into the seat (2) (fig. 23a) making the raised piece (2) (fig. 23b) of the lever coincide with the slot (3) (fig. 23a);
– turn the lever clockwise (fig. 23c) and push hard until it is fully inserted;
– from the inserted position, turn the lever anticlockwise until the reference indicators coincide (4) and the operating lever is coupled (fig. 23d);
– make sure that by pulling the handle upwards the door does not open (fig. 23e).

**b) Putting out of service**

– Turn the lever (1) in fig. 23d clockwise and pull it outwards until the isolated position click;
– withdraw the operating lever (1) (fig. 23b) from the seat (fig. 23a) making the raised piece (2) (fig. 23b) of the lever coincide with the slot (3) (fig. 23a);
– open the door pulling the handle upwards. In this condition the VT truck is isolated and earthed and the VT auxiliary circuits are also isolated.

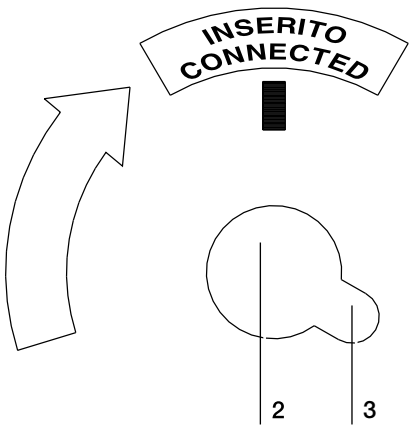



Fig. 23a

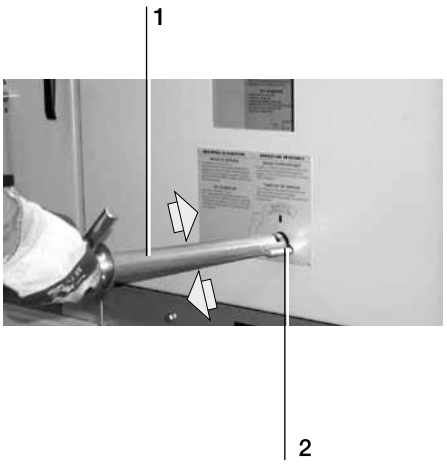



Fig. 23b



Fig. 23c

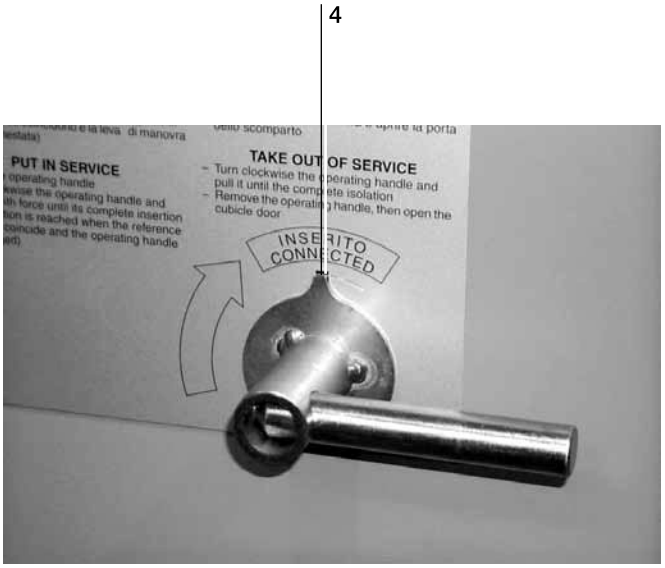



Fig. 23d



Fig. 23e

# 7. VT fuse replacement (PB/M-PB/RM)

- **All the operations below must only be carried out by qualified and skilled personnel with in-depth knowledge of the apparatus.**
- **Make sure that the rated normal current value of the fuses to be installed is the same as the one shown on the fuse-holder nameplate.**
- **Only use fuses indicated by ABB.**

**Procedure**

– Open the unit door pulling the handle (3) (fig. 24a) upwards;
– move the pin (2) (fig. 24q) right so as to unlock the closing lock bolt of the VT compartment door;
– turn the actuator of the door locking bolt anticlockwise (1) (fig. 24q);
– loosen the door fixing screws (fig. 24c);
– remove the door (fig. 24d);
– insert the left and right supplementary guides (fig. 24e);
– pull the truck outwards until it is blocked (fig. 24f);
– turn the fuse contact ring nut (fig. 24g) clockwise and remove it;
– remove the fuse and replace it (fig. 24h);
– insert the ring nut and turn it anticlockwise (fig. 24i);
– push the VT truck backwards until it is blocked (fig. 24l);
– remove the left and right supplementary guides (fig. 24m);
– hook the door (fig. 24n) and insert the door earthing connection;
– tighten the door fixing screws (fig. 24o - fig. 24p);
– move the pin leftwards thus freeing the coupling slot of the operating lever (2) (fig. 24q);
– turn the actuator of the door locking bolt clockwise (1) (fig. 24q);
– close the compartment door pushing the handle (3) (fig. 24a) downwards.

**Replacing the VT compartment fuses**

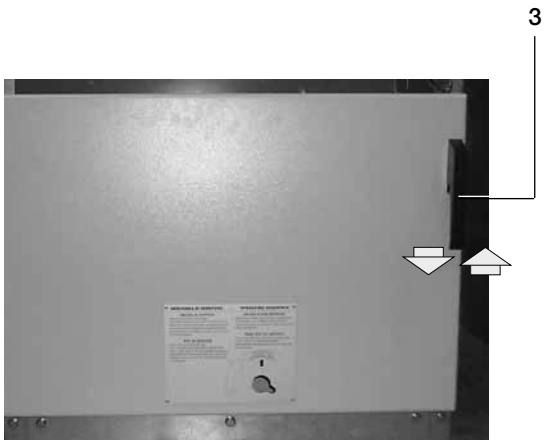



**Fig. 24a**



**Fig. 24b**

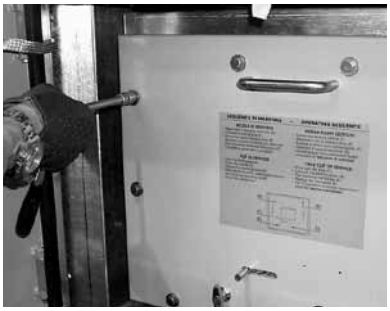


**Fig. 24c**

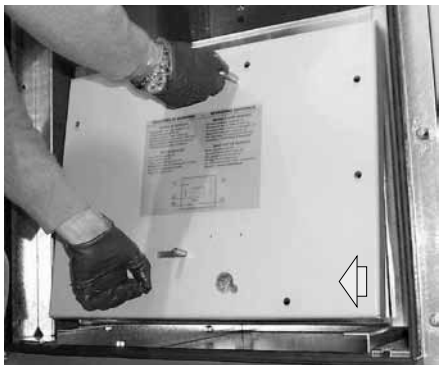


Fig. 24d



Fig. 24e



Fig. 24f



Fig. 24g

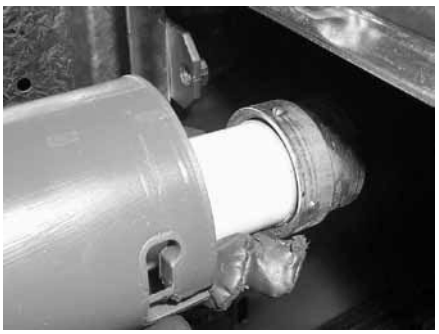


Fig. 24h



Fig. 24i



Fig. 24l

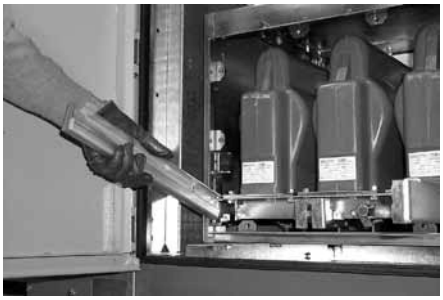


Fig. 24m

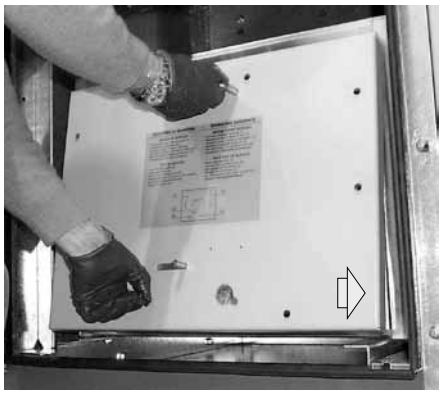


Fig. 24n

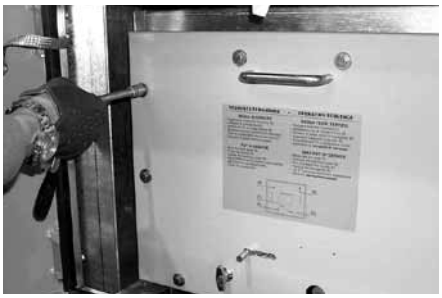


Fig. 24o



Fig. 24p

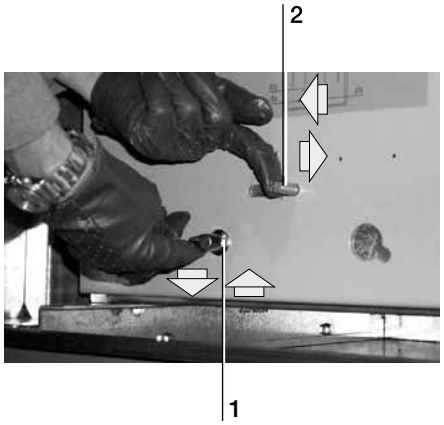



Fig. 24q

# 8. Installation

## 8.1. General information

- **Correct installation is of paramount importance. The instructions given by the manufacturer must be thoroughly studied and followed.**
- **Installation must be carried out by skilled personnel with in-depth knowledge of the apparatus.**
- **It is advisable to wear gloves for handling the components.**
- **Before removing the operating mechanism cover make sure that the circuit-breaker is open and the closing springs discharged.**

## 8.2. Normal installation room conditions

| | |
|---|---|
| Maximum air temperature | + 40 °C |
| Minimum air temperature | – 5 °C |
| Relative humidity | % ≤ 95 |
| Altitude | ≤ 1000 |

**For shipping reasons, the gas pressure in the HD4 circuit-breakers can be reduced. In this case, before putting the apparatus into service recover the pressure using SF6 gas in compliance with the CEI 10-7 - IEC 60376 Standards.**
**Filling with gas must be carried out by ABB personnel or by suitably qualified customer personnel with indepth knowledge of the apparatus.**

For any special conditions, please contact us.
For other installation room characteristics, please refer to the product standards (IEC 60694).
For any special conditions, please contact us.

## 8.3. Foundations and fixing surface (PB/M-PB/RM)

The floor or the foundation must be strong enough to bear the weight of the module (plus all the apparatus) without any deformation.
The general foundation drawing is shown in fig. 25a.
The switchboard can be fixed (fig. 25b) either to the floor or to special base irons (supplied on request):
– for floor fixing put the expansion and anchoring bolts in the fixing holes;
– special bolt blocks are supplied for base iron fixing. The base irons must be fixed and buried in concrete.

The base of each module is prepared with four fixing holes. For switchgear positioning, the planarity of the fixing surface must be checked, with special attention paid to longitudinal levelling (maximum planarity: 2/1000).

### 8.3.1. Module fixing systems (fig. 25b)

**Fixing with base irons and masonry floor**

The base irons, which can be supplied on request, must be installed in the slab before finishing the floor:
– rest the irons on the floor and line them up so that they are parallel and are spaced from each other as shown in the foundation drawing;
– level the irons both longitudinally and transversally;
– fix the base irons in this position with expansion anchor bolts, using the holes provided in the irons;
– complete the flooring so that the base irons extend out at least 0.5 mm from the finished floor surface.

**Fixing to floor with anchoring and masonry floor**

**Procedure**

– Clean the installation area;
– on the slab, visibly trace the perimeter of all the cubicles making up the switchboard, taking the minimum wall and obstacle clearances into account;
– level the floor both longitudinally and transversally;
– drill the floor at the fixing points foreseen, referring to our slab drilling drawings. To make the holes, use a hammer drill with a Ø = 16 mm bit;
– insert the expansion anchoring bolts in the holes.

**Fixing to a floating floor**

**Procedure**

– Clean the installation area;
– on the slab, visibly trace the perimeter of all the cubicles making up the switchboard, taking the minimum wall and obstacle clearances into account;
– drill the floor at the fixing points foreseen, referring to our slab drilling drawings. To make the holes, use a drill with a suitable bit for the type of fixing to be made (through or threaded hole).

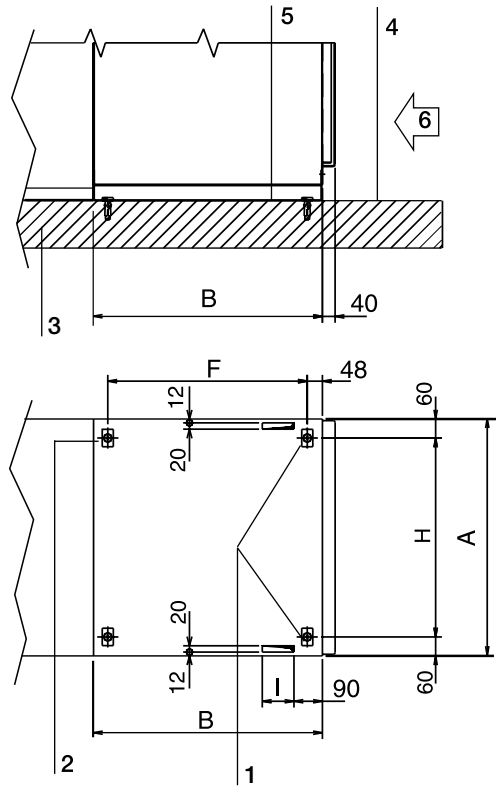
## 8.4. Tightening torque

The screw and nut tightening torque values for fixing and coupling switchboards and busbars are given in the table below.

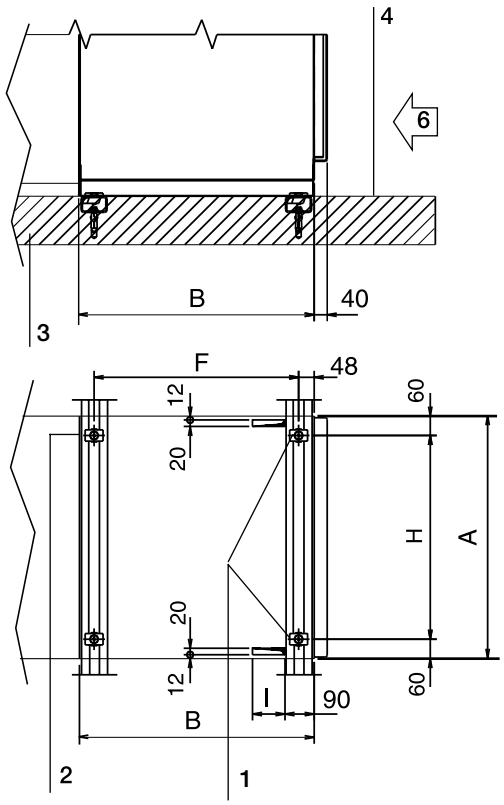
| Nut or screw | Tightening torque (Nm) | | Key for exhagonal nut or screw |
|---|---|---|---|
| | Acc. 4.8 | Acc. 8.8 | |
| M3 | 0.5 | 1.2 | 5.5 |
| M4 | 1.1 | 2.7 | 7 |
| M5 | 2 | 5 | 8 |
| M6 | 3.7 | 9 | 10 |
| M8 | 9 | 22 | 13 |
| M10 | 18 | 45 | 17 |
| M12 | 30 | 75 | 19 |
| M16 | 75 | 185 | 24 |
| M18 | 104 | 260 | 27 |
| M20 | 148 | 370 | 30 |

### Foundations

**Version with anchoring bolts**




**Version with base irons**




| Module | A | B | F | H | I |
|---|---|---|---|---|---|
| 12-17.5 kV | 600 | 723 | 630 | 480 | 200 |
| | 750 | 723 | 630 | 630 | 200 |
| | 1000 | 723 | 630 | 880 | 200 |
| 24 kV | 750 | 873 | 770 | 630 | 200 |
| | 1000 | 873 | 770 | 880 | 200 |

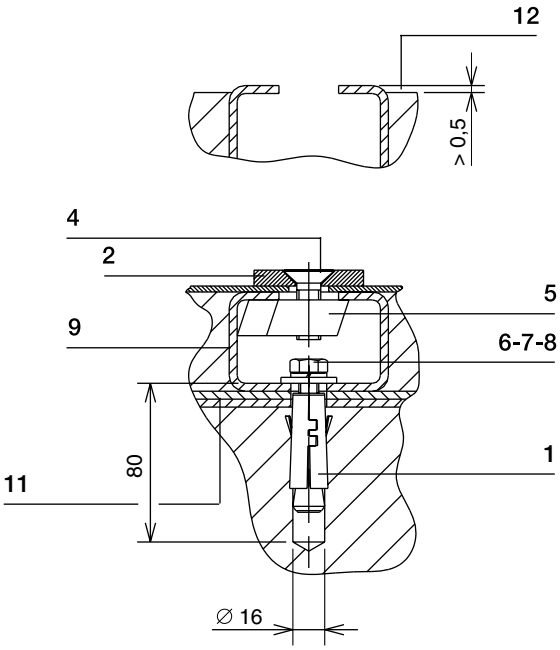
Caption

1 Passage of auxiliary circuit cables
2 Slot for module fixing
3 Slab
4 Finished floor surface
5 Module base sheet
6 Module front

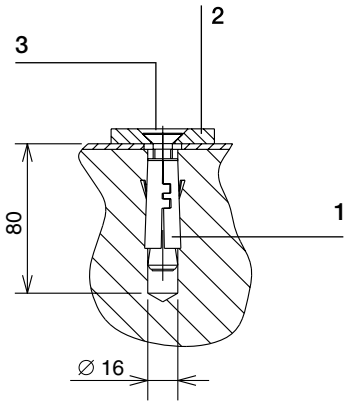
**Fig. 25a**

## Masonry floor

**Version with base iron**

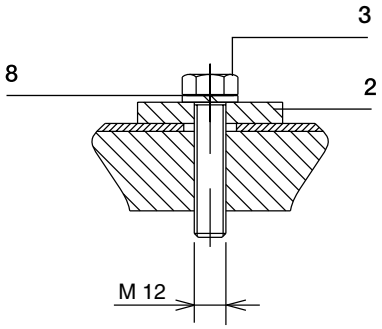



**Version with anchoring bolts**

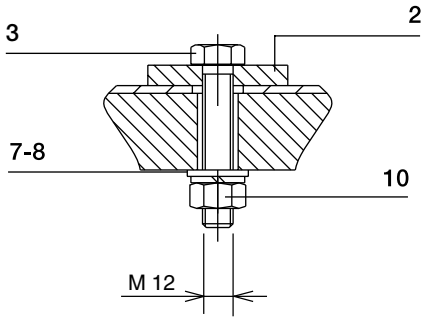



## Metal structure

**Version with threaded hole**




**Version with through hole**




Caption

1 Anchoring bolt
2 Plate
3 Screw
4 Screw
5 Block
6 Hexagonal-head screw
7 Washer
8 Spring washer
9 Steel section
10 Nut
11 Level by means of suitable shims (not supplied)
12 Floor level

**Fig. 25b**

## 8.5. Access from the front to the cable connection area (PB/M)

### 8.5.1. Access through the feeder unit

**Circuit-breaker racking out**

Follow the instructions given in para. 6.2.

**Dismantling the panels**

**Disconnect the fan power supply in the case of units with forced ventilation.**

**Procedure**

– Loosen the fixing screws of the front panel (fig. 26a)
– loosen the two fixing screws (right side) of the circuit-breaker compartment panel (fig. 26b)
– loosen the two fixing screws (left side) of the circuit-breaker unit panel (fig. 26c)
– lift and remove the circuit-breaker unit panel (fig. 26d)
– access the cable connection area of the unit (fig. 26e).

### 8.5.2. Access through the VT unit

**Racking the VT truck out**

Follow the instructions in para. 6.2.

**VT compartment dismantling**

– Loosen the fixing screws (right and left side) of the VT unit (fig. 27b-27c);
– move the guides (right and left) against the switchboard walls (fig. 27d);
– loosen the panel fixing screws on the switchboard base (fig. 27e).
– loosen the fixing screws of the VT unit base (fig. 27f-27g);
– withdraw the VT unit as in fig. 27h;
– position the VT unit as in fig. 27i.

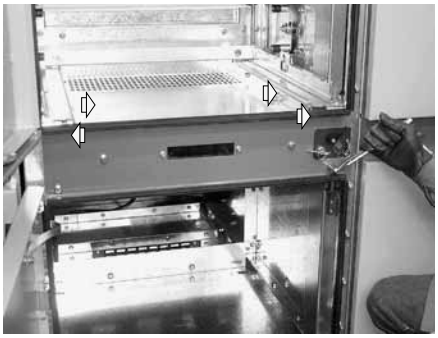


Fig. 26a

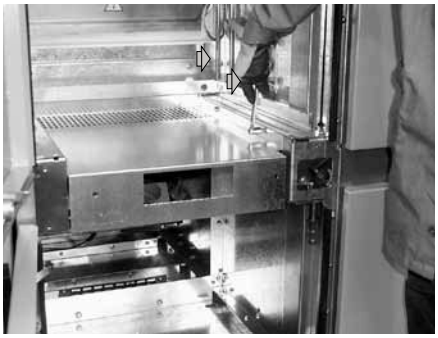


Fig. 26b



Fig. 26c



Fig. 26d



Fig. 26e

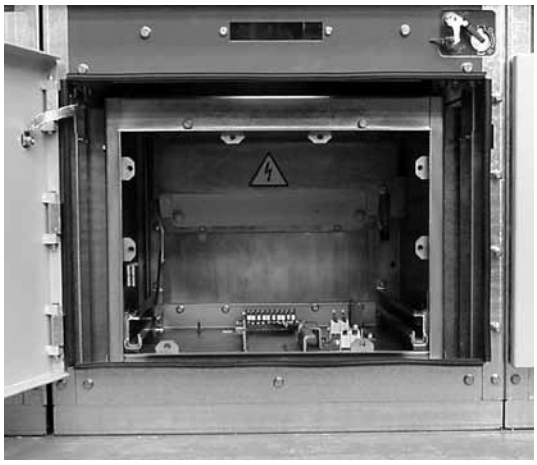


Fig. 27a

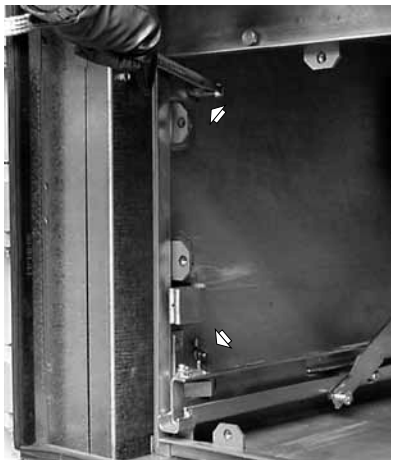


Fig. 27b



Fig. 27c

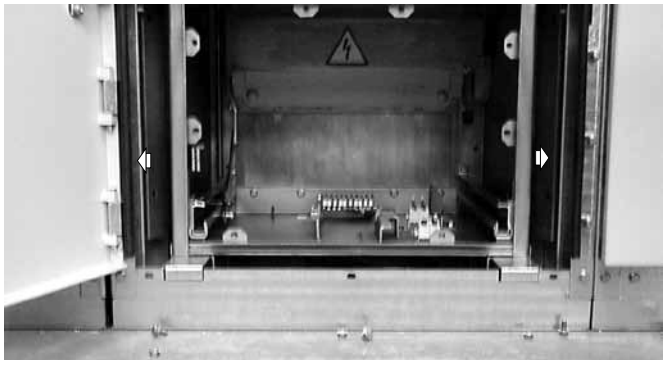


Fig. 27d

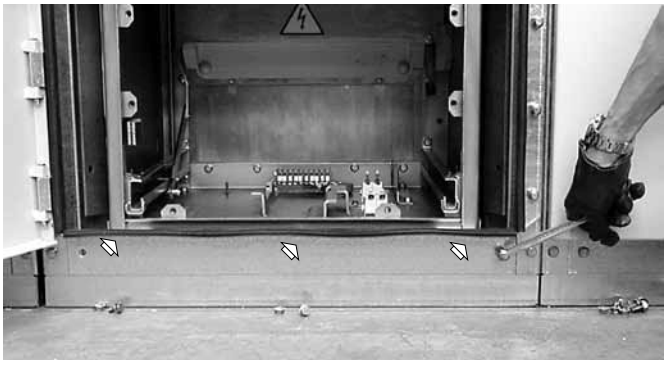


Fig. 27e

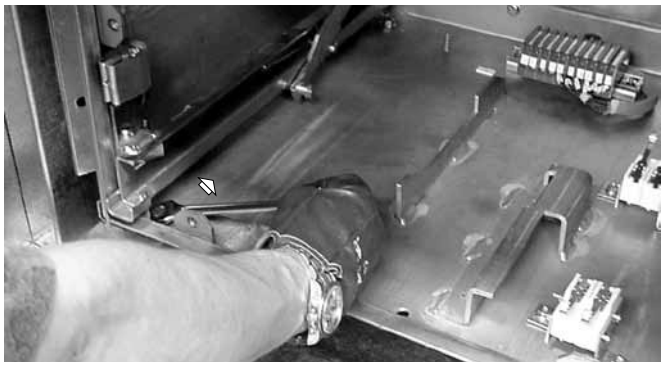


Fig. 27f

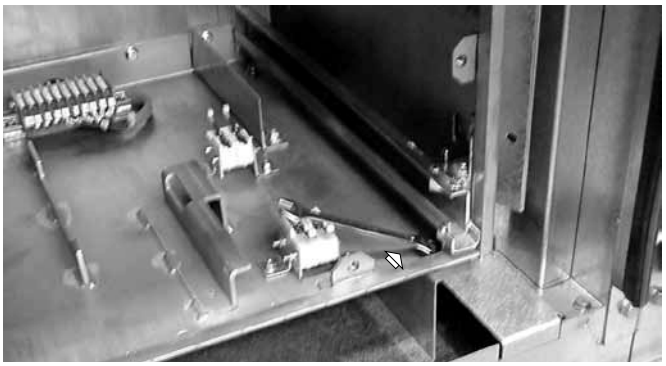


Fig. 27g



Fig. 27h

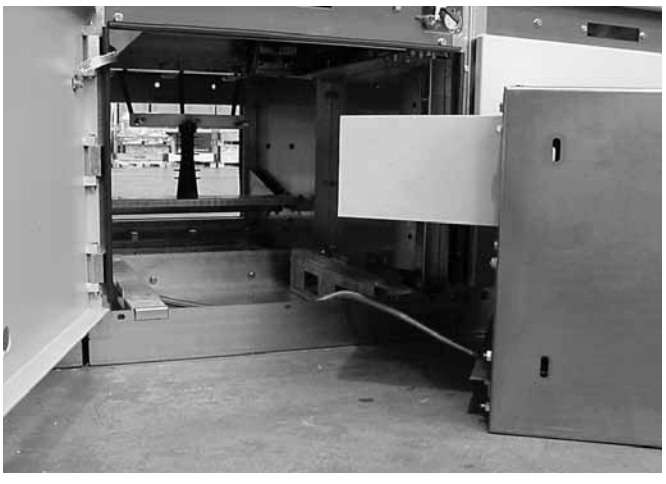
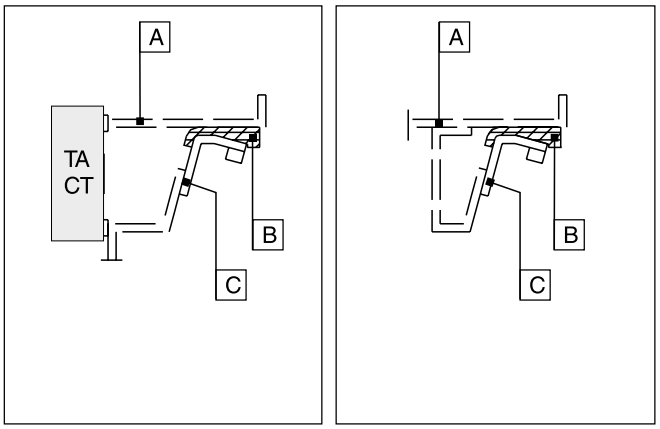


Fig. 27i

### 8.5.3. Connection of the lower terminals for units with earthing switch (with and without CT).

**The PowerCube units are preset for connection of the CTs between the A and C contacts of the lower terminals.**
**If this is not done, connect contacts A and C to each other using a conductor with the same cross-section as the one in detail C.**
**In both cases, the connection must be made - by the customer - respecting the geometry indicated in the figure so that the making capacity of the earthing switch is guaranteed.**




Caption
A = Lower terminal
B = Insulating support
C = Fixed contact

**Fig. 27I**

## 8.6. Hints on constructing switchgear units with 4000 A rated current

The PowerCube modules are provided for rated currents up to 3600 A, but can also be used to construct switchgear units with rated current up to 4000 A.
This can be done thanks to applying a special fan in the rear part of the unit.
The characteristics of the fan used are listed below. This fan can be ordered as an accessory for the 3600 A enclosure. Assembly is to be carried out by the customer. In any case, certification of the completed switchgear remains the responsibility of the customer.

### Fan characteristics

| | | | 50 Hz | 60 Hz |
|---|---|---|---|---|
| Frequency | f | Hz | 50 | 60 |
| Rated voltage | U | V | 230 | 230 |
| Power consumption | $P_1$ | W | 270 | 280 |
| Speed | n | $min^{-1}$ | 2470 | 2600 |
| Capacity | C | µF | 6 | 6 |
| Max air volume | V | $m^3/h$ | 1180 | 1240 |
| Minimum pressure | | | 80Pa | 80Pa |

### Performance curve

We suggest putting the fan in the position shown in the figure 28b.

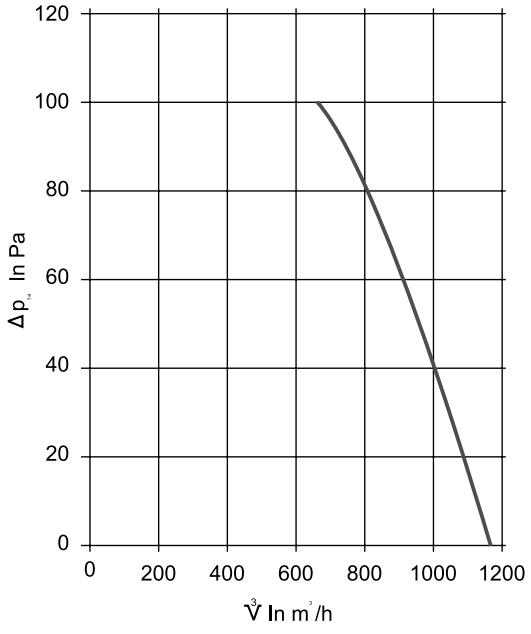
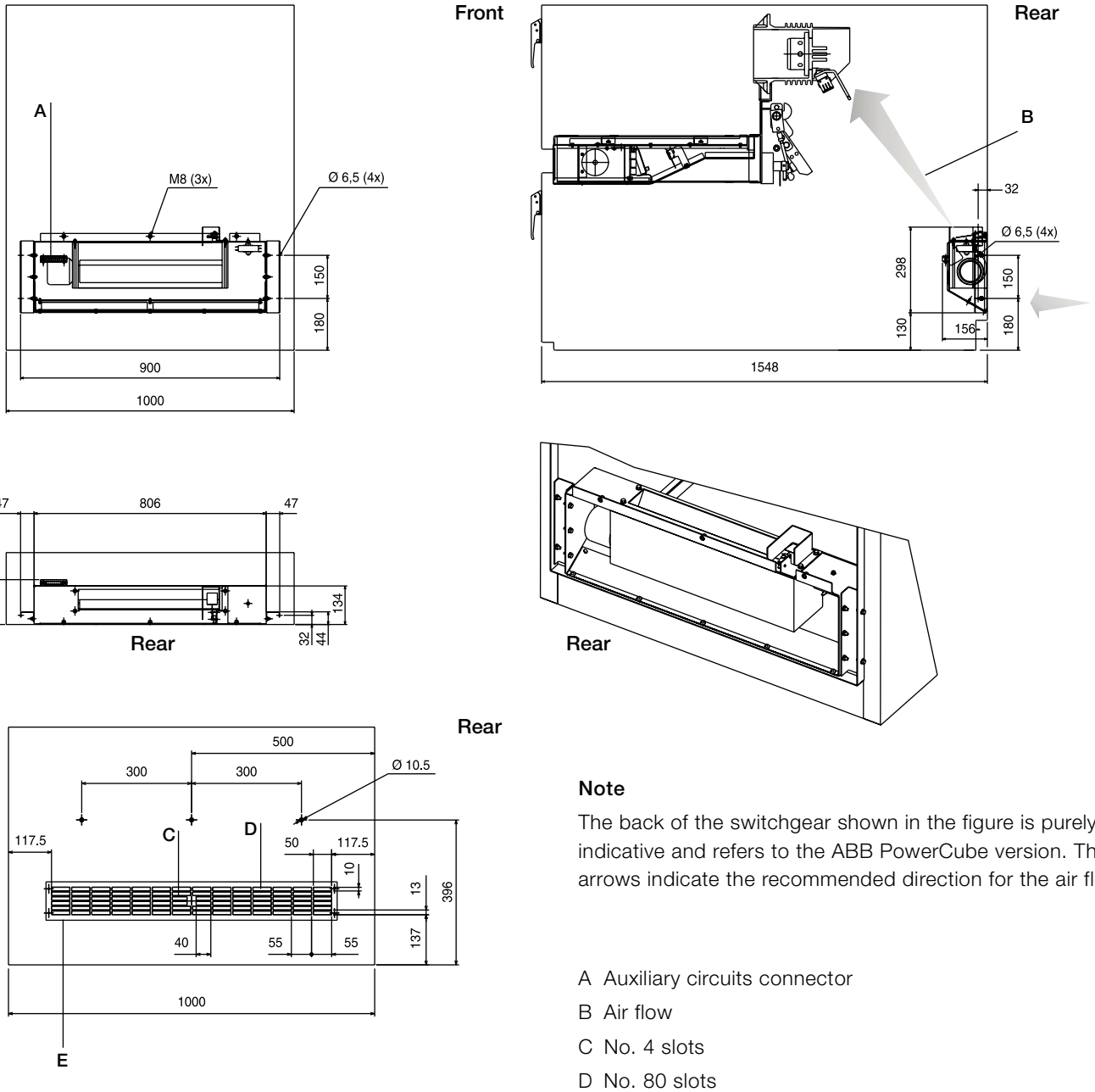



**Fig. 28a**




**Note**

The back of the switchgear shown in the figure is purely indicative and refers to the ABB PowerCube version. The arrows indicate the recommended direction for the air flow.

A Auxiliary circuits connector

B Air flow

C No. 4 slots

D No. 80 slots

E Rear sheet steel cut out of the panel

**Note**

We recommend the following procedures for turning the fans fitted on the PowerCube modules on and off.

**PowerCube Modules PB3 12-17 kV / 3600-4000 A**

Turning fans on if at least one phase exceeds the following current thresholds:

– 3000 A: delay of 60 s and consequent turning on of just the front fan
– 3600 A: delay of 60 s and consequent turning on of the rear fan as well as the front one

Turning fans off if all the phases drop below the following current thresholds:

– 3500 A: delay of 300 s and consequent turning off of just the rear fan
– 2900 A: delay of 300 s and consequent turning off of the front fan.

**PowerCube Modules PB5 24 kV / 2500 A**

Turning the fans on if at least one phase exceeds the 2250 A threshold: delay of 60 s and consequent turning on of the front fan.

Turning fans off if all the phases drop below the 2150 A threshold: delay of 300 s and consequent turning off of the front fan.

**Fig. 28b**

# 9. Putting into service

- **All operations for putting into service must be carried out by skilled personnel.**
- **Should the operations be prevented, do not force the mechanical interlocks but make sure that the operating sequence is correct.**
- **Before opening the door check the apparatus position through the inspection windows.**

Before putting into service, all the apparatus installed must be checked and tested as prescribed below, bearing in mind that in case of special installation configurations, **the tests indicated in the table may have to be integrated with others which are to be established by the plant technical manager.**

## 9.1. Preliminary operations

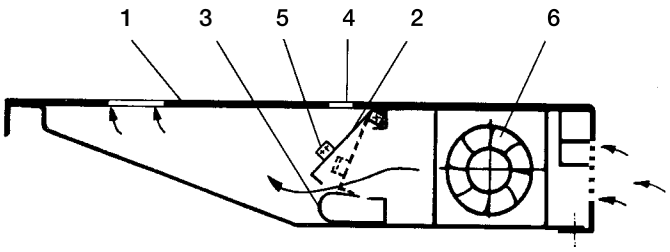
– Make sure there is no evident damage and remove any foreign bodies;
– make sure that the internal metal segregations (if supplied) are present;
– make sure that any insulating barriers or hoods previously removed have been remounted;
– check connection tightness;
– make sure that the sheets have been properly mounted and have not been deformed;
– make sure that all the metallic frame screws have been properly tightened;
– thoroughly clean the sheets and the insulating components by means of brushes and clean, dry cloths. Avoid any compressed air blasts unless they are dry and free of lubricating oil;
– remove dust and dirt from any air vent grids and ventilation ducts;
– for the units with 3600 A and 4000 A circuit-breaker up to 17.5 kV and 2500 A up to 24 kV, check operation of the fan and the free movement of the internal flap (see fig. 29);
– make sure that the vacuum interrupters of the V-Contact contactor and VD4, Vmax, VM1, eVM1 circuit-breaker have not been accidentally damaged, **in case of doubt do not hesitate to contact us;**
– insert the apparatus into the compartments in the isolated position with the apparatus open and insert the auxiliary instrument connectors;
– power the auxiliary circuits;
– make sure that the value of the circuit power supply ranges between 85% and 110% of the apparatus rated voltage value.

If all the above tests have been successful, carry out the inspection and testing procedures indicated in para. 11.2. **Should any problem arise, do not hesitate to contact us.**

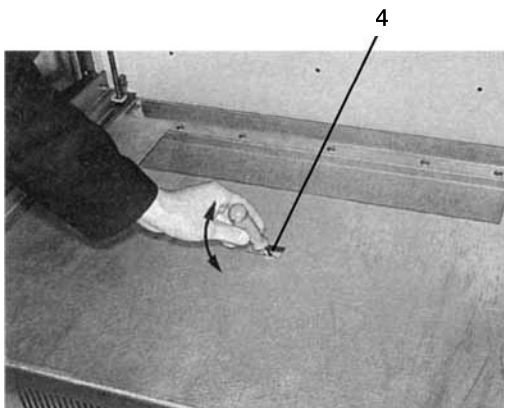
## 9.2. Measurements and tests

Carry out the tests indicated below only after performing the preliminary operations prescribed in para. 9.1.

- **The check is only successful if all the above tests have been passed successfully.**
- **If the inspection gives negative results, do not put the apparatus into service but contact us if necessary.**
- **Only supply the module with circuit-breakers open and doors closed.**




1 Horizontal surface
2 Flap
3 Spring hook
4 Opening for inspection
5 Stop
6 Centrifugal fan




**Lateral view of fan application.**
**The internal flap is shown in the service position (open).**

**Fig. 29**

| Subject of inspection | | Procedure | Positive test |
|---|---|---|---|
| 1 | Insulation resistance. | Main circuit: by means of a 5000 V Megger, measure the insulating resistance between phases as well as between phases and the exposed conductive part. | The insulation resistance value should not be lower than 1000 MΩ and constant in time. |
| 2 | Industrial frequency voltage test. | Main circuit: the voltage test is performed after installation in order to check the busbar duct connection insulation. The voltage test value must reach 80% of the test value prescribed for the individual tests (IEC 60271-200) | No electrical discharges should occur. |
| 3 | Electrical functionality test. | Supply the auxiliary circuits and perform some operations. | Normal operations and signals. |
| 4 | Open/closed control indicator. Operation counter (if supplied). | Put the apparatus in the isolated for test position and perform a few openings and closings. | Normal operations and signals. |
| 5 | Apparatus operations. | With the apparatus open, close the enclosure door and perform racking in, carry out a few openings and closings. | Normal operations and signals. |
| 6 | Electromechanical door interlock with apparatus in the inserted and intermediate positions (if supplied). | With the door closed, insert the apparatus first partially and then fully.i. | The door must not open after about two handle turns. |
| | | Isolate the truck and try to open the door. | The door opens. |
| 7 | Mechanical and electrical lock for preventing apparatus closing in the position between connected and isolated. | Put the truck in the intermediate position between isolated and connected. Attempt contactor closing. | Closing is not possible. |
| 8 | Lock for preventing racking in between apparatus with different characteristics. | From the withdrawn position, try to insert the plug into the socket. | Insertion is not possible. |
| 9 | Truck locking electromagnet. | De-energise the electromagnet and try to move it using the relevant handle. | The truck does not move. |
| 10 | Mechanical lock for preventing apparatus racking in/out when closed. | Put the truck in the isolated position, close the apparatus and try the racking in operation. | The operation is not possible. |
| 11 | Key lock for preventing racking in (if supplied). | With the contactor in the isolated position, turn the key 90° | Apparatus racking-in is prevented after about two handle turns.<br>The key can be removed. |
| 12 | IEC lock with plug-socket. | With apparatus racked in and in the positions between connected and isolated. | The plug-socket cannot be removed. |
| 13 | Shutter mechanical lock when the apparatus is withdrawn (if supplied). | With apparatus withdrawn try to manually move the shutters. | It is not possible to open the shutters. |
| 14 | Key lock for preventing earthing truck racking in (if supplied). | Trip the lock turning the key 180° and remove it. | The earthing truck cannot be inserted switching from the withdrawn to the isolated position. |
| 15 | Earthing switch (if supplied). | With isolated apparatus, close the earthing switch and re-open it. | The operation is possible. Check that the position signalled on the circuit-breaker front is correct. |
| | | Try to close the earthing switch with the apparatus inserted. | The earthing switch cannot be closed. |
| | | Try to insert the apparatus with isolated apparatus and earthing switch closed. | The operation is prevented after about two handle turns. |
| | | Try to operate the earthing switch with the apparatus in the intermediate position between isolated and connected. | The earthing switch operating lever cannot be inserted. |
| 16 | Key lock for earthing switch open (if supplied). | Turn the key 90° with apparatus isolated, earthing switch open and lever withdrawn. | The earthing switch operating lever cannot be inserted. |
| 17 | Key lock for earthing switch closed (if supplied). | Turn the key 90° with apparatus isolated, earthing switch closed and lever withdrawn. | The earthing switch operating lever cannot be inserted. |
| 18 | Double key lock for earthing switch open and closed (if supplied). | Turn the key 90° with apparatus isolated, earthing switch closed and lever withdrawn. | The earthing switch operating lever cannot be inserted. |
| 19 | Earthing switch electromechanical lock (if supplied). | With earthing switch open or closed and lock deenergised. | The earthing switch operations are not possible. |
| 20 | Operating pushbuttons with the apparatus door closed (if provided). | For HD4 and VD4, carry out the opening and closing operations using the pushbuttons.<br>For VM1 and contactors carry out the emergency opening operation. | The operations are normal. |

After performing the tests, make sure that all normal service conditions are restored.
Check that all the mechanical and electrical locks, (if deenergised to carry out the putting into service tests with switchboard disconnected) have been restored.

# 10. Periodic checks

- **The periodic checks must be carried out by skilled personnel.**
- **Before carrying out any operation, make sure that the apparatus is open with springs discharged.**
- **Before opening the door check the apparatus and earthing switch positions through the inspection windows.**

## 10.1. General information

During normal service the modules are maintenance-free. Any possible intervention depends on specific installation aspects such as operation frequency, interrupted current value, power factor and ambient conditions.
As a precaution, the paragraph below shows the inspection programme table with the relevant periodic checks. At least for the first check, it is advisable to follow what is specified in the table.

According to the results obtained, establish the best interval for subsequent operations.
It is advisable to keep a maintenance card and a service book containing all the operations performed along with date, description of possible anomalies, reference to the data needed to identify the apparatus (see chapter 2) etc.
For further information, refer to article 10 of IEC 60694 Standards.
In any case, should there be any problems, do not hesitate to contact us.
It is recommendable to perform an inspection within one year from putting the apparatus into service.

## 10.2. Inspection programme

| Subject of inspection | | Time intervals | Procedure |
|---|---|---|---|
| 1 | Carry out two mechanical closing and opening operations of the apparatus. | 3 years and in any case after a time not exceeding the one specified. | Check operation and transmission functionality. The apparatus must work normally without stopping in intermediate positions and the torque applied must not exceed 200 Nm. |
| 2 | Visual inspection of insulating parts. | 3 years and in any case in relation to the environmental pollution. | Insulating parts must be free from dust, dirt, cracks, traces of surface discharges and damage. Remove any dust and dirt by means of a vacuum cleaner and dry, clean cloths. |
| 3 | Auxiliary contacts. | 3 years. In any case, refer to the specific manuals of the apparatus. | Check functionality and signals. |
| 4 | Auxiliary circuit conductors. | 5 years. | Check whether any cabling strap is loose or broken and connection tightness. |
| 5 | Interlocks. | 3 years. | Check device functionality. |
| 6 | Visual inspection of earthing switch contacts. | 5 years. | Check that contacts are not deformed, eroded or oxidised. Lubricate the contacts with Molydal EL/5 (Industrial Service) grease or Vaseline. |
| 7 | Apparatus springs. | 5 years. In any case, refer to the specific manuals of the apparatus. | Check that the seal placed on the spring register is intact. |
| 8 | Power connections. | 3 years. | The connections must be tight and have no traces of overheating or oxidisation. |
| 9 | Insulation resistance measurement. | 3 years. | See para. 9.2. (table). |

**For the routine checks and maintenance of apparatus and protection devices, please refer to the relative instruction manuals.**

# 11. Maintenance operations

- **Maintenance must be carried out either by our personnel or by qualified skilled personnel. Should the customer's personnel be in charge of maintenance, the customer is responsible for any operation performed on the apparatus.**
- **While performing routine checks and maintenance operations, de-energise all the components.**
- **The spare parts shown in the table "List of spare parts/accessories" can only be replaced by our personnel. For the apparatus, consult the relevant manuals.**
- **Use original spare parts only.**

## 11.1. General information

Thanks to their simple design, PowrBox modules do not require any particular maintenance except for the "Periodic checks" in paragraph 10.
In order to avoid any hazardous deterioration of the insulating level, it is advisable to perform the first inspection six months after putting into service so as to establish the routine check intervals and the maintenance card.
Moreover, it is recommendable to follow the instructions for the single items according to the instruction manuals supplied with the apparatus.
It is advisable to keep a maintenance card and a service book containing all the operations performed along with date, description of possible anomalies, reference to the data needed to identify the apparatus (see chapter 2) etc.
For further information, refer to article 10 of the IEC 60694 Standards.
Should you have any problems, do not hesitate to contact us.
The electrical apparatus is easily affected by ambient conditions and can be damaged by abnormal service conditions.
Dust, heat, humidity, corrosive atmosphere, chemical residues, fumes, vibrations and other elements can influence apparatus and the life of the electrical apparatus.
Especially when combined, these conditions cause premature faults.
The most important rules to follow are:
– keep clean;
– keep dry;
– tighten bolts and connections;
– preserve the mechanical parts from excessive friction.

The instructions concerning the operations to be carried out on the various parts of the module, excluding the apparatus for which the relevant instruction manuals should be referred to.

## 11.2. Metallic structure

This comprises the supporting construction complete with removable panels, vertical and horizontal segregating sheets, hinges, doors and locks.
These parts can either be galvanised or painted.

### Painted parts

The module doors are painted using epoxy powder paints whose minimum thickness is more than 40 µm.

### Painting

Any damage, scratches or scrapes caused to the module external paint during installation can be touched up using the paint supplied with the special paint.

### Touching up

On request, sufficient paint for touching up after installation can be supplied with the module. For its use follow the paint supplier's instructions. If these are not available, proceed as follows:

- clean the part to be touched up with damp abrasive paper and smooth off the edges of the damaged area;
- prepare the necessary amount of paint adding some catalyst (30% of the paint by weight);
- try the paint on a piece of sheet first and see the result. Any brush marks can be reduced by adding more solvent to the paint, which can be kept in the fridge for about 24 hours before it solidifies.

### Cleaning

The painted components can be cleaned using either a cloth with water and soap or a paint solvent when very dirty. In this case, try the solvent on a surface out of sight to make sure it doesn't remove the paint coating.

### Galvanised components

The galvanised and passivated components can be cleaned by means of a dry cloth.
Oil and grease can be removed using a cloth soaked in a suitable solvent. To polish the surface, repeat the previous operation.

## 11.3. Mechanical actuators

The mechanical actuators comprise all the mechanical parts of the module for carrying out the operations, locks and safety devices. The force, prevention and safety locks are all considered mechanical actuators.
The moving components are lubricated and tested while assembling the switchboard. Contact our personnel for mounting any accessories on a switchboard already installed.

**The mechanical interlocks must not be ignored, but used properly so as to avoid any hazardous situations.**

The mechanical interlocks must reach the final locked/unlocked positions without any intermediate stops.
They must be tested several times to check that they operate perfectly. The operating force required must also be checked.
Always make sure that the mechanical interlock position corresponds with the position of both the part controlled device and with the interlocked apparatus.
If excessive force is required to activate the device it means that the mechanism is prevented from moving.
In this case, please contact us.

# 12. Accessories and spare parts

- **Either our personnel or qualified skilled customer personnel must mount the spare parts and/or the accessories carefully following the instructions enclosed.**
- **Before performing any operation make sure that all the apparatus is open and de-energised (main circuit and auxiliary circuits).**

To order spare parts or accessories, always specify the serial number of the modules in which the spare parts are to be installed.
For any enquiry about spare part availability and ordering, please contact us.

## 12.1. Accessories and tools for operations

**Standard completion accessories:**

The module is usually supplied complete with:
– operating lever for any earthing switches;
– emergency opening lever for VM1circuit-breaker and VSC contactor.
– handle for circuit-breaker racking in/out;
– project diagrams and drawings;
– instructions for installation, service and maintenance;
– auxiliary position contacts (5 isolated changeover contacts plus 5 connected changeover contacts).

**Completion items and accessories on request**

On request, the module can be completed with supply of the following accessories:
– lifting eyebolts;
– truck for transporting the circuit-breaker out of switchboard;
– auxiliary contacts for signalling earthing switch open/closed (5-10 closing contacts plus 5-10 opening contacts);
– voltage indicators;
– anti-condensation heaters and thermostat (rated voltage values: 110-220 V);
– opening and closing pushbutton for VD4-HD4 circuit-breakers (to be specified at the time of ordering because they cannot be applied afterwards (only for PB/E);
– rear fan;
– electro-mechanical lock on the earthing switch

**Other components**

– shutter Fail-safe device;
– contact for signalling connected and key lock on earthing truck insertion
– electromechanical interlock on circuit-breaker unit door.

## 12.2 . Spare parts

For the apparatus, refer to the relative installation, service and maintenance instructions.
The module spare parts normally supplied as a rule are listed in the table below.

| Description of spare part | Assembly by the customer |
|---|---|
| Earthing switch | No |
| Auxiliary contacts for limit switch inserted | Yes |
| Auxiliary contacts for limit switch isolated | Yes |

For more information please contact:

**ABB S.p.A.**
**Power Products Division**
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RELION® PROTECTION AND CONTROL

# REX640

## Technical Manual







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# Section 1 Introduction

## 1.1 This manual

The technical manual contains application and functionality descriptions and lists function blocks, logic diagrams, input and output signals, setting parameters and technical data sorted per function. The manual can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

## 1.2 Intended audience

This manual addresses system engineers and installation and commissioning personnel, who use technical data during engineering, installation and commissioning, and in normal service.

The system engineer must have a thorough knowledge of protection systems, protection equipment, protection functions and the configured functional logic in the protection relays. The installation and commissioning personnel must have a basic knowledge in handling electronic equipment.

# 1.3 Product documentation

## 1.3.1 Product documentation set

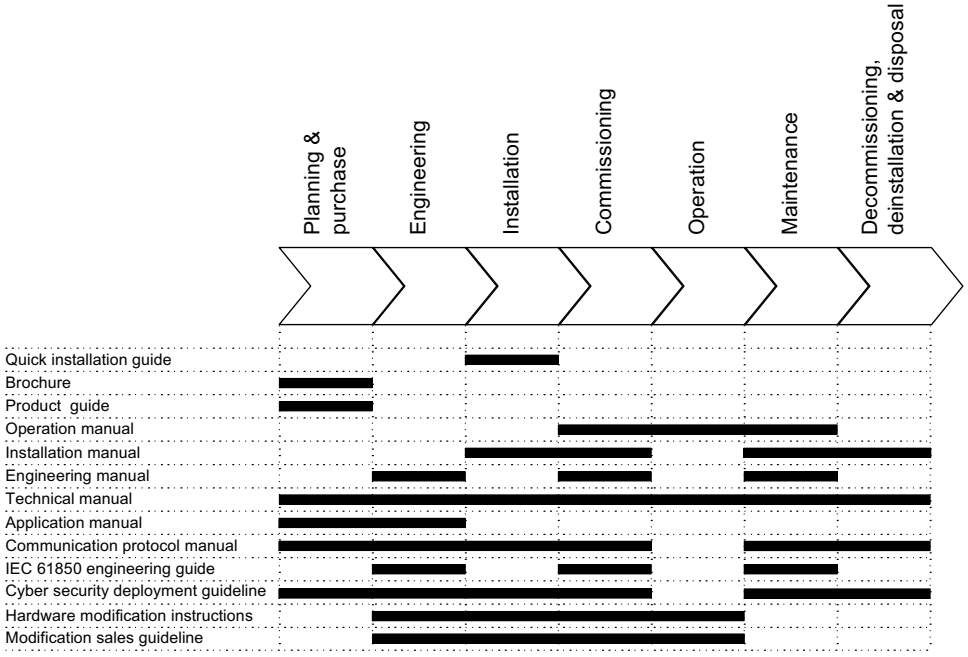



*Figure 1: The intended use of documents during the product life cycle*

## 1.3.2 Document revision history

| Document revision/date | Product connectivity level (PCL) | History |
|---|---|---|
| A/2018-12-14 | 1 | First release |
| B/2019-03-27 | 1 | Content updated |
| C/2019-08-15 | 1 | Content updated |

### 1.3.3 Related documentation

| Name of the document | Document ID |
|---|---|
| TISSUES Implementation Conformance Statement (TICS) for the IEC 61850 interface in REX640 | 1MRS759027 |
| Protocol Implementation extra Information for Testing (PIXIT) for the IEC 61850 interface in REX640 | 1MRS759030 |
| Protocol Implementation extra Information for Testing (PIXIT) for the IEC 61850 9–2LE interface in REX640 | 1MRS759037 |
| Protocol Implementation Conformance Statement (PICS) for the IEC 61850 interface in REX640 | 1MRS759029 |
| IEC 61850 Ed2 Model Implementation Conformance Statement (MICS) for REX640 | 1MRS759028 |

Download the latest documents from the ABB Web site www.abb.com/relion.

## 1.4 Symbols and conventions

### 1.4.1 Symbols

The electrical warning icon indicates the presence of a hazard which could result in electrical shock.

The warning icon indicates the presence of a hazard which could result in personal injury.

The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

The information icon alerts the reader of important facts and conditions.

The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

## 1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms are spelled out in the glossary. The glossary also contains definitions of important terms.
- Menu paths are presented in bold.
  Select **Main menu/Settings**.
- Parameter names are shown in italics.
  The function can be enabled and disabled with the *Operation* setting.
- Parameter values are indicated with quotation marks.
  The corresponding parameter values are "On" and "Off".
- Input/output messages and monitored data names are shown in Courier font.
  When the function starts, the START output is set to TRUE.
- This document assumes that the parameter setting visibility is "Advanced".
- Protective earthing is indicated in figures with the symbol ⏚.

## 1.4.3 Functions, codes and symbols

*Table 1: Functions included in the relay*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| **Protection** | | | |
| Distance protection | DSTPDIS | Z< | 21P,21N |
| Local acceleration logic | DSTPLAL | LAL | 21LAL |
| Scheme communication logic | DSOCPSCH | CL | 85 21SCHLGC |
| Current reversal and weak-end infeed logic | CRWPSCH | CLCRW | 85 21CREV,WEI |
| Communication logic for residual overcurrent | RESCPSCH | CLN | 85 67G/N SCHLGC |
| Current reversal and weak-end infeed logic for residual overcurrent | RCRWPSCH | CLCRWN | 85 67G/N CREV,WEI |
| Line differential protection with inzone power transformer | LNPLDF | 3Id/I> | 87L |
| Binary signal transfer | BSTGAPC | BST | BST |
| Switch-onto-fault protection | CVPSOF | CVPSOF | SOTF |
| Three-phase non-directional overcurrent protection, low stage | PHLPTOC | 3I> | 51P-1 |
| Three-phase non-directional overcurrent protection, high stage | PHHPTOC | 3I>> | 51P-2 |

Table continues on next page

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Three-phase non-directional overcurrent protection, instantaneous stage | PHIPTOC | 3I>>> | 50P |
| Three-phase directional overcurrent protection, low stage | DPHLPDOC | 3I> -> | 67P/51P-1 |
| Three-phase directional overcurrent protection, high stage | DPHHPDOC | 3I>> -> | 67P/51P-2 |
| Non-directional earth-fault protection, low stage | EFLPTOC | Io> | 51G/51N-1 |
| Non-directional earth-fault protection, high stage | EFHPTOC | Io>> | 51G/51N-2 |
| Non-directional earth-fault protection, instantaneous stage | EFIPTOC | Io>>> | 50G/50N |
| Directional earth-fault protection, low stage | DEFLPDEF | Io> -> | 67G/N-1 51G/N-1 |
| Directional earth-fault protection, high stage | DEFHPDEF | Io>> -> | 67G/N-1 51G/N-2 |
| Three-phase power directional element | DPSRDIR | I1 -> | 67P-TC |
| Neutral power directional element | DNZSRDIR | I2 ->, Io -> | 67N-TC |
| Admittance-based earth-fault protection | EFPADM | Yo> -> | 21NY |
| Multifrequency admittance-based earth-fault protection | MFADPSDE | Io> -> Y | 67NYH |
| Wattmetric-based earth-fault protection | WPWDE | Po> -> | 32N |
| Transient/intermittent earth-fault protection | INTRPTEF | Io> -> IEF | 67NTEF/NIEF |
| Harmonics-based earth-fault protection | HAEFPTOC | Io>HA | 51NH |
| Negative-sequence overcurrent protection | NSPTOC | I2>M | 46M |
| Phase discontinuity protection | PDNSPTOC | I2/I1> | 46PD |
| Residual overvoltage protection | ROVPTOV | Uo> | 59G/59N |
| Three-phase undervoltage protection | PHPTUV | 3U< | 27 |
| Three-phase overvoltage variation protection | PHVPTOV | 3Urms> | 59.S1 |
| Three-phase overvoltage protection | PHPTOV | 3U> | 59 |
| Positive-sequence overvoltage protection | PSPTOV | U1> | 59PS |
| Positive-sequence undervoltage protection | PSPTUV | U1< | 27PS |
| Negative-sequence overvoltage protection | NSPTOV | U2> | 59NS |
| Frequency protection | FRPFRQ | f>/f<,df/dt | 81 |
| Three-phase voltage-dependent overcurrent protection | PHPVOC | 3I(U)> | 51V |
| Overexcitation protection | OEPVPH | U/f> | 24 |

Table continues on next page

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Three-phase thermal protection for feeders, cables and distribution transformers | T1PTTR | 3Ith>F | 49F |
| Three-phase thermal overload protection, two time constants | T2PTTR | 3Ith>T/G/C | 49T/G/C |
| Three-phase overload protection for shunt capacitor banks | COLPTOC | 3I> 3I< | 51,37,86C |
| Current unbalance protection for shunt capacitor banks | CUBPTOC | dI>C | 60N |
| Three-phase current unbalance protection for shunt capacitor banks | HCUBPTOC | 3dI>C | 60P |
| Shunt capacitor bank switching resonance protection, current based | SRCPTOC | TD> | 55ITHD |
| Compensated neutral unbalance voltage protection | CNUPTOV | CNU> | 59NU |
| Directional negative-sequence overcurrent protection | DNSPDOC | I2> -> | 67Q |
| Low-voltage ride-through protection | LVRTPTUV | UU | 27RT |
| Voltage vector shift protection | VVSPPAM | VS | 78VS |
| Directional reactive power undervoltage protection | DQPTUV | Q> -> ,3U< | 32Q,27 |
| Reverse power/directional overpower protection | DOPPDPR | P>/Q> | 32R/32O |
| Underpower protection | DUPPDPR | P< | 32U |
| Three-phase underimpedance protection | UZPDIS | ZZ | 21G |
| Three-phase underexcitation protection | UEXPDIS | X< | 40 |
| Third harmonic-based stator earth-fault protection | H3EFPSEF | dUo>/Uo3H | 64TN |
| Rotor earth-fault protection (injection method) | MREFPTOC | Io>R | 64R |
| High-impedance or flux-balance based differential protection | MHZPDIF | 3dIHi>M | 87HIM |
| Out-of-step protection with double blinders | OOSRPSB | OOS | 78PS |
| Negative-sequence overcurrent protection for machines | MNSPTOC | I2>M | 46M |
| Loss of phase, undercurrent | PHPTUC | 3I< | 37 |
| Loss of load supervision | LOFLPTUC | 3I< | 37 |
| Motor load jam protection | JAMPTOC | Ist> | 50TDJAM |
| Motor start-up supervision | STTPMSU | Is2t n< | 49,66,48,50TDLR |
| Motor start counter | MSCPMRI | n< | 66 |
| Phase reversal protection | PREVPTOC | I2>> | 46R |
| Thermal overload protection for motors | MPTTR | 3Ith>M | 49M |

Table continues on next page

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Stabilized and instantaneous differential protection for machines | MPDIF | 3dI>M/G | 87M/87G |
| Underpower factor protection | MPUPF | PF< | 55U |
| Stabilized and instantaneous differential protection for two- or three-winding transformers | TR3PTDF | 3dI>3W | 87T3 |
| Stabilized and instantaneous differential protection for two-winding transformers | TR2PTDF | 3dI>T | 87T |
| Numerical stabilized low-impedance restricted earth-fault protection | LREFPNDF | dIoLo> | 87NLI |
| High-impedance based restricted earth-fault protection | HREFPDIF | dIoHi> | 87NHI |
| High-impedance differential protection for phase A | HIAPDIF | dHi_A> | 87_A |
| High-impedance differential protection for phase B | HIBPDIF | dHi_B> | 87_B |
| High-impedance differential protection for phase C | HICPDIF | dHi_C> | 87_C |
| Circuit breaker failure protection | CCBRBRF | 3I>/Io>BF | 50BF |
| Three-phase inrush detector | INRPHAR | 3I2f> | 68HB |
| Master trip | TRPPTRC | Master Trip | 94/86 |
| Arc protection | ARCSARC | ARC | AFD |
| High-impedance fault detection | PHIZ | HIF | HIZ |
| Fault locator | SCEFRFLO | FLOC | FLOC |
| Load-shedding and restoration | LSHDPFRQ | UFLS/R | 81LSH |
| Multipurpose protection | MAPGAPC | MAP | MAP |
| **Control** | | | |
| Circuit-breaker control | CBXCBR | I <-> O CB | 52 |
| Three-state disconnector control | P3SXSWI | I<->O P3S | 29DS/GS |
| Disconnector control | DCXSWI | I <-> O DCC | 29DS |
| Earthing switch control | ESXSWI | I <-> O ESC | 29GS |
| Three-state disconnector position indication | P3SSXSWI | I<->O P3SS | 29DS/GS |
| Disconnector position indication | DCSXSWI | I <-> O DC | 29DS |
| Earthing switch position indication | ESSXSWI | I <-> O ES | 29GS |
| Emergency start-up | ESMGAPC | ESTART | EST,62 |
| Autoreclosing | DARREC | O -> I | 79 |
| Autosynchronizer for generator breaker | ASGCSYN | AUTOSYNCG | 25AUTOSYNCG |
| Autosynchronizer for network breaker | ASNSCSYN | AUTOSYNCBT/T | 25AUTOSYNCBT/T |
| Autosynchronizer co-ordinator | ASCGAPC | AUTOSYNC | 25AUTOSYNC |
| Synchronism and energizing check | SECRSYN | SYNC | 25 |

Table continues on next page

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Tap changer control with voltage regulator | OL5ATCC | COLTC | 90V |
| Transformer data combiner | OLGAPC | OLGAPC | OLGAPC |
| Petersen coil controller | PASANCR | ANCR | 90 |
| **Condition monitoring and supervision** | | | |
| Circuit-breaker condition monitoring | SSCBR | CBCM | 52CM |
| Hot-spot and insulation ageing rate monitoring for transformers | HSARSPTR | 3Ihp>T | 26/49HS |
| Trip circuit supervision | TCSSCBR | TCS | TCM |
| Current circuit supervision | CCSPVC | MCS 3I | CCM |
| Current circuit supervision for transformers | CTSRCTF | MCS 3I,I2 | CCM 3I,I2 |
| Current transformer supervision for high-impedance protection scheme for phase A | HZCCASPVC | MCS I_A | CCM_A |
| Current transformer supervision for high-impedance protection scheme for phase B | HZCCBSPVC | MCS I_B | CCM_B |
| Current transformer supervision for high-impedance protection scheme for phase C | HZCCCSPVC | MCS I_C | CCM_C |
| Fuse failure supervision | SEQSPVC | FUSEF | VCM, 60 |
| Protection communication supervision | PCSITPC | PCS | PCS |
| Runtime counter for machines and devices | MDSOPT | OPTS | OPTM |
| Three-phase remanent undervoltage supervision | MSVPR | 3U<R | 27R |
| **Measurement** | | | |
| Three-phase current measurement | CMMXU | 3I | IA, IB, IC |
| Sequence current measurement | CSMSQI | I1, I2, I0 | I1, I2, I0 |
| Residual current measurement | RESCMMXU | Io | IG |
| Three-phase voltage measurement | VMMXU | 3U | VA, VB, VC |
| Single-phase voltage measurement | VAMMXU | U_A | V_A |
| Residual voltage measurement | RESVMMXU | Uo | VG/VN |
| Sequence voltage measurement | VSMSQI | U1, U2, U0 | V1, V2, V0 |
| Three-phase power and energy measurement | PEMMXU | P, E | P, E |
| Load profile recorder | LDPRLRC | LOADPROF | LOADPROF |
| Frequency measurement | FMMXU | f | f |
| Tap changer position indication | TPOSYLTC | TPOSM | 84T |
| **Power quality** | | | |
| Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics | CHMHAI | PQM3IH | PQM ITHD,IDC |

Table continues on next page

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics | VHMHAI | PQM3VH | PQM VTHD,VDC |
| Voltage variation | PHQVVR | PQMU | PQMV SWE,SAG,INT |
| Voltage unbalance | VSQVUB | PQUUB | PQMV UB |
| **Traditional LED indication** | | | |
| LED indication control | LEDPTRC | LEDPTRC | LEDPTRC |
| Virtual programmable LED control | LED | LED | LED |
| **Logging functions** | | | |
| Disturbance recorder (common functionality) | RDRE | DR | DFR |
| Disturbance recorder, analog channels 1...12 | A1RADR | A1RADR | A1RADR |
| Disturbance recorder, analog channels 13...24 | A2RADR | A2RADR | A2RADR |
| Disturbance recorder, binary channels 1...32 | B1RBDR | B1RBDR | B1RBDR |
| Disturbance recorder, binary channels 33...64 | B2RBDR | B2RBDR | B2RBDR |
| Fault recorder | FLTRFRC | FAULTREC | FR |
| **Other functionality** | | | |
| Parameter setting groups | PROTECTION | PROTECTION | PROTECTION |
| Time master supervision | GNRLLTMS | GNRLLTMS | GNRLLTMS |
| Serial port supervision | SERLCCH | SERLCCH | SERLCCH |
| IEC 61850-1 MMS | MMSLPRT | MMSLPRT | MMSLPRT |
| IEC 61850-1 GOOSE | GSELPRT | GSELPRT | GSELPRT |
| IEC 60870-5-103 protocol | I3CLPRT | I3CLPRT | I3CLPRT |
| DNP3 protocol | DNPLPRT | DNPLPRT | DNPLPRT |
| Modbus protocol | MBSLPRT | MBSLPRT | MBSLPRT |
| OR gate with two inputs | OR | OR | OR |
| OR gate with six inputs | OR6 | OR6 | OR6 |
| OR gate with twenty inputs | OR20 | OR20 | OR20 |
| AND gate with two inputs | AND | AND | AND |
| AND gate with six inputs | AND6 | AND6 | AND6 |
| AND gate with twenty inputs | AND20 | AND20 | AND20 |
| XOR gate with two inputs | XOR | XOR | XOR |
| NOT gate | NOT | NOT | NOT |
| Real maximum value selector | MAX3R | MAX3R | MAX3R |
| Real minimum value selector | MIN3R | MIN3R | MIN3R |
| Rising edge detector | R_TRIG | R_TRIG | R_TRIG |
| Falling edge detector | F_TRIG | F_TRIG | F_TRIG |
| Real switch selector | SWITCHR | SWITCHR | SWITCHR |

Table continues on next page

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Integer 32-bit switch selector | SWITCHI32 | SWITCHI32 | SWITCHI32 |
| SR flip-flop, volatile | SR | SR | SR |
| RS flip-flop, volatile | RS | RS | RS |
| Minimum pulse timer, two channels | TPGAPC | TP | 62TP |
| Minimum pulse timer second resolution, two channels | TPSGAPC | TPS | 62TPS |
| Minimum pulse timer minutes resolution, two channels | TPMGAPC | TPM | 62TPM |
| Pulse counter for energy measurement | PCGAPC | PCGAPC | PCGAPC |
| Pulse timer, eight channels | PTGAPC | PT | 62PT |
| Time delay off, eight channels | TOFGAPC | TOF | 62TOF |
| Time delay on, eight channels | TONGAPC | TON | 62TON |
| Daily timer | DTMGAPC | DTM | DTM |
| Calendar function | CALGAPC | CAL | CAL |
| SR flip-flop, eight channels, nonvolatile | SRGAPC | SR | SR |
| Boolean value event creation | MVGAPC | MV | MV |
| Integer value event creation | MVI4GAPC | MVI4 | MVI4 |
| Analog value event creation with scaling | SCA4GAPC | SCA4 | SCA4 |
| Generic control points | SPCGAPC | SPC | SPCG |
| Generic up-down counter | UDFCNT | UDCNT | UDCNT |
| Local/Remote control | CONTROL | CONTROL | CONTROL |
| External HMI wake-up | EIHMI | EIHMI | EIHMI |
| Real addition | ADDR | ADDR | ADDR |
| Real subtraction | SUBR | SUBR | SUBR |
| Real multiplication | MULR | MULR | MULR |
| Real division | DIVR | DIVR | DIVR |
| Real equal comparator | EQR | EQR | EQR |
| Real not equal comparator | NER | NER | NER |
| Real greater than or equal comparator | GER | GER | GER |
| Real less than or equal comparator | LER | LER | LER |
| Voltage switch | VMSWI | VSWI | VSWI |
| Current sum | CMSUM | CSUM | CSUM |
| Current switch | CMSWI | CMSWI | CMSWI |
| Phase current preprocessing | ILTCTR | ILTCTR | ILTCTR |
| Residual current preprocessing | RESTCTR | RESTCTR | RESTCTR |
| Phase and residual voltage preprocessing | UTVTR | UTVTR | UTVTR |
| SMV stream receiver (IEC 61850-9-2LE) | SMVRCV | SMVRCV | SMVRCV |

Table continues on next page

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| SMV stream sender (IEC 61850-9-2LE) | SMVSENDER | SMVSENDER | SMVSENDER |
| Redundant Ethernet channel supervison | RCHLCCH | RCHLCCH | RCHLCCH |
| Ethernet channel supervision | SCHLCCH | SCHLCCH | SCHLCCH |
| HMI Ethernet channel supervision | HMILCCH | HMILCCH | HMILCCH |
| Received GOOSE binary information | GOOSERCV_BIN | GOOSERCV_BIN | GOOSERCV_BIN |
| Received GOOSE double binary information | GOOSERCV_DP | GOOSERCV_DP | GOOSERCV_DP |
| Received GOOSE measured value information | GOOSERCV_MV | GOOSERCV_MV | GOOSERCV_MV |
| Received GOOSE 8b-it integer value information | GOOSERCV_INT8 | GOOSERCV_INT8 | GOOSERCV_INT8 |
| Received GOOSE 32-bit integer value information | GOOSERCV_INT32 | GOOSERCV_INT32 | GOOSERCV_INT32 |
| Received GOOSE interlocking information | GOOSERCV_INTL | GOOSERCV_INTL | GOOSERCV_INTL |
| Received GOOSE measured value (phasor) information | GOOSERCV_CMV | GOOSERCV_CMV | GOOSERCV_CMV |
| Received GOOSE enumerator value information | GOOSERCV_ENUM | GOOSERCV_ENUM | GOOSERCV_ENUM |
| Bad signal quality | QTY_BAD | QTY_BAD | QTY_BAD |
| Good signal quality | QTY_GOOD | QTY_GOOD | QTY_GOOD |
| GOOSE communication quality | QTY_GOOSE_COMM | QTY_GOOSE_COMM | QTY_GOOSE_COMM |
| GOOSE data health | T_HEALTH | T_HEALTH | T_HEALTH |
| Fault direction evaluation | T_DIR | T_DIR | T_DIR |
| Enumerator to boolean conversion | T_TCMD | T_TCMD | T_TCMD |
| 32-bit integer to binary command conversion | T_TCMD_BIN | T_TCMD_BIN | T_TCMD_BIN |
| Binary command to 32-bit integer conversion | T_BIN_TCMD | T_BIN_TCMD | T_BIN_TCMD |
| Switching device status decoder - CLOSE position | T_POS_CL | T_POS_CL | T_POS_CL |
| Switching device status decoder - OPEN position | T_POS_OP | T_POS_OP | T_POS_OP |
| Switching device status decoder - OK status | T_POS_OK | T_POS_OK | T_POS_OK |
| Controllable gate, 8 Channels | GATEGAPC | GATEGAPC | GATEGAPC |
| Security application | GSAL | GSAL | GSAL |
| Hotline tag | HLTGAPC | HLTGAPC | HLTGAPC |
| 16 settable 32-bit integer values | SETI32GAPC | SETI32GAPC | SETI32GAPC |
| 16 settable real values | SETRGAPC | SETRGAPC | SETRGAPC |
| Boolean to integer 32-bit conversion | T_B16_TO_I32 | T_B16_TO_I32 | T_B16_TO_I32 |
| Integer 32-bit to boolean conversion | T_I32_TO_B16 | T_I32_TO_B16 | T_I32_TO_B16 |

Table continues on next page

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Integer 32-bit to real conversion | T_I32_TO_R | T_I32_TO_R | T_I32_TO_R |
| Real to integer 8-bit conversion | T_R_TO_I8 | T_R_TO_I8 | T_R_TO_I8 |
| Real to integer 32-bit conversion | T_R_TO_I32 | T_R_TO_I32 | T_R_TO_I32 |
| Constant FALSE | FALSE | FALSE | FALSE |
| Constant TRUE | TRUE | TRUE | TRUE |

# Section 2 REX640 overview

## 2.1 Overview

REX640 is a powerful all-in-one protection and control relay for use in advanced power distribution and generation applications with unmatched flexibility available during the complete life cycle of the device – from ordering of the device, through testing and commissioning to upgrading the functionality of the modular software and hardware as application requirements change.

The modular design of both hardware and software elements facilitates the coverage of any comprehensive protection application requirement that may arise during the complete life cycle of the relay and substation.

REX640 makes modification and upgrading easy and pushes the limits of what can be achieved with a single device.

### 2.1.1 PCM600 and relay connectivity package version

- Protection and Control IED Manager PCM600 2.9 Hotfix 1 or later
- REX640 Connectivity Package Ver.1.0 or later



Download connectivity packages from the ABB Web site www.abb.com/relion or directly with Update Manager in PCM600.

## 2.2 Relay hardware

The relay includes a Ready LED on the power supply module that indicates the relay's status. In normal situations, the Ready LED has a steady green light. Any other situation that requires the operator’s attention is indicated with a flashing light.

The relay has mandatory and optional slots. A mandatory slot always contains a module but an optional slot may be empty, depending on the composition variant ordered.

*Table 2: Module slots*

| Module | Slot A1 | Slot A2 | Slot B | Slot C | Slot D | Slot E | Slot F | Slot G |
|---|---|---|---|---|---|---|---|---|
| ARC1001 | o | | | | | | | |
| COM1001 | | ● | | | | | | |
| COM1002 | | ● | | | | | | |
| COM1003 | | ● | | | | | | |
| COM1004 | | ● | | | | | | |
| COM1005 | | ● | | | | | | |
| BIO1001 | | | ● | o | o | | | |
| BIO1002 | | | ● | o | o | | | |
| BIO1003 | | | | | | o | | |
| BIO1004 | | | | | | o | | |
| RTD1001 | | | | o | o | | | |
| AIM1001 | | | | | | o | ● | |
| AIM1002 | | | | | | o | ● | |
| SIM1001 | | | | | | o | ● | |
| PSM1001 | | | | | | | | ● |
| PSM1002 | | | | | | | | ● |
| PSM1003 | | | | | | | | ● |

● = Mandatory to have one of the allocated modules in the slot
o = Optional to have one of the allocated modules in the slot. The population (order) of the modules in the optional slots depends on the composition variant ordered.

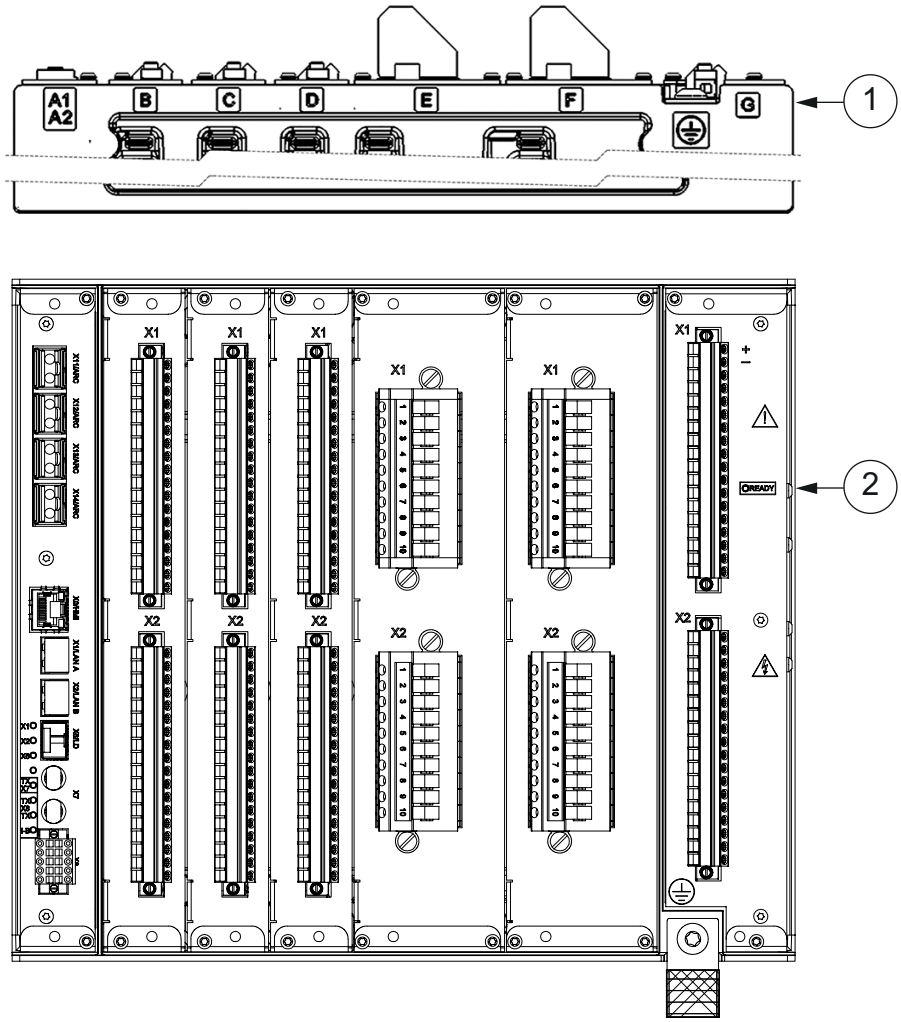



*Figure 2: Hardware module slot overview of the REX640 relay*

1 Slot markings in enclosure (top and bottom)

2 Ready LED

*Table 3: Module description*

| Module | Description |
|---|---|
| ARC1001 | 4 × ARC sensor inputs (lense, loop or mixed) |
| COM1001 | 1 × RJ-45 (LHMI port) + 3 × RJ-45 + 1 × LD-SFP[1)] |
| COM1002 | 1 × RJ-45 (LHMI port) + 2 × LC + 1 × RJ-45 + 1 × LD-SFP |
| COM1003 | 1 × RJ-45 (LHMI port) + 3 × LC + 1 × LD-SFP |
| COM1004 | 1 × RJ-45 (LHMI port) + 2 × RJ-45 + 1 × LD-SFP + 1 × RS-485/IRIG-B + 1 × FO UART |
| COM1005 | 1 × RJ-45 (LHMI port) + 2 × LC + 1 × LD-SFP + 1 × RS-485/IRIG-B + 1 × FO UART |
| Table continues on next page | |

| Module | Description |
|---|---|
| BIO1001/ BIO1003 | 14 × BI + 8 × SO |
| BIO1002/ BIO1004 | 6 × SPO + 2 × SPO (TCS) + 9 × BI |
| RTD1001 | 10 × RTD channels + 2 × mA channels (input/output) |
| AIM1001 | 4 × CT + 1 × CT (sensitive, for residual current only) + 5 × VT |
| AIM1002 | 6 × CT + 4 × VT |
| SIM1001 | 3 × combi sensor inputs + 1 × CT (sensitive, for residual current only) + 1 × VT |
| PSM1001 | 24...60 VDC, 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO |
| PSM1002 | 48...250 VDC / 100...240 VAC, 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO |
| PSM1003 | 110/125 VDC (77...150 VDC), 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO |
| PO = Power Output<br>SO = Signal Output<br>SPO = Static Power Output<br>SSO = Static Signal Output | |

1) Line distance/line differential protection communication + binary signal transfer, optical multimode or single-mode LC small form-factor pluggable transceiver (SFP)

The relay has a nonvolatile memory which does not need any periodical maintenance. The nonvolatile memory stores all events, recordings and logs to a memory which retains data if the relay loses its auxiliary supply.

## 2.3 Local HMI

The LHMI is used for setting, monitoring and controlling the protection relay and the related process. It comprises a 7-inch color screen with capacitive touch sensing and a Home button at the bottom of the LHMI.



The LHMI must be paired with the protection relay to enable all the functionalities in it. See the operation manual for the pairing procedure.



The LHMI is an accessory for the relay which is fully operational even without the LHMI.

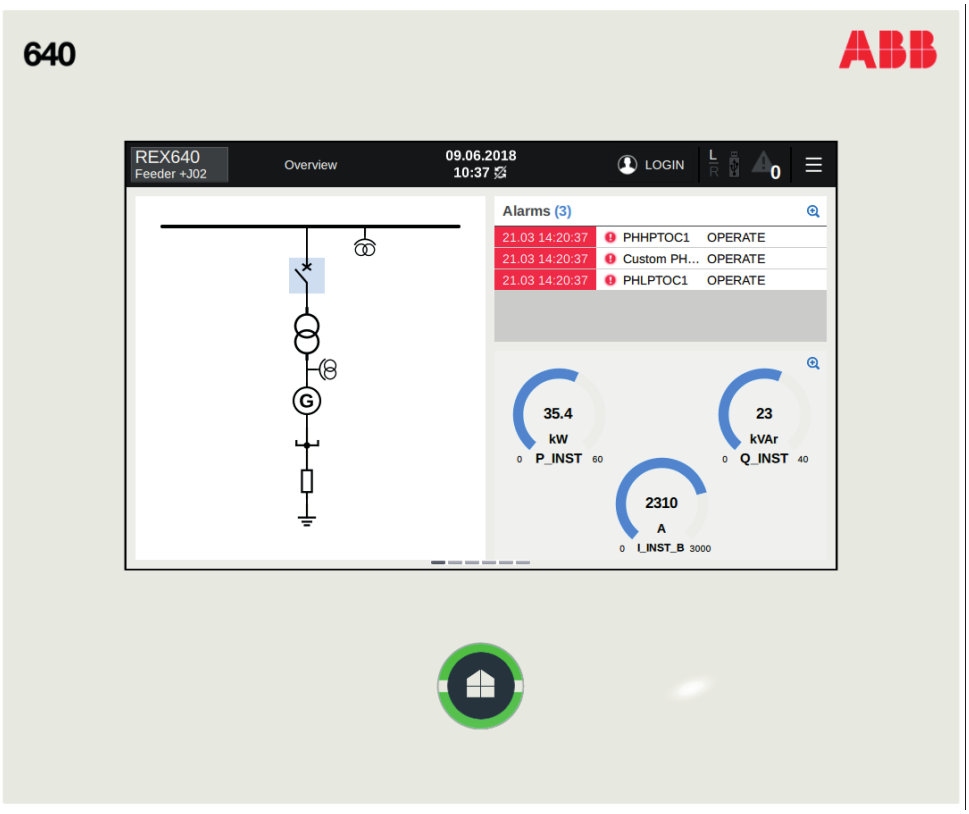



*Figure 3: Example of a local HMI page*

The LHMI presents pages in two categories.

- Operator pages are typically required as a part of an operator's normal activities, such as a single-line diagram, controls, measurements, events or alarms
- Engineer pages are specifically designed pages supporting relay parametrization, troubleshooting, testing and commissioning activities

The Operator pages can be scrolled either by pressing the Home button or by swiping the actual pages. The Engineer pages are accessible by tapping the menu button in the menu bar on the top of the LHMI display.

The Home button indicates the relay's status at a glance. In normal situations, the Home button shows a steady green light. Any other situation that requires the operator's attention is indicated with a flashing light, a red light or a combination of these.

*Table 4: Power supply module Ready LED and local HMI Home button LED*

| State | Power supply module Ready LED | LHMI Home button | Alarm acknowledged |
|---|---|---|---|
| Relay under normal operation and LHMI connected | Steady green | Steady green | N/A |
| Relay's IRF activated, but communicates with LHMI | High frequency blinking green[1)] | High frequency blinking red[1)] | N/A |
| Communication lost between Relay and LHMI, but no IRF | Steady green | High frequency blinking green[1)] | N/A |
| LHMI not running normally or in start-up initialization phase | Steady green | High frequency blinking green[1)] | N/A |
| Process related alarm active | Steady green | Low frequency blinking red[2)] | No |
| Process related alarm active | Steady green | Steady red | Yes |
| Process related alarm has been active earlier, but is not any more active. | Steady green | Low frequency blinking red[2)] | No |
| Process related alarm has been active earlier, but is not any more active. | Steady green | Steady green | Yes |
| Relay set to Test Mode | Low frequency blinking green[2)] | Low frequency blinking green[2)] | No |

1) High frequency = 3 Hz
2) Low frequency = 1 Hz

The Operator pages can be used as such or customized according to the project's requirements using Graphical Display Editor in PCM600. The Engineer pages are fixed and cannot be customized.

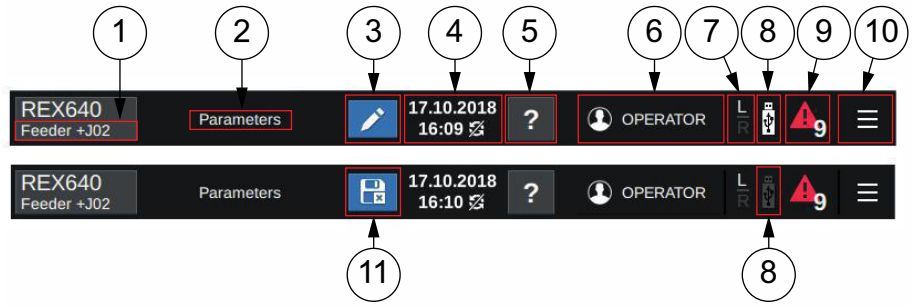



*Figure 4: Menu bar elements*

1 Bay name for the relay
2 Page name
3 Edit mode active (parameter editing)
4 Date, time and time synchronization status
5 Page help (visible if help is available for the page)
6 Login button/logged in user indication
7 Local/remote indication
8 USB memory not connected/connected (visible only if USB port is enabled)
9 Number of active alarms
10 Menu button for Engineer pages
11 Store or reject changed parameters indication

*Table 5: Local HMI default pages*

| Page category | Pages | Subpages |
|---|---|---|
| Operator pages | Overview | Alarms |
| | Events | |
| | Fault Records | |
| | Timeline | |
| | Measurements | Phasors<br>Load Profile Records |
| Table continues on next page | | |

| Page category | Pages | Subpages |
|---|---|---|
| Engineer pages | Parameters | |
| | Testing and Commissioning | Force Functions<br>Force Outputs<br>Simulate Inputs<br>View I/O<br>Send Events<br>Secondary Injection Monitoring<br>Protection Measurement Direction<br>Coil Controller Commissioning[1)]<br>View GOOSE sending<br>View GOOSE receiving<br>View SMV sending<br>View SMV receiving |
| | Relay Status | Monitoring |
| | Clear | |
| | Disturbance Records | |
| | Alarms | |
| | Device Information | |
| | USB Actions | |

1) Available with the Petersen coil control application package

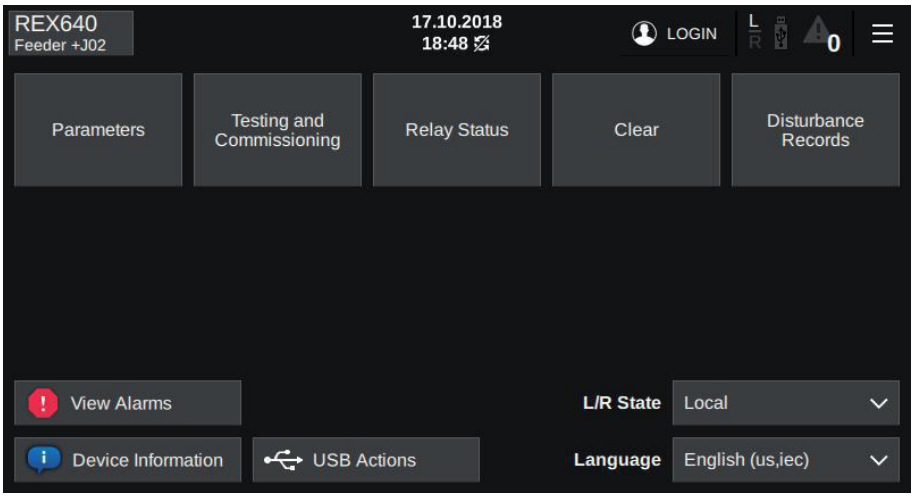



*Figure 5: Engineer pages menu*

## 2.3.1 Physical ports

The relay communication module has a dedicated port where the LHMI is connected using an RJ-45 connector and a CAT 6 S/FTP galvanic cable. The LHMI can be connected to the relay also via station communication network if a longer distance is required between the relay and the LHMI. For more information, see the operation manual.

Additionally, the LHMI contains one Ethernet service port with an RJ-45 connector and one USB port. The service port can be used for the PCM600 connection or for WHMI connection. Data transfer to a USB stick is enabled via the USB port. By default the USB port is disabled and has to be taken into use with a specific parameter.

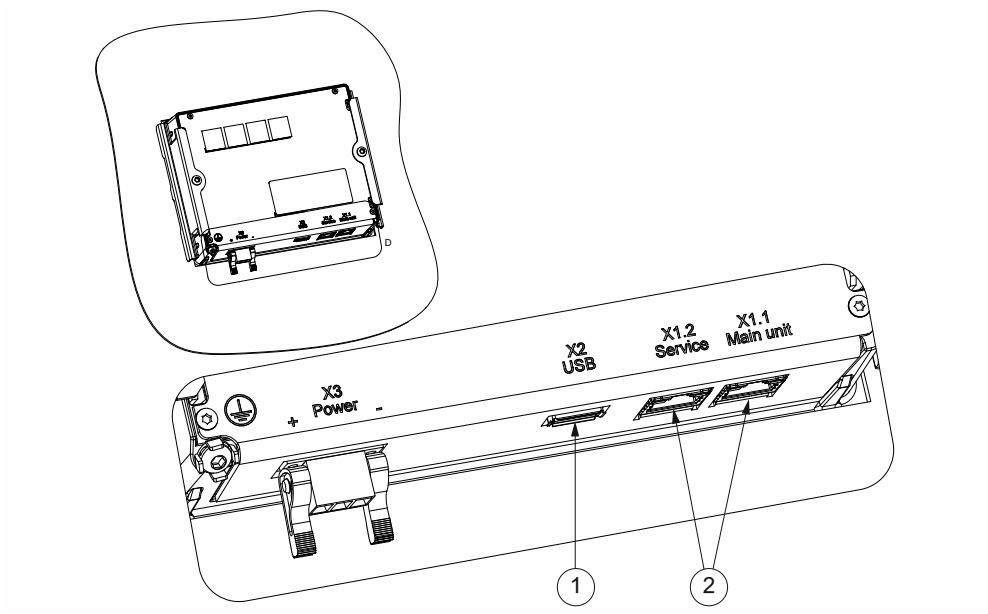



*Figure 6: Local HMI connectors*

1 USB port
2 RJ-45 ports

## 2.4 Web HMI

The WHMI allows secure access to the protection relay via a Web browser. The WHMI is verified with Google Chrome, Mozilla Firefox, Internet Explorer 11.0 and Microsoft Edge.

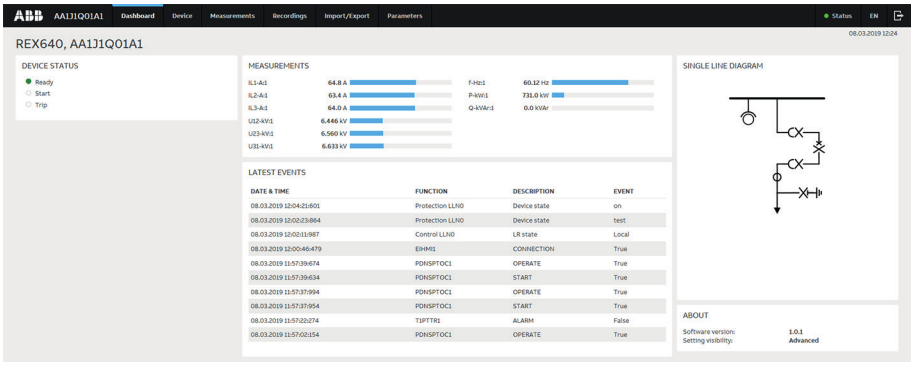



*Figure 7: Example view of the Web HMI*

WHMI offers several functions. The menu tree structure on the WHMI is almost identical to the one on the LHMI.

***Table 6: Web HMI main groups and submenus***

| Main groups | Submenus | Description |
|---|---|---|
| Dashboard | | Used to see an overview of the protection relay including status, measurements, single-line diagram and latest events |
| Device | Monitoring<br>Information<br>Self-supervision<br>Single Line Diagram<br>Clear<br>Change Password<br>About | Used to navigate to monitoring, information, self-supervision, single-line diagram or clear pages |
| Measurements | Measurements<br>Phasor Diagrams | Used to navigate to the measurements or phasor diagrams |
| Recordings | Events<br>Disturbance records<br>Fault records<br>Load Profile Record<br>Alarm List | Used to view the events, disturbance records, fault records, load profile records and alarms |
| Import/Export | Report Summary<br>Import/Export Settings<br>Parameter List | Used to export a parameter list or a report summary, and to import and export settings |
| Parameters | | Used to view the menu tree structure for the protection relay's setting parameters |
| Language selection | | Used to change the language |
| Logout | | Used to end the session |

The WHMI can be accessed locally and remotely.

- Locally by connecting the laptop to the protection relay
- Remotely over LAN/WAN

## 2.5 User authorization

The user management for the protection relay can be handled in two possible ways.

Only one user management way can be enabled in the protection relay at a time. This can be done with the *Device CAM mode* parameter in Account Management in PCM600.

*Table 7: Device CAM mode values*

| Parameter | Values | Description |
|---|---|---|
| Device CAM mode | Enabled | Authentication done from the CAM server |
| | Disabled (Default) | Authentication done from the local user account management database |

For more information, see the cyber security deployment guideline.

### Local user account management

Four factory default user accounts (VIEWER, OPERATOR, ENGINEER and ADMINISTRATOR) have been predefined for the LHMI and the WHMI, each with different rights and default passwords. The roles for these user accounts are the same as the username. Additional user accounts can be added for the protection relay.

IED Users in PCM600 is used to manage the user accounts. Each protection relay supports eight fixed roles and 50 user accounts belonging to any one of these roles. Each user account can be mapped to a maximum of eight roles.

The factory default passwords can be changed with Administrator user rights or by the users themselves. Relay user passwords can be changed using the LHMI, IED Users in PCM600 or the WHMI. Only Administrator can create user accounts and update the roles-to-rights mapping. Administrator can also reset the passwords of the users.

User authorization is disabled by default for the LHMI and can be enabled with the *Local override* parameter via the menu path **Configuration/Authorization/ Passwords**. WHMI always requires authentication. Changes in user management settings do not cause the protection relay to reboot. The changes are taken into use immediately after committing the changed settings.

### Central account management

The user accounts and roles can be created and authenticated centrally in a CAM server. CAM needs to be activated in the protection relay from Account Management in PCM600.

A CAM server can be a tool such as SDM600 or it can be an Active Directory server such as Windows AD. There can also be a secondary or redundant CAM server

configured which can act as a backup CAM server if the primary CAM server is not accessible.

The protection relay is the CAM client and can maintain its own replica database of the user accounts and roles configured in the CAM server. This CAM replica database acts as a backup authentication mechanism if primary and secondary CAM servers are not accessible from the protection relay.

Each protection relay supports eight roles and 50 user accounts in the CAM replica database. Each user account can be mapped to a maximum of eight roles.

For more information on user management and security logging, see the cyber security deployment guideline.

For user authorization for PCM600, see the PCM600 documentation.

## 2.6 Station communication

Operational information and controls are available through a wide range of communication protocols including IEC 61850 Edition 2, IEC 61850-9-2 LE, IEC 60870-5-103, Modbus® and DNP3. Full communication capabilities, for example, horizontal communication between the relays, are only enabled by IEC 61850.

The IEC 61850 protocol is a core part of the relay as the protection and control application is fully based on standard modelling. The relay supports Edition 2 and Edition 1 versions of the standard. With Edition 2 support, the relay has the latest functionality modelling for substation applications and the best interoperability for modern substations.

## 2.7 Modification Sales

Modification Sales is a concept that provides modification support for already delivered relays. Under Modification Sales it is possible to modify both the hardware and software capabilities of the existing relay. The same options are available as when a new relay variant is configured and ordered from the factory: it is possible to add new hardware modules into empty slots, change the type of the existing modules within the slots or add software functions by adding application and, if necessary, add-on packages. If it is needed to use the possibilities provided by the Modification Sales concept, please contact your local ABB unit.

# Section 3 Basic functions

## 3.1 General parameters

*Table 8: Authorization settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Security/Remote Update | 0=Disable<br>1=Enable | | | 0=Disable | Remote update |
| Security/Thumbprint | | | | 0 | ClientThumb Print |
| Passwords/Remote override | 0=False<br>1=True | | | 1=True | Disable authority |
| Passwords/Local override | 0=False<br>1=True | | | 1=True | Disable authority |
| CAM/Clear AD userlist | 0=False<br>1=True | | | 0=False | Clear Active Directory user list |
| Network1/FTP write access | 0=Off<br>1=On | | | 1=On | FTP write access |
| Network1/MMS write access | 0=Off<br>1=On | | | 1=On | MMS write access |
| Network1/HTTPS write access | 0=Off<br>1=On | | | 1=On | HTTPS write access |
| Network2/FTP write access | 0=Off<br>1=On | | | 1=On | FTP write access |
| Network2/MMS write access | 0=Off<br>1=On | | | 1=On | MMS write access |
| Network2/HTTPS write access | 0=Off<br>1=On | | | 1=On | HTTPS write access |
| HMI/FTP write access | 0=Off<br>1=On | | | 1=On | FTP write access |
| HMI/MMS write access | 0=Off<br>1=On | | | 1=On | MMS write access |

*Table 9: Binary input settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Slot specific threshold | 0=False<br>1=True | | | 0=False | Use slot specific binary input voltage threshold |
| Slot specific hysteresis | 0=False<br>1=True | | | 0=False | Use slot specific binary input voltage hysteresis |
| Input threshold voltage | 16...176 | Vdc | 2 | 16 | Global binary input threshold for all slots |
| Table continues on next page | | | | | |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Input threshold hysteresis | 10...50 | % | 2 | 10 | Global binary input hysteresis for all slots |
| Input osc. level | 2...50 | events/s | 1 | 30 | Binary input oscillation suppression threshold |
| Input osc. hyst | 2...50 | events/s | 1 | 10 | Binary input oscillation suppression hysteresis |

*Table 10: Network address settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| IP address | | | | 192.168.2.10 | IP address for Network1 |
| Subnet mask | | | | 255.255.255.0 | Subnet mask for Network1 |
| Default gateway | | | | 192.168.2.1 | Default gateway for Network1 |
| Mac address | | | | XX-XX-XX-XX-XX-XX | Mac address for Network1 |

*Table 11: System settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Rated frequency | 1=50Hz<br>2=60Hz | | | 1=50Hz | Rated frequency of the network |
| Phase rotation | 1=ABC<br>2=ACB | | | 1=ABC | Phase rotation order |
| Blocking mode | 1=Freeze timer<br>2=Block all<br>3=Block OPERATE output | | | 1=Freeze timer | Behaviour for function BLOCK inputs |
| Bay name | | | | REX640 | Bay name in system |
| IDMT Sat point | 10...50 | I/I> | 1 | 50 | Overcurrent IDMT saturation point |
| Frequency adaptivity | 0=Disable<br>1=Enable | | | 0=Disable | Enabling frequency adaptivity |
| SMV Max Delay | 0=2/2 ms<br>1=3/3 ms<br>2=5/4 ms<br>3=6/5 ms<br>4=7/6 ms | | | 1=3/3 ms | SMV Maximum allowed delay[1)] |

1) Delay given for 50 Hz/60 Hz

*Table 12: HMI settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| FB naming convention | 1=IEC61850<br>2=IEC60617<br>3=ANSI | | | 1=IEC61850 | FB naming convention used in the protection relay |
| Default view | 1=Measurements<br>2=Main menu<br>3=SLD | | | 1=Measurements | LHMI default view |
| Backlight timeout | 1...60 | min | 1 | 3 | LHMI backlight timeout |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Web HMI mode | 0=Off<br>1=On | | | 1=On | Web HMI functionality |
| HMI timeout | 1...60 | min | 1 | 3 | HMI login timeout |
| SLD symbol format | 1=IEC<br>2=ANSI | | | 1=IEC | Single Line Diagram symbol format |
| Autoscroll delay | 0...30 | s | 1 | 0 | Autoscroll delay for Measurements view |
| Setting visibility | 1=Basic<br>2=Advanced | | | 1=Basic | Setting visibility for HMI |
| User defined name | 0=Disabled<br>1=Enabled | | | false | Configuration of User defined name |

*Table 13: IEC 60870-5-103 settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 5=off | Selects if this protocol instance is enabled or disabled |
| Serial port | 1=COM 1<br>2=COM 2 | | | 1=COM 1 | COM port |
| Address | 1...255 | | 1 | 1 | Unit address |
| Start delay | 0...20 | char | 1 | 4 | Start frame delay in chars |
| End delay | 0...20 | char | 1 | 4 | End frame delay in chars |
| DevFunType | 0...255 | | 1 | 9 | Device Function Type |
| UsrFunType | 0...255 | | 1 | 10 | Function type for User Class 2 Frame |
| UsrInfNo | 0...255 | | 1 | 230 | Information Number for User Class2 Frame |
| Class1Priority | 0=Ev High<br>1=Ev/DR Equal<br>2=DR High | | | 0=Ev High | Class 1 data sending priority relationship between Events and Disturbance Recorder data. |
| Class2Interval | 0...86400 | s | 1 | 0 | Interval in seconds to send class 2 response |
| Frame1InUse | -1=Not in use<br>0=User frame<br>1=Standard frame 1<br>2=Standard frame 2<br>3=Standard frame 3<br>4=Standard frame 4<br>5=Standard frame 5<br>6=Private frame 6<br>7=Private frame 7 | | | 6=Private frame 6 | Active Class2 Frame 1 |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Frame2InUse | -1=Not in use<br>0=User frame<br>1=Standard frame 1<br>2=Standard frame 2<br>3=Standard frame 3<br>4=Standard frame 4<br>5=Standard frame 5<br>6=Private frame 6<br>7=Private frame 7 | | | -1=Not in use | Active Class2 Frame 2 |
| Frame3InUse | -1=Not in use<br>0=User frame<br>1=Standard frame 1<br>2=Standard frame 2<br>3=Standard frame 3<br>4=Standard frame 4<br>5=Standard frame 5<br>6=Private frame 6<br>7=Private frame 7 | | | -1=Not in use | Active Class2 Frame 3 |
| Frame4InUse | -1=Not in use<br>0=User frame<br>1=Standard frame 1<br>2=Standard frame 2<br>3=Standard frame 3<br>4=Standard frame 4<br>5=Standard frame 5<br>6=Private frame 6<br>7=Private frame 7 | | | -1=Not in use | Active Class2 Frame 4 |
| Class1OvInd | 0=No indication<br>1=Both edges<br>2=Rising edge | | | 2=Rising edge | Overflow Indication |
| Class1OvFType | 0...255 | | 1 | 10 | Function Type for Class 1 overflow indication |
| Class1OvInfNo | 0...255 | | 1 | 255 | Information Number for Class 1 overflow indication |
| Class1OvBackOff | 0...500 | | 1 | 500 | Backoff Range for Class1 buffer |
| GI Optimize | 0=Standard behaviour<br>1=Skip spontaneous<br>2=Only overflown<br>3=Combined | | | 0=Standard behaviour | Optimize GI traffic |
| DR Notification | 0=False<br>1=True | | | 0=False | Disturbance Recorder spontaneous indications enabled/disabled |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Block Monitoring | 0=Not in use<br>1=Discard events<br>2=Keep events | | | 0=Not in use | Blocking of Monitoring Direction |
| Internal Overflow | 0=False<br>1=True | | | 0=False | Internal Overflow: TRUE-System level overflow occured (indication only) |
| EC_FRZ | 0=False<br>1=True | | | 0=False | Control point for freezing energy counters |

*Table 14: IEC 61850-8-1 MMS settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Protocols\MMS\Unit mode | 1=Primary[1)]<br>0=Nominal[2)]<br>2=Primary-Nominal[3)] | | | 0=Nominal | IEC 61850-8-1 unit mode |
| Protocols \Network1\MMS | 0=Off<br>1=On | | | 1=On | MMS communication mode |
| Protocols \Network2\MMS | 0=Off<br>1=On | | | 1=On | MMS communication mode |
| Protocols\HMI port\MMS | 0=Off<br>1=On | | | 1=On | MMS communication mode |

1) MMS client expects primary values from event reporting and data attribute reads
2) MMS client expects nominal values from event reporting and data attribute reads; this is the default for PCM600
3) For PCM600 use only. When *Unit mode* is set to "Primary", the PCM600 client can force its session to "Nominal" by selecting "Primary-Nominal" and thus parameterizing in native form. The selection is not stored and is therefore effective only for one session. This value has no effect if selected via the LHMI.

*Table 15: Modbus settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 5=off | Enable or disable this protocol instance |
| Port | 1=COM 1<br>2=COM 2<br>3=Ethernet - TCP 1 | | | 3=Ethernet - TCP 1 | Port selection for this protocol instance. Select between serial and Ethernet based communication. |
| Mapping selection | 1...2 | | 1 | 1 | Chooses which mapping scheme will be used for this protocol instance. |
| Address | 1...254 | | 1 | 1 | Unit address |
| Link mode | 1=RTU<br>2=ASCII | | | 1=RTU | Selects between ASCII and RTU mode. For TCP, this should always be RTU. |
| TCP port | 1...65535 | | 1 | 502 | Defines the listening port for the Modbus TCP server. Default = 502. |
| Parity | 0=none<br>1=odd<br>2=even | | | 2=even | Parity for the serial connection. |
| Start delay | 0...20 | | 1 | 4 | Start delay in character times for serial connection |
| End delay | 0...20 | | 1 | 4 | End delay in character times for serial connections |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| CRC order | 0=Hi-Lo<br>1=Lo-Hi | | | 0=Hi-Lo | Selects between normal or swapped byte order for checksum for serial connection. Default: Hi-Lo. |
| Client IP | | | | 0.0.0.0 | Sets the IP address of the client. If set to zero, connection from any client is accepted. |
| Write authority | 0=Read only<br>1=Disable 0x write<br>2=Full access | | | 2=Full access | Selects the control authority scheme |
| Time format | 0=UTC<br>1=Local | | | 1=Local | Selects between UTC and local time for events and timestamps. |
| Event ID selection | 0=Address<br>1=UID | | | 0=Address | Selects whether the events are reported using the MB address or the UID number. |
| Event buffering | 0=Keep oldest<br>1=Keep newest | | | 0=Keep oldest | Selects whether the oldest or newest events are kept in the case of event buffer overflow. |
| Event backoff | 1...500 | | 1 | 200 | Defines how many events have to be read after event buffer overflow to allow new events to be buffered. Applicable in "Keep oldest" mode only. |
| ControlStructPWd 1 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 2 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 3 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 4 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 5 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 6 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 7 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 8 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| Modbus | 0=Off<br>1=On | | | 1=On | Modbus communication mode |
| Modbus | 0=Off<br>1=On | | | 1=On | Modbus communication mode |

*Table 16: DNP3 settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 5=off | Operation Off / On |
| Port | 1=COM 1<br>2=COM 2<br>3=Ethernet - TCP 1<br>4=Ethernet TCP +UDP 1 | | | 3=Ethernet - TCP 1 | Communication interface selection |
| Unit address | 1...65519 | | 1 | 1 | DNP unit address |
| Master address | 1...65519 | | 1 | 3 | DNP master and UR address |
| Mapping select | 1...2 | | 1 | 1 | Mapping select |
| ClientIP | | | | 0.0.0.0 | IP address of client |
| TCP port | 20000...65535 | | 1 | 20000 | TCP Port used on ethernet communication |
| TCP write authority | 0=No clients<br>1=Reg. clients<br>2=All clients | | | 2=All clients | 0=no client controls allowed; 1=Controls allowed by registered clients; 2=Controls allowed by all clients |
| Link keep-alive | 0...65535 | s | 1 | 0 | Link keep-alive interval for DNP |
| Validate master addr | 1=Disable<br>2=Enable | | | 1=Disable | Validate master address on receive |
| Self address | 1=Disable<br>2=Enable | | | 2=Enable | Support self address query function |
| Need time interval | 0...65535 | min | 1 | 30 | Period to set IIN need time bit |
| Time format | 0=UTC<br>1=Local | | | 1=Local | UTC or local. Coordinate with master. |
| CROB select timeout | 1...65535 | s | 1 | 10 | Control Relay Output Block select timeout |
| Data link confirm | 0=Never<br>1=Only Multiframe<br>2=Always | | | 0=Never | Data link confirm mode |
| Data link confirm TO | 100...65535 | ms | 1 | 3000 | Data link confirm timeout |
| Data link retries | 0...65535 | | 1 | 3 | Data link retries count |
| Data link Rx to Tx delay | 0...255 | ms | 1 | 0 | Turnaround transmission delay |
| Data link inter char delay | 0...20 | char | 1 | 4 | Inter character delay for incoming messages |
| App layer confirm | 1=Disable<br>2=Enable | | | 1=Disable | Application layer confirm mode |
| App confirm TO | 100...65535 | ms | 1 | 5000 | Application layer confirm and UR timeout |
| App layer fragment | 256...2048 | bytes | 1 | 2048 | Application layer fragment size |
| UR mode | 1=Disable<br>2=Enable | | | 1=Disable | Unsolicited responses mode |
| UR retries | 0...65535 | | 1 | 3 | Unsolicited retries before switching to UR offline mode |
| UR TO | 0...65535 | ms | 1 | 5000 | Unsolicited response timeout |
| UR offline interval | 0...65535 | min | 1 | 15 | Unsolicited offline interval |
| UR Class 1 Min events | 0...999 | | 1 | 2 | Min number of class 1 events to generate UR |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| UR Class 1 TO | 0...65535 | ms | 1 | 50 | Max holding time for class 1 events to generate UR |
| UR Class 2 Min events | 0...999 | | 1 | 2 | Min number of class 2 events to generate UR |
| UR Class 2 TO | 0...65535 | ms | 1 | 50 | Max holding time for class 2 events to generate UR |
| UR Class 3 Min events | 0...999 | | 1 | 2 | Min number of class 3 events to generate UR |
| UR Class 3 TO | 0...65535 | ms | 1 | 50 | Max holding time for class 3 events to generate UR |
| Legacy master UR | 1=Disable<br>2=Enable | | | 1=Disable | Legacy DNP master unsolicited mode support. When enabled relay does not send initial unsolicited message. |
| Legacy master SBO | 1=Disable<br>2=Enable | | | 1=Disable | Legacy DNP Master SBO sequence number relax enable |
| Default Var Obj 01 | 1=1:BI<br>2=2:BI&status | | | 1=1:BI | 1=BI; 2=BI with status. |
| Default Var Obj 02 | 1=1:BI event<br>2=2:BI event&time | | | 2=2:BI event&time | 1=BI event; 2=BI event with time. |
| Default Var Obj 03 | 1=1:DBI<br>2=2:DBI&status | | | 1=1:DBI | 1=DBI; 2=DBI with status. |
| Default Var Obj 04 | 1=1:DBI event<br>2=2:DBI<br>event&time | | | 2=2:DBI<br>event&time | 1=DBI event; 2=DBI event with time. |
| Default Var Obj 20 | 1=1:32bit Cnt<br>2=2:16bit Cnt<br>5=5:32bit Cnt<br>noflag<br>6=6:16bit Cnt<br>noflag | | | 2=2:16bit Cnt | 1=32 bit counter; 2=16 bit counter; 5=32 bit counter without flag; 6=16 bit counter without flag. |
| Default Var Obj 21 | 1=1:32bit FrzCnt<br>2=2:16bit FrzCnt<br>5=5:32bit<br>FrzCnt&time<br>6=6:16bit<br>FrzCnt&time<br>9=9:32bit FrzCnt<br>noflag<br>10=10:16bit FrzCnt<br>noflag | | | 6=6:16bit<br>FrzCnt&time | 1=32 bit frz counter; 2=16 bit frz counter; 5=32 bit frz counter with time; 6=16 bit frz counter with time; 9=32 bit frz counter without flag;10=16 bit frz counter without flag. |
| Default Var Obj 22 | 1=1:32bit Cnt evt<br>2=2:16bit Cnt evt<br>5=5:32bit Cnt<br>evt&time<br>6=6:16bit Cnt<br>evt&time | | | 6=6:16bit Cnt<br>evt&time | 1=32 bit counter event; 2=16 bit counter event; 5=32 bit counter event with time; 6=16 bit counter event with time. |
| Default Var Obj 23 | 1=1:32bit FrzCnt<br>evt<br>2=2:16bit FrzCnt<br>evt<br>5=5:32bit FrzCnt<br>evt&time<br>6=6:16bit FrzCnt<br>evt&time | | | 6=6:16bit FrzCnt<br>evt&time | 1=32 bit frz counter event; 2=16 bit frz counter event; 5=32 bit frz counter event with time; 6=16 bit frz counter event with time. |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Default Var Obj 30 | 1=1:32bit AI<br>2=2:16bit AI<br>3=3:32bit AI noflag<br>4=4:16bit AI noflag<br>5=5:AI float<br>6=6:AI double | | | 5=5:AI float | 1=32 bit AI; 2=16 bit AI; 3=32 bit AI without flag; 4=16 bit AI without flag; 5=AI float; 6=AI double. |
| Default Var Obj 32 | 1=1:32bit AI evt<br>2=2:16bit AI evt<br>3=3:32bit AI evt&time<br>4=4:16bit AI evt&time<br>5=5: float AI evt<br>6=6:double AI evt<br>7=7:float AI evt&time<br>8=8:double AI evt&time | | | 7=7:float AI evt&time | 1=32 bit AI event; 2=16 bit AI event; 3=32 bit AI event with time; 4=16 bit AI event with time; 5=float AI event; 6=double AI event; 7=float AI event with time; 8=double AI event with time. |
| Default Var Obj 40 | 1=1:32bit AO<br>2=2:16bit AO<br>3=3:AO float<br>4=4:AO double | | | 2=2:16bit AO | 1=32 bit AO; 2=16 bit AO; 3=AO float; 4=AO double. |
| Default Var Obj 42 | 1=1:32bit AO evt<br>2=2:16bit AO evt<br>3=3:32bit AO evt&time<br>4=4:16bit AO evt&time<br>5=5:float AO evt<br>6=6:double AO evt<br>7=7:float AO evt&time<br>8=8:double AO evt&time | | | 4=4:16bit AO evt&time | 1=32 bit AO event; 2=16 bit AO event; 3=32 bit AO event with time; 4=16 bit AO event with time; 5=float AO event; 6=double AO event; 7=float AO event with time; 8=double AO event with time. |
| DNP | 0=Off<br>1=On | | | 1=On | DNP communication mode |
| DNP | 0=Off<br>1=On | | | 1=On | DNP communication mode |

*Table 17: COM1 serial communication settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Fiber mode | 0=No fiber<br>1=Fiber light ON loop<br>2=Fiber light OFF loop<br>3=Fiber light ON star<br>4=Fiber light OFF star | | | 0=No fiber | Fiber mode |
| Serial mode | 1=RS485 2Wire<br>2=RS485 4Wire | | | 1=RS485 2Wire | Serial mode |
| CTS delay | 0...60000 | ms | 1 | 0 | CTS delay |
| RTS delay | 0...60000 | ms | 1 | 0 | RTS delay |
| Baudrate | 1=300<br>2=600<br>3=1200<br>4=2400<br>5=4800<br>6=9600<br>7=19200<br>8=38400<br>9=57600<br>10=115200 | | | 6=9600 | Baudrate |

*Table 18: COM2 serial communication settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Fiber mode | 0=No fiber<br>1=Fiber light ON loop<br>2=Fiber light OFF loop<br>3=Fiber light ON star<br>4=Fiber light OFF star | | | 0=No fiber | Fiber mode |
| Serial mode | 1=RS485 2Wire<br>2=RS485 4Wire | | | 1=RS485 2Wire | Serial mode |
| CTS delay | 0...60000 | ms | 1 | 0 | CTS delay |
| RTS delay | 0...60000 | ms | 1 | 0 | RTS delay |
| Baudrate | 1=300<br>2=600<br>3=1200<br>4=2400<br>5=4800<br>6=9600<br>7=19200<br>8=38400<br>9=57600<br>10=115200 | | | 6=9600 | Baudrate |

## 3.2 Communication

The protection relay supports a range of communication protocols including IEC 61850, IEC 61850-9-2 LE, IEC 60870-5-103, Modbus® and DNP3. Profibus DPV1 communication protocol is supported by using the protocol converter SPA-ZC 302. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the protection relays, is only enabled by the IEC 61850 communication protocol.

One full IEC 61850-9-2 LE stream containing both voltages and currents can be sent. Receiving of up to four SMV streams is supported with a total of maximum 16 channels. The channels are freely configurable with the possibility to engineer SMV stream redundancy using the voltage and current switch functions with either another SMV stream or local measurements. The SMV stream quality along with other Application Configuration logic can be used for switching between measurement sources.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter settings, disturbance recordings and fault records can be accessed using the IEC 61850 protocol. Disturbance recordings are available to any Ethernet-based application in the IEC 60255-24 standard COMTRADE file format. The protection relay can send and receive binary signals from other devices (so-called horizontal communication) using the IEC 61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported. Furthermore, the protection relay supports sending and receiving of analog values using GOOSE messaging. The protection relay meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard.

The protection relay can support five simultaneous clients. If PCM600 reserves one client connection, only four client connections are left, for example, for IEC 61850 and Modbus.

All communication connectors are placed on integrated optional communication modules. The protection relay can be connected to Ethernet-based communication systems via the RJ-45 connector (100Base-TX) or the fiber-optic LC connector (100Base-FX).

The HMI has two RJ-45 connectors. One is for connecting the HMI to the protection relay main unit and the second is a service port which is used for connecting the HMI and a single computer. This computer can be, for example, a laptop with the PCM600 engineering tool or a browser for WHMI.

An optional serial interface is available for RS-485 communication.

## 3.2.1 Self-healing Ethernet ring

The protection relay supports a self-healing ring solution for small installations. For the correct operation of self-healing ring topology, the network topology must be a ring. It is essential that the external switches in the network support the RSTP protocol and that it is enabled in the switches. Otherwise, connecting the ring topology can cause problems to the network.

The protection relay itself does not support link-down detection or RSTP. The ring recovery process is based on the aging of the MAC addresses and the link-up/link-down events can cause temporary breaks in communication. For a better performance of the self-healing ring, it is recommended that the external switch furthest from the protection relay loop is assigned as the root switch (bridge priority = 0) and the bridge priority increases towards the protection relay ring. The end links of the protection relay loop can be attached to the same external switch or to two adjacent external switches.

A self-healing Ethernet ring requires a communication module with at least two Ethernet interfaces for all protection relays.



The self-healing ring solution supports the connection of up to 30 protection relays. If more than 30 protection relays should be connected in the same system or if SMV is used, it is recommended to use the HSR or PRP protocols for Ethernet redundancy to ensure proper functionality.

## 3.2.2 Ethernet redundancy

IEC 61850 specifies a network redundancy scheme that improves the system availability for substation communication. It is based on two complementary protocols defined in the IEC 62439-3:2012 standard: parallel redundancy protocol PRP and high-availability seamless redundancy HSR protocol. Both protocols rely on the duplication of all transmitted information via two Ethernet ports for one logical network connection. Therefore, both are able to overcome the failure of a link or switch with a zero-switchover time, thus fulfilling the most demanding real-time application requirements for the substation automation.

Ethernet network redundancy can be achieved using HSR or PRP, or with a self-healing ring using RSTP in the managed switches. Ethernet redundancy is applied to all services using the Ethernet/TCP network.

PRP specifies that each device is connected in parallel to two local area networks. HSR applies the PRP principle to rings and to the rings of rings to achieve cost-effective redundancy. Thus, each device incorporates a switch element that forwards frames from port to port.

IEC 62439-3:2012 cancels and replaces the first edition published in 2010. These standard versions are also referred to as IEC 62439-3 Edition 1 and IEC 62439-3 Edition 2. The protection relay supports IEC 62439-3:2016 (Edition 3) and IEC 62439-3:2012 and it is not compatible with IEC 62439-3:2010.

## PRP

Each PRP node, called a double attached node with PRP (DAN), is attached to two independent LANs operated in parallel. These parallel networks in PRP are called LAN A and LAN B. The networks are completely separated to ensure failure independence, and they can have different topologies. Both networks operate in parallel, thus providing zero-time recovery and continuous checking of redundancy to avoid communication failures. Non-PRP nodes, called single attached nodes (SANs), are either attached to one network only (and can therefore communicate only with DANs and SANs attached to the same network), or are attached through a redundancy box, a device that behaves like a DAN.

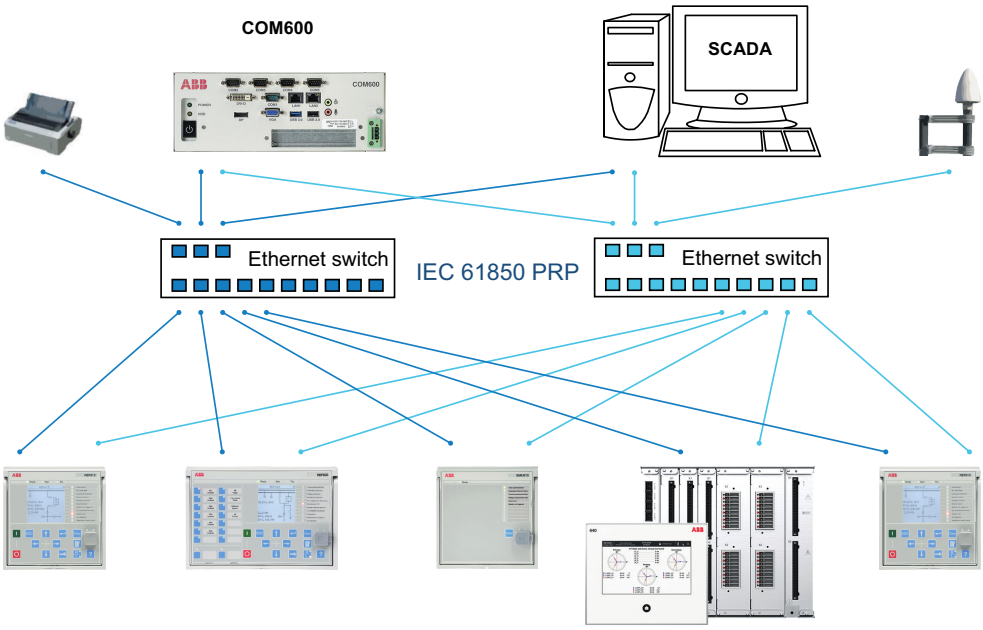



*Figure 8: Parallel redundancy protocol solution*

In case a laptop or a PC workstation is connected as a non-PRP node to one of the PRP networks, LAN A or LAN B, it is recommended to use a redundancy box device or an Ethernet switch with similar functionality between the PRP network and SAN to remove additional PRP information from the Ethernet frames. In some cases, default PC workstation adapters are not able to handle the maximum-length Ethernet frames with the PRP trailer.

There are different alternative ways to connect a laptop or a workstation as SAN to a PRP network.

- Via an external redundancy box (RedBox) or a switch capable of connecting to PRP and normal networks
- By connecting the node directly to LAN A or LAN B as SAN
- By connecting the node to the protection relay's interlink port

### HSR

HSR applies the PRP principle of parallel operation to a single ring, treating the two directions as two virtual LANs. For each frame sent, a node, DAN, sends two frames, one over each port. Both frames circulate in opposite directions over the ring and each node forwards the frames it receives, from one port to the other. When the originating node receives a frame sent to itself, it discards that to avoid loops; therefore, no ring protocol is needed. Individually attached nodes, SANs, such as laptops and printers, must be attached through a “redundancy box” that acts as a ring element. For example, a REX640 protection relay with HSR support can be used as a redundancy box.

Each protection relay has a 50-µs store-and-forward delay. To fulfil the performance requirements for fast horizontal communication for protection applications using GOOSE and SMV, the ring size is limited to 30 protection relays.

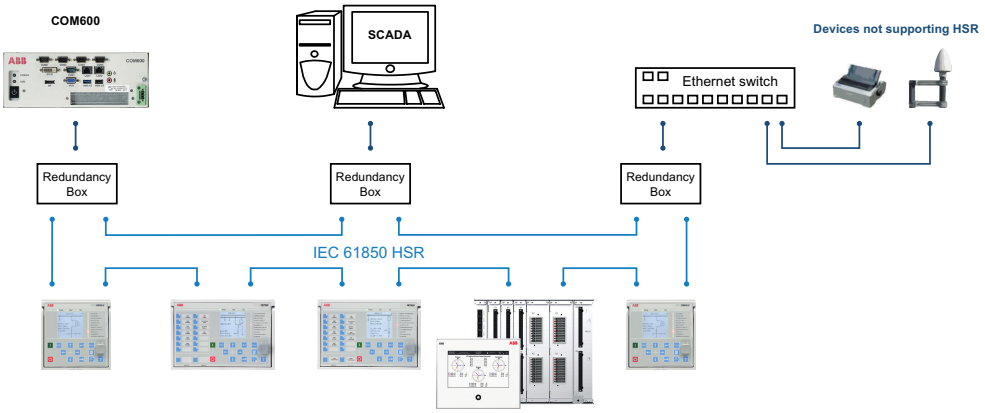



*Figure 9: High-availability seamless redundancy solution*

## 3.2.3 Process bus

Process bus IEC 61850-9-2 defines the transmission of Sampled Measured Values within the substation automation system. International Users Group created a guideline IEC 61850-9-2 LE that defines an application profile of IEC 61850-9-2 to facilitate implementation and enable interoperability. Process bus is used for distributing process data from the primary circuit to all process bus compatible devices in the local network in a real-time manner. The data can then be processed by any protection relay to perform different protection, automation and control functions.

Redundant SMV streams are also supported by using the voltage (VMSWI) and current (CMSWI) function blocks. Automatic switching to the backup SMV stream can be configured in Application Configuration using SMV quality and/or other logic.

UniGear Digital switchgear concept relies on the process bus together with current and voltage sensors. The process bus enables several advantages for the UniGear Digital like simplicity with reduced wiring, flexibility with data availability to all devices, improved diagnostics and longer maintenance cycles.

With process bus the galvanic interpanel wiring for sharing busbar voltage value can be replaced with Ethernet communication. Transmitting measurement samples over process bus brings also higher error detection because the signal transmission is automatically supervised. Additional contribution to the higher availability is the possibility to use redundant Ethernet network for transmitting SMV signals.

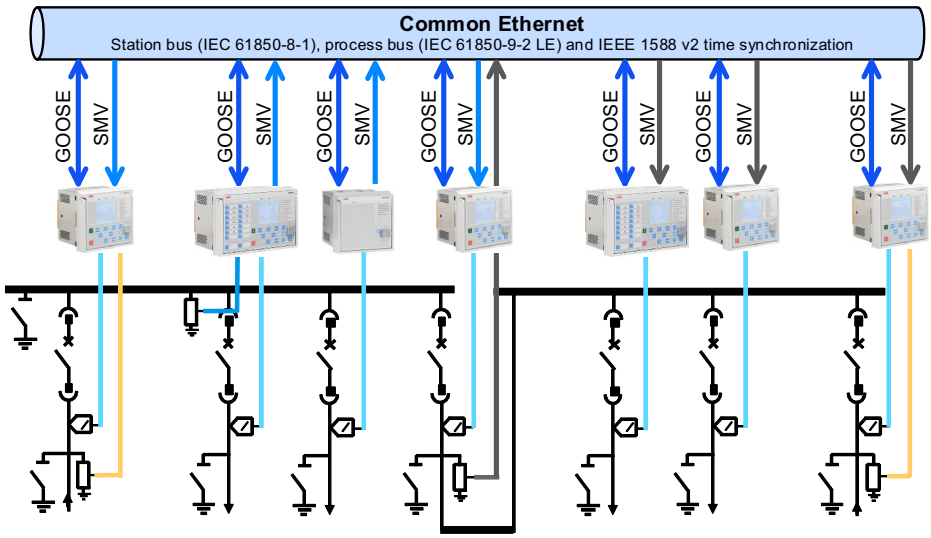



*Figure 10: Process bus application of voltage sharing and synchrocheck*

REX640 supports IEC 61850 process bus with sampled values of analog currents and voltages. The measured values are transferred as sampled values using the IEC 61850-9-2 LE protocol which uses the same physical Ethernet network as the IEC 61850-8-1 station bus. One example application is sharing the measured busbar voltage from one or several REX640 relays with the other REX640 relays. This can be done even for a double busbar switchgear installation using automatic 9-2 stream selection based on the bus disconnectors' physical position.

REX640 protection relays with process bus based applications use IEEE 1588 v2 Precision Time Protocol (PTP) according to IEEE C37.238-2011 Power Profile for high accuracy time synchronization. With IEEE 1588 v2, the cabling infrastructure requirement is reduced by allowing time synchronization information to be transported over the same Ethernet network as the data communications.

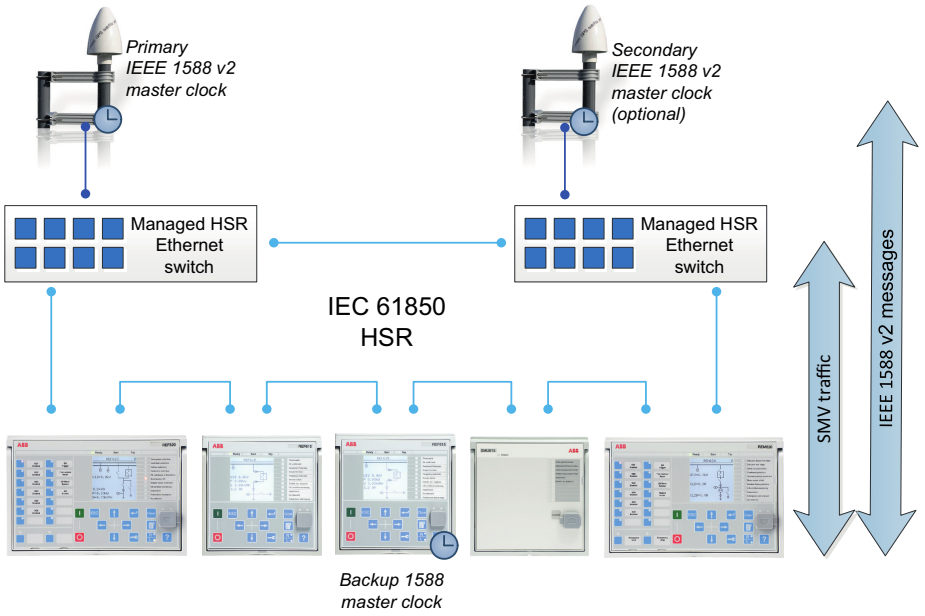



*Figure 11: Example network topology with process bus, redundancy and IEEE 1588 v2 time synchronization*

## 3.2.4 Secure communication

The protection relay supports secure communication for WHMI and file transfer protocol using Transport Layer Security protocol. The WHMI must be connected from a Web browser using the HTTPS protocol. File transfer client must use explicit FTPS.

## 3.2.5 Communication services control

### 3.2.5.1 Ethernet ports

The protection relay allows the use of a secondary IP address for the station ports on the communication modules COM1001...COM1003. This secondary IP network is assigned to a single Ethernet port and can be used to make separate networks for different communication protocols or, for example, a separate service network for configuration purposes. Multicast station/bus communication, such as IEC 61850-9-2 LE sampled values and GOOSE, is only supported on the Network 1 interface. The parameters for setting the secondary IP network are located under **Configuration/ Communication/Ethernet/Network 2 address**.

*Table 19: Secondary IP address parameters*

| Parameter | Options | Description |
|---|---|---|
| Configuration/Communication/ Ethernet/Network 2 address/ Enable | False (default) | Network 2 disabled |
| | TRUE | Network 2 enabled |
| Configuration/Communication/ Ethernet/Network 2 address/IP address | 0.0.0.0 | IP address for Network 2 |
| Configuration/Communication/ Ethernet/Network 2 address/IP address | 0.0.0.0 | Subnet address for Network 2 |
| Configuration/Communication/ Ethernet/Network 2 address/MAC address | xx-xx-xx-xx-xx-xx | MAC address for Network 2 |

The IP address for Network 2 is disabled by default settings, and all Ethernet ports are assigned to the same IP address used in the Network 1 address menu **Configuration/ Communication/Ethernet/Network 1**. If Network 2 is taken into use by the setting *Enable*="True" (requires reboot), the interlink port X3 of the COM module is assigned to this second network, using the IP address and subnet parameters in the Network 2 address menu **Configuration/Communication/Ethernet/Network 2 address**.

If the Network 2 interface is enabled, PTP time synchronization and SMV/GOOSE multicast are disabled for that port.

The secondary IP setting must not collide with the primary Network 1 IP address or LHMI IP address 192.168.0.x, otherwise the secondary IP address is not taken into use.

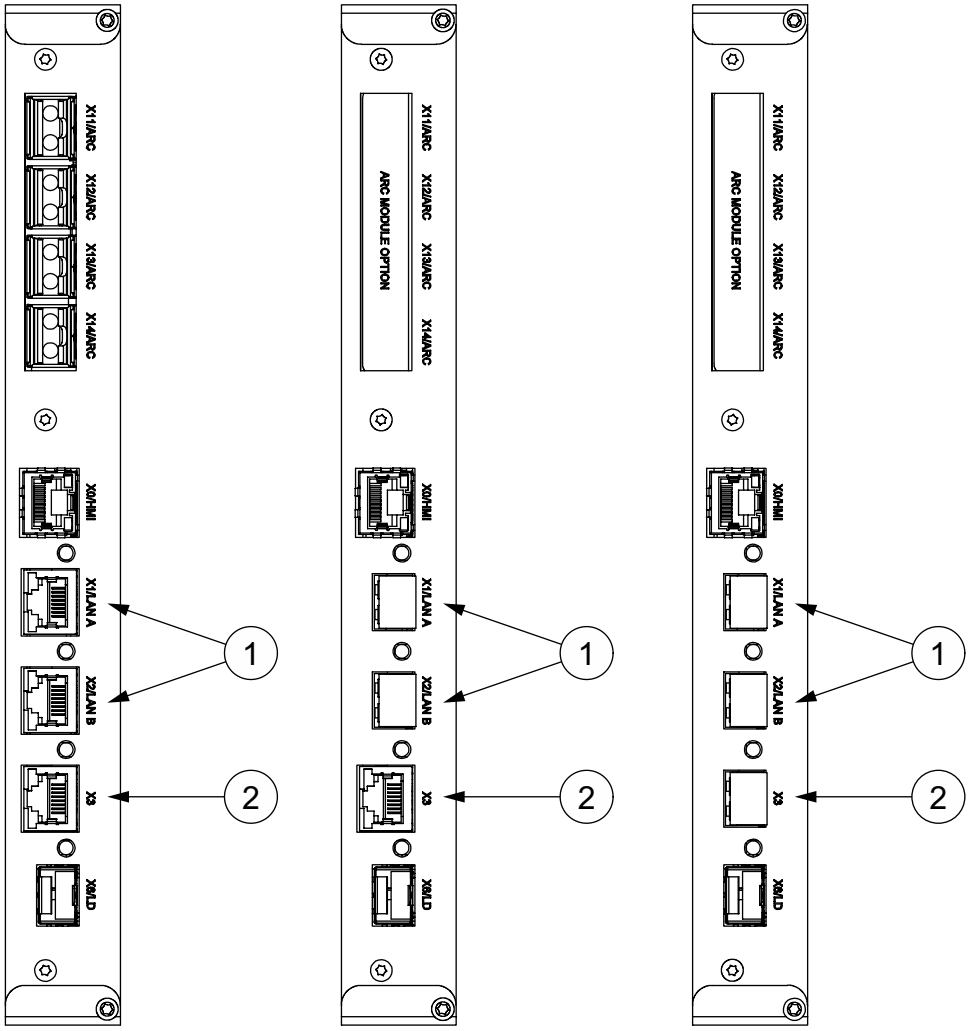



*Figure 12: Ethernet modes with Network 1 and Network 2*

1 Network 1

2 Network 1/Network 2

### 3.2.5.2 Protocol control

It is possible to allow or block different protocols for different network interfaces in the protection relay using the parameters in **Configuration/Communication/Protocols/Network1**, **Configuration/Communication/Protocols/Network2** and **Configuration/Communication/Protocols/HMI Port**.

All protocols are allowed for each network by default, and can be separately disabled.

*Table 20: Protocol control in the protection relay*

| Parameter | Options | Description |
|---|---|---|
| Configuration/Communication/ Protocols/Network1/FTP | Off | Denies FTP and FTPS |
| | On (Default) | Allows FTP and FTPS |
| | Secure | Allows FTPS only |
| Configuration/Communication/ Protocols/Network2/FTP | Off | Denies FTP and FTPS |
| | On (Default) | Allows FTP and FTPS |
| | Secure | Allows FTPS only |
| Configuration/Communication/ Protocols/HMI Port/FTP | Off | Denies FTP and FTPS |
| | On (Default) | Allows FTP and FTPS |
| | Secure | Allows FTPS only |
| Configuration/Communication/ Protocols/Network1/HTTPS | Off | Denies HTTPS |
| | On (Default) | Allows HTTPS |
| Configuration/Communication/ Protocols/Network2/HTTPS | Off | Denies HTTPS |
| | On (Default) | Allows HTTPS |
| Configuration/Communication/ Protocols/Network1/MMS | Off | Denies IEC 61850 MMS |
| | On (Default) | Allows IEC 61850 MMS |
| Configuration/Communication/ Protocols/Network2/MMS | Off | Denies IEC 61850 MMS |
| | On (Default) | Allows IEC 61850 MMS |
| Configuration/Communication/ Protocols/HMI Port/MMS | Off | Denies IEC 61850 MMS |
| | On (Default) | Allows IEC 61850 MMS |
| Configuration/Communication/ Protocols/Network1/DNP | Off | Denies DNP3 |
| | On (Default) | Allows DNP3 |
| Configuration/Communication/ Protocols/Network2/DNP | Off | Denies DNP3 |
| | On (Default) | Allows DNP3 |
| Configuration/Communication/ Protocols/Network1/Modbus | Off | Denies Modbus |
| | On (Default) | Allows Modbus |
| Configuration/Communication/ Protocols/Network2/Modbus | Off | Denies Modbus |
| | On (Default) | Allows Modbus |

### 3.2.5.3 Protocol write access rights

Write access rights are configurable for FTP, MMS, and HTTPS protocols in **Configuration/Authorization**. The write access parameters are used to narrow down services that allow setting changes on different network interfaces. Disabling the FTP and IEC 61850 MMS write access on Network 1 and 2 prevents the user from updating the configuration to the protection relay from PCM600. Disabling the HTTPS write access prevents the user from writing setting changes from WHMI.

*Table 21: Protocol write access in the protection relay*

| Parameter | Options | Description |
|---|---|---|
| Configuration/Authorization/ Network1/FTP write access | Off | FTP write access denied for Network 1 |
| | On (Default) | FTP write access allowed for Network 1 |
| Configuration/Authorization/ Network1/MMS write access | Off | IEC 61850 MMS write access denied for Network 1 |
| | On (Default) | IEC 61850 MMS write access allowed for Network 1 |
| Configuration/Authorization/ Network1/HTTPS write access | Off | HTTPS write access denied for Network 1 |
| | On (Default) | HTTPS write access allowed for Network 1 |
| Configuration/Authorization/ Network2/FTP write access | Off | FTP write access denied for Network 2 |
| | On (Default) | FTP write access allowed for Network 2 |
| Configuration/Authorization/ Network2/MMS write access | Off | IEC 61850 MMS write access denied for Network 2 |
| | On (Default) | IEC 61850 MMS write access allowed for Network 2 |
| Configuration/Authorization/ Network2/HTTPS write access | Off | HTTPS write access denied for Network 2 |
| | On (Default) | HTTPS write access allowed for Network 2 |
| Configuration/ Authorization/HMI/FTP write access | Off | FTP write access denied for the HMI port |
| | On (Default) | FTP write access allowed for the HMI port |
| Configuration/ Authorization/HMI/MMS write access | Off | IEC 61850 MMS write access denied for the HMI port |
| | On (Default) | IEC 61850 MMS write access allowed for the HMI port |

If the FTP write access is disabled for a network, the read operation from Parameter Setting Tool in PCM600 is not be possible for that network.

Enabling Network 2 IP address requires additional configuration in PCM600 to define IEC 61580 subnetworks. This configuration is done via Ethernet Configuration and IEC 61850 Configuration in PCM600.

## 3.2.6 Serial port supervision SERLCCH

### 3.2.6.1 Function block




*Figure 13: Function block*

### 3.2.6.2 Functionality

The serial port supervision function SERLCCH represents one serial communication port driver. Depending on the hardware configuration, the protection relay can be equipped with two UART-based serial communication ports. The communication ports can be both galvanic (RS-485) or one port could be fiber-optic. The protection relay uses the ports for serial communication protocol links.

Serial communication drivers are identified in the device configuration as COM1 and COM2, which correspond to function blocks SERLCCH1 and SERLCCH2, respectively. Each COM port driver has its own setting parameters on the HMI under **Configuration/Communication/COMn (n=1,2)**.

Output `LNKxLIV` is active (TRUE) whenever characters are received on the serial interface. Output `CHxLIV` is active (TRUE) while complete link frames are received. Both outputs go to FALSE state after 15 seconds of inactivity on the port.

## 3.2.7 Assigning of a serial communication protocol to a COM serial port

The settings of the serial communication protocol instance include a setting parameter, called either *Port* or *Serial port*, which is used to select the COM1 or COM2 setting.

Since not all serial protocol standards allow changes in link parameters, all link setting parameters are not found in the COMn settings. Additional link setting parameters are found in the setting parameter list of the used serial protocol.

## 3.2.8 Physical locations of the serial channels

The physical location of the COM1 and COM2 drivers depends on the link mode used which, in turn, depends on the used communication hardware option. Serial channels can be found on communication boards COM1004...COM1005.

- X7 is the fiber-optic interface. Only driver COM2 can be configured into fiber-optic mode.
- X8 is the RS-485/IRIG-B interface. Both drivers COM1 and COM2 can be configured to this interface: COM1 and COM2 can act as two RS-485 2-wire links or, alternatively, COM1 can act as one single RS-485 4-wire link. Both ports are galvanically isolated serial communication ports.

*Table 22: Connector X8 signals*

| Pin No | Pin name | Description | Alternative |
|---|---|---|---|
| 1 | GND | EARTH | |
| 2 | GNDC | GND connected to earth via 1nF capacitor | |
| 3 | NC | | |
| 4 | IRIG-B - | ISOL2_GND | |
| 5 | IRIG-B + | | |
| 6 | ISOL_GND | RS485 GND | |
| 7 | RS485 B1/- | 2-wire - , COM1 | 4-wire TX pair, COM1 |
| 8 | RS485 A1/+ | 2-wire + , COM1 | 4-wire TX pair, COM1 |
| 9 | RS485 B2/- | 2-wire - , COM2 | 4-wire RX pair, COM1 |
| 10 | RS485 A2/+ | 2-wire + , COM2 | 4-wire RX pair, COM1 |

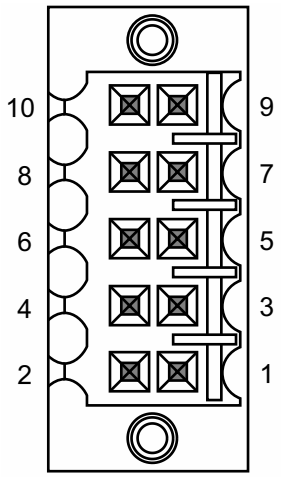



*Figure 14: X8 connector pinout*

*Table 23: LED configuration (COM1004...COM1005)*

| LED | Description |
|---|---|
| X1 | X1 LANA |
| X2 | X2 LANB |
| X6 | X6 LD |
| X7 TX | FO-UART |
| Table continues on next page | |

| LED | Description |
|---|---|
| X8 TX | RS-485/COM2 |
| X8 TX | RS-485/COM1 |
| IRIG-B | IRIG-B |

## 3.2.9 RS-485 bias and termination settings

A 6 x DIP switch is located on the bottom side of the COM1004...COM1005 boards. RS-485 biasing and termination settings are possible through this switch. If the switch is in “OFF” position, bias and termination are disabled and in “ON” position, they are enabled.

*Table 24: Bias and termination DIP switch*

| Switch | Signal | X8 pin | Type |
|---|---|---|---|
| 1 | RS485_A1/+ | 8 | Bias |
| 2 | RS485_A1/+<br>RS485_B1/- | | Bus termination |
| 3 | RS485_B1/- | 7 | Bias |
| 4 | RS485_A2/+ | 10 | Bias |
| 5 | RS485_A2/+<br>RS485_B2/- | | Bus termination |
| 6 | RS485_B2/- | 9 | Bias |

## 3.2.10 Serial link diagnostics and monitoring

Serial communication diagnostics and monitoring is divided between the serial link driver and the serial communication protocol. The lower-level physical and protocol-independent aspects of the UART-based serial communication are monitored in the serial link driver. Diagnostic counters and monitoring values are located on the HMI under **Monitoring/Communication/COMn (n= 1,2,…)**.

Depending on the communication protocol, the serial driver software receives single characters or complete protocol frames, based on the frame start/stop characters or on link frame timing.

*Table 25: Setting parameters*

| Parameter | Description |
|---|---|
| Fiber mode | Defines the fiber-optic mode used. Setting "No fiber" is the same as galvanic mode. |
| Serial mode | Used for galvanic RS-485 modes 2- or 4-wire. This setting is relevant only if *Fiber mode* is set to "No fiber". |
| Baudrate | Communication speed used |

*Table 26: Diagnostic counters and indications*

| Counters | Description |
|---|---|
| Characters received | Counts all incoming non-erroneous characters. This counter operates regardless of whether the serial driver is set to detect a whole protocol link frame or just separate characters. |
| Frames received | Counts all protocol-specific non-erroneous frames received. Protocol-specific frames can be based on timing (for example, Modbus RTU) or on special start and stop characters (for example, Modbus ASCII). |
| Frames discarded | Counts all protocol-specific erroneous frames received. If the driver detects an error while receiving a frame, the whole frame is automatically discarded. This also means that the protocol in question never receives a faulty link frame from the driver. When this counter is incremented, one of the detailed error counters (Parity, Overrun, Framing) can also be incremented. |
| Frames transmitted | Counts all protocol-specific frames transmitted from the COM channel |
| Collisions | Counts the number of transmission collisions that have occurred. Used in RS-485 mode by some protocols where transmissions could collide with reception. For example, DNP3 unsolicited reporting mode |
| Parity errors | Counts the number of parity errors detected in characters received |
| Overrun errors | Counts the number of overrun errors detected in characters received |
| Framing errors | Counts the number of framing errors detected in characters received |
| Link status | In write direction: By writing value 1 to this parameter, all the diagnostic counters are reset to 0. |
| Link status | In monitoring direction: If the driver instance is in use by any communication protocol, the monitoring value shows value 1. Otherwise, the value is 0. |

## 3.2.11 Modbus protocol MBSLPRT

### 3.2.11.1 Function block




*Figure 15: Function block*

### 3.2.11.2 Functionality

The function block represents a Modbus server protocol instance in the protection relay. Function block settings include communication interface assignment for the instance, that is, Ethernet/TCP or serial.

A Modbus server protocol instance is activated if the function block instance is added to the application configuration. The setting *Operation* should be "On" and setting *Port* should have the communication interface assignment.

The STATUS output of the function block is active if Modbus client requests have been received on the communication interface within 15 seconds.

By default no Modbus data is mapped to the protocol interface. Protocol data has to be created using Communication Management in PCM600. There are two mapping sets, “Mapping 1” and “Mapping 2”, and either can be used. Setting parameter *Mapping selection* points to the mapping set used. Several Modbus protocol instances can point to the same mapping set.

For more information on the Modbus server protocol, see the Modbus communication protocol manual.

## 3.2.12 DNP3 protocol DNPLPRT

### 3.2.12.1 Function block




*Figure 16: Function block*

### 3.2.12.2 Functionality

The function block represents one DNP3 server protocol instance in the protection relay. Function block settings include communication interface assignment for the instance, that is, Ethernet/TCP(+UDP) or serial.

A DNP3 server protocol instance is activated if the function block instance is added to the application configuration. The setting *Operation* should be "On" and setting *Port* should have the communication interface assignment.

The STATUS output of the function block is active if DNP3 client requests or DNP3 supervision messages have been received on the communication interface within an interval defined by the link keep-alive parameter.

By default no DNP3 data is mapped to the protocol interface. Protocol data has to be created using Communication Management in PCM600. There are two mapping sets,

"Mapping 1" and "Mapping 2", and either can be used. Setting parameter *Mapping selection* points to the mapping set used. Several DNP3 protocol instances can point to the same mapping set.

For more information on the DNP3 server protocol, see the DNP3 communication protocol manual.

## 3.2.13 IEC 60870-5-103 protocol I3CLPRT

### 3.2.13.1 Function block




*Figure 17: Function block*

### 3.2.13.2 Functionality

The function block represents one IEC 60870-5-103 server protocol instance in the protection relay. Function block settings include communication interface assignment for the instance, that is, serial communication port 1 or 2.

An IEC 60870-5-103 server protocol instance is activated if the function block instance is added to the application configuration. The setting *Operation* should be "On" and setting *Serial port* should have the communication interface assignment.

The STATUS output of the function block is active if IEC 60870-5-103 client requests have been received on the communication interface within 15 seconds.

The function block input EC_FRZ relates to possible ASDU 205 (mostly energy) counters defined in the protection relay. Activation of the EC_FRZ input freezes and captures the current ASDU 205 counter values and sends them to the IEC 60870-5-103 client. Several options for the activation exist.

1. EC_FRZ object exists as a control object in the IEC 60870-5-103 data model, and can be written from the client.
2. EC_FRZ physical input can be activated from an internal or external timer application signal.

By default most IEC 60870-5-103 data is pre-mapped to the protocol interface. However, protocol data can be deleted, added and modified using Communication Management in PCM600.

For more information on the IEC 60870-5-103 server protocol, see the IEC 60870-5-103 communication protocol manual.

# 3.3 Self-supervision

The protection relay's extensive self-supervision system continuously supervises the software and the electronics. It handles the run-time fault situation and informs the user about a fault via the LHMI, the relay's main unit power module Ready LED and through the communication channels.

There are two types of fault indications.

- Internal faults
- Warnings

On the LHMI, the self-supervision status is available as an advanced page under Relay Status page. The self-supervision status is indicated with Internal Fault, Warning and All OK LEDs. In normal operation, All OK LED is lit.

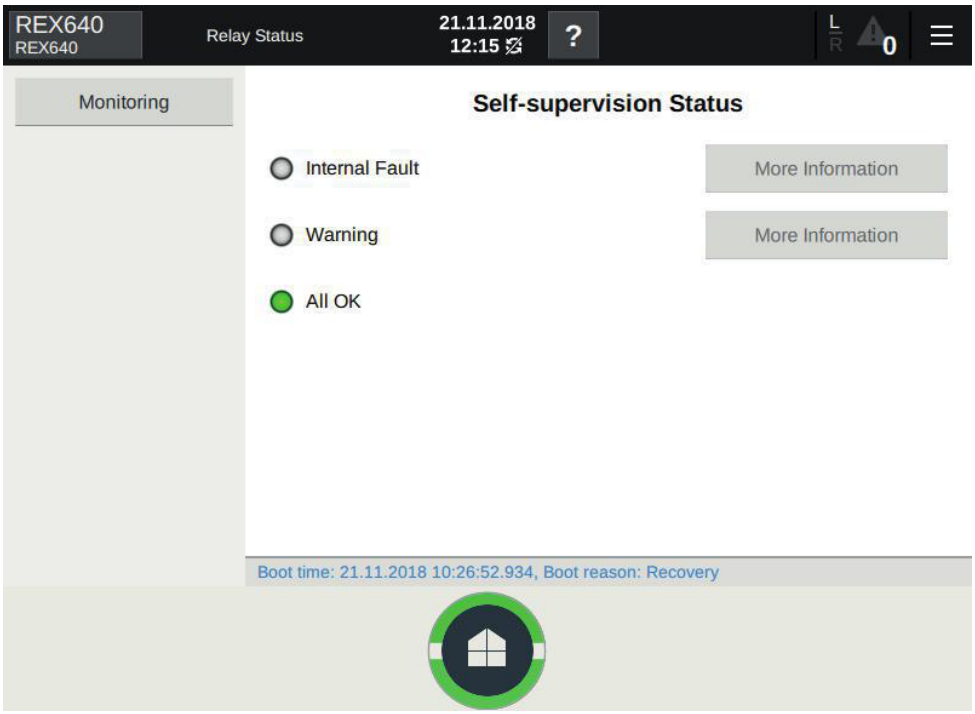



*Figure 18: Relay self-supervision status on local HMI*

On the WHMI, the self-supervision status is available under Device menu. The top right LED indicates the relay status.

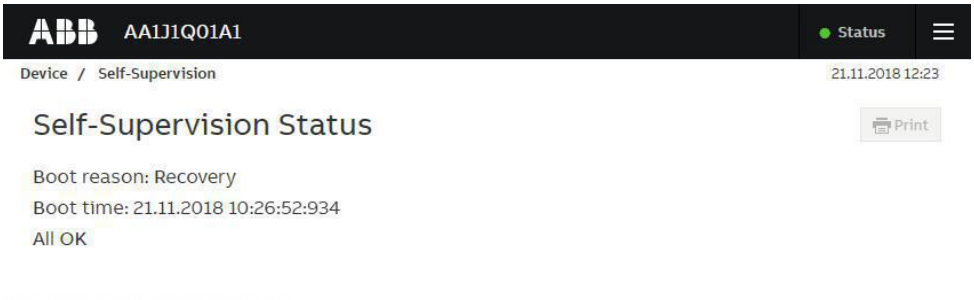



*Figure 19: Relay self-supervision status on Web HMI*

In addition, the last boot reason and time are shown on both LHMI and WHMI.

## 3.3.1 Internal faults

When an internal relay fault is detected, relay protection operation is disabled and the self-supervision output contact is activated. In the main unit, the main indication of an internal fault is a flashing green Ready LED behind the power module, and on the HMI, a rapidly flashing red Home button.

Different actions are taken depending on the severity of the fault. The protection relay tries to eliminate the fault by restarting. In case of a permanent fault, the protection relay stays in the internal fault mode. All other output contacts are released and locked for the internal fault. The protection relay continues to perform internal tests during the fault situation.

If the internal fault disappears, the fault indication LEDs stop flashing and the protection relay returns to the normal service state.

The self-supervision signal output operates on the closed-circuit principle. Under normal conditions, the protection relay is energized and the contact gap 3-5 in slot B is closed. If the auxiliary power supply fails or an internal fault is detected, the contact gap 3-5 is opened.

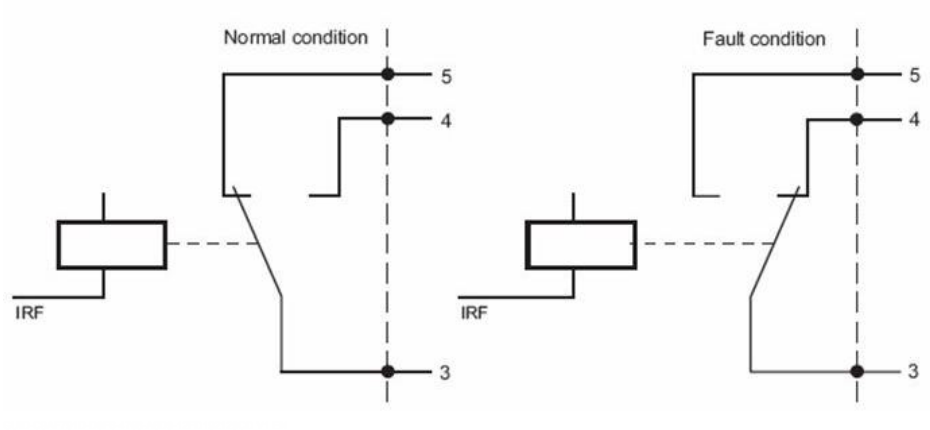



*Figure 20: Output contact*

The internal fault code indicates the type of internal relay fault. When a fault appears, the code must be recorded so that it can be reported to ABB customer service.

More details about the active internal fault are found on the Relay Status page. On the LHMI, the internal fault state is indicated with a red LED. More information about the fault and recovery options can be accessed by tapping More Information.

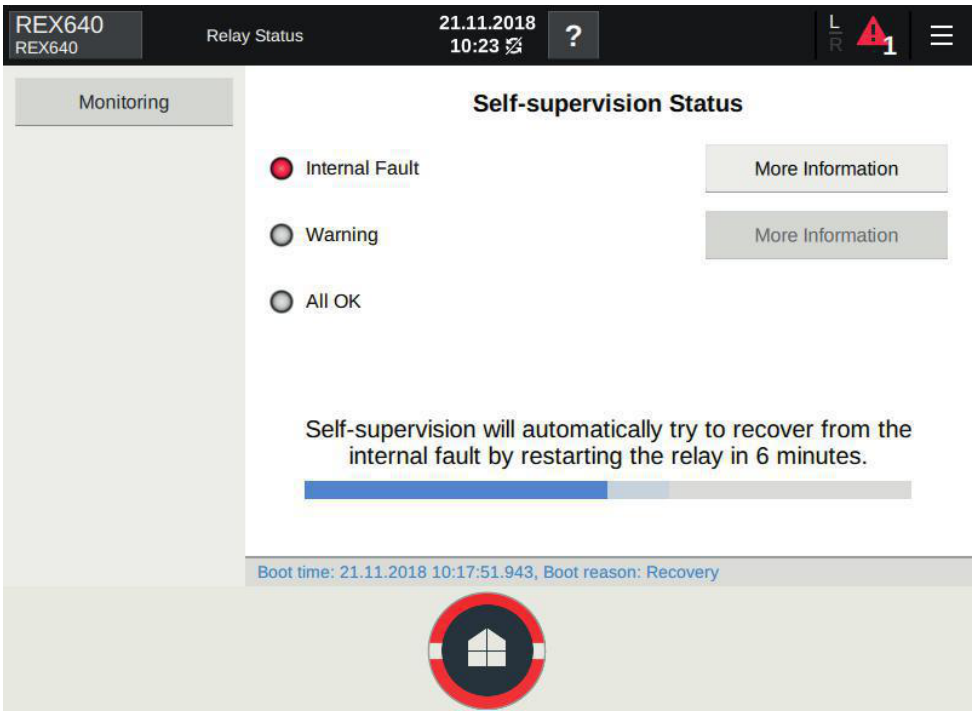



*Figure 21: Internal fault state indicated with red LED*

More Information shows all active faults and the corresponding fault codes. In addition, a recovery procedure is described.

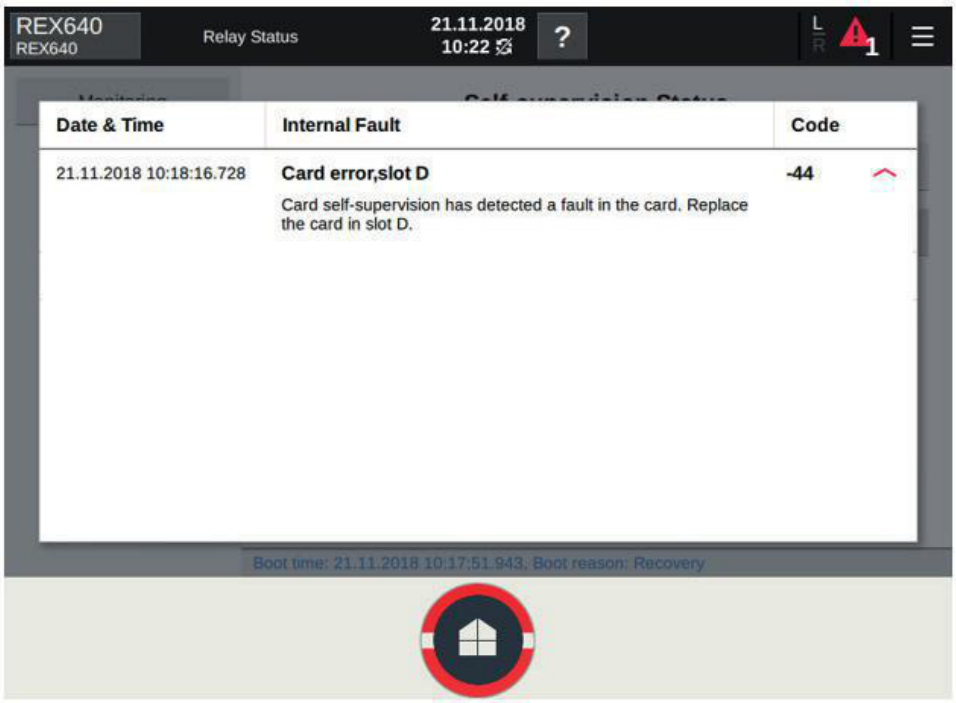



*Figure 22: More information about the fault*

On the WHMI, internal fault information is shown under Self-Supervision Status.

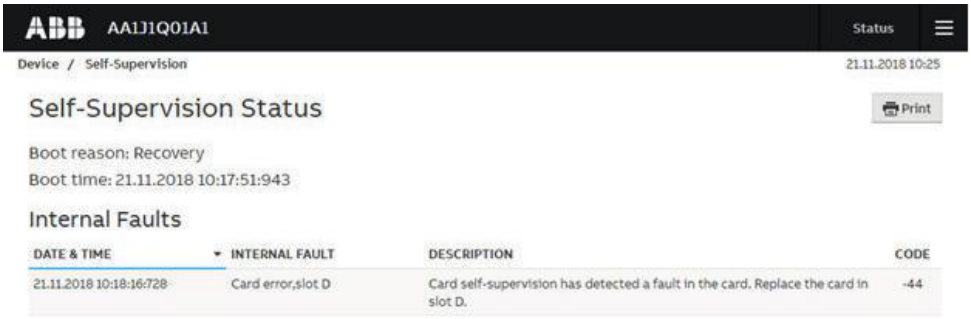



*Figure 23: Internal fault information on Web HMI*

***Table 27: Internal fault indications and codes***

| Fault indication | Fault code | Additional information |
|---|---|---|
| System error | 2 | An internal system error has occurred. |
| File system error | 7 | A file system error has occurred. |
| Test | 8 | Internal fault test activated manually by the user |
| SW watchdog error | 10 | Watchdog reset has occurred too many times within an hour. |
| Table continues on next page | | |

| Fault indication | Fault code | Additional information |
|---|---|---|
| SO-relay(s),slot C | -10 | Faulty Signal Output relay(s) in module located in slot C |
| SO-relay(s),slot E | -11 | Faulty Signal Output relay(s) in module located in slot E |
| SO-relay(s),slot B | -13 | Faulty Signal Output relay(s) in module located in slot B |
| SO-relay(s),slot D | -14 | Faulty Signal Output relay(s) in module located in slot D |
| SO-relay(s),slot G | -16 | Faulty Signal Output relay(s) in module located in slot G |
| PO-relay(s),slot C | -20 | Faulty Power Output relay(s) in module located in slot C |
| PO-relay(s),slot E | -21 | Faulty Power Output relay(s) in module located in slot E |
| PO-relay(s),slot B | -23 | Faulty Power Output relay(s) in module located in slot B |
| PO-relay(s),slot D | -24 | Faulty Power Output relay(s) in module located in slot D |
| PO-relay(s),slot G | -26 | Faulty Power Output relay(s) in module located in slot G |
| Conf.error,slot C | -30 | Module in slot C is wrong type, is missing, does not belong to original configuration or module firmware is faulty. |
| Conf.error,slot E | -31 | Module in slot E is wrong type, is missing, does not belong to original configuration or module firmware is faulty. |
| Conf.error,slot A2 | -32 | Module in slot A2 is wrong type, is missing, does not belong to original configuration or module firmware is faulty. |
| Conf.error,slot B | -33 | Module in slot B is wrong type, is missing, does not belong to original configuration or module firmware is faulty. |
| Conf.error,slot D | -34 | Module in slot D is wrong type, is missing, does not belong to original configuration or module firmware is faulty. |
| Conf.error,slot F | -35 | Module in slot F is wrong type, is missing, does not belong to original configuration or module firmware is faulty. |
| Conf.error,slot G | -36 | Module in slot G is wrong type, is missing, does not belong to original configuration or module firmware is faulty. |
| Conf.error,slot A1 | -37 | Module in slot A1 is wrong type, is missing, does not belong to original configuration or module firmware is faulty. |
| Card error,slot C | -40 | Module in slot C is faulty. |

Table continues on next page

| Fault indication | Fault code | Additional information |
|---|---|---|
| Card error,slot E | -41 | Module in slot E is faulty. |
| Card error,slot A2 | -42 | Module in slot A2 is faulty. |
| Card error,slot B | -43 | Module in slot B is faulty. |
| Card error,slot D | -44 | Module in slot D is faulty. |
| Card error,slot F | -45 | Module in slot F is faulty. |
| Card error,slot G | -46 | Module in slot G is faulty. |
| Card error,slot A1 | -47 | Module in slot A1 is faulty. |
| Prod license error | -62 | Error in product license |
| RAM error | 80 | Error in the RAM memory on the CPU module |
| ROM error | 81 | Error in the ROM memory on the CPU module |
| EEPROM error | 82 | Error in the EEPROM memory on the CPU module |
| FPGA error | 83 | Error in the FPGA on the CPU module |
| RTC error | 84 | Error in the RTC on the CPU module |
| COM card error | 116 | Error in the COM module |

## 3.3.2 Warnings

In case of a warning, the protection relay continues to operate except for those protection functions affected by the fault. The main unit status LED remains lit as during normal operation. If the device warning event is configured as alarms, the LHMI Home button flashes red.



If a warning appears, record the name and code so that it can be provided to ABB customer service.

On the LHMI, an active warning is indicated with a yellow LED. More information about the warning and recovery options can be accessed by tapping More Information.

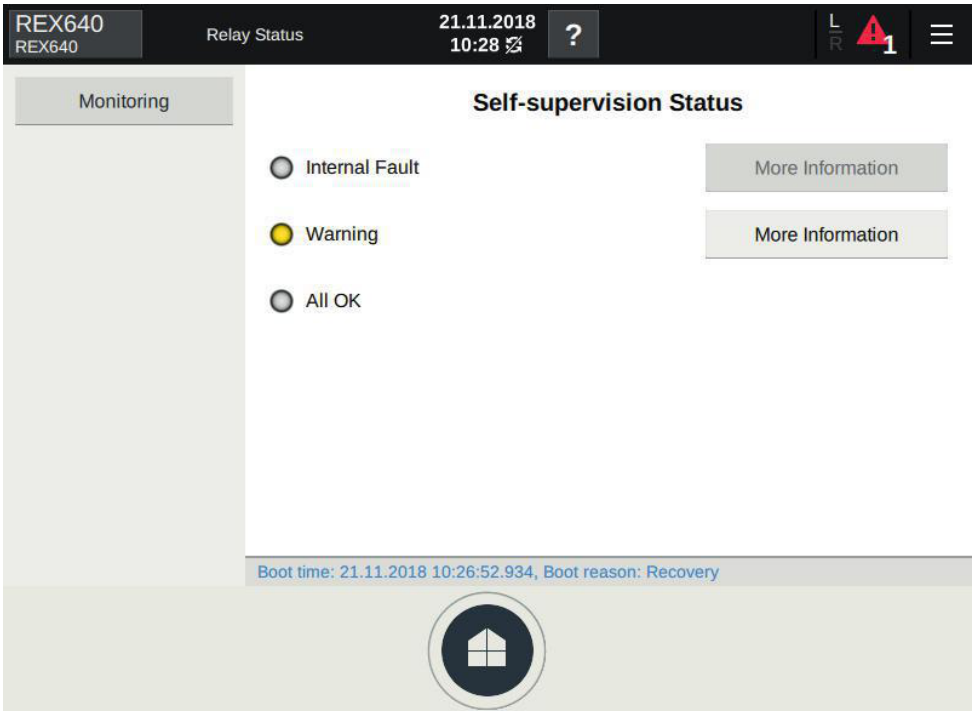



*Figure 24: Active warning on local HMI*

More information shows all active warnings and corresponding fault codes. In addition, a recovery procedure is described.

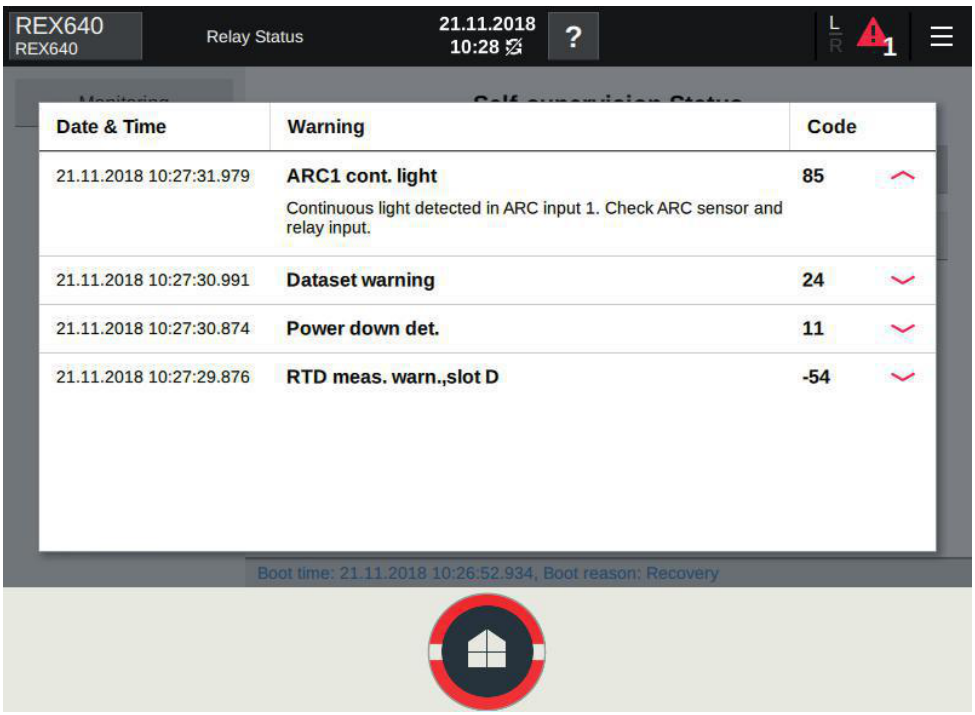



*Figure 25: More information about the warning*

*Table 28: Warning indications and codes*

| Warning indication | Warning code | Additional information |
|---|---|---|
| Watchdog reset | 10 | A watchdog reset has occurred. |
| Power down det. | 11 | The auxiliary supply voltage has dropped too low. |
| DNP3 warning | 22 | Error in the DNP3 communication |
| Dataset warning | 24 | Error in the Data set(s) |
| Report cont. warning | 25 | Error in the Report control block(s) |
| GOOSE contr. warning | 26 | Error in the GOOSE control block(s) |
| SCL config warning | 27 | Error in the SCL configuration file or the file is missing |
| Logic warning | 28 | |
| SMT logic warning | 29 | |
| GOOSE input warning | 30 | |
| ACT warning | 31 | Analog channel configuration warning |
| GOOSE rec. warning | 32 | |
| AFL warning | 33 | |
| SMV warning | 34 | Error in the SMV configuration |
| Comm. channel down | 35 | Redundant Ethernet (HSR/ PRP) communication interrupted |
| Settings mismatch | 36 | Mismatch between parameter settings and application configuration |
| Protection comm. | 50 | Error in protection communication |
| ARC1 cont. light | 85 | A continuous light has been detected on the ARC light input 1. |
| ARC2 cont. light | 86 | A continuous light has been detected on the ARC light input 2. |
| ARC3 cont. light | 87 | A continuous light has been detected on the ARC light input 3. |
| ARC4 cont. light | 88 | A continuous light has been detected on the ARC light input 4. |
| RTD meas. warn.,slot D | -54 | Abnormal signal from sensor(s) received in slot D |
| RTD meas. warn.,slot C | -50 | Abnormal signal from sensor(s) received in slot C |
| mA output warn.,slot D | -24 | Temporary error occurred in RTD module located in slot D |
| mA output warn.,slot C | -20 | Temporary error occurred in RTD module located in slot C |

### 3.3.3 Power supply module Ready LED and local HMI Home button LED

Both power supply module Ready LED and LHMI Home button LED visualize the self-supervision state of the relay. Table 29 shows how these states are indicated.

*Table 29: Power supply module Ready LED and local HMI Home button LED*

| State | Power supply module Ready LED | LHMI Home button | Alarm acknowledged |
|---|---|---|---|
| Relay under normal operation and LHMI connected | Steady green | Steady green | N/A |
| Relay's IRF activated, but communicates with LHMI | HF blinking green | HF blinking red | N/A |
| Communication lost between Relay and LHMI, but no IRF | Steady green | HF blinking green | N/A |
| LHMI not running normally or in start-up initialization phase | Steady green | HF blinking green | N/A |
| Process related alarm active | Steady green | LF blinking red | No |
| Process related alarm active | Steady green | Steady red | Yes |
| Process related alarm has been active earlier, but is not any more active. | Steady green | LF blinking red | No |
| Process related alarm has been active earlier, but is not any more active. | Steady green | Steady green | Yes |
| Relay set to Test Mode | LF blinking green | LF blinking green | No |

## 3.4 LED indication control LEDPTRC

### 3.4.1 Function block

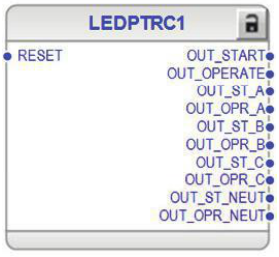



*Figure 26: Function block*

### 3.4.2 Functionality

The protection relay includes a global conditioning function LEDPTRC that is used to control the virtual Start and Trip indication LEDs.

LED indication control should never be used for tripping purposes. There is a separate trip logic function TRPPTRC available in the relay configuration.

LED indication control is preconfigured in a such way that all the protection function general start and operate signals are combined with this function (available as output signals OUT_START and OUT_OPERATE). These signals are internally connected to Device Status on WHMI Dashboard and the Device Status widget on the LHMI if the widget has been instantiated in the LHMI engineering phase. LEDPTRC collects and combines phase information from different protection functions (available as output signals OUT_ST_A /_B /_C and OUT_OPR_A /_B /_C). There is also combined earth fault information collected from all the earth-fault functions available in the relay configuration (available as output signals OUT_ST_NEUT and OUT_OPR_NEUT).

## 3.5 Virtual programmable LED control

### 3.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE identification |
|---|---|---|---|
| Virtual programmable LED control | LED | LED | LED |

### 3.5.2 Function block

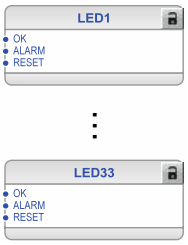



*Figure 27: Function block*

## 3.5.3 Functionality

The virtual, programmable LEDs are visible on the Programmable LEDs page in LHMI and on the WHMI dashboard.

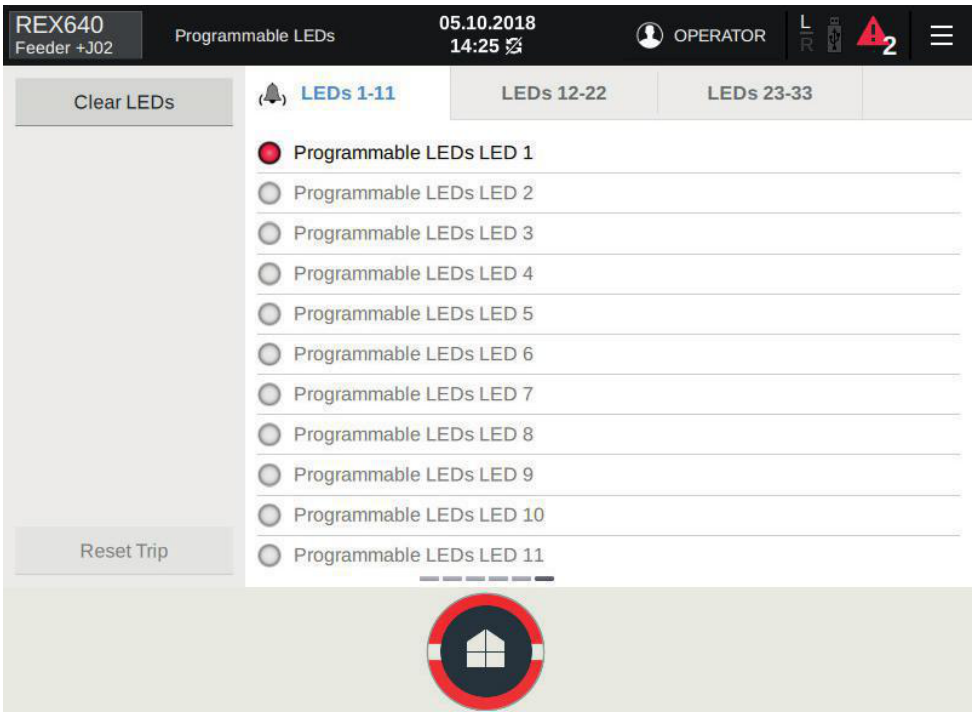



*Figure 28: Programmable LEDs page in LHMI*




*Figure 29: Programmable LEDs status in WHMI*

Programmable LEDs are available only when at least one LED has been instantiated and the OK or ALARM signal is connected in Application Configuration in PCM600.

All the programmable LEDs on the protection relay's HMI have two colors, green and red. For each LED, the different colors are individually controllable.

Each LED has two control inputs, ALARM and OK. The color setting is common for all the LEDs. It is controlled with the *Alarm colour* setting, the default value being

"Red". The OK input corresponds to the color that is available, with the default value being "Green".

Changing the *Alarm colour* setting to "Green" changes the color behavior of the OK inputs to red.

The ALARM input has a higher priority than the OK input. When a LED is in the alarming state, a bell symbol is shown on the LHMI next to the title of the Programmable LEDs page.

Each LED is seen in Application Configuration as an individual function block. Each LED has a user-editable description text for event description. The state ("None", "OK", "Alarm") of each LED can also be read under a common monitored data view for programmable LEDs.

The LED status also provides a means for resetting the individual LED via communication. The LED can also be reset from configuration with the RESET input.

The resetting and clearing function for all LEDs is available at the left side of the Programmable LEDs page and under the Clear menu.

The menu structure for the programmable LEDs is presented in Figure 30. The common color selection setting *Alarm colour* for all ALARM inputs is in the General menu, while the LED-specific settings are under the LED-specific menu nodes.

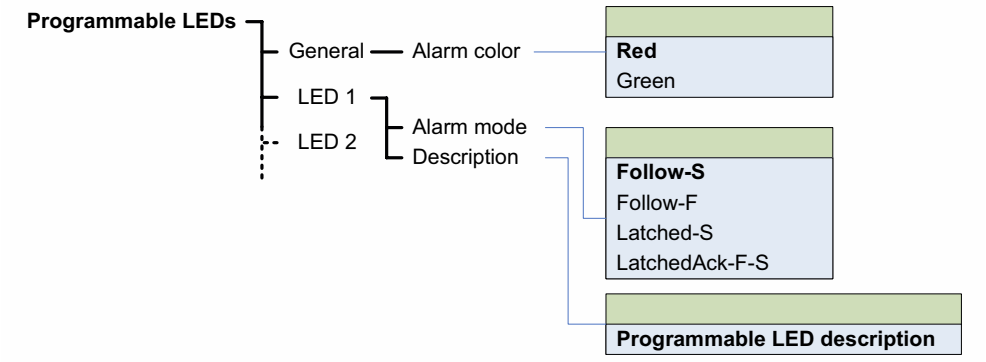



*Figure 30: Menu structure*

## Alarm mode alternatives

The ALARM input behavior can be selected with the alarm mode settings from the alternatives "Follow-S", "Follow-F", "Latched-S" and "LatchedAck-F-S". The OK input behavior is always according to "Follow-S". The alarm input latched modes can be cleared with the reset input in the application logic.

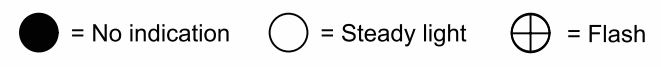



*Figure 31: Symbols used in the sequence diagrams*

### "Follow-S": Follow Signal, ON

In this mode ALARM follows the input signal value, Non-latched.

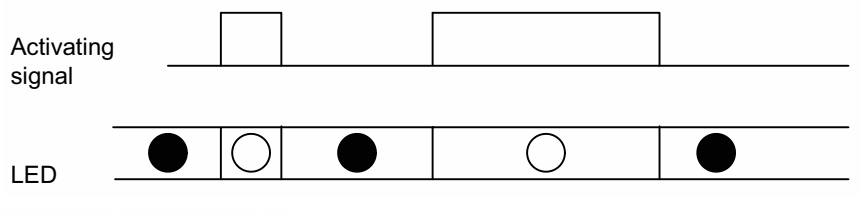



*Figure 32: Operating sequence "Follow-S"*

### "Follow-F": Follow Signal, Flashing

Similar to "Follow-S", but instead the LED is flashing when the input is active, Non-latched.

### "Latched-S": Latched, ON

This mode is a latched function. At the activation of the input signal, the alarm shows a steady light. After acknowledgement by the local operator pressing any key on the keypad, the alarm disappears.

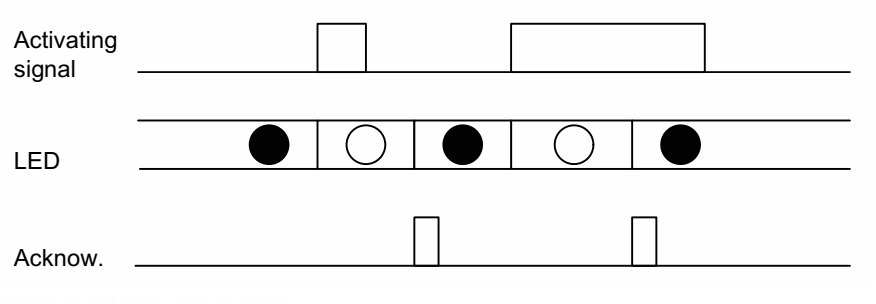



*Figure 33: Operating sequence "Latched-S"*

### "LatchedAck-F-S": Latched, Flashing-ON

This mode is a latched function. At the activation of the input signal, the alarm starts flashing. After acknowledgement, the alarm disappears if the signal is not present and gives a steady light if the signal is present.

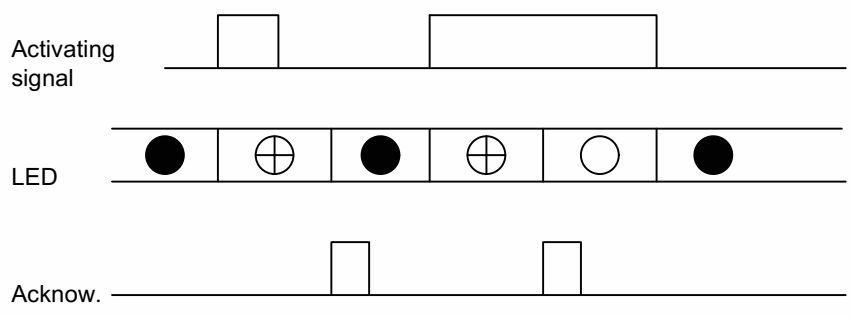



*Figure 34: Operating sequence "LatchedAck-F-S"*

## 3.5.4 Signals

*Table 30: Input signals for LEDs 1...33*

| Name | Type | Default | Description |
|---|---|---|---|
| OK | BOOLEAN | 0=False | Ok input for the LED |
| ALARM | BOOLEAN | 0=False | Alarm input for the LED |
| RESET | BOOLEAN | 0=False | Reset input for the LED |

## 3.5.5 Settings

*Table 31: Settings for LEDs 1...33*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Alarm colour | 1=Green<br>2=Red | | | 2=Red | Colour for the alarm state of the LED |
| Alarm mode | 0=Follow-S<br>1=Follow-F<br>2=Latched-S<br>3=LatchedAck-F-S | | | 0=Follow-S | Alarm mode for the programmable LED |

## 3.5.6 Monitored data

*Table 32: Monitored data for LEDs 1...33*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Programmable LED n[1)] | Enum | 0=None<br>1=Ok<br>3=Alarm | | Status of the programmable LED |

1) n = 1...33

*Table 33: IEC 61850 mapping*

| LED instance in Application Configuration | Mapping in IEC 61850 data model (ALARM and OK signals) |
|---|---|
| LED1...LED11 | LEDGGIO1.Alm1...LEDGGIO1.Alm11 |
| | LEDGGIO1.Ind1...LEDGGIO1.Ind11 |
| LED12...LED22 | LEDGGIO1.Alm11...LEDGGIO1.Alm22 |
| | LEDGGIO1.Ind12...LEDGGIO1.Ind22 |
| LED23...LED33 | LEDGGIO1.Alm23...LEDGGIO1.Alm33 |
| | LEDGGIO1.Ind23...LEDGGIO1.Ind33 |

# 3.6 Time synchronization

## 3.6.1 Time master supervision GNRLLTMS

### 3.6.1.1 Function block




*Figure 35: Function block*

### 3.6.1.2 Functionality

The protection relay has an internal real-time clock which can be either free-running or synchronized to an external source. The real-time clock is used for time stamping events, recorded data and disturbance recordings.

The protection relay is provided with a 48-hour capacitor backup that enables the real-time clock to keep time in case of an auxiliary power failure.

The setting *Synch source* determines the method for synchronizing the real-time clock. If it is set to "None", the clock is free-running and the settings *Date* and *Time* can be used to set the time manually. Other setting values activate a communication protocol that provides the time synchronization. Only one synchronization method can be active at a time. Both IEEE 1588 v2 and SNTP provide time master backup functionality.

Connect at least one measurement channel in Application Configuration in PCM600 either from the hardware (AIM or SIM) or from SMVRCV to ensure that the time system works correctly.

The protection relay supports SNTP, IRIG-B, IEEE 1588 v2, DNP3, Modbus, IEC 60870-5-101/104 and IEC 60870-5-103 to update the real-time clock. IEEE 1588 v2 with the GPS grandmaster clock provides the accuracy of ±1 µs. The accuracy is ±1 µs with IRIG-B and ±1 ms with SNTP.

When using line differential communication between the protection relays, the time synchronization messages can be received from the other line end protection relay within the protection telegrams. The protection relay begins to synchronize its real-time clock with the remote end protection relay's time if the "Line differential" time synchronization source is selected. This does not affect the protection synchronization used in the line differential protection or the selection of the remote end protection relay's time synchronization method.

GNRLLTMS supervision functionality depends on the synchronization source. This means that the GNRLLTMS supervision signal values and their combinations have different meanings depending on the used synchronization source.

## SNTP

The relay can use one of two SNTP servers, the primary or the secondary server. The primary server is mainly in use, whereas the secondary server is used if the primary server cannot be reached. While using the secondary SNTP server, the relay tries to switch back to the primary server on every third SNTP request attempt. If the primary server becomes available, the warning is cleared. If both the SNTP servers are offline, event time stamps have the time invalid status.

The time is requested from the SNTP server every 60 seconds. Supported SNTP versions are 3 and 4.

## IEEE 1588v2

The protection relay's 1588 time synchronization complies with the IEEE C37.238-2011 Power Profile, interoperable with IEEE 1588 v2. According to the power profile, the frame format used is IEEE 802.3 Ethernet frames with 88F7 Ethertype as the communication service and the delay mechanism is P2P. *PTP announce mode* determines the format of PTP announce frames sent by the protection relay when acting as a 1588 master, with options "Basic IEEE1588" and "Power Profile". In the "Power Profile" mode, the TLVs required by the IEEE C37.238-2011 Power Profile are included in announce frames.

Time synchronization with IEEE 1588 v2 can create many possible scenarios since it is a dynamic synchronization method whereby the current master is determined with BMC algorithm. GNRLLTMS outputs are reflective of this status. When IEEE 1588 v2 is used as a time synchronization source, the device stores the grandmasters in priority order according to the BMC algorithm. When the grandmaster clock is lost, alarm and warning are activated based on the stored grandmasters' list. The alarm is activated when there are no clocks available which have equivalent capabilities as primary or secondary grandmaster clocks. The warning is activated when primary grandmaster clock is not available. The grandmaster list can be cleared using the *Clear clock list* setting, for example, if the grandmaster clocks need to be replaced. The setting affects only the alarm and warning states.

If the current master is not within the 1 µs accuracy, ALARM is set to TRUE. If the current master is not the saved primary master, WARNING is set to TRUE. The EXTCLKMSTR output indicates if the current master is external.

Since the list is updated via the current primary master in the network, it is possible to lower the current grandmasters priority to a point where another clock takes the role and the priority value in the list for the original master is no longer updated. This means that there is a discrepancy between the list and the device. Consequently, the GNRLLTMS warning status becomes TRUE as the saved primary master is no longer considered as connected. The list logic can be reset to clear the clock list.

When IEEE 1588 v2 time synchronization is used, the recommended maximum number of hops from the grandmaster is 15 to ensure that the accuracy stays within 1 µs.

### IRIG-B

IRIG-B time synchronization requires IRIG-B format B00x and IRIG-B time code extensions according to IEEE Std C37.118.1™-2011. The extensions are defined by the Annex D.

The synchronization time in IRIG-B can be either UTC time or local time. As no reboot is necessary, the time synchronization starts immediately after the IRIG-B synchronization source is selected and the IRIG-B signal source is connected. GNRLLTMS signals reflect the signal status from the IRIG-B master.

IRIG-B time synchronization requires a COM module with an IRIG-B input.

### DNP3, Modbus, IEC 60870-5-101/104 and IEC 60870-5-103

With DNP3 the synchronization interval can be set manually. The synchronization message must be received within a minute after the synchronization interval has expired. Otherwise bad synchronization status is raised for the protection relay.

With Modbus, IEC 60870-5-101/104 and IEC 60870-5-103 the synchronization message must be received within four minutes from the previous synchronization. Otherwise bad synchronization status is raised for the protection relay.

When Modbus TCP or DNP3 over TCP/IP is used, PTP, SNTP or IRIG-B time synchronization is recommended to be used for better synchronization accuracy.

### 3.6.1.3 Signals

*Table 34: SNTP Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm status for clock synchronization<br>TRUE if the connection to both primary and secondary SNTP servers has been lost. “<br>FALSE if the connection to the secondary SNTP server is detected. |
| WARNING | BOOLEAN | Warning status for clock synchronization<br>TRUE if the connection to SNTP primary server has been lost. Otherwise FALSE. |
| EXTCLKMSTR | BOOLEAN | Status of the protection relay's clock synchronization<br>TRUE if the protection relay has been synchronized by an SNTP server.<br>FALSE if the clock has not been synchronized by an SNTP server. |

*Table 35: IEEE 1588v2 Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm status for clock synchronization<br>TRUE if the current master’s accuracy is not within 1µs or priority1 is bigger than that of first secondary’s. Also TRUE if the external master was lost and the protection relay itself acts as a master. Otherwise FALSE. |
| WARNING | BOOLEAN | Warning status for clock synchronization<br>TRUE if a previously connected and stored primary master has been lost. Otherwise FALSE. |
| EXTCLKMSTR | BOOLEAN | Status of the protection relay's clock synchronization<br>TRUE if the protection relay has been synchronized by an external master.<br>FALSE if the clock has not been synchronized by an external master. |

*Table 36: IRIG-B Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm status for clock synchronization<br>TRUE if the signal has been lost for a minute. Otherwise FALSE. |
| WARNING | BOOLEAN | Warning status for clock synchronization<br>TRUE if the signal connection is lost.<br>FALSE if the relay is synchronized to an IRIG-B master. |
| EXTCLKMSTR | BOOLEAN | Status of the protection relay's clock synchronization<br>TRUE if the protection relay has been synchronized to an IRIG-B master. Otherwise FALSE. |

*Table 37: DNP3, Modbus, IEC 60870-5-101/104 and IEC 60870-5-103 Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm status for clock synchronization<br>TRUE if the clock has not been synchronized by the master.<br>FALSE if the clock has been synchronized by the master. |
| WARNING | BOOLEAN | Warning status for clock synchronization<br>TRUE if the clock has not been synchronized by the master.<br>FALSE if the clock has been synchronized by the master. |
| EXTCLKMSTR | BOOLEAN | Status of the protection relay's clock synchronization<br>TRUE if the protection relay has been synchronized by an external master.<br>FALSE if the clock has not been synchronized by an external master. |

### 3.6.1.4 Settings

*Table 38: Time format*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Time format | 1=24H:MM:SS:MS<br>2=12H:MM:SS:MS | | | 1=24H:MM:SS:MS | Time format |
| Date format | 1=DD.MM.YYYY<br>2=DD/MM/YYYY<br>3=DD-MM-YYYY<br>4=MM.DD.YYYY<br>5=MM/DD/YYYY<br>6=YYYY-MM-DD<br>7=YYYY-DD-MM<br>8=YYYY/DD/MM | | | 1=DD.MM.YYYY | Date format |

*Table 39: Time settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Synch source | 0=None<br>1=SNTP<br>2=Modbus<br>3=IEEE 1588<br>5=IRIG-B<br>8=Line differential<br>9=DNP<br>17=IEC60870-5-103 | | | 1=SNTP | Time synchronization source |
| PTP domain ID | 0...255 | | 1 | 0 | The domain is identified by an integer, the domainNumber, in the range of 0 to 255. |
| PTP priority 1 | 0...255 | | 1 | 128 | PTP priority 1, in the range of 0 to 255. |
| PTP priority 2 | 0...255 | | 1 | 128 | PTP priority 2, in the range of 0 to 255. |
| PTP announce mode | 1=Basic IEEE1588<br>2=Power Profile | | | 1=Basic IEEE1588 | PTP announce frame mode |
| Clear clock list | 0=False<br>1=True | | | 0=False | Clears the stored master clock list |

*Table 40: Time settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Date | | | | 0 | Date |
| Time | | | | 0 | Time |
| Local time offset | -840...840 | min | 1 | 0 | Local time offset in minutes |

*Table 41: Time settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| IP SNTP primary | | | | 10.58.125.165 | IP address for SNTP primary server |
| IP SNTP secondary | | | | 192.168.2.165 | IP address for SNTP secondary server |

*Table 42: Time settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| DST in use | 0=False<br>1=True | | | 1=True | DST in use setting |
| DST on time (hours) | 0...23 | h | | 2 | Daylight saving time on, time (hh) |
| DST on time (minutes) | 0...59 | min | | 0 | Daylight saving time on, time (mm) |
| DST on date (day) | 1...31 | | | 1 | Daylight saving time on, date (dd:mm) |
| DST on date (month) | 1=January<br>2=February<br>3=March<br>4=April<br>5=May<br>6=June<br>7=July<br>8=August<br>9=September<br>10=October<br>11=November<br>12=December | | | 5=May | Daylight saving time on, date (dd:mm) |
| DST on day (weekday) | 0=reserved<br>1=Monday<br>2=Tuesday<br>3=Wednesday<br>4=Thursday<br>5=Friday<br>6=Saturday<br>7=Sunday | | | 0=reserved | Daylight saving time on, day of week |
| DST off time (hours) | 0...23 | h | | 2 | Daylight saving time off, time (hh) |
| DST off time (minutes) | 0...59 | min | | 0 | Daylight saving time off, time (mm) |
| DST off date (day) | 1...31 | | | 25 | Daylight saving time off, date (dd:mm) |
| DST off date (month) | 1=January<br>2=February<br>3=March<br>4=April<br>5=May<br>6=June<br>7=July<br>8=August<br>9=September<br>10=October<br>11=November<br>12=December | | | 9=September | Daylight saving time off, date (dd:mm) |
| DST off day (weekday) | 0=reserved<br>1=Monday<br>2=Tuesday<br>3=Wednesday<br>4=Thursday<br>5=Friday<br>6=Saturday<br>7=Sunday | | | 0=reserved | Daylight saving time off, day of week |
| DST offset | -720...720 | min | 1 | 60 | Daylight saving time offset |

### 3.6.1.5 Monitored data

*Table 43: Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Synch source | Enum | 0=Not defined<br>1=SNTP primary<br>2=SNTP secondary<br>4=IEEE 1588 master<br>5=IEEE 1588 slave<br>7=IRIG-B<br>8=DNP 3.0<br>9=Modbus<br>17=IEC 60870-5-103<br>21=Line differential<br>99=Free running | | Time synchronization source |
| Synch status | Bool | 0=Down<br>1=Up | | Time synchronization status |
| Synch accuracy | Int | 0...128 | | Time synchronization accuracy. Number of the significant bits in fraction of second. |
| Table continues on next page | | | | |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| PTP gm identity | String | | | PTP grand master clock identity according PTP standard |
| PTP gm time Src | Enum | 1=Atomic clock<br>2=GPS<br>3=Terrestrial radio<br>4=PTP<br>5=NTP<br>6=Hand set<br>7=Other<br>8=Internal oscil. | | PTP grand master clock source type |
| PTP gm accuracy | Enum | 1=25 ns<br>2=100 ns<br>3=250 ns<br>4=1 us<br>5=2.5 us<br>6=10 us<br>7=25 us<br>8=100 us<br>9=250 us<br>10=1 ms<br>11=2.5 ms<br>12=10 ms<br>13=25 ms<br>14=100 ms<br>15=250 ms<br>16=1 s<br>17=10 s<br>18=more than 10 s | | PTP grand master accuracy according PTP standard |

# 3.7 Generic protection control

## 3.7.1 Function block

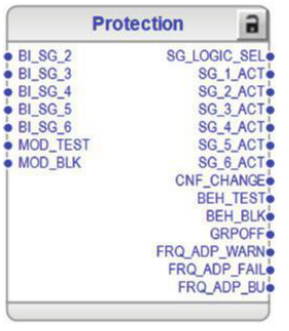



*Figure 36: Function block*

## 3.7.2 Functionality

### Setting group control

The protection relay supports six setting groups. Each setting group contains parameters categorized as group settings inside application functions. The customer can change the active setting group at run time.

The active setting group can be changed by a parameter or via binary inputs depending on the mode selected with the **Configuration/Setting Group/SG operation mode** setting.

The default value of all inputs is FALSE, which makes it possible to use only the required number of inputs and leave the rest disconnected. The setting group selection is not dependent on the SG_x_ACT outputs.

*Table 44: Optional operation modes for setting group selection*

| SG operation mode | Description |
|---|---|
| Operator (Default) | Setting group can be changed with the setting **Settings/Setting group/Active group**.<br>Value of the SG_LOGIC_SEL output is FALSE. |
| Logic mode 1 | Setting group can be changed with binary inputs (BI_SG_2...BI_SG_6). The highest TRUE binary input defines the active setting group.<br>Value of the SG_LOGIC_SEL output is TRUE. |
| Logic mode 2 | Setting group can be changed with binary inputs where BI_SG_4 is used for selecting setting groups 1-3 or 4-6.<br>When binary input BI_SG_4 is FALSE, setting groups 1-3 are selected with binary inputs BI_SG_2 and BI_SG_3. When binary input BI_SG_4 is TRUE, setting groups 4-6 are selected with binary inputs BI_SG_5 and BI_SG_6.<br>Value of the SG_LOGIC_SEL output is TRUE. |

For example, six setting groups can be controlled with three binary inputs. *SG operation mode* is set to "Logic mode 2" and inputs BI_SG_2 and BI_SG_5 are connected together the same way as inputs BI_SG_3 and BI_SG_6.

*Table 45: SG operation mode = "Logic mode 1"*

| Input | | | | | |
|---|---|---|---|---|---|
| BI_SG_2 | BI_SG_3 | BI_SG_4 | BI_SG_5 | BI_SG_6 | Active group |
| FALSE | FALSE | FALSE | FALSE | FALSE | 1 |
| TRUE | FALSE | FALSE | FALSE | FALSE | 2 |
| any | TRUE | FALSE | FALSE | FALSE | 3 |
| any | any | TRUE | FALSE | FALSE | 4 |
| any | any | any | TRUE | FALSE | 5 |
| any | any | any | any | TRUE | 6 |

*Table 46: SG operation mode = "Logic mode 2"*

| Input | | | | | |
|---|---|---|---|---|---|
| BI_SG_2 | BI_SG_3 | BI_SG_4 | BI_SG_5 | BI_SG_6 | Active group |
| FALSE | FALSE | FALSE | any | any | 1 |
| TRUE | FALSE | FALSE | any | any | 2 |
| any | TRUE | FALSE | any | any | 3 |
| any | any | TRUE | FALSE | FALSE | 4 |
| any | any | TRUE | TRUE | FALSE | 5 |
| any | any | TRUE | any | TRUE | 6 |

Setting group 1 can be copied to any other or all groups from HMI (Copy group 1).

## Test mode

The function has two outputs, BEH_TST and BEH_BLK, which are activated in test mode according to Table 47.

*Table 47: Test mode*

| Test mode | Description | Protection BEH_BLK | Protection BEH_TST |
|---|---|---|---|
| Normal mode | Normal operation | FALSE | FALSE |
| IED blocked | Protection works as in “Normal mode” but the ACT configuration can be used to block physical outputs to process. Control function commands are blocked. | TRUE | FALSE |
| IED test | Protection works as in “Normal mode” but protection functions work in parallel with test parameters. | FALSE | TRUE |
| IED test and blocked | Protection works as in “Normal mode” but protection functions work in parallel with the test parameter. The ACT configuration can be used to block physical outputs to process. Control function command is blocked. | TRUE | TRUE |

For more information, see the Test mode section in this manual.

### Frequency adaptivity

The FRQ_ADP_WARN output is active when full adaptation to the actual frequency is not reached or guaranteed. The FRQ_ADP_FAIL output is active when no frequency source has sufficient amplitude and the nominal frequency window size is used in measurements. The FRQ_ADP_BU output is active when the backup adaptivity frequency source is active.

When switching from the main frequency source to the backup frequency source, there is an interval of 200 ms where the last known frequency is used to determine the measurement window size. During this period, FRQ_ADP_WARN is activated. This also happens when no frequency source has sufficient amplitude and the last frequency is held for 3 s before activating output FRQ_ADP_FAIL.

### Special function block outputs

The function block has a few outputs dedicated for special purposes.

*Table 48: Special function block outputs*

| Output | Description |
|---|---|
| CNF_CHANGE | Any setting change in the protection relay activates this output. |
| GRPOFF | Some application function blocks do now allow unconnected analog inputs. In such a case, GRPOFF must be connected to such an input. |
| DEV_WARN | A protection relay's internal warning activates this output. For more information, see Warnings under the Self-supervision section. |

## 3.7.3 Signals

*Table 49: PROTECTION Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| BI_SG2 | BOOLEAN | 0 | Setting group 2 is active |
| BI_SG3 | BOOLEAN | 0 | Setting group 3 is active |
| BI_SG4 | BOOLEAN | 0 | Setting group 4 is active |
| BI_SG5 | BOOLEAN | 0 | Setting group 5 is active |
| BI_SG6 | BOOLEAN | 0 | Setting group 6 is active |
| MOD_TEST | BOOLEAN | 0 | Activation of test mode |
| MOD_BLK | BOOLEAN | 0 | Block test mode |

*Table 50: PROTECTION Output signals*

| Name | Type | Description |
|---|---|---|
| SG_LOGIC_SEL | BOOLEAN | Logic selection for setting group |
| SG_1_ACT | BOOLEAN | Setting group 1 is active |
| SG_2_ACT | BOOLEAN | Setting group 2 is active |
| SG_3_ACT | BOOLEAN | Setting group 3 is active |
| SG_4_ACT | BOOLEAN | Setting group 4 is active |
| SG_5_ACT | BOOLEAN | Setting group 5 is active |
| SG_6_ACT | BOOLEAN | Setting group 6 is active |
| CNF_CHANGE | BOOLEAN | Active after any setting change |
| BEH_TEST | BOOLEAN | Logical device LD0 test status |
| BEH_BLK | BOOLEAN | Logical device LD0 block status |
| GRPOFF | Group signal | Group off signal for function blocks |
| DEV_WARN | BOOLEAN | Protection relay internal warning |
| FRQ_ADP_WARN | BOOLEAN | Frequency adaptivity warning |
| FRQ_ADP_FAIL | BOOLEAN | Frequency adaptivity status fail |
| FRQ_ADP_BU | BOOLEAN | Main frequency adaptivity source |

### 3.7.4 Settings

*Table 51: PROTECTION Settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| SG operation mode | 1=Operator<br>2=Logic mode 1<br>3=Logic mode 2 | | | 1=Operator | Operation mode for setting group change |

## 3.8 Local/Remote control CONTROL

### 3.8.1 Function block




*Figure 37: Function block*

## 3.8.2 Functionality

Local/Remote control is by default realized through the R/L button on the front panel. The control via binary input can be enabled by setting the value of the *LR control* setting to "Binary input". The binary input control requires that the CONTROL function is instantiated in the product configuration.

Local/Remote control supports multilevel access for control operations in substations according to the IEC 61850 standard. Multilevel control access with separate station control access level is not supported by other protocols than IEC 61850.

The actual Local/Remote control state is evaluated by the priority scheme on the function block inputs. If more than one input is active, the input with the highest priority is selected. The priority order is “off”, “local”, “station”, “remote”, “all”.

The actual state is reflected on the CONTROL function outputs. Only one output is active at a time.

*Table 52: Truth table for CONTROL*

| Input | | | | | Output |
|---|---|---|---|---|---|
| CTRL_OFF | CTRL_LOC | CTRL_STA | CTRL_REM | CTRL_ALL | |
| TRUE | N/A | N/A | N/A | N/A | OFF = TRUE |
| FALSE | TRUE | N/A | N/A | N/A | LOCAL = TRUE |
| FALSE | FALSE | TRUE | N/A | N/A | STATION = TRUE |
| FALSE | FALSE | FALSE | TRUE | TRUE | REMOTE = TRUE |
| FALSE | FALSE | FALSE | FALSE | TRUE | ALL = TRUE |
| FALSE | FALSE | FALSE | FALSE | FALSE | OFF = TRUE |

## 3.8.3 L/R control access

Four different Local/Remote control access scenarios are possible depending on the selected station authority level: “L,R”, “L,R,L+R”, “L,S,R” and “L, S, S+R, L+S, L +S+R”. If control commands need to be allowed from multiple levels, multilevel access can be used. Multilevel access is possible only by using the station authority levels “L,R,L+R” and “L, S, S+R, L+S, L+S+R”. Multilevel access status is available from IEC 61850 data object CTRL.LLN0.MltLev.

Control access selection is made with R/L button or CONTROL function block and IEC 61850 data object CTRL.LLN0.LocSta. When writing CTRL.LLN0.LocSta IEC 61850 data object, IEC 61850 command originator category station must be used by the client, and remote IEC 61850 control access must be allowed by the relay station authority. CTRL.LLN0.LocSta data object value is retained in the nonvolatile memory. The present control status can be monitored in the HMI or PCM600 via **Monitoring/Control command** with the *LR state* parameter or from the IEC 61850 data object CTRL.LLN0. LocKeyHMI.

IEC 61850 command originator category is always set by the IEC 61850 client. The relay supports station and remote IEC 61850 command originator categories, depending on the selected station authority level.

## 3.8.4 Station authority level “L,R”

Relay's default station authority level is “L,R”. In this scenario only local or remote control access is allowed. Control access with IEC 61850 command originator category station is interpreted as remote access. There is no multilevel access.

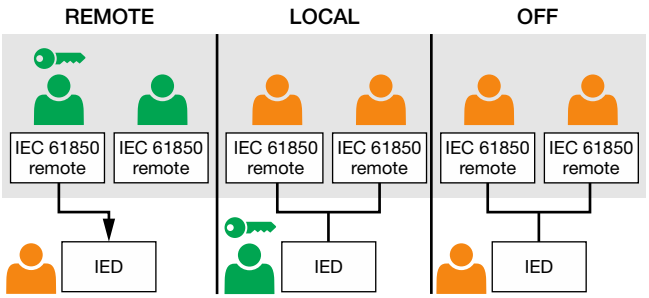



*Figure 38: Station authority is “L,R”*

When station authority level “L,R” is used, control access can be selected using R/L button or CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block inputs `CTRL_STA` and `CTRL_ALL` are not applicable for this station authority level.

*Table 53: Station authority level “L,R” using R/L button*

| L/R control | | L/R control status | | Control access | |
|---|---|---|---|---|---|
| R/L button | CTRL.LLN0.LocSta | CTRL.LLN0.MltLev | L/R state CTRL.LLN0.LocKeyHMI | Local user | IEC 61850 client 1) |
| Local | N/A | FALSE | 1 | x | |
| Remote | N/A | FALSE | 2 | | x |
| Off | N/A | FALSE | 0 | | |

1) Client IEC 61850 command originator category check is not performed.

*Table 54: Station authority “L,R” using CONTROL function block*

| L/R control | | L/R control status | | Control access | |
|---|---|---|---|---|---|
| Control FB input | CTRL.LLN0.LocSta | CTRL.LLN0.MltLev | L/R state CTRL.LLN0.LocKeyHMI | Local user | IEC 61850 client 1) |
| CTRL_OFF | N/A | FALSE | 0 | | |
| CTRL_LOC | N/A | FALSE | 1 | x | |
| CTRL_STA | N/A | FALSE | 0 | | |
| CTRL_REM | N/A | FALSE | 2 | | x |
| CTRL_ALL | N/A | FALSE | 0 | | |

1) Client IEC 61850 command originator category check is not performed.

## 3.8.5 Station authority level “L,R,L+R”

Station authority level “L,R, L+R” adds multilevel access support. Control access can also be simultaneously permitted from local or remote location. Simultaneous local or remote control operation is not allowed as one client and location at time can access controllable objects and they remain reserved until the previously started control operation is first completed by the client. Control access with IEC61850 originator category station is interpreted as remote access.

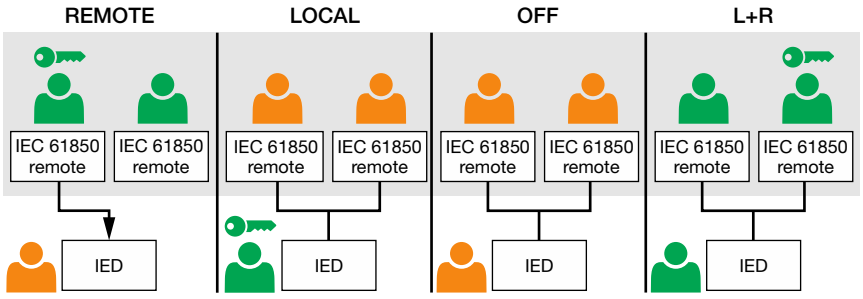



*Figure 39: Station authority is “L,R,L+R”*

When station authority level “L,R, L+R” is used, the control access can be selected using R/L button or CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block input `CTRL_STA` are not applicable for this station authority level.

*Table 55: Station authority level “L,R,L+R” using R/L button*

| L/R Control | | L/R Control status | | Control access | |
|---|---|---|---|---|---|
| R/L button | CTRL.LLN0.LocSta | CTRL.LLN0.MltLev | L/R state CTRL.LLN0.LocKeyHMI | Local user | IEC 61850 client 1) |
| Local | N/A | FALSE | 1 | x | |
| Remote | N/A | FALSE | 2 | | x |
| Local + Remote | N/A | TRUE | 4 | x | x |
| Off | N/A | FALSE | 0 | | |

1) Client IEC 61850 command originator category check is not performed.

*Table 56: Station authority “L,R,L+R” using CONTROL function block*

| L/R Control | | L/R Control status | | Control access | |
|---|---|---|---|---|---|
| Control FB input | CTRL.LLN0.LocSta | CTRL.LLN0.MltLev | L/R state CTRL.LLN0.LocKeyHMI | Local user | IEC 61850 client 1) |
| CTRL_OFF | N/A | FALSE | 0 | | |
| CTRL_LOC | N/A | FALSE | 1 | x | |
| CTRL_STA | N/A | FALSE | 0 | | |
| CTRL_REM | N/A | FALSE | 2 | | x |
| CTRL_ALL | N/A | TRUE | 4 | x | x |

1) Client IEC 61850 command originator category check is not performed.

## 3.8.6 Station authority level “L,S,R”

Station authority level “L,S,R” adds station control access. In this level IEC 61850 command originator category validation is performed to distinguish control commands with IEC 61850 command originator category set to “Remote” or “Station”. There is no multilevel access.

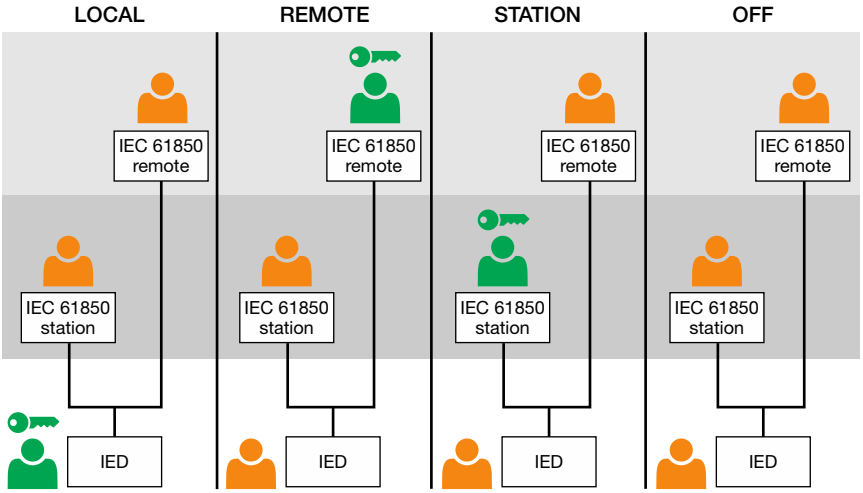



*Figure 40: Station authority is “L,S,R”*

When the station authority level “L,S,R” is used, the control access can be selected using R/L button or CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block input `CTRL_STA` are applicable for this station authority level.

Station control access can be reserved by using R/L button or CONTROL function block together with IEC 61850 data object CTRL.LLN0.LocSta.

*Table 57: Station authority level “L,S,R” using R/L button*

| L/R Control | | L/R Control status | | Control access | | |
|---|---|---|---|---|---|---|
| R/L button | CTRL.LLN0.LocSta 1) | CTRL.LLN0.MltLev | L/R state CTRL.LLN0.LocKeyHMI | Local user | IEC 61850 client 2) | IEC 61850 client 3) |
| Local | FALSE | FALSE | 1 | x | | |
| Remote | FALSE | FALSE | 2 | | x | |
| Remote | TRUE | FALSE | 3 | | | x |
| Off | FALSE | FALSE | 0 | | | |

1) Station client reserves the control operating by writing controllable point LocSta.
2) Client IEC 61850 command originator category is remote.
3) Client IEC 61850 command originator category is station.

*Table 58: Station authority level "L,S,R" using CONTROL function block*

| L/R Control | | L/R Control status | | Control access | | |
|---|---|---|---|---|---|---|
| Control FB input | CTRL.LLN0.LocSta [1] | CTRL.LLN0.MltLev | L/R state CTRL.LLN0.LocKeyHMI | Local user | IEC 61850 client [2] | IEC 61850 client [3] |
| CTRL_OFF | FALSE | FALSE | 0 | | | |
| CTRL_LOC | FALSE | FALSE | 1 | x | | |
| CTRL_STA | TRUE | FALSE | 3 | | | x |
| CTRL_REM [4] | TRUE | FALSE | 3 | | | x |
| CTRL_REM | FALSE | FALSE | 2 | | x | |
| CTRL_ALL | FALSE | FALSE | 0 | | | |

1) Station client reserves the control operating by writing controllable point LocSta.
2) Client IEC 61850 command originator category is remote.
3) Client IEC 61850 command originator category is station.
4) CTRL_STA unconnected in application configuration. Station client reserves the control operating by writing controllable point LocSta.

## 3.8.7 Station authority level "L,S,S+R,L+S,L+S+R"

Station authority level "L,S,S+R,L+S,L+S+R" adds station control access together with several different multilevel access scenarios. Control access can also be simultaneously permitted from local, station or remote location. Simultaneous local, station or remote control operation is not allowed as one client and location at time can access controllable objects and they remain reserved until the previously started control operation is first completed by the client.

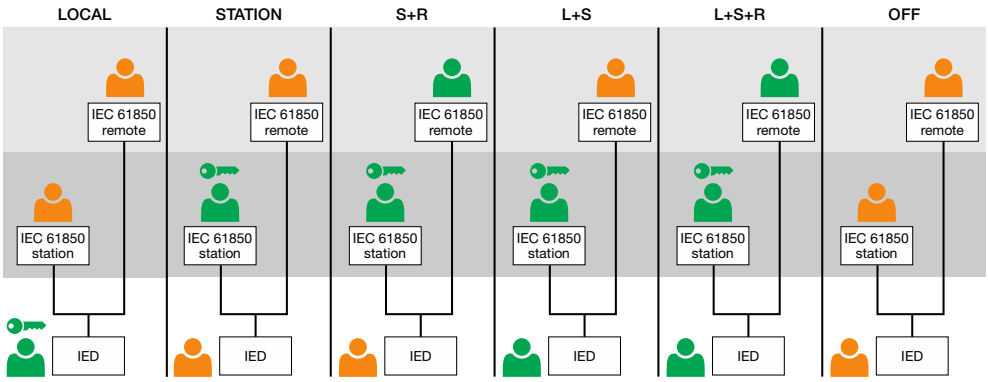



*Figure 41: Station authority is "L,S,S+R,L+S,L+S+R"*

When station authority level "L,S,S+R,L+S,L+S+R" is used, control access can be selected using R/L button or CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block input `CTRL_STA` are applicable for this station authority level.

"Station" and "Local + Station" control access can be reserved by using R/L button or CONTROL function block in combination with IEC 61850 data object CTRL.LLN0.LocSta.

*Table 59: Station authority level "L,S,S+R,L+S,L+S+R" using R/L button*

| L/R Control | | L/R Control status | | Control access | | |
|---|---|---|---|---|---|---|
| R/L button | CTRL.LLN0.LocSta [1] | CTRL.LLN0.MltLev | L/R state CTRL.LLN0.LocKeyHMI | Local user | IEC 61850 client [2] | IEC 61850 client [3] |
| Local | FALSE | FALSE | 1 | x | | |
| Remote | FALSE | TRUE | 7 | | x | x |
| Remote | TRUE | FALSE | 3 | | | x |
| Local + Remote | FALSE | TRUE | 6 | x | x | x |
| Local + Remote | TRUE | TRUE | 5 | x | | x |
| Off | FALSE | FALSE | 0 | | | |

1) Station client reserves the control operating by writing controllable point LocSta.
2) Client IEC61850 command originator category is remote.
3) Client IEC61850 command originator category is station.

*Table 60: Station authority level "L,S,S+R,L+S,L+S+R" using CONTROL function block*

| L/R Control | | L/R Control status | | Control access | | |
|---|---|---|---|---|---|---|
| Control FB input | CTRL.LLN0.LocSta [1] | CTRL.LLN0.MltLev | L/R state CTRL.LLN0.LocKeyHMI | Local user | IEC 61850 client [2] | IEC 61850 client [3] |
| CTRL_OFF | FALSE | FALSE | 0 | | | |
| CTRL_LOC | FALSE | FALSE | 1 | x | | |
| CTRL_STA | FALSE | FALSE | 3 | | | x |
| CTRL_REM [4] | TRUE | TRUE | 3 | | | x |
| CTRL_REM | FALSE | TRUE | 7 | | x | x |
| CTRL_ALL | FALSE | TRUE | 6 | x | x | x |
| CTRL_ALL [4] | TRUE | TRUE | 5 | x | | x |

1) Station client reserves the control operating by writing controllable point LocSta.
2) Client IEC61850 command originator category is remote.
3) Client IEC61850 command originator category is station.
4) CTRL_STA unconnected in application configuration. Station client reserves the control operating by writing controllable point LocSta.

## 3.8.8 Control mode

The function has two outputs BEH_TST and BEH_BLK which are activated in test mode according to Table 61.

*Table 61: Control mode*

| Control mode | Description | Control BEH_BLK |
|---|---|---|
| On | Normal operation | FALSE |
| Blocked | Control function commands blocked | TRUE |
| Off | Control functions disabled | FALSE |

For more information, see the Test mode chapter in this manual.

## 3.8.9 Signals

*Table 62: CONTROL Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| CTRL_OFF | BOOLEAN | 0 | Control input OFF |
| CTRL_LOC | BOOLEAN | 0 | Control input Local |
| CTRL_STA | BOOLEAN | 0 | Control input Station |
| CTRL_REM | BOOLEAN | 0 | Control input Remote |
| CTRL_ALL | BOOLEAN | 0 | Control input All |

*Table 63: CONTROL Output signals*

| Name | Type | Description |
|---|---|---|
| OFF | BOOLEAN | Control output OFF |
| LOCAL | BOOLEAN | Control output Local |
| STATION | BOOLEAN | Control output Station |
| REMOTE | BOOLEAN | Control output Remote |
| ALL | BOOLEAN | Control output All |
| BEH_BLK | BOOLEAN | Logical device CTRL block status |
| BEH_TST | BOOLEAN | Logical device CTRL test status |

## 3.8.10 Settings

*Table 64: Non group settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| LR control | 1=LR key<br>2=Binary input | | | 1=LR key | LR control through LR key or binary input |
| Station authority | 1=L,R<br>2=L,S,R<br>3=L,R,L+R<br>4=L,S,S+R,L+S,L+S+R | | | 1=L,R | Control command originator category usage |
| Control mode | 1=On<br>2=Blocked<br>5=Off | | | 1=On | Enabling and disabling control |

## 3.8.11 Monitored data

*Table 65: Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Command response | Enum | 0=No commands<br>1=Select open<br>2=Select close<br>3=Operate open<br>4=Operate close<br>5=Direct open<br>6=Direct close<br>7=Cancel<br>8=Position reached<br>9=Position timeout<br>10=Object status only<br>11=Object direct<br>12=Object select<br>13=RL local allowed<br>14=RL remote allowed<br>15=RL off<br>16=Function off<br>17=Function blocked<br>18=Command progress<br>19=Select timeout<br>20=Missing authority<br>21=Close not enabled<br>22=Open not enabled<br>23=Internal fault<br>24=Already close<br>25=Wrong client<br>26=RL station allowed<br>27=RL change<br>28=Abortion by trip<br>29=Reed not closed<br>30=Motor blocked<br>31=Motor wrong direction | | Latest command response |
| LR state | Enum | 0=Off<br>1=Local<br>2=Remote<br>3=Station<br>4=L+R<br>5=L+S<br>6=L+S+R<br>7=S+R | | LR state monitoring |

# 3.9 Fault recorder FLTRFRC

## 3.9.1 Function block




*Figure 42: Function block*

## 3.9.2 Functionality

The protection relay has the capacity to store the records of the latest 128 fault events. Fault records include fundamental or RMS current values. The records enable the user to analyze recent power system events. Each fault record (FLTRFRC) is marked with an up-counting fault number and a time stamp that is taken from the beginning of the fault.

The fault recording period begins from the start event of any protection function connected to the START input and ends if any protection function connected to the OPERATE input trips or the start is restored before the operate event. If a start is restored without an operate event, the start duration shows the protection function that has started first. The TRIG input can be used to start the fault recording period with, for example, binary input.

If *Start duration* has the value "100%", it indicates that a protection function has operated during the fault; if none of the protection functions has operated, *Start duration* always shows values less than 100%.

The fault recorded data *Protection* (rec. set 1 or rec. set 2) and *Start duration* are from the same protection function. The fault recorded data operate time shows the time of the actual fault period. This value is the time difference between the activation of the internal start and operate signals. The actual operate time also includes the starting time and the delay of the output relay. The fault recorded data *Breaker clear time* is the time difference between the internal operate signal and the activation of the CB_CLRD input.

If some functions in the relay application are sensitive to start frequently, it might be advisable to set the setting parameter *Trig mode* to "From operate". Then only faults that cause an operate event trigger a new fault recording.

The fault-related current, voltage, frequency, angle values, shot pointer and the active setting group number are taken from the moment of the operate event, or from the beginning of the fault if only a start event occurs during the fault. The maximum current value collects the maximum fault currents during the fault. If frequency cannot be measured, nominal frequency is used for frequency and zero for frequency gradient and validity is set accordingly.

The measuring mode for phase current and residual current values can be selected with the *A measurement mode* setting parameter.

## 3.9.3 Analog channel configuration

FLTFRC has twelve analog group inputs which must be properly configured.

*Table 66: Analog inputs*

| Input | Description |
|---|---|
| I3P1[1)] | Three-phase currents |
| I3P2[1)] | Three-phase currents |
| I3P3[1)] | Three-phase currents |
| IRES1[1)] | Residual current (measured or calculated) |
| IRES2[1)] | Residual current (measured or calculated) |
| IRES3[1)] | Residual current (measured or calculated) |
| U3P1[1)] | Three-phase voltages |
| U3P2[1)] | Three-phase voltages |
| U3P3[1)] | Three-phase voltages |
| URES1[1)] | Residual voltage (measured or calculated) |
| URES2[1)] | Residual voltage (measured or calculated) |
| URES3[1)] | Residual voltage (measured or calculated) |

1) Can be connected to GRPOFF

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

*Table 67: Special conditions*

| Condition | Description |
|---|---|
| *U3P1* connected to real measurements | The function requires that at least one voltage channel is connected. |
| *U3P2* connected to real measurements | The function requires that at least one voltage channel is connected. |
| *U3P3* connected to real measurements | The function requires that at least one voltage channel is connected. |
| *URES1* | The function requires that all three voltage channels are connected. |
| *URES2* | The function requires that all three voltage channels are connected. |
| *URES3* | The function requires that all three voltage channels are connected. |

## 3.9.4 Signals

*Table 68: FLTRFRC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| I3P3 | SIGNAL | - | Three-phase currents 3 |
| IRES1 | SIGNAL | - | Residual current 1 |
| IRES2 | SIGNAL | - | Residual current 2 |
| IRES3 | SIGNAL | - | Residual current 3 |
| U3P1 | SIGNAL | - | Three-phase voltages 1 |
| U3P2 | SIGNAL | - | Three-phase voltages 2 |
| U3P3 | SIGNAL | - | Three-phase voltages 3 |
| URES1 | SIGNAL | - | Residual voltage 1 |
| URES2 | SIGNAL | - | Residual voltage 2 |
| URES3 | SIGNAL | - | Residual voltage 3 |
| BLOCK | BOOLEAN | 0 | Block signal for all binary outputs |
| CB_CLRD | BOOLEAN | 0 | Breaker open status |
| START | BOOLEAN | 0 | Start input for triggering |
| OPERATE | BOOLEAN | 0 | Operate input for triggering |
| TRIG | BOOLEAN | 0 | Input for external triggering |

## 3.9.5 Settings

*Table 69: FLTRFRC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Trig mode | 0=From all faults<br>1=From operate<br>2=From only start | | | 0=From all faults | Triggering mode |

*Table 70: FLTRFRC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| A measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode phase currents and residual current |

## 3.9.6 Monitored data

*Table 71: FLTRFRC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Fault number | INT32 | 0...999999 | | Fault record number |
| Time and date | Timestamp | | | Fault record time stamp |
| Protection (rec. set 1) | Enum | 0=None<br>1=PHLPTOC1<br>2=PHLPTOC2<br>6=PHHPTOC1<br>7=PHHPTOC2<br>8=PHHPTOC3<br>9=PHHPTOC4<br>12=PHIPTOC1<br>13=PHIPTOC2<br>17=EFLPTOC1<br>18=EFLPTOC2<br>19=EFLPTOC3<br>22=EFHPTOC1<br>23=EFHPTOC2<br>24=EFHPTOC3<br>25=EFHPTOC4<br>30=EFIPTOC1<br>31=EFIPTOC2<br>32=EFIPTOC3<br>35=NSPTOC1<br>36=NSPTOC2<br>-7=INTRPTEF1<br>-5=STTPMSU1<br>-3=JAMPTOC1<br>41=PDNSPTOC1<br>44=T1PTTR1<br>46=T2PTTR1<br>48=MPTTR1<br>50=DEFLPDEF1<br>51=DEFLPDEF2<br>53=DEFHPDEF1<br>56=EFPADM1<br>57=EFPADM2<br>58=EFPADM3<br>59=FRPFRQ1<br>60=FRPFRQ2<br>61=FRPFRQ3<br>62=FRPFRQ4<br>63=FRPFRQ5<br>64=FRPFRQ6 | | Protection function (rec. set1) |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 65=LSHDPFRQ1<br>66=LSHDPFRQ2<br>67=LSHDPFRQ3<br>68=LSHDPFRQ4<br>69=LSHDPFRQ5<br>71=DPHLPDOC1<br>72=DPHLPDOC2<br>74=DPHHPDOC1<br>77=MAPGAPC1<br>78=MAPGAPC2<br>79=MAPGAPC3<br>85=MNSPTOC1<br>86=MNSPTOC2<br>88=LOFLPTUC1<br>90=TR2PTDF1<br>91=LNPLDF1<br>92=LREFPNDF1<br>94=MPDIF1<br>96=HREFPDIF1<br>100=ROVPTOV1<br>101=ROVPTOV2<br>102=ROVPTOV3<br>104=PHPTOV1<br>105=PHPTOV2<br>106=PHPTOV3<br>108=PHPTUV1<br>109=PHPTUV2<br>110=PHPTUV3<br>112=NSPTOV1<br>113=NSPTOV2<br>116=PSPTUV1<br>118=ARCSARC1<br>119=ARCSARC2<br>120=ARCSARC3<br>-96=SPHIPTOC1<br>-93=SPHLPTOC2<br>-92=SPHLPTOC1<br>-89=SPHHPTOC2<br>-88=SPHHPTOC1<br>-87=SPHPTUV4<br>-86=SPHPTUV3<br>-85=SPHPTUV2<br>-84=SPHPTUV1 | | |
| Table continues on next page | | | | |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | -83=SPHPTOV4<br>-82=SPHPTOV3<br>-81=SPHPTOV2<br>-80=SPHPTOV1<br>-25=OEPVPH4<br>-24=OEPVPH3<br>-23=OEPVPH2<br>-22=OEPVPH1<br>-19=PSPTOV2<br>-18=PSPTOV1<br>-15=PREVPTOC1<br>-12=PHPTUC2<br>-11=PHPTUC1<br>-9=PHIZ1<br>5=PHLTPTOC1<br>20=EFLPTOC4<br>26=EFHPTOC5<br>27=EFHPTOC6<br>37=NSPTOC3<br>38=NSPTOC4<br>45=T1PTTR2<br>54=DEFHPDEF2<br>75=DPHHPDOC2<br>89=LOFLPTUC2<br>103=ROVPTOV4<br>117=PSPTUV2<br>-13=PHPTUC3<br>3=PHLPTOC3<br>10=PHHPTOC5<br>11=PHHPTOC6<br>28=EFHPTOC7<br>29=EFHPTOC8<br>107=PHPTOV4<br>111=PHPTUV4<br>114=NSPTOV3<br>115=NSPTOV4<br>-30=PHDSTPDIS1<br>-29=TR3PTDF1<br>-28=HICPDIF1<br>-27=HIBPDIF1<br>-26=HIAPDIF1<br>-32=LSHDPFRQ8<br>-31=LSHDPFRQ7<br>70=LSHDPFRQ6<br>80=MAPGAPC4<br>81=MAPGAPC5<br>82=MAPGAPC6<br>83=MAPGAPC7<br>-102=MAPGAPC12<br>-101=MAPGAPC11<br>-100=MAPGAPC10 | | |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | -99=MAPGAPC9<br>-98=RESCPSCH1<br>-57=FDEFLPDEF2<br>-56=FDEFLPDEF1<br>-54=FEFLPTOC1<br>-53=FDPHLPDOC2<br>-52=FDPHLPDOC1<br>-50=FPHLPTOC1<br>-47=FRPFRQ8<br>-46=FRPFRQ7<br>-45=MAPGAPC24<br>-44=MAPGAPC23<br>-43=MAPGAPC22<br>-42=MAPGAPC21<br>-41=MAPGAPC20<br>-40=MAPGAPC19<br>-37=HAEFPTOC1<br>-35=WPWDE3<br>-34=WPWDE2<br>-33=WPWDE1<br>52=DEFLPDEF3<br>84=MAPGAPC8<br>93=LREFPNDF2<br>97=HREFPDIF2<br>-117=XDEFLPDEF2<br>-116=XDEFLPDEF1<br>-115=SDPHLPDOC2<br>-114=SDPHLPDOC1<br>-113=XNSPTOC2<br>-112=XNSPTOC1<br>-111=XEFIPTOC2<br>-110=XEFHPTOC4<br>-109=XEFHPTOC3<br>-108=XEFLPTOC3<br>-107=XEFLPTOC2<br>-66=DQPTUV1<br>-65=VVSPPAM1 | | |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | -64=PHPVOC1<br>-63=H3EFPSEF1<br>-60=HCUBPTOC1<br>-59=CUBPTOC1<br>-72=DOPPDPR1<br>-69=DUPPDPR1<br>-61=COLPTOC1<br>-106=MAPGAPC16<br>-105=MAPGAPC15<br>-104=MAPGAPC14<br>-103=MAPGAPC13<br>-76=MAPGAPC18<br>-75=MAPGAPC17<br>-62=SRCPTOC1<br>-74=DOPPDPR3<br>-73=DOPPDPR2<br>-70=DUPPDPR2<br>-58=UZPDIS1<br>-36=UEXPDIS1<br>14=MFADPSDE1<br>-10=LVRTPTUV1<br>-8=LVRTPTUV2<br>-6=LVRTPTUV3<br>-122=DPH3LPDOC1<br>-121=DPH3HPDOC2<br>-120=DPH3HPDOC1<br>-119=PH3LPTOC2<br>-118=PH3LPTOC1<br>-79=PH3HPTOC2<br>-78=PH3HPTOC1<br>-77=PH3IPTOC1<br>-127=PHAPTUV1<br>-124=PHAPTOV1<br>-123=DPH3LPDOC2<br>-68=PHPVOC2<br>-67=DQPTUV2<br>-39=UEXPDIS298=MHZPDIF1<br>-4=MREFPTOC1<br>-16=MPUPF1<br>-14=OOSRPSB1<br>121=PSPTUV3<br>122=PSPTOV3 | | |
| Table continues on next page | | | | |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 123=PHVPTOV1<br>139=DNSPDOC1<br>140=DNSPDOC2<br>-126=PHCPTOV1<br>-125=PHBPTOV1<br>-97=HIAPDIF3<br>-95=HICPDIF3<br>-94=HICPDIF2<br>-91=HIBPDIF3<br>-90=HIBPDIF2<br>-71=HIAPDIF2<br>-55=FRPFRQ12<br>-51=FRPFRQ11<br>-49=FRPFRQ10<br>-48=FRPFRQ9<br>-38=DSTPDIS1<br>-21=CUBPTOC3<br>-20=CUBPTOC2<br>-17=MPUPF2<br>-2=PHCPTUV1<br>-1=PHBPTUV1<br>4=PHIPTOC3<br>15=MFADPSDE2<br>16=MFADPSDE3<br>73=DPHLPDOC3<br>76=DPHHPDOC3<br>95=HCUBPTOC2<br>99=MREFPTOC2<br>124=PSPTUV4<br>125=PSPTOV4<br>127=JAMPTOC2<br>21=DEFHPDEF4<br>33=DPHHPDOC4<br>34=DPHLPDOC4<br>47=DEFLPDEF4<br>55=DEFHPDEF3 | | |
| Protection (rec. set 2) | Enum | 0=None<br>1=External | | Protection function (rec. set 2) |
| Start duration | FLOAT32 | 0.00...100.00 | % | Maximum start duration of all stages during the fault |
| Operate time | FLOAT32 | 0.000...999999.999 | s | Operate time |
| Breaker clear time | FLOAT32 | 0.000...3.000 | s | Breaker clear time |
| Fault distance | FLOAT32 | 0.00...3000.00 | pu | Distance to fault measured in pu |
| Fault resistance | FLOAT32 | 0.00...1000000.00 | ohm | Fault resistance |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Fault reactance | FLOAT32 | 0.0...1000000.0 | ohm | Fault reactance |
| Active group | INT32 | 1...6 | | Active setting group |
| Shot pointer | INT32 | 1...7 | | Autoreclosing shot pointer value |
| Max diff current IL1:1 | FLOAT32 | 0.000...80.000 | pu | Maximum phase A differential current (1) |
| Max diff current IL2:1 | FLOAT32 | 0.000...80.000 | pu | Maximum phase B differential current (1) |
| Max diff current IL3:1 | FLOAT32 | 0.000...80.000 | pu | Maximum phase C differential current (1) |
| Diff current IL1:1 | FLOAT32 | 0.000...80.000 | pu | Differential current phase A (1) |
| Diff current IL2:1 | FLOAT32 | 0.000...80.000 | pu | Differential current phase B (1) |
| Diff current IL3:1 | FLOAT32 | 0.000...80.000 | pu | Differential current phase C (1) |
| Max bias current IL1:1 | FLOAT32 | 0.000...50.000 | pu | Maximum phase A bias current: (1) |
| Max bias current IL2:1 | FLOAT32 | 0.000...50.000 | pu | Maximum phase B bias current (1) |
| Max bias current IL3:1 | FLOAT32 | 0.000...50.000 | pu | Maximum phase C bias current (1) |
| Bias current IL1:1 | FLOAT32 | 0.000...50.000 | pu | Bias current phase A (1) |
| Bias current IL2:1 | FLOAT32 | 0.000...50.000 | pu | Bias current phase B (1) |
| Bias current IL3:1 | FLOAT32 | 0.000...50.000 | pu | Bias current phase C (1) |
| Diff current Io:1 | FLOAT32 | 0.000...80.000 | pu | Differential current residual (1) |
| Bias current Io:1 | FLOAT32 | 0.000...50.000 | pu | Bias current residual (1) |
| Max current IL1:1 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase A current (1) |
| Max current IL2:1 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase B current (1) |
| Max current IL3:1 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase C current (1) |
| Max current Io:1 | FLOAT32 | 0.000...50.000 | xIn | Maximum residual current (1) |
| Current IL1:1 | FLOAT32 | 0.000...50.000 | xIn | Phase A current (1) |
| Current IL2:1 | FLOAT32 | 0.000...50.000 | xIn | Phase B current (1) |
| Current IL3:1 | FLOAT32 | 0.000...50.000 | xIn | Phase C current (1) |
| Current Io:1 | FLOAT32 | 0.000...50.000 | xIn | Residual current (1) |
| Current Io-Calc:1 | FLOAT32 | 0.000...50.000 | xIn | Calculated residual current (1) |
| Current Ps-Seq:1 | FLOAT32 | 0.000...50.000 | xIn | Positive sequence current (1) |
| Current Ng-Seq:1 | FLOAT32 | 0.000...50.000 | xIn | Negative sequence current (1) |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Max current IL1:2 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase A current (2) |
| Max current IL2:2 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase B current (2) |
| Max current IL3:2 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase C current (2) |
| Max current Io:2 | FLOAT32 | 0.000...50.000 | xIn | Maximum residual current (2) |
| Current IL1:2 | FLOAT32 | 0.000...50.000 | xIn | Phase A current (2) |
| Current IL2:2 | FLOAT32 | 0.000...50.000 | xIn | Phase B current (2) |
| Current IL3:2 | FLOAT32 | 0.000...50.000 | xIn | Phase C current (2) |
| Current Io:2 | FLOAT32 | 0.000...50.000 | xIn | Residual current (2) |
| Current Io-Calc:2 | FLOAT32 | 0.000...50.000 | xIn | Calculated residual current (2) |
| Current Ps-Seq:2 | FLOAT32 | 0.000...50.000 | xIn | Positive sequence current (2) |
| Current Ng-Seq:2 | FLOAT32 | 0.000...50.000 | xIn | Negative sequence current (2) |
| Max current IL1:3 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase A current (3) |
| Max current IL2:3 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase B current (3) |
| Max current IL3:3 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase C current (3) |
| Max current Io:3 | FLOAT32 | 0.000...50.000 | xIn | Maximum residual current (3) |
| Current IL1:3 | FLOAT32 | 0.000...50.000 | xIn | Phase A current (3) |
| Current IL2:3 | FLOAT32 | 0.000...50.000 | xIn | Phase B current (3) |
| Current IL3:3 | FLOAT32 | 0.000...50.000 | xIn | Phase C current (3) |
| Current Io:3 | FLOAT32 | 0.000...50.000 | xIn | Residual current (3) |
| Current Io-Calc:3 | FLOAT32 | 0.000...50.000 | xIn | Calculated residual current (3) |
| Current Ps-Seq:3 | FLOAT32 | 0.000...50.000 | xIn | Positive sequence current (3) |
| Current Ng-Seq:3 | FLOAT32 | 0.000...50.000 | xIn | Negative sequence current (3) |
| Voltage UL1:1 | FLOAT32 | 0.000...4.000 | xUn | Phase A voltage |
| Voltage UL2:1 | FLOAT32 | 0.000...4.000 | xUn | Phase B voltage |
| Voltage UL3:1 | FLOAT32 | 0.000...4.000 | xUn | Phase C voltage |
| Voltage U12:1 | FLOAT32 | 0.000...4.000 | xUn | Phase A to phase B voltage |
| Voltage U23:1 | FLOAT32 | 0.000...4.000 | xUn | Phase B to phase C voltage |
| Voltage U31:1 | FLOAT32 | 0.000...4.000 | xUn | Phase C to phase A voltage |
| Voltage Uo:1 | FLOAT32 | 0.000...4.000 | xUn | Residual voltage |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Voltage Zro-Seq:1 | FLOAT32 | 0.000...4.000 | xUn | Zero sequence voltage |
| Voltage Ps-Seq:1 | FLOAT32 | 0.000...4.000 | xUn | Positive sequence voltage |
| Voltage Ng-Seq:1 | FLOAT32 | 0.000...4.000 | xUn | Negative sequence voltage |
| Voltage UL1:2 | FLOAT32 | 0.000...4.000 | xUn | Phase A voltage (2) |
| Voltage UL2:2 | FLOAT32 | 0.000...4.000 | xUn | Phase B voltage (2) |
| Voltage UL3:2 | FLOAT32 | 0.000...4.000 | xUn | Phase B voltage (2) |
| Voltage U12:2 | FLOAT32 | 0.000...4.000 | xUn | Phase A to phase B voltage (2) |
| Voltage U23:2 | FLOAT32 | 0.000...4.000 | xUn | Phase B to phase C voltage (2) |
| Voltage U31:2 | FLOAT32 | 0.000...4.000 | xUn | Phase C to phase A voltage (2) |
| Voltage Uo:2 | FLOAT32 | 0.000...4.000 | xUn | Residual voltage (2) |
| Voltage Zro-Seq:2 | FLOAT32 | 0.000...4.000 | xUn | Zero sequence voltage (2) |
| Voltage Ps-Seq:2 | FLOAT32 | 0.000...4.000 | xUn | Positive sequence voltage (2) |
| Voltage Ng-Seq:2 | FLOAT32 | 0.000...4.000 | xUn | Negative sequence voltage (2) |
| Voltage UL1:3 | FLOAT32 | 0.000...4.000 | xUn | Phase A voltage (3) |
| Voltage UL2:3 | FLOAT32 | 0.000...4.000 | xUn | Phase B voltage (3) |
| Voltage UL3:3 | FLOAT32 | 0.000...4.000 | xUn | Phase C voltage (3) |
| Voltage UL12:3 | FLOAT32 | 0.000...4.000 | xUn | Phase A to phase B voltage (3) |
| Voltage UL23:3 | FLOAT32 | 0.000...4.000 | xUn | Phase B to phase C voltage (3) |
| Voltage UL31:3 | FLOAT32 | 0.000...4.000 | xUn | Phase C to phase A voltage (3) |
| Voltage Uo:3 | FLOAT32 | 0.000...4.000 | xUn | Residual voltage (3) |
| Voltage Zro-Seq:3 | FLOAT32 | 0.000...4.000 | xUn | Zero sequence voltage (3) |
| Voltage Ps-Seq:3 | FLOAT32 | 0.000...4.000 | xUn | Positive sequence voltage (3) |
| Voltage Ng-Seq:3 | FLOAT32 | 0.000...4.000 | xUn | Negative sequence voltage (3) |
| PTTR thermal level | FLOAT32 | 0.00...99.99 | | PTTR calculated temperature of the protected object relative to the operate level |
| PDNSPTOC1 rat. I2/I1 | FLOAT32 | 0.00...999.99 | % | PDNSPTOC1 ratio I2/I1 |
| Frequency:1 | FLOAT32 | 0.00...80.00 | Hz | Frequency (1) |
| Frequency gradient:1 | FLOAT32 | -10.00...10.00 | Hz/s | Frequency gradient (1) |
| Frequency:2 | FLOAT32 | 0.00...80.00 | Hz | Frequency gradient (2) |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Frequency gradient:2 | FLOAT32 | -10.00...10.00 | Hz/s | Frequency gradient (2) |
| Frequency:3 | FLOAT32 | 0.00...80.00 | Hz | Frequency gradient (3) |
| Frequency gradient:3 | FLOAT32 | -10.00...10.00 | Hz/s | Frequency gradient (3) |
| Conductance Yo | FLOAT32 | -1000.00...1000.00 | mS | Conductance Yo |
| Susceptance Yo | FLOAT32 | -1000.00...1000.00 | mS | Susceptance Yo |
| Angle Uo:1 - Io:1 | FLOAT32 | -180.00...180.00 | deg | Angle residual voltage (1) - residual current (1) |
| Angle U23:1- IL1:1 | FLOAT32 | -180.00...180.00 | deg | Angle phase B to phase C voltage (1) - phase A current (1) |
| Angle U31:1 - IL2:1 | FLOAT32 | -180.00...180.00 | deg | Angle phase C to phase A voltage (1) - phase B current (1) |
| Angle U12:1 - IL3:1 | FLOAT32 | -180.00...180.00 | deg | Angle phase A to phase B voltage (1) - phase C current (1) |
| Angle Uo:2 - Io:2 | FLOAT32 | -180.00...180.00 | deg | Angle residual voltage (2) - residual current (2) |
| Angle U23:2 - IL1:2 | FLOAT32 | -180.00...180.00 | deg | Angle phase B to phase C voltage (2) - phase A current (2) |
| Angle U31:2 - IL2:2 | FLOAT32 | -180.00...180.00 | deg | Angle phase C to phase A voltage (2) - phase B current (2) |
| Angle U12:2 - IL3:2 | FLOAT32 | -180.00...180.00 | deg | Angle phase A to phase B voltage (2) - phase C current (2) |
| Angle Uo:3 - Io:3 | FLOAT32 | -180.00...180.00 | deg | Angle residual voltage (3) - residual current (3) |
| Angle U23:3 - IL1:3 | FLOAT32 | -180.00...180.00 | deg | Angle phase B to phase C voltage (3) - phase A current (3) |
| Angle U31:3 - IL2:3 | FLOAT32 | -180.00...180.00 | deg | Angle phase C to phase A voltage (3) - phase B current (3) |
| Angle U12:3 - IL3:3 | FLOAT32 | -180.00...180.00 | deg | Angle phase A to phase B voltage (3) - phase C current (3) |

## 3.10 Nonvolatile memory

The relay does not include any battery backup power. If the auxiliary power is lost, critical information such as relay configuration and settings, events, disturbance recordings and other critical data are saved to the relay’s nonvolatile memory. The relay’s real-time clock keeps running via a 48-hour capacitor backup.

- Up to 1024 events are stored. The stored events are visible in HMI and Event viewer tool in PCM600.
- Recorded data
  - Fault records (up to 128)
  - Maximum demands
- Circuit breaker condition monitoring
- Latched alarm and trip LEDs' statuses
- Trip circuit lockout
- Counter values

## 3.11 Analog measurement channels

The maximum number of physical analog measurement channels is 20. This can be achieved with two analog input modules. The protection relay also supports up to 16 SMV channels in four separate 9-2 streams. In addition to the local or 9-2 channels, a certain number of numerical channels is always calculated from physical measurements. This number depends on the connection type of the TVTR / TCTR function block.

*Table 72: TVTR/TCTR connection types and numerical channels*

| Connection type | Function block | Physical channels | Numerical channels |
|---|---|---|---|
| ULx × 1 | ULxTVTR | 1 | 0 |
| URES | ULxTVTR | 1 | 0 |
| ULx × 2 | ULxTVTR | 2 | 4 |
| ULx × 2 + URES | ULxTVTR | 3 | 4 |
| ULx × 3 (Delta) | ULxTVTR | 3 | 3 |
| ULx × 3 (Wye) | ULxTVTR | 3 | 4 |
| ILx × 3 | ILxTCTR | 3 | 1 |
| IRES | RESxTCTR | 1 | 0 |
| ILx × 6 | CMSUM | 6 | 4 |

The maximum number of measurement channels is 64. This can be calculated by adding physical and numerical channels together.

## 3.12 Sensor inputs for currents and voltages

This chapter gives short examples on how to define the correct parameters for sensors.

Sensors have corrections factors, measured and verified by the sensor manufacturer, to increase the measurement accuracy of primary values. Correction factors are recommended to be set. Two types of

correction factors are available for voltage and Rogowski sensors. The Amplitude correction factor is named *Amplitude corr. A(B/C)* and Angle correction factor is named *Angle corr A(B/C)*. These correction factors can be found on the Sensor's rating plate. If the correction factors are not available, contact the sensor manufacturer for more information.

## Rogowski sensor setting example

In this example, an 80 A/0.150 V at 50 Hz sensor is used and the application has a 150 A nominal current (In). As the Rogowski sensor is linear and does not saturate, the 80 A/0.150 V at 50 Hz sensor also works as a 150 A/0.28125 V at 50 Hz sensor. When defining another primary value for the sensor, also the nominal voltage has to be redefined to maintain the same transformation ratio. However, the setting in the protection relay (*Rated Secondary Value*) is not in V but in mV/Hz, which makes the same setting value valid for both 50 and 60 Hz nominal frequency.

$$RSV = \frac{\frac{I_n}{I_{pr}} \cdot K_r}{f_n}$$

(Equation 1)

| | |
|---|---|
| RSV | *Rated Secondary Value* in mV/Hz |
| $I_n$ | Application nominal current |
| $I_{pr}$ | Sensor-rated primary current |
| $f_n$ | Network nominal frequency |
| $K_r$ | Sensor-rated voltage at the rated current in mV |

In this example, the value is as calculated using the equation.

$$\frac{\frac{150A}{80A} \cdot 150mV}{50Hz} = 5.625\frac{mV}{Hz}$$

(Equation 2)

With this information, the protection relay's Rogowski sensor settings can be set.

*Table 73: Example setting values for rogowski sensor*

| Setting | Value |
|---|---|
| Primary current | 150 A |
| Rated secondary value | 5.625 mV/Hz |

If the ratio of the application nominal current $I_n$ and sensor-rated primary current $I_{pr}$ becomes higher, and the rated secondary value needs to be set higher than 46.875 mV/

Hz, the highest value that the relay is able to measure before the current sensor input is saturated is smaller than the maximum setting value of the current protection.

*Table 74: Maximum current protection setting values*

| Application nominal current ($I_n$) | Rated secondary value with 80 A/ 0.150 V at 50 Hz | Current protection maximum setting value not to be exceeded |
|---|---|---|
| ...1250 A | 1.000...46.875 mV/Hz | 40 × $I_n$ (Also the maximum of the start value setting range) |
| 1250...2500 A | 46.875...93.750 mV/Hz | 20 × $I_n$ |
| 2500...4000 A | 93.750...150.000 mV/Hz | 12.5 × $I_n$ |

### Voltage sensor setting example

The voltage sensor is based on the resistive divider or capacitive divider principle. Therefore, the voltage is linear throughout the whole measuring range. The output signal is a voltage, directly proportional to the primary voltage. For the voltage sensor all parameters are readable directly from its rating plate and conversions are not needed.

In this example the system phase-to-phase voltage rating is 10 kV. Thus, the *Primary voltage* parameter is set to 10 kV. For protection relays with sensor measurement support the *Voltage input type* is always set to “Voltage sensor” and it cannot be changed. The same applies for the *VT connection* parameter which is always set to “WYE” type. The division ratio for ABB voltage sensors is most often 10000:1. Thus, the *Division ratio* parameter is usually set to “10000”. The primary voltage is proportionally divided by this division ratio.

*Table 75: Example setting values for voltage sensor*

| Setting | Value |
|---|---|
| Primary voltage | 10 kV |
| VT connection | Wye |
| Voltage input type | 3=Voltage sensor |
| Division ratio | 10000 |

## 3.13 Binary inputs

The binary inputs are mainly assembled in groups of three inputs that have one common connection. The binary inputs are bipolar so the common connection can be tied to ground or to supply voltage. Input groups are isolated from each other and from the secondary side. In addition, there can be groups with only one input. For more information, see the Module diagrams section in this manual.

Every binary input has an oxide-burn feature, that is, wetting current. The oxide-burn feature can be disabled only on binary input 14 that can be used as a pulse counter input.

The pulse counter input is enabled by setting the parameter *Input 14 counter-mode* in **Configuration/I/O modules/Slot #/Input filtering**. When enabled, the pulse counter input has dedicated *Input counter threshold voltage* and *Input counter threshold hysteresis* settings.

## 3.13.1 Binary input threshold voltage

The parameter *Input threshold voltage* is used to set the threshold level of the binary inputs. *Input threshold voltage* determines the voltage level for the activation of the inputs. The threshold can be set for every module or slot specifically depending on the *Slot specific threshold* setting.

*Table 76: Input threshold voltage parameters*

| Parameter | Values | Default |
|---|---|---|
| Slot specific threshold | 0=False<br>1=True | 0=False |
| Input threshold voltage | 16…176 V | 16 V |

## 3.13.2 Threshold hysteresis

Threshold hysteresis is used to determine the deactivation threshold for the binary inputs in case of voltage drops in the auxiliary voltage supply. Threshold hysteresis value determines how low the deactivation voltage is compared to the activation voltage as a percentage. Hysteresis can be set for every module or slot specifically depending on the *Slot specific hysteresis* setting.



Binary inputs always deactivate when the voltage level drops below 14 V.

*Table 77: Threshold hysteresis parameters*

| Parameter | Values | Default |
|---|---|---|
| Slot specific hysteresis | 0=False<br>1=True | 0=False |
| Input threshold hysteresis | 10…50% | 10% |

## 3.13.3 Binary input filter time

The filter time eliminates debounces and short disturbances on a binary input. The filter time is set for each binary input of the protection relay.

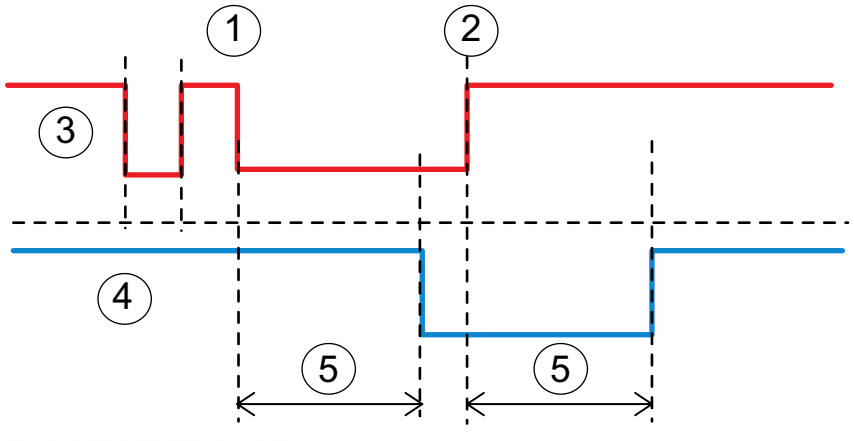



*Figure 43: Binary input filtering*

1 $t_0$
2 $t_1$
3 Input signal
4 Filtered input signal
5 Filter time

At the beginning, the input signal is at the high state, the short low state is filtered and no input state change is detected. The low state starting from the time $t_0$ exceeds the filter time, which means that the change in the input state is detected and the time tag attached to the input change is $t_0$. The high state starting from $t_1$ is detected and the time tag $t_1$ is attached.

Each binary input has a filter time parameter "Input # filter", where # is the number of the binary input of the module in question (for example "Input 1 filter").

*Table 78: Input filter parameter values*

| Parameter | Values | Default |
|---|---|---|
| Input # filter time | 5...1000 ms | 5 ms |

## 3.13.4 Binary input inversion

The parameter *Input # invert* is used to invert a binary input.

*Table 79: Binary input states*

| Control voltage | Input # invert | State of binary input |
|---|---|---|
| No | 0 | FALSE (0) |
| Yes | 0 | TRUE (1) |
| No | 1 | TRUE (1) |
| Yes | 1 | FALSE (0) |

When a binary input is inverted, the state of the input is TRUE (1) when no control voltage is applied to its terminals. Accordingly, the input state is FALSE (0) when a control voltage is applied to the terminals of the binary input.

### 3.13.5 Oscillation suppression

Oscillation suppression is used to reduce the load from the system when a binary input starts oscillating. A binary input is regarded as oscillating if the number of valid state changes (= number of events after filtering) during one second is equal to or greater than the set oscillation level value. During oscillation, the binary input is blocked (the status is invalid) and an event is generated. The state of the input will not change when it is blocked, that is, its state depends on the condition before blocking.

The binary input is regarded as non-oscillating if the number of valid state changes during one second is less than the set oscillation level value minus the set oscillation hysteresis value. Note that the oscillation hysteresis must be set lower than the oscillation level to enable the input to be restored from oscillation. When the input returns to a non-oscillating state, the binary input is deblocked (the status is valid) and an event is generated.

*Table 80: Oscillation parameters*

| Parameter | Value | Default |
|---|---|---|
| Input osc. level | 2...50 events/s | 30 events/s |
| Input osc. hyst | 2...50 events/s | 10 events/s |

## 3.14 Binary outputs

The protection relay provides a number of binary outputs used for tripping, executing local or remote control actions of a breaker or a disconnector, and for connecting the protection relay to external annunciation equipment for indicating, signalling and recording.

Power output contacts are used when the current rating requirements of the contacts are high, for example, for controlling a breaker, such as energizing the breaker trip and closing coils.

The contacts used for external signalling, recording and indicating, the signal outputs, need to adjust to smaller currents, but they can require a minimum current (burden) to ensure a guaranteed operation.

The protection relay provides both power output and signal output contacts. To guarantee proper operation, the type of the contacts used are chosen based on the operating and reset time, continuous current rating, make and carry for short time, breaking rate and minimum connected burden. A combination of series or parallel contacts can also be used for special applications. When appropriate, a signal output

can also be used to energize an external trip relay, which in turn can be configured to energize the breaker trip or close coils.

Using an external trip relay can require an external trip circuit supervision relay. It can also require wiring a separate trip relay contact back to the protection relay for breaker failure protection function.

All contacts are freely programmable, except the internal fault output IRF.

## 3.14.1 Power output contacts

Power output contacts are normally used for energizing the breaker closing coil and trip coil, external high burden lockout or trip relays.

### 3.14.1.1 Dual single-pole power outputs POSP1 and POSP2

Dual (series-connected) single-pole (normally open/form A) power output contacts POSP1 and POSP2 are rated for continuous current of 8 A. The contacts are normally used for closing circuit breakers and energizing high burden trip relays. They can be arranged to trip the circuit breakers when the trip circuit supervision is not available or when external trip circuit supervision relay is provided.

The power outputs are included in the power supply module in slot G.

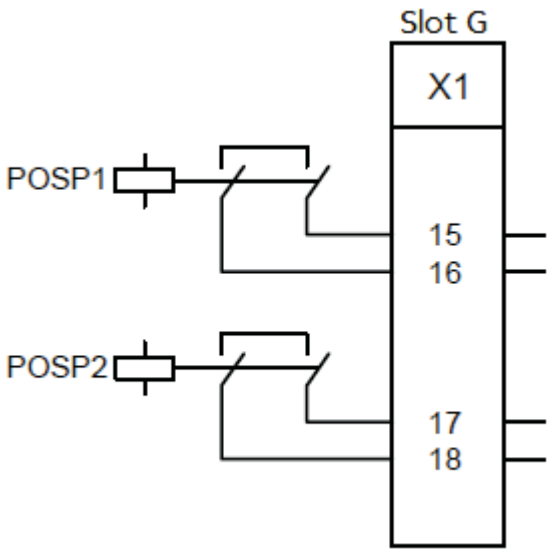



*Figure 44: Dual single-pole power outputs in power supply module*

### 3.14.1.2 Double-pole power outputs PODP1, PODP2 and PODP3 with trip circuit supervision

The power outputs PODP1, PODP2 and PODP3 are double-pole normally open/form A power outputs with trip circuit supervision. The trip circuit supervision hardware includes constant current generator to provide trip circuit supervision (TCS) current and TCS input that can be connected to the TCS function with Application Configuration in PCM600. See Trip circuit supervision TCSSCBR function for TCS connections.

When the two poles of the contacts are connected in series, they have the same technical specification as POSP1/POSP2 for breaking duty. Contacts PODP1, PODP2 and PODP3 are usually used for energizing the breaker trip coils.

The power outputs are included in the power supply module in slot G.

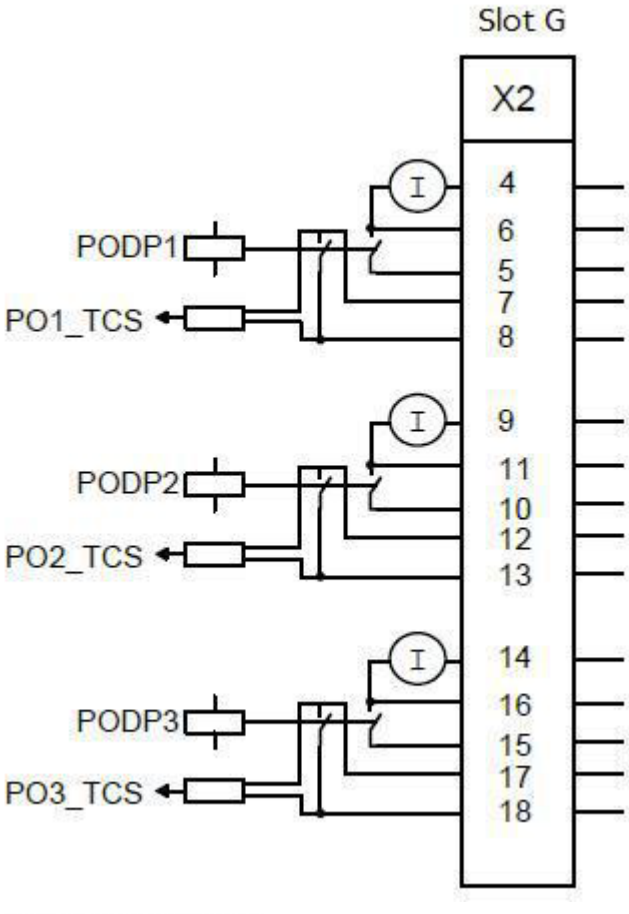



*Figure 45: Double-pole power outputs with trip circuit supervision in power supply module*

### 3.14.1.3 Static power outputs SPO1...SPO8

The outputs are normally used in applications that require fast relay output contact activation time to achieve fast opening of a breaker, such as, arc-protection or breaker failure protection, where fast operation is required either to minimize fault effects to the equipment or to avoid a fault to expand to a larger area. With the static power outputs, the total time from the application to the relay output contact activation is 4...6 ms shorter than when using output contacts with conventional mechanical output relays.

SPO5 and SPO7 are equipped with constant current generator to provide trip circuit supervision (TCS) current. SPO6 and SPO8 are equipped with TCS input that can be connected to the TCS function with Application Configuration in PCM600. See Trip circuit supervision TCSSCBR function for TCS connections.

The static power outputs are included in BIO1002 and BIO1004 modules.

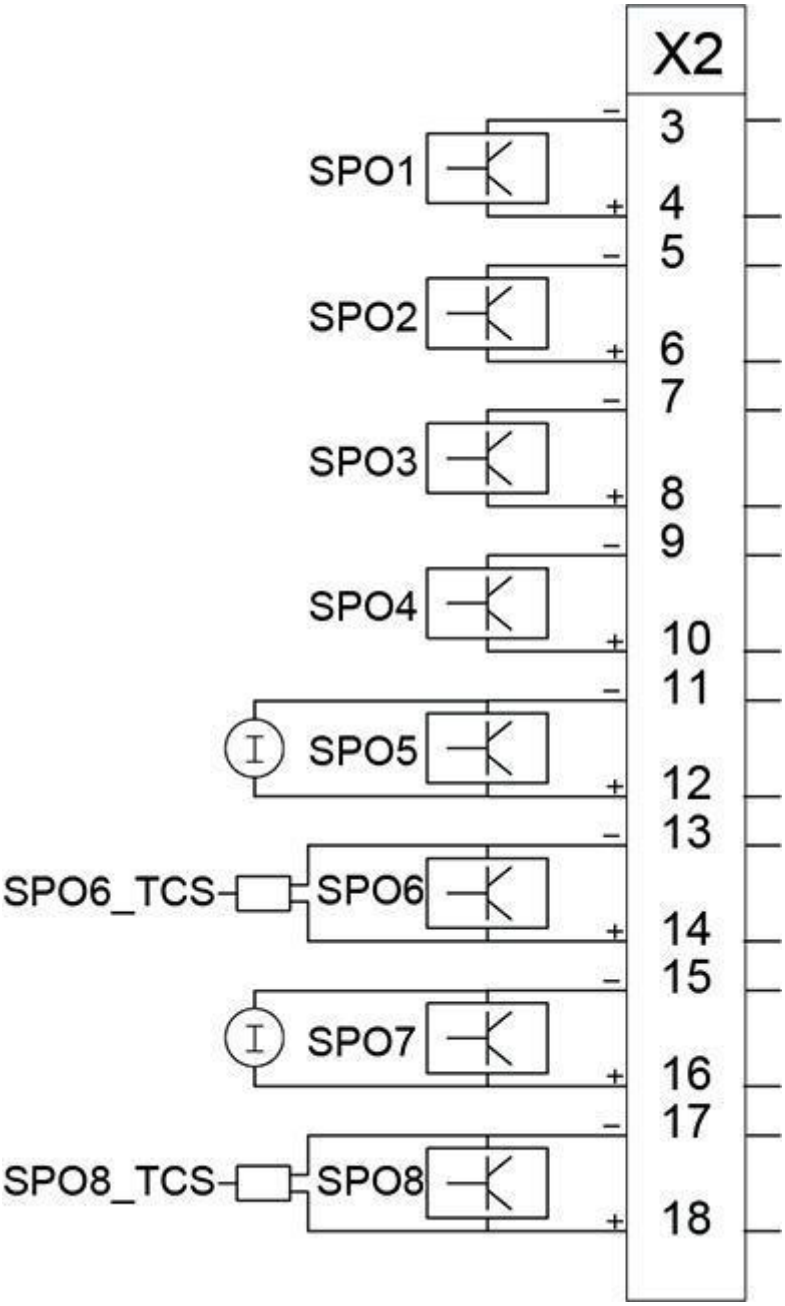



*Figure 46: Static power outputs SPO1...SPO8*

## 3.14.2 Signal output contacts

Signal output contacts are single-pole, single (normally open/form A or change-over/form C) signal output contacts (SO1, SO2, ...) or parallel connected dual contacts.

The signal output contacts are used for energizing, for example, external low burden trip relays, auxiliary relays, annunciators and LEDs.

A single signal contact is rated for a continuous current of 5 A. It has a make and carry for 0.5 seconds at 15 A.

When two contacts are connected in parallel, the relay is of a different design. It has the make and carry rating of 30 A for 0.5 seconds. This can be applied for energizing breaker close coil and tripping coil. Due to the limited breaking capacity, a breaker auxiliary contact can be required to break the circuit.

Static signal outputs (SSO1, SSO2) are light-duty fast binary signal outputs and can also be used as pulse outputs.

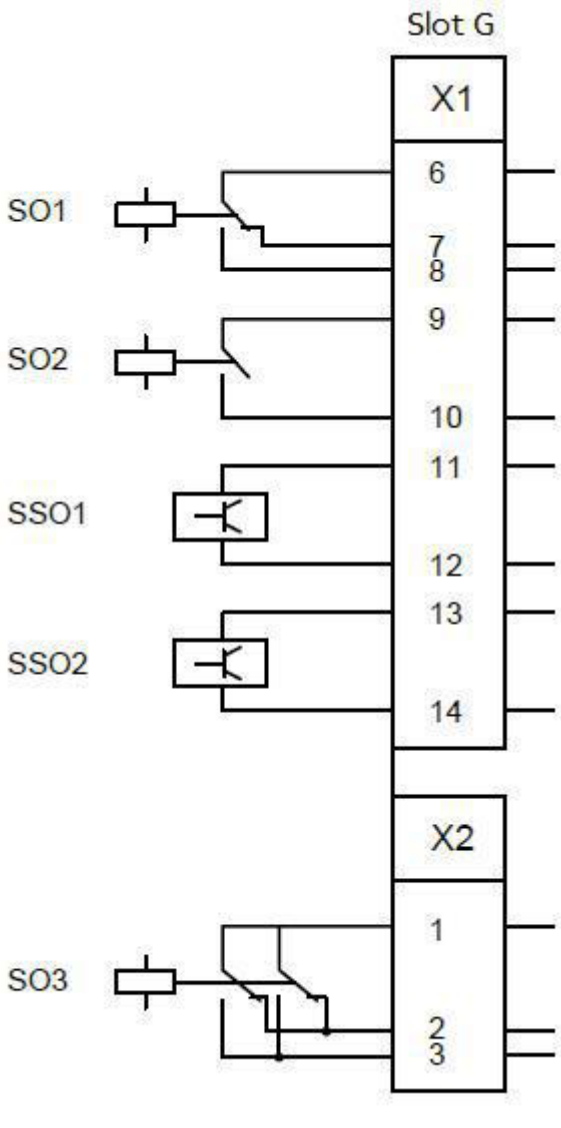



*Figure 47: Signal outputs in power supply module*

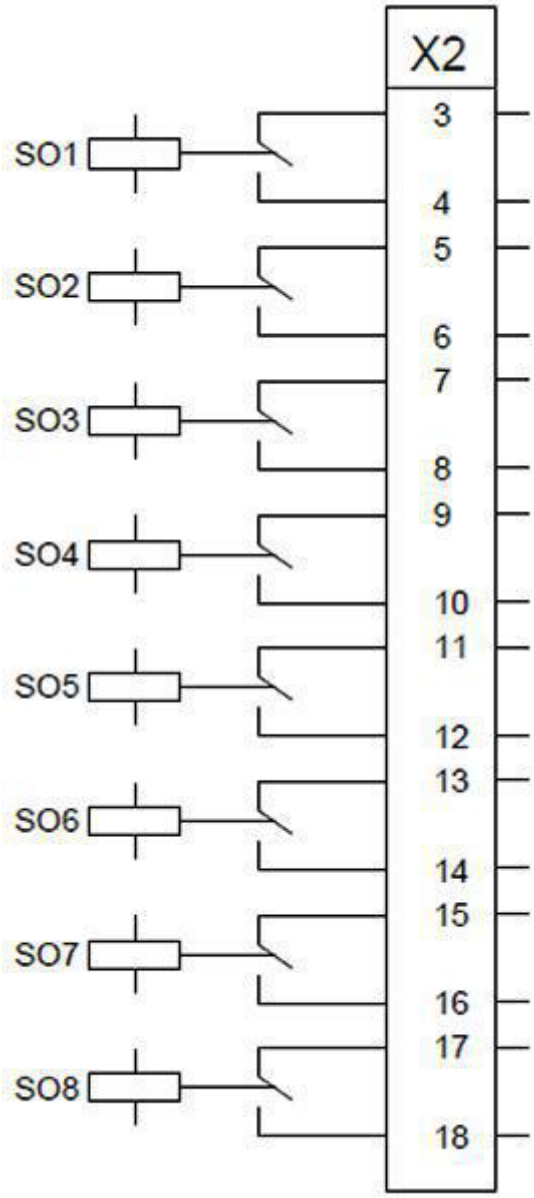



*Figure 48: Signal outputs in BIO1001 and BIO1003 modules*

### 3.14.2.1 Internal fault signal output IRF

The internal fault signal output (change-over/form C) IRF is a single contact included in the power supply module of the protection relay in slot G.

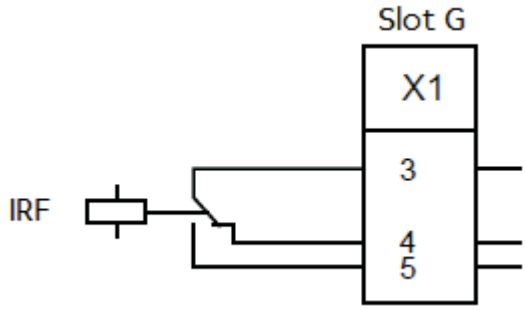



*Figure 49: Internal fault signal output IRF*

# 3.15 RTD/mA inputs/mA outputs

## 3.15.1 Function blocks

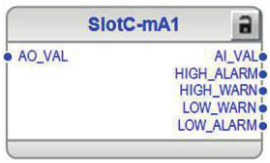



*Figure 50: Function block for mA channel*

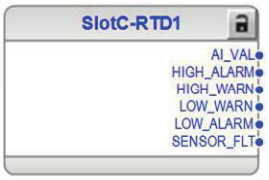



*Figure 51: Function block for RTD channel*

## 3.15.2 Functionality

The Slot#-mA#/RTD# function is an interface function between the relay's mA/RTD hardware channels. The function is split into separate function blocks for each hardware channel.

The mA function block works as an interface for the mA current channel. The channel can be defined either as a measuring input or a controllable output.

The RTD function block works as an interface for the RTD measuring channel that supports various types of RTD sensors.

Both function blocks have limit supervision alarm outputs and an output for sensor fault.

## 3.15.3 Operation principle

The operation of Slot#-mA#/RTD# can be described with a module diagram that illustrates a single input-output combination of the actual function block. All the modules in the diagram are explained in the next sections.

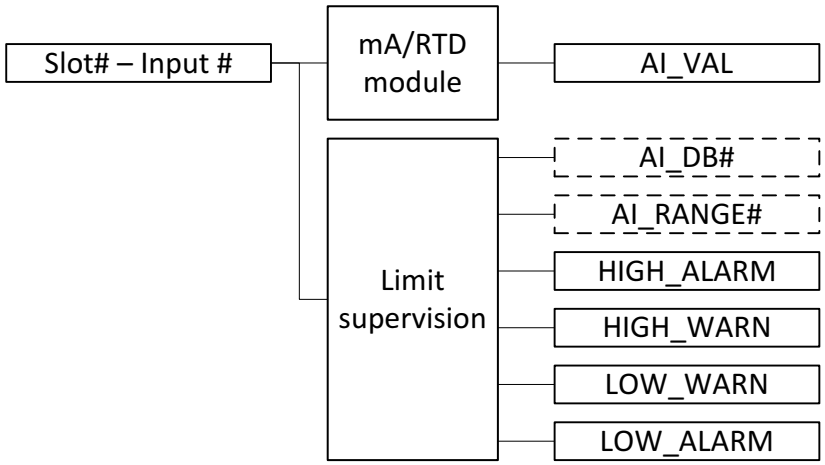



*Figure 52: Functional module diagram for input mode*

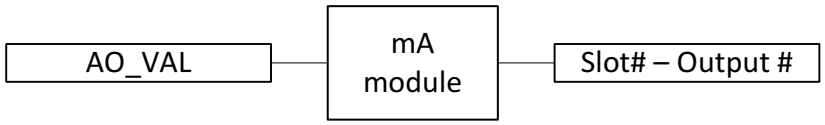



*Figure 53: Functional module diagram for output mode*

### mA modules

Channels 1 and 2 are used for input current measurement or output current control in the range of -20…20 mA (DC current). The channels are configured for particular input or output signal types by using channel-specific settings. When Input 1 is activated with setting "-20…20mA", the Output 1 mode is blocked. If Output 2 mode is activated with setting "-20…20mA", the Input 2 mode is blocked. When a channel is configured as an output, the alarm outputs are deactivated.

### RTD modules

Channels 3...12 are used for resistance measurements and they are only input channels. The inputs are configured for a particular input signal type by using the channel-specific *Input mode* setting. The default mode for each channel (1...12) is "Not in use" which means that the channel is not sampled and the output value quality is set accordingly.

All the channels are independent mA/RTD channels with separated protection, filtering, reference, A/D-conversion and isolation. Thus, the RTD group is isolated from mA channels.

The RTD inputs measure resistance in the range of 0...4000 Ω. All inputs are calibrated and the calibration factors are stored on the module in nonvolatile memory. The calibration circuitry monitors the RTD channels continuously and reports the circuitry break of any channel.

The RTD inputs have separate setting values for value update interval. The settings are: "No delay", "10 ms delay", "50 ms delay" and "100 ms delay". Between the update intervals the RTD input constantly returns the last valid value before updating to the new value after the interval time expires.

### 3.15.3.1 Input mode

*Table 81: Analog input modes for the mA inputs 1 and 2*

| Input mode | Description |
|---|---|
| Not in use | Default selection when the corresponding input is not used |
| -20...20mA | The analog input covers the range of -20...20 mA.<br>The input can be used in a narrower range by setting *Input minimum* and *Input maximum*. Settings *Value minimum* and *Value maximum* are used to scale the output within the appropriate range. The output unit is selected with the set *Value unit*. |

*Table 82: Analog input modes for the RTD inputs 1...10*

| Input mode | Description |
|---|---|
| Not in use | Default selection when the corresponding input is not used |
| Resistance | Freely settable resistance input<br>*Input minimum* and *Input maximum* define the resistive input range. The corresponding output can be scaled based on *Value minimum* and *Value maximum*. The output unit is selected with the set *Value unit*. |
| Pt 100 | The input is expected to be the selected temperature sensor. The set *Value unit* should be set to degrees Celsius. The expected input range is -40...200°C. However, the output can be scaled to a narrower output range by setting *Value minimum* and *Value maximum*. |
| Pt 250 | |
| Ni 100 | |
| Ni 120 | |
| Ni 250 | |

The function has a built-in functionality for the resistance inputs. It monitors all the enabled inputs and detects if the sensor is removed from the input. If the sensor is removed when the input is enabled, a warning indication is displayed, `SENSOR_FLT` is activated and quality is set accordingly.

#### Selection of value unit format

Each input has an independent *Value unit* setting that is used to select the unit for the channel value representation. The default value for the *Value unit* setting is

"Dimensionless". The *Input minimum*, *Input maximum*, *Value maximum* and *Value minimum* settings have to be adjusted according to the input channel and if *Value unit* is changed.

When the RTD channel input is used for the temperature sensor type, the *Value unit* setting needs to be changed to "Degrees Celsius". When *Value unit* is set to "Degrees Celsius", linear scaling is not applied but the default range (-40…200°C) can be decreased with the *Value maximum* and *Value minimum* settings.

When the DC milliampere signal is connected to the mA channel and the application requires a linear scaling of the input range, the *Value unit* setting value has to be set to "Dimensionless" so that the input range can be linearly scaled with the settings *Input minimum* and *Input maximum* to *Value minimum* and *Value maximum*. When milliampere is used as a value unit, *Value unit* has to be "Ampere". When *Value unit* is set to "Ampere", the default range (-20…20 mA) can be decreased with the *Value maximum* and *Value minimum* settings.

When a resistance type signal is connected to the RTD channel and the application requires a linear scaling of the input range, the *Value unit* setting value has to be set to "Dimensionless" so that the input range can be linearly scaled with the settings *Input minimum* and *Input maximum* to *Value minimum* and *Value maximum*. When resistance is used as a value unit, *Value unit* has to be "Ohm". When *Value unit* is set to "Ohm", the default range (0…4000 Ω) can be decreased with the *Value maximum* and *Value minimum* settings.

## RTD temperature vs. resistance

The resistance values of temperature sensors at specified temperatures are given in Table 83.

*Table 83: Temperature vs. resistance*

| Temp °C | Platinum TCR 0.00385 | | Nickel TCR 0.00618 | | |
|---|---|---|---|---|---|
| | Pt 100 | Pt 250 | Ni 100 | Ni 120 | Ni 250 |
| -40 | 84.28 | 210.70 | 79.13 | 94.96 | 197.83 |
| -30 | 88.22 | 220.56 | 84.15 | 100.97 | 210.36 |
| -20 | 92.16 | 230.40 | 89.30 | 107.16 | 223.24 |
| -10 | 96.09 | 240.21 | 94.58 | 113.50 | 236.45 |
| 0 | 100.00 | 250.00 | 100.00 | 120.00 | 250.00 |
| 10 | 103.90 | 259.76 | 105.55 | 126.66 | 263.88 |
| 20 | 107.79 | 269.48 | 111.24 | 133.48 | 278.09 |
| 30 | 111.67 | 279.18 | 117.06 | 140.47 | 292.64 |
| 40 | 115.54 | 288.85 | 123.01 | 147.61 | 307.53 |
| 50 | 119.40 | 298.49 | 129.11 | 154.93 | 322.76 |
| 60 | 123.24 | 308.10 | 135.34 | 162.41 | 338.35 |
| 70 | 127.08 | 317.69 | 141.72 | 170.06 | 354.30 |
| 80 | 130.90 | 327.24 | 148.25 | 177.90 | 370.63 |
| 90 | 134.71 | 336.77 | 154.93 | 185.92 | 387.34 |

Table continues on next page

| Temp °C | Platinum TCR 0.00385 | | Nickel TCR 0.00618 | | |
|---|---|---|---|---|---|
| | Pt 100 | Pt 250 | Ni 100 | Ni 120 | Ni 250 |
| 100 | 138.51 | 346.26 | 161.78 | 194.13 | 404.45 |
| 110 | 142.29 | 355.73 | 168.79 | 202.55 | 421.97 |
| 120 | 146.07 | 365.17 | 175.97 | 211.17 | 439.93 |
| 130 | 149.83 | 374.58 | 183.33 | 220.00 | 458.34 |
| 140 | 153.58 | 383.96 | 190.89 | 229.06 | 477.22 |
| 150 | 157.33 | 393.31 | 198.63 | 238.36 | 496.59 |
| 160 | 161.05 | 402.64 | 206.59 | 247.91 | 516.47 |
| 170 | 164.77 | 411.93 | 214.76 | 257.71 | 536.89 |
| 180 | 168.48 | 421.20 | 223.15 | 267.78 | 557.88 |
| 190 | 172.17 | 430.43 | 231.78 | 278.14 | 579.46 |
| 200 | 175.86 | 439.64 | 240.66 | 288.79 | 601.65 |

## Self-supervision

Each input contains functionality to monitor the input measurement chain. The circuitry monitors the RTD channels continuously and reports a circuitry break of any enabled input channel. If the measured input value is outside the limits, the minimum/maximum value is shown in the corresponding output. The quality of the corresponding output is set accordingly and the fault is reported at `SENSOR_FLT` to indicate misbehavior in the mA/RTD input.

*Table 84: Limits for the mA/RTD inputs*

| mA/RTD input | Limit value |
|---|---|
| RTD temperature, high | >200°C |
| RTD temperature, low | <-40°C |
| mA current, high | >24 mA |
| mA current, low | <-24 mA |
| Resistance, high | >4000 Ω |
| Resistance, low | Not defined[1)] |

1) Low limit is not defined for the resistance input. In practice the low limit is 0 because the resistance cannot be negative.

RTD sensor currents are measured continuously at a fixed rate. The delay between the RTD current/connectivity checks is about 10s at a maximum (if all 10 RTD channels are active). If the RTD current is not within ±5% of the expected current, the measurement is considered to be invalid and the channel is discarded until a valid current is obtained.

The expected currents are 1 mA for RTD sensors and 0.21 mA for pure resistance. While the quality of the invalid input is set accordingly, a warning is also provided on the Relay Status page of LHMI/WHMI. The invalid signal is deactivated as soon as the corresponding input signal is within the valid range.

When necessary, the valid measuring range may be narrower than the default of the selected measuring range. A narrower range can be defined with the *Value minimum* and *Value maximum* settings.

### 3.15.3.2 Output mode

A measurement value from another function, mA input or RTD input can be represented by the mA output. The mA output scaling principle is otherwise similar to the input scaling but there is also a possibility to use up to four different knee points. To be able to cover a wide range of input units, the input settings used for scaling are dimensionless. The output range of the mA output is selected with parameters *Value maximum* and *Value minimum* and the selected number of knee points with parameter *Num of knee points*. Depending on the amount of *Num of knee points*, the knee point settings *Input knee point 1-4* and *Value knee point 1-4* are visible.

*Table 85: Analog output modes for the mA outputs 1 and 2*

| Output mode | Description |
|---|---|
| Not in use | Default selection when the corresponding output is not used |
| -20...20 mA | Analog output can operate in the range of -20...20 mA.<br>The output can be used in a narrower range by setting *Value minimum* and *Value maximum*. |

## 3.15.4 Application

The general function block can be used in REX640 relays that are equipped with an RTD/analog module.

The function can be applied to various applications, for example, to measure temperature, pressure or flow.

### 3.15.4.1 Input scaling

Each mA/RTD input can be scaled linearly by constructing a separate scaling curve for each input. The curve consists of two points where the x-axis of the curve illustrates a range selected for the input and the y-axis is the scaled absolute value of the input. The input scaling is enabled only when mA or resistance input is used.

When the scaling is enabled, the settings *Value maximum* and *Value minimum* affect the scaled range. The range of the scaled input is defined with the settings *Input minimum* and *Input maximum*.

#### Scaling example 1

The function is used with a Pt100 temperature sensor. Predefined scaling can be selected when *Input mode* is set to "Pt100".

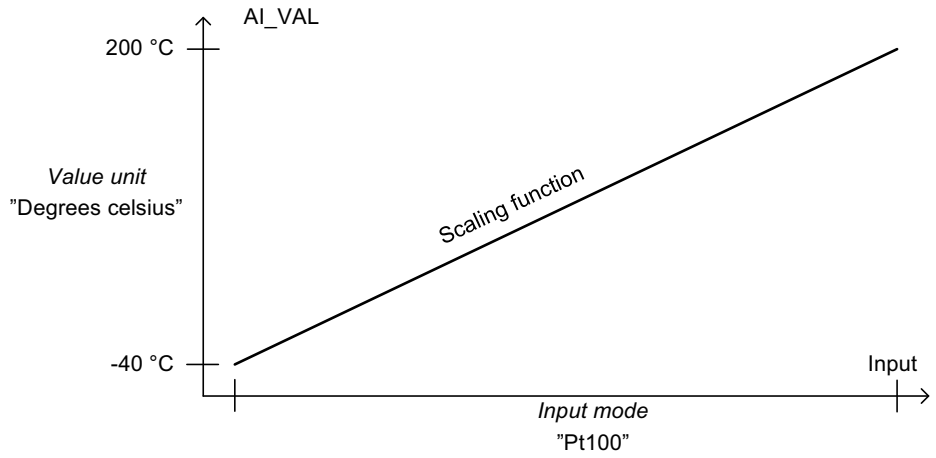



*Figure 54: Pt100 scaling function*

## Scaling example 2

*Input mode* is set to -20...20 mA that is used for tap position information fed from the tap changer. The tap positions are between -36...36. Thus, the scaling setting *Value minimum* is set to "-36" and *Value maximum* is set to "36". These settings apply the input scaling to the output. In the tap position case, the *Value unit* should be set to "Dimensionless".

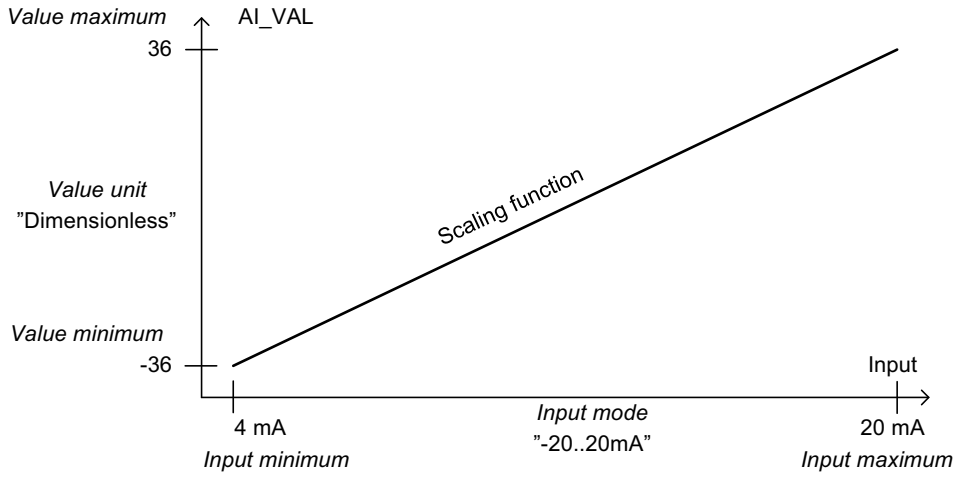



*Figure 55: Tap changer position from mA input*

## Scaling example 3

When *Input mode* is set to "Resistance", the output can be scaled as desired. For example, the desired function output is a ratio in a function of resistance. If the input resistance varies between 100...1600 ohms, *Input minimum* is set to "100" and *Input maximum* is set to "1600". As the wanted output should be in percents, the setting *Value unit* is set to "Dimensionless". When *Input mode* is set to "Resistance", output scaling is enabled. Thus, *Value minimum* is set to "0" and *Value maximum* is set to

"100". These settings allow the input values to be scaled as a ratio of the resistance range.

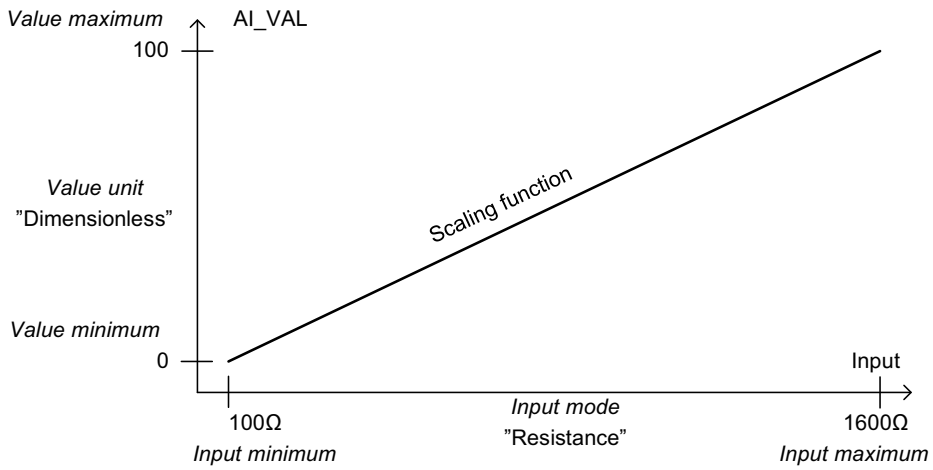



*Figure 56: Output as a ratio of the resistance range*

The output scaling function:

$$k = \frac{Input\ maximum - Input\ minimum}{Value\ maximum - Value\ minimum}$$

(Equation 3)

$$f = -k \cdot Value\ minimum + Input\ minimum$$

(Equation 4)

$$AI_VAL = \frac{Input - f}{k}$$

(Equation 5)

### 3.15.4.2 Limit value supervision

All the measurement inputs have individual limit supervision modules that operate similarly as in the measurement functions. The measured values are compared against their set value limits. The limit supervision outputs are `HIGH_ALARM`, `HIGH_WARN`, `LOW_WARN` and `LOW_ALARM`.

When an output is scaled, *Value maximum* and *Value minimum* are the range limits to which the output value is limited or scaled. Hysteresis is added to the range limit values so that the output value is allowed to slightly exceed or go below the limit value before being treated as out of range.

The pre-defined hysteresis values are set based on the set *Value unit*.

*Table 86: Pre-defined hysteresis values based on Value unit*

| Value unit | Hysteresis |
|---|---|
| Dimensionless | Based on the scaling function[1)] |
| Ampere | 0.1 mA |
| Degrees Celsius | 0.5°C |
| Ohm | 2 Ω |

1) When the input is scaled to the "Dimensionless" output, the additional hysteresis is added the initial table value.

$$Hysteresis \cdot \left| \frac{Value\ maximum - Value\ minimum}{Input\ maximum - Input\ minimum} \right|$$

(Equation 6)

## Example

Ampere input -20…20 mA is scaled to tap position information 0...36. The actual hysteresis for limit supervision is 0.18.

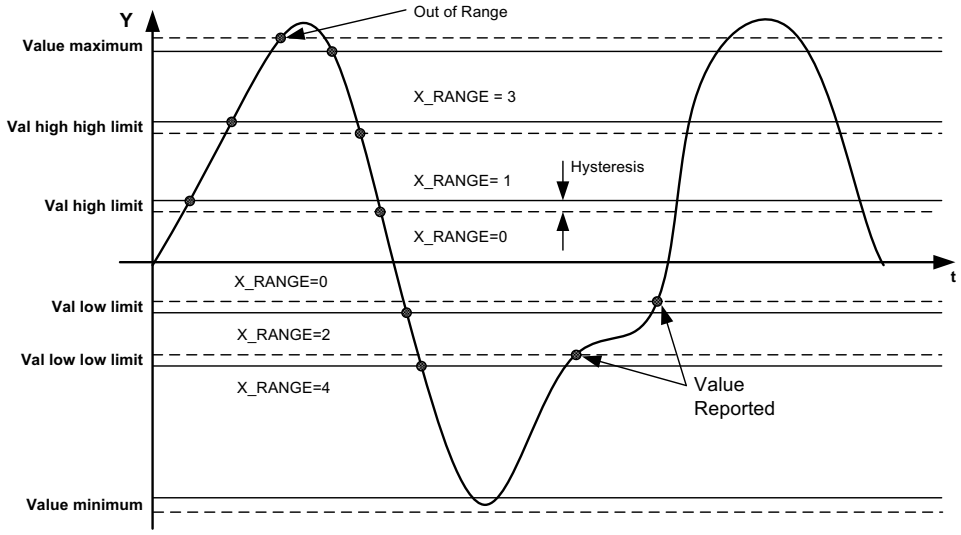



*Figure 57: Limit value supervision*

### 3.15.4.3 Deadband supervision

This is the same functionality as in measurement functions.

### 3.15.4.4 Output scaling

The mA outputs are scaled linearly by constructing linear scaling curves for each output.

*Value maximum* and *Value minimum* affect the scaled output range. The range of the scaled input is defined with the settings *Input minimum* and *Input maximum*. Depending on setting *Num of knee points*, the output can be scaled with up to five linear curves. The knee points are defined by parameters *Input knee point 1-4* and *Value knee point 1-4*.

## Example 1: VMMXU1 to mA output

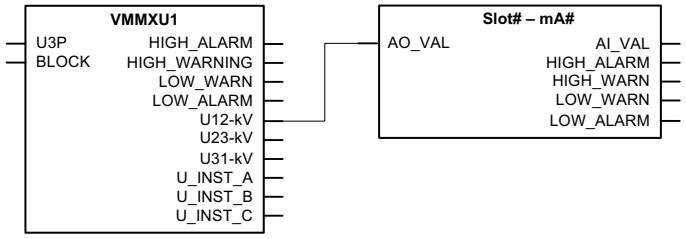



*Figure 58: Application example for VMMXU1 to mA output*

The measured phase-to-phase voltage from VMMXU is connected to AO_VAL. *Input maximum* value is set to "24" (kV) and *Input minimum* value is set to "18" (kV). The input unit is not significant as long as the value range is in the same scale. *Value maximum* is set to "20" mA and *Value minimum* to "4" mA. *Num of knee points* is set to "0".

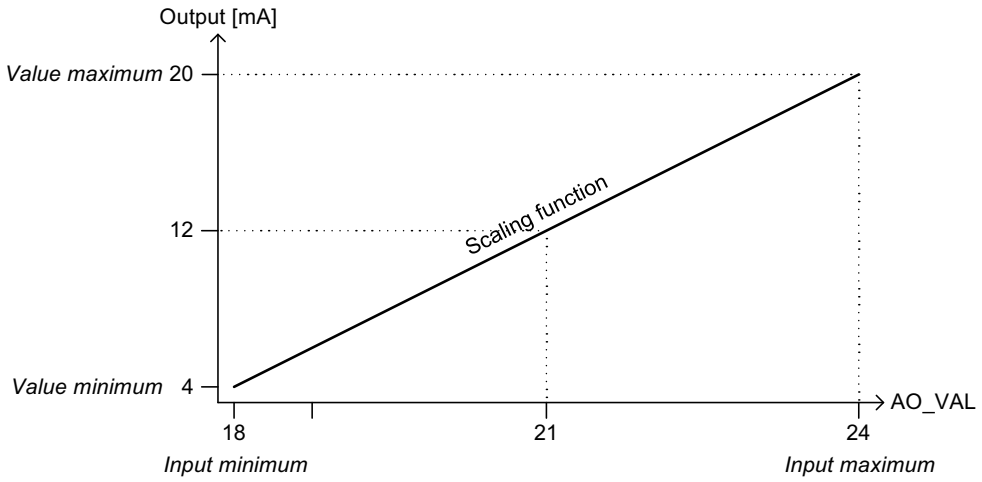



*Figure 59: Scaling of AO_VAL to mA output*

## Example 2: mA input to mA output

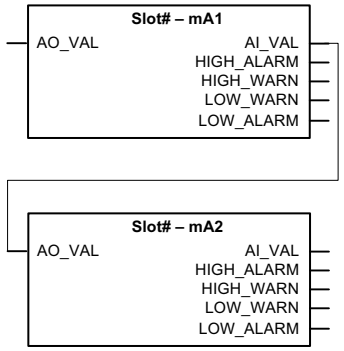



*Figure 60: Application example for mA input to mA output*

mA current is measured at channel 1. AI_VAL from measuring channel 1 is connected to AO_VAL of output channel 2. *Input maximum* is set to "20" (mA) and *Input minimum* to "-20" (mA). *Value maximum* is set to "20" mA and *Value minimum* is set to "0" mA. *Num of knee points* is set to "2".

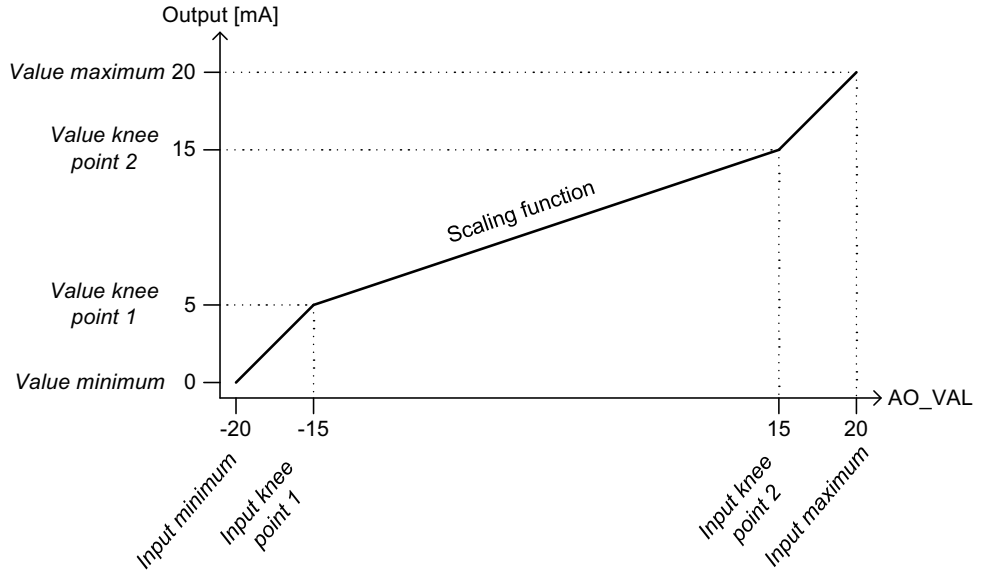



*Figure 61: Scaling of AO_VAL to mA output with two knee points*

## Example 3: RTD input to mA output

Tap position is measured by the RTD channel 7. AI_VAL from channel 7 is connected to AO_VAL of channel 1. *Input maximum* is set to "160" (ohm) and *Input minimum* to "10" (ohm). *Value maximum* is set to "20" mA and *Value minimum* is set to "4" mA. *Num of knee points* is set to "4".

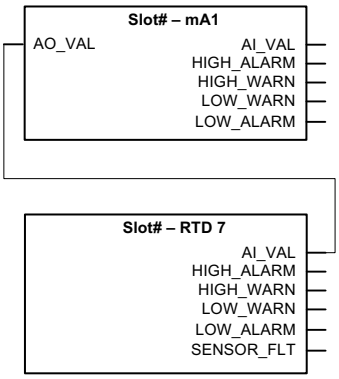



*Figure 62: Application example for RTD input to mA output*

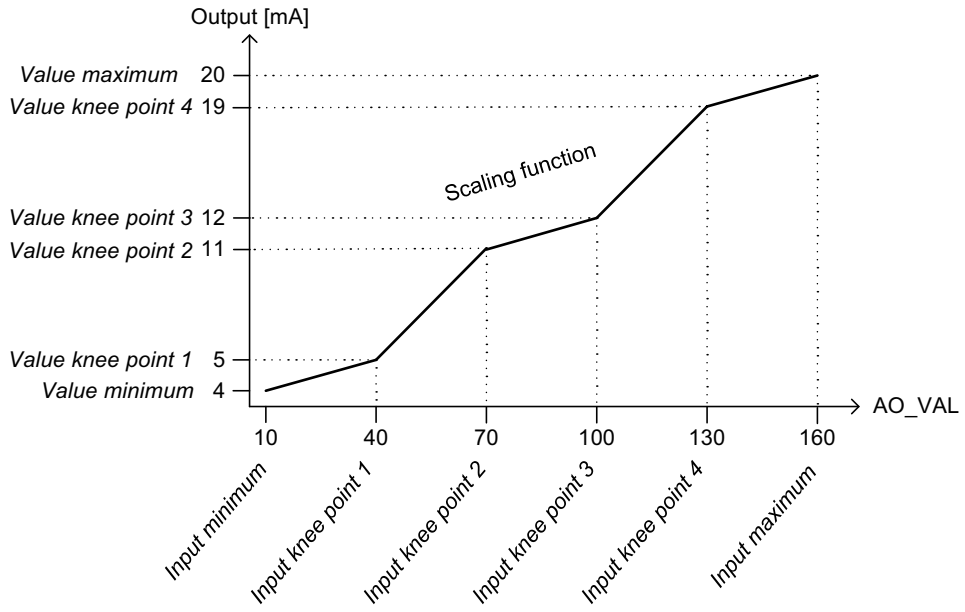



*Figure 63: Scaling of AO_VAL to mA output with four knee points*

Incorrect knee point values against the minimum and maximum values and a too narrow interval between the knee point values can cause inaccuracy to the output scaling function. Use increasing linearity and a value interval >1.0 for most accurate results.

## 3.15.5 RTD/mA input/mA output connection

RTD inputs can be used with a 2-wire or 3-wire connection with common ground. When using the 3-wire connection, it is important that all three wires connecting the

sensor are symmetrical, that is, the wires are of the same type and length. Thus the wire resistance is automatically compensated.

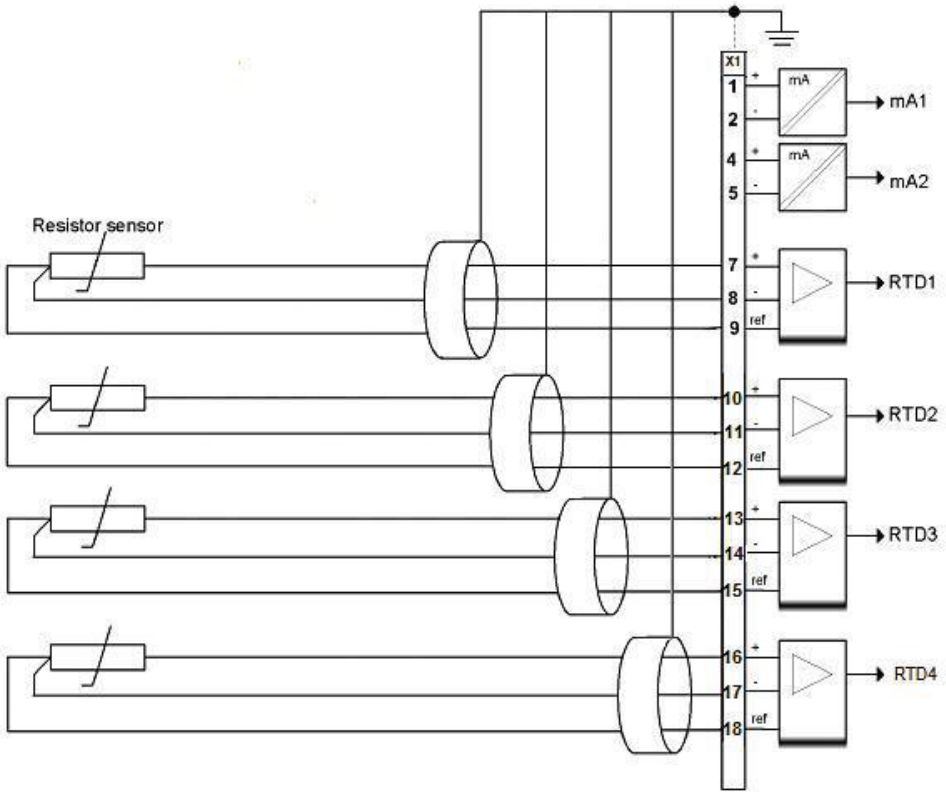



*Figure 64: Four RTD/resistance sensors connected according to the 3-wire connection*

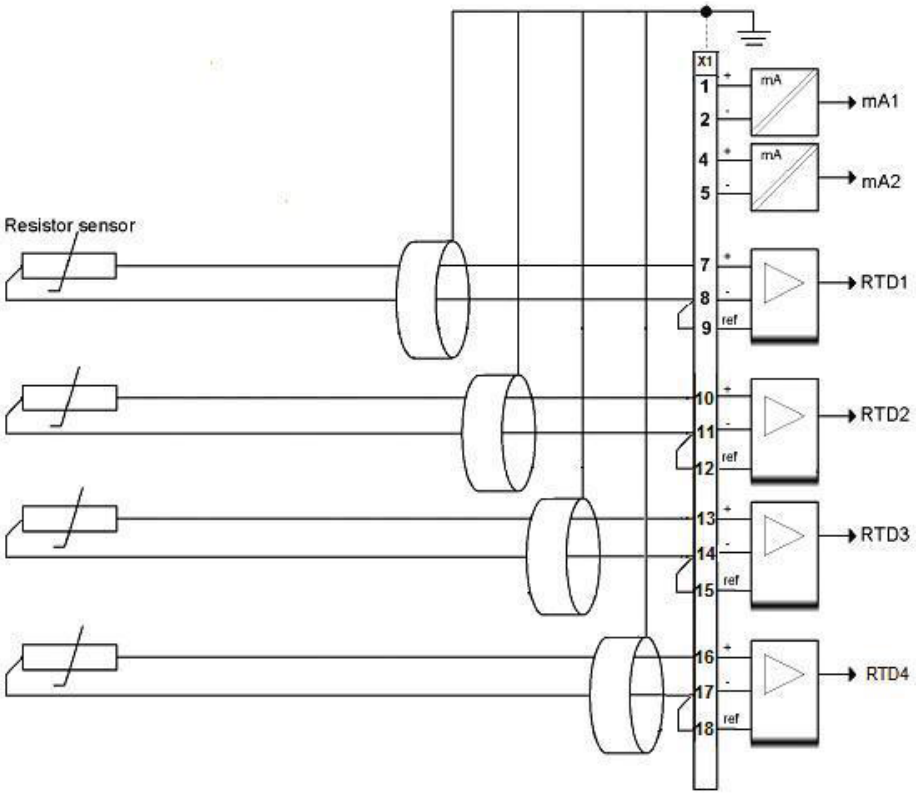



*Figure 65: Four RTD/resistance sensors connected according to the 2-wire connection*

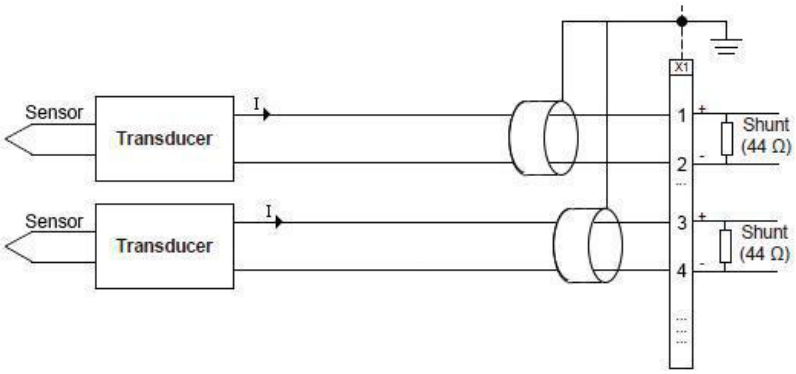



*Figure 66: mA channels working as mA inputs*

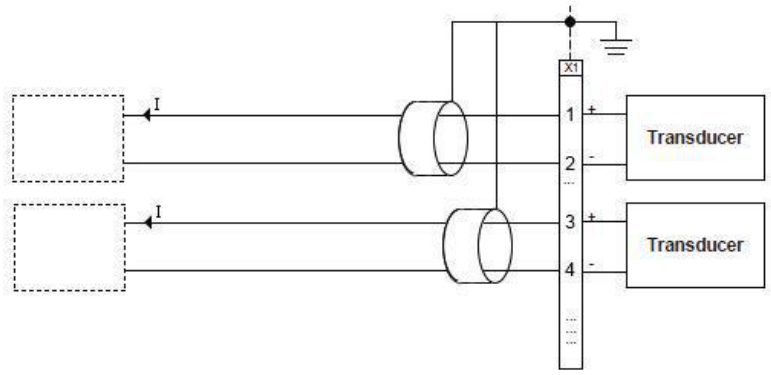



*Figure 67: mA channels working as mA outputs*

## 3.15.6 Signals

*Table 87: mA1 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| AO_VAL | FLOAT32 | 0 | mA output, Connector A pins 1-2, instantaneous value |

*Table 88: mA2 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| AO_VAL | FLOAT32 | 0 | mA output, Connector A pins 4-5, instantaneous value |

*Table 89: mA1 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | mA input, Connector A pins 1-2, instantaneous value |

*Table 90: mA2 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | mA input, Connector A pins 4-5, instantaneous value |

*Table 91: RTD1 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | RTD input, Connector A pins 7-8-9c, instantaneous value |
| SENSOR_FLT | BOOLEAN | Sensor fault |

*Table 92: RTD2 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | RTD input, Connector A pins 10-11-12c, instantaneous value |
| SENSOR_FLT | BOOLEAN | Sensor fault |

*Table 93: RTD3 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | RTD input, Connector A pins 13-14-15c, instantaneous value |
| SENSOR_FLT | BOOLEAN | Sensor fault |

*Table 94: RTD4 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | RTD input, Connector A pins 16-17-18c, instantaneous value |
| SENSOR_FLT | BOOLEAN | Sensor fault |

*Table 95: RTD5 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | RTD input, Connector B pins 1-2-3c, instantaneous value |
| SENSOR_FLT | BOOLEAN | Sensor fault |

*Table 96: RTD6 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | RTD input, Connector B pins 4-5-6c, instantaneous value |
| SENSOR_FLT | BOOLEAN | Sensor fault |

*Table 97: RTD7 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | RTD input, Connector B pins 7-8-9c, instantaneous value |
| SENSOR_FLT | BOOLEAN | Sensor fault |

*Table 98: RTD8 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | RTD input, Connector B pins 10-11-12c, instantaneous value |
| SENSOR_FLT | BOOLEAN | Sensor fault |

*Table 99: RTD9 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | RTD input, Connector B pins 13-14-15c, instantaneous value |
| SENSOR_FLT | BOOLEAN | Sensor fault |

*Table 100: RTD10 Output signals*

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | RTD input, Connector B pins 16-17-18c, instantaneous value |
| SENSOR_FLT | BOOLEAN | Sensor fault |

*Table 101: Common outputs for each function block*

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | General high alarm |
| HIGH_WARN | BOOLEAN | General high warning |
| LOW_WARN | BOOLEAN | General low warning |
| LOW_ALARM | BOOLEAN | General low alarm |

## 3.15.7 Settings

*Table 102: Input-specific settings for mA1 and mA2*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Input mode | 1=Not in use<br>5=0..20mA | | | 1=Not in use | Analog input mode |
| Input maximum | -20...20 | mA | | 20 | Maximum analog input value for mA or resistance scaling |
| Input minimum | -20...20 | mA | | -20 | Minimum analog input value for mA or resistance scaling |
| Value unit | 1=Dimensionless<br>5=Ampere<br>23=Degrees celsius<br>30=Ohm | | | 1=Dimensionless | Selected unit for output value format |
| Value maximum | -10000.0...10000.0 | | | 10000 | Maximum output value for scaling and supervision |
| Value minimum | -10000.0...10000.0 | | | -10000 | Minimum output value for scaling and supervision |
| Val high high limit | -10000.0...10000.0 | | | 10000 | Output value high alarm limit for supervision |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Value high limit | -10000.0...10000.0 | | | 10000 | Output value high warning limit for supervision |
| Value low limit | -10000.0...10000.0 | | | -10000 | Output value low warning limit for supervision |
| Value low low limit | -10000.0...10000.0 | | | -10000 | Output value low alarm limit for supervision |
| Value deadband | 100...100000 | | | 1000 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |

*Table 103: Input-specific settings for RTD1...10*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Input mode | 1=Not in use<br>2=Resistance<br>10=Pt100<br>11=Pt250<br>20=Ni100<br>21=Ni120<br>22=Ni250<br>30=Cu10 | | | 1=Not in use | Analog input mode |
| Input maximum | 0...4000 | Ω | | 4000 | Maximum analog input value for mA or resistance scaling |
| Input minimum | 0...4000 | Ω | | 0 | Minimum analog input value for mA or resistance scaling |
| Value unit | 1=Dimensionless<br>5=Ampere<br>23=Degrees celsius<br>30=Ohm | | | 1=Dimensionless | Selected unit for output value format |
| Value maximum | -10000.0...10000.0 | | | 10000 | Maximum output value for scaling and supervision |
| Value minimum | -10000.0...10000.0 | | | -10000 | Minimum output value for scaling and supervision |
| Val high high limit | -10000.0...10000.0 | | | 10000 | Output value high alarm limit for supervision |
| Value high limit | -10000.0...10000.0 | | | 10000 | Output value high warning limit for supervision |
| Value low limit | -10000.0...10000.0 | | | -10000 | Output value low warning limit for supervision |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Value low low limit | -10000.0...10000.0 | | | -10000 | Output value low alarm limit for supervision |
| Value deadband | 100...100000 | | | 1000 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |
| Update interval | 0=No delay<br>1=10 ms<br>2=50 ms<br>3=100 ms | | | 0 | Value update interval |

*Table 104: Output-specific settings for mA1 and mA2*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Output mode | 1=Not in use<br>6=0...20mA | | | 1=Not in use | Analog output mode |
| Num of knee points | 0...4 | | | 0 | Number of knee points in scaling |
| Input maximum | -10000.0...10000.0 | | | 10000.0 | Maximum analog input value for mA scaling |
| Input knee point 4 | -10000.0...10000.0 | | | 0.0 | Input knee point value 4 for scaling |
| Input knee point 3 | -10000.0...10000.0 | | | 0.0 | Input knee point value 3 for scaling |
| Input knee point 2 | -10000.0...10000.0 | | | 0.0 | Input knee point value 2 for scaling |
| Input knee point 1 | -10000.0...10000.0 | | | 0.0 | Input knee point value 1 for scaling |
| Input minimum | -10000.0...10000.0 | | | -10000.0 | Minimum analog input value for mA scaling |
| Value maximum | -20.0...20.0 | mA | | 20 | Maximum analog output value for mA output |
| Value knee point 4 | -20.0...20.0 | mA | | 0 | Knee point value 4 for output scaling |
| Value knee point 3 | -20.0...20.0 | mA | | 0 | Knee point value 3 for output scaling |
| Value knee point 2 | -20.0...20.0 | mA | | 0 | Knee point value 2 for output scaling |
| Value knee point 1 | -20.0...20.0 | mA | | 0 | Knee point value 1 for output scaling |
| Value minimum | -20.0...20.0 | mA | | -20 | Minimum analog output value for mA output |

## 3.15.8 Monitored data

*Table 105: mA1 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | mA input 1, Connector A pins 1-2, range |
| AI_DB | FLOAT32 | | | mA input 1, Connector A pins 1-2, reported value |

*Table 106: mA2 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | mA input 2, Connector A pins 4-5, range |
| AI_DB | FLOAT32 | | | mA input 2, Connector A pins 4-5, reported value |

*Table 107: RTD1 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | RTD input 1, Connector A pins 7-8-9c, range |
| AI_DB | FLOAT32 | | | RTD input 1, Connector A pins 7-8-9c, reported value |

*Table 108: RTD2 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | RTD input 2, Connector A pins 10-11-12c, range |
| AI_DB | FLOAT32 | | | RTD input 2, Connector A pins 10-11-12c, reported value |

*Table 109: RTD3 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | RTD input 3, Connector A pins 13-14-15c, range |
| AI_DB | FLOAT32 | | | RTD input 3, Connector A pins 13-14-15c, reported value |

*Table 110: RTD4 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | RTD input 4, Connector A pins 16-17-18c, range |
| AI_DB | FLOAT32 | | | RTD input 4, Connector A pins 16-17-18c, reported value |

*Table 111: RTD5 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | RTD input 5, Connector B pins 1-2-3c, range |
| AI_DB | FLOAT32 | | | RTD input 5, Connector B pins 1-2-3c, reported value |

*Table 112: RTD6 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | RTD input 6, Connector B pins 4-5-6c, range |
| AI_DB | FLOAT32 | | | RTD input 6, Connector B pins 4-5-6c, reported value |

*Table 113: RTD7 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | RTD input 7, Connector B pins 7-8-9c, range |
| AI_DB | FLOAT32 | | | RTD input 7, Connector B pins 7-8-9c, reported value |

*Table 114: RTD8 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | RTD input 8, Connector B pins 10-11-12c, range |
| AI_DB | FLOAT32 | | | RTD input 8, Connector B pins 10-11-12c, reported value |

*Table 115: RTD9 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | RTD input 9, Connector B pins 13-14-15c, range |
| AI_DB | FLOAT32 | | | RTD input 9, Connector B pins 13-14-15c, reported value |

*Table 116: RTD10 Monitored data*

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | RTD input 10, Connector B pins 16-17-18c, range |
| AI_DB | FLOAT32 | | | RTD input 10, Connector B pins 16-17-18c, reported value |

## 3.16 SMV function blocks

SMV function blocks are used in the process bus applications with the IEC 61850-9-2 LE protocol. Function blocks represent the sending of the sampled measured values of analog currents and voltages and the receiving of the sampled values of analog currents and voltages.

## 3.16.1 SMV stream sender (IEC 61850-9-2LE) SMVSENDER

### 3.16.1.1 Function block

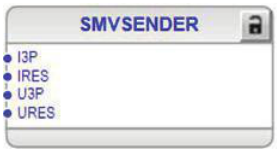



*Figure 68: Function block*

### 3.16.1.2 Functionality

The SMV stream sender (IEC 61850-9-2LE) function SMVSENDER is used for activating the SMV sending functionality. It adds/removes the sampled value control block and the related data set into/from the sending device's configuration. It has only input signals.

SMVSENDER can be disabled with the *Operation* setting value "off". Toggling SMVSENDER “on” or “off” can be done from the LHMI. When disabled, the sending of the sample values is disabled.

### 3.16.1.3 Settings

*Table 117: SMVSENDER Settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation |

## 3.16.2 SMV stream receiver (IEC 61850-9-2LE) SMVRCV

### 3.16.2.1 Function block

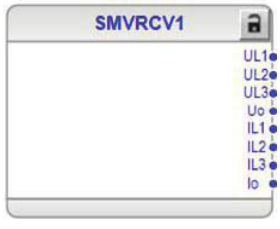



*Figure 69: Function block*

### 3.16.2.2 Functionality

The SMV stream receiver (IEC 61850-9-2LE) function SMVRCV is used for connecting SMV channels to the application.

### 3.16.2.3 Signals

*Table 118: SMVRCV Output signals*

| Name | Type | Description |
|---|---|---|
| UL1 | INT32-UL1 | IEC61850-9-2 phase 1 voltage |
| UL2 | INT32-UL2 | IEC61850-9-2 phase 2 voltage |
| UL3 | INT32-UL3 | IEC61850-9-2 phase 3 voltage |
| U0 | INT32-Uo | IEC61850-9-2 residual voltage |

# 3.17 Preprocessing blocks

## 3.17.1 Phase current preprocessing ILTCTR

### 3.17.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Phase current preprocessing | ILTCTR | ILTCTR | ILTCTR |

### 3.17.1.2 Function block

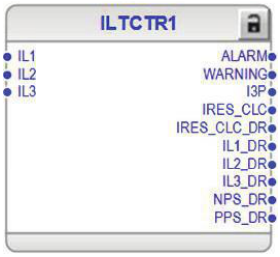



*Figure 70: Function block*

### 3.17.1.3 Functionality

The phase current preprocessing function ILTCTR is used for setting up the three phase current measurement channels. The input channels for ILTCTR are either physical hardware or IEC 61850-9-2 sampled value channels. The output `I3P` channel of ILTCTR can be connected to different applications which require 3 phase

current and positive- and negative-sequence current. The output IRES_CLC can be connected to functions using the calculated residual current.

The current transducer selection can be made by setting *Current input type* to "Current trafo" for conventional CT sensor or to "Current sensor" for current sensor type.

The sensor's or the CT's primary rated current can be set using *Primary current* setting. The setting *Secondary current* defines the nominal current of the CT's secondary winding. This is used as a reference to scale the measurements accordingly. These settings also affect the scaling of the calculated residual current.

Current magnitude correction of an external CT can be made using settings *Amplitude Corr A*, *Amplitude Corr B* and *Amplitude Corr C*.

Current angle correction of an external CT can be made using settings *Angle Corr A*, *Angle Corr B* and *Angle Corr C*.

*Rated secondary Val* setting defines the ratio for sensor use. This value multiplied by the *Rated frequency* setting (under **Configuration/System**) gives the sensor's nominal voltage corresponding to the sensors' primary rated current.

*Reverse polarity* setting is used to reverse the polarity of phase CTs.

The WARNING output in the receiver is activated if the synchronization accuracy of the sender or the receiver is worse than 4 μs. The output remains on for 10 seconds after the synchronization accuracy returns within limits.

The ALARM in the receiver is activated if the synchronization accuracy of the sender or the receiver is not within tolerances. The output is held on for 10 seconds after the synchronization accuracy returns within limits. If the effect on protection is negligible, the WARNING or ALARM output is not activated.

The *SMV Max Delay* setting defines how long the receiver waits for the SMV frames before activating the ALARM output. This setting can be accessed via **Configuration/ System**. Waiting for the SMV frames delays the local measurements of the receiver to keep them correctly time aligned. The *SMV Max Delay* values include sampling, processing and network delay.

Frequency adaptive measurements for a three-phase current can be activated with the setting *Frequency adaptivity*. Three selections are provided.

*Table 119: Frequency adaptivity setting for three-phase current measurement*

| Setting value | Description |
|---|---|
| Disable | Frequency adaptive measurements are disabled for this ILTCTR. Measurements are fixed to nominal frequency defined with **Configuration/ System/Rated frequency**. |
| Enable | Frequency adaptive measurements are enabled. In this case, the estimated network frequency is defined by another preprocessing block. |
| Backup frequency source | Frequency adaptive measurements are enabled. If the main frequency source cannot determine the network frequency, the currents of the preprocessing block determine the network frequency. |

All three phases must be always connected.

ILTCTR setting *Frequency adaptivity* is visible only if the system setting **Configuration/System/Frequency adaptivity** is set to "Enable".

### 3.17.1.4 Signals

*Table 120: ILTCTR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IL1 | SIGNAL | - | Analog input |
| IL2 | SIGNAL | - | Analog input |
| IL3 | SIGNAL | - | Analog input |

*Table 121: ILTCTR Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm |
| WARNING | BOOLEAN | Warning |
| I3P | SIGNAL | Three-phase currents |
| IRES_CLC | SIGNAL | Residual current, calculated |
| IRES_CLC_DR | SIGNAL | Residual current, calculated, for disturbance recorder |
| IL1_DR | SIGNAL | Phase current IL1 for disturbance recorder |
| IL2_DR | SIGNAL | Phase current IL2 for disturbance recorder |

Table continues on next page

| Name | Type | Description |
|---|---|---|
| IL3_DR | SIGNAL | Phase current IL3 for disturbance recorder |
| NPS_DR | SIGNAL | Negative sequence current for disturbance recorder |
| PPS_DR | SIGNAL | Positive sequence current for disturbance recorder |

### 3.17.1.5 Settings

*Table 122: ILTCTR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current input type | 2=Current trafo<br>4=Current sensor | | | 2=Current trafo | Type of the current input |
| Primary current | 1.0...15000.0 | A | 0.1 | 100.0 | Rated primary current |
| Secondary current | 2=1A<br>3=5A | | | 2=1A | Rated secondary current |
| Rated secondary Val | 1.000...150.000 | mV/Hz | 0.001 | 3.000 | Rated Secondary Value (RSV) ratio |
| Amplitude Corr A | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase A amplitude correction factor |
| Amplitude Corr B | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase B amplitude correction factor |
| Amplitude Corr C | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase C amplitude correction factor |
| Angle Corr A | -20.0000...20.0000 | deg | 0.0001 | 0.0000 | Phase A angle correction factor |
| Angle Corr B | -20.0000...20.0000 | deg | 0.0001 | 0.0000 | Phase B angle correction factor |
| Angle Corr C | -20.0000...20.0000 | deg | 0.0001 | 0.0000 | Phase C angle correction factor |

*Table 123: ILTCTR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reverse polarity | 0=False<br>1=True | | | 0=False | Reverse the polarity of the phase CTs |
| Frequency adaptivity | 0=Disable<br>1=Enable<br>3=Backup frequency source | | | 0=Disable | Frequency adaptivity selection |

### 3.17.1.6 Monitored data

Monitored data is available in three locations.

- **Monitoring/I/O status/Analog inputs**
- **Monitoring/IED status/SMV traffic**
- **Monitoring/IED status/SMV accuracy**

## 3.17.2 Residual current preprocessing RESTCTR

### 3.17.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Residual current preprocessing | RESTCTR | RESTCTR | RESTCTR |

### 3.17.2.2 Function block




*Figure 71: Function block*

### 3.17.2.3 Functionality

The residual current preprocessing function RESTCTR is used for setting up the residual current measurement channels. Input channels for RESTCTR are either physical hardware or IEC 61850-9-2 sampled value channels. The output IRES_MEAS channel of RESTCTR can be connected to different applications which require measured residual current.

The residual CTs' primary rated current can be set using *Primary current* setting. The setting *Secondary current* defines the nominal current of the CT's secondary winding. This is used as a reference to scale measurements accordingly.

Residual current magnitude correction of an external CT can be made using the *Amplitude Corr* setting.

Residual current angle correction of an external CT can be made using the *Angle correction* setting.

The *Reverse polarity* setting is used to reverse the polarity of the residual CT.

The WARNING output in the receiver is activated if the synchronization accuracy of the sender or the receiver is worse than 4 µs. The output is held on for 10 seconds after the synchronization accuracy returns within limits.

The ALARM in the receiver is activated if the synchronization accuracy of the sender or the receiver is not within tolerances. The output is held on for 10 seconds after the synchronization accuracy returns within limits. If the effect on protection is negligible, the WARNING or ALARM outputs are not activated.

The *SMV Max Delay* setting defines how long the receiver waits for the SMV frames before activating the ALARM output. This setting can be accessed via **Configuration/ System**. Waiting for the SMV frames also delays the local measurements of the receiver to keep them correctly time aligned. The *SMV Max Delay* values include sampling, processing and network delay.

Frequency adaptive measurements for residual current can be activated with the setting *Frequency adaptivity*. Two selections are provided.

*Table 124: Frequency adaptivity setting for residual current measurement*

| Setting value | Description |
|---|---|
| Disable | Frequency adaptive measurements are disabled for this UTVTR. Measurements are fixed to nominal frequency defined with **Configuration/ System/Rated frequency**. |
| Enable | Frequency adaptive measurements are enabled. In this case, the estimated network frequency is defined by another preprocessing block. |

RESTCTR setting *Frequency adaptivity* is visible only if system setting **Configuration/System/Frequency adaptivity** is set to "Enable".

### 3.17.2.4 Settings

*Table 125: Non group settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Primary current | 1.0...6000.0 | A | 0.1 | 100.0 | Primary current |
| Secondary current | 1=0.2A<br>2=1A<br>3=5A | | | 2=1A | Secondary current |
| Rated current | 1.0...6000.0 | A | 0.1 | 100.0 | Network rated current (Ir) |
| Amplitude Corr | 0.9000...1.1000 | | 0.0001 | 1.0000 | Amplitude correction |
| Reverse polarity | 0=False<br>1=True | | | 0=False | Reverse the polarity of the residual CT |
| Angle correction | -20.0000...20.0000 | deg | 0.0001 | 0.0000 | Angle correction factor |
| Frequency adaptivity | 0=Disable<br>1=Enable | | | 0=Disable | Frequency adaptivity selection |

### 3.17.2.5 Monitored data

Monitored data is available in three locations.

- **Monitoring/I/O status/Analog inputs**
- **Monitoring/IED status/SMV traffic**
- **Monitoring/IED status/SMV accuracy**

## 3.17.3 Phase and residual voltage preprocessing UTVTR

### 3.17.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Phase and residual voltage preprocessing | UTVTR | UTVTR | UTVTR |

### 3.17.3.2 Function block

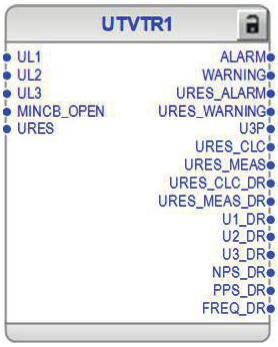



*Figure 72: Function block*

### 3.17.3.3 Functionality

The phase and residual voltage preprocessing function UTVTR is used for setting up the three phase voltage measurement channels and residual voltage measurement. The input channels for UTVTR are either physical hardware or IEC 61850-9-2 sampled value channels.

The output channel U3P of UTVTR can be connected to different applications which require phase voltage, positive and negative sequence.

Outputs URES_MEAS and URES_CLC can be connected to different applications which require measured residual voltage or calculated residual voltage (from phase voltages), respectively.

If only two phase-to-earth voltages are available, then the third phase-to-earth voltage can be calculated without URES input connected (assumed to be zero in that case). Positive- and negative-sequence components are also calculated using these voltages. The accuracy of the calculated values is affected if the actual residual voltage is not zero.

If an application function requires only the frequency value, output U3P of UTVTR still needs to be connected since the frequency is calculated from the voltage.

The voltage transducer selection can be made by setting *Voltage input type* to "Voltage trafo" for conventional VT sensor or to "Voltage sensor" for voltage sensor type.

The sensor's or the VTs' primary rated voltage can be set using *Primary voltage* setting. The setting *Secondary voltage* defines the nominal voltage of the VT's secondary winding. This is used as a reference to scale the measurements accordingly.

*Division ratio* setting defines the ratio for sensor use.

The division ratio for ABB voltage sensors is typically 10000:1. Thus, the *Division ratio* setting is usually set to "10000". For more information on *Division ratio*, see Sensor inputs for currents and voltages section.

The Voltage (Uo) residual voltage settings are also used for scaling the calculated residual voltage in comparison to the measured residual voltage.

The Voltage (Uo) settings must be set for output URES_MEAS and URES_CLC scaling. If the residual voltage is not connected to UTVTR, Voltage (Uo) settings must be set only for the calculated residual voltage URES_CLC scaling.

If the residual voltage is not connected to UTVTR, the **Voltage (Uo)/ *Primary voltage*** cannot be set smaller than 1/√3 times **Voltage (3U)/ *Primary voltage***.

Voltage magnitude correction can be made using settings *Amplitude Corr A*, *Amplitude Corr B* and *Amplitude Corr C* for an external three-phase VT and *Amplitude Corr* setting for an external residual VT.

Voltage angle correction can be made using settings *Angle Corr A*, *Angle Corr B* and *Angle Corr C* for an external three-phase VT and *Angle correction* setting for an external residual VT.

The VT connection can be set using *VT connection*. For three phase-to-earth voltage measurements, *VT connection* can be set to "Wye", and for three phase-to-phase voltage measurements, *VT connection* can be set to "Delta".

The MINCB_OPEN input signal is connected through a relay binary input to the NC auxiliary contact of the MCB protecting the VT secondary circuit. The MINCB_OPEN

signal receives information about the MCB open state. When MINCB_OPEN is active, the outputs ALARM and WARNING are activated.



The MCB open state does not affect IEC 61850-9-2 sampled value quality information.

The WARNING and URES_WARNING outputs in the receiver are activated if the synchronization accuracy of the sender or the receiver is worse than 4 µs. The outputs remain on for 10 seconds after the synchronization accuracy returns within limits.

ALARM and URES_ALARM in the receiver are activated if the synchronization accuracy of the sender or the receiver is not within tolerances. The outputs remain on for 10 seconds after the synchronization accuracy returns within limits. If the effect on protection is negligible, the WARNING, URES_WARNING, ALARM or URES_ALARM outputs are not activated.

The *SMV Max Delay* setting defines how long the receiver waits for the SMV frames before activating the ALARM and URES_ALARM outputs. This setting can be accessed via **Configuration/System**. Waiting for the SMV frames delays the local measurements of the receiver to keep them correctly time aligned. The *SMV Max Delay* values include sampling, processing and network delay.

Outputs WARNING and URES_WARNING are always internally active whenever outputs ALARM and URES_ALARM, respectively, are active.

The receiver activates the WARNING, URES_WARNING, ALARM and URES_ALARM outputs if any of the quality bits, except for the derived bit, is activated. When the receiver is in the test mode, it accepts SMV frames with test bit without activating the WARNING, URES_WARNING, ALARM and URES_ALARM outputs.

Frequency adaptive measurements for three-phase voltages can be activated with the setting *Frequency adaptivity*. Four selections are provided.

*Table 126: Frequency adaptivity setting for three-phase voltage measurement*

| Setting value | Description |
|---|---|
| Disable | Frequency adaptive measurements are disabled for this UTVTR. Measurements are fixed to nominal frequency defined with **Configuration/ System/Rated frequency**. |
| Enable | Frequency adaptive measurements are enabled. In this case, the estimated network frequency is defined by another preprocessing block. |
| Main frequency source | Frequency adaptive measurements are enabled and other preprocessing blocks follow the network frequency defined by this preprocessing block. |
| Backup frequency source | Frequency adaptive measurements are enabled. If the main frequency source cannot determine the network frequency, the voltages of this preprocessing block determine the network frequency. |

All three phases must to be connected if the main or backup frequency source is selected.

Frequency adaptive measurements for residual voltage can be activated with the setting *Frequency adaptivity*. Two selections are provided.

*Table 127: Frequency adaptivity setting for residual voltage measurement*

| Setting value | Description |
|---|---|
| Disable | Frequency adaptive measurements are disabled for this UTVTR. Measurements are fixed to nominal frequency defined with **Configuration/ System/Rated frequency**. |
| Enable | Frequency adaptive measurements are enabled. In this case, the estimated network frequency is defined by another preprocessing block. |

UTVTR setting *Frequency adaptivity* is visible only if system setting **Configuration/System/Frequency adaptivity** is set to "Enable".

### 3.17.3.4 Residual voltage scaling

Calculated $U_0$ is scaled to the same level as measured $U_0$. The scaling is determined by the ratio of ULTVTR primary voltage and RESTVTR primary voltage within one UTVTR instance. The assumption is open-delta $U_0$ measurement type.

Typical markings of an open-delta $U_0$ transformer in a 20 kV network can be: **20kV/ sqrt(3) :100V/sqrt(3) :100V/3**. In case of a solid earth fault, this transformer gives 100 V output which corresponds to 11.547 kV. If ULTVTR primary voltage is set to 20 kV and RESTVTR primary voltage is set to 11.547 kV when this transformer is used, URES_CLC and URES_MEAS output equal amplitude.

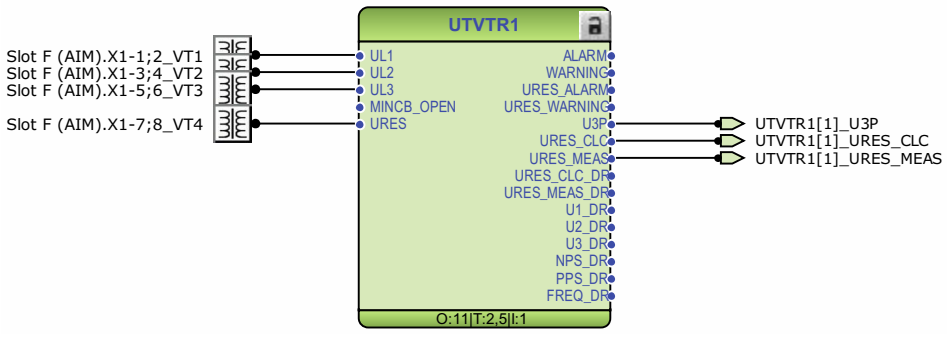



*Figure 73: UTVTR1 configured with both measured and calculated $U_0$*

The VT connection mode must be "WYE".

In this case, ROVPTOV1 and ROVPTOV2 in Figure 74 can both use the same $U_0$ reference level in their settings. URES_CLC and URES_MEAS in Figure 73 are scaled to the same level.

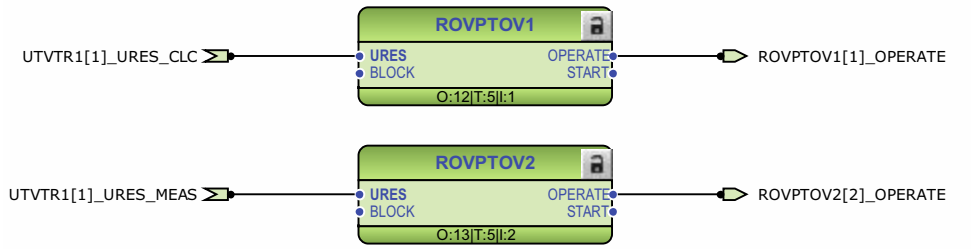



*Figure 74: Two ROVPTOV instances, one using calculated $U_0$ and the other measured $U_0$*

## 3.17.3.5 Signals

*Table 128: UTVTR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| UL1 | SIGNAL | - | Analog input |
| UL2 | SIGNAL | - | Analog input |
| UL3 | SIGNAL | - | Analog input |
| URES | SIGNAL | - | Residual voltage |
| MINCB_OPEN | BOOLEAN | 0=False | Active when external MCB opens protected voltage circuit |

*Table 129: UTVTR Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm |
| WARNING | BOOLEAN | Warning |
| URES_ALARM | BOOLEAN | Alarm |
| URES_WARNING | BOOLEAN | Warning |
| U3P | SIGNAL | Three-phase voltages |
| URES_CLC | SIGNAL | Residual voltage, calculated |
| URES_MEAS | SIGNAL | Residual voltage, measured |
| URES_CLC_DR | SIGNAL | Residual voltage, calculated, for disturbance recorder |
| URES_MEAS_DR | SIGNAL | Residual voltage, measured, for disturbance recorder |
| U1_DR | SIGNAL | Phase voltage U1 for disturbance recorder |
| U2_DR | SIGNAL | Phase voltage U2 for disturbance recorder |
| U3_DR | SIGNAL | Phase voltage U3 for disturbance recorder |
| Table continues on next page | | |

| Name | Type | Description |
|---|---|---|
| NPS_DR | SIGNAL | Negative sequence current for disturbance recorder |
| PPS_DR | SIGNAL | Positive sequence current for disturbance recorder |
| FREQ_DR | SIGNAL | Measured frequency for disturbance recorder |

### 3.17.3.6 Settings

*Table 130: UTVTR (3U) Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage input type | 1=Voltage trafo<br>3=Voltage sensor | | | 1=Voltage trafo | Type of the voltage input |
| Primary voltage | 0.100...440.000 | kV | 0.001 | 20.000 | Primary rated voltage |
| Secondary voltage | 57...240 | V | 1 | 100 | Secondary rated voltage |
| Division ratio | 1000...20000 | | 1 | 10000 | Voltage sensor division ratio |
| VT connection | 1=Wye<br>2=Delta | | | 2=Delta | Voltage transducer measurement connection |
| Amplitude Corr A | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase A Voltage phasor magnitude correction of an external voltage transformer |
| Amplitude Corr B | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase B Voltage phasor magnitude correction of an external voltage transformer |
| Amplitude Corr C | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase C Voltage phasor magnitude correction of an external voltage transformer |
| Angle Corr A | -20.0000...20.0000 | deg | 0.0001 | 0.0000 | Phase A Voltage phasor angle correction of an external voltage transformer |
| Angle Corr B | -20.0000...20.0000 | deg | 0.0001 | 0.0000 | Phase B Voltage phasor angle correction of an external voltage transformer |
| Angle Corr C | -20.0000...20.0000 | deg | 0.0001 | 0.0000 | Phase C Voltage phasor angle correction of an external voltage transformer |

*Table 131: UTVTR (3U) Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Frequency adaptivity | 0=Disable<br>1=Enable<br>2=Main frequency source<br>3=Backup frequency source | | | 0=Disable | Frequency adaptivity selection |

*Table 132: UTVTR (Uo) Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Primary voltage | 0.100...440.000 | kV | 0.001 | 11.547 | Primary voltage |
| Secondary voltage | 57...240 | V | 1 | 100 | Secondary voltage |
| Amplitude Corr | 0.9000...1.1000 | | 0.0001 | 1.0000 | Amplitude correction |
| Angle correction | -20.0000...20.0000 | deg | 0.0001 | 0.0000 | Angle correction factor |

*Table 133: UTVTR (Uo) Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Frequency adaptivity | 0=Disable<br>1=Enable | | | 0=Disable | Frequency adaptivity selection |

# 3.18 GOOSE function blocks

GOOSE function blocks are used for connecting incoming GOOSE data to application. They support BOOLEAN, Dbpos, Enum, FLOAT32, INT8 and INT32 data types.

## Common signals

The VALID output indicates the validity of received GOOSE data, which means in case of valid, that the GOOSE communication is working and received data quality bits (if configured) indicate good process data. Invalid status is caused either by bad data quality bits or GOOSE communication failure. See IEC 61850 engineering guide for details.

The OUT output passes the received GOOSE value for the application. Default value (0) is used if VALID output indicates invalid status. The IN input is defined in the GOOSE configuration and can always be seen in SMT sheet.

## Settings

The GOOSE function blocks do not have any parameters available in LHMI or PCM600.

# 3.18.1 Received GOOSE binary information GOOSERCV_BIN

## 3.18.1.1 Function block




*Figure 75: Function block*

### 3.18.1.2 Functionality

The received GOOSE binary information function GOOSERCV_BIN is used to connect the GOOSE binary inputs to the application.

### 3.18.1.3 Signals

*Table 134: GOOSERCV_BIN Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | BOOLEAN | 0 | Input signal |

*Table 135: GOOSERCV_BIN Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.2 Received GOOSE double binary information GOOSERCV_DP

### 3.18.2.1 Function block




*Figure 76: Function block*

### 3.18.2.2 Functionality

The received GOOSE double binary information function GOOSERCV_DP is used to connect the GOOSE double binary inputs to the application.

### 3.18.2.3 Signals

*Table 136: GOOSERCV_DP Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Dbpos | 00 | Input signal |

*Table 137: GOOSERCV_DP Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | Dbpos | Output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.3 Received GOOSE measured value information GOOSERCV_MV

### 3.18.3.1 Function block




*Figure 77: Function block*

### 3.18.3.2 Functionality

The received GOOSE measured value information function GOOSERCV_MV is used to connect the GOOSE measured value inputs to the application.

### 3.18.3.3 Signals

*Table 138: GOOSERCV_MV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | FLOAT32 | 0 | Input signal |

*Table 139: GOOSERCV_MV Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | FLOAT32 | Output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.4 Received GOOSE 8-bit integer value information GOOSERCV_INT8

### 3.18.4.1 Function block




*Figure 78: Function block*

### 3.18.4.2 Functionality

The received GOOSE 8-bit integer value information function GOOSERCV_INT8 is used to connect the GOOSE 8-bit integer inputs to the application.

### 3.18.4.3 Signals

*Table 140: GOOSERCV_INT8 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | INT8 | 0 | Input signal |

*Table 141: GOOSERCV_INT8 Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | INT8 | Output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.5 Received GOOSE 32-bit integer value information GOOSERCV_INT32

### 3.18.5.1 Function block




*Figure 79: Function block*

### 3.18.5.2 Functionality

The received GOOSE 32-bit integer value information function GOOSERCV_INT32 is used to connect GOOSE 32-bit integer inputs to the application.

### 3.18.5.3 Signals

*Table 142: GOOSERCV_INT32 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | INT32 | 0 | Input signal |

*Table 143: GOOSERCV_INT32 Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | INT32 | Output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.6 Received GOOSE interlocking information GOOSERCV_INTL

### 3.18.6.1 Function block




*Figure 80: Function block*

### 3.18.6.2 Functionality

The received GOOSE interlocking information function GOOSERCV_INTL is used to connect the GOOSE double binary input to the application and extracting single binary position signals from the double binary position signal.

The OP output signal indicates that the position is open. Default value (0) is used if VALID output indicates invalid status.

The CL output signal indicates that the position is closed. Default value (0) is used if VALID output indicates invalid status.

The OK output signal indicates that the position is neither in faulty or intermediate state. The default value (0) is used if VALID output indicates invalid status.

### 3.18.6.3 Signals

*Table 144: GOOSERCV_INTL Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Dbpos | 00 | Input signal |

*Table 145: GOOSERCV_INTL Output signals*

| Name | Type | Description |
|---|---|---|
| OP | BOOLEAN | Position open output signal |
| CL | BOOLEAN | Position closed output signal |
| OK | BOOLEAN | Position OK output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.7 Received GOOSE measured value (phasor) information GOOSERCV_CMV

### 3.18.7.1 Function block




*Figure 81: Function block*

### 3.18.7.2 Functionality

The received GOOSE measured value (phasor) information function GOOSERCV_CMV is used to connect GOOSE measured value inputs to the application. The MAG_IN (amplitude) and ANG_IN (angle) inputs are defined in the GOOSE configuration (PCM600).

The MAG output passes the received GOOSE (amplitude) value for the application. Default value (0) is used if VALID output indicates invalid status.

The ANG output passes the received GOOSE (angle) value for the application. Default value (0) is used if VALID output indicates invalid status.

### 3.18.7.3 Signals

*Table 146: GOOSERCV_CMV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| MAG_IN | FLOAT32 | 0 | Input signal (amplitude) |
| ANG_IN | FLOAT32 | 0 | Input signal (angle) |

*Table 147: GOOSERCV_CMV Output signals*

| Name | Type | Description |
|---|---|---|
| MAG | FLOAT32 | Output signal (amplitude) |
| ANG | FLOAT32 | Output signal (angle) |
| VALID | BOOLEAN | Output signal |

## 3.18.8 Received GOOSE enumerator value information GOOSERCV_ENUM

### 3.18.8.1 Function block




*Figure 82: Function block*

### 3.18.8.2 Functionality

The received GOOSE enumerator value information function GOOSERCV_ENUM is used to connect GOOSE enumerator inputs to the application.

### 3.18.8.3 Signals

*Table 148: GOOSERCV_ENUM Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Enum | 0 | Input signal |

*Table 149: GOOSERCV_ENUM Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | Enum | Output signal |
| VALID | BOOLEAN | Output signal |

# 3.19 Type conversion function blocks

## 3.19.1 Good signal quality QTY_GOOD

### 3.19.1.1 Function block




*Figure 83: Function block*

### 3.19.1.2 Functionality

The good signal quality function QTY_GOOD evaluates the quality bits of the input signal and passes it as a Boolean signal for the application.

The IN input can be connected to any logic application signal (except preprocessing block). Due to application logic quality bit propagation, each (simple and even combined) signal has quality which can be evaluated.

The OUT output indicates quality good of the input signal. Input signals that have no quality bits set or only test bit is set, will indicate quality good status.

### 3.19.1.3 Signals

*Table 150: QTY_GOOD Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Any | 0 | Input signal |

*Table 151: QTY_GOOD Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output signal |

## 3.19.2 Bad signal quality QTY_BAD

### 3.19.2.1 Function block




*Figure 84: Function block*

### 3.19.2.2 Functionality

The bad signal quality function QTY_BAD evaluates the quality bits of the input signal and passes it as a Boolean signal for the application.

The IN input can be connected to any logic application signal (except preprocessing block). Due to application logic quality bit propagation, each (simple and even combined) signal has quality which can be evaluated.

The OUT output indicates quality bad of the input signal. Input signals that have any other than test bit set, will indicate quality bad status.

### 3.19.2.3 Signals

*Table 152: QTY_BAD Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Any | 0 | Input signal |

*Table 153: QTY_BAD Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output signal |

## 3.19.3 GOOSE communication quality QTY_GOOSE_COMM

### 3.19.3.1 Function block




*Figure 85: Function block*

### 3.19.3.2 Functionality

The GOOSE communication quality function QTY_GOOSE_COMM evaluates the peer device communication status from the quality bits of the input signal and passes it as a Boolean signal to the application.

The IN input can be connected to any GOOSE application logic output signal, for example, GOOSERCV_BIN.

The OUT output indicates the communication status of the GOOSE function block. When the output is in the true (1) state, the GOOSE communication is active. The value false (0) indicates communication timeout.

### 3.19.3.3 Signals

*Table 154: QTY_GOOSE_COMM Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Any | 0 | Input signal |

*Table 155: QTY_GOOSE_COMM Output signals*

| Name | Type | Description |
|---|---|---|
| COMMVALID | BOOLEAN | Output signal |

## 3.19.4 GOOSE data health T_HEALTH

### 3.19.4.1 Function block




*Figure 86: Function block*

### 3.19.4.2 Functionality

The GOOSE data health function T_HEALTH evaluates enumerated data of "Health" data attribute. This function block can only be used with GOOSE.

The IN input can be connected to GOOSERCV_ENUM function block, which is receiving the LD0.LLN0.Health.stVal data attribute sent by another device.

The outputs OK, WARNING and ALARM are extracted from the enumerated input value. Only one of the outputs can be active at a time. In case the GOOSERCV_ENUM function block does not receive the value from the sending device or it is invalid, the default value (0) is used and the ALARM is activated in the T_HEALTH function block.

### 3.19.4.3 Signals

*Table 156: T_HEALTH Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Any | 0 | Input signal |

*Table 157: T_HEALTH Output signals*

| Name | Type | Description |
|---|---|---|
| OK | BOOLEAN | Output signal |
| WARNING | BOOLEAN | Output signal |
| ALARM | BOOLEAN | Output signal |

## 3.19.5 Fault direction evaluation T_DIR

### 3.19.5.1 Function block




*Figure 87: Function block*

### 3.19.5.2 Functionality

The fault direction evaluation function T_DIR evaluates enumerated data of the FAULT_DIR data attribute of the directional functions. T_DIR can only be used with GOOSE.

The DIR input can be connected to the GOOSERCV_ENUM function block, which is receiving the LD0.<function>.Str.dirGeneral or LD0.<function>.Dir.dirGeneral data attribute sent by another device. In case the GOOSERCV_ENUM function block does not receive the value from the sending device or it is invalid, the default value (0) is used in function outputs.

The outputs FWD and REV are extracted from the enumerated input value.

### 3.19.5.3 Signals

*Table 158: T_DIR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| DIR | Enum | 0 | Input signal |

*Table 159: T_DIR Output signals*

| Name | Type | Description |
|---|---|---|
| FWD | BOOLEAN | Direction forward |
| REV | BOOLEAN | Direction backward |

## 3.19.6 Enumerator to boolean conversion T_TCMD

### 3.19.6.1 Function block

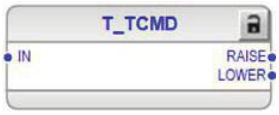



*Figure 88: Function block*

### 3.19.6.2 Functionality

The enumerator to boolean conversion function T_TCMD is used to convert enumerated input signals to boolean output signals.

*Table 160: Conversion from enumerated to boolean*

| IN | RAISE | LOWER |
|---|---|---|
| 0 | FALSE | FALSE |
| 1 | FALSE | TRUE |
| 2 | TRUE | FALSE |
| x | FALSE | FALSE |

### 3.19.6.3 Signals

*Table 161: T_TCMD Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Enum | 0 | Input signal |

*Table 162: T_TCMD Output signals*

| Name | Type | Description |
|---|---|---|
| RAISE | BOOLEAN | Raise command |
| LOWER | BOOLEAN | Lower command |

## 3.19.7 32-bit integer to binary command conversion T_TCMD_BIN

### 3.19.7.1 Function block

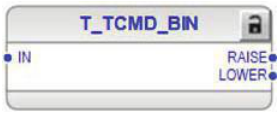



*Figure 89: Function block*

### 3.19.7.2 Functionality

The 32-bit integer to binary command conversion function T_TCMD_BIN is used to convert 32 bit integer input signal to boolean output signals.

*Table 163: Conversion from integer to boolean*

| IN | RAISE | LOWER |
|---|---|---|
| 0 | FALSE | FALSE |
| 1 | FALSE | TRUE |
| 2 | TRUE | FALSE |
| x | FALSE | FALSE |

### 3.19.7.3 Signals

*Table 164: T_TCMD_BIN Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN | INT32 | 0 | Input signal |

*Table 165: T_TCMD_BIN Output signals*

| Name | Type | Description |
|---|---|---|
| RAISE | BOOLEAN | Raise command |
| LOWER | BOOLEAN | Lower command |

## 3.19.8 Binary command to 32-bit integer conversion T_BIN_TCMD

### 3.19.8.1 Function block




*Figure 90: Function block*

### 3.19.8.2 Functionality

The binary command to 32-bit integer conversion function T_BIN_TCMD is used to convert boolean input signals to 32 bit integer output signals.

*Table 166: Conversion from boolean to integer*

| RAISE | LOWER | OUT |
|---|---|---|
| FALSE | FALSE | 0 |
| FALSE | TRUE | 1 |
| TRUE | FALSE | 2 |

### 3.19.8.3 Signals

*Table 167: T_BIN_TCMD Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| RAISE | BOOLEAN | 0 | Raise command |
| LOWER | BOOLEAN | 0 | Lower command |

*Table 168: T_BIN_TCMD Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | INT32 | Output signal |

## 3.19.9 Integer 32-bit to real conversion T_I32_TO_R

### 3.19.9.1 Function block




*Figure 91: Function block*

### 3.19.9.2 Functionality

The integer 32-bit to real conversion function T_I32_TO_R converts a 32-bit integer to a real value. The output quality follows the input quality information.

If the integer value is greater than 2097151, then the real value is set to 2097151 and the output quality is set as bad. If the integer value is less than -2097152, then the real value is set to -2097152 and the output quality is set as bad.

### 3.19.9.3 Signals

*Table 169: T_I32_TO_R Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| INT32_IN | INT32 | 0 | Integer input value |

*Table 170: T_I32_TO_R Output signals*

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output value |

## 3.19.10 Real to integer 8-bit conversion T_R_TO_I8

### 3.19.10.1 Function block




*Figure 92: Function block*

### 3.19.10.2 Functionality

The real to integer 8-bit conversion function T_R_TO_I8 converts a real to an integer 8-bit value. The real value is floored to integer value. The output quality follows the input quality information.

If the real value is 10.6, 10.5, 10.4, -10.6, -10.5, -10.4, the integer value is converted to 10, 10, 10, -11, -11, -11, respectively.

### 3.19.10.3 Signals

*Table 171: T_R_TO_I8 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN | FLOAT32 | 0 | Real input value |

*Table 172: T_R_TO_I8 Output signals*

| Name | Type | Description |
|---|---|---|
| INT8_OUT | INT8 | Integer output value |

## 3.19.11 Real to integer 32-bit conversion T_R_TO_I32

### 3.19.11.1 Function block




*Figure 93: Function block*

### 3.19.11.2 Functionality

The real to integer 32-bit conversion function T_R_TO_I32 converts a real to an integer 32-bit value. The real value is floored to integer value. The output quality follows the input quality information.

If the real value is 10.6, 10.5, 10.4, -10.6, -10.5, -10.4, the integer value is converted to 10, 10, 10, -11, -11, -11, respectively.

### 3.19.11.3 Signals

*Table 173: T_R_TO_I32 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN | FLOAT32 | 0 | Real input value |

*Table 174: T_R_TO_I32 Output signals*

| Name | Type | Description |
|---|---|---|
| INT32_OUT | INT32 | Integer output value |

## 3.19.12 Integer 32-bit switch selector SWITCHI32

### 3.19.12.1 Function block




*Figure 94: Function block*

### 3.19.12.2 Functionality

The integer 32-bit switch selector function SWITCHI32 is operated by the `CTL_SW` input, which selects the output value `INT32_OUT` between the `INT32_IN1` and `INT32_IN2` inputs.

*Table 175: SWITCHI32*

| CTL_SW value | INT_OUT value |
|---|---|
| TRUE (1) | INT32_IN1 |
| FALSE (0) | INT32_IN2 |

### 3.19.12.3 Signals

*Table 176: SWITCHI32 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| CTL_SW | BOOLEAN | 0 | Control Switch |
| INT_IN1 | INT32 | 0 | Integer input value 1 |
| INT_IN2 | INT32 | 0 | Integer input value 2 |

*Table 177: SWITCHI32 Output signals*

| Name | Type | Description |
|---|---|---|
| INT_OUT | INT32 | Integer switch output |

# 3.19.13 Integer 32-bit to boolean conversion T_I32_TO_B16

## 3.19.13.1 Function block




*Figure 95: Function block*

## 3.19.13.2 Functionality

The integer 32-bit to boolean conversion function T_I32_TO_B16 is used to transform an integer input INT32_IN into a set of 16 binary (logical) signals OUT1... OUT16. T_I32_TO_B16 is designed for receiving the integer input locally.

Conversion is done for the lowest 16 bits only. If INT32_IN is higher than 65535 ($2^{16}$ - 1), the higher bits are ignored in conversion.

## 3.19.13.3 Signals

*Table 178: T_I32_TO_B16 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| INT32_IN | INT32 | 0 | Integer input value |

*Table 179: T_I32_TO_B16 Output signals*

| Name | Type | Description |
|---|---|---|
| OUT1 | BOOLEAN | Boolean output value 1 |
| OUT2 | BOOLEAN | Boolean output value 2 |
| OUT3 | BOOLEAN | Boolean output value 3 |
| OUT4 | BOOLEAN | Boolean output value 4 |
| OUT5 | BOOLEAN | Boolean output value 5 |
| OUT6 | BOOLEAN | Boolean output value 6 |
| OUT7 | BOOLEAN | Boolean output value 7 |
| Table continues on next page | | |

| Name | Type | Description |
|---|---|---|
| OUT8 | BOOLEAN | Boolean output value 8 |
| OUT9 | BOOLEAN | Boolean output value 9 |
| OUT10 | BOOLEAN | Boolean output value 10 |
| OUT11 | BOOLEAN | Boolean output value 11 |
| OUT12 | BOOLEAN | Boolean output value 12 |
| OUT13 | BOOLEAN | Boolean output value 13 |
| OUT14 | BOOLEAN | Boolean output value 14 |
| OUT15 | BOOLEAN | Boolean output value 15 |
| OUT16 | BOOLEAN | Boolean output value 16 |

## 3.19.14 Boolean to integer 32-bit conversion T_B16_TO_I32

### 3.19.14.1 Function block




*Figure 96: Function block*

### 3.19.14.2 Functionality

The boolean to integer 32-bit conversion function T_B16_TO_I32 is used to transform a set of 16 binary (logical) signals `IN1`...`IN16` into an integer 32-bit output `INT32_OUT` value.

### 3.19.14.3 Signals

*Table 180: T_B16_TO_I32 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0 (FALSE) | Boolean input value 1 |
| IN2 | BOOLEAN | 0 (FALSE) | Boolean input value 2 |
| IN3 | BOOLEAN | 0 (FALSE) | Boolean input value 3 |
| IN4 | BOOLEAN | 0 (FALSE) | Boolean input value 4 |
| Table continues on next page | | | |

| Name | Type | Default | Description |
|---|---|---|---|
| IN5 | BOOLEAN | 0 (FALSE) | Boolean input value 5 |
| IN6 | BOOLEAN | 0 (FALSE) | Boolean input value 6 |
| IN7 | BOOLEAN | 0 (FALSE) | Boolean input value 7 |
| IN8 | BOOLEAN | 0 (FALSE) | Boolean input value 8 |
| IN9 | BOOLEAN | 0 (FALSE) | Boolean input value 9 |
| IN10 | BOOLEAN | 0 (FALSE) | Boolean input value 10 |
| IN11 | BOOLEAN | 0 (FALSE) | Boolean input value 11 |
| IN12 | BOOLEAN | 0 (FALSE) | Boolean input value 12 |
| IN13 | BOOLEAN | 0 (FALSE) | Boolean input value 13 |
| IN14 | BOOLEAN | 0 (FALSE) | Boolean input value 14 |
| IN15 | BOOLEAN | 0 (FALSE) | Boolean input value 15 |
| IN16 | BOOLEAN | 0 (FALSE) | Boolean input value 16 |

*Table 181: T_B16_TO_I32 Output signals*

| Name | Type | Description |
|---|---|---|
| INT32_OUT | INT32 | Integer output value |

# 3.20 Configurable logic blocks

## 3.20.1 Minimum pulse timer

### 3.20.1.1 Minimum pulse timer, two channels TPGAPC

#### Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Minimum pulse timer, two channels | TPGAPC | TP | 62TP |

#### Function block




*Figure 97: Function block*

#### Functionality

The minimum pulse timer, two channels, function TPGAPC contains two independent timers. The function has a settable pulse length (in milliseconds). The

timers are used for setting the minimum pulse length for example, the signal outputs. Once the input is activated, the output is set for a specific duration using the *Pulse time* setting. Both timers use the same setting parameter.

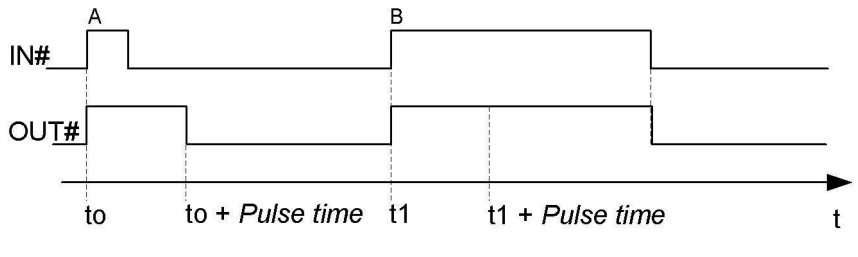



*Figure 98: A = Trip pulse is shorter than Pulse time setting, B = Trip pulse is longer than Pulse time setting*

## Signals

*Table 182: TPGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 |
| IN2 | BOOLEAN | 0=False | Input 2 |

*Table 183: TPGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| OUT1 | BOOLEAN | Output 1 status |
| OUT2 | BOOLEAN | Output 2 status |

## Settings

*Table 184: TPGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pulse time | 0...60000 | ms | 1 | 0 | Minimum pulse time |

### 3.20.1.2 Minimum pulse timer second resolution, two channels TPSGAPC

## Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Minimum pulse timer second resolution, two channels | TPSGAPC | TPS | 62TPS |

## Function block




*Figure 99: Function block*

## Functionality

The minimum pulse timer second resolution, two channels, function TPSGAPC contains two independent timers. The function has a settable pulse length (in seconds). The timers are used for setting the minimum pulse length for example, the signal outputs. Once the input is activated, the output is set for a specific duration using the *Pulse time* setting. Both timers use the same setting parameter.

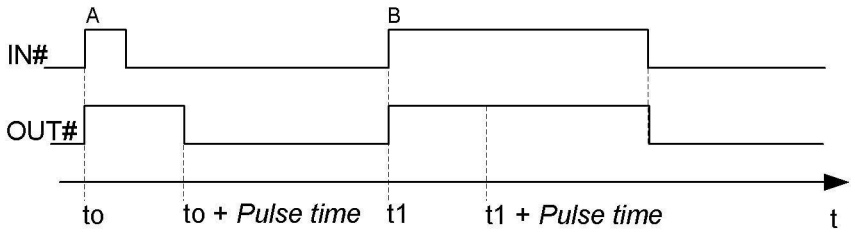



*Figure 100: A = Trip pulse is shorter than Pulse time setting, B = Trip pulse is longer than Pulse time setting*

## Signals

*Table 185: TPSGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 |
| IN2 | BOOLEAN | 0=False | Input 2 |

*Table 186: TPSGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| OUT1 | BOOLEAN | Output 1 status |
| OUT2 | BOOLEAN | Output 2 status |

## Settings

*Table 187: TPSGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pulse time | 0...300 | s | 1 | 0 | Minimum pulse time |

### 3.20.1.3 Minimum pulse timer minutes resolution, two channels TPMGAPC

## Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Minimum pulse timer minutes resolution, two channels | TPMGAPC | TPM | 62TPM |

## Function block

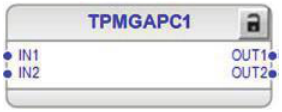



*Figure 101: Function block*

## Functionality

The minimum pulse timer minutes resolution, two channels, function TPMGAPC contains two independent timers. The function has a settable pulse length (in minutes). The timers are used for setting the minimum pulse length for example, the signal outputs. Once the input is activated, the output is set for a specific duration using the *Pulse time* setting. Both timers use the same setting parameter.

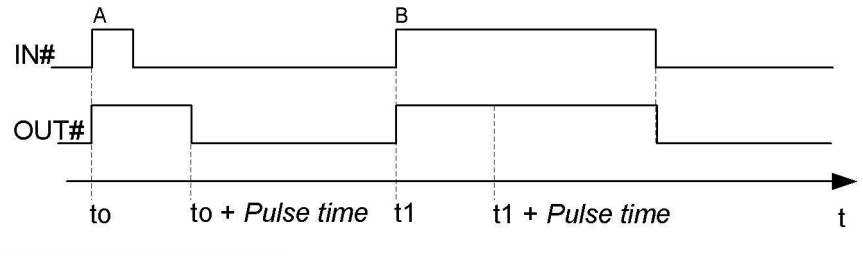



*Figure 102: A = Trip pulse is shorter than Pulse time setting, B = Trip pulse is longer than Pulse time setting*

## Signals

***Table 188: TPMGAPC Input signals***

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 |
| IN2 | BOOLEAN | 0=False | Input 2 |

***Table 189: TPMGAPC Output signals***

| Name | Type | Description |
|---|---|---|
| OUT1 | BOOLEAN | Output 1 status |
| OUT2 | BOOLEAN | Output 2 status |

### Settings

*Table 190: TPMGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pulse time | 0...300 | min | 1 | 0 | Minimum pulse time |

## 3.20.2 Pulse timer, eight channels PTGAPC

### 3.20.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Pulse timer, eight channels | PTGAPC | PT | 62PT |

### 3.20.2.2 Function block

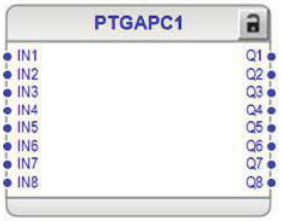



*Figure 103: Function block*

### 3.20.2.3 Functionality

The pulse timer function PTGAPC contains eight independent timers. The function has a settable pulse length. Once the input is activated, the output is set for a specific duration using the *Pulse delay time* setting.

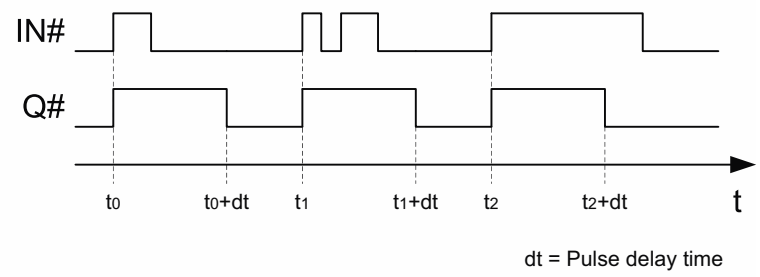



*Figure 104: Timer operation*

### 3.20.2.4 Signals

*Table 191: PTGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 status |
| IN2 | BOOLEAN | 0=False | Input 2 status |
| IN3 | BOOLEAN | 0=False | Input 3 status |
| IN4 | BOOLEAN | 0=False | Input 4 status |
| IN5 | BOOLEAN | 0=False | Input 5 status |
| IN6 | BOOLEAN | 0=False | Input 6 status |
| IN7 | BOOLEAN | 0=False | Input 7 status |
| IN8 | BOOLEAN | 0=False | Input 8 status |

*Table 192: PTGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Output 1 status |
| Q2 | BOOLEAN | Output 2 status |
| Q3 | BOOLEAN | Output 3 status |
| Q4 | BOOLEAN | Output 4 status |
| Q5 | BOOLEAN | Output 5 status |
| Q6 | BOOLEAN | Output 6 status |
| Q7 | BOOLEAN | Output 7 status |
| Q8 | BOOLEAN | Output 8 status |

### 3.20.2.5 Settings

*Table 193: PTGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pulse time 1 | 0...3600000 | ms | 10 | 0 | Pulse time |
| Pulse time 2 | 0...3600000 | ms | 10 | 0 | Pulse time |
| Pulse time 3 | 0...3600000 | ms | 10 | 0 | Pulse time |
| Pulse time 4 | 0...3600000 | ms | 10 | 0 | Pulse time |
| Pulse time 5 | 0...3600000 | ms | 10 | 0 | Pulse time |
| Pulse time 6 | 0...3600000 | ms | 10 | 0 | Pulse time |
| Pulse time 7 | 0...3600000 | ms | 10 | 0 | Pulse time |
| Pulse time 8 | 0...3600000 | ms | 10 | 0 | Pulse time |

### 3.20.2.6 Technical data

*Table 194: PTGAPC Technical data*

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

## 3.20.3 Daily timer DTMGAPC

### 3.20.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Daily timer | DTMGAPC | DTM | DTM |

### 3.20.3.2 Function block




*Figure 105: Function block*

### 3.20.3.3 Functionality

The daily timer function DTMGAPC is used to activate or deactivate its output at the set time of the day. It is possible to set a different activation or deactivation time separately for each day of the week.

### 3.20.3.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DTMGAPC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

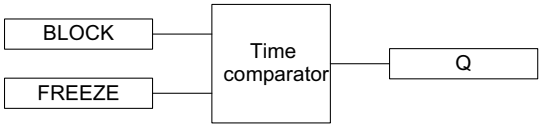



*Figure 106: Functional module diagram*

### Time comparator

This module compares the current day and time with the activation hour and minute defined with the settings *xxx Act hour* and *xxx Act Mn*, respectively. When the time of the day reaches the set activation time, output Q is activated and remains active for the duration defined by the setting *xxx off delay*.

The output remains active until the next day if the value for *xxx off delay* is set so that it results into rollover of the day.

Different activation and deactivation times can be set for all days of the week. The activation and deactivation can also be disabled for a specific day. For example, if the activation or deactivation is not needed on Sundays, the setting *Sunday Act enable* can be set as "False".

Activation of the BLOCK input deactivates the function output whereas the activation of the FREEZE input freezes the output. The BLOCK input always has a higher priority than the FREEZE input.

## 3.20.3.5 Application

DTMGAPC is useful in applications that require signal activation and deactivation at a specific time of the day. Different activation times and duration can be set for different days of the week. For example, if the signal should be active on Mondays between 7:15 and 16:00, the *Monday Act enable* setting should be "True", *Monday Act hour* should be "7", *Monday Act Mn* should be "15", and *Monday off delay* should be "525" minutes. The behavior of output Q is illustrated in Figure 107.

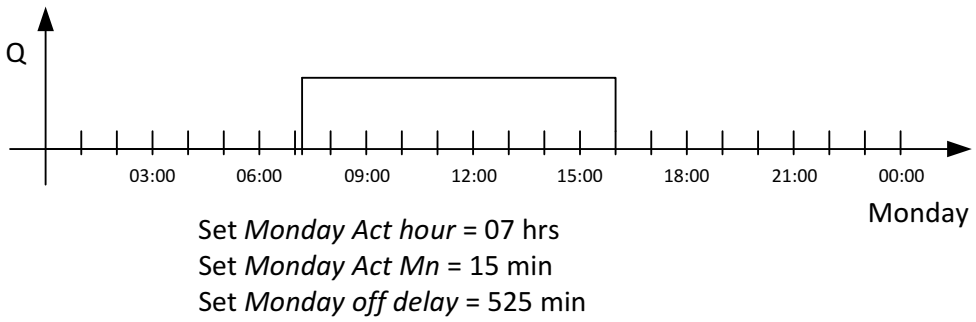



*Figure 107: Example setting values for output Q activation*

## 3.20.3.6 Signals

*Table 195: DTMGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for binary output |
| FREEZE | BOOLEAN | 0=False | Freeze signal for binary output |

*Table 196: DTMGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Output status |

### 3.20.3.7 Settings

*Table 197: DTMGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Monday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Monday |
| Monday Act hour | 0...23 | h | | 8 | Activation hour time for Monday |
| Monday Act Mn | 0...59 | min | | 0 | Activation minute time for Monday |
| Monday off delay | 1...1440 | min | 1 | 60 | Activation duration for Monday |
| Tuesday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Tuesday |
| Tuesday Act hour | 0...23 | h | | 8 | Activation hour time for Tuesday |
| Tuesday Act Mn | 0...59 | min | | 0 | Activation minute time for Tuesday |
| Tuesday off delay | 1...1440 | min | 1 | 60 | Activation duration for Tuesday |
| Wednesday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Wednesday |
| Wednesday Act hour | 0...23 | h | | 8 | Activation hour time for Wednesday |
| Wednesday Act Mn | 0...59 | min | | 0 | Activation minute time for Wednesday |
| Wednesday off delay | 1...1440 | min | 1 | 60 | Activation duration for Wednesday |
| Thursday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Thursday |
| Thursday Act hour | 0...23 | h | | 8 | Activation hour time for Thursday |
| Thursday Act Mn | 0...59 | min | | 0 | Activation minute time for Thursday |
| Thursday off delay | 1...1440 | min | 1 | 60 | Activation duration for Thursday |
| Friday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Friday |
| Friday Act hour | 0...23 | h | | 8 | Activation hour time for Friday |
| Friday Act Mn | 0...59 | min | | 0 | Activation minute time for Friday |
| Friday off delay | 1...1440 | min | 1 | 60 | Activation duration for Friday |
| Saturday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Saturday |
| Saturday Act hour | 0...23 | h | | 8 | Activation hour time for Saturday |
| Saturday Act Mn | 0...59 | min | | 0 | Activation minute time for Saturday |
| Saturday off delay | 1...1440 | min | 1 | 60 | Activation duration for Saturday |
| Sunday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Sunday |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Sunday Act hour | 0...23 | h | | 8 | Activation hour time for Sunday |
| Sunday Act Mn | 0...59 | min | | 0 | Activation minute time for Sunday |
| Sunday off delay | 1...1440 | min | 1 | 60 | Activation duration for Sunday |

#### 3.20.3.8 Monitored data

*Table 198: DTMGAPC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| DTMGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 3.20.4 Calendar function CALGAPC

### 3.20.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Calendar function | CALGAPC | CAL | CAL |

### 3.20.4.2 Function block

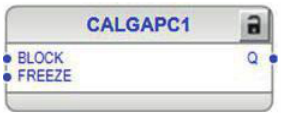



*Figure 108: Function block*

### 3.20.4.3 Functionality

The calendar function CALGAPC is used to activate a function output at a set activation date of the calendar year. The output remains activated till the set deactivation date of the calendar year.

### 3.20.4.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of CALGAPC can be described with a module diagram.

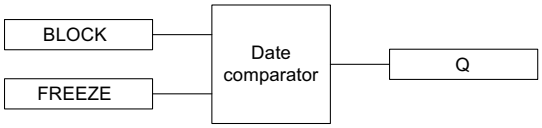



*Figure 109: Functional module diagram*

## Date comparator

This module compares the current date (excluding the calendar year) with the set activation and deactivation date and month settings. If the system date and month are the same or greater than *Activation day* and *Activation month* settings, output `Q` is activated and remains active till the date reaches the set *Deactivation day* and *Deactivation month* settings.

Activation of the `BLOCK` input deactivates the function output whereas the activation of the `FREEZE` input freezes the output. The `BLOCK` input always has a higher priority than the `FREEZE` input.

The module automatically handles the leap day and different month lengths.

- The function output remains active during the leap day if the leap day falls within the set activation period.
- If the set *Activation day* is not a valid date (for example, 31st April), then the output does not activate.
- If the set *Deactivation day* is not a valid date (for example, 31st April), then the last date of the month is considered.

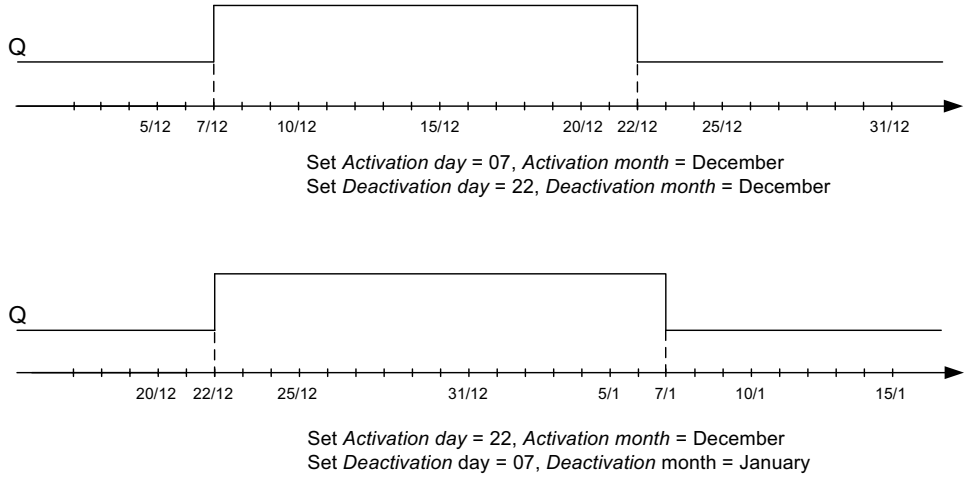



*Figure 110: Examples of how output Q is activated for different settings*

### 3.20.4.5 Application

The function activates an output for a specific set duration of the calendar year.

Consider an application where the output of the daily timer function DTMGAPC needs to be activated only for specific days of the calendar year. The output of CALGAPC can be connected to the BLOCK input of DTMGAPC (using NOT gate) so that DTMGAPC activates only for the duration defined by CALGAPC.

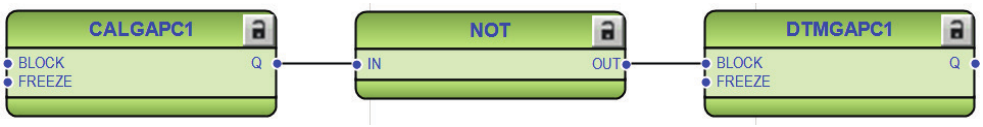



*Figure 111: Example of Calendar function usage*

### 3.20.4.6 Signals

*Table 199: CALGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for binary output |
| FREEZE | BOOLEAN | 0=False | Freeze signal for binary output |

*Table 200: CALGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Output status |

### 3.20.4.7 Settings

*Table 201: CALGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Activation day | 1...31 | | | 1 | Activation day |
| Activation month | 1=January<br>2=February<br>3=March<br>4=April<br>5=May<br>6=June<br>7=July<br>8=August<br>9=September<br>10=October<br>11=November<br>12=December | | | 1=January | Activation month |
| Deactivation day | 1...31 | | | 31 | Deactivation day |
| Deactivation month | 1=January<br>2=February<br>3=March<br>4=April<br>5=May<br>6=June<br>7=July<br>8=August<br>9=September<br>10=October<br>11=November<br>12=December | | | 1=January | Deactivation month |

### 3.20.4.8 Monitored data

*Table 202: CALGAPC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| CALGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 3.20.5 Time delay off, eight channels TOFGAPC

### 3.20.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Time delay off, eight channels | TOFGAPC | TOF | 62TOF |

### 3.20.5.2 Function block

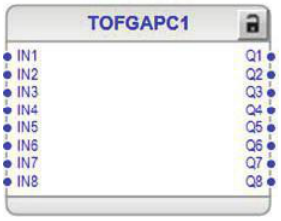



*Figure 112: Function block*

### 3.20.5.3 Functionality

The time delay off, eight channels, function TOFGAPC can be used, for example, for a drop-off-delayed output related to the input signal. The function contains eight independent timers. There is a settable delay in the timer. Once the input is activated, the output is set immediately. When the input is cleared, the output stays on until the time set with the *Off delay time* setting has elapsed.

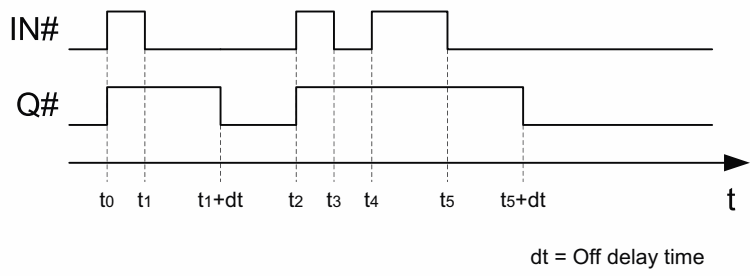



*Figure 113: Timer operation*

### 3.20.5.4 Signals

*Table 203: TOFGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 status |
| IN2 | BOOLEAN | 0=False | Input 2 status |
| IN3 | BOOLEAN | 0=False | Input 3 status |
| IN4 | BOOLEAN | 0=False | Input 4 status |
| IN5 | BOOLEAN | 0=False | Input 5 status |
| IN6 | BOOLEAN | 0=False | Input 6 status |
| IN7 | BOOLEAN | 0=False | Input 7 status |
| IN8 | BOOLEAN | 0=False | Input 8 status |

*Table 204: TOFGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Output 1 status |
| Q2 | BOOLEAN | Output 2 status |
| Q3 | BOOLEAN | Output 3 status |
| Q4 | BOOLEAN | Output 4 status |
| Q5 | BOOLEAN | Output 5 status |
| Q6 | BOOLEAN | Output 6 status |
| Q7 | BOOLEAN | Output 7 status |
| Q8 | BOOLEAN | Output 8 status |

### 3.20.5.5 Settings

*Table 205: TOFGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Off delay time 1 | 0...3600000 | ms | 10 | 0 | Off delay time |
| Off delay time 2 | 0...3600000 | ms | 10 | 0 | Off delay time |
| Off delay time 3 | 0...3600000 | ms | 10 | 0 | Off delay time |
| Off delay time 4 | 0...3600000 | ms | 10 | 0 | Off delay time |
| Off delay time 5 | 0...3600000 | ms | 10 | 0 | Off delay time |
| Off delay time 6 | 0...3600000 | ms | 10 | 0 | Off delay time |
| Off delay time 7 | 0...3600000 | ms | 10 | 0 | Off delay time |
| Off delay time 8 | 0...3600000 | ms | 10 | 0 | Off delay time |

### 3.20.5.6 Technical data

*Table 206: TOFGAPC Technical data*

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

## 3.20.6 Time delay on, eight channels TONGAPC

### 3.20.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Time delay on, eight channels | TONGAPC | TON | 62TON |

### 3.20.6.2 Function block

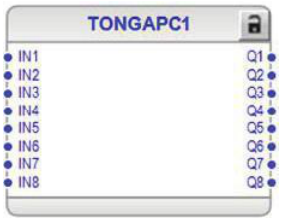



*Figure 114: Function block*

### 3.20.6.3 Functionality

The time delay on, eight channels, function TONGAPC can be used, for example, for time-delaying the output related to the input signal. TONGAPC contains eight independent timers. The timer has a settable time delay. Once the input is activated, the output is set after the time set by the *On delay time* setting has elapsed.

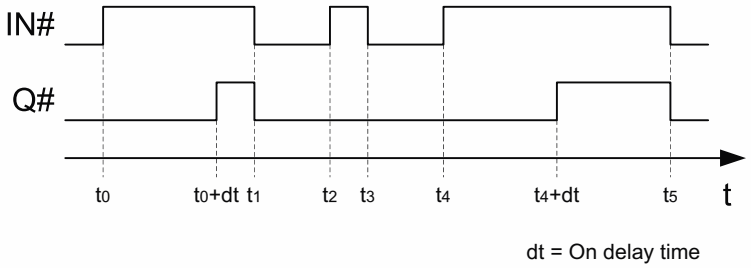



*Figure 115: Timer operation*

### 3.20.6.4 Signals

*Table 207: TONGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 |
| IN2 | BOOLEAN | 0=False | Input 2 |
| IN3 | BOOLEAN | 0=False | Input 3 |
| IN4 | BOOLEAN | 0=False | Input 4 |
| IN5 | BOOLEAN | 0=False | Input 5 |
| IN6 | BOOLEAN | 0=False | Input 6 |
| IN7 | BOOLEAN | 0=False | Input 7 |
| IN8 | BOOLEAN | 0=False | Input 8 |

*Table 208: TONGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Output 1 |
| Q2 | BOOLEAN | Output 2 |
| Q3 | BOOLEAN | Output 3 |
| Q4 | BOOLEAN | Output 4 |
| Q5 | BOOLEAN | Output 5 |
| Q6 | BOOLEAN | Output 6 |
| Q7 | BOOLEAN | Output 7 |
| Q8 | BOOLEAN | Output 8 |

### 3.20.6.5 Settings

*Table 209: TONGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| On delay time 1 | 0...3600000 | ms | 10 | 0 | On delay time |
| On delay time 2 | 0...3600000 | ms | 10 | 0 | On delay time |
| On delay time 3 | 0...3600000 | ms | 10 | 0 | On delay time |
| On delay time 4 | 0...3600000 | ms | 10 | 0 | On delay time |
| On delay time 5 | 0...3600000 | ms | 10 | 0 | On delay time |
| On delay time 6 | 0...3600000 | ms | 10 | 0 | On delay time |
| On delay time 7 | 0...3600000 | ms | 10 | 0 | On delay time |
| On delay time 8 | 0...3600000 | ms | 10 | 0 | On delay time |

### 3.20.6.6 Technical data

*Table 210: TONGAPC Technical data*

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

## 3.20.7 SR flip-flop, eight channels, nonvolatile SRGAPC

### 3.20.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| SR flip-flop, eight channels, nonvolatile | SRGAPC | SR | SR |

### 3.20.7.2 Function block

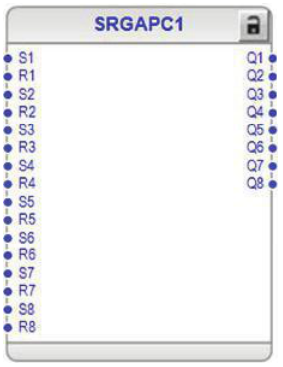



*Figure 116: Function block*

### 3.20.7.3 Functionality

The SR flip-flop, eight channels, nonvolatile function SRGAPC is a simple SR flip-flop with a memory that can be set or that can reset an output from the S# or R# inputs, respectively. The function contains eight independent set-reset flip-flop latches where the SET input has the higher priority over the RESET input. The status of each Q# output is retained in the nonvolatile memory. The individual reset for each Q# output is available on the LHMI or through tool via communication.

*Table 211: Truth table for SRGAPC*

| S# | R# | Q# |
|---|---|---|
| 0 | 0 | 0[1)] |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

1) Keep state/no change

### 3.20.7.4 Signals

*Table 212: SRGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| S1 | BOOLEAN | 0=False | Set Q1 output when set |
| R1 | BOOLEAN | 0=False | Resets Q1 output when set |
| S2 | BOOLEAN | 0=False | Set Q2 output when set |
| R2 | BOOLEAN | 0=False | Resets Q2 output when set |
| S3 | BOOLEAN | 0=False | Set Q3 output when set |
| R3 | BOOLEAN | 0=False | Resets Q3 output when set |
| S4 | BOOLEAN | 0=False | Set Q4 output when set |

Table continues on next page

| Name | Type | Default | Description |
|---|---|---|---|
| R4 | BOOLEAN | 0=False | Resets Q4 output when set |
| S5 | BOOLEAN | 0=False | Set Q5 output when set |
| R5 | BOOLEAN | 0=False | Resets Q5 output when set |
| S6 | BOOLEAN | 0=False | Set Q6 output when set |
| R6 | BOOLEAN | 0=False | Resets Q6 output when set |
| S7 | BOOLEAN | 0=False | Set Q7 output when set |
| R7 | BOOLEAN | 0=False | Resets Q7 output when set |
| S8 | BOOLEAN | 0=False | Set Q8 output when set |
| R8 | BOOLEAN | 0=False | Resets Q8 output when set |

*Table 213: SRGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Q1 status |
| Q2 | BOOLEAN | Q2 status |
| Q3 | BOOLEAN | Q3 status |
| Q4 | BOOLEAN | Q4 status |
| Q5 | BOOLEAN | Q5 status |
| Q6 | BOOLEAN | Q6 status |
| Q7 | BOOLEAN | Q7 status |
| Q8 | BOOLEAN | Q8 status |

### 3.20.7.5 Settings

*Table 214: SRGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset Q1 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q1 output when set |
| Reset Q2 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q2 output when set |
| Reset Q3 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q3 output when set |
| Reset Q4 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q4 output when set |
| Reset Q5 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q5 output when set |
| Reset Q6 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q6 output when set |
| Reset Q7 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q7 output when set |
| Reset Q8 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q8 output when set |

## 3.20.8 Boolean value event creation MVGAPC

### 3.20.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Boolean value event creation | MVGAPC | MV | MV |

### 3.20.8.2 Function block

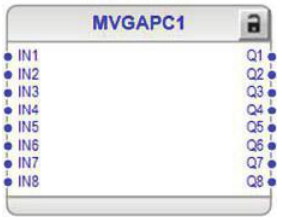



*Figure 117: Function block*

### 3.20.8.3 Functionality

The boolean value event creation function MVGAPC is used for user logic bits. Each input state is directly copied to the output state. This allows the creating of events from advanced logic combinations.

### 3.20.8.4 Signals

*Table 215: MVGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | IN1 status |
| IN2 | BOOLEAN | 0=False | IN2 status |
| IN3 | BOOLEAN | 0=False | IN3 status |
| IN4 | BOOLEAN | 0=False | IN4 status |
| IN5 | BOOLEAN | 0=False | IN5 status |
| IN6 | BOOLEAN | 0=False | IN6 status |
| IN7 | BOOLEAN | 0=False | IN7 status |
| IN8 | BOOLEAN | 0=False | IN8 status |

*Table 216: MVGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Q1 status |
| Q2 | BOOLEAN | Q2 status |
| Q3 | BOOLEAN | Q3 status |
| Q4 | BOOLEAN | Q4 status |
| Q5 | BOOLEAN | Q5 status |
| Q6 | BOOLEAN | Q6 status |
| Q7 | BOOLEAN | Q7 status |
| Q8 | BOOLEAN | Q8 status |

### 3.20.8.5 Settings

*Table 217: MVGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Description | | | | MVGAPC1 Q1 | Output description |
| Description | | | | MVGAPC1 Q2 | Output description |
| Description | | | | MVGAPC1 Q3 | Output description |
| Description | | | | MVGAPC1 Q4 | Output description |
| Description | | | | MVGAPC1 Q5 | Output description |
| Description | | | | MVGAPC1 Q6 | Output description |
| Description | | | | MVGAPC1 Q7 | Output description |
| Description | | | | MVGAPC1 Q8 | Output description |

## 3.20.9 Integer value event creation MVI4GAPC

### 3.20.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Integer value event creation | MVI4GAPC | MVI4 | MVI4 |

### 3.20.9.2 Function block




*Figure 118: Function block symbol*

### 3.20.9.3 Functionality

The integer value event creation function MVI4GAPC is used for creation of the events from the integer values. The integer input value is received via `IN1...4` input. The integer output value is available on `OUT1...4` output.

The integer input range is from -2147483648 to 2147483647.

### 3.20.9.4 Signals

*Table 218: MVI4GAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | INT32 | 0 | Integer input value 1 |
| IN2 | INT32 | 0 | Integer input value 2 |
| IN3 | INT32 | 0 | Integer input value 3 |
| IN4 | INT32 | 0 | Integer input value 4 |

*Table 219: MVI4GAPC Output signals*

| Name | Type | Description |
|---|---|---|
| OUT1 | INT32 | Integer output value 1 |
| OUT2 | INT32 | Integer output value 2 |
| OUT3 | INT32 | Integer output value 3 |
| OUT4 | INT32 | Integer output value 4 |

## 3.20.10 Analog value event creation with scaling SCA4GAPC

### 3.20.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Analog value event creation with scaling | SCA4GAPC | SCA4 | SCA4 |

### 3.20.10.2 Function block

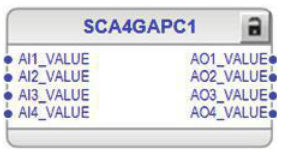



*Figure 119: Function block symbol*

### 3.20.10.3 Functionality

The analog value event creation with scaling function SCA4GAPC is used for scaling the analog value. It allows creating events from analog values.

The analog value received via the AIn_VALUE input is scaled with the *Scale ratio n* setting. The scaled value is available on the AOn_VALUE output.

Analog input range is from -10000.0 to 10000.0.

Analog output range is from -2000000.0 to 2000000.0.

If the value of the AIn_VALUE input exceeds the analog input range, AOn_VALUE is set to 0.0.

If the result of AIn_VALUE multiplied by the *Scale ratio n* setting exceeds the analog output range, AOn_VALUE shows the minimum or maximum value, according to analog value range.

### 3.20.10.4 Signals

*Table 220: SCA4GAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| AI1_VALUE | FLOAT32 | 0.0 | Analog input value of channel 1 |
| AI2_VALUE | FLOAT32 | 0.0 | Analog input value of channel 2 |
| AI3_VALUE | FLOAT32 | 0.0 | Analog input value of channel 3 |
| AI4_VALUE | FLOAT32 | 0.0 | Analog input value of channel 4 |

*Table 221: SCA4GAPC Output signals*

| Name | Type | Description |
|---|---|---|
| AO1_VALUE | FLOAT32 | Analog value 1 after scaling |
| AO2_VALUE | FLOAT32 | Analog value 2 after scaling |
| AO3_VALUE | FLOAT32 | Analog value 3 after scaling |
| AO4_VALUE | FLOAT32 | Analog value 4 after scaling |

### 3.20.10.5 Settings

*Table 222: SCA4GAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Scale ratio 1 | 0.001...1000.000 | | 0.001 | 1.000 | Scale ratio for analog value 1 |
| Scale ratio 2 | 0.001...1000.000 | | 0.001 | 1.000 | Scale ratio for analog value 2 |
| Scale ratio 3 | 0.001...1000.000 | | 0.001 | 1.000 | Scale ratio for analog value 3 |
| Scale ratio 4 | 0.001...1000.000 | | 0.001 | 1.000 | Scale ratio for analog value 4 |

## 3.20.11 16 settable real values SETRGAPC

### 3.20.11.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| 16 settable real values | SETRGAPC | SETRGAPC | SETRGAPC |

### 3.20.11.2 Function block




*Figure 120: Function block*

### 3.20.11.3 Functionality

The value of function outputs AO1_VALUE...AO16_VALUE can be set with settings *Set value 1...Set value 16*.

### 3.20.11.4 Signals

*Table 223: SETRGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| AO1_VALUE | FLOAT32 | Analog value 1 |
| AO2_VALUE | FLOAT32 | Analog value 2 |
| AO3_VALUE | FLOAT32 | Analog value 3 |
| AO4_VALUE | FLOAT32 | Analog value 4 |
| AO5_VALUE | FLOAT32 | Analog value 5 |
| AO6_VALUE | FLOAT32 | Analog value 6 |
| AO7_VALUE | FLOAT32 | Analog value 7 |
| AO8_VALUE | FLOAT32 | Analog value 8 |
| AO9_VALUE | FLOAT32 | Analog value 9 |
| AO10_VALUE | FLOAT32 | Analog value 10 |
| AO11_VALUE | FLOAT32 | Analog value 11 |
| AO12_VALUE | FLOAT32 | Analog value 12 |
| AO13_VALUE | FLOAT32 | Analog value 13 |
| AO14_VALUE | FLOAT32 | Analog value 14 |
| AO15_VALUE | FLOAT32 | Analog value 15 |
| AO16_VALUE | FLOAT32 | Analog value 16 |

### 3.20.11.5 Settings

*Table 224: SETRGAPC Non-group settings (Basic)*

| IEC name | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Set value 1 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 1 |
| Set value 2 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 2 |
| Set value 3 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 3 |
| Set value 4 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 4 |
| Set value 5 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 5 |
| Set value 6 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 6 |
| Set value 7 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 7 |
| Set value 8 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 8 |
| Set value 9 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 9 |

Table continues on next page

| IEC name | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Set value 10 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 10 |
| Set value 11 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 11 |
| Set value 12 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 12 |
| Set value 13 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 13 |
| Set value 14 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 14 |
| Set value 15 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 15 |
| Set value 16 | -2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 16 |

## 3.20.12 16 settable 32-bit integer values SETI32GAPC

### 3.20.12.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| 16 settable 32-bit integer values | SETI32GAPC | SETI32GAPC | SETI32GAPC |

### 3.20.12.2 Function block

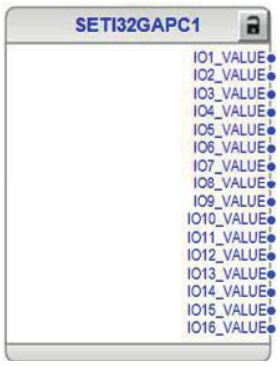



*Figure 121: Function block*

### 3.20.12.3 Functionality

The value of function outputs `IO1_VALUE`...`IO16_VALUE` can be set with settings *Set value 1*...*Set value 16*.

### 3.20.12.4 Signals

*Table 225: SETI32GAPC Output signals*

| Name | Type | Description |
|---|---|---|
| IO1_VALUE | INT32 | Integer value 1 |
| IO2_VALUE | INT32 | Integer value 2 |
| IO3_VALUE | INT32 | Integer value 3 |
| IO4_VALUE | INT32 | Integer value 4 |
| IO5_VALUE | INT32 | Integer value 5 |
| IO6_VALUE | INT32 | Integer value 6 |
| IO7_VALUE | INT32 | Integer value 7 |
| IO8_VALUE | INT32 | Integer value 8 |
| IO9_VALUE | INT32 | Integer value 9 |
| IO10_VALUE | INT32 | Integer value 10 |
| IO11_VALUE | INT32 | Integer value 11 |
| IO12_VALUE | INT32 | Integer value 12 |
| IO13_VALUE | INT32 | Integer value 13 |
| IO14_VALUE | INT32 | Integer value 14 |
| IO15_VALUE | INT32 | Integer value 15 |
| IO16_VALUE | INT32 | Integer value 16 |

### 3.20.12.5 Settings

*Table 226: SETI32GAPC Non-group settings (Basic)*

| IEC name | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Set value 1 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 1 |
| Set value 2 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 2 |
| Set value 3 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 3 |
| Set value 4 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 4 |
| Set value 5 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 5 |
| Set value 6 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 6 |
| Set value 7 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 7 |
| Set value 8 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 8 |
| Set value 9 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 9 |

Table continues on next page

| IEC name | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Set value 10 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 10 |
| Set value 11 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 11 |
| Set value 12 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 12 |
| Set value 13 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 13 |
| Set value 14 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 14 |
| Set value 15 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 15 |
| Set value 16 | -2147483648...2147483647 | | 1 | 0 | Set value for integer value 16 |

## 3.20.13 Generic control points SPCGAPC

### 3.20.13.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Generic control points | SPCGAPC | SPC | SPCG |

### 3.20.13.2 Function block

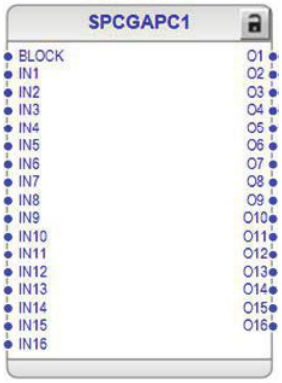



*Figure 122: Function block*

### 3.20.13.3 Functionality

The generic control points function SPCGAPC contains 16 independent control points. SPCGAPC offers the capability to activate its outputs through a local or remote control. The local control request can be issued through the buttons in the single-line diagram or via inputs and the remote control request through communication. The

rising edge of the input signal is interpreted as a control request, and the output operation is triggered. When remote control requests are used the control points behaves as persistent.

The *Loc Rem restriction* setting is used for enabling or disabling the restriction for SPCGAPC to follow the R/L button state. If *Loc Rem restriction* is "True", as it is by default, the local or remote control operations are accepted according to the R/L button state.

Each of the 16 generic control point outputs has the *Operation mode*, *Pulse length* and *Description* setting. If *Operation mode* is "Toggle", the output state is toggled for every control request received. If *Operation mode* is "Pulsed", the output pulse of a preset duration (the *Pulse length* setting) is generated for every control request received. The *Description* setting can be used for storing information on the actual use of the control point in application, for instance.

For example, if the *Operation mode* is "Toggle", the output O# is initially “False”. The rising edge in IN# sets O# to “True”. The falling edge of IN# has no effect. Next rising edge of IN# sets O# to “False”.

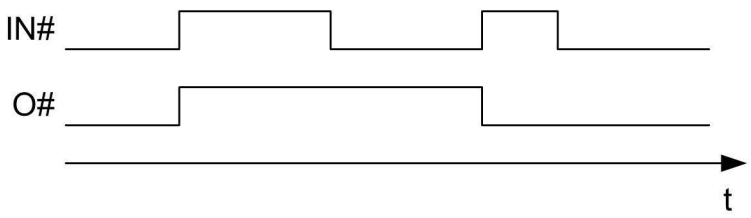



*Figure 123: Operation in "Toggle" mode*

The BLOCK input can be used for blocking the functionality of the outputs. The operation of the BLOCK input depends on the *Operation mode* setting. If *Operation mode* is "Toggle", the output state freezes and cannot be changed while the BLOCK input is active. If *Operation mode* is "Pulsed", the activation of the BLOCK input resets the outputs to the "False" state and further control requests are ignored while the BLOCK input is active.

From the remote communication point of view SPCGAPC toggled operation mode is always working as persistent mode. The output O# follows the value written to the input IN#.

### 3.20.13.4 Signals

*Table 227: SPCGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| IN1 | BOOLEAN | 0=False | Input of control point 1 |
| IN2 | BOOLEAN | 0=False | Input of control point 2 |
| IN3 | BOOLEAN | 0=False | Input of control point 3 |
| IN4 | BOOLEAN | 0=False | Input of control point 4 |
| IN5 | BOOLEAN | 0=False | Input of control point 5 |
| IN6 | BOOLEAN | 0=False | Input of control point 6 |
| IN7 | BOOLEAN | 0=False | Input of control point 7 |
| IN8 | BOOLEAN | 0=False | Input of control point 8 |
| IN9 | BOOLEAN | 0=False | Input of control point 9 |
| IN10 | BOOLEAN | 0=False | Input of control point 10 |
| IN11 | BOOLEAN | 0=False | Input of control point 11 |
| IN12 | BOOLEAN | 0=False | Input of control point 12 |
| IN13 | BOOLEAN | 0=False | Input of control point 13 |
| IN14 | BOOLEAN | 0=False | Input of control point 14 |
| IN15 | BOOLEAN | 0=False | Input of control point 15 |
| IN16 | BOOLEAN | 0=False | Input of control point 16 |

*Table 228: SPCGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| O1 | BOOLEAN | Output 1 status |
| O2 | BOOLEAN | Output 2 status |
| O3 | BOOLEAN | Output 3 status |
| O4 | BOOLEAN | Output 4 status |
| O5 | BOOLEAN | Output 5 status |
| O6 | BOOLEAN | Output 6 status |
| O7 | BOOLEAN | Output 7 status |
| O8 | BOOLEAN | Output 8 status |
| O9 | BOOLEAN | Output 9 status |
| O10 | BOOLEAN | Output 10 status |
| O11 | BOOLEAN | Output 11 status |
| O12 | BOOLEAN | Output 12 status |
| O13 | BOOLEAN | Output 13 status |
| O14 | BOOLEAN | Output 14 status |
| O15 | BOOLEAN | Output 15 status |
| O16 | BOOLEAN | Output 16 status |

### 3.20.13.5 Settings

*Table 229: SPCGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Loc Rem restriction | 0=False<br>1=True | | | 1=True | Local remote switch restriction |
| Operation mode | 0=Pulsed<br>1=Toggle/<br>Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1<br>Output 1 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/<br>Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1<br>Output 2 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/<br>Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1<br>Output 3 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/<br>Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1<br>Output 4 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/<br>Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1<br>Output 5 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/<br>Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1<br>Output 6 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/<br>Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 7 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/ Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 8 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/ Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 9 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/ Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 10 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/ Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 11 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/ Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 12 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/ Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 13 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/ Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Description | | | | SPCGAPC1 Output 14 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/ Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 15 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/ Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 16 | Generic control point description |

## 3.20.14 Pulse counter for energy measurement PCGAPC

### 3.20.14.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Pulse counter for energy measurement | PCGAPC | PCGAPC | PCGAPC |

### 3.20.14.2 Function block

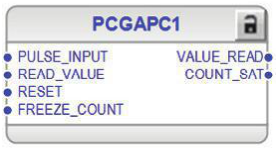



*Figure 124: Function block*

### 3.20.14.3 Functionality

The pulse counter for energy measurement function PCGAPC counts externally generated binary pulses, for example, pulses coming from an external energy meter, for the calculation of energy consumption values. The pulses are captured by the binary input module and read by PCGAPC. The number of pulses in the counter is then reported via the station bus to the automation system or read via the station monitoring system as a service value. The scaled value is also available over IEC 61850 communication.

The pulses are captured by the binary input module and read by PCGAPC with a frequency of up to 40 Hz. PCGAPC can also be used as a general-purpose counter.

### 3.20.14.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of PCGAPC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

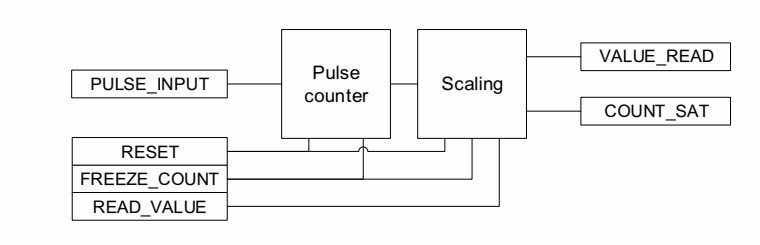



*Figure 125: Functional module diagram*

#### Pulse counter

This module counts the number of pulses available at PULSE_INPUT. The count value is incremented depending upon *Count criteria* setting.

*Table 230: Relation between setting Count criteria and count value behavior*

| *Count criteria* values | PULSE_INPUT count value |
|---|---|
| Rising edge | Count value is incremented on the rising edge of PULSE_INPUT |
| Falling edge | Count value is incremented on the falling edge of PULSE_INPUT |
| On change | Count value is incremented each time a rising edge or falling edge is available at PULSE_INPUT. |
| Freeze | Counting is frozen. |

The count value is available at COUNT_VALUE in the Monitored data view and is stored in a nonvolatile memory. This output is updated cyclically and sent to the station HMI over various communication protocols, depending on the *Reporting interval* setting. The start of *Reporting interval* corresponds to the start of the function operation in the protection relay.

Binary output VALUE_READ activates for a fixed 200 ms each time the reporting timer completes its cycle. It is also possible to update COUNT_VALUE before completion of *Reporting interval* and make it available for communication by providing a minimum 1-second-long pulse at READ_VALUE input. Besides

COUNT_VALUE activation, READ_VALUE also activates output VALUE_READ for 200 ms.

The activation of RESET resets COUNT_VALUE to zero. Activation of FREEZE_COUNT freezes further counting.

Changing *Count criteria* does not reset COUNT_VALUE.

## Scaling

This module scales the count value available at COUNT_VALUE. The scaling depends on the *Unit selection* setting. When the function is used for general-purpose counting, *Unit selection* is set as "Count" and the count value is multiplied by the *Pulse quantity* setting to calculate the scaled value.

When using this function for energy measurement, *Unit selection* is set accordingly, that is, real, active or apparent energy and the count value is divided by *Impulse ratio* to calculate the scaled value. The prefix for unit of *Impulse ratio* is defined by setting *Impulse ratio prefix*.

The energy meter defines the impulse ratio (also known as meter constant), that is, it indicates the number of pulses the meter generated per kWh (or MWh). *Impulse ratio* must be set based on the energy meter used.
For example, if the impulse ratio is 100 impulses / MWh, set *Impulse ratio* as 100 and *Impulse ratio prefix* as Mega.
If the impulse ratio is 800 impulses / KWh, set *Impulse ratio* as 800 and *Impulse ratio prefix* as Kilo.

The scaled value is available at SCALED_VALUE in the Monitored data view. This output is updated cyclically and sent to the station HMI over various communication protocols depending on *Reporting interval* setting. The start of *Reporting interval* corresponds to the start of the function operation in the protection relay.

The activation of RESET resets SCALED_VALUE to zero.

If *Pulse quantity*, *Impulse ratio* or *Impulse ratio prefix* is changed in between, SCALED_VALUE is updated immediately based on the new setting.

Binary output VALUE_READ activates for a fixed 200 ms each time the reporting timer completes its cycle.

It is also possible to update SCALED_VALUE before completion of *Reporting interval* and make it available for communication by providing a pulse at READ_VALUE input. The pulse width should be greater than 1 s. Besides updating

SCALED_VALUE, the READ_VALUE activation also activates output VALUE_READ for 200 ms.

Activation of FREEZE_COUNT input immediately updates SCALED_VALUE output with a pulse at VALUE_READ output.

Output COUNT_SAT activates when either SCALED_VALUE or COUNT_VALUE exceeds the count range and it is not possible to count further.

Figure 126 and Figure 127 explain PCGAPC operation.

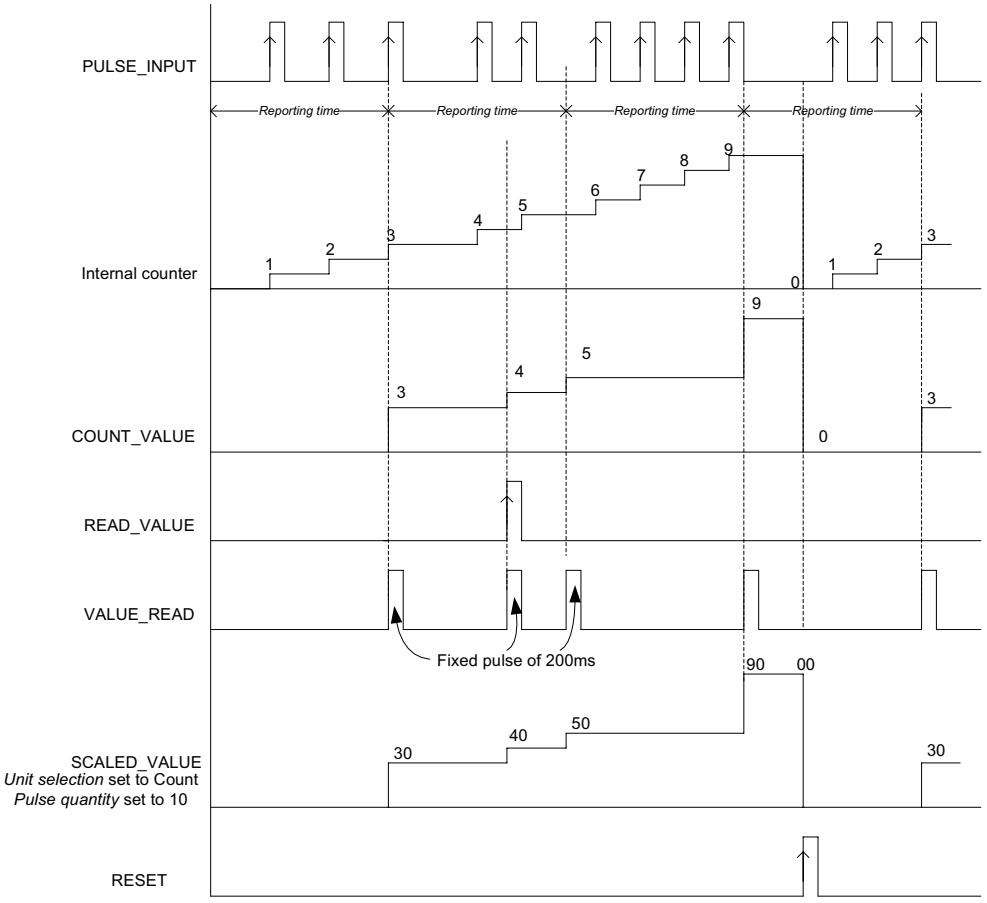



*Figure 126: PCGAPC operation*

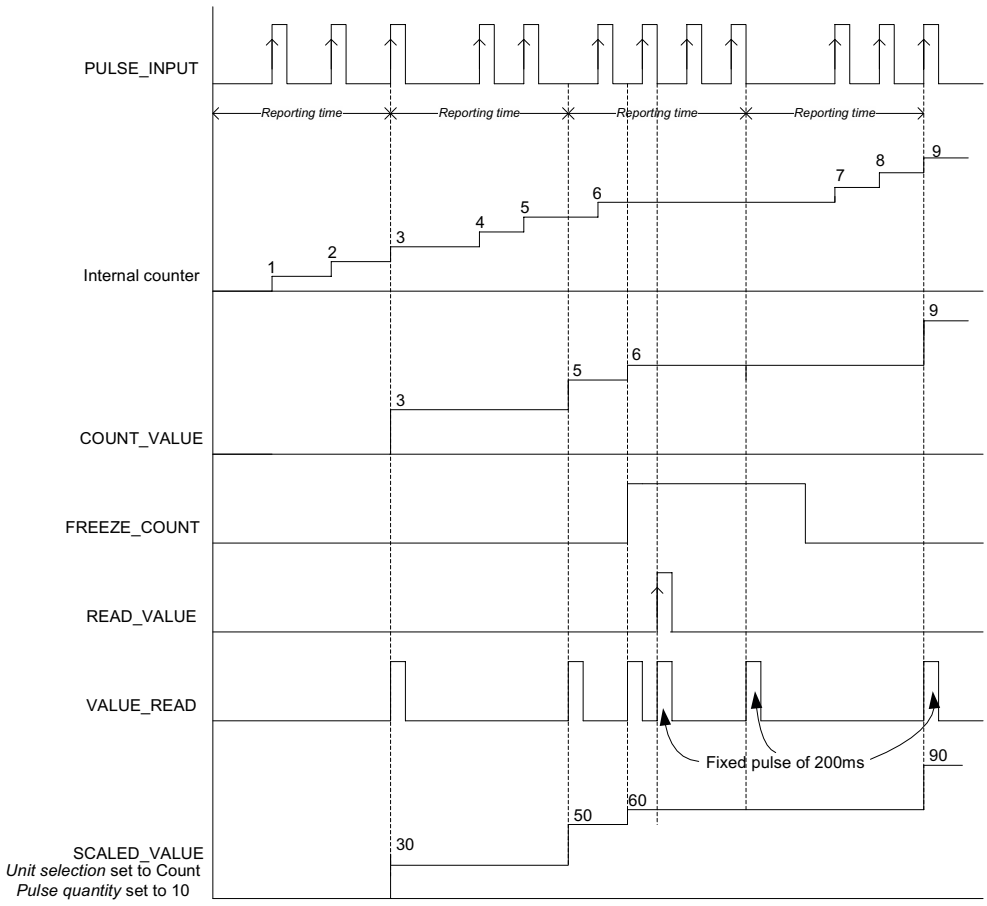



*Figure 127: Behavior of `FREEZE_COUNT` input*

## 3.20.14.5 Application

PCGAPC counts externally generated binary pulses, for example, pulses coming from an external energy meter, for the calculation of energy consumption values. The pulses are captured by the binary input module and read by PCGAPC with a frequency of up to 40 Hz. The number of pulses in the counter is then reported via the station bus to the substation automation system or read via the station monitoring system as a service value. When using IEC 61850, a scaled service value is available over the station bus.

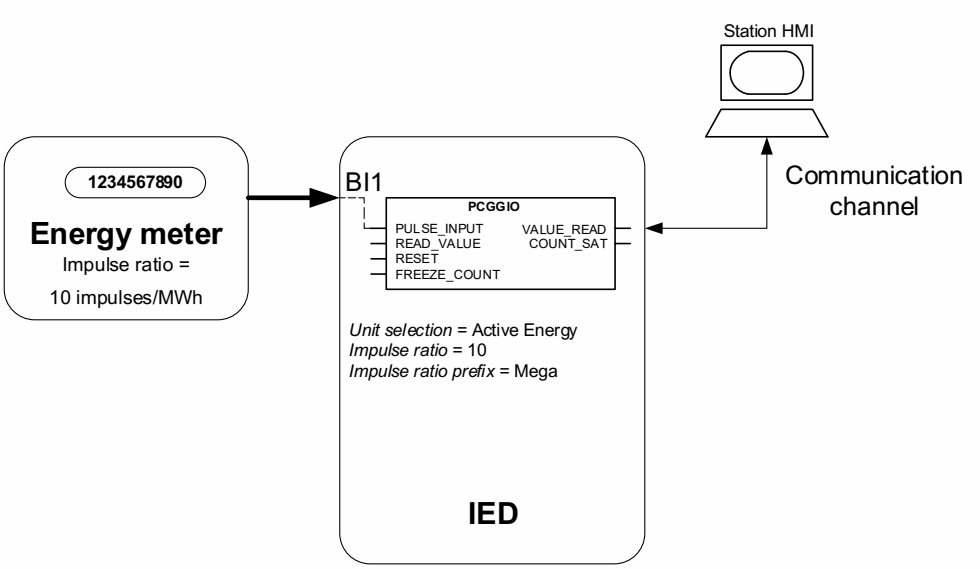



*Figure 128: Typical application of PCGAPC*

PCGAPC can also be used as a general-purpose counter.

## 3.20.15 Hotline tag HLTGAPC

### 3.20.15.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Hotline tag | HLTGAPC | HLTGAPC | HLTGAPC |

### 3.20.15.2 Function block




*Figure 129: Function block*

### 3.20.15.3 Functionality

The hotline tag function HLTGAPC is used to block all reclosing of the breaker, from both local and remote sources, when activated. When the function is activated locally, it can only be reset locally. If activated remotely, it can be reset depending on the *Remote tag mode* setting.

### 3.20.15.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off". When the *Operation* setting is changed from "off" to "on", the monitored variable TAG_SOURCE is set to “None” and saved to a nonvolatile memory.

When the *Operation* setting is "on" and a reboot occurs, the TAG_SOURCE variable is read from the nonvolatile memory.

The operation of HLTGAPC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

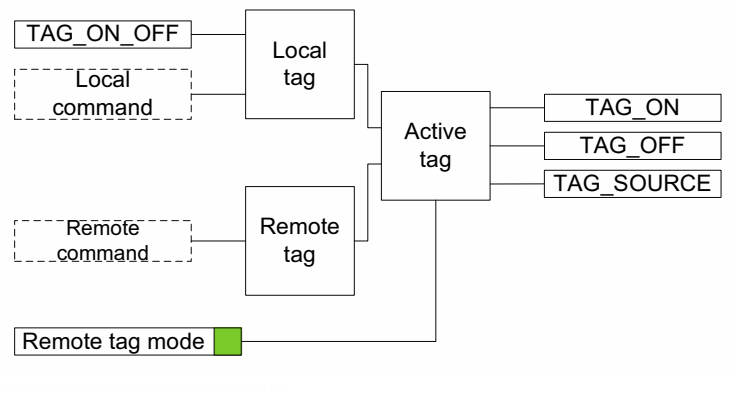



*Figure 130: Functional module diagram*

#### Local tag

Local tag is activated or deactivated on rising edge detection of `TAG_ON_OFF` input or with a local command from the LHMI when the protection relay is in local mode.

If a rising edge tag is detected locally, and the status of the nonvolatile variable TAG_SOURCE is “None”, the tag is locally activated. TAG_SOURCE changes to “Local” while `TAG_ON` is set to TRUE and `TAG_OFF` to FALSE.

If a rising edge tag is detected locally, and the status of TAG_SOURCE is “Local”, the tag is locally deactivated. TAG_SOURCE changes to “None” while `TAG_ON` is set to FALSE and `TAG_OFF` to TRUE.

When TAG_SOURCE is “Remote” and the *Remote tag mode* setting is "Untag Rem only", all local commands are prohibited. However, when the *Remote tag mode* setting is "Untag Loc or Rem", deactivation can be done locally.

#### Remote tag

Remote tag is activated or deactivated on rising edge detection through a communication channel in remote mode.

If a rising edge tag is detected remotely, and the status of the nonvolatile variable TAG_SOURCE is “None”, the tag is remotely activated. TAG_SOURCE changes to “Remote” while TAG_ON is set to TRUE and TAG_OFF to FALSE.

If a rising edge tag is detected remotely, and the status of TAG_SOURCE is “Remote”, the tag is remotely deactivated. TAG_SOURCE changes to “None” while TAG_ON is set to FALSE and TAG_OFF to TRUE.

If TAG_SOURCE is “Local”, remote commands are always prohibited.

### 3.20.15.5 Application

HLTGAPC is used to prevent the protection relay from reclosing and re-energizing a feeder where maintenance is performed. While HLTGAPC is active, no reclosing is allowed regardless of whether it is initiated through a protection trip, requested locally through the LHMI, or remotely through a communications command.

In order to operate correctly, HLTGAPC must be properly configured with Application Configuration. The TAG_ON and TAG_OFF outputs are connected where they can block or enable any reclosing that is configured. Typically, TAG_ON can be used on a recloser function block to inhibit reclosing and TAG_OFF can be used on a circuit breaker function block to enable closing.

A LED or a button on the LHMI can be used to indicate that the HLTGAPC condition is active. HLTGAPC can be activated, and the panel tagged, from the LHMI or from a remote communications command. The protection relay retains the original source (local or remote) of HLTGAPC and allows HLTGAPC to be deactivated only from the same source. That is, a locally initiated HLTGAPC can only be deactivated locally and a remotely initiated HLTGAPC can only be deactivated remotely. An exception to this rule allowing remotely initiated HLTGAPC commands to be deactivated locally can be made by changing the *Remote tag mode* setting from the default "Untag Rem only" to "Untag Loc or Rem". It is not possible to allow locally initiated HLTGAPC to be deactivated remotely.

As an alternative to using a button to activate HLTGAPC locally, the function can be activated from the Control menu of the LHMI.

The HLTGAPC status and the original source of the function are retained if power is removed and restored or through any other re-initialization of the protection relay. The HLTGAPC condition prior to the protection relay's reboot is automatically restored after the protection relay re-initializes.

The tag activation, deactivation and status information can be configured through the Graphical Display Editor (GDE).

### 3.20.15.6 Signals

*Table 231: HLTGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| TAG_ON_OFF | BOOLEAN | 0=False | Toggles the local tag on/off with each rising edge |

*Table 232: HLTGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| TAG_ON | BOOLEAN | Hotline tag active |
| TAG_OFF | BOOLEAN | Hotline tag is not active |

### 3.20.15.7 Settings

*Table 233: HLTGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Remote tag mode | 1=Untag Rem only<br>2=Untag Loc or Rem | | | 1=Untag Rem only | Deactivation mode for remotely set hotline tag |

### 3.20.15.8 Monitored data

*Table 234: HLTGAPC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TAG_SOURCE | Enum | 0=None<br>1=Local<br>2=Remote | | Source of active hotline tag |
| HLTGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 3.20.16 Voltage switch VMSWI

### 3.20.16.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Voltage switch | VMSWI | VSWI | VSWI |

### 3.20.16.2 Function block

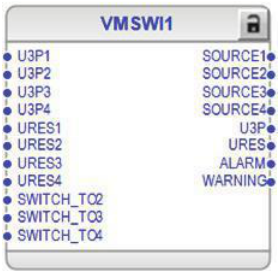



*Figure 131: Function block*

### 3.20.16.3 Functionality

The voltage switch function VMSWI performs the switching function between up to four voltage groups (Bus1, Bus 2, Bus 3 and Bus 4).

Residual voltage input can be optional and depends of the application configuration. The switching operation can also be associated with the residual voltage if available.

The calculated components U+, U- and $U_0$ and the calculated P2P / P2E (depending of the wye/delta mode) are switch-controlled as well.

### 3.20.16.4 Analog channel configuration

VMSWI has eight analog group inputs which must be properly configured.

*Table 235: Analog inputs*

| Input | Description |
|---|---|
| U3P1[1)] | Three-phase voltages |
| U3P2[1)] | Three-phase voltages |
| U3P3[1)] | Three-phase voltages |
| U3P4[1)] | Three-phase voltages |
| URES1[1)] | Residual voltage (measured or calculated) |
| URES2[1)] | Residual voltage (measured or calculated) |
| URES3[1)] | Residual voltage (measured or calculated) |
| URES4[1)] | Residual voltage (measured or calculated) |

1) Can be connected to GRPOFF

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

*Table 236: Special conditions*

| Condition | Description |
|---|---|
| U3P1/U3P2/U3P3/U3P4 connected to real measurements | The function requires that at least one voltage channel is connected. |
| URES1/URES2/URES3/URES4 calculated | The function requires that all three voltage channels are connected to calculate the residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

### 3.20.16.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

For this function, the setting is hidden and fixed to "on".

The switch logic depends on inputs SWITCH_TO2, SWITCH_TO3 and SWITCH_TO4. Source 1 is selected as default and switching is done on increased priority.

GRPOFF signal must be connected to unused voltage inputs. GRPOFF signal is available as output from the Protection function block.

*Table 237: Switching operation*

| Control input signals | | | Outputs | | | | | |
|---|---|---|---|---|---|---|---|---|
| SWITCH_TO2 | SWITCH_TO3 | SWITCH_TO4 | SOURCE1 | SOURCE2 | SOURCE3 | SOURCE4 | Source for U3P | Source for URES |
| FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | U3P1 | URES1 |
| TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | U3P2 | URES2 |
| x[1)] | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | U3P3 | URES3 |
| x[1)] | x[1)] | TRUE | FALSE | FALSE | FALSE | TRUE | U3P4 | URES4 |

1) No difference

If the numbers of channels connected to U3P1...U3P4 and URES1...URES4 does not match with the number of connected SWITCH_TOx inputs, the configuration of the function fails.

Outputs ALARM and URES_ALARM indicate bad quality data of system measurements for selected U3P and URES, respectively.

Outputs WARNING and URES_WARNING indicate questionable quality data of system measurements for selected U3P and URES, respectively.

Depending on the connected U3P channels to the voltage switch, the *Primary voltage* settings between the source U3P must match. Respectively, depending on the connected URES channels, the *Primary voltage* settings between the source URES must match. Setting validation for the primary voltages fails unless they are all stored simultaneously to the protection relay.

### 3.20.16.6 Signals

*Table 238: VMSWI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P1 | SIGNAL | - | Three-phase voltages 1 |
| U3P2 | SIGNAL | - | Three-phase voltages 2 |
| U3P3 | SIGNAL | - | Three-phase voltages 3 |
| U3P4 | SIGNAL | - | Three-phase voltages 4 |
| URES1 | SIGNAL | - | Residual voltage 1 |
| URES2 | SIGNAL | - | Residual voltage 2 |
| URES3 | SIGNAL | - | Residual voltage 3 |
| URES4 | SIGNAL | - | Residual voltage 4 |
| SWITCH_TO2 | BOOLEAN | 0=False | Switch to source 2 |
| SWITCH_TO3 | BOOLEAN | 0=False | Switch to source 3 |
| SWITCH_TO4 | BOOLEAN | 0=False | Switch to source 4 |

*Table 239: VMSWI Output signals*

| Name | Type | Description |
|---|---|---|
| SOURCE1 | BOOLEAN | Selected voltage source is source 1 |
| SOURCE2 | BOOLEAN | Selected voltage source is source 2 |
| SOURCE3 | BOOLEAN | Selected voltage source is source 3 |
| SOURCE4 | BOOLEAN | Selected voltage source is source 4 |
| U3P | SIGNAL | Three-phase voltages |
| URES | SIGNAL | Residual voltage |
| ALARM | BOOLEAN | Alarm |
| WARNING | BOOLEAN | Warning |

### 3.20.16.7 Monitored data

*Table 240: VMSWI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SWITCH_POS | Enum | 1=Source 1<br>2=Source 2<br>3=Source 3<br>4=Source 4 | | Switch position |

## 3.20.17 Current switch CMSWI

### 3.20.17.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current switch | CMSWI | CMSWI | CMSWI |

### 3.20.17.2 Function block

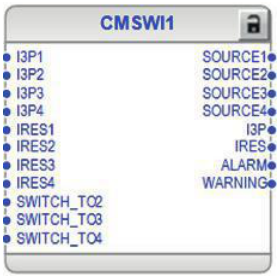



*Figure 132: Function block*

### 3.20.17.3 Functionality

The current switch function CMSWI performs the switching function between up to four voltage groups (Bus1, Bus 2, Bus 3 and Bus 4). The residual current input is optional and depends of the application configuration. Switching operation can also be associated with the residual current if this is available.

### 3.20.17.4 Analog channel configuration

CMSWI has eight analog group inputs which must be properly configured.

*Table 241: Analog inputs*

| Input | Description |
|---|---|
| I3P1[1)] | Three-phase currents |
| I3P2[1)] | Three-phase currents |
| I3P3[1)] | Three-phase currents |
| I3P4[1)] | Three-phase currents |
| IRES1[1)] | Residual current (measured or calculated) |
| IRES2[1)] | Residual current (measured or calculated) |
| IRES3[1)] | Residual current (measured or calculated) |
| IRES4[1)] | Residual current (measured or calculated) |

1) Can be connected to GRPOFF

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

### 3.20.17.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

For this function, the setting is hidden and fixed to "on".

The switch logic depends on inputs SWITCH_TO2, SWITCH_TO3 and SWITCH_TO4. Source 1 is selected as default and switching is done on increased priority.

GRPOFF signal must be connected to unused current inputs. GRPOFF signal is available as output from the Protection function block.

*Table 242: Switching operation*

| Control input signals | | | Outputs | | | | | |
|---|---|---|---|---|---|---|---|---|
| SWITCH_TO2 | SWITCH_TO3 | SWITCH_TO4 | SOURCE1 | SOURCE2 | SOURCE3 | SOURCE4 | Source for I3P | Source for IRES |
| FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | I3P1 | IRES1 |
| TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | I3P2 | IRES2 |
| x[1)] | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | I3P3 | IRES3 |
| x[1)] | x[1)] | TRUE | FALSE | FALSE | FALSE | TRUE | I3P4 | IRES4 |

1) No difference

If the numbers of channels connected to I3P1...I3P4 and IRES1...IRES4 does not match with the number of connected SWITCH_TOx inputs, the configuration of the function fails.

Outputs ALARM and IRES_ALARM indicate bad quality data of system measurements for selected I3P and IRES, respectively.

Outputs WARNING and IRES_WARNING indicate questionable quality data of system measurements for selected I3P and IRES, respectively.

Depending on the connected I3P channels to the current switch, the *Primary current* settings between the source I3P must match. Depending on the connected IRES channels, the *Primary current* settings between the source IRES must match.
Setting validation for the primary current fails unless they are all stored simultaneously to the protection relay.

### 3.20.17.6 Signals

*Table 243: CMSWI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| I3P3 | SIGNAL | - | Three-phase currents 3 |
| I3P4 | SIGNAL | - | Three-phase currents 4 |
| IRES1 | SIGNAL | - | Residual current 1 |
| IRES2 | SIGNAL | - | Residual current 2 |
| IRES3 | SIGNAL | - | Residual current 3 |
| IRES4 | SIGNAL | - | Residual current 4 |
| SWITCH_TO2 | BOOLEAN | 0=False | Switch to source 2 |
| SWITCH_TO3 | BOOLEAN | 0=False | Switch to source 3 |
| SWITCH_TO4 | BOOLEAN | 0=False | Switch to source 4 |

*Table 244: CMSWI Output signals*

| Name | Type | Description |
|---|---|---|
| SOURCE1 | BOOLEAN | Selected current source is source 1 |
| SOURCE2 | BOOLEAN | Selected current source is source 2 |
| SOURCE3 | BOOLEAN | Selected current source is source 3 |
| SOURCE4 | BOOLEAN | Selected current source is source 4 |
| I3P | SIGNAL | Three-phase currents |

Table continues on next page

| Name | Type | Description |
|---|---|---|
| IRES | SIGNAL | Residual current |
| ALARM | BOOLEAN | Alarm |
| WARNING | BOOLEAN | Warning |

### 3.20.17.7 Monitored data

*Table 245: CMSWI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SWITCH_POS | Enum | 1=Source 1<br>2=Source 2<br>3=Source 3<br>4=Source 4 | | Switch position |

## 3.20.18 Generic up-down counter UDFCNT

### 3.20.18.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Generic up-down counter | UDFCNT | UDCNT | UDCNT |

### 3.20.18.2 Function block

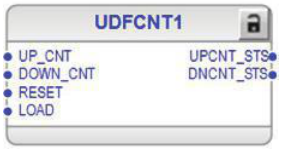



*Figure 133: Function block*

### 3.20.18.3 Functionality

The Generic up-down counter function UDFCNT counts up or down for each positive edge of the corresponding inputs. The counter value output can be reset to zero or preset to some other value if required.

The function provides up-count and down-count status outputs, which specify the relation of the counter value to a loaded preset value and to zero respectively.

### 3.20.18.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of UDFCNT can be described with a module diagram. All the modules in the diagram are explained in the next sections.

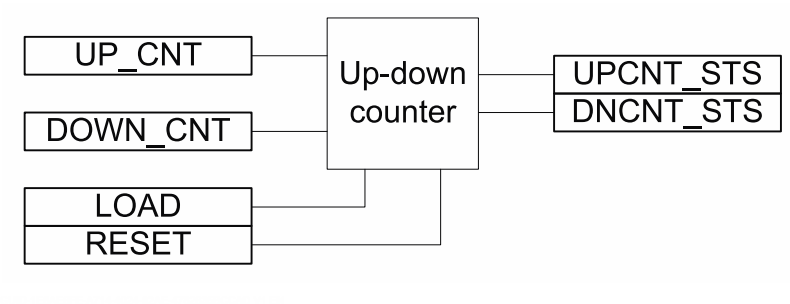



*Figure 134: Functional module diagram*

### Up-down counter

Each rising edge of the UP_CNT input increments the counter value CNT_VAL by one and each rising edge of the DOWN_CNT input decrements the CNT_VAL by one. If there is a rising edge at both the inputs UP_CNT and DOWN_CNT, the counter value CNT_VAL is unchanged. The CNT_VAL is available in the monitored data view.

The counter value CNT_VAL is stored in a nonvolatile memory. The range of the counter is 0...+2147483647. The count of CNT_VAL saturates at the final value of 2147483647, that is, no further increment is possible.

The value of the setting *Counter load value* is loaded into counter value CNT_VAL either when the LOAD input is set to "True" or when the *Load Counter* is set to "Load" in the LHMI. Until the LOAD input is "True", it prevents all further counting.

The function also provides status outputs UPCNT_STS and DNCNT_STS. The UPCNT_STS is set to "True" when the CNT_VAL is greater than or equal to the setting *Counter load value*. DNCNT_STS is set to "True" when the CNT_VAL is zero.

The RESET input is used for resetting the function. When this input is set to "True" or when *Reset counter* is set to "reset", the CNT_VAL is forced to zero.

## 3.20.18.5 Signals

*Table 246: UDFCNT Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| UP_CNT | BOOLEAN | 0=False | Input for up counting |
| DOWN_CNT | BOOLEAN | 0=False | Input for down counting |
| RESET | BOOLEAN | 0=False | Reset input for counter |
| LOAD | BOOLEAN | 0=False | Load input for counter |

*Table 247: UDFCNT Output signals*

| Name | Type | Description |
|---|---|---|
| UPCNT_STS | BOOLEAN | Status of the up counting |
| DNCNT_STS | BOOLEAN | Status of the down counting |

### 3.20.18.6 Settings

*Table 248: UDFCNT Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Counter load value | 0...2147483647 | | 1 | 10000 | Preset counter value |
| Reset counter | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets counter value |
| Load counter | 0=Cancel<br>1=Load | | | 0=Cancel | Loads the counter to preset value |

### 3.20.18.7 Monitored data

*Table 249: UDFCNT Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| CNT_VAL | INT64 | 0...2147483647 | | Output counter value |

## 3.20.19 Current sum CMSUM

### 3.20.19.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current sum | CMSUM | CSUM | CSUM |

### 3.20.19.2 Function block

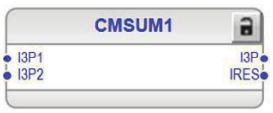



*Figure 135: Function block*

### 3.20.19.3 Functionality

The current sum function CMSUM is a phase-by-phase specific summing function for two current triplets. Output `I3P` can be used as normal current input for the application functions using current. Different measurement modes (DFT, RMS, Peak-to-peak) are supported. Also, positive, negative and zero-sequence components are calculated for the summed currents. Output `IRES` provides the calculated residual current based on the summed currents.

Example configuration:

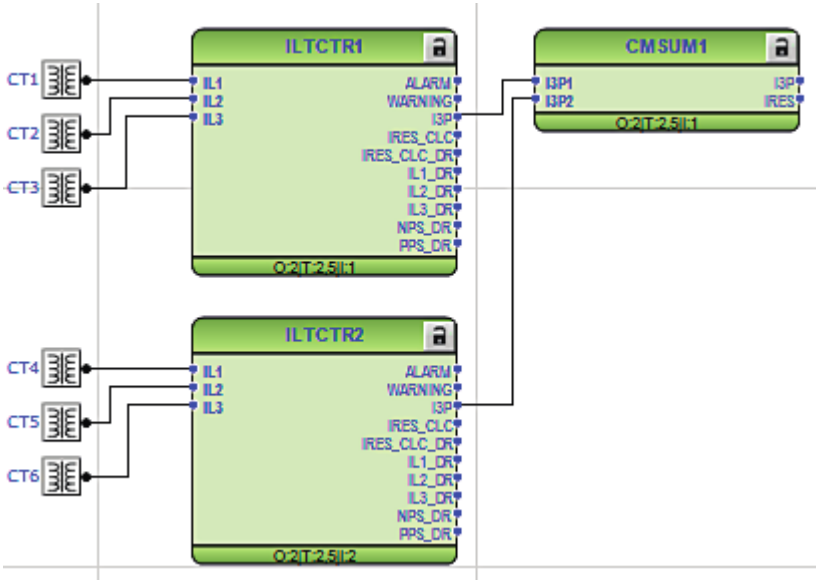



*Figure 136: Current summing configuration*

### 3.20.19.4 Analog channel configuration

CMSUM has two analog group inputs which must be properly configured.

*Table 250: Analog signals*

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

### 3.20.19.5 Signals

*Table 251: CMSUM Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |

*Table 252: CMSUM Output signals*

| Name | Type | Description |
|---|---|---|
| I3P | SIGNAL | Summed three-phase currents |
| IRES | SIGNAL | Calculated residual current of summed three-phase currents |

## 3.20.20 Transformer data combiner OLGAPC

### 3.20.20.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Transformer data combiner | OLGAPC | OLGAPC | OLGAPC |

### 3.20.20.2 Function block




*Figure 137: Function block*

### 3.20.20.3 Functionality

The transformer data combiner function OLGAPC is intended for the voltage regulator function OL5ATCC.

### 3.20.20.4 Operation principle

The function of OLGAPC is to collect data from a parallel transformer via GOOSE communication. The `TR_DAT` output, which contains the combined input data, is connected to the OL5ATCC function block.

### 3.20.20.5 Application

See the application example in Figure 138.

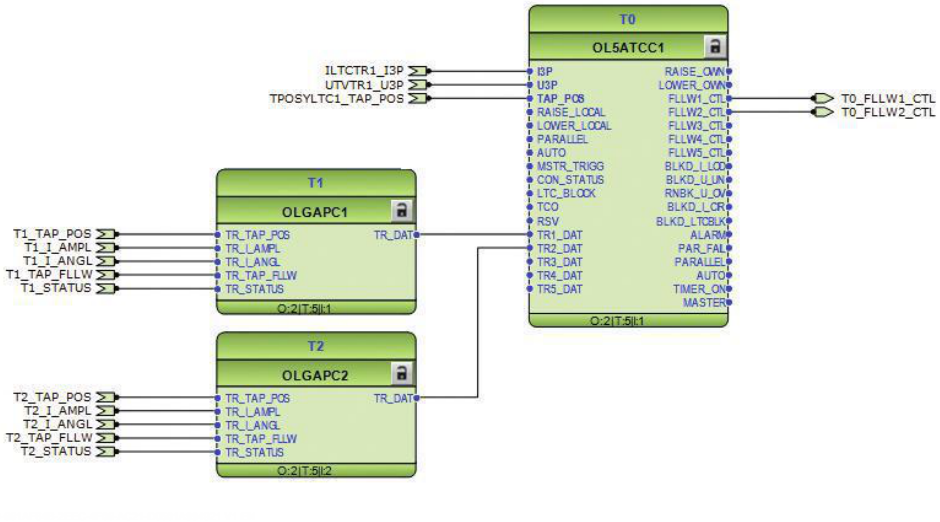



*Figure 138: Application example*

### 3.20.20.6 Signals

*Table 253: OLGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| TR_TAP_POS | INT32 | 0 | Integer value representing tap changer position of transformer |
| TR_I_AMPL | FLOAT32 | 0.00 | Received current magnitude from transformer |
| TR_I_ANGL | FLOAT32 | 0.00 | Received current angle from transformer |
| TR_STATUS | Enum | 0=Independent | Transformer status information |

*Table 254: OLGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| TR_DAT | INT8_TRDAT | Analog output |

## 3.20.21 Controllable gate, 8 channels GATEGAPC

### 3.20.21.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Controllable gate, 8 channels | GATEGAPC | GATEGAPC | GATEGAPC |

### 3.20.21.2 Function block

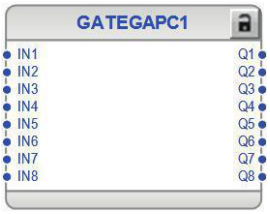



*Figure 139: Function block*

### 3.20.21.3 Functionality

Controllable gate function GATEGAPC can pass each input IN1...IN8 to output Q1...Q8 depending on the related setting *Connect INx to Qx*. Additionally, each output Qx can be named with *Description* setting.

### 3.20.21.4 Signals

*Table 255: GATEGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0 | IN1 status |
| IN2 | BOOLEAN | 0 | IN2 status |
| IN3 | BOOLEAN | 0 | IN3 status |
| IN4 | BOOLEAN | 0 | IN4 status |
| IN5 | BOOLEAN | 0 | IN5 status |
| IN6 | BOOLEAN | 0 | IN6 status |
| IN7 | BOOLEAN | 0 | IN7 status |
| IN8 | BOOLEAN | 0 | IN8 status |

*Table 256: GATEGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Q1 status |
| Q2 | BOOLEAN | Q2 status |
| Q3 | BOOLEAN | Q3 status |
| Q4 | BOOLEAN | Q4 status |
| Q5 | BOOLEAN | Q5 status |
| Q6 | BOOLEAN | Q6 status |
| Q7 | BOOLEAN | Q7 status |
| Q8 | BOOLEAN | Q8 status |

### 3.20.21.5 Settings

*Table 257: GATEGAPC Settings*

| Parameter | Values | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Connect IN1 to Q1 | 1=On<br>0=Off | | | 0=Off | IN1 to Q1 connection |
| Description | GATEGAPC1 Q1 | | | | Output description |
| Connect IN2 to Q2 | 1=On<br>0=Off | | | 0=Off | IN2 to Q2 connection |
| Description | GATEGAPC1 Q2 | | | | Output description |
| Connect IN3 to Q3 | 1=On<br>0=Off | | | 0=Off | IN3 to Q3 connection |
| Description | GATEGAPC1 Q3 | | | | Output description |
| Connect IN4 to Q4 | 1=On<br>0=Off | | | 0=Off | IN4 to Q4 connection |
| Description | GATEGAPC1 Q4 | | | | Output description |
| Connect IN5 to Q5 | 1=On<br>0=Off | | | 0=Off | IN5 to Q5 connection |
| Description | GATEGAPC1 Q5 | | | | Output description |
| Connect IN6 to Q6 | 1=On<br>0=Off | | | 0=Off | IN6 to Q6 connection |
| Description | GATEGAPC1 Q6 | | | | Output description |
| Connect IN7 to Q7 | 1=On<br>0=Off | | | 0=Off | IN7 to Q7 connection |
| Description | GATEGAPC1 Q7 | | | | Output description |
| Connect IN8 to Q8 | 1=On<br>0=Off | | | 0=Off | IN8 to Q8 connection |
| Description | GATEGAPC1 Q8 | | | | Output description |

# 3.21 Standard logic operators

## 3.21.1 OR gate with two inputs OR, six inputs OR6 and twenty inputs OR20

### 3.21.1.1 Function block

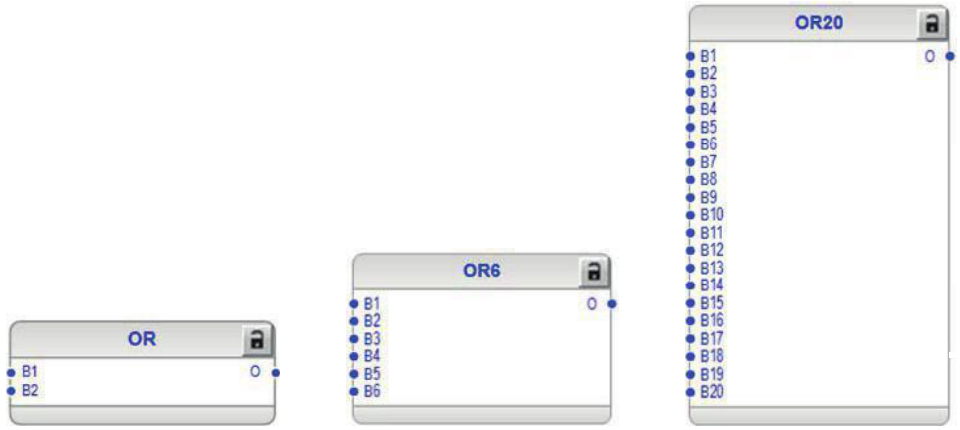



*Figure 140: Function blocks*

### 3.21.1.2 Functionality

OR, OR6 and OR20 are used to form general combinatory expressions with boolean variables.

The O output is activated when at least one input has the value TRUE. The default value of all inputs is FALSE, which makes it possible to use only the required number of inputs and leave the rest disconnected.

OR has two inputs, OR6 six and OR20 twenty inputs.

### 3.21.1.3 Signals

*Table 258: OR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 0 | Input signal 1 |
| B2 | BOOLEAN | 0 | Input signal 2 |

*Table 259: OR6 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 0 | Input signal 1 |
| B2 | BOOLEAN | 0 | Input signal 2 |
| B3 | BOOLEAN | 0 | Input signal 3 |
| B4 | BOOLEAN | 0 | Input signal 4 |
| B5 | BOOLEAN | 0 | Input signal 5 |
| B6 | BOOLEAN | 0 | Input signal 6 |

*Table 260: Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 0 | Input signal 1 |
| B2 | BOOLEAN | 0 | Input signal 2 |
| B3 | BOOLEAN | 0 | Input signal 3 |
| B4 | BOOLEAN | 0 | Input signal 4 |
| B5 | BOOLEAN | 0 | Input signal 5 |
| B6 | BOOLEAN | 0 | Input signal 6 |
| B7 | BOOLEAN | 0 | Input signal 7 |
| B8 | BOOLEAN | 0 | Input signal 8 |
| B9 | BOOLEAN | 0 | Input signal 9 |
| B10 | BOOLEAN | 0 | Input signal 10 |
| B11 | BOOLEAN | 0 | Input signal 11 |
| B12 | BOOLEAN | 0 | Input signal 12 |
| B13 | BOOLEAN | 0 | Input signal 13 |
| B14 | BOOLEAN | 0 | Input signal 14 |
| B15 | BOOLEAN | 0 | Input signal 15 |
| B16 | BOOLEAN | 0 | Input signal 16 |
| B17 | BOOLEAN | 0 | Input signal 17 |
| B18 | BOOLEAN | 0 | Input signal 18 |
| B19 | BOOLEAN | 0 | Input signal 19 |
| B20 | BOOLEAN | 0 | Input signal 20 |

*Table 261: OR Output signals*

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

*Table 262: OR6 Output signals*

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

*Table 263: OR20 Output signals*

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

### 3.21.1.4 Settings

The function does not have any parameters available in the LHMI or in PCM600.

## 3.21.2 AND gate with two inputs AND, six inputs AND6 and twenty inputs AND20

### 3.21.2.1 Function block

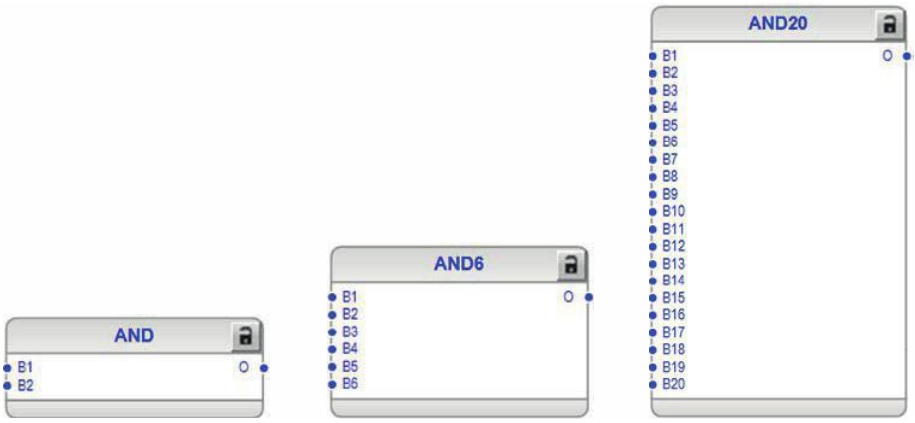



*Figure 141: Function blocks*

### 3.21.2.2 Functionality

AND, AND6 and AND20 are used to form general combinatory expressions with boolean variables.

The default value in all inputs is logical TRUE, which makes it possible to use only the required number of inputs and leave the rest disconnected.

AND has two inputs, AND6 six inputs and AND20 twenty inputs.

### 3.21.2.3 Signals

*Table 264: AND Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 1 | Input signal 1 |
| B2 | BOOLEAN | 1 | Input signal 2 |

*Table 265: AND6 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 1 | Input signal 1 |
| B2 | BOOLEAN | 1 | Input signal 2 |
| B3 | BOOLEAN | 1 | Input signal 3 |
| B4 | BOOLEAN | 1 | Input signal 4 |
| B5 | BOOLEAN | 1 | Input signal 5 |
| B6 | BOOLEAN | 1 | Input signal 6 |

*Table 266: AND20 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 0 | Input signal 1 |
| B2 | BOOLEAN | 0 | Input signal 2 |
| B3 | BOOLEAN | 0 | Input signal 3 |
| B4 | BOOLEAN | 0 | Input signal 4 |
| B5 | BOOLEAN | 0 | Input signal 5 |
| B6 | BOOLEAN | 0 | Input signal 6 |
| B7 | BOOLEAN | 0 | Input signal 7 |
| B8 | BOOLEAN | 0 | Input signal 8 |
| B9 | BOOLEAN | 0 | Input signal 9 |
| B10 | BOOLEAN | 0 | Input signal 10 |
| B11 | BOOLEAN | 0 | Input signal 11 |
| B12 | BOOLEAN | 0 | Input signal 12 |
| B13 | BOOLEAN | 0 | Input signal 13 |
| B14 | BOOLEAN | 0 | Input signal 14 |
| B15 | BOOLEAN | 0 | Input signal 15 |
| B16 | BOOLEAN | 0 | Input signal 16 |
| B17 | BOOLEAN | 0 | Input signal 17 |
| B18 | BOOLEAN | 0 | Input signal 18 |
| B19 | BOOLEAN | 0 | Input signal 19 |
| B20 | BOOLEAN | 0 | Input signal 20 |

*Table 267: AND Output signals*

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

*Table 268: AND6 Output signals*

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

*Table 269: AND20 output signals*

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

### 3.21.2.4 Settings

The function does not have any parameters available in the LHMI or in PCM600.

## 3.21.3 XOR gate with two inputs XOR

### 3.21.3.1 Function block




*Figure 142: Function block*

### 3.21.3.2 Functionality

The exclusive OR function XOR is used to generate combinatory expressions with boolean variables.

The output signal is TRUE if the input signals are different and FALSE if they are equal.

### 3.21.3.3 Signals

*Table 270: XOR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 0 | Input signal 1 |
| B2 | BOOLEAN | 0 | Input signal 2 |

*Table 271: XOR Output signal*

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

### 3.21.3.4 Settings

The function does not have any parameters available in the LHMI or in PCM600.

## 3.21.4 NOT gate NOT

### 3.21.4.1 Function block

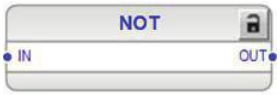



*Figure 143: Function block*

### 3.21.4.2 Functionality

NOT is used to generate combinatory expressions with boolean variables.

NOT inverts the input signal.

### 3.21.4.3 Signals

*Table 272: NOT Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I | BOOLEAN | 0 | Input signal |

*Table 273: NOT Output signal*

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

### 3.21.4.4 Settings

The function does not have any parameters available in the LHMI or in PCM600.

## 3.21.5 Rising edge detector R_TRIG

### 3.21.5.1 Function block




*Figure 144: Function block*

### 3.21.5.2 Functionality

R_TRIG is used as a rising edge detector.

R_TRIG detects the transition from FALSE to TRUE at the CLK input. When the rising edge is detected, the element assigns the output to TRUE. At the next execution round, the output is returned to FALSE despite the state of the input.

### 3.21.5.3 Signals

*Table 274: R_TRIG Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| CLK | BOOLEAN | 0 | Input signal |

*Table 275: R_TRIG Output signals*

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Output signal |

### 3.21.5.4 Settings

The function does not have any parameters available in the LHMI or in PCM600.

## 3.21.6 Falling edge detector F_TRIG

### 3.21.6.1 Function block




*Figure 145: Function block*

### 3.21.6.2 Functionality

F_TRIG is used as a falling edge detector.

The function detects the transition from TRUE to FALSE at the CLK input. When the falling edge is detected, the element assigns the Q output to TRUE. At the next execution round, the output is returned to FALSE despite the state of the input.

### 3.21.6.3 Signals

*Table 276: F_TRIG Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| CLK | BOOLEAN | 0 | Input signal |

*Table 277: F_TRIG Output signals*

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Output signal |

### 3.21.6.4 Settings

The function does not have any parameters available in the LHMI or in PCM600.

## 3.21.7 Switching device status decoder CLOSE position T_POS_CL, OPEN position T_POS_OP and OK status T_POS_OK

### 3.21.7.1 Function block




*Figure 146: Function blocks*

### 3.21.7.2 Functionality

The circuit breaker position information can be communicated with the IEC 61850 GOOSE messages. The position information is a double binary data type which is fed to the POS input.

T_POS_CL and T_POS_OP are used for extracting the circuit breaker status information. Respectively, T_POS_OK is used to validate the intermediate or faulty breaker position.

*Table 278: Cross reference between circuit breaker position and function block output*

| Circuit breaker position | Output of the function block | | |
|---|---|---|---|
| | T_POS_CL | T_POS_OP | T_POS_OK |
| Intermediate '00' | FALSE | FALSE | FALSE |
| Close '01' | TRUE | FALSE | TRUE |
| Open '10' | FALSE | TRUE | TRUE |
| Faulty '11' | TRUE | TRUE | FALSE |

### 3.21.7.3 Signals

*Table 279: T_POS_CL Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| POS | Double binary | 0 | Input signal |

*Table 280: T_POS_OP Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| POS | Double binary | 0 | Input signal |

*Table 281: T_POS_OK Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| POS | Double binary | 0 | Input signal |

*Table 282: T_POS_CL Output signals*

| Name | Type | Description |
|---|---|---|
| CLOSE | BOOLEAN | Output signal |

*Table 283: T_POS_OP Output signals*

| Name | Type | Description |
|---|---|---|
| OPEN | BOOLEAN | Output signal |

*Table 284: T_POS_OK Output signals*

| Name | Type | Description |
|---|---|---|
| OK | BOOLEAN | Output signal |

### 3.21.7.4 Settings

The function does not have any parameters available in the LHMI or in PCM600.

## 3.21.8 SR flip-flop, volatile SR

### 3.21.8.1 Function block




*Figure 147: Function block*

### 3.21.8.2 Functionality

The SR flip-flop output Q can be set or reset from the S or R inputs. S input has a higher priority over the R input. Output NOTQ is the negation of output Q.

The statuses of outputs Q and NOTQ are not retained in the nonvolatile memory.

*Table 285: Truth table for SR flip-flop*

| S | R | Q |
|---|---|---|
| 0 | 0 | 0[1)] |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

1) Keep state/no change

### 3.21.8.3 Signals

*Table 286: SR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| S | BOOLEAN | 0=False | Set Q output when set |
| R | BOOLEAN | 0=False | Resets Q output when set |

*Table 287: SR Output signals*

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Q status |
| NOTQ | BOOLEAN | NOTQ status |

## 3.21.9 RS flip-flop, volatile RS

### 3.21.9.1 Function block




*Figure 148: Function block*

### 3.21.9.2 Functionality

The RS flip-flop output Q can be set or reset from the S or R inputs. R input has a higher priority over the S input. Output NOTQ is the negation of output Q.

The statuses of outputs Q and NOTQ are not retained in the nonvolatile memory.

*Table 288: Truth table for RS flip-flop*

| S | R | Q |
|---|---|---|
| 0 | 0 | 0[1)] |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

1) Keep state/no change

### 3.21.9.3 Signals

*Table 289: RS Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| S | BOOLEAN | 0=False | Set Q output when set |
| R | BOOLEAN | 0=False | Resets Q output when set |

*Table 290: RS Output signals*

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Q status |
| NOTQ | BOOLEAN | NOTQ status |

# 3.22 Mathematical operators

## 3.22.1 Real addition ADDR

### 3.22.1.1 Function block




*Figure 149: Function block*

### 3.22.1.2 Functionality

The real addition function ADDR adds the inputs REAL_IN1 and REAL_IN2 together. ADDR executes the equation

REAL_OUT = REAL_IN1 + REAL_IN2

If the value of the sum is outside the range, then the output quality is set as bad and VALID is set to FALSE. The minimum negative sum value is restricted to -2097152.000 and the maximum positive sum value is restricted to 2097152.000.

### 3.22.1.3 Signals

*Table 291: ADDR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |

*Table 292: ADDR Output signals*

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output 1 |
| VALID | BOOLEAN | Output validity |

## 3.22.2 Real division DIVR

### 3.22.2.1 Function block




*Figure 150: Function block*

### 3.22.2.2 Functionality

The real division function DIVR divides the REAL_IN1 input by REAL_IN2. DIVR executes the equation

$$REAL_OUT = \frac{REAL_IN1}{REAL_IN2}$$

(Equation 7)

If the denominator value is less than ≅ 0.001, the resultant quotient is considered out of range.

If the value of the quotient is outside the range, then the output quality is set as bad and VALID is set to FALSE. The minimum negative quotient value is restricted to -2097152.000 and the maximum positive quotient value is restricted to 2097152.000.

### 3.22.2.3 Signals

*Table 293: DIVR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |

*Table 294: DIVR Output signals*

| Name | Type | Description |
|---|---|---|
| REAL_OUT | IN1 | Real output |
| VALID | BOOLEAN | Output validity |

## 3.22.3 Real multiplication MULR

### 3.22.3.1 Function block




*Figure 151: Function block*

### 3.22.3.2 Functionality

The real multiplication function MULR multiplies the real input REAL_IN1 by the real input REAL_IN2. MULR executes the equation

$$REAL_OUT = REAL_IN1 \cdot REAL_IN2$$

If the value of the product is outside the range, then the output quality is set as bad and VALID is set to FALSE. The minimum negative product value is restricted to -2097152.000 and the maximum positive product value is restricted to 2097152.000.

### 3.22.3.3 Signals

*Table 295: MULR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |

*Table 296: MULR Output signals*

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output |
| VALID | BOOLEAN | Output validity |

## 3.22.4 Real subtraction SUBR

### 3.22.4.1 Function block




*Figure 152: Function block*

### 3.22.4.2 Functionality

The real subtraction function SUBR subtracts input REAL_IN2 from REAL_IN1. SUBR executes the equation

REAL_OUT = REAL_IN1 - REAL_IN2

If the value of the difference is outside the range, then the output quality is set as bad and VALID is set to FALSE. The minimum negative difference value is restricted to -2097152.000 and the maximum positive difference value is restricted to 2097152.000.

### 3.22.4.3 Signals

*Table 297: SUBR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |

*Table 298: SUBR Output signals*

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output |
| VALID | BOOLEAN | Output validity |

## 3.22.5 Real equal comparator EQR

### 3.22.5.1 Function block




*Figure 153: Function block*

### 3.22.5.2 Functionality

The real equal comparator function EQR compares the real input REAL_IN1 with the real input REAL_IN2 and activates the binary output OUT if REAL_IN1 is within the region of REAL_IN2 + TOLR and REAL_IN2 - TOLR, that is, if REAL_IN1≥ (REAL_IN2 - TOLR) and REAL_IN1≤ (REAL_IN2 + TOLR), OUT = 1, else OUT = 0.

If inputs REAL_IN1 or REAL_IN2 are outside the range, then OUT is set to 0.

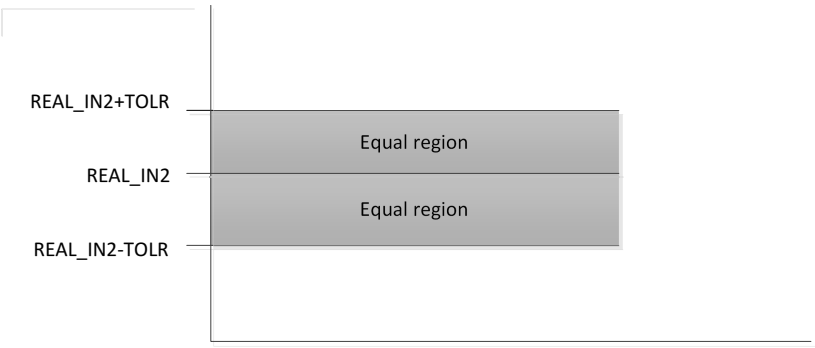



*Figure 154: Region of EQR comparison*

EQR requires a positive value for TOLR, otherwise it may not function properly. The TOLR value can be set using SETRGAPC.

EQR function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have closely varying values.

### 3.22.5.3 Signals

*Table 299: EQR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |
| TOLR | FLOAT32 | 0 | Tolerance for comparison |

*Table 300: EQR Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output value |

## 3.22.6 Real not equal comparator NER

### 3.22.6.1 Function block




*Figure 155: Function block*

### 3.22.6.2 Functionality

The real not equal comparator function NER compares the real input REAL_IN1 with the real input REAL_IN2 and activates the binary output OUT if REAL_IN1 is outside the region of REAL_INT2 + TOLR and REAL_IN2 - TOLR. That is, if REAL_IN1< (REAL_IN2 - TOLR) or REAL_IN1 > (REAL_IN2 + TOLR), OUT = 1, else OUT = 0.

If inputs REAL_IN1 or REAL_IN2 are outside the range, then OUT is set to 0.

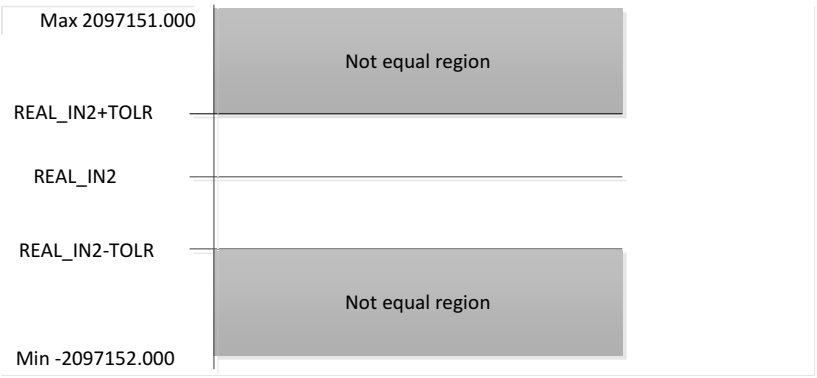



*Figure 156: Region of NER comparison*

NER requires a positive value for TOLR, otherwise it may not function properly. The TOLR value can be set using SETRGAPC.

NER function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have closely varying values.

### 3.22.6.3 Signals

*Table 301: NER Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |
| TOLR | FLOAT32 | 0 | Tolerance for comparison |

*Table 302: NER Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output value |

## 3.22.7 Real greater than or equal comparator GER

### 3.22.7.1 Function block




*Figure 157: Function block*

### 3.22.7.2 Functionality

The real greater than or equal comparator function GER compares the real input REAL_IN1 with the real input REAL_IN2 and activates the binary output OUT if REAL_IN1 is equal to or greater than REAL_IN2 - TOLR or greater than input REAL_IN2. That is, if REAL_IN1≥ (REAL_IN2 - TOLR) or REAL_IN1 > (REAL_IN2), OUT = 1, else OUT = 0.

If input REAL_IN1 or REAL_IN2 is outside the range, then OUT is set to 0.

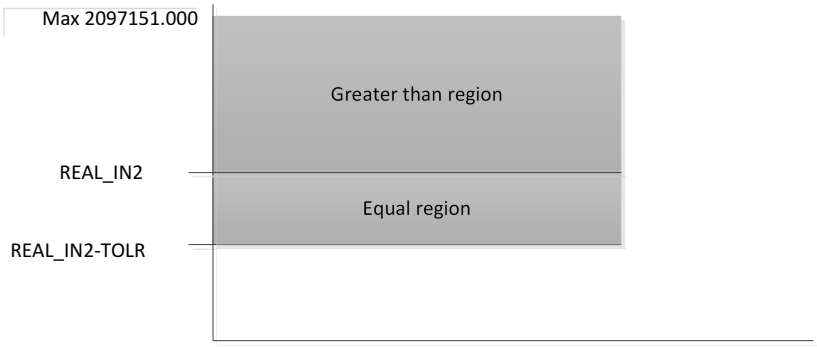



*Figure 158: Region of GER comparison*

GER function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have closely varying values.

### 3.22.7.3 Signals

*Table 303: GER Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |
| TOLR | FLOAT32 | 0 | Tolerance for comparison |

*Table 304: GER Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output value |

## 3.22.8 Real less than or equal comparator LER

### 3.22.8.1 Function block




*Figure 159: Function block*

### 3.22.8.2 Functionality

The real less than or equal comparator function LER compares real input REAL_IN1 with real input REAL_IN2 and activates binary output OUT if REAL_IN1 is equal to or less than REAL_IN2 + TOLR or less than REAL_IN2 input. That is, if REAL_IN1≤ (REAL_IN2 + TOLR) or REAL_IN1 < (REAL_IN2), OUT = 1, else OUT = 0.

LER function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have closely varying values.

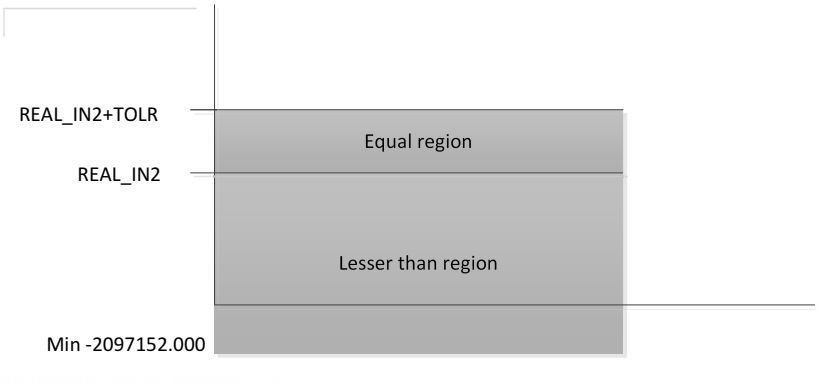



*Figure 160: Region of LER comparison*

### 3.22.8.3 Signals

*Table 305: LER Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |
| TOLR | FLOAT32 | 0 | Tolerance for comparison |

*Table 306: LER Output signals*

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output value |

## 3.22.9 Real maximum value selector MAX3R

### 3.22.9.1 Function block

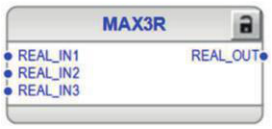



*Figure 161: Function block*

### 3.22.9.2 Functionality

The real maximum value selector function MAX3R selects the maximum value from three analog values. Disconnected inputs and inputs whose quality is bad are ignored. If all inputs are disconnected or the quality is bad, MAX3R output value is set to $-2^{21}$.

### 3.22.9.3 Signals

*Table 307: MAX3R Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input value 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input value 2 |
| REAL_IN3 | FLOAT32 | 0 | Real input value 3 |

*Table 308: MAX3R Output signals*

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output value |

## 3.22.10 Real minimum value selector MIN3R

### 3.22.10.1 Function block




*Figure 162: Function block*

### 3.22.10.2 Functionality

The real minimum value selector function MIN3R selects the minimum value from three analog values. Disconnected inputs and inputs whose quality is bad are ignored. If all inputs are disconnected or the quality is bad, MIN3R output value is set to $2^{21}$.

### 3.22.10.3 Signals

*Table 309: MIN3R Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input value 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input value 2 |
| REAL_IN3 | FLOAT32 | 0 | Real input value 3 |

*Table 310: MIN3R Output signals*

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output value |

# 3.22.11 Real switch selector SWITCHR

## 3.22.11.1 Function block




*Figure 163: Function block*

## 3.22.11.2 Functionality

The real switch selector function SWITCHR is operated by the CTL_SW input and selects the output value REAL_OUT between the REAL_IN1 and REAL_IN2 inputs.

*Table 311: SWITCHR*

| CTL_SW value | REAL_OUT value |
|---|---|
| TRUE (1) | REAL_IN1 |
| FALSE (0) | REAL_IN2 |

## 3.22.11.3 Signals

*Table 312: SWITCHR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| CTL_SW | BOOLEAN | 0 | Control Switch |
| REAL_IN1 | FLOAT32 | 0 | Real input value 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input value 2 |

*Table 313: SWITCHR Output signals*

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real switch output |

## 3.22.12 Integer 32-bit switch selector SWITCHI32

### 3.22.12.1 Function block




*Figure 164: Function block*

### 3.22.12.2 Functionality

The integer 32-bit switch selector function SWITCHI32 is operated by the CTL_SW input, which selects the output value INT32_OUT between the INT32_IN1 and INT32_IN2 inputs.

*Table 314: SWITCHI32*

| CTL_SW value | INT_OUT value |
|---|---|
| TRUE (1) | INT32_IN1 |
| FALSE (0) | INT32_IN2 |

### 3.22.12.3 Signals

*Table 315: SWITCHI32 Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| CTL_SW | BOOLEAN | 0 | Control Switch |
| INT_IN1 | INT32 | 0 | Integer input value 1 |
| INT_IN2 | INT32 | 0 | Integer input value 2 |

*Table 316: SWITCHI32 Output signals*

| Name | Type | Description |
|---|---|---|
| INT_OUT | INT32 | Integer switch output |

# 3.23 Factory settings restoration

In case of configuration data loss or any other file system error that prevents the protection relay from working properly, the whole file system can be restored to the original factory state. All default settings and configuration files stored in the factory are restored. For further information on restoring factory settings, see the operation manual.

# 3.24 Load profile LDPRLRC

## 3.24.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Load profile recorder | LDPRLRC | LOADPROF | LOADPROF |

## 3.24.2 Function block

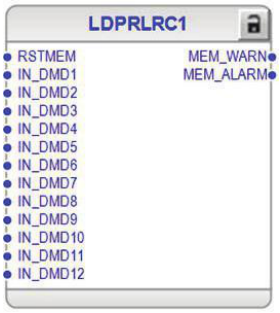



*Figure 165: Function block*

## 3.24.3 Functionality

The protection relay is provided with a load profile recorder. The load profile feature stores the historical load data captured at a periodical time interval (demand interval). Up to 12 load quantities can be selected for recording and storing in a nonvolatile memory. The value range for the recorded load quantities is about eight times the nominal value, and values larger than that saturate. The recording time depends on a settable demand interval parameter and the amount of quantities selected. The record output is in the COMTRADE format.

### 3.24.3.1 Quantities

Selectable quantities are product-dependent.

If the data source for the selected quantity is removed, for example, with Application Configuration in PCM600, the load profile recorder stops recording it and the previously collected data are cleared.

### 3.24.3.2 Length of record

The recording capability is about 7.4 years when one quantity is recorded and the demand interval is set to 180 minutes. The recording time scales down proportionally when a shorter demand time is selected or more quantities are recorded. When the recording buffer is fully occupied, the oldest data are overwritten by the newest data.

*Table 317: Recording capability in days with different settings*

| | Demand interval | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 minute | 5 minutes | 10 minutes | 15 minutes | 30 minutes | 60 minutes | 180 minutes |
| **Amount of quantities** | **Recording capability in days** | | | | | | |
| 1 | 15.2 | 75.8 | 151.6 | 227.4 | 454.9 | 909.7 | 2729.2 |
| 2 | 11.4 | 56.9 | 113.7 | 170.6 | 341.1 | 682.3 | 2046.9 |
| 3 | 9.1 | 45.5 | 91.0 | 136.5 | 272.9 | 545.8 | 1637.5 |
| 4 | 7.6 | 37.9 | 75.8 | 113.7 | 227.4 | 454.9 | 1364.6 |
| 5 | 6.5 | 32.5 | 65.0 | 97.5 | 194.9 | 389.9 | 1169.6 |
| 6 | 5.7 | 28.4 | 56.9 | 85.3 | 170.6 | 341.1 | 1023.4 |
| 7 | 5.1 | 25.3 | 50.5 | 75.8 | 151.6 | 303.2 | 909.7 |
| 8 | 4.5 | 22.7 | 45.5 | 68.2 | 136.5 | 272.9 | 818.8 |
| 9 | 4.1 | 20.7 | 41.4 | 62.0 | 124.1 | 248.1 | 744.3 |
| 10 | 3.8 | 19.0 | 37.9 | 56.9 | 113.7 | 227.4 | 682.3 |
| 11 | 3.5 | 17.5 | 35.0 | 52.5 | 105.0 | 209.9 | 629.8 |
| 12 | 3.2 | 16.2 | 32.5 | 48.7 | 97.5 | 194.9 | 584.8 |

### 3.24.3.3 Uploading of record

The protection relay stores the load profile COMTRADE files to the C:\LDP \COMTRADE folder. The files can be uploaded with PCM600 or any appropriate computer software that can access the C:\LDP\COMTRADE folder.

The load profile record consists of two COMTRADE file types: the configuration file (.CFG) and the data file (.DAT). The file name is same for both file types.

To ensure that both the uploaded file types are generated from the same data content, the files need to be uploaded successively. Once either of the files is uploaded, the recording buffer is halted to give time to upload the other file.

Data content of the load profile record is sequentially updated. Therefore, the size attribute for both COMTRADE files is "0".

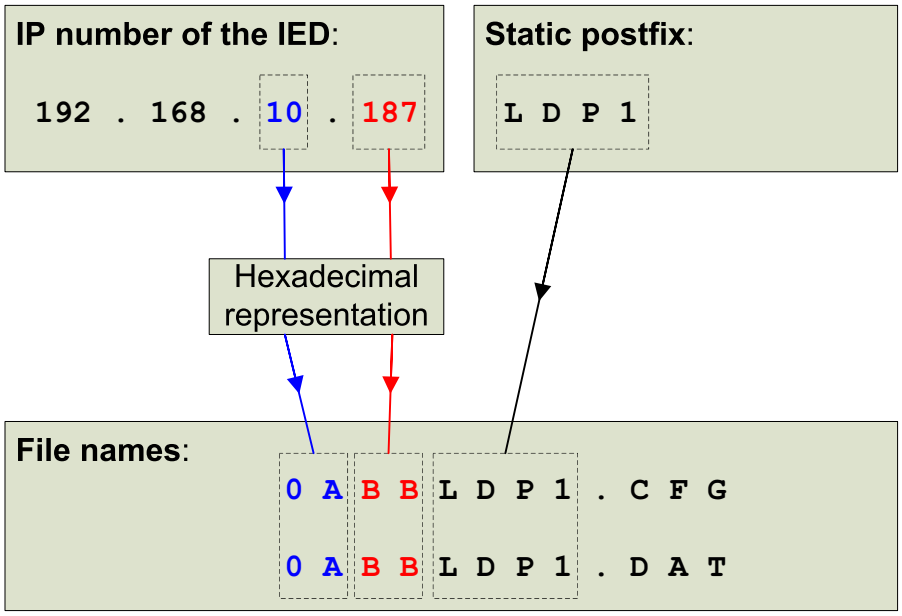



*Figure 166: Load profile record file naming*

### 3.24.3.4 Clearing of record

The load profile record can be cleared with *Reset load profile rec* via HMI, communication or the ACT input in PCM600. Clearing of the record is allowed only on the engineer and administrator authorization levels.

The load profile record is automatically cleared if the quantity selection parameters are changed or any other parameter which affects the content of the COMTRADE configuration file is changed. Also, if data source for selected quantity is removed, for example, with ACT, the load profile recorder stops recording and previously collected data are cleared.

## 3.24.4 Configuration

The load profile record can be configured with PCM600 or any tool supporting the IEC 61850 standard.

The load profile record can be enabled or disabled with the *Operation* setting under the **Configuration/Load Profile Record** menu.

Any demand output can be connected to any of the quantity channels of the load profile record. The mapping is done in Application Configuration in PCM600.

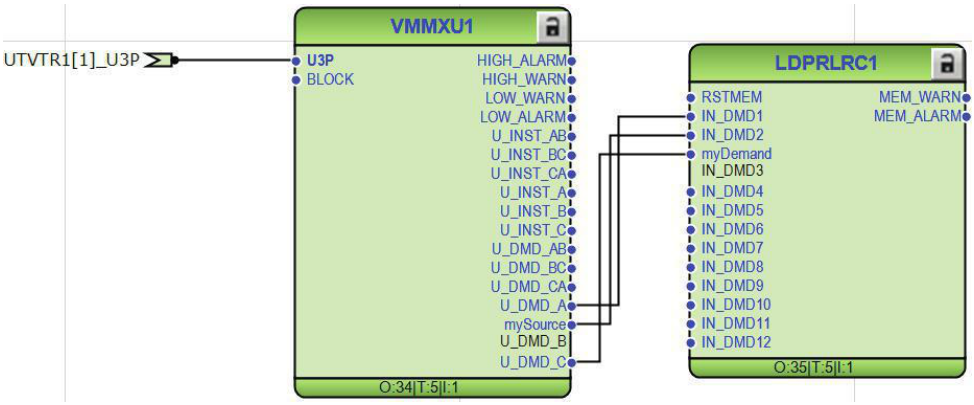



*Figure 167: Example of a load profile record ACT configuration*

The memory consumption of load profile record is supervised, and indicated with two signals MEM_WARN and MEM_ALARM, which could be used to notify the customer that recording should be backlogged by reading the recorded data from the protection relay. The levels for MEM_WARN and MEM_ALARM are set by two parameters *Mem.warn level* and *Mem. Alarm level*.

The IP number of the protection relay and the content of the *Bay name* setting are both included in the COMTRADE configuration file for identification purposes.

## 3.24.5 Signals

*Table 318: LDPRLRC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| RSTMEM | Boolean | | Reset load profile record |
| IN_DMD1 | Signal | | Measured demand quantity |
| IN_DMD2 | Signal | | Measured demand quantity |
| IN_DMD3 | Signal | | Measured demand quantity |
| IN_DMD4 | Signal | | Measured demand quantity |
| IN_DMD5 | Signal | | Measured demand quantity |
| IN_DMD6 | Signal | | Measured demand quantity |
| IN_DMD7 | Signal | | Measured demand quantity |
| IN_DMD8 | Signal | | Measured demand quantity |

Table continues on next page

| Name | Type | Default | Description |
|---|---|---|---|
| IN_DMD9 | Signal | | Measured demand quantity |
| IN_DMD10 | Signal | | Measured demand quantity |
| IN_DMD11 | Signal | | Measured demand quantity |
| IN_DMD12 | Signal | | Measured demand quantity |

*Table 319: LDPRLRC Output signals*

| Name | Type | Description |
|---|---|---|
| MEM_WARN | BOOLEAN | Recording memory warning status |
| MEM_ALARM | BOOLEAN | Recording memory alarm status |

## 3.24.6 Settings

*Table 320: LDPRLRC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Mem. warning level | 0...100 | % | 1 | 0 | Set memory warning level |
| Mem. alarm level | 0...100 | % | 1 | 0 | Set memory alarm level |

## 3.24.7 Monitored data

*Table 321: LDPRLRC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Rec. memory used | INT32 | 0...100 | % | How much recording memory is currently used |

# 3.25 Ethernet channel supervision functions

## 3.25.1 Redundant Ethernet channel supervison RCHLCCH

### 3.25.1.1 Function block




*Figure 168: Function block*

### 3.25.1.2 Functionality

Redundant Ethernet channel supervision RCHLCCH represents LAN A and LAN B redundant Ethernet channels.

### 3.25.1.3 Signals

*Table 322: RCHLCCH Output signals*

| Name | Values (Range) | Description |
|---|---|---|
| CHLIV | BOOLEAN | Status of redundant Ethernet channel LAN A<br>When *Redundant mode* is set to "HSR" or "PRP", value is TRUE if the protection relay is receiving redundancy supervision frames. Otherwise the value is FALSE. |
| REDCHLIV | BOOLEAN | Status of redundant Ethernet channel LAN B<br>When *Redundant mode* is set to "HSR" or "PRP", value is TRUE if the protection relay is receiving redundancy supervision frames. Otherwise the value is FALSE. |
| LNKLIV | BOOLEAN | Link status of redundant port LAN A<br>Valid only when *Redundant mode* is set to "HSR" or "PRP". Value is "Up" or "Down". |
| REDLNKLIV | BOOLEAN | Link status of redundant port LAN B<br>Valid only when *Redundant mode* is set to "HSR" or "PRP". Value is "Up" or "Down". |

### 3.25.1.4 Settings

*Table 323: RCHLCCH Settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Redundant mode | Off<br>PRP<br>HSR | | | | Mode selection for Ethernet switch on redundant communication modules. The "None" mode is used with normal and Self-healing Ethernet topologies. |
| Filter Mode A_B | Off<br>SMV<br>GOOSE<br>GOOSE & SMV | | | Off | Filtering selection for message types |
| Goose rate limiter A_B | 0.512...90.000 | | | 10.000 | Goose rate limit (Mbps) |
| SMV rate limit A_B | 0.512...90.000 | | | 70.000 | Sampled measured values rate limit (Mbps) |
| Def. rate limit A_B | 0.512...90.000 | | | 8.000 | Default rate limit (Mbps) |

### 3.25.1.5 Monitored data

Monitored data is available in four locations.

- **Monitoring/Communication/Ethernet/Activity/CHLIV_A**
- **Monitoring/Communication/Ethernet/Activity/REDCHLIV_B**
- **Monitoring/Communication/Ethernet/Link statuses/LNKLIV_A**
- **Monitoring/Communication/Ethernet/Link statuses/REDLNKLIV_B**

### 3.25.1.6 Diagnostics

Diagnostics data is available in **Monitoring/Communication/Ethernet/ Diagnostics/A_B**.

*Table 324: Diagnostic parameters for the redundant Ethernet channels LAN A and LAN B*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset counters | FALSE<br>TRUE | | | FALSE | Reset counters command |
| GOOSE limit count | 0...1000000 | | | 0 | Goose rate limit exceed count |
| SMV limit count | 0...1000000 | | | 0 | Sampled measured values limit exceed count |
| Ucast limit count | 0...1000000 | | | 0 | Unicast rate limit exceed count |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Def. limit count | 0...1000000 | | | 0 | Default rate limit exceed count |
| GOOSE limit alarm | FALSE<br>TRUE | | | FALSE | Goose rate limit exceed alarm |
| SMV limit alarm | FALSE<br>TRUE | | | FALSE | Sampled measured values limit alarm |
| Ucast limit alarm | FALSE<br>TRUE | | | FALSE | Unicast rate limit exceed alarm |
| Def. limit alarm | FALSE<br>TRUE | | | FALSE | Default rate limit exceed alarm |

## 3.25.2 Ethernet channel supervision SCHLCCH

### 3.25.2.1 Function block




*Figure 169: Function block*

### 3.25.2.2 Functionality

Ethernet channel supervision SCHLCCH represents X1/LAN, X2/LAN and X3/LAN Ethernet channels.

An unused Ethernet port can be set "Off" with the setting **Configuration/ Communication/Ethernet/Port Modes**. This setting closes the port from software, disabling the Ethernet communication in that port. Closing an unused Ethernet port enhances the cyber security of the relay.

### 3.25.2.3 Signals

*Table 325: SCHLCCH1 Output signals*

| Name | Type | Description |
|---|---|---|
| CH1LIV | BOOLEAN | Status of Ethernet channel X1/LAN<br>When *Redundant mode* is set to "None" or port is not one of the redundant ports (LAN A or LAN B), value is TRUE if the port is receiving Ethernet frames. Otherwise the value is FALSE. |
| LNK1LIV | BOOLEAN | Link status of Ethernet port X1/LAN<br>Value is "Up" or "Down". |

*Table 326: SCHLCCH2 Output signals*

| Name | Type | Description |
|---|---|---|
| CH2LIV | BOOLEAN | Status of Ethernet channel X2/LAN<br>When *Redundant mode* is set to "None" or port is not one of the redundant ports (LAN A or LAN B), value is TRUE if the port is receiving Ethernet frames. Otherwise the value is FALSE. |
| LNK2LIV | BOOLEAN | Link status of Ethernet port X2/LAN<br>Value is "Up" or "Down". |

*Table 327: SCHLCCH3 Output signals*

| Name | Type | Description |
|---|---|---|
| CH3LIV | BOOLEAN | Status of Ethernet channel X3/LAN<br>When *Redundant mode* is set to "None" or port is not one of the redundant ports (LAN A or LAN B), value is TRUE if the port is receiving Ethernet frames. Otherwise the value is FALSE. |
| LNK3LIV | BOOLEAN | Link status of Ethernet port X3/LAN<br>Value is "Up" or "Down". |

### 3.25.2.4 Settings

*Table 328: SCHLCCH Settings*

| Parameter[1)] | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Port n Mode | Off<br>On | | | On | Mode selection for rear port(s). If port is not used, it can be set to “Off”. Port cannot be set to “Off” when Redundant mode is “HSR” or “PRP” and port is one of the redundant ports (LAN A or LAN B). |
| Filter Mode Xn | Off<br>SMV<br>GOOSE<br>GOOSE & SMV | | | Off | Selection for message filtering |
| Goose rate limiter Xn | 0.512...90.000 | | | 10.000 | Goose rate limit (Mbps) |
| SMV rate limit Xn | 0.512...90.000 | | | 70.000 | Sampled measured values rate limit (Mbps) |
| Def. rate limit Xn | 0.512...90.000 | | | 8.000 | Default rate limit (Mbps) |

1) n = 1...3

### 3.25.2.5 Monitored data

Monitored data is available in six locations.

- **Monitoring/Communication/Ethernet/Activity/CH1LIV**
- **Monitoring/Communication/Ethernet/Activity/CH2LIV**
- **Monitoring/Communication/Ethernet/Activity/CH3LIV**
- **Monitoring/Communication/Ethernet/Link statuses/LNK1LIV**
- **Monitoring/Communication/Ethernet/Link statuses/LNK2LIV**
- **Monitoring/Communication/Ethernet/Link statuses/LNK3LIV**

### 3.25.2.6 Diagnostics

Diagnostics data is available in **Monitoring/Communication/Ethernet/ Diagnostics/Xn** (n = 1...3).

*Table 329: Diagnostic parameters for X1/LAN, X2/LAN and X3/LAN*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset counters | FALSE<br>TRUE | | | FALSE | Reset counters command |
| GOOSE limit count | 0...1000000 | | | 0 | Goose rate limit exceed count |
| SMV limit count | 0...1000000 | | | 0 | Sampled measured values limit exceed count |
| Ucast limit count | 0...1000000 | | | 0 | Unicast rate limit exceed count |
| Def. limit count | 0...1000000 | | | 0 | Default rate limit exceed count |
| GOOSE limit alarm | FALSE<br>TRUE | | | FALSE | Goose rate limit exceed alarm |
| SMV limit alarm | FALSE<br>TRUE | | | FALSE | Sampled measured values limit alarm |
| Ucast limit alarm | FALSE<br>TRUE | | | FALSE | Unicast rate limit exceed alarm |
| Def. limit alarm | FALSE<br>TRUE | | | FALSE | Default rate limit exceed alarm |

# 3.26 External HMI wake-up EIHMI

## 3.26.1 Function block




*Figure 170: Function block*

## 3.26.2 Functionality

The external HMI wake-up function EIHMI is a control block that is used to control certain parts of the HMI with Application Configuration in PCM600.

Some data can be bound to control options to enable the required features: remote HMI wake-up, information when the device has been woken up and indication when the Home button on the HMI is activated.

All functionalities described here are applicable only to paired HMI devices.

## 3.26.3 Operation principle

The input signal WAKEUP is used to wake the HMI from a low-power state and restore the display's backlight if it has been dimmed or turned off. The display's backlight can be controlled with parameter *Backlight timeout* under **Configuration/HMI**. The HMI remains in normal operation mode as long as there is user input from the HMI or a wake-up signal before the time set with *Backlight timeout* elapses.

The signal used to wake up the HMI is boolean rising edge. The wake-up can be triggered only after the connected signal has been in FALSE state for longer than a single function cycle.

The output signal HOME is activated when the capacitive Home button is activated on the HMI unit. This generates a boolean TRUE value pulse that persists for a second until the output is reset to FALSE. The output remains in this state until the Home button is pressed again.

The output signal WOKEN is activated whenever the HMI device is woken from a low-power state. This generates a one-second boolean TRUE value pulse. After one second, the output is reset to FALSE. A new output can be triggered once the HMI has entered the low-power state.

The output CONNECTION is activated whenever the paired HMI is connected to the protection relay. If the communication between the protection relay and the HMI is severed, this output resets itself to FALSE until communication has been restored.

### PCM600 parameters

EIHMI contains three paths to populate parameters visible in Parameter Setting in PCM600.

- **Configuration/HMI**
- **Monitoring/Detached LHMI**
- **Information/HW modules/EIHMI1**

## 3.26.4 Application

### Substation HMI wake-up (door sensor)

In this example, substation HMI devices need to be woken up when a person enters the substation to see that everything works as expected.

A switch signal is directly connected to the binary input, which activates the paired HMI.

Depending on the hardware solution, this hardware signal can be distributed to all affected protection relays on the substation. Optionally, the processed signal can be routed in horizontal communication through process bus communications, that is, GOOSE, to other protection relays.

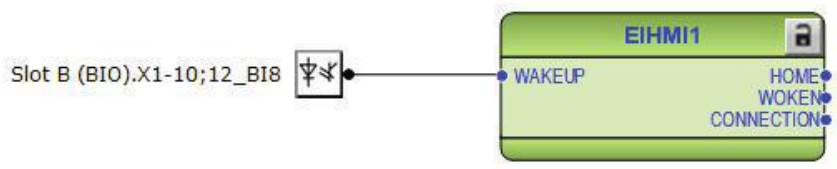



*Figure 171: Binary input connection*

## 3.26.5 Signals

*Table 330: EIHMI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| WAKEUP | BOOLEAN | 0=False | HMI wakeup command |

*Table 331: EIHMI Output signals*

| Name | Type | Description |
|---|---|---|
| HOME | BOOLEAN | HMI home button indicator |
| WOKEN | BOOLEAN | HMI woken indicator |
| CONNECTION | BOOLEAN | HMI connection status indicator |

### 3.26.6 Settings

*Table 332: HMI configuration parameters*

| Parameter | Description |
|---|---|
| Backlight brightness | Controls the HMI maximum backlight brightness. Actual brightness can be lower due to thermal compensation. |
| Enable USB access | Enables or disables HMI connector X2 |
| Enable HMI service port | Enables or disables HMI service port X1.2 |

### 3.26.7 Monitored data

*Table 333: HMI monitoring parameters*

| Parameter | Description |
|---|---|
| CONNECTION | Status of connection between the protection relay and HMI. The parameter is set TRUE when the paired HMI is connected to the protection relay. |
| Service port IP address | IP address of service port connector X1.2. Changes to this setting are available only on the HMI. |
| Main unit port IP address | IP address assigned to the main unit port connector X1.1. Changes to this setting are available only on the HMI. |

## 3.27 HMI Ethernet channel supervision HMILCCH

### 3.27.1 Function block




*Figure 172: Function block*

### 3.27.2 Functionality

Ethernet channel supervision HMILCCH represents the X0/HMI Ethernet channel.

### 3.27.3 Signals

*Table 334: HMILCCH Output signals*

| Name | Type | Description |
|---|---|---|
| HMICHLIV | BOOLEAN | Status of the Ethernet channel X0/LAN<br>Value is TRUE if the port is receiving Ethernet frames. Otherwise the value is FALSE. |
| HMILNKLIV | BOOLEAN | Link status of Ethernet port X0/LAN<br>Value is "Up" or "Down". |

### 3.27.4 Settings

*Table 335: HMILCCH Settings*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| IP Address | | | | 192.168.2.254 | Default IP address for the HMI. This parameter is read-only. |
| MAC Address | | | | XX-XX-XX-XX-XX-XX | MAC address for the HMI. This parameter is read-only. |

### 3.27.5 Monitored data

Monitored data is available in two locations.

- **Monitoring/Communication/Ethernet/Activity/HMICHLIV**
- **Monitoring/Communication/Ethernet/Link statuses/HMICHLIV**

## 3.28 Line differential communication port supervision SCHLCCH6

### 3.28.1 Function block




*Figure 173: Function block*

## 3.28.2 Functionality

Line differential channel supervision function SCHLCCH6 represents the X6/LD line differential channel.

## 3.28.3 Signals

*Table 336: SCHLCCH6 Output signals*

| Name | Type | Description |
|---|---|---|
| CH6LIV | BOOLEAN | Status of the line differential port X5/LD<br>Value is TRUE if the port is receiving Ethernet frames. Otherwise the value is FALSE. |
| LNK6LIV | BOOLEAN | Link status of the line differential port X6/LD<br>Value is "Up" or "Down". |

## 3.28.4 Monitored data

Monitored data is available in two locations.

- **Monitoring/Communication/Ethernet/Activity/CH6LIV**
- **Monitoring/Communication/Ethernet/Link statuses/LNK6LIV**

## 3.28.5 Diagnostics

Diagnostics data is available in **Monitoring/Communication/Ethernet/ Diagnostics/X6**.

*Table 337: Parameters read from the SFP module connected in the X6/LD line differential channel*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Temperature | -128.0...128.0 | C | | 0 | Measured SFP transceiver temperature |
| Voltage | 0.000...6.550 | V | | 0 | Measured SFP transceiver voltage |
| Bias current | 0.0...131.0 | mA | | 0 | Measured SFP transceiver bias current |
| Tx power | 0.000...6.550 | mW | | 0 | Measured SFP transceiver's transmitter power |
| Rx power | 0.000...6.550 | mW | | 0 | Measured SFP transceiver's receiver power |
| XCVR detected | FALSE<br>TRUE | | | FALSE | SFP Transceiver detection state |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Rx Power alarm | FALSE<br>TRUE | | | FALSE | SFP Receiver power alarm |
| Tx Power alarm | FALSE<br>TRUE | | | FALSE | SFP Transmitter power alarm |
| Voltage alarm | FALSE<br>TRUE | | | FALSE | SFP transceiver voltage alarm |
| Temperature alarm | FALSE<br>TRUE | | | FALSE | SFP temperature alarm |
| Part name | SFP not inserted<br>SFP not supported<br>2RCA045621 (MM 2 km)<br>2RCA045622 (SM 20 km)<br>2RCA045623 (SM 50 km) | | | SFP not inserted | Name, type and operational distance for the SFP module |

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# Section 4 Protection functions

## 4.1 Three-phase current protection

### 4.1.1 Three-phase non-directional overcurrent protection PHxPTOC

#### 4.1.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase non-directional overcurrent protection, low stage | PHLPTOC | 3I> | 51P-1 |
| Three-phase non-directional overcurrent protection, high stage | PHHPTOC | 3I>> | 51P-2 |
| Three-phase non-directional overcurrent protection, instantaneous stage | PHIPTOC | 3I>>> | 50P |

#### 4.1.1.2 Function block




*Figure 174: Function block*

#### 4.1.1.3 Functionality

The three-phase non-directional overcurrent protection function PHxPTOC is used as one-phase, two-phase or three-phase non-directional overcurrent and short-circuit protection.

The function starts when the current exceeds the set limit. The operate time characteristics for low stage PHLPTOC and high stage PHHPTOC can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). The instantaneous stage PHIPTOC always operates with the DT characteristic.

In the DT mode, the function operates after a predefined operate time and resets when the fault current disappears. The IDMT mode provides current-dependent timer characteristics.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.1.1.4 Analog input configuration

PHxPTOC has one analog group input which must be properly configured.

*Table 338: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PHxPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

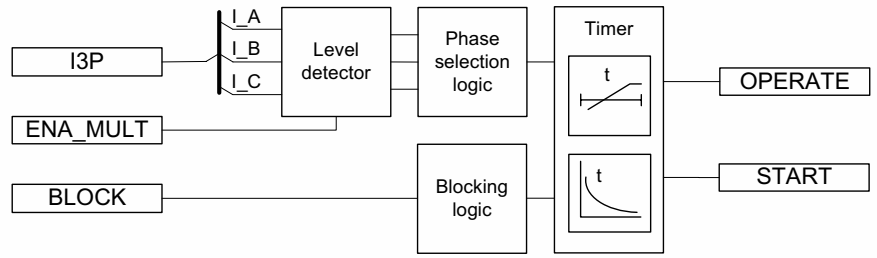



*Figure 175: Functional module diagram*

#### Level detector

The measured phase currents are compared phasewise to the set *Start value*. If the measured value exceeds the set *Start value*, the level detector reports the exceeding of the value to the phase selection logic. If the ENA_MULT input is active, the *Start value* setting is multiplied by the *Start value Mult* setting.

The protection relay does not accept the *Start value* or *Start value Mult* setting if the product of these settings exceeds the *Start value* setting range.

The start value multiplication is normally done when the inrush detection function (INRPHAR) is connected to the ENA_MULT input.

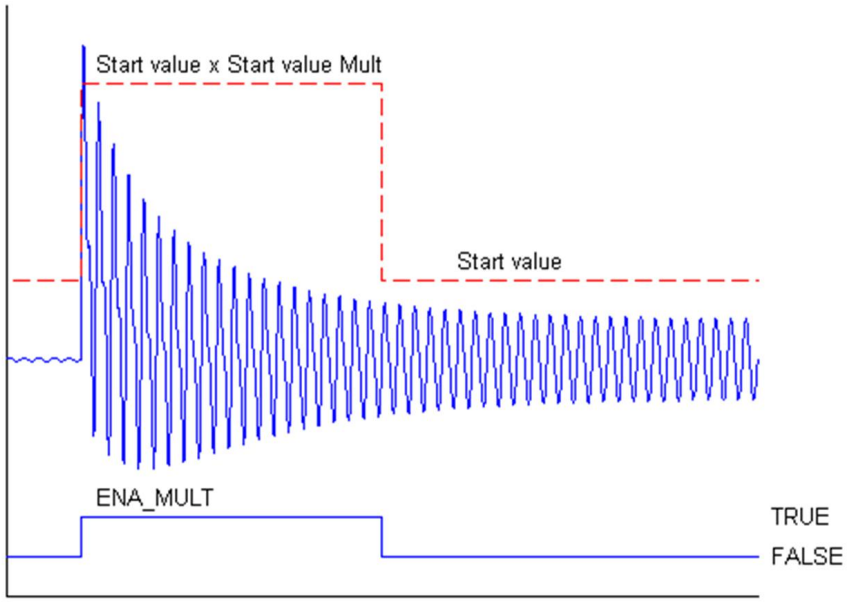



*Figure 176: Start value behavior with ENA_MULT input activated*

## Phase selection logic

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the measured current exceeds the setting. If the phase information matches the *Num of start phases* setting, the phase selection logic activates the timer module.

## Timer

Once activated, the timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The functionality of the timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation. The START output is deactivated when the reset timer has elapsed.



The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operate and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.



The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see the IDMT curves for overcurrent protection section in this manual.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

## Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.1.1.6 Measurement modes

The function operates on four alternative measurement modes: "RMS", "DFT", "Peak-to-Peak" and "P-to-P + backup". Additionally, there is “Wide P-to-P” measurement mode in some products variants. The measurement mode is selected with the setting *Measurement mode*.

*Table 339: Measurement modes supported by PHxPTOC stages*

| Measurement mode | PHLPTOC | PHHPTOC | PHIPTOC |
|---|---|---|---|
| RMS | x | x | |
| DFT | x | x | |
| Peak-to-Peak | x | x | |
| P-to-P + backup | | | x |
| Wide P-to-P | x | | |

For a detailed description of the measurement modes, see the Measurement modes section in this manual.

### 4.1.1.7 Timer characteristics

PHxPTOC supports both DT and IDMT characteristics. The user can select the timer characteristics with the *Operating curve type* and *Type of reset curve* settings. When the DT characteristic is selected, it is only affected by the *Operate delay time* and *Reset delay time* settings.

The protection relay provides 16 IDMT characteristics curves, of which seven comply with the IEEE C37.112 and six with the IEC 60255-3 standard. Two curves follow the special characteristics of ABB praxis and are referred to as RI and RD. One curve is for rectifier bridge protection. In addition to this, a user programmable curve can be used if none of the standard curves are applicable. The DT characteristics can be chosen by selecting the *Operating curve type* values "ANSI Def. Time" or "IEC Def. Time". The functionality is identical in both cases.

The timer characteristics supported by different stages comply with the list in the IEC 61850-7-4 specification, indicate the characteristics supported by different stages:

*Table 340: Timer characteristics supported by different stages*

| Operating curve type | PHLPTOC | PHHPTOC |
|---|---|---|
| (1) ANSI Extremely Inverse | x | x |
| (2) ANSI Very Inverse | x | |
| (3) ANSI Normal Inverse | x | x |
| (4) ANSI Moderately Inverse | x | |
| (5) ANSI Definite Time | x | x |
| (6) Long Time Extremely Inverse | x | |

Table continues on next page

| Operating curve type | PHLPTOC | PHHPTOC |
|---|---|---|
| (7) Long Time Very Inverse | x | |
| (8) Long Time Inverse | x | |
| (9) IEC Normal Inverse | x | x |
| (10) IEC Very Inverse | x | x |
| (11) IEC Inverse | x | |
| (12) IEC Extremely Inverse | x | x |
| (13) IEC Short Time Inverse | x | |
| (14) IEC Long Time Inverse | x | |
| (15) IEC Definite Time | x | x |
| (17) User programmable | x | x |
| (18) RI type | x | |
| (19) RD type | x | |
| (20) UK rectifier | x | |

PHIPTOC supports only definite time characteristic.

For a detailed description of timers, see the General function block features section in this manual.

*Table 341: Reset time characteristics supported by different stages*

| Reset curve type | PHLPTOC | PHHPTOC | Note |
|---|---|---|---|
| (1) Immediate | x | x | Available for all operate time curves |
| (2) Def time reset | x | x | Available for all operate time curves |
| (3) Inverse reset | x | x | Available only for ANSI and user programmable curves |

The *Type of reset curve* setting does not apply to PHIPTOC or when the DT operation is selected. The reset is purely defined by the *Reset delay time* setting.

### 4.1.1.8 Application

PHxPTOC is used in several applications in the power system. The applications include but are not limited to:

- Selective overcurrent and short-circuit protection of feeders in distribution and subtransmission systems
- Backup overcurrent and short-circuit protection of power transformers and generators
- Overcurrent and short-circuit protection of various devices connected to the power system, for example shunt capacitor banks, shunt reactors and motors
- General backup protection

PHxPTOC is used for single-phase, two-phase and three-phase non-directional overcurrent and short-circuit protection. Typically, overcurrent protection is used for clearing two and three-phase short circuits. Therefore, the user can choose how many phases, at minimum, must have currents above the start level for the function to operate. When the number of start-phase settings is set to "1 out of 3", the operation of PHxPTOC is enabled with the presence of high current in one-phase.



When the setting is "2 out of 3" or "3 out of 3", single-phase faults are not detected. The setting "3 out of 3" requires the fault to be present in all three phases.

Many applications require several steps using different current start levels and time delays. PHxPTOC consists of three protection stages.

- Low PHLPTOC
- High PHHPTOC
- Instantaneous PHIPTOC

PHLPTOC is used for overcurrent protection. The function contains several types of time-delay characteristics. PHHPTOC and PHIPTOC are used for fast clearance of very high overcurrent situations.

## Transformer overcurrent protection

The purpose of transformer overcurrent protection is to operate as main protection, when differential protection is not used. It can also be used as coarse back-up protection for differential protection in faults inside the zone of protection, that is, faults occurring in incoming or outgoing feeders, in the region of transformer terminals and tank cover. This means that the magnitude range of the fault current can be very wide. The range varies from $6xI_n$ to several hundred times $I_n$, depending on the impedance of the transformer and the source impedance of the feeding network. From this point of view, it is clear that the operation must be both very fast and selective, which is usually achieved by using coarse current settings.

The purpose is also to protect the transformer from short circuits occurring outside the protection zone, that is through-faults. Transformer overcurrent protection also provides protection for the LV-side busbars. In this case the magnitude of the fault current is typically lower than $12xI_n$ depending on the fault location and transformer impedance. Consequently, the protection must operate as fast as possible taking into

account the selectivity requirements, switching-in currents, and the thermal and mechanical withstand of the transformer and outgoing feeders.

Traditionally, overcurrent protection of the transformer has been arranged as shown in Figure 177. The low-set stage PHLPTOC operates time-selectively both in transformer and LV-side busbar faults. The high-set stage PHHPTOC operates instantaneously making use of current selectivity only in transformer HV-side faults. If there is a possibility, that the fault current can also be fed from the LV-side up to the HV-side, the transformer must also be equipped with LV-side overcurrent protection. Inrush current detectors are used in start-up situations to multiply the current start value setting in each particular protection relay where the inrush current can occur. The overcurrent and contact based circuit breaker failure protection CCBRBRF is used to confirm the protection scheme in case of circuit breaker malfunction.

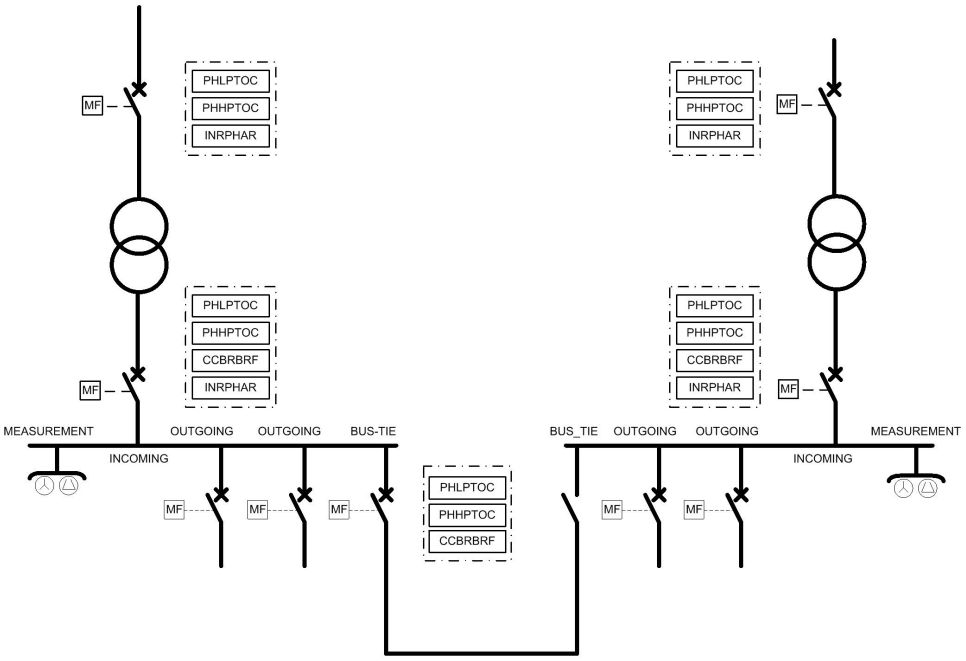



*Figure 177: Example of traditional time selective transformer overcurrent protection*

The operating times of the main and backup overcurrent protection of the above scheme become quite long, this applies especially in the busbar faults and also in the transformer LV-terminal faults. In order to improve the performance of the above scheme, a multiple-stage overcurrent protection with reverse blocking is proposed. Figure 179 shows this arrangement.

## Overcurrent protection with line differential protection

The line differential protection relay has also four separate overcurrent functions which can be used as the backup protection of line differential function for lines and cables. There are three stages available with definite or inverse time characteristics and an instantaneous stage.

The differential protection is available only if the communication between the units is working properly and no CT failure situation is detected. If a communication failure exists, the protect area or unit is left out from the primary protection scheme. Therefore it is practical to use overcurrent protection as a local backup functionality.

In the standard configuration of the protection relay, the backup overcurrent protection is implemented with four overcurrent stages so that under normal conditions, that is, when the line differential communication is healthy, only two lowest stages are available for the remote backup protection. In case a line differential communication failure exists, two more stages are released for rapid local backup overcurrent and short circuit protection. These stages are blocked in normal situation and automatically unblocked when the communication failure is detected. The setting of the overcurrent stages for local backup protection has to be considered carefully in order to achieve the best possible protection performance under abnormal conditions.

Two situations, case A and B, are shown in Figure 178. In case A, the communication media is valid and therefore the line differential protection is in operation. In this case, the two lowest stages of overcurrent protection are in operation simultaneously. In case B, a communication failure causes a situation where the line differential function is not able to work properly. Unblocking of the two highest overcurrent protection stages releases these functions to protect the line against overcurrents and short-circuits.

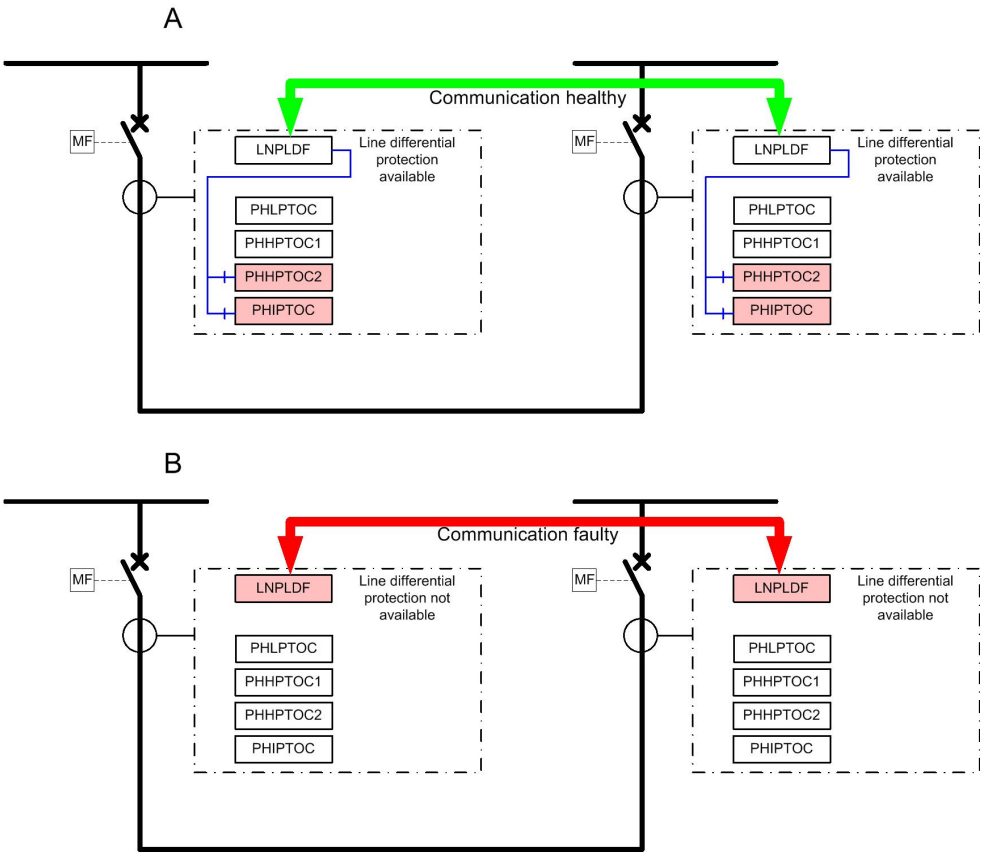



*Figure 178: Backup overcurrent protection for line differential applications*

## Transformer and busbar overcurrent protection with reverse blocking principle

By implementing a full set of overcurrent protection stages and blocking channels between the protection stages of the incoming feeders, bus-tie and outgoing feeders, it is possible to speed up the operation of overcurrent protection in the busbar and transformer LV-side faults without impairing the selectivity. Also, the security degree of busbar protection is increased, because there is now a dedicated, selective and fast busbar protection functionality which is based on the blockable overcurrent protection principle. The additional time selective stages on the transformer HV and LV-sides provide increased security degree of backup protection for the transformer, busbar and also for the outgoing feeders.

Depending on the overcurrent stage in question, the selectivity of the scheme in Figure 179 is based on the operating current, operating time or blockings between successive overcurrent stages. With blocking channels, the operating time of the protection can be drastically shortened if compared to the simple time selective protection. In addition to the busbar protection, this blocking principle is applicable for the protection of transformer LV terminals and short lines. The functionality and performance of the proposed overcurrent protections can be summarized as seen in the table.

*Table 342: Proposed functionality of numerical transformer and busbar overcurrent protection. DT = definite time, IDMT = inverse definite minimum time*

| O/C-stage | Operating char. | Selectivity mode | Operation speed | Sensitivity |
|---|---|---|---|---|
| HV/3I> | DT/IDMT | time selective | low | very high |
| HV/3I>> | DT | blockable/time selective | high/low | high |
| HV/3I>>> | DT | current selective | very high | low |
| LV/3I> | DT/IDMT | time selective | low | very high |
| LV/3I>> | DT | time selective | low | high |
| LV/3I>>> | DT | blockable | high | high |

In case the bus-tie breaker is open, the operating time of the blockable overcurrent protection is approximately 100 ms (relaying time). When the bus-tie breaker is closed, that is, the fault current flows to the faulted section of the busbar from two directions, the operation time becomes as follows: first the bus-tie relay unit trips the tie breaker in the above 100 ms, which reduces the fault current to a half. After this the incoming feeder relay unit of the faulted bus section trips the breaker in approximately 250 ms (relaying time), which becomes the total fault clearing time in this case.

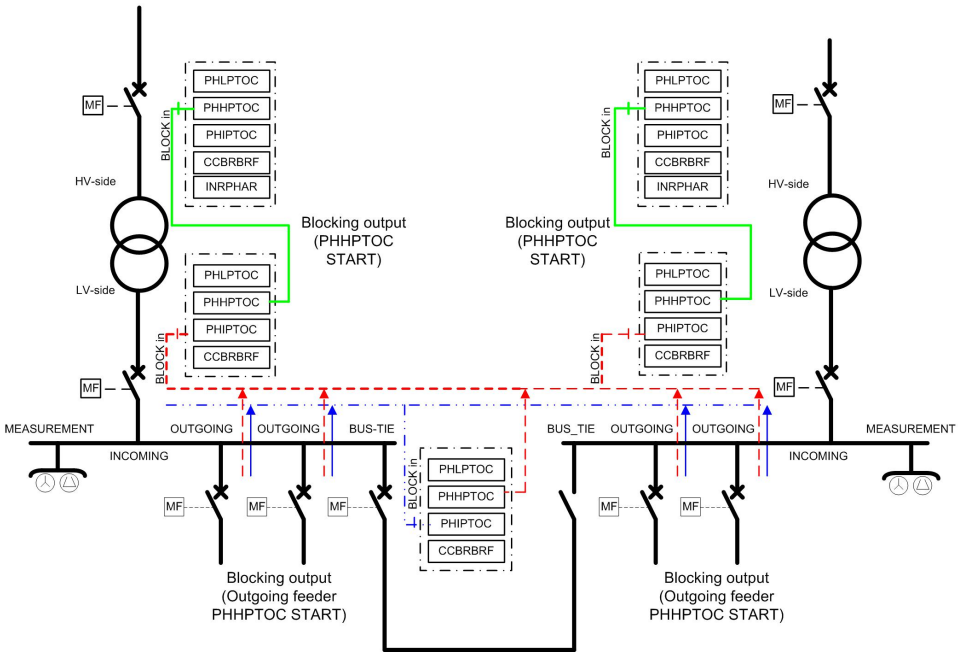



*Figure 179: Numerical overcurrent protection functionality for a typical sub-transmission/distribution substation (feeder protection not shown). Blocking output = digital output signal from the start of a protection stage, Blocking in = digital input signal to block the operation of a protection stage*

The operating times of the time selective stages are very short, because the grading margins between successive protection stages can be kept short. This is mainly due to the advanced measuring principle allowing a certain degree of CT saturation, good operating accuracy and short retardation times of the numerical units. So, for example, a grading margin of 150 ms in the DT mode of operation can be used, provided that the circuit breaker interrupting time is shorter than 60 ms.

The sensitivity and speed of the current-selective stages become as good as possible due to the fact that the transient overreach is very low. Also, the effects of switching inrush currents on the setting values can be reduced by using the protection relay's logic, which recognizes the transformer energizing inrush current and blocks the operation or multiplies the current start value setting of the selected overcurrent stage with a predefined multiplier setting.

Finally, a dependable trip of the overcurrent protection is secured by both a proper selection of the settings and an adequate ability of the measuring transformers to reproduce the fault current. This is important in order to maintain selectivity and also for the protection to operate without additional time delays. For additional information about available measuring modes and current transformer requirements, see the Measurement modes chapter in this manual.

## Radial outgoing feeder overcurrent protection

The basic requirements for feeder overcurrent protection are adequate sensitivity and operation speed taking into account the minimum and maximum fault current levels along the protected line, selectivity requirements, inrush currents and the thermal and mechanical withstand of the lines to be protected.

In many cases the above requirements can be best fulfilled by using multiple-stage overcurrent units. Figure 180 shows an example of this. A brief coordination study has been carried out between the incoming and outgoing feeders.

The protection scheme is implemented with three-stage numerical overcurrent protection, where the low-set stage PHLPTOC operates in IDMT-mode and the two higher stages PHHPTOC and PHIPTOC in DT-mode. Also the thermal withstand of the line types along the feeder and maximum expected inrush currents of the feeders are shown. Faults occurring near the station where the fault current levels are the highest are cleared rapidly by the instantaneous stage in order to minimize the effects of severe short circuit faults. The influence of the inrush current is taken into consideration by connecting the inrush current detector to the start value multiplying input of the instantaneous stage. By this way the start value is multiplied with a predefined setting during the inrush situation and nuisance tripping can be avoided.

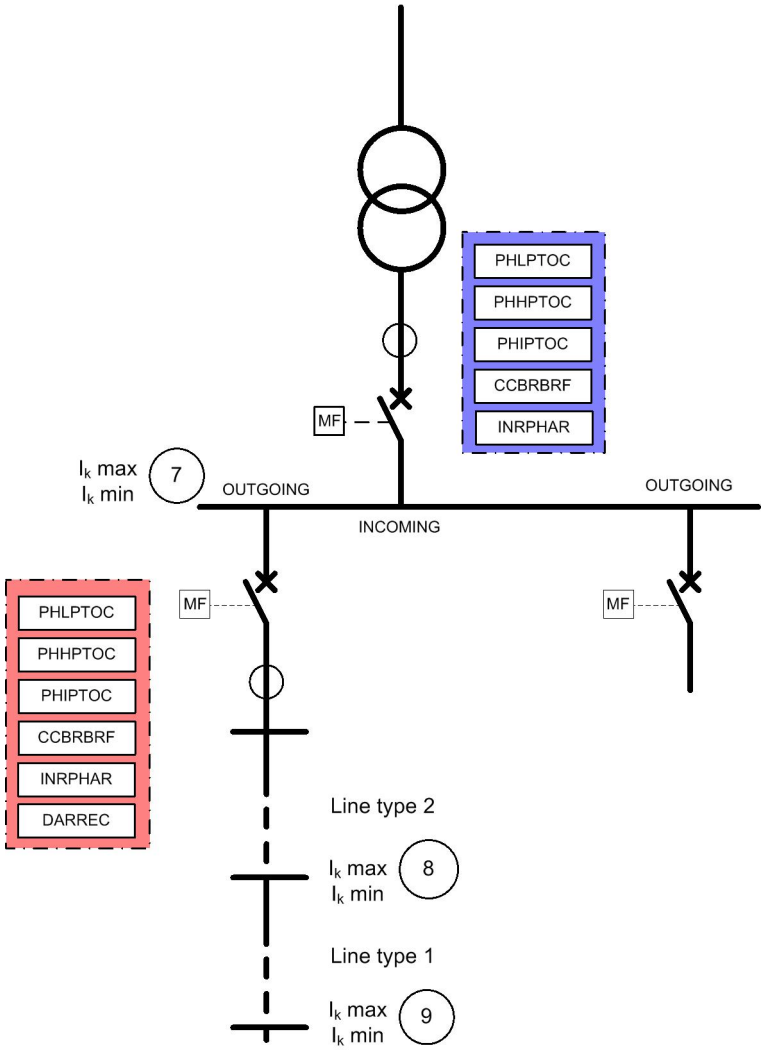



*Figure 180: Functionality of numerical multiple-stage overcurrent protection*

The coordination plan is an effective tool to study the operation of time selective operation characteristics. All the points mentioned earlier, required to define the overcurrent protection parameters, can be expressed simultaneously in a coordination plan. In Figure 181, the coordination plan shows an example of operation characteristics in the LV-side incoming feeder and radial outgoing feeder.

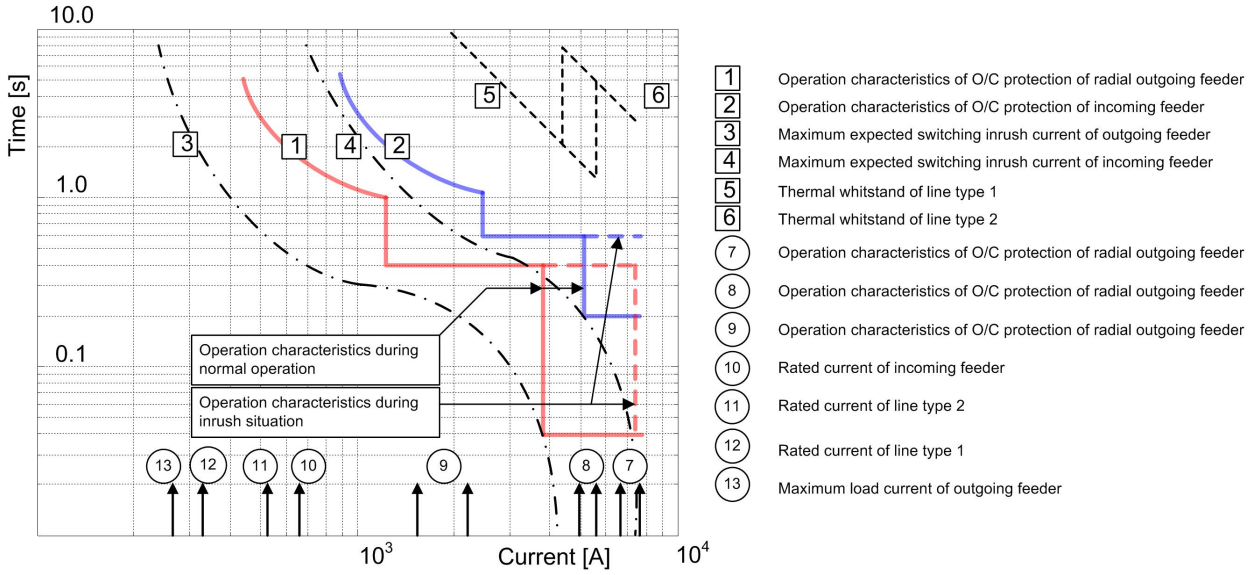



*Figure 181: Example coordination of numerical multiple-stage overcurrent protection*

## 4.1.1.9 Signals

*Table 343: PHLPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

*Table 344: PHHPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

*Table 345: PHIPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

*Table 346: PHLPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

*Table 347: PHHPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

*Table 348: PHIPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.1.1.10 Settings

*Table 349: PHLPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...5.00 | xIn | 0.01 | 0.05 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type<br>20=UK rectifier | | | 15=IEC Def. Time | Selection of time delay curve type |

*Table 350: PHLPTOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

*Table 351: PHLPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.0086...50000.000 0 | | 1 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 1 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...6.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 1 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 352: PHLPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak<br>5=Wide P-to-P | | | 2=DFT | Selects used measurement mode |

*Table 353: PHHPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.10...40.00 | xIn | 0.01 | 0.10 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>3=ANSI Norm. inv.<br>5=ANSI Def. Time<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>12=IEC Ext. inv.<br>15=IEC Def. Time<br>17=Programmable | | | 15=IEC Def. Time | Selection of time delay curve type |

*Table 354: PHHPTOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

*Table 355: PHHPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.0086...120.0000 | | 1 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 1 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 1 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 356: PHHPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

*Table 357: PHIPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.10...40.00 | xIn | 0.01 | 1.00 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Operate delay time | 20...300000 | ms | 10 | 20 | Operate delay time |

*Table 358: PHIPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |

*Table 359: PHIPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.1.1.11 Monitored data

*Table 360: PHLPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHLPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

*Table 361: PHHPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHHPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

*Table 362: PHIPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHIPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.1.1.12 Technical data

*Table 363: PHxPTOC Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | PHLPTOC | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| | PHHPTOC and PHIPTOC | ±1.5% of the set value or ±0.002 × $I_n$ (at currents in the range of 0.1…10 × $I_n$) ±5.0% of the set value (at currents in the range of 10…40 × $I_n$) | | |
| Start time[1] | | Minimum | Typical | Maximum |
| | PHIPTOC[2]: $I_{Fault}$ = 2 × set *Start value* | 8 ms | 12 ms | 15 ms |
| | $I_{Fault}$ = 10 × set *Start value* | 7 ms | 9 ms | 12 ms |
| | PHHPTOC and PHLPTOC[3]: $I_{Fault}$ = 2 × set *Start value* | 23 ms | 26 ms | 29 ms |
| Reset time | | Typically <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [4] | | |
| Suppression of harmonics | | RMS: No suppression DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression P-to-P+backup: No suppression | | |

1) *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Measured with static signal output (SSO)
3) Includes the delay of the signal output contact (SO)
4) Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in the range of 1.5...20

## 4.1.2 Three-phase directional overcurrent protection DPHxPDOC

### 4.1.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase directional overcurrent protection, low stage | DPHLPDOC | 3I> -> | 67P/51P-1 |
| Three-phase directional overcurrent protection, high stage | DPHHPDOC | 3I>> -> | 67P/51P-2 |

### 4.1.2.2 Function block

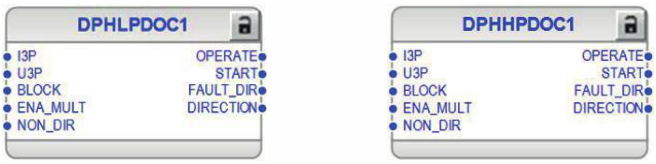



*Figure 182: Function block*

### 4.1.2.3 Functionality

The three-phase directional overcurrent protection function DPHxPDOC is used as one-phase, two-phase or three-phase directional overcurrent and short-circuit protection for feeders.

DPHxPDOC starts up when the value of the current exceeds the set limit and directional criterion is fulfilled. The operate time characteristics for low stage DPHLPDOC and high stage DPHHPDOC can be selected to be either definite time (DT) or inverse definite minimum time (IDMT).

In the DT mode, the function operates after a predefined operate time and resets when the fault current disappears. The IDMT mode provides current-dependent timer characteristics.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.1.2.4 Analog channel configuration

DPHxPDOC has two analog group inputs which must be properly configured.

*Table 364: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 365: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DPHxPDOC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

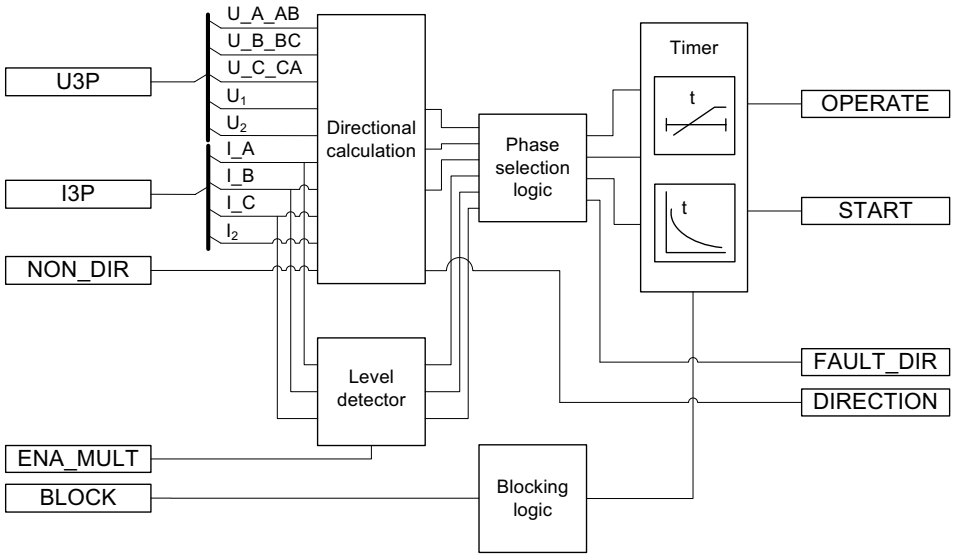



*Figure 183: Functional module diagram*

#### Directional calculation

The directional calculation compares the current phasors to the polarizing phasor. A suitable polarization quantity can be selected from the different polarization quantities, which are the positive sequence voltage, negative sequence voltage, self-polarizing (faulted) voltage and cross-polarizing voltages (healthy voltages). The polarizing method is defined with the *Pol quantity* setting.

***Table 366: Polarizing quantities***

| Polarizing quantity | Description |
|---|---|
| Pos. seq. volt | Positive sequence voltage |
| Neg. seq. volt | Negative sequence voltage |
| Self pol | Self polarization |
| Cross pol | Cross polarization |

The directional operation can be selected with the *Directional mode* setting. The user can select either "Non-directional", "Forward" or "Reverse" operation. By setting the value of *Allow Non Dir* to "True", the non-directional operation is allowed when the directional information is invalid.

The *Characteristic angle* setting is used to turn the directional characteristic. The value of *Characteristic angle* should be chosen in such a way that all the faults in the operating direction are seen in the operating zone and all the faults in the opposite direction are seen in the non-operating zone. The value of *Characteristic angle* depends on the network configuration.

Reliable operation requires both the operating and polarizing quantities to exceed certain minimum amplitude levels. The minimum amplitude level for the operating quantity (current) is set with the *Min operate current* setting. The minimum amplitude level for the polarizing quantity (voltage) is set with the *Min operate voltage* setting. If the amplitude level of the operating quantity or polarizing quantity is below the set level, the direction information of the corresponding phase is set to "Unknown".

The polarizing quantity validity can remain valid even if the amplitude of the polarizing quantity falls below the value of the *Min operate voltage* setting. In this case, the directional information is provided by a special memory function for a time defined with the *Voltage Mem time* setting.

DPHxPDOC is provided with a memory function to secure a reliable and correct directional protection relay operation in case of a close short circuit or an earth fault characterized by an extremely low voltage. At sudden loss of the polarization quantity, the angle difference is calculated on the basis of a fictive voltage. The fictive voltage is calculated using the positive phase sequence voltage measured before the fault occurred, assuming that the voltage is not affected by the fault. The memory function enables the function to operate up to a maximum of three seconds after a total loss of voltage. This time can be set with the *Voltage Mem time* setting. The voltage memory cannot be used for the "Negative sequence voltage" polarization because it is not possible to substitute the positive sequence voltage for negative sequence voltage without knowing the network unsymmetry level. This is the reason why the fictive voltage angle and corresponding direction information are frozen immediately for this polarization mode when the need for a voltage memory arises and these are kept frozen until the time set with *Voltage Mem time* elapses.



The value for the *Min operate voltage* setting should be carefully selected since the accuracy in low signal levels is strongly affected by the measuring device accuracy.

When the voltage falls below *Min operate voltage* at a close fault, the fictive voltage is used to determine the phase angle. The measured voltage is applied again as soon as the voltage rises above *Min operate voltage* and hysteresis. The fictive voltage is also discarded if the measured voltage stays below *Min operate voltage* and hysteresis for longer than *Voltage Mem time* or if the fault current disappears while the fictive voltage is in use. When the voltage is below *Min operate voltage* and hysteresis and

the fictive voltage is unusable, the fault direction cannot be determined. The fictive voltage can be unusable for two reasons:

- The fictive voltage is discarded after *Voltage Mem time*
- The phase angle cannot be reliably measured before the fault situation.

DPHxPDOC can be forced to the non-directional operation with the NON_DIR input. When the NON_DIR input is active, DPHxPDOC operates as a non-directional overcurrent protection, regardless of the *Directional mode* setting.

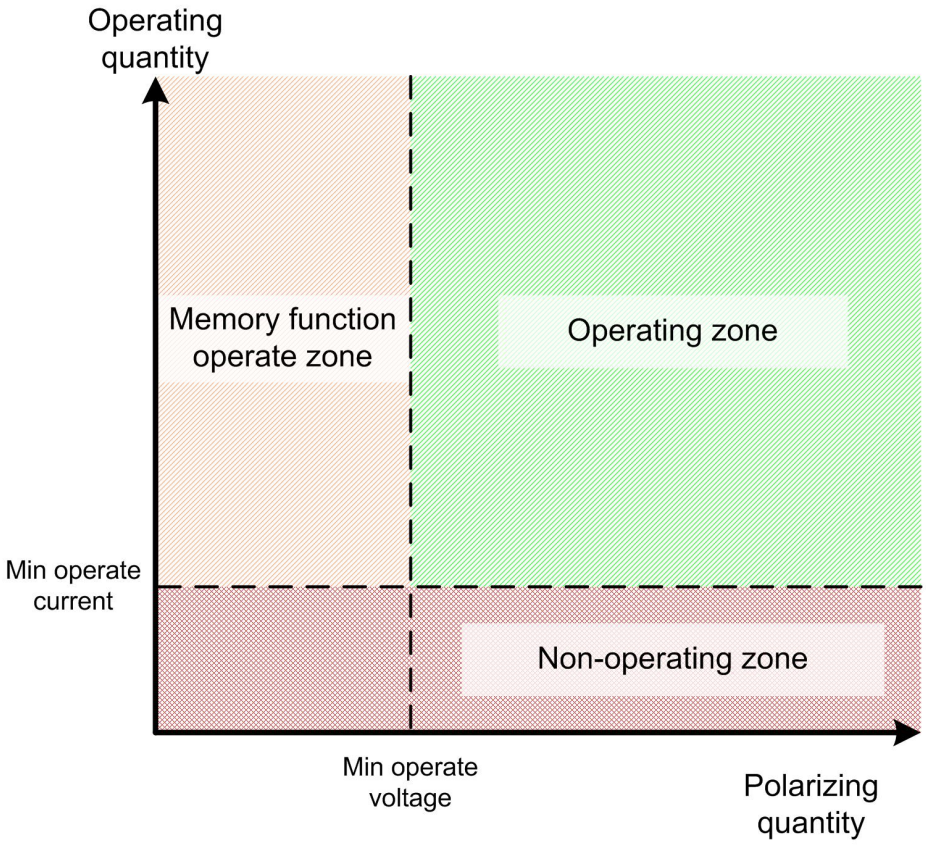



*Figure 184: Operating zones at minimum magnitude levels*

The DIRECTION output indicates on which operating sector the current is measured. The value combines phase-specific directions which are available in monitored data as DIR_A, DIR_B and DIR_C.

## Level detector

The measured phase currents are compared phasewise to the set *Start value*. If the measured value exceeds the set *Start value*, the level detector reports the exceeding of the value to the phase selection logic. If the ENA_MULT input is active, the *Start value* setting is multiplied by the *Start value Mult* setting.

The protection relay does not accept the *Start value* or *Start value Mult* setting if the product of these settings exceeds the *Start value* setting range.

The start value multiplication is normally done when the inrush detection function (INRPHAR) is connected to the ENA_MULT input.

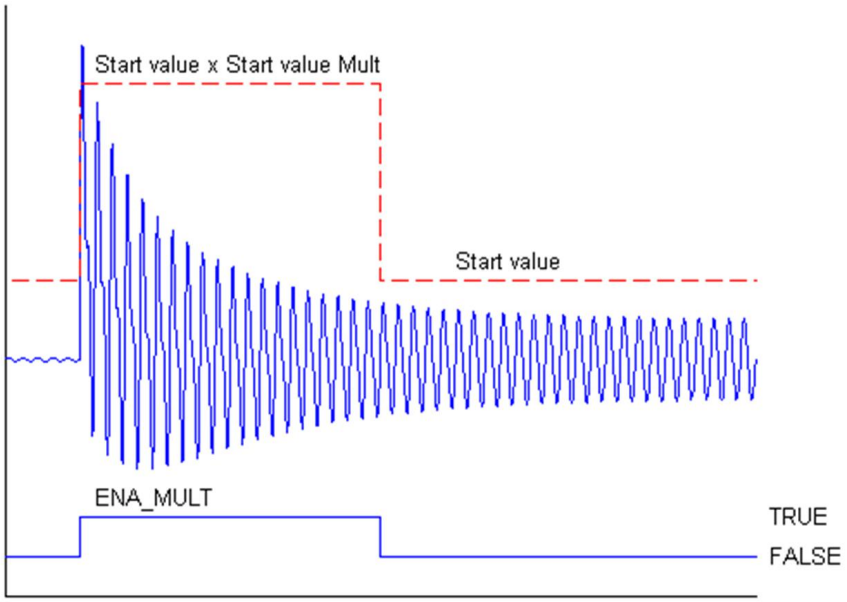



*Figure 185: Start value behavior with ENA_MULT input activated*

## Phase selection logic

If the fault criteria are fulfilled in the level detector and the directional calculation, the phase selection logic detects the phase or phases in which the measured current exceeds the setting. If the phase information matches the *Num of start phases* setting, the phase selection logic activates the timer module.

FAULT_DIR gives the detected direction of the fault during fault situations, that is, when the START output is active.

## Timer

Once activated, the timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The functionality of the timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation. The START output is deactivated when the reset timer has elapsed.



The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operate and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.



The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see the IDMT curves for overcurrent protection section in this manual.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

## Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is

blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.1.2.6 Measurement modes

The function operates on three alternative measurement modes: “RMS”, “DFT” and “Peak-to-Peak” . The measurement mode is selected with the *Measurement mode* setting.

*Table 367: Measurement modes supported by DPHxPDOC stages*

| Measurement mode | DPHLPDOC | DPHHPDOC |
|---|---|---|
| RMS | x | x |
| DFT | x | x |
| Peak-to-Peak | x | x |

### 4.1.2.7 Directional overcurrent characteristics

The forward and reverse sectors are defined separately. The forward operation area is limited with the *Min forward angle* and *Max forward angle* settings. The reverse operation area is limited with the *Min reverse angle* and *Max reverse angle* settings.



The sector limits are always given as positive degree values.

In the forward operation area, the *Max forward angle* setting gives the counterclockwise sector and the *Min forward angle* setting gives the corresponding clockwise sector, measured from the *Characteristic angle* setting.

In the backward operation area, the *Max reverse angle* setting gives the counterclockwise sector and the *Min reverse angle* setting gives the corresponding clockwise sector, a measurement from the *Characteristic angle* setting that has been rotated 180 degrees.

Relay characteristic angle (RCA) is set positive if the operating current lags the polarizing quantity and negative if the operating current leads the polarizing quantity.

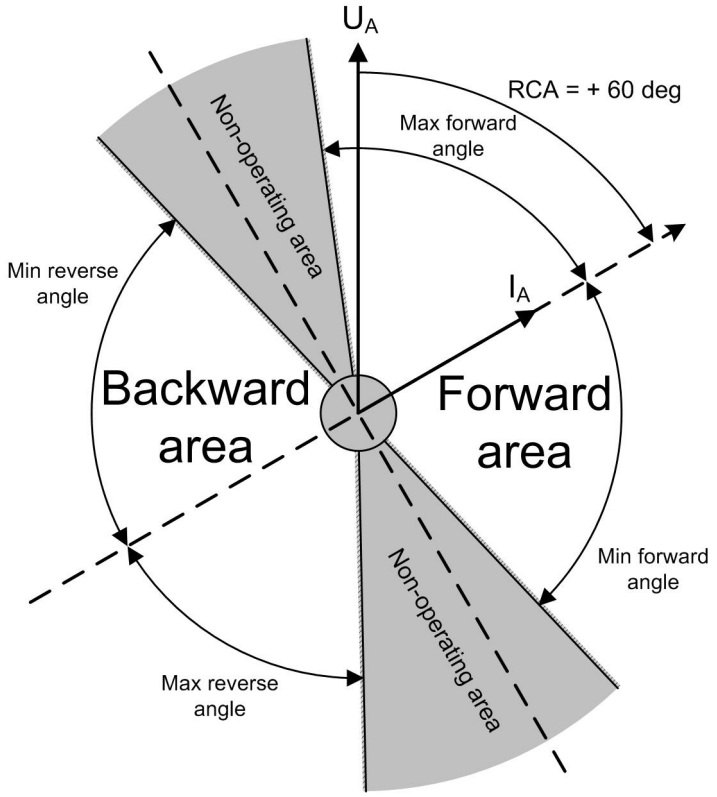



*Figure 186: Configurable operating sectors*

*Table 368: Momentary per phase direction value for monitored data view*

| Criterion for per phase direction information | The value for DIR_A/_B/_C |
|---|---|
| The ANGLE_X is not in any of the defined sectors, or the direction cannot be defined due too low amplitude | 0 = unknown |
| The ANGLE_X is in the forward sector | 1 = forward |
| The ANGLE_X is in the reverse sector | 2 = backward |
| (The ANGLE_X is in both forward and reverse sectors, that is, when the sectors are overlapping) | 3 = both |

*Table 369: Momentary phase combined direction value for monitored data view*

| Criterion for phase combined direction information | The value for DIRECTION |
|---|---|
| The direction information (DIR_X) for all phases is unknown | 0 = unknown |
| The direction information (DIR_X) for at least one phase is forward, none being in reverse | 1 = forward |
| The direction information (DIR_X) for at least one phase is reverse, none being in forward | 2 = backward |
| The direction information (DIR_X) for some phase is forward and for some phase is reverse | 3 = both |

FAULT_DIR gives the detected direction of the fault during fault situations, that is, when the START output is active.

## Self-polarizing as polarizing method

*Table 370: Equations for calculating angle difference for self-polarizing method*

| Faulted phases | Used fault current | Used polarizing voltage | Angle difference |
|---|---|---|---|
| A | $\underline{I}_A$ | $\underline{U}_A$ | $ANGLE_A = \varphi(\underline{U}_A) - \varphi(\underline{I}_A) - \varphi_{RCA}$ (Equation 8) |
| B | $\underline{I}_B$ | $\underline{U}_B$ | $ANGLE_B = \varphi(\underline{U}_B) - \varphi(\underline{I}_B) - \varphi_{RCA}$ (Equation 9) |
| C | $\underline{I}_C$ | $\underline{U}_C$ | $ANGLE_C = \varphi(\underline{U}_C) - \varphi(\underline{I}_C) - \varphi_{RCA}$ (Equation 10) |
| A - B | $\underline{I}_A - \underline{I}_B$ | $\underline{U}_{AB}$ | $ANGLE_A = \varphi(\underline{U}_{AB}) - \varphi(\underline{I}_A - \underline{I}_B) - \varphi_{RCA}$ (Equation 11) |
| B - C | $\underline{I}_B - \underline{I}_C$ | $\underline{U}_{BC}$ | $ANGLE_B = \varphi(\underline{U}_{BC}) - \varphi(\underline{I}_B - \underline{I}_C) - \varphi_{RCA}$ (Equation 12) |
| C - A | $\underline{I}_C - \underline{I}_A$ | $\underline{U}_{CA}$ | $ANGLE_C = \varphi(\underline{U}_{CA}) - \varphi(\underline{I}_C - \underline{I}_A) - \varphi_{RCA}$ (Equation 13) |

In an example case of the phasors in a single-phase earth fault where the faulted phase is phase A, the angle difference between the polarizing quantity $U_A$ and operating quantity $I_A$ is marked as φ. In the self-polarization method, there is no need to rotate the polarizing quantity.

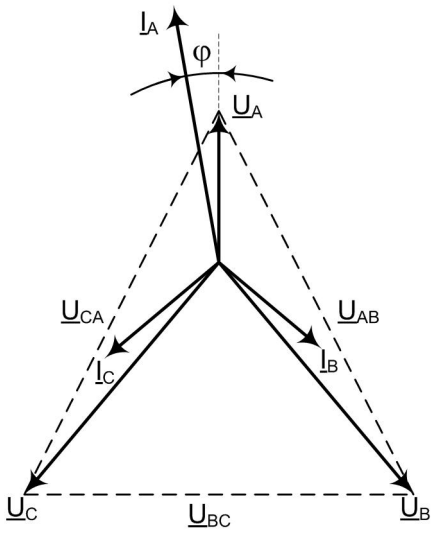



*Figure 187: Single-phase earth fault, phase A*

In an example case of a two-phase short-circuit failure where the fault is between phases B and C, the angle difference is measured between the polarizing quantity $U_{BC}$ and operating quantity $\underline{I}_B$ - $\underline{I}_C$ in the self-polarizing method.

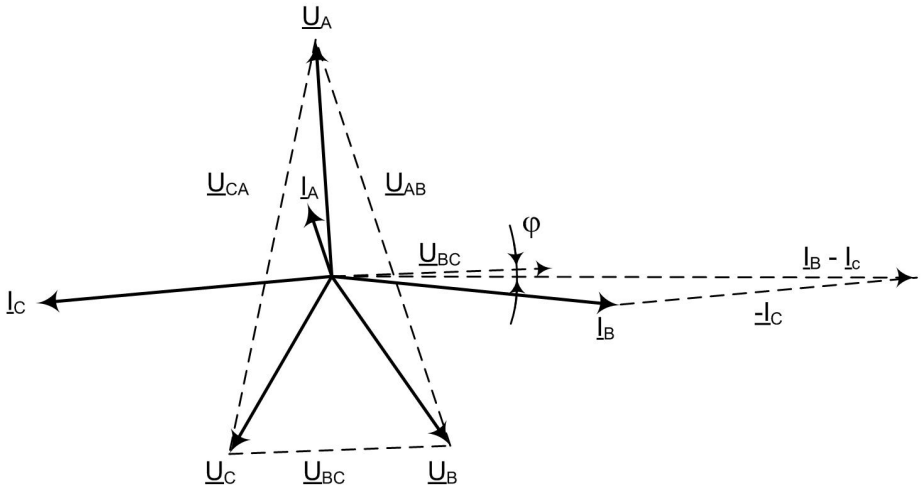



*Figure 188: Two-phase short circuit, short circuit is between phases B and C*

## Cross-polarizing as polarizing quantity

*Table 371: Equations for calculating angle difference for cross-polarizing method*

| Faulted phases | Used fault current | Used polarizing voltage | Angle difference |
|---|---|---|---|
| A | $\underline{I}_A$ | $\underline{U}_{BC}$ | $ANGLE_A = \varphi(\underline{U}_{BC}) - \varphi(\underline{I}_A) - \varphi_{RCA} + 90^o$ (Equation 14) |
| B | $\underline{I}_B$ | $\underline{U}_{CA}$ | $ANGLE_B = \varphi(\underline{U}_{CA}) - \varphi(\underline{I}_B) - \varphi_{RCA} + 90^o$ (Equation 15) |
| C | $\underline{I}_C$ | $\underline{U}_{AB}$ | $ANGLE_C = \varphi(\underline{U}_{AB}) - \varphi(\underline{I}_C) - \varphi_{RCA} + 90^o$ (Equation 16) |
| A - B | $\underline{I}_A - \underline{I}_B$ | $\underline{U}_{BC} - \underline{U}_{CA}$ | $ANGLE_A = \varphi(\underline{U}_{BC} - \underline{U}_{CA}) - \varphi(\underline{I}_A - \underline{I}_B) - \varphi_{RCA} + 90^o$ (Equation 17) |
| B - C | $\underline{I}_B - \underline{I}_C$ | $\underline{U}_{CA} - \underline{U}_{AB}$ | $ANGLE_B = \varphi(\underline{U}_{CA} - \underline{U}_{AB}) - \varphi(\underline{I}_B - \underline{I}_C) - \varphi_{RCA} + 90^o$ (Equation 18) |
| C - A | $\underline{I}_C - \underline{I}_A$ | $\underline{U}_{AB} - \underline{U}_{BC}$ | $ANGLE_C = \varphi(\underline{U}_{AB} - \underline{U}_{BC}) - \varphi(\underline{I}_C - \underline{I}_A) - \varphi_{RCA} + 90^o$ (Equation 19) |

The angle difference between the polarizing quantity $U_{BC}$ and operating quantity $I_A$ is marked as φ in an example of the phasors in a single-phase earth fault where the faulted phase is phase A. The polarizing quantity is rotated with 90 degrees. The characteristic angle is assumed to be ~ 0 degrees.

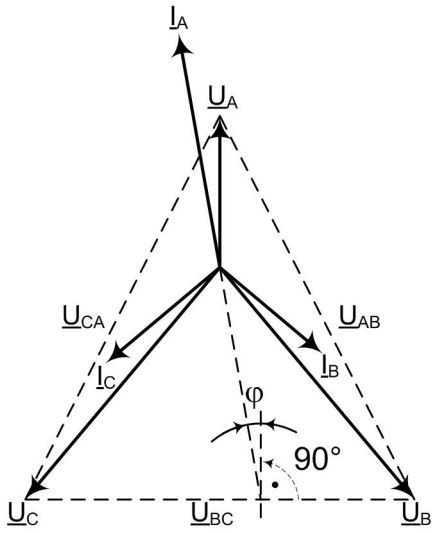



*Figure 189: Single-phase earth fault, phase A*

In an example of the phasors in a two-phase short-circuit failure where the fault is between the phases B and C, the angle difference is measured between the polarizing quantity $\underline{U}_{AB}$ and operating quantity $\underline{I}_B$ - $\underline{I}_C$ marked as φ.

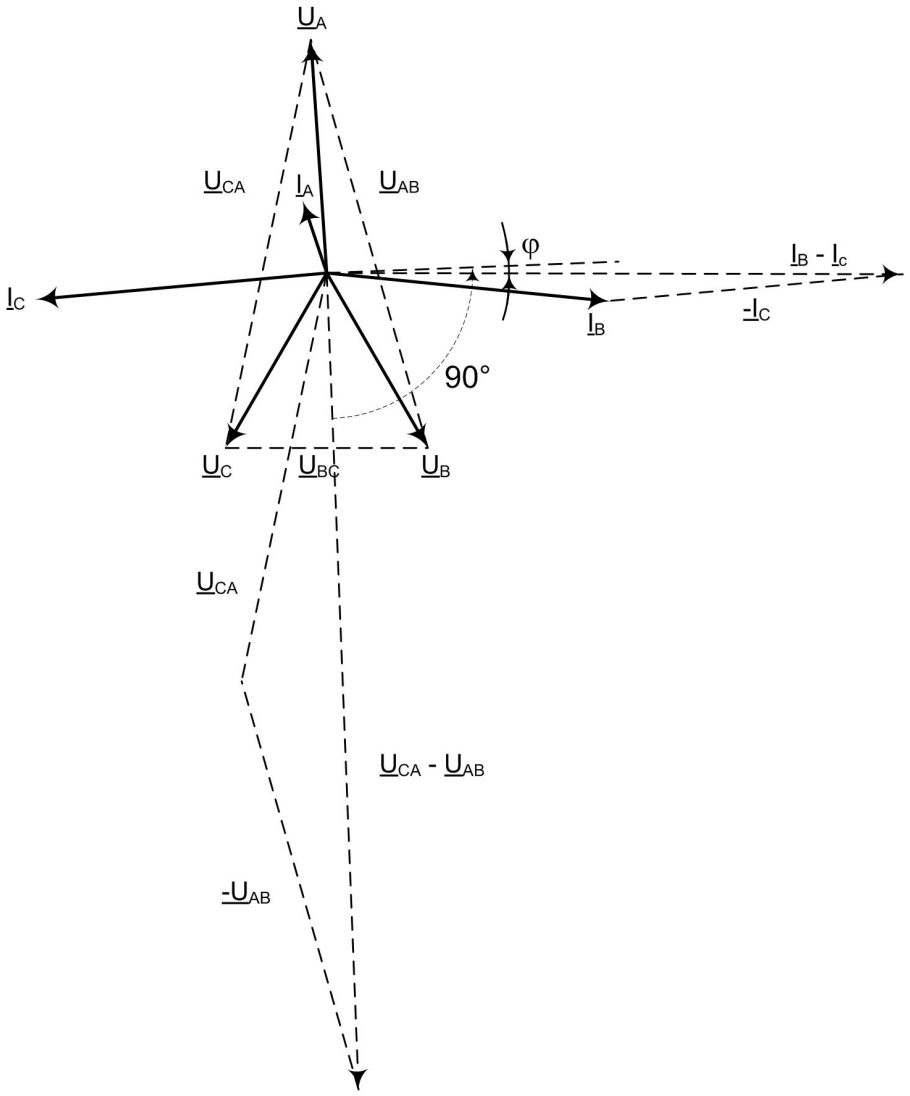



*Figure 190: Two-phase short circuit, short circuit is between phases B and C*

The equations are valid when network rotating direction is counter-clockwise, that is, ABC. If the network rotating direction is reversed, 180 degrees is added to the calculated angle difference. This is done automatically with a system parameter *Phase rotation*.

## Negative sequence voltage as polarizing quantity

When the negative voltage is used as the polarizing quantity, the angle difference between the operating and polarizing quantity is calculated with the same formula for all fault types:

$$ANGLE_X = \varphi(-\underline{U}_2) - \varphi(\underline{I}_2) - \varphi_{RCA}$$

(Equation 20)

This means that the actuating polarizing quantity is -$\underline{U}_2$.

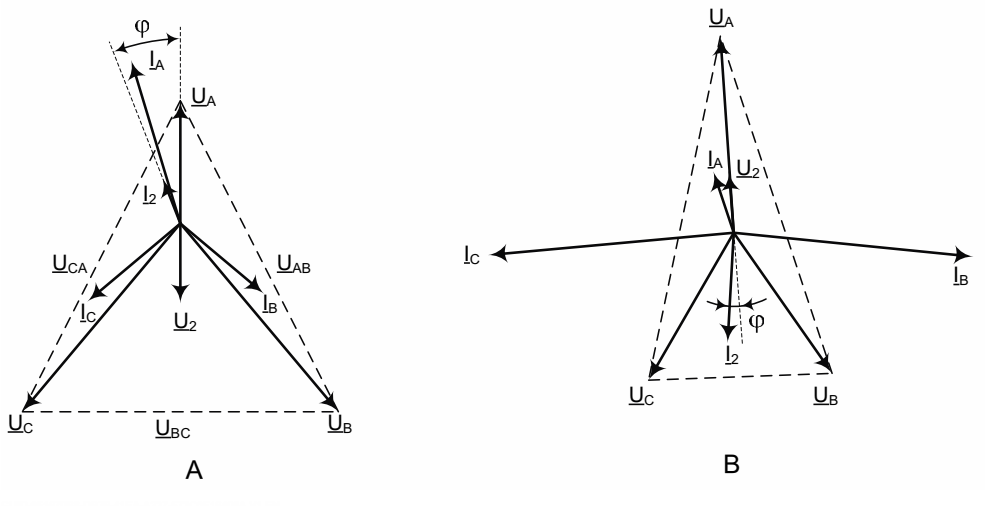



*Figure 191: Phasors in a single-phase earth fault, phases A-N, and two-phase short circuit, phases B and C, when the actuating polarizing quantity is the negative-sequence voltage -U2*

## Positive sequence voltage as polarizing quantity

*Table 372: Equations for calculating angle difference for positive-sequence quantity polarizing method*

| Faulted phases | Used fault current | Used polarizing voltage | Angle difference |
|---|---|---|---|
| A | $\underline{I}_A$ | $\underline{U}_1$ | $ANGLE_A = \varphi(\underline{U}_1) - \varphi(\underline{I}_A) - \varphi_{RCA}$ (Equation 21) |
| B | $\underline{I}_B$ | $\underline{U}_1$ | $ANGLE_B = \varphi(\underline{U}_1) - \varphi(\underline{I}_B) - \varphi_{RCA} - 120^\circ$ (Equation 22) |
| C | $\underline{I}_C$ | $\underline{U}_1$ | $ANGLE_C = \varphi(\underline{U}_1) - \varphi(\underline{I}_C) - \varphi_{RCA} + 120^\circ$ (Equation 23) |
| Table continues on next page | | | |

| Faulted phases | Used fault current | Used polarizing voltage | Angle difference |
|---|---|---|---|
| A - B | $\underline{I}_A$ - $\underline{I}_B$ | $\underline{U}_1$ | $ANGLE_A = \varphi(\underline{U}_1) - \varphi(\underline{I}_A - \underline{I}_B) - \varphi_{RCA} + 30^\circ$ (Equation 24) |
| B - C | $\underline{I}_B$ - $\underline{I}_C$ | $\underline{U}_1$ | $ANGLE_B = \varphi(\underline{U}_1) - \varphi(\underline{I}_B - \underline{I}_C) - \varphi_{RCA} - 90^\circ$ (Equation 25) |
| C - A | $\underline{I}_C$ - $\underline{I}_A$ | $\underline{U}_1$ | $ANGLE_C = \varphi(\underline{U}_1) - \varphi(\underline{I}_C - \underline{I}_A) - \varphi_{RCA} + 150^\circ$ (Equation 26) |

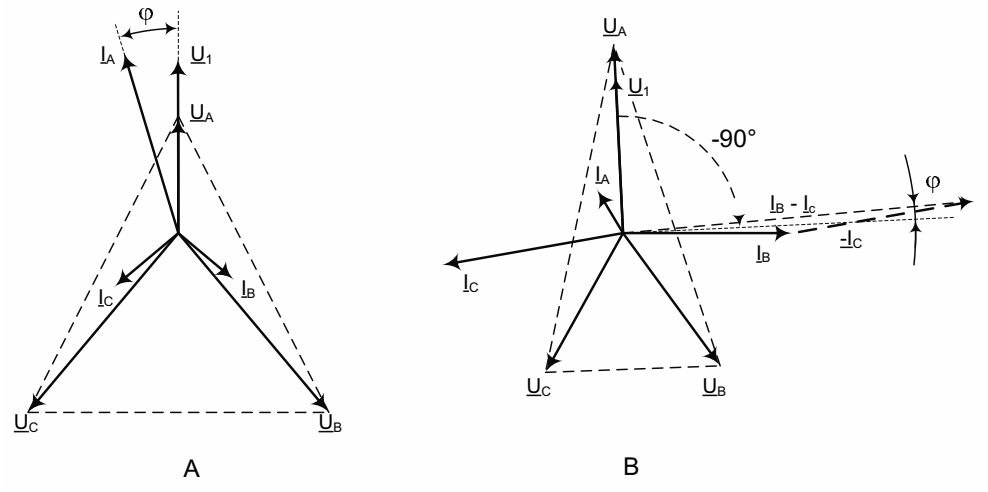



*Figure 192: Phasors in a single-phase earth fault, phase A to ground, and a two-phase short circuit, phases B-C, are short-circuited when the polarizing quantity is the positive-sequence voltage $U_1$*

## Network rotation direction

Typically, the network rotating direction is counter-clockwise and defined as "ABC". If the network rotating direction is reversed, meaning clockwise, that is, "ACB", the equations for calculating the angle difference needs to be changed. The network rotating direction is defined with a system parameter *Phase rotation*. The change in the network rotating direction affects the phase-to-phase voltages polarization method where the calculated angle difference needs to be rotated 180 degrees. Also, when the sequence components are used, which are, the positive sequence voltage or negative sequence voltage components, the calculation of the components are affected but the angle difference calculation remains the same. When the phase-to-ground voltages are used as the polarizing method, the network rotating direction change has no effect on the direction calculation.

The network rotating direction is set in the protection relay using the parameter in the HMI menu **Configuration/System/Phase rotation**. The default parameter value is "ABC".

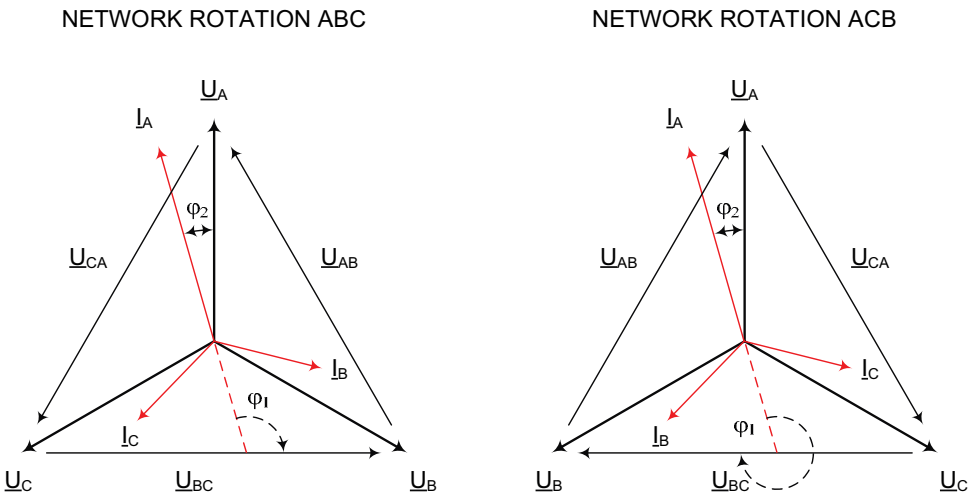



*Figure 193: Examples of network rotating direction*

## 4.1.2.8 Application

DPHxPDOC is used as short-circuit protection in three-phase distribution or sub transmission networks operating at 50 or 60 Hz.

In radial networks, phase overcurrent protection relays are often sufficient for the short circuit protection of lines, transformers and other equipment. The current-time characteristic should be chosen according to the common practice in the network. It is recommended to use the same current-time characteristic for all overcurrent protection relays in the network. This includes the overcurrent protection of transformers and other equipment.

The phase overcurrent protection can also be used in closed ring systems as short circuit protection. Because the setting of a phase overcurrent protection system in closed ring networks can be complicated, a large number of fault current calculations are needed. There are situations with no possibility to have the selectivity with a protection system based on overcurrent protection relays in a closed ring system.

In some applications, the possibility of obtaining the selectivity can be improved significantly if DPHxPDOC is used. This can also be done in the closed ring networks and radial networks with the generation connected to the remote in the system thus giving fault current infeed in reverse direction. Directional overcurrent protection relays are also used to have a selective protection scheme, for example in case of parallel distribution lines or power transformers fed by the same single source. In ring connected supply feeders between substations or feeders with two feeding sources, DPHxPDOC is also used.

## Parallel lines or transformers

When the lines are connected in parallel and if a fault occurs in one of the lines, it is practical to have DPHxPDOC to detect the direction of the fault. Otherwise, there is a risk that the fault situation in one part of the feeding system can de-energize the whole system connected to the LV side.

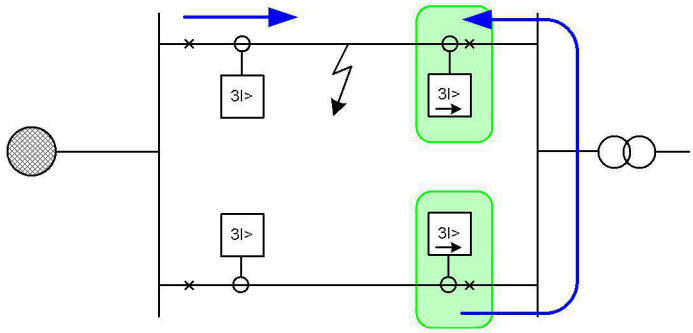



*Figure 194: Overcurrent protection of parallel lines using directional protection relays*

DPHxPDOC can be used for parallel operating transformer applications. In these applications, there is a possibility that the fault current can also be fed from the LV-side up to the HV-side. Therefore, the transformer is also equipped with directional overcurrent protection.

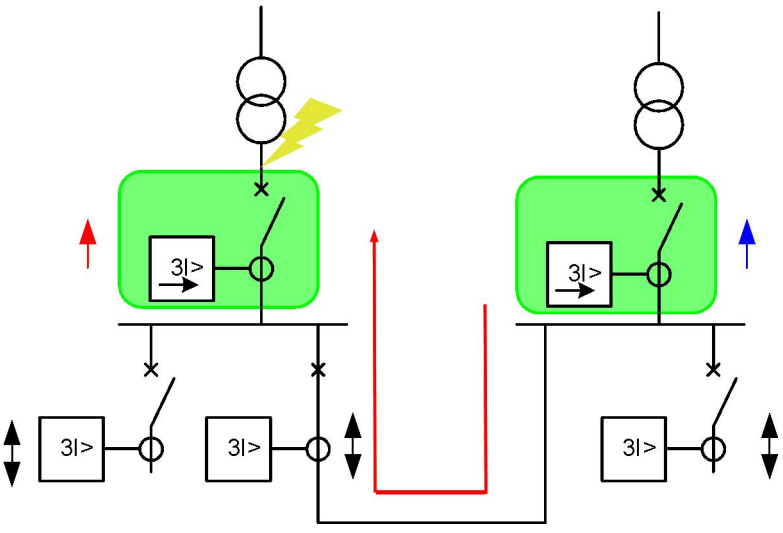



*Figure 195: Overcurrent protection of parallel operating transformers*

## Closed ring network topology

The closed ring network topology is used in applications where electricity distribution for the consumers is secured during network fault situations. The power is fed at least from two directions which means that the current direction can be varied. The time

grading between the network level stages is challenging without unnecessary delays in the time settings. In this case, it is practical to use the directional overcurrent protection relays to achieve a selective protection scheme. Directional overcurrent functions can be used in closed ring applications. The arrows define the operating direction of the directional functionality. The double arrows define the non-directional functionality where faults can be detected in both directions.

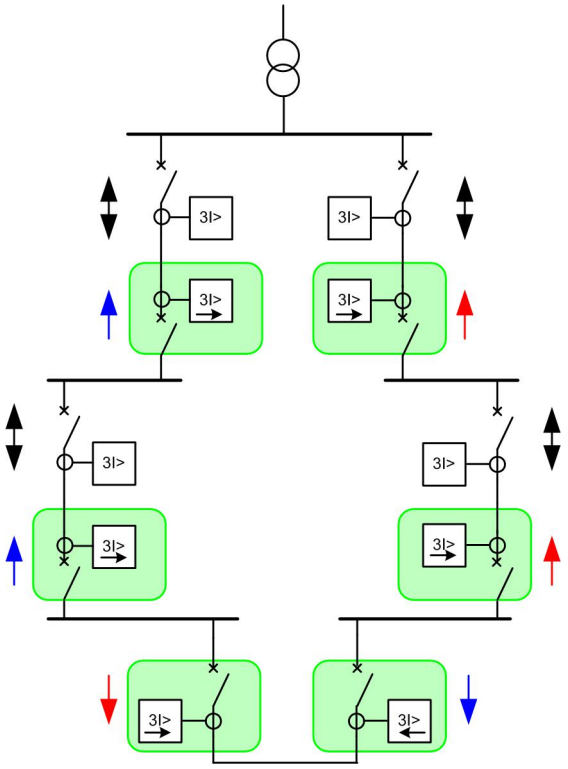



*Figure 196: Closed ring network topology where feeding lines are protected with directional overcurrent protection relays*

## 4.1.2.9 Signals

*Table 373: DPHLPDOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |
| NON_DIR | BOOLEAN | 0=False | Forces protection to non-directional |

*Table 374: DPHHPDOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |
| NON_DIR | BOOLEAN | 0=False | Forces protection to non-directional |

*Table 375: DPHLPDOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| FAULT_DIR | Enum | Detected fault direction |
| DIRECTION | Enum | Direction information |

*Table 376: DPHHPDOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| FAULT_DIR | Enum | Detected fault direction |
| DIRECTION | Enum | Direction information |

### 4.1.2.10 Settings

*Table 377: DPHLPDOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...5.00 | xIn | 0.01 | 0.05 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Characteristic angle | -179...180 | deg | 1 | 60 | Characteristic angle |
| Max forward angle | 0...90 | deg | 1 | 80 | Maximum phase angle in forward direction |
| Max reverse angle | 0...90 | deg | 1 | 80 | Maximum phase angle in reverse direction |
| Min forward angle | 0...90 | deg | 1 | 80 | Minimum phase angle in forward direction |
| Min reverse angle | 0...90 | deg | 1 | 80 | Minimum phase angle in reverse direction |

*Table 378: DPHLPDOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |
| Voltage Mem time | 0...3000 | ms | 1 | 40 | Voltage memory time |
| Pol quantity | 1=Self pol<br>4=Neg. seq. volt.<br>5=Cross pol<br>7=Pos. seq. volt. | | | 5=Cross pol | Reference quantity used to determine fault direction |

*Table 379: DPHLPDOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.0086...120.0000 | | 1 | 28.2000 | Parameter A for customer programmable curve |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Curve parameter B | 0.0000...0.7120 | | 1 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 1 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 380: DPHLPDOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |
| Allow Non Dir | 0=False<br>1=True | | | 0=False | Allows prot activation as non-dir when dir info is invalid |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.01 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.01 | Minimum operating voltage |

*Table 381: DPHHPDOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.10...40.00 | xIn | 0.01 | 0.10 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operating curve type | 1=ANSI Ext. inv.<br>3=ANSI Norm. inv.<br>5=ANSI Def. Time<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>12=IEC Ext. inv.<br>15=IEC Def. Time<br>17=Programmable | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Characteristic angle | -179...180 | deg | 1 | 60 | Characteristic angle |
| Max forward angle | 0...90 | deg | 1 | 80 | Maximum phase angle in forward direction |
| Max reverse angle | 0...90 | deg | 1 | 80 | Maximum phase angle in reverse direction |
| Min forward angle | 0...90 | deg | 1 | 80 | Minimum phase angle in forward direction |
| Min reverse angle | 0...90 | deg | 1 | 80 | Minimum phase angle in reverse direction |

*Table 382: DPHHPDOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |
| Voltage Mem time | 0...3000 | ms | 1 | 40 | Voltage memory time |
| Pol quantity | 1=Self pol<br>4=Neg. seq. volt.<br>5=Cross pol<br>7=Pos. seq. volt. | | | 5=Cross pol | Reference quantity used to determine fault direction |

*Table 383: DPHHPDOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 1 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 1 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 1 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |

*Table 384: DPHHPDOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Allow Non Dir | 0=False<br>1=True | | | 0=False | Allows prot activation as non-dir when dir info is invalid |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.01 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.01 | Minimum operating voltage |

### 4.1.2.11 Monitored data

*Table 385: DPHLPDOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| DIR_A | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase A |
| DIR_B | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase B |
| DIR_C | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase C |
| ANGLE_A | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase A |
| ANGLE_B | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase B |
| ANGLE_C | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase C |
| VMEM_USED | BOOLEAN | 0=False<br>1=True | | Voltage memory in use status |
| DPHLPDOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

*Table 386: DPHHPDOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| DIR_A | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase A |
| DIR_B | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase B |
| DIR_C | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase C |
| ANGLE_A | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase A |
| ANGLE_B | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase B |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ANGLE_C | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase C |
| VMEM_USED | BOOLEAN | 0=False<br>1=True | | Voltage memory in use status |
| DPHHPDOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 4.1.2.12 Technical data

*Table 387: DPHxPDOC Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | DPHLPDOC | Depending on the frequency of the current/voltage measured: $f_n$ ±2 Hz | | |
| | | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle: ±2° | | |
| | DPHHPDOC | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$)<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle: ±2° | | |
| Start time[1)2)] | $I_{Fault}$ = 2.0 × set *Start value* | Minimum | Typical | Maximum |
| | | 39 ms | 43 ms | 47 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms[3)] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) *Measurement mode* and *Pol quantity* = default, current before fault = 0.0 × $I_n$, voltage before fault = 1.0 × $U_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 1.5...20

## 4.1.3 Three-phase voltage-dependent overcurrent protection PHPVOC

### 4.1.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase voltage-dependent overcurrent protection | PHPVOC | 3I(U)> | 51V |

### 4.1.3.2 Function block




*Figure 197: Function block*

### 4.1.3.3 Functionality

The three-phase voltage-dependent overcurrent protection function PHPVOC is used for single-phase, two-phase or three-phase voltage-dependent time overcurrent protection of generators against overcurrent and short circuit conditions.

PHPVOC starts when the input phase current exceeds a limit which is dynamically calculated based on the measured terminal voltages. The operating characteristics can be selected to be either inverse definite minimum time IDMT or definite time DT.

PHPVOC contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.1.3.4 Analog channel configuration

PHPVOC has two analog group inputs which all must be properly configured.

*Table 388: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 389: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of PHPVOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

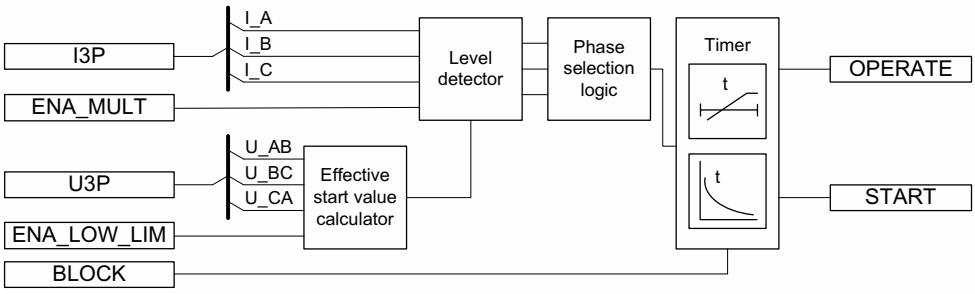



*Figure 198: Functional module diagram*

#### Effective start value calculator

The normal starting current above which the overcurrent protection starts is set through the *Start value* setting. The Effective start value of the current may need to be changed during certain conditions like magnetizing inrush or when the terminal voltages drop due to a fault. Hence, the effective start value calculator module dynamically calculates the effective start value above which the overcurrent protection starts.

Four methods of calculating the effective start value are provided in PHPVOC. These can be chosen with the *Control mode* setting to be either "Voltage control", "Input control", "Volt & Input Ctrl" or "No Volt dependency".

The calculated effective start value per phase, EFF_ST_VAL_A, EFF_ST_VAL_B, EFF_ST_VAL_C, is available in the Monitored data view and is used by the Level detector module.

All three phase-to-phase voltages should be available for the function to operate properly.

## Voltage control mode

In the Voltage control mode, the Effective start value is calculated based on the magnitude of input voltages U_AB, U_BC and U_CA. The voltage dependency is phase sensitive, which means that the magnitude of one input voltage controls the start value of only the corresponding phase, that is, the magnitude of voltage inputs U_AB, U_BC and U_CA independently control the current start values of phases A, B and C.

Two voltage control characteristics, voltage step and voltage slope, can be achieved with the *Voltage high limit* and *Voltage low limit* settings.

The voltage step characteristic is achieved when the *Voltage high limit* setting is equal to the *Voltage low limit* setting. The effective start value is calculated based on the equations.

| Voltage level | Effective start value (I> effective) |
|---|---|
| U < *Voltage high limit* | *Start value low* |
| U ≥ *Voltage high limit* | *Start value* |

In this example, U represents the measured input voltage. This voltage step characteristic is graphically represented in Figure 199.

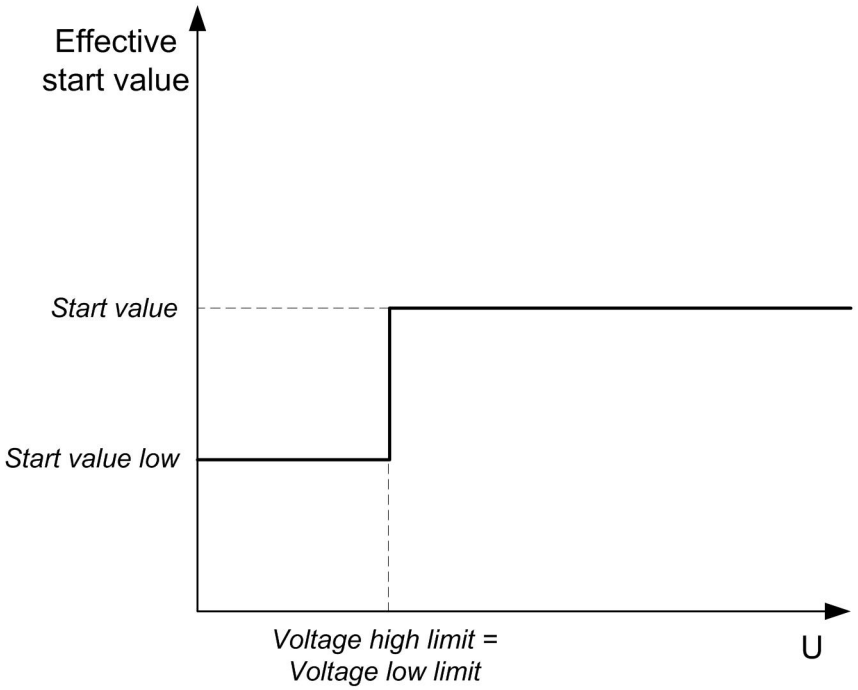



*Figure 199: Effective start value for voltage step characteristic*

The voltage slope characteristic is achieved by assigning different values to *Voltage high limit* and *Voltage low limit*. The effective start value calculation is based on the equations.

| Voltage level | Effective start value (I> effective) |
|---|---|
| U < *Voltage low limit* | *Start value low* |
| U ≥ *Voltage high limit* | *Start value* |

If *Voltage low limit* ≤ U < *Voltage high limit*,

$$I > (effective) = A - \left[ \left( \frac{A - I>}{C - D} \right) \cdot (C - U) \right]$$

(Equation 27)

A is set Start value low

I> is set Start value

C is set *Voltage high limit*

D is set *Voltage low limit*

Here U represents the measured input voltage. The voltage slope characteristic is graphically represented.

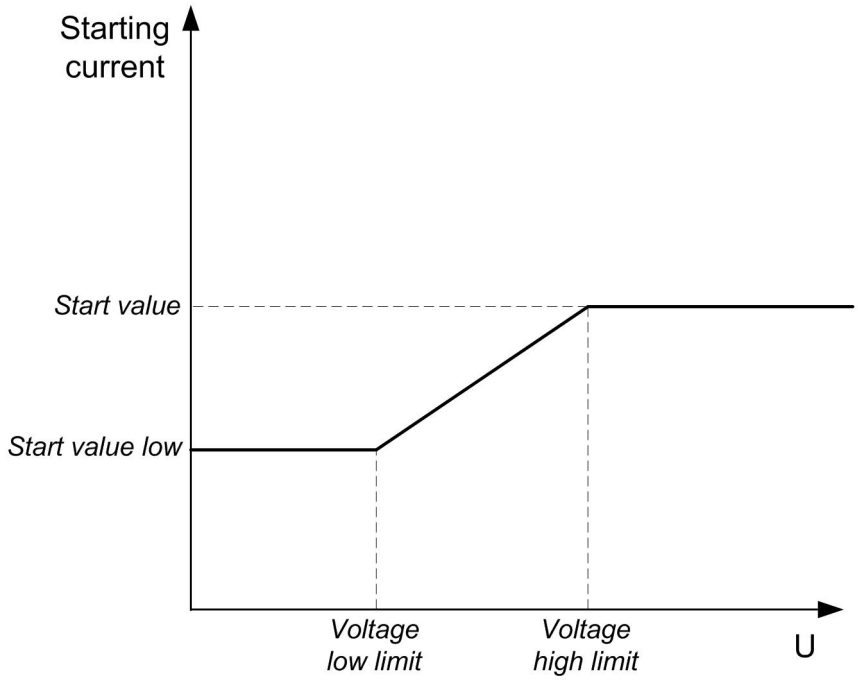



*Figure 200: Effective start value or voltage slope characteristic*

To achieve the voltage slope characteristics, *Voltage high limit* must always be set to a value greater than *Voltage low limit*.
If *Voltage high limit* is lower than *Voltage low limit*, the voltage step characteristic is active with *Voltage low limit* being the cutoff value.

The value of the setting *Start value* should always be greater than the setting *Start value low*. Otherwise, *Start value low* is used as the effective start value.

## External input control mode

The External input control mode is used to enable voltage control from an external application. If *Control mode* is set to the "Input Control" mode, the effective start value for all phases is influenced by the status of the binary input `ENA_LOW_LIM`.

*If ENA_LOW_LIM is TRUE :*
*Effective start value = Start value low*

(Equation 28)

*If ENA_LOW_LIM is FALSE :*
*Effective start value = Start value*

(Equation 29)

### Voltage and input control mode

If *Control mode* is set to "Voltage and input Ctrl", both the "Voltage control" and "Input control" modes are used. However, the “Input control” functionality is dominant over the “Voltage control” mode when ENA_LOW_LIM is active.

### No voltage dependency mode

When *Control mode* is set to "No Volt dependency", the effective start value has no voltage dependency and the function acts as a normal time overcurrent function with effective start value being equal to the *Start value* setting.

### Level detector

The measured phase currents are compared phasewise to the calculated effective start value. If the measured value exceeds the calculated effective start value, the Level detector reports the exceeding value to the phase selection logic. If the ENA_MULT input is active, the effective start value is multiplied by the *Start value Mult* setting.



Do not set the multiplier *Start value Mult* setting higher than necessary. If the value is too high, the function may not operate at all during an inrush followed by a fault, no matter how severe the fault is.

The start value multiplication is normally done when the inrush detection function INRPHAR is connected to the ENA_MULT input.

### Phase selection logic

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the measured current exceeds the setting. If the phase information matches the *Num of start phases* setting, the phase selection logic activates the Timer module.

### Timer

Once activated, the Timer module activates the START output.

Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user programmable IDMT curve is selected, the operation time characteristics are defined by the settings *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

In a drop-off situation, that is, when a fault suddenly disappears before the operating delay is exceeded, the timer reset state is activated. The functionality of the Timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or

"Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation. The START output is deactivated when the reset timer has elapsed.

The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The *Time multiplier* is used for scaling the IDMT operate and reset times.

The *Minimum operate time* setting defines the minimum desired operating time for IDMT operation. The setting is applicable only when the IDMT curves are used.

Though the *Time multiplier* and *Minimum operate time* settings are common for different IDMT curves, the operating time essentially depends upon the type of IDMT curve chosen.

The Timer calculates the start duration value START_DUR which indicates the percentage ratio of the start situation and the set operating time. This output is available in the Monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*. The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.1.3.6 Application

The three-phase voltage-dependent overcurrent protection is used as a backup protection for the generators and system from damage due to the phase faults which are not cleared by primary protection and associated breakers.

In case of a short circuit, the sustained fault current of the generator, determined by the machine synchronous reactance, could be below the full-load current. If the generator excitation power is fed from the generator terminals, a voltage drop caused by a short circuit also leads to low fault current. The primary protection, like normal overcurrent protection, might not detect this kind of fault situation. In some cases, the automatic

voltage regulator AVR can help to maintain high fault currents by controlling the generator excitation system. If the AVR is out of service or if there is an internal fault in the operation of AVR, the low fault currents can go unnoticed and therefore a voltage-depended overcurrent protection should be used for backup.

Two voltage control characteristics, voltage step and voltage slope, are available in PHPVOC. The choice is made based on the system conditions and the level of protection to be provided.

Voltage step characteristic is applied to generators used in industrial systems. Under close-up fault conditions when the generator terminal voltages drop below the settable threshold value, a new start value of the current, well below the normal load current, is selected. The control voltage setting should ensure that PHPVOC does not trip under the highest loading conditions to which the system can be subjected. Choosing too high a value for the control voltage may allow an undesired operation of the function during wide-area disturbances. When the terminal voltage of the generator is above the control voltage value, the normal start value is used. This ensures that PHPVOC does not operate during normal overloads when the generator terminal voltages are maintained near the normal levels.

Voltage slope characteristic is often used as an alternative to impedance protection on small to medium (5...150 MVA) size generators to provide backup to the differential protection. Other applications of the voltage slope characteristic protection exist in networks to provide better coordination and fault detection than plain overcurrent protection. The voltage slope method provides an improved sensitivity of overcurrent operation by making the overcurrent start value proportional to the terminal voltage. The current start value varies correspondingly with the generator terminal voltages between the set voltage high limit and voltage low limit, ensuring the operation of PHPVOC despite the drop in fault current value.

The operation of PHPVOC should be time-graded with respect to the main protection scheme to ensure that PHPVOC does not operate before the main protection.

### 4.1.3.7 Signals

*Table 390: PHPVOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |
| ENA_LOW_LIM | BOOLEAN | 0=False | Enable signal for voltage dependent lower start value |

*Table 391: PHPVOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.1.3.8 Settings

*Table 392: PHPVOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...5.00 | xIn | 0.01 | 0.05 | Start value |
| Start value low | 0.05...1.00 | xIn | 0.01 | 0.05 | Lower start value based on voltage control |
| Voltage high limit | 0.01...1.00 | xUn | 0.01 | 1.00 | Voltage high limit for voltage control |
| Voltage low limit | 0.01...1.00 | xUn | 0.01 | 1.00 | Voltage low limit for voltage control |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.05...15.00 | | 0.01 | 1.00 | Time multiplier in IEC/ANSI IDMT curves |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 40...200000 | ms | 10 | 40 | Operate delay time |

*Table 393: PHPVOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

*Table 394: PHPVOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.0086...120.0000 | | 1 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 1 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 1 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 395: PHPVOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |
| Control mode | 1=Voltage control<br>2=Input control<br>3=Voltage and input Ctl<br>4=No Volt dependency | | | 1=Voltage control | Type of control |
| Minimum operate time | 40...60000 | ms | 1 | 40 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.1.3.9 Monitored data

*Table 396: PHPVOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| EFF_ST_VAL_A | FLOAT32 | 0.00...50.00 | xIn | Effective start value for phase A |
| EFF_ST_VAL_B | FLOAT32 | 0.00...50.00 | xIn | Effective start value for phase B |
| EFF_ST_VAL_C | FLOAT32 | 0.00...50.00 | xIn | Effective start value for phase C |
| PHPVOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.1.3.10 Technical data

*Table 397: PHPVOC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage:<br>$f_n$ ±2 Hz |
| | Current:<br>±1.5% of the set value or ± 0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$ |
| Start time[1)2)] | Typically 26 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in inverse time mode | ±5.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

1) *Measurement mode* = default, current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.1.4 Three-phase thermal protection for feeders, cables and distribution transformers T1PTTR

### 4.1.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase thermal protection for feeders, cables and distribution transformers | T1PTTR | 3Ith>F | 49F |

### 4.1.4.2 Function block




*Figure 201: Function block*

### 4.1.4.3 Functionality

The increased utilization of power systems closer to the thermal limits has generated a need for a thermal overload function also for power lines.

A thermal overload is in some cases not detected by other protection functions, and the introduction of the three-phase thermal protection for feeders, cables and distribution transformers function T1PTTR allows the protected circuit to operate closer to the thermal limits.

An alarm level gives an early warning to allow operators to take action before the line trips. The early warning is based on the three-phase current measuring function using a thermal model with first order thermal loss with the settable time constant. If the temperature rise continues the function will operate based on the thermal model of the line.

Re-energizing of the line after the thermal overload operation can be inhibited during the time the cooling of the line is in progress. The cooling of the line is estimated by the thermal model.

### 4.1.4.4 Analog channel configuration

T1PTTR has one analog group input which must be properly configured.

*Table 398: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of T1PTTR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

The function uses ambient temperature which can be measured locally or remotely. Local measurement is done by the protection relay. Remote measurement uses analog GOOSE to connect AMB_TEMP input.

If the quality of remotely measured temperature is invalid or communication channel fails the function uses ambient temperature set in *Env temperature Set*.

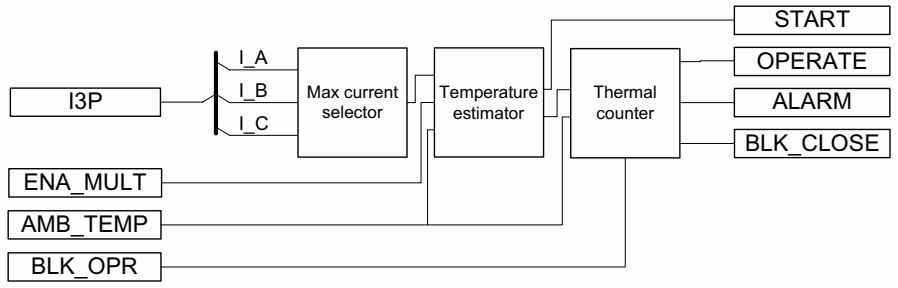



*Figure 202: Functional module diagram*

## Max current selector

The max current selector of the function continuously checks the highest measured TRMS phase current value. The selector reports the highest value to the temperature estimator.

## Temperature estimator

The final temperature rise is calculated from the highest of the three-phase currents according to the expression:

$$\Theta_{final} = \left( \frac{I}{I_{ref}} \right)^2 \cdot T_{ref}$$

(Equation 30)

I the largest phase current

$I_{ref}$ set *Current reference*

$T_{ref}$ set *Temperature rise*

The ambient temperature is added to the calculated final temperature rise estimation, and the ambient temperature value used in the calculation is also available in the monitored data as TEMP_AMB in degrees. If the final temperature estimation is larger than the set *Maximum temperature*, the START output is activated.

*Current reference* and *Temperature rise* setting values are used in the final temperature estimation together with the ambient temperature. It is suggested to set these values to the maximum steady state current allowed for the line or cable under

emergency operation for a few hours per years. Current values with the corresponding conductor temperatures are given in cable manuals. These values are given for conditions such as ground temperatures, ambient air temperature, the way of cable laying and ground thermal resistivity.

## Thermal counter

The actual temperature at the actual execution cycle is calculated as:

$$\Theta_n = \Theta_{n-1} + \left(\Theta_{final} - \Theta_{n-1}\right) \cdot \left(1 - e^{-\frac{\Delta t}{\tau}}\right)$$

(Equation 31)

$\Theta_n$ calculated present temperature

$\Theta_{n-1}$ calculated temperature at previous time step

$\Theta_{final}$ calculated final temperature with actual current

$\Delta t$ time step between calculation of actual temperature

$\tau$ thermal time constant for the protected device (line or cable), set *Time constant*

The actual temperature of the protected component (line or cable) is calculated by adding the ambient temperature to the calculated temperature, as shown above. The ambient temperature can be given a constant value or it can be measured. The calculated component temperature can be monitored as it is exported from the function as a real figure.

When the component temperature reaches the set alarm level *Alarm value*, the output signal ALARM is set. When the component temperature reaches the set trip level *Maximum temperature*, the OPERATE output is activated. The OPERATE signal pulse length is fixed to 100 ms

There is also a calculation of the present time to operation with the present current. This calculation is only performed if the final temperature is calculated to be above the operation temperature:

$$t_{operate} = -\tau \cdot \ln\left(\frac{\Theta_{final} - \Theta_{operate}}{\Theta_{final} - \Theta_n}\right)$$

(Equation 32)

Caused by the thermal overload protection function, there can be a lockout to reconnect the tripped circuit after operating. The lockout output BLK_CLOSE is activated at the same time when the OPERATE output is activated and is not reset until the device temperature has cooled down below the set value of the *Reclose temperature* setting. The *Maximum temperature* value must be set at least two degrees above the set value of *Reclose temperature*.

The time to lockout release is calculated, that is, the calculation of the cooling time to a set value. The calculated temperature can be reset to its initial value (the *Initial temperature* setting) via a control parameter that is located under the clear menu. This

is useful during testing when secondary injected current has given a calculated false temperature level.

$$t_{lockout_release} = -\tau \cdot \ln\left(\frac{\Theta_{final} - \Theta_{lockout_release}}{\Theta_{final} - \Theta_{n}}\right)$$

(Equation 33)

Here the final temperature is equal to the set or measured ambient temperature.

In some applications, the measured current can involve a number of parallel lines. This is often used for cable lines where one bay connects several parallel cables. By setting the *Current multiplier* parameter to the number of parallel lines (cables), the actual current on one line is used in the protection algorithm. To activate this option, the ENA_MULT input must be activated.

The ambient temperature can be measured with the RTD measurement. The measured temperature value is then connected, for example, from the AI_VAL3 output of the RTD function to the AMB_TEMP input of T1PTTR.

The *Env temperature Set* setting is used to define the ambient temperature if the ambient temperature measurement value is not connected to the AMB_TEMP input. The *Env temperature Set* setting is also used when the ambient temperature measurement connected to T1PTTR is set to “Not in use” in the RTD function.

The temperature calculation is initiated from the value defined with the *Initial temperature* setting parameter. This is done in case the protection relay is powered up, the function is turned "Off" and back "On" or reset through the Clear menu. The temperature is also stored in the nonvolatile memory and restored in case the protection relay is restarted.

The thermal time constant of the protected circuit is given in seconds with the *Time constant* setting. Please see cable manufacturers manuals for further details.

T1PTTR thermal model complies with the IEC 60255-149 standard.

### 4.1.4.6 Application

The lines and cables in the power system are constructed for a certain maximum load current level. If the current exceeds this level, the losses will be higher than expected. As a consequence, the temperature of the conductors will increase. If the temperature of the lines and cables reaches too high values, it can cause a risk of damages by, for example, the following ways:

- The sag of overhead lines can reach an unacceptable value.
- If the temperature of conductors, for example aluminium conductors, becomes too high, the material will be destroyed.
- In cables the insulation can be damaged as a consequence of overtemperature, and therefore phase-to-phase or phase-to-earth faults can occur.

In stressed situations in the power system, the lines and cables may be required to be overloaded for a limited time. This should be done without any risk for the above-mentioned risks.

The thermal overload protection provides information that makes temporary overloading of cables and lines possible. The thermal overload protection estimates the conductor temperature continuously. This estimation is made by using a thermal model of the line/cable that is based on the current measurement.

If the temperature of the protected object reaches a set warning level, a signal is given to the operator. This enables actions in the power system to be done before dangerous temperatures are reached. If the temperature continues to increase to the maximum allowed temperature value, the protection initiates a trip of the protected line.

### 4.1.4.7 Signals

*Table 399: T1PTTR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLK_OPR | BOOLEAN | 0=False | Block signal for operate outputs |
| ENA_MULT | BOOLEAN | 0=False | Enable Current multiplier |
| AMB_TEMP | FLOAT32 | 0 | The ambient temperature used in the calculation |

*Table 400: T1PTTR Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Thermal Alarm |
| BLK_CLOSE | BOOLEAN | Thermal overload indicator. To inhibite reclose. |

### 4.1.4.8 Settings

*Table 401: T1PTTR Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Env temperature Set | -50...100 | °C | 1 | 40 | Ambient temperature used when no external temperature measurement available |
| Current reference | 0.05...4.00 | xIn | 0.01 | 1.00 | The load current leading to Temperature raise temperature |
| Temperature rise | 0.0...200.0 | °C | 0.1 | 75.0 | End temperature rise above ambient |
| Time constant | 60...60000 | s | 1 | 2700 | Time constant of the line in seconds. |
| Maximum temperature | 22.0...200.0 | °C | 0.1 | 90.0 | Temperature level for operate |
| Alarm value | 20.0...150.0 | °C | 0.1 | 80.0 | Temperature level for start (alarm) |
| Reclose temperature | 20.0...150.0 | °C | 0.1 | 70.0 | Temperature for reset of block reclose after operate |

*Table 402: T1PTTR Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current multiplier | 1...5 | | 1 | 1 | Current multiplier when function is used for parallel lines |

*Table 403: T1PTTR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 404: T1PTTR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Initial temperature | -50.0...100.0 | °C | 0.1 | 0.0 | Temperature raise above ambient temperature at startup |

### 4.1.4.9 Monitored data

*Table 405: T1PTTR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TEMP | FLOAT32 | -100.0...9999.9 | °C | The calculated temperature of the protected object |
| TEMP_RL | FLOAT32 | 0.00...99.99 | | The calculated temperature of the protected object relative to the operate level |
| T_OPERATE | INT32 | 0...60000 | s | Estimated time to operate |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| T_ENA_CLOSE | INT32 | 0...60000 | s | Estimated time to deactivate BLK_CLOSE |
| TEMP_AMB | FLOAT32 | -99...999 | °C | The ambient temperature used in the calculation |
| T1PTTR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.1.4.10 Technical data

*Table 406: T1PTTR Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current measurement: ±1.5% of the set value or ±0.002 × $I_n$ (at currents in the range of 0.01...4.00 × $I_n$) |
| Operate time accuracy[1)] | ±2.0% of the theoretical value or ±0.50 s |

1) Overload current > 1.2 × Operate level temperature

## 4.1.5 Three-phase thermal overload protection, two time constants T2PTTR

### 4.1.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase thermal overload protection, two time constants | T2PTTR | 3Ith>T/G/C | 49T/G/C |

### 4.1.5.2 Function block




*Figure 203: Function block*

### 4.1.5.3 Functionality

The three-phase thermal overload protection, two time constants, function T2PTTR protects the transformer mainly from short-time overloads. The transformer is protected from long-time overloads with the oil temperature detector included in its equipment.

The alarm signal gives an early warning to allow the operators to take action before the transformer trips. The early warning is based on the three-phase current measuring function using a thermal model with two settable time constants. If the temperature rise continues, T2PTTR operates based on the thermal model of the transformer.

After a thermal overload operation, the re-energizing of the transformer is inhibited during the transformer cooling time. The transformer cooling is estimated with a thermal model.

### 4.1.5.4 Analog channel configuration

T2PTTR has one analog group input which must be properly configured.

*Table 407: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |



See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of T2PTTR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

The function uses ambient temperature which can be measured locally or remotely. Local measurement is done by the protection relay. Remote measurement uses analog GOOSE to connect `AMB_TEMP` input.

If the quality of remotely measured temperature is invalid or communication channel fails the function uses ambient temperature set in *Env temperature Set*.

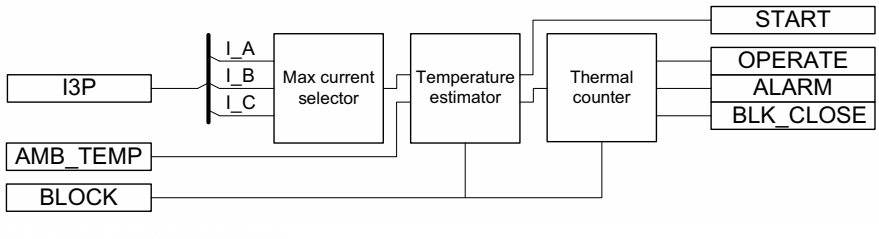



*Figure 204: Functional module diagram*

## Max current selector

The max current selector of the function continuously checks the highest measured TRMS phase current value. The selector reports the highest value to the thermal counter.

## Temperature estimator

The final temperature rise is calculated from the highest of the three-phase currents according to the expression:

$$\Theta_{final} = \left( \frac{I}{I_{ref}} \right)^2 \cdot T_{ref}$$

(Equation 34)

I highest measured phase current

$I_{ref}$ the set value of the *Current reference* setting

$T_{ref}$ the set value of the *Temperature rise* setting (temperature rise (°C) with the steady-state current $I_{ref}$

The ambient temperature value is added to the calculated final temperature rise estimation. If the total value of temperature is higher than the set operate temperature level, the START output is activated.

The *Current reference* setting is a steady-state current that gives the steady-state end temperature value *Temperature rise*. It gives a setting value corresponding to the rated power of the transformer.

The *Temperature rise* setting is used when the value of the reference temperature rise corresponds to the *Current reference* value. The temperature values with the corresponding transformer load currents are usually given by transformer manufacturers.

## Thermal counter

T2PTTR applies the thermal model of two time constants for temperature measurement. The temperature rise in degrees Celsius (°C) is calculated from the highest of the three-phase currents according to the expression:

$$\Delta\Theta = \left[ p \cdot \left( \frac{I}{I_{ref}} \right)^2 \cdot T_{ref} \right] \cdot \left( 1 - e^{-\frac{\Delta t}{\tau 1}} \right) + \left[ (1-p) \cdot \left( \frac{I}{I_{ref}} \right)^2 \cdot T_{ref} \right] \cdot \left( 1 - e^{-\frac{\Delta t}{\tau 2}} \right)$$

(Equation 35)

| | |
|---|---|
| ΔΘ | calculated temperature rise (°C) in transformer |
| I | measured phase current with the highest TRMS value |
| Iref | the set value of the *Current reference* setting (rated current of the protected object) |
| Tref | the set value of the *Temperature rise* setting (temperature rise setting (°C) with the steady-state current $I_{ref}$) |
| p | the set value of the *Weighting factor p* setting (weighting factor for the short time constant) |
| Δt | time step between the calculation of the actual temperature |
| $\tau_1$ | the set value of the *Short time constant* setting (the short heating / cooling time constant) |
| $\tau_2$ | the set value of the *Long time constant* setting (the long heating / cooling time constant) |

The warming and cooling following the two time-constant thermal curve is a characteristic of transformers. The thermal time constants of the protected transformer are given in seconds with the *Short time constant* and *Long time constant* settings. The *Short time constant* setting describes the warming of the transformer with respect to windings. The *Long time constant* setting describes the warming of the transformer with respect to the oil. Using the two time-constant model, the protection relay is able to follow both fast and slow changes in the temperature of the protected object.

The *Weighting factor p* setting is the weighting factor between *Short time constant* $\tau_1$ and *Long time constant* $\tau_2$. The higher the value of the *Weighting factor p* setting, the larger is the share of the steep part of the heating curve. When *Weighting factor p* =1, only *Short-time constant* is used. When *Weighting factor p* = 0, only *Long time constant* is used.

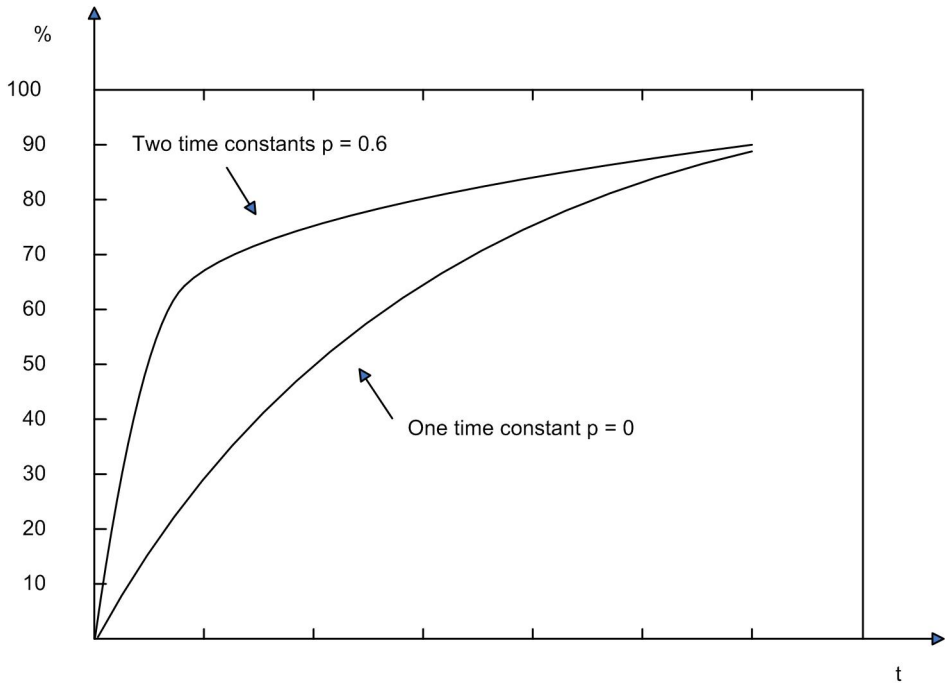



*Figure 205: Effect of the Weighting factor p factor and the difference between the two time constants and one time constant models*

The actual temperature of the transformer is calculated by adding the ambient temperature to the calculated temperature.

$$\Theta = \Delta\Theta + \Theta_{amb}$$

(Equation 36)

| | |
|---|---|
| $\Theta$ | temperature in transformer (°C) |
| $\Delta\Theta$ | calculated temperature rise (°C) in transformer |
| $\Theta_{amb}$ | set value of the *Env temperature Set* setting or measured ambient temperature |

The ambient temperature can be measured with RTD measurement. The measured temperature value is connected, for example, from the `AI_VAL3` output of the RTD function to the `AMB_TEMP` input of T2PTTR.

The *Env temperature Set* setting is used to define the ambient temperature if the ambient temperature measurement value is not connected to the `AMB_TEMP` input. The *Env temperature Set* setting is also used when the ambient temperature measurement connected to T2PTTR is set to “Not in use” in the RTD function.

The temperature calculation is initiated from the value defined with the *Initial temperature* and *Max temperature* setting parameters. The initial value is a percentage of *Max temperature* defined by *Initial temperature*. This is done when the protection relay is powered up or the function is turned off and back on or reset through the Clear

menu. The temperature is stored in a nonvolatile memory and restored if the protection relay is restarted.

The *Max temperature* setting defines the maximum temperature of the transformer in degrees Celsius (°C). The value of the *Max temperature* setting is usually given by transformer manufacturers. The actual alarm, operating and lockout temperatures for T2PTTR are given as a percentage value of the *Max temperature* setting.

When the transformer temperature reaches the alarm level defined with the *Alarm temperature* setting, the ALARM output signal is set. When the transformer temperature reaches the trip level value defined with the *Operate temperature* setting, the OPERATE output is activated. The OPERATE output is deactivated when the value of the measured current falls below 10 percent of the *Current Reference* value or the calculated temperature value falls below *Operate temperature*.

There is also a calculation of the present time to operation with the present current. T_OPERATE is only calculated if the final temperature is calculated to be above the operation temperature. The value is available in the monitored data view.

After operating, there can be a lockout to reconnect the tripped circuit due to the thermal overload protection function. The BLK_CLOSE lockout output is activated when the device temperature is above the *Reclose temperature* lockout release temperature setting value. The time to lockout release T_ENA_CLOSE is also calculated. The value is available in the monitored data view.

### 4.1.5.6 Application

The transformers in a power system are constructed for a certain maximum load current level. If the current exceeds this level, the losses are higher than expected. This results in a rise in transformer temperature. If the temperature rise is too high, the equipment is damaged:

- Insulation within the transformer ages faster, which in turn increases the risk of internal phase-to-phase or phase-to-earth faults.
- Possible hotspots forming within the transformer degrade the quality of the transformer oil.

During stressed situations in power systems, it is required to overload the transformers for a limited time without any risks. The thermal overload protection provides information and makes temporary overloading of transformers possible.

The permissible load level of a power transformer is highly dependent on the transformer cooling system. The two main principles are:

- ONAN: The air is naturally circulated to the coolers without fans, and the oil is naturally circulated without pumps.
- OFAF: The coolers have fans to force air for cooling, and pumps to force the circulation of the transformer oil.

The protection has several parameter sets located in the setting groups, for example one for a non-forced cooling and one for a forced cooling situation. Both the permissive steady-state loading level as well as the thermal time constant are influenced by the transformer cooling system. The active setting group can be changed by a parameter, or through a binary input if the binary input is enabled for it. This feature can be used for transformers where forced cooling is taken out of operation or extra cooling is switched on. The parameters can also be changed when a fan or pump fails to operate.

The thermal overload protection continuously estimates the internal heat content, that is, the temperature of the transformer. This estimation is made by using a thermal model of the transformer which is based on the current measurement.

If the heat content of the protected transformer reaches the set alarm level, a signal is given to the operator. This enables the action that needs to be taken in the power systems before the temperature reaches a high value. If the temperature continues to rise to the trip value, the protection initiates the trip of the protected transformer.

After the trip, the transformer needs to cool down to a temperature level where the transformer can be taken into service again. T2PTTR continues to estimate the heat content of the transformer during this cooling period using a set cooling time constant. The energizing of the transformer is blocked until the heat content is reduced to the set level.

The thermal curve of two time constants is typical for a transformer. The thermal time constants of the protected transformer are given in seconds with the *Short time constant* and *Long time constant* settings. If the manufacturer does not state any other value, the *Long time constant* can be set to 4920 s (82 minutes) for a distribution transformer and 7260 s (121 minutes) for a supply transformer. The corresponding *Short time constants* are 306 s (5.1 minutes) and 456 s (7.6 minutes).

If the manufacturer of the power transformer has stated only one, that is, a single time constant, it can be converted to two time constants. The single time constant is also used by itself if the p-factor *Weighting factor p* setting is set to zero and the time constant value is set to the value of the *Long time constant* setting. The thermal image corresponds to the one time constant model in that case.

*Table 408: Conversion table between one and two time constants*

| Single time constant (min) | *Short time constant* (min) | *Long time constant* (min) | *Weighting factor p* |
|---|---|---|---|
| 10 | 1.1 | 17 | 0.4 |
| 15 | 1.6 | 25 | 0.4 |
| 20 | 2.1 | 33 | 0.4 |
| 25 | 2.6 | 41 | 0.4 |
| 30 | 3.1 | 49 | 0.4 |
| 35 | 3.6 | 58 | 0.4 |
| 40 | 4.1 | 60 | 0.4 |
| 45 | 4.8 | 75 | 0.4 |

Table continues on next page

| Single time constant (min) | *Short time constant* (min) | *Long time constant* (min) | *Weighting factor p* |
|---|---|---|---|
| 50 | 5.1 | 82 | 0.4 |
| 55 | 5.6 | 90 | 0.4 |
| 60 | 6.1 | 98 | 0.4 |
| 65 | 6.7 | 107 | 0.4 |
| 70 | 7.2 | 115 | 0.4 |
| 75 | 7.8 | 124 | 0.4 |

The default *Max temperature* setting is 105°C. This value is chosen since even though the IEC 60076-7 standard recommends 98°C as the maximum allowable temperature in long-time loading, the standard also states that a transformer can withstand the emergency loading for weeks or even months, which may produce the winding temperature of 140°C. Therefore, 105°C is a safe maximum temperature value for a transformer if the *Max temperature* setting value is not given by the transformer manufacturer.

### 4.1.5.7 Signals

*Table 409: T2PTTR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| AMB_TEMP | FLOAT32 | 0 | The ambient temperature used in the calculation |

*Table 410: T2PTTR Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Thermal Alarm |
| BLK_CLOSE | BOOLEAN | Thermal overload indicator. To inhibite reclose. |

### 4.1.5.8 Settings

*Table 411: T2PTTR Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Env temperature Set | -50...100 | °C | 1 | 40 | Ambient temperature used when no external temperature measurement available |
| Temperature rise | 0.0...200.0 | °C | 0.1 | 78.0 | End temperature rise above ambient |
| Max temperature | 22.0...200.0 | °C | 0.1 | 105.0 | Maximum temperature allowed for the transformer |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate temperature | 80.0...120.0 | % | 0.1 | 100.0 | Operate temperature, percent value |
| Alarm temperature | 40.0...100.0 | % | 0.1 | 90.0 | Alarm temperature, percent value |
| Reclose temperature | 40.0...100.0 | % | 0.1 | 60.0 | Temperature for reset of block reclose after operate |
| Short time constant | 6...60000 | s | 1 | 450 | Short time constant in seconds |
| Long time constant | 60...60000 | s | 1 | 7200 | Long time constant in seconds |
| Weighting factor p | 0.00...1.00 | | 0.01 | 0.40 | Weighting factor of the short time constant |

*Table 412: T2PTTR Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current reference | 0.05...4.00 | xIn | 0.01 | 1.00 | The load current leading to Temperature raise temperature |

*Table 413: T2PTTR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 414: T2PTTR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Initial temperature | 0.0...100.0 | % | 0.1 | 80.0 | Initial temperature, percent value |

### 4.1.5.9 Monitored data

*Table 415: T2PTTR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TEMP | FLOAT32 | -100.0...9999.9 | °C | The calculated temperature of the protected object |
| TEMP_RL | FLOAT32 | 0.00...99.99 | | The calculated temperature of the protected object relative to the operate level |
| T_OPERATE | INT32 | 0...60000 | s | Estimated time to operate |
| T_ENA_CLOSE | INT32 | 0...60000 | s | Estimated time to deactivate BLK_CLOSE in seconds |
| TEMP_AMB | FLOAT32 | -99...999 | °C | The ambient temperature used in the calculation |
| T2PTTR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.1.5.10 Technical data

*Table 416: T2PTTR Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current measurement: ±1.5% of the set value or ±0.002 x $I_n$ (at currents in the range of 0.01...4.00 x $I_n$) |
| Operate time accuracy[1)] | ±2.0% of the theoretical value or ±0.50 s |

1) Overload current > 1.2 x Operate level temperature

## 4.1.6 Motor load jam protection JAMPTOC

### 4.1.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Motor load jam protection | JAMPTOC | Ist> | 50TDJAM |

### 4.1.6.2 Function block




*Figure 206: Function block*

### 4.1.6.3 Functionality

The motor load jam protection function JAMPTOC is used for protecting the motor in stall or mechanical jam situations during the running state.

When the motor is started, a separate function is used for the startup protection, and JAMPTOC is normally blocked during the startup period. When the motor has passed the starting phase, JAMPTOC monitors the magnitude of phase currents. The function starts when the measured current exceeds the breakdown torque level, that is, above the set limit. The operation characteristic is definite time.

The function contains a blocking functionality. It is possible to block the function outputs.

### 4.1.6.4 Analog channel configuration

JAMPTOC has one analog group input which must be properly configured.

*Table 417: Analog signals*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of JAMPTOC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

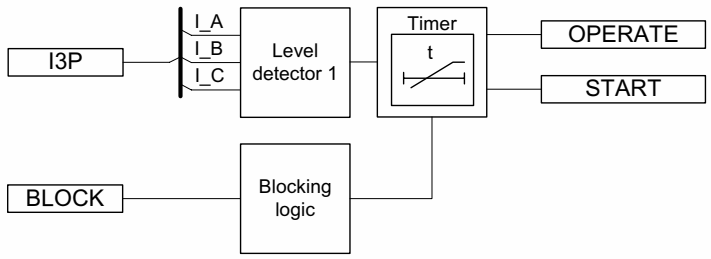



*Figure 207: Functional module diagram*

#### Level detector

The measured phase currents are compared to the set *Start value*. The TRMS values of the phase currents are considered for the level detection. The timer module is enabled if at least two of the measured phase currents exceed the set *Start value*.

#### Timer

Once activated, the internal `START` signal is activated. The value is available only through the Monitored data view. The time characteristic is according to DT. When the operation timer has reached the *Operate delay time* value, the `OPERATE` output is activated.

When the timer has elapsed but the motor stall condition still exists, the `OPERATE` output remains active until the phase currents values drop below the *Start value*, that is, until the stall condition persists. If the drop-off situation occurs while the operating

time is still counting, the reset timer is activated. If the drop-off time exceeds the set *Reset delay time*, the operating timer is reset.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.1.6.6 Application

The motor protection during stall is primarily needed to protect the motor from excessive temperature rise, as the motor draws large currents during the stall phase. This condition causes a temperature rise in the stator windings. Due to reduced speed, the temperature also rises in the rotor. The rotor temperature rise is more critical when the motor stops.

The physical and dielectric insulations of the system deteriorate with age and the deterioration is accelerated by the temperature increase. Insulation life is related to the time interval during which the insulation is maintained at a given temperature.

An induction motor stalls when the load torque value exceeds the breakdown torque value, causing the speed to decrease to zero or to some stable operating point well below the rated speed. This occurs, for example, when the applied shaft load is suddenly increased and is greater than the producing motor torque due to the bearing failures. This condition develops a motor current almost equal to the value of the locked-rotor current.

JAMPTOC is designed to protect the motor in stall or mechanical jam situations during the running state. To provide a good and reliable protection for motors in a stall situation, the temperature effects on the motor have to be kept within the allowed limits.

### 4.1.6.7 Signals

*Table 418: JAMPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 419: JAMPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |

### 4.1.6.8 Settings

*Table 420: JAMPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Start value | 0.10...10.00 | xIn | 0.01 | 2.50 | Start value |
| Operate delay time | 100...120000 | ms | 10 | 2000 | Operate delay time |

*Table 421: JAMPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 100 | Reset delay time |

### 4.1.6.9 Monitored data

*Table 422: JAMPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START | BOOLEAN | 0=False<br>1=True | | Start |
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| JAMPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.1.6.10 Technical data

*Table 423: JAMPTOC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

## 4.1.7 Loss of load supervision LOFLPTUC

### 4.1.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Loss of load supervision | LOFLPTUC | 3I< | 37 |

### 4.1.7.2 Function block




*Figure 208: Function block*

### 4.1.7.3 Functionality

The loss of load supervision function LOFLPTUC is used to detect a sudden load loss which is considered as a fault condition.

LOFLPTUC starts when the current is less than the set limit. It operates with the definite time (DT) characteristics, which means that the function operates after a predefined operate time and resets when the fault current disappears.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.1.7.4 Analog channel configuration

LOFLPTUC has one analog group input which must be properly configured.

*Table 424: Analog signals*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.7.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of LOFLPTUC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

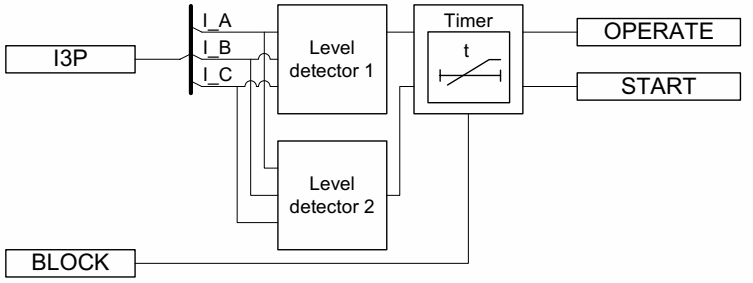



*Figure 209: Functional module diagram*

#### Level detector 1

This module compares the phase currents (RMS value) to the set *Start value high* setting. If all the phase current values are less than the set *Start value high* value, the loss of load condition is detected and an enable signal is sent to the timer. This signal is disabled after one or several phase currents have exceeded the set *Start value high* value of the element.

#### Level detector 2

This is a low-current detection module, which monitors the de-energized condition of the motor. It compares the phase currents (RMS value) to the set *Start value low* setting. If any of the phase current values is less than the set *Start value low*, a signal is sent to block the operation of the timer.

### Timer

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

The BLOCK signal blocks the operation of the function and resets the timer.

## 4.1.7.6 Application

When a motor runs with a load connected, it draws a current equal to a value between the no-load value and the rated current of the motor. The minimum load current can be determined by studying the characteristics of the connected load. When the current drawn by the motor is less than the minimum load current drawn, it can be inferred that the motor is either disconnected from the load or the coupling mechanism is faulty. If the motor is allowed to run in this condition, it may aggravate the fault in the coupling mechanism or harm the personnel handling the machine. Therefore, the motor has to be disconnected from the power supply as soon as the above condition is detected.

LOFLPTUC detects the condition by monitoring the current values and helps disconnect the motor from the power supply instantaneously or after a delay according to the requirement.

When the motor is at standstill, the current will be zero and it is not recommended to activate the trip during this time. The minimum current drawn by the motor when it is connected to the power supply is the no load current, that is, the higher start value current. If the current drawn is below the lower start value current, the motor is disconnected from the power supply. LOFLPTUC detects this condition and interprets that the motor is de-energized and disables the function to prevent unnecessary trip events.

## 4.1.7.7 Signals

*Table 425: LOFLPTUC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block all binary outputs by resetting timers |

*Table 426: LOFLPTUC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.1.7.8 Settings

*Table 427: LOFLPTUC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value low | 0.01...0.50 | xIn | 0.01 | 0.10 | Current setting/Start value low |
| Start value high | 0.01...1.00 | xIn | 0.01 | 0.50 | Current setting/Start value high |
| Operate delay time | 400...600000 | ms | 10 | 2000 | Operate delay time |

*Table 428: LOFLPTUC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 429: LOFLPTUC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.1.7.9 Monitored data

*Table 430: LOFLPTUC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| LOFLPTUC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.1.7.10 Technical data

*Table 431: LOFLPTUC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Start time | Typically 300 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 1.04 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

## 4.1.8 Loss of phase, undercurrent PHPTUC

### 4.1.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Loss of phase, undercurrent | PHPTUC1 | 3I< | 37 |

### 4.1.8.2 Function block

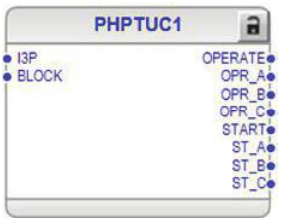



*Figure 210: Function block*

### 4.1.8.3 Functionality

The phase undercurrent protection function PHPTUC is used to detect an undercurrent that is considered as a fault condition.

PHPTUC starts when the current is less than the set limit. Operation time characteristics are according to definite time (DT).

The function contains a blocking functionality. It is possible to block function outputs and reset the definite timer.

### 4.1.8.4 Analog input configuration

PHPTUC has one analog group input which must be properly configured.

*Table 432: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks

in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.8.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PHPTUC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

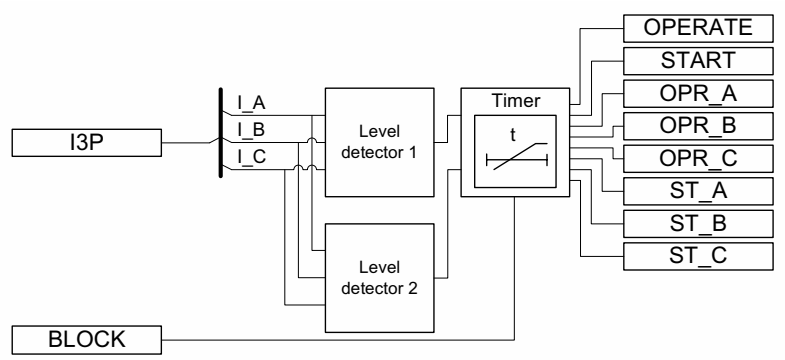



*Figure 211: Functional module diagram*

#### Level detector 1

This module compares the phase currents (RMS value) to the *Start value high* setting. The *Operation mode* setting can be used to select the "3-phase" or "1-phase" mode.

If in the "3-phase" mode all the phase current values are less than the value of the *Start value high* setting, the condition is detected and an enable signal is sent to the timer. This signal is disabled after one or several phase currents have exceeded the set *Start value high* value of the element.

If in the "1-phase" mode any of the phase current values are less than the value of the *Start value high* setting, the condition is detected and an enable signal is sent to the timer. This signal is disabled after all the phase currents have exceeded the set *Start value high* value of the element.

The protection relay does not accept the *Start value* to be smaller than *Current block value*

#### Level detector 2

This is a low-current detection module that monitors the de-energized condition of the protected object. The module compares the phase currents (RMS value) to the *Start value low* setting. If all the phase current values are less than the *Start value low* setting, a signal is sent to block the operation of the timer.

### Timer

Once activated, the timer activates the START output and the phase-specific ST_X output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output and the phase-specific OPR_X output are activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available through the monitored data view.

The BLOCK signal blocks the operation of the function and resets the timer.

## 4.1.8.6 Application

In some cases, smaller distribution power transformers are used where the high-side protection involves only power fuses. When one of the high-side fuses blows in a single-phase condition, knowledge of it on the secondary side is lacking. The resulting negative-sequence current leads to a premature failure due to excessive heating and breakdown of the transformer insulation. Knowledge of this condition when it occurs allows for a quick fuse replacement and saves the asset.

The *Start value low* setting can be set to zero to not block PHPTUC with a low three-phase current. However, this results in an unnecessary event sending when the transformer or protected object is disconnected.

Phase-specific start and operate can give a better picture about the evolving faults when one phase has started first and another follows.

PHPTUC is meant to be a general protection function, so that it could be used in other cases too.

In case of undercurrent-based motor protection, see the Loss of load protection.

## 4.1.8.7 Signals

*Table 433: PHPTUC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block all binary outputs by resetting timers |

*Table 434: PHPTUC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| OPR_A | BOOLEAN | Operate phase A |
| OPR_B | BOOLEAN | Operate phase B |
| OPR_C | BOOLEAN | Operate phase C |
| START | BOOLEAN | Start |
| ST_A | BOOLEAN | Start phase A |
| ST_B | BOOLEAN | Start phase B |
| ST_C | BOOLEAN | Start phase C |

### 4.1.8.8 Settings

*Table 435: PHPTUC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current block value | 0.00...0.50 | xIn | 0.01 | 0.10 | Low current setting to block internally |
| Start value | 0.01...1.00 | xIn | 0.01 | 0.50 | Current setting to start |
| Operate delay time | 50...200000 | ms | 10 | 2000 | Operate delay time |

*Table 436: PHPTUC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=Three Phase<br>2=Single Phase | | | 1=Three Phase | Number of phases needed to start |

*Table 437: PHPTUC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.1.8.9 Monitored data

*Table 438: PHPTUC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHPTUC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.1.8.10 Technical data

*Table 439: PHPTUC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the current measured: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Start time | Typically <55 ms |
| Reset time | <40 ms |
| Reset ratio | Typically 1.04 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | mode ±1.0% of the set value or ±20 ms |

## 4.1.9 Thermal overload protection for motors MPTTR

### 4.1.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Thermal overload protection for motors | MPTTR | 3Ith>M | 49M |

### 4.1.9.2 Function block




*Figure 212: Function block*

### 4.1.9.3 Functionality

The thermal overload protection for motors function MPTTR protects the electric motors from overheating. MPTTR models the thermal behavior of motor on the basis of the measured load current and disconnects the motor when the thermal content reaches 100 percent. The thermal overload conditions are the most often encountered abnormal conditions in industrial motor applications. The thermal overload conditions are typically the result of an abnormal rise in the motor running current, which produces an increase in the thermal dissipation of the motor and temperature or reduces cooling. MPTTR prevents an electric motor from drawing excessive current and overheating, which causes the premature insulation failures of the windings and, in worst cases, burning out of the motors.

### 4.1.9.4 Analog channel configuration

MPTTR has one analog group input which must be properly configured.

*Table 440: Analog signals*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.9.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of MPTTR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

The function uses ambient temperature which can be measured locally or remotely. Local measurement is done by the protection relay. Remote measurement uses analog GOOSE to connect `AMB_TEMP` input.

If the quality of remotely measured temperature is invalid or communication channel fails the function uses ambient temperature set in *Env temperature Set*.

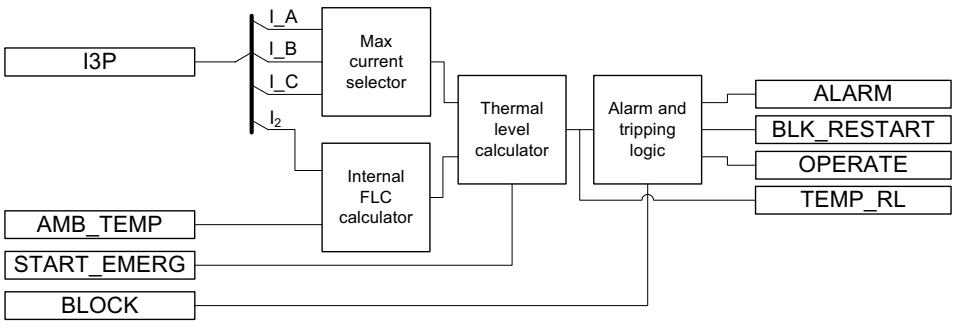



*Figure 213: Functional module diagram*

## Max current selector

Max current selector selects the highest measured TRMS phase current and reports it to Thermal level calculator.

## Internal FLC calculator

Full load current (FLC) of the motor is defined by the manufacturer at an ambient temperature of 40°C. Special considerations are required with an application where the ambient temperature of a motor exceeds or remains below 40°C. A motor operating at a higher temperature, even if at or below rated load, can subject the motor windings to excessive temperature similar to that resulting from overload operation at normal ambient temperature. The motor rating has to be appropriately reduced for operation in such high ambient temperatures. Similarly, when the ambient temperature is considerably lower than the nominal 40°C, the motor can be slightly overloaded. For calculating thermal level it is better that the FLC values are scaled for different temperatures. The scaled currents are known as internal FLC. An internal FLC is calculated based on the ambient temperature shown in the table. The *Env temperature mode* setting defines whether the thermal level calculations are based on FLC or internal FLC.

When the value of the *Env temperature mode* setting is set to the "FLC Only" mode, no internal FLC is calculated. Instead, the FLC given in the data sheet of the manufacturer is used. When the value of the *Env temperature mode* setting is set to "Set Amb Temp" mode, the internal FLC is calculated based on the ambient temperature taken as an input through the *Env temperature Set* setting. When the *Env temperature mode* setting is on "Use input" mode, the internal FLC is calculated from temperature data available through resistance temperature detectors (RTDs) using the AMB_TEMP input.

*Table 441: Modification of internal FLC*

| Ambient Temperature $T_{amb}$ | Internal FLC |
|---|---|
| <20°C | FLC x 1.09 |
| 20 to <40°C | FLC x (1.18 - $T_{amb}$ x 0.09/20) |
| 40°C | FLC |
| >40 to 65°C | FLC x (1 –[($T_{amb}$ -40)/100]) |
| >65°C | FLC x 0.75 |

The ambient temperature is used for calculating thermal level and it is available in the monitored data view from the TEMP_AMB output. The activation of the BLOCK input does not affect the TEMP_AMB output.

The *Env temperature Set* setting is used:

- If the ambient temperature measurement value is not connected to the AMB_TEMP input in ACT.
- When the ambient temperature measurement connected to 49M is set to "Not in use" in the RTD function.
- In case of any errors or malfunctioning in the RTD output.

## Thermal level calculator

The module calculates the thermal load considering the TRMS and negative-sequence currents. The heating up of the motor is determined by the square value of the load current.

However, in case of unbalanced phase currents, the negative-sequence current also causes additional heating. By deploying a protection based on both current components, abnormal heating of the motor is avoided.

The thermal load is calculated based on different situations or operations and it also depends on the phase current level. The equations used for the heating calculations are:

$$\theta_B = \left[ \left( \frac{I}{k \cdot I_r} \right)^2 + K_2 \cdot \left( \frac{I_2}{k \cdot I_r} \right)^2 \right] \cdot \left( 1 - e^{-t/\tau} \right) \cdot p\%$$

(Equation 37)

$$\theta_A = \left[ \left( \frac{I}{k \cdot I_r} \right)^2 + K_2 \cdot \left( \frac{I_2}{k \cdot I_r} \right)^2 \right] \cdot \left( 1 - e^{-t/\tau} \right) \cdot 100\%$$

(Equation 38)

I TRMS value of the measured max of phase currents

$I_r$ set *Current reference*, FLC or internal FLC

$I_2$ measured negative sequence current

k set value of *Overload factor*

$K_2$ set value of *Negative Seq factor*

p set value of *Weighting factor*

$\tau$ time constant

The equation $\theta_B$ is used when the values of all the phase currents are below the overload limit, that is, k x $I_r$. The equation $\theta_A$ is used when the value of any one of the phase currents exceeds the overload limit.

During overload condition, the thermal level calculator calculates the value of $\theta_B$ in background, and when the overload ends the thermal level is brought linearly from $\theta_A$ to $\theta_B$ with a speed of 1.66 percent per second. For the motor at standstill, that is, when the current is below the value of 0.12 x $I_r$, the cooling is expressed as:

$$\theta = \theta_{02} \cdot e^{\frac{-t}{\tau}}$$

(Equation 39)

$\theta_{02}$ initial thermal level when cooling begins

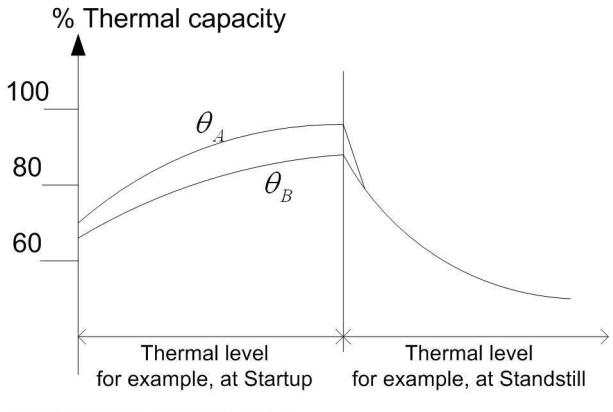



*Figure 214: Thermal behavior*

The required overload factor and negative sequence current heating effect factor are set by the values of the *Overload factor* and *Negative Seq factor* settings.

In order to accurately calculate the motor thermal condition, different time constants are used in the above equations. These time constants are employed based on different motor running conditions, for example starting, normal or stop, and are set through the *Time constant start*, *Time constant normal* and *Time constant stop* settings. Only one time constant is valid at a time.

*Table 442: Time constant and the respective phase current values*

| Time constant (tau) in use | Phase current |
|---|---|
| Time constant start | Any current whose value is over 2.5 x $I_r$ |
| Time constant normal | Any current whose value is over 0.12 x $I_r$ and all currents are below 2.5 x $I_r$ |
| Time constant stop | All the currents whose values are below 0.12 x $I_r$ |

The *Weighting factor p* setting determines the ratio of the thermal increase of the two curves $\theta_A$ and $\theta_B$.

The thermal level at the power-up of the protection relay is defined by the *Initial thermal Val* setting.

The temperature calculation is initiated from the value defined in the *Initial thermal Val* setting. This is done if the protection relay is powered up or the function is turned off and back on or reset through the Clear menu.

The calculated temperature of the protected object relative to the operate level, the TEMP_RL output, is available through the monitored data view or through the output signal TEMP_RL. The activation of the BLOCK input does not affect the calculated temperature.

The thermal level at the beginning of the start-up condition of a motor and at the end of the start-up condition is available in the monitored data view at the THERMLEV_ST and THERMLEV_END outputs respectively. The activation of the BLOCK input does not have any effect on these outputs.

## Alarm and tripping logic

The module generates alarm, restart inhibit and tripping signals.

When the thermal level exceeds the set value of the *Alarm thermal value* setting, the ALARM output is activated. Sometimes a condition arises when it becomes necessary to inhibit the restarting of a motor, for example in case of some extreme starting condition like long starting time. If the thermal content exceeds the set value of the *Restart thermal val* setting, the BLK_RESTART output is activated. The time for the next possible motor start-up is available through the monitored data view from the T_ENARESTART output. The T_ENARESTART output estimates the time for the BLK_RESTART deactivation considering as if the motor is stopped.

When the emergency start signal START_EMERG is set high, the thermal level is set to a value below the thermal restart inhibit level. This allows at least one motor start-up, even though the thermal level has exceeded the restart inhibit level.

When the thermal content reaches 100 percent, the OPERATE output is activated. The OPERATE output is deactivated when the value of the measured current falls below 12 percent of *Current reference* or the thermal content drops below 100 percent.

The activation of the BLOCK input blocks the ALARM, BLK_RESTART and OPERATE outputs.

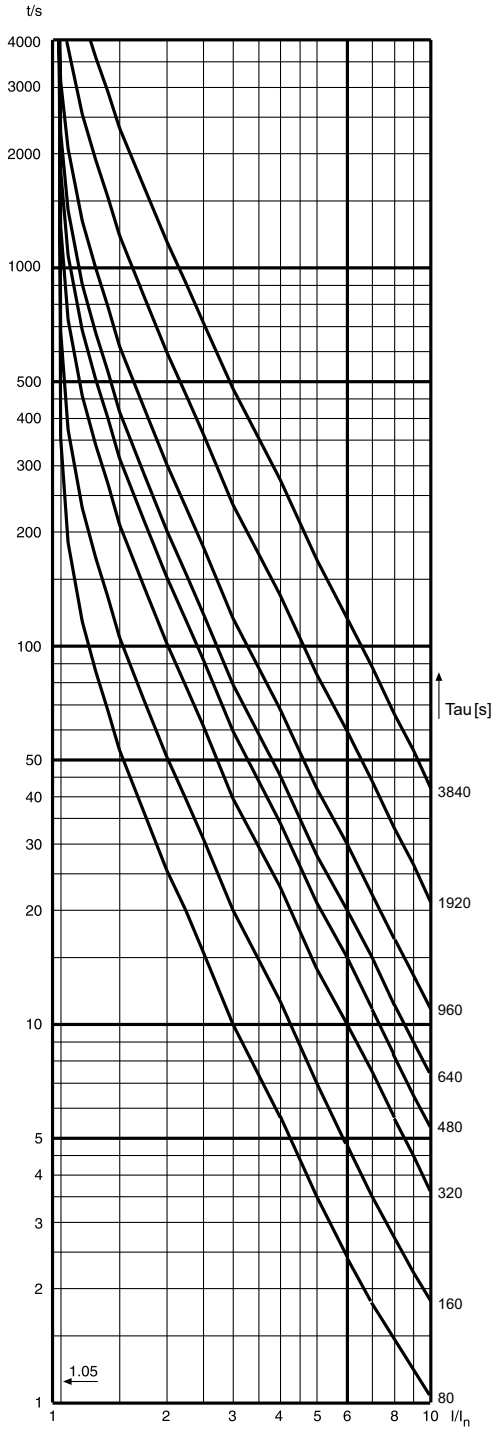



*Figure 215: Trip curves when no prior load and p=20...100 %. Overload factor = 1.05.*

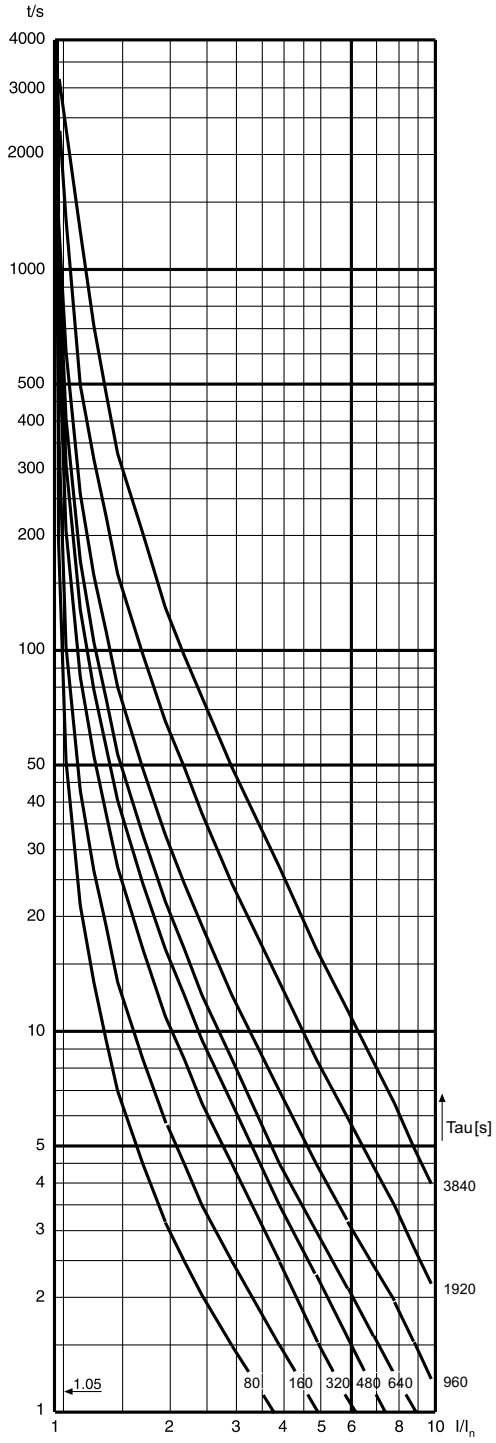



*Figure 216: Trip curves at prior load 1 x FLC and p=100 %, Overload factor = 1.05.*

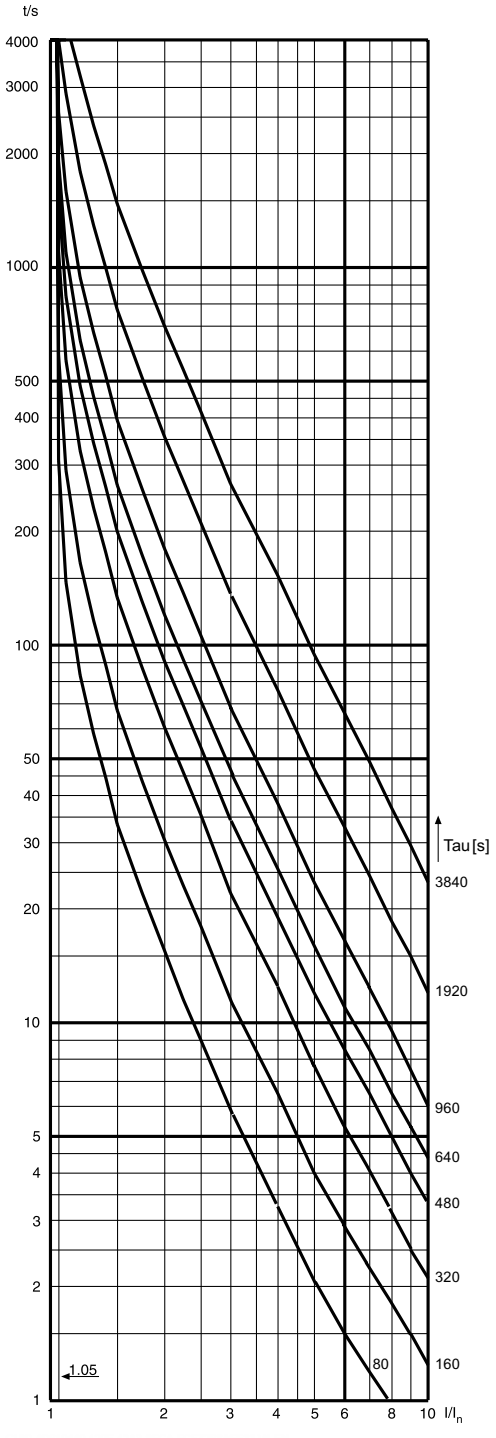



*Figure 217: Trip curves at prior load 1 x FLC and p=50 %. Overload factor = 1.05.*

### 4.1.9.6 Application

MPTTR is intended to limit the motor thermal level to predetermined values during the abnormal motor operating conditions. This prevents a premature motor insulation failure.

The abnormal conditions result in overheating and include overload, stalling, failure to start, high ambient temperature, restricted motor ventilation, reduced speed operation, frequent starting or jogging, high or low line voltage or frequency, mechanical failure of the driven load, improper installation and unbalanced line voltage or single phasing. The protection of insulation failure by the implementation of current sensing cannot detect some of these conditions, such as restricted ventilation. Similarly, the protection by sensing temperature alone can be inadequate in cases like frequent starting or jogging. The thermal overload protection addresses these deficiencies to a larger extent by deploying a motor thermal model based on load current.

The thermal load is calculated using the true RMS phase value and negative sequence value of the current. The heating up of the motor is determined by the square value of the load current. However, while calculating the thermal level, the rated current should be re-rated or de-rated depending on the value of the ambient temperature. Apart from current, the rate at which motor heats up or cools is governed by the time constant of the motor.

#### Setting the weighting factor

There are two thermal curves: one which characterizes the short-time loads and long-time overloads and which is also used for tripping and another which is used for monitoring the thermal condition of the motor. The value of the *Weighting factor p* setting determines the ratio of the thermal increase of the two curves.

When the *Weighting factor p* setting is 100 percent, a pure single time constant thermal unit is produced which is used for application with the cables. As presented in Figure 218, the hot curve with the value of *Weighting factor p* being 100 percent only allows an operate time which is about 10 percent of that with no prior load. For example, when the set time constant is 640 seconds, the operate time with the prior load 1 x FLC (full Load Current) and overload factor 1.05 is only 2 seconds, even if the motor could withstand at least 5 to 6 seconds. To allow the use of the full capacity of the motor, a lower value of *Weighting factor p* should be used.

Normally, an approximate value of half of the thermal capacity is used when the motor is running at full load. Thus by setting *Weighting factor p* to 50 percent, the protection relay notifies a 45 to 50 percent thermal capacity use at full load.

For direct-on-line started motors with hot spot tendencies, the value of *Weighting factor p* is typically set to 50 percent, which will properly distinguish between short-time thermal stress and long-time thermal history. After a short period of thermal stress, for example a motor start-up, the thermal level starts to decrease quite sharply, simulating the leveling out of the hot spots. Consequently, the probability of successive allowed start-ups increases.

When protecting the objects without hot spot tendencies, for example motors started with soft starters, and cables, the value of *Weighting factor p* is set to 100 percent. With the value of *Weighting factor p* set to 100 percent, the thermal level decreases slowly after a heavy load condition. This makes the protection suitable for applications where no hot spots are expected. Only in special cases where the thermal overload protection is required to follow the characteristics of the object to be protected more closely and the thermal capacity of the object is very well known, a value between 50 and 100 percent is required.

For motor applications where, for example, two hot starts are allowed instead of three cold starts, the value of the setting *Weighting factor p* being 40 percent has proven to be useful. Setting the value of *Weighting factor p* significantly below 50 percent should be handled carefully as there is a possibility to overload the protected object as a thermal unit might allow too many hot starts or the thermal history of the motor has not been taken into account sufficiently.

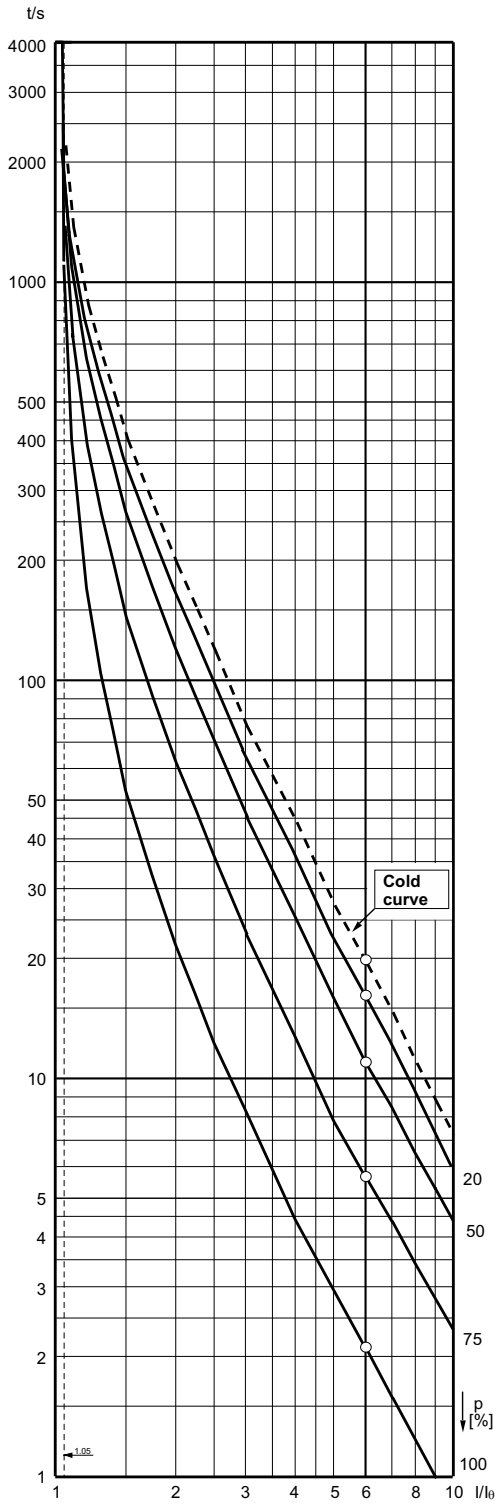



*Figure 218: The influence of Weighting factor p at prior load 1xFLC, timeconstant = 640 s, and Overload factor = 1.05*

## Setting the overload factor

The value of *Overload factor* defines the highest permissible continuous load. The recommended value is 1.05.

## Setting the negative sequence factor

During the unbalance condition, the symmetry of the stator currents is disturbed and a counter-rotating negative sequence component current is set up. An increased stator current causes additional heating in the stator and the negative sequence component current excessive heating in the rotor. Also mechanical problems like rotor vibration can occur.

The most common cause of unbalance for three-phase motors is the loss of phase resulting in an open fuse, connector or conductor. Often mechanical problems can be more severe than the heating effects and therefore a separate unbalance protection is used.

Unbalances in other connected loads in the same busbar can also affect the motor. A voltage unbalance typically produces 5 to 7 times higher current unbalance. Because the thermal overload protection is based on the highest TRMS value of the phase current, the additional heating in stator winding is automatically taken into account. For more accurate thermal modeling, the *Negative Seq factor* setting is used for taking account of the rotor heating effect.

$$Negative\,Seq\,factor = \frac{R_{R2}}{R_{R1}}$$

(Equation 40)

$R_{R2}$ rotor negative sequence resistance

$R_{R1}$ rotor positive sequence resistance

A conservative estimate for the setting can be calculated:

$$Negative\,Seq\,factor = \frac{175}{I_{LR}^2}$$

(Equation 41)

$I_{LR}$ locked rotor current (multiple of set *Rated current*). The same as the start-up current at the beginning of the motor start-up.

For example, if the rated current of a motor is 230 A, start-up current is 5.7 x $I_r$,

$$Negative\,Seq\,factor = \frac{175}{5.7^2} = 5.4$$

(Equation 42)

### Setting the thermal restart level

The restart disable level can be calculated as follows:

$$\theta_i = 100\% - \left( \frac{\text{startup time of the motor}}{\text{operate time when no prior load}} \cdot 100\% + \text{margin} \right)$$

(Equation 43)

For example, the motor start-up time is 11 seconds, start-up current 6 x rated and *Time constant start* is set for 800 seconds. Using the trip curve with no prior load, the operation time at 6 x rated current is 25 seconds, one motor start-up uses 11/25 ≈ 45 percent of the thermal capacity of the motor. Therefore, the restart disable level must be set to below 100 percent - 45 percent = 55 percent, for example to 50 percent (100 percent - (45 percent + margin), where margin is 5 percent).

### Setting the thermal alarm level

Tripping due to high overload is avoided by reducing the load of the motor on a prior alarm.

The value of *Alarm thermal value* is set to a level which allows the use of the full thermal capacity of the motor without causing a trip due to a long overload time. Generally, the prior alarm level is set to a value of 80 to 90 percent of the trip level.

## 4.1.9.7 Signals

*Table 443: MPTTR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| START_EMERG | BOOLEAN | 0=False | Signal for indicating the need for emergency start |
| AMB_TEMP | FLOAT32 | 0 | The ambient temperature used in the calculation |

*Table 444: MPTTR Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| ALARM | BOOLEAN | Thermal Alarm |
| BLK_RESTART | BOOLEAN | Thermal overload indicator, to inhibit restart |
| TEMP_RL | FLOAT32 | Analog output |

### 4.1.9.8 Settings

*Table 445: MPTTR Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Overload factor | 1.00...1.20 | | 0.01 | 1.05 | Overload factor (k) |
| Alarm thermal value | 50.0...100.0 | % | 0.1 | 95.0 | Thermal level above which function gives an alarm |
| Restart thermal Val | 20.0...80.0 | % | 0.1 | 40.0 | Thermal level above which function inhibits motor restarting |
| Negative Seq factor | 0.0...10.0 | | 0.1 | 0.0 | Heating effect factor for negative sequence current |
| Weighting factor p | 20.0...100.0 | % | 0.1 | 50.0 | Weighting factor (p) |
| Time constant normal | 80...4000 | s | 1 | 320 | Motor time constant during the normal operation of motor |
| Time constant start | 80...4000 | s | 1 | 320 | Motor time constant during the start of motor |
| Time constant stop | 80...60000 | s | 1 | 500 | Motor time constant during the standstill condition of motor |
| Env temperature mode | 1=FLC Only<br>2=Use input<br>3=Set Amb Temp | | | 1=FLC Only | Mode of measuring ambient temperature |
| Env temperature Set | -20.0...70.0 | °C | 0.1 | 40.0 | Ambient temperature used when no external temperature measurement available |

*Table 446: MPTTR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 447: MPTTR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current reference | 0.30...2.00 | xIn | 0.01 | 1.00 | Rated current (FLC) of the motor |
| Initial thermal Val | 0.0...100.0 | % | 0.1 | 74.0 | Initial thermal level of the motor |

### 4.1.9.9 Monitored data

*Table 448: MPTTR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TEMP_AMB | FLOAT32 | -99...999 | °C | The ambient temperature used in the calculation |
| THERMLEV_ST | FLOAT32 | 0.00...9.99 | | Thermal level at beginning of motor startup |
| THERMLEV_END | FLOAT32 | 0.00...9.99 | | Thermal level at the end of motor startup situation |
| T_ENARESTART | INT32 | 0...99999 | s | Estimated time to reset of block restart |
| MPTTR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| Therm-Lev:1 | FLOAT32 | 0.00...9.99 | | Thermal level of protected object (1.00 is the operate level) |

### 4.1.9.10 Technical data

*Table 449: MPTTR Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current measurement: ±1.5% of the set value or ±0.002 × $I_n$ (at currents in the range of 0.01...4.00 × $I_n$) |
| Operate time accuracy[1)] | ±2.0% of the theoretical value or ±0.50 s |

1) Overload current > 1.2 × Operate level temperature

# 4.2 Earth-fault protection

## 4.2.1 Non-directional earth-fault protection EFxPTOC

### 4.2.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Non-directional earth-fault protection, low stage | EFLPTOC | Io> | 51G/51N-1 |
| Non-directional earth-fault protection, high stage | EFHPTOC | Io>> | 51G/51N-2 |
| Non-directional earth-fault protection, instantaneous stage | EFIPTOC | Io>>> | 50G/50N |

### 4.2.1.2 Function block




*Figure 219: Function block*

### 4.2.1.3 Functionality

The non-directional earth-fault protection function EFxPTOC is used as non-directional earth-fault protection for feeders.

The function starts and operates when the residual current exceeds the set limit. The operate time characteristic for low stage EFLPTOC and high stage EFHPTOC can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). The instantaneous stage EFIPTOC always operates with the DT characteristic.

In the DT mode, the function operates after a predefined operate time and resets when the fault current disappears. The IDMT mode provides current-dependent timer characteristics.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.1.4 Analog channel configuration

EFxPTOC has one analog group input which must be properly configured.

*Table 450: Analog inputs*

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of EFxPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

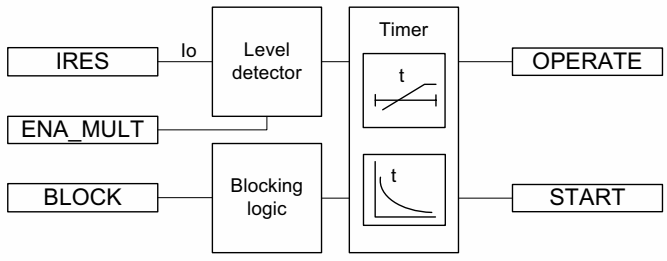



*Figure 220: Functional module diagram*

#### Level detector

The measured residual current is compared to the set *Start value*. If the measured value exceeds the set *Start value*, the level detector sends an enable-signal to the timer module. If the ENA_MULT input is active, the *Start value* setting is multiplied by the *Start value Mult* setting.

The protection relay does not accept the *Start value* or *Start value Mult* setting if the product of these settings exceeds the *Start value* setting range.

The start value multiplication is normally done when the inrush detection function (INRPHAR) is connected to the ENA_MULT input.

## Timer

Once activated, the timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The functionality of the timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation. The START output is deactivated when the reset timer has elapsed.



The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operate and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.



The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see the IDMT curves for overcurrent protection section in this manual.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

## Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled

by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.2.1.6 Measurement modes

The function operates on three alternative measurement modes: "RMS", "DFT" and "Peak-to-Peak". The measurement mode is selected with the *Measurement mode* setting.

*Table 451: Measurement modes supported by EFxPTOC stages*

| Measurement mode | EFLPTOC | EFHPTOC | EFIPTOC |
|---|---|---|---|
| RMS | x | x | |
| DFT | x | x | |
| Peak-to-Peak | x | x | x |

For a detailed description of the measurement modes, see the Measurement modes section in this manual.

### 4.2.1.7 Timer characteristics

EFxPTOC supports both DT and IDMT characteristics. The user can select the timer characteristics with the *Operating curve type* and *Type of reset curve* settings. When the DT characteristic is selected, it is only affected by the *Operate delay time* and *Reset delay time* settings.

The protection relay provides 16 IDMT characteristics curves, of which seven comply with the IEEE C37.112 and six with the IEC 60255-3 standard. Two curves follow the special characteristics of ABB praxis and are referred to as RI and RD. In addition to this, a user programmable curve can be used if none of the standard curves are applicable. The user can choose the DT characteristic by selecting the *Operating curve type* values "ANSI Def. Time" or "IEC Def. Time". The functionality is identical in both cases.

The following characteristics, which comply with the list in the IEC 61850-7-4 specification, indicate the characteristics supported by different stages.

*Table 452: Timer characteristics supported by different stages*

| Operating curve type | EFLPTOC | EFHPTOC |
|---|---|---|
| (1) ANSI Extremely Inverse | x | x |
| (2) ANSI Very Inverse | x | |
| (3) ANSI Normal Inverse | x | x |
| (4) ANSI Moderately Inverse | x | |
| (5) ANSI Definite Time | x | x |
| (6) Long Time Extremely Inverse | x | |
| (7) Long Time Very Inverse | x | |
| (8) Long Time Inverse | x | |
| (9) IEC Normal Inverse | x | x |
| (10) IEC Very Inverse | x | x |
| (11) IEC Inverse | x | |
| (12) IEC Extremely Inverse | x | x |
| (13) IEC Short Time Inverse | x | |
| (14) IEC Long Time Inverse | x | |
| (15) IEC Definite Time | x | x |
| (17) User programmable curve | x | x |
| (18) RI type | x | |
| (19) RD type | x | |

EFIPTOC supports only definite time characteristics.

For a detailed description of timers, see the General function block features section in this manual.

*Table 453: Reset time characteristics supported by different stages*

| Reset curve type | EFLPTOC | EFHPTOC | Note |
|---|---|---|---|
| (1) Immediate | x | x | Available for all operate time curves |
| (2) Def time reset | x | x | Available for all operate time curves |
| (3) Inverse reset | x | x | Available only for ANSI and user programmable curves |

The *Type of reset curve* setting does not apply to EFIPTOC or when the DT operation is selected. The reset is purely defined by the *Reset delay time* setting.

### 4.2.1.8 Application

EFxPTOC is designed for protection and clearance of earth faults in distribution and sub-transmission networks where the neutral point is isolated or earthed via a resonance coil or through low resistance. It also applies to solidly earthed networks and earth-fault protection of different equipment connected to the power systems, such as shunt capacitor bank or shunt reactors and for backup earth-fault protection of power transformers.

Many applications require several steps using different current start levels and time delays. EFxPTOC consists of three different protection stages.

- Low EFLPTOC
- High EFHPTOC
- Instantaneous EFIPTOC

EFLPTOC contains several types of time-delay characteristics. EFHPTOC and EFIPTOC are used for fast clearance of serious earth faults.

### 4.2.1.9 Signals

*Table 454: EFLPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

*Table 455: EFHPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

*Table 456: EFIPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

*Table 457: EFLPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

*Table 458: EFHPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

*Table 459: EFIPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.2.1.10 Settings

*Table 460: EFLPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.010...5.000 | xIn | 0.005 | 0.010 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |

*Table 461: EFLPTOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

*Table 462: EFLPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 1 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 1 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 1 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 463: EFLPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

*Table 464: EFHPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.10...40.00 | xIn | 0.01 | 0.10 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>3=ANSI Norm. inv.<br>5=ANSI Def. Time<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>12=IEC Ext. inv.<br>15=IEC Def. Time<br>17=Programmable | | | 15=IEC Def. Time | Selection of time delay curve type |

*Table 465: EFHPTOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

*Table 466: EFHPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 1 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 1 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 1 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 467: EFHPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

*Table 468: EFIPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 1.00...40.00 | xIn | 0.01 | 1.00 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Operate delay time | 20...300000 | ms | 10 | 20 | Operate delay time |

*Table 469: EFIPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 470: EFIPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.2.1.11 Monitored data

*Table 471: EFLPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| EFLPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

*Table 472: EFHPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| EFHPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

*Table 473: EFIPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| EFIPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.1.12 Technical data

*Table 474: EFxPTOC Technical data*

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | EFLPTOC | ±1.5% of the set value or ±0.002 × $I_n$ |
| | EFHPTOC and EFIPTOC | ±1.5% of the set value or ±0.002 × $I_n$ (at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value (at currents in the range of 10…40 × $I_n$) |

Table continues on next page

| Characteristic | | Value | | |
|---|---|---|---|---|
| Start time [1] | | Minimum | Typical | Maximum |
| | EFIPTOC[2]: $I_{Fault}$ = 2 × set *Start value*<br>$I_{Fault}$ = 10 × set *Start value* | 8 ms<br>8 ms | 11 ms<br>9 ms | 14 ms<br>11 ms |
| | EFHPTOC and EFLPTOC[3]: $I_{Fault}$ = 2 × set *Start value* | 23 ms | 26 ms | 29 ms |
| Reset time | | Typically <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [4] | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

1) *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Measured with static signal output (SSO)
3) Includes the delay of the signal output contact (SO)
4) Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in the range of 1.5...20

## 4.2.2 Directional earth-fault protection DEFxPDEF

### 4.2.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Directional earth-fault protection, low stage | DEFLPDEF | Io> -> | 67G/N-1<br>51G/N-1 |
| Directional earth-fault protection, high stage | DEFHPDEF | Io>> -> | 67G/N-1<br>51G/N-2 |

### 4.2.2.2 Function block

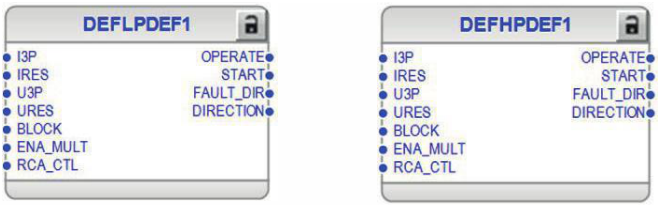



*Figure 221: Function block*

### 4.2.2.3 Functionality

The directional earth-fault protection function DEFxPDEF is used as directional earth-fault protection for feeders.

The function starts and operates when the operating quantity (current) and polarizing quantity (voltage) exceed the set limits and the angle between them is inside the set operating sector. The operate time characteristic for low stage (DEFLPDEF) and high stage (DEFHPDEF) can be selected to be either definite time (DT) or inverse definite minimum time (IDMT).

In the DT mode, the function operates after a predefined operate time and resets when the fault current disappears. The IDMT mode provides current-dependent timer characteristics.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.2.4 Analog channel configuration

DEFxPDEF has four analog group inputs which must be properly configured.

*Table 475: Analog inputs*

| Input | Description |
|---|---|
| I3P[1)] | Three-phase currents<br>Necessary when *Pol quantity* is set to "Neg. seq. volt." |
| IRES | Residual current (measured or calculated) |
| U3P[1)] | Three-phase voltages<br>Necessary when *Pol quantity* is set to "Neg. seq. volt." |
| URES[2)] | Residual voltage (measured or calculated)<br>Necessary when *Pol quantity* is set to "Zero seq. volt." |

1) Can be connected to GRPOFF if *Pol quantity* is set to "Zero seq. volt" or *Directional mode* is set to "Non-directional"
2) Can be connected to GRPOFF if *Pol quantity* is set to "Neg. seq. volt" or *Directional mode* is set to "Non-directional"



See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

*Table 476: Special conditions*

| Condition | Description |
|---|---|
| U3P connected real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |
| URES calculated | Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DEFxPDEF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

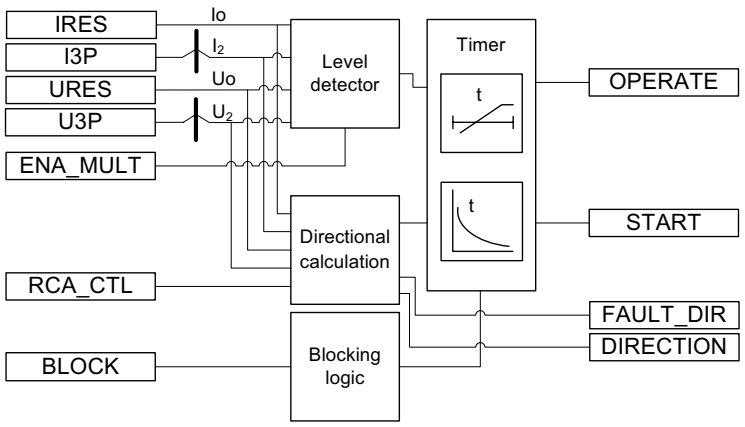



*Figure 222: Functional module diagram*

#### Level detector

The magnitude of the operating quantity is compared to the set *Start value* and the magnitude of the polarizing quantity is compared to the set *Voltage start value*. If both the limits are exceeded, the level detector sends an enabling signal to the timer module. When the *Enable voltage limit* setting is set to "False", *Voltage start value* has no effect and the level detection is purely based on the operating quantity. If the ENA_MULT input is active, the *Start value* setting is multiplied by the *Start value Mult* setting.

If the *Enable voltage limit* setting is set to "True", the magnitude of the polarizing quantity is checked even if the *Directional mode* was set to "Non-directional" or *Allow Non Dir* to "True". The protection relay does not accept the *Start value* or *Start value Mult* setting if the product of these settings exceeds the *Start value* setting range.

Typically, the ENA_MULT input is connected to the inrush detection function INRHPAR. In case of inrush, INRPHAR activates the ENA_MULT input, which multiplies *Start value* by the *Start value Mult* setting.

### Directional calculation

The directional calculation module monitors the angle between the polarizing quantity and operating quantity. Depending on the *Pol quantity* setting, the polarizing quantity can be the residual voltage (measured or calculated) or the negative sequence voltage. When the angle is in the operation sector, the module sends the enabling signal to the timer module.

The minimum signal level which allows the directional operation can be set with the *Min operate current* and *Min operate voltage* settings.

If *Pol quantity* is set to "Zero. seq. volt", the residual current and residual voltage are used for directional calculation.

If *Pol quantity* is set to "Neg. seq. volt", the negative sequence current and negative sequence voltage are used for directional calculation.

In the phasor diagrams representing the operation of DEFxPDEF, the polarity of the polarizing quantity (Uo or U2) is reversed, that is, the polarizing quantity in the phasor diagrams is either -Uo or -U2. Reversing is done by switching the polarity of the residual current measuring channel (see the connection in the Protection relay's physical connections section). Similarly the polarity of the calculated Io and $I_2$ is also switched.

For defining the operation sector, there are five modes available through the *Operation mode* setting.

*Table 477: Operation modes*

| Operation mode | Description |
|---|---|
| Phase angle | The operating sectors for forward and reverse are defined with the settings *Min forward angle*, *Max forward angle*, *Min reverse angle* and *Max reverse angle*. |
| IoSin | The operating sectors are defined as "forward" when \|Io\| x sin (ANGLE) has a positive value and "reverse" when the value is negative. ANGLE is the angle difference between -Uo and Io. |
| IoCos | As "IoSin" mode. Only cosine is used for calculating the operation current. |
| Phase angle 80 | The sector maximum values are frozen to 80 degrees respectively. Only *Min forward angle* and *Min reverse angle* are settable. |
| Phase angle 88 | The sector maximum values are frozen to 88 degrees. Otherwise as "Phase angle 80" mode. |

Polarizing quantity selection "Neg. seq. volt." is available only in the "Phase angle" operation mode.

The directional operation can be selected with the *Directional mode* setting. The alternatives are "Non-directional", "Forward" and "Reverse" operation. The operation criterion is selected with the *Operation mode* setting. By setting *Allow Non Dir* to "True", non-directional operation is allowed when the directional information is invalid, that is, when the magnitude of the polarizing quantity is less than the value of the *Min operate voltage* setting.

Typically, the network rotating direction is counter-clockwise and defined as "ABC". If the network rotating direction is reversed, meaning clockwise, that is, "ACB", the equation for calculating the negative sequence voltage component need to be changed. The network rotating direction is defined with a system parameter *Phase rotation*. The calculation of the component is affected but the angle difference calculation remains the same. When the residual voltage is used as the polarizing method, the network rotating direction change has no effect on the direction calculation.

The network rotating direction is set in the protection relay using the parameter in the HMI menu: **Configuration/System/Phase rotation**. The default parameter value is "ABC".

If the *Enable voltage limit* setting is set to "True", the magnitude of the polarizing quantity is checked even if *Directional mode* is set to "Non-directional" or *Allow Non Dir* to "True".

The *Characteristic angle* setting is used in the "Phase angle" mode to adjust the operation according to the method of neutral point earthing so that in an isolated network the *Characteristic angle* ($\varphi_{RCA}$) = -90° and in a compensated network $\varphi_{RCA}$

= 0°. In addition, the characteristic angle can be changed via the control signal RCA_CTL. RCA_CTL affects the *Characteristic angle* setting.

The *Correction angle* setting can be used to improve selectivity due the inaccuracies in the measurement transformers. The setting decreases the operation sector. The correction can only be used with the "IoCos" or "IoSin" modes.

The polarity of the polarizing quantity can be reversed by setting the *Pol reversal* to "True", which turns the polarizing quantity by 180 degrees.



For definitions of different directional earth-fault characteristics, see the Directional earth-fault characteristics section in this manual.

The DIRECTION output indicates on which operating sector the operating quantity is measured. The FAULT_DIR output indicates in which operation sector the fault current is measured. The output is operational once the function is started.

The directional calculation module calculates several values which are presented in the monitored data.

*Table 478: Monitored data values*

| Monitored data values | Description |
|---|---|
| ANGLE | Also called operating angle, shows the angle difference between the polarizing quantity (Uo, $U_2$) and operating quantity (Io, $I_2$). |
| ANGLE_RCA | The angle difference between the operating angle and *Characteristic angle*, that is, ANGLE_RCA = ANGLE – *Characteristic angle*. |
| I_OPER | The current that is used for fault detection. If the *Operation mode* setting is "Phase angle", "Phase angle 80" or "Phase angle 88", I_OPER is the measured or calculated residual current. If the *Operation mode* setting is "IoSin", I_OPER is calculated as follows I_OPER = Io x sin(ANGLE). If the *Operation mode* setting is "IoCos", I_OPER is calculated as follows I_OPER = Io x cos(ANGLE). |

## Timer

Once activated, the timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The functionality of the timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation. The START output is deactivated when the reset timer has elapsed.



The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operate and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.



The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see the IDMT curves for overcurrent protection section in this manual.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

## Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*

.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.2.2.6 Directional earth-fault principles

In many cases it is difficult to achieve selective earth-fault protection based on the magnitude of residual current only. To obtain a selective earth-fault protection scheme, it is necessary to take the phase angle of Io into account. This is done by comparing the phase angle of the operating and polarizing quantity.

#### Relay characteristic angle

The *Characteristic angle* setting, also known as Relay Characteristic Angle (RCA), Relay Base Angle or Maximum Torque Angle (MTA), is used in the "Phase angle" mode to turn the directional characteristic if the expected fault current angle does not coincide with the polarizing quantity to produce the maximum torque. That is, RCA is the angle between the maximum torque line and polarizing quantity. If the polarizing quantity is in phase with the maximum torque line, RCA is 0 degrees. The angle is positive if the operating current lags the polarizing quantity and negative if it leads the polarizing quantity.

**Example 1**

The "Phase angle" mode is selected, compensated network (φRCA = 0 deg)

=> *Characteristic angle* = 0 deg

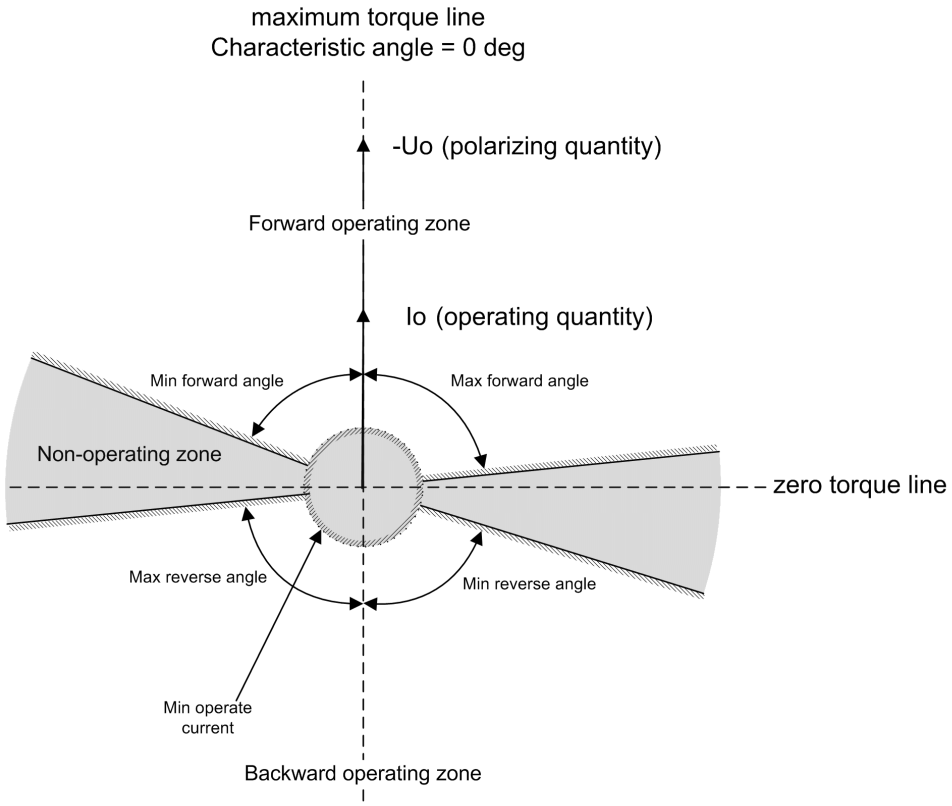



*Figure 223: Definition of the relay characteristic angle, RCA=0 degrees in a compensated network*

**Example 2**

The "Phase angle" mode is selected, solidly earthed network (φRCA = +60 deg)

=> *Characteristic angle* = +60 deg

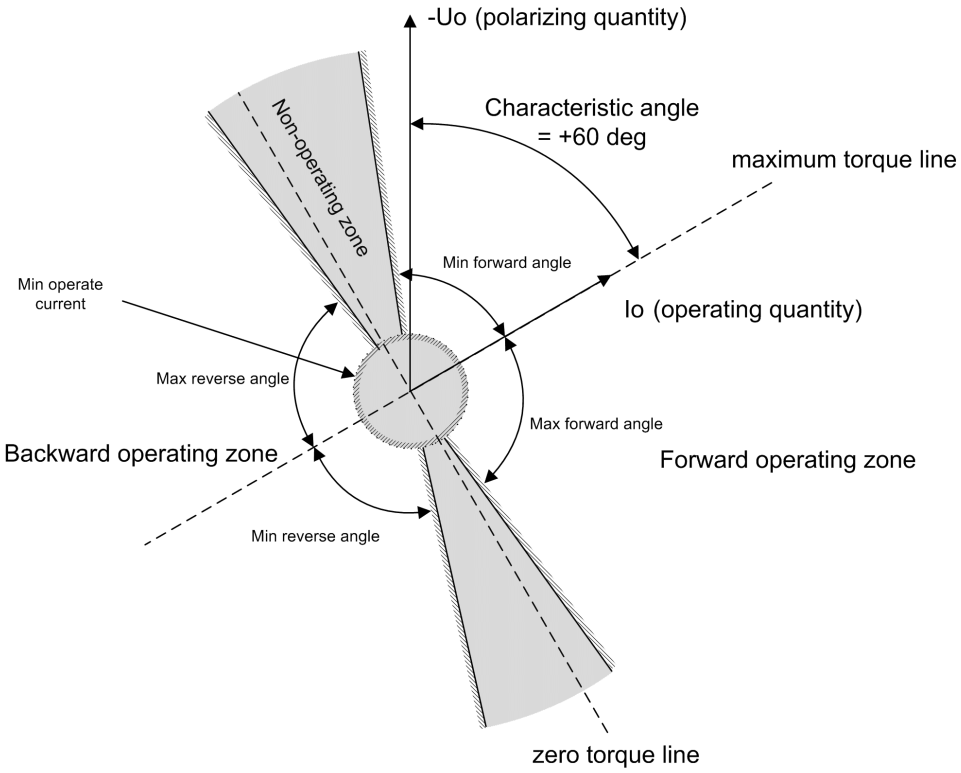



*Figure 224: Definition of the relay characteristic angle, RCA=+60 degrees in a solidly earthed network*

**Example 3**

The "Phase angle" mode is selected, isolated network (φRCA = -90 deg)

=> *Characteristic angle* = -90 deg

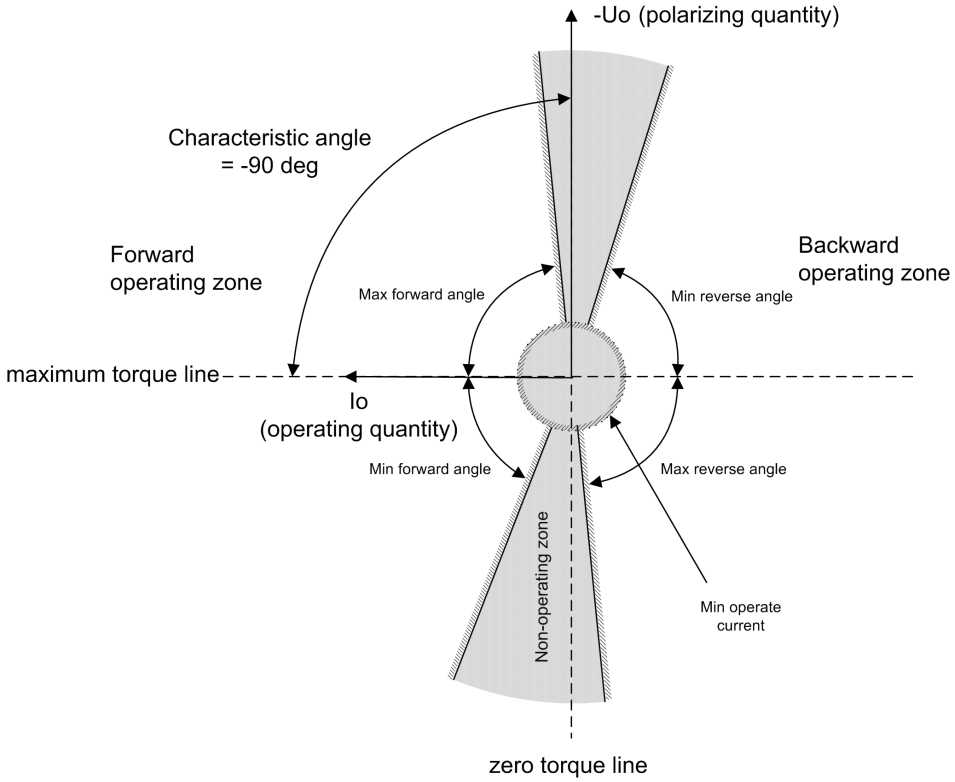



*Figure 225: Definition of the relay characteristic angle, RCA=–90 degrees in an isolated network*

## Directional earth-fault protection in an isolated neutral network

In isolated networks, there is no intentional connection between the system neutral point and earth. The only connection is through the phase-to-earth capacitances ($C_0$) of phases and leakage resistances ($R_0$). This means that the residual current is mainly capacitive and has a phase shift of -90 degrees compared to the polarizing voltage. Consequently, the relay characteristic angle (RCA) should be set to -90 degrees and the operation criteria to "IoSin" or "Phase angle". The width of the operating sector in the phase angle criteria can be selected with the settings *Min forward angle*, *Max forward angle*, *Min reverse angle* or *Max reverse angle*. Figure 226 illustrates a simplified equivalent circuit for an unearthed network with an earth fault in phase C.

For definitions of different directional earth-fault characteristics, see Directional earth-fault characteristics.

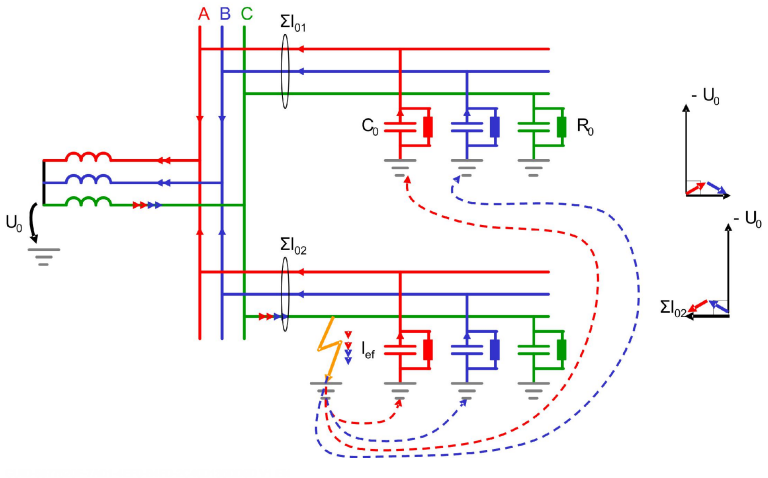



*Figure 226: Earth-fault situation in an isolated network*

## Directional earth-fault protection in a compensated network

In compensated networks, the capacitive fault current and the inductive resonance coil current compensate each other. The protection cannot be based on the reactive current measurement, since the current of the compensation coil would disturb the operation of the protection relays. In this case, the selectivity is based on the measurement of the active current component. The magnitude of this component is often small and must be increased by means of a parallel resistor in the compensation equipment. When measuring the resistive part of the residual current, the *Operation mode* should be set to "Phase angle" and the relay characteristic angle (RCA) should be set to 0 degrees. Alternatively, the *Operation mode* can be set to "IoCos". Figure 227 illustrates a simplified equivalent circuit for a compensated network with an earth fault in phase C.

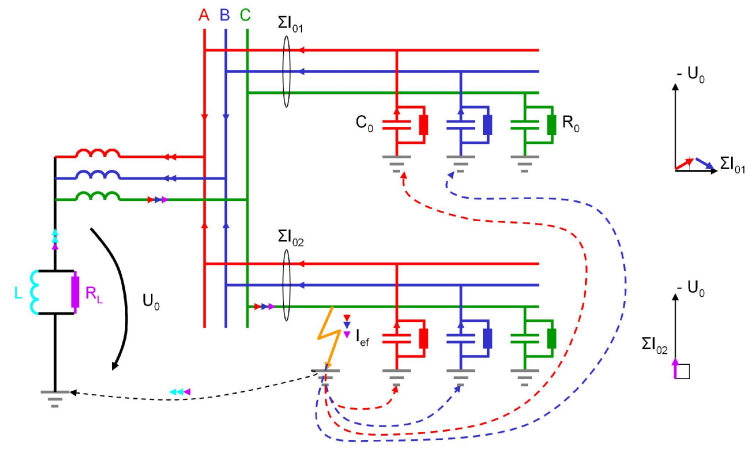



*Figure 227: Earth-fault situation in a compensated network*

The Petersen coil or the earthing resistor may be temporarily out of operation. To keep the protection scheme selective, it is necessary to update the characteristic angle setting accordingly. This can be done with an auxiliary input in the relay which receives a signal from an auxiliary switch of the disconnector of the Petersen coil in

compensated networks. As a result the characteristic angle is set automatically to suit the earthing method used. The RCA_CTL input can be used to change the operation criteria as described in Table 479 and Table 480.

*Table 479: Relay characteristic angle control in Iosin(φ) and Iocos(φ) operation criteria*

| *Operation mode* setting: | RCA_CTL = FALSE | RCA_CTL = TRUE |
|---|---|---|
| Iosin | Actual operation mode: Iosin | Actual operation mode: Iocos |
| Iocos | Actual operation mode: Iocos | Actual operation mode: Iosin |

*Table 480: Characteristic angle control in phase angle operation mode*

| *Characteristic angle* setting | RCA_CTL = FALSE | RCA_CTL = TRUE |
|---|---|---|
| -90° | $\varphi_{RCA}$ = -90° | $\varphi_{RCA}$ = 0° |
| 0° | $\varphi_{RCA}$ = 0° | $\varphi_{RCA}$ = -90° |

## Use of the extended phase angle characteristic

The traditional method of adapting the directional earth-fault protection function to the prevailing neutral earthing conditions is done with the *Characteristic angle* setting. In an unearthed network, *Characteristic angle* is set to -90 degrees and in a compensated network *Characteristic angle* is set to 0 degrees. In case the earthing method of the network is temporarily changed from compensated to unearthed due to the disconnection of the arc suppression coil, the *Characteristic angle* setting should be modified correspondingly. This can be done using the setting groups or the RCA_CTL input. Alternatively, the operating sector of the directional earth-fault protection function can be extended to cover the operating sectors of both neutral earthing principles. Such characteristic is valid for both unearthed and compensated network and does not require any modification in case the neutral earthing changes temporarily from the unearthed to compensated network or vice versa.

The extended phase angle characteristic is created by entering a value of over 90 degrees for the *Min forward angle* setting; a typical value is 170 degrees (*Min reverse angle* in case *Directional mode* is set to "Reverse"). The *Max forward angle* setting should be set to cover the possible measurement inaccuracies of current and voltage transformers; a typical value is 80 degrees (*Max reverse angle* in case *Directional mode* is set to "Reverse").

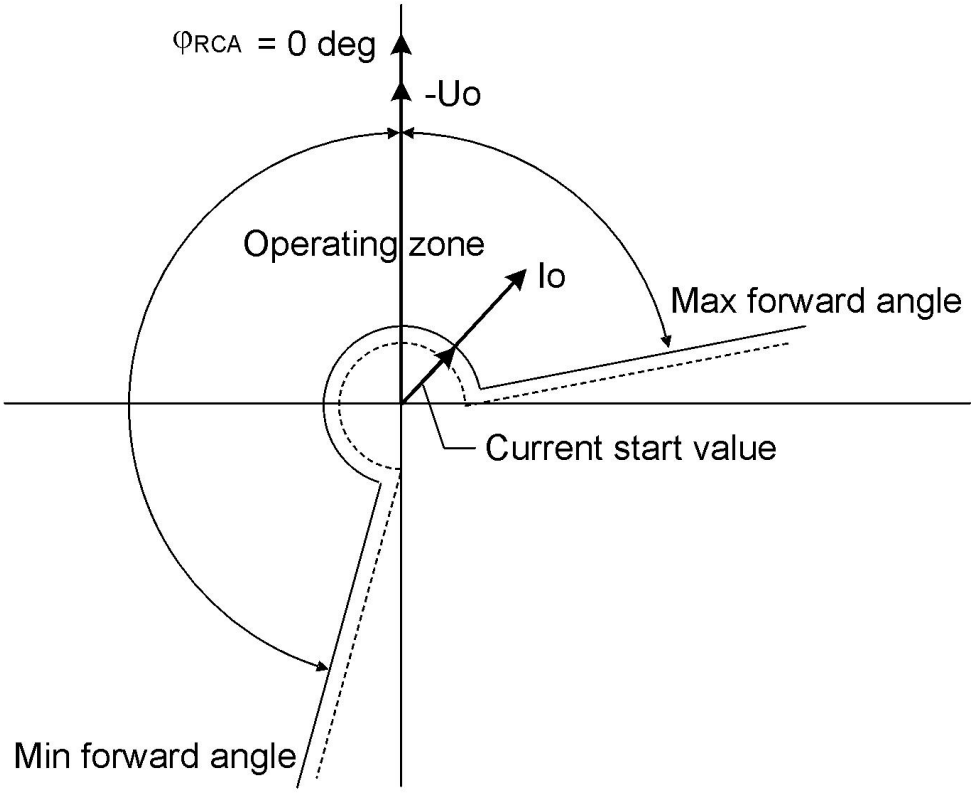



*Figure 228: Extended operation area in directional earth-fault protection*

### 4.2.2.7 Measurement modes

The function operates on three alternative measurement modes: "RMS", "DFT" and "Peak-to-Peak". The measurement mode is selected with the *Measurement mode* setting.

***Table 481: Measurement modes supported by DEFxPDEF stages***

| Measurement mode | DEFLPDEF | DEFHPDEF |
|---|---|---|
| RMS | x | x |
| DFT | x | x |
| Peak-to-Peak | x | x |

For a detailed description of the measurement modes, see the Measurement modes section in this manual.

### 4.2.2.8 Timer characteristics

DEFxPDEF supports both DT and IDMT characteristics. The user can select the timer characteristics with the *Operating curve type* setting.

The protection relay provides 16 IDMT characteristics curves, of which seven comply with the IEEE C37.112 and six with the IEC 60255-3 standard. Two curves follow the special characteristics of ABB praxis and are referred to as RI and RD. In addition to this, a user programmable curve can be used if none of the standard curves are applicable. The user can choose the DT characteristic by selecting the *Operating curve type* values "ANSI Def. Time" or "IEC Def. Time". The functionality is identical in both cases.

The following characteristics, which comply with the list in the IEC 61850-7-4 specification, indicate the characteristics supported by different stages.

*Table 482: Timer characteristics supported by different stages*

| Operating curve type | DEFLPDEF | DEFHPDEF |
|---|---|---|
| (1) ANSI Extremely Inverse | x | x |
| (2) ANSI Very Inverse | x | |
| (3) ANSI Normal Inverse | x | x |
| (4) ANSI Moderately Inverse | x | |
| (5) ANSI Definite Time | x | x |
| (6) Long Time Extremely Inverse | x | |
| (7) Long Time Very Inverse | x | |
| (8) Long Time Inverse | x | |
| (9) IEC Normal Inverse | x | |
| (10) IEC Very Inverse | x | |
| (11) IEC Inverse | x | |
| (12) IEC Extremely Inverse | x | |
| (13) IEC Short Time Inverse | x | |
| (14) IEC Long Time Inverse | x | |
| (15) IEC Definite Time | x | x |
| (17) User programmable curve | x | x |
| (18) RI type | x | |
| (19) RD type | x | |



For a detailed description of the timers, see the General function block features section in this manual.

*Table 483: Reset time characteristics supported by different stages*

| Reset curve type | DEFLPDEF | DEFHPDEF | Note |
|---|---|---|---|
| (1) Immediate | x | x | Available for all operate time curves |
| (2) Def time reset | x | x | Available for all operate time curves |
| (3) Inverse reset | x | x | Available only for ANSI and user programmable curves |

### 4.2.2.9 Directional earth-fault characteristics

#### Phase angle characteristic

The operation criterion phase angle is selected with the *Operation mode* setting using the value "Phase angle".

When the phase angle criterion is used, the DIRECTION output indicates on which operating sector the operating quantity is measured. The FAULT_DIR output indicates in which operation sector the fault current is measured. The output is operational once the function is started.

The forward and reverse sectors are defined separately. The forward operation area is limited with the *Min forward angle* and *Max forward angle* settings. The reverse operation area is limited with the *Min reverse angle* and *Max reverse angle* settings.



The sector limits are always given as positive degree values.

In the forward operation area, the *Max forward angle* setting gives the clockwise sector and the *Min forward angle* setting correspondingly the counterclockwise sector, measured from the *Characteristic angle* setting.

In the reverse operation area, the *Max reverse angle* setting gives the clockwise sector and the *Min reverse angle* setting correspondingly the counterclockwise sector, measured from the complement of the *Characteristic angle* setting (180 degrees phase shift) .

The relay characteristic angle (RCA) is set to positive if the operating current lags the polarizing quantity. It is set to negative if it leads the polarizing quantity.

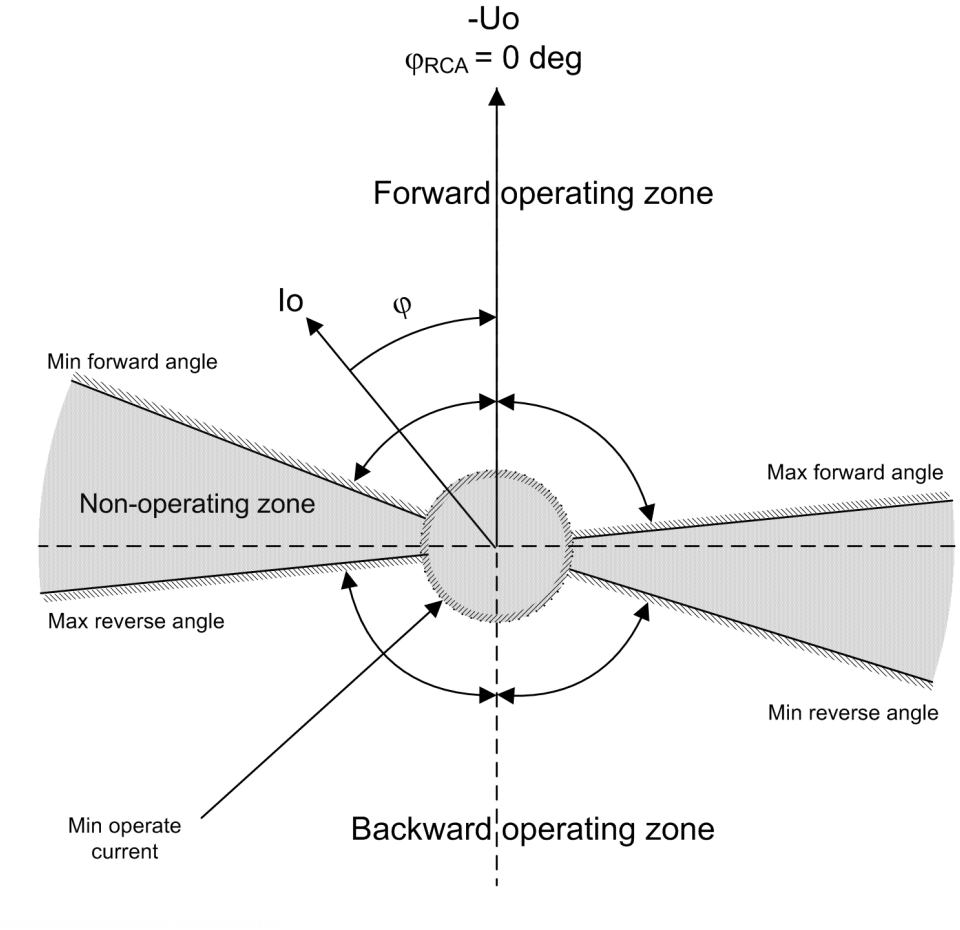



*Figure 229: Configurable operating sectors in phase angle characteristic*

***Table 484: Momentary operating direction***

| Fault direction | The value for DIRECTION |
|---|---|
| Angle between the polarizing and operating quantity is not in any of the defined sectors. | 0 = unknown |
| Angle between the polarizing and operating quantity is in the forward sector. | 1= forward |
| Angle between the polarizing and operating quantity is in the reverse sector. | 2 = backward |
| Angle between the polarizing and operating quantity is in both the forward and the reverse sectors, that is, the sectors are overlapping. | 3 = both |

If the *Allow Non Dir* setting is "False", the directional operation (forward, reverse) is not allowed when the measured polarizing or operating quantities are invalid, that is, their magnitude is below the set minimum values. The minimum values can be defined with the settings *Min operate current* and *Min operate voltage*. In case of low magnitudes, the FAULT_DIR and DIRECTION outputs are set to 0 = unknown, except when the *Allow non dir* setting is "True". In that case, the function is allowed

to operate in the directional mode as non-directional, since the directional information is invalid.

## Iosin(φ) and Iocos(φ) criteria

A more modern approach to directional protection is the active or reactive current measurement. The operating characteristic of the directional operation depends on the earthing principle of the network. The Iosin(φ) characteristics is used in an isolated network, measuring the reactive component of the fault current caused by the earth capacitance. The Iocos(φ) characteristics is used in a compensated network, measuring the active component of the fault current.

The operation criteria Iosin(φ) and Iocos(φ) are selected with the *Operation mode* setting using the values "IoSin" or "IoCos" respectively.

The angle correction setting can be used to improve selectivity. The setting decreases the operation sector. The correction can only be used with the Iosin(φ) or Iocos(φ) criterion. The RCA_CTL input is used to change the Io characteristic:

*Table 485: Relay characteristic angle control in the IoSin and IoCos operation criteria*

| Operation mode: | RCA_CTL = "False" | RCA_CTL = "True" |
|---|---|---|
| IoSin | Actual operation criterion: Iosin(φ) | Actual operation criterion: Iocos(φ) |
| IoCos | Actual operation criterion: Iocos(φ) | Actual operation criterion: Iosin(φ) |

When the Iosin(φ) or Iocos(φ) criterion is used, the component indicates a forward- or reverse-type fault through the FAULT_DIR and DIRECTION outputs, in which 1 equals a forward fault and 2 equals a reverse fault. Directional operation is not allowed (the *Allow non dir* setting is "False") when the measured polarizing or operating quantities are not valid, that is, when their magnitude is below the set minimum values. The minimum values can be defined with the *Min operate current* and *Min operate voltage* settings. In case of low magnitude, the FAULT_DIR and DIRECTION outputs are set to 0 = unknown, except when the *Allow non dir* setting is "True". In that case, the function is allowed to operate in the directional mode as non-directional, since the directional information is invalid.

The calculated Iosin(φ) or Iocos(φ) current used in direction determination can be read through the I_OPER monitored data. The value can be passed directly to a decisive element, which provides the final start and operate signals.



The I_OPER monitored data gives an absolute value of the calculated current.

The following examples show the characteristics of the different operation criteria:

**Example 1.**

Iosin(φ) criterion selected, forward-type fault

```
=> FAULT_DIR = 1
```

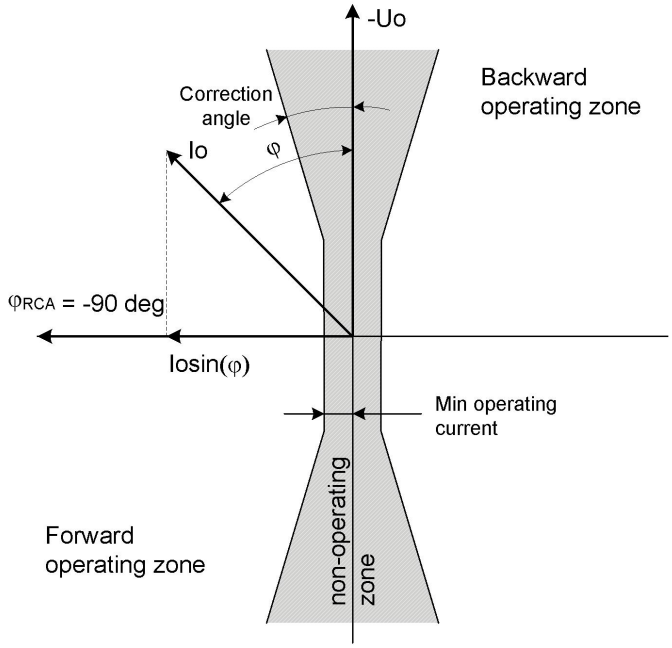



*Figure 230: Operating characteristic Iosin(φ) in forward fault*

The operating sector is limited by angle correction, that is, the operating sector is 180 degrees - 2*(angle correction).

**Example 2.**

Iosin(φ) criterion selected, reverse-type fault

```
=> FAULT_DIR = 2
```

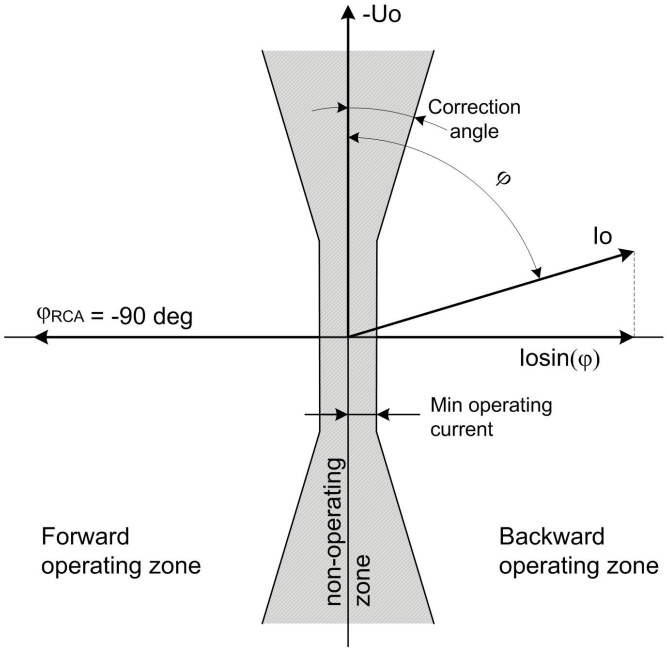



*Figure 231: Operating characteristic Iosin(φ) in reverse fault*

**Example 3.**

Iocos(φ) criterion selected, forward-type fault

```
=> FAULT_DIR = 1
```

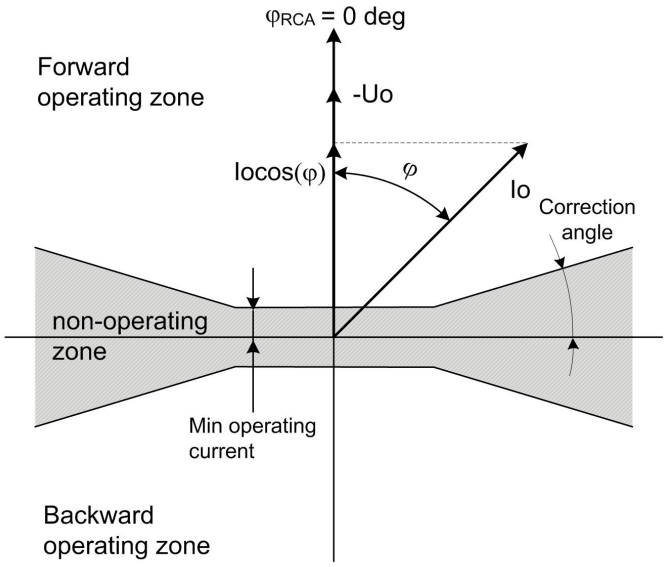



*Figure 232: Operating characteristic Iocos(φ) in forward fault*

**Example 4.**

Iocos(φ) criterion selected, reverse-type fault

=> FAULT_DIR = 2

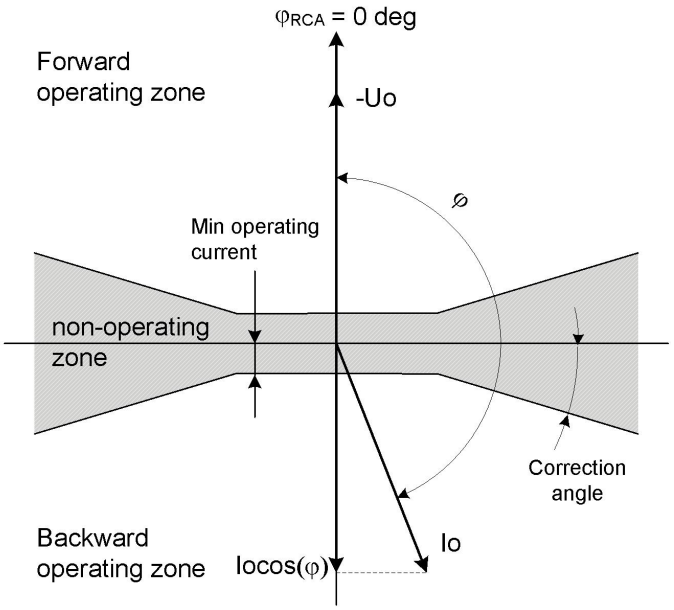



*Figure 233: Operating characteristic Iocos(φ) in reverse fault*

## Phase angle 80

The operation criterion phase angle 80 is selected with the *Operation mode* setting by using the value "Phase angle 80".

Phase angle 80 implements the same functionality as the phase angle but with the following differences:

- The *Max forward angle* and *Max reverse angle* settings cannot be set but they have a fixed value of 80 degrees
- The sector limits of the fixed sectors are rounded.

The sector rounding is used for cancelling the CT measurement errors at low current amplitudes. When the current amplitude falls below three percent of the nominal current, the sector is reduced to 70 degrees at the fixed sector side. This makes the protection more selective, which means that the phase angle measurement errors do not cause faulty operation.

There is no sector rounding on the other side of the sector.

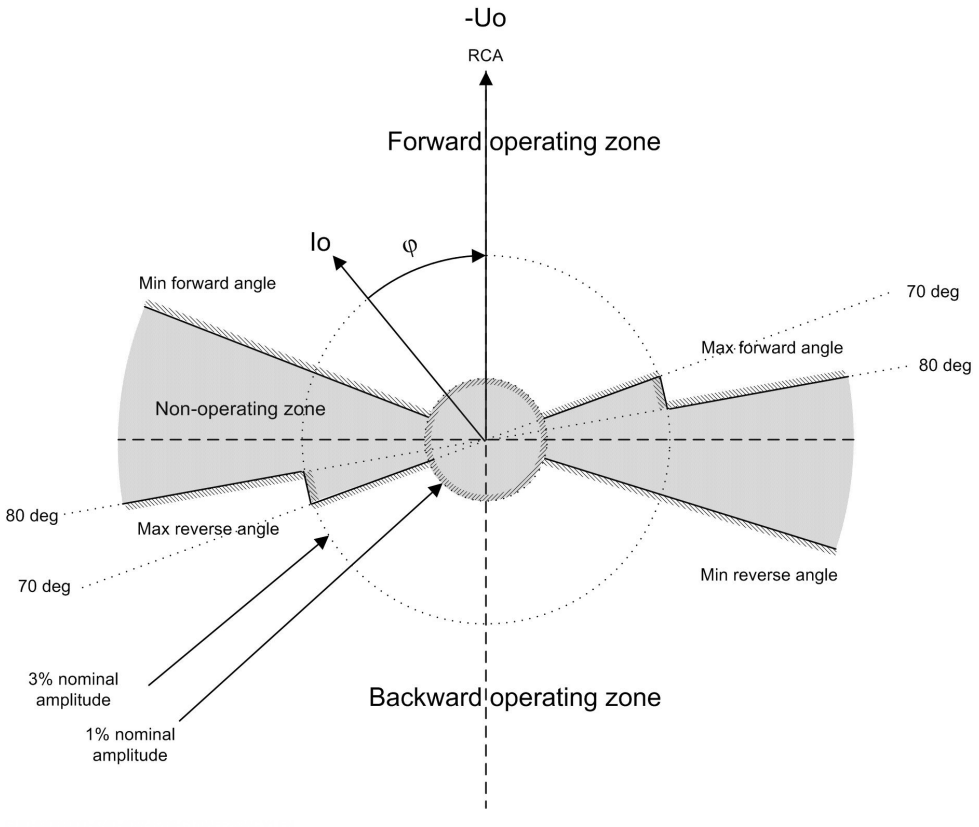



*Figure 234: Operating characteristic for phase angle 80*

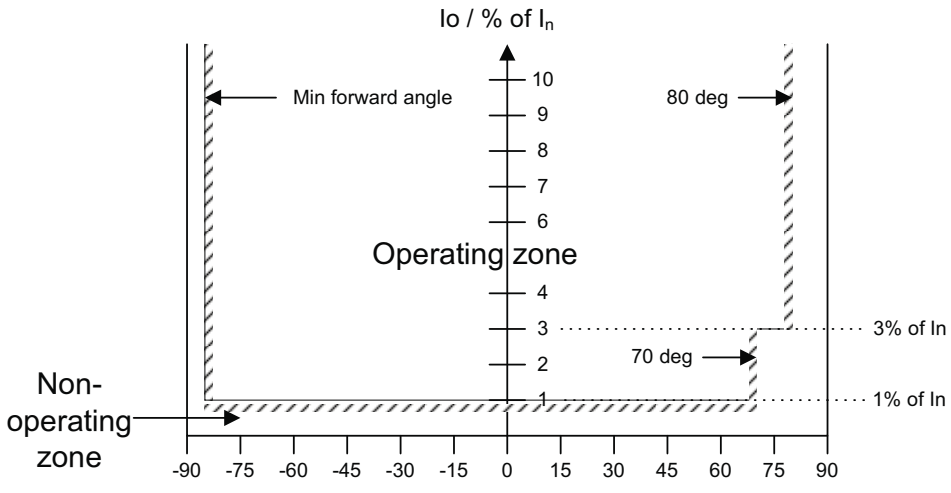



*Figure 235: Phase angle 80 amplitude (Directional mode = Forward)*

## Phase angle 88

The operation criterion phase angle 88 is selected with the *Operation mode* setting using the value "Phase angle 88".

Phase angle 88 implements the same functionality as the phase angle but with the following differences:

- The *Max forward angle* and *Max reverse angle* settings cannot be set but they have a fixed value of 88 degrees
- The sector limits of the fixed sectors are rounded.

Sector rounding in the phase angle 88 consists of three parts.

- If the current amplitude is between 1...20 percent of the nominal current, the sector limit increases linearly from 73 degrees to 85 degrees
- If the current amplitude is between 20...100 percent of the nominal current, the sector limit increases linearly from 85 degrees to 88 degrees
- If the current amplitude is more than 100 percent of the nominal current, the sector limit is 88 degrees.

There is no sector rounding on the other side of the sector.

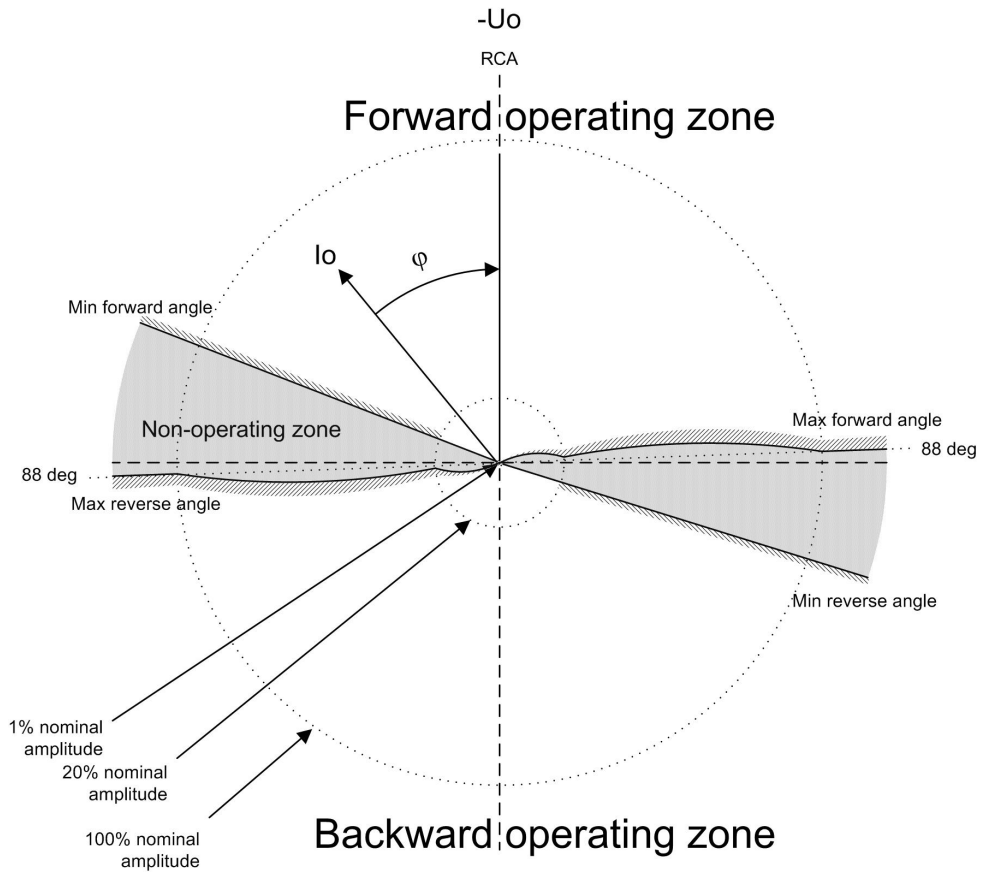



*Figure 236: Operating characteristic for phase angle 88*

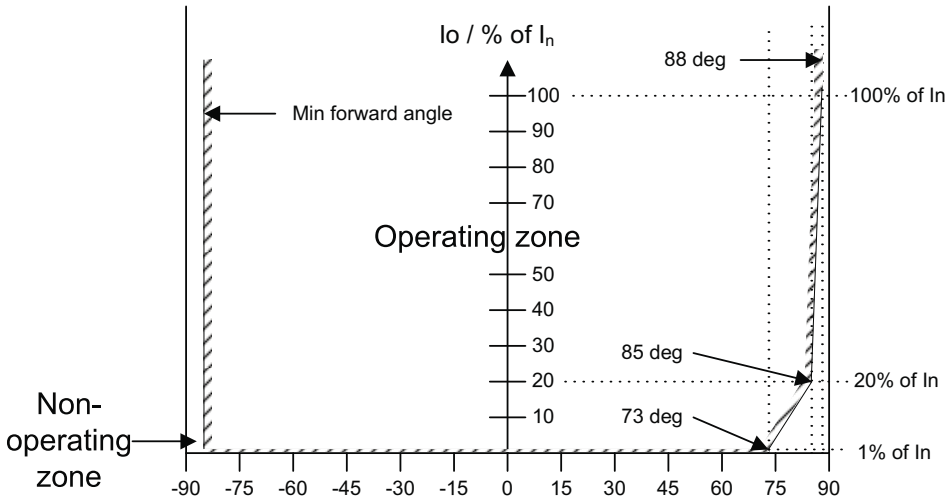



*Figure 237: Phase angle 88 amplitude (Directional mode = Forward)*

### 4.2.2.10 Application

The directional earth-fault protection DEFxPDEF is designed for protection and clearance of earth faults and for earth-fault protection of different equipment connected to the power systems, such as shunt capacitor banks or shunt reactors, and for backup earth-fault protection of power transformers.

Many applications require several steps using different current start levels and time delays. DEFxPDEF consists of two different stages.

- Low DEFLPDEF
- High DEFHPDEF

DEFLPDEF contains several types of time delay characteristics. DEFHPDEF is used for fast clearance of serious earth faults.

The protection can be based on the phase angle criterion with extended operating sector. It can also be based on measuring either the reactive part Iosin(φ) or the active part Iocos(φ) of the residual current. In isolated networks or in networks with high impedance earthing, the phase-to-earth fault current is significantly smaller than the short-circuit currents. In addition, the magnitude of the fault current is almost independent of the fault location in the network.

The function uses the residual current components Iocos(φ) or Iosin(φ) according to the earthing method, where φ is the angle between the residual current and the reference residual voltage (-Uo). In compensated networks, the phase angle criterion with extended operating sector can also be used. When the relay characteristic angle RCA is 0 degrees, the negative quadrant of the operation sector can be extended with the *Min forward angle* setting. The operation sector can be set between 0 and -180 degrees, so that the total operation sector is from +90 to -180 degrees. In other words, the sector can be up to 270 degrees wide. This allows the protection settings to stay the

same when the resonance coil is disconnected from between the neutral point and earth.

System neutral earthing is meant to protect personnel and equipment and to reduce interference for example in telecommunication systems. The neutral earthing sets challenges for protection systems, especially for earth-fault protection.

In isolated networks, there is no intentional connection between the system neutral point and earth. The only connection is through the line-to-earth capacitances ($C_0$) of phases and leakage resistances ($R_0$). This means that the residual current is mainly capacitive and has –90 degrees phase shift compared to the residual voltage (-Uo). The characteristic angle is -90 degrees.

In resonance-earthed networks, the capacitive fault current and the inductive resonance coil current compensate each other. The protection cannot be based on the reactive current measurement, since the current of the compensation coil would disturb the operation of the relays. In this case, the selectivity is based on the measurement of the active current component. This means that the residual current is mainly resistive and has zero phase shift compared to the residual voltage (-Uo) and the characteristic angle is 0 degrees. Often the magnitude of this component is small, and must be increased by means of a parallel resistor in the compensation equipment.

In networks where the neutral point is earthed through low resistance, the characteristic angle is also 0 degrees (for phase angle). Alternatively, Iocos(φ) operation can be used.

In solidly earthed networks, the *Characteristic angle* is typically set to +60 degrees for the phase angle. Alternatively, Iosin(φ) operation can be used with a reversal polarizing quantity. The polarizing quantity can be rotated 180 degrees by setting the *Pol reversal* parameter to "True" or by switching the polarity of the residual voltage measurement wires. Although the Iosin(φ) operation can be used in solidly earthed networks, the phase angle is recommended.

### Connection of measuring transformers in directional earth fault applications

The residual current Io can be measured with a core balance current transformer or the residual connection of the phase current signals. If the neutral of the network is either isolated or earthed with high impedance, a core balance current transformer is recommended to be used in earth-fault protection. To ensure sufficient accuracy of residual current measurements and consequently the selectivity of the scheme, the core balance current transformers should have a transformation ratio of at least 70:1. Lower transformation ratios such as 50:1 or 50:5 are not recommended.

Attention should be paid to make sure the measuring transformers are connected correctly so that DEFxPDEF is able to detect the fault current direction without failure. As directional earth fault uses residual current and residual voltage (-Uo), the poles of the measuring transformers must match each other and also the fault current direction. Also the earthing of the cable sheath must be taken into notice when using

core balance current transformers. The following figure describes how measuring transformers can be connected to the protection relay.

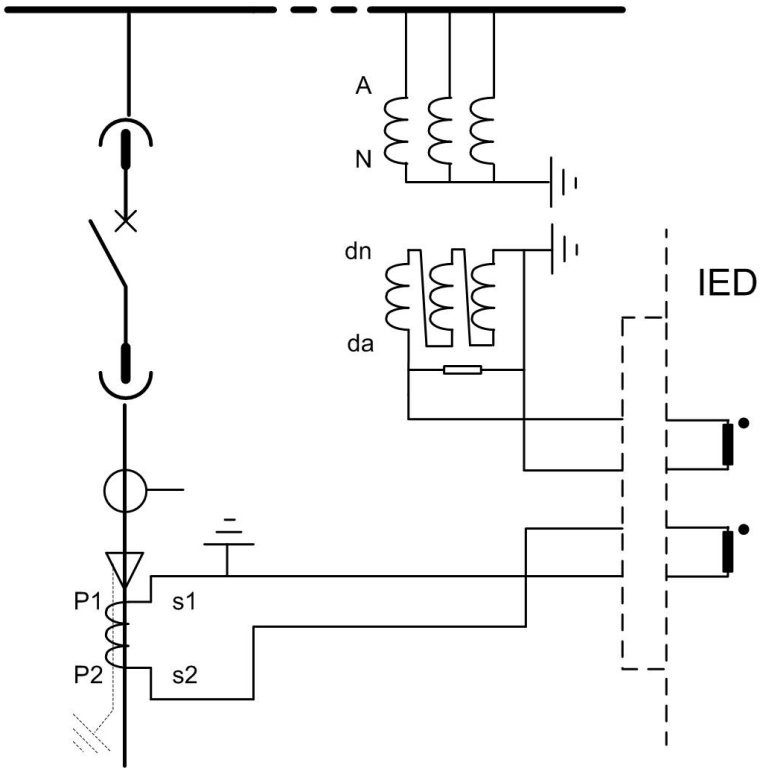



*Figure 238: Connection of measuring transformers*

## 4.2.2.11 Signals

*Table 486: DEFLPDEF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |
| RCA_CTL | BOOLEAN | 0=False | Relay characteristic angle control |

*Table 487: DEFHPDEF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |
| RCA_CTL | BOOLEAN | 0=False | Relay characteristic angle control |

*Table 488: DEFLPDEF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| FAULT_DIR | Enum | Detected fault direction |
| DIRECTION | Enum | Direction information |

*Table 489: DEFHPDEF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| FAULT_DIR | Enum | Detected fault direction |
| DIRECTION | Enum | Direction information |

## 4.2.2.12 Settings

*Table 490: DEFLPDEF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.010...5.000 | xIn | 0.005 | 0.010 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 50...300000 | ms | 10 | 50 | Operate delay time |
| Characteristic angle | -179...180 | deg | 1 | -90 | Characteristic angle |
| Max forward angle | 0...180 | deg | 1 | 80 | Maximum phase angle in forward direction |
| Max reverse angle | 0...180 | deg | 1 | 80 | Maximum phase angle in reverse direction |
| Min forward angle | 0...180 | deg | 1 | 80 | Minimum phase angle in forward direction |
| Min reverse angle | 0...180 | deg | 1 | 80 | Minimum phase angle in reverse direction |
| Voltage start value | 0.010...1.000 | xUn | 0.001 | 0.010 | Voltage start value |

*Table 491: DEFLPDEF Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |
| Operation mode | 1=Phase angle<br>2=IoSin<br>3=IoCos<br>4=Phase angle 80<br>5=Phase angle 88 | | | 1=Phase angle | Operation criteria |
| Enable voltage limit | 0=False<br>1=True | | | 1=True | Enable voltage limit |

*Table 492: DEFLPDEF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 1 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 1 | 0.1217 | Parameter B for customer programmable curve |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 1 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 493: DEFLPDEF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Minimum operate time | 50...60000 | ms | 1 | 50 | Minimum operate time for IDMT curves |
| Allow Non Dir | 0=False<br>1=True | | | 0=False | Allows prot activation as non-dir when dir info is invalid |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |
| Min operate current | 0.5...100.0 | %In | 0.1 | 0.5 | Minimum operating current |
| Min operate voltage | 1.0...100.0 | %Un | 0.1 | 1.0 | Minimum operating voltage |
| Correction angle | 0.0...10.0 | deg | 0.1 | 0.0 | Characteristic correction angle in IoCos and IoSin mode |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |
| Pol quantity | 3=Zero seq. volt.<br>4=Neg. seq. volt. | | | 3=Zero seq. volt. | Reference quantity used to determine fault direction |

*Table 494: DEFHPDEF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.10...40.00 | xIn | 0.01 | 0.10 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operating curve type | 1=ANSI Ext. inv.<br>3=ANSI Norm. inv.<br>5=ANSI Def. Time<br>15=IEC Def. Time<br>17=Programmable | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Characteristic angle | -179...180 | deg | 1 | -90 | Characteristic angle |
| Max forward angle | 0...180 | deg | 1 | 80 | Maximum phase angle in forward direction |
| Max reverse angle | 0...180 | deg | 1 | 80 | Maximum phase angle in reverse direction |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min forward angle | 0...180 | deg | 1 | 80 | Minimum phase angle in forward direction |
| Min reverse angle | 0...180 | deg | 1 | 80 | Minimum phase angle in reverse direction |
| Voltage start value | 0.010...1.000 | xUn | 0.001 | 0.010 | Voltage start value |

*Table 495: DEFHPDEF Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |
| Operation mode | 1=Phase angle<br>2=IoSin<br>3=IoCos<br>4=Phase angle 80<br>5=Phase angle 88 | | | 1=Phase angle | Operation criteria |
| Enable voltage limit | 0=False<br>1=True | | | 1=True | Enable voltage limit |

*Table 496: DEFHPDEF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 1 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 1 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 1 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 497: DEFHPDEF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Minimum operate time | 40...60000 | ms | 1 | 40 | Minimum operate time for IDMT curves |
| Allow Non Dir | 0=False<br>1=True | | | 0=False | Allows prot activation as non-dir when dir info is invalid |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |
| Min operate current | 0.5...100.0 | %In | 0.1 | 0.5 | Minimum operating current |
| Min operate voltage | 1.00...100.00 | %Un | 1.00 | 1.00 | Minimum operating voltage |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Correction angle | 0.0...10.0 | deg | 0.1 | 0.0 | Characteristic correction angle in IoCos and IoSin mode |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |
| Pol quantity | 3=Zero seq. volt.<br>4=Neg. seq. volt. | | | 3=Zero seq. volt. | Reference quantity used to determine fault direction |

### 4.2.2.13 Monitored data

*Table 498: DEFLPDEF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| ANGLE_RCA | FLOAT32 | -180.00...180.00 | deg | Angle between operating angle and characteristic angle |
| ANGLE | FLOAT32 | -180.00...180.00 | deg | Angle between polarizing and operating quantity |
| I_OPER | FLOAT32 | 0.00...40.00 | xIn | Calculated operating current |
| DEFLPDEF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

*Table 499: DEFHPDEF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| ANGLE_RCA | FLOAT32 | -180.00...180.00 | deg | Angle between operating angle and characteristic angle |
| ANGLE | FLOAT32 | -180.00...180.00 | deg | Angle between polarizing and operating quantity |
| I_OPER | FLOAT32 | 0.00...40.00 | xIn | Calculated operating current |
| DEFHPDEF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.2.14 Technical data

*Table 500: DEFxPDEF Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | DEFLPDEF | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle:<br>±2° | | |
| | DEFHPDEF | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$)<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle:<br>±2° | | |
| Start time [1)2)] | | Minimum | Typical | Maximum |
| | DEFHPDEF<br>$I_{Fault}$ = 2 × set *Start value* | 42 ms | 46 ms | 49 ms |
| | DEFLPDEF<br>$I_{Fault}$ = 2 × set *Start value* | 58 ms | 62 ms | 66 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [3)] | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

1) *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 1.5...20

## 4.2.3 Transient/intermittent earth-fault protection INTRPTEF

### 4.2.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Transient/intermittent earth-fault protection | INTRPTEF | Io> -> IEF | 67NTEF/NIEF |

### 4.2.3.2 Function block

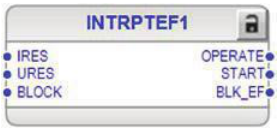



*Figure 239: Function block*

### 4.2.3.3 Functionality

The transient/intermittent earth-fault protection function INTRPTEF is a function designed for the protection and clearance of permanent and intermittent earth faults in distribution and sub-transmission networks. Fault detection is done from the residual current and residual voltage signals by monitoring the transients.

The operating time characteristics are according to definite time (DT).

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.3.4 Analog channel configuration

INTRPTEF has two analog group inputs which must be properly configured.

*Table 501: Analog inputs*

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |
| URES | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 502: Special conditions*

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected for calculating the residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks

in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of INTRPTEF can be described with a module diagram. All the modules in the diagram are explained in the next sections.

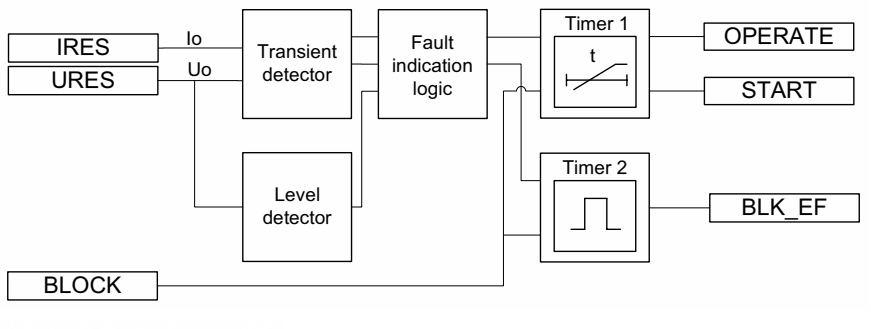



*Figure 240: Functional module diagram*

#### Level detector

The Level detector module is used only when selected *Operation mode* is "Transient EF". The module compares the measured residual voltage to the set *Voltage start value*. If the measured value exceeds the set *Voltage start value*, the module reports the exceeding of the value to the Fault indication logic.

#### Transient detector

The Transient detector module is used for detecting transients in the residual current and residual voltage signals.

The transient detection is supervised with a settable current threshold. With a special filtering technique, the setting *Min operate current* is based on the fundamental frequency current. This setting should be set based on the value of the parallel resistor of the coil, with security margin. For example, if the resistive current of the parallel resistor is 10 A, then a value of 0.7×10 A = 7 A could be used. The same setting is also applicable in case the coil is disconnected and the network becomes unearthed. Generally, a smaller value should be used and it must never exceed the value of the parallel resistor in order to allow operation of the faulted feeder.

#### Fault indication logic

Depending on the set *Operation mode*, INTRPTEF has two independent modes for detecting earth faults. The "Transient EF" mode is intended to detect all kinds of earth faults. The "Intermittent EF" mode is dedicated for detecting intermittent earth faults in cable networks.

To satisfy the sensitivity requirements, basic earth fault protection (based on fundamental frequency phasors) should always be used in parallel with the INTRPTEF function.

The Fault indication logic module determines the direction of the fault. The fault direction determination is secured by multi-frequency neutral admittance measurement and special filtering techniques. This enables fault direction determination which is not sensitive to disturbances in measured Io and Uo signals, for example, switching transients.

When *Directional mode* setting "Forward" is used, the protection operates when the fault is in the protected feeder. When *Directional mode* setting "Reverse" is used, the protection operates when the fault is outside the protected feeder (in the background network). If the direction has no importance, the value "Non-directional" can be selected. The detected fault direction (FAULT_DIR) is available in the monitored data view.

In the "Transient EF" mode, when the start transient of the fault is detected and the Uo level exceeds the set "Voltage start value", Timer 1 is activated. Timer 1 is kept activated until the Uo level exceeds the set value or in case of a drop-off, the drop-off duration is shorter than the set *Reset delay time*.

In the "Intermittent EF" mode, when the start transient of the fault is detected and the Uo level exceeds the set *Voltage start value*, the Timer 1 is activated. When a required number of intermittent earth-fault transients set with the *Peak counter limit* setting are detected without the function being reset (depends on the drop-off time set with the *Reset delay time* setting), the START output is activated. The Timer 1 is kept activated as long as transients are occurring during the drop-off time defined by setting *Reset delay time*.

### Timer 1

The time characteristic is according to DT.

In the "Transient EF" mode, the OPERATE output is activated after *Operate delay time* if the residual voltage exceeds the set "Voltage start value". The *Reset delay time* starts to elapse when residual voltage falls below *Voltage start value*. If there is no OPERATE activation, for example, the fault disappears momentarily, START stays activated until the the *Reset delay time* elapses. After OPERATE activation, START and OPERATE signals are reset as soon as Uo falls below *Voltage start value*.

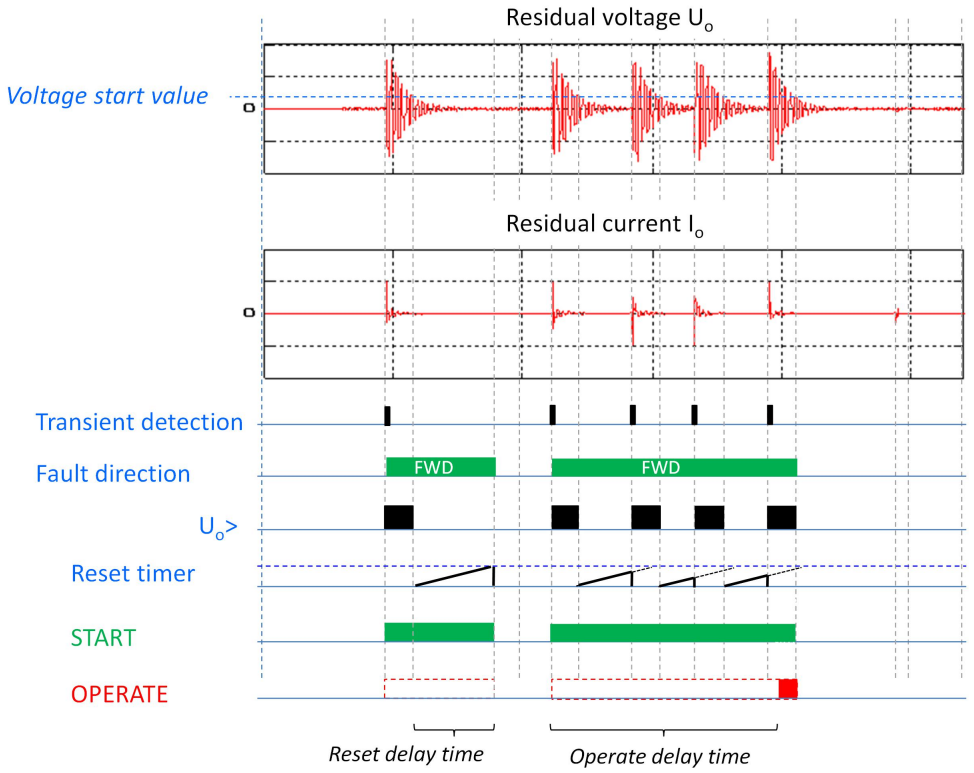



*Figure 241: Example of INTRPTEF operation in "Transient EF" mode in the faulty feeder*

In the "Intermittent EF" mode the OPERATE output is activated when the following conditions are fulfilled:

- the number of transients that have been detected exceeds the *Peak counter limit* setting
- the timer has reached the time set with the *Operate delay time*
- and one additional transient is detected during the drop-off cycle

The *Reset delay time* starts to elapse from each detected transient (peak). In case there is no OPERATE activation, for example, the fault disappears momentarily START stays activated until the *Reset delay time* elapses, that is, reset takes place if time between transients is more than *Reset delay time*. After OPERATE activation, a fixed pulse length of 100 ms for OPERATE is given, whereas START is reset after *Reset delay time* elapses

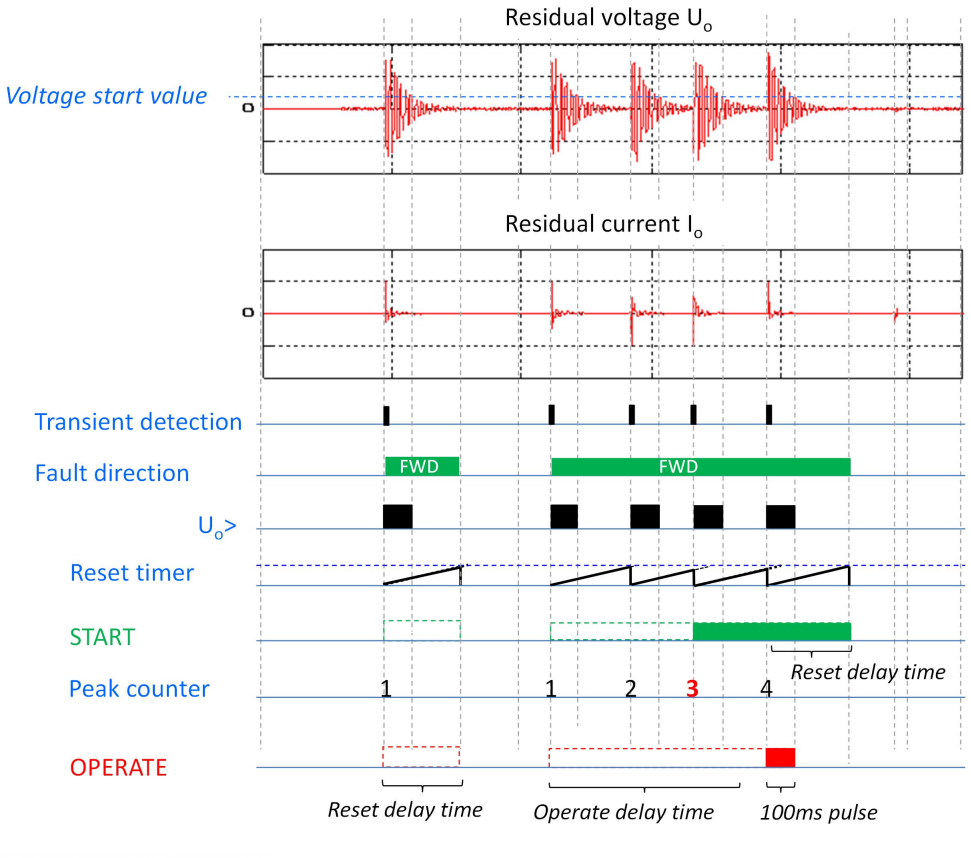



*Figure 242: Example of INTRPTEF operation in "Intermittent EF" mode in the faulty feeder, Peak counter limit=3*

The timer calculates the start duration value START_DUR which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

## Timer 2

If the function is used in the directional mode and an opposite direction transient is detected, the BLK_EF output is activated for the fixed delay time of 25 ms. If the START output is activated when the BLK_EF output is active, the BLK_EF output is deactivated.

## Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking* mode setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the

whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, the function operates normally but the OPERATE output is not activated.

### 4.2.3.6 Application

INTRPTEF is an earth-fault function dedicated to operate in intermittent and permanent earth faults occurring in distribution and sub-transmission networks. Fault detection is done from the residual current and residual voltage signals by monitoring the transients with predefined criteria. As the function has a dedicated purpose for the fault types, fast detection and clearance of the faults can be achieved.

#### Intermittent earth fault

Intermittent earth fault is a special type of fault that is encountered especially in compensated networks with underground cables. A typical reason for this type of fault is the deterioration of cable insulation either due to mechanical stress or due to insulation material aging process where water or moisture gradually penetrates the cable insulation. This eventually reduces the voltage withstand of the insulation, leading to a series of cable insulation breakdowns. The fault is initiated as the phase-to-earth voltage exceeds the reduced insulation level of the fault point and mostly extinguishes itself as the fault current drops to zero for the first time, as shown in Figure 243. As a result, very short transients, that is, rapid changes in the form of spikes in residual current (Io) and in residual voltage (Uo), can be repeatedly measured. Typically, the fault resistance in case of an intermittent earth fault is only a few ohms.

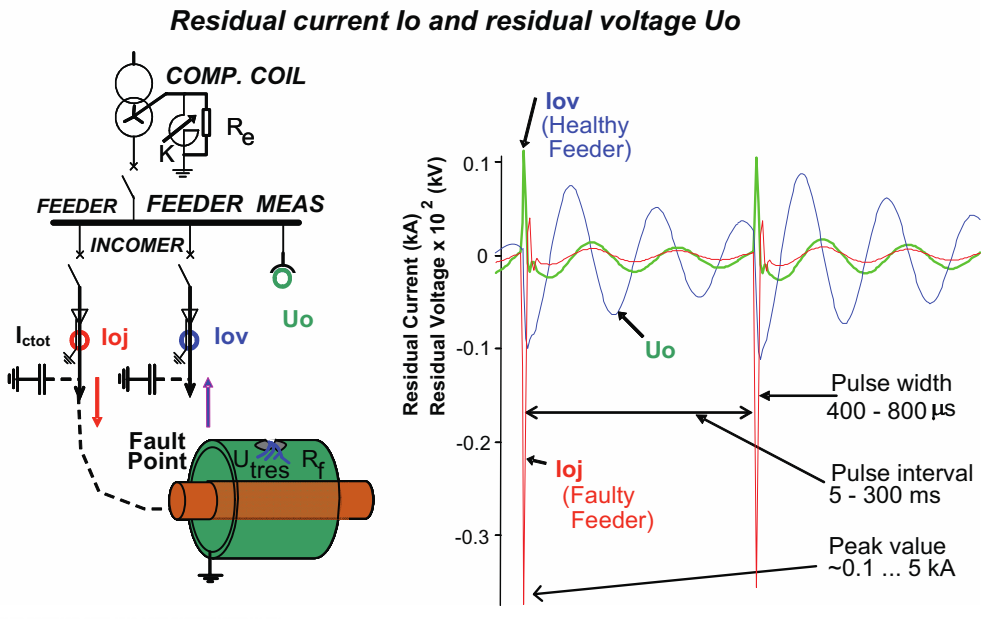



*Figure 243: Typical intermittent earth-fault characteristics*

### Earth-fault transients

In general, earth faults generate transients in currents and voltages. There are several factors that affect the magnitude and frequency of these transients, such as the fault moment on the voltage wave, fault location, fault resistance and the parameters of the feeders and the supplying transformers. In the fault initiation, the voltage of the faulty phase decreases and the corresponding capacitance is discharged to earth (→ discharge transients). At the same time, the voltages of the healthy phases increase and the related capacitances are charged (→ charge transient).

If the fault is permanent (non-transient) in nature, only the initial fault transient in current and voltage can be measured, whereas the intermittent fault creates repetitive transients.

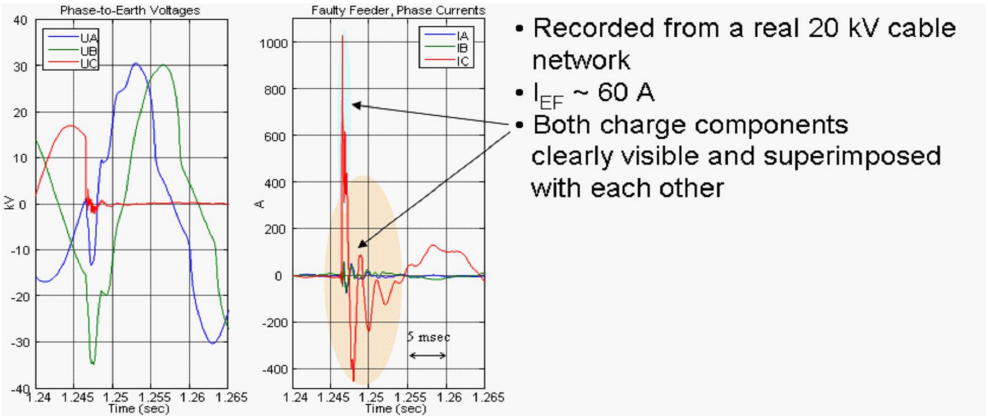



*Figure 244: Example of earth-fault transients, including discharge and charge transient components, when a permanent fault occurs in a 20 kV network in phase C*

## 4.2.3.7 Signals

*Table 503: INTRPTEF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 504: INTRPTEF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| BLK_EF | BOOLEAN | Block signal for EF to indicate opposite direction peaks |

### 4.2.3.8 Settings

*Table 505: INTRPTEF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Operate delay time | 40...1200000 | ms | 10 | 500 | Operate delay time |
| Voltage start value | 0.05...0.50 | xUn | 0.01 | 0.20 | Voltage start value |

*Table 506: INTRPTEF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=Intermittent EF<br>2=Transient EF | | | 1=Intermittent EF | Operation criteria |

*Table 507: INTRPTEF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 40...60000 | ms | 1 | 500 | Reset delay time |
| Peak counter limit | 2...20 | | 1 | 2 | Min requirement for peak counter before start in IEF mode |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.01 | Minimum operating current for transient detector |

### 4.2.3.9 Monitored data

*Table 508: INTRPTEF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| FAULT_DIR | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Detected fault direction |
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| INTRPTEF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.3.10 Technical data

*Table 509: INTRPTEF Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy (Uo criteria with transient protection) | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × Uo |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5 |

## 4.2.4 Admittance-based earth-fault protection EFPADM

### 4.2.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Admittance-based earth-fault protection | EFPADM | Yo> -> | 21NY |

### 4.2.4.2 Function block

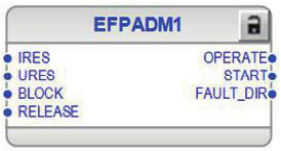



*Figure 245: Function block*

### 4.2.4.3 Functionality

The admittance-based earth-fault protection function EFPADM provides a selective earth-fault protection function for high-resistance earthed, unearthed and compensated networks. It can be applied for the protection of overhead lines as well as with underground cables. It can be used as an alternative solution to traditional residual current-based earth-fault protection functions, such as the IoCos mode in DEFxPDEF. Main advantages of EFPADM include a versatile applicability, good sensitivity and easy setting principles.

EFPADM is based on evaluating the neutral admittance of the network, that is, the quotient:

$$\underline{Yo} = \frac{\underline{Io}}{-\underline{Uo}}$$

(Equation 44)

The measured admittance is compared to the admittance characteristic boundaries in the admittance plane. The supported characteristics include overadmittance, oversusceptance, overconductance or any combination of the three. The directionality of the oversusceptance and overconductance criteria can be defined as forward, reverse or non-directional, and the boundary lines can be tilted if required by the application. This allows the optimization of the shape of the admittance characteristics for any given application.

EFPADM supports two calculation algorithms for admittance. The admittance calculation can be set to include or exclude the prefault zero-sequence values of Io and Uo. Furthermore, the calculated admittance is recorded at the time of the trip and it can be monitored for post-fault analysis purposes.

To ensure the security of the protection, the admittance calculation is supervised by a residual overvoltage condition which releases the admittance protection during a fault condition. Alternatively, the release signal can be provided by an external binary signal.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.4.4 Analog channel configuration

EFPADM has two analog group inputs which must be properly configured.

*Table 510: Analog inputs*

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |
| URES | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 511: Special conditions*

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of EFPADM can be described using a module diagram. All the modules in the diagram are explained in the next sections.

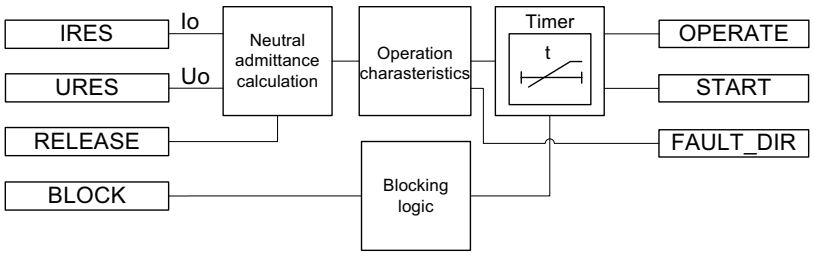



*Figure 246: Functional module diagram*

#### Neutral admittance calculation

When the residual voltage exceeds the set threshold *Voltage start value*, an earth fault is detected and the neutral admittance calculation is released.

To ensure a sufficient accuracy for the Io and Uo measurements, it is required that the residual voltage exceeds the value set by *Min operate voltage*. If the admittance calculation mode is "Delta", the minimum change in the residual voltage due to a fault must be 0.01 × Un to enable the operation. Similarly, the residual current must exceed the value set by *Min operate current*.

The polarity of the polarizing quantity Uo can be changed, that is, rotated by 180 degrees, by setting the *Pol reversal* parameter to "True" or by switching the polarity of the residual voltage measurement wires.

As an alternative for the internal residual overvoltage-based start condition, the neutral admittance protection can also be externally released by utilizing the RELEASE input.

When *Admittance Clc mode* is set to "Delta", the external logic used must be able to give RELEASE in less than 0.1 s from fault initiation. Otherwise the collected pre-fault values are overwritten with fault time values. If it is slower, *Admittance Clc mode* must be set to “Normal”.

Neutral admittance is calculated as the quotient between the residual current and residual voltage (polarity reversed) fundamental frequency phasors. The *Admittance Clc mode* setting defines the calculation mode.

*Admittance Clc mode* = "Normal"

$$\underline{Yo} = \frac{\underline{Io}_{fault}}{-\underline{Uo}_{fault}}$$

(Equation 45)

*Admittance Clc mode* = "Delta"

$$\underline{Yo} = \frac{\underline{Io}_{fault} - \underline{Io}_{prefault}}{-(\underline{Uo}_{fault} - \underline{Uo}_{prefault})} = \frac{\Delta \underline{Io}}{-\Delta \underline{Uo}}$$

(Equation 46)

| | |
|---|---|
| $\underline{Yo}$ | Calculated neutral admittance [Siemens] |
| $\underline{Io}_{fault}$ | Residual current during the fault [Amperes] |
| $\underline{Uo}_{fault}$ | Residual voltage during the fault [Volts] |
| $\underline{Io}_{prefault}$ | Prefault residual current [Amperes] |
| $\underline{Uo}_{prefault}$ | Prefault residual voltage [Volts] |
| $\Delta\underline{Io}$ | Change in the residual current due to fault [Amperes] |
| $\Delta\underline{Uo}$ | Change in the residual voltage due to fault [Volts] |

Traditionally, admittance calculation is done with the calculation mode "Normal", that is, with the current and voltage values directly measured during the fault. As an alternative, by selecting the calculation mode "Delta", the prefault zero-sequence asymmetry of the network can be removed from the admittance calculation. Theoretically, this makes the admittance calculation totally immune to fault resistance, that is, the estimated admittance value is not affected by fault resistance. Utilization of the change in Uo and Io due to a fault in the admittance calculation also mitigates the effects of the VT and CT measurement errors, thus improving the measuring accuracy, the sensitivity and the selectivity of the protection.

Calculation mode "Delta" is recommended in case a high sensitivity of the protection is required, if the network has a high degree of asymmetry during the healthy state or if the residual current measurement is based on sum connection, that is, the Holmgren connection.

Neutral admittance calculation produces certain values during forward and reverse faults.

Fault in reverse direction, that is, outside the protected feeder.

$$\underline{Yo} = -\underline{Y}_{Fdtot}$$

(Equation 47)

$$\approx -j \cdot \frac{I_{eFd}}{U_{ph}}$$

(Equation 48)

| | |
|---|---|
| $\underline{Y}_{Fdtot}$ | Sum of the phase-to-earth admittances ($\underline{Y}_{FdA}$, $\underline{Y}_{FdB}$, $\underline{Y}_{FdC}$) of the protected feeder |
| $I_{eFd}$ | Magnitude of the earth-fault current of the protected feeder when the fault resistance is zero ohm |
| $U_{ph}$ | Magnitude of the nominal phase-to-earth voltage of the system |

Equation 47 shows that in case of outside faults, the measured admittance equals the admittance of the protected feeder with a negative sign. The measured admittance is dominantly reactive; the small resistive part of the measured admittance is due to the leakage losses of the feeder. Theoretically, the measured admittance is located in the third quadrant in the admittance plane close to the im($\underline{Y}$o) axis, see Figure 247.

The result of Equation 47 is valid regardless of the neutral earthing method. In compensated networks the compensation degree does not affect the result. This enables a straightforward setting principle for the neutral admittance protection: admittance characteristic is set to cover the value $\underline{Y}o = -\underline{Y}_{Fdtot}$ with a suitable margin.

Due to inaccuracies in voltage and current measurement, the small real part of the calculated neutral admittance may appear as positive, which brings the measured admittance in the fourth quadrant in the admittance plane. This should be considered when setting the admittance characteristic.

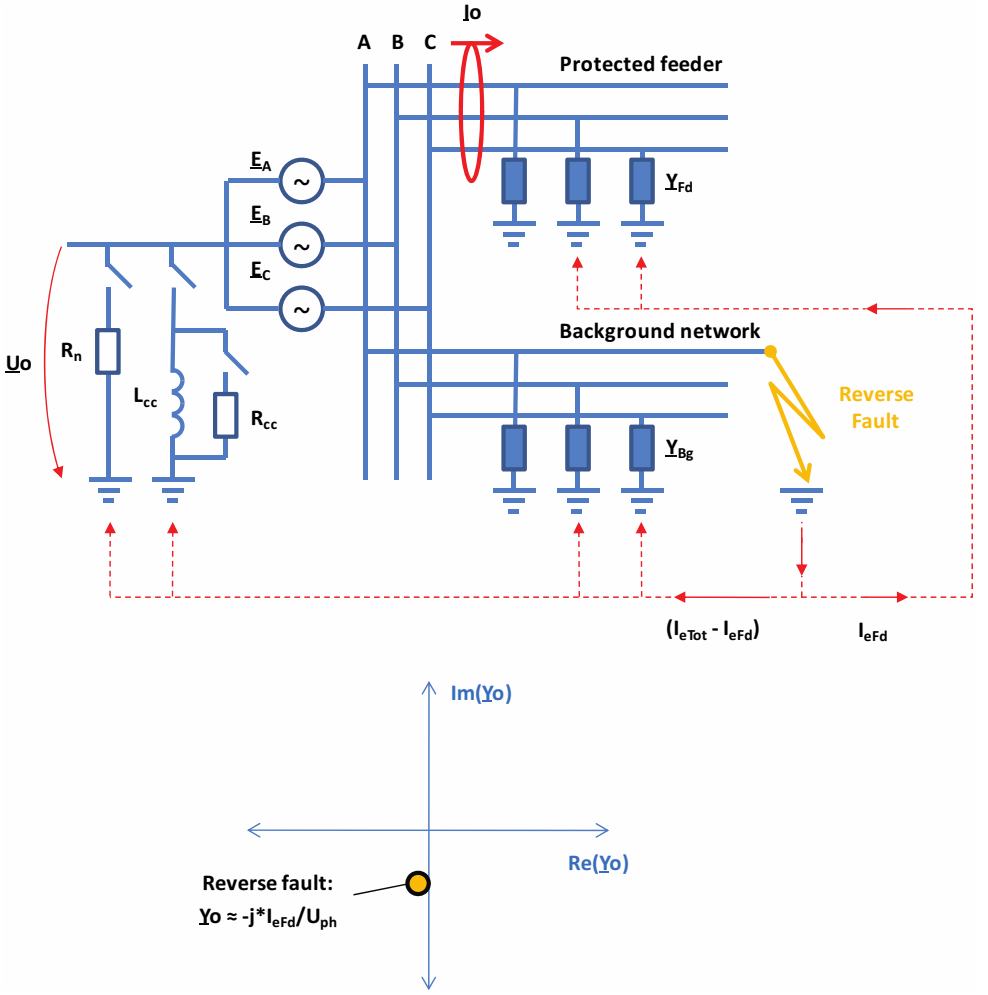



*Figure 247: Admittance calculation during a reverse fault*

| | |
|---|---|
| $R_{CC}$ | Resistance of the parallel resistor |
| $L_{CC}$ | Inductance of the compensation coil |
| $R_n$ | Resistance of the neutral earthing resistor |
| $\underline{Y}_{Fd}$ | Phase-to-earth admittance of the protected feeder |
| $\underline{Y}_{Bg}$ | Phase-to-earth admittance of the background network |

For example, in a 15 kV compensated network with the magnitude of the earth-fault current in the protected feeder being 10 A (Rf = 0 Ω), the theoretical value for the measured admittance during an earth fault in the reverse direction, that is, outside the protected feeder, can be calculated.

$$\underline{Yo} \approx -j \cdot \frac{I_{eFd}}{U_{ph}} = -j \cdot \frac{10A}{\frac{15}{\sqrt{3}}kV} = -j \cdot 1.15\ mS$$

(Equation 49)

The result is valid regardless of the neutral earthing method.

In this case, the resistive part of the measured admittance is due to leakage losses of the protected feeder. As they are typically very small, the resistive part is close to zero. Due to inaccuracies in the voltage and current measurement, the small real part of the apparent neutral admittance may appear positive. This should be considered in the setting of the admittance characteristic.

Fault in the forward direction, that is, inside the protected feeder.

Unearthed network.

$$\underline{Yo} = \underline{Y}_{Bgtot}$$

(Equation 50)

$$\approx j \cdot \left( \frac{I_{eTot} - I_{eFd}}{U_{ph}} \right)$$

(Equation 51)

Compensated network:

$$\underline{Yo} = \underline{Y}_{Bgtot} + \underline{Y}_{CC}$$

(Equation 52)

$$\approx \frac{I_{Rcc} + j \cdot \left( I_{eTot} \cdot (1 - K) - I_{eFd} \right)}{U_{ph}}$$

(Equation 53)

High-resistance earthed network:

$$\underline{Yo} = \underline{Y}_{Bgtot} + \underline{Y}_{Rn}$$

(Equation 54)

$$\approx \frac{I_{Rn} + j \cdot \left( I_{eTot} - I_{eFd} \right)}{U_{ph}}$$

(Equation 55)

| | |
|---|---|
| $\underline{Y}_{Bgtot}$ | Sum of the phase-to-earth admittances ($\underline{Y}_{BgA}$, $\underline{Y}_{BgB}$, $\underline{Y}_{BgC}$) of the background network |
| $\underline{Y}_{CC}$ | Admittance of the earthing arrangement (compensation coil and parallel resistor) |
| $I_{Rcc}$ | Rated current of the parallel resistor |
| $I_{eFd}$ | Magnitude of the earth-fault current of the protected feeder when the fault resistance is zero ohm |
| $I_{eTot}$ | Magnitude of the uncompensated earth-fault current of the network when Rf is zero ohm |
| K | Compensation degree, K = 1 full resonance, K<1 undercompensated, K>1 overcompensated |
| $I_{Rn}$ | Rated current of the neutral earthing resistor |

Equation 50 shows that in case of a fault inside the protected feeder in unearthed networks, the measured admittance equals the admittance of the background network. The admittance is dominantly reactive; the small resistive part of the measured

admittance is due to the leakage losses of the background network. Theoretically, the measured admittance is located in the first quadrant in the admittance plane, close to the im(Yo) axis, see Figure 248.

Equation 52 shows that in case of a fault inside the protected feeder in compensated networks, the measured admittance equals the admittance of the background network and the coil including the parallel resistor. Basically, the compensation degree determines the imaginary part of the measured admittance and the resistive part is due to the parallel resistor of the coil and the leakage losses of the background network and the losses of the coil. Theoretically, the measured admittance is located in the first or fourth quadrant in the admittance plane, depending on the compensation degree, see Figure 248.



Before the parallel resistor is connected, the resistive part of the measured admittance is due to the leakage losses of the background network and the losses of the coil. As they are typically small, the resistive part may not be sufficiently large to secure the discrimination of the fault and its direction based on the measured conductance. This and the rating and the operation logic of the parallel resistor should be considered when setting the admittance characteristic in compensated networks.

Equation 54 shows that in case of a fault inside the protected feeder in high-resistance earthed systems, the measured admittance equals the admittance of the background network and the neutral earthing resistor. Basically, the imaginary part of the measured admittance is due to the phase-to-earth capacitances of the background network, and the resistive part is due to the neutral earthing resistor and the leakage losses of the background network. Theoretically, the measured admittance is located in the first quadrant in the admittance plane, see Figure 248.

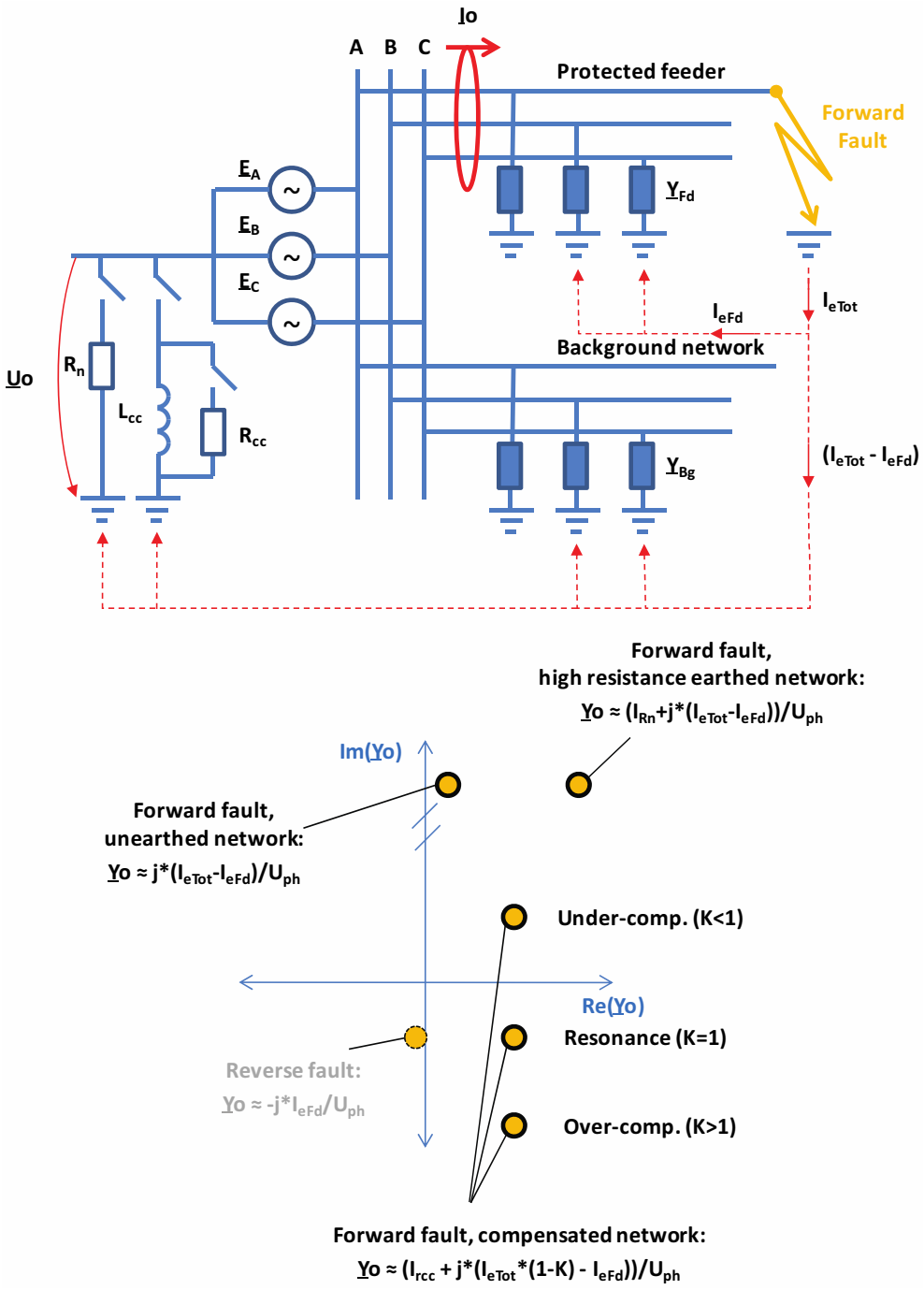



*Figure 248: Admittance calculation during a forward fault*

When the network is fully compensated in compensated networks, theoretically during a forward fault, the imaginary part of the measured admittance equals the susceptance of the protected feeder with a negative sign. The discrimination between a forward and reverse fault must therefore be based on the real part of the measured admittance, that is, conductance. Thus, the best selectivity is achieved

when the compensated network is operated either in the undercompensated or overcompensated mode.

For example, in a 15 kV compensated network, the magnitude of the earth fault current of the protected feeder is 10 A (Rf = 0 Ω) and the magnitude of the network is 100 A (Rf = 0 Ω). During an earth fault, a 15 A resistor is connected in parallel to the coil after a 1.0 second delay. Compensation degree is overcompensated, K = 1.1.

During an earth fault in the forward direction, that is, inside the protected feeder, the theoretical value for the measured admittance after the connection of the parallel resistor can be calculated.

$$\underline{Yo} \approx \frac{I_{Rcc} + j \cdot \left(I_{eTot} \cdot (1-K) - I_{eFd}\right)}{U_{ph}}$$
$$= \frac{15A + j \cdot \left(100A \cdot (1-1.1) - 10A\right)}{\frac{15kV}{\sqrt{3}}} \approx (1.73 - j \cdot 2.31)\ mS$$

(Equation 56)

Before the parallel resistor is connected, the resistive part of the measured admittance is due to the leakage losses of the background network and the losses of the coil. As they are typically small, the resistive part may not be sufficiently large to secure the discrimination of the fault and its direction based on the measured conductance. This and the rating and the operation logic of the parallel resistor should be considered when setting the admittance characteristic.

When a high sensitivity of the protection is required, the residual current should be measured with a cable/ring core CT, that is, the Ferranti CT. Also the use of the sensitive `Io` input should be considered. The residual voltage measurement should be done with an open delta connection of the three single pole-insulated voltage transformers.

The sign of the admittance characteristic settings should be considered based on the location of characteristic boundary in the admittance plane. All forward-settings are given with positive sign and reverse-settings with negative sign.

## Operation characteristic

After the admittance calculation is released, the calculated neutral admittance is compared to the admittance characteristic boundaries in the admittance plane. If the calculated neutral admittance Yo moves outside the characteristic, the enabling signal is sent to the timer.

EFPADM supports a wide range of different characteristics to achieve the maximum flexibility and sensitivity in different applications. The basic characteristic shape is selected with the *Operation mode* and *Directional mode* settings. *Operation mode* defines which operation criterion or criteria are enabled and *Directional mode* defines if the forward, reverse or non-directional boundary lines for that particular operation mode are activated. The FAULT_DIR output indicates which operation sector the fault is measured. The output is operational once the function is started.

*Table 512: Operation criteria*

| Operation mode | Description |
|---|---|
| Yo | Admittance criterion |
| Bo | Susceptance criterion |
| Go | Conductance criterion |
| Yo, Go | Admittance criterion combined with the conductance criterion |
| Yo, Bo | Admittance criterion combined with the susceptance criterion |
| Go, Bo | Conductance criterion combined with the susceptance criterion |
| Yo, Go, Bo | Admittance criterion combined with the conductance and susceptance criterion |

The options for the *Directional mode* setting are "Non-directional", "Forward" and "Reverse".

Figure 249, Figure 250 and Figure 251 illustrate the admittance characteristics supported by EFPADM and the settings relevant to that particular characteristic. The most typical characteristics are highlighted and explained in details in the chapter Neutral admittance characteristics. Operation is achieved when the calculated neutral admittance Yo moves outside the characteristic (the operation area is marked with gray).

The settings defining the admittance characteristics are given in primary milliSiemens (mS). The conversion equation for the admittance from secondary to primary is:

$$Y_{pri} = Y_{sec} \cdot \frac{ni_{CT}}{nu_{VT}}$$

(Equation 57)

$ni_{CT}$ CT ratio for the residual current Io

$nu_{VT}$ VT ratio for the residual voltage Uo

Example: Admittance setting in the secondary is 5.00 milliSiemens. The CT ratio is 100/1 A and the VT ratio is 11547/100 V. The admittance setting in the primary can be calculated.

$$Y_{pri} = 5.00\ mS \cdot \frac{\frac{100}{1}A}{\frac{11547}{100}V} = 4.33\ mS$$

(Equation 58)

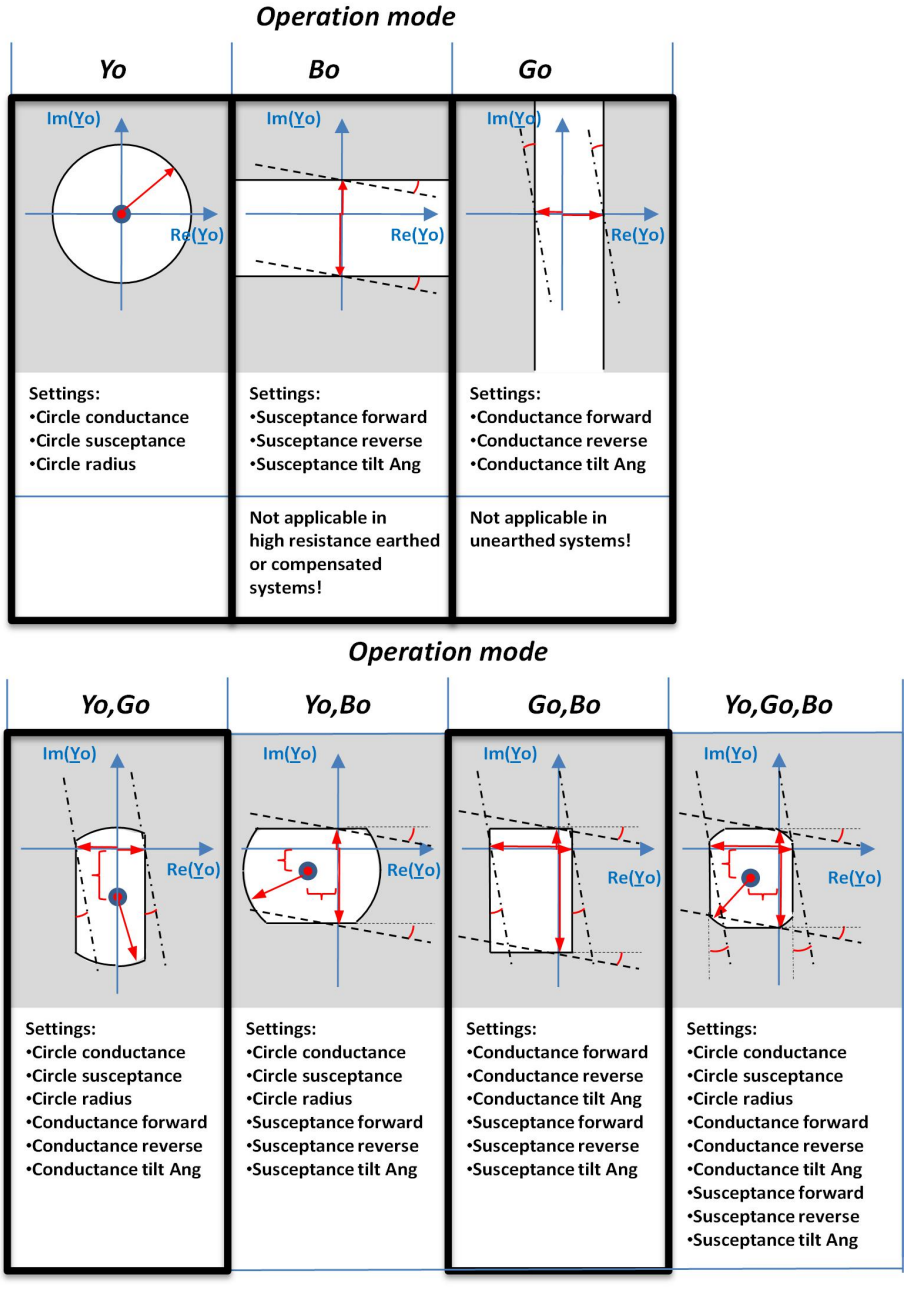



*Figure 249: Admittance characteristic with different operation modes when Directional mode = "Non-directional"*

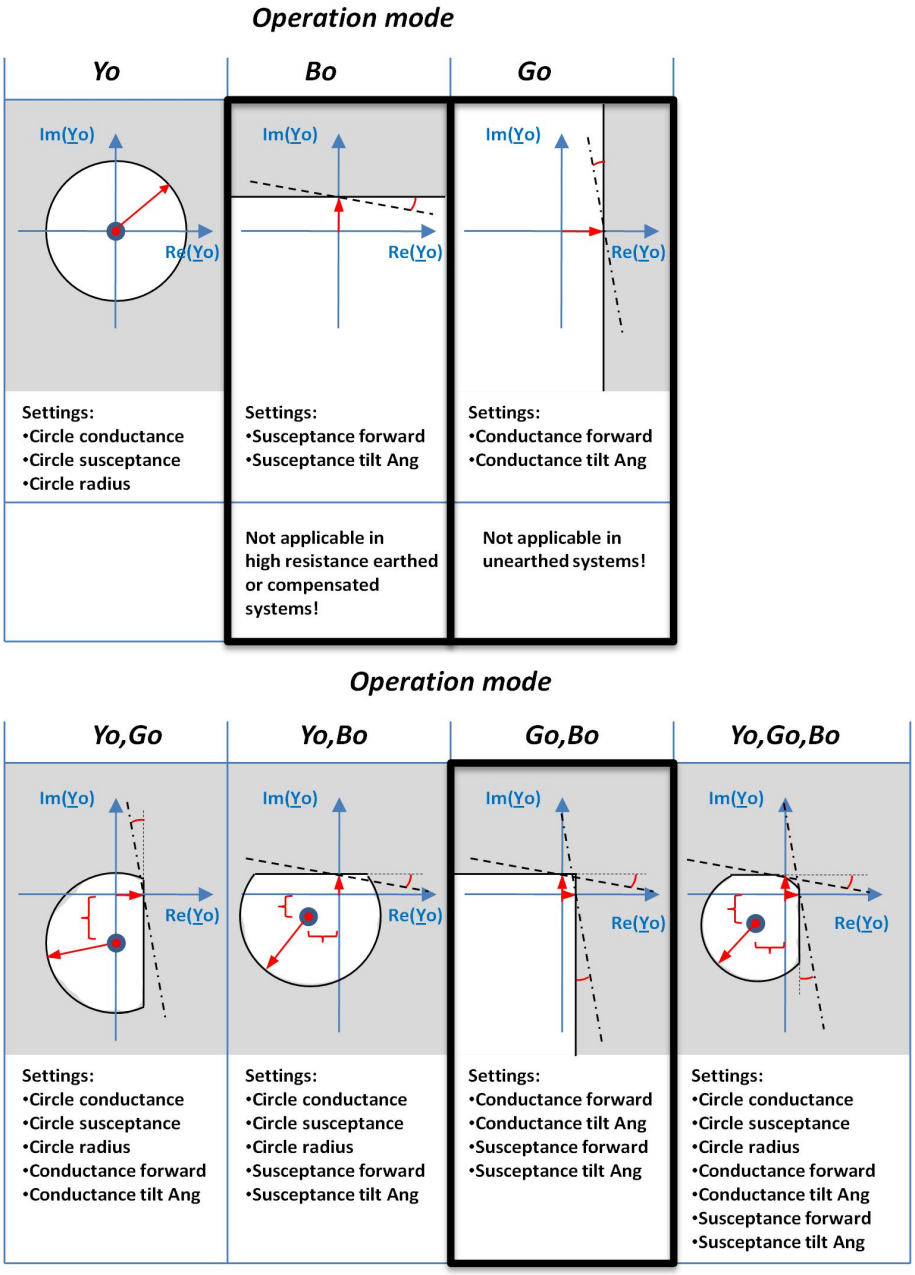



*Figure 250: Admittance characteristic with different operation modes when Directional mode = "Forward"*

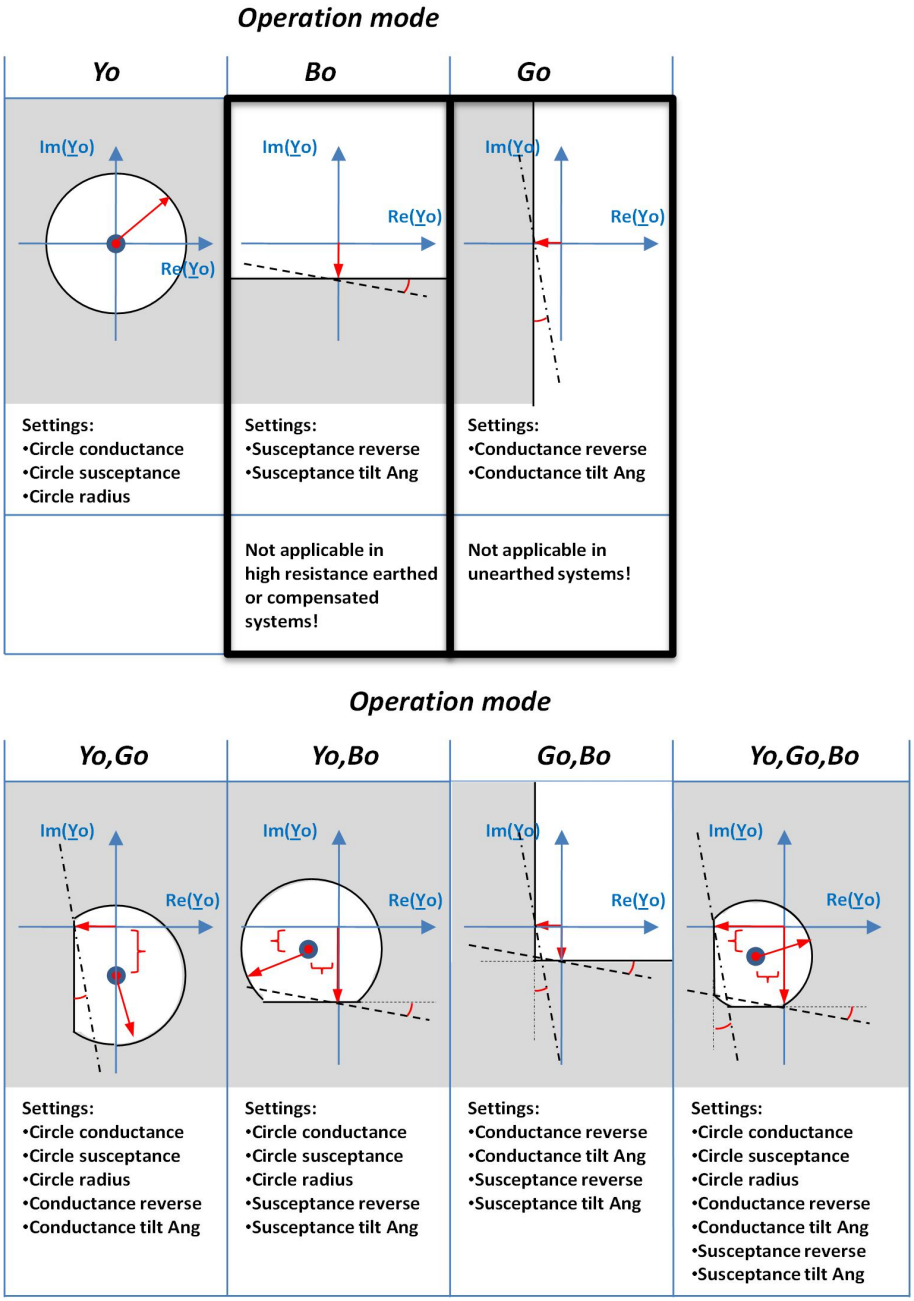



*Figure 251: Admittance characteristic with different operation modes when Directional mode = "Reverse"*

## Timer

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set with the *Operate delay time* setting, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set with the *Reset delay time* setting, the operation timer resets and the START output is

deactivated. The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.2.4.6 Neutral admittance characteristics

The applied characteristic should always be set to cover the total admittance of the protected feeder with a suitable margin. However, more detailed setting value selection principles depend on the characteristic in question.



The settings defining the admittance characteristics are given in primary milliSiemens.

The forward and reverse boundary settings should be set so that the forward setting is always larger than the reverse setting and that there is space between them.

### Overadmittance characteristic

The overadmittance criterion is enabled with the setting *Operation mode* set to "Yo". The characteristic is a circle with the radius defined with the *Circle radius* setting. For the sake of application flexibility, the midpoint of the circle can be moved away from the origin with the *Circle conductance* and *Circle susceptance* settings. Default values for *Circle conductance* and *Circle susceptance* are 0.0 mS, that is, the characteristic is an origin-centered circle.

Operation is achieved when the measured admittance moves outside the circle.

The overadmittance criterion is typically applied in unearthed networks, but it can also be used in compensated networks, especially if the circle is set off from the origin.

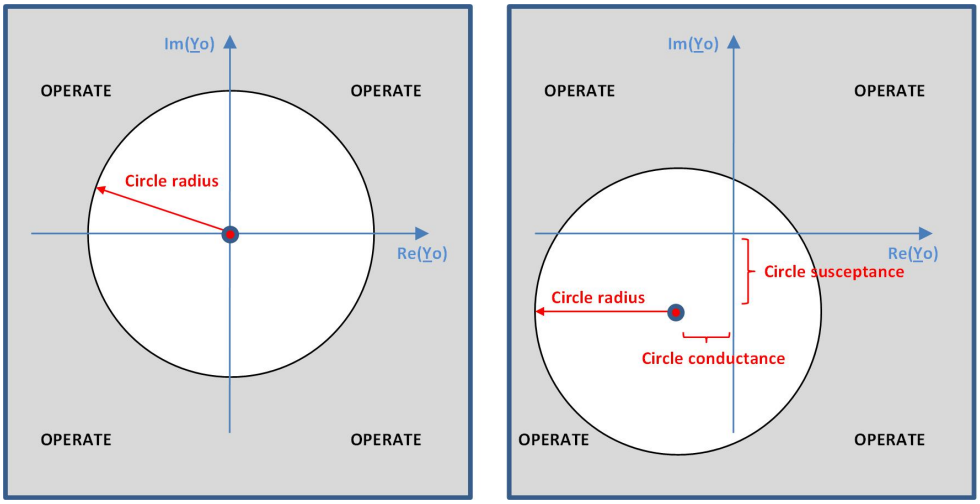



*Figure 252: Overadmittance characteristic. Left figure: classical origin-centered admittance circle. Right figure: admittance circle is set off from the origin.*

## Non-directional overconductance characteristic

The non-directional overconductance criterion is enabled with the *Operation mode* setting set to "Go" and *Directional mode* to "Non-directional". The characteristic is defined with two overconductance boundary lines with the *Conductance forward* and *Conductance reverse* settings. For the sake of application flexibility, the boundary lines can be tilted by the angle defined with the *Conductance tilt Ang* setting. By default, the tilt angle is zero degrees, that is, the boundary line is a vertical line in the admittance plane. A positive tilt value rotates the boundary line counterclockwise from the vertical axis.

In case of non-directional conductance criterion, the *Conductance reverse* setting must be set to a smaller value than *Conductance forward*.

Operation is achieved when the measured admittance moves over either of the boundary lines.

The non-directional overconductance criterion is applicable in high-resistance earthed and compensated networks. It must not be applied in unearthed networks.

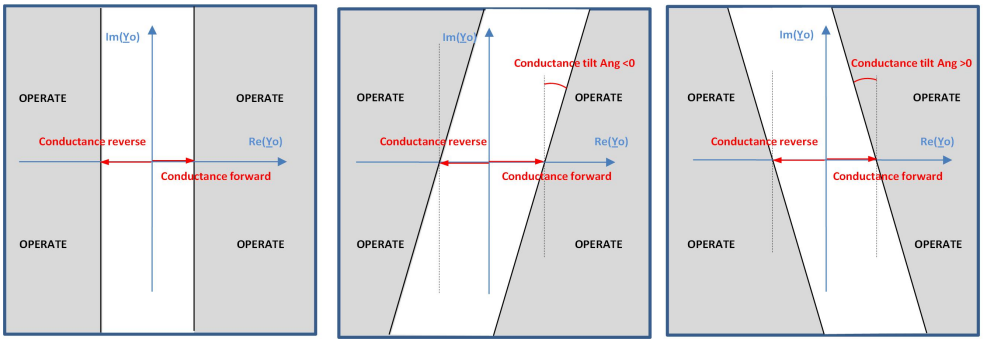



*Figure 253: Non-directional overconductance characteristic. Left figure: classical non-directional overconductance criterion. Middle figure: characteristic is tilted with negative tilt angle. Right figure: characteristic is tilted with positive tilt angle.*

## Forward directional overconductance characteristic

The forward directional overconductance criterion is enabled with the *Operation mode* setting set to "Go" and *Directional mode* set to "Forward". The characteristic is defined by one overconductance boundary line with the *Conductance forward* setting. For the sake of application flexibility, the boundary line can be tilted with the angle defined with the *Conductance tilt Ang* setting. By default, the tilt angle is zero degrees, that is, the boundary line is a vertical line in the admittance plane. A positive tilt value rotates the boundary line counterclockwise from the vertical axis.

Operation is achieved when the measured admittance moves over the boundary line.

The forward directional overconductance criterion is applicable in high-resistance earthed and compensated networks. It must not be applied in unearthed networks.

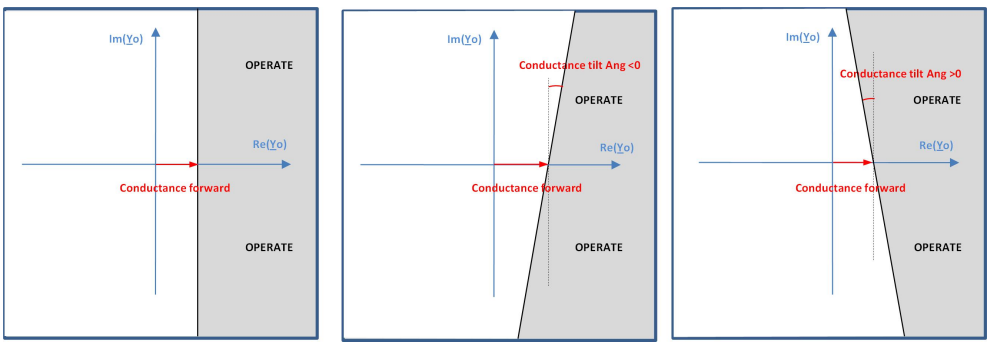



*Figure 254: Forward directional overconductance characteristic. Left figure: classical forward directional overconductance criterion. Middle figure: characteristic is tilted with negative tilt angle. Right figure: characteristic is tilted with positive tilt angle.*

## Forward directional oversusceptance characteristic

The forward directional oversusceptance criterion is enabled with the *Operation mode* setting set to "Bo" and *Directional mode* to "Forward". The characteristic is defined by one oversusceptance boundary line with the *Susceptance forward* setting. For the sake of application flexibility, the boundary line can be tilted by the angle defined with the *Susceptance tilt Ang* setting. By default, the tilt angle is zero degrees, that is, the boundary line is a horizontal line in the admittance plane. A positive tilt value rotates the boundary line counterclockwise from the horizontal axis.

Operation is achieved when the measured admittance moves over the boundary line.

The forward directional oversusceptance criterion is applicable in unearthed networks. It must not be applied to compensated networks.

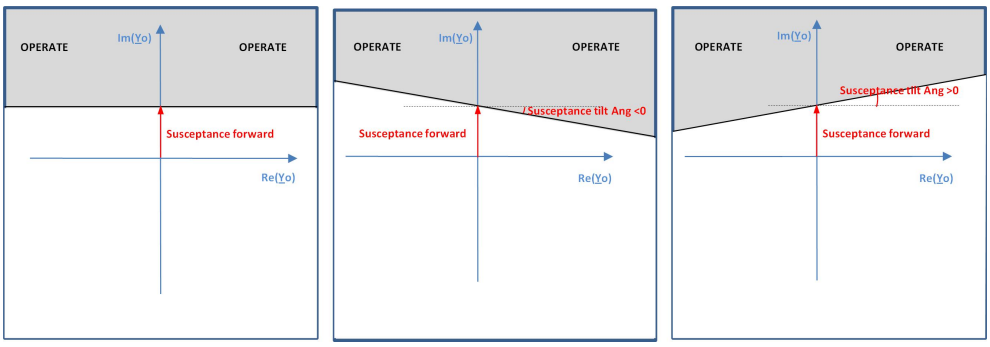



*Figure 255: Forward directional oversusceptance characteristic. Left figure: classical forward directional oversusceptance criterion. Middle figure: characteristic is tilted with negative tilt angle. Right figure: characteristic is tilted with positive tilt angle.*

## Combined overadmittance and overconductance characteristic

The combined overadmittance and overconductance criterion is enabled with the *Operation mode* setting set to "Yo, Go" and *Directional mode* to "Non-directional". The characteristic is a combination of a circle with the radius defined with the *Circle radius* setting and two overconductance boundary lines with the settings *Conductance forward* and *Conductance reverse*. For the sake of application flexibility, the midpoint of the circle can be moved from the origin with the *Circle conductance* and *Circle susceptance* settings. Also the boundary lines can be tilted by the angle defined with the *Conductance tilt Ang* setting. By default, the *Circle conductance* and *Circle susceptance* are 0.0 mS and *Conductance tilt Ang* equals zero degrees, that is, the characteristic is a combination of an origin-centered circle with two vertical overconductance boundary lines. A positive tilt value for the *Conductance tilt Ang* setting rotates boundary lines counterclockwise from the vertical axis.

In case of the non-directional conductance criterion, the *Conductance reverse* setting must be set to a smaller value than *Conductance forward*.

Operation is achieved when the measured admittance moves outside the characteristic.

The combined overadmittance and overconductance criterion is applicable in unearthed, high-resistance earthed and compensated networks or in systems where the system earthing may temporarily change during normal operation from compensated network to unearthed system.

Compared to the overadmittance criterion, the combined characteristic improves sensitivity in high-resistance earthed and compensated networks. Compared to the non-directional overconductance criterion, the combined characteristic enables the protection to be applied also in unearthed systems.

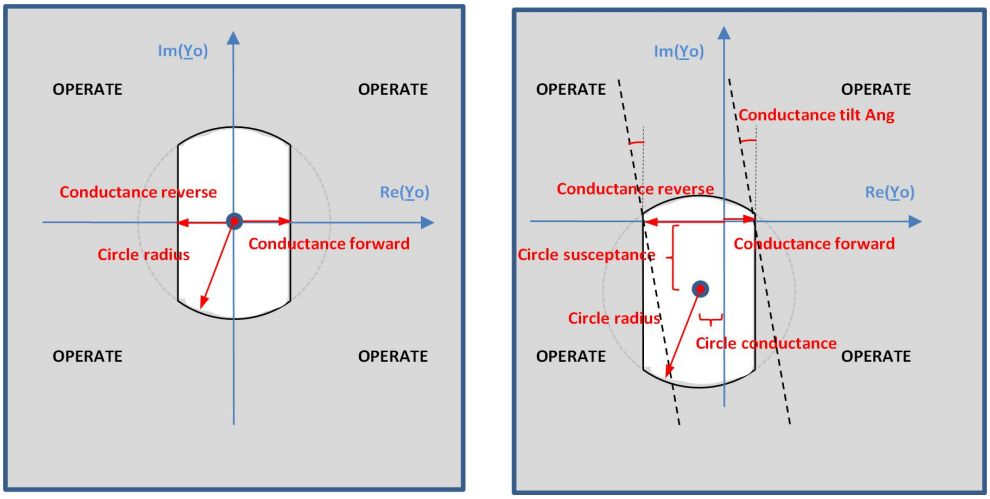



*Figure 256: Combined overadmittance and overconductance characteristic. Left figure: classical origin-centered admittance circle combined with two overconductance boundary lines. Right figure: admittance circle is set off from the origin.*

## Combined overconductance and oversusceptance characteristic

The combined overconductance and oversusceptance criterion is enabled with the *Operation mode* setting set to "Go, Bo".

By setting *Directional mode* to "Forward", the characteristic is a combination of two boundary lines with the settings *Conductance forward* and *Susceptance forward*. See Figure 257.

By setting *Directional mode* to "Non-directional", the characteristic is a combination of four boundary lines with the settings *Conductance forward*, *Conductance reverse*, *Susceptance forward* and *Susceptance reverse*. See Figure 258.

For the sake of application flexibility, the boundary lines can be tilted by the angle defined with the *Conductance tilt Ang* and *Susceptance tilt Ang* settings. By default, the tilt angles are zero degrees, that is, the boundary lines are straight lines in the admittance plane. A positive *Conductance tilt Ang* value rotates the overconductance

boundary line counterclockwise from the vertical axis. A positive *Susceptance tilt Ang* value rotates the oversusceptance boundary line counterclockwise from the horizontal axis.

In case of the non-directional conductance and susceptance criteria, the *Conductance reverse* setting must be set to a smaller value than *Conductance forward* and the *Susceptance reverse* setting must be set to a smaller value than *Susceptance forward*.

Operation is achieved when the measured admittance moves outside the characteristic.

The combined overconductance and oversusceptance criterion is applicable in high-resistance earthed, unearthed and compensated networks or in the systems where the system earthing may temporarily change during normal operation from compensated to unearthed system.

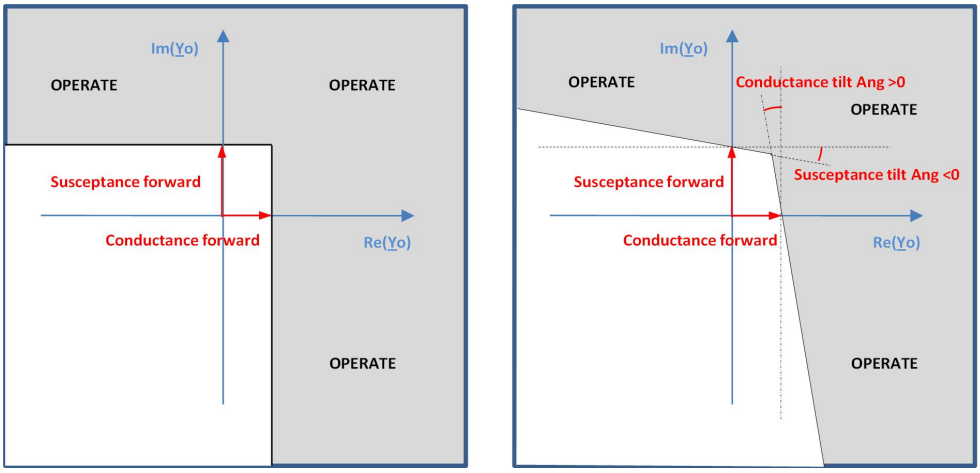



*Figure 257: Combined forward directional overconductance and forward directional oversusceptance characteristic. Left figure: the Conductance tilt Ang and Susceptance tilt Ang settings equal zero degrees. Right figure: the setting Conductance tilt Ang > 0 degrees and the setting Susceptance tilt Ang < 0 degrees.*

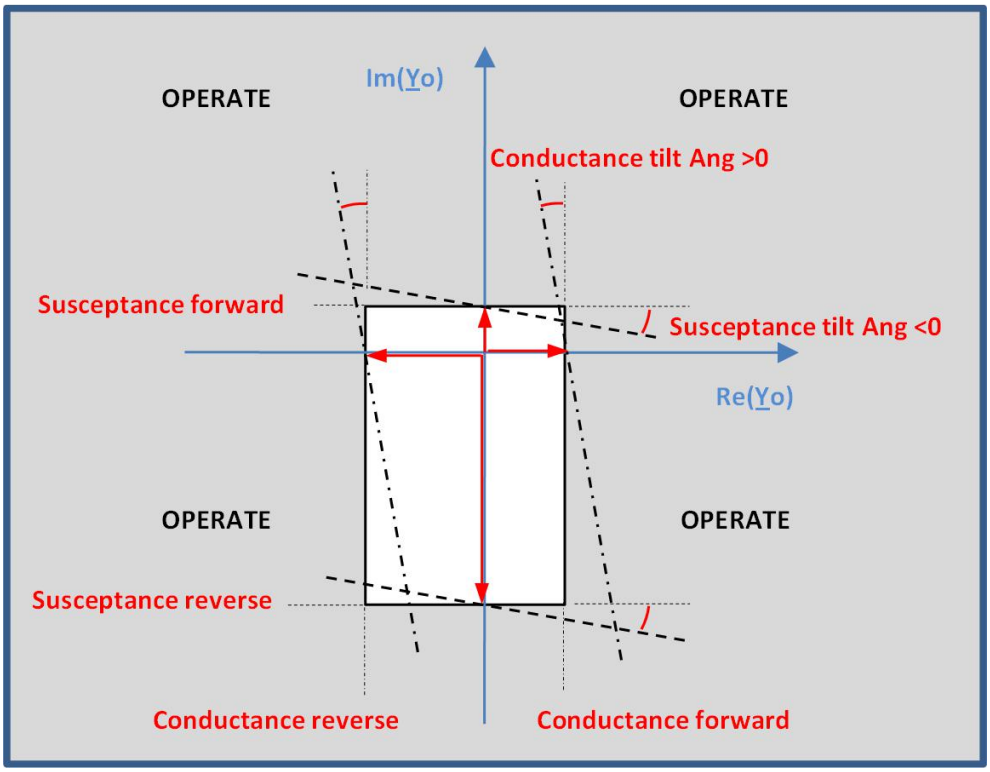



*Figure 258: Combined non-directional overconductance and non-directional oversusceptance characteristic*

The non-directional overconductance and non-directional oversusceptance characteristic provides a good sensitivity and selectivity when the characteristic is set to cover the total admittance of the protected feeder with a proper margin.

The sign of the admittance characteristic settings should be considered based on the location of characteristic boundary in the admittance plane. All forward-settings are given with positive sign and reverse-settings with negative sign.

### 4.2.4.7 Application

Admittance-based earth-fault protection provides a selective earth-fault protection for high-resistance earthed, unearthed and compensated networks. It can be applied for the protection of overhead lines as well as with underground cables. It can be used as an alternative solution to traditional residual current-based earth-fault protection functions, for example the IoCos mode in DEFxPDEF. Main advantages of EFPADM include versatile applicability, good sensitivity and easy setting principles.

Residual overvoltage condition is used as a start condition for the admittance-based earth-fault protection. When the residual voltage exceeds the set threshold *Voltage start value*, an earth fault is detected and the neutral admittance calculation is released. In order to guarantee a high security of protection, that is, avoid false starts, the *Voltage start value* setting must be set above the highest possible value of Uo during normal operation with a proper margin. It should consider all possible operation conditions and configuration changes in the network. In unearthed systems, the healthy-state Uo is typically less than 1%×Uph (Uph = nominal phase-to-earth voltage). In compensated networks, the healthy-state Uo may reach values even up to 30%×Uph if the network includes large parts of overheadlines without a phase transposition. Generally, the highest Uo is achieved when the compensation coil is tuned to the full resonance and when the parallel resistor of the coil is not connected.

The residual overvoltage-based start condition for the admittance protection enables a multistage protection principle. For example, one instance of EFPADM could be used for alarming to detect faults with a high fault resistance using a relatively low value for the *Voltage start value* setting. Another instance of EFPADM could then be set to trip with a lower sensitivity by selecting a higher value of the *Voltage start value* setting than in the alarming instance (stage).

To apply the admittance-based earth-fault protection, at least the following network data are required:

- System earthing method
- Maximum value for Uo during the healthy state
- Maximum earth-fault current of the protected feeder when the fault resistance Rf is zero ohm
- Maximum uncompensated earth-fault current of the system (Rf = 0 Ω)
- Rated current of the parallel resistor of the coil (active current forcing scheme) in the case of a compensated neutral network
- Rated current of the neutral earthing resistor in the case of a high-resistance earthed system
- Knowledge of the magnitude of Uo as a function of the fault resistance to verify the sensitivity of the protection in terms of fault resistance

Figure 259 shows the influence of fault resistance on the residual voltage magnitude in unearthed and compensated networks. Such information should be available to verify the correct *Voltage start value* setting, which helps fulfill the requirements for the sensitivity of the protection in terms of fault resistance.

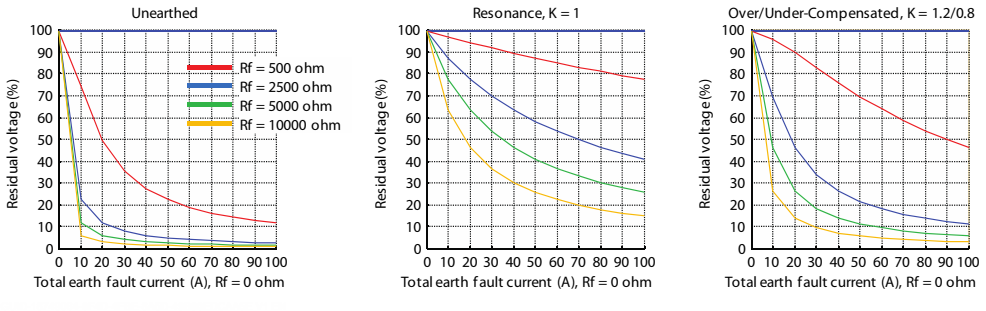



*Figure 259: Influence of fault resistance on the residual voltage magnitude in 10 kV unearthed and compensated networks. The leakage resistance is assumed to be 30 times larger than the absolute value of the capacitive reactance of the network. Parallel resistor of the compensation coil is assumed to be disconnected.*

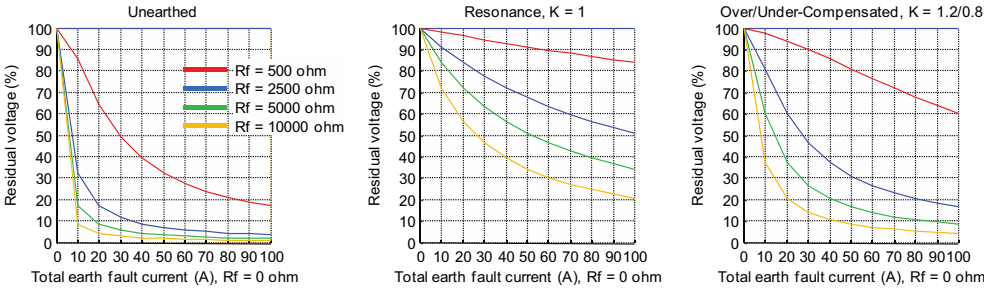



*Figure 260: Influence of fault resistance on the residual voltage magnitude in 15 kV unearthed and compensated networks. The leakage resistance is assumed to be 30 times larger than the absolute value of the capacitive reactance of the network. Parallel resistor of the compensation coil is assumed to be disconnected.*

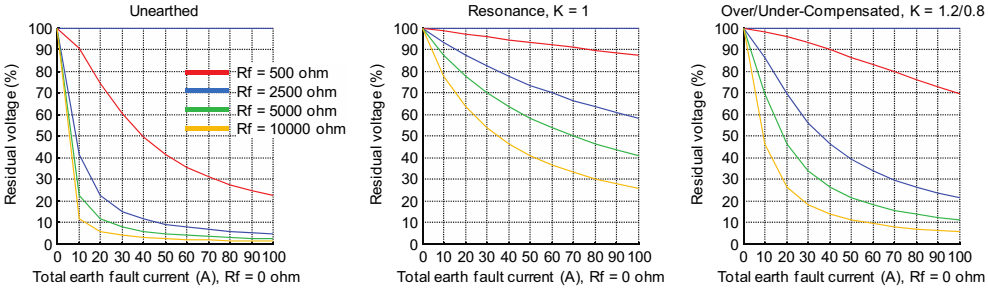



*Figure 261: Influence of fault resistance on the residual voltage magnitude in 20 kV unearthed and compensated networks. The leakage resistance is assumed to be 30 times larger than the absolute value of the capacitive reactance of the network. Parallel resistor of the compensation coil is assumed to be disconnected.*

## Example

In a 15 kV, 50 Hz compensated network, the maximum value for Uo during the healthy state is 10%×Uph. Maximum earth-fault current of the system is 100 A. The maximum earth fault current of the protected feeder is 10 A (Rf = 0 Ω). The applied active current forcing scheme uses a 15 A resistor (at 15 kV), which is connected in parallel to the coil during the fault after a 1.0 second delay.

Solution: As a start condition for the admittance-based earth-fault protection, the internal residual overvoltage condition of EFPADM is used. The *Voltage start value* setting must be set above the maximum healthy-state Uo of 10%×Uph with a suitable margin.

*Voltage start value* = 0.15 × Un

According to Figure 260, this selection ensures at least a sensitivity corresponding to a 2000 ohm fault resistance when the compensation degree varies between 80% and 120%. The greatest sensitivity is achieved when the compensation degree is close to full resonance.

An earth-fault current of 10 A can be converted into admittance.

$$\underline{Y}_{Fdtot} = \frac{10A}{15kV/\sqrt{3}} \approx j \cdot 1.15\ mS$$

(Equation 59)

A parallel resistor current of 15 A can be converted into admittance.

$$G_{cc} = \frac{15A}{15kV/\sqrt{3}} \approx 1.73\ mS$$

(Equation 60)

According to Equation 47, during an outside fault EFPADM measures the following admittance:

$$\underline{Yo} = -\underline{Y}_{Fdtot} \approx -j \cdot 1.15\ mS$$

(Equation 61)

According to Equation 50, during an inside fault EFPADM measures the admittance after the connection of the parallel resistor:

$$\underline{Yo} = \underline{Y}_{Bgtot} + \underline{Y}_{CC} \approx (1.73 + j \cdot B)\ mS$$

(Equation 62)

Where the imaginary part of the admittance, B, depends on the tuning of the coil (compensation degree).

The admittance characteristic is selected to be the combined overconductance and oversusceptance characteristic ("Box"-characteristics) with four boundary lines:

*Operation mode* = "Go, Bo"

*Directional mode* = "Non-directional"

The admittance characteristic is set to cover the total admittance of the protected feeder with a proper margin, see Figure 262. Different setting groups can be used to allow adaptation of protection settings to different feeder and network configurations.

**Conductance forward**

This setting should be set based on the parallel resistor value of the coil. It must be set to a lower value than the conductance of the parallel resistor, in order to enable dependable operation. The selected value should move the boundary line from origin to include some margin for the admittance operation point due to CT/VT-errors, when fault is located outside the feeder.

*Conductance forward*: 15 A/(15 kV/sqrt(3)) * 0.2 = +0.35 mS corresponding to 3.0 A (at 15 kV). The selected value provides margin considering also the effect of CT/VT-errors in case of outside faults.

In case of smaller rated value of the parallel resistor, for example, 5 A (at 15 kV), the recommended security margin should be larger, for example 0.7, so that sufficient margin for CT/VT-errors can be achieved.

**Susceptance forward**

By default, this setting should be based on the minimum operate current of 1 A.

*Susceptance forward*: 1 A/(15 kV/sqrt(3)) = +0.1 mS

**Susceptance reverse**

This setting should be set based on the value of the maximum earth-fault current produced by the feeder (considering possible feeder topology changes) with a security margin. This ensures that the admittance operating point stays inside the "Box"-characteristics during outside fault. The recommended security margin should not be lower than 1.5.

*Susceptance reverse*: - (10 A * 1.5)/ (15 kV/sqrt(3)) = -1.73 mS

**Conductance reverse**

This setting is used to complete the non-directional characteristics by closing the "Box"-characteristic. In order to keep the shape of the characteristic reasonable and to allow sufficient margin for the admittance operating point during outside fault, it is recommended to use the same value as for setting Susceptance reverse.

*Conductance reverse* = -1.73 mS

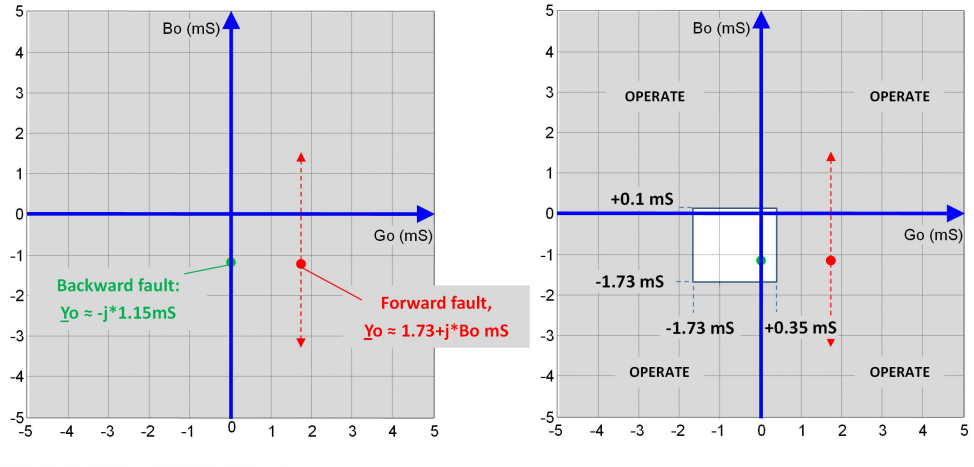



*Figure 262: Admittances of the example*

## 4.2.4.8 Signals

*Table 513: EFPADM Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RELEASE | BOOLEAN | 0=False | External trigger to release neutral admittance protection |

*Table 514: EFPADM Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| FAULT_DIR | Enum | Detected fault direction |

### 4.2.4.9 Settings

*Table 515: EFPADM Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage start value | 0.01...2.00 | xUn | 0.01 | 0.15 | Voltage start value |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Operation mode | 1=Yo<br>2=Go<br>3=Bo<br>4=Yo, Go<br>5=Yo, Bo<br>6=Go, Bo<br>7=Yo, Go, Bo | | | 1=Yo | Operation criteria |
| Operate delay time | 60...300000 | ms | 10 | 60 | Operate delay time |
| Circle radius | 0.05...500.00 | mS | 0.01 | 1.00 | Admittance circle radius |
| Circle conductance | -500.00...500.00 | mS | 0.01 | 0.00 | Admittance circle midpoint, conductance |
| Circle susceptance | -500.00...500.00 | mS | 0.01 | 0.00 | Admittance circle midpoint, susceptance |
| Conductance forward | -500.00...500.00 | mS | 0.01 | 1.00 | Conductance threshold in forward direction |
| Conductance reverse | -500.00...500.00 | mS | 0.01 | -1.00 | Conductance threshold in reverse direction |
| Susceptance forward | -500.00...500.00 | mS | 0.01 | 1.00 | Susceptance threshold in forward direction |
| Susceptance reverse | -500.00...500.00 | mS | 0.01 | -1.00 | Susceptance threshold in reverse direction |

*Table 516: EFPADM Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Conductance tilt Ang | -30...30 | deg | 1 | 0 | Tilt angle of conductance boundary line |
| Susceptance tilt Ang | -30...30 | deg | 1 | 0 | Tilt angle of susceptance boundary line |

*Table 517: EFPADM Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 518: EFPADM Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Admittance Clc mode | 1=Normal<br>2=Delta | | | 1=Normal | Admittance calculation mode |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.01 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.01 | Minimum operating voltage |

### 4.2.4.10 Monitored data

*Table 519: EFPADM Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| COND_RES | FLOAT32 | -1000.00...1000.00 | mS | Real part of calculated neutral admittance |
| SUS_RES | FLOAT32 | -1000.00...1000.00 | mS | Imaginary part of calculated neutral admittance |
| EFPADM | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.4.11 Technical data

*Table 520: EFPADM Technical data*

| Characteristic | Value | | |
|---|---|---|---|
| Operation accuracy[1)] | At the frequency f = $f_n$ | | |
| | ±1.0% or ±0.01 mS<br>(In range of 0.5...100 mS) | | |
| Start time[2)] | Minimum | Typical | Maximum |
| | 56 ms | 60 ms | 64 ms |
| Reset time | 40 ms | | |
| Operate time accuracy | ±1.0% of the set value of ±20 ms | | |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) Uo = 1.0 × Un
2) Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

## 4.2.5 Rotor earth-fault protection, injection method MREFPTOC

### 4.2.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Rotor earth-fault protection, injection method | MREFPTOC | Io>R | 64R |

### 4.2.5.2 Function block




*Figure 263: Function block*

### 4.2.5.3 Functionality

The rotor earth-fault protection, injection method, function MREFPTOC is used to detect an earth fault in the rotor circuit of synchronous machines. MREFPTOC is used with the injection device REK510, which requires a secured 58, 100 or 230 V AC 50/60 Hz input source and injects a 100 V AC voltage via its coupling capacitors to the rotor circuit towards earth.

MREFPTOC consists of independent alarm and operating stages. The operating time characteristic is according to definite time (DT) for both stages.

MREFPTOC contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.5.4 Analog channel configuration

MREFPTOC has one analog group input which must be properly configured.

*Table 521: Analog signals*

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For

troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of MREFPTOC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

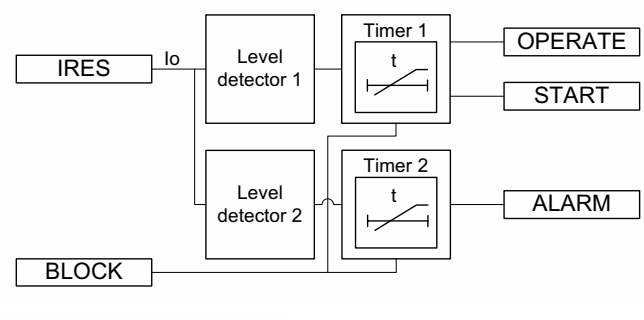



*Figure 264: Functional module diagram*

#### Level detector 1

The measured rotor earth-fault current (DFT value) is compared to the *Operate start value* setting. If the measured value exceeds that of the *Operate start value* setting, Level detector 1 sends a signal to start the Timer 1 module.

#### Level detector 2

The measured rotor earth-fault current (DFT value) is compared to the set *Alarm start value*. If the measured value exceeds that of the *Alarm start value* setting, Level detector 2 sends a signal to start the Timer 2 module.

For MREFPTOC, the earth-fault current is the current that flows due to the voltage injected by the injection device in the rotor circuit when an earth fault arises.

A considerable amount of harmonics, mainly 3rd and 6th, can occur in the excitation current under normal no-fault conditions, especially with the thyristor excitation and rotating diode rectifier systems. MREFPTOC uses DFT value calculation to filter DC and harmonic components which could otherwise give out false alarms or trips.

### Timer 1

Once activated, the Timer activates the START output. The timer characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time* in the DT mode, the OPERATE output is activated. If a drop-off situation occurs, that is, a fault suddenly disappears before the operating delay is exceeded, the timer reset state is activated. The reset time depends on the *Reset delay time* setting.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all outputs and resets the internal timers.

### Timer 2

Once activated, the Timer activates the alarm timer. The timer characteristic is according to DT. When the alarm timer has reached the value set by *Alarm delay time* in the DT mode, the ALARM output is activated. If a drop-off situation occurs, that is, a fault suddenly disappears before the alarm delay is exceeded, the timer reset state is activated. The reset time depends on the *Alm reset delay time* setting.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all outputs and resets the internal timers.

## 4.2.5.6 Application

The rotor circuit of synchronous machines is normally isolated from the earth. The rotor circuit can be exposed to an abnormal mechanical or thermal stress due to, for example, vibrations, overcurrent and choked cooling medium flow. This can result in the breakdown of the insulation between the field winding and the rotor iron at the point exposed to excessive stress. If the isolation resistance is decreased significantly, this can be seen as an earth fault. For generators with slip rings, the rotor insulation resistance is sometimes reduced due to the accumulated carbon dust layer produced by the carbon brushes. As the circuit has a high impedance to earth, a single earth fault does not lead to any immediate damage because the fault current is small due to a low voltage. There is, however, a risk that a second earth fault appears, creating a rotor winding interturn fault and causing severe magnetic imbalance and heavy rotor vibrations that soon lead to a severe damage.

Therefore, it is essential that any occurrence of an insulation failure is detected and that the machine is disconnected as soon as possible. Normally, the device is tripped after a short time delay.

A 50/60 Hz voltage is injected via the injection device REK 510 to the rotor field winding circuit of the synchronous machine as shown in Figure 265. The injected voltage is 100 V AC via the coupling capacitors. A coupling capacitor prevents a DC current leakage through the injection device.

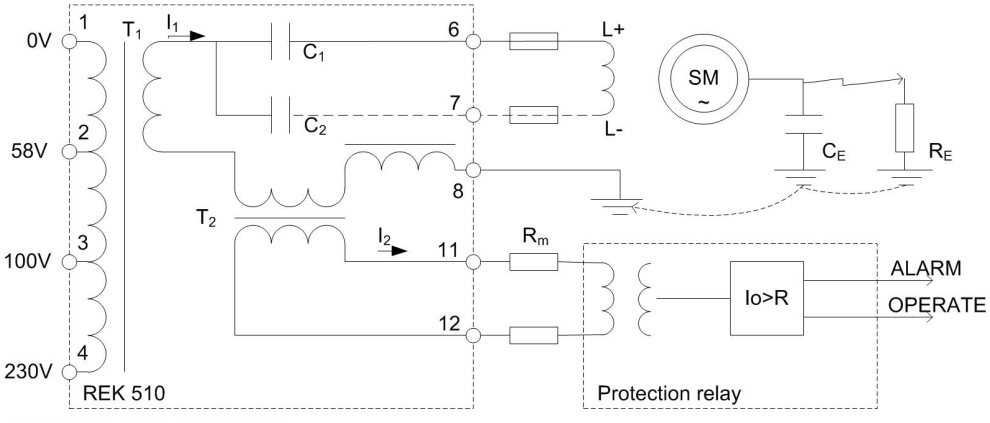



*Figure 265: Principle of the rotor earth-fault protection with the current injection device*

The auxiliary AC voltage forms a small charging current $I_1$ to flow via the coupling capacitors, resistances of the brushes and the leakage capacitance between the field circuit and earth. The field-to-earth capacitance $C_E$ affects the level of the resulting current to an extent which is a few milliamperes during normal no-fault operating conditions.

If an earth fault arises in the rotor field circuit, this current increases and can reach a level of 130 mA at a fully developed earth fault (fault resistance $R_E = 0$, one coupling capacitor $C_1 = 2\mu F$ is used). The integrated current transformer of the injection device REK 510 then amplifies this current with the ratio of 1:10 to a measurable level. MREFPTOC is used to measure this current.

An example of the measured curves with various field-to-earth leakage capacitance values is given in Figure 266.

It is recommended that the alarm and operation stages of MREFPTOC are both used. The alarm stage for giving an indication for weakly developed earth faults with a start value setting corresponds to a 10 kΩ fault resistance with a 10-second delay. The operation stage for a protection against fully developed earth faults with a start value setting corresponds to a 1...2 kΩ fault resistance with a 0.5-second delay.

The current setting values corresponding to the required operating fault resistances can be tested by connecting an adjustable fault-simulating resistor between the excitation winding poles and the earth. Whether only one of the coupling capacitors or both should be used in a parallel connection should be determined on a case-by-case basis, taking into consideration the consequences of a possibly excessive current at a direct earth fault.

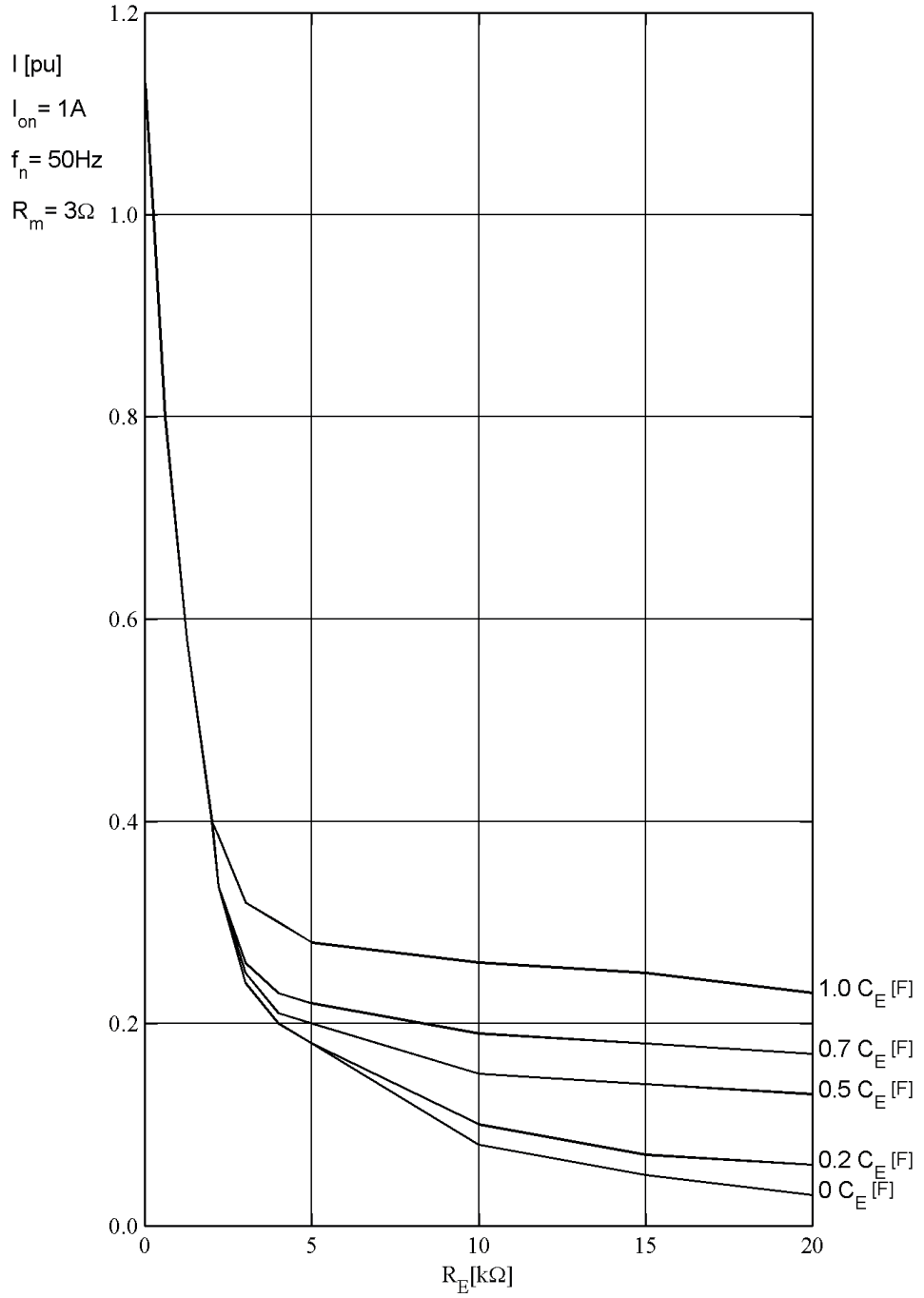



*Figure 266: Measured current as a function of the rotor earth-fault resistance with various field-to-earth capacitance values with the measuring circuit resistance $R_m$ = 3.0 Ω, $f_n$ = 50 Hz. Only one coupling capacitor is used.*

### 4.2.5.7 Signals

*Table 522: MREFPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 523: MREFPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Alarm |

### 4.2.5.8 Settings

*Table 524: MREFPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate start value | 0.010...2.000 | xIn | 0.001 | 0.010 | Operate start value |
| Alarm start value | 0.010...2.000 | xIn | 0.001 | 0.010 | Alarm start value |
| Operate delay time | 40...20000 | ms | 1 | 500 | Operate delay time |
| Alarm delay time | 40...200000 | ms | 1 | 10000 | Alarm delay time |

*Table 525: MREFPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 526: MREFPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Alm reset delay time | 0...60000 | ms | 1 | 20 | Alarm reset delay time |

### 4.2.5.9 Monitored data

*Table 527: MREFPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| MREFPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.5.10 Technical data

*Table 528: MREFPTOC Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the current measured: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 1.2 × set *Start value* | 30 ms | 34 ms | 38 ms |
| Reset time | | <50 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <50 ms | | |
| Operate time accuracy | | ±1.0% of the set value of ±20 ms | | |
| Suppression of harmonics | | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) Current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.2.6 Harmonics-based earth-fault protection HAEFPTOC

### 4.2.6.1 Identification

| Description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Harmonics-based earth-fault protection | HAEFPTOC | Io>HA | 51NH |

### 4.2.6.2 Function block




*Figure 267: Function block*

### 4.2.6.3 Functionality

The harmonics-based earth-fault protection function HAEFPTOC is used instead of a traditional earth-fault protection in networks where a fundamental frequency component of the earth-fault current is low due to compensation.

By default, HAEFPTOC is used as a standalone mode. Substation-wide application can be achieved using horizontal communication where the detection of a faulty feeder is done by comparing the harmonics earth-fault current measurements.

The function starts when the harmonics content of the earth-fault current exceeds the set limit. The operation time characteristic is either definite time (DT) or inverse definite minimum time (IDMT). If the horizontal communication is used for the exchange of current values between the protection relays, the function operates according to the DT characteristic.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

### 4.2.6.4 Analog channel configuration

HAEFPTOC has one analog group input which must be properly configured.

*Table 529: Analog signals*

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of HAEFPTOC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

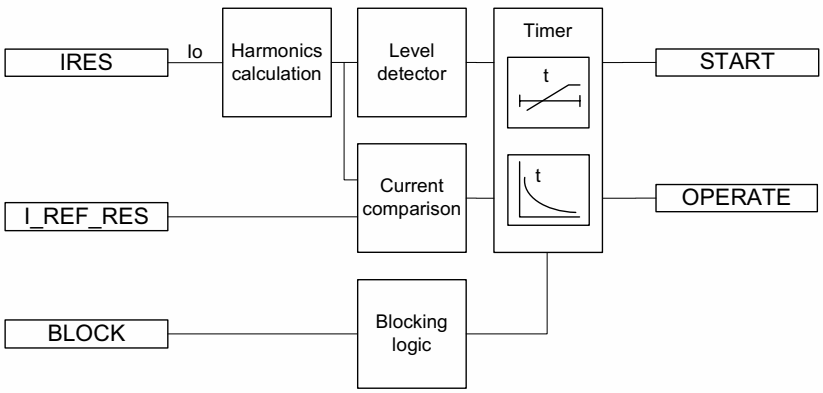



*Figure 268: Functional module diagram*

#### Harmonics calculation

This module feeds the measured residual current to the high-pass filter, where the frequency range is limited to start from two times the fundamental frequency of the network (for example, in a 50 Hz network the cutoff frequency is 100 Hz), that is, summing the harmonic components of the network from the second harmonic. The output of the filter, later referred to as the harmonics current, is fed to the Level detector and Current comparison modules.

The harmonics current I_HARM_RES is available in the monitored data view. The value is also sent over horizontal communication to the other protection relays on the parallel feeders configured in the protection scheme.

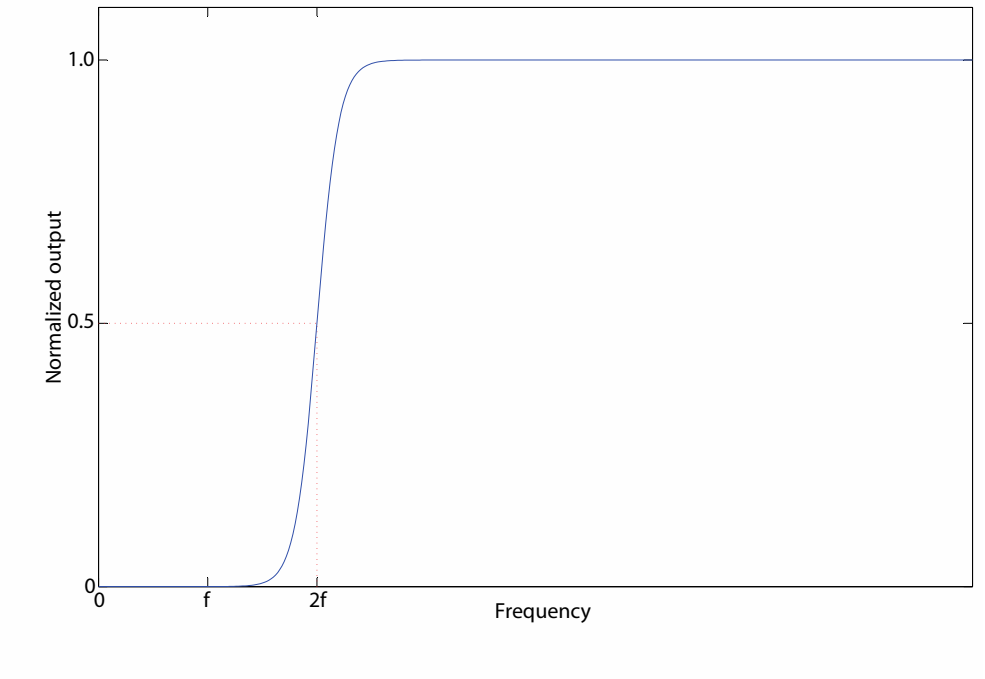



*Figure 269: High-pass filter*

## Level detector

The harmonics current is compared to the *Start value* setting. If the value exceeds the value of the *Start value* setting, Level detector sends an enabling signal to the Timer module.

## Current comparison

The maximum of the harmonics currents reported by other parallel feeders in the substation, that is, in the same busbar, is fed to the function through the I_REF_RES input. If the locally measured harmonics current is higher than I_REF_RES, the enabling signal is sent to Timer.

If the locally measured harmonics current is lower than I_REF_RES, the fault is not in that feeder. The detected situation blocks Timer internally, and simultaneously also the BLKD_I_REF output is activated.

The module also supervises the communication channel validity which is reported to the Timer.

## Timer

The START output is activated when Level detector sends the enabling signal. Functionality and the time characteristics depend on the selected value of the *Enable reference use* setting.

*Table 530: Values of the Enable reference use setting*

| *Enable reference use* | | Functionality |
|---|---|---|
| Standalone | | In the standalone mode, depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of the *Operate delay time* setting in the DT mode or the value defined by the inverse time curve, the OPERATE output is activated. |
| Reference use | Communication valid | When using the horizontal communication, the function is forced to use the DT characteristics. When the operation timer has reached the value of the *Minimum operate time* setting and simultaneously the enabling signal from the Current comparison module is active, the OPERATE signal is activated. |
| | Communication invalid | Function operates as in the standalone mode. |

The *Enable reference use* setting forces the function to use the DT characteristics where the operating time is set with the *Minimum operate time* setting.

If the communication for some reason fails, the function switches to use the *Operation curve type* setting, and if DT is selected, *Operate delay time* is used. If the IDMT curve is selected, the time characteristics are according to the selected curve and the *Minimum operate time* setting is used for restricting too fast an operation time.

In case of a communication failure, the start duration may change substantially depending on the user settings.

When the programmable IDMT curve is selected, the operation time characteristics are defined with the *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E* parameters.

If a drop-off situation happens, that is, a fault suddenly disappears before the operation delay is exceeded, the Timer reset state is activated. The functionality of Timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the value of the *Reset delay time* setting is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation. If the drop-off situation continues, the reset timer is reset and the START output is deactivated.

The "Inverse reset" selection is only supported with ANSI or the programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operation and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operation time for IDMT. The setting is applicable only when the IDMT curves are used



The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve but always at least the value of the *Minimum operate time* setting. More information can be found in the IDMT curves for overcurrent protection.

Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation, and the set operating time, which can be either according to DT or IDMT. The value is available in the monitored data view.

More information can be found in the General function block features.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the “Block all” mode, the whole function is blocked and the timers are reset. In the *Block OPERATE output* mode, the function operates normally but the OPERATE output is not activated.

## 4.2.6.6 Application

During an earth fault, HAEFPTOC calculates the maximum current for the current feeder. The value is sent over an analog GOOSE to other protection relays of the busbar in the substation. At the configuration level, all the values received over the analog GOOSE are compared through the MAX function to find the maximum value. The maximum value is sent back to HAEFPTOC as the I_REF_RES input. The operation of HAEFPTOC is allowed in case I_REF_RES is lower than the locally measured harmonics current. If I_REF_RES exceeds the locally measured harmonics current, the operation of HAEFPTOC is blocked.

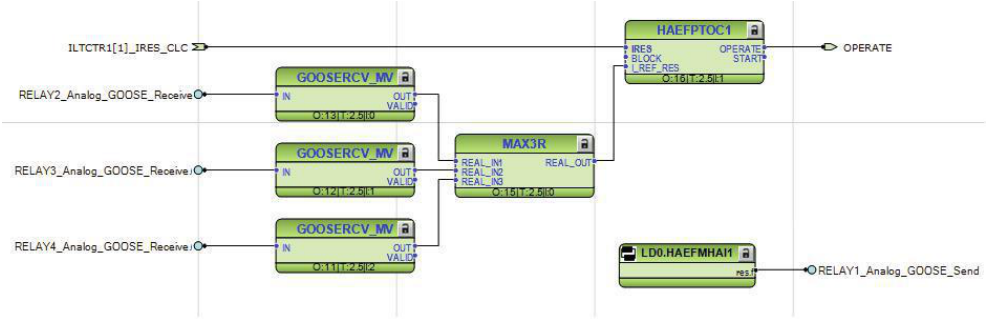



*Figure 270: Protection scheme based on the analog GOOSE communication with three analog GOOSE receivers*

## 4.2.6.7 Signals

*Table 531: HAEFPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| I_REF_RES | FLOAT32 | 0.0 | Reference current |

*Table 532: HAEFPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.2.6.8 Settings

*Table 533: HAEFPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...5.00 | xIn | 0.01 | 0.10 | Start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 100...300000 | ms | 10 | 600 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |

*Table 534: HAEFPTOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 100...200000 | ms | 10 | 500 | Minimum operate time for IDMT curves |
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |
| Enable reference use | 0=False<br>1=True | | | 0=False | Enable using current reference from other IEDs instead of stand-alone |

*Table 535: HAEFPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 1 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 1 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 1 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 536: HAEFPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |

### 4.2.6.9 Monitored data

*Table 537: HAEFPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| I_HARM_RES | FLOAT32 | 0.0...30000.0 | A | Calculated harmonics current |
| BLKD_I_REF | BOOLEAN | 0=False<br>1=True | | Current comparison status indicator |
| HAEFPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.6.10 Technical data

*Table 538: HAEFPTOC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±5% of the set value or ±0.004 × $I_n$ |
| Start time [1)2)] | Typically 77 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in IDMT mode [3)] | ±5.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = $f_n$ |
| | -3 dB at f = 13 × $f_n$ |

1) Fundamental frequency current = 1.0 × $I_n$, harmonics current before fault = 0.0 × $I_n$, harmonics fault current 2.0 × *Start value*, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 2...20

## 4.2.7 Wattmetric-based earth-fault protection WPWDE

### 4.2.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Wattmetric-based earth-fault protection | WPWDE | Po> -> | 32N |

### 4.2.7.2 Function block




*Figure 271: Function block*

### 4.2.7.3 Functionality

The wattmetric-based earth-fault protection function WPWDE can be used to detect earth faults in unearthed networks, compensated networks (Petersen coil-earthed networks) or networks with a high-impedance earthing. It can be used as an alternative solution to the traditional residual current-based earth-fault protection functions, for example, the IoCos mode in the directional earth-fault protection function DEFxPDEF.

WPWDE measures the earth-fault power 3UoIoCosφ and gives an operating signal when the residual current Io, residual voltage Uo and the earth-fault power exceed the set limits and the angle (φ) between the residual current and the residual voltage is inside the set operating sector, that is, forward or backward sector. The operating time characteristic can be selected to be either definite time (DT) or a special wattmetric-type inverse definite minimum type (wattmetric type IDMT).

The wattmetric-based earth-fault protection is very sensitive to current transformer errors and it is recommended that a core balance CT is used for measuring the residual current.

WPWDE contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.7.4 Analog channel configuration

WPWDE has two analog group inputs which must be properly configured.

*Table 539: Analog inputs*

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |
| URES | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 540: Special conditions*

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected for calculating the residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.7.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

For WPWDE, certain notations and definitions are used.
Residual voltage Uo = (UA+UB+UC)/3 = $U_0$, where $U_0$ = zero-sequence voltage
Residual current Io = -(IA+IB+IC) = 3×- $I_0$, where $I_0$ = zero-sequence current
The minus sign (-) is needed to match the polarity of calculated and measured residual currents.

The operation of WPWDE can be described with a module diagram. All the modules in the diagram are explained in the next sections.

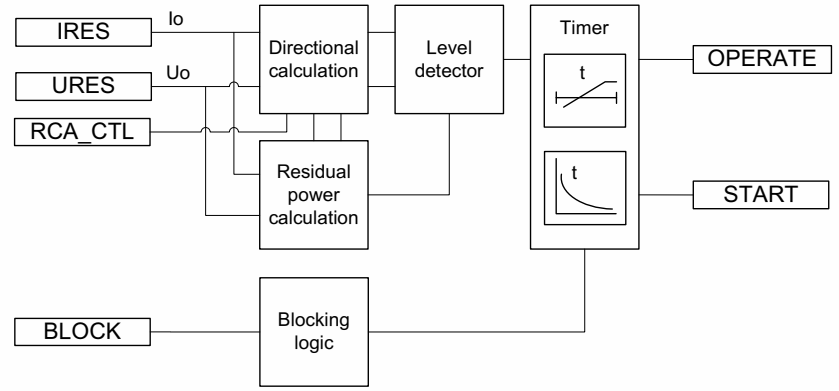



*Figure 272: Function module diagram*

## Directional calculation

The Directional calculation module monitors the angle between the operating quantity (residual current Io) and polarizing quantity (residual voltage Uo). When the angle between operating quantity and polarizing quantity after considering the *Characteristic angle* setting is in the operation sector, the module sends an enabling signal to Level detector. The directional operation is selected with the *Directional mode* setting. Either the “Forward” or “Reverse” operation mode can be selected. The direction of fault is calculated based on the phase angle difference between the operating quantity Io and polarizing quantity Uo, and the value (ANGLE) is available in the monitored data view.

In the phasor diagrams representing the operation of WPWDE, the polarity of the polarizing quantity (residual voltage Uo) is reversed. Reversing is done by switching the polarity of the residual current measuring channel (see the connection in the Protection relay's physical connections section).

If the angle difference lies between -90° to 0° or 0° to +90°, a forward-direction fault is considered. If the phase angle difference lies within -90° to -180° or +90° to +180°, a reverse-direction fault is detected. Thus, the normal width of a sector is 180°.

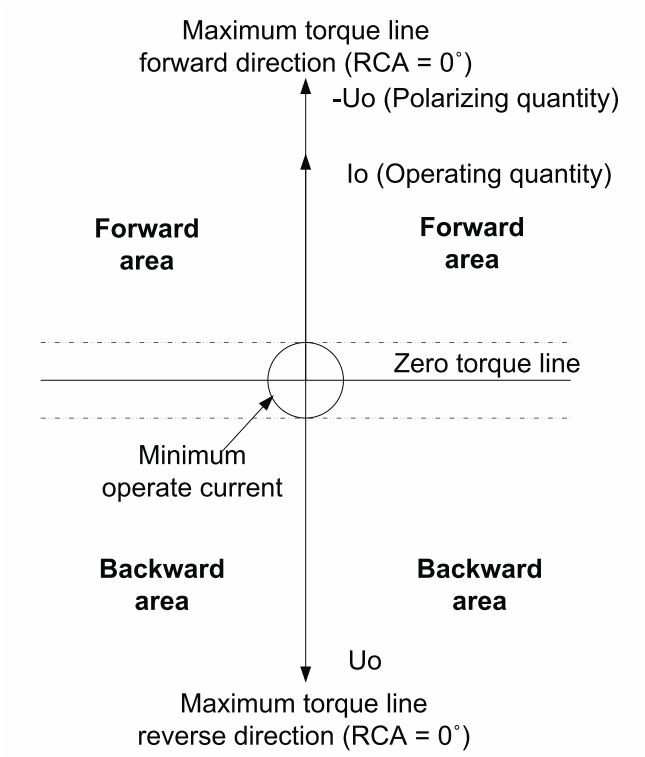



*Figure 273: Definition of the relay characteristic angle*

The phase angle difference is calculated based on the *Characteristic angle* setting (also known as Relay Characteristic Angle (RCA) or Relay Base Angle or Maximum Torque Angle (MTA)). The *Characteristic angle* setting is done based on the method of earthing employed in the network. For example, in case of an unearthed network, the *Characteristic angle* setting is set to -90°, and in case of a compensated network, the *Characteristic angle* setting is set to 0°. In general, *Characteristic angle* is selected so that it is close to the expected fault angle value, which results in maximum sensitivity. *Characteristic angle* can be set anywhere between -179° to +180°. Thus, the effective phase angle ($\phi$) for calculating the residual power considering characteristic angle is according to the equation.

$$\phi = \left(\angle(-Uo) - \angle Io - Characteristic\ angle\right)$$

(Equation 63)

In addition, the characteristic angle can be changed via the control signal RCA_CTL. The RCA_CTL input is used in the compensated networks where the compensation coil sometimes is temporarily disconnected. When the coil is disconnected, the compensated network becomes isolated and the *Characteristic angle* setting must be changed. This can be done automatically with the RCA_CTL input, which results in the addition of -90° in the *Characteristic angle* setting.

The value (ANGLE_RCA) is available in the monitored data view.

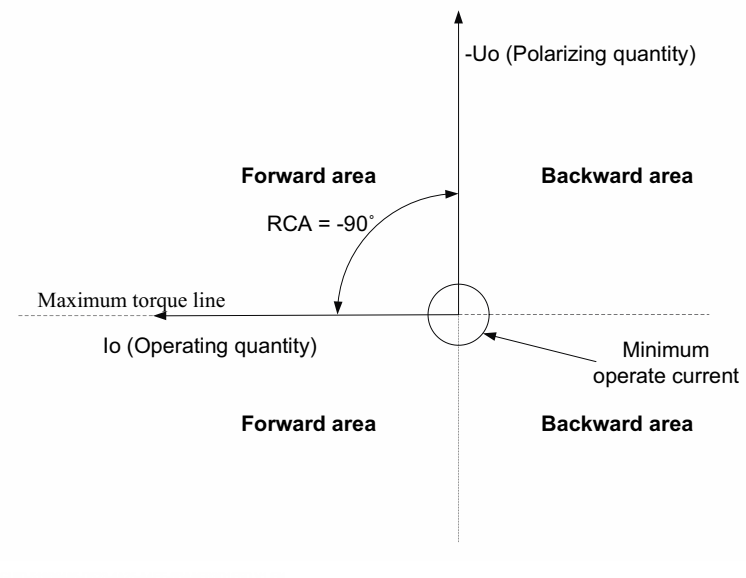



*Figure 274: Definition of relay characteristic angle, RCA = -90° in an isolated network*

*Characteristic angle* should be set to a positive value if the operating signal lags the polarizing signal and to a negative value if the operating signal leads the polarizing signal.

| Type of network | Recommended characteristic angle |
|---|---|
| Compensated network | 0° |
| Unearthed network | -90° |

In unearthed networks, when the characteristic angle is -90°, the measured residual power is reactive (varmetric power).

The fault direction is also indicated `FAULT_DIR` (available in the monitored data view), which indicates 0 if a fault is not detected, 1 for faults in the forward direction and 2 for faults in the backward direction.

The direction of the fault is detected only when the correct angle calculation can be made. If the magnitude of the operating quantity or polarizing quantity is not high enough, the direction calculation is not reliable. Hence, the magnitude of the operating quantity is compared to the *Min operate current* setting and the magnitude of the polarizing quantity is compared to *Min operate voltage*, and if both the operating quantity and polarizing quantity are higher than their respective limit, a valid angle is calculated and the residual power calculation module is enabled.

The *Correction angle* setting can be used to improve the selectivity when there are inaccuracies due to the measurement transformer. The setting decreases the operation

sector. The *Correction angle* setting should be done carefully as the phase angle error of the measurement transformer varies with the connected burden as well as with the magnitude of the actual primary current that is being measured. An example of how *Correction angle* alters the operating region is as shown:

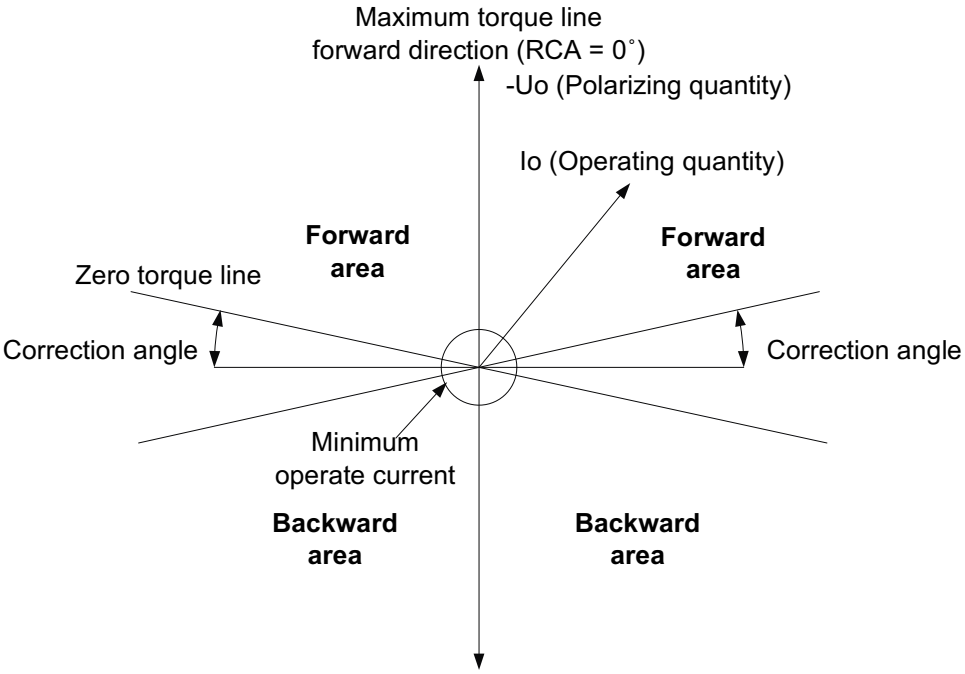



*Figure 275: Definition of correction angle*

The polarity of the polarizing quantity can be changed (rotated by 180°) by setting *Pol reversal* to "True" or by switching the polarity of the residual voltage measurement wires.

## Residual power calculation

The Residual power calculation module calculates the magnitude of residual power 3UoIoCosφ. Angle φ is the angle between the operating quantity and polarizing quantity, compensated with a characteristic angle. The angle value is received from the Directional calculation module. The Directional calculation module enables the residual power calculation only if the minimum signal levels for both operating quantity and polarizing quantity are exceeded. However, if the angle calculation is not valid, the calculated residual power is zero. Residual power (RES_POWER) is calculated continuously and it is available in the monitored data view. The power is given in relation to nominal power calculated as Pn = Un × In, where Un and In are obtained from the entered voltage transformer and current transformer ratios entered.

## Level detector

Level detector compares the magnitudes of the measured operating quantity (residual current Io), polarizing quantity (residual voltage Uo) and calculated residual power to

the set *Current start value (×In)*, *Voltage start value (×Un)* and *Power start value (×Pn)* respectively. When all three quantities exceed the limits, Level detector enables the Timer module.

As nominal power is the result of the multiplication of the nominal current and the nominal voltage Pn = Un × In, the calculation of the setting value for Power start value (×Pn) depends on whether Io and Uo are measured or calculated from the phase quantities.

### Timer

Once activated, Timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or wattmetric IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated. If a drop-off situation happens, that is, a fault suddenly disappears before the operating delay is exceeded, the timer reset state is activated. The reset time is identical for both DT or wattmeter IDMT. The reset time depends on the *Reset delay time* setting.

Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, the function operates normally but the OPERATE output is not activated.

## 4.2.7.6 Timer characteristics

In the wattmetric IDMT mode, the OPERATE output is activated based on the timer characteristics:

$$t[s] = \frac{k \cdot P_{ref}}{P_{cal}}$$

(Equation 64)

| | |
|---|---|
| t[s] | operation time in seconds |
| k | set value of *Time multiplier* |
| $P_{ref}$ | set value of *Reference power* |
| $P_{cal}$ | calculated residual power |

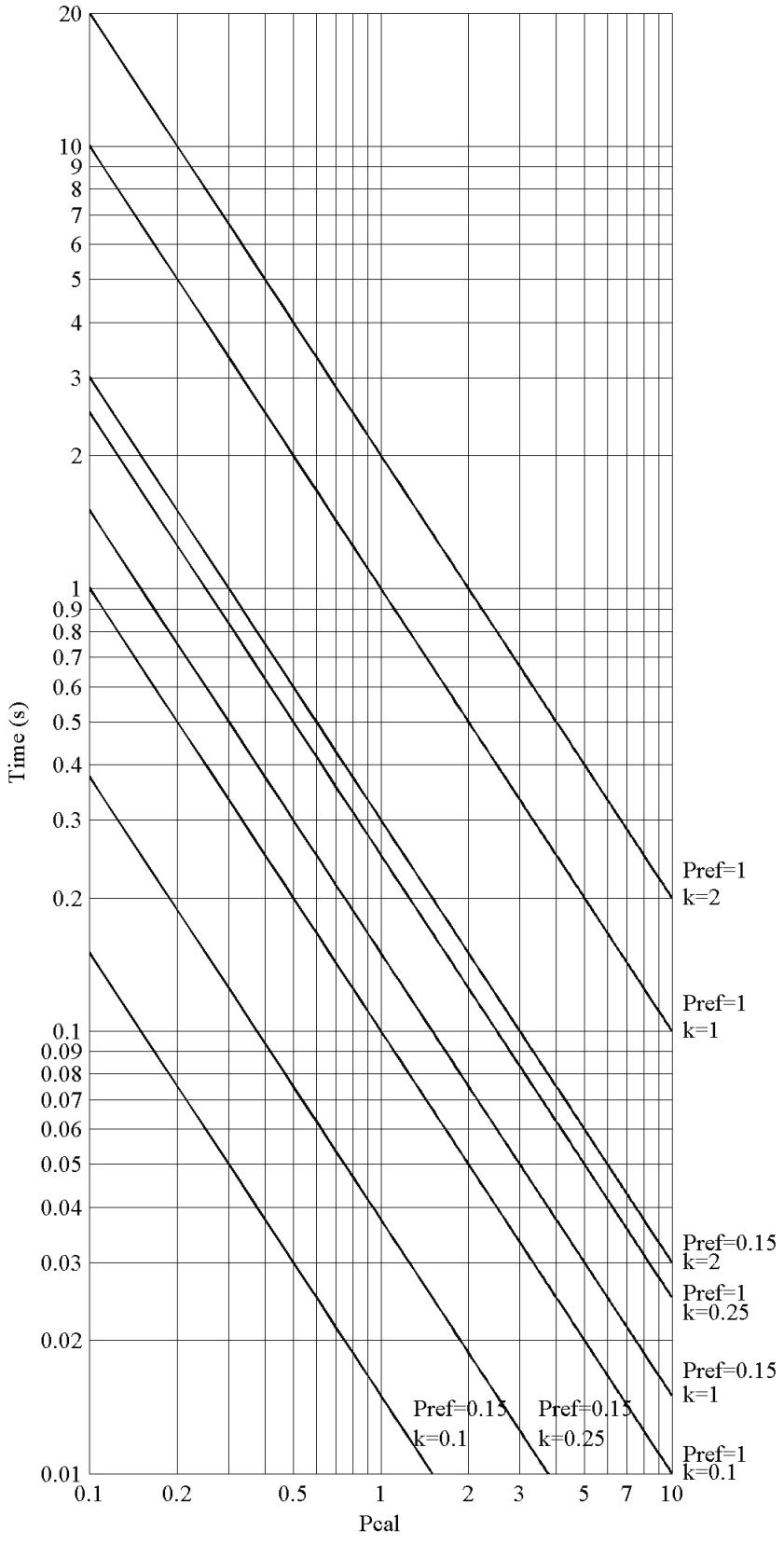

Time (s)
Pcal
20
10
9
8
7
6
5
4
3
2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.1
0.2
0.5
1
2
3
5
7
10
Pref=1
k=2
Pref=1
k=1
Pref=0.15
k=2
Pref=1
k=0.25
Pref=0.15
k=1
Pref=1
k=0.1
Pref=0.15
k=0.1
Pref=0.15
k=0.25

*Figure 276: Operation time curves for wattmetric IDMT for $S_{ref}$ set at 0.15 xPn*

### 4.2.7.7 Measurement modes

The function operates on three alternative measurement modes: "RMS", "DFT" and "Peak-to-Peak". The measurement mode is selected with the *Measurement mode* setting.

### 4.2.7.8 Application

The wattmetric method is one of the commonly used directional methods for detecting the earth faults especially in compensated networks. The protection uses the residual power component 3UoIoCosφ (φ is the angle between the polarizing quantity and operating quantity compensated with a relay characteristic angle).

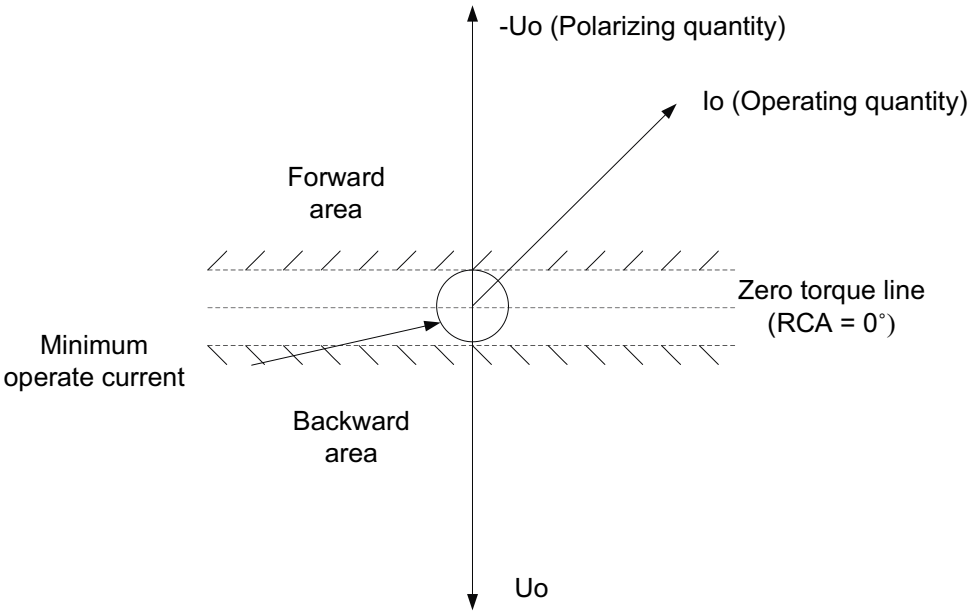



*Figure 277: Characteristics of wattmetric protection*

In a fully compensated radial network with two outgoing feeders, the earth-fault currents depend mostly on the system earth capacitances ($C_0$) of the lines and the compensation coil (L). If the coil is tuned exactly to the system capacitance, the fault current has only a resistive component. This is due to the resistances of the coil and distribution lines together with the system leakage resistances ($R_0$). Often a resistor ($R_L$) in parallel with the coil is used for increasing the fault current.

When a single phase-to-earth fault occurs, the capacitance of the faulty phase is bypassed and the system becomes unsymmetrical. The fault current is composed of the currents flowing through the earth capacitances of two healthy phases. The protection relay in the healthy feeder tracks only the capacitive current flowing

through its earth capacitances. The capacitive current of the complete network (sum of all feeders) is compensated with the coil.

A typical network with the wattmetric protection is an undercompensated network where the coil current $I_L = I_{Ctot} - I_{Cfd}$ ($I_{Ctot}$ is the total earth-fault current of the network and $I_{Cfd}$ is the earth-fault current of the healthy feeder).

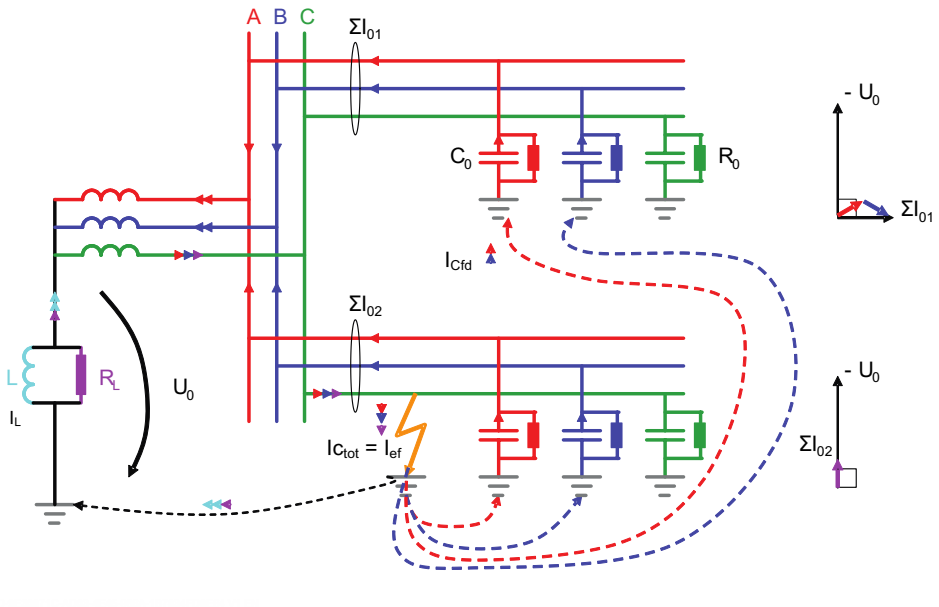



*Figure 278: Typical radial compensated network employed with wattmetric protection*

The wattmetric function is activated when the residual active power component exceeds the set limit. However, to ensure a selective operation it is also required that the residual current and residual voltage also exceed the set limit.

It is highly recommended that core balance current transformers are used for measuring Io when using the wattmetric method. When a low transformation ratio is used, the current transformer can suffer accuracy problems and even a distorted secondary current waveform with some core balance current transformers. Therefore, to ensure a sufficient accuracy of the residual current measurement and consequently a better selectivity of the scheme, the core balance current transformer should preferably have a transformation ratio of at least 70:1. Lower transformation ratios such as 50:1 or 50:5 are not recommended, unless the phase displacement errors and current transformer amplitude are checked first.

It is not recommended to use the directional wattmetric protection in case of a ring or meshed system as the wattmetric requires a radial power flow to operate.

The relay characteristic angle needs to be set based on the system earthing. In an unearthed network, that is, when the network is only coupled to earth via the capacitances between the phase conductors and earth, the characteristic angle is chosen as -90°.

In compensated networks, the capacitive fault current and inductive resonance coil current compensate each other, meaning that the fault current is mainly resistive and has zero phase shift compared to the residual voltage. In such networks, the characteristic angle is chosen as 0º. Often the magnitude of an active component is small and must be increased by means of a parallel resistor in a compensation coil. In networks where the neutral point is earthed through a low resistance, the characteristic angle is always 0º.

As the amplitude of the residual current is independent of the fault location, the selectivity of the earth-fault protection is achieved with time coordination.

The use of wattmetric protection gives a possibility to use the dedicated inverse definite minimum time characteristics. This is applicable in large high-impedance earthed networks with a large capacitive earth-fault current.

In a network employing a low-impedance earthed system, a medium-size neutral point resistor is used. Such a resistor gives a resistive earth-fault current component of about 200 - 400 A for an excessive earth fault. In such a system, the directional residual power protection gives better possibilities for selectivity enabled by the inverse time power characteristics.

### 4.2.7.9 Signals

*Table 541: WPWDE Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RCA_CTL | BOOLEAN | 0=False | Relay characteristic angle control |

*Table 542: WPWDE Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.2.7.10 Settings

*Table 543: WPWDE Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Directional mode | 2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Current start value | 0.010...5.000 | xIn | 0.001 | 0.010 | Minimum operate residual current for deciding fault direction |
| Voltage start value | 0.010...1.000 | xUn | 0.001 | 0.010 | Start value for residual voltage |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Power start value | 0.003...1.000 | xSn | 0.001 | 0.003 | Start value for residual active power |
| Reference power | 0.050...1.000 | xSn | 0.001 | 0.150 | Reference value of residual power for Wattmetric IDMT curves |
| Characteristic angle | -179...180 | deg | 1 | -90 | Characteristic angle |
| Time multiplier | 0.025...2.000 | | 0.005 | 1.000 | Time multiplier for Wattmetric IDMT curves |
| Operating curve type | 5=ANSI Def. Time<br>15=IEC Def. Time<br>20=Wattmetric IDMT | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 60...300000 | ms | 10 | 60 | Operate delay time for definite time |

*Table 544: WPWDE Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 545: WPWDE Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used current measurement mode |
| Correction angle | 0.0...10.0 | deg | 0.1 | 2.0 | Angle correction |
| Min operate current | 0.010...1.000 | xIn | 0.001 | 0.010 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.01 | Minimum operating voltage |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |

## 4.2.7.11 Monitored data

*Table 546: WPWDE Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| FAULT_DIR | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Detected fault direction |
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| DIRECTION | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction information |
| ANGLE | FLOAT32 | -180.00...180.00 | deg | Angle between polarizing and operating quantity |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ANGLE_RCA | FLOAT32 | -180.00...180.00 | deg | Angle between operating angle and characteristic angle |
| RES_POWER | FLOAT32 | -160.000...160.000 | xPn | Calculated residual active power |
| WPWDE | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.7.12 Technical data

*Table 547: WPWDE Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current and voltage:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Power:<br>±3% of the set value or ±0.002 × $P_n$ |
| Start time [1)2)] | Typically 63 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in IDMT mode | ±5.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2,3,4,5,… |

1) Io varied during the test, Uo = 1.0 × $U_n$ = phase to earth voltage during earth fault in compensated or un-earthed network, the residual power value before fault = 0.0 pu, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.2.8 Third harmonic-based stator earth-fault protection H3EFPSEF

### 4.2.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Third harmonic-based stator earth-fault protection | H3EFPSEF | dUo>/Uo3H | 64TN |

### 4.2.8.2 Function block




*Figure 279: Function block*

### 4.2.8.3 Functionality

The third harmonic-based stator earth-fault protection H3EFPSEF is used to detect stator earth fault at the neutral point and at least up to 15...20% from the neutral point along the stator winding. H3EFPSEF compares the third harmonic voltages produced by the generator itself at both neutral and terminal side of the generator for detecting earth fault.

H3EFPSEF provides two alternative protection methods:

- Differential of the third harmonic component measured both at generator neutral and terminal side
- Neutral side third harmonic undervoltage

H3EFPSEF operates with the definite time DT characteristics.

H3EFPSEF contains a blocking functionality. Blocking deactivates all outputs and reset timers.

### 4.2.8.4 Analog channel configuration

H3EFPSEF has three analog group inputs which must be properly configured.

*Table 548: Analog inputs*

| Input | Description |
|---|---|
| U3P[1)] | Three-phase voltages<br>Necessary when *Voltage selection* is set to "Uo", "Phase A", "Phase B" or "Phase C" |
| URES[2)] | Residual voltage (measured or calculated)<br>Necessary when *Voltage selection* is set to "Uo" |
| UNEUT | Residual voltage (measured or calculated) |

1) Can be connected to GRPOFF if *Voltage selection* is set to "No voltage" or "Uo"
2) Can be connected to GRPOFF if *Voltage selection* is other than "Uo"

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

*Table 549: Special conditions*

| Condition | Desription |
|---|---|
| U3P connected to real measurements | The function can work with at least one voltage channel connected. |
| URES calculated | The function requires that all three voltage channels from the terminal side are connected to calculate residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |
| UNEUT calculated | The function requires that all three voltage channels from the neutral side are connected to calculate residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.8.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of the third harmonic-based stator earth-fault protection function can be described using a module diagram. All the modules in the diagram are explained in the next sections.

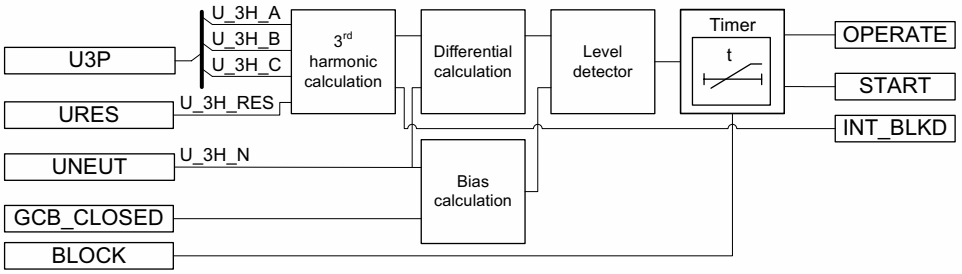



*Figure 280: Functional module diagram*

### 3rd harmonic calculation (terminal side)

3rd harmonic calculation calculates the magnitude and phase angle of the third harmonic voltage at the generator terminal $\bar{U}_{3H_T}$. Calculation of the third harmonic voltage depends on the availability of terminal side voltage and is specified by the *Voltage selection* setting.

- *Voltage selection* setting is set to "No voltage" if phase-to-earth voltages are not available at the terminal side. Even in a situation where only phase-to-phase voltages are available, *Voltage selection* is set to "No voltage" because phase-to-phase voltages do not contain a third harmonic component. With *Voltage selection* set to "No voltage", third harmonic-based earth-fault protection is based on third harmonic neutral side undervoltage protection.
- *Voltage selection* setting is set to "Uo" if the third harmonic voltage is measured directly from an open-delta voltage connection of the voltage transformer or the third harmonic voltage is calculated using all three phase-to-earth voltages.
  If the terminal side voltage is fed from an open-delta voltage connection of the voltage transformer, the terminal side third harmonic voltage Û3H_T is the same as the measured open-delta voltage Û3H_RES.

  $$\bar{U}_{3H_T} = \bar{U}_{3H_RES}$$

  (Equation 65)

  If all three phase-to-earth voltages are available, the terminal side third harmonic voltage is calculated as a vector average of the third harmonic voltages of all three phases.

  $$\bar{U}_{3H_T} = \frac{1}{3} \cdot (\bar{U}_{3H_A} + \bar{U}_{3H_B} + \bar{U}_{3H_C})$$

  (Equation 66)
- If only one phase-to-earth voltage is available, the *Voltage selection* setting is set to the respective phase, that is, "Phase A" or "Phase B" or "Phase C" based on the available phase. In this case, the magnitude of the terminal side third harmonic voltage is assumed to be equal to the third harmonic voltage of the phase available.

  $$\bar{U}_{3H_T} = \bar{U}_{3H_A} \text{ or } \bar{U}_{3H_B} \text{ or } \bar{U}_{3H_C}$$

  (Equation 67)

The function is internally blocked if the magnitude of calculated $\bar{U}_{3H_T}$ is lower than the set *Voltage block value*. This also activates the `INT_BLKD` output.

### Differential calculation

The amplitude of the third harmonic differential voltage can be calculated using the following equation.

$$UD_{3H} = \left| \bar{U}_{3H_T} + \bar{U}_{3H_N} \right|$$

(Equation 68)

$UD_{3H}$ Magnitude of the third harmonic differential voltage

$\bar{U}_{3H_T}$ Terminal side third harmonic voltage phasor

$\bar{U}_{3H_N}$ Neutral side third harmonic voltage phasor

The magnitude of the third harmonic differential voltage UD_3H and the phase angle difference between the terminal side and neutral side third harmonic voltage U_3HANGL_T_N are available in the Monitored data view.

## Bias calculation

The amplitude of the third harmonic bias voltage can be calculated using the following equation.

$$UB_{3H} = Beta \cdot \left|\bar{U}_{3H_N}\right|$$

(Equation 69)

$UB_{3H}$ Magnitude of the third harmonic bias voltage

*Beta* Setting to achieve the required degree of security under healthy conditions

$\bar{U}_{3H_N}$ Neutral side third harmonic voltage phasor

The third harmonic bias voltage calculation shown in Equation 69 is valid under all operating conditions if there is no generator circuit breaker between generator and transformer. But if the generator circuit breaker is used, it is needed to reduce the sensitivity of the protection when it is open. The use of the generator circuit breaker is defined by *Generator CB used* setting set to "Yes" and the open position is sensed when the binary input GCB_CLOSED available is FALSE.

With the generator breaker in the open position, function desensitizes the protection by multiplying the value of the *Beta* setting with the set constant *CB open factor* setting.

$$UB_{3H} = CB\ open\ factor \cdot Beta \cdot \left|\bar{U}_{3H_N}\right|$$

(Equation 70)

Neutral side third harmonic voltage is measured via a voltage transformer between the generator neutral point and the earth. The magnitude of the third harmonic biased voltage UB_3H is available in the Monitored data view.

## Level detector

In the third harmonic differential method, Level detector compares the third harmonic differential voltage with the third harmonic bias voltage. If the differential voltage exceeds the biased voltage, the module sends an enabling signal to start the timer.

If the terminal voltage is not available, that is, *Voltage selection* is set to "No voltage" the module compares the neutral side third harmonic voltage U_3H_N to the set *Voltage N 3.H Lim*.

### Timer

Once activated, Timer activates the START output. The Timer characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

Timer calculates the start duration START_DUR value, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all outputs and resets internal timers.

## 4.2.8.6 Application

Mechanical and thermal stress deteriorates stator winding insulation, which can eventually cause an earth fault between the winding and stator core.

The fault current magnitude in case of stator earth fault depends on the grounding type. Common practice in most countries is to earth the generator neutral side through a resistor. The resistor is selected such as to limit the maximum earth-fault current in the range of 5...10 A. The same can be done by connecting a single phase voltage transformer between the neutral side and earth, and with an equivalent resistor on the secondary side of the transformer.

In a normal operating condition, that is, when there is no earth fault, the residual voltage is close to zero with no zero-sequence current flowing in the generator. When a phase-to-earth fault occurs, the residual voltage increases and the current flows through the neutral. The simplest way to protect the stator winding against an earth fault is by providing residual overvoltage protection (or residual/neutral overcurrent protection). However, at best these simple schemes can protect only 95% of the stator winding, leaving 5% of the neutral end unprotected. This is because the voltage generated in the faulted winding decreases as the fault point becomes closer to the neutral point and it is not enough to drive the protection. Under certain unfavorable conditions, the blind zone may extend up to 20% from the neutral point.

An earth fault close to the neutral point is not dangerous, but an undetected fault may develop into an interturn fault or phase-to-phase fault. Also an undetected earth fault near the neutral point is bypassing the high-impedance grounding, and then another earth fault at the terminal results in a catastrophic situation.

Therefore, it is important to extend the protection to full 100%. The third harmonic voltage-based protection is one such protection which provides effective protection during an earth fault at the neutral point, and at least in the range up to 15...20% from the neutral point along the stator winding.

To achieve a complete stator earth-fault protection, two protection functions should always run in parallel.

- Fundamental frequency-based residual overvoltage protection ROVPTOV
- Third harmonic-based stator earth-fault protection H3EFPSEF

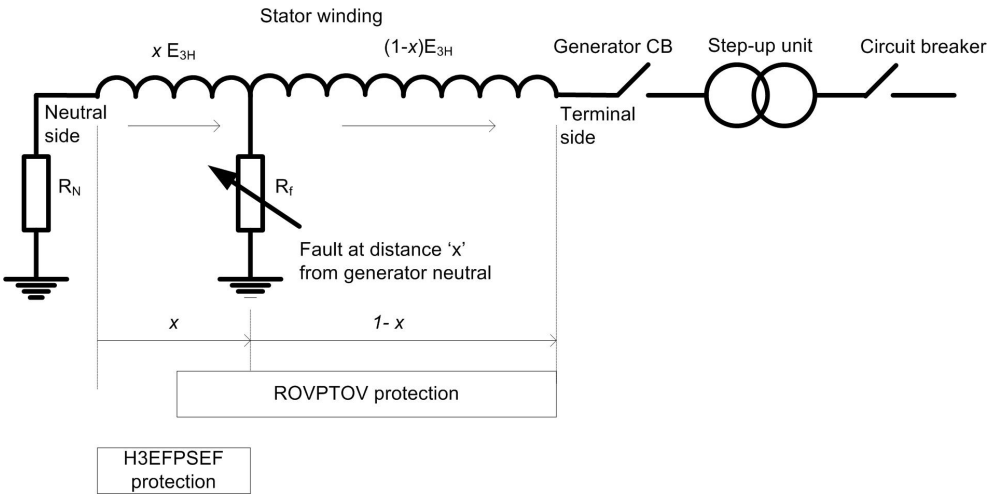



*Figure 281: Complete stator earth-fault protection*

## Third harmonic voltage-based differential protection

The voltage generated by a generator is not a perfect sinusoidal wave but contains triplen harmonics voltages. These triplen harmonics appear in each phase with the same magnitude and angle, due to which they do not sum to zero and thus also appear in the neutral side of the generator as a zero-sequence quantity. Among all the triplen harmonics voltages generated, the third harmonic voltage has the highest magnitude with the magnitude varying between 1% and 10% of the terminal voltage, depending on the generator design philosophy. However, for a particular generator the magnitude of third harmonics on the neutral side and terminal side depends also on the active power generated.

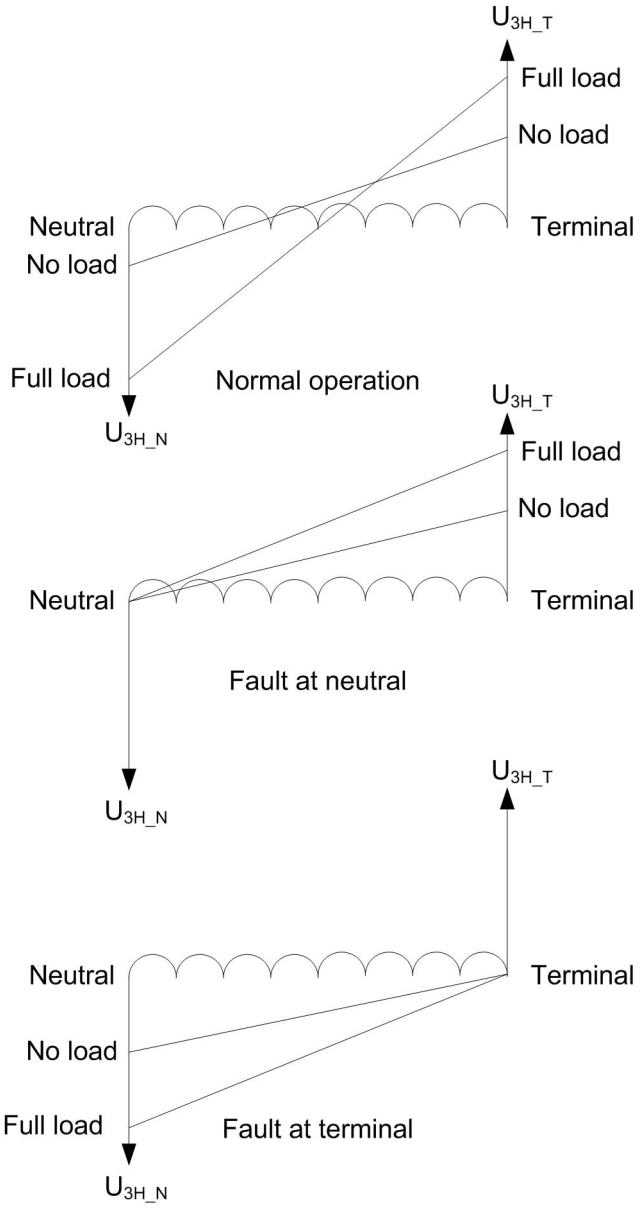



*Figure 282: Typical example of the third-harmonic voltage measured at the generator neutral and terminals under different conditions*

The operating equation of the protection is described in the following equation.

$$\left|\bar{U}_{3H_T} + \bar{U}_{3H_N}\right| - Beta \cdot \left|\bar{U}_{3H_N}\right| = 0$$

(Equation 71)

The third harmonic voltages $\bar{U}_{3H_T}$ and $\bar{U}_{3H_N}$ are the phasor with its real and imaginary parts. $\bar{U}_{3H_T}$ is approximately in the opposite direction to that of the $\bar{U}_{3H_N}$, however the actual no-fault angle between those two phasors depends on the type of generator earthing. For example, the angle is about 145 degrees for a high-resistance-earthed unit generator.

The equation defines the "operate" and "restrain" regions of the protection. The third harmonic differential protection operates according to the following equation.

$$\left|\bar{U}_{3H_T} + \bar{U}_{3H_N}\right| \geq Beta \cdot \left|\bar{U}_{3H_N}\right|$$

(Equation 72)

| | |
|---|---|
| $\bar{U}_{3H_N}$ | Neutral side third harmonic voltage phasor |
| $\bar{U}_{3H_T}$ | Terminal side third harmonic voltage phasor |
| *Beta* | Setting to achieve a required degree of security under healthy conditions |
| $\lvert\bar{U}_{3H_T}+\bar{U}_{3H_N}\rvert$ | Magnitude of the third harmonic differential voltage |
| $Beta \cdot \lvert\bar{U}_{3H_N}\rvert$ | Magnitude of the third harmonic bias (restrain) voltage |

Factor *Beta*, which is a setting, can be determined from the condition.

$$\frac{Beta \cdot \left|\bar{U}_{3H_N}\right|}{\left|\bar{U}_{3H_T} + \bar{U}_{3H_N}\right|} = K$$

(Equation 73)

K is the security factor, for example K = 1.5. Equation 73 must be satisfied in the normal, healthy condition of the protected generator, with a high enough value for K, so that no unwanted operation of the protection should be expected, regardless the load on the generator.

To assure a reliable functioning of the protection, it is necessary that the generator produces third harmonic voltage which is at least 1% of the generator rated voltage.

As phase-to-phase voltages do not contain a third harmonic component, in situations where the VTs on the terminal side are connected between phase-to-phase, the differential protection in Equation 73 cannot work. In such case, the *Voltage selection* setting is set to "No voltage" and H3EFPSEF operates as a simple neutral side third harmonic undervoltage protection.

When H3EFPSEF is reduced to function as only a third harmonic neutral point undervoltage protection, it is necessary to block the function during startup and shutdown of generator and also when there is no sufficient voltage.

## Calculating Beta value

The setting *Beta* gives the proportion of the third harmonic voltage in the neutral point of the generator to be used as bias quantity. *Beta* must be set so that there is no risk of trip during the normal, non-faulted operation of the generator. If *Beta* is set high, this limits the portion of the stator winding covered by the protection. In most cases, the default setting “3.00” gives an acceptable sensitivity for an earth fault near the neutral

point of the stator winding. However, to assure the best performance, measurements during the normal operation of the generator are to be made during commissioning.

1. The value of the *Beta* setting must be set to “1.00”.
2. Loading of the generator is done at 5 to 10 different load points and the third harmonic differential and bias voltage are measured. Both quantities can be obtained from the Monitored data view of the function.
3. A graph indicating differential and bias voltages as a functions of the load on the generator must be plotted.
4. Based on the graph, such value of the *Beta* setting must be selected that the bias voltage, even in the worst condition, is at least 30% to 50% higher than the differential voltage.

The angle between the third harmonic voltage phasors $\bar{U}_{3H_T}$ and $\bar{U}_{3H_N}$ is 150°, and with the *Beta* setting value "1.0", protection guarantees a stability margin of 25%. This requires the value of *Beta* to be increased so as to increase the stability of protection. The recommended value of the *Beta* setting is at least “1.2”.

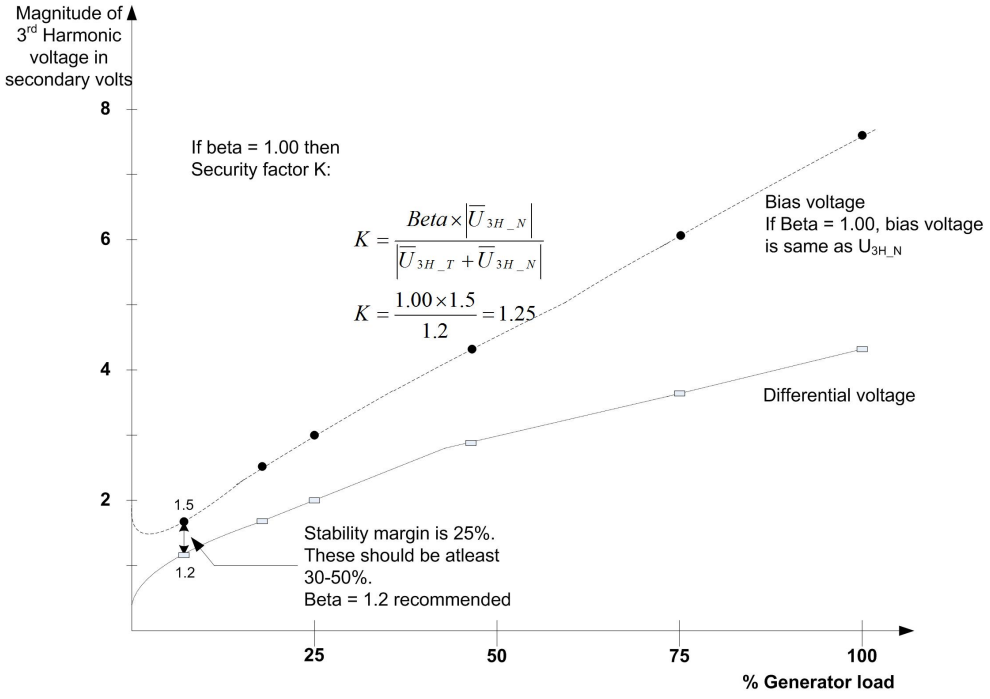



*Figure 283: Typical example of variation of the bias voltage and differential voltage with a change in the active generated load (the angle between the third harmonic terminal and neutral voltage is 150°)*

## Calculating CB open factor

One of the factors, though not major, governing the magnitude of the generated third harmonic voltage is the generator terminal capacitance. If there is no generator breaker, the capacitive coupling to earth is the same under all operating conditions.

However, the generator breaker normally exists between the protected generator and its power transformer.

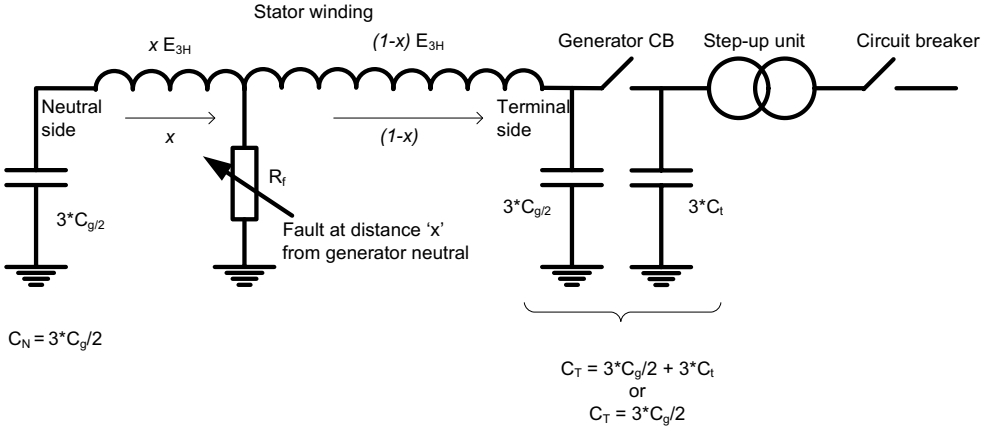



*Figure 284: Capacitance seen at generator terminal and neutral side*

- $C_g$ Phase capacitance of generator stator winding
- $C_t$ Total external phase capacitance of the system as seen from the generator
- $C_N$ Phase-to-ground lumped capacitance of the generator stator winding, between the earth-fault location and the generator neutral
- $C_T$ Phase-to-ground lumped capacitance of the generator stator winding, between the generator terminal and earth-fault location

When there is a generator breaker, the capacitive coupling to earth differs between the operating conditions when the generator is running with the generator breaker open (before synchronization) and with the circuit breaker closed.

With the generator breaker open, the total capacitance is smaller compared to normal operating conditions. This means that the neutral side third harmonic voltage is reduced compared to the normal operating condition. Therefore, there is a need to reduce the sensitivity of the protection. When generator breaker is open, H3EFPSEF desensitizes the protection by multiplying the *Beta* setting with a set constant *CB open factor* setting.

$$\left|\overline{U}_{3H_T} + \overline{U}_{3H_N}\right| \geq CB\ open\ factor \cdot Beta \cdot \left|\overline{U}_{3H_N}\right|$$

(Equation 74)

The *CB open factor* setting is obtained during commissioning.

1. For a particular value of *Beta* the third harmonic neutral voltage is measured with the generator in the no-load condition and the circuit breaker in the closed position.
2. With the same condition, the third harmonic neutral voltage with the circuit breaker in the open position is measured.
3. *CB open factor* should be set equal to the ratio of the third harmonic neutral voltage measured with the circuit breaker in the closed position to that in the open.

### 4.2.8.7 Signals

*Table 550: H3EFPSEF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| UNEUT | SIGNAL | - | Analog input |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| GCB_CLOSED | BOOLEAN | 0=False | Generator CB in closed position |

*Table 551: H3EFPSEF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| INT_BLKD | BOOLEAN | Protection internally blocked |

### 4.2.8.8 Settings

*Table 552: H3EFPSEF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Beta | 0.50...10.00 | | 0.01 | 3.00 | Portion of neutral side 3rd harmonic used as bias |
| Voltage N 3.H Lim | 0.005...0.200 | xUn | 0.001 | 0.010 | Start value for 3rd harmonic residual undervoltage protection |
| Operate delay time | 20...300000 | ms | 10 | 20 | Operate delay time |

*Table 553: H3EFPSEF Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage selection | 1=No voltage<br>2=Uo<br>4=Phase A<br>5=Phase B<br>6=Phase C | | | 2=Uo | Type of voltage connection available at generator terminal |
| CB open factor | 1.00...10.00 | | 0.01 | 1.00 | Multiplication factor for beta when CB is in open condition |

*Table 554: H3EFPSEF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 555: H3EFPSEF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage block value | 0.010...0.100 | xUn | 0.001 | 0.010 | Low level blocking for 3rd harmonic differential protection |
| Generator CB used | 0=No<br>1=Yes | | | 0=No | Defines if generator circuit breaker exists |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.2.8.9 Monitored data

*Table 556: H3EFPSEF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| UD_3H | FLOAT32 | 0.00...40.00 | xUn | 3rd harmonic differential voltage amplitude |
| UB_3H | FLOAT32 | 0.00...40.00 | xUn | 3rd harmonic bias voltage amplitude |
| U_3H_T | FLOAT32 | 0.00...40.00 | xUn | Terminal side 3rd harmonic voltage amplitude |
| U_3H_N | FLOAT32 | 0.00...40.00 | xUn | Neutral side 3rd harmonic voltage amplitude |
| U_3H_N | FLOAT32 | 0.00...40.00 | xUn | Neutral side 3rd harmonic voltage amplitude |
| U_3HANGL_T_N | FLOAT32 | -180.00...180.00 | deg | Phase angle between 3rd harmonic terminal and neutral voltage |
| H3EFPSEF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.8.10 Technical data

*Table 557: H3EFPSEF Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n$ ±2 Hz |
| | ±5% of the set value or ±0.004 × $U_n$ |
| Start time[1)2)] | Typically 35 ms |
| Reset time | Typically 35 ms |
| Reset ratio | Typically 0.96 (differential mode)<br>Typically 1.04 (undervoltage mode) |
| Operate time accuracy | ±1.0% of the set value of ±20 ms |

1) $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.2.9 Multifrequency admittance-based earth-fault protection MFADPSDE

### 4.2.9.1 Identification

| Description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Multifrequency admittance-based earth-fault protection | MFADPSDE | Io> ->Y | 67NYH |

### 4.2.9.2 Function block

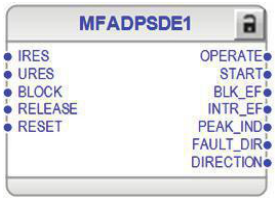



*Figure 285: Function block*

### 4.2.9.3 Functionality

The multifrequency admittance-based earth-fault protection function MFADPSDE provides selective directional earth-fault protection for high-impedance earthed networks, that is, for compensated, unearthed and high-resistance earthed systems. It can be applied for the earth-fault protection of overhead lines and underground cables, regardless of the earth-fault type (continuous, transient or intermittent) or the fault resistance value (low or high ohmic). MFADPSDE replaces traditional sensitive

directional earth-fault protection (such as Iocos) and transient earth-fault protection (such as Wischer principle) combining the same functionality into a single function block (see Table 558).

*Table 558: Comparison of the MFADPSDE functionality with traditional methods in resonant earthed networks*

| | Earth-fault type | | | | |
|---|---|---|---|---|---|
| | Transient | Continuous | Restriking/ Intermittent | Low-ohmic | High-ohmic |
| Traditional Iocos | | x | | x | x |
| Traditional Wischer | x | | x | x | |
| MFADPSDE | x | x | x | x | x |

As shown by numerous practical field tests, MFADPSDE provides better sensitivity and selectivity compared with traditional methods with less complexity in settings and configuration. MFADPSDE provides enhanced earth-fault protection performance, especially in networks with cable feeders where distributed compensation coils are applied and the earth-fault type is typically intermittent. It is applicable in feeders with distributed compensation regardless of the size or localization of distributed coils. Selective protection can be achieved also in case of overcompensated feeders.

The neutral point in compensated networks is earthed via a controllable centralized arc suppression coil located typically in the primary substation. Additionally, (fixed) distributed compensation coils can be used, which are installed in relevant locations along the protected feeders.

In unearthed networks, the neutral point in the primary substation is not connected to earth. However, in unearthed networks (fixed) distributed compensation coils can also be used to compensate a part of the total capacitive earth-fault current. Typically, the resulting compensation degree is less than 50 percent. Thus, unearthed networks with or without distributed compensation coils are generally referred to as unearthed networks in this manual.

MFADPSDE operation is based on multifrequency neutral admittance measurement using the cumulative phasor summing technique. This concept provides extremely secure, dependable and selective earth-fault protection also when the residual quantities are highly distorted and contain non-fundamental frequency components.

The sensitivity that can be achieved is comparable with traditional fundamental frequency based methods such as IoCos/IoSin (DEFxPTOC), Watt/Varmetric (WPWDE) and neutral admittance (EFPADM).

MFADPSDE can detect faults with dominantly fundamental frequency content as well as transient, intermittent and restriking earth faults. The function can be used as an alternative solution to transient or intermittent function INTRPTEF.

MFADPSDE supports fault direction indication both in operate and in non-operate direction, which can be used during fault location process. The in-built transient detector can be used to identify restriking or intermittent earth faults, and discriminate them from permanent or continuous earth faults.

The operation characteristic is defined by a tilted operation sector, which is universally valid for unearthed and compensated networks.

The operating time characteristic is according to the definite time (DT).

MFADPSDE contains a blocking functionality to block function outputs, timers or the function itself.

### 4.2.9.4 Analog channel configuration

MFADPSDE has two analog group inputs which must be properly configured.

*Table 559: Analog inputs*

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |
| URES | Residual voltage (measured or calculated) |



See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 560: Special conditions*

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected to calculate the residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.9.5 Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "on" and "off".

The operation of MFADPSDE can be described using a module diagram. All the modules in the diagram are explained in the following sections.

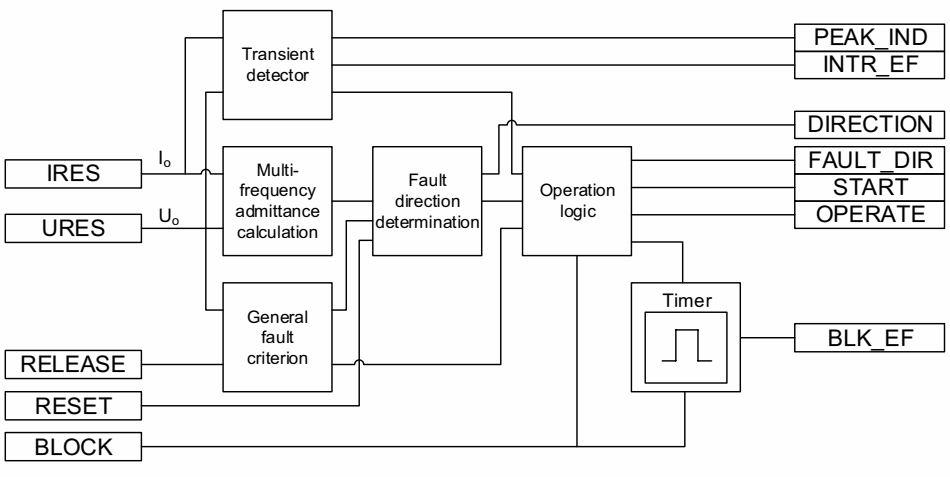



*Figure 286: Functional module diagram*

## General fault criterion

The General fault criterion (GFC) module monitors the presence of earth faults in the network. It is based on the value of the fundamental frequency zero-sequence voltage defined as the vector sum of fundamental frequency phase voltage phasors divided by three.

$$\overline{U_0^1} = \frac{\left(\overline{U_A^1} + \overline{U_B^1} + \overline{U_C^1}\right)}{3}$$

(Equation 75)

MFADPSDE supports zero-sequence voltage monitoring based on measurement (from open-delta winding) or calculated (derived from phase-to-earth voltages).

When the magnitude of $U_0^1$ exceeds setting *Voltage start value*, an earth fault is detected. The GFC module reports the exceeded value to the Fault direction determination module and Operation logic. The reporting is referenced as General Fault Criterion release.

The setting *Voltage start value* defines the basic sensitivity of MFADPSDE. To avoid unselective start or operation, *Voltage start value* must always be set above the maximum healthy-state zero-sequence voltage value, considering network topology changes, compensation coil and parallel resistor switching status and compensation degree variations. The setting *Voltage start value* can be easily selected based on the resonance curve calculated by the coil controller in corresponding network conditions (see Figure 287).

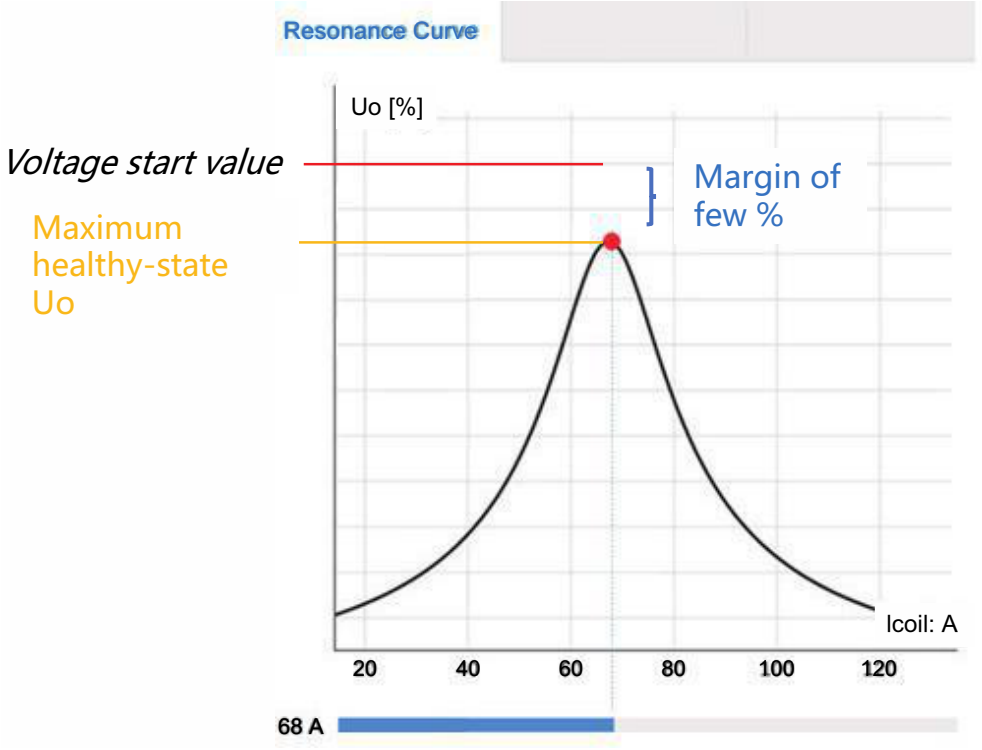



*Figure 287: Example of selection of setting Voltage start value to maximize the earth-fault detection sensitivity based on the resonance curve calculated by the coil controller*

There are three MFADPSDE instances (stages) available. The sensitivity of different stages should be selected differently. For example, stage 1 could have the highest *Voltage start value* and the shortest *Operate delay time*. Thus it would fulfill the requirements for protection operation speed by providing fast operation for low-ohmic earth faults. Stage 2 should have lower *Voltage start value* and longer *Operate delay time* compared with stage 1. This stage would fulfill the requirements for protection sensitivity (in terms of fault resistance value). Stage 3 could be used to detect high-ohmic earth faults and generate alarms for them. To maximize the earth-fault detection sensitivity of stage 3, *Voltage start value* should be selected based on the network's resonance curve (see Figure 287).

Such coordination of different protection stages enables:

- Indication (but no tripping) of transient, self-extinguishing earth faults, where the zero-sequence voltage may temporarily rise to a high value and then decay slowly away. This can be achieved by monitoring the START outputs. Delayed operation

times of stages 1 and 2 avoid unnecessary breaker operations during self-extinguishing earth faults.
- Fast tripping of low-ohmic permanent earth faults regardless of their type (continuous or intermittent), stage 1
- Delayed tripping of higher-ohmic permanent earth faults regardless of their type (continuous or intermittent), stage 2
- Alarms (but no tripping) about high-ohmic earth faults in order to monitor the insulation status of the network and provide early indication of evolving faults before they cause tripping (by stages 1 or 2), stage 3.

Besides the internal start condition based on residual zero-sequence overvoltage, MFADPSDE can also be externally released by using the RELEASE input. In this case, the external release signal overrides the *Voltage start value* setting and sets the internal limit to the minimum value.

## Multi-frequency admittance calculation

The Multi-frequency admittance calculation module calculates neutral admittances using fundamental frequency and the 2nd, 3rd, 5th, 7th and 9th harmonic components of residual current and zero-sequence voltage. The fundamental frequency admittance (conductance and susceptance) is calculated if the magnitude of a harmonic in residual current and zero-sequence voltage is measurable by the relay.

$$\overline{Y_0^1} = \frac{3 \cdot \overline{I_0^1}}{-\overline{U_0^1}} = G_o^1 + j \cdot B_o^1$$

(Equation 76)

$\overline{Y_0^1}$ Fundamental frequency neutral admittance phasor

$\overline{I_0^1}$ Fundamental frequency zero-sequence current phasor $(= \frac{(\overline{I_A^1} + \overline{I_B^1} + \overline{I_C^1})}{3})$

$\overline{U_0^1}$ Fundamental frequency zero-sequence voltage phasor $(= \frac{(\overline{U_A^1} + \overline{U_B^1} + \overline{U_C^1})}{3})$

$G_o^1$ Fundamental frequency conductance, $\mathrm{Re}\left(\overline{Y_0^1}\right)$

$B_o^1$ Fundamental frequency susceptance, $\mathrm{Im}\left(\overline{Y_0^1}\right)$

$$\mathrm{Im}\left[\overline{Y_0^n}\right] = \mathrm{Im}\left[\frac{3 \cdot \overline{I_0^n}}{-\overline{U_0^n}}\right] = j \cdot B_o^n$$

(Equation 77)

n 2, 3, 5, 7 and 9

$\overline{Y_0^n}$ nth harmonic frequency neutral admittance phasor

$\overline{I_0^n}$ nth harmonic frequency zero-sequence current phasor

$\overline{U_0^n}$ nth harmonic frequency zero-sequence voltage phasor

$B_o^n$ nth harmonic frequency susceptance, $\mathrm{Im}\left(\overline{Y_0^n}\right)$

For fault direction determination, the fundamental frequency admittance and harmonic susceptances are summed together in phasor format. The result is the sum admittance phasor defined as

$$\overline{Y}_{osum} = \mathrm{Re}\left[\overline{Y_0^1}\right] + j \cdot \mathrm{Im}\left[\overline{Y_0^1} + \sum_{n=2}^{9} \overline{Y_0^n}\right] = G_o^1 + j \cdot B_{osum}$$

(Equation 78)

The polarity of the polarizing quantity (residual voltage) can be changed (rotated by 180 degrees) by setting the *Pol reversal* parameter to "True" or by switching the polarity of the residual voltage measurement wires.

## Fault direction determination

If an earth fault is detected by the GFC module, the fault direction is evaluated based on the calculated sum admittance phasor $\overline{Y}_{osum}$ obtained from the Multi-frequency admittance calculation module. To obtain dependable and secure fault direction determination regardless of the fault type (transient, intermittent, restriking, permanent, high or low ohmic), the fault direction is calculated using a special filtering algorithm, Cumulative Phasor Summing (CPS) technique. This filtering method is advantageous during transient, intermittent and restriking earth faults with dominantly non-sinusoidal or transient content. It is equally valid during continuous (stable) earth faults.

The concept of CPS is illustrated in Figure 288. It is the result of adding the values of the measured sum admittance phasors together in phasor format in chronological order during the fault. Using the discrete sum admittance phasors $\overline{Y}_{osum}$ in different time instants ($t_1$...$t_5$), the corresponding accumulated sum admittance phasor

$\overline{Y}_{osum_CPS}$ is calculated. This phasor is used as directional phasor in determining the direction of the fault.

$$\overline{Y}_{osum_CPS}(t_1) = \overline{Y}_{osum}(t_1)$$

(Equation 79)

$$\overline{Y}_{osum_CPS}(t_2) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2)$$

(Equation 80)

$$\overline{Y}_{osum_CPS}(t_3) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2) + \overline{Y}_{osum}(t_3)$$

(Equation 81)

$$\overline{Y}_{osum_CPS}(t_4) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2) + \overline{Y}_{osum}(t_3) + \overline{Y}_{osum}(t_4)$$

(Equation 82)

$$\overline{Y}_{osum_CPS}(t_5) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2) + \overline{Y}_{osum}(t_3) + \overline{Y}_{osum}(t_4) + \overline{Y}_{osum}(t_5)$$

(Equation 83)

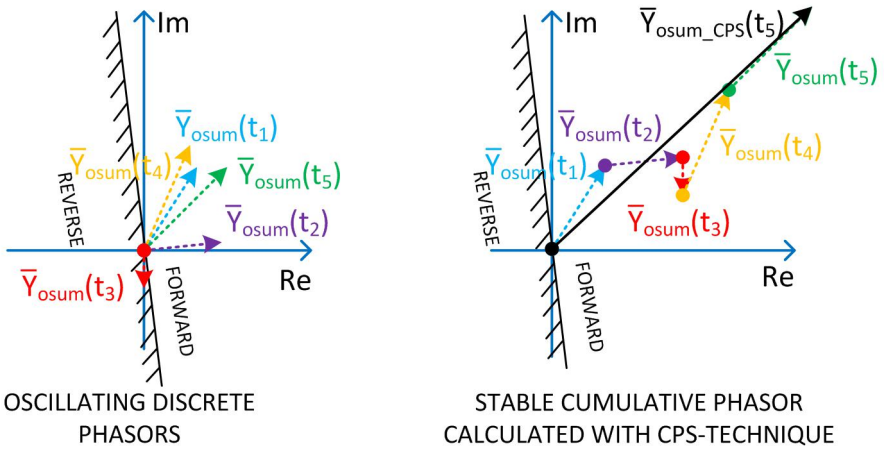



*Figure 288: Principle of Cumulative Phasor Summing (CPS)*

The CPS technique provides a stable directional phasor quantity despite individual phasors varying in magnitude and phase angle in time due to an unstable fault type such as a restriking or intermittent earth fault. This is also true for harmonic components included in the sum admittance phasor. Harmonics typically have a highly fluctuating character.

Harmonic components provide a more distinctive directional determination in compensated networks than the fundamental frequency component. With higher frequencies, the compensation coil appears as very high impedance and the harmonics are not affected by compensation coil and degree of compensation. When harmonics are present, they cause the sum admittance phasor to behave as in case of an unearthed network, where directional phasors point in opposite directions in the faulty and healthy feeder.

The direction of MFADPSDE is defined with setting *Directional mode* as "Forward" or "Reverse". The operation characteristic is defined by a tilted operation sector as illustrated in Figure 289. The characteristic provides universal applicability, that is, it is valid in both compensated and unearthed networks even if the compensation coil is temporarily switched off. The tilt of the operation sector is defined with setting *Tilt angle* to compensate the measurement errors of residual current and voltage transformers. The typical setting value of 5 degrees is recommended, but it should always reflect the maximum expected measurement errors.



In case of unearthed network operation, an adequate tilt angle must be allowed to ensure dependable operation of MFADPSDE.

In Figure 289, phasors 1...4 demonstrate the behavior of the directional phasor in different network fault conditions.

- Phasor 1 depicts the direction of the accumulated sum admittance phasor in case of earth fault outside the protected feeder (assuming that the admittance of the protected feeder is dominantly capacitive). The result is valid regardless of the fault type (low ohmic, high(er) ohmic, permanent, intermittent or restriking). If harmonic components are present in the fault quantities, they turn the phasor alignment to the negative Im(Yo) axis.
- Phasor 2 depicts the direction of accumulated sum admittance phasor in case of earth fault inside the protected feeder when the network is unearthed. The result is also valid in compensated networks when there are harmonic components in the fault quantities (typically low-ohmic permanent, intermittent or restriking fault). In this case, the result is valid regardless of network's actual compensation degree. Harmonics would turn the phasor align to the positive Im(Yo) axis.
- Phasors 3 and 4 depict the direction of accumulated sum admittance phasor in case of higher-ohmic earth fault in the protected feeder without harmonics in the fault quantities when the network is compensated. As no harmonic components are present, the phase angle of the accumulated phasor is determined by the compensation degree of the network. With a high degree of overcompensation, the phasor turns towards the negative Im(Yo) axis (as phasor 4).

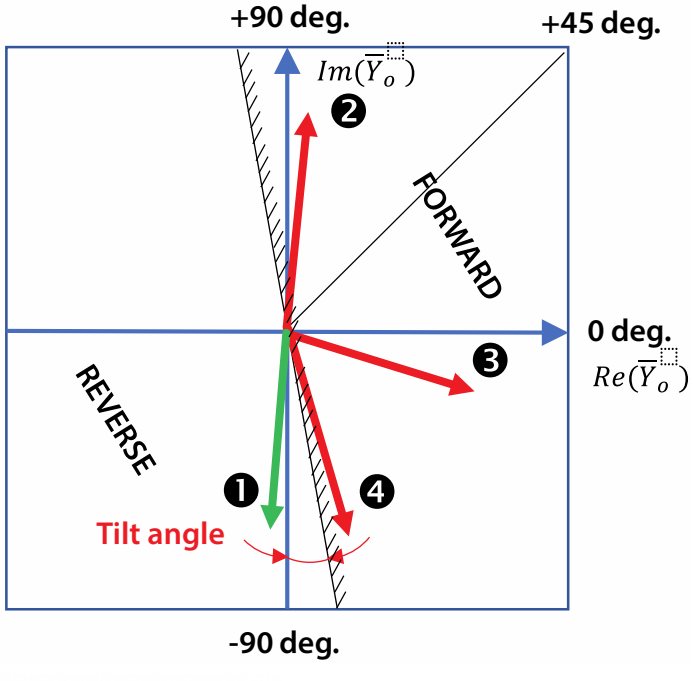



*Figure 289: Directional characteristic of MFADPSDE*

The residual current should be measured with accurate Core Balance Current Transformer (CBCT) to minimize the measurement errors, especially phase displacement. This is especially important when high sensitivity of protection is targeted.

The characteristic *Tilt angle* should reflect the measurement errors, that is, the larger the measurement errors, the larger the *Tilt angle* setting should be. A typical setting value of 5 degrees is recommended.

The maximum value for characteristic *Tilt angle* depends on the ratio of the resistive and reactive component in the measured residual current Io. The operation point moves away from the operation sector mid-point; the lower is the ratio of the resistive and reactive component in the measured residual current Io. The phase angle of operation point in the faulted feeder can be approximated with equation

$$\varphi = atan\left(\frac{I_{EFFd} + I_{detuning}}{I_{damping}}\right)$$

(Equation 84)

$I_{EFFd}$ Earth-fault current produced by the protected feeder [A]

$I_{detuning}$ Detuning of the arc suppression coil [A]

$I_{damping}$ System damping [A]

**Example 1:**

$I_{EFFd} = 30$ A, $I_{detuning} = +10$ A and $I_{damping} = 10$ A. From Equation 84, $\varphi = 76$ deg. Thus *Tilt angle* should not exceed ~10 deg.

**Example 2:**

$I_{EFFd} = 50$ A, $I_{detuning} = +10$ A and $I_{damping} = 5$ A. From Equation 84, $\varphi = 85$ deg. Thus *Tilt angle* should not exceed ~3 deg. However, such a low *Tilt angle* setting may endanger the security of protection due to measurement errors of the CBCTs. In this case, the phase angle of operation point should be increased by considering:

1. System damping increase by increasing the current value of the parallel resistor of the coil
2. Reduction of the earth-fault current produced by the protected feeder by, for example, installation of distributed compensation coils or by change of the feeder topology
3. Reduction of overcompensation of the network. The recommendation is to use the undercompensation mode.

The DIRECTION output indicates on which operating sector the current is measured. The FAULT_DIR output indicates in which operation sector the fault current is measured. The output is operational once the function is started.

To adapt the fault direction determination to a fault direction change during the fault, for example, during manual fault location process, a cyclic accumulation of sum admittance phasors is conducted. The duration of this directional evaluation cycle is 1.2 · *Reset delay time* (minimum 600 ms). If the fault direction based on the cyclic phasor accumulation is opposite to the function direction output for *Reset delay time* or 500 ms (minimum 500 ms), the function is reset and the fault direction calculation of MFADPSDE is restarted.

If the earth-fault protection generates alarms, MFADPSDE also includes a RESET input which can be used to externally re-trigger the fault direction determination if re-evaluation of fault direction during a persistent earth fault is required.

It is also recommended to connect the start signal of non-directional earth fault protection (EFxPTOC), set to operate in case of a cross-country fault, to RESET input or BLOCK input of MFADPSDE to reset phasor accumulation during a cross-country

fault. MFADPSDE can then adapt to a fault direction change more rapidly if a single-phase earth fault persists in the system after the other faulty feeder has been tripped (the cross-country fault has been transformed into a single-phase earth fault).

The direction of MFADPSDE is supervised by a settable current magnitude threshold, setting *Min operate current*. The operate current used in the magnitude supervision is measured with a special filtering method, which provides a stable residual current estimate regardless of the fault type. This estimate is the result of the fundamental frequency admittance calculation using the CPS technique. The stabilized current value is obtained (after conversion) from the corresponding admittance value by multiplying it by the system nominal phase-to-earth voltage value. The equations for calculating the stabilized values of the fundamental frequency admittance and the corresponding current are given below.

$$\overline{Y^1_{o\ stab}} = \frac{3 \cdot \overline{I^1_{0\,CPS}}}{-\overline{U^1_{0\,CPS}}} = \mathrm{Re}\left[\overline{Y^1_{o\ stab}}\right] + j \cdot \mathrm{Im}\left[\overline{Y^1_{o\ stab}}\right] = G^1_{ostab} + j \cdot B^1_{ostab}$$

(Equation 85)

$\overline{Y^1_{o\ stab}}$ Stabilized fundamental frequency admittance estimate, which is the result of the fundamental frequency admittance calculation using the CPS technique

$\overline{I^1_{0\,CPS}}$ Fundamental frequency zero-sequence current phasor calculated using the CPS technique

$\overline{U^1_{0\,CPS}}$ Fundamental frequency zero-sequence voltage phasor calculated using the CPS technique

$G^1_{o\,stab}$ Real part of stabilized fundamental frequency conductance estimate

$B^1_{o\,stab}$ Imaginary part of stabilized fundamental frequency susceptance estimate

$$\overline{I^1_{o\ stab}} = (G^1_{ostab} + j \cdot B^1_{ostab}) \cdot U_{baseres} = I^1_{oCosstab} + j \cdot I^1_{oSinstab}$$

(Equation 86)

$\overline{I^1_{o\ stab}}$ Stabilized fundamental frequency residual current estimate, which is obtained (after conversion) from the corresponding admittance value by multiplying it by the system nominal phase-to-earth voltage value

$\overline{I^1_{o\ Cosstab}}$ Real part of stabilized fundamental frequency residual current estimate

$\overline{I^1_{o\ Sinstab}}$ Imaginary part of stabilized fundamental frequency residual current estimate

$U_{baseres}$ System nominal phase-to-earth voltage value

The main advantage of the filtering method is that due to the admittance calculation, the resulting current value does not depend on the fault resistance value, that is, the estimated current magnitude equals the value that is measured during a solid earth

fault (Rf = 0 Ω). Another advantage of the method is that it can estimate correct current magnitude also during intermittent or restriking faults.

The setting *Min operate current* defines the minimum operate current which must be exceeded for the function to start or operate.

Setting *Operating quantity* defines whether the current magnitude supervision is based on the “Adaptive”, “Amplitude” or “Resistive” methods.

*Table 561: Comparison of Operating quantity of MFADPSDE with traditional methods*

| Traditional method | Setting Operating quantity of MFADPSDE | | |
|---|---|---|---|
| | Adaptive | Amplitude | Resistive |
| Iosin | | x | |
| Iocos | | | x |
| Iosin/Iocos | x | | |

When *Operating quantity* is set to "Adaptive", the method adapts the principle of current magnitude supervision to the system earthing condition. This is done by monitoring the phase angle of accumulated sum admittance phasor, (see Figure 290).

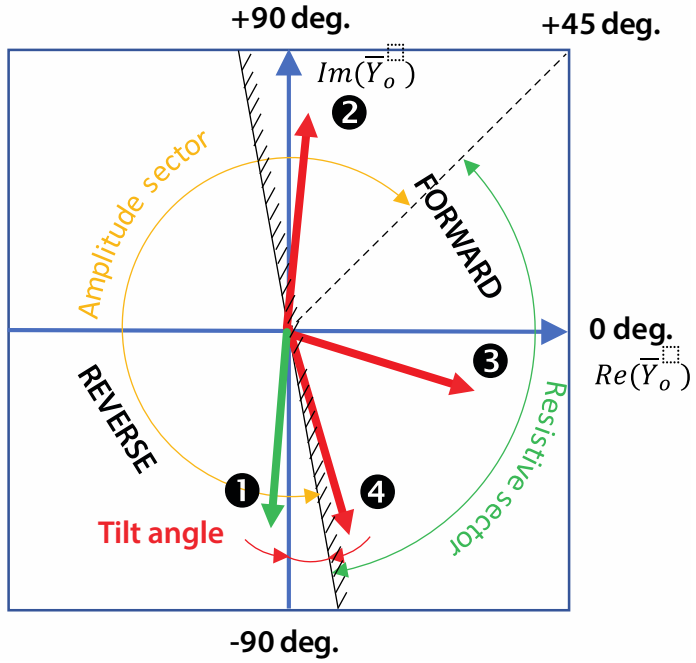



*Figure 290: Automatic adaptation of current magnitude supervision condition (setting Min operate current) to either resistive part or amplitude of $I^1_{ostab}$ based on the phase angle of accumulated sum admittance phasor, when setting Operating quantity = “Adaptive”. Directional mode = “Forward”*

If the phase angle of accumulated sum admittance phasor is greater than 45 degrees, current magnitude supervision is based on the amplitude of $\overline{I^1_{o\ stab}}$, which must exceed the set minimum operate current threshold. If the phase angle of accumulated sum admittance phasor is below 45 degrees, current magnitude supervision is based on the resistive part of $\overline{I^1_{o\ stab}}$, which must exceed the set minimum operate current threshold. This automatic adaptation of the magnitude supervision condition enables secure and dependable directional determination in compensated networks, and it is also valid when the network is unearthed (compensation coil is switched off).

If operation direction is set to reverse, the resistive and amplitude sectors are mirrored in the operation characteristics.

Setting *Operating quantity* should be set to "Adaptive" in resonant earthed systems, except when protected feeders are overcompensated by distributed coils. In such a case, *Operating quantity* should be set to "Resistive".

Setting *Operating quantity* to "Adaptive" enables secure and dependable directional determination in compensated networks, which is also valid when the compensation coil is switched off and the network becomes unearthed. In case of an unearthed network, *Min operate current* is automatically compared to the amplitude of $\overline{I^1_{o\ stab}}$. In case of restriking earth-faults, harmonics created by the fault type make the accumulated sum admittance phasor behave as in case of an unearthed network. Therefore, operation can be achieved without the need for resistive part of $\overline{I^1_{o\ stab}}$. This also means that in compensated networks during earth faults with rich harmonic content in residual quantities, operation can be achieved without the parallel resistor of the centralized compensation coil.

When *Operating quantity* is set to "Resistive", the set minimum operate current threshold (setting *Min operate current*) is compared to the resistive component of $\overline{I^1_{o\ stab}}$ in the whole defined operate sector (see Figure 291).

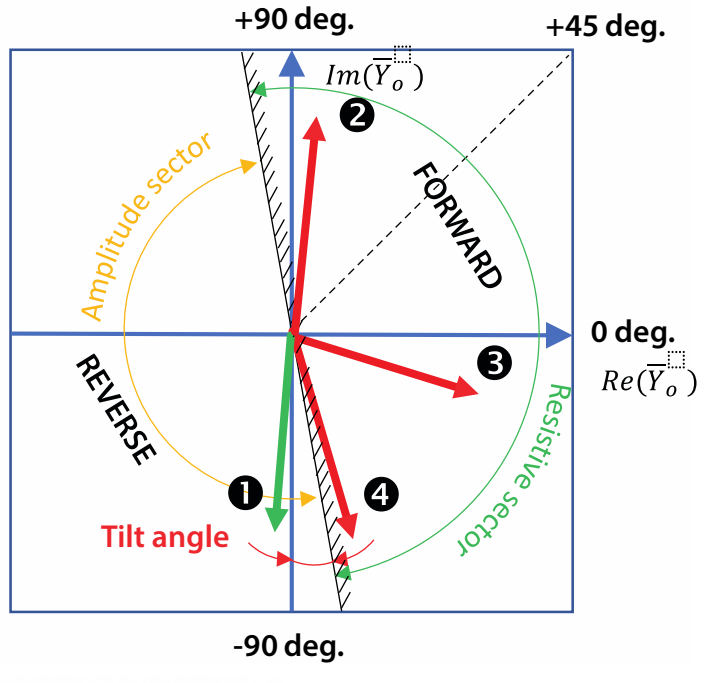



*Figure 291: Operating quantity = "Resistive" and Directional mode = "Forward"*

The resistive mode is valid for resonant earthed networks and high-resistance earthed systems, but not in case of unearthed networks. The resistive mode must be selected when there is a risk of local overcompensation of a protected feeder, that is, when the earth-fault current is compensated with distributed compensation coils and their inductive current exceeds the amount of capacitive current produced by the phase-to-earth capacitances of the feeder.

In compensated networks, where distributed compensation coils are also used to compensate earth-fault current, setting *Operating quantity* should be set to "Resistive". This enables secure and dependable directional determination also in case of local overcompensation where the earth-fault current produced by the healthy feeder can become inductive.

When *Operating quantity* is set to "Amplitude", the set minimum operate current threshold (setting *Min operate current*) is compared to the amplitude of $\overline{I^1_{o\ stab}}$ in the whole defined operate sector (see Figure 292). This selection can be used in unearthed networks.

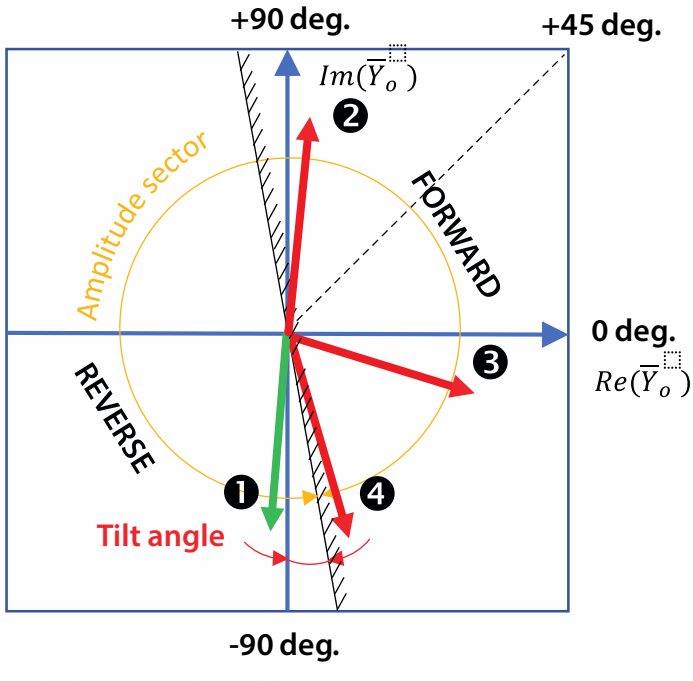



*Figure 292: Operating quantity = "Amplitude" and Directional mode = "Forward"*

If the “Adaptive” or “Resistive” operating quantity is selected, the setting *Min operate current* should be set to value:

$$[pu] < p \cdot IRtot$$

(Equation 87)

| | |
|---|---|
| [pu] | Min operate current |
| IRtot | Total resistive earth-fault current of the network corresponding to the resistive current of the parallel resistor of the coil and the natural losses of the system (typically 1...5 % of the total capacitive earth-fault current of the network) |
| p | security factor = 0.5…0.7 |

It must be set to a value which is lower than the total resistive earth-fault current in order to enable dependable operation.

Estimation of the total resistive earth-fault current of the network including the parallel resistor of the coil and the network losses can be obtained from the network calculation results of the coil controller in resonant earthed networks. In Petersen coil controller, this value is denoted as ‘I_DAMPING’ [A]. When evaluating this numerical value, the connection status of the parallel resistor of the coil must be considered. See the example in Figure 293. In this case, the parallel resistor of the coil has value 8.6 A and it is permanently connected. The total system damping is calculated as 11.29 A. Thus the natural network losses including the losses of the coil are 11.29 A - 8.6 A = 2.69 A.

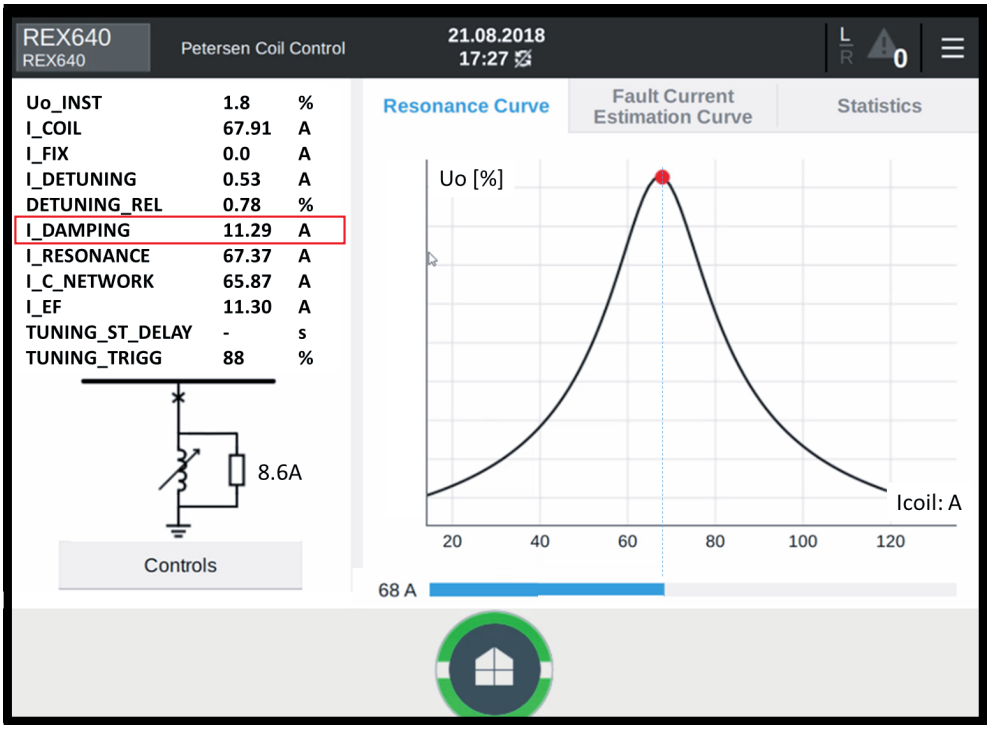



*Figure 293: Example of interpretation of network damping value, I_DAMPING, calculated by the coil controller*

For example, if the resistive current of the parallel resistor is 10 A (at primary voltage level), then a value of 0.5 · 10 A = 5 A could be used for setting *Min operate current*.

The network damping value, I_DAMPING, calculated by the coil controller can be used as a base for setting *Min operate current*.

If *Operating quantity* is set to "Adaptive", the setting value *Min operate current* is also applicable if the coil is disconnected and the network becomes unearthed. In this case, the current magnitude supervision is automatically based on the amplitude of $\overline{I^1_{o\ stab}}$). The selected setting value must never exceed the ampere value of the parallel resistor in order to allow operation in the faulty feeder. In case of smaller ampere value of the parallel resistor, for example 5 A, the recommended security factor should be larger, for example 0.7, so that sufficient margin for CT and VT errors can be achieved.

If *Operating quantity* is set to "Amplitude", the *Min operate current* setting should be selected based on the capacitive earth-fault current values produced by the background network in case of a solid earth fault with a security margin.

The main task of the current magnitude supervision module is to secure the correct directional determination of an earth fault so that only the faulty feeder is disconnected or generates alarms. Therefore, the threshold value *Min operate current* should be selected carefully

and should not be set too high as this can inhibit the disconnection of the faulty feeder.

The residual current should be measured with an accurate CBCT to minimize the measurement errors, especially phase displacement.

The parallel resistor should be kept connected during the healthy state so that in case of a fault, earth-fault protection can immediately see sufficient value of resistive component for operation. If the parallel resistor is kept disconnected during the healthy state, it should be immediately connected when the earth fault is detected. This enables the earth-fault protection to operate without delay.

## Transient detector

The Transient detector module is used for detecting transients in the residual current and zero-sequence voltage signals. Whenever a transient is detected, this is indicated with the PEAK_IND output. When the number of detected transients equals or exceeds the *Peak counter limit* setting (without the function being reset, depending on the drop-off time set with the *Reset delay time* setting), INTR_EF output is activated. This indicates detection of a restriking or intermittent earth fault in the network.

Transient detector affects the operation of MFADPSDE (START and OPERATE outputs) when operation mode is “Intermittent EF”. For other operation modes, (“General EF”, “Alarming EF”), PEAK_IND and INTR_EF outputs can be used for monitoring purposes. The operation of Transient detector is illustrated in Figure 294.

Several factors affect the magnitude and frequency of fault transients, such as the fault inception angle on the voltage wave, fault location, fault resistance and the parameters of the feeders and the supplying transformers. If the fault is permanent (non-transient), the initial fault transient in current and voltage can be measured, whereas the intermittent fault creates repetitive transients. The practical sensitivity of transient detection is limited to approximately a few hundreds of ohms of fault resistance. Therefore the application of transient detection is limited to low-ohmic earth faults.

Transient detector is a non-directional function. Thus, if detection of restriking or intermittent earth faults is wanted only in the faulted feeder, the START and INTR_EF outputs must be ANDed in the configuration.

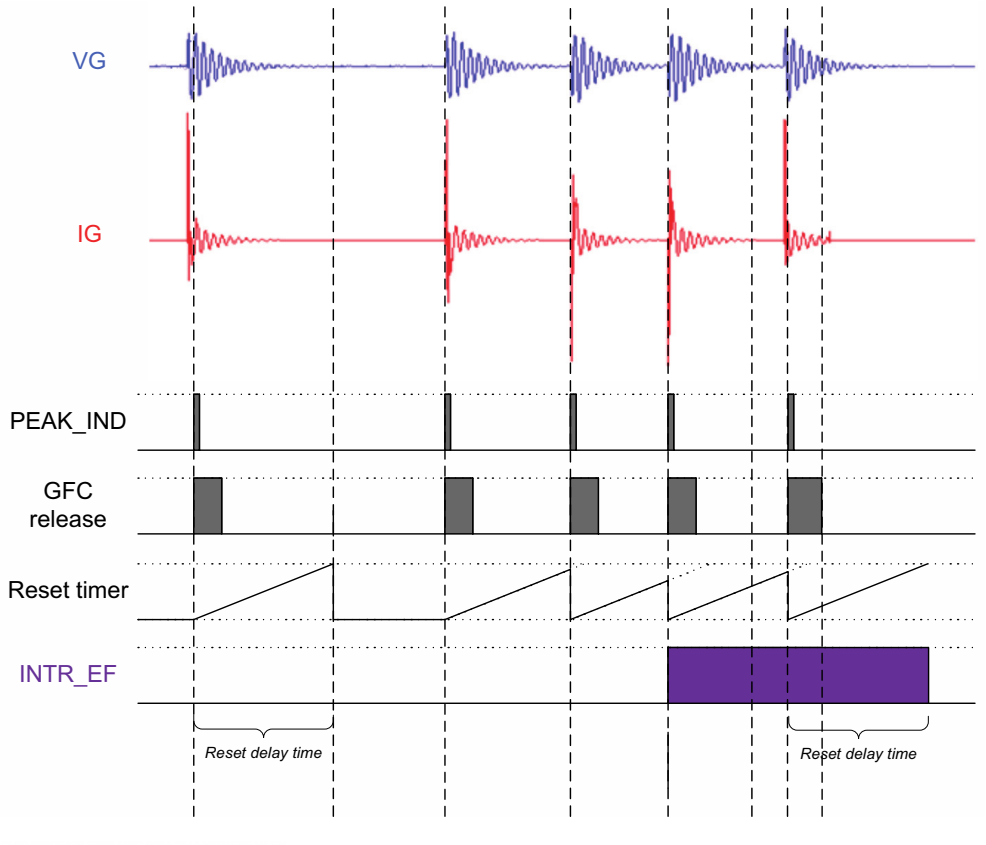



*Figure 294: Example of operation of Transient detector: indication of detected transient by PEAK_IND output and detection of restriking or intermittent earth fault by INTR_EF output (setting Peak counter limit = 3)*

## Operation logic

MFADPSDE supports four operation modes selected with setting *Operation mode*: "General EF", "Alarming EF", "Intermittent EF" and "Transient EF".

### General EF

Operation mode “General EF” is applicable to various earth faults in high-impedance earthed networks, that is, in compensated, unearthed and high-resistance earthed networks. It detects earth faults regardless of their type (transient, intermittent or restriking, permanent, high or low ohmic) and provides definite operate time for protection regardless of the fault type.

In “General EF” mode, the operate timer is started in the following conditions.

- Earth fault is detected by the GFC
- Fault direction equals *Directional mode* setting
- Estimated stabilized fundamental frequency residual current $\overline{I^{1}_{o\,stab}}$ exceeds the set *Min operate current* level, which is applied in current magnitude threshold

supervision, and which is further defined with setting *Operating quantity* (available options are "Adaptive", "Amplitude" and "Resistive").

The START output is activated once *Start delay time* has elapsed. OPERATE output is activated once *Operate delay time* has elapsed and the above three conditions are valid. Reset timer is started if any of the above three conditions is not valid. If the fault is transient and self-extinguishes, START output stays activated until the reset timer expires (setting *Reset delay time*). After OPERATE output activation, START and OPERATE outputs are reset immediately if any of the above three conditions is not valid. The start duration value START_DUR, available in the Monitored data view, indicates the percentage ratio of the start time and the set operating time.



If detection of temporary earth faults is not desired, the activation of START output can be delayed with setting *Start delay time*. The same setting can also be used to avoid restarting of the function during long-lasting post-fault oscillations if the time constant of post-fault oscillations is very long (network losses and damping is low).



To keep the operate timer activated between current spikes during intermittent or restriking earth faults, *Reset delay time* should be set above the maximum expected time interval between fault spikes (obtained at full resonance condition). The recommended value is at least 300 ms.

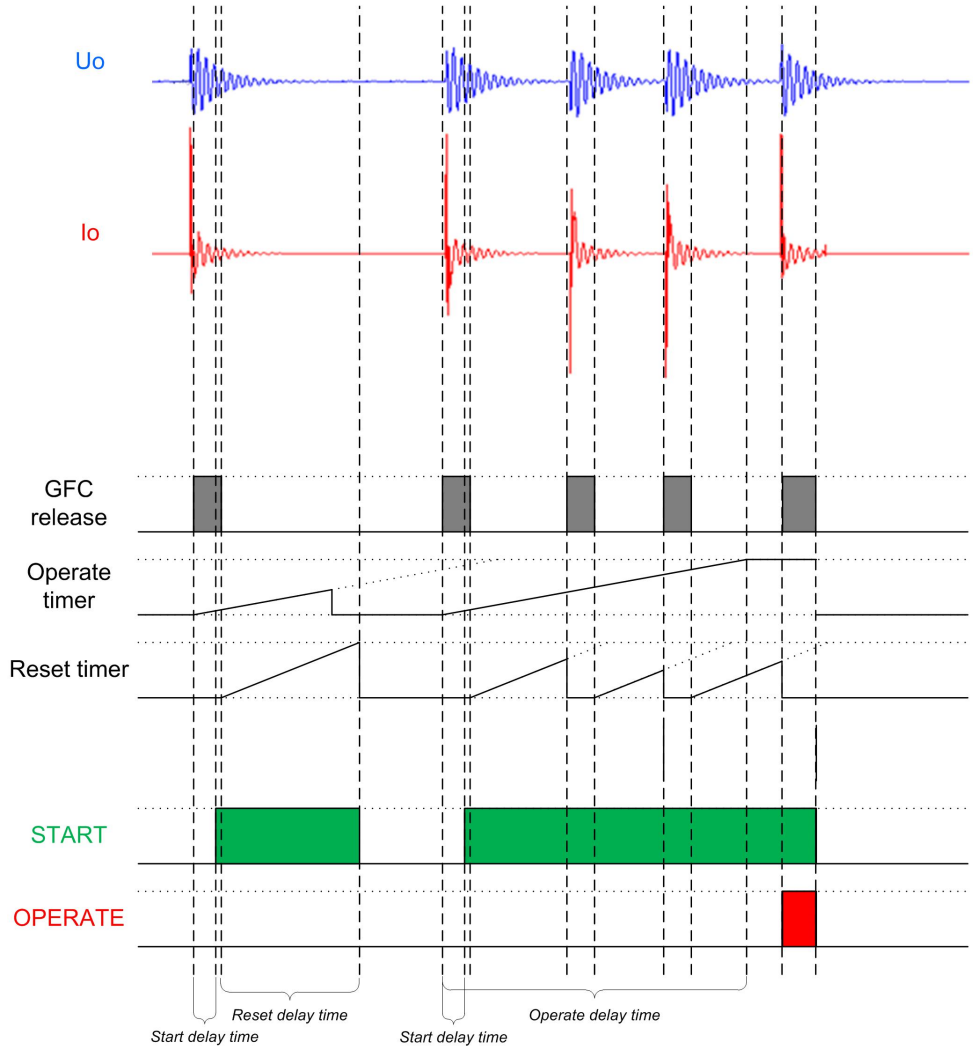



*Figure 295: Operation in "General EF" mode*

**Alarming EF**

Operation mode "Alarming EF" is applicable in all kinds of earth faults in high-impedance earthed networks, that is, in compensated, unearthed and high resistance earthed networks, where fault detection is only alarming. It is intended to detect earth faults regardless of their type (transient, intermittent or restriking, permanent, high or low ohmic).

In "Alarming EF" mode, the operate timer is started during the following conditions.

- Earth fault is detected by the GFC
- Fault direction equals *Directional mode* setting
- Estimated stabilized fundamental frequency residual current $\overline{I^{1}_{o\,stab}}$ exceeds the set *Min operate current* level, which is applied in current magnitude threshold

supervision, and which is further defined with setting *Operating quantity* (available options are "Adaptive", "Amplitude" and "Resistive").

The START output is activated once *Start delay time* has elapsed. OPERATE output is not valid in the “Alarming EF” mode. Reset timer is started if any of the above three conditions are not valid. If the fault is transient and self-extinguishes, START output stays activated until the elapse of reset timer (setting *Reset delay time*).

If detection of temporary earth faults is not desired, the activation of START output can be delayed with setting *Start delay time*.

To keep the operate timer activated between current spikes during intermittent or restriking earth fault, the *Reset delay time* should be set above the maximum expected time interval between fault spikes (obtained at full resonance condition). The recommended value is at least 300 ms.

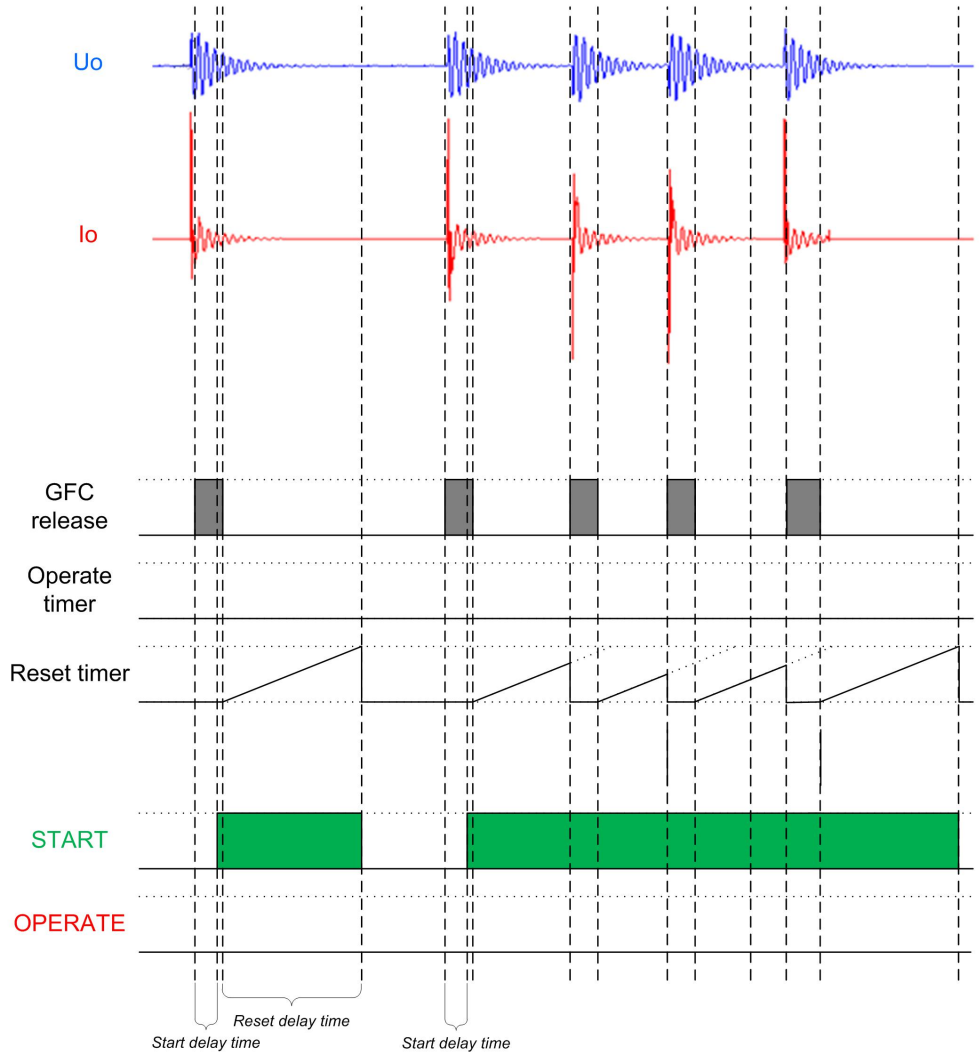



*Figure 296: Operation in "Alarming EF" mode*

**Intermittent EF**

Operation mode "Intermittent EF" is used to detect restriking or intermittent earth faults. A required number of intermittent earth fault transients set with the *Peak counter limit* setting must be detected for operation. Therefore, transient faults or permanent faults with only initial fault ignition transient are not detected in this mode. The application of "Intermittent EF" mode is limited to low ohmic intermittent or restriking earth faults.

In the "Intermittent EF" mode, the operate timer is started when the following conditions are met.

- Transient is detected by Transient detector (indicated with PEAK_IND output)
- Earth fault is detected by the GFC at the time of transient
- Fault direction equals *Directional mode* setting
- Estimated stabilized fundamental frequency residual current $\overline{I^{1}_{o\,stab}}$ exceeds the set *Min operate current* level, which is applied in current magnitude threshold supervision, and which is further defined with setting *Operating quantity* (available options are "Adaptive", "Amplitude" and "Resistive").

When a required number of intermittent earth-fault transients set with the *Peak counter limit* setting are detected and the function is not reset (depends on the drop-off time set with the *Reset delay time* setting), the START output is activated. The INTR_EF output is activated to indicate the fault type is intermittent or restriking. The operate timer is kept activated as long as transients occur during the drop-off time defined by setting *Reset delay time*.

The OPERATE output is activated when *Operate delay time* has elapsed, the required number of transients has been detected, earth fault is detected by the GFC, the fault direction matches the *Directional mode* setting and the estimated stabilized fundamental frequency residual current exceeds the set *Min operate current* setting.

*Reset delay time* starts to elapse for each detected transient. The function is reset if the time between current peaks is more than *Reset delay time* or if the GFC release is reset. After OPERATE output activation, START and OPERATE outputs are reset immediately at the falling edge of the GFC release, that is, when zero-sequence voltage falls below *Voltage start value*. This should be considered if “Intermittent EF" mode is applied if earth faults are only alarmed to avoid repetitive start and operate events.

*Peak counter limit* setting should not be set below 3 in order to provide secure indication of intermittent/restriking earth faults. This is due to the fact that sometimes the fault ignition transient is characterized by highly distorted waveform, which may result in multiple transient detection at time of fault ignition. By increasing the value of *Peak counter limit* setting, the security of correct fault type identification is increased.

To keep the operate timer activated between current spikes during intermittent or restriking earth faults, *Reset delay time* should be set above the maximum expected time interval between fault spikes (obtained at full resonance condition). The recommended value is at least 300 ms.

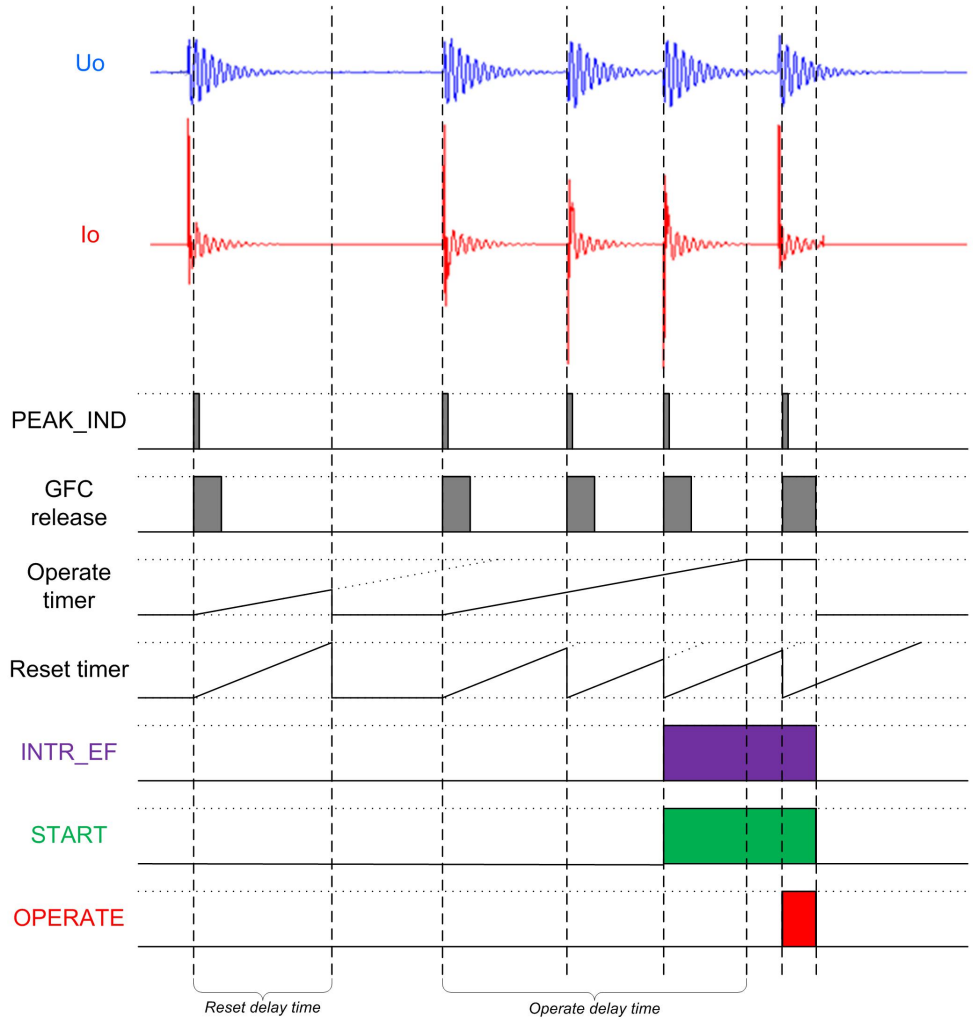



*Figure 297: Operation in "Intermittent EF" mode, Peak counter limit = 3*

**Transient EF**

Operation mode "Transient EF" is dedicated for detecting fast transient faults where the fault current stays on only for a very short time. It is recommended method in networks, where network damping has very small value or when parallel resistor of the coil is not used, for example in sub-transmission networks.

In the "Transient EF" mode, the fault direction is determined from the beginning of the fault and is held until earth-fault is detected by GFC.

In the "Transient EF" mode, the operate timer is started when the following conditions are met.

- Earth fault is detected by the GFC
- Fault direction equals *Directional mode* setting and fault direction detection is done only at the beginning of the fault
- Estimated stabilized fundamental frequency residual current $\overline{I^{1}_{o\,stab}}$ exceeds the set *Min operate current* level, which is applied in current magnitude threshold supervision, and which is further defined with setting *Operating quantity* (available options are "Adaptive", "Amplitude" and "Resistive").

In the “Transient EF” mode, the START output is activated immediately when start conditions are met.

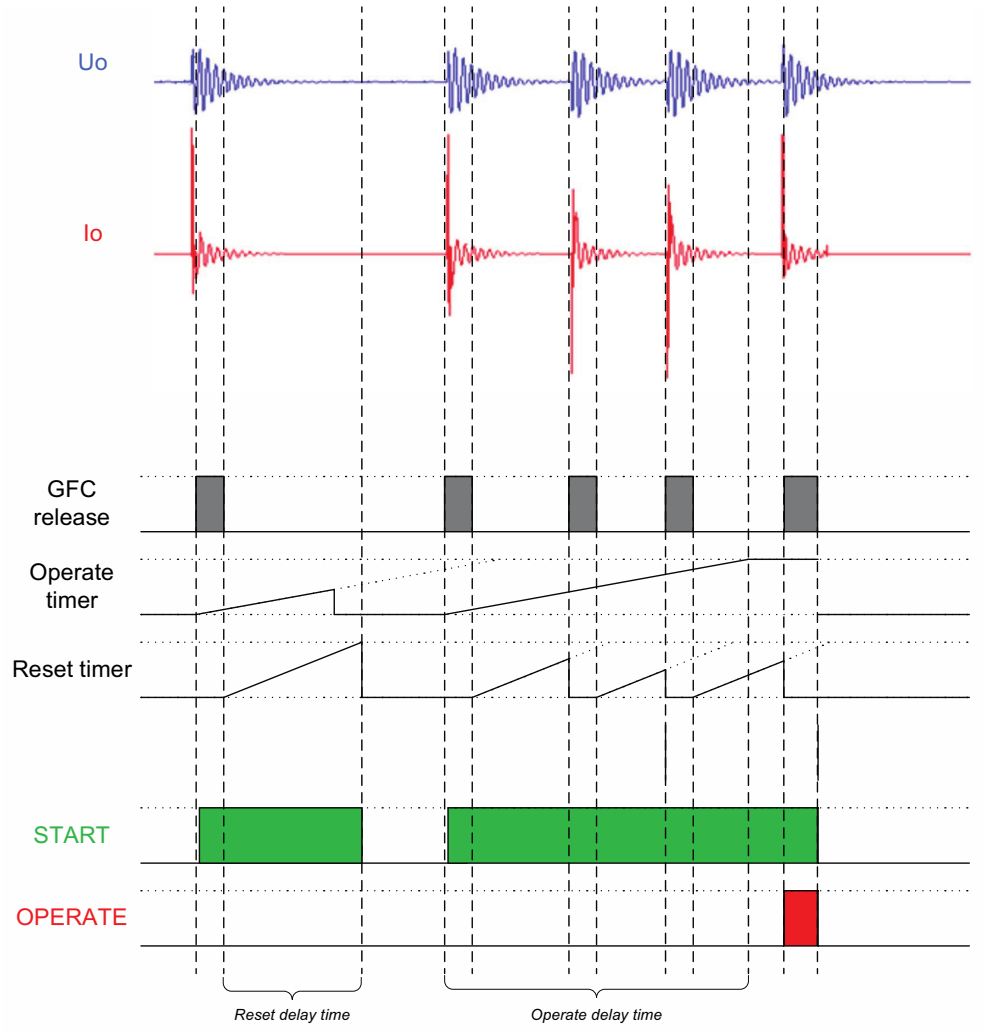



*Figure 298: Operation in “Transient EF” mode*

When operation mode “Transient EF” is selected, *Operating quantity* should be set to "Resistive" and *Min operate current* to the minimum

value. *Tilt angle* should be 10 degrees especially if the residual current is measured with Holmgreen (sum) connection of phase current CTs.

## Blocking logic

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

If the BLOCK input of MFADPSDE is used in the configuration, then "Block all" mode is recommended.

Recommended uses of the BLOCK input of MFADPSDE are:

1. Connecting the start signal of non-directional earth fault protection (EFxPTOC), set to operate in case of a cross-country fault, to BLOCK input of MFADPSDE to reset phasor accumulation during a cross-country fault. MFADPSDE can then adapt to a fault direction change more rapidly if a single-phase earth fault persists in the system after the other faulty feeder has been tripped (the cross-country fault has been transformed into a single-phase earth fault).
2. Connecting the ‘Auto-Reclose in progress’ output (INPRO) from DARREC to BLOCK input of MFADPSDE to allow faster reset of MFADPSDE during high-speed auto-reclosing cycle HSAR when setting *Reset delay time* equals or is higher than the dead time of high-speed auto-reclosing cycle HSAR.
3. In case of a network with distributed coils but no centralized arc suppression coil at the primary substation (unearthed network), it is recommended to add an additional logic to protection configuration, which blocks MFADPSDE if the frequency of measured Uo and Io becomes lower than nominal. Such condition is valid in network when earth fault becomes disconnected and a phenomenon called ‘post-fault oscillation’ is initiated.
4. If the parallel resistor of the coil has long connection delay, it is recommended to add an additional logic to protection configuration to enable the release of MFADPSDE at the time of the parallel resistor switching.

The logic to release MFADPSDE at time of resistor (re)connection is illustrated in Figure 299.

- Detection of earth fault from residual overvoltage, ROVPTOV
- Delay of release MFADPSDE using TONGAPC connected to the BLOCK input of MFA (inversed)
- Delay of release (TONGAPC: On delay time (ms)) based on known time delays in resistor connection
- Protection operate delay time to be set smaller than the resistor connection duration

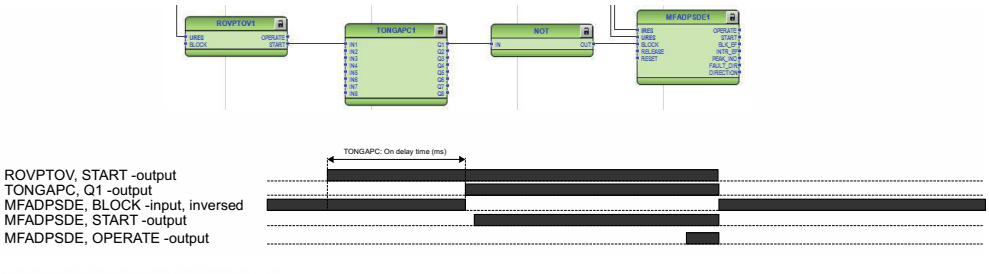



*Figure 299: Logic to release MFADPSDE at the time of resistor (re)connection*

The logic enables exact operate time of MFADPSDE elapsed from time of resistor (re)connection.

In the configuration, equal *Reset delay time* and *Voltage start value* must be used for ROVPTOV and MFADPSDE.

The release delay should be based on known delays in resistor (re)connection:

- Logic OFF-ON-OFF: *Switch on delay* of the parallel resistor
- Logic ON-OFF-ON: *Switch off delay* +*Time off* time of the parallel resistor

The resulting total protection operate time is defined as follows:

- Logic OFF-ON-OFF: *Switch on delay* of the parallel resistor + set *Operate delay time* of MFADPSDE
- Logic ON-OFF-ON: *Switch off delay* +*Time off* time of the parallel resistor + set *Operate delay time* of MFADPSDE
- Set *Operate delay time* of MFADPSDE smaller than the connection duration time of the resistor

If earth faults are only alarmed, the external logic is not needed.

When the proposed logic is used and indication of transient earth faults is needed, the START output from INTRPTEF can be used.

## Timer

If the detected fault direction is opposite to the set directional mode and GFC release is active, BLK_EF output is activated once *Start delay time* has elapsed. The reset timer is activated at the falling edge of the GFC release, that is, when the zero-

sequence voltage falls below *Voltage start value*. BLK_EF is reset once the reset delay time elapses. Activation of the BLOCK input deactivates the BLK_EF output and resets Timer.

BLK_EF output is activated when the following conditions are met:

- Earth fault is detected by the GFC.
- Fault direction is opposite to *Directional mode* setting.

The estimated stabilized fundamental frequency residual current $\overline{I^{1}_{o\,stab}}$ exceeds the internally fixed threshold, which is 1% of In. This current magnitude threshold supervision is based on the “Amplitude” method.

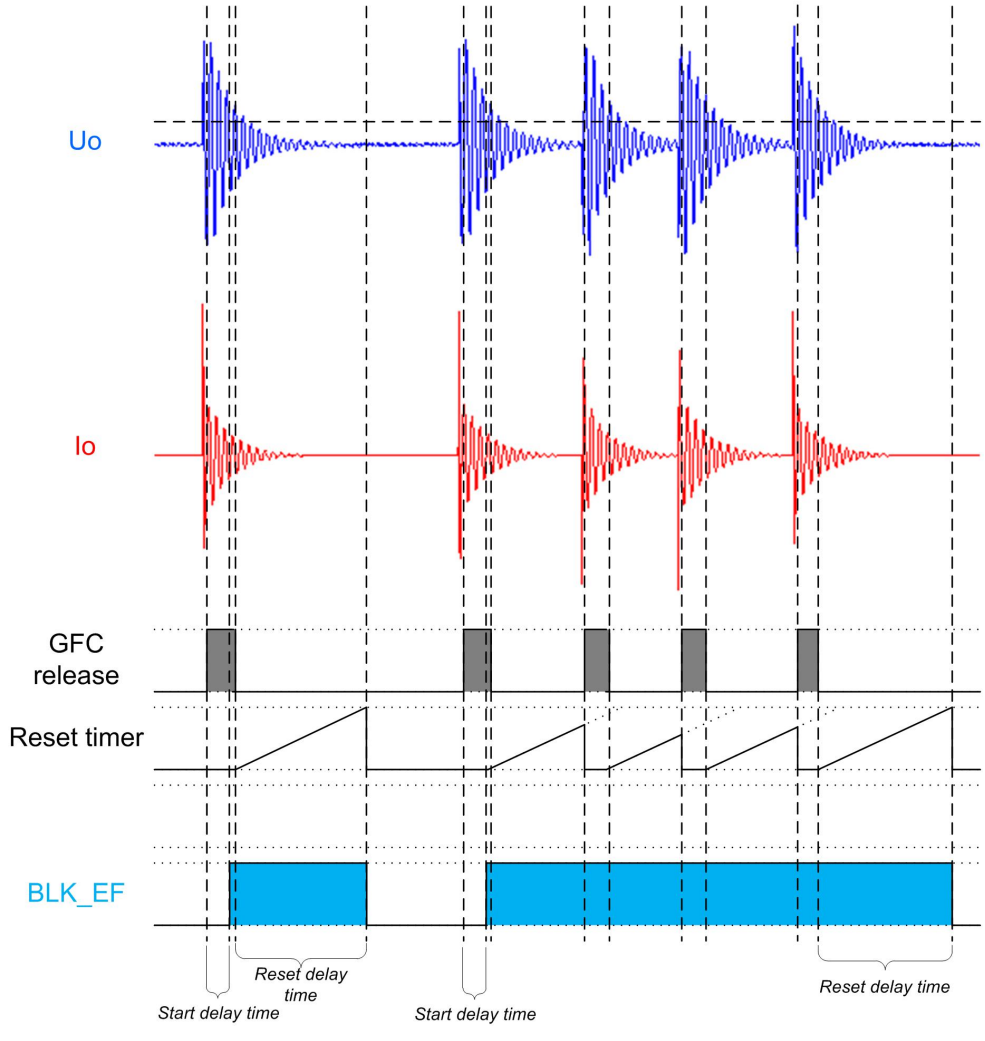



*Figure 300: Activation of BLK_EF output (indication that the fault is located opposite the set operate direction)*

### 4.2.9.6 Application

MFADPSDE provides selective directional earth-fault protection for high-impedance earthed networks, that is, for compensated, unearthed and high-resistance earthed systems. It can be applied for the earth-fault protection of overhead lines and underground cables, regardless of the earth-fault type (continuous, transient or intermittent) or the fault resistance value (low or high ohmic). MFADPSDE replaces traditional sensitive directional earth-fault protection (such as Iocos) and transient earth-fault protection (such as Wischer principle) combining the same functionality into a single function block (see Table 562).

*Table 562: Comparison of the MFADPSDE functionality with traditional methods in resonant earthed networks*

| | Earth-fault type | | | | |
|---|---|---|---|---|---|
| | Transient | Continuous | Restriking/ Intermittent | Low-ohmic | High-ohmic |
| Traditional Iocos | | x | | x | x |
| Traditional Wischer | x | | x | x | |
| New MFADPSDE | x | x | x | x | x |

As shown by numerous practical field tests, MFADPSDE provides better sensitivity and selectivity compared with traditional methods with less complexity in settings and configuration. MFADPSDE provides enhanced earth-fault protection performance, especially in networks with cable feeders where distributed compensation coils are applied and earth-fault type is typically intermittent. It is applicable in feeders with distributed compensation regardless of the size or localization of distributed coils. Selective protection can be achieved also in case of overcompensated feeders.

MFADPSDE operation is based on multifrequency neutral admittance measurement using the cumulative phasor summing technique. This concept provides extremely secure, dependable and selective earth-fault protection also when the residual quantities are highly distorted and contain non-fundamental frequency components. MFADPSDE is well-suited for compensated networks where measurement signals may have such characteristics, for example, during intermittent earth faults.

MFADPSDE can operate with both low-ohmic and higher-ohmic earth faults, where the sensitivity limit is defined with the residual overvoltage condition. This allows earth faults with several kilohms of fault resistance to be detected in a symmetrical system. The achieved sensitivity is comparable with traditional fundamental frequency based methods such as the IoCos/IoSin (DEFxPTOC), Watt/Varmetric (WPWDE) and neutral admittance (EFPADM).

MFADPSDE can detect faults with dominantly fundamental frequency content as well as transient, intermittent or restriking earth faults. MFADPSDE can be used as an alternative solution to transient or intermittent function INTRPTEF.

MFADPSDE supports fault direction indication in operate and non-operate directions which can be used during fault location process. The in-built transient detector can be used to identify restriking or intermittent earth faults, and discriminate them from permanent or continuous earth faults.

The direction of MFADPSDE can be set as forward or reverse. The operation characteristic is defined by a tilted operation sector, which is universally valid both in unearthed and compensated networks. The tilt of the operation sector should be selected based on the measurement errors of the applied residual current and voltage measurement transformers.

The operating time characteristic is according to the definite time (DT).

The function contains a blocking functionality to block function outputs, timers or the function itself.

MFADPSDE supports both tripping and alarming operation modes. For the alarming earth-fault protection application, the function contains a dedicated operation mode. MFADPSDE provides reliability and sensitivity of protection with a single function. This enables a protection scheme implementation that is simpler than separate fault type dedicated earth-fault functions which need to be coordinated. Other advantages of MFADPSDE include versatile applicability, good selectivity, good sensitivity and easy setting principles.

Three instances (stages) of MFADPSDE are available.

### 4.2.9.7 Signals

*Table 563: MFADPSDE Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RELEASE | BOOLEAN | 0=False | External trigger to release neutral admittance protection |
| RESET | BOOLEAN | 0=False | External trigger to reset direction calculatio |

*Table 564: MFADPSDE Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| BLK_EF | BOOLEAN | Block signal for EF to indicate opposite direction peaks |
| INTR_EF | BOOLEAN | Intermittent earth-fault indication |
| PEAK_IND | BOOLEAN | Current transient detection indication |
| FAULT_DIR | Enum | Detected fault direction |
| DIRECTION | Enum | Direction information |

### 4.2.9.8 Settings

*Table 565: MFADPSDE Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Directional mode | 2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Voltage start value | 0.01...1.00 | xUn | 0.01 | 0.10 | Voltage start value |
| Operate delay time | 60...1200000 | ms | 10 | 500 | Operate delay time |

*Table 566: MFADPSDE Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operating quantity | 1=Adaptive<br>2=Amplitude<br>3=Resistive | | | 1=Adaptive | Operating quantity selection |
| Min operate current | 0.005...5.000 | xIn | 0.001 | 0.010 | Minimum operate current |
| Tilt angle | 2.0...20.0 | deg | 0.1 | 5.0 | Characteristic tilt angle |

*Table 567: MFADPSDE Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=Intermittent EF<br>2=Transient EF<br>3=General EF<br>4=Alarming EF | | | 3=General EF | Operation criteria |

*Table 568: MFADPSDE Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Peak counter limit | 2...20 | | 1 | 2 | Peak counter limit for restriking EF |
| Start delay time | 30...60000 | ms | 1 | 30 | Start delay time |
| Reset delay time | 0...60000 | ms | 1 | 500 | Reset delay time |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |

### 4.2.9.9 Monitored data

*Table 569: MFADPSDE Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| ANGLE | FLOAT32 | -180.00...180.00 | deg | Angle between polarizing and operating quantity |
| I_OPER | FLOAT32 | 0.000...40.000 | xIn | Calculated operating current |
| MFADPSDE | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.9.10 Technical data

*Table 570: MFADPSDE Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $U_n$ |
| Start time[1)] | Typically 35 ms |
| Reset time | Typically 40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

1) Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

# 4.3 Differential protection

## 4.3.1 Line differential protection with inzone power transformer LNPLDF

### 4.3.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Line differential protection with in-zone power transformer | LNPLDF | 3Id/I> | 87L |

### 4.3.1.2 Function block




*Figure 301: Function block*

### 4.3.1.3 Functionality

The line differential protection with in-zone power transformer LNPLDF is used as feeder differential protection for the distribution network lines and cables. LNPLDF includes low, stabilized and high, non-stabilized stages. The line differential protection can also be used when there is an in-zone transformer in the protected feeder section.

The stabilized low stage provides a fast clearance of faults while remaining stable with high currents passing through the protected zone increasing errors on current measuring. Second harmonic restraint insures that the low stage does not operate due to energizing of a tapped or in-zone transformer. The high stage provides a very fast clearance of severe faults with a high differential current regardless of their harmonics.

The operating time characteristic for the low stage can be selected to be either definite time (DT) or inverse definite time (IDMT). The direct inter-trip ensures both ends are always operated, even without local criteria.

### 4.3.1.4 Analog channel configuration

LNPLDF has one analog group input which must be properly configured.

*Table 571: Analog signals*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks

in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The function can also be set into test mode by setting the *Operation* setting to "test/blocked".

The operation of the line differential protection and related measurements, stabilized and instantaneous stages can be described using a module diagram.

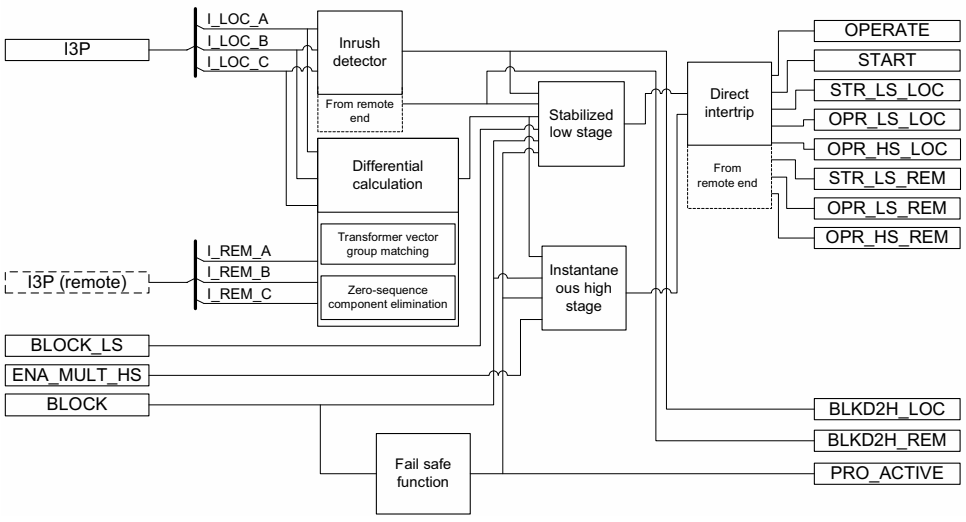



*Figure 302: Functional module diagram. I_LOC_x stands for current of the local end and I_REM_x for phase currents of the remote ends.*

#### Stabilized low stage

In the stabilized low stage, the higher the load current is, the higher the differential current required for tripping is. This happens on normal operation or during external faults. When an internal fault occurs, the currents on both sides of the protected object flow towards the fault and cause the stabilizing current to be considerably lower. This makes the operation more sensitive during internal faults. The low stage includes a timer delay functionality.

The characteristic of the low stage taking the apparent differential current into account is influenced by various factors:

- Small tapped loads within the protection zone
- Current transformer errors
- Current transformer saturation
- Small asymmetry of the communication channel go and return paths

- Small steady state line charging current
- In-zone transformer no load current
- Impact of tap changer positions

The timer is activated according to the calculated differential, stabilizing current and the set differential characteristic.

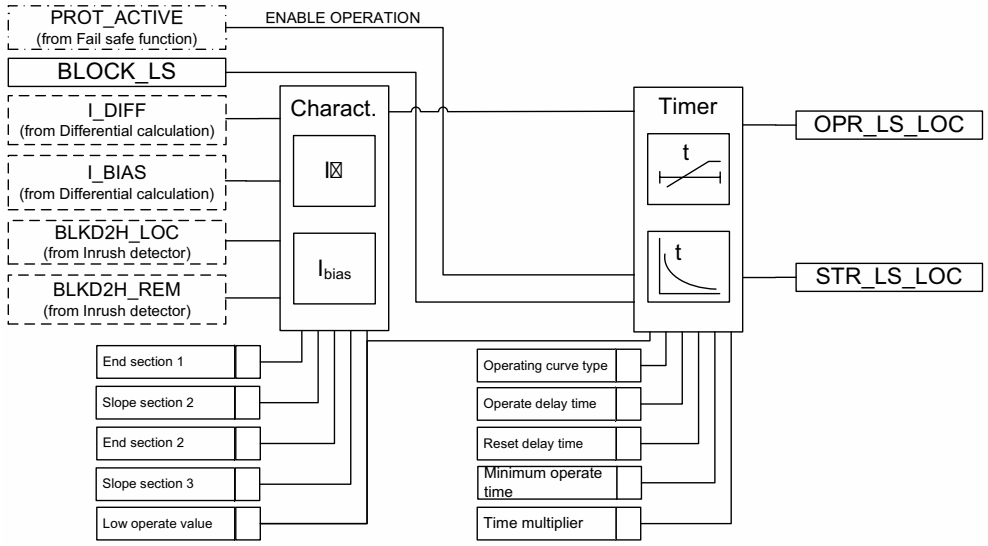



*Figure 303: Operation logic of the stabilized low stage*

The stabilization affects the operation of the function.

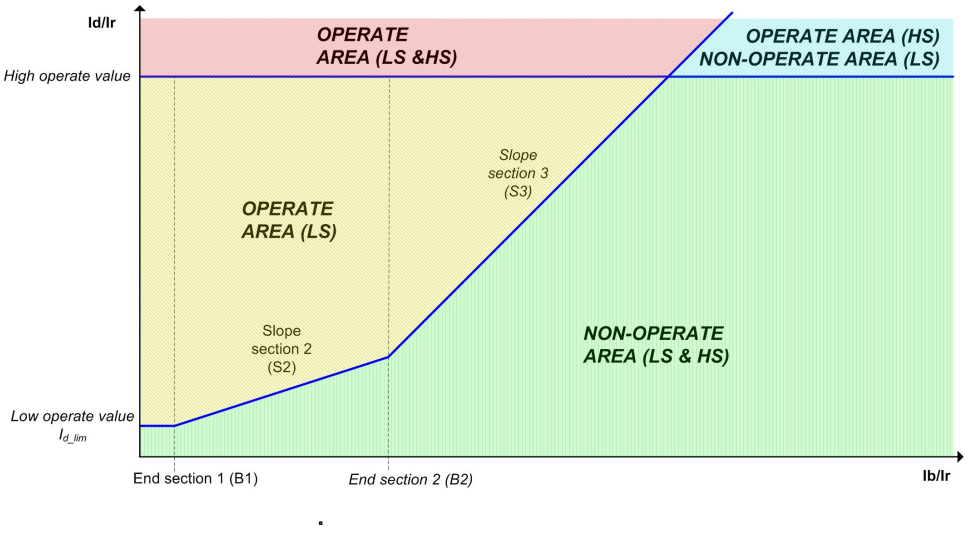



*Figure 304: Operating characteristics of the protection. (LS) stands for the low stage and (HS) for the high stage.*

The slope of the operating characteristic curve of the differential function varies in the different sections of the range:

- Section 1 where $0.0 < I_b/I_r <$ *End section 1*. The differential current required for tripping is constant. The value of the differential current is the same as the basic setting (*Low operate value*) selected for the function. The basic setting allows the appearance of the no-load current of the line, the load current of the tapped load and minor inaccuracies of the current transformers. It can also be used to influence the overall level of the operating characteristic.
- Section 2 where *End section 1* $< I_b/I_r <$ *End section 2*. This is called the influence area of the starting ratio. In this section, the variations in the starting ratio affect the slope of the characteristic, meaning the required change for tripping in the differential current in comparison with the change in the load current. CT errors should be considered in the starting ratio.
- Section 3 where *End section 2* $< I_b/I_r$. By setting the slope in this section, attention can be paid to prevent unnecessary operation of the protection when there is an external fault, and the differential current is mainly produced by saturated current transformers.

The operation of the differential protection is based on the fundamental frequency components. The operation is accurate and stable and the DC component and the harmonics of the current do not cause unwanted operations.

## Inrush detector

The transformer inrush currents cause high degrees of second harmonic to the measured phase currents. The inrush detector detects inrush situations in transformers. The second harmonic based local blocking is selected into use with the *Restraint mode* parameter. The blocking for the low stage on the local end is issued when the second harmonic blocking is selected and the inrush is detected.

The inrush detector calculates the ratio of the second harmonic current `I_2H_LOC_A` and the fundamental frequency current `I_1H_LOC_A`. If the line differential protection is used in normal mode (*Winding selection* is “Not in use”), the calculated value is compared with the parameter value of the *Start value 2.H* setting. If the calculated value exceeds the set value and the fundamental frequency current `I_1H_LOC_A` is more than seven percent of the nominal current, the output signal `BLK2H_A` is activated. The inrush detector handles the other phases the same way.

If the line differential protection is used in the in-zone transformer mode (*Winding selection* is “Winding 1” or “Winding 2”), the weighted average is calculated for the 2$^{nd}$ harmonic ratios in different phases and the weighted ratio is then compared with the value of the *Start value 2.H* setting. If the calculated weighted ratio value exceeds the set value and the fundamental frequency current `I_1H_LOC_A` is more than seven percent of the nominal current, output signal `BLK2H_A` is activated.

The locally detected transformer inrush is also transferred to the remote end as a binary indication signal independently of the local *Restraint mode* setting parameter value. When the internal blocking of the stabilized low stage is activated, the `RSTD2H_LOC` and `RSTD2H_REM` outputs will also be activated at the same time depending on whether the inrush has been detected on local or remote end or on both ends.

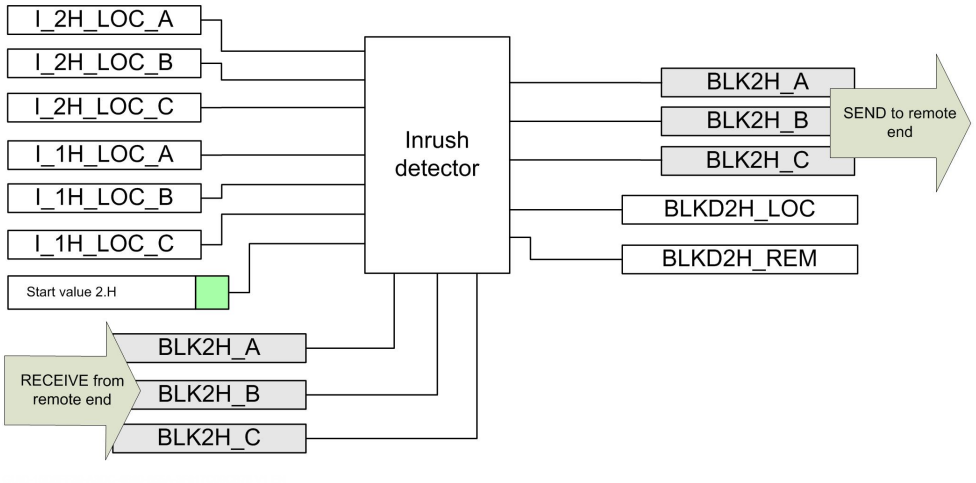



*Figure 305: Inrush current detection logic*

## Differential calculation

The operating principle is to calculate on both ends differential current from currents entering and leaving the protection zone by utilizing the digital communication channels for data exchange. The differential currents are almost zero on normal operation. The differential protection is phase segregated and the differential currents are calculated separately on both ends.

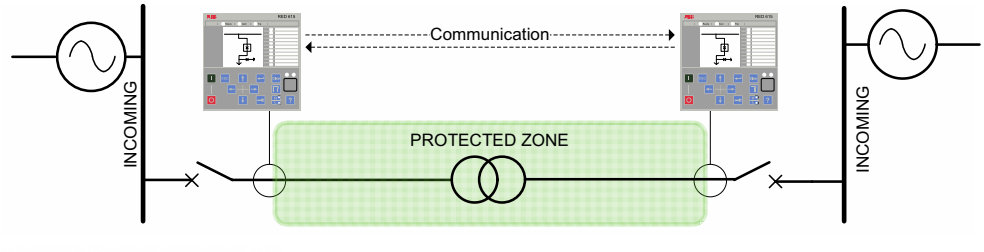



*Figure 306: Basic protection principle*

The differential current IΔ ($I_d$) of the protection relay is obtained on both ends with the formula:

$$I_d = \left| \bar{I}_{LOC} + \bar{I}_{REM} \right|$$

(Equation 88)

The stabilizing current $I_{bias}$ ($I_b$) of the protection relay is obtained on both ends with the formula:

$$I_b = \frac{\left| \bar{I}_{LOC} - \bar{I}_{REM} \right|}{2}$$

(Equation 89)

Depending on the location of the star points of the current transformers, the polarity of the local end remote currents may be different causing malfunction of the

calculation algorithms. The CT transformation ratio may be different and this needs to be compensated to provide a correct differential current calculation result on both ends.

The operation characteristics related settings are given in units as percentage of the current transformer secondary nominal current on each line end protection relay. For the actual primary setting, the corresponding CT ratio on each line end has to be considered. An example of how the *CT ratio correction* parameter values should be selected on both line ends in the example case to compensate the difference in the nominal levels can be presented.

Another example for differential application without in-zone transformer where line rated current is 400 A. The ratio of CTs are 800/1 and 400/1.

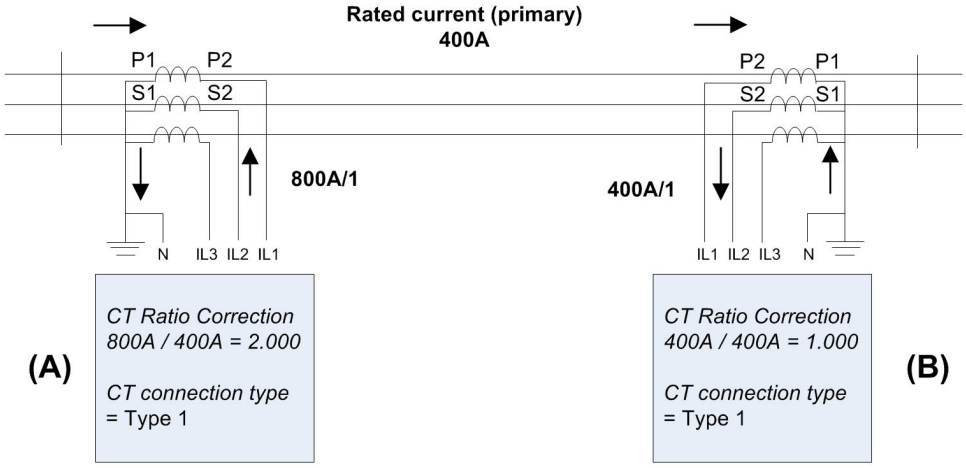



*Figure 307: Example of CT ratio correction setting calculation in line differential application*

The settings for *CT ratio correction* for protection relay A and protection relay (B) are:

CT ratio correction (A) = 800 A / 400 A = 2.000

CT ratio correction (B) = 400 A / 400 A = 1.000

The CT secondary current often differs from the rated current at the rated load of the power transformer. The CT transforming ratio can be corrected on both sides of the power transformer with the *CT ratio correction* setting.

First, the rated load of the power transformer is calculated on both sides when the apparent power and phase-to-phase voltage are known.

$$I_{nT} = \frac{S_n}{\sqrt{3} \cdot U_n}$$

(Equation 90)

| | |
|---|---|
| $I_{nT}$ | Rated load of the power transformer |
| $S_n$ | Rated power of the power transformer |
| $U_n$ | Rated phase-to-phase voltage |

Next, the settings for the CT ratio correction can be calculated with the formula:

$$CT\ ratio\ correction = \frac{I_n}{I_{nT}}$$

(Equation 91)

| | |
|---|---|
| $I_n$ | Nominal primary current of the CT |

After the CT ratio correction, the measured currents and corresponding setting values of LNPLDF are expressed in multiples of the rated power transformer current Ir (×Ir) or percentage value of Ir (%Ir).

An example shows how the CT ratio correction settings are calculated; when the rated power of the transformer is 5 MVA, the ratio of CTs on the 20 kV side is 200/1 and that on the 10.5 kV side is 300/1.

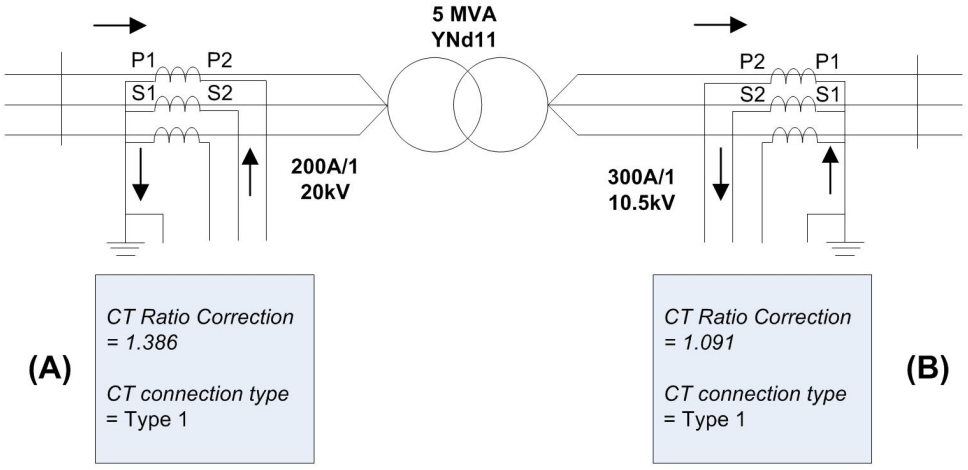



*Figure 308: Example of CT ratio correction setting calculation with in-zone transformer*

The rated load of the transformer is:

HV side (A): $I_{nT_A}$ = 5 MVA / (1.732 × 20 kV) = 144.3 A

LV side (A): $I_{nT_B}$ = 5 MVA / (1.732 × 10.5 kV) = 274.9 A

So the settings for *CT ratio correction* at HV (A) and LV (B) side are:

CT ratio correction (A) = 200 A / 144.3 A = 1.386

CT ratio correction (B) = 300 A / 274.9 A = 1.091

## CT connections

The connections of the primary current transformers are designated as “Type 1” and “Type 2”.

- If the positive directions of the winding 1 and winding 2 protection relay currents are opposite, the *CT connection type* setting parameter is “Type 1”. The connection examples of “Type 1” are as shown in the Figure 309 and Figure 310.
- If the positive directions of the winding 1 and winding 2 protection relay currents equate, the *CT connection type* setting parameter is “Type 2”. The connection examples of “Type 2” are as shown in the Figure 311 and Figure 312.
- The default value of the *CT connection type* setting is “Type 1”.

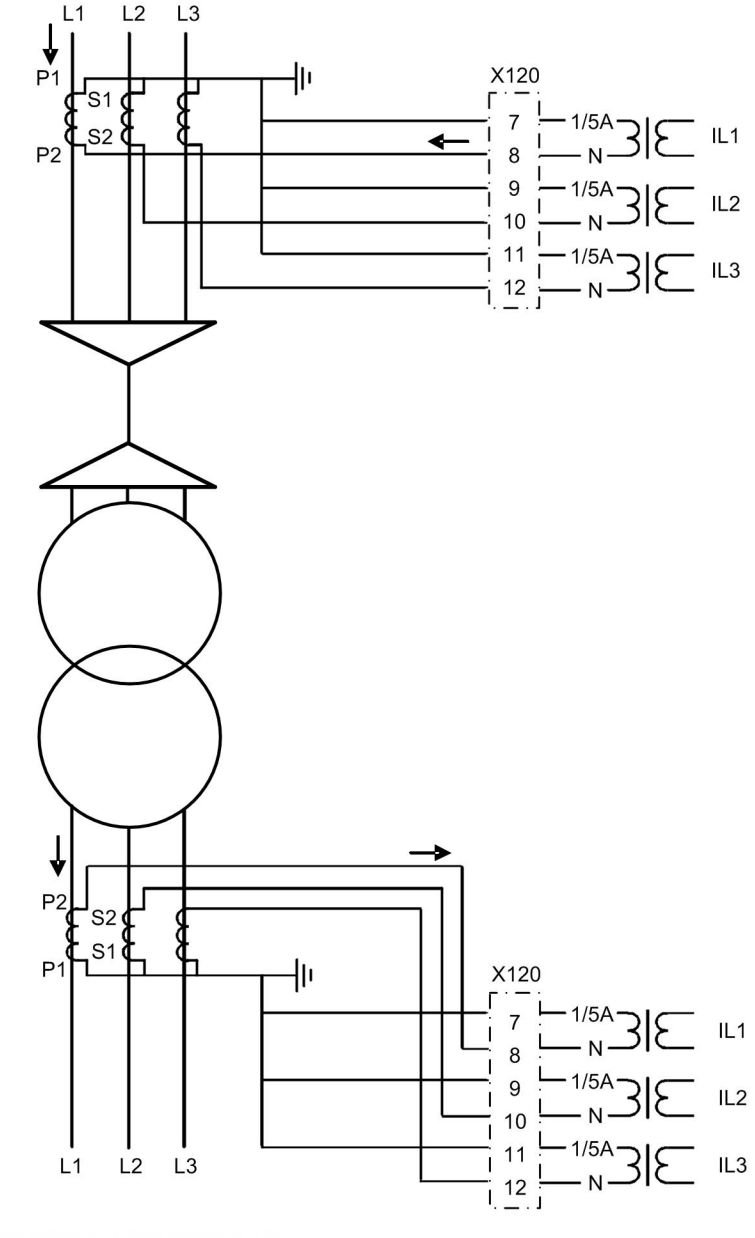



*Figure 309: Connection example of current transformers of Type 1*

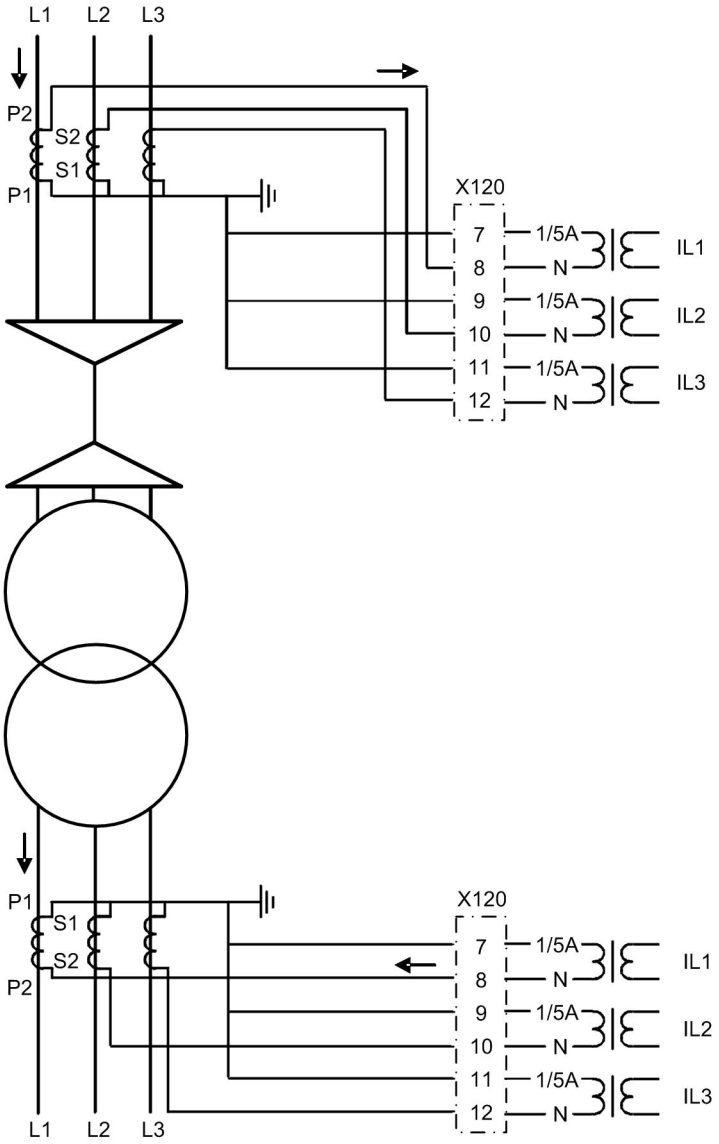



*Figure 310: Connection example of current transformers of Type 1*

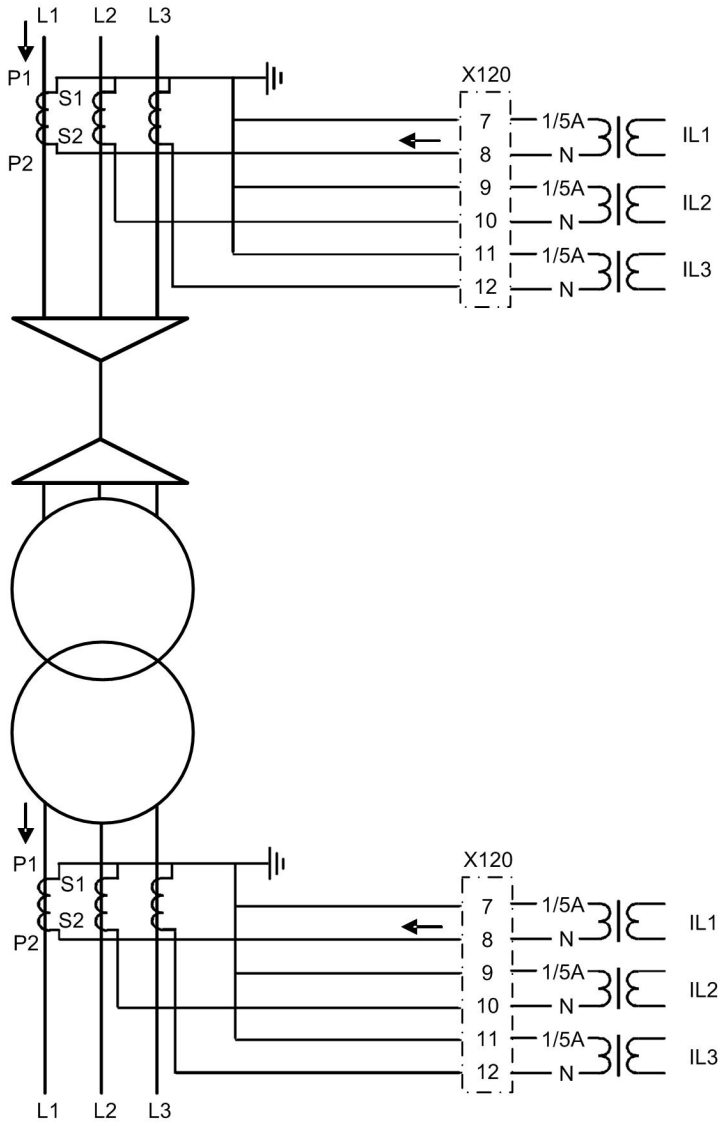



*Figure 311: Connection example of current transformers of Type 2*

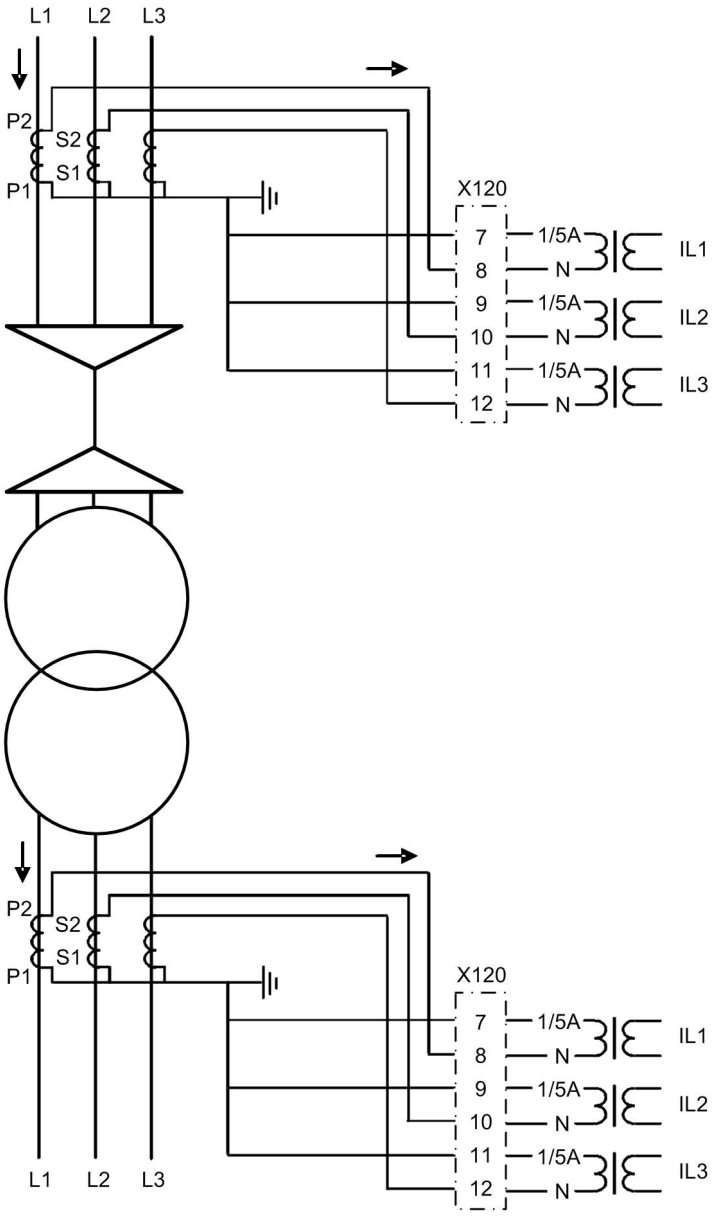



*Figure 312: Connection example of current transformers of Type 2*

## Transformer vector group matching

Before differential and bias currents can be calculated, the phase difference of the currents must be vector group matched based on the transformer connection type. The vector group of the power transformer is numerically matched on the high voltage and low voltage sides by means of the *Winding selection*, *Winding 1 type*, *Winding 2 type* and *Clock number* settings. Thus no interposing CTs are needed if there is only a power transformer inside the protected zone. The matching is based on phase shifting and a numerical delta connection in the protection relay. If the neutral of a star-connected power transformer is earthed, any earth-fault in the network is perceived by the protection relay as a differential current. The elimination of the zero-sequence

component can be selected for that winding by setting the *Zro A elimination* parameter.

*Winding selection* setting defines the protection relay location respect to the transformer. If the protection relay is situated at the HV side of the transformer, then protection relay location setting is set to “Winding 1” and respectively to “Winding 2” if protection relay is situated at the LV side. If the differential protection relays are used to protect a line without in-zone transformer, then the setting is set to “Not in use”. In this case vector group matching is ignored.

The matching of the phase difference is based on the phase shifting and the numerical delta connection inside the protection relay. The *Winding 1 type* parameter determines the connection on winding 1 (“Y”, “YN”, “D”, “Z”, “ZN”). The vector group matching can be implemented either on both, winding 1 and winding 2, or only on winding 1 or winding 2, at intervals of 30° with the *Clock number* setting. Similarly, the *Winding 2 type* parameter determines the connections of the phase windings on the low voltage side (“y”, “yn”, “d”, “z”, “zn”).

When the vector group matching is Yy0 and the *CT connection type* is according to “Type 2”, the phase angle of the phase currents connected to the protection relay does not change. When the vector group matching is Yy6, the phase currents are on one side turned 180° in the protection relay.

Example 1, vector group matching of an YNd11-connected power transformer on winding 1, *CT connection type* according to type 1. The *Winding 1 type* setting is “YN”, *Winding 2 type* is “d” and *Clock number* is “Clk Num 11”. This is compensated internally by giving winding 1 internal compensation value +30° and winding 2 internal compensation value 0°:

$$\bar{I}_{L1mHV} = \frac{\bar{I}_{L1} - \bar{I}_{L2}}{\sqrt{3}}$$

(Equation 92)

$$\bar{I}_{L2mHV} = \frac{\bar{I}_{L2} - \bar{I}_{L3}}{\sqrt{3}}$$

(Equation 93)

$$\bar{I}_{L3mHV} = \frac{\bar{I}_{L3} - \bar{I}_{L1}}{\sqrt{3}}$$

(Equation 94)

Example 2, if vector group is Yd11 and *CT connection type* is according to type 1, the compensation is a little different. The *Winding 1 type* setting is “Y”, *Winding 2 type* is “d” and *Clock number* is “Clk Num 11”. This is compensated internally by giving winding 1 internal compensation value 0° and winding 2 internal compensation value -30°:

$$\bar{I}_{L1mLV} = \frac{\bar{I}_{L1} - \bar{I}_{L3}}{\sqrt{3}}$$

(Equation 95)

$$\bar{I}_{L2mLV} = \frac{\bar{I}_{L2} - \bar{I}_{L1}}{\sqrt{3}}$$

(Equation 96)

$$\bar{I}_{L3mLV} = \frac{\bar{I}_{L3} - \bar{I}_{L2}}{\sqrt{3}}$$

(Equation 97)

The “Y” side currents stay untouched, while the “d” side currents are compensated to match the currents actually flowing in the windings.

In this example there is no neutral current on either side of the transformer (assuming there are no earthing transformers installed). In the previous example, the matching is done differently to have the winding 1 neutral current compensated at the same time.

*Table 572: LNPLDF vector group matching*

| Vector group of the transformer | Winding 1 type | Winding 2 type | Phase shift | Zero sequence current elimination |
|---|---|---|---|---|
| Yy0 | Y | y | 0 | Not needed |
| YNy0 | YN | y | 0 | HV side |
| YNyn0 | YN | yn | 0 | HV & LV side |
| Yyn0 | Y | yn | 0 | LV side |
| Yy2 | Y | y | 2 | Not needed |
| YNy2 | YN | y | 2 | (Automatic) |
| YNyn2 | YN | yn | 2 | (Automatic) |
| Yyn2 | Y | yn | 2 | (Automatic) |
| Yy4 | Y | y | 4 | Not needed |
| YNy4 | YN | y | 4 | (Automatic) |
| YNyn4 | YN | yn | 4 | (Automatic) |
| Yyn4 | Y | yn | 4 | (Automatic) |
| Yy6 | Y | y | 6 | Not needed |
| YNy6 | YN | y | 6 | HV side |
| YNyn6 | YN | yn | 6 | HV & LV side |
| Yyn6 | Y | yn | 6 | LV side |
| Yy8 | Y | y | 8 | Not needed |
| YNy8 | YN | y | 8 | (Automatic) |
| YNyn8 | YN | yn | 8 | (Automatic) |
| Yyn8 | Y | yn | 8 | (Automatic) |
| Yy10 | Y | y | 10 | Not needed |
| YNy10 | YN | y | 10 | (Automatic) |
| YNyn10 | YN | yn | 10 | (Automatic) |
| Yyn10 | Y | yn | 10 | (Automatic) |
| Yd1 | Y | d | 1 | Not needed |

Table continues on next page

| Vector group of the transformer | Winding 1 type | Winding 2 type | Phase shift | Zero sequence current elimination |
|---|---|---|---|---|
| YNd1 | YN | d | 1 | (Automatic) |
| Yd5 | Y | d | 5 | Not needed |
| YNd5 | YN | d | 5 | (Automatic) |
| Yd7 | Y | d | 7 | Not needed |
| YNd7 | YN | d | 7 | (Automatic) |
| Yd11 | Y | d | 11 | Not needed |
| YNd11 | YN | d | 11 | (Automatic |
| Dd0 | D | d | 0 | Not needed |
| Dd2 | D | d | 2 | Not needed |
| Dd4 | D | d | 4 | Not needed |
| Dd6 | D | d | 6 | Not needed |
| Dd8 | D | d | 8 | Not needed |
| Dd10 | D | d | 10 | Not needed |
| Dy1 | D | y | 1 | Not needed |
| Dyn1 | D | yn | 1 | (Automatic) |
| Dy5 | D | y | 5 | Not needed |
| Dyn5 | D | yn | 5 | (Automatic) |
| Dy7 | D | y | 7 | Not needed |
| Dyn7 | D | yn | 7 | (Automatic) |
| Dy11 | D | y | 11 | Not needed |
| Dyn11 | D | yn | 11 | (Automatic) |
| Yz1 | Y | z | 1 | Not needed |
| YNz1 | YN | z | 1 | (Automatic) |
| YNzn1 | YN | zn | 1 | LV side |
| Yzn1 | Y | zn | 1 | (Automatic) |
| Yz5 | Y | z | 5 | Not needed |
| YNz5 | YN | z | 5 | (Automatic) |
| YNzn5 | YN | zn | 5 | LV side |
| Yzn5 | Y | zn | 5 | (Automatic) |
| Yz7 | Y | z | 7 | Not needed |
| YNz7 | YN | z | 7 | (Automatic) |
| YNzn7 | YN | zn | 7 | LV side |
| Yzn7 | Y | zn | 7 | (Automatic) |
| Yz11 | Y | z | 11 | Not needed |
| YNz11 | YN | z | 11 | (Automatic) |
| YNzn11 | YN | zn | 11 | LV side |
| Yzn11 | Y | zn | 11 | (Automatic) |
| Zy1 | Z | y | 1 | Not needed |
| Zyn1 | Z | yn | 1 | (Automatic) |

Table continues on next page

| Vector group of the transformer | Winding 1 type | Winding 2 type | Phase shift | Zero sequence current elimination |
|---|---|---|---|---|
| ZNyn1 | ZN | yn | 1 | HV side |
| ZNy1 | ZN | y | 1 | (Automatic) |
| Zy5 | Z | y | 5 | Not needed |
| Zyn5 | Z | yn | 5 | (Automatic) |
| ZNyn5 | ZN | yn | 5 | HV side |
| ZNy5 | ZN | y | 5 | (Automatic) |
| Zy7 | Z | y | 7 | Not needed |
| Zyn7 | Z | yn | 7 | (Automatic) |
| ZNyn7 | ZN | yn | 7 | HV side |
| ZNy7 | ZN | y | 7 | (Automatic) |
| Zy11 | Z | y | 11 | Not needed |
| Zyn11 | Z | yn | 11 | (Automatic) |
| ZNyn11 | ZN | yn | 11 | HV side |
| ZNy11 | ZN | y | 11 | (Automatic) |
| Dz0 | D | z | 0 | Not needed |
| Dzn0 | D | zn | 0 | LV side |
| Dz2 | D | z | 2 | Not needed |
| Dzn2 | D | zn | 2 | (Automatic) |
| Dz4 | D | z | 4 | Not needed |
| Dzn4 | D | zn | 4 | (Automatic) |
| Dz6 | D | z | 6 | Not needed |
| Dzn6 | D | zn | 6 | LV side |
| Dz8 | D | z | 8 | Not needed |
| Dzn8 | D | zn | 8 | (Automatic) |
| Dz10 | D | z | 10 | Not needed |
| Dzn10 | D | zn | 10 | (Automatic) |
| Zd0 | Z | d | 0 | Not needed |
| ZNd0 | ZN | d | 0 | HV side |
| Zd2 | Z | d | 2 | Not needed |
| ZNd2 | ZN | d | 2 | (Automatic) |
| Zd4 | Z | d | 4 | Not needed |
| ZNd4 | ZN | d | 4 | (Automatic) |
| Zd6 | Z | d | 6 | Not needed |
| ZNd6 | ZN | d | 6 | HV side |
| Zd8 | Z | d | 8 | Not needed |
| ZNd8 | ZN | d | 8 | (Automatic) |
| Zd10 | Z | d | 10 | Not needed |
| ZNd10 | ZN | d | 10 | (Automatic) |
| Zz0 | Z | z | 0 | Not needed |

Table continues on next page

| Vector group of the transformer | Winding 1 type | Winding 2 type | Phase shift | Zero sequence current elimination |
|---|---|---|---|---|
| ZNz0 | ZN | z | 0 | HV side |
| ZNzn0 | ZN | zn | 0 | HV & LV side |
| Zzn0 | Z | zn | 0 | LV side |
| Zz2 | Z | z | 2 | Not needed |
| ZNz2 | ZN | z | 2 | (Automatic) |
| ZNzn2 | ZN | zn | 2 | (Automatic) |
| Zzn2 | Z | zn | 2 | (Automatic) |
| Zz4 | Z | z | 4 | Not needed |
| ZNz4 | ZN | z | 4 | (Automatic) |
| ZNzn4 | ZN | zn | 4 | (Automatic) |
| Zzn4 | Z | zn | 4 | (Automatic) |
| Zz6 | Z | z | 6 | Not needed |
| ZNz6 | ZN | z | 6 | HV side |
| ZNzn6 | ZN | zn | 6 | HV & LV side |
| Zzn6 | Z | zn | 6 | LV side |
| Zz8 | Z | z | 8 | Not needed |
| ZNz8 | ZN | z | 8 | (Automatic) |
| ZNzn8 | ZN | zn | 8 | (Automatic) |
| Zzn8 | Z | zn | 8 | (Automatic) |
| Zz10 | Z | z | 10 | Not needed |
| ZNz10 | ZN | z | 10 | (Automatic) |
| ZNzn10 | ZN | zn | 10 | (Automatic) |
| Zzn10 | Z | zn | 10 | (Automatic) |

## Zero-sequence component elimination

If *Clock number* is “Clk Num 2“, “Clk Num 4”, “Clk Num 8” or “Clk Num 10”, the vector group matching is always done on both, winding 1 and winding 2. The combination results in the correct compensation. In this case the zero-sequence component is always removed from both sides automatically. The *Zro A elimination* parameter cannot change this.

If *Clock number* is “Clk Num 1”, “Clk Num 5”, “Clk Num 7” or “Clk Num 11”, the vector group matching is done on one side only. A possible zero-sequence component of the phase currents at earth faults occurring outside the protection area is automatically eliminated in the numerically implemented delta connection before the differential current and the biasing current are calculated. This is why the vector group matching is almost always made on the star connected side of the “Ynd” and “Dyn” connected transformers.

If *Clock number* is “Clk Num 0” or “Clk Num 6”, the zero-sequence component of the phase currents is not eliminated automatically on either side. Therefore, the zero-

sequence component on the star connected side that is earthed at its star point has to be eliminated by using the *Zro A elimination* parameter.

The same parameter has to be used to eliminate the zero-sequence component if there is, for example, an earthing transformer on the delta-connected side of the “Ynd” power transformer in the area to be protected. In this case, the vector group matching is normally made on the side of the star connection. On the side of the delta connection, the elimination of the zero-sequence component has to be eliminated by using the *Zro A elimination* parameter.

By using the *Zro A elimination* parameter, the zero-sequence component of the local phase currents is calculated and reduced for each phase current:

$$\bar{I}_{LOC_A} = \bar{I}_{LOC_A} - \frac{1}{3} \cdot \left( \bar{I}_{LOC_A} + \bar{I}_{LOC_B} + \bar{I}_{LOC_C} \right)$$

(Equation 98)

$$\bar{I}_{LOC_B} = \bar{I}_{LOC_B} - \frac{1}{3} \cdot \left( \bar{I}_{LOC_A} + \bar{I}_{LOC_B} + \bar{I}_{LOC_C} \right)$$

(Equation 99)

$$\bar{I}_{LOC_C} = \bar{I}_{LOC_C} - \frac{1}{3} \cdot \left( \bar{I}_{LOC_A} + \bar{I}_{LOC_B} + \bar{I}_{LOC_C} \right)$$

(Equation 100)

## Fail safe function

To prevent malfunction during communication interference, the operation of LNPLDF is blocked when the protection communication supervision detects severe interference in the communication channel. The timer reset stage is activated in case the stabilized stage is started during a communication interruption. The protection communication supervison is connected internally from PCSITPC to LNPLDF (dotted OK line).

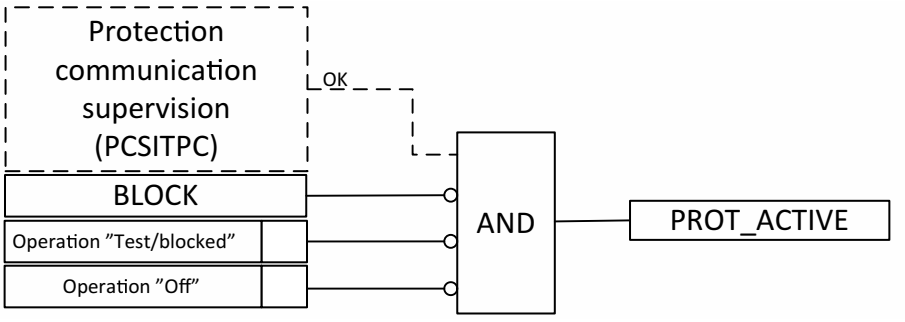



*Figure 313: Operation logic of the fail safe function*

The function can also be set into “test/blocked” state with the *Operation* setting. This can also be utilized during the commissioning.

The BLOCK input is provided for blocking the function with the logic. When the function is blocked, the monitored data and measured values are still available but the

binary outputs are blocked. When the function is blocked, the direct inter-trip is also blocked.

The PRO_ACTIVE output is always active when the protection function is capable of operating. PRO_ACTIVE can be used as a blocking signal for backup protection functions.

### Timer

Once activated, the timer activates the STR_LS_LOC output. Depending on the value of the set *Operating curve type*, the timer characteristics are according to DT or IDMT. When the operation timer has reached the value set with the *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPR_LS_LOC output is activated. When the operation mode is according to IDMT, *Low operate value* is used as reference value (Start value) in the IDMT equations presented in the Standard inverse-time characteristics section.

A timer reset state is activated when a drop-off situation happens. The reset is done according to the DT characteristics.

For a detailed description of the timer characteristics, see the General function block features section in this manual.

### Instantaneous high stage

In addition to the stabilized low stage, LNPLDF has an instantaneous high stage. The stabilizing is not done with the instantaneous high stage. The instantaneous high stage operates immediately when the differential current amplitude is higher than the set value of the *High operate value* setting. If the ENA_MULT_HS input is active, the *High operate value* setting is internally multiplied by the *High Op value Mult* setting.

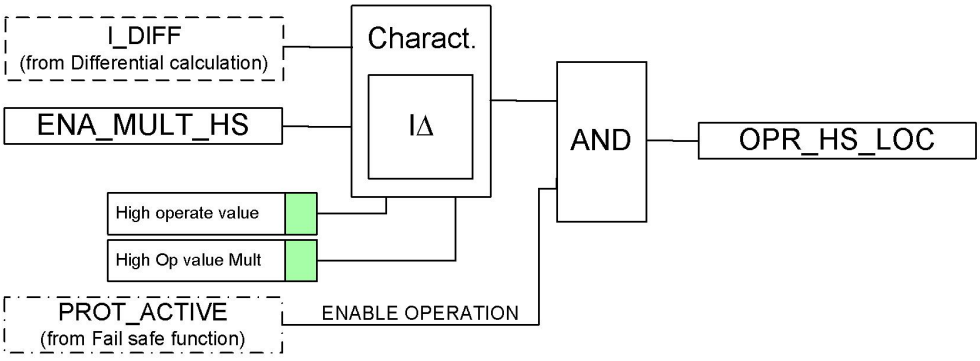



*Figure 314: Operation logic of instantaneous high stage*

### Direct inter-trip

Direct inter-trip is used to ensure the simultaneous opening of the circuit breakers at both ends of the protected line when a fault is detected. Both start and operate signals

are sent to the remote end via communication. The direct-intertripping of the line differential protection is included into LNPLDF. The OPERATE output combines the operate signals from both stages, local and remote, so that it can be used for the direct inter-trip signal locally.

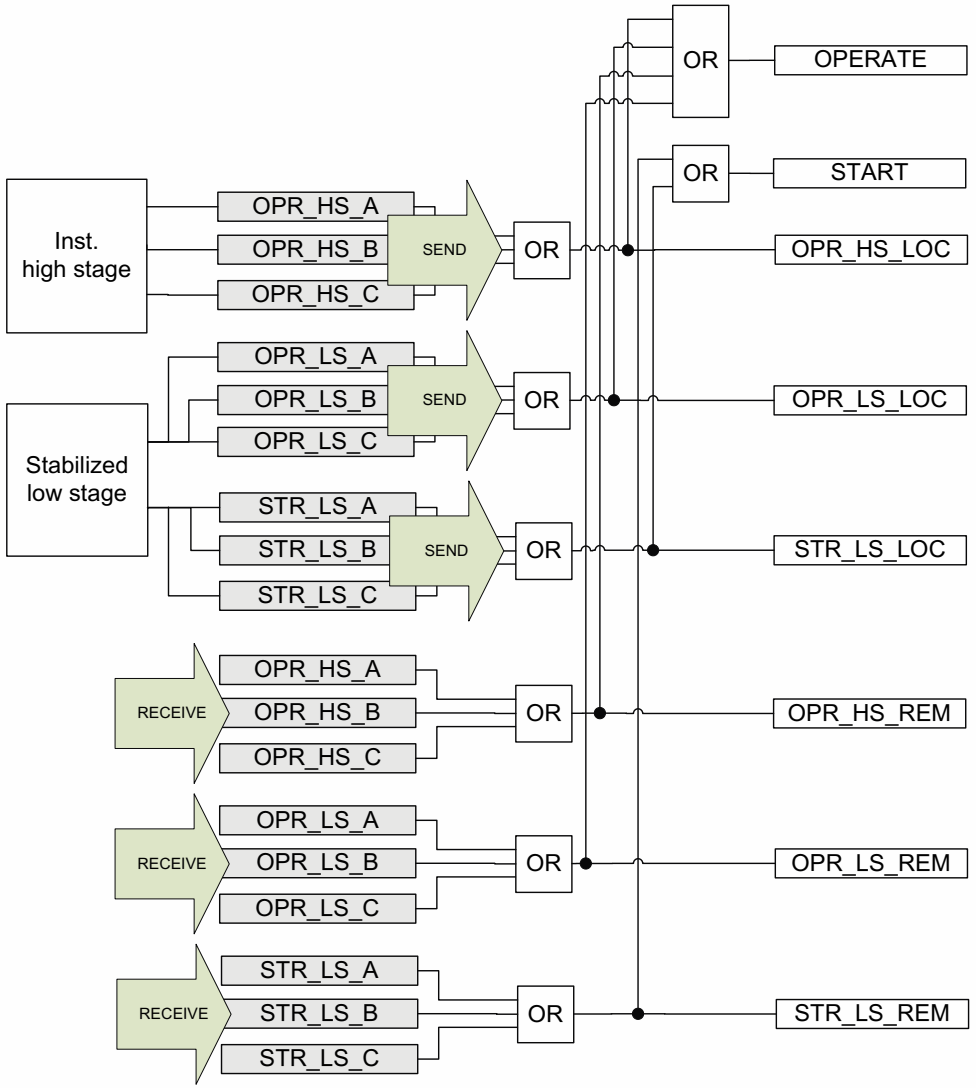



*Figure 315: Operation logic of the direct intertrip function*

The start and operate signals are provided separately for the low and high stages, and in the local and remote.

## Blocking functionality

There are two independent inputs that can be used for blocking the function: BLOCK and BLOCK_LS. The difference between these inputs is that BLOCK_LS (when TRUE) blocks only the stabilized low stage leaving the instantaneous high stage operative. BLOCK (when TRUE) blocks both stages and also the PRO_ACTIVE

output is updated according to the BLOCK input status, as described in the Fail safe function chapter.

The BLOCK and BLOCK_LS input statuses affect only the behavior of the local protection instance. When a line differential protection stage (stabilized low or instantaneous high) is blocked, also the received remote signals related to the corresponding stage are ignored (received direct inter-trip signals from the remote end). The binary signal transfer functionality should therefore be used for transferring the possible additional blocking information between the local and remote terminals whenever the blocking logic behavior needs to be the same on both line ends.

## Test mode

The line differential function in one protection relay can be set to test mode, that is, the *Operation* setting is set to “test/blocked”. This blocks the line differential protection outputs in the protection relay and sets the remote protection relay to a remote test mode, such that the injected currents are echoed back with the shifted phase. It is also possible that both protection relays are simultaneously in the test mode. When the line differential protection function is in the test mode:

- The remote end protection relay echoes locally injected current samples back with the shifted phase. The current samples that are sent to the remote protection relay are scaled with the CT ratio correction setting.
- The operation of both stages (stabilized low or instantaneous high) are blocked, and also the direct inter-trip functionality is blocked (both receive and send) in the protection relay where the test mode is active.
- The remote end line differential protection function that is in the normal mode (On) is not affected by the local end being in the test mode. This means that the remote end function is operative but, at the same time, it ignores the received current samples from the other end protection relay which is in the test mode.
- The PRO_ACTIVE output is false only in the protection relay that is currently in the test mode.

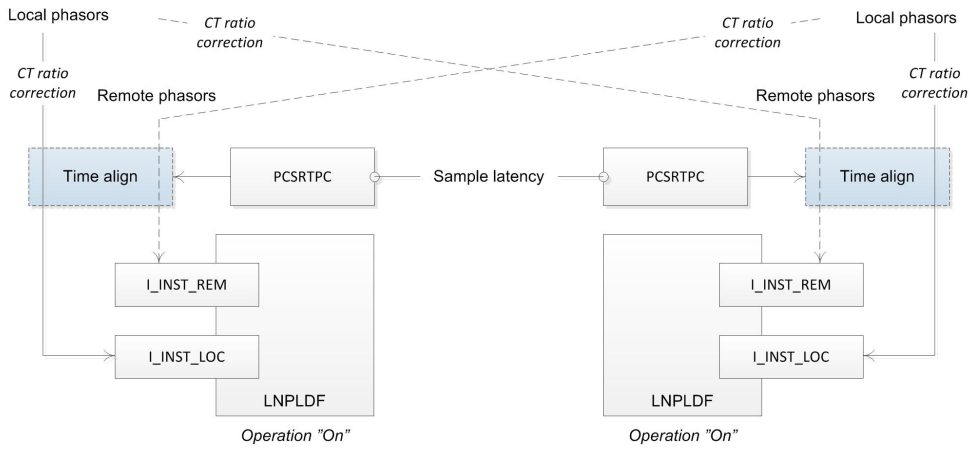



*Figure 316: Operation during the normal operation of the line differential protection*

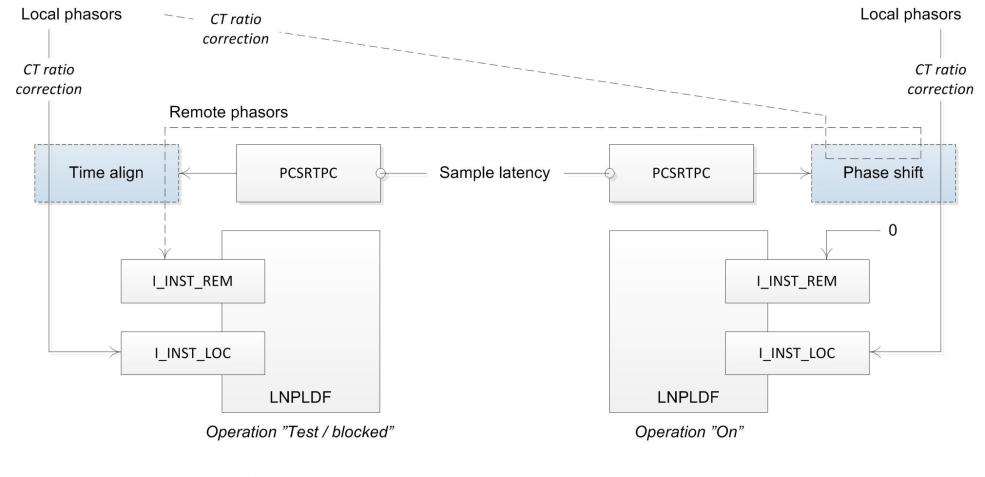



*Figure 317: Operation during test operation of the line differential protection*

### 4.3.1.6 Commissioning

The commissioning of the line differential protection scheme would be difficult without any support features in the functionality because of the relatively long distance between the protection relays. This has been taken into consideration in the design of the line differential protection. The communication channel can be used for echoing the locally fed current phasors from the remote end. By using this mode, it is possible to verify that differential calculation is done correctly in each phase. Also, the protection communication operation is taken into account with the differential current calculation when this test mode is used.

#### Required material for testing the protection relay

- Calculated settings
- Terminal diagram
- Circuit diagrams
- Technical and application manuals of the protection relay
- Single of three-phase secondary current source
- Single of three-phase primary current source
- Timer with start and stop interfaces
- Auxiliary voltage source for the protection relays
- PC with related software, a Web browser for WHMI

The setting and configuration of the protection relay must be completed before testing.

The terminal diagram, available in the technical manual, is a general diagram of the protection relay.

The same diagram is not always applicable to each specific delivery, especially for the configuration of all the binary inputs and outputs.

Therefore, before testing, check that the available terminal diagram corresponds to the protection relay.

The circuit diagrams of the application are recommended to be available. These are required for checking the terminal block numbers of the current, trip, alarm and possibly other auxiliary circuits.

The technical and application manuals contain application and functionality summaries, function blocks, logic diagrams, input and output signals, setting parameters and technical data sorted per function.

The minimum requirement for a secondary current injection test device is the ability to work as a one phase current source.

The protection relay should be prepared for the test before testing a particular function. The logic diagram of the tested protection function must be considered while performing the test. All included functions in the protection relay are tested according to the corresponding test instructions in this chapter. The functions can be tested in any order according to user preferences. Therefore, the test instructions are presented in alphabetical order. Only the functions that are in use (*Operation* is set to "on") should be tested.

The response from the test can be viewed in different ways.

- Binary output signals
- Monitored data values in the LHMI (logical signals)
- A PC with a Web browser for WHMI use (logical signals and phasors)

All used setting groups should be tested.

## Checking of the external optical and electrical connections

The user must check the installation to verify that the protection relay is connected to the other required parts of the protection system. The protection relay and all the connected circuits are to be de-energized during the check-up.

### Checking of CT circuits

Check that the wiring is in strict accordance with the supplied connection diagram.

The CTs must be connected in accordance with the terminal diagram provided with the protection relay, both with regards to phases and polarity. The following tests are recommended for every primary CT or CT core connected to the protection relay.

- Primary injection test to verify the current ratio of the CT, the correct wiring up to the protection relay and correct phase sequence connection (that is L1, L2, L3.)
- Polarity check to prove that the predicted direction of the secondary current flow is correct for a given direction of the primary current flow. This is an essential test

for the proper operation of the directional function, protection or measurement in the protection relay.

- CT secondary loop resistance measurement to confirm that the current transformer secondary loop DC resistance is within specification and that there are no high resistance joints in the CT winding or wiring.
- CT excitation test to ensure that the correct core in the CT is connected to the protection relay. Normally only a few points along the excitation curve are checked to ensure that there are no wiring errors in the system, for example, due to a mistake in connecting the CT's measurement core to the protection relay.
- CT excitation test to ensure that the CT is of the correct accuracy rating and that there are no short circuited turns in the CT windings. Manufacturer's design curves should be available for the CT to compare the actual results.
- Earthing check of the individual CT secondary circuits to verify that each three-phase set of main CTs is properly connected to the station earth and only at one electrical point.
- Insulation resistance check.
- Phase identification of CT shall be made.



CT and VT connectors are pre-coded, and the CT and VT connector markings are different. For more information, see the installation manual.



Both the primary and the secondary sides must be disconnected from the line and the protection relay when plotting the excitation characteristics.



If the CT secondary circuit is opened or its earth connection is missing or removed without the CT primary being de-energized first, dangerous voltages may be produced. This can be lethal and cause damage to the insulation. The re-energizing of the CT primary should be prohibited as long as the CT secondary is open or unearthed.

### Checking of the power supply

Check that the auxiliary supply voltage remains within the permissible input voltage range under all operating conditions. Check that the polarity is correct before powering the protection relay.

### Checking binary I/O circuits

Always check the binary input circuits from the equipment to the protection relay interface to make sure that all signals are connected correctly. If there is no need to test a particular input, the corresponding wiring can be disconnected from the terminal of the protection relay during testing. Check all the connected signals so that both input voltage level and polarity are in accordance with the protection relay specifications. However, attention must be paid to the electrical safety instructions.

Always check the binary output circuits from the protection relay to the equipment interface to make sure that all signals are connected correctly. If a particular output needs to be tested, the corresponding wiring can be disconnected from the terminal of the protection relay during testing. Check all the connected signals so that both load and polarity are in accordance with the protection relay specifications. However, attention must be paid to the electrical safety instructions.

### Checking of optical connections

Check that the Tx and Rx optical connections are correct.



A relay equipped with optical connections requires a minimum depth of 180 mm for plastic fiber cables and 275 mm for glass fiber cables. Check the allowed minimum bending radius from the optical cable manufacturer.

## Applying of required settings for the protection relay

Download all calculated settings and measurement transformer parameters in the protection relay.

## Connecting of test equipment to the protection relay

Before testing, connect the test equipment according to the protection relay specific connection diagram.

Pay attention to the correct connection of the input and output current terminals. Check that the input and output logical signals in the logic diagram for the function under test are connected to the corresponding binary inputs and outputs of the protection relay. Select the correct auxiliary voltage source according to the power supply module of the protection relay. Select the correct auxiliary voltage source according to the power supply module of the protection relay.

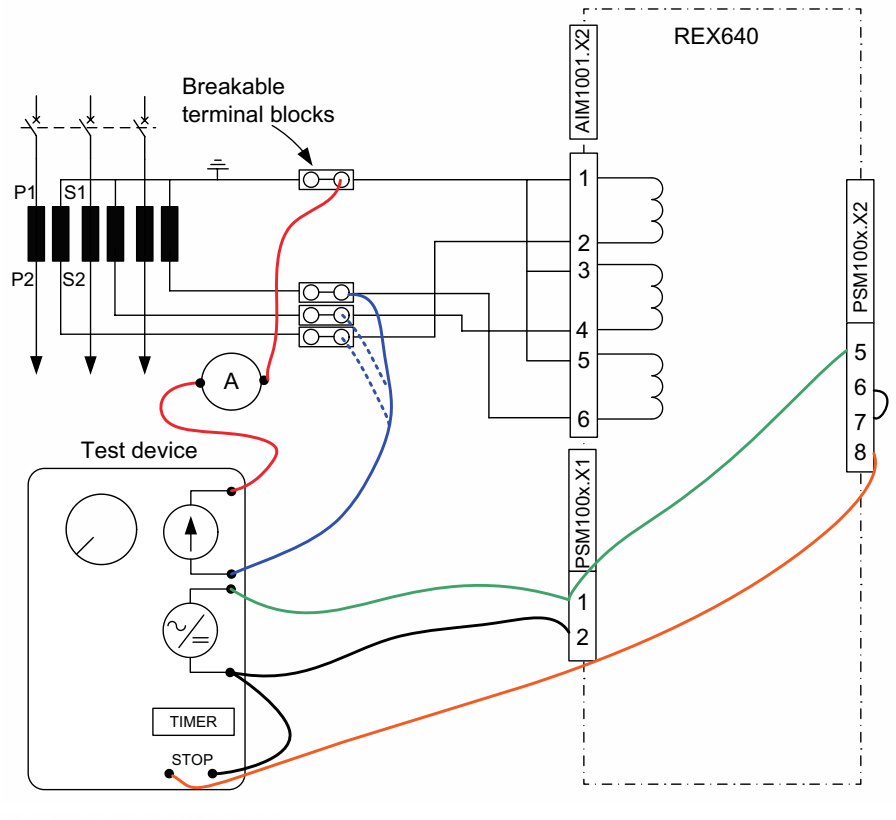



*Figure 318: Example of connections to test the line differential protection relay*

## Secondary current injection

There are two alternative modes to check the operation of a line differential protection relay. These are not exclusive methods for each other and can be used for various test on the protection relay.

### Normal mode

In normal mode, that is, the mode when the function is on normal operation, the local end protection relay sends phasors to the remote end protection relay and receives phasors measured by the remote end protection relay. This mode can be used in testing the operating level and time of the low and high stages of the local end protection relay. This is due to a test situation when the remote end does not measure any current and therefore, all the current fed to the local end current circuit is seen as differential current at both ends.

Testing of the line differential protection is done with both protection relays separated geographically from each other. It is important to note that local actions in one protection relay cause operation also in the remotely located protection relay. When testing the line differential function, actions have to be done in both protection relays.

Before the test, the trip signal to the circuit breaker shall be blocked, for example by breaking the trip circuit by opening the terminal block or by using some other suitable method.

When injecting current to one phase in the local end protection relay, the current is seen as a differential current at both ends. If a current $I_{injected}$ is injected, L1 in phase L1, the differential and stabilizing currents for phase L1 are:

$$ID_A = I_{injected}$$

(Equation 101)

$$IB_A = \frac{I_{injected}}{2}$$

(Equation 102)

The operation is equal for phases L2 and L3.

### Verifying the settings

1. Block the unwanted trip signals from the protection relay units involved.
2. Inject a current in phase L1 and increase the current until the function operates for phase L1.
   The injected operate current corresponds to the set *Low operate value*. The monitored values for ID_A should be equal to the injected current.
3. Repeat point 2 by current injection in phases L2 and L3.
4. Measure the operating time by injecting the single-phase current in phase L1. The injected current should be four times the operating current. The time measurement is stopped by the trip output from the protection relay unit.
5. Disconnect the test equipment and reconnect the current transformers and all other circuits including the trip circuit.

### Phasor echoing method

The line differential function in one protection relay can be set to special test mode, that is, the *Operation* setting is set to “test/blocked”. When this mode is in use, the remote end protection relay echoes locally injected current phasors back with the shifted phase and settable amplitude. Therefore, the local end line differential function is also automatically blocked and the remote end line differential function discards the phasors it receives from the protection relay in the test mode.

When the test mode is active, the *CT connection type* is still used by the line differential protection function as in the normal operation mode. The setting can be used for shifting the phase (0 or 180 degrees).

Parameter Settings - LNPLDF1

Edit | Refresh Values | Setting Group 1*

| PARAMETER NAME | RELAY VALUE | UNIT | MIN. | MAX. | STEP |
|---|---|---|---|---|---|
| Operation | test/blocked | | | | |
| Winding selection | Not in use | | | | |
| CT ratio correction | 1.000 | | 0.2 | 5 | 0.001 |
| CT connection type | Type 2 | | | | |
| Restraint mode | None | | | | |
| Reset delay time | 0 | ms | 0 | 60000 | 1 |
| **Setting Group 1** | | | | | |
| Low operate value | 10 | %Ir | 10 | 200 | 1 |
| High operate value | 200 | %Ir | 200 | 4000 | 1 |
| High Op value Mult | 1.0 | | 0.5 | 1 | 0.1 |
| End section 1 | 100 | %Ir | 0 | 200 | 1 |
| Slope section 2 | 50 | % | 10 | 50 | 1 |
| End section 2 | 200 | %Ir | 200 | 2000 | 1 |
| Slope section 3 | 150 | % | 10 | 200 | 1 |
| Operating curve type | IEC Def. Time | | | | |
| Operate delay time | 45 | ms | 45 | 200000 | 1 |

*Figure 319: An example of a test mode situation where three-phase currents are injected to the local end protection relay*

## 4.3.1.7 Application

LNPLDF is designed for the differential protection of overhead line and cable feeders in a distribution network. LNPLDF provides absolute selectivity and fast operating times as unit protection also in short lines where distance protection cannot be applied.

LNPLDF provides selective protection for radial, looped and meshed network topologies and can be used in isolated neutral networks, resistance earthed networks, compensated (impedance earthed) networks and solidly earthed networks. In a typical network configuration where the line differential protection scheme is applied, the protected zone, that is, the line or cable, is fed from two directions.

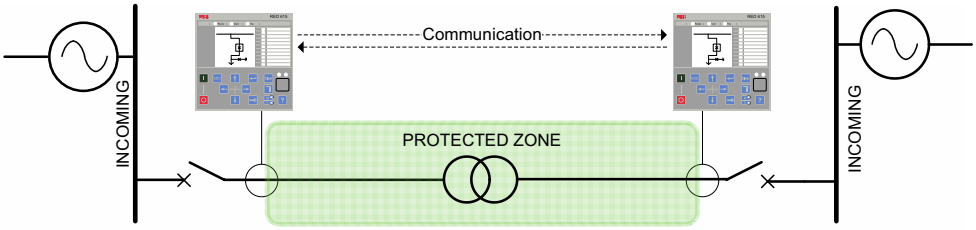



*Figure 320: Line protection with phase segregated line differential with in-zone transformer*

LNPLDF can be utilized for various types of network configurations or topologies. Case A shows the protection of a ring-type distribution network. The network is also used in the closed ring mode. LNPLDF is used as the main protection for different sections of the feeder. In case B, the interconnection of two substations is done with parallel lines and each line is protected with the line differential protection. In case C, the connection line to mid scale power generation (typical size around 10...50 MVA) is protected with the line differential function. The protection includes the transformer from the protection field. In case D, the connection between two substations and a

small distribution transformer is located at the tapped load. The usage of LNPLDF is not limited to these applications.

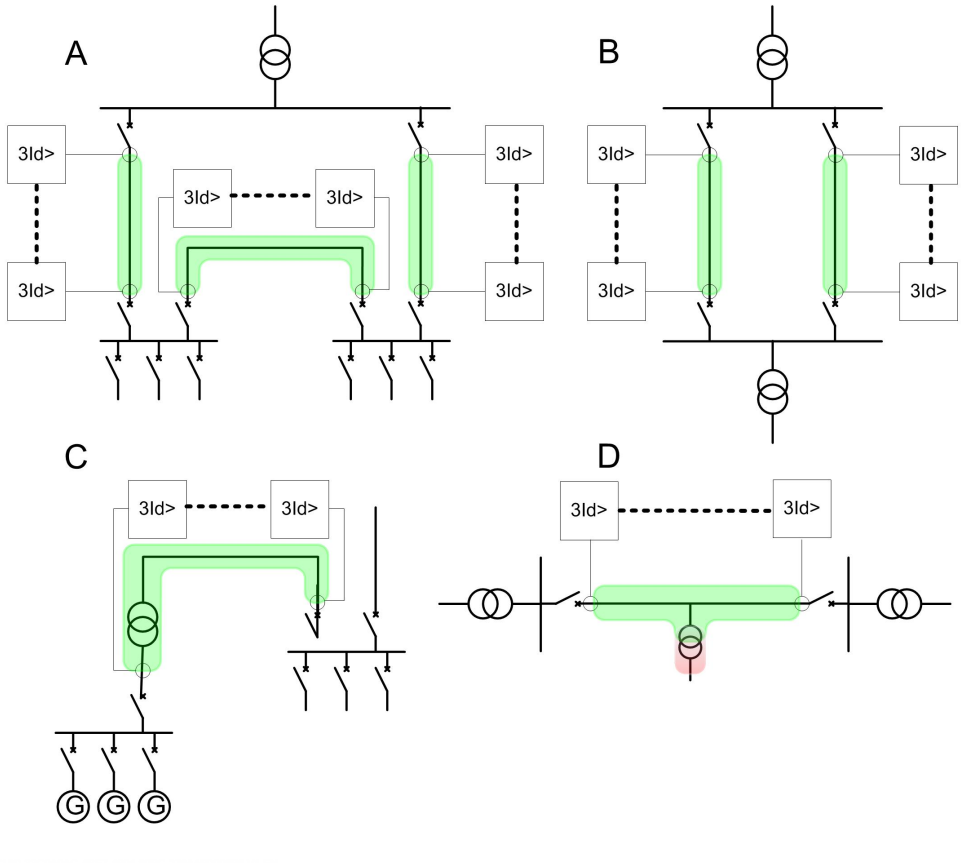



*Figure 321: Line differential applications*

## Communication supervision

A typical line differential protection application includes LNPLDF as the main protection. Backup over current functions is needed if a protection communication failure occurs. When the communication supervision function detects a failure in the communication between the protective units, the safe operation of the line is still guaranteed by blocking the line differential protection and unblocking the over current functions.

When a communication failure is detected, the protection communication supervision function issues block for the LNPLDF line differential protection and unblock for the instantaneous and high stages (instance 2) of the over current protection. These are used to give backup protection for the remote end feeder protection relay. In situations where the selectivity is weaker than usually, the protection should still be available for the system.

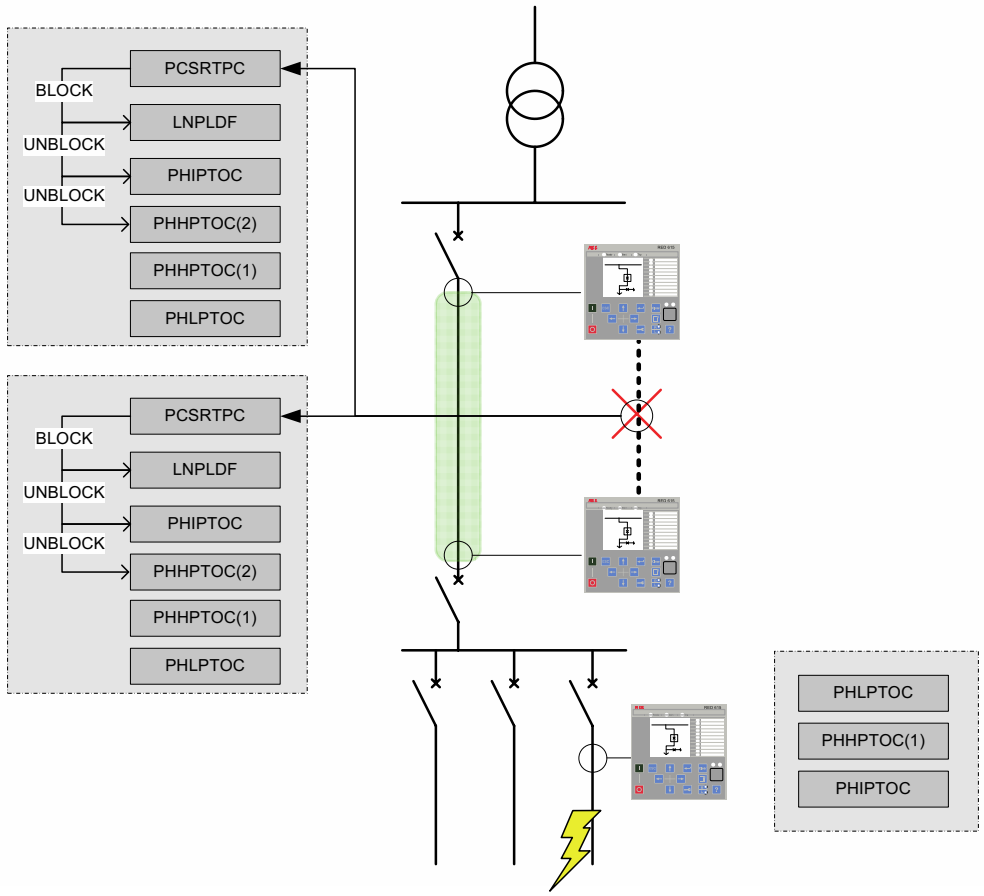



*Figure 322: Protection communication supervision detects failures on communication*

## In-zone transformer

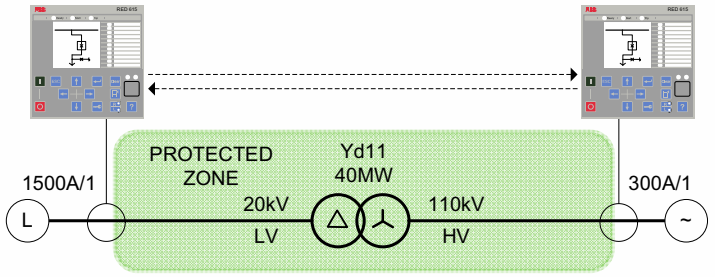



*Figure 323: In-zone transformer example about CT ratio correction calculation*

The CT ratio correction calculation starts with the rated load current calculation for HV and LV sides. The rated load current is defined as the rated power of the transformer divided by the square root of three times the nominal phase-to-phase voltage at the HV or LV side.

$$I_{nT} = \frac{S_n}{\sqrt{3} \cdot U_n}$$

(Equation 103)

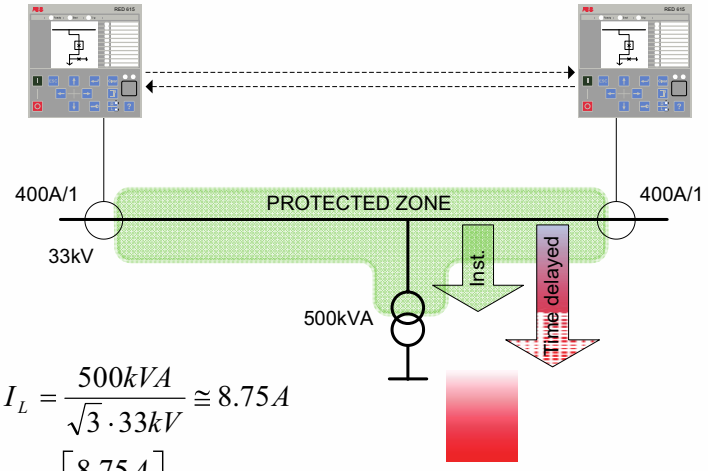
The rated load current of the transformer on the HV side is 209.9 A (40 MW / (√3 × 110 kV)) and the rated load current of the transformer on the LV side is 1154.7 A (40 MW / (√3 × 20 kV)). This means that the CT ratio corrections for the HV and LV sides are:

CT ratio correction (HV) = 1.429 (300 A / 209.9 A)

CT ratio correction (LV) = 1.299 (1500 A / 1154.7 A)

## Small power transformers in a tap

With a relatively small power transformer in a line tap, the line differential protection can be applied without the need of current measurement from the tap. In such cases, the line differential function is time delayed for low differential currents below the high set limit and LNPLDF coordinates with the downstream protection relays in the relevant tap. For differential currents above the set limit, the operation is instantaneous. As a consequence, when the load current of the tap is negligible, the low resistive line faults are cleared instantaneously at the same time as maximum sensitivity for the high resistive faults are maintained but with a time delayed operation. The maximum sensitivity for high resistive faults is maintained at the same time, but with a time delayed operation.




$$I_L = \frac{500kVA}{\sqrt{3} \cdot 33kV} \cong 8.75A$$

$$I_\Delta > \left[\frac{8.75A}{400\ A}\right] * 1A = 0.02A = 2\%$$

*Figure 324: Influence of the tapped transformer load current to the stabilized low stage setting*

The stabilized stage provides both DT and IDMT characteristics that are used for time selective protection against faults which are not covered by the instantaneous stage. The impedance of the line is typically an order of magnitude lower than the transformer impedance providing significantly higher fault currents when the fault is located on the line.

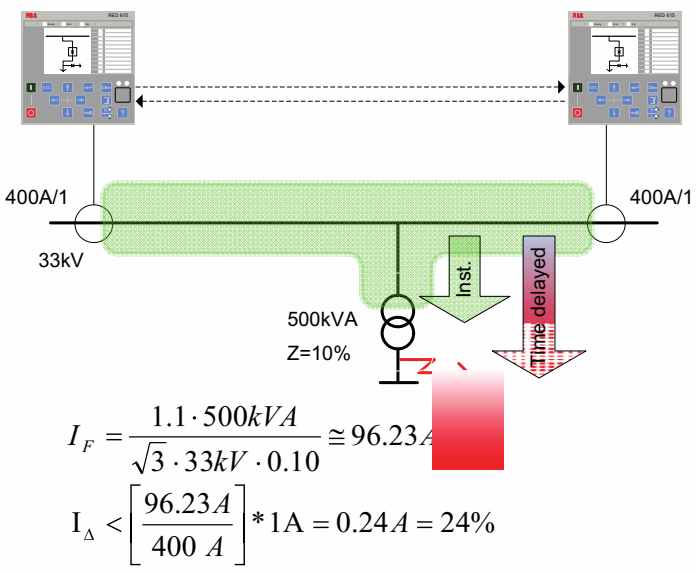



*Figure 325: Influence of the short circuit current at LV side of the tapped transformer to the differential current*

## Detection of the inrush current during transformer start-up

When the line is energized, the transformer magnetization inrush current is seen as differential current by the line differential protection and may cause malfunction of the protection if not taken into account. The inrush situation may only be detected on one end but the differential current is always seen on both ends. The inrush current includes high order harmonic components which can be detected and used as the blocking criteria for the stabilized stage. The inrush detection information is changed between two ends so that fast and safe blocking of the stabilized stage can be issued on both ends.

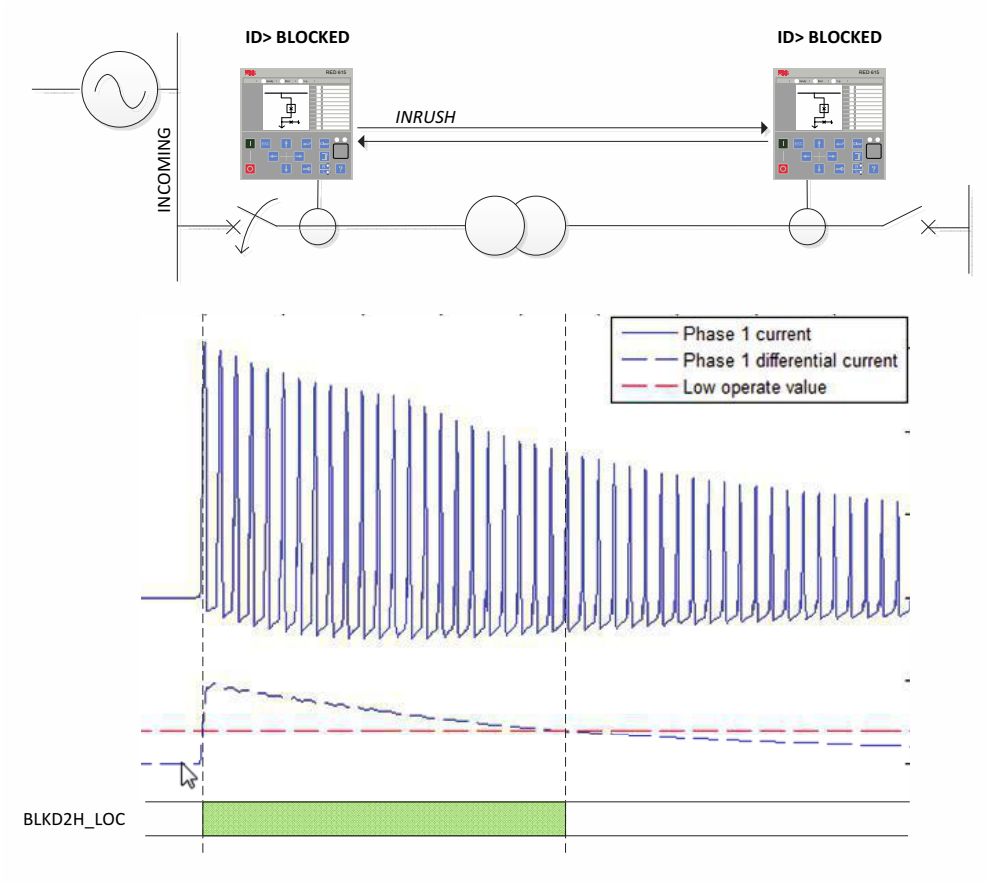



*Figure 326: Blocking of line differential functions during detected transformer startup current*

If the protection stage is allowed to start during the inrush situation, the time delay can be selected so that the stabilized stage does not operate in the inrush situation.

### 4.3.1.8 Signals

*Table 573: LNPLDF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Signal for blocking the function |
| BLOCK_LS | BOOLEAN | 0=False | Signal for blocking the stab. stage |
| ENA_MULT_HS | BOOLEAN | 0=False | Enables the high stage multiplier |

*Table 574: LNPLDF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate, local or remote, stabilized or instantaneous stage |
| START | BOOLEAN | Start, local or remote |
| STR_LS_LOC | BOOLEAN | Start stabilized stage local |
| STR_LS_REM | BOOLEAN | Start stabilized stage remote |
| OPR_LS_LOC | BOOLEAN | Operate stabilized stage local |
| OPR_LS_REM | BOOLEAN | Operate stabilized stage remote |
| OPR_HS_LOC | BOOLEAN | Operate instantaneous stage local |
| OPR_HS_REM | BOOLEAN | Operate instantaneous stage remote |
| BLKD2H_LOC | BOOLEAN | Restraint due 2nd harmonics detected local |
| BLKD2H_REM | BOOLEAN | Restraint due 2nd harmonics detected remote |
| PRO_ACTIVE | BOOLEAN | Status of the protection, true when function is operative |

### 4.3.1.9 Settings

*Table 575: LNPLDF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Low operate value | 10...200 | %Ir | 1 | 10 | Basic setting for the stabilized stage start |
| High operate value | 200...4000 | %Ir | 1 | 2000 | Instantaneous stage operate value |
| Start value 2.H | 10...50 | % | 1 | 20 | The ratio of the 2. harmonic component to fundamental component required for blocking |
| High Op value Mult | 0.5...1.0 | | 0.1 | 1.0 | Multiplier for scaling the high stage operate value |
| Time multiplier | 0.05...15.00 | | 0.01 | 1.00 | Time multiplier in IDMT curves |
| End section 1 | 0...200 | %Ir | 1 | 100 | Turn-point between the first and the second line of the operating characteristics |
| Slope section 2 | 10...50 | % | 1 | 50 | Slope of the second line of the operating characteristics |
| End section 2 | 200...2000 | %Ir | 1 | 500 | Turn-point between the second and the third line of the operating characteristics |
| Slope section 3 | 10...200 | % | 1 | 150 | Slope of the third line of the operating characteristics |
| Operating curve type | 1=ANSI Ext. inv.<br>3=ANSI Norm. inv.<br>5=ANSI Def. Time<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>12=IEC Ext. inv.<br>15=IEC Def. Time | | | 15=IEC Def. Time | Selection of time delay curve for stabilized stage |
| Operate delay time | 45...200000 | ms | 1 | 45 | Operate delay time for stabilized stage |

*Table 576: LNPLDF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>4=test/blocked<br>5=off | | | 1=on | Operation mode of the function |
| Winding selection | 1=Not in use<br>2=Winding 1<br>3=Winding 2 | | | 1=Not in use | IED location respect to transformer, HV (Winding 1) side or LV (Winding 2) side |
| Winding 1 type | 1=Y<br>2=YN<br>3=D<br>4=Z<br>5=ZN | | | 1=Y | Connection of the HV side windings |
| Winding 2 type | 1=y<br>2=yn<br>3=d<br>4=z<br>5=zn | | | 1=y | Connection of the LV side windings |
| Clock number | 0=Clk Num 0<br>1=Clk Num 1<br>2=Clk Num 2<br>4=Clk Num 4<br>5=Clk Num 5<br>6=Clk Num 6<br>7=Clk Num 7<br>8=Clk Num 8<br>10=Clk Num 10<br>11=Clk Num 11 | | | 0=Clk Num 0 | Setting the phase shift between HV and LV with clock number for connection group compensation (e.g. Dyn11 -> 11) |
| CT ratio correction | 0.200...5.000 | | 0.001 | 1.000 | Local phase current transformer ratio correction |
| CT connection type | 1=Type 1<br>2=Type 2 | | | 1=Type 1 | CT connection type. Determined by the directions of the connected current transformers. |
| Zro A elimination | 1=Not eliminated<br>2=Winding 1<br>3=Winding 2<br>4=Winding 1 and 2 | | | 1=Not eliminated | Elimination of the zero-sequence current |
| Restraint mode | 1=None<br>2=Harmonic2 | | | 1=None | Selects what restraint modes are in use |

*Table 577: LNPLDF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 0 | Reset delay time for stabilized stage |
| Minimum operate time | 45...60000 | ms | 1 | 45 | Minimum operate time for stabilized stage IDMT curves |

### 4.3.1.10 Monitored data

*Table 578: LNPLDF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| I_AMPL_LOC_A | FLOAT32 | 0.00...40.00 | xIr | Local phase A amplitude after correction |
| I_AMPL_LOC_B | FLOAT32 | 0.00...40.00 | xIr | Local phase B amplitude after correction |
| I_AMPL_LOC_C | FLOAT32 | 0.00...40.00 | xIr | Local phase C amplitude after correction |
| I_AMPL_REM_A | FLOAT32 | 0.00...40.00 | xIr | Remote phase A amplitude after correction |
| I_AMPL_REM_B | FLOAT32 | 0.00...40.00 | xIr | Remote phase B amplitude after correction |
| I_AMPL_REM_C | FLOAT32 | 0.00...40.00 | xIr | Remote phase C amplitude after correction |
| ID_A | FLOAT32 | 0.00...80.00 | xIr | Differential current phase A |
| ID_B | FLOAT32 | 0.00...80.00 | xIr | Differential current phase B |
| ID_C | FLOAT32 | 0.00...80.00 | xIr | Differential current phase C |
| IB_A | FLOAT32 | 0.00...80.00 | xIr | Stabilization current phase A |
| IB_B | FLOAT32 | 0.00...80.00 | xIr | Stabilization current phase B |
| IB_C | FLOAT32 | 0.00...80.00 | xIr | Stabilization current phase C |
| I_ANGL_DIFF_A | FLOAT32 | -180.00...180.00 | deg | Current phase angle differential between local and remote, phase A |
| I_ANGL_DIFF_B | FLOAT32 | -180.00...180.00 | deg | Current phase angle differential between local and remote, phase B |
| I_ANGL_DIFF_C | FLOAT32 | -180.00...180.00 | deg | Current phase angle differential between local and remote, phase C |
| LNPLDF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| IL1-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL1 |
| IL2-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL2 |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| IL3-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL3 |
| IL1-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL1 |
| IL2-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL2 |
| IL3-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL3 |

### 4.3.1.11 Technical data

*Table 579: LNPLDF Technical data*

| Characteristics | Value | | |
|---|---|---|---|
| Operation accuracy[1)] | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | Low stage | ±2.5% of the set value | |
| | High stage | ±2.5% of the set value | |
| High stage, operate time [2)3)] | Minimum | Typical | Maximum |
| | 20 ms | 23 ms | 27 ms |
| Reset time | Typically 40 ms | | |
| Reset ratio | Typically 0.96 | | |
| Retardation time | <40 ms | | |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | ±5.0% of the set value or ±20 ms [4)] | | |
| Suppression of harmonics | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

1) With the symmetrical communication channel (as when using dedicated fiber optic).
2) Without additional delay in the communication channel (as when using dedicated fiber optic).
3) Measured with static power output. When differential current = 2 × *High operate value* and $f_n$ = 50 Hz with galvanic pilot wire link + 5 ms.
4) *Low operate value* multiples in the range of 1.5...20

## 4.3.2 Stabilized and instantaneous differential protection for two-winding transformers TR2PTDF

### 4.3.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Stabilized and instantaneous differential protection for two-winding transformers | TR2PTDF | 3dI>T | 87T |

### 4.3.2.2 Function block

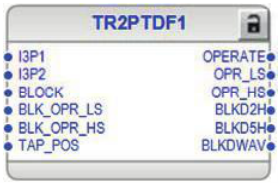



*Figure 327: Function block*

### 4.3.2.3 Functionality

The stabilized and instantaneous differential protection for two-winding transformers function TR2PTDF is designed to protect two-winding transformers and generator-transformer blocks. TR2PTDF includes low biased and high instantaneous stages.

The biased low stage provides a fast clearance of faults while remaining stable with high currents passing through the protected zone increasing errors on current measuring. The second harmonic restraint, together with the waveform based algorithms, ensures that the low stage does not operate due to the transformer inrush currents. The fifth harmonic restraint ensures that the low stage does not operate on apparent differential current caused by a harmless transformer over-excitation.

The instantaneous high stage provides a very fast clearance of severe faults with a high differential current regardless of their harmonics.

The setting characteristic can be set more sensitive with the aid of tap changer position compensation. The correction of transformation ratio due to the changes in tap position is done automatically based on the tap changer status information.

### 4.3.2.4 Analog channel configuration

TR2PTDF has two analog group inputs which must be properly configured.

*Table 580: Analog inputs*

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks

in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of TR2PTDF can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

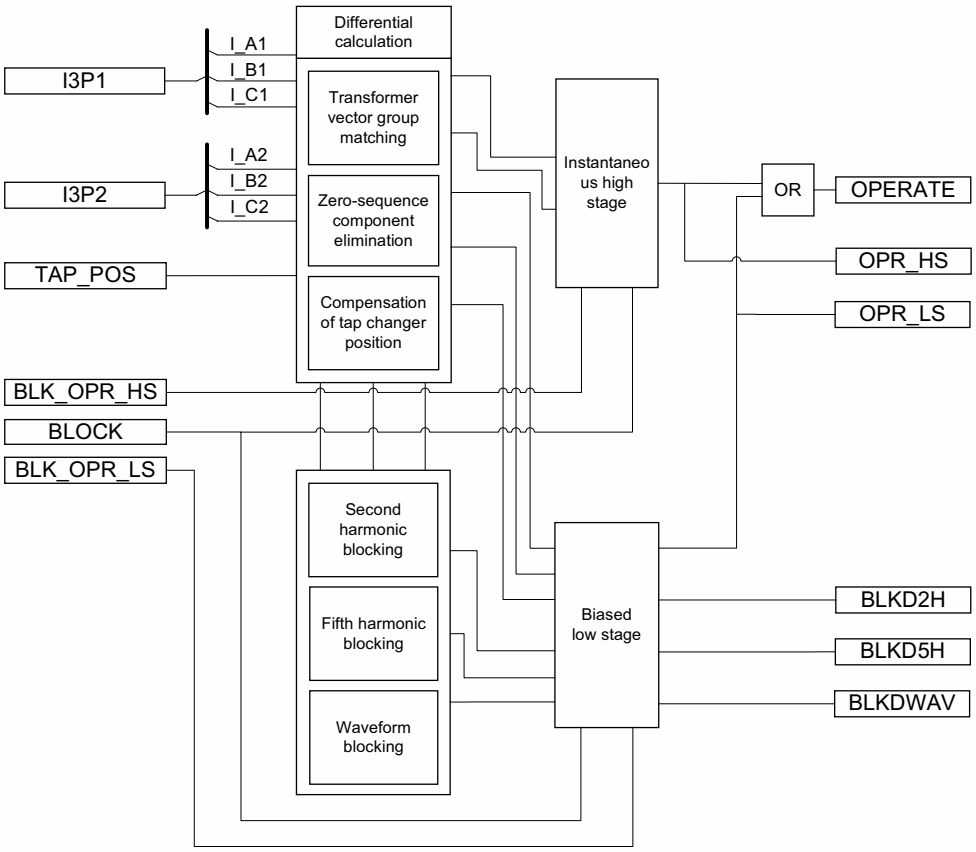



*Figure 328: Functional module diagram*

#### Differential calculation

TR2PTDF operates phase-wise on a difference of incoming and outgoing currents. The positive direction of the currents is towards the protected object.

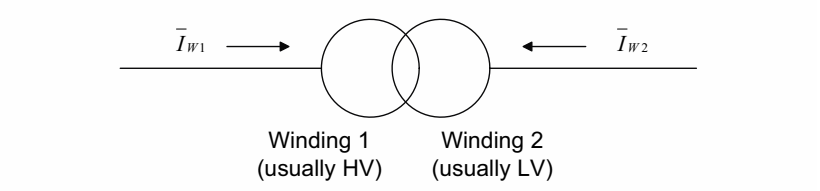



*Figure 329: Positive direction of the currents*

$$I_d = \left|\bar{I}_{W1} + \bar{I}_{W2}\right|$$

(Equation 104)

In a normal situation, no fault occurs in the area protected by TR2PTDF. Then the currents $\bar{I}_{W1}$ and $\bar{I}_{W2}$ are equal and the differential current $I_d$ is zero. In practice, however, the differential current deviates from zero in normal situations. In the power transformer protection, the differential current is caused by CT inaccuracies, variations in tap changer position (if not compensated), transformer no-load current and instantaneous transformer inrush currents. An increase in the load current causes the differential current, caused by the CT inaccuracies and the tap changer position, to grow at the same percentage rate.

In a biased differential protection relay in normal operation or during external faults, the higher the load current is the higher is the differential current required for tripping. When an internal fault occurs, the currents on both sides of the protected object are flowing into it. This causes the biasing current to be considerably smaller, which makes the operation more sensitive during internal faults.

$$I_b = \frac{\left|\bar{I}_{W1} - \bar{I}_{W2}\right|}{2}$$

(Equation 105)

If the biasing current is small compared to the differential current or if the phase angle between the winding 1 and winding 2 phase currents is close to zero (in a normal situation, the phase difference is 180 degrees), a fault has most certainly occurred in the area protected by the differential protection relay. Then the operation value set for the instantaneous stage is automatically halved and the internal blocking signals of the biased stage are inhibited.

## Transformer vector group matching

The phase difference of the winding 1 and winding 2 currents that is caused by the vector group of the power transformer is numerically compensated. The matching of the phase difference is based on the phase shifting and the numerical delta connection inside the protection relay. The *Winding 1 type* parameter determines the connection on winding 1 (”Y”, ”YN”, ”D”, ”Z”, ”ZN”). The *Winding 2 type* parameter determines the connections of the phase windings on the low voltage side (“y”, ”yn”, ”d”, ”z”, ”zn”).

The vector group matching can be implemented either on both, winding 1 and winding 2, or only on winding 1 or winding 2, at intervals of 30° with the *Clock number* setting.

When the vector group matching is Yy0 and the *CT connection type* is according to "Type 2", the phase angle of the phase currents connected to the protection relay does not change. When the vector group matching is Yy6, the phase currents are turned 180° in the protection relay.

## Example 1

Vector group matching of a Ynd11-connected power transformer on winding 1, *CT connection type* according to type 1. The *Winding 1 type* setting is ”YN”, *Winding 2 type* is “d” and *Clock number* is “Clk Num 11”. This is compensated internally by giving winding 1 internal compensation value +30° and winding 2 internal compensation value 0°:

$$\bar{I}_{L1mHV} = \frac{\bar{I}_{L1} - \bar{I}_{L2}}{\sqrt{3}}$$
$$\bar{I}_{L2mHV} = \frac{\bar{I}_{L2} - \bar{I}_{L3}}{\sqrt{3}}$$
$$\bar{I}_{L3mHV} = \frac{\bar{I}_{L3} - \bar{I}_{L1}}{\sqrt{3}}$$

(Equation 106)

## Example 2

But if vector group is Yd11 and *CT connection type* is according to type 1, the compensation is a little different. The *Winding 1 type* setting is ”Y”, *Winding 2 type* is “d” and *Clock number* is “Clk Num 11”. This is compensated internally by giving winding 1 internal compensation value 0° and winding 2 internal compensation value -30°;

$$\bar{I}_{L1mLV} = \frac{\bar{I}_{L1} - \bar{I}_{L3}}{\sqrt{3}}$$
$$\bar{I}_{L2mLV} = \frac{\bar{I}_{L2} - \bar{I}_{L1}}{\sqrt{3}}$$
$$\bar{I}_{L3mLV} = \frac{\bar{I}_{L3} - \bar{I}_{L2}}{\sqrt{3}}$$

(Equation 107)

The "Y" side currents stay untouched, while the "d" side currents are compensated to match the currents actually flowing in the windings.

In this example there is no neutral current on either side of the transformer (assuming there are no earthing transformers installed). In the previous example, however, the matching is done differently to have the winding 1 neutral current compensated at the same time.

## Zero-sequence component elimination

If *Clock number* is "Clk Num 2", "Clk Num 4", "Clk Num 8" or "Clk Num 10", the vector group matching is always done on both, winding 1 and winding 2. The combination results in the correct compensation. In this case the zero-sequence component is always removed from both sides automatically. The *Zro A elimination* parameter cannot change this.

If *Clock number* is "Clk Num 1", "Clk Num 5", "Clk Num 7" or "Clk Num 11", the vector group matching is done on one side only. A possible zero-sequence component of the phase currents at earth faults occurring outside the protection area is eliminated in the numerically implemented delta connection before the differential current and the biasing current are calculated. This is why the vector group matching is almost always made on the star connected side of the "Ynd" and "Dyn" connected transformers.

If *Clock number* is "Clk Num 0" or "Clk Num 6", the zero-sequence component of the phase currents is not eliminated automatically on either side. Therefore, the zero-sequence component on the star connected side that is earthed at its star point has to be eliminated by using the *Zro A elimination* parameter.

The same parameter has to be used to eliminate the zero-sequence component if there is, for example, an earthing transformer on the delta-connected side of the "Ynd" power transformer in the area to be protected. In this case, the vector group matching is normally made on the side of the star connection. On the side of the delta connection, the elimination of the zero-sequence component has to be separately selected.

By using the *Zro A elimination* parameter, the zero-sequence component of the phase currents is calculated and reduced for each phase current:

$$\bar{I}_{L1m} = \bar{I}_{L1} - \frac{1}{3} \cdot \left( \bar{I}_{L1} + \bar{I}_{L2} + \bar{I}_{L3} \right)$$

$$\bar{I}_{L2m} = \bar{I}_{L2} - \frac{1}{3} \cdot \left( \bar{I}_{L1} + \bar{I}_{L2} + \bar{I}_{L3} \right)$$

$$\bar{I}_{L3m} = \bar{I}_{L3} - \frac{1}{3} \cdot \left( \bar{I}_{L1} + \bar{I}_{L2} + \bar{I}_{L3} \right)$$

(Equation 108)

In many cases with the earthed neutral of a "wye" winding, it is possible to make the compensation so that a zero-sequence component of the phase currents is automatically eliminated. For example, in a case of a "Ynd" transformer, the compensation is made on the winding 1 side to automatically eliminate the zero-sequence component of the phase currents on that side (and the "d" side does not have them). In those cases, explicit elimination is not needed.

## Compensation of tap changer position

The position of the tap changer used for voltage control can be compensated and the position information is provided for the protection function through the tap position indication function TPOSYLTC.

Typically, the tap changer is located within the high voltage winding, that is, winding 1, of the power transformer. The *Tapped winding* parameter specifies whether the tap changer is connected to the high voltage side winding or the low voltage side winding. This parameter is also used to enable and disable the automatic adaptation to the tap changer position. The possible values are "Not in use", "Winding 1" or "Winding 2".

The *Tap nominal* parameter tells the number of the tap, which results in the nominal voltage (and current). When the current tap position deviates from this value, the input current values on the side where the tap changer resides are scaled to match the currents on the other side.

A correct scaling is determined by the number of steps and the direction of the deviation from the nominal tap and the percentage change in voltage resulting from a deviation of one tap step. The percentage value is set using the *Step of tap* parameter.

The operating range of the tap changer is defined by the *Min winding tap* and *Max winding tap* parameters. The *Min winding tap* parameter tells the tap position number resulting in the minimum effective number of winding turns on the side of the transformer where the tap changer is connected. Correspondingly, the *Max winding tap* parameter tells the tap position number resulting in the maximum effective number of winding turns.

The *Min winding tap* and *Max winding tap* parameters help the tap position compensation algorithm know in which direction the compensation is being made. This ensures also that if the current tap position information is corrupted for some reason, the automatic tap changer position adaptation does not try to adapt to any unrealistic position values.

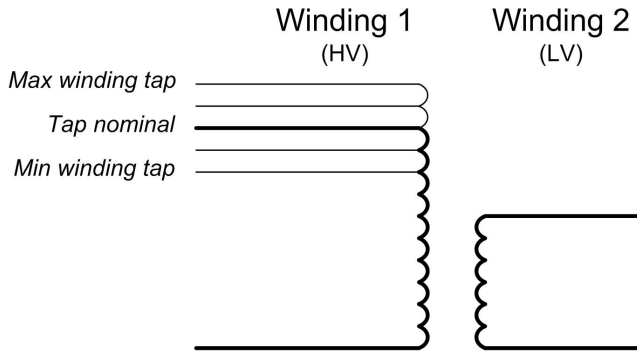



*Figure 330: Simplified presentation of the high voltage and medium voltage windings with demonstration of the Max winding tap, Min winding tap and Tap nominal parameters*

The position value is available through the Monitored data view on LHMI or through other communication tools in the tap position indication function. When the quality of the TAP_POS value is not good, the position information in TAP_POS is not used but the last value with the good quality information is used instead. In addition, the minimum sensitivity of the biased stage, set by the *Low operate value* setting, is automatically desensitized with the total range of the tap position correction. The new acting low operate value is

$$Desensitized\ Low\ operate\ value = Low\ operate\ value + ABS(Max\ Winding\ tap - Min\ winding\ tap) \cdot Step\ of\ tap$$

(Equation 109)

## Second harmonic blocking

The transformer magnetizing inrush currents occur when energizing the transformer after a period of de-energization. The inrush current can be many times the rated current and the halving time can be up to several seconds. To the differential protection, the inrush current represents a differential current, which would cause the differential protection to operate almost always when the transformer is connected to the network. Typically, the inrush current contains a large amount of second harmonics.

Blocking the operation of the TR2PTDF biased low stage at a magnetizing inrush current is based on the ratio of the amplitudes of the second harmonic digitally filtered from the differential current and the fundamental frequency (Id2f /Id1f).

The blocking also prevents unwanted operation at the recovery and sympathetic magnetizing inrushes. At the recovery inrush, the magnetizing current of the transformer to be protected increases momentarily when the voltage returns to normal after the clearance of a fault outside the protected area. The sympathetic inrush is caused by the energization of another transformer running in parallel with the protected transformer already connected to the network.

The ratio of the second harmonic to a fundamental component can vary considerably between the phases. Especially when the delta compensation is done for a Ynd1 connected transformer and the two phases of the inrush currents are otherwise equal but opposite in phase angle, the subtraction of the phases in a delta compensation results in a very small second harmonic component.

Some measures have to be taken in order to avoid the false tripping of a phase having too low a ratio of the second harmonic to the fundamental component. One way could be to always block all the phases when the second harmonic blocking conditions are fulfilled in at least one phase. The other way is to calculate the weighted ratios of the second harmonic to the fundamental component for each phase using the original ratios of the phases. The latter option is used here. The second harmonic ratios I_2H_RAT_x are given in Monitored data.

The ratio to be used for second harmonic blocking is, therefore, calculated as a weighted average on the basis of the ratios calculated from the differential currents of the three phases. The ratio of the concerned phase is of most weight compared to the ratios of the other two phases. In this protection relay, if the weighting factors are four, one and one, four is the factor of the phase concerned. The operation of the biased

stage on the concerned phase is blocked if the weighted ratio of that phase is above the set blocking limit *Start value 2.H* and if blocking is enabled through the *Restraint mode* parameter.

Using separate blocking for the individual phases and weighted averages calculated for the separate phases provides a blocking scheme that is stable at the connection inrush currents.

If the peak value of the differential current is very high, that is $I_r$>12×In, the limit for the second harmonic blocking is desensitized (in the phase in question) by increasing it proportionally to the peak value of the differential current.

The connection of the power transformer against a fault inside the protected area does not delay the operation of the tripping, because in such a situation the blocking based on the second harmonic of the differential current is prevented by a separate algorithm based on a different waveform and a different rate of change of the normal inrush current and the inrush current containing the fault current. The algorithm does not eliminate the blocking at inrush currents, unless there is a fault in the protected area.

The feature can also be enabled and disabled with the *Harmonic deblock 2.H* parameter.

### Fifth harmonic blocking

The inhibition of TR2PTDF operation in the situations of overexcitation is based on the ratio of the fifth harmonic and the fundamental component of the differential current (Id5f/Id1f). The ratio is calculated separately for each phase without weighting . If the ratio exceeds the setting value of *Start value 5.H* and if blocking is enabled through the *Restraint mode* parameter, the operation of the biased stage of TR2PTDF in the concerned phase is blocked. The fifth harmonic ratios I_5H_RAT_x are given in Monitored data.

At dangerous levels of overvoltage, which can cause damage to the transformer, the blocking can be automatically eliminated. If the ratio of the fifth harmonic and the fundamental component of the differential current exceeds the *Stop value 5.H* parameter, the blocking removal is enabled. The enabling and disabling of deblocking feature is also done through the *Harmonic deblock 5.H* parameter.

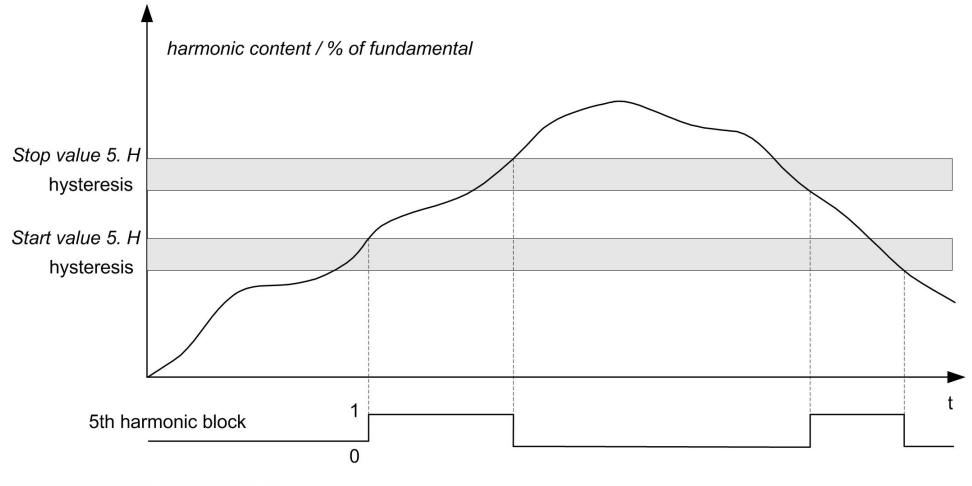



*Figure 331: The limits and operation of the fifth harmonic blocking when both blocking and deblocking features are enabled using the Harmonic deblock 5.H control parameter.*

The fifth harmonic blocking has a hysteresis to avoid rapid fluctuation between "TRUE" and "FALSE". The blocking also has a counter, which counts the required consecutive fulfillments of the condition. When the condition is not fulfilled, the counter is decreased (if >0).

Also the fifth harmonic deblocking has a hysteresis and a counter which counts the required consecutive fulfillments of the condition. When the condition is not fulfilled, the counter is decreased (if >0).

## Waveform blocking

The biased low stage can always be blocked with waveform blocking. The stage can not be disabled with the *Restraint mode* parameter. This algorithm has two parts. The first part is intended for external faults while the second is intended for inrush situations. The algorithm has criteria for a low current period during inrush where also the differential current (not derivative) is checked.

## Biased low stage

The current differential protection needs to be biased because the possible appearance of a differential current can be due to something else than an actual fault in the transformer (or generator).

In the case of transformer protection, a false differential current can be caused by:

- CT errors
- Varying tap changer positions (if not automatically compensated)
- Transformer no-load current
- Transformer inrush currents
- Transformer overexcitation in overvoltage
- Underfrequency situations
- CT saturation at high currents passing through the transformer

The differential current caused by CT errors or tap changer positions increases at the same percent ratio as the load current.

In the protection of generators, the false differential current can be caused by various factors.

- CT errors
- CT saturation at high currents passing through the generator

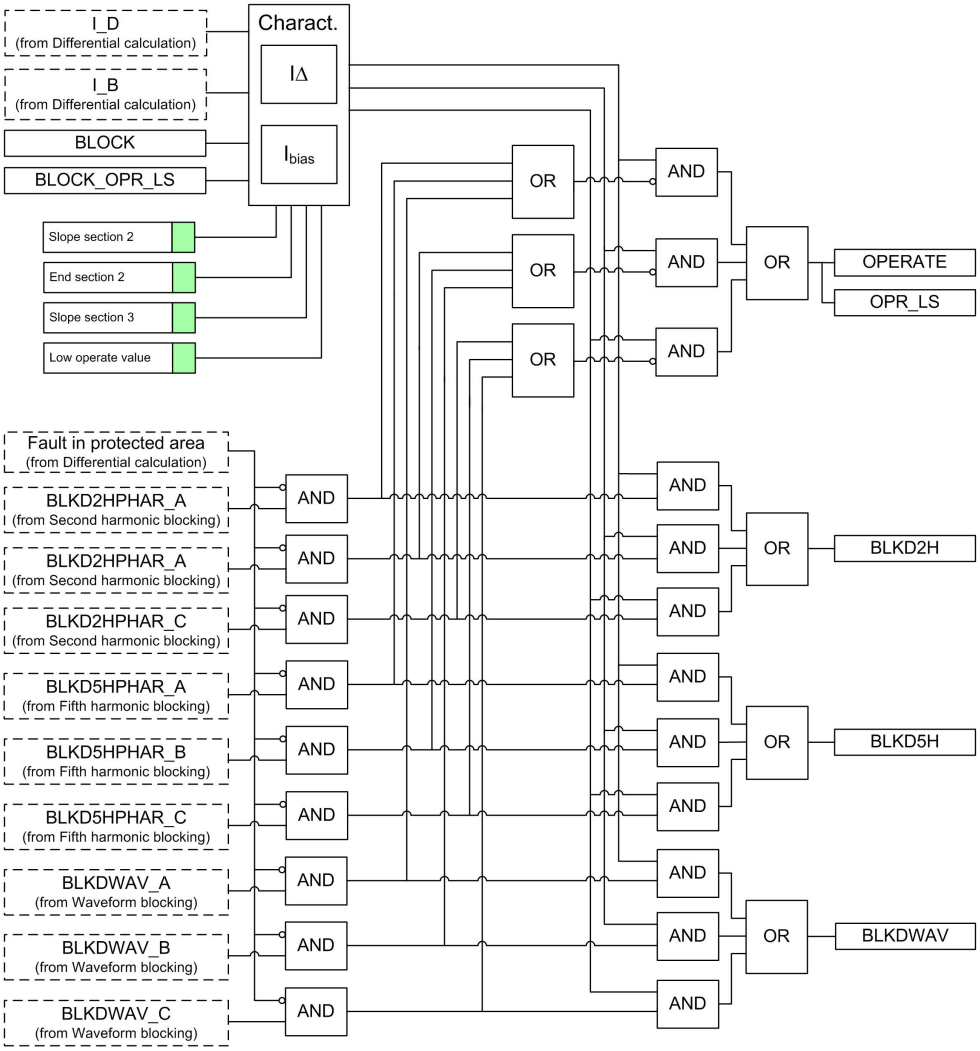



*Figure 332: Operation logic of the biased low stage*

The high currents passing through a protected object can be caused by the short circuits outside the protected area, the large currents fed by the transformer in motor startup or the transformer inrush situations. Therefore, the operation of the differential protection is biased in respect to the load current. In biased differential protection, the higher the differential current required for the protection to operate, the higher the load current.

The operating characteristic of the biased low stage is determined by *Low operate value*, *Slope section 2* and the setting of the second turning point of the operating characteristic curve, *End section 2* (the first turning point is fixed). The settings are the same for all the phases. When the differential current exceeds the operating value determined by the operating characteristic, the differential function awakes. If the differential current stays above the operating value continuously for a suitable period, which is 1.1 times the fundamental cycle, the OPR_LS output is activated. The OPERATE output is always activated when the OPR_LS output is activated.

The stage can be blocked internally by the second or fifth harmonic restraint, or by special algorithms detecting inrush and current transformer saturation at external faults. When the operation of the biased low stage is blocked by the second harmonic blocking functionality, the BLKD2H output is activated.

When operation of the biased low stage is blocked by the fifth harmonic blocking functionality, the BLKD5H output is activated. Correspondingly, when the operation of the biased low stage is blocked by the waveform blocking functionality, the BLKDWAV output is activated according to the phase information.

When required, the operate outputs of the biased low stage can be blocked by the BLK_OPR_LS or BLOCK external control signals.

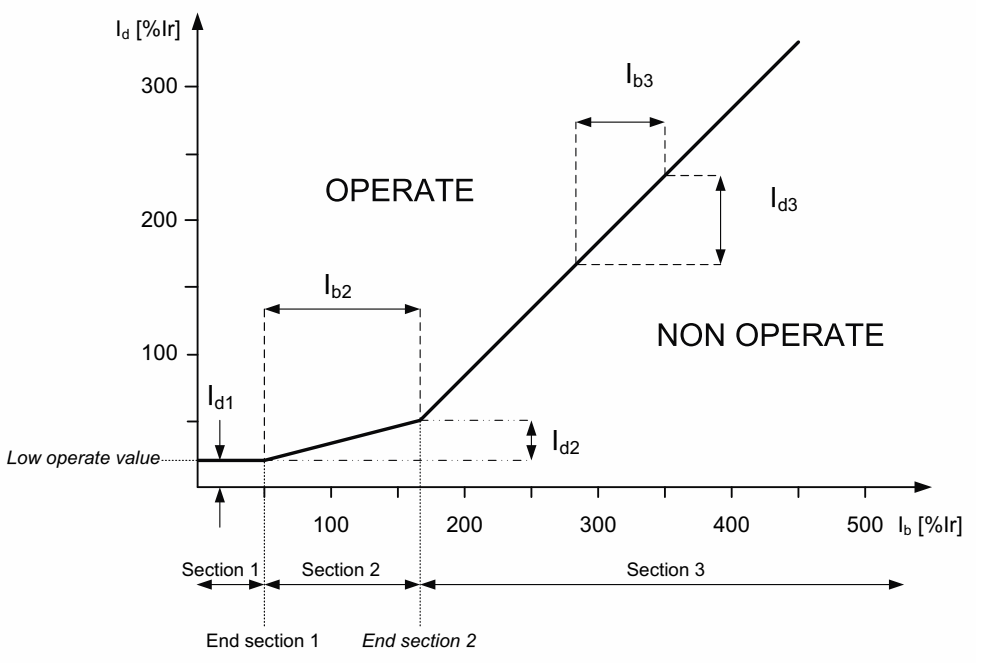



*Figure 333: Operation characteristic for biased operation of TR2PTDF*

The *Low operate value* of the biased stage of the differential function is determined according to the operation characteristic:

*Low operate value* = Id1

*Slope section 2* and *Slope section 3* are determined correspondingly:

$$Slope\ section2 = \frac{I_{d2}}{I_{b2}} \cdot 100\%$$

(Equation 110)

$$Slope\ section3 = \frac{I_{d3}}{I_{b3}} \cdot 100\%$$

(Equation 111)

The second turning point *End section 2* can be set in the range of 100 percent to 500 percent.

The slope of the differential function's operating characteristic curve varies in the different sections of the range.

- In section 1, where 0 percent Ir < Ib < End section 1, End section 1 being fixed to 50 percent Ir, the differential current required for tripping is constant. The value of the differential current is the same as the *Low operate value* selected for the function. *Low operate value* basically allows the no-load current of the power transformer and small inaccuracies of the current transformers, but it can also be used to influence the overall level of the operating characteristic. At the rated current, the no-load losses of the power transformer are about 0.2 percent. If the supply voltage of the power transformer suddenly increases due to operational disturbances, the magnetizing current of the transformer increases as well. In general the magnetic flux density of the transformer is rather high at rated voltage and a rise in voltage by a few percent causes the magnetizing current to increase by tens of percent. This should be considered in *Low operate value*
- In section 2, where End section 1 < Ib/In < *End section 2*, is called the influence area of *Slope section 2*. In this section, variations in the starting ratio affect the slope of the characteristic, that is, how big a change in the differential current is required for tripping in comparison with the change in the load current. The starting ratio should consider CT errors and variations in the transformer tap changer position (if not compensated). Too high a starting ratio should be avoided, because the sensitivity of the protection for detecting inter-turn faults depends basically on the starting ratio.
- In section 3, where Ib/In > *End section 2*, the slope of the characteristic can be set by *Slope section 3* that defines the increase in the differential current to the corresponding increase in the biasing current.

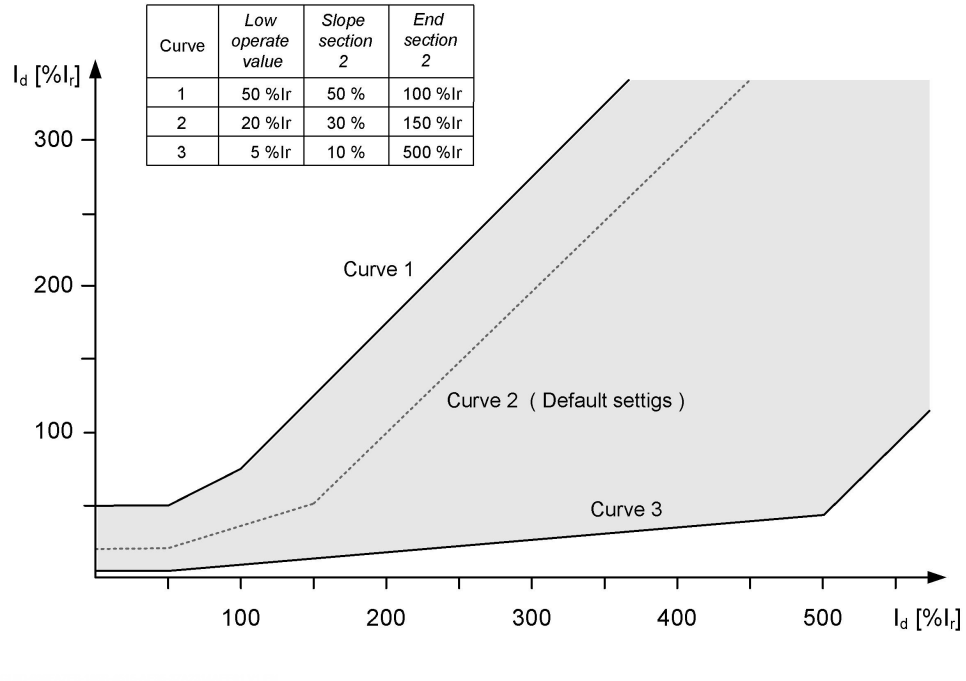



*Figure 334: Setting range for biased low stage*

If the biasing current is small compared to the differential current of the phase angle between the winding 1 and winding 2 phase currents is close to zero (in a normal situation, the phase difference is 180 degrees), a fault has most likely occurred in the area protected by TR2PTDF. Then the internal blocking signals of the biased stage are inhibited.

## Instantaneous high stage

The instantaneous high stage operation can be enabled and disabled with the *Enable high set* setting. The corresponding parameter values are "TRUE" and "FALSE."

The operation of the instantaneous high stage is not biased. The instantaneous stage operates and the output `OPR_HS` is activated when the amplitude of the fundamental frequency component of the differential current exceeds the set *High operate value* or when the instantaneous value of the differential current exceeds 2.5 times the value of *High operate value*. The factor 2.5 (=1.8 × √2) is due to the maximum asymmetric short circuit current.

If the biasing current is small compared to the differential current or the phase angle between the winding 1 and winding 2 phase currents is close to zero (in a normal situation, the phase difference is 180 degrees), a fault has occurred in the area protected by TR2PTDF. Then the operation value set for the instantaneous stage is automatically halved and the internal blocking signals of the biased stage are inhibited.

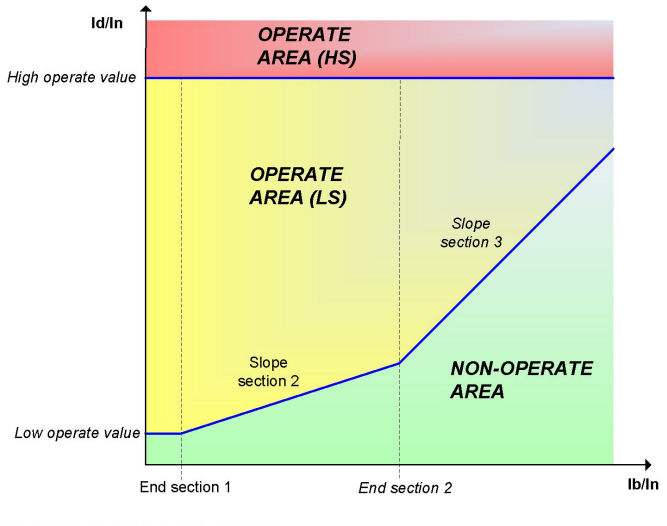



*Figure 335: Operating characteristics of the protection. (LS) stands for the biased low stage and (HS) for the instantaneous high stage*

The OPERATE output is activated always when the OPR_HS output activates.

The internal blocking signals of the differential function do not prevent the operate signal of the instantaneous differential current stage. When required, the operate outputs of the instantaneous high stage can be blocked by the BLK_OPR_HS and BLOCK external control signals.

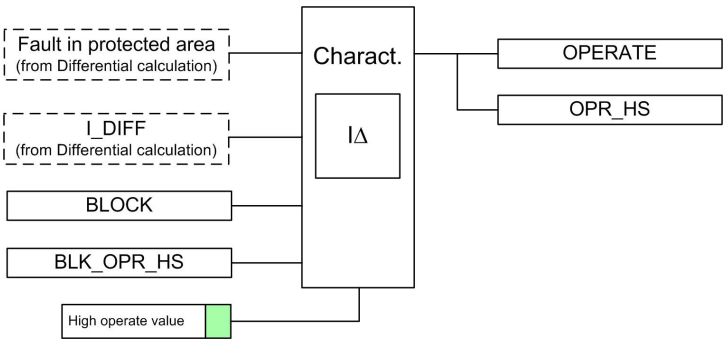



*Figure 336: Operation logic of instantaneous high stage*

## Reset of the blocking signals (de-block)

All three blocking signals, that is, waveform and second and fifth harmonic, have a counter, which holds the blocking on for a certain time after the blocking conditions have ceased to be fulfilled. The deblocking takes place when those counters have elapsed. This is a normal case of deblocking.

The blocking signals can be reset immediately if a very high differential current is measured or if the phase difference of the compared currents (the angle between the compared currents) is close to zero after the automatic vector group matching has been made (in a normal situation, the phase difference is 180 degrees). This does not,

however, reset the counters holding the blockings, so the blocking signals may return when these conditions are not valid anymore.

### External blocking functionality

TR2PTDF has three inputs for blocking.

- When the BLOCK input is active ("TRUE"), the operation of the function is blocked but measurement output signals are still updated.
- When the BLK_OPR_LS input is active ("TRUE"), TR2PTDF operates normally except that the OPR_LS output is not active or activated in any circumstance. Additionally, the OPERATE output can be activated only by the instantaneous high stage (if not blocked as well).
- When the BLK_OPR_HS input is active ("TRUE"), TR2PTDF operates normally except that the OPR_HS output is not active or activated in any circumstance. Additionally, the OPERATE output can be activated only by the biased low stage (if not blocked as well).

## 4.3.2.6 Application

TR2PTDF is a unit protection function serving as the main protection for transformers in case of winding failure. The protective zone of a differential protection includes the transformer, the bus-work or the cables between the current transformer and the power transformer. When bushing current transformers are used for the differential protection relay, the protective zone does not include the bus work or cables between the circuit breaker and the power transformer.

In some substations, there is a current differential protection for the busbar. The busbar protection includes bus work or cables between the circuit breaker and the power transformer. Internal electrical faults are very serious and cause immediate damage. Short circuits and earth faults in windings and terminals are normally detected by the differential protection. If enough turns are short-circuited, the interturn faults, which are flashovers between the conductors within the same physical winding, are also detected. The interturn faults are the most difficult transformer-winding faults to detect with electrical protections. A small interturn fault including a few turns results in an undetectable amount of current until the fault develops into an earth fault. Therefore, it is important that the differential protection has a high level of sensitivity and that it is possible to use a sensitive setting without causing unwanted operations for external faults.

It is important that the faulty transformer is disconnected as fast as possible. As TR2PTDF is a unit protection function, it can be designed for fast tripping, thus providing a selective disconnection of the faulty transformer. TR2PTDF should never operate to faults outside the protective zone.

TR2PTDF compares the current flowing into the transformer to the current leaving the transformer. A correct analysis of fault conditions by TR2PTDF must consider the changes to voltages, currents and phase angles. The traditional transformer differential protection functions required auxiliary transformers for the correction of

the phase shift and turns ratio. The numerical microprocessor based differential algorithm implemented in TR2PTDF compensates for both the turns ratio and the phase shift internally in the software.

The differential current should theoretically be zero during normal load or external faults if the turns ratio and the phase shift are correctly compensated. However, there are several different phenomena other than internal faults that cause unwanted and false differential currents. The main reasons for unwanted differential currents are:

- Mismatch due to varying tap changer positions
- Different characteristics, loads and operating conditions of the current transformers
- Zero sequence currents that only flow on one side of the power transformer
- Normal magnetizing currents
- Magnetizing inrush currents
- Overexcitation magnetizing currents.

TR2PTDF is designed mainly for the protection of two-winding transformers. TR2PTDF can also be utilized for the protection of generator-transformer blocks as well as short cables and overhead lines. If the distance between the measuring points is relatively long in line protection, interposing CTs can be required to reduce the burden of the CTs.

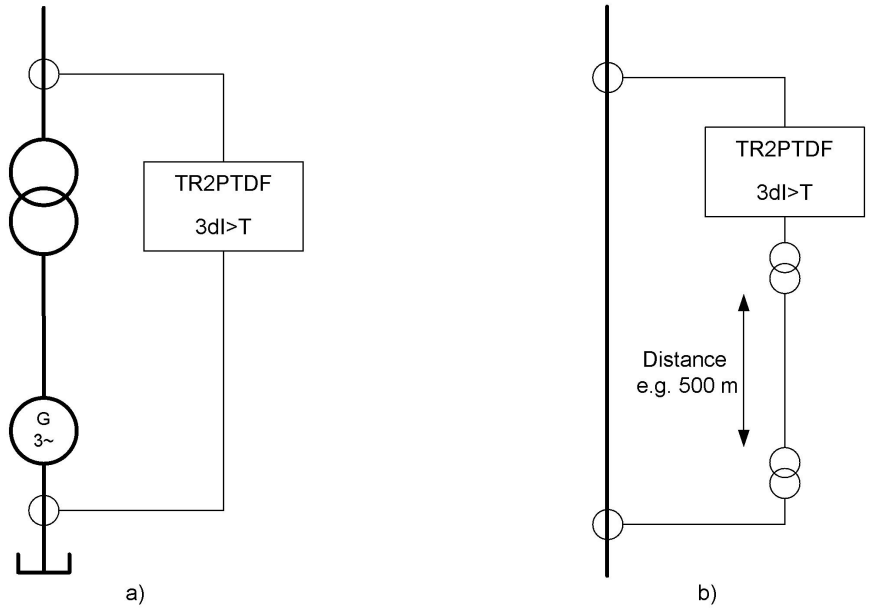



*Figure 337: Differential protection of a generator-transformer block and short cable/line*

TR2PTDF can also be used in three-winding transformer applications or two-winding transformer applications with two output feeders.

On the double-feeder side of the power transformer, the current of the two CTs per phase must be summed by connecting the two CTs of each phase in parallel. Generally

this requires the interposing CTs to handle the vector group and/or ratio mismatch between the two windings/feeders.

The accuracy limit factor for the interposing CT must fulfill the same requirements as the main CTs. Please note that the interposing CT imposes an additional burden to the main CTs.

The most important rule in these applications is that at least 75 percent of the short-circuit power has to be fed on the side of the power transformer with only one connection to the protection relay.

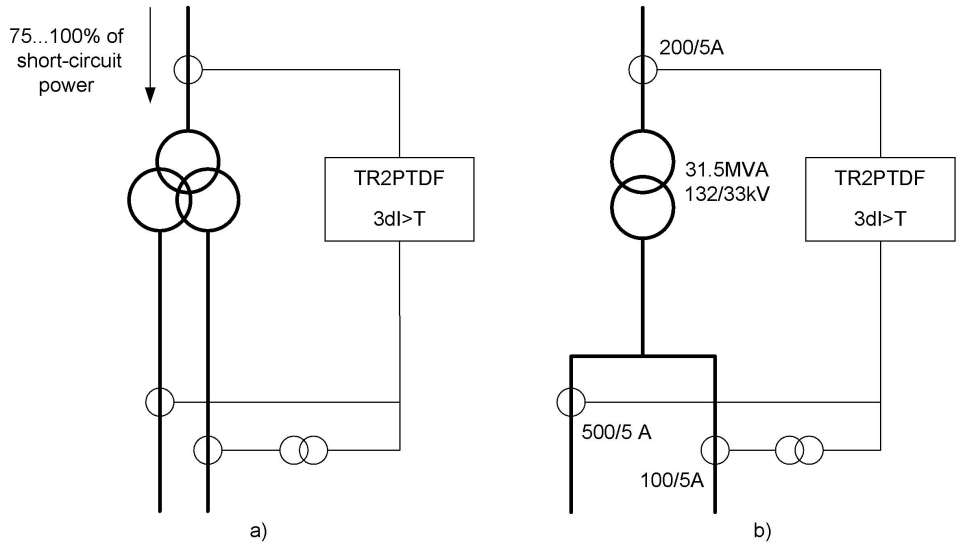



*Figure 338: Differential protection of a three-winding transformer and a transformer with two output feeders*

TR2PTDF can also be used for the protection of the power transformer feeding the frequency converter. An interposing CT is required for matching the three-winding transformer currents to a two-winding protection relay.

The fundamental frequency component is numerically filtered with a Fourier filter, DFT. The filter suppresses frequencies other than the set fundamental frequency, and therefore the protection relay is not adapted for measuring the output of the frequency converter, that is, TR2PTDF is not suited for protecting of a power transformer or motor fed by a frequency converter

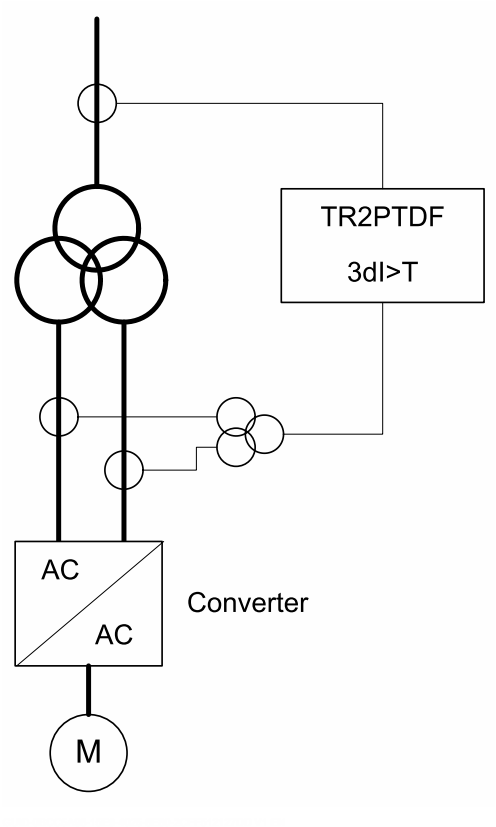



*Figure 339: Protection of the power transformer feeding the frequency converter*

## Transforming ratio correction of CTs

The CT secondary currents often differ from the rated current at the rated load of the power transformer. The CT transforming ratios can be corrected on both sides of the power transformer with the *CT ratio Cor Wnd 1* and *CT ration Cor Wnd 2* settings.

First, the rated load of the power transformer must be calculated on both sides when the apparent power and phase-to-phase voltage are known.

$$I_{nT} = \frac{S_n}{\sqrt{3} \cdot U_n}$$

(Equation 112)

$I_{nT}$ rated load of the power transformer

$S_n$ rated power of the power transformer

$U_n$ rated phase-to-phase voltage

$$CT\ ratio\ correction = \frac{I_{1n}}{I_{nT}}$$

(Equation 113)

$I_{1n}$ nominal primary current of the CT

Next, the settings for the CT ratio correction can be calculated.

After the CT ratio correction, the measured currents and corresponding setting values of TR2PTDF are expressed in multiples of the rated power transformer current $I_r$ ($xI_r$) or percentage value of $I_r$ ($\%I_r$).

The rated input current (1A or 5A) of the relay does not have to be same for the HV and the LV side. For example, the rated secondary current of 5 A can be used on the HV side, while 1A is used on the LV side or vice versa.

## Example

The rated power of the transformer is 25 MVA, the ratio of the CTs on the 110 kV side is 300/1 and that on the 21 kV side is 1000/1.

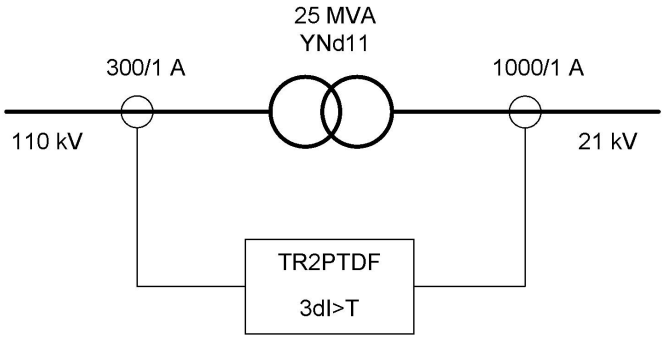



*Figure 340: Example of two-winding power transformer differential protection*

The rated load of the transformer is calculated:

HV side: $I_{nT_Wnd1}$ = 25 MVA / (1.732 x 110 kV) = 131.2 A

LV side: $I_{nT_Wnd2}$ = 25 MVA / (1.732 x 21 kV) = 687.3 A

## Settings:

*CT ratio Cor Wnd 1*= 300 A / 131.2 A = “2.29”

*CT ratio Cor Wnd 2*= 1000 A / 687.3 A = “1.45”

## Vector group matching and elimination of the zero-sequence component

The vector group of the power transformer is numerically matched on the high voltage and low voltage sides by means of the *Winding 1 type*, *Winding 2 type* and *Clock number* settings. Thus no interposing CTs are needed if there is only a power transformer inside the protected zone. The matching is based on phase shifting and a numerical delta connection in the protection relay. If the neutral of a star-connected power transformer is earthed, any earth fault in the network is perceived by the protection relay as a differential current. The elimination of the zero-sequence component can be selected for that winding by setting the *Zro A elimination* parameter.

*Table 581: TR2PTDF settings corresponding to the power transformer vector groups and zero-sequence elimination*

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| Yy0 | Y | y | Clk Num 0 | Not needed |
| YNy0 | YN | y | Clk Num 0 | HV side |
| YNyn0 | YN | yn | Clk Num 0 | HV & LV side |
| Yyn0 | Y | yn | Clk Num 0 | LV side |
| Yy2 | Y | y | Clk Num 2 | Not needed |
| YNy2 | YN | y | Clk Num 2 | Not needed |
| YNyn2 | YN | yn | Clk Num 2 | Not needed |
| Yyn2 | Y | yn | Clk Num 2 | Not needed |
| Yy4 | Y | y | Clk Num 4 | Not needed |
| YNy4 | YN | y | Clk Num 4 | Not needed |
| YNyn4 | YN | yn | Clk Num 4 | Not needed |
| Yyn4 | Y | yn | Clk Num 4 | Not needed |
| Yy6 | Y | y | Clk Num 6 | Not needed |
| YNy6 | YN | y | Clk Num 6 | HV side |
| YNyn6 | YN | yn | Clk Num 6 | HV & LV side |
| Yyn6 | Y | yn | Clk Num 6 | LV side |
| Yy8 | Y | y | Clk Num 8 | Not needed |
| YNy8 | YN | y | Clk Num 8 | Not needed |
| YNyn8 | YN | yn | Clk Num 8 | Not needed |
| Yyn8 | Y | yn | Clk Num 8 | Not needed |
| Yy10 | Y | y | Clk Num 10 | Not needed |
| YNy10 | YN | y | Clk Num 10 | Not needed |
| YNyn10 | YN | yn | Clk Num 10 | Not needed |
| Yyn10 | Y | yn | Clk Num 10 | Not needed |
| Yd1 | Y | d | Clk Num 1 | Not needed |
| YNd1 | YN | d | Clk Num 1 | Not needed |
| Yd5 | Y | d | Clk Num 5 | Not needed |

Table continues on next page

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| YNd5 | YN | d | Clk Num 5 | Not needed |
| Yd7 | Y | d | Clk Num 7 | Not needed |
| YNd7 | YN | d | Clk Num 7 | Not needed |
| Yd11 | Y | d | Clk Num 11 | Not needed |
| YNd11 | YN | d | Clk Num 11 | Not needed |
| Dd0 | D | d | Clk Num 0 | Not needed |
| Dd2 | D | d | Clk Num 2 | Not needed |
| Dd4 | D | d | Clk Num 4 | Not needed |
| Dd6 | D | d | Clk Num 6 | Not needed |
| Dd8 | D | d | Clk Num 8 | Not needed |
| Dd10 | D | d | Clk Num 10 | Not needed |
| Dy1 | D | y | Clk Num 1 | Not needed |
| Dyn1 | D | yn | Clk Num 1 | Not needed |
| Dy5 | D | y | Clk Num 5 | Not needed |
| Dyn5 | D | yn | Clk Num 5 | Not needed |
| Dy7 | D | y | Clk Num 7 | Not needed |
| Dyn7 | D | yn | Clk Num 7 | Not needed |
| Dy11 | D | y | Clk Num 11 | Not needed |
| Dyn11 | D | yn | Clk Num 11 | Not needed |
| Yz1 | Y | z | Clk Num 1 | Not needed |
| YNz1 | YN | z | Clk Num 1 | Not needed |
| YNzn1 | YN | zn | Clk Num 1 | LV side |
| Yzn1 | Y | zn | Clk Num 1 | Not needed |
| Yz5 | Y | z | Clk Num 5 | Not needed |
| YNz5 | YN | z | Clk Num 5 | Not needed |
| YNzn5 | YN | zn | Clk Num 5 | LV side |
| Yzn5 | Y | zn | Clk Num 5 | Not needed |
| Yz7 | Y | z | Clk Num 7 | Not needed |
| YNz7 | YN | z | Clk Num 7 | Not needed |
| YNzn7 | YN | zn | Clk Num 7 | LV side |
| Yzn7 | Y | zn | Clk Num 7 | Not needed |
| Yz11 | Y | z | Clk Num 11 | Not needed |
| YNz11 | YN | z | Clk Num 11 | Not needed |
| YNzn11 | YN | zn | Clk Num 11 | LV side |
| Yzn11 | Y | zn | Clk Num 11 | Not needed |
| Zy1 | Z | y | Clk Num 1 | Not needed |
| Zyn1 | Z | yn | Clk Num 1 | Not needed |
| ZNyn1 | ZN | yn | Clk Num 1 | HV side |
| ZNy1 | ZN | y | Clk Num 1 | Not needed |

Table continues on next page

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| Zy5 | Z | y | Clk Num 5 | Not needed |
| Zyn5 | Z | yn | Clk Num 5 | Not needed |
| ZNyn5 | ZN | yn | Clk Num 5 | HV side |
| ZNy5 | ZN | y | Clk Num 5 | Not needed |
| Zy7 | Z | y | Clk Num 7 | Not needed |
| Zyn7 | Z | yn | Clk Num 7 | Not needed |
| ZNyn7 | ZN | yn | Clk Num 7 | HV side |
| ZNy7 | ZN | y | Clk Num 7 | Not needed |
| Zy11 | Z | y | Clk Num 11 | Not needed |
| Zyn11 | Z | yn | Clk Num 11 | Not needed |
| ZNyn11 | ZN | yn | Clk Num 11 | HV side |
| ZNy11 | ZN | y | Clk Num 11 | Not needed |
| Dz0 | D | z | Clk Num 0 | Not needed |
| Dzn0 | D | zn | Clk Num 0 | LV side |
| Dz2 | D | z | Clk Num 2 | Not needed |
| Dzn2 | D | zn | Clk Num 2 | Not needed |
| Dz4 | D | z | Clk Num 4 | Not needed |
| Dzn4 | D | zn | Clk Num 4 | Not needed |
| Dz6 | D | z | Clk Num 6 | Not needed |
| Dzn6 | D | zn | Clk Num 6 | LV side |
| Dz8 | D | z | Clk Num 8 | Not needed |
| Dzn8 | D | zn | Clk Num 8 | Not needed |
| Dz10 | D | z | Clk Num 10 | Not needed |
| Dzn10 | D | zn | Clk Num 10 | Not needed |
| Zd0 | Z | d | Clk Num 0 | Not needed |
| ZNd0 | ZN | d | Clk Num 0 | HV side |
| Zd2 | Z | d | Clk Num 2 | Not needed |
| ZNd2 | ZN | d | Clk Num 2 | Not needed |
| Zd4 | Z | d | Clk Num 4 | Not needed |
| ZNd4 | ZN | d | Clk Num 4 | Not needed |
| Zd6 | Z | d | Clk Num 6 | Not needed |
| ZNd6 | ZN | d | Clk Num 6 | HV side |
| Zd8 | Z | d | Clk Num 8 | Not needed |
| ZNd8 | ZN | d | Clk Num 8 | Not needed |
| Zd10 | Z | d | Clk Num 10 | Not needed |
| ZNd10 | ZN | d | Clk Num 10 | Not needed |
| Zz0 | Z | z | Clk Num 0 | Not needed |
| ZNz0 | ZN | z | Clk Num 0 | HV side |
| ZNzn0 | ZN | zn | Clk Num 0 | HV & LV side |

Table continues on next page

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| Zzn0 | Z | zn | Clk Num 0 | LV side |
| Zz2 | Z | z | Clk Num 2 | Not needed |
| ZNz2 | ZN | z | Clk Num 2 | Not needed |
| ZNzn2 | ZN | zn | Clk Num 2 | Not needed |
| Zzn2 | Z | zn | Clk Num 2 | Not needed |
| Zz4 | Z | z | Clk Num 4 | Not needed |
| ZNz4 | ZN | z | Clk Num 4 | Not needed |
| ZNzn4 | ZN | zn | Clk Num 4 | Not needed |
| Zzn4 | Z | zn | Clk Num 4 | Not needed |
| Zz6 | Z | z | Clk Num 6 | Not needed |
| ZNz6 | ZN | z | Clk Num 6 | HV side |
| ZNzn6 | ZN | zn | Clk Num 6 | HV & LV side |
| Zzn6 | Z | zn | Clk Num 6 | LV side |
| Zz8 | Z | z | Clk Num 8 | Not needed |
| ZNz8 | ZN | z | Clk Num 8 | Not needed |
| ZNzn8 | ZN | zn | Clk Num 8 | Not needed |
| Zzn8 | Z | zn | Clk Num 8 | Not needed |
| Zz10 | Z | z | Clk Num 10 | Not needed |
| ZNz10 | ZN | z | Clk Num 10 | Not needed |
| ZNzn10 | ZN | zn | Clk Num 10 | Not needed |
| Zzn10 | Z | zn | Clk Num 10 | Not needed |
| Yy0 | Y | y | Clk Num 0 | Not needed |
| YNy0 | YN | y | Clk Num 0 | HV side |
| YNyn0 | YN | yn | Clk Num 0 | HV & LV side |
| Yyn0 | Y | yn | Clk Num 0 | LV side |
| Yy2 | Y | y | Clk Num 2 | Not needed |
| YNy2 | YN | y | Clk Num 2 | Not needed |
| YNyn2 | YN | yn | Clk Num 2 | Not needed |
| Yyn2 | Y | yn | Clk Num 2 | Not needed |
| Yy4 | Y | y | Clk Num 4 | Not needed |
| YNy4 | YN | y | Clk Num 4 | Not needed |
| YNyn4 | YN | yn | Clk Num 4 | Not needed |
| Yyn4 | Y | yn | Clk Num 4 | Not needed |
| Yy6 | Y | y | Clk Num 6 | Not needed |
| YNy6 | YN | y | Clk Num 6 | HV side |
| YNyn6 | YN | yn | Clk Num 6 | HV & LV side |
| Yyn6 | Y | yn | Clk Num 6 | LV side |
| Yy8 | Y | y | Clk Num 8 | Not needed |
| YNy8 | YN | y | Clk Num 8 | Not needed |

Table continues on next page

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| YNyn8 | YN | yn | Clk Num 8 | Not needed |
| Yyn8 | Y | yn | Clk Num 8 | Not needed |
| Yy10 | Y | y | Clk Num 10 | Not needed |
| YNy10 | YN | y | Clk Num 10 | Not needed |
| YNyn10 | YN | yn | Clk Num 10 | Not needed |
| Yyn10 | Y | yn | Clk Num 10 | Not needed |
| Yd1 | Y | d | Clk Num 1 | Not needed |
| YNd1 | YN | d | Clk Num 1 | Not needed |
| Yd5 | Y | d | Clk Num 5 | Not needed |
| YNd5 | YN | d | Clk Num 5 | Not needed |
| Yd7 | Y | d | Clk Num 7 | Not needed |
| YNd7 | YN | d | Clk Num 7 | Not needed |
| Yd11 | Y | d | Clk Num 11 | Not needed |
| YNd11 | YN | d | Clk Num 11 | Not needed |
| Dd0 | D | d | Clk Num 0 | Not needed |
| Dd2 | D | d | Clk Num 2 | Not needed |
| Dd4 | D | d | Clk Num 4 | Not needed |
| Dd6 | D | d | Clk Num 6 | Not needed |
| Dd8 | D | d | Clk Num 8 | Not needed |
| Dd10 | D | d | Clk Num 10 | Not needed |
| Dy1 | D | y | Clk Num 1 | Not needed |
| Dyn1 | D | yn | Clk Num 1 | Not needed |
| Dy5 | D | y | Clk Num 5 | Not needed |
| Dyn5 | D | yn | Clk Num 5 | Not needed |
| Dy7 | D | y | Clk Num 7 | Not needed |
| Dyn7 | D | yn | Clk Num 7 | Not needed |
| Dy11 | D | y | Clk Num 11 | Not needed |
| Dyn11 | D | yn | Clk Num 11 | Not needed |
| Yz1 | Y | z | Clk Num 1 | Not needed |
| YNz1 | YN | z | Clk Num 1 | Not needed |
| YNzn1 | YN | zn | Clk Num 1 | LV side |
| Yzn1 | Y | zn | Clk Num 1 | Not needed |
| Yz5 | Y | z | Clk Num 5 | Not needed |
| YNz5 | YN | z | Clk Num 5 | Not needed |
| YNzn5 | YN | zn | Clk Num 5 | LV side |
| Yzn5 | Y | zn | Clk Num 5 | Not needed |
| Yz7 | Y | z | Clk Num 7 | Not needed |
| YNz7 | YN | z | Clk Num 7 | Not needed |
| YNzn7 | YN | zn | Clk Num 7 | LV side |

Table continues on next page

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| Yzn7 | Y | zn | Clk Num 7 | Not needed |
| Yz11 | Y | z | Clk Num 11 | Not needed |
| YNz11 | YN | z | Clk Num 11 | Not needed |
| YNzn11 | YN | zn | Clk Num 11 | LV side |
| Yzn11 | Y | zn | Clk Num 11 | Not needed |
| Zy1 | Z | y | Clk Num 1 | Not needed |
| Zyn1 | Z | yn | Clk Num 1 | Not needed |
| ZNyn1 | ZN | yn | Clk Num 1 | HV side |
| ZNy1 | ZN | y | Clk Num 1 | Not needed |
| Zy5 | Z | y | Clk Num 5 | Not needed |
| Zyn5 | Z | yn | Clk Num 5 | Not needed |
| ZNyn5 | ZN | yn | Clk Num 5 | HV side |
| ZNy5 | ZN | y | Clk Num 5 | Not needed |
| Zy7 | Z | y | Clk Num 7 | Not needed |
| Zyn7 | Z | yn | Clk Num 7 | Not needed |
| ZNyn7 | ZN | yn | Clk Num 7 | HV side |
| ZNy7 | ZN | y | Clk Num 7 | Not needed |
| Yy0 | Y | y | Clk Num 0 | Not needed |

## Commissioning

The correct settings, which are *CT connection type*, *Winding 1 type*, *Winding 2 type* and *Clock number*, for the connection group compensation can be verified by monitoring the angle values `I_ANGL_A1_B1`, `I_ANGL_B1_C1`, `I_ANGL_C1_A1`, `I_ANGL_A2_B2`, `I_ANGL_B2_C2`, `I_ANGL_C2_A2`, `I_ANGL_A1_A2`, `I_ANGL_B1_B2` and `I_ANGL_C1_C2` while injecting the current into the transformer. These angle values are calculated from the compensated currents. See signal description from Monitored data table.

When a station service transformer is available, it can be used to provide current to the high voltage side windings while the low voltage side windings are short-circuited. This way the current can flow in both the high voltage and low voltage windings. The commissioning signals can be provided by other means as well. The minimum current to allow for phase current and angle monitoring is 0.015 $I_r$.

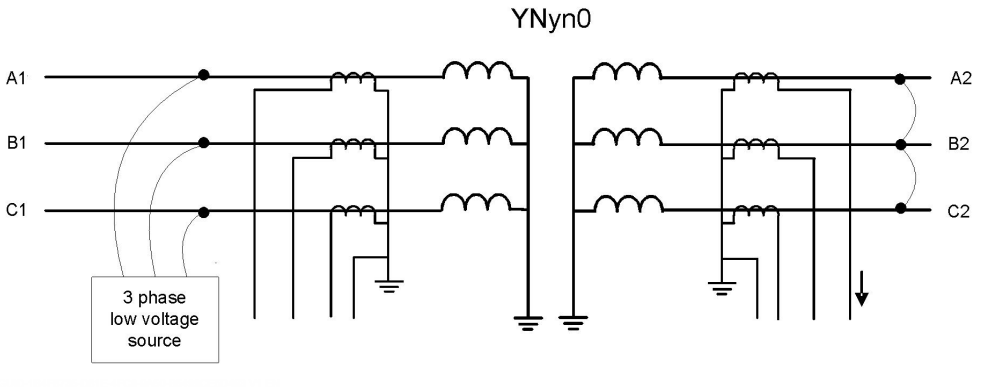



*Figure 341: Low voltage test arrangement. The three-phase low voltage source can be the station service transformer.*

The *Tapped winding* control setting parameter has to be set to “Not in use” to make sure that the monitored current values are not scaled by the automatic adaptation to the tap changer position. When only the angle values are required, the setting of *Tapped winding* is not needed since angle values are not affected by the tap changer position adaptation.

When injecting the currents in the high voltage winding, the angle values `I_ANGL_A1_B1`, `I_ANGL_B1_C1`, `I_ANGL_C1_A1`, `I_ANGL_A2_B2`, `I_ANGL_B2_C2` and `I_ANGL_C2_A2` have to show +120 deg. Otherwise the phase order can be wrong or the polarity of a current transformer differs from the polarities of the other current transformers on the same side.

If the angle values `I_ANGL_A1_B1`, `I_ANGL_B1_C1` and `I_ANGL_C1_A1` show -120 deg, the phase order is wrong on the high voltage side. If the angle values `I_ANGL_A2_B2`, `I_ANGL_B2_C2` and `I_ANGL_C2_A2` show -120 deg, the phase order is wrong on the low voltage side. If the angle values `I_ANGL_A1_B1`, `I_ANGL_B1_C1` and `I_ANGL_C1_A1` do not show the same value of +120, the polarity of one current transformer can be wrong. For instance, if the polarity of the current transformer measuring IL2 is wrong, `I_ANGL_A1_B1` shows -60 deg, `I_ANGL_B1_C1` shows -60 deg and `I_ANGL_C1_A1` shows +120 deg.

When the phase order and the angle values are correct, the angle values `I_ANGL_A1_A2`, `I_ANGL_B1_B2` and `I_ANGL_C1_C2` usually show ±180 deg. There can be several reasons if the angle values are not ±180 deg. If the values are 0 deg, the value given for *CT connection type* is probably wrong. If the angle values are something else, the value for *Clock number* can be wrong. Another reason is that the combination of *Winding 1 type* and *Winding 2 type* does not match *Clock number*. This means that the resulting connection group is not supported.

## Example

If *Winding 1 type* is set to "Y", *Winding 2 type* is set to "y" and *Clock number* is set to "Clk num 1", the resulting connection group "Yy1" is not a supported combination. Similarly if *Winding 1 type* is set to "Y", *Winding 2 type* is set to "d" and *Clock number*

is set to "Clk num 0", the resulting connection group "Yd0" is not a supported combination. All the non-supported combinations of *Winding 1 type*, *Winding 2 type* and *Clock number* settings result in the default connection group compensation that is "Yy0".

#### 4.3.2.7 CT connections and transformation ratio correction

The connections of the primary current transformers are designated as "Type 1" and "Type 2".

- If the positive directions of the winding 1 and winding 2 protection relay currents are opposite, the *CT connection type* setting parameter is "Type 1". The connection examples of "Type 1" are as shown in Figure 342 and Figure 343.
- If the positive directions of the winding 1 and winding 2 protection relay currents equate, the *CT connection type* setting parameter is "Type 2". The connection examples of "Type 2" are as shown in Figure 344 and Figure 345.
- The default value of the *CT connection type* setting is "Type 1".

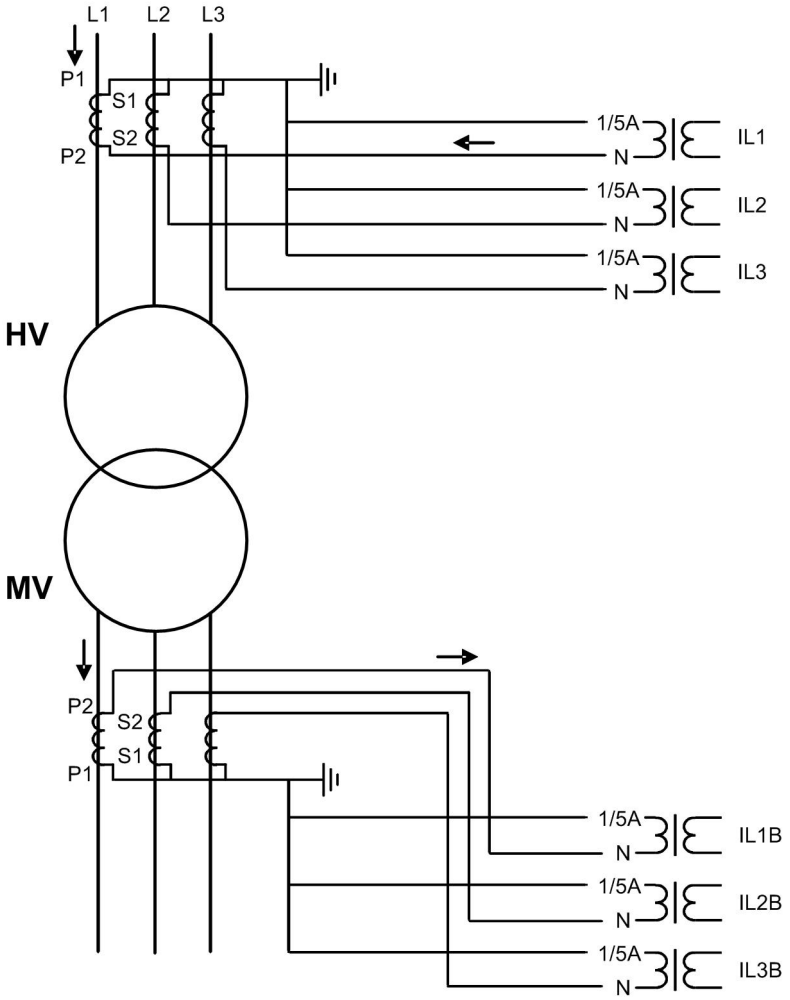



*Figure 342: Connection example of current transformers of Type 1*

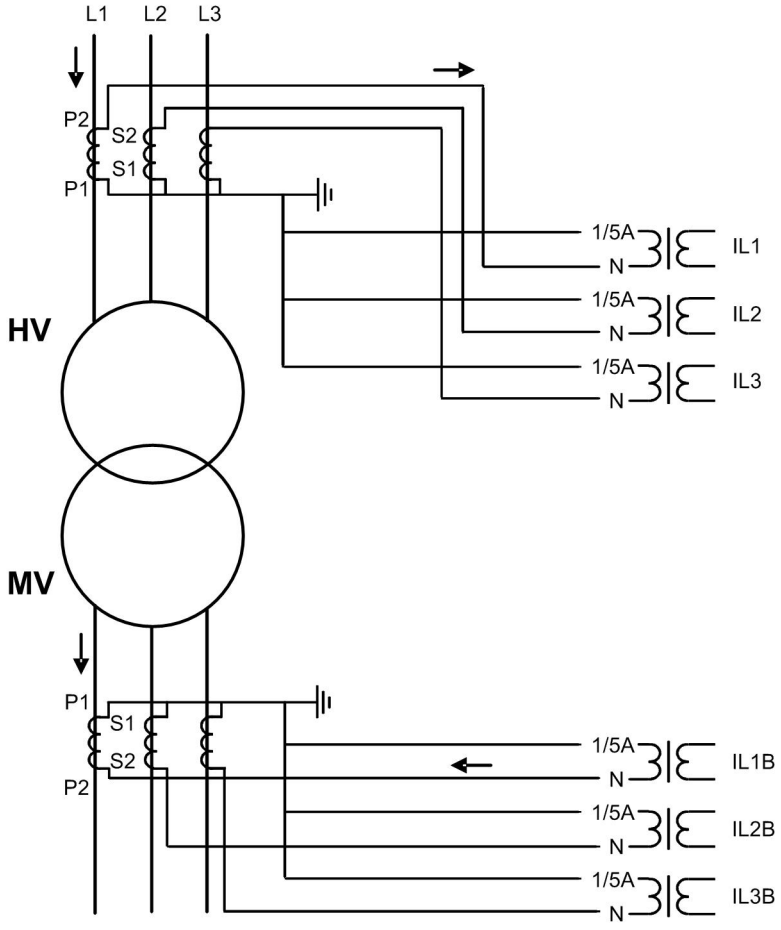



*Figure 343: Alternative connection example of current transformers of Type 1*

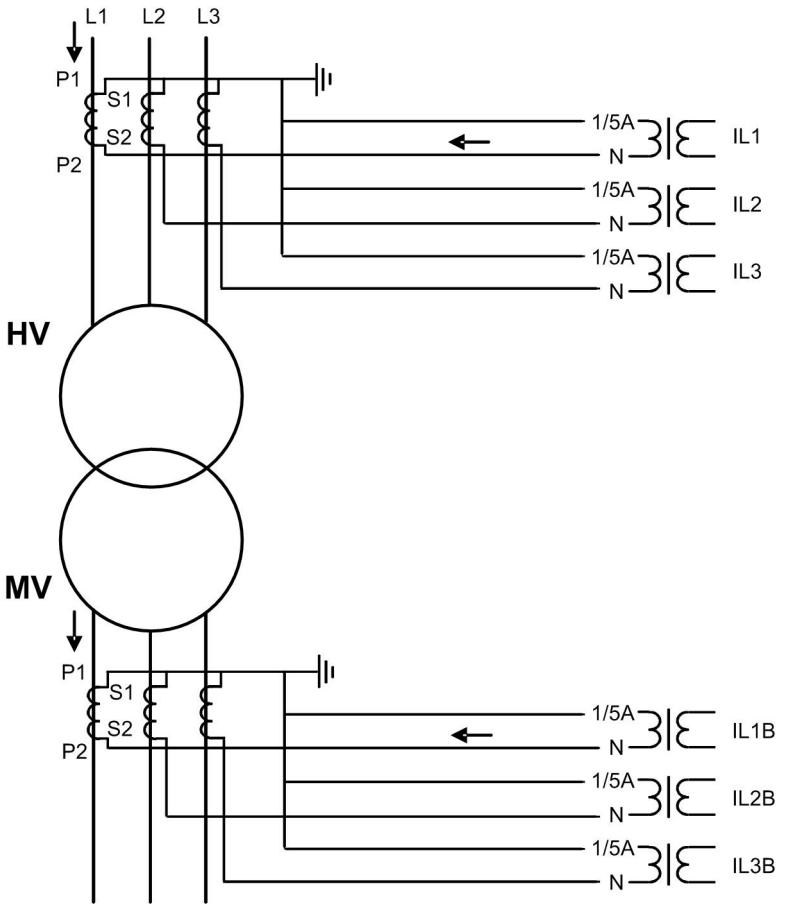



*Figure 344: Connection of current transformers of Type 2 and example of the currents during an external fault*

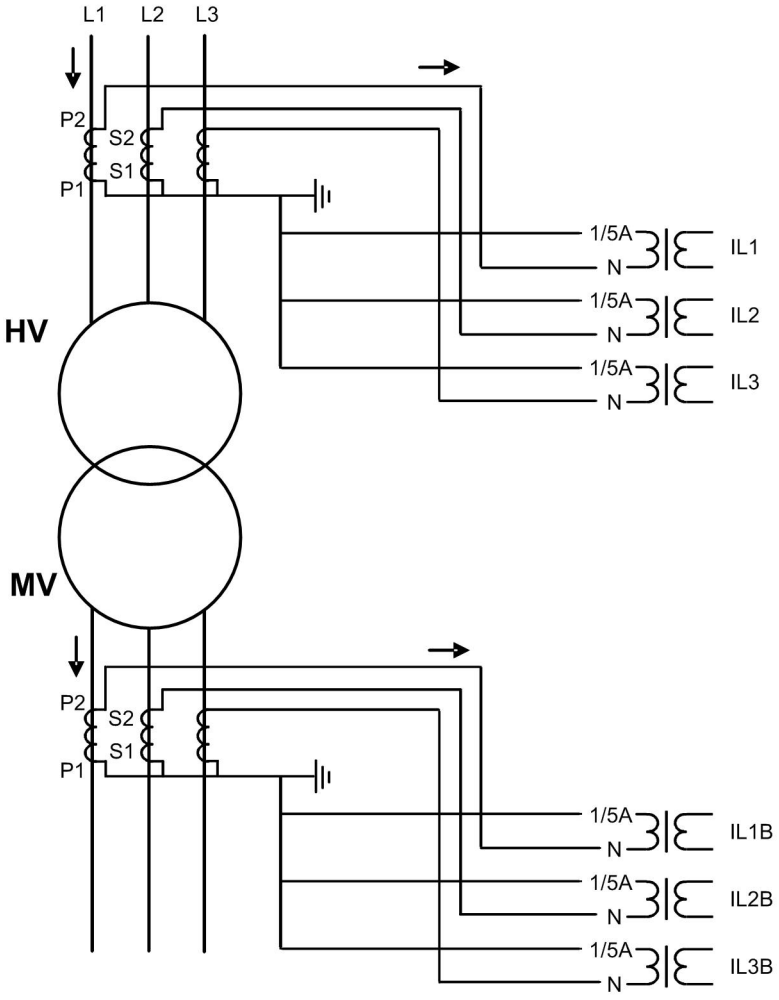



*Figure 345: Alternative connection example of current transformers of Type 2*

The CT secondary currents often differ from the rated current at the rated load of the power transformer. The CT transforming ratios can be corrected on both sides of the power transformer with the *CT ratio Cor Wnd 1* and *CT ratio Cor Wnd 2* settings.

### 4.3.2.8 Signals

*Table 582: TR2PTDF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| BLOCK | BOOLEAN | 0=False | Block |
| BLK_OPR_LS | BOOLEAN | 0=False | Blocks operate outputs from biased stage |
| BLK_OPR_HS | BOOLEAN | 0=False | Blocks operate outputs from instantaneous stage |
| TAP_POS | INT8 | 0 | Tap position indication |

*Table 583: TR2PTDF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate combined |
| OPR_LS | BOOLEAN | Operate from low set |
| OPR_HS | BOOLEAN | Operate from high set |
| BLKD2H | BOOLEAN | 2nd harmonic restraint block status |
| BLKD5H | BOOLEAN | 5th harmonic restraint block status |
| BLKDWAV | BOOLEAN | Waveform blocking status |

### 4.3.2.9 Settings

*Table 584: TR2PTDF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| High operate value | 500...3000 | %Ir | 10 | 1000 | Instantaneous stage setting |
| Low operate value | 5...50 | %Ir | 1 | 20 | Basic setting for biased operation |
| Slope section 2 | 10...50 | % | 1 | 30 | Slope of the second line of the operating characteristics |
| End section 2 | 100...500 | %Ir | 1 | 150 | Turn-point between the second and the third line of the operating characteristics |
| Restraint mode | 5=Waveform<br>6=2.h + waveform<br>8=5.h + waveform<br>9=2.h + 5.h + wav | | | 9=2.h + 5.h + wav | Restraint mode |
| Start value 2.H | 7...20 | % | 1 | 15 | 2. harmonic blocking ratio |
| Start value 5.H | 10...50 | % | 1 | 35 | 5. harmonic blocking ratio |

*Table 585: TR2PTDF Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Enable high set | 0=False<br>1=True | | | 1=True | Enable high set stage |
| Slope section 3 | 10...100 | % | 1 | 100 | Slope of the third line of the operating characteristics |
| Harmonic deblock 2. | 0=False<br>1=True | | | 1=True | 2. harmonic deblocking in case of switch on to fault |
| Stop value 5.H | 10...50 | % | 1 | 35 | 5. harmonic deblocking ratio |
| Harmonic deblock 5. | 0=False<br>1=True | | | 0=False | 5. harmonic deblocking in case of severe overvoltage |

*Table 586: TR2PTDF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off/On |
| CT connection type | 1=Type 1<br>2=Type 2 | | | 1=Type 1 | CT connection type. Determined by the directions of the connected current transformers |
| Winding 1 type | 1=Y<br>2=YN<br>3=D<br>4=Z<br>5=ZN | | | 1=Y | Connection of the HV side windings |
| Winding 2 type | 1=y<br>2=yn<br>3=d<br>4=z<br>5=zn | | | 1=y | Connection of the LV side windings |
| Clock number | 0=Clk Num 0<br>1=Clk Num 1<br>2=Clk Num 2<br>4=Clk Num 4<br>5=Clk Num 5<br>6=Clk Num 6<br>7=Clk Num 7<br>8=Clk Num 8<br>10=Clk Num 10<br>11=Clk Num 11 | | | 0=Clk Num 0 | Setting the phase shift between HV and LV with clock number for connection group compensation (e.g. Dyn11 -> 11) |
| Zro A elimination | 1=Not eliminated<br>2=Winding 1<br>3=Winding 2<br>4=Winding 1 and 2 | | | 1=Not eliminated | Elimination of the zero-sequence current |
| CT ratio Cor Wnd 1 | 0.40...4.00 | | 0.01 | 1.00 | CT ratio correction, winding 1 |
| CT ratio Cor Wnd 2 | 0.40...4.00 | | 0.01 | 1.00 | CT ratio correction, winding 2 |

*Table 587: TR2PTDF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min winding tap | -36...36 | | 1 | 36 | The tap position number resulting the minimum number of effective winding turns on the side of the transformer where the tap changer is. |
| Max winding tap | -36...36 | | 1 | 0 | The tap position number resulting the maximum number of effective winding turns on the side of the transformer where the tap changer is. |
| Tap nominal | -36...36 | | 1 | 18 | The nominal position of the tap changer resulting the default transformation ratio of the transformer (as if there was no tap changer) |
| Tapped winding | 1=Not in use<br>2=Winding 1<br>3=Winding 2 | | | 1=Not in use | The winding where the tap changer is connected to |
| Step of tap | 0.60...9.00 | % | 0.01 | 1.50 | The percentage change in voltage corresponding one step of the tap changer |

### 4.3.2.10 Monitored data

*Table 588: TR2PTDF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| OPR_A | BOOLEAN | 0=False<br>1=True | | Operate phase A |
| OPR_B | BOOLEAN | 0=False<br>1=True | | Operate phase B |
| OPR_C | BOOLEAN | 0=False<br>1=True | | Operate phase C |
| BLKD2H_A | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase A status |
| BLKD2H_B | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase B status |
| BLKD2H_C | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase C status |
| BLKD5H_A | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase A status |
| BLKD5H_B | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase B status |
| BLKD5H_C | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase C status |
| BLKDWAV_A | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase A status |
| BLKDWAV_B | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase B status |
| BLKDWAV_C | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase C status |
| BLKD2HPHAR | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, combined |
| BLKD2HPHAR_A | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase A |
| BLKD2HPHAR_B | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase B |
| BLKD2HPHAR_C | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase C |
| BLKD5HPHAR | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, combined |
| BLKD5HPHAR_A | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase A |
| BLKD5HPHAR_B | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase B |
| BLKD5HPHAR_C | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase C |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_AMPL_A1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase A |
| I_AMPL_B1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase B |
| I_AMPL_C1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase C |
| I_AMPL_A2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase A |
| I_AMPL_B2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase B |
| I_AMPL_C2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase C |
| ID_A | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase A |
| ID_B | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase B |
| ID_C | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase C |
| IB_A | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase A |
| IB_B | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase B |
| IB_C | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase C |
| I_2H_RAT_A | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase A |
| I_2H_RAT_B | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase B |
| I_2H_RAT_C | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase C |
| I_ANGL_A1_B1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, winding 1 |
| I_ANGL_B1_C1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, winding 1 |
| I_ANGL_C1_A1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, winding 1 |
| I_ANGL_A2_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, winding 2 |
| I_ANGL_B2_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, winding 2 |
| I_ANGL_C2_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, winding 2 |
| I_ANGL_A1_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase A |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_ANGL_B1_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase B |
| I_ANGL_C1_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase C |
| I_5H_RAT_A | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase A |
| I_5H_RAT_B | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase B |
| I_5H_RAT_C | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase C |
| TR2PTDF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| IL1-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL1 |
| IL2-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL2 |
| IL3-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL3 |
| IL1-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL1 |
| IL2-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL2 |
| IL3-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL3 |

## 4.3.2.11 Technical data

*Table 589: TR2PTDF Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±3.0% of the set value or ±0.002 × $I_n$ | | |
| Operate time[1)2)] | | Minimum | Typical | Maximum |
| | Low stage<br>High stage | 31 ms<br>15 ms | 35 ms<br>17 ms | 40 ms<br>20 ms |
| Reset time | | <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, … | | |

1) Current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz. Injected differential current = 2.0 × set operation value
2) Measured with static power output. $f_n$ = 50 Hz

## 4.3.3 Stabilized and instantaneous differential protection for two- or three-winding transformers TR3PTDF

### 4.3.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Stabilized and instantaneous differential protection for two- or three-winding transformers | TR3PTDF | 3dI>3W | 87T3 |

### 4.3.3.2 Function block

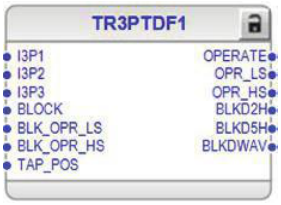



*Figure 346: Function block*

### 4.3.3.3 Functionality

The stabilized and instantaneous differential protection for two- or three-winding transformers function TR3PTDF provides up to three three-phase current sets or restraints designed for the protection of two-winding or three-winding transformers and generator-transformer blocks. It is possible to have two three-phase current sets either on the winding 1 or winding 2 side in case of two-winding transformer protection. The function includes a biased low stage and an instantaneous high stage.

The biased low stage provides fast fault clearing while remaining stable with the high currents passing through the protected zone, which increase the errors in current measuring. The second harmonic restraint, together with waveform-based algorithms, ensures that the low stage does not operate due to the transformer inrush currents. The fifth harmonic restraint ensures that the low stage does not operate on apparent differential current caused by a harmless transformer overexcitation.

The instantaneous high stage provides very fast clearing of severe faults with a high differential current regardless of their harmonics.

The setting characteristic can be set more sensitive with tap changer position compensation. The correction of the transformation ratio due to changes in tap position is done automatically based on the tap changer status information provided to the function through input.

### 4.3.3.4 Analog channel configuration

TR3PTDF has three analog group inputs which must be properly configured.

*Table 590: Analog inputs*

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase currents |
| I3P3[1)] | Three-phase currents<br>Necessary when *Current group 3 type* is other than "Not in use" |

1) Can be connected to GRPOFF if *Current group 3 type* is set to "Not in use"



See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of TR3PTDF can be described with a module diagram. All the modules in the diagram are explained in the next sections.

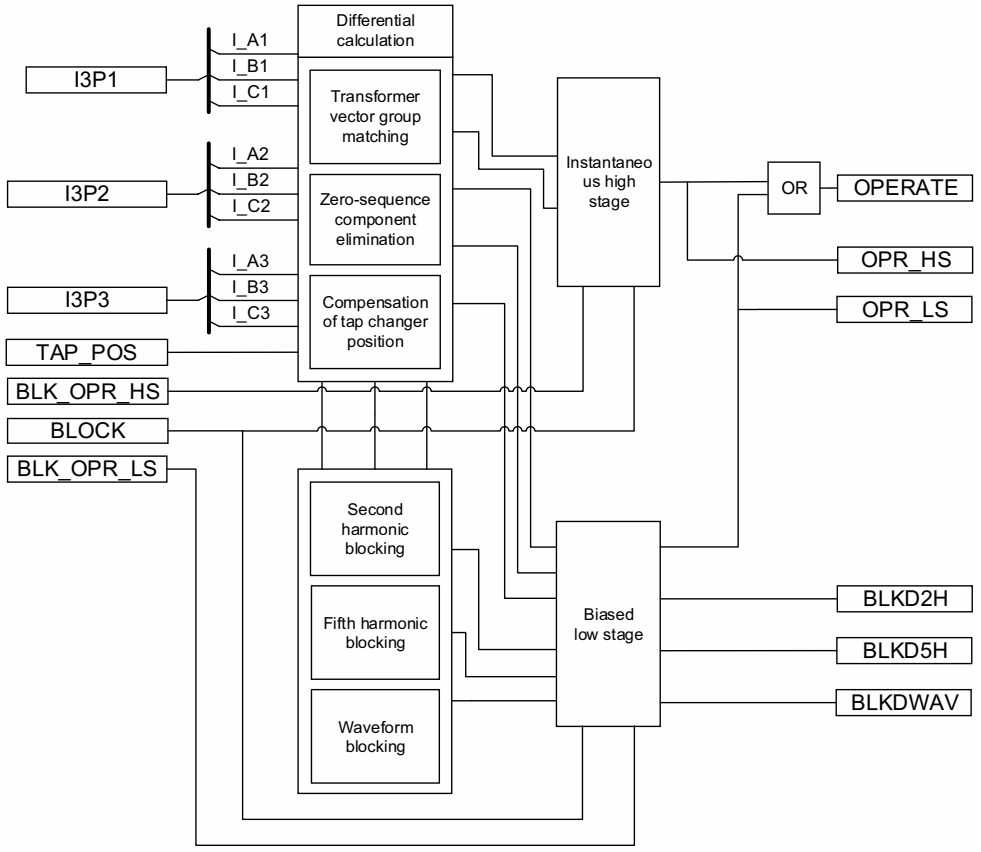



*Figure 347: Functional module diagram*

## Differential calculation

TR3PTDF operates phasewise on the difference of incoming and outgoing currents. The positive direction of the currents is towards the protected object.

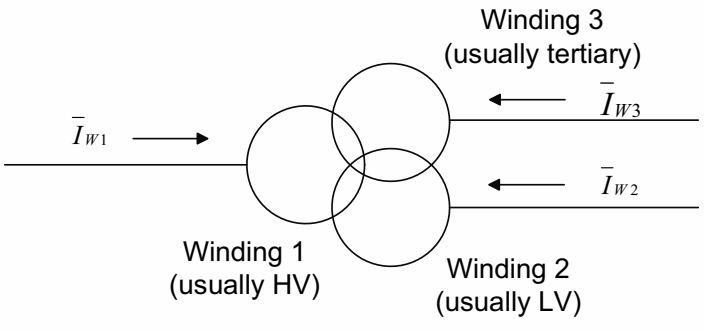



*Figure 348: Single-line diagram of the positive direction of the currents in a three-winding transformer*

The normalized amplitude of the differential current per phase $I_d$ is obtained using the equation:

$$I_d = \left| \bar{I}_{W1} + \bar{I}_{W2} + \bar{I}_{W3} \right|$$

(Equation 114)

In a normal situation, no fault occurs in the area protected by TR3PTDF. Then the currents $I_{W1}$, $I_{W2}$ and $I_{W3}$ cancel each other and the differential current $I_d$ is zero. In practice, however, the differential current deviates from zero in normal situations. In the power transformer protection, the differential current is caused by CT inaccuracies, variations in tap changer position (if not compensated), transformer no-load current and instantaneous transformer inrush currents. An increase in the load current makes the differential current, caused by the CT inaccuracies and the tap changer position, grow at the same percentage rate.

In a biased differential protection relay in normal operation or during external faults, the higher the load current is, the higher the differential current required for tripping. When an internal fault occurs, the currents on both sides of the protected object are flowing into it. This causes the bias current to be considerably smaller, which makes the operation more sensitive during internal faults.

$$I_b = \frac{\left| \bar{I}_X - \bar{I}_Y - \bar{I}_Z \right|}{2}$$

(Equation 115)

| | |
|---|---|
| $I_X$ | One of the normalized currents $I_{W1}$, $I_{W2}$ and $I_{W3}$ determined by the angle differences between the currents and their amplitudes |
| $I_Y$ and $I_Z$ | Remaining two currents |

$I_X$ is selected based on one of the criteria below.

- The angle between $I_X$ and $I_Y$ and also between $I_X$ and $I_Z$ is over 120 degrees while the amplitude of $I_X$ is not less than
  $0.9 \cdot MAX(|I_X|, |I_Y|, |I_Z|)$
- The one with the highest amplitude ($I_X = MAX(|I_X|, |I_Y|, |I_Z|)$ )

In case of a two-winding transformer having additional restraint (additional three-phase current set) either on the winding 1 or winding 2 side, currents are connected to the third winding current inputs. This ensures that if the currents of the opposite direction are measured in the restraints (through current), meaning the current is passing through the protected zone, this current affects the bias current of the differential protection.

If the bias current is small compared to the differential current or if the phase angle between the currents of two windings with the highest phase current (in case of three-winding transformer) or the phase angle between the compared phase currents (in case

of two-winding transformer) is close to zero, a fault has most certainly occurred in the area protected by the differential protection relay. The operating value set for the instantaneous stage is automatically halved and the internal blocking signals of the biased stage are inhibited.

## Transformer vector group matching

The phase differences of the winding 1 and winding 2 currents (winding 1 and winding 3 in case of a three-winding transformer) that are caused by the vector groups of the power transformer are numerically compensated in the function.

Phase difference matching is based on the ABB-patented generalized transform-method. Settings *Phase shift Wnd 1-2* and *Phase shift Wnd 1-3* determine the current phase angle difference between windings 1 and 2 and between 1 and 3, respectively.

Normally, the transformer vector group designation includes the winding configurations and the phase angle difference between given with a clock number. For example, YNd1 has clock number 1. Settings *Phase shift Wnd 1-2* and *Phase shift Wnd 1-3* are calculated as clock number · 30 deg.

*Table 591: Examples of Phase shift Wnd 1-2 (and Phase shift Wnd 1-3) settings for some common vector groups*

| Vector group between windings 1 and 2 (or windings 1 and 3) | Phase angle |
|---|---|
| YNd1, Yd1, Dyn1, Dy1 | 30° |
| YNd5, Yd5, Dyn5, Dy5 | 150° |
| YNd7, Yd7, Dyn7, Dy7 | 210° |
| YNd11, Yd11, Dyn11, Dy11 | 330° |

The vector group matching can be set in the resolution of 0.1 degrees, which allows for cycloconverter applications with a phase angle difference of, for example, 7.5 degrees between windings.

The *Phase Ref winding* setting is used to define which of the windings is the reference. The phase reference can be selected from *Phase Ref winding* as "Winding 1", "Winding 2" or "Winding 3". The currents in the winding selected as the phase reference are not modified (except the removal of the zero-sequence current if set active) when the currents in other windings are matched with the reference winding (if the set phase shift between the windings is not zero).



The *Phase Ref winding* setting does not affect settings *Phase shift Wnd 1-2* and *Phase shift Wnd 1-3*.

## Zero-sequence component elimination

If a wye-connected power transformer neutral is earthed, or if there is a separate earthing transformer inside the differential protection zone, any out-of-zone earth

fault in the network is seen as differential current unless the zero-sequence component is correctly eliminated.

The zero-sequence elimination is done with the *Zro A elimination* setting. The recommended rules for this setting are:

- For power transformer wye-connected windings with earthed neutral point, *Zro A elimination* must be activated.
- For power transformer wye-connected windings with isolated neutral, and for delta-connected windings, *Zro A elimination* is not activated unless there is a separate earthing transformer inside the protected zone (that is, between the power transformer winding and CTs).
- It does no harm to activate *Zro A elimination* even if it is not needed.

## Compensation of tap changer position

The position of the tap changer used for voltage control can be compensated according to the actual tap changer position. The position information is provided to the protection function through the tap changer position indication function TPOSYLTC.

Typically, the tap changer is located within the HV winding, that is, winding 1 of the power transformer. The *Tapped winding* setting parameter specifies whether the tap changer is connected to winding 1, winding 2 or winding 3. The *Tapped winding* setting parameter is also used to enable or disable the automatic adaptation to the tap changer position. The possible values are "Not in use", "Winding 1", "Winding 2", "Winding 3".



There can be only one tap changer in the transformer, that is, the function can take into account and compensate only for one tap changer.

The *Tap nominal* setting parameter provides the number of the tap which results in the nominal voltage and current. When the current tap position deviates from this value, the input current values where the tap changer resides are scaled to match the currents on the other side.

A correct scaling is determined by the number of steps, the direction of the deviation from the nominal tap and the percentage change in the voltage resulting from a deviation of one tap step. The percentage value is set via the *Step of tap* setting.

The operating range of the tap changer is defined by the *Min winding tap* and *Max winding tap* settings. The *Min winding tap* setting gives the tap position number resulting from the minimum effective number of winding turns on the side of the transformer where the tap changer is connected. Correspondingly, the *Max winding tap* setting gives the tap position number resulting from the maximum effective number of winding turns.

The *Min winding tap* and *Max winding tap* settings help the tap position compensation algorithm find the direction of the compensation. This also ensures that if the current

tap position information is corrupted, the automatic tap changer position adaptation does not try to adapt to any unrealistic position values.

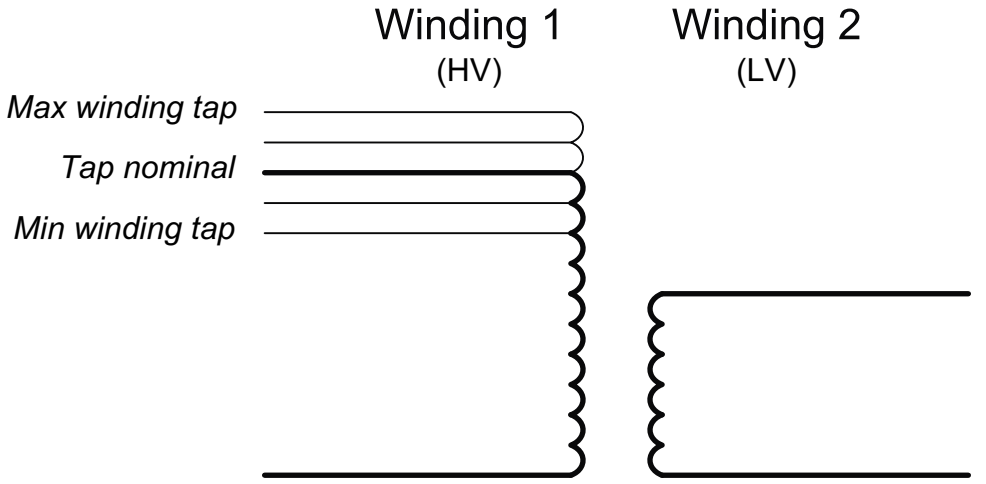



*Figure 349: Simplified presentation of the HV and LV windings of a two-winding transformer with demonstration of the settings Max winding tap, Min winding tap and Tap nominal*

The position value is available in the Monitored data view on LHMI or through other communication tools in TPOSYLTC. When the quality of the TAP_POS input value is not good, the position information in the TAP_POS input is not used, and the last value with the good quality information is used instead. In addition, the minimum sensitivity of the biased stage, set by the *Low operate value* setting, is automatically desensitized with the total range of the tap position correction. The new acting low operate value can be calculated.

$$Desensitized\ Low\ operate\ value = Low\ operate\ value + ABS(Max\ winding\ tap - Min\ winding\ tap) \cdot Step\ of\ tap$$

(Equation 116)

## Second harmonic blocking

Transformer-magnetizing inrush currents occur when the transformer is energized after a period of de-energization. The inrush current may be many times the rated current, and the half-life can be up to several seconds. To the differential protection relay, the inrush current represents a differential current that causes the protection relay to operate almost always when the transformer is connected to the network. Typically, the inrush current contains a large amount of second harmonics.

The blocking of the biased low stage of the protection relay at magnetizing inrush current is based on the ratio of the amplitudes of the second harmonic to the fundamental frequency component of the differential current (Id2f / Id1f).

The blocking also prevents an unwanted operation at recovery and a sympathetic magnetizing inrush. At recovery inrush, the magnetizing current of the transformer to be protected increases momentarily when the voltage returns to normal after the clearance of a fault outside the protected area. The sympathetic inrush is caused by the

energization of another transformer running in parallel with the protected transformer already connected to the network.

The ratio of the second harmonic to the fundamental component can vary considerably between the phases. Especially when the delta compensation is done for a Ynd1-connected transformer and the two phases of the inrush currents are otherwise equal but opposite in phase angle, their subtraction in a delta compensation results in a very small second harmonic component.

Because of the small second harmonic component, some action must be taken to avoid false tripping of the phase having a too low ratio of the second harmonic to the fundamental component. One way could be to block all phases when the second harmonic blocking conditions are fulfilled at least in one phase. The other way is to calculate weighted ratios of the second harmonic to the fundamental for each phase using the original ratios of the phases. The latter option is used here.

The ratio used for the second harmonic blocking is calculated as a weighted average on the basis of the ratios calculated from the differential currents of the three phases. The ratio of the phase has the most weight compared to the ratios of the other two phases (the weighting factors are 4, 1 and 1, where 4 is the factor of the phase). The operation of the biased stage on the phase is blocked if the weighted ratio of that phase is above the set *Start value 2.H* blocking limit and if the blocking is enabled through the *Restraint mode* setting.

Using separate blocking for the individual phases and weighted averages calculated for the separate phases provides a stable blocking scheme at connection inrush currents.

The switching of the power transformer onto fault inside the protected area does not delay the operation of the tripping, because in such a situation the blocking based on the second harmonic of the differential current is prevented by a separate algorithm based on the different waveform and the different rate of change of the normal inrush current and the inrush current containing the fault current. The algorithm does not eliminate the blocking at inrush currents unless there is a fault in the protected area.

The feature can be enabled and disabled through the *Harmonic deblock 2.* setting.

### Fifth harmonic blocking

The inhibition of the protection relay operation in situations of overexcitation is based on the ratio of the fifth harmonic to the fundamental component of the differential current (Id5f / Id1f). The ratio is calculated separately for each phase without weighting factors. If the ratio exceeds the set value of *Start value 5.H* and blocking is enabled through the *Restraint mode* setting, the operation of the biased stage of the protection relay in the phase is blocked.

At dangerous levels of overvoltage which may cause damage to the transformer, the blocking can be automatically eliminated. The blocking is removed if the ratio of the fifth harmonic to the fundamental component of the differential current exceeds the set value of the *Stop value 5.H* setting, and the blocking removal is enabled. The deblocking feature can be enabled or disabled with the *Harmonic deblock 5.* setting.

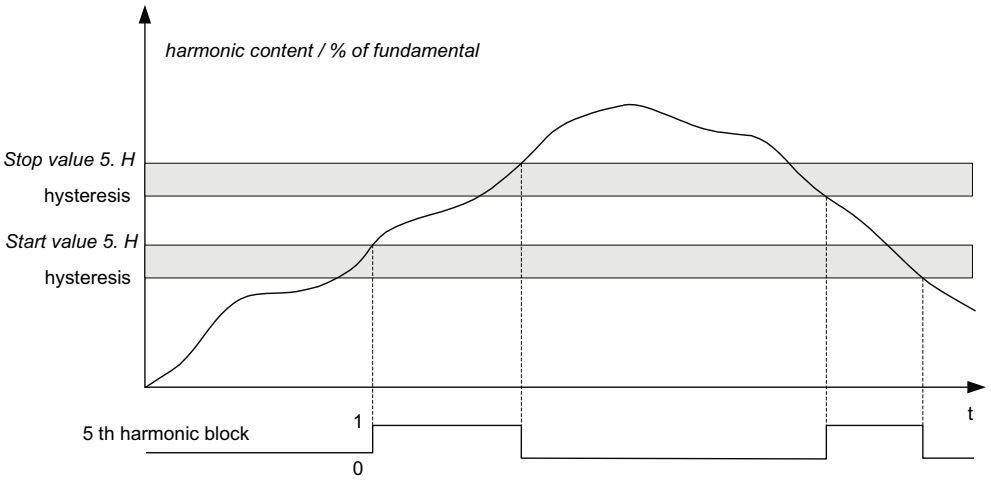



*Figure 350: The fifth harmonic blocking limits and the operation when both blocking and deblocking features are enabled through the Harmonic deblock 5. setting*

Fifth harmonic blocking has a hysteresis to avoid rapid fluctuation between TRUE and FALSE. The required consecutive fulfillments of the condition can be counted using the blocking counter. When the condition is not fulfilled, the counter is decreased (if >0).

Also fifth harmonic deblocking (based on the higher limit, *Stop value 5.H*, if enabled with *Harmonic deblock 5.*) has a hysteresis and a counter which counts the required consecutive fulfillments of the condition. When the condition is not fulfilled, the counter is decreased (if >0).

## Waveform blocking

The biased low stage can always be blocked with waveform blocking; it cannot be disabled with *Restraint mode*. This algorithm has two parts. The first part is intended for external faults while the second is intended for inrush situations. The algorithm has criteria for the low-current periods of differential current during the inrush and external fault.

## Blocking reset

All three blocking signals, that is, waveform and the second and fifth harmonic, have a counter or time limit which holds the blocking on for a certain time after the blocking conditions have ceased to be fulfilled. The deblocking takes place when the counters or time have elapsed. This is a normal case of deblocking.

The blocking signals can be reset immediately if a very high differential current is measured or if the phase difference (angle) between the compared currents is close to zero (in normal situations, the phase difference is 180 degrees).

### Biased low stage

Biasing of the current differential protection is needed since a possible appearance of a differential current can also be due to something else than an actual fault in the transformer (or generator).

In the case of transformer protection, there can be several reasons for the false differential current.

- CT errors
- Varying tap changer positions (if not automatically compensated)
- Transformer no-load current
- Transformer inrush currents
- Transformer overexcitation during overvoltage situations
- Transformer overexcitation during underfrequency situations
- CT saturation at high currents passing through the transformer

The differential current caused by CT errors and tap changer position increases at the same percentage ratio as the load current.

In the protection of generators, the false differential current can be caused by several reasons.

- CT errors
- CT saturation at high currents flowing through the generator

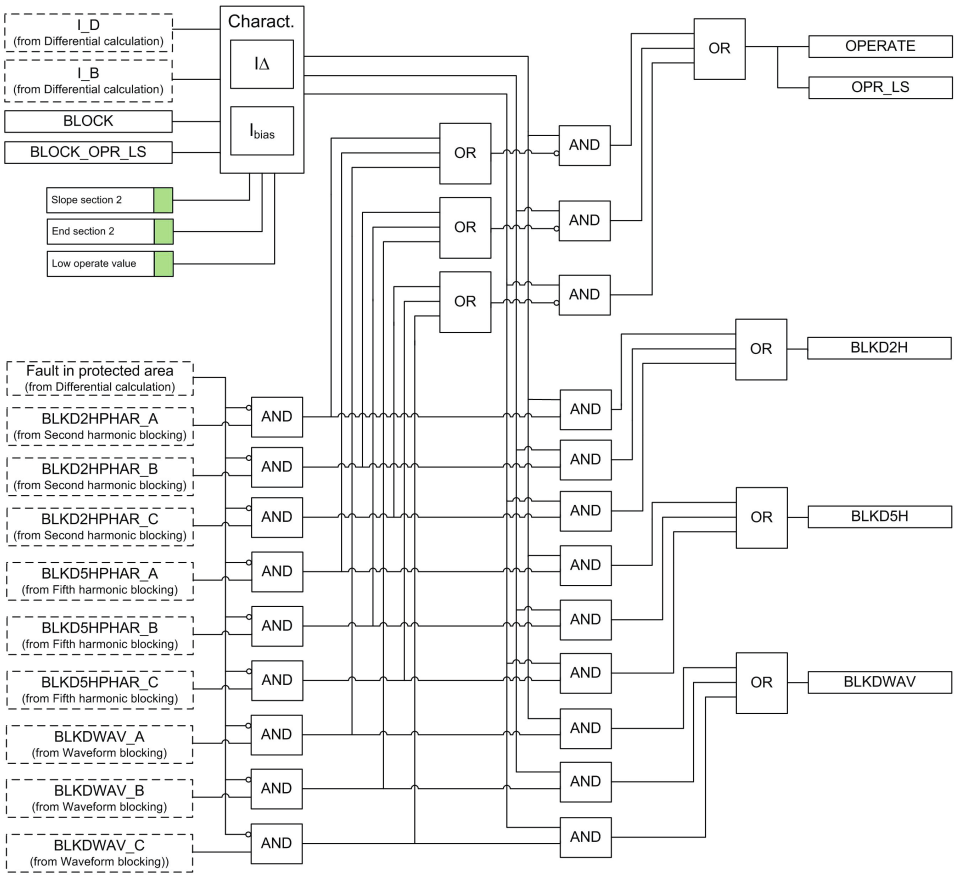



*Figure 351: Operation logic of the biased low stage*

The high currents passing through a protected object can be caused by the short circuits outside the protected area, the large currents fed by the transformer in a motor startup or transformer inrush situations. Therefore, the operation of the differential protection is biased with respect to the load current. In biased differential protection, the higher the differential current required for the protection to trip, the higher the load current.

The operation characteristic of the biased low stage is determined by *Low operate value*, *Slope section 2* and the second turning point setting of the operating characteristic curve, *End section 2* (the first turning point and the slope of the last part of the characteristic are fixed). The settings are the same for each phase. When the differential current exceeds the operating value determined by the operating characteristic, the differential function is activated. If the differential current stays above the operating value continuously for a suitable period, the `OPR_LS` output is activated. The activation of the `OPR_LS` output activates the `OPERATE` output.

The stage can be blocked internally by the second or the fifth harmonic restraint, or by special algorithms detecting the inrush and current transformer saturation at external faults. When the operation of the biased low stage is blocked by the second harmonic blocking functionality, the `BLKD2H` output is activated.

The BLKD5H output is activated when the biased low stage is blocked by the fifth harmonic blocking functionality. Correspondingly, when the operation of the biased low stage is blocked by the waveform blocking functionality, the BLKDWAV output is activated according to the phase information.

When required, the operating outputs of the biased low stage can be blocked by the external control signals BLK_OPR_LS and BLOCK.

The operation of the protection relay is affected by biasing as shown in Figure 352.

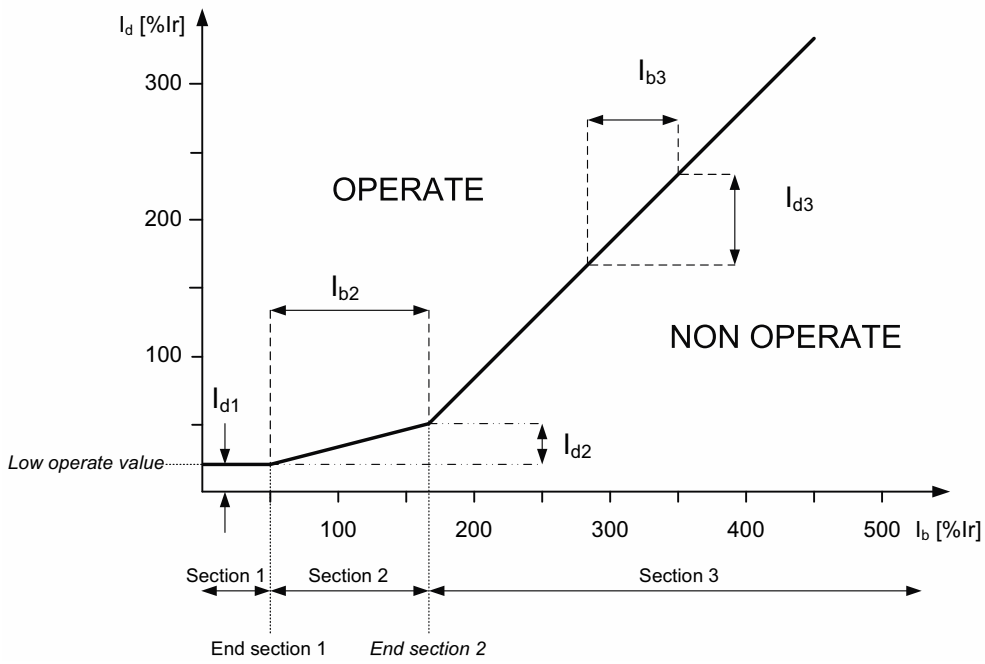



*Figure 352: Operation characteristic for biased operation of TR3PTDF*

The *Low operate value* setting of the biased stage of the differential function is determined according to the operating characteristics curve:

$$Low\,operate\,value = Id1$$

(Equation 117)

The *Slope section 2* setting is determined correspondingly:

$$Slope\ section\ 2 = \frac{Id2}{Ib2} \cdot 100\,\%$$

(Equation 118)

The second turning point *End section 2* can be set in the range 100...500%.

The slope of the operating characteristic curve of the differential function varies in three different sections of the range.

*Table 592: Different sections of the range and their operation*

| Sections | Operation |
|---|---|
| Section 1 | In section 1, where 0 percent Ir < Ib < End section 1, with End section 1 being fixed to 50 percent of Ir, the differential current required for tripping is constant. The value of the differential current is the same as the *Low operate value* selected for the function. The *Low operate value* setting allows for the no-load current of the power transformer and small inaccuracies of the current transformers, but it can also be used to influence the overall level of the operation characteristic. At the rated current, the no-load losses of the power transformer are about 0.2 percent. If the supply voltage of the power transformer suddenly increases due to operational disturbances, the magnetizing current of the transformer increases as well. In general, the magnetic flux density of the transformer is rather high at the rated voltage and the rise in voltage by a few percent causes the magnetizing current to increase by tens percent. This should be considered in *Low operate value*. |
| Section 2 | Section 2, where End section 1 < Ib < *End section 2*, is called the influence area of *Slope section 2*. In this section, the variations in the starting ratio affect the slope of the characteristic, that is, how big a change in the differential current is required for tripping compared to the change in the load current. The starting ratio should consider CT errors and variations in the transformer tap changer position (if not compensated). Too high a starting ratio should be avoided, because the sensitivity of the protection for detecting inter-turn faults depends on the starting ratio. |
| Section 3 | In section 3, where Ib > *End section 2*, the slope of the characteristic is constant. The slope is 100 percent, which means that the increase in the differential current is equal to the corresponding increase in the biasing current. |

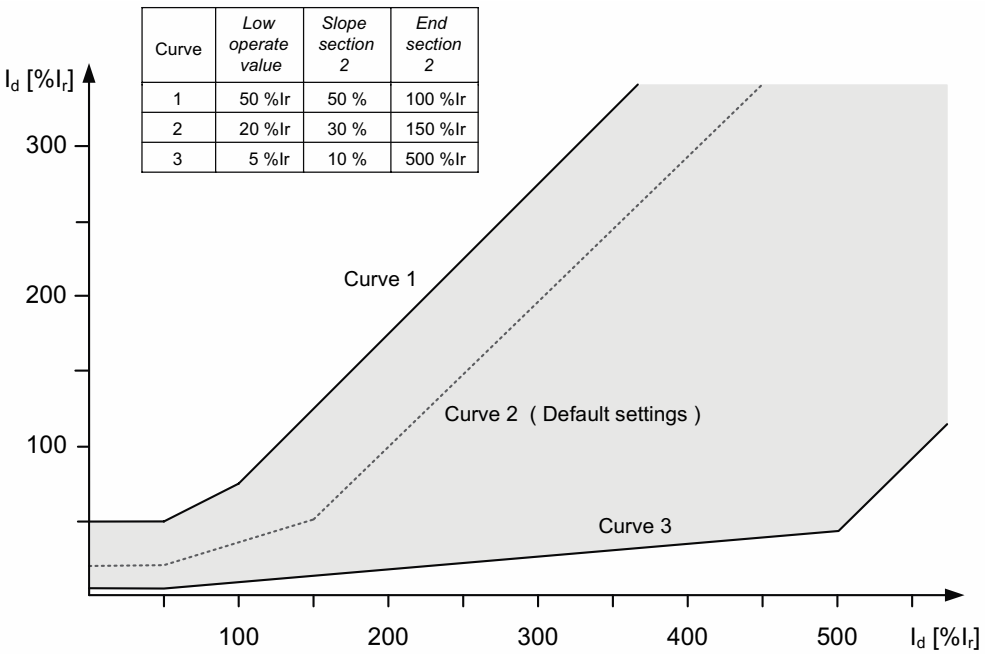



*Figure 353: Setting range for biased low stage*

If the biasing current is small compared to the differential current or if the phase angle between the currents of two windings with the highest phase current is close to zero (normally, the phase difference is 180 degrees) or the phase angle between the compared phase currents (in case of two-winding transformer) is close to zero, a fault

has most certainly occurred in the area protected by the differential protection relay. The internal blocking signals of the biased stage are inhibited.

The operation of the differential protection is based on the fundamental frequency components. The operation is accurate and stable: the DC component and harmonics of the current do not cause unwanted operations.

## Instantaneous high stage

Instantaneous high stage can be enabled or disabled with the *Enable high set* setting. The corresponding parameter values are "True" and "False".

The operation of Instantaneous high stage is not biased. The instantaneous stage operates and the OPR_HS output is activated when the amplitude of the fundamental frequency component of the differential current exceeds the set operation value *High operate value* or when the instantaneous value of the differential current exceeds 2.5 · *High operate value*. The value 2.5 (=1.8 · √2) is due to the maximum asymmetric short circuit current.

If the biasing current is small compared to the differential current, or if the phase angle between the currents of the two windings with the highest phase current is close to zero (normally, the phase difference is 180 degrees) or the phase angle between the compared phase currents (in case of a two-winding transformer) is close to zero, a fault has occurred in the area protected by the differential protection. The operating value set for the instantaneous stage is automatically halved and the internal blocking signals of the biased stage are inhibited.

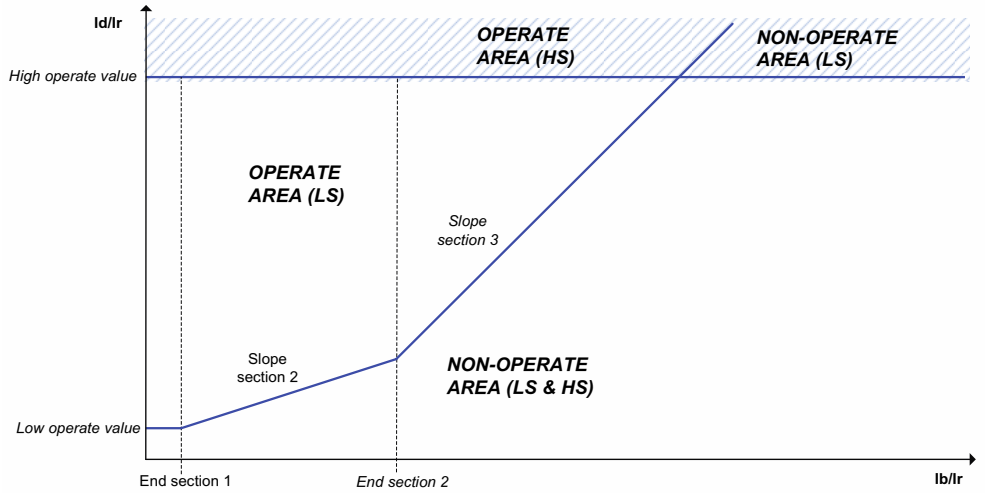



*Figure 354: Operating characteristics of the protection. LS stands for the biased low stage and HS for the instantaneous high stage.*

The OPERATE output is always activated with the OPR_HS output. The internal blocking signals of the differential function do not prevent the trip signal of the instantaneous differential current stage from being activated. When required, the operating outputs of Instantaneous high stage can be blocked by the external control signals BLK_OPR_HS or BLOCK.

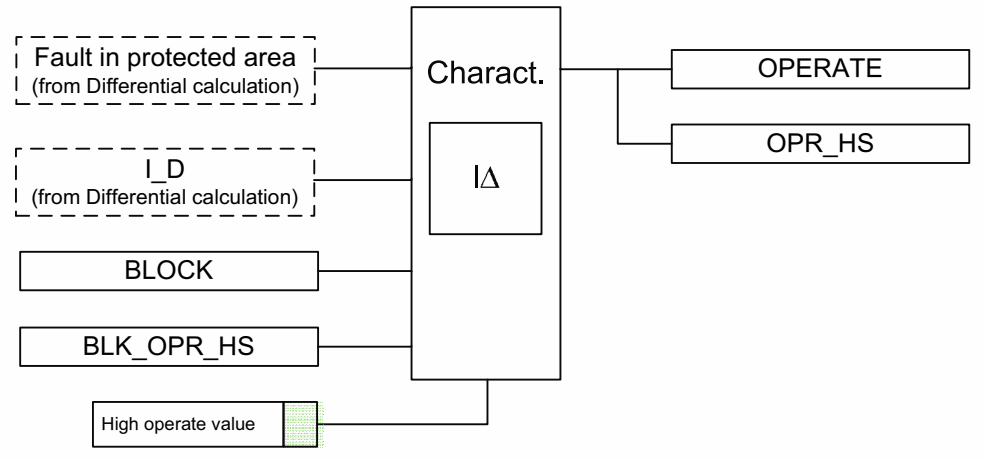



*Figure 355: Operation logic of Instantaneous high stage*

### External blocking functionality

TR3PTDF has three inputs for blocking.

| Blocking inputs | Description |
|---|---|
| BLOCK | When active (TRUE), the operation of the function is blocked; only measurement value outputs are updated. |
| BLK_OPR_LS | When active (TRUE), TR3PTDF acts normally except that the OPR_LS output is not active or activated in any circumstances. Additionally, the OPERATE output can be activated only by the instantaneous high stage (if not blocked). |
| BLK_OPR_HS | When active (TRUE), TR3PTDF acts normally except that the OPR_HS output is not active or activated in any circumstances. Additionally, the OPERATE output can be activated only by the biased low stage (if not blocked). |

## 4.3.3.6 Current transformer connections and transformation ratio correction

The combinations of the connections of the primary current transformers are designated as "Type 1" and "Type 2". The type needs to be selected separately for the combination of CT connections on the winding 1 and 2 sides as well as for the combination of CT connections on the winding 1 and 3 sides in case of three-winding transformer.

- If the positive directions of the winding 1 and winding 2 relay currents are opposite, the setting parameter *CT connection 1-2* is "Type 1", as shown in Figure 356
- If the positive directions of the winding 1 and winding 2 relay currents are equal, the setting parameter *CT connection 1-2* is "Type 2", as shown in Figure 357
- The default value of the *CT connection 1-2* settings is "Type 1".
- The same applies for the *CT connection 1-3* settings.

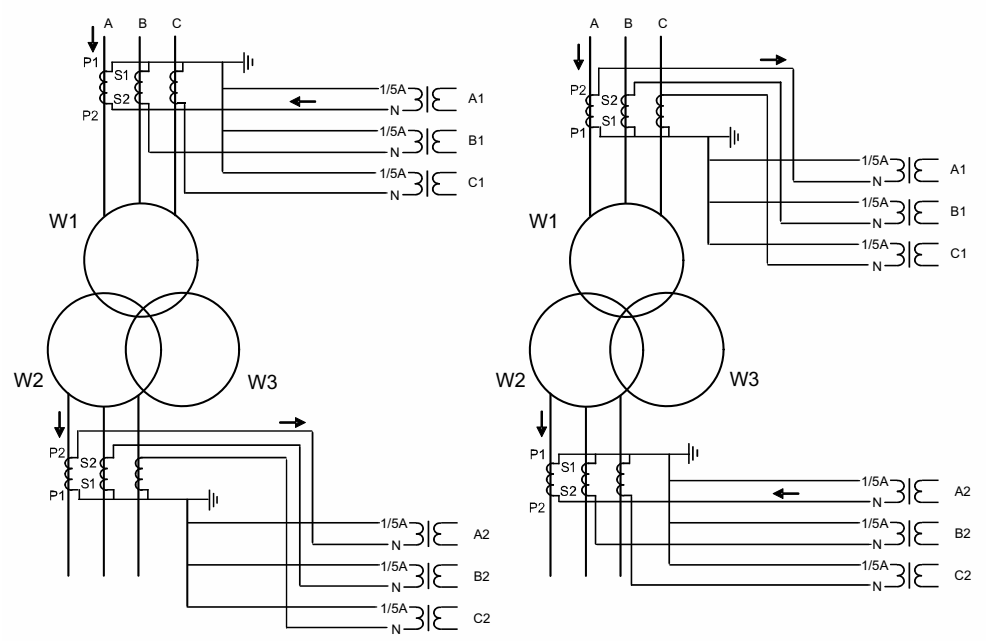



*Figure 356: Connection of current transformers of Type 1 and example of currents during an external fault*

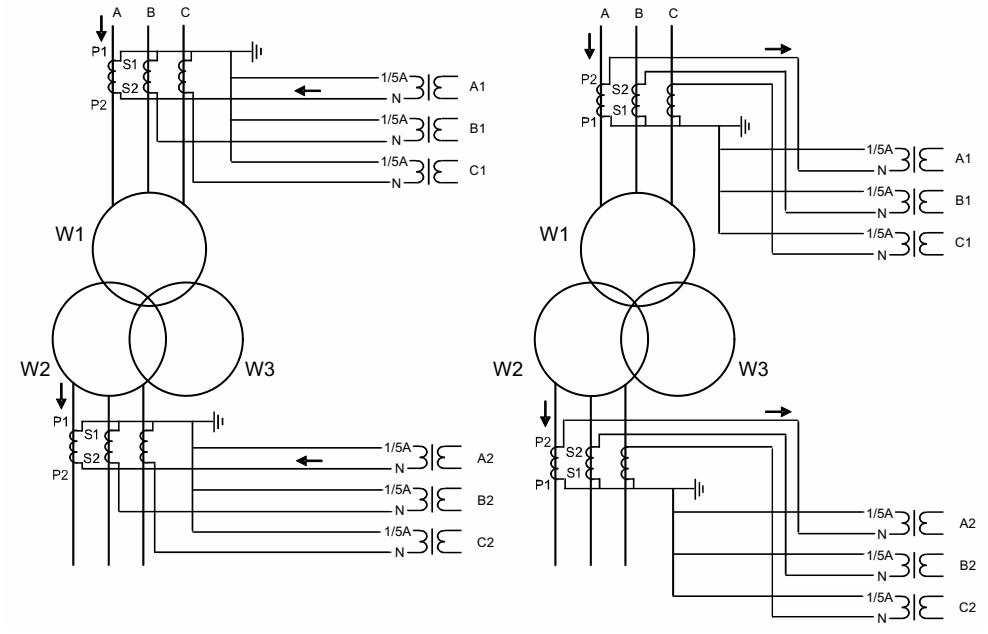



*Figure 357: Connection of current transformers of Type 2 and example of currents during an external fault*

Similar connections are done for a three-winding transformer.

If the rated primary current of the current transformers is not equal to the rated current of the power transformer on a side of the transformer, setting parameters *CT ratio Cor*

*Wnd 1*, *CT ratio Cor Wnd 2* and *CT ratio Cor 3* must be used to correct the transformation ratios. *CT ratio Cor Wnd 1* and *CT ratio Cor Wnd 2* are used to correct the ratios on winding 1 and 2 while the use of *CT ratio Cor 3* depends on the setting *Current group 3 type*. If *Current group 3 type* is "Winding 3", the *CT ratio Cor 3* setting is used to correct the ratios on winding 3. If *Current group 3 type* is "Wnd 2 restraint", the ratio correction is made to the ratios of the second restraint on winding 2. If *Current group 3 type* is "Wnd 1 restraint", the ratio correction is made to the ratios of the second restraint on winding 1.

### 4.3.3.7 Application

TR3PTDF is a unit protection. It acts as the main protection of transformers in case of winding failure. The protective zone of a differential protection includes the transformer itself and the bus work or cables between the current transformer and the power transformer. When bushing current transformers are used for the differential protection relay, the protective zone does not include the bus work or cables between the circuit breaker and the power transformer.

In some substations, there is a current differential protection for the busbar. Such a busbar protection includes the bus work or cables between the circuit breaker and the power transformer. The internal electrical faults are serious and cause immediate damage. The short circuits and earth faults in the windings and terminals are normally detected by the differential protection. Inter-turn faults, which are flashovers between conductors within the same physical winding, can also be detected if a large enough number of turns are short-circuited. Inter-turn faults are the most difficult transformer winding faults to detect with electrical protections. A small inter-turn fault including just a few turns results in an undetectable amount of current until it develops into an earth fault. Therefore the differential protection must have a high level of sensitivity and it must be possible to use a sensitive setting without causing unwanted operations for external faults.

The faulty transformer must be disconnected as fast as possible. As the differential protection is a unit protection, it can be designed for fast tripping, thus providing a selective disconnection of the faulty transformer. The differential protection should not operate because of faults outside the protective zone.

A transformer differential protection compares the current flowing into the transformer to the current leaving the transformer. A correct analysis of fault conditions by the differential protection must consider changes to voltages, currents and phase angles. The traditional transformer differential protection functions required auxiliary transformers for the correction of the phase shift and ratio. The numerical microprocessor-based differential algorithm implemented in TR3PTDF compensates for both the turns ratio and the phase shift internally in the software.

The differential current should theoretically be zero during a normal load or external faults if the turns ratio and phase shift are correctly compensated. However, there are several different phenomena other than internal faults that cause unwanted and false differential currents. There can be several main reasons for unwanted differential currents.

- Mismatch due to varying tap changer positions
- Different characteristics, loads and operating conditions of the CTs
- Zero-sequence currents that flow only on one side of the power transformer
- Normal magnetizing currents
- Magnetizing inrush currents
- Overexcitation of magnetizing currents

TR3PTDF is designed mainly for protection of two-winding or three-winding transformers. TR3PTDF can also be used for the protection of generator-transformer blocks as well as short cables and overhead lines. If the distance between the measuring points is relatively long in line protection, interposing CTs might be needed to reduce the burden of the CTs. For the interposing CT, the accuracy limit factor must fulfill the same requirements as for the main CTs. The interposing CT imposes an additional burden to the main CTs.

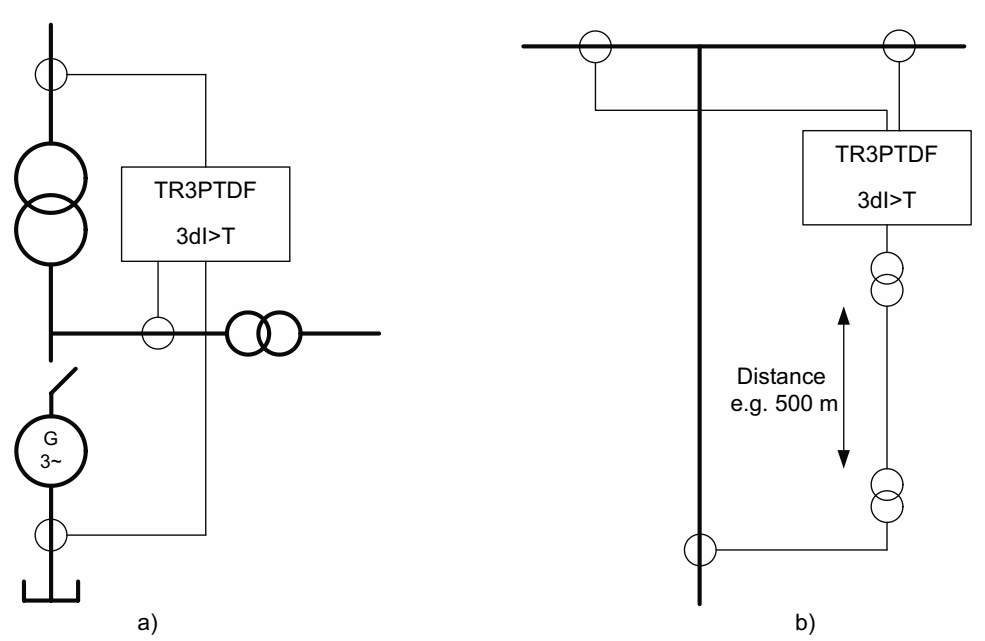



*Figure 358: Differential protection of a generator-transformer block and short cable or line*

TR3PTDF can be used in three-winding transformer applications or two-winding transformer applications with two output feeders.

On the double-feeder side of the two-winding power transformer, the currents from the other feeder are connected to the third three-phase current set of the protection relay (*Current group 3 type* to be set as "Wnd 2 restraint").

If the double-feeder side is on the input side of the transformer, *Current group 3 type* must be set as "Wnd 1 restraint".

In three-winding transformer applications, currents from winding 3 are always connected to the third three-phase current input set of the protection relay (*Current group 3 type* to be set as "Winding 3").

In the normal two-winding transformer application with one set of three-phase currents on both sides of the transformer, the *Current group 3 type* setting must be set as "Not in use".

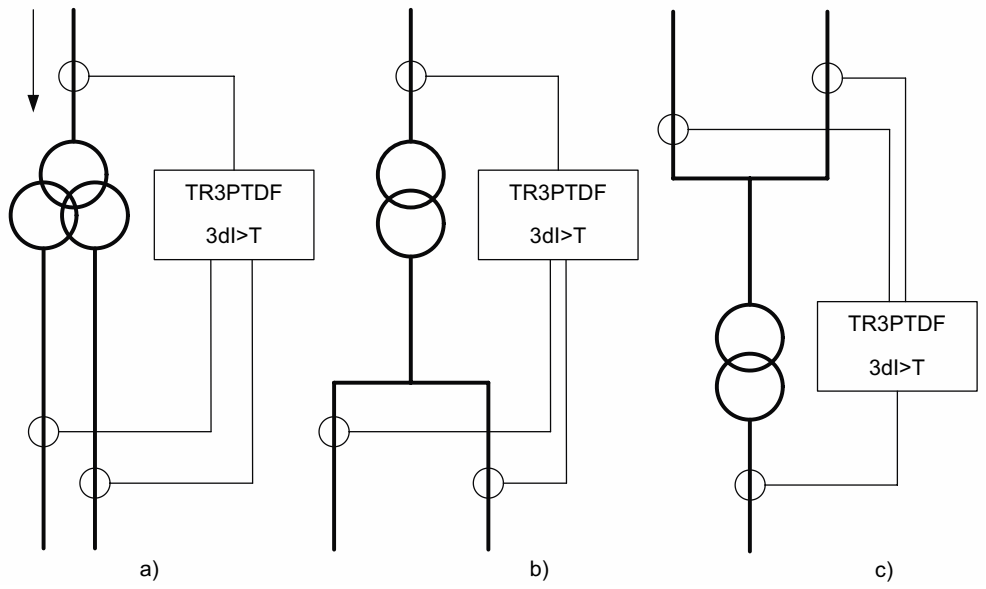



*Figure 359: Differential protection of a three-winding transformer, transformer with two output feeders and transformer with two input feeders*

## Transforming ratio correction of CTs

The CT secondary currents often differ from the rated current at the rated load of the power transformer. The CT transforming ratios can be corrected on all sides of the power transformer with the CT ratio correction settings.

$$I_{nT} = \frac{S_n}{\sqrt{3} \cdot U_n}$$

(Equation 119)

$I_{nT}$ Rated load of the power transformer

$S_n$ Rated power of the power transformer

$U_n$ Rated phase-to-phase voltage

### Two-winding transformer with one set of currents on both sides of the transformer

The rated power of the transformer is 25 MVA, the ratio of the CTs on the 110 kV side is 300/1 and that on the 21 kV side is 1000/1.

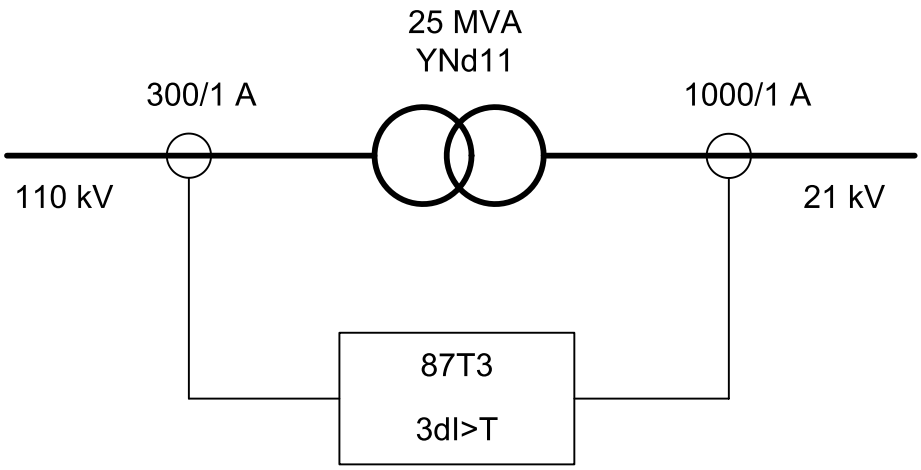



*Figure 360: Example of two-winding power transformer differential protection*

The rated load of the transformer can be calculated.

HV side: $I_{nT_Wnd1}$ = 25 MVA / (1.732 · 110 kV) = 131.2 A

LV side: $I_{nT_Wnd2}$ = 25 MVA / (1.732 · 21 kV) = 687.3 A

TR3PTDF settings:

*CT ratio Cor Wnd 1* = 300 A / 131.2 A = 2.29

*CT ratio Cor Wnd 2* = 1000 A / 687.3 A = 1.45

*CT ratio Cor 3* is not applicable in this case.

*Current group 3 type* = "Not in use"

*Phase Ref winding* = "Winding 1" (source of power)

*Zro A elimination* = "Winding 1" (if winding 1 neutral is earthed)

*Phase shift Wnd 1-2* = "330 deg" (for clock number 11)

### Vector group matching and elimination of the zero-sequence component

The vector group of the power transformer is numerically matched on the windings on different sides of the transformer by the *Phase shift Wnd 1-2* and *Phase shift Wnd 1-3* settings. Thus no interposing CTs are needed if there is only a power transformer inside the protected zone. The matching is based on phase shifting and a numerical delta connection in the function.

If the neutral of a star-connected power transformer is earthed, any earth fault in the network is perceived by the protection as differential current. The elimination of the zero-sequence component can be selected to be on or off for that winding by the *Zro A elimination* setting. By default, the elimination is done for every winding.

## Commissioning

The settings for the connection group compensation (*CT connection 1-2*, *Phase shift Wnd 1-2* and, in case of a three-winding transformer, also *CT connection 1-3* and *Phase shift Wnd 1-3* settings) can be verified by monitoring the angle values (I_ANGL_A1_B1, I_ANGL_B1_C1, I_ANGL_C1_A1, I_ANGL_A2_B2, I_ANGL_B2_C2, I_ANGL_C2_A2, I_ANGL_A1_A2, I_ANGL_B1_B2 and I_ANGL_C1_C2 and in case of three-winding transformer also I_ANGL_A3_B3, I_ANGL_B3_C3, I_ANGL_C3_A3, I_ANGL_A1_A3, I_ANGL_B1_B3 and I_ANGL_C1_C3) when injecting the current into the transformer. These angle values are calculated from the compensated currents.

When a station service transformer is available, it can be used to provide current into the winding 1 side, for example, HV windings, while the winding 2 side, for example, LV windings are short-circuited, as shown in Figure 361 (in case of a three-winding transformer, the tertiary winding side is short-circuited). This way the current can flow both in high-voltage and low-voltage windings (and in winding 3 in case of three-winding transformer). The commissioning signals can also be provided through other means. The currents need to be at least 0.015 pu to allow the phase current and angle monitoring.

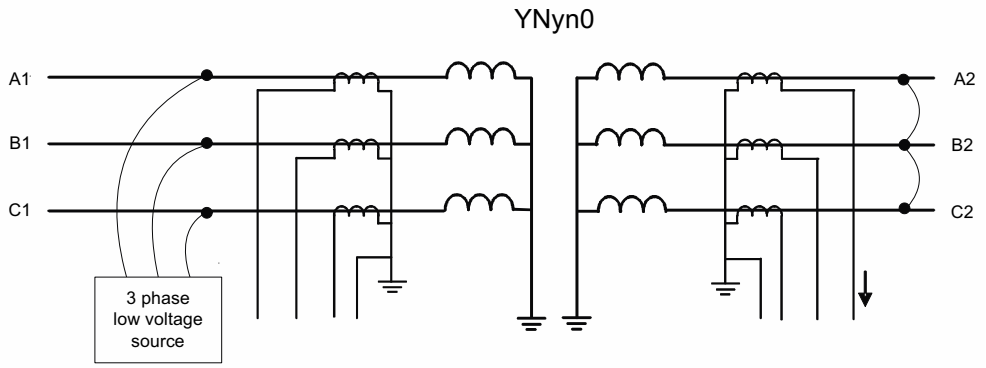



*Figure 361: Low-voltage test arrangement. The three-phase low-voltage source can be the station service transformer, for example.*

The control setting *Tapped winding* should be set to value "Not in use" to ensure that the monitored current values are not scaled by the automatic adaptation to the tap changer position. When only the angle values are taken, this is not needed since the angle values are not affected by the tap changer position.

When injecting the currents into the HV winding, the angle values I_ANGL_A1_B1, I_ANGL_B1_C1, I_ANGL_C1_A1, I_ANGL_A2_B2, I_ANGL_B2_C2 and I_ANGL_C2_A2, and in case of three winding transformer, I_ANGL_A3_B3, I_ANGL_B3_C3 and I_ANGL_C3_A3, should be +120.

Otherwise, the phase order may be wrong or the polarity of one current transformer differs from the polarities of the other current transformers on the same side. If the angle values I_ANGL_A1_B1, I_ANGL_B1_C1 and I_ANGL_C1_A1 show -120°, the phase order is wrong on winding 1, for example, the high-voltage side. If the angle

values I_ANGL_A2_B2, I_ANGL_B2_C2 and I_ANGL_C2_A2 show -120°, the phase order is wrong on winding 2, for example, the low-voltage side. If the angle values I_ANGL_A3_B3, I_ANGL_B3_C3 and I_ANGL_C3_A3 show -120°, the phase order is wrong on winding 3, for example, the tertiary side. If the angle values I_ANGL_A1_B1, I_ANGL_B1_C1 and I_ANGL_C1_A1 do not show the same value (+120°), the polarity of one current transformer may be wrong. For example, if the polarity of the current transformer measuring IL2 is wrong, I_ANGL_A1_B1 shows -60°, I_ANGL_B1_C1 shows -60° and I_ANGL_C1_A1 shows +120°.

When the phase order and the angle values are correct, the angle values I_ANGL_A1_A2, I_ANGL_B1_B2 and I_ANGL_C1_C2 should show ±180° and in case of a three-winding transformer, also the angle values I_ANGL_A1_A3, I_ANGL_B1_B3 and I_ANGL_C1_C3 should show ±180°. There can be several reasons if this is not the case. If the angle values are 0, most probably the value given for *CT connection 1-2* (or *CT connection 1-3*) is wrong. If the angle values are something else, the value for *Phase shift Wnd 1-2* or *Phase shift Wnd 1-3* may be wrong.

*Table 593: Angle outputs when settings CT connection 1-2 and CT connection 1-3 match the actual CT connections on windings 1, 2 and 3*

| Angle output name | Angle value | Possible reason if not OK |
|---|---|---|
| I_ANGL_A1_B1 | +120 | OK |
| I_ANGL_B1_C1 | +120 | OK |
| I_ANGL_C1_A1 | +120 | OK |
| I_ANGL_A2_B2 | +120 | OK |
| I_ANGL_B2_C2 | +120 | OK |
| I_ANGL_C2_A2 | +120 | OK |
| I_ANGL_A3_B3 | +120 | OK |
| I_ANGL_B3_C3 | +120 | OK |
| I_ANGL_C3_A3 | +120 | OK |
| I_ANGL_A1_A2 | ±180 | OK |
| I_ANGL_B1_B2 | ±180 | OK |
| I_ANGL_C1_C2 | ±180 | OK |
| I_ANGL_A1_A3 | ±180 | OK |
| I_ANGL_B1_B3 | ±180 | OK |
| I_ANGL_C1_C3 | ±180 | OK |

*Table 594: Angle outputs when settings CT connection 1-2 and CT connection 1-3 match the actual CT connections on windings 1, 2 and 3 but the phase order is wrong on winding 1*

| Angle output name | Angle value | Possible reason if not OK |
|---|---|---|
| I_ANGL_A1_B1 | -120 | Wrong phase order |
| I_ANGL_B1_C1 | -120 | Wrong phase order |
| I_ANGL_C1_A1 | -120 | Wrong phase order |
| Table continues on next page | | |

| Angle output name | Angle value | Possible reason if not OK |
|---|---|---|
| I_ANGL_A2_B2 | +120 | OK |
| I_ANGL_B2_C2 | +120 | OK |
| I_ANGL_C2_A2 | +120 | OK |
| I_ANGL_A3_B3 | +120 | OK |
| I_ANGL_B3_C3 | +120 | OK |
| I_ANGL_C3_A3 | +120 | OK |
| I_ANGL_A1_A2 | +60 | Winding 1 phase B connected as phase A |
| I_ANGL_B1_B2 | -60 | Winding 1 phase A connected as phase B |
| I_ANGL_C1_C2 | ±180 | OK |
| I_ANGL_A1_A3 | +60 | Winding 1 phase B connected as phase A |
| I_ANGL_B1_B3 | -60 | Winding 1 phase A connected as phase B |
| I_ANGL_C1_C3 | ±180 | OK |

*Table 595: Angle outputs when settings CT connection 1-2 and CT connection 1-3 match the actual CT connections on windings 1, 2 and 3 but the phase order is wrong on winding 2*

| Angle output name | Angle value | Possible reason if not OK |
|---|---|---|
| I_ANGL_A1_B1 | +120 | OK |
| I_ANGL_B1_C1 | +120 | OK |
| I_ANGL_C1_A1 | +120 | OK |
| I_ANGL_A2_B2 | -120 | Wrong phase order |
| I_ANGL_B2_C2 | -120 | Wrong phase order |
| I_ANGL_C2_A2 | -120 | Wrong phase order |
| I_ANGL_A3_B3 | +120 | OK |
| I_ANGL_B3_C3 | +120 | OK |
| I_ANGL_C3_A3 | +120 | OK |
| I_ANGL_A1_A2 | -60 | Winding 2 phase B connected as phase A |
| I_ANGL_B1_B2 | +60 | Winding 2 phase A connected as phase B |
| I_ANGL_C1_C2 | ±180 | OK |
| I_ANGL_A1_A3 | ±180 | OK |
| I_ANGL_B1_B3 | ±180 | OK |
| I_ANGL_C1_C3 | ±180 | OK |

*Table 596: Angle outputs when settings CT connection 1-2 and CT connection 1-3 match the actual CT connections on windings 1, 2 and 3 but the phase B polarity is wrong compared to other phases on winding 2*

| Angle output name | Angle value | Possible reason if not OK |
|---|---|---|
| I_ANGL_A1_B1 | +120 | OK |
| I_ANGL_B1_C1 | +120 | OK |
| I_ANGL_C1_A1 | +120 | OK |
| I_ANGL_A2_B2 | -60 | Wrong polarity phase B |
| I_ANGL_B2_C2 | -60 | Wrong polarity phase B |
| I_ANGL_C2_A2 | +120 | OK |
| I_ANGL_A3_B3 | +120 | OK |
| I_ANGL_B3_C3 | +120 | OK |
| I_ANGL_C3_A3 | +120 | OK |
| I_ANGL_A1_A2 | ±180 | OK |
| I_ANGL_B1_B2 | 0 | Winding 2, wrong polarity phase B |
| I_ANGL_C1_C2 | ±180 | OK |
| I_ANGL_A1_A3 | ±180 | OK |
| I_ANGL_B1_B3 | ±180 | OK |
| I_ANGL_C1_C3 | ±180 | OK |

### 4.3.3.8 Recommendations for current transformers

The more important the object to be protected, the more attention should be paid to the CTs. Normally, it is not possible to dimension the CTs so that they repeat currents with high DC components without saturating when the residual flux of the current transformer is high. TR3PTDF operates reliably even though the CTs are partially saturated. The purpose of the following current transformer recommendations is to secure the stability of the relay at high through-currents and the quick and sensitive operation of the relay at faults occurring in the protected area where the fault currents can be high.

The accuracy class recommended for CTs to be used with TR3PTDF is 5P, where the limit of the current error at the rated primary current is 1 percent and the limit of the phase displacement is 60 minutes. The limit of the composite error at the rated accuracy limit primary current is 5 percent.

The approximate value of the accuracy limit factor $F_a$ corresponding to the actual CT burden can be calculated on the basis of the rated accuracy limit factor $F_n$ (ALF) at the rated burden, the rated burden $S_n$, the internal burden $S_{in}$ and the actual burden $S_a$ of the CT.

$$F_a = F_n \cdot \frac{S_{in} + S_n}{S_{in} + S_a}$$

(Equation 120)

## Example 1

In the example, the rated burden $S_n$ of the CTs 5P20 is 10 VA, the secondary rated current 5A, the internal resistance $R_{in}$ = 0.07 Ω and the accuracy limit factor $F_n$(ALF) corresponding to the rated burden is 20 (5P20). The internal burden of the current transformer is $S_{in} = (5\ A)^2 \cdot 0.07\ \Omega = 1.75$ VA. The input impedance of the relay at a rated current of 5 A is < 20 mΩ. If the measurement conductors have a resistance of 0.113 Ω, the actual burden of the current transformer is $S_a = (5\ A)^2 \cdot (0.113 + 0.020)\ \Omega = 3.33$ VA. Thus the accuracy limit factor $F_a$ corresponding to the actual burden is 46.

The CT burden can grow considerably at the rated current of 5 A. At the rated current of 1 A, the actual burden of the current transformer decreases, while the repeatability simultaneously improves.

At faults occurring in the protected area, the fault currents can be very high compared to the rated currents of the CTs. Due to the instantaneous stage of the differential function block, it is enough that during the first cycle, the CTs can repeat the current required for instantaneous tripping.

The CTs should be able to reproduce the asymmetric fault current without saturating within the next 10 ms after the occurrence of the fault, to secure that the operating times of the protection relay comply with the times stated in the Technical data section.

The accuracy limit factors corresponding to the actual burden of the phase current transformer to be used in differential protection fulfill the requirement of the equation.

$$Fa > K_r \ I_{kmax} \cdot (T_{dc} \cdot \omega \cdot (1 - e^{-\frac{Tm}{Tdc}}) + 1)$$

(Equation 121)

| | |
|---|---|
| $I_{kmax}$ | Maximum through-going fault current (in pu) at which the protection is not allowed to operate |
| $T_{dc}$ | Primary DC time constant related to $I_{kmax}$ |
| ω | Angular frequency, that is, 2 · π · 50 Hz |
| $T_m$ | Time to saturate, that is, the duration of the saturation-free transformation |
| $K_r$ | Remanence factor, 1/(1-r) |

The parameter *r* gives the maximum remanence flux density in the CT core. The value of the parameter *r* depends on the magnetic material used and on the construction of the CT. For example, the value *r* = "0.4" means that the remanence flux density may be 40 percent of the saturation flux density. The manufacturer of the CT should be contacted when an accurate value for the parameter *r* is needed. The value *r* = "0.4" is recommended to be used when an accurate value is not available.

The minimum time to saturate ($T_m$) in TR3PTDF is 10 ms.

Two typical cases considered for the determination of the sufficient accuracy limit factor ($F_a$) are a fault occurring at the substation bus and re-energizing against a fault occurring further down in the network.

## A fault occurring at the substation bus

The protection must be stable when a fault occurs during a normal operating situation. Re-energizing the transformer against a bus fault leads to very high fault currents and thermal stress. Therefore, re-energizing is not preferred in this case.

With this assumption, the remanence can be neglected.

The maximum through-going fault current $I_{kmax}$ is typically 10 pu for a substation's main transformer. At a short circuit fault close to the supply transformer, the DC time constant ($T_{dc}$) of the fault current is almost the same as that of the transformer, the typical value being 100 ms.

$$F_a > K_r \cdot I_{kmax} \cdot (T_{dc} \cdot \omega \cdot (1 - e^{-\frac{Tm}{Tdc}}) + 1) \approx 40$$

(Equation 122)

$I_{kmax}$ 10 (pu)

$T_{dc}$ 100 (ms)

ω 100π (Hz)

$T_m$ 10 (ms)

$K_r$ 1

## Re-energizing against a fault occurring further down in the network

The protection must be stable during the re-energization against a fault on the line. In this case, the existence of remanence is very probable. In this example, it is 40 percent.

The fault current is now smaller and since the ratio of the resistance to the reactance is greater in this location, having a full DC offset is not possible. Furthermore, the DC time constant ($T_{dc}$) of the fault current is now smaller, here 50 ms.

Assuming a maximum fault current is 30 percent lower than in the bus fault and a DC offset 90 percent of the maximum

$$F_a > K_r \cdot I_{kmax} \cdot 0.9 \cdot (T_{dc} \cdot \omega \cdot (1 - e^{-\frac{Tm}{Tdc}}) + 1) \approx 40$$

(Equation 123)

$I_{kmax}$ 0.7 · 10 = 7 (pu)

$T_{dc}$ 50 (ms)

ω 100π (Hz)

$T_m$ 10 (ms)

$K_r$ 1/(1-0.4) = 1.6667

If the actual burden of the current transformer ($S_a$) in Equation 120 cannot be reduced enough to provide a sufficient value for $F_a$, there are two alternatives.

- A current transformer with a higher rated burden $S_n$ can be chosen (which also means a higher rated accuracy limit $F_n$) or
- A current transformer with a higher nominal primary current $I1_n$ (but the same rated burden) can be chosen.

### Example 2

Assuming that the actions according to the current transformer with a higher nominal primary current $I1_n$ (but the same rated burden) are taken to improve the actual accuracy limit factor ($F_a$):

| | |
|---|---|
| $I_{rTR}$ = 1000 A | Rated secondary current of the transformer |
| $I_{rCT}$ = 1500 A | Rated primary current of the CT on the transformer secondary side |
| $F_n$ = 30 | Rated accuracy limit factor of the CT |
| $F_a = (I_{rCT} / I_{rTR}) \cdot F_n$ | Actual accuracy limit factor due to oversizing the CT |

$$F_a = (1500/1000) \cdot 30 = 45$$

In differential protection it is important that the accuracy limit factors ($F_a$) at both sides of the phase CTs correspond with each other, that is, the burdens of the CTs on both sides should be as equal as possible. If high inrush or start currents with high DC components flow through the protected object when it is connected to the network, special attention should be paid to the performance and the burdens of the CTs and to the settings of the function block.

## 4.3.3.9 Signals

*Table 597: TR3PTDF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| I3P3 | SIGNAL | - | Three-phase currents 3 |
| BLOCK | BOOLEAN | 0=False | Block |
| BLK_OPR_LS | BOOLEAN | 0=False | Blocks operate outputs from biased stage |
| BLK_OPR_HS | BOOLEAN | 0=False | Blocks operate outputs from instantaneous stage |
| TAP_POS | INT8 | 0 | Tap position indication |

*Table 598: TR3PTDF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate combined |
| OPR_LS | BOOLEAN | Operate from low set |
| OPR_HS | BOOLEAN | Operate from high set |
| BLKD2H | BOOLEAN | 2nd harmonic restraint block status |
| BLKD5H | BOOLEAN | 5th harmonic restraint block status |
| BLKDWAV | BOOLEAN | Waveform blocking status |

### 4.3.3.10 Settings

*Table 599: TR3PTDF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| High operate value | 500...3000 | %Ir | 10 | 1000 | Instantaneous stage setting |
| Enable high set | 0=False<br>1=True | | | 1=True | Enable high set stage |
| Low operate value | 5...50 | %Ir | 1 | 20 | Basic setting for biased operation |
| Slope section 2 | 10...50 | % | 1 | 30 | Slope of the second line of the operating characteristics |
| End section 2 | 100...500 | %Ir | 1 | 150 | Turn-point between the second and the third line of the operating characteristics |
| Restraint mode | 5=Waveform<br>6=2.h + waveform<br>8=5.h + waveform<br>9=2.h + 5.h + wav | | | 9=2.h + 5.h + wav | Restraint mode |
| Start value 2.H | 7...20 | % | 1 | 15 | 2. harmonic blocking ratio |
| Start value 5.H | 10...50 | % | 1 | 35 | 5. harmonic blocking ratio |
| Stop value 5.H | 10...50 | % | 1 | 35 | 5. harmonic deblocking ratio |
| Harmonic deblock 2. | 0=False<br>1=True | | | 1=True | 2. harmonic deblocking in case of switch on to fault |
| Harmonic deblock 5. | 0=False<br>1=True | | | 0=False | 5. harmonic deblocking in case of severe overvoltage |

*Table 600: TR3PTDF Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Slope section 3 | 10...100 | % | 1 | 100 | Slope of the third line of the operating characteristics |

*Table 601: TR3PTDF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off/On |
| Current group 3 type | 1=Not in use<br>2=Winding 3<br>3=Wnd 1 restraint<br>4=Wnd 2 restraint | | | 2=Winding 3 | Type of the third set/group of current inputs |
| CT connection 1-2 | 1=Type 1<br>2=Type 2 | | | 1=Type 1 | CT connection type consideration between current groups 1 and 2 |
| CT connection 1-3 | 1=Type 1<br>2=Type 2 | | | 1=Type 1 | CT connection type consideration between current groups 1 and 3 |
| Phase Ref winding | 2=Winding 1<br>3=Winding 2<br>4=Winding 3 | | | 2=Winding 1 | Reference winding for vector group matching |
| Zro A elimination | 1=Not eliminated<br>2=Winding 1<br>3=Winding 2<br>4=Winding 1 and 2<br>5=Winding 3<br>6=Winding 1 and 3<br>7=Winding 2 and 3<br>8=Winding 1, 2, 3 | | | 1=Not eliminated | Elimination of the zero-sequence current |
| Phase shift Wnd 1-2 | 0.0...359.9 | deg | 0.1 | 0.0 | Setting the phase shift between winding 1 and 2 in degrees |
| Phase shift Wnd 1-3 | 0.0...359.9 | deg | 0.1 | 0.0 | Setting the phase shift between winding 1 and 3 in degrees |
| Min winding tap | -36...36 | | 1 | 36 | The tap position number resulting the minimum number of effective winding turns on the side of the transformer where the tap changer is. |
| Max winding tap | -36...36 | | 1 | 0 | The tap position number resulting the maximum number of effective winding turns on the side of the transformer where the tap changer is. |
| Tap nominal | -36...36 | | 1 | 18 | The nominal position of the tap changer resulting the default transformation ratio of the transformer (as if there was no tap changer) |
| Tapped winding | 1=Not in use<br>2=Winding 1<br>3=Winding 2<br>4=Winding 3 | | | 1=Not in use | The winding where the tap changer is connected to |
| Step of tap | 0.60...9.00 | % | 0.01 | 1.50 | The percentage change in voltage corresponding one step of the tap changer |
| CT ratio Cor Wnd 1 | 0.20...5.00 | | 0.01 | 1.00 | CT ratio correction, winding 1 |
| CT ratio Cor Wnd 2 | 0.20...5.00 | | 0.01 | 1.00 | CT ratio correction, winding 2 |
| CT ratio Cor 3 | 0.20...5.00 | | 0.01 | 1.00 | CT ratio correction, current group 3 |

### 4.3.3.11 Monitored data

*Table 602: TR3PTDF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| OPR_A | BOOLEAN | 0=False<br>1=True | | Operate phase A |
| OPR_B | BOOLEAN | 0=False<br>1=True | | Operate phase B |
| OPR_C | BOOLEAN | 0=False<br>1=True | | Operate phase C |
| BLKD2H_A | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase A status |
| BLKD2H_B | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase B status |
| BLKD2H_C | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase C status |
| BLKD5H_A | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase A status |
| BLKD5H_B | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase B status |
| BLKD5H_C | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase C status |
| BLKDWAV_A | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase A status |
| BLKDWAV_B | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase B status |
| BLKDWAV_C | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase C status |
| BLKD2HPHAR | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, combined |
| BLKD2HPHAR_A | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase A |
| BLKD2HPHAR_B | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase B |
| BLKD2HPHAR_C | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase C |
| BLKD5HPHAR | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, combined |
| BLKD5HPHAR_A | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase A |
| BLKD5HPHAR_B | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase B |
| BLKD5HPHAR_C | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase C |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_AMPL_A1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase A |
| I_AMPL_B1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase B |
| I_AMPL_C1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase C |
| I_AMPL_A2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase A |
| I_AMPL_B2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase B |
| I_AMPL_C2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase C |
| I_AMPL_A3 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated tertiary current phase A |
| I_AMPL_B3 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated tertiary current phase B |
| I_AMPL_C3 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated tertiary current phase C |
| ID_A | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase A |
| ID_B | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase B |
| ID_C | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase C |
| IB_A | FLOAT32 | 0.00...80.00 | xIr | Restraint current phase A |
| IB_B | FLOAT32 | 0.00...80.00 | xIr | Restraint current phase B |
| IB_C | FLOAT32 | 0.00...80.00 | xIr | Restraint current phase C |
| I_2H_RAT_A | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase A |
| I_2H_RAT_B | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase B |
| I_2H_RAT_C | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase C |
| I_5H_RAT_A | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase A |
| I_5H_RAT_B | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase B |
| I_5H_RAT_C | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase C |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_ANGL_A1_B1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, winding 1 |
| I_ANGL_B1_C1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, winding 1 |
| I_ANGL_C1_A1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, winding 1 |
| I_ANGL_A2_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, winding 2 |
| I_ANGL_B2_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, winding 2 |
| I_ANGL_C2_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, winding 2 |
| I_ANGL_A3_B3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, winding 3 |
| I_ANGL_B3_C3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, winding 3 |
| I_ANGL_C3_A3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, winding 3 |
| I_ANGL_A1_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase A |
| I_ANGL_B1_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase B |
| I_ANGL_C1_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase C |
| I_ANGL_A1_A3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 3, phase A |
| I_ANGL_B1_B3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 3, phase B |
| I_ANGL_C1_C3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 3, phase C |
| TR3PTDF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| IL1-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL1 |
| IL2-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL2 |
| IL3-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL3 |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| IL1-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL1 |
| IL2-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL2 |
| IL3-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL3 |

### 4.3.3.12 Technical data

*Table 603: TR3PTDF Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±3.0% of the set value or ±0.002 × $I_n$ | | |
| Start time [1)2)] | | Minimum | Typical | Maximum |
| | Low stage<br>High stage | 30 ms<br>17 ms | 35 ms<br>18 ms | 40 ms<br>20 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5... | | |

1) Current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz. Injected differential current = 2.0 × set operation value.
2) Measured with static power output (SPO)

## 4.3.4 Numerical stabilized low-impedance restricted earth-fault protection LREFPNDF

### 4.3.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Numerical stabilized low-impedance restricted earth-fault protection | LREFPNDF | dIoLo> | 87NLI |

### 4.3.4.2 Function block




*Figure 362: Function block*

### 4.3.4.3 Functionality

The numerical stabilized low-impedance restricted earth-fault protection function LREFPNDF for a two-winding transformer is based on the numerically stabilized differential current principle. No external stabilizing resistor or non-linear resistor are required.

The fundamental components of the currents are used for calculating the residual current of the phase currents, the neutral current, differential currents and stabilizing currents. The operating characteristics are according to the definite time.

LREFPNDF contains a blocking functionality. The neutral current second harmonic is used for blocking during the transformer inrush situation. It is also possible to block function outputs, timers or the function itself.

### 4.3.4.4 Analog channel configuration

LREFPDIF has two analog group inputs which must be properly configured.

*Table 604: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| IRES | Residual current (measured or calculated) |



See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 605: Special conditions*

| Condition | Description |
|---|---|
| IRES measured | The function requires that the current measured from the neutral side is connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of LREFPNDF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

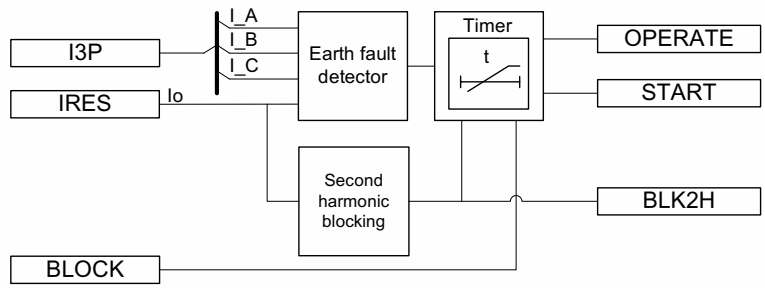



*Figure 363: Functional module diagram*

## Earth-fault detector

The operation is based on comparing the amplitude and the phase difference between the sum of the fundamental frequency component of the phase currents (ΣI, residual current) and the fundamental frequency component of the neutral current (Io) flowing in the conductor between the transformer or generator's neutral point and earth. The differential current is calculated as the absolute value of the difference between the residual current, that is, the sum of the fundamental frequency components of the phase currents I_A, I_B and I_C, and the neutral current. The directional differential current ID_COSPHI is the product of the differential current and cosφ. The value is available in the monitored data view.

$$ID_COSPHI = \left(\left|\overline{\Sigma I} - \bar{I}o\right|\right) \cdot \cos\varphi$$

(Equation 124)

| | |
|---|---|
| $\overline{\Sigma I}$ | Residual current |
| $\varphi$ | Phase difference between the residual and neutral currents |
| $\bar{I}o$ | Neutral current |

An earth fault occurring in the protected area, that is, between the phase CTs and the neutral connection CT, causes a differential current. The directions, that is, the phase difference of the residual current and the neutral current, are considered in the operation criteria to maintain selectivity. A correct value for *CT connection type* is determined by the connection polarities of the current transformer.

The current transformer ratio mismatch between the phase current transformer and neutral current transformer (residual current in the

analog input settings) is taken into account by the function with the properly set analog input setting values.

During an earth fault in the protected area, the currents ΣI and Io are directed towards the protected area. The factor cosφ is 1 when the phase difference of the residual current and the neutral current is 180 degrees, that is, when the currents are in opposite direction at the earth faults within the protected area. Similarly, ID_COSPHI is specified to be 0 when the phase difference between the residual current and the neutral current is less than 90 degrees in situations where there is no earth fault in the protected area. Thus tripping is possible only when the phase difference between the residual current and the neutral current is above 90 degrees.

The stabilizing current IB used by the stabilizing current principle is calculated as an average of the phase currents in the windings to be protected. The value is available in the monitored data view.

$$IB = \frac{\left|\overline{I_A}\right| + \left|\overline{I_B}\right| + \left|\overline{I_C}\right|}{3}$$

(Equation 125)

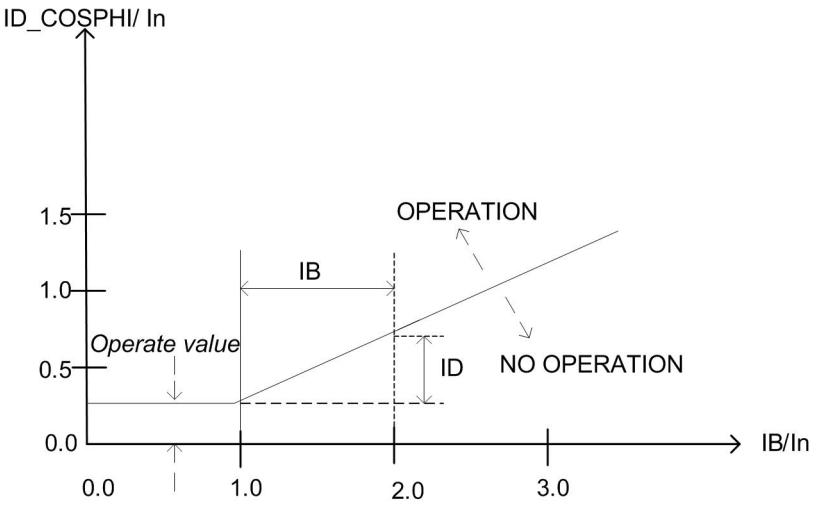



*Figure 364: Operating characteristics of the stabilized earth-fault protection function*

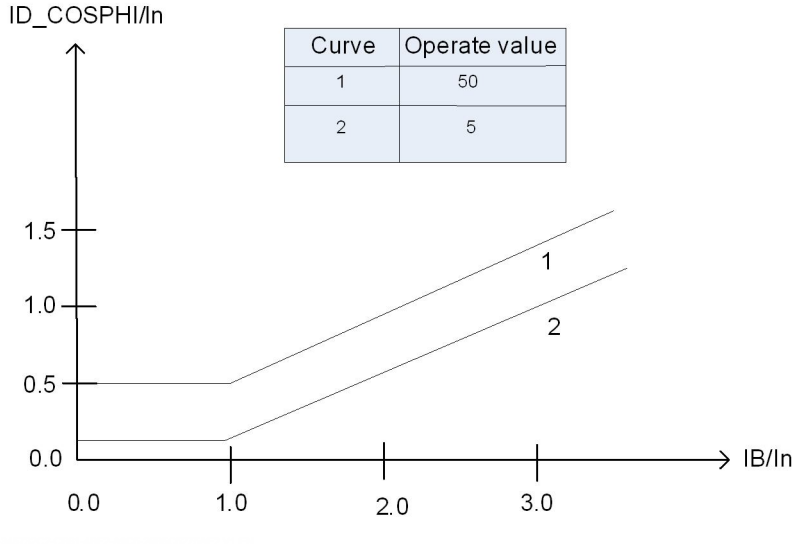



*Figure 365: Setting range of the operating characteristics for the stabilized differential current principle of the earth-fault protection function*

The *Operate value* setting is used for defining the characteristics of the function. The differential current value required for tripping is constant at the stabilizing current values 0.0 < IB/In < 1.0, where In is the nominal current, and the In in this context refers to the nominal of the phase current inputs. When the stabilizing current is higher than 1.0, the slope of the operation characteristic (ID/IB) is constant at 50 percent. Different operating characteristics are possible based on the *Operate value* setting.

For the protection of the trip, the measured neutral current has to be above 4 percent. When the condition has been fulfilled, the measured neutral current must stay above 2 percent, otherwise reset time is started.

To calculate the directional differential current ID_COSPHI, the fundamental frequency amplitude of both the residual and neutral currents has to be above 4 percent of In. If neither or only one condition is fulfilled at a time, the cosφ term is forced to 1. After the conditions are fulfilled, both currents must stay above 2 percent of In to allow the continuous calculation of the cosφ term.

## Second harmonic blocking

This module compares the ratio of the current second harmonic ($I_0$_2H) and $I_0$ to the set value *Start value 2.H*. If the ratio ($I_0$_2H / $I_0$) value exceeds the set value, the `BLK2H` output is activated.

The blocking also prevents unwanted operation at the recovery and sympathetic magnetizing inrushes. At the recovery inrush, the magnetizing current of the transformer to be protected increases momentarily when the voltage returns to normal after the clearance of a fault outside the protected area. The sympathetic inrush is caused by the energization of a transformer running in parallel with the protected transformer connected to the network.

The second harmonic blocking is disabled when *Restraint mode* is set to "None" and enabled when set to "Harmonic2".

### Timer

Once activated, the Timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Minimum operate time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the reset timer resets and the START output is deactivated.

The Timer calculates the start duration value START_DUR which indicates the percentage ratio of the start situation and the set operate time. The value is available through the Monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated. The activation of the output of the second harmonic blocking signal BLK2H deactivates the OPERATE output.

## 4.3.4.6 Application

An earth-fault protection using an overcurrent element does not adequately protect the transformer winding in general and the star-connected winding in particular.

The restricted earth-fault protection is mainly used as a unit protection for the transformer windings. LREFPNDF is a sensitive protection applied to protect the star-connected winding of a transformer. This protection system remains stable for all the faults outside the protected zone.

LREFPNDF provides higher sensitivity for the detection of earth faults than the overall transformer differential protection. This is a high-speed unit protection scheme applied to the star-connected winding of the transformer. LREFPNDF is normally applied when the transformer is earthed solidly or through low-impedance resistor (NER). LREFPNDF can be also applied on the delta side of the transformer if an earthing transformer (zig-zag transformer) is used there. In LREFPNDF, the difference of the fundamental component of all three phase currents and the neutral

current is provided to the differential element to detect the earth fault in the transformer winding based on the numerical stabilized differential current principle.

## Connection of current transformers

The connections of the primary current transformers are designated as "Type 1" and "Type 2".

- If the positive directions of the winding 1 and winding 2 protection relay currents are opposite, the *CT connection type* setting parameter is "Type 1". The connection examples of "Type 1" are as shown in figures 366 and 367.
- If the positive directions of the winding 1 and winding 2 protection relay currents equate, the *CT connection type* setting parameter is "Type 2". The connection examples of "Type 2" are as shown in figures 368 and 369.
- The default value of the *CT connection type* setting is "Type 1".

In case the earthings of the current transformers on the phase side and the neutral side are both either inside or outside the area to be protected, the setting parameter *CT connection type* is "Type 1".

If the earthing of the current transformers on the phase side is inside the area to be protected and the neutral side is outside the area to be protected or if the earthing on the phase side is outside the area and on the neutral side inside the area, the setting parameter *CT connection type* is "Type 2".

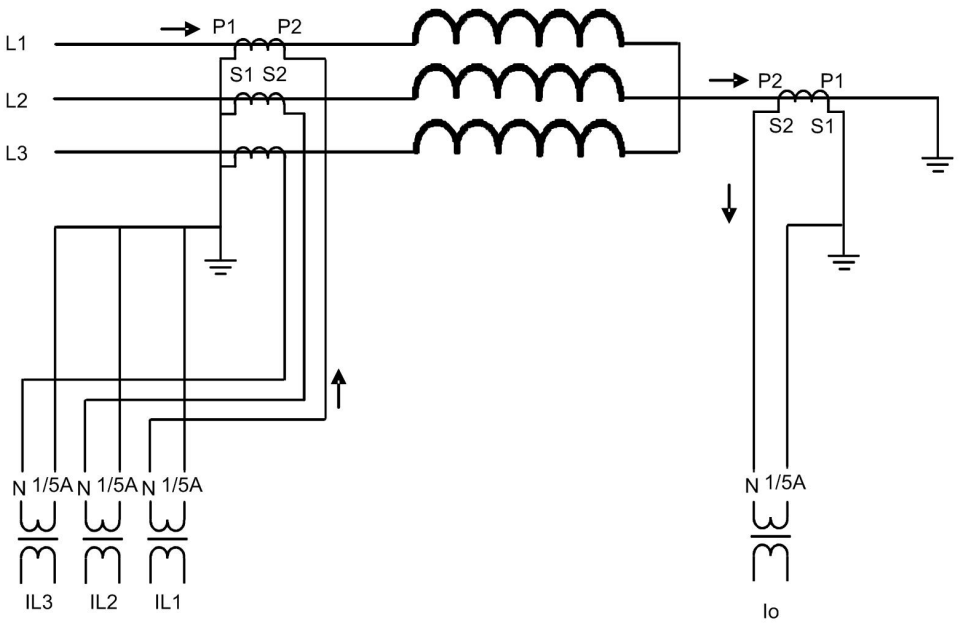



*Figure 366: Connection of the current transformers of Type 1. The connected phase currents and the neutral current have opposite directions at an external earth-fault situation. Both earthings are inside the area to be protected.*

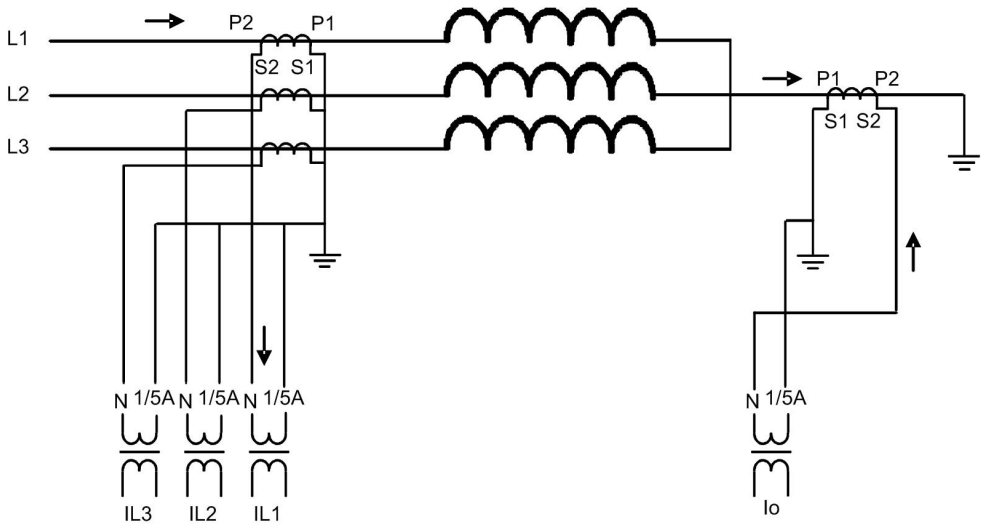



*Figure 367: Connection of the current transformers of Type 1. The connected phase currents and the neutral current have opposite directions at an external earth-fault situation. Both earthings are outside the area to be protected.*

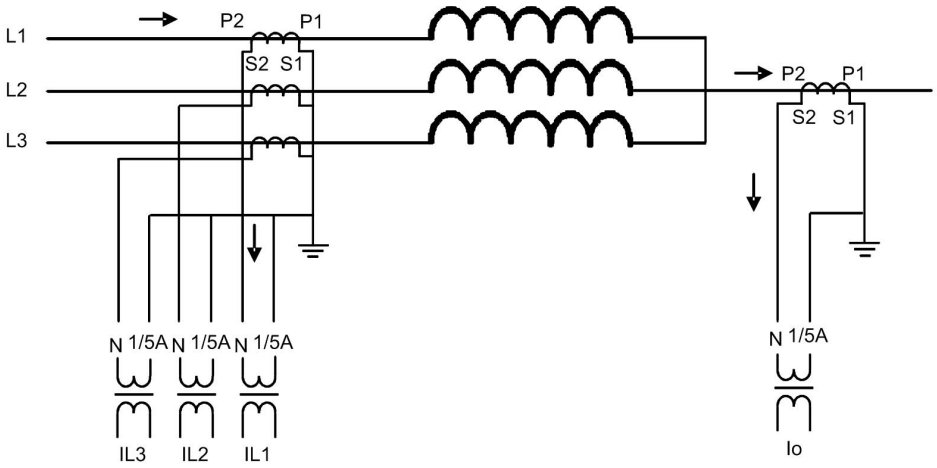



*Figure 368: Connection of the current transformers of Type 2. The phase currents and the neutral current have equal directions at an external earth-fault situation. Phase earthing is inside and neutral earthing is outside the area to be protected.*

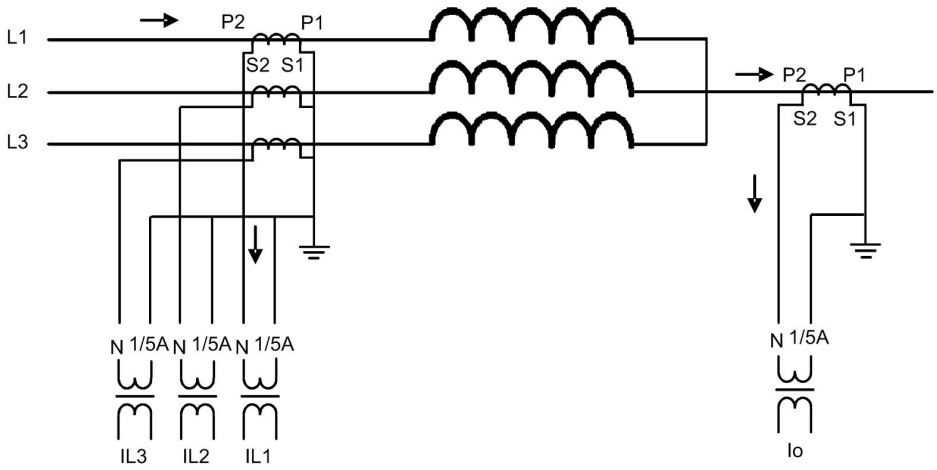



*Figure 369: Connection of the current transformers of Type 2. The phase currents and the neutral current have equal directions at an external earth-fault situation. Phase earthing is outside and neutral earthing is inside the area to be protected.*

## Internal and external faults

LREFPNDF does not respond to any faults outside the protected zone. An external fault is detected by checking the phase angle difference of the neutral current and the sum of the phase currents. When the difference is less than 90 degrees, the operation is internally restrained or blocked. Hence the protection is not sensitive to an external fault.

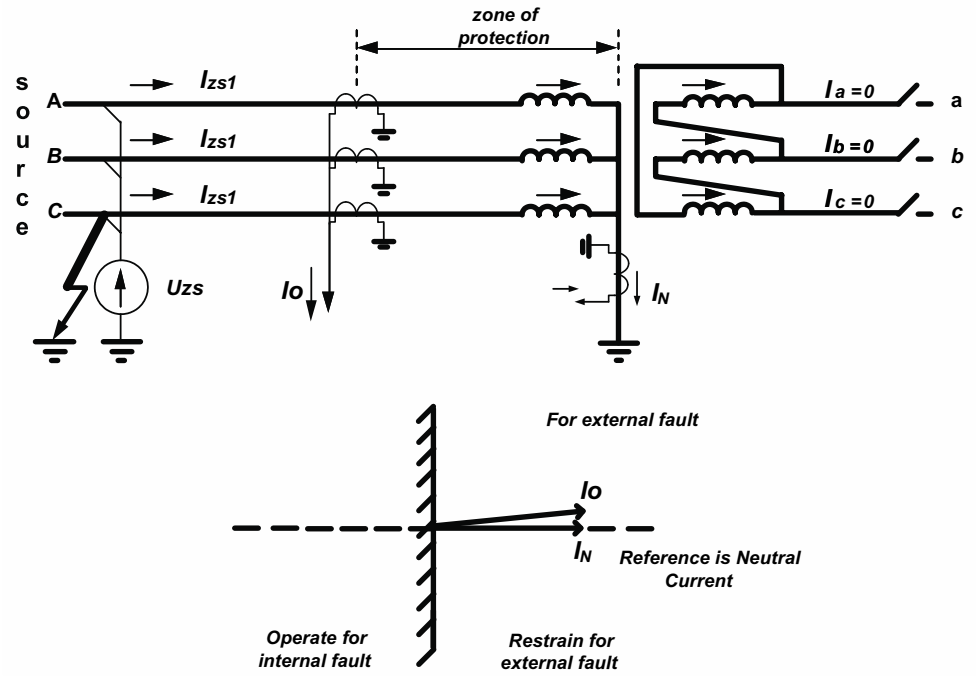



*Figure 370: Current flow in all the CTs for an external fault*

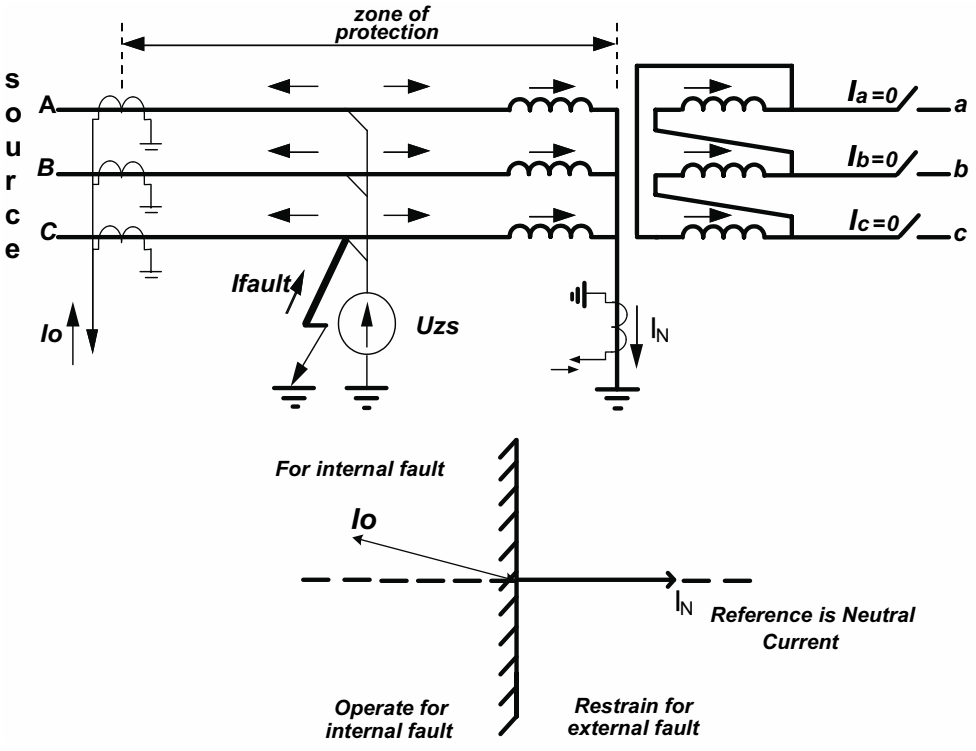



*Figure 371: Current flow in all the CTs for an internal fault*

LREFPNDF does not respond to phase-to-phase faults either, as in this case the fault current flows between the two line CTs and so the neutral CT does not experience this fault current.

### Blocking based on the second harmonic of the neutral current

The transformer magnetizing inrush currents occur when the transformer is energized after a period of de-energization. The inrush current can be many times the rated current, and the halving time can be up to several seconds. For the differential protection relay, the inrush current represents the differential current, which causes the protection relay to operate almost always when the transformer is connected to the network. Typically, the inrush current contains a large amount of second harmonics.

The blocking also prevents unwanted operation at the recovery and sympathetic magnetizing inrushes. At the recovery inrush, the magnetizing current of the transformer to be protected increases momentarily when the voltage returns to normal after the clearance of a fault outside the protected area. The sympathetic inrush is caused by the energization of a transformer running in parallel with the protected transformer already connected to the network.

Blocking the starting of the restricted earth-fault protection at the magnetizing inrush is based on the ratio of the second harmonic and the fundamental frequency amplitudes of the neutral current Io_2H / Io. Typically, the second harmonic content of the neutral current at the magnetizing inrush is higher than that of the phase currents.

## 4.3.4.7 Signals

*Table 606: LREFPNDF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 607: LREFPNDF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| BLK2H | BOOLEAN | 2nd harmonic block |

## 4.3.4.8 Settings

*Table 608: LREFPNDF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 5.0...50.0 | %In | 1.0 | 5.0 | Operate value |

*Table 609: LREFPNDF Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 40...300000 | ms | 1 | 40 | Minimum operate time |
| Restraint mode | 1=None<br>2=Harmonic2 | | | 1=None | Restraint mode |
| Start value 2.H | 10...50 | % | 1 | 50 | The ratio of the 2. harmonic to fundamental component required for blocking |

*Table 610: LREFPNDF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| CT connection type | 1=Type 1<br>2=Type 2 | | | 2=Type 2 | CT connection type |

*Table 611: LREFPNDF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.3.4.9 Monitored data

*Table 612: LREFPNDF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| RES2H | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint |
| ID_COSPHI | FLOAT32 | 0.00...80.00 | xIn | Directional differential current Id cosphi |
| IB | FLOAT32 | 0.00...80.00 | xIn | Bias current |
| LREFPNDF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.3.4.10 Technical data

*Table 613: LREFPNDF Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±2.5% of the set value or ±0.002 x $I_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Operate value* | 37 ms | 41 ms | 45 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, … | | |

1) Current before fault = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.3.5 High-impedance based restricted earth-fault protection HREFPDIF

### 4.3.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| High-impedance based restricted earth-fault protection | HREFPDIF | dIoHi> | 87NHI |

### 4.3.5.2 Function block




*Figure 372: Function block*

### 4.3.5.3 Functionality

The high-impedance based restricted earth-fault protection function HREFPDIF is used for the restricted earth-fault protection of generators and power transformers.

The function starts when the differential neutral current exceeds the set limit. HREFPDIF operates with the DT characteristic.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.3.5.4 Analog channel configuration

HREFPDIF has one analog group input which must be properly configured.

*Table 614: Analog inputs*

| Input | Description |
|---|---|
| IRES | Residual current (measured) |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of HREFPDIF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

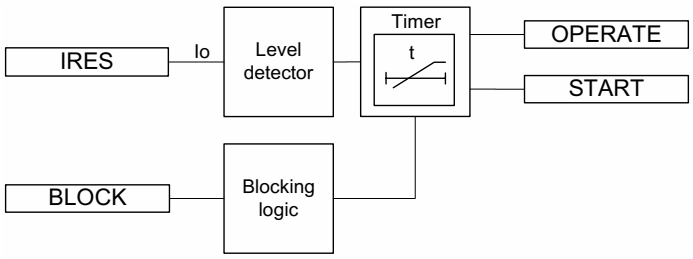



*Figure 373: Functional module diagram*

#### Level detector

The level detector compares the differential neutral current IDo to the set value of the *Operate value* setting. If the differential neutral current exceeds the *Operate value* setting, the level detector sends an enable signal to the timer module to start the definite timer.

### Timer

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Minimum operate time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the ratio of the start situation and the set operation time. The value is available in the monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.3.5.6 Application

In solidly earthed systems, the restricted earth-fault protection is always deployed as a complement to the normal transformer differential protection. The advantage of the restricted earth-fault protection is its high sensitivity. Sensitivities of close to 1.0 percent can be achieved, whereas normal differential protection relays have their minimum sensitivity in the range of 5 to 10 percent. The level for HREFPDIF is dependent on the current transformers' magnetizing currents. The restricted earth-fault protection is also very fast due to the simple measuring principle as it is a unit type of protection.

The differences in measuring principle limit the biased differential protection relay's possibility to detect the earth faults. Such faults are then only detected by the restricted earth-fault function.

The restricted earth-fault protection relay is connected across each directly or to low-ohmic earthed transformer winding. If the same CTs are connected to other protection relays, separate cores are to be used.

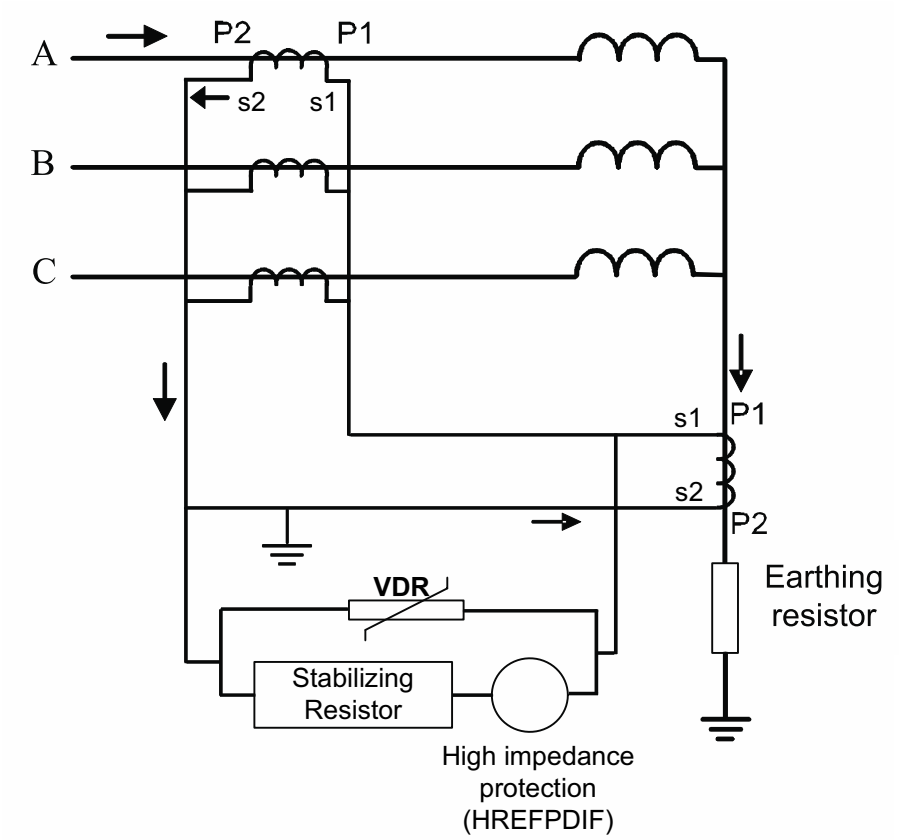



*Figure 374: Connection scheme for the restricted earth-fault protection according to the high-impedance principle*

## High-impedance principle

High-impedance principle is stable for all types of faults outside the zone of protection. The stabilization is obtained by a stabilizing resistor in the differential circuit. This method requires that all the CTs used have a similar magnetizing characteristic, same ratio and relatively high knee point voltage. CTs on each sides are connected in parallel along with a relay-measuring branch as shown in Figure 375. The measuring branch is a series connection of stabilizing resistor and protection relay.

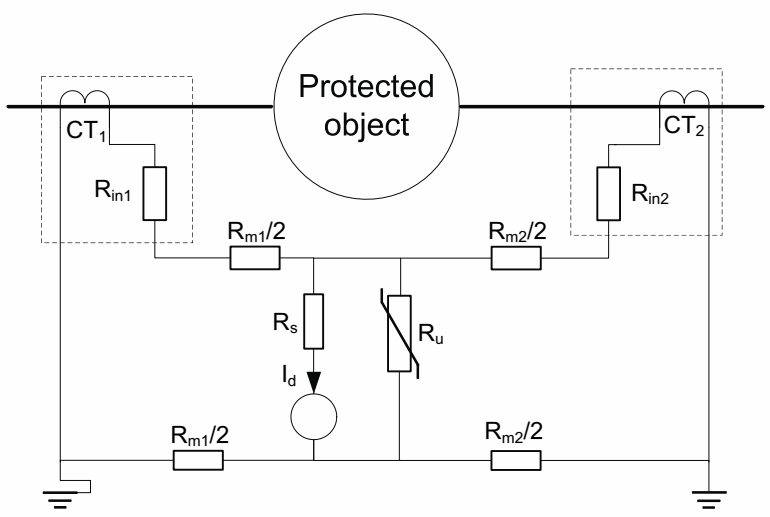



*Figure 375: High-impedance principle*

The stability of the protection is based on the use of the stabilizing resistor (Rs) and the fact that the impedance of the CT secondary quickly decreases as the CT saturates. The magnetization reactance of a fully saturated CT goes to zero and the impedance is formed only by the resistance of the winding ($R_{in}$) and lead resistance ($R_m$).

The CT saturation causes a differential current which now has two paths to flow: through the saturated CT because of the near-zero magnetizing reactance and through the measuring branch. The stabilizing resistor is selected as such that the current in the measuring branch is below the relay operating current during out-of-zone faults. As a result, the operation is stable during the saturation and can still be sensitive at the non-saturated parts of the current waveform as shown in Figure 376.

In case of an internal fault, the fault current cannot circulate through the CTs but it flows through the measuring branch and the protection operates. Partial CT saturation can occur in case of an internal fault, but the non-saturated part of the current waveform causes the protection to operate.

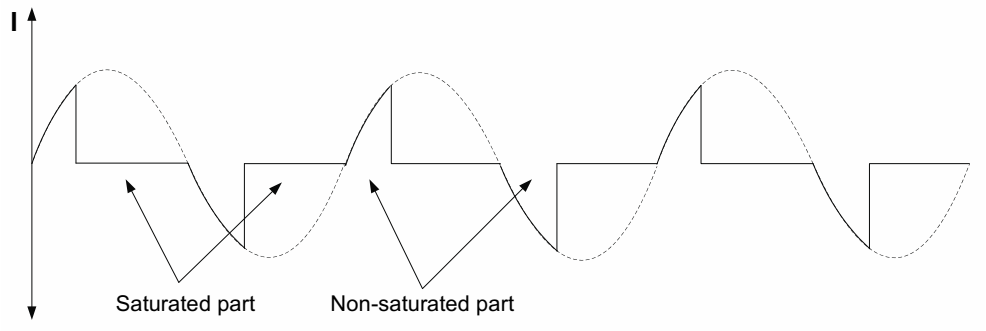



*Figure 376: Secondary waveform of a saturated CT*

At internal fault, the secondary circuit voltage can easily exceed the isolation voltage of the CTs, connection wires and protection relay. To limit this voltage, a voltage-dependent resistor VDR is used as shown in Figure 375.

The whole scheme, that is, the stabilizing resistor, voltage-dependent resistor and wiring, must be adequately maintained (operation- and insulation-tested regularly) to be able to withstand the high-voltage pulses which appear during an internal fault throughout the lifetime of the equipment. Otherwise, during a fault within the zone of protection, any flashover in the CT secondary circuits or in any other part of the scheme may prevent a correct operation of the high-impedance differential function.

### 4.3.5.7 The measuring configuration

The external measuring configuration is composed of four current transformers measuring the currents and a stabilizing resistor. A varistor is needed if high overvoltages are expected.

The value of the stabilizing resistor is calculated with the formula:

$$R_s = \frac{U_s}{I_{rs}}$$

(Equation 126)

$R_s$ the resistance of the stabilizing resistor

$U_s$ the stabilizing voltage of the protection relay

$I_{rs}$ the value of the *Low operate value* setting

The stabilizing voltage is calculated with the formula:

$$U_s = \frac{I_{k\max}}{n} \cdot (R_{in} + R_m)$$

(Equation 127)

$I_{kmax}$ the highest through-fault current

n the turns ratio of the CT

$R_{in}$ the secondary internal resistance of the CT

$R_m$ the resistance of the longest loop of secondary circuit

Additionally, it is required that the current transformers' knee-point voltages $U_k$ are at least twice the stabilizing voltage value $U_s$.

### 4.3.5.8 Recommendations for current transformers

The sensitivity and reliability of the protection depends a lot on the characteristics of the current transformers. The CTs must have an identical transformation ratio. It is

recommended that all current transformers have an equal burden and characteristics and are of same type, preferably from the same manufacturing batch, that is, an identical construction should be used. If the CT characteristics and burden values are not equal, calculation for each branch in the scheme should be done separately and the worst-case result is then used.

First, the stabilizing voltage, that is, the voltage appearing across the measuring branch during the out-of-zone fault, is calculated assuming that one of the parallel connected CT is fully saturated. The stabilizing voltage can be calculated with the formula

$$U_s = \frac{I_{k\max}}{n} \cdot (R_{in} + R_m)$$

(Equation 128)

$I_{kmax}$ the highest through-fault current in primary amps. The highest earth-fault or short circuit current during the out-of-zone fault.

n the turns ratio of the CT

$R_{in}$ the secondary internal resistance of the CT in ohms

$R_m$ the resistance (maximum of $R_{in}$ + $R_m$) of the CT secondary circuit in ohms

The current transformers must be able to force enough current to operate the protection relay through the differential circuit during a fault condition inside the zone of protection. To ensure this, the knee point voltage $U_{kn}$ should be at least two times higher than the stabilizing voltage $U_s$.

The required knee point voltage $U_{kn}$ of the current transformer is calculated using the formula

$$U_{kn} \geq 2 \cdot U_s$$

(Equation 129)

$U_{kn}$ the knee point voltage

$U_s$ the stabilizing voltage

The factor two is used when no delay in the operating time of the protection in any situation is acceptable. To prevent the knee point voltage from growing too high, it is advisable to use current transformers, the secondary winding resistance of which is of the same size as the resistance of the measuring loop.

As the impedance of the protection relay alone is low, a stabilizing resistor is needed. The value of the stabilizing resistor is calculated with the formula

$$R_s = \frac{U_s}{I_{rs}}$$

(Equation 130)

$R_s$ the resistance of the stabilizing resistor

$U_s$ the stabilizing voltage of the protection relay

$I_{rs}$ the value of the *Operate value* setting in secondary amps.

The stabilizing resistor should be capable to dissipate high energy within a very short time; therefore, the wire wound-type resistor should be used. Because of the possible CT inaccuracy, which might cause some current through the stabilizing resistor in a normal load situation, the rated power should be 25 W minimum.

If $U_{kn}$ is high or the stabilizing voltage is low, a resistor with a higher power rating is needed. Often resistor manufacturers allow 10 times rated power for 5 seconds. Thus the power of the resistor can be calculated with the equation

$$\frac{U_{kn}^2}{R_s \cdot 10}$$

(Equation 131)

The actual sensitivity of the protection is affected by the protection relay setting, the magnetizing currents of the parallel connected CTs and the shunting effect of the voltage-dependent resistor (VDR). The value of the primary current $I_{prim}$ at which the protection relay operates at a certain setting can be calculated with the formula

$$I_{prim} = n \cdot (I_{rs} + I_u + m \cdot I_m)$$

(Equation 132)

$I_{prim}$ the primary current at which the protection is to start

n the turn ratio of the current transformer

$I_{rs}$ the value of the *Operate value* setting

$I_u$ the leakage current flowing through the VDR at the $U_s$ voltage

m the number of current transformers included in the protection per phase (=4)

$I_m$ the magnetizing current per current transformer at the $U_s$ voltage

The $I_e$ value given in many catalogs is the excitation current at the knee point voltage.

Assuming $U_{kn} \approx 2$ x $U_s$, the value of $I_m \approx \frac{I_e}{2}$ gives an approximate value for Equation 132.

The selection of current transformers can be divided into procedures:

1. In principle, the highest through-fault should be known. However, when the necessary data are not available, approximates can be used:

- Small power transformers: $I_{kmax}$ = 16 x $I_n$ (corresponds to $z_k$ = 6% and infinite grid)
- Large power transformers: $I_{kmax}$ = 12 x $I_n$ (corresponds to $z_k$ = 8% and infinite grid)
- Generators and motors: $I_{kmax}$ = 6 x $I_n$
  Where $I_n$ = rated current and $z_k$ = short circuit impedance of the protected object

2. The rated primary current $I_{1n}$ of the CT has to be higher than the rated current of the machine.
   The choice of the CT also specifies $R_{in}$.
3. The required $U_{kn}$ is calculated with Equation 129. If the $U_{kn}$ of the CT is not high enough, another CT has to be chosen. The value of the $U_{kn}$ is given by the manufacturer in the case of Class X current transformers or it can be estimated with Equation 133.
4. The sensitivity $I_{prim}$ is calculated with Equation 132. If the achieved sensitivity is sufficient, the present CT is chosen. If a better sensitivity is needed, a CT with a bigger core is chosen.

If other than Class X CTs are used, an estimate for $U_{kn}$ is calculated with the equation

$$U_{kn} = 0.8 \cdot F_n \cdot I_{2n} \cdot \left( R_{in} + \frac{S_n}{I_{2n}^2} \right)$$

(Equation 133)

$F_n$ the rated accuracy limit factor corresponding to the rated burden $S_n$

$I_{2n}$ the rated secondary current of the CT

$R_{in}$ the secondary internal resistance of the CT

$S_n$ the volt-amp rating of the CT

The formulas are based on choosing the CTs according to Equation 129, which results an absolutely stable scheme. In some cases, it is possible to achieve stability with knee point voltages lower than stated in the formulas. The conditions in the network, however, have to be known well enough to ensure the stability.

1. If $U_k \geq 2$ x $U_s$, fast protection relay operation is secure.
2. If $U_k \geq 1.5$ x $U_s$ and $< 2$ x $U_s$, protection relay operation can be slightly prolonged and should be studied case by case.
   If $U_k < 1.5$ x $U_s$, the protection relay operation is jeopardized. Another CT has to be chosen.

The need for the VDR depends on certain conditions.

First, voltage $U_{max}$, ignoring the CT saturation during the fault, is calculated with the equation

$$U_{\max} = \frac{I_{k\max in}}{n} \cdot \left(R_{in} + R_m + R_s\right) \approx \frac{I_{k\max in}}{n} \cdot R_s$$

(Equation 134)

$I_{kmaxin}$ the maximum fault current inside the zone, in primary amps

n the turns ration of the CT

$R_{in}$ the internal resistance of the CT in ohms

$R_m$ the resistance of the longest loop of the CT secondary circuit, in ohms

$R_s$ the resistance of the stabilized resistor, in ohms

Next, the peak voltage û, which includes the CT saturation, is estimated with the formula (given by P.Mathews, 1955)

$$\beta = 2\sqrt{2 \cdot U_{kn} \cdot \left(U_{\max} - U_{kn}\right)}$$

(Equation 135)

$U_{kn}$ the knee point voltage of the CT

The VDR is recommended when the peak voltage û ≥ 2kV, which is the insulation level for which the protection relay is tested.

If $R_s$ was smaller, the VDR could be avoided. However, the value of $R_s$ depends on the protection relay operation current and stabilizing voltage. Thus, either a higher setting must be used in the protection relay or the stabilizing voltage must be lowered.

### 4.3.5.9 Setting examples

#### Example 1

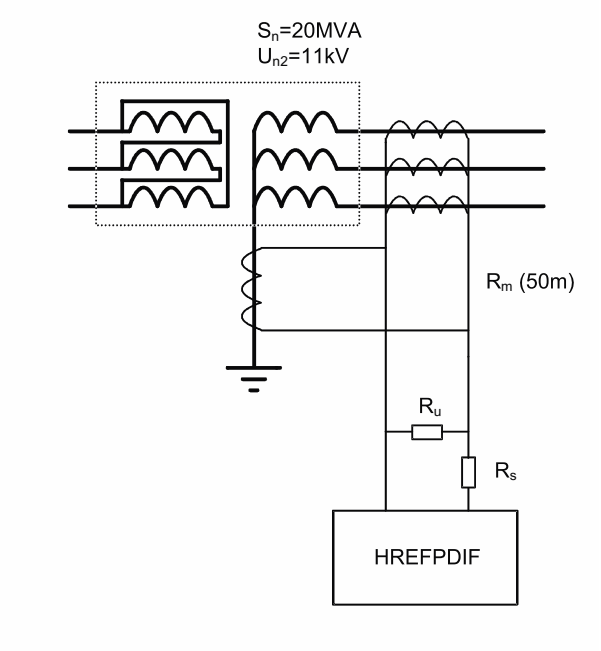



*Figure 377: Restricted earth-fault protection of a transformer*

The data for the protected power transformer are:

$S_n$ = 20 MVA

$U_{2n}$ = 11 kV

The longest distance of the secondary circuit is 50 m (the whole loop is 100 m) and the area of the cross section is 10 $mm^2$.

$I_n = S_n / (\sqrt{3} \cdot U_n) = 1050$ A

$I_{kmax} = 12 \cdot I_n = 12600$ A

In this example, the CT type is IHBF 12, the core size is 35 percent, the primary current is 1200 A and the secondary current is 5 A.

$R_{in}$ = 0.26 Ω (value given by the manufacturer).

$U_k$ = 40 V (value given by the manufacturer).

$I_e$ = 0.055 A (value given by the manufacturer).

$R_m = 1.81\ \Omega/km \cdot 2 \cdot 0.05\ km = 0.181\ \Omega \approx 0.18\ \Omega$

$$U_s = \frac{12600 \cdot (0.26 + 0.18)}{240} V \approx 23 V$$

(Equation 136)

According to the criterion, the value of $U_k$ should be $2 \cdot U_s = 2 \cdot 23$ V = 46 V. It depends on if the stability of the scheme is achieved with $U_k$ = 40 V. Otherwise, it is possible to choose a bigger core of 65 percent with:

$R_{in}$ = 0.47 Ω (value given by the manufacturer).

$U_k$ = 81 V (value given by the manufacturer).

$R_m$ = 0.18 Ω

$$U_s = \frac{12600 \cdot (0.47 + 0.18)}{240} V \approx 34 V$$

(Equation 137)

$U_k = 2 \cdot U_s$ = 68 V (required value).

As mentioned earlier, $I_m = 0.5 \cdot I_e$ gives a realistic value for $I_{prim}$ in Equation 132. If $I_u = 0$ and $I_{rs} = m \cdot 0.5 \cdot I_o$, the value for the sensitivity is:

$I_{prim} = n \cdot m \cdot I_e = 240 \cdot 4 \cdot 0.055$ A ≈ 53 A

$I_{rs} = 4 \cdot 0.5 \cdot 0.055$ A = 0.11 A

The setting value can be calculated with:

$$Operate\,value = \left( \frac{I_{rs}}{I_{CT_n2}} \right) = \left( \frac{0.11A}{5A} \right) \approx 2.2\%$$

(Equation 138)

The resistance of the stabilizing resistor can be calculated:

$R_s = U_s / I_{rs} = 34$ V / 0.11 A ≈ 309 Ω

However, the sensitivity can be calculated more accurately when the actual values of $I_u$ and $I_{rs}$ are known. The stabilizing resistor of the relay is chosen freely in the above example and it is assumed that the resistor value is not fixed.

## Example 2a

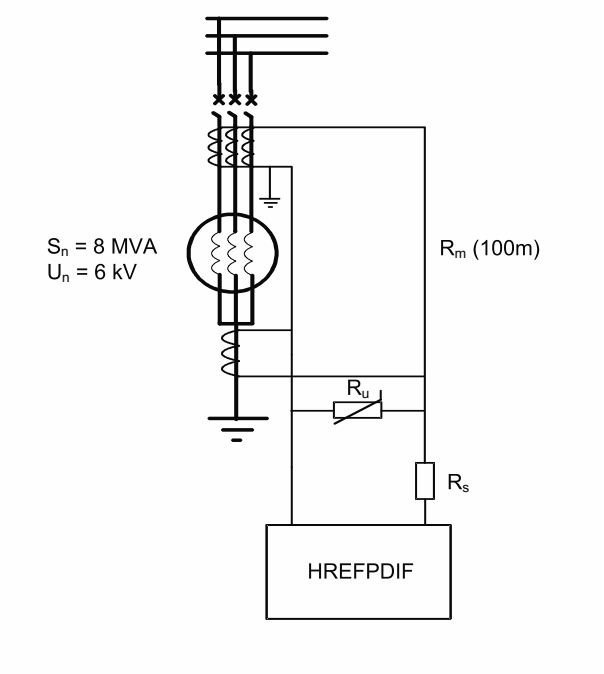



*Figure 378: Restricted earth-fault protection of a generator*

In the protected generator:

$S_n$ = 8 MVA

$U_n$ = 6 kV.

$I_n$ = 770 A

$I_{kmax} = 6 \cdot I_n = 6 \cdot 770 \text{ A} = 4620 \text{ A}$

In this example, the CT type is KOFD 12 A 21 with:

$I_{CT_1n}$ = 1000 A (value given by the manufacturer).

$I_{CT_2n}$ = 1 A (value given by the manufacturer).

$U_k$ = 323 V (value given by the manufacturer).

$R_{in}$ = 15.3 Ω (value given by the manufacturer).

$I_e$ = 0.012 A (value given by the manufacturer).

If the length of the secondary circuit is 100 m (the whole loop is 200 m) and the area of the cross section is 2.5 $mm^2$:

$R_m = 7.28 \text{ Ω/km} \cdot 2 \cdot 0.1 \text{ km} \approx 1.46 \text{ Ω}$

The required knee-point voltage can be calculated using equation

$U_k = 2 \cdot ( 4620 \text{ A} / 1000 ) \cdot ( 15.3 + 1.46 ) \approx 155 \text{ V}$.

The value 155 V is lower than the value 323 V, which means that the value of $U_k$ is high enough.

As mentioned earlier, $I_m = 0.5 \cdot I_e$ gives a realistic value for $I_{prim}$ in Equation 132. If $I_u = 0$ and $I_{rs} = m \cdot 0.5 \cdot I_e$, the value for the sensitivity is:

$I_{prim} = n \cdot m \cdot I_e = 1000 \cdot 4 \cdot 0.012 \text{ A} = 48 \text{ A} ( \approx 6 \% \text{ x } I_n)$.

$I_{rs} = 4 \cdot 0.5 \cdot 0.012 \text{ A} = 0.024 \text{ A}$.

The setting value can be calculated with:

$$Operate\,value = \left( \frac{I_{rs}}{I_{CT_2n}} \right) = \left( \frac{0.024\,A}{1A} \right) \approx 2.4\%$$

(Equation 139)

The resistance of the stabilizing resistor can now be calculated:

$R_s = U_s / I_{rs} = 78 \text{ V} / (2 \cdot I_e) = 78 \text{ V} / (2 \cdot 0.012 \text{ A}) = 3250 \Omega$.

### Example 2b

In this example, $I_{rs} = 4 \text{ x } 12 \text{ mA} = 48 \text{ mA}$ and $I_u = 30 \text{ mA}$. This results in the sensitivity:

$I_{prim} = n \cdot ( I_{rs} + I_u + m \cdot I_m ) = 1000 \cdot (48 + 30 + 24) \text{ mA} = 102 \text{ A}$

The setting value can be calculated with:

$$Operate\,value = \left( \frac{I_{rs}}{I_{CT_2n}} \right) = \left( \frac{0.048\,A}{1A} \right) \approx 4.8\%$$

(Equation 140)

The resistance of the stabilizing resistor is now:

$R_s = U_s / I_{rs} = 78 \text{ V} / 48 \text{ mA} \approx 1630 \Omega$

In this example, the relay is of such a type that the stabilizing resistor can be chosen freely.

## 4.3.5.10 Signals

*Table 615: HREFPDIF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 616: HREFPDIF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.3.5.11 Settings

*Table 617: HREFPDIF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 1.0...50.0 | %In | 0.1 | 1.0 | Low operate value, percentage of the nominal current |
| Minimum operate time | 40...300000 | ms | 1 | 40 | Minimum operate time |

*Table 618: HREFPDIF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 619: HREFPDIF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.3.5.12 Monitored data

*Table 620: HREFPDIF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| HREFPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.3.5.13 Technical data

*Table 621: HREFPDIF Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Operate value*<br>$I_{Fault}$ = 10.0 × set *Operate value* | 16 ms<br>11 ms | 21 ms<br>13 ms | 23 ms<br>14 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |

1) Current before fault = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.3.6 High-impedance differential protection HIxPDIF

### 4.3.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| High-impedance differential protection for phase A | HIAPDIF | dHi_A> | 87_A |
| High-impedance differential protection for phase B | HIBPDIF | dHi_B> | 87_B |
| High-impedance differential protection for phase C | HICPDIF | dHi_C> | 87_C |

### 4.3.6.2 Function block




*Figure 379: Function block*

### 4.3.6.3 Functionality

The high-impedance differential protection function HIxPDIF is a general differential protection. It provides a phase-segregated short circuit protection for the busbar.

However, the function can also be used for providing generator, motor, transformer and reactor protection.

The function starts and operates when the differential current exceeds the set limit. The operate time characteristics are according to definite time (DT).

The function contains a blocking functionality. It is possible to block the function outputs, timer or the whole function.

### 4.3.6.4 Analog channel configuration

HIxPDIF has one analog group input which must be properly configured.

*Table 622: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of HIxPDIF can be described with a module diagram. All the modules in the diagram are explained in the next sections.

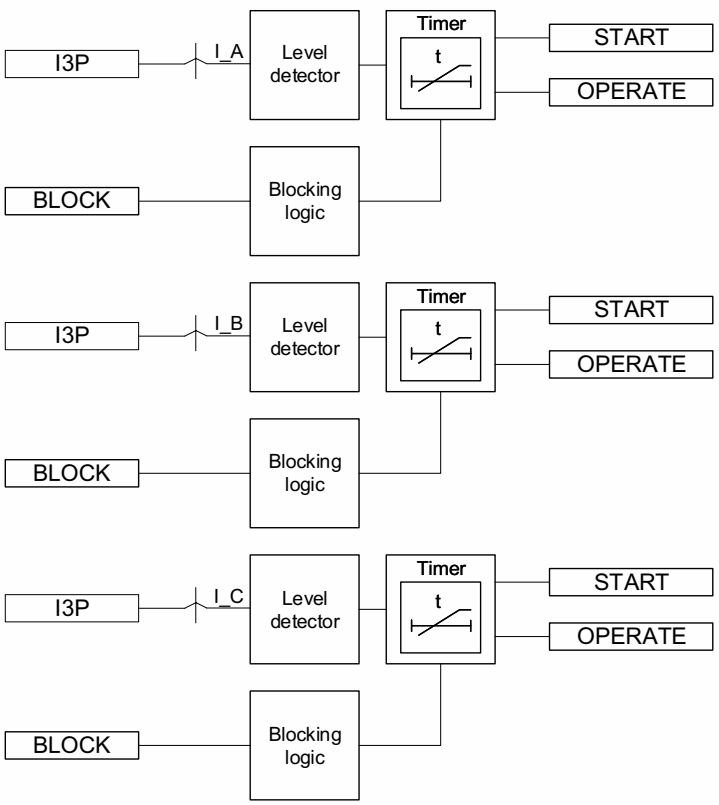



*Figure 380: Functional module diagram*

The module diagram illustrates all the phases of the function. Functionality for phases A, B and C is identical.

All three phases have independent settings.

## Level detector

The module compares differential currents `I_A` calculated by the peak-to-peak measurement mode to the set *Operate value*. The Timer module is activated if the differential current exceeds the value of the *Operate value* setting.

## Timer

Once activated, Timer activates the `START` output. The time characteristic is according to DT. When the operation timer reaches the value set by *Minimum operate time*, the `OPERATE` output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the `START` output is deactivated.

Timer calculates the start duration START_DUR value, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the Monitored data view.

The activation of the BLOCK input resets Timer and deactivates the START and OPERATE outputs.

### Blocking logic

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.3.6.6 Application

HIxPDIF provides a secure and dependable protection scheme against all types of faults.The high-impedance principle is used for differential protection due to its capability to manage the through-faults also with the heavy current transformer (CT) saturation.

For current transformer recommendations, see the Requirements for measurement transformers section in this manual.

### High-impedance principle

The phase currents are measured from both the incoming and the outgoing feeder sides of the busbar. The secondary of the current transformer in each phase is connected in parallel with a protection relay measuring branch. Hence, the relay measures only the difference of the currents. In an ideal situation, there is a differential current to operate the relay only if there is a fault between the CTs, that is, inside the protected zone.

If there is a fault outside the zone, a high current, known as the through-fault current, can go through the protected object. This can cause partial saturation in the CTs. The relay operation is avoided with a stabilizing resistor ($R_s$) in the protection relay measuring branch. $R_s$ increases the impedance of the protection relay; hence the name high-impedance differential scheme.

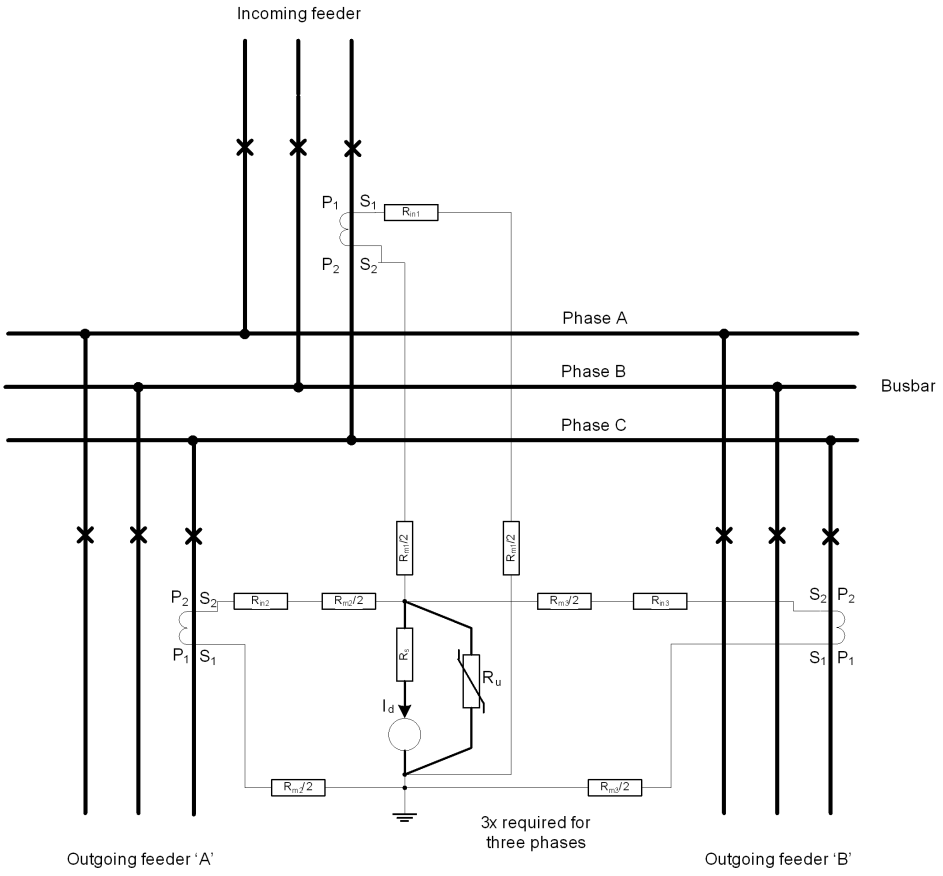



*Figure 381: Phase-segregated bus differential protection based on high-impedance principle*

CT secondary winding resistances ($R_{in}$) and connection wire resistances ($R_m/2$) are also shown in Figure 382.

Figure 382 demonstrates a simplified circuit consisting only of one incoming and outgoing feeder. To keep it simple, the voltage-dependent resistor ($R_u$) is not included. The wiring resistances are presented as total wiring resistances $R_{m1}$ and $R_{m2}$.

$R_{m1}$ is the maximum wiring resistance concerning all incoming feeder sets, whereas $R_{m2}$ is the maximum wiring resistance concerning all outgoing feeder sets.

The lower part of Figure 382 shows the voltage balance when there is no fault in the system and no CT saturation.

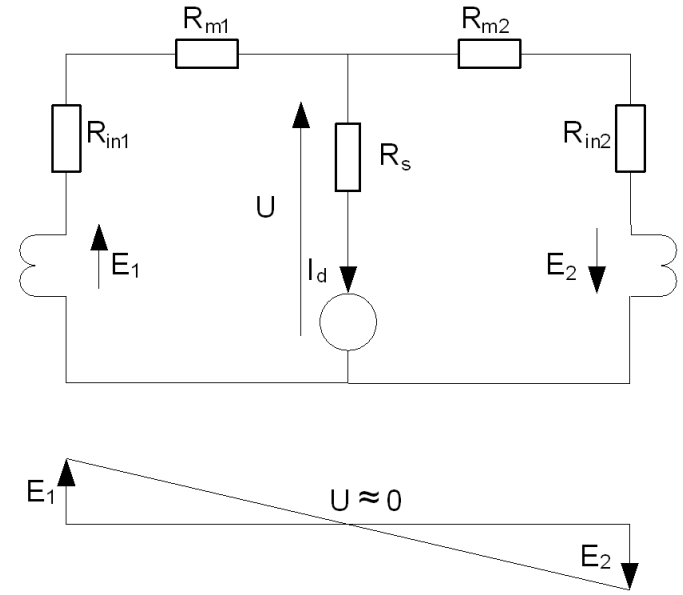



*Figure 382: Equivalent circuit when there is no fault or CT saturation*

When there is no fault, the CT secondary currents and their emf voltages, $E_1$ and $E_2$, are opposite and the protection relay measuring branch has no voltage or current. If an in-zone fault occurs, the secondary currents have the same direction. The relay measures the sum of the currents as a differential and trips the circuit breaker. If the fault current goes through only one CT, its secondary emf magnetizes the opposite CT, that is, $E_1 \approx E_2$.

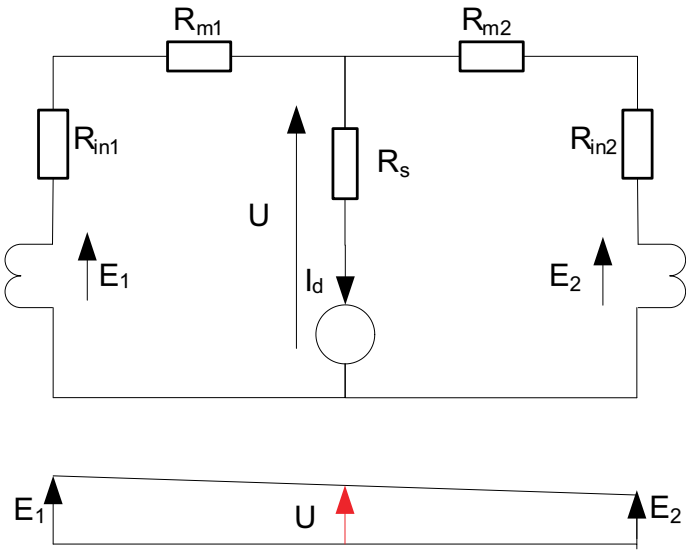



*Figure 383: Equivalent circuit in case of in-zone fault*

Figure 384 shows CT saturation at a through-fault, that is, out-of-zone, situation. The magnetization impedance of a saturated CT is almost zero. The saturated CT winding

can be presented as a short circuit. When one CT is saturated, the current of the non-saturated CT follows two paths, one through the protection relay measuring branch ($R_s$ + relay) and the other through the saturated CT ($R_m$ + $R_{in2}$).

The protection relay must not operate during the saturation. This is achieved by increasing the relay impedance by using the stabilizing resistor ($R_s$) which forces the majority of the differential current to flow through the saturated CT. As a result, the relay operation is avoided, that is, the relay operation is stabilized against the CT saturation at through-fault current. The stabilizing voltage $U_s$ is the basis of all calculations.

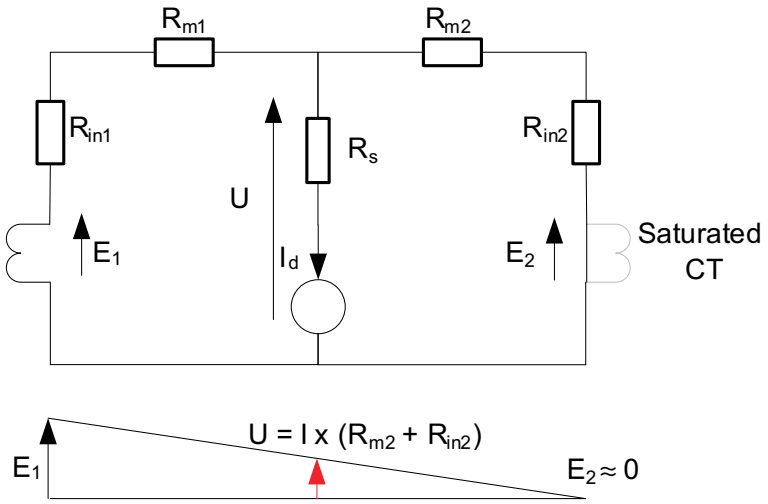



*Figure 384: Equivalent circuit in case of the CT saturation at through-fault*

The CT saturation happens most likely in the case of an in-zone fault. This is not a problem, because although the operation remains stable (non-operative) during the saturated parts of the CT secondary current waveform, the non-saturated part of the current waveform causes the protection to operate.

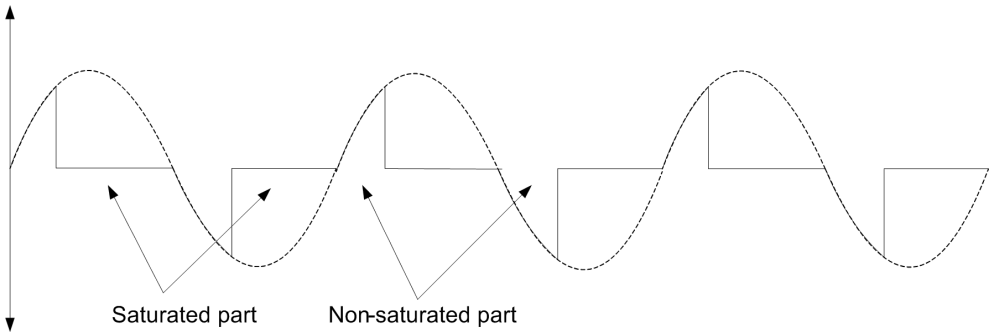



*Figure 385: Secondary waveform of a saturated CT*

The secondary circuit voltage can easily exceed the isolation voltage of the CTs, connection wires and the protection relay because of the stabilizing resistance and CT saturation. A voltage dependent resistor (VDR, $R_u$) is used to limit the voltage as shown in Figure 381.

## Busbar protection scheme

The basic concept for any bus differential protection relay is a direct use of Kirchoff's first law that the sum of all currents connected to one differential protection zone is zero. If the sum is not zero, an internal fault has occurred. In other words, as seen by the busbar differential protection, the sum of all currents that flow into the protection zone, that is, currents with positive value, must be equal to currents that flow out of the protection zone, that is, currents with negative value, at any instant of time.

Figure 386 shows an example of a phase segregated single busbar protection employing high-impedance differential protection. The example system consists of a single incoming busbar feeder and two outgoing busbar feeders. The CTs from both the outgoing busbar feeders and the incoming busbar feeders are connected in parallel with the polarity. During normal load conditions, the total instantaneous incoming current is equal to the total instantaneous outgoing current and the difference current is negligible. A fault in the busbar results in an imbalance between the incoming and the outgoing current. The difference current flows through the protection relay, which generates a trip signal.

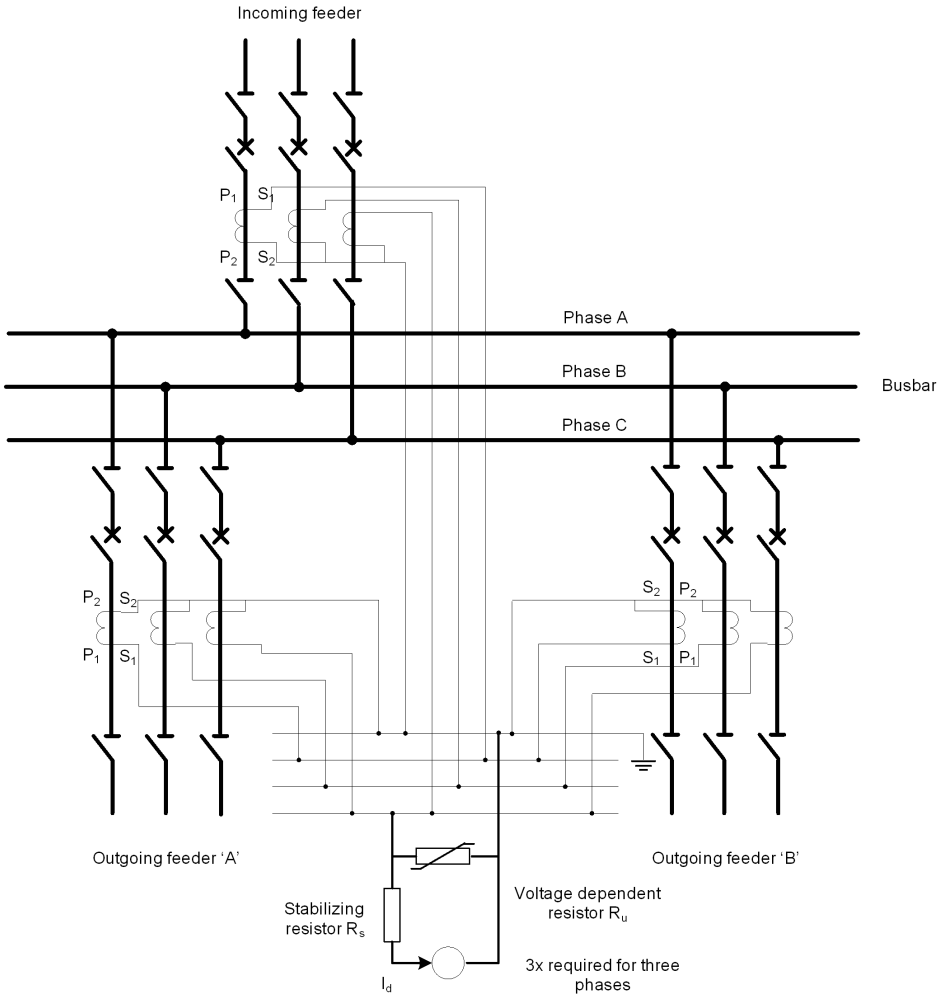



*Figure 386: Phase-segregated single busbar protection employing high-impedance differential protection*

Figure 387 shows an example for a system consisting of two busbar section coupled with a bus coupler. Each busbar section consists of two feeders and both sections are provided with a separate differential protection to form different zones. The formed zones overlap at the bus coupler.

When the bus coupler is in the open position, each section of the busbar handles the current flow independently, that is, the instantaneous incoming current is equal to the total instantaneous outgoing current and the difference current is negligible. The difference current is no longer zero with a fault in the busbar and the protection operates.

With the bus coupler in the closed position, the current also flows from one busbar section to another busbar section. Thus, the current flowing through the bus coupler needs to be considered in calculating differential current. During normal condition, the summation of the current on each bus section is zero. However, if there is a fault

in any busbar section, the difference current is no longer zero and the protection operates.

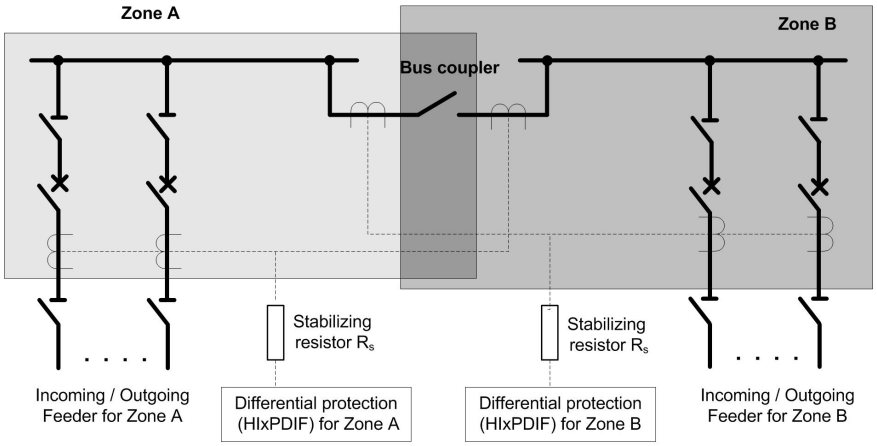



*Figure 387: Differential protection on busbar with bus coupler (Single-phase representation)*

### 4.3.6.7 Example calculations for busbar high-impedance differential protection

The protected object in the example for busbar differential protection is a single-bus system with two zones of protection.

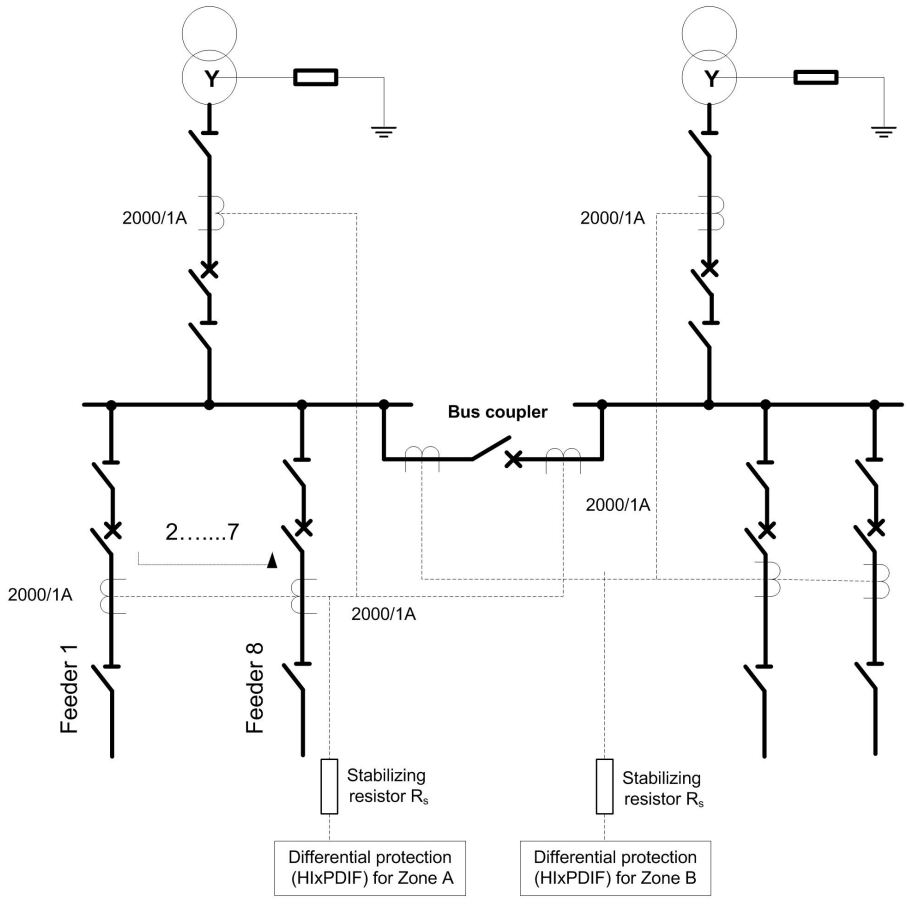



*Figure 388: Example for busbar differential protection*

Bus data:

| | |
|---|---|
| $U_n$ | 20 kV |
| $I_n$ | 2000 A |
| $I_{kmax}$ | 25 kA |

10 feeders per protected zone including bus coupler and incomer.

CT data is assumed to be:

| | |
|---|---|
| CT | 2000/1 A |
| $R_{in}$ | 15.75 Ω |
| $U_{kn}$ | 436 V |
| $I_e$ | <7 mA (at $U_{kn}$) |
| $R_m$ | 1Ω |

The stabilizing voltage is calculated using the formula:

$$U_s = \frac{25000A}{2000} \cdot (15.75\Omega + 1.\Omega) \approx 209.37\ V$$

(Equation 141)

In this case, the requirement for the current transformer knee point voltage is fulfilled because $U_{kn} > 2U_s$.

The magnetizing curve of the CT is assumed to be linear. The magnetizing current at the stabilizing voltage can be estimated as:

$$I_m = \frac{U_s}{U_{kn}} \cdot I_e$$

(Equation 142)

$$I_m = \frac{209.37V}{436\,V} \cdot 7mA \approx 3.4mA$$

(Equation 143)

To obtain adequate protection stability, the setting current $I_{rs}$ must be at the minimum of the sum of magnetizing currents of all connected CTs.

$$I_{rs} = 10 \cdot 3.4mA \approx 34\,mA$$

(Equation 144)

The resistance of the stabilizing resistor is calculated based on Equation 145.

$$R_s = \frac{209.37\ V}{0.034\,A} \approx 6160\,\Omega$$

(Equation 145)

The calculated value is the maximum value for the stabilizing resistor. If the value is not available, the next available value below should be selected and the protection relay setting current is tuned according to the selected resistor. For example, in this case, the resistance value 5900 Ω is used.

$$I_{rs} = \frac{209.37\,V}{5900\,\Omega} \approx 35\,mA$$

(Equation 146)

The sensitivity of the protection is obtained as per Equation 147, assuming $I_u = 0$.

$$I_{prim} = 2000 \cdot (0.035\,A + 10 \cdot 0.0034\,A + 0\,A) \approx 140\,A$$

(Equation 147)

The power of the stabilizing resistor is calculated:

$$P \geq \frac{(436V)^2}{5900\Omega} \approx 32\,W$$

(Equation 148)

Based on Equation 149 and Equation 150, the need for voltage-dependent resistor is checked.

$$U_{max} = \frac{25000\,A}{2000} \cdot (5900\,\Omega + 15.75\Omega + 1.00\,\Omega) \approx 74.0\,kV$$

(Equation 149)

$$\breve{u} = 2 \cdot \sqrt{2 \cdot 436V \cdot (74000V - 436V)} \approx 16.0\,kV$$

(Equation 150)

The voltage-dependent resistor (one for each phase) is needed in this case as the voltage during the fault is higher than 2 kV.

The leakage current through the VDR at the stabilizing voltage can be available from the VDR manual, assuming that to be approximately 2 mA at stabilizing voltage

$$Iu \approx 0.002\,A$$

(Equation 151)

The sensitivity of the protection can be recalculated taking into account the leakage current through the VDR as per Equation 152.

$$I_{prim} = 2000 \cdot (0.035\,A + 10 \cdot 0.0034\,A + 0.002\,A) \approx 142A$$

(Equation 152)

### 4.3.6.8 Signals

*Table 623: HIAPDIF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 624: HIBPDIF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 625: HICPDIF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 626: HIAPDIF Output signals*

| Name | Type | Description |
|---|---|---|
| START | BOOLEAN | Start |
| OPERATE | BOOLEAN | Operate |

*Table 627: HIBPDIF Output signals*

| Name | Type | Description |
|---|---|---|
| START | BOOLEAN | Start |
| OPERATE | BOOLEAN | Operate |

*Table 628: HICPDIF Output signals*

| Name | Type | Description |
|---|---|---|
| START | BOOLEAN | Start |
| OPERATE | BOOLEAN | Operate |

### 4.3.6.9 Settings

*Table 629: HIAPDIF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 1.0...200.0 | %In | 1.0 | 5.0 | Operate value, percentage of the nominal current |
| Minimum operate time | 20...300000 | ms | 10 | 20 | Minimum operate time |

*Table 630: HIAPDIF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 631: HIAPDIF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |

*Table 632: HIBPDIF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 1.0...200.0 | %In | 1.0 | 5.0 | Operate value, percentage of the nominal current |
| Minimum operate time | 20...300000 | ms | 10 | 20 | Minimum operate time |

*Table 633: HIBPDIF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 634: HIBPDIF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |

*Table 635: HICPDIF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 1.0...200.0 | %In | 1.0 | 5.0 | Operate value, percentage of the nominal current |
| Minimum operate time | 20...300000 | ms | 10 | 20 | Minimum operate time |

*Table 636: HICPDIF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 637: HICPDIF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |

### 4.3.6.10 Monitored data

*Table 638: HIAPDIF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| HIAPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

*Table 639: HIBPDIF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| HIBPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

*Table 640: HICPDIF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| HICPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 4.3.6.11 Technical data

*Table 641: HIxPDIF Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the current measured: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Start value* | 8 ms | 11 ms | 19 ms |
| | $I_{Fault}$ = 10 × set *Start value* | 7 ms | 9 ms | 11 ms |
| Reset time | | Typically <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |

1) *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Measured with static signal output (SSO)

## 4.3.7 Stabilized and instantaneous differential protection for machines MPDIF

### 4.3.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Stabilized and instantaneous differential protection for machines | MPDIF | 3dI>G/M | 87M/87G |

### 4.3.7.2 Function block

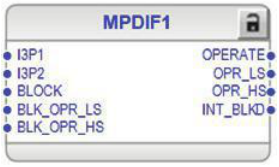



*Figure 389: Function block*

### 4.3.7.3 Functionality

The stabilized and instantaneous differential protection for machines function MPDIF is a unit protection function. The possibility of internal failures of the machine is relatively low. However, the consequences in terms of cost and production loss are often serious, which makes the differential protection an important protection function.

The stability of the differential protection is enhanced by a DC restraint feature. This feature decreases the sensitivity of the differential protection optionally for a temporary time period to avoid an unnecessary disconnection of the machine during the external faults that have a fault current with high DC currents. MPDIF also includes a CT saturation-based blocking which prevents unnecessary tripping in case of the detection of the magnetizing inrush currents which can be present at the switching operations, overvoltages or external faults.

### 4.3.7.4 Analog channel configuration

MPDIF has two analog group inputs which must be properly configured.

*Table 642: Analog inputs*

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.7.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of MPDIF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

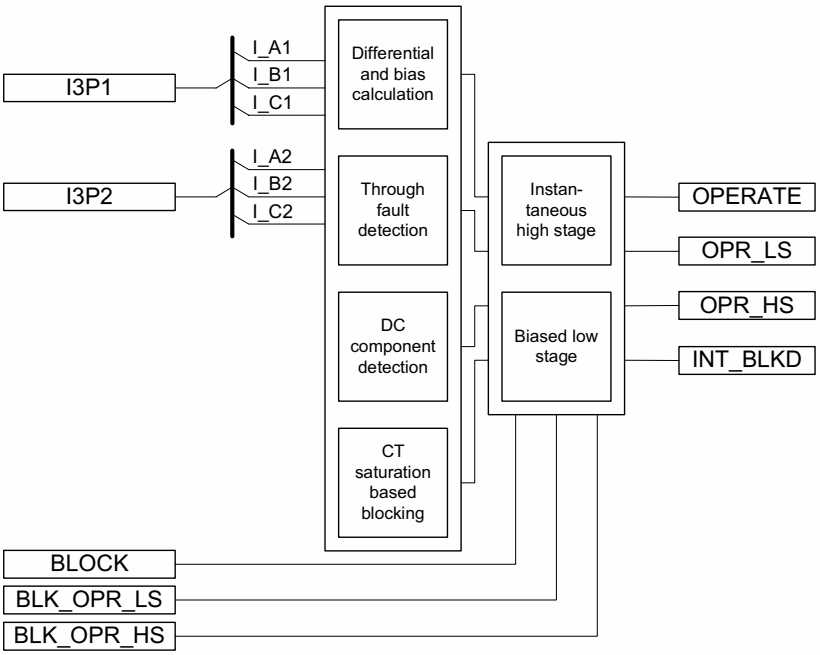



*Figure 390: Functional module diagram*

#### Differential and bias calculation

Differential calculation module calculates the differential current. The differential current is the difference in current between the phase and neutral sides of the machine.

The phase currents $\bar{I}_1$ and $\bar{I}_2$ denote the fundamental frequency components on the phase and neutral sides of the current. The amplitude of the differential current $I_d$ is obtained using the equation (assuming that the positive direction of the current is towards the machine):

$$I_d = \left| \bar{I}_1 + \bar{I}_2 \right|$$

(Equation 153)

During normal conditions, there is no fault in the area protected by the function block, so the currents $\bar{I}_1$ and $\bar{I}_2$ are equal and the differential current $I_d = 0$. However, in practice some differential current exists due to inaccuracies in the current transformer on the phase and neutral sides, but it is very small during normal conditions.

The module calculates the differential current for all three phases.

The low-stage differential protection is stabilized with a bias current. The bias current is also known as the stabilizing current. Stabilization means that the differential current required for tripping increases according to the bias current and the operation characteristics. When an internal fault occurs, the currents on both sides of the protected object are flowing into it. This causes the biasing current to be considerably smaller, which makes the operation more sensitive during internal faults.

The traditional way for calculating the stabilized current is:

$$I_b = \left| \frac{\bar{I}_1 - \bar{I}_2}{2} \right|$$

(Equation 154)

The module calculates the bias current for all three phases.

## Through-fault detection

Through-fault (TF) detection module is for detecting whether the fault is external, that is, going through, or internal. This information is essential for ensuring the correct operation of the protection in case of the CT saturation.

- In a through-fault situation, CTs can saturate because of a high fault current magnitude. Such AC saturation does not happen immediately when the fault begins. Thus, the TF module sees the fault as external because the bias current is high but the differential current remains low. If the AC saturation then occurs, a CT saturation-based blocking is allowed to work to prevent tripping.
- Normally, the phase angle between the machine neutral and line side CTs is 180 degrees. If an internal fault occurs during a through fault, an angle less than 50 degrees clearly indicates an internal fault and the TF module overrules, that is, deblocks the presence of any blocking due to CT saturation.

## CT saturation-based blocking

Higher currents during the motor startup or abnormally high magnetizing currents at an overvoltage (transformer-fed motor) or an external fault may saturate the current transformers. The uneven saturation of the star and line side CTs (for example, due to burden differences) may lead to a differential current which can cause a differential protection to operate. This module blocks the operation of MPDIF biased low stage internally in case of the CT saturation. Once the blocking is activated, it is held for a certain time after the blocking conditions have ceased to be fulfilled.

## DC component detection

On detection of a DC component, the function temporarily desensitizes the differential protection. The functioning of this module depends on the *DC restrain Enable* setting. The DC components are continuously extracted from the three instantaneous differential currents. The highest DC component of all three is taken as a kind of DC restraint in a sense that the highest effective, temporary sensitivity of the protection is temporarily decreased as a function of this highest DC offset. The calculated DC restraint current is not allowed to decay (from its highest ever measured value) faster than with a time constant of one second. The value of the temporarily effective sensitivity limit is limited upwards to the rated current of the machine or 3.3 times that of *Low operate value*, whichever is smaller. The temporary extra limit decays exponentially from its maximum value with a time constant of one second.

This feature should be used in case of networks where very long time constants are expected. The temporary sensitivity limit is higher to the set operating characteristics. In other words, the temporary limit has superposed the unchanged operating characteristics and temporarily determines the highest sensitivity of the protection. The temporary sensitivity is less than the sensitivity in section 1 of the operating characteristic and is supposed to prevent an unwanted trip during the external faults with lower currents.

## Biased low stage

The current differential protection needs to be biased because of the possible appearance of a differential current which can be due to something else than an actual fault in the machine. In case of differential protection, a false differential current can be caused by:

- CT errors
- CT saturation at high currents passing through the machine

The differential current caused by CT errors increases at the same percent ratio as the load current.

The high currents passing through the protected object can be caused by the through fault. Therefore, the operation of the differential protection is biased with respect to the load current. In the biased differential protection, the higher the differential current required for the protection of operation, the higher the load current.

Based on the conditions checked from the through-fault module, the DC (component) detection module and the CT saturation-based blocking modules, the biased low-stage module decides whether the differential current is due to the internal faults or some false reason. In case of detection of the TF, DC or CT saturation, the internal differential blocking signal is generated, which in turn blocks the operating signal. In case of internal faults, the operation of the differential protection is affected by the bias current .

The *Low operate value* setting for the stabilized stage of the function block is determined with the equation:

$$Low\ operate\ value = I_{d1}$$

(Equation 155)

The *Slope section 2* and *Slope section 3* settings are determined correspondingly:

$$Slope\ section2 = \frac{I_{d2}}{I_{b2}} \cdot 100\%$$

(Equation 156)

$$Slope\ section3 = \frac{I_{d3}}{I_{b3}} \cdot 100\%$$

(Equation 157)

The end of the first section *End section 1* can be set at a desired point within the range of 0 to 100 percent (or % $I_r$). Accordingly, the end of the second section *End section 2* can be set within the range of 100 percent to 300 percent (or % $I_r$).

The slope of the operating characteristic for the function block varies in different parts of the range.

In section 1, where 0.0 < $I_b/I_n$ < *End section 1*, the differential current required for tripping is constant. The value of the differential current is the same as the *Low operate value* setting selected for the function block. The *Low operate value* setting allows for small inaccuracies of the current transformers but it can also be used to influence the overall level of the operating characteristic.

Section 2, where *End section 1* < $I_b/I_n$ < *End section 2*, is called the influence area of the setting *Slope section 2*. In this section, variations in *End section 2* affect the slope of the characteristic, that is, how big the change in the differential current required for tripping is in comparison to the change in the load current. The *End section 2* setting allows for CT errors.

In section 3, where $I_b/I_n$ > *End section 2*, the slope of the characteristic can be set by *Slope section 3* that defines the increase in the differential current to the corresponding increase in the biasing current.

The required differential current for tripping at a certain stabilizing current level can be calculated using the formulae:

For a stabilizing current lower than *End section 1*

$$I_{doperate}[\%I_r] = Set\ Low\ operate\ value$$

(Equation 158)

For a stabilizing current higher than *End section 1* but lower than *End section 2*

$$I_{doperate}[\%I_r] = Low\ operate\ value + (I_b[\%Ir] - End\ section1) \cdot Slope\ section2$$

(Equation 159)

For higher stabilizing current values exceeding *End section 2*

$$I_{d\,operate}[\%I_r] = Low\ operate\ value + (End\ section2 - End\ section1) \cdot Slope\ section2 + (I_b[\%I_r] - End\ section2) \cdot Slope\ section3$$

(Equation 160)

When the differential current exceeds the operating value determined by the operating characteristics, the OPR_LS output is activated. The OPERATE output is always activated when the OPR_LS output activates.

The operate signal due to the biased stage can be blocked by the activation of the BLK_OPR_LS or BLOCK input. Also, when the operation of the biased low stage is blocked by the waveform blocking functionality, the INT_BLKD output is activated according to the phase information.

The phase angle difference between the two currents I_A1 and I_A2 is theoretically 180 electrical degrees for the external fault and 0 electrical degrees for the internal fault conditions. If the phase angle difference is less than 50 electrical degrees or if the biasing current drops below 30 percent of the differential current, a fault has most likely occurred in the area protected by MPDIF. Then the internal blocking signals (CT saturation and DC blocking) of the biased stage are inhibited.

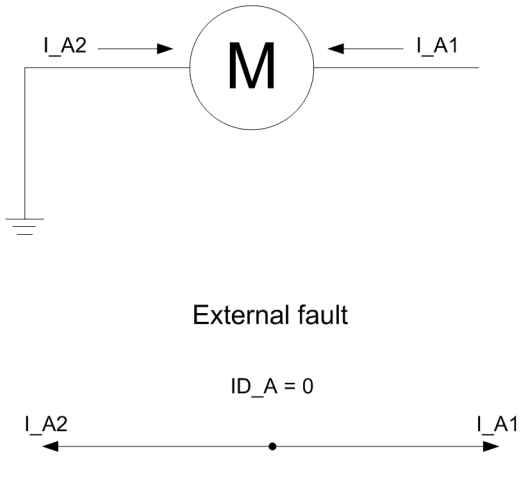



*Figure 391: Positive direction of current*

## Instantaneous high stage

The differential protection includes an unbiased instantaneous high stage. The instantaneous stage operates and the OPR_HS output is activated when the amplitude of the fundamental frequency component of the differential current exceeds the set *High operate value* or when the instantaneous peak values of the differential current exceed 2.5 · *High operate value*. The factor 2.5 (= 1.8 · √2) is due to the maximum asymmetric short circuit current.

The OPERATE output is always activated when the OPR_HS output activates.

The internal blocking signals of the function block do not prevent the operation of the instantaneous stage. When required, the operate signal due to instantaneous operation can be blocked by the binary inputs BLK_OPR_HS or BLOCK.

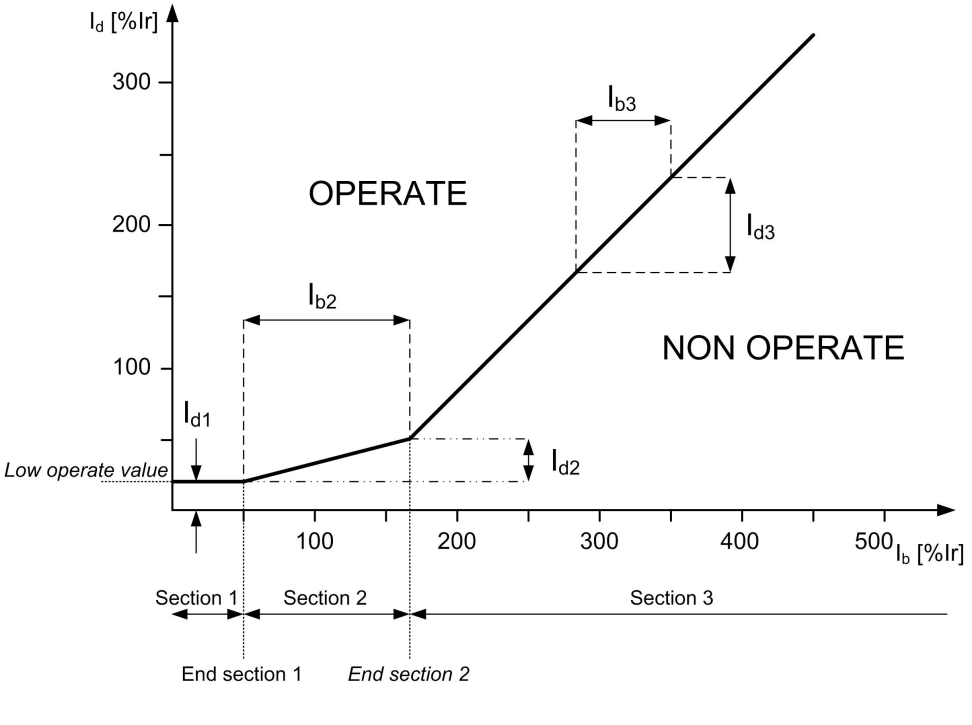



*Figure 392: Operating characteristic for the stabilized stage of the generator differential protection function*

## 4.3.7.6 Application

The differential protection works on the principle of calculating the differential current at the two ends of the winding, that is, the current entering the winding is compared to the current exiting the winding. In case of any internal fault, the currents entering and exiting the winding are different, which results in a differential current, which is then used as a base for generating the operating signal. Due to this principle, the differential protection does not trip during external faults. However, it should be noted that interturn faults in the same phase are usually not detected unless they developed into some other kind of fault.

The short circuit between the phases of the stator windings normally causes large fault currents. The short circuit creates a risk of damages to the insulation, windings and stator core. The large short circuit currents cause large current forces which can damage other components in the machine. The short circuit can also initiate explosion and fire. When a short circuit occurs in a machine, there is a damage that has to be repaired. The severity and the repair time depend on the degree of damage, which is highly dependent on the fault time. The fast fault clearance of this fault type is of greatest importance to limit the damages and the economic loss.

To limit the damages in connection to the stator winding short circuits, the fault clearance time must be as short as possible (instantaneous). The fault current

contributions from both the external power system (via the machine or the block circuit breaker) and from the machine itself must be disconnected as fast as possible.

The DC restraint feature should be used in case of an application with a long DC time constant in the fault currents is present. This fault current may be of a lesser magnitude (less than rated current) but is unpleasant and tends to saturate the CT and operate the differential protection for external faults. This feature is effective at moderate through-currents and ineffective at higher through-currents.

Although the short circuit fault current is normally very large, that is, significantly larger than the rated current of the machine, it is possible that a short circuit can occur between phases close to the neutral point of the machine, causing a relatively small fault current. The fault current fed from the synchronous machine can also be limited due to a low excitation of the synchronous generator. This is normally the case at the run-up of the synchronous machine, before synchronization to the network. Therefore, it is desired that the detection of the machine phase-to-phase short circuits shall be relatively sensitive, thus detecting the small fault currents.

It is also important that the machine short circuit protection does not trip for external faults when a large fault current is fed from the machine. To combine fast fault clearance, sensitivity and selectivity, the machine current differential protection is normally the best alternative for the phase-to-phase short circuits.

The risk of an unwanted differential protection operation caused by the current transformer saturation is a universal differential protection problem. If a big synchronous machine is tripped in connection to an external short circuit, it gives an increased risk of a power system collapse. Besides, there is a production loss for every unwanted trip of the machine. Therefore, preventing the unwanted disconnection of machines has a great economical value.

### Recommendations for current transformers

The more important the object to be protected is, the more attention is paid to the current transformers. It is not normally possible to dimension the current transformers so that they repeat the currents with high DC components without saturating when the residual flux of the current transformer is high. The differential protection function block operates reliably even though the current transformers are partially saturated.

The accuracy class recommended for current transformers to be used with the differential function block is 5P, in which the limit of the current error at the rated primary current is 1 percent and the limit of the phase displacement is 60 minutes. The limit of the composite error at the rated accuracy limit primary current is 5 percent.

The approximate value of the actual accuracy limit factor $F_a$ corresponding to the actual CT burden can be calculated on the basis of the rated accuracy limit factor $F_n$ (ALF) at the rated burden, the rated burden $S_n$, the internal burden $S_{in}$ and the actual burden $S_a$ of the current transformer.

$$F_a = F_n \cdot \frac{S_{in} + S_n}{S_{in} + S_a}$$

(Equation 161)

## Example 1

The rated burden $S_n$ of the current transformer 5P20 is 10 VA, the secondary rated current 5A, the internal resistance $R_{in}$ = 0.07 Ω and the rated accuracy limit factor $F_n$ corresponding to the rated burden is 20 (5P20). The internal burden of the current transformer is $S_{in} = (5A)^2 \times 0.07\ \Omega = 1.75$ VA. The input impedance of the protection relay at a rated current of 5A is < 20 mΩ. If the measurement conductors have a resistance of 0.113 Ω, the actual burden of the current transformer is $S_a = (5A)^2 \times (0.113 + 0.020)\ \Omega = 3.33$ VA. Thus, the accuracy limit factor $F_a$ corresponding to the actual burden is about 46.

The CT burden can grow considerably at the rated current 5A. The actual burden of the current transformer decreases at the rated current of 1 A while the repeatability simultaneously improves.

At faults occurring in the protected area, the fault currents can be very high compared to the rated currents of the current transformers. Due to the instantaneous stage of the differential function block, it is sufficient that the current transformers are capable of repeating the current required for an instantaneous tripping during the first cycle.

Thus the current transformers usually are able to reproduce the asymmetric fault current without saturating within the next 10 ms after the occurrence of the fault to secure the operating times of the protection relay comply with the retardation time.

The accuracy limit factors corresponding to the actual burden of the phase current transformer to be used in differential protection must fulfill the requirement:

$$F_a > K_r \cdot Ik_{max} \cdot (T_{dc} \cdot \omega \cdot (1 - e^{\frac{-T_m}{T_{dc}}}) + 1)$$

(Equation 162)

| | |
|---|---|
| $Ik_{max}$ | The maximum through-going fault current (in $I_R$) at which the protection is not allowed to operate |
| $T_{dc}$ | The primary DC time constant related to $Ik_{max}$ |
| ω | The angular frequency, that is, 2 x π x $f_n$ |
| $T_m$ | The time to saturate, that is, the duration of the saturation-free transformation |
| $K_r$ | The remanence factor 1/(1-r), where r is the maximum remanence flux in pu from the saturation flux |

The parameter r is the maximum remanence flux density in the CT core in pu from the saturation flux density. The value of the parameter r depends on the magnetic material used and also on the construction of the CT. For instance, if the value r = 0.4, the remanence flux density can be 40 percent of the saturation flux density. The manufacturer of the CT has to be contacted when an accurate value for the parameter r is needed. The value r = 0.4 is recommended to be used when an accurate value is not available.

The required minimum time-to-saturate $T_m$ in MPDIF is half-fundamental cycle period (10 ms when $f_n$ = 50 Hz).

Two typical cases are considered for the determination of the sufficient actual accuracy limit factor $F_a$:

1. A fault occurring at the substation bus.

   The protection must be stable at a fault arising during a normal operating situation. The reenergizing of the transformer against a bus fault leads to very high fault currents and thermal stress. Therefore, reenergizing is not preferred in this case. The remanence can be neglected.
   The maximum through-going fault current $Ik_{max}$ is typically 6 $I_R$ for a motor. At a short circuit fault close to the supply transformer, the DC time constant $T_{dc}$ of the fault current is almost the same as that of the transformer, the typical value being 100 ms.

   $Ik_{max}$ = 6 $I_R$
   $T_{dc}$ = 100 ms
   $\omega$ = 100π Hz
   $T_m$ = 10 ms
   $K_r$ = 1

   Equation 162 with these values gives the result:

$$F_a > K_r \cdot Ik_{max} \cdot (T_{dc} \cdot \omega \cdot (1 - e^{\frac{-T_m}{T_{dc}}}) + 1) \approx 24$$

(Equation 163)

2. Reenergizing against a fault occurring further down in the network.

   The protection must be stable also during reenergization against a fault on the line. In this case, the existence of remanence is very probable. It is assumed to be 40 percent here.
   On the other hand, the fault current is now smaller and since the ratio of the resistance and reactance is greater in this location, having a full DC offset is not possible. Furthermore, the DC time constant ($T_{dc}$) of the fault current is now smaller, assumed to be 50 ms here.
   Assuming the maximum fault current is 30 percent lower than in the bus fault and a DC offset 90 percent of the maximum.

   $Ik_{max}$ = 0.7 × 6 = 4.2 ($I_R$)
   $T_{dc}$ = 50 ms
   $\omega$ = 100π Hz
   $T_m$ = 10 ms

$K_r$ = 1/(1-0.4) = 1.6667

Equation 162 with these values gives the result:

$$F_a > K_r \cdot Ik_{max} \cdot 0.9 \cdot (T_{dc} \cdot \omega \cdot (1 - e^{\frac{-T_m}{T_{dc}}}) + 1) \approx 24$$

(Equation 164)

If the actual burden of the current transformer $S_a$ in the accuracy limit factor equation cannot be reduced low enough to provide a sufficient value for $F_a$, there are two alternatives to deal with the situation.

1. A current transformer with a higher rated burden $S_n$ can be chosen (which also means a higher rated accurate limit $F_n$).
2. A current transformer with a higher nominal primary current $I_{1n}$ (but the same rated burden) can be chosen.

Alternative 2 is more cost-effective and therefore often better, although the sensitivity of the scheme is slightly reduced.

## Example 2

Here the actions according to alternative 2 are taken to improve the actual accuracy limit factor.

$$F_a = \left( \frac{I_R CT}{I_R Motor} \right) \cdot F_n$$

(Equation 165)

| | |
|---|---|
| $I_R$CT | rated primary current of the CT, for example, 1500A |
| $I_R$Motor | rated current of the motor under protection, for example, 1000A |
| $F_n$ | rated accuracy limit factor of the CT, for example, 30 |
| $F_a$ | actual accuracy limit factor due to oversizing the CT, substituting the values in the equation, $F_a$ = 45 |

In differential protection it is important that the accuracy limit factors $F_a$ of the phase current transformers at both sides correspond with each other, that is, the burdens of the current transformers on both sides are to be as close to each other as possible. If high inrush or start currents with high DC components pass through the protected object when it is connected to the network, special attention is required for the performance and the burdens of the current transformers and the settings of the function block.

## Connection of current transformers

The connections of the primary current transformers are designated as Type 1 and Type 2.

- If the positive directions of the winding 1 and winding 2 protection relay currents are opposite, the *CT connection type* is of "Type 1". The connection examples of "Type 1" are as shown in figures 393 and 394.
- If the positive directions of the winding 1 and winding 2 protection relay currents equate, the *CT connection type* setting parameter is "Type 2". The connection examples of "Type 2" are as shown in figures 395 and 396.
- The default value of the *CT connection type* setting is "Type 1".

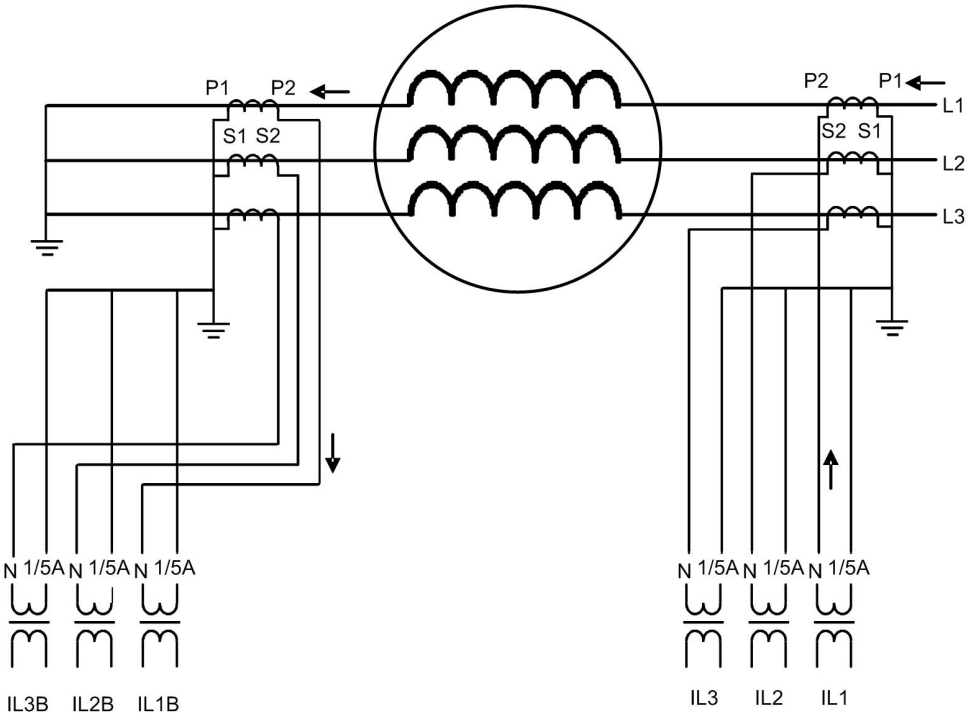



*Figure 393: Connection of current transformer of Type 1, example 1*

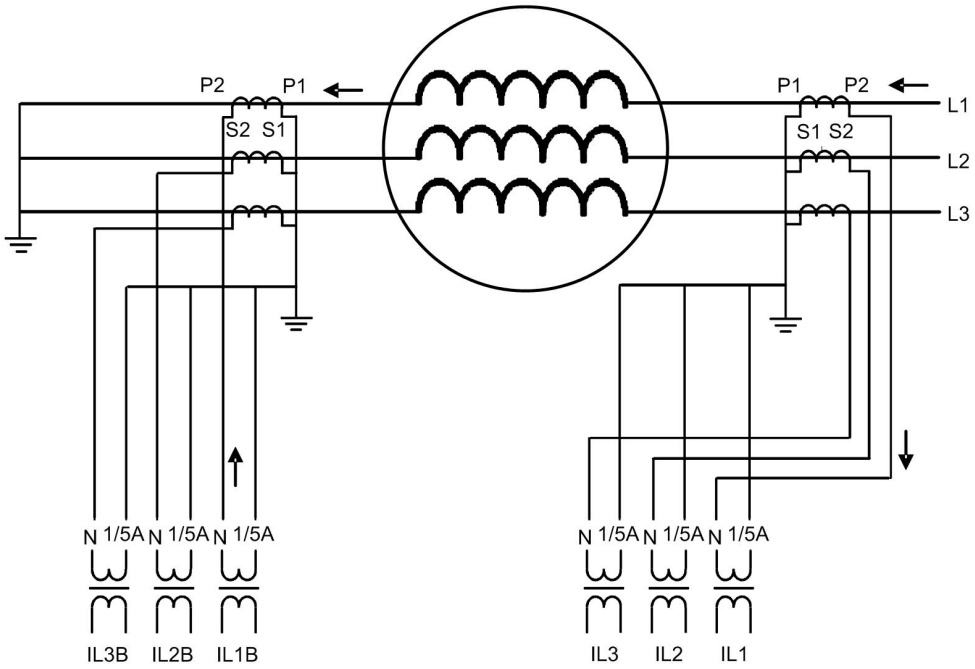



*Figure 394: Connection of current transformer of Type 1, example 2*

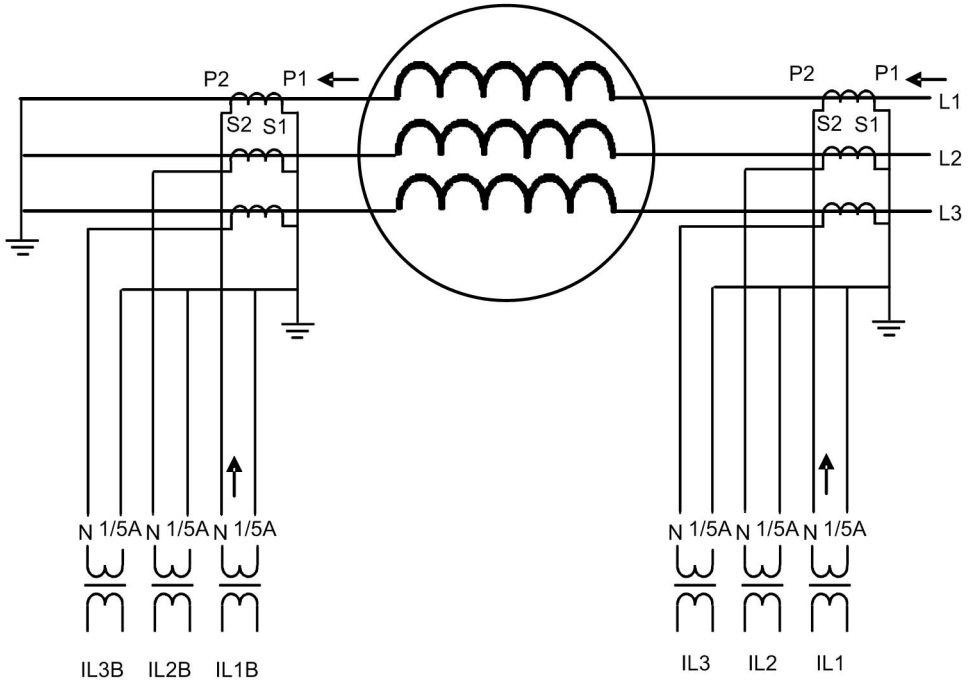



*Figure 395: Connection of current transformer of Type 2, example 1*

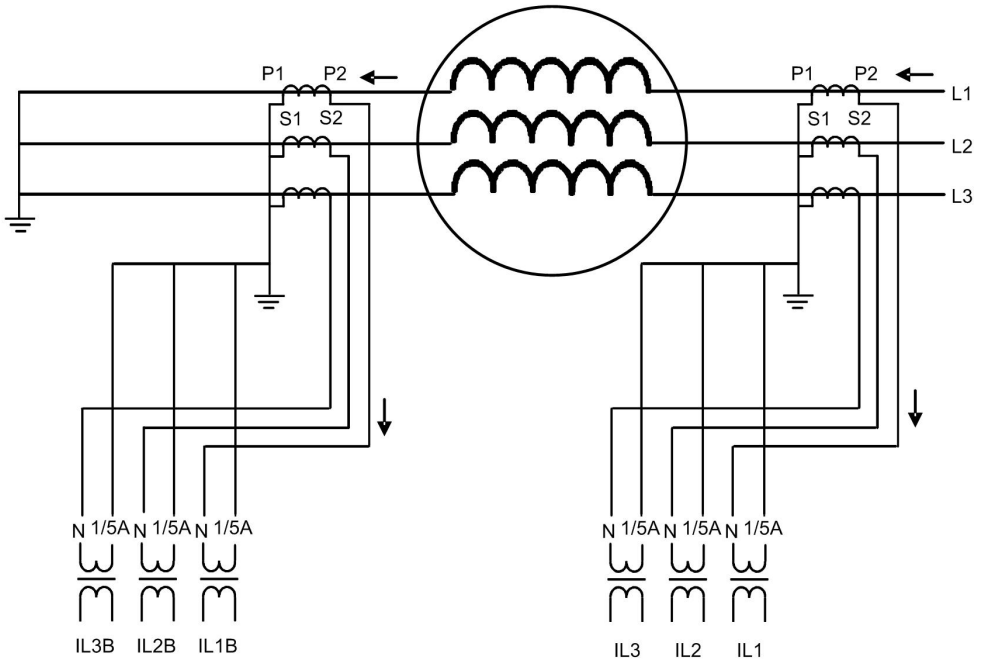



*Figure 396: Connection of current transformer of Type 2, example 2*

## Saturation of current transformers

There are basically two types of saturation phenomena that have to be detected: the AC saturation and the DC saturation. The AC saturation is caused by a high fault current where the CT magnetic flux exceeds its maximum value. As a result, the secondary current is distorted as shown in Figure 397. A DC component in the current also causes the flux to increase until the CT saturates. This is known as DC saturation.

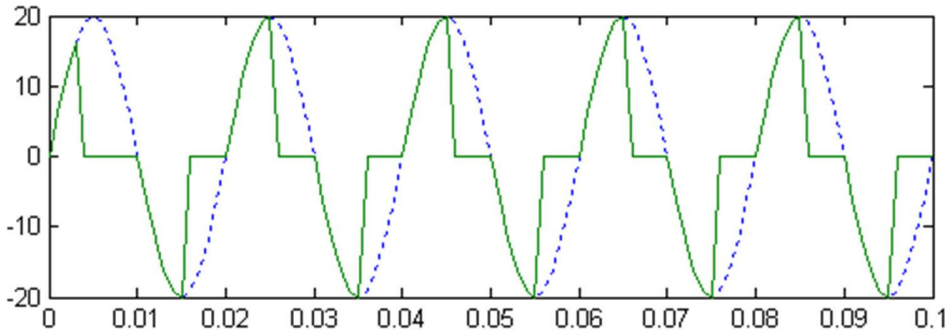



*Figure 397: AC saturation*

When having a short circuit in a power line, the short circuit current contains a DC component. The magnitude of the DC component depends on the phase angle when the short circuit occurs. Figure 398 shows the secondary current of the CT in the fault situation. Because of the DC component, the flux reaches its maximum value at 0.07 seconds, causing saturation. As the DC component decays, the CT recovers gradually from the saturation.

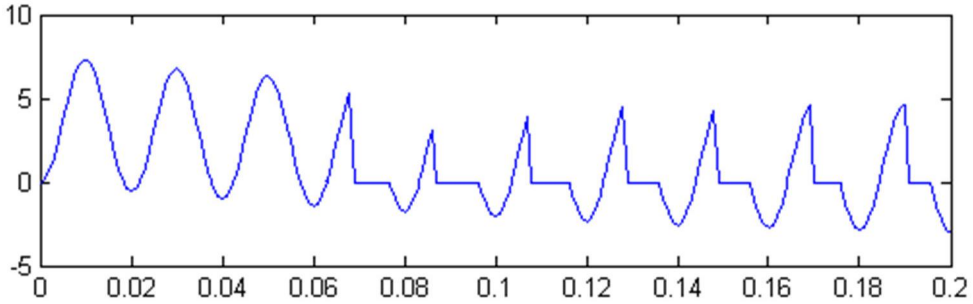



*Figure 398: DC saturation*

### 4.3.7.7 Signals

*Table 643: MPDIF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_OPR_LS | BOOLEAN | 0=False | Blocks operate outputs from biased stage |
| BLK_OPR_HS | BOOLEAN | 0=False | Blocks operate outputs from instantaneous stage |

*Table 644: MPDIF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| OPR_LS | BOOLEAN | Operate from low set |
| OPR_HS | BOOLEAN | Operate from high set |
| INT_BLKD | BOOLEAN | Internal block status |

### 4.3.7.8 Settings

*Table 645: MPDIF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Low operate value | 5...30 | %Ir | 1 | 5 | Basic setting for the stabilized stage start |
| High operate value | 100...1000 | %Ir | 10 | 500 | Instantaneous stage operate value |
| Slope section 2 | 10...50 | % | 1 | 30 | Slope of the second line of the operating characteristics |
| End section 1 | 0...100 | %Ir | 1 | 50 | Turn-point between the first and the second line of the operating characteristics |
| End section 2 | 100...300 | %Ir | 1 | 150 | Turn-point between the second and the third line of the operating characteristics |

*Table 646: MPDIF Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Slope section 3 | 10...100 | % | 1 | 100 | Slope of the third line of the operating characteristics |
| DC restrain enable | 0=False<br>1=True | | | 0=False | Setting for enabling DC restrain feature |

*Table 647: MPDIF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| CT connection type | 1=Type 1<br>2=Type 2 | | | 1=Type 1 | CT connection type. Determined by the directions of the connected current transformers |
| CT ratio Cor Line | 0.40...4.00 | | 0.01 | 1.00 | CT ratio correction, line side |
| CT ratio Cor Neut | 0.40...4.00 | | 0.01 | 1.00 | CT ratio correction, neutral side |

## 4.3.7.9 Monitored data

*Table 648: MPDIF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| OPR_A | BOOLEAN | 0=False<br>1=True | | Operate phase A |
| OPR_B | BOOLEAN | 0=False<br>1=True | | Operate phase B |
| OPR_C | BOOLEAN | 0=False<br>1=True | | Operate phase C |
| INT_BLKD_A | BOOLEAN | 0=False<br>1=True | | Internal block status phase A |
| INT_BLKD_B | BOOLEAN | 0=False<br>1=True | | Internal block status phase B |
| INT_BLKD_C | BOOLEAN | 0=False<br>1=True | | Internal block status phase C |
| ID_A | FLOAT32 | 0.00...80.00 | xIr | Differential current phase A |
| ID_B | FLOAT32 | 0.00...80.00 | xIr | Differential current phase B |
| ID_C | FLOAT32 | 0.00...80.00 | xIr | Differential current phase C |
| IB_A | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase A |
| IB_B | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase B |
| IB_C | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase C |
| I_ANGL_A1_B1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, line side |
| I_ANGL_B1_C1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, line side |
| I_ANGL_C1_A1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, line side |
| I_ANGL_A2_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, neutral side |
| I_ANGL_B2_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, neutral side |
| I_ANGL_C2_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, neutral side |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_ANGL_A1_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between line and neutral side, Phase A |
| I_ANGL_B1_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between line and neutral side, Phase B |
| I_ANGL_C1_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between line and neutral side, Phase C |
| MPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| IL1-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL1 |
| IL2-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL2 |
| IL3-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL3 |
| IL1-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL1 |
| IL2-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL2 |
| IL3-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL3 |

## 4.3.7.10 Technical data

*Table 649: MPDIF Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±3.0% of the set value or ±0.002 x $I_n$ | | |
| Operate time [1)2)] | | Minimum | Typical | Maximum |
| | Low stage | 32 ms | 35 ms | 37 ms |
| | High stage | 9 ms | 13 ms | 19 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.95 | | |
| Retardation time | | <20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5... | | |

1) $F_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Measured with static power output (SPO)

## 4.3.8 High-impedance or flux-balance based differential protection MHZPDIF

### 4.3.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| High-impedance or flux-balance based differential protection | MHZPDIF | 3dIHi>M | 87HIM |

### 4.3.8.2 Function block




*Figure 399: Function block*

### 4.3.8.3 Functionality

The high-impedance/flux-balance based differential protection for motors function MHZPDIF provides winding short circuit protection for motors.

MHZPDIF starts and operates when any of the three-phase differential currents, ID_A, ID_B or ID_C, exceeds the set limit. The operation timer characteristic is according to the definite time (DT).

This function contains a blocking functionality. It is possible to block the function outputs, timers or the function itself.

### 4.3.8.4 Analog channel configuration

MHZPDIF has one analog group input which must be properly configured.

*Table 650: Analog signals*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks

in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.8.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of MHZPDIF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

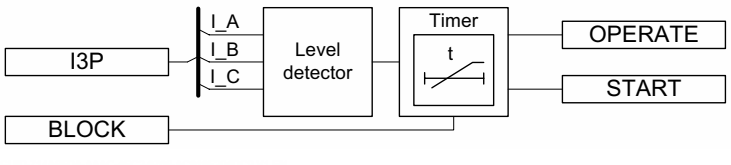



*Figure 400: Functional module diagram*

#### Level detector

This module compares the three-phase differential currents to the set *Operate value*. If any of the differential currents ID_A, ID_B or ID_C exceeds the set *Operate value*, the Level detector module sends an enable signal to the Timer module to start the definite timer (DT).

#### Timer

Once activated, the Timer activates the START output. The Timer characteristic is according to DT. When the operation timer has reached the value set by *Minimum operate time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

The Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

The activation of the BLOCK signal resets the Timer and deactivates the START and OPERATE outputs.

### 4.3.8.6 Application

MHZPDIF provides the winding short circuit and earth-fault protection for motors. The high-impedance or flux-balance principle has been used through many years for differential protection due to the capability to manage through-faults with a heavy current transformer (CT) saturation.

## High-impedance principle

The high-impedance principle is stable for all types of faults outside the protection zone. The stabilization is obtained by a stabilizing resistor in the differential circuit. This method requires all the CTs to have a similar magnetizing characteristic, same ratio and a relatively high knee point voltage. The CTs in each phase are connected in parallel with a relay measuring branch. The measuring branch is a series connection of the stabilizing resistor and the protection relay.

The stability of the protection is based on the use of the stabilizing resistor ($R_s$) and the fact that the impedance of the CT secondary quickly decreases as the CT saturates. The magnetization reactance of a fully saturated CT drops to zero and the impedance is formed only by the resistance of the winding ($R_{in}$) and lead resistance ($R_m$).

The CT saturation causes a differential current which can flow through the saturated CT, because of the near-zero magnetizing reactance, or through the measuring branch. The stabilizing resistor is selected so that the current in the measuring branch is below the protection relay's operating current during out-of-zone faults. As a result, the operation is stable during the saturation and can still be sensitive at the undistorted parts of the current waveform.

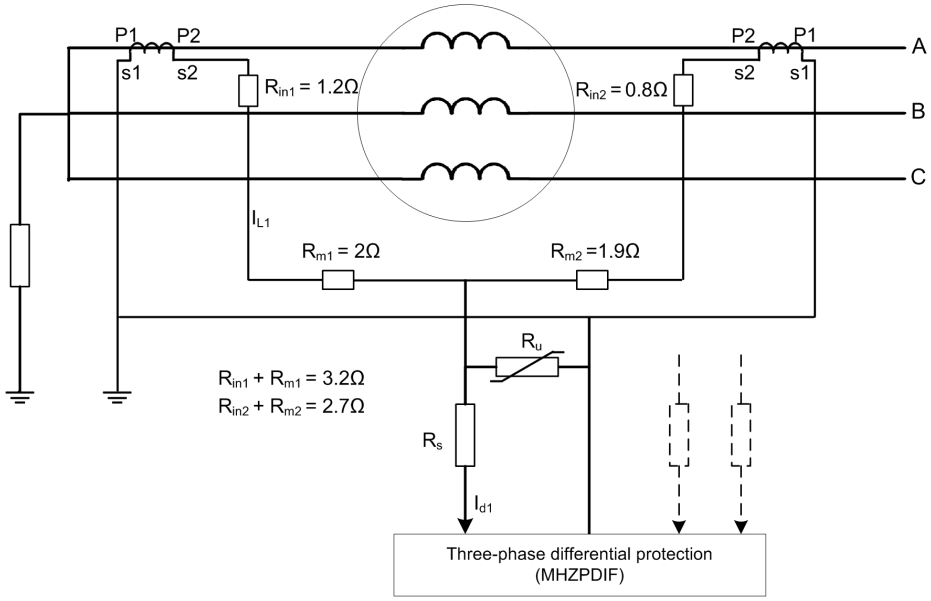



*Figure 401: Three-phase differential protection for motors based on high-impedance principle*

In case of an internal fault, the fault current cannot circulate through the CTs. It flows through the measuring branch, and the protection operates. A partial CT saturation can occur in case of an internal fault, but the undistorted part of the current waveform causes the protection to operate.

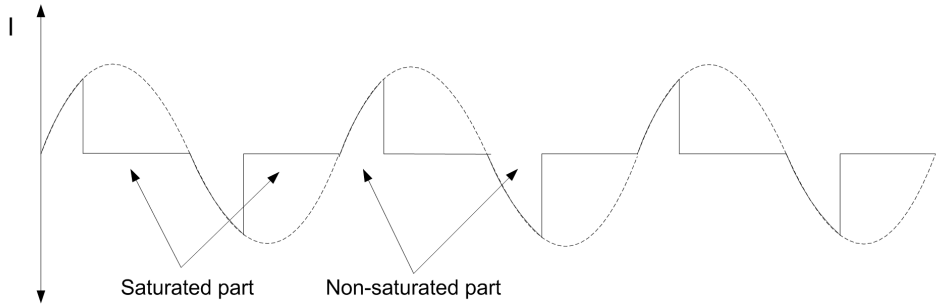



*Figure 402: Secondary waveform of a saturated CT*

At an internal fault, the secondary circuit voltage can easily exceed the isolation voltage of the CTs, connection wires and the protection relay. To limit this voltage, a voltage-dependent resistor (VDR) is used.

The whole scheme, that is, the stabilizing resistor, voltage-dependent resistor and wiring, must be adequately maintained (operation and insulation tested regularly) to be able to withstand the high-voltage pulses that appear during an internal fault throughout the lifetime of the equipment. Otherwise, during a fault within the zone of protection, any flashover in the CT secondary circuits or any other part of the scheme can prevent the correct operation of MHZPDIF.

## Flux-balancing principle

In a measuring configuration for the three-phase differential currents according to the flux-balancing principle, no stabilizing resistors are needed. The configuration, however, requires the use of core balance current transformers. The compared currents, the one at the line end and the other at the neutral end, are both measured by the same core balance current transformer.

In this scheme, the currents flowing through one core balance transformer cancel each other out when there is no fault within the protected zone. When a fault occurs within the protected zone, the currents flowing through the core balance transformer amplify each other and the differential protection operates.

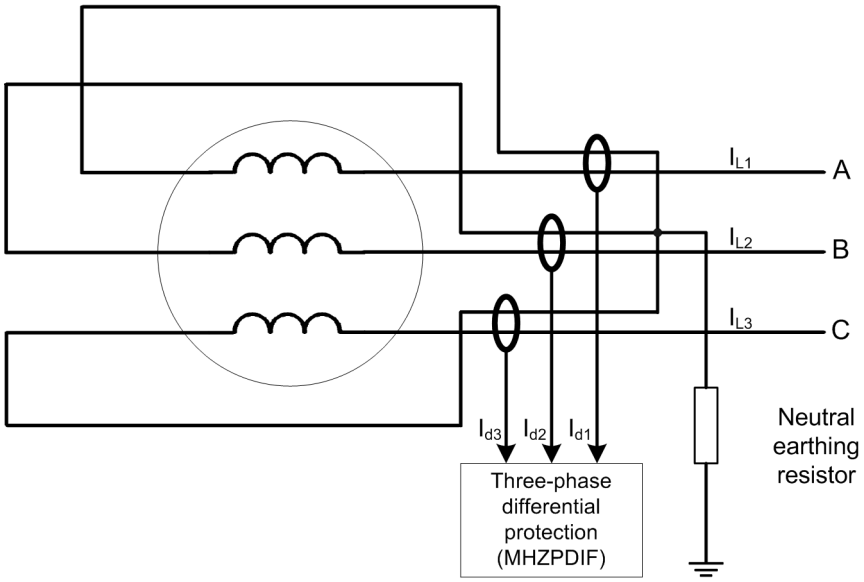



*Figure 403: Three-phase differential protection for motors based on flux-balancing principle*

The advantage of this scheme is that the CT rated primary current can be selected smaller than the rated current of the machine.

If six current transformers are used, the flux-balancing principle, that is, summing two CTs in each phase, cannot be used. Instead, the high-impedance principle or stabilized three-phase differential protection must be used.

### 4.3.8.7 Recommendations for current transformers

#### High-impedance principle

The sensitivity and reliability of the protection depend on the characteristics of the current transformers. The CTs must have an identical transformation ratio. It is recommended that all current transformers have an equal burden and characteristics and that they are of the same type. This means that they should be preferably from the same manufacturing batch, that is, an identical construction is used. If the CT characteristics and the burden values are not equal, the calculation for each branch in the scheme should be done separately and the worst-case result is used. If the CT winding resistance and the burden of the branches are not equal, the maximum burden equal to 3.2 Ω should be used for calculating the stabilized voltage.

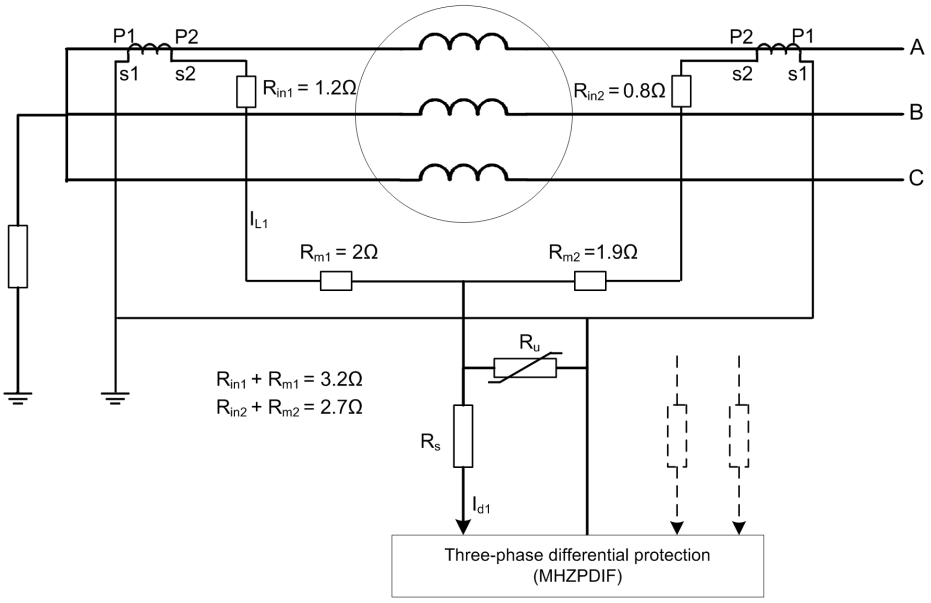



*Figure 404: High-impedance differential protection with different CT burden value on each branch*

The stabilizing voltage, that is the voltage appearing across the measuring branch during an out-of-zone fault, is calculated assuming that one of the CTs connected in parallel is fully saturated. The stabilizing voltage can be calculated using Equation 166.

$$U_s = \frac{I_{kmax}}{n} \cdot \left(R_{in} + R_m\right)$$

(Equation 166)

$I_{kmax}$ The highest through-fault current in primary Amps. The highest earth fault or short circuit current during out-of-zone fault

n The turns ratio of the CT

$R_{in}$ The secondary winding resistance of CT in ohms

$R_m$ The resistance (maximum of $R_{in}$+ $R_m$) of the CT secondary circuit in ohms

The current transformers must be able to force enough current to operate the relay through the differential circuit during a fault condition inside the protection zone. To ensure this, the knee point voltage $U_{kn}$ should be at least twice higher than the stabilizing voltage $U_s$.

The required knee point voltage $U_{kn}$ of the current transformer is calculated using Equation 167.

$$U_{kn} \geq 2 \cdot U_s$$

(Equation 167)

$U_{kn}$ Knee point voltage

$U_s$ Stabilizing voltage

The factor two is used when delay in the operating time of the protection is not acceptable in any situation. It is advisable to use current transformers whose secondary winding resistance is of the same size as the resistance of the measuring loop to prevent the knee point voltage from growing too high.

As the impedance of the protection relay is low, a stabilizing resistor is needed. The value of the stabilizing resistor is calculated using Equation 168.

$$R_s = \frac{U_s}{I_{rs}}$$

(Equation 168)

$R_s$ The resistance of the stabilizing resistor

$U_s$ The stabilizing voltage of the protection relay

$I_{rs}$ The value of *Operate value* setting in secondary amperes

The stabilizing resistor should be capable of dissipating high energy within a very short time. Therefore, a wire wound type resistor should be used. The rated power should be in class of a few tens of watts in minimum because of the possible CT inaccuracy, which might cause some current through the stabilizing resistor in a normal load situation.

If the $U_{kn}$ is high or the stabilizing voltage is low, a resistor with a higher power rating is needed. Often the resistor manufacturers allow ten times rated power for five seconds. Thus the power of the resistor can be calculated using Equation 169.

$$\frac{U_{kn}^2}{R_s \cdot 10}$$

(Equation 169)

The actual sensitivity of the protection is affected by the protection relay setting, the magnetizing currents of the CTs connected in parallel and the shunting effect of the voltage dependent resistor. The value of the primary current $I_{prim}$ at which the protection relay operates at certain setting can be calculated using Equation 170.

$$I_{prim} = n \cdot (I_{rs} + I_u + m \cdot I_m)$$

(Equation 170)

| | |
|---|---|
| $I_m$ | The magnetizing current per current transformer at $U_s$ voltage |
| $I_{prim}$ | The primary current level at which the protection is to start |
| $I_{rs}$ | The value of *Operate value* setting |
| $I_u$ | The leakage current through the VDR at $U_s$ voltage |
| n | Turn ratio of the current transformer |
| m | The number of current transformers included in the protection per phase (=2) |

The $I_e$ value given in many catalogues is the excitation current at knee point voltage.

Assuming $U_{kn} \approx 2 \cdot U_s$, the value of $I_m \approx \frac{I_e}{2}$ gives an approximate value for Equation 170.

The selection of current transformers can be divided into the following steps.

1. The rated current In of the protected machine should be known. The value of $I_n$ also affects the magnitude of $I_{kmax}$. Normally the $I_{kmax}$ value for motors is $6 \cdot I_n$.
2. The rated primary current $I_{1n}$ of the CT has to be higher than the rated current of the machine. The choice of the CT also specifies $R_{in}$.
3. The required $U_{kn}$ is calculated using Equation 167. If the $U_{kn}$ of the CT is not high enough, another CT has to be chosen. The value of the $U_{kn}$ is given by the manufacturer in case of a Class X current transformer or it can be estimated using Equation 171.
4. The sensitivity $I_{prim}$ is calculated using Equation 170. If the achieved sensitivity is sufficient, the present CT is chosen. A CT with a bigger core is chosen if a better sensitivity is needed.

If a Class X CT is not used, an estimate for $U_{kn}$ is calculated using Equation 171.

$$U_{kn} = 0.8 \cdot F_n \cdot I_{2n} \cdot \left( R_{in} + \frac{Sn}{I_{2n}^2} \right)$$

(Equation 171)

| | |
|---|---|
| $F_n$ | The rated accuracy limit factor corresponding to rated burden $S_n$ |
| $I_{2n}$ | The rated secondary current of the CT |
| $R_{in}$ | The secondary internal resistance of the CT |
| $S_n$ | The voltage-ampere rating of the CT |

The formulas are based on choosing the CTs according to Equation 167 which results an absolute stable scheme. In some cases, it is possible to achieve stability with knee point voltages lower than the

voltage stated in the formulas. However, the network conditions have to be known well enough to ensure the stability.

- If $U_k \geq 2 \cdot U_s$, the fast relay operation is secure.
- If $U_k \geq 1.5 \cdot U_s$ and $< 2 \cdot U_s$, the relay operation can be slightly prolonged and should be studied case by case.
- If $U_k < 1.5 \cdot U_s$, the relay operation is jeopardized. Another CT has to be chosen.

The need for voltage dependent resistor (VDR) depends on the insulation level for which the protection relays are tested.

Voltage $U_{max}$, ignoring the CT saturation during the fault is calculated using Equation 172.

$$U_{\max} = \frac{I_{k\max in}}{n} \cdot \left(R_{in} + R_m + R_s\right) \approx \frac{I_{k\max in}}{n} \cdot R_s$$

(Equation 172)

$I_{kmaxin}$ Maximum fault current inside the zone, in primary amperes

n Turns ratio of CT

$R_{in}$ Internal resistance of CT in ohms

$R_m$ Resistance of the longest loop of the CT secondary circuit in ohms

$R_s$ Resistance of the stabilized resistor in ohms

The peak voltage û, which includes the CT saturation, is estimated by using Equation 173 (given by P. Mathews 1955).

$$\breve{u} = 2\sqrt{2 \cdot U_{kn} \cdot \left(U_{\max} - U_{kn}\right)}$$

(Equation 173)

$U_{kn}$ Knee point voltage of CT

The VDR is recommended when the peak voltage û ≥ 2 kV. This the insulation level for which protection relays are tested.

For example, the maximum fault current in case of a fault inside the zone is 12.6 kA in primary, CT is of 1250/5 A, that is, ratio n = 240, and knee point voltage is 81 V. The stabilizing resistor is 330 Ohms.

$$U_{\max} = \frac{12600\,A}{240} \cdot 330\,\Omega = 17325\,V$$

(Equation 174)

$$\breve{u} = 2\sqrt{2 \cdot 81 \cdot \left(17325 - 81\right)} \approx 3.34\,kV$$

(Equation 175)

As the peak voltage û = 3.2 kV, VDR must be used. In some cases, VDR can be avoided if $R_s$ is smaller. The value of $R_s$ depends on the protection relay operation current and stabilizing voltage. Thus, a higher setting in the protection relay must be used or the stabilizing voltage lowered.

### Flux-balancing principle

When the function block is used with the flux-balancing principle, there are no extra requirements for the measuring devices. The core-balance transformers used in an ordinary overcurrent protection are adequate here as well.

## 4.3.8.8 Example calculations for high-impedance differential protection

The example shows the calculations for the *Operate value* setting, stabilizing resistor value ($R_s$) and required knee point voltage ($U_{kn}$) of the CTs.

*Table 651: Protected generator values*

| Quantity | Value |
|---|---|
| $S_n$ | 8 MVA |
| $U_n$ | 6 kV |
| $I_n$ | 770 A |
| $I_{kmax}$ | 4620 A (6 × $I_n$) out-of-zone fault |
| $I_{kmaxin}$ | 9.24 kA (12 × $I_n$) in-zone fault |

*Table 652: Assumed CT data*

| Quantity | Value |
|---|---|
| CT | 1000/1 A |
| $R_{in}$ | 15.3 Ω |
| $U_{kn}$ | 323 V |
| $I_e$ | 35 mA (at $U_{kn}$) |

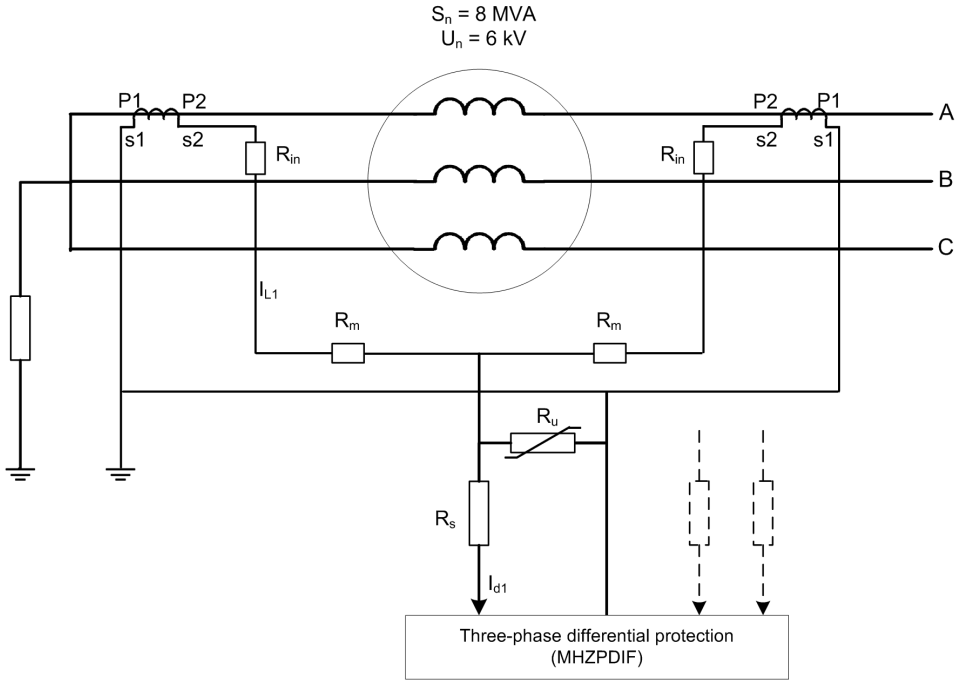



*Figure 405: Example calculation for high-impedance differential protection (only one phase is presented in detail)*

The length of the secondary circuit loop is 200 m and the area of the cross-section is 2.5 mm$^2$. Resistance at 75°C is 0.00865 Ω/m.

$$R_m = 0.00865 \frac{\Omega}{m} \cdot 200m \approx 1.73\Omega$$

(Equation 176)

First the stabilizing voltage is calculated based on Equation 166.

$$U_s = \frac{6 \cdot 770\,A}{1000} \cdot (15.3\,\Omega + 1.73\,\Omega) \approx 78.7V$$

(Equation 177)

In this case the requirement for the current transformer knee point voltage is fulfilled because $U_{kn} > 2U_s$.

The magnetising curve of the CT is assumed to be linear. The magnetizing current at the stabilizing voltage can be estimated.

$$I_m = \frac{U_s}{U_{kn}} \cdot I_e$$

(Equation 178)

$$I_m = \frac{78.7V}{323V} \cdot 35mA \approx 8.5mA$$

(Equation 179)

The setting current $I_{rs}$ should be at the minimum of the sum of the magnetizing currents of all connected CTs to obtain adequate protection stability.

$$I_{rs} = 2 \cdot 8.5\,mA \approx 17\,mA$$

(Equation 180)

The resistance of the stabilizing resistor is calculated based on Equation 168.

$$R_s = \frac{78.7\,V}{0.017\,A} \approx 4629\,\Omega$$

(Equation 181)

The calculated value 4629 Ω is the maximum value for the stabilizing resistor. If this value is not available, the next available value downwards should be chosen and the protection relay setting current is to be tuned according to the selected resistor. For example in this case the resistance value 3900 Ω is used.

$$I_{rs} = \frac{78.7\,V}{3900\,V} \approx 20\,mA$$

(Equation 182)

The sensitivity of the protection is obtained as per Equation 170, assuming $I_u$ to be zero.

$$I_{prim} = 1000 \cdot (0.020\,A + 2 \cdot 0.0085\,A + 0\,A) \approx 37\,A$$

(Equation 183)

The power of the stabilizing resistor is calculated as follows.

$$P \geq \frac{(323\,V)^2}{3900\,\Omega} \approx 27\,W$$

(Equation 184)

Based on Equation 172 and Equation 173, the need for voltage dependent resistor is checked.

$$U_{max} = \frac{12 \cdot 770\,A}{1000} \cdot (3900\,\Omega + 15.3\,\Omega + 1.73\,\Omega + 0.10\,\Omega) \approx 36.2\,kV$$

(Equation 185)

$$\check{u} = 2\sqrt{2 \cdot 323\,V \cdot (36200\,V - 323\,V)} \approx 9.6\,kV$$

(Equation 186)

The voltage dependent resistor, one for each phase, is needed in this case because the voltage during the fault is much higher than 2 kV.

The leakage current through the varistor at the stabilizing voltage can be available from the varistor manual, assuming that to be approximately 2 mA at stabilizing voltage.

$$Iu \approx 0.002\,A$$

(Equation 187)

The sensitivity of the protection can be re-calculated taking into account the leakage current through the varistor as per Equation 170.

$$I_{prim} = 1000 \cdot (0.020\,A + 2 \cdot 0.0085\,A + 0.002\,A) \approx 39\,A$$

(Equation 188)

### 4.3.8.9 Signals

*Table 653: MHZPDIF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 654: MHZPDIF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.3.8.10 Settings

*Table 655: MHZPDIF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 0.5...50.0 | %In | 0.1 | 0.5 | Operate value, percentage of the nominal current |
| Minimum operate time | 20...300000 | ms | 10 | 20 | Minimum operate time |

*Table 656: MHZPDIF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 657: MHZPDIF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 0 | Reset delay time |

### 4.3.8.11 Monitored data

*Table 658: MHZPDIF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| ID_A | FLOAT32 | 0.00...80.00 | xIn | Differential current phase A |
| ID_B | FLOAT32 | 0.00...80.00 | xIn | Differential current phase B |
| ID_C | FLOAT32 | 0.00...80.00 | xIn | Differential current phase C |
| MHZPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.3.8.12 Technical data

*Table 659: MHZPDIF Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or 0.002 × $I_n$ | | |
| Start time [1)2)] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Start Value* (one phase fault) | 13 ms | 17 ms | 21 ms |
| | $I_{Fault}$ = 2.0 × set *Start Value* (three phases fault) | 11 ms | 14 ms | 17 ms |
| Reset time | | <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value of ±20 ms | | |

1) *Measurement mode* = “Peak-to-Peak”, current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

# 4.4 Unbalance protection

## 4.4.1 Negative-sequence overcurrent protection NSPTOC

### 4.4.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Negative-sequence overcurrent protection | NSPTOC | I2>M | 46M |

### 4.4.1.2 Function block

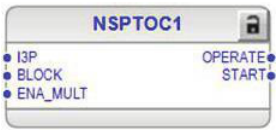



*Figure 406: Function block*

### 4.4.1.3 Functionality

The negative-sequence overcurrent protection function NSPTOC is used for increasing sensitivity to detect single-phase and phase-to-phase faults or unbalanced loads due to, for example, broken conductors or unsymmetrical feeder voltages.

NSPTOC can also be used for detecting broken conductors.

The function is based on the measurement of the negative sequence current. In a fault situation, the function starts when the negative sequence current exceeds the set limit. The operate time characteristics can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). In the DT mode, the function operates after a predefined operate time and resets when the fault current disappears. The IDMT mode provides current-dependent timer characteristics.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.4.1.4 Analog channel configuration

NSPTOC has one analog group input which must be properly configured.

*Table 660: Analog signals*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.4.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of NSPTOC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

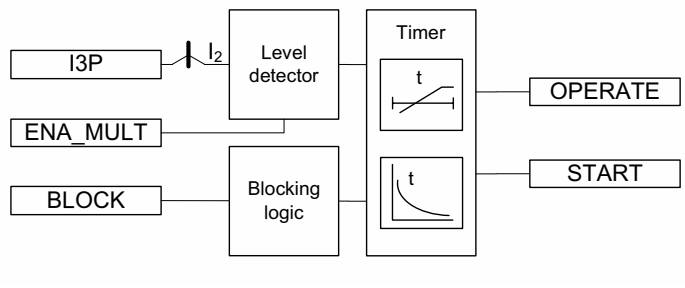



*Figure 407: Functional module diagram*

#### Level detector

The measured negative-sequence current is compared to the set *Start value*. If the measured value exceeds the set *Start value*, Level detector activates the Timer module. If the ENA_MULT input is active, the set *Start value* is multiplied by the set *Start value Mult*.

The protection relay does not accept the *Start value* or *Start value Mult* setting if the product of the settings exceeds the *Start value* setting range.

## Timer

Once activated, Timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The functionality of the timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation. The START output is deactivated when the reset timer has elapsed.



The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operate and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.



The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see the IDMT curves for overcurrent protection section in this manual.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

## Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled

by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.4.1.6 Application

Since the negative sequence current quantities are not present during normal, balanced load conditions, the negative sequence overcurrent protection elements can be set for faster and more sensitive operation than the normal phase-overcurrent protection for fault conditions occurring between two phases. The negative sequence overcurrent protection also provides a back-up protection functionality for the feeder earth-fault protection in solid and low resistance earthed networks.

The negative sequence overcurrent protection provides the back-up earth-fault protection on the high voltage side of a delta-wye connected power transformer for earth faults taking place on the wye-connected low voltage side. If an earth fault occurs on the wye-connected side of the power transformer, negative sequence current quantities appear on the delta-connected side of the power transformer.

The most common application for the negative sequence overcurrent protection is probably rotating machines, where negative sequence current quantities indicate unbalanced loading conditions (unsymmetrical voltages). Unbalanced loading normally causes extensive heating of the machine and can result in severe damages even over a relatively short time period.

Multiple time curves and time multiplier settings are also available for coordinating with other devices in the system.

### 4.4.1.7 Signals

*Table 661: NSPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

*Table 662: NSPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.4.1.8 Settings

*Table 663: NSPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...5.00 | xIn | 0.01 | 0.30 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...200000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |

*Table 664: NSPTOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

*Table 665: NSPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 1 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 1 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 1 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 666: NSPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.4.1.9 Monitored data

*Table 667: NSPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| NSPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.4.1.10 Technical data

*Table 668: NSPTOC Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [1)2)] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2 × set *Start value*<br>$I_{Fault}$ = 10 × set *Start value* | 23 ms<br>15 ms | 26 ms<br>18 ms | 28 ms<br>20 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [3)] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) Negative sequence current before fault = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 1.5...20

## 4.4.2 Directional negative-sequence overcurrent protection DNSPDOC

### 4.4.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Directional negative-sequence overcurrent protection | DNSPDOC | I2> -> | 67Q |

### 4.4.2.2 Function block

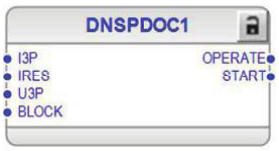



*Figure 408: Function block*

### 4.4.2.3 Functionality

The directional negative-sequence overcurrent protection function DNSPDOC is used as directional overcurrent and short-circuit protection.

DNSPDOC starts up when the fundamental value of the operating quantity (negative-sequence or residual current) exceeds the set limit and the directional criterion is fulfilled. The operate time characteristic is according to definite time (DT).

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.4.2.4 Analog channel configuration

DNSPDOC has three analog group inputs which must be properly configured.

*Table 669: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| IRES[1)] | Residual current (measured or calculated) Necessary when *Operating quantity* is "Residual" or "Residual (calc)" |
| U3P | Three-phase voltages |

1) Can be connected to `GRPOFF` if *Operating quantity* is set to "Negative seq"

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

*Table 670: Special conditions*

| Condition | Description |
|---|---|
| U3P connected real measurements | The function requires that at least two voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.4.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DNSPDOC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

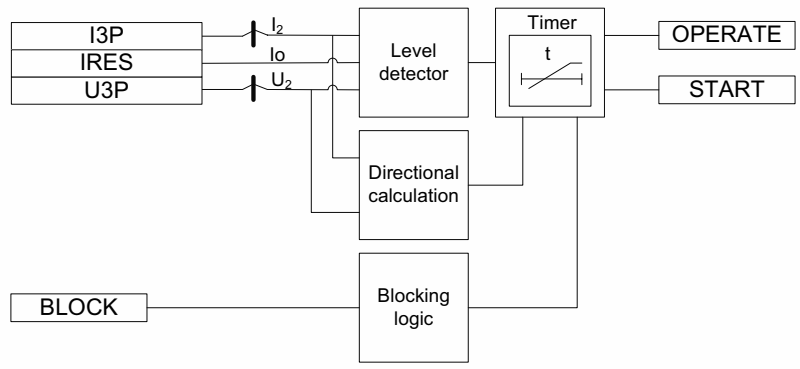



*Figure 409: Functional module diagram*

#### Level detector

The operating signal is compared to the set *Start value*. If the operating signal exceeds the set *Start value*, Level detector sends an enabling signal to the Timer module. Timer starts when it is enabled and the directional criterion is fulfilled. A suitable operating quantity can be selected with the *Operating quantity* setting. The options are "Negative seq" or "Residual". The value of operating quantity I_OPER is also available in the Monitored data view.

Irrespective of the operating quantity selected, directional calculation is always determined using the negative-sequence current.

### Directional calculation

Directional calculation compares the negative-sequence current phasor with the negative-sequence voltage phasor, that is, the polarizing quantity. The directional operation can be selected with the *Directional mode* setting. The options are "Non-directional", "Forward" or "Reverse" operation. By setting the value of *Allow Non Dir* to "True", the non-directional operation is allowed when the directional information is invalid.

The *Characteristic angle* setting is used to turn the directional characteristics. The value of *Characteristic angle* should be chosen so that all the faults in the operating direction are seen in the operating zone and all the faults in the opposite direction are seen in the non-operating zone. The value of *Characteristic angle* depends on the network configuration.

Reliable directional calculation requires that both negative-sequence current and negative-sequence voltage quantities exceed certain minimum amplitude levels. The minimum amplitude level for the negative-sequence current is set with the *Min operate current* setting. The minimum amplitude level for the polarizing quantity, that is, the negative-sequence voltage, is set with the *Min operate voltage* setting. If the amplitude level of the operating quantity or polarizing quantity is below the set level, the direction information of the corresponding phase is set to “unknown”. If the negative-sequence voltage before the fault situation is below *Min operate voltage*, the voltage direction cannot be determined.

The value for the *Min operate voltage* setting should be carefully selected since the accuracy in low signal levels is strongly affected by the measuring device accuracy.

### Timer

Once activated, Timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated if the operating signal persists.

In a drop-off situation, that is, if a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated. The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, the function operates normally but the OPERATE output is not activated.

## 4.4.2.6 Directional overcurrent characteristics

The forward and reverse sectors are defined separately. The forward operation area is limited with the *Min forward angle* and *Max forward angle* settings. The reverse operation area is limited with the *Min reverse angle* and *Max reverse angle* settings.



The sector limits are always given as positive degree values.

In the forward operation area, the *Max forward angle* setting gives the counterclockwise sector and the *Min forward angle* setting gives the corresponding clockwise sector, measured from the *Characteristic angle* setting.

In the backward operation area, the *Max reverse angle* setting gives the counterclockwise sector and the *Min reverse angle* setting gives the corresponding clockwise sector, a measurement from the *Characteristic angle* setting that has been rotated 180 degrees.

Relay characteristic angle (RCA) is set positive if the operating current lags the polarizing quantity, and negative if the operating current leads the polarizing quantity.

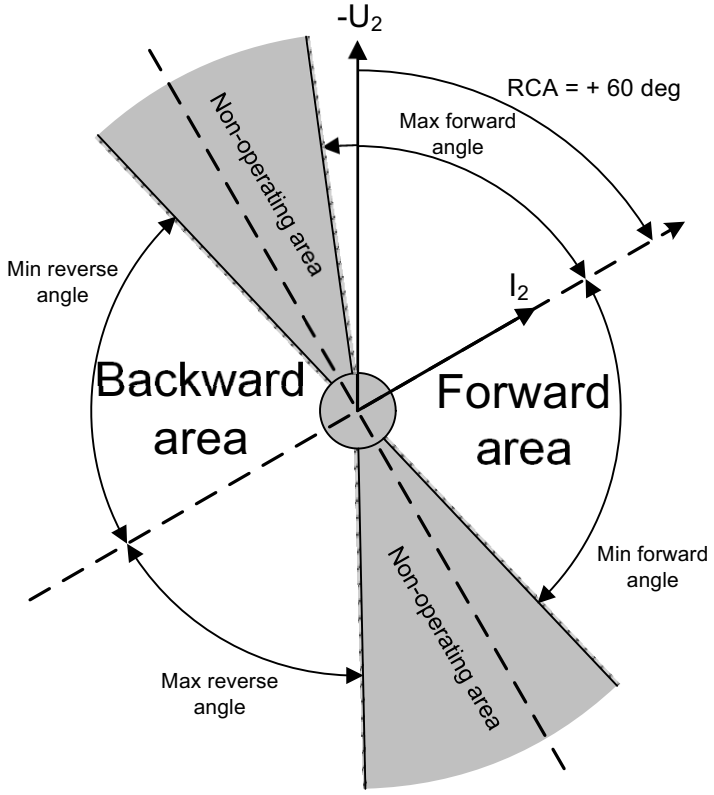



*Figure 410: Configurable operating sectors*

The angle difference ANGLE between the negative-sequence current and the polarizing quantity is calculated as shown below and is available in the Monitored data view.

$$ANGLE = \phi(-U_2) - \phi(I_2) - \phi_{RCA}$$

(Equation 189)

Based on the ANGLE value, the direction information DIRECTION is evaluated and is made available in the Monitored data view.

*Table 671: Momentary direction value for monitored data view*

| Criterion for direction information | Value for DIRECTION |
|---|---|
| ANGLE is not in any of the defined sectors, or the direction cannot be defined due to low amplitude. | 0 = unknown |
| ANGLE is in the forward sector. | 1 = forward |
| ANGLE is in the reverse sector. | 2 = backward |

FAULT_DIR gives the detected direction of the fault during fault situations, that is, when the START output is active.

### 4.4.2.7 Application

The ability of a protection relay to provide direction information for faults is referred to as its directional security. It is extremely important for the directional protection function to identify the direction of the fault relative to the location of the protection relay. The fault direction can be either downstream (forward fault) or upstream of the protection relay (backward fault).

Different directional elements are used to determine the fault direction. One such element is the negative-sequence voltage. As directional element, the negative-sequence voltage can identify the direction of all unbalance faults. One of the advantages of using negative-sequence elements is that the negative-sequence component is insensitive to zero-sequence mutual coupling. The negative sequence is also used where the source is not strong enough because with such a source the value of the negative sequence near the protection relay has higher magnitude.

### 4.4.2.8 Signals

*Table 672: DNSPDOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 673: DNSPDOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.4.2.9 Settings

*Table 674: DNSPDOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...5.00 | xIn | 0.01 | 0.05 | Start value |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Characteristic angle | -179...180 | deg | 1 | 60 | Characteristic angle |
| Max forward angle | 0...90 | deg | 1 | 80 | Maximum phase angle in forward direction |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max reverse angle | 0...90 | deg | 1 | 80 | Maximum phase angle in reverse direction |
| Min forward angle | 0...90 | deg | 1 | 80 | Minimum phase angle in forward direction |
| Min reverse angle | 0...90 | deg | 1 | 80 | Minimum phase angle in reverse direction |

*Table 675: DNSPDOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operating quantity | 1=Negative seq<br>2=Residual | | | 1=Negative seq | Operating quantity |

*Table 676: DNSPDOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 677: DNSPDOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Allow Non Dir | 0=False<br>1=True | | | 0=False | Allows prot activation as non-dir when dir info is invalid |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.01 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.01 | Minimum operating voltage |

## 4.4.2.10 Monitored data

*Table 678: DNSPDOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| FAULT_DIR | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Detected fault direction |
| DIRECTION | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction information |
| Table continues on next page | | | | |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ANGLE | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference |
| I_OPER | FLOAT32 | 0.00...40.00 | xIn | Calculated operating current |
| DNSPDOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.4.2.11 Technical data

*Table 679: DNSPDOC Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle:<br>±2° | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2 × set *Start value* | 31 ms | 34 ms | 37 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

1) Measurement mode NPS, NPS current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault NPS current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Measured with static signal output (SSO)

## 4.4.3 Phase discontinuity protection PDNSPTOC

### 4.4.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Phase discontinuity protection | PDNSPTOC | I2/I1> | 46PD |

### 4.4.3.2 Function block




*Figure 411: Function block*

### 4.4.3.3 Functionality

The phase discontinuity protection function PDNSPTOC is used for detecting unbalance situations caused by broken conductors.

The function starts and operates when the unbalance current $I_2/I_1$ exceeds the set limit. To prevent faulty operation at least one phase current needs to be above the minimum level. PDNSPTOC operates with DT characteristic.

The function contains a blocking functionality. It is possible to block the function output, timer or the function itself.

### 4.4.3.4 Analog channel configuration

PDNSPTOC has one analog group input which must be properly configured.

*Table 680: Analog signals*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.4.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PDNSPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

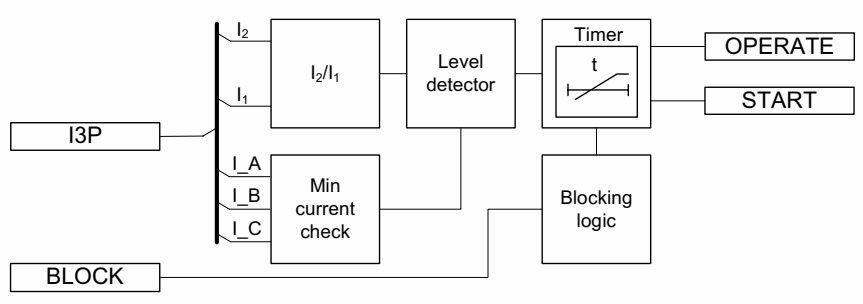



*Figure 412: Functional module diagram*

## $I_2/I_1$

The $I_2/I_1$ module calculates the ratio of the negative and positive sequence current. It reports the calculated value to the level detector.

### Level detector

The level detector compares the calculated ratio of the negative- and positive-sequence currents to the set *Start value*. If the calculated value exceeds the set *Start value* and the min current check module has exceeded the value of *Min phase current*, the level detector reports the exceeding of the value to the timer.

### Min current check

The min current check module checks whether the measured phase currents are above the set *Min phase current*. At least one of the phase currents needs to be above the set limit to enable the level detector module.

### Timer

Once activated, the timer activates the `START` output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the `OPERATE` output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the `START` output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the `BLOCK` input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The `BLOCK` input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the `BLOCK` signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.4.3.6 Application

In three-phase distribution and subtransmission network applications the phase discontinuity in one phase can cause an increase of zero-sequence voltage and short overvoltage peaks and also oscillation in the corresponding phase.

PDNSPTOC is a three-phase protection with DT characteristic, designed for detecting broken conductors in distribution and subtransmission networks. The function is applicable for both overhead lines and underground cables.

The operation of PDNSPTOC is based on the ratio of the positive-sequence and negative-sequence currents. This gives a better sensitivity and stability compared to plain negative-sequence current protection since the calculated ratio of positive-sequence and negative-sequence currents is relatively constant during load variations.

The unbalance of the network is detected by monitoring the negative-sequence and positive-sequence current ratio, where the negative-sequence current value is $I_2$ and $I_1$ is the positive-sequence current value. The unbalance is calculated with the equation.

$$Iratio = \frac{I_2}{I_1}$$

(Equation 190)

Broken conductor fault situation can occur in phase A in a feeder.

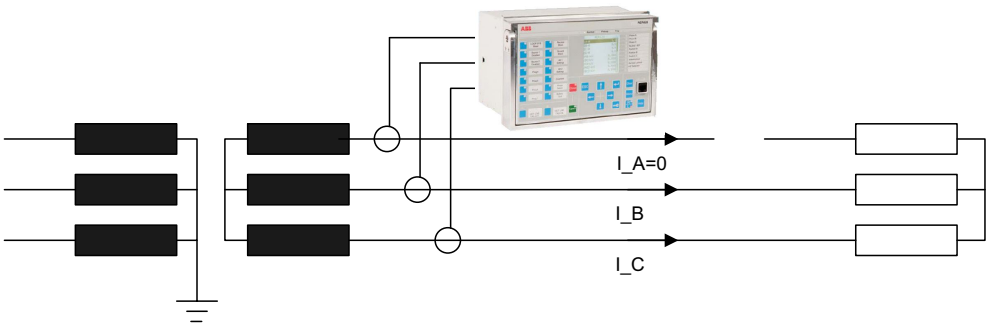



*Figure 413: Broken conductor fault situation in phase A in a distribution or subtransmission feeder*

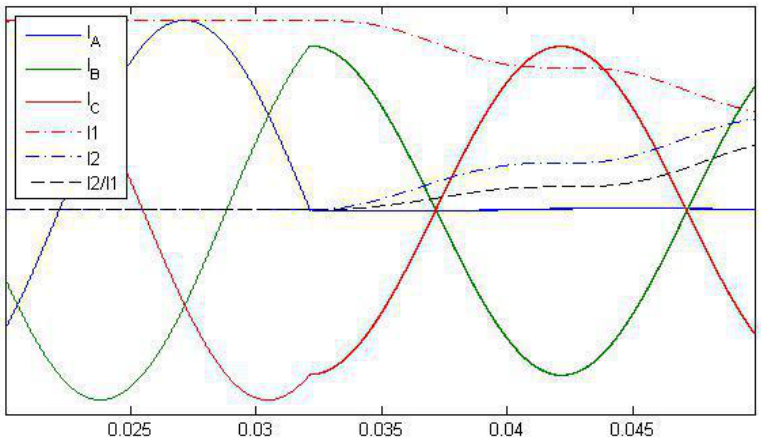



*Figure 414: Three-phase current quantities during the broken conductor fault in phase A with the ratio of negative-sequence and positive-sequence currents*

## 4.4.3.7 Signals

*Table 681: PDNSPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 682: PDNSPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

## 4.4.3.8 Settings

*Table 683: PDNSPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 10...100 | % | 1 | 10 | Start value |
| Operate delay time | 100...30000 | ms | 1 | 100 | Operate delay time |

*Table 684: PDNSPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 685: PDNSPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Min phase current | 0.05...0.30 | xIn | 0.01 | 0.10 | Minimum phase current |

### 4.4.3.9 Monitored data

*Table 686: PDNSPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| RATIO_I2_I1 | FLOAT32 | 0.00...999.99 | % | Measured current ratio I2 / I1 |
| PDNSPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.4.3.10 Technical data

*Table 687: PDNSPTOC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±2% of the set value |
| Start time | <70 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 4.4.4 Phase reversal protection PREVPTOC

### 4.4.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Phase reversal protection | PREVPTOC | I2>> | 46R |

### 4.4.4.2 Function block




*Figure 415: Function block*

### 4.4.4.3 Functionality

The phase reversal protection function PREVPTOC is used to detect the reversed connection of the phases to a three-phase motor by monitoring the negative phase sequence current $I_2$ of the motor.

PREVPTOC starts and operates when $I_2$ exceeds the set limit. PREVPTOC operates on definite time (DT) characteristics. PREVPTOC is based on the calculated $I_2$, and the function detects too high $I_2$ values during the motor startup. The excessive $I_2$ values are caused by incorrectly connected phases, which in turn makes the motor rotate in the opposite direction.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

### 4.4.4.4 Analog input configuration

PREVPTOC has one analog group input which must be properly configured.

*Table 688: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.4.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PREVPTOC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

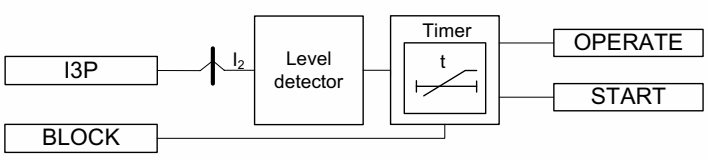



*Figure 416: Functional module diagram*

### Level detector

The level detector compares the negative-sequence current to the set *Start value*. If the $I_2$ value exceeds the set *Start value*, the level detector sends an enabling signal to the timer module.

### Timer

Once activated, the timer activates the `START` output. When the operation timer has reached the set *Operate delay time* value, the `OPERATE` output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value of 200 ms, the operation timer resets and the `START` output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

## 4.4.4.6 Application

The rotation of a motor in the reverse direction is not a desirable operating condition. When the motor drives fans and pumps, for example, and the rotation direction is reversed due to a wrong phase sequence, the driven process can be disturbed and the flow of the cooling air of the motor can become reversed too. With a motor designed only for a particular rotation direction, the reversed rotation direction can lead to an inefficient cooling of the motor due to the fan design.

In a motor, the value of the negative-sequence component of the phase currents is very negligible when compared to the positive-sequence component of the current during a healthy operating condition of the motor. But when the motor is started with the phase connections in the reverse order, the magnitude of $I_2$ is very high. So whenever the value of $I_2$ exceeds the start value, the function detects the reverse rotation direction and provides an operating signal that disconnects the motor from the supply.

### 4.4.4.7 Signals

*Table 689: PREVPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 690: PREVPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.4.4.8 Settings

*Table 691: PREVPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...1.00 | xIn | 0.01 | 0.75 | Start value |
| Operate delay time | 100...60000 | ms | 10 | 100 | Operate delay time |

*Table 692: PREVPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

### 4.4.4.9 Monitored data

*Table 693: PREVPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PREVPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.4.4.10 Technical data

*Table 694: PREVPTOC Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time[1)2)] | $I_{Fault}$ = 2.0 × set *Start value* | Minimum | Typical | Maximum |
| | | 23 ms | 25 ms | 28 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) Negative-sequence current before = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.4.5 Negative-sequence overcurrent protection for machines MNSPTOC

### 4.4.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Negative-sequence overcurrent protection for machines | MNSPTOC | I2>M | 46M |

### 4.4.5.2 Function block




*Figure 417: Function block*

### 4.4.5.3 Functionality

The negative-sequence overcurrent protection for machines function MNSPTOC protects electric motors from phase unbalance. A small voltage unbalance can produce a large negative-sequence current flow in the motor. For example, a 5 percent voltage unbalance produces a stator negative-sequence current of 30 percent of the

full load current, which can severely heat the motor. MNSPTOC detects the large negative-sequence current and disconnects the motor.

The function contains a blocking functionality. It is possible to block the function outputs, timers or the function itself.

### 4.4.5.4 Analog channel configuration

MNSPTOC has one analog group input which must be properly configured.

*Table 695: Analog signals*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.4.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of MNSPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

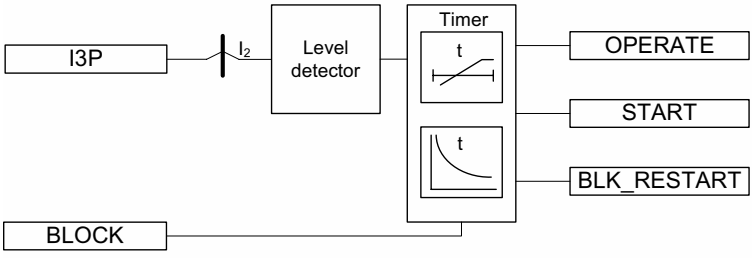



*Figure 418: Functional module diagram*

#### Level detector

The calculated negative-sequence current is compared to the *Start value* setting. If the measured value exceeds the *Start value* setting, the function activates the timer module.

### Timer

Once activated, the timer activates the START output. Depending on the value of the set *Operating curve type*, the time characteristics are according to DT or IDMT. When the operation timer has reached the value set by *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

In a drop-off situation, that is, when the value of the negative-sequence current drops below the *Start value* setting, the reset timer is activated and the START output resets after the time delay of *Reset delay time* for the DT characteristics. For IDMT, the reset time depends on the curve type selected.

For the IDMT curves, it is possible to define minimum and maximum operate times with the *Minimum operate time* and *Maximum operate time* settings. The *Machine time Mult* setting parameter corresponds to the machine constant, equal to the $I_2^2t$ constant of the machine, as stated by the machine manufacturer. In case there is a mismatch between the used CT and the protected motor's nominal current values, it is possible to fit the IDMT curves for the protected motor using the *Current reference* setting.

The activation of the OPERATE output activates the BLK_RESTART output. The deactivation of the OPERATE output activates the cooling timer. The timer is set to the value entered in the *Cooling time* setting. The BLK_RESTART output is kept active until the cooling timer is exceeded. If the negative-sequence current increases above the set value during this period, the OPERATE output is activated immediately.

The T_ENARESTART output indicates the duration for which the BLK_RESTART output remains active, that is, it indicates the remaining time of the cooling timer. The value is available in the monitored data view.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

## 4.4.5.6 Timer characteristics

MNSPTOC supports both DT and IDMT characteristics. The DT timer characteristics can be selected with "ANSI Def. Time" or "IEC Def. Time" in the *Operating curve type* setting. The functionality is identical in both cases. When the DT characteristics are selected, the functionality is only affected by the *Operate delay time* and *Reset delay time* settings.

The protection relay provides two user-programmable IDMT characteristics curves, "Inv. curve A" and "Inv. curve B".

### Current-based inverse definite minimum time curve (IDMT)

In inverse-time modes, the operate time depends on the momentary value of the current: the higher the current, the shorter the operate time. The operate time

calculation or integration starts immediately when the current exceeds the set *Start value* and the START output is activated.

The OPERATE output of the component is activated when the cumulative sum of the integrator calculating the overcurrent situation exceeds the value set by the inverse time mode. The set value depends on the selected curve type and the setting values used.

The *Minimum operate time* and *Maximum operate time* settings define the minimum operate time and maximum operate time possible for the IDMT mode. For setting these parameters, a careful study of the particular IDMT curves is recommended.

### *Inv. curve A*

The inverse time equation for curve type A is:

$$t[s] = \frac{k}{\left(\frac{I_2}{I_r}\right)^2}$$

(Equation 191)

t[s] Operate time in seconds

k Set *Machine time Mult*

$I_2$ Negative-sequence current

$I_r$ Set *Rated current*

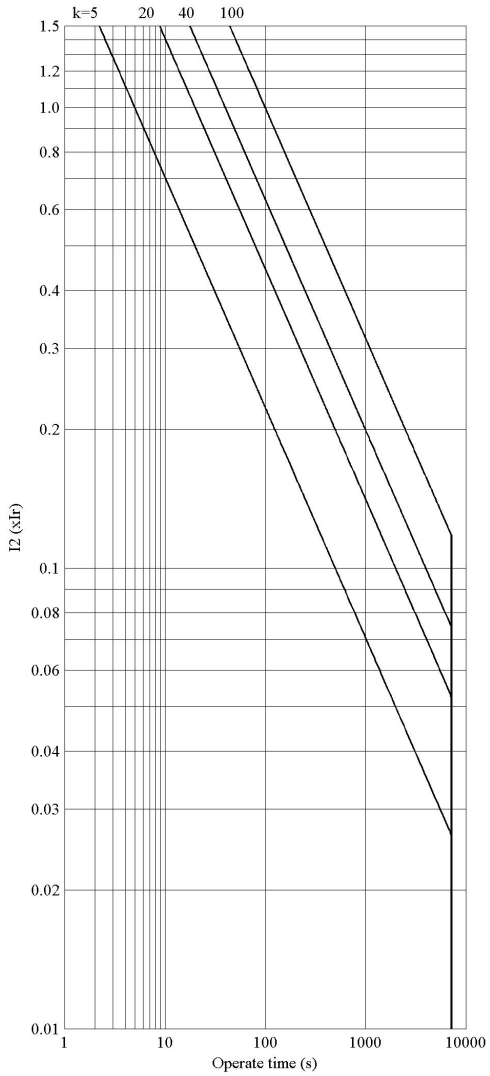



*Figure 419: MNSPTOC Inverse Curve A*

If the negative sequence current drops below the *Start value* setting, the reset time is defined as:

$$t[s] = a \cdot \left( \frac{b}{100} \right)$$

(Equation 192)

t[s] Reset time in seconds

a set *Cooling time*

b percentage of start time elapse (START_DUR)

When the reset period is initiated, the time for which START has been active is saved. If the fault reoccurs, that is, the negative-sequence current rises above the set value during the reset period, the operate calculations are continued using the saved values. If the reset period elapses without a fault being detected, the operate timer is reset and the saved values of start time and integration are cleared.

### *Inv. curve B*

The inverse time equation for curve type B is:

$$t[s] = \frac{k}{\left(\frac{I_2}{I_r}\right)^2 - \left(\frac{I_S}{I_r}\right)^2}$$

(Equation 193)

t[s] Operate time in seconds

k *Machine time Mult*

$I_2$ Negative-sequence current

$I_S$ Set *Start value*

$I_r$ Set *Rated current*

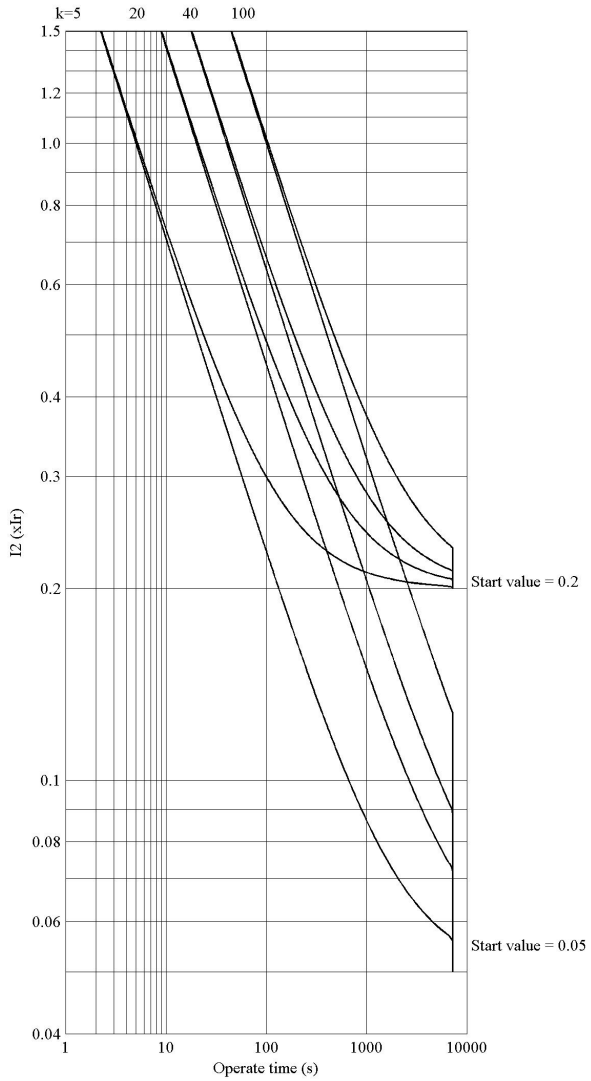



*Figure 420: MNSPTOC Inverse Curve B*

If the fault disappears, the negative-sequence current drops below the *Start value* setting and the START output is deactivated. The function does not reset instantaneously. Resetting depends on the equation or the *Cooling time* setting.

The timer is reset in two ways:

- When the negative sequence current drops below start value the subtraction in the denominator becomes negative and the cumulative sum starts to decrease. The decrease in the sum indicates the cooling of the machine and the cooling speed

depends on the value of the negative-sequence current. If the sum reaches zero without a fault being detected, the accumulation stops and the timer is reset.
- If the reset time set through the *Cooling time* setting elapses without a fault being detected, the timer is reset.

The reset period thus continues for a time equal to the *Cooling time* setting or until the operate time decreases to zero, whichever is less.

### 4.4.5.7 Application

In a three-phase motor, the conditions that can lead to unbalance are single phasing, voltage unbalance from the supply and single-phase fault. The negative sequence current damages the motor during the unbalanced voltage condition, and therefore the negative sequence current is monitored to check the unbalance condition.

When the voltages supplied to an operating motor become unbalanced, the positive-sequence current remains substantially unchanged, but the negative-sequence current flows due to the unbalance. For example, if the unbalance is caused by an open circuit in any phase, a negative-sequence current flows and it is equal and opposite to the previous load current in a healthy phase. The combination of positive and negative-sequence currents produces phase currents approximately 1.7 times the previous load in each healthy phase and zero current in the open phase.

The negative-sequence currents flow through the stator windings inducing negative-sequence voltage in the rotor windings. This can result in a high rotor current that damages the rotor winding. The frequency of the induced current is approximately twice the supply frequency. Due to skin effect, the induced current with a frequency double the supply frequency encounters high rotor resistance which leads to excessive heating even with phase currents with value less than the rated current of the motor.

The negative-sequence impedance of induction or a synchronous motor is approximately equal to the locked rotor impedance, which is approximately one-sixth of the normal motor impedance, considering that the motor has a locked-rotor current of six times the rated current. Therefore, even a three percent voltage unbalance can lead to 18 percent stator negative sequence current in windings. The severity of this is indicated by a 30-40 percent increase in the motor temperature due to the extra current.

### 4.4.5.8 Signals

*Table 696: MNSPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 697: MNSPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| BLK_RESTART | BOOLEAN | Overheated machine reconnection blocking |

### 4.4.5.9 Settings

*Table 698: MNSPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...0.50 | xIn | 0.01 | 0.20 | Start value |
| Operating curve type | 5=ANSI Def. Time<br>15=IEC Def. Time<br>17=Inv. Curve A<br>18=Inv. Curve B | | | 15=IEC Def. Time | Selection of time delay curve type |
| Machine time Mult | 5.0...100.0 | | 0.1 | 5.0 | Machine related time constant |
| Operate delay time | 100...120000 | ms | 10 | 1000 | Operate delay time |

*Table 699: MNSPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Maximum operate time | 500000...7200000 | ms | 1000 | 1000000 | Max operate time regardless of the inverse characteristic |
| Minimum operate time | 100...120000 | ms | 1 | 100 | Minimum operate time for IDMT curves |
| Cooling time | 5...7200 | s | 1 | 50 | Time required to cool the machine |

*Table 700: MNSPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current reference | 0.30...2.00 | xIn | 0.01 | 1.00 | Rated current (Ir) of the machine (used only in the IDMT) |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.4.5.10 Monitored data

*Table 701: MNSPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| T_ENARESTART | INT32 | 0...10000 | s | Estimated time to reset of block restart |
| MNSPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.4.5.11 Technical data

*Table 702: MNSPTOC Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ | | |
| | | ±1.5% of the set value or ±0.002 x $I_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Start value* | 23 | 25 ms | 28 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms[3)] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) Negative-sequence current before = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) *Start value* multiples in range of 1.10...5.00

# 4.5 Voltage protection

## 4.5.1 Three-phase overvoltage protection PHPTOV

### 4.5.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase overvoltage protection | PHPTOV | 3U> | 59 |

### 4.5.1.2 Function block




*Figure 421: Function block*

### 4.5.1.3 Functionality

The three-phase overvoltage protection function PHPTOV is applied on power system elements, such as generators, transformers, motors and power lines, to protect the system from excessive voltages that could damage the insulation and cause insulation breakdown. The three-phase overvoltage function includes a settable value for the detection of overvoltage either in a single phase, two phases or three phases.

PHPTOV includes both definite time (DT) and inverse definite minimum time (IDMT) characteristics for the delay of the trip.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

### 4.5.1.4 Analog channel configuration

PHPTOV has one analog group input which must be properly configured.

*Table 703: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 704: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected if *Num of start phases* is set to "1 out of 3". Otherwise, all three voltage channels must be connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks

in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PHPTOV can be described using a module diagram. All the modules in the diagram are explained in the next sections.

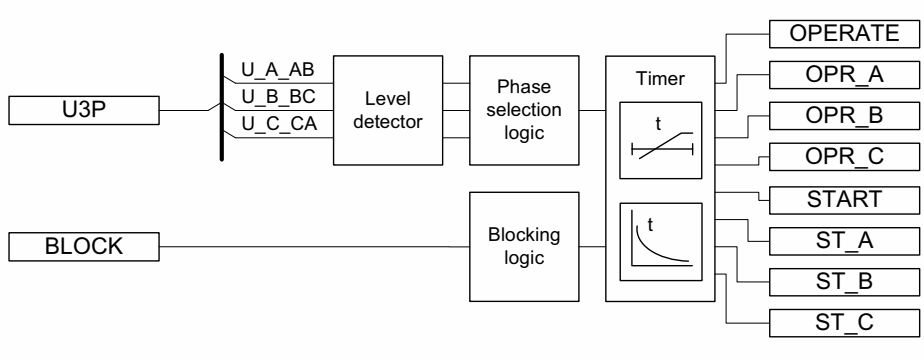



*Figure 422: Functional module diagram*

#### Level detector

The fundamental frequency component of the measured three-phase voltages are compared phase-wise to the set value of the *Start value* setting. If the measured value is higher than the set value of the *Start value* setting, the level detector enables the phase selection logic module. The *Relative hysteresis* setting can be used for preventing unnecessary oscillations if the input signal slightly differs from the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return to the hysteresis area.

The *Voltage selection* setting is used for selecting phase-to-earth or phase-to-phase voltages for protection.

For the voltage IDMT operation mode, the used IDMT curve equations contain discontinuity characteristics. The *Curve Sat relative* setting is used for preventing undesired operation.

For a more detailed description of the IDMT curves and the use of the *Curve Sat Relative* setting, see the IDMT curve saturation of overvoltage protection section in this manual.

## Phase selection logic

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the fault level is detected. If the number of faulty phases match with the set *Num of start phases*, the phase selection logic activates the Timer.

## Timer

Once activated, the Timer activates the START output. Depending on the value of the set *Operating curve type*, the time characteristics are selected according to DT or IDMT.



For a detailed description of the voltage IDMT curves, see the IDMT curves for overvoltage protection section in this manual.

When the operation timer has reached the value set by *Operate delay time* in the DT mode or the maximum value defined by the IDMT, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operate time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation occurs, that is, a fault suddenly disappears before the operate delay is exceeded, the reset state is activated. The behavior in the drop-off situation depends on the selected operate time characteristics. If the DT characteristics are selected, the reset timer runs until the set *Reset delay time* value is exceeded. If the drop-off situation exceeds the set *Reset delay time*, the Timer is reset and the START output is deactivated.

When the IDMT operate time curve is selected, the functionality of the Timer in the drop-off state depends on the combination of the *Type of reset curve*, *Type of time reset* and *Reset delay time* settings.

*Table 705: Reset time functionality when IDMT operation time curve selected*

| Reset functionality | | Setting Type of reset curve | Setting Type of time reset | Setting Reset delay time |
|---|---|---|---|---|
| Instantaneous reset | Operation timer is “Reset instantaneously” when drop-off occurs | “Immediate” | Setting has no effect | Setting has no effect |
| Frozen timer | Operation timer is frozen during drop-off | “Def time reset” | “Freeze Op timer” | Operate timer is reset after the set *Reset delay time* has elapsed |
| Linear decrease | Operation timer value linearly decreases during the drop-off situation | “Def time reset” | “Decrease Op timer” | Operate timer is reset after the set *Reset delay time* has elapsed |

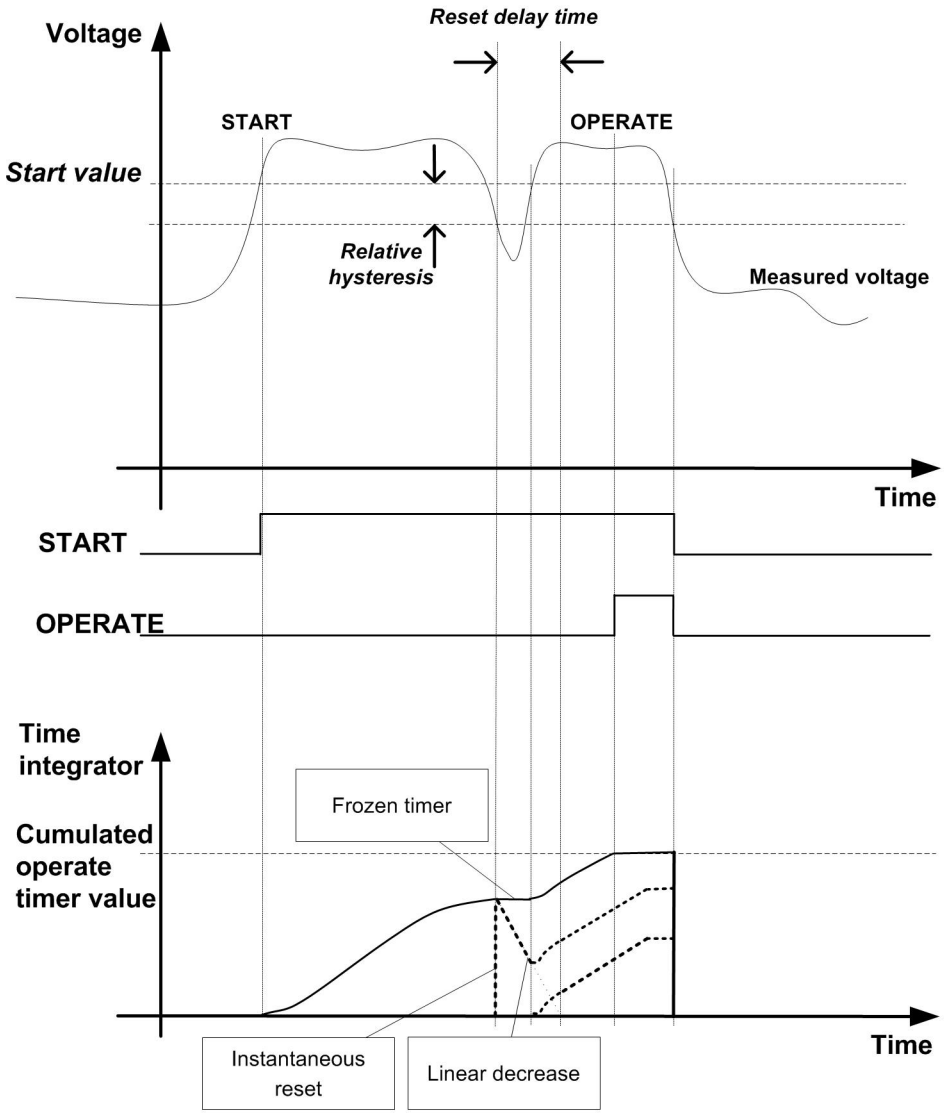



*Figure 423: Behavior of different IDMT reset modes. Operate signal is based on settings Type of reset curve = "Def time reset" and Type of time reset= "Freeze Op timer". The effect of other reset modes is also presented*

The *Time multiplier* setting is used for scaling the IDMT operate times.

The *Minimum operate time* setting parameter defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see the IDMT curves for overvoltage protection section in this manual.

The Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK input signal activation is preselected with the global *Blocking mode* setting.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the Timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

The “Freeze timers” mode of blocking has no effect during the inverse reset mode.

## 4.5.1.6 Timer characteristics

The operating curve types supported by PHPTOV are:

*Table 706: Timer characteristics supported by IDMT operate curve types*

| Operating curve type |
|---|
| (5) ANSI Def. Time |
| (15) IEC Def. Time |
| (17) Inv. Curve A |
| (18) Inv. Curve B |
| (19) Inv. Curve C |
| (20) Programmable |

## 4.5.1.7 Application

Overvoltage in a network occurs either due to the transient surges on the network or due to prolonged power frequency overvoltages. Surge arresters are used to protect the network against the transient overvoltages, but the relay's protection function is used to protect against power frequency overvoltages.

The power frequency overvoltage may occur in the network due to contingencies such as:

- The defective operation of the automatic voltage regulator when the generator is in isolated operation.
- Operation under manual control with the voltage regulator out of service. A sudden variation of load, in particular the reactive power component, gives rise to a substantial change in voltage because of the inherent large voltage regulation of a typical alternator.
- Sudden loss of load due to the tripping of outgoing feeders, leaving the generator isolated or feeding a very small load. This causes a sudden rise in the terminal voltage due to the trapped field flux and overspeed.

If a load sensitive to overvoltage remains connected, it leads to equipment damage.

It is essential to provide power frequency overvoltage protection, in the form of time delayed element, either IDMT or DT to prevent equipment damage.

### 4.5.1.8 Signals

*Table 707: PHPTOV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 708: PHPTOV Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.1.9 Settings

*Table 709: PHPTOV Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...1.60 | xUn | 0.01 | 1.10 | Start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 5=ANSI Def. Time<br>15=IEC Def. Time<br>17=Inv. Curve A<br>18=Inv. Curve B<br>19=Inv. Curve C<br>20=Programmable | | | 15=IEC Def. Time | Selection of time delay curve type |

*Table 710: PHPTOV Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset | | | 1=Immediate | Selection of reset curve type |
| Type of time reset | 1=Freeze Op timer<br>2=Decrease Op timer | | | 1=Freeze Op timer | Selection of time reset |

*Table 711: PHPTOV Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.005...200.000 | | 1 | 1.000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.50...100.00 | | 1 | 1.00 | Parameter B for customer programmable curve |
| Curve parameter C | 0.0...1.0 | | 1 | 0.0 | Parameter C for customer programmable curve |
| Curve parameter D | 0.000...60.000 | | 1 | 0.000 | Parameter D for customer programmable curve |
| Curve parameter E | 0.000...3.000 | | 1 | 1.000 | Parameter E for customer programmable curve |
| Voltage selection | 1=phase-to-earth<br>2=phase-to-phase | | | 2=phase-to-phase | Parameter to select phase or phase-to-phase voltages |

*Table 712: PHPTOV Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 40...60000 | ms | 1 | 40 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Curve Sat Relative | 0.0...10.0 | | 0.1 | 0.0 | Tuning parameter to avoid curve discontinuities |
| Relative hysteresis | 1.0...5.0 | % | 0.1 | 4.0 | Relative hysteresis for operation |

### 4.5.1.10 Monitored data

*Table 713: PHPTOV Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.1.11 Technical data

*Table 714: PHPTOV Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 1.1 × set *Start value* | 23 ms | 27 ms | 31 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms[3)] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) *Start value* = 1.0 × $U_n$, Voltage before fault = 0.9 × $U_n$, $f_n$ = 50 Hz, overvoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 1.20 × $U_n$, *Start value* multiples in range of 1.10...2.00

## 4.5.2 Three-phase undervoltage protection PHPTUV

### 4.5.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase undervoltage protection | PHPTUV | 3U< | 27 |

### 4.5.2.2 Function block




*Figure 424: Function block*

### 4.5.2.3 Functionality

The three-phase undervoltage protection function PHPTUV is used to disconnect from the network devices, for example electric motors, which are damaged when subjected to service under low voltage conditions. PHPTUV includes a settable value for the detection of undervoltage either in a single phase, two phases or three phases.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

### 4.5.2.4 Analog channel configuration

PHPTUV has one analog group input which must be properly configured.

*Table 715: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 716: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected if *Num of start phases* is set to "1 out of 3" but the other two channels must be fed with high values (considerably above *Start value*). For other values of *Num of start phases*, all three voltage channels must be connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PHPTUV can be described using a module diagram. All the modules in the diagram are explained in the next sections.

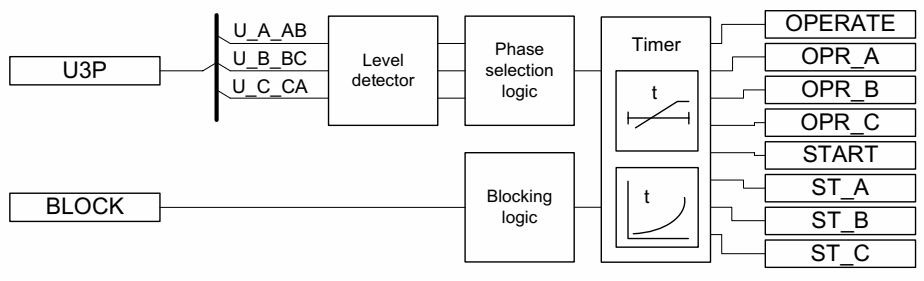



*Figure 425: Functional module diagram*

## Level detector

The fundamental frequency component of the measured three phase voltages are compared phase-wise to the set *Start value*. If the measured value is lower than the set value of the *Start value* setting, the level detector enables the phase selection logic module. The *Relative hysteresis* setting can be used for preventing unnecessary oscillations if the input signal slightly varies above or below the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return back to the hysteresis area.

The *Voltage selection* setting is used for selecting the phase-to-earth or phase-to-phase voltages for protection.

For the voltage IDMT mode of operation, the used IDMT curve equations contain discontinuity characteristics. The *Curve Sat relative* setting is used for preventing unwanted operation.

For more detailed description on IDMT curves and usage of *Curve Sat Relative* setting, see the IDMT curves for undervoltage protection section in this manual.

The level detector contains a low-level blocking functionality for cases where one of the measured voltages is below the desired level. This feature is useful when unnecessary starts and operates are wanted to avoid during, for example, an autoreclose sequence. The low-level blocking is activated by default (*Enable block value* is set to "True") and the blocking level can be set with the *Voltage block value* setting.

## Phase selection logic

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the fault level is detected. If the number of faulty phases match with the set *Num of start phases*, the phase selection logic activates the Timer.

## Timer

Once activated, the Timer activates the `START` output. Depending on the value of the set *Operating curve type*, the time characteristics are selected according to DT or IDMT.

For a detailed description of the voltage IDMT curves, see the IDMT curves for undervoltage protection section in this manual.

When the operation timer has reached the value set by *Operate delay time* in the DT mode or the maximum value defined by the IDMT, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operate time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation occurs, that is, a fault suddenly disappears before the operate delay is exceeded, the reset state is activated. The behavior in the drop-off situation depends on the selected operate time characteristics. If the DT characteristics are selected, the reset timer runs until the set *Reset delay time* value is exceeded. If the drop-off situation exceeds the set *Reset delay time*, the Timer is reset and the START output is deactivated.

When the IDMT operate time curve is selected, the functionality of the Timer in the drop-off state depends on the combination of the *Type of reset curve*, *Type of time reset* and *Reset delay time* settings.

*Table 717: Reset time functionality when IDMT operation time curve selected*

| Reset functionality | | Setting Type of reset curve | Setting Type of time reset | Setting Reset delay time |
|---|---|---|---|---|
| Instantaneous reset | Operation timer is “Reset instantaneously” when drop-off occurs | “Immediate” | Setting has no effect | Setting has no effect |
| Frozen timer | Operation timer is frozen during drop-off | “Def time reset” | “Freeze Op timer” | Operate timer is reset after the set *Reset delay time* has elapsed |
| Linear decrease | Operation timer value linearly decreases during the drop-off situation | “Def time reset” | “Decrease Op timer” | Operate timer is reset after the set *Reset delay time* has elapsed |

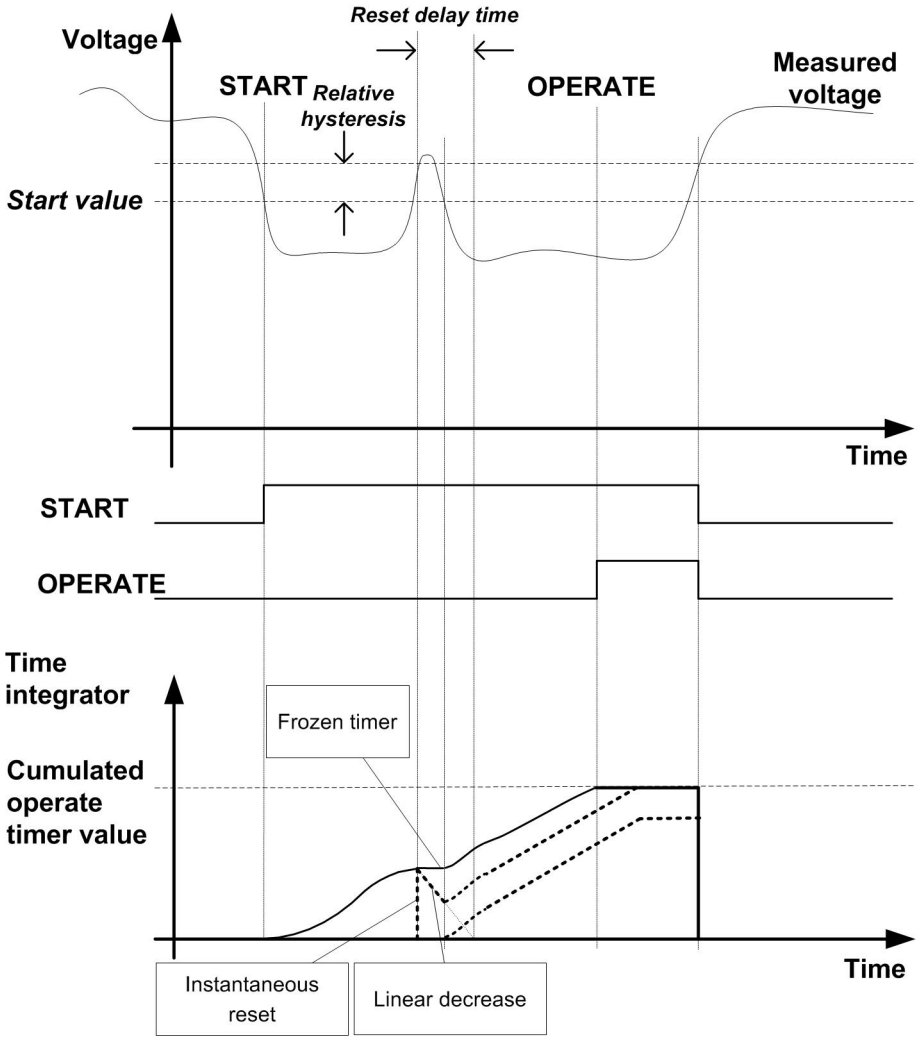



*Figure 426: Behavior of different IDMT reset modes. Operate signal is based on settings Type of reset curve = "Def time reset" and Type of time reset= "Freeze Op timer". The effect of other reset modes is also presented*

The *Time multiplier* setting is used for scaling the IDMT operate times.

The *Minimum operate time* setting parameter defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see the IDMT curves for undervoltage protection section in this manual.

The Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK input signal activation is preselected with the global *Blocking mode* setting.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the Timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.



The “Freeze timers” mode of blocking has no effect during the “Inverse reset” mode.

## 4.5.2.6 Timer characteristics

The operating curve types supported by PHPTUV are:

*Table 718: Supported IDMT operate curve types*

| Operating curve type |
|---|
| (5) ANSI Def. Time |
| (15) IEC Def. Time |
| (21) Inv. Curve A |
| (22) Inv. Curve B |
| (23) Programmable |

## 4.5.2.7 Application

PHPTUV is applied to power system elements, such as generators, transformers, motors and power lines, to detect low voltage conditions. Low voltage conditions are caused by abnormal operation or a fault in the power system. PHPTUV can be used in combination with overcurrent protections. PHPTUV is also used to initiate voltage correction measures, such as insertion of shunt capacitor banks, to compensate for a reactive load and thereby to increase the voltage.

PHPTUV can be used to disconnect from the network devices, such as electric motors, which are damaged when subjected to service under low voltage conditions.

PHPTUV deals with low voltage conditions at power system frequency. Low voltage conditions can be caused by:

- Malfunctioning of a voltage regulator or incorrect settings under manual control (symmetrical voltage decrease)
- Overload (symmetrical voltage decrease)
- Short circuits, often as phase-to-earth faults (unsymmetrical voltage increase)

PHPTUV prevents sensitive equipment from running under conditions that could cause overheating and thus shorten their life time expectancy. In many cases, PHPTUV is a useful function in circuits for local or remote automation processes in the power system.

### 4.5.2.8 Signals

*Table 719: PHPTUV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 720: PHPTUV Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.2.9 Settings

*Table 721: PHPTUV Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...1.20 | xUn | 0.01 | 0.90 | Start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 60...300000 | ms | 10 | 60 | Operate delay time |
| Operating curve type | 5=ANSI Def. Time<br>15=IEC Def. Time<br>21=Inv. Curve A<br>22=Inv. Curve B<br>23=Programmable | | | 15=IEC Def. Time | Selection of time delay curve type |

*Table 722: PHPTUV Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset | | | 1=Immediate | Selection of reset curve type |
| Type of time reset | 1=Freeze Op timer<br>2=Decrease Op timer | | | 1=Freeze Op timer | Selection of time reset |

*Table 723: PHPTUV Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.005...200.000 | | 1 | 1.000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.50...100.00 | | 1 | 1.00 | Parameter B for customer programmable curve |
| Curve parameter C | 0.0...1.0 | | 1 | 0.0 | Parameter C for customer programmable curve |
| Curve parameter D | 0.000...60.000 | | 1 | 0.000 | Parameter D for customer programmable curve |
| Curve parameter E | 0.000...3.000 | | 1 | 1.000 | Parameter E for customer programmable curve |
| Voltage selection | 1=phase-to-earth<br>2=phase-to-phase | | | 2=phase-to-phase | Parameter to select phase or phase-to-phase voltages |

*Table 724: PHPTUV Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 60...60000 | ms | 1 | 60 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Curve Sat Relative | 0.0...10.0 | | 0.1 | 0.0 | Tuning parameter to avoid curve discontinuities |
| Voltage block value | 0.05...1.00 | xUn | 0.01 | 0.20 | Low level blocking for undervoltage mode |
| Enable block value | 0=False<br>1=True | | | 1=True | Enable internal blocking |
| Relative hysteresis | 1.0...5.0 | % | 0.1 | 4.0 | Relative hysteresis for operation |

### 4.5.2.10 Monitored data

*Table 725: PHPTUV Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHPTUV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.2.11 Technical data

*Table 726: PHPTUV Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 0.9 × set *Start value* | 62 ms | 66 ms | 70 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms[3)] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) *Start value* = 1.0 × $U_n$, Voltage before fault = 1.1 × $U_n$, $f_n$ = 50 Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.50, *Start value* multiples in range of 0.90...0.20

## 4.5.3 Residual overvoltage protection ROVPTOV

### 4.5.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Residual overvoltage protection | ROVPTOV | Uo> | 59G/59N |

### 4.5.3.2 Function block




*Figure 427: Function block*

### 4.5.3.3 Functionality

The residual overvoltage protection function ROVPTOV is used in distribution networks where the residual overvoltage can reach non-acceptable levels in, for example, high impedance earthing.

The function starts when the residual voltage exceeds the set limit. ROVPTOV operates with the definite time (DT) characteristic.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.5.3.4 Analog channel configuration

ROVPTOV has one analog group input which must be properly configured.

*Table 727: Analog inputs*

| Input | Description |
|---|---|
| URES | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 728: Special conditions*

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected to calculate residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of ROVPTOV can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

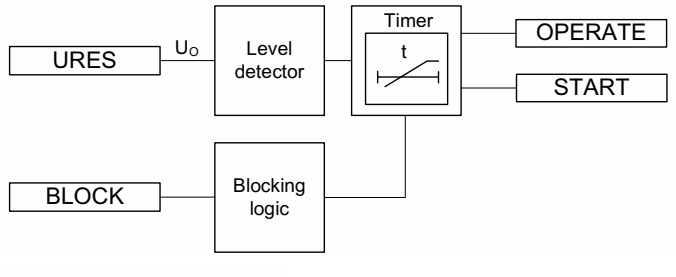



*Figure 428: Functional module diagram*

### Level detector

The residual voltage is compared to the set *Start value*. If the value exceeds the set *Start value*, the level detector sends an enable signal to the timer.

### Timer

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.5.3.6 Application

ROVPTOV is designed to be used for earth-fault protection in isolated neutral, resistance earthed or reactance earthed systems. In compensated networks, starting of the function can be used to control the switching device of the neutral resistor. The function can also be used for the back-up protection of feeders for busbar protection when a more dedicated busbar protection would not be justified.

In compensated and isolated neutral systems, the system neutral voltage, that is, the residual voltage, increases in case of any fault connected to earth. Depending on the type of the fault and the fault resistance, the residual voltage reaches different values. The highest residual voltage, equal to the phase-to-earth voltage, is achieved for a single-phase earth fault. The residual voltage increases approximately the same amount in the whole system and does not provide any guidance in finding the faulty component. Therefore, this function is often used as a backup protection or as a release signal for the feeder earth-fault protection.

The protection can also be used for the earth-fault protection of generators and motors and for the unbalance protection of capacitor banks.

The residual voltage can be calculated internally based on the measurement of the three-phase voltage. This voltage can also be measured by a single-phase voltage transformer, located between a transformer star point and earth, or by using an open-delta connection of three single-phase voltage transformers.

### 4.5.3.7 Signals

*Table 729: ROVPTOV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 730: ROVPTOV Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.3.8 Settings

*Table 731: ROVPTOV Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.010...1.000 | xUn | 0.001 | 0.030 | Residual overvoltage start value |
| Operate delay time | 40...300000 | ms | 1 | 40 | Operate delay time |

*Table 732: ROVPTOV Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 733: ROVPTOV Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.5.3.9 Monitored data

*Table 734: ROVPTOV Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| ROVPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.3.10 Technical data

*Table 735: ROVPTOV Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1)2)] | $U_{Fault}$ = 2 × set *Start value* | Minimum | Typical | Maximum |
| | | 48 ms | 51 ms | 54 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) Residual voltage before fault = 0.0 × $U_n$, $f_n$ = 50 Hz, residual voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.5.4 Positive-sequence overvoltage protection PSPTOV

### 4.5.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Positive-sequence overvoltage protection | PSPTOV | U1> | 59PS |

### 4.5.4.2 Function block




*Figure 429: Function block*

### 4.5.4.3 Functionality

The positive-sequence overvoltage protection function PSPTOV is used as an alternative to the ordinary three-phase overvoltage protection. PSPTOV is used for supervision and for detection of abnormal conditions, and, together with the other protection functions, increases the security of the protection system.

The function starts when the positive-sequence voltage exceeds the set limit. PSPTOV operates on definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.5.4.4 Analog channel configuration

PSPTOV has one analog group input which must be properly configured.

*Table 736: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 737: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of PSPTOV can be described with a module diagram. All the modules in the diagram are explained in the next sections.

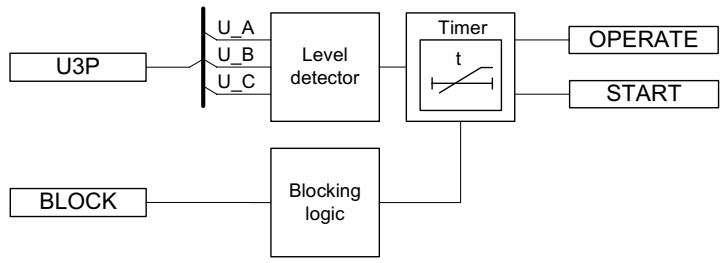



*Figure 430: Functional module diagram*

#### Level detector

The calculated positive-sequence voltage is compared to the set *Start value* setting. If the value exceeds the set *Start value*, the level detector enables the timer. The *Relative hysteresis* setting can be used for preventing unnecessary oscillations if the input signal slightly varies from the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return to the hysteresis area.

#### Timer

Once activated, Timer activates the `START` output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the `OPERATE` output is activated if the overvoltage condition persists. If the positive-sequence voltage normalizes before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the `START` output is deactivated.

Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

#### Blocking logic

The binary input `BLOCK` can be used to block the function. The activation of the `BLOCK` input deactivates all outputs and resets internal timers.

### 4.5.4.6 Application

A sudden power loss, tap changer regulating failures and open line ends on long lines are abnormal conditions which cause overvoltage in a power system. PSPTOV is

applied to power system elements, such as generators, transformers, motors and power lines, to detect overvoltage conditions.

PSPTOV can be used in combination with low-current signals or a directional reactive overpower function to identify the distribution line with an open remote end. PSPTOV can also be used to initiate voltage correction measures, such as insertion of shunt reactors or switching out capacitor banks, to control the voltage.

Overvoltage faced by the power transformer can lead to an overexcitation problem. Overexcitation normally occurs when the voltage-to-frequency ratio increases much above the design value resulting into transformer operation under a nonlinear region. A transformer can be in such an overvoltage situation during a sudden loss of load due to underfrequency load shedding. Overexcitation results in an increase of the exciting current which leads to core heating and thus to transformer damage. PSPTOV along with the underfrequency protection can be used for the protection of the transformer during overexcitation.

Some common reasons leading to positive-sequence overvoltages are:

- Broken conductor falling to a crossing overhead line, transformer flash overfault from high-voltage winding to low-voltage winding
- Malfunctioning of a voltage regulator or wrong settings under manual control (symmetrical voltage increase)
- Low load compared to the reactive power generation (symmetrical voltage increase)

PSPTOV prevents sensitive equipment from running under overvoltage conditions which cause equipment overheating or stress on insulation material.

### 4.5.4.7 Signals

*Table 738: PSPTOV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 739: PSPTOV Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.4.8 Settings

*Table 740: PSPTOV Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.400...1.600 | xUn | 0.001 | 0.650 | Start value |
| Operate delay time | 40...120000 | ms | 10 | 40 | Operate delay time |

*Table 741: PSPTOV Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 742: PSPTOV Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Relative hysteresis | 1.0...5.0 | % | 0.1 | 4.0 | Relative hysteresis for operation |

### 4.5.4.9 Monitored data

*Table 743: PSPTOV Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PSPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

*Table 744: PSPTOV Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 1.1 × set *Start value* | 29 ms | 32 ms | 34 ms |
| | $U_{Fault}$ = 2 × set *Start value* | 32 ms | 24 ms | 26 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |

Table continues on next page

| Characteristic | Value |
|---|---|
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

1) Positive-sequence voltage before fault = 0.0 × $U_n$, $f_n$ = 50 Hz, positive-sequence overvoltage of nominal frequency injected from random phase angle
2) Measured with static signal output (SSO)

## 4.5.5 Negative-sequence overvoltage protection NSPTOV

### 4.5.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Negative-sequence overvoltage protection | NSPTOV | U2> | 59NS |

### 4.5.5.2 Function block




*Figure 431: Function block*

### 4.5.5.3 Functionality

The negative-sequence overvoltage protection function NSPTOV is used to detect negative sequence overvoltage conditions. NSPTOV is used for the protection of machines.

The function starts when the negative sequence voltage exceeds the set limit. NSPTOV operates with the definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.5.5.4 Analog channel configuration

NSPTOV has one analog group input which must be properly configured.

*Table 745: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 746: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that any two voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of NSPTOV can be described using a module diagram. All the modules in the diagram are explained in the next sections.

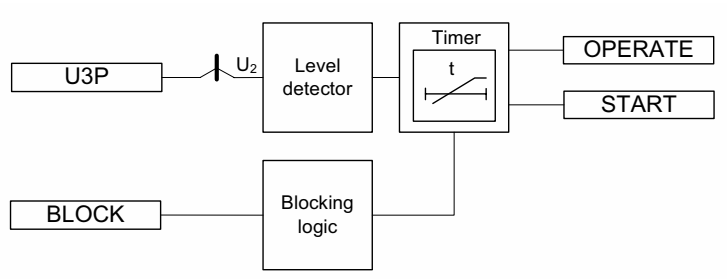



*Figure 432: Functional module diagram*

#### Level detector

The calculated negative-sequence voltage is compared to the set *Start value* setting. If the value exceeds the set *Start value*, the level detector enables the timer.

#### Timer

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated if the overvoltage condition persists. If the negative-sequence voltage normalizes before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.5.5.6 Application

A continuous or temporary voltage unbalance can appear in the network for various reasons. The voltage unbalance mainly occurs due to broken conductors or asymmetrical loads and is characterized by the appearance of a negative-sequence component of the voltage. In rotating machines, the voltage unbalance results in a current unbalance, which heats the rotors of the machines. The rotating machines, therefore, do not tolerate a continuous negative-sequence voltage higher than typically 1-2 percent x $U_n$.

The negative-sequence component current $I_2$, drawn by an asynchronous or a synchronous machine, is linearly proportional to the negative-sequence component voltage $U_2$. When $U_2$ is P% of $U_n$, $I_2$ is typically about 5 x P% x $I_n$.

The negative-sequence overcurrent NSPTOC blocks are used to accomplish a selective protection against the voltage and current unbalance for each machine separately. Alternatively, the protection can be implemented with the NSPTOV function, monitoring the voltage unbalance of the busbar.

If the machines have an unbalance protection of their own, the NSPTOV operation can be applied as a backup protection or it can be used as an alarm. The latter can be applied when it is not required to trip loads tolerating voltage unbalance better than the rotating machines.

If there is a considerable degree of voltage unbalance in the network, the rotating machines should not be connected to the network at all. This logic can be implemented by inhibiting the closure of the circuit breaker if the NSPTOV operation has started. This scheme also prevents connecting the machine to the network if the phase sequence of the network is not correct.

An appropriate value for the setting parameter *Voltage start value* is approximately 3 percent of $U_n$. A suitable value for the setting parameter *Operate delay time* depends on the application. If the NSPTOV operation is used as backup protection, the operate time should be set in accordance with the operate time of NSPTOC used as main protection. If the NSPTOV operation is used as main protection, the operate time should be approximately one second.

### 4.5.5.7 Signals

*Table 747: NSPTOV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 748: NSPTOV Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.5.8 Settings

*Table 749: NSPTOV Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.010...1.000 | xUn | 0.001 | 0.030 | Start value |
| Operate delay time | 40...120000 | ms | 1 | 40 | Operate delay time |

*Table 750: NSPTOV Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 751: NSPTOV Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.5.5.9 Monitored data

*Table 752: NSPTOV Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| NSPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.5.10 Technical data

*Table 753: NSPTOV Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the voltage measured: $f_n$ | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 1.1 × set *Start value*<br>$U_{Fault}$ = 2.0 × set *Start value* | 33 ms<br>24 ms | 35 ms<br>26 ms | 37 ms<br>28 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) Negative-sequence voltage before fault = 0.0 × $U_n$, $f_n$ = 50 Hz, negative-sequence overvoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.5.6 Positive-sequence undervoltage protection PSPTUV

### 4.5.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Positive-sequence undervoltage protection | PSPTUV | U1< | 27PS |

### 4.5.6.2 Function block




*Figure 433: Function block*

### 4.5.6.3 Functionality

The positive-sequence undervoltage protection function PSPTUV is used to detect positive-sequence undervoltage conditions. PSPTUV is used for the protection of small power generation plants. The function helps in isolating an embedded plant from a fault line when the fault current fed by the plant is too low to start an overcurrent function but high enough to maintain the arc. Fast isolation of all the fault current sources is necessary for a successful autoreclosure from the network-end circuit breaker.

The function starts when the positive-sequence voltage drops below the set limit. PSPTUV operates with the definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.5.6.4 Analog channel configuration

PSPTUV has one analog group input which must be properly configured.

*Table 754: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 755: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For

troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of PSPTUV can be described using a module diagram. All the modules in the diagram are explained in the next sections.

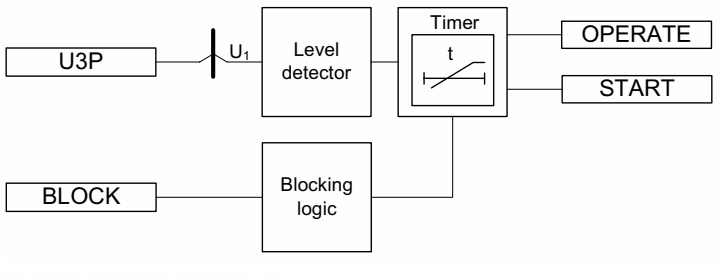



*Figure 434: Functional module diagram. $U_1$ is used for representing positive phase sequence voltage.*

#### Level detector

The calculated positive-sequence voltage is compared to the set *Start value* setting. If the value drops below the set *Start value*, the level detector enables the timer. The *Relative hysteresis* setting can be used for preventing unnecessary oscillations if the input signal slightly varies from the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return to the hysteresis area.

The level detector contains a low-level blocking functionality for cases where the positive-sequence voltage is below the desired level. This feature is useful when unnecessary starts and operates are wanted to avoid during, for example, an autoreclose sequence. The low-level blocking is activated by default (*Enable block value* is set to “Enabled”) and the blocking level can be set with the *Voltage block value* setting.

#### Timer

Once activated, the timer activates the `START` output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the `OPERATE` output is activated if the undervoltage condition persists. If the positive-sequence voltage normalizes before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the `START` output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.5.6.6 Application

PSPTUV can be applied for protecting a power station used for embedded generation when network faults like short circuits or phase-to-earth faults in a transmission or a distribution line cause a potentially dangerous situations for the power station. A network fault can be dangerous for the power station for various reasons. The operation of the protection can cause an islanding condition, also called a loss-of-mains condition, in which a part of the network, that is, an island fed by the power station, is isolated from the rest of the network. There is then a risk of an autoreclosure taking place when the voltages of different parts of the network do not synchronize, which is a straining incident for the power station. Another risk is that the generator can lose synchronism during the network fault. A sufficiently fast trip of the utility circuit breaker of the power station can avoid these risks.

The lower the three-phase symmetrical voltage of the network is, the higher is the probability that the generator loses the synchronism. The positive-sequence voltage is also available during asymmetrical faults. It is a more appropriate criterion for detecting the risk of loss of synchronism than, for example, the lowest phase-to-phase voltage.

Analyzing the loss of synchronism of a generator is rather complicated and requires a model of the generator with its prime mover and controllers. The generator can be able to operate synchronously even if the voltage drops by a few tens of percent for some hundreds of milliseconds. The setting of PSPTUV is thus determined by the need to protect the power station from the risks of the islanding conditions since that requires a higher setting value.

The loss of synchronism of a generator means that the generator is unable to operate as a generator with the network frequency but enters into an unstable condition in which it operates by turns as a generator and a motor. Such a condition stresses the

generator thermally and mechanically. This kind of loss of synchronism should not be mixed with the one between an island and the utility network. In the islanding situation, the condition of the generator itself is normal but the phase angle and the frequency of the phase-to-phase voltage can be different from the corresponding voltage in the rest of the network. The island can have a frequency of its own relatively fast when fed by a small power station with a low inertia.

PSPTUV complements other loss-of-grid protection principles based on the frequency and voltage operation.

Motor stalling and failure to start can lead to a continuous undervoltage. The positive-sequence undervoltage is used as a backup protection against the motor stall condition.

### 4.5.6.7 Signals

*Table 756: PSPTUV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 757: PSPTUV Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.6.8 Settings

*Table 758: PSPTUV Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.010...1.200 | xUn | 0.001 | 0.500 | Start value |
| Operate delay time | 40...120000 | ms | 10 | 40 | Operate delay time |

*Table 759: PSPTUV Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage block value | 0.01...1.00 | xUn | 0.01 | 0.20 | Internal blocking level |
| Enable block value | 0=False<br>1=True | | | 1=True | Enable Internal Blocking |

*Table 760: PSPTUV Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 761: PSPTUV Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Relative hysteresis | 1.0...5.0 | % | 0.1 | 4.0 | Relative hysteresis for operation |

### 4.5.6.9 Monitored data

*Table 762: PSPTUV Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PSPTUV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.6.10 Technical data

*Table 763: PSPTUV Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 0.99 × set *Start value*<br>$U_{Fault}$ = 0.9 × set *Start value* | 52 ms<br>44 ms | 55 ms<br>47 ms | 58 ms<br>50 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) *Start value* = 1.0 × $U_n$, positive-sequence voltage before fault = 1.1 × $U_n$, $f_n$ = 50 Hz, positive sequence undervoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.5.7 Overexcitation protection OEPVPH

### 4.5.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Overexcitation protection | OEPVPH | U/f> | 24 |

### 4.5.7.2 Function block

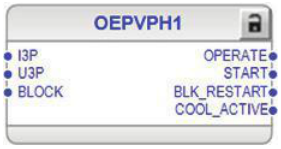



*Figure 435: Function block*

### 4.5.7.3 Functionality

The overexcitation protection function OEPVPH is used to protect generators and power transformers against an excessive flux density and saturation of the magnetic core.

The function calculates the U/f ratio (volts/hertz) proportional to the excitation level of the generator or transformer and compares this value to the setting limit. The function starts when the excitation level exceeds the set limit and operates when the set operating time has elapsed. The operating time characteristic can be selected to be either definite time (DT) or overexcitation inverse definite minimum time (overexcitation type IDMT).

This function contains a blocking functionality. It is possible to block the function outputs, reset timer or the function itself.

### 4.5.7.4 Analog channel configuration

OEPVPH has two analog group inputs which all must be properly configured.

*Table 764: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 765: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with at least one voltage channel connected (A, B or C according to *Phase selection* "1", "2" or "3") if *Voltage selection* is set to "phase-to-earth". |
| | The function can work with any two voltage channels connected (AB, BC or CA according to *Phase selection* "1", "2" or "3") if *Voltage selection* is set to "phase-to-phase". |
| | The function requires that all three voltage channels are connected if *Voltage selection* is set to "pos sequence". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.7.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of OEPVPH can be described using a module diagram. All the modules in the diagram are explained in the next sections.

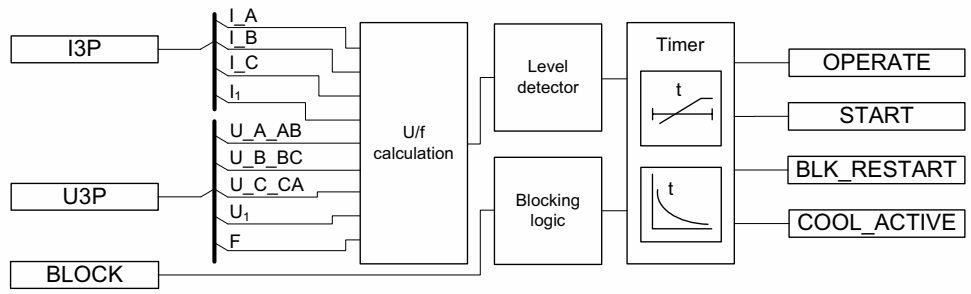



*Figure 436: Functional module diagram*

#### U/f calculation

This module calculates the U/f ratio, that is, the excitation level from the internal induced voltage (E) and frequency. The actual measured voltage ($U_m$) deviates from the internal induced voltage (E), a value the equipment has to withstand. This voltage compensation is based on the load current ($I_L$) and the leakage reactance ($X_{leak}$) of the

equipment. The leakage reactance of the transformer or generator is set through the *Leakage React* setting in percentage of the Z base.

The internal induced voltage (E) is calculated from the measured voltage. The settings *Voltage selection* and *Phase supervision* determine which voltages and currents are to be used. If the *Voltage selection* setting is set to "phase-to-earth" or "phase-to-phase", the *Phase supervision* setting is used for determining which phases or phase-to-phase voltages ("A or AB", "B or BC" and "C or CA") and currents are to be used for the calculation of the induced voltage.

*Table 766: Voltages and currents used for induced voltage (emf) E calculation*

| Voltage selection setting | Phase supervision setting | Calculation of internal induced voltage (emf) E[1)] |
|---|---|---|
| phase-to-earth | A or AB | $\overline{E} = \sqrt{3} \cdot \left(\overline{U_A} + \overline{I_A} \cdot (j \cdot X_{leak})\right)$ (Equation 194) |
| phase-to-earth | B or BC | $\overline{E} = \sqrt{3} \cdot \left(\overline{U_B} + \overline{I_B} \cdot (j \cdot X_{leak})\right)$ (Equation 195) |
| phase-to-earth | C or CA | $\overline{E} = \sqrt{3} \cdot \left(\overline{U_C} + \overline{I_C} \cdot (j \cdot X_{leak})\right)$ (Equation 196) |
| phase-to-phase | A or AB | $\overline{E} = \overline{U_{AB}} + \left((\overline{I_A} - \overline{I_B}) \cdot (j \cdot X_{leak})\right)$ (Equation 197) |
| phase-to-phase | B or BC | $\overline{E} = \overline{U_{BC}} + \left((\overline{I_B} - \overline{I_C}) \cdot (j \cdot X_{leak})\right)$ (Equation 198) |
| phase-to-phase | C or CA | $\overline{E} = \overline{U_{CA}} + \left((\overline{I_C} - \overline{I_A}) \cdot (j \cdot X_{leak})\right)$ (Equation 199) |
| Pos sequence | N/A | $\overline{E} = \sqrt{3} \cdot \left(\overline{U_1} + \overline{I_1} \cdot (j \cdot X_{leak})\right)$ (Equation 200) |

1) Voltages, currents and the leakage reactance $X_{leak}$ in the calculations are given in volts, amps and ohms.

If all three phase or phase-to-phase voltages and phase currents are fed to the protection relay, the positive-sequence alternative is recommended.

If the leakage reactance of the protected equipment is unknown or if the measured voltage ($U_m$) is to be used in the excitation level calculation, then by setting the leakage reactance value to zero the calculated induced voltage (E) is equal to the measured voltage.

The calculated U/f ratio is scaled to a value based on the nominal $U_n/f_n$ ratio. However, the highest allowed continuous voltage (in % $U_n$) can be defined by setting the parameter *Voltage Max Cont* to change the basis of the voltage. The measured voltage is compared to the new base value to obtain the excitation level.

The excitation level (M) can be calculated:

$$M = \frac{\frac{E}{f_m}}{\frac{U_n}{f_n} \cdot \frac{Volt\ Max\ continuous}{100}}$$

(Equation 201)

M excitation level (U/f ratio or volts/hertz) in pu

E internal induced voltage (emf)

$f_m$ measured frequency

$U_n$ nominal phase-to-phase voltage

$f_n$ nominal frequency

If the input frequency ($f_m$) is less than 20 percent of the nominal frequency ($f_n$), the calculation of the excitation level is disabled and forced to zero value. This means that the function is blocked from starting and operating during a low-frequency condition.

The calculated excitation level (U/f ratio or volts/hertz) VOLTPERHZ is available in the Monitored data view.

## Level detector

Level detector compares the calculated excitation level to the *Start value* setting. If the excitation level exceeds the set limit, the module sends an enabling signal to start Timer.

## Timer

Once activated, Timer activates the `START` output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value set by *Operate delay time* in the DT mode or the value defined by the inverse time curve, the `OPERATE` output is activated.

In a drop-off situation, that is, when the excitation level drops below *Start value* before the function operates, the reset timer is activated and the `START` output resets after the time delay of *Reset delay time* for the DT characteristics. For the IDMT curves, the reset operation is as described in the Timer characteristics chapter.

For the IDMT curves, it is possible to define the maximum and minimum operating times via the *Minimum operate time* and *Maximum operate time* settings. The *Maximum operate time* setting is used to prevent infinite start situations at low degrees

of overexcitation. The *Time multiplier* setting is used for scaling the IDMT operate times.

The activation of the OPERATE output activates the BLK_RESTART output.

For the DT characteristics, the deactivation of the OPERATE output activates the cooling timer. The timer is set to the value entered in the *Cooling time* setting. The BLK_RESTART and COOL_ACTIVE outputs are kept active until the cooling timer is reset. If the excitation increases above the set value during this period, the OPERATE output is activated immediately. For IDMT, the deactivation of BLK_RESTART and COOL_ACTIVE depends on the curve type selected.

The T_ENARESTART output indicates in seconds the duration for which the BLK_RESTART output still remains active. The value is available in the Monitored data view.

Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the Monitored data view.

### Blocking logic

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.5.7.6 Timer characteristics

OEPVPH supports both DT and IDMT characteristics. The DT timer characteristics can be selected as "ANSI Def. Time" or "IEC Def. Time" in the *Operating curve type* setting. The functionality is identical in both cases. When the DT characteristics are selected, the functionality is only affected by the *Operate delay time* and *Reset delay time* settings.

OEPVPH also supports four overexcitation IDMT characteristic curves: "OvExt IDMT Crv1", "OvExt IDMT Crv2", "OvExt IDMT Crv3" and "OvExt IDMT Crv4".

### Overexcitation inverse definite minimum time curve (IDMT)

In the inverse time modes, the operate time depends on the momentary value of the excitation: the higher the excitation level, the shorter the operate time. The operate

time calculation or integration starts immediately when the excitation level exceeds the set *Start value* and the START output is activated.

The OPERATE output is activated when the cumulative sum of the integrator calculating the overexcitation situation exceeds the value set by the inverse time mode. The set value depends on the selected curve type and the setting values used.

The *Minimum operate time* and *Maximum operate time* settings define the minimum operate time and maximum operate time possible for the IDMT mode. For setting these parameters, a careful study of the particular IDMT curves is recommended.

The operation time of the function block can vary much between different operating curve types even if other setting parameters for the curves were not changed.

Once activated, the Timer activates the START output for the IDMT curves. If the excitation level drops below the *Start value* setting before the function operates, the reset timer is activated and the START output resets immediately. If START reoccurs during the reset time, the operation calculation is made based on the effects of the period when START was previously active. This is intended to allow an operating condition to occur in less time to account for the heating effects from the previous active start period.

When START becomes active, the reset time is based on the following equation.

$$reset\ time = \left( \frac{START_DUR}{100} \right) \cdot Cooling\ time$$

(Equation 202)

For the IDMT curves, when START is deactivated, the integral value calculated during START is continuously decremented by a constant that causes its value to become zero when the reset time elapses during the reset period. If a fault reoccurs, the integration continues from the current integral value and the start time is adjusted, as shown in Figure 437. The start time becomes the value at the time when the fault dropped off minus the amount of reset time that occurred. If the reset period elapses without a fault being detected, the saved values of the start time and integration are cleared.

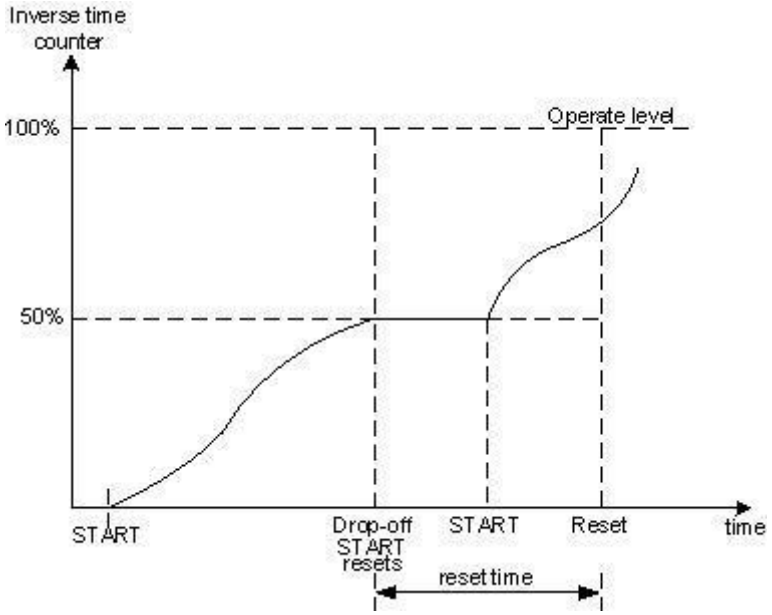



*Figure 437: An example of a delayed reset in the inverse time characteristics. When the start becomes active during the reset period, the operate time counter continues from the level corresponding to the drop-off (reset time = 0.50 · Cooling time)*

## Overexcitation IDMT curves 1, 2 and 3

The base equation for the IDMT curves "OvExt IDMT Crv1", "OvExt IDMT Crv2" and "OvExt IDMT Crv3" is:

$$t(s) = 60 \cdot e^{\left(\frac{ak+b-100M}{c}\right)}$$

(Equation 203)

t(s) Operate time in seconds

M Excitation level (U/f ratio or volts/hertz) in pu

k *Time multiplier* setting

The constant "60" in Equation converts time from minutes to seconds.

*Table 767: Parameters a, b and c for different IDMT curves*

| *Operating curve type* setting | a | b | c |
|---|---|---|---|
| OvExt IDMT Crv1 | 2.5 | 115.00 | 4.886 |
| OvExt IDMT Crv2 | 2.5 | 113.50 | 3.040 |
| OvExt IDMT Crv3 | 2.5 | 108.75 | 2.443 |

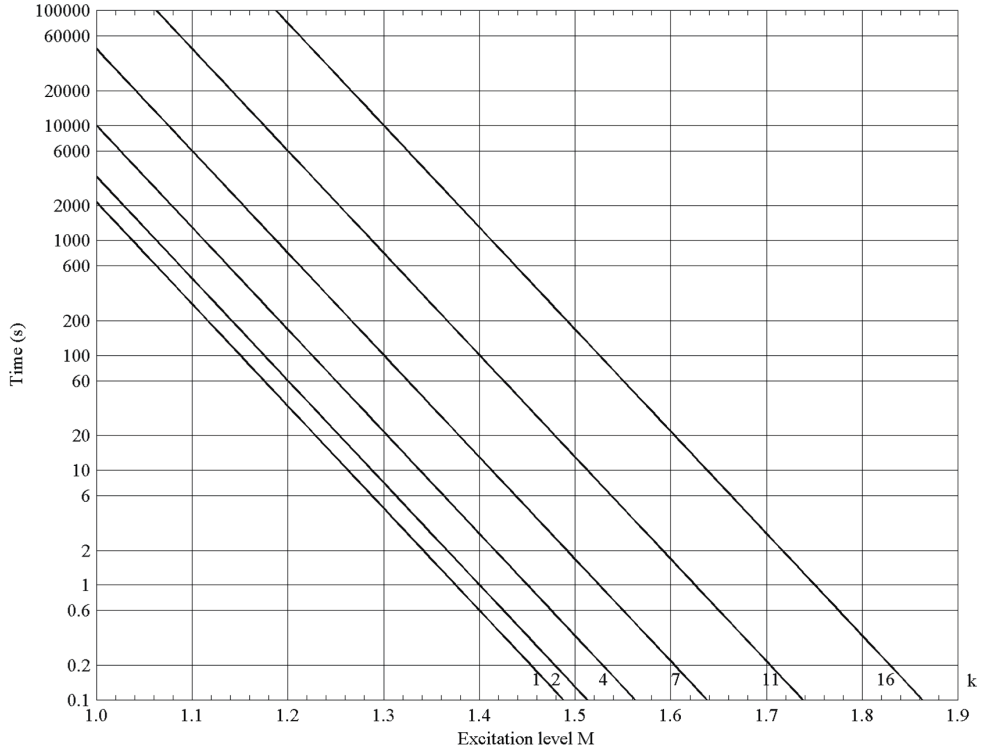



*Figure 438: Operating time curves for the overexcitation IDMT curve ("OvExt IDMT Crv1") for parameters a = 2.5, b = 115.0 and c = 4.886*

## Overexcitation IDMT curve 4

The base equation for the IDMT curve "OvExt IDMT Crv4" is:

$$t(s) = d + \frac{0.18k}{(M-1)^2}$$

(Equation 204)

t(s) Operate time in seconds

d *Constant delay* setting in milliseconds

M Excitation value (U/f ratio or volts/hertz) in pu

k *Time multiplier* setting

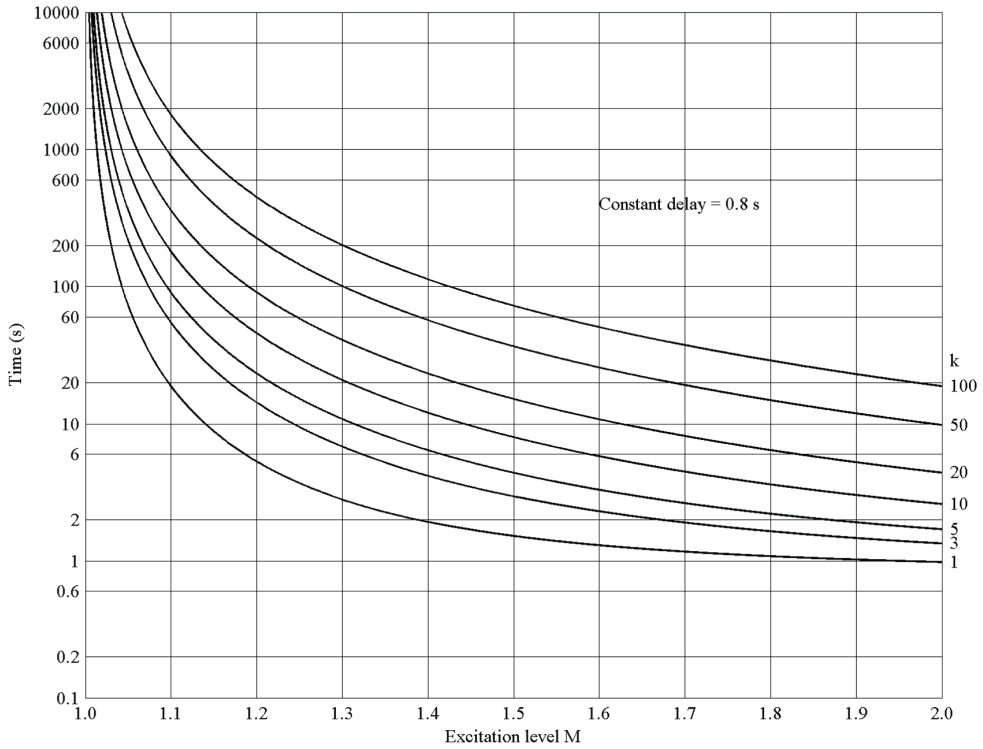



*Figure 439: Operating time curves for the overexcitation IDMT curve 4 ("OvExt IDMT Crv4") for different values of the Time multiplier setting when the Constant delay is 800 milliseconds*

The activation of the OPERATE output activates the BLK_RESTART output.

If the excitation level increases above the set value when BLK_RESTART is active, the OPERATE output is activated immediately.

If the excitation level increases above the set value when BLK_RESTART is not active but COOL_ACTIVE is active, the OPERATE output is not activated instantly. In this case, the remaining part of the cooling timer affects the calculation of the operate timer as shown in Figure 440. This compensates for the heating effect and makes the overall operate time shorter.

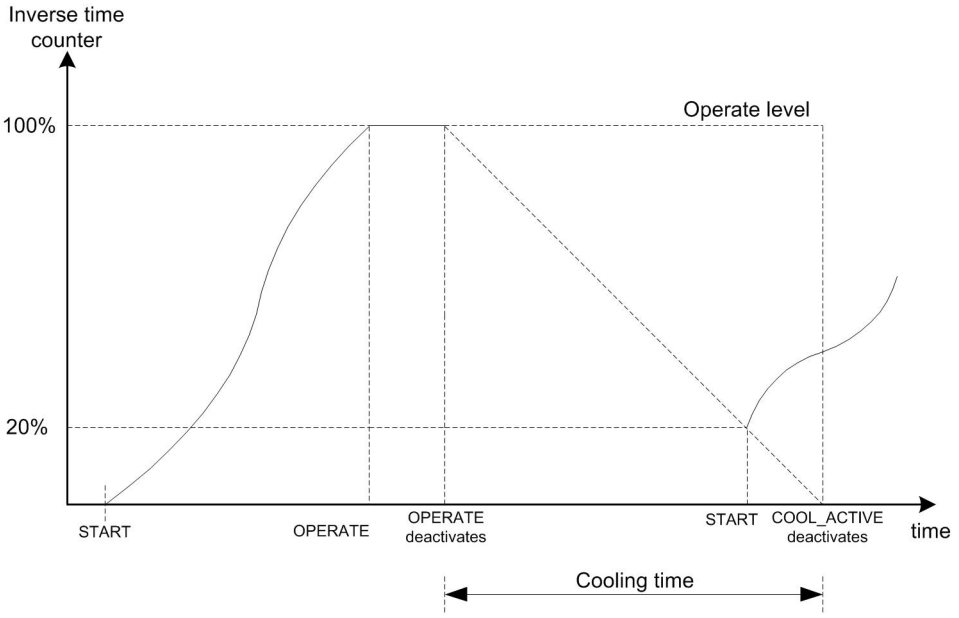



*Figure 440: Example of an inverse time counter operation if* `START` *occurs when* `BLK_RESTART` *is inactive while* `COOL_ACTIVE` *is active.*

### 4.5.7.7 Application

If the laminated core of a power transformer or generator is subjected to a magnetic flux density beyond its designed limits, the leakage flux increases. This results in a heavy hysteresis and eddy current losses in the non-laminated parts. These losses can cause excessive heating and severe damage to the insulation and adjacent parts in a relatively short time.

Overvoltage, underfrequency or a combination of the two, results in an excessive flux density level. Since the flux density is directly proportional to the voltage and inversely proportional to the frequency, the overexcitation protection calculates the relative V/Hz ratio instead of measuring the flux density directly. The nominal level (nominal voltage at nominal frequency) is usually considered as the 100 percent level, which can be exceeded slightly based on the design.

The greatest risk for overexcitation exists in a thermal power station when the generator-transformer unit is disconnected from the rest of the network or in the network islands where high voltages or low frequencies can occur.

Overexcitation can occur during the start-up and shutdown of the generator if the field current is not properly adjusted. The loss-of-load or load shedding can also result in overexcitation if the voltage control and frequency governor do not function properly. The low frequency in a system isolated from the main network can result in overexcitation if the voltage-regulating system maintains a normal voltage.

Overexcitation protection for the transformer is generally provided by the generator overexcitation protection, which uses the VTs connected to the generator terminals.

The curves that define the generator and transformer V/Hz limits must be coordinated properly to protect both equipment.

If the generator can be operated with a leading power factor, the high-side voltage of the transformer can have a higher pu V/Hz than the generator V/Hz. This needs to be considered in a proper overexcitation protection of the transformer. Also, measurement for the voltage must not be taken from any winding where OLTC is located.

It is assumed that overexcitation is a symmetrical phenomenon caused by events such as loss-of-load. A high phase-to-earth voltage does not mean overexcitation. For example, in an unearthed power system, a single phase-to-earth fault means high voltages of the healthy two phases to earth but no overexcitation on any winding. The phase-to-phase voltages remain essentially unchanged. An important voltage to be considered for the overexcitation is the voltage between the two ends of each winding.

## Example calculations for overexcitation protection

## Example 1

Nominal values of the machine

| | |
|---|---|
| Nominal phase-to-phase voltage ($U_n$) | 11000 V |
| Nominal phase current ($I_n$) | 7455 A |
| Nominal frequency ($f_n$) | 50 Hz |
| Leakage reactance ($X_{leak}$) | 20% or 0.2 pu |

Measured voltage and load currents of the machine

| | |
|---|---|
| Phase A-to-phase B voltage ($U_{AB}$) | 11500∠0° V |
| Phase A current ($I_A$) | 5600∠-63.57° A |
| Phase B current ($I_B$) | 5600∠176.42° A |
| Measured frequency ($f_m$) | 49.98 Hz |
| The setting *Voltage Max Cont* | 100% |
| The setting *Voltage selection* | phase-to-phase |
| The setting *Phase supervision* | A or AB |

The pu leakage reactance $X_{leakPU}$ is converted to ohms.

$$X_{leak\Omega} = X_{leakPU} \cdot \frac{U_n}{I_n \cdot \sqrt{3}} = 0.2 \cdot \frac{11000}{7455 \cdot \sqrt{3}} = 0.170378\ Ohms$$

(Equation 205)

The internal induced voltage E of the machine is calculated.

$$\overline{E} = \overline{U_{AB}} + (\overline{I_A} - \overline{I_B}) \cdot (jX_{leak})$$

(Equation 206)

E = 11500∠0°+ (5600∠-63.57°- 5600∠176.42°) · (0.170378∠90°) = 12490 V

The excitation level M of the machine is calculated.

$$Excitation\ level\ M = \frac{\frac{12490}{49.98}}{\frac{11000}{50} \cdot 1.00} = 1.1359$$

(Equation 207)

## Example 2

The situation and the data are according to Example 1. In this case, the manufacturer of the machine allows the continuous operation at 105 percent of the nominal voltage at the rated load and this value to be used as the base for overexcitation.

Usually, the U/f characteristics are specified so that the ratio is 1.00 at the nominal voltage and nominal frequency. Therefore, the value 100 percent for the setting *Voltage Max Cont* is recommended.

If the *Voltage Max Cont* setting is 105 percent, the excitation level M of the machine is calculated with the equation.

$$Excitation\ level\ M = \frac{\frac{12490}{49.98}}{\frac{11000}{50} \cdot 1.05} = 1.0818$$

(Equation 208)

## Example 3

In this case, the function operation is according to IDMT. The *Operating curve type* setting is selected as "OvExt IDMT Crv2". The corresponding example settings for the IDMT curve operation are given as: *Start value* = 110%, *Voltage Max Cont* = 100%, *Time multiplier* = 4, *Maximum operate time* = 1000 s, *Minimum operate time* = 1 s and *Cooling time* = 200 s.

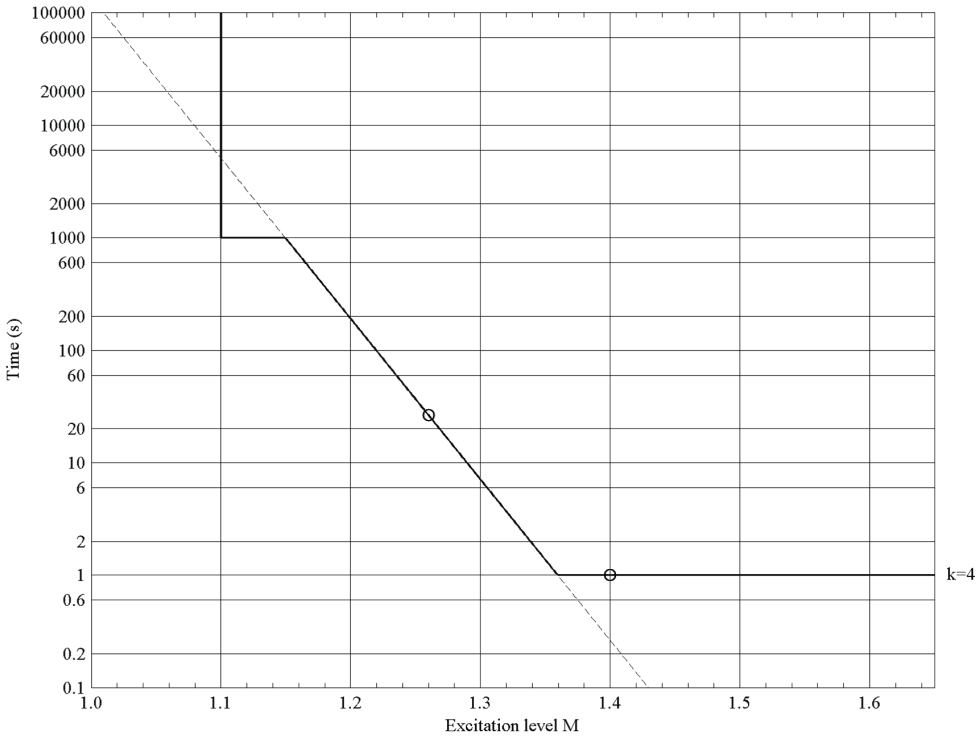



*Figure 441: Operating curve of "OvExt IDMT Crv2" based on the settings specified in example 3. The two dots marked on the curve are referred to in the text.*

If the excitation level stays at 1.26, the operation occurs after 26.364 s as per the marked dot in Figure 441. For the excitation level of 1.4, the second dot in Figure 441, the curve "OvExt IDMT Crv2" gives 0.2636 s as per Equation 203, but the *Minimum operate time* setting limits the operate time to 1.0 s.

The Maximum operate time setting limits the operate time to 1000 s if the excitation level stays between 1.1 and 1.16.

In general, however, the excitation level seldom remains constant. Therefore, the exact operate times in any inverse time mode are difficult to predict.

## Example 4

In this case, the function operation is according to IDMT. The *Operating curve type* setting is selected as "OvExt IDMT Crv4". The corresponding example settings for the IDMT curve operation are given as: *Start value* = 110%, *Voltage Max Cont* = 100%, *Time multiplier* = 5, *Maximum operate time* = 3600 s, *Constant delay* = 0.8 s and *Cooling time* = 100 s.

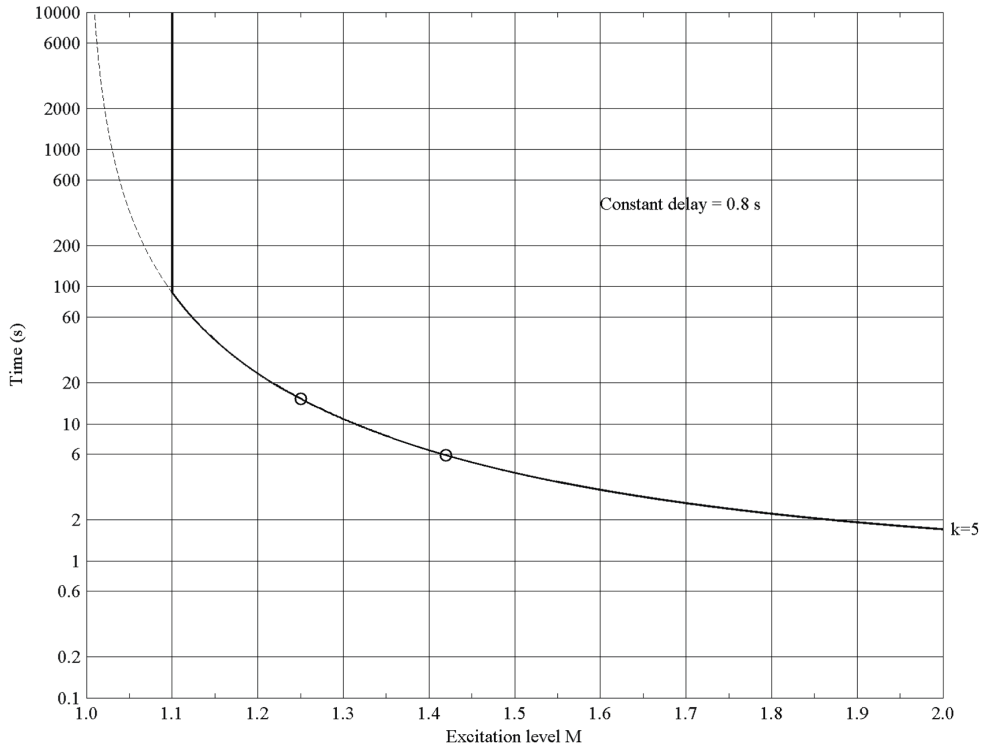



*Figure 442: Operating curve of "OvExt IDMT Crv4" based on the specified settings. The two dots marked on the curve are referred to in the text.*

If the excitation level stays at 1.25, the operation occurs after 15.20 s. At the excitation level of 1.42, the time to operation would be 5.90 s as per the two dots in Figure 442. In this case, the setting *Maximum operate time* 3600 s does not limit the maximum operate time because the operate time at *Start value* = 110% (1.1 pu) is approximately 75 s.

### 4.5.7.8 Signals

*Table 768: OEPVPH Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal |

*Table 769: OEPVPH Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operated |
| START | BOOLEAN | Started |
| BLK_RESTART | BOOLEAN | Signal for blocking reconnection of an overheated machine |
| COOL_ACTIVE | BOOLEAN | Signal to indicate machine is in cooling process |

### 4.5.7.9 Settings

*Table 770: OEPVPH Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 100...200 | % | 1 | 100 | Over excitation start value |
| Operating curve type | 5=ANSI Def. Time<br>15=IEC Def. Time<br>17=OvExt IDMT Crv1<br>18=OvExt IDMT Crv2<br>19=OvExt IDMT Crv3<br>20=OvExt IDMT Crv4 | | | 15=IEC Def. Time | Selection of time delay curve type |
| Time multiplier | 0.1...100.0 | | 0.1 | 3.0 | Time multiplier for Overexcitation IDMT curves |
| Operate delay time | 200...200000 | ms | 10 | 500 | Operate delay time in definite- time mode |

*Table 771: OEPVPH Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Mode Off / On |
| Cooling time | 5...10000 | s | 1 | 600 | Time required to cool the machine |
| Constant delay | 100...120000 | ms | 10 | 800 | Parameter constant delay |
| Maximum operate time | 500000...10000000 | ms | 10 | 1000000 | Maximum operate time for IDMT curves |
| Voltage selection | 1=phase-to-earth<br>2=phase-to-phase<br>3=pos sequence | | | 3=pos sequence | Selection of phase / phase-to-phase / pos sequence voltages |
| Phase selection | 1=A or AB<br>2=B or BC<br>3=C or CA | | | 1=A or AB | Parameter for phase selection |
| Leakage React | 0.0...50.0 | % | 0.1 | 0.0 | Leakage reactance of the machine |
| Voltage Max Cont | 80...160 | % | 1 | 110 | Maximum allowed continuous operating voltage ratio |

*Table 772: OEPVPH Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 100 | Resetting time of the operate time counter in DT mode |
| Minimum operate time | 200...60000 | ms | 10 | 200 | Minimum operate time for IDMT curves |

### 4.5.7.10 Monitored data

*Table 773: OEPVPH Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time (in %) |
| T_ENARESTART | INT32 | 0...10000 | s | Estimated time to reset of block restart |
| VOLTPERHZ | FLOAT32 | 0.00...10.00 | pu | Excitation level, i.e U/f ratio or Volts/Hertz |
| OEPVPH | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.7.11 Technical data

*Table 774: OEPVPH Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±3.0% of the set value |
| Start time 1) | Frequency change:<br>Typically 200 ms |
| | Voltage change:<br>Typically 40 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite-time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in inverse-time mode | ±5.0% of the theoretical value or ±50 ms |

1) Includes the delay of the signal output contact

## 4.5.8 Low-voltage ride-through protection LVRTPTUV

### 4.5.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Low-voltage ride-through protection | LVRTPTUV | U<RT | 27RT |

### 4.5.8.2 Function block




*Figure 443: Function block*

### 4.5.8.3 Functionality

The low-voltage ride-through protection function LVRTPTUV is principally a three-phase undervoltage protection. It differs from the traditional three-phase undervoltage protection PHPTUV by allowing the grid operators to define its own Low-Voltage Ride-Through (LVRT) curve for generators, as defined by local or national grid codes. The LVRT curve can be defined accurately according to the requirements by setting the appropriate time-voltage coordinates.

This function contains a blocking functionality. LVRTPTUV can be blocked with the `BLOCK` input. Blocking resets timers and outputs.

### 4.5.8.4 Analog channel configuration

LVRTPTUV has one analog group input which must be properly configured.

*Table 775: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 776: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that at least two voltage channels are connected as the the third channel can then be derived. However, it is recommended that all three voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.8.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of LVRTPTUV is described using a module diagram. All modules in the diagram are explained in the next sections.

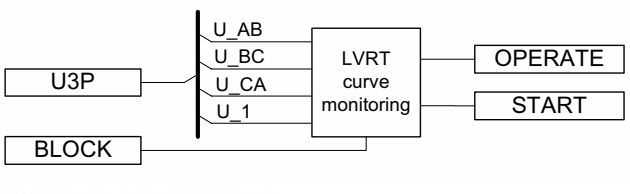



*Figure 444: Functional module diagram*

#### LVRT curve monitoring

LVRT curve monitoring starts with detection of undervoltage. Undervoltage detection depends on *Voltage selection* setting. All selectable options are based on fundamental frequency components.

Function uses phase-to-earth voltages when *Voltage selection* is set to “Highest Ph-to-E” or “Lowest Ph-to-E” and phase-to-phase voltages when *Voltage selection* is set to “Highest Ph-to-Ph” or “Lowest Ph-to-Ph”.

When the *Voltage selection* setting is set to “Highest Ph-to-E”, “Lowest Ph-to-E”, “Highest Ph-to-Ph” or “Lowest Ph-to-Ph”, the measured three-phase voltages are compared phase-wise to the set *Voltage start value*. If the measured value is lower than the set *Voltage start value* setting in number of phases equal to that set *Num of start phases*, the `START` output is activated.

The setting options available for *Num of start phases* are “Exactly 1 of 3”, "Exactly 2 of 3", and “Exactly 3 of 3”, which are different from conventional setting options available in other functions. For example, *Num of start phases* is set to "Exactly 2 of 3", any two voltages should drop below *Voltage start value* within one cycle network for the `START` output to activate. Even if more than two voltages drop below *Voltage start value*, `START` output is not activated.

When the *Voltage selection* setting is “Positive Seq”, the positive-sequence component is compared with the set *Voltage start value*. If it is lower than the set *Voltage start value*, the `START` output is activated.

Once `START` is activated, the function monitors the behavior of the voltage defined by *Voltage selection* setting with the defined LVRT curve. When defined voltage enters the operating area, the `OPERATE` output is activated instantaneously. The pulse length of `OPERATE` is fixed to 100 ms. `START` also deactivates along with `OPERATE`.

If a drop-off situation occurs, that is, voltage restores above *Voltage start value*, before OPERATE is activated, the function does not reset until maximum recovery time under consideration has elapsed, that is, START output remains active.

LVRT curve is defined using time-voltage settings coordinates. The settings available are *Recovery time 1…Recovery time 10* and *Voltage level 1…Voltage level 10*. The number of coordinates required to define a LVRT curve is set by *Active coordinates* setting.

When *Recovery time 1* is set to non-zero value, it results into horizontal characteristics from point of fault till *Recovery time 1*.

Two examples of LVRT curve are defined in Figure 445 and Figure 446 with corresponding settings in Table 777.

It is necessary to set the coordinate points correctly in order to avoid maloperation. For example, setting for *Recovery time 2* should be greater than *Recovery time 1*. *Recovery time 1…Recovery time 10* are the respective time setting from the point of fault.

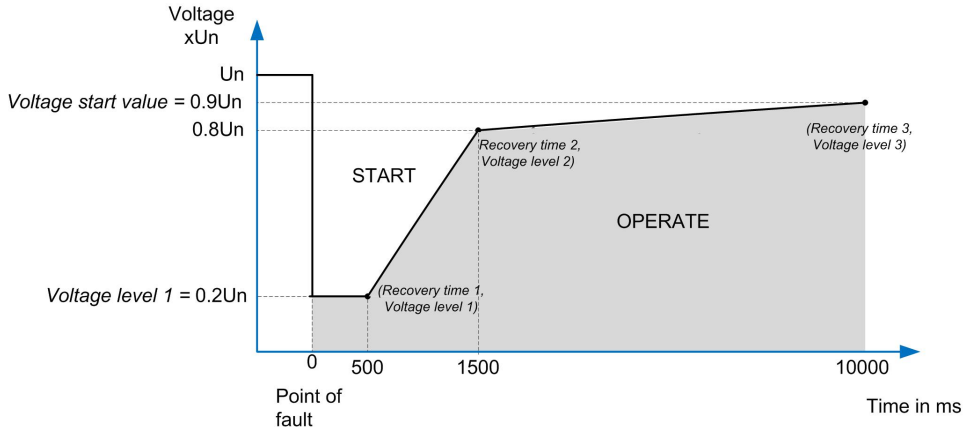



*Figure 445: Low voltage ride through example curve A*

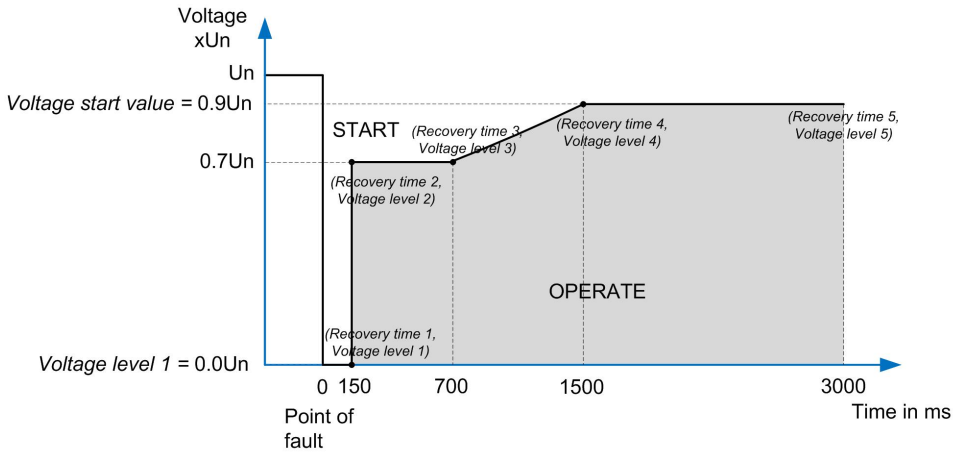



*Figure 446: Low voltage ride through example curve B*

***Table 777: Settings for example A and B***

| Settings | Curve A | Curve B |
|---|---|---|
| Voltage start value | 0.9 · Un | 0.9 · Un |
| Active coordinates | 3 | 5 |
| Voltage level 1 | 0.2 · Un | 0 · Un |
| Recovery time 1 | 500 ms | 150 ms |
| Voltage level 2 | 0.8 · Un | 0.7 · Un |
| Recovery time 2 | 1500 ms | 150 ms |
| Voltage level 3 | 0.9 · Un | 0.7 · Un |
| Recovery time 3 | 10000 ms | 700 ms |
| Voltage level 4 | - | 0.9 · Un |
| Recovery time 4 | - | 1500 ms |
| Voltage level 5 | - | 0.9 · Un |
| Recovery time 5 | - | 3000 ms |

It is necessary that the last active *Voltage level X* setting is set greater than or equal to *Voltage start value*. Settings are not accepted if the last active *Voltage level X* setting is not set greater than or equal to *Voltage start value*.

Figure 447 describes an example of operation of LVRTPTUV protection function set to operate with *Num of start phases* set to “Exactly 2 of 3” and *Voltage selection* as “Lowest Ph-to-Ph” voltage.

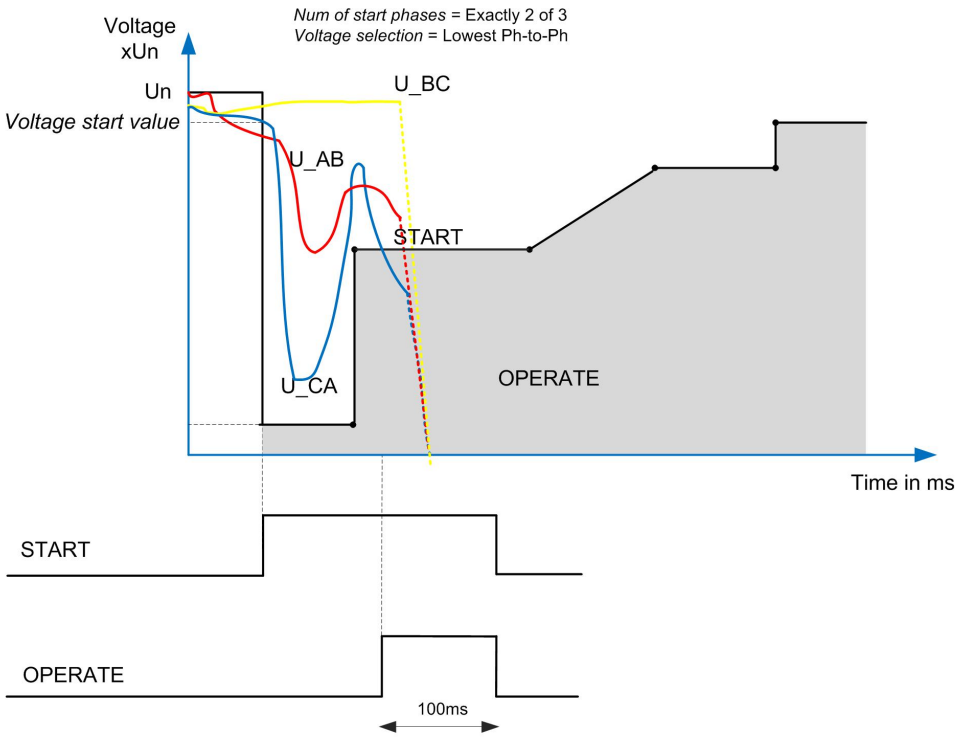



*Figure 447: Typical example of operation of LVRTPTUV*

Activation of the BLOCK input resets the timers and deactivates the function outputs.

### 4.5.8.6 Application

Distributed generation, mainly wind and solar farms, are rapidly increasing due to liberalized markets (deregulation) and the global trend to use more renewable sources of energy. These farms are directly connected to grids, and due to their large size may influence the behavior of the grid. These farms are now required to comply with stringent grid connection requirement, which was previously mandatory only for high capacity power plants. These requirements include helping grid in maintaining system stability, reactive power support, transient recovery and voltage-frequency regulation. These requirements make it necessary for the wind and solar farms to remain in operation in the event of network disturbances.

Many grid codes now demand that the distributed generation connected to HV grids must withstand voltage dips to a certain percentage of nominal voltage (down to 0% in some cases) and for a specific duration. Such requirements are known as Low-Voltage Ride-Through (LVRT) or Fault-Ride-Through (FRT) and are described by a voltage versus time characteristics.

Typical LVRT behavior of a distributed generation can be divided into three areas according to the variation in voltage over time.

- At the time of system faults, the magnitude of the voltage may dip to *Voltage level 1* for time defined by *Recovery time 1*. The generating unit has to remain connected to the network during such condition. This boundary defines area A.
- Area B defines the linear growth recovery voltage level from *Voltage level 1* to *Voltage level 2* in a time period from *Recovery time 1* to *Recovery time 2*.
- Area C is the zone where voltage stabilizes. *Voltage level 3* is defined to same value as *Voltage level 2*. The system should remain above this voltage in a time period from *Recovery time 2* to *Recovery time 3*.

The system restores to a normal state and function resets when the voltage is equal or greater than *Voltage level 4* after *Recovery time 4* time period.

When the voltage at the point of common coupling is above the LVRT curve, the generation unit must remain connected, and must be disconnected only if the voltage takes values below the curve.

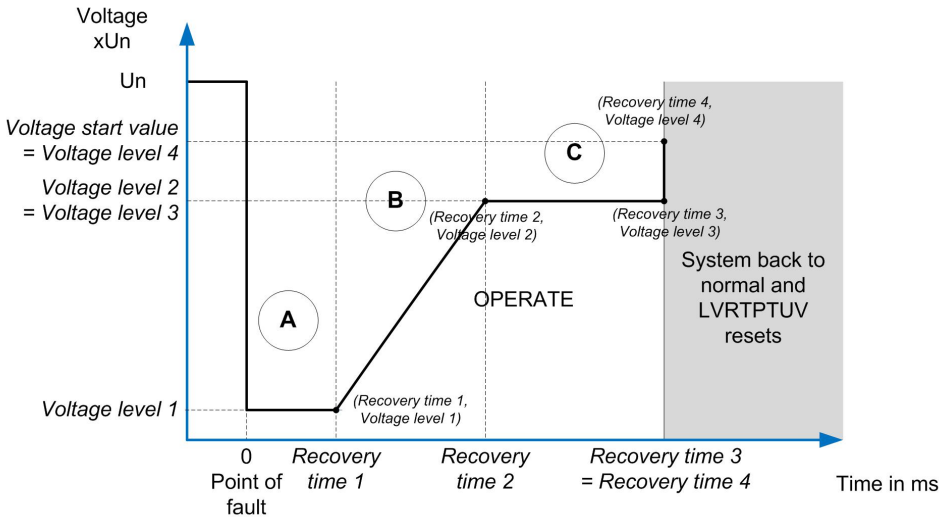



*Figure 448: A typical required ride-through voltage capability of generating unit*

The LVRT requirement depends on the power system characteristics and the protection employed, varying significantly from each other. The requirement also differs from country to country. LVRTPTUV function incorporates four types of LVRT curves which satisfy most of the power system needs. Grid operators can fine-tune the LVRT curve by setting the parameters as per their requirement, making the use simpler in comparison with different conventional undervoltage protection with different operate time setting and logics.

### 4.5.8.7 Signals

*Table 778: LVRTPTUV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 779: LVRTPTUV Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

## 4.5.8.8 Settings

*Table 780: LVRTPTUV Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage start value | 0.05...1.20 | xUn | 0.01 | 0.90 | Voltage value below which function starts |

*Table 781: LVRTPTUV Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 4=Exactly 1 of 3<br>5=Exactly 2 of 3<br>6=Exactly 3 of 3 | | | 4=Exactly 1 of 3 | Number of faulty phases |
| Voltage selection | 1=Highest Ph-to-E<br>2=Lowest Ph-to-E<br>3=Highest Ph-to-Ph<br>4=Lowest Ph-to-Ph<br>5=Positive Seq | | | 4=Lowest Ph-to-Ph | Parameter to select voltage for curve monitoring |
| Active coordinates | 1...10 | | 1 | 3 | Coordinates used for defining LVRT curve |
| Voltage level 1 | 0.00...1.20 | xUn | 0.01 | 0.20 | 1st voltage coordinate for defining LVRT curve |
| Voltage level 2 | 0.00...1.20 | xUn | 0.01 | 0.80 | 2nd voltage coordinate for defining LVRT curve |
| Voltage level 3 | 0.00...1.20 | xUn | 0.01 | 0.90 | 3rd voltage coordinate for defining LVRT curve |
| Voltage level 4 | 0.00...1.20 | xUn | 0.01 | 0.90 | 4th voltage coordinate for defining LVRT curve |
| Voltage level 5 | 0.00...1.20 | xUn | 0.01 | 0.90 | 5th voltage coordinate for defining LVRT curve |
| Voltage level 6 | 0.00...1.20 | xUn | 0.01 | 0.90 | 6th voltage coordinate for defining LVRT curve |
| Voltage level 7 | 0.00...1.20 | xUn | 0.01 | 0.90 | 7th voltage coordinate for defining LVRT curve |
| Voltage level 8 | 0.00...1.20 | xUn | 0.01 | 0.90 | 8th voltage coordinate for defining LVRT curve |
| Voltage level 9 | 0.00...1.20 | xUn | 0.01 | 0.90 | 9th voltage coordinate for defining LVRT curve |
| Voltage level 10 | 0.00...1.20 | xUn | 0.01 | 0.90 | 10th voltage coordinate for defining LVRT curve |
| Recovery time 1 | 0...300000 | ms | 1 | 500 | 1st time coordinate for defining LVRT curve |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Recovery time 2 | 0...300000 | ms | 1 | 1000 | 2nd time coordinate for defining LVRT curve |
| Recovery time 3 | 0...300000 | ms | 1 | 10000 | 3rd time coordinate for defining LVRT curve |
| Recovery time 4 | 0...300000 | ms | 1 | 10000 | 4th time coordinate for defining LVRT curve |
| Recovery time 5 | 0...300000 | ms | 1 | 10000 | 5th time coordinate for defining LVRT curve |
| Recovery time 6 | 0...300000 | ms | 1 | 10000 | 6th time coordinate for defining LVRT curve |
| Recovery time 7 | 0...300000 | ms | 1 | 10000 | 7th time coordinate for defining LVRT curve |
| Recovery time 8 | 0...300000 | ms | 1 | 10000 | 8th time coordinate for defining LVRT curve |
| Recovery time 9 | 0...300000 | ms | 1 | 10000 | 9th time coordinate for defining LVRT curve |
| Recovery time 10 | 0...300000 | ms | 1 | 10000 | 10th time coordinate for defining LVRT curve |

### 4.5.8.9 Monitored data

*Table 782: LVRTPTUV Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LVRTPTUV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.8.10 Technical data

*Table 783: LVRTPTUV Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $U_n$ |
| Start time[1)2)] | Typically 40 ms |
| Reset time | Based on maximum value of *Recovery time* setting |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

1) Tested for *Number of Start phases* = 1 out of 3, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.5.9 Vector shift protection VVSPPAM

### 4.5.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Voltage vector shift protection | VVSPPAM | VS | 78VS |

### 4.5.9.2 Function block




*Figure 449: Function block*

### 4.5.9.3 Functionality

The voltage vector shift protection function VVSPPAM, also known as vector surge or delta phi function, measures continuously the duration of a voltage cycle. At the instance of islanding, the duration of measured voltage cycle becomes shorter or longer than the previous one, that is, the measured voltage cycle shifts with time. This shifting of voltage is measured in terms of phase angle. VVSPPAM issues an instantaneous trip when the shift in voltage vector exceeds the set value.

VVSPPAM can be blocked with `BLOCK` input. Blocking resets timers and outputs.

### 4.5.9.4 Analog channel configuration

VVSPPAM has one analog group input which must be properly configured.

*Table 784: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 785: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.9.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “on” and “off”.

The operation of VVSPPAM can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

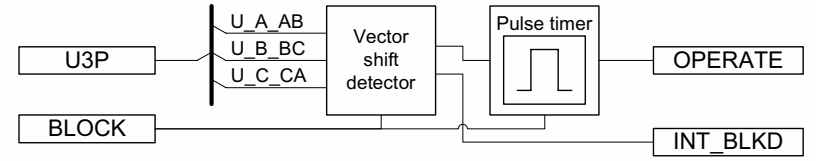



*Figure 450: Functional module diagram*

#### Vector shift detector

This module measures the duration of each cycle of the voltage signal phase. The duration of the present cycle is compared to the previous cycle, considered as reference. When the mains is lost, a sudden change is seen in the cycle length, if loading of the generator changes suddenly and power mismatch or unbalance (generation vs. load) in the islanded part of the network is large enough. The cycle shifts with time, that is, the frequency may not change but a vector shift is seen in phase as shown in Figure 451.

This step is measured in degrees for each voltage signal defined by the *Phase supervision* setting. The *Phase supervision* setting determines which voltage is used for detecting vector shift. The available *Phase supervision* options are “All” and “Pos sequence”. If the calculated value of Δδ exceeds the set *Start value* setting for all the defined phases, the module sends an enabling signal to start the Pulse timer.

The *Voltage selection* setting is used to select whether the available voltage signal is phase-to-earth or phase-to-phase voltage.

The recommended and the default value for *Phase supervision* is “Pos sequence”.

If the magnitude of the voltage level of any of the monitored voltage signal, defined by the *Phase supervision* setting, drops below *Under Volt Blk value* or exceeds *Over Volt Blk value*, the calculation of vector shift is disabled and the `INT_BLKD` output is activated.

The function is blocked and LOWAMPL_BLKD is activated, if the measured frequency deviates ±5% from the nominal value.

The magnitude of calculated vector shift for three phase-to-earth or phase-to-phase voltages, USHIFT_A_AB, USHIFT_B_BC and USHIFT_C_CA or positive sequence voltage U1SHIFT, which resulted in the activation of last OPERATE output, are available in the Monitored data view.

The activation of BLOCK input deactivates the INT_BLKD output.

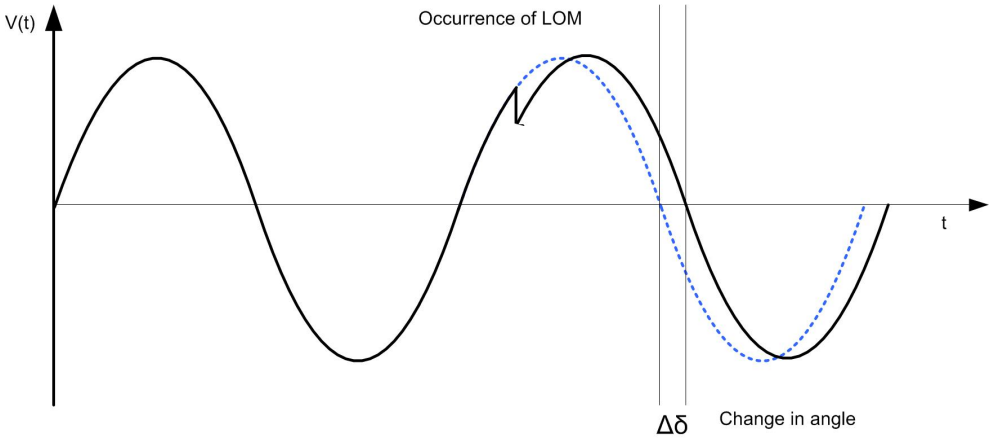



*Figure 451: Vector shift during Loss of Mains*

### Pulse timer

Once the Pulse timer is activated, it activates the OPERATE output. The pulse length of OPERATE is fixed to 100 ms.

The activation of the BLOCK input deactivates the OPERATE binary output and resets the timer.

## 4.5.9.6 Application

Use of distributed generation (DG) units is increasing due to liberalized markets (deregulation) and the global trend to use more renewable sources of energy. They generate power in the range of 10 kW...10 MW and most of them are interconnected to the distribution network. They can supply power into the network as well as to the local loads. It is not common to connect generators directly to the distribution networks and thus the distributed generation can cause some challenges for the protection of distribution networks. From the protection point of view, one of the most challenging issue is islanding.

Islanding is defined as a condition in which a distributed generation unit continues to supply power to a certain part of the distribution network when power from the larger utility main grid is no longer available after the opening of a circuit-breaker. Islanding is also referred as Loss of Mains (LOM) or Loss of Grid (LOG). When LOM occurs,

neither the voltage or the frequency is controlled by the utility supply. These distributed generators are not equipped with voltage and frequency control; therefore, the voltage magnitude of an islanded network may not be kept within the desired limits which causes undefined voltage magnitudes during islanding situations and frequency instability. Uncontrolled frequency represents a high risk for drives and other machines. Islanding can occur as a consequence of a fault in the network, due to circuit breaker maloperation or due to circuit breaker opening during maintenance. If the distributed generator continues its operation after the utility supply is disconnected, faults do not clear under certain conditions as the arc is charged by the distributed generators. Moreover, the distributed generators are incompatible with the current reclosing practices. During the reclosing sequence dead time, the generators in the network tend to drift out of synchronism with the grid and reconnecting them without synchronizing may damage the generators introducing high currents and voltages in the neighboring network.

To avoid these technical challenges, protection is needed to disconnect the distributed generation once it is electrically isolated from the main grid supply. Various techniques are used for detecting Loss of Mains. However, the present function focuses on voltage vector shift.

The vector shift detection guarantees fast and reliable detection of mains failure in almost all operational conditions when a distributed generation unit is running in parallel with the mains supply, but in certain cases this may fail.

If the active and reactive power generated by the distributed generation units is nearly balanced (for example, if the power mismatch or unbalance is less than 5...10%) with the active and reactive power consumed by loads, a large enough voltage phase shift may not occur which can be detected by the vector shift algorithm. This means that the vector shift algorithm has a small non-detection-zone (NDZ) which is also dependent on the type of generators, loads, network and start or operate value of the vector shift algorithm. Other network events like capacitor switching, switching of very large loads in weak network or connection of parallel transformer at HV/MV substation, in which the voltage magnitude is not changed considerably (unlike in faults) can potentially cause maloperation of vector shift algorithm, if very sensitive settings are used.

The vector shift detection also protects synchronous generators from damaging due to islanding or loss-of-mains. To detect loss-of-mains with vector shift function, the generator should aim to export or import at least 5...10% of the generated power to the grid, in order to guarantee detectable change in loading after islanding or loss-of-mains.

### Multicriteria Loss of Mains

Apart from vector shift, there are other passive techniques which are used for detecting Loss of Mains. Some of these passive techniques are over/undervoltage, over/underfrequency, rate of change of frequency, voltage unbalance, rate of change of power and so on. These passive methods use voltage and frequency to identify Loss of Mains. The performance of these methods depends on the power mismatch between local generation and load. The advantage of all these methods is that, they are simple

and cost effective, but each method has a non detectable zone. To overcome this problem, it is recommended to combine different criteria for detecting Loss of Mains.

Two or more protection functions run in parallel to detect Loss of Mains. When all criteria are fulfilled to indicate Loss of Mains, an alarm or a trip can be generated. Vector shift and rate of change of frequency are two parallel criteria typically used for detection of Loss of Mains.

Chosen protection criteria can be included in the Application Configuration tool to create multicriteria loss of mains alarm or trip.

### 4.5.9.7 Signals

*Table 786: VVSPPAM Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 787: VVSPPAM Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| INT_BLKD | BOOLEAN | Protection function internally blocked |

### 4.5.9.8 Settings

*Table 788: VVSPPAM Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 2.0...30.0 | deg | 0.1 | 6.0 | Start value for vector shift |

*Table 789: VVSPPAM Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Over Volt Blk value | 0.40...1.50 | xUn | 0.01 | 1.20 | Voltage above which function will be internally blocked |
| Under Volt Blk value | 0.15...1.00 | xUn | 0.01 | 0.80 | Voltage below which function will be internally blocked |

*Table 790: VVSPPAM Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 791: VVSPPAM Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase supervision | 7=Ph A + B + C<br>8=Pos sequence | | | 8=Pos sequence | Monitored voltage phase |

### 4.5.9.9 Monitored data

*Table 792: VVSPPAM Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| VEC_SHT_A_AB | FLOAT32 | -180.00...180.00 | deg | Vector shift for phase to earth voltage A or phase to phase voltage AB |
| VEC_SHT_B_BC | FLOAT32 | -180.00...180.00 | deg | Vector shift for phase to earth voltage B or phase to phase voltage BC |
| VEC_SHT_C_CA | FLOAT32 | -180.00...180.00 | deg | Vector shift for phase to earth voltage C or phase to phase voltage CA |
| VEC_SHT_U1 | FLOAT32 | -180.00...180.00 | deg | Vector shift for positive sequence voltage |
| VVSPPAM | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.9.10 Technical data

*Table 793: VVSPPAM Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n$ ±1 Hz |
| | ±1° |
| Operate time[1)2)] | Typically 53 ms |

1) $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.5.10 Three-phase overvoltage variation protection PHVPTOV

### 4.5.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase overvoltage variation protection | PHVPTOV | 3Urms> | 59.S1 |

### 4.5.10.2 Function block




*Figure 452: Function block*

### 4.5.10.3 Functionality

The three-phase overvoltage variation protection function PHVPTOV monitors the quality of the voltages. The function evaluates the power quality in the voltage by calculating the average RMS value of the voltage over a set period. The function includes a settable limit for the detection of overvoltage in a single phase, two phases or three phases.

The function starts when the average RMS value of the voltage exceeds the set limit. PHVPTOV operates with the definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.5.10.4 Analog channel configuration

PHVPTOV has one analog group input which must be properly configured.

*Table 794: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 795: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected if *Num of start phases* is set to "1 out of 3". Otherwise, all three voltage channels must be connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For

troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.10.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of PHVPTOV can be described with a module diagram. All the modules in the diagram are explained in the next sections.

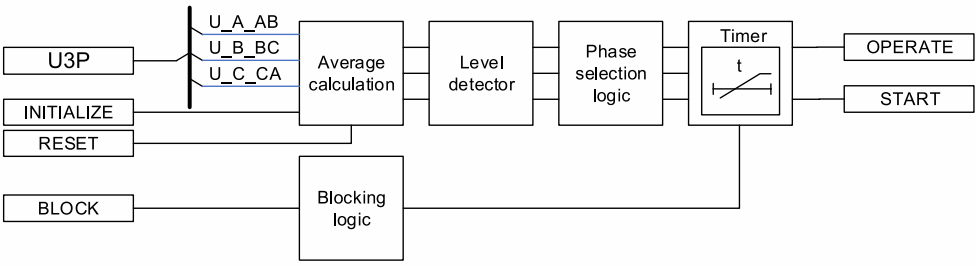



*Figure 453: Functional module diagram*

#### Average calculation

The module calculates the average voltage magnitude variation for each of the three input phase voltages. The calculation is done in three successive aggregations.

- 10/12-cycle voltage input samples are aggregated to calculate the 10/12-cycle RMS voltage.
- 10/12-cycle RMS voltages are aggregated over a time period of $T_{refresh}$ to get the refresh value.
- Refresh values are aggregated over a time period $T_{average}$ to get the average RMS voltage magnitude.

The *Voltage selection* setting is used for selecting phase-to-earth or phase-to-phase voltages for protection.

**Calculation of 10/12-cycle RMS voltage**

The 10/12-cycle RMS voltage is calculated for each of the three input voltages by applying the standard RMS formula using the voltage samples over a range of 0.2 s. Depending on the *Voltage selection* setting, voltage samples are either phase-to-earth or phase-to-phase voltage samples.

**Calculation of RMS refresh voltage**

The RMS refresh voltage is calculated by aggregating the $U_{10cycles}$ / $U_{12cycles}$ RMS voltage over a time period of $T_{refresh}$. The time period $T_{refresh}$ depends on the setting *Time interval*.

$$T_{refresh} = Roundup\left(\frac{Time\ interval\ in\ seconds}{200}\right)$$

(Equation 209)

The function Roundup rounds up the result to the next higher time multiple of 0.2 s because the result of the division is not a multiple of 0.2 s in case of an odd *Time interval* setting (1, 3, 5…120 mins).

$$U_{Refresh} = \sqrt{\frac{1}{N}\sum_{i=1}^{N} U_{10/12cycles}^{\ 2}(i)}$$

(Equation 210)

N Number of values to be aggregated as defined by Equation 211

$$N = \left(\frac{T_{refresh}}{0.2}\right)$$

(Equation 211)

**Calculation of RMS average voltage**

The RMS average voltage is calculated by aggregating the RMS $U_{Refresh}$ voltage over a time period equal to the *Time interval*.

$$U_{Average} = \sqrt{\frac{1}{M}\sum_{i=1}^{M} U_{Refresh}^{\ 2}(i)}$$

(Equation 212)

M Number of values to be aggregated as defined by Equation 213

$$M = Round\left(\frac{Time\ interval\ in\ seconds}{T_{Refresh}}\right)$$

(Equation 213)

At the initialization of the function, the average voltage is calculated considering initial values as zero. On the IEC 61850 mapped data, the quality of the calculated average voltage value is indicated as “Questionable” until the first complete time interval passes. The calculated average voltage measurement for the set *Time interval* for all three phase-to-earth and phase-to-phase voltages U_MEAN_A, U_MEAN_B, U_MEAN_C, U_MEAN_AB, U_MEAN_BC and U_MEAN_CA is available in the Monitored data view.

The calculated average voltage can be reset by the RESET binary input. The calculated average voltage can also be reset using PHVPTOV1 Reset mean on the Clear menu.

When the INITIALIZE input is activated, the average voltage measurement value is initialized with the 10/12-cycle RMS voltage. The average voltage measurement value can also be initialized using PHVPTOV1 Ini mean on the Clear menu.

### Level detector

The calculated average voltage for all three voltages is compared phase-wise to the set *Start value* setting. If the calculated voltage value is higher than the set value of the *Start value* setting, Level detector enables the Phase selection logic module. The *Relative hysteresis* setting can be used for preventing unnecessary oscillations if the input signal slightly differs from the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return to the hysteresis area.

### Phase selection logic

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the fault level is detected. If the number of faulty phases matches with the set *Num of start phases*, the phase selection logic activates the Timer module.

### Timer

Once activated, the timer activates the START output. The operate delay time is not settable directly but it depends on the *Operate delay Mult* setting and refresh timer $T_{refresh}$. The operate delay time is calculated as:

$$Operate\ delay\ time\ in\ s = Operate\ delay\ Mult \cdot T_{refresh}$$

(Equation 214)

When the operation timer has reached the value equal to *Operate delay time*, the OPERATE output is activated if the overvoltage condition persists. If the average voltage value normalizes before the module operates, the reset timer is activated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.



When the relay has tripped due to variation overvoltage protection, check that operation is safe before closing the breaker. Clear the average voltage value by using *PHVPTOV1 Reset mean* on the **Clear** menu to prevent immediate retripping of breaker by PHVPTOV.



Considering the slow dynamic of the measurement, the protection may remain in the START status for a long time. If the measured voltage returns to a value lower than *Start value*, the function does not

immediately reset. The function resets when the calculated average RMS value drops below *Start value*.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, the function operates normally but the OPERATE output is not activated.

## 4.5.10.6 Application

Overvoltage in a network occurs either due to the transient surges on the network or due to power frequency overvoltages. Surge arresters are used to protect the network against the transient overvoltages; power frequency overvoltage of magnitude greater than 15...20% of nominal voltage is normally handled by traditional overvoltage protection. However, slow voltage variations are usually quantified by calculating the RMS value of the voltage. To assess the RMS voltage, measurements are taken over a relatively long period of time to avoid any instantaneous effect caused by switching transients or faults.

It is important to monitor such slow voltage variation which can cause sub-optimal operation of the equipment. EN 50160 quantifies slow voltage variation using 10 min mean RMS value. CEI EN 50160 standard indicates that the RMS value of the voltage calculated over a period of 10 min should not exceed 110% of the nominal voltage; if the voltage exceeds this level, the generator must be disconnected from the network within 3 s. PHVPTOV provides overvoltage protection by calculating the RMS value over a period of 10 min.

A sudden change in the magnitude of the supply voltage is not immediately detected by the RMS calculation; hence this is mainly used as an indication of voltage quality supplied by the utility.

### 4.5.10.7 Signals

*Table 796: PHVPTOV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| INITIALIZE | BOOLEAN | 0=False | Initialize the voltage average measurement |
| RESET | BOOLEAN | 0=False | Reset the voltage average measurement values |

*Table 797: PHVPTOV Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.10.8 Settings

*Table 798: PHVPTOV Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...3.00 | xUn | 0.01 | 1.10 | Start value |
| Time interval | 1...120 | min | 1 | 10 | Time interval for average voltage calculation |
| Operate delay Mult | 0...100 | | 1 | 1 | Trip delay expressed as a multiple of refresh time |

*Table 799: PHVPTOV Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Voltage selection | 1=phase-to-earth<br>2=phase-to-phase | | | 1=phase-to-earth | Parameter to select phase or phase-to-phase voltages |

*Table 800: PHVPTOV Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Relative hysteresis | 1.0...5.0 | % | 0.1 | 4.0 | Relative hysteresis for operation |

### 4.5.10.9 Monitored data

*Table 801: PHVPTOV Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| U_MEAN_A | FLOAT32 | 0.00...5.00 | xUn | Mean value of phase to earth voltage A |
| U_MEAN_B | FLOAT32 | 0.00...5.00 | xUn | Mean value of phase to earth voltage B |
| U_MEAN_C | FLOAT32 | 0.00...5.00 | xUn | Mean value of phase to earth voltage C |
| U_MEAN_AB | FLOAT32 | 0.00...5.00 | xUn | Mean value of Phase to phase voltage AB |
| U_MEAN_BC | FLOAT32 | 0.00...5.00 | xUn | Mean value of Phase to phase voltage BC |
| U_MEAN_CA | FLOAT32 | 0.00...5.00 | xUn | Mean value of Phase to phase voltage CA |
| PHVPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.10.10 Technical data

*Table 802: PHVPTOV Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage: $f_n$ |
| | ±1.5% of the set value or ±0.002 × $U_n$ |
| Reset ratio | Depends on the set *Relative hysteresis* |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

# 4.6 Frequency protection

## 4.6.1 Frequency protection FRPFRQ

### 4.6.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Frequency protection | FRPFRQ | f>/f<,df/dt | 81 |

### 4.6.1.2 Function block

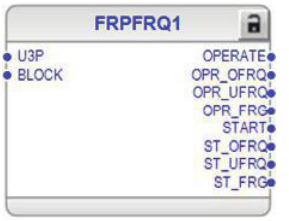



*Figure 454: Function block*

### 4.6.1.3 Functionality

The frequency protection function FRPFRQ is used to protect network components against abnormal frequency conditions.

The function provides basic overfrequency, underfrequency and frequency rate-of-change protection. Additionally, it is possible to use combined criteria to achieve even more sophisticated protection schemes for the system.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

### 4.6.1.4 Analog channel configuration

FRPFRQ has one analog group input which must be properly configured.

*Table 803: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 804: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that at least one phase or phase-to-phase voltage channel is connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks

in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.6.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of FRPFRQ can be described using a module diagram. All the modules in the diagram are explained in the next sections.

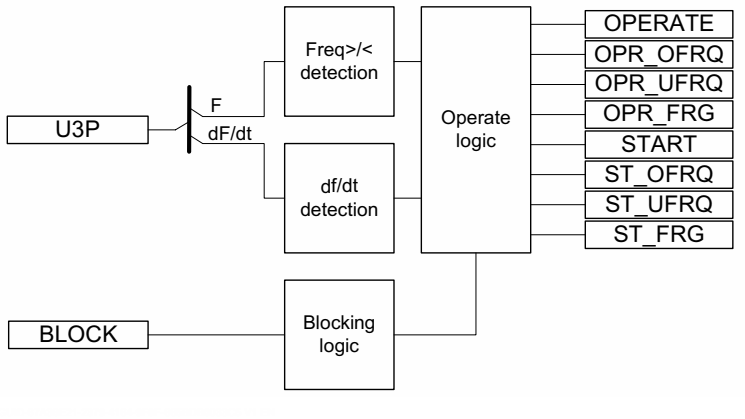



*Figure 455: Functional module diagram*

#### Freq>/< detection

The frequency detection module includes an overfrequency or underfrequency detection based on the *Operation mode* setting.

In the “Freq>” mode, the measured frequency is compared to the set *Start value Freq>*. If the measured value exceeds the set value of the *Start value Freq>* setting, the module reports the exceeding of the value to the operate logic module.

In the “Freq<” mode, the measured frequency is compared to the set *Start value Freq<*. If the measured value is lower than the set value of the *Start value Freq<* setting, the module reports the value to the operate logic module.

#### df/dt detection

The frequency gradient detection module includes a detection for a positive or negative rate-of-change (gradient) of frequency based on the set *Start value df/dt* value. The negative rate-of-change protection is selected when the set value is negative. The positive rate-of-change protection is selected when the set value is positive. When the frequency gradient protection is selected and the gradient exceeds the set *Start value df/dt* value, the module reports the exceeding of the value to the operate logic module.

The protection relay does not accept a value between -0.002...+0.002 for the *Start value df/dt* setting.

## Operate logic

This module is used for combining different protection criteria based on the frequency and the frequency gradient measurement to achieve a more sophisticated behavior of the function. The criteria are selected with the *Operation mode* setting.

*Table 805: Operation modes for operation logic*

| *Operation mode* | Description |
|---|---|
| Freq< | The function operates independently as the underfrequency ("Freq<") protection function. When the measured frequency is below the set value of the *Start value Freq<* setting, the module activates the START and STR_UFRQ outputs. The time characteristic is according to DT. When the operation timer has reached the value set by the *Operate Tm Freq* setting, the OPERATE and OPR_UFRQ outputs are activated. If the frequency restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm Freq* setting, the operate timer resets and the START and STR_UFRQ outputs are deactivated. |
| Freq> | The function operates independently as the overfrequency ("Freq>") protection function. When the measured frequency exceeds the set value of the *Start value Freq>* setting, the module activates the START and STR_OFRQ outputs. The time characteristic is according to DT. When the operation timer has reached the value set by the *Operate Tm Freq* setting, the OPERATE and OPR_OFRQ outputs are activated. If the frequency restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm Freq* setting, the operate timer resets and the START and STR_OFRQ outputs are deactivated. |
| df/dt | The function operates independently as the frequency gradient ("df/dt"), rate-of-change, protection function. When the frequency gradient exceeds the set value of the *Start value df/dt* setting, the module activates the START and STR_FRG outputs. The time characteristic is according to DT. When the operation timer has reached the value set by the *Operate Tm df/dt* setting, the OPERATE and OPR_FRG outputs are activated. If the frequency gradient restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm df/dt* setting, the operate timer resets and the START and STR_FRG outputs are deactivated. |

Table continues on next page

| *Operation mode* | Description |
|---|---|
| Freq< + df/dt | A consecutive operation is enabled between the protection methods. When the measured frequency is below the set value of the *Start value Freq<* setting, the frequency gradient protection is enabled. After the frequency has dropped below the set value, the frequency gradient is compared to the set value of the *Start value df/dt* setting. When the frequency gradient exceeds the set value, the module activates the START and STR_FRG outputs. The time characteristic is according to DT. When the operation timer has reached the value set by the *Operate Tm df/dt* setting, the OPERATE and OPR_FRG outputs are activated. If the frequency gradient restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm df/dt* setting, the operate timer resets and the START and STR_FRG outputs are deactivated. The OPR_UFRQ output is not active when this operation mode is used. |

Table continues on next page

| *Operation mode* | Description |
|---|---|
| Freq> + df/dt | A consecutive operation is enabled between the protection methods. When the measured frequency exceeds the set value of the *Start value Freq>* setting, the frequency gradient protection is enabled. After the frequency exceeds the set value, the frequency gradient is compared to the set value of the *Start value df/dt* setting. When the frequency gradient exceeds the set value, the module activates the START and STR_FRG outputs. The time characteristic is according to DT. When the operation timer has reached the value set by the *Operate Tm df/dt* setting, the OPERATE and OPR_FRG outputs are activated. If the frequency gradient restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm df/dt* setting, the operate timer resets and the START and STR_FRG outputs are deactivated. The OPR_OFRQ output is not active when this operation mode is used. |
| Freq< OR df/dt | A parallel operation between the protection methods is enabled. The START output is activated when either of the measured values of the protection module exceeds its set value. Detailed information about the active module is available at the STR_UFRQ and STR_FRG outputs. The shortest operate delay time from the set *Operate Tm Freq* or *Operate Tm df/dt* is dominant regarding the OPERATE output. The time characteristic is according to DT. The characteristic that activates the OPERATE output can be seen from the OPR_UFRQ or OPR_FRG output. If the frequency gradient restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm df/dt* setting, the operate timer resets and the STR_FRG output is deactivated. If the frequency restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm Freq* setting, the operate timer resets and the STR_UFRQ output is deactivated. |
| Freq> OR df/dt | A parallel operation between the protection methods is enabled. The START output is activated when either of the measured values of the protection module exceeds its set value. A detailed information from the active module is available at the STR_OFRQ and STR_FRG outputs. The shortest operate delay time from the set *Operate Tm Freq* or *Operate Tm df/dt* is dominant regarding the OPERATE output. The time characteristic is according to DT. The characteristic that activates the OPERATE output can be seen from the OPR_OFRQ or OPR_FRG output. If the frequency gradient restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm df/dt* setting, the operate timer resets and the STR_FRG output is deactivated. If the frequency restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm Freq* setting, the operate timer resets and the STR_UFRQ output is deactivated. |

The module calculates the start duration value which indicates the percentage ratio of the start situation and set operate time (DT). The start duration is available according to the selected value of the *Operation mode* setting.

*Table 806: Start duration value*

| Operation mode in use | Available start duration value |
|---|---|
| Freq< | ST_DUR_UFRQ |
| Freq> | ST_DUR_OFRQ |
| df/dt | ST_DUR_FRG |

The combined start duration START_DUR indicates the maximum percentage ratio of the active protection modes.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.6.1.6 Application

The frequency protection function uses the positive phase-sequence voltage to measure the frequency reliably and accurately.

The system frequency stability is one of the main principles in the distribution and transmission network maintenance. To protect all frequency-sensitive electrical apparatus in the network, the departure from the allowed band for a safe operation should be inhibited.

The overfrequency protection is applicable in all situations where high levels of the fundamental frequency of a power system voltage must be reliably detected. The high fundamental frequency in a power system indicates an unbalance between production and consumption. In this case, the available generation is too large compared to the power demanded by the load connected to the power grid. This can occur due to a sudden loss of a significant amount of load or due to failures in the turbine governor system. If the situation continues and escalates, the power system loses its stability.

The underfrequency is applicable in all situations where a reliable detection of a low fundamental power system voltage frequency is needed. The low fundamental

frequency in a power system indicates that the generated power is too low to meet the demands of the load connected to the power grid.

The underfrequency can occur as a result of the overload of generators operating in an isolated system. It can also occur as a result of a serious fault in the power system due to the deficit of generation when compared to the load. This can happen due to a fault in the grid system on the transmission lines that link two parts of the system. As a result, the system splits into two with one part having the excess load and the other part the corresponding deficit.

The frequency gradient is applicable in all the situations where the change of the fundamental power system voltage frequency should be detected reliably. The frequency gradient can be used for both increasing and decreasing the frequencies. This function provides an output signal suitable for load shedding, generator shedding, generator boosting, set point change in sub-transmission DC systems and gas turbine startup. The frequency gradient is often used in combination with a low frequency signal, especially in smaller power systems where the loss of a large generator requires quick remedial actions to secure the power system integrity. In such situations, the load shedding actions are required at a rather high frequency level. However, in combination with a large negative frequency gradient, the underfrequency protection can be used at a high setting.

### 4.6.1.7 Signals

*Table 807: FRPFRQ Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 808: FRPFRQ Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| OPR_OFRQ | BOOLEAN | Operate signal for overfrequency |
| OPR_UFRQ | BOOLEAN | Operate signal for underfrequency |
| OPR_FRG | BOOLEAN | Operate signal for frequency gradient |
| START | BOOLEAN | Start |
| ST_OFRQ | BOOLEAN | Start signal for overfrequency |
| ST_UFRQ | BOOLEAN | Start signal for underfrequency |
| ST_FRG | BOOLEAN | Start signal for frequency gradient |

### 4.6.1.8 Settings

*Table 809: FRPFRQ Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation mode | 1=Freq<<br>2=Freq><br>3=df/dt<br>4=Freq< + df/dt<br>5=Freq> + df/dt<br>6=Freq< OR df/dt<br>7=Freq> OR df/dt | | | 1=Freq< | Frequency protection operation mode selection |
| Start value Freq> | 0.9000...1.2000 | xFn | 0.0001 | 1.0500 | Frequency start value overfrequency |
| Start value Freq< | 0.8000...1.1000 | xFn | 0.0001 | 0.9500 | Frequency start value underfrequency |
| Start value df/dt | -0.2000...0.2000 | xFn/s | 0.0001 | 0.0100 | Frequency start value rate of change |
| Operate Tm Freq | 80...200000 | ms | 10 | 200 | Operate delay time for frequency |
| Operate Tm df/dt | 120...200000 | ms | 10 | 400 | Operate delay time for frequency rate of change |

*Table 810: FRPFRQ Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 811: FRPFRQ Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay Tm Freq | 0...60000 | ms | 1 | 0 | Reset delay time for frequency |
| Reset delay Tm df/dt | 0...60000 | ms | 1 | 0 | Reset delay time for rate of change |

### 4.6.1.9 Monitored data

*Table 812: FRPFRQ Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Start duration |
| ST_DUR_OFRQ | FLOAT32 | 0.00...100.00 | % | Start duration |
| ST_DUR_UFRQ | FLOAT32 | 0.00...100.00 | % | Start duration |
| ST_DUR_FRG | FLOAT32 | 0.00...100.00 | % | Start duration |
| FRPFRQ | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.6.1.10 Technical data

*Table 813: FRPFRQ Technical data*

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | f>/f< | ±5 mHz |
| | df/dt | ±50 mHz/s (in range \|df/dt\| <5 Hz/s)<br>±2.0% of the set value (in range 5 Hz/s < \|df/dt\| < 15 Hz/s) |
| Start time | f>/f< | <80 ms |
| | df/dt | <120 ms |
| Reset time | | <150 ms |
| Operate time accuracy | | ±1.0% of the set value or ±30 ms |

## 4.6.2 Load-shedding and restoration LSHDPFRQ

### 4.6.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Load-shedding and restoration | LSHDPFRQ | UFLS/R | 81LSH |

### 4.6.2.2 Function block




*Figure 456: Function block*

### 4.6.2.3 Functionality

The load-shedding and restoration function LSHDPFRQ is capable of performing load-shedding based on underfrequency and the rate of change of the frequency. The load that is shed during the frequency disturbance can be restored once the frequency has stabilized to the normal level.

The measured system frequency is compared to the set value to detect the underfrequency condition. The measured rate of change of frequency (df/dt) is compared to the set value to detect a high frequency reduction rate. The combination of the detected underfrequency and the high df/dt is used for the activation of the load-shedding. There is a definite time delay between the detection of the underfrequency

and high df/dt and the activation of LSHDPFRQ. This time delay can be set and it is used to prevent unwanted load-shedding actions when the system frequency recovers to the normal level.

Throughout this document, “high df/dt” is used to mean “a high rate of change of the frequency in negative direction.”

Once the frequency has stabilized, LSHDPFRQ can restore the load that is shed during the frequency disturbance. The restoration is possible manually or automatically.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.6.2.4 Analog channel configuration

LSHDPFRQ has one analog group input which must be properly configured.

*Table 814: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 815: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that at least one phase or phase-to-phase voltage channel is connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.6.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of LSHDPFRQ can be described using a module diagram. All the modules are explained in the next sections.

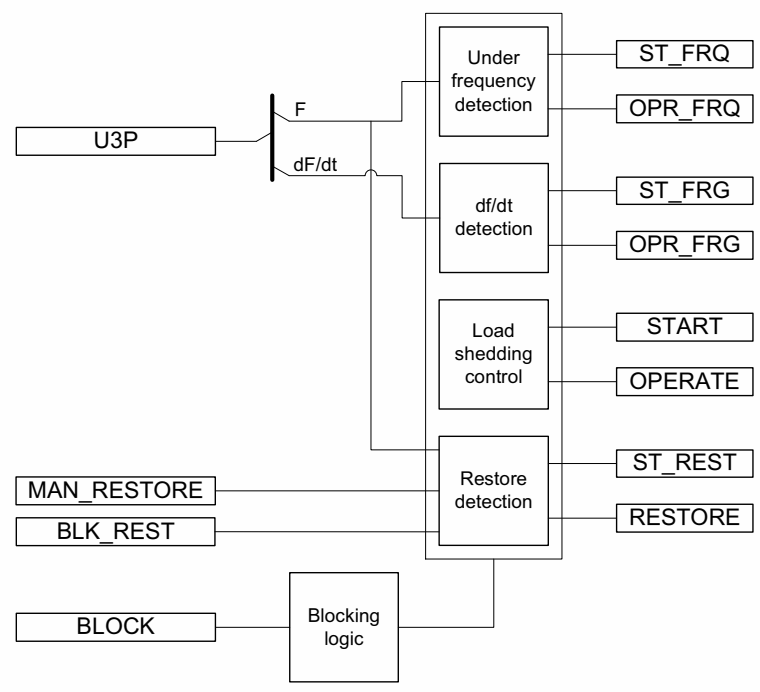



*Figure 457: Functional module diagram*

## Underfrequency detection

The underfrequency detection measures the input frequency calculated from the voltage signal. An underfrequency is detected when the measured frequency drops below the set value of the *Start value Freq* setting.

The underfrequency detection module includes a timer with the definite time (DT) characteristics. Upon detection of underfrequency, operation timer activates the ST_FRQ output. When the underfrequency timer has reached the value set by *Operate Tm Freq*, the OPR_FRQ output is activated if the underfrequency condition still persists. If the frequency becomes normal before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the timer resets and the ST_FRQ output is deactivated.

## df/dt detection

The df/dt detection measures the input frequency calculated from the voltage signal and calculates its gradient. A high df/dt condition is detected by comparing the gradient to the *Start value df/dt* setting.The df/dt detection is activated when the frequency gradient decreases at a faster rate than the set value of *Start value df/dt*.

The df/dt detection module includes a timer with the DT characteristics. Upon detection of df/dt, operation timer activates the ST_FRG output. When the timer has reached the value set by *Operate Tm df/dt*, the OPR_FRG output is activated if the df/dt condition still persists. If df/dt becomes normal before the module operates, the

reset timer is activated. If the reset timer reaches the value of the *Reset delay time* setting, the timer resets and the ST_FRG output is deactivated.

### Load-shedding control

The way of load-shedding, that is, whether to operate based on underfrequency or high df/dt or both, is defined with the *Load shed mode* user setting. The valid operation modes for the *Load shed mode* settings are "Freq<", "Freq< AND df/dt" and "Freq< OR df/dt".

Once the selected operation mode conditions are satisfied, the START and OPERATE output signals are activated.

When the START output is active, the percentage of the elapsed delay time can be monitored through START_DUR which is available as monitored data.

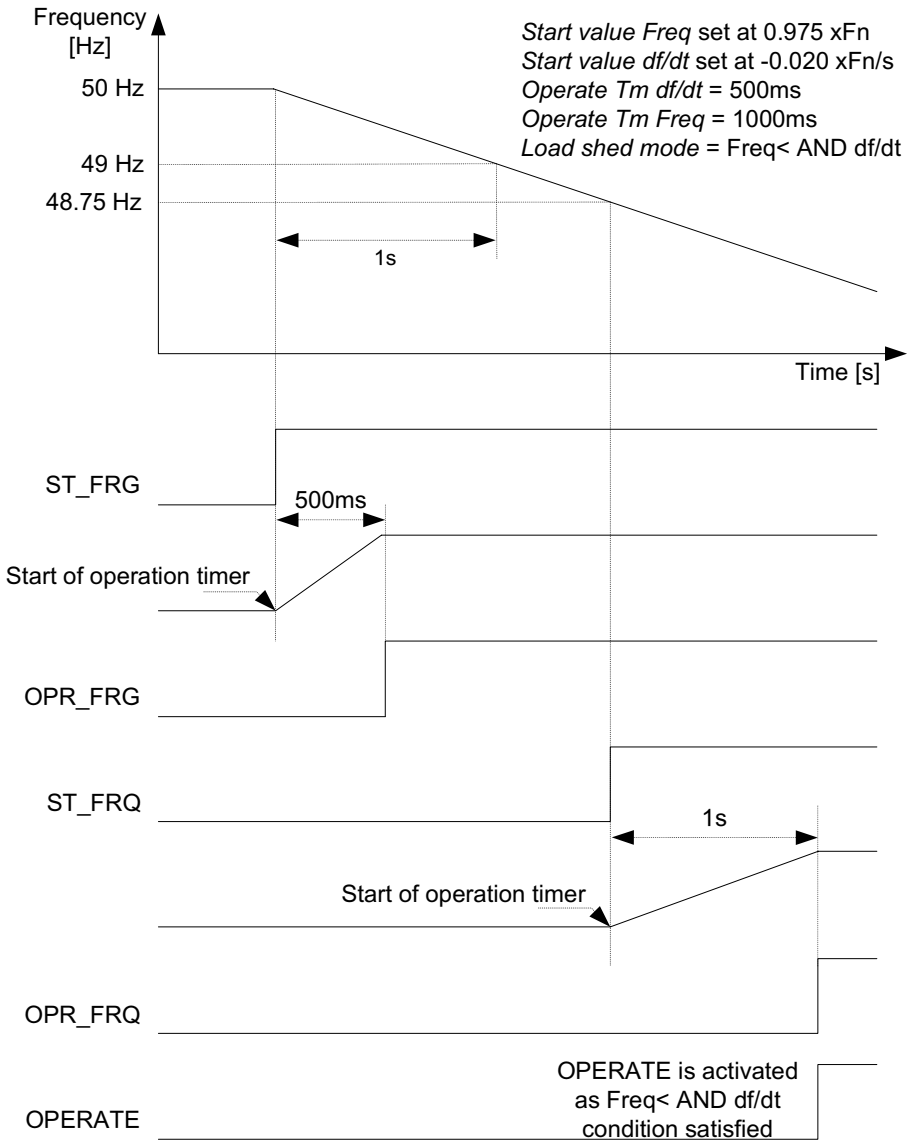



*Figure 458: Load-shedding operation in the "Freq< AND df/dt>" mode when both Freq< and df/dt conditions are satisfied (Rated frequency=50 Hz)*

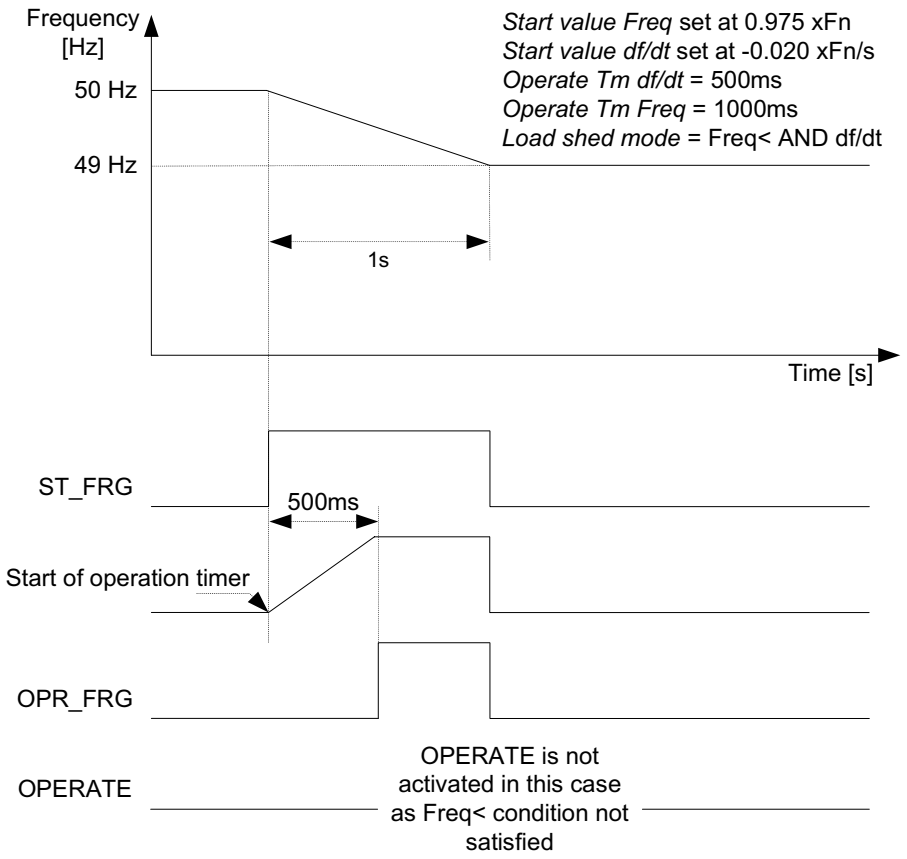



*Figure 459: Load-shedding operation in the "Freq< AND df/dt>" mode when only the df/dt condition is satisfied (Rated frequency=50 Hz)*

## Restore detection

If after the activation of the OPERATE output the frequency recovers to a level above the *Restore start Val* setting, the RESTORE signal output is activated. The RESTORE output remains active for 100 ms. The *Restore mode* setting is used to select the restoring mode to be "Disabled", "Auto" or "Manual".

| Restoring mode | Description |
|---|---|
| Disabled | Load restoration is disabled. |
| Auto | In the “Auto” mode, input frequency is continuously compared to the *Restore start Val* setting. The restore detection module includes a timer with the DT characteristics. Upon detection of restoring, the operation timer activates the ST_REST output. When the timer has reached the value of the *Restore delay time* setting, the RESTORE output is activated if the restoring condition still persists. If the frequency drops below the *Restore start Val* before the RESTORE output is activated, the reset timer is activated. If the reset timer reaches the value of the *Reset delay time* setting, the timer resets and the ST_REST start output is deactivated. |
| Manual | In the “Manual” mode, a manual restoration is possible through the MAN_RESTORE input or via communication. The ST_REST output is activated if the MAN_RESTORE command is available and the frequency has exceeded the *Restore start Val* setting. The manual restoration includes a timer with the DT characteristics. When the timer has reached the set value of the *Restore delay time* setting, the RESTORE output is activated if the restoring condition still persists. If the frequency drops below the *Restore start Val* setting before the RESTORE output is activated, the reset timer is activated. If the reset timer reaches the value of the *Reset delay time* setting, the timer resets and the ST_REST start output is deactivated. |

A condition can arise where the restoring operation needs to be canceled. Activating the BLK_REST input for the "Auto" or "Manual" modes cancels the restoring operation. In the "Manual" restoring mode, the cancellation happens even if MAN_RESTORE is present.

Once the RESTORE output command is cancelled, the reactivation of RESTORE is possible only after the reactivation of the OPERATE output, that is, when the next load-shedding operation is detected.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** that selects the blocking mode. The BLOCK input can be controlled with a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK input signal activation is preselected with the *Blocking mode* global setting.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE, OPR_FRQ and OPR_FRG outputs are not activated.

## 4.6.2.6 Application

An AC power system operates at a defined rated frequency. The nominal frequency in most systems in the world is 50 Hz or 60 Hz. The system operation is such that the operating frequency remains approximately at the nominal frequency value by a small

margin. The safe margin of operation is usually less than ±0.5 Hz. The system frequency stability is one of the main concerns in the transmission and distribution network operation and control. To protect the frequency-sensitive electrical equipment in the network, departure from the allowed band for safe operation should be inhibited.

Any increase in the connected load requires an increase in the real power generation to maintain the system frequency. Frequency variations form whenever there are system conditions that result in an unbalance between the generation and load. The rate of change of the frequency represents the magnitude of the difference between the load and generation. A reduction in frequency and a negative rate of change of the frequency are observed when the load is greater than the generation, and an increase in the frequency along with a positive rate of change of the frequency are observed if the generation is greater than the load. The rate of change of the frequency is used for a faster decision of load-shedding. In an underfrequency situation, the load-shedding trips out the unimportant loads to stabilize the network. Thus, loads are normally prioritized so that the less important loads are shed before the important loads.

During the operation of some of the protective schemes or other system emergencies, the power system is divided into small islands. There is always a load - generation imbalance in such islands that leads to a deviation in the operating frequency from the nominal frequency. This off-nominal frequency operation is harmful to power system components like turbines and motors. Therefore, such situation must be prevented from continuing. The frequency-based load-shedding scheme should be applied to restore the operation of the system to normal frequency. This is achieved by quickly creating the load - generation balance by disconnecting the load.

As the formation of the system islands is not always predefined, several load-shedding relays are required to be deployed at various places near the load centers. A quick shedding of a large amount of load from one place can cause a significant disturbance in the system. The load-shedding scheme can be made most effective if the shedding of load feeders is distributed and discrete, that is, the loads are shed at various locations and in distinct steps until the system frequency reaches the acceptable limits.

Due to the action of load-shedding schemes, the system recovers from the disturbance and the operating frequency value recovers towards the nominal frequency. The load that was shed during the disturbance can be restored. The load-restoring operation should be done stepwise in such a way that it does not lead the system back to the emergency condition. This is done through an operator intervention or in case of remote location through an automatic load restoration function. The load restoration function also detects the system frequency and restores the load if the system frequency remains above the value of the set restoration frequency for a predefined duration.

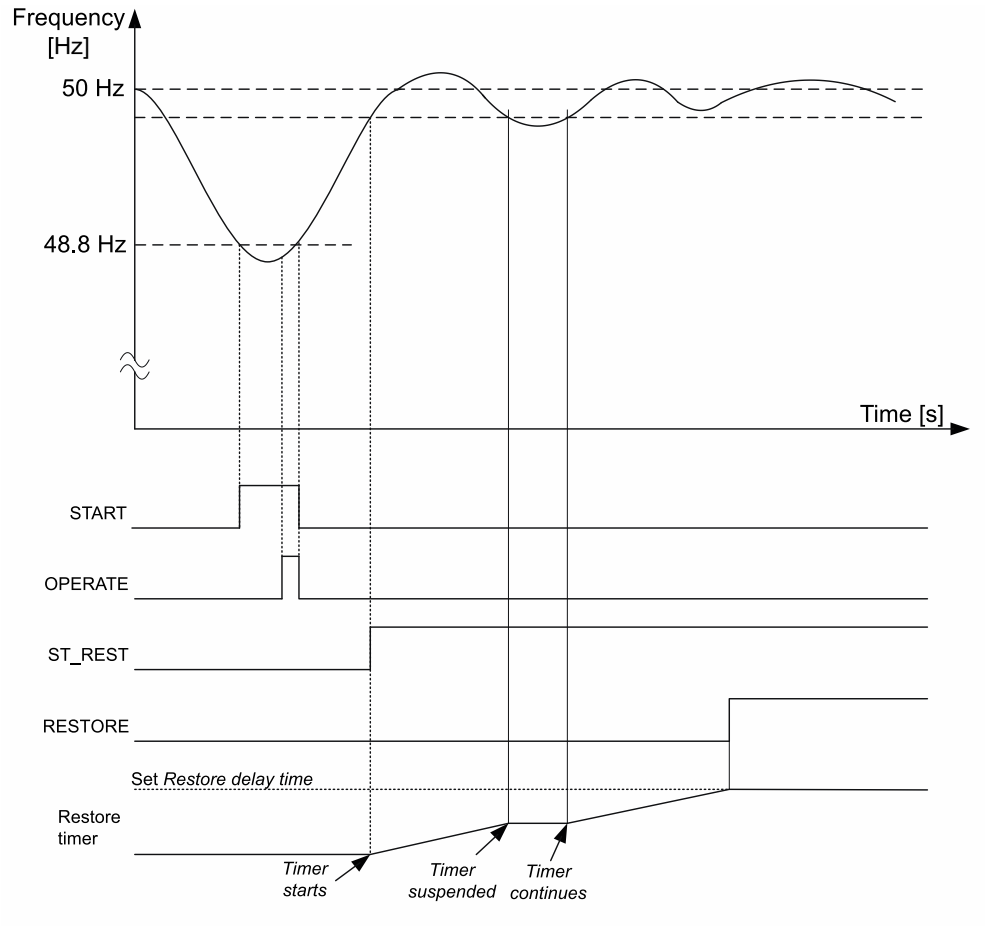



*Figure 460: Operation of the load-shedding function*

## Power system protection by load-shedding

The decision on the amount of load that is required to be shed is taken through the measurement of frequency and the rate of change of frequency (df/dt). At a single location, many steps of load-shedding can be defined based on different criteria of the frequency and df/dt. Typically, the load-shedding is performed in six or four steps with each shedding increasing the portion of load from five to twenty-five percent of full load within a few seconds. After every shedding, the system frequency is read back and further shedding actions are taken only if necessary. In order to take the effect of any transient, a sufficient time delay should be set.

The value of the setting has to be well below the lowest occurring normal frequency and well above the lowest acceptable frequency of the system. The setting level, the number of steps and the distance between two steps (in time or in frequency) depend on the characteristics of the power system under consideration. The size of the largest loss of generation compared to the size of the power system is a critical parameter. In large systems, the load-shedding can be set at a high frequency level and the time delay is normally not critical. In small systems, the frequency start level has to be set at a low value and the time delay must be short.

If a moderate system operates at 50 Hz, an underfrequency should be set for different steps from 49.2 Hz to 47.5 Hz in steps of 0.3 – 0.4 Hz. The operating time for the underfrequency can be set from a few seconds to a few fractions of a second stepwise from a higher frequency value to a lower frequency value.

*Table 816: Setting for a five-step underfrequency operation*

| Load-shedding steps | Start value Freq setting | Operate Tm Freq setting |
|---|---|---|
| 1 | 0.984 · Fn (49.2 Hz) | 45000 ms |
| 2 | 0.978 · Fn (48.9 Hz) | 30000 ms |
| 3 | 0.968 · Fn (48.4 Hz) | 15000 ms |
| 4 | 0.958 · Fn (47.9 Hz) | 5000ms |
| 5 | 0.950 · Fn (47.5 Hz) | 500 ms |

The rate of change of frequency function is not instantaneous since the function needs time to supply a stable value. It is recommended to have a time delay long enough to take care of the signal noise.

Small industrial systems can experience the rate of change of frequency as large as 5 Hz/s due to a single event. Even large power systems can form small islands with a large imbalance between the load and generation when severe faults or combinations of faults are cleared. Up to 3 Hz/s has been experienced when a small island becomes isolated from a large system. For normal severe disturbances in large power systems, the rate of change of the frequency is much less, often just a fraction of 1.0 Hz/s.

Similarly, the setting for df/dt can be from 0.1 Hz/s to 1.2 Hz/s in steps of 0.1 Hz/s to 0.3 Hz/s for large distributed power networks, with the operating time varying from a few seconds to a few fractions of a second. Here, the operating time should be kept in minimum for the higher df/dt setting.

*Table 817: Setting for a five-step df/dt< operation*

| Load-shedding steps | Start value df/dt setting | Operate Tm df/dt setting |
|---|---|---|
| 1 | -0.005 · Fn /s (-0.25 Hz/s) | 8000 ms |
| 2 | -0.010 · Fn /s (-0.50 Hz/s) | 2000 ms |
| 3 | -0.015 · Fn /s (-0.75 Hz/s) | 1000 ms |
| 4 | -0.020 · Fn /s (-1.00 Hz/s) | 500 ms |
| 5 | -0.025 · Fn /s (-1.25 Hz/s) | 250 ms |

Once the frequency has stabilized, the shed load can be restored. The restoring operation should be done stepwise, taking care that it does not lead the system back to the emergency condition.

*Table 818: Setting for a five-step restoring operation*

| Load-shedding steps | Restore start Val setting | Restore delay time setting |
|---|---|---|
| 1 | 0.990 · Fn (49.5 Hz) | 200000 ms |
| 2 | 0.990 · Fn (49.5 Hz) | 160000 ms |
| 3 | 0.990 · Fn (49.5 Hz) | 100000 ms |
| 4 | 0.990 · Fn (49.5 Hz) | 50000 ms |
| 5 | 0.990 · Fn (49.5 Hz) | 10000 ms |

### 4.6.2.7 Signals

*Table 819: LSHDPFRQ Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_REST | BOOLEAN | 0=False | Block restore |
| MAN_RESTORE | BOOLEAN | 0=False | Manual restore signal |

*Table 820: LSHDPFRQ Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operation of load shedding |
| OPR_FRQ | BOOLEAN | Operate signal for under frequency |
| OPR_FRG | BOOLEAN | Operate signal for high df/dt |
| START | BOOLEAN | Start |
| ST_FRQ | BOOLEAN | Pick-Up signal for under frequency detection |
| ST_FRG | BOOLEAN | Pick-Up signal for high df/dt detection |
| RESTORE | BOOLEAN | Restore signal for load restoring purposes |
| ST_REST | BOOLEAN | Restore frequency attained and restore timer started |

### 4.6.2.8 Settings

*Table 821: LSHDPFRQ Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Load shed mode | 1=Freq<<br>6=Freq< OR df/dt<br>8=Freq< AND df/dt | | | 1=Freq< | Set the operation mode for load shedding function |
| Restore mode | 1=Disabled<br>2=Auto<br>3=Manual | | | 1=Disabled | Mode of operation of restore functionality |
| Start value Freq | 0.800...1.200 | xFn | 0.001 | 0.975 | Frequency setting/start value |
| Start value df/dt | -0.2000...0.0050 | xFn/s | 0.0001 | -0.010 | Setting of frequency gradient for df/dt detection |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate Tm Freq | 80...200000 | ms | 10 | 200 | Time delay to operate for under frequency stage |
| Operate Tm df/dt | 120...200000 | ms | 10 | 200 | Time delay to operate for df/dt stage |
| Restore start Val | 0.800...1.200 | xFn | 0.001 | 0.998 | Restore frequency setting value |
| Restore delay time | 80...200000 | ms | 10 | 300 | Time delay to restore |

*Table 822: LSHDPFRQ Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 823: LSHDPFRQ Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 50 | Time delay after which the definite timers will reset |

### 4.6.2.9 Monitored data

*Table 824: LSHDPFRQ Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Start duration |
| LSHDPFRQ | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.6.2.10 Technical data

*Table 825: LSHDPFRQ Technical data*

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | f< | ±5 mHz |
| | df/dt | ±100 mHz/s (in range \|df/dt\| < 5 Hz/s)<br>± 2.0% of the set value (in range 5 Hz/s < \|df/dt\| < 15 Hz/s) |
| Start time | f< | <80 ms |
| | df/dt | <120 ms |
| Reset time | | <150 ms |
| Operate time accuracy | | ±1.0% of the set value or ±30 ms |

# 4.7 Impedance protection

## 4.7.1 Distance protection DSTPDIS

### 4.7.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Distance protection | DSTPDIS | Z< | 21P, 21N |

### 4.7.1.2 Function block




*Figure 461: Function block*

### 4.7.1.3 Functionality

The distance protection function DSTPDIS provides a full-scheme distance protection function for distribution networks where three-phase tripping is allowed for all kinds of faults.

DSTPDIS has five flexible, configurable impedance zones for protection (Z1...Z5).

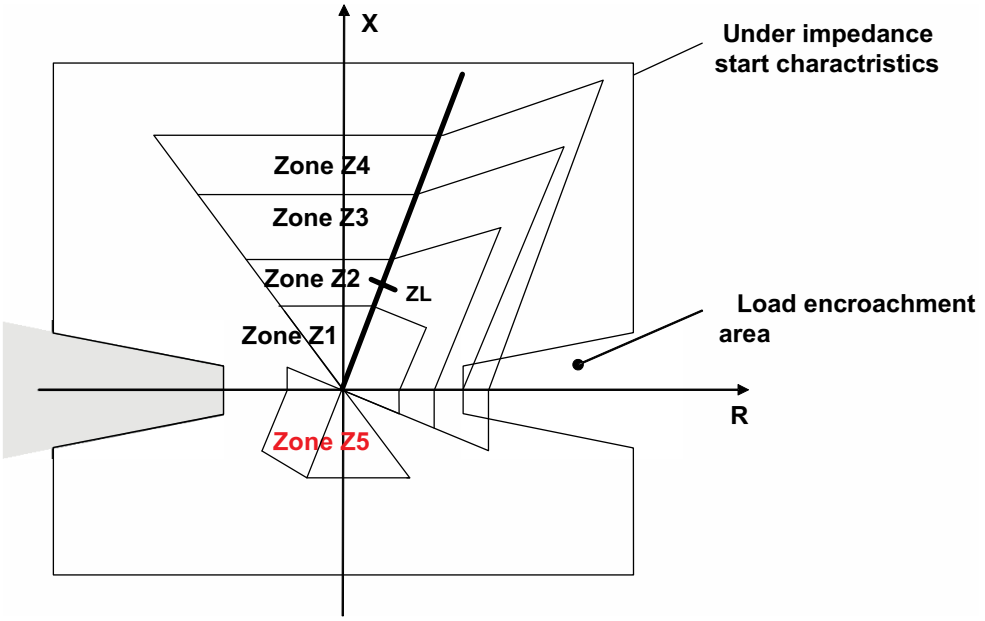



*Figure 462: Zones of DSTPDIS function (example 1)*

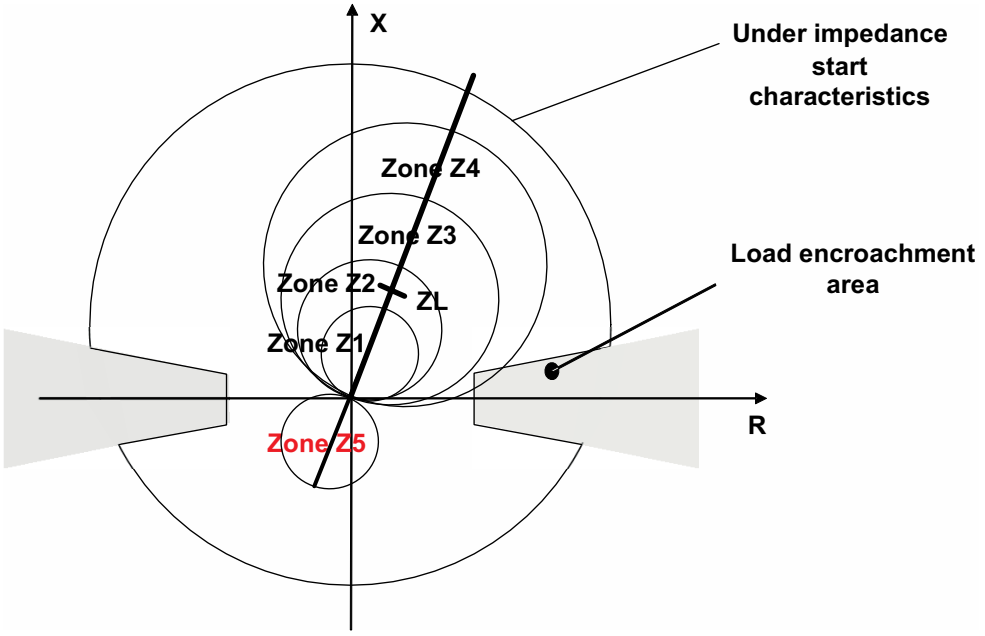



*Figure 463: Zones of DSTPDIS function (example 2)*

The supported zone characteristic shapes are quadrilateral, mho (circular) or bullet (quadrilateral and mho characteristics combined). Mho can be combined with directional lines to secure directionality and to enable increased fault resistance coverage with an offset mho circle.

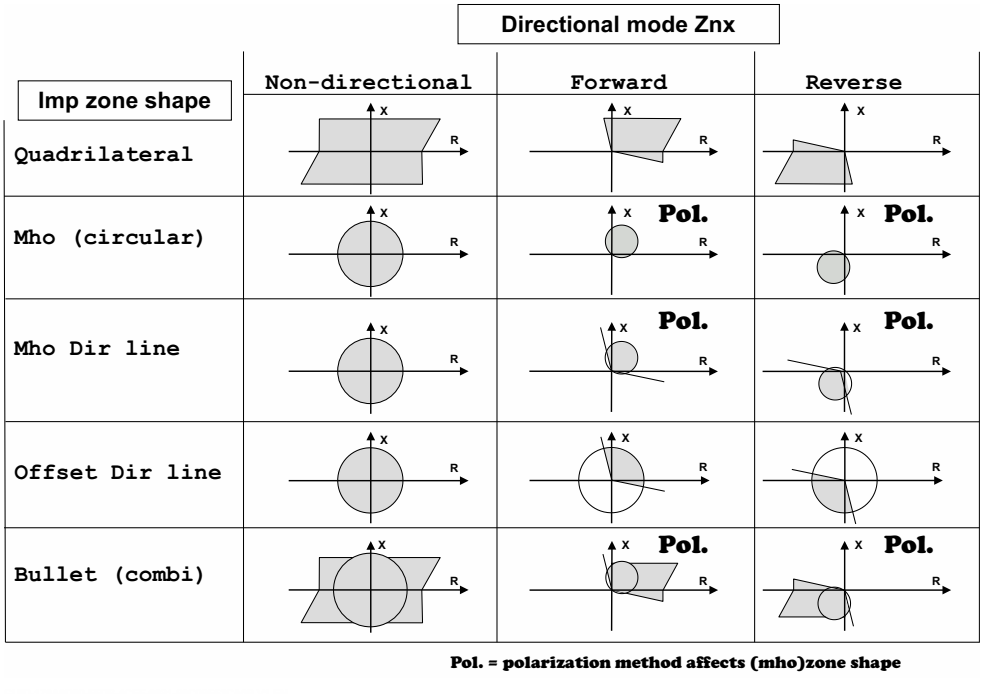



*Figure 464: Possible combinations of Directional mode Znx and Zone characteristics settings. Pol. here means that the shape of the characteristic is affected by the selected polarization method of mho circle (Pol quantity zone = "Cross pol", "Pos. seq. volt.", "Self pol")*

The directional lines are polarized with the set polarizing quantity of all impedance measuring elements. In addition, the memory voltage that is based on positive-sequence voltage substitute for the measured voltage with any impedance measurement element polarization if the corresponding voltage drops too low.

DSTPDIS has separate and independent measurement elements for each fault loop in the distance protection zone. In addition to the full scheme design, the separate measuring elements are used for general fault detection and faulted phase selection.

DSTPDIS supports both fault detection dependent control of zone timers and zone-dedicated phasewise timer control for maximum application flexibility.

The impedance measurement is always done the same way regardless of the zone shape. The operation is based on the impedance mapping approach where the fault loop impedance is first calculated and then compared to the zone boundaries. If impedance is recognized within the operation zone, the corresponding operate output is activated after the operate time has elapsed.

The impedance measurement is based on full-cycle DFT filtered current and voltage phasors.

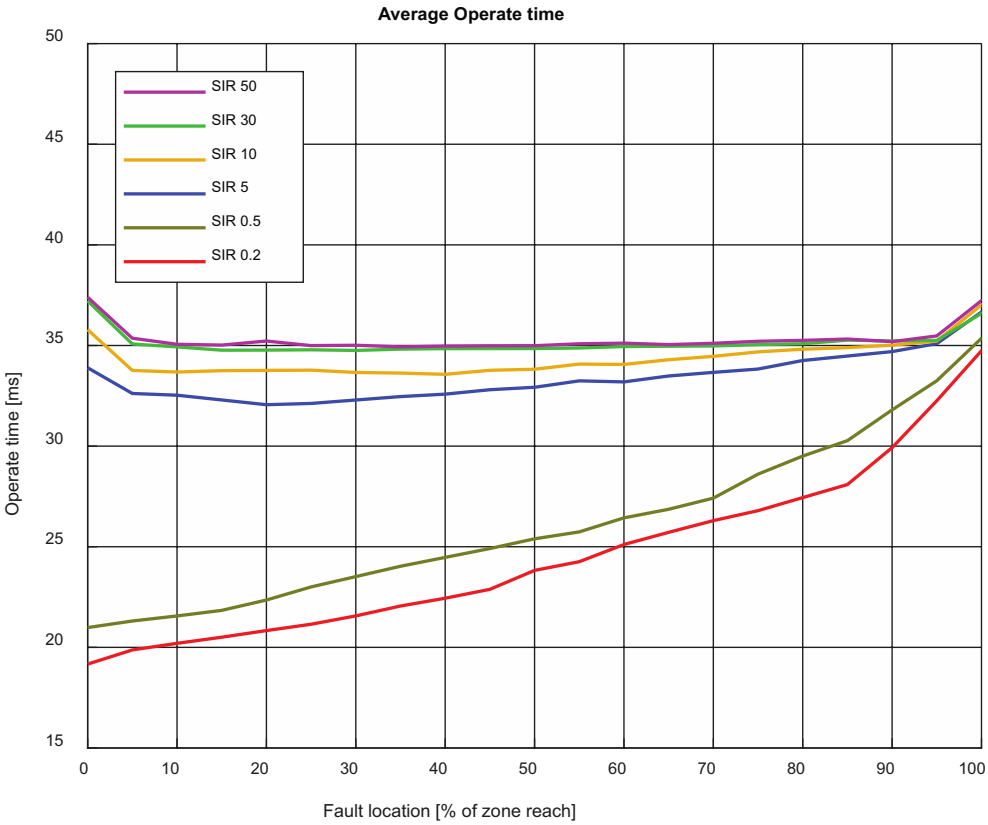



*Figure 465: Average operate time of DSTPDIS according to IEC 60255-121 network models Short line and Long line (50 Hz)*

SIR curves are plotted from the data which includes variation of fault location (0…100% of zone reach, 5% step), fault type (LN, LL, LLN, LLL) and fault inception angle (0, 30, 60, 90 degrees). Each combination has been repeated ten times giving the total number of 26880 shots. The operate times include the delay of relay output contacts. The SIR curves presented in Figure 465 were obtained using the static power outputs (SPOs) and with *Zone timer mode* = "common".

### 4.7.1.4 Analog channel configuration

DSTPDIS has five analog group inputs which must be properly configured.

*Table 826: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| I3P_PAR[1)] | Three-phase currents<br>Necessary when *Par line Comp zone x* is set to True |
| I3P_REF[2)] | Three-phase currents<br>Necessary when *EF detection Mod GFC* is set to "Io AND IoRef" |
| U3P | Three-phase voltages |
| URES[3)] | Residual voltage (measured)<br>Necessary when *EF detection Mod GFC* is set to "Io OR Uo" or "Io AND Uo". Necessary also if only main voltages are available but *Phase voltage Meas* is set to "Accurate". |

1) Can be connected to GRPOFF if *Par line Comp zone x* is set to False.
2) Can be connected to GRPOFF if *EF detection Mod GFC* is not set to "Io AND IoRef"
3) Can be connected to GRPOFF if *EF detection Mod GFC* is set to "Io" or "Io AND IoRef" or *Phase voltage Meas* is set to "Ph-to-ph without Uo"

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

*Table 827: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.7.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The function consists of sub-functions which are described in the next sections.

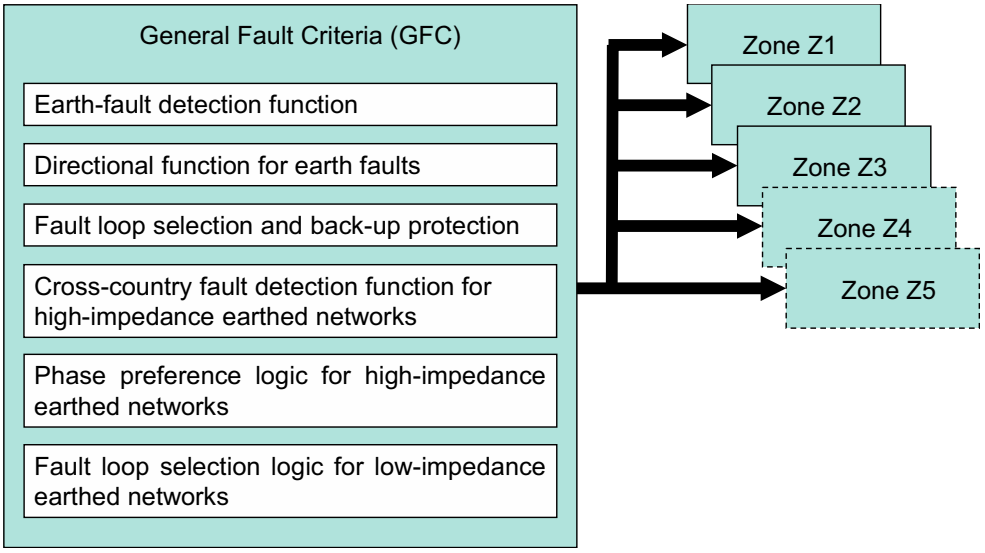



*Figure 466: Main functionality of DSTPDIS*

All outputs and the operation of all sub-functions can be blocked with the BLOCK binary input signal. In addition, it resets the timers.

## Blocking

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE_Z1...5 output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE_Z1...5 output is not activated.

In addition, the function has zone-specific blocking signals BLOCK_Z1...5. The signal resets zone timers disabling the corresponding start and operate output activation.

BLOCK_GFC deactivates START_GFC and OPERATE_GFC. It also resets GFC operate time (set by *Operate delay GFC*). Blocking does not prevent GFC operation.

## Earth-fault detection function

The recognition of an earth fault is an important part in identifying the correct fault type. This information is used in faulted loop (phase) selection to release the correct impedance-measuring elements. The earth-fault recognition is always required to release the phase-to-earth impedance-measuring elements.

The earth-fault detection is indicated with the EARTH_FLT monitored data. The earth-fault detection criterion can be defined with the *EF detection Mod GFC* setting. The fundamental criterion is based on the residual current. The residual voltage and reference neutral current, measured from the transformer neutral point, can be used for the earth-fault detection criteria.

*Table 828: Selection of earth-fault detection criteria*

| Setting | Enumerator name |
|---|---|
| EF detection Mod GFC | • Io<br>• Io OR Uo<br>• Io AND Uo<br>• Io AND IoRef |

If the residual current Io is derived from the phase currents either by the summation connection of CTs, that is, the Holmgreen connection, or by internally summing the phase currents, there is a risk of a false earth-fault detection due to apparent residual current from the current transformer errors. This risk can be eliminated using a stabilized residual current measurement. The stabilization is enabled by setting the *EF Cur stabilization* setting to "True". The stabilization increases the residual current *Gnd Op current GFC* threshold setting when the maximum phase current exceeds the nominal current. The increase is defined with the *Stab slope 1 GFC* setting. The apparent residual current may exist during short circuits and in inrush current situations if the CTs saturate partially. The earth-fault detection function takes the CT saturation into account with additional stabilization settings *Gnd Op current 2 GFC*, *A Ph Stab value GFC* and *Stab slope 2 GFC*.

Setting *EF Cur stabilization* to "False" disables the stabilization of the residual current measurement and should be used only when the residual current is measured with a cable current transformer. The residual current threshold setting for earth-fault detection is *Gnd Op current GFC*. If the residual current is measured from a transformer neural point, *Gnd Op A Ref GFC* is used. This is valid when the setting *EF detection Mod GFC* is "Io AND IoRef".

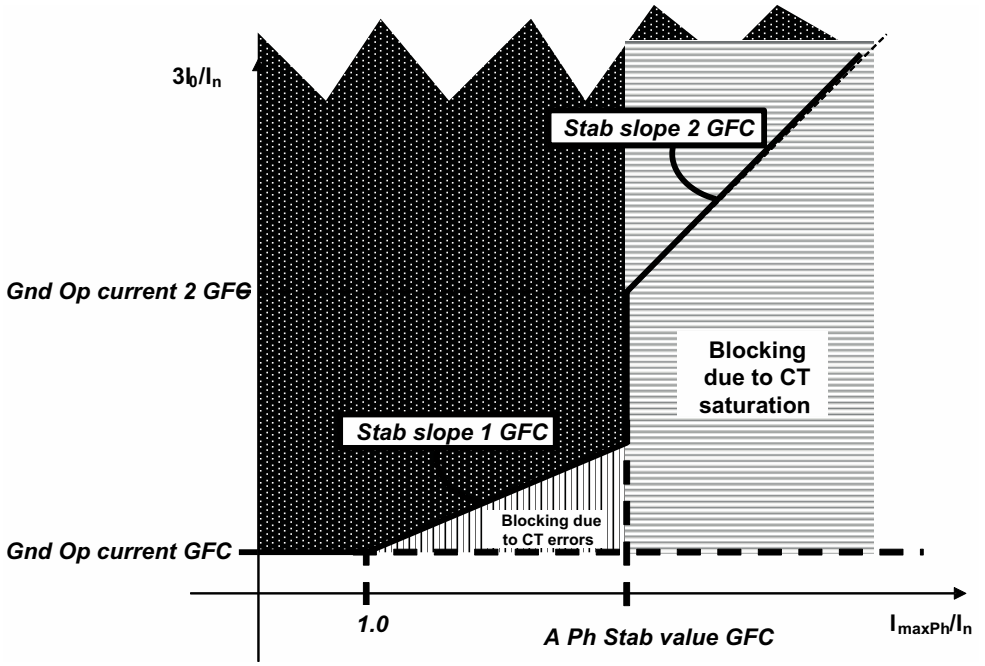



*Figure 467: Stabilized residual current measurement for earth-fault detection*

The residual voltage can also be used as a complementary criterion for earth-fault detection. This is valid when the setting *EF detection Mod GFC* is "Io OR Uo" or *EF detection Mod GFC* is "Io AND Uo". The threshold setting for the residual voltage is *Gnd Str voltage GFC*.

## Directional function for earth faults

In low-impedance earthed networks, when the *System grounding GFC* setting is set to "Low impedance", the earth-fault detection function can be optionally supervised by a directional function which can be enabled with the *Dir mode EF GFC* setting. If *Dir mode EF GFC* is set to "Forward" or "Reverse", the earth-fault direction is also detected. The calculated direction for the earth fault is indicated in the DIR_E_FLT monitored data ("unknown", "forward", "backward" (reverse), "both"). Direction criteria do not directly affect earth-fault detection, but the earth-fault direction information is used for zone starting, when only those directional zones that are set to the indicated earth-fault direction can be started.

The operation characteristic of the directional function is defined by three settings: *Chr angle GFC*, *Min phase angle GFC* and *Max phase angle GFC*.

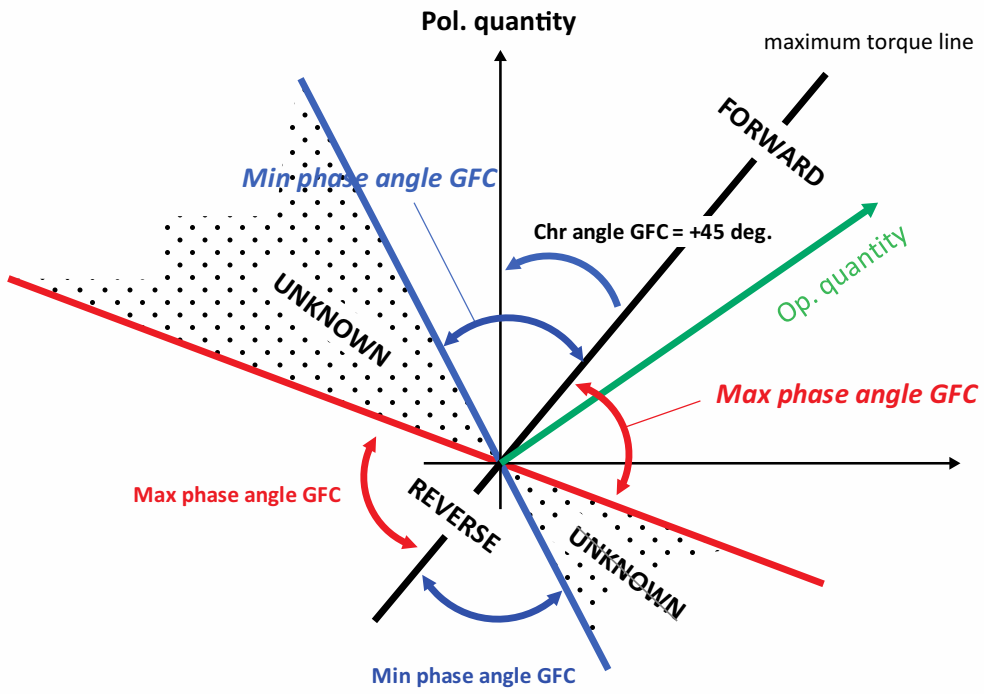



*Figure 468: Characteristic of the directional function for earth faults*

The *Chr angle GFC* setting, also known as relay characteristic angle or basic angle, is used to turn the directional characteristic. It has a positive value when the operating quantity lags the polarizing quantity and a negative value when the operating quantity leads the polarizing quantity. For low-impedance earthed networks, *Chr angle GFC* equals the angle of the fault loop impedance and is typically positive.

The *Min phase angle GFC* and *Max phase angle GFC* settings define the width of the operating sector. These settings are mirror-symmetric to the origin for reverse (backward).

The directional function for earth faults must operate at fault current values below the magnitude of the load currents. The use of sequence quantities is preferred for polarizing quantity as phase quantities are affected by the load currents. Four possibilities are available and defined by the *Pol quantity GFC* setting.

***Table 829: Polarizing quantities for optional directional function for earth faults in low-impedance earthed networks***

| Pol quantity GFC | Polarizing quantity | Operating quantity | Description |
|---|---|---|---|
| Zero seq. volt. | $-U_0$ | $I_0$ | Zero-sequence voltage polarization |
| Neg. seq. volt. | $-U_2$ | $I_2$ | Negative-sequence voltage polarization |
| Zero seq. cur. | $I_{oref}$ | $I_0$ | Zero-sequence current polarization |
| Zro vol.OR cur. | $-U_0$ OR $I_{oref}$ | $I_0$ | Dual polarization |

The polarizing quantity is $-U_0$ and the operating quantity is $I_0$ in case of zero-sequence voltage polarization.
The polarizing quantity is $-U_2$ and the operating quantity is $I_2$ in case of negative-sequence polarization.

In case of zero-sequence current polarization "Zero seq. cur.", the zero-sequence current $I_0$ of the protected line is the operating quantity while another reference zero-sequence current $I_{0ref}$ is the polarizing quantity. $I_{0ref}$, for example, could be the current from the neutral of a power transformer. In case of zero-sequence current polarization, the relay characteristic angle *Chr angle GFC* is internally fixed and is equal to zero degrees. The zero-sequence current direction must remain unchanged during all network configurations and faults. Therefore, all transformer configurations or constructions are not suitable for polarization.

In case of dual polarization "Zro vol. OR cur.", the zero-sequence voltage polarization and zero-sequence current polarization elements are logically OR:ed. Typically, when $I_0$ is high, $U_0$ is low, and when $I_0$ is low, $U_0$ is high. Hence the protection can benefit from both elements as the two polarization methods complement each other. If the zero-sequence current polarization source is switched off for service, the flexibility is increased as the zero-sequence voltage polarization can be used.

## Faulted loop phase selection

A reliable identification of a fault and faulted phases is needed to guarantee a selective operation of the distance protection. This information is used to release correct measuring elements of the protection zones.

In DSTPDIS, the faulted phase selection can be done in various ways and defined with the *Phase Sel mode GFC* setting.

*Table 830: Supported methods for phase selection*

| Setting | Enumerator value |
|---|---|
| Phase Sel mode GFC | • Overcurrent<br>• Vol Dep Overcur<br>• Under impedance<br>• OC AND Und impedance |

The “Overcurrent” method is the basic method for identifying the faulted phases. It can be used in applications where the fault current magnitude exceeds the load current despite the changes in the network configuration and fault type.

The “Vol Dep Overcur” method combines overcurrent and undervoltage conditions. An undervoltage condition allows lower current threshold settings and increases the sensitivity of the fault detection.

The “Under impedance” method uses fault loop impedance for identifying the faulted phases. The underimpedance characteristic can be either quadrilateral or circular in shape. The sensitivity of the fault detection is defined by an independent setting in

resistive and reactive reaches. The underimpedance method is supervised by a load encroachment logic which ensures that the load impedance does not interfere with the faulted phase selection.

The ”OC AND Und impedance” method combines “Overcurrent” and “Under impedance” methods so that both criteria have to be fulfilled.

All phase selection methods require that all three phase currents are measured and all three phase-to-earth voltages are available. If only phase-to-phase voltages are available (*Phase voltage Meas* = "Ph-to-ph without Uo"), only phase-to-phase measuring loops can be released for measurement. The release of phase-to-earth fault measuring elements is then blocked, RELEASE_PE = “No fault”.

The operation of the faulted phase selection function is highly dependent on the earth-fault detection function. The phase preference or faulted loop selection logic can be set to filter the faulted phases to be released for measurement in the protection zones.

The general indication of a fault is given in the binary output START_GFC. The faulted phase information can be found from the integer monitored data signal STARTS_GFC.

*Table 831: Enumeration values for integer monitored data signal STARTS_GFC*

| Enumerator name | Value |
|---|---|
| No fault | -5 |
| AG Fault | 1 |
| BG Fault | 2 |
| CG Fault | 3 |
| AB Fault | 4 |
| BC Fault | 5 |
| CA Fault | 6 |
| ABC Fault | 7 |

The fault loops released for measurement are indicated with the integer monitored data signals RELEASE_PE and RELEASE_PP. These signals may be filtered by the phase preference of the faulted loop selection logic.

*Table 832: Enumeration values for integer monitored data signal RELEASE_PE*

| Enumerator name | Value |
|---|---|
| No fault | -5 |
| AG Fault | 1 |
| BG Fault | 2 |
| CG Fault | 3 |
| AB Fault | 4 |
| BC Fault | 5 |
| CA Fault | 6 |
| ABC Fault | 7 |

*Table 833: Enumeration values for integer monitored data signal RELEASE_PP*

| Enumerator name | Value |
|---|---|
| No fault | -5 |
| AB Fault | 4 |
| BC Fault | 5 |
| CA Fault | 6 |
| ABC Fault | 7 |

The phase selection function can be set to issue an operate signal as the faulted phase selection uses independent measuring elements from the distance protection zones. This can be applied as a back-up protection for the measurement zones. The time delay of the operate signals is defined with the *Operate delay GFC* setting. The operate signal is the binary output OPERATE_GFC.

### Faulted loop phase selection by the overcurrent method

The "Overcurrent" method is the basic method used for identifying the faulted phases. It can be used in applications where the fault current magnitude exceeds the load current despite the possible changes in the network configuration and fault type.

In the overcurrent-based faulted phase selection method, the amplitude of each phase current is compared to the *Str A Ph Sel GFC* threshold setting. If the phase current magnitude exceeds the value of *Str A Ph Sel GFC*, that particular phase is faulty.

Earth-fault recognition is always required to release a phase-to-earth impedance-measuring element.

*Table 834: Conversion from element start to monitored data signals*

| Start of element | START_GFC | STARTS_GFC | RELEASE PE | RELEASE PP |
|---|---|---|---|---|
| $I_A$> & EARTH_FLT | TRUE | AG Fault | AG Fault | No fault |
| $I_B$> & EARTH_FLT | TRUE | BG Fault | BG Fault | No fault |
| $I_C$> & EARTH_FLT | TRUE | CG Fault | CG Fault | No fault |
| $I_A$> & $I_B$> | TRUE | AB Fault | No fault | AB Fault |
| $I_B$> & $I_C$> | TRUE | BC Fault | No fault | BC Fault |
| $I_C$> & $I_A$> | TRUE | CA Fault | No fault | CA Fault |
| $I_A$> & $I_B$> & EARTH_FLT | TRUE | AB Fault | AB Fault | AB Fault |
| $I_B$> & $I_C$> & EARTH_FLT | TRUE | BC Fault | BC Fault | BC Fault |

Table continues on next page

| Start of element | START_GFC | STARTS_GFC | RELEASE PE | RELEASE PP |
|---|---|---|---|---|
| $I_C$> & $I_A$> & EARTH_FLT | TRUE | CA Fault | CA Fault | CA Fault |
| $I_A$> & $I_B$> & $I_C$>[1)] | TRUE | ABC Fault | No fault | ABC Fault |
| $I_A$> & $I_B$> & $I_C$> & EARTH_FLT[2)] | TRUE | ABC Fault | ABC Fault | ABC Fault |

1) This applies to near three-phase faults. If voltages are still relatively high, all PP releases are given.
2) This applies to near three-phase faults with EF indication. If voltages are still relatively high, all PE and PP releases (except ABC Fault) are given.

In case of a high-impedance earthed network, a phase preference logic can be added to complement the phase selection in case of a cross-country fault. This can affect the RELEASE_PE signals.

In case of a low-impedance earthed network, a faulted loop selection logic can be added to complement the phase selection in case of a two-phase-to-earth fault. This can affect the RELEASE_PE and RELEASE_PP signals.

### Faulted phase selection, the voltage-dependent overcurrent method

The "Voltdep overcur" method combines the overcurrent and undervoltage conditions. The phase current amplitude is compared to the *Str A Ph Sel GFC* threshold setting but a lower current *Lo A Ph Sel GFC* threshold is valid during an undervoltage condition. This increases the sensitivity of the fault detection. The amplitude of phase-to-earth and phase-to-phase voltages is compared to the *Ph V Ph Sel GFC* and *PP V Ph Sel GFC* settings. In case of a three-phase fault, the phase-to-phase voltages are monitored and compared to the *PP V Ph Sel GFC* setting.

Earth-fault recognition is always required to release a phase-to-earth impedance-measuring element.

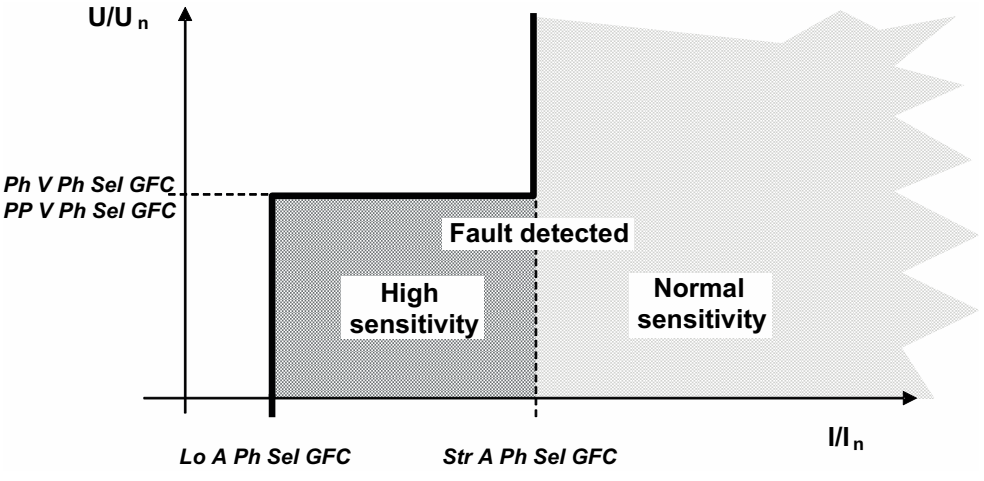



*Figure 469: Overcurrent/undervoltage characteristics*

*Table 835: Conversion from element start to monitored data signals*

| Start of element | START_GFC | STARTS_GFC | RELEASE PE | RELEASE PP |
|---|---|---|---|---|
| $I_A$> & $U_A$< & EARTH_FLT \| $I_A$>> & EARTH_FLT | TRUE | AG Fault | AG Fault | No fault |
| $I_B$> & $U_B$< & EARTH_FLT \| $I_B$>> & EARTH_FLT | TRUE | BG Fault | BG Fault | No fault |
| $I_C$> & $U_C$< & EARTH_FLT \| $I_C$>> & EARTH_FLT | TRUE | CG Fault | CG Fault | No fault |
| $I_A$> & $I_B$> & $U_{AB}$< \| $I_A$>> & $I_B$>> | TRUE | AB Fault | No fault | AB Fault |
| $I_B$> & $I_C$> & $U_{BC}$< \| $I_B$>> & $I_C$>> | TRUE | BC Fault | No fault | BC Fault |
| $I_C$> & $I_A$> & $U_{CA}$< \| $I_C$>> & $I_A$>> | TRUE | CA Fault | No fault | CA Fault |
| $I_A$> & $I_B$> & $U_{AB}$< & EARTH_FLT \| $I_A$>> & $I_B$>> & EARTH_FLT | TRUE | AB Fault | AB Fault | AB Fault |
| $I_B$> & $I_C$> & $U_{BC}$< & EARTH_FLT \| $I_B$>>$I_C$>> & EARTH_FLT | TRUE | BC Fault | BC Fault | BC Fault |
| $I_C$> & $I_A$> & $U_{CA}$< & EARTH_FLT \| $I_C$>>$I_A$>> & EARTH_FLT | TRUE | CA Fault | CA Fault | CA Fault |
| $I_A$> & $I_B$> & $I_C$ & $U_{AB}$< & $U_{BC}$< $U_{CA}$< \| $I_A$>>, $I_B$>> & $I_C$ >>[1)] | TRUE | ABC Fault | No fault | ABC Fault |
| $I_A$> & $I_B$> & $I_C$ & $U_{AB}$< & $U_{BC}$< $U_{CA}$< & EARTH_FLT \| $I_A$>>, $I_B$>> & $I_C$ >> & EARTH_FLT[2)] | TRUE | ABC Fault | No fault | ABC Fault |

1) This applies to near three-phase faults. If voltages are still relatively high, all PP releases are given.
2) This applies to near three-phase faults with EF indication. If voltages are still relatively high, all PE and PP releases (except ABC Fault) are given.

Ix> Phase current exceeds the *Lo A Ph Sel GFC* setting

Ix>> Phase current exceeds the *Str A Ph Sel GFC* setting

Ux< Phase voltage undershoots the *Ph V Ph Sel GFC* setting

Uxy< Phase-to-phase voltage undershoots the *PP V Ph Sel GFC* setting

### Faulted phase selection, the underimpedance method

The "Under impedance" and "OC AND Und impedance" methods use fault loop impedance for identifying the faulted phases. The advantage of the underimpedance criterion is that the sensitivity of the fault detection is independent of the source impedance. The underimpedance function has six impedance measuring elements. The phase-to-earth measuring elements are calculated:

$$\underline{Z}_A = \frac{\underline{U}_A}{\underline{I}_A}$$

(Equation 215)

$$\underline{Z}_B = \frac{\underline{U}_B}{\underline{I}_B}$$

(Equation 216)

$$\underline{Z}_C = \frac{\underline{U}_C}{\underline{I}_C}$$

(Equation 217)

The phase-to-phase measuring elements are based on the formula:

$$\underline{Z}_{AB} = \frac{\underline{U}_{AB}}{\underline{I}_{AB}}$$

(Equation 218)

$$\underline{Z}_{BC} = \frac{\underline{U}_{BC}}{\underline{I}_{BC}}$$

(Equation 219)

$$\underline{Z}_{CA} = \frac{\underline{U}_{CA}}{\underline{I}_{CA}}$$

(Equation 220)

The faulted phase identification is done by comparing the measured impedance to the operating characteristics in the impedance domain. If a measured fault loop impedance is inside the characteristics, the corresponding phases are identified as faulty.

The shape of the characteristic is selected with the *Z Chr Mod Ph Sel GFC* setting. Two shapes are available.

- "Mho (circular)", Non-directional mho
- "Quadrilateral", Non-directional quadrilateral

The two shapes can be flexibly configured. It is possible to set the reactive reaches independently in forward and in reverse direction and for phase-to-earth (Gnd) and phase-to-phase (PP) measurement elements, for example, the *X Gnd Fwd reach GFC*, *X Gnd Rv reach GFC*, *X PP Fwd reach GFC* and *X PP Rv reach GFC* settings. Also, the resistive reach in case of quadrilateral characteristic can be set both forward and reverse independently of reactive reaches, for example, the *Ris Gnd Fwd Rch GFC*,

*Ris Gnd Rv Rch GFC*, *Ris PP Fwd Rch GFC* and *Ris PP Rv Rch GFC* settings. The characteristic is always mirror-symmetric around the reactance axis.

The impedance settings are in primary ohms.

In case of heavy loaded feeders, the optional load encroachment logic can be enabled with the *Load Dsr mode GFC* setting. The logic reserves an area for load impedance defined by the *Ris Fwd Rch Lod GFC*, *Ris Rv Rch Lod GFC* and *Angle load area GFC* settings.

The underimpedance characteristics in case of phase-to-earth measuring elements are illustrated in Figure 470 and Figure 471. Similar characteristics apply also to phase-to-phase measuring elements with independent settings.

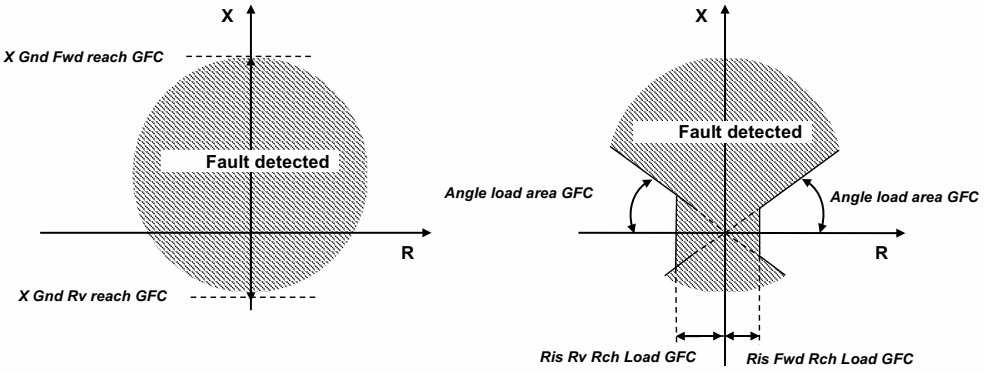



*Figure 470: Circular mho underimpedance characteristics*

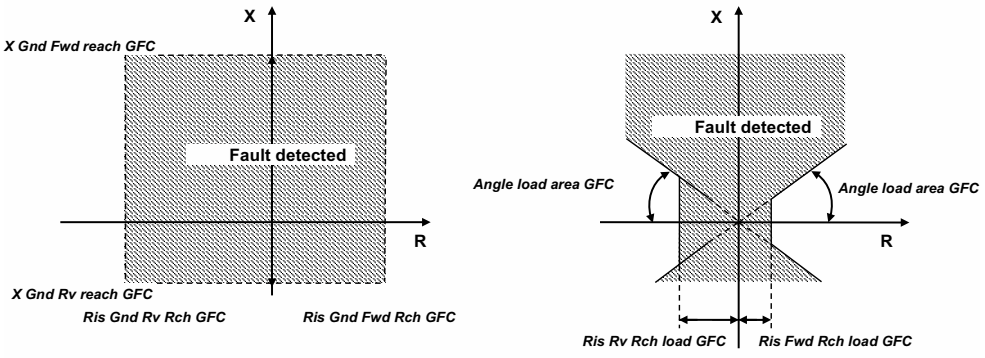



*Figure 471: Quadrilateral underimpedance characteristics*

*Table 836: Conversion from element start to monitored data signals*

| Start of element | START_GFC | STARTS_GFC | RELEASE PE | RELEASE PP |
|---|---|---|---|---|
| $Z_A$< & EARTH_FLT | TRUE | AG Fault | AG Fault | No fault |
| $Z_B$< & EARTH_FLT | TRUE | BG Fault | BG Fault | No fault |
| $Z_C$ < & EARTH_FLT | TRUE | CG Fault | CG Fault | No fault |
| $Z_{AB}$< | TRUE | AB Fault | No fault | AB Fault |
| $Z_{BC}$< | TRUE | BC Fault | No fault | BC Fault |
| $Z_{CA}$< | TRUE | CA Fault | No fault | CA Fault |
| $Z_{AB}$< & EARTH_FLT | TRUE | AB Fault | AB Fault | AB Fault |
| $Z_{BC}$< & EARTH_FLT | TRUE | BC Fault | BC Fault | BC Fault |
| $Z_{CA}$< & EARTH_FLT | TRUE | CA Fault | CA Fault | CA Fault |
| $Z_{AB}$< & $Z_{BC}$< & $Z_{CA}$<[1)] | TRUE | ABC Fault | No fault | ABC Fault |
| $Z_{AB}$< & $Z_{BC}$< & $Z_{CA}$< & EARTH_FLT[2)] | TRUE | ABC Fault | No fault | ABC Fault |

1) This applies to near three-phase faults. If voltages are still relatively high, all PP releases are given, depending on the impedances seen inside the GFC zone.
2) This applies to near three-phase faults with EF indication. If voltages are still relatively high, all or some PE and PP releases (except ABC Fault) are given, depending on the impedances seen inside the GFC zone.

In case of a high-impedance earthed network, a phase preference logic can be added to complement the phase selection in case of a cross-country fault. This can affect the RELEASE_PE signals.

In case of a low-impedance earthed network, a faulted loop selection logic can be added to complement the phase selection in case of a two-phase-to-earth fault. This can affect the RELEASE_PE and RELEASE_PP monitored data signals.

## Cross-country fault detection function for high-impedance earthed networks

In isolated and high-impedance earthed networks, the overvoltages produced by a single-phase earth fault may lead to a cross-country fault, where two simultaneous single-phase earth faults are present in the system but in different locations and phases. The cross-country fault is hazardous because the magnitude of the fault current through earth can be as high as in the case of a two-phase short circuit fault. The protection must therefore remove the cross-country fault quickly without sacrificing the selectivity. This can be done with a phase preference logic which is activated by the cross-country fault detection function. The phase preference logic

transforms the fault into an ordinary single-phase earth fault by selectively tripping one of the faulted feeders.

The cross-country detecting function can become active only if the network is either isolated or high-impedance earthed (*System grounding GFC* = "High impedance" or selection "From input" and binary input SYS_EARTHING is active).

The fault detection is based on monitoring two quantities.

- Residual current
- Phase-to-phase voltages

A cross-country fault is detected if:

- An earth fault is detected, EARTH_FLT = True
  AND
- The calculated residual current exceeds the value of *Gnd Op A XC GFC* setting. This setting value should exceed the highest expected single-phase earth-fault current (calculated from phase currents). The condition is needed because the cable current transformer saturates easily due to the high fault current.
  AND
- The residual overcurrent condition must be valid at least for the duration defined by the *Cross-country Dl GFC* setting. This shows that the detection is not misled by the high-magnitude initial transients of a single-phase earth fault.
  OR
- Any phase-to-phase voltage drops below the value of the *PP voltage XC GFC* setting. The undervoltage condition is based on the fact that during a single-phase earth fault, the phase-to-phase voltages are unaffected in isolated and high-impedance earthed networks. The fulfilment of this criterion in combination with the residual overcurrent condition avoids the need for any delays.

The detection of a cross-country fault is indicated by the XC_FLT output signal.

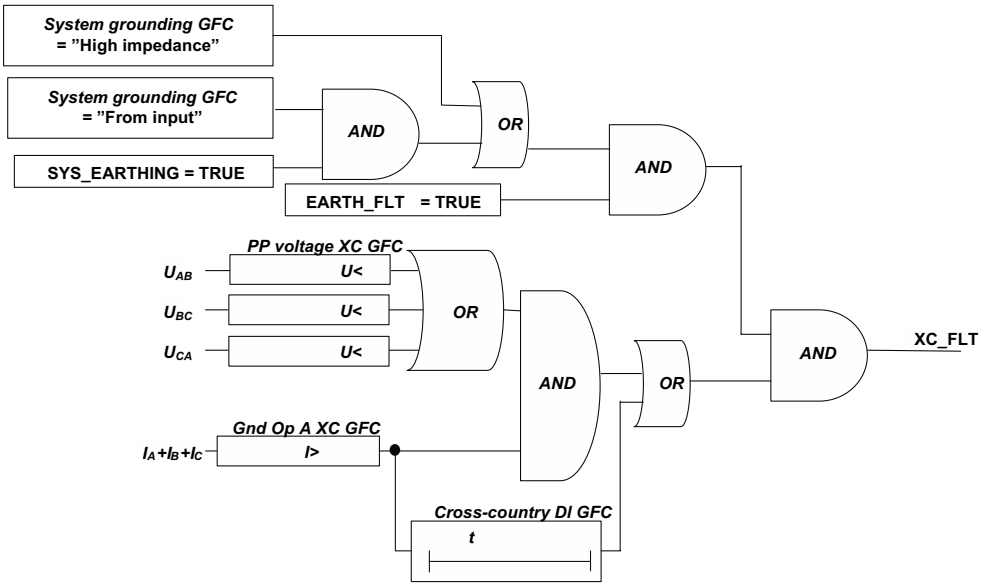



*Figure 472: Cross-country fault detection logic for high-impedance earthed networks*

## Phase preference logic for high-impedance earthed networks

The phase preference logic is applicable only in isolated and high-impedance earthed networks. The phase preference logic for high-impedance earthed networks is a supplement to the faulted phase identification function. It provides selective filtering of phase-to-earth measurement elements in case of a cross-country fault or double earth-fault in isolated and high-impedance earthed networks.

The logic releases the preferred phase-to-earth loop for measurement when a cross-country fault with two faulted phase-to-earth loops is detected. If only one faulted phase-to-earth loop is detected by phase selection logic (GFC), the other faulted phase-to-earth loop is determined by analysing voltages. The phase preference scheme must be set in the same way for the entire system so that all distance relays measure the same preferred phase-to-earth loop. As a result, the cross-country fault is changed into an ordinary single-phase earth-fault by selectively tripping one of the faulted feeders.

The phase preference logic influences only the selection of the phase-earth loops and has no effect on the selection of the phase-to-phase loops. The influence is seen in the RELEASE_PE monitored data. The logic does not affect the RELEASE_PP monitored data or START_GFC/STARTS_GFC outputs.

All schemes, except "No filter", require a cross-country fault detection XC_FLT = TRUE; otherwise all the phase-to-earth measuring elements are blocked resulting in RELEASE_PE value "No fault". This guarantees that tripping at a single-phase earth fault in the high-impedance earthed network is blocked.

If a cross-country fault is detected, XC_FLT = TRUE and only a single fault loop can be identified as faulty by the faulted phase selection function, then that loop is directly

selected for measurement. In such a case, simultaneous tripping of both faulted feeders during a cross-country fault is expected.

**Example**

Consider a cross-country fault where phases A and B become faulted simultaneously. All relays, R1, R2, R3 and R4, are equipped with an "Acyc C-A-B" phase preference scheme.

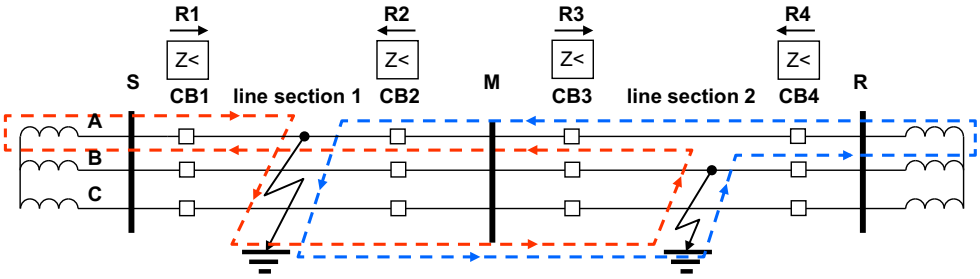



*Figure 473: Cross-country fault (or double earth fault) in a high-impedance earthed system*

The expected operations of the relays are:

- R1: The cross-country fault cannot be detected as the residual current does not flow through relay R1. The phase-to-phase loop AB is measured in the forward direction but the estimated impedance represents an average impedance between two fault locations and therefore is not seen in zone Z1.
- R2: The cross-country fault is detected as a large residual current flows through relay R2. Phase A earth fault is seen in forward direction and phase B earth fault in reverse direction. Based on "Acyc C-A-B" phase preference scheme, phase A is selected for measurement. Relay R2 operates without delay and opens the CB2 circuit breaker.
- R3: The cross-country fault is detected when a large residual current flows through relay R3. The phase A earth fault is seen in reverse direction and phase B earth fault in forward direction. Based on the "Acyc C-A-B" phase preference scheme, phase A is selected for measurement. As the fault direction does not coincide with the zone direction, relay R3 does not operate.
- R4: Same as relay R1

As a result of the circuit breaker CB2 operation, the cross-country fault is transformed into an ordinary single-phase earth fault.

Table 837, Table 838 and Table 839 summarize the available phase preference logic schemes and their operation in different fault scenarios. The logic is selected with the *Ph Prf mode Hi Z GFC* setting. In case the logic is not required, then the "No filter" option should be selected.

"No filter" option does not block the single-phase earth-faults, therefore this option should be used with caution.

*Table 837: Supported phase preference logic schemes for high-impedance earthed networks and their operation in case of single phase start with and without cross-country fault detection*

| Ph Prf mode Hi Z GFC | | Faulted loops | | | | | |
|---|---|---|---|---|---|---|---|
| | | A & EARTH_FLT | B & EARTH_FLT | C & EARTH_FLT | A & XC_FLT | B & XC_FLT | C & XC_FLT |
| | | RELEASE_PE | | | RELEASE_PP | | |
| 1 | No filter | AG Fault | BG Fault | CG Fault | AG Fault | BG Fault | CG Fault |
| 2 | No preference | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 3 | Cyc A-B-C-A | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 4 | Cyc A-C-B-A | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 5 | Acyc A-B-C | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 6 | Acyc A-C-B | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 7 | Acyc B-A-C | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 8 | Acyc B-C-A | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 9 | Acyc C-A-B | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 10 | Acyc C-B-A | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |

*Table 838: Supported phase preference logic schemes for high-impedance earthed networks and their operation in case of two phase starts without cross-country fault detection*

| Ph Prf mode Hi Z GFC | | Faulted loops | | | | | |
|---|---|---|---|---|---|---|---|
| | | A & B EARTH_FLT | B & C EARTH_FLT | C & A EARTH_FLT | A & B EARTH_FLT | B & C EARTH_FLT | C & A EARTH_FLT |
| | | RELEASE_PE | | | RELEASE_PP | | |
| 1 | No filter | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 2 | No preference | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 3 | Cyc A-B-C-A | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 4 | Cyc A-C-B-A | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 5 | Acyc A-B-C | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 6 | Acyc A-C-B | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 7 | Acyc B-A-C | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 8 | Acyc B-C-A | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 9 | Acyc C-A-B | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 10 | Acyc C-B-A | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |

*Table 839: Supported phase preference logic schemes for high-impedance earthed networks and their operation in case of two phase starts with cross-country fault detection*

| Ph Pref logic Hi Imp | | Faulted loops | | | | | |
|---|---|---|---|---|---|---|---|
| | | A & B XC_FLT | B & C XC_FLT | C & A XC_FLT | A & B XC_FLT | B & C XC_FLT | C & A XC_FLT |
| | | RELEASE_PE | | | RELEASE_PP | | |
| 1 | No filter | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 2 | No preference | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 3 | Cyc A-B-C-A | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 4 | Cyc A-C-B-A | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |

Table continues on next page

| Ph Pref logic Hi Imp | | Faulted loops | | | | | |
|---|---|---|---|---|---|---|---|
| | | A & B XC_FLT | B & C XC_FLT | C & A XC_FLT | A & B XC_FLT | B & C XC_FLT | C & A XC_FLT |
| | | RELEASE_PE | | | RELEASE_PP | | |
| 5 | Acyc A-B-C | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 6 | Acyc A-C-B | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 7 | Acyc B-A-C | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 8 | Acyc B-C-A | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 9 | Acyc C-A-B | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 10 | Acyc C-B-A | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |

## Faulted loop phase selection for low-impedance earthed networks

The faulted loop selection logic for low-impedance earthed networks serves as a supplement to the faulted phase identification function and it provides a selective filtering of measurement elements in case of a two-phase-to-earth fault in low-impedance earthed networks. The earth faults can be located close to each other.




*Figure 474: Two-phase-to-earth fault in low-impedance earthed system*

Impedance can be measured during a two-phase-to-earth fault when the earth faults are located in the same direction and they are in close proximity to each other. Generally, too large an impedance is measured for the lagging phase-to-earth loop, for example phase B in an AB-E fault. Similarly, low impedance is measured for the leading phase-to-earth loop, for example phase A in an AB-E fault. The corresponding phase-to-phase loop is measured correctly, for example phase-to-phase loop AB in an AB-E fault.

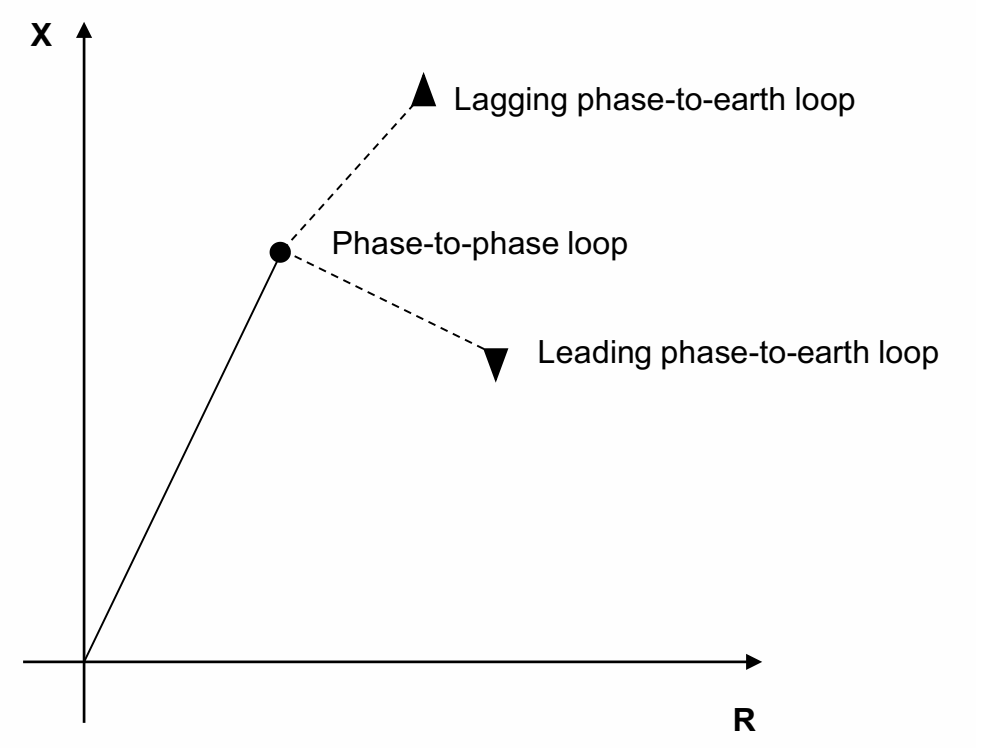



*Figure 475: Impedance measured during a two-phase-to-earth fault*

The available faulted loop selection logic schemes allow blocking the phase-earth loop of the leading phase to prevent overreaching *Ph Prf mode Lo Z GFC* = "BLK leading PE".

It is also possible to block the lagging phase-earth loop, *Ph Prf mode Lo Z GFC* = "BLK lagging PE". If only the phase-to-phase loop or phase-to-earth loops must be measured, settings *Ph Prf mode Lo Z GFC* = "PP only" or *Ph Prf mode Lo Z GFC* = "PE only" should be used, and if the logic is not required, "All loops" option should be selected.

The tables summarize the available faulted loop selection logic schemes and their operations. The logic is selected with the *Ph Prf mode Lo Z GFC* setting.

*Table 840: Supported faulted loop phase selection schemes for low-impedance earthed networks and their influence on the RELEASE_PE monitored data*

| | Ph Prf mode Lo Z GFC | | | | |
|---|---|---|---|---|---|
| Element start | All loops | PE only | PP only | BLK leading PE | BLK lagging PE |
| | RELEASE_PE | | | | |
| A & B & EARTH_FLT | AB Fault | AB Fault | No fault | BG Fault | AG Fault |
| B & C & EARTH_FLT | BC Fault | BC Fault | No fault | CG Fault | BG Fault |
| C & A & EARTH_FLT | CA Fault | CA Fault | No fault | AG Fault | CG Fault |

*Table 841: Supported faulted loop phase selection schemes for low-impedance earthed networks and their influence on the RELEASE_PP monitored data*

| | Ph Prf mode Lo Z GFC | | | | |
|---|---|---|---|---|---|
| Element start | All loops | PE only | PP only | BLK leading PE | BLK lagging PE |
| | RELEASE_PP | | | | |
| A & B & EARTH_FLT | AB Fault | No fault | AB Fault | AB Fault | AB Fault |
| B & C & EARTH_FLT | BC Fault | No fault | BC Fault | BC Fault | BC Fault |
| C & A & EARTH_FLT | CA Fault | No fault | CA Fault | CA Fault | CA Fault |

## Impedance protection zones

DSTPDIS has five flexible and configurable impedance zones Z1..Z5. The number of active zones has to be selected by setting *Select active zones*. For example, all five zones can be set active by selection "All 5 zones" and only zone 1 is activated by "Zone 1". The purpose of this setting is effectively dimming non-active zone settings in PCM600 or the protection relay's HMI.

**Example:**

If only zones 1 and 3 should be activated, "Zones 1-3" should be selected and then zone 2 timers can be disabled or `BLOCK_Z2` can be activated to hide zone 2 operations.

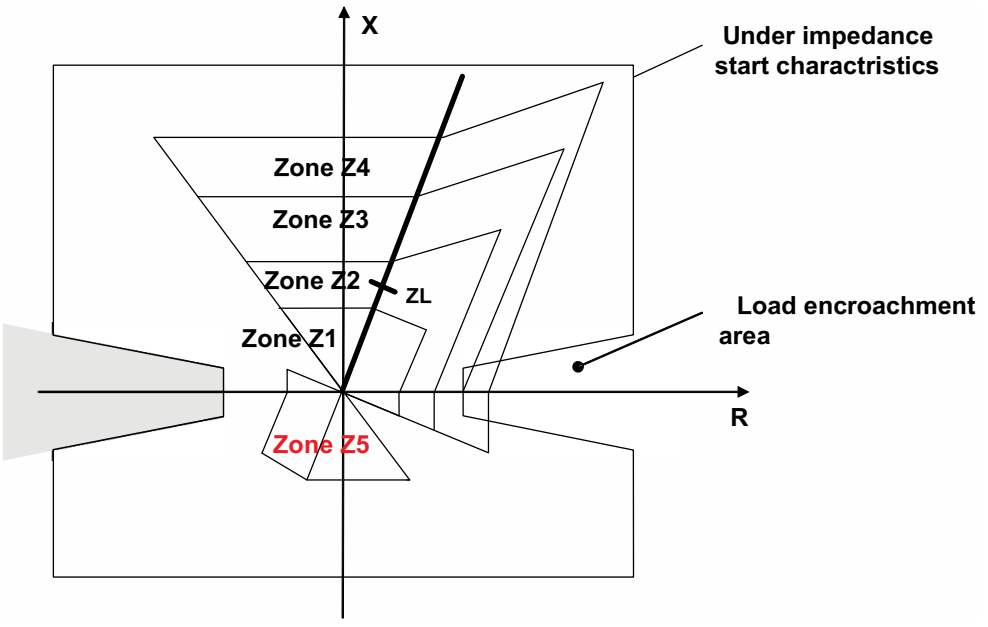



*Figure 476: Zones of DSTPDIS function (example 1)*

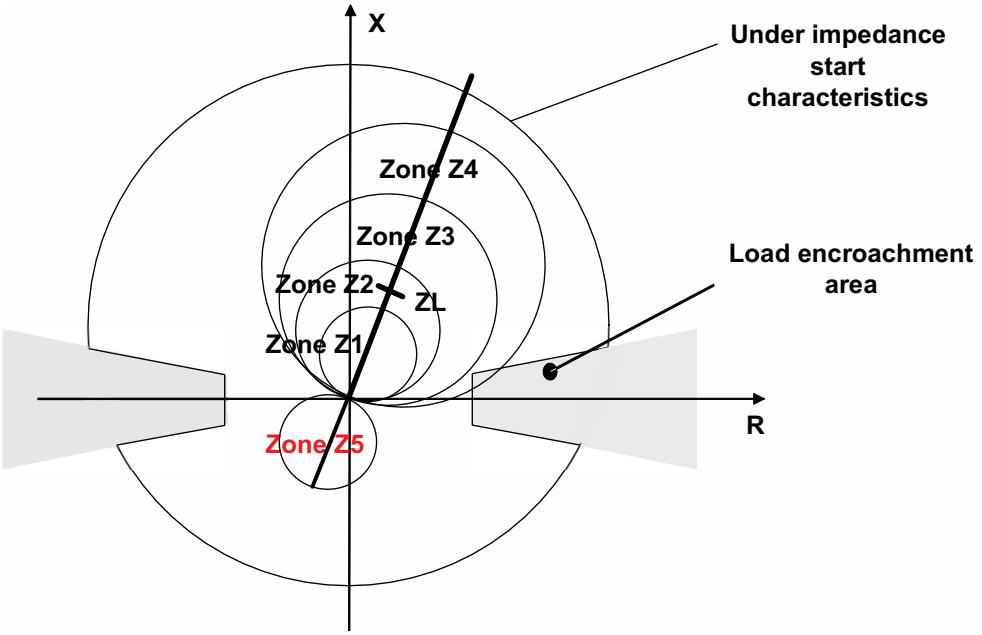



*Figure 477: Zones of DSTPDIS function (example 2)*

Each zone in DSTPDIS provides three independent phase-to-earth and three phase-to-phase measuring elements. A three-phase fault is measured with a dedicated measuring element. Each measuring element is controlled by the faulted loop phase selection function. Based on the recognized fault type, the release signals are given for the corresponding measuring elements.

DSTPDIS supports both fault detection dependent control of zone timers and zone-dedicated timer control for maximum application flexibility. Zone-dedicated timer control is enabled when configuration parameter *Zone timer mode* is set to "Independent" (change requires relay reboot). In this case, operate delay timers of protection zones are independent of each other and start when a fault is seen in their protection zone. Fault detection dependent control of zone timers is enabled when *Zone timer mode* is set to "Common". In this case, operate delay timers of all protection zones start simultaneously as soon as the fault is seen by the GFC. The operation of a particular zone is given after the set *Operate delay GFC* (considering the fault type) is detected. The actual operate time is the value calculated from the initial fault detection and it is not affected, for example, in case the fault moves between zones.

The general indication of fault for each zone is given in the `START_Zx` (x = 1...5) binary output. The faulted phase information can be found from the STARTS_Zx (x = 1... 5) integer type output signal. This signal indicates (bitwise) the started measuring elements for the corresponding phase. Value 0 does not exist but due to the IEC 61850 standard requirement, it is shown by value “-5” as “No fault”. Value range is thus -5, 1..63. The three-phase fault is here indicated by “AB Fault, BC Fault, CA Fault”. However, three-phase fault indication for GFC depends also on the additional condition for voltage (see Table 835.

*Table 842: STARTS_Zx information*

| Value | Value information |
|---|---|
| -5 | No zone starts |
| 1 | AG Fault |
| 2 | BG Fault |
| 3 | AG Fault, BG Fault |
| 4 | CG Fault |
| 5 | AG Fault, CG Fault |
| 6 | BG Fault, CG Fault |
| 7 | AG Fault, BG Fault, CG Fault |
| 8 | AB Fault |
| 9 | AG Fault, AB Fault |
| 10 | BG Fault, AB Fault |
| 11 | AG Fault, BG Fault, AB Fault |
| 12 | CG Fault, AB Fault |
| 13 | AG Fault, CG Fault, AB Fault |
| 14 | BG Fault, CG Fault, AB Fault |
| 15 | AG Fault, BG Fault, CG Fault, AB Fault |
| 16 | BC Fault |
| 17 | AG Fault, BC Fault |
| 18 | BG Fault, BC Fault |
| 19 | AG Fault, BG Fault, BC Fault |
| 20 | CG Fault, BC Fault |
| 21 | AG Fault, CG Fault, BC Fault |
| 22 | BG Fault, CG Fault, BC Fault |
| 23 | AG Fault, BG Fault, CG Fault, BC Fault |
| 24 | AB Fault, BC Fault |
| 25 | AG Fault, AB Fault, BC Fault |
| 26 | BG Fault, AB Fault, BC Fault |
| 27 | AG Fault, BG Fault, AB Fault, BC Fault |
| 28 | CG Fault, AB Fault, BC Fault |
| 29 | AG Fault, CG Fault, AB Fault, BC Fault |
| 30 | BG Fault, CG Fault, AB Fault, BC Fault |
| 31 | AG Fault, BG Fault, CG Fault, AB Fault, BC Fault |
| 32 | CA Fault |
| 33 | AG Fault, CA Fault |
| 34 | BG Fault, CA Fault |
| 35 | AG Fault, BG Fault, CA Fault |
| 36 | CG Fault, CA Fault |
| 37 | AG Fault, CG Fault, CA Fault |

Table continues on next page

| Value | Value information |
|---|---|
| 38 | BG Fault, CG Fault, CA Fault |
| 39 | AG Fault, BG Fault, CG Fault, CA Fault |
| 40 | AB Fault, CA Fault |
| 41 | AG Fault, AB Fault, CA Fault |
| 42 | BG Fault, AB Fault, CA Fault |
| 43 | AG Fault, BG Fault, AB Fault, CA Fault |
| 44 | CG Fault, AB Fault, CA Fault |
| 45 | AG Fault, CG Fault, AB Fault, CA Fault |
| 46 | BG Fault, CG Fault, AB Fault, CA Fault |
| 47 | AG Fault, BG Fault, CG Fault, AB Fault, CA Fault |
| 48 | BC Fault, CA Fault |
| 49 | AG Fault, BC Fault, CA Fault |
| 50 | BG Fault, BC Fault, CA Fault |
| 51 | AG Fault, BG Fault, BC Fault, CA Fault |
| 52 | CG Fault, BC Fault, CA Fault |
| 53 | AG Fault, CG Fault, BC Fault, CA Fault |
| 54 | BG Fault, CG Fault, BC Fault, CA Fault |
| 55 | AG Fault, BG Fault, CG Fault, BC Fault, CA Fault |
| 56 | AB Fault, BC Fault, CA Fault |
| 57 | AG Fault, AB Fault, BC Fault, CA Fault |
| 58 | BG Fault, AB Fault, BC Fault, CA Fault |
| 59 | AG Fault, BG Fault, AB Fault, BC Fault, CA Fault |
| 60 | CG Fault, AB Fault, BC Fault, CA Fault |
| 61 | AG Fault, CG Fault, AB Fault, BC Fault, CA Fault |
| 62 | BG Fault, CG Fault, AB Fault, BC Fault, CA Fault |
| 63 | AG Fault, BG Fault, CG Fault, AB Fault, BC Fault, CA Fault |



The operate signal from each zone is the OPERATE_Zx (x = 1...5) binary output signal.

The output from each zone can be blocked and the timers are also reset with the BLOCK_Zx (x = 1...5) binary input signal.

The TLT_ANG_CONFLICT monitored data is an assisting integer output which supervises the validity of a tilt angle of quadrilateral characteristics so that the characteristics always produce a closed boundary.

### Impedance measurement

DSTPDIS provides three independent phase-to-earth and phase-to-phase measuring elements per zone. The three-phase fault is measured with a dedicated measurement element.

The impedance measurement is done similarly regardless of the zone shape. The operation is based on impedance mapping where the fault loop impedance is first calculated and then compared with the zone boundaries. If impedance is recognized inside the operation zone, the corresponding operate output is activated after the operate time has elapsed.

### Phase-to-earth impedance measuring elements

The phase-to-earth impedance measuring elements provide the basic earth-fault protection in direct or low-impedance earthed networks. The earth-fault protection is enabled with the setting *Op Mod Gnd loops Znx* (x = 1...5) = "True". The enabling requires that all three phase-to-earth voltages are measured. Otherwise, the release of the earth-fault measuring elements is automatically blocked.

The reach of phase-to-earth measuring elements is based on loop impedance

$$\underline{Z}_1 + \underline{Z}_N + RF = \left( R_1 + \frac{R_0 - R_1}{3} \right) + j \cdot \left( X_1 + \frac{X_0 - X_1}{3} \right) + RF$$

(Equation 221)



The earth return path impedance is included in the calculated fault loop impedance of the phase-to-earth measuring element.

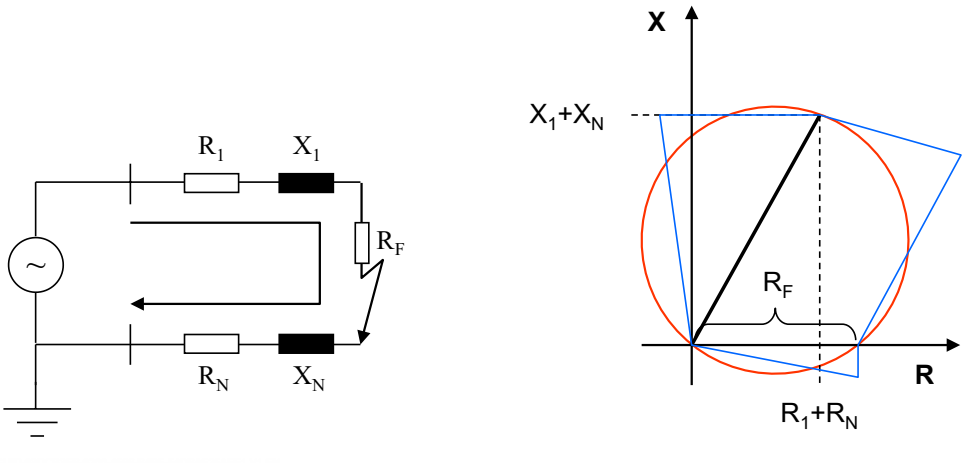



*Figure 478: The fault loop impedance model for phase-to-earth impedance measuring elements*

$R_1$ Positive-sequence resistance from measuring point to fault location

$X_1$ Positive-sequence reactance from measuring point to fault location

$R_N$ Earth return path resistance = $(R_0 - R_1)/3$ from measuring point to fault location

$X_N$ Earth return path reactance = $(X_0 - X_1)/3$ from measuring point to fault location

$R_0$ Zero-sequence resistance from measuring point to fault location

$X_0$ Zero-sequence reactance from measuring point to fault location

$R_F$ Physical fault resistance between phase and earth (includes arc and earthing resistances)

Considering the load in case of a single line-to-earth fault, conventional distance protection might overreach at the exporting end and underreach at the importing end. DSTPDIS has a load compensation functionality which increases the security in such applications. Load compensation is enabled with the setting *Load Comp zone x* (x = 1...5) = "True".

Load compensation is used only with single phase-to-earth faults. Load compensation is not used if multiple phases are included in the fault (more than one single earth fault release).

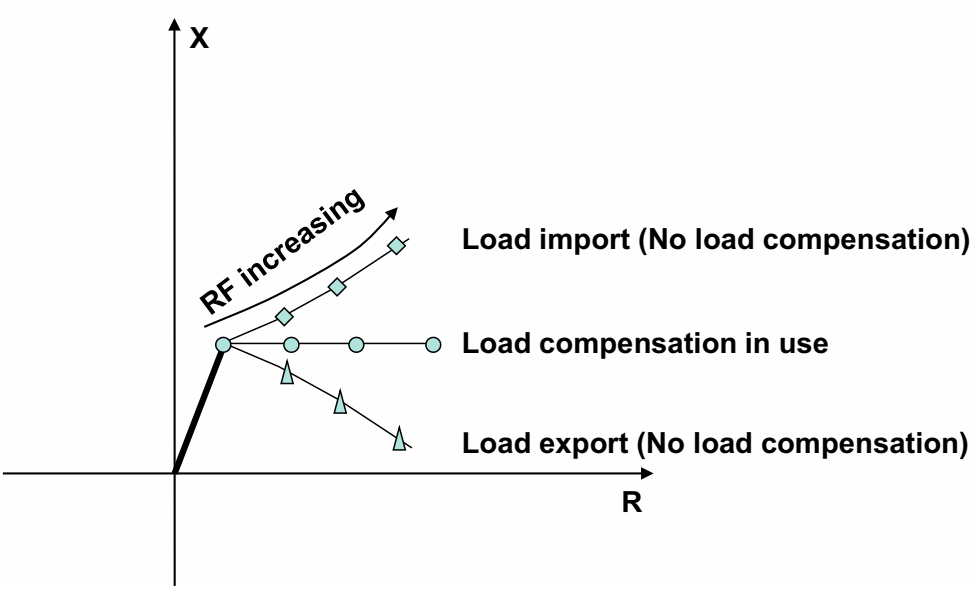



*Figure 479: Operation principle of load compensation functionality*

When three-phase feeders are placed close to each other, a mutual inductive zero-sequence coupling of the current path exists. This has an impact during earth faults. If no measures are taken, this leads to errors in the impedance calculation. The residual current of the parallel line induces a voltage in the protection line and changes the measured voltage at the relay location. The influence depends on the system configuration, that is, the magnitude and polarity of the residual current in a parallel line.

The phase-to-earth impedance measuring elements in DSTPDIS take the zero-sequence mutual coupling into account in impedance calculation. The compensation is enabled and set with settings *Par line Comp zone x* (="True"), *Mutual R0 zone x* and *Mutual X0 zone x* (x = 1...5). The residual current of the parallel line must be available and connected to the `I3P_PAR` input. The earth-current balance logic is implemented to prevent malfunctioning of the protection relay on the healthy parallel line. This means that the parallel compensation functionality is internally blocked when the ratio between residual current of the parallel line and protected lines exceeds the *Fact EF current Bal* configuration setting.

The parallel line compensation functionality is only used with single phase-to-earth faults. Parallel line compensation is not used if multiple phases are included into fault (more than one single earth fault releases).

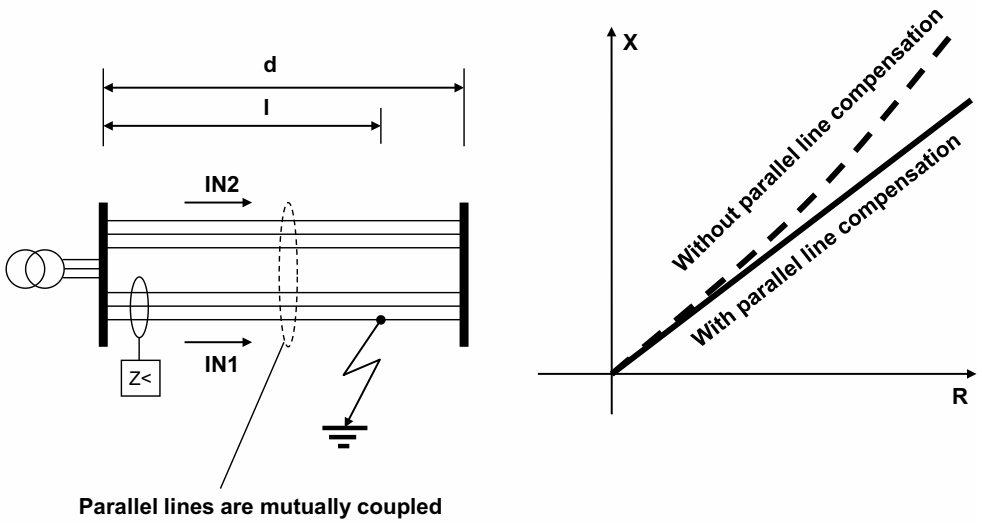



*Figure 480: Operation principle of parallel line compensation functionality*

The operation time delay is defined with the *Gnd operate Dl Znx* (x = 1...5) setting. The timer can be disabled with the *Gnd Op Dl mode Znx* = "False" setting. This blocks the OPERATE_Zx (x = 1...5) output of the phase-to-earth measuring elements.

### Phase-to-phase impedance measuring elements

The phase-to-phase distance protection is suitable as a basic protection function against two-phase short circuit faults in various networks, regardless of the treatment of the neutral point. The short circuit fault protection is enabled with the *Op Mod PP loops Znx* (x = 1...5) = "True" setting.

The reach of the phase-to-phase measuring elements is based on the loop impedance

$$\underline{Z}_1 + \frac{R_F}{2} = R_1 + j \cdot X_1 + \frac{R_F}{2}$$

(Equation 222)

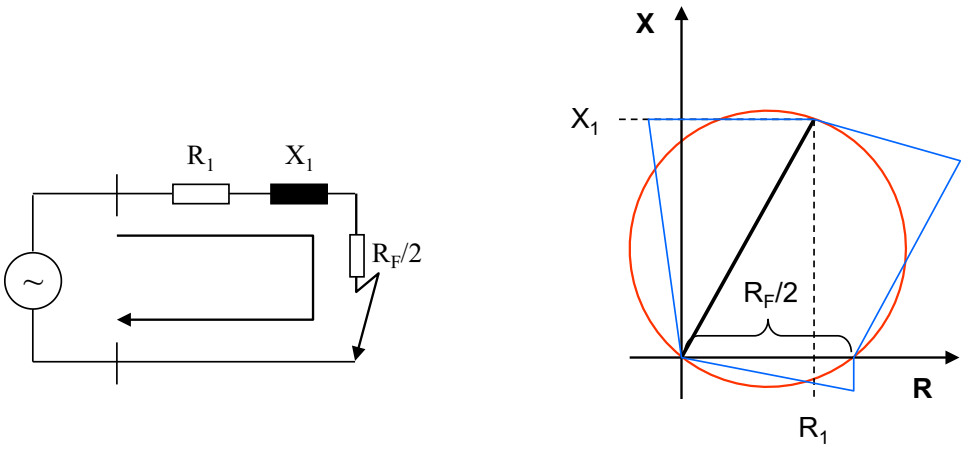



*Figure 481: The fault loop impedance model for phase-to-phase impedance measuring elements*

$R_1$ Positive-sequence resistance from measuring point to fault location

$X_1$ Positive-sequence reactance from measuring point to fault location

$R_F$ Physical fault resistance between phases, for example, arc resistance

The phase-to-phase impedance measuring elements measure only half of the physical fault resistance between phases. This must be taken into account when the resistive reach of the phase-to-phase elements is set (that is, setting the value of 5 Ω corresponds to 5 + 5=10 Ω of physical arc resistance between phases).

The resistive reach setting is common for phase-to-phase and three-phase impedance measuring elements.

The operation time delay is defined with the setting *PP operate delay Znx* (x = 1... 5). The timer can be disabled with the setting *PP Op delay Mod Znx* = "False". This blocks the `OPERATE_Zx` (x = 1... 5) output of the phase-to-phase measuring elements.

### Three-phase impedance measuring element

DSTPDIS has a dedicated measuring element for a three-phase short circuit fault for each zone. The three-phase measuring element uses the positive-sequence quantities for a fault loop impedance estimation which increases the accuracy by reducing the influence of line parameter asymmetry. This is advantageous especially in case of non-transposed, asymmetrical lines. The three-phase impedance measuring element is enabled together with the phase-to-phase impedance elements by the setting *Op Mod PP loops Znx* (x = 1... 5) = "True".

The reach of the three-phase measuring element is based on the loop impedance

*Three-phase measuring element reach = $Z_1$ + $R_F$ = $R_1$ + j $X_1$ + $R_F$*

(Equation 223)

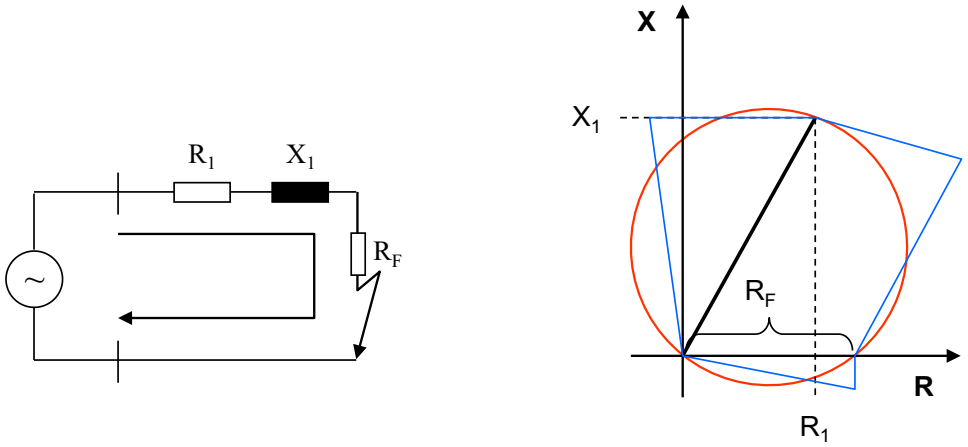



*Figure 482: The fault loop impedance model for three-phase impedance measuring element*

$R_1$ Positive-sequence resistance from measuring point to fault location

$X_1$ Positive-sequence reactance from measuring point to fault location

$R_F$ Physical fault resistance per phase, for example, arc resistance

The three-phase impedance measuring element measures the physical fault resistance per phase. The resistive reach setting is common for three-phase and phase-to-phase impedance measuring elements.

The time delay of operation is defined with the *PP operate delay Znx* (x = 1... 5) setting. The timer can be disabled with the setting *PP Op delay Mod Znx* = "False". This blocks the `OPERATE_Zx` (x = 1... 5) output of the three-phase measuring elements.

### Entering the line reach

The line reach is entered in primary ohms. The impedance format is selected with *Impedance mode Zn* = "Rectangular" for the vectors R, X and "Polar" for the magnitude and angle.

### *Impedance mode Zn* = Rectangular

In case of phase-to-phase or three-phase impedance measuring elements, the line reach is defined with:

- Resistive reach: *R1 zone x* (x = 1...5)
- Reactive reach: *X1 zone x* (x = 1...5)

In case of non-directional characteristics, the reactive reach in reverse direction is defined with the *X1 reverse zone x* (x = 1...5) setting. The characteristic line angle, denoted as α, is the same for both forward and reverse direction.

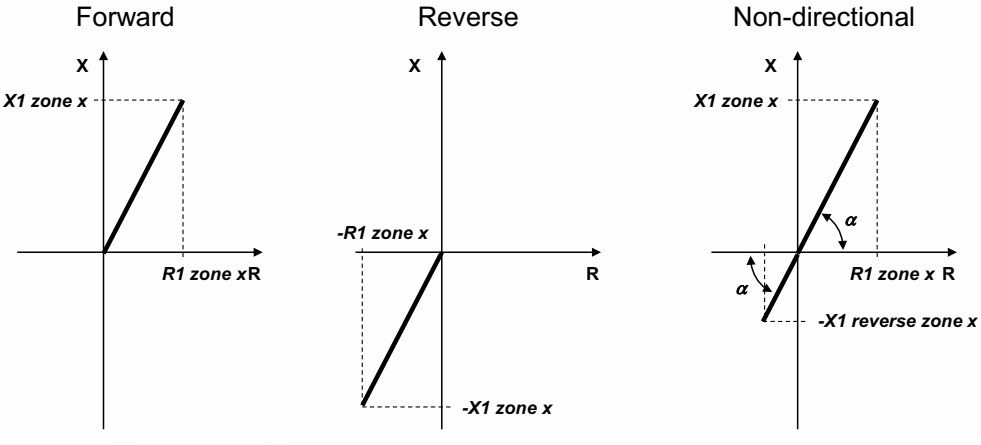



*Figure 483: Settings which define the line reach for phase-to-phase or three-phase impedance measuring elements if Impedance mode Zn = "Rectangular"*

In case of phase-to-earth impedance measuring elements, the line reach is defined with:

- Resistive reach: $(2 \cdot R1\ zone\ x + R0\ zone\ x)/3$, (x = 1...5)
- Reactive reach: $(2 \cdot X1\ zone\ x + X0\ zone\ x)/3$, (x = 1...5)

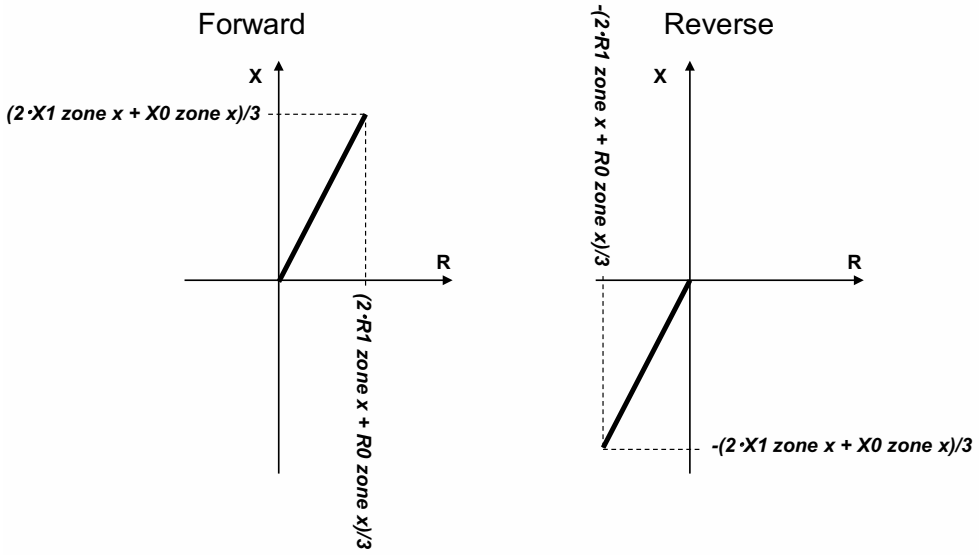



*Figure 484: Settings which define the line reach for phase-to-earth impedance measuring elements if Impedance mode Zn = "Rectangular", forward or reverse directionality*

In case of non-directional characteristics, the reactive reach in reverse direction is defined with the *X1 reverse zone x* (x = 1...5) setting. The total reactive reach in reverse direction includes a part which is common to both forward and reverse direction. This part is automatically calculated based on the values of the settings *R1 zone x*, *R0 zone 0*, *X1 zone x* and *X0 zone x*. The characteristic line angle, denoted as α, is the same for forward and reverse direction.

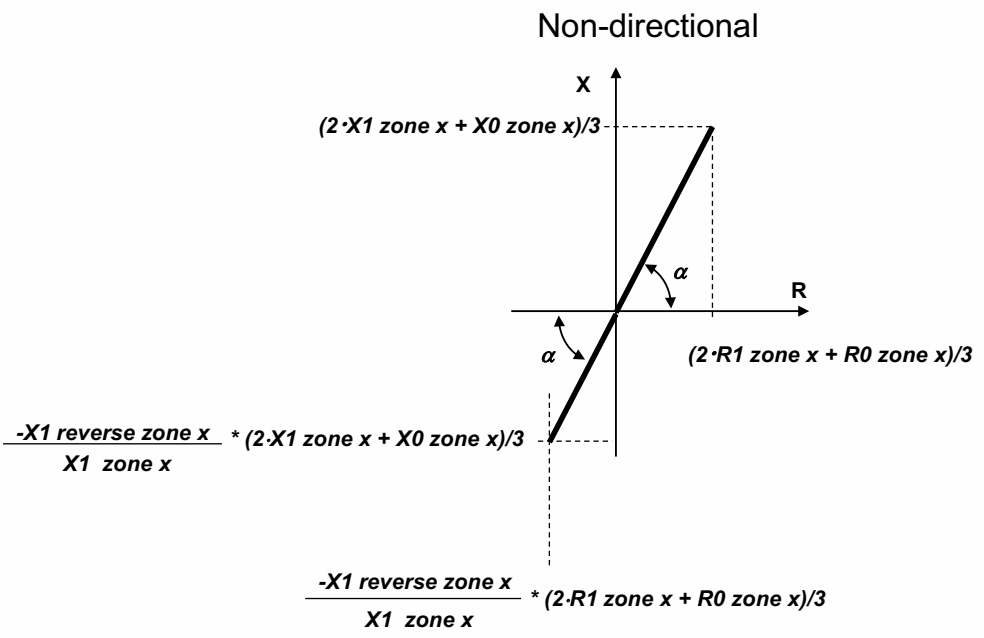



*Figure 485: Settings which define the line reach for phase-to-earth impedance measuring elements if Impedance mode Zn = "Rectangular", non-directional directionality*

## Impedance mode Zn = Polar

In case of phase-to-phase or three-phase impedance measuring elements, the line reach is defined with:

- *Z1 zone x* (x = 1...5)
- *Z1 angle zone x* (x = 1...5)

In case of non-directional characteristics, the reactive reach magnitude in reverse direction is defined with the *Z1 reverse zone x* (x = 1...5) setting. The characteristic line angle, *Z1 angle zone x*, is the same for forward and reverse direction.

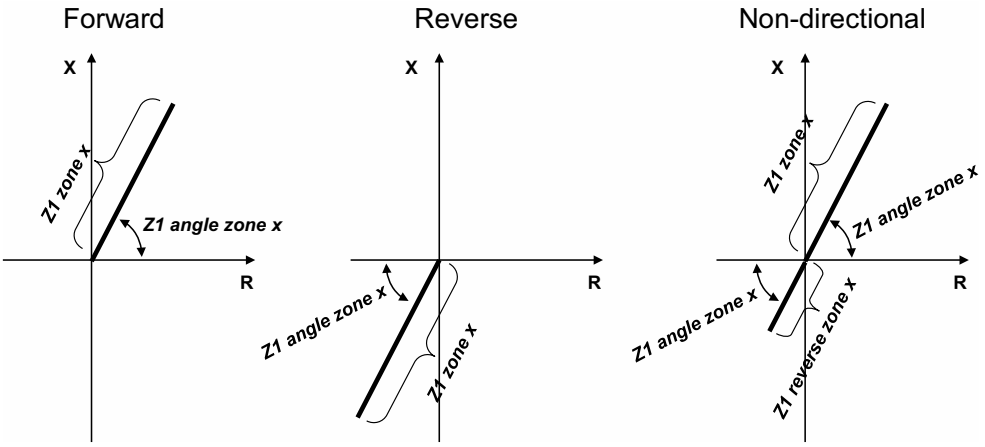



*Figure 486: Settings which define the line reach for phase-to-phase or three-phase impedance measuring elements if Impedance mode Zn = "Polar"*

In case of phase-to-earth impedance measuring elements, the line reach is defined with:

- *Z1 zone x* (x = 1...5)
- *Z1 angle zone x* (x = 1...5)
- *Factor K0 zone x* (x = 1...5)
- *Factor K0 angle Zn x* (x = 1...5)

The reach magnitude and angle are:

$$Magnitude = abs(\underline{Z}1 + \underline{Z}1 \cdot \underline{K}_N)$$

(Equation 224)

$$Angle = angle(\underline{Z}1 + \underline{Z}1\underline{K}_N)$$

(Equation 225)

$$\underline{Z}_1 = Z1\ zone\ x(\cos(Z1 angle\ zone\ x) + j\sin(Z1 angle\ zone\ x))$$

$$\underline{K}_N = Factor\ K0\ zone\ x(\cos(Factor\ K0 angle\ znx) + j\sin(Factor\ K0 angle\ znx))$$

In case of non-directional characteristics, the reactive reach in reverse direction is defined with the *Z1 reverse zone x* (x = 1...5) setting.

$$\underline{Z}_{1R} = Z1 reverse\ zone\ x(\cos(Z1 angle\ zone\ x) + j\sin(Z1 angle\ zone\ x))$$

(Equation 228)

The total reactive reach in reverse direction includes a part which is defined by the residual compensation factor $\underline{K}_N$. The characteristic line angle, denoted as α, is the same for forward and reverse direction.

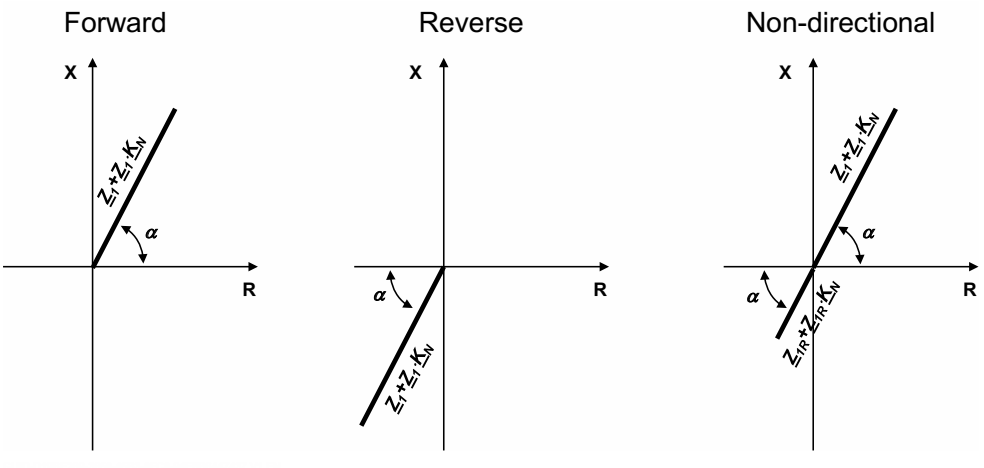



*Figure 487: Settings which define the line reach for phase-to-earth impedance measuring elements if Impedance mode Zn = "Polar"*

### Protection zone characteristics

DSTPDIS has both “Quadrilateral” and “Mho (circular)” characteristics available for the protection zones and they can be combined also with the bullet characteristic. The shape of a tripping characteristic can be set independently for phase-to-earth, phase-to-phase or three-phase impedance elements. The zone shape is defined with the *Impedance Chr Gnd Zn* setting for phase-to-earth impedance elements, and with the *Impedance Chr PP Zn* setting for phase-to-phase or three-phase impedance elements. The alternatives are "Quadrilateral", "Mho (circular)", "Mho Dir line", "Offset Dir line" and "Bullet (combi)".

All impedance values defining the zone shape are entered in primary ohms. Angles are given in degrees.

### Quadrilateral characteristic

If the zone has the "Quadrilateral" shape, DSTPDIS has a polygonal tripping characteristic.

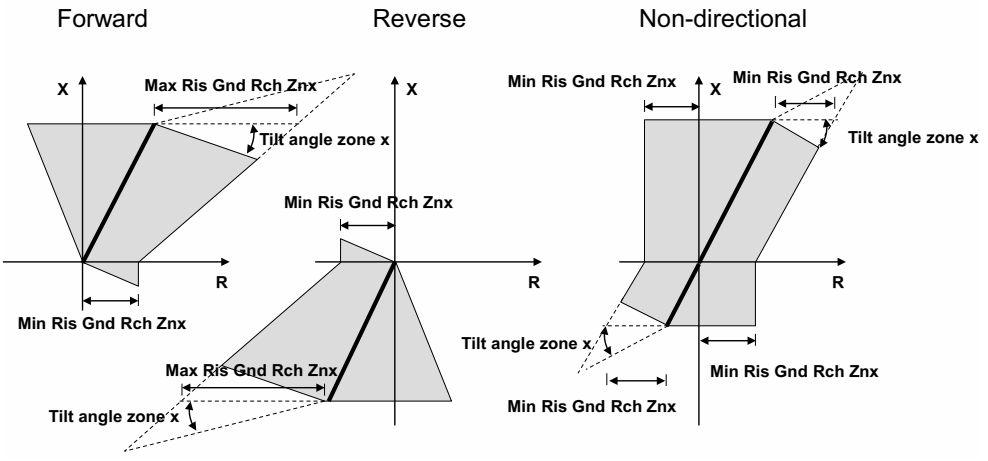



*Figure 488: Tripping characteristic for phase-to-earth impedance elements if the zone shape is quadrilateral. The tilt angle is set to compensate for possible under- or overreaching.*

The reach in the reactive direction is defined by the line reach independently for phase-to-earth and for phase-to-phase/three-phase elements. The resistive reach is defined at the minimum and maximum resistive reach with settings *Min Ris Gnd Rch Znx*, *Max Ris Gnd Rch Znx*, *Min Ris PP Rch Znx*, *Max Ris PP Rch Znx* (x = 1...5). In case of a non-directional zone, only settings *Min Ris Gnd Rch Znx* and *Min Ris PP Rch Znx* (x = 1...5) are valid. The resistive reach can be set independently for phase-to-earth and for phase-to-phase or three-phase elements.

In case of phase-to-earth impedance elements, the resistive reach value corresponds to the physical fault resistance between phase and earth including arc and earthing resistance.

The reactive reach can be adjusted by tilting the top reactance boundary line by an angle defined with *Tilt angle zone x* (x = 1...5). The negative value decreases the tripping zone area while the positive value increases the tripping area. The negative value is used in case of underreaching zones to compensate a possible overreaching. The positive value is used in case of overreaching zones to compensate a possible underreaching.

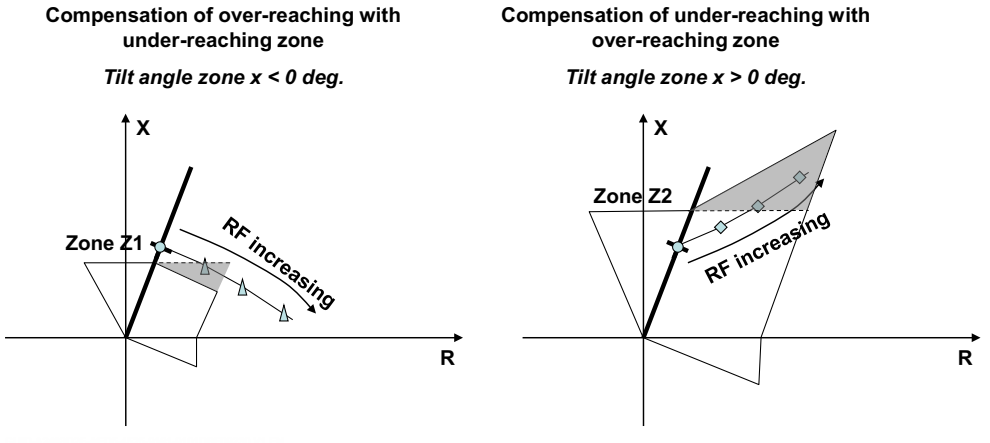



*Figure 489: Operation principle of top reactance line tilting*

The tilt angle must be carefully set. If the tilt angle has been set to a value where polygon boundaries do not form a close loop for an element, an internal mechanism modifies the tilt angle for that element so that the polygon boundary is always closed. If the set tilt angle is suitable for another element, the tilt angle of that element is not internally modified. Tilt angle conflicts are monitored by TLT_ANG_CONFLICT value. This integer value is a ten-bit value indicating tilt angle modifications per zone and fault type.

*Table 843: TLT_ANG_CONFLICT description*

| TLT_ANG_CONFLICT bit field | Description |
|---|---|
| (MSB) xx xx xx xx YZ (LSB) | Y active = Zone 1 earth-fault impedance element tilt angle modified<br>Z active = Zone 1 short circuit impedance element tilt angle modified |
| (MSB) xx xx xx YZ zz (LSB) | Y active = Zone 2 earth-fault impedance element tilt angle modified<br>Z active = Zone 2 short circuit impedance element tilt angle modified |
| (MSB) xx xx YZ xx xx (LSB) | Y active = Zone 3 earth-fault impedance element tilt angle modified<br>Z active = Zone 3 short circuit impedance element tilt angle modified |
| (MSB) xx YZ xx xx xx (LSB) | Y active = Zone 4 earth-fault impedance element tilt angle modified<br>Z active = Zone 4 short circuit impedance element tilt angle modified |
| (MSB) YZ xx xx xx xx (LSB) | Y active = Zone 5 earth-fault impedance element tilt angle modified<br>Z active = Zone 5 short circuit impedance element tilt angle modified |

For example, TLT_ANG_CONFLICT value “36” = “00 00 10 01 00” indicates that the tilt angles of the zone 2 earth-fault impedance element and zone 3 short circuit or three-phase impedance element have been modified. These zone settings should be

checked to see whether a non-zero TLT_ANG_CONFLICT value has been found although, internally, the polygon boundary has been closed for existing settings.

### Directional lines

The direction of a zone is defined with setting *Directional mode Znx* = "Non-directional", "Forward" or "Reverse". The directionality of each zone can be set independently of other zones. For example, zones Z1 and Z2 can be set in the "Forward" direction and Z3 in the "Reverse"direction. Furthermore, the optionally supervised earth-fault directional criteria (in low-impedance earthed networks) given for GFC are checked here together with zone direction criteria fulfilment.

The directionality of a quadrilateral zone is defined with two independent directional lines. The directional lines can be included into the mho characteristics to secure the directionality or to transform the non-directional mho characteristic into a directional one.

The directional lines are adjusted with the *Min phase angle zone* and *Max phase angle zone* settings, which are common for all the zones. The angles are given in degrees. The directional lines are polarized with the *Pol quantity zone* method. By default, the polarization method is positive-sequence voltage ("Pos. seq. volt.").

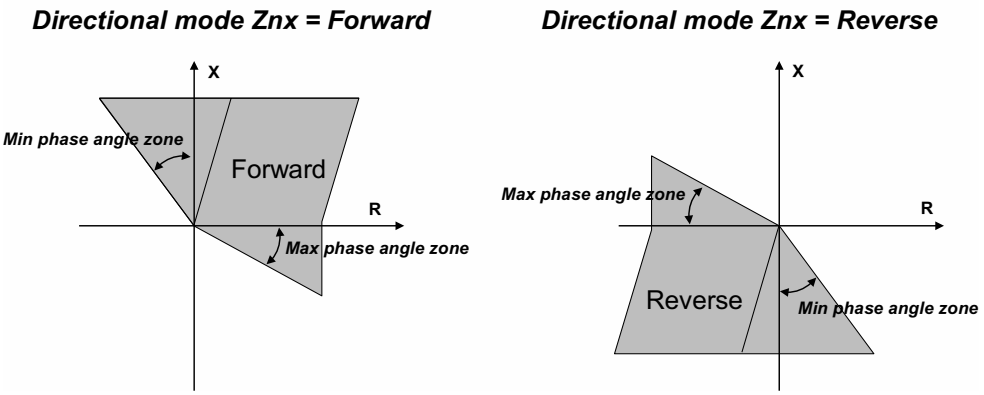



*Figure 490: Settings that adjust directional lines in case of quadrilateral characteristics*

The calculated direction of the fault or load (if there is no fault present) current is indicated in the monitored data DIRECTION = "unknown", "forward", "backward" or "both". It is important to check setting *X1 reverse zone x* (or *Z1 reverse zone x* reactance part) for quadrilateral directional characteristics (see Figure 482 and the corresponding phase-to-earth impedance given in Figure 484) so that it does not restrict the negative-reactance reach defined by settings *Min Ris Gnd*/*PP Rch Znx* and *Max phase angle zone*.

### Memory voltage

The memory voltage is based on the healthy positive-sequence voltage stored during the network healthy state. This fictive voltage is substituted for the measured voltage with any impedance measurement element polarization if the corresponding voltage drops too low (limit is 5% Un). Fictive voltage use is indicated by the active monitored data output VMEM_USED. The polarized impedance direction for a corresponding

impedance element is frozen after a fixed 100 ms of fictive voltage use, but the memory function enables impedance polarization to operate up to a maximum of 300 s. This time can be set with the *Voltage Mem time* setting. After set *Voltage Mem time* elapses, fictive voltage (and frozen impedance direction) can no more be used without memory refreshment by a healthy positive-sequence voltage and also the frozen impedance direction is reset.

Switch onto fault function (CVPSOF) should be used together with distance protection. CVPSOF accelerates and secures the operation of the protection if a close-in three-phase fault is detected immediately after circuit breaker closing.

### Mho circular characteristic

When the zone characteristic is "Mho (circular)", the distance protection has a circular tripping characteristic. The zone reach is defined independently by the line reach for phase-to-earth and phase-to-phase or three-phase elements. The resistive reach of the tripping characteristic depends on the selected polarization method defined with setting *Pol quantity zone* = "Cross pol", "Pos. seq. volt." or "Self pol". The non-directional mho characteristic is an exception as it is independent of the selected polarization method. It is always explicitly defined by the reach settings and thus fixed in the impedance plane.

*Table 844: Polarization methods and corresponding polarization voltages*

| Fault loop | Self pol | Cross pol | Pos. seq. volt. |
|---|---|---|---|
| $Z_A$ | $U_{L1}$ | $j \cdot U_{L23}/\sqrt{3}$ | $U_1$ |
| $Z_B$ | $U_{L2}$ | $j \cdot U_{L31}/\sqrt{3}$ | $U_1 \cdot 1\angle -120°$ |
| $Z_C$ | $U_{L3}$ | $j \cdot U_{L23}/\sqrt{3}$ | $U_1 \cdot 1\angle 120°$ |
| $Z_{AB}$ | $U_{L12}$ | $j \cdot (U_{L23} - U_{L31})/\sqrt{3}$ | $U_1 \cdot \sqrt{3} \cdot 1\angle 30°$ |
| $Z_{BC}$ | $U_{L23}$ | $j \cdot (U_{L31} - U_{L12})/\sqrt{3}$ | $U_1 \cdot \sqrt{3} \cdot 1\angle -90°$ |
| $Z_{CA}$ | $U_{L31}$ | $j \cdot (U_{L12} - U_{L23})/\sqrt{3}$ | $U_1 \cdot \sqrt{3} \cdot 1\angle 150°$ |
| $Z_{ABC}$ | $U_1$ | | |

In case of cross-polarization "Cross pol", the polarization voltages are theoretically quadrature to the fault loop voltage. The phase angle of the polarization voltage is rotated 90° to match the original fault loop voltage. The cross-polarization expands the tripping characteristic according to the prevailing system conditions. In case of short circuit faults, the circle expands as a function of the source impedance magnitude $Z_{1source}$. In case of an earth fault, the circle expands as a function of the source impedance $Z_{1source}$, $Z_{0source}$ and earthing impedance magnitudes $Z_E$ as $(2 \cdot Z_{1source} + Z_{0source})/3 + Z_E$.

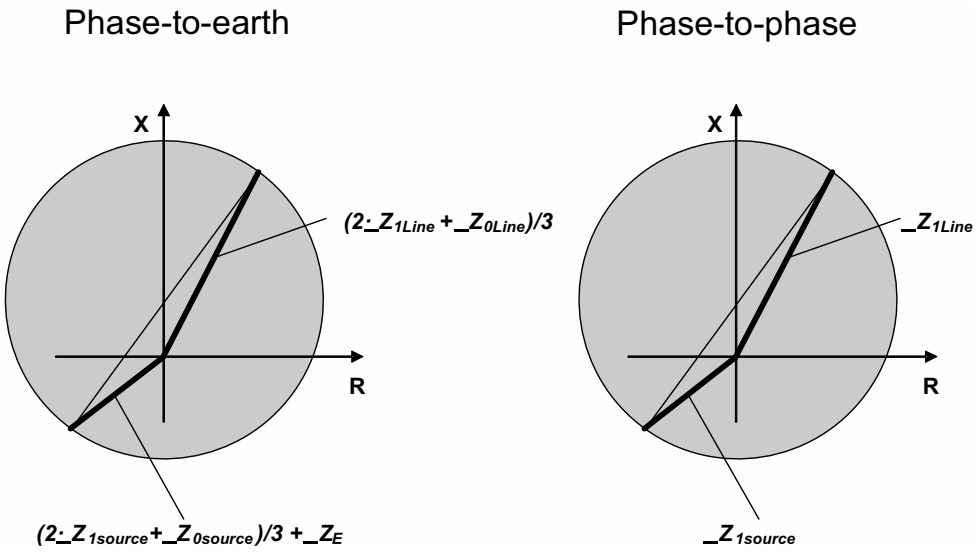



*Figure 491: Tripping characteristic in case the zone characteristic is "Mho (circular)" and Pol quantity zone is "Cross pol"*

In case of positive-sequence polarization "Pos. seq. volt.", the polarization voltage is the positive-sequence voltage. The voltage phase angle is rotated to match the original fault loop voltage. The positive-sequence polarization expands the tripping characteristic according to the prevailing system conditions. In case of short circuit faults, the circle expands as a function of the source impedance magnitude $Z_{1source}/2$. In case of an earth fault, the circle expands as a function of source impedance and earthing impedance magnitudes: $(Z_{1source} + Z_{0source})/3 + Z_E$.

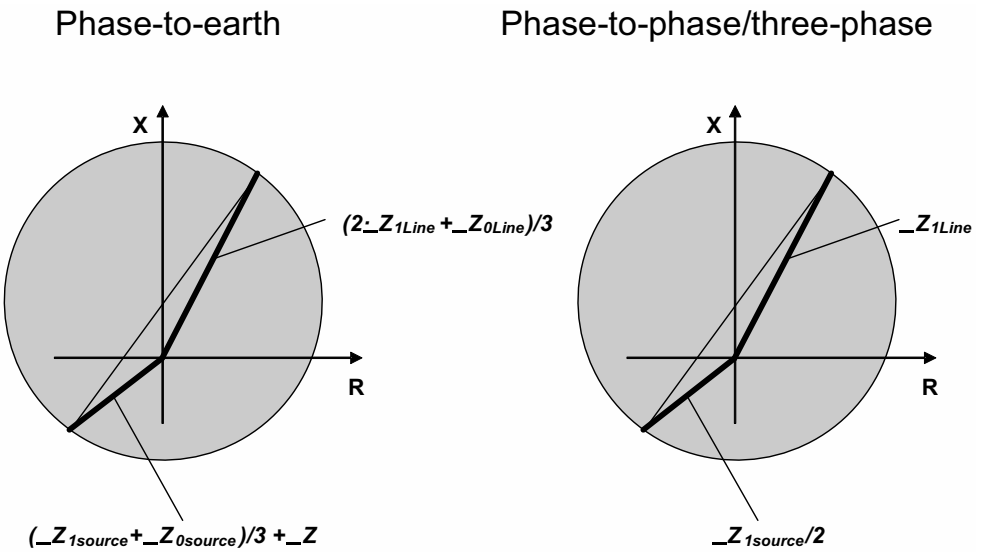



*Figure 492: Tripping characteristic in case the zone characteristic is "Mho (circular)" and Pol quantity zone is "Pos. seq. volt."*

One alternative for polarization is also "Self pol" despite the drawbacks when using it as a polarization method. The mho circle does not expand when using this polarization method.

In case of cross and positive-sequence polarization, the expansion of the mho circle is a positive feature as the fault resistance coverage is increased. The reach of the zone is not affected by the expansion. The greatest expansion is obtained with cross-polarization.

The directional offset mho is explicitly defined by the reach settings and is thus fixed in the impedance plane. The polarization method does not expand this circle even for directional mode. However, directional lines criteria are defined using polarized signals.

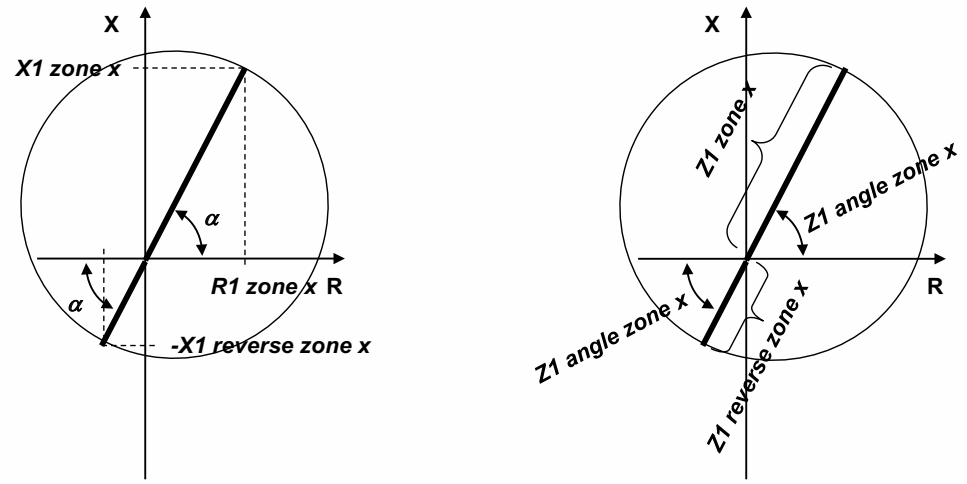



*Figure 493: Tripping characteristic for phase-to-phase or three-phase impedance measuring elements ifImpedance Chr PP Zn is "Mho (circular)" and Directional mode Znx is "Non-directional". On the left, Impedance mode Zn is "Rectangular". On the right, Impedance mode Zn is "Polar".*

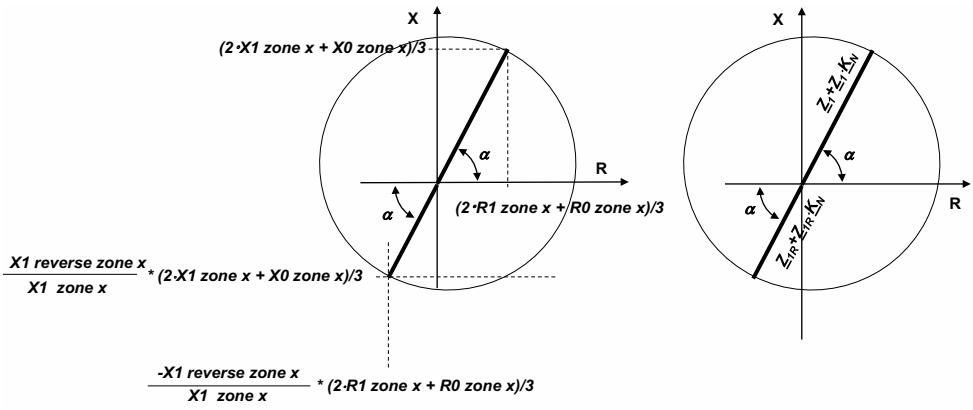



*Figure 494: Tripping characteristic for phase-to-earth impedance measuring elements if Impedance Chr GND Zn is "Mho (circular)" and Directional mode Znx is "Non-directional". On the left, Impedance mode Zn is "Rectangular". On the right, Impedance mode Zn is "Polar".*

### Adding of directional lines into circular mho characteristic

Directional lines which are always included in the directional quadrilateral characteristic can also be included in the mho characteristics to secure the directionality or to transform the non-directional mho characteristics into a directional one.

Directional lines with mho are available only when the zone is set to directional, that is, *Directional mode Znx* is "Forward" or "Reverse".

The directionality of the directional mho characteristic is secured with directional lines by setting *Impedance Chr Gnd Zn* and *Impedance Chr PP Zn* to "Mho Dir line". The directional mho characteristic can also be created by adding directional lines in the offset mho characteristic. This is done by selecting *Impedance Chr Gnd Zn* and *Impedance Chr PP Zn* as "Offset Dir line".

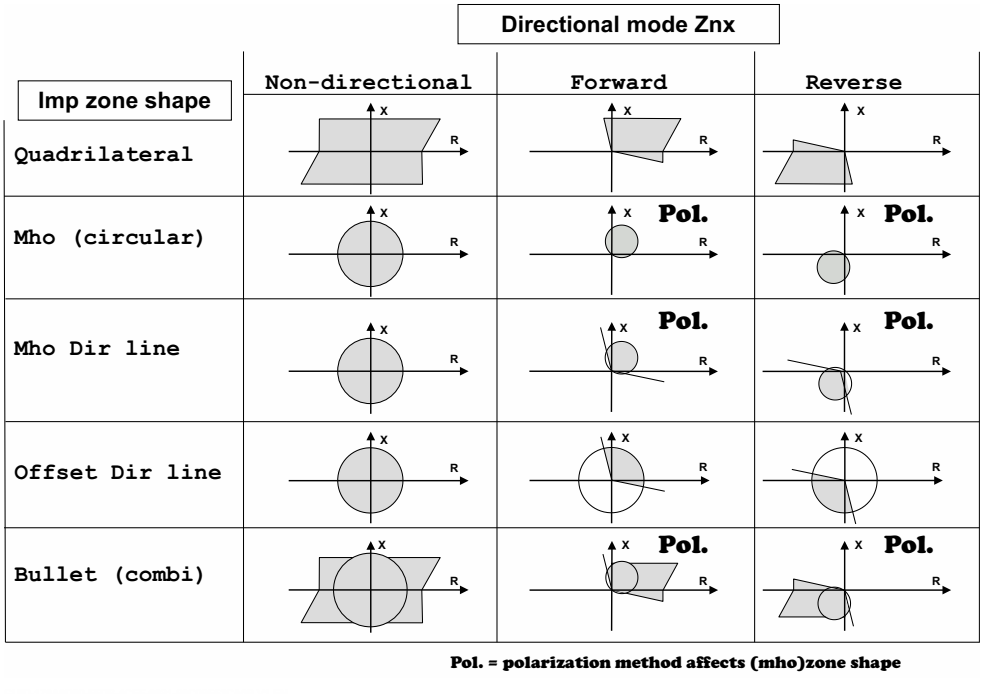



*Figure 495: Possible combinations of Directional mode Znx and zone characteristics settings. Pol. in the figure means that the shape of the characteristic is affected by the selected polarization method of the mho circle, Pol quantity zone = "Cross pol", "Pos. seq. volt.", "Self pol").*

### Bullet combi characteristic

If the impedance zone shape equals "Bullet (combi)", the distance protection has a tripping characteristic which is a combination of the quadrilateral and mho. All settings relevant to the quadrilateral and mho are applicable. The shape of the "Bullet (combi)" characteristic is affected by the selected polarization method of the mho circle (*Pol quantity zone* = "Cross pol", "Pos. seq. volt.", "Self pol").

The directionality of the "Bullet (combi)" characteristic is defined by the directional lines when *Directional mode Znx* is "Forward" or "Reverse". For directional "Bullet (combi)" characteristic, the quadrilateral resistance does not reach negative (positive) values for “Forward” (“Reverse”) direction (see Figure 496).

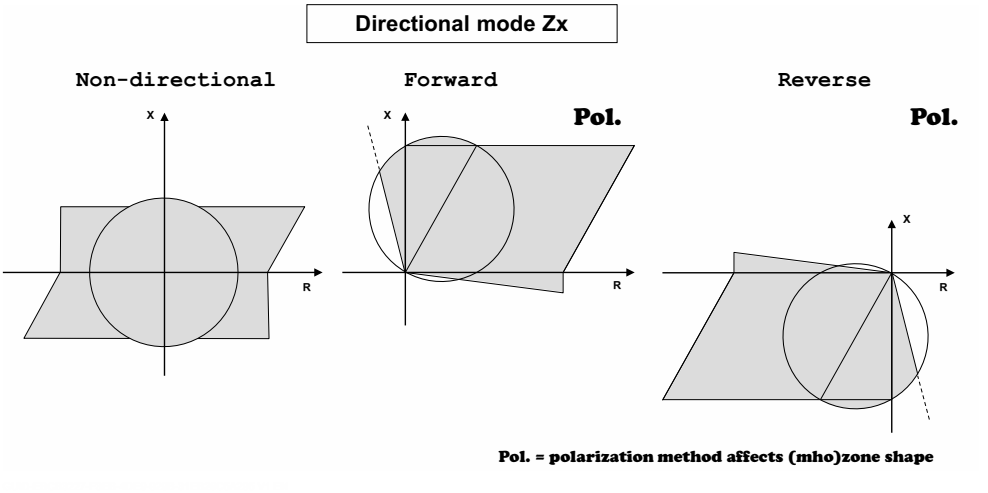



*Figure 496: Bullet combi tripping characteristic. Pol. in the figure means the shape of the characteristic is affected by the selected polarization method, Pol quantity zone = "Cross pol", "Pos. seq. volt.", "Self pol"*

### 4.7.1.6 Recorded data

The required information for later fault analysis is recorded when the recording function of DSTPDIS is triggered by activating TRIGG_REC input or writing to the corresponding DO “LD0.GFCPDIS1.RcdTrg.stVal”. During external triggering (input signal TRIGG_REC), the recorded data of all zones and the phase selection function are recorded.

A total of three sets of recorded data are saved in data banks Fault 1, 2 and 3. Data bank Fault 1 holds the most recent recorded data and the older data is moved into the following banks (1->2 and 2->3) when triggering occurs. When all three banks have data and a new triggering occurs, the latest data is placed into bank 1 and the data in bank 3 is overwritten by the data from bank 2.

*Table 845: Recorded data for the phase selection function*

| Parameter name | Description |
|---|---|
| Time | Recorded data time stamp |
| Release PE-loop | Release signals for PE loops, GFC |
| Release PP-loop | Release signals for PP/3P loops, GFC |
| Earth fault detected | Indication of a single-phase earth fault, GFC |
| Cross country fault | Indication of a cross-country fault (high imp. earthed), GFC |
| Earth fault direction | Earth-fault direction (low imp. earthed), GFC |
| Operate of all zones | Operate signals of all zones (this is zone information but it is taken here because it represents all zone information combined) |

The values of parameter *Operate of all zones* indicate by a number (0...31) which zones have been operated.

*Table 846: Enumerator values for parameter Operate of all zones*

| Enumerator value | Description |
|---|---|
| 0 | No zone operates |
| 1 | Zone 1 |
| 2 | Zone 2 |
| 3 | Zones 1 and 2 |
| 4 | Zone 3 |
| 5 | Zones 1 and 3 |
| 6 | Zones 2 and 3 |
| 7 | Zones 1,2 and 3 |
| 8 | Zone 4 |
| 9 | Zones 1 and 4 |
| 10 | Zones 2 and 4 |
| 11 | Zones 1,2 and 4 |
| 12 | Zones 3 and 4 |
| 13 | Zones 1,3 and 4 |
| 14 | Zones 2,3 and 4 |
| 15 | Zones 1,2,3 and 4 |
| 16 | Zone 5 |
| 17 | Zones 1 and 5 |
| 18 | Zones 2 and 5 |
| 19 | Zones 1,2 and 5 |
| 20 | Zones 3 and 5 |
| 21 | Zones 1,3 and 5 |
| 22 | Zones 2,3 and 5 |
| 23 | Zones 1,2,3 and 5 |
| 24 | Zones 4 and 5 |
| 25 | Zones 1,4 and 5 |
| 26 | Zones 2,4 and 5 |
| 27 | Zones 1,2,4 and 5 |
| 28 | Zones 3,4 and 5 |
| 29 | Zones 1,3,4 and 5 |
| 30 | Zones 2,3,4 and 5 |
| 31 | Zones 1,2,3,4 and 5 |

*Table 847: Recorded data parameters regarding specific zones*

| Parameter | Description |
|---|---|
| Fault/load Dir Znx | Direction of fault or load zone Zx |
| Dir resistance Znx | Direction resistance, zone Zx |
| Dir reactance Znx | Direction reactance, zone Zx |
| Flt loop 1st Ris Znx | First PE-Loop resistance, zone Zx |
| Flt loop 1st Rea Znx | First PE-Loop reactance, zone Zx |
| Flt loop 2nd Ris Znx | Second PE-Loop resistance, zone Zx |
| Flt loop 2nd Rea Znx | Second PE-Loop reactance, zone Zx |
| Flt PP-loop Ris Znx | PP-Loop resistance, zone Zx |
| Flt PP-loop Rea Znx | PP-Loop reactance, zone Zx |
| Phase reactance Znx | Phase reactance Znx |

Besides the already mentioned recorded data, the monitored data zone outputs give information regarding zone 1 particularly. The direction of the fault is indicated with the monitored data DIRECTION ("unknown", "forward", "backward " or "both"). In case of a no-fault condition, the direction of the load current seen by a three-phase fault measuring element (based on positive-sequence signal data) is indicated. DIR_LOOP_R and DIR_LOOP_X are the loop resistance and reactance from the impedance calculation used in directional discrimination for zone 1. Depending on the released fault loops, the calculated fault loop impedance can be read from the parameters FLTLOOP_RFST, FLTLOOP_XFST, FLTLOOP_RPP and FLTLOOP_XPP. If two phase-to-earth loops are released simultaneously for measurement, the second phase-to-earth impedance can be found from the parameters FLTLOOP_RSND and FLTLOOP_XSND. The corresponding positive-sequence phase-to-earth fault reactance can be found from parameter FLTPH_X.



The impedances are shown in primary ohms.

### 4.7.1.7 Application

DSTPDIS provides a fast and reliable protection for overhead lines and power cables. The function is applied in distribution and sub-transmission networks where three-phase tripping is allowed for all kinds of faults.

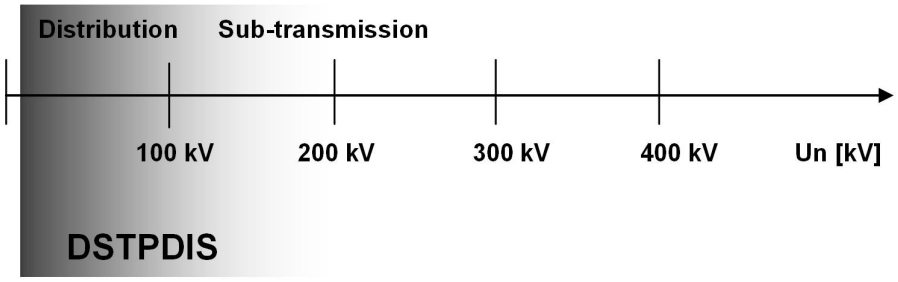



*Figure 497: Application scope of DSTPDIS*

Typically these networks are operated in ring or meshed type configurations. The switching state of these networks is changed frequently due to daily operation and load flow considerations. The networks also include varying capacities of distributed generation which makes it impossible to apply simple overcurrent-based schemes. In these networks, DSTPDIS is used to provide a fast and selective protection for overhead lines and power cables. It can also be applied for radial feeders to increase the sensitivity of the protection, especially if the short circuit power of the source is low or it changes due to network operation.

From the selectivity point of view, it is advantageous that in the protection chain all functions in different positions operate according to the same measuring principle. Therefore, DSTPDIS can also be applied for the backup protection of main transformers and buses. This way, selectivity in the distance protection of the outgoing lines is easier to achieve.

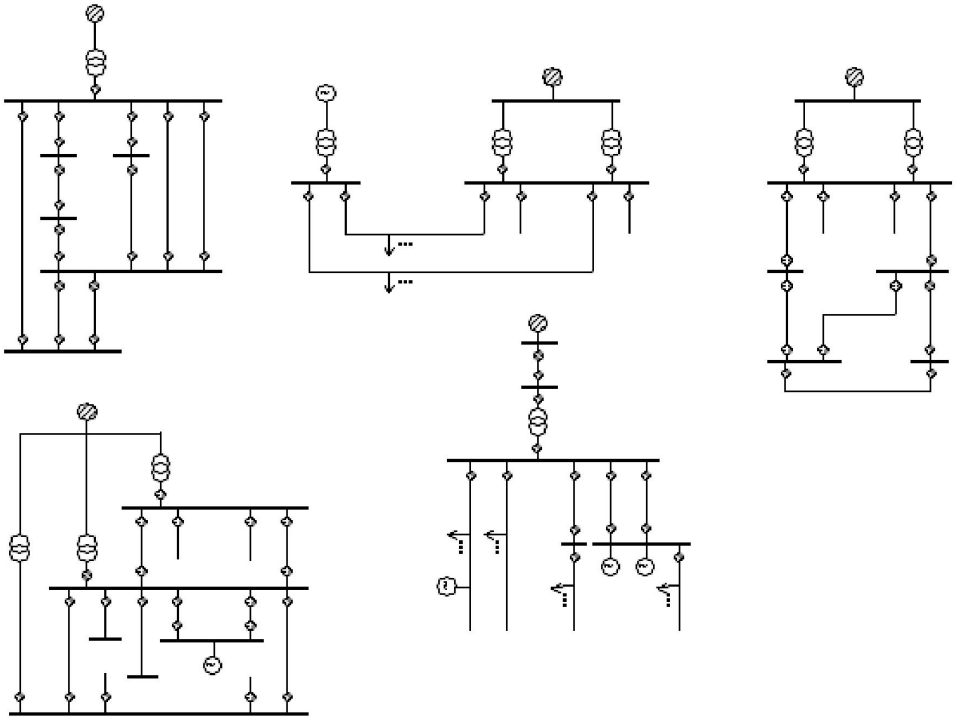


*Figure 498: Typical network configurations for DSTPDIS application*

DSTPDIS has five flexible configurable impedance zones for protection (Z1...Z5).

Phase-to-earth distance protection is a basic earth-fault protection in solidly or low-impedance earthed networks. Together with the phase preference logic, it also serves as a selective protection function at cross-country faults in isolated or Petersen coil compensated networks. In certain applications, system earthing is changed during operation from high-impedance to low-impedance earthed system due to fault location procedures. DSTPDIS can be used in such applications by setting *System grounding GFC* to "From input" and by providing information about the type of earthing through binary input `SYS_EARTHING`. Low (inactive) `SYS_EARTHING` input indicates low-impedance earthing system.

DSTPDIS is suitable as a basic protection function against two- and three-phase faults in various networks, regardless of the treatment of the neutral point. The independent setting of the reach in the reactive and the resistive directions makes it possible to create a fast and selective short circuit protection in many applications.

### 4.7.1.8 Signals

*Table 848: DSTPDIS Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| I3P_PAR | SIGNAL | - | Three-phase currents |
| I3P_REF | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| SYS_EARTHING | BOOLEAN | 0=False | Network earthing method |
| TRIGG_REC | BOOLEAN | 0=False | External triggering for all recorded data |
| BLOCK_GFC | BOOLEAN | 0=False | Block GFC operate |
| BLOCK_Z1 | BOOLEAN | 0=False | Block zone 1 |
| BLOCK_Z2 | BOOLEAN | 0=False | Block zone 2 |
| BLOCK_Z3 | BOOLEAN | 0=False | Block zone 3 |
| BLOCK_Z4 | BOOLEAN | 0=False | Block zone 4 |
| BLOCK_Z5 | BOOLEAN | 0=False | Block zone 5 |

*Table 849: DSTPDIS Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE_GFC | BOOLEAN | Time delayed operate signal, GFC |
| OPERATE_Z1 | BOOLEAN | Time delayed operate signal, zone 1 |
| OPERATE_Z2 | BOOLEAN | Time delayed operate signal, zone 2 |
| OPERATE_Z3 | BOOLEAN | Time delayed operate signal, zone 3 |
| OPERATE_Z4 | BOOLEAN | Time delayed operate signal, zone 4 |
| Table continues on next page | | |

| Name | Type | Description |
|---|---|---|
| OPERATE_Z5 | BOOLEAN | Time delayed operate signal, zone 5 |
| START_GFC | BOOLEAN | Start, GFC |
| START_Z1 | BOOLEAN | General start signal, zone 1 |
| START_Z2 | BOOLEAN | General start signal, zone 2 |
| START_Z3 | BOOLEAN | General start signal, zone 3 |
| START_Z4 | BOOLEAN | General start signal, zone 4 |
| START_Z5 | BOOLEAN | General start signal, zone 5 |
| XC_FLT | BOOLEAN | Indication of a cross-country-fault (high imp. earthed), GFC |

### 4.7.1.9 Settings

*Table 850: DSTPDIS Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase Sel mode GFC | 1=Overcurrent<br>2=Vol Dep Overcur<br>3=Under impedance<br>4=OC AND Und impedance | | | 1=Overcurrent | Phase selection method |
| EF detection Mod GFC | 1=Io<br>2=Io OR Uo<br>3=Io AND Uo<br>4=Io AND IoRef | | | 1=Io | Earth-fault (EF) detection method |
| Operate delay GFC | 100...60000 | ms | 10 | 3000 | Time delay to operate, GFC |
| Str A Ph Sel GFC | 0.10...10.00 | xIn | 0.01 | 2.00 | Phase current start value, PSL |
| Lo A Ph Sel GFC | 0.10...10.00 | xIn | 0.01 | 0.80 | Phase current start value, voltage dep. over current, PSL |
| Ph V Ph Sel GFC | 0.05...1.00 | xUn | 0.01 | 0.46 | PE-voltage start value, voltage dep. over current, PSL |
| PP V Ph Sel GFC | 0.10...1.00 | xUn | 0.01 | 0.80 | PP-voltage start value, voltage dep. over current, PSL |
| Z Chr Mod Ph Sel GFC | 1=Quadrilateral<br>2=Mho (circular) | | | 1=Quadrilateral | Impedance characteristic, underimpedance, PSL |
| Load Dsr mode GFC | 0=False<br>1=True | | | 0=False | Enable load discrimination, underimpedance, PSL |
| X Gnd Fwd reach GFC | 0.00...3000.00 | ohm | 0.01 | 40.00 | Reactive forward reach for PE-loops, underimpedance, PSL |
| X Gnd Rv reach GFC | 0.00...3000.00 | ohm | 0.01 | 40.00 | Reactive reverse reach for PE-loops, underimpedance, PSL |
| Ris Gnd Fwd Rch GFC | 0.00...500.00 | ohm | 0.01 | 100.00 | Resistive forward reach for PE-loops, underimpedance, PSL |
| Ris Gnd Rv Rch GFC | 0.00...500.00 | ohm | 0.01 | 100.00 | Resistive reverse reach for PE-loops, underimpedance, PSL |
| X PP Fwd reach GFC | 0.00...3000.00 | ohm | 0.01 | 40.00 | Reactive forward reach for PP-loops, underimpedance, PSL |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| X PP Rv reach GFC | 0.00...3000.00 | ohm | 0.01 | 40.00 | Reactive reverse reach for PP-loops, underimpedance, PSL |
| Ris PP Fwd Rch GFC | 0.00...100.00 | ohm | 0.01 | 30.00 | Resistive forward reach for PP-loops, underimpedance, PSL |
| Ris PP Rv Rch GFC | 0.00...100.00 | ohm | 0.01 | 30.00 | Resistive reverse reach for PP-loops, underimpedance, PSL |
| Ris Fwd Rch Lod GFC | 0.00...3000.00 | ohm | 0.01 | 80.00 | Resistive forward reach for load discrimination, undrerimpedance, PSL |
| Ris Rv Rch Lod GFC | 0.00...3000.00 | ohm | 0.01 | 80.00 | Resistive reverse reach for load discrimination, undrerimpedance, PSL |
| Angle load area GFC | 5.0...45.0 | deg | 0.1 | 25.0 | Load discrimination angle, PSL |
| Gnd Op current GFC | 0.00...10.00 | xIn | 0.01 | 0.10 | Basic start value for residual curr., EF-detection function |
| Gnd Op A Ref GFC | 0.01...10.00 | xIn | 0.01 | 0.10 | Transformer neutral curr. start val., EF-detection function |
| Gnd Str voltage GFC | 0.02...1.00 | xUn | 0.01 | 0.15 | Residual voltage start value, EF-detection function |
| Gnd Op A XC GFC | 0.10...10.00 | xIn | 0.01 | 0.20 | Residual current start value, XC-fault detection function |
| PP voltage XC GFC | 0.10...1.00 | xUn | 0.01 | 0.80 | PP-voltage start value, XC-fault detection function |
| Directional mode Zn1 | 2=Forward<br>3=Reverse<br>1=Non-directional | | | 2=Forward | Directional mode, zone 1 |
| Op Mod PP loops Zn1 | 0=False<br>1=True | | | 0=False | Enable PP/3P-loop measurement, zone 1 |
| PP Op delay Mod Zn1 | 0=False<br>1=True | | | 1=True | Enable operate timer for PP/3P-loops, zone 1 |
| R1 zone 1 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence resistive reach, zone 1 |
| X1 zone 1 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive reach, zone 1 |
| X1 reverse zone 1 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Pos. seq. reactive reach in rev. dir., non-dir. zone 1 |
| Z1 zone 1 | 0.01...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach, zone 1 |
| Z1 angle zone 1 | 15.0...90.0 | deg | 0.1 | 45.0 | Positive sequence line angle, zone 1 |
| Z1 reverse zone 1 | 0.00...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach in rev. dir., non-dir. zone 1 |
| Min Ris PP Rch Zn1 | 0.00...100.00 | ohm | 0.01 | 30.00 | Minimum resistive reach of PP/3P-loops, zone 1 |
| Max Ris PP Rch Zn1 | 0.00...100.00 | ohm | 0.01 | 30.00 | Maximum resistive reach of PP/3P-loops, zone 1 |
| PP operate delay Zn1 | 20...60000 | ms | 1 | 20 | Time delay to operate of PP/3P-loops, zone 1 |
| Op Mod Gnd loops Zn1 | 0=False<br>1=True | | | 0=False | Enable PE-loop measurement, zone 1 |
| Gnd Op Dl mode Zn1 | 0=False<br>1=True | | | 1=True | Enable operate timer for PE-loops, zone 1 |
| Load Comp zone 1 | 0=False<br>1=True | | | 1=True | Enable load compensation for PE-loops, zone 1 |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| R0 zone 1 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence resistive reach, zone 1 |
| X0 zone 1 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence reactive reach, zone 1 |
| Factor K0 zone 1 | 0.0...4.0 | | 0.1 | 1.0 | Residual compensation factor magnitude, zone 1 |
| Factor K0 angle Zn1 | -135...135 | deg | 1 | 0 | Residual compensation factor angle, zone 1 |
| Min Ris Gnd Rch Zn1 | 0.00...500.00 | ohm | 0.01 | 100.00 | Minimum resistive reach of PE-loops, zone 1 |
| Max Ris Gnd Rch Zn1 | 0.00...500.00 | ohm | 0.01 | 100.00 | Maximum resistive reach of PE-loops, zone 1 |
| Gnd operate Dl Zn1 | 20...60000 | ms | 1 | 20 | Time delay to operate of PE-loops, zone 1 |
| Directional mode Zn2 | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode, zone 2 |
| Op Mod PP loops Zn2 | 0=False<br>1=True | | | 0=False | Enable PP/3P-loop measurement, zone 2 |
| PP Op delay Mod Zn2 | 0=False<br>1=True | | | 1=True | Enable operate timer for PP/3P-loops, zone 2 |
| R1 zone 2 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence resistive reach, zone 2 |
| X1 zone 2 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive reach, zone 2 |
| X1 reverse zone 2 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Pos. seq. reactive reach in rev. dir., non-dir. zone 2 |
| Z1 zone 2 | 0.01...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach, zone 2 |
| Z1 angle zone 2 | 15.0...90.0 | deg | 0.1 | 45.0 | Positive sequence line angle, zone 2 |
| Z1 reverse zone 2 | 0.00...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach in rev. dir., non-dir. zone 2 |
| Min Ris PP Rch Zn2 | 0.00...100.00 | ohm | 0.01 | 30.00 | Minimum resistive reach of PP/3P-loops, zone 2 |
| Max Ris PP Rch Zn2 | 0.00...100.00 | ohm | 0.01 | 30.00 | Maximum resistive reach of PP/3P-loops, zone 2 |
| PP Op delay Mod Zn2 | 20...60000 | ms | 1 | 20 | Enable operate timer for PP/3P-loops, zone 2 |
| Op Mod Gnd loops Zn2 | 0=False<br>1=True | | | 0=False | Enable PE-loop measurement, zone 2 |
| Gnd Op Dl mode Zn2 | 0=False<br>1=True | | | 1=True | Enable operate timer for PE-loops, zone 2 |
| Load Comp zone 2 | 0=False<br>1=True | | | 1=True | Enable load compensation for PE-loops, zone 2 |
| R0 zone 2 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence resistive reach, zone 2 |
| X0 zone 2 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence reactive reach, zone 2 |
| Factor K0 zone 2 | 0.0...4.0 | | 0.1 | 1.0 | Residual compensation factor magnitude, zone 2 |
| Factor K0 angle Zn2 | -135...135 | deg | 1 | 0 | Residual compensation factor angle, zone 2 |
| Min Ris Gnd Rch Zn2 | 0.00...500.00 | ohm | 0.01 | 100.00 | Minimum resistive reach of PE-loops, zone 2 |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max Ris Gnd Rch Zn2 | 0.00...500.00 | ohm | 0.01 | 100.00 | Maximum resistive reach of PE-loops, zone 2 |
| Gnd operate Dl Zn2 | 20...60000 | ms | 1 | 20 | Time delay to operate of PE-loops, zone 2 |
| Directional mode Zn3 | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode, zone 3 |
| Op Mod PP loops Zn3 | 0=False<br>1=True | | | 0=False | Enable PP/3P-loop measurement, zone 3 |
| PP Op delay Mod Zn3 | 0=False<br>1=True | | | 1=True | Enable operate timer for PP/3P-loops, zone 3 |
| R1 zone 3 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence resistive reach, zone 3 |
| X1 zone 3 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive reach, zone 3 |
| X1 reverse zone 3 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Pos. seq. reactive reach in rev. dir., non-dir. zone 3 |
| Z1 zone 3 | 0.01...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach, zone 3 |
| Z1 angle zone 3 | 15.0...90.0 | deg | 0.1 | 45.0 | Positive sequence line angle, zone 3 |
| Z1 reverse zone 3 | 0.00...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach in rev. dir., non-dir. zone 3 |
| Min Ris PP Rch Zn3 | 0.00...100.00 | ohm | 0.01 | 30.00 | Minimum resistive reach of PP/3P-loops, zone 3 |
| Max Ris PP Rch Zn3 | 0.00...100.00 | ohm | 0.01 | 30.00 | Maximum resistive reach of PP/3P-loops, zone 3 |
| PP operate delay Zn3 | 20...60000 | ms | 1 | 20 | Time delay to operate of PP/3P-loops, zone 3 |
| Op Mod Gnd loops Zn3 | 0=False<br>1=True | | | 0=False | Enable PE-loop measurement, zone 3 |
| Gnd Op Dl mode Zn3 | 0=False<br>1=True | | | 1=True | Enable operate timer for PE-loops, zone 3 |
| Load Comp zone 3 | 0=False<br>1=True | | | 1=True | Enable load compensation for PE-loops, zone 3 |
| R0 zone 3 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence resistive reach, zone 3 |
| X0 zone 3 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence reactive reach, zone 3 |
| Factor K0 zone 3 | 0.0...4.0 | | 0.1 | 1.0 | Residual compensation factor magnitude, zone 3 |
| Factor K0 angle Zn3 | -135...135 | deg | 1 | 0 | Residual compensation factor angle, zone 3 |
| Min Ris Gnd Rch Zn3 | 0.00...500.00 | ohm | 0.01 | 100.00 | Minimum resistive reach of PE-loops, zone 3 |
| Max Ris Gnd Rch Zn3 | 0.00...500.00 | ohm | 0.01 | 100.00 | Maximum resistive reach of PE-loops, zone 3 |
| Gnd operate Dl Zn3 | 20...60000 | ms | 1 | 20 | Time delay to operate of PE-loops, zone 3 |
| Directional mode Zn4 | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode, zone 4 |
| Op Mod PP loops Zn4 | 0=False<br>1=True | | | 0=False | Enable PP/3P-loop measurement, zone 4 |
| PP Op delay Mod Zn4 | 0=False<br>1=True | | | 1=True | Enable operate timer for PP/3P-loops, zone 4 |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| R1 zone 4 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence resistive reach, zone 4 |
| X1 zone 4 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive reach, zone 4 |
| X1 reverse zone 4 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Pos. seq. reactive reach in rev. dir., non-dir. zone 4 |
| Z1 zone 4 | 0.01...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach, zone 4 |
| Z1 angle zone 4 | 15.0...90.0 | deg | 0.1 | 45.0 | Positive sequence line angle, zone 4 |
| Z1 reverse zone 4 | 0.00...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach in rev. dir., non-dir. zone 4 |
| Min Ris PP Rch Zn4 | 0.00...100.00 | ohm | 0.01 | 30.00 | Minimum resistive reach of PP/3P-loops, zone 4 |
| Max Ris PP Rch Zn4 | 0.00...100.00 | ohm | 0.01 | 30.00 | Maximum resistive reach of PP/3P-loops, zone 4 |
| PP operate delay Zn4 | 20...60000 | ms | 1 | 20 | Time delay to operate of PP/3P-loops, zone 4 |
| Op Mod Gnd loops Zn4 | 0=False<br>1=True | | | 0=False | Enable PE-loop measurement, zone 4 |
| Gnd Op Dl mode Zn4 | 0=False<br>1=True | | | 1=True | Enable operate timer for PE-loops, zone 4 |
| Load Comp zone 4 | 0=False<br>1=True | | | 1=True | Enable load compensation for PE-loops, zone 4 |
| R0 zone 4 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence resistive reach, zone 4 |
| X0 zone 4 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence reactive reach, zone 4 |
| Factor K0 zone 4 | 0.0...4.0 | | 0.1 | 1.0 | Residual compensation factor magnitude, zone 4 |
| Factor K0 angle Zn4 | -135...135 | deg | 1 | 0 | Residual compensation factor angle, zone 4 |
| Min Ris Gnd Rch Zn4 | 0.00...500.00 | ohm | 0.01 | 100.00 | Minimum resistive reach of PE-loops, zone 4 |
| Max Ris Gnd Rch Zn4 | 0.00...500.00 | ohm | 0.01 | 100.00 | Maximum resistive reach of PE-loops, zone 4 |
| Gnd operate Dl Zn4 | 20...60000 | ms | 1 | 20 | Time delay to operate of PE-loops, zone 4 |
| Directional mode Zn5 | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode, zone 5 |
| Op Mod PP loops Zn5 | 0=False<br>1=True | | | 0=False | Enable PP/3P-loop measurement, zone 5 |
| PP Op delay Mod Zn5 | 0=False<br>1=True | | | 1=True | Enable operate timer for PP/3P-loops, zone 5 |
| R1 zone 5 | 0.00...3000.00 | ohm | 0.01 | 40.00 | ositive sequence resistive reach, zone 5 |
| X1 zone 5 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive reach, zone 5 |
| X1 reverse zone 5 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Pos. seq. reactive reach in rev. dir., non-dir. zone 5 |
| Z1 zone 5 | 0.01...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach, zone 5 |
| Z1 angle zone 5 | 15.0...90.0 | deg | 0.1 | 45.0 | Positive sequence line angle, zone 5 |
| Z1 reverse zone 5 | 0.00...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach in rev. dir., non-dir. zone 5 |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min Ris PP Rch Zn5 | 0.00...100.00 | ohm | 0.01 | 30.00 | Minimum resistive reach of PP/3P-loops, zone 5 |
| Max Ris PP Rch Zn5 | 0.00...100.00 | ohm | 0.01 | 30.00 | Maximum resistive reach of PP/3P-loops, zone 5 |
| PP operate delay Zn5 | 20...60000 | ms | 1 | 20 | Time delay to operate of PP/3P-loops, zone 5 |
| Op Mod Gnd loops Zn5 | 0=False<br>1=True | | | 0=False | Enable PE-loop measurement, zone 5 |
| Gnd Op Dl mode Zn5 | 0=False<br>1=True | | | 1=True | Enable operate timer for PE-loops, zone 5 |
| Load Comp zone 5 | 0=False<br>1=True | | | 1=True | Enable load compensation for PE-loops, zone 5 |
| R0 zone 5 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence resistive reach, zone 5 |
| X0 zone 5 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence reactive reach, zone 5 |
| Factor K0 zone 5 | 0.0...4.0 | | 0.1 | 1.0 | Residual compensation factor magnitude, zone 5 |
| Factor K0 angle Zn5 | -135...135 | deg | 1 | 0 | Residual compensation factor angle, zone 5 |
| Min Ris Gnd Rch Zn5 | 0.00...500.00 | ohm | 0.01 | 100.00 | Minimum resistive reach of PE-loops, zone 5 |
| Max Ris Gnd Rch Zn5 | 0.00...500.00 | ohm | 0.01 | 100.00 | Maximum resistive reach of PE-loops, zone 5 |
| Gnd operate Dl Zn5 | 20...60000 | ms | 1 | 20 | Time delay to operate of PE-loops, zone 5 |

*Table 851: DSTPDIS Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Gnd Op current 2 GFC | 0.10...10.00 | xIn | 0.01 | 1.00 | Res. curr. start value for slope 2, EF-detection function |
| Stab slope 1 GFC | 0.00...0.30 | | 0.01 | 0.10 | Slope 1 for res. curr. stabilization, EF-detection function |
| Stab slope 2 GFC | 0.00...1.00 | | 0.01 | 1.00 | Slope 2 for res. current stabilization, EF-detection function |
| A Ph Stab value GFC | 1.00...10.00 | xIn | 0.01 | 2.00 | Phase current start value for slope 2, EF-detection function |
| Dir mode EF GFC | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 1=Non-directional | Directional mode, earth-fault directional function |
| Pol quantity GFC | -1=Zro vol.OR cur.<br>2=Zero seq. cur.<br>3=Zero seq. volt.<br>4=Neg. seq. volt. | | | 3=Zero seq. volt. | Polarization method, earth-fault directional function |
| Chr angle GFC | -179...180 | deg | 1 | 75 | Characteristic angle, earth-fault directional function |
| Max phase angle GFC | 0...90 | deg | 1 | 80 | Right hand side angle, earth-fault directional function |
| Min phase angle GFC | 0...90 | deg | 1 | 80 | Left hand side angle, earth-fault directional function |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Cross-country DI GFC | 0...10000 | ms | 10 | 100 | Time delay for residual current, XC-fault detection function |
| Tilt angle zone 1 | -45...45 | deg | 1 | 0 | Tilt angle (positive value increases zone area), zone 1 |
| Par line Comp zone 1 | 0=False<br>1=True | | | 0=False | Enable parallel line compensation for PE-loops, zone 1 |
| Mutual R0 zone 1 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual resistance, zone 1 |
| Mutual X0 zone 1 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual reactance, zone 1 |
| Tilt angle zone 2 | -45...45 | deg | 1 | 0 | Tilt angle (positive value increases zone area), zone 2 |
| Par line Comp zone 2 | 0=False<br>1=True | | | 0=False | Enable parallel line compensation for PE-loops, zone 2 |
| Mutual R0 zone 2 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual resistance, zone 2 |
| Mutual X0 zone 2 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual reactance, zone 2 |
| Tilt angle zone 3 | -45...45 | deg | 1 | 0 | Tilt angle (positive value increases zone area), zone 3 |
| Par line Comp zone 3 | 0=False<br>1=True | | | 0=False | Enable parallel line compensation for PE-loops, zone 3 |
| Mutual R0 zone 3 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual resistance, zone 3 |
| Mutual X0 zone 3 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual reactance, zone 3 |
| Tilt angle zone 4 | -45...45 | deg | 1 | 0 | Tilt angle (positive value increases zone area), zone 4 |
| Par line Comp zone 4 | 0=False<br>1=True | | | 0=False | Enable parallel line compensation for PE-loops, zone 4 |
| Mutual R0 zone 4 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual resistance, zone 4 |
| Mutual X0 zone 4 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual reactance, zone 4 |
| Tilt angle zone 5 | -45...45 | deg | 1 | 0 | Tilt angle (positive value increases zone area), zone 5 |
| Par line Comp zone 5 | 0=False<br>1=True | | | 0=False | Enable parallel line compensation for PE-loops, zone 5 |
| Mutual R0 zone 5 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual resistance, zone 5 |
| Mutual X0 zone 5 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual reactance, zone 5 |

*Table 852: DSTPDIS Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Phase voltage Meas | 1=Accurate<br>2=Ph-to-ph without Uo | | | 1=Accurate | Phase voltage measurement principle |
| Select active zones | 1=Zone 1<br>2=Zones 1-2<br>3=Zones 1-3<br>4=Zones 1-4<br>5=All 5 zones | | | 1=Zone 1 | Active zones selection |
| System grounding GFC | 1=High impedance<br>2=Low impedance<br>3=From input | | | 2=Low impedance | Network neutral earthing method |
| Ph Prf mode Lo Z GFC | 1=All loops<br>2=PE only<br>3=PP only<br>4=BLK leading PE<br>5=BLK lagging PE | | | 1=All loops | Loop selection mode for low impedance earthed network |
| Ph Prf mode Hi Z GFC | 1=No filter<br>2=No preference<br>3=Cyc A-B-C-A<br>4=Cyc A-C-B-A<br>5=Acyc A-B-C<br>6=Acyc A-C-B<br>7=Acyc B-A-C<br>8=Acyc B-C-A<br>9=Acyc C-A-B<br>10=Acyc C-B-A | | | 1=No filter | Phase preference mode for high impedance earthed network |
| Impedance mode Zn | 1=Rectangular<br>2=Polar | | | 1=Rectangular | Impedance characteristic, underimpedance, PSL |
| Impedance Chr Gnd Zn | 1=Quadrilateral<br>2=Mho (circular)<br>3=Mho Dir line<br>4=Offset Dir line<br>5=Bullet (combi) | | | 1=Quadrilateral | Impedance characteristic for PE-loops, zones |
| Impedance Chr PP Zn | 1=Quadrilateral<br>2=Mho (circular)<br>3=Mho Dir line<br>4=Offset Dir line<br>5=Bullet (combi) | | | 1=Quadrilateral | Impedance characteristic for PP/3P-loops, zones |
| Pol quantity zone | 5=Cross pol<br>7=Pos. seq. volt.<br>1=Self pol | | | 7=Pos. seq. volt. | Mho polarization method for zones |
| Max phase angle zone | 0...45 | deg | 1 | 15 | Angle from R-axis to right hand side directional line |
| Min phase angle zone | 90...135 | deg | 1 | 115 | Angle from R-axis to left hand side directional line |

*Table 853: DSTPDIS Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| EF Cur stabilization | 0=False<br>1=True | | | 0=False | EF current stabilization enabled |
| Fact EF current Bal | 1.000...2.000 | | 0.001 | 1.200 | Residual current ratio for parallel line compensation |
| Zone timer mode | 1=Independent<br>2=Common | | | 1=Independent | Operate timer start mode, zones |
| Voltage Mem time | 0...300000 | ms | 10 | 40 | Voltage memory time |

## 4.7.1.10 Monitored data

*Table 854: DSTPDIS Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| STARTS_GFC | Enum | 4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault<br>-5=No fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault | | Start signals for phases A, B and C, GFC |
| RELEASE_PE | Enum | -5=No fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault | | Release signals for PE-loops, GFC |
| RELEASE_PP | Enum | 5=BC Fault<br>6=CA Fault<br>7=ABC Fault<br>4=AB Fault<br>-5=No fault | | Release signals for PP/3P loops, GFC |
| EARTH_FLT | BOOLEAN | 0=False<br>1=True | | Indication of a single phase earth-fault, GFC |
| DIR_E_FLT | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Earth-fault direction (low imp. earthed), GFC |
| STARTS_Z1 | INT32 | -5...31 | | Start signals for phases A, B and C, zone 1 |
| STARTS_Z2 | INT32 | -5...31 | | Start signals for phases A, B and C, zone 2 |
| STARTS_Z3 | INT32 | -5...31 | | Start signals for phases A, B and C, zone 3 |
| STARTS_Z4 | INT32 | -5...31 | | Start signals for phases A, B and C, zone 4 |
| STARTS_Z5 | INT32 | -5...31 | | Start signals for phases A, B and C, zone 5 |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| DIRECTION | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load |
| DIR_LOOP_R | FLOAT32 | -3000.00...3000.00 | ohm | Resistance used in dir. evaluation, zone 1 |
| DIR_LOOP_X | FLOAT32 | -3000.00...3000.00 | ohm | Reactance used in dir. eval., zone 1 |
| FLTLOOP_RFST | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 1 |
| FLTLOOP_XFST | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 1 |
| FLTLOOP_RSND | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 1 |
| FLTLOOP_XSND | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 1 |
| FLTLOOP_RPP | FLOAT32 | -3000.00...3000.00 | ohm | PP/3P-loop resistance, zone 1 |
| FLTLOOP_XPP | FLOAT32 | -3000.00...3000.00 | ohm | PP/3P-loop reactance, zone 1 |
| FLTPH_X | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 1 |
| VMEM_USED | BOOLEAN | 0=False<br>1=True | | Voltage memory in use status |
| TLT_ANG_CONFLICT | INT32 | 0...1023 | | Tilt angle conflict |
| DSTPDIS | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| Time | Timestamp | | | Time |
| Release PE-loop | Enum | -5=No fault<br>-4=ABCG Fault<br>-3=CAG Fault<br>-2=BCG Fault<br>-1=ABG Fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault | | Release signals for PE-loops, GFC |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Release PP-loop | Enum | -5=No fault<br>-4=ABCG Fault<br>-3=CAG Fault<br>-2=BCG Fault<br>-1=ABG Fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault | | Release signals for PP/3P loops. GFC |
| Cross country fault | BOOLEAN | 0=False<br>1=True | | Indication of a cross-country-fault (high imp. earthed), GFC |
| Earth fault detected | BOOLEAN | 0=False<br>1=True | | Indication of a single phase earth-fault, GFC |
| Earth-fault direction | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Earth-fault direction (low impedance earthed), GFC |
| Operate of all zones | INT32 | 0...31 | | Operate signal of all zones |
| Fault/load Dir Zn1 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 1 |
| Dir resistance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 1 |
| Dir reactance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 1 |
| Flt loop 1st Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 1 |
| Flt loop 1st Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 1 |
| Flt loop 2nd Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 1 |
| Flt loop 2nd Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 1 |
| Flt PP-loop Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 1 |
| Flt PP-loop Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 1 |
| Phase reactance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 1 |
| Fault/load Dir Zn2 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 2 |
| Dir resistance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 2 |
| Dir reactance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 2 |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Flt loop 1st Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 2 |
| Flt loop 1st Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 2 |
| Flt loop 2nd Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 2 |
| Flt loop 2nd Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 2 |
| Flt PP-loop Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 2 |
| Flt PP-loop Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 2 |
| Phase reactance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 2 |
| Fault/load Dir Zn3 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 3 |
| Dir resistance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 3 |
| Dir reactance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 3 |
| Flt loop 1st Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 3 |
| Flt loop 1st Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 3 |
| Flt loop 2nd Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 3 |
| Flt loop 2nd Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 3 |
| Flt PP-loop Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 3 |
| Flt PP-loop Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 3 |
| Phase reactance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 3 |
| Fault/load Dir Zn4 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 4 |
| Dir resistance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 4 |
| Dir reactance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 4 |
| Flt loop 1st Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 4 |
| Flt loop 1st Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 4 |
| Flt loop 2nd Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 4 |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Flt loop 2nd Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 4 |
| Flt PP-loop Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 4 |
| Flt PP-loop Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 4 |
| Phase reactance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 4 |
| Fault/load Dir Zn5 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 5 |
| Dir resistance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 5 |
| Dir reactance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 5 |
| Flt loop 1st Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 5 |
| Flt loop 1st Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 5 |
| Flt loop 2nd Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 5 |
| Flt loop 2nd Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 5 |
| Flt PP-loop Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 5 |
| Flt PP-loop Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 5 |
| Phase reactance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 5 |

## 4.7.1.11 Technical data

*Table 855: DSTPDIS Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Impedance:<br>±2.5% of the set value or ±0.05 Ω<br>Phase angle: ±2° |
| Shortest operate time[1] SIR[2]: 0.1...50 | 25 ms |
| Transient overreach SIR = 0.1...50 | <8.5% |
| Table continues on next page | |

| Characteristic | Value |
|---|---|
| Reset time | Typically 45 ms |
| Reset ratio | Typically 0.96/1.04 |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

1) Measured with static power output (SPO)
2) SIR = Source impedance ratio

## 4.7.2 Out of step protection with double blinders OOSRPSB

### 4.7.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Out-of-step protection | OOSRPSB | OOS | 78 |

### 4.7.2.2 Function block




*Figure 499: Function block*

### 4.7.2.3 Functionality

The out-of-step protection function OOSRPSB detects out of step conditions by monitoring impedance.

The protection uses two impedance measurement elements known as inner and outer blinders on mho characteristics with a timer. The function calculates the impedance. If the measured impedance stays between inner and outer blinder for a predetermined time and moves farther inside the inner blinder, then an out of step condition is indicated. Operate is generated if out of step is indicated and impedance moves out of mho characteristics. The mho characteristic can be divided into two zones so separate trips can be generated based on the zone. Operating can also be selected to occur when the impedance is on the way into the zone or for when the impedance is on the way out of the zone.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.7.2.4 Analog channel configuration

OOSRPSB has two analog group inputs which must be properly configured.

*Table 856: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 857: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.7.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of OOSRPSB can be described using a module diagram. All the modules in the diagram are explained in the next sections.

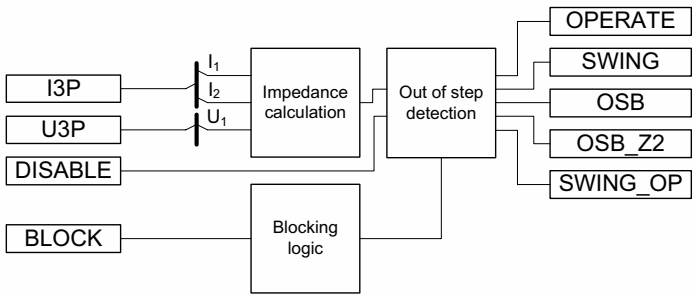



*Figure 500: Functional module diagram*

## Impedance calculation

This module calculates the positive-sequence impedance (Z1) using positive-sequence voltage and current. For the module to calculate impedance it is required that the positive-sequence current is above *Min Ps Seq current* setting and the negative-sequence current is below the *Max Ng Seq current* setting.

The calculated positive-sequence impedance amplitude Z1_AMPL and angle Z1_ANGLE are available in ohms and degrees, respectively, in the Monitored data view.



The calculated impedance is converted to ohms as the operating characteristics are defined with the ohm settings.

## Out of step detection

The operating characteristic is a circular offset mho on the impedance plane with two pair of blinders. The mho characteristic is defined with the *Forward reach*, *Reverse reach*, and *Impedance angle* settings. *Forward reach* defines the impedance from the origin to the edge of circle on the top side. *Reverse reach* defines the impedance from the origin to the edge of the circle on the bottom side. The diameter of the mho characteristics is the sum of *Forward reach* and *Reverse reach* settings. Two sets of blinders are defined by *Inner blinder R* and *Outer blinder R* intercepting at R-axis. The blinders are at the same angle as the *Impedance angle*. The second blinder of each outer and inner pair is automatically made symmetrical with the origin of the R-X plane.



For a correct operation, it is required that the setting for *Inner blinder R* is less than the setting for *Outer blinder R*.

The circular mho characteristic can be further divided into two zones by setting *Zone 2 enable* to “Yes”. The boundary between zones is set using the setting *Zone 1 reach*. The lower portion of the circle, Zone 1, is separated from the upper portion, Zone 2, by a line, perpendicular to the blinders, located at a set percentage of the *Forward reach* setting from the origin.

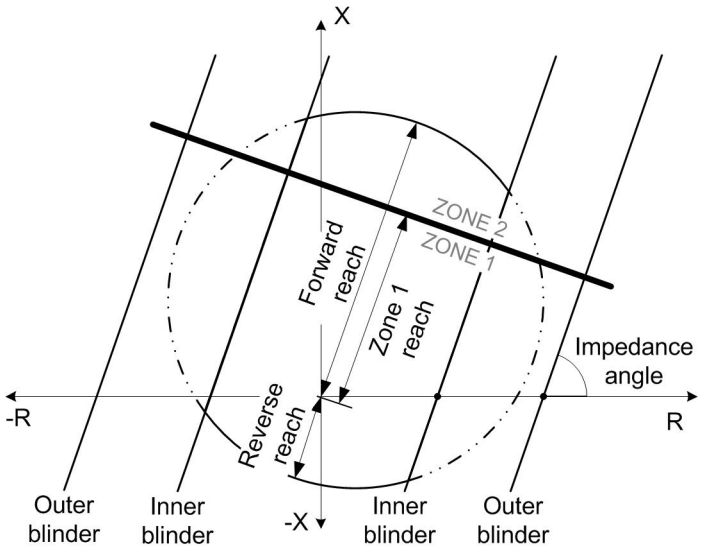



*Figure 501: Operating region for out of step with double blinder*

An impedance is only considered to be within the mho circle if it is also between the inner blinders.

A third zone, Zone 3, can be enabled by setting *Zone 3 enable* to “Yes”. Zone 3 is defined to include the area outside of the circular mho characteristic but inside the area that is bound with the magnitude of the minimum positive-sequence current defined by setting *Min Ps Seq*. Figure 502 shows the three zones. Settings that determine the shape of the zones should be coordinated with the settings for any distance protection functions. The zones and their respective slip counters are applicable only for Way out operations when the *Oos operation mode* setting option is “Way out” or “Adaptive”.

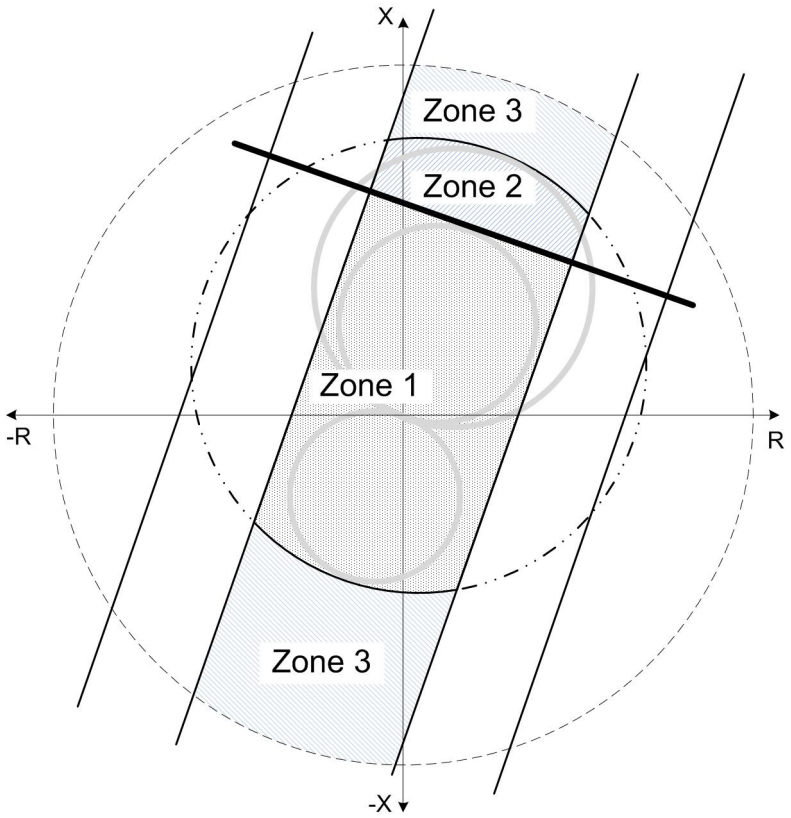



*Figure 502: Defined zones*

The impedance is continuously monitored for detecting an out of step condition. When the impedance enters inside from the outer blinder, the out of step detection timer is triggered. If impedance remains between outer and inner blinder for the duration of the *Swing time* setting, output SWING is activated. If the impedance enters the mho circle in zone 1, out of step blocking (OSB) for zone 1 is detected and output OSB is activated, or if the impedance enters the mho circle in zone 2, OSB for zone 2 is detected and output OSB_Z2 is activated if setting *Zone 2 enable* is set to "Yes". Both OSB and OSB_Z2 can be activated if the impedance passes through zone 1 and zone 2 while inside the mho circle. The OSB or OSB_Z2 output deactivates when impedance exits and remains outside the mho circle and the inner blinder for a duration of five cycles.

Activation of the OPERATE output depends on the *Oos operate mode* selected. The available options are "Way in", "Way out", and "Adaptive". If the "Way in" option is selected, the function triggers the delay timer after detecting an OSB condition. When the set *Operate delay time* has elapsed, the OPERATE output is activated. When using the "Way in" option, the zone-related settings and zone slip counters are not applicable.

If the "Way out" option is selected, after detecting an OSB condition, the function further checks if impedance exits the outer blinder. On exiting the outer blinder, Way out timer defined by *Operate delay time* setting is triggered and the respective zone

slip counter is incremented after the set *Operate delay time* has elapsed. If the slip counter value is equal to the set number of slips in the respective enabled zone, the OPERATE output is activated. If the swing impedance passes through both zone 1 and zone 2, only the zone 1 slip counter is incremented. The zone 2 slip counter is incremented if the impedance passes through the Mho circle but only through the zone 2 portion. The zone 3 slip counter is incremented if the impedance misses the Mho circle entirely and the setting *Zone 3 enable* is also set to “Yes”. Increment of the slip counter triggers also the Reset timer. All of the zone slip counters reset after the set *Reset time* has elapsed and the impedance does not cross into the outer blinder again, or on activation of the OPERATE output.

When the “Way out” or "Adaptive" option is selected, the breaker open time, if known, can be incorporated to optimize breaker trip time when a way out trip command is issued. The ideal time for the breaker to interrupt current is when the swing angle approaches zero. If the swing angle is $\delta_0$ when the impedance exits the outer blinder, the dynamic Trip delay, $T_{od}$, can be set as shown in Equation 229.

$$T_{od} = \frac{1 - 2 \cdot f_{slip} \cdot (T_{co} + BrkropenTm)}{2 \cdot f_{slip}}$$

(Equation 229)

| | |
|---|---|
| $T_{od}$ | Dynamic Trip delay |
| $T_{co}$ | The time for the impedance to travel from the center impedance line (where the swing angle is π radians) to the outer blinder on the opposite side from which it entered. |
| BrkopenTm | Set *Breaker open time* |
| $f_{slip}$ | Slip frequency |

The *Breaker open time* setting should include the time from when the relay issues a trip command to the time when the breaker receives the command. The function uses the *Breaker open time* setting to determine the trip delay time if it is not set to “0”. If the *Breaker open time* is set to “0”, the function does not dynamically calculate a trip delay but uses the fixed *Operate delay time* before activating the OPERATE output.

The slip frequency is calculated using Equation 230.

$$f_{slip} = \frac{\delta_i - \delta_0}{2 \cdot \pi \cdot T_{oi}}$$

(Equation 230)

| | |
|---|---|
| $f_{slip}$ | Slip frequency |
| $T_{oi}$ | The time for the impedance to pass from the outer to the inner blinder. |
| $\delta_0$ | Swing angle at the outer blinder |
| $\delta_I$ | Swing angle at the inner blinder |

The swing angles, $\delta_0$ and $\delta_I$, are estimated from the measured impedance when crossing the blinders. It is the difference in these quantities that is important for determining the slip frequency.

If the “Adaptive” option is selected, after detecting an OSB condition, the function further examines the slip frequency $f_{slip}$, *V dip time* setting, and swing angle at the outer blinder ($\delta_0$) to determine if the operate is asserted on the way in or on the way out. OPERATE is activated on the way in, entering the mho circle from an inner blinder, if the relationship in Equation 231 is true.

$$f_{slip} \le \frac{(\pi - \delta_0)}{\pi \cdot VoltagedipTm}$$

(Equation 231)

| | |
|---|---|
| $f_{slip}$ | Slip frequency |
| $\delta_0$ | Swing angle at the outer blinder |
| VoltagedipTm | Set *V dip time* |

Otherwise, OPERATE is activated on the way out, when the impedance exits an outer blinder and the swing repeats for the set *Max number slips* count in the respective enabled zone that the swing has passed through.

If the *Swing time* has elapsed but the impedance exits the inner blinder and continues through the opposite blinders without passing through the mho circle, the SWING output is activated. The SWING output remains activated for a time determined by the *Reset time* setting unless another swing occurs before the reset time expires causing the output to remain active for another *Reset time* interval. If this swing is repeated for the set *Max Num slips Zn3* count and the *Zone 3 enable* setting is “Yes”, the SWING_OP output is activated. The SWING_OP output remains activated for a time determined by the *Operate dropout time* setting.

If the “Adaptive” option is selected and an OSB condition is not detected, but the impedance enters the mho circle after remaining between the inner and outer blinders for greater than 1.5 cycles, the function assumes a severe swing and assert the OPERATE output.

The drop out delay for OPERATE output can be set by *Operate dropout time* setting.

If the polarity of the voltage signal is opposite to the normal polarity, the correction can be done by setting *Voltage reversal* to “Yes”, which rotates the impedance vector by 180 degrees.

The DISABLE input can be used to coordinate the correct operation during the start-up situation. The function is blocked by activating the DISABLE signal. Once the DISABLE signal is deactivated, the function remains blocked (outputs disabled) for additional time duration as set through the setting *Disable time*.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, the function operates normally but the OPERATE output is not activated.

## 4.7.2.6 Application

Out of step protection functions detect stable power swings and out of step conditions based on the fact that the voltage/current variation during a power swing is slow compared to the step change during a fault. Both faults and power swings may cause the measured impedance to enter into the operating characteristic of a distance relay element. The apparent impedance moves from the pre-fault value to a fault value in a very short time, a few milliseconds, during a fault condition. However, the rate of change of the impedance is much slower during a power swing or out of step condition than during a fault depending on the slip frequency of the out of step. The impedance measurement should not be used by itself to distinguish between a fault condition and an out of step condition from a phase fault. The fundamental method for discriminating between faults and power swings is to track the rate of change of the measured impedance.

The function measures the rate of change of the impedance using two impedance measurement elements known as blinders together with a timing device. If the measured impedance stays between the blinders for a predetermined time, the function declares a power swing condition and asserts an output that can be used to block the distance protection. However, if the impedance passes the inner blinder and exits on the other side of the mho characteristics (that is, the resistive component of impedance has opposite sign as at the time of point of entry) an out of step operate is issued by the function. Figure 503 gives an example of out of step detection.

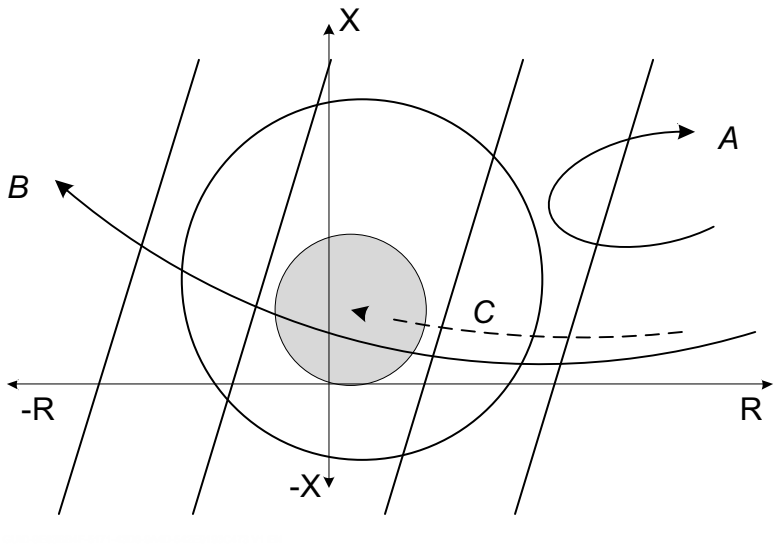



*Figure 503: Example of out of step detection*

The shaded region indicates a fault zone in a distance protection function. For curve A, the impedance moves into the out of step zone and leaves slowly, indicating the occurrence of a swing that quickly stabilizes. For curve B, the impedance moves slowly into the out of step zone and exits the zone indicating that the network is becoming unstable. For curve C, impedance rapidly moves into, and remains in, the fault zone indicating an actual fault and not an out of step condition.

### 4.7.2.7 Signals

*Table 858: OOSRPSB Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| DISABLE | BOOLEAN | 0=False | Disable input |

*Table 859: OOSRPSB Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Out of step operate on zone 1 or zone 2 |
| SWING | BOOLEAN | Swing condition detected |
| OSB | BOOLEAN | Out of step block for zone 1 |
| OSB_Z2 | BOOLEAN | Out of step block for zone 2 |
| SWING_OP | BOOLEAN | Out of step operate on zone 3 |

### 4.7.2.8 Settings

*Table 860: OOSRPSB Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Oos operate mode | 1=Way in<br>2=Way out<br>3=Adaptive | | | 2=Way out | Operate mode for tripping when out of step condition is detected |
| Forward reach | 0.00...6000.00 | ohm | 0.01 | 1000.00 | Forward reach of mho circle |
| Reverse reach | 0.00...6000.00 | ohm | 0.01 | 100.00 | Reverse reach of mho circle |
| Inner blinder R | 1.00...6000.00 | ohm | 0.01 | 150.00 | Resistance value if inner blinder at R axis |
| Outer blinder R | 1.01...10000.00 | ohm | 0.01 | 400.00 | Resistance value of outer blinder at R axis |
| Impedance angle | 10.0...90.0 | deg | 0.1 | 90.0 | Angle of mho circle and blinders with respect to R axis |
| Swing time | 20...300000 | ms | 10 | 500 | Time between blinders for swing to be detected |

*Table 861: OOSRPSB Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Zone 1 reach | 1...100 | % | 1 | 70 | Percent of Mho forward reach indicating the end of zone 1 and the beginning of zone 2 |
| Max number slips | 1...10 | | 1 | 1 | Number of pole slips before operating zone 1 |
| Max Num slips Zn2 | 1...20 | | 1 | 1 | Number of pole slips before operating zone 2 |
| Max Num slips Zn3 | 1...20 | | 1 | 1 | Number of pole slips before operating zone 3 |
| Operate delay time | 20...60000 | ms | 10 | 300 | Delay after OOS operate detected |
| Operate dropout time | 20...60000 | ms | 10 | 100 | Time operate output remains active |
| V dip time | 500...5000 | ms | 10 | 2000 | Maximum allowable time for voltage to dip |
| Zone 2 enable | 1=Yes<br>0=No | | | 0=No | Enable zone 2 feature |
| Zone 3 enable | 1=Yes<br>0=No | | | 0=No | Enable zone 3 feature |

*Table 862: OOSRPSB Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 863: OOSRPSB Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min Ps Seq current | 0.01...10.00 | xIn | 0.01 | 0.10 | Minimum positive sequence current for operation |
| Max Ng Seq current | 0.01...10.00 | xIn | 0.01 | 0.20 | Maximum negative sequence current for operation |
| Breaker open time | 0...300 | ms | 1 | 30 | Opening time of the breaker |
| Disable time | 20...60000 | ms | 10 | 5000 | Additional time function is disabled after removal of DISABLE input |
| Reset time | 20...60000 | ms | 10 | 5000 | Time to reset OOS condition and counters |
| Voltage reversal | 0=No<br>1=Yes | | | 0=No | Rotate voltage signals by 180 degrees |

### 4.7.2.9 Monitored data

*Table 864: OOSRPSB Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Z1_AMPL | FLOAT32 | 0.00...99999.00 | ohm | Positive sequence impedance amplitude |
| Z1_ANGLE | FLOAT32 | -180...180 | deg | Positive sequence impedance phase angle |
| SLIP_CNT_Z1 | INT32 | 0...9999 | | Zone 1 slip counter |
| SLIP_CNT_Z2 | INT32 | 0...9999 | | Zone 2 slip counter |
| SLIP_CNT_Z3 | INT32 | 0...9999 | | Zone 3 slip counter |
| OOSRPSB | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.7.2.10 Technical data

*Table 865: OOSRPSB Technical data*

| Characteristic | Value |
|---|---|
| Impedance reach | Depending on the frequency of the measured current and voltage: $f_n$ ±2 Hz |
| | ±3.0% of the reach value or ±0.2% of $U_n/(\sqrt{3} \cdot I_n)$ |
| Reset time | ±1.0% of the set value or ±40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5... |

## 4.7.3 Three-phase underexcitation protection UEXPDIS

### 4.7.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase underexcitation protection | UEXPDIS | X< | 40 |

### 4.7.3.2 Function block




*Figure 504: Function block*

### 4.7.3.3 Functionality

The three-phase underexcitation protection function UEXPDIS is used to protect the synchronous machine against the underexcitation or loss of excitation condition.

The protection is based on the offset-mho circular characteristics on the impedance plane. The function calculates the apparent impedance from the machine terminal voltages and currents. If the impedance vector enters the offset-mho circle, the function gives the operating signal after a set definite time. The operating time characteristics are according to definite time (DT).

This function contains a blocking functionality. It is possible to block the function outputs, timer or the function itself.

### 4.7.3.4 Analog channel configuration

UEXPDIS has two analog group inputs which all must be properly configured.

*Table 866: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 867: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected (*Phase Sel for Z Clc* set to "A or AB", "B or BC" or "C or CA"), if the setting *Impedance Meas mode* is se to "1Phase-to-earth" or "1Phase-to-phase". |
| | The function requires that all three voltage channels are connected if *Impedance Meas mode* is set to "3Phase-to-earth", "3Phase-to-phase" or "Pos sequence". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.7.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of UEXPDIS can be described using a module diagram. All the modules in the diagram are explained in the next sections.

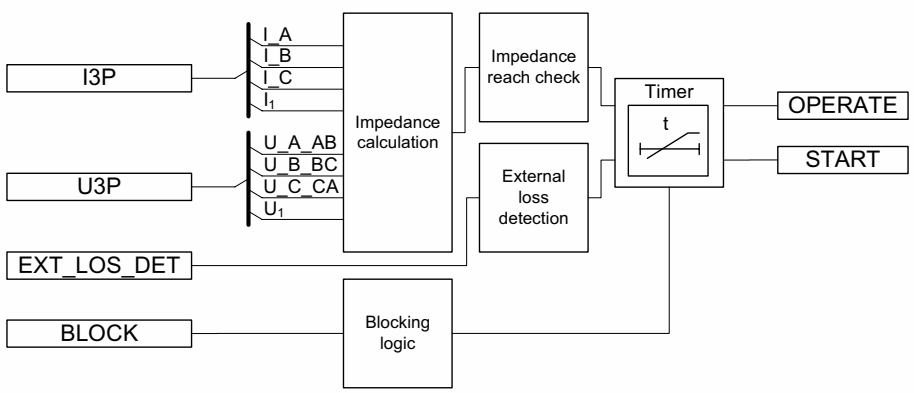



*Figure 505: Functional module diagram*

#### Impedance calculation

This module calculates the apparent impedance based on the selected voltages and currents. The *Impedance Meas mode* and *Phase Sel for Z Clc* settings determine which voltages and currents are to be used. If the *Impedance Meas mode* is set to "1Phase-earth" or "1Phase-phase", the *Phase Sel for Z Clc* setting is needed for determining which phase or phase-phase voltages ("A or AB", "B or BC" and "C or CA") and currents should be used for calculating the impedance.

*Table 868: Voltages and currents used in impedance calculation*

| Measurement mode | Phase Sel for Z Clc | Voltages and currents |
|---|---|---|
| 1Phase-earth | A or AB | U_A, I_A |
| 1Phase-earth | B or BC | U_B, I_B |
| 1Phase-earth | C or CA | U_C, I_C |
| 1Phase-phase | A or AB | U_AB, I_A, I_B |
| 1Phase-phase | B or BC | U_BC, I_B, I_C |
| 1Phase-phase | C or CA | U_CA, I_C, I_A |
| 3Phase-earth | N/A | U_A, U_B, U_C, I_A, I_B, I_C |
| 3Phase-phase | N/A | U_AB, U_BC, U_CA, I_A, I_B, I_C |
| Pos seqn | N/A | { U_A,U_B,U_C } or { U_AB,U_BC,U_CA } and I_A, I_B, I_C |

If all three phase voltages and phase currents are fed to the protection relay, the positive-sequence alternative is recommended.

If the polarity of the voltage signals is opposite to the normal polarity, the correction can be done by setting *Voltage reversal* to "Yes", which rotates the impedance vector by 180 degrees.

If the magnitude of the voltage is less than $0.05 \cdot U_N$, the calculated impedance is not reliable and the impedance calculation is disabled. $U_N$ is the rated phase-to-phase voltage.

The calculated impedance magnitudes and angles are available in the Monitored data view. The impedance angles are provided between -180...180 degrees.

The calculated apparent impedance is converted to pu impedance as the operating characteristics are defined with the pu settings.

## Impedance reach check

The operating characteristic is a circular offset mho on the impedance plane. The operating characteristics are defined with the *Offset*, *Diameter* and *Displacement* settings. If the calculated impedance value enters the circle in the impedance plane, the module sends an enabling signal to start the Timer.

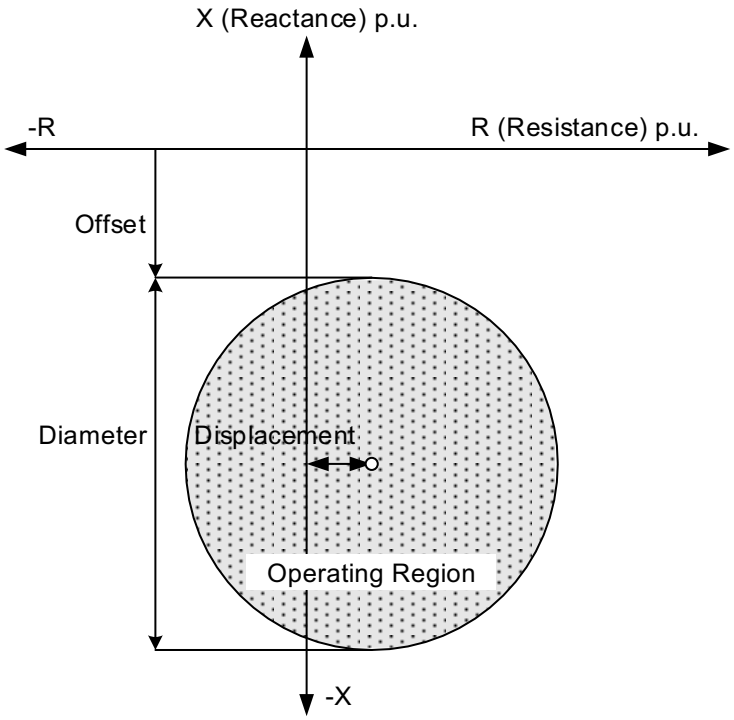



*Figure 506: Operating region of the impedance mho circle*

A fault in Automatic Voltage Regulator (AVR) or in the excitation system may cause a total loss of excitation. A short circuit on the slip rings reduces the excitation voltage to zero. This causes a gradual reduction of the excitation current and eventually a loss of excitation. An open circuit in the field circuit also causes a loss of excitation. These are typical examples which cause underexcitation in synchronous machines. This module detects the underexcitation condition for the above cases when the calculated impedance enters the operating characteristics.

## External loss detection

The module checks the status information of the excitation system. It is activated when the *External Los Det Ena* setting is set to "Enable". The total loss of excitation current or a failure in the excitation system is indicated by connecting the external binary signal to the `EXT_LOS_DET` input. The Timer is enabled immediately when the `EXT_LOS_DET` input is activated.

## Timer

Once activated, the Timer activates the `START` output. The time characteristic is according to DT. When the duration of the underexcitation exceeds the set definite *Operate delay time*, the `OPERATE` output is activated. If the impedance locus moves out of the offset-mho operating characteristics before the module operates, the reset

timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operating timer resets and the START output is deactivated.

The Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time (DT). The value is available in the Monitored data view.

### Blocking logic

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.7.3.6 Application

There are limits for the underexcitation of a synchronous machine. A reduction of the excitation current weakens the coupling between the rotor and the external power system. The machine may lose the synchronism and start to operate like an induction machine, which increases the consumption of the reactive power. Even if the machine does not lose synchronism, it is not recommended to operate in this state. The underexcitation causes excessive heating in the end region of the stator winding. This can damage the insulation of the stator winding and even the iron core.

The underexcitation also causes the generator to operate in the asynchronous mode. This increases the rotor speed, which causes heating in the rotor iron and damps the windings. A high intake of the reactive power from the network during underexcitation causes problems in the network, for example voltage dip, stability and power swings. Power swings stress the prime mover, causing for example turbine blade cavitation and mechanical stress in the gearbox.

The capability curve of a synchronous generator describes the underexcitation capability of the machine. An excessive capacitive load on the synchronous machine causes it to drop out-of-step. The reason is the steady-state stability limit as defined by the load angle being 90°, which can only be reached when the unit is underexcited.

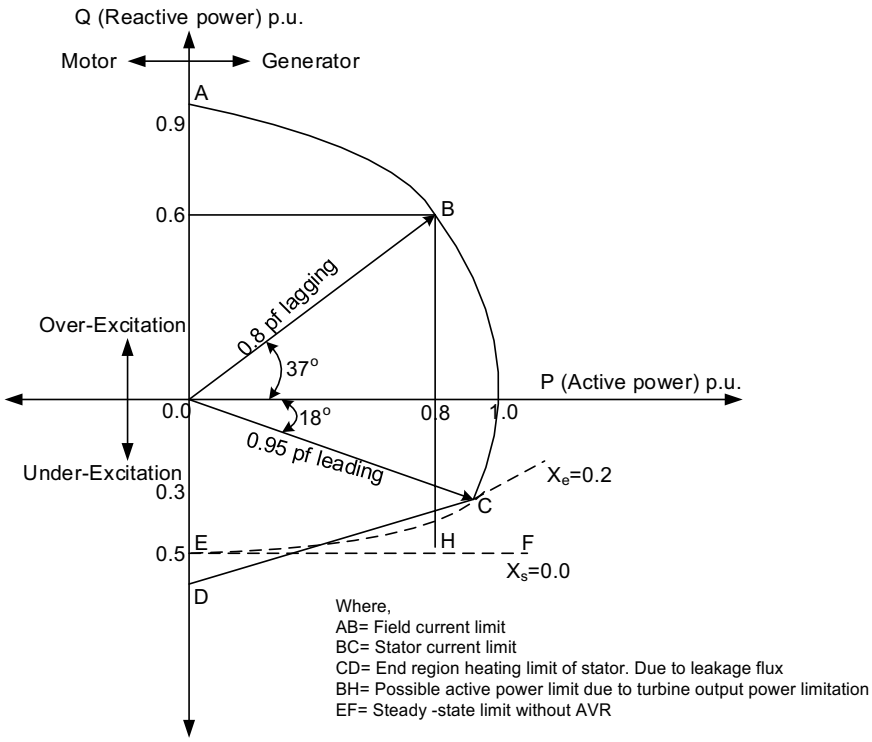



*Figure 507: Capability curve of a synchronous generator*

UEXPDIS protects the synchronous machines against an unstable operation due to loss of excitation. A partial or total loss of excitation causes a reactive power intake from the network to the machine, and the reactance of the system viewed from the machine terminals turns negative. This kind of drop-of-reactance condition can be detected by measuring the impedance of the system.

The operating characteristic is an offset-mho circle in the impedance plane, and the circle is parameterized with the *Offset*, *Diameter* and *Displacement* setting values.

*Table 869: Parameters of the circle*

| Setting values | Description |
|---|---|
| Offset | Distance of the top of the circle from the R-axis. This is usually set equal to - $x_d$'/2, where $x_d$' is the transient reactance of the machine. The sign of the setting value determines the top of the circle regarding the R-axis. If the sign is negative, the circle lies below the R-axis. |
| Diameter | Normally set equal to the machine's synchronous reactance $x_d$, which determines the size of the impedance circle. |
| Displacement | Displacement of the center of the circle from the reactance axis or the R-coordinate of the center. The setting can be used to adjust the sensitivity of the underexcitation protection. If the sign of the setting is positive, the circle is shifted to the right, that is, closer to the normal operating point. Respectively, if the sign is negative, the circle is shifted to the left and thus moves away from the normal operating point. |

The setting parameters of the off-set mho circle are to be given in pu values. The base impedance ($Z_N$) in ohms is:

$$Z_N = \left| \frac{U_N^2}{S_N} \right|$$

(Equation 232)

$U_N$ rated (phase-to-phase) voltage in kV

$S_N$ rated power of the protected machine in MVA

The corresponding calculation to convert ohms to pu values is:

$$X_{pu} = \frac{X_{ohm}}{Z_N}$$

(Equation 233)

$X_{pu}$ pu value

$X_{ohm}$ reactance in ohms

$Z_N$ base impedance

## Example of impedance locus in underexcitation

In an example of a typical impedance locus, once the impedance locus enters the relay operation characteristics, the relay operates after a settable definite time.

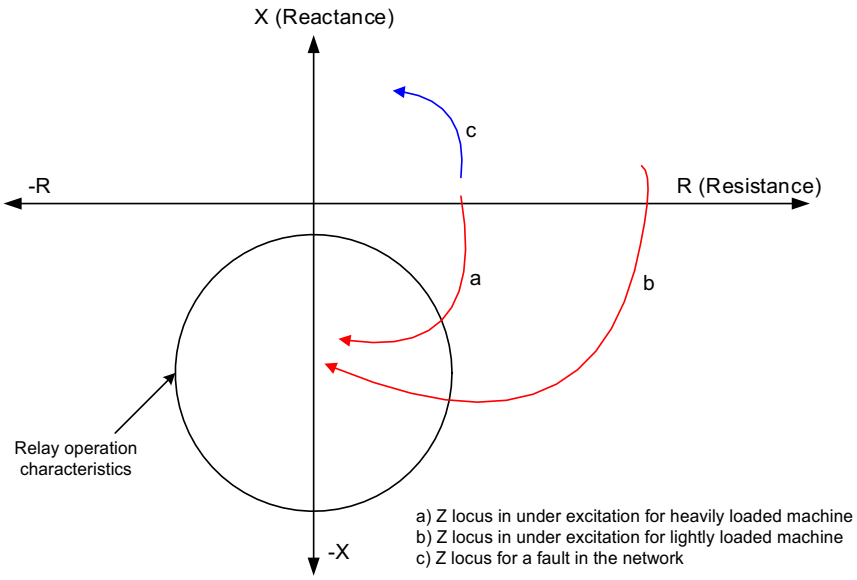



*Figure 508: Typical impedance locus in underexcitation: a) heavy load b) light load c) fault in the network*

## 4.7.3.7 Signals

*Table 870: UEXPDIS Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| EXT_LOS_DET | BOOLEAN | 0=False | External signal for excitation loss detection |

*Table 871: UEXPDIS Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.7.3.8 Settings

*Table 872: UEXPDIS Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Diameter | 1...6000 | %Zn | 1 | 200 | Diameter of the Mho diagram |
| Offset | -1000...1000 | %Zn | 1 | -10 | Offset of top of the impedance circle from the R-axis |
| Displacement | -1000...1000 | %Zn | 1 | 0 | Displacement of impedance circle centre from the X-axis |
| Operate delay time | 60...200000 | ms | 10 | 5000 | Operate delay time |

*Table 873: UEXPDIS Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| External Los Det Ena | 0=Disable<br>1=Enable | | | 1=Enable | Enable external excitation loss detection |
| Voltage reversal | 0=No<br>1=Yes | | | 0=No | Rotate voltage signals by 180 degrees |
| Impedance Meas mode | 1=1Phase-to-earth<br>2=1Phase-to-phase<br>3=3Phase-to-earth<br>4=3Phase-to-phase<br>5=Pos sequence | | | 5=Pos sequence | Select voltage and currents for impedance calculation |
| Phase Sel for Z Clc | 1=A or AB<br>2=B or BC<br>3=C or CA | | | 1=A or AB | Voltage phase selection |

*Table 874: UEXPDIS Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 3000 | Reset delay time |

### 4.7.3.9 Monitored data

*Table 875: UEXPDIS Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time (in %) |
| Z_AMPL_A | FLOAT32 | 0.00...200.00 | xZn | Impedance amplitude phase A |
| Z_ANGLE_A | FLOAT32 | -180.00...180.00 | deg | Impedance angle phase A |
| Z_AMPL_B | FLOAT32 | 0.00...200.00 | xZn | Impedance amplitude phase B |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Z_ANGLE_B | FLOAT32 | -180.00...180.00 | deg | Impedance angle phase B |
| Z_AMPL_C | FLOAT32 | 0.00...200.00 | xZn | Impedance amplitude phase C |
| Z_ANGLE_C | FLOAT32 | -180.00...180.00 | deg | Impedance angle phase C |
| Z_AMPL_AB | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase A-B impedance amplitude |
| Z_ANGLE_AB | FLOAT32 | -180.00...180.00 | deg | Phase-to-phase A-B impedance phase angle |
| Z_AMPL_BC | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase B-C impedance amplitude |
| Z_ANGLE_BC | FLOAT32 | -180.00...180.00 | deg | Phase-to-phase B-C impedance phase angle |
| Z_AMPL_CA | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase C-A impedance amplitude |
| Z_ANGLE_CA | FLOAT32 | -180.00...180.00 | deg | Phase-to-phase C-A impedance phase angle |
| Z1_AMPL | FLOAT32 | 0.00...200.00 | xZn | Positive sequence impedance amplitude |
| Z1_ANGLE | FLOAT32 | -180.00...180.00 | deg | Positive sequence impedance phase angle |
| UEXPDIS | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 4.7.3.10 Technical data

*Table 876: UEXPDIS Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage:<br>$f = f_n \pm 2$ Hz |
| | ±3.0% of the set value or ±0.2% Zb |
| Start time[1)2)] | Typically 45 ms |
| Reset time | Typically 30 ms |
| Reset ratio | Typically 1.04 |
| Retardation time | Total retardation time when the impedance returns from the operating circle <40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,… |

1) $f_n$= 50Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.7.4 Three-phase underimpedance protection UZPDIS

### 4.7.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase underimpedance protection | UZPDIS | Z<G | 21G |

### 4.7.4.2 Function block

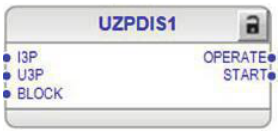



*Figure 509: Function block*

### 4.7.4.3 Functionality

The three-phase underimpedance protection UZPDIS is generally applied as a backup protection for generators and transformers against short circuit faults.

The protection is based on the origin-centric circular characteristics on the impedance plane. The function calculates the impedance value from the voltage and current phasors. If the impedance vector enters the origin-centric circle, the function produces the operating signal after a set delay. The operating time characteristics are according to definite time (DT).

This function contains a blocking functionality. It is possible to block the function outputs, reset timer or the function itself.

### 4.7.4.4 Analog channel configuration

UZPDIS has two analog group inputs which all must be properly configured.

*Table 877: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 878: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected (*Phase Sel for Z Clc* set to "AB", "BC" or "CA"), if the setting *Impedance Meas mode* is set to "1Phase-to-phase". |
| | The function requires that all three voltage channels are connected if *Impedance Meas mode* is set to "3Phase-to-phase". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.7.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of UZPDIS can be described with a module diagram. All the modules in the diagram are explained in the next sections.

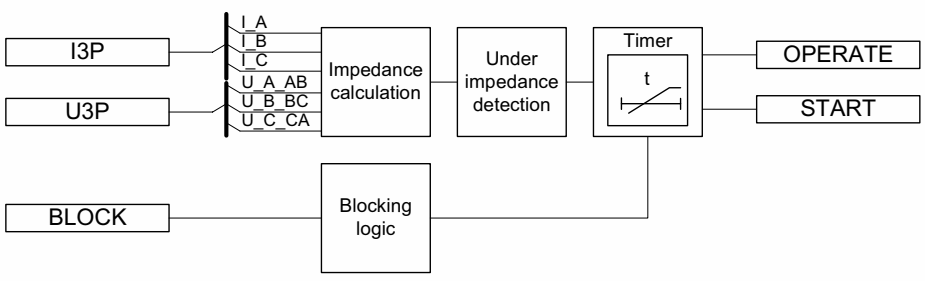



*Figure 510: Functional module diagram*

#### Impedance calculation

This module calculates the impedance based on the selected voltages and currents. The *Impedance Meas mode* and *Phase Sel for Z Clc* settings determine which voltages and currents are to be used. If *Impedance Meas mode* is set to "1Phase-to-phase", the *Phase Sel for Z Clc* setting is needed for determining which phase-phase voltages ("AB", "BC" and "CA") and currents should be used for calculating the impedance.

*Table 879: Voltages and currents used in impedance calculation*

| Impedance Meas mode | Phase Sel for Z Clc | Voltages and currents used in impedance calculation[1)] |
|---|---|---|
| 1Phase-to-phase | AB | $\overline{ZAB} = \frac{U_AB}{I_A - I_B}$ |
| 1Phase-to-phase | BC | $\overline{ZBC} = \frac{U_BC}{I_B - I_C}$ |
| 1Phase-to-phase | CA | $\overline{ZCA} = \frac{U_CA}{I_C - I_A}$ |
| 3Phase-to-phase | N/A | $\overline{ZAB} = \frac{U_AB}{I_A - I_B}$<br>$\overline{ZBC} = \frac{U_BC}{I_B - I_C}$<br>$\overline{ZCA} = \frac{U_CA}{I_C - I_A}$ |

1) Voltages and currents in the calculations are given in volts and amps.

If all three phase or phase-phase voltages and phase currents are fed to the protection relay, the "3Phase-to-phase" mode is recommended.

The current measurement of the function is based on two alternative measurement modes, "DFT" and "Peak-to-Peak". The measurement mode is selected using the *Measurement mode* setting.

If the current magnitude is below $0.02 \cdot I_N$, where $I_N$ is the nominal phase current, the impedance value is not evaluated and the maximum impedance value (99.999 pu) is shown in the Monitored data view.

The calculated impedances are converted to a pu impedance as the operating characteristics are defined using the *Polar reach* setting in %Zb.

The calculated phase-phase impedance amplitudes Z_AMPL_AB, Z_AMPL_BC and Z_AMPL_CA are available as pu values in the Monitored data view.

## Underimpedance detection

The operating characteristic is an origin-centric circle on the impedance plane. The origin-centric circular characteristic is defined using the *Polar reach* setting. If the calculated impedance value enters the circle in the impedance plane, the module sends an enabling signal to start the Timer.

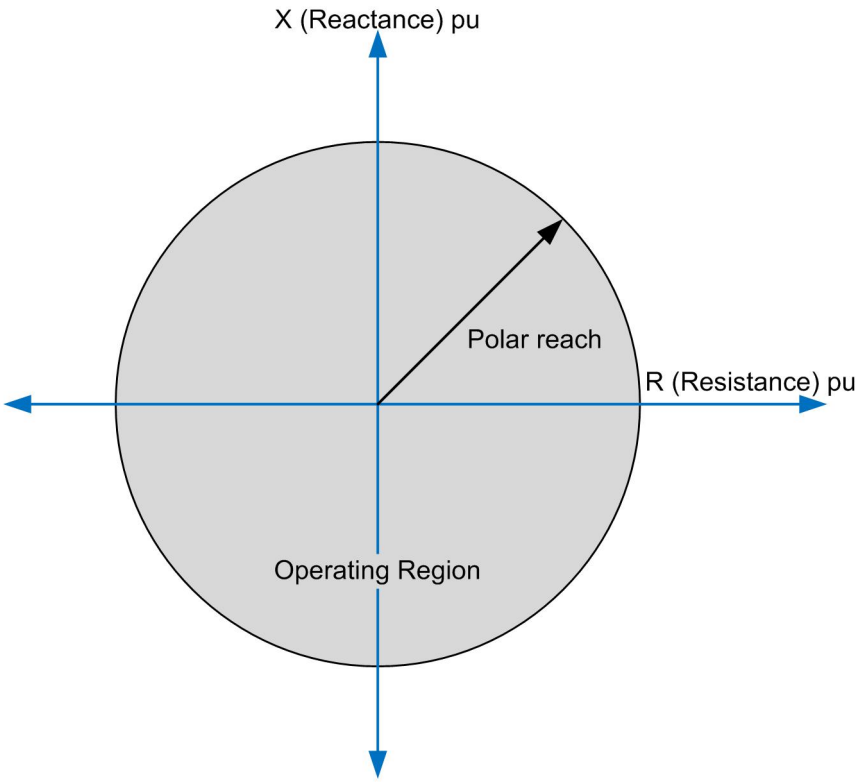



*Figure 511: Origin-centric circular operating characteristics*

More than one impedance value is available when *Impedance Meas mode* is set to "3Phase-to-phase", and the function considers the lowest impedance value for starting and operating.

## Timer

Once activated, Timer activates START output. The time characteristic is according to DT. When the duration of the underimpedance condition exceeds the set definite *Operate delay time*, the OPERATE output is activated. If the impedance locus moves out of circular operating characteristics before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operating timer resets and the START output is deactivated.

Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time (DT). The value is available in the Monitored data view.

## Blocking logic

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/**

**Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.7.4.6 Application

The three-phase underimpedance protection is used as a backup protection against short circuit faults at the generator terminals or on the high-voltage side of a step-up transformer. This function can be used either instead of the definite time voltage-dependent overcurrent protection or to obtain a limited protection zone and the optimum operating time instead of the non-directional overcurrent protection.

#### Comparison between overcurrent and underimpedance protection

Phase current for three-phase short circuit is shown in Figure 512. In this case, with an ordinary over current relay having the current setting as $1.2 \cdot I_n$, the time setting should be less than 0.2 seconds, since with a higher value the short-circuit current decays below the set value and the relay drops off. The current setting can also be reduced to $1.1 \cdot I_n$, although this provides no substantial rise in the time setting. In some situations, either of the above current settings is appropriate, but if longer tripping times are required to maintain the time selectivity, the underimpedance protection is needed.

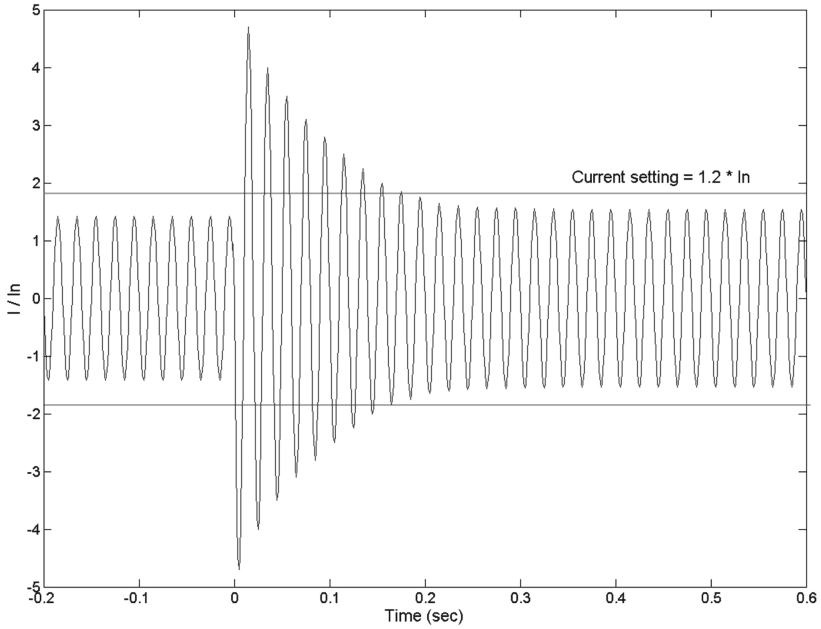



*Figure 512: Short circuit current waveform, fault occurs at time 0 seconds (Current setting limit is multiplied by the square root of 2)*

The phase voltage in a three-phase short circuit when a fault occurs at time = 0 s is shown in Figure 513. The voltage drop caused by a three-phase fault provides more time for determining the fault by means of an underimpedance protection.

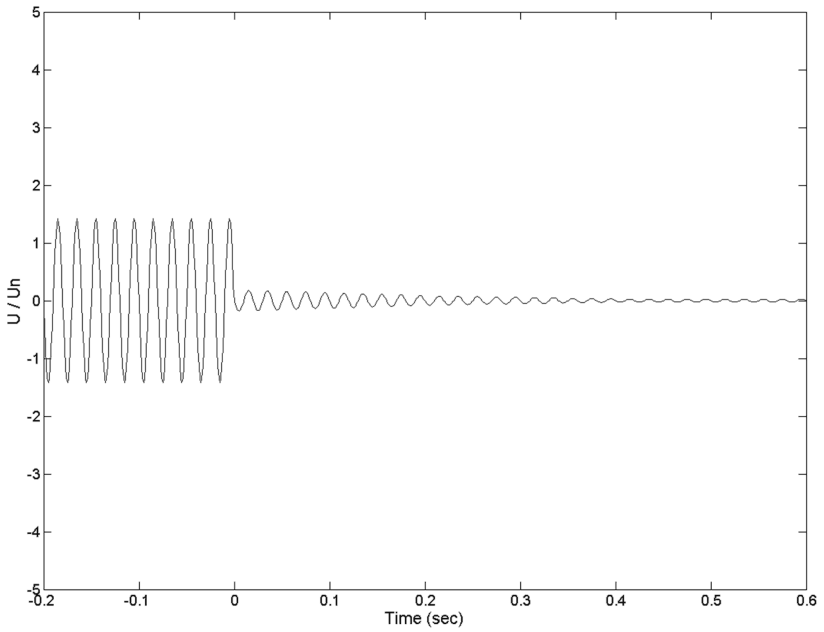



*Figure 513: Short-circuit voltage waveform, fault occurs at time 0 seconds*

In a typical impedance trajectory during a short circuit, the fault impedance remains inside the impedance circle for a longer time, in which case the underimpedance protection provides longer tripping delay times to maintain the time selectivity.

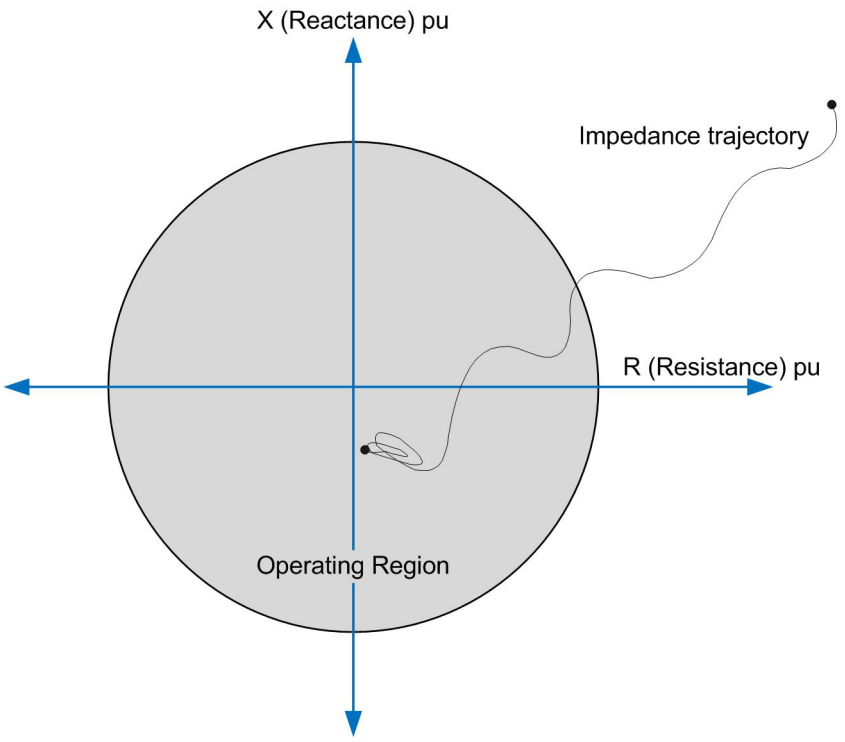



*Figure 514: Typical impedance trajectory during a short circuit*

## Underimpedance protection for transformers

The underimpedance function is used as a short circuit protection instead of the overcurrent protection. It is also used as a backup to the differential protection of transformers.

The voltage and current phasors are measured with the VTs and CTs connected on the HV side of the transformer.

The phase and current shifts due to transformer D/Y connections and other factors complicate the settings for the faults in the secondary winding (as seen from the protection relay), and detailed calculations are necessary for a good coverage.

The *Polar reach* setting is set to a value equal to 150 percent of the transformer short circuit impedance. The setting also provides a backup protection for the busbar and feeder faults on the HV side.

## Underimpedance protection for generators

The underimpedance protection is set to protect the zone between the generator windings and the generator side windings of the step-up transformer. The function

mainly protects the generator bus, the low-voltage part of the step-up transformer and a part of the stator winding against any short circuits.

The voltages should be measured from the generator terminals and the phase currents from the neutral point of the generator.

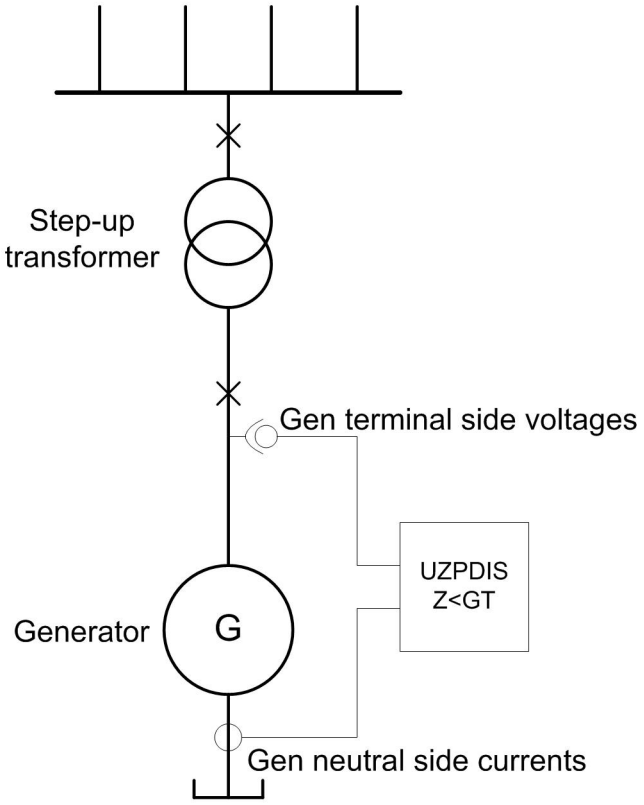



*Figure 515: Current and voltage signals for underimpedance protection*

To prevent malfunctioning of the underimpedance protection in case of nearby faults, the *Polar reach* setting is set to a value equal to 70 percent of the step-up transformer short circuit impedance.

In directly connected machines where the impedance towards the network is limited only by the lines or bus bars, it must be secured that the function does not cause any selectivity problems. In such cases, it is recommended to use the voltage-dependent overcurrent protection instead of the underimpedance protection.

## Function blocking guidelines

The operation of the underimpedance protection must be restrained if the voltage in one or more phases suddenly drops close to zero without any significant change in the current observed at the same time. This situation is considered as a fuse failure or a miniature circuit breaker operation in the voltage transformer secondary circuit. The voltage drop could cause an unwanted operation of the function block since the

calculated impedance could fall below the set operating limit even if there is no actual fault in the primary system.

The blocking operation is provided by an external function block, the fuse failure supervision SEQSPVC, whose output is connected to the BLOCK input of UZPDIS.

### 4.7.4.7 Signals

*Table 880: UZPDIS Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 881: UZPDIS Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.7.4.8 Settings

*Table 882: UZPDIS Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Polar reach | 1...6000 | %Zn | 1 | 7 | Impedance start value, i.e. radius of impedance circle |
| Operate delay time | 40...200000 | ms | 10 | 200 | Operate delay time |

*Table 883: UZPDIS Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Measurement mode | 2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |
| Impedance Meas mode | 2=1Phase-to-phase<br>4=3Phase-to-phase | | | 4=3Phase-to-phase | Select voltage and current signals for impedance calculation |
| Phase Sel for Z Clc | 1=AB<br>2=BC<br>3=CA | | | 1=AB | Select phase/ phase-phase voltages and currents for Z calculation. |

*Table 884: UZPDIS Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |

### 4.7.4.9 Monitored data

*Table 885: UZPDIS Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time (in %) |
| Z_AMPL_AB | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase A-B impedance amplitude |
| Z_AMPL_BC | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase B-C impedance amplitude |
| Z_AMPL_CA | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase C-A impedance amplitude |
| UZPDIS | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.7.4.10 Technical data

*Table 886: UZPDIS Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage: $f_n$ ±2 Hz |
| | ±3.0% of the set value or ±0.2 %Zb |
| Start time[1)2)] | Typically 50 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 1.04 |
| Retardation time | <40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

1) $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

# 4.8 Power protection

## 4.8.1 Underpower protection DUPPDPR

### 4.8.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Underpower protection | DUPPDPR | P< | 32U |

### 4.8.1.2 Function block




*Figure 516: Function block*

### 4.8.1.3 Functionality

The underpower protection function DUPPDPR is used for protecting generators and prime movers against the effects of very low power outputs or reverse power condition.

The function operates when the measured active power falls below the set value. The operating characteristics are according to definite time DT.

This function contains a blocking functionality. It is possible to block the function outputs, timer or the function itself.

### 4.8.1.4 Analog channel configuration

DUPPDPR has two analog group inputs which must be properly configured.

*Table 887: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 888: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with the corresponding one voltage channel connected if the measurement mode is set to "PhsA", "PhsB" or "PhsC". |
| | The function can work with the corresponding two voltage channels connected if the measurement mode is set to "PhsA", "PhsB" or "PhsC". |
| | The function requires that all three voltage channels are connected for the other measurement modes. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.8.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DUPPDPR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

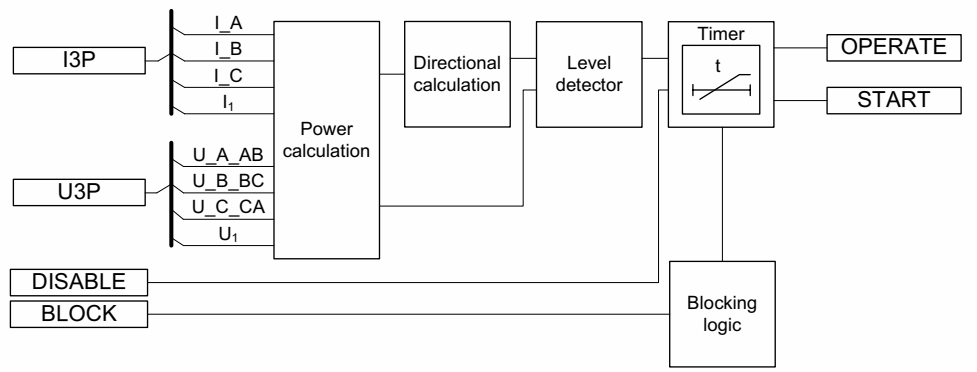



*Figure 517: Functional module diagram*

#### Power calculation

This module calculates the apparent power based on the selected voltage and current measurements as described in Table 889. The *Measurement mode* setting determines which voltage and current measurements are to be used.

It is also possible to use positive-sequence components for calculating apparent power, which makes the determination of power insensitive to the possible asymmetry in currents or voltages and corresponds to the real load of the prime mover of the generator.

*Table 889: Power calculation*

| Measurement mode setting | Power calculation |
|---|---|
| PhsA, PhsB, PhsC | $\bar{S} = \bar{U}_a \cdot \bar{I}_a^* + \bar{U}_b + \bar{I}_b^* + \bar{U}_c \cdot \bar{I}_c^*$<br>$P = \mathrm{Re}(\bar{S})$ |
| Arone | $\bar{S} = \bar{U}_{ab} \cdot \bar{I}_a^* - \bar{U}_{bc} \cdot \bar{I}_c^*$<br>$P = \mathrm{Re}(\bar{S})$ |
| Pos Seq | $\bar{S} = 3 \cdot \bar{U}_1 \cdot \bar{I}_1^*$<br>$P = \mathrm{Re}(\bar{S})$ |
| PhsAB | $\bar{S} = \sqrt{3} \cdot \bar{U}_{ab} \cdot (\bar{I}_a^* - \bar{I}_b^*)$<br>$P = \mathrm{Re}(\bar{S})$ |
| PhsBC | $\bar{S} = \sqrt{3} \cdot \bar{U}_{bc} \cdot (\bar{I}_b^* - \bar{I}_c^*)$<br>$P = \mathrm{Re}(\bar{S})$ |
| PhsCA | $\bar{S} = \sqrt{3} \cdot \bar{U}_{ca} \cdot (\bar{I}_c^* - \bar{I}_a^*)$<br>$P = \mathrm{Re}(\bar{S})$ |
| PhsA | $\bar{S} = 3 \cdot \bar{U}_a \cdot \bar{I}_a^*$<br>$P = \mathrm{Re}(\bar{S})$ |
| PhsB | $\bar{S} = 3 \cdot \bar{U}_b \cdot \bar{I}_b^*$<br>$P = \mathrm{Re}(\bar{S})$ |
| PhsC | $\bar{S} = 3 \cdot \bar{U}_c \cdot \bar{I}_c^*$<br>$P = \mathrm{Re}(\bar{S})$ |

If all three phase voltages and phase currents are fed to the protection relay, the positive-sequence alternative is recommended (default).

Depending on the set *Measurement mode*, the power calculation calculates active power, reactive power and apparent power values from the available set of measurements. The calculated powers S, P, Q and the power factor angle, PF_ANGL, are available in the Monitored data.

## Directional calculation

Directional calculation determines the direction of the measured power. The measured power is considered to be in the forward direction if the active power is positive, else it is considered to be in the reverse direction.

A typical error is, for example, that the VT or CT poles are wrongly connected. This is seen as a power flow opposite to that of the intended direction. The *Pol Reversal* setting can be used to correct the situation. By setting the value to "True", the measured apparent power is turned 180 degrees.

## Level detector

Level detector compares the calculated value of the active power with a set *Start value*. If the calculated value of the active power falls below *Start value* in the forward direction or if the measured power is in the reverse direction, Level detector enables the Timer module.

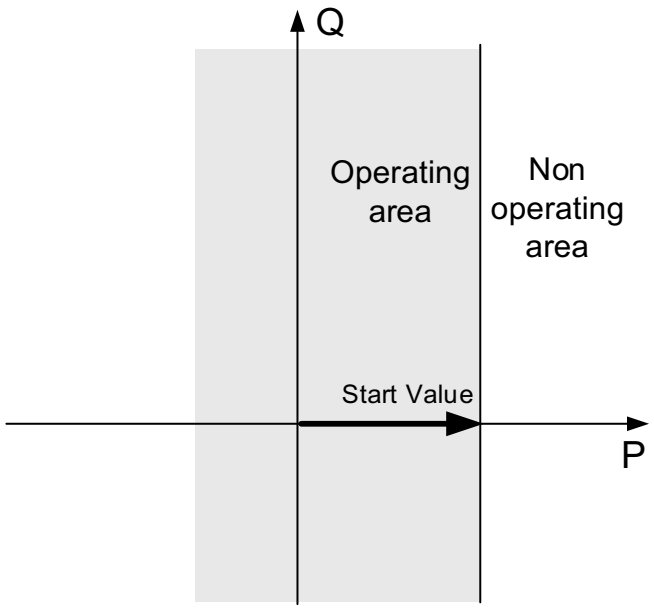



*Figure 518: Operating characteristics of DUPPDPR with setting Start value*

## Timer

Once activated, Timer activates the START output. The time characteristics are according to DT. When the operation timer has reached the value of *Operate delay time*, the OPERATE output is activated. In a drop-off situation, that is, if the underpower condition disappears before the operation delay is exceeded, the timer reset state is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

Timer calculates the START_DUR value which indicates the percentage of the time elapsed since the activation of the START output with respect to *Operate delay time*. The value is available in the Monitored data.

The DISABLE input can be used to coordinate the correct operation during the generator start-up situation. By activating the DISABLE signal, both the START and OPERATE outputs are blocked. Once the DISABLE signal is deactivated, the Timer remains blocked for an additional time duration as set through the setting *Disable time*.

### Blocking logic

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.8.1.6 Application

The task of a generator in a power plant is to convert mechanical energy into electrical energy. Sometimes the mechanical power from the prime mover may decrease so much that it does not cover the internal losses. The task of an underpower protection is to protect the generator from very low power output conditions.

Steam turbines become easily overheated if the steam flow becomes too low or if the steam ceases to flow through the turbine. Hydro turbine of the Kaplan type may be damaged due to the fact that the turbine blade surfs on the water and sets up axial pressure on the bearing. Diesel engines may be damaged due to insufficient lubrication.

If the generator size is very large, it is uneconomical to continue running it with low generated power. In the reverse power condition, large generators draw a considerable amount of power from the rest of the system to feed their internal losses. Hence, it is desirable to disconnect the generator in such situations.

In case of the parallel-connected generators, for example, the load of one generator may be so low that it is better to disconnect it and let the remaining generators feed the network.



Where a low value of power setting is required, for example less than 2%, the correction parameters should be used to compensate for the measuring errors. The manufacturer of the measuring devices is to be contacted for information on the measuring errors.

If the measuring errors are not compensated for, the underpower setting should not be lower than the sum of the current-measuring and voltage-measuring errors.
For example, if the error of the current-measuring device is 2% and that of the voltage-measuring device is 1%, the minimum setting is (2 + 1)% = 3%.

### 4.8.1.7 Signals

*Table 890: DUPPDPR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| DISABLE | BOOLEAN | 0=False | Signal to block the function during generator startup |

*Table 891: DUPPDPR Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.8.1.8 Settings

*Table 892: DUPPDPR Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...2.00 | xSn | 0.01 | 0.10 | Start value |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |

*Table 893: DUPPDPR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation On/Off |

*Table 894: DUPPDPR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=PhsA, PhsB, PhsC<br>2=Arone<br>3=Pos Seq<br>4=PhsAB<br>5=PhsBC<br>6=PhsCA<br>7=PhsA<br>8=PhsB<br>9=PhsC | | | 3=Pos Seq | Selection of power calculation method |
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |
| Pol reversal | 0=False<br>1=True | | | 0=False | Reverse the definition of the power direction |
| Disable time | 0...60000 | ms | 1000 | 0 | Additional wait time after CB closing |

## 4.8.1.9 Monitored data

*Table 895: DUPPDPR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| P | FLOAT32 | -160.000...160.000 | xSn | Active power |
| Q | FLOAT32 | -160.000...160.000 | xSn | Reactive power |
| S | FLOAT32 | 0.000...160.000 | xSn | Apparent power |
| PF_ANGLE | FLOAT32 | -180.00...180.00 | deg | Power factor angle |
| DUPPDPR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 4.8.1.10 Technical data

*Table 896: DUPPDPR Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy [1)] | Depending on the frequency of the measured current and voltage:<br>$f_n$ ±2 Hz |
| | Power measurement accuracy ±3% of the set value or ±0.002 × $S_n$<br>Phase angle: ±2° |
| Start time[2)3)] | Typically 45 ms |
| Reset time | Typically 30 ms |

Table continues on next page

| Characteristic | Value |
|---|---|
| Reset ratio | Typically 1.04 |
| Operate time accuracy | ±1.0% of the set value of ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

1) *Measurement mode* = “Pos Seq” (default)
2) U = $U_n$, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
3) Includes the delay of the signal output contact

## 4.8.2 Reverse power/directional overpower protection DOPPDPR

### 4.8.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEE C37.2 device number |
|---|---|---|---|
| Reverse power/directional overpower protection | DOPPDPR | P>/Q> | 32R/32O |

### 4.8.2.2 Function block




*Figure 519: Function block*

### 4.8.2.3 Functionality

The reverse power/directional overpower protection function DOPPDPR can be used for generator protection against delivering an excessive power beyond the generator's capacity to the grid, against the generator running like a motor, and against the motor running like a generator and for protecting a motor which consumes more reactive power due to loss of field. It can also be used in feeder protection for indicating overload on the distribution system, to indicate that a customer is supplying power into the grid and for protecting the transformer from delivering an excessive load.

The function starts and operates when the measured power exceeds the set limit and in a specified direction. The operate time characteristics are according to definite time (DT).

This function contains a blocking functionality. It is possible to block the function outputs, timer or the function itself.

### 4.8.2.4 Analog channel configuration

DOPPDPR has two analog group inputs which must be properly configured.

*Table 897: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 898: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with the corresponding one voltage channel connected if *Measurement mode* is set to "PhsA", "PhsB" or "PhsC". |
| | The function can work with the corresponding two voltage channels connected if *Measurement mode* is set to "PhsAB", "PhsBC" or "PhsCA". |
| | The function requires that all three voltage channels are connected for other measurement modes. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.8.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of DOPPDPR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

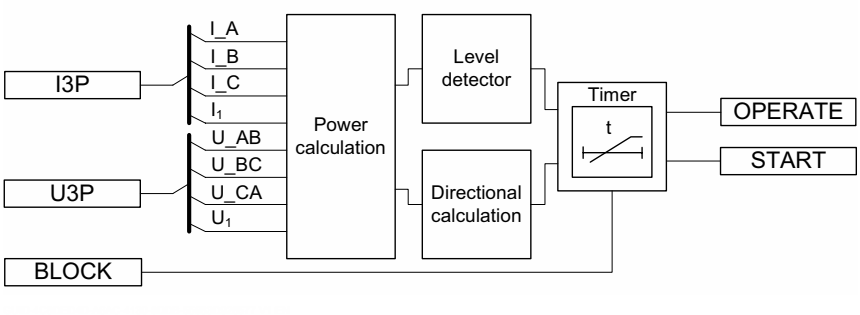



*Figure 520: Functional module diagram*

## Power calculation

This module calculates the apparent power based on the selected voltages and currents. The *Measurement mode* setting determines which voltages and currents are used. It is also possible to use positive-sequence components for calculating the apparent power which makes the determination of power insensitive to a possible asymmetry in currents or voltages and corresponds to the real load on the prime mover of the generator.

***Table 899: Power calculation***

| Measurement mode setting | Power calculation |
|---|---|
| PhsA, PhsB, PhsC | $\bar{S} = \bar{U}_a \cdot \bar{I}_a^* + \bar{U}_b + \bar{I}_b^* + \bar{U}_c \cdot \bar{I}_c^*$<br>$P = \mathrm{Re}(\bar{S})$ |
| Arone | $\bar{S} = \bar{U}_{ab} \cdot \bar{I}_a^* - \bar{U}_{bc} \cdot \bar{I}_c^*$<br>$P = \mathrm{Re}(\bar{S})$ |
| Pos Seq | $\bar{S} = 3 \cdot \bar{U}_1 \cdot \bar{I}_1^*$<br>$P = \mathrm{Re}(\bar{S})$ |
| PhsAB | $\bar{S} = \sqrt{3} \cdot \bar{U}_{ab} \cdot (\bar{I}_a^* - \bar{I}_b^*)$<br>$P = \mathrm{Re}(\bar{S})$ |
| PhsBC | $\bar{S} = \sqrt{3} \cdot \bar{U}_{bc} \cdot (\bar{I}_b^* - \bar{I}_c^*)$<br>$P = \mathrm{Re}(\bar{S})$ |
| PhsCA | $\bar{S} = \sqrt{3} \cdot \bar{U}_{ca} \cdot (\bar{I}_c^* - \bar{I}_a^*)$<br>$P = \mathrm{Re}(\bar{S})$ |
| Table continues on next page | |

| Measurement mode setting | Power calculation |
|---|---|
| PhsA | $\bar{S} = 3 \cdot \bar{U}_a \cdot \bar{I}_a^*$<br>$P = \mathrm{Re}(\bar{S})$ |
| PhsB | $\bar{S} = 3 \cdot \bar{U}_b \cdot \bar{I}_b^*$<br>$P = \mathrm{Re}(\bar{S})$ |
| PhsC | $\bar{S} = 3 \cdot \bar{U}_c \cdot \bar{I}_c^*$<br>$P = \mathrm{Re}(\bar{S})$ |

If all three phase voltages and phase currents are fed to the protection relay, the positive-sequence alternative is recommended.

The calculated powers S, P, Q and the power factor angle PF_ANGL are available in the Monitored data view.

## Level detector

The Level detector compares the magnitude of the measured apparent power to the set *Start value*. If the measured value exceeds the set *Start value*, the Level detector sends an enabling signal to the Timer module.

## Directional calculation

The Directional calculation module monitors the direction of the apparent power. When the apparent power flow is in the operating area, the module sends the enabling signal to the Timer module. The directional operation can be selected with the combination of the settings *Directional mode* and *Power angle*. The selectable options for the *Directional mode* setting are "Forward" and "Reverse". The *Power angle* setting can be used to set the power direction between the reactive and active power.

A typical error is, for example, that the VT or CT poles are wrongly connected. This is seen as a power flow opposite to that of the intended direction. The *Pol Reversal* setting can be used to correct the situation. By setting the value to "True", the measured apparent power is turned 180 degrees.

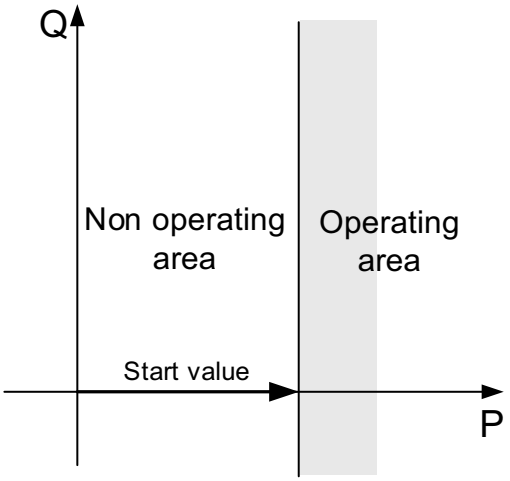



*Figure 521: Operating characteristics with the Start Value setting, the Power angle setting being 0 and Directional mode "Forward"*

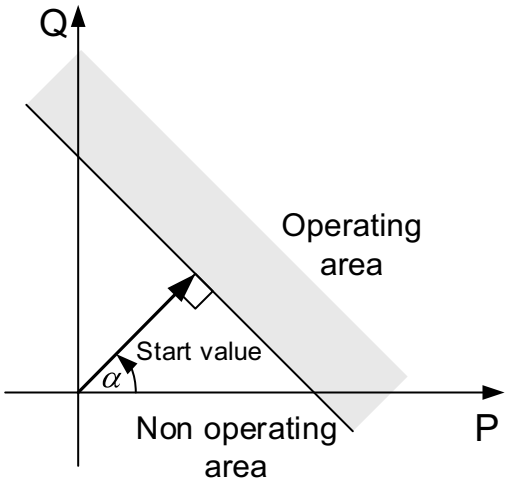



*Figure 522: Operating characteristics with the Start Value setting, Power angle (α) being +45 and Directional mode "Forward"*

### Timer

Once activated, the Timer activates the START output. The time characteristics are according to DT. When the operation timer has reached the value of *Operate delay time*, the OPERATE output is activated. If a drop-off situation happens, that is, the value of power drops below *Start value* before the operate delay is exceeded, the timer reset state is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time (DT). The value is available in the Monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode**, which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.8.2.6 Application

DOPPDPR is used to provide protection against an excessive power flow in the set operating direction. The main application is the protection of generators and turbines. It can also be used in feeder protection applications, for example, the ring network.

DOPPDPR in the forward direction can be used to protect the generators or motors from delivering or consuming excess power. For example, the generator overpower protection can be used to shed a noncritical feeder load or to start parallel generators. A synchronous motor may start consuming more reactive power in case of loss of excitation, in which case the forward overpower protection is used to detect such condition.

The DOPPDPR function has many applications when used as reverse power protection. A generator in a power plant converts mechanical energy to electrical energy. Sometimes the mechanical power from a prime mover may decrease to a limit that it does not cover the internal losses. The synchronous generator becomes a synchronous motor and starts importing power from the system. The effect of a generator acting as a motor implies no risk to the machine but can cause damage to the prime mover. The extent of the damage depends on the type of the prime mover.

Steam turbines become overheated easily if the steam flow drops too low or if the steam ceases to flow through the turbine. The break of a main steam pipe, damage to

one or more blades in the steam turbine or an inadvertent closing of the main stop valves are typical causes for the low steam flow. The steam turbines of turbo generators can be protected during a low steam flow with the overpower protection operating in reverse direction. Hydroturbines tolerate reverse power much better than steam turbines do. There is a risk that the turbine runner moves axially and touches stationary parts. They are not always strong enough to withstand the associated stresses.

A hydroturbine that rotates in water with the closed wicket gates draws about 10% of the rated power from the rest of the power system if the intake is blocked due to ice, snow, branches or leaves. A complete blockage of the intake may cause cavitations. If there is only air in the hydroturbine, the power demand drops to about 3%. The risk of damages to the hydroturbines can justify the reverse operation of the overpower protection in unattended plants.



Whenever a low value of the reverse power setting is required, an underpower protection should also be used in conjunction with DOPPDPR. The limit depends on the CT and VT accuracy.

Diesel engines should have overpower protection in reverse direction. The generator takes about 15% or more of its rated power from the system. A stiff engine may require 25% of the rated power to motor it. A well run engine may need no more than 5%. It is necessary to obtain information from the engine manufacturer and to measure the reverse power during commissioning.

Reverse overpower can also act as an alternative for an under excitation protection in case of small generators. If the field excitation is reduced, the generator may start importing the reactive power, making the generator run as an asynchronous generator. A synchronous generator is not designed to work asynchronously and may become damaged due to heating in the damper windings or heating in the rotor due to slip frequency current.

When operated in reverse power direction, DOPPDPR can be used as an alarm if the power flowing from the industry is feeding the grid, which may not be desired as per the rules and regulations of the utility owning the grid.

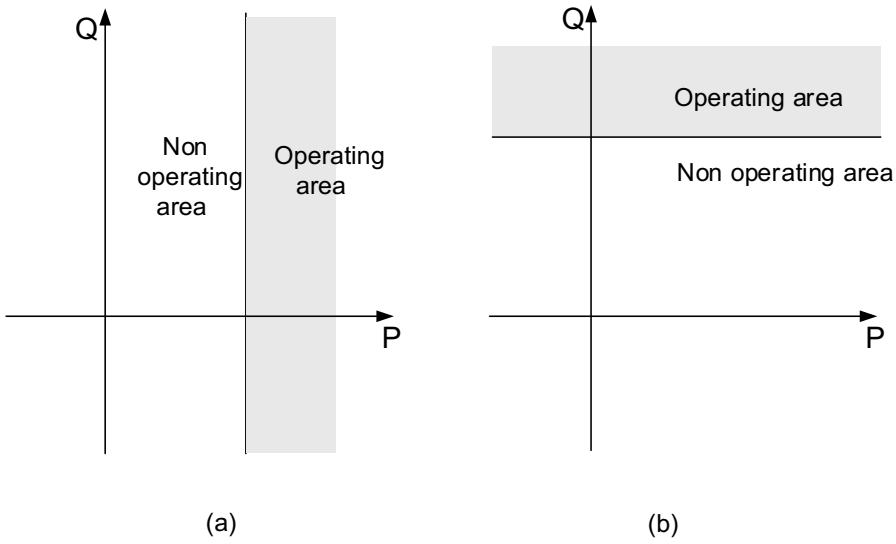



*Figure 523: Forward active overpower characteristics (a) and forward reactive overpower characteristics (b)*

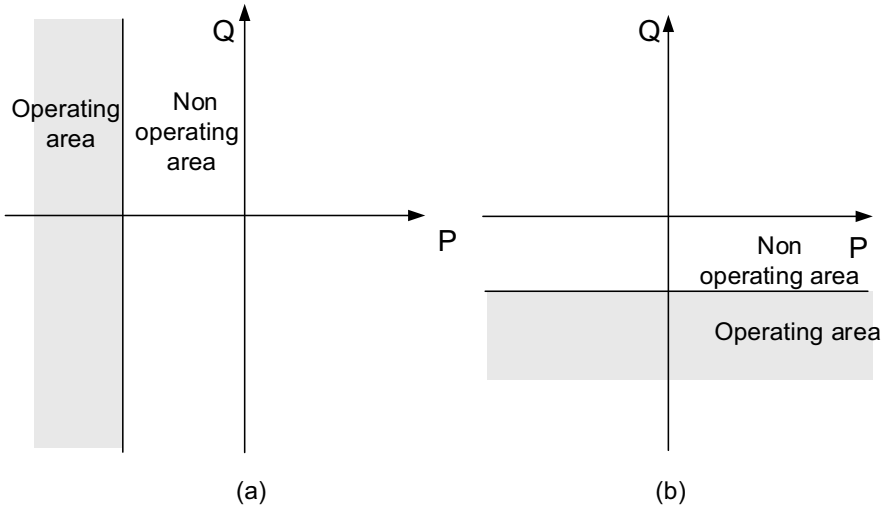



*Figure 524: Reverse active overpower characteristics (a) and reverse reactive overpower characteristics (b)*

### 4.8.2.7 Signals

*Table 900: DOPPDPR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 901: DOPPDPR Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.8.2.8 Settings

*Table 902: DOPPDPR Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...2.00 | xSn | 0.01 | 1.00 | Start value |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Directional mode | 2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Power angle | -90...90 | deg | 1 | 0 | Adjustable angle for power |

*Table 903: DOPPDPR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation On/Off |
| Measurement mode | 1=PhsA, PhsB, PhsC<br>2=Arone<br>3=Pos Seq<br>4=PhsAB<br>5=PhsBC<br>6=PhsCA<br>7=PhsA<br>8=PhsB<br>9=PhsC | | | 3=Pos Seq | Selection of power calculation method |

*Table 904: DOPPDPR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |
| Pol reversal | 0=False<br>1=True | | | 0=False | Reverse the definition of the power direction |

### 4.8.2.9 Monitored data

*Table 905: DOPPDPR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| P | FLOAT32 | -160.000...160.000 | xSn | Active power |
| Q | FLOAT32 | -160.000...160.000 | xSn | Reactive power |
| S | FLOAT32 | 0.000...160.000 | xSn | Apparent power |
| PF_ANGLE | FLOAT32 | -180.00...180.00 | deg | Power factor angle |
| DOPPDPR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.8.2.10 Technical data

*Table 906: DOPPDPR Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy [1] | Depending on the frequency of the measured current and voltage:<br>$f = f_n \pm 2$ Hz |
| | Power measurement accuracy ±3% of the set value or $\pm 0.002 \times S_n$<br>Phase angle: ±2° |
| Start time[2][3] | Typically 45 ms |
| Reset time | Typically 30 ms |
| Reset ratio | Typically 0.94 |
| Operate time accuracy | ±1.0% of the set value of ±20 ms |
| Suppression of harmonics | -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,… |

1) *Measurement mode* = “Pos Seq” (default)
2) $U = U_n$, $f_n = 50$ Hz, results based on statistical distribution of 1000 measurements
3) Includes the delay of the signal output contact

## 4.8.3 Directional reactive power undervoltage protection DQPTUV

### 4.8.3.1 Identification

| Description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Directional reactive power undervoltage protection | DQPTUV | Q> ->,3U< | 32Q,27 |

### 4.8.3.2 Function block




*Figure 525: Function block*

### 4.8.3.3 Functionality

The directional reactive power undervoltage protection function DQPTUV is used at the grid connection point of distributed power generating units as stipulated by various grid codes to prevent voltage collapse of the grid due to network faults. DQPTUV measures phase voltages and current at the grid connection point. The generating facility is disconnected from the network with a specific time delay if all phase voltages decrease and remain at or below the specified limit and if reactive power is simultaneously consumed (that is, under-excitation operation).

DQPTUV contains a blocking functionality to block function outputs, timer or the function itself.

### 4.8.3.4 Analog channel configuration

DQPTUV has two analog group inputs which must be properly configured.

*Table 907: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 908: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks

in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.8.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DQPTUV can be described using a module diagram. All the modules in the diagram are explained in the next sections.

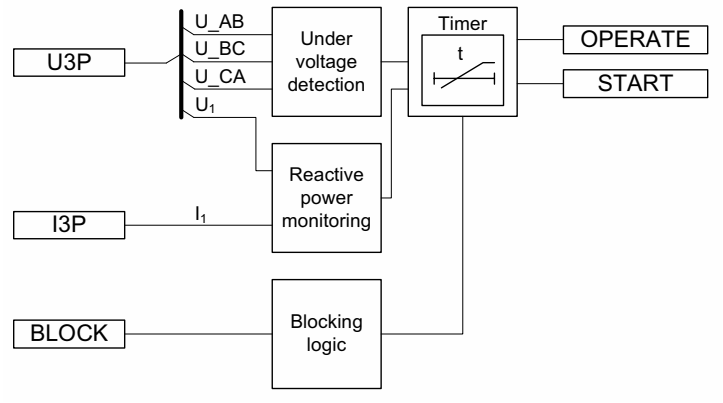



*Figure 526: Functional module diagram*

#### Under voltage detection

Under voltage detection compares the fundamental frequency component of all three phase-to-phase voltages with the set *Voltage start value*. When all three phase-to-phase voltages are lower than the set *Voltage start value*, the Under voltage detection module sends an enable signal to the Timer indicating an undervoltage condition at the grid connection point.

#### Reactive power monitoring

This module calculates and monitors the reactive power based on positive sequence current and voltage. The use of a positive sequence component makes the determination of power insensitive to a possible asymmetry in current and voltages. When the reactive power exceeds *Min reactive power* and flows in the operating area, the module sends an enable signal to the Timer indicating that the reactive power is being consumed at the grid connection point. A slight tilt in the curve can be obtained by the setting *Pwr sector reduction*.

To avoid false tripping, reactive power calculation is blocked if the magnitude of the positive-sequence current is less than the set *Min Ps Seq current*.

The magnitude of calculated reactive power Q is available in the Monitored data view.

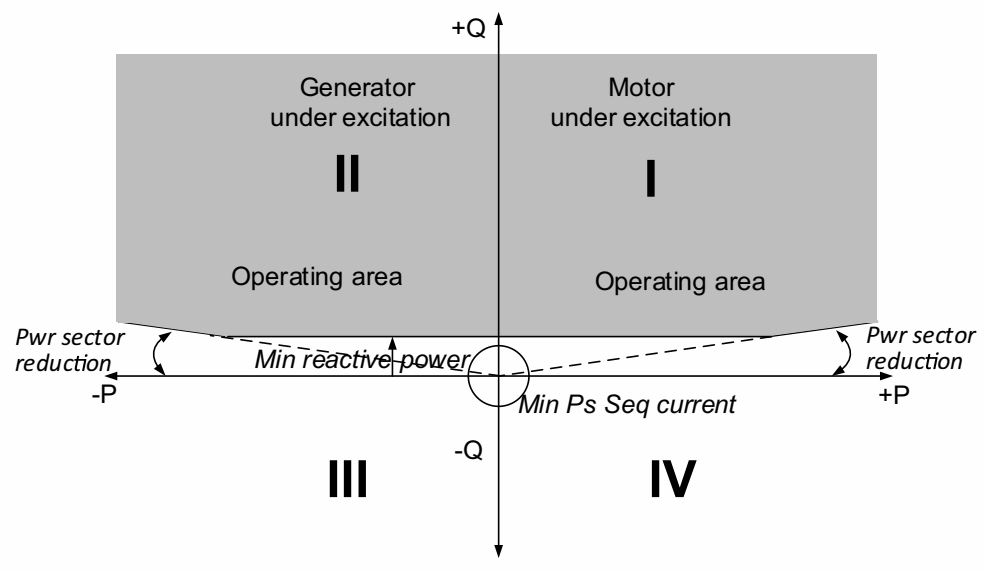



*Figure 527: Operating area of DQPTUV function*

| | |
|---|---|
| Quadrant II | Generator produces active power, but draws reactive power (under-excited) |
| Quadrant III | Generator produces both active and reactive power |

The power direction can be reversed by setting *Pol reversal* to "True".

## Timer

Once activated by both Under voltage detection and Reactive power monitoring module, Timer activates the START output. The Timer characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If the fault disappears before the module operates, the Timer is reset instantaneously.

Timer calculates the start duration value START_DUR which indicates the percentage ratio of the start situation and the set operating time. The value is available through the Monitored data view.

## Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode setting* has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.8.3.6 Application

Use of distributed power generating units (PGU) is rapidly increasing due to liberalized markets (deregulation) and the global trend to use more renewable sources of energy. As the capacity of these generating units increase, they are connected directly to medium voltage networks. Until recent years it had been a practice by grid operators to disconnect the distributed power generator from the network in case of fault in the network.

If there is a considerable loss in the power generation, it may affect the system's ability to recover. To ensure power system stability, various grid codes have revised their requirements and therefore require that the distributed PGUs have to make a contribution to network support. In case of network faults, the distributed power generator should not be immediately disconnected from the network. Instead, as a matter of principle, generating plants connected to the medium-voltage network must be capable of participating in steady-state voltage control and dynamic network support. However, if the generators stay connected, it must be ensured that they do not take reactive power from the network because this may lead to collapse of the grid. DQPTUV is used for detecting such situations, that is, simultaneous undervoltage and reactive power (under excited generators) and trip the generators.

The protection function DQPTUV is developed considering various grid codes. For example, in the BDEW Technical Guideline "Generating Plants Connected to the Medium-Voltage Network" (June 2008 issue, Germany), it is stated that if all three phase-to-phase voltages at the grid connection point decrease and remain at and below a value of 85% of the rated and if reactive power is simultaneously consumed at the grid connection point (under-excited operation), the generating facility must be disconnected from the network with a time delay of 0.5 s.

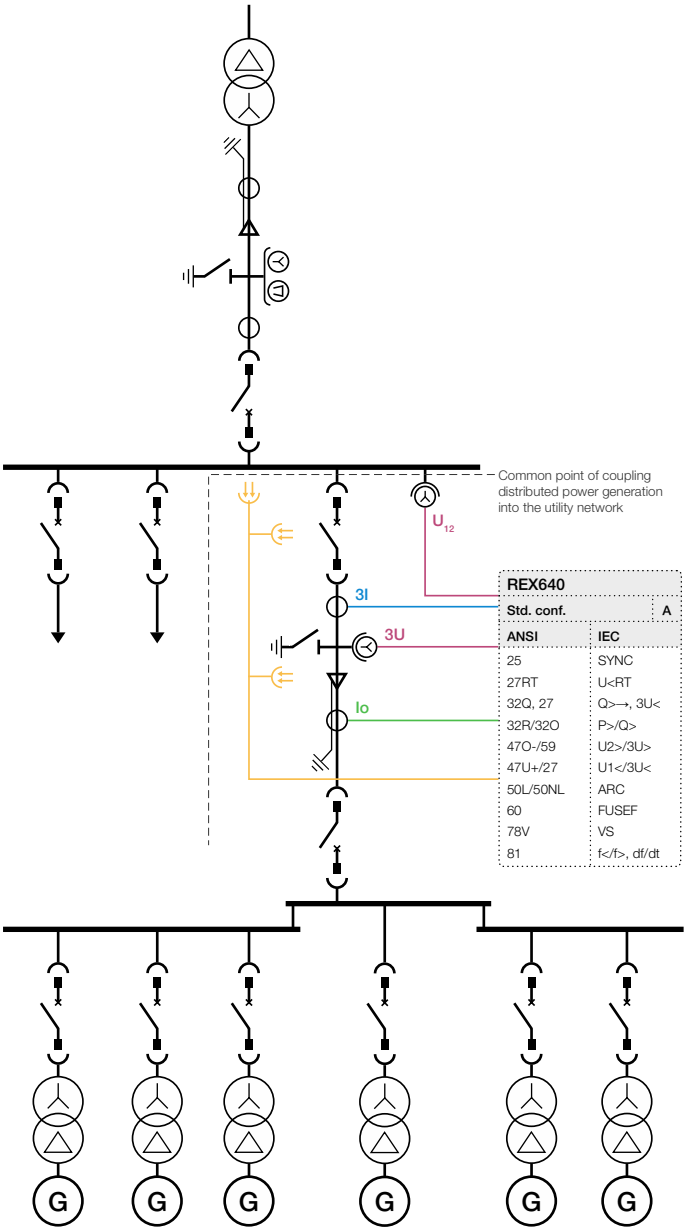



*Figure 528: Application example of wind power plant as distributed power generation coupled into the utility network*

## 4.8.3.7 Signals

*Table 909: DQPTUV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 910: DQPTUV Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.8.3.8 Settings

*Table 911: DQPTUV Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage start value | 0.20...1.20 | xUn | 0.01 | 0.85 | Start value for under voltage detection |
| Operate delay time | 100...300000 | ms | 10 | 500 | Operate delay time |

*Table 912: DQPTUV Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation On/Off |

*Table 913: DQPTUV Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min reactive power | 0.01...0.50 | xSn | 0.01 | 0.05 | Minimum reactive power needed for function to operate |
| Min Ps Seq current | 0.02...0.20 | xIn | 0.01 | 0.05 | Minimum positive sequence current |
| Pwr sector reduction | 0...10 | deg | 1 | 3 | Power sector reduction |
| Pol reversal | 0=False<br>1=True | | | 0=False | Reverse the definition of the positive reactive power direction |

### 4.8.3.9 Monitored data

*Table 914: DQPTUV Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| Q | FLOAT32 | -160.000...160.000 | xSn | Reactive power |
| DQPTUV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.8.3.10 Technical data

*Table 915: DQPTUV Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage:<br>$f_n$ ±2 Hz<br>Reactive power range \|PF\| <0.71 |
| | Power:<br>±3.0% or ±0.002 × $Q_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$ |
| Start time[1)2)] | Typically 46 ms |
| Reset time | <50 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

1) *Start value* = 0.05 × $S_n$, reactive power before fault = 0.8 × *Start value*, reactive power overshoot 2 times, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.8.4 Underpower factor protection MPUPF

### 4.8.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Underpower factor protection | MPUPF | PF< | 55U |

### 4.8.4.2 Function block

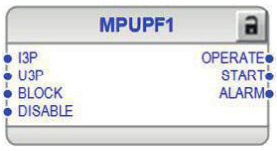



*Figure 529: Function block*

### 4.8.4.3 Functionality

The under power factor function MPUPF is used to provide out-of-step and loss of, or under excitation protection for small synchronous motors and generators. The function calculates the power factor and uses a threshold of under power factor as an indication of an out-of-step and/or loss of excitation condition.

In addition, the function can be applied as a power factor controller.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.8.4.4 Analog channel configuration

MPUPF has two analog group inputs which must be properly configured.

*Table 916: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |



See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 917: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that any two voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.8.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of MPUPF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

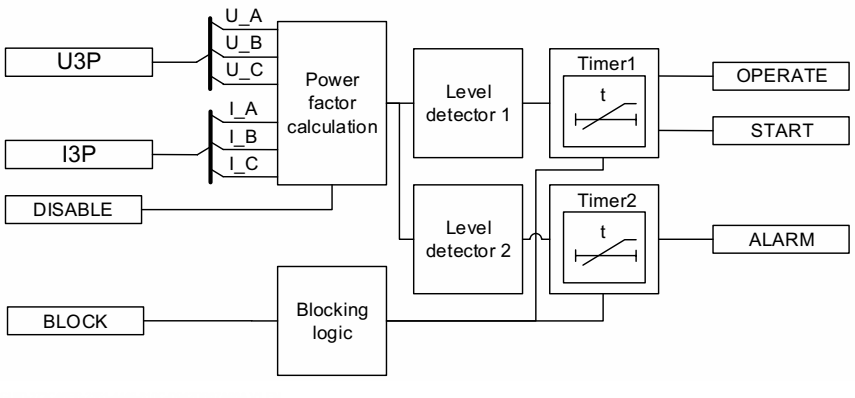



*Figure 530: Functional module diagram*

## Power factor calculation

This module calculates three phase power factor using phase currents and voltages.

The three-phase power is calculated from the fundamental frequency components (DFT) of the phase-to-earth voltages and phase-to-earth currents.

$$\overline{S} = \overline{U}_A \cdot \overline{I}_A^* + \overline{U}_B \cdot \overline{I}_B^* + \overline{U}_C \cdot \overline{I}_C^*$$

(Equation 234)

$$P = \mathrm{Re}(\overline{S})$$

(Equation 235)

$$PF = \frac{P}{\left|\overline{S}\right|}$$

(Equation 236)

Figure 531 shows the resulting sign of the power factor. This should be consistent with the settings in the power and energy metering function of the relay.

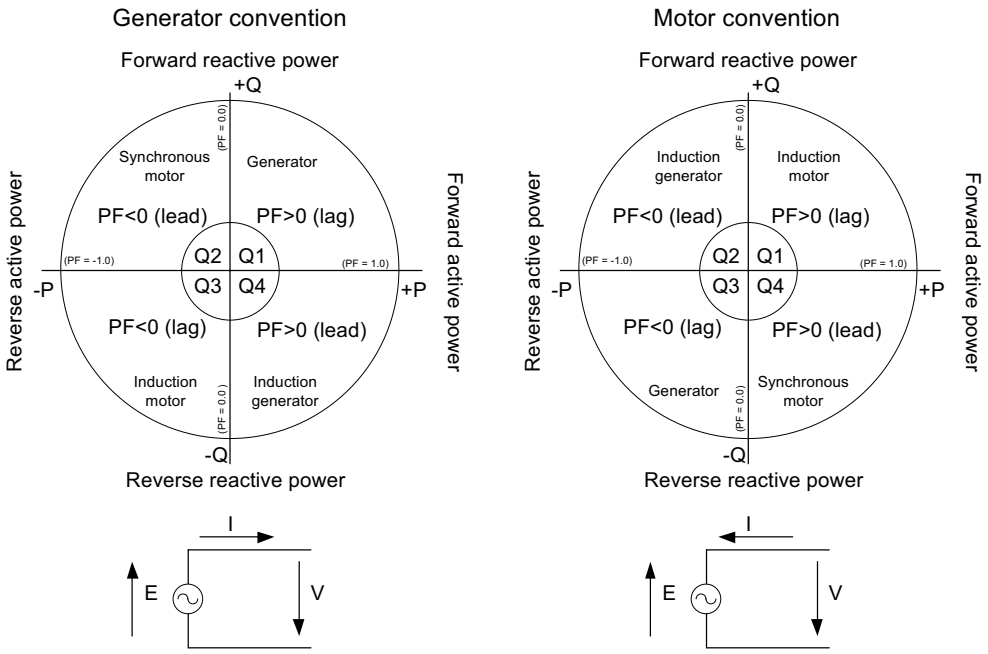



*Figure 531: Power factor quadrant*

If the polarity of the voltage signal is opposite to the normal polarity, the correction can be done by setting *Voltage reversal* to “Yes”, which rotates the power factor vector by 180 degrees.

If the magnitude of all three phase currents or voltages are respectively less than *Current block value* and *Voltage block value* settings, the power factor is set as unity that is 1.00 and the function is disabled internally.

The DISABLE input can be used to coordinate the correct operation during the start-up situation. By activating the DISABLE signal, the power factor calculation is blocked. Once the DISABLE signal is deactivated, the function remains blocked for additional time duration as set through the setting *Disable time*.

## Level detector 1

The Level detector 1 compares the calculated power factor to the set *Start value*. If the power factor value goes below the set *Start value* in the direction as defined by *Dir start value*, the Level detector sends an enabling signal to the Timer 1 module.

## Level detector 2

The Level detector 2 compares the calculated power factor to the set *Alarm value*. If the power factor value goes below the set *Alarm value* in the direction as defined by *Dir alarm value*, the Level detector sends an enabling signal to the Timer 2 module.

## Timer 1

Once activated, the Timer 1 activates the START output. The timer characteristic is according to DT. When the operate timer has reached the value set by *Start delay time*

in the DT mode, the OPERATE output is activated. If a drop-off situation occurs, that is, a power factor improves and exceeds the *Start reset value* in the direction as defined by *Dir start reset value* before the operate delay is exceeded or either magnitude of all three phase current or voltages goes below *Current block value* and *Voltage block value* respectively, the timer reset state is activated. The reset timer depends on the *Reset delay time* setting.

The Timer 1 calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the Monitored data view.

### Timer 2

Once activated, the Timer 2 activates the alarm timer. The timer characteristic is according to DT. When the alarm timer has reached the value set by *Alarm delay time* in the DT mode, the ALARM output is activated. If a drop-off situation occurs, that is, a power factor improves and exceeds the *Alarm reset value* in the direction as defined by *Dir alarm reset value* before the alarm delay is exceeded or either magnitude of all three phase current or voltages goes below *Current block value* and *Voltage block value* respectively, the timer reset state is activated. The reset timer depends on the *Reset delay time* setting.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.8.4.6 Application

The MPUPF function can be used to detect loss of excitation or for power factor correction. Synchronous motors are mostly operated at leading power factor and its operation as lagging power for extended period can be used an indication of an out-of-step condition possibly caused by under or loss of excitation. To detect such a situation, the relay is typically set to operate when the current into a motor lags more than 30 degrees, that is, a power factor goes below +0.87 lagging.

The function provides alarm facility which can be used as an early indication that the power factor is moving outside the allowable range; therefore the *Alarm value* setting should be set higher than the *Start value*. The delay time for alarm should also be set as low as possible, only long enough to prevent spurious activation of the output.

In a power factor correction application, the ALARM and START outputs can be used as controls to switch in capacitive loads when the *Alarm value* and *Start value* settings, respectively, are exceeded. The ALARM output is set for a higher value to add the first corrective load and the START output set for a second stage of corrective load, if needed. The *Start reset value* and *Alarm reset value* settings allow their respective outputs to remain activated to maintain the correction after power factor rises as a result, but to drop out after it reaches a level where corrective capacitive loading is no longer needed.

There are two general applications which can best utilize under power factor protection; power-factor control and loss of excitation.

When applying the function for power-factor control, both the start value and the start reset value should be the same sign (positive/negative) as well as the same direction (leading/lagging). Additionally, the absolute value of the start reset value should be greater than or equal to the absolute value of the start value. This allows the function to properly control any power factor controls within the system.

When applying the function for loss of excitation, both the start value and the start reset value should be the same sign (positive/negative), but the directions should be different (leading/lagging). This application is well-suited to protect against back-spinning. In this case the start reset value will only come into play once the system provides power in the opposite quadrant of the start value, for example, lagging PF turns to leading PF.

### 4.8.4.7 Signals

*Table 918: MPUPF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| DISABLE | BOOLEAN | 0=False | Signal to block the function during machine startup |

*Table 919: MPUPF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Alarm |

### 4.8.4.8 Settings

*Table 920: MPUPF Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value Dir | 1=Lagging<br>2=Leading | | | 1=Lagging | PF direction for start value |
| Start reset Val Dir | 1=Lagging<br>2=Leading | | | 1=Lagging | PF direction for start reset value |
| Alarm value Dir | 1=Lagging<br>2=Leading | | | 1=Lagging | PF direction for alarm value |
| Alarm reset Val Dir | 1=Lagging<br>2=Leading | | | 1=Lagging | PF direction for alarm reset value |
| Start value | -0.99...0.99 | | 0.01 | 0.80 | Start value |
| Start reset value | -0.99...0.99 | | 0.01 | 0.85 | Value at which start resets, drops out |
| Alarm value | -0.99...0.99 | | 0.01 | 0.85 | Alarm start value |
| Alarm reset value | -0.99...0.99 | | 0.01 | 0.90 | Value at which alarm resets, drops out |
| Operate delay time | 100...300000 | ms | 1 | 500 | Time delay for operation |
| Alarm delay time | 100...300000 | ms | 1 | 500 | Time delay for alarm |

*Table 921: MPUPF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Min operate current | 0.05...0.65 | xIn | 0.01 | 0.10 | Minimum operating current |
| Min operate voltage | 0.05...0.50 | xUn | 0.01 | 0.10 | Minimum operating voltage |
| Disable time | 0...60000 | ms | 1 | 5000 | Additional wait time after CB closing |
| Voltage reversal | 0=No<br>1=Yes | | | 0=No | Rotates the PF by 180 degrees |

*Table 922: MPUPF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.8.4.9 Monitored data

*Table 923: MPUPF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PF | FLOAT32 | -1.00...1.00 | | Calculated value of the 3–phase power factor |
| MPUPF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.8.4.10 Technical data

*Table 924: MPUPF Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Dependent on the frequency of the current measured: $f_n$ ±2 Hz |
| | ±0.018 for power factor |
| Operate time accuracy | ±(1.0% or 30 ms) |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, 6, 7 |
| Reset time | <40 ms |

## 4.9 Arc protection ARCSARC

### 4.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Arc protection | ARCSARC | ARC | AFD |

### 4.9.2 Function block




*Figure 532: Function block*

## 4.9.3 Functionality

The arc protection function ARCSARC detects arc situations in air-insulated metal-clad switchgears caused by, for example, human errors during maintenance or insulation breakdown during operation.

The function detects light from an arc either locally or via a remote light signal. The function also monitors phase and residual currents to be able to make accurate decisions on ongoing arcing situations.

The function contains a blocking functionality. Blocking deactivates all outputs and resets timers.

## 4.9.4 Analog channel configuration

ARCSARC has two analog group inputs which must be properly configured.

*Table 925: Analog inputs*

| Input | Description |
|---|---|
| I3P[1)] | Three-phase currents<br>Necessary when the operation mode "Light +current" is used |
| IRES[1)] | Residual current (measured or calculated)<br>Necessary when the operation mode "Light +current" is used |

1) Can be connected to GRPOFF if "Light only" or "BI controlled" operation modes are used



See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 4.9.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of ARCSARC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

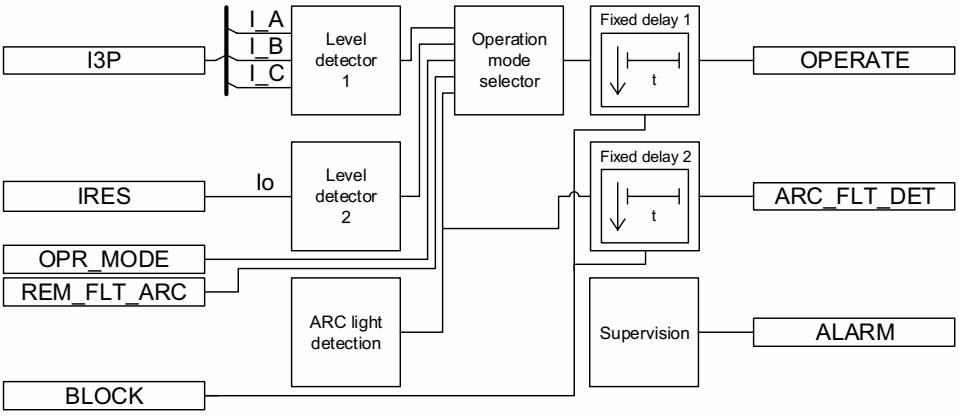



*Figure 533: Functional module diagram*

## Level detector 1

The measured phase currents are compared phasewise to the set *Phase start value*. If the measured value exceeds the set *Phase start value*, the level detector reports the exceeding of the value to Operation mode selector.

## Level detector 2

The measured residual currents are compared to the set *Ground start value*. If the measured value exceeds the set *Ground start value*, the level detector reports the exceeding of the value to Operation mode selector.

## ARC light detection

ARC detection information is received directly from the relay hardware input. The detected ARC fault is directly signalled to the Operation mode selector and Fixed delay 2 modules. There are four ARC detection inputs in the protection relay. Each input is connected to a dedicated ARCSARC function.

*Table 926: ARC detection inputs connected to ARCSARC*

| ARC input | ARC protection function |
|---|---|
| X11/ARC | ARCSARC1 |
| X12/ARC | ARCSARC2 |
| X13/ARC | ARCSARC3 |
| X14/ARC | ARCSARC4 |

## Operation mode selector

Depending on the *Operation mode* setting, Operation mode selector makes sure that all required criteria are fulfilled for a reliable decision of an arc fault situation. The operation is based on both current and light information in “Light+current” mode, on light information only in “Light only” mode or on remotely controlled information in “BI controlled” mode. When the "BI controlled" mode is in use and the OPR_MODE

input is activated, the operation of the function is based on light information only. When the OPR_MODE input is deactivated, the operation of the function is based on both light and current information. When the required criteria are met, Fixed delay 1 timer is activated.

### Fixed delay 1

Once this timer is activated, the OPERATE signal output is activated immediately. The output is kept active for minimum 25 ms or as long as the input is activated. The BLOCK signal can be used to block the OPERATE signal.

### Fixed delay 2

Once this timer is activated, the ARC_FLT_DET output is activated immediately. The output is kept active for minimum 25 ms or as long as the input is activated. The BLOCK signal can be used to block the ARC light signal output ARC_FLT_DET.

### Supervision

If a faulty arc sensor is internally detected or if the connection to the arc sensor is lost, ALARM output is activated if *Sensor supervision* is set to "on".

When *Sensor supervision* is set to "off", ALARM output stays false even though the arc sensor is faulty or unconnected.

## 4.9.6 Application

The arc protection can be realized as a stand-alone function in a single relay or as a station-wide arc protection, including several protection relays. If realized as a station-wide arc protection, different tripping schemes can be selected for the operation of the circuit breakers of the incoming and outgoing feeders. Consequently, the relays in the station can, for example, be set to trip the circuit breaker of either the incoming or the outgoing feeder, depending on the fault location in the switchgear. For maximum safety, the relays can be set to always trip both the circuit breaker of the incoming feeder and that of the outgoing feeder.

The arc protection consists of:

- Optional arc light detection hardware with automatic backlight compensation for lens type sensors
- Light signal output ARC_FLT_DET for routing indication of locally detected light signal to another relay
- Protection stage with phase- and earth-fault current measurement.

The function detects light from an arc either locally or via a remote light signal. Locally, the light is captured either by lens type point sensors or transparent fiber loop sensors connected to the light sensor input of the relay. This captured light is guided via optical fiber to the sensor input of the relay, where it is converted to electrical signal by means of a photo diode. The optical light sensors can be placed in the various

compartments of the switchgear, for example, in the busbar compartment, the circuit breaker compartments, the bus riser and the outgoing feeder cable end compartments.

The light detected by the lens sensor inputs is compared to an automatically adjusted reference level. Each light sensor input has its own reference level. When the light exceeds the reference level of one of the inputs, the light is detected locally. When the light has been detected locally or remotely and, depending on the operation mode, if one or several phase currents exceed the set *Phase start value* limit, or the earth-fault current the set *Ground start value* limit, the arc protection stage generates an operation signal. The stage is reset in 30 ms, after all three-phase currents and the earth-fault current have fallen below the set current limits.

The light signal output from an arc protection stage `ARC_FLT_DET` is activated immediately in the detection of light in all situations. A station-wide arc protection is realized by routing the light signal outputs to output contacts connected via physical wires to the binary inputs of other relays, or by routing the light signal outputs through the communication (IEC 61850/GOOSE signaling) to the virtual inputs of other relays.

It is possible to block the tripping and the light signal output of the arc protection stage with a binary input or a signal from another function block.

### Arc protection with one protection relay

In installations, with limited possibilities to realize signaling between protection relays protecting incoming and outgoing feeders, or if only the protection relay for the incoming feeder is to be exchanged, an arc protection with a less selective level can be achieved with one protection relay. In arc detection, the arc protection stage trips the circuit breaker of the incoming feeder. The maximum recommended installation distance between the two lens sensors in the busbar area is six meters and the maximum distance from a lens sensor to the end of the busbar is three meters.

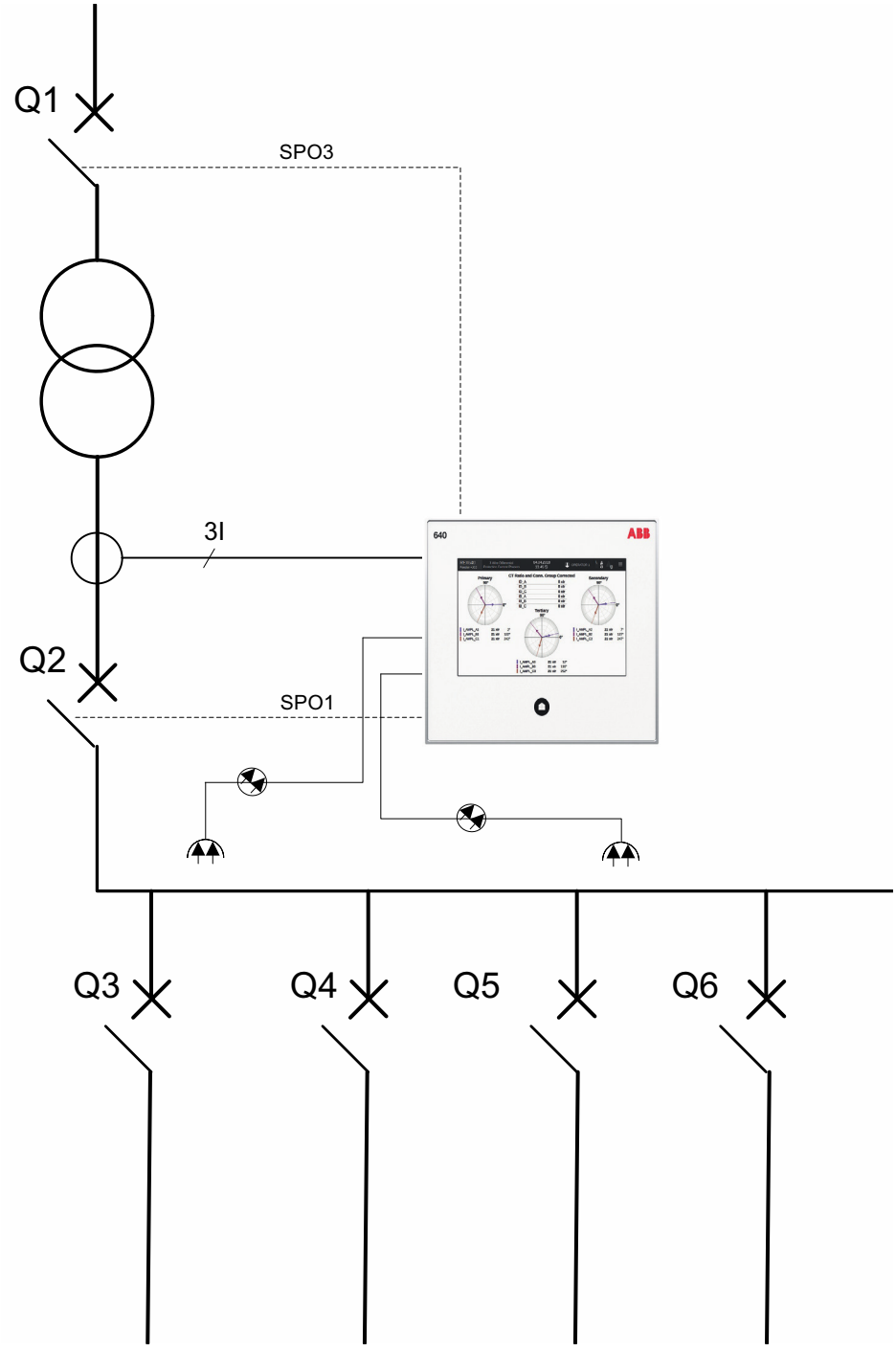



*Figure 534: Arc protection with one protection relay*

## Arc protection with several protection relays

When using several protection relays, the protection relay protecting the outgoing feeder trips the circuit breaker of the outgoing feeder when detecting an arc at the cable terminations. If the protection relay protecting the outgoing feeder detects an arc on

the busbar or in the breaker compartment via one of the other lens sensors, it generates a signal to the protection relay protecting the incoming feeder. When detecting the signal, the protection relay protecting the incoming feeder trips the circuit breaker of the incoming feeder and generates an external trip signal to all protection relays protecting the outgoing feeders, which in turn results in tripping of all circuit breakers of the outgoing feeders. For maximum safety, the protection relays can be configured to trip all the circuit breakers regardless of where the arc is detected.

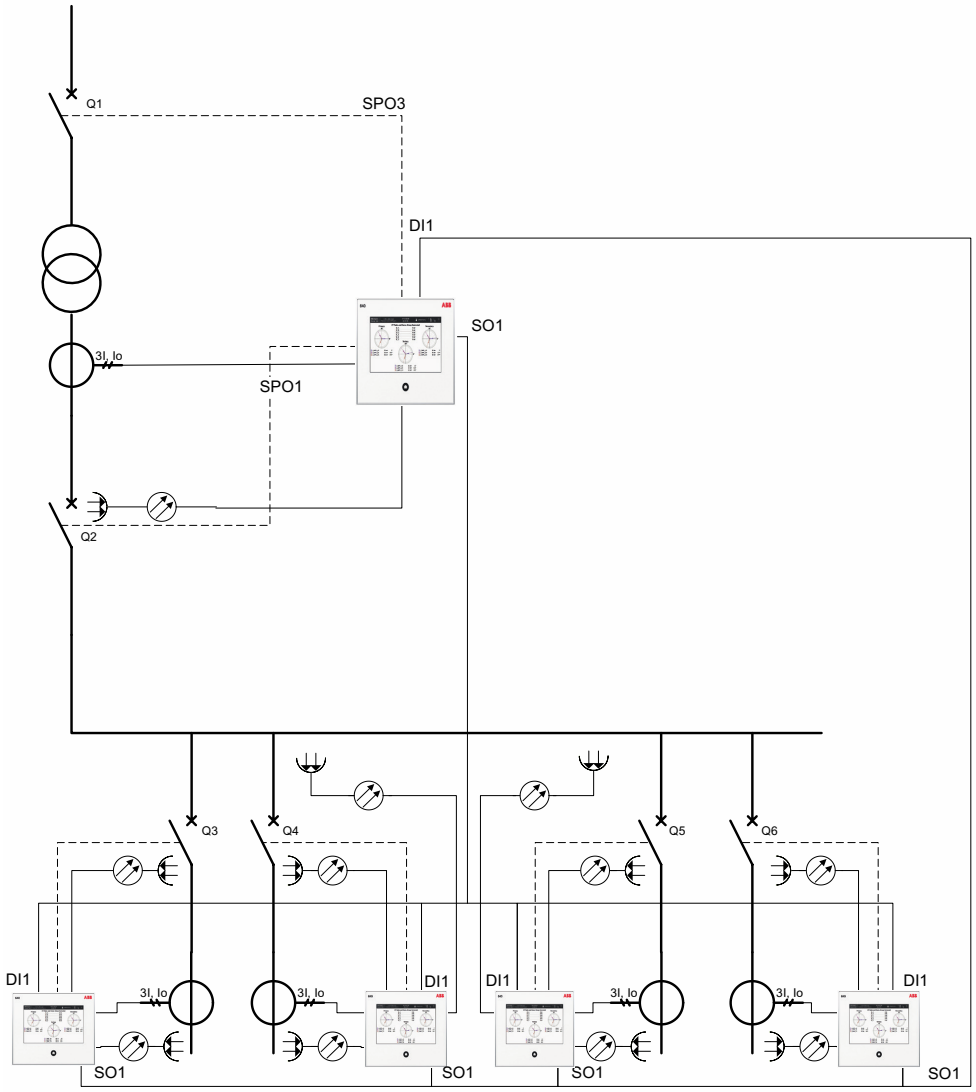



*Figure 535: Arc protection with several protection relays and normal outputs*

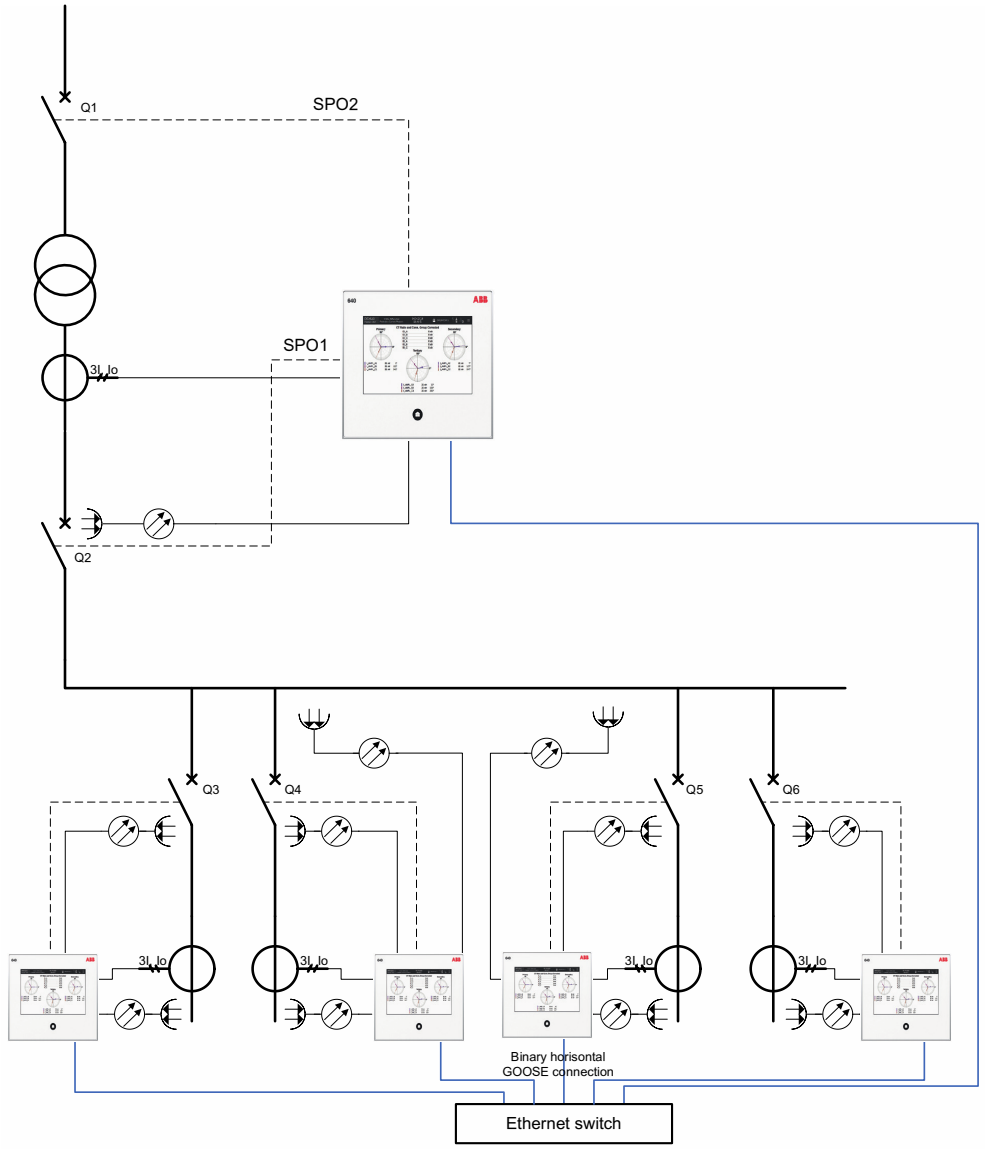



*Figure 536: Arc protection with several protection relays and high-speed outputs and GOOSE*

## 4.9.7 Signals

*Table 927: ARCSARC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |
| REM_FLT_ARC | BOOLEAN | 0=False | Remote Fault arc detected |
| OPR_MODE | BOOLEAN | 0=False | Operation mode input |

*Table 928: ARCSARC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| ARC_FLT_DET | BOOLEAN | Fault arc detected=light signal output |
| ALARM | BOOLEAN | Self supervision alarm |

## 4.9.8 Settings

*Table 929: ARCSARC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase start value | 0.50...40.00 | xIn | 0.01 | 2.50 | Operating phase current |
| Ground start value | 0.05...8.00 | xIn | 0.01 | 0.20 | Operating residual current |
| Operation mode | 1=Light+current<br>2=Light only<br>3=BI controlled | | | 1=Light+current | Operation mode |

*Table 930: ARCSARC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Sensor supervision | 0=off<br>1=on | | | 1=on | Sensor supervision selection |

## 4.9.9 Monitored data

*Table 931: ARCSARC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ARCSARC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.9.10 Technical data

*Table 932: ARCSARC Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | ±3.0% of the set value or ±0.01 × $I_n$ | | |
| Operate time TC | | Minimum | Typical | Maximum |
| | *Operation mode* = "Light+current"[1] | 9 ms[2]<br>3 ms[3] | 10 ms[2]<br>5 ms[3] | 13 ms[2]<br>6 ms[3] |
| | *Operation mode* = "Light only"[2] | 8 ms[2]<br>3 ms[3] | 10 ms[2]<br>5 ms[3] | 13 ms[2]<br>6 ms[3] |
| Reset time | | Typically 50 ms | | |
| Reset ratio | | Typically 0.96 | | |

1) *Phase start value* = 1.0 × $I_n$, current before fault = 2.0 × set *Phase start value*, $f_n$ = 50 Hz, fault with nominal frequency, results based on statistical distribution of 200 measurements
2) Includes the delay of the power output (PO) contact
3) Measured with static power output (SPO)

## 4.10 Motor start-up supervision STTPMSU

### 4.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Motor start-up supervision | STTPMSU | Is2t n< | 49,66,48,50TDL R |

### 4.10.2 Function block

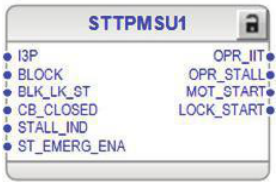



*Figure 537: Function block*

### 4.10.3 Functionality

The motor start-up supervision function STTPMSU is designed for protection against excessive starting time and locked rotor conditions of the motor during starting. For a good and reliable operation of the motor, the thermal stress during the motor starting is maintained within the allowed limits.

The starting of the motor is supervised by monitoring the TRMS magnitude of all the phase currents or by monitoring the status of the circuit breaker connected to the motor.

During the start-up period of the motor, STTPMSU calculates the integral of the $I^2t$ value. If the calculated value exceeds the set value, the operate signal is activated.

STTPMSU has the provision to check the locked rotor condition of the motor using the speed switch, which means checking if the rotor is able to rotate or not. This feature operates after a predefined operating time.

STTPMSU also protects the motor from an excessive number of start-ups. Upon exceeding the specified number of start-ups within certain duration, STTPMSU blocks further starts. The restart of the motor is also inhibited after each start and continues to be inhibited for a set duration. When the lock of start of motor is enabled, STTPMSU gives the time remaining until the restart of the motor.

STTPMSU contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

## 4.10.4 Analog input configuration

STTPMSU has one analog group input which must be properly configured.

*Table 933: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |



See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 4.10.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of STTPMSU can be described with a module diagram. All the modules in the diagram are explained in the next sections.

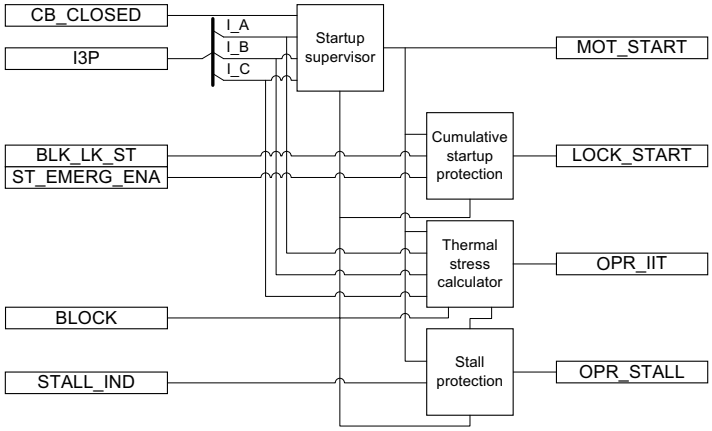



*Figure 538: Functional module diagram*

## Startup supervisor

This module detects the starting of the motor. The starting and stalling motor conditions are detected in four different modes of operation. This is done through the *Operation mode* setting.

When the *Operation mode* setting is operated in the "IIt" mode, the function calculates the value of the thermal stress of the motor during the start-up condition. In this mode, the start-up condition is detected by monitoring the TRMS currents.

The *Operation mode* setting in the "IIt, CB" mode enables the function to calculate the value of the thermal stress when a start-up is monitored in addition to the CB_CLOSED input.

In the "IIt & stall" mode, the function calculates the thermal stress of the motor during the start-up condition. The start-up condition is detected by monitoring the TRMS currents.

In the "IIt & stall, CB" mode, the function calculates the thermal stress of the motor during the start-up condition but the start-up condition is detected by monitoring the TRMS current as well as the circuit breaker status.

In both the "IIt & stall" and "IIt & stall, CB" mode, the function also checks for motor stalling by monitoring the speed switch.

When the measured current value is used for start-up supervision in the "IIt" and "IIt & stall" modes, the module initially recognizes the de-energized condition of the motor when the values of all three phase currents are less than *Motor standstill A* for longer than 100 milliseconds. If any of the phase currents of the de-energized condition rises to a value equal to or greater than *Motor standstill A*, the MOT_START output signal is activated indicating that the motor start-up is in progress. The MOT_START output remains active until the values of all three phase currents drop below 90 percent of the set value of *Start detection A* and remain below that level for a time of *Str over delay time*, that is, until the start-up situation is over.

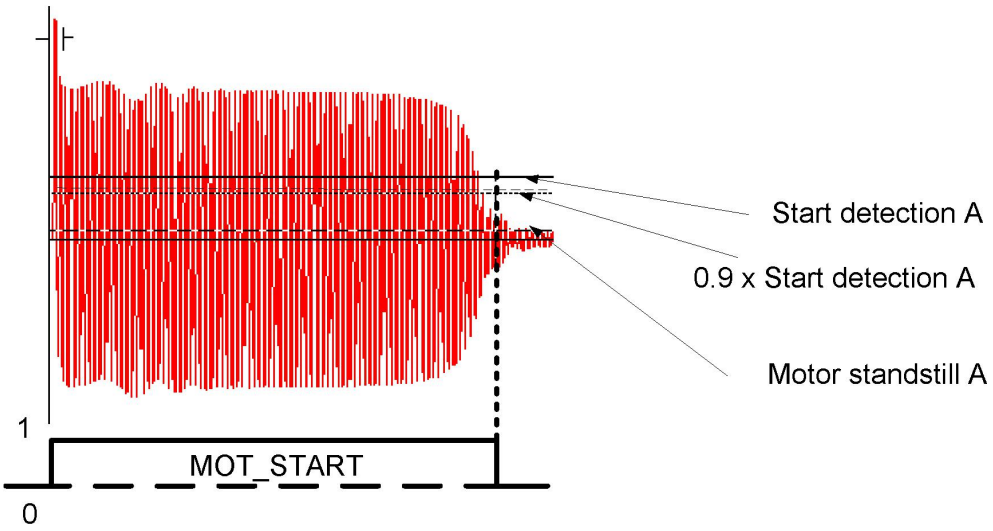



*Figure 539: Functionality of start-up supervision in the "IIt and IIt&stall" mode*

In case of the "IIt, CB" or "IIt & stall, CB" modes, the function initially recognizes the de-energized condition of the motor when the value of all three phase currents is below the value of the *Motor standstill A* setting for 100 milliseconds. The beginning of the motor start-up is recognized when CB is closed, that is, when the CB_CLOSED input is activated and at least one phase current value exceeds the *Motor standstill A* setting.

These two events do not take place at the same instant, that is, the CB main contact is closed first, in which case the phase current value rises above 0.1 pu and after some delay the CB auxiliary contact gives the information of the CB_CLOSED input. In some cases, the CB_CLOSED input can be active but the value of current may not be greater than the value of the *Motor standstill A* setting. To allow both possibilities, a time slot of 200 milliseconds is provided for current and the CB_CLOSED input. If both events occur during this time, the motor start-up is recognized.

The motor start-up ends either within the value of the *Str over delay time* setting from the beginning of the start-up or the opening of CB or when the CB_CLOSED input is deactivated. The operation of the MOT_START output signal in this operation mode is as illustrated in Figure 540.

This CB mode can be used in soft-started or slip ring motors for protection against a large starting current, that is, a problem in starting and so on.

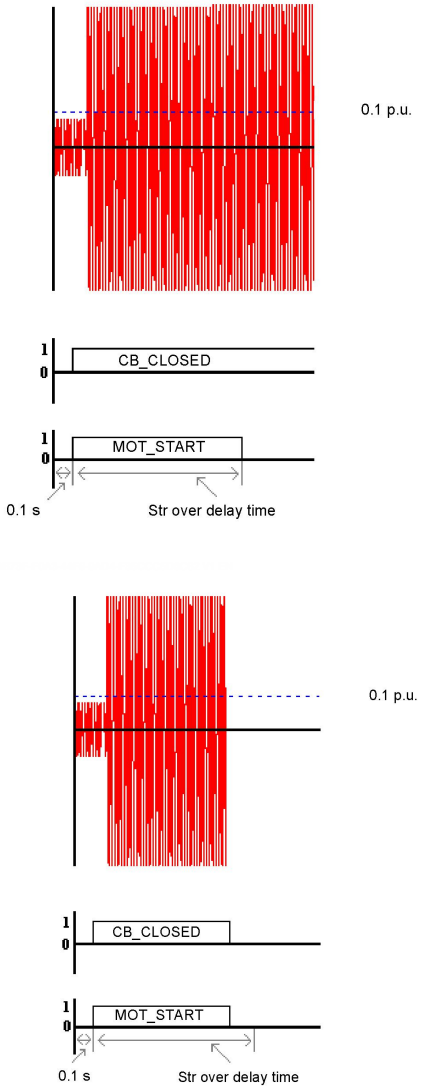



*Figure 540: Functionality of start-up supervision in the "IIt, CB" mode and the "IIt and stall, CB" mode*

The *Str over delay time* setting has different purposes in different modes of operation.

- In the “IIt” or “IIt & stall” modes, the aim of this setting is to check for the completion of the motor start-up period. The purpose of this time delay setting is to allow for short interruptions in the current without changing the state of the MOT_START output. In this mode of operation, the value of the setting is in the range of around 100 milliseconds.
- In the “IIt, CB” or “IIt & stall, CB” modes, the purpose of this setting is to check for the life of the protection scheme after the CB_CLOSED input has been activated. Based on the values of the phase currents, the completion of the start-up period cannot be judged. So in this mode of operation, the value of the time delay setting can even be as high as within the range of seconds, for example around 30 seconds.

The activation of the BLOCK input signal deactivates the MOT_START output.

## Thermal stress calculator

Because of the high current surges during the start-up period, a thermal stress is imposed on the rotor. With less air circulation in the ventilation of the rotor before it reaches its full speed, the situation becomes even worse. Consequently, a long start-up causes a rapid heating of the rotor.

This module calculates the thermal stress developed in the motor during start-up. The heat developed during the starting can be calculated with the equation.

$$W = R_s \int_0^t i_s^2(t)\,dt$$

(Equation 237)

$R_s$ combined rotor and stator resistance

$i_s$ starting current of the motor

t starting time of the motor

This equation is normally represented as the integral of I²t. It is a commonly used method in protective protection relays to protect the motor from thermal stress during starting. The advantage of this method over the traditional definite time overcurrent protection is that when the motor is started with a reduced voltage as in the star-delta starting method, the starting current is lower. This allows more starting time for the motor since the module is monitoring the integral of I²t.

The module calculates the accumulated heat continuously and compares it to the limiting value obtained from the product of the square of the values of the *Motor start-up A* and *Motor start-up time* settings. When the calculated value of the thermal stress exceeds this limit, the OPR_IIT output is activated.

The module also measures the time START_TIME required by the motor to attain the rated speed and the relative thermal stress IIT_RL. The values are available in the Monitored data view.

The activation of the BLOCK input signal resets the thermal stress calculator and deactivates the OPR_IIT output.

## Stall protection

This module is activated only when the selected *Operation mode* setting value is "IIt & stall" or "IIt & stall, CB".

The start-up current is specific to each motor and depends on the start-up method used, such as direct online, autotransformer and rotor resistance insertion. The start-up time is dependent on the load connected to the motor.

Based on the motor characteristics supplied by the manufacturer, this module is required if the stalling time is shorter than or too close to the starting time. In such cases, a speed switch must be used to indicate whether a motor is accelerating during start-up or not.

At motor standstill, the STALL_IND input is active. It indicates that the rotor is not rotating. When the motor is started, at certain revolution the deactivation of the STALL_IND by the speed switch indicates that the rotor is rotating. If the input is not deactivated within *Lock rotor time*, the OPR_STALL output is activated.

The module calculates the duration of the motor in stalling condition, the STALL_RL output indicating the percent ratio of the start situation and the set value of *Lock rotor time*. The value is available in the Monitored data view.

The activation of the BLOCK input signal resets the operation time and deactivates the OPR_STALL output.

## Cumulative start-up protection

This module protects the motor from an excessive number of start-ups.

Whenever the motor is started, the latest value of START_TIME is added to the existing value of T_ST_CNT and the updated cumulative start-up time is available at T_ST_CNT. If the value of T_ST_CNT is greater than the value of *Cumulative time Lim*, the LOCK_START output is activated and lockout condition for the restart of motor is enabled during the time the output is active. The LOCK_START output remains high until the T_ST_CNT value reduces to a value less than the value of *Cumulative time Lim*. The start time counter reduces at the rate of the value of *Counter Red rate*.

The LOCK_START output becomes activated at the start of MOT_START. The output remains active for a period of *Restart inhibit time*.

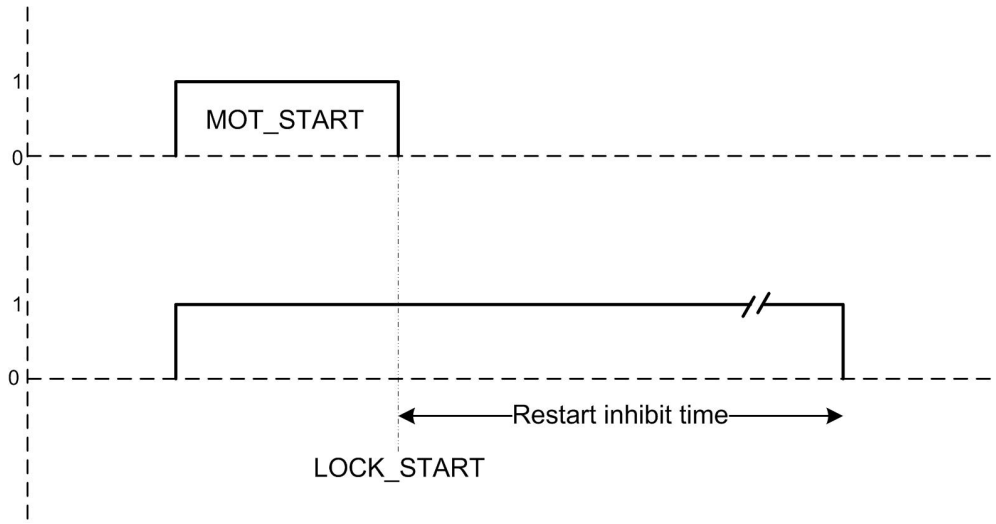



*Figure 541: Time delay for cumulative start*

This module also protects the motor from consecutive start-ups. When the LOCK_START output is active, T_RST_ENA shows the possible time for next restart. The value of T_RST_ENA is calculated by the difference of *Restart inhibit time* and the elapsed time from the instant LOCK_START is enabled.

When the ST_EMERG_ENA emergency start is set high, the value of the cumulative start-up time counter is set to *Cumulative time Lim* - 60s · *Emg start Red rate*. This disables LOCK_START and in turn makes the restart of the motor possible.

This module also calculates the total number of start-ups occurred, START_CNT. The value can be reset from the Clear menu.

The old *Number of motor start-ups occurred* counter value (START_CNT) can be taken into use by writing the value to the *Ini start up counter* parameter and resetting the value via the Clear menu from WHMI or LHMI.

The calculated values of T_RST_ENA, T_ST_CNT and START_CNT are available in the Monitored data view.

The activation of the BLK_LK_ST input signal deactivates the LOCK_START output. The activation of the BLOCK input signal resets the cumulative start-up counter module.

## 4.10.6 Application

When a motor is started, it draws a current well in excess of the motor's full-load rating throughout the period it takes for the motor to run up to the rated speed. The motor starting current decreases as the motor speed increases and the value of current remains close to the rotor-locked value for most of the acceleration period.

The full-voltage starting or the direct-on-line starting method is used out of the many methods used for starting the induction motor. If there is either an electrical or mechanical constraint, this starting method is not suitable. The full-voltage starting produces the highest starting torque. A high starting torque is generally required to start a high-inertia load to limit the acceleration time. In this method, full voltage is applied to the motor when the switch is in the "On" position. This method of starting results in a large initial current surge, which is typically four to eight times that of the full-load current drawn by the motor. If a star-delta starter is used, the value of the line current will only be about one-third of the direct-on-line starting current.

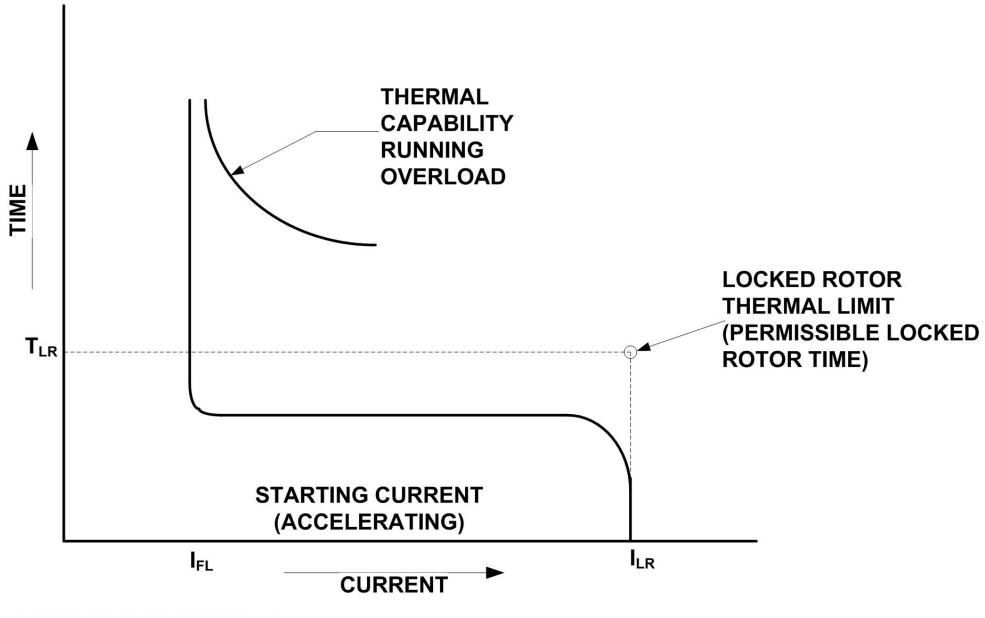



*Figure 542: Typical motor starting and capability curves*

The start-up supervision of a motor is an important function because of the higher thermal stress developed during starting. During the start-up, the current surge imposes a thermal strain on the rotor. This is exaggerated as the air flow for cooling is less because the fans do not rotate in their full speed. Moreover, the difference of speed between the rotating magnetic field and the rotor during the start-up time induces a high magnitude of slip current in the rotor at frequencies higher than when the motor is at full speed. The skin effect is stronger at higher frequencies and all these factors increase the losses and the generated heat. This is worse when the rotor is locked.

The starting current for slip-ring motors is less than the full load current and therefore it is advisable to use the circuit breaker in the closed position to indicate the starting for such type of motors.

The starting times vary depending on motor design and load torque characteristics. The time taken may vary from less than two seconds to more than 60 seconds. The starting time is determined for each application.

When the permissible stall time is less than the starting time of the motor, the stalling protection is used and the value of the time delay setting should be set slightly less than the permissible stall time. The speed switch on the motor shaft must be used for detecting whether the motor begins to accelerate or not. However, if the safe stall time is longer than the start-up time of the motor, the speed switch is not required.

The failure of a motor to accelerate or to reach its full nominal speed in an acceptable time when the stator is energized is caused by several types of abnormal conditions, including a mechanical failure of the motor or load bearings, low supply voltage, open circuit in one phase of a three-phase voltage supply or too high starting voltage. All these abnormal conditions result in overheating.

Repeated starts increase the temperature to a high value in the stator or rotor windings, or both, unless enough time is allowed for the heat to dissipate. To ensure a safe operation it is necessary to provide a fixed-time interval between starts or limit the number of starts within a period of time. This is why the motor manufacturers have restrictions on how many starts are allowed in a defined time interval. This function does not allow starting of the motor if the number of starts exceeds the set level in the register that calculates them. This insures that the thermal effects on the motor for consecutive starts stay within permissible levels.

For example, the motor manufacturer may state that three starts at the maximum are allowed within 4 hours and the start-up situation time is 60 seconds. By initiating three successive starts we reach the situation as illustrated. As a result, the value of the register adds up to a total of 180 seconds. Right after the third start has been initiated, the output lock of start of motor is activated and the fourth start will not be allowed, provided the time limit has been set to 121 seconds.

Furthermore, a maximum of three starts in 4 hours means that the value of the register should reach the set start time counter limit within 4 hours to allow a new start. Accordingly, the start time counter reduction should be 60 seconds in 4 hours and should thus be set to 60 s / 4 h = 15 s / h.

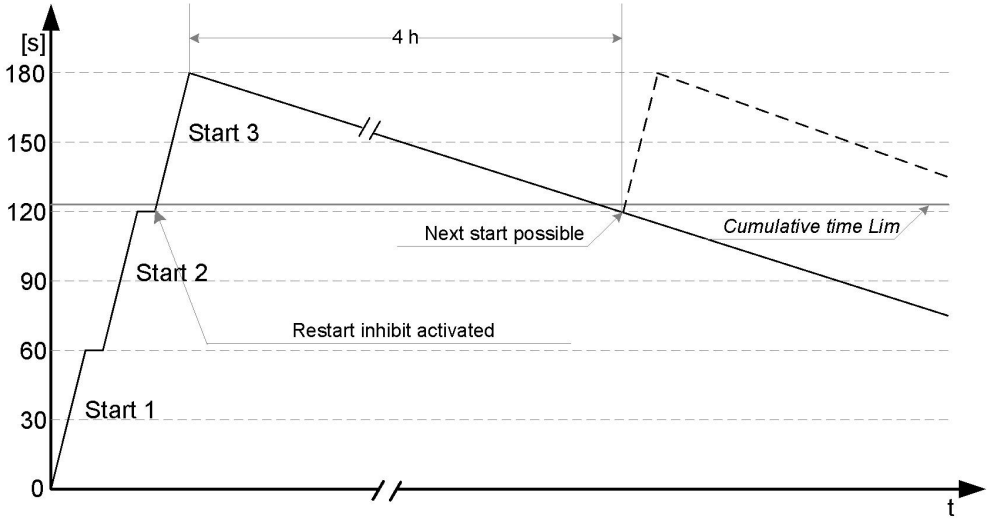



*Figure 543: Typical motor-starting and capability curves*

$$\sum t_{si} = (n-1) \cdot t + margin$$

(Equation 238)

## Setting of *Cumulative time Lim*

*Cumulative time Lim* is calculated by

n specified maximum allowed number of motor start-ups

t start-up time of the motor (in seconds)

margin safety margin (~10...20 percent)

### Setting of *Counter Red rate*

*Counter Red rate* is calculated by

$$\Delta\sum t_s = \frac{t}{t_{reset}}$$

(Equation 239)

t specified start time of the motor in seconds

$t_{reset}$ duration during which the maximum number of motor start-ups stated by the manufacturer can be made; time in hours

## 4.10.7 Signals

*Table 934: STTPMSU Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block of function |
| BLK_LK_ST | BOOLEAN | 0=False | Blocks lock out condition for restart of motor |
| CB_CLOSED | BOOLEAN | 0=False | Input showing the status of motor circuit breaker |
| STALL_IND | BOOLEAN | 0=False | Input signal for showing the motor is not stalling |
| ST_EMERG_ENA | BOOLEAN | 0=False | Enable emergency start to disable lock of start of motor |

*Table 935: STTPMSU Output signals*

| Name | Type | Description |
|---|---|---|
| OPR_IIT | BOOLEAN | Operate/trip signal for thermal stress. |
| OPR_STALL | BOOLEAN | Operate/trip signal for stalling protection. |
| MOT_START | BOOLEAN | Signal to show that motor startup is in progress |
| LOCK_START | BOOLEAN | Lock out condition for restart of motor. |

## 4.10.8 Settings

*Table 936: STTPMSU Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Motor start-up A | 1.0...10.0 | xIn | 0.1 | 2.0 | Motor starting current |
| Motor start-up time | 1...80 | s | 1 | 5 | Motor starting time |
| Lock rotor time | 2...120 | s | 1 | 10 | Permitted stalling time |
| Str over delay time | 0...60000 | ms | 1 | 100 | Time delay to check for completion of motor startup period |

*Table 937: STTPMSU Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start detection A | 0.1...10.0 | xIn | 0.1 | 1.5 | Current value for detecting starting of motor. |

*Table 938: STTPMSU Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=IIt<br>2=IIt, CB<br>3=IIt + stall<br>4=IIt + stall, CB | | | 1=IIt | Motor start-up operation mode |
| Counter Red rate | 2.0...250.0 | s/h | 0.1 | 60.0 | Start time counter reduction rate |
| Cumulative time Lim | 1...500 | s | 1 | 10 | Cumulative time based restart inhibit limit |
| Emg start Red rate | 0.00...100.00 | % | 0.01 | 20.00 | Start time reduction factor when emergency start is On |
| Restart inhibit time | 0...250 | min | 1 | 30 | Time delay between consecutive startups |
| Ini start up counter | 0...999999 | | 1 | 0 | Initial value for the START_CNT |

*Table 939: STTPMSU Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Motor standstill A | 0.05...0.20 | xIn | 0.01 | 0.12 | Current limit to check for motor standstill condition |

## 4.10.9 Monitored data

*Table 940: STTPMSU Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_CNT | INT32 | 0...999999 | | Number of motor start-ups occurred |
| START_TIME | FLOAT32 | 0.0...999.9 | s | Measured motor latest startup time in sec |
| T_ST_CNT | FLOAT32 | 0.0...99999.9 | s | Cumulated start-up time in sec |
| T_RST_ENA | INT32 | 0...999 | min | Time left for restart when lockstart is enabled in minutes |
| IIT_RL | FLOAT32 | 0.00...100.00 | % | Thermal stress relative to set maximum thermal stress |
| STALL_RL | FLOAT32 | 0.00...100.00 | % | Start time relative to the operate time for stall condition |
| STTPMSU | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 4.10.10 Technical data

*Table 941: STTPMSU Technical data*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 1.1 × set *Start detection A* | 27 ms | 30 ms | 34 ms |
| Operate time accuracy | | ±1.0% of the set value or ±20 ms | | |
| Reset ratio | | Typically 0.90 | | |

1) Current before = 0.0 × $I_n$, $f_n$ = 50 Hz, overcurrent in one phase, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

# 4.11 Multipurpose protection MAPGAPC

## 4.11.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Multipurpose protection | MAPGAPC | MAP | MAP |

## 4.11.2 Function block

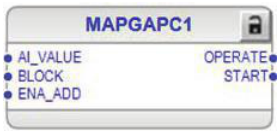



*Figure 544: Function block*

## 4.11.3 Functionality

The multipurpose protection function MAPGAPC is used as a general protection with many possible application areas as it has flexible measuring and setting facilities. The function can be used as an under- or overprotection with a settable absolute hysteresis limit. The function operates with the definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

## 4.11.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of MAPGAPC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

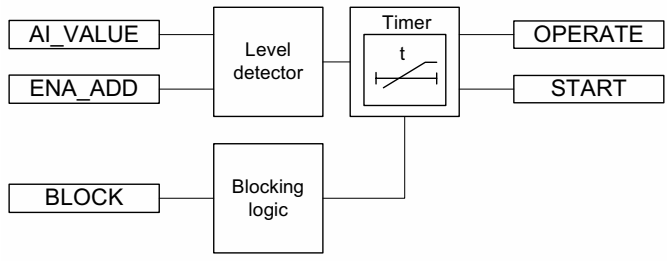



*Figure 545: Functional module diagram*

## Level detector

Level detector compares AI_VALUE to the *Start value* setting. The *Operation mode* setting defines the direction of the level detector.

*Table 942: Operation mode types*

| Operation mode | Description |
|---|---|
| Under | If the input signal AI_VALUE is lower than the set value of the *Start value* setting, the level detector enables the timer module. |
| Over | If the input signal AI_VALUE exceeds the set value of the *Start value* setting, the level detector enables the timer module. |

The *Absolute hysteresis* setting can be used for preventing unnecessary oscillations if the input signal is slightly above or below the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return to the hysteresis area. If the ENA_ADD input is activated, the threshold value of the internal comparator is the sum of the *Start value Add* and *Start value* settings. The resulting threshold value for the comparator can be increased or decreased depending on the sign and value of the *Start value Add* setting.

## Timer

Once activated, Timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If the starting condition disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

## Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.11.5 Application

The function block can be used for any general analog signal protection, either underprotection or overprotection. The setting range is wide, allowing various protection schemes for the function. Thus, the absolute hysteresis can be set to a value that suits the application.

The temperature protection using the RTD sensors can be done using the function block. The measured temperature can be fed from the RTD sensor to the function input that detects too high temperatures in the motor bearings or windings, for example. When the ENA_ADD input is enabled, the threshold value of the internal comparator is the sum of the *Start value Add* and *Start value* settings. This allows a temporal increase or decrease of the level detector depending on the sign and value of the *Start value Add* setting, for example, when the emergency start is activated. If, for example, *Start value* is 100, *Start value Add* is 20 and the ENA_ADD input is active, the input signal needs to rise above 120 before MAPGAPC operates.

## 4.11.6 Signals

*Table 943: MAPGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| AI_VALUE | FLOAT32 | 0.0 | Analogue input value |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_ADD | BOOLEAN | 0=False | Enable start added |

*Table 944: MAPGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

## 4.11.7 Settings

*Table 945: MAPGAPC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | -10000.0...10000.0 | | 0.1 | 0.0 | Start value |
| Start value Add | -100.0...100.0 | | 0.1 | 0.0 | Start value Add |
| Operate delay time | 0...200000 | ms | 100 | 0 | Operate delay time |

*Table 946: MAPGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=Over<br>2=Under | | | 1=Over | Operation mode |

*Table 947: MAPGAPC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 100 | 0 | Reset delay time |
| Absolute hysteresis | 0.01...100.00 | | 0.01 | 0.10 | Absolute hysteresis for operation |

### 4.11.8 Monitored data

*Table 948: MAPGAPC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| MAPGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.11.9 Technical data

*Table 949: MAPGAPC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.0% of the set value or ±20 ms |

## 4.12 Capacitor bank protection

### 4.12.1 Three-phase overload protection for shunt capacitor banks COLPTOC

#### 4.12.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase overload protection for shunt capacitor banks | COLPTOC | 3I> 3I< | 51,37,86C |

### 4.12.1.2 Function block

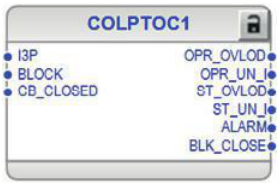



*Figure 546: Function block*

### 4.12.1.3 Functionality

The three-phase overload protection for shunt capacitor banks function COLPTOC provides single-phase, two-phase and three-phase protection against overloads caused by harmonic currents and overvoltages in shunt capacitor banks. The operation of overload and alarm is based on the peak value of the integrated current which is proportional to the voltage across the capacitor.

The overload function operates with IDMT characteristic and an alarm function operates with DT characteristic.

COLPTOC provides undercurrent protection to detect disconnection of the capacitor. COLPTOC has breaker reclosing inhibit feature to enable complete capacitor discharging before breaker reclosing after it has operated.

COLPTOC contains blocking functionality. It is possible to block the function outputs, timers or the function itself.

### 4.12.1.4 Analog channel configuration

COLPTOC has one analog group input which must be properly configured.

*Table 950: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.12.1.5 Operation principle

The function can be enabled and disabled with the Operation setting. The corresponding parameter values are “on” and “off”.

The operation of COLPTOC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

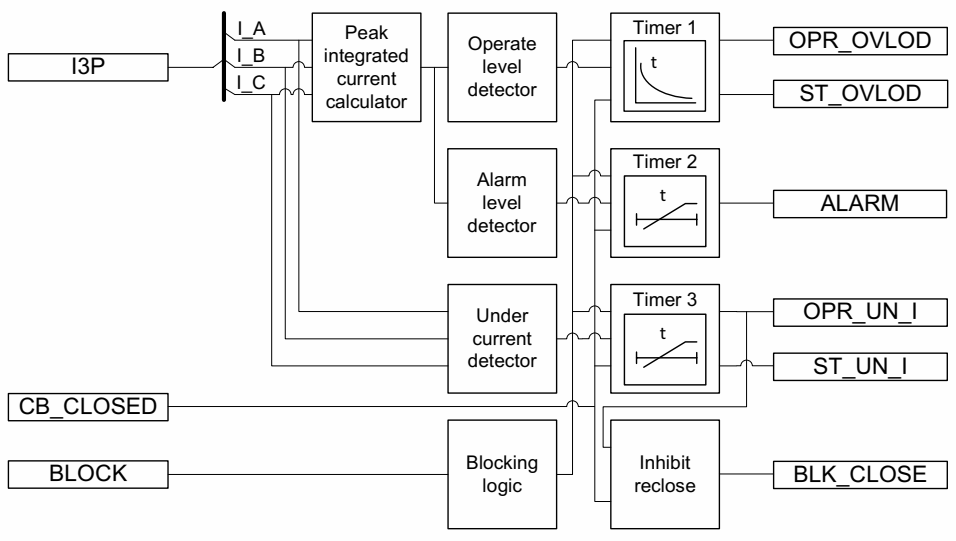



*Figure 547: Functional module diagram*

#### Peak integrated current calculator

The peak integrated current calculator calculates peak value of integrated current (I_PEAK_INT_A, I_PEAK_INT_B and I_PEAK_INT_C) which is proportional to the voltage over capacitor. The I_PEAK_INT_A, I_PEAK_INT_B and I_PEAK_INT_C values are available in monitored data view. The frequency response of the peak integrated current calculator can be seen in Figure 548.

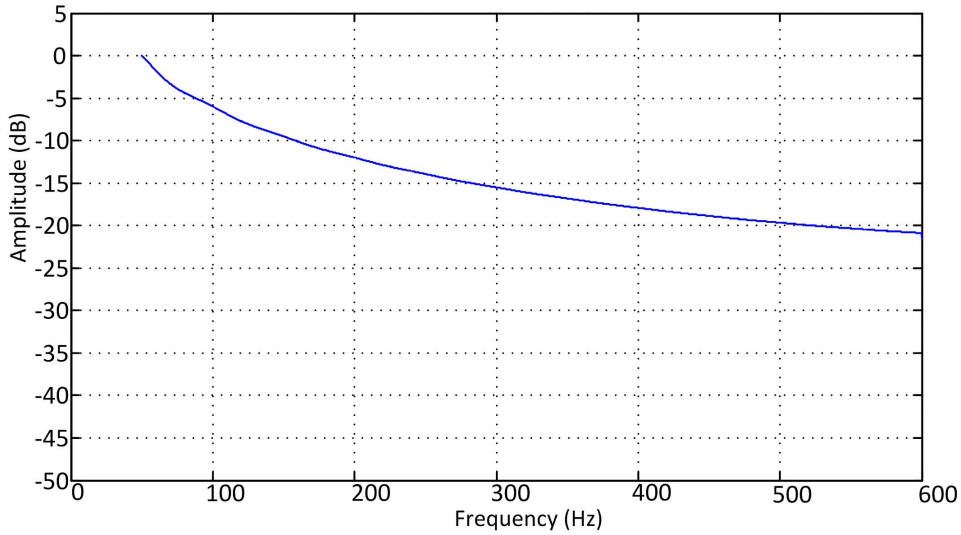



*Figure 548: Frequency response of the peak integrated current calculator*

## Operate level detector

The Operate level detector compares I_PEAK_INT_x value to *Start value overload*. If the phase or phases in which I_PEAK_INT_x exceeds the setting matches the *Num of start phases* setting, the Operate level detector module activates the Timer 1 module.

## Timer 1

Once activated, the Timer 1 module activates the ST_OVLOD output. The operation time depends on the overload level and *Time multiplier*. The operation time under standard characteristics is based on ANSI/IEEE 37.99 and IEC 60871-1 recommendations.

*Table 951: Standard Curve characteristics for IDMT Curve*

| Overload value | Relay operate time(s) with k = 1 | Standard |
|---|---|---|
| 1.10 | 43200 | IEC60871-1 |
| 1.15 | 1800 | IEC60871-1 |
| 1.20 | 300 | IEC60871-1 |
| 1.30 | 60 | ANSI/IEEE37.99,IEC60871-1 |
| 1.40 | 15 | ANSI/IEEE37.99 |
| 1.70 | 1 | ANSI/IEEE37.99 |
| 2.20 | 0.120 | ANSI/IEEE37.99 |

Operate time is based on maximum value of I_PEAK_INT_A, I_PEAK_INT_B and I_PEAK_INT_C. From maximum value calculated , operate time between any two consecutive points in the standard table is based on logarithmic interpolation.

The operate time can be scaled using the *Time multiplier* setting. The OPR_OVLOD output is activated if the overload situation lasts long enough to exceed the operation time.

The operate time for the operation overload stage is limited between 0.1 s to 43200 s (12 hours) if *Time multiplier* is used.

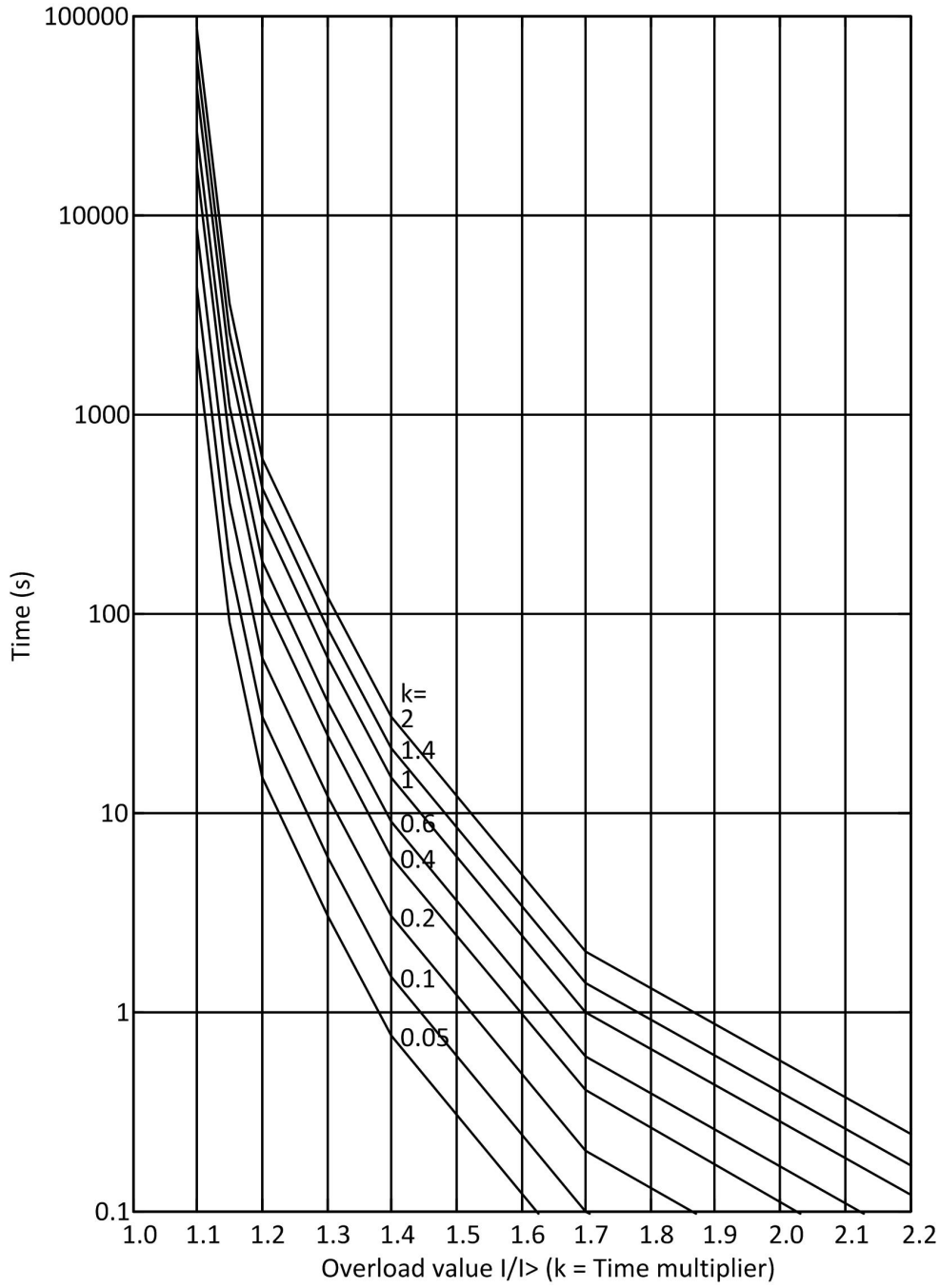



*Figure 549: Inverse-time characteristic curves for overload stage*

If the integrated current exceeds 1.1 times the setting *Start value overload* for a short period but does not operate as the current decreases within *Start value overload*, the output `ST_OVLOD` is kept active but the operation timer is frozen. However, if the integrated current exceeds 1.1 times the *Start value overload* setting value again, the operation timer continue from the freezing point. Thus, the operation timer is cumulative. If the integrated current exceeds 1.1 times the setting *Start value overload*

only once and remains within the *Start value overload* area for 24 hours, the operation timer and the output ST_OVLOD are reset.

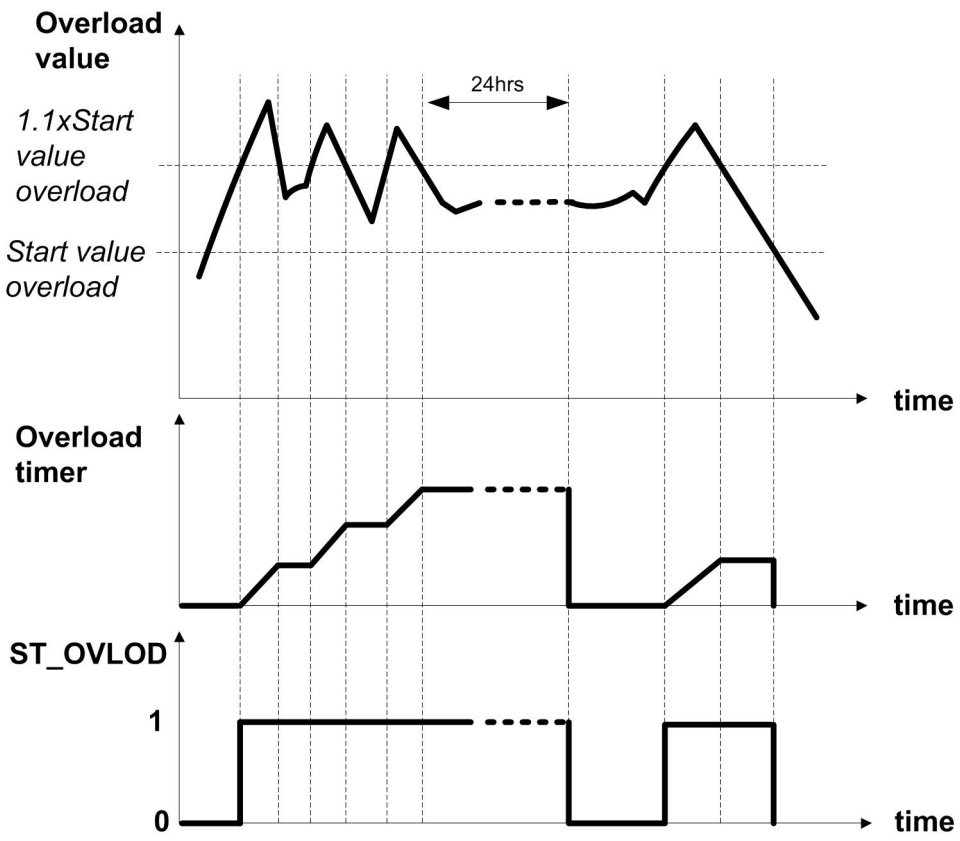



*Figure 550: The behavior of the IDMT timer and the output ST_OVLOD*

The ST_DUR_OVLOD output indicates the percentage ratio of the start situation and the operation time in the Timer 1 module and is available in the monitored data view.

The Timer 1 module is internally blocked for one second after the capacitor bank is connected by detecting the rising edge of the CB_CLOSED signal. The CB_CLOSED signal is True when the CB position is closed.

## Alarm level detector

The Alarm level detector compares I_PEAK_INT_x value to *Alarm start value*. If the phase or phases in which I_PEAK_INT_x exceeds the setting matches the *Num of start phases* setting, the Alarm level detector module activates the Timer 2 module.

The *Num of start phases* setting is a common setting for both Operate level detector and Alarm level detector.

### Timer 2

The Timer 2 characteristics are according to Definite Time (DT) .When the operation timer has reached the value of *Alarm delay time*, the ALARM output is activated.

If a drop-off situation happens, the timer is reset.

The Timer 2 module is internally blocked for one second after the capacitor bank is connected by detecting the rising edge of the CB_CLOSED signal. The CB_CLOSED signal is True when the CB position is closed.

### Under current detector

The Under current detector module can be enabled by setting *Enable under current* to “Enable” and disabled by setting it to “Disable”. The Under current detector module is also disabled when CB_CLOSED is FALSE, that is, when circuit breaker is open.

The fundamental frequency component of phase currents is compared to the setting *Start value Un Cur*. If all the three-phase currents are below the setting *Start value Un Cur*, the Under current detector module enables the Timer 3 module.

### Timer 3

Once activated, the Timer 3 module activates the ST_UN_I output. The operation is based on DT characteristics. When the operation timer has reached the value of *Un Cur delay time*, the OPR_UN_I output is activated.

If the undercurrent situation disappears, the operation timer is reset. The ST_DUR_UN_I output indicates the percentage ratio of the undercurrent start situation and the set operation time in the Timer 3 module and is available in the monitored data view.

The OPR_UN_I output is of pulse type and remains TRUE for 150 ms. After that, ST_DUR_UN_I and OPR_UN_I are deactivated and ST_DUR_UN_I is reset.

If the circuit breaker closed status signal is not detected, the constant value TRUE has to be connected to CB_CLOSED input to enable the undercurrent detector.

If the circuit breaker status signal is not connected to CB_CLOSED input, the OPR_UN_I output is activated even if the circuit breaker is open and undercurrent is detected.

### Inhibit reclose

When the output OPR_UN_I becomes active or when the CB_CLOSED state changes from TRUE to FALSE, that is, when circuit breaker opens, the reclosing inhibition module activates output BLK_CLOSE.

If *Enable under current* is set to “Disable”, the reclosing inhibition operation is based purely on the CB_CLOSED input.

The behavior of the BLK_CLOSE output depends on *Reclose inhibit mode*. If *Reclose inhibit mode* is set to “Lockout”, the BLK_CLOSE output needs to be reset manually from the clearing menu parameter *COLPTOC inhibit recl*. If *Reclose inhibit mode* is set to “Non-latched”, the BLK_CLOSE output resets after the set *Reclose inhibit time* has elapsed.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, COLPTOC is executed normally but the OPR_OVLOD and OPR_UN_I outputs are not allowed to activate.

The BLOCK input does not block the BLK_CLOSE signal.

## 4.12.1.6 Application

The application area for three-phase overload protection function of shunt capacitor bank is the protection of power capacitor banks intended for reactive power compensation and filtering of the harmonics. Shunt capacitor banks provide a low-impedance path to harmonic currents and hence attract harmonic currents flowing in the system. Increased harmonic currents result in excessive voltage stress across the capacitor bank. According to the standards, a high-voltage capacitor shall be able to withstand 10% overload. Loading beyond that can cause damage to the capacitor bank and in turn to the system. Hence, COLPTOC is specially designed for the protection against overloads produced by harmonic currents and overvoltage.

Undercurrent protection is used to disconnect the capacitor bank from the rest of the power system when the voltage at the capacitor bank terminals is too low for too long

a period of time. To avoid an undercurrent trip operation when the capacitor bank is disconnected from the power system, the undercurrent functionality is blocked by using the capacitor bank circuit breaker status signal.

Furthermore, the reclosing inhibition feature provides protection against the reconnection of a charged capacitor to a live network. Whenever the capacitor bank circuit breaker is opened, the reclosing is inhibited for the duration of the discharge time of the capacitor. The reclosing inhibition functionality can be disabled manually or automatically. In the manual mode, the inhibition reclosing has to be manually reset and in automatic mode, the reclosing inhibitionl resets automatically after the set time.

### 4.12.1.7 Signals

*Table 952: COLPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| CB_CLOSED | BOOLEAN | 0=False | Input showing the status of capacitor circuit breaker |

*Table 953: COLPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPR_OVLOD | BOOLEAN | Overload operated |
| OPR_UN_I | BOOLEAN | Operate under current |
| ST_OVLOD | BOOLEAN | Overload started |
| ST_UN_I | BOOLEAN | Under current started |
| ALARM | BOOLEAN | Alarm |
| BLK_CLOSE | BOOLEAN | Inhibit re-close of capacitor bank |

### 4.12.1.8 Settings

*Table 954: COLPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value overload | 0.30...1.50 | xIn | 0.01 | 1.00 | Start value for overload stage |
| Alarm start value | 80...120 | % | 1 | 105 | Alarm start value (% of Start value overload) |
| Start value Un Cur | 0.10...0.70 | xIn | 0.01 | 0.50 | Start value for under current operation |
| Time multiplier | 0.05...2.00 | | 0.01 | 1.00 | Time multiplier for Capacitor Bank protection curves |
| Alarm delay time | 500...6000000 | ms | 100 | 300000 | Alarm delay time |
| Un Cur delay time | 100...120000 | ms | 100 | 1000 | Delay time for under current operation |

*Table 955: COLPTOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reclose inhibit time | 1...6000 | s | 1 | 1 | Reclose inhibit time |

*Table 956: COLPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Reclose inhibit mode | 1=Non-latched<br>3=Lockout | | | 1=Non-latched | Reclose inhibit mode |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |

*Table 957: COLPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Enable under current | 0=Disable<br>1=Enable | | | 1=Enable | Enable under current functionality |

### 4.12.1.9 Monitored data

*Table 958: COLPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ST_DUR_OVLOD | FLOAT32 | 0.00...100.00 | % | Start duration for overload stage |
| ST_DUR_UN_I | FLOAT32 | 0.00...100.00 | % | Start duration for under current operation |
| I_PEAK_INT_A | FLOAT32 | 0.00...40.00 | | Phase A peak value of the integrated current of the capacitor |
| I_PEAK_INT_B | FLOAT32 | 0.00...40.00 | | Phase B peak value of the integrated current of the capacitor |
| I_PEAK_INT_C | FLOAT32 | 0.00...40.00 | | Phase C peak value of the integrated current of the capacitor |
| COLPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.12.1.10 Technical data

*Table 959: COLPTOC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz, and no harmonics |
| | 5% of the set value or 0.002 × $I_n$ |
| Start time for overload stage[1)2)] | Typically 75 ms |
| Start time for under current stage[2)3)] | Typically 26 ms |
| Reset time for overload and alarm stage | Typically 60 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | 1% of the set value or ±20 ms |
| Operate time accuracy in inverse time mode | 10% of the theoretical value or ±20 ms |
| Suppression of harmonics for under current stage | DFT: -50 dB at f = n × $f_n$, where n = 2,3,4,5,.. |

1) Harmonics current before fault = 0.5 × $I_n$, harmonics fault current 1.5 × *Start value*, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Harmonics current before fault = 1.2 × $I_n$, harmonics fault current 0.8 × *Start value*, results based on statistical distribution of 1000 measurements

## 4.12.2 Current unbalance protection for shunt capacitor banks CUBPTOC

### 4.12.2.1 Identification

*Table 960: Function identification*

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current unbalance protection for shunt capacitor banks | CUBPTOC | dI>C | 60N |

### 4.12.2.2 Function block

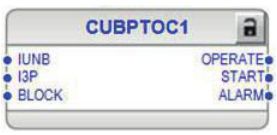



*Figure 551: Function block symbol*

### 4.12.2.3 Functionality

The current unbalance protection for shunt capacitor banks function CUBPTOC is used to protect the double-Y-connected capacitor banks from internal faults.

CUBPTOC is suitable for the protection of internally fused, externally fused and fuseless applications.

CUBPTOC has two stages of operation, that is, operation stage and alarm stage. In the operating stage, CUBPTOC starts when the measured unbalance current exceeds the set limit. The operation time characteristics can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). The operation under alarm stage is either based on the DT characteristics or the faulty element counter of a capacitor bank.

CUBPTOC has a blocking functionality. It is possible to block the function outputs, timers or the function itself, if required.

### 4.12.2.4 Analog channel configuration

CUBPTOC has two analog group inputs which must be properly configured.

*Table 961: Analog inputs*

| Input | Description |
|---|---|
| IUNB | Unbalance current (measured) |
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 962: Special conditions*

| Condition | Description |
|---|---|
| IUNB measurement | The function requires that the unbalance current measurement is connected to the RESTCTR function block. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.12.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”. The current unbalance protection for shunt capacitor banks operates on the DFT measurement mode.

The operation of CUBPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

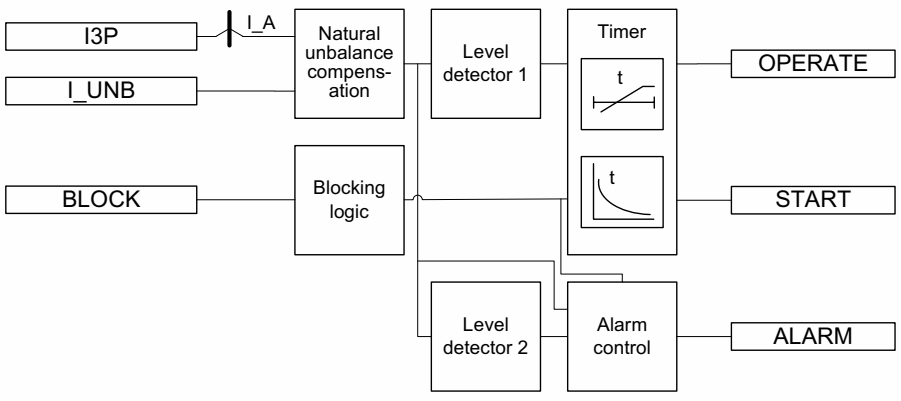



*Figure 552: Functional module diagram*

## Natural unbalance Compensation

A standard double-Y-connected shunt capacitor bank configuration is shown in Figure 553. The fundamental frequency component of an unbalance current is measured on the common neutral connecting the two balanced parts of a shunt capacitor bank, that is, between star point 1 and star point 2.

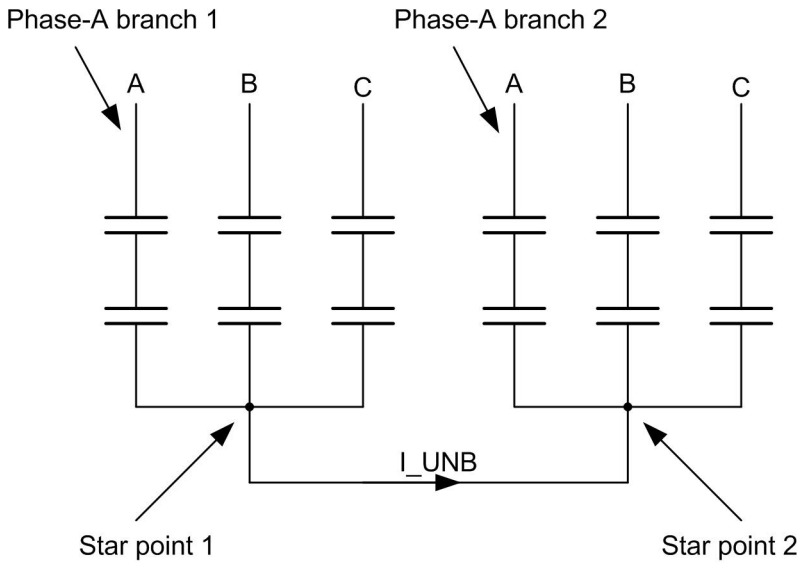



*Figure 553: Double-Y-connected capacitor bank*

The phase angle of the measured fundamental frequency component of the unbalance current I_UNB is synchronized by using the phase current I_A as a reference.

$$\angle\overline{I_{unb}} = \angle\overline{I_UNB} - \angle\overline{I_A}$$

(Equation 240)

In a three-phase star-connected capacitor bank circuit, there may be some amount of natural unbalance current flowing through the neutral, which is primarily due to capacitor manufacturing tolerances. The natural unbalance current must be compensated for before using the measured unbalance current for the function operation. The natural unbalance current needs to be recorded when there is no fault in the capacitor banks, and it is initiated through the command *Record unbalance*, available under menu path **Control/CUBPTOC**. By selecting *Record unbalance* with value “Record”, the measured unbalance current $\bar{I}_{Unb}$ is considered as the natural unbalance current $\bar{I}_{NatUnb}$ and is stored as a reference. The amplitude and angle of the recorded natural unbalance current I_AMPL_NAT and I_ANGL_NAT are available in the monitored data view.

Once the natural unbalance current is recorded during further executions of the function, the natural unbalance current is subtracted from the measured unbalance current $\bar{I}_{Unb}$ to obtain the compensated unbalance current $\bar{I}_{CompUnb}$ as shown in Figure 554.

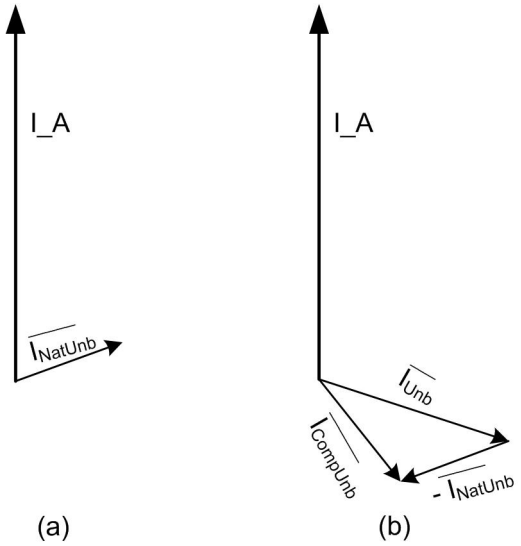



*Figure 554: Natural unbalance compensation. (a) Healthy condition when the natural unbalance is recorded (b) Unbalance compensation during faulty conditions*

The natural unbalance current compensation is enabled using the setting *Natural Comp Enable*. If *Natural Comp Enable* is set to “FALSE”, the unbalance current is not compensated. If *Natural Comp Enable* is set to “TRUE”, the compensated unbalance current is calculated based on the equation.

$$\bar{I}_{CompUnb} = \bar{I}_{Unb} - \bar{I}_{NatUnb}$$

(Equation 241)

The amplitude I_AMPL_COMP and the angle I_ANGL_COMP of the compensated unbalance current $\bar{I}_{CompUnb}$ are available in the monitored data view.

### Level detector 1

The calculated compensated unbalance current I_AMPL_COMP is compared to the set "Start value". If I_AMPL_COMP exceeds the set "Start value", the Level detector 1 sends an enabling signal to the Timer 1 module.

### Timer 1

Once activated, the Timer 1 module activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated. When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters "Curve parameter A", *Curve parameter B*, *Curve parameter C* and *Curve parameter E*.

In a drop-off situation, that is when a fault suddenly disappears before the operate delay is exceeded, the Timer 1 reset state is activated. The functionality of the Timer 1 in the reset state depends on the combination of the Operating curve type and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, an immediate reset occurs. The START output is deactivated when the reset timer has elapsed.

The setting *Time multiplier* is used for scaling the IDMT operation and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operation time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve but always at least the value of the *Minimum operate time* setting.

The Timer 1 module calculates the start duration value START_DUR, which indicates the percentile ratio of the start situation and the set operation time. The value is available in the monitored data view.

In a typical double-Y-connected configuration (Figure 553), there are two branches in every phase and hence six individual counters COUNT_BR1_A, COUNT_BR2_A, COUNT_BR1_B, COUNT_BR2_B, COUNT_BR1_C and COUNT_BR2_C are maintained. Based on the phase angle of the compensated unbalance current I_ANGL_COMP, the phase and the branch of the element failure location is detected. However, the element failure location also depends on the type of capacitor banks, that is, whether internal or external fuses are used. The setting *Fuse location* is used to set the capacitor bank type as “External” or “Internal”.

For an external fuse capacitor bank, the element failure location and corresponding counters to be incremented are determined based on the phase angle of the compensated unbalance current.

*Table 963: Element failure location and counters to be incremented for external fuse case*

| Phase angle of the compensated unbalance current (degrees) | Phase and branch of the element failure | Counters to be incremented |
|---|---|---|
| -15...+15 | Phase-A branch 1 | COUNT_BR1_A |
| -15...-45 | Phase-A branch 1<br>Phase-C branch 2 | COUNT_BR1_A<br>COUNT_BR2_C |
| -45...-75 | Phase-C branch 2 | COUNT_BR2_C |
| -75...-105 | Phase-B branch 1<br>Phase-C branch 2 | COUNT_BR1_B<br>COUNT_BR2_C |
| -105...-135 | Phase-B branch 1 | COUNT_BR1_B |
| -135...-165 | Phase-B branch 1<br>Phase-A branch 2 | COUNT_BR1_B<br>COUNT_BR2_A |
| -165...-180 | Phase-A branch 2 | COUNT_BR2_A |
| +165...+180 | Phase-A branch2 | COUNT_BR2_A |
| +135...+165 | Phase-C branch 1<br>Phase-A branch 2 | COUNT_BR1_C<br>COUNT_BR2_A |
| +105...+135 | Phase-C branch 1 | COUNT_BR1_C |
| +75...+105 | Phase-C branch1<br>Phase-B branch2 | COUNT_BR1_C<br>COUNT_BR2_B |
| +45...+75 | Phase-B branch2 | COUNT_BR2_B |
| +15...+45 | Phase-A branch1<br>Phase-B branch2 | COUNT_BR1_A<br>COUNT_BR2_B |

If the capacitor bank is fuseless, then the setting *Fuse location* should be set to “External” and Table 963 can be used to determine the element failure location.

If the compensated unbalance current I_AMPL_COMP is greater than three times the set *Alarm value*, it is considered to be a case of blown external fuse. For the internal fuse and blown fuse cases, the element failure location and corresponding counters to be incremented are determined based on the phase angle of the compensated unbalance current.

*Table 964: Element failure location and counters to be incremented for internal fuse and blown fuse case*

| Phase angle of the compensated unbalance current (degrees) | Phase and branch of the element failure | Counters to be incremented |
|---|---|---|
| -15...+15 | Phase-A branch 2 | COUNT_BR2_A |
| -15... -45 | Phase-A branch 2<br>Phase-C branch 1 | COUNT_BR2_A<br>COUNT_BR1_C |
| -45...-75 | Phase-C branch 1 | COUNT_BR1_C |
| Table continues on next page | | |

| Phase angle of the compensated unbalance current (degrees) | Phase and branch of the element failure | Counters to be incremented |
|---|---|---|
| -75...-105 | Phase-B branch 2<br>Phase-C branch 1 | COUNT_BR2_B<br>COUNT_BR1_C |
| -105...-135 | Phase-B branch 2 | COUNT_BR2_B |
| -135...-165 | Phase-B branch 2<br>Phase-A branch 1 | COUNT_BR2_B<br>COUNT_BR1_A |
| -165...-180 | Phase-A branch 1 | COUNT_BR1_A |
| +165...+180 | Phase-A branch 1 | COUNT_BR1_A |
| +135...+165 | Phase-C branch 2<br>Phase-A branch 1 | COUNT_BR2_C<br>COUNT_BR1_A |
| +105...+135 | Phase-C branch 2 | COUNT_BR2_C |
| +75...+105 | Phase-C branch 2<br>Phase-B branch 1 | COUNT_BR2_C<br>COUNT_BR1_B |
| +45...+75 | Phase-B branch 1 | COUNT_BR1_B |
| +15...+45 | Phase-A branch 2<br>Phase-B branch 1 | COUNT_BR2_A<br>COUNT_BR1_B |

After *Alarm delay time* has elapsed, the corresponding counter value is incremented based on the magnitude of the unbalance current. If I_AMPL_COMP is less than 1.5 times the set *Alarm value*, the counter is incremented by one. Furthermore, if I_AMPL_COMP is between 1.5 and 2.5 times the set *Alarm value*, the counter is incremented by two and so on.

Normally, the setting *Alarm value* is about 0.1 percent lower than the value of the unbalance current which is caused by one faulty element. This setting value has to be chosen carefully because a slightly lower value may lead to a situation where the counters show more failures than the actual. Too high setting leads to a situation where a fault is not detected.

The counter values COUNT_BR1_A, COUNT_BR2_A, COUNT_BR1_B, COUNT_BR2_B, COUNT_BR1_C and COUNT_BR2_C are available in the monitoring data view. The total number of element failures in double-Y-connected capacitor banks, FAIL_COUNT, is available in the monitored data view.

The ALARM output is activated, when the value of FAIL_COUNT exceeds the setting *Element failure limit*.

The counter values can be reset via *CUBPTOC counters* which is located under the Clear menu.

## Level detector 2

The calculated compensated unbalance current I_AMPL_COMP is compared to the set *Alarm start value*. If the I_AMPL_COMP exceeds the set *Alarm value* the Level detector 2 sends enabling signal to the Alarm control module.

### Alarm control

Depending on the *Alarm mode* setting, the alarm stage operation is according to "Normal mode" or "Element counter mode".

In the "Normal mode" the time characteristic is according to DT. When the alarm timer has reached the value set by *Alarm delay time*, the ALARM output is activated. If the fault disappears before the alarm activates, the alarm timer is reset immediately.

The "Element counter mode" is used to detect faulty elements of the capacitor bank and count the number of element failures in each branch and line. On activation, this module increments the corresponding element failure counters after the set *Alarm delay time* has elapsed.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode**, which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, CUBPTOC operates normally but the OPERATE output is not activated.

## 4.12.2.6 Application

CUBPTOC is designed for the protection against internal faults in double-Y-connected capacitor banks. This unbalance protection detects an asymmetry in the capacitor bank caused by blown fuses or short circuits across bushings or between capacitor units and the racks in which they are mounted.

Normally, the capacitor units are designed to withstand 110 percent of the nominal voltage continuously. When an element inside a capacitor bank fails, the remaining healthier elements experience an increase in voltage across them. If the voltage exceeds the 110 percent value of the nominal voltage, it can lead to a failure of the healthier elements of the bank and in turn fail the entire capacitor bank. Since the capacitor unbalance current is directly proportional to the element failures, unbalance protection is an effective way of detecting capacitor element failures. The current unbalance protection function is usually used with the three-phase capacitor bank overload protection function to increase the sensitivity of protection for capacitor banks.

Due to the two-stage (operation and alarm stage) unbalance protection and the natural unbalance compensation facility, the protection of capacitor banks with internal fuses can be implemented with a very high degree of sensitivity. Furthermore, CUBPTOC

provides a sophisticated method of detecting the number of faulty elements in each phase by calculating the differential unbalance current.

The unbalance protection function can be used for internally fused, externally fused and fuseless shunt capacitor banks. Since a fuseless capacitor bank lacks the individual capacitor unit fuses, current unbalance protection becomes even more critical for fuseless applications.

When an individual element fails, it causes unbalance current. With an increasing number of element failures, the unbalance current increases and CUBPTOC gives an alarm. The alarm level is normally set to 50 percent of the maximum permitted level. The capacitor bank needs to be taken out of service to replace the faulty units. If this is not done, the capacitor bank is tripped when the maximum allowed unbalance current level is exceeded.



If two simultaneous faults occur in the same phase but in different branches, there is no change in the unbalance current and CUBPTOC does not detect this type of faults.



If two simultaneous faults occur in the same branch but in different phases, it may cause a phase angle equal to a situation where there is only one fault in the branch. Therefore, the element failure counters show only one fault instead of two.

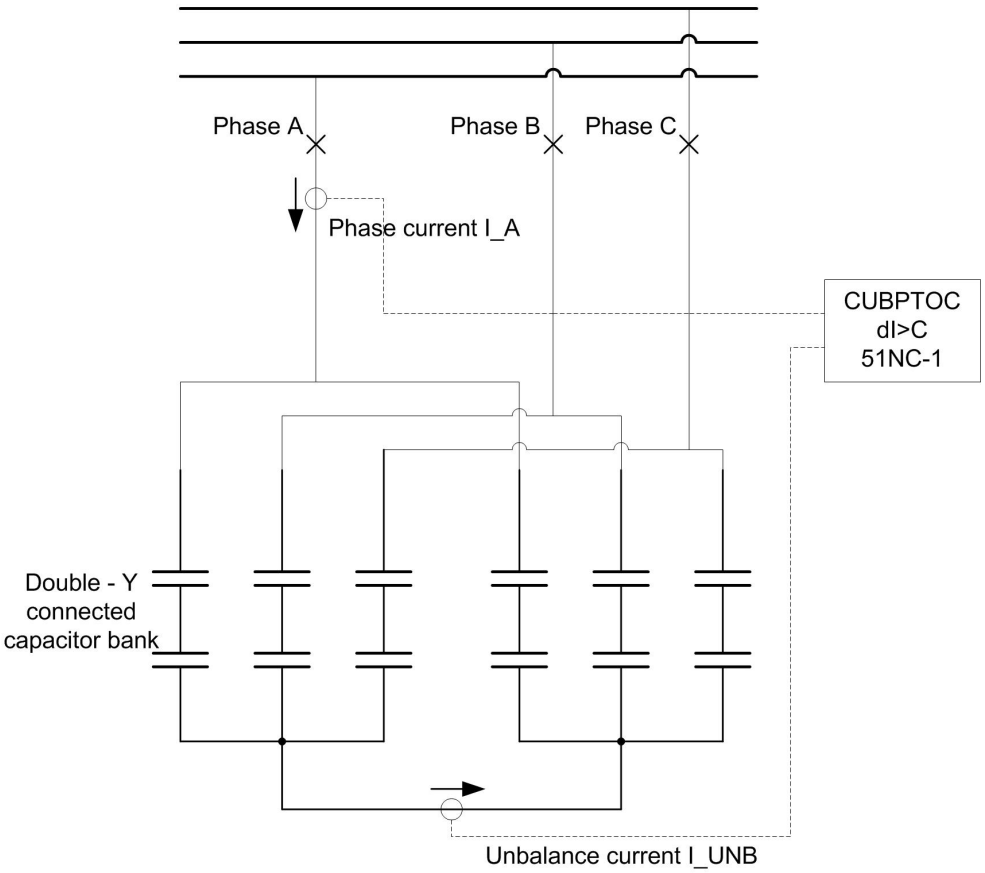



*Figure 555: Example of double-Y-connected shunt capacitor bank unbalance protection*

Connect the phase current analog input `I_A` and unbalance current `I_UNB` to the protection relay for the CUBPTOC function to start working.

## Steps to measure natural unbalance current

1. The setting *Natural Comp Enable* must be set to “TRUE”.
2. The capacitor bank must be energized.
3. The capacitor bank compensated unbalance current `I_COM_AMPL` is observed from Monitored data.
4. The command *Record unbalance* must be activated by selecting the value “Record” which stores the unbalance reference for future unbalance calculations.
5. The compensated unbalance current (`I_COM_AMPL`) is re-checked to be approximately zero.

The natural unbalance recording should be made only during the steady-state condition and when all the capacitor bank elements are assumed to be in service.

### 4.12.2.7 Signals

*Table 965: CUBPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IUNB | SIGNAL | - | Analog input |
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 966: CUBPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Alarm |

### 4.12.2.8 Settings

*Table 967: CUBPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Alarm mode | 1=Normal<br>2=Element counter | | | 1=Normal | Mode of operation for Alarm stage |
| Start value | 0.01...1.00 | xIn | 0.01 | 0.10 | Start value |
| Alarm start value | 0.01...1.00 | xIn | 0.01 | 0.05 | Alarm start value |
| Time multiplier | 0.05...15.00 | | 0.01 | 1.00 | Time multiplier in IEC/ANSI IDMT curves |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 50...200000 | ms | 10 | 5000 | Operate delay time |
| Alarm delay time | 50...200000 | ms | 10 | 200000 | Alarm delay time |

*Table 968: CUBPTOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Fuse location | 1=Internal<br>2=External | | | 1=Internal | Location of capacitor fuse |
| Element fail limit | 1...100 | | 1 | 3 | Element failure limit above which alarm is active |
| Natural Comp enable | 0=False<br>1=True | | | 0=False | Enable natural unbalance compensation |

*Table 969: CUBPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.00860...120.00000 | | 1 | 28.20000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.00000...0.71200 | | 1 | 0.12170 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 970: CUBPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |

### 4.12.2.9 Monitored data

*Table 971: CUBPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| I_NAT_AMPL | FLOAT32 | 0.00...5.00 | xIn | Recorded natural unbalance current amplitude |
| I_NAT_ANGL | FLOAT32 | -179.00...179.00 | deg | Recorded natural unbalance current angle |
| I_COM_AMPL | FLOAT32 | 0.00...5.00 | xIn | Compensated unbalance current amplitude |
| I_COM_ANGL | FLOAT32 | -179.00...179.00 | deg | Compensated unbalance current angle |
| COUNT_BR1_A | INT32 | 0...2147483647 | | Number of element failures in branch1 phase-A |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| COUNT_BR2_A | INT32 | 0...2147483647 | | Number of element failures in branch2 phase-A |
| COUNT_BR1_B | INT32 | 0...2147483647 | | Number of element failures in branch1 phase-B |
| COUNT_BR2_B | INT32 | 0...2147483647 | | Number of element failures in branch2 phase-B |
| COUNT_BR1_C | INT32 | 0...2147483647 | | Number of element failures in branch1 phase-C |
| COUNT_BR2_C | INT32 | 0...2147483647 | | Number of element failures in branch2 phase-C |
| FAIL_COUNT | INT32 | 0...2147483647 | | Total number of element failures |
| CUBPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| I-unb-xIn:1 | FLOAT32 | 0.00...5.00 | xIn | Measured neutral unbalance current amplitude |

## 4.12.2.10 Technical data

*Table 972: CUBPTOC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | 1.5% of the set value or 0.002 × $I_n$ |
| Start time[1)2)] | Typically 26 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | 1% of the theoretical value or ±20 ms |
| Operate time accuracy in inverse definite minimum time mode | 5% of the theoretical value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2,3,4,5,.. |

1) Fundamental frequency current = 1.0 × $I_n$, current before fault = 0.0 × $I_n$, fault current = 2.0 × *Start value*, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.12.3 Three-phase current unbalance protection for shunt capacitor banks HCUBPTOC

### 4.12.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase current unbalance protection for shunt capacitor banks | HCUBPTOC | 3dI>C | 60P |

### 4.12.3.2 Function block

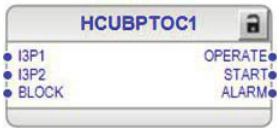



*Figure 556: Function block symbol*

### 4.12.3.3 Functionality

The three-phase current unbalance protection function for shunt capacitor banks HCUBPTOC is used to protect the H-bridge capacitor banks against internal faults. HCUBPTOC is suitable for protection of internally fused, externally fused and fuse-less capacitor bank applications.

HCUBPTOC has two stages of operation, the operation stage and alarm stage. In the operation stage, HCUBPTOC starts when the measured unbalance current exceeds the set limit. The operating time characteristics can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). In the alarm stage, the alarm starts when the measured unbalance current exceeds the set alarm limit. The alarm time characteristics are based on DT.

HCUBPTOC contains blocking functionality. It is possible to block the function outputs, timers or the function itself.

### 4.12.3.4 Analog channel configuration

HCUBPTOC has two analog group inputs which all must be properly configured.

*Table 973: Analog inputs*

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase unbalance currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.12.3.5 Operation principle

The function can be enabled and disabled with the Operation setting. The corresponding parameter values are “On” and “Off”.

The three-phase current unbalance protection for shunt capacitor banks operates on the DFT measurement mode. The operation of HCUBPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

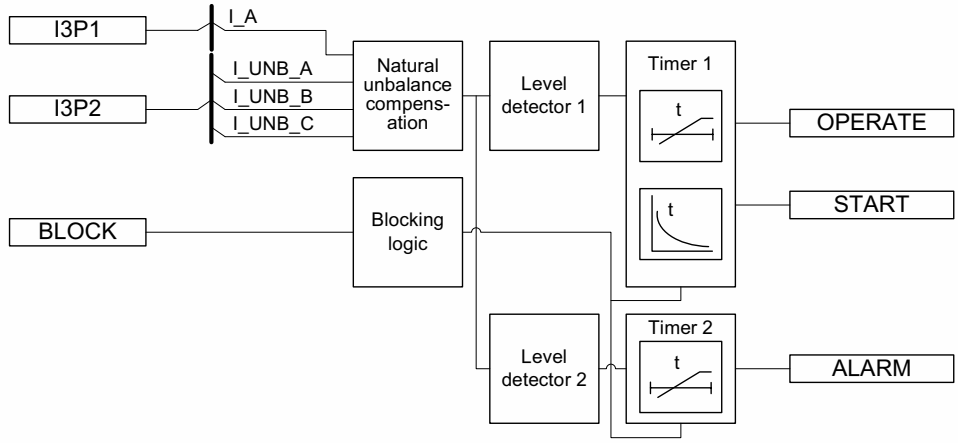



*Figure 557: Function module diagram*

#### Natural unbalance compensation

In the three-phase H-bridge-connected shunt capacitor bank configuration, the unbalance currents `I_UNB_A`, `I_UNB_B` and `I_UNB_C` are measured at the common points of the H-bridge.

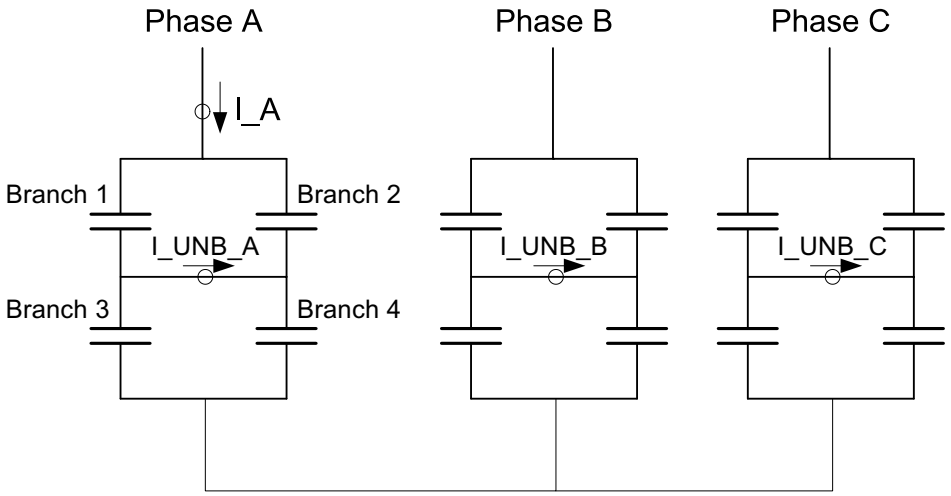



*Figure 558: H-Bridge-connected capacitor bank*

The phase angles of three-phase measured unbalance currents are synchronized using the phase current I_A as reference. The phase-A unbalance current phase angle can be calculated with the equation.

$$\angle\overline{I_{Unb_A}} = \angle\overline{I_UNB_A} - \angle\overline{I_A}$$

(Equation 242)

A three-phase H-bridge-connected capacitor bank circuit may have some amount of natural unbalance current flowing through the common points of H-bridge, which may primarily be due to capacitor manufacturing tolerances. Therefore, the natural unbalance current must be compensated for before using the measured unbalance current for function operation.

The natural unbalance current needs to be recorded when there is no fault in the capacitor banks, and it is initiated through the command *Record unbalance* available under menu path **Control/HCUBPTOC**. The natural unbalance currents are recorded for all the phases at the same time by setting command *Record unbalance* to “Record all phases” or each natural unbalance current can be recorded separately for individual phases by setting command *Record unbalance* to “Record phase A” or “Record phase B” or “Record phase C”. By selecting *Record unbalance* with value “Record”, the measured three-phase unbalance currents ( $\overline{I}_{Unb_A}, \overline{I}_{Unb_B}, \overline{I}_{Unb_C}$ ) are considered the natural unbalance currents for each phase respectively and stored as a reference. The amplitude and angle of the phasewise-recorded natural unbalance currents I_NAT_AMPL_A, I_NAT_ANGL_A, I_NAT_AMPL_B, I_NAT_ANGL_B, I_NAT_AMPL_C and I_NAT_ANGL_C are available in the monitored data view.

Once a natural unbalance current is recorded, the phasewise natural unbalance current is subtracted from the corresponding phase-measured unbalance current ( $\overline{I}_{Unb}$ ) during further executions of the function to obtain the compensated unbalance current ( $\overline{I}_{CompUnb}$ ) .

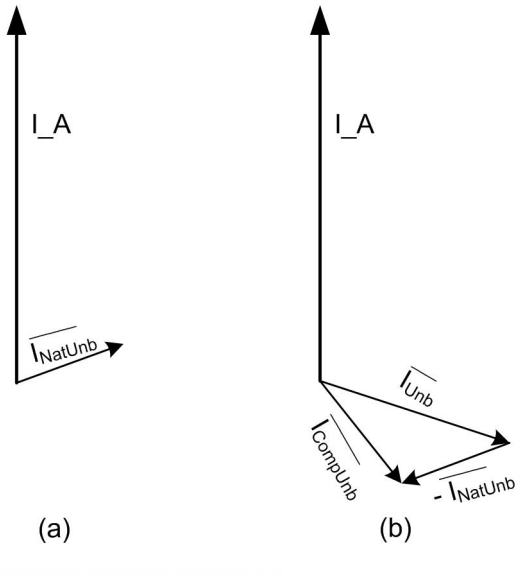



*Figure 559: Natural unbalance compensation. (a) Healthy condition when the natural unbalance is recorded (b) Unbalance compensation during faulty conditions*

The natural unbalance compensation for each phase is enabled based on the settings *Natural Comp Ena PhA*, *Natural Comp Ena PhB* and *Natural Comp Ena PhC* respectively. For example, if *Natural Comp Ena PhA* is set to “FALSE”, the unbalance current is not compensated. If *Natural Comp Ena PhA* is set to “TRUE”, the compensated unbalance current for phase A is calculated based on the equation.

$$\overline{I_{CompUnb_A}} = \overline{I_{Unb_A}} - \overline{I_{NatUnb_A}}$$

(Equation 243)

| | |
|---|---|
| $I_{CompUnb_A}$ | Phase A-compensated unbalance current |
| $I_{Urb_A}$ | Phase A-measured unbalance current |
| $I_{NatUnb_A}$ | Phase A-recorded natural unbalance current |

The phasewise-compensated unbalance current amplitudes and angles `I_COM_AMPL_A`, `I_COM_ANGL_A`, `I_COM_AMPL_B`, `I_COM_ANGL_B`, `I_COM_AMPL_C` and `I_COM_ANGL_C` are available in the monitored data view.

The phase angles of the unbalance currents indicate the branch of a faulty element in a capacitor bank. For an internal fuse capacitor bank, the element failure branch location is determined based on the phase angle of the compensated unbalance current.

*Table 974: Detection of element failure location for internal fuse capacitor bank*

| Name of the phase angle | Phase angle of unbalance current | Element failure branch location (Figure 558) |
|---|---|---|
| I_COM_ANGL_A | ~+180$^0$ | Phase A - Branch 1 or Phase A - Branch 4 |
| I_COM_ANGL_A | ~0$^0$ | Phase A - Branch 2 or Phase A - Branch 3 |
| I_COM_ANGL_B | ~+60$^0$ | Phase B - Branch 1 or Phase B - Branch 4 |
| I_COM_ANGL_B | ~–120$^0$ | Phase B - Branch 2 or Phase B - Branch 3 |
| I_COM_ANGL_C | ~–60$^0$ | Phase C - Branch 1 or Phase C - Branch 4 |
| I_COM_ANGL_C | ~+120$^0$ | Phase C - Branch 2 or Phase C - Branch 3 |

If external fuses are used, the direction of an unbalance current is opposite to that of the bank where internal fuses are in use.

*Table 975: Detection of element failure location for external fuse capacitor bank*

| Name of the phase angle | Phase angle of unbalance current | Element failure branch location (Figure 558) |
|---|---|---|
| I_COM_ANGL_A | ~0$^0$ | Phase A - Branch 1 or Phase A - Branch 4 |
| I_COM_ANGL_A | ~+180$^0$ | Phase A - Branch 2 or Phase A - Branch 3 |
| I_COM_ANGL_B | ~–120$^0$ | Phase B - Branch 1 or Phase B - Branch 4 |
| I_COM_ANGL_B | ~+60$^0$ | Phase B - Branch 2 or Phase B - Branch 3 |
| I_COM_ANGL_C | ~+120$^0$ | Phase C - Branch 1 or Phase C - Branch 4 |
| I_COM_ANGL_C | ~–60$^0$ | Phase C - Branch 2 or Phase C - Branch 3 |

## Level detector 1

The phasewise-compensated unbalance currents `I_COM_AMPL_A`, `I_COM_AMPL_B` and `I_COM_AMPL_C` are compared to the set *Start value*. If the compensated unbalance current in one or more phases exceeds the set *Start value*, the Level detector 1 module sends the enabling signal to the Timer 1 module.

## Timer 1

Once activated, the Timer 1 module activates the `START` output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the

DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C* and *Curve parameter E*.

In a drop-off situation, that is, when a fault suddenly disappears before the operation delay is exceeded, the Timer 1 reset state is activated. The functionality of Timer 1 in the reset state depends on the combination of the *Operating curve type* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, an immediate reset occurs. The START output is deactivated when the reset timer has elapsed.

The setting *Time multiplier* is used for scaling the IDMT operation times.

The setting parameter *Minimum operate time* defines the minimum desired operation time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting.

Timer 1 calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

### Level detector 2

The phasewise-compensated unbalance currents I_COM_AMPL_A, I_COM_AMPL_B and I_COM_AMPL_C are compared to the set *Alarm start value*. If the compensated unbalance current in one or more phases exceeds the set *Alarm start value*, the Level detector 2 module sends the enabling signal to the Timer 2 module.

### Timer 2

Once activated, the timer activates the alarm timer. The timer characteristic is according to DT. When the alarm timer has reached the value set by *Alarm delay time*, the ALARM output is activated.

If the fault disappears before the alarm activates, the alarm timer is reset immediately.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, HCUBPTOC operates normally but the OPERATE output is not activated.

### 4.12.3.6 Application

Shunt capacitor banks (SCBs) are widely used in transmission and distribution networks to produce reactive power support. Located in relevant places such as in the vicinity of load centers, SCBs have beneficial effects on power system performance: increased power factor, reduced losses, improved system capacity and better voltage level at load points.

The capacitor bank terminology ‘Bank’, ‘Unit’ and ‘Element’ is shown in Figure 560.

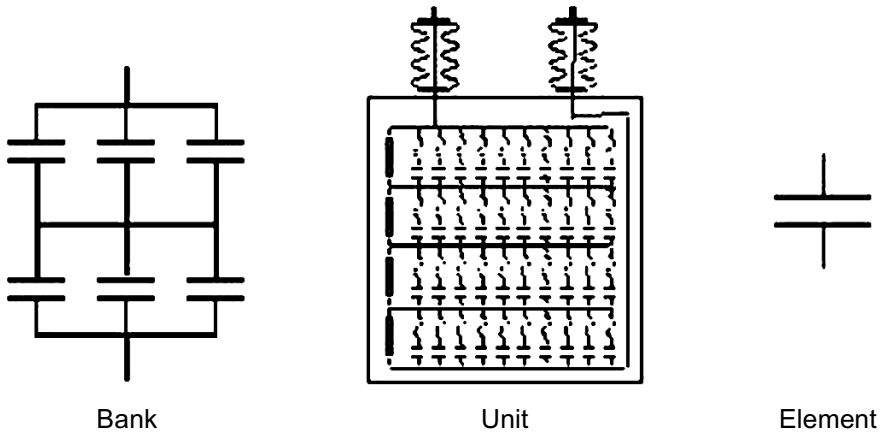



*Figure 560: Bank, unit and element of a capacitor bank*

HCUBPTOC is designed for the protection against internal faults in H-bridge-connected capacitor banks. This unbalance protection detects an asymmetry in the capacitor bank, caused by blown fuses or short-circuits across bushings, or between capacitor units and the racks in which they are mounted.

Normally, the capacitor units are designed to withstand 110% of the nominal voltage continuously. When an element inside a capacitor bank fails, the remaining healthy elements experience an increase in voltage across them. If the voltage exceeds 110% of the nominal voltage, it can lead to a failure of the healthy elements of the bank and in turn fail the entire capacitor bank. Since the capacitor unbalance current is directly proportional to element failures, unbalance protection is an effective way of detecting capacitor element failures. The current unbalance protection function is usually used along with the three-phase capacitor bank overload protection function to increase the sensitivity of protection for capacitor banks.

Due to the two-stage (operation and alarm stage) unbalance protection and the natural unbalance compensation facility, the protection of capacitor banks with internal fuses can be implemented with a very high degree of sensitivity.

The unbalance protection function can be used for internally fused, externally fused and fuseless shunt capacitor banks. Since a fuseless capacitor bank lacks the individual capacitor unit fuses, current unbalance protection becomes even more critical for fuseless applications.

When an individual element fails, it creates current unbalance. With an increasing number of element failures, the unbalance current increases and HCUBPTOC gives an alarm. The alarm level is normally set to 50% of the maximum permitted level. The capacitor bank then should be taken out of service to replace the faulty units. If not, the capacitor bank is tripped when the maximum allowed unbalance current level is exceeded.

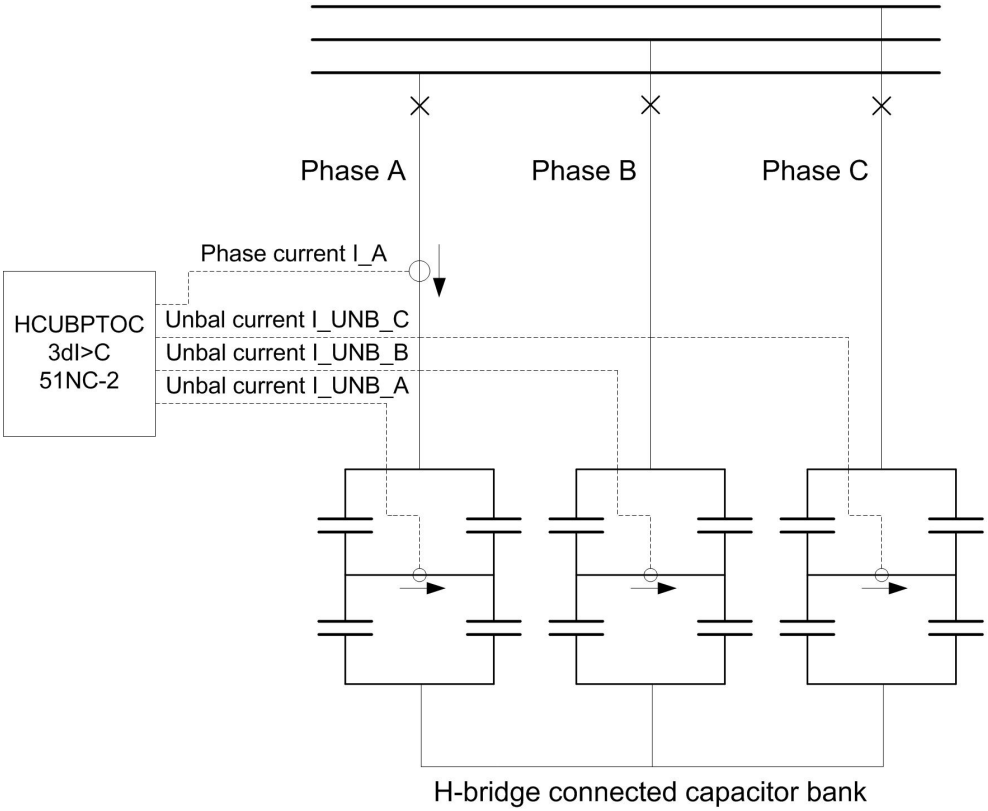



*Figure 561: Application example of capacitor bank unbalance protection*

The phase current analog input I_A and at least one unbalance current must be connected to the protection relay for the HCUBPTOC function to start working.

### Steps to measure natural unbalance current

1. The setting *Natural Comp Enable* must be set to “TRUE”.
2. The capacitor bank must be energized.
3. The capacitor bank compensated unbalance current `I_COM_AMPL` is observed from Monitored data.
4. The command *Record unbalance* must be activated by selecting the value “Record” which stores the unbalance reference for future unbalance calculations.
5. The compensated unbalance current (`I_COM_AMPL`) is re-checked to be approximately zero.

The natural unbalance recording should be made only during the steady-state condition and when all the capacitor bank elements are assumed to be in service.

## 4.12.3.7 Signals

*Table 976: HCUBPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 977: HCUBPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Alarm |

## 4.12.3.8 Settings

*Table 978: HCUBPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...1.00 | xIn | 0.01 | 0.10 | Start value |
| Alarm start value | 0.01...1.00 | xIn | 0.01 | 0.05 | Alarm start value |
| Time multiplier | 0.05...15.00 | | 0.01 | 1.00 | Time multiplier in IEC/ANSI IDMT curves |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 40...200000 | ms | 10 | 5000 | Operate delay time |
| Alarm delay time | 40...200000 | ms | 10 | 200000 | Alarm delay time |

*Table 979: HCUBPTOC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Natural Comp Ena PhA | 0=False<br>1=True | | | 0=False | Enable natural unbalance compensation PhA |
| Natural Comp Ena PhB | 0=False<br>1=True | | | 0=False | Enable natural unbalance compensation PhB |
| Natural Comp Ena PhC | 0=False<br>1=True | | | 0=False | Enable natural unbalance compensation PhC |

*Table 980: HCUBPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.00860...120.00000 | | 1 | 28.20000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.00000...0.71200 | | 1 | 0.12170 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 1 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 1 | 1.0 | Parameter E for customer programmable curve |

*Table 981: HCUBPTOC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |

## 4.12.3.9 Monitored data

*Table 982: HCUBPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| I_NAT_AMPL_A | FLOAT32 | 0.00...5.00 | xIn | Recorded natural unbalance current amplitude phase A |
| I_NAT_ANGL_A | FLOAT32 | -179.00...179.00 | deg | Recorded natural unbalance current angle phase A |
| I_NAT_AMPL_B | FLOAT32 | 0.00...5.00 | xIn | Recorded natural unbalance current amplitude phase B |
| I_NAT_ANGL_B | FLOAT32 | -179.00...179.00 | deg | Recorded natural unbalance current angle phase B |
| I_NAT_AMPL_C | FLOAT32 | 0.00...5.00 | xIn | Recorded natural unbalance current amplitude phase C |
| I_NAT_ANGL_C | FLOAT32 | -179.00...179.00 | deg | Recorded natural unbalance current angle phase C |
| I_COM_AMPL_A | FLOAT32 | 0.00...5.00 | xIn | Compensated unbalance current amplitude phase A |
| I_COM_ANGL_A | FLOAT32 | -179.00...179.00 | deg | Compensated unbalance current angle phase A |
| I_COM_AMPL_B | FLOAT32 | 0.00...5.00 | xIn | Compensated unbalance current amplitude phase B |
| I_COM_ANGL_B | FLOAT32 | -179.00...179.00 | deg | Compensated unbalance current angle phase B |
| I_COM_AMPL_C | FLOAT32 | 0.00...5.00 | xIn | Compensated unbalance current amplitude phase C |
| I_COM_ANGL_C | FLOAT32 | -179.00...179.00 | deg | Compensated unbalance current angle phase C |
| HCUBPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| IL1-unb:1 | FLOAT32 | 0.00...5.00 | xIn | Measured unbalance current amplitude phase A |
| IL2-unb:1 | FLOAT32 | 0.00...5.00 | xIn | Measured unbalance current amplitude phase B |
| IL3-unb:1 | FLOAT32 | 0.00...5.00 | xIn | Measured unbalance current amplitude phase C |

### 4.12.3.10 Technical data

*Table 983: HCUBPTOC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | 1.5% of the set value or 0.002 × $I_n$ |
| Start time[1)2)] | Typically 26 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | 1% of the theoretical value or ±20 ms |
| Operate time accuracy in IDMT mode | 5% of the theoretical value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2,3,4,5,.. |

1) Fundamental frequency current = 1.0 × $I_n$, current before fault = 0.0 × $I_n$, fault current = 2.0 × *Start value*, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

## 4.12.4 Shunt capacitor bank switching resonance protection, current based SRCPTOC

### 4.12.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Shunt capacitor bank switching resonance protection, current based | SRCPTOC | TD> | 55ITHD |

### 4.12.4.2 Function block




*Figure 562: Function block symbol*

### 4.12.4.3 Functionality

The shunt capacitor bank switching resonance protection, current based, function SRCPTOC is used for detecting three-phase resonance caused by capacitor switching or topology changes in the network. The operating characteristic is a definite time (DT).

SRCPTOC contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.12.4.4 Analog input configuration

SRCPTOC has one analog group input which must be properly configured.

*Table 984: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.12.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”.

The operation of SRCPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

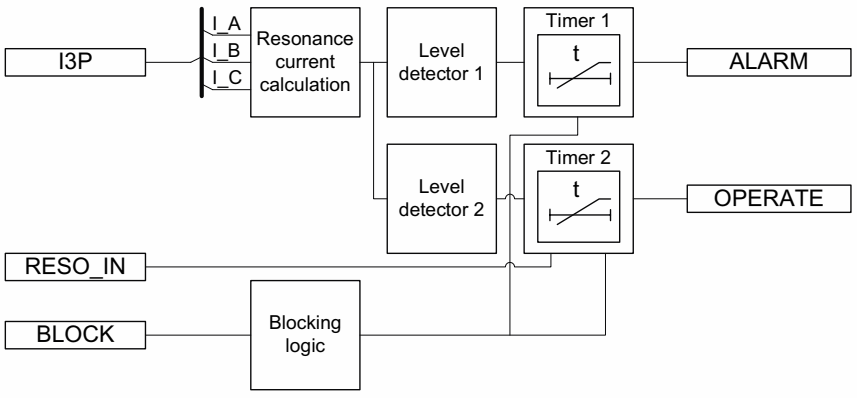



*Figure 563: Functional module diagram*

#### Resonance current calculation

This module calculates the resonance current per phase set as per setting *Tuning harmonic Num*. The resonance current for phase A is calculated with the equation.

$$I_RESO_A = \sqrt{I^2_{RMS_A} - I^2_{1_A} - I^2_{DC_A} - I^2_{K_A}}$$

(Equation 244)

| | |
|---|---|
| $I_{RMS_A}$ | RMS value of current in phase A (contains up to 11$^{th}$ harmonic) |
| $I_{DC_A}$ | DC-component in phase A current |
| $I_{1_A}$ | Fundamental component in phase A current |
| $I_{K_A}$ | K$^{th}$ harmonic component in phase A current, K is defined by setting *Tuning harmonic Num* |
| I_RESO_A | Calculated resonance current for phase A |

The resonance current is calculated through the filter implementation. The DC and fundamental components are removed by passing the total RMS current through the High pass filter. The K$^{th}$ harmonic component is removed by passing the High pass filter output through the K$^{th}$ harmonic Band stop filter. The magnitude response of the High pass filter and all the harmonic Band stop filters are shown in Figure 564.

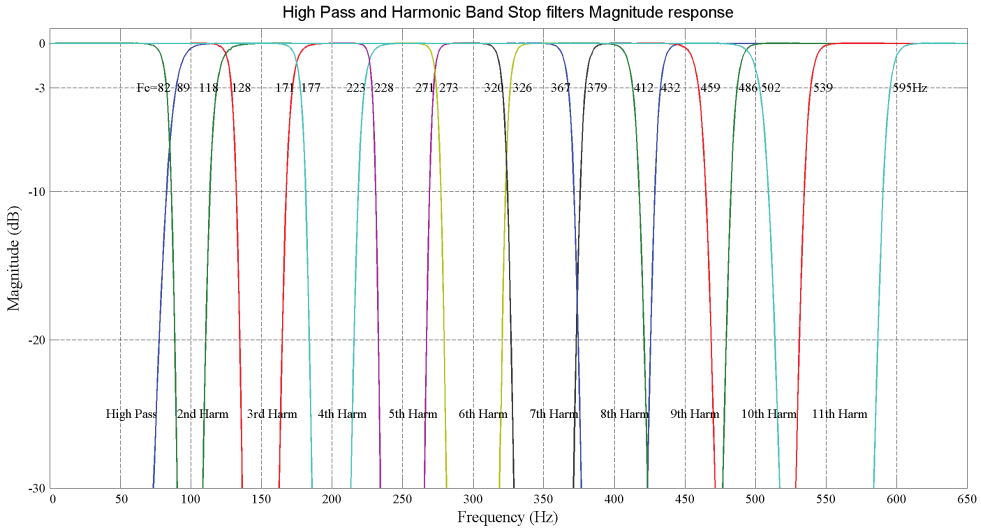



*Figure 564: Magnitude response of High pass and all the harmonic Band stop filters*

Similarly resonance current is calculated in the same way for phase B and phase C. Resonance currents I_RESO_A, I_RESO_B and I_RESO_C are available in the monitored data view.

The maximum of the three calculated resonance currents is further considered for calculation.

$$I_RESONANCE = Max(I_RESO_A, I_RESO_B, I_RESO_C)$$

(Equation 245)

If a capacitor bank is used only for reactive power compensation and there is no series reactor in a filter branch, the resonance protection is very important. In this case, the setting *Tuning harmonic Num* should be set to 1 because the capacitor branch is not tuned for a special frequency as in tuned filter applications. Even though *Tuning harmonic Num* is set to 1, the fundamental component is subtracted only once from $I_{RMS}$.

### Level detector 1

The maximum calculated resonance current is compared to the set *Alarm start value*. If the calculated I_RESONANCE exceeds the set *Alarm start value*, the module sends the enabling signal to the Timer 1 module.

### Level detector 2

The maximum calculated resonance current is compared to the set *Start value*. If the calculated I_RESONANCE exceeds the set *Start value*, this module sends the enabling signal to the Timer 2 module.

### Timer 1

Once activated, the timer activates the alarm timer. The timer characteristic is according to DT. When the alarm timer has reached the value set by *Alarm delay time*, the ALARM output is activated.

If the fault disappears before the alarm activates, the alarm timer is reset immediately.

### Timer 2

Once activated, the timer activates the operation timer. The timer characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated.

If the fault disappears before the operate activates, the operation timer is reset immediately.

If the input RESO_IN becomes active, the OPERATE output is activated immediately. If the resonance protection at a higher-order filter branch has already operated, the function in lower-order filter branches can be tripped immediately using this feature.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, SRCPTOC operates normally but the OPERATE output is not activated.

### 4.12.4.6 Application

Switched shunt capacitor banks are widely used by utilities and customers in industrial distribution systems to provide voltage support and to improve the power factor of a load. Capacitor steps may be switched in and out of circuits routinely as the demand for capacitive VAR compensation of a load fluctuates. Normally, automatic power factor controllers are employed which automatically switch on or off the capacitors of the capacitor bank, depending upon the prevalent reactive power requirement in the system.

One potential problem for the application of automatic power factor controllers is that it may cause harmonic resonance under certain system conditions. Capacitor switching changes the parameters of the system, which may cause the resonance frequency of the circuit to be equal to one of the frequencies of the harmonic sources prevalent in the system. Harmonic resonance, when it occurs, may result in severe voltage and current distortions, which increases losses and causes overheating of other equipment in the circuit.

A traditional way of solving the problem is to conduct a detailed system study for each individual installation and use the results to properly size the capacitors and determine the right operating range of capacitors to avoid harmonic resonance with other system components. However, this method is not economical but more time-consuming.

The capacitor switching-resonance protection function can be used as a solution to the above mentioned problem. The basis for the harmonic resonance protection is the detection of a current harmonic resonance condition caused by capacitor switching. A prolonged increase of the harmonic distortion level after a switching operation is a clear indication of such condition. When a resonant condition caused by capacitor switching occurs in a circuit, SRCPTOC detunes the circuit by taking the reverse action, that is, switching the capacitor bank off if switching it on causes resonance. If the resonance situation has been detected and SRCPTOC has switched off a capacitor bank, power factor controller should not try to switch on the capacitor bank until the switching resonance function reset.

The capacitor switching-resonance protection function can also be used to protect harmonic filters. In harmonic filter bank applications, the SRCPTOC function can be tuned to harmonic frequency for which the harmonic filter is designed to ensure that the function does not include thr tuned harmonic frequency current into the calculation of the resonance current. If there is more than one harmonic filter bank involved, each SRCPTOC tunes to the harmonic frequency of its corresponding filter bank. The interlinking between the functions can be done in such a way that if resonance occurs in a higher harmonic frequency filter bank, all the lower harmonic frequency filter banks can be tripped immediately by activating the function input RESO_IN.

The settings *Alarm start value* and *Start value* determine the portion of the total harmonic current (excluding the harmonic defined by the setting *Tuning harmonic Num*) in relation to the CT nominal value required for SRCPTOC to give alarm and operate respectively.

For power factor correction application

- *Tuning harmonic Num* must be set to 1.
- *Alarm start value* and *Start value* must be set according to the standard IEEE519 -1992.

For harmonic filter application

- *Tuning harmonic Num* must be set to the filter design tuning frequency.
- *Alarm start value* and *Start value* must be set according to the standard IEEE519 -1992.

Settings *Alarm start value* and *Start value* should be selected as such that in normal operation SRCPTOC should not operate.

### 4.12.4.7 Signals

*Table 985: SRCPTOC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RESO_IN | BOOLEAN | 0=False | Input signal from higher frequency resonance branch |

*Table 986: SRCPTOC Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm |
| OPERATE | BOOLEAN | Operate signal |

### 4.12.4.8 Settings

*Table 987: SRCPTOC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Alarm start value | 0.03...0.50 | xIn | 0.01 | 0.03 | Alarm limit for filtered harmonic currents |
| Start value | 0.03...0.50 | xIn | 0.01 | 0.03 | Tripping limit for filtered harmonic currents indicating resonance condition |
| Tuning harmonic Num | 1...11 | | 1 | 11 | Tuning frequency harmonic number of the filter branch |
| Operate delay time | 120...360000 | ms | 1 | 200 | Operate delay time for resonance |
| Alarm delay time | 120...360000 | ms | 1 | 200 | Alarm delay time for resonance alarm |

*Table 988: SRCPTOC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

### 4.12.4.9 Monitored data

*Table 989: SRCPTOC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_RESO_A | FLOAT32 | 0.00...40.00 | xIn | Resonance current for phase A |
| I_RESO_B | FLOAT32 | 0.00...40.00 | xIn | Resonance current for phase B |
| I_RESO_C | FLOAT32 | 0.00...40.00 | xIn | Resonance current for phase C |
| SRCPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.12.4.10 Technical data

*Table 990: SRCPTOC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: fn ±2 Hz |
| | Operate value accuracy:<br>±3% of the set value or ±0.002 × $I_n$ (for 2nd order Harmonics)<br>±1.5% of the set value or ±0.002 × $I_n$ (for 3rd order < Harmonics < 10th order)<br>±6% of the set value or ±0.004 × $I_n$ (for Harmonics >= 10th order) |
| Reset time | Typically 45 ms or maximum 50 ms |
| Retardation time | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = $f_n$ |

## 4.12.5 Compensated neutral unbalance voltage protection CNUPTOV

### 4.12.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Compensated neutral unbalance voltage protection | CNUPTOV | CNU> | 59NU |

### 4.12.5.2 Function block




*Figure 565: Function block*

### 4.12.5.3 Functionality

The compensated neutral unbalance voltage protection function CNUPTOV detects overvoltage at the neutral point of the shunt capacitor. A blown fuse or a short-circuited capacitor element results in unbalance in the shunt capacitor bank causing increase in neutral point voltage. With CNUPTOV, an inherent capacitor bank

unbalance which results in non-zero neutral point voltage can be compensated automatically on a continuous basis.

The function starts when the fundamental (DFT) component of the compensated neutral unbalance voltage exceeds the set limit. CNUPTOV operates with the definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.12.5.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of CNUPTOV can be described with a module diagram. All the modules in the diagram are explained in the next sections.

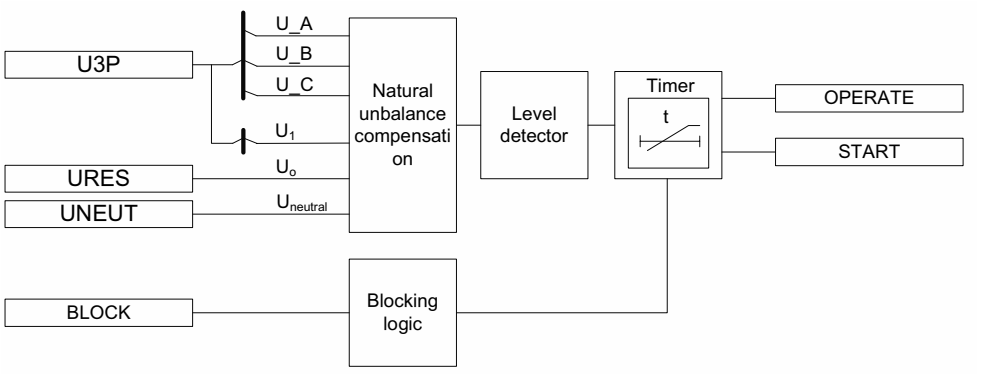



*Figure 566: Functional module diagram*

#### Natural unbalance compensation

This module calculates the natural unbalance compensation. Calculation for compensation is initiated through the command Record unbalance, available under the menu path **Control/CNUPTOV**. The function equates the operating signal to zero and calculates $\overline{U_{unb}}$ from the available known quantities. $\overline{U_{unb}}$ is memorized as $\overline{U_{unb}}(m)$. This memorized value is then used when calculating the operating quantity. For more information, see the Operating quantity section in this manual.

If the positive-sequence voltage is available at the time of memorizing the $\overline{U_{unb}}(m)$ value, the positive-sequence voltage is also memorized as $\overline{U_1}(m)$. The function then applies the revised compensation voltage to account for change in bus voltages between the moment of memorizing the compensation voltage and the time of applying it.

$$\overline{U_{unb}} = \overline{U_{unb}}(m) \cdot \frac{\overline{U_1}}{\overline{U_1}(m)}$$

(Equation 246)

### Level detector

The operating signal is compared to the set *Start value*. If the operating signal exceeds the set *Start value*, Level detector sends an enabling signal to the Timer module.

### Timer

Once activated, Timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated if the operating signal persists. If a drop-off situation happens, that is, the fault disappears before the operate delay is exceeded, the timer reset state is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, the function operates normally but the OPERATE output is not activated.

## 4.12.5.5 Operating quantity

### Operating quantity in ungrounded SCB

Consider a case of a standard ungrounded shunt capacitor bank as shown in Figure 567.

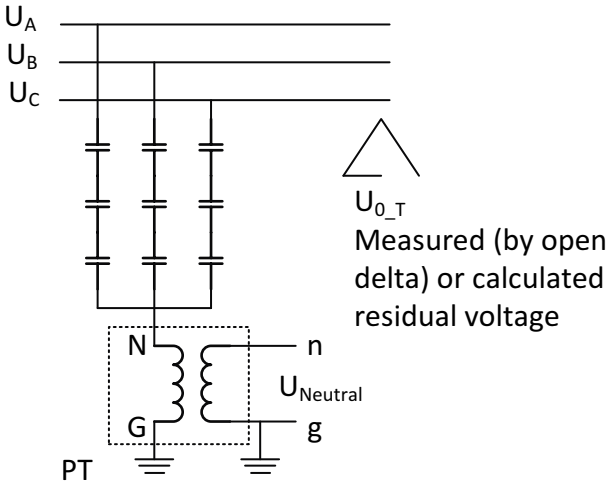



*Figure 567: Ungrounded SCB*

The operating signal for the compensated neutral voltage unbalance in per unit with reference to the neutral side of an ungrounded SCB is as indicated in Equation 247.

$$Operating\ signal = \left| \frac{\overline{U}_{Neutral}}{U_{N_sr}} - \frac{n_{Uo}}{U_{N_pr}} \cdot \overline{U}_{o} - \overline{U}_{unb} \right|$$

(Equation 247)

$\overline{U}_{Neutral}$ Measured shunt capacitor neutral voltage

$\overline{U}_{o}$ Measured open delta voltage

$\overline{U}_{unb}$ Natural unbalance compensation component

$n_{Uo}$ Voltage ratio of open delta VT

$U_{N_sr}$ Rated secondary voltage of neutral connected VT

$U_{N_pr}$ Rated primary voltage of neutral connected VT

The rated *Primary voltage* and *Secondary voltage* for the neutral voltage channel $U_{Neutral}$, and for $U_{N_pr}$ and $U_{N_sr}$ are set in the global setting under **Configuration/ Analog inputs/Voltage (Uo,VT)**.

The operating signal setting is given as multiple of the neutral VT rated voltage.

## 4.12.5.6 Application

Shunt capacitor banks are provided with an unbalance protection function which is mainly used to detect problems within capacitor units using the presumed symmetry

in the impedances of the protected bank. The unbalance protection responds to unbalances in the measured signals caused by changes in the impedance of the capacitor bank.

In compensating unbalance protection, the operating signal compensates both the inherent capacitor bank unbalance and the system unbalance. The method involves measuring the residual voltage at the capacitor terminal side and at the neutral side. The terminal side's residual voltage component is obtained directly by VTs connected in open delta or by deriving open delta voltage using all three terminal side phase voltages. The neutral side's residual voltage is measured directly by connecting a VT between the neutral point and earth. It is advisable to block the function with the fuse failure function.

### Example 1, ungrounded SCB

Figure 568 illustrates how much the neutral voltage changes in case of failure of some phase elements of the ungrounded SCB.

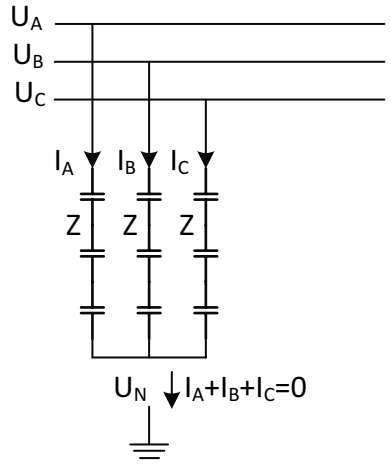



*Figure 568: Ungrounded SCB*

In a healthy ungrounded capacitor bank, the sum of the phase currents is

$$\bar{I}_A + \bar{I}_B + \bar{I}_C = 0$$

(Equation 248)

If the capacitor bank is symmetrical, that is, there is equal impedance in each phase, the equation can be

$$\left(\frac{\bar{U}_A - \bar{U}_N}{Z}\right) + \left(\frac{\bar{U}_B - \bar{U}_N}{Z}\right) + \left(\frac{\bar{U}_C - \bar{U}_N}{Z}\right) = 0$$

(Equation 249)

If the fault in the capacitor bank changes the phase A impedance to kZ

$$\left(\frac{\bar{U}_A - \bar{U}_N}{kZ}\right) + \left(\frac{\bar{U}_B - \bar{U}_N}{Z}\right) + \left(\frac{\bar{U}_C - \bar{U}_N}{Z}\right) = 0$$

(Equation 250)

$$\frac{\overline{U}_A}{kZ} + \frac{\overline{U}_B}{Z} + \frac{\overline{U}_C}{Z} = \overline{U}_N \cdot \left( \frac{1}{kZ} + \frac{2}{Z} \right)$$

(Equation 251)

$$\overline{U}_A + k \cdot \left( \overline{U}_B + \overline{U}_C \right) = \overline{U}_N \cdot \left( 1 + 2 \cdot k \right)$$

(Equation 252)

If the system is symmetrical, that is, the system is healthy without any fault

$$\overline{U}_A + \overline{U}_B + \overline{U}_C = 0$$

(Equation 253)

Combining Equation 252 and Equation 253 results in

$$\overline{U}_A + k \cdot \left( -\overline{U}_A \right) = \overline{U}_N \cdot \left( 1 + 2 \cdot k \right)$$

(Equation 254)

$$\overline{U}_N = \overline{U}_A \cdot \frac{\left( 1 - k \right)}{\left( 1 + 2 \cdot k \right)}$$

(Equation 255)

Considering the neutral VT ratio, per unit voltage referred to the neutral side is given by

$$\overline{U}_N = \frac{\overline{U}_A \cdot \frac{\left( 1 - k \right)}{\left( 1 + 2 \cdot k \right)}}{U_{N_pr}}$$

(Equation 256)

For example, if the impedance of the 20 kV system ($U_A$ = 11.547 kV) capacitance drops by 5 percent, that is, k = 0.95, the neutral voltage is around 200 V according to Equation 255. If the voltage rating of a neutral VT is 20 kV/100 V, then in per unit terms refer to neutral side, the neutral voltage is around 0.01 · Un, that is, *Start value* should be set around 0.01.

In addition, assume that residual voltage (terminal side) is measured directly using an open-delta VT having ratio of $\frac{20kV}{\sqrt{3}} / \frac{100V}{\sqrt{3}} / \frac{100V}{3}$. Also, the *Primary voltage* and *Secondary voltage* settings under **Configuration/Analog inputs/Voltage (UoB,VT)** in a grounded system are set as 11.547 kV and 100 V, respectively. Similarly, if the VT connected at the neutral point has a ratio of $\frac{20kV}{\sqrt{3}} / \frac{100V}{\sqrt{3}}$, the *Primary voltage* and *Secondary voltage* settings under **Configuration/Analog inputs/Voltage (Uo,VT)** must be set as 20 kV and 100 V, respectively.

### 4.12.5.7 Signals

*Table 991: CNUPTOV Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| UNEUT | SIGNAL | - | Analog input |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 992: CNUPTOV Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.12.5.8 Settings

*Table 993: CNUPTOV Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...1.00 | xUn | 0.01 | 0.01 | Start value |
| Operate delay time | 100...300000 | ms | 100 | 100 | Operate delay time |

*Table 994: CNUPTOV Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 995: CNUPTOV Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.12.5.9 Monitored data

*Table 996: CNUPTOV Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| U_AMPL_RES | FLOAT32 | 0.00...5.00 | xUn | Magnitude of capacitor terminal open delta voltage (either calculated or derived) |
| U_ANGL_RES | FLOAT32 | -180.00...180.00 | deg | Angle of capacitor terminal open delta voltage (either calculated or derived) |
| U_AMPL_N | FLOAT32 | 0.00...5.00 | xUn | Magnitude of capacitor neutral zero sequence voltage |
| U_ANGL_N | FLOAT32 | -180.00...180.00 | deg | Angle of capacitor neutral zero sequence voltage |
| U_UNB_AMPL | FLOAT32 | 0.00...5.00 | xUn | Magnitude of recorded natural unbalance compensation component voltage |
| U_UNB_ANGL | FLOAT32 | -180.00...180.00 | deg | Angle of recorded natural unbalance compensation component voltage |
| U_OPR | FLOAT32 | 0.00...5.00 | xUn | Calculated operating voltage |
| CNUPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.12.5.10 Technical data

*Table 997: CNUPTOV Technical data*

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz |
| | | ±1.5% of the set value or ±0.002 × $U_n$ |
| Start time[1)2)] | $U_{Fault}$ = 1.1 × set *Start value* | Typically 75 ms |
| Reset time | | Typically 40 ms |
| Reset ratio | | Typically 0.96 |

Table continues on next page

| Characteristic | Value |
|---|---|
| Retardation time | <35 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

1) *Start value* = 0.1 × $U_n$, Voltage before fault = 0.9 × $U_n$, $f_n$ = 50 Hz, overvoltage in one phase-to-earth with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Measured with static signal output (SSO)

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# Section 5 Protection related functions

## 5.1 Three-phase inrush detector INRPHAR

### 5.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase inrush detector | INRPHAR | 3I2f> | 68HB |

### 5.1.2 Function block

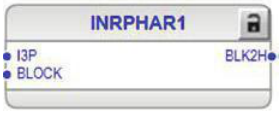



*Figure 569: Function block*

### 5.1.3 Functionality

The three-phase inrush detector function INRPHAR is used to detect transformer inrush situations in distribution networks.

Transformer inrush detection is based on the following principle: the output signal BLK2H is activated once the numerically derived ratio of second harmonic current I_2H and the fundamental frequency current I_1H exceeds the set value.

The operate time characteristic for the function is of definite time (DT) type.

The function contains a blocking functionality. Blocking deactivates all outputs and resets timers.

### 5.1.4 Analog channel configuration

INRPHAR has one analog group input which must be properly configured.

*Table 998: Analog signals*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of INRPHAR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

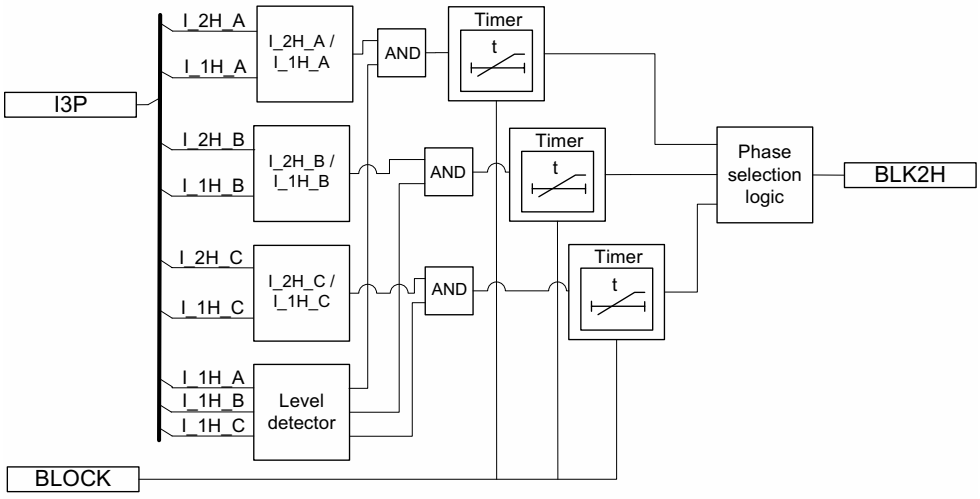



*Figure 570: Functional module diagram*

### I_2H/I_1H

These modules calculate the ratio of the second harmonic (I_2H) and fundamental frequency (I_1H) of the phase currents. The calculated value is compared to the set *Start value*. If the calculated value exceeds the set *Start value*, the module output is activated.

### Level detector

The output of the phase-specific level detector is activated when the fundamental frequency current I_1H exceeds the set *Min operate current* of the nominal current.

### Timer

Once activated, Timer runs until the set *Operate delay time* value is exceeded. The time characteristics is according to DT. When the operation timer has reached the *Operate delay time* value, the Timer module output is activated. If the timer has elapsed and the inrush situation still exists, the Timer module output remains active until the I_2H/I_1H ratio drops below the set *Start value*, that is, until the inrush situation is over. If the drop-off situation occurs within the operate time up counting, the reset timer is activated. If the drop-off time exceeds *Reset delay time*, the operate timer is reset.

The BLOCK input can be controlled with a binary input, a horizontal communication input or an internal signal of the relay program. The activation of the BLOCK input prevents the BLK2H output from being activated.

### Phase selection logic

This module determines the number of phases used for activating the BLK2H output. If *Num of start phases* = "1 out of 3", an inrush on any of the phases activates output BLK2H. If the set value equals "2 out of 3", an inrush or at least two phases are required to activate output BLK2H.

## 5.1.6 Application

Transformer protections require high stability to avoid tripping during magnetizing inrush conditions. A typical example of an inrush detector application is doubling the start value of an overcurrent protection during inrush detection.

The inrush detection function can be used to selectively block overcurrent and earth-fault function stages when the ratio of the second harmonic component to the fundamental component exceeds the set value.

Other applications of this function include the detection of inrush in lines connected to a transformer.

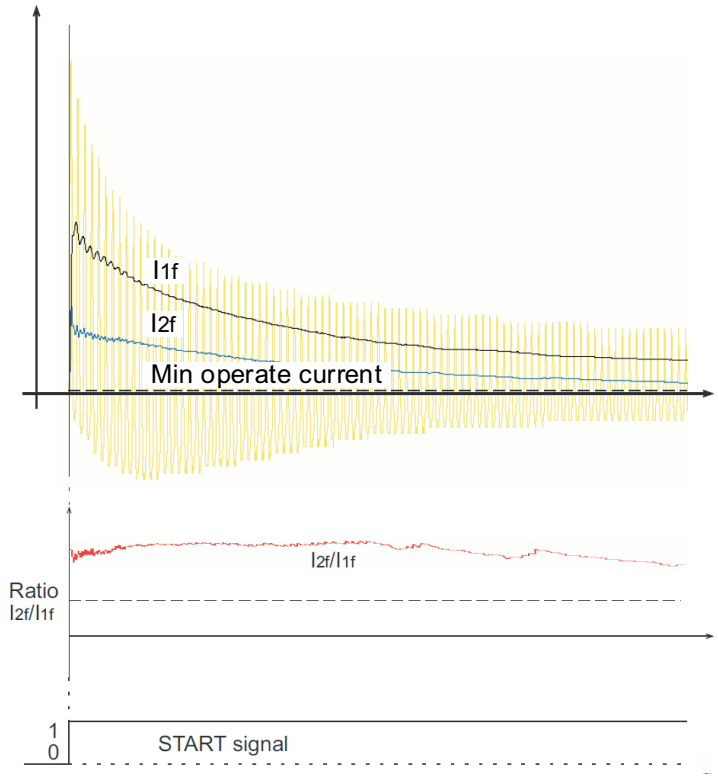



*Figure 571: Inrush current in transformer*

It is recommended to use the second harmonic and the waveform-based inrush blocking from the transformer differential protection function TR2PTDF if available.

## 5.1.7 Signals

*Table 999: INRPHAR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block input status |

*Table 1000: INRPHAR Output signals*

| Name | Type | Description |
|---|---|---|
| BLK2H | BOOLEAN | Second harmonic based block |

## 5.1.8 Settings

*Table 1001: INRPHAR Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 5...100 | % | 1 | 20 | Ratio of the 2. to the 1. harmonic leading to restraint |
| Operate delay time | 20...60000 | ms | 1 | 20 | Operate delay time |

*Table 1002: INRPHAR Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min operate current | 5...500 | %In | 1 | 5 | Minimum fundamental component of phase current for activation |

*Table 1003: INRPHAR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 1004: INRPHAR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Num of start phases | 1=1 out of 3<br>2=2 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

## 5.1.9 Monitored data

*Table 1005: INRPHAR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| INRPHAR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 5.1.10 Technical data

*Table 1006: INRPHAR Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | Current measurement:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Ratio I2f/I1f measurement:<br>±5.0% of the set value |
| Reset time | +35 ms / -0 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy | +35 ms / -0 ms |

## 5.2 Circuit breaker failure protection CCBRBRF

### 5.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Circuit breaker failure protection | CCBRBRF | 3I>/Io>BF | 50BF |

### 5.2.2 Function block

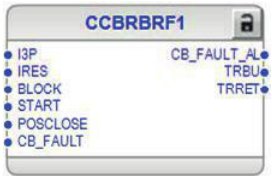



*Figure 572: Function block*

### 5.2.3 Functionality

The circuit breaker failure protection function CCBRBRF is activated by trip commands from the protection functions or through binary inputs. CCBRBRF includes a conditional or unconditional re-trip function, and also a conditional back-up trip function.

The operating values of the current measuring elements can be set within a predefined setting range. The function has two independent timers for trip purposes: a re-trip timer for the repeated tripping of its own breaker and a back-up timer for the trip logic operation for upstream breakers. A minimum trip pulse length can be set independently for the trip output.

The function contains a blocking functionality which can be used to block the function outputs.

## 5.2.4 Analog channel configuration

CCBRBRF has two analog group inputs which must be properly configured.

*Table 1007: Analog inputs*

| Input | Description |
|---|---|
| I3P[1)] | Three-phase currents<br>Necessary when *CB failure mode* is set other than "Breaker status" |
| IRES[1)] | Residual current (measured or calculated)<br>Necessary when *CB failure mode* is set other than "Breaker status" |

1) Can be connected to GRPOFF if *CB failure mode* is set to "Breaker status" and *CB fail retrip mode* is not set to "Current check"



See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of CCBRBRF can be described using a module diagram. All the modules in the diagram are explained in the next sections. Also further information on the retrip and backup trip logics is given in sub-module diagrams.

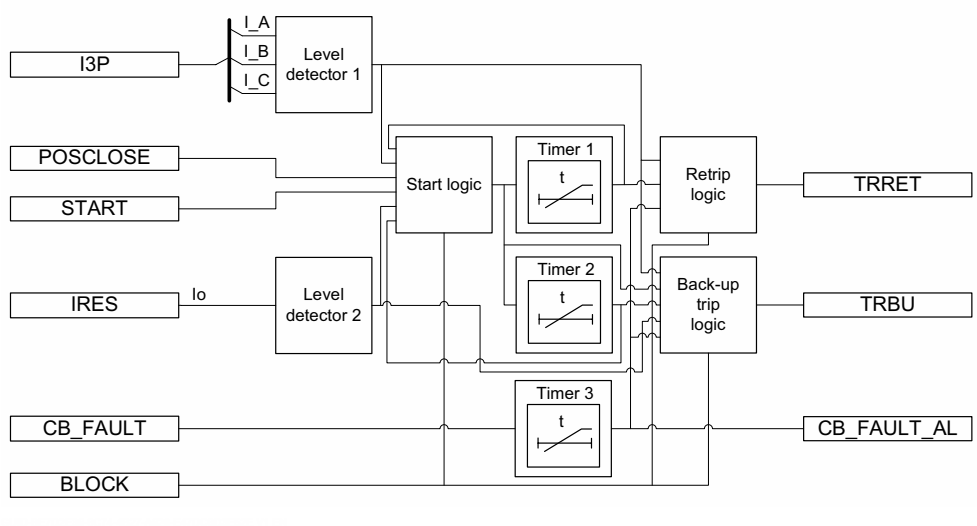



*Figure 573: Functional module diagram*

## Level detector 1

The measured phase currents are compared phasewise to the set *Current value*. If the measured value exceeds the set *Current value*, the level detector reports the exceeding of the value to the start, retrip and backup trip logics. The parameter should be set low enough so that breaker failure situations with small fault current or high load current can be detected. The setting can be chosen in accordance with the most sensitive protection function to start the breaker failure protection.

## Level detector 2

The measured residual current is compared to the set *Current value Res*. If the measured value exceeds the set *Current value Res*, the level detector reports the exceeding of the value to the start and backup trip logics. In high-impedance earthed systems, the residual current at phase-to-earth faults is normally much smaller than the short circuit currents. To detect a breaker failure at single-phase earth faults in these systems, it is necessary to measure the residual current separately. In effectively earthed systems, also the setting of the earth-fault current protection can be chosen at a relatively low current level. The current setting should be chosen in accordance with the setting of the sensitive earth-fault protection.

## Start logic

Start logic is used to manage the starting of Timer 1 and Timer 2. It also resets the function after the circuit breaker failure is handled. On the rising edge of the `START` input, the enabling signal is sent to Timer 1 and Timer 2. Typically, the `START` input is activated when any protection function operates and trips the circuit breaker.

The Start logic module is reset depending on the settings *CB failure mode* and *CB failure trip mode* as shown in Table 1008. In all cases in Table 1008, however, the resetting is possible only after 150 ms from the activation of Start logic. This time is for ensuring correct operation in case of oscillation in the starting signal.

*Table 1008: Start logic operation*

| Value of setting CB failure mode | Value of setting CB failure trip mode | Start logic reset condition |
|---|---|---|
| Current | 1 out of 3 | All phase currents drop below *Current value* setting. |
| | 1 out of 4 | All phase currents drop below *Current value* setting and the residual current drops below *Current value Res* setting. |
| | 2 out of 4 | Either of the following is true:<br>• All phase currents drop below *Current value* setting.<br>• The residual current drops below *Current value Res* setting and (at least) two phases are below *Current value* setting. |
| Breaker status | 1 out of 3<br>1 out of 4<br>2 out of 4 | CB is in open position. |
| Both(AND) | 1 out of 3 | Either of the following is true:<br>• CB is in open position.<br>• All phase currents drop below *Current value* setting. |
| | 1 out of 4 | Either of the following is true:<br>• CB is in open position.<br>• All phase currents drop below *Current value* setting and the residual current drops below *Current value Res* setting. |
| | 2 out of 4 | One of the following is true:<br>• CB is in open position.<br>• All phase currents drop below *Current value* setting.<br>• The residual current drops below *Current value Res* setting and (at least) two phases are below *Current value* setting. |
| Both(OR) | 1 out of 3 | CB is in open position and all phase currents drop below *Current value* setting. |
| | 1 out of 4 | CB is in open position and all phase currents drop below *Current value* setting and the residual current drops below *Current value Res* setting. |
| | 2 out of 4 | CB is in open position and either of the following is true:<br>• All phase currents drop below *Current value* setting.<br>• The residual current drops below *Current value Res* setting and (at least) two phases are below *Current value* setting. |

In addition, the function is immediately reset if:

- *Start latching mode* is set to "Level sensitive", and the START signal is deactivated. The recommended setting value is "Rising edge".
- The BLOCK input is activated.

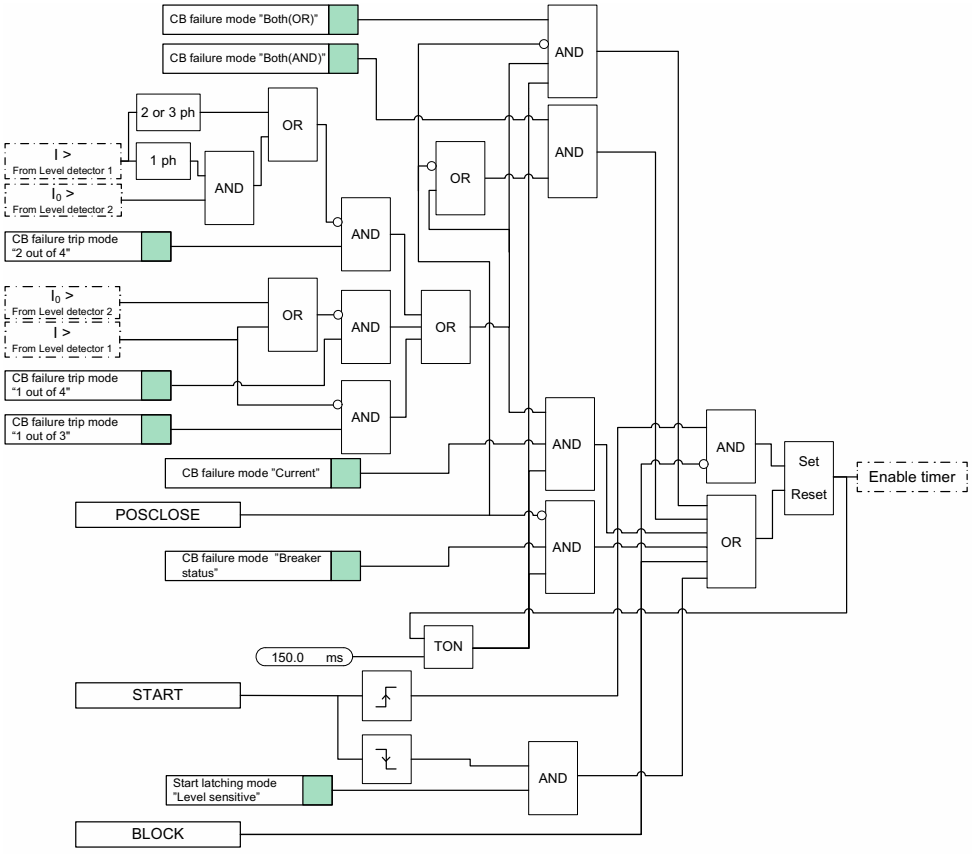



*Figure 574: Start logic*

## Timer 1

Once activated, the timer runs until the set *Retrip time* value has elapsed. The time characteristic is according to DT. When the operation timer has reached the value set with *Retrip time*, the retrip logic is activated. A typical setting is 0...50 ms.

## Timer 2

Once activated, the timer runs until the set *CB failure delay* value has elapsed. The time characteristic is according to DT. When the operation timer has reached the set maximum time value *CB failure delay*, the backup trip logic is activated. The value of this setting is made as low as possible at the same time as any unwanted operation is avoided. A typical setting is 90 - 150 ms, which is also dependent on the retrip timer.

The minimum time delay for the CB failure delay can be estimated as:

$$CBfailuredelay \geq Retriptime + t_{cbopen} + t_{BFP_reset} + t_{margin}$$

(Equation 257)

$t_{cbopen}$ Maximum opening time for the circuit breaker

$t_{BFP_reset}$ Maximum time for the breaker failure protection to detect the correct breaker function (the current criteria reset)

$t_{margin}$ Safety margin

It is often required that the total fault clearance time is less than the given critical time. This time often depends on the ability to maintain transient stability in case of a fault close to a power plant.

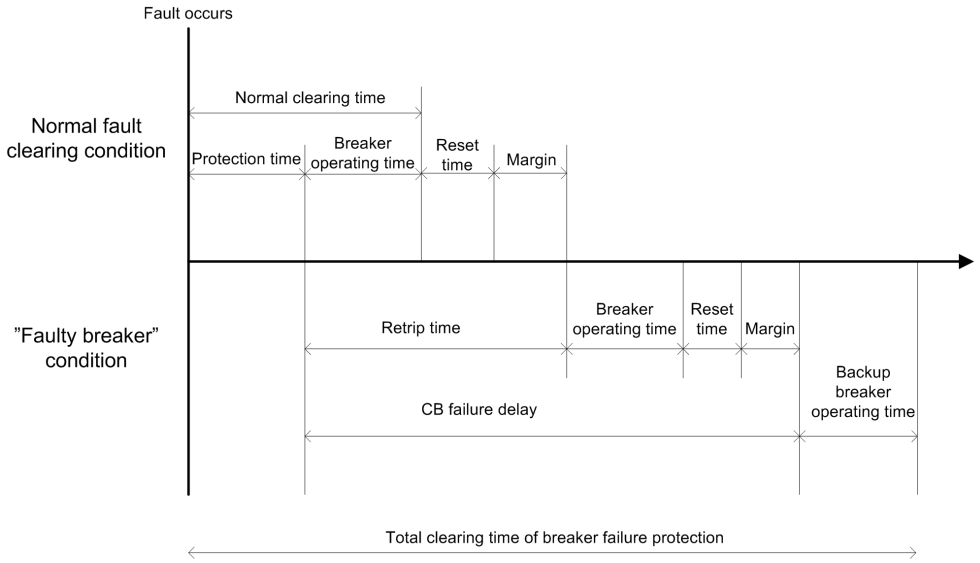



*Figure 575: Timeline of the breaker failure protection*

## Timer 3

This module is activated by the CB_FAULT signal. Once activated, the timer runs until the set *CB fault delay* value has elapsed. The time characteristic is according to DT. When the operation timer has reached the maximum time value *CB fault delay*, the CB_FAULT_AL output is activated. After the set time, an alarm is given so that the circuit breaker can be repaired. A typical value is 5 s.

## Retrip logic

Timer 1 activates Retrip logic, which can be used to give a retrip signal TRRET for the main circuit breaker. The operation of Retrip logic depends on the settings *CB failure mode* and *CB fail retrip mode* as shown in Table 1009.

*Table 1009: Retrip logic operation*

| Value of setting CB fail retrip mode | Value of setting CB failure mode | Retrip functionality |
|---|---|---|
| Off | Current<br>Breaker status<br>Both(AND)<br>Both(OR) | Retrip functionality switched off. TRRET is not activated. |
| Without Check | Current<br>Breaker status<br>Both(AND)<br>Both(OR) | TRRET is activated after Timer 1 elapses. |
| Current check | Current | TRRET is activated after Timer 1 elapses and any phase current exceeds *Current value* setting. |
| | Breaker status | TRRET is activated after Timer 1 elapses and CB is in closed position. |
| | Both(AND) | TRRET is activated after Timer 1 elapses and CB is in closed position and any phase current exceeds *Current value* setting. |
| | Both(OR) | TRRET is activated after Timer 1 elapses and either of the following is true:<br>• CB is in closed position.<br>• Any phase current exceeds *Current value* setting. |

TRRET activation is blocked if either CB_FAULT_AL output (from Timer 3) is active or the BLOCK input is activated.

Once activated, TRRET remains active for the set *Trip pulse time* or until the reasons for activation are reset. TRRET is also reset if CB_FAULT_AL or BLOCK is activated.

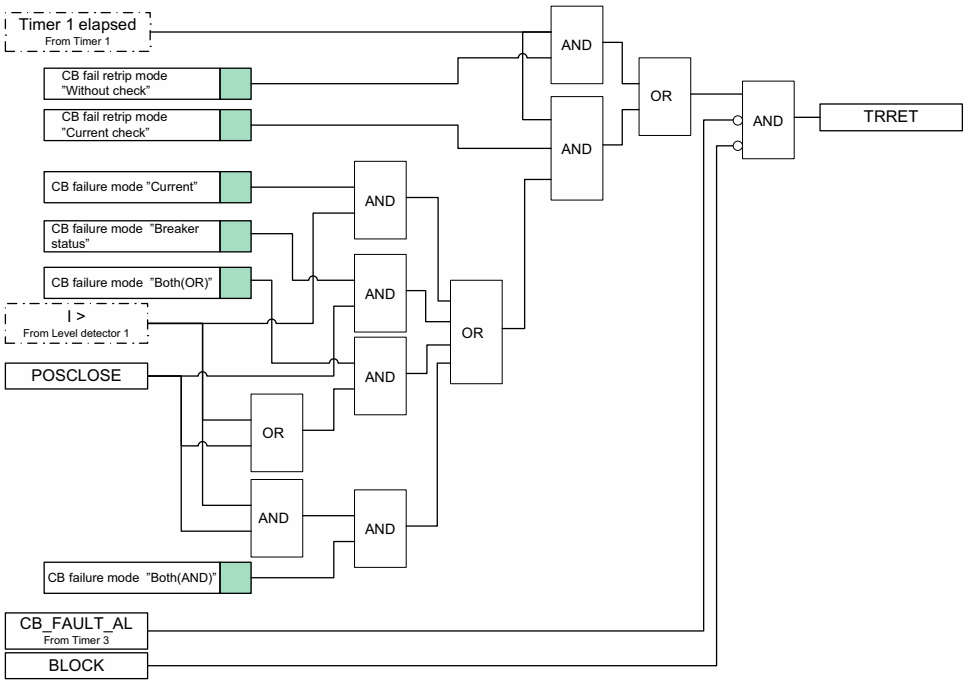



*Figure 576: Retrip logic*

## Backup trip logic

Timer 2 activates Backup trip logic, which gives a backup trip `TRBU` for the upstream circuit breaker if the main circuit breaker fails to clear the fault. Backup trip logic is also activated if the timer-enabling signal from the Start logic module (rising edge of the `START` input detected) and `CB_FAULT_AL` are both active.

The operation of Backup trip logic depends on the settings *CB failure mode* and *CB failure trip mode* as shown in Table 1010.

***Table 1010: Backup trip logic operation***

| Value of setting CB failure mode | Value of setting CB failure trip mode | Conditions for activating Backup trip logic |
|---|---|---|
| Current | 1 out of 3 | Any phase current exceeds *Current value* setting. |
| | 1 out of 4 | Either of the following is true:<br>• Any phase current exceeds *Current value* setting.<br>• The residual current exceeds *Current value Res* setting. |
| | 2 out of 4 | Either of the following is true:<br>• Any phase current exceeds *Current value* setting and the residual current exceeds *Current value Res* setting.<br>• Two or three phase currents exceed *Current value* setting. |
| Table continues on next page | | |

| Value of setting CB failure mode | Value of setting CB failure trip mode | Conditions for activating Backup trip logic |
|---|---|---|
| Breaker status | 1 out of 3<br>1 out of 4<br>2 out of 4 | CB is in closed position. |
| Both(AND) | 1 out of 3 | CB is in closed position and any phase current exceeds *Current value* setting. |
| | 1 out of 4 | CB is in closed position and either of the following is true:<br>• Any phase current exceeds *Current value* setting.<br>• The residual current exceeds *Current value Res* setting. |
| | 2 out of 4 | CB is in closed position and either of the following is true:<br>• Any phase current exceeds *Current value* setting and the residual current exceeds *Current value Res* setting.<br>• Two or three phase currents exceed *Current value* setting. |
| Both(OR) | 1 out of 3 | Either of the following is true:<br>• CB is in closed position.<br>• Any phase current exceeds *Current value* setting. |
| | 1 out of 4 | One of the following is true:<br>• CB is in closed position.<br>• Any phase current exceeds *Current value* setting.<br>• The residual current exceeds *Current value Res* setting. |
| | 2 out of 4 | One of the following is true:<br>• CB is in closed position.<br>• Any phase current exceeds *Current value* setting and the residual current exceeds *Current value Res* setting.<br>• Two or three phase currents exceed *Current value* setting. |

Once activated, TRBU remains active until the set *Trip pulse time* or until the reasons for activation are reset. TRRET is also reset if BLOCK is activated.

In most applications, "1 out of 3" is sufficient.

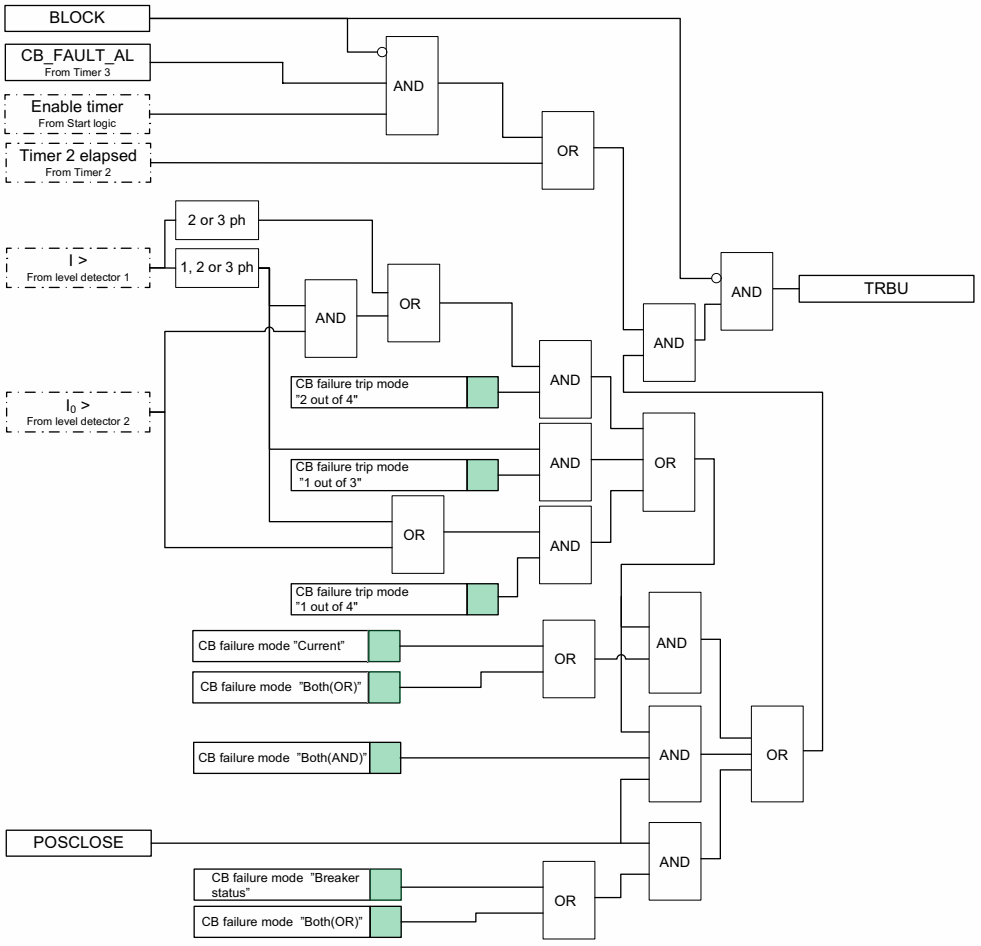



*Figure 577: Backup trip logic*

## 5.2.6 Application

The n-1 criterion is often used in the design of a fault clearance system. This means that the fault is cleared even if some component in the fault clearance system is faulty. A circuit breaker is a necessary component in the fault clearance system. For practical and economical reasons, it is not feasible to duplicate the circuit breaker for the protected component, but breaker failure protection is used instead.

The breaker failure function issues a backup trip command to up-stream circuit breakers in case the original circuit breaker fails to trip for the protected component. The detection of a failure to break the current through the breaker is made by measuring the current or by detecting the remaining trip signal (unconditional).

CCBRBRF can also retrip. This means that a second trip signal is sent to the protected circuit breaker. The retrip function is used to increase the operational reliability of the breaker. The function can also be used to avoid backup tripping of several breakers in case mistakes occur during protection relay maintenance and tests.

CCBRBRF is initiated by operating different protection functions or digital logics inside the protection relay. It is also possible to initiate the function externally through a binary input.

CCBRBRF can be blocked by using an internally assigned signal or an external signal from a binary input. This signal blocks the function of the breaker failure protection even when the timers have started or the timers are reset.

The retrip timer is initiated after the start input is set to true. When the pre-defined time setting is exceeded, CCBRBRF issues the retrip and sends a trip command, for example, to the circuit breaker's second trip coil. Both a retrip with current check and an unconditional retrip are available. When a retrip with current check is chosen, the retrip is performed only if there is a current flow through the circuit breaker.

The backup trip timer is also initiated at the same time as the retrip timer. If CCBRBRF detects a failure in tripping the fault within the set backup delay time, which is longer than the retrip time, it sends a backup trip signal to the chosen backup breakers. The circuit breakers are normally upstream breakers which feed fault current to a faulty feeder.

The backup trip always includes a current check criterion. This means that the criterion for a breaker failure is that there is a current flow through the circuit breaker after the set backup delay time.

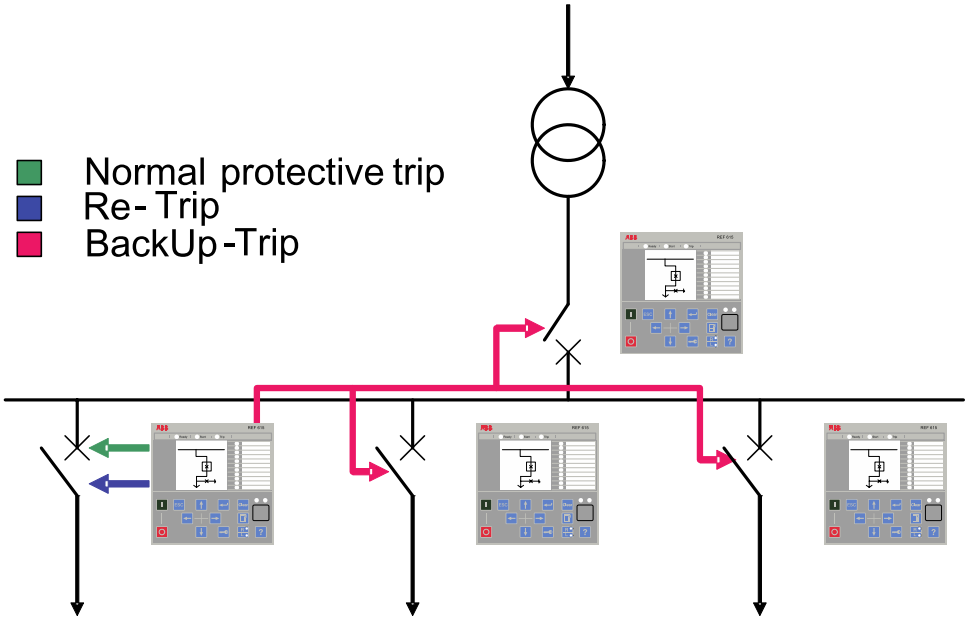



*Figure 578: Typical breaker failure protection scheme in distribution substations*

## 5.2.7 Signals

*Table 1011: CCBRBRF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block CBFP operation |
| START | BOOLEAN | 0=False | CBFP start command |
| POSCLOSE | BOOLEAN | 0=False | CB in closed position |
| CB_FAULT | BOOLEAN | 0=False | CB faulty and unable to trip |

*Table 1012: CCBRBRF Output signals*

| Name | Type | Description |
|---|---|---|
| CB_FAULT_AL | BOOLEAN | Delayed CB failure alarm |
| TRBU | BOOLEAN | Backup trip |
| TRRET | BOOLEAN | Retrip |

## 5.2.8 Settings

*Table 1013: CCBRBRF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Current value | 0.05...2.00 | xIn | 0.01 | 0.30 | Operating phase current |
| Current value Res | 0.05...2.00 | xIn | 0.01 | 0.30 | Operating residual current |
| CB failure trip mode | 1=2 out of 4<br>2=1 out of 3<br>3=1 out of 4 | | | 2=1 out of 3 | Backup trip current check mode |
| CB failure mode | 1=Current<br>2=Breaker status<br>3=Both (AND)<br>-1=Both (OR) | | | 1=Current | Operating mode of function |
| CB fail retrip mode | 1=Off<br>2=Without Check<br>3=Current check | | | 1=Off | Operating mode of retrip logic |
| Retrip time | 0...60000 | ms | 10 | 120 | Delay timer for retrip |
| CB failure delay | 0...60000 | ms | 10 | 240 | Delay timer for backup trip |

*Table 1014: CCBRBRF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| CB fault delay | 0...60000 | ms | 10 | 5000 | Circuit breaker faulty delay |
| Measurement mode | 2=DFT<br>3=Peak-to-Peak | | | 3=Peak-to-Peak | Phase current measurement mode of function |
| Trip pulse time | 0...60000 | ms | 10 | 200 | Pulse length of retrip and backup trip outputs |
| Start latching mode | 1=Rising edge<br>2=Level sensitive | | | 1=Rising edge | Start reset delayed or immediately |

## 5.2.9 Monitored data

*Table 1015: CCBRBRF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| CCBRBRF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.2.10 Technical data

*Table 1016: CCBRBRF Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Reset time | Typically 40 ms |
| Retardation time | <20 ms |

# 5.3 Master trip TRPPTRC

## 5.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Master trip | TRPPTRC | Master Trip | 94/86 |

## 5.3.2 Function block




*Figure 579: Function block*

## 5.3.3 Functionality

The master trip function TRPPTRC is used as a trip command collector and handler after the protection functions. The features of this function influence the trip signal behavior of the circuit breaker. The minimum trip pulse length can be set when the non-latched mode is selected. It is also possible to select the latched or lockout mode for the trip signal.

## 5.3.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".



When the TRPPTRC function is disabled, all trip outputs intended to go through the function to the circuit breaker trip coil are blocked.

The operation of TRPPTRC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

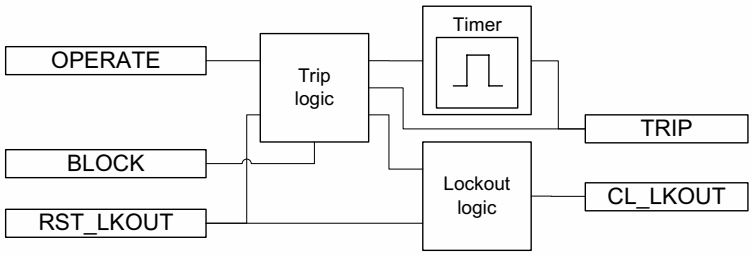



*Figure 580: Functional module diagram*

### Timer

The duration of the TRIP output signal from TRPPTRC can be adjusted with the *Trip pulse time* setting when the "Non-latched" operation mode is used. The pulse length should be long enough to secure the opening of the breaker. For three-pole tripping, TRPPTRC has a single input OPERATE, through which all trip output signals are routed from the protection functions within the protection relay, or from external protection functions via one or more of the protection relay's binary inputs. The

function has a single trip output TRIP for connecting the function to one or more of the protection relay's binary outputs, and also to other functions within the protection relay requiring this signal.

The BLOCK input blocks the TRIP output and resets the timer.

### Lockout logic

TRPPTRC is provided with possibilities to activate a lockout. When activated, the lockout can be manually reset after checking the primary fault by activating the RST_LKOUT input or from the LHMI clear menu parameter. When using the "Latched" mode, the resetting of the TRIP output can be done similarly as when using the "Lockout" mode. It is also possible to reset the "Latched" mode remotely through a separate communication parameter.

The minimum pulse trip function is not active when using the "Lockout" or "Latched" modes but only when the "Non-latched" mode is selected.

The CL_LKOUT and TRIP outputs can be blocked with the BLOCK input.

*Table 1017: Operation modes for the TRPPTRC trip output*

| Mode | Operation |
|---|---|
| Non-latched | The *Trip pulse length* parameter gives the minimum pulse length for TRIP |
| Latched | TRIP is latched ; both local and remote clearing is possible. |
| Lockout | TRIP is locked and can be cleared only locally via menu or the RST_LKOUT input. |

## 5.3.5 Application

All trip signals from different protection functions are routed through the trip logic. The most simplified application of the logic function is linking the trip signal and ensuring that the signal is long enough.

The tripping logic in the protection relay is intended to be used in the three-phase tripping for all fault types (3ph operating). To prevent the closing of a circuit breaker after a trip, TRPPTRC can block the CBXCBR closing.

TRPPTRC is intended to be connected to one trip coil of the corresponding circuit breaker. If tripping is needed for another trip coil or another circuit breaker which needs, for example, different trip pulse time, another trip logic function can be used. The two instances of the PTRC function are identical, only the names of the functions, TRPPTRC1 and TRPPTRC2, are different. Therefore, even if all references are made only to TRPPTRC1, they also apply to TRPPTRC2.

The inputs from the protection functions are connected to the OPERATE input. Usually, a logic block OR is required to combine the different function outputs to this input. The TRIP output is connected to the binary outputs on the IO board. This signal can also be used for other purposes within the protection relay, for example when starting the breaker failure protection.

TRPPTRC is used for simple three-phase tripping applications.

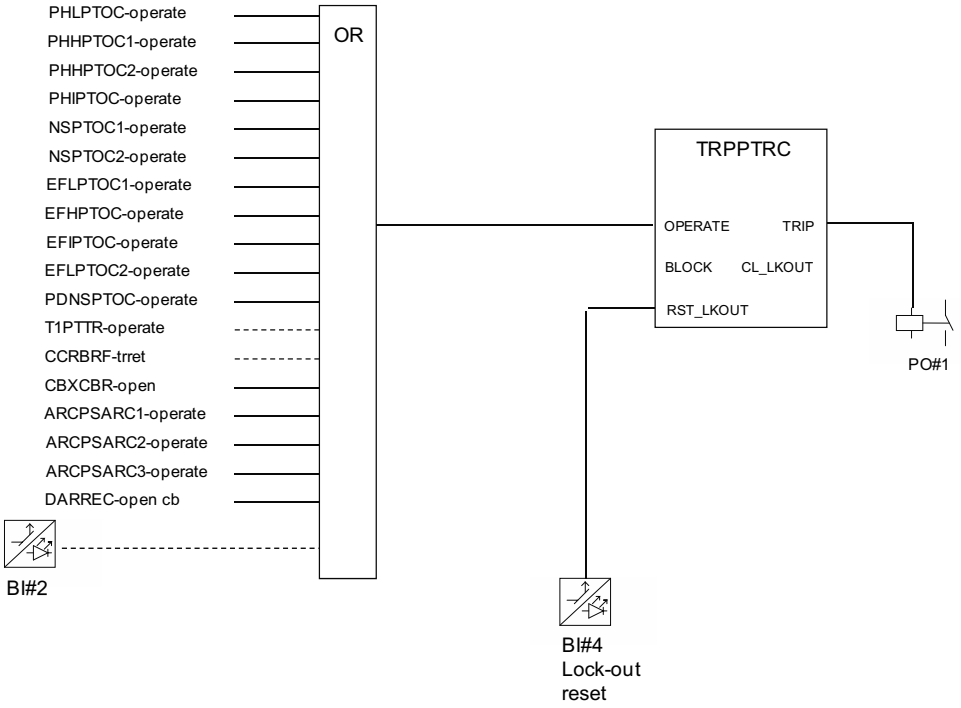



*Figure 581: Typical TRPPTRC connection*

## 5.3.6 Signals

*Table 1018: TRPPTRC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block of function |
| OPERATE | BOOLEAN | 0=False | Operate |
| RST_LKOUT | BOOLEAN | 0=False | Input for resetting the circuit breaker lockout function |

*Table 1019: TRPPTRC Output signals*

| Name | Type | Description |
|---|---|---|
| TRIP | BOOLEAN | General trip output signal |
| CL_LKOUT | BOOLEAN | Circuit breaker lockout output (set until reset) |

### 5.3.7 Settings

*Table 1020: TRPPTRC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Trip pulse time | 20...60000 | ms | 1 | 250 | Minimum duration of trip output signal |
| Trip output mode | 1=Non-latched<br>2=Latched<br>3=Lockout | | | 1=Non-latched | Select the operation mode for trip output |

### 5.3.8 Monitored data

*Table 1021: TRPPTRC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TRPPTRC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.4 High-impedance fault detection PHIZ

### 5.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| High-impedance fault detection | PHIZ | HIF | HIZ |

### 5.4.2 Function block




*Figure 582: Function block*

### 5.4.3 Functionality

A small percentage of earth faults have a very large impedance. They are comparable to load impedance and consequently have very little fault current. These high-

impedance faults do not pose imminent danger to power system equipment. However, they are a substantial threat to humans and properties; people can touch or get close to conductors carrying large amounts of energy.

ABB has developed a patented technology (US Patent 7,069,116 B2 June 27, 2006, US Patent 7,085,659 B2 August 1, 2006) to detect a high-impedance fault.

The high-impedance fault detection function PHIZ also contains a blocking functionality. It is possible to block function outputs.

## 5.4.4 Analog channel configuration

PHIZ has two analog group inputs which all must be properly configured.

*Table 1022: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| IRES | Residual current (measured or calculated) |



See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

PHIZ uses a multi-algorithm approach. Each algorithm uses various features of earth currents to detect a high-impedance fault.

Although the PHIZ algorithm is very sophisticated, the setting required to operate the function is simple. The *Security Level* setting, with the setting range of 1 to 10, is set to strike a balance between the extremes of security and dependability which together constitute the reliability of any system. The setting value “10” is more secure than “1”.

The higher the *Security Level* setting, the lower the probability of false detection, but the system might miss out some genuine fault. On the other hand, a lower setting would make the system operate more dependably for high-impedance faults in the line, but the operation is more likely for other transients in the system. There are events in electrical networks which can cause similar current waveforms like high-impedance faults. These events could then be detected by the PHIZ algorithm causing

unnecessary detections. Normally, electrical network operator does not know the existence of these events well and those can also be happening very randomly. The effect is also always dependent on event location compared to protection relay measurement location. All these facts make the PHIZ algorithm operation in certain electrical networks quite hard to measure and forecast beforehand. There is not any direct formula which can calculate the exact right setting based on known electrical network parameters.

It is hence recommended to set the value midway to “5” initially. Based on experience and confidence gained in a particular application, the setting can be moved either side. In many cases, it would be a good practice to use PHIZ as an indicative function during a piloting phase, until enough experience has been gathered and a suitable setting found.

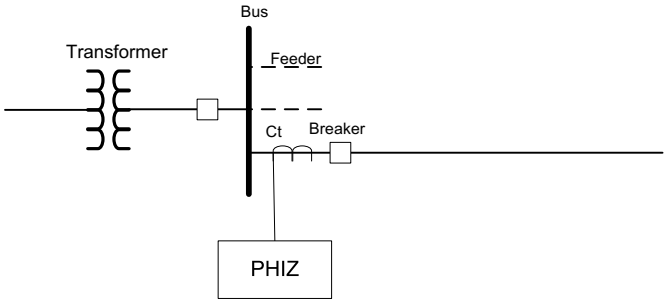



*Figure 583: Electrical power system equipped with PHIZ*

Power system signals are acquired, filtered and then processed by individual high-impedance fault detection algorithm. The results of these individual algorithms are further processed by a decision logic to provide the detection decision. The decision logic can be modified depending on the application requirement.

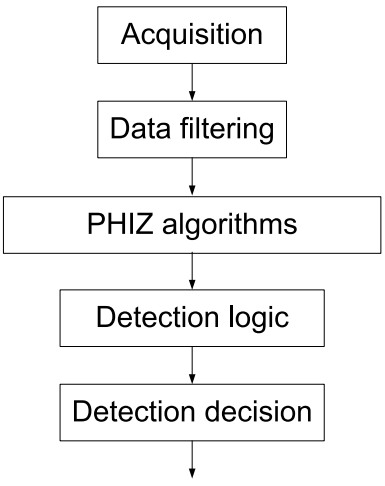



*Figure 584: Block diagram of PHIZ*

PHIZ is based on algorithms that use earth current signatures which are considered non-stationary, temporally volatile and of various burst duration. All harmonic and

non-harmonic components within the available data window can play a vital role in the high-impedance fault detection. A major challenge is to develop a data model that acknowledges that high-impedance faults could take place at any time within the observation window of the signal and could be delayed randomly and attenuated substantially. The model is motivated by extensive research, actual experimental observations in the laboratory, field testing and what traditionally represents an accurate depiction of a non-stationary signal with a time-dependent spectrum.



*Figure 585: Validation of PHIZ on gravel*



*Figure 586: Validation of PHIZ on concrete*



*Figure 587: Validation of PHIZ on sand*



*Figure 588: Validation of PHIZ on grass*

## 5.4.6 Application

PHIZ is used to detect a downed conductor dropping to a very resistive ground, causing an earth fault which is very difficult to detect by a conventional protection relay functionality. PHIZ is then targeted to be used with overhead lines. PHIZ must be used in electrical networks with efficiently grounded or isolated neutral.

Electric power lines experience faults for many reasons. In most cases, electrical faults manifest in mechanical damage, which must be repaired before returning the line to service.

Most of the electrical network faults are earth faults. Conventional protection systems based on overcurrent, impedance or other principles are suitable for detecting relatively low-impedance faults which have a relatively large fault current.

However, a small percentage of the earth faults have a very large impedance. They are comparable to load impedance and consequently have very little fault current. These high-impedance faults do not pose imminent danger to power system equipment. However, they are a considerable threat to people and property. The IEEE Power System Relay Committee working group on High Impedance Fault Detection Technology defines High Impedance Faults as those that 'do not produce enough fault current to be detectable by conventional overcurrent relays or fuses.



PHIZ always needs sensitive Io measurement.

High-impedance fault (PHIZ) detection requires a different approach than that for conventional low-impedance faults. Reliable detection of PHIZ provides safety to humans and animals. ABB has developed innovative technology for high-impedance fault detection with over ten years of research resulting in many successful field tests.

## 5.4.7 Signals

*Table 1023: PHIZ Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| CB_CLOSED | BOOLEAN | 0=False | Circuit Breaker Closed input |
| CB_OPEN | BOOLEAN | 0=False | Circuit Breaker Open input |

*Table 1024: PHIZ Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |

## 5.4.8 Settings

*Table 1025: PHIZ Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Security Level | 1...10 | | 1 | 5 | Security Level |

*Table 1026: PHIZ Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| System type | 1=Grounded<br>2=Ungrounded | | | 1=Grounded | System Type |

### 5.4.9 Monitored data

*Table 1027: PHIZ Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Position | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Position |
| PHIZ | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.5 Binary signal transfer BSTGAPC

### 5.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Binary signal transfer | BSTGAPC | BST | BST |

### 5.5.2 Function block

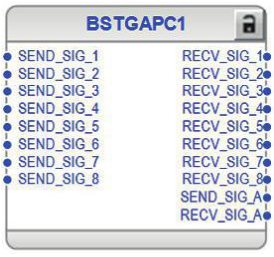



*Figure 589: Function block*

## 5.5.3 Functionality

The binary signal transfer function BSTGAPC is used for transferring binary signals between the local and remote end line differential protection relays. The function includes eight binary signals that are transferred in the protection communication telegram and can be freely configured and used for any purpose in the line differential application.

BSTGAPC transfers binary data continuously over the protection communication channel between the terminals. Each of the eight signals are bidirectional and the binary data sent locally is available remotely as a received signal.

BSTGAPC includes a minimum pulse time functionality for the received binary signals. Each received signal has its own minimum pulse time setting parameter.

BSTGAPC includes two alarm output signals. The SEND_SIG_A output signal is updated according to the status of the sent binary signals. The RECV_SIG_A output signal is updated according to the status of the received binary signals. Each signal can be separately included or excluded from the alarm logic with a setting parameter.

## 5.5.4 Operation principle

The *Signal 1...8 mode* setting can be used for changing the operation of the bidirectional signal channel. The signal channel can be disabled by setting the corresponding parameter value to “Not in use”. When the signal channel is disabled locally or remotely, the corresponding RECV_SIG_1...8 signal status is always false on both ends.

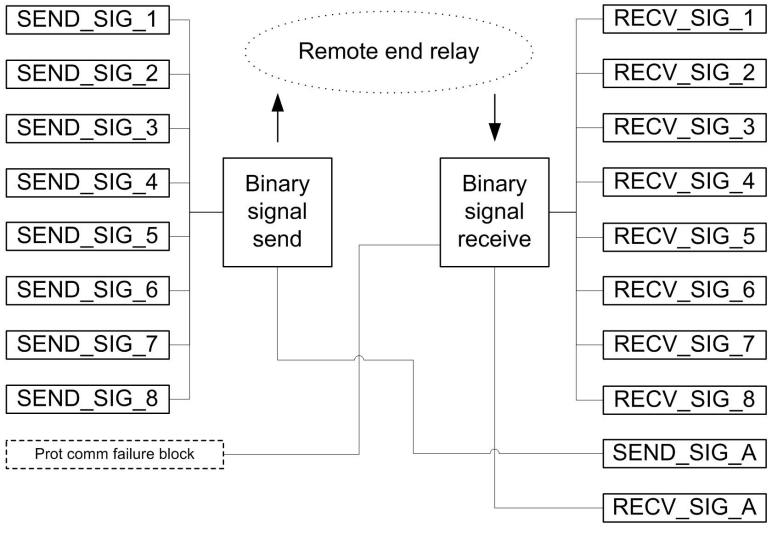



*Figure 590: Functional module diagram*

### Binary signal send

The status of the inputs is continuously sent in the line differential protection telegrams. SEND_SIG_A can be used for alarming based on the status of SEND_SIG_1...8. By selecting the signal mode as "In use, alarm sel.", the sending status of the corresponding signal affects also the activation criteria of SEND_SIG_A. Further, in case more than one signal channels are selected into the alarm logic, the activation criteria can be defined according to "Any of selected" (OR) or "All of selected" (AND).

### Binary signal receive

The function receives continuous binary data within the protection telegrams from the remote end protection relay. This received binary data status is then available as the RECV_SIG_1...8 outputs on the local end protection relay. RECV_SIG_A can be used for alarming based on the status of RECV_SIG_1...8. By selecting the signal mode as "In use, alarm sel.", the received status of the corresponding signal affects the activation criteria of RECV_SIG_A. Further, in case more than one signal channels are selected into the alarm logic, the activation criteria can be defined according to "Any of selected" (OR) or "All of selected" (AND). Each signal has also the *Pulse time 1...8* setting that defines the minimum pulse length for RECV_SIG_1...8. Also, in case the protection communication supervision detects a failure in the communication, the RECV_SIG_1...8 outputs are not set to false sooner than the minimum pulse length defined is first ensured for each signal.

## 5.5.5 Application

Among with the analog data, the binary data can also be exchanged with the line differential protection relays. The usage of the binary data is application specific and can vary in each separate case. The demands for the speed of the binary signals vary depending on the usage of the data. When the binary data is used as blocking signals for the line differential protection, the transfer response is extremely high. Binary signal interchange can be used in applications such as:

- Remote position indications
- Inter-tripping of the circuit breakers on both line ends
- Blocking of the line differential protection during transformer inrush or current circuit supervision failure
- Protection schemes; blocking or permissive
- Remote alarming

The figure shows the overall chain to transfer binary data in an example application. The position indication of the local circuit breaker is connected to the protection relay's input interface and is then available for the relay configuration. The circuit breaker position indication is connected to the first input of BSTGAPC which is used to send information to the remote end via communication. In the remote end, this information is handled as a remote circuit breaker open position and it is available from the first output of BSTGAPC. This way the information can be exchanged.

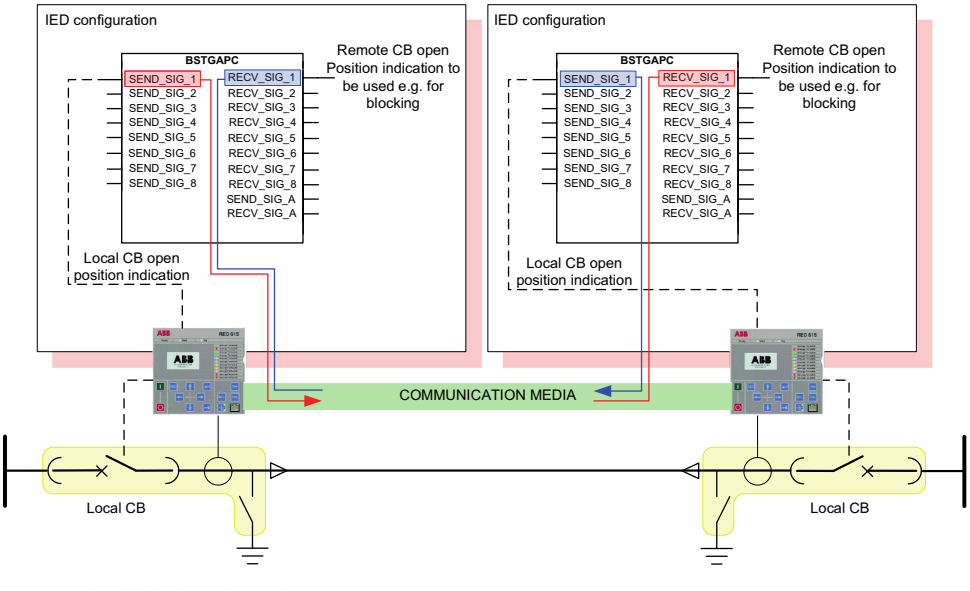



*Figure 591: Example of usage of binary signal transfer for position indication change*

## 5.5.6 Signals

*Table 1028: BSTGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| SEND_SIG_1 | BOOLEAN | 0=False | Send signal 1 state |
| SEND_SIG_2 | BOOLEAN | 0=False | Send signal 2 state |
| SEND_SIG_3 | BOOLEAN | 0=False | Send signal 3 state |
| SEND_SIG_4 | BOOLEAN | 0=False | Send signal 4 state |
| SEND_SIG_5 | BOOLEAN | 0=False | Send signal 5 state |
| SEND_SIG_6 | BOOLEAN | 0=False | Send signal 6 state |
| SEND_SIG_7 | BOOLEAN | 0=False | Send signal 7 state |
| SEND_SIG_8 | BOOLEAN | 0=False | Send signal 8 state |

*Table 1029: BSTGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| RECV_SIG_1 | BOOLEAN | Receive signal 1 state |
| RECV_SIG_2 | BOOLEAN | Receive signal 2 state |
| RECV_SIG_3 | BOOLEAN | Receive signal 3 state |
| RECV_SIG_4 | BOOLEAN | Receive signal 4 state |
| RECV_SIG_5 | BOOLEAN | Receive signal 5 state |
| RECV_SIG_6 | BOOLEAN | Receive signal 6 state |
| RECV_SIG_7 | BOOLEAN | Receive signal 7 state |
| Table continues on next page | | |

| Name | Type | Description |
|---|---|---|
| RECV_SIG_8 | BOOLEAN | Receive signal 8 state |
| SEND_SIG_A | BOOLEAN | Binary signal transfer sending alarm state |
| RECV_SIG_A | BOOLEAN | Binary signal transfer receive alarm state |

## 5.5.7 Settings

*Table 1030: BSTGAPC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Signal 1 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 2=In use, alarm sel. | Operation mode for signal 1 |
| Signal 2 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 2=In use, alarm sel. | Operation mode for signal 2 |
| Signal 3 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 1=In use | Operation mode for signal 3 |
| Signal 4 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 1=In use | Operation mode for signal 4 |
| Signal 5 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 1=In use | Operation mode for signal 5 |
| Signal 6 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 1=In use | Operation mode for signal 6 |
| Signal 7 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 1=In use | Operation mode for signal 7 |
| Signal 8 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 1=In use | Operation mode for signal 8 |
| Pulse time 1 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 1 |
| Pulse time 2 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 2 |
| Pulse time 3 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 3 |
| Pulse time 4 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 4 |
| Pulse time 5 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 6 |
| Pulse time 6 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 6 |
| Pulse time 7 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 7 |
| Pulse time 8 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 8 |

*Table 1031: BSTGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Alarm mode | 1=Any of selected<br>2=All of selected | | | 1=Any of selected | Selects the used alarm logic mode for activating SEND_SIG_A and RECV_SIG_A |

### 5.5.8 Monitored data

### 5.5.9 Technical data

*Table 1032: BSTGAPC Technical data*

| Characteristic | | Value |
|---|---|---|
| Signalling delay | Fiber optic link | <5 ms |
| | Galvanic pilot wire link | <10 ms |

## 5.6 Emergency start-up ESMGAPC

### 5.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Emergency start-up | ESMGAPC | ESTART | EST,62 |

### 5.6.2 Function block




*Figure 592: Function block*

### 5.6.3 Functionality

An emergency condition can arise in cases where the motor needs to be started despite knowing that this can increase the temperature above limits or cause a thermal overload that can damage the motor. The emergency start-up function ESMGAPC allows motor start-ups during such emergency conditions. ESMGAPC is only to force the protection relay to allow the restarting of the motor. After the emergency start input is activated, the motor can be started normally. ESMGAPC itself does not actually restart the motor.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

### 5.6.4 Analog channel configuration

ESMGAPC has one analog group input which must be properly configured.

*Table 1033: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of ESMGAPC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

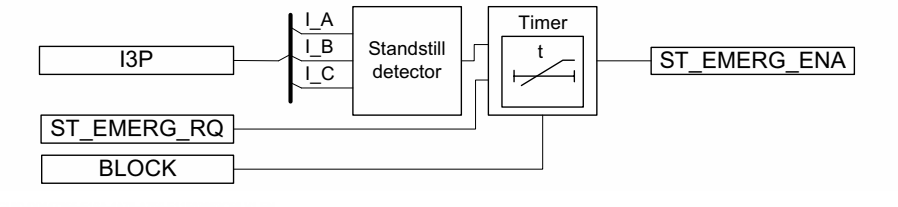



*Figure 593: Functional module diagram*

### Standstill detector

The module detects if the motor is in a standstill condition. The standstill condition can be detected based on the phase current values. If all three phase currents are below the set value of *Motor standstill A*, the motor is considered to be in a standstill condition.

### Timer

The timer is a fixed 10-minute timer that is activated when the ST_EMERG_RQ input is activated and motor standstill condition is fulfilled. Thus, the activation of the ST_EMERG_RQ input activates the ST_EMERG_ENA output, provided that the motor is in a standstill condition. The ST_EMERG_ENA output remains active for 10 minutes or as long as the ST_EMERG_RQ input is high, whichever takes longer.

The activation of the BLOCK input blocks and also resets the timer.

The function also provides the ST_EMERG_ENA output change date and time, T_ST_EMERG. The information is available in the monitored data view.

## 5.6.6 Application

If the motor needs to be started in an emergency condition at the risk of damaging the motor, all the external restart inhibits are ignored, allowing the motor to be restarted. Furthermore, if the calculated thermal level is higher than the restart inhibit level at an emergency start condition, the calculated thermal level is set slightly below the restart inhibit level. Also, if the register value of the cumulative start-up time counter exceeds the restart inhibit level, the value is set slightly below the restart disable value to allow at least one motor start-up.

The activation of the ST_EMERG_RQ digital input allows to perform emergency start. The protection relay is forced to a state which allows the restart of motor, and the operator can now restart the motor. A new emergency start cannot be made until the 10 minute time-out has passed or until the emergency start is released, whichever takes longer.

The last change of the emergency start output signal is recorded.

## 5.6.7 Signals

*Table 1034: ESMGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ST_EMERG_RQ | BOOLEAN | 0=False | Emergency start input |

*Table 1035: ESMGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| ST_EMERG_ENA | BOOLEAN | Emergency start |

## 5.6.8 Settings

*Table 1036: ESMGAPC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Motor standstill A | 0.05...0.20 | xIn | 0.01 | 0.12 | Current limit to check for motor standstill condition |

*Table 1037: ESMGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

## 5.6.9 Monitored data

*Table 1038: ESMGAPC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| T_ST_EMERG | Timestamp | | | Emergency start activation timestamp |
| ESMGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.6.10 Technical data

*Table 1039: ESMGAPC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±1.5% of the set value or ±0.002 × $U_n$ |

# 5.7 Fault locator SCEFRFLO

## 5.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Fault locator | SCEFRFLO | FLOC | FLOC |

## 5.7.2 Function block

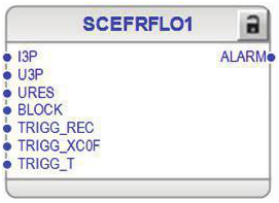



*Figure 594: Function block*

## 5.7.3 Functionality

The fault locator function SCEFRFLO provides impedance-based fault location. It is designed for radially operated distribution systems, and it can locate short circuits in all kinds of distribution networks. Earth faults can be located in effectively earthed

and in low-resistance or low-reactance earthed networks. With certain limitations, SCEFRFLO can also be used for locating an earth fault in unearthed distribution networks. Moreover, SCEFRFLO can be applied to compensated (resonant earthed) networks where an earth-fault current raising resistor is connected in parallel with the arc suppression coil. The location of the continuous low-ohmic earth fault can be determined by using the switching of the parallel resistor of the coil during an earth fault.

The fault distance calculation is based on the locally measured fundamental frequency current and voltage phasors. The full operation of SCEFRFLO requires all phase currents and phase-to-earth voltages to be measured.

The fault distance estimate is obtained when SCEFRFLO is externally or internally triggered.

## 5.7.4 Analog channel configuration

SCEFRFLO has three analog group inputs which must be properly configured.

*Table 1040: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |
| URES[1)] | Residual voltage (measured)<br>Necessary when the phase-to-phase voltages are measured and *Phase voltage Meas* is set to "Accurate" |

1) Can be connected to GRPOFF if *Phase voltage Meas* is set to "Ph-to-ph without Uo"



See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

*Table 1041: Special conditions*

| Condition | Description |
|---|---|
| U3P connected real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.7.5 Operation principle

The function can be enabled or disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of SCEFRFLO can be described with a module diagram. All the modules in the diagram are explained in the next sections.

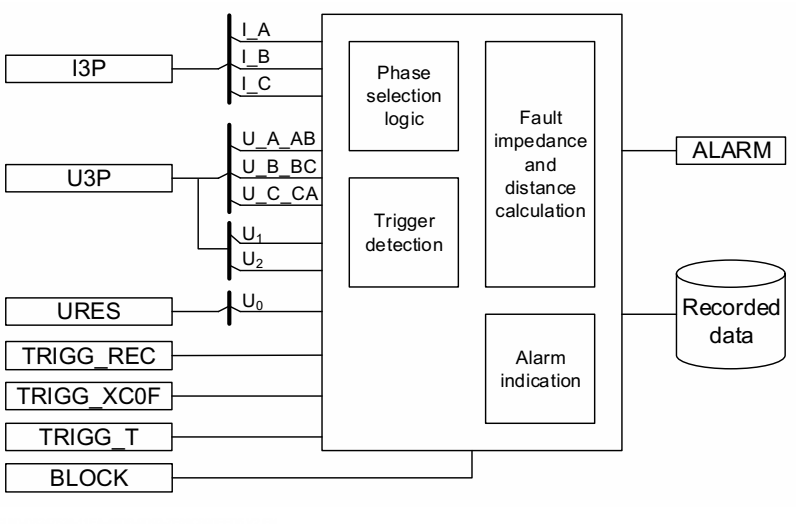



*Figure 595: Functional module diagram*

The fault distance calculation is done in two steps. First, the fault type is determined with the in-built Phase selection logic (PSL). Second, based on the selected impedance measuring element (fault loop) the fault distance from the measuring point to the fault location is calculated.

The phase current magnitude's minimum threshold value is 1% xIn.

### Phase selection logic

Phase selection logic identifies the faulty phases based on a combined impedance and current criterion. Phase selection logic is virtually setting-free and has only one parameter, *Z Max phase load*, for discriminating a large symmetrical load from a three-phase fault. The setting *Z Max phase load* can be calculated using the equation

$$Z\,Max\,phase\,load = 0.8 \cdot \frac{U_{xy}^2}{S_{max}}$$

(Equation 258)

$U_{xy}$ Nominal phase-to-phase voltage

$S_{max}$ Maximum three-phase load

For example, if $U_{xy}$ = 20 kV and $S_{max}$ = 1 MVA, then *Z Max phase load* = 320.0 Ω.

The identification of the faulty phases is compulsory for the correct operation of SCEFRFLO. This is because only one of the impedance-measuring elements (fault loops) provides the correct result for a specific fault type. A three-phase fault is an exception and it can be calculated with any of the fault loops. The fault loop used in the fault distance calculation is indicated in the recorded data Flt loop as specified in Table 1042.

*Table 1042: Fault types and corresponding fault loops*

| Fault type | Description | Flt loop |
|---|---|---|
| - | No fault | No fault |
| A-E | Phase A-to-earth fault | AG Fault |
| B-E | Phase B-to-earth fault | BG Fault |
| C-E | Phase C-to-earth fault | CG Fault |
| A-B | Phase A-to-B short circuit fault | AB Fault |
| B-C | Phase B-to-C short circuit fault | BC Fault |
| C-A | Phase C-to-A short circuit fault | CA Fault |
| A-B-C-(E) | Three-phase short circuit | ABC Fault |

In case of two-phase-to-earth-faults (A-B-E, B-C-E or C-A-E), the selected fault loop depends on the location of the earth faults. When the faults are located at the same feeder, the corresponding phase-to-phase loop (“AB Fault”, “BC Fault” or “CA Fault”) is used for calculation. When the faults are located at different feeders, the phase-to-earth loop (“AG Fault”, “BG Fault” or “CG Fault”) corresponding to the faulty phase at the protected feeder is used for calculation.

## Fault impedance and distance calculation

As soon as a fault condition is recognized by Phase selection logic, the fault distance calculation is started with one of the seven impedance-measuring elements, that is, the fault loops. SCEFRFLO uses independent algorithms for each fault type to achieve optimal performance.

The inherent result from the fault distance calculation is the ohmic fault loop impedance value.

*Table 1043: The calculated impedance values available in the recorded data*

| Impedance value | Description |
|---|---|
| Flt phase reactance | Estimated positive sequence reactance from the substation to the fault location in primary ohms |
| Flt point resistance | Fault resistance value in the fault spot in primary ohms. The composition of this term depends on the fault loop as described in the following subsections. |
| Flt loop resistance | The total fault loop resistance from the substation to the fault location in primary ohms. Fault point resistance is included in this value. The composition of this term is different for short-circuit and earth-fault loops as described in the following subsections. |
| Flt loop reactance | The total fault loop reactance from the substation to the fault location in primary ohms. The composition of this term is different for short-circuit and earth-fault loops as described in the following subsections. |

These impedance values can be used as such or they can be further processed in system-level fault location applications, such as distribution management system (DMS).

### Fault loops “AG Fault”, “BG Fault” and “CG Fault”

Fault loops “AG Fault”, “BG Fault” and “CG Fault” are used for single-phase-to-earth faults. When the earth faults are located at different feeders, they are also applied in the case of two-phase-to-earth faults. In this case, the phase-to-earth loop (“AG Fault”, “BG Fault” or “CG Fault”) corresponding to the faulty phase at the protected feeder is used for calculation. Figure 596 shows the phase-to-earth fault loop model. The following impedances are measured and stored in the recorded data of SCEFRFLO.

$$Flt\ point\ resistance = R_{fault}$$

(Equation 259)

$$Flt\ loop\ resistance = R_1 + R_N + R_{fault}$$

(Equation 260)

$$Flt\ loop\ reactance = X_1 + X_N$$

(Equation 261)

$$Flt\ phase\ reactance = X_1$$

(Equation 262)

| | |
|---|---|
| $R_1$ | Estimated positive-sequence resistance from the substation to the fault location |
| $X_1$ | Estimated positive-sequence reactance from the substation to the fault location |
| $R_0$ | Estimated zero-sequence resistance from the substation to the fault location |
| $X_0$ | Estimated zero-sequence reactance from the substation to the fault location |
| $R_N$ | Estimated earth return path resistance (= (R0 – R1)/3) from the substation to the fault location |
| $X_N$ | Estimated earth return path reactance (= (X0 – X1)/3) from the substation to the fault |
| $R_{fault}$ | Estimated fault resistance at the fault location |

The recorded data Flt phase reactance provides the estimated positive-sequence reactance from the substation to the fault location.

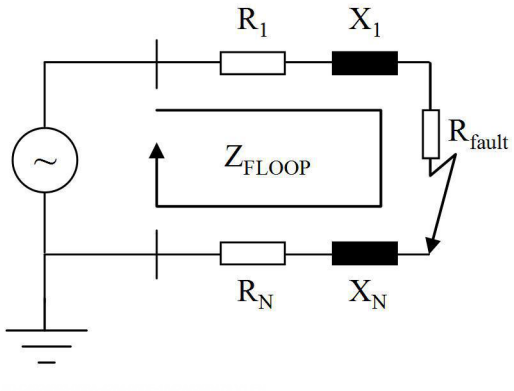



*Figure 596: Fault loop impedance for phase-to-earth fault loops “AG Fault”, “BG Fault” or “CG Fault”*

Setting *Flt Loc Det mode* is used for selecting between different algorithms for the calculation of the earth-fault distance. In case of compensated (resonant earthed) networks where an earth-fault current raising resistor is used, setting *Flt Loc Det mode* = "Comp, switched R" should be selected. In all other cases of system neutral point earthing (effectively earthed, low-resistance, low-reactance or unearthed networks), setting "Non-comp" should be selected.

**Earth-fault distance calculation in case of non-compensated networks**

In case of non-compensated networks (effectively earthed, low-resistance, low-reactance or unearthed networks), the setting *Flt Loc Det mode* is equal to "Non-comp". Furthermore, the earth-fault distance calculation algorithm is selected with setting *EF algorithm Sel*. Options for the selection are "Load compensation" and "Load modelling". For the correct operation of both algorithms, there should not be any zero-sequence current sources, for example, earthing transformers, in front of the protection relay.

The “Load compensation” algorithm uses symmetrical components to compensate for the effect of load on the measured voltages and currents. In case of radial feeders, this algorithm should be selected with low-impedance/effectively earthed systems where the fault current is fed from one side only and there are no in-feeds along the protected line.

The “Load modelling” algorithm takes into account the effect of the load in the measured currents and voltages by considering it in the fault loop model. In case of radial feeders, this algorithm can be applied with low-impedance/effectively earthed systems where the fault current is fed from one side only. The “Load modelling” algorithm has been especially designed for unearthed systems.

The “Load modelling” algorithm requires the *Equivalent load Dis* setting, that is, an equivalent load distance, as an additional parameter. The derivation and meaning of this parameter is illustrated in Figure 597, where the load is assumed to be evenly distributed along the feeder, resulting in the actual voltage drop curve as seen in the middle part of Figure 597.

In case of evenly distributed load, *Equivalent load Dis* ~ 0.5. When the load is tapped at the end of the feeder, *Equivalent load Dis* = 1.0. If the load distribution is unknown, a default value of 0.5 can be used for *Equivalent load Dis*.

The maximum value of the voltage drop, denoted as $U_{drop}$(real), appears at the end of the feeder. The *Equivalent load Dis* setting is the distance at which a single load tap corresponding to the total load of the feeder results in a voltage drop equal to $U_{drop}$(real). The dashed curve shows the voltage drop profile in this case.

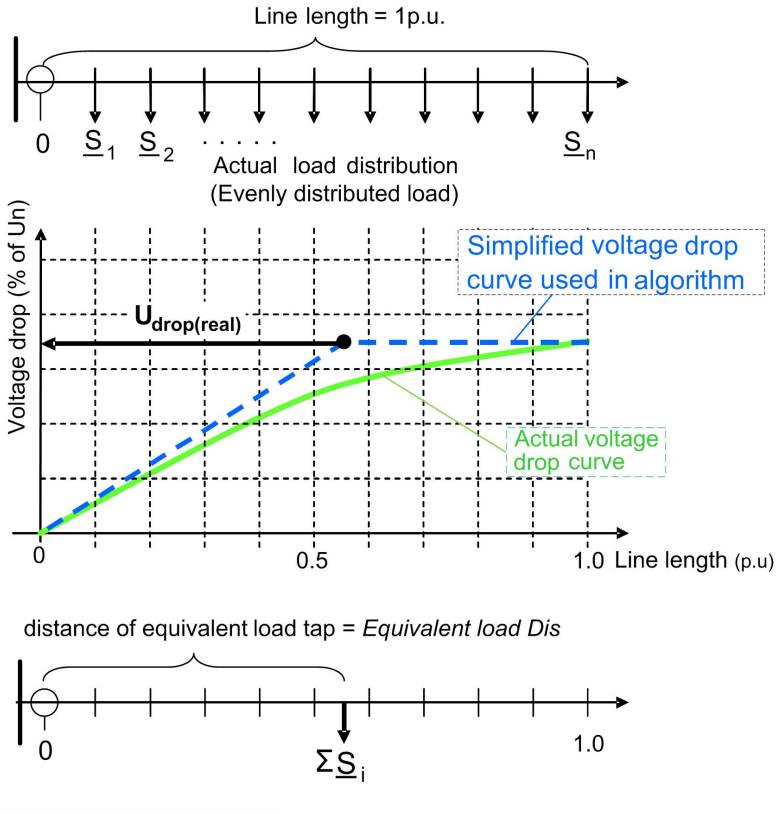



*Figure 597: Description of the equivalent load distance*

The exact value for *Equivalent load Dis* can be calculated based on the load flow and voltage drop calculations using data from the DMS system and the following equation.

$$Equivalent\ load\ Dis = \frac{U_{drop(real)}}{U_{drop(tap,d=1)}}$$

(Equation 263)

| | |
|---|---|
| $U_{d(real)}$ | Actual maximum voltage drop of the feeder |
| $U_{d(tap,d=1)}$ | Fictional voltage drop if the entire load were tapped at the end (d=1) of the feeder (not drawn in Figure 597). The calculation of this value requires data from the DMS system. |

Alternatively, the setting *Equivalent load Dis* can be determined by conducting a single-phase earth-fault test ($R_{fault}$ = 0 Ω) at that point of the feeder where the maximum actual voltage drop takes place. This point is typically located at the end of the main line. The calculated value is stored in the recorded data Equivalent load Dis.

In addition, when the setting *EF algorithm Sel* is equal to "Load modelling", the *EF algorithm Cur Sel* setting determines whether the used algorithm is based on zero-sequence "Io based" or negative-sequence "I2 based" current. The difference between "Io based" and "I2 based" methods is that "I2 based" does not require the *Ph capacitive React* and *Ph leakage Ris* settings. In case of "Io based", these settings are needed to compensate for the influence of the line-charging capacitances of the protected feeder. This improves the accuracy of the fault location estimate when fault resistance is involved in the fault.

With certain restrictions, the “Load modelling” algorithm can also be applied to unearthed networks. In this case, the *EF algorithm Cur Sel* setting should be set to "Io based" and thus *Ph capacitive React* and *Ph leakage Ris* settings must be determined.

The prerequisite for the operation of SCEFRFLO in earth faults in unearthed networks is that the earth-fault current of the network corresponding to a solid fault exceeds the pre-fault load current; that is Equation 264 is valid.

$$Flt\ to\ Lod\ Cur\ ratio = \frac{\left|I_{ef\,(Rfault=0)}\right|}{\left|I_{Load}\right|} \geq 1$$

(Equation 264)

This ratio is estimated by SCEFRFLO and stored in the recorded data Flt to Lod Cur ratio together with the fault distance estimate.

In case of an unearthed network, sufficient fault current magnitude resulting in Flt to Lod Cur ratio >1 can be achieved, for example, with proper switching operations in the background network, if possible, which increase the fault current. If the faulty feeder is re-energized after the switching operation, a new estimate for the fault distance can be obtained. Fault resistance decreases the fault location accuracy so the resistance should not be higher than a few hundred ohms. Also, a low value of Flt to Lod Cur ratio causes inaccuracy and affects the quality of the fault distance estimate. The inaccuracies affecting the calculated fault distance estimate are reported in the recorded result quality indicator value Flt Dist quality in Table 1044.

**Earth-fault distance calculation in case of compensated (resonant earthed) networks where an earth-fault current raising resistor is used**

In case of compensated (resonant earthed) networks where an earth-fault current raising resistor is used, the setting *Flt Loc Det mode* is equal to "Comp, switched R". The algorithm for calculation of earth-fault distance requires a measurable change in the measured phase currents and phase-to-earth voltages during an earth fault. Such a change can be accomplished by switching on the resistor of the PAW winding (Power Auxiliary Winding) of the compensation coil during the fault.

The algorithm requires three independent time instances, which are assumed to be known by the algorithm:

- $t_0$ = time instance before the fault
- $t_1$ = time instance before the change during the earth fault
- $t_2$ = time instance after the change during the earth fault

The effect of loads is considered by applying “Load modelling” algorithm.

The required settings of the algorithm are:

- R1 = Positive-sequence resistance of the protected feeder [ohm, prim]
- X1 = Positive-sequence reactance of the protected feeder [ohm, prim]
- R0 = Zero-sequence resistance of the protected feeder [ohm, prim]
- X0 = Zero-sequence reactance of the protected feeder [ohm, prim]
- s = Equivalent load distance [pu]

**Determining timings of changes: determination of earth fault occurrence and time instance $t_0$**

Timing $t_0$ is needed to store the current and voltage phasors right before the occurrence of the earth fault. Timing $t_0$ is common to both triggering types (*Calculation Trg mode* either “Internal” or “External”). Pre-fault (indicating healthy network) phasors are continuously updated and stored at intervals of 300 ms until the earth fault is indicated. When the earth fault is detected (internal detection), the pre-fault phasor is stored at least 300 ms before the detection of the earth fault. This time instance before the earth fault is noted as $t_0$ (see Figure 598).

**Determining timings of changes: determination of changes during an earth fault due to parallel resistor switching, time instances $t_1$ and $t_2$**

- Time instance $t_1$ equals the time during earth fault, right before the switching of the parallel resistor of the coil (see Figure 598)
- Time instance $t_2$ equals the time during earth fault, just after the switching of the parallel resistor of the coil (see Figure 598)

In case of external triggering, time instances $t_1$ and $t_2$ are determined using input `TRIGG_T` and delay setting *Time delay*. `TRIGG_T` input should be activated when the parallel resistor is switched ON. Time instance $t_1$ is taken at least one fundamental cycle before `TRIGG_T` rising edge. Time instance $t_2$ is taken according to the set *Time delay* after the rising edge of `TRIGG_T` signal. Setting *Time delay* should be few hundreds of ms and it is needed due to oscillations in currents and voltages after the switching of the parallel resistor.

TRIGG_T activation must be given after the initial earth-fault ignition transients. Only one activation of TRIGG_T is allowed during an earth fault. However, further activations are internally disabled.

Activation of input TRIGG_REC is required in case of external triggering to record the calculated estimates for fault distance. TRIGG_REC should be activated during the earth fault after the switching of the parallel resistor.

In case of internal triggering, time instances $t_1$ and $t_2$ are determined by monitoring the change of the resistive component of Io current using admittance calculation during the earth fault and comparing the magnitude of change to setting *Zero Ris Curr change*. Time instance $t_1$ is taken at least one fundamental cycle before and $t_2$ at least one fundamental cycle after the change in the resistive component of Io exceeding the start value (setting *Zero Ris Curr change*). The value for setting *Zero Ris Curr change* should be chosen based on the rated current value of the parallel resistor with proper margin:

*Zero Ris Curr change* < Ipar_rated [A] · q

where q = 0.5-0.7

For example, if the rated current value of the parallel resistor is 10A@20kV and In = 100 A for Io channel, then

*Zero Ris Curr change* < 0.05-0.07xIn

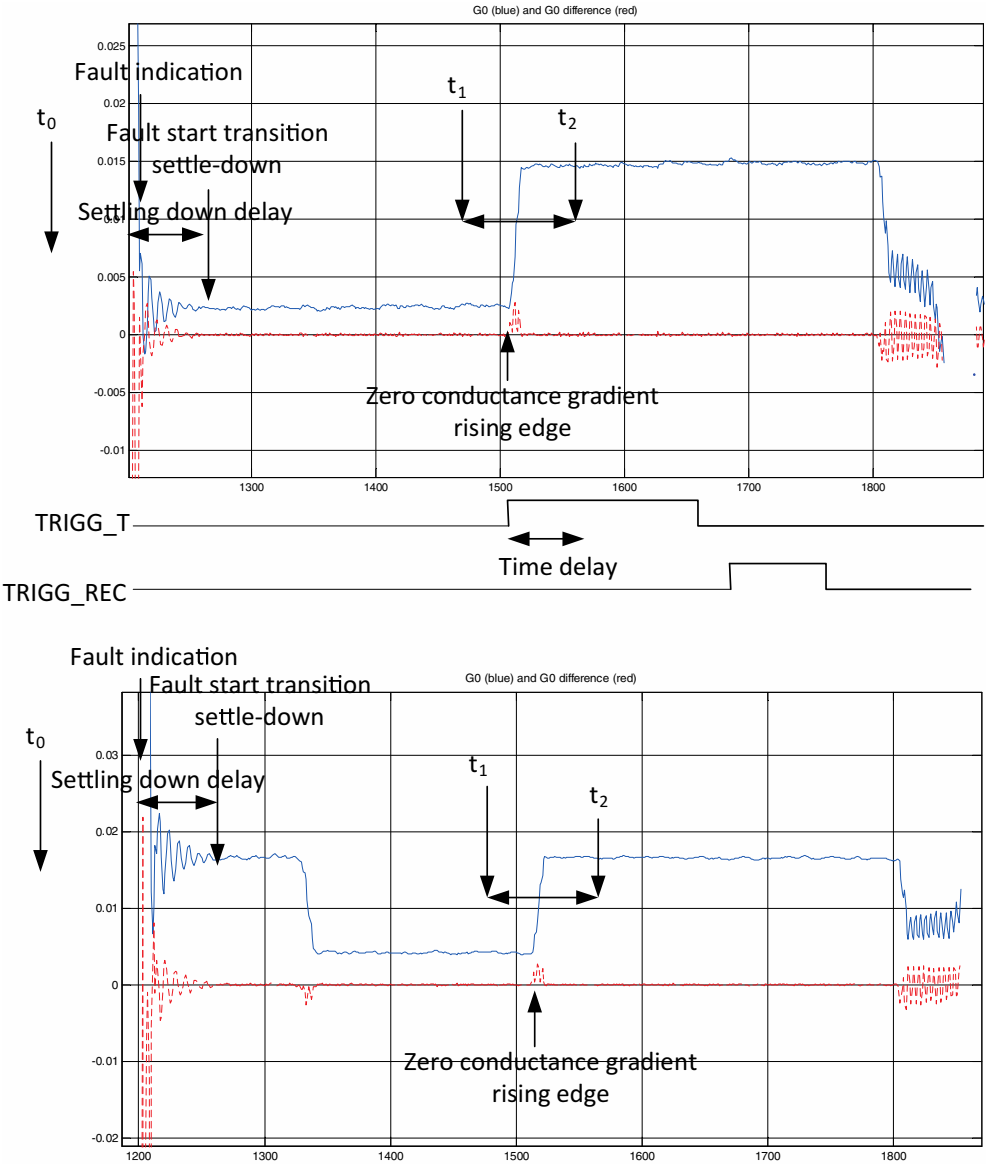



*Figure 598: Fault distance estimate triggering moment definitions*

## Fault loops “AB Fault”, “BC Fault” and “CA Fault”

Fault loops “AB Fault”, “BC Fault” and “CA Fault” are used for phase-to-phase short circuit faults as well as in the case of a two-phase-to-earth fault if the individual earth faults are located at the same feeder. Figure 599 shows the phase-to-phase fault loop model. The following impedances are measured and stored in the recorded data of SCEFRFLO.

$$Flt\ point\ resistance = \frac{R_{fault}}{2}$$

(Equation 265)

$$Flt\ loop\ resistance = R_1 + \frac{R_{fault}}{2}$$

(Equation 266)

$$Flt\ loop\ reactance = Flt\ phase\ reactance = X_1$$

(Equation 267)

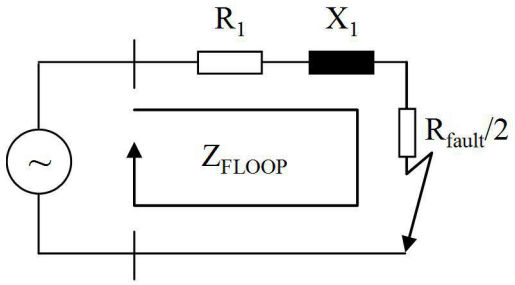



*Figure 599: Fault loop impedance for phase-to-phase fault loops (“AB Fault”, “BC Fault” or “CA Fault”)*

The fault distance calculation algorithm for the phase-to-phase fault loops is defined by using settings *Load Com PP loops* and *Enable simple model*. Options for the selection are "Disabled" or "Enabled".

Load compensation can be enabled or disabled with setting *Load Com PP loops*. Load compensation should be disabled only if the ratio between the fault current and load current is large or when the value of the fault distance estimate for the short circuit fault is required from each shot of an autoreclosing sequence.

The fault distance calculation is most accurate when calculated with the fault loop model. This model requires positive-sequence impedances of the protected feeder to be given as settings. If these settings are not available, valid impedance values can be calculated also without the fault loop model with setting *Enable simple model* = "Enabled". However, a valid distance estimate, that is, the conversion of measured impedance (“electrical fault distance’’) into a physical fault distance requires accurate positive-sequence impedance settings.

## Fault loop “ABC Fault”

Fault loop “ABC Fault” is used exclusively for the three-phase short circuit fault. Figure 600 shows the three-phase fault loop model. The following impedances are measured and stored in the recorded data of SCEFRFLO.

$$Flt\ point\ resistance = R_{fault}$$

(Equation 268)

$$Flt\ loop\ resistance = R_1 + R_{fault}$$

(Equation 269)

$$Flt\ loop\ reactance = Flt\ phase\ reactance = X_1$$

(Equation 270)

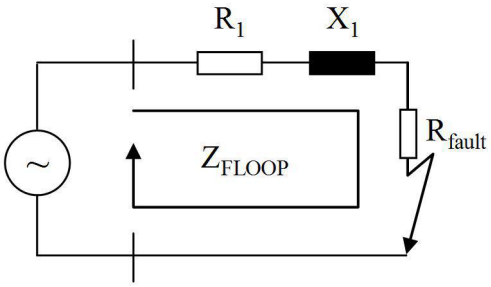



*Figure 600: Fault loop impedance for a three-phase fault loop (“ABC Fault”)*

The three-phase fault distance is calculated with a special measuring element using positive-sequence quantities. This is advantageous especially in case of non-transposed (asymmetric) lines, as the influence of line parameter asymmetry is reduced. If the line is non-transposed, all the phase-to-phase loops have different fault loop reactances. The use of positive-sequence quantities results in the average value of phase-to-phase loop reactances, that is, the most representative estimate in case of three-phase faults.

The fault distance calculation algorithm for the three-phase fault loop is defined with settings *Load Com PP loops* and *Enable simple model*. Options for the selection are "Disabled" or "Enabled".

Load compensation can be enabled or disabled with setting *Load Com PP loops*. The load compensation should be disabled only if the ratio between the fault current and load current is large or when the value of the fault distance estimate for the short circuit fault is required from each shot of an autoreclosing sequence.

The fault distance calculation is most accurate when the calculation is made with the fault loop model. This model requires positive sequence impedances of the protected feeder to be given as settings. If these settings are not available, valid impedance values can be calculated also without the fault loop model with setting *Enable simple model* = "Enabled". However, a valid distance estimate, that is, the conversion of measured impedance (“electrical fault distance’’) into a physical fault distance requires accurate positive-sequence impedance settings.

## Estimation of fault resistance in different fault loops

The fault point resistance value provided by the impedance calculation is available in recorded data Flt point resistance and it depends on the applied fault loop as shown in Figure 601. In case of earth faults, the estimated fault point resistance includes the total fault point resistance between the faulty phase and earth, for example, the arc and earthing resistances. In case of phase-to-phase faults, the estimated fault point resistance is half of the total fault point resistance between the phases. In case of a three-phase fault, the estimated fault point resistance equals the total fault point resistance per phase, for example, the arc resistance per phase.

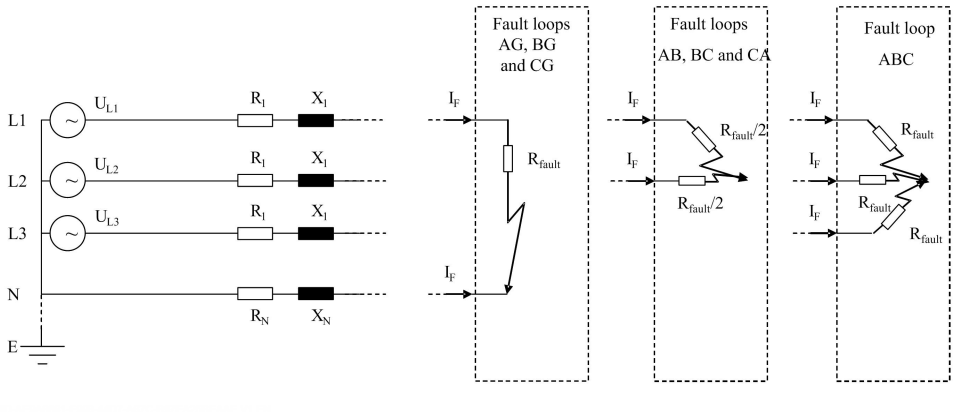



*Figure 601: Definition of a physical fault point resistance in different fault loops*

## Steady-state asymmetry and load compensation

Power systems are never perfectly symmetrical. The asymmetry produces steady-state quantities in the form of zero-sequence and negative-sequence voltages and currents. If not compensated, these are error sources for fault distance calculation especially in case of earth faults. All earth-fault distance calculation algorithms of SCEFRFLO use the delta quantities which mitigate the effects of the steady-state asymmetry.

The load current is another error source for fault distance calculation. Its influence increases with higher fault resistance values. SCEFRFLO employs independent load compensation methods for each fault type to achieve optimal performance. The purpose of load compensation is to improve the accuracy of the fault distance calculation models by estimating the actual fault current in the fault location. Delta-quantities are used for this to mitigate the effect of load current on fault distance estimation.

For earth faults, the load compensation is done automatically inside the fault distance calculation algorithm. For short circuit faults, load compensation is enabled with setting *Load Com PP loops*. The default value is "Enabled". The parameter should be set to "Disabled" only if the ratio between the expected fault current and load current is large or when the fault distance estimate for the short circuit fault is required for each shot of an autoreclosing sequence.

The delta quantity describes the change in measured signal due to the fault.

$$\Delta x = x_{fault} + x_{pre\text{-}fault}$$

(Equation 271)

$x_{fault}$ Signal value during fault

$x_{pre\text{-}fault}$ Signal value during healthy state just before fault

## Result quality indicator

The quality of the estimated fault distance is judged and reported in recorded data as the Flt Dist quality together with the fault distance estimate. The Flt Dist quality is a bit vector indicating detected sources of inaccuracy in the fault distance estimate. If Flt Dist quality equals 1, the result is not affected by error sources. This results in good quality for the fault distance estimate. If factors affecting negatively the fault distance estimation are detected, the Flt Dist quality is according to Table 1044. In this case, the estimated fault distance (Flt distance) value is given on the HMI in parentheses.

*Table 1044: Fault distance quality indicator Flt Dist quality*

| Value | Corresponding inaccuracy description |
|---|---|
| 2 | Estimation stability criterion has not been reached |
| 4 | Fault point resistance exceeds 500 Ω |
| 8 | Fault point resistance exceeds 5 × $X_{loop}$ 1) |
| 16 | Fault point resistance exceeds 20 × $X_{loop}$ 1) |
| 32 | Flt to Lod Cur ratio is below 1.00 |
| 64 | Fault distance estimate outside tolerances (<-0.1 pu or >1.1 pu) |
| 128 | Distance estimate calculation is not done due to too low magnitudes of I or U |
| 256 | Distance estimate calculation cannot be performed (for example avoiding internal division by zero) |

1) Xloop is the total loop reactance according to settings

For example, if fault point resistance exceeds 500 Ω and Flt to Lod Cur ratio is below 1.0, Flt Dist quality is “36”. As another example, if no error sources are found, but stability criterion is not met, the value of Flt Dist quality is “2”.

## Impedance settings

The fault distance calculation in SCEFRFLO is based on the fault loop impedance modeling. The fault loop is parametrized with the impedance settings and these can be set at maximum for three line sections (A, B and C). Each section is enabled by entering a section length, which ranges from zero to settings *Line Len section A*, *Line Len section B* or *Line Len section C* in the order section A-> section B-> section C.

The earth-fault loops require both positive-sequence and zero-sequence impedances, for example, *R1 line section A* and *X1 line section A*, *R0 line section A* and *X0 line section A*. For the short circuit loops, only positive-sequence impedances are needed, but they can be omitted if the setting *Enable simple model* equals "Enabled".

If the impedance settings are in use, it is important that the settings closely match the impedances of the used conductor types. The impedance settings are given in primary ohms [ohm/pu] and the line section lengths in per unit [pu]. Thus, impedances can be either given in ohm/km and section length in km, or ohm/mile and section length in miles. The resulting Flt distance matches the units entered for the line section lengths.

## Positive-sequence impedance values

Fault location requires accurate setting values for line impedances. Positive-sequence impedances are required both for the location of short circuits and earth faults. As data sheet impedance per unit values are generally valid only for a certain tower configuration, the values should be adjusted according to the actual installation configuration. This minimizes the fault location errors caused by inaccurate settings.

The positive-sequence reactance per unit and per phase can be calculated with an approximation equation which applies to symmetrically transposed three-phase aluminium overhead lines without ground wires.

$$X_1 \approx \omega_n \cdot 10^{-4} \left( 2 \cdot \ln \frac{a_{en}}{r} + 0.5 \right) [\Omega / km]$$

(Equation 272)

$\omega_n$ $2 \cdot \pi \cdot f_n$, where $f_n$ = fundamental frequency [Hz]

$a_{en}$ $\sqrt[3]{(a_{12} \cdot a_{23} \cdot a_{31})}$

Geometric average of phase distances [m]

$a_{xy}$ Distance [m] between phases x and y

r Radius [m] for single conductor

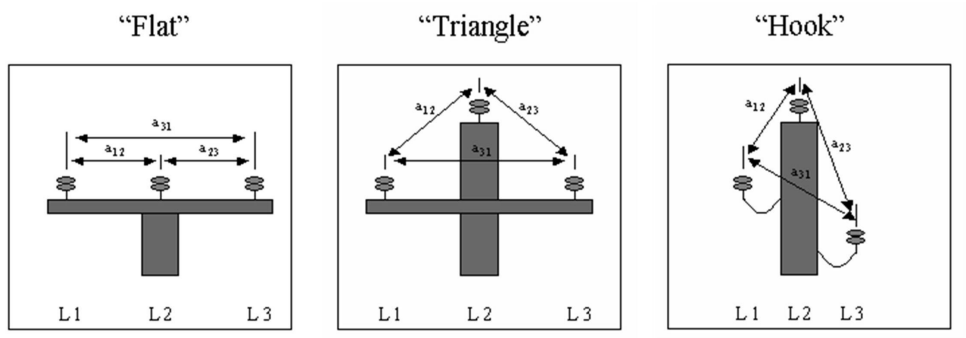



*Figure 602: Typical distribution line tower configurations*

Example values of positive-sequence impedances for typical medium-voltage overhead lines are given in the following tables.

*Table 1045: Positive-sequence impedance values for typical 11 kV conductors, "Flat" tower configuration*

| Name | R1 [Ω/km] | X1 [Ω/km] |
|---|---|---|
| ACSR 50 SQ.mm | 0.532 | 0.373 |
| ACSR 500 SQ.mm | 0.0725 | 0.270 |

*Table 1046: Positive-sequence impedance values for typical 10/20 kV conductors, "Flat" tower configuration*

| Name | R1 [Ω/km] | X1 [Ω/km] |
|---|---|---|
| Al/Fe 36/6 Sparrow | 0.915 | 0.383 |
| Al/Fe 54/9 Raven | 0.578 | 0.368 |
| Al/Fe 85/14 Pigeon | 0.364 | 0.354 |
| Al/Fe 93/39 Imatra | 0.335 | 0.344 |
| Al/Fe 108/23 Vaasa | 0.287 | 0.344 |
| Al/Fe 305/39 Duck | 0.103 | 0.314 |

*Table 1047: Positive-sequence impedance values for typical 33 kV conductors, "Flat" tower configuration*

| Name | R1 [Ω/km] | X1 [Ω/km] |
|---|---|---|
| ACSR 50 sq.mm | 0.529 | 0.444 |
| ACSR 100 sq.mm | 0.394 | 0.434 |
| ACSR 500 sq.mm | 0.0548 | 0.346 |

## Zero-sequence impedance values

Location of earth faults requires both positive-sequence and zero-sequence impedances. For short circuit faults, zero-sequence impedances are not required.

The positive-sequence impedance per unit values for the lines are typically known or can easily be obtained from data sheets. The zero-sequence values are generally not as easy to obtain as they depend on the actual installation conditions and configurations. Sufficient accuracy can, however, be obtained with rather simple calculations using the following equations, which apply per phase for symmetrically transposed three-phase aluminium overhead lines without ground wires.

$$R_0\,[50Hz] \approx R1 + 0.14804\,[\Omega / km]$$

(Equation 274)

$$R_0\,[60Hz] \approx R1 + 0.17765\,[\Omega / km]$$

(Equation 275)

$$X_0 \approx 2 \cdot \omega_n \cdot 10^{-4} \left( 3 \cdot \ln \frac{W}{r_{en}} + 0.25 \right) [\Omega / km]$$

(Equation 276)

$R_1$ Conductor AC resistance [Ω/km]

W $658 \sqrt{\frac{\rho_{earth}}{f_n}}$

Equivalent depth [m] of the earth return path

$\rho_{earth}$ Earth resistivity [Ωm]

$r_{en}$ $\sqrt[3]{r \cdot \sqrt[3]{a_{12}^2 \cdot a_{23}^2 \cdot a_{31}^2}}$

Equivalent radius [m] for conductor bundle

r Radius [m] for single conductor

$a_{xy}$ Distance [m] between phases x and y

## *Ph leakage Ris* and *Ph capacitive React* settings

The *Ph leakage Ris* and *Ph capacitive React* settings are used for improving fault distance estimation accuracy for earth faults. They are critical for an accurate fault location in unearthed networks. In other types of networks they are less critical. The *Ph leakage Ris* setting represents the leakage losses of the protected feeder in terms of resistance per phase. The *Ph capacitive React* setting represents the total phase-to-earth capacitive reactance of the protected feeder per phase. Based on experience, a proper estimate for *Ph leakage Ris* should be about 20…40 · *Ph capacitive React*.

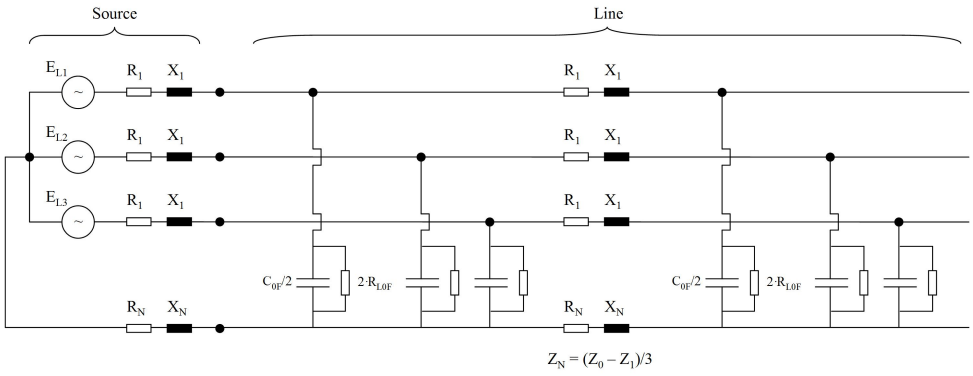



*Figure 603: Equivalent diagram of the protected feeder. $R_{L0F}$ = Ph leakage Ris.*

The determination of the *Ph capacitive React* setting can be based either on network data or measurement. If the total phase-to-earth capacitance (including all branches) per phase $C_{0F}$ of the protected feeder is known, the setting value can be calculated.

$$Ph\ capacitive\ React = \frac{1}{\left(\omega_n \cdot C_{0F}\right)}$$

(Equation 277)

In case of unearthed network, if the earth-fault current produced by the protected feeder $I_{ef}$ is known, the setting value can be calculated.

$$Ph\ capacitive\ React = \frac{\sqrt{3} \cdot U_{xy}}{I_{ef}}$$

(Equation 278)

$U_{xy}$ Phase-to-phase voltage

SCEFRFLO can also determine the value for the *Ph capacitive React* setting by measurements. The calculation of *Ph capacitive React* is triggered by the binary signal connected to the TRIGG_XC0F input when an earth-fault test is conducted outside the protected feeder during commissioning, for example, at the substation busbar. The *Calculation Trg mode* has to be "External". After the activation of the TRIGG_XC0F triggering input, the calculated value for setting *Ph capacitive React* is obtained from recorded data as parameter *XC0F Calc*. This value has to be manually entered for the *Ph capacitive React* setting. The calculated value matches the current switching state of the feeder so if the switching state of the protected feeder changes, the value should be updated.

Figure 604 shows an example configuration, which enables the measurement of setting *Ph capacitive React*.

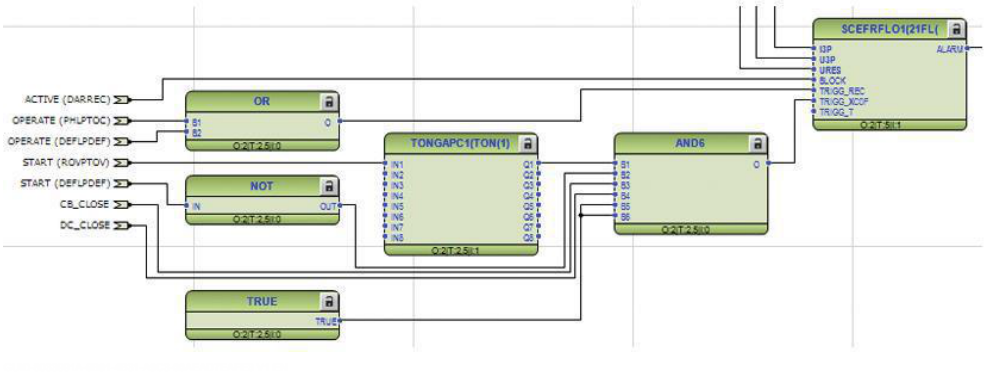



*Figure 604: An example configuration, which enables the measurement of setting Ph capacitive React*

If the earth fault is detected by the residual overvoltage function (START of ROVPTOV), but not seen by the forward-looking earth-fault protection function (START of DEFLPDEF), the fault is located outside the protected feeder. This is mandatory for a valid measurement of setting *Ph capacitive React*. After a set delay (TONGAPC), the input TRIGG_XC0F is activated and the parameter *XC0F Calc* in the recorded data is updated. The delay (TONGAPC) must be set longer than the start delay of the directional earth-fault function DEFLPDEF, but shorter than the minimum operating time of the directional earth-fault functions in any of the feeders. For example, if the start delay is 100 ms and the shortest operating time is 300 ms, a value of 300 ms can be used. Circuit breaker and disconnector status is used to verify that the entire feeder is measured.

## Modeling a non-homogeneous line

A typical distribution feeder is built with several different types of overhead lines and cables. This means that the feeder is electrically non-homogeneous. SCEFRFLO allows the modeling of the line impedance variation in the protection relay with three line sections with independent impedance settings. This improves the accuracy of the physical fault distance conversion done in the protection relay, especially when the line impedance non-homogeneity is severe. Each section is enabled by entering a

section length, which differs from zero, to settings *Line Len section A*, *Line Len section B* or *Line Len section C* in the order section A-> section B-> section C.

The impedance model with one line section is enabled by setting *Line Len section A* to differ from zero. In this case, the impedance settings *R1 line section A*, *X1 line section A*, *R0 line section A* and *X0 line section A* are used for the fault distance calculation and for conversion from reactance to physical fault distance. This option should be used only in the case of a homogeneous line, that is, when the protected feeder consists of only one conductor type.

The impedance model with two line sections is enabled by setting both *Line Len section A* and *Line Len section B* to differ from zero. In this case, the impedance settings *R1 line section A*, *X1 line section A*, *R0 line section A*, *X0 line section A*, *R1 line section B*, *X1 line section B*, *R0 line section B* and *X0 line section B* are used for the fault distance calculation and for conversion from reactance to physical fault distance. This option should be used in the case of a non-homogeneous line when the protected feeder consists of two types of conductors.

The impedance model with three line sections is enabled by setting *Line Len section A*, *Line Len section B* and *Line Len section C* to differ from zero. In this case, the impedance settings *R1 line section A*, *X1 line section A*, *R0 line section A*, *X0 line section A*, *R1 line section B*, *X1 line section B*, *R0 line section B*, *X0 line section B*, *R1 line section C*, *X1 line section C*, *R0 line section C* and *X0 line section C* are used for the fault distance calculation and for conversion from reactance to physical fault distance. This option should be used in the case of a non-homogeneous line when the protected feeder consists of more than two types of conductors.

The effect of line impedance non-homogeneity on the conversion of fault loop reactance into physical fault distance is demonstrated in the example shown in Figure 605 with a 10-km-long feeder with three line types. The total line impedance for the 10 km line is R1 = 6.602 Ω (0.660 Ω/km) and X1 = 3.405 Ω (0.341 Ω/km), consisting of the following sections and impedance values.

- 4 km of PAS 150 (R1 = 0.236 Ω/km, X1 = 0.276 Ω/km)
- 3 km of Al/Fe 54/9 Raven (R1 = 0.536 Ω/km, X1 = 0.369 Ω/km)
- 3 km of Al/Fe 21/4 Swan (R1 = 1.350 Ω/km, X1 = 0.398 Ω/km)

The non-homogeneity of feeder impedance can be illustrated by drawing the protected feeder in RX-diagram (in the impedance plane), as shown in Figure 605.

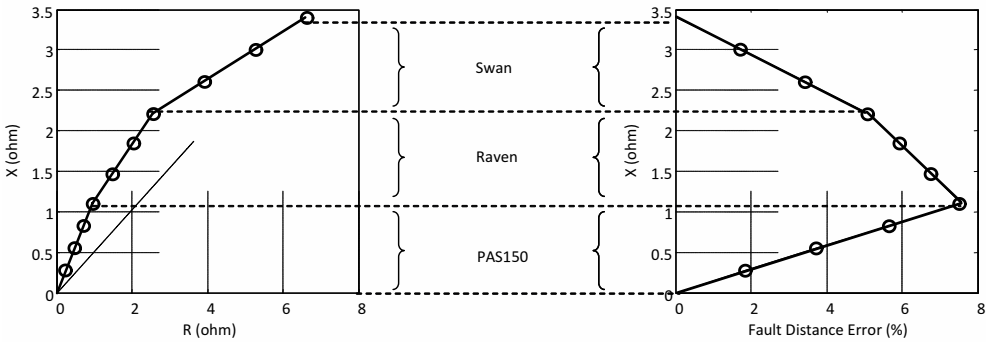



*Figure 605: Example impedance diagram of an electrically non-homogeneous feeder (left), and the resulting error in fault distance if the measured fault loop reactance is converted into physical fault distance by using only one line section parameters (right).*

In Figure 605 the feeder is modeled either with one or three line sections with parameters given in Table 1048.

*Table 1048: Impedance settings*

| Parameter | Impedance model with one section | Impedance model with three sections |
|---|---|---|
| R1 line section A | 0.660 Ω/pu | 0.236 Ω/pu |
| X1 line section A | 0.341 Ω/pu | 0.276 Ω/pu |
| Line Len section A | 10.000 pu | 4.000 pu |
| R1 line section B | N/A | 0.536 Ω/pu |
| X1 line section B | N/A | 0.369 Ω/pu |
| Line Len section B | 0.000 pu | 3.000 pu |
| R1 line section C | N/A | 1.350 Ω/pu |
| X1 line section C | N/A | 0.398 Ω/pu |
| Line Len section C | 0.000 pu | 3.000 pu |

Figure 605 illustrates the error when converting the measured fault loop reactance into physical fault distance. The fault location is varied from 1 km to 10 km in 1 km steps (marked with circles). An error of nearly eight per cent at maximum is created by the conversion procedure when modeling a non-homogenous line with only one section. By using impedance model with three line sections, there is no error in the conversion.

The previous example assumed a short circuit fault and thus, only positive-sequence impedance settings were used. The results, however, also apply to earth faults.

## Taps or spurs in the feeder

If the protected feeder consists of taps or spurs, the measured fault impedance corresponds to several physical fault locations (for example, A or B in Figure 606). The actual fault location must be identified using additional information, for example, short circuit current indicators placed on tapping points.

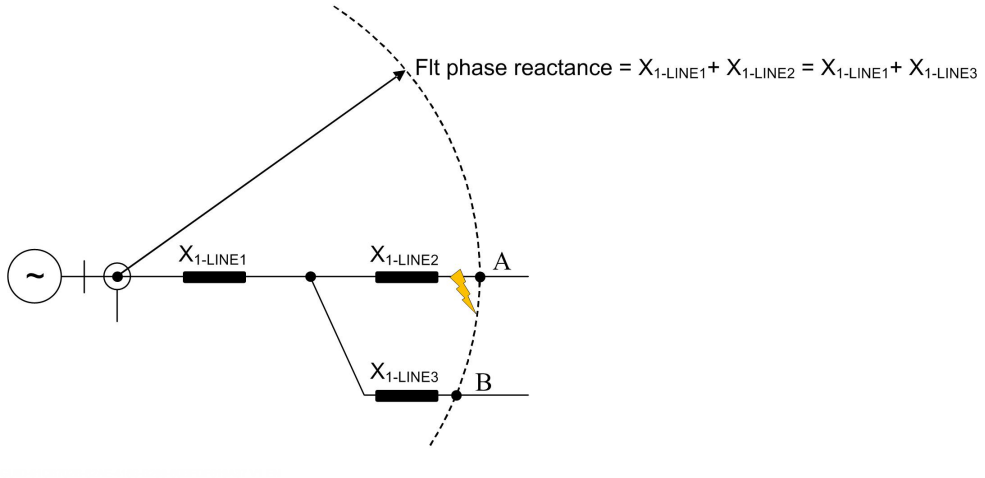



*Figure 606: Fault on a distribution line with spurs*

## Trigger detection

The fault distance estimate is obtained when SCEFRFLO is triggered. The triggering method is defined with setting *Calculation Trg mode*. The options for selection are "External" or "Internal", where the default value is "External". The TRIGG_OUT event indicates the fault distance value recording moment. The fault distance estimate, Flt distance, together with the time stamp of actual triggering are saved in the recorded data of SCEFRFLO.

- In case of external triggering, an external trigger signal should be connected to the TRIGG_REC input. The triggering signal is typically a trip signal from a protective function. At triggering moment the fault distance is stored into recorded data. It is important that triggering be timed suitably to provide sufficient time for the distance estimation calculation before tripping of the feeder circuit breaker.
- In case of internal triggering, the TRIGG_REC input is not used for triggering. Instead, the trigger signal is created internally so that the estimation is started when Phase selection logic detects a fault and the estimate is triggered when its value has stabilized sufficiently. This is judged by maximum variation in fault distance estimate and defined with setting *Distance estimate Va* (in the same unit as the fault distance estimate). When successive estimates during one fundamental cycle are within “final value ± *Distance estimate Va*”, the fault distance estimate (mean of successive estimates) is recorded. If the stabilization criterion has not been fulfilled, the fault distance estimate is given right before the fault ends. Phase selection logic is a non-directional function so internal triggering should not be used when directionality is required.

Generally, SCEFRFLO requires a minimum of two fundamental cycles of measuring time after the fault occurrence. Figure 607 illustrates the typical behavior of fault distance estimate of SCEFRFLO as a function of time.

- Immediately after the fault occurrence, the estimate is affected by initial fault transients in voltages and currents.
- Approximately one fundamental cycle after the fault occurrence, the fault distance estimate starts to approach the final value.
- Approximately two fundamental cycles after the fault occurrence, the stability criterion for fault distance estimate is fulfilled and the TRIGG_OUT event is sent. The recorded data values are stored at this moment.

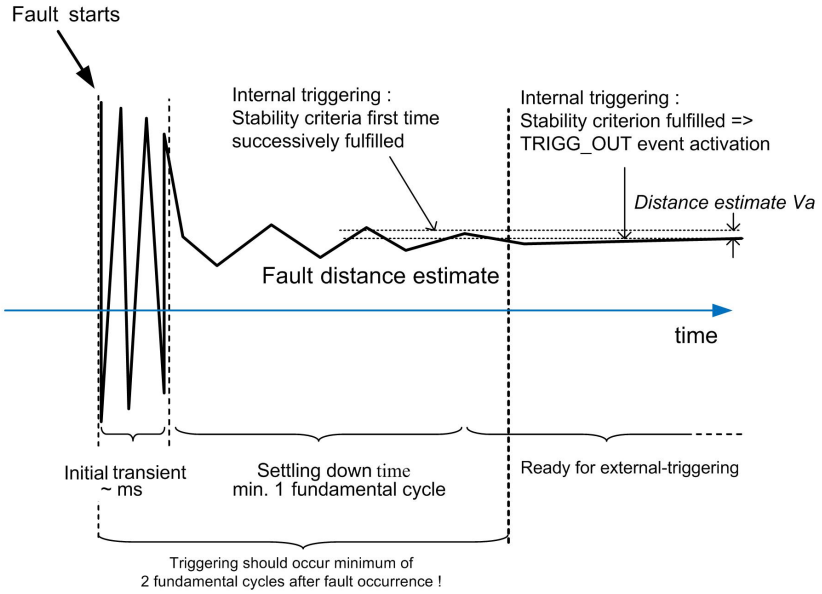



*Figure 607: The behavior of fault distance estimate in time*

## Alarm indication

SCEFRFLO contains an alarm output for the calculated fault distance. If the calculated fault distance FLT_DISTANCE is between the settings *Low alarm Dis limit* and *High alarm Dis limit*, the ALARM output is activated. If setting *High alarm Dis limit* has been set below *Low alarm Dis limit*, the ALARM operation is inverted: the ALARM output is activated if *High alarm Dis limit* is undershot or *Low alarm Dis limit* is exceeded. The default value for both is zero so that no distance estimate activates ALARM.

The ALARM output can be used, for example, in regions with waterways or other places where knowledge of certain fault locations is of high importance.

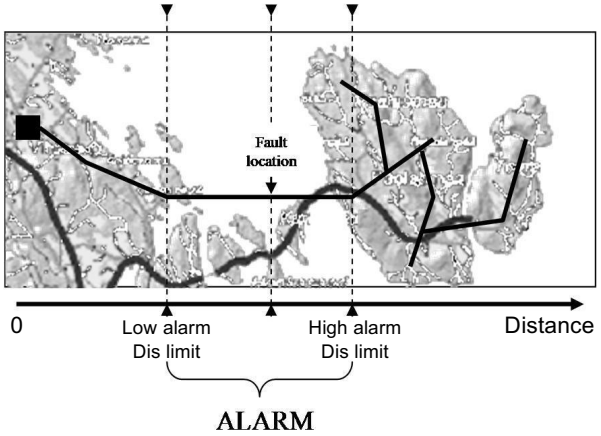



*Figure 608: An example of the ALARM output use*

### Recorded data

All the information required for a later fault analysis is recorded to SCEFRFLO recorded data. In the protection relay, recorded data is found in **Monitoring/ Recorded data/Other protection/SCEFRFLO**.

SCEFRFLO has also monitored data values which are used for the readout of continuous calculation values. Table 1049 shows which of the recorded data values are available as continuous monitoring values during a fault.

*Table 1049: Recorded and monitored data values*

| Recorded data | Monitored data |
|---|---|
| Flt loop | FAULT_LOOP |
| Flt distance | FLT_DISTANCE |
| Flt Dist quality | FLT_DIST_Q |
| Flt loop resistance | RFLOOP |
| Flt loop reactance | XFLOOP |
| Flt phase reactance | XFPHASE |
| Flt point resistance | RF |
| Flt to Lod Cur ratio | IFLT_PER_ILD |
| Equivalent load Dis | S_CALC |
| XC0F Calc | XC0F_CALC |

## 5.7.6 Measurement modes

The full operation of SCEFRFLO requires that all three phase-to-earth voltages are measured. The voltages can be measured with conventional voltage transformers or voltage dividers connected between the phase and earth (*VT connection* is set to "Wye"). Another alternative is to measure phase-to-phase voltages (*VT connection* is

set to "Delta") and residual voltage (Uo). Both alternatives are covered by setting the configuration parameter *Phase voltage Meas* to "Accurate".

The function can operate correctly with only two phase-to-earth voltages if the residual voltage is also measured and connected to the source UTVTR which provides the phase-to-earth voltages to the function. In this case, the missing phase-to-earth voltage is correctly calculated internally in the relay. If the measured residual voltage is connected to SCEFRFLO input URES, *Phase voltage Meas* can be set to "Accurate".

When the *Phase voltage Meas* setting is set to "Ph-to-ph without Uo" and only phase-to-phase voltages are available (but not Uo), only short-circuit measuring loops (fault loops “AB Fault”, “BC Fault”, “CA Fault” or “ABC Fault”) can be measured accurately. In this case, the earth-fault loops (fault loops “AG Fault”, “BG Fault” or “CG Fault”) cannot provide correct fault distance estimates and the triggering of the function in case of an earth fault is automatically disabled. The situation is similar if only two phase-to-earth voltages are measured and the measured residual voltage is not connected to SCEFRFLO.

## 5.7.7 Application

The main objective of the feeder terminals is a fast, selective and reliable operation in case of faults inside the protected feeder. In addition, information on the distance to the fault point is very important for those involved in operation and maintenance. Reliable information on the fault location greatly decreases the downtime of the protected feeders and increases the total availability of a power system.

SCEFRFLO provides impedance-based fault location. It is designed for radially operated distribution systems and is applicable for locating short circuits in all kinds of distribution networks. Earth faults can be located in effectively earthed and low-resistance/low-reactance earthed networks. With certain limitations, SCEFRFLO can also be used for locating an earth fault in unearthed distribution networks.

### Configuration example

A typical configuration example for SCEFRFLO triggering is illustrated in Figure 604 where external triggering is applied, that is, *Calculation Trg mode* is set to "External".

The OPERATE signal from the non-directional overcurrent function PHLPTOC is used to provide an indication of a short circuit fault. The OPERATE signal from the directional earth-fault function DEFLPDEF is used to provide an indication of an earth fault at the protected feeder.

### SCEFRFLO with the autoreclosing function

When SCEFRFLO is used with the autoreclosing sequence, the distance estimate from the first trip is typically the most accurate one. The fault distance estimates from successive trips are possible but accuracy can be decreased due to inaccurate load compensation. During the dead time of an autoreclosing sequence, the load condition of the feeder is uncertain.

The triggering of SCEFRFLO can also be inhibited during the autoreclosing sequence. This is achieved by connecting the signal ACTIVE from the autoreclosing function DARREC, which indicates that the autoreclosing sequence is in progress, to the BLOCK input of SCEFRFLO. Blocking of the SCEFRFLO triggering is indicated during the autoreclosing sequence when the load compensation or steady-state asymmetry elimination is based on the delta quantities. This applies to the short circuit faults when *Load Com PP loops* is set to "Enabled" or, to earth faults, when *EF algorithm Sel* is set to "Load compensation" or "Load modelling".

## 5.7.8 Signals

*Table 1050: SCEFRFLO Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Signal for blocking the triggering |
| TRIGG_REC | BOOLEAN | 0=False | Distance calculation triggering signal |
| TRIGG_XC0F | BOOLEAN | 0=False | XC0F calculation triggering signal |
| TRIGG_T | BOOLEAN | 0=False | Start calculation sequence for compensation network |

*Table 1051: SCEFRFLO Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Fault location alarm signal |

## 5.7.9 Settings

*Table 1052: SCEFRFLO Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Flt Loc Det mode | 2=Non-comp<br>1=Comp, switched R | | | 2=Non-comp | Fault location detection mode |
| Z Max phase load | 1.0...10000.0 | ohm | 0.1 | 80.0 | Impedance per phase of max. load, overcurr./under-imp., PSL |
| Ph leakage Ris | 20...1000000 | ohm | 1 | 210000 | Line PhE leakage resistance in primary ohms |
| Ph capacitive React | 10...1000000 | ohm | 1 | 7000 | Line PhE capacitive reactance in primary ohms |
| R1 line section A | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line resistance, line section A |
| X1 line section A | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line reactance, line section A |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| R0 line section A | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line resistance, line section A |
| X0 line section A | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line reactance, line section A |
| Line Len section A | 0.000...1000.000 | pu | 0.001 | 0.000 | Line length, section A |

*Table 1053: SCEFRFLO Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| High alarm Dis limit | 0.000...1.000 | pu | 0.001 | 0.000 | High alarm limit for calculated distance |
| Low alarm Dis limit | 0.000...1.000 | pu | 0.001 | 0.000 | Low alarm limit for calculated distance |
| Equivalent load Dis | 0.00...1.00 | | 0.01 | 0.50 | Equivalent load distance when EF algorithm equals to load modelling |
| R1 line section B | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line resistance, line section B |
| X1 line section B | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line reactance, line section B |
| R0 line section B | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line resistance, line section B |
| X0 line section B | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line reactance, line section B |
| Line Len section B | 0.000...1000.000 | pu | 0.001 | 0.000 | Line length, section B |
| R1 line section C | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line resistance, line section C |
| X1 line section C | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line reactance, line section C |
| R0 line section C | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line resistance, line section C |
| X0 line section C | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line reactance, line section C |
| Line Len section C | 0.000...1000.000 | pu | 0.001 | 0.000 | Line length, section C |

*Table 1054: SCEFRFLO Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Phase voltage Meas | 1=Accurate<br>2=Ph-to-ph without Uo | | | 1=Accurate | Phase voltage measurement principle |
| Calculation Trg mode | 1=Internal<br>2=External | | | 2=External | Trigger mode for distance calculation |

*Table 1055: SCEFRFLO Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| EF algorithm Sel | 1=Load compensation<br>2=Load modelling | | | 1=Load compensation | Selection for PhE-loop calculation algorithm |
| EF algorithm Cur Sel | 1=Io based<br>2=I2 based | | | 1=Io based | Selection for earth-fault current model |
| Load Com PP loops | 0=Disabled<br>1=Enabled | | | 1=Enabled | Enable load compensation for PP/3P-loops |
| Enable simple model | 0=Disabled<br>1=Enabled | | | 0=Disabled | Enable calc. without impedance settings for PP/3P-loops |
| Time delay | 0...3000 | ms | 10 | 100 | Time delay to start calculation in compensated networks |
| Zero Ris Curr change | 0.005...1.000 | xIn | 0.001 | 0.010 | Change in measured resistive component current due to fault |
| Distance estimate Va | 0.001...0.300 | | 0.001 | 0.015 | Allowed variation of short circuit distance estimate |

## 5.7.10 Monitored data

*Table 1056: SCEFRFLO Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| RF | FLOAT32 | 0.0...1000000.0 | ohm | Fault point resistance in primary ohms |
| FAULT_LOOP | Enum | 1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault<br>-5=No fault | | Fault impedance loop |
| FLT_DISTANCE | FLOAT32 | 0.00...3000.00 | pu | Fault distance in units selected by the user |
| FLT_DIST_Q | INT32 | 0...511 | | Fault distance quality |
| RFLOOP | FLOAT32 | 0.0...1000000.0 | ohm | Fault loop resistance in primary ohms |
| XFLOOP | FLOAT32 | 0.0...1000000.0 | ohm | Fault loop reactance in primary ohms |
| XFPHASE | FLOAT32 | 0.0...1000000.0 | ohm | Positive sequence fault reactance in primary ohms |
| IFLT_PER_ILD | FLOAT32 | 0.00...60000.00 | | Fault to load current ratio |
| S_CALC | FLOAT32 | 0.00...1.00 | | Estimated equivalent load distance |
| XC0F_CALC | FLOAT32 | 0.0...1000000.0 | ohm | Estimated PhE capacitive reactance of line |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SCEFRFLO | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| Triggering time | Timestamp | | | Estimate triggering time |
| Flt loop | Enum | 1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault<br>-5=No fault | | Fault loop |
| Flt distance | FLOAT32 | 0.00...3000.00 | pu | Fault distance |
| Flt Dist quality | INT32 | 0...511 | | Fault distance quality |
| Flt loop resistance | FLOAT32 | 0.0...1000000.0 | ohm | Fault loop resistance |
| Flt loop reactance | FLOAT32 | 0.0...1000000.0 | ohm | Fault loop reactance |
| Flt phase reactance | FLOAT32 | 0.0...1000000.0 | ohm | Fault phase reactance |
| Flt point resistance | FLOAT32 | 0.0...1000000.0 | ohm | Fault resistance |
| Flt to Lod Cur ratio | FLOAT32 | 0.00...60000.00 | | Fault to load current ratio |
| Equivalent load Dis | FLOAT32 | 0.00...1.00 | | Estimated equivalent load distance |
| XC0F Calc | FLOAT32 | 0.0...1000000.0 | ohm | Estimated PhE capacitive reactance of the line |
| Pre fault time | Timestamp | | | Pre-fault time |
| A Pre Flt Phs A Magn | FLOAT32 | 0.00...40.00 | xIn | Pre-fault current phase A, magnitude |
| A Pre Flt Phs A Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault current phase A, angle |
| A Pre Flt Phs B Magn | FLOAT32 | 0.00...40.00 | xIn | Pre-fault current phase B, magnitude |
| A Pre Flt Phs B Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault current phase B, angle |
| A Pre Flt Phs C Magn | FLOAT32 | 0.00...40.00 | xIn | Pre-fault current phase C, magnitude |
| A Pre Flt Phs C Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault current phase C, angle |
| V Pre Flt Phs A Magn | FLOAT32 | 0.00...40.00 | xUn | Pre-fault voltage phase A, magnitude |
| V Pre Flt Phs A Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault voltage phase A, angle |
| V Pre Flt Phs B Magn | FLOAT32 | 0.00...40.00 | xUn | Pre-fault voltage phase B, magnitude |
| V Pre Flt Phs B Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault voltage phase B, angle |
| V Pre Flt Phs C Magn | FLOAT32 | 0.00...40.00 | xUn | Pre-fault voltage phase C, magnitude |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| V Pre Flt Phs C Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault voltage phase C, angle |
| A Flt Phs A Magn | FLOAT32 | 0.00...40.00 | xIn | Fault current phase A, magnitude |
| A Flt Phs A angle | FLOAT32 | -180.00...180.00 | deg | Fault current phase A, angle |
| A Flt Phs B Magn | FLOAT32 | 0.00...40.00 | xIn | Fault current phase B, magnitude |
| A Flt Phs B angle | FLOAT32 | -180.00...180.00 | deg | Fault current phase B, angle |
| A Flt Phs C Magn | FLOAT32 | 0.00...40.00 | xIn | Fault current phase C, magnitude |
| A Flt Phs C angle | FLOAT32 | -180.00...180.00 | deg | Fault current phase C, angle |
| V Flt Phs A Magn | FLOAT32 | 0.00...40.00 | xUn | Fault voltage phase A, magnitude |
| V Flt Phs A angle | FLOAT32 | -180.00...180.00 | deg | Fault voltage phase A, angle |
| V Flt Phs B Magn | FLOAT32 | 0.00...40.00 | xUn | Fault voltage phase B, magnitude |
| V Flt Phs B angle | FLOAT32 | -180.00...180.00 | deg | Fault voltage phase B, angle |
| V Flt Phs C Magn | FLOAT32 | 0.00...40.00 | xUn | Fault voltage phase C, magnitude |
| V Flt Phs C angle | FLOAT32 | -180.00...180.00 | deg | Fault voltage phase C, angle |

## 5.7.11 Technical data

*Table 1057: SCEFRFLO Technical data*

| Characteristic | Value |
|---|---|
| Measurement accuracy | At the frequency f = $f_n$<br>Impedance:<br>±2.5% or ±0.05 Ω<br>Distance:<br>±2.0% or ±0.04 km/0.025 mile<br>XC0F_CALC:<br>±3% or ±0.01 Zn/1.15 Ω<br>IFLT_PER_ILD:<br>±5% or ±0.05 |

# 5.8 Switch-onto-fault protection CVPSOF

## 5.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Switch-onto-fault protection | CVPSOF | CVPSOF | SOFT |

## 5.8.2 Function block




*Figure 609: Function block*

## 5.8.3 Functionality

The switch-onto-fault function CVPSOF is a complementary function, especially to the distance protection function (DSTPDIS), but it can also be used to complement the non-directional or directional overcurrent protection functions (PHxPTOC, DPHxPDOC).

CVPSOF accelerates the operation of the protection ensuring a fast trip when the breaker is closed onto faulted feeder or bus. Without CVPSOF the measured voltages may be too small for the impedance zones or the directional overcurrent stages to operate reliably. This condition exists when the voltage transformers are located in the feeder or the bus side to be energized and therefore the voltage memory required for a correct directional measurement is not available.

## 5.8.4 Analog channel configuration

CVPSOF has two analog group inputs which must be properly configured.

*Table 1058: Analog inputs*

| Input | Description |
|---|---|
| I3P[1)] | Three-phase currents<br>Necessary when *Operation mode* is other than "Start" |
| U3P[2)] | Three-phase voltages<br>Necessary when *Operation mode* is other than "Start" |

1) Can be connected to GRPOFF if *Operation mode* is set to "Start" and *Automatic SOTF Ini* is set to "DLD disabled" or "Voltage"
2) Can be connected to GRPOFF if *Operation mode* is set to "Start" and *Automatic SOTF Ini* is set to "DLD disabled" or "Current"

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

*Table 1059: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.8.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of CVPSOF can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

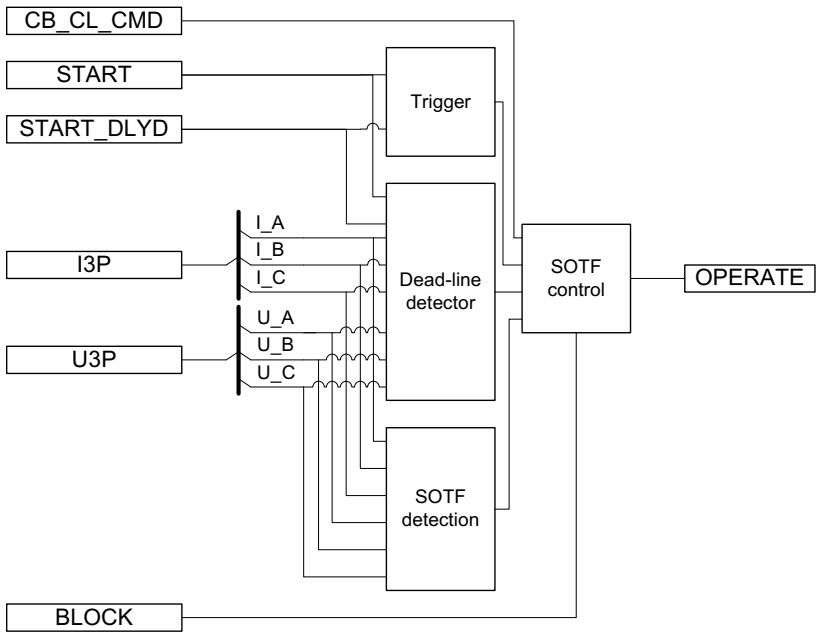



*Figure 610: Functional module diagram*

## Trigger

This module is used for detecting a possible fault immediately after circuit breaker closing. The use of external protection function, typically the start signal from a non-directional distance zone or overcurrent stage, is required for fault indication. The START and START_DLYD inputs are available for the purpose.

- The START input has no delay. Thus, a switch-onto-fault situation is immediately signalled to SOTF control.
- START_DLYD is used when an additional delay is required to start the signal. The switch-onto-fault situation is signalled to the SOTF control after the set *Operate delay time*.

## Dead-line detector

The dead line detection should be used only when the voltage transformers are located on the line side of the circuit breaker.

The *Automatic SOTF Ini* setting is used to configure the internal dead line detection function.

*Table 1060: Options for dead line detection*

| Automatic SOTF Ini | Description |
|---|---|
| DLD disabled | The dead line detection function is disabled. This operation mode must be applied when voltage transformers are located on the bus side of the circuit breaker. |
| Voltage | The dead line detection function is enabled and based solely on the undervoltage condition. A dead line condition is declared, if all the phase voltages are below the *Voltage dead Lin Val* setting. The dead line is detected if the dead line condition is declared and simultaneously no fault is detected by the START and START_DLYD inputs . The dead line condition is signalled to the SOTF control after the delay defined with the *Dead line time* setting. |
| Current | The dead line detection function is enabled and based solely on the undercurrent condition. A dead line condition is declared, if all the phase currents are below the *Current dead Lin Val* setting. The dead line is detected if the dead line condition is declared and simultaneously no fault is detected by the START and START_DLYD inputs. The dead line condition is signalled to the SOTF control after delay defined with the *Dead line time* setting. |
| Current & Voltage | The dead line detection function is enabled and based on undercurrent and undervoltage condition. A dead line condition is declared, if all the phase currents are below the *Current dead Lin Val* setting and simultaneously all phase voltages are below the *Voltage dead Lin Val* setting. The dead line is detected if the dead line condition is declared and simultaneously no fault is detected by the START and START_DLYD inputs. The dead line condition is signalled to the SOTF control after delay defined with the *Dead line time* setting. |

## SOTF detection

The purpose of this module is to detect the switch onto fault situation based on the current and voltage measurements. If the voltage, in any of the phases, is below the *Voltage dead Lin Val* setting and simultaneously the current in the same phase exceeds the *Current dead Lin Val* setting, the SOTF situation is signalled to SOTF control module after the set *Cur voltage Det time*.

## SOTF control

The SOTF control module needs to be activated before the operation is possible in the switch-onto-fault situation. There are two ways to activate the SOTF control module.

- By CB_CL_CMD (circuit breaker closing command)
- By the dead line condition received from the dead line detection module

Dead line detection should be used only when the voltage transformers are located on the line side of the circuit breaker.

When the CB_CL_CMD input is activated or the dead line condition is detected, the SOTF control module becomes active. The reset timer is started when CB_CL_CMD is inactivated or the dead line condition disappears. Thus, the module becomes inactive after the set *SOTF reset time* is exceeded.

When the SOTF control module is active, the *Operation mode* setting defines the operation criteria for the detection of a switch-onto-fault condition. The detection can be based on the external start signals from the distance or overcurrent functions, on the measured internal voltage and current levels, or on both.

*Table 1061: Options for SOTF detection*

| Operation mode | Description |
|---|---|
| Start | The OPERATE output is activated immediately after a signal from the trigger module. This indicates that the breaker is closed onto fault. |
| Current & Voltage | The OPERATE output is activated immediately after a signal from the SOTF detection module. This indicates that the breaker is closed onto fault. This operation mode can be used, for example, if the non-directional distance zone is not available. |
| Both | The OPERATE output is activated immediately after a signal from the trigger or SOTF detection modules. This indicates that the breaker is closed onto fault. |

The OPERATE output can be blocked by activating the BLOCK input.

## 5.8.6 Application

The operation of CVPSOF is generally based on the non-directional distance zone or the non-directional overcurrent stage. When the feeder-side voltage transformers are used for providing the polarization quantity for the distance or directional overcurrent protection, the use of non-directional impedance or current based protection for starting CVPSOF secures a fast switch-onto-fault tripping in the close-in three-phase short circuits. The non-directional protection provides a fast fault clearance when the protection is used for energizing a bus from the feeder with a short circuit fault in it. Other protection functions, like time delayed zero-sequence overcurrent functions, can be connected to CVPSOF to increase the dependability of the scheme. The other main advantage of using CVPSOF is that it typically accelerates the tripping in case of energizing a feeder onto a fault. Without CVPSOF, this tripping is normally performed by the normal time-graded protection or alternatively by the time-delayed local backup protection, for which operating times are considerably longer than with CVPSOF tripping.

An internal dead line detection check is provided to activate the function when the voltage transformers are located on the feeder side. An initiation by the dead line detection is highly recommended for the busbar configurations where more than one circuit breaker at one feeder end can energize the protected feeder or the feeder can also be energized from the other end.

### Setting guidelines

Input START: If a distance zone is used for starting the switch-onto-fault function, the zone has to be set to cover the entire protected feeder with a safety margin of minimum 20 percent. If the non-directional zone is not available, the internal *Current & Voltage* criterion or the start signal from the GFC function can be used instead. If a non-directional overcurrent is used for starting, the current setting must not be higher than what is required for the non-delayed and dependable tripping for a close-in three-phase fault during minimum source conditions. If the short-circuit current along the feeder is considerably higher than the maximum load currents, it is possible that the whole feeder length is covered by CVPSOF tripping. If it is required to delay the tripping, for example, due to high inrush currents, the starting signal can be connected to the START_DLYD input instead.

The *Current dead Lin Val* setting parameter is set to 20 percent of the base current by default. The parameter must be set with a sufficient margin of 15...20 percent under the minimum expected load current. The setting must still exceed the maximum charging current of a feeder.

The *Voltage dead Lin Val* setting parameter is set to 70 percent of the base voltage by default. This is a suitable setting in most cases, but it is recommended to check the suitability in the actual application.

The *Cur voltage Det time* setting parameter is set to 0.02 seconds by default. This is suitable in most applications. This delay can be coordinated, for example, with the dead time settings of the AR shots to prevent the release of CVPSOF by the dead line detection function when the high-speed autoreclosing is in progress.

The *Dead line time* setting parameter is set to 0.2 seconds by default. This is suitable in most applications. The delay must not be set too short to avoid unwanted activations during the transients in the system.

The *SOTF reset time* setting parameter is set to 1 second by default. This is suitable for most applications.

## 5.8.7 Signals

*Table 1062: CVPSOF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| Table continues on next page | | | |

| Name | Type | Default | Description |
|---|---|---|---|
| CB_CL_CMD | BOOLEAN | 0=False | External enabling of SOTF by CB close command |
| START | BOOLEAN | 0=False | Start from function to be accelerated by SOTF |
| START_DLYD | BOOLEAN | 0=False | Start from function to be accelerated with delay by SOTF |

*Table 1063: CVPSOF Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |

## 5.8.8 Settings

*Table 1064: CVPSOF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 1065: CVPSOF Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation mode | 1=Start<br>2=Current&voltage<br>3=Both | | | 3=Both | Mode of operation of SOTF Function |
| Automatic SOTF Ini | 1=DLD disabled<br>2=Voltage<br>3=Current<br>4=Current&voltage | | | 2=Voltage | Automatic switch onto fault initialization |
| Current dead Lin Val | 0.01...1.00 | xIn | 0.01 | 0.20 | Dead line value, current. Used also in auto activation logic |
| Voltage dead Lin Val | 0.01...0.58 | xUn | 0.01 | 0.40 | Dead line value, voltage. Used also in auto activation logic |
| Cur voltage Det time | 0...60000 | ms | 10 | 20 | Time delay for voltage and current based detection |
| Operate time delay | 0...120000 | ms | 10 | 20 | Delay for the delayed start input |
| SOTF reset time | 0...60000 | ms | 10 | 1000 | SOTF detection period after initialization |
| Dead line time | 0...60000 | ms | 10 | 200 | Delay time for activation of dead line detection |

## 5.8.9 Monitored data

*Table 1066: CVPSOF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| CVPSOF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 5.8.10 Technical data

*Table 1067: CVPSOF Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2Hz |
| | Current: ±1.5% of the set value or ±0.002 × $I_n$<br>Voltage: ±1.5% of the set value or ±0.002 × $U_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 5.9 Local acceleration logic DSTPLAL

### 5.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Local acceleration logic | DSTPLAL | LAL | 21LAL |

### 5.9.2 Function block




*Figure 611: Function block*

### 5.9.3 Functionality

The local acceleration logic function DSTPLAL is a complementary function to the distance protection function DSTPDIS. DSTPLAL is not intended for a stand-alone use.

The main purpose of DSTPLAL is to achieve a fast fault clearing which is independent of the fault location on the protected feeder when no communication channel is available between the local and remote terminals. DSTPLAL enables a fast fault clearing during certain conditions, but the function cannot completely replace the communication scheme logic.

DSTPLAL can be controlled either by the autorecloser (zone extension logic) or by monitoring the loss of load currents (the loss of load logic). Both operation modes are enabled independently.

## 5.9.4 Analog channel configuration

DSTPLAL has one analog group input which must be properly configured.

*Table 1068: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.9.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DSTPLAL can be described with a module diagram. All the modules in the diagram are explained in the next sections.

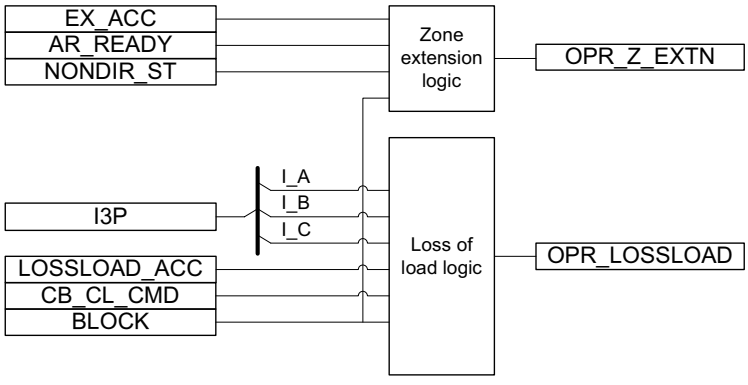



*Figure 612: Functional module diagram*

### Zone extension logic

Zone extension logic is enabled with *Operation mode* = "Zone extension".

When the zone extension operation mode is enabled, the autoreclosing function DARREC enables a fast fault clearance that covers the entire length of the protected feeder. This is achieved by allowing a time-delayed overreaching zone to trip instantaneously when a fault occurs. For this purpose, one of the DSTPDIS zones can be configured with an independently set reach.

After the overreaching zone instantaneously trips, the autoreclosing sequence starts. If the fault is transient, the system may get restored in the first shot of AR. However, in case of a persistent fault only the first trip of the AR sequence is accelerated by Zone extension logic. During the rest of the sequence, Zone extension logic is blocked and AR initiation is performed selectively by the time-graded distance zones.

If the fault is located on the adjacent feeder or bus within the reach of the overreaching zone, tripping and AR initiation take place in an external fault.

Zone extension logic can be described using a module diagram.

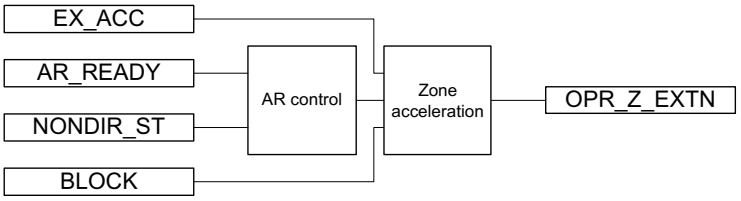



*Figure 613: Functional module diagram of Zone extension logic*

## AR control

The AR control module supervises the zone acceleration by monitoring the status of the AR_READY and NONDIR_ST input signals. The READY output signal from the autorecloser (AR) function, which indicates the status of the autoreclosing, is connected to the AR_READY input. The start signal from the non-directional zone is connected to the NONDIR_ST input. If the non-directional zone is not available for this, then the start output from the overreaching zone with the biggest reach or GFC can be used instead.

The permission for zone acceleration is given if AR_READY = TRUE, that is, the AR function is ready to start a new AR sequence. If the set reclaim time of the AR function expires before the fault is cleared, the NONDIR_ST input signal is used to block the activation of the zone acceleration. This ensures that the accelerated trip followed by the AR initiation is not repeated for the same fault regardless of the reclaim time setting and the reach of the overreaching zone connected to the EX_ACC input. Otherwise, this could lead to pumping of the circuit breaker, that is, the repetition of the first shot without being able to complete the desired AR sequence.

The AR control module blocks the Zone acceleration module after the initiation of the first shot until the AR sequence has been completed, that is, until the AR_READY input signal changes its state back from FALSE to TRUE.

## Zone acceleration

The start signal from the overreaching zone whose operation is to be accelerated is connected to the EX_ACC input. When the EX_ACC input is activated and, simultaneously, the AR control module gives permission for acceleration, the operate signal from Zone extension logic is obtained from the OPR_Z_EXTN output, which is used to trip the circuit breaker and initiate the autoreclosing (the AR shot).

The activation of the BLOCK input blocks the OPR_Z_EXTN output.

## Loss of load logic

Loss of load logic is enabled with *Operation mode* = "Loss of load".

When the loss of load operation mode is enabled, a time-delayed overreaching zone is allowed to trip instantaneously if the loss of load current condition is detected.

The loss of load function does not operate in case of a three-phase fault as all the phases are faulty. Therefore, none of the current values drops below the *Minimum current* setting, meaning that the loss of load current condition cannot be detected.

Loss of load logic can be described using a module diagram.

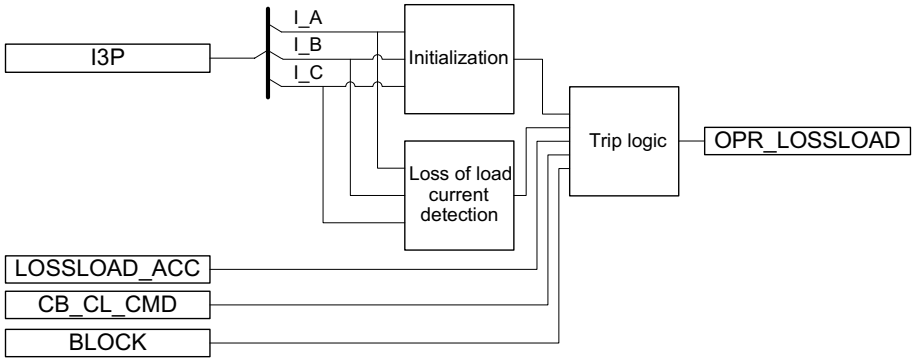



*Figure 614: Functional module diagram of Loss of load logic*

## Initialization

The Initialization module gives an enabling signal to the Trip logic module when the values of all three phase currents are above the set value of *Load current value* for

more than the time set with *Load release on time*. The enabling signal has a drop-off delay defined with the *Load release off Tm* setting.

### Loss of load current detection

The Loss of load current detection module gives an enabling signal to the Trip logic module if any of the phase current values drops below the *Minimum current* setting due to a remote end breaker opening and, simultaneously, the value of at least one phase current exceeds the value of the *Load current value* setting due to a fault. Such a condition has to be valid for longer than the *Minimum current time* setting.

### Trip logic

The operate signal is obtained from the OPR_LOSSLOAD output if the enable signal is received from both Initialization and Loss of load current detection modules and, simultaneously, a fault is seen by the overreaching zone connected to the LOSSLOAD_ACC input.

The activation of the BLOCK input blocks the OPR_LOSSLOAD output. Temporary blocking is achieved using the circuit breaker's close command pulse connected to the CB_CL_CMD input. It is used to prevent an unwanted operation due to initial transients after the breaker is closed, for example, in case of inrush currents.

## 5.9.6 Application

DSTPLAL is used in those applications where the conventional communication scheme logic cannot be applied (when no communication channel is available), but the user still requires a fast clearance for the faults on the entire feeder.

DSTPLAL enables a fast fault clearing during certain conditions, but it is unable to replace the communication scheme logic due to a possible lack of selectivity during the first trip and AR initiation and also as the loss of load logic cannot operate for three-phase faults. DSTPLAL is controlled either by the autoreclosing (Zone extension logic) or by monitoring the loss of load current (Loss of load logic).

### Zone extension logic

The zone extension operation mode can be applied when the autoreclosing function DARREC is in operation. When the zone extension is enabled, DARREC is used to enable the fast fault clearance independent of the fault location on the protected feeder. This is achieved by allowing a time-delayed overreaching zone to trip instantly when a fault occurs. Also, if there are tapped loads on the protected feeder, it is required to set a dedicated zone to initiate one or two shots as fast as possible before the protection devices of these taps clear. If the fault is still present after these shots, further tripping is delayed in accordance with the other zones so that the operation becomes slower than the protection of the load taps, enabling it to clear. The final tripping that ends the sequence is always performed selectively according to the time grading of the zones.

If the fault is located on the adjacent feeder or bus within the reach of the overreaching zone, the tripping and the AR initiation take place during an external fault.

### Setting guidelines

The *Load current value* setting must be set below the minimum three-phase load current during the healthy state. A security factor of 0.5 is used:

$$\textit{Load current value} = 0.5 \cdot I_{minload}$$

$I_{minload}$ minimum load current during normal operation conditions

The loss of load function is released after *Load release on time* is elapsed and the load current in all three phases is above the *Load current value* setting. If the current values drop below the *Load current value* setting, the release condition stays activated until the drop-out delay time has expired (the *Load release off Tm* setting). The value of *Load release off Tm* is by default set to "0.3 s". The *Load release on time* setting is used to increase the security of the loss of load function, for example, in the case of transient inrush currents during the energizing of a power transformer. When there is no need for delaying the release, the *Load release on time* is set to zero in applications.

The *Minimum current* setting is used to detect the loss of load condition in healthy phases during the fault. The *Minimum current* setting is set to a value higher than the maximum current flowing in the healthy phases during the fault when the breaker at the remote end has been opened and the load flowing through has therefore been disconnected. This current can be, for example, due to the charging current of the phases or the load current of the tapped loads. The *Minimum current* setting value is set below the *Load current value* setting. By default, the *Minimum current* setting value is set to "0.05 pu".

The *Minimum current time* setting is used to provide the start delay for the loss of load current detection to avoid an unwanted release of the function. The value of *Minimum current time* is by default set to "0.2 s".

## 5.9.7 Signals

*Table 1069: DSTPLAL Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| AR_READY | BOOLEAN | 0=False | Autoreclosure ready, releases function used for fast trip |
| CB_CL_CMD | BOOLEAN | 0=False | CB close command |
| Table continues on next page | | | |

| Name | Type | Default | Description |
|---|---|---|---|
| EX_ACC | BOOLEAN | 0=False | Connected to function used for tripping at zone extension |
| LOSSLOAD_ACC | BOOLEAN | 0=False | Connected to function used for tripping at loss of load |
| NONDIR_ST | BOOLEAN | 0=False | Non directional criteria used to prevent instantaneous trip |

*Table 1070: DSTPLAL Output signals*

| Name | Type | Description |
|---|---|---|
| OPR_LOSSLOAD | BOOLEAN | Operate by loss of load |
| OPR_Z_EXTN | BOOLEAN | Operate by zone extension |

## 5.9.8 Settings

*Table 1071: DSTPLAL Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Load current value | 0.01...1.00 | xIn | 0.01 | 0.10 | Load current before disturbance |
| Minimum current | 0.01...1.00 | xIn | 0.01 | 0.05 | Level taken as current loss due to remote CB trip |
| Load release off Tm | 0...60000 | ms | 10 | 300 | Time delay on drop off for load current release |
| Minimum current time | 0...60000 | ms | 10 | 200 | Time delay on pick-up for Minimum current value |
| Operation mode | 1=Zone extension<br>2=Loss of load<br>3=Both | | | 3=Both | Operation mode |
| Load release on time | 0...60000 | ms | 10 | 0 | Time delay on pick-up for load current release |

## 5.9.9 Monitored data

*Table 1072: DSTPLAL Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| DSTPLAL | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 5.9.10 Technical data

*Table 1073: DSTPLAL Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 5.10 Scheme communication logic DSOCPSCH

### 5.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Scheme communication logic | DSOCPSCH | CL | 85 21SCHLGC |

### 5.10.2 Function block

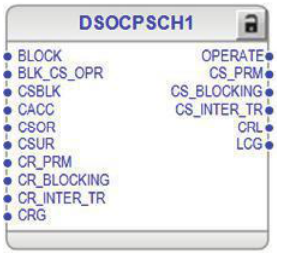



*Figure 615: Function block*

### 5.10.3 Functionality

The scheme communication logic function DSOCPSCH is used to achieve instantaneous fault clearing independent of the fault location on the protected feeder. Several communication scheme types are available.

- Direct underreaching transfer trip DUTT
- Permissive underreaching transfer trip PUTT
- Permissive overreaching transfer trip POTT
- Directional comparison blocking scheme DCB

The directional comparison unblocking scheme DCUB can also be implemented by complementing the permissive schemes with an additional logic called the unblocking function, which is also included in DSOCPSCH.

If the permissive overreach scheme is used, some of the power system conditions require additional special logic circuits, such as the current reversal and weak-end infeed logic function CRWPSCH.

## 5.10.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DSOCPSCH can be described with a module diagram. All the modules in the diagram are explained in the next sections.

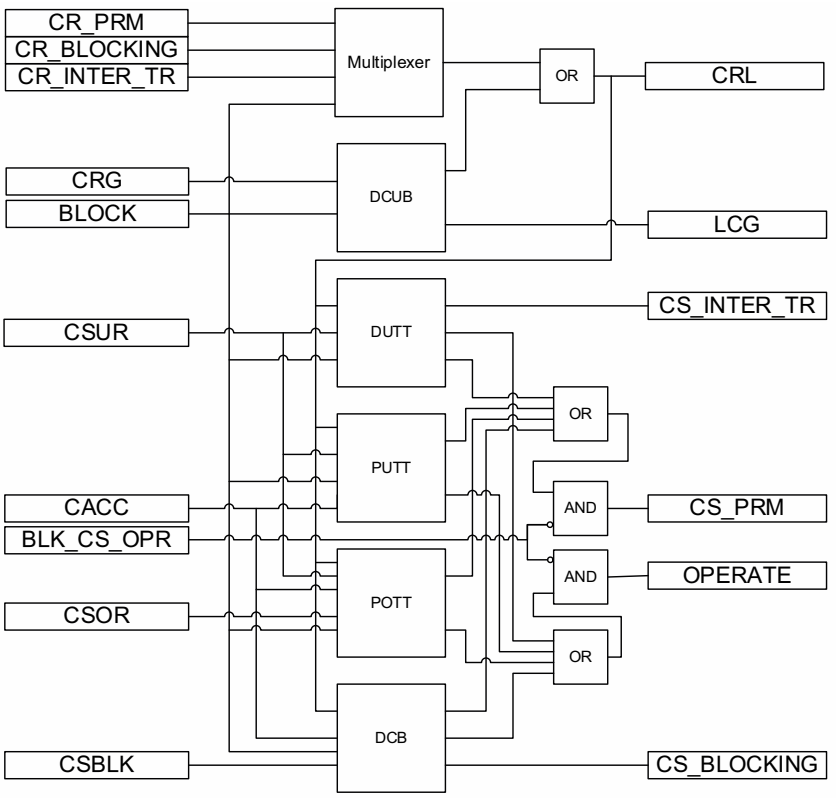



*Figure 616: Functional module diagram*

The applied communication scheme logic in DSOCPSCH is selected with the *Scheme type* setting.

*Table 1074: Communication scheme based on the Scheme type value*

| *Scheme type* value | Communication scheme |
|---|---|
| "Intertrip" | DUTT |
| "Permissive Underreach" | PUTT |
| "Permissive Overreach" | POTT |
| "Blocking" | DCB |

The unblocking scheme (DCUB) is enabled with the *Unblock Mode* setting.

### Multiplexer

The multiplexer connects an input signal to an output based on the value of the *Scheme type* setting.

*Table 1075: Connected inputs based on the Scheme type value*

| *Scheme type* value | Inputs connected to an output |
|---|---|
| "Intertrip" | CR_INTER_TR |
| "Permissive Underreach" or "Permissive Overreach" | CR_PRM |
| "Blocking" | CR_BLOCKING |

### Direct underreaching transfer trip scheme DUTT

The direct intertrip scheme is enabled with *Scheme type* = "Intertrip".

In the direct intertrip scheme, the start signal from the underreaching zone Z1 is connected to the CSUR input to create a carrier send CS_INTER_TR signal. The duration of the CSUR input signal is prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration for the CS_INTER_TR signal.

The local circuit breaker is directly tripped (activation of the OPERATE output) with the carrier received CR_INTER_TR signal after a settable pick-up delay *Coordination Time* has elapsed without further local criteria.

The unblocking function (*Unblock Mode* = "Permanent" and *Unblock Mode* = "Time window") must not be enabled with the DUTT scheme, as the lost guard signal results in an immediate trip of the local circuit breaker.

The activation of the BLOCK input totally blocks the direct intertrip scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

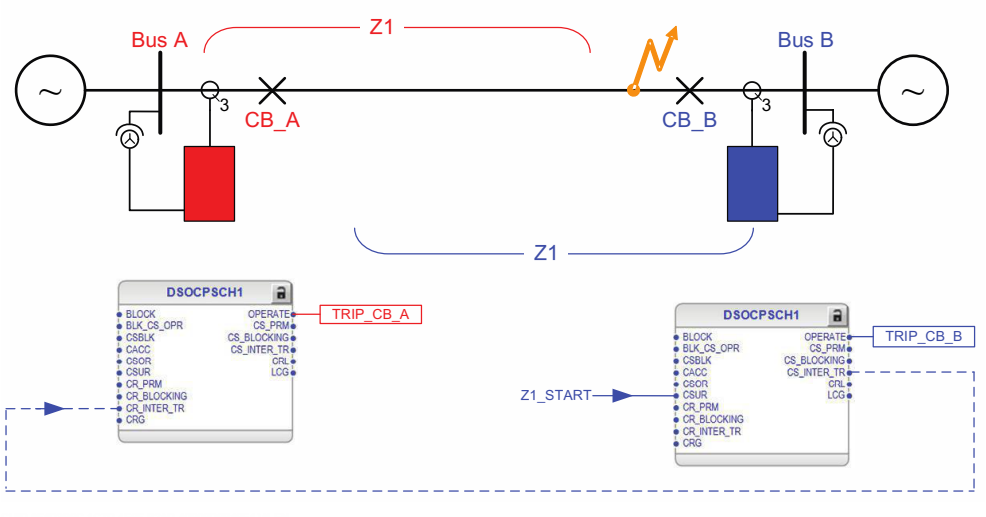



*Figure 617: Simplified functional diagram of the direct intertrip scheme*

## Permissive underreaching transfer trip scheme PUTT

The permissive underreach scheme is enabled with *Scheme type* = "Permissive Underreach".

In the permissive underreach scheme, the start signal from the underreaching zone Z1 is connected to the CSUR input to create a CS_PRM signal. The duration of the CSUR input signal can be prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_PRM signal.

In the permissive underreach scheme, the CR_PRM signal, or the CRL signal if the unblocking function is enabled, is used to allow the overreaching zone Z2 to trip (activation of the OPERATE output) after the pick-up delay *Coordination Time*. The start signal from the overreaching zone Z2 is connected to the CACC input.

Activating the BLOCK input totally blocks the permissive underreach scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

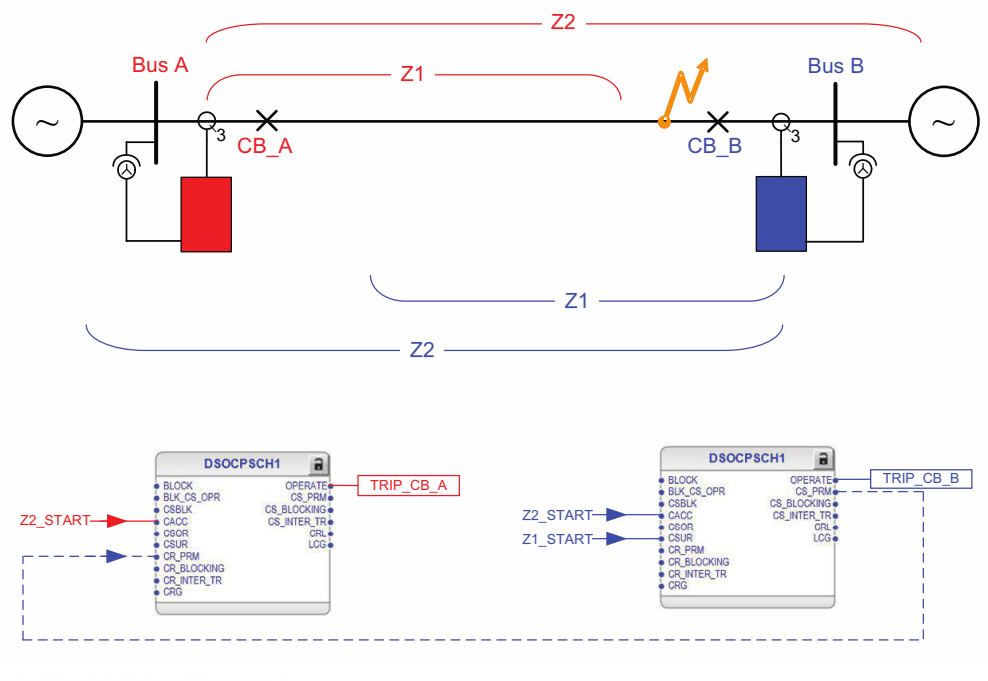



*Figure 618: Simplified functional diagram of the permissive underreach scheme*

## Permissive overrreaching transfer trip scheme POTT

The permissive overreach scheme is enabled with *Scheme type* = "Permissive Overreach".

In this scheme, the start signal from the overreaching zone Z2 is connected to the CSOR input to create a CS_PRM signal. The CS_PRM signal can also be issued simultaneously from the underreaching zone Z1. In this case, the start signal from the underreaching zone Z1 is connected to the CSUR input. The duration of the CSUR input signal is prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_PRM signal.

In case of parallel feeders, and when the external current reversal logic (CRWPSCH) is enabled, the CS_PRM signal is not prolonged and the value of *Carrier Min Dur* is set to zero to secure correct operation.

In the permissive overreach scheme, the received signal CR_PRM, or CRL if the unblocking function is enabled, is used to allow the overreaching zone Z2 to trip (activation of the OPERATE output) after the settable pick-up delay *Coordination Time*. The start signal from the overreaching zone is connected to the CACC input.

Activating the BLOCK input totally blocks the permissive overreach scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

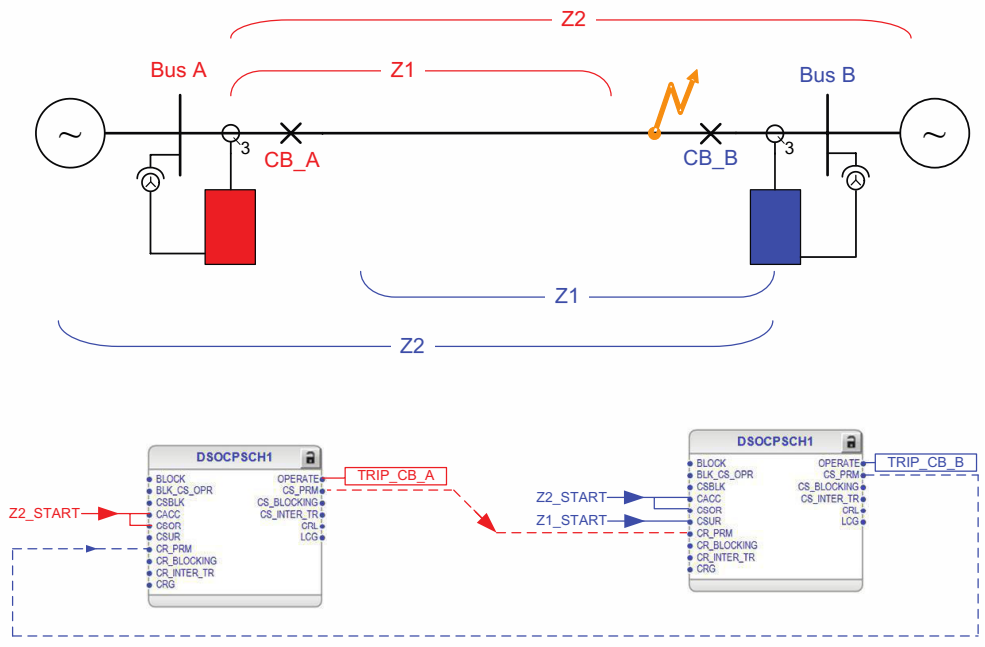



*Figure 619: Simplified functional diagram of the permissive overreach scheme*

## Directional comparison blocking scheme DCB

The directional comparison blocking scheme is enabled with *Scheme type* = "Blocking".

In the blocking scheme, the start signal from the reverse-looking zone Z3 is connected to the CSBLK input to create a CS_BLOCKING signal. The starting of the reverse-looking zone indicates that the fault is located outside the protected feeder. The duration of the CSBLK input signal can be prolonged with the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_BLOCKING signal.

The blocking scheme is mainly used to allow the overreaching zone Z2 to trip (activation of the OPERATE output) after the settable *Coordination Time* has elapsed, and if no blocking signal is received from the remote terminal. To prevent a false trip in case of an external fault, the block signal CR_BLOCKING must be received before the *Coordination Time* has elapsed. The start signal from the overreaching zone Z2 is connected to the CACC input.

The *Coordination Time* setting in the blocking scheme depends, for example, on the communication system delay and on the terminal's response times in transmitting the CS_BLOCKING signal to the other feeder end. The *Coordination Time* setting must not be zero.

Activating the BLOCK input totally blocks the directional comparison blocking scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

In Figure 620, in case of internal faults, the CS_BLOCKING signal is not sent because the fault is not sent as it is not seen by the reverse-looking zones (Z3).

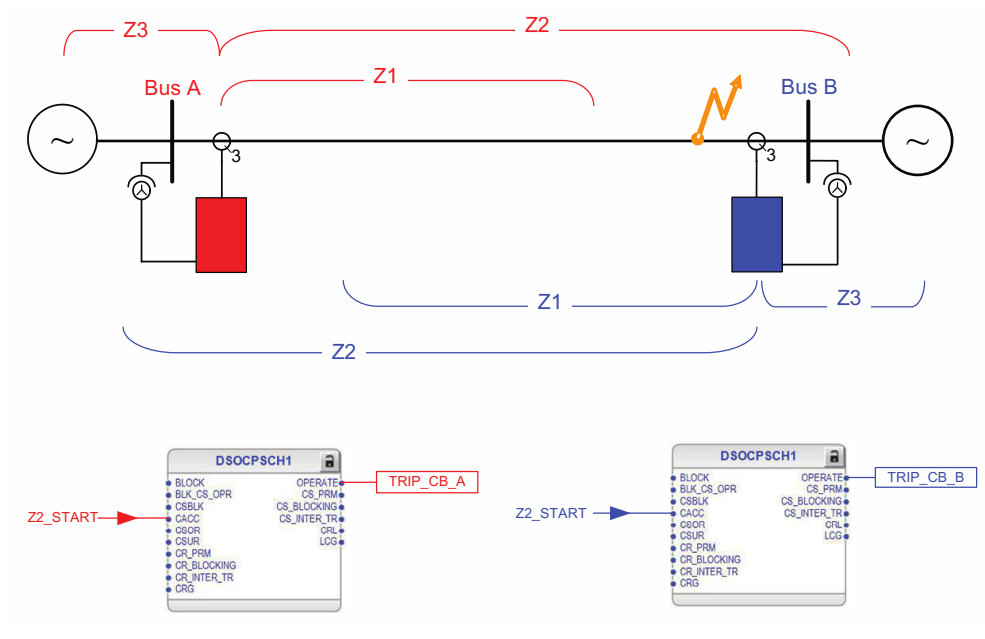



*Figure 620: Simplified functional diagram of the blocking scheme, internal fault*

In Figure 621, in case of external faults, the protection relay at bus B sees the fault in the reverse direction and sends a blocking signal CS_BLOCKING to the protection relay at bus A. There is no CB operation at either end.

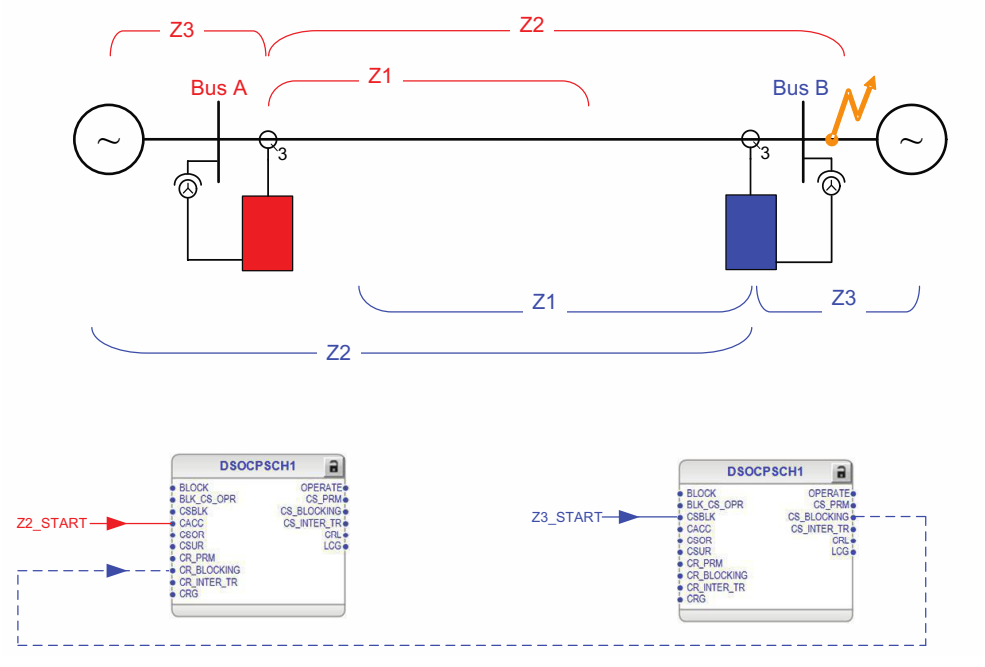



*Figure 621: Simplified functional diagram of the blocking scheme, external fault*

The unblocking function used with the blocking function provides a possibility to supervise the communication channel. In this case, the CRL output signal is used as a local blocking signal.

The operation mode *Unblock Mode* = "Time window" is not recommended as the blocking is activated only for 150 ms after the guard signal disappears. This results in an unwanted operation of the protection.

## Directional comparison unblocking scheme DCUB

The unblocking function is a complementary logic which can be used together with the permissive communication schemes. In the unblocking scheme, the dependability of the permissive schemes is improved by using the loss of guard signal from the communication equipment to create a CRL output signal locally. This enables the permissive scheme to operate even if the communication channel is interrupted or lost.

The unblocking function uses a carrier guard signal which must always be present. The absence of the CRG signal for a time longer than the value of the *Loss of carrier time* setting generates a logical CRL signal. A communication failure shorter than the value of the *Loss of carrier time* setting is always ignored.

The unblocking function is configured with the *Unblock Mode* setting.

- *Unblock Mode* = "Off": The unblocking function is disabled.
- *Unblock Mode* = "Permanent": If the CRG signal disappears for a longer time than defined in the *Loss of carrier time* setting, the logical CRL signal is generated. The CRL output signal remains active until the CRG signal reappears. The communication failure is not signaled by the LCG output.
- *Unblock Mode* = "Time window": If the CRG signal disappears for a longer time than defined in the *Loss of carrier time* setting, the CRL output signal is generated. The CRL output signal remains active for 150 ms, after which a communication failure is signaled by the LCG output. The LCG output is reset 200 ms after the CRG signal reappears. The purpose of this mode is to ensure tripping during a fixed delay of 150 ms after the loss of communication due to possible consequences of an internal fault. After this time, the accelerated tripping is allowed only if the CR_PRM signal is received again.

With operation modes *Unblock Mode* = "Permanent" and *Unblock Mode* = "Time window", the created CRL output signal is internally ORed with the CR_PRM input to allow the permissive scheme to operate even when the communication channel has been interrupted or lost. The CRL and LCG output signals are also available as outputs for monitoring purposes. Activating the BLOCK input blocks the CRL and LCG outputs.

## 5.10.5 Application

To achieve fast fault clearing on the part of the protected feeder not covered by the instantaneous zone Z1, the stepped distance protection function can be used with DSOCPSCH.

Applying DSOCPSCH requires a communication channel capable of transmitting an "On" or "Off" signal in each direction. To enable fast tripping, the most important requirement for the communication channel is the communication speed.

The performance of DSOCPSCH is directly related to the communication channel speed, and to the security against false or lost signals. Therefore, dedicated communication channels are recommended. With short distances of up to a few kilometers, a typical communication media is a simple pilot wire based on auxiliary power. With distances of up to 50 km with the integrated communication interface or up to 150 km with external equipment, fibre-optic cables using digital data transmission can be used. To avoid false signals causing unwanted operation, the security of the communication channel should be emphasized. Also, the dependability of the communication channel should be considered to ensure that the signals are reliably transmitted during the power system faults.

DSOCPSCH supports five communication schemes.

- Direct underreaching transfer trip DUTT
- Permissive underreaching transfer trip PUTT
- Permissive overreaching transfer trip POTT
- Directional comparison blocking scheme DCB
- Directional comparison unblocking scheme DCUB

Depending on whether the communication channel is used for sending a block or a trip signal, the communication schemes can be divided into blocking schemes and permissive schemes.

In permissive schemes, the trip signals of the distance zones are interchanged between the terminals to receive a permission to trip during an internal fault. The tripping of the local terminal depends on both the starting of its own forward-looking zone and on the received signal from the opposite terminal. In the underreaching scheme, no signals are sent during an external fault. During an external fault, a trip signal is also sent to the opposite terminal if the fault is seen in the forward direction and the overreaching scheme is used. However, in case of external faults, tripping is always blocked because either no signal is received as the opposite terminal sees a reverse fault or because the signal is received but the fault is seen in the reverse direction. In either case, the blocking is not dependent on the received signal so a lost communication channel does not result in false operation.

In the blocking scheme, a blocking signal is sent to the opposite terminal if the fault is locally seen in the reverse direction, that is, during an external fault. Thus, the blocking is dependent on the received signal, and there is typically a need to delay the tripping of the terminal receiving the blocking signal. This delay depends, for

example, on the response times of the communication channel and terminals. During an internal fault, there is no signal transmission between the terminals, so the tripping does not depend on the received signal from the opposite terminal.

In conclusion, compared to the blocking schemes, the permissive schemes are inherently faster and have better security [1] against false tripping, since tripping in an external fault is not possible in case of a channel interruption. In a blocking scheme, a lost communication channel and a simultaneous external fault may lead to a false operation of the protection if the communication channel is not supervised. On the other hand, as the fast trip of the permissive scheme depends on the received signal, its dependability [2] is lower than that of the blocking scheme.

The unblocking scheme enhances the dependability of the permissive scheme. If the communication channel is interrupted and, simultaneously, a fault occurs in the forward direction, tripping is still possible either during a fixed time interval, counting from the beginning of the interruption, or for as long as the communication channel is lost. This is achieved by connecting the supervision output of the implemented communication functionality to the dedicated carrier guard signal input of DSOCPSCH. In general, the unblocking scheme provides better security than the blocking scheme because tripping in external faults is only possible if the fault occurs within the fixed time interval after the beginning of the channel interruption.

The direct transfer trip scheme uses the underreaching zone to trip the local breaker and to transfer the trip signal to a remote terminal. The remote terminal operates immediately based on the received transfer trip signal, without any additional conditions. This scheme is very simple, but the security is low as a spurious signal results in false operation of the protection.

## Direct underreaching transfer trip DUTT

In some applications, there is a need to trip the remote-end breaker immediately because of fault detection by the local measurements. This applies, for example, when the transformers or reactors are connected to the system without circuit breakers, or for remote tripping after the operation of the local breaker failure protection (CBFP).

In the direct intertrip scheme (DUTT), the carrier send signal `CS_INTER_TR` is initiated by an underreaching zone, or by the tripping signal from an external protection relay, such as transformer or reactor protection. At the remote end, the received signal initiates a breaker trip immediately without any further local protection criteria. To limit the risk of an unwanted trip due to spurious sending of signals, the trip can be delayed by the *Coordination Time* setting, which should be set to 10...30 ms, depending on the type of the communication channel. The communication channel operating in direct intertripping applications should be secure and dependable.

**Setting guidelines for the intertrip scheme DUTT**

*Scheme type* = "Intertrip"

[1] The ability to block operation in case of an external fault
[2] The ability to operate in case of an internal fault

*Coordination Time* = "0.050" s (10 ms + maximal transmission time)

*Carrier Min Dur* = "0.1" s

## Permissive underreaching transfer trip PUTT

In the permissive underreach scheme, the permission to trip is obtained locally from the underreaching zone and sent to the remote end. The received signal is combined with the local fault indication from the overreaching zone resulting in a trip command after a settable pick-up delay *Coordination Time*.

The protection relay of either feeder end sends a permissive signal to trip the other end. The communication channel must be able to receive and transmit at the same time. In permissive schemes, the communication channel must be fast and secure, but also dependable. Inadequate security causes unwanted tripping for the external faults. Inadequate speed or dependability causes delayed tripping for internal faults.

The CS_PRM signal is issued based on the underreaching zone Z1.

The underreach scheme is not applicable on short feeder lengths because the impedance measurement cannot easily distinguish between the internal and external faults in such cases.

The underreaching zones Z1 at the local and remote ends must overlap to prevent a gap between the protection zones, where the faults are not detected. If the underreaching zone does not meet the required sensitivity, for example, the fault infeed from a remote end, the blocking or permissive overreach scheme is considered.

To achieve an instantaneous trip, the carrier received signal CR_PRM must be received when the overreaching zone Z2 is still starting. In some cases, due to a fault in current distribution, the overreaching zone can operate only after the fault has been cleared by the remote terminal. In this case, there is a risk that if the remote terminal is tripped directly by, for example, zone Z1, the CS_PRM signal issued by the zone resets before the overreaching zone of the local end terminal has operated. To assure a sufficient duration of the CR_PRM signal, the CS_PRM signal can be prolonged by the time *Carrier Min Dur*. The recommended value of the *Carrier Min Dur* setting is "0.1" s.

The received communication signal is combined with the output from the local overreaching zone. Therefore, there is less concern about a false signal causing an incorrect trip, and therefore the timer *Coordination Time* is set to "0". A communication channel failure does not affect the selectivity, but delays the tripping at the other end for certain fault locations.

**Setting guidelines for the permissive underreach scheme PUTT**

*Scheme type* = "Permissive Underreach"

*Coordination Time* = "0" s

*Carrier Min Dur* = "0.1" s

## Permissive overreaching transfer trip POTT

In the permissive overreach scheme, the permission to trip is obtained locally from an overreaching zone and sent to the remote end. The received signal is then combined with the local fault indication from the overreaching zone, resulting in a trip command after a settable pick-up delay *Coordination Time*.

The protection relay at either end of the feeder sends a permissive signal to trip the other end. Therefore the communication channel must be able to receive and transmit at the same time. The communication on permissive schemes should be fast and secure.

The CS_PRM signal is issued based on the overreaching zone Z2.

The permissive overreach scheme can be used for all feeder types and lengths.

In the permissive overreach scheme, the communication channel plays an essential role in obtaining a fast tripping at both ends. Typically, a lost communication channel does not cause false tripping. However, it delays the operation of the protection for the faults anywhere on the feeder.

The communication channel for a permissive overreach scheme must be fast and secure, but also dependable. Inadequate security can cause unwanted tripping for external faults. Inadequate speed or dependability can cause delayed tripping for internal faults.

In the permissive overreaching scheme, the CS_PRM signal can be issued in parallel both from the overreaching and underreaching zones. The CS_PRM signal from the overreaching zone must not be prolonged, while the CS_PRM signal from the underreaching zone must typically be prolonged. In parallel feeder applications, the scheme typically needs to be complemented by the current reversal logic. To ensure the correct operation in this case, the CS_PRM signal must not be prolonged (*Carrier Min Dur* = "0" s). There is no need to delay the tripping while receiving the carrier signal, so the timer *Coordination Time* is set to "0".

**Setting guidelines for the permissive overreaching transfer trip scheme POTT**

*Scheme type* = "Permissive Overreach"

*Coordination Time* = "0" s

*Carrier Min Dur* = "0.1" s

*Carrier Min Dur* = "0" s (in case of parallel lines and current reversal logic)

## Directional comparison blocking scheme DCB

In the blocking scheme, the reverse-looking zone Z3 is used for sending a block signal to the remote end to block the overreaching zone.

The blocking scheme is very dependable because it operates on faults anywhere on the protected feeder, even if the communication channel is out of service. Conversely, it

is less secure than a permissive scheme because it trips for the external faults within the reach of the overreaching local zone if the communication channel is out of service and no block signal is received.

Inadequate speed or low dependability of the communication channel can cause spurious tripping for external faults.

To secure that the blocking signal arrives before the local overreaching zone trips, the trip is delayed by the *Coordination Time* setting. This setting must be set longer than the sum of the maximal transmission time of the channel and the start and response times of the protection relays sending and receiving the CS_BLOCKING signal. A security margin of at least 10 ms should be considered. The time delay *Carrier Min Dur* for prolonging the CS_BLOCKING signal is set to "0".

**Setting guidelines for the blocking scheme DCB**

*Scheme type* = "Blocking"

*Coordination Time* = "0.1" s (10 ms + maximal transmission time)

*Carrier Min Dur* = "0" s

## Directional comparison unblocking scheme DCUB

Metallic communication paths unfavorably affected by fault-generated noise or by other electrical phenomena, such as lightning, are not suitable for conventional permissive schemes that rely on the signal transmitted during a fault in the protected feeder. Principally, the communication media must be properly shielded or otherwise designed to provide an adequate performance during such conditions.

The unblocking scheme can be used to overcome the lower dependability of permissive schemes. The function is used in older, less reliable communication, where the signal has to be sent through the primary fault. The unblocking function uses a carrier guard signal CRG which must always be present, even when no CR_PRM signal is received. Due to the absence of the CRG signal during the security time, the *Loss of carrier time* setting is used as a CR_PRM signal. This also enables a permissive scheme to operate when the communication channel is temporarily lost during an internal fault.

**Setting guidelines for the unblocking scheme DCUB**

The unblocking function is configured with the *Unblock Mode* setting.

- *Unblock Mode* = "Off": The unblocking function is disabled.
- *Unblock Mode* = "Permanent": If the CRG signal disappears for a longer time than defined in the *Loss of carrier time* setting, a logical carrier received signal CRL is generated. The CRL signal remains active until the CRG signal is present. The communication failure is not signalled by the LCG output. The *Loss of carrier time* setting is set to "35" ms.
- *Unblock Mode* = "Time window": If the CRG signal disappears for a longer time period than the *Loss of carrier time* setting, a CRL signal is generated. The CRL signal remains active for 150 ms, after which a communication failure is signalled

by the LCG output. The value of the LCG output is reset 200 ms after the CRG signal reappears. The *Loss of carrier time* setting is set to "35" ms.

## 5.10.6 Signals

*Table 1076: DSOCPSCH Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_CS_OPR | BOOLEAN | 0=False | Signal for blocking CS and Operate in all schemes |
| CSBLK | BOOLEAN | 0=False | Reverse directed distance protection zone signal for requesting activation of TxBlk |
| CACC | BOOLEAN | 0=False | Permissive distance protection zone signal |
| CSOR | BOOLEAN | 0=False | Overreaching distance protection zone signal |
| CSUR | BOOLEAN | 0=False | Underreaching distance protection zone signal |
| CR_PRM | BOOLEAN | 0=False | Received teleprotection permissive from the other side |
| CR_BLOCKING | BOOLEAN | 0=False | Received teleprotection blocking from the other side |
| CR_INTER_TR | BOOLEAN | 0=False | Received direct trip from the other side |
| CRG | BOOLEAN | 0=False | Carrier guard signal received |

*Table 1077: DSOCPSCH Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| CS_PRM | BOOLEAN | Permissive transmitted to the other side |
| CS_BLOCKING | BOOLEAN | Blocking transmitted to the other side |
| CS_INTER_TR | BOOLEAN | Direct trip transmitted to the other side |
| CRL | BOOLEAN | Carrier received after unblock logic |
| LCG | BOOLEAN | Loss of guard |

## 5.10.7 Settings

*Table 1078: DSOCPSCH Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Scheme type | 1=None<br>2=Intertrip<br>3=Permissive Underreach<br>4=Permissive Overreach<br>5=Blocking | | | 3=Permissive Underreach | Scheme type, mode of operation |
| Carrier Min Dur | 0...60000 | ms | 1 | 100 | Minimum duration of a carrier send signal |
| Coordination Time | 0...60000 | ms | 1 | 35 | Co-ordination timer for blocking scheme |

*Table 1079: DSOCPSCH Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Unblock Mode | 1=Off<br>2=Permanent<br>3=Time window | | | 1=Off | Operation mode of unblocking logic |
| Loss of carrier time | 0...60000 | ms | 1 | 35 | Pickup security timer on loss of carrier guard signal |

## 5.10.8 Monitored data

*Table 1080: DSOCPSCH Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| DSOCPSCH | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.10.9 Technical data

*Table 1081: DSOCPSCH Technical data*

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

# 5.11 Communication logic for residual overcurrent RESCPSCH

## 5.11.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Communication logic for residual overcurrent | RESCPSCH | CLN | 85 67G/N SCHLGC |

## 5.11.2 Function block

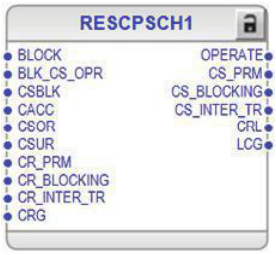



*Figure 622: Function block*

## 5.11.3 Functionality

The communication logic for residual overcurrent function RESCPSCH is used to achieve instantaneous fault clearing independent of the fault location on the protected feeder. There are four available communication scheme types.

- Direct underreaching transfer trip DUTT
- Permissive underreaching transfer trip PUTT
- Permissive overreaching transfer trip POTT
- Directional comparison blocking scheme DCB

The directional comparison unblocking scheme DCUB can also be provided by complementing the permissive schemes with an additional logic called the unblocking function, which is also included in RESCPSCH.

If the permissive overreaching scheme is used, some of the power system conditions require additional special logic circuits, such as the current reversal and weak-end infeed logic for residual overcurrent function RCRWPSCH.

## 5.11.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of RESCPSCH can be described with a module diagram. All the modules in the diagram are explained in the next sections.

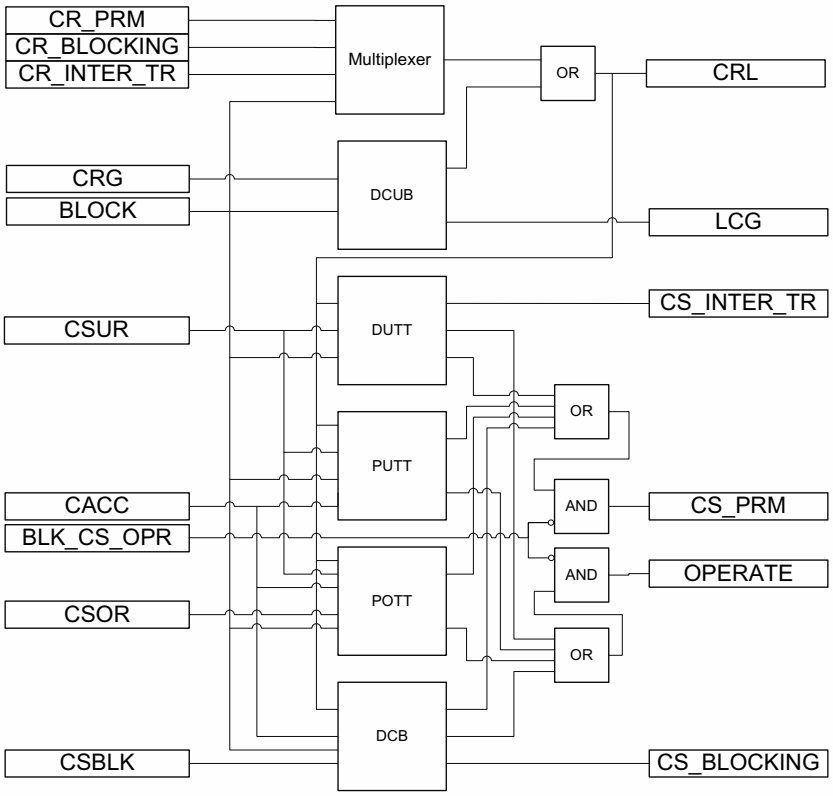



*Figure 623: Functional module diagram*

The applied communication scheme logic in RESCPSCH is selected with the *Scheme type* setting.

*Table 1082: Communication scheme based on the Scheme type value*

| *Scheme type* value | Communication scheme |
|---|---|
| "Intertrip" | DUTT |
| "Permissive Underreach" | PUTT |
| "Permissive Overreach" | POTT |
| "Blocking" | DCB |

The unblocking scheme (DCUB) is enabled with the *Unblock mode* setting.

## Multiplexer

The multiplexer connects an input signal to an output based on the value of the *Scheme type* setting.

*Table 1083: Connected inputs based on the Scheme type value*

| *Scheme type* value | Inputs connected to an output |
|---|---|
| "Intertrip" | CR_INTER_TR |
| "Permissive Underreach" or "Permissive Overreach" | CR_PRM |
| "Blocking" | CR_BLOCKING |

## Direct underreaching transfer trip scheme DUTT

The direct intertrip scheme is enabled with *Scheme type* = "Intertrip".

In the direct intertrip scheme, the start signal from the underreaching (instantaneous) residual overcurrent function DEFHPDEF is connected to the CSUR input to create a carrier send CS_INTER_TR signal. The duration of the CSUR input signal can be prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration for the CS_INTER_TR signal.

The local circuit breaker is directly tripped (activation of the OPERATE output) with the carrier received CR_INTER_TR signal after a settable pick-up delay *Coordination time* has elapsed without further local criteria.

The unblocking function (*Unblock mode* = "Permanent" and *Unblock mode* = "Time window") must not be enabled with the DUTT scheme, as the lost guard signal results in an immediate trip of the local circuit breaker.

The activation of the BLOCK input totally blocks the direct intertrip scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

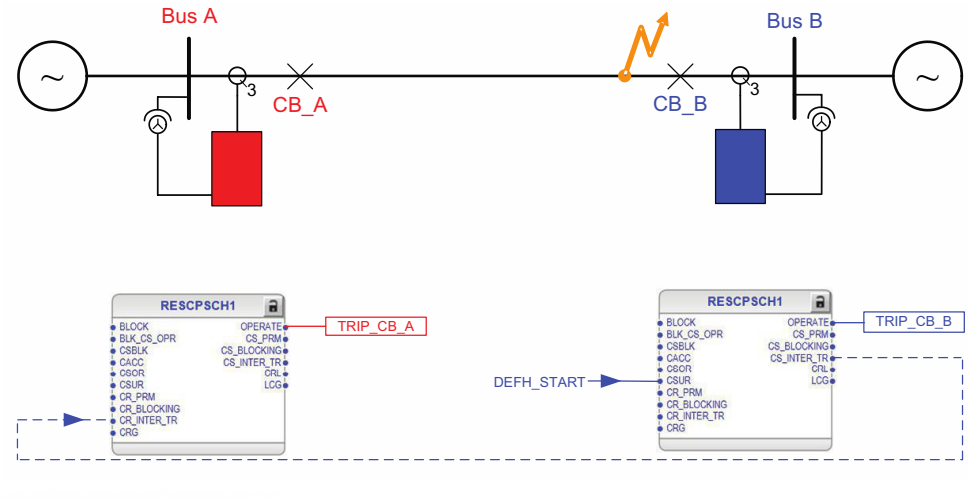



*Figure 624: Simplified functional diagram of the direct intertrip scheme*

## Permissive underreaching transfer trip scheme PUTT

The permissive underreach scheme is enabled with *Scheme type* = "Permissive Underreach".

In the permissive underreach scheme, the start signal from the underreaching (instantaneous) residual overcurrent function DEFHPDEF is connected to the CSUR input to create a CS_PRM signal. The duration of the CSUR input signal can be prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_PRM signal.

In the permissive underreach scheme, the CR_PRM signal or CRL signal, if the unblocking function is enabled, is used to allow the overreaching residual overcurrent function DEFLPDEF to trip (activation of the OPERATE output) after the pick-up delay *Coordination time*. The start signal from the overreaching function is connected to the CACC input. A general start signal in the forward direction can also be connected to the CACC input.

The CS_PRM signal is also generated if the CR_PRM signal is received and the local carrier acceleration signal CACC is active.

Activating the BLOCK input totally blocks the permissive underreach scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

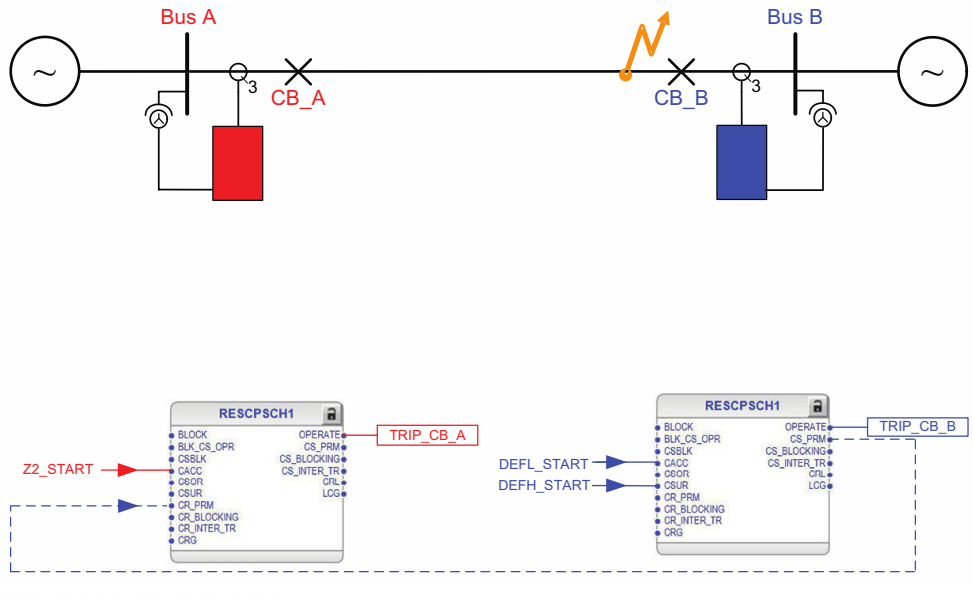



*Figure 625: Simplified functional diagram of the permissive underreach scheme*

## Permissive overrreaching transfer trip scheme POTT

The permissive overreach scheme is enabled with *Scheme type* = "Permissive Overreach".

In this scheme, the START signal from the overreaching residual overcurrent function DEFLPDEF is connected to the CSOR input to create a CS_PRM signal. The CS_PRM signal can also be issued simultaneously from the underreaching residual overcurrent function DEFHPDEF. In this case, the start signal from the underreaching function is connected to the CSUR input. The duration of the CSUR input signal can be prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_PRM signal.

In case of parallel feeders, when the external current reversal logic (RCRWPSCH) is enabled, the CS_PRM signal is not prolonged and the value of *Carrier Min Dur* is set to zero to secure correct operation.

In the permissive overreach scheme, the received signal CR_PRM or CRL, if the unblocking function is enabled, is used to allow the overreaching residual overcurrent function DEFLPDEF to trip (activation of the OPERATE output) after the settable pick-up delay *Coordination time*. The start signal from the overreaching zone is connected to the CACC input.

The CS_PRM signal is also generated if the CR_PRM signal is received and the local carrier acceleration signal CACC is active.

Activating the BLOCK input totally blocks the permissive overreach scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

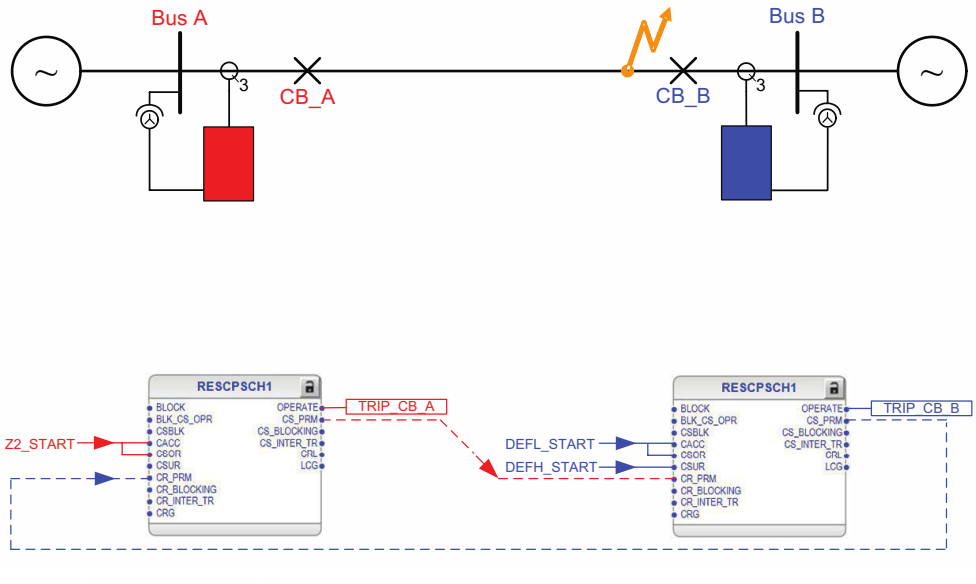



*Figure 626: Simplified functional diagram of the permissive overreach scheme*

## Directional comparison blocking scheme DCB

The directional comparison blocking scheme is enabled with *Scheme type* = "Blocking".

In the blocking scheme, the START signal from the reverse-looking residual overcurrent function DEFLPDEF set to operate for the reverse direction earth fault, is connected to the CSBLK input to create a CS_BLOCKING signal. The starting of the reverse-looking function indicates that the fault is located outside the protected feeder. The duration of the CSBLK input signal can be prolonged with the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_BLOCKING signal.

The blocking scheme is mainly used to allow the forward-looking overreaching residual overcurrent function to trip (activation of the OPERATE output) after the settable *Coordination time*, and if no block signal is received from the remote terminal. To prevent a false trip in case of external faults, the CR_BLOCKING signal must be received before the *Coordination time* has elapsed. The start signal from the overreaching residual overcurrent function DEFLPDEF is connected to the CACC input.

The *Coordination time* setting in the blocking scheme depends, for example, on the communication system delay and on the terminal's response times in transmitting a CS_BLOCKING signal to the other feeder end. The *Coordination time* setting must not be zero.

Activating the BLOCK input totally blocks the directional comparison blocking scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

In Figure 627, in case of internal faults, the CS_BLOCKING signal is not sent as the fault is not seen by the reverse-looking overreaching function.

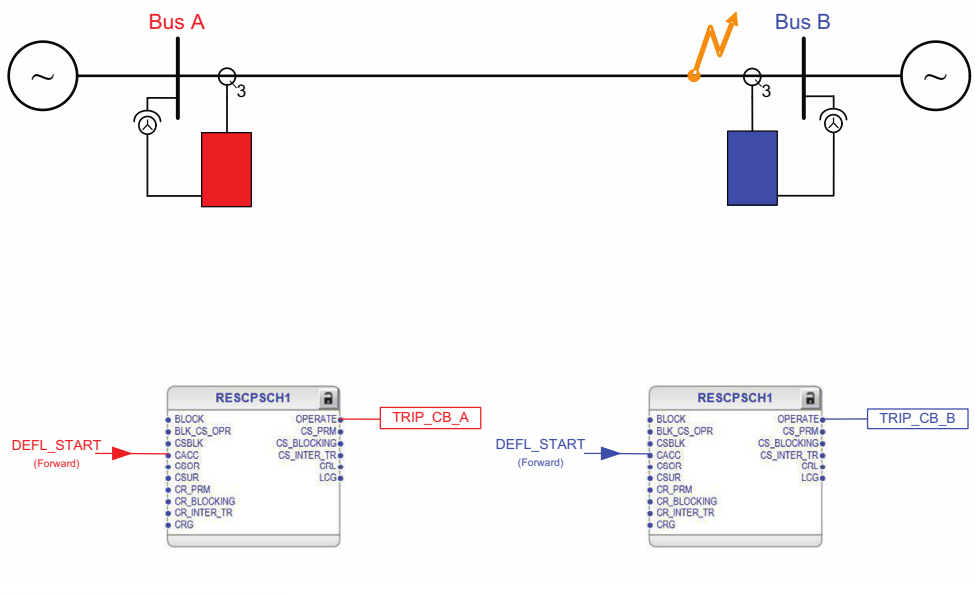



*Figure 627: Simplified functional diagram of the blocking scheme, internal fault*

In Figure 628, in case of external faults, the protection relay at bus B sees the fault in the reverse direction and sends a blocking signal CS_BLOCKING to the protection relay at bus A. There is no CB operation at either end.

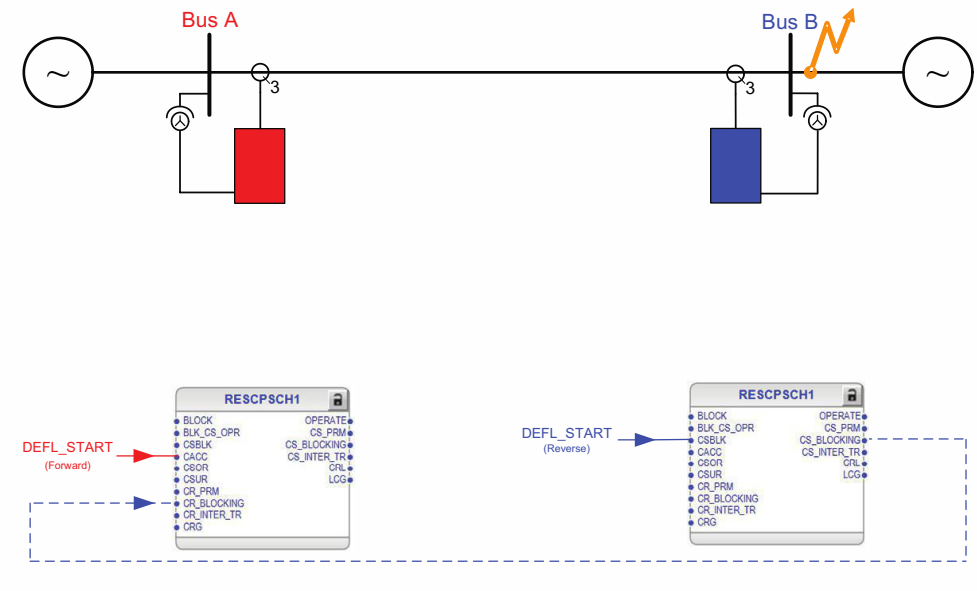



*Figure 628: Simplified functional diagram of the blocking scheme, external fault*

The unblocking function used with the blocking function provides a possibility to supervise the communication channel. In this case, the CRL output signal is used as a local blocking signal.

The operation mode *Unblock mode* = "Time window" is not recommended as the blocking is activated only for 150 ms after the guard signal disappears. This results in an unwanted operation of the protection.

### Directional comparison unblocking scheme DCUB

The unblocking function is a complementary logic which can be used together with the permissive communication schemes. In the unblocking scheme, the dependability of the permissive schemes is improved by using the loss of guard signal from the communication equipment to create a CRL output signal locally. This enables the permissive scheme to operate even if the communication channel is interrupted or lost.

The unblocking function uses a carrier guard signal which must always be present. The absence of the CRG signal for a time longer than the value of the *Loss of carrier time* setting generates a logical CRL signal. A communication failure shorter than the value of the *Loss of carrier time* setting is always ignored.

The unblocking function is configured with the *Unblock mode* setting.

- *Unblock mode* = "Off": The unblocking function is disabled.
- *Unblock mode* = "Permanent": If the CRG signal disappears for a longer time than defined in the *Loss of carrier time* setting, the logical CRL signal is generated. The CRL output signal remains active until the CRG signal reappears. The communication failure is not signaled by the LCG output.
- *Unblock mode* = "Time window": If the CRG signal disappears for a longer time than defined in the *Loss of carrier time* setting, the CRL output signal is generated. The CRL output signal remains active for 150 ms, after which a communication failure is signaled by the LCG output. The LCG output is reset 200 ms after the CRG signal is present again. The purpose of this mode is to ensure tripping during a fixed delay of 150 ms after the loss of communication due to possible consequences of an internal fault. After this time, the accelerated tripping is allowed only if the CR_PRM signal is received again.

With operation modes *Unblock mode* = "Permanent" and *Unblock mode* = "Time window", the created CRL output signal is internally ORed with the CR_PRM input to allow the permissive scheme to operate even when the communication channel has been interrupted or lost. The values of CRL and LCG output signals are also available through the Monitored data view. Activating the BLOCK input blocks the CRL and LCG outputs.

## 5.11.5 Application

To achieve fast fault clearing on the part of the protected feeder not covered by the instantaneous step of the residual overcurrent protection, the directional residual overcurrent protection can be used with RESCPSCH.

Applying RESCPSCH requires a communication channel capable of transmitting an "On" or "Off" signal in each direction. To enable fast tripping, the most important requirement for communication is the communication speed.

The performance of RESCPSCH is directly related to the communication channel speed, and to the security against false or lost signals. Therefore, dedicated communication channels are recommended. With short distances of up to a few kilometers, a typical communication media is a simple pilot wire based on auxiliary power. With distances of up to 150 km, fibre-optic cables using digital data transmission can be used. To avoid false signals that could cause unwanted operation, the security of the communication channel should be emphasized. Also, the dependability of the communication channel should be considered to ensure that the signals are reliably transmitted during power system faults.

RESCPSCH supports five communication schemes.

- Direct underreaching transfer trip DUTT
- Permissive underreaching transfer trip PUTT
- Permissive overreaching transfer trip POTT
- Directional comparison blocking scheme DCB
- Directional comparison unblocking scheme DCUB

Depending on whether the communication channel is used for sending a block or a trip signal, the communication schemes can be divided into blocking schemes and permissive schemes.

In permissive schemes, the trip signals of the directional residual overcurrent protection are interchanged between the terminals to receive a permission to trip during an internal fault. The tripping of the local terminal depends on both the starting of its own forward-looking function and the received signal from the opposite terminal. In the underreaching scheme, no signals are sent during an external fault. A trip signal is sent to the opposite terminal during an external fault if the fault is seen in the forward direction and the overreaching scheme is used. However, in case of external faults, tripping is always blocked because either no signal is received as the opposite terminal sees a reverse fault or the signal is received but locally the fault is seen in the reverse direction. In either case, the blocking is not dependent on the received signal so a lost communication channel does not result in false operation.

In the blocking scheme, a blocking signal is sent to the opposite terminal if the fault is locally seen in the reverse direction, that is, during an external fault. Thus, the blocking is dependent on the received signal, and there is typically a need to delay the tripping of the terminal receiving the blocking signal. This delay depends, for example, on the response times of the communication channel and terminals. During an internal fault, there is no signal transmission between the terminals, so the tripping does not depend on the received signal from the opposite terminal.

In conclusion, permissive schemes are inherently faster and have better security [3] against false tripping than a blocking scheme, since tripping in an external fault is not

[3] The ability to block operation in case of an external fault

possible in case of a channel interruption. In a blocking scheme, a lost communication channel and a simultaneous external fault may lead to a false operation of the protection if the communication channel is not supervised. On the other hand, as the fast trip of the permissive scheme depends on a received signal, its dependability [4] is lower than that of the blocking scheme.

The unblocking scheme enhances the dependability of the permissive scheme. If the communication channel is interrupted and, simultaneously, a fault occurs in the forward direction, tripping is still possible either during a fixed time interval after the beginning of the interruption or as long as the communication channel is lost. This is achieved by connecting the supervision output of the implemented communication functionality to the dedicated carrier guard signal input of RESCPSCH. In general, the unblocking scheme provides better security than the blocking scheme because tripping in external faults is only possible if the fault occurs within the fixed time interval after the beginning of the channel interruption.

The direct transfer trip scheme uses the underreaching function to trip the local breaker and to transfer the trip signal to the remote terminal. The remote terminal operates immediately based on the received transfer trip signal, without any additional conditions. This scheme is very simple, but its security is low as a spurious signal results in false operation of the protection.

### Direct underreaching transfer trip DUTT

In some applications, there is a need to trip the remote end breaker immediately because of fault detection by the local measurements. This applies, for example, when the transformers or reactors are connected to the system without circuit breakers, or for remote tripping following the operation of the local breaker failure protection (CBFP).

In the direct intertrip scheme (DUTT), the carrier send signal `CS_INTER_TR` is initiated by the underreaching or the tripping signal of an external protection relay, such as transformer or reactor protection. At the remote end, the received signal initiates the breaker trip immediately without any further local protection criteria. To limit the risk of an unwanted trip due to spurious sending of signals, the trip can be delayed by the *Coordination time* setting, which should be set to 10...30 ms, depending on the type of the communication channel. The communication channel operating in direct intertripping applications should be secure and dependable.

**Setting guidelines for the intertrip scheme DUTT**

*Scheme type* = "Intertrip"

*Coordination time* = "0.050" s (10 ms + maximal transmission time)

*Carrier Min Dur* = "0.1" s

[4] The ability to operate in case of an internal fault

## Permissive underreaching transfer trip PUTT

In the permissive underreach scheme, a permission to trip is obtained locally from the underreaching function and sent to the remote end. The received signal is then combined with the local fault indication from the overreaching function resulting in a trip command after a settable pick-up delay *Coordination time*.

The protection relay of either feeder end sends a permissive signal to trip the other end. The communication channel must be able to receive and transmit at the same time. In permissive schemes, the communication channel must be fast and secure, but also dependable. Inadequate security causes unwanted tripping for external faults. Inadequate speed or dependability causes delayed tripping for internal faults.

The CS_PRM signal is issued based on the underreaching residual overcurrent protection function.

The permissive scheme is not applicable on short feeder lengths because the residual overcurrent protection cannot easily distinguish between the internal and external faults in such cases.

The residual overcurrent function may start only at one end due to the system conditions such as weak zero-sequence source at one end, or high fault resistance. However, fast tripping from both ends can be achieved by connecting a general forward start signal to CACC. So, even if the local overreaching residual overcurrent function has not picked up, the local OPERATE output is activated. The function also generates a CS_PRM signal by combining the carrier received CR_PRM signal from a remote end and also the local activation of CACC, giving the permission to a remote function to trip instantaneously.

The CR_PRM signal must be received when the overreaching residual overcurrent protection is still active to achieve an instantaneous trip. In some cases, due to the fault current distribution, the overreaching protection can operate only after the fault has been cleared by the remote terminal. In this case, there is a risk that if the remote terminal is tripped directly by the instantaneous underreaching function, the CS_PRM signal that it issues resets before the overreaching function of the local end terminal is operated. To ensure a sufficient duration of the CR_PRM signal, the CS_PRM signal can be prolonged by time *Carrier Min Dur*. The recommended value of the *Carrier Min Dur* setting is "0.1" s.

The received communication signal is combined with the output from the local overreaching function. Therefore, there is less concern about a false signal causing an incorrect trip. Therefore, the timer *Coordination time* can be set to "0". A communication channel failure does not affect the selectivity, but delays the tripping at the other end for certain fault locations.

**Setting guidelines for the permissive underreach scheme PUTT**

*Scheme type* = "Permissive Underreach"

*Coordination time* = "0" s

*Carrier Min Dur* = "0.1" s

## Permissive overreaching transfer trip POTT

In the permissive overreach scheme, the permission to trip is obtained locally from an overreaching function and sent to the remote end. The received signal is then combined with the local fault indication from the overreaching function, resulting in a trip command after a settable pick-up delay *Coordination time*.

The protection relay at either end of the feeder sends a permissive signal to trip the other end. Therefore the communication channel must be able to receive and transmit at the same time. A general requirement for the communication on permissive schemes is that it should be fast and secure.

In the permissive overreach scheme, the CS_PRM signal is issued based on the start of the overreaching residual overcurrent function.

The residual overcurrent function may start at one end due to the system conditions such as weak zero-sequence source at one end, or high fault resistance. However, fast tripping from both ends can be achieved by connecting a general forward start signal to CACC. So, even if the local overreaching residual overcurrent function has not picked up, the local OPERATE is activated. The function also generates a CS_PRM signal by combining the CR_PRM signal from a remote end and local activation of CACC, giving permission to the remote function to trip instantaneously.

The permissive overreach scheme can be used for all feeder types and lengths.

In the permissive overreach scheme, the communication channel is essential for obtaining fast tripping at both ends. Typically, a lost communication channel does not cause false tripping, but it delays the operation of the protection for the faults on the feeder.

The communication channel for a permissive overreach scheme must be fast and secure, but also dependable. Inadequate security can cause unwanted tripping for external faults. Inadequate speed or dependability can cause delayed tripping for internal faults.

In the permissive overreaching scheme, the CS_PRM signal can be issued in parallel both from the overreaching and underreaching functions. The CS_PRM signal from the overreaching function must not be prolonged, while the CS_PRM signal from the underreaching function must typically be prolonged. In parallel feeder applications, the scheme typically needs to be complemented by the current reversal logic. To ensure a correct operation in this case, the CS_PRM signal must not be prolonged (*Carrier Min Dur* = "0" s). There is no need to delay the tripping when receiving the carrier signal, so the time *Coordination time* is set to "0".

**Setting guidelines for the permissive overreaching transfer trip scheme POTT**

*Scheme type* = "Permissive Overreach"

*Coordination time* = "0" s

*Carrier Min Dur* = "0.1" s

*Carrier Min Dur* = "0" s (in case of parallel lines and current reversal logic)

## Directional comparison blocking scheme DCB

In the blocking scheme, the reverse-looking residual overcurrent function is used for sending a block signal to the remote end to block the overreaching forward-looking residual overcurrent function.

The blocking scheme is very dependable because it operates for faults anywhere on the protected feeder, even if the communication channel is out of service. Conversely, it is less secure than a permissive scheme because it trips for the external faults within the reach of the overreaching local function if the communication channel is out of service and no block signal is received.

Inadequate speed or low dependability of the communication channel can cause spurious tripping for external faults.

To secure that the blocking signal arrives before the local overreaching function trips, the trip is delayed by the *Coordination time* setting. This setting must be set longer than the sum of the maximal transmission time of the channel and the start and response times of the protection relays sending and receiving the `CS_PRM` signal. A security margin of at least 10 ms should be considered. The time delay *Carrier Min Dur* for prolonging the `CS_PRM` signal is set to "0".

**Setting guidelines for the blocking scheme**

*Scheme type* = "Blocking"

*Coordination time* = "0.1" s (10 ms + maximal transmission time)

*Carrier Min Dur* = "0" s

## Directional comparison unblocking scheme DCUB

Metallic communication paths adversely affected by fault-generated noise or by other electrical phenomena, such as lightning, are not suitable for conventional permissive schemes that rely on signal transmission during a fault in the protected feeder. Principally, the communication media must be properly shielded or otherwise designed to provide an adequate performance during such conditions.

The unblocking scheme can be used to overcome the lower dependability of permissive schemes. The function is used in older, less reliable communication, where the signal has to be sent through the primary fault. The unblocking function uses a carrier guard signal `CRG` which must always be present, even when no `CR_PRM` signal is received. Due to the absence of the `CRG` signal during the security time, the *Loss of carrier time* setting is used as a `CR_PRM` signal. This also enables a permissive scheme to operate when the communication channel is temporarily lost during an internal fault.

**Setting guidelines for the unblocking scheme**

- *Unblock mode* = "Off": The unblocking function is disabled.
- *Unblock mode* = "Permanent": If the CRG signal disappears for a longer time period than defined in the *Loss of carrier time* setting, a logical carrier received signal CRL is generated. The CRL signal remains active until the CRG signal is present. The communication failure is not signalled by the LCG output. The *Loss of carrier time* setting is set to "35" ms.
- *Unblock mode* = "Time window": If the CRG signal disappears for a longer time period than the *Loss of carrier time* setting, a CRL signal is generated. The CRL signal remains active for 150 ms, after which a communication failure is signalled by the LCG output. The value of the LCG output is reset 200 ms after the CRG signal reappears. The *Loss of carrier time* setting is set to "35" ms.

## 5.11.6 Signals

*Table 1084: RESCPSCH Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_CS_OPR | BOOLEAN | 0=False | Signal for blocking CS and OPR in all schemes |
| CSBLK | BOOLEAN | 0=False | Reverse residual overcurrent signal for Carrier Send |
| CACC | BOOLEAN | 0=False | Signal to be used for tripping by Communication Scheme |
| CSOR | BOOLEAN | 0=False | Overreaching residual overcurrent signal for Carrier Send |
| CSUR | BOOLEAN | 0=False | Underreaching residual overcurrent signal for Carrier Send |
| CR_PRM | BOOLEAN | 0=False | Received teleprotection permissive from the other side |
| CR_BLOCKING | BOOLEAN | 0=False | Received teleprotection blocking from the other side |
| CR_INTER_TR | BOOLEAN | 0=False | Received direct trip from the other side |
| CRG | BOOLEAN | 0=False | Carrier guard signal received |

*Table 1085: RESCPSCH Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| CS_PRM | BOOLEAN | Permissive transmitted to the other side |
| CS_BLOCKING | BOOLEAN | Blocking transmitted to the other side |
| CS_INTER_TR | BOOLEAN | Direct trip transmitted to the other side |
| CRL | BOOLEAN | Carrier received after unblock logic |
| LCG | BOOLEAN | Loss of guard |

## 5.11.7 Settings

*Table 1086: RESCPSCH Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Scheme type | 1=None<br>2=Intertrip<br>3=Permissive Underreach<br>4=Permissive Overreach<br>5=Blocking | | | 3=Permissive Underreach | Scheme type, mode of operation |
| Carrier Min Dur | 0...60000 | ms | 1 | 100 | Minimum duration of carrier send signal |
| Coordination time | 0...60000 | ms | 1 | 35 | Co-ordination timer for blocking scheme |

*Table 1087: RESCPSCH Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Unblock mode | 1=Off<br>2=Permanent<br>3=Time window | | | 1=Off | Unblock function mode for scheme type |
| Loss of carrier time | 0...60000 | ms | 1 | 35 | Pickup security timer on loss of carrier guard signal |

## 5.11.8 Monitored data

*Table 1088: RESCPSCH Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| RESCPSCH | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.11.9 Technical data

*Table 1089: RESCPSCH Technical data*

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

# 5.12 Current reversal and weak-end infeed logic CRWPSCH

## 5.12.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current reversal and weak-end infeed logic | CRWPSCH | CLCRW | 85 21CREV,WEI |

## 5.12.2 Function block




*Figure 629: Function block*

## 5.12.3 Functionality

The current reversal and weak-end infeed logic function CRWPSCH can be used when the scheme communication logic DSOCPSCH requires additional logics to operate correctly in all power system conditions.

In parallel feeder applications, the fault current direction on the healthy feeder can change when the circuit breaker on the faulty feeder opens to clear the fault. This can lead to an unwanted operation of the distance protection on the healthy parallel feeder when DSOCPSCH is used with the permissive overreach scheme. The main purpose of the current reversal logic is to prevent such unwanted operations.

The permissive communication schemes can operate only when the protection in the remote terminal can detect the fault. This detection requires sufficient minimum fault current. If such current is not available due to a too weak remote end source, the weak-end infeed logic can be used to overcome the situation and trip the remote end breaker.

## 5.12.4 Analog channel configuration

CRWPSCH has one analog group input which must be properly configured.

*Table 1090: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1091: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phases connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.12.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of CRWPSCH can be described with a module diagram. All the modules in the diagram are explained in the next sections.

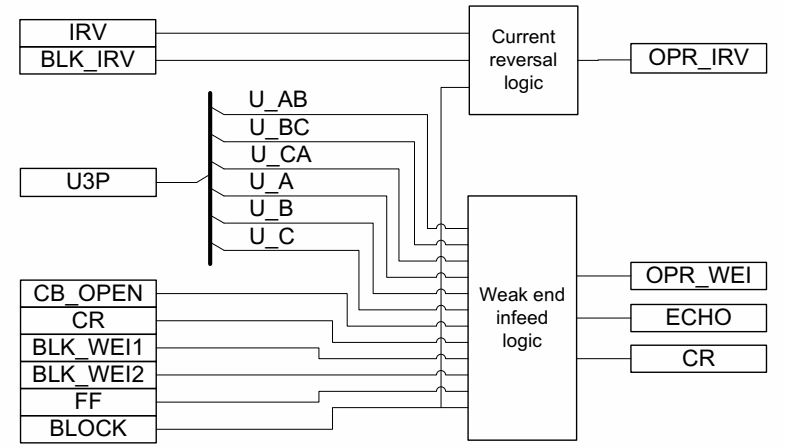



*Figure 630: Functional module diagram*

### Current reversal logic

Current reversal logic is enabled by changing the value of the *Reversal mode* setting to "On".

This logic uses the start signal of the reverse-looking zone (Z3) connected to the IRV input, which is used to recognize the fault in the reverse direction, that is, in the parallel feeder. When the reverse zone is activated after a start delay (the *Reversal time* setting), the logic is ready to issue an OPR_IRV output signal. The OPR_IRV signal is connected to the BLK_CS_OPR input of DSOCPSCH in order to block the sending of the carrier send signal (CS) and the activation of the OPERATE output of the communication logic. The OPR_IRV signal has a drop-off delay defined with the *Reversal reset time* setting.

An internal 10 ms drop-off timer enables the current reversal logic to be activated for the short-duration input signals even if the *Reversal reset time* setting is set to zero.

The BLK_IRV input is used to block the activation of the OPR_IRV output. The BLK_IRV input is typically connected to the forward-looking zone start signals within the terminal. General blocking is achieved by activating the BLOCK input.

## Weak-end infeed logic

Weak-end infeed logic is used to activate the distance protection function when the fault current infeed is too low due to, for example, high source impedance or fault current distribution between sources. When activated, the CR signal is logically combined with the local criteria to initiate the tripping of the weak-end breaker. The received signal is echoed back to accelerate the tripping in the opposite end with the stronger source.

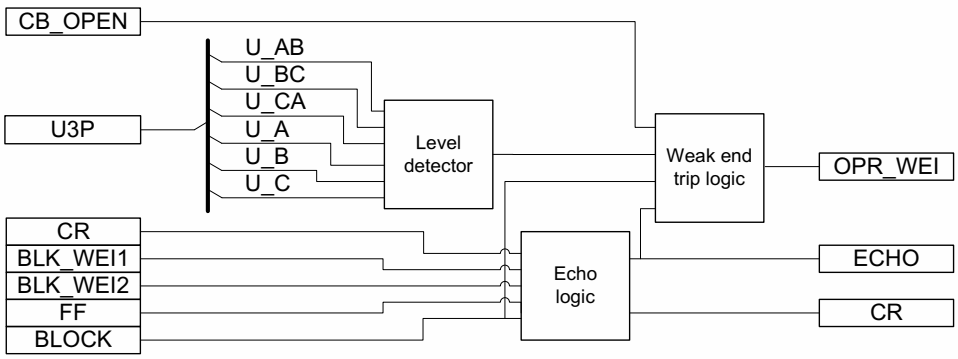



*Figure 631: Functional module diagram of weak-end infeed logic*

The WEI logic is enabled using the *Wei mode* setting.

- If *Wei mode*= "Off", the WEI logic is disabled.
- If *Wei mode*= "Echo", the WEI logic is enabled without Level detector.
- If *Wei mode*= "Echo and Operate", the WEI logic is enabled with Level detector.

### Level detector

Both phase-to-earth and phase-to-phase voltages are monitored. The undervoltage criteria are applied to the phase-to-phase voltages with the *PPV level for Wei* setting and to the phase-to-earth voltages with the *PhV level for Wei*. Level detector sends an enable signal for a phase to Weak-end trip logic when one or more voltages are below the corresponding settings. Level detector blocks the enable signal if all three-phase voltages are above the set value more than 100 ms. This is to avoid sending an unnecessary operate signal if the breaker is already open.

### Echo logic

Echo logic returns the received carrier signal with the ECHO output when it receives a CR signal if no fault has been detected by the forward- and reverse-looking zones and the duration of CR is longer than the coordination time delay (setting *Wei Crd time*). The received carrier receive signal is also given as the CR output.



When the WEI logic is enabled at both feeder ends, a spurious signal can be looped round by Echo logic. To avoid a continuous lockup of the system, the duration of the echoed signal is limited to 200 ms.

The ECHO and CR outputs can be blocked by activating the BLOCK input. The FF, BLK_WEI1 and BLK_WEI2 inputs can be used to block the ECHO output. The FF input is usually connected to the functional output of the fuse failure function, and the BLK_WEI1 input is typically connected to the start signals of the forward and reverse directional residual overcurrent functions within the terminal. The BLK_WEI2 signal has an in-built 200 ms drop-off delay. The BLK_WEI2 input is usually connected to all the fault detection functions within the terminal except the residual overvoltage function.

### Weak-end trip logic

Weak-end trip logic is activated if it receives an enable signal from Level detector and ECHO output of Echo logic is activated. Then a general trip signal OPR_WEI is activated. The activation of the CB_OPEN input blocks the tripping.

The OPR_WEI output can be blocked by activating the BLOCK input.

## 5.12.6 Application

### Current reversal logic

In parallel feeder applications, when the overreaching permissive communication schemes are used, unselective tripping may result due to the current reversal. Such a condition can occur in the healthy feeder when the fault is cleared in the faulty feeder. The tripping of the healthy parallel feeder may lead to losing the connection between the two buses. To avoid this situation, the current reversal logic (transient blocking logic) can be used.

Assume that Relay A1, Relay A2, Relay B1 and Relay B2 are equipped with DSOCPSCH and the permissive overreach scheme is enabled. A fault occurs at Feeder 1 close to bus B. Relay A2 at the healthy Feeder 2 recognizes the fault in the forward direction within the overreaching zone Z2 and sends a CS signal to Relay B2 according to the POTT scheme. Relay B2 does not recognize the fault in the forward direction and does not operate even though a permissive CR signal is received from Relay A2. Moreover, Relay B2 does not send a permissive signal to Relay A2.

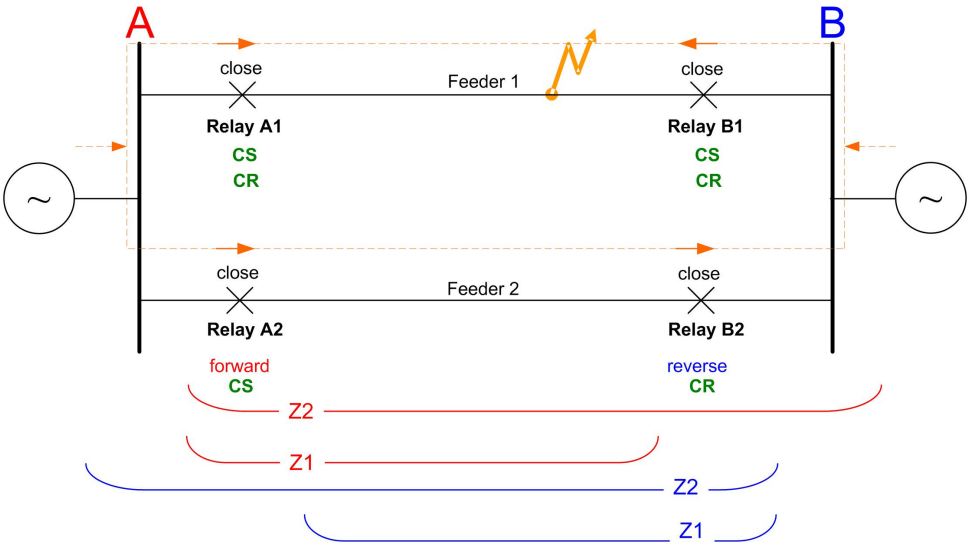



*Figure 632: The fault occurs at one of the parallel lines.*

The faulty feeder (Feeder 1) is not simultaneously tripped at both ends and it might occur that, for example, the circuit breaker closer to the fault at Relay B1 is tripped faster than the breaker at bus A due to the direct operation of the zone Z1 of Relay B1. Thus, when the breaker at Relay B1 opens, the direction of the fault current at the healthy feeder (Feeder 2) is reversed.

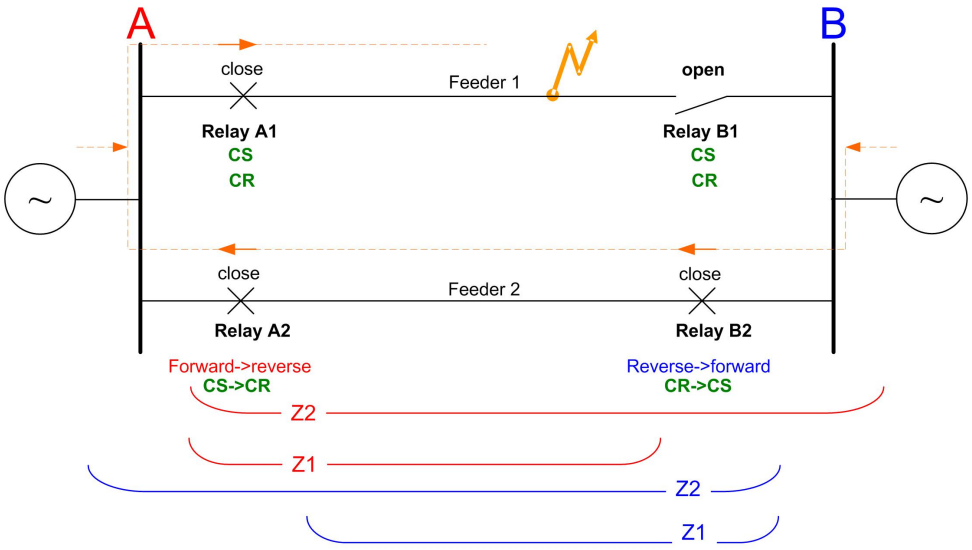



*Figure 633: The circuit breaker at Relay B1 opens and creates a current reversal condition*

Relay A2 is still sending the CS signal because of the reset time delay of the forward zone of Relay A2 when the overreaching zone of Relay B2 starts to recognize the fault in the forward direction. Relay B2 can malfunction and trip the breaker of the healthy feeder.

This problem can be solved by using the reverse-looking zone (Z3) to recognize the fault in reverse direction and temporarily block the operation of DSOCPSCH due to the current reversal condition. This is used in CRWPSCH.

## Weak-end infeed logic

Avoid using the WEI function at both feeder ends. It can only be enabled at the weak end.

The weak-end infeed logic should be used only in permissive schemes.

## Setting guidelines for current reversal logic

Setting *Reversal reset time*: Set the *Reversal reset time* setting to the maximum reset time of the communication channel. A minimum setting of 40 ms is recommended. A long *Reversal reset time* setting increases the security against unwanted tripping, but delays the fault clearing if the fault develops in one feeder and involves the other. However, the probability of this type of fault is small.

Setting *Reversal time*: Set the start delay *Reversal time* setting to less than 80 percent of the breaker operate time, but to a minimum of 20 ms.

### Setting guidelines for weak-end infeed logic

The WEI function returns the received carrier signal with the ECHO output when it receives the carrier signal (CR) if no fault has been detected by forward- and reverse-looking zones and the signal duration is longer than the *Wei Crd time* coordination time delay setting. Set the *Wei Crd time* = "0.010" s to avoid the spurious carrier received signals that activate the WEI logic and cause unwanted communication.

Set the voltage criteria *PPV level for Wei* and *PhV level for Wei* for the weak-end trip to 70 percent of the system's base voltage. The setting should be below the minimum operate voltage of the system but above the voltage that occurs for a fault on the protected feeder. The phase-to-phase elements must be verified not to operate for the phase-to-earth faults.

## 5.12.7 Signals

*Table 1092: CRWPSCH Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_IRV | BOOLEAN | 0=False | Block of current reversal function |
| BLK_WEI1 | BOOLEAN | 0=False | Block of WEI Logic |
| BLK_WEI2 | BOOLEAN | 0=False | Block of WEI logic due to operation of other protections |
| IRV | BOOLEAN | 0=False | Activation of current reversal logic |
| FF | BOOLEAN | 0=False | Block of trip from WEI logic through fuse-failure function |
| CB_OPEN | BOOLEAN | 0=False | Block of trip from WEI logic by an open breaker |
| CR | BOOLEAN | 0=False | POR Carrier receive for WEI logic |

*Table 1093: CRWPSCH Output signals*

| Name | Type | Description |
|---|---|---|
| OPR_IRV | BOOLEAN | Operation of WEI logic in phase B |
| OPR_WEI | BOOLEAN | Operation of WEI logic in phase C |
| ECHO | BOOLEAN | Carrier send by WEI logic |
| CR | BOOLEAN | POR Carrier signal received from remote end |

## 5.12.8 Settings

*Table 1094: CRWPSCH Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Reversal mode | 1=Off<br>2=On | | | 1=Off | Operating mode of Current Reversal Logic |
| Wei mode | 1=Off<br>3=Echo<br>4=Echo and Operate | | | 1=Off | Operating mode of WEI logic |
| PhV level for Wei | 0.10...0.90 | xUn | 0.01 | 0.70 | Phase to Neutral voltage for detection of fault condition |
| PPV level for Wei | 0.10...0.90 | xUn | 0.01 | 0.70 | Phase to Phase voltage for detection of fault condition |
| Reversal time | 0...60000 | ms | 10 | 20 | Pickup time for current reversal logic |
| Reversal reset time | 0...60000 | ms | 10 | 60 | Time Delay to prevent Carrier send and local trip |
| Wei Crd time | 0...60000 | ms | 10 | 10 | Coordination time for the WEI logic |

## 5.12.9 Monitored data

*Table 1095: CRWPSCH Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| CRWPSCH | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.12.10 Technical data

*Table 1096: CRWPSCH Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±1.5% of the set value or ±0.002 × $U_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

# 5.13 Current reversal and weak-end infeed logic for residual overcurrent RCRWPSCH

## 5.13.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current reversal and weak-end infeed logic for residual overcurrent | RCRWPSCH | CLCRWN | 85 67G/N CREV,WEI |

## 5.13.2 Function block

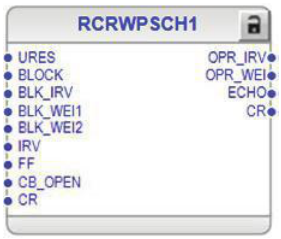



*Figure 634: Function block*

## 5.13.3 Functionality

The current reversal and weak-end infeed logic for residual overcurrent function RCRWPSCH can be used when the communication logic for residual overcurrent RESCPSCH requires additional logics to operate correctly in all power system conditions.

In parallel feeder applications, the direction of the fault current on the healthy feeder can change when the circuit breaker on the faulty feeder opens to clear the fault. This can lead to an unwanted operation of the residual overcurrent protection on the healthy parallel feeder when RESCPSCH with the permissive overreach scheme is used. The main purpose of the current reversal logic is to prevent such unwanted operations.

The permissive communication schemes can operate only when the protection in the remote terminal can detect the fault. This detection requires sufficient minimum fault current. If such current is not available due to too weak a remote end source, the WEI logic can be used to overcome the situation and trip the remote end breaker.

## 5.13.4 Analog channel configuration

RCRWPSCH has one analog group input which must be properly configured.

*Table 1097: Analog inputs*

| Input | Description |
|---|---|
| URES[1)] | Residual voltage (measured or calculated) Necessary when *Wei mode* is set to "Echo and Operate" |

1) Can be connected to GRPOFF if *Wei mode* is set to "Off" or "Echo"

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

*Table 1098: Special conditions*

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected to calculate the residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.13.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of RCRWPSCH can be described with a module diagram. All the modules in the diagram are explained in the next sections.

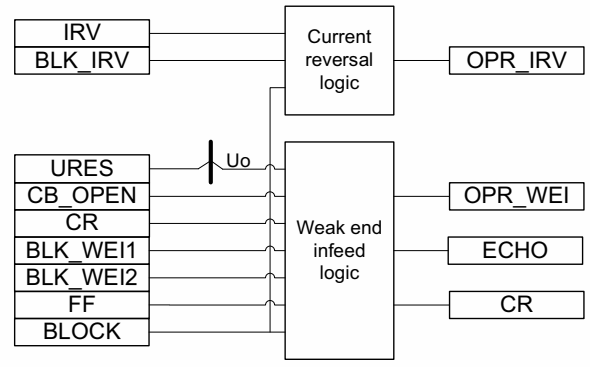



*Figure 635: Functional module diagram*

## Current reversal logic

Current reversal logic is enabled by changing the value of the *Reversal mode* setting to "On".

Current reversal logic uses the start signal of the reverse directional residual overcurrent function connected to the IRV input, which is used to recognize the fault in the reverse direction, that is, in the parallel feeder. When the reverse directional residual overcurrent function is activated, the logic is ready to issue an OPR_IRV output signal after a start delay (setting *Reversal time*). The OPR_IRV signal is connected to the BLK_CS_OPR input of the scheme communication logic function to block the sending of the carrier send signal (CS) and the activation of the OPERATE output of the communication logic. The OPR_IRV signal has a drop-off delay defined with the *Reversal reset time* setting.

An internal 10 ms drop-off timer is provided which ensures the current reversal logic is activated for short-duration input signals, even if the *Reversal reset time* setting is set to zero.

The BLK_IRV input is used to block the activation of the OPR_IRV output. The BLK_IRV input is typically connected to the start signals of the forward-looking residual overcurrent function in the terminal. General blocking is achieved by activating the BLOCK input.

## Weak-end infeed (WEI) logic

The WEI logic is used to activate the residual overcurrent protection function when the fault current infeed is too low due to, for example, high source impedance or fault current distribution between sources. When activated, the carrier receive (CR) signal is logically combined with the local criteria to initiate the tripping of the weak-end breaker. The received signal is also echoed back to accelerate the tripping at the opposite end with the stronger source.

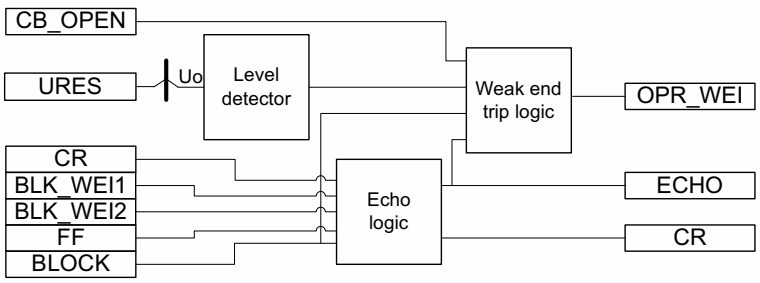



*Figure 636: Functional module diagram of Weak-end infeed logic*

The WEI logic is enabled using the *Wei mode* setting.

- If *Wei mode* = "Off", the WEI logic is disabled.
- If *Wei mode* = "Echo", the WEI logic is enabled without Level detector.
- If *Wei mode* = "Echo and Operate", the WEI logic is enabled with Level detector.

### Level detector

Level detector sends an enabling signal to Weak-end trip logic when the residual voltage is above the *Residual voltage Val* setting.

### Echo logic

Echo logic returns the received carrier signal with the ECHO output when it receives a carrier receive signal (CR) if no fault has been detected by the forward and reverse directional residual overcurrent functions and the duration of CR is longer than the coordination time delay (the setting *Wei Crd time*). The received carrier receive signal is also given as the CR output.

When the WEI logic is enabled at both feeder ends, a spurious signal can be looped round by Echo logic. To avoid a continuous lockup of the system, the duration of the echoed signal is limited to 200 ms.

The ECHO and CR outputs can be blocked by activating the BLOCK input. The FF, BLK_WEI1 and BLK_WEI2 inputs can be used to block the ECHO output. The FF input is usually connected to the functional output of the fuse failure function, and the BLK_WEI1 input is typically connected to the start signals of the forward and reverse directional residual overcurrent functions in the terminal. The BLK_WEI2 signal has an in-built 200 ms drop-off delay and is usually connected to all the fault detection functions in the terminal except the residual overvoltage function.

### Weak-end trip logic

Weak-end trip logic is activated if it receives an enable signal from Level detector and ECHO output of Echo logic is activated. Then a general trip signal OPR_WEI is activated. The activation of the CB_OPEN input blocks the tripping.

The OPR_WEI output can be blocked by activating the BLOCK input.

## 5.13.6 Application

### Current reversal logic

When the overreaching permissive communication schemes are used in parallel feeder applications, the current reversal can result in unselective tripping. Such a condition can occur in the healthy feeder when the fault is cleared in the faulty feeder. The tripping of the healthy parallel feeder can lead to losing the connection between the two buses. To avoid this situation, the current reversal logic (transient blocking logic) can be used.

In the current reversal condition, the relays Relay A1, Relay A2, Relay B1 and Relay B2 can be equipped with the scheme communication logic RESCPSCH and the permissive overreach scheme can be enabled.

A fault occurs at Feeder 1 close to bus B. Relay A2 at the healthy feeder 2 recognizes the fault in the forward direction and sends a CS signal to Relay B2 according to the PUTT scheme. Relay B2 does not recognize the fault in the forward direction and hence does not send a permissive signal to Relay A2.

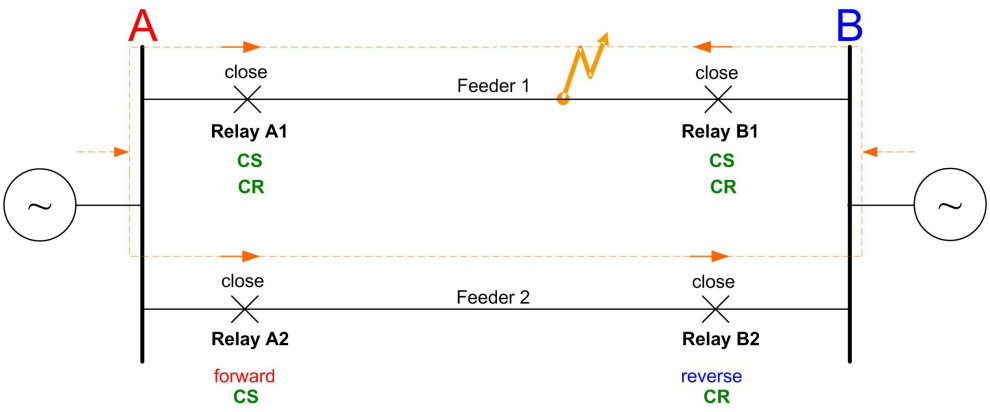



*Figure 637: Fault occurs at one of the parallel lines. CS=carrier signal sending, CR=carrier signal receiving*

The faulty feeder (Feeder 1) is not simultaneously tripped at both ends and, for example, the circuit breaker closer to the fault at Relay B1 may be tripped faster than the breaker at bus A. As a result, when the breaker at Relay B1 opens, the direction of the fault current at the healthy feeder (Feeder 2) is reversed.

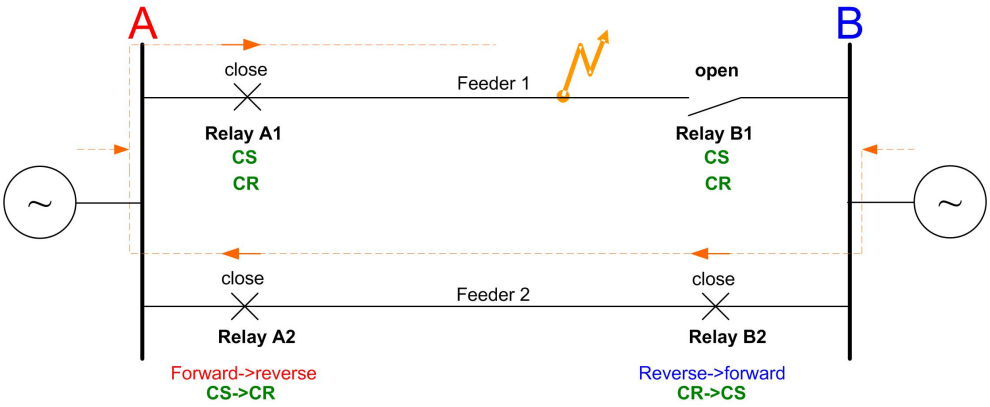



*Figure 638: Circuit breaker at Relay B1 opens and creates a current reversal condition. CS=carrier signal sending, CR=carrier signal receiving.*

Relay A2 still sends the CS signal because of the reset time delay of the forward direction residual overcurrent function of Relay A2. When Relay B2 starts to recognize the fault in the forward direction, Relay B2 can malfunction and trip the breaker of the healthy feeder.

This problem can be solved using the reverse directional residual overcurrent function to recognize the fault in reverse direction and temporarily block the operation of the scheme communication logic due to the current reversal condition. This is used in RCRWPSCH.

### Weak-end infeed (WEI) logic

Do not use the WEI function at both feeder ends. It can only be enabled at the weak end.

The WEI logic is recommended to be used only in the permissive schemes.

### Setting guidelines for current reversal logic

*Reversal reset time*: This setting can be set to the maximum reset time of the communication channel. A minimum setting of 40 ms is recommended. A long *Reversal reset time* setting increases the security against unwanted tripping, but delays the fault clearing if the fault develops from one feeder to involve the other. However, the probability of this type of fault is small.

*Reversal time*: Set the start delay reversal time below 80 percent of the breaker operate time, but to a minimum of 20 ms.

### Setting guidelines for Weak-end infeed (WEI) logic

The WEI logic returns the received carrier signal with the ECHO output when it receives the carrier signal (CR) if no fault has been detected by the forward and reverse directional measuring elements and the duration is longer than the *Wei Crd time* coordination time delay setting. To prevent the spurious carrier receive signals from activating the WEI logic and causing unwanted communication, the *Wei Crd time* setting can be set to "0.010 s".

## 5.13.7 Signals

*Table 1099: RCRWPSCH Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_IRV | BOOLEAN | 0=False | Block of current reversal function |
| BLK_WEI1 | BOOLEAN | 0=False | Block of WEI Logic |
| BLK_WEI2 | BOOLEAN | 0=False | Block of WEI logic due to operation of other protections |
| IRV | BOOLEAN | 0=False | Activation of current reversal logic |
| FF | BOOLEAN | 0=False | Block of trip from WEI logic through fuse-failure function |
| CB_OPEN | BOOLEAN | 0=False | Block of trip from WEI logic by an open breaker |
| CR | BOOLEAN | 0=False | POR Carrier receive for WEI logic |
| CR | BOOLEAN | 0=False | POR Carrier signal received from remote end |

*Table 1100: RCRWPSCH Output signals*

| Name | Type | Description |
|---|---|---|
| OPR_IRV | BOOLEAN | Operation of current reversal logic |
| OPR_WEI | BOOLEAN | Operation of WEI logic |
| ECHO | BOOLEAN | Carrier send by WEI logic |
| CR | BOOLEAN | POR Carrier signal received from remote end |

## 5.13.8 Settings

*Table 1101: RCRWPSCH Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Reversal mode | 1=Off<br>2=On | | | 1=Off | Operating mode of Current Reversal Logic |
| Wei mode | 1=Off<br>3=Echo<br>4=Echo and Operate | | | 1=Off | Operating mode of WEI logic |
| Residual voltage Val | 0.05...0.70 | xUn | 0.01 | 0.25 | Neutral voltage setting for fault conditions measurement |
| Reversal time | 0...60000 | ms | 10 | 20 | Pickup time for current reversal logic |
| Reversal reset time | 0...60000 | ms | 10 | 60 | Time Delay to prevent Carrier send and local trip |
| Wei Crd time | 0...60000 | ms | 10 | 0 | Coordination time for the WEI logic |

## 5.13.9 Monitored data

*Table 1102: RCRWPSCH Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| RCRWPSCH | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.13.10 Technical data

*Table 1103: RCRWPSCH Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

# 5.14 Three-phase power directional element DPSRDIR

## 5.14.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase power directional element | DPSRDIR | I1-> | 67P-TC |

## 5.14.2 Function block




*Figure 639: Function block*

## 5.14.3 Functionality

The three-phase power directional element function DPSRDIR is used to detect positive-sequence power direction. The output of the function is used for blocking or releasing other functions in protection scheme.

The directional positive-sequence power protection contains a blocking functionality which blocks function output and resets Timer.

DPSRDIR executes on the direction of positive-sequence power and not the value. If overpower or underpower is needed, refer to DOPPDPR and DUPPDPR. DPSRDIR is generally used for directional controls.

## 5.14.4 Analog channel configuration

DPSRDIR has two analog group inputs which must be properly configured.

*Table 1104: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1105: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.14.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DPSRDIR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

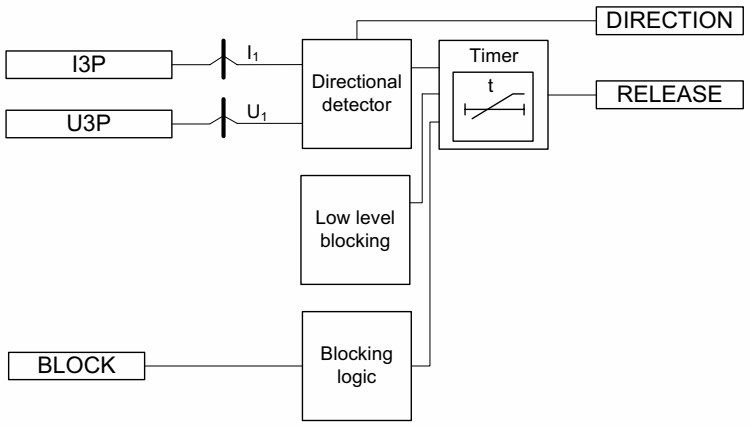



*Figure 640: Functional module diagram*

### Directional detector

The Directional detector module compares the angle of the positive-sequence current I1 to the angle of the positive-sequence voltage V1. Using the positive-sequence voltage angle as reference, the positive-sequence current angle is compared to the *Characteristic angle* setting. If the angular difference is within the operating sector selected with the *Directional mode* setting, the On signal is sent to Timer.

The operating sector is defined by the setting *Min forward angle*, *Max forward angle*, *Min reverse angle* and *Max reverse angle*. The options that can be selected for the *Directional mode* setting are “Forward” and “Reverse”.

The sector limits are always given as positive degree values.

The *Characteristic angle* setting is also known as Relay Characteristic Angle (RCA), Relay Base Angle or Maximum Torque Line.

*Figure 641: Configurable directional settings*

### Low-level blocking

For a reliable operation, signal levels should be greater than the minimum level. If they are not greater than the minimum level, Timer is blocked. If the amplitude of the positive-sequence current is greater than the *Min trip current* value and the positive-sequence voltage amplitude is greater than the *Min trip voltage* value, the On signal is sent to Timer.

### Timer

Once activated, the internal operating timer is started. The Timer characteristic is according to definite time DT. When Timer has reached the value of *Release delay time*, the RELEASE output is activated. If a drop-off situation happens, that is, if the operating current moves outside the operating sector or signal amplitudes drop below the minimum level before *Release delay time* is exceeded, the Timer reset state is activated. If the drop-off continues for more than *Reset delay time*, Timer is deactivated.

### Blocking logic

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates the RELEASE output and resets Timer.

## 5.14.6 Application

The three-phase power directional element function DPSRDIR improves the possibility to obtain a selective function of the overcurrent protection in meshed networks. DPSRDIR is used to block or release other overcurrent protection functions.

## 5.14.7 Signals

*Table 1106: DPSRDIR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 1107: DPSRDIR Output signals*

| Name | Type | Description |
|---|---|---|
| RELEASE | BOOLEAN | Release signal if direction criteria is satisified |
| DIRECTION | Enum | Direction information |

## 5.14.8 Settings

*Table 1108: DPSRDIR Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Release delay time | 0...1000 | ms | 1 | 10 | Release delay time |
| Characteristic angle | -179...180 | deg | 1 | 60 | Characteristic angle |
| Max forward angle | 0...90 | deg | 1 | 88 | Maximum phase angle in forward direction |
| Max reverse angle | 0...90 | deg | 1 | 88 | Maximum phase angle in reverse direction |
| Min forward angle | 0...90 | deg | 1 | 88 | Minimum phase angle in forward direction |
| Min reverse angle | 0...90 | deg | 1 | 88 | Minimum phase angle in reverse direction |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |

*Table 1109: DPSRDIR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 1110: DPSRDIR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.10 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.30 | Minimum operating voltage |

### 5.14.9 Monitored data

*Table 1111: DPSRDIR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ANGLE_RCA | FLOAT32 | -180.00...180.00 | deg | Angle between operating angle and characteristic angle |
| DPSRDIR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.15 Neutral power directional element DNZSRDIR

### 5.15.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Neutral power directional element | DNZSRDIR | I2->, Io-> | 67N-TC |

### 5.15.2 Function block




*Figure 642: Function block*

### 5.15.3 Functionality

Neutral power directional element function DNZSRDIR is used to detect negative or residual power direction. The output of the function is used for blocking or releasing other functions in protection scheme.

In negative-sequence voltage selection, if the angle difference between negative-sequence voltage and negative-sequence current is in a predefined direction (either in forward or reverse direction), DNZSRDIR gives a release signal after a definite time delay.

In residual voltage selection, if the angle difference between residual voltage and residual current is in a predefined direction (either in forward or reverse direction), DNZSRDIR gives release signal after a definite time delay.

This function contains a blocking functionality which blocks the function output and resets Timer.

DNZSRDIR executes on the direction of either negative-sequence or zero-sequence power and not the value. The function is generally used for directional controls.

## 5.15.4 Analog channel configuration

DNZSRDIR has four analog group inputs which must be properly configured.

*Table 1112: Analog inputs*

| Input | Description |
|---|---|
| I3P[1)] | Three-phase currents<br>Necessary when *Pol quantity* is "Neg. seq. volt." |
| IRES[2)] | Residual current (measured or calculated)<br>Necessary when *Pol quantity* is "Zero seq. volt." |
| U3P[1)] | Three-phase voltages<br>Necessary when *Pol quantity* is "Neg. seq. volt." |
| URES[2)] | Residual voltage (measured or calculated)<br>Necessary when *Pol quantity* is "Zero seq. volt." |

1) Can be connected to GRPOFF if *Pol quantity* is set to "Zero seq. volt."
2) Can be connected to GRPOFF if *Pol quantity* is set to "Neg. seq. volt."

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

*Table 1113: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |
| URES calculated | The function requires that all three voltage channels are connected to calculate residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.15.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DNZSRDIR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

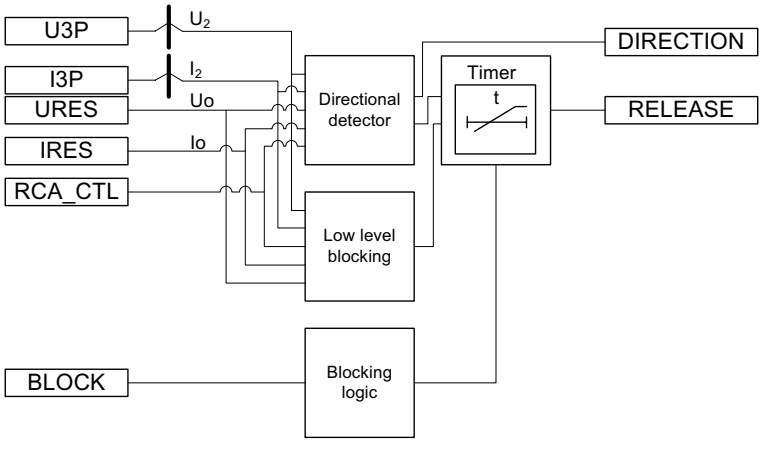



*Figure 643: Functional module diagram*

### Directional detector

When "Neg. seq. volt." selection is made using the *Pol quantity* setting, the Directional detector module compares the angle of the negative-sequence current ($I_2$) to the negative-sequence voltage ($-U_2$). Using the negative-sequence voltage angle as the reference, the negative-sequence current angle is compared to the *Characteristic angle* setting. If the angle difference is within the operating sector selected by *Direction mode* setting, the Enable signal is sent to Timer.

The value of *Characteristic angle* should be chosen in such way that all the faults in the operating direction are seen in the operating zone and all the faults in the opposite direction are seen in the backward zone.

The operating sector is defined by the settings *Max forward angle*, *Max reverse angle*, *Min forward angle* and *Min reverse angle*. The options that can be selected for *Directional mode* settings are “Forward” and “Reverse”.

*Characteristic angle* is also known as Relay Characteristic Angle RCA, Relay Base Angle or Maximum Torque Line.

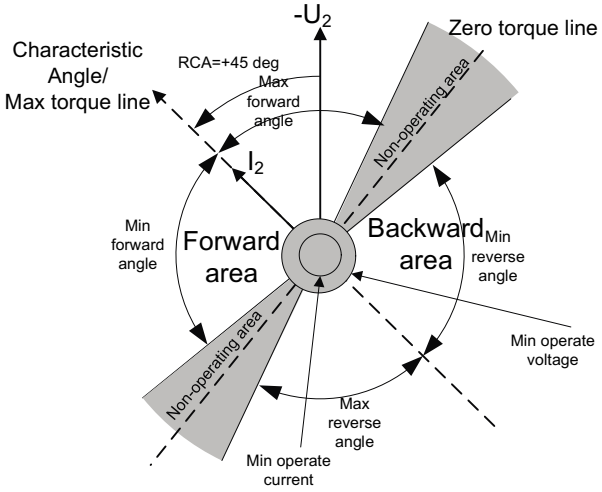



*Figure 644: Configurable directional setting when "Neg. seq. volt." selection is made using the Pol quantity setting*

When *Zero seq. volt.* voltage selection is made using *Pol quantity* setting, the directional detector module compares the angle of the residual current to the residual voltage. Using the residual voltage as reference, the residual current angle is compared to the *Characteristic angle* setting. If the angle difference is within the operating sector selected by the *Directional mode* setting, the Enable signal is sent to Timer.

The polarizing quantity (residual voltage) is inverted because of switched voltage measurement cables, the correction can be done by setting the *Pol reversal* setting to "True", which rotates the polarizing quantity by 180 degrees.

The directional characteristic for the measured or calculated residual power is same.

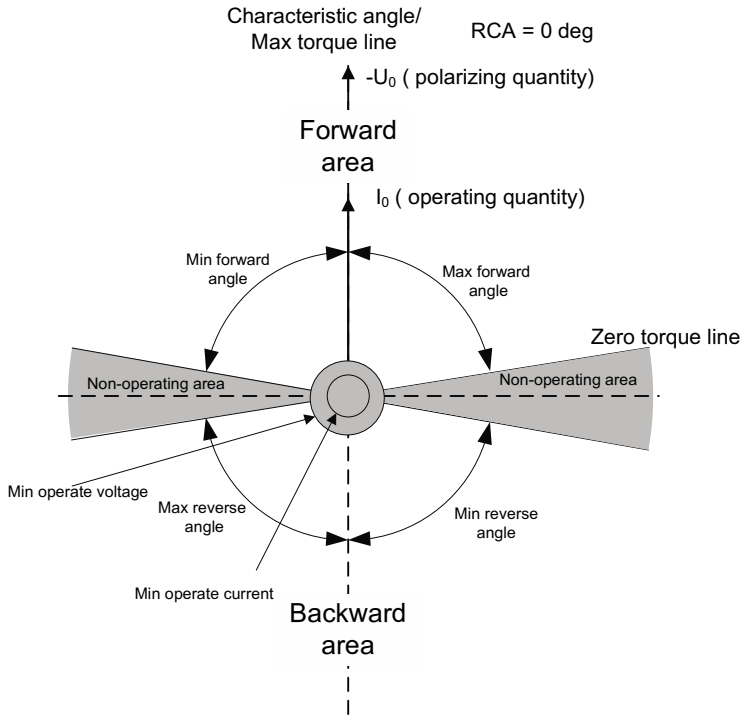



*Figure 645: Configurable directional setting for Zero seq. volt. (residual voltage) using the Pol quantity setting*

The *Characteristic angle* setting is done based on method of grounding employed in the network. For example, in case of an isolated network, *Characteristic angle* is set to -90°, and in case of a compensated network, *Characteristic angle* is set to 0° and 60° for solidly grounded systems. In general *Characteristic angle* is selected so that it matches close to the expected fault angle value, which results in maximum sensitivity. *Characteristic angle* can be set anywhere between -179° to +180°. The figures show examples of the operating area with RCA set to +60° and -90°, respectively.

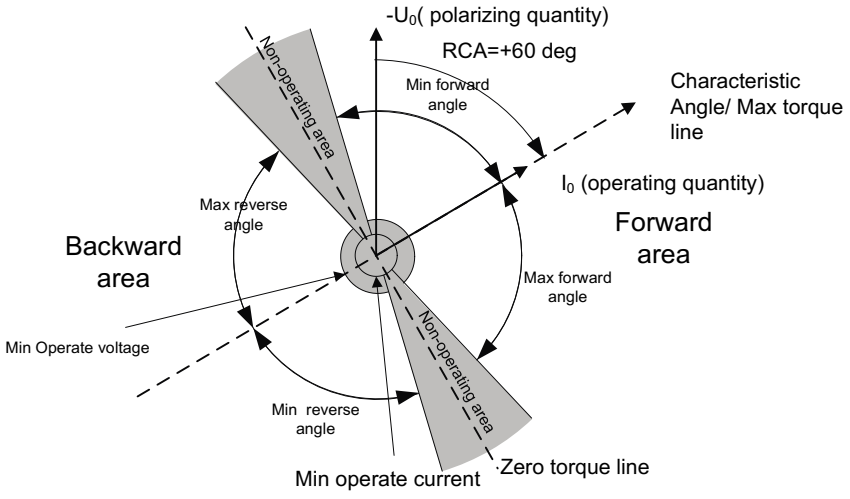



*Figure 646: Configurable directional characteristics (RCA =+60˚) for a solidly earthed network*

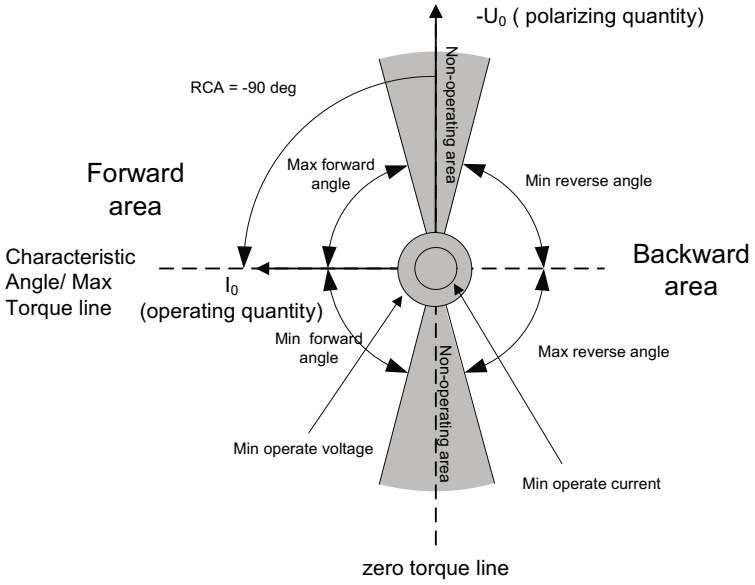



*Figure 647: Configurable directional characteristics (RCA = -90˚) for an isolated network*

*Characteristic angle* should be set to a positive value if the operating signal lags the polarizing quantity -VG or -VN, respectively, and a negative value if operating signal leads the polarizing quantity, respectively.

*Table 1114: Recommended Characteristic angle setting for different network*

| Type of network | Characteristic angle recommended |
|---|---|
| Compensated network | 0° |
| Solidly grounded network | +60° |
| Isolated network | -90° |

The *Characteristic angle* setting is adjusted to the operation according to the method of neutral-point grounding, so that in an isolated network *Characteristic angle* is -90° and in a compensated network 0°. In addition, *Characteristic angle* can be changed via the control signal RCA_CTL, in which case the alternatives are -90° and 0°. The operation of the RCA_CTL input depends on the *Characteristic angle* setting.

The Peterson coil or the grounding resistor may be temporarily out of operation. To keep the protection scheme selective, it is necessary to update the *Characteristic angle* settings accordingly. This is done with an auxiliary input in the relay which receives a signal from an auxiliary switch of the disconnector of the Peterson coil in compensated networks or of the grounding resistor in grounded network as a result the *Characteristic angle* is set automatically to suit the earthing method.

*Table 1115: Characteristic angle control for the RCA_CTL condition*

| Characteristic angle Setting | RCA_CTL=FALSE | RCA_CTL=TRUE |
|---|---|---|
| -90° | *Characteristic angle* =-90° | *Characteristic angle* = 0° |
| 0° | *Characteristic angle* = 0° | *Characteristic angle* =-90° |

When the phase angle criterion is used, the DIRECTION output indicates on which operating sector the negative or residual power is measured.

## Low-level blocking

For a reliable operation, signal levels should be greater than the minimum level. If they are not greater than the minimum level, Timer is blocked.

In the "Neg. seq. volt." polarization selection using the *Pol quantity* setting, if the amplitude of the negative-sequence current is greater than the *Min operate current* value and the negative-sequence voltage amplitude is greater than the *Min operate voltage* value, the Enable signal is sent to Timer.

In the "Zero seq. volt." polarization selection using *Pol quantity*, if the amplitude of the residual current is greater than the *Min operate current* value and residual voltage amplitude is greater than the *Min operate voltage* value, the Enable signal is sent to Timer.

## Timer

Once activated, the internal operating timer is started. The Timer characteristic is according to DT. When Timer has reached the value of *Release delay time*, the RELEASE output is activated. If a drop-off situation happens, that is, if the operating

current moves out of the operating sector or signal amplitudes drop below the minimum levels, before *Release delay time* is exceeded, the Timer reset state is activated. If the drop-off continues for more than *Reset delay time*, Timer is deactivated.

### Blocking logic

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates RELEASE output and resets Timer.

## 5.15.6 Application

The neutral power directional element function DNZSRDIR improves the possibility to obtain selective function of the overcurrent protection in meshed networks. DNZSRDIR is used to block or release other overcurrent protection functions.

## 5.15.7 Signals

*Table 1116: DNZSRDIR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RCA_CTL | BOOLEAN | 0=False | Relay characteristic angle control |

*Table 1117: DNZSRDIR Output signals*

| Name | Type | Description |
|---|---|---|
| RELEASE | BOOLEAN | Release signal if direction criteria is satisified |
| DIRECTION | Enum | Direction information |

## 5.15.8 Settings

*Table 1118: DNZSRDIR Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Release delay time | 0...1000 | ms | 10 | 10 | Release delay time |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Characteristic angle | -179...180 | deg | 1 | 60 | Characteristic angle |
| Max forward angle | 0...180 | deg | 1 | 88 | Maximum phase angle in forward direction |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min forward angle | 0...180 | deg | 1 | 88 | Minimum phase angle in forward direction |
| Max reverse angle | 0...180 | deg | 1 | 88 | Maximum phase angle in reverse direction |
| Min reverse angle | 0...180 | deg | 1 | 88 | Minimum phase angle in reverse direction |

*Table 1119: DNZSRDIR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Pol quantity | 3=Zero seq. volt.<br>4=Neg. seq. volt. | | | 3=Zero seq. volt. | Reference quantity used to determine fault direction |

*Table 1120: DNZSRDIR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Min operate current | 1.0...100.0 | %In | 0.1 | 10.0 | Minimum operating current |
| Min operate voltage | 1.0...100.0 | %Un | 0.1 | 30.0 | Minimum operating voltage |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |

## 5.15.9 Monitored data

*Table 1121: DNZSRDIR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ANGLE_RCA | FLOAT32 | -180.00...180.00 | deg | Angle between operating angle and characteristic angle |
| DNZSRDIR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

# Section 6 Supervision functions

## 6.1 Trip circuit supervision TCSSCBR

### 6.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Trip circuit supervision | TCSSCBR | TCS | TCM |

### 6.1.2 Function block




*Figure 648: Function block*

### 6.1.3 Functionality

The trip circuit supervision function TCSSCBR is designed to supervise the control circuit of the circuit breaker. The invalidity of a control circuit is detected by using a dedicated output contact that contains the supervision functionality. The failure of a circuit is reported to the corresponding function block in the relay configuration.

The function starts and operates when TCSSCBR detects a trip circuit failure. The operating time characteristic for the function is DT. The function operates after a predefined operating time and resets when the fault disappears.

The function contains a blocking functionality. Blocking deactivates the ALARM output and resets the timer.

### 6.1.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of TCSSCBR can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

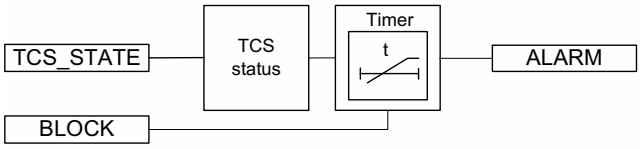



*Figure 649: Functional module diagram*

### TCS status

This module receives the trip circuit status from the hardware. A detected failure in the trip circuit activates the timer.

### Timer

Once activated, the timer runs until the set value of *Operate delay time* has elapsed. The time characteristic is according to DT. When the operation timer has reached the maximum time value, the `ALARM` output is activated. If a drop-off situation occurs during the operate time up counting, the fixed 0.5 s reset timer is activated. After that time, the operation timer is reset.

The `BLOCK` input can be controlled with a binary input, a horizontal communication input or an internal signal of the relay program. The activation of the `BLOCK` input prevents the `ALARM` output to be activated.

## 6.1.5 Application

TCSSCBR detects faults in the electrical control circuit of the circuit breaker. The function can supervise both open and closed coil circuits. This supervision is necessary to find out the vitality of the control circuits continuously.

Figure 650 shows an application of the trip circuit supervision function use. Example of both mechanical (on the left) and static (on the right) outputs TCS connections are shown.

The mechanical outputs (PODPx) are used in both AC or DC circuits, and polarity is insignificant. The static outputs (SPOx) can be used in DC only and polarity must be correct.

The best solution is to connect an external $R_{ext}$ shunt resistor in parallel with the circuit breaker internal contact as shown with the dashed line. This way, although the circuit breaker auxiliary contact is open, TCS can see the trip circuit through $R_{ext}$. The $R_{ext}$ resistor should have such a resistance that the current through the circuit breaker coil remains small, that is, it does not harm or overload the circuit breaker's trip coil if the trip is latched/locked-out.

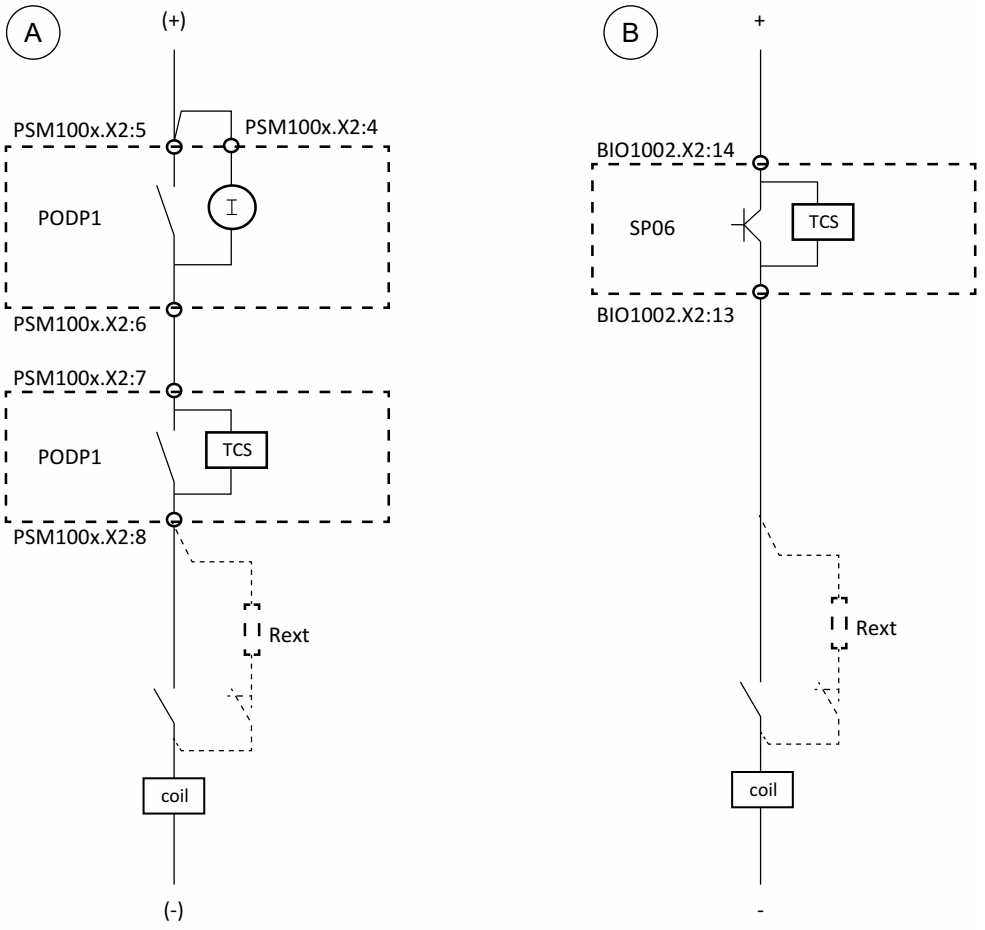



*Figure 650: Operating principle of the trip-circuit supervision, single-pole connection*

If TCS is required only in a closed position, the external shunt resistance can be omitted. When the circuit breaker is in the open position, TCS sees the situation as a faulty circuit. One way to avoid TCS operation in this situation is to block the supervision function whenever the circuit breaker is open.

It is also recommended to block the supervision function when the trip output is active. Otherwise, TCS issues an alarm if the trip remains active over the set TCS *Operate delay time*.

Figure 651 shows a double-pole connection of the trip circuit supervision. For the static output, this requires using SPO5 or SPO6 output in series of the circuit.

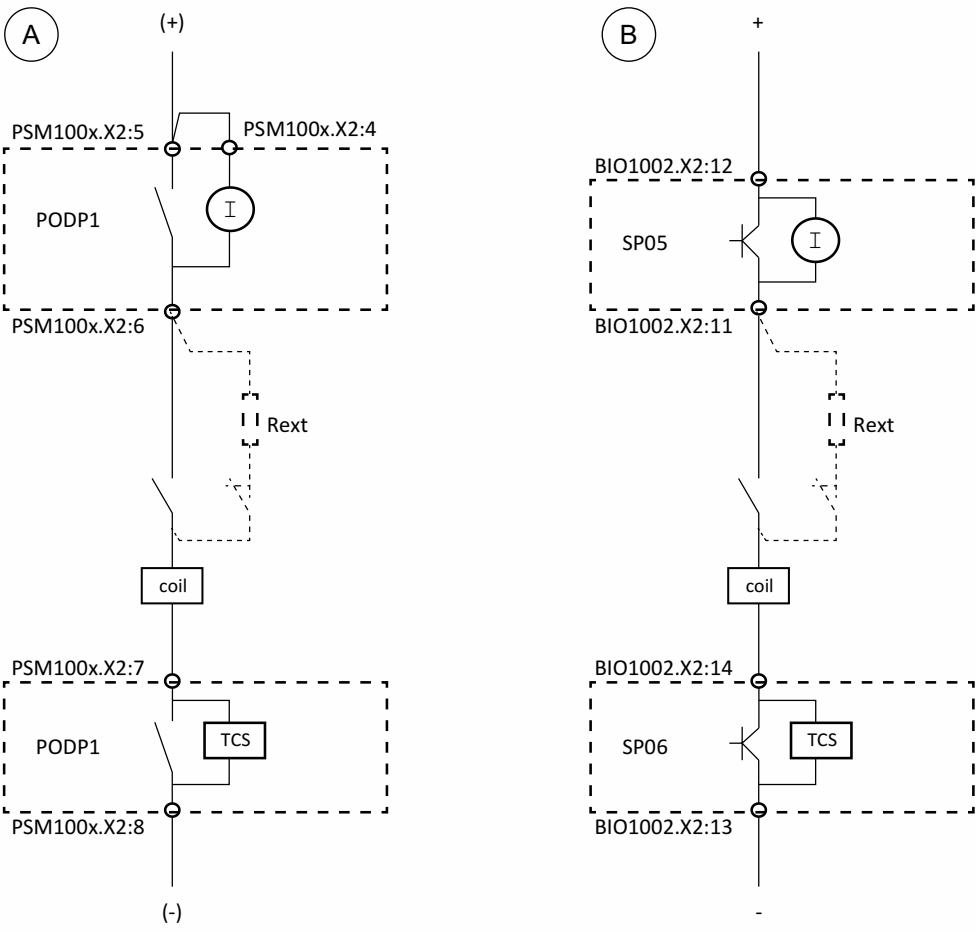



*Figure 651: Operating principle of the trip-circuit supervision, double-pole connection*

## Trip circuit supervision and other trip contacts

It is typical that the trip circuit contains more than one trip contact in parallel, for example in transformer feeders where the trip of a Buchholz relay is connected in parallel with the feeder terminal and other relays involved. The supervising current cannot detect if one or all the other contacts connected in parallel are not connected properly.

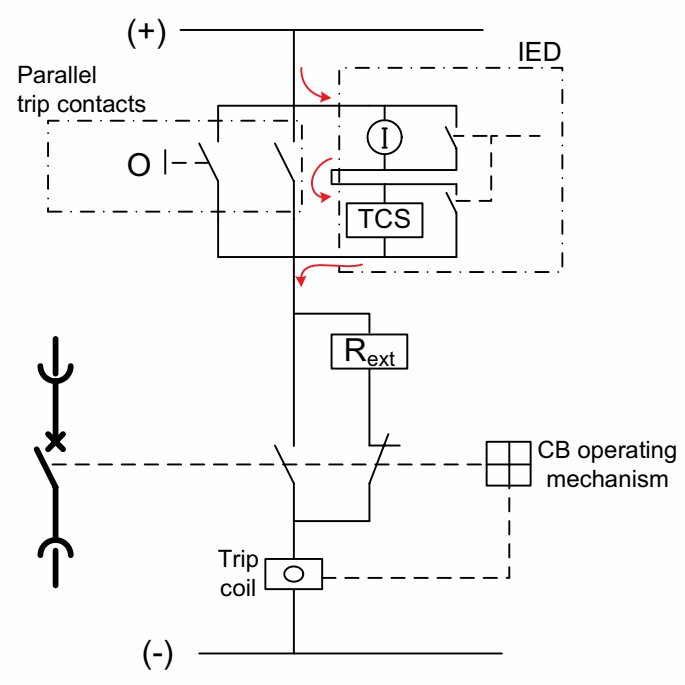



*Figure 652: Constant test current flow in parallel trip contacts and trip circuit supervision*

In case of parallel trip contacts, the recommended way to do the wiring is that the TCS test current flows through all wires and joints.

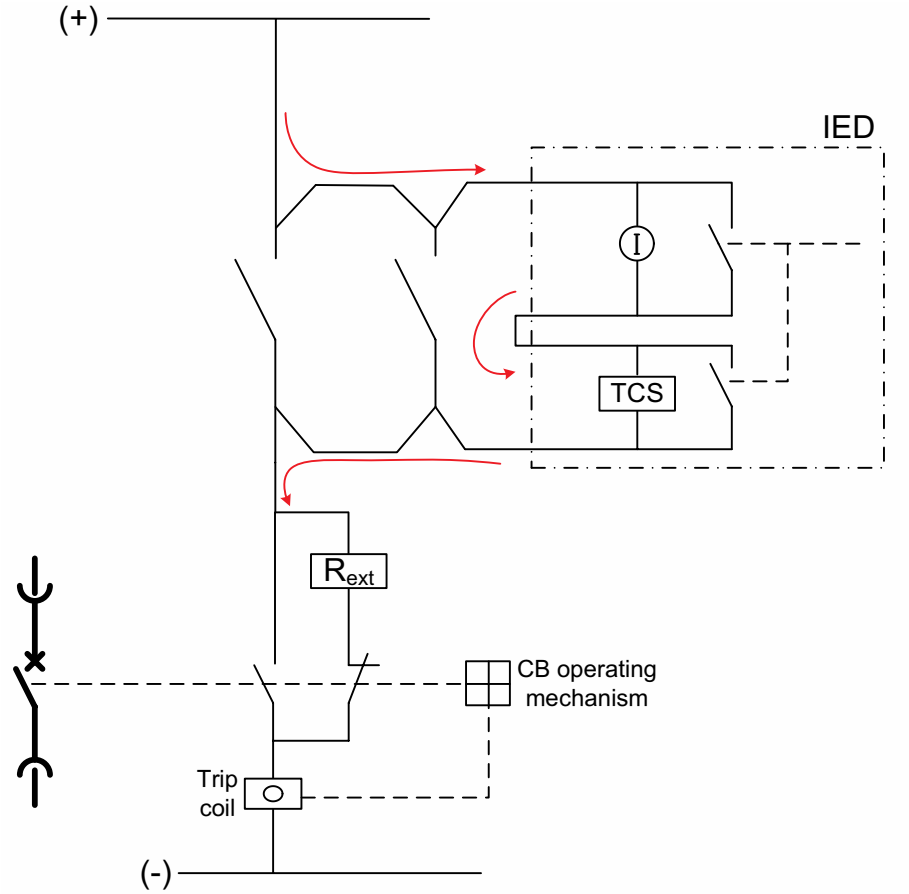



*Figure 653: Improved connection for parallel trip contacts where the test current flows through all wires and joints*

## Several trip circuit supervision functions parallel in circuit

Not only the trip circuit often have parallel trip contacts, it is also possible that the circuit has multiple TCS circuits in parallel. Each TCS circuit causes its own supervising current to flow through the monitored coil and the actual coil current is a sum of all TCS currents. This must be taken into consideration when determining the resistance of $R_{ext}$.

Setting the TCS function in a protection relay not-in-use does not typically affect the supervising current injection.

## Trip circuit supervision with auxiliary relays

Many retrofit projects are carried out partially, that is, the old electromechanical relays are replaced with new ones but the circuit breaker is not replaced. This creates a problem that the coil current of an old type circuit breaker can be too high for the protection relay trip contact to break.

The circuit breaker coil current is normally cut by an internal contact of the circuit breaker. In case of a circuit breaker failure, there is a risk that the protection relay trip contact is destroyed since the contact is obliged to disconnect high level of electromagnetic energy accumulated in the trip coil.

An auxiliary relay can be used between the protection relay trip contact and the circuit breaker coil. This way the breaking capacity question is solved, but the TCS circuit in the protection relay monitors the healthy auxiliary relay coil, not the circuit breaker coil. The separate trip circuit supervision relay is applicable for this to supervise the trip coil of the circuit breaker.

## Dimensioning of the external resistor

Under normal operating conditions, the applied external voltage is divided between the relay's internal circuit and the external trip circuit so that at the minimum 20 V (15...20 V) remains over the relay's internal circuit. Should the external circuit's resistance be too high or the internal circuit's too low, for example due to welded relay contacts, a fault is detected.

Mathematically, the operation condition can be expressed as:

$$U_C - U_D - I_C \cdot (R_s + R_{ext}) \geq 20V \quad AC / DC$$

(Equation 279)

| | |
|---|---|
| $U_c$ | Operating voltage over the supervised trip circuit |
| $U_D$ | Voltage drop over internal 3 mA current drain, about 6.5 V |
| $I_c$ | Measuring current through the trip circuit, appr. 1.5 mA (0.99...1.72 mA) |
| $R_{ext}$ | External shunt resistance |
| $R_s$ | Trip coil resistance |

If the external shunt resistance is used, it has to be calculated not to interfere with the functionality of the supervision or the trip coil. Too high a resistance causes too high a voltage drop, jeopardizing the requirement of at least 20 V over the internal circuit, while a resistance too low can enable false operations of the trip coil.

*Table 1122: Values recommended for the external resistor $R_{ext}$*

| Operating voltage $U_c$ | Shunt resistor $R_{ext}$ |
|---|---|
| 48 V AC/DC | 1.2 kΩ, 5 W |
| 60 V AC/DC | 5.6 kΩ, 5 W |
| 110...130 V AC/DC | 22 kΩ, 5 W |
| 220...250 V AC/DC | 33 kΩ, 5 W |

Due to the requirement that the voltage over the TCS contact must be 20 V or higher, the correct operation is not guaranteed with auxiliary operating voltages lower than 48 V DC because of the voltage drop in $U_D$ and $R_{ext}$ and the operating coil or even voltage

drop of the feeding auxiliary voltage system which can cause too low voltage values over the TCS contact. In this case, erroneous alarming can occur.

At lower (<48 V DC) auxiliary circuit operating voltages, it is recommend either to use the static output and single-pole connection (as then there is no internal current drain and $U_D = 0$ V), or not to use $R_{ext}$ and block TCS when the circuit breaker is open.

### Using power output contacts without trip circuit supervision

In case of mechanical outputs, if TCS is not used, the internal current drain (PSM100x.X2:4, PSM100x.X2:9 and PSM100x.X2:14 in PODP1, PODP2 and PODP2 outputs, respectively) can be left unconnected. The output can then be used as a normal power output.

### Incorrect connections and use of trip circuit supervision

Although the TCS circuit in the PODP1, PODP2 and PODP2 outputs consists of two separate contacts, it must be noted that those are designed to be used as series connected to guarantee the breaking capacity given in the technical manual of the protection relay. Figure 654 shows incorrect usage of a TCS circuit when only one of the contacts is used.

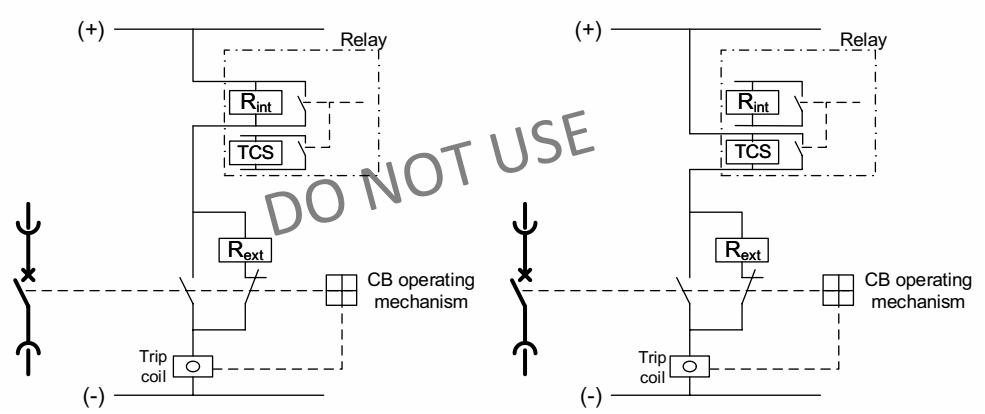



*Figure 654: Incorrect connection of trip-circuit supervision*

## 6.1.6 Signals

*Table 1123: TCSSCBR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| TCS_STATE | BOOLEAN | 0=False | Trip circuit supervision status |
| BLOCK | BOOLEAN | 0=False | Block input status |

*Table 1124: TCSSCBR Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm output |

### 6.1.7 Settings

*Table 1125: TCSSCBR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operate delay time | 1000...300000 | ms | 1 | 3000 | Operate delay time |

*Table 1126: TCSSCBR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 20...60000 | ms | 1 | 1000 | Reset delay time |

### 6.1.8 Monitored data

*Table 1127: TCSSCBR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TCSSCBR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 6.2 Current circuit supervision CCSPVC

### 6.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current circuit supervision | CCSPVC | MCS 3I | CCM |

### 6.2.2 Function block




*Figure 655: Function block*

## 6.2.3 Functionality

The current circuit supervision function CCSPVC is used for monitoring current transformer secondary circuits.

CCSPVC calculates internally the sum of phase currents (I_A, I_B and I_C) and compares the sum against the measured single reference current (I_REF). The reference current must originate from other three-phase CT cores than the phase currents (I_A, I_B and I_C) and it is to be externally summated, that is, outside the protection relay.

CCSPVC detects a fault in the measurement circuit and issues an alarm or blocks the protection functions to avoid unwanted tripping.

It must be remembered that the blocking of protection functions at an occurring open CT circuit means that the situation remains unchanged and extremely high voltages stress the secondary circuit.

## 6.2.4 Analog channel configuration

CCSPVC has two analog group inputs which must be properly configured.

*Table 1128: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| IRES | Residual current (measured) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1129: Special conditions*

| Condition | Description |
|---|---|
| IRES measured | In case IRES needs to be derived, the function requires that all CT cores, except for the one used for phase current measurement, must be used and summed externally. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 6.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of CCSPVC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

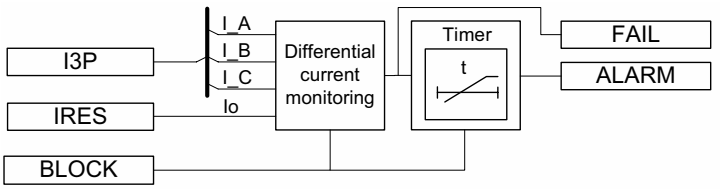



*Figure 656: Functional module diagram*

### Differential current monitoring

Differential current monitoring supervises the difference between the summed phase currents I_A, I_B and I_C and the reference current I_REF.

The current operating characteristics can be selected with the *Start value* setting. When the highest phase current is less than 1.0 × In, the differential current limit is defined with *Start value*. When the highest phase current is more than 1.0 × In, the differential current limit is calculated with the equation.

$$MAX(I_A, I_B, I_C) \cdot Start\ value$$

(Equation 280)

The differential current is limited to 1.0 × In.

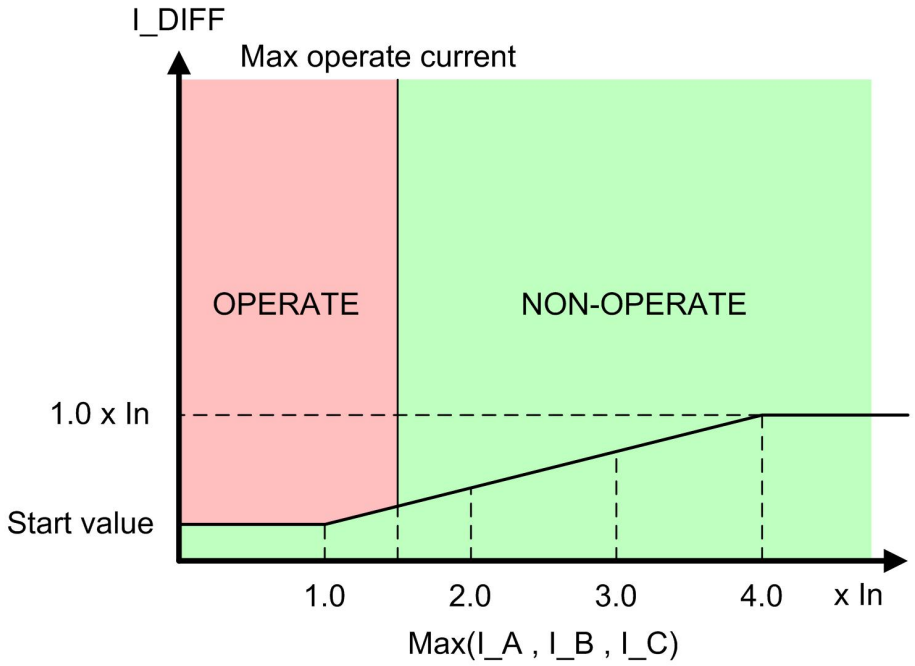



*Figure 657: CCSPVC operating characteristics*

When the differential current I_DIFF is in the operating region, the FAIL output is activated.

The function is internally blocked if any phase current is higher than the set *Max operate current*. When the internal blocking activates, the FAIL output is deactivated immediately. The internal blocking is used for avoiding false operation during a fault situation when the current transformers are saturated due to high fault currents.

The value of the differential current is available in the monitored data view on the LHMI or through other communication tools. The value is calculated with the equation.

$$I_DIFF = \left|\overline{I_A} + \overline{I_B} + \overline{I_C}\right| - \left|\overline{I_REF}\right|$$

(Equation 281)

The *Start value* setting is given in units of ×In of the phase current transformer. The possible difference in the phase and reference current transformer ratios is internally compensated by scaling I_REF with the value derived from the *Primary current* setting values. These setting parameters can be found in the Basic functions section.

The activation of the BLOCK input deactivates the FAIL output immediately.

## Timer

The timer is activated with the FAIL signal. The ALARM output is activated after a fixed 200 ms delay. FAIL needs to be active during the delay.

When the internal blocking is activated, the FAIL output deactivates immediately. However, the ALARM output deactivates after a fixed delay of three seconds.

The function resets when the differential current is below the start value and the highest phase current is more than 5 percent of the nominal current (0.05 × In).

If the current falls to zero when the FAIL or ALARM outputs are active, the deactivation of these outputs is prevented.

The activation of the BLOCK input deactivates the ALARM output.

## 6.2.6 Application

Open or short-circuited current transformer cores can cause unwanted operation in many protection functions such as differential, earth-fault current and negative-sequence current functions. When currents from two independent three-phase sets of CTs or CT cores measuring the same primary currents are available, reliable current circuit supervision can be arranged by comparing the currents from the two sets. When an error in any CT circuit is detected, the protection functions concerned can be blocked and an alarm given.

In case of high currents, the unequal transient saturation of CT cores with a different remanence or saturation factor can result in differences in the secondary currents from the two CT cores. An unwanted blocking of protection functions during the transient stage must then be avoided.

The supervision function must be sensitive and have a short operation time to prevent unwanted tripping from fast-acting, sensitive numerical protections in case of faulty CT secondary circuits.



Open CT circuits create extremely high voltages in the circuits, which may damage the insulation and cause further problems. This must be taken into consideration especially when the protection functions are blocked.



When the reference current is not connected to the protection relay, the function should be turned off. Otherwise, the FAIL output is activated when unbalance occurs in the phase currents even if there was nothing wrong with the measurement circuit.

### Reference current measured with core-balanced current transformer

CCSPVC compares the sum of phase currents to the current measured with the core-balanced CT.

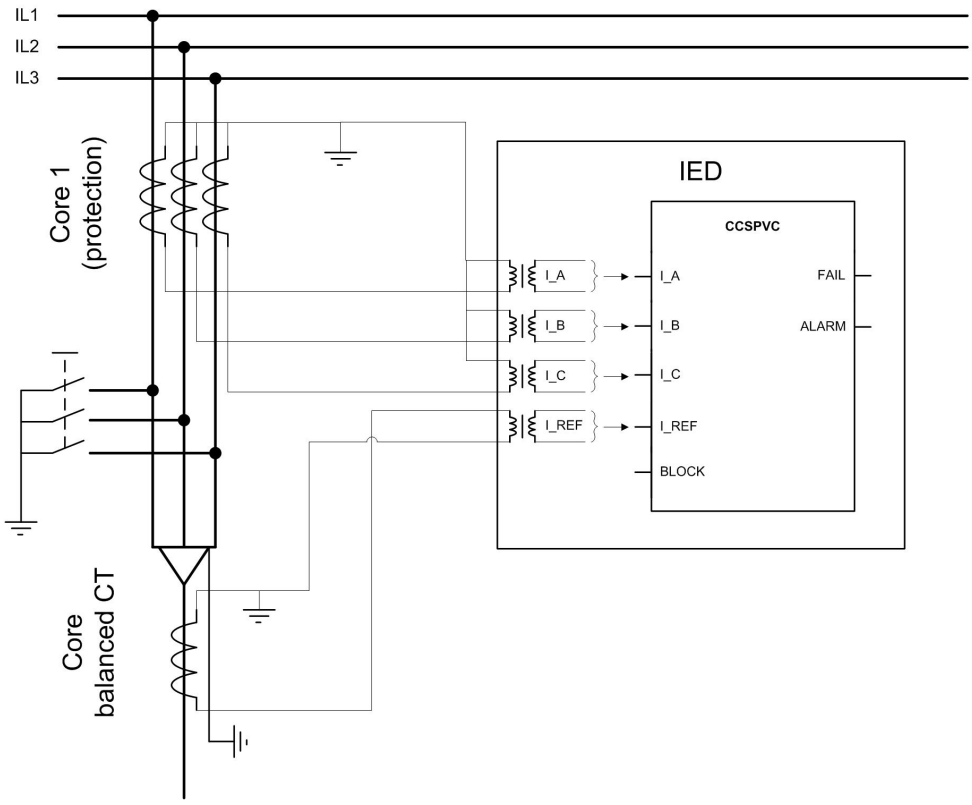



*Figure 658: Connection diagram for reference current measurement with core-balanced current transformer*

## Current measurement with two independent three-phase sets of CT cores

Figure 659 and Figure 660 show diagrams of connections where the reference current is measured with two independent three-phase sets of CT cores.

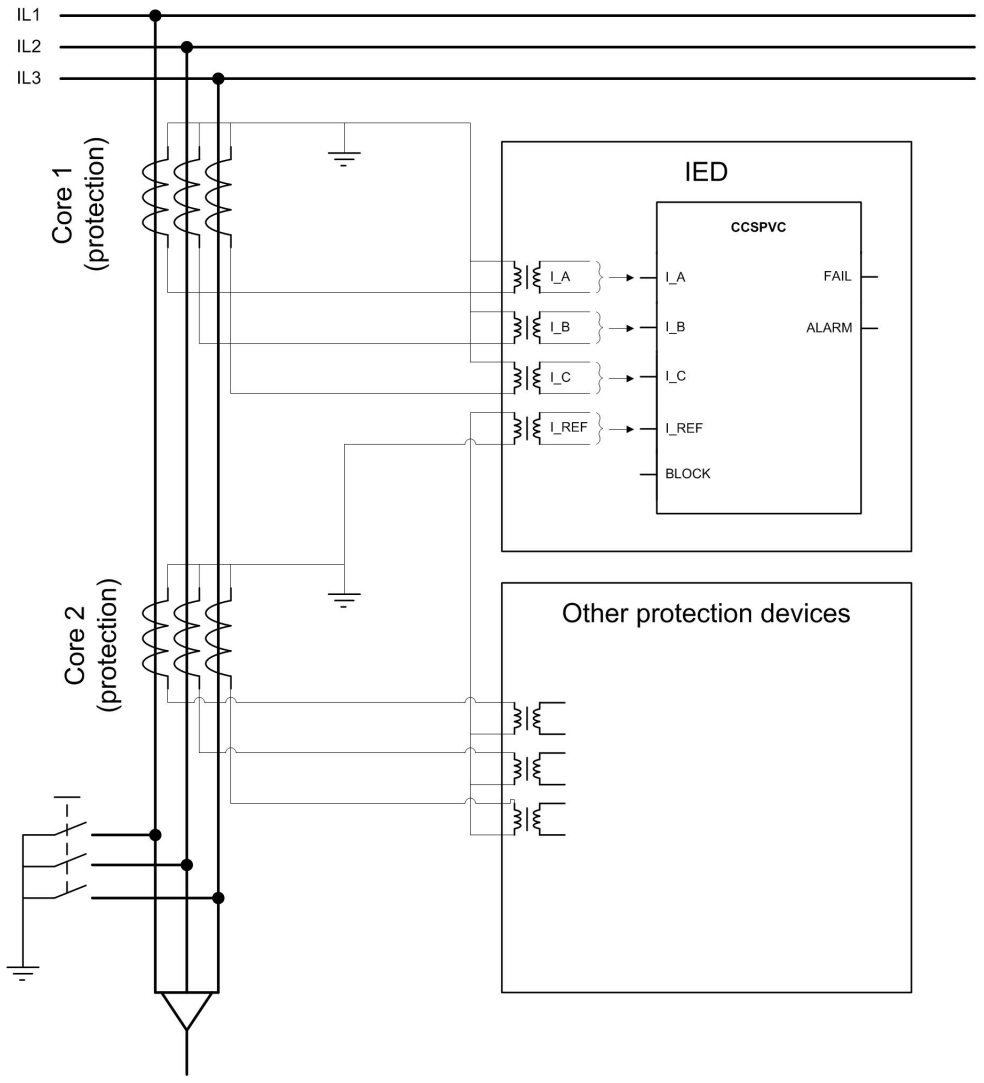



*Figure 659: Connection diagram for current circuit supervision with two sets of three-phase current transformer protection cores*

When using the measurement core for reference current measurement, it should be noted that the saturation level of the measurement core is much lower than with the protection core. This should be taken into account when setting the current circuit supervision function.

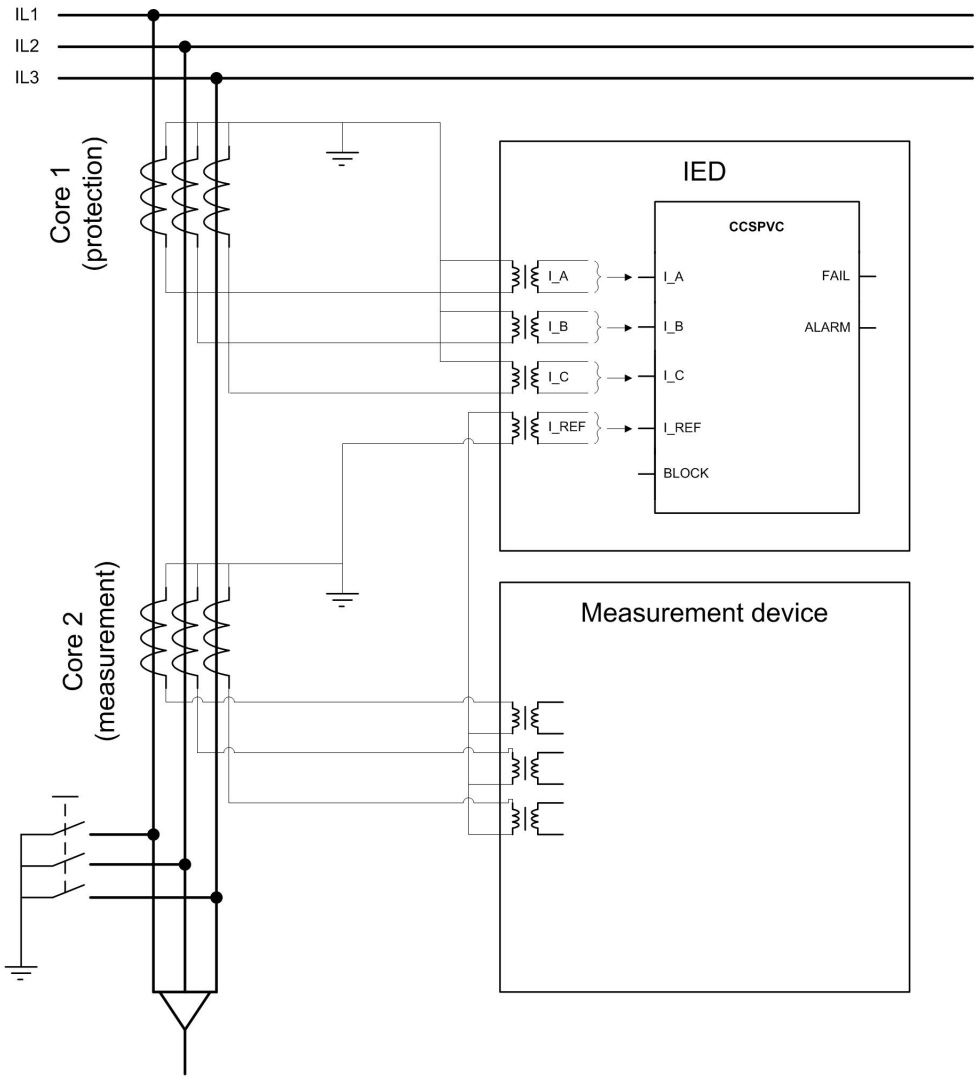



*Figure 660: Connection diagram for current circuit supervision with two sets of three-phase current transformer cores (protection and measurement)*

## Example of incorrect connection

The currents must be measured with two independent cores, that is, the phase currents must be measured with a different core than the reference current. A connection diagram shows an example of a case where the phase currents and the reference currents are measured from the same core.

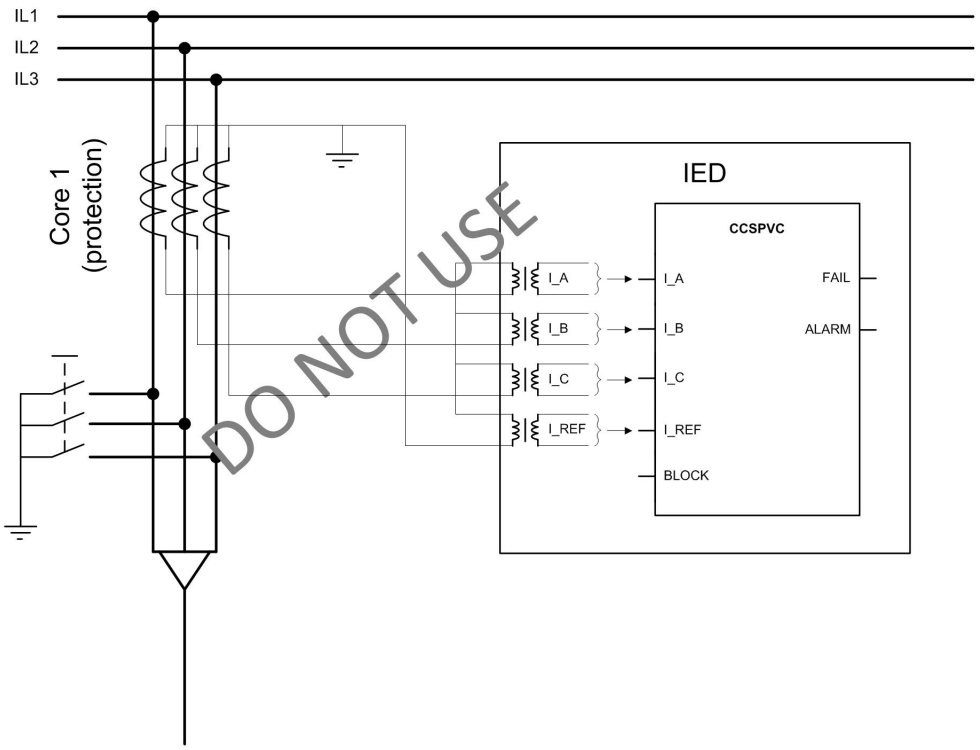



*Figure 661: Example of incorrect reference current connection*

## 6.2.7 Signals

***Table 1130: CCSPVC Input signals***

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

***Table 1131: CCSPVC Output signals***

| Name | Type | Description |
|---|---|---|
| FAIL | BOOLEAN | Fail output |
| ALARM | BOOLEAN | Alarm output |

## 6.2.8 Settings

*Table 1132: CCSPVC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation On / Off |
| Start value | 0.05...0.20 | xIn | 0.01 | 0.05 | Minimum operate current differential level |

*Table 1133: CCSPVC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max operate current | 1.00...5.00 | xIn | 0.01 | 1.50 | Block of the function at high phase current |

## 6.2.9 Monitored data

*Table 1134: CCSPVC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| IDIFF | FLOAT32 | 0.00...40.00 | xIn | Differential current |
| CCSPVC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 6.2.10 Technical data

*Table 1135: CCSPVC Technical data*

| Characteristic | Value |
|---|---|
| Operate time [1)] | <30 ms |

1) Including the delay of the output contact

# 6.3 Current transformer supervision for high-impedance protection scheme HZCCxSPVC

## 6.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current transformer supervision for high-impedance protection scheme for phase A | HZCCASPVC | MCS I_A | CCM_A |
| Current transformer supervision for high-impedance protection scheme for phase B | HZCCBSPVC | MCS I_B | CCM_B |
| Current transformer supervision for high-impedance protection scheme for phase C | HZCCCSPVC | MCS I_C | CCM_C |

## 6.3.2 Function block




*Figure 662: Function block*

## 6.3.3 Functionality

The current transformer supervision for high-impedance protection scheme function HZCCxSPVC is a dedicated phase-segregated supervision function to be used along with the high-impedance differential protection for detecting the broken CT secondary wires. The differential current is taken as an input for the protection relay. During normal CT condition, the value of the differential current is zero. However, when the CT is broken, the secondary differential current starts flowing and it is used for generating alarms.

To avoid maloperation, HZCCxSPVC should have a sensitive setting, compared to the high-impedance differential protection. The function is likely to start under through-fault conditions. However, by incorporating a high time delay (3 s or more), the downstream protection clears the fault before an alarm is generated.

HZCCxSPVC generates an alarm when the differential current exceeds the set limit. The function operates within the DT characteristic.

HZCCxSPVC contains a blocking functionality. It is possible to block the function output, Timer or the whole function.

## 6.3.4 Analog channel configuration

HZCCxSPVC has one analog group input which must be properly configured.

*Table 1136: Analog signals*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 6.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of HZCCxSPVC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

The module diagram illustrates all the phases of the function. However, the functionality is described only for phase A. The functionality for phase B and C is identical.

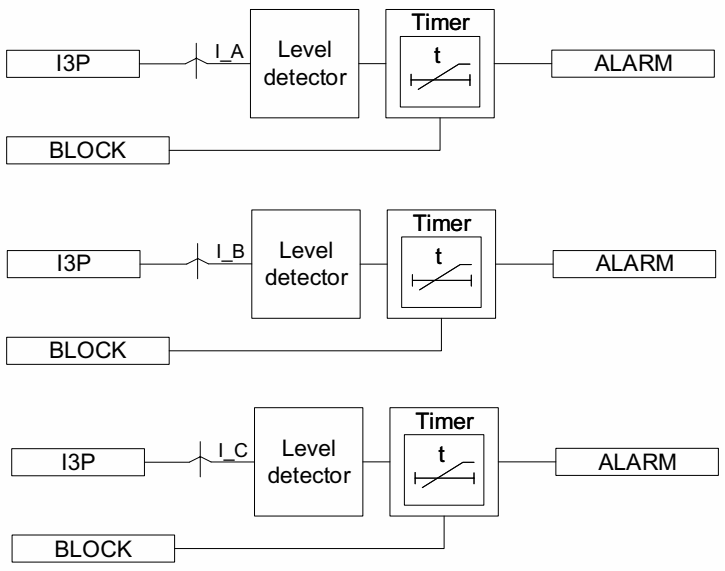



*Figure 663: Functional module diagram*

### Level detector

This module compares the differential current `I_A` to the set *Start value*. The timer module is activated if the differential current exceeds the value set in the *Start value* setting.

### Timer

The time characteristic is according to DT. When the alarm timer reaches the value set by *Alarm delay time*, the `ALARM` output is activated. If the fault disappears before the module generates an alarm signal, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the alarm timer resets. The activation of the `BLOCK` signal resets the Timer and deactivates the `ALARM` output.

### Lockout logic

HZCCxSPVC is provided with the possibility to activate a lockout for the `ALARM` output depending on the *Alarm output mode* setting. In the "Lockout" mode, the `ALARM` must be reset manually from the LHMI Clear menu after checking the CT secondary circuit. In the "Non-latched" mode, the `ALARM` output functions normally, that is, it resets as soon as the fault is cleared.

## 6.3.6 Measuring modes

The function operates on two alternative measurement modes, DFT and Peak-to-Peak. The measurement mode is selected using the *Measurement mode* setting.

## 6.3.7 Application

HZCCxSPVC is a dedicated phase-segregated supervision function to be used along with the high-impedance differential protection for detecting the broken CT secondary wires. The operation principle of HZCCxSPVC is similar to the high-impedance differential protection function HIxPDIF. However, the current setting of HZCCxSPVC is set to be much more sensitive than HIxPDIF and it operates with a higher time delay. A typical example of the HZCCxSPVC *Start value* setting is 0.1 pu with an *Alarm delay time* of 3 s or more.

As the current setting of HZCCxSPVC is more sensitive than the actual differential stage, it can start internally under the through-fault conditions; however, a sufficient time delay prevents false alarm. If the bus wire is broken, differential current arises depending on the load of the feeder with the broken bus wire.

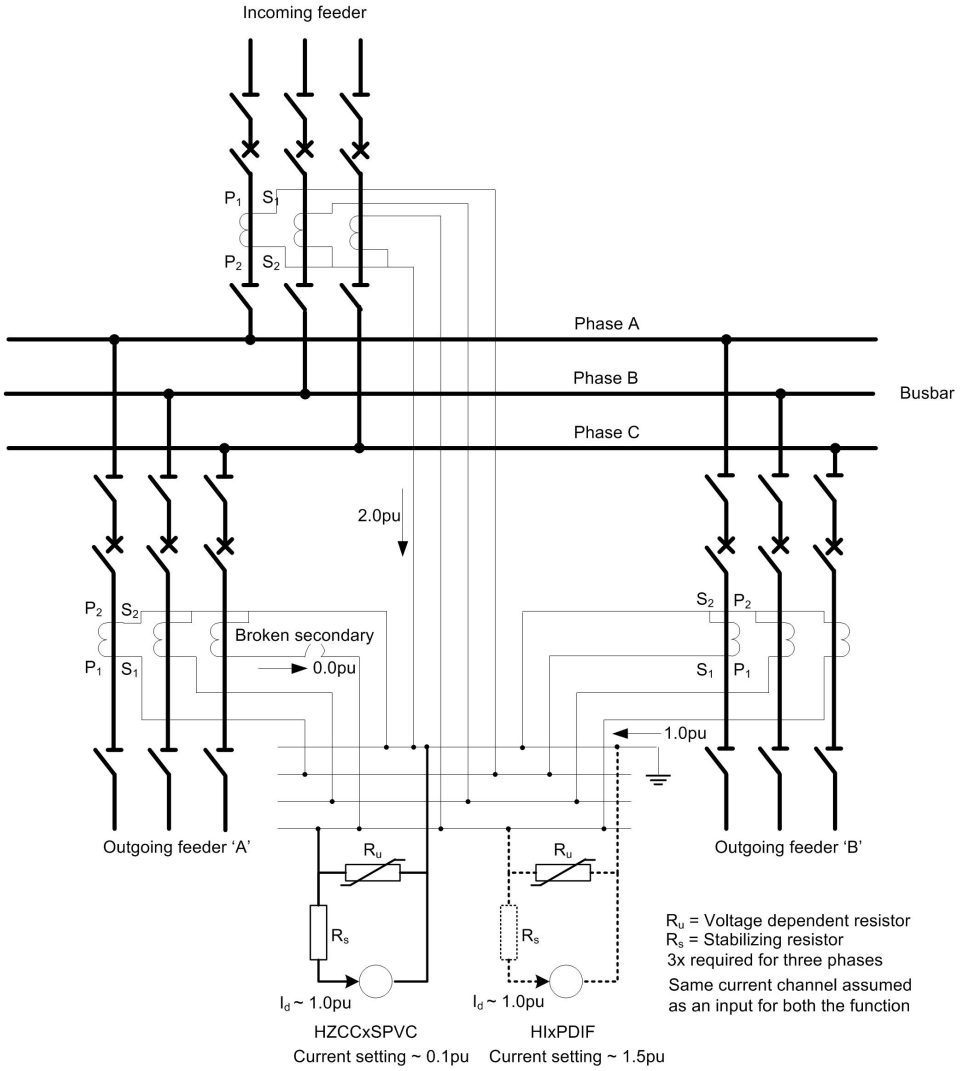



*Figure 664: Broken secondary detection by HZCCxSPVC*

In the example, the incoming feeder is carrying a load of 2.0 pu and both outgoing feeders carry an equal load of 1.0 pu However, both HIxPDIF and HZCCxSPVC consider the current as an increased differential or unbalance current because of the broken CT wire in phase C. Both HIxPDIF and HZCCxSPVC receive the differential current of approximately 1.0 pu The main differential protection HIxPDIF cannot operate because of the higher current setting.

All CTs must have the same ratio.

The ALARM output of the CT supervision function can be used to energize an auxiliary relay which can short-circuit the current CT wires, making the busbar differential protection inoperative. This arrangement does not prevent unwanted operation of HIxPDIF if the start setting is below the rated load. For example, if the start setting for HIxPDIF in the example is set as 0.8 pu HIxPDIF will operate before HZCCxSPVC.

## 6.3.8 Signals

*Table 1137: HZCCASPVC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating blocking mode |

*Table 1138: HZCCBSPVC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating blocking mode |

*Table 1139: HZCCCSPVC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating blocking mode |

*Table 1140: HZCCASPVC Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm output |

*Table 1141: HZCCBSPVC Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm output |

*Table 1142: HZCCCSPVC Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm output |

## 6.3.9 Settings

*Table 1143: HZCCASPVC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Start value | 1.0...100.0 | %In | 0.1 | 10.0 | Start value, percentage of the nominal current |
| Alarm delay time | 100...300000 | ms | 10 | 3000 | Alarm delay time |
| Alarm output mode | 1=Non-latched<br>3=Lockout | | | 3=Lockout | Select the operation mode for alarm output |

*Table 1144: HZCCASPVC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |
| Measurement mode | 2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

*Table 1145: HZCCBSPVC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Start value | 1.0...100.0 | %In | 0.1 | 10.0 | Start value, percentage of the nominal current |
| Alarm delay time | 100...300000 | ms | 10 | 3000 | Alarm delay time |
| Alarm output mode | 1=Non-latched<br>3=Lockout | | | 3=Lockout | Select the operation mode for alarm output |

*Table 1146: HZCCBSPVC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |
| Measurement mode | 2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

*Table 1147: HZCCCSPVC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Start value | 1.0...100.0 | %In | 0.1 | 10.0 | Start value, percentage of the nominal current |
| Alarm delay time | 100...300000 | ms | 10 | 3000 | Alarm delay time |
| Alarm output mode | 1=Non-latched<br>3=Lockout | | | 3=Lockout | Select the operation mode for alarm output |

*Table 1148: HZCCCSPVC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |
| Measurement mode | 2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

## 6.3.10 Monitored data

*Table 1149: HZCCASPVC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| HZCCASPVC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

*Table 1150: HZCCBSPVC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| HZCCBSPVC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

*Table 1151: HZCCCSPVC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| HZCCCSPVC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 6.3.11 Technical data

*Table 1152: HZCCxSPVC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the current measured: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Reset time | <40 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

## 6.4 Protection communication supervision PCSITPC

### 6.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Protection communication supervision | PCSITPC | PCS | PCS |

### 6.4.2 Function block

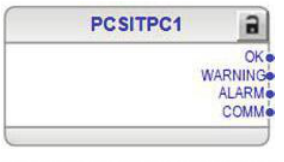



*Figure 665: Function block*

### 6.4.3 Functionality

The protection communication supervision function PCSITPC monitors the protection communication channel. PCSITPC blocks the line differential protection functions when interference in the protection communication channel is detected. The blocking takes place automatically for the LNPLDF and BSTGAPC functions which are dependent on the continuous availability of the protection communication channel.

The protection communication channel is continuously monitored by PCSITPC. The function detects missing or delayed protection telegrams. Protection telegrams are used for transferring the sampled analog and other protection related data. Missing or

delayed protection telegrams can jeopardize the demand operate speed of the differential protection.

When a short-term interference is detected in the protection communication channel, the function issues a warning and the line differential functions are automatically internally blocked. PCSITPC reacts fast for the protection communication interferences. The blocking takes place at the latest when a communication interruption lasting for two fundamental network periods is detected. When a severe and long lasting interference or total interruption in the protection communication channel is detected, an alarm is issued (after a five-second delay). The protection communication supervision quality status is exchanged continuously online by the local and remote PCSITPC instances. This ensures that both local and remote ends protection blocking is issued coordinately. This further enhances the security of the line differential protection by forcing both line end protection relays to the same blocking state during a protection communication interference, even in cases where the interference is detected with only one line end protection relay. There is also the *Reset delay time* settings parameter available which is used for changing the required interference-free time before releasing the line-differential protection back in operation after a blocking due to an interference in communication.

## 6.4.4 Operation principle

The operation of protection communication supervision can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

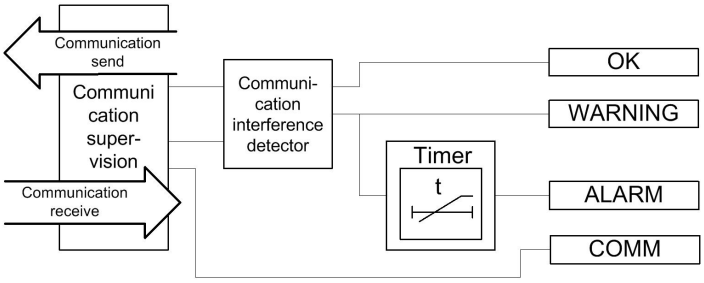



*Figure 666: Functional module diagram*

### Communication supervision

The protection communication is supervised because the differential calculation is dependent on the refreshing of new analog phasor samples from the remote terminal within the protection telegram. The new protection telegram also updates the status of the binary signals sent by the remote terminal. The calculation of the differential current is based on comparing the remote and local terminal measured current samples. It is therefore essential that the protection communication telegrams are supervised and the result of the sample latency calculation can be used further in the differential current calculation. When the communication is able to receive telegrams correctly from the remote end via the communication media, the communication is assumed to be operating correctly and the COMM output is kept active.

### Communication interference detector

The communication interference detector is continuously measuring and observing the sample latency of the protection telegrams. This value is also available as monitored data. The function provides three output signals of which only the corresponding one is active at a time depending on if the protection communication supervision is in OK, WARNING or ALARM. The OK state indicates the correct operation of the protection. The WARNING state indicates that the protection is internally blocked due to detected interference. The WARNING state is switched to ALARM if the interference lasts for a longer period. The protection communication supervision can sometimes be in the WAITING state. This state indicates that the terminal is waiting for the communication to start or restart from the remote end terminal.

### Timer

Once activated with the WARNING signal, the timer has a constant time delay value of five seconds. If the communication failure exists after the delay, the ALARM output is activated.

## 6.4.5 Application

### Communication principle

Analog samples, trip-, start- and user programmable signals are transferred in each protection telegram and the exchange of these protection telegrams is done eight times per power system cycle (every 2.5 ms when $F_n$ = 50 Hz).

Master-Master communication arrangement is used in the two-terminal line differential solution. Current samples are sent from both line ends and the protection algorithms are also executed on both line ends. The direct-intertrip, however, ensures that both ends are always operated simultaneously.

### Time synchronization

In numerical line differential protection, the current samples from the protections which are located geographically apart from each other must be time coordinated so that the current samples from both ends of the protected line can be compared without introducing irrelevant errors. The time coordination requires an extremely high accuracy.

As an example, an inaccuracy of 0.1 ms in a 50 Hz system gives a maximum amplitude error of approximately around 3 percent. An inaccuracy of 1 ms gives a maximum amplitude error of approximately 31 percent. The corresponding figures for a 60 Hz system are 4 and 38 percent respectively.

In the protection relay, the time coordination is done with an echo method. The protection relays create their own time reference between each other so that the system clocks do not need to synchronize.

The figure shows that in the time synchronization the transmission time to send a message from station B to station A, T1→T2, and the time to receive a message from A to B, T4→T5, are measured. The station A protection relay delay from the sampling to the start of send, T3→T4, and the local delay from receive to the station B protection relay sampling T5→T6 time, are also measured for the station B protection relay, and vice versa. This way the time alignment factor for the local and remote samples is achieved.

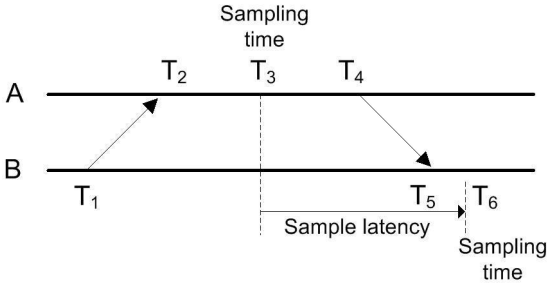



*Figure 667: Measuring sampling latency*

$$P_d = \frac{(T_2 - T_1) + (T_5 - T_4)}{2}$$

(Equation 282)

$$S_d = P_d + (T_4 - T_3) + (T_6 - T_5)$$

(Equation 283)

The sampling latency $S_d$ is calculated for each telegram on both ends. The algorithm assumes that the one-way propagation delay $P_d$ is equal for both directions.

The echo method without GPS can be used in telecommunication transmission networks as long as delay symmetry exists, that is, the sending and receiving delays are equal.

## 6.4.6 Signals

*Table 1153: PCSITPC Output signals*

| Name | Type | Description |
|---|---|---|
| OK | BOOLEAN | Protection communication ok |
| WARNING | BOOLEAN | Protection communication warning |
| ALARM | BOOLEAN | Protection communication alarm |
| COMM | BOOLEAN | Communication detected, active when data is received |

### 6.4.7 Settings

*Table 1154: PCSITPC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 100...300000 | ms | 10 | 1000 | Reset delay time from alarm and warning into ok state |
| Alarm count | 0...99999 | | 1 | 0 | Set new alarm count value |
| Warning count | 0...99999 | | 1 | 0 | Set new warning count value |

### 6.4.8 Monitored data

*Table 1155: PCSITPC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| HEALTH | Enum | 1=Ok<br>2=Warning<br>3=Alarm<br>-2=Waiting | | Communication link health |
| ALARM_CNT | INT32 | 0...99999 | | Number of alarms detected |
| WARN_CNT | INT32 | 0...99999 | | Number of warnings detected |
| SMPL_LATENCY | FLOAT32 | 0.000...99.999 | ms | Measured sample latency |
| PROPAGTN_DLY | FLOAT32 | 0.000...99.999 | ms | Measured propagation delay |
| RND_TRIP_DLY | FLOAT32 | 0.000...99.999 | ms | Measured round trip delay |
| T_ALARM_CNT | Timestamp | | | Time when alarm count was last changed |
| T_WARN_CNT | Timestamp | | | Time when warning count was last changed |

## 6.5 Fuse failure supervision SEQSPVC

### 6.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Fuse failure supervision | SEQSPVC | FUSEF | VCM, 60 |

## 6.5.2 Function block




*Figure 668: Function block*

## 6.5.3 Functionality

The fuse failure supervision function SEQSPVC is used to block the voltage-measuring functions when failure occurs in the secondary circuits between the voltage transformer (or combi sensor or voltage sensor) and protection relay to avoid misoperations of the voltage protection functions.

SEQSPVC has two algorithms, a negative sequence-based algorithm and a delta current and delta voltage algorithm.

A criterion based on the delta current and the delta voltage measurements can be activated to detect three-phase fuse failures which usually are more associated with the voltage transformer switching during station operations.

## 6.5.4 Analog channel configuration

SEQSPVC has two analog group inputs which all must be properly configured.

*Table 1156: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1157: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 6.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of SEQSPVC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

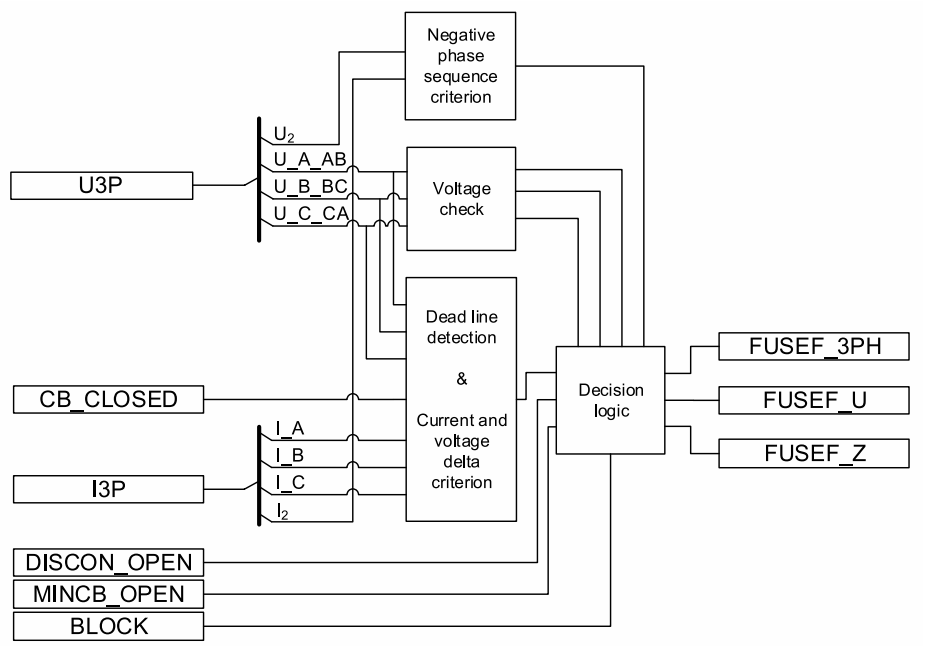



*Figure 669: Functional module diagram*

### Negative phase-sequence criterion

A fuse failure based on the negative-sequence criterion is detected if the measured negative-sequence voltage exceeds the set *Neg Seq voltage Lev* value and the measured negative-sequence current is below the set *Neg Seq current Lev* value. The detected fuse failure is reported to the decision logic module.

### Voltage check

The phase voltage magnitude is checked when deciding whether the fuse failure is a three, two or a single-phase fault.

The module makes a phase-specific comparison between each voltage input and the *Seal in voltage* setting. If the input voltage is lower than the setting, the corresponding phase is reported to the decision logic module.

### Current and voltage delta criterion

The delta function can be activated by setting the *Change rate enable* parameter to "True". Once the function is activated, it operates in parallel with the negative sequence-based algorithm. The current and voltage are continuously measured in all three phases to calculate:

- Change of voltage dU/dt
- Change of current dI/dt

The calculated delta quantities are compared to the respective set values of the *Current change rate* and *Voltage change rate* settings.

The delta current and delta voltage algorithms detect a fuse failure if there is a sufficient negative change in the voltage amplitude without a sufficient change in the current amplitude in each phase separately. This is performed when the circuit breaker is closed. Information about the circuit breaker position is connected to the `CB_CLOSED` input.

There are two conditions for activating the current and voltage delta function.

- The magnitude of dU/dt exceeds the corresponding value of the *Voltage change rate* setting and magnitude of dI/dt is below the value of the *Current change rate* setting in any phase at the same time due to the closure of the circuit breaker (`CB_CLOSED` = TRUE).
- The magnitude of dU/dt exceeds the value of the *Voltage change rate* setting and the magnitude of dI/dt is below the *Current change rate* setting in any phase at the same time and the magnitude of the phase current in the same phase exceeds the *Min Op current delta* setting.

The first condition requires the delta criterion to be fulfilled in any phase at the same time as the circuit breaker is closed. Opening the circuit breaker at one end and energizing the line from the other end onto a fault could lead to an improper operation of SEQSPVC with an open breaker. If this is considered to be an important disadvantage, the `CB_CLOSED` input is to be connected to FALSE. In this way only the second criterion can activate the delta function.

The second condition requires the delta criterion to be fulfilled in one phase together with a high current for the same phase. The measured phase current is used to reduce the risk of a false fuse failure detection. If the current on the protected line is low, a voltage drop in the system (not caused by the fuse failure) is not followed by a current change and a false fuse failure can occur. To prevent this, the minimum phase current criterion is checked.

The fuse failure detection is active until the voltages return above the *Min Op voltage delta* setting. If a voltage in a phase is below the *Min Op voltage delta* setting, a new

fuse failure detection for that phase is not possible until the voltage returns above the setting value.

## Decision logic



If voltages are Wye-connected, it is recommended to scale the default values of voltage-based settings with 1/sqrt(3) because the default setting values apply for Delta-connected settings.

The fuse failure detection outputs FUSEF_U and FUSEF_3PH are controlled according to the detection criteria or external signals.

*Table 1158: Fuse failure output control*

| Fuse failure detection criterion | Conditions and function response |
|---|---|
| Negative-sequence criterion | If a fuse failure is detected based on the negative sequence criterion, the FUSEF_U output is activated. |
| | If the fuse failure detection is active for more than five seconds and at the same time all the phase voltage values are below the set value of the *Seal in voltage* setting with *Enable seal in* turned to "True", the function activates the FUSE_3PH output signal. |
| | The FUSEF_U output signal is also activated if all the phase voltages are above the *Seal in voltage* setting for more than 60 seconds and at the same time the negative sequence voltage is above *Neg Seq voltage Lev* for more than 5 seconds, all the phase currents are below the *Current dead Lin Val* setting and the circuit breaker is closed, that is,CB_CLOSED is TRUE. |
| Current and voltage delta function criterion | If the current and voltage delta criterion detects a fuse failure condition, but all the voltages are not below the *Seal in voltage* setting, only the FUSEF_U output is activated. |
| | If the fuse failure detection is active for more than five seconds and at the same time all the phase voltage values are below the set value of the *Seal in voltage* setting with *Enable seal in* turned to "True", the function activates the FUSE_3PH output signal. |
| External fuse failure detection | The MINCB_OPEN input signal is supposed to be connected through a protection relay binary input to the N.C. auxiliary contact of the miniature circuit breaker protecting the VT secondary circuit. The MINCB_OPEN signal sets the FUSEF_U output signal to block all the voltage-related functions when MCB is in the open state. |
| | The DISCON_OPEN input signal is supposed to be connected through a protection relay binary input to the N.C. auxiliary contact of the line disconnector. The DISCON_OPEN signal sets the FUSEF_U output signal to block the voltage-related functions when the line disconnector is in the open state. |

It is recommended to always set *Enable seal in* to "True". This secures that the blocked protection functions remain blocked until normal voltage conditions are restored if the fuse failure has been active for 5 seconds, that is, the fuse failure outputs are deactivated when the normal voltage conditions are restored.

The activation of the BLOCK input deactivates both FUSEF_U and FUSEF_3PH outputs.

## 6.5.6 Application

Some protection functions operate on the basis of the measured voltage value in the protection relay point. These functions can fail if there is a fault in the measuring circuits between the voltage transformer (or combi sensor or voltage sensor) and protection relay.

A fault in the voltage-measuring circuit is called a fuse failure. This term is misleading since a blown fuse is just one of the many possible reasons for a broken circuit. Since incorrectly measured voltage can result in a faulty operation of some of the protection functions, it is important to detect the fuse failures. A fast fuse failure detection is one of the means to block voltage-based functions before they operate.

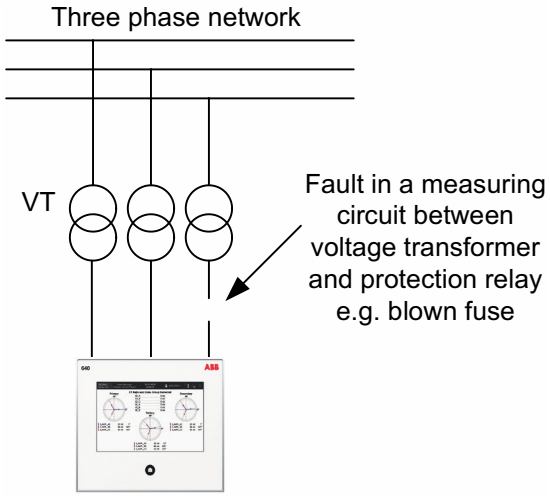



*Figure 670: Fault in a circuit from the voltage transformer to the protection relay*

A fuse failure occurs due to blown fuses, broken wires or intended substation operations. The negative sequence component-based function can be used to detect different types of single-phase or two-phase fuse failures. However, at least one of the three circuits from the voltage transformers must be intact. The supporting delta-based function can also detect a fuse failure due to three-phase interruptions.

In the negative sequence component-based part of the function, a fuse failure is detected by comparing the calculated value of the negative sequence component voltage to the negative sequence component current. The sequence entities are

calculated from the measured current and voltage data for all three phases. The purpose of this function is to block voltage-dependent functions when a fuse failure is detected. Since the voltage dependence differs between these functions, SEQSPVC has two outputs for this purpose.

## 6.5.7 Signals

*Table 1159: SEQSPVC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block of function |
| CB_CLOSED | BOOLEAN | 0=False | Active when circuit breaker is closed |
| DISCON_OPEN | BOOLEAN | 0=False | Active when line disconnector is open |
| MINCB_OPEN | BOOLEAN | 0=False | Active when external MCB opens protected voltage circuit |

*Table 1160: SEQSPVC Output signals*

| Name | Type | Description |
|---|---|---|
| FUSEF_3PH | BOOLEAN | Three-phase start of function |
| FUSEF_U | BOOLEAN | General start of function |

## 6.5.8 Settings

*Table 1161: SEQSPVC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

*Table 1162: SEQSPVC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Neg Seq current Lev | 0.03...0.20 | xIn | 0.01 | 0.03 | Operate level of neg seq undercurrent element |
| Neg Seq voltage Lev | 0.03...0.20 | xUn | 0.01 | 0.10 | Operate level of neg seq overvoltage element |
| Current change rate | 0.01...0.50 | xIn | 0.01 | 0.15 | Operate level of change in phase current |
| Voltage change rate | 0.25...0.90 | xUn | 0.01 | 0.40 | Operate level of change in phase voltage |
| Change rate enable | 0=False<br>1=True | | | 0=False | Enabling operation of change based function |
| Min Op voltage delta | 0.01...1.00 | xUn | 0.01 | 0.50 | Minimum operate level of phase voltage for delta calculation |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min Op current delta | 0.01...1.00 | xIn | 0.01 | 0.10 | Minimum operate level of phase current for delta calculation |
| Seal in voltage | 0.01...1.00 | xUn | 0.01 | 0.50 | Operate level of seal-in phase voltage |
| Enable seal in | 0=False<br>1=True | | | 0=False | Enabling seal in functionality |
| Current dead Lin Val | 0.05...1.00 | xIn | 0.01 | 0.05 | Operate level for open phase current detection |

## 6.5.9 Monitored data

*Table 1163: SEQSPVC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SEQSPVC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 6.5.10 Technical data

*Table 1164: SEQSPVC Technical data*

| Characteristic | | Value | |
|---|---|---|---|
| Operate time[1)] | NPS function | $U_{Fault}$ = 1.1 × set *Neg Seq voltage Lev* | <33 ms |
| | | $U_{Fault}$ = 5.0 × set *Neg Seq voltage Lev* | <18 ms |
| | Delta function | ΔU = 1.1 × set *Voltage change rate* | <30 ms |
| | | ΔU = 2.0 × set *Voltage change rate* | <24 ms |

1) Includes the delay of the signal output contact, $f_n$ = 50 Hz, fault voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

# 6.6 Runtime counter for machines and devices MDSOPT

## 6.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Runtime counter for machines and devices | MDSOPT | OPTS | OPTM |

## 6.6.2 Function block




*Figure 671: Function block*

## 6.6.3 Functionality

The runtime counter for machines and devices function MDSOPT calculates and presents the accumulated operation time of a machine or device as the output. The unit of time for accumulation is hour. The function generates a warning and an alarm when the accumulated operation time exceeds the set limits. It utilizes a binary input to indicate the active operation condition.

The accumulated operation time is one of the parameters for scheduling a service on the equipment like motors. It indicates the use of the machine and hence the mechanical wear and tear. Generally, the equipment manufacturers provide a maintenance schedule based on the number of hours of service.

## 6.6.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of MDSOPT can be described using a module diagram. All the modules in the diagram are explained in the next sections.

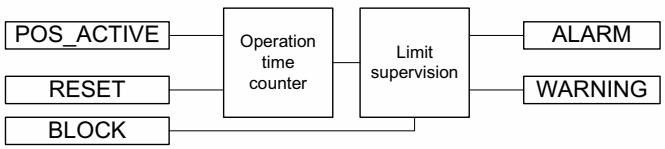



*Figure 672: Functional module diagram*

### Operation time counter

This module counts the operation time. When POS_ACTIVE is active, the count is continuously added to the time duration until it is deactivated. At any time the OPR_TIME output is the total duration for which POS_ACTIVE is active. The unit of time duration count for OPR_TIME is hour. The value is available through the Monitored data view.

The OPR_TIME output is a continuously increasing value and it is stored in a nonvolatile memory. When POS_ACTIVE is active, the OPR_TIME count starts

increasing from the previous value. The count of OPR_TIME saturates at the final value of 299999, that is, no further increment is possible. The activation of RESET can reset the count to the *Initial value* setting.

### Limit supervision

This module compares the motor run-time count to the set values of *Warning value* and *Alarm value* to generate the WARNING and ALARM outputs respectively when the counts exceed the levels.

The activation of the WARNING and ALARM outputs depends on the *Operating time mode* setting. Both WARNING and ALARM occur immediately after the conditions are met if *Operating time mode* is set to “Immediate”. If *Operating time mode* is set to “Timed Warn”, WARNING is activated within the next 24 hours at the time of the day set using the *Operating time hour* setting. If *Operating time mode* is set to “Timed Warn Alm”, the WARNING and ALARM outputs are activated at the time of day set using *Operating time hour*.



The *Operating time hour* setting is used to set the hour of day in Coordinated Universal Time (UTC). The setting has to be adjusted according to the local time and local daylight-saving time.

The function contains a blocking functionality. Activation of the BLOCK input blocks both WARNING and ALARM.

## 6.6.5 Application

The machine operating time since commissioning indicates the use of the machine. For example, the mechanical wear and lubrication requirement for the shaft bearing of the motors depend on the use hours.

If some motor is used for long duration runs, it might require frequent servicing, while for a motor that is not used regularly the maintenance and service are scheduled less frequently. The accumulated operating time of a motor together with the appropriate settings for warning can be utilized to trigger the condition based maintenance of the motor.

The operating time counter combined with the subsequent reset of the operating-time count can be used to monitor the motor's run time for a single run.

Both the long term accumulated operating time and the short term single run duration provide valuable information about the condition of the machine and device. The information can be co-related to other process data to provide diagnoses for the process where the machine or device is applied.

## 6.6.6 Signals

*Table 1165: MDSOPT Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block input status |
| POS_ACTIVE | BOOLEAN | 0=False | When active indicates the equipment is running |
| RESET | BOOLEAN | 0=False | Resets the accumulated operation time to initial value |

*Table 1166: MDSOPT Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm accumulated operation time exceeds Alarm value |
| WARNING | BOOLEAN | Warning accumulated operation time exceeds Warning value |

## 6.6.7 Settings

*Table 1167: MDSOPT Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Warning value | 0...299999 | h | 1 | 8000 | Warning value for operation time supervision |
| Alarm value | 0...299999 | h | 1 | 10000 | Alarm value for operation time supervision |

*Table 1168: MDSOPT Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Initial value | 0...299999 | h | 1 | 0 | Initial value for operation time supervision |
| Operating time hour | 0...23 | h | 1 | 0 | Time of day when alarm and warning will occur |
| Operating time mode | 1=Immediate<br>2=Timed Warn<br>3=Timed Warn Alm | | | 1=Immediate | Operating time mode for warning and alarm |

### 6.6.8 Monitored data

*Table 1169: MDSOPT Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| MDSOPT | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| OPR_TIME | INT32 | 0...299999 | h | Total operation time in hours |

### 6.6.9 Technical data

*Table 1170: MDSOPT Technical data*

| Description | Value |
|---|---|
| Motor runtime measurement accuracy[1)] | ±0.5% |

1) Of the reading, for a stand-alone relay, without time synchronization

## 6.7 Motor start counter MSCPMRI

### 6.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Motor start counter | MSCPMRI | n< | 66 |

### 6.7.2 Function block




*Figure 673: Function block*

### 6.7.3 Functionality

The motor start counter function MSCPMRI counts the number of motor starts and distinguishes between cold and warm starts. The allowed number is generally provided by the motor manufacturer. The motor starting MOT_START output of the motor start-up supervision function is used to count the starts. The motor thermal level

TEMP_RL calculated by the thermal overload protection is used to distinguish between a cold and warm start.

The function contains a blocking functionality. It is possible to block the function outputs or the function itself.

## 6.7.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of MSCPMRI can be described with a module diagram. All the modules in the diagram are explained in the next sections.

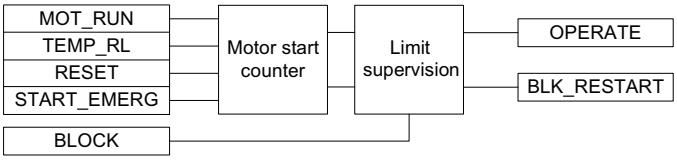



*Figure 674: Functional module diagram*

### Motor start counter

This module counts the number of motor starts. The value of the cold count COLD_COUNT and warm count WARM_COUNT is available in the Monitored data view. On the rising edge of MOT_RUN, the module increments the cold start counter. If the thermal content available at the TEMP_RL input is above the set *Warm start level* when the rising edge of the MOT_RUN input is received, both cold and warm start counter values are incremented.

If *Operation* of the thermal overload protection for motors function MPTTR is set as "Off", the TEMP_RL value is not available. In this case, the warm start counter does not increase.

The counter decrease timer also starts at the first increment of the cold start counter (that is the first time when the counter increases from zero). When *Cnt decrease time* elapses, both cold and warm start counters decrease by one and the counter decrease timer restarts. This is repeated until both cold and warm counters are zero.

When the motor is not in operation, that is, the motor is in stop condition, it takes more time to cool. During such condition *Cnt decrease time* is multiplied by a *Cnt Dec timer Mult* setting.

The motor start detection is available at the MOT_START output of the motor start-up supervision function STTPMSU. The MOT_START output of STTPMSU must be connected to the MOT_RUN input of this function in Application Configuration in

PCM600. Similarly, the TEMP_RL output of MPTTR must be connected to the TEMP_RL input of this function in Application Configuration in PCM600.

When the emergency start signal START_EMERG is set high and if the value of the cold or warm counter is above its start value setting, the value of the counter is set one count less than the respective maximum number of start value setting. This disables BLK_RESTART and OPERATE which makes the restart of motor possible.

The values can be reset by activating the RESET binary input. The activation of the RESET input also resets the counter decrease timer. The counter value can also be reset on the Clear menu.

### Limit supervision

This module compares the motor cold and warm count to the set *Max Num cold start* and *Max Num warm start*, respectively. The BLK_RESTART output is activated when either the cold or the warm start counter reaches the set *Max Num cold start* or *Max Num warm start*, respectively. The OPERATE output is activated when either the cold or the warm start counter exceeds the set *Max Num cold start* or *Max Num warm start*, respectively.

When the BLK_RESTART output is active, T_RST_ENA shows the possible time for the next restart. The value of T_RST_ENA is calculated as the time left for both counters to decrease below their maximum number of starts.

Activation of the BLOCK input blocks both OPERATE and BLK_RESTART outputs.

## 6.7.5 Application

Repeated motor starts increase the temperature to a high value in the stator or rotor windings, or both, unless enough time is allowed for the heat to dissipate. To ensure a safe operation, it is necessary to provide a fixed-time interval between starts or limit the number of starts within a period of time. This is why the motor manufacturers have restrictions on how many starts are allowed in a defined time interval.

This function counts the number of cold and warm starts and provides a block restart signal when the number of starts reaches the permitted limit. The customer can use this signal for blocking a new start operation. An operate signal is also available which can be used to disconnect the motor when the number of starts exceeds the limit.

## 6.7.6 Signals

*Table 1171: MSCPMRI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| START_EMERG | BOOLEAN | 0=False | Signal to indicate the need of emergency start |
| RESET | BOOLEAN | 0=False | Reset cold and warm start counter value |
| MOT_RUN | BOOLEAN | 0=False | Signal to show that motor start up is in progress |
| TEMP_RL | FLOAT32 | 0.00 | Thermal level of the motor |

*Table 1172: MSCPMRI Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate signal |
| BLK_RESTART | BOOLEAN | Restart inhibited |

## 6.7.7 Settings

*Table 1173: MSCPMRI Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Warm start level | 20.0...100.0 | % | 0.1 | 35.0 | Thermal threshold to define a warm start |
| Max Num cold start | 1...10 | | 1 | 2 | Maximum number of cold start allowed |
| Max Num warm start | 1...10 | | 1 | 1 | Maximum number of warm start allowed |
| Cnt decrease time | 1...180 | min | 1 | 60 | Counter decrease time |

*Table 1174: MSCPMRI Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Cnt Dec timer Mult | 1.00...10.00 | | 0.01 | 1.00 | Multiplier for counter decrease timer |

*Table 1175: MSCPMRI Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

## 6.7.8 Monitored data

*Table 1176: MSCPMRI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| COLD_COUNT | INT32 | 0...100 | | Count value of cold start |
| WARM_COUNT | INT32 | 0...100 | | Count value of warm start |
| T_RST_ENA | INT32 | 0...180 | min | Time left for restart when lockstart is enabled in minutes |
| MSCPMRI | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

# 6.8 Three-phase remanent undervoltage supervision MSVPR

## 6.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase remanent undervoltage supervision | MSVPR | 3U<R | 27R |

## 6.8.2 Function block




*Figure 675: Function block*

## 6.8.3 Functionality

The three-phase remanent undervoltage supervision function MSVPR is used to supervise the remanent voltage of the motor. The rotor with high inertia load may continue to rotate after the primary supply voltage is switched off. Re-energizing the motor immediately can result in catastrophic failure.

MSVPR gives permissive output when the remanent voltage of the motor reaches a safe level to re-energize. Supervision can be selected for one-phase or for three-phase operation. MSVPR can also adapt to a frequency range of 10...70 Hz.

The function contains a blocking functionality. It is possible to block the function output, timer or the function itself.

## 6.8.4 Analog channel configuration

MSVPR has one analog group input which must be properly configured.

*Table 1177: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1178: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected when *Phase supervision* is set to "A or AB", "B or BC" or "C or CA". |
| | The function requires that all three voltage channels are connected if *Phase supervision* is set to "A&B&C or AB&BC&CA". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 6.8.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of MSVPR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

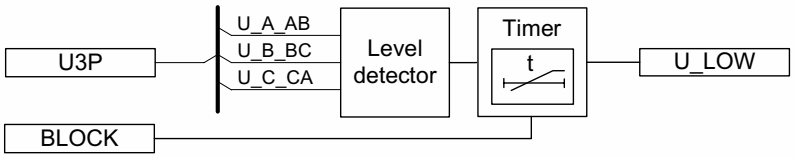



*Figure 676: Functional module diagram*

### Level detector

The *Voltage selection* setting is used for selecting the phase-to-earth or phase-to-phase voltages for supervision.

The voltage measurement can adapt the frequency to a range of 10...70 Hz.

Level detector supports one- or three-phase operation. Selection can be made with setting *Phase supervision*.

*Table 1179: Functionality depending on Phase supervision*

| Value of *Phase supervision* | Functionality |
|---|---|
| 1 = A or AB<br>2 = B or BC<br>4 = C or CA | This selection implements single-phase voltage supervision on the selected phase.<br>If the measured voltage of the supervised phase is lower than the set value of the *Start value* setting, Level detector enables the Timer module. |
| 7 = A&B&C or AB&BC&CA | This selection implements three-phase voltage supervision. The measured voltage of three supervised phases is compared against the *Start value* setting.<br>If the number of phases where the voltage is below the setting matches the *Num of phases* setting, Level detector enables the Timer module. |

### Timer

Once activated, Timer runs until the value of *Operate delay time* has elapsed. The time characteristic is according to DT. When the operation timer has reached the value of *Operate delay time*, the U_LOW output is activated.

In a drop-off case, the remanent voltage returns to a value higher than the set value of *Start value* before *Operate delay time* is exceeded. Also, the timer reset state is activated. The reset timer runs until the *Reset delay time* value is exceeded. If the duration of the voltage drop-off exceeds the set *Reset delay time*, the operate timer is reset and the U_LOW output is deactivated.

The BLOCK input can be controlled with a binary input, a horizontal communication input or an internal signal of the relay program. The activation of the BLOCK input resets Timer and prevents the U_LOW output from being activated.

## 6.8.6 Application

Systems with critical motor applications provide a backup power source that can be switched in when the primary power source becomes faulty. When the power to a motor is suddenly lost, the motor terminal voltage does not immediately fall to zero because the rotating motor now acts as a generator producing its own voltage. Remanent voltage decays as the motor comes to a stop at a rate depending on the motor and load. Connecting the backup power source while the remanent voltage is at a high level can result in damage to the motor shaft and windings.

MSVPR is used to monitor the motor remanent voltage over a decaying frequency after power supply is lost, before allowing connection of backup power. It provides a permissive signal indicating when the backup power can be safely connected.

This application example describes the re-energization process. MSVPR is used to supervise the Bus1 remanent voltage. Control logic is used to detect the loss of primary power source and initiate the transfer to backup power. Normally, bus tie breaker CB5 is open and motor voltage power is supplied by incoming Feeder1 (see Figure 677).

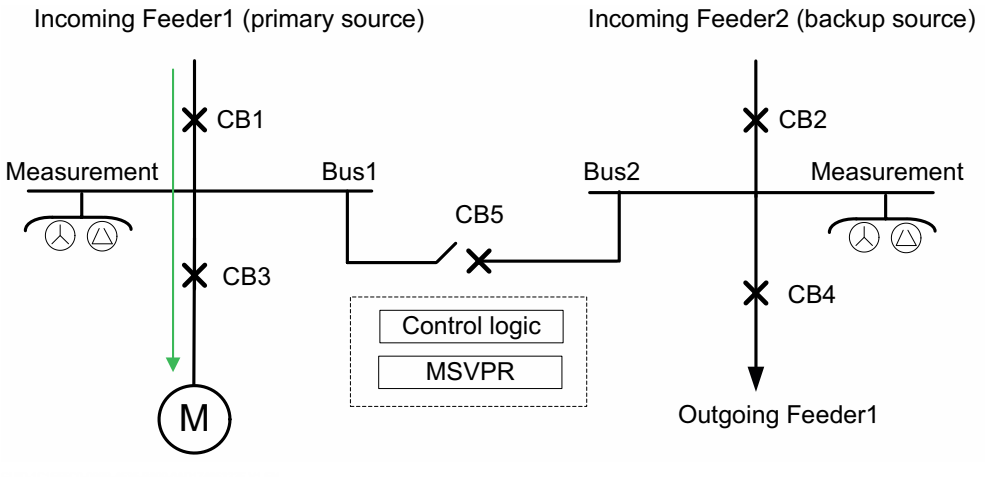



*Figure 677: Example of remanent voltage supervision before fault*

CB1 is tripped when a fault occurs on incoming Feeder1. MSVPR gives permission to control logic when the remanent voltage of the motor reaches a safe level on Bus1. Control logic closes the tie breaker CB5 if closing conditions are met. Finally, the motor is re-energized by incoming Feeder2 (see Figure 678).

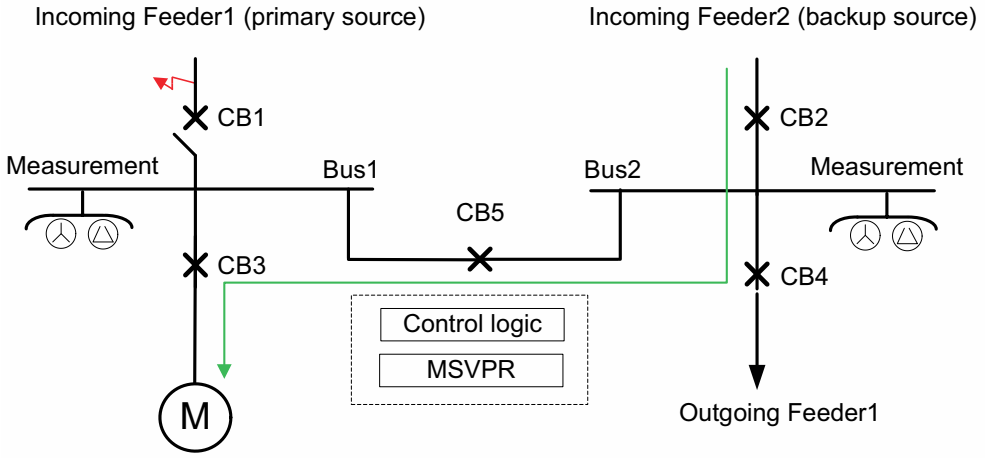



*Figure 678: Example of remanent voltage supervision after fault*

MSVPR runs in the range of 10...70 Hz. If the frequency is lower than 10 Hz, the motor terminal voltage is very low. The remanent voltage setting is typically set to 20...30 percent of the rated voltage.

## 6.8.7 Signals

*Table 1180: MSVPR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 1181: MSVPR Output signals*

| Name | Type | Description |
|---|---|---|
| U_LOW | BOOLEAN | Low remanent voltage |

## 6.8.8 Settings

*Table 1182: MSVPR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Start value | 0.05...1.20 | xUn | 0.01 | 0.25 | Start value |
| Operate delay time | 100...300000 | ms | 100 | 100 | Operate delay time |
| Voltage selection | 1=phase-to-earth<br>2=phase-to-phase | | | 2=phase-to-phase | Parameter to select phase or phase-to-phase voltages |
| Num of phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 3=3 out of 3 | Number of phases required for voltage supervision |
| Phase supervision | 1=A or AB<br>2=B or BC<br>4=C or CA<br>7=A&B&C or AB&BC&CA | | | 7=A&B&C or AB&BC&CA | Monitored voltage phase |

*Table 1183: MSVPR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

## 6.8.9 Monitored data

*Table 1184: MSVPR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U_AMPL_A | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase A |
| U_AMPL_B | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase B |
| U_AMPL_C | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase C |
| U_AMPL_AB | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase to phase AB |
| Table continues on next page | | | | |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U_AMPL_BC | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase to phase BC |
| U_AMPL_CA | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase to phase CA |
| MSVPR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 6.8.10 Technical data

*Table 1185: MSVPR Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage: |
| | 20 Hz < f ≤ 70 Hz:<br>±1.5% of the set value or ±0.002 × $U_n$<br>10 Hz < f ≤ 20 Hz:<br>±4.0% of the set value or ±0.002 × $U_n$ |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 1.04 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

# 6.9 Current circuit supervision for transformers CTSRCTF

## 6.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current circuit supervision for transformers | CTSRCTF | MCS 3I,I2 | CCM 3I,I2 |

## 6.9.2 Function block

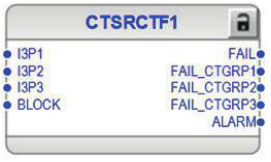



*Figure 679: Function block*

## 6.9.3 Functionality

The current circuit supervision for transformers function CTSRCTF is used for monitoring the current transformer secondary circuit where a separate reference current transformer input for comparison is not available or where a separate voltage channel for calculating or measuring the zero-sequence voltage is not available. CTSRCTF can be used for detecting the single-phase failure on the current transformer secondary for protection application involving two or three sets of the three-phase current transformers.

CTSRCTF detects a fault in the measurement circuit and issues an alarm which can be used for blocking the protection functions, for example, differential protection, to avoid unwanted tripping.

CTSRCTF is internally blocked in case of a transformer under no-load condition or if a current in any one phase exceeds the set maximum limit.

## 6.9.4 Analog channel configuration

CTSRCTF has three analog group inputs which must be properly configured.

*Table 1186: Analog inputs*

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase currents |
| I3P3[1)] | Three-phase currents |

1) Can be connected to GRPOFF



See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 6.9.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of CTSRCTF can be described with a module diagram. All the modules in the diagram are explained in the next sections.

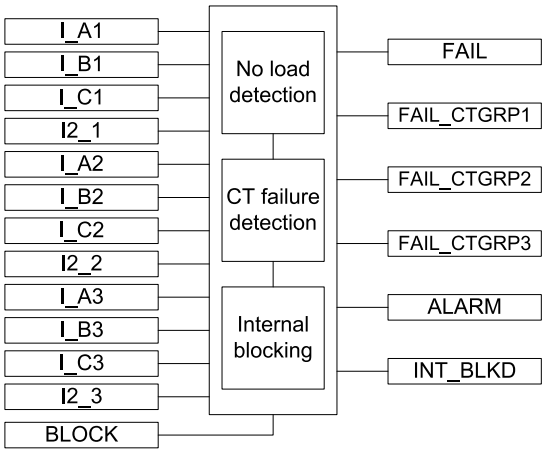



*Figure 680: Functional module diagram*

## No-load detection

No-load detection module detects the loading condition. If all the three-phase currents of any two sets of current transformer are zero, the protected equipment is considered to be in the no-load condition and the function is internally blocked by activating the `INT_BLKD` output.

To avoid any false operation, the function is also internally blocked if any two-phase currents of any set of current transformers are below *Min operate current*. This activates `INT_BLKD`. The value of the *Min operate current* setting depends on the type of equipment to be protected. For example, in case of transformer protection, *Min operate current* depends on the no-load current rating. Typically, it can be set equal to the transformer no-load current rating.

## CT failure detection

This module detects the CT secondary failure in any sets of current transformers. The module continuously scans the value of all the three-phase currents in all groups of current transformers to detect any sudden drop in the current value to zero. The detection of a zero current should not be the only criterion for considering a fault in the current transformer secondary. Two other criteria are evaluated to confirm the CT failure:

- A zero current due to the CT failure does not result in a negative-sequence current on healthy CT sets.

  On the detection of a zero current in any phase on either group of CT, the negative-sequence current $I_2$ is further evaluated. For a genuine CT secondary failure, the magnitude of $I_2$ changes only on the side where zero current has been detected. The change in the magnitude of $I_2$ ($\Delta I_2$) on the other sets of the current transformer (other than where zero current is detected) is calculated. If the change is detected on the healthy sets of CT, it is an indication of system failure.

- A zero current due to the CT failure does not result in a phase angle difference between the healthy phases.

  If a system faults happens on the phase A, it results in a change in the phase angle difference between phase B and phase C. This change in the phase angle difference between the healthy phases is evaluated in all three sets of current transformer, and if the change is detected in any set of CT, it is an indication of the system failure.

If both conditions are satisfied at zero current, the FAIL output is activated immediately. The ALARM output is activated after a fixed 200 ms delay. FAIL needs to be active during the delay. The outputs FAIL, CTGRP1, FAIL_CTGRP2 and FAIL_CTGRP3 are activated according to the CT group where the secondary failure is detected.

Activation of the BLOCK input deactivates the FAIL and ALARM outputs.



It is not possible to detect the CT secondary failure happening simultaneously with the system faults or failures or two simultaneous failures in the secondary circuit. The function resets if the zero current does not exist longer than 200 ms.

### Internal blocking

This module blocks the function internally under specific condition to avoid any false operation during a system fault situation. When any of the following condition is satisfied, the function is internally blocked and the FAIL output is deactivated immediately.

- Magnitude of any phase current for any group of current transformers exceeds the *Max operate current* setting. The magnitude of phase current is calculated from the peak-to-peak value.
- Magnitude of the negative-sequence current $I_2$ on the healthy set of current transformer exceeds the *Max Nq Seq current* setting.

The INT_BLKD output is activated when FAIL is deactivated if any of the above conditions is satisfied. The ALARM output is also deactivated after a fixed three-second delay after the FAIL output is deactivated.

## 6.9.6 Application

Open or short-circuited current transformer secondary can cause unwanted operation in many protection functions, such as earth-fault current and differential. The simplest method for detecting the current transformer secondary failure is by comparing currents from two independent three-phase sets of CTs or the CT cores measuring the same primary currents. Another widely used method is the detection of a zero-sequence current and zero-sequence voltage. The detection of a zero-sequence current

in the absence of a zero-sequence voltage is an indication of the current transformer secondary failure. However, both methods have disadvantages as they require an additional set of current transformer, or a voltage channel is needed for detecting a zero-sequence voltage.

The methods may not be applicable where additional current channels or voltage channels are not available. This CT secondary circuit supervision presents an algorithm that can be used as an example for detecting the CT secondary failure used for the unit protection of a two-winding or three-winding transformer. However, the function has a limitation that it cannot detect failure in case of equipment under protection in no-load condition or when two simultaneous secondary CT failures occur.

The detection of a zero current in any one phase is a partial indication of failure in the current transformer secondary. Furthermore, if this current zero is due to the failure in the current transformer secondary, it results in a change in the magnitude of the negative-sequence current in the group only where current zero has been detected. However, changes in the negative-sequence current in other groups of three-phase current transformers at the instance of zero-current detection is an indication of a system problem. Also, it may happen that after the detection of a failure in the current transformer secondary, a fault may occur in the system. During such condition, functions are internally blocked.

### Phase discontinuity

A zero current detected due to the phase discontinuity results in an asymmetry in all the sets of the current transformer, which then results in a change in the negative-sequence current ($\Delta I_2$) in the healthy set. This change in the negative-sequence current on the healthy sides, that is, other than where a zero current has been detected, blocks the function.

In case of a lightly loaded transformer (up to 30%) the change in the negative-sequence current may be very negligible. However, a phase discontinuity results in a change in the phase angle difference between two healthy phases in the set of CTs where a zero current has been detected as well as on the primary side of the transformer. This change in the value of the angle blocks the function internally.

### Overload / System short circuit condition

It is required that any overload or short circuit conditions after a CT failure should block the function. During overload or short circuit condition, the phase current increases beyond its rated value; if any phase current on any set of current transformer exceeds the set limit, the function is blocked internally. Also in case of an unsymmetrical fault, the negative-sequence current increases. If the negative-sequence current increases beyond the set limit, the function is blocked internally. The overcurrent and negative-sequence current setting both can be set equal to the overcurrent and negative-sequence protection function start value.

The internal blocking is thus useful for avoiding false operation during a fault situation.

## 6.9.7 Signals

*Table 1187: CTSRCTF Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| I3P3 | SIGNAL | - | Three-phase currents 3 |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 1188: CTSRCTF Output signals*

| Name | Type | Description |
|---|---|---|
| FAIL | BOOLEAN | CT secondary failure |
| FAIL_CTGRP1 | BOOLEAN | CT secondary failure group 1 |
| FAIL_CTGRP2 | BOOLEAN | CT secondary failure group 2 |
| FAIL_CTGRP3 | BOOLEAN | CT secondary failure group 3 |
| ALARM | BOOLEAN | Alarm |

## 6.9.8 Settings

*Table 1189: CTSRCTF Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Min operate current | 0.01...0.50 | xIn | 0.01 | 0.02 | Minimum operate current |
| Max operate current | 1.00...5.00 | xIn | 0.01 | 1.30 | Maximum operate current |
| Max Ng Seq current | 0.01...1.00 | xIn | 0.01 | 0.10 | Maximum I2 current in healthy set |

## 6.9.9 Monitored data

*Table 1190: CTSRCTF Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| INT_BLKD | BOOLEAN | 0=False<br>1=True | | Function blocked internally |
| CTSRCTF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 6.9.10 Technical data

*Table 1191: CTSRCTF Technical data*

| Characteristic | Value |
|---|---|
| Operate time[1)] | <30 ms |

1) Including the delay of the output contact

# Section 7 Condition monitoring functions

## 7.1 Circuit-breaker condition monitoring SSCBR

### 7.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Circuit-breaker condition monitoring | SSCBR | CBCM | 52CM |

### 7.1.2 Function block




*Figure 681: Function block*

### 7.1.3 Functionality

The circuit-breaker condition monitoring function SSCBR is used to monitor different parameters of the circuit breaker. The breaker requires maintenance when the number of operations has reached a predefined value. The energy is calculated from the measured input currents as a sum of $I^yt$ values. Alarms are generated when the calculated values exceed the threshold settings.

The function contains a blocking functionality which can be used to block the function outputs.

### 7.1.4 Analog input configuration

SSCBR has one analog group input which must be properly configured.

*Table 1192: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 7.1.5 Operation principle

The circuit breaker condition monitoring function includes different metering and monitoring sub-functions. The functions can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”. The operation counters are cleared when *Operation* is set to “Off”.

The operation of SSCBR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

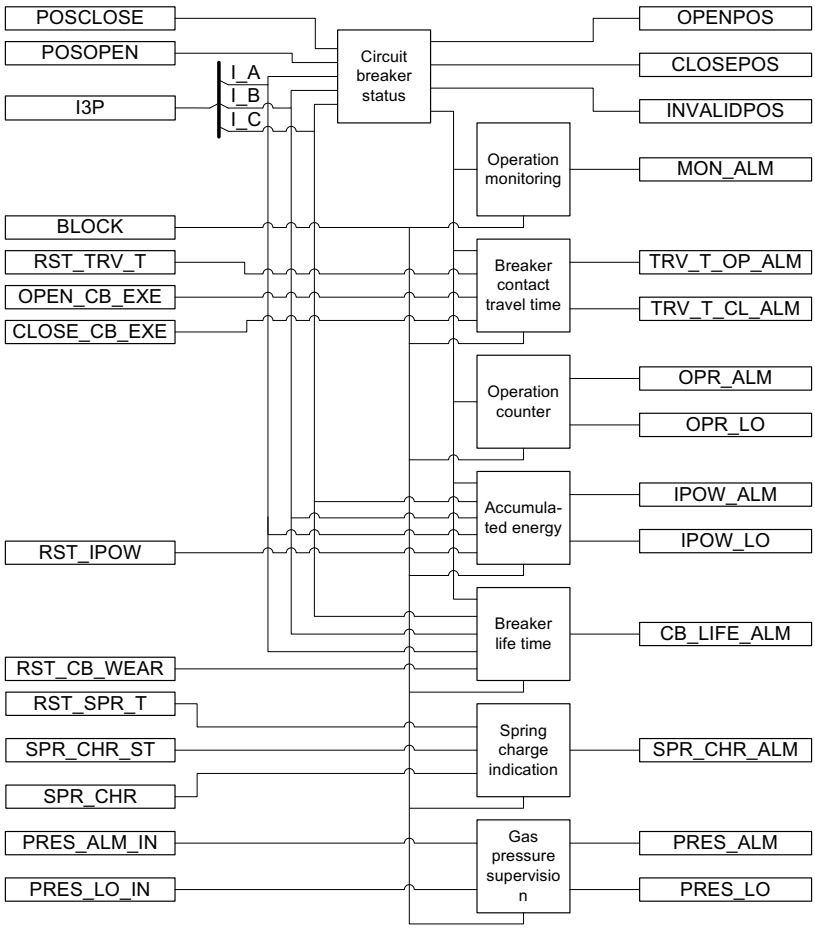



*Figure 682: Functional module diagram*

### 7.1.5.1 Circuit breaker status

The Circuit breaker status sub-function monitors the position of the circuit breaker, that is, whether the breaker is in open, closed or invalid position. The operation of the

breaker status monitoring can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

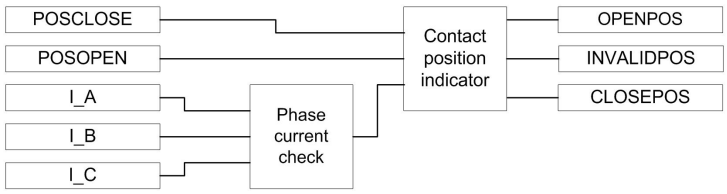



*Figure 683: Functional module diagram for monitoring circuit breaker status*

### Phase current check

This module compares the three phase currents to the setting *Acc stop current*. If the current in a phase exceeds the set level, information about the phase is reported to the contact position indicator module.

### Contact position indicator

The OPENPOS output is activated when the auxiliary input contact POSCLOSE is FALSE, the POSOPEN input is TRUE and all the phase currents are below the setting *Acc stop current*.

The CLOSEPOS output is activated when the auxiliary POSOPEN input is FALSE and the POSCLOSE input is TRUE.

The INVALIDPOS output is activated when both the auxiliary contacts have the same value, that is, both are in the same logical level, or if the auxiliary input contact POSCLOSE is FALSE and the POSOPEN input is TRUE and any of the phase currents exceed the setting Acc stop current.

The status of the breaker is indicated by the binary outputs OPENPOS, INVALIDPOS and CLOSEPOS for open, invalid and closed position respectively.

## 7.1.5.2 Circuit breaker operation monitoring

The purpose of the circuit breaker operation monitoring subfunction is to indicate if the circuit breaker has not been operated for a long time.

The operation of the circuit breaker operation monitoring can be described with a module diagram. All the modules in the diagram are explained in the next sections.

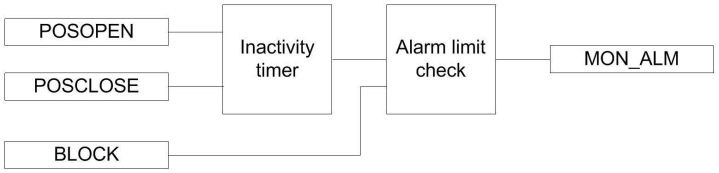



*Figure 684: Functional module diagram for calculating inactive days and alarm for circuit breaker operation monitoring*

### Inactivity timer

The module calculates the number of days the circuit breaker has remained inactive, that is, has stayed in the same open or closed state. The calculation is done by monitoring the states of the POSOPEN and POSCLOSE auxiliary contacts.

The inactive days INA_DAYS is available in the monitored data view. It is also possible to set the initial inactive days with the *Ini inactive days* parameter.

### Alarm limit check

When the inactive days exceed the limit value defined with the *Inactive Alm days* setting, the MON_ALM alarm is initiated. The time in hours at which this alarm is activated can be set with the *Inactive Alm hours* parameter as coordinates of UTC. The alarm signal MON_ALM can be blocked by activating the binary input BLOCK.

## 7.1.5.3 Breaker contact travel time

The Breaker contact travel time module calculates the breaker contact travel time for the closing and opening operation. The operation of the breaker contact travel time measurement can be described with a module diagram. All the modules in the diagram are explained in the next sections.

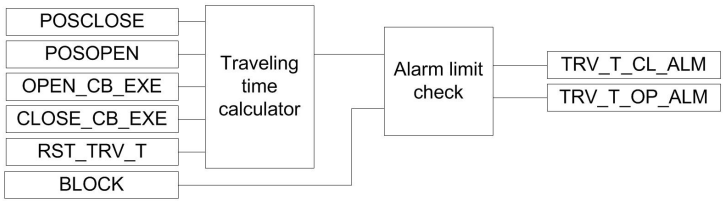



*Figure 685: Functional module diagram for breaker contact travel time*

### Traveling time calculator

The travel time can be calculated using two different methods based on the setting *Travel time Clc mode*.

When the setting *Travel time Clc mode* is “From Pos to Pos”, the contact travel time of the breaker is calculated from the time between auxiliary contacts' state change. The opening travel time is measured between the opening of the POSCLOSE auxiliary

contact and the closing of the POSOPEN auxiliary contact. The travel time is also measured between the opening of the POSOPEN auxiliary contact and the closing of the POSCLOSE auxiliary contact.

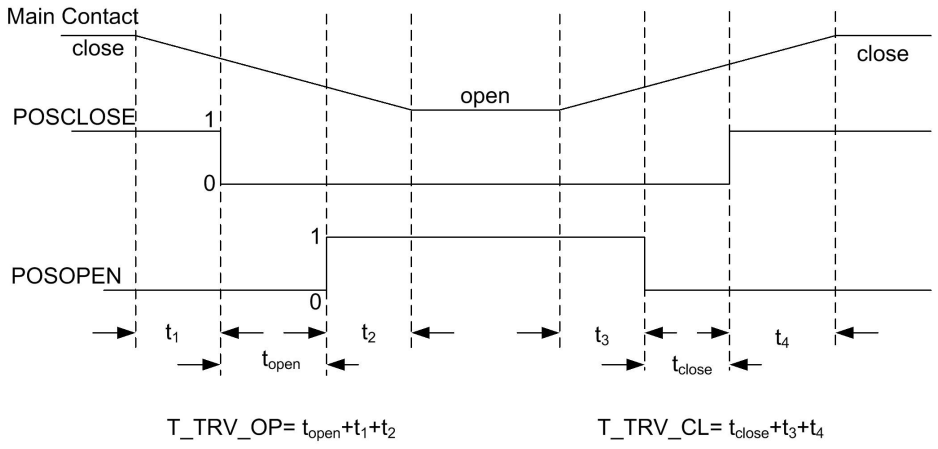



*Figure 686: Travel time calculation when Travel time Clc mode is "From Pos to Pos"*

There is a time difference $t_1$ between the start of the main contact opening and the opening of the POSCLOSE auxiliary contact. Similarly, there is a time gap $t_2$ between the time when the POSOPEN auxiliary contact opens and the main contact is completely open. To incorporate the time $t_1 + t_2$, a correction factor needs to be added with $t_{open}$ to get the actual opening time. This factor is added with the *Opening time Cor* (= $t_1 + t_2$) setting. The closing time is calculated by adding the value set with the *Closing time Cor* ($t_3 + t_4$) setting to the measured closing time.

When the setting *Travel time Clc mode* is "From Cmd to Pos", the contact travel time of the breaker is calculated from the time between the circuit breaker opening or closing command and the auxiliary contacts' state change. The opening travel time is measured between the rising edge of the OPEN_CB_EXE command and the POSOPEN auxiliary contact. The closing travel time is measured between the rising edge of the CLOSE_CB_EXEC command and the POSCLOSE auxiliary contact.

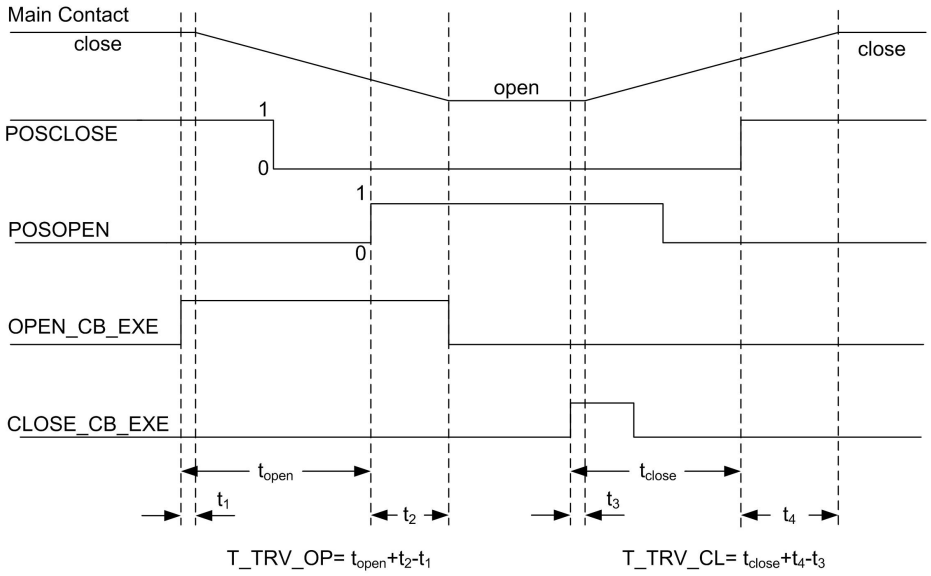



*Figure 687: Travel time calculation when Travel time Clc mode is "From Cmd to Pos"*

There is a time difference $t_1$ between the start of the main contact opening and the OPEN_CB_EXE command. Similarly, there is a time gap $t_2$ between the time when the POSOPEN auxiliary contact opens and the main contact is completely open. Therefore, to incorporate the times $t_1$ and $t_2$, a correction factor needs to be added with $t_{open}$ to get the actual opening time. This factor is added with the *Opening time Cor* (= $t_2 - t_1$) setting. The closing time is calculated by adding the value set with the *Closing time Cor* ($t_4 - t_3$) setting to the measured closing time.

The last measured opening travel time T_TRV_OP and the closing travel time T_TRV_CL are available in the monitored data view on the LHMI or through tools via communications.

### Alarm limit check

When the measured opening travel time is longer than the value set with the *Open alarm time* setting, the TRV_T_OP_ALM output is activated. Respectively, when the measured closing travel time is longer than the value set with the *Close alarm time* setting, the TRV_T_CL_ALM output is activated.

It is also possible to block the TRV_T_CL_ALM and TRV_T_OP_ALM alarm signals by activating the BLOCK input.

## 7.1.5.4 Operation counter

The operation counter subfunction calculates the number of breaker operation cycles. The opening and closing operations are both included in one operation cycle. The operation counter value is updated after each opening operation.

The operation of the subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

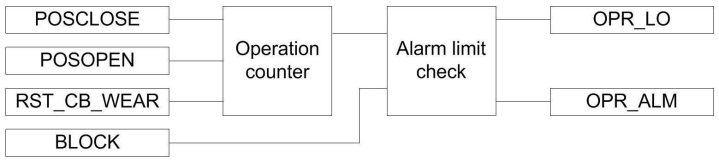



*Figure 688: Functional module diagram for counting circuit breaker operations*

### Operation counter

The operation counter counts the number of operations based on the state change of the binary auxiliary contacts inputs POSCLOSE and POSOPEN.

The number of operations NO_OPR is available in the monitored data view on the LHMI or through tools via communications. The old circuit breaker operation counter value can be taken into use by writing the value to the *Counter initial Val* parameter and by setting the parameter *CB wear values* in the clear menu from WHMI or LHMI.

### Alarm limit check

The OPR_ALM operation alarm is generated when the number of operations exceeds the value set with the *Alarm Op number* threshold setting. However, if the number of operations increases further and exceeds the limit value set with the *Lockout Op number* setting, the OPR_LO output is activated.

The binary outputs OPR_LO and OPR_ALM are deactivated when the BLOCK input is activated.

## 7.1.5.5 Accumulation of $I^yt$

Accumulation of the $I^yt$ module calculates the accumulated energy.

The operation of the module can be described with a module diagram. All the modules in the diagram are explained in the next sections.

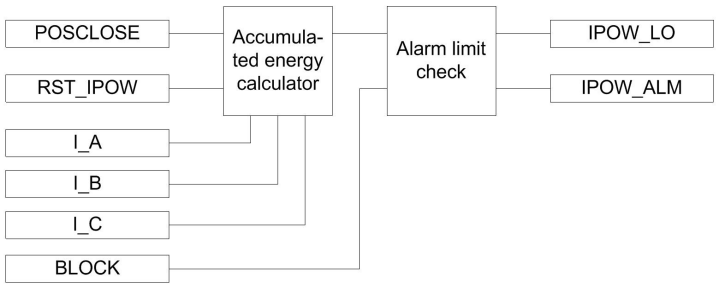



*Figure 689: Functional module diagram for calculating accumulative energy and alarm*

### Accumulated energy calculator

This module calculates the accumulated energy $I^yt$ [(kA)$^y$s]. The factor y is set with the *Current exponent* setting.

The calculation is initiated with the POSCLOSE input opening events. It ends when the RMS current becomes lower than the *Acc stop current* setting value.

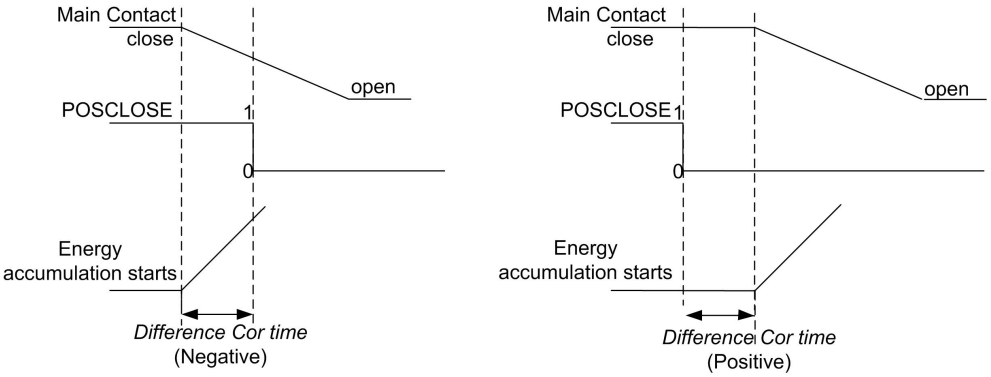



*Figure 690: Significance of the Difference Cor time setting*

The *Difference Cor time* setting is used instead of the auxiliary contact to accumulate the energy from the time the main contact opens. If the setting is positive, the calculation of energy starts after the auxiliary contact has opened and when the delay is equal to the value set with the *Difference Cor time* setting. When the setting is negative, the calculation starts in advance by the correction time before the auxiliary contact opens.

The accumulated energy outputs IPOW_A (_B, _C) are available in the monitored data view on the LHMI or through tools via communications. The values can be reset by setting the parameter *CB accum. currents power* setting to true in the clear menu from WHMI or LHMI.

### Alarm limit check

The IPOW_ALM alarm is activated when the accumulated energy exceeds the value set with the *Alm Acc currents Pwr* threshold setting. However, when the energy exceeds the limit value set with the *LO Acc currents Pwr* threshold setting, the IPOW_LO output is activated.

The IPOW_ALM and IPOW_LO outputs can be blocked by activating the binary input BLOCK.

## 7.1.5.6 Remaining life of circuit breaker

Every time the breaker operates, the life of the circuit breaker reduces due to wearing. The wearing in the breaker depends on the tripping current, and the remaining life of the breaker is estimated from the circuit breaker trip curve provided by the

manufacturer. The remaining life is decremented at least with one when the circuit breaker is opened.

The operation of the remaining life of the circuit breaker subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

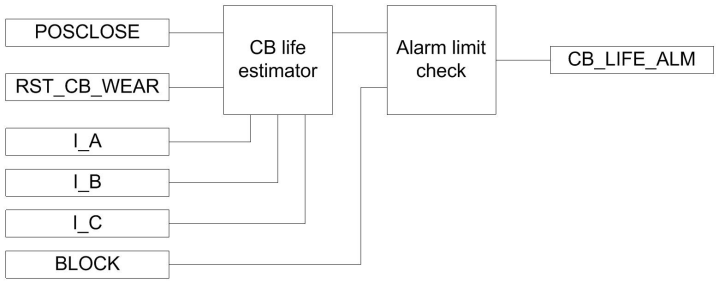



*Figure 691: Functional module diagram for estimating the life of the circuit breaker*

## Circuit breaker life estimator

The circuit breaker life estimator module calculates the remaining life of the circuit breaker. If the tripping current is less than the rated operating current set with the *Rated Op current* setting, the remaining operation of the breaker reduces by one operation. If the tripping current is more than the rated fault current set with the *Rated fault current* setting, the possible operations are zero. The remaining life of the tripping current in between these two values is calculated based on the trip curve given by the manufacturer. The *Op number rated* and *Op number fault* parameters set the number of operations the breaker can perform at the rated current and at the rated fault current, respectively.

The remaining life is calculated separately for all three phases and it is available as a monitored data value `CB_LIFE_A (_B,_C)`. The values can be cleared by setting the parameter *CB wear values* in the clear menu from WHMI or LHMI.

Clearing *CB wear values* also resets the operation counter.

## Alarm limit check

When the remaining life of any phase drops below the *Life alarm level* threshold setting, the corresponding circuit breaker life alarm `CB_LIFE_ALM` is activated.

It is possible to deactivate the `CB_LIFE_ALM` alarm signal by activating the binary input `BLOCK`. The old circuit breaker operation counter value can be taken into use by writing the value to the *Initial CB Rmn life* parameter and resetting the value via the clear menu from WHMI or LHMI.

### 7.1.5.7 Circuit breaker spring-charged indication

The circuit breaker spring-charged indication subfunction calculates the spring charging time.

The operation of the subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

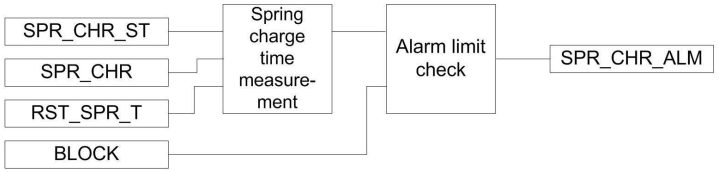



*Figure 692: Functional module diagram for circuit breaker spring-charged indication and alarm*

#### Spring charge time measurement

Two binary inputs, SPR_CHR_ST and SPR_CHR, indicate spring charging started and spring charged, respectively. The spring-charging time is calculated from the difference of these two signal timings.

The spring charging time T_SPR_CHR is available in the monitored data view on the LHMI or through tools via communications.

#### Alarm limit check

If the time taken by the spring to charge is more than the value set with the *Spring charge time* setting, the subfunction generates the SPR_CHR_ALM alarm.

It is possible to block the SPR_CHR_ALM alarm signal by activating the BLOCK binary input.

### 7.1.5.8 Gas pressure supervision

The gas pressure supervision subfunction monitors the gas pressure inside the arc chamber.

The operation of the subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

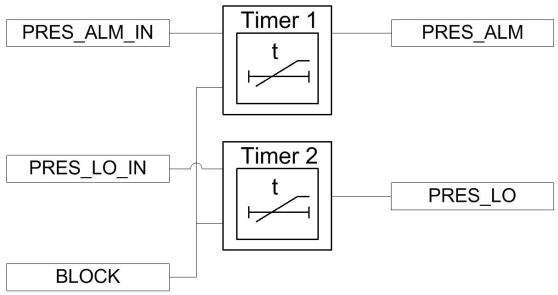



*Figure 693: Functional module diagram for circuit breaker gas pressure alarm*

The gas pressure is monitored through the binary input signals PRES_LO_IN and PRES_ALM_IN.

### Timer 1

When the PRES_ALM_IN binary input is activated, the PRES_ALM alarm is activated after a time delay set with the *Pressure alarm time* setting. The PRES_ALM alarm can be blocked by activating the BLOCK input.

### Timer 2

If the pressure drops further to a very low level, the PRES_LO_IN binary input becomes high, activating the lockout alarm PRES_LO after a time delay set with the *Pres lockout time* setting. The PRES_LO alarm can be blocked by activating the BLOCK input.

## 7.1.6 Application

SSCBR includes different metering and monitoring subfunctions.

### Circuit breaker status

Circuit breaker status monitors the position of the circuit breaker, that is, whether the breaker is in an open, closed or intermediate position.

### Circuit breaker operation monitoring

The purpose of the circuit breaker operation monitoring is to indicate that the circuit breaker has not been operated for a long time. The function calculates the number of days the circuit breaker has remained inactive, that is, has stayed in the same open or closed state. There is also the possibility to set an initial inactive day.

### Breaker contact travel time

High traveling times indicate the need for the maintenance of the circuit breaker mechanism. Therefore, detecting excessive traveling time is needed. During the opening cycle operation, the main contact starts opening. The auxiliary contact A opens, the auxiliary contact B closes and the main contact reaches its opening position. During the closing cycle, the first main contact starts closing. The auxiliary contact B

opens, the auxiliary contact A closes and the main contact reaches its closed position. The travel times are calculated based on the state changes of the auxiliary contacts and the adding correction factor to consider the time difference of the main contact's and the auxiliary contact's position change.

## Operation counter

Routine maintenance of the breaker, such as lubricating breaker mechanism, is generally based on a number of operations. A suitable threshold setting to raise an alarm when the number of operation cycle exceeds the set limit helps preventive maintenance. This can also be used to indicate the requirement for oil sampling for dielectric testing in case of an oil circuit breaker.

The change of state can be detected from the binary input of the auxiliary contact. There is a possibility to set an initial value for the counter which can be used to initialize this functionality after a period of operation or in case of refurbished primary equipment.

## Accumulation of $I^yt$

Accumulation of $I^yt$ calculates the accumulated energy $\Sigma I^yt$, where the factor y is known as the current exponent. The factor y depends on the type of the circuit breaker. For oil circuit breakers, the factor y is normally 2. In case of a high-voltage system, the factor y can be 1.4...1.5.

## Remaining life of the breaker

Every time the breaker operates, the life of the circuit breaker reduces due to wearing. The wearing in the breaker depends on the tripping current, and the remaining life of the breaker is estimated from the circuit breaker trip curve provided by the manufacturer.

**Example for estimating the remaining life of a circuit breaker**

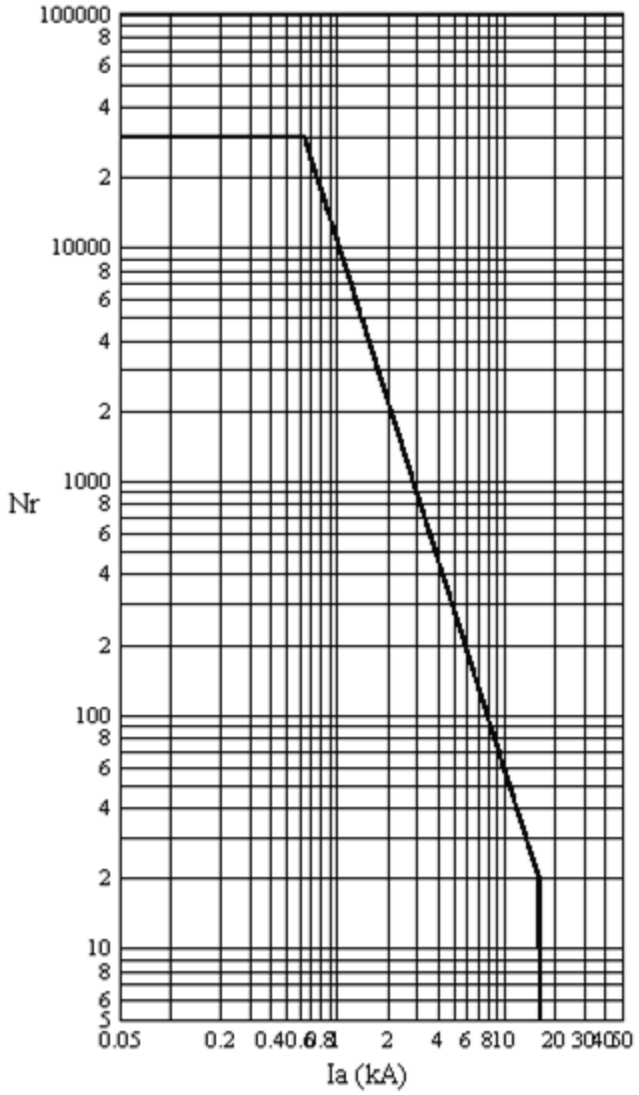



*Figure 694: Trip Curves for a typical 12 kV, 630 A, 16 kA vacuum interrupter*

| | |
|---|---|
| Nr | the number of closing-opening operations allowed for the circuit breaker |
| Ia | the current at the time of tripping of the circuit breaker |

### Calculation of Directional Coef

The directional coefficient is calculated according to the formula:

$$Directional\,Coef = \frac{\log\left(\frac{B}{A}\right)}{\log\left(\frac{I_f}{I_r}\right)} = -2.2609$$

(Equation 284)

| | |
|---|---|
| $I_r$ | Rated operating current = 630 A |
| $I_f$ | Rated fault current = 16 kA |
| A | Op number rated = 30000 |
| B | Op number fault = 20 |

**Calculation for estimating the remaining life**

Figure 694 shows that there are 30,000 possible operations at the rated operating current of 630 A and 20 operations at the rated fault current 16 kA. Therefore, if the tripping current is 10 kA, one operation at 10 kA is equivalent to 30,000/60=500 operations at the rated current. It is also assumed that prior to this tripping, the remaining life of the circuit breaker is 15,000 operations. Therefore, after one operation of 10 kA, the remaining life of the circuit breaker is 15,000-500=14,500 at the rated operating current.

$$Remaining\ \ life\ \ reduction = \left(\frac{I}{I_r}\right)^{-Directional\ Coef}$$

(Equation 285)

### Spring-charged indication

For normal operation of the circuit breaker, the circuit breaker spring should be charged within a specified time. Therefore, detecting long spring-charging time indicates that it is time for the circuit breaker maintenance. The last value of the spring-charging time can be used as a service value.

### Gas pressure supervision

The gas pressure supervision monitors the gas pressure inside the arc chamber. When the pressure becomes too low compared to the required value, the circuit breaker operations are locked. A binary input is available based on the pressure levels in the function, and alarms are generated based on these inputs.

## 7.1.7 Signals

*Table 1193: SSCBR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block input status |
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| Table continues on next page | | | |

| Name | Type | Default | Description |
|---|---|---|---|
| POSCLOSE | BOOLEAN | 0=False | Signal for closeposition of apparatus from I/O |
| OPEN_CB_EXE | BOOLEAN | 0=False | Signal for open command to coil |
| CLOSE_CB_EXE | BOOLEAN | 0=False | Signal for close command to coil |
| PRES_ALM_IN | BOOLEAN | 0=False | Binary pressure alarm input |
| PRES_LO_IN | BOOLEAN | 0=False | Binary pressure input for lockout indication |
| SPR_CHR_ST | BOOLEAN | 0=False | CB spring charging started input |
| SPR_CHR | BOOLEAN | 0=False | CB spring charged input |
| RST_IPOW | BOOLEAN | 0=False | Reset accumulation energy |
| RST_CB_WEAR | BOOLEAN | 0=False | Reset input for CB remaining life and operation counter |
| RST_TRV_T | BOOLEAN | 0=False | Reset input for CB closing and opening travel times |
| RST_SPR_T | BOOLEAN | 0=False | Reset input for the charging time of the CB spring |

*Table 1194: SSCBR Output signals*

| Name | Type | Description |
|---|---|---|
| TRV_T_OP_ALM | BOOLEAN | CB open travel time exceeded set value |
| TRV_T_CL_ALM | BOOLEAN | CB close travel time exceeded set value |
| SPR_CHR_ALM | BOOLEAN | Spring charging time has crossed the set value |
| OPR_ALM | BOOLEAN | Number of CB operations exceeds alarm limit |
| OPR_LO | BOOLEAN | Number of CB operations exceeds lockout limit |
| IPOW_ALM | BOOLEAN | Accumulated currents power (Iyt),exceeded alarm limit |
| IPOW_LO | BOOLEAN | Accumulated currents power (Iyt),exceeded lockout limit |
| CB_LIFE_ALM | BOOLEAN | Remaining life of CB exceeded alarm limit |
| MON_ALM | BOOLEAN | CB 'not operated for long time' alarm |
| PRES_ALM | BOOLEAN | Pressure below alarm level |
| PRES_LO | BOOLEAN | Pressure below lockout level |
| OPENPOS | BOOLEAN | CB is in open position |
| INVALIDPOS | BOOLEAN | CB is in invalid position (not positively open or closed) |
| CLOSEPOS | BOOLEAN | CB is in closed position |

## 7.1.8 Settings

*Table 1195: SSCBR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Acc stop current | 5.00...500.00 | A | 0.01 | 10.00 | RMS current setting below which engy acm stops |
| Open alarm time | 0...200 | ms | 1 | 40 | Alarm level setting for open travel time in ms |
| Close alarm time | 0...200 | ms | 1 | 40 | Alarm level Setting for close travel time in ms |
| Spring charge time | 0...60000 | ms | 10 | 15000 | Setting of alarm for spring charging time of CB in ms |
| Alarm Op number | 0...99999 | | 1 | 200 | Alarm limit for number of operations |
| Lockout Op number | 0...99999 | | 1 | 300 | Lock out limit for number of operations |
| Current exponent | 0.00...2.00 | | 0.01 | 2.00 | Current exponent setting for energy calculation |
| Difference Cor time | -10...10 | ms | 1 | 5 | Corr. factor for time dif in aux. and main contacts open time |
| Alm Acc currents Pwr | 0.00...20000.00 | | 0.01 | 2500.00 | Setting of alarm level for accumulated currents power |
| LO Acc currents Pwr | 0.00...20000.00 | | 0.01 | 2500.00 | Lockout limit setting for accumulated currents power |
| Directional Coef | -3.00...-0.50 | | 0.01 | -1.50 | Directional coefficient for CB life calculation |
| Initial CB Rmn life | 0...99999 | | 1 | 5000 | Initial value for the CB remaining life |
| Rated Op current | 100.00...5000.00 | A | 0.01 | 1000.00 | Rated operating current of the breaker |
| Rated fault current | 500.00...75000.00 | A | 0.01 | 5000.00 | Rated fault current of the breaker |
| Op number rated | 1...99999 | | 1 | 10000 | Number of operations possible at rated current |
| Op number fault | 1...10000 | | 1 | 1000 | Number of operations possible at rated fault current |
| Inactive Alm days | 0...9999 | | 1 | 2000 | Alarm limit value of the inactive days counter |
| Travel time Clc mode | 1=From Cmd to Pos<br>2=From Pos to Pos | | | 2=From Pos to Pos | Travel time calculation mode selection |

*Table 1196: SSCBR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Opening time Cor | -100...100 | ms | 1 | 10 | Correction factor for open travel time in ms |
| Closing time Cor | -100...100 | ms | 1 | 10 | Correction factor for CB close travel time in ms |
| Counter initial Val | 0...99999 | | 1 | 0 | The operation numbers counter initialization value |
| Ini Acc currents Pwr | 0.00...20000.00 | | 0.01 | 0.00 | Initial value for accumulation energy (Iyt) |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Life alarm level | 0...99999 | | 1 | 500 | Alarm level for CB remaining life |
| Pressure alarm time | 0...60000 | ms | 1 | 10 | Time delay for gas pressure alarm in ms |
| Pres lockout time | 0...60000 | ms | 10 | 10 | Time delay for gas pressure lockout in ms |
| Ini inactive days | 0...9999 | | 1 | 0 | Initial value of the inactive days counter |
| Inactive Alm hours | 0...23 | h | 1 | 0 | Alarm time of the inactive days counter in hours |

## 7.1.9 Monitored data

*Table 1197: SSCBR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| T_TRV_OP | FLOAT32 | 0...60000 | ms | Travel time of the CB during opening operation |
| T_TRV_CL | FLOAT32 | 0...60000 | ms | Travel time of the CB during closing operation |
| T_SPR_CHR | FLOAT32 | 0.00...99.99 | s | The charging time of the CB spring |
| NO_OPR | INT32 | 0...99999 | | Number of CB operation cycle |
| INA_DAYS | INT32 | 0...9999 | | The number of days CB has been inactive |
| CB_LIFE_A | INT32 | -99999...99999 | | CB Remaining life phase A |
| CB_LIFE_B | INT32 | -99999...99999 | | CB Remaining life phase B |
| CB_LIFE_C | INT32 | -99999...99999 | | CB Remaining life phase C |
| IPOW_A | FLOAT32 | 0.000...30000.000 | | Accumulated currents power (Iyt), phase A |
| IPOW_B | FLOAT32 | 0.000...30000.000 | | Accumulated currents power (Iyt), phase B |
| IPOW_C | FLOAT32 | 0.000...30000.000 | | Accumulated currents power (Iyt), phase C |
| SSCBR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 7.1.10 Technical data

*Table 1198: SSCBR Technical data*

| Characteristic | Value |
|---|---|
| Current measuring accuracy | ±1.5% or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0%<br>(at currents in the range of 10…40 × $I_n$) |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Travelling time measurement | +10 ms / -0 ms |

## 7.2 Hot-spot and insulation ageing rate monitoring for transformers HSARSPTR

### 7.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Hot-spot and insulation ageing rate monitoring for transformers | HSARSPTR | 3Ihp>T | 26/49HS |

### 7.2.2 Function block

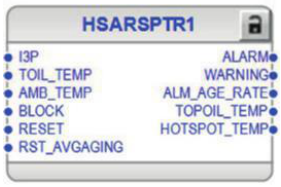



*Figure 695: Function block*

### 7.2.3 Functionality

The hot-spot and insulation ageing rate monitoring for transformers function HSARSPTR is used for online monitoring of transformers. The function monitors the hot-spot temperature of the transformer winding and the ageing rate of the insulation caused by thermal stress. The function can be applied for new transformers as well as for transformers already in service.

The hot-spot temperature and loss of life of transformer are calculated for one winding of the transformer from three phase currents and RTD inputs for top oil temperature and ambient temperature.

The hot-spot temperature and the momentary ageing rate are calculated based on the IEC 60076-7 or the IEEE C57.91-2011 standard, depending upon a user defined setting. The total ageing and loss of transformer insulation life is calculated in years.

The function generates WARNING and ALARM signals if the calculated hot-spot temperature exceeds the set value.

## 7.2.4 Analog channel configuration

HSARSPTR has one analog group input which must be properly configured.

*Table 1199: Analog signals*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 7.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of HSARSPTR can be described with a module diagram. All modules in the diagram are explained in the next sections.

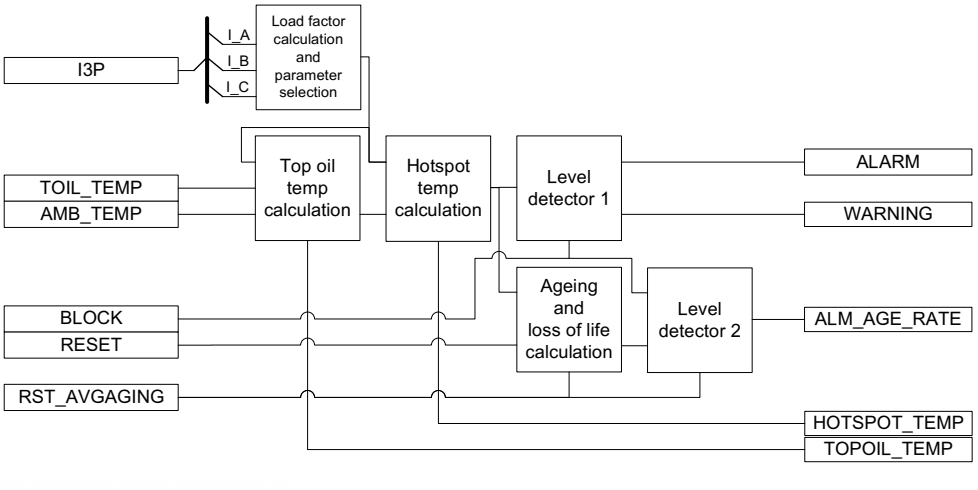



*Figure 696: Functional module diagram*

## Load factor calculation and parameter selection

The transformer top oil and hot-spot temperatures are dependent on the load factor, the winding conductor properties and the cooling oil properties of the transformer. This module calculates the load factor based on the measured phase currents and selects the transformer parameters based on user defined settings.

### Load factor calculation

Load factor is a ratio of the load current to the rated current. Since the thermal content of all the three phase currents influence the temperature inside the transformer, the load factor is calculated as a ratio of the root of sum of squared phase currents to three times the rated current.

$$K = \sqrt{\frac{I_A^2 + I_B^2 + I_C^2}{3 \cdot I_{rated}^2}}$$

(Equation 286)

Where

| | |
|---|---|
| K | Load factor |
| I_A, I_B and I_C | RMS value of input phase currents (Amperes) |
| $I_{rated}$ | Rated current (Amperes) |

If *Transformer type* is set to “Single phase”, the denominator consists only of $I^2_{rated}$ instead of $3 \times I^2_{rated}$.

Equation 286 assumes that voltage is constant and tap changer position is not considered.

For a star-delta transformer, it is recommended to use the function on the star winding, since the circulating zero sequence currents (in case of unbalance) cannot be measured on the delta winding of the transformer.

### Transformer parameter selection

The transformer parameters are selected based on the *Parameter Sel method*, *Cooling mode*, *Transformer type*, and *Transformer rating* settings.

If the *Parameter Sel method* setting is set to "IEC", the transformer parameters' values are automatically selected as per the IEC 60076-7 guidelines based on Table 1200.

*Table 1200: Constants based IEC guidelines*

| | Distribution Transformers | Medium and Large power transformers | | | |
|---|---|---|---|---|---|
| **Cooling mode** | **ONAN** | **ONAN** | **ONAF** | **OFAF** | **ODAF** |
| Oil Exponent (x) | 0.8 | 0.8 | 0.8 | 1.0 | 1.0 |
| Winding Exponent (y) | 1.6 | 1.3 | 1.3 | 1.3 | 2.0 |
| Constant K11 ($k_{11}$) | 1.00 | 0.50 | 0.50 | 1.00 | 1.00 |
| Constant K21 ($k_{21}$) | 1.00 | 2.00 | 2.00 | 1.30 | 1.00 |
| Constant K22 ($k_{22}$) | 2.00 | 2.00 | 2.00 | 1.00 | 1.00 |
| Oil Time Constant ($\tau_0$) [minutes] | 180 | 210 | 150 | 90 | 90 |
| Winding Tm Constant ($\tau_w$) [minutes] | 4 | 10 | 7 | 7 | 7 |

If *Parameter Sel method* is set to "IEEE", the constants are selected as per the IEEE C57.91™-2011 standard based on Table 1201.

*Table 1201: Constants based on IEEE guidelines*

| | Distribution Transformers | Medium and Large power transformers | | | |
|---|---|---|---|---|---|
| **Cooling mode** | **ONAN** | **ONAN** | **ONAF** | **OFAF** | **ODAF** |
| Oil Exponent (x) | 0.8 | 0.8 | 0.8 | 0.8 | 1.0 |
| Winding Exponent (y) | 0.8 | 0.8 | 0.9 | 0.9 | 1.0 |
| Constant K11 ($k_{11}$) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Constant K21 ($k_{21}$) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Constant K22 ($k_{22}$) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Oil Time Constant ($\tau_0$) [minutes] | 180 | 210 | 150 | 90 | 90 |
| Winding Tm Constant ($\tau_w$) [minutes] | 4 | 10 | 7 | 7 | 7 |

A transformer is a distribution transformer if the *Transformer rating* setting < 2.5 MVA and *Transformer type* is set to "Three phase" or if the *Transformer rating* setting < 0.833 MVA and *Transformer type* is set to "Single phase".

Transformer parameters vary with the material used for winding and insulating oil. The *Parameter Sel method* setting can be set to "Manual" and the constants can be set individually through the *Oil exponent*, *Winding exponent*, *Constant K11*, *Constant K21*, *Constant K22*, *Oil time constant* and *Winding Tm constant* settings.

If *Parameter Sel method* is set to "Manual", the *Cooling mode* setting has no effect on the transformer parameters.

Since there is no direct *Cooling mode* based time constants' selection mentioned in the IEEE Std C57.91™- 2011 standard, the oil time constant ($\tau_0$) and winding time constant ($\tau_w$) in the Table 1201 are kept same as in the Table 1200.
For more accuracy, the values of the constants can be entered manually by setting *Parameter Sel method* to "Manual".

## Top oil temp calculation

The function receives two sensor inputs for measuring top oil temperature and ambient temperature.

The top oil temperature of the tank is obtained through a sensor placed at the upper inner turn of the winding. If the top oil temperature sensor status `TOIL_SNSFLT` is FALSE, the top oil temperature is directly obtained from the `TOIL_TEMP` input.

If the status of `TOIL_SNSFLT` is TRUE, indicating that the sensor is faulty, the top oil temperature is calculated with the help of measured ambient temperature.

The status of the ambient temperature sensor is obtained through the `AMB_SNSFLT` binary input. If `AMB_SNSFLT` is FALSE, indicating the healthy status of the sensor, the ambient temperature is directly measured through the `AMB_TEMP` input. Else, if `AMB_SNSFLT` is TRUE, the ambient temperature is taken from the *Average ambient Tmp* setting.

The formula for calculating the top oil temperature from the measured or set ambient temperature is shown in Equation 287.

$$D\theta_{0(n)} = \frac{Dt}{(k_{11} \cdot \tau_o)} \cdot \left( \left[ \frac{1 + (K^2 \cdot R)}{1 + R} \right]^x \cdot \Delta\theta_{or} - \left[ \theta_{0(n-1)} - \theta_a \right] \right)$$

(Equation 287)

Where

| | |
|---|---|
| $\theta_{0(n)}$ | Top oil temperature in the tank at $n^{th}$ time step |
| $\theta_a$ | Ambient temperature [°C] |
| $\Delta\theta_{or}$ | Top oil temperature rise over ambient temperature at rated load, given by the setting *Top oil Tmp rise* |
| R | Ratio of losses at rated current to no load losses, given by the setting *Ratio of losses* |

$k_{11}$, $\tau_0$, K and x are as defined in the Parameter selection module in Figure 696.

The D operator implies a difference in the associated variable that corresponds to each time step Dt. At each time step, the $n^{th}$ value of $D\theta_{0(n)}$ is calculated from the $(n-1)^{th}$ value.

The initial conditions are calculated by setting the time derivative equal to zero in $D\theta_{0(n)}$ equation, resulting in the following equations.

$$\theta_{0(0)} = \left[\frac{1+\left(K^2 \cdot R\right)}{1+R}\right]^x \cdot \Delta\theta_{or} + \theta_a$$

(Equation 288)

The top oil temperature at the $n^{th}$ time step is calculated as shown below.

$$TOPOIL_TEMP = \theta_{0(n-1)} + D\theta_{0(n)}$$

(Equation 289)

The measured/calculated top oil temperature TOPOIL_TEMP is available in the Monitored data view.

If the top oil temperature sensor is valid, the TOPOIL_TEMP output is equal to the measured top oil temperature TOIL_TEMP input.

## Hot-spot temp calculation

Winding hot-spot temperature depends on the winding temperature rise due to the load factor and oil flow. These two factors act complimentary to each other in the influence of temperature rise.

The differential equations for hot-spot temperature rise above top oil temperature is solved as the sum of two differential equations.

$$\Delta\theta_{h(n)} = \Delta\theta_{h1(n)} - \Delta\theta_{h2(n)}$$

(Equation 290)

The two differential equations are shown in the Equation 291 and Equation 292.

$$D\Delta\theta_{h1(n)} = \frac{Dt}{(k_{22} \cdot \tau_w)} \cdot \left(k_{21} \cdot \Delta\theta_{hr} \cdot K^y - \Delta\theta_{h1(n-1)}\right)$$

(Equation 291)

$$D\Delta\theta_{h2(n)} = \frac{Dt}{\left(\left(\frac{1}{k_{22}}\right) \cdot \tau_o\right)} \cdot \left((k_{21} - 1) \cdot \Delta\theta_{hr} \cdot K^y - \Delta\theta_{h2(n-1)}\right)$$

(Equation 292)

Where

| | |
|---|---|
| $\Delta\theta_{hr}$ | Hot-spot-to-top-oil gradient at rated current [°C] |

The constants $\tau_w$, $k_{21}$, $k_{22}$ and y are varying according to the *Cooling mode* setting and are obtained from the Load factor calculation and parameter selection module.

The rated hot-spot to top oil gradient, HS_TOIL_GRA ($\Delta\theta_{hr}$), is calculated using the formula as shown in the Equation 293.

$$\Delta\theta_{hr} = \frac{Hotspot\ \ Tmp\ rise - Top\ oil\ \ Tmp\ rise}{\left(\frac{Current\ type\ test}{I_{rated}}\right)^y}$$

(Equation 293)

Where

| | |
|---|---|
| $I_{rated}$ | Rated current of the transformer |
| Hotspot Tmp rise | Hot-spot temperature rise over ambient at rated load |
| Top oil Tmp rise | Top oil temperature rise over ambient at rated load |
| Current type test | Current applied in type testing to reach rated hot-spot temperature |

At each time step, the $n^{th}$ value of $D\Delta\theta_{h1(n)}$ and $D\Delta\theta_{h2(n)}$ are calculated from the (n-1) value; the solutions of which are combined in accordance with the hot-spot temperature rise equation.

$$\Delta\theta_{h1(n)} = \Delta\theta_{h1(n-1)} + D\Delta\theta_{h1(n)}$$

(Equation 294)

$$\Delta\theta_{h2(n)} = \Delta\theta_{h2(n-1)} + D\Delta\theta_{h2(n)}$$

(Equation 295)

The initial conditions are calculated by setting the time derivative equal to zero in $D\Delta\theta_{h1(n)}$ and $D\Delta\theta_{h2(n)}$ equations, resulting in the following equations.

$$\Delta\theta_{h1(0)} = k_{21} \cdot \Delta\theta_{hr} \cdot K^{y}$$

(Equation 296)

$$\Delta\theta_{h2(0)} = (k_{21} - 1) \cdot \Delta\theta_{hr} \cdot K^{y}$$

(Equation 297)

The final hot-spot temperature is calculated as the sum of top oil temperature and the rise of hot-spot temperature over the top oil temperature.

The hot-spot temperature at the nth time step is calculated as shown in the Equation 298.

$$HOTSPOT_TEMP = \theta_{o(n)} + \Delta\theta_{h(n)}$$

(Equation 298)

The calculated hot-spot temperature HOTSPOT_TEMP and rated hot-spot to top oil gradient, HS_TOIL_GRA are available in the Monitored data view.

### Level detector 1

This module compares the calculated hot-spot temperature, HOTSPOT_TEMP value with the *Alarm level* and *Warning level* settings.

If HOTSPOT_TEMP is greater than the *Warning level*, the module activates the WARNING output after a settable *Warning delay time*.

If HOTSPOT_TEMP is greater than the *Alarm level*, the module activates the ALARM output after a settable *Alarm delay time*.

Assuming existing conditions, as long as the alarm/warning conditions are not reached, the module calculates the available load reserve in percentage to reach the alarm condition LD_RSV_ALM_PCT and to reach the warning condition, LD_RSV_WRN_PCT. These outputs can be obtained from the Monitored data view.

If the warning condition is reached, the LD_RSV_WRN_PCT output is forced to zero and if the alarm condition is reached, LD_RSV_ALM_PCT is forced to zero.

The load reserve outputs are only indicative and are calculated based on rated current, assuming the same ambient temperature and cooling modes.
If, for any reason, the load reserve calculation is not feasible, the load reserve outputs are shown as zero.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates WARNING and ALARM outputs and resets the internal timers.

### Ageing and loss of life calculation

This module calculates the rate at which transformer insulation ageing is accelerating compared with the ageing rate at rated hot-spot temperature and equivalent ageing over a time period.

If transformer insulation paper is not upgraded, that is, if setting *Insul paper type* is set to "Normal", the setting *Ageing rate method* selects between the IEC and IEEE methods of calculation. If *Ageing rate method* is set to "IEC", the relative ageing rate is calculated as shown in the Equation 299.

$$V_{IEC} = 2^{\frac{(\theta_h - 98)}{6}}$$

(Equation 299)

If the setting *Ageing rate method* is set to "IEEE", the ageing rate is calculated as shown in the Equation 300.

$$V_{IEEE} = e^{\frac{15000}{110+273} - \frac{15000}{\theta_h+273}}$$

(Equation 300)

Where

| | |
|---|---|
| $V_{IEC}$ | Momentary ageing rate as per IEC method |
| $V_{IEEE}$ | Momentary ageing rate as per IEEE method |
| $\theta_h$ | The calculated hot-spot temperature |

If the setting *Insul paper type* is set to "Upgraded", the IEEE method is used for calculating the ageing rate irrespective of the value of *Ageing rate method* setting.

The calculated value of the relative ageing rate, AGEING_RATE is given as an output in the Monitored data view.

The module also calculates the average ageing rate, AVG_AGE_RATE, over a specified time period given by the *Avg Age rate period* setting. The setting *Avg Age rate period* can be set to "DAY", "WEEK", "MONTH" or "YEAR".

For example, if the *Avg Age rate period* is set to "MONTH", the output AVG_AGE_RATE is updated every day with the average ageing rate since the day the calculation started. Once a month is completed, the AVG_AGE_RATE is calculated over the previous 30 days. That is, after the 31st day, the average ageing rate is calculated from day 2 to day 31 and so on.

If the *Avg Age rate period* is set to "DAY", "WEEK" or "MONTH", the calculated AVG_AGE_RATE is refreshed every day at 12:00 hours, but if it is set to "YEAR", the AVG_AGE_RATE is refreshed once in 30 days.

The calculated AVG_AGE_RATE is given as an output in the Monitored data view.

The function considers month as 30 days and correspondingly a year as 12 months or 360 days.

**Loss of life calculation**

The momentary loss of life can be calculated as the product of the momentary ageing rate and the time step over which the momentary ageing is calculated.

$$DL_n = V_n \cdot Dt$$

(Equation 301)

The total loss of life is the sum of the momentary loss of life and the total loss of life until time, n-1.

$$L_n = L_{n-1} + DL_n$$

(Equation 302)

The initial loss of life $L_0$, is taken from the setting *Initial loss of life*.

For new transformer installations, the *Initial loss of life* setting should be “0”. For previously installed transformers, the *Initial loss of life* can be set to the consumed transformer life in months.

The calculated value of the loss of life in years, LOSS_OF_LIFE, is given as an output in the Monitored data view.

The calculated value of LOSS_OF_LIFE can be reset through the input RESET.

## Level detector 2

This module compares the ALM_AGE_RATE output with the setting *Alarm level Age Rte*.

If the calculated AVG_AGE_RATE over the *Avg Age rate period* setting is greater than *Alarm level Age Rte*, the module activates the binary output ALM_AGE_RATE.

The binary input RST_AVGAGING can be used to reset the output ALM_AGE_RATE and also the calculated value of AVG_AGE_RATE.

Once the RST_AVGAGING input is active, the average ageing rate values stored over the *Avg Age rate period* setting is erased and the calculation of AVG_AGE_RATE is restarted.

If the *Avg Age rate period* is set to "YEAR", the output AVG_AGE_RATE is refreshed once in 30 days starting from the time the relay is installed or since the last activation of binary input RST_AVGAGING.

The activation of the BLOCK input deactivates the ALM_AGE_RATE output.

## 7.2.6 Application

The insulation used in transformer windings is paper oil insulation that can degrade over a period of time. The deterioration of insulation is a time function of temperature, moisture and oxygen content. With modern oil preservation systems, the moisture and oxygen contributions to insulation deterioration can be minimized, leaving insulation temperature as the controlling parameter.

Since, in most of the transformers the temperature distribution is not uniform, the part that is operating at the highest (hot-spot) temperature normally undergoes the greatest deterioration. Hot-spot temperature of winding needs to be monitored continuously in order to not exceed the flashover value of transformer insulation oil. The first step in monitoring the insulation age is the calculation of hot-spot temperature of the transformer.

A simplified representation of the variation of temperature inside the transformer is shown in the Figure 697 (IEC 60076-7).

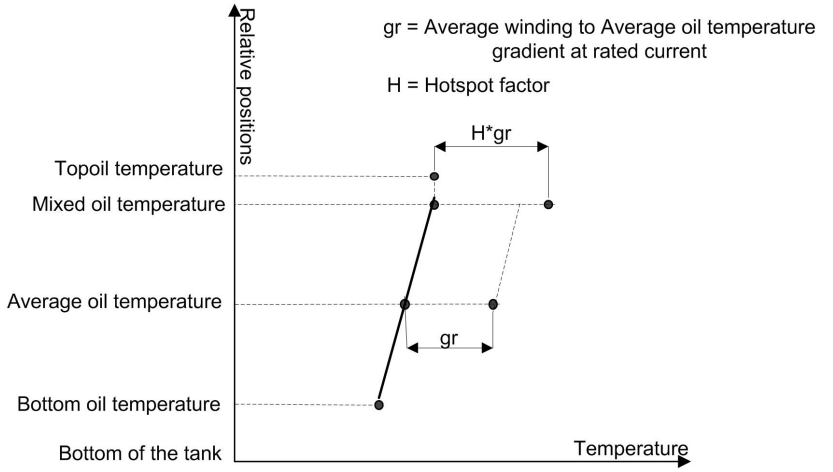



*Figure 697: Transformer thermal diagram*

The winding hot-spot temperature depends on the load losses, type of cooling and ambient temperature. Usually the conductors near the top of the winding experience the maximum leakage field and the highest surrounding oil temperature (due to convection effect). It is natural to consider that the top conductors contain the hottest spot. Measurements have shown that the hottest spot can also be moved to lower conductors.

Direct measurement of hot-spot temperature with fiber optic probes became available in mid 1980s. Experience has shown that there might be gradients of more than 10 °C between different locations at the top of a transformer winding. It is unlikely that the insertion of one to three sensors detect the real hot-spot. Direct measurement of hot-spot temperature is difficult and it is calculated using the empirical formulae.

The hot-spot temperature calculation is dependent upon the thermal properties of the winding material, cooling oil and the cooling mode of the transformer. The thermal

model may also differ from IEC and IEEE markets, though the underlying principle of temperature calculation remains the same. The transformer constants are decided based on a user defined setting to select the preferred type of thermal model (IEC, IEEE or Manual).

For most transformers in service, the top oil temperature inside a winding is difficult to measure. On the other hand, the top oil temperature at the top of the tank is well known, either by measurement or by calculation. The winding hot-spot temperature rise above the top oil temperature is calculated. By adding this value to the measured or calculated top oil temperature, the winding hot-spot temperature is obtained. A pictorial representation of the location of top oil temperature sensor is shown in the Figure 698.

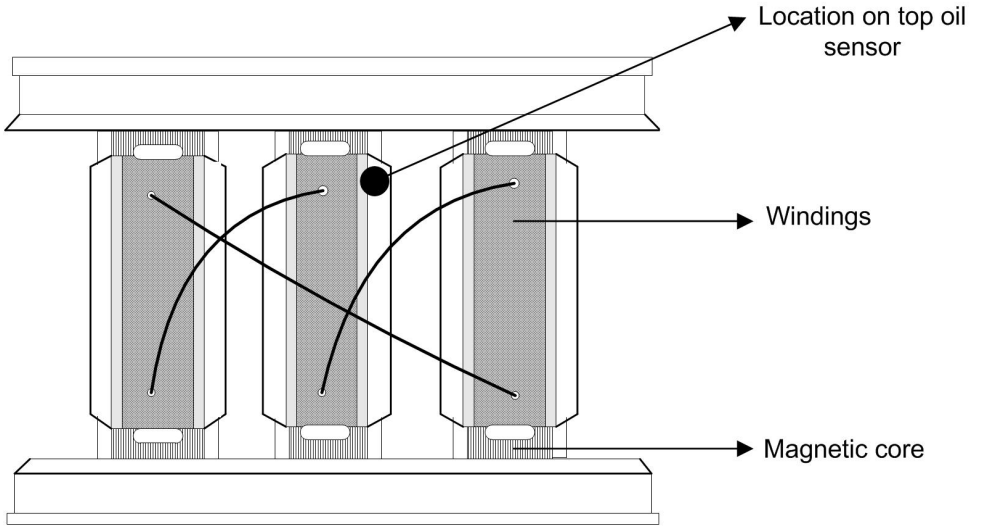



*Figure 698: Location of top oil sensor*

WARNING and ALARM signals are provided for the operator to take corrective actions to reduce the temperature inside the transformer. Corrective actions include switching on coolers, reducing the load on the transformers and so on.

Normally, warning level is set to indicate if the temperature is nearing the limiting value and alarm is generated when the limiting condition has reached. Hence, alarm level is set at a higher value than the warning level.

The function only calculates hot-spot temperature based on the load factor of the winding. This function does not calculate the rise in actual hot-spot temperature, which occurs due to oil flow blockage or malfunction of cooler groups. That said, the set oil and winding properties can be updated manually to indicate this change.

Based on the calculated hot-spot temperature, the function calculates the relative ageing, that is, the accelerated or decelerated ageing of the insulation at current load compared to its ageing at rated load. The variation of ageing acceleration factor with

respect to the hot-spot temperature for a sample transformer is plotted in Figure 699. Here, 110 °C is taken as the rated hot-spot temperature at which point an ageing acceleration factor of 1.0 is achieved.

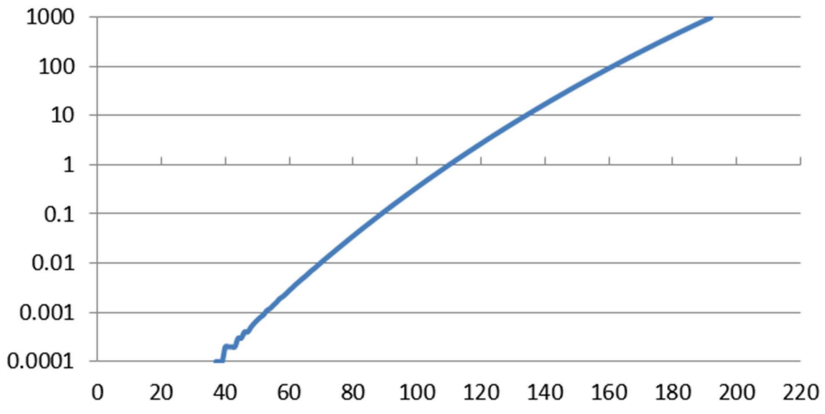



*Figure 699: Variation of insulation ageing factor with hot-spot temperature (Graph produced using values from Table 11 of IEEE Std. C57.91-1995)*

The variation of insulation life with respect to the hot-spot temperature depends upon the type of insulation paper used. Thermally upgraded insulation paper neutralizes the production of acids caused by the hydrolysis of the material over the lifetime of the transformer and slows down insulation ageing when compared to the normal insulation paper (IEC 60076-7). The proper selection of insulation paper type is needed for better accuracy of loss of life calculation.

In certain cases, it is necessary to monitor the loading of the transformer over a defined time period. For example, during a planned overloading of a transformer for a period of one month. In such cases it is important to know the ageing rate during that period of overload rather than the overall loss of life transformer. Hence, an additional output on average ageing rate over a settable average ageing period is provided in the function.

The function can be applied for new transformers and also for transformers already in service using the *Initial loss of life* setting.

## 7.2.7 Signals

*Table 1202: HSARSPTR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| TOIL_TEMP | FLOAT32 | 0 | Measured top oil temperature |
| AMB_TEMP | FLOAT32 | 0 | Measured ambient temperature |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RESET | BOOLEAN | 0=False | Reset loss of life calculation |
| RST_AVGAGING | BOOLEAN | 0=False | Reset average ageing rate calculation |

*Table 1203: HSARSPTR Output signals*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm signal |
| WARNING | BOOLEAN | Warning signal |
| ALM_AGE_RATE | BOOLEAN | Alarm signal for Avg ageing rate over set time period |
| TOPOIL_TEMP | FLOAT32 | Calculated value of top oil temperature |
| HOTSPOT_TEMP | FLOAT32 | Calculated value of hot spot temperature |

## 7.2.8 Settings

*Table 1204: HSARSPTR Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Cooling mode | 1=ONAN<br>2=ONAF<br>3=OFAF<br>4=ODAF | | | 1=ONAN | Transformer cooling method |
| Alarm level | 50.0...350.0 | °C | 0.1 | 120.0 | Alarm level for hotspot temperature |
| Warning level | 50.0...350.0 | °C | 0.1 | 100.0 | Warning level for hotspot temperature |
| Alarm delay time | 0...3600000 | ms | 10 | 10000 | Time delay for hotspot temperature alarm |
| Warning delay time | 0...3600000 | ms | 10 | 10000 | Time delay for hotspot temperature warning |
| Average ambient Tmp | -20.00...70.00 | °C | 0.01 | 20.00 | Average ambient temperature |

*Table 1205: HSARSPTR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Transformer type | 1=Single phase<br>2=Three phase | | | 2=Three phase | Number of phases of the transformer |
| Parameter Sel method | 1=IEC<br>2=IEEE<br>3=Manual | | | 1=IEC | Transformer parameter selection method |
| Ageing rate method | 1=IEC<br>2=IEEE | | | 1=IEC | Ageing rate calculation method |
| Insul paper type | 1=Normal<br>2=Upgraded | | | 1=Normal | Type of transformer paper insulation |
| Transformer rating | 1.00...500.00 | MVA | 0.01 | 2.50 | Rating of the transformer |
| Initial loss of life | 0...1000 | | 1 | 0 | Initial value for winding insulation loss of life in months |
| Hotspot Tmp rise | 50.0...350.0 | °C | 0.1 | 80.0 | Hotspot temperature rise over ambient at rated load |
| Top oil Tmp rise | 50.0...350.0 | °C | 0.1 | 65.0 | Top oil temperature rise over ambient at rated load |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current type test | 0.01...2.00 | xIn | 0.01 | 1.00 | Current applied in type testing to reach rated hotspot Temp |
| Ratio of losses | 0.1...500000.0 | | 0.1 | 25.0 | Ratio of load losses at rated load to no-load losses |
| CT ratio correction | 0.200...5.000 | | 0.001 | 0.200 | Current transformer ratio correction factor |
| Oil exponent | 0.10...10.00 | | 0.01 | 0.10 | User defined value for oil exponent |
| Winding exponent | 0.10...10.00 | | 0.01 | 0.10 | User defined value for winding exponent |
| Constant K11 | 0.01...10.00 | | 0.01 | 1.00 | User defined value of thermal model constant K11 |
| Constant K21 | 0.01...10.00 | | 0.01 | 1.00 | User defined value of thermal model constant K21 |
| Constant K22 | 0.01...10.00 | | 0.01 | 2.00 | User defined value of thermal model constant K22 |
| Oil time constant | 1...20000 | s | 1 | 10800 | Oil time constant in seconds |
| Winding Tm constant | 1...20000 | s | 1 | 240 | Winding time constant in seconds |
| Alarm level Age Rte | 0.00...100.00 | | 1 | 1.00 | Alarm level for average ageing rate over set time period |

*Table 1206: HSARSPTR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Avg Age rate period | 4=DAY<br>5=WEEK<br>6=MONTH<br>7=YEAR | | | 6=MONTH | Time period over which average ageing rate is calculated |

## 7.2.9 Monitored data

*Table 1207: HSARSPTR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| HS_TOIL_GRA | FLOAT32 | 0...1000 | | Rated hot spot to top oil temperature gradient |
| LD_RSV_WRN_PCT | FLOAT32 | 0.0...1000.0 | % | Percentage load reserve for reaching warning condition |
| LD_RSV_ALM_PCT | FLOAT32 | 0.0...1000.0 | % | Percentage load reserve for reaching alarm condition |
| AGEING_RATE | FLOAT32 | 0.00...50.00 | | Momentary relative ageing rate |
| LOSS_OF_LIFE | FLOAT32 | 0...100 | | Loss of life in years |
| AVG_AGE_RATE | FLOAT32 | 0...100 | | Average ageing rate over set time period |
| HSARSPTR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 7.2.10 Technical data

*Table 1208: HSARSPTR technical data*

| Characteristic | Value |
|---|---|
| Warning/alarm time accuracy | ±1.0% of the set value or ±0.50 s |

# Section 8 Measurement functions

## 8.1 Basic measurements

### 8.1.1 Functions

The three-phase current measurement function CMMXU is used for monitoring and metering the phase currents of the power system.

The three-phase voltage measurement function VMMXU is used for monitoring and metering the phase-to-phase voltages of the power system. The phase-to-earth voltages are also available in VMMXU.

Single-phase voltage measurement function VAMMXU is used for monitoring and metering the single-phase voltage of the power system.

The residual current measurement function RESCMMXU is used for monitoring and metering the residual current of the power system.

The residual voltage measurement function RESVMMXU is used for monitoring and metering the residual voltage of the power system.

The frequency measurement function FMMXU is used for monitoring and metering the frequency of the power system.

The sequence current measurement CSMSQI is used for monitoring and metering the phase sequence currents.

The sequence voltage measurement VSMSQI is used for monitoring and metering the phase sequence voltages.

The frequency measurement FMMXU is used for monitoring and metering the power system frequency.

The three-phase power and energy measurement PEMMXU is used for monitoring and metering active power (P), reactive power (Q), apparent power (S) and power factor (PF) and for calculating the accumulated energy separately as forward active, reversed active, forward reactive and reversed reactive. PEMMXU calculates these quantities using the fundamental frequency phasors, that is, the DFT values of the measured phase current and phase voltage signals.

The information of the measured quantity is available for the operator both locally in LHMI or WHMI and remotely to a network control center with communication.

If the measured data in LHMI or WHMI is within parentheses, there are some problems to express the data.

## 8.1.2 Measurement functionality

The functions can be enabled or disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

Some of the measurement functions operate on two alternative measurement modes: "DFT" and "RMS". The measurement mode is selected with the *X Measurement mode* setting. Depending on the measuring function if the measurement mode cannot be selected, the measuring mode is "DFT".

### Demand value calculation

The demand values are calculated separately for each measurement function and per phase when applicable. The available measurement modes are "Linear" and "Logarithmic". The "Logarithmic" measurement mode is only effective for phase current and residual current demand value calculations. The demand value calculation mode is selected with the setting parameter **Configuration/Measurements/A demand Av mode**. The time interval for all demand value calculations is selected with the setting parameter **Configuration/Measurements/Demand interval**.

If the *Demand interval* setting is set to "15 minutes", for example, the demand values are updated every quarter of an hour. The demand time interval is synchronized to the real-time clock of the protection relay. When the demand time interval or calculation mode is changed, it initializes the demand value calculation. For the very first demand value calculation interval, the values are stated as invalid until the first refresh is available.

The "Linear" calculation mode uses the periodic sliding average calculation of the measured signal over the demand time interval. A new demand value is obtained once in a minute, indicating the analog signal demand over the demand time interval proceeding the update time. The actual rolling demand values are stored in the memory until the value is updated at the end of the next time interval.

The "Logarithmic" calculation mode uses the periodic calculation using a log10 function over the demand time interval to replicate thermal demand ammeters. The logarithmic demand calculates a snapshot of the analog signal every 1/15 x demand time interval.

Each measurement function has its own recorded data values. In protection relay, these are found in **Monitoring/Recorded data/Measurements**. In the technical manual these are listed in the monitored data section of each measurement function. These values are periodically updated with the maximum and minimum demand values. The time stamps are provided for both values.

*Reset of Recorded data* initializes a present demand value to the minimum and maximum demand values.

## Value reporting

The measurement functions are capable of reporting new values for network control center (SCADA system) based on various functions.

- Zero-point clamping
- Deadband supervision
- Limit value supervision

In the three-phase voltage measurement function VMMXU the supervision functions are based on the phase-to-phase voltages. However, the phase-to-earth voltage values are also reported with the phase-to-phase voltages.

GOOSE is an event based protocol service. Analog GOOSE uses the same event generation functions as vertical SCADA communication for updating the measurement values. Update interval of 500 ms is used for data that do not have zero-point clamping, deadband supervision or limit value supervision.

## Zero-point clamping

A measured value under the zero-point clamping limit is forced to zero. This allows the noise in the input signal to be ignored. The active clamping function forces both the actual measurement value and the angle value of the measured signal to zero. In the three-phase or sequence measuring functions, each phase or sequence component has a separate zero-point clamping function. The zero-value detection operates so that once the measured value exceeds or falls below the value of the zero-clamping limit, new values are reported.

*Table 1209: Zero-point clamping limits*

| Function | Zero-clamping limit |
|---|---|
| Three-phase current measurement (CMMXU) | 1% of nominal (In) |
| Three-phase voltage measurement (VMMXU) | 1% of nominal (Un) |
| Residual current measurement (RESCMMXU) | 1% of nominal (In) |
| Residual voltage measurement (RESVMMXU) | 1% of nominal (Un) |
| Phase sequence current measurement (CSMSQI) | 1% of the nominal (In) |
| Phase sequence voltage measurement (VSMSQI) | 1% of the nominal (Un) |
| Three-phase power and energy measurement (PEMMXU) | 1.5% of the nominal (Sn) |

When the frequency measurement function FMMXU is unable to measure the network frequency in the undervoltage situation, the

measured values are set to the nominal and also the quality information of the data set accordingly. The undervoltage limit is fixed to 10 percent of the nominal for the frequency measurement.

## Limit value supervision

The limit value supervision function indicates whether the measured value of X_INST exceeds or falls below the set limits. The measured value has the corresponding range information X_RANGE and has a value in the range of 0 to 4:

- 0: "normal"
- 1: "high"
- 2: "low"
- 3: "high-high"
- 4: "low-low"

The range information changes and the new values are reported.

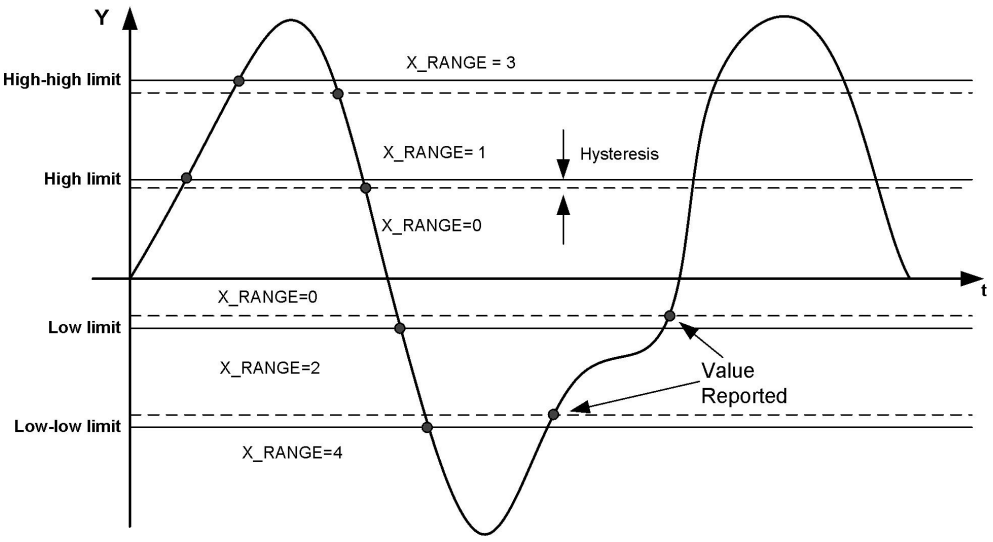



*Figure 700: Presentation of operating limits*

The range information can also be decoded into boolean output signals on some of the measuring functions and the number of phases required to exceed or undershoot the limit before activating the outputs and can be set with the *Num of phases* setting in the three-phase measurement functions CMMXU and VMMXU. The limit supervision boolean alarm and warning outputs can be blocked.

*Table 1210: Settings for limit value supervision*

| Function | Settings for limit value supervision | |
|---|---|---|
| Three-phase current measurement (CMMXU) | High limit | A high limit |
| | Low limit | A low limit |
| | High-high limit | A high high limit |
| | Low-low limit | A low low limit |
| Three-phase voltage measurement (VMMXU) | High limit | V high limit |
| | Low limit | V low limit |
| | High-high limit | V high high limit |
| | Low-low limit | V low low limit |
| Single-phase voltage measurement (VAMMXU) | High limit | V high limit |
| | Low limit | V low limit |
| | High-high limit | V high high limit |
| | Low-low limit | V low low limit |
| Residual current measurement (RESCMMXU) | High limit | A high limit res |
| | Low limit | - |
| | High-high limit | A Hi high limit res |
| | Low-low limit | - |
| Frequency measurement (FMMXU) | High limit | F high limit |
| | Low limit | F low limit |
| | High-high limit | F high high limit |
| | Low-low limit | F low low limit |
| Residual voltage measurement (RESVMMXU) | High limit | V high limit res |
| | Low limit | - |
| | High-high limit | V Hi high limit res |
| | Low-low limit | - |
| Phase sequence current measurement (CSMSQI) | High limit | Ps Seq A high limit, Ng Seq A high limit, Zro A high limit |
| | Low limit | Ps Seq A low limit, Ng Seq A low limit, Zro A low limit |
| | High-high limit | Ps Seq A Hi high Lim, Ng Seq A Hi high Lim, Zro A Hi high Lim |
| | Low-low limit | Ps Seq A low low Lim, Ng Seq A low low Lim, Zro A low low Lim |

Table continues on next page

| Function | Settings for limit value supervision | |
|---|---|---|
| Phase sequence voltage measurement (VSMSQI) | High limit | Ps Seq V high limit, Ng Seq V high limit, Zro V high limit |
| | Low limit | Ps Seq V low limit, Ng Seq V low limit, Zro V low limit |
| | High-high limit | Ps Seq V Hi high Lim, Ng Seq V Hi high Lim, Zro V Hi high Lim |
| | Low-low limit | Ps Seq V low low Lim, Ng Seq V low low Lim, Zro V low low Lim |
| Three-phase power and energy measurement (PEMMXU) | High limit | - |
| | Low limit | - |
| | High-high limit | - |
| | Low-low limit | - |

## Deadband supervision

The deadband supervision function reports the measured value according to integrated changes over a time period. In Figure 701 the values are reported at points Y1, Y2, Y3 and Y4. There is no value report at the end of |A3 + A4 + A5 + A6 + A7| because the positive and negative areas counteract each other. The integrated changes, |A3 + A4 + A5 + A6 + A7|, equal approximately zero.

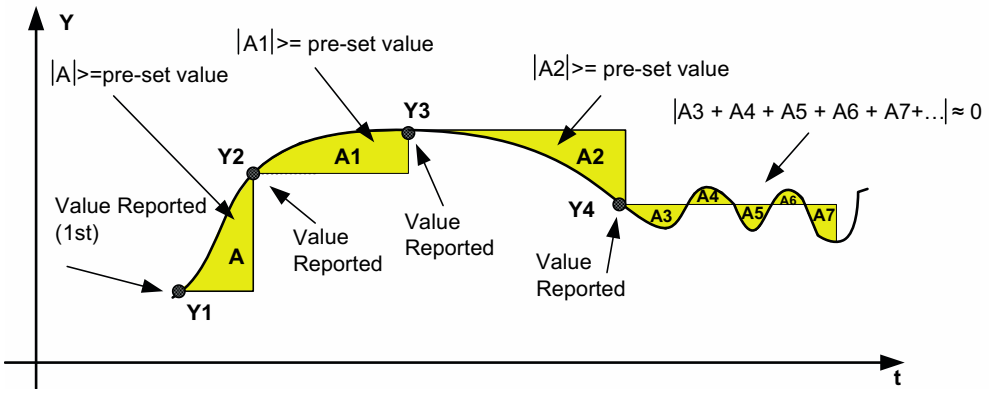



*Figure 701: Integral deadband supervision*

The deadband value used in the integral calculation is configured with the *X deadband* setting. The value represents the percentage of the difference between the maximum and minimum limit in the units of 0.001 percent x seconds.

The reporting delay of the integral algorithms in seconds is calculated with the formula:

$$t(s) = \frac{(\max - \min) \times deadband / 1000}{|\Delta Y| \times 100\%}$$

(Equation 303)

Example for CMMXU:

A deadband = 2500 (2.5% of the total measuring range of 40)

I_INST_A = I_DB_A = 0.30

If I_INST_A changes to 0.40, the reporting delay is:

$$t(s) = \frac{(40-0)\times 2500/1000}{|0.40-0.30|\times 100\%} = 10s$$

*Table 1211: Parameters for deadband calculation*

| Function | Settings | Maximum/minimum (=range) |
|---|---|---|
| Three-phase current measurement (CMMXU) | A deadband | 40/0 (=40xIn) |
| Three-phase voltage measurement (VMMXU) | V Deadband | 4/0 (=4xUn) |
| Single-phase voltage measurement (VAMMXU) | V Deadband | 4/0 (=4xUn) |
| Residual current measurement (RESCMMXU) | A deadband res | 40/0 (=40xIn) |
| Residual voltage measurement (RESVMMXU) | V deadband res | 4/0 (=4xUn) |
| Frequency measurement (FMMXU) | F deadband | 75/35 (=40 Hz) |
| Phase sequence current measurement (CSMSQI) | Ps Seq A deadband, Ng Seq A deadband, Zro A deadband | 40/0 (=40xIn) |
| Phase sequence voltage measurement (VSMSQI) | Ps Seq V deadband, Ng Seq V deadband, Zro V deadband | 4/0 (=4xUn) |
| Three-phase power and energy measurement (PEMMXU) | - | |

In the three-phase power and energy measurement function PEMMXU, the deadband supervision is done separately for the apparent power S, and the power factor PF. These deadbands are fixed and linear in the following way:

- A change of 10% x Sn is reported in one second.
- An absolute change of 0.1 in the PF value (-1..0..+1) is reported in one second.

All the power measurement-related values (P, Q, S and PF) are reported simultaneously each time either S or PF causes a reporting.

## Power and energy calculation

The three-phase power is calculated from the selected voltage and current measurements as described in Table 1212. The setting *Measurement mode* determines which voltage and current measurements are used.

It is also possible to use positive-sequence components for calculating the apparent power, which makes the determination of power insensitive to any asymmetry in currents or voltages.

*Table 1212: Measured apparent power*

| *Measurement mode* setting values | Power calculation |
|---|---|
| PhsA, PhsB, PhsC | $\overline{S} = \overline{U_A} \cdot \overline{I_A}^* + \overline{U_B} \cdot \overline{I_B}^* + \overline{U_C} \cdot \overline{I_C}^*$ (Equation 304) |
| Arone | $\overline{S} = \overline{U_{AB}} \cdot \overline{I_A}^* - \overline{U_{BC}} \cdot \overline{I_C}^*$ (Equation 305) |
| Pos Seq | $\overline{S} = 3 \cdot \overline{U_1} \cdot \overline{I_1}^*$ (Equation 306) |
| PhsAB | $\overline{S} = \overline{U_{AB}} \cdot \left( \overline{I_A}^* - \overline{I_B}^* \right)$ (Equation 307) |
| PhsBC | $\overline{S} = \overline{U_{BC}} \cdot \left( \overline{I_B}^* - \overline{I_C}^* \right)$ (Equation 308) |
| PhsCA | $\overline{S} = \overline{U_{CA}} \cdot \left( \overline{I_C}^* - \overline{I_A}^* \right)$ (Equation 309) |
| PhsA | $\overline{S} = 3 \cdot \overline{U_A} \cdot \overline{I_A}^*$ (Equation 310) |
| PhsB | $\overline{S} = 3 \cdot \overline{U_B} \cdot \overline{I_B}^*$ (Equation 311) |
| PhsC | $\overline{S} = 3 \cdot \overline{U_C} \cdot \overline{I_C}^*$ (Equation 312) |

Depending upon the set *Measurement mode*, the Power and energy calculation module calculates active power, reactive power and apparent power values from the available set of measurements.

$$P = \mathrm{Re}(\overline{S})$$

(Equation 313)

$$Q = \mathrm{Im}(\overline{S})$$

(Equation 314)

$$S = \left|\overline{S}\right| = \sqrt{P^2 + Q^2}$$

(Equation 315)

$$Cos\varphi = \frac{P}{S}$$

(Equation 316)

The calculated powers are available as function outputs S_INST, P_INST, Q_INST and the power factor angle as PF_INST.

Depending on the unit multiplier selected with *Power unit Mult*, the calculated power values in the monitored data and measurement view are presented in units of kVA/kW/kVAr or in units of MVA/MW/MVAr.

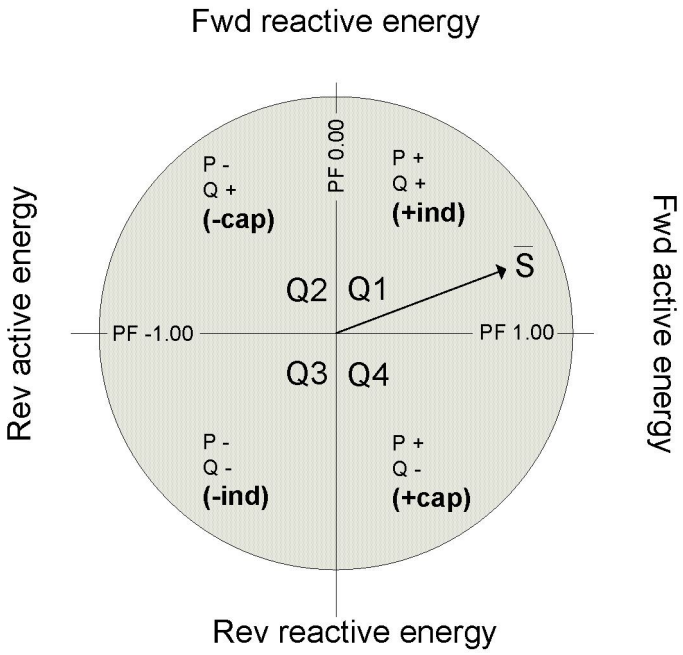



*Figure 702: Complex power and power quadrants*

*Table 1213: Power quadrants*

| Quadrant | Current | P | Q | PF | Power |
|---|---|---|---|---|---|
| Q1 | Lagging | + | + | 0…+1.00 | +ind |
| Q2 | Lagging | - | + | 0…-1.00 | -cap |
| Q3 | Leading | - | - | 0…-1.00 | -ind |
| Q4 | Leading | + | - | 0…+1.00 | +cap |

The active power P direction can be selected between forward and reverse with *Active power Dir* and correspondingly the reactive power Q direction can be selected with *Reactive power Dir*. This affects also the accumulated energy directions.

The accumulated energy is calculated separately as forward active (EA_FWD_ACM), reverse active (EA_RV_ACM), forward reactive (ER_FWD_ACM) and reverse reactive (ER_RV_ACM). Depending on the value of the unit multiplier selected with *Energy unit Mult*, the calculated power values are presented in units of kWh/kVArh or in units of MWh/MVArh.

When the energy counter reaches its defined maximum value, the counter value is reset and restarted from zero. Changing the value of the *Energy unit Mult* setting resets the accumulated energy values to the initial values, that is, EA_FWD_ACM to *Forward Wh Initial*, EA_RV_ACM to *Reverse Wh Initial*, ER_FWD_ACM to *Forward VArh Initial* and ER_RV_ACM to *Reverse VArh Initial*. It is also possible to reset the accumulated energy to initial values through a parameter or with the RSTACM input.

### Sequence components

The phase-sequence components are calculated using the phase currents and phase voltages. More information on calculating the phase-sequence components can be found in Calculated measurements in this manual.

## 8.1.3 Measurement function applications

The measurement functions are used for power system measurement, supervision and reporting to LHMI, a monitoring tool within PCM600, or to the station level, for example, with IEC 61850. The possibility to continuously monitor the measured values of active power, reactive power, currents, voltages, power factors and so on, is vital for efficient production, transmission, and distribution of electrical energy. It provides a fast and easy overview of the present status of the power system to the system operator. Additionally, it can be used during testing and commissioning of protection and control protection relays to verify the proper operation and connection of instrument transformers, that is, the current transformers (CTs) and voltage transformers (VTs). The proper operation of the protection relay analog measurement chain can be verified during normal service by a periodic comparison of the measured value from the protection relay to other independent meters.

When the zero signal is measured, the noise in the input signal can still produce small measurement values. The zero point clamping function can be used to ignore the noise in the input signal and, hence, prevent the noise to be shown in the user display. The zero clamping is done for the measured analog signals and angle values.

The demand values are used to neglect sudden changes in the measured analog signals when monitoring long time values for the input signal. The demand values are linear average values of the measured signal over a settable demand interval. The demand values are calculated for the measured analog three-phase current signals.

The limit supervision indicates, if the measured signal exceeds or goes below the set limits. Depending on the measured signal type, up to two high limits and up to two low limits can be set for the limit supervision.

The deadband supervision reports a new measurement value if the input signal has gone out of the deadband state. The deadband supervision can be used in value reporting between the measurement point and operation control. When the deadband supervision is properly configured, it helps to keep the communication load to a minimum and yet measurement values are reported frequently enough.

The instantaneous measurement values of several measurement functions are available as primary values for further use in Application Configuration. The current values are in amperes while voltage values are in kilovolts and power values in kilovolt-amperes, watts or volt-amperes reactive.

## 8.1.4 Three-phase current measurement CMMXU

### 8.1.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase current measurement | CMMXU | 3I | IA, IB, IC |

### 8.1.4.2 Function block

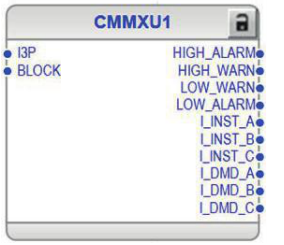



*Figure 703: Function block*

### 8.1.4.3 Functionality

The three-phase current measurement function CMMXU provides limit value supervision output (`HIGH_ALARM`, `HIGH_WARN`, `LOW_WARN`, `LOW_ALARM`). The delay of the activation and deactivation of these outputs can be controlled with setting parameters *On delay time* and *Off delay time*.

Instantaneous phase currents (`I_INST_A`, `I_INST_B` and `I_INST_C`) are provided as outputs in amperes. These can be used in the application configuration.

Phase current demand values (`I_DMD_A`, `I_DMD_B` and `I_DMD_C`) are provided as outputs in amperes. These outputs are dedicated for Load profile recorder (LDPRLRC).

### 8.1.4.4 Analog channel configuration

CMMXU has one analog group input which must be properly configured.

*Table 1214: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.4.5 Signals

*Table 1215: CMMXU Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

*Table 1216: CMMXU Output signals*

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | High alarm |
| HIGH_WARN | BOOLEAN | High warning |
| LOW_WARN | BOOLEAN | Low warning |
| LOW_ALARM | BOOLEAN | Low alarm |
| I_INST_A | FLOAT32 | Phase A current instantaneous value amplitude in amperes |
| I_INST_B | FLOAT32 | Phase B current instantaneous value amplitude in amperes |
| I_INST_C | FLOAT32 | Phase C current instantaneous value amplitude in amperes |
| I_DMD_A | FLOAT32 | Demand value of IL1 current |
| I_DMD_B | FLOAT32 | Demand value of IL2 current |
| I_DMD_C | FLOAT32 | Demand value of IL3 current |

### 8.1.4.6 Settings

*Table 1217: CMMXU Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required by limit supervision |
| A high high limit | 0.00...40.00 | xIn | 1 | 1.40 | High alarm current limit |
| A high limit | 0.00...40.00 | xIn | 1 | 1.20 | High warning current limit |
| A low limit | 0.00...40.00 | xIn | 1 | 0.00 | Low warning current limit |
| A low low limit | 0.00...40.00 | xIn | 1 | 0.00 | Low alarm current limit |
| A deadband | 100...100000 | | 1 | 2500 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |

*Table 1218: CMMXU Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT | | | 2=DFT | Selects used measurement mode |
| On delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs |
| Off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs |

### 8.1.4.7 Monitored data

*Table 1219: CMMXU Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| IL1-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured current amplitude phase A |
| IL2-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured current amplitude phase B |
| IL3-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured current amplitude phase C |
| Max demand IL1 | FLOAT32 | 0.00...40.00 | xIn | Maximum demand for Phase A |
| Max demand IL2 | FLOAT32 | 0.00...40.00 | xIn | Maximum demand for Phase B |
| Max demand IL3 | FLOAT32 | 0.00...40.00 | xIn | Maximum demand for Phase C |
| Min demand IL1 | FLOAT32 | 0.00...40.00 | xIn | Minimum demand for Phase A |
| Min demand IL2 | FLOAT32 | 0.00...40.00 | xIn | Minimum demand for Phase B |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Min demand IL3 | FLOAT32 | 0.00...40.00 | xIn | Minimum demand for Phase C |
| Time max demand IL1 | Timestamp | | | Time of maximum demand phase A |
| Time max demand IL2 | Timestamp | | | Time of maximum demand phase B |
| Time max demand IL3 | Timestamp | | | Time of maximum demand phase C |
| Time min demand IL1 | Timestamp | | | Time of minimum demand phase A |
| Time min demand IL2 | Timestamp | | | Time of minimum demand phase B |
| Time min demand IL3 | Timestamp | | | Time of minimum demand phase C |
| BLOCK | BOOLEAN | 0=False<br>1=True | | Block signal for all binary outputs |
| HIGH_ALARM | BOOLEAN | 0=False<br>1=True | | High alarm |
| HIGH_WARN | BOOLEAN | 0=False<br>1=True | | High warning |
| LOW_WARN | BOOLEAN | 0=False<br>1=True | | Low warning |
| LOW_ALARM | BOOLEAN | 0=False<br>1=True | | Low alarm |
| I_INST_A | FLOAT32 | 0.00...40.00 | xIn | IL1 Amplitude, magnitude of instantaneous value |
| I_ANGL_A | FLOAT32 | -180.00...180.00 | deg | IL1 current angle |
| I_DB_A | FLOAT32 | 0.00...40.00 | xIn | IL1 Amplitude, magnitude of reported value |
| I_DMD_A | FLOAT32 | 0.00...40.00 | xIn | Demand value of IL1 current |
| I_RANGE_A | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | IL1 Amplitude range |
| I_INST_B | FLOAT32 | 0.00...40.00 | xIn | IL2 Amplitude, magnitude of instantaneous value |
| I_ANGL_B | FLOAT32 | -180.00...180.00 | deg | IL2 current angle |
| I_DB_B | FLOAT32 | 0.00...40.00 | xIn | IL2 Amplitude, magnitude of reported value |
| I_DMD_B | FLOAT32 | 0.00...40.00 | xIn | Demand value of IL2 current |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_RANGE_B | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | IL2 Amplitude range |
| I_INST_C | FLOAT32 | 0.00...40.00 | xIn | IL3 Amplitude, magnitude of instantaneous value |
| I_ANGL_C | FLOAT32 | -180.00...180.00 | deg | IL3 current angle |
| I_DB_C | FLOAT32 | 0.00...40.00 | xIn | IL3 Amplitude, magnitude of reported value |
| I_DMD_C | FLOAT32 | 0.00...40.00 | xIn | Demand value of IL3 current |
| I_RANGE_C | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | IL3 Amplitude range |

### 8.1.4.8 Technical data

*Table 1220: CMMXU Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±0.5% or ±0.002 × $I_n$<br>(at currents in the range of 0.01...4.00 × $I_n$) |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

## 8.1.5 Three-phase voltage measurement VMMXU

### 8.1.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase voltage measurement | VMMXU | 3U | VA, VB, VC |

### 8.1.5.2 Function block

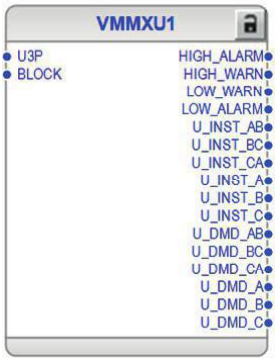



*Figure 704: Function block*

### 8.1.5.3 Functionality

The three-phase voltage measurement function VMMXU provides limit value supervision output (HIGH_ALARM, HIGH_WARN, LOW_WARN, LOW_ALARM). Setting parameters *On delay time* and *Off delay time* are used for controlling the activation and the deactivation of alarm and warning outputs.

Instantaneous phase-to-phase and phase-to-earth voltages in volts are available for application configurations through outputs U_INST_AB, U_INST_BC and U_INST_CA and U_INST_A, U_INST_B and U_INST_C, respectively.

Phase current demand values in volts are for connecting to Load profile recorder (LDPRLRC) through outputs I_DMD_A, I_DMD_B and I_DMD_C.

### 8.1.5.4 Analog channel configuration

VMMXU has one analog group input which must be properly configured.

*Table 1221: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1222: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that at least one voltage channel is connected if *Num of start phases* is set to "1 out of 3". |
| | The function requires that at least two voltage channels are connected if *Num of start phases* is set to "2 out of 3". |
| | The function requires that all three voltage channels are connected if *Num of start phases* is set to "3 out of 3". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.5.5 Signals

*Table 1223: VMMXU Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

*Table 1224: VMMXU Output signals*

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | High alarm |
| HIGH_WARN | BOOLEAN | High warning |
| LOW_WARN | BOOLEAN | Low warning |
| LOW_ALARM | BOOLEAN | Low alarm |
| U_INST_AB | FLOAT32 | Phase AB voltage instantaneous value amplitude in kV |
| U_INST_BC | FLOAT32 | Phase BC voltage instantaneous value amplitude in kV |
| U_INST_CA | FLOAT32 | Phase CA voltage instantaneous value amplitude in kV |
| U_INST_A | FLOAT32 | Phase A voltage instantaneous value amplitude in kV |
| U_INST_B | FLOAT32 | Phase B voltage instantaneous value amplitude in kV |
| U_INST_C | FLOAT32 | Phase C voltage instantaneous value amplitude in kV |
| U_DMD_AB | FLOAT32 | Demand value of U12 voltage |
| U_DMD_BC | FLOAT32 | Demand value of U23 voltage |

Table continues on next page

| Name | Type | Description |
|---|---|---|
| U_DMD_CA | FLOAT32 | Demand value of U31 voltage |
| U_DMD_A | FLOAT32 | Demand value of UL1 voltage |
| U_DMD_B | FLOAT32 | Demand value of UL2 voltage |
| U_DMD_C | FLOAT32 | Demand value of UL3 voltage |

### 8.1.5.6 Settings

*Table 1225: VMMXU Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required by limit supervision |
| V high high limit | 0.00...4.00 | xUn | 1 | 1.40 | High alarm voltage limit |
| V high limit | 0.00...4.00 | xUn | 1 | 1.20 | High warning voltage limit |
| V low limit | 0.00...4.00 | xUn | 1 | 0.00 | Low warning voltage limit |
| V low low limit | 0.00...4.00 | xUn | 1 | 0.00 | Low alarm voltage limit |
| V deadband | 100...100000 | | 1 | 10000 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |

*Table 1226: VMMXU Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT | | | 2=DFT | Selects used measurement mode |
| On delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs |
| Off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs |

### 8.1.5.7 Monitored data

*Table 1227: VMMXU Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U12-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured phase to phase voltage amplitude phase AB |
| U23-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured phase to phase voltage amplitude phase BC |
| U31-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured phase to phase voltage amplitude phase CA |
| Table continues on next page | | | | |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| UL1-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to earth voltage amplitude phase A |
| UL2-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to earth voltage amplitude phase B |
| UL3-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to earth voltage amplitude phase C |
| BLOCK | BOOLEAN | 0=False<br>1=True | | Block signal for all binary outputs |
| HIGH_ALARM | BOOLEAN | 0=False<br>1=True | | High alarm |
| HIGH_WARN | BOOLEAN | 0=False<br>1=True | | High warning |
| LOW_WARN | BOOLEAN | 0=False<br>1=True | | Low warning |
| LOW_ALARM | BOOLEAN | 0=False<br>1=True | | Low alarm |
| U_INST_AB | FLOAT32 | 0.00...4.00 | xUn | U12 amplitude, magnitude of instantaneous value |
| U_ANGL_AB | FLOAT32 | -180.00...180.00 | deg | U12 angle |
| U_DB_AB | FLOAT32 | 0.00...4.00 | xUn | U12 amplitude, magnitude of reported value |
| U_DMD_AB | FLOAT32 | 0.00...4.00 | xUn | Demand value of U12 voltage |
| U_RANGE_AB | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | U12 amplitude range |
| U_INST_BC | FLOAT32 | 0.00...4.00 | xUn | U23 amplitude, magnitude of instantaneous value |
| U_ANGL_BC | FLOAT32 | -180.00...180.00 | deg | U23 angle |
| U_DB_BC | FLOAT32 | 0.00...4.00 | xUn | U23 amplitude, magnitude of reported value |
| U_DMD_BC | FLOAT32 | 0.00...4.00 | xUn | Demand value of U23 voltage |
| U_RANGE_BC | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | U23 amplitude range |
| U_INST_CA | FLOAT32 | 0.00...4.00 | xUn | U31 amplitude, magnitude of instantaneous value |
| U_ANGL_CA | FLOAT32 | -180.00...180.00 | deg | U31 angle |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U_DB_CA | FLOAT32 | 0.00...4.00 | xUn | U31 amplitude, magnitude of reported value |
| U_DMD_CA | FLOAT32 | 0.00...4.00 | xUn | Demand value of U31 voltage |
| U_RANGE_CA | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | U31 amplitude range |
| U_INST_A | FLOAT32 | 0.00...5.00 | xUn | UL1 amplitude, magnitude of instantaneous value |
| U_ANGL_A | FLOAT32 | -180.00...180.00 | deg | UL1 angle |
| U_DMD_A | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL1 voltage |
| U_INST_B | FLOAT32 | 0.00...5.00 | xUn | UL2 amplitude, magnitude of instantaneous value |
| U_ANGL_B | FLOAT32 | -180.00...180.00 | deg | UL2 angle |
| U_DMD_B | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL2 voltage |
| U_INST_C | FLOAT32 | 0.00...5.00 | xUn | UL3 amplitude, magnitude of instantaneous value |
| U_ANGL_C | FLOAT32 | -180.00...180.00 | deg | UL3 angle |
| U_DMD_C | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL3 voltage |

#### 8.1.5.8 Technical data

*Table 1228: VMMXU Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz<br>At voltages in range 0.01…1.15 × $U_n$ |
| | ±0.5% or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

## 8.1.6 Single-phase voltage measurement VAMMXU

### 8.1.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Single-phase voltage measurement | VAMMXU | U_A | V_A |

### 8.1.6.2 Function block

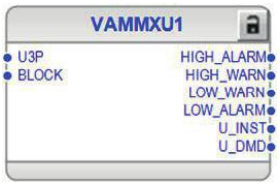



*Figure 705: Function block symbol*

### 8.1.6.3 Functionality

The single-phase voltage measurement function VAMMXU provides limit value supervision output (HIGH_ALARM, HIGH_WARN, LOW_WARN, LOW_ALARM).

Instantaneous single-phase voltage in volt is available for application configurations through output U_INST. Phase voltage demand value in volt is for connecting to Load profile recorder (LDPRLRC) through output U_DMD.

### 8.1.6.4 Analog channel configuration

VAMMXU has one analog group input which must be properly configured.

*Table 1229: Analog inputs*

| Input | Description |
|---|---|
| U3P | Voltage group signal |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1230: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that the first phase voltage U_A or U_AB is connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.6.5 Signals

*Table 1231: VAMMXU Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

*Table 1232: VAMMXU Output signals*

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | High alarm |
| HIGH_WARN | BOOLEAN | High warning |
| LOW_WARN | BOOLEAN | Low warning |
| LOW_ALARM | BOOLEAN | Low alarm |
| U_INST | FLOAT32 | Voltage instantaneous value amplitude in kV |
| U_DMD | FLOAT32-DMD | Analog output |

### 8.1.6.6 Settings

*Table 1233: VAMMXU Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| V high high limit | 0.00...4.00 | xUn | 1 | 1.40 | High alarm voltage limit |
| V high limit | 0.00...4.00 | xUn | 1 | 1.20 | High warning voltage limit |
| V low limit | 0.00...4.00 | xUn | 1 | 0.00 | Low warning voltage limit |
| V low low limit | 0.00...4.00 | xUn | 1 | 0.00 | Low alarm voltage limit |
| V deadband | 100...100000 | | 1 | 10000 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |

*Table 1234: VAMMXU Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT | | | 2=DFT | Selects used measurement mode |

### 8.1.6.7 Monitored data

*Table 1235: VAMMXU Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U12-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured phase to phase voltage amplitude phase AB |
| UL1-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to ground voltage amplitude phase A |
| BLOCK | BOOLEAN | 0=False<br>1=True | | Block signal for all binary outputs |
| HIGH_ALARM | BOOLEAN | 0=False<br>1=True | | High alarm |
| HIGH_WARN | BOOLEAN | 0=False<br>1=True | | High warning |
| LOW_WARN | BOOLEAN | 0=False<br>1=True | | Low warning |
| LOW_ALARM | BOOLEAN | 0=False<br>1=True | | Low alarm |
| U_INST_AB | FLOAT32 | 0.00...4.00 | xUn | U12 Amplitude, magnitude of instantaneous value |
| U_ANGL_AB | FLOAT32 | -180.00...180.00 | deg | U12 angle |
| U_DB_AB | FLOAT32 | 0.00...4.00 | xUn | U12 Amplitude, magnitude of reported value |
| U_DMD_AB | FLOAT32 | 0.00...4.00 | xUn | Demand value of U12 voltage |
| U_RANGE_AB | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | U12 Amplitude range |
| U_INST_A | FLOAT32 | 0.00...5.00 | xUn | UL1 Amplitude, magnitude of instantaneous value |
| U_ANGL_A | FLOAT32 | -180.00...180.00 | deg | UL1 angle |
| U_DB_A | FLOAT32 | 0.00...5.00 | xUn | UL1 Amplitude, magnitude of reported value |
| U_DMD_A | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL1 voltage |
| U_RANGE_A | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | UL1 Amplitude range |

### 8.1.6.8 Technical data

*Table 1236: VAMMXU Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz<br>At voltages in range 0.01…1.15 × $U_n$ |
| | ±0.5% or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

## 8.1.7 Residual current measurement RESCMMXU

### 8.1.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Residual current measurement | RESCMMXU | Io | IG |

### 8.1.7.2 Function block




*Figure 706: Function block*

### 8.1.7.3 Functionality

The residual current measurement function RESCMMXU provides limit value supervision output (HIGH_ALARM, HIGH_WARN). Setting parameters *On delay time* and *Off delay time* are used for controlling the activation and, respectively, the deactivation of alarm and warning outputs.

Instantaneous residual current in amperes is available for application configurations through output I_INST_RES. The residual current demand value in amperes is for connecting to Load profile recorder (LDPRLRC) through output I_DMD_RES.

### 8.1.7.4 Analog channel configuration

RESCMMXU has one analog group input which must be properly configured.

*Table 1237: Analog inputs*

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.7.5 Signals

*Table 1238: RESCMMXU Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

*Table 1239: RESCMMXU Output signals*

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | High alarm |
| HIGH_WARN | BOOLEAN | High warning |
| I_INST_RES | FLOAT32 | Residual current instantaneous value amplitude in amperes |
| I_DMD_RES | FLOAT32 | Demand value of residual current |

### 8.1.7.6 Settings

*Table 1240: RESCMMXU Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| A Hi high limit res | 0.00...40.00 | xIn | 1 | 0.20 | High alarm current limit |
| A high limit res | 0.00...40.00 | xIn | 1 | 0.05 | High warning current limit |
| A deadband res | 100...100000 | | 1 | 2500 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |

*Table 1241: RESCMMXU Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT | | | 2=DFT | Selects used measurement mode |
| On delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs |
| Off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs |

### 8.1.7.7 Monitored data

*Table 1242: RESCMMXU Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Io-A:1 | FLOAT32 | 0.00...40.00 | xIn | Residual current |
| BLOCK | BOOLEAN | 0=False<br>1=True | | Block signal for all binary outputs |
| HIGH_ALARM | BOOLEAN | 0=False<br>1=True | | High alarm |
| HIGH_WARN | BOOLEAN | 0=False<br>1=True | | High warning |
| I_INST_RES | FLOAT32 | 0.00...40.00 | xIn | Residual current Amplitude, magnitude of instantaneous value |
| I_ANGL_RES | FLOAT32 | -180.00...180.00 | deg | Residual current angle |
| I_DB_RES | FLOAT32 | 0.00...40.00 | xIn | Residual current Amplitude, magnitude of reported value |
| I_DMD_RES | FLOAT32 | 0.00...40.00 | xIn | Demand value of residual current |
| I_RANGE_RES | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Residual current Amplitude range |
| Max demand Io | FLOAT32 | 0.00...40.00 | xIn | Maximum demand for residual current |
| Min demand Io | FLOAT32 | 0.00...40.00 | xIn | Minimum demand for residual current |
| Time max demand Io | Timestamp | | | Time of maximum demand residual current |
| Time min demand Io | Timestamp | | | Time of minimum demand residual current |

### 8.1.7.8 Technical data

*Table 1243: RESCMMXU Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±0.5% or ±0.002 × $I_n$<br>(at currents in the range of 0.01...4.00 × $I_n$) |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

## 8.1.8 Residual voltage measurement RESVMMXU

### 8.1.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Residual voltage measurement | RESVMMXU | Uo | VG/VN |

### 8.1.8.2 Function block




*Figure 707: Function block*

### 8.1.8.3 Functionality

The residual voltage measurement function RESVMMXU provides limit value supervision output (HIGH_ALARM, HIGH_WARN). Setting parameters *On delay time* and *Off delay time* are used for controlling the activation and, respectively, the deactivation of alarm and warning outputs.

Instantaneous residual voltage in volt is available for application configurations through output U_INST_RES. The residual voltage demand value in volt is for connecting to Load profile recorder (LDPRLRC) through output U_DMD_RES.

### 8.1.8.4 Analog channel configuration

RESVMMXU has one analog group input which must be properly configured.

*Table 1244: Analog inputs*

| Input | Description |
|---|---|
| URES | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1245: Special conditions*

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected to calculate residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.8.5 Signals

*Table 1246: RESVMMXU Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

*Table 1247: RESVMMXU Output signals*

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | High alarm |
| HIGH_WARN | BOOLEAN | High warning |
| U_INST_RES | FLOAT32 | Residual voltage instantaneous value amplitude in kV |
| U_DMD_RES | FLOAT32 | Demand value of residual voltage |

### 8.1.8.6 Settings

*Table 1248: RESVMMXU Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| V Hi high limit res | 0.00...4.00 | xUn | 1 | 0.20 | High alarm voltage limit |
| V high limit res | 0.00...4.00 | xUn | 1 | 0.05 | High warning voltage limit |
| V deadband res | 100...100000 | | 1 | 10000 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |

*Table 1249: RESVMMXU Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT | | | 2=DFT | Selects used measurement mode |
| On delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs |
| Off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs |

### 8.1.8.7 Monitored data

*Table 1250: RESVMMXU Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Uo-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Residual voltage |
| BLOCK | BOOLEAN | 0=False<br>1=True | | Block signal for all binary outputs |
| HIGH_ALARM | BOOLEAN | 0=False<br>1=True | | High alarm |
| HIGH_WARN | BOOLEAN | 0=False<br>1=True | | High warning |
| U_INST_RES | FLOAT32 | 0.00...4.00 | xUn | Residual voltage Amplitude, magnitude of instantaneous value |
| U_ANGL_RES | FLOAT32 | -180.00...180.00 | deg | Residual voltage angle |
| U_DB_RES | FLOAT32 | 0.00...4.00 | xUn | Residual voltage Amplitude, magnitude of reported value |
| U_DMD_RES | FLOAT32 | 0.00...4.00 | xUn | Demand value of residual voltage |
| U_RANGE_RES | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Residual voltage Amplitude range |

### 8.1.8.8 Technical data

*Table 1251: RESVMMXU Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage: $f/f_n$ = ±2 Hz |
| | ±0.5% or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

## 8.1.9 Frequency measurement FMMXU

### 8.1.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Frequency measurement | FMMXU | f | f |

### 8.1.9.2 Function block




*Figure 708: Function block*

### 8.1.9.3 Functionality

The frequency measurement range is 35...75 Hz. The measured frequencies outside the measurement range are considered to be out of range and the minimum and maximum values are then shown in parentheses.

There is an extended range of 10...75 Hz in a 50 Hz network and 12...75 Hz in a 60 Hz network. The measured frequencies outside 35...75 Hz are shown in parentheses.

When the frequencies cannot be measured, for example, due to too low voltage amplitude, the default value for frequency measurement can be selected with the *Def frequency Sel* setting parameter. In the “Nominal” mode the frequency is set to 50 Hz (or 60 Hz) and in “Zero” mode the frequency is set to zero and shown in parentheses.

FMMXU provides instantaneous frequency in hertz which is available for application configurations through output `F_INST`.

### 8.1.9.4 Signals

*Table 1252: FMMXU Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |

*Table 1253: FMMXU Output signals*

| Name | Type | Description |
|---|---|---|
| F_INST | FLOAT32 | Frequency, instantaneous value |

### 8.1.9.5 Settings

*Table 1254: FMMXU Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| F high high limit | 35.00...75.00 | Hz | 1 | 60.00 | High alarm frequency limit |
| F high limit | 35.00...75.00 | Hz | 1 | 55.00 | High warning frequency limit |
| F low limit | 35.00...75.00 | Hz | 1 | 45.00 | Low warning frequency limit |
| F low low limit | 35.00...75.00 | Hz | 1 | 40.00 | Low alarm frequency limit |
| F deadband | 100...100000 | | 1 | 1000 | Deadband configuration value for integral calculation (percentage of difference between min and max as 0,001 % s) |

*Table 1255: FMMXU Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Def frequency Sel | 1=Nominal<br>2=Zero | | | 1=Nominal | Default frequency selection |

### 8.1.9.6 Monitored data

*Table 1256: FMMXU Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| f-Hz:1 | FLOAT32 | 35.00...75.00 | Hz | Measured frequency |
| F_INST | FLOAT32 | 35.00...75.00 | Hz | Frequency, instantaneous value |
| F_DB | FLOAT32 | 35.00...75.00 | Hz | Frequency, reported value |
| F_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Measured frequency range |

### 8.1.9.7 Technical data

*Table 1257: FMMXU Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | ±5 mHz<br>(in measurement range 35...75 Hz) |

## 8.1.10 Sequence current measurement CSMSQI

### 8.1.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Sequence current measurement | CSMSQI | I1, I2, I0 | I1, I2, I0 |

### 8.1.10.2 Function block

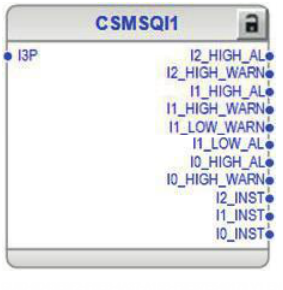



*Figure 709: Function block*

### 8.1.10.3 Functionality

The sequence current measurement function CSMSQI provides limit value supervision outputs (`I2_HIGH_AL`, `I2_HIGH_WARN`, `I1_HIGH_AL`, `I1_HIGH_WARN`, `I1_LOW_WRN`, `I1_LOW_AL`, `I0_HIGH_AL`, `I0_HIGH_WARN`). Setting parameters *Ps Seq A on delay time*, *Ps Seq A off delay time*, *Ng Seq A on delay time*, *Ng Seq A off delay time*, *Zro Seq A on delay time*, *Zro Seq A off delay time* are used for controlling the activation and the deactivation of alarm and warning outputs.

Instantaneous sequence currents in amperes are available for application configurations through outputs `I2_INST`, `I1_INST` and `I0_INST`.

### 8.1.10.4 Analog channel configuration

CSMSQI has one analog group input which must be properly configured.

*Table 1258: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.10.5 Signals

*Table 1259: CSMSQI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |

*Table 1260: CSMSQI Output signals*

| Name | Type | Description |
|---|---|---|
| I2_HIGH_AL | BOOLEAN | Negative sequence high alarm |
| I2_HIGH_WARN | BOOLEAN | Negative sequence high warning |
| I1_HIGH_AL | BOOLEAN | Positive sequence high alarm |
| I1_HIGH_WARN | BOOLEAN | Positive sequence high warning |
| I1_LOW_WARN | BOOLEAN | Positive sequence low warning |
| I1_LOW_AL | BOOLEAN | Positive sequence low alarm |
| I0_HIGH_AL | BOOLEAN | Zero sequence high alarm |
| I0_HIGH_WARN | BOOLEAN | Zero sequence high warning |
| I2_INST | FLOAT32 | Negative sequence current amplitude, instantaneous value (A) |
| I1_INST | FLOAT32 | Positive sequence current amplitude, instantaneous value (A) |
| I0_INST | FLOAT32 | Zero sequence current amplitude, instantaneous value (A) |

### 8.1.10.6 Settings

*Table 1261: CSMSQI Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Ps Seq A Hi high Lim | 0.00...40.00 | xIn | 1 | 1.40 | High alarm current limit for positive sequence current |
| Ps Seq A high limit | 0.00...40.00 | xIn | 1 | 1.20 | High warning current limit for positive sequence current |
| Ps Seq A low limit | 0.00...40.00 | xIn | 1 | 0.00 | Low warning current limit for positive sequence current |
| Ps Seq A low low Lim | 0.00...40.00 | xIn | 1 | 0.00 | Low alarm current limit for positive sequence current |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Ps Seq A deadband | 100...100000 | | 1 | 2500 | Deadband configuration value for positive sequence current for integral calculation. (percentage of difference between min and max as 0,001 % s) |
| Ng Seq A Hi high Lim | 0.00...40.00 | xIn | 1 | 0.20 | High alarm current limit for negative sequence current |
| Ng Seq A High limit | 0.00...40.00 | xIn | 1 | 0.05 | High warning current limit for negative sequence current |
| Ng Seq A low limit | 0.00...40.00 | xIn | 1 | 0.00 | Low warning current limit for negative sequence current |
| Ng Seq A low low Lim | 0.00...40.00 | xIn | 1 | 0.00 | Low alarm current limit for negative sequence current |
| Ng Seq A deadband | 100...100000 | | 1 | 2500 | Deadband configuration value for negative sequence current for integral calculation. (percentage of difference between min and max as 0,001 % s) |
| Zro A Hi high Lim | 0.00...40.00 | xIn | 1 | 0.20 | High alarm current limit for zero sequence current |
| Zro A High limit | 0.00...40.00 | xIn | 1 | 0.05 | High warning current limit for zero sequence current |
| Zro A low limit | 0.00...40.00 | xIn | 1 | 0.00 | Low warning current limit for zero sequence current |
| Zro A low low Lim | 0.00...40.00 | xIn | 1 | 0.00 | Low alarm current limit for zero sequence current |
| Zro A deadband | 100...100000 | | 1 | 2500 | Deadband configuration value for zero sequence current for integral calculation. (percentage of difference between min and max as 0,001 % s) |

*Table 1262: CSMSQI Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Ps Seq A on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for positive sequence current |
| Ps Seq A off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for positive sequence current |
| Ng Seq A on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for negative sequence current |
| Ng Seq A off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for negative sequence current |
| Zro A on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for zero sequence current |
| Zro A off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for zero sequence current |

## 8.1.10.7 Monitored data

*Table 1263: CSMSQI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| NgSeq-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured negative sequence current |
| PsSeq-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured positive sequence current |
| ZrSeq-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured zero sequence current |
| I2_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Negative sequence high alarm |
| I2_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Negative sequence high warning |
| I1_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Positive sequence high alarm |
| I1_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Positive sequence high warning |
| I1_LOW_WARN | BOOLEAN | 0=False<br>1=True | | Positive sequence low warning |
| I1_LOW_AL | BOOLEAN | 0=False<br>1=True | | Positive sequence low alarm |
| I0_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Zero sequence high alarm |
| I0_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Zero sequence high warning |
| I2_INST | FLOAT32 | 0.00...40.00 | xIn | Negative sequence current amplitude, instantaneous value |
| I2_ANGL | FLOAT32 | -180.00...180.00 | deg | Negative sequence current angle |
| I2_DB | FLOAT32 | 0.00...40.00 | xIn | Negative sequence current amplitude, reported value |
| I2_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Negative sequence current amplitude range |
| I1_INST | FLOAT32 | 0.00...40.00 | xIn | Positive sequence current amplitude, instantaneous value |
| I1_ANGL | FLOAT32 | -180.00...180.00 | deg | Positive sequence current angle |
| I1_DB | FLOAT32 | 0.00...40.00 | xIn | Positive sequence current amplitude, reported value |
| I1_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Positive sequence current amplitude range |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I0_INST | FLOAT32 | 0.00...40.00 | xIn | Zero sequence current amplitude, instantaneous value |
| I0_ANGL | FLOAT32 | -180.00...180.00 | deg | Zero sequence current angle |
| I0_DB | FLOAT32 | 0.00...40.00 | xIn | Zero sequence current amplitude, reported value |
| I0_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Zero sequence current amplitude range |

### 8.1.10.8 Technical data

*Table 1264: CSMSQI Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f/f_n$ = ±2 Hz |
| | ±1.0% or ±0.002 × $I_n$<br>at currents in the range of 0.01...4.00 × $I_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 8.1.11 Sequence voltage measurement VSMSQI

### 8.1.11.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Sequence voltage measurement | VSMSQI | U1, U2, U0 | V1, V2, V0 |

### 8.1.11.2 Function block

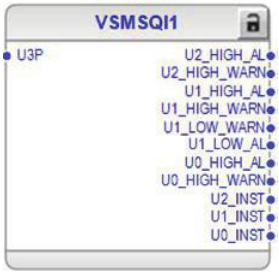



*Figure 710: Function block*

### 8.1.11.3 Functionality

The sequence voltage measurement function VSMSQI provides limit value supervision outputs (U2_HIGH_AL, U2_HIGH_WARN, U1_HIGH_AL, U1_HIGH_WARN, U1_LOW_WRN, U1_LOW_AL, U0_HIGH_AL, U0_HIGH_WARN). Setting parameters *Ps Seq V on delay time*, *Ps Seq V off delay time*, *Ng Seq V on delay time*, *Ng Seq V off delay time*, *Zro Seq V on delay time*, *Zro Seq V off delay time* are used for controlling the activation and the deactivation of alarm and warning outputs.

Instantaneous sequence voltages in volt are available for application configurations through outputs U2_INST, U1_INST and U0_INST.

### 8.1.11.4 Analog channel configuration

VSMSQI has one analog group input which must be properly configured.

*Table 1265: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1266: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that any two voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.11.5 Signals

*Table 1267: VSMSQI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |

*Table 1268: VSMSQI Output signals*

| Name | Type | Description |
|---|---|---|
| U2_HIGH_AL | BOOLEAN | Negative sequence high alarm |
| U2_HIGH_WARN | BOOLEAN | Negative sequence high warning |
| U1_HIGH_AL | BOOLEAN | Positive sequence high alarm |
| U1_HIGH_WARN | BOOLEAN | Positive sequence high warning |
| U1_LOW_WARN | BOOLEAN | Positive sequence low warning |
| U1_LOW_AL | BOOLEAN | Positive sequence low alarm |
| U0_HIGH_AL | BOOLEAN | Zero sequence high alarm |
| U0_HIGH_WARN | BOOLEAN | Zero sequence high warning |
| U2_INST | FLOAT32 | Negative sequence voltage amplitude, instantaneous value (kV) |
| U1_INST | FLOAT32 | Positive sequence voltage amplitude, instantaneous value (kV) |
| U0_INST | FLOAT32 | Zero sequence voltage amplitude, instantaneous value (kV) |

## 8.1.11.6 Settings

*Table 1269: VSMSQI Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Ps Seq V Hi high Lim | 0.00...4.00 | xUn | 1 | 1.40 | High alarm voltage limit for positive sequence voltage |
| Ps Seq V high limit | 0.00...4.00 | xUn | 1 | 1.20 | High warning voltage limit for positive sequence voltage |
| Ps Seq V low limit | 0.00...4.00 | xUn | 1 | 0.00 | Low warning voltage limit for positive sequence voltage |
| Ps Seq V low low Lim | 0.00...4.00 | xUn | 1 | 0.00 | Low alarm voltage limit for positive sequence voltage |
| Ps Seq V deadband | 100...100000 | | 1 | 10000 | Deadband configuration value for positive sequence voltage for integral calculation. (percentage of difference between min and max as 0,001 % s) |
| Ng Seq V Hi high Lim | 0.00...4.00 | xUn | 1 | 0.20 | High alarm voltage limit for negative sequence voltage |
| Ng Seq V High limit | 0.00...4.00 | xUn | 1 | 0.05 | High warning voltage limit for negative sequence voltage |
| Ng Seq V low limit | 0.00...4.00 | xUn | 1 | 0.00 | Low warning voltage limit for negative sequence voltage |
| Ng Seq V low low Lim | 0.00...4.00 | xUn | 1 | 0.00 | Low alarm voltage limit for negative sequence voltage |
| Ng Seq V deadband | 100...100000 | | 1 | 10000 | Deadband configuration value for negative sequence voltage for integral calculation. (percentage of difference between min and max as 0,001 % s) |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Zro V Hi high Lim | 0.00...4.00 | xUn | 1 | 0.20 | High alarm voltage limit for zero sequence voltage |
| Zro V High limit | 0.00...4.00 | xUn | 1 | 0.05 | High warning voltage limit for zero sequence voltage |
| Zro V low limit | 0.00...4.00 | xUn | 1 | 0.00 | Low warning voltage limit for zero sequence voltage |
| Zro V low low Lim | 0.00...4.00 | xUn | 1 | 0.00 | Low alarm voltage limit for zero sequence voltage |
| Zro V deadband | 100...100000 | | 1 | 10000 | Deadband configuration value for zero sequence voltage for integral calculation. (percentage of difference between min and max as 0,001 % s) |

*Table 1270: VSMSQI Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Ps Seq V on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for positive sequence voltage |
| Ps Seq V off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for positive sequence voltage |
| Ng Seq V on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for negative sequence voltage |
| Ng Seq V off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for negative sequence voltage |
| Zro V on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for zero sequence voltage |
| Zro V off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for zero sequence voltage |

## 8.1.11.7 Monitored data

*Table 1271: VSMSQI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| NgSeq-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured negative sequence voltage |
| PsSeq-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured positive sequence voltage |
| ZrSeq-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured zero sequence voltage |
| U2_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Negative sequence high alarm |
| U2_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Negative sequence high warning |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U1_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Positive sequence high alarm |
| U1_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Positive sequence high warning |
| U1_LOW_WARN | BOOLEAN | 0=False<br>1=True | | Positive sequence low warning |
| U1_LOW_AL | BOOLEAN | 0=False<br>1=True | | Positive sequence low alarm |
| U0_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Zero sequence high alarm |
| U0_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Zero sequence high warning |
| U2_INST | FLOAT32 | 0.00...4.00 | xUn | Negative sequence voltage amplitude, instantaneous value |
| U2_ANGL | FLOAT32 | -180.00...180.00 | deg | Negative sequence voltage angle |
| U2_DB | FLOAT32 | 0.00...4.00 | xUn | Negative sequence voltage amplitude, reported value |
| U2_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Negative sequence voltage amplitude range |
| U1_INST | FLOAT32 | 0.00...4.00 | xUn | Positive sequence voltage amplitude, instantaneous value |
| U1_ANGL | FLOAT32 | -180.00...180.00 | deg | Positive sequence voltage angle |
| U1_DB | FLOAT32 | 0.00...4.00 | xUn | Positive sequence voltage amplitude, reported value |
| U1_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Positive sequence voltage amplitude range |
| U0_INST | FLOAT32 | 0.00...4.00 | xUn | Zero sequence voltage amplitude, instantaneous value |
| U0_ANGL | FLOAT32 | -180.00...180.00 | deg | Zero sequence voltage angle |
| U0_DB | FLOAT32 | 0.00...4.00 | xUn | Zero sequence voltage amplitude, reported value |
| U0_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Zero sequence voltage amplitude range |

### 8.1.11.8 Technical data

*Table 1272: VSMSQI Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz<br>At voltages in range 0.01…1.15 × $U_n$ |
| | ±1.0% or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 8.1.12 Three-phase power and energy measurement PEMMXU

### 8.1.12.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase power and energy measurement | PEMMXU | P, E | P, E |

### 8.1.12.2 Function block




*Figure 711: Function block*

### 8.1.12.3 Functionality

The three-phase power and energy measurement function PEMMXU calculates energy and power from the available current and voltage inputs. The function stores the accumulated values of the real and reactive energy in both directions, and presents these values as numerical and pulse outputs.

PEMMXU provides pulse outputs EAFPULSE, EARPULSE, ERFPULSE and ERRPULSE which are activated based on the calculated values of forward and reverse, active and reactive accumulated energy. The activation of the pulse depends on the *Pulse quantity* setting. For example, if *Pulse quantity* is set as "10000" Wh, EAFPULSE is activated every time accumulated energy EA_FWD_ACM increases

by 10000 Wh. The pulse-on and -off time duration can be set using the *Pulse on time* and *Pulse off time* settings.

Instantaneous three-phase power and power factor measurements are available for application configurations through output S_INST, P_INST, Q_INST and PF_INST.

Three-phase power and power factor demand values (S_DMD, P_DMD, Q_DMD and PF_DMD) are provided as outputs. These outputs are dedicated for Load profile recorder (LDPRLRC).

### 8.1.12.4 Analog channel configuration

PEMMXU has two analog group inputs which all must be properly configured.

*Table 1273: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1274: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with the corresponding one voltage channel connected if *Measurement mode* is set to "PhsAB", "PhsBC" or "PhsCA". |
| | The function can work with the corresponding two voltage channels connected if *Measurement mode* is set to "PhsA", "PhsB" or "PhsC". |
| | The function requires that all three voltage channels are connected for the other measurement modes. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.12.5 Signals

*Table 1275: PEMMXU Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| RSTACM | BOOLEAN | 0=False | Reset of accumulated energy reading |

*Table 1276: PEMMXU Output signals*

| Name | Type | Description |
|---|---|---|
| S_INST | FLOAT32 | Apparent power, magnitude of instantaneous value in kVA |
| P_INST | FLOAT32 | Active power, magnitude of instantaneous value in kW |
| Q_INST | FLOAT32 | Reactive power, magnitude of instantaneous value in kvar |
| PF_INST | FLOAT32 | Power factor, magnitude of instantaneous value |
| EAFPULSE | SIGNAL | Accumulated forward active energy pulse |
| EARPULSE | SIGNAL | Accumulated reverse active energy pulse |
| ERFPULSE | SIGNAL | Accumulated forward reactive energy pulse |
| ERRPULSE | SIGNAL | Accumulated reverse reactive energy pulse |
| S_DMD | FLOAT32 | Demand value of apparent power |
| P_DMD | FLOAT32 | Demand value of active power |
| Q_DMD | FLOAT32 | Demand value of reactive power |
| PF_DMD | FLOAT32 | Demand value of power factor |

### 8.1.12.6 Settings

*Table 1277: PEMMXU Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Power unit Mult | 3=Kilo<br>6=Mega | | | 3=Kilo | Unit multiplier for presentation of the power related values |
| Energy unit Mult | 3=Kilo<br>6=Mega | | | 3=Kilo | Unit multiplier for presentation of the energy related values |
| Active power Dir | 1=Forward<br>2=Reverse | | | 1=Forward | Direction of active power flow: Forward, Reverse |
| Reactive power Dir | 1=Forward<br>2=Reverse | | | 1=Forward | Direction of reactive power flow: Forward, Reverse |
| Pulse quantity | 1...10000000 | Wh/VArh | 1 | 100000 | Pulse quantity for the energy pulse outputs |

*Table 1278: PEMMXU Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Forward Wh Initial | 0...999999999 | | 1 | 0 | Preset Initial value for forward active energy |
| Reverse Wh Initial | 0...999999999 | | 1 | 0 | Preset Initial value for reverse active energy |
| Forward VArh Initial | 0...999999999 | | 1 | 0 | Preset Initial value for forward reactive energy |
| Reverse VArh Initial | 0...999999999 | | 1 | 0 | Preset Initial value for reverse reactive energy |
| Measurement mode | 1=PhsA, PhsB, PhsC<br>2=Arone<br>3=Pos Seq<br>4=PhsAB<br>5=PhsBC<br>6=PhsCA<br>7=PhsA<br>8=PhsB<br>9=PhsC | | | 1=PhsA, PhsB, PhsC | Selected measurement mode for power calculation |
| Pulse on time | 0.050...60.000 | s | 0.001 | 1.000 | Energy accumulated pulse ON time in secs |
| Pulse off time | 0.050...60.000 | s | 0.001 | 0.500 | Energy accumulated pulse OFF time in secs |

## 8.1.12.7 Monitored data

*Table 1279: PEMMXU Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| S-kVA:1 | FLOAT32 | -999999.9...999999.9 | kVA | Total Apparent Power |
| P-kW:1 | FLOAT32 | -999999.9...999999.9 | kW | Total Active Power |
| Q-kVAr:1 | FLOAT32 | -999999.9...999999.9 | kVAr | Total Reactive Power |
| PF:1 | FLOAT32 | -1.00...1.00 | | Average Power factor |
| RSTACM | BOOLEAN | 0=False<br>1=True | | Reset of accumulated energy reading |
| S_INST | FLOAT32 | -999999.9...999999.9 | kVA | Apparent power, magnitude of instantaneous value |
| S_DB | FLOAT32 | -999999.9...999999.9 | kVA | Apparent power, magnitude of reported value |
| S_DMD | FLOAT32 | -999999.9...999999.9 | kVA | Demand value of apparent power |
| P_INST | FLOAT32 | -999999.9...999999.9 | kW | Active power, magnitude of instantaneous value |
| P_DB | FLOAT32 | -999999.9...999999.9 | kW | Active power, magnitude of reported value |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| P_DMD | FLOAT32 | -999999.9...999999.9 | kW | Demand value of active power |
| Q_INST | FLOAT32 | -999999.9...999999.9 | kVAr | Reactive power, magnitude of instantaneous value |
| Q_DB | FLOAT32 | -999999.9...999999.9 | kVAr | Reactive power, magnitude of reported value |
| Q_DMD | FLOAT32 | -999999.9...999999.9 | kVAr | Demand value of reactive power |
| PF_INST | FLOAT32 | -1.00...1.00 | | Power factor, magnitude of instantaneous value |
| PF_DB | FLOAT32 | -1.00...1.00 | | Power factor, magnitude of reported value |
| PF_DMD | FLOAT32 | -1.00...1.00 | | Demand value of power factor |
| EA_RV_ACM | INT64 | 0...999999999 | kWh | Accumulated reverse active energy value |
| ER_RV_ACM | INT64 | 0...999999999 | kVArh | Accumulated reverse reactive energy value |
| EA_FWD_ACM | INT64 | 0...999999999 | kWh | Accumulated forward active energy value |
| ER_FWD_ACM | INT64 | 0...999999999 | kVArh | Accumulated forward reactive energy value |
| Max demand S | FLOAT32 | -999999.9...999999.9 | kVA | Maximum demand value of apparent power |
| Min demand S | FLOAT32 | -999999.9...999999.9 | kVA | Minimum demand value of apparent power |
| Max demand P | FLOAT32 | -999999.9...999999.9 | kW | Maximum demand value of active power |
| Min demand P | FLOAT32 | -999999.9...999999.9 | kW | Minimum demand value of active power |
| Max demand Q | FLOAT32 | -999999.9...999999.9 | kVAr | Maximum demand value of reactive power |
| Min demand Q | FLOAT32 | -999999.9...999999.9 | kVAr | Minimum demand value of reactive power |
| Time max dmd S | Timestamp | | | Time of maximum demand |
| Time min dmd S | Timestamp | | | Time of minimum demand |
| Time max dmd P | Timestamp | | | Time of maximum demand |
| Time min dmd P | Timestamp | | | Time of minimum demand |
| Time max dmd Q | Timestamp | | | Time of maximum demand |
| Time min dmd Q | Timestamp | | | Time of minimum demand |

### 8.1.12.8 Technical data

*Table 1280: PEMMXU Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | At all three currents in range 0.10…1.20 × $I_n$<br>At all three voltages in range 0.50…1.15 × $U_n$<br>At the frequency $f_n$ ±1 Hz |
| | ±1.5% for apparent power S<br>±1.5% for active power P and active energy[1)]<br>±1.5% for reactive power Q and reactive energy[2)]<br>±0.015 for power factor |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

1) |PF| >0.5 which equals |cosφ| >0.5
2) |PF| <0.86 which equals |sinφ| >0.5

## 8.2 Disturbance recorder, common functionality RDRE

### 8.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Disturbance recorder, common functionality | RDRE | DR | DFR |

### 8.2.2 Function block




*Figure 712: Function block*

### 8.2.3 Functionality

The protection relay is provided with a disturbance recorder featuring up to 24 analog and 64 binary signal channels. The analog channels can be set to record either the waveform or the trend of the currents and voltages measured and they can trigger the recording function when the measured value falls below or exceeds the set values.

The binary signal channels can be set to start a recording either on the rising or the falling edge of the binary signal or on both. By default, the binary channels are set to record external or internal relay signals, for example, the start or trip signals of the relay stages, or external blocking or control signals. Binary relay signals, such as protection start and trip signals, or an external relay control signal via a binary input

can be set to trigger the recording. Recorded information is stored in a nonvolatile memory and can be uploaded for subsequent fault analysis.

### 8.2.3.1 Recorded analog and binary inputs

The relay's analog and binary signals for disturbance recorder can be configured with Application Configuration in PCM600. In addition, each channel of the disturbance recorder can be enabled or disabled by setting the *Operation* parameter of the corresponding channel to "on" or "off".

All channels of the disturbance recorder that are enabled and have a valid signal connected are included in the recording.

### 8.2.3.2 Triggering alternatives

The recording can be triggered by any of the following alternatives.

- Triggering according to the state change of any of the binary channels of the disturbance recorder. The level sensitivity can be set with the *Level trigger mode* parameter of the corresponding binary channel.
- Triggering on limit violations of the analog channels of the disturbance recorder (high and low limit)
- Manual triggering via the *Trig recording* parameter (LHMI or communication)
- Periodic triggering

Regardless of the triggering type, each recording generates the Recording started and Recording made events. The Recording made event indicates that the recording has been stored to the nonvolatile memory. In addition, every analog channel and binary channel of the disturbance recorder has its own *Channel triggered* parameter. Manual trigger has the *Manual triggering* parameter and periodic trigger has the *Periodic triggering* parameter.

#### Triggering by binary channels

The input signals for the binary channels of the disturbance recorder can be formed from any of the digital signals that can be dynamically mapped. A change in the status of a monitored signal triggers the recorder according to the configuration and settings. Triggering on the rising edge of a digital input signal means that the recording sequence starts when the input signal is activated. Correspondingly, triggering on the falling edge means that the recording sequence starts when the active input signal resets. It is also possible to trigger from both edges. In addition, the monitored signal can be non-triggering. The trigger setting can be set individually for each binary channel of the disturbance recorder with the *Level trigger mode* parameter of the corresponding binary channel.

#### Triggering by analog channels

The trigger level can be set for triggering in a limit violation situation. The limit values can be set with the *High trigger level* and *Low trigger level* parameters of the

corresponding analog channel. Both high-level and low-level violation triggering can be active simultaneously for the same analog channel. If the duration of the limit violation condition exceeds the filter time of approximately 50 ms, the recorder triggers. In case of a low-level limit violation, if the measured value falls below approximately 0.05 during the filter time, the situation is considered to be a circuit breaker operation and therefore, the recorder does not trigger. This is useful especially in undervoltage situations. The filter time of approximately 50 ms is common to all the analog channel triggers of the disturbance recorder. The value used for triggering is the calculated peak-to-peak value. Either high or low analog channel trigger can be disabled by setting the corresponding trigger level parameter to zero.



Frequency cannot be used as a trigger to disturbance recorder.

#### Manual triggering

The recorder can be triggered manually via the LHMI or via communication by setting the *Trig recording* parameter to "Trig".

#### Periodic triggering

Periodic triggering means that the recorder automatically makes a recording at certain time intervals. The interval can be adjusted with the *Periodic trig time* parameter. If the value of the parameter is changed, the new setting takes effect when the next periodic triggering occurs. Setting the parameter to zero disables the triggering alternative and the setting becomes valid immediately. If a new non-zero setting needs to be valid immediately, the *Periodic trig time* parameter should first be set to zero and then to the new value. The time remaining to the next triggering can be monitored with the Time to trigger monitored data which counts downwards.

### 8.2.3.3 Length of recordings

The recording length can be defined with the *Record length* parameter. The length is given as the number of fundamental cycles.

According to the memory available and the number of analog channels used, the disturbance recorder automatically calculates the remaining number of recordings that fit into the available recording memory. This information can be seen with the Rem. amount of rec. monitored data. The fixed memory size allocated to the recorder can fit in two recordings that are ten seconds long. The recordings contain data from all analog and binary channels of the disturbance recorder, at the sample rate of 32 samples per fundamental cycle.

The number of recordings in the memory can be viewed with the Number of recordings monitored data. The used memory space can be viewed with the Rec. memory used monitored data. It is shown as a percentage value.

The maximum number of recordings is 100.

### 8.2.3.4 Sampling frequencies

The sampling frequency of the disturbance recorder analog channels depends on the set rated frequency. One fundamental cycle always contains the number of samples set with the *Storage rate* parameter. Since the states of the binary channels are sampled once per task execution of the disturbance recorder, the sampling frequency of binary channels is 400 Hz at the rated frequency of 50 Hz and 480 Hz at the rated frequency of 60 Hz.

*Table 1281: Sampling frequencies of the disturbance recorder analog and binary channels*

| Storage rate (samples per fundamental cycle) | Recording length | Rated frequency = 50 Hz | | Rated frequency = 60 Hz | |
|---|---|---|---|---|---|
| | | Sampling frequency of analog channels | Sampling frequency of binary channels | Sampling frequency of analog channels | Sampling frequency of binary channels |
| 32 | 1 · Record length | 1600 Hz | 400 Hz | 1920 Hz | 480 Hz |
| 16 | 2 · Record length | 800 Hz | 400 Hz | 960 Hz | 480 Hz |
| 8 | 4 · Record length | 400 Hz | 400 Hz | 480 Hz | 480 Hz |

### 8.2.3.5 Uploading of recordings

The protection relay stores COMTRADE files to the `C:\COMTRADE` folder. The files can be uploaded with PCM600 or any appropriate computer software that can access the `C:\COMTRADE` folder.

One complete disturbance recording consists of two COMTRADE file types: the configuration file and the data file. The file name is the same for both file types. The configuration file has .CFG and the data file .DAT as the file extension.

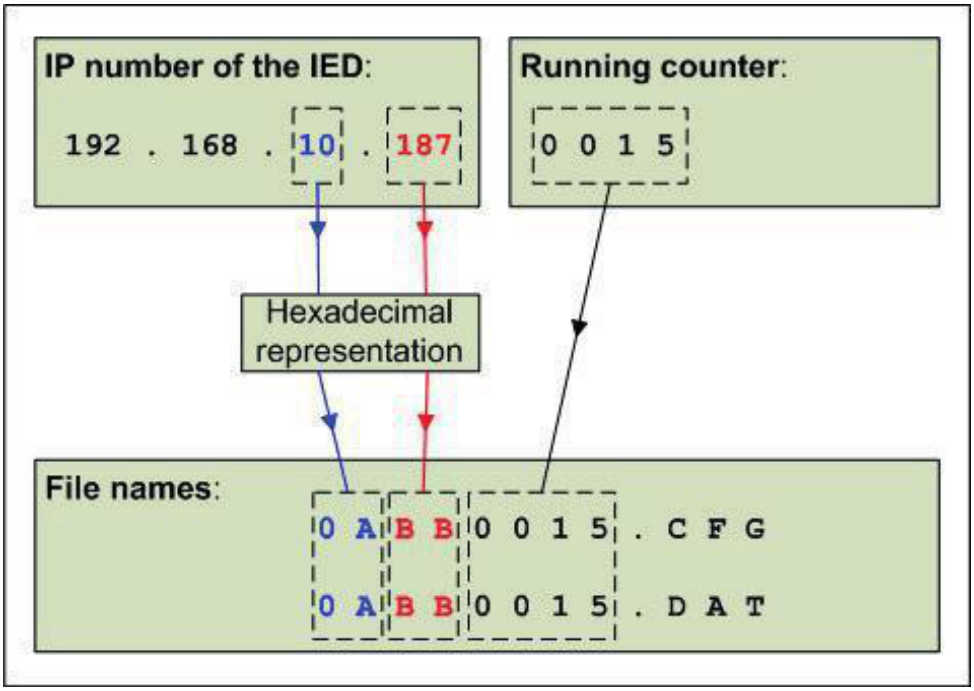



*Figure 713: Disturbance recorder file naming*

The naming convention of 8+3 characters is used in COMTRADE file naming. The file name is composed of the last two octets of the protection relay's IP number and a running counter, which has a range of 1...9999. A hexadecimal representation is used for the IP number octets. The appropriate file extension is added to the end of the file name.

### 8.2.3.6 Deletion of recordings

The recordings can be deleted individually or all at once.

Individual disturbance recordings can be deleted with PCM600 or any appropriate computer software, which can access the protection relay's `C:\COMTRADE` folder. The disturbance recording is not removed from the protection relay's memory until both of the corresponding COMTRADE files, .CFG and .DAT, are deleted. Both file types may need to be deleted separately, depending on the software used.

Deleting all disturbance recordings at once is done either with PCM600 or any appropriate computer software, or from the LHMI via the **Clear/Disturbance records** menu. Deleting all disturbance recordings at once also clears the pre-trigger recording in progress.

### 8.2.3.7 Storage mode

The disturbance recorder can capture data in two modes: waveform and trend mode. The storage mode can be set individually for each trigger source with the *Storage mode* parameter of the corresponding analog channel or binary channel, the *Stor.*

*mode manual* parameter for manual trigger and the *Stor. mode periodic* parameter for periodic trigger.

In the waveform mode, the samples are captured according to the *Storage rate* and *Pre-trg length* parameters.

In the trend mode, one value is recorded for each enabled analog channel, once per fundamental cycle. The recorded values are RMS values, which are scaled to peak level. The binary channels of the disturbance recorder are also recorded once per fundamental cycle in the trend mode.



Only post-trigger data is captured in trend mode.

The trend mode enables recording times of 32 · *Record length*.

### 8.2.3.8 Pre-trigger and post-trigger data

The waveforms of the disturbance recorder analog channels and the states of the disturbance recorder binary channels are constantly recorded into the history memory of the recorder. The percentage of the data duration preceding the triggering, that is, the pre-trigger time, can be adjusted with the *Pre-trg length* parameter. The duration of the data following the triggering, that is, the post-trigger time, is the difference between the recording length and the pre-trigger time. Changing the pre-trigger time resets the history data and the current recording under collection.

### 8.2.3.9 Operation modes

The disturbance recorder has two operation modes: saturation and overwrite mode. The operation mode of the disturbance recorder can be changed with the *Operation mode* parameter.

#### Saturation mode

In saturation mode, the captured recordings cannot be overwritten with new recordings. Capturing the data is stopped when the recording memory is full, that is, when the maximum number of recordings is reached. In this case, the event is sent via the state change (TRUE) of the *Memory full* parameter. When there is memory available again, another event is generated via the state change (FALSE) of the *Memory full* parameter.

#### Overwrite mode

In the overwrite mode, if the recording memory is full, the oldest recording is overwritten with the pre-trigger data collected for the next recording. Each time a recording is overwritten, the event is generated via the state change of the *Overwrite of rec.* parameter.

The overwrite mode is recommended if it is important to have the latest recordings in the memory. The saturation mode is preferred when the oldest recordings are more important.

New triggerings are blocked in both modes until the previous recording is completed, but a new triggering can be accepted before all pre-trigger samples are collected for the new recording. In such a case, the recording is as much shorter as there are pre-trigger samples lacking.

#### 8.2.3.10 Exclusion mode

Exclusion mode is on when the value of the *Exclusion time* parameter is higher than zero. During the exclusion mode, new triggerings are ignored if the triggering reason is the same as in the previous recording. The *Exclusion time* parameter controls how long the exclusion of triggerings of same type is active after a triggering. The exclusion mode applies only to the analog and binary channel triggerings, not to periodic and manual triggerings.

When the value set with the *Exclusion time* parameter is zero, the exclusion mode is disabled and there are no restrictions on the triggering types of the successive recordings.

The exclusion time setting is global for all inputs, but there is an individual counter for each analog and binary channel of the disturbance recorder, counting the remaining exclusion time. The remaining exclusion time can be monitored with the *Exclusion time rem* parameter (only visible via communication, IEC 61850 data ExclTmRmn) of the corresponding analog or binary channel. The *Exclusion time rem* parameter counts downwards.

### 8.2.4 Configuration

The disturbance recorder can be configured with PCM600 or any tool supporting the IEC 61850 standard.

RDRE1 should always be included in Application Configuration when the disturbance recorder is used.

The disturbance recorder can be enabled or disabled with the *Operation* parameter under **Configuration/Disturbance recorder/General**.

One analog signal type of the protection relay can be mapped to each of the analog channels of the disturbance recorder. The mapping is done in Application Configuration in PCM600. The name of the analog channel is user-configurable. It can be modified by writing the new name to the *Channel id text* parameter of the corresponding analog channel.

Any external or internal digital signal of the protection relay which can be dynamically mapped can be connected to the binary channels of the disturbance

recorder. These signals can be, for example, the start and trip signals from protection function blocks or the external binary inputs of the protection relay. The connection is made with dynamic mapping to the binary channel of the disturbance recorder using, for example, Signal Matrix of PCM600. It is also possible to connect several digital signals to one binary channel of the disturbance recorder. In that case, the signals can be combined with logical functions, for example AND and OR. The name of the binary channel can be configured and modified by writing the new name to the *Channel id text* parameter of the corresponding binary channel.

The *Channel id text* parameter is used in COMTRADE configuration files as a channel identifier.

The recording always contains all binary channels of the disturbance recorder. If one of the binary channels is disabled, the recorded state of the channel is continuously FALSE and the state changes of the corresponding channel are not recorded. The corresponding channel name for disabled binary channels in the COMTRADE configuration file is Unused BI.

To enable or disable an analog or a binary channel of the disturbance recorder, the *Operation* parameter of the corresponding analog or binary channel is set to "on" or "off".

The states of manual triggering and periodic triggering are not included in the recording, but they create a state change to the *Periodic triggering* and *Manual triggering* status parameters, which in turn create events.

The `TRIGGERED` output can be used to control the indication LEDs of the protection relay. The triggering of the disturbance recorder sets the `TRIGGERED` output to TRUE. The output remains in this state until all the data for the corresponding recording has been recorded.

The IP number of the protection relay and the value of the *Bay name* parameter are both included in the COMTRADE configuration file for identification purposes.

## 8.2.5 Application

The disturbance recorder is used for post-fault analysis and for verifying the correct operation of protection relays and circuit breakers. It can record both analog and binary signal information. The analog inputs are recorded as instantaneous values and converted to primary peak value units when the protection relay converts the recordings to the COMTRADE format.

COMTRADE is the general standard format used for storing disturbance recordings.

The binary channels are sampled once per task execution of the disturbance recorder. The task execution interval for the disturbance recorder is the same as for the protection functions. During the COMTRADE conversion, the digital status values are repeated so that the sampling frequencies of the analog and binary channels correspond to each other. This is required by the COMTRADE standard.

The disturbance recorder follows the 1999 version of the COMTRADE standard and uses the binary data file format.

## 8.2.6 Signals

*Table 1282: RDRE Output signals*

| Name | Type | Description |
|---|---|---|
| TRIGGERED | BOOLEAN | Recording started |

## 8.2.7 Settings

*Table 1283: RDRE Non group general settings (basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Disturbance recorder on / off |
| Record length | 10...500 | cycles | 1 | 50 | Record length in fundamental cycles |
| Pre-trg length | 0...100 | % | 1 | 50 | Length of the recording preceding the triggering |

*Table 1284: RDRE Non group general settings (advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation mode | 1=Overwrite<br>2=Saturation | | | 2 | Saturation / overwrite |
| Exclusion time | 0...1 000 000 | ms | 10 | 0 | The time during which triggerings of same type are ignored |
| Storage rate | 32, 16, 8 | samples per fundamental cycle | | 32 | Storage rate for waveform recordings in samples per cycle |
| Periodic trig time | 0...604 800 | s | 10 | 0 | Time between periodic triggerings in seconds |
| Stor. mode periodic | 0=Waveform<br>1=Trend / cycle | | | 0 | Storage mode selection (waveform / trend) for periodic trigger |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Stor. mode periodic | 0=Waveform<br>1=Trend / cycle | | | 0 | Storage mode selection (waveform / trend) for periodic trigger |
| Stor. mode manual | 0=Waveform<br>1=Trend / cycle | | | 0 | Storage mode selection (waveform / trend) for manual trigger |

*Table 1285: RDRE Control data (basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Trig recording | 0=Cancel<br>1=Trig | | | 0=Cancel | Manual trigger for the disturbance recorder |
| Clear recordings | 0=Cancel<br>1=Clear | | | 0=Cancel | Clear all disturbance recordings in the memory |

## 8.2.8 Monitored data

*Table 1286: RDRE Monitored data (basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Number of recordings | 0...100 | | | | Number of recordings in the memory |
| Rem. amount of rec. | 0...100 | | | | Remaining amount of recordings that fit into the available recording memory, when present settings are used |
| Rec. memory used | 0...100 | % | | | How much recording memory is currently used |
| Time to trigger | 0...604 800 | s | | | Time remaining to the next periodic triggering |

# 8.3 Disturbance recorder, analog channels 1...24 A1RADR and A2RADR

## 8.3.1 Function block




*Figure 714: Function block*

## 8.3.2 Signals

The input signal tables for A1RADR and A2RADR are similar except for the channel numbers.

- A1RADR, CH1...CH12
- A2RADR, CH13...CH24

*Table 1287: A1RADR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| CH1 | SIGNAL | | Signal for input 1 |

Values are the same for each input signal. The channel numbers are shown after the parameter name in the HMI and PCM600.

## 8.3.3 Settings

Setting tables for all A1RADR and A2RADR channels are similar except for the channel numbers.

*Table 1288: A1RADR Non group general settings (basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Analog channel on / off |
| Channel id text | | | | Analog ch 1 input | Channel identifier text |
| High trigger level | 0.00...60.00 | | 0.01 | 10 | Over limit |
| Low trigger level | 0.00...2.00 | | 0.01 | 0 | Under limit |

*Table 1289: A1RADR Non group general settings (advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Storage mode | 0=Waveform<br>1=Trend / cycle | | | 0 | Storage mode selection (waveform / trend) |

# 8.4 Disturbance recorder, binary channels 1...64 B1RBDR and B2RBDR

## 8.4.1 Function block




*Figure 715: Function block*

## 8.4.2 Signals

The input signal tables for B1RBDR and B2RBDR are similar except for the channel numbers.

- B1RBDR, C1...C32
- B2RBDR, C33...C64

*Table 1290: B1RBDR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| C1 | BOOLEAN | 0=False | Signal for input 1 |

Values are the same for each input signal. The channel numbers are shown after the parameter name in the HMI and PCM600.

## 8.4.3 Settings

Setting tables for all B1RBDR and B2RBDR channels are similar except for the channel numbers.

*Table 1291: B1RBDR Non group general settings (basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 5=off | Binary channel on / off |
| Level trigger mode | 1=Positive or Rising<br>2=Negative or Falling<br>3=Both<br>4=Level trigger off | | | 1 | Rising / falling / both / trigger off |

*Table 1292: B1RBDR Non group general settings (advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Storage mode | 0=Waveform<br>1=Trend / cycle | | | 0=Waveform | Storage mode selection (waveform / trend) |
| Channel id text | | | | Binary ch 1 input | Channel identifier text |

# 8.5 Tap changer position indication TPOSYLTC

## 8.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Tap changer position indication | TPOSYLTC | TPOSM | 84T |

## 8.5.2 Function block

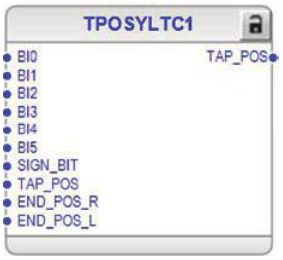



*Figure 716: Function block*

## 8.5.3 Functionality

The tap changer position indication function TPOSYLTC is used for transformer tap position supervision. The binary inputs can be used for converting a binary-coded tap changer position to a tap position status indication. The RTD module, available as an option, provides the RTD sensor information to be used and the versatile analog inputs enabling the tap position supervision through mA.

There are three user-selectable conversion modes available for the 7-bit binary inputs where MSB is used as the SIGN bit: the natural binary-coded boolean input to the signed integer output, binary coded decimal BCD input to the signed integer output and binary reflected GRAY coded input to the signed integer output.

## 8.5.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off". When the function is disabled, the tap position quality information is changed accordingly. When the tap position information is not available, it is recommended to disable this function with the *Operation* setting.

The operation of TPOSYLTC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

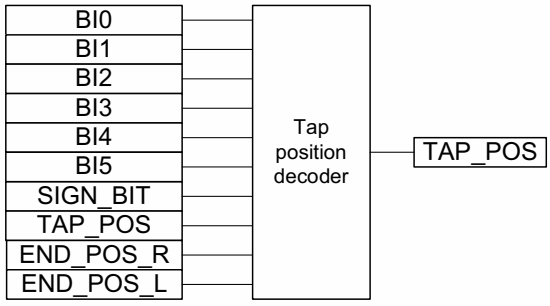



*Figure 717: Functional module diagram*

## Tap position decoder

When there is a wired connection to the TAP_POS input connector, the corresponding tap changer position is decoded from the mA or RTD input. When there is no wired connection to the TAP_POS connector, the binary inputs are expected to be used for the tap changer position information. The tap changer position value and quality are internally shared to other functions. The value is available in the Monitored data view or as a TAP_POS output signal.

The function has three alternative user selectable operation modes: "NAT2INT", "BCD2INT" and "GRAY2INT". The operation mode is selected with the *Operation mode* setting. Each operation mode can be used to convert a maximum of 6–bit coded input to an 8–bit signed short integer output. For less than 6–bit input, for example 19 positions with 5 bits when the BCD coding is used, the rest of the bits can be set to FALSE (0).

The operation mode "NAT2INT" is selected when the natural binary coding is used for showing the position of the transformer tap changer. The basic principle of the natural binary coding is to calculate the sum of the bits set to TRUE (1). The LSB has the factor 1. Each following bit has the previous factor multiplied by 2. This is also called dual coding.

The operation mode "BCD2INT" is selected when the binary-coded decimal coding is used for showing the position of the transformer tap changer. The basic principle with the binary-coded decimal coding is to calculate the sum of the bits set to TRUE (1). The four bits nibble (BI3...BI0) have a typical factor to the natural binary coding. The sum of the values should not be more than 9. If the nibble sum is greater than 9, the tap position output validity is regarded as bad.

The operation mode “GRAY2INT” is selected when the binary-reflected Gray coding is used for showing the position of the transformer tap changer. The basic principle of the Gray coding is that only one actual bit changes value with consecutive positions. This function is based on the common binary-reflected Gray code which is used with some tap changers. Changing the bit closest to the right side bit gives a new pattern.

An additional separate input, SIGN_BIT, can be used for negative values. If the values are positive, the input is set to FALSE (0). If the SIGN_BIT is set to TRUE (1)

making the number negative, the remaining bits are identical to those of the coded positive number.

The tap position validity is set to good in all valid cases. The quality is set to bad in invalid combinations in the binary inputs. For example, when the “BCD2INT” mode is selected and the input binary combination is “0001101”, the quality is set to bad. For negative values, when the SIGN_BIT is set to TRUE (1) and the input binary combination is “1011011”, the quality is set to bad.

If the tap changer has auxiliary contacts for indicating the extreme positions of the tap changer, their status can be connected to END_POS_R and END_POS_L inputs. The END_POS_R (End position raise or highest allowed tap position reached) status refers to the extreme position that results in the highest number of the taps in the tap changer. Similarly, END_POS_L (End position lower or lowest allowed tap position reached) status refers to the extreme position that results in the lowest number of the taps in the tap changer. TAP_POS output is dedicated for transferring the validated tap position for the functions that need tap position information, for example OLATCC and TRxPTDF. It includes both the actual position information and the status of reached end positions, assuming that inputs END_POS_R and END_POS_L are connected.

*Table 1293: Truth table of the decoding modes*

| Inputs | | | | | | | TAP_POS outputs | | |
|---|---|---|---|---|---|---|---|---|---|
| SIGN_BIT | BI5 | BI4 | BI3 | BI2 | BI1 | BI0 | NAT2INT | BCD2INT | GRAY2INT |
| ... | | ... | | ... | | ... | ... | ... | ... |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | -3 | -3 | -2 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | -2 | -2 | -3 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | -1 | -1 | -1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 3 |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 3 | 2 |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 4 | 7 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | 5 | 5 | 6 |
| 0 | 0 | 0 | 0 | 1 | 1 | 0 | 6 | 6 | 4 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 7 | 7 | 5 |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 8 | 8 | 15 |
| 0 | 0 | 0 | 1 | 0 | 0 | 1 | 9 | 9 | 14 |
| 0 | 0 | 0 | 1 | 0 | 1 | 0 | 10 | 9 | 12 |
| 0 | 0 | 0 | 1 | 0 | 1 | 1 | 11 | 9 | 13 |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 | 12 | 9 | 8 |
| 0 | 0 | 0 | 1 | 1 | 0 | 1 | 13 | 9 | 9 |
| 0 | 0 | 0 | 1 | 1 | 1 | 0 | 14 | 9 | 11 |
| 0 | 0 | 0 | 1 | 1 | 1 | 1 | 15 | 9 | 10 |

Table continues on next page

| Inputs | | | | | | | TAP_POS outputs | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 16 | 10 | 31 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 17 | 11 | 30 |
| 0 | 0 | 1 | 0 | 0 | 1 | 0 | 18 | 12 | 28 |
| 0 | 0 | 1 | 0 | 0 | 1 | 1 | 19 | 13 | 29 |
| 0 | 0 | 1 | 0 | 1 | 0 | 0 | 20 | 14 | 24 |
| 0 | 0 | 1 | 0 | 1 | 0 | 1 | 21 | 15 | 25 |
| 0 | 0 | 1 | 0 | 1 | 1 | 0 | 22 | 16 | 27 |
| 0 | 0 | 1 | 0 | 1 | 1 | 1 | 23 | 17 | 26 |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | 24 | 18 | 16 |
| 0 | 0 | 1 | 1 | 0 | 0 | 1 | 25 | 19 | 17 |
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 26 | 19 | 19 |
| 0 | 0 | 1 | 1 | 0 | 1 | 1 | 27 | 19 | 18 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 28 | 19 | 23 |
| 0 | 0 | 1 | 1 | 1 | 0 | 1 | 29 | 19 | 22 |
| 0 | 0 | 1 | 1 | 1 | 1 | 0 | 30 | 19 | 20 |
| 0 | 0 | 1 | 1 | 1 | 1 | 1 | 31 | 19 | 21 |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 32 | 20 | 63 |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 33 | 21 | 62 |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 34 | 22 | 60 |
| 0 | 1 | 0 | 0 | 0 | 1 | 1 | 35 | 23 | 61 |
| 0 | 1 | 0 | 0 | 1 | 0 | 0 | 36 | 24 | 56 |
| ... | | ... | | ... | | ... | ... | ... | ... |

## 8.5.5 Application

TPOSYLTC provides tap position information for other functions as a signed integer value that can be fed to the tap position input.

The position information of the tap changer can be coded in various methods for many applications, for example, the differential protection algorithms. In this function, the binary inputs in the transformer terminal connector are used as inputs to the function. The coding method can be chosen by setting the mode parameter. The available coding methods are BCD, Gray and Natural binary coding. Since the number of binary inputs are limited to seven, the coding functions are limited to seven bits including the sign bit and thus the six bits are used in the coding functions. The position limits for the tap positions at BCD, Gray and Natural binary coding are ±39, ±63 and ±63 respectively.

In this example, the transformer tap changer position indication is wired as a mA signal from the corresponding measuring transducer. The position indication is connected to input 1 (`AI_VAL1`) of the (RTD) module. The tap changer operating range from the minimum to maximum turns of the tap and a corresponding mA signal

for the tap position are set in the RTD module. Since the values of the RTD module outputs are floating point numbers, the float to integer (T_R_TO_I8) conversion is needed before the tap position information can be fed to TPOSYLTC. When there is a wired connection to the TAP_POS connector, the validated tap changer position is presented in the TAP_POS output that is connected to other functions, for example, OLATCC1. When there is no wired connection to the TAP_POS connector, the binary inputs are expected to be used for the tap changer position information.




*Figure 718: RTD/analog input configuration example*

## 8.5.6 Signals

*Table 1294: TPOSYLTC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| BI0 | BOOLEAN | 0=False | Binary input 1 |
| BI1 | BOOLEAN | 0=False | Binary input 2 |
| BI2 | BOOLEAN | 0=False | Binary input 3 |
| BI3 | BOOLEAN | 0=False | Binary input 4 |
| BI4 | BOOLEAN | 0=False | Binary input 5 |
| BI5 | BOOLEAN | 0=False | Binary input 6 |
| SIGN_BIT | BOOLEAN | 0=False | Binary input sign bit |
| END_POS_R | BOOLEAN | 0=False | End position raise or highest allowed tap position reached |
| END_POS_L | BOOLEAN | 0=False | End position lower or lowest allowed tap position reached |
| TAP_POS | INT8 | 0 | Tap position indication |

*Table 1295: TPOSYLTC Output signals*

| Name | Type | Description |
|---|---|---|
| TAP_POS | INT8-TAPPOS | Tap position indication |

## 8.5.7 Settings

*Table 1296: TPOSYLTC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=NAT2INT<br>2=BCD2INT<br>3=GRAY2INT | | | 2=BCD2INT | Operation mode selection |

## 8.5.8 Monitored data

*Table 1297: TPOSYLTC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| BI0 | BOOLEAN | 0=False<br>1=True | | Binary input 1 |
| BI1 | BOOLEAN | 0=False<br>1=True | | Binary input 2 |
| BI2 | BOOLEAN | 0=False<br>1=True | | Binary input 3 |
| BI3 | BOOLEAN | 0=False<br>1=True | | Binary input 4 |
| BI4 | BOOLEAN | 0=False<br>1=True | | Binary input 5 |
| BI5 | BOOLEAN | 0=False<br>1=True | | Binary input 6 |
| SIGN_BIT | BOOLEAN | 0=False<br>1=True | | Binary input sign bit |
| END_POS_R | BOOLEAN | 0=False<br>1=True | | End position raise or highest allowed tap position reached |
| END_POS_L | BOOLEAN | 0=False<br>1=True | | End position lower or lowest allowed tap position reached |
| TAP_POS | INT8 | -63...63 | | Tap position indication |

## 8.5.9 Technical data

*Table 1298: TPOSYLTC Technical data*

| Descrpition | Value |
|---|---|
| Response time for binary inputs | Typical 100 ms |

# Section 9 Control functions

## 9.1 Circuit-breaker control CBXCBR, Disconnector control DCXSWI and Earthing switch control ESXSWI

### 9.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Circuit-breaker control | CBXCBR | I<->O CB | 52 |
| Disconnector control | DCXSWI | I<->O DCC | 29DS |
| Earthing switch control | ESXSWI | I<->O ESC | 29GS |

### 9.1.2 Function block

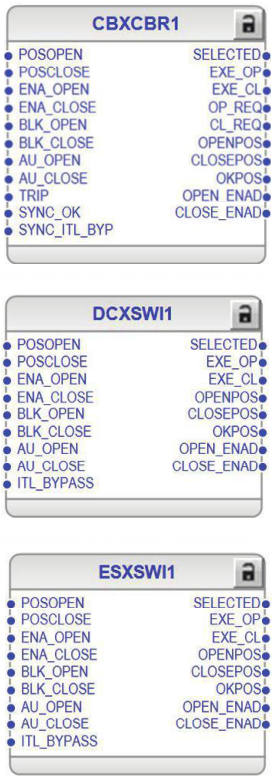



*Figure 719: Function block*

## 9.1.3 Functionality

CBXCBR, DCXSWI and ESXSWI are intended for circuit breaker, disconnector and earthing switch control and status information purposes. These functions execute commands and evaluate block conditions and different time supervision conditions. The functions perform an execution command only if all conditions indicate that a switch operation is allowed. If erroneous conditions occur, the functions indicate an appropriate cause value. The functions are designed according to the IEC 61850-7-4 standard with logical nodes CILO, CSWI and XSWI/XCBR.

The circuit breaker, disconnector and earthing switch control functions have an operation counter for closing and opening cycles. The counter value can be read and written remotely from the place of operation or via LHMI.

## 9.1.4 Operation principle

### Status indication and validity check

The object state is defined by two digital inputs, POSOPEN and POSCLOSE, which are also available as outputs OPENPOS and CLOSEPOS together with the OKPOS according to Table 1299. The debouncing and short disturbances in an input are eliminated by filtering. The binary input filtering time can be adjusted separately for each digital input used by the function block. The validity of the digital inputs that indicate the object state is used as additional information in indications and event logging. The reporting of faulty or intermediate position of the apparatus occurs after the *Event delay* setting, assuming that the circuit breaker is still in a corresponding state.

*Table 1299: Status indication*

| Input | | Status | Output | | |
|---|---|---|---|---|---|
| POSOPEN | POSCLOSE | POSITION (Monitored data) | OKPOS | OPENPOS | CLOSEPOS |
| 1=True | 0=False | 1=Open | 1=True | 1=True | 0=False |
| 0=False | 1=True | 2=Closed | 1=True | 0=False | 1=True |
| 1=True | 1=True | 3=Faulty/Bad (11) | 0=False | 0=False | 0=False |
| 0=False | 0=False | 0=Intermediate (00) | 0=False | 0=False | 0=False |

### Enabling and blocking

CBXCBR, DCXSWI and ESXSWI have an enabling and blocking functionality for interlocking and synchrocheck purposes.

### Circuit breaker control CBXCBR

Normally, the CB closing is enabled (that is, CLOSE_ENAD signal is TRUE) by activating both ENA_CLOSE and SYNC_OK inputs. Typically, the ENA_CLOSE

comes from the interlocking, and SYNC_OK comes from the synchronism and energizing check. The input SYNC_ITL_BYP can be used for bypassing this control. The SYNC_ITL_BYP input can be used to activate CLOSE_ENAD discarding the ENA_CLOSE and SYNC_OK input states. However, the BLK_CLOSE input always blocks the CLOSE_ENAD output.

The CB opening (OPEN_ENAD) logic is the same as CB closing logic, except that SYNC_OK is used only in closing. The SYNC_ITL_BYP input is used in both CLOSE_ENAD and OPEN_ENAD logics.

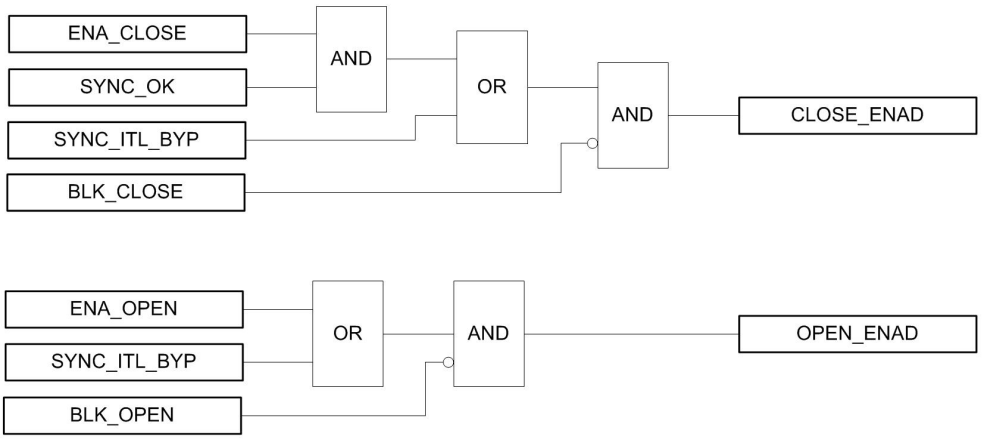



*Figure 720: Enabling and blocking logic for CLOSE_ENAD and OPEN_ENAD signals*

## Disconnector control DCXSWI and earthing switch control ESXSWI

Normally, the switch closing is enabled (that is, the CLOSE_ENAD signal is TRUE) by activating the ENA_CLOSE input. The input ITL_BYPASS can be used for bypassing this control. The ITL_BYPASS input can be used to activate the CLOSE_ENAD discarding the ENA_CLOSE input state. However, the BLK_CLOSE input always blocks the CLOSE_ENAD output.

The CB opening (OPEN_ENAD) logic is identical to CB closing logic. The ITL_BYPASS input is used in both CLOSE_ENAD and OPEN_ENAD logics.

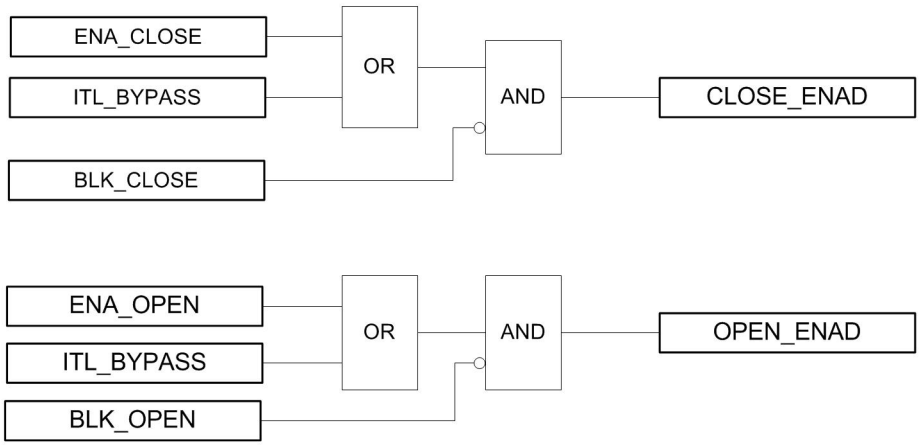



*Figure 721: Enabling and blocking logic for CLOSE_ENAD and OPEN_ENAD signals*

## Opening and closing operations

The opening and closing operations are available via communication, binary inputs or LHMI commands. As a prerequisite for control commands, there are enabling and blocking functionalities for both opening and closing commands (CLOSE_ENAD and OPEN_ENAD signals). If the control command is executed against the blocking or if the enabling of the corresponding command is not valid, CBXCBR, DCXSWI and ESXSWI generate an error message.

When close command is given from communication, via LHMI or activating the AU_CLOSE input, it is carried out (the EXE_CL output) only if CLOSE_ENAD is TRUE.

If the SECRSYN function is used in “Command” mode, the CL_REQ output can be used in CBXCBR. Initially, the SYNC_OK input is FALSE. When the close command given, it activates the CL_REQ output, which should be routed to SECRSYN. The close command is then processed only after SYNC_OK is received from SECRSYN.

When using SECRSYN in the “Command” mode, the CBXCBR setting *Operation timeout* should be set longer than SECRSYN setting *Maximum Syn time*.

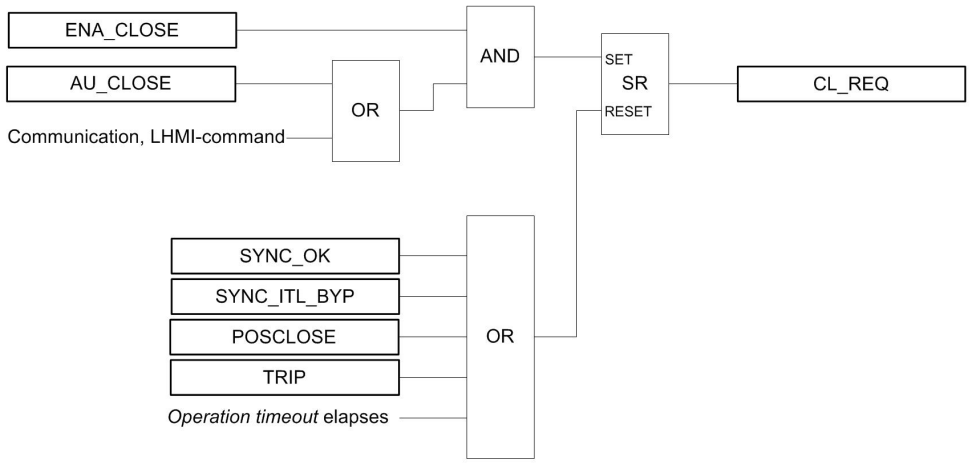



*Figure 722: Condition for enabling the close request (CL_REQ) for CBXCBR*

When the open command is given from communication, via LHMI or activating the AU_OPEN input, it is processed only if OPEN_ENAD is TRUE. OP_REQ output is also available.

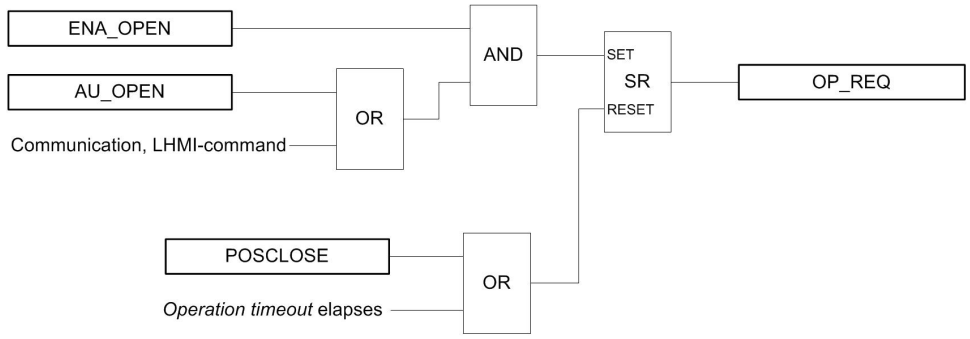



*Figure 723: Condition for enabling the open request (OP_REQ) for CBXCBR*

## OPEN and CLOSE outputs

The EXE_OP output is activated when the open command is given (AU_OPEN, via communication or from LHMI) and OPEN_ENAD signal is TRUE. In addition, the protection trip commands can be routed through the CBXCBR function by using the TRIP input. When the TRIP input is TRUE, the EXE_OP output is activated immediately and bypassing all enabling or blocking conditions.

The EXE_CL output is activated when the close command is given (AU_CLOSE, via communication or from LHMI) and CLOSE_ENAD signal is TRUE. When the TRIP input is “TRUE”, CB closing is not allowed.

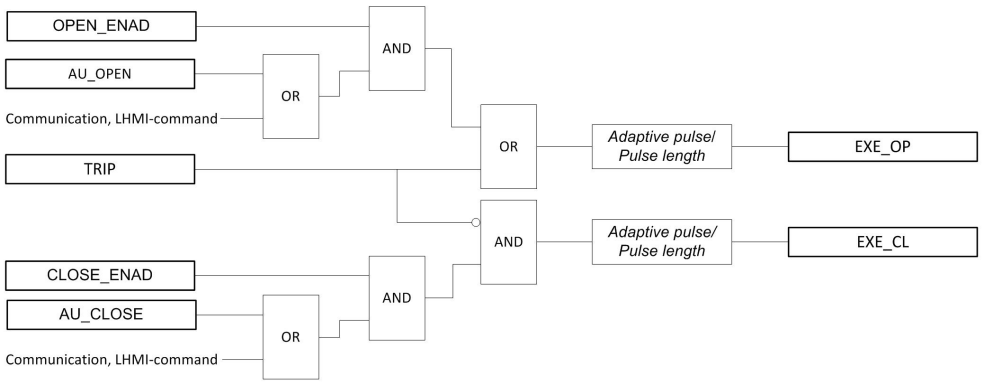



*Figure 724: OPEN and CLOSE outputs logic for CBXCBR*

## Opening and closing pulse widths

The pulse width type can be defined with the *Adaptive pulse* setting. The function provides two modes to characterize the opening and closing pulse widths. When the *Adaptive pulse* is set to "TRUE", it causes a variable pulse width, which means that the output pulse is deactivated when the object state shows that the apparatus has entered the correct state. If apparatus fails to enter the correct state, the output pulse is deactivated after the set *Operation timeout* setting, and an error message is displayed. When the *Adaptive pulse* is set to "FALSE", the functions always use the maximum pulse width, defined by the user-configurable *Pulse length* setting. The *Pulse length* setting is the same for both the opening and closing commands. When the apparatus already is in the right position, the maximum pulse length is given.

The *Pulse length* setting does not affect the length of the trip pulse.

## Control methods

The command execution mode can be set with the *Control model* setting. The alternatives for command execution are direct control and secured object control, which can be used to secure controlling.

The secured object control SBO is an important feature of the communication protocols that support horizontal communication, because the command reservation and interlocking signals can be transferred with a bus. All secured control operations require two-step commands: a selection step and an execution step. The secured object control is responsible for the several tasks.

- Command authority: ensures that the command source is authorized to operate the object
- Mutual exclusion: ensures that only one command source at a time can control the object
- Interlocking: allows only safe commands
- Execution: supervises the command execution
- Command canceling: cancels the controlling of a selected object.

In direct operation, a single message is used to initiate the control action of a physical device. The direct operation method uses less communication network capacity and bandwidth than the SBO method, because the procedure needs fewer messages for accurate operation.

The “status-only” mode means that control is not possible (non-controllable) via communication or from LHMI. However, it is possible to control a disconnector (DCXSWI) from AU_OPEN and AU_CLOSE inputs.



AU_OPEN and AU_CLOSE control the object directly regardless of the set *Control model*. These inputs can be used when control is wanted to be implemented purely based on ACT logic and no additional exception handling is needed. However, in case of simultaneous open and close control, the open control is always prioritized.

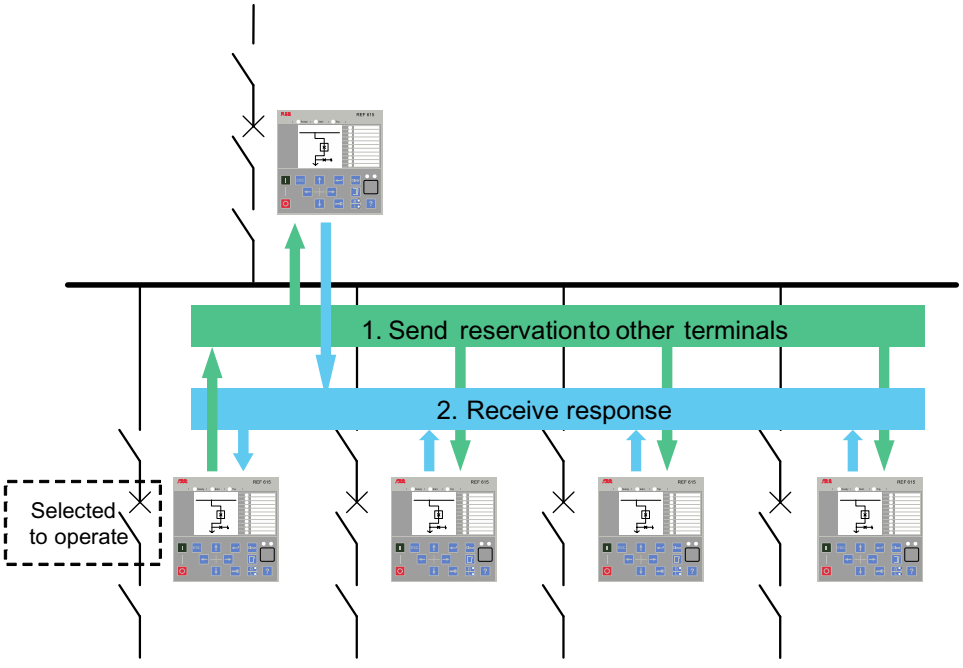



*Figure 725: Control procedure in the SBO method*

### Local/Remote operations

The local/remote selection affects the CBXCBR, DCXSWI and ESXSWI.

- Local: the opening and closing via communication is disabled.
- Remote: the opening and closing via LHMI is disabled.
- AU_OPEN and AU_CLOSE inputs function regardless of the local/remote selection.

## 9.1.5 Application

In the field of distribution and sub-transmission automation, reliable control and status indication of primary switching components both locally and remotely is in a significant role. They are needed especially in modern remotely controlled substations.

Control and status indication facilities are implemented in the same package with CBXCBR, DCXSWI and ESXSWI. When primary components are controlled in the energizing phase, for example, the correct execution sequence of the control commands must be ensured. This can be achieved, for example, with interlocking based on the status indication of the related primary components. The interlocking on the substation level can be applied using the IEC61850 GOOSE messages between feeders.

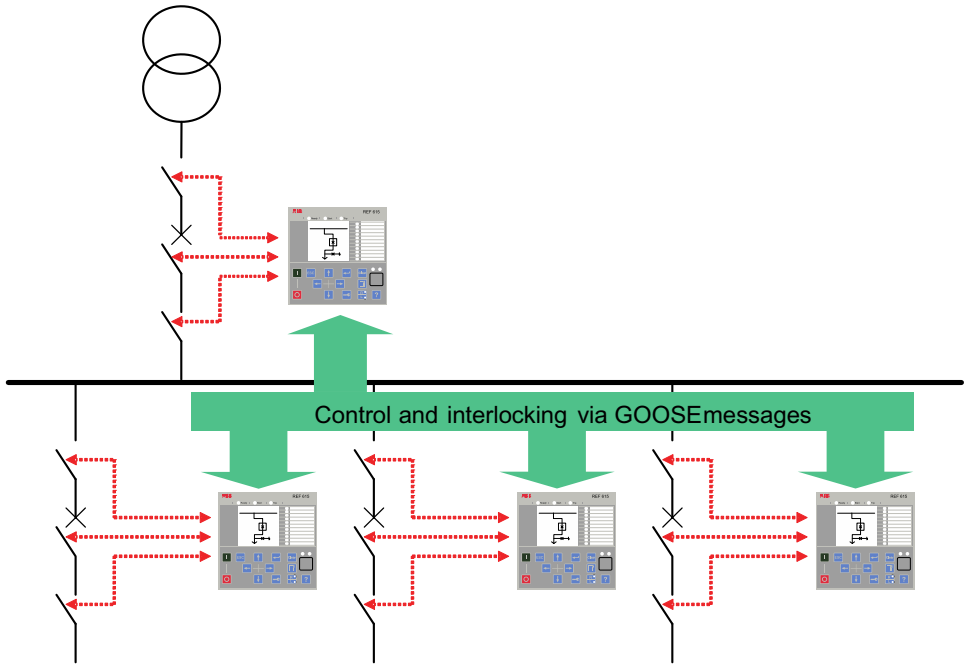



*Figure 726: Status indication-based interlocking via the GOOSE messaging*

## 9.1.6 Signals

*Table 1300: CBXCBR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |
| ENA_OPEN | BOOLEAN | 1=True | Enables opening |
| ENA_CLOSE | BOOLEAN | 1=True | Enables closing |
| BLK_OPEN | BOOLEAN | 0=False | Blocks opening |
| BLK_CLOSE | BOOLEAN | 0=False | Blocks closing |
| AU_OPEN | BOOLEAN | 0=False | Auxiliary open |
| AU_CLOSE | BOOLEAN | 0=False | Auxiliary close |
| TRIP | BOOLEAN | 0=False | Trip signal |
| SYNC_OK | BOOLEAN | 1=True | Synchronism-check OK |
| SYNC_ITL_BYP | BOOLEAN | 0=False | Discards ENA_OPEN and ENA_CLOSE interlocking when TRUE |

*Table 1301: DCXSWI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |
| ENA_OPEN | BOOLEAN | 1=True | Enables opening |
| ENA_CLOSE | BOOLEAN | 1=True | Enables closing |
| BLK_OPEN | BOOLEAN | 0=False | Blocks opening |
| BLK_CLOSE | BOOLEAN | 0=False | Blocks closing |
| AU_OPEN | BOOLEAN | 0=False | Auxiliary open |
| AU_CLOSE | BOOLEAN | 0=False | Auxiliary close |
| ITL_BYPASS | BOOLEAN | 0=False | Discards ENA_OPEN and ENA_CLOSE interlocking when TRUE |

*Table 1302: ESXSWI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |
| ENA_OPEN | BOOLEAN | 1=True | Enables opening |
| ENA_CLOSE | BOOLEAN | 1=True | Enables closing |
| BLK_OPEN | BOOLEAN | 0=False | Blocks opening |
| BLK_CLOSE | BOOLEAN | 0=False | Blocks closing |
| AU_OPEN | BOOLEAN | 0=False | Auxiliary open |
| AU_CLOSE | BOOLEAN | 0=False | Auxiliary close |
| ITL_BYPASS | BOOLEAN | 0=False | Discards ENA_OPEN and ENA_CLOSE interlocking when TRUE |

*Table 1303: CBXCBR Output signals*

| Name | Type | Description |
|---|---|---|
| SELECTED | BOOLEAN | Object selected |
| EXE_OP | BOOLEAN | Executes the command for open direction |
| EXE_CL | BOOLEAN | Executes the command for close direction |
| OP_REQ | BOOLEAN | Open request |
| CL_REQ | BOOLEAN | Close request |
| OPENPOS | BOOLEAN | Apparatus open position |
| CLOSEPOS | BOOLEAN | Apparatus closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |
| OPEN_ENAD | BOOLEAN | Opening is enabled based on the input status |
| CLOSE_ENAD | BOOLEAN | Closing is enabled based on the input status |

*Table 1304: DCXSWI Output signals*

| Name | Type | Description |
|---|---|---|
| SELECTED | BOOLEAN | Object selected |
| EXE_OP | BOOLEAN | Executes the command for open direction |
| EXE_CL | BOOLEAN | Executes the command for close direction |
| OPENPOS | BOOLEAN | Apparatus open position |
| CLOSEPOS | BOOLEAN | Apparatus closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |
| OPEN_ENAD | BOOLEAN | Opening is enabled based on the input status |
| CLOSE_ENAD | BOOLEAN | Closing is enabled based on the input status |

*Table 1305: ESXSWI Output signals*

| Name | Type | Description |
|---|---|---|
| SELECTED | BOOLEAN | Object selected |
| EXE_OP | BOOLEAN | Executes the command for open direction |
| EXE_CL | BOOLEAN | Executes the command for close direction |
| OPENPOS | BOOLEAN | Apparatus open position |
| CLOSEPOS | BOOLEAN | Apparatus closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |
| OPEN_ENAD | BOOLEAN | Opening is enabled based on the input status |
| CLOSE_ENAD | BOOLEAN | Closing is enabled based on the input status |

## 9.1.7 Settings

*Table 1306: CBXCBR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation mode on/off |
| Select timeout | 10000...300000 | ms | 10000 | 30000 | Select timeout in ms |
| Pulse length | 10...60000 | ms | 1 | 200 | Open and close pulse length |
| Control model | 0=status-only<br>1=direct-with-normal-security<br>4=sbo-with-enhanced-security | | | 4=sbo-with-enhanced-security | Select control model |
| Operation timeout | 10...60000 | ms | 1 | 500 | Timeout for negative termination |
| Identification | | | | CBXCBR1 switch position | Control Object identification |

*Table 1307: CBXCBR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation counter | 0...99999 | | 1 | 0 | Nr of opening operations |
| Adaptive pulse | 0=False<br>1=True | | | 1=True | Deactivate control pulse when apparatus has reached correct position |
| Event delay | 0...10000 | ms | 1 | 200 | Event delay of the intermediate and faulty position |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

*Table 1308: DCXSWI Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation mode on/off |
| Select timeout | 10000...300000 | ms | 10000 | 30000 | Select timeout in ms |
| Pulse length | 10...60000 | ms | 1 | 100 | Open and close pulse length |
| Control model | 0=status-only<br>1=direct-with-normal-security<br>4=sbo-with-enhanced-security | | | 4=sbo-with-enhanced-security | Select control model |
| Operation timeout | 10...60000 | ms | 1 | 30000 | Timeout for negative termination |
| Identification | | | | DCXSWI1 switch position | Control Object identification |

*Table 1309: DCXSWI Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation counter | 0...10000 | | 1 | 0 | Nr of opening operations |
| Adaptive pulse | 0=False<br>1=True | | | 1=True | Deactivate control pulse when apparatus has reached correct position |
| Event delay | 0...60000 | ms | 1 | 10000 | Event delay of the intermediate and faulty position |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

*Table 1310: ESXSWI Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation mode on/off |
| Select timeout | 10000...300000 | ms | 10000 | 30000 | Select timeout in ms |
| Pulse length | 10...60000 | ms | 1 | 100 | Open and close pulse length |
| Control model | 0=status-only<br>1=direct-with-normal-security<br>4=sbo-with-enhanced-security | | | 4=sbo-with-enhanced-security | Select control model |
| Operation timeout | 10...60000 | ms | 1 | 30000 | Timeout for negative termination |
| Identification | | | | ESXSWI1 switch position | Control Object identification |

*Table 1311: ESXSWI Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation counter | 0...10000 | | 1 | 0 | Nr of opening operations |
| Adaptive pulse | 0=False<br>1=True | | | 1=True | Deactivate control pulse when apparatus has reached correct position |
| Event delay | 0...60000 | ms | 1 | 10000 | Event delay of the intermediate and faulty position |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

## 9.1.8 Monitored data

*Table 1312: CBXCBR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Apparatus position indication |

*Table 1313: DCXSWI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Apparatus position indication |

*Table 1314: ESXSWI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Apparatus position indication |

# 9.2 Three-state disconnector control P3SXSWI

## 9.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-state disconnector control | P3SXSWI | I<->O P3S | 29DS/GS |

## 9.2.2 Function block

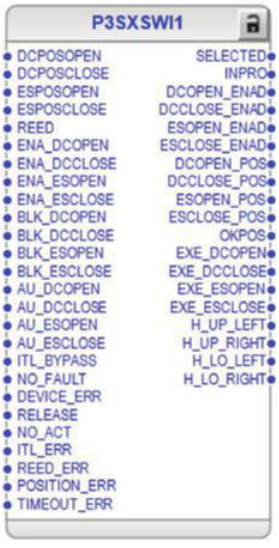



*Figure 727: Function block*

## 9.2.3 Functionality

The three-state disconnector control function P3SXSWI is used to control a three-state switch (disconnector closed, both open, earthing switch closed) and to provide status information on the MV air-insulated switchgear (AIS) and gas-insulated switchgear (GIS). P3SXSWI executes commands to RIO600 SCM or directly drives the switchgear motor by direct control of the protection relay's H-bridge (if available). The function evaluates blocking conditions and different supervision conditions and it performs an execution command only if all conditions are fulfilled. If erroneous conditions occur, the function indicates an appropriate cause value. The function is designed according to the IEC 61850-7-4 standard including logical nodes CILO, CSWI and XSWI.

P3SXSWI has operation counters for disconnector operation and earthing switch operation. The counter values can be read and written remotely from the place of operation or via LHMI.

The function can also be configured to handle only two-position switches (earthing switch or disconnector).

## 9.2.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The switch type is determined depending on the connected inputs in Application Configuration.

- If inputs `DCPOSOPEN`, `DCPOSCLOSE`, `ESPOSOPEN` and `ESPOSCLOSE` are connected, the switch type is three-position switch.
- When only inputs `DCPOSOPEN` and `DCPOSCLOSE` are connected, the switch type is disconnector.
- When only inputs `ESPOSOPEN` and `ESPOSCLOSE` are connected, the switch type is earthing switch.

Any other connection leads to a configuration error.

The motor control application of the three-position switch can be selected with parameter setting *Control mode*. If "With RIO600 SCM" is selected, the motor control is handled externally by the RIO600 SCM module; the protection relay only supervises the switch position and interlocking but provides commands to RIO600. If "Direct control" is selected, the motor control is handled by the protection relay's H-bridge and no external RIO600 SCM device is needed.

### Position indication and validity check

Depending on the switch type connection, a three-position switch, disconnector or earthing switch can be configured.

Be aware of the physical switch type and corresponding connections in Application Configuration, both for P3SXSWI and in RIO600 SCM, if used. A wrong connection according to the physical switch type can cause misleading position indication.

In certain three-position switches an additional reed contact is available to indicate safe earthing. The contact is TRUE only when the earthing switch is in closed position. The reed contact is given a short time window to confirm closed earthing switch position, in case of vibrations. If the earthing switch has closed but the reed contact does not close within the time window, faulty position is reported.

*Table 1315: Reed contact detection*

| Control mode | Reed contact detection |
|---|---|
| Direct control | The availability of the reed contact needs to be set through the *Reed contact* setting by setting it as "Available". The reed contact signal is connected at input REED. |
| With RIO600 SCM | Reed detection is handled externally by the module. The input ESPOSCLOSE is not indicated TRUE by RIO600 if reed contact closing is not detected. Therefore, unsecure earthing is reported to input REED_ERR so that P3SXSWI can indicate faulty position in this control mode. |

The state of the switch is indicated at outputs DCCLOSE_POS, DCOPEN_POS, ESCLOSE_POS and ESOPEN_POS together with the OKPOS information.

Debouncing and short disturbances in an input are eliminated by filtering. The binary input filtering timer can be adjusted separately for each digital input used by the function block. The reporting of faulty or intermediate position of the apparatus occurs after the *Event delay* setting.

*Table 1316: Status indication for a three-position switch with auxiliary contacts in direct control mode*

| Status | Inputs | | | | | Outputs | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| POSITION | DCPOSCLOSE | DCPOSOPEN | ESPOSCLOSE | ESPOSOPEN | REED | DCCLOSE_POS | DCOPEN_POS | ESCLOSE_POS | ESOPEN_POS | OKPOS |
| Disconnector closed | 1 | 0 | 0 | 1 | x | 1 | 0 | 0 | 1 | 1 |
| Disconnector intermediate | 0 | 0 | 0 | 1 | x | 0 | 0 | 0 | 1 | 0 |
| Both open | 0 | 1 | 0 | 1 | x | 0 | 1 | 0 | 1 | 1 |
| Earthing switch intermediate | 0 | 1 | 0 | 0 | x | 0 | 1 | 0 | 0 | 0 |
| Earthing switch closed | 0 | 1 | 1 | 0 | 1[1)] | 0 | 1 | 1 | 0 | 1 |
| Faulty | 0 | 1 | 1 | 0 | 0[2)] | 0 | 1 | 0 | 0 | 0 |
| Faulty | 0 | 1 | 1 | 1 | x | 0 | 1 | 0 | 0 | 0 |
| Faulty | 1 | 1 | 0 | 1 | x | 0 | 0 | 0 | 1 | 0 |
| Faulty | 1 | x | 1 | x | x | 0 | 0 | 0 | 0 | 0 |
| Faulty | x | 0 | x | 0 | x | 0 | 0 | 0 | 0 | 0 |
| x = no difference | | | | | | | | | | |

1) REED input has been detected as closed within time-out and earthing switch is indicated as closed.
2) REED input has not been detected as closed within time-out and faulty position is indicated.

The REED input is only supervised during a short time window when earthing switch has closed and if *Reed contact* setting is set as "Available" in direct control mode.

When a two-position switch type is used, the opponent switch outputs are disabled. For example, if the switch type is disconnector, the status of the two-position switch is based only on the connected inputs DCPOSOPEN and DCPOSCLOSE. Furthermore, the outputs ESOPEN_POS and ESCLOSE_POS are disabled.

Common three-position status is indicated at variable POSITION, regardless of the switch type. For example, if only a disconnector is available, and the disconnector is in open state, the open indication equals “both open”.

*Table 1317: Position indication values based on switch type*

| Status | Switch type | | |
|---|---|---|---|
| POSITION | Three-position switch | Disconnector | Earthing switch |
| Earthing switch closed | Earthing switch closed and disconnector open | N/A | Earthing switch closed |
| Earthing switch intermediate | Earthing switch intermediate and disconnector open | N/A | Earthing switch intermediate |
| Both open | Earthing switch open and disconnector open | Disconnector open | Earthing switch open |
| Disconnector intermediate | Earthing switch open and disconnector intermediate | Disconnector intermediate | N/A |
| Disconnector closed | Earthing switch open and disconnector closed | Disconnector closed | N/A |
| Faulty | Earthing switch faulty or disconnector faulty (or incorrect combination) | Faulty | Faulty |

When controlling P3SXSWI with RIO600 SCM, the switch's position information should be made available to the function in the protection relay via GOOSE or binary inputs from RIO600 to reflect correct position and status information.

## Control of a three-position switch

There are three possible end positions in a three-position switch: earthing switch closed, both open, and disconnector closed. Additionally, there are two intermediate states: earthing switch intermediate and disconnector intermediate. The function follows the command order in cyclic order as shown in Figure 728. For example, at disconnector close state only disconnector open command can be executed. Similarly, when the state is both open, both disconnector close and earth close commands can be executed. When the switch indicates earthing switch or disconnector intermediate position (for example, the motor has stopped due to timeout), a specified open command is allowed only.

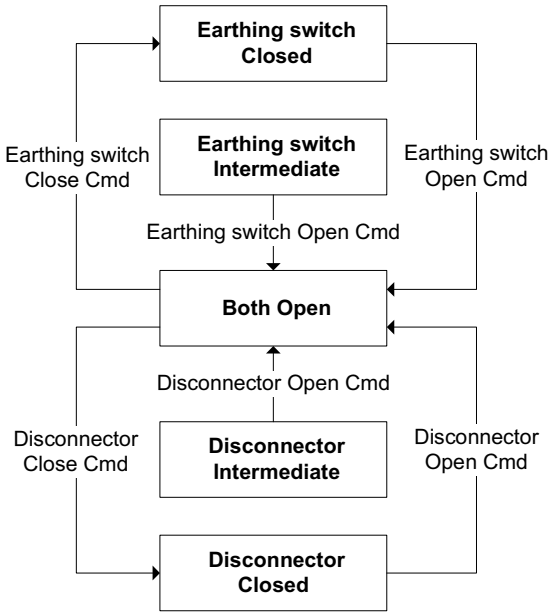



*Figure 728: Control of a three-position switch by commands*

## Blocking

The function has a blocking functionality to prevent human errors that can cause injuries to the operator and damages to the system components.

The control operations are allowed if the interlocking signals for the operations are TRUE. These signals are ENA_DCOPEN, ENA_DCCLOSE, ENA_ESOPEN and ENA_ESCLOSE.

In addition, the function provides a general interlocking bypass input ITL_BYPASS. When ITL_BYPASS is TRUE, the apparatus can be controlled by discarding the ENA_DCOPEN, ENA_DCCLOSE, ENA_ESOPEN and ENA_ESCLOSE input states.

However, the BLK_DCOPEN, BLK_DCCLOSE, BLK_ESOPEN and BLK_ESCLOSE input signals are not bypassed with the interlocking bypass functionality since they always have higher priority.

In Table 1318 the interlocking condition is switch-specific by row.

*Table 1318: Interlocking conditions for enabling the closing/opening command*

| Inputs | | | Outputs |
|---|---|---|---|
| ITL_BYPASS | ENA_DCCLOSE | BLK_DCCLOSE | DCCLOSE_ENAD |
| | ENA_DCOPEN | BLK_DCOPEN | DCOPEN_ENAD |
| | ENA_ESCLOSE | BLK_ESCLOSE | ESCLOSE_ENAD |
| | ENA_ESOPEN | BLK_ESOPEN | ESOPEN_ENAD |
| 0 = False | 0 = False | 0 = False | 0 = False |
| 0 = False | 0 = False | 1 = True | 0 = False |
| 0 = False | 1 = True | 0 = False | 1 = True |

Table continues on next page

| Inputs | | | Outputs |
|---|---|---|---|
| ITL_BYPASS | ENA_DCCLOSE | BLK_DCCLOSE | DCCLOSE_ENAD |
| | ENA_DCOPEN | BLK_DCOPEN | DCOPEN_ENAD |
| | ENA_ESCLOSE | BLK_ESCLOSE | ESCLOSE_ENAD |
| | ENA_ESOPEN | BLK_ESOPEN | ESOPEN_ENAD |
| 0 = False | 1 = True | 1 = True | 0 = False |
| 1 = True | 0 = False | 0 = False | 1 = True |
| 1 = True | 0 = False | 1 = True | 0 = False |
| 1 = True | 1 = True | 0 = False | 1 = True |
| 1 = True | 1 = True | 1 = True | 0 = False |

However, the enabled outputs also depend on the actual position of the switch, according to Figure 728 and if any motor operation is ongoing. Internal blocking based on switch position or motor in progress always overrides the enabled output regardless of the status of enable, block and interlock bypass inputs.

For two-position switches, the enabling outputs of the opposite switch type are disabled regardless of the input status. For example, if the switch type is earthing switch, DCCLOSE_ENAD and DCOPEN_ENAD are forced to FALSE.

Operation of the three-position switch is permitted only when the circuit breaker is in open position. The closed circuit breaker information can be connected to the BLK inputs in Application Configuration.

## Various operations

The required operation command is available via communication, binary inputs or LHMI. As a prerequisite for control commands, there are enabling and blocking functionalities for all the operations. If the control command is executed against the blocking or if the enabling of the corresponding command is not valid, the function generates an error message. The command operations are requested through binary inputs AU_DCOPEN, AU_DCCLOSE, AU_ESOPEN and AU_ESCLOSE. The requested operation is possible provided the apparatus is not blocked by the interlocking logic and no other previous request is active.

When the function block is selected for performing any of the operations locally from the HMI, the output SELECTED is activated. Once the function is selected, the command for execution of operation should be issued before *Select timeout* time lapses.

The function contains two operation counters: disconnector counter *Operation counter DC* and earthing switch counter *Operation counter ES*. The first one indicates each disconnector opening state and the latter one indicates each earthing switch opening state. The counter values are resettable and writable and stored in a nonvolatile memory.

Output INPRO indicates any active motor operation, including braking and pause operation.

### 9.2.4.1 Control of three-position switch using RIO600 smart control module

When using RIO600 smart control module (SCM) for controlling a three-position switch, the setting *Control mode* should be set as "With RIO600 SCM".

SCM is available with RIO600 to be able to drive a three-position switch. The motor of the three-position switch is directly driven by the RIO600 SCM. RIO600 sends the status information to the protection relay by GOOSE communication, and the switch position is indicated on the HMI on the protection relay. When a three-position switch operation is requested and enabled by the protection relay, it generates commands via EXE_DCOPEN, EXE_DCCLOSE, EXE_ESOPEN or EXE_ESCLOSE, which are transmitted to RIO600 over GOOSE communication. Though the command handling is pre-checked by P3SXSWI, RIO600 SCM further checks for command priority and if the requested command is allowed. The commands are always checked on rising edge by the RIO600 SCM.

In RIO600 SCM control mode, the operation timeouts in P3SXSWI are not available due to external motor handling by the SCM module. Status feedback from the module is returned to the protection relay via GOOSE. The inputs for P3SXSWI shown in Figure 729 must be connected by GOOSE status signals from SCM. Input REED remains unconnected in this control mode.

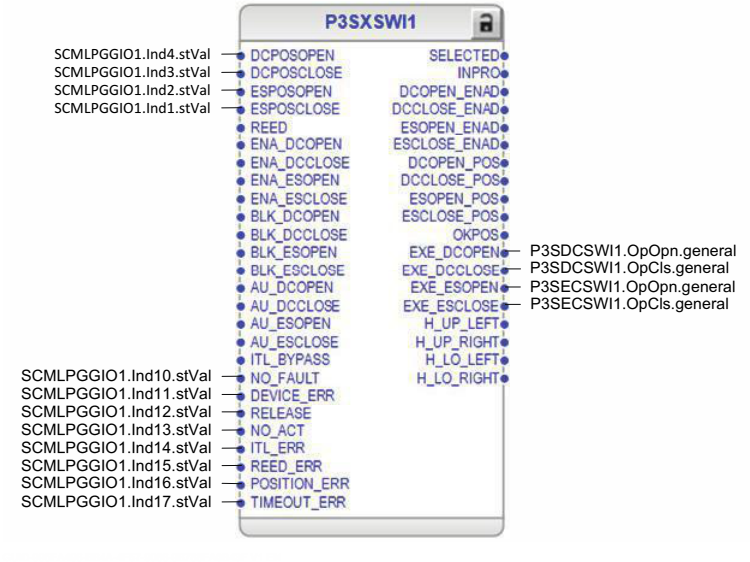



*Figure 729: Connections in P3SXSWI when using RIO600 SCM for a three-position switch*

See the RIO600 and SCM manual when using RIO600 SCM for three-position switch motor control. All the signals from RIO600 must be connected to the P3SXSWI function block as in Figure 3.

### 9.2.4.2 Control of three-position switch using H-bridge with static outputs of the protection relay

When using the protection relay for direct motor control of the three-position switch, the setting *Control mode* must be set as "Direct control".

If the protection relay is equipped with static outputs, the three-position switchgear motor can be controlled with an H-bridge. The function has four outputs for motor control.

- H-bridge upper-left: `H_UP_LEFT`
- H-bridge upper-right: `H_UP_RIGHT`
- H-bridge lower-left: `H_LO_LEFT`
- H-bridge lower-right: `H_LO_RIGHT`

These outputs must be connected to the static outputs of the protection relay. With the H-bridge functionality it is possible to drive the motor to left or to right, and brake the motor. The auxiliary voltage ($U_{aux}$) connected to the H-bridge has to match the voltage of the motor.

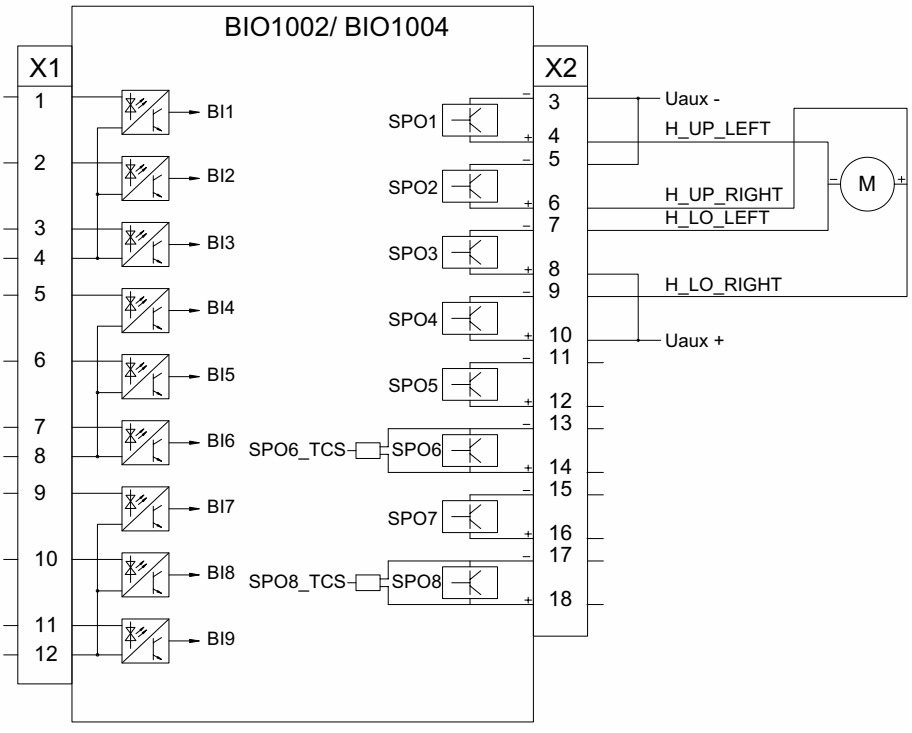



*Figure 730: H-bridge motor control for a protection relay equipped with BIO1002 module*

*Table 1319: H-bridge motor operation depending on active outputs*

| Motor direction | Static outputs | | | |
|---|---|---|---|---|
| | H_UP_LEFT | H_UP_RIGHT | H_LO_LEFT | H_LO_RIGHT |
| Motor right | 1 | 0 | 0 | 1 |
| Motor left | 0 | 1 | 1 | 0 |
| Motor brake | 1 | 1 | 0 | 0 |
| Motor brake | 0 | 0 | 1 | 1 |
| Motor free | 0 | 0 | 0 | 0 |



Be aware of the motor polarity so that a correct connection between the motor and the H-bridge is established. The H-bridge needs to be properly connected to the static outputs of the protection relay in Application Configuration. Wrong connections affect the motor functionality and may cause personal injury or damage to the equipment.

## Motor logic and parameters

To prevent damage to the motor, the motor is protected by several settable timeouts. With setting parameter *Motor start timeout*, the maximum start time for the motor to recognize a position indication change is defined. If a position indication change is not recognized during this time, the motor is stopped. If *Motor start timeout* is set to zero, the motor start timeout is disabled.

With timeout *Operation timeout DC*, the maximum time for the disconnector to go from one state to another is defined.

With timeout *Operation timeout ES*, the maximum time for the earthing switch to go from one state to another is defined. If a state change is not fulfilled within this time, the motor is stopped.

If an unexpected position is detected based on the requested command, in other words the motor is running in the wrong direction, or if faulty position of the switch is detected, the motor is immediately stopped. Additionally, an activated block input that corresponds to the active command stops the running motor immediately.

If any of the cases above occur, the specific event is displayed on the HMI or reported via communication.

When the motor operates and reaches the final destination, the motor brakes if the *Motor braking* setting is selected as "True". The braking time of the motor is selectable with the *Motor brake time* parameter. After the motor has braked and stopped, the motor is in a free state, meaning that the switch is mechanically operable by hand-crank. A successful operation is also displayed on the HMI or reported via communication.

After each operation the motor is paused for one second before any new control command can pass through.

### 9.2.4.3 Control methods

The command execution mode can be set with the *Control model* setting. The alternatives for command execution are direct control and secured object control, which can be used to secure controlling.

The secured object control SBO is an important feature of the communication protocols that support horizontal communication, because the command reservation and interlocking signals can be transferred with a bus. All secured control operations require two-step commands: a selection step and an execution step. The secured object control is responsible for several tasks.

- Command authority: ensures that the command source is authorized to operate the object
- Mutual exclusion: ensures that only one command source at a time can control the object
- Interlocking: allows only safe commands
- Execution: supervises the command execution
- Command canceling: cancels the controlling of a selected object

In direct operation, a single message is used to initiate the control action of a physical device. The direct operation method uses less communication network capacity and bandwidth than the SBO method, because the procedure needs fewer messages for accurate operation.

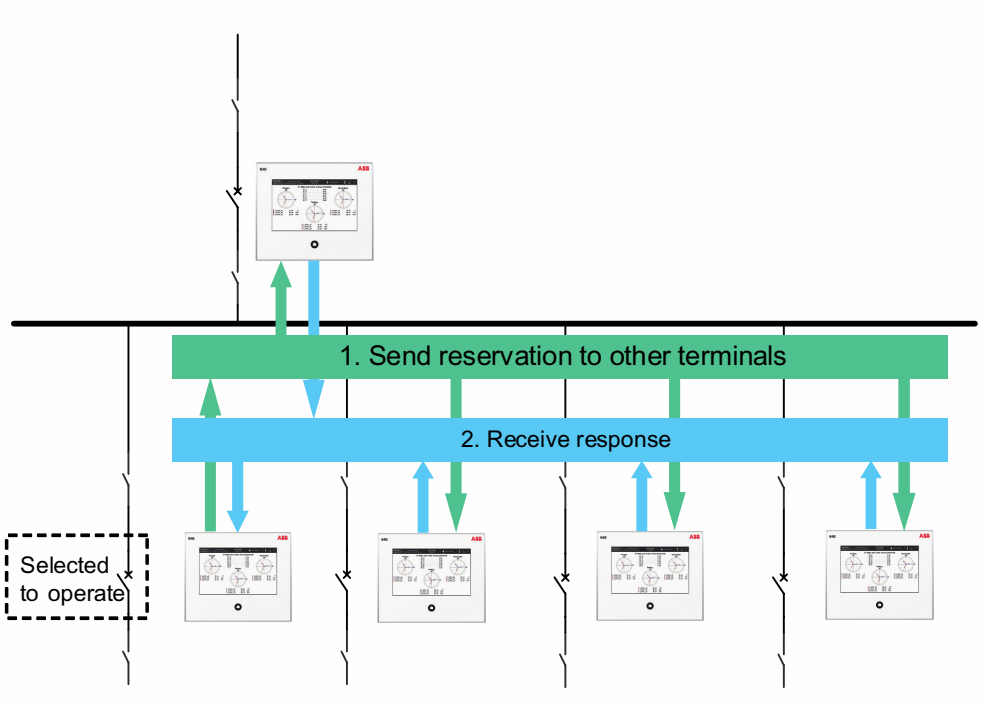



*Figure 731: Control procedure in the SBO method*

## 9.2.5 Application

In the field of distribution and sub-transmission, automatic, reliable control and status indication of primary switching components, both locally and remotely, are of significant importance. They are needed especially in modern remotely controlled substations.

P3SXSWI is designed to be used for the control of two- (open, closed) and three-state (earthing switch closed, disconnector closed and both open) switches. The function also handles user-defined interlocking logics and provides commands.

Control and status indication facilities are implemented in the same package with P3SXSWI. When primary components are controlled in the energizing phase, for example, the correct execution sequence of the control command must be ensured. This can be achieved, for example, with interlocking based on the status indication of the related primary components.

The interlocking on the substation level can be applied using the IEC 61850 GOOSE message between feeders.

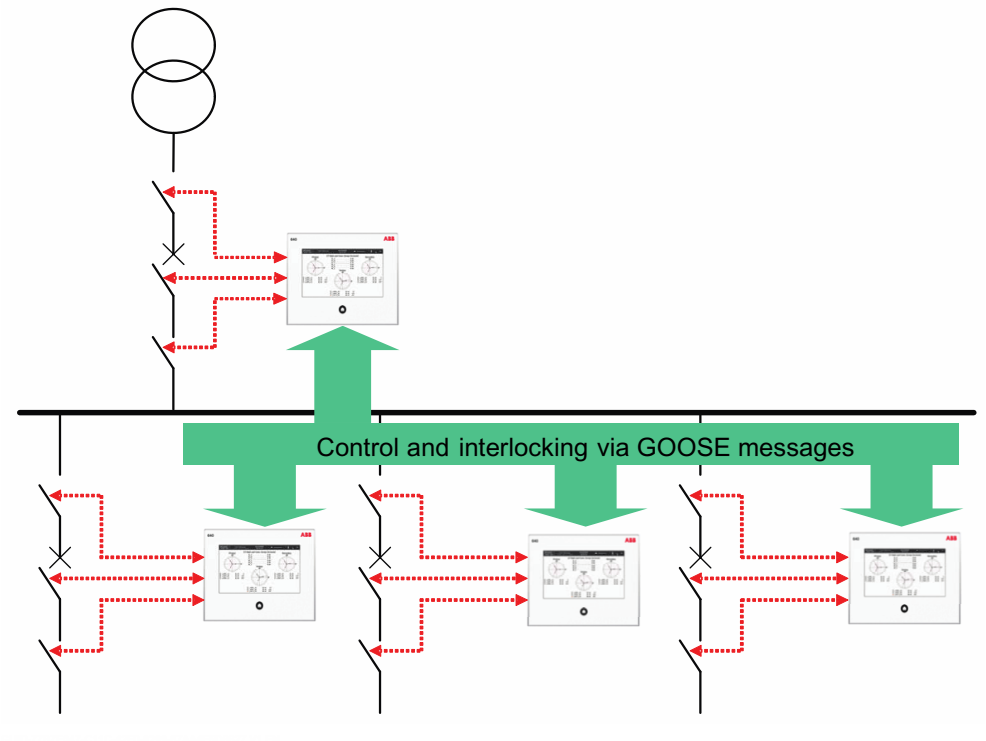



*Figure 732: Status indication-based interlocking via the GOOSE messaging*

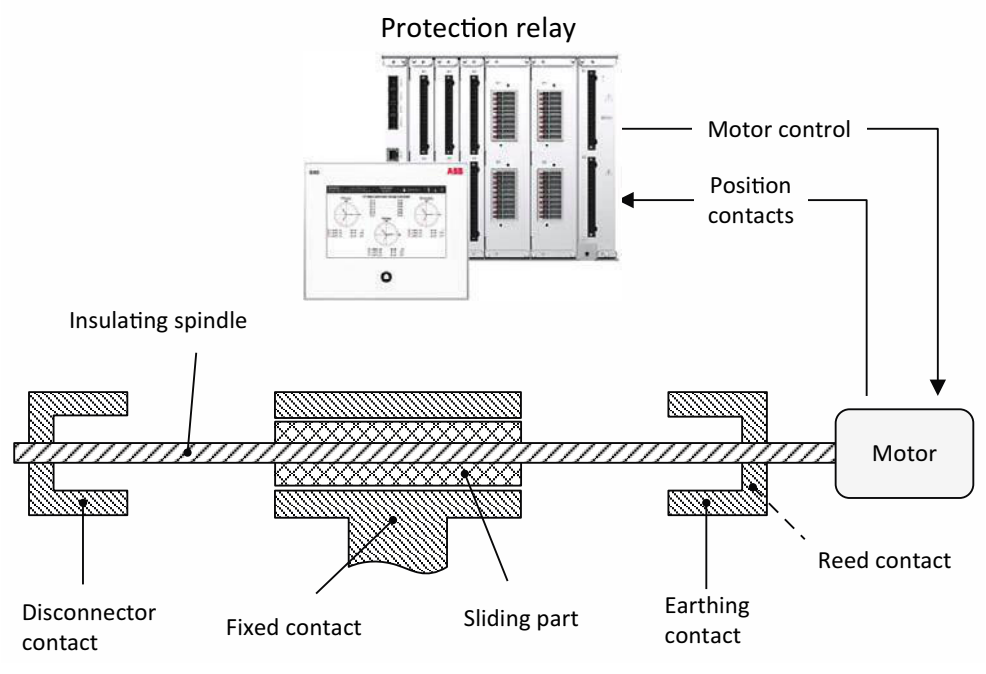



*Figure 733: Connection diagram for direct control of a three-position switchgear motor*

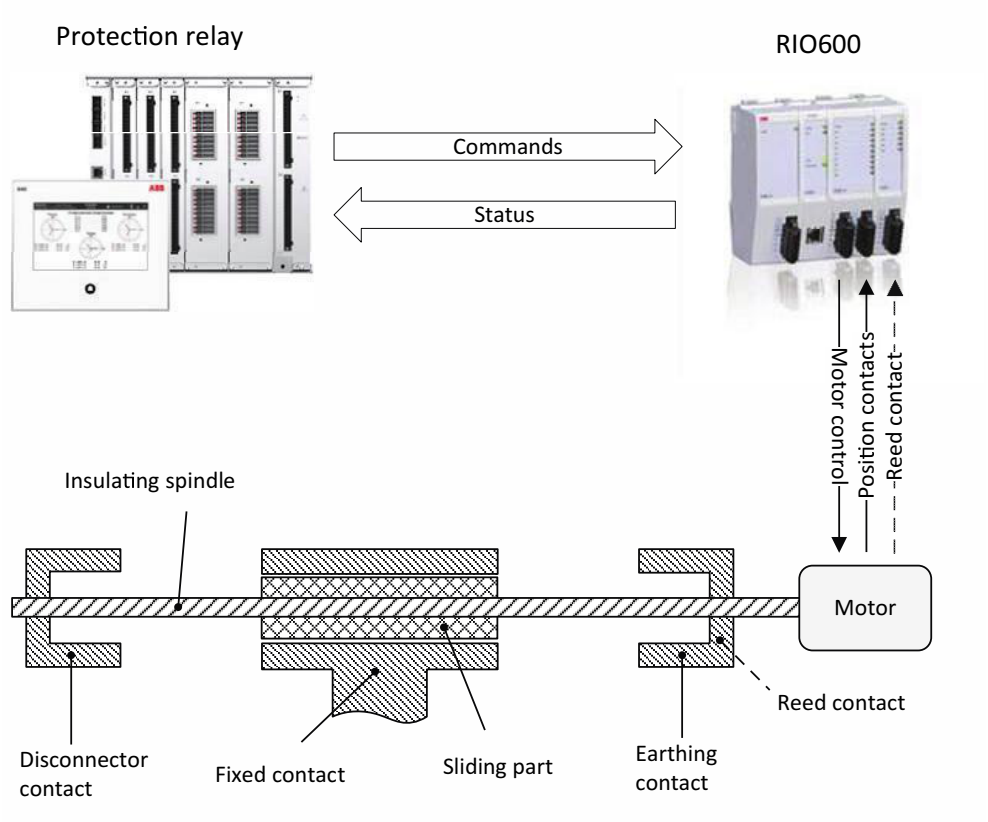



*Figure 734: Connection diagram for RIO600 control of a three-position switchgear motor*

When the RIO600 SCM module is selected as control mode, outputs EXE_DCCLOSE, EXE_DCOPEN, EXE_ESCLOSE and EXE_ESOPEN are connected in Application Configuration. When direct motor control is selected as control mode, static outputs H_UP_LEFT, H_UP_RIGHT, H_LO_LEFT and H_LO_RIGHT are connected in Application Configuration.

## 9.2.6 Signals

*Table 1320: P3SXSWI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| DCPOSOPEN | BOOLEAN | 0=False | Signal for open position of disconnector |
| DCPOSCLOSE | BOOLEAN | 0=False | Signal for close position of disconnector |
| ESPOSOPEN | BOOLEAN | 0=False | Signal for open position of earthing switch |
| ESPOSCLOSE | BOOLEAN | 0=False | Signal for close position of earthing switch |
| REED | BOOLEAN | 0=False | Signal for close position of reed contact |
| Table continues on next page | | | |

| Name | Type | Default | Description |
|---|---|---|---|
| ENA_DCOPEN | BOOLEAN | 1=True | Enables opening command for disconnector |
| ENA_DCCLOSE | BOOLEAN | 1=True | Enables closing command for disconnector |
| ENA_ESOPEN | BOOLEAN | 1=True | Enables opening command for earthing switch |
| ENA_ESCLOSE | BOOLEAN | 1=True | Enables closing command for earthing switch |
| BLK_DCOPEN | BOOLEAN | 0=False | Blocks opening of disconnector |
| BLK_DCCLOSE | BOOLEAN | 0=False | Blocks closing of disconnector |
| BLK_ESOPEN | BOOLEAN | 0=False | Blocks opening of earthing switch |
| BLK_ESCLOSE | BOOLEAN | 0=False | Blocks closing of earthing switch |
| AU_DCOPEN | BOOLEAN | 0=False | Auxiliary open disconnector |
| AU_DCCLOSE | BOOLEAN | 0=False | Auxiliary close disconnector |
| AU_ESOPEN | BOOLEAN | 0=False | Auxiliary open earthing switch |
| AU_ESCLOSE | BOOLEAN | 0=False | Auxiliary close earthing switch |
| ITL_BYPASS | BOOLEAN | 0=False | Discards enable interlocking when TRUE |
| NO_FAULT | BOOLEAN | 1=True | RIO600 SCM no fault |
| DEVICE_ERR | BOOLEAN | 0=False | RIO600 SCM device error |
| RELEASE | BOOLEAN | 0=False | RIO600 SCM release information |
| NO_ACT | BOOLEAN | 1=True | RIO600 SCM no motor action |
| ITL_ERR | BOOLEAN | 0=False | RIO600 SCM interlocking error |
| REED_ERR | BOOLEAN | 0=False | RIO600 SCM reed error |
| POSITION_ERR | BOOLEAN | 0=False | RIO600 SCM position error |
| TIMEOUT_ERR | BOOLEAN | 0=False | RIO600 SCM timeout error |

*Table 1321: P3SXSWI Output signals*

| Name | Type | Description |
|---|---|---|
| SELECTED | BOOLEAN | Obejct selected |
| INPRO | BOOLEAN | Motor operation in progress |
| DCOPEN_ENAD | BOOLEAN | Disconnector opening is enabled |
| DCCLOSE_ENAD | BOOLEAN | Disconnector closing is enabled |
| ESOPEN_ENAD | BOOLEAN | Earthing switch opening is enabled |
| ESCLOSE_ENAD | BOOLEAN | Earthing switch closing is enabled |
| DCOPEN_POS | BOOLEAN | Disconnector in open position |
| DCCLOSE_POS | BOOLEAN | Disconnector in closed position |
| ESOPEN_POS | BOOLEAN | Earthing switch in open position |
| ESCLOSE_POS | BOOLEAN | Earthing switch in closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |
| EXE_DCOPEN | BOOLEAN | Command to RIO600 SCM for opening disconnector |
| EXE_DCCLOSE | BOOLEAN | Command to RIO600 SCM for closing disconnector |

Table continues on next page

| Name | Type | Description |
|---|---|---|
| EXE_ESOPEN | BOOLEAN | Command to RIO600 SCM for opening earthing switch |
| EXE_ESCLOSE | BOOLEAN | Command to RIO600 SCM for closing earthing switch |
| H_UP_LEFT | BOOLEAN | H-bridge output upper left |
| H_UP_RIGHT | BOOLEAN | H-bridge output upper right |
| H_LO_LEFT | BOOLEAN | H-bridge output lower left |
| H_LO_RIGHT | BOOLEAN | H-bridge output lower right |

## 9.2.7 Settings

*Table 1322: P3SXSWI Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Control mode | 1=Direct control<br>2=With RIO600 SCM | | | 1=Direct control | Direct control or RIO600 SCM control |
| Reed contact | 0=Not available<br>1=Available | | | 0=Not available | Availability of reed contact |
| Select timeout | 10000...300000 | ms | 10000 | 30000 | Select timeout in ms |
| Control model | 0=status-only<br>1=direct-with-normal-security<br>4=sbo-with-enhanced-security | | | 4=sbo-with-enhanced-security | Select control model |
| Operation timeout DC | 10...60000 | ms | 1 | 30000 | Timeout for negative termination for disconnector |
| Operation timeout ES | 10...60000 | ms | 1 | 30000 | Timeout for negative termination for earthing switch |
| Motor braking | 0=False<br>1=True | | | 1=True | Motor braking on/off selection |
| Identification | | | | P3SXSWI1 switch position | Control object identification |

*Table 1323: P3SXSWI Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation counter DC | 0...10000 | | 1 | 0 | Disconnector operation cycles |
| Operation counter ES | 0...10000 | | 1 | 0 | Earthing switch operation cycles |
| Event delay | 0...60000 | ms | 1 | 10000 | Event delay of intermediate or faulty position |
| Motor start timeout | 0...32000 | ms | 100 | 0 | Timeout for motor to start |
| Motor brake time | 10...500 | ms | 1 | 100 | Motor brake time |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

### 9.2.8 Monitored data

*Table 1324: P3SXSWI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Enum | 0=earthing switch closed<br>1=earthing switch intermediate<br>2=both open<br>3=disconnector intermediate<br>4=disconnector closed<br>5=faulty | | 3-position switch position |
| POSITION_DC | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Disconnector position |
| POSITION_ES | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Earthing switch position |
| SWTYPE | Enum | 1=3-position switch<br>2=Disconnector<br>3=Earthing switch<br>4=Unknown | | Switch type |

## 9.3 Three-state disconnector position indication P3SSXSWI

### 9.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-state disconnector position indication | P3SSXSWI | I<->O P3SS | 29DS/GS |

## 9.3.2 Function block

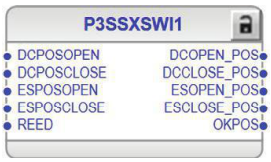



*Figure 735: Function block*

## 9.3.3 Functionality

The three-state disconnector position indication function P3SSXSWI provides status information on three-state switches: MV air-insulated switchgear (AIS) and gas-insulated switchgear (GIS). The function is designed according to the IEC 61850-7-4 standard including logical nodes CSWI and XSWI.

## 9.3.4 Operation principle

### Position indication

In certain three-position switches an additional reed contact is available to indicate safe earthing. The contact is TRUE only when the earthing switch is in closed position. The reed contact is given a short time window to confirm closed earthing switch position, in case of vibrations. If the earthing switch has closed but the reed contact does not close within the time window, faulty position is reported. The availability of the reed contact needs to be set through *Reed contact* setting by setting it as "Available". The reed contact signal is connected at input `REED` in this control mode.

The state of the switch is indicated at outputs `DCCLOSE_POS`, `DCOPEN_POS`, `ESCLOSE_POS` and `ESOPEN_POS` together with the `OKPOS` information.

Debouncing and short disturbances in an input are eliminated by filtering. The binary input filtering timer can be adjusted separately for each digital input used by the function block. The reporting of faulty or intermediate position of the apparatus occurs after the *Event delay* setting. A common three-position status is indicated at variable POSITION.

*Table 1325: Status indication for a three-position switch based on auxiliary contacts*

| Status | Inputs | | | | | Outputs | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| POSITION | DCPOSCLOSE | DCPOSOPEN | ESPOSCLOSE | ESPOSOPEN | REED | DCCLOSE_POS | DCOPEN_POS | ESCLOSE_POS | ESOPEN_POS | OKPOS |
| Disconnector closed | 1 | 0 | 0 | 1 | x | 1 | 0 | 0 | 1 | 1 |
| Disconnector intermediate | 0 | 0 | 0 | 1 | x | 0 | 0 | 0 | 1 | 0 |
| Both open | 0 | 1 | 0 | 1 | x | 0 | 1 | 0 | 1 | 1 |
| Earthing switch intermediate | 0 | 1 | 0 | 0 | x | 0 | 1 | 0 | 0 | 0 |

Table continues on next page

| Status | Inputs | | | | | Outputs | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| POSITION | DCPOSCLOSE | DCPOSOPEN | ESPOSCLOSE | ESPOSOPEN | REED | DCCLOSE_POS | DCOPEN_POS | ESCLOSE_POS | ESOPEN_POS | OKPOS |
| Earthing switch closed | 0 | 1 | 1 | 0 | 1[1)] | 0 | 1 | 1 | 0 | 1 |
| Faulty | 0 | 1 | 1 | 0 | 0[2)] | 0 | 1 | 0 | 0 | 0 |
| Faulty | 0 | 1 | 1 | 1 | x | 0 | 1 | 0 | 0 | 0 |
| Faulty | 1 | 1 | 0 | 1 | x | 0 | 0 | 0 | 1 | 0 |
| Faulty | 1 | x | 1 | x | x | 0 | 0 | 0 | 0 | 0 |
| Faulty | x | 0 | x | 0 | x | 0 | 0 | 0 | 0 | 0 |
| x = no difference | | | | | | | | | | |

1) REED input has been detected as closed within timeout and earthing switch is indicated as closed.
2) REED input has not been detected as closed within timeout and faulty position is indicated.

The REED input is only supervised during a short time window when earthing switch has closed and if *Reed contact* setting is set as "Available".

## 9.3.5 Application

In the field of distribution and sub-transmission automatic, reliable control and status indication of primary switching components both locally and remotely is of significant importance. They are needed especially in modern remotely controlled substations.

P3SSXSWI is designed to be used for status indication of a three-state (earthing switch closed, disconnector closed and both open) switch.

## 9.3.6 Signals

*Table 1326: P3SSXSWI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| DCPOSOPEN | BOOLEAN | 0=False | Signal for open position of disconnector |
| DCPOSCLOSE | BOOLEAN | 0=False | Signal for close position of disconnector |
| ESPOSOPEN | BOOLEAN | 0=False | Signal for open position of earthing switch |
| ESPOSCLOSE | BOOLEAN | 0=False | Signal for close position of earthing switch |
| REED | BOOLEAN | 0=False | Signal for close position of reed contact |

*Table 1327: P3SSXSWI Output signals*

| Name | Type | Description |
|---|---|---|
| DCOPEN_POS | BOOLEAN | Disconnector in open position |
| DCCLOSE_POS | BOOLEAN | Disconnector in closed position |
| ESOPEN_POS | BOOLEAN | Earthing switch in open position |
| ESCLOSE_POS | BOOLEAN | Earthing switch in closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |

## 9.3.7 Settings

*Table 1328: P3SSXSWI Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reed contact | 0=Not available<br>1=Available | | | 0=Not available | Availability of reed contact |
| Identification | | | | P3SSXSWI1 switch position | Control object identification |

*Table 1329: P3SSXSWI Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Event delay | 0...60000 | ms | 1 | 10000 | Event delay of intermediate or faulty position |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

## 9.3.8 Monitored data

*Table 1330: P3SSXSWI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Enum | 0=earthing switch closed<br>1=earthing switch intermediate<br>2=both open<br>3=disconnector intermediate<br>4=disconnector closed<br>5=faulty | | 3-position switch position |
| POSITION_DC | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Disconnector position |
| POSITION_ES | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Earthing switch position |

# 9.4 Disconnector position indicator DCSXSWI and Earthing switch position indication ESSXSWI

## 9.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Disconnector position indication | DCSXSWI | I<->O DC | 29DS |
| Earthing switch position indication | ESSXSWI | I<->O ES | 29GS |

## 9.4.2 Function block




*Figure 736: Function block*




*Figure 737: Function block*

## 9.4.3 Functionality

The functions DCSXSWI and ESSXSWI indicate remotely and locally the open, close and undefined states of the disconnector and earthing switch. The functionality of both is identical, but each one is allocated for a specific purpose visible in the function names. For example, the status indication of disconnectors or circuit breaker truck can be monitored with the DCSXSWI function.

The functions are designed according to the IEC 61850-7-4 standard with the logical node XSWI.

## 9.4.4 Operation principle

### Status indication and validity check

The object state is defined by the two digital inputs POSOPEN and POSCLOSE, which are also available as outputs OPENPOS and CLOSEPOS together with the OKPOS according to Table 1331. The debounces and short disturbances in an input are

eliminated by filtering. The binary input filtering time can be adjusted separately for each digital input used by the function block. The validity of digital inputs that indicate the object state is used as additional information in indications and event logging.

*Table 1331: Status indication*

| Input | | Status | Output | | |
|---|---|---|---|---|---|
| POSOPEN | POSCLOSE | POSITION (Monitored data) | OKPOS | OPENPOS | CLOSEPOS |
| 1=True | 0=False | 1=Open | 1=True | 1=True | 0=False |
| 0=False | 1=True | 2=Closed | 1=True | 0=False | 1=True |
| 1=True | 1=True | 3=Faulty/Bad (11) | 0=False | 0=False | 0=False |
| 0=False | 0=False | 0=Intermediate (00) | 0=False | 0=False | 0=False |

## 9.4.5 Application

In the field of distribution and sub-transmission automation, the reliable control and status indication of primary switching components both locally and remotely is in a significant role. These features are needed especially in modern remote controlled substations. The application area of DCSXSWI and ESSXSWI functions covers remote and local status indication of, for example, disconnectors, air-break switches and earthing switches, which represent the lowest level of power switching devices without short-circuit breaking capability.

## 9.4.6 Signals

*Table 1332: DCSXSWI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |

*Table 1333: ESSXSWI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |

*Table 1334: DCSXSWI Output signals*

| Name | Type | Description |
|---|---|---|
| OPENPOS | BOOLEAN | Apparatus open position |
| CLOSEPOS | BOOLEAN | Apparatus closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |

*Table 1335: ESSXSWI Output signals*

| Name | Type | Description |
|---|---|---|
| OPENPOS | BOOLEAN | Apparatus open position |
| CLOSEPOS | BOOLEAN | Apparatus closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |

## 9.4.7 Settings

*Table 1336: DCSXSWI Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Identification | | | | DCSXSWI1 switch position | Control Object identification |

*Table 1337: DCSXSWI Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Event delay | 0...60000 | ms | 1 | 30000 | Event delay of the intermediate and faulty position |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

*Table 1338: ESSXSWI Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Identification | | | | ESSXSWI1 switch position | Control Object identification |

*Table 1339: ESSXSWI Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Event delay | 0...60000 | ms | 1 | 30000 | Event delay of the intermediate and faulty position |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

## 9.4.8 Monitored data

*Table 1340: DCSXSWI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Apparatus position indication |

*Table 1341: ESSXSWI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Apparatus position indication |

# 9.5 Synchronism and energizing check SECRSYN

## 9.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Synchronism and energizing check | SECRSYN | SYNC | 25 |

## 9.5.2 Function block




*Figure 738: Function block*

## 9.5.3 Functionality

The synchronism and energizing check function SECRSYN checks the condition across the circuit breaker from separate power system parts and gives the permission to close the circuit breaker. SECRSYN includes the functionality of synchrocheck and energizing check.

Asynchronous operation mode is provided for asynchronously running systems. The main purpose of the asynchronous operation mode is to provide a controlled closing of circuit breakers when two asynchronous systems are connected.

The synchrocheck operation mode checks that the voltages on both sides of the circuit breaker are perfectly synchronized. It is used to perform a controlled reconnection of two systems which are divided after islanding and it is also used to perform a controlled reconnection of the system after reclosing.

The energizing check function checks that at least one side is dead to ensure that closing can be done safely.

The function contains a blocking functionality. It is possible to block function outputs and timers.

## 9.5.4 Analog channel configuration

SECRSYN has two analog group inputs which must be properly configured.

*Table 1342: Analog inputs*

| Input | Description |
|---|---|
| U3P1 | Three-phase voltages (bus side) |
| U3P2 | Three-phase voltages (line side) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1343: Special conditions*

| Condition | Description |
|---|---|
| U3P1 connected to real measurements | The function requires that any two voltage channels from the bus side are connected. |
| U3P2 connected to real measurements | The function requires that one voltage channel from the line side is connected to channel 1 or any two voltage channels from the line side. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 9.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

SECRSYN has two parallel functionalities, the synchro check and energizing check functionality. The operation of SECRSYN can be described using a module diagram. All the modules in the diagram are explained in the next sections.

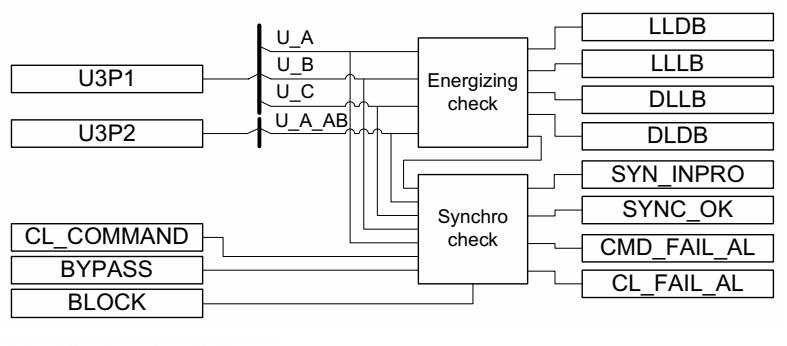



*Figure 739: Functional module diagram*

If Energizing check is passed, no further conditions need to be fulfilled to permit closing. Otherwise, Synchro check function can operate either with the U_AB or U_A voltages. The selection of used voltages is defined with the *VT connection* setting of the line voltage general parameters.

By default, voltages U_BUS and U_LINE are connected as presented in Figure 748. If necessary, connections can be switched by setting *Voltage source switch* to “True”.

## Energizing check

The Energizing check function checks the energizing direction. Energizing is defined as a situation where a dead network part is connected to an energized section of the network. The conditions of the network sections to be controlled by the circuit breaker, that is, which side has to be live and which side dead, are determined by the setting. A situation where both sides are dead is possible as well. The actual value for defining the dead line or bus is given with the *Dead bus value* and *Dead line value* settings. Similarly, the actual values of live line or bus are defined with the *Live bus value* and *Live line value* settings.

***Table 1344: Live dead mode of operation under which switching can be carried out***

| Live dead mode | Description |
|---|---|
| Both Dead | Both line and bus de-energized |
| Live L, Dead B | Bus de-energized and line energized |
| Dead L, Live B | Line de-energized and bus energized |
| Dead Bus, L Any | Both line and bus de-energized or bus de-energized and line energized |
| Dead L, Bus Any | Both line and bus de-energized or line de-energized and bus energized |
| One Live, Dead | Bus de-energized and line energized or line de-energized and bus energized |
| Not Both Live | Both line and bus de-energized or bus de-energized and line energized or line de-energized and bus energized |

When the energizing direction corresponds to the settings, the situation has to be constant for a time set with the *Energizing time* setting before the circuit breaker closing is permitted. The purpose of this time delay is to ensure that the dead side remains de-energized and also that the situation is not caused by a temporary interference. If the conditions do not persist for a specified operation time, the timer is reset and the procedure is restarted when the conditions allow. The circuit breaker closing is not permitted if the measured voltage on the live side is greater than the set value of *Max energizing V*.

The measured energized state is available as a monitored data value ENERG_STATE and as four function outputs `LLDB` (live line / dead bus), `LLLB` (live line / live bus), `DLLB` (dead line / live bus) and `DLDB` (dead line / dead bus), of which only one can be active at a time. It is also possible that the measured energized state indicates “Unknown” if at least one of the measured voltages is between the limits set with the dead and live setting parameters.

## Synchro check

The Synchro check function measures the difference between the line voltage and bus voltage. The function permits the closing of the circuit breaker when certain conditions are simultaneously fulfilled.

- The measured line and bus voltages are higher than the set values of *Live bus value* and *Live line value* (ENERG_STATE equals to "Both Live").
- The measured bus and line frequency are both within the range of 95 to 105 percent of the value of $f_n$.
- The measured voltages for the line and bus are less than the set value of *Max energizing V*.

In case *Syncro check mode* is set to "Syncronous", the additional conditions must be fulfilled.

- In the synchronous mode, the closing is attempted so that the phase difference at closing is close to zero.
- The synchronous mode is only possible when the frequency slip is below 0.1 percent of the value of $f_n$.
- The voltage difference must not exceed the 1 percent of the value of $U_n$.

In case *Syncro check mode* is set to “Asyncronous”, the additional conditions must be fulfilled.

- The measured difference of the voltages is less than the set value of *Difference voltage*.
- The measured difference of the phase angles is less than the set value of *Difference angle*.
- The measured difference in frequency is less than the set value of *Frequency difference*.
- The estimated breaker closing angle is decided to be less than the set value of *Difference angle*.

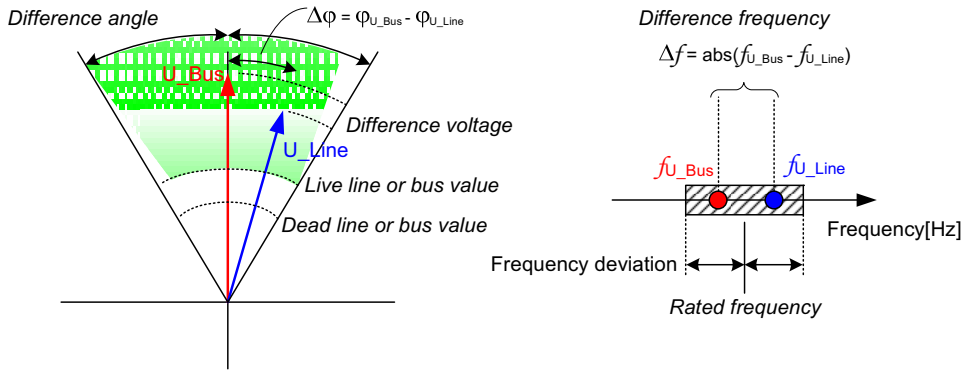



*Figure 740: Conditions to be fulfilled when detecting synchronism between systems*

When the frequency, phase angle and voltage conditions are fulfilled, the duration of the synchronism conditions is checked so as to ensure that they are still met when the condition is determined on the basis of the measured frequency and phase difference. Depending on the circuit breaker and the closing system, the delay from the moment the closing signal is given until the circuit breaker finally closes is about 50...250 ms. The selected *Closing time of CB* informs the function how long the conditions have to persist. The Synchro check function compensates for the measured slip frequency and the circuit breaker closing delay. The phase angle advance is calculated continuously with the formula.

$$Closing\ angle = \left| \left( \angle U_{Bus} - \angle U_{Line} \right)° + \left( \left( f_{Bus} - f_{line} \right) \cdot \left( T_{CB} + T_{PL} \right) \cdot 360° \right) \right|$$

(Equation 317)

$\angle U_{Bus}$ Measured bus voltage phase angle

$\angle U_{Line}$ Measured line voltage phase angle

$f_{Bus}$ Measured bus frequency

$f_{line}$ Measured line frequency

$T_{CB}$ Total circuit breaker closing delay, including the delay of the protection relay output contacts defined with the *Closing time of CB* setting parameter value

$T_{PL}$ Output type dependent delay according to Table 1345

*Table 1345: Typical delays for different output types*

| Output type | Recommended value for $T_{PL}$ |
|---|---|
| Semiconductor output (HSO, SPO) | 0 ms |
| Mechanical relay output (POSP, PODP, PO) | 6 ms |

The closing angle is the estimated angle difference after the breaker closing delay.

The *Minimum Syn time* setting time can be set, if required, to demand the minimum time within which conditions must be simultaneously fulfilled before the SYNC_OK output is activated.

The measured voltage, frequency and phase angle difference values between the two sides of the circuit breaker are available as monitored data values U_DIFF_MEAS, FR_DIFF_MEAS and PH_DIFF_MEAS. Also, the indications of the conditions that are not fulfilled and thus preventing the breaker closing permission are available as monitored data values U_DIFF_SYNC, PH_DIF_SYNC and FR_DIFF_SYNC. These monitored data values are updated only when the Synchro check is enabled with the *Synchro check mode* setting and the measured ENERG_STATE is "Both Live".

## Continuous mode

The continuous mode is activated by setting the parameter *Control mode* to "Continuous". In the continuous control mode, Synchro check is continuously checking the synchronism. When synchronism is detected (according to the settings), the SYNC_OK output is set to TRUE (logic '1') and it stays TRUE as long as the conditions are fulfilled. The command input is ignored in the continuous control mode. The mode is used for situations where Synchro check only gives the permission to the control block that executes the CB closing.

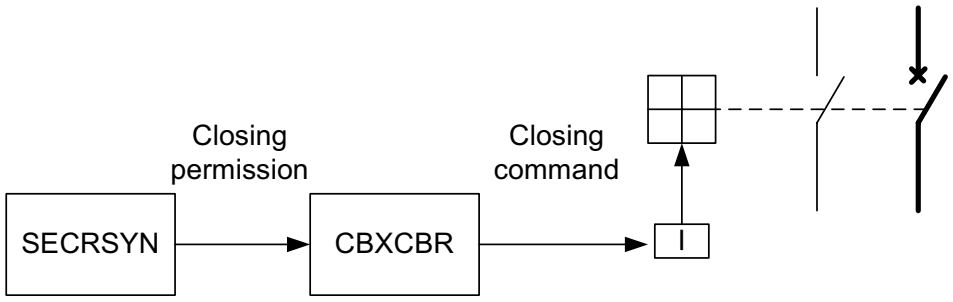



*Figure 741: A simplified block diagram of the Synchro check function in the continuous mode operation*

## Command mode

If *Control mode* is set to "Command", the purpose of the Synchro check functionality in the command mode is to find the instant when the voltages on both sides of the circuit breaker are in synchronism. The conditions for synchronism are met when the voltages on both sides of the circuit breaker have the same frequency and are in phase with a magnitude that makes the concerned busbars or lines such that they can be regarded as live.

In the command mode operation, an external command signal CL_COMMAND, besides the normal closing conditions, is needed for delivering the closing signal. In the command control mode operation, the Synchro check function itself closes the breaker via the SYNC_OK output when the conditions are fulfilled. In this case, the control function block delivers the command signal to close the Synchro check

function for the releasing of a closing-signal pulse to the circuit breaker. If the closing conditions are fulfilled during a permitted check time set with *Maximum Syn time*, the Synchro check function delivers a closing signal to the circuit breaker after the command signal is delivered for closing.

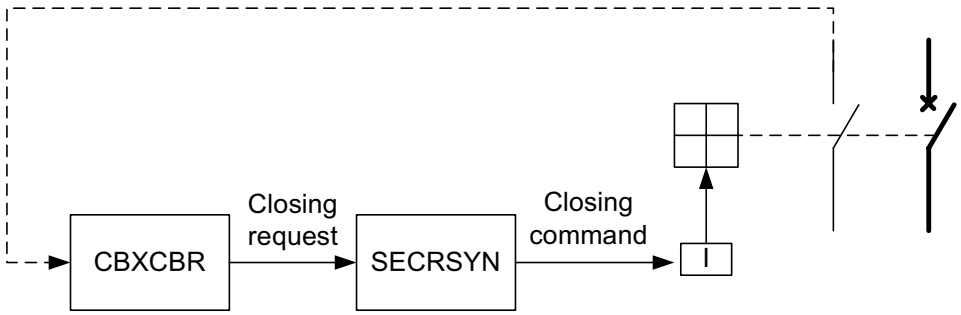



*Figure 742: A simplified block diagram of SECRSYN in the command mode operation*

The closing signal is delivered only once for each activated external closing command signal. The pulse length of the delivered closing is set with the *Close pulse* setting.

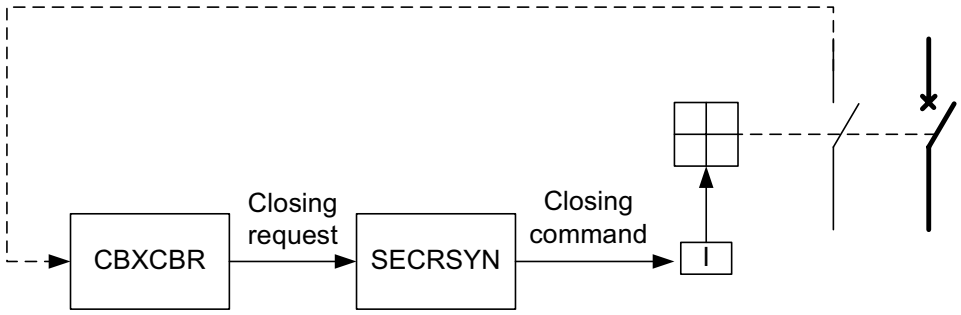



*Figure 743: Determination of the pulse length of the closing signal*

In the command control mode operation, there are alarms for a failed closing attempt (CL_FAIL_AL) and for a command signal that remains active too long (CMD_FAIL_AL).

If the conditions for closing are not fulfilled within the set time of *Maximum Syn time*, a failed closing attempt alarm is given. The CL_FAIL_AL alarm output signal is pulse-shaped and the pulse length is 500 ms. If the external command signal is removed too early, that is, before conditions are fulfilled and the closing pulse is given, the alarm timer is reset.

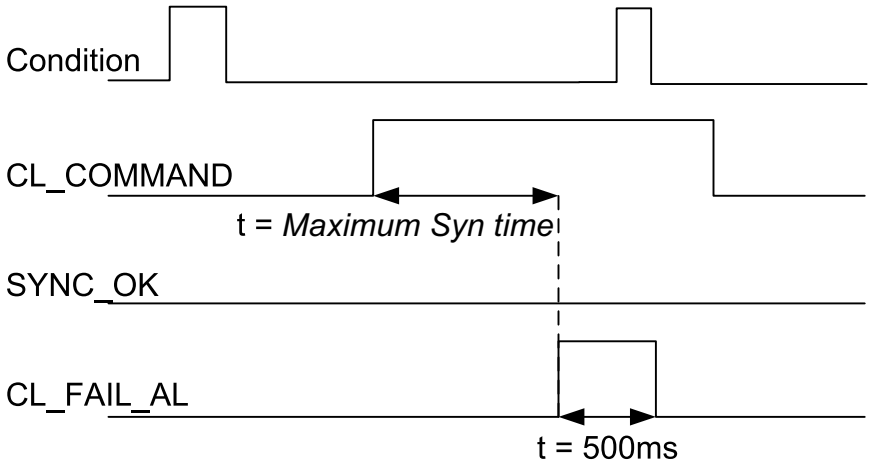



*Figure 744: Determination of the checking time for closing*

The control module receives information about the circuit breaker status and thus is able to adjust the command signal to be delivered to the Synchro check function. If the external command signal CL_COMMAND is kept active longer than necessary, the CMD_FAIL_AL alarm output is activated. The alarm indicates that the control module has not removed the external command signal after the closing operation. To avoid unnecessary alarms, the duration of the command signal should be set in such a way that the maximum length of the signal is always below *Maximum Syn time* + 5s.

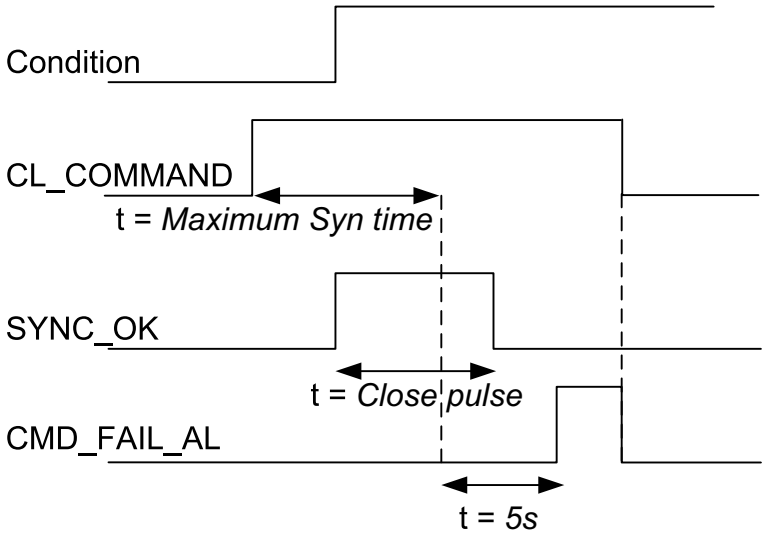



*Figure 745: Determination of the alarm limit for a still-active command signal*

Closing is permitted during *Maximum Syn time*, starting from the moment the external command signal CL_COMMAND is activated. The CL_COMMAND input must be kept active for the whole time that the closing conditions are waited to be fulfilled. Otherwise, the procedure is cancelled. If the closing-command conditions are fulfilled during *Maximum Syn time*, a closing pulse is delivered to the circuit breaker. If the closing conditions are not fulfilled during the checking time, the alarm CL_FAIL_AL

is activated as an indication of a failed closing attempt. The closing pulse is not delivered if the closing conditions become valid after *Maximum Syn time* has elapsed. The closing pulse is delivered only once for each activated external command signal, and a new closing-command sequence cannot be started until the external command signal is reset and reactivated. The SYNC_INPRO output is active when the closing-command sequence is in progress and it is reset when the CL_COMMAND input is reset or *Maximum Syn time* has elapsed.

## Bypass mode

SECRSYN can be set to the bypass mode by setting the parameters *Synchrocheck mode* and *Live dead mode* to "Off" or alternatively by activating the BYPASS input.

In the bypass mode, the closing conditions are always considered to be fulfilled by SECRSYN. Otherwise, the operation is similar to the normal mode.

## Voltage angle difference adjustment

In application where the power transformer is located between the voltage measurement and the vector group connection gives phase difference to the voltages between the high- and low-voltage sides, the angle adjustment can be used to meet synchronism.

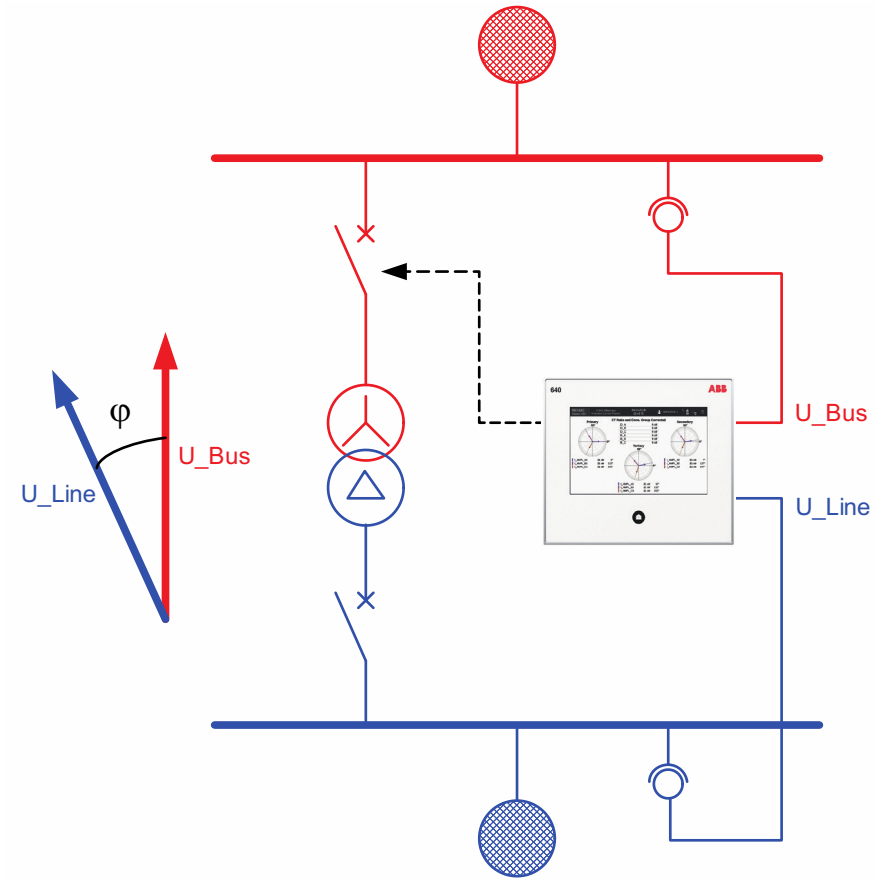



*Figure 746: Angle difference when power transformer is in sychrocheck zone*

The vector group of the power transformer is defined with clock numbers, where the value of the hour pointer defines the low-voltage-side phasor and the high-voltage-side phasor is always fixed to the clock number 12, which is same as zero. The angle between clock numbers is 30 degrees. When comparing phase angles, the U_BUS input is always the reference. This means that when the Yd11 power transformer is used, the low-voltage-side voltage phasor leads by 30 degrees or lags by 330 degrees the high-voltage-side phasor. The rotation of the phasors is counterclockwise.

The generic rule is that a low-voltage-side phasor lags the high-voltage-side phasor by clock number * 30º. This is called angle difference adjustment and can be set for SECRSYN with the *Phase shift* setting.

## 9.5.6 Application

The main purpose of the synchrocheck function is to provide control over the closing of the circuit breakers in power networks to prevent the closing if the conditions for synchronism are not detected. This function is also used to prevent the reconnection of two systems which are divided after islanding and a three-pole reclosing.

The Synchro check function block includes both the synchronism check function and the energizing function to allow closing when one side of the breaker is dead.

Network and the generator running in parallel with the network are connected through the line AB. When a fault occurs between A and B, the protection relay protection opens the circuit breakers A and B, thus isolating the faulty section from the network and making the arc that caused the fault extinguish. The first attempt to recover is a delayed autoreclosure made a few seconds later. Then, the autoreclose function DARREC gives a command signal to the synchrocheck function to close the circuit breaker A. SECRSYN performs an energizing check, as the line AB is de-energized (U_BUS> *Live bus value*, U_LINE< *Dead line value*). After verifying the line AB is dead and the energizing direction is correct, the protection relay energizes the line (U_BUS -> U_LINE) by closing the circuit breaker A. The PLC of the power plant discovers that the line has been energized and sends a signal to the other synchrocheck function to close the circuit breaker B. Since both sides of the circuit breaker B are live (U_BUS > *Live bus value*, U_LINE > *Live bus value*), the synchrocheck function controlling the circuit breaker B performs a synchrocheck and, if the network and the generator are in synchronism, closes the circuit breaker.

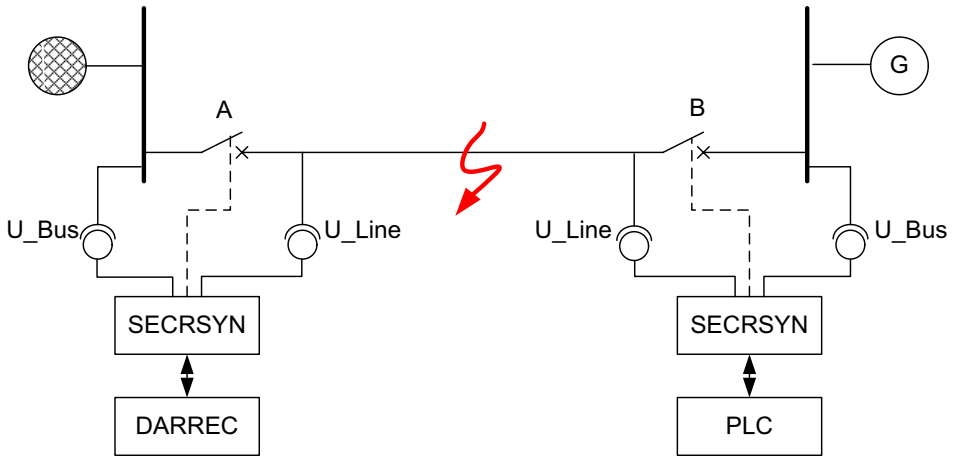



*Figure 747: Synchrocheck function SECRSYN checking energizing conditions and synchronism*

## Connections

A special attention is paid to the connection of the protection relay. Furthermore it is checked that the primary side wiring is correct.

A faulty wiring of the voltage inputs of the protection relay causes a malfunction in the synchrocheck function. If the wires of an energizing input have changed places, the polarity of the input voltage is reversed (180°). In this case, the protection relay permits the circuit breaker closing in a situation where the voltages are in opposite phases. This can damage the electrical devices in the primary circuit. Therefore, it is extremely important that the wiring from the voltage transformers to the terminals on the rear of the protection relay is consistent regarding the energizing inputs `U_BUS` (bus voltage) and `U_LINE` (line voltage).

The wiring should be verified by checking the reading of the phase difference measured between the `U_BUS` and `U_LINE` voltages. The phase difference measured by the protection relay has to be close to zero within the permitted accuracy tolerances. The measured phase differences are indicated in the LHMI. At the same time, it is recommended to check the voltage difference and the frequency differences presented in the monitored data view. These values should be within the permitted tolerances, that is, close to zero.

Figure 748 shows an example where the synchrocheck is used for the circuit breaker closing between a busbar and a line. The phase-to-phase voltages are measured from the busbar and also one phase-to-phase voltage from the line is measured.

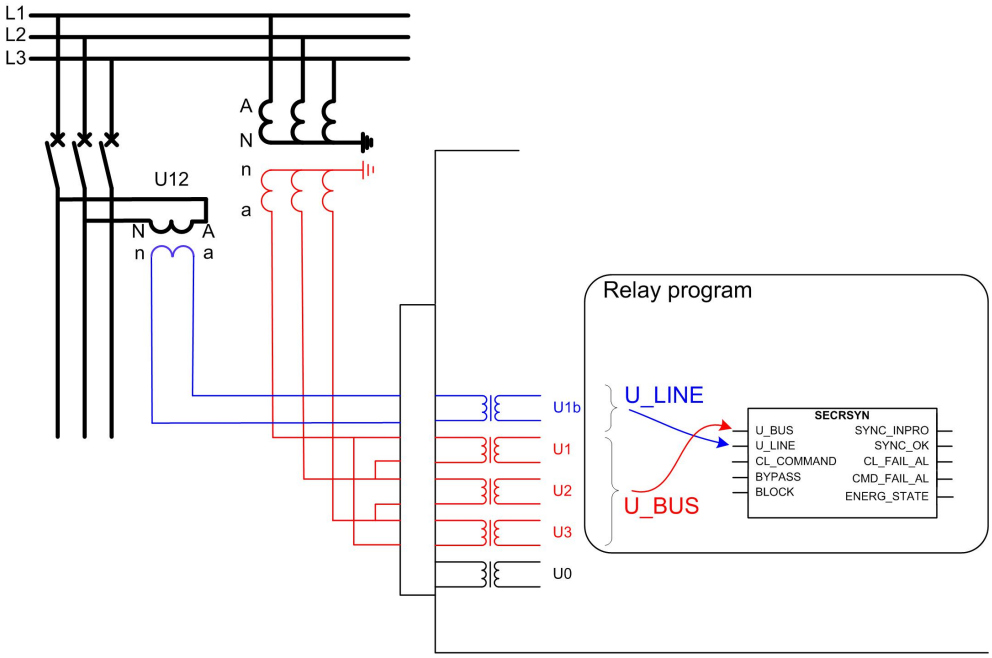



*Figure 748: Connection of voltages for the protection relay and signals used in synchrocheck*

## 9.5.7 Signals

*Table 1346: SECRSYN Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P1 | SIGNAL | - | Three-phase voltages 1 |
| U3P2 | SIGNAL | - | Three-phase voltages 2 |
| BLOCK | BOOLEAN | 0=False | Blocking signal of the synchro check and voltage check function |
| CL_COMMAND | BOOLEAN | 0=False | External closing request |
| BYPASS | BOOLEAN | 0=False | Request to bypass synchronism check and voltage check |

*Table 1347: SECRSYN Output signals*

| Name | Type | Description |
|---|---|---|
| SYNC_INPRO | BOOLEAN | Synchronizing in progress |
| SYNC_OK | BOOLEAN | Systems in synchronism |
| CL_FAIL_AL | BOOLEAN | CB closing failed |
| CMD_FAIL_AL | BOOLEAN | CB closing request failed |
| LLDB | BOOLEAN | Live Line, Dead Bus |
| LLLB | BOOLEAN | Live Line, Live Bus |
| DLLB | BOOLEAN | Dead Line, Live Bus |
| DLDB | BOOLEAN | Dead Line, Dead Bus |

## 9.5.8 Settings

*Table 1348: SECRSYN Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Live dead mode | -1=Off<br>1=Both Dead<br>2=Live L, Dead B<br>3=Dead L, Live B<br>4=Dead Bus, L Any<br>5=Dead L, Bus Any<br>6=One Live, Dead<br>7=Not Both Live | | | 1=Both Dead | Energizing check mode |
| Difference voltage | 0.01...0.50 | xUn | 0.01 | 0.05 | Maximum voltage difference limit |
| Difference frequency | 0.0002...0.1000 | xFn | 0.0001 | 0.0010 | Maximum frequency difference limit |
| Difference angle | 5...90 | deg | 1 | 5 | Maximum angle difference limit |

*Table 1349: SECRSYN Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Synchro check mode | 1=Off<br>2=Synchronous<br>3=Asynchronous | | | 3=Asynchronous | Synchro check operation mode |
| Dead line value | 0.1...0.8 | xUn | 0.1 | 0.2 | Voltage low limit line for energizing check |
| Live line value | 0.2...1.0 | xUn | 0.1 | 0.8 | Voltage high limit line for energizing check |
| Dead bus value | 0.1...0.8 | xUn | 0.1 | 0.2 | Voltage low limit bus for energizing check |
| Live bus value | 0.2...1.0 | xUn | 0.1 | 0.5 | Voltage high limit bus for energizing check |
| Max energizing V | 0.50...1.15 | xUn | 0.01 | 1.05 | Maximum voltage for energizing |

*Table 1350: SECRSYN Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Control mode | 1=Continuous<br>2=Command | | | 1=Continuous | Selection of synchro check command or Continuous control mode |
| Close pulse | 200...60000 | ms | 10 | 200 | Breaker closing pulse duration |
| Phase shift | -180...180 | deg | 1 | 0 | Correction of phase difference between measured U_BUS and U_LINE |
| Minimum Syn time | 0...60000 | ms | 10 | 0 | Minimum time to accept synchronizing |
| Maximum Syn time | 100...6000000 | ms | 10 | 2000 | Maximum time to accept synchronizing |
| Energizing time | 100...60000 | ms | 10 | 100 | Time delay for energizing check |
| Closing time of CB | 40...250 | ms | 10 | 60 | Closing time of the breaker |
| Voltage source switch | 0=False<br>1=True | | | 0=False | Voltage source switch |

## 9.5.9 Monitored data

*Table 1351: SECRSYN Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ENERG_STATE | Enum | 0=Unknown<br>1=Both Live<br>2=Live L, Dead B<br>3=Dead L, Live B<br>4=Both Dead | | Energization state of Line and Bus |
| U_DIFF_MEAS | FLOAT32 | -3.00...3.00 | xUn | Calculated voltage amplitude difference |
| FR_DIFF_MEAS | FLOAT32 | -1.500...1.500 | xFn | Calculated voltage frequency difference |
| PH_DIFF_MEAS | FLOAT32 | -180.00...180.00 | deg | Calculated voltage phase angle difference |
| U_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Voltage difference out of limit for synchronizing |
| PH_DIF_SYNC | BOOLEAN | 0=False<br>1=True | | Phase angle difference out of limit for synchronizing |
| FR_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Frequency difference out of limit for synchronizing |
| SECRSYN | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 9.5.10 Technical data

*Table 1352: SECRSYN Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±1 Hz |
| | Voltage:<br>±3.0% of the set value or ±0.01 × $U_n$<br>Frequency:<br>±10 mHz<br>Phase angle:<br>±3° |
| Reset time | <50 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

# 9.6 Autosynchronizer for generator breaker ASGCSYN

## 9.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Autosynchronizer for generator breaker | ASGCSYN | AUTOSYNCG | 25AUTOSYNCG |

## 9.6.2 Function block




*Figure 749: Function block*

## 9.6.3 Functionality

The autosynchronizer for generator breaker function ASGCSYN checks the conditions across the circuit breaker from generator and bus side and issues the pulse commands to the automatic voltage regulator (AVR) and prime mover governor to match the voltage and frequency conditions if required. Once the synchronization check and close CB conditions are fulfilled, the function gives permission to close the circuit breaker. ASGCSYN includes the functionality of energizing check, synchronization check and voltage and frequency matching.

The energizing check function checks that bus side is dead to ensure that breaker closing can be done safely. The synchronization check function checks that the voltages and frequency on both sides of the circuit breaker are within the predefined setting. It is used to perform a controlled reconnection of two systems.

In the auto synchronization control mode, the function's automatic, semi-automatic and manual operation modes decide the operation of voltage and frequency matching and the auto synchronization process.

The voltage and frequency matching function issues raise or lower pulse commands to AVR and the governor to match the voltage and frequency, based on the calculated voltage and frequency difference across the circuit breaker to be synchronized. ASGCSYN also participates in voltage and frequency matching for network breaker synchronization.

## 9.6.4 Analog channel configuration

ASGCSYN has two analog group inputs which must be properly configured.

*Table 1353: Analog inputs*

| Input | Description |
|---|---|
| U3P1 | Three-phase voltages (generator side) |
| U3P2 | Three-phase voltages (bus side) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1354: Special conditions*

| Condition | Description |
|---|---|
| U3P1 and U3P2 connected to real measurements | When one voltage channel from the generator side is connected to channel 1 of U3P1 and one voltage channel from the bus side is connected to channel 1 of U3P2, the function can only work if UTVTR's *VT connection* settings on the generator and bus sides are similar. |
| | The function can work if one voltage channel from the generator side is connected to channel 1 of U3P1 and three voltage channels from the bus side are connected to U3P2. |
| | The function can work if one voltage channel from the generator side is connected to channel 1 of U3P1 and two voltage channels along with the residual voltage from the bus side are connected to U3P2. |
| | The function can work if three voltage channels from the generator side are connected to U3P1 and one voltage channel from the bus side is connected to channel 1 of U3P2. |
| | The function can work if two voltage channels and the residual voltage from the generator side are connected to U3P1 and one voltage channel from the bus side is connected to channel 1 of U3P2. |
| Dissimilar VT connection settings for UTVTR on the generator and bus sides | The function requires that all three voltage channels or two voltage channels and the residual voltage are connected to either U3P1 or U3P2. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 9.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of ASGCSYN can be described with a module diagram. All the modules in the diagram are explained in the next sections.

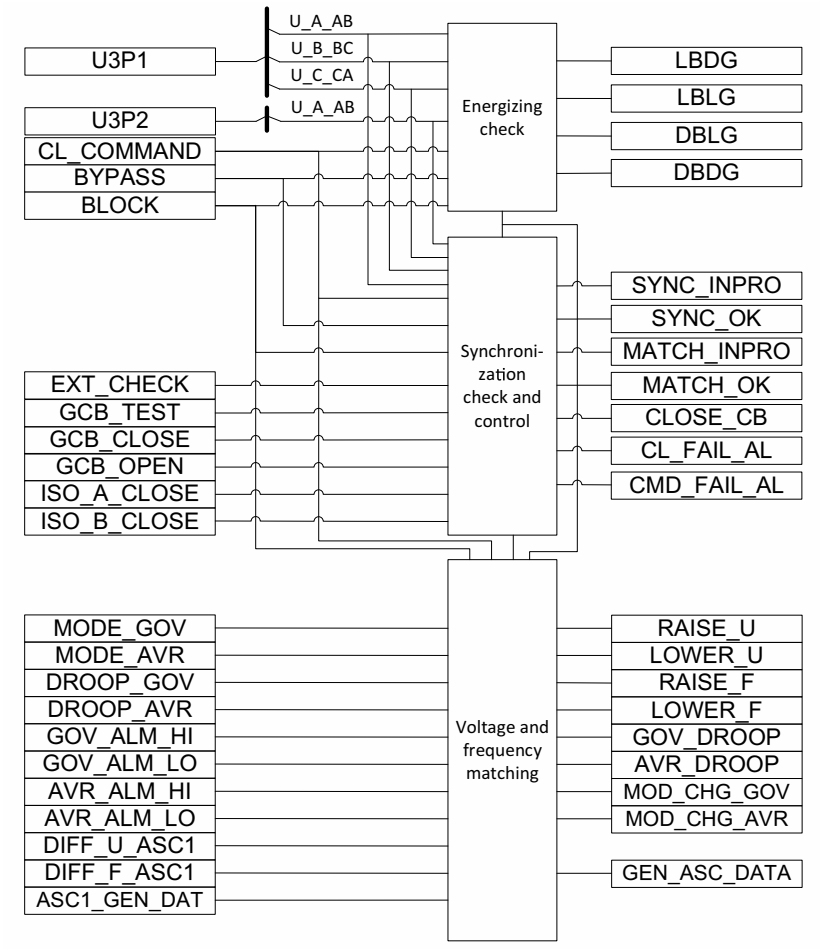



*Figure 750: Functional module diagram*

ASGCSYN can operate either with the U_AB or U_A voltages. The selection of used voltages is defined with the *VT connection* setting of the voltage measurement parameters.

## Energizing check

The Energizing check module checks the energizing direction. Energizing is the situation where a dead network part is connected to an energized section of the network. The conditions of the network sections to be controlled by the circuit breaker, that is, which side has to be live and which side dead, are determined by the setting *Live dead mode*.

*Live dead mode* can be set in two ways: either through settings or through the command control.

If the *Live dead mode* parameter under the Setting menu is set as "Command", then *Live dead mode Ctl* parameter under the Control menu can be used to select the values in Table 1355. Otherwise, the *Live dead mode* parameter under the Setting menu is used to select the values in Table 1355.

*Table 1355: Live dead mode of operation when switching can be carried out*

| Live dead mode | Description |
|---|---|
| Off | Live dead mode setting is in off status |
| Both Dead | Both bus and generator de-energized |
| Live G, Dead B | Bus de-energized and generator energized |
| Dead B, G Any | Bus de-energized and generator energized or de-energized |

The actual value for defining the dead bus or generator is given with the *Dead voltage value* setting. Similarly, the actual values of live bus or generator are defined with the *Live voltage value* setting.

When the energizing direction corresponds to the settings, the situation has to be constant for a time set with the *Energizing time* setting before the circuit breaker closing is permitted. This time delay ensures that the dead side remains de-energized and that the situation is not caused by a temporary interference. If the conditions do not persist for a specified operate time, the timer is reset and the procedure is restarted when the conditions allow it. The circuit breaker does not close if the measured voltage on the live side is greater than the set value of *Maximum voltage*.

The measured energized state is available as a monitored data value ENERG_STATE and as four function outputs `LBLG` (“Both Live”), `LBDG` (“Live B, Dead G”), `DBLG` (“Dead B, Live G”) and `DBDG` (“Both Dead”), of which only one can be active at a time. The measured energized state indicates “Unknown” if at least one of the measured voltages is between the limits set with the dead and live setting parameters.

## Synchronization check and control

The operation of Synchronization check and control can be described with a module diagram. All the modules in the diagram are explained in the next sections.

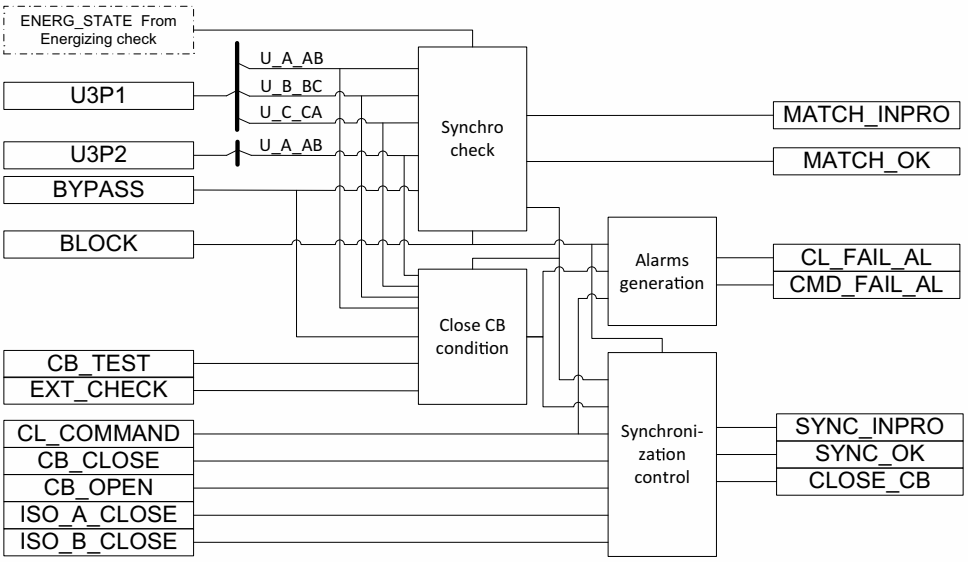



*Figure 751: Module diagram for Synchronization check and control*

## Synchro check

The function measures the voltage difference U_DIFF_MEAS, frequency difference FR_DIFF_MEAS and phase angle difference PH_DIFF_MEAS between the bus voltage and generator voltage. In the calculation of PH_DIFF_MEAS, setting *Phase shift* is used to compensate the angle shift caused if a power transformer is located between the voltage measurements. Offset correction due to different channel measurements (for voltage and frequency values) can be done using *Voltage offset* and *Frequency offset*. The user can select the direction of generator synchronization using the setting *Synchronization Dir*.

$$U_DIFF_MEAS = U_{Gen} - U_{Bus} - Voltage\ offset$$

(Equation 318)

| | |
|---|---|
| $U_{Bus}$ | Measured bus side voltage |
| $U_{Gen}$ | Measured generator side voltage |
| Voltage offset | Setting *Voltage offset* |

$$FR_DIFF_MEAS = f_{Gen} - f_{Bus} - Frequency\ offset$$

(Equation 319)

| | |
|---|---|
| $f_{Bus}$ | Measured bus side frequency |
| $f_{Gen}$ | Measured generator side frequency |
| Frequency offset | Setting *Frequency offset* |

$$PH_DIFF_MEAS = \angle U_{Gen} - \angle U_{Bus} - Phase\ shift$$

(Equation 320)

| | |
|---|---|
| $\angle U_{Bus}$ | Measured bus side voltage phase angle |
| $\angle U_{Gen}$ | Measured generator side voltage phase angle |
| Phase shift | Setting *Phase shift* |

The synchronism conditions are checked according to several criteria.

- The measured bus and generator voltages are higher than the set value of *Live voltage value* (ENERG_STATE equals “Both Live”).
- The measured bus and generator frequencies are both within the range of 95...105 percent of the nominal frequency ($f_n$).
- The measured bus and generator voltages are lower than the set value of *Maximum voltage*.

If the *Synchrocheck mode* parameter under the Setting menu is set as "Command", then the *SynchroChk Mod Ctl* parameter under the Control menu is used to set values "OFF/Asynchronous". Otherwise, the *Synchrocheck mode* parameter under the Setting menu is used to set the values "Off/Asynchronous".

Some additional conditions must also be fulfilled as per the set *Synchrocheck mode*.

*Table 1356: Additional conditions for the synchro check*

| Measurements | Synchrocheck mode “Asynchronous” |
|---|---|
| U_DIFF_MEAS | < Voltage Diff Ov Ex and > -Voltage Diff Un Ex |
| PH_DIFF_MEAS | < Angle Diff positive and > - Angle Diff negative |
| FR_DIFF_MEAS | < Freq Diff OV Synch and > -Freq Diff sub Synch |
| Closing angle | < Angle Diff positive and >- Angle Diff negative |

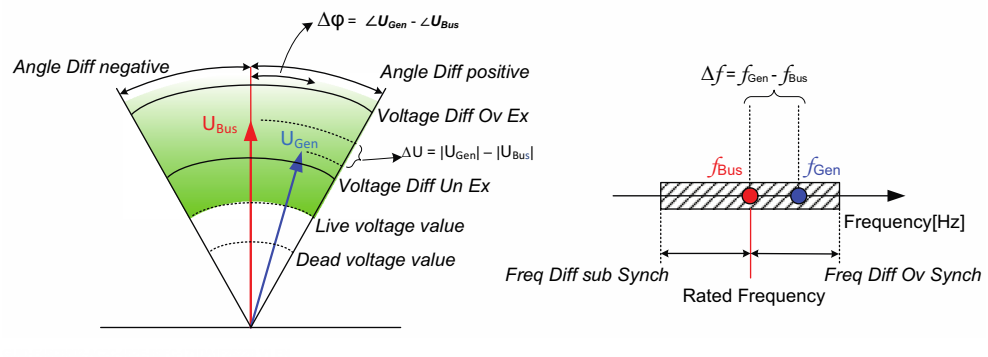



*Figure 752: Conditions to be fulfilled when detecting synchronism between systems*

When the measured differences in voltage and frequency are within the synchro check limits, the output MATCH_OK is activated. The output MATCH_INPRO is active while the voltage and frequency matching is in progress.

When the frequency, phase angle and voltage conditions are fulfilled, the duration of the synchronism conditions is checked to ensure that they are still met when the condition is determined on the basis of the measured frequency and phase difference. Depending on the circuit breaker and the closing system, the delay between the closing signal and the circuit breaker closing is about 50...250 ms. The selected *Closing time of CB* informs the function how long the conditions have to persist. The value covers both circuit breaker closing delay and output type dependent delay. The synchro check function compensates for the measured slip frequency and the circuit breaker closing delay. The closing angle advance is calculated continuously:

$$Closing\ angle = \left| (\angle U_{Gen} - \angle U_{Bus})° + \left( (f_{Gen} - f_{Bus}) \cdot \left( \frac{TCB}{1000} \right) \cdot 360° \right) \right|$$

(Equation 321)

$\angle U_{Gen}$ Measured generator voltage phase angle

$\angle U_{Bus}$ Measured bus voltage phase angle

TCB Parameter *Closing time of CB* to be set as in Equation 322

$$TCB = t_{CB} + T_{PL} + x$$

(Equation 322)

$t_{CB}$ Circuit breaker closing delay in ms

$T_{PL}$ Output type dependent delay in ms (see Table 1357)

x Hardware delays between the protection relay and CB in ms; delays due to, for example, auxiliary relays and contactors, if used

*Table 1357: Typical delays for different output types*

| Output type | Recommended value for $T_{PL}$ | |
|---|---|---|
| | Generator voltage measurement: Non-Adaptive<br>Bus voltage measurement: Non-Adaptive | Generator voltage measurement: Adaptive<br>Bus voltage measurement: Non-Adaptive |
| Semiconductor output (SPO) | 16 ms | 7 ms |
| Mechanical relay output (POSP, PODP) | 23 ms | 13 ms |

The *Minimum Syn time* setting defines the minimum time for which synchro check conditions must be simultaneously fulfilled.

ASGCSYN can be set to the bypass mode by setting the parameters *Synchrocheck mode* and *Live dead mode* to "Off" or, alternatively, by activating the BYPASS input. In the bypass mode, the synchro check conditions are always fulfilled. Otherwise, the operation is similar to the normal mode.

The frequency slip acceleration (ds/dt) FR_SLIP_ACCL is the average value of frequency slip difference (Δs) calculated over a time period of 0.5 s.

$$Frequency\ slip(s) = \frac{(f_{Gen} - f_{Bus})}{f_{Bus}}$$

(Equation 323)

The measured bus voltage ($U_{Bus}$), bus frequency ($f_{Bus}$), generator voltage ($U_{Gen}$), generator frequency($f_{Gen}$) and phase angle difference values between the two sides of the circuit breaker are available as monitored data values U_BUS_MEAS, FR_BUS_MEAS, U_GEN_MEAS, FR_GEN_MEAS, U_DIFF_MEAS, FR_DIFF_MEAS and PH_DIFF_MEAS. The calculated frequency slip acceleration (ds/dt) is available as monitored data value FR_SLIP_ACCL. Also, the indications of the conditions that are not fulfilled and thus preventing the breaker closing permission are available as monitored data values U_DIFF_SYNC, PH_DIF_SYNC and FR_DIFF_SYNC. These monitored data values are updated only when the setting *Synchrocheck mode* is set to "Asynchronous" and the measured ENERG_STATE is "Both Live".

The measured voltage, frequency are updated in the monitored data irrespective of any condition.

## Close CB condition

When *Synchrocheck mode* is set to "Asynchronous", the close CB condition is generated as explained below.

From the frequency slip s, the acceleration ds/dt, the bus frequency FR_BUS_MEAS ($f_{Bus}$) and the set *Closing time of CB*, the function calculates the necessary lead angle

($\alpha_{Lead}$) by which the close CB command is shifted forward in time so that the main contacts close on phase coincidence.

$$\alpha_{Lead} = \left( 360 \cdot f_{Bus} \cdot \left( s + \frac{\frac{TCB}{2} \cdot \frac{ds}{dt}}{1000} \right) \cdot \frac{TCB}{1000} \right)$$

(Equation 324)

| | |
|---|---|
| $f_{Bus}$ | Bus side frequency |
| s | Frequency slip |
| ds/dt | Frequency slip acceleration |
| TCB | Setting *Closing time of CB* |

ASGCSYN can be set to the bypass mode by setting the parameters *Synchrocheck mode* and *Live dead mode* to "Off" or, alternatively, by activating the BYPASS input. In the bypass mode, the close CB conditions are always fulfilled. Otherwise, the operation is similar to the normal mode.

The monitored data CB_CL_BLKD depends on the inputs GCB_TEST and EXT_CHECK, and also on IED test mode as described in Table 1358. CB_CL_BLKD is available in the Monitored data view.

*Table 1358: Monitored data CB_CL_BLKD activation based on the inputs*

| IED test mode | Inputs | | Monitored data |
|---|---|---|---|
| | GCB_TEST | EXT_CHECK | CB_CL_BLKD |
| TRUE | TRUE | TRUE | 1(“Unblocked”) |
| FALSE | FALSE | | |
| TRUE | TRUE | FALSE | 2(“Ext Check Fail”) |
| FALSE | FALSE | | |
| TRUE | FALSE | N/A | 3(“IED Test CB Service”) |
| FALSE | TRUE | N/A | 4(“IED Service CB Test”) |

The close CB condition is blocked if the CB_CL_BLKD status is 2(“Ext Check Fail”), 3(“IED Test CB Service”) or 4(“IED Service CB Test”).

In case for BYPASS input activation,

- If GCB_TEST is activated, CLOSE_CB is activated.
- If GCB_TEST is deactivated, and the bus and generator terminal voltages are both live or one side live, CLOSE_CB is not activated.

## Synchronization control

The general bus bar arrangement for a generator bus is shown in Figure 753. The bus to which the generator is connected is determined based on the circuit breaker and isolator position inputs (GCB_OPEN, GCB_CLOSE, ISO_A_CLOSE and ISO_B_CLOSE). The generator's bus connection status is shared with the autosynchronizer co-ordinator function ASCGAPC as part of the GEN_ASC_DATA output.

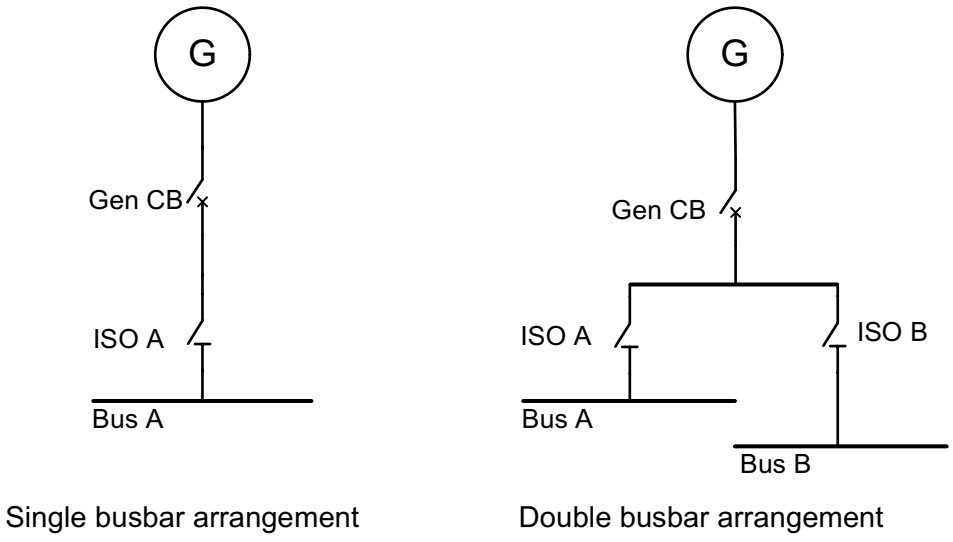



*Figure 753: Different bus bar arrangements for a generator bus*

**Auto synchronization mode**

In this mode, the closing signal is delivered if either the command *Synchronize CB* or the input CL_COMMAND is set to TRUE. The relay should be in the local mode if synchronization is initiated with the Synchronize CB command.

If the setting *Auto Syn mode* is set as "Manual mode" or "Semi-automatic synchronising mode", the additional command Manual CB release should be active for the closing signal CLOSE_CB to be activated. If the setting *Auto Syn mode* is set as "Automatic synchronising mode", no additional command is required to activate the closing signal CLOSE_CB.

In this auto synchronization mode, once all the closing conditions are satisfied within the set *Maximum Syn time*, the outputs SYNC_OK and CLOSE_CB become TRUE and remain active as long as the closing conditions are fulfilled. If *Multiple command* is set to "Off", then only CLOSE_CB outputs are delivered once for each activated input signal as shown in Figure 754. If *Multiple command* is set to "On", then CLOSE_CB outputs are delivered each time the conditions are satisfied as shown in Figure 755.

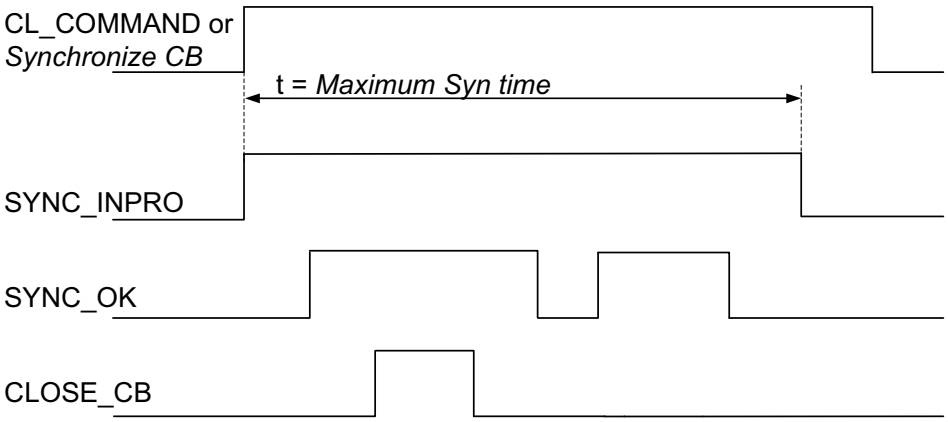



*Figure 754: Determination of closing signal CLOSE_CB when Multiple command is set to "Off"*

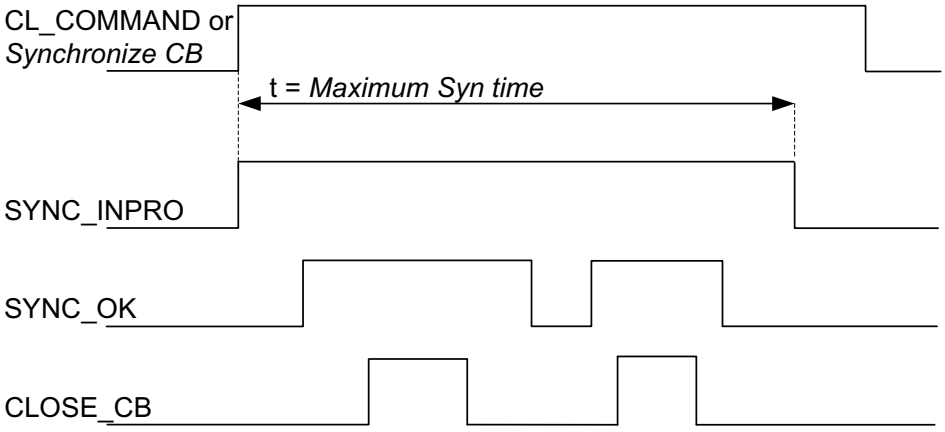



*Figure 755: Determination of closing signal CLOSE_CB when Multiple command is set to "On"*

The SYNC_INPRO output is active when the close command (CL_COMMAND or *Synchronize CB*) is in progress and it is reset when the close command is reset or *Maximum Syn time* has elapsed.

If the closing conditions are fulfilled during a permitted check time set with *Maximum Syn time*, ASGCSYN gives synchro check permission to the breaker control function block after the closing command signal is delivered. The simplified configuration block diagram of ASGCSYN with CLOSE_CB to the breaker control function block is shown in Figure 756.

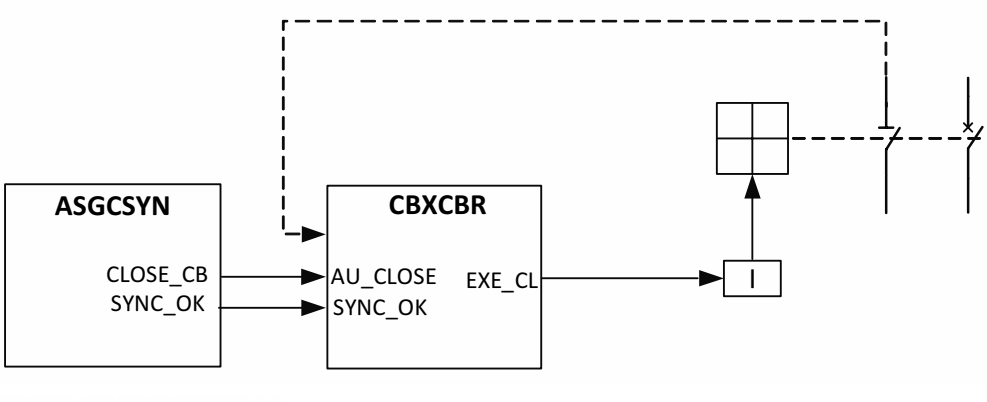



*Figure 756: Simplified configuration block diagram of ASGCSYN in auto synchronization mode operation*

## Alarms generation

In the synchro check command and auto synchronization control mode operation, there are alarms for failed closing attempt (CL_FAIL_AL) and for a command signal that remains active too long (CMD_FAIL_AL).

In the auto synchronization control mode, the closing command generation is activated either by the command input CL_COMMAND or by the command parameter *Synchronize CB*.

From the closing command activation, if the conditions for closing CB are not fulfilled within the set time of *Maximum Syn time*, a failed closing attempt alarm is given. The CL_FAIL_AL alarm output signal is pulse-shaped and the pulse length is 500 ms.

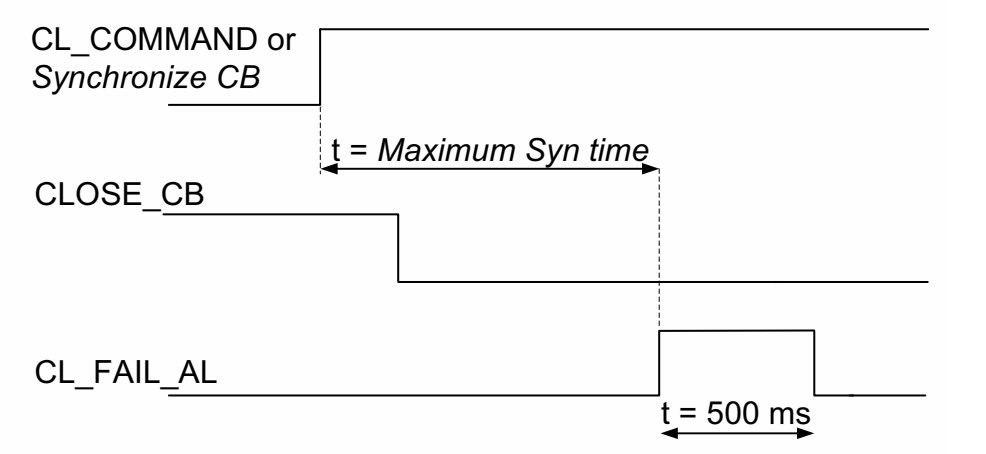



*Figure 757: Determination of checking time for closing*

CB closing is permitted during *Maximum Syn time*, starting from the moment the close command is activated. The close command must be active while the closing conditions are fulfilled, otherwise the procedure is cancelled. If the closing conditions are fulfilled during *Maximum Syn time*, a closing pulse output is delivered to the

circuit breaker. If the closing conditions are not fulfilled during the checking time, the alarm CL_FAIL_AL is activated as an indication of a failed closing attempt. The closing pulse is not delivered if the closing conditions become valid after *Maximum Syn time* has elapsed. The closing pulse is delivered only once for each activated close command, and a new closing command sequence cannot be started until the close command is reset and reactivated.

The circuit breaker control function block receives information about the circuit breaker status and thus is able to adjust the command signal to be delivered to ASGCSYN. If the closing command is active longer than necessary, the CMD_FAIL_AL alarm output is activated. To avoid unnecessary alarms, the maximum length of the closing command signal should be below *Maximum Syn time* + 5 s.

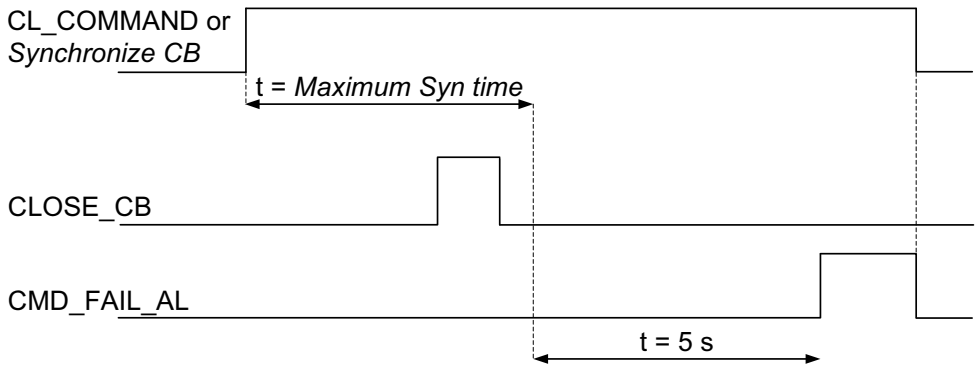



*Figure 758: Determination of the alarm limit for a still-active command signal*

## Voltage and frequency matching

The operation of the Voltage and frequency matching module can be described with a module diagram. All the modules in the diagram are explained in the next sections.

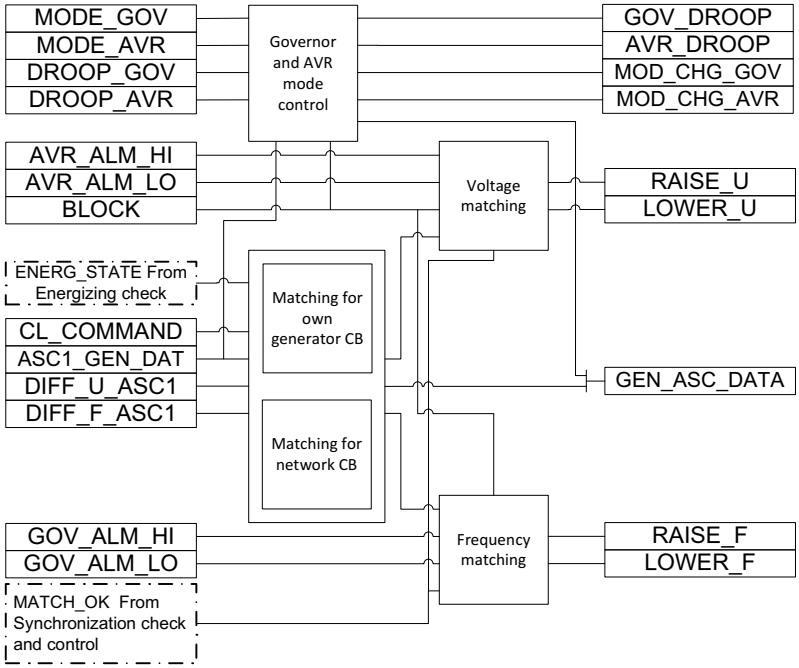



*Figure 759: Module diagram for Voltage and frequency matching*

The voltage and frequency matching is activated automatically during the “Autosynchronization” mode.

## Governor and AVR mode control

If the setting *Central PMS present* is set to "Yes", then the governor and AVR mode is decided based on the inputs MODE_GOV and MODE_AVR, respectively. If the setting *Central PMS present* is set to "No", then the governor and AVR mode is decided based on the inputs DROOP_GOV and DROOP_AVR, respectively.

For the matching of frequency and voltage, the governor or AVR mode must be 1(“Droop”) or 2(“Fixed MW’). Otherwise, the MOD_CHG_GOV or MOD_CHG_AVR output is used for the mode change request.

When the setting *Central PMS present* is set to "Yes" and the Governor or AVR mode is not 1(“Droop”) or 2(“Fixed MW’), then the function sets MOD_CHG_GOV or MOD_CHG_AVR output to (“Droop”) or (“Fixed MW’). Otherwise, the function sets MOD_CHG_GOV or MOD_CHG_AVR output to “No change”.

When the setting *Central PMS present* is set to "No" and the Governor or AVR mode is not Droop mode, then the function activates the binary output GOV_DROOP or AVR_DROOP by using the input DROOP_GOV or DROOP_AVR.

The governor and AVR modes can also be changed through the command parameters *Gov mode change* and *AVR mode change*, respectively. If the command parameter *Gov mode change* is set to "Droop" or "Fixed MW", the function activates the binary output GOV_DROOP and sets integer output MOD_CHG_GOV to 1(“Droop”) or

2(“Fixed MW’), respectively. If the command parameter *AVR mode change* is set to "Droop" or "Fixed MVAr", the function activates the binary output AVR_DROOP and sets integer output MOD_CHG_AVR to 9(“Droop”) or 11(“Fixed MVAr”), respectively.

## Matching for own generator CB

If the command ‘Synchronize CB’ is set to “TRUE” or input CL_COMMAND is TRUE, the generator CB is selected for synchronizing. For the voltage and frequency matching to start, the generator CB should be in open position and *Synchrocheck mode* should be set to "Asynchronous".

The measured voltage difference U_DIFF_MEAS is used for generating AVR raise or lower pulses to match the voltages across the CB. The measured frequency difference FR_DIFF_MEAS is used for generating governor raise or lower pulses to match the frequencies across the CB. The voltage and frequency matching starts only when the ENERG_STATE is “Both Live”.

Voltage difference (ΔU) = U_DIFF_MEAS

Frequency difference (ΔF) = FR_DIFF_MEAS

## Matching for network CB

The generator is ready for network CB matching only when the generator CB is closed, the protection relay is in remote mode and the generator is requested for matching from non-source function.

After receiving the acknowledgement from ASGCSYN, the autosynchronizer co-ordinator function ASCGAPC gives permission to participate in the voltage and frequency matching across the CB to be synchronized in the network. ASCGAPC also shares the information about how many generators participate in the voltage matching (NgV) and frequency matching (NgF). Depending on the number of participating generators, the voltage and frequency difference is divided among the generators.

The voltage and frequency difference calculated for generating raise or lower pulses for AVR and governor are

Voltage difference (ΔU) = DIFF_U_ASC1 / NgV

Frequency difference (ΔF) = DIFF_F_ASC1 / NgF

The sign bit for voltage difference and frequency difference is decided based on the data received from ASCGAPC. The calculated voltage difference and frequency difference are available in the Monitored data view U_DIFF_NTW and FR_DIFF_NTW, respectively.

## Voltage matching

**Working range of the voltage matcher**

If the bus voltage U_BUS is between settings *Minimum voltage* and *Maximum voltage* and the generator voltage U_GEN is greater than the setting *Dead voltage value*, the adjusting commands are released. The direction of the adjusting commands depends on the polarity of ΔU. As an additional condition, both frequencies must be in the range $f_n$ ±5 Hz.

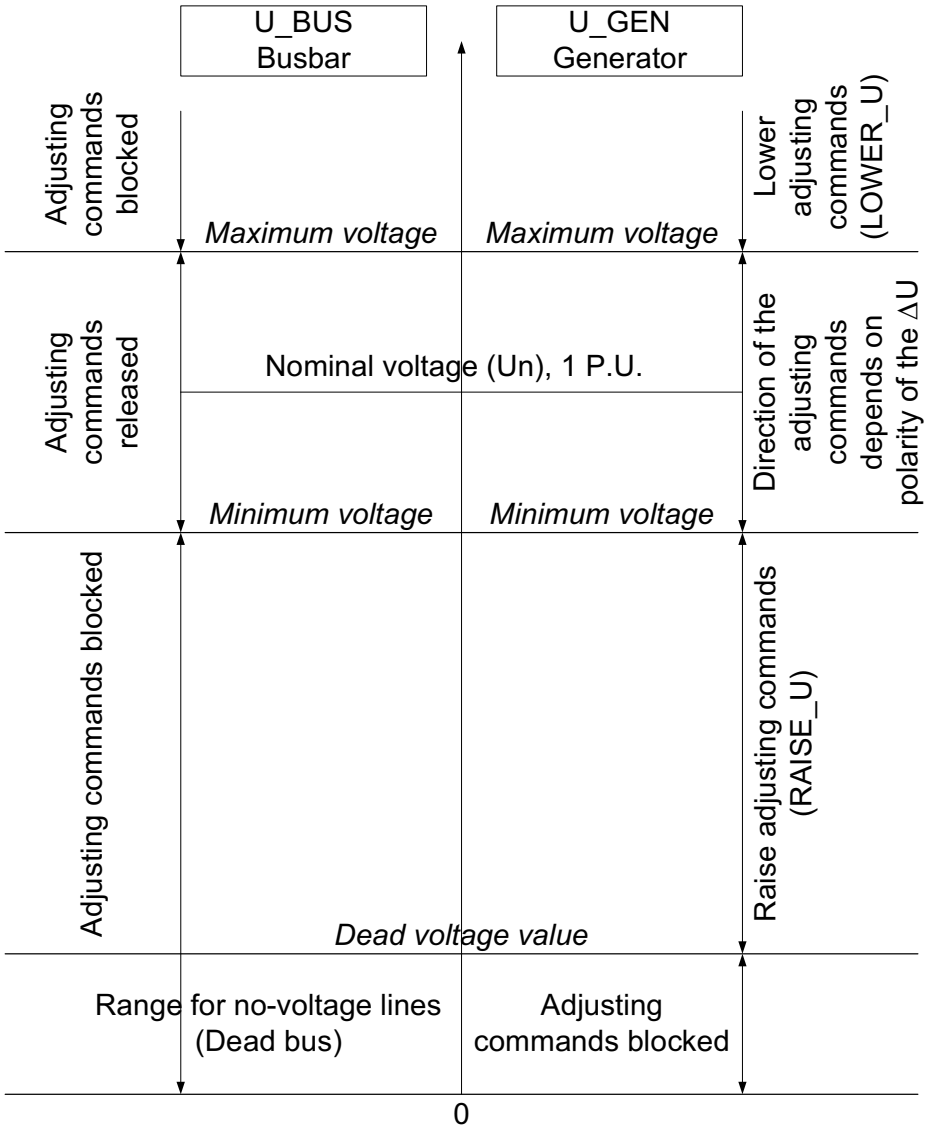



*Figure 760: Working range of the voltage matcher*

If *Auto Syn mode* is set to either "Semi-automatic synchronizing mode" or "Automatic synchronizing mode", the voltage raise or lower command pulses are generated from the function based on the voltage difference across the breaker and AVR response characteristics. If the voltage difference (ΔU) is negative, it means the reference side voltage is greater than the running side voltage. So the voltage matching generates the voltage raise command pulse `RAISE_U`. If the voltage difference (ΔU) is positive, it

means the reference side voltage is lower than the running side voltage. So the voltage matching generates the voltage lower command pulse LOWER_U.

The length of the voltage raise and lower command pulse (tpU) and the pulse off interval (tsU) are calculated based on the setting *Voltage match mode*.

**Voltage matching in manual mode**

If *Auto Syn mode* is set to "Manual mode", the voltage raise or lower command pulses are generated manually from the function's user commands.

If the command *AVR voltage raise* is set to "RAISE", the function activates the voltage raise command pulse RAISE_U. If the command *AVR voltage lower* is set to "LOWER", the function activates the voltage lower command pulse LOWER_U.

The lengths of these generated pulses tpU and pulse off interval tsU are based on the settings as: tpU = *Volt pulse Min Dur*; tsU = *Volt pulse off Intv*.

**Voltage matching with variable command pulse lengths**

When the setting *Voltage match mode* is set to "Variable Pulse", the voltage matching is done with variable command pulse lengths.

The voltage matcher issues a command with a length proportional to the voltage difference. The proportionality factor setting *Volt rate of change* (dU/dt) can be adapted to the voltage regulator. The voltage matcher aims at a value in the middle of the set tolerance band.

The adjusting voltage command pulse length tpU is calculated as

$$tpU = \frac{\Delta U - \left( \frac{+\Delta U\max - \left| -\Delta U\max \right|}{2} \right)}{\frac{dU}{dt}}$$

(Equation 325)

| | |
|---|---|
| ΔU | Measured voltage difference across the CB to be synchronized |
| +ΔUmax | Setting *Voltage Diff Ov Ex* |
| -ΔUmax | Setting *Voltage Diff Un Ex* |
| dU/dt | Setting *Volt rate of change* |

The adjusting pulse is discontinued as soon as the voltage difference exceeds the target value. The command length does not fall below a settable minimum value *Volt pulse Min Dur*. After an adjusting command, the system waits for the set *Volt pulse off Intv* (tsU) so that the actual values can stabilize to the new set point.

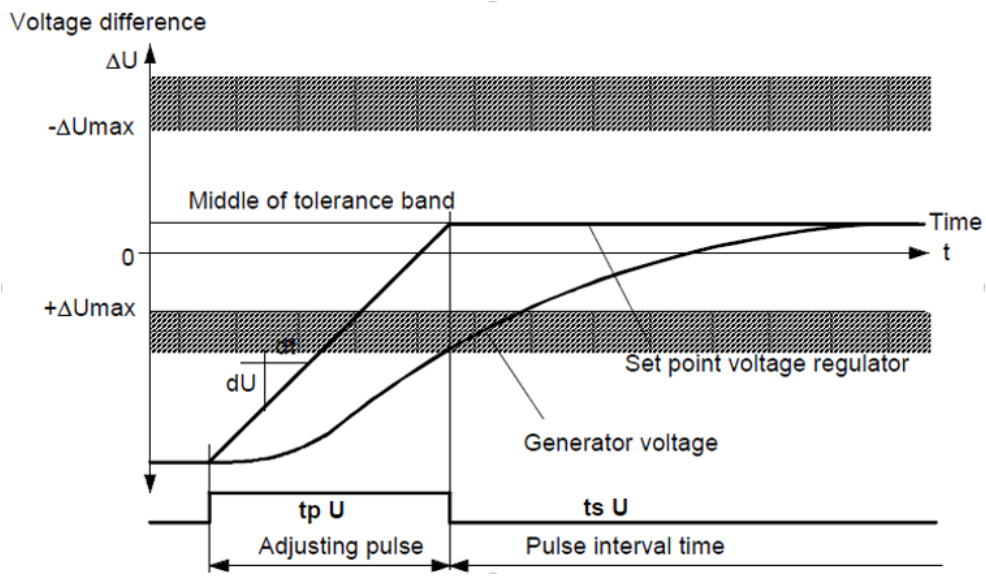



*Figure 761: Voltage matching pulse generation with variable command pulse length*

**Voltage matching with variable command pulse off intervals**

When the setting *Voltage match mode* is set to "Variable Interval", the voltage matching is done with variable command pulse off intervals.

The voltage match command pulses are now the same length, but the intervals are inversely proportional to the voltage difference.

Pulse length (tpU): adjustable with the setting *Volt pulse Min Dur* (tpUmin)

Pulse off interval (tsU): adjustable with the setting *Volt pulse off Intv*, and also dependent on settings *Voltage Diff Ov Ex* and *Voltage Diff Un Ex* as per Equation 326.

$$tsU = Volt\ pulse\ off\ Intv \cdot \left(1 - 0.325 \cdot \left(\Delta U - \frac{\left(+\Delta U\max + \left|-\Delta U\max\right|\right)}{2}\right)\right) \geq 0$$

(Equation 326)

| | |
|---|---|
| ΔU | Measured voltage difference across the CB to be synchronized |
| +ΔUmax | Setting *Voltage Diff Ov Ex* |
| -ΔUmax | Setting *Voltage Diff Un Ex* |

**Reset of voltage raise and lower command pulses**

The generated voltage raise and lower command pulses `RAISE_U` and `LOWER_U` are immediately reset if any of the following conditions is met.

- During matching of its own CB synchronization

- If AVR lower limit alarm AVR_ALM_LO is TRUE, it resets the voltage lower command LOWER_U. If AVR high limit alarm AVR_ALM_HI is TRUE, it resets the voltage raise command RAISE_U.
- If the output MATCH_OK is TRUE, the raise and lower commands are reset.
- If the voltage difference reaches the target value with a hysteresis band that is in the middle of the tolerance band specified by the settings *Voltage Diff Ov Ex* and *Voltage Diff Un Ex*, the raise and lower commands are reset.

- During matching of network CB synchronization
  - If either of the AVR limit alarms AVR_ALM_LO and AVR_ALM_HI is TRUE, it resets the voltage raise and lower commands.
  - When the generator is selected for fine tuning, if the voltage difference is within the limits of tolerance band specified by the settings *Voltage Diff Ov Ex* and *Voltage Diff Un Ex*, the raise and lower commands are reset.
  - When the generator is selected for coarse tuning, if the voltage difference reaches within the limits of *Coarse Volt Diff Ov* and *Coarse Volt Diff Un*, the raise and lower commands are reset.

**Voltage rate of change tuning**

When the control command parameter *Tune V and F match* is set to "Volt match rate", the function calculates the generator voltage matching rate (dU/dt). The calculated voltage matching rate is stored to the nonvolatile memory output VOLT_CHG_RTE and is available in the Monitored data view. Once stored, the value from the output VOLT_CHG_RTE can be used to set the setting *Volt rate of change*.

This tuned voltage matching rate proceeds as follows:

1. The generator voltage is adjusted until it lies in the range of 95...97% of the line voltage, then the adjusting pulse is discontinued.
2. Ten seconds after the first adjusting pulse, the voltage difference ΔU0 is measured, then a voltage raise command RAISE_U lasting 5 s is given. Ten seconds after the end of the pulse, the voltage difference ΔU is measured and dU/dt calculated according to the following formula:

$$\frac{dU}{dt} = \frac{\Delta U - \Delta U_0}{5}$$

(Equation 327)

3. With this dU/dt value, the generator voltage is brought back to approximately 96%.

Ten seconds later, the generator voltage is brought to approximately 100 % with the same dU/dt value. After ten seconds, dU/dt is calculated again and shown as monitored data output VOLT_CHG_RTE.

## Frequency matching

**Working range of the frequency matcher**

No adjustment takes place between 1/3 and 2/3 of smax. The adjusting pulse is discontinued as soon as the slip passes through zero. The command length does not fall below a settable *Freq pulse Min Dur*. After an adjusting command, the system waits for the set *Freq pulse off Intv* so that the actual values can stabilize to the new set point.

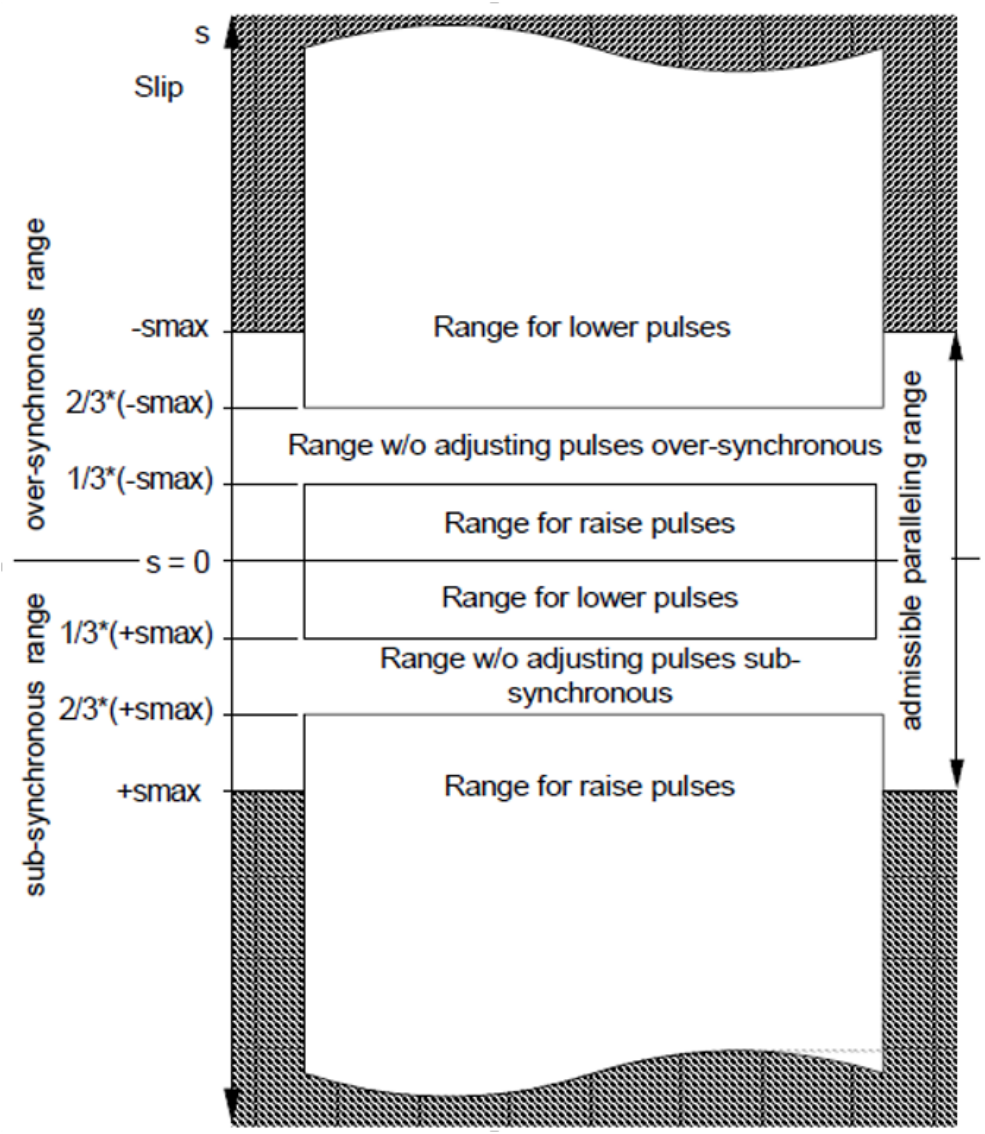



*Figure 762: Working range of the frequency matcher*

If *Auto Syn mode* is set to either "Semi-automatic synchronizing mode" or "Automatic synchronizing mode", the frequency raise or lower command pulses are generated from the function based on the frequency difference across the CB and governor response characteristics.

If the frequency difference (DF) is negative, the reference side frequency is greater than the running side frequency. So the frequency matching generates frequency raise command pulse `RAISE_F`.

If the frequency difference (DF) is positive, it means the reference side frequency is lower than the running side frequency. So the frequency matching generates frequency lower command pulse LOWER_F.

The length of the frequency raise and lower command pulses (tpf) and pulse off interval (tsf) are calculated based on the setting *Frequency match mode*.

**Frequency matching in manual mode**

If *Auto Syn mode* is set to "Manual mode", the frequency raise or lower command pulses are generated manually from the function's user commands.

If the command Gov frequency raise is set to “RAISE”, the function activates the frequency raise command pulse RAISE_F. If the command Gov frequency lower is set to “LOWER”, the function activates the frequency lower command pulse LOWER_F.

The length of these generated pulses tpf and pulse off interval tsf are based on the settings as: tpf = *Freq pulse Min Dur*; tsf = *Freq pulse off Intv*.

**Frequency matching with variable command pulse lengths**

When the setting *Frequency match mode* is set to "Variable Pulse", the frequency matching is done with variable command pulse lengths.

The frequency matcher issues a command with a length proportional to the current slip. The proportionality factor df/dt can be adapted to the governor. The frequency matcher aims at a value midway between the nearer slip limit and zero.

The adjusting frequency command pulse length tpf is calculated as

$$tpf = \frac{|\pm s| - \frac{|\pm s\max|}{2}}{\frac{df}{dt}}$$

(Equation 328)

| | |
|---|---|
| s | Measured frequency difference across the CB to be synchronized |
| +smax | Setting *Freq Diff Ov Synch* |
| -smax | Setting *Freq Diff sub Synch* |
| df/dt | Setting *Freq rate of change* |

The command length does not fall below a settable minimum value *Freq pulse Min Dur*. After an adjusting command, the system waits for the set *Freq pulse off Intv* (tsf) so that the actual values can stabilize to the new set point.

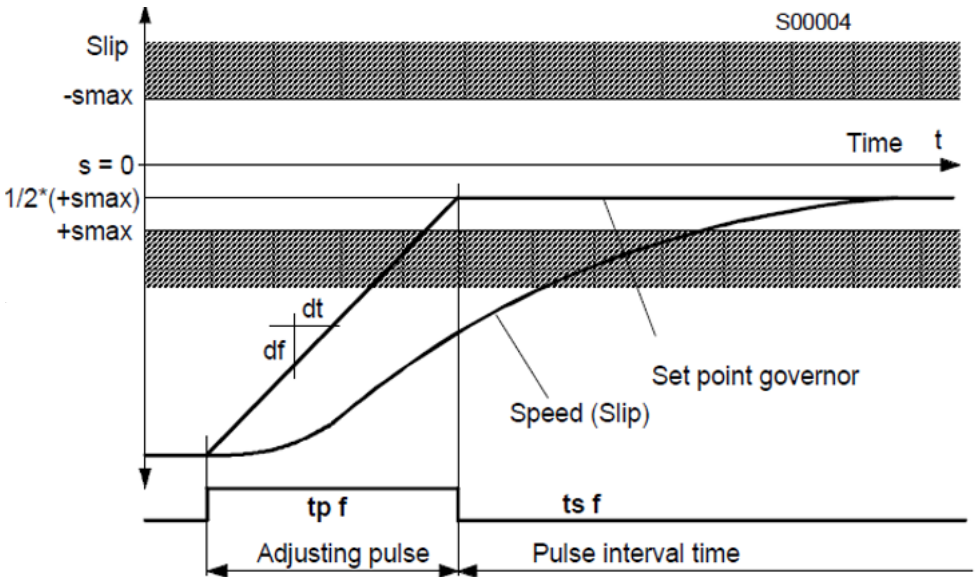



*Figure 763: Frequency matching pulses generation with variable command pulse length*

**Frequency matching with variable command pulse off intervals**

When the setting *Frequency match mode* is set to "Variable Interval", the frequency matching is done with variable command pulse off intervals.

The voltage match command pulses are now the same length, but the intervals are inversely proportional to the frequency slip.

Pulse length (tpf): adjustable with the setting *Freq pulse Min Dur* (tpfmin)

Pulse off interval (tsf): calculated as

$$tsf = \frac{1}{f_{Gen} - f_{Bus}} = \frac{1}{f_{Gen}|s|} \leq 30\ [Sec]$$

(Equation 329)

s Measured frequency slip across the CB to be synchronized

$f_{Gen}$ Measured generator side frequency

$f_{Bus}$ Measured bus side frequency

**Reset of frequency raise and lower command pulses**

The generated frequency raise and lower command pulses RAISE_F and LOWER_F are immediately reset if any of the following conditions is met.

- During matching of its own CB synchronization

    - If governor lower limit alarm GOV_ALM_LO is TRUE, it resets the frequency lower command LOWER_F. If governor high limit alarm GOV_ALM_HI is TRUE, it resets the frequency raise command RAISE_F.
    - If the output MATCH_OK is TRUE, the raise and lower commands are reset.
    - If the frequency difference reaches the target value "± Smax/2" with the hysteresis band specified by the settings *Freq Diff Ov Synch* and *Freq Diff sub Synch*, the raise and lower commands are reset.
- During matching of network CB synchronization
    - If any of the governor limit alarms GOV_ALM_HI or GOV_ALM_LO is TRUE, the raise and lower commands are reset.
    - When the generator is selected for fine tuning, if the frequency difference reaches to target value "± Smax/2" with the hysteresis band specified by the settings *Freq Diff Ov Synch* and *Freq Diff sub Synch*, the raise and lower commands are reset.
    - When the generator is selected for coarse tuning, if the frequency difference reaches within the limits of *Coarse Freq Diff Ov* and *Coarse Freq Diff sub*, the raise and lower commands are reset.

When the matching is done for its own CB synchronization, the output MATCH_OK is activated if the measured voltage and frequency differences are within the set synchro check limits. The MATCH_INPRO output is active while the matching is in progress.

When the matching is done for network CB synchronization, the monitored data NTWMATCH_OK is activated if the network breaker voltage and frequency differences are within the set match limits. NTWMATCH_PRO is active while the matching is in progress. NTWMATCH_OK and NTWMATCH_PRO are available in the Monitored data view.

**Frequency rate of change tuning**

When the control command parameter *Tune V and F match* is set to "Freq match rate", the function calculates the generator frequency matching rate (dF/dt). The calculated frequency matching rate is stored to the nonvolatile memory output FREQ_CHG_RTE and is available in the Monitored data view. Once stored, the value from FREQ_CHG_RTE can be used to set the setting *Freq rate of change*.

This tune frequency matching rate proceeds as follows:

1. The slip is adjusted until this lies in the range of +1...+3%, then the adjusting pulse is discontinued.
2. Ten seconds after the first adjusting pulse, the slip s0 is measured, then a frequency raise command RAISE_F lasting 3 s is given. Ten seconds after the end of the pulse, the slip s is measured and df/dt is calculated according to the formula

$$\frac{df}{dt} = \frac{s - s0}{3}$$

(Equation 330)

3. With this df/dt value, the slip is brought back to approximately +2%.

Ten seconds later, the slip is brought to 0% with the same df/dt value. After ten seconds, df/dt is calculated again and shown as monitored data output FREQ_CHG_RTE.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all binary outputs, binary monitored data and resets the internal timers.

## 9.6.6 Application

A circuit breaker is used to connect two different power networks. It is essential to ensure that these power networks are synchronized before closing the circuit breaker, otherwise it may lead to disturbances in the power system, causing stress and damage to the connected equipment.

ASGCSYN controls the closing of the generator circuit breakers in power networks; it enables the closing after matching the voltage and frequency conditions to achieve synchronism. ASGCSYN also participates in matching voltage and frequency conditions for the network breaker synchronization.

ASGCSYN includes both the synchronization check function and the energizing function to allow closing when one side of the breaker is dead.

The participation of ASGCSYN in matching of voltage and frequency conditions for the network breaker synchronization is described via one of the typical application example as shown in Figure 764.

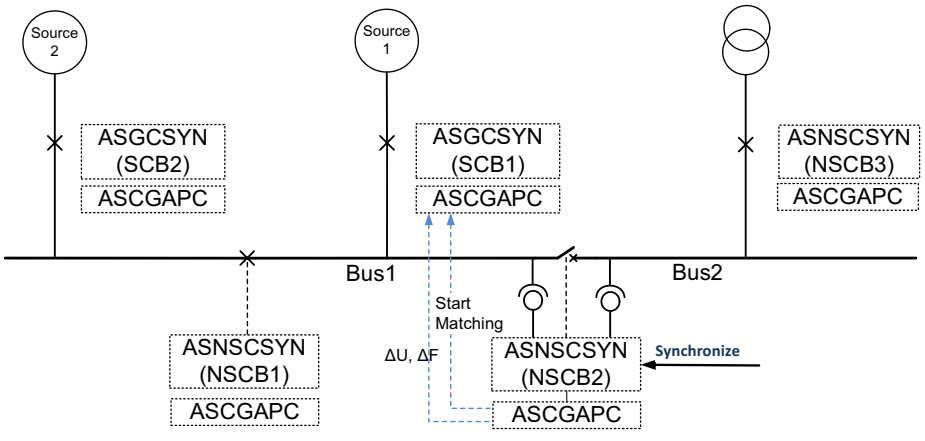



*Figure 764: ASGCSYN participation in matching of V, F during network breaker synchronization*

In this application example, breaker NSCB2 must be closed, so the synchronizing conditions between the Bus1 and Bus2 power systems are checked by the autosynchronizer for network breaker function ASNSCSYN. If the synchro check conditions are not met, then ASNSCSYN sends the auto synchronization request and voltage and frequency difference (ΔU, ΔF) between Bus1 and Bus2 to the autosynchronizer co-ordinator function ASCGAPC.

ASCGAPC transfers the voltage and frequency difference sent by ASNSCSYN to the ASCGAPC of the generator1 ASGCSYN function. It also sends permission to the generator to start matching the voltage and frequency. The generator's ASGCSYN function gives the raise or lower pulses to AVR and governor to raise or lower their voltage and frequency on Bus2. The matching process is carried out so that the voltage and frequency difference between Bus1 and Bus2 measured by ASNSCSYN reduces and comes within the synchro check limits. This satisfies the synchro check conditions for breaker NSCB2 which can then be synchronized by ASNSCSYN.

**Voltage angle difference adjustment**

In applications where the power transformer is located between the voltage measurement and the generator circuit breaker, the vector group connection gives phase difference to the voltages between the high- and low-voltage sides. The angle adjustment can be used to meet synchronism.

The vector group of the power transformer is defined with clock numbers, where the value of the hour pointer defines the low-voltage side phasor and the high-voltage side phasor is always fixed to the clock number 12, which is the same as zero. The angle between clock numbers is 30º. When comparing phase angles, the U_BUS input is always the reference. This means that when the Yd11 power transformer is used, the low-voltage side voltage phasor leads the high-voltage side phasor by 30º or lags by 330º. The rotation of the phasors is counterclockwise.

The generic rule is that a low-voltage side phasor lags the high-voltage side phasor by clock number · 30º. This is called angle difference adjustment and can be set for ASGCSYN with the *Phase shift* setting.

## 9.6.7 Signals

*Table 1359: ASGCSYN Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P1 | SIGNAL | - | Three-phase voltages (generator side) |
| U3P2 | SIGNAL | - | Three-phase voltages (bus side) |
| BLOCK | BOOLEAN | 0=False | Blocking signal of the auto synchronization function |
| CL_COMMAND | BOOLEAN | 0=False | External closing request |
| EXT_CHECK | BOOLEAN | 0=False | External permissive check for CB close |
| BYPASS | BOOLEAN | 0=False | Request to bypass synchronism check and voltage check |
| GCB_TEST | BOOLEAN | 0=False | Circuit breaker test position status |
| Table continues on next page | | | |

| Name | Type | Default | Description |
|---|---|---|---|
| GCB_CLOSE | BOOLEAN | 0=False | Circuit breaker close status |
| GCB_OPEN | BOOLEAN | 0=False | Circuit breaker open status |
| ISO_A_CLOSE | BOOLEAN | 0=False | Isolator A close status |
| ISO_B_CLOSE | BOOLEAN | 0=False | Isolator B close status |
| MODE_GOV | Enum | 1=Droop | Governor working mode |
| MODE_AVR | Enum | 9=Droop | AVR working mode |
| DROOP_GOV | BOOLEAN | 0=False | Governor droop mode status |
| DROOP_AVR | BOOLEAN | 0=False | AVR droop mode status |
| GOV_ALM_HI | BOOLEAN | 0=False | Governor alarm due to high limits |
| GOV_ALM_LO | BOOLEAN | 0=False | Governor alarm due to low limits |
| AVR_ALM_HI | BOOLEAN | 0=False | AVR alarm due to high limits |
| AVR_ALM_LO | BOOLEAN | 0=False | AVR alarm due to low limits |
| DIFF_U_ASC1 | FLOAT32 | 0.00 | Network breaker voltage difference from ASCGAPC1 |
| DIFF_F_ASC1 | FLOAT32 | 0.000 | Network breaker frequency difference from ASCGAPC1 |
| ASC1_GEN_DAT | INT32 | 0 | Integer weighted input data from ASCGAPC1 |

*Table 1360: ASGCSYN Output signals*

| Name | Type | Description |
|---|---|---|
| SYNC_INPRO | BOOLEAN | Auto synchronization in progress |
| SYNC_OK | BOOLEAN | Systems in synchronism |
| MATCH_INPRO | BOOLEAN | Voltage and frequency matching in progress |
| MATCH_OK | BOOLEAN | Voltage and frequency of the systems matched |
| CLOSE_CB | BOOLEAN | CB close signal |
| CL_FAIL_AL | BOOLEAN | CB closing failed |
| CMD_FAIL_AL | BOOLEAN | CB closing request failed |
| LBDG | BOOLEAN | Live bus, dead generator |
| LBLG | BOOLEAN | Live bus, live generator |
| DBLG | BOOLEAN | Dead bus, live generator |
| DBDG | BOOLEAN | Dead bus, dead generator |
| CB_SELECTED | BOOLEAN | CB selected for synchronization |
| RAISE_U | BOOLEAN | Raise voltage pulse |
| LOWER_U | BOOLEAN | Lower voltage pulse |
| RAISE_F | BOOLEAN | Raise frequency pulse |
| LOWER_F | BOOLEAN | Lower frequency pulse |
| GOV_DROOP | BOOLEAN | Command for governor mode change to droop |
| AVR_DROOP | BOOLEAN | Command for AVR mode change to droop |

Table continues on next page

| Name | Type | Description |
|---|---|---|
| MOD_CHG_GOV | Enum | MOD_CHG_GOV |
| MOD_CHG_AVR | Enum | MOD_CHG_AVR |
| GEN_ASC_DATA | INT32 | Integer weighted output data to ASCGAPC |

## 9.6.8 Settings

*Table 1361: ASGCSYN Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Live dead mode | -1=Off<br>-2=Command<br>1=Both Dead<br>4=Dead B, G Any<br>2=Live G, Dead B | | | -1=Off | Live dead mode |
| Freq Diff Ov Synch | 0.000...0.060 | xFn | 0.001 | 0.004 | Over synchronous limit for admissible paralleling range |
| Freq Diff sub Synch | 0.000...0.060 | xFn | 0.001 | 0.004 | Sub synchronous limit for admissible paralleling range |
| Coarse Freq Diff Ov | 0.000...0.060 | xFn | 0.001 | 0.005 | Over synchronous limit during generator coarse matching |
| Coarse Freq Diff sub | 0.000...0.060 | xFn | 0.001 | 0.005 | Sub synchronous limit during generator coarse matching |
| Voltage Diff Ov Ex | 0.00...0.40 | xUn | 0.01 | 0.03 | Maximum voltage difference limit allowed during matching |
| Voltage Diff Un Ex | 0.00...0.40 | xUn | 0.01 | 0.03 | Maximum voltage difference limit allowed during matching |
| Coarse Volt Diff Ov | 0.00...0.40 | xUn | 0.01 | 0.03 | Maximum voltage difference limit allowed during matching |
| Coarse Volt Diff Un | 0.00...0.40 | xUn | 0.01 | 0.03 | Maximum voltage difference limit allowed during matching |
| Angle Diff positive | 5...90 | deg | 1 | 5 | Maximum angle difference limit |
| Angle Diff negative | 5...90 | deg | 1 | 5 | Maximum angle difference limit |
| Volt rate of change | 0.001...0.050 | xUn/s | 0.001 | 0.003 | dU/dt adapted to AVR for voltage matching pulses |
| Freq rate of change | 0.001...0.050 | xFn/s | 0.001 | 0.002 | dF/dt adapted to governor for frequency matching pulses |

*Table 1362: ASGCSYN Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase shift | -180...180 | deg | 1 | 0 | Correction of phase difference between measured voltages |
| Closing time of CB | 40...250 | ms | 1 | 60 | Closing time of the breaker |
| Multiple command | 0=Off<br>1=On | | | 0=Off | Multiple command generation |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Synchronization Dir | 1=Always over synchronous<br>2=Both direction | | | 2=Both direction | Synchronization direction |
| Voltage offset | -0.100...0.100 | xUn | 0.001 | 0.000 | Voltage offset |
| Frequency offset | -0.010...0.010 | xFn | 0.001 | 0.000 | Frequency offset |

*Table 1363: ASGCSYN Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Synchrocheck mode | 1=Off<br>3=Asynchronous<br>4=Command | | | 3=Asynchronous | Synchrocheck operation mode |
| Dead voltage value | 0.10...0.80 | xUn | 0.10 | 0.20 | Voltage low limit for energizing check |
| Live voltage value | 0.20...1.00 | xUn | 0.10 | 0.50 | Voltage high limit for energizing check |
| Maximum voltage | 0.50...1.30 | xUn | 0.01 | 1.05 | Maximum voltage above which no paralleling takes place |
| Minimum voltage | 0.50...0.95 | xUn | 0.01 | 0.80 | Minimum voltage below which no paralleling takes place |
| Voltage match mode | 1=Off<br>2=Variable Pulse<br>3=Variable Interval | | | 2=Variable Pulse | Voltage matcher mode |
| Frequency match mode | 1=Off<br>2=Variable Pulse<br>3=Variable Interval | | | 2=Variable Pulse | Frequency matcher mode |
| Auto Syn mode | -1=Semi-automatic synchronising mode<br>1=Automatic synchronising mode<br>3=Manual mode | | | 3=Manual mode | Auto synchronization operation mode |

*Table 1364: ASGCSYN Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum Syn time | 0...60000 | ms | 10 | 0 | Minimum time to accept synchronizing |
| Maximum Syn time | 100...6000000 | ms | 10 | 60000 | Maximum time to accept synchronizing |
| Energizing time | 100...60000 | ms | 10 | 100 | Time delay for energizing check |
| Central PMS present | 1=No<br>2=Yes | | | 1=No | Centralized Power Management System present |
| Volt pulse off Intv | 1000...20000 | ms | 10 | 2000 | Set voltage pulse off interval time |
| Volt pulse Min Dur | 50...2000 | ms | 10 | 50 | Set voltage pulse minimum duration |
| Freq pulse off Intv | 1000...120000 | ms | 10 | 20000 | Set frequency pulse off interval time |
| Freq pulse Min Dur | 50...2000 | ms | 10 | 50 | Set frequency pulse minimum duration |

## 9.6.9 Monitored data

*Table 1365: ASGCSYN Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ENERG_STATE | Enum | 0=Unknown<br>1=Both Live<br>2=Live G, Dead B<br>3=Dead G, Live B<br>4=Both Dead | | Energization state of bus and generator |
| U_DIFF_MEAS | FLOAT32 | -3.00...3.00 | xUn | Calculated voltage amplitude difference |
| FR_DIFF_MEAS | FLOAT32 | -1.500...1.500 | xFn | Calculated voltage frequency difference |
| PH_DIFF_MEAS | FLOAT32 | -180.00...180.00 | deg | Calculated voltage phase angle difference |
| U_BUS_MEAS | FLOAT32 | 0.00...5.00 | xUn | Calculated bus voltage amplitude |
| U_GEN_MEAS | FLOAT32 | 0.00...5.00 | xUn | Calculated generator voltage amplitude |
| FR_BUS_MEAS | FLOAT32 | 35.00...75.00 | Hz | Calculated bus frequency |
| FR_GEN_MEAS | FLOAT32 | 35.00...75.00 | Hz | Calculated generator frequency |
| FR_SLIP_ACCL | FLOAT32 | 0.000...5.000 | xFn/s | Calculated rate of change of frequency slip |
| U_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Voltage difference out of limit for synchronizing |
| FR_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Frequency difference out of limit for synchronizing |
| PH_DIF_SYNC | BOOLEAN | 0=False<br>1=True | | Phase angle difference out of limit for synchronizing |
| CB_CL_BLKD | Enum | 1=Unblocked<br>2=Ext Check Fail<br>3=IED Test CB Service<br>4=IED Service CB Test | | CB close blocked status |
| VOLT_CHG_RTE | FLOAT32 | 0.000...0.050 | xUn/s | Calculated generator matching voltage rate of change |
| FREQ_CHG_RTE | FLOAT32 | 0.000...0.050 | xFn/s | Calculated generator matching frequency rate of change |
| U_DIFF_NTW | FLOAT32 | -3.00...3.00 | xUn | Voltage amplitude difference of the network breaker |
| FR_DIFF_NTW | FLOAT32 | -1.500...1.500 | xFn | Voltage frequency difference of the network breaker |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| NTWMATCH_PRO | BOOLEAN | 0=False<br>1=True | | Matching in progress for network breaker synchronization |
| NTWMATCH_OK | BOOLEAN | 0=False<br>1=True | | Voltage, frequency across the network breaker systems matched |
| SYNCCHK_STS | Enum | 1=Off<br>3=Asynchronous | | Synchro check mode status |
| LIVEDEAD_STS | Enum | -1=Off<br>1=Both Dead<br>2=Live G, Dead B<br>4=Dead B, G Any | | Live dead mode status |
| ASGCSYN | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 9.6.10 Technical data

*Table 1366: ASGCSYN Technical data*

| Characteristic | Value |
|---|---|
| Measurement accuracy | Depending on the frequency of the voltage measured:<br>$f_n$ ±2 Hz |
| | Voltage difference:<br>±1.0% or ±0.004 × $U_n$<br>Frequency difference:<br>±10 mHz<br>Phase angle difference:<br>±1° |
| Operation accuracy | MATCH_OK for voltage:<br>±0.001 × $U_n$<br>MATCH_OK for frequency:<br>±10 mHz |
| Operation time accuracy | Raise/Lower output pulse width:<br>±1.0% of the set value or ±20 ms<br>*Energizing time* for dead-bus closing:<br>±1.0% of the set value or ±35 ms<br>*Minimum Syn time* for SYNC_OK:<br>±1.0% of the set value or ±60 ms |
| Reset time | Typically 20 ms |
| Closing angle accuracy | ±1° |

# 9.7 Autosynchronizer for network breaker ASNSCSYN

## 9.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Autosynchronizer for network breaker | ASNSCSYN | AUTOSYNCBT/T | 25AUTOSYNCBT/T |

## 9.7.2 Function block




*Figure 765: Function block*

## 9.7.3 Functionality

The autosynchronizer for network breaker function ASNSCSYN can be used for the controlled closing of a bus coupler or tie feeder circuit breaker (CB). ASNSCSYN includes the functionality of synchrocheck, energizing check and autosynchronization.

ASNSCSYN checks the power system conditions between both networks across the circuit breaker. The energizing check is used to check that at least one side is dead to ensure that closing can be done safely.

In case of a synchronous system, the closing command is issued after considering the function modes, essential checks, CB closing time and the paralleling conditions. In case of asynchronous systems, the function initiates the matching of voltage and frequency with the help of available generators through Autosynchronizer co-ordinator ASCGAPC.

The function contains a blocking functionality. It is possible to block function outputs.

## 9.7.4 Analog input configuration

ASNSCSYN has two analog group inputs which must be properly configured.

*Table 1367: Analog inputs*

| Input | Description |
|---|---|
| U3P1 | Three-phase voltages (Bus B side) |
| U3P2 | Three-phase voltages (Bus A side) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1368: Special conditions*

| Condition | Description |
|---|---|
| U3P1 and U3P2 connected to real measurements | When one voltage channel from the Bus B side is connected to channel 1 of U3P1 and one voltage channel from the Bus A side is connected to channel 1 of U3P2, the function can only work if UTVTR's VT connection settings on the Bus A and Bus B sides are similar. |
| | The function can work if one voltage channel from the Bus B side is connected to channel 1 of U3P1 and three voltage channels from the Bus A side are connected to U3P2. |
| | The function can work if one voltage channel from the Bus B side is connected to channel 1 of U3P1 and two voltage channels along with the residual voltage from the Bus A side are connected to U3P2. |
| | The function can work if three voltage channels from the Bus B side are connected to U3P1 and one voltage channel from the Bus A side is connected to channel 1 of U3P2. |
| | The function can work if two voltage channels along with the residual voltage from the Bus B side are connected to U3P1 and one voltage channel from the Bus A side is connected to channel 1 of U3P2. |
| Dissimilar VT connection settings for UTVTR on the Bus A and Bus B sides | The function requires that all three voltage channels or two voltage channels along with the residual voltage are connected to either U3P1 or U3P2. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 9.7.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of ASNSCSYN can be described with a module diagram. All the modules in the diagram are explained in the next sections.

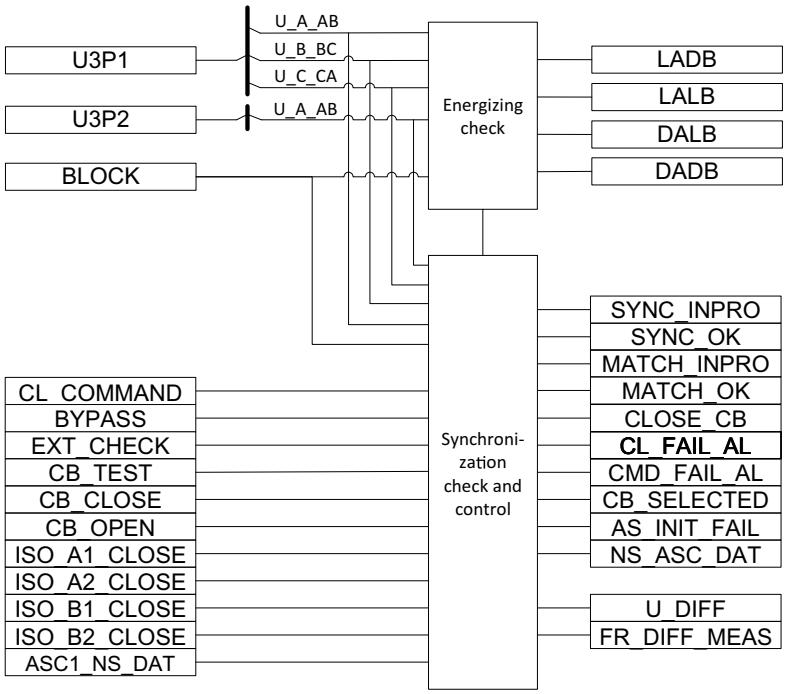



*Figure 766: Functional module diagram*

This function can operate either with the U_AB or U_A voltages. The selection of used voltages is defined with the *VT connection* setting of the line voltage general parameters.

### Energizing check

The Energizing check module checks the energizing direction. Energizing is the situation where a dead network part is connected to an energized section of the network. The *Live dead mode* setting is used to set the energized condition of the bus section across the CB, that is, whether the bus section across the CB is live or dead.

When the *Live dead mode* setting parameter is set to "Command", then the energized condition (see Table 1369) of bus sections across the CB can be set using the *Live dead mode Ctl* control command only. If the *Live dead mode* setting parameter is not set to "Command", then the *Live dead mode* setting parameter is used to set the energized condition (see Table 1369) of the bus section across the CB.

*Table 1369: Live dead mode of operation when switching can be carried out*

| Live dead mode | Description |
|---|---|
| Command | The *Live dead mode* setting uses *Live dead mode Ctl* control command. |
| Off | *Live dead mode* is set to "Off". |
| Both Dead | Both Bus A and Bus B de-energized |
| Live B, Dead A | Bus B energized and Bus A de-energized |
| Dead B, Live A | Bus B de-energized and Bus A energized |
| Dead A , B Any | Bus A de-energized and Bus B energized or de-energized |
| Dead B, A Any | Bus B de-energized and Bus A energized or de-energized |
| One Live, Dead | Bus A de-energized and Bus B energized or Bus B de-energized and Bus A energized |
| Not Both Live | Both Bus A and B de-energized or Bus A de-energized and Bus B energized or Bus B de-energized and Bus A energized |

When the energizing direction corresponds to the settings, the situation has to be constant for a time set with the *Energizing time* setting before the CB closing is permitted. This time delay ensures that the dead side remains de-energized and that the situation is not caused by a temporary interference. If the conditions do not persist for a specified operation time, the timer is reset and the procedure is restarted when the conditions allow it. The CB does not close if the measured voltage on the live side is greater than the set value of *Max energizing V*.

The measured energized state is available as a monitored data value ENERG_STATE and as four function outputs LADB (live bus A and dead bus B), LALB (live bus A and live bus B), DALB (dead bus A and live bus B) and DADB (dead bus A and dead bus B), of which only one can be active at a time. The measured energized state indicates “Unknown” if at least one of the measured voltages is between the limits set with the dead and live setting parameters.

## Synchronization check and control

The operation of Synchronization check and control modes can be described with a module diagram.

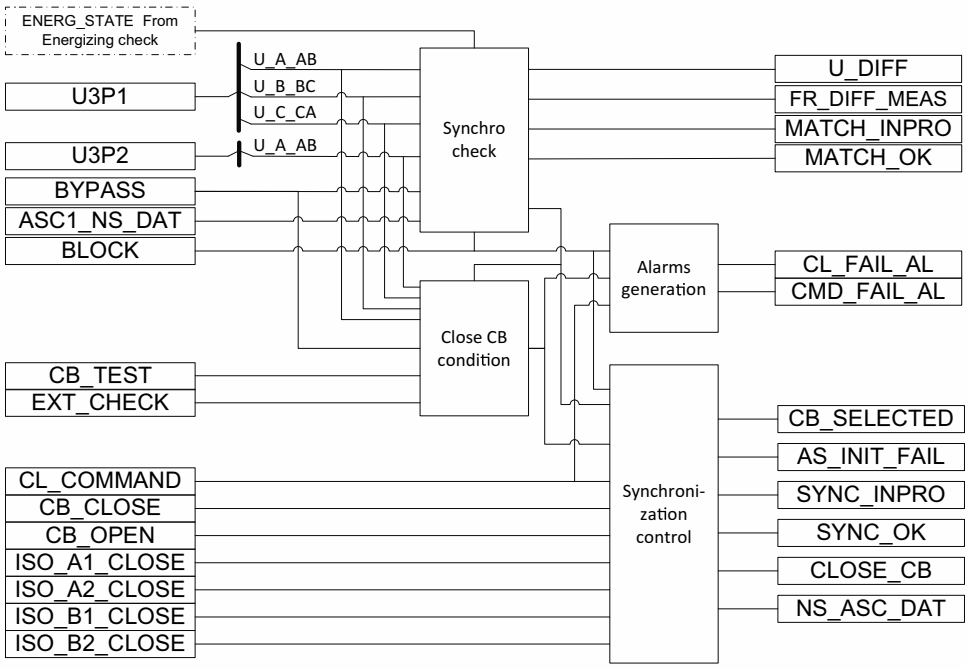



*Figure 767: Module diagram for Synchronization check and control*

### Synchro check

The function measures the voltage difference U_DIFF_MEAS, frequency difference FR_DIFF_MEAS and phase angle difference PH_DIFF_MEAS between the two bus sides.

$$U_DIFF_MEAS = U_{BusA} - U_{BusB} + Voltage\ offset$$

(Equation 331)

| | |
|---|---|
| $U_{BusA}$ | Measured bus A side voltage |
| $U_{BusB}$ | Measured bus B side voltage |
| Voltage offset | Setting *Voltage offset* |

$$FR_DIFF_MEAS = f_{BusA} - f_{BusB} + Frequency\ offset$$

(Equation 332)

| | |
|---|---|
| $f_{BusA}$ | Measured bus A side frequency |
| $f_{BusB}$ | Measured bus B side frequency |
| Frequency offset | Setting *Frequency offset* |

$$PH_DIFF_MEAS = \angle U_{BusA} - \angle U_{BusB} + Phase\ shift$$

(Equation 333)

| | |
|---|---|
| $\angle U_{BusA}$ | Measured bus A side voltage phase angle |
| $\angle U_{BusB}$ | Measured bus B side voltage phase angle |
| Phase shift | Setting *Phase shift* |

The calculated voltage and phase angle difference values between these voltages are available as monitored data U_DIFF_MEAS and PH_DIFF_MEAS. The setting *Phase shift* is used to compensate the angle shift caused if a power transformer is located between the voltage measurements.

The synchronism condition and CB closing instance are checked according to several criteria.

- The measured bus A and bus B voltages are higher than the set value of *Live bus voltage* (ENERG_STATE equals “Both Live”).
- The measured bus A and bus B frequencies are both within the range of 95...105 % of the value of the nominal frequency ($f_n$).
- The measured bus A and bus B voltages are lower than the set value of *Max energizing V*.

When the *Synchrocheck mode* setting parameter is set to "Command", then the “Synchronous”, “Asynchronous” or “Off” condition of the network across the CB can be set using the *SynchroChk Mod Ctl* control command only. If the *Synchrocheck mode* setting parameter is not set to "Command", then the *Synchrocheck mode* setting parameter is used to set the “Synchronous”, “Asynchronous” or “Off” condition of the network across the CB.

Some additional conditions must be fulfilled according to the set *Synchrocheck mode*.

*Table 1370: Additional conditions for the Synchro check*

| Measurements | *Synchrocheck mode* | |
|---|---|---|
| | “Synchronous” | “Asynchronous” |
| U_DIFF_MEAS | < 0.01 x Nominal voltage ($U_n$) | < Difference voltage |
| PH_DIFF_MEAS | < 5 degree | < Difference angle |
| FR_DIFF_MEAS | < 0.001 x Nominal frequency ($f_n$) | < Frequency difference |
| Estimated closing angle | N/A | < Difference angle |

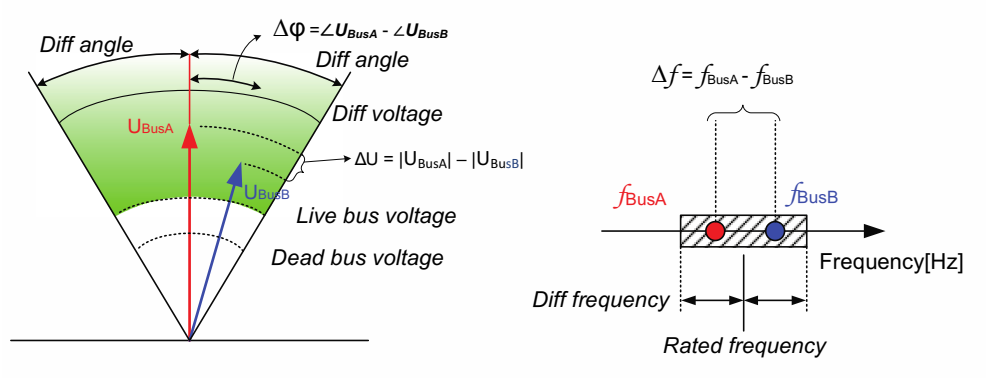



*Figure 768: Conditions to be fulfilled when detecting synchronism between systems*

When the measured difference of voltages (U_DIFF_MEAS) and measured difference in frequency (FR_DIFF_MEAS) are within the synchro check limits given in Table 1370, the output MATCH_OK is activated. The output MATCH_INPRO is activated when the voltage and frequency matching is in progress. The matching status input is received via ASC1_NS_DAT signal from ASCGAPC.

When the frequency, phase angle and voltage conditions are fulfilled, the duration of the synchronism conditions is checked to ensure that they are still met when the condition is determined on the basis of the measured frequency and phase difference. Depending on the CB and the closing system, the delay between the closing signal and the CB closing is about 50...250 ms. The selected *Closing time of CB* informs the function how long the conditions have to persist. The value covers both the CB closing delay and the output type dependent delay. The synchro check function compensates for the measured slip frequency and the CB closing delay.

The closing angle advance is calculated continuously:

$$Closing\ angle = \left| (\angle U_{BusA} - \angle U_{BusB})° + \left( (f_{BusA} - f_{BusB}) \cdot \left( \frac{TCB}{1000} \right) \cdot 360° \right) \right|$$

(Equation 334)

$\angle U_{BusA}$ Measured bus A voltage phase angle

$\angle U_{BusB}$ Measured bus B voltage phase angle

TCB Parameter *Closing time of CB* to be set as in Equation 335

$$TCB = t_{CB} + T_{PL} + x$$

(Equation 335)

$t_{CB}$ CB closing delay in ms

$T_{PL}$ Output type dependent delay in ms (see Table 1371)

x Hardware delays between the protection relay and CB in ms; delays due to, for example, auxiliary relays and contactors, if used

*Table 1371: Typical delays for different output types*

| Output type | Recommended value for $T_{PL}$ | |
|---|---|---|
| | Both Bus side voltage measurements: Non-Adaptive or Both Bus side voltage measurements: Adaptive. | Any one of the Bus side voltage measurement: Adaptive, The other Bus side voltage measurement: Non Adaptive |
| Semiconductor output (SPO) | 16 ms | 7 ms |
| Mechanical relay output (POSP, PODP) | 23 ms | 13 ms |

The *Minimum Syn time* setting defines the minimum time for which synchro check conditions must be simultaneously fulfilled.

The frequency slip acceleration (ds/dt) SLIP_ACCL is the average value of frequency slip difference (Δs) calculated over a time period of 0.5 s.

$$Frequency\ slip(s) = \frac{(f_{BusA} - f_{BusB})}{f_{BusA}}$$

(Equation 336)

The measured bus A voltage ($U_{BusA}$), bus A frequency ($f_{BusA}$), measured bus B voltage ($U_{BusB}$), bus B frequency ($f_{BusB}$), and phase angle difference (PH_DIFF_MEAS) values between the two sides of the CB are available as monitored data values.

If the measured U_DIFF_MEAS does not fulfill the condition given in Table 1370 and thus synchronism is prevented, the monitored data U_DIFF_SYNC is activated. Similarly PH_DIF_SYNC and FR_DIFF_SYNC are activated based on the measurements PH_DIFF_MEAS and FR_DIFF_MEAS, respectively. These monitored data values are updated only when the setting *Synchrocheck mode* is set to either "Synchronous" or "Asynchronous" and the measured ENERG_STATE is "Both Live". The outputs `U_DIFF` and `FR_DIFF_MEAS` give the calculated phase-to-phase voltage difference and the frequency difference values, respectively. These `U_DIFF` and `FR_DIFF_MEAS` outputs are sent to ASCGAPC.

The monitored data ACT_ASC_CB indicates the ASCGAPC CB number. The CB number of the protection relay's ASCGAPC is received via `ASC1_NS_DAT` signal.

**Close CB condition**

If *Synchrocheck mode* is set to "Asynchronous", the CB close command is generated as explained below.

From the frequency slip s, the acceleration ds/dt, the bus frequency FR_BUS_MEAS ($f_{Bus}$) and the set *Closing time of CB*, the function calculates the necessary lead angle ($\alpha_{Lead}$) by which the close CB command is shifted forward in time so that the main contacts close on phase coincidence.

$$\alpha_{Lead} = \left( 360 \cdot f_{BusA} \cdot \left( s + \frac{\frac{TCB}{2} \cdot \frac{ds}{dt}}{1000} \right) \cdot \frac{TCB}{1000} \right)$$

(Equation 337)

$f_{BusA}$ Bus A side frequency

s Frequency slip

ds/dt Frequency slip acceleration

TCB Setting *Closing time of CB*

The breaker closes only when the measured phase-angle difference across the breaker (PH_DIFF_MEAS) equals the calculated lead angle ($\alpha_{Lead}$) and all synchronization check conditions are fulfilled.

If *Synchrocheck mode* is set to "Synchronous", a zero-passage of the phase-angle difference is not necessary and CB closing is permitted as soon as all the synchrocheck conditions are fulfilled. Similarly for dead bus synchronization, CB closing is possible when the energizing check permits.

The CB closing signal can be blocked based on the inputs CB_TEST and EXT_CHECK and IED test mode as described in Table 1372. This blocking status is available in the monitored data CB_CL_BLKD.

*Table 1372: CB_CL_BLKD status based on the inputs*

| IED test mode | Inputs | | Monitored data |
|---|---|---|---|
| | CB_TEST | EXT_CHECK | CB_CL_BLKD |
| TRUE | TRUE | TRUE | 1(“Unblocked”) |
| FALSE | FALSE | | |
| TRUE | TRUE | FALSE | 2(“Ext check fail”) |
| FALSE | FALSE | | |
| TRUE | FALSE | N/A | 3(“IED Test, CB Service”) |
| FALSE | TRUE | N/A | 4(“IED Service, CB Test”) |

ASNSCSYN can be set to the bypass mode by setting the parameters *Synchrocheck mode* and *Live dead mode* to "Off" or, alternatively, by activating the BYPASS input. In the bypass mode, the closing conditions are always considered to be fulfilled by ASNSCSYN.

**Synchronization control**

The general bus bar arrangement for a non-source CB bus is shown in Figure 769. The bus to which the generator is connected is determined based on the CB and isolator position inputs (CB_OPEN, CB_CLOSE, ISO_A1_CLOSE, ISO_A2_CLOSE, ISO_B1_CLOSE and ISO_B2_CLOSE). The generator's bus connection status is shared with ASCGAPCs as part of the NS_ASC_DAT output.

The equipment which is capable of voltage and frequency adjustment, that is, the generator, is referred to as source and the rest as non-source. Hence the generator's CB is referred to as source CB and the bus coupler or tie feeder CB as non-source CB.

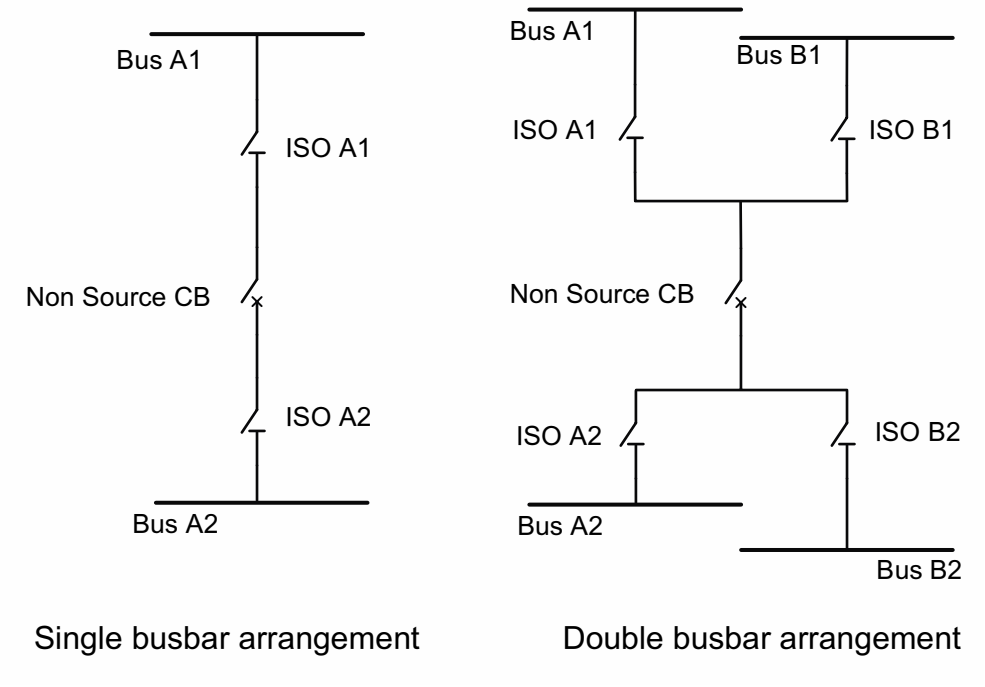



*Figure 769: Different busbar arrangement for a non-source CB*

**Auto synchronization mode**

In this mode, the closing signal is delivered if either the command *Synchronize CB* or the input CL_COMMAND is set to TRUE. The device should be in local mode if initiation *Synchronize CB* is given for synchronization.

If the setting *Auto Syn mode* is set as "Manual mode" or "Semi-automatic synchronising mode", the additional command Manual CB release should be active for the closing signal CLOSE_CB to be activated. If the setting *Auto Syn mode* is set as "Automatic synchronising mode", no additional command is required to activate the closing signal CLOSE_CB.

In this auto synchronization mode, once all the closing conditions are satisfied within the set *Maximum Syn time*, the outputs SYNC_OK and CLOSE_CB become TRUE and

remain active as long as the closing conditions are fulfilled. If *Multiple command* is set to "Off", then only CLOSE_CB outputs are delivered once for each activated input signal as shown in Figure 770. If *Multiple command* is set to "On", then CLOSE_CB outputs are delivered each time the conditions are satisfied as shown in Figure 771. In this auto synchronization mode, once all the closing conditions are satisfied within the set *Maximum Syn time*, the outputs SYNC_OK and CLOSE_CB become TRUE. These outputs remain active as long as the respective conditions are fulfilled. If *Multiple command* is set to "Off", then only CLOSE_CB outputs are delivered only once for each activated input signal as shown in Figure 770. If *Multiple command* is set to "On", then CLOSE_CB outputs are delivered each time the conditions are satisfied as shown in Figure 771.

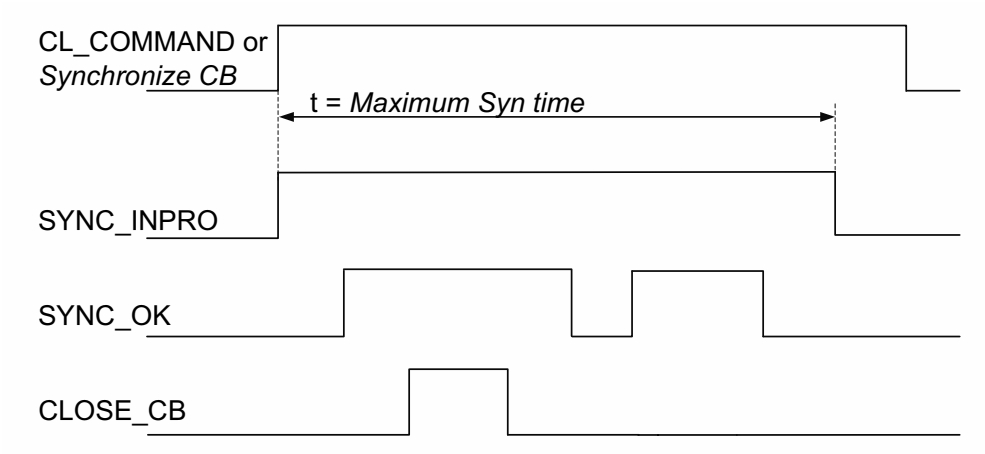



*Figure 770: Determination of closing signal CLOSE_CB when Multiple command is set to "Off"*

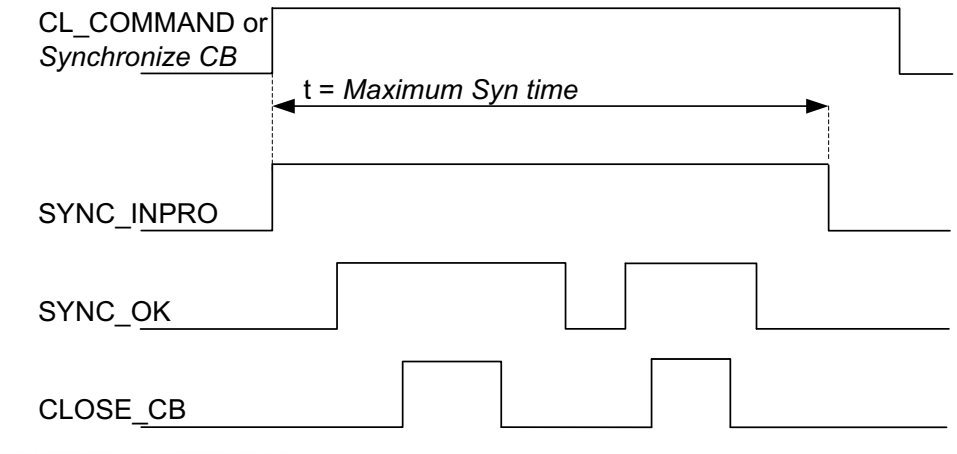



*Figure 771: Determination of closing signal CLOSE_CB when Multiple command is set to "On"*

The SYNC_INPRO output is active when the close command (CL_COMMAND or *Synchronize CB*) is in progress and it is reset when the close command is reset or

*Maximum Syn time* has elapsed. In this automatic mode the closing signal CLOSE_CB is activated automatically once all the closing conditions are satisfied.

If the closing conditions are fulfilled during a permitted check time set with *Maximum Syn time*, ASNSCSYN gives synchro check permission to Circuit-breaker control CBXCBR after the closing command signal is delivered. The simplified configuration block diagram of ASNSCSYN with CLOSE_CB to CBXCBR is as shown in Figure 772.

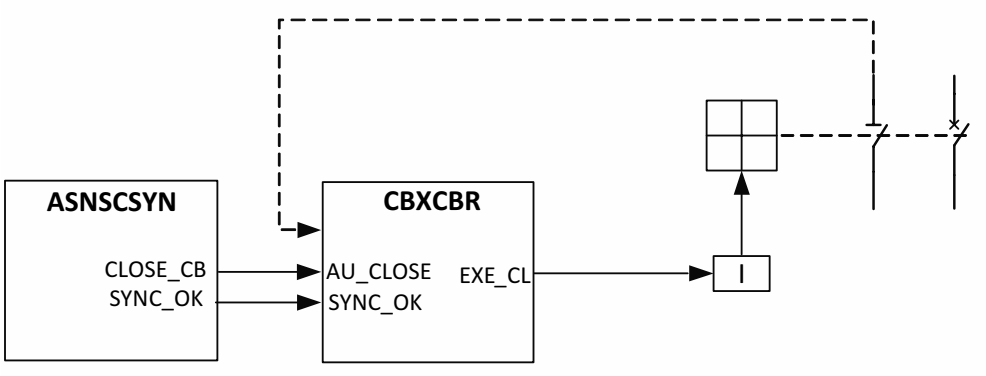



*Figure 772: Simplified configuration block diagram of ASNSCSYN in auto synchronization mode operation*

**Alarms generation**

In auto synchronization control mode, the closing command generation is activated by either command input CL_COMMAND or by command parameter *Synchronize CB*.

After the closing command activation, if the conditions for closing CB are not fulfilled within the set time of *Maximum Syn time*, a failed closing attempt alarm is given. The CL_FAIL_AL alarm output signal is pulse-shaped and the pulse length is 500 ms.

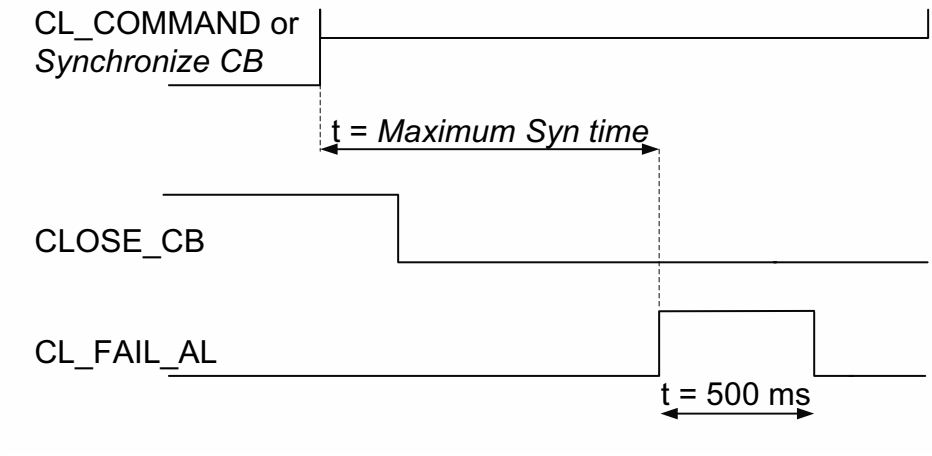



*Figure 773: Determination of checking time for closing*

CB closing is permitted during *Maximum Syn time*, starting from the moment the close command is activated. The close command must be active while the closing conditions are fulfilled, otherwise the procedure is cancelled. If the closing conditions are fulfilled during *Maximum Syn time*, a closing pulse output is delivered to the CB. If the closing conditions are not fulfilled during the checking time, the alarm CL_FAIL_AL is activated as an indication of a failed closing attempt. The closing pulse is not delivered if the closing conditions become valid after *Maximum Syn time* has elapsed. The closing pulse is delivered only once for each activated close command, and a new closing command sequence cannot be started until the close command is reset and reactivated.

CBXCBR receives information about the CB status and thus is able to adjust the command signal to be delivered to ASNSCSYN. If the closing command is active longer than necessary, the CMD_FAIL_AL alarm output is activated. To avoid unnecessary alarms, the maximum length of the closing command signal should be below *Maximum Syn time* + 5 s.

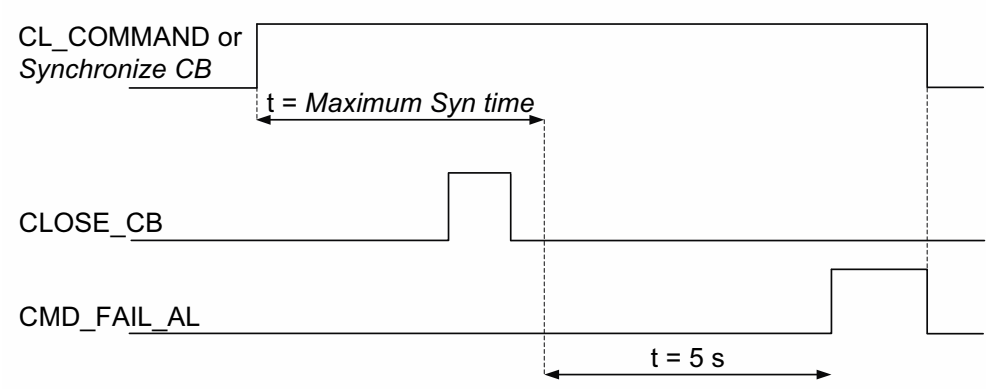



*Figure 774: Determination of the alarm limit for a still-active command signal*

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all binary outputs and resets the internal timers.

## 9.7.6 Application

A circuit breaker is used to connect two different power networks. It is essential to ensure that these power networks are synchronized before closing the CB, otherwise it may lead to disturbances in the power system, causing stress and damage to the connected equipment.

ASNSCSYN can be used for the synchronization of any bus coupler or tie feeder CB. It checks for the synchronization conditions across the CB and releases the CB closing command. If these conditions are not fulfilled, the sources in the power network connected across this bus coupler or tie feeder CB have to change their operating points to meet the requirements. This is achieved with Autosynchronizer co-ordinator ASCGAPC available with the source (ASGCSYN) function and non-source (ASNSCSYN) function.

ASCGAPC assists in the participating sources selection based on the network topology and interacts with the sources to initiate the voltage and frequency matching for the bus coupler or tie feeder CB to be synchronized. When any non-source circuit breaker (NSCB) is selected for synchronization, a synchronization procedure is started. ASCGAPC located in the NSCB relay starts communicating with ASCGAPCs of possible source circuit breaker (SCB) relays for matching the voltage and frequency difference. Both ASCGAPCs pass the required information to the participating sources. A non-source CB synchronization is described with one typical example in Figure 775.

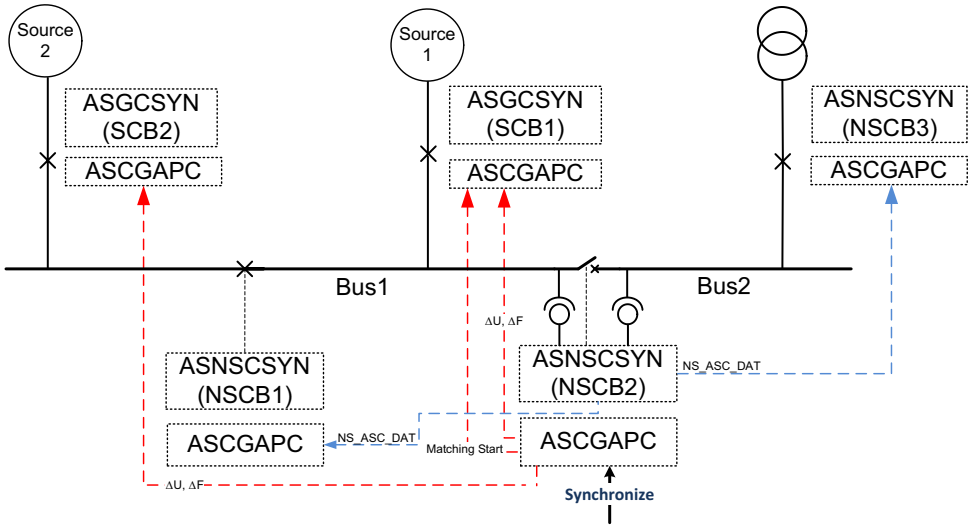



*Figure 775: NSCB2 synchronization*

In this application example, breaker NSCB2 must be closed. So the synchronizing conditions between Bus1 and Bus2 are checked by ASNSCSYN. ASNSCSYN sends the auto synchronization request and the voltage and frequency difference (ΔU, ΔF) between Bus1 and Bus2 to ASCGAPC.

ASCGAPC transfers the voltage and frequency difference sent by ASNSCSYN to the selected ASCGAPC function of source 1 ASGCSYN function. It also sends the permission to the source to start matching the voltage and frequency. The matching process is carried out so that the voltage and frequency difference between Bus1 and Bus2 measured by ASNSCSYN reduces and comes within the synchro check limits. This satisfies the synchro check conditions for breaker NSCB2 which can then be synchronized by ASNSCSYN. Similarly, the synchronization of NSCB1 and NSCB3 having ASCGAPC is done as shown in Figure 776 and Figure 777.

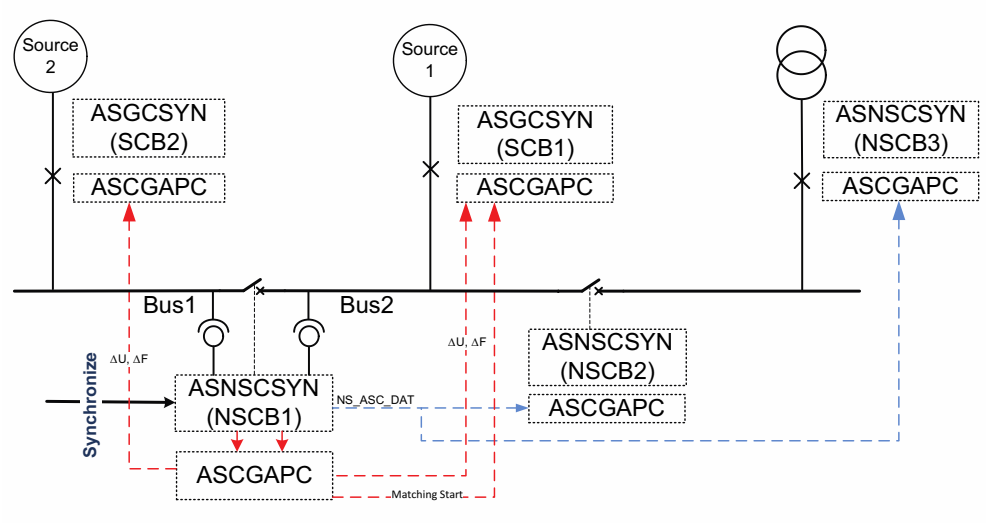



*Figure 776: NSCB1 synchronization*

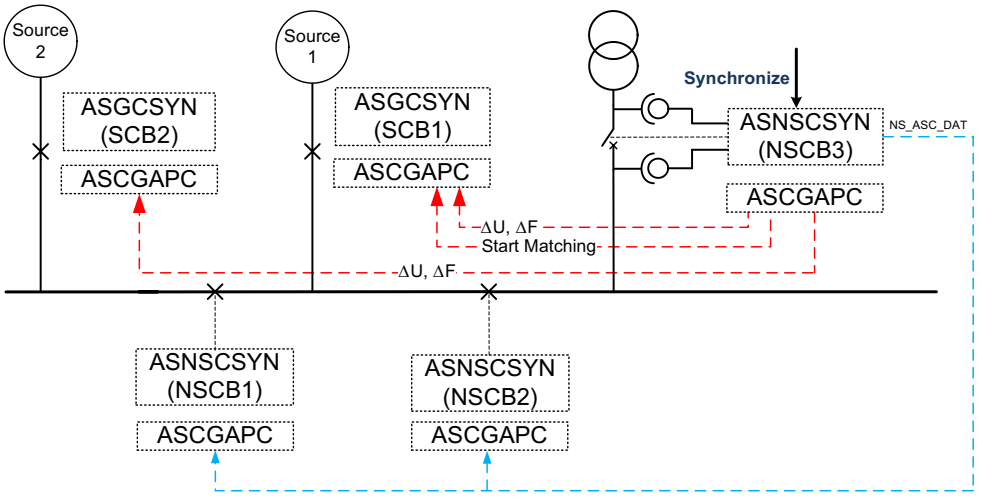



*Figure 777: NSCB3 synchronization*

This function supports manual, semi-automatic and automatic synchronizing, which adds flexibility in the user operation. In the manual synchronization, the matching is done manually and the closing command is released from the function on user request. In the semi-automatic synchronization, the matching is done automatically with coordination from ASCGAPC and the closing command is released from the function on user request. In the automatic synchronization, the matching is done automatically with coordination from ASCGAPC and the subsequent closing command is released from the function without user intervention.

This function output can be used to block the other functions in the power network to ensure that only one CB is synchronized at a time. This logic has to be developed outside the function block.

**Voltage angle difference adjustment**

In applications where the power transformer is located between the voltage measurement and the CB, the vector group connection gives phase difference to the voltages between the high- and low-voltage sides. The angle adjustment can be used to meet synchronism.

The vector group of the power transformer is defined with clock numbers, where the value of the hour pointer defines the low-voltage-side phasor and the high-voltage-side phasor is always fixed to the clock number 12, which is the same as zero. The angle between clock numbers is 30°. When comparing phase angles, the U_BUS_A input is always the reference. This means that when the Yd11 power transformer is used, the low-voltage-side voltage phasor leads the high-voltage-side phasor by 30º or lags by 330º. The rotation of the phasors is counterclockwise.

The generic rule is that a low-voltage-side phasor lags the high-voltage-side phasor by clock number · 30º. This is called angle difference adjustment and can be set for ASNSCSYN with the *Phase shift* setting.

## 9.7.7 Signals

*Table 1373: ASNSCSYN Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P1 | SIGNAL | - | Three-phase voltages (Bus B side) |
| U3P2 | SIGNAL | - | Three-phase voltages (Bus A side) |
| BLOCK | BOOLEAN | 0=False | Blocking signal of the auto synchronization function |
| BYPASS | BOOLEAN | 0=False | Bypass for synchronization and closing conditions check |
| CL_COMMAND | BOOLEAN | 0=False | External closing request |
| EXT_CHECK | BOOLEAN | 0=False | External permissive check for CB close |
| CB_TEST | BOOLEAN | 0=False | Circuit breaker test position status |
| CB_OPEN | BOOLEAN | 0=False | Circuit breaker open status |
| CB_CLOSE | BOOLEAN | 0=False | Circuit breaker close status |
| ISO_A1_CLOSE | BOOLEAN | 0=False | Isolator A1 close status |
| ISO_B1_CLOSE | BOOLEAN | 0=False | Isolator B1 close status |
| ISO_A2_CLOSE | BOOLEAN | 0=False | Isolator A2 close status |
| ISO_B2_CLOSE | BOOLEAN | 0=False | Isolator B2 close status |
| ASC1_NS_DAT | INT32 | 0 | Coded integer data from ASCGAPC1 |

*Table 1374: ASNSCSYN Output signals*

| Name | Type | Description |
|---|---|---|
| CL_FAIL_AL | BOOLEAN | CB closing failed |
| CMD_FAIL_AL | BOOLEAN | CB closing request failed |
| AS_INIT_FAIL | BOOLEAN | Synchronization not initiated |

Table continues on next page

| Name | Type | Description |
|---|---|---|
| CLOSE_CB | BOOLEAN | CB close signal |
| SYNC_OK | BOOLEAN | Systems in synchronism |
| MATCH_OK | BOOLEAN | Voltage and frequency of the systems matched |
| MATCH_INPRO | BOOLEAN | Voltage and frequency matching in progress |
| SYNC_INPRO | BOOLEAN | Synchronization in progress |
| LADB | BOOLEAN | Live bus A, dead bus B |
| LALB | BOOLEAN | Live bus A, live bus B |
| DALB | BOOLEAN | Dead bus A, live bus B |
| DADB | BOOLEAN | Dead bus A, dead bus B |
| U_DIFF | FLOAT32 | Line voltage difference across synchronizing CB |
| FR_DIFF_MEAS | FLOAT32 | Calculated voltage frequency difference |
| CB_SELECTED | BOOLEAN | CB selected for synchronization |
| NS_ASC_DAT | INT32 | Integer weighted output data to ASCGAPC |

## 9.7.8 Settings

*Table 1375: ASNSCSYN Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Live dead mode | -2=Command<br>-1=Off<br>1=Both Dead<br>2=Live B, Dead A<br>3=Dead B, Live A<br>4=Dead A, B Any<br>5=Dead B, A Any<br>6=One Live, Dead<br>7=Not Both Live | | | 1=Both Dead | Live dead mode |
| Diff voltage | 0.01...0.50 | xUn | 0.01 | 0.05 | Maximum voltage difference limit |
| Diff frequency | 0.001...0.060 | xFn | 0.001 | 0.001 | Maximum frequency difference limit |
| Diff angle | 5...90 | deg | 1 | 5 | Maximum angle difference limit |

*Table 1376: ASNSCSYN Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Multiple command | 0=Off<br>1=On | | | 0=Off | Multiple command to the circuit breaker |
| Voltage offset | -0.100...0.100 | xUn | 0.001 | 0.000 | Voltage offset |
| Frequency offset | -0.010...0.010 | xFn | 0.001 | 0.000 | Frequency offset |

*Table 1377: ASNSCSYN Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Synchrocheck mode | 1=Off<br>2=Synchronous<br>3=Asynchronous<br>4=Command | | | 3=Asynchronous | Synchrocheck operation mode |
| Dead bus voltage | 0.1...0.8 | xUn | 0.1 | 0.2 | Voltage low limit for energizing check |
| Live bus voltage | 0.2...1.0 | xUn | 0.1 | 0.5 | Voltage high limit for energizing check |
| Max energizing V | 0.50...1.30 | xUn | 0.01 | 1.05 | Maximum voltage above which no paralleling takes place |
| Auto Syn mode | -1=Semi-automatic synchronising mode<br>1=Automatic synchronising mode<br>3=Manual mode | | | 3=Manual mode | Autosynchronization operation mode |

*Table 1378: ASNSCSYN Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase shift | -180...180 | deg | 1 | 0 | Phase difference correction between bus A and bus B voltages |
| Minimum Syn time | 0...60000 | ms | 10 | 0 | Minimum time to accept synchronizing |
| Maximum Syn time | 100...6000000 | ms | 10 | 60000 | Maximum time to accept synchronizing |
| Energizing time | 100...60000 | ms | 10 | 100 | Time delay for energizing check |
| Closing time of CB | 40...250 | ms | 1 | 60 | Closing time of the breaker |

## 9.7.9 Monitored data

*Table 1379: ASNSCSYN Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ENERG_STATE | Enum | 0=Unknown<br>1=Both Live<br>2=Live Bus B, Dead Bus A<br>3=Dead Bus B, Live Bus A<br>4=Both Dead | | Energization state of bus A and bus B |
| U_DIFF_MEAS | FLOAT32 | -3.00...3.00 | xUn | Calculated voltage amplitude difference |
| PH_DIFF_MEAS | FLOAT32 | -180.00...180.00 | deg | Calculated voltage phase angle difference |
| U_BUSA_MEAS | FLOAT32 | 0.00...5.00 | xUn | Calculated bus A voltage amplitude |
| U_BUSB_MEAS | FLOAT32 | 0.00...5.00 | xUn | Calculated bus B voltage amplitude |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| FR_BUSA_MEAS | FLOAT32 | 35.00...75.00 | Hz | Calculated bus A frequency |
| FR_BUSB_MEAS | FLOAT32 | 35.00...75.00 | Hz | Calculated bus B frequency |
| U_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Voltage difference out of limit for synchronizing |
| FR_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Frequency difference out of limit for synchronizing |
| PH_DIF_SYNC | BOOLEAN | 0=False<br>1=True | | Phase angle difference out of limit for synchronizing |
| SLIP_ACCL | FLOAT32 | 0.000...5.000 | xFn/s | Calculated rate of change of frequency slip |
| ACT_ASC_CB | INT32 | 0...2147483647 | | Active ASCGAPC host circuit breaker number |
| CB_CL_BLKD | Enum | 1=Unblocked<br>2=Ext Check Fail<br>3=IED Test CB Service<br>4=IED Service CB Test | | CB close blocked status |
| SYNCCHK_STS | Enum | 1=Off<br>2=Synchronous<br>3=Asynchronous | | Synchro check mode status |
| LIVEDEAD_STS | Enum | -1=Off<br>1=Both Dead<br>2=Live B, Dead A<br>3=Dead B, Live A<br>4=Dead A, B Any<br>5=Dead B, A Any<br>6=One Live, Dead<br>7=Not Both Live | | Live dead mode status |
| ASNSCSYN | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 9.7.10 Technical data

*Table 1380: ASNSCSYN Technical data*

| Characteristic | Value |
|---|---|
| Measurement accuracy | Depending on the frequency of the voltage measured:<br>$f_n$ ±2 Hz |
| | Voltage difference:<br>±1.0% or ±0.004 × $U_n$<br>Frequency difference:<br>±10 mHz<br>Phase angle difference:<br>±1° |
| Operation accuracy | MATCH_OK for voltage:<br>±0.001 × $U_n$<br>MATCH_OK for frequency:<br>±10 mHz |
| Operation time accuracy | *Energizing time* for dead-bus closing:<br>±1.0% of the set value or ±35 ms<br>*Minimum Syn time* for SYNC_OK:<br>±1.0% of the set value or ±60 ms |
| Reset time | Typically 20 ms |
| Closing angle accuracy | ±1° |

## 9.8 Autosynchronizer co-ordinator ASCGAPC

### 9.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Autosynchronizer co-ordinator | ASCGAPC | AUTOSYNC | 25AUTOSYNC |

## 9.8.2 Function block

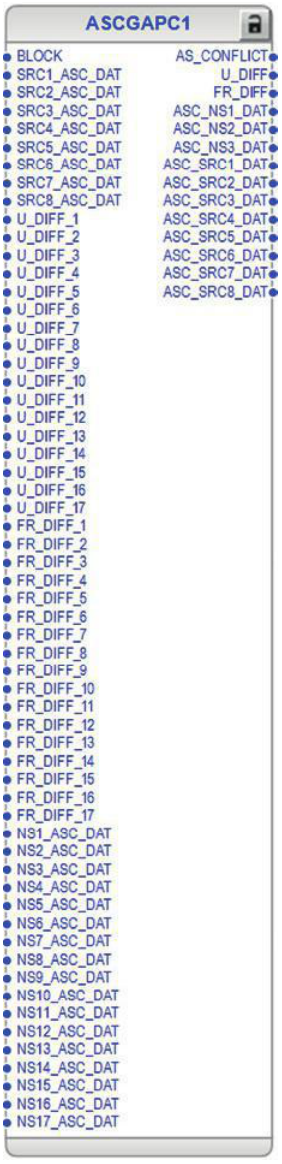



*Figure 778: Function block*

## 9.8.3 Functionality

The autosynchronizer co-ordinator function ASCGAPC can be used as a coordinator for the synchronization of any bus coupler or grid transformer incomer breakers in the power network. ASCGAPC must be present on the relay configuration together with the bus coupler or grid transformer autosynchronization functions (ASNSCSYN) as well as in generator autosynchronization functions (ASGCSYN).

ASCGAPC performs the network topology determination to identify the subnetworks within the whole network. It routes the voltage and frequency difference values from the synchronizing CB to all the generator sources. It also identifies the sources which are eligible to participate in matching the voltage and frequency difference. ASCGAPC allows to select sources for synchronization and gives permission for matching to the selected sources after essential checks.

ASCGAPC allows autosynchronization of only one non-source circuit breaker at a time. It also provides the voltage and frequency matching status for the synchronization in progress.

## 9.8.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of ASCGAPC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

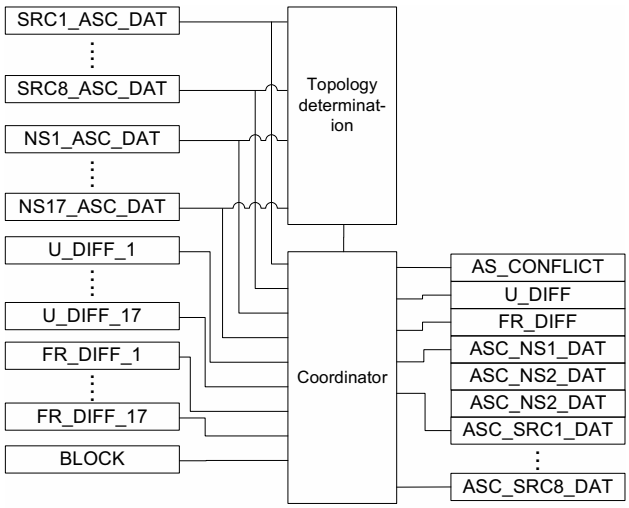



*Figure 779: Functional module diagram*

### Topology determination

This module identifies the group of busbars, power sources and network circuit breakers electrically connected together and calculates the subnetwork number for each group. It also identifies the sources and buses which are electrically connected to the external network. The maximum network configuration considered is 8 sources, 8 source CBs (SCB), 15 busbars and 17 non-source CBs (NSCB).

The equipment which is capable of voltage and frequency adjustment, that is, the generator, is referred to as source and the rest as non-source. Hence the generator CB is referred to as source CB and the bus

coupler or tie feeder CB as non-source CB. Also, any bus or system, external to this network is referred to as grid.

The general busbar arrangement across any NSCB is shown in Figure 780. For each NSCB, the numbers for Bus A1, Bus A2, Bus B1 and Bus B2 must be set. These bus numbers for non-source CB 1 are set in *NonSrc1 bus A1 Num*, *NonSrc1 bus A2 Num*, *NonSrc1 bus B1 Num* and *NonSrc1 bus B2 Num*, respectively. Each of these settings can be set to values "Bus 1"..."Bus 15" or to "Not Configured".

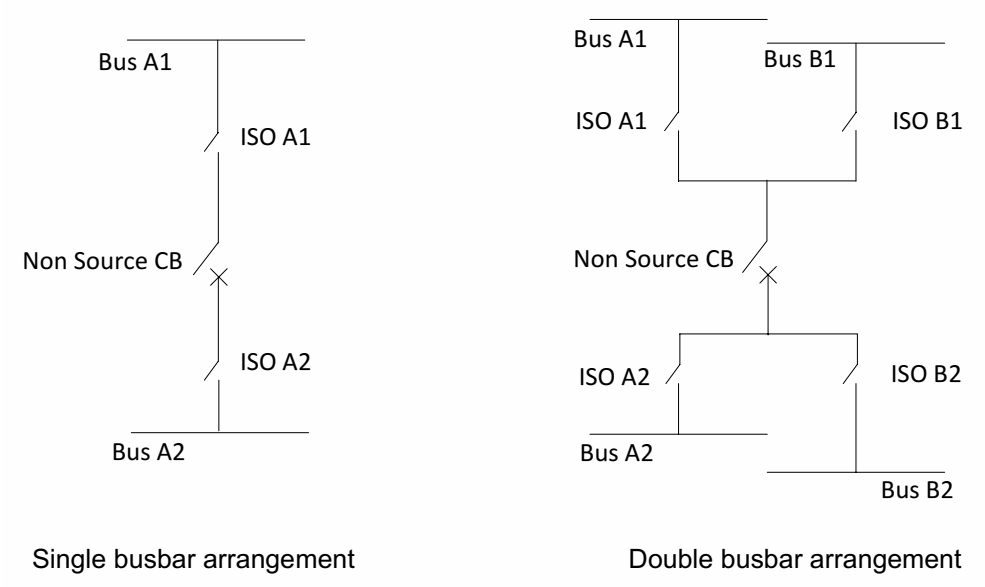



*Figure 780: Different busbar arrangement across any non-source CB*

The general busbar arrangement across any SCB is shown in Figure 781. For each source CB, the Bus A and Bus B numbers are to be set. These bus numbers for source CB 1 are set in *Src1 bus A Num* and *Src1 bus B Num*, respectively. Each of these settings can be set to values "Bus 1"..."Bus 15" or to "Not Configured".

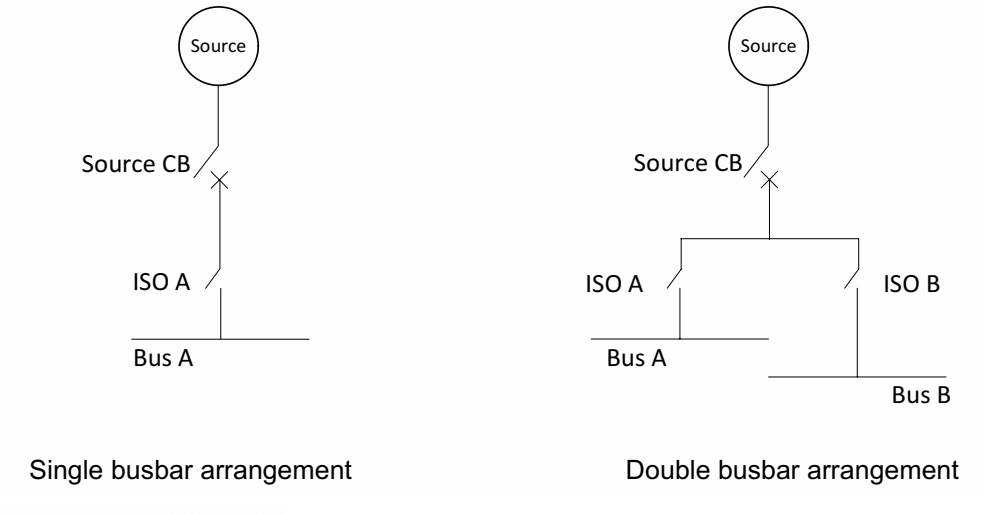



*Figure 781: Different busbar arrangement for any source CB*

The subnetwork group identification is based on the set busbar arrangement across each CB and the connection status input received from the corresponding ASGCSYN via SRC1_ASC_DAT...SRC8_ASC_DAT or from the corresponding ASNSCSYN via signals NS1_ASC_DAT...NS17_ASC_DAT.

An example of the subnetwork group identification is shown in Figure 782. Since NSCB 2 connects bus bar 1 and bus bar 2, then setting *NonSrc2 bus A1 Num* is set to "Bus 1" and *NonSrc2 bus A2 Num* is set as "Bus 2". Based on the bus connection status received via the input NS2_ASC_DAT, this module determines that Bus 1, Bus 2 and NSCB 2 are electrically connected. Similarly for SCB 2, *Src2 bus A Num* is set as "Bus 2" and the source CB closed status input is received via SRC1_ASC_DAT. So SCB 2 is electrically connected to Bus 2. Hence it is determined that SCB 2, Bus 2, Bus 1 and NSCB 2 are electrically connected to each other.

Two subnetworks are identified in Figure 782. The first comprises Bus 1, Bus 2, NSCB 1, NSCB 2, SCB 2 and source 2. The second comprises Bus 3, Bus 4, NSCB 4, SCB 3 and source 3. Each network group is assigned a subnetwork number which is the lowest bus bar number in the subgroup. Hence the first group is assigned subnetwork number 1 and the second group is assigned subnetwork number 3.

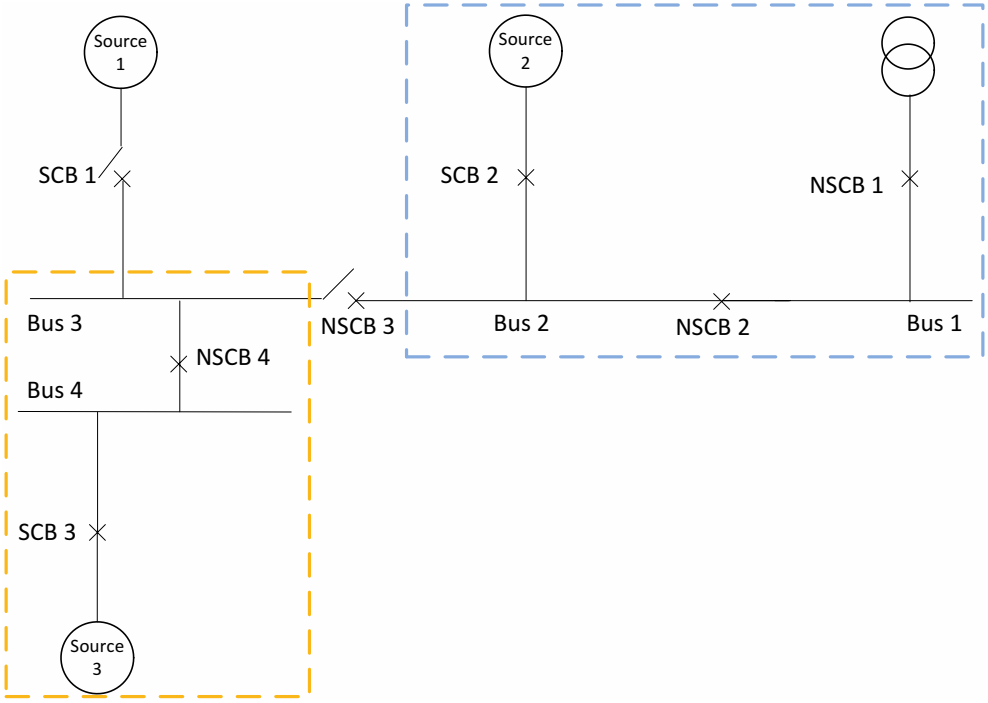



*Figure 782: An example of subnetwork group identification*

***Table 1381: ASCGAPC settings of NSCB1 for given example***

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Non source CB 1 | ASC1 host circuit breaker number 1 |
| Number of sources | 3 | Total number of sources present in the system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |
| Src1 bus A Num | Bus 3 | Source1 CB connected bus A number |
| Src2 bus A Num | Bus 2 | Source1 CB connected bus A number |
| Src3 bus A Num | Bus 4 | Source1 CB connected bus A number |
| NonSrc1 bus A1 Num | Bus 1 | Non-source CB1 connected bus A1 number |
| NonSrc1 bus A2 Num | Grid | Non-source CB1 connected bus A2 number |
| NonSrc2 bus A1 Num | Bus 1 | Non-source CB2 connected bus A1 number |
| NonSrc2 bus A2 Num | Bus 2 | Non-source CB2 connected bus A2 number |
| NonSrc3 bus A1 Num | Bus 2 | Non-source CB3 connected bus A1 number |

*Table 1382: Settings of ASCGAPC of NSCB2 for given example*

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Non source CB 2 | ASC1 host circuit breaker number 2 |
| Number of sources | 3 | Total number of sources present in system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |
| Src1 bus A Num | Bus 3 | Source1 CB connected bus A number |
| Src2 bus A Num | Bus 2 | Source1 CB connected bus A number |
| Src3 bus A Num | Bus 4 | Source1 CB connected bus A number |
| NonSrc1 bus A1 Num | Bus 1 | Non-source CB1 connected bus A1 number |
| NonSrc1 bus A2 Num | Grid | Non-source CB1 connected bus A2 number |
| NonSrc2 bus A1 Num | Bus 1 | Non-source CB2 connected bus A1 number |
| NonSrc2 bus A2 Num | Bus 2 | Non-source CB2 connected bus A2 number |
| NonSrc3 bus A1 Num | Bus 2 | Non-source CB3 connected bus A1 number |

*Table 1383: Settings of ASCGAPC of NSCB3 for given example*

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Non source CB 3 | ASC1 host circuit breaker number 3 |
| Number of sources | 3 | Total number of sources present in system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |
| Src1 bus A Num | Bus 3 | Source1 CB connected bus A number |
| Src2 bus A Num | Bus 2 | Source1 CB connected bus A number |
| Src3 bus A Num | Bus 4 | Source1 CB connected bus A number |
| NonSrc1 bus A1 Num | Bus 1 | Non-source CB1 connected bus A1 number |
| NonSrc1 bus A2 Num | Grid | Non-source CB1 connected bus A2 number |
| NonSrc2 bus A1 Num | Bus 1 | Non-source CB2 connected bus A1 number |
| NonSrc2 bus A2 Num | Bus 2 | Non-source CB2 connected bus A2 number |
| NonSrc3 bus A1 Num | Bus 2 | Non-source CB3 connected bus A1 number |

*Table 1384: Settings of ASCGAPC of NSCB4 for given example*

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Non source CB 4 | ASC1 host circuit breaker number 4 |
| Number of sources | 3 | Total number of sources present in system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |
| Src1 bus A Num | Bus 3 | Source1 CB connected bus A number |
| Src2 bus A Num | Bus 2 | Source1 CB connected bus A number |
| Src3 bus A Num | Bus 4 | Source1 CB connected bus A number |
| NonSrc1 bus A1 Num | Bus 1 | Non-source CB1 connected bus A1 number |
| NonSrc1 bus A2 Num | Grid | Non-source CB1 connected bus A2 number |
| NonSrc2 bus A1 Num | Bus 1 | Non-source CB2 connected bus A1 number |
| NonSrc2 bus A2 Num | Bus 2 | Non-source CB2 connected bus A2 number |
| NonSrc3 bus A1 Num | Bus 2 | Non-source CB3 connected bus A1 number |
| NonSrc3 bus A2 Num | Bus 3 | Non-source CB3 connected bus A2 number |
| NonSrc4 bus A1 Num | Bus 3 | Non-source CB4 connected bus A1 number |
| NonSrc4 bus A2 Num | Bus 4 | Non-source CB4 connected bus A2 number |

*Table 1385: Settings of ASCGAPC of SCB1 for given example*

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Source CB 1 | ASC1 host circuit breaker number 1 |
| Number of sources | 3 | Total number of sources present in system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |

*Table 1386: Settings of ASCGAPC of SCB2 for given example*

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Source CB 2 | ASC1 host circuit breaker number 2 |
| Number of sources | 3 | Total number of sources present in system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |

*Table 1387: Settings of ASCGAPC of SCB3 for given example*

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Source CB 3 | ASC1 host circuit breaker number 3 |
| Number of sources | 3 | Total number of sources present in system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |

The subnetwork numbers of eight power sources are available in monitored data SBNW_SRC1...SBNW_SRC8. The subnetwork numbers of NSCBs are available in monitored data SBNW_NSCB1...SBNW_NSCB17. The subnetwork numbers of busbars are available in monitored data SBNW_BB1...SBNW_BB15.

The monitored data SRC1_GRI_CON...SRC8_GRI_CON give the grid connection status of source 1...source 8. In Figure 782, source 2 is electrically connected to the grid, so the monitored data SRC2_GRID_NW is TRUE. Also, zero subnetwork number is assigned to all the open CBs. Hence SCB 1 and NSCB3 are assigned zero as subnetwork number.

The CB status is assumed uncertain in abnormal conditions (communication failure, bad quality of the data received from any ASGCSYN or ASNSCSYN) or when the CB status inhibit input is received via `SRC1_ASC_DAT...SRC8_ASC_DAT` or `NS1_ASC_DAT...NS17_ASC_DAT` signal. When the status of the CB is uncertain, the group including this CB or the groups connected across this CB are assigned zero as the subnetwork number. For example, if the SCB1 status is uncertain, then source 1, source 3, SCB1, SCB3, NSCB4, Bus 3 and Bus 4 are assigned zero as subnetwork number.

All subnetwork numbers are displayed as zero when *ASC CB Num1* = "Sourcex", x= 1...8.

## Coordinator

Three instances of ASNSCSYN can be configured for the synchronization of three NSCBs. The CB number can be set using settings *ASC CB Num1*, *ASC CB Num2* and *ASC CB Num3*. The function allows only NSCBs to be synchronized at a time. If synchronization is initiated for one of the three breakers, Coordinator sends the synchronized status to all the sources via `ASC_SRC1_DAT...ASC_SRC8_DAT` signal and to all the non-sources via `ASC_NS_DAT` signal. The rest of the operation is explained in Figure 783.

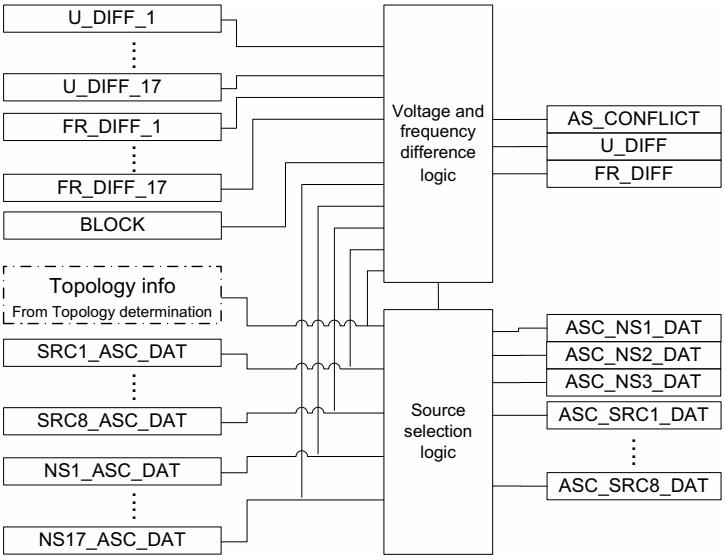



*Figure 783: Module diagram of Coordinator*

**Voltage and frequency difference logic**

This module sends the voltage and frequency difference values received from the NSCB to be synchronized to all the sources with appropriate sign according to the topology.

Of the two busbars connected across any NSCB, the voltage transformer (VT) from the lower-number busbar should be connected to bus A voltage channel (U_BUS_A) and the other to bus B voltage channel (U_BUS_B).

If these VT connections are interchanged physically, then the correction can be done in function using *NonSrc1 VT Conn*...*NonSrc17 VT Conn* for NSCB 1...NSCB 17. When the coordinator is active and NSCB 1 is selected for synchronization, the corresponding voltage and frequency difference inputs `U_DIFF_1` and `FR_DIFF_1` are available as outputs `U_DIFF` and `FR_DIFF`, respectively, with their sign adjusted according to the setting *NonSrc1 VT Conn*. If set as "No Change", the sign of `U_DIFF` and `FR_DIFF` remains the same. If set as "Reverse", the sign is reversed. Similarly, when any of the NSCB 2...NSCB 17 is selected for synchronization, the corresponding inputs `U_DIFF_2`...`U_DIFF_17` and `FR_DIFF_2`...`FR_DIFF_17` are passed as the outputs `U_DIFF` and `FR_DIFF`, respectively.

The output `AS_CONFLICT` is active in any of the following conditions:

- If more than one NSCB are selected for synchronization at the same time.
- If a NSCB is selected for synchronization while source synchronization is in progress.
- If more than one source are in synchronization.

When AS_CONFLICT is TRUE, then the Coordinator module stops the ongoing coordination activities till a new synchronization request is received from any NSCB. This conflict status is available in the monitored data CONFL_STATUS as given in Table 1388.

*Table 1388: States of CONFL_STATUS*

| Monitored data | Value |
|---|---|
| CONFL_STATUS | 1(“No conflict”) |
| | 2(“Multiple NSCB sync”) |
| | 3(“Multiple SCB sync”) |
| | 4(“NSCB and SCB sync”) |

### Source Selection Logic

Source selection logic is responsible for the selection and coordination of the sources for the voltage and frequency matching. It is enabled only when the autosynchronization function of the selected NSCB is in “Semiautomatic” or “Automatic” mode.

A source is available for participation in the voltage and frequency matching if the corresponding autosynchronization function is in “Semi-automatic” or “Automatic” mode and the host protection relay is in remote mode. This information is received from the corresponding source via input signals SRC1_ASC_DAT...SRC8_ASC_DAT.

All the sources in the network can be divided into nine participation groups based on topology and their availability for participation.

*Table 1389: Groups for source participation (monitored data SRC1_PTC_GRP...SRC8_PTC_GRP)*

| Source participation group | Description |
|---|---|
| Group 1 | All the sources which are unavailable for participation, are electrically connected to the grid or are not part of either subnetwork which must be synchronized by the selected CB |
| Group 2 | The sources which do not belong to Group 1 and are part of the subnetwork which includes the lower-number busbar of the two busbars connected across the selected CB |
| Group 3 | The sources which do not belong to Group 1 and are part of the other subnetwork, which includes the higher-number busbar. |
| Group 4 | The sources in Group 2 which are not ready for participation in matching |
| Group 5 | The sources which are part of Group 3, but not ready for participation in matching. |

Table continues on next page

| Source participation group | Description |
|---|---|
| Group 6 | The sources which are part of Group 2 or Group 3, but the network is internally connected and setting *Synchrocheck mode* in ASNSCSYN is "Synchronous" |
| Group 7 | The sources which are part of Group 2 or Group 3, but the network is internally connected and the setting *Synchrocheck mode* in ASNSCSYN is "Asynchronous" |
| Group 8 | The sources which are part of Group 2 or Group 3, but the network is internally asynchronous and setting *Synchrocheck mode* in ASNSCSYN is "Synchronous" |
| Group 9 | The sources which are part of Group 2 or Group 3, but setting *Synchrocheck mode* in ASNSCSYN is "Off" |

The participation group number for source 1...source 9 is available in the monitored output SRC1_PTC_GRP...SRC8_PTC_GRP.

Any source can be nominated for participation in voltage and frequency matching from the command parameter *Source1 selected*...*Source8 selected*. This selection is confirmed from the command parameter *Confirm source Sel*. The selected participation group information is available in monitored data SELECTED_GRP.

ASCGAPC allows multiple sources to participate in the voltage and frequency matching simultaneously, but all the sources nominated for matching should belong to either participation Group 2 or participation Group 3.

One of the participating sources (set with *Tuning source*) is used for the fine tuning of voltage and frequency. This information is sent to the corresponding source via the respective output signal ASC_SRC1_DAT...ASC_SRC8_DAT.

***Table 1390: States of MATCH STATUS***

| Value | Description |
|---|---|
| 1(“No request”) | No NSCB is selected for synchronization. |
| 2(“Request received”) | Synchronization request is received. |
| 3(“No source selection”) | The request is received and the command parameter *Confirm source Sel* is "FALSE". |
| 4(“Correct Src selection”) | The synchronization request is received, the command parameter *Confirm source Sel* is "TRUE", and the nominated sources belong to either Group 2 or Group 3. |
| 5(“Wrong source selection”) | The synchronization request is received, the command parameter *Confirm source Sel* is "FALSE", and the nominated sources do not belong to Group 2 or all belong to Group 3. |
| 6(“Wrong tuning Src Sel”) | The source selected for fine tuning is not among the nominated sources. |
| Table continues on next page | |

| Value | Description |
|---|---|
| 8(“Source ready”) | Any of the selected sources are ready for matching. |
| 9(“GOV-AVR modes not OK”) | Any source is selected for matching and the governor and AVR of all the participating sources are not in droop mode and non-participating sources are not in “Fixed MW” and “Fixed MVAr” mode.<br>The governor and Automatic Voltage Regulator (AVR) modes corresponding to each source are received via the corresponding input signal SRC1_ASC_DAT...SRC8_ASC_DAT. If modes are different, then mode change request is sent to the sources via the corresponding output signal ASC_SRC1_DAT...ASC_SRC8_DAT. |
| 10(“GOV-AVR modes OK”) | Any source is selected for matching, and its governor and AVR are in droop mode and non-participating sources are in “Fixed MW” and “Fixed MVAr” mode. |
| 11(“Matching in progress”) | All the selected sources are issued the permission for matching. |
| 12(“Matching done”) | Matching is complete according to the NSCB under synchronization. |
| 13(“Matching not done”) | Matching is not done within the set *Max matching time*. |
| 14(“Int Connect,set Sync”) | The network is internally connected and setting *Synchrocheck mode* in ASNSCSYN is "Synchronous". |
| 15(“Int Connect,set Async”) | The network is internally connected and setting *Synchrocheck mode* in ASNSCSYN is "Asynchronous". |
| 16(“Externally connected”) | The network is externally connected. |
| 17(“Int Async,set Sync”) | The network is internally asynchronous and setting *Synchrocheck mode* in ASNSCSYN is "Synchronous". |

### Internally connected

A network where Bus1 is connected to Bus3, Bus2 is connected to Bus4 and CB1 is closed is seen as an internally connected network by CB2.

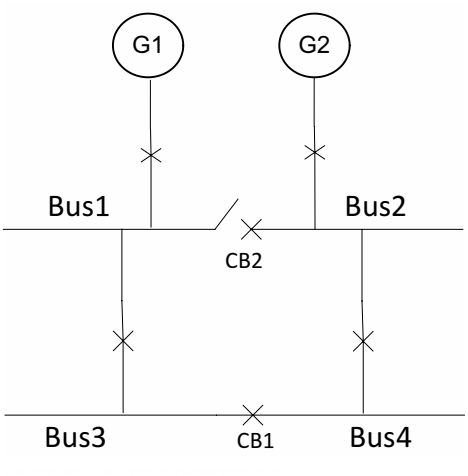



*Figure 784: Example of an internally connected network*

**Externally connected**

A network where both Bus3 and Bus4 are connected to the grid across CB1 is considered an externally connected network.

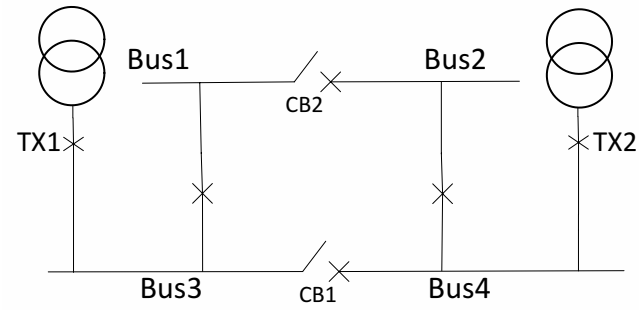



*Figure 785: Example of an externally connected network*

The number of sources active in the voltage and frequency matching is shared to sources via the corresponding output signal ASC_SRC1_DAT...ASC_SRC8_DAT.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all binary outputs and resets the internal timers.

## 9.8.5 Application

A circuit breaker is used to connect two different power networks. It is essential to ensure that these power networks are synchronized before closing the CB, otherwise it may lead to disturbances in the power system, causing stress and damage to the connected equipment.

The synchronization of any bus coupler or tie feeder is not feasible if the voltage and frequency differences across the circuit breaker are not within the allowed limits. In this case, the sources which are part of the power network connected across this bus

coupler or tie feeder CB have to adjust their voltage and frequency. ASCGAPC can be used as coordinator for selection and coordination with the sources, during the synchronization of any bus coupler or tie feeder circuit breaker. The function allows the synchronization of only one circuit breaker at a time. In case of any conflict, the synchronization process is stopped.

As a coordinator the function assists in the participating sources selection based on the network topology and interacts with the sources to initiate the voltage and frequency matching for the bus coupler or tie feeder CB to be synchronized.

When selected for synchronization, any NSCB communicates with ASCGAPC for matching of voltage and frequency difference. ASCGAPC passes the required information to the participating sources along with their active status. An NSCB synchronization is described with one typical example in Figure 786.

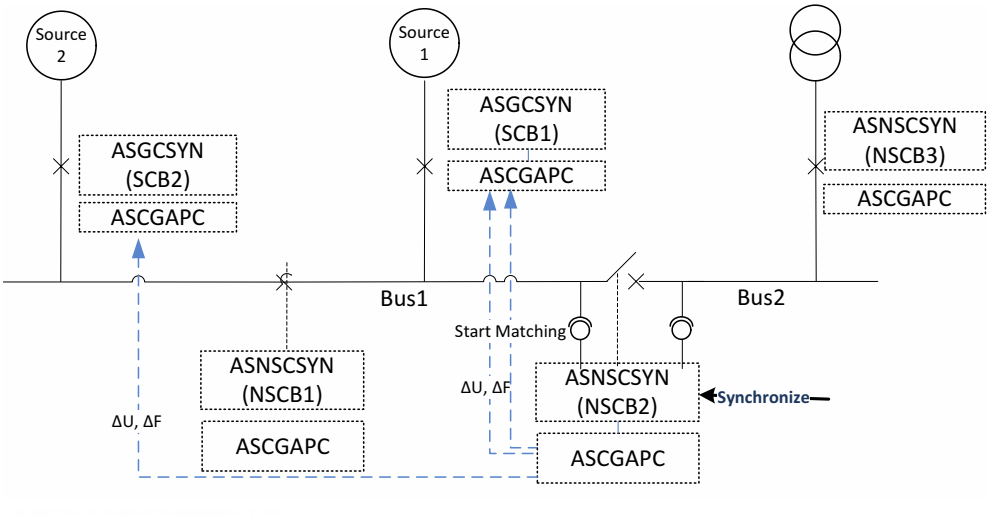



*Figure 786: NSCB2 synchronization*

In this application example, breaker NSCB2 must be closed so the synchronizing conditions between Bus1 and Bus2 are checked by ASNSCSYN. ASNSCSYN sends the autosynchronization request and voltage and frequency difference (ΔU, ΔF) between the Bus1 and Bus2 to the Autosynchronization coordinator functions ASCGAPC.

ASCGAPC transfers the voltage and frequency difference sent by ASNSCSYN to the ASCGAPC of source 1 ASGCSYN function as well as to the ASCGAPC of source 2 ASGCSYN function. It also sends the permission to the source to start matching the voltage and frequency. The matching process is carried out so that the voltage and frequency difference between Bus1 and Bus2 measured by ASNSCSYN reduces and comes within the synchrocheck limits. This satisfies the synchrocheck conditions for breaker NSCB2 which can then be synchronized by ASNSCSYN.

## 9.8.6 Signals

*Table 1391: ASCGAPC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Blocking output signal of the function |
| SRC1_ASC_DAT | INT32 | 0 | Input data from source number 1 |
| SRC2_ASC_DAT | INT32 | 0 | Input data from source number 2 |
| SRC3_ASC_DAT | INT32 | 0 | Input data from source number 3 |
| SRC4_ASC_DAT | INT32 | 0 | Input data from source number 4 |
| SRC5_ASC_DAT | INT32 | 0 | Input data from source number 5 |
| SRC6_ASC_DAT | INT32 | 0 | Input data from source number 6 |
| SRC7_ASC_DAT | INT32 | 0 | Input data from source number 7 |
| SRC8_ASC_DAT | INT32 | 0 | Input data from source number 8 |
| NS1_ASC_DAT | INT32 | 0 | Input data from non-source CB number 1 |
| NS2_ASC_DAT | INT32 | 0 | Input data from non-source CB number 2 |
| NS3_ASC_DAT | INT32 | 0 | Input data from non-source CB number 3 |
| NS4_ASC_DAT | INT32 | 0 | Input data from non-source CB number 4 |
| NS5_ASC_DAT | INT32 | 0 | Input data from non-source CB number 5 |
| NS6_ASC_DAT | INT32 | 0 | Input data from non-source CB number 6 |
| NS7_ASC_DAT | INT32 | 0 | Input data from non-source CB number 7 |
| NS8_ASC_DAT | INT32 | 0 | Input data from non-source CB number 8 |
| NS9_ASC_DAT | INT32 | 0 | Input data from non-source CB number 9 |
| NS10_ASC_DAT | INT32 | 0 | Input data from non-source CB number 10 |
| NS11_ASC_DAT | INT32 | 0 | Input data from non-source CB number 11 |
| NS12_ASC_DAT | INT32 | 0 | Input data from non-source CB number 12 |
| NS13_ASC_DAT | INT32 | 0 | Input data from non-source CB number 13 |
| NS14_ASC_DAT | INT32 | 0 | Input data from non-source CB number 14 |
| NS15_ASC_DAT | INT32 | 0 | Input data from non-source CB number 15 |
| NS16_ASC_DAT | INT32 | 0 | Input data from non-source CB number 16 |
| NS17_ASC_DAT | INT32 | 0 | Input data from non-source CB number 17 |
| U_DIFF_1 | FLOAT32 | 0.00 | Voltage difference from non-source CB 1 |
| U_DIFF_2 | FLOAT32 | 0.00 | Voltage difference from non-source CB 2 |
| U_DIFF_3 | FLOAT32 | 0.00 | Voltage difference from non-source CB 3 |
| U_DIFF_4 | FLOAT32 | 0.00 | Voltage difference from non-source CB 4 |
| U_DIFF_5 | FLOAT32 | 0.00 | Voltage difference from non-source CB 5 |
| U_DIFF_6 | FLOAT32 | 0.00 | Voltage difference from non-source CB 6 |
| U_DIFF_7 | FLOAT32 | 0.00 | Voltage difference from non-source CB 7 |
| U_DIFF_8 | FLOAT32 | 0.00 | Voltage difference from non-source CB 8 |
| U_DIFF_9 | FLOAT32 | 0.00 | Voltage difference from non-source CB 9 |
| U_DIFF_10 | FLOAT32 | 0.00 | Voltage difference from non-source CB 10 |

Table continues on next page

| Name | Type | Default | Description |
|---|---|---|---|
| U_DIFF_11 | FLOAT32 | 0.00 | Voltage difference from non-source CB 11 |
| U_DIFF_12 | FLOAT32 | 0.00 | Voltage difference from non-source CB 12 |
| U_DIFF_13 | FLOAT32 | 0.00 | Voltage difference from non-source CB 13 |
| U_DIFF_14 | FLOAT32 | 0.00 | Voltage difference from non-source CB 14 |
| U_DIFF_15 | FLOAT32 | 0.00 | Voltage difference from non-source CB 15 |
| U_DIFF_16 | FLOAT32 | 0.00 | Voltage difference from non-source CB 16 |
| U_DIFF_17 | FLOAT32 | 0.00 | Voltage difference from non-source CB 17 |
| FR_DIFF_1 | FLOAT32 | 0.000 | Frequency difference from non-source CB 1 |
| FR_DIFF_2 | FLOAT32 | 0.000 | Frequency difference from non-source CB 2 |
| FR_DIFF_3 | FLOAT32 | 0.000 | Frequency difference from non-source CB 3 |
| FR_DIFF_4 | FLOAT32 | 0.000 | Frequency difference from non-source CB 4 |
| FR_DIFF_5 | FLOAT32 | 0.000 | Frequency difference from non-source CB 5 |
| FR_DIFF_6 | FLOAT32 | 0.000 | Frequency difference from non-source CB 6 |
| FR_DIFF_7 | FLOAT32 | 0.000 | Frequency difference from non-source CB 7 |
| FR_DIFF_8 | FLOAT32 | 0.000 | Frequency difference from non-source CB 8 |
| FR_DIFF_9 | FLOAT32 | 0.000 | Frequency difference from non-source CB 9 |
| FR_DIFF_10 | FLOAT32 | 0.000 | Frequency difference from non-source CB 10 |
| FR_DIFF_11 | FLOAT32 | 0.000 | Frequency difference from non-source CB 11 |
| FR_DIFF_12 | FLOAT32 | 0.000 | Frequency difference from non-source CB 12 |
| FR_DIFF_13 | FLOAT32 | 0.000 | Frequency difference from non-source CB 13 |
| FR_DIFF_14 | FLOAT32 | 0.000 | Frequency difference from non-source CB 14 |
| FR_DIFF_15 | FLOAT32 | 0.000 | Frequency difference from non-source CB 15 |
| FR_DIFF_16 | FLOAT32 | 0.000 | Frequency difference from non-source CB 16 |
| FR_DIFF_17 | FLOAT32 | 0.000 | Frequency difference from non-source CB 17 |

*Table 1392: ASCGAPC Output signals*

| Name | Type | Description |
|---|---|---|
| AS_CONFLICT | BOOLEAN | Auto synchronization conflict |
| U_DIFF | FLOAT32 | Voltage difference across the synchronizing CB |
| FR_DIFF | FLOAT32 | Frequency difference across the synchronizing CB |
| ASC_NS1_DAT | INT32 | Output data to non-source CB 1 |
| ASC_NS2_DAT | INT32 | Output data to non-source CB 2 |
| ASC_NS3_DAT | INT32 | Output data to non-source CB 3 |
| ASC_SRC1_DAT | INT32 | Output data to source number 1 |
| ASC_SRC2_DAT | INT32 | Output data to source number 2 |
| ASC_SRC3_DAT | INT32 | Output data to source number 3 |
| ASC_SRC4_DAT | INT32 | Output data to source number 4 |
| ASC_SRC5_DAT | INT32 | Output data to source number 5 |
| Table continues on next page | | |

| Name | Type | Description |
|---|---|---|
| ASC_SRC6_DAT | INT32 | Output data to source number 6 |
| ASC_SRC7_DAT | INT32 | Output data to source number 7 |
| ASC_SRC8_DAT | INT32 | Output data to source number 8 |

## 9.8.7 Settings

*Table 1393: ASCGAPC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Number of sources | 1...8 | | 1 | 8 | Total number of sources present in the system |
| Number of NonSrc CB | 1...17 | | 1 | 17 | Number of bus coupler or grid transformer CB in the system |

*Table 1394: ASCGAPC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Src1 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 1 CB connected bus A number |
| Src1 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 1 CB connected bus B number |
| Src2 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 2 CB connected bus A number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Src2 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 2 CB connected bus B number |
| Src3 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 3 CB connected bus A number |
| Src3 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 3 CB connected bus B number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Src4 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 4 CB connected bus A number |
| Src4 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 4 CB connected bus B number |
| Src5 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 5 CB connected bus A number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Src5 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 5 CB connected bus B number |
| Src6 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 6 CB connected bus A number |
| Src6 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 6 CB connected bus B number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Src7 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 7 CB connected bus A number |
| Src7 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 7 CB connected bus B number |
| Src8 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 8 CB connected bus A number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Src8 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 8 CB connected bus B number |
| NonSrc1 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB1 connected bus A1 number |
| NonSrc1 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB1 connected bus A2 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc1 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB1 connected bus B1 number |
| NonSrc1 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB1 connected bus B2 number |
| NonSrc2 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB2 connected bus A1 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc2 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB2 connected bus A2 number |
| NonSrc2 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB2 connected bus B1 number |
| NonSrc2 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB2 connected bus B2 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc3 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB3 connected bus A1 number |
| NonSrc3 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB3 connected bus A2 number |
| NonSrc3 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB3 connected bus B1 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc3 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB3 connected bus B2 number |
| NonSrc4 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB4 connected bus A1 number |
| NonSrc4 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB4 connected bus A2 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc4 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB4 connected bus B1 number |
| NonSrc4 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB4 connected bus B2 number |
| NonSrc5 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB5 connected bus A1 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc5 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB5 connected bus A2 number |
| NonSrc5 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB5 connected bus B1 number |
| NonSrc5 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB5 connected bus B2 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc6 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB6 connected bus A1 number |
| NonSrc6 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB6 connected bus A2 number |
| NonSrc6 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB6 connected bus B1 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc6 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB6 connected bus B2 number |
| NonSrc7 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB7 connected bus A1 number |
| NonSrc7 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB7 connected bus A2 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc7 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB7 connected bus B1 number |
| NonSrc7 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB7 connected bus B2 number |
| NonSrc8 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB8 connected bus A1 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc8 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB8 connected bus A2 number |
| NonSrc8 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB8 connected bus B1 number |
| NonSrc8 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB8 connected bus B2 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc9 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB9 connected bus A1 number |
| NonSrc9 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB9 connected bus A2 number |
| NonSrc9 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB9 connected bus B1 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc9 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB9 connected bus B2 number |
| NonSrc10 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB10 connected bus A1 number |
| NonSrc10 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB10 connected bus A2 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc10 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB10 connected bus B1 number |
| NonSrc10 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB10 connected bus B2 number |
| NonSrc11 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB11 connected bus A1 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc11 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB11 connected bus A2 number |
| NonSrc11 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB11 connected bus B1 number |
| NonSrc11 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB11 connected bus B2 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc12 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB12 connected bus A1 number |
| NonSrc12 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB12 connected bus A2 number |
| NonSrc12 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB12 connected bus B1 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc12 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB12 connected bus B2 number |
| NonSrc13 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB13 connected bus A1 number |
| NonSrc13 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB13 connected bus A2 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc13 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB13 connected bus B1 number |
| NonSrc13 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB13 connected bus B2 number |
| NonSrc14 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB14 connected bus A1 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc14 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB14 connected bus A2 number |
| NonSrc14 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB14 connected bus B1 number |
| NonSrc14 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB14 connected bus B2 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc15 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB15 connected bus A1 number |
| NonSrc15 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB15 connected bus A2 number |
| NonSrc15 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB15 connected bus B1 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc15 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB15 connected bus B2 number |
| NonSrc16 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB16 connected bus A1 number |
| NonSrc16 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB16 connected bus A2 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc16 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB16 connected bus B1 number |
| NonSrc16 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB16 connected bus B2 number |
| NonSrc17 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB17 connected bus A1 number |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc17 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB17 connected bus A2 number |
| NonSrc17 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB17 connected bus B1 number |
| NonSrc17 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB17 connected bus B2 number |
| NonSrc1 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB1 |
| NonSrc2 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB2 |
| NonSrc3 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB3 |
| NonSrc4 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB4 |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc5 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB5 |
| NonSrc6 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB6 |
| NonSrc7 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB7 |
| NonSrc8 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB8 |
| NonSrc9 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB9 |
| NonSrc10 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB10 |
| NonSrc11 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB11 |
| NonSrc12 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB12 |
| NonSrc13 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB13 |
| NonSrc14 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB14 |
| NonSrc15 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB15 |
| NonSrc16 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB16 |
| NonSrc17 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB17 |

*Table 1395: ASCGAPC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| ASC CB Num1 | 1=Non source CB 1<br>2=Non source CB 2<br>3=Non source CB 3<br>4=Non source CB 4<br>5=Non source CB 5<br>6=Non source CB 6<br>7=Non source CB 7<br>8=Non source CB 8<br>9=Non source CB 9<br>10=Non source CB 10<br>11=Non source CB 11<br>12=Non source CB 12<br>13=Non source CB 13<br>14=Non source CB 14<br>15=Non source CB 15<br>16=Non source CB 16<br>17=Non source CB 17<br>18=Source CB 1<br>19=Source CB 2<br>20=Source CB 3<br>21=Source CB 4<br>22=Source CB 5<br>23=Source CB 6<br>24=Source CB 7<br>25=Source CB 8 | | | 1=Non source CB 1 | ASC host circuit breaker number 1 |
| ASC CB Num2 | 0=Not Configured<br>1=Non source CB 1<br>2=Non source CB 2<br>3=Non source CB 3<br>4=Non source CB 4<br>5=Non source CB 5<br>6=Non source CB 6<br>7=Non source CB 7<br>8=Non source CB 8<br>9=Non source CB 9<br>10=Non source CB 10<br>11=Non source CB 11<br>12=Non source CB 12<br>13=Non source CB 13<br>14=Non source CB 14<br>15=Non source CB 15<br>16=Non source CB 16<br>17=Non source CB 17 | | | 0=Not Configured | ASC host circuit breaker number 2 |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| ASC CB Num3 | 0=Not Configured<br>1=Non source CB 1<br>2=Non source CB 2<br>3=Non source CB 3<br>4=Non source CB 4<br>5=Non source CB 5<br>6=Non source CB 6<br>7=Non source CB 7<br>8=Non source CB 8<br>9=Non source CB 9<br>10=Non source CB 10<br>11=Non source CB 11<br>12=Non source CB 12<br>13=Non source CB 13<br>14=Non source CB 14<br>15=Non source CB 15<br>16=Non source CB 16<br>17=Non source CB 17 | | | 0=Not Configured | ASC host circuit breaker number 3 |

*Table 1396: ASCGAPC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max matching time | 100...6000000 | ms | 1 | 60000 | Maximum time to complete the voltage and frequency matching |
| Central PMS present | 1=No<br>2=Yes | | | 1=No | Centralized power management system present |
| Double busbar | 0=False<br>1=True | | | 0=False | Double busbar present in the system |

## 9.8.8 Monitored data

*Table 1397: ASCGAPC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SBNW_SRC1 | INT32 | 0...99 | | Source 1 subnetwork number |
| SBNW_SRC2 | INT32 | 0...99 | | Source 2 subnetwork number |
| SBNW_SRC3 | INT32 | 0...99 | | Source 3 subnetwork number |
| SBNW_SRC4 | INT32 | 0...99 | | Source 4 subnetwork number |
| SBNW_SRC5 | INT32 | 0...99 | | Source 5 subnetwork number |
| SBNW_SRC6 | INT32 | 0...99 | | Source 6 subnetwork number |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SBNW_SRC7 | INT32 | 0...99 | | Source 7 subnetwork number |
| SBNW_SRC8 | INT32 | 0...99 | | Source 8 subnetwork number |
| SBNW_NSCB1 | INT32 | 0...99 | | Non-source CB 1 subnetwork number |
| SBNW_NSCB2 | INT32 | 0...99 | | Non-source CB 2 subnetwork number |
| SBNW_NSCB3 | INT32 | 0...99 | | Non-source CB 3 subnetwork number |
| SBNW_NSCB4 | INT32 | 0...99 | | Non-source CB 4 subnetwork number |
| SBNW_NSCB5 | INT32 | 0...99 | | Non-source CB 5 subnetwork number |
| SBNW_NSCB6 | INT32 | 0...99 | | Non-source CB 6 subnetwork number |
| SBNW_NSCB7 | INT32 | 0...99 | | Non-source CB 7 subnetwork number |
| SBNW_NSCB8 | INT32 | 0...99 | | Non-source CB 8 subnetwork number |
| SBNW_NSCB9 | INT32 | 0...99 | | Non-source CB 9 subnetwork number |
| SBNW_NSCB10 | INT32 | 0...99 | | Non-source CB 10 subnetwork number |
| SBNW_NSCB11 | INT32 | 0...99 | | Non-source CB 11 subnetwork number |
| SBNW_NSCB12 | INT32 | 0...99 | | Non-source CB 12 subnetwork number |
| SBNW_NSCB13 | INT32 | 0...99 | | Non-source CB 13 subnetwork number |
| SBNW_NSCB14 | INT32 | 0...99 | | Non-source CB 14 subnetwork number |
| SBNW_NSCB15 | INT32 | 0...99 | | Non-source CB 15 subnetwork number |
| SBNW_NSCB16 | INT32 | 0...99 | | Non-source CB 16 subnetwork number |
| SBNW_NSCB17 | INT32 | 0...99 | | Non-source CB 17 subnetwork number |
| SBNW_BB1 | INT32 | 0...99 | | Bus 1 subnetwork number |
| SBNW_BB2 | INT32 | 0...99 | | Bus 2 subnetwork number |
| SBNW_BB3 | INT32 | 0...99 | | Bus 3 subnetwork number |
| SBNW_BB4 | INT32 | 0...99 | | Bus 4 subnetwork number |
| SBNW_BB5 | INT32 | 0...99 | | Bus 5 subnetwork number |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SBNW_BB6 | INT32 | 0...99 | | Bus 6 subnetwork number |
| SBNW_BB7 | INT32 | 0...99 | | Bus 7 subnetwork number |
| SBNW_BB8 | INT32 | 0...99 | | Bus 8 subnetwork number |
| SBNW_BB9 | INT32 | 0...99 | | Bus 9 subnetwork number |
| SBNW_BB10 | INT32 | 0...99 | | Bus 10 subnetwork number |
| SBNW_BB11 | INT32 | 0...99 | | Bus 11 subnetwork number |
| SBNW_BB12 | INT32 | 0...99 | | Bus 12 subnetwork number |
| SBNW_BB13 | INT32 | 0...99 | | Bus 13 subnetwork number |
| SBNW_BB14 | INT32 | 0...99 | | Bus 14 subnetwork number |
| SBNW_BB15 | INT32 | 0...99 | | Bus 15 subnetwork number |
| SRC1_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 1 grid connection status |
| SRC2_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 2 grid connection status |
| SRC3_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 3 grid connection status |
| SRC4_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 4 grid connection status |
| SRC5_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 5 grid connection status |
| SRC6_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 6 grid connection status |
| SRC7_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 7 grid connection status |
| SRC8_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 8 grid connection status |
| ASC ACTIVE | BOOLEAN | 0=False<br>1=True | | ASC active status |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| MATCH STATUS | Enum | 1=No request<br>2=Request received<br>3=No source selection<br>4=Correct Src selection<br>5=Wrong source selection<br>6=Wrong tuning Src Sel<br>8=Source ready<br>9=GOV-AVR modes not OK<br>10=GOV-AVR modes OK<br>11=Matching in progress<br>12=Matching done<br>13=Matching not done<br>14=Int Connect,set Sync<br>15=Int Connect,set Async<br>16=Externally connected<br>17=Int Async,set Sync | | Matching status |
| SRC1_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 1 participation group |
| SRC2_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 2 participation group |
| SRC3_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 3 participation group |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SRC4_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 4 participation group |
| SRC5_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 5 participation group |
| SRC6_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 6 participation group |
| SRC7_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 7 participation group |
| SRC8_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 8 participation group |
| SELECTED_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3 | | Selected source participation group |
| CONFL_STATUS | Enum | 1=No conflict<br>2=Multiple NSCB sync<br>3=Multiple SCB sync<br>4=NSCB and SCB sync | | Autosynchronization conflict status |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| NSCB_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Operation mode of non-source CB undergoing synchronization |
| SRC1_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 1 |
| SRC2_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 2 |
| SRC3_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 3 |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SRC4_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 4 |
| SRC5_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 5 |
| SRC6_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 6 |
| SRC7_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 7 |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SRC8_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 8 |
| NSCB_UND_SYN | INT32 | 0...99 | | Non-source CB undergoing synchronization |
| SRC1_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 1 participation status |
| SRC2_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 2 participation status |
| SRC3_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 3 participation status |
| SRC4_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 4 participation status |
| SRC5_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 5 participation status |
| SRC6_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 6 participation status |
| SRC7_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 7 participation status |
| SRC8_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 8 participation status |
| ASCGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

# 9.9 Autoreclosing DARREC

## 9.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Autoreclosing | DARREC | O -> I | 79 |

## 9.9.2 Function block

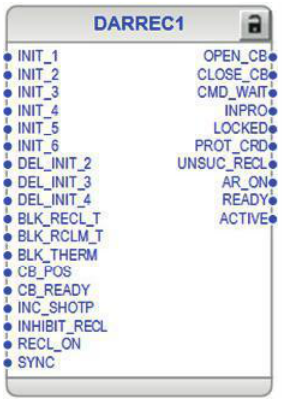



*Figure 787: Function block*

## 9.9.3 Functionality

About 80 to 85 percent of faults in the MV overhead lines are transient and automatically cleared with a momentary de-energization of the line. The rest of the faults, 15 to 20 percent, can be cleared by longer interruptions. The de-energization of the fault location for a selected time period is implemented through automatic reclosing, during which most of the faults can be cleared.

In case of a permanent fault, the automatic reclosing is followed by final tripping. A permanent fault must be located and cleared before the fault location can be re-energized.

The autoreclosing function DARREC can be used with any circuit breaker suitable for autoreclosing. The function provides five programmable autoreclosing shots which can perform one to five successive autoreclosings of desired type and duration, for instance one high-speed and one delayed autoreclosing.

When the reclosing is initiated with starting of the protection function, the autoreclosing function can execute the final trip of the circuit breaker in a short operate time, provided that the fault still persists when the last selected reclosing has been carried out.

### 9.9.3.1 Protection signal definition

The *Control line* setting defines which of the initiation signals are protection start and trip signals and which are not. With this setting, the user can distinguish the blocking signals from the protection signals. The *Control line* setting is a bit mask, that is, the lowest bit controls the `INIT_1` line and the highest bit the `INIT_6` line. Some example combinations of the *Control line* setting are as follows:

*Table 1398: Control line setting definition*

| *Control line* setting | INIT_1 | INIT_2 DEL_INIT_2 | INIT_3 DEL_INIT_3 | INIT_4 DEL_INIT_4 | INIT_5 | INIT_6 |
|---|---|---|---|---|---|---|
| 0 | other | other | other | other | other | other |
| 1 | prot | other | other | other | other | other |
| 2 | other | prot | other | other | other | other |
| 3 | prot | prot | other | other | other | other |
| 4 | other | other | prot | other | other | other |
| 5 | prot | other | prot | other | other | other |
| ...63 | prot | prot | prot | prot | prot | prot |

prot = protection signal

other = non-protection signal

When the corresponding bit or bits in both the *Control line* setting and the INIT_X line are TRUE:

- The CLOSE_CB output is blocked until the protection is reset
- If the INIT_X line defined as the protection signal is activated during the discrimination time, the AR function goes to lockout
- If the INIT_X line defined as the protection signal stays active longer than the time set by the *Max trip time* setting, the AR function goes to lockout (long trip)
- The UNSUC_RECL output is activated after a pre-defined two minutes (alarming earth-fault).

### 9.9.3.2 Zone coordination

Zone coordination is used in the zone sequence between local protection units and downstream devices. At the falling edge of the INC_SHOTP line, the value of the shot pointer is increased by one, unless a shot is in progress or the shot pointer already has the maximum value.

The falling edge of the INC_SHOTP line is not accepted if any of the shots are in progress.

### 9.9.3.3 Master and slave scheme

With the cooperation between the AR units in the same protection relay or between protection relays, sequential reclosings of two breakers at a line end in a 1½-breaker, double breaker or ring-bus arrangement can be achieved. One unit is defined as a master and it executes the reclosing first. If the reclosing is successful and no trip takes place, the second unit, that is the slave, is released to complete the reclose shot. With persistent faults, the breaker reclosing is limited to the first breaker.

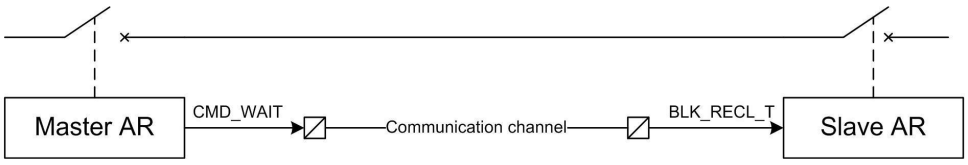



*Figure 788: Master and slave scheme*

If the AR unit is defined as a master by setting its terminal priority to high:

- The unit activates the CMD_WAIT output to the low priority slave unit whenever a shot is in progress, a reclosing is unsuccessful or the BLK_RCLM_T input is active
- The CMD_WAIT output is reset one second after the reclose command is given or if the sequence is unsuccessful when the reclaim time elapses.

If the AR unit is defined as a slave by setting its terminal priority to low:

- The unit waits until the master releases the BLK_RECL_T input (the CMD_WAIT output in the master). Only after this signal has been deactivated, the reclose time for the slave unit can be started.
- The slave unit is set to a lockout state if the BLK_RECL_T input is not released within the time defined by the *Max wait time* setting , which follows the initiation of an autoreclosing shot.

If the terminal priority of the AR unit is set to "none", the AR unit skips all these actions.

### 9.9.3.4 Thermal overload blocking

An alarm or start signal from the thermal overload protection (T1PTTR) can be routed to the input BLK_THERM to block and hold the reclose sequence. The BLK_THERM signal does not affect the starting of the sequence. When the reclose time has elapsed and the BLK_THERM input is active, the shot is not ready until the BLK_THERM input deactivates. Should the BLK_THERM input remain active longer than the time set by the setting *Max Thm block time*, the AR function goes to lockout.

If the BLK_THERM input is activated when the auto wait timer is running, the auto wait timer is reset and the timer restarted when the BLK_THERM input deactivates.

## 9.9.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off". Setting *Operation* to "off" resets non-volatile counters.

The reclosing operation can be enabled and disabled with the *Reclosing operation* setting. This setting does not disable the function, only the reclosing functionality. The

setting has three parameter values: “On”, “External Ctl” and ”Off”. The setting value “On” enables the reclosing operation and “Off” disables it. When the setting value “External Ctl” is selected, the reclosing operation is controlled with the RECL_ON input. AR_ON is activated when reclosing operation is enabled.

The operation of DARREC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

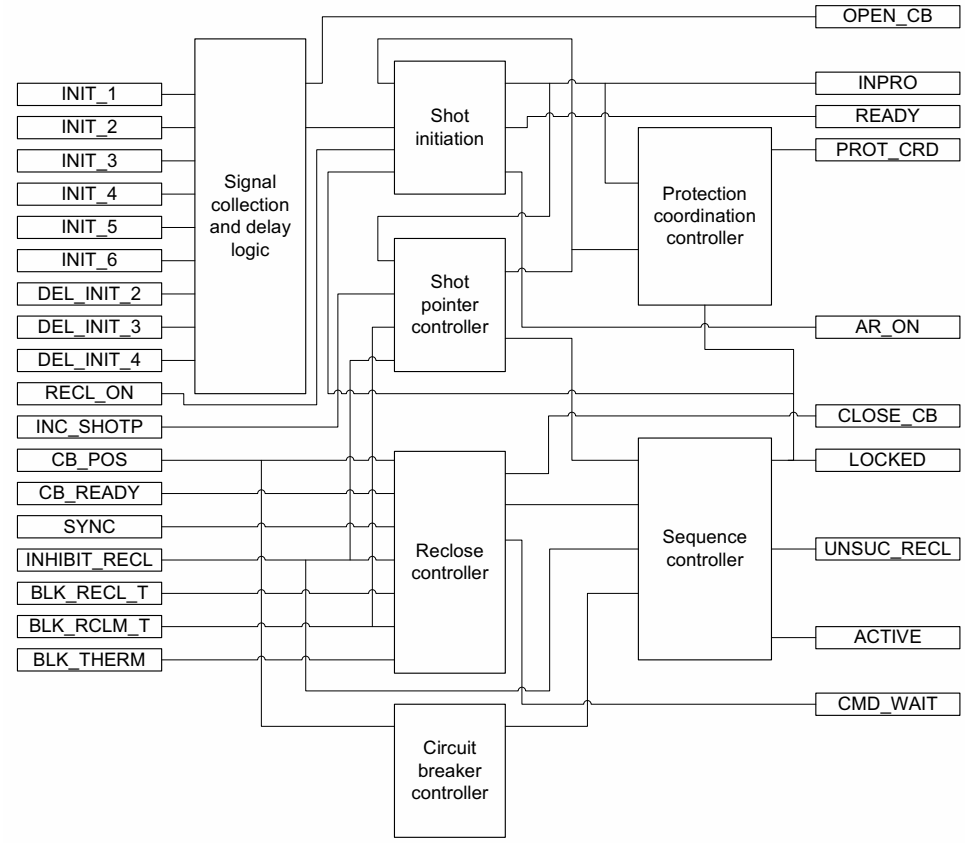



*Figure 789: Functional module diagram*

## Signal collection and delay logic

When the protection trips, the initiation of autoreclosing shots is in most applications executed with the INIT_1...6 inputs. The DEL_INIT2...4 inputs are not used. In some countries, starting the protection stage is also used for the shot initiation. This is the only time when the DEL_INIT inputs are used.

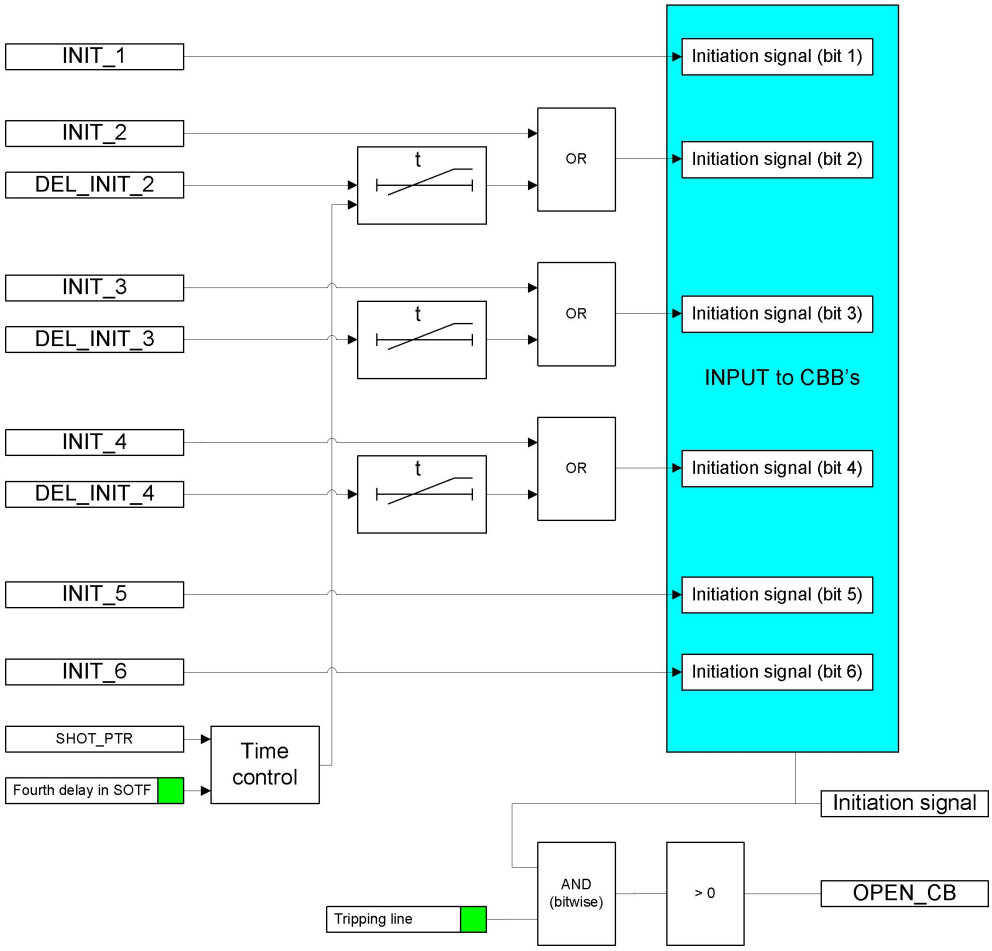



*Figure 790: Schematic diagram of delayed initiation input signals*

In total, the AR function contains six separate initiation lines used for the initiation or blocking of the autoreclosing shots. These lines are divided into two types of channels. In three of these channels, the signal to the AR function can be delayed, whereas the other three channels do not have any delaying capability.

Each channel that is capable of delaying a start signal has four time delays. The time delay is selected based on the shot pointer in the AR function. For the first reclose attempt, the first time delay is selected; for the second attempt, the second time delay and so on. For the fourth and fifth attempts, the time delays are the same.

Time delay settings for the `DEL_INIT_2` signal

- *Str 2 delay shot 1*
- *Str 2 delay shot 2*
- *Str 2 delay shot 3*
- *Str 2 delay shot 4*

Time delay settings for the `DEL_INIT_3` signal

- *Str 3 delay shot 1*
- *Str 3 delay shot 2*
- *Str 3 delay shot 3*
- *Str 3 delay shot 4*

Time delay settings for the DEL_INIT_4 signal

- *Str 4 delay shot 1*
- *Str 4 delay shot 2*
- *Str 4 delay shot 3*
- *Str 4 delay shot 4*

Normally, only two or three reclosing attempts are made. The third and fourth attempts are used to provide the so-called fast final trip to lockout.

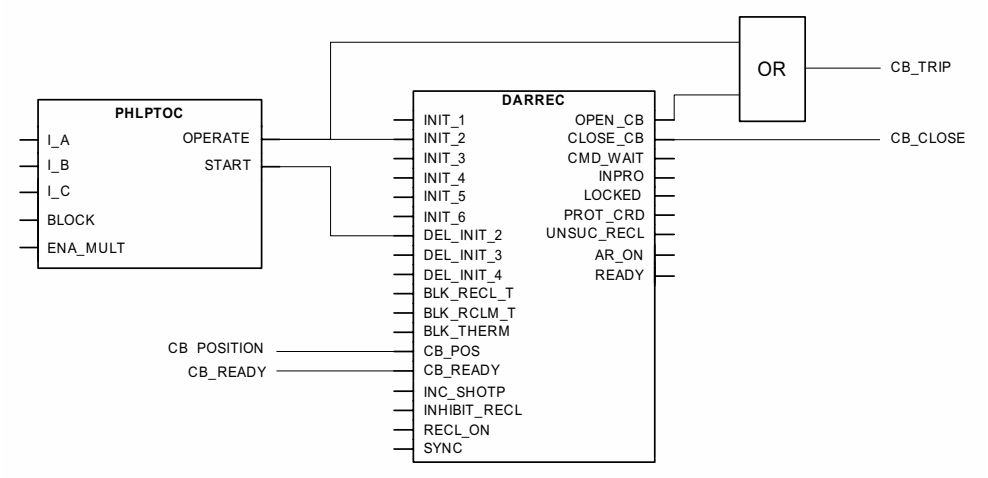



*Figure 791: Autoreclosing configuration example*

Delayed DEL_INIT_2...4 signals are used only when the autoreclosing shot is initiated with the start signal of a protection stage. After a start delay, the AR function opens the circuit breaker and an autoreclosing shot is initiated. When the shot is initiated with the trip signal of the protection, the protection function trips the circuit breaker and simultaneously initiates the autoreclosing shot.

If the circuit breaker is manually closed against the fault, that is, if SOTF is used, the fourth time delay can automatically be taken into use. This is controlled with the internal logic of the AR function and the *Fourth delay in SOTF* parameter.

A typical autoreclose situation is where one autoreclosing shot has been performed after the fault was detected. There are two types of such cases: operation initiated with protection start signal and operation initiated with protection trip signal. In both cases, the autoreclosing sequence is successful: the reclaim time elapses and no new sequence is started.

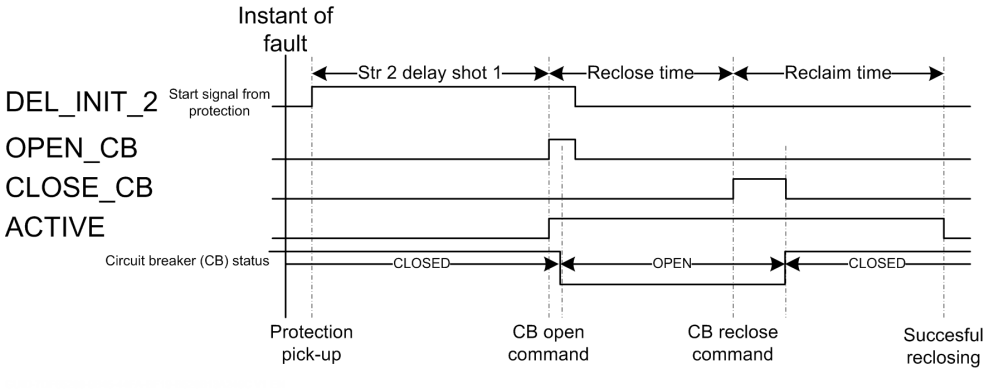



*Figure 792: Signal scheme of autoreclosing operation initiated with protection start signal*

The autoreclosing shot is initiated with a start signal of the protection function after the start delay time has elapsed. The autoreclosing starts when the *Str 2 delay shot 1* setting elapses.

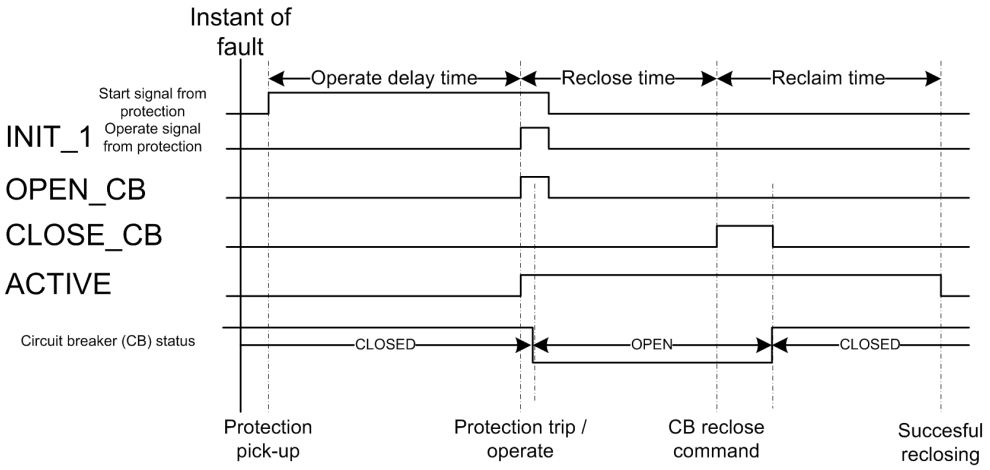



*Figure 793: Signal scheme of autoreclosing operation initiated with protection operate signal*

The autoreclosing shot is initiated with a trip signal of the protection function. The autoreclosing starts when the protection operate delay time elapses.

Normally, all trip and start signals are used to initiate an autoreclosing shot and trip the circuit breaker. ACTIVE output indicates reclosing sequence in progress. If any of the input signals INIT_X or DEL_INIT_X are used for blocking, the corresponding bit in the *Tripping line* setting must be FALSE. This is to ensure that the circuit breaker does not trip from that signal, that is, the signal does not activate the OPEN_CB output. The default value for the setting is "63", which means that all initiation signals activate the OPEN_CB output. The lowest bit in the *Tripping line* setting corresponds to the INIT_1 input, the highest bit to the INIT_6 line.

## Shot initiation

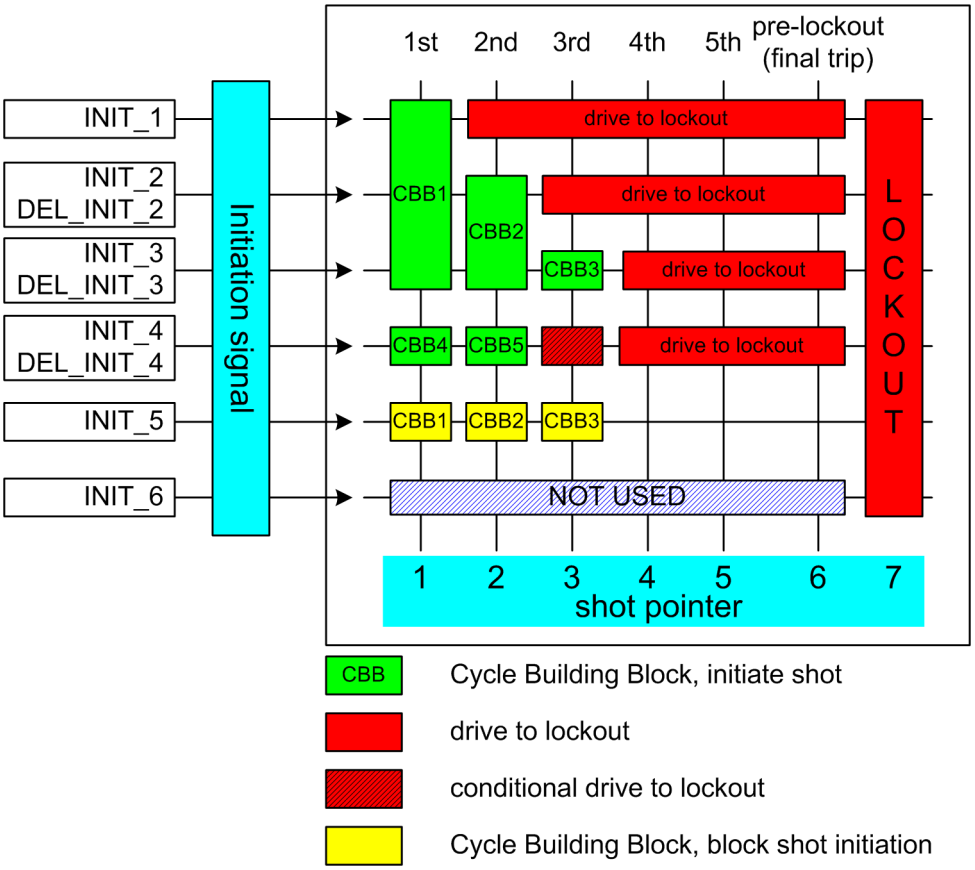



*Figure 794: Example of an autoreclosing program with a reclose scheme matrix*

In the AR function, each shot can be programmed to locate anywhere in the reclose scheme matrix. The shots are like building blocks used to design the reclose program. The building blocks are called CBBs. All blocks are alike and have settings which give the attempt number (columns in the matrix), the initiation or blocking signals (rows in the matrix) and the reclose time of the shot.

The settings related to CBB configuration are:

- *First...Seventh reclose time*
- *Init signals CBB1...CBB7*
- *Blk signals CBB1...CBB7*
- *Shot number CBB1...CBB7*

The reclose time defines the open and dead times, that is, the time between the `OPEN_CB` and the `CLOSE_CB` commands. The *Init signals CBBx* setting defines the initiation signals. The *Blk signals CBBx* setting defines the blocking signals that are related to the CBB (rows in the matrix). The *Shot number CBB1...CBB7* setting defines which shot is related to the CBB (columns in the matrix). For example, CBB1 settings are:

- *First reclose time* = 1.0s
- *Init signals CBB1* = 7 (three lowest bits: 111000 = 7)
- *Blk signals CBB1* = 16 (the fifth bit: 000010 = 16)
- *Shot number CBB1* = 1

CBB2 settings are:

- *Second reclose time* = 10s
- *Init signals CBB2* = 6 (the second and third bits: 011000 = 6)
- *Blk signals CBB2* = 16 (the fifth bit: 000010 = 16)
- *Shot number CBB2* = 2

CBB3 settings are:

- *Third reclose time* = 30s
- *Init signals CBB3* = 4 (the third bit: 001000 = 4)
- *Blk signals CBB3* = 16 (the fifth bit: 000010 = 16)
- *Shot number CBB3* = 3

CBB4 settings are:

- *Fourth reclose time* = 0.5s
- *Init signals CBB4* = 8 (the fourth bit: 000100 = 8)
- *Blk signals CBB4* = 0 (no blocking signals related to this CBB)
- *Shot number CBB4* = 1

If a shot is initiated from the INIT_1 line, only one shot is allowed before lockout. If a shot is initiated from the INIT_3 line, three shots are allowed before lockout.

A sequence initiation from the INIT_4 line leads to a lockout after two shots. In a situation where the initiation is made from both the INIT_3 and INIT_4 lines, a third shot is allowed, that is, CBB3 is allowed to start. This is called conditional lockout. If the initiation is made from the INIT_2 and INIT_3 lines, an immediate lockout occurs.

The INIT_5 line is used for blocking purposes. If the INIT_5 line is active during a sequence start, the reclose attempt is blocked and the AR function goes to lockout.

If more than one CBBs are started with the shot pointer, the CBB with the smallest individual number is always selected. For example, if the INIT_2 and INIT_4 lines are active for the second shot, that is, the shot pointer is 2, CBB2 is started instead of CBB5.

Even if the initiation signals are not received from the protection functions, the AR function can be set to continue from the second to the fifth reclose shot. The AR function can, for example, be requested to automatically continue with the sequence when the circuit breaker fails to close when requested. In such a case, the AR function

issues a CLOSE_CB command. When the wait close time elapses, that is, the closing of the circuit breaker fails, the next shot is automatically started. Another example is the embedded generation on the power line, which can make the synchronism check fail and prevent the reclosing. If the auto-reclose sequence is continued to the second shot, a successful synchronous reclosing is more likely than with the first shot, since the second shot lasts longer than the first one.

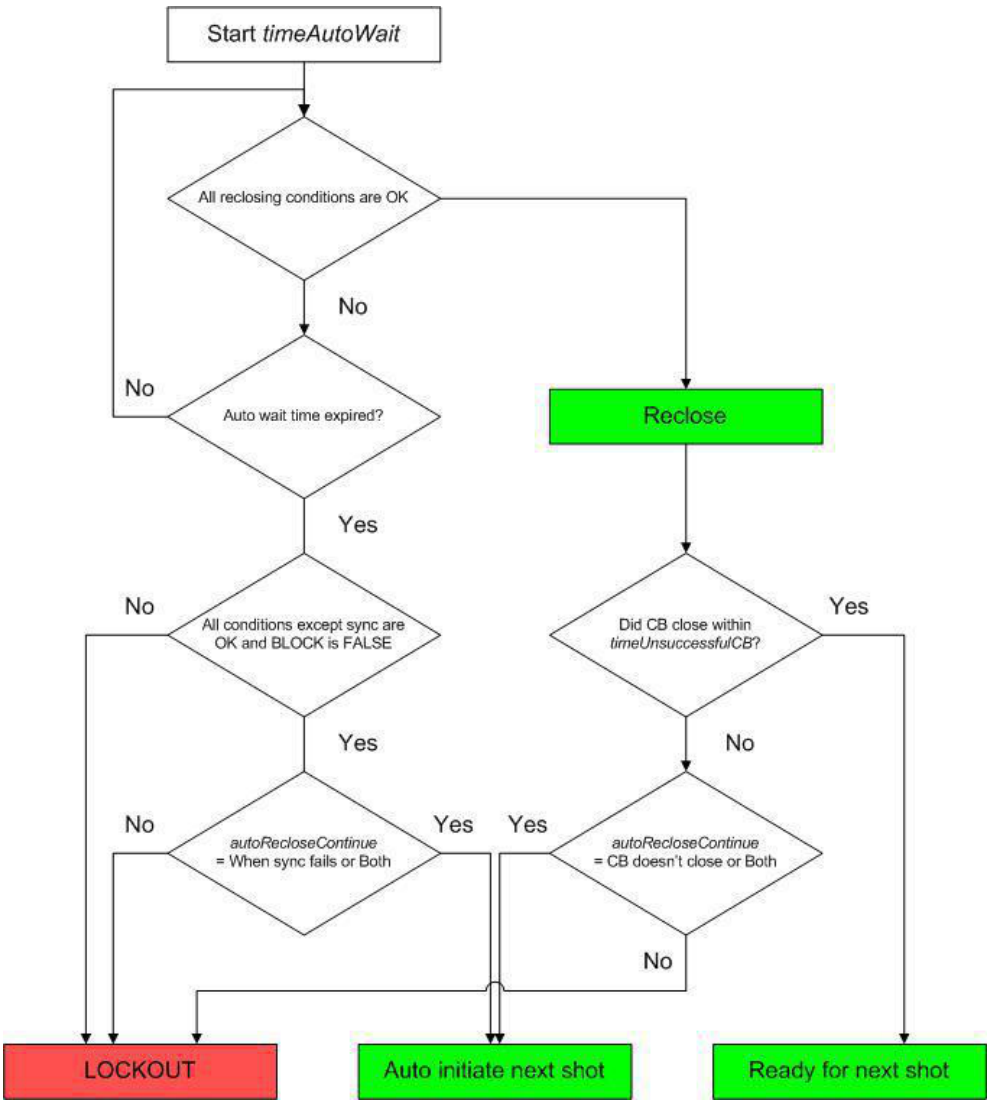



*Figure 795: Logic diagram of auto-initiation sequence detection*

Automatic initiation can be selected with the *Auto initiation Cnd* setting to be the following:

- Not allowed: no automatic initiation is allowed
- When the synchronization fails, the automatic initiation is carried out when the auto wait time elapses and the reclosing is prevented due to a failure during the synchronism check
- When the circuit breaker does not close, the automatic initiation is carried out if the circuit breaker does not close within the wait close time after issuing the reclose command
- Both: the automatic initiation is allowed when synchronization fails or the circuit breaker does not close.

The *Auto init* parameter defines which INIT_X lines are activated in the auto-initiation. The default value for this parameter is "0", which means that no auto-initiation is selected.

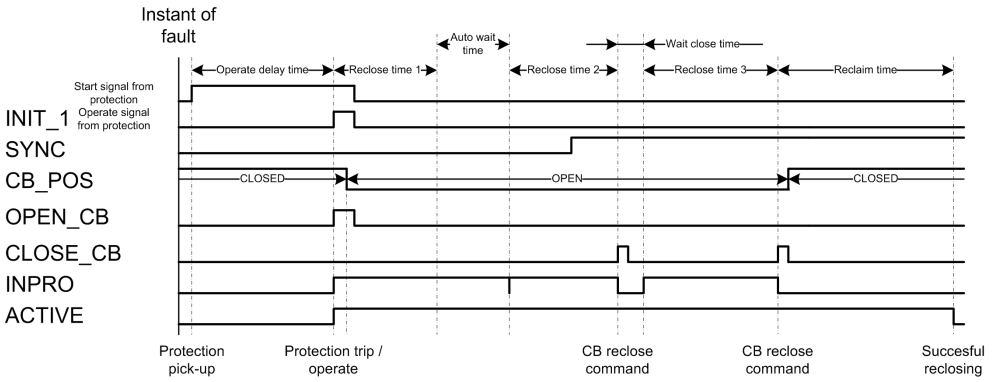



*Figure 796: Example of an auto-initiation sequence with synchronization failure in the first shot and circuit breaker closing failure in the second shot*

In the first shot, the synchronization condition is not fulfilled (SYNC is FALSE). When the auto wait timer elapses, the sequence continues to the second shot. During the second reclosing, the synchronization condition is fulfilled and the close command is given to the circuit breaker after the second reclose time has elapsed.

After the second shot, the circuit breaker fails to close when the wait close time has elapsed. The third shot is started and a new close command is given after the third reclose time has elapsed. The circuit breaker closes normally and the reclaim time starts. When the reclaim time has elapsed, the sequence is concluded successful.

## Shot pointer controller

The execution of a reclose sequence is controlled by a shot pointer. It can be adjusted with the SHOT_PTR monitored data.

The shot pointer starts from an initial value "1" and determines according to the settings whether or not a certain shot is allowed to be initiated. After every shot, the shot pointer value increases. This is carried out until a successful reclosing or lockout takes place after a complete shot sequence containing a total of five shots.

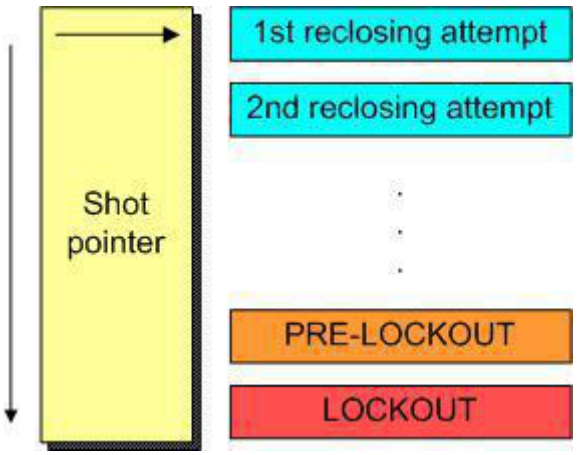



*Figure 797: Shot pointer function*

Every time the shot pointer increases, the reclaim time starts. When the reclaim time ends, the shot pointer sets to its initial value, unless no new shot is initiated. The shot pointer increases when the reclose time elapses or at the falling edge of the INC_SHOTP signal.

When SHOT_PTR has the value six, the AR function is in a so called pre-lockout state. If a new initiation occurs during the pre-lockout state, the AR function goes to lockout. Therefore, a new sequence initiation during the pre-lockout state is not possible.

The AR function goes to the pre-lockout state in the following cases:

- During SOTF
- When the AR function is active, it stays in a pre-lockout state for the time defined by the reclaim time
- When all five shots have been executed
- When the frequent operation counter limit is reached. A new sequence initiation forces the AR function to lockout.

## Reclose controller

The reclose controller calculates the reclose, discrimination and reclaim times. The reclose time is started when the INPRO signal is activated, that is, when the sequence starts and the activated CBB defines the reclose time.

When the reclose time has elapsed, the CLOSE_CB output is not activated until the following conditions are fulfilled:

- The SYNC input must be TRUE if the particular CBB requires information about the synchronism
- All AR initiation inputs that are defined protection lines (using the *Control line* setting) are inactive
- The circuit breaker is open
- The circuit breaker is ready for the close command, that is, the CB_READY input is TRUE. This is indicated by active READY output.

If at least one of the conditions is not fulfilled within the time set with the *Auto wait time* parameter, the auto-reclose sequence is locked.

The synchronism requirement for the CBBs can be defined with the *Synchronisation set* setting, which is a bit mask. The lowest bit in the *Synchronisation set* setting is related to CBB1 and the highest bit to CBB7. For example, if the setting is set to "1", only CBB1 requires synchronism. If the setting is it set to "7", CBB1, CBB2 and CBB3 require the SYNC input to be TRUE before the reclosing command can be given.

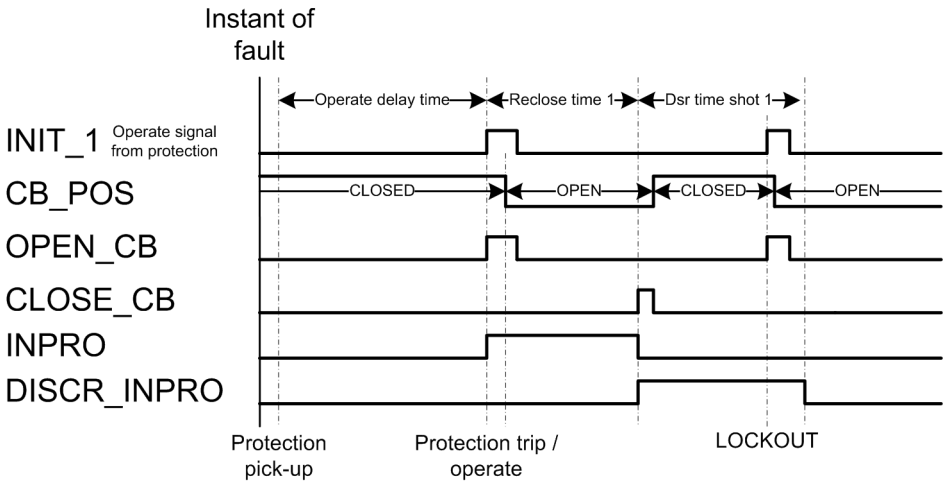



*Figure 798: Initiation during discrimination time - AR function goes to lockout*

The discrimination time starts when the close command CLOSE_CB has been given. If a start input is activated before the discrimination time has elapsed, the AR function goes to lockout. The default value for each discrimination time is zero. The discrimination time can be adjusted with the *Dsr time shot 1...4* parameter.

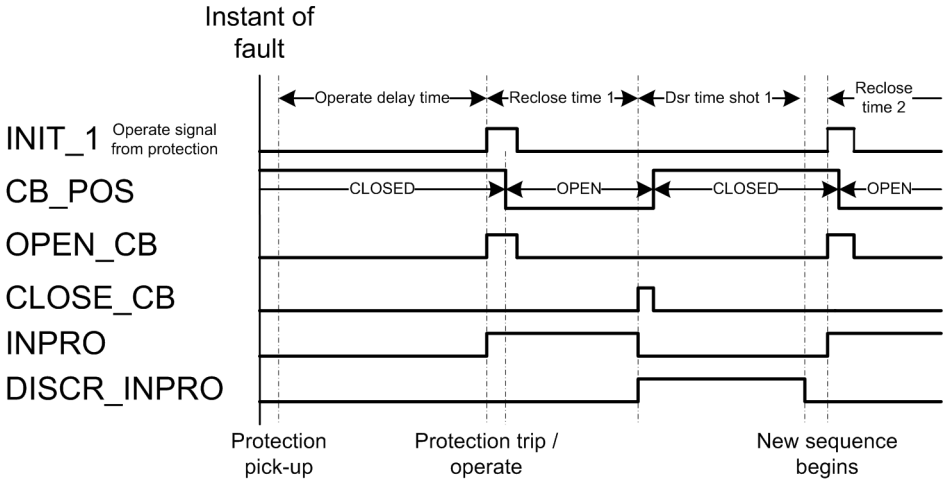



*Figure 799: Initiation after elapsed discrimination time - new shot begins*

## Sequence controller

When the LOCKED output is active, the AR function is in lockout. This means that new sequences cannot be initialized, because AR is insensitive to initiation commands. It can be released from the lockout state in the following ways.

- The function is reset through communication with the *RecRs* parameter. The same functionality can also be found in the Clear menu (DARREC1 reset).
- The lockout is automatically reset after the reclaim time, if the *Auto lockout reset* setting is in use.



If the *Auto lockout reset* setting is not in use, the lockout can be released only with the *RecRs* parameter.

The AR function can go to lockout for many reasons.

- The INHIBIT_RECL input is active.
- All shots have been executed and a new initiation is made (final trip).
- The time set with the *Auto wait time* parameter expires and the automatic sequence initiation is not allowed because of a synchronization failure.
- The time set with the *Wait close time* parameter expires, that is, the circuit breaker does not close or the automatic sequence initiation is not allowed due to a closing failure of the circuit breaker.
- A new shot is initiated during the discrimination time.
- The time set with the *Max wait time* parameter expires, that is, the master unit does not release the slave unit.
- The frequent operation counter limit is reached and new sequence is initiated. The lockout is released when the recovery timer elapses.
- The protection trip signal has been active longer than the time set with the *Max wait time* parameter since the shot initiation.
- The circuit breaker is closed manually during an autoreclosing sequence and the manual close mode is FALSE.

## Protection coordination controller

The PROT_CRD output is used for controlling the protection functions. In several applications, such as fuse-saving applications involving down-stream fuses, tripping and initiation of shot 1 should be fast (instantaneous or short-time delayed). The tripping and initiation of shots 2, 3 and definite tripping time should be delayed.

In this example, two overcurrent elements PHLPTOC and PHIPTOC are used. PHIPTOC is given an instantaneous characteristic and PHLPTOC is given a time delay.

The PROT_CRD output is activated, if the SHOT_PTR value is the same or higher than the value defined with the *Protection crd limit* setting and all initialization signals have been reset. The PROT_CRD output is reset under the following conditions:

- If the cut-out time elapses
- If the reclaim time elapses and the AR function is ready for a new sequence
- If the AR function is in lockout or disabled, that is, if the value of the *Protection crd mode* setting is "AR inoperative" or "AR inop, CB man".

The PROT_CRD output can also be controlled with the *Protection crd mode* setting. The setting has the following modes:

- "no condition": the PROT_CRD output is controlled only with the *Protection crd limit* setting
- "AR inoperative": the PROT_CRD output is active, if the AR function is disabled or in the lockout state, or if the INHIBIT_RECL input is active
- "CB close manual": the PROT_CRD output is active for the reclaim time if the circuit breaker has been manually closed, that is, the AR function has not issued a close command
- "AR inop, CB man": both the modes "AR inoperative" and "CB close manual" are effective
- "always": the PROT_CRD output is constantly active

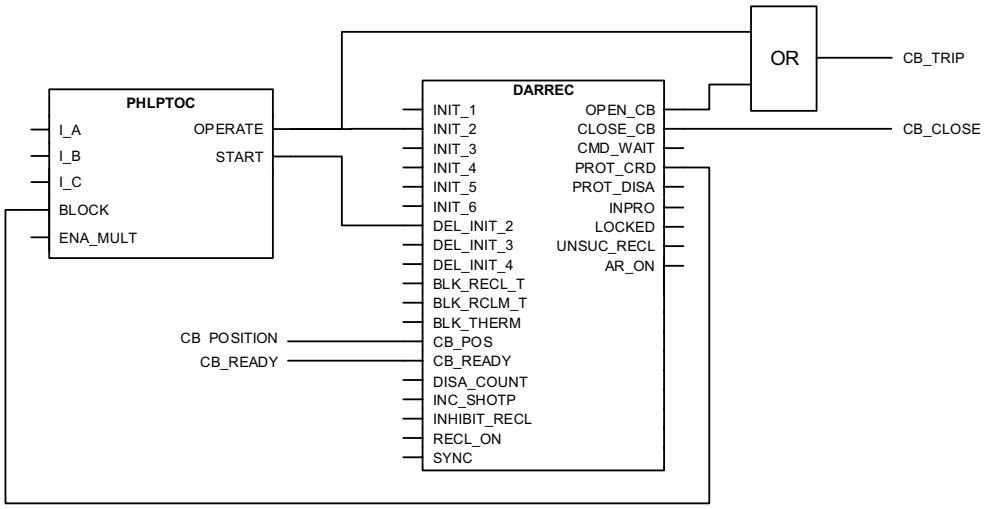



*Figure 800: Configuration example of using the PROT_CRD output for protection blocking*

If the *Protection crd limit* setting has the value "1", the instantaneous three-phase overcurrent protection function PHIPTOC is disabled or blocked after the first shot.

## Circuit breaker controller

Circuit breaker controller contains two features: SOTF and frequent-operation counter. SOTF protects the AR function in permanent faults.

The circuit breaker position information is controlled with the *CB closed Pos status* setting. The setting value "TRUE" means that when the circuit breaker is closed, the CB_POS input is TRUE. When the setting value is "FALSE", the CB_POS input is

FALSE, provided that the circuit breaker is closed. The reclose command pulse time can be controlled with the *Close pulse time* setting: the CLOSE_CB output is active for the time set with the *Close pulse time* setting. The CLOSE_CB output is deactivated also when the circuit breaker is detected to be closed, that is, when the CB_POS input changes from open state to closed state. The *Wait close time* setting defines the time after the CLOSE_CB command activation, during which the circuit breaker should be closed. If the closing of circuit breaker does not happen during this time, the autoreclosing function is driven to lockout or, if allowed, an auto-initiation is activated.

The main motivation for autoreclosing to begin with is the assumption that the fault is temporary by nature, and that a momentary de-energizing of the power line and an automatic reclosing restores the power supply. However, when the power line is manually energized and an immediate protection trip is detected, it is very likely that the fault is of a permanent type. A permanent fault is, for example, energizing a power line into a forgotten earthing after a maintenance work along the power line. In such cases, SOTF is activated, but only for the reclaim time after energizing the power line and only when the circuit breaker is closed manually and not by the AR function.

SOTF disables any initiation of an autoreclosing shot. The energizing of the power line is detected from the CB_POS information.

SOTF is activated when the AR function is enabled or when the AR function is started and the SOTF should remain active for the reclaim time.

When SOTF is detected, the parameter *SOTF* is active.

If the *Manual close mode* setting is set to FALSE and the circuit breaker has been manually closed during an autoreclosing shot, the AR unit goes to an immediate lockout.

If the *Manual close mode* setting is set to TRUE and the circuit breaker has been manually closed during an autoreclosing shot (the INPRO is active), the shot is considered as completed.

When SOTF starts, reclaim time is restarted, provided that it is running.

The frequent-operation counter is intended for blocking the autoreclosing function in cases where the fault causes repetitive autoreclosing sequences during a short period of time. For instance, if a tree causes a short circuit and, as a result, there are autoreclosing shots within a few minutes interval during a stormy night. These types of faults can easily damage the circuit breaker if the AR function is not locked by a frequent-operation counter.

The frequent-operation counter has three settings:

- *Frq Op counter limit*
- *Frq Op counter time*
- *Frq Op recovery time*

The *Frq Op counter limit* setting defines the number of reclose attempts that are allowed during the time defined with the *Frq Op counter time* setting. If the set value is reached within a pre-defined period defined with the *Frq Op counter time* setting, the AR function goes to lockout when a new shot begins, provided that the counter is still above the set limit. The lockout is released after the recovery time has elapsed. The recovery time can be defined with the *Frq Op recovery time* setting .

If the circuit breaker is manually closed during the recovery time, the reclaim time is activated after the recovery timer has elapsed.

## 9.9.5 Counters

The AR function contains six counters. Their values are stored in a semi-retain memory. The counters are increased at the rising edge of the reclosing command. The counters count the following situations.

- COUNTER: counts every reclosing command activation
- CNT_SHOT1: counts reclosing commands that are executed from shot 1
- CNT_SHOT2: counts reclosing commands that are executed from shot 2
- CNT_SHOT3: counts reclosing commands that are executed from shot 3
- CNT_SHOT4: counts reclosing commands that are executed from shot 4
- CNT_SHOT5: counts reclosing commands that are executed from shot 5

The counters are disabled through communication with the *DsaCnt* parameter. When the counters are disabled, the values are not updated.

The counters are reset through communication with the *CntRs* parameter. The same functionality can also be found in the clear menu (DARREC1 counters).

## 9.9.6 Application

Modern electric power systems can deliver energy to users very reliably. However, different kind of faults can occur. Protection relays play an important role in detecting failures or abnormalities in the system. They detect faults and give commands for corresponding circuit breakers to isolate the defective element before excessive damage or a possible power system collapse occurs. A fast isolation also limits the disturbances caused for the healthy parts of the power system.

The faults can be transient, semi-transient or permanent. Permanent fault, for example in power cables, means that there is a physical damage in the fault location that must first be located and repaired before the network voltage can be restored.

In overhead lines, the insulating material between phase conductors is air. The majority of the faults are flash-over arcing faults caused by lightning, for example.

Only a short interruption is needed for extinguishing the arc. These faults are transient by nature.

A semi-transient fault can be caused for example by a bird or a tree branch falling on the overhead line. The fault disappears on its own if the fault current burns the branch or the wind blows it away.

Transient and semi-transient faults can be cleared by momentarily de-energizing the power line. Using the auto-reclose function minimizes interruptions in the power system service and brings the power back on-line quickly and effortlessly.

The basic idea of the auto-reclose function is simple. In overhead lines, where the possibility of self-clearing faults is high, the auto-reclose function tries to restore the power by reclosing the breaker. This is a method to get the power system back into normal operation by removing the transient or semi-transient faults. Several trials, that is, auto-reclose shots are allowed. If none of the trials is successful and the fault persists, definite final tripping follows.

The auto-reclose function can be used with every circuit breaker that has the ability for a reclosing sequence. In DARREC auto-reclose function the implementing method of auto-reclose sequences is patented by ABB

*Table 1399: Important definitions related to autoreclosing*

| | |
|---|---|
| Autoreclose shot | An operation where after a preset time the breaker is closed from the breaker tripping caused by protection |
| Autoreclose sequence | A predefined method to do reclose attempts (shots) to restore the power system |
| SOTF | If the protection detects a fault immediately after an open circuit breaker has been closed, it indicates that the fault was already there. It can be, for example, a forgotten earthing after maintenance work. Such closing of the circuit breaker is known as switch on to fault. Autoreclosing in such conditions is prohibited. |
| Final trip | Occurs in case of a permanent fault, when the circuit breaker is opened for the last time after all programmed auto-reclose operations. Since no auto-reclosing follows, the circuit breaker remains open. This is called final trip or definite trip. |

### 9.9.6.1 Shot initiation

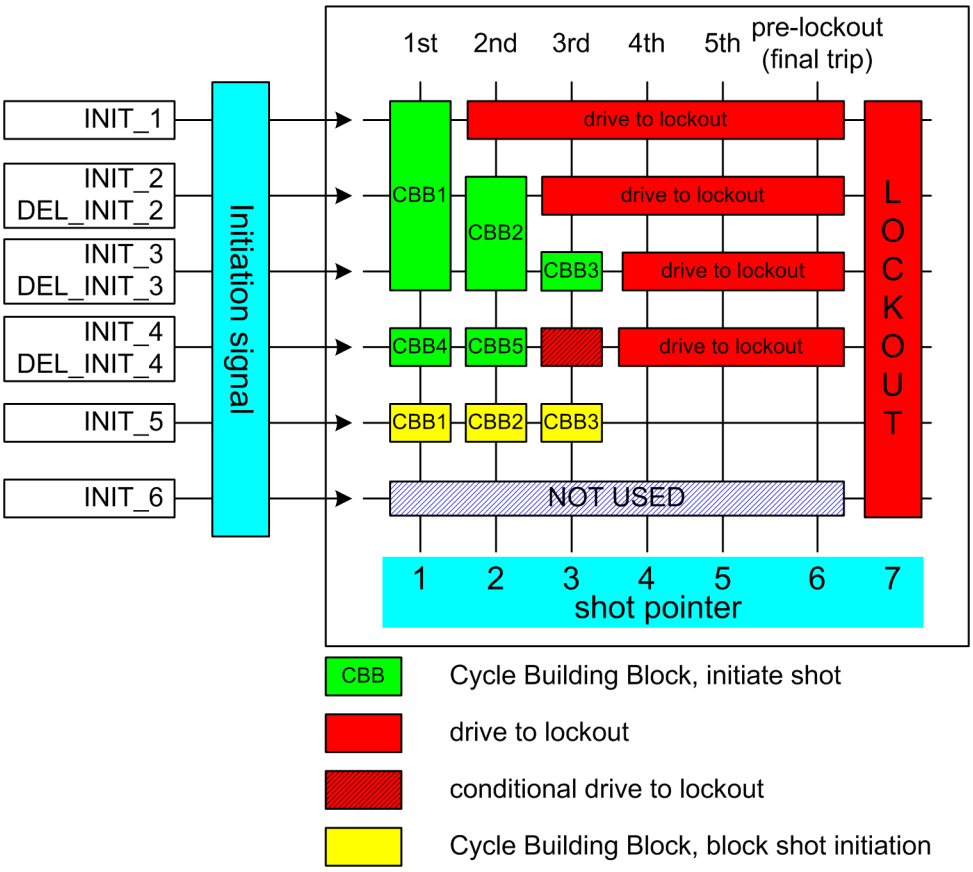



*Figure 801: Example of an autoreclosing program with a reclose scheme matrix*

In the AR function, each shot can be programmed to locate anywhere in the reclose scheme matrix. The shots are like building blocks used to design the reclose program. The building blocks are called CBBs. All blocks are alike and have settings which give the attempt number (columns in the matrix), the initiation or blocking signals (rows in the matrix) and the reclose time of the shot.

The settings related to CBB configuration are:

- *First...Seventh reclose time*
- *Init signals CBB1...CBB7*
- *Blk signals CBB1...CBB7*
- *Shot number CBB1...CBB7*

The reclose time defines the open and dead times, that is, the time between the `OPEN_CB` and the `CLOSE_CB` commands. The *Init signals CBBx* setting defines the initiation signals. The *Blk signals CBBx* setting defines the blocking signals that are related to the CBB (rows in the matrix). The *Shot number CBB1...CBB7* setting defines which shot is related to the CBB (columns in the matrix). For example, CBB1 settings are:

- *First reclose time* = 1.0s
- *Init signals CBB1* = 7 (three lowest bits: 111000 = 7)
- *Blk signals CBB1* = 16 (the fifth bit: 000010 = 16)
- *Shot number CBB1* = 1

CBB2 settings are:

- *Second reclose time* = 10s
- *Init signals CBB2* = 6 (the second and third bits: 011000 = 6)
- *Blk signals CBB2* = 16 (the fifth bit: 000010 = 16)
- *Shot number CBB2* = 2

CBB3 settings are:

- *Third reclose time* = 30s
- *Init signals CBB3* = 4 (the third bit: 001000 = 4)
- *Blk signals CBB3* = 16 (the fifth bit: 000010 = 16)
- *Shot number CBB3* = 3

CBB4 settings are:

- *Fourth reclose time* = 0.5s
- *Init signals CBB4* = 8 (the fourth bit: 000100 = 8)
- *Blk signals CBB4* = 0 (no blocking signals related to this CBB)
- *Shot number CBB4* = 1

If a shot is initiated from the INIT_1 line, only one shot is allowed before lockout. If a shot is initiated from the INIT_3 line, three shots are allowed before lockout.

A sequence initiation from the INIT_4 line leads to a lockout after two shots. In a situation where the initiation is made from both the INIT_3 and INIT_4 lines, a third shot is allowed, that is, CBB3 is allowed to start. This is called conditional lockout. If the initiation is made from the INIT_2 and INIT_3 lines, an immediate lockout occurs.

The INIT_5 line is used for blocking purposes. If the INIT_5 line is active during a sequence start, the reclose attempt is blocked and the AR function goes to lockout.

If more than one CBBs are started with the shot pointer, the CBB with the smallest individual number is always selected. For example, if the INIT_2 and INIT_4 lines are active for the second shot, that is, the shot pointer is 2, CBB2 is started instead of CBB5.

Even if the initiation signals are not received from the protection functions, the AR function can be set to continue from the second to the fifth reclose shot. The AR function can, for example, be requested to automatically continue with the sequence when the circuit breaker fails to close when requested. In such a case, the AR function

issues a CLOSE_CB command. When the wait close time elapses, that is, the closing of the circuit breaker fails, the next shot is automatically started. Another example is the embedded generation on the power line, which can make the synchronism check fail and prevent the reclosing. If the auto-reclose sequence is continued to the second shot, a successful synchronous reclosing is more likely than with the first shot, since the second shot lasts longer than the first one.

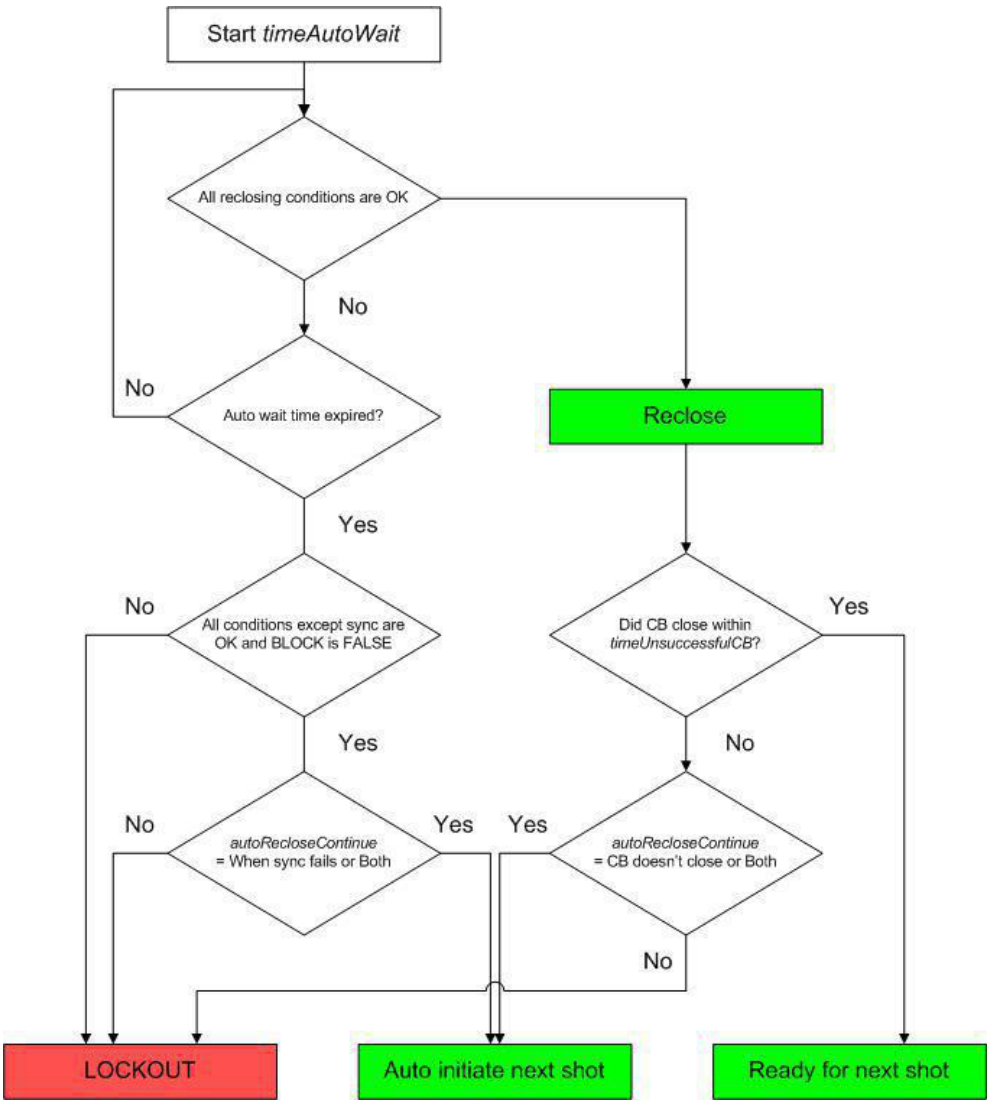



*Figure 802: Logic diagram of auto-initiation sequence detection*

Automatic initiation can be selected with the *Auto initiation Cnd* setting to be the following:

- Not allowed: no automatic initiation is allowed
- When the synchronization fails, the automatic initiation is carried out when the auto wait time elapses and the reclosing is prevented due to a failure during the synchronism check
- When the circuit breaker does not close, the automatic initiation is carried out if the circuit breaker does not close within the wait close time after issuing the reclose command
- Both: the automatic initiation is allowed when synchronization fails or the circuit breaker does not close.

The *Auto init* parameter defines which INIT_X lines are activated in the auto-initiation. The default value for this parameter is "0", which means that no auto-initiation is selected.

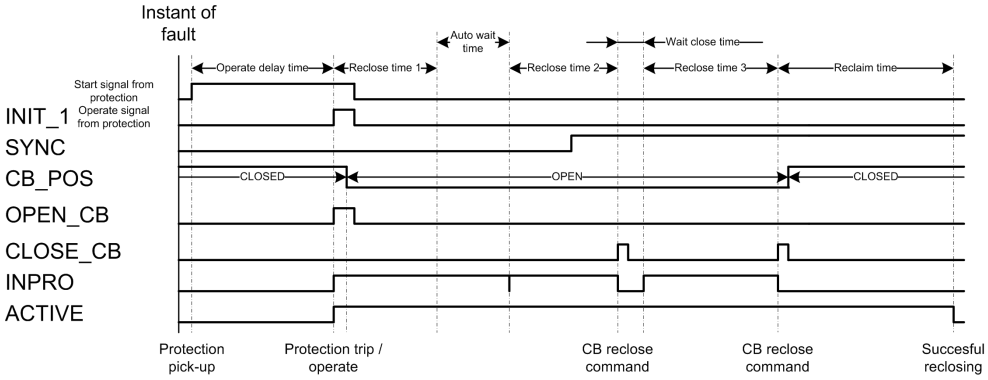



*Figure 803: Example of an auto-initiation sequence with synchronization failure in the first shot and circuit breaker closing failure in the second shot*

In the first shot, the synchronization condition is not fulfilled (SYNC is FALSE). When the auto wait timer elapses, the sequence continues to the second shot. During the second reclosing, the synchronization condition is fulfilled and the close command is given to the circuit breaker after the second reclose time has elapsed.

After the second shot, the circuit breaker fails to close when the wait close time has elapsed. The third shot is started and a new close command is given after the third reclose time has elapsed. The circuit breaker closes normally and the reclaim time starts. When the reclaim time has elapsed, the sequence is concluded successful.

### 9.9.6.2 Sequence

The auto reclose sequence is implemented by using CBBs. The highest possible amount of CBBs is seven. If the user wants to have, for example, a sequence of three shots, only the first three CBBs are needed. Using building blocks instead of fixed shots gives enhanced flexibility, allowing multiple and adaptive sequences.

Each CBB is identical. The *Shot number CBB_* setting defines at which point in the auto-reclose sequence the CBB should be performed, that is, whether the particular CBB is going to be the first, second, third, fourth or fifth shot.

During the initiation of a CBB, the conditions of initiation and blocking are checked. This is done for all CBBs simultaneously. Each CBB that fulfils the initiation conditions requests an execution.

The function also keeps track of shots already performed, that is, at which point the auto-reclose sequence is from shot 1 to lockout. For example, if shots 1 and 2 have already been performed, only shots 3 to 5 are allowed.

Additionally, the *Enable shot jump* setting gives two possibilities:

- Only such CBBs that are set for the next shot in the sequence can be accepted for execution. For example, if the next shot in the sequence should be shot 2, a request from CBB set for shot 3 is rejected.
- Any CBB that is set for the next shot or any of the following shots can be accepted for execution. For example, if the next shot in the sequence should be shot 2, also CBBs that are set for shots 3, 4 and 5 are accepted. In other words, shot 2 can be ignored.

In case there are multiple CBBs allowed for execution, the CBB with the smallest number is chosen. For example, if CBB2 and CBB4 request an execution, CBB2 is allowed to execute the shot.

The auto-reclose function can perform up to five auto-reclose shots or cycles.

### 9.9.6.3 Configuration examples

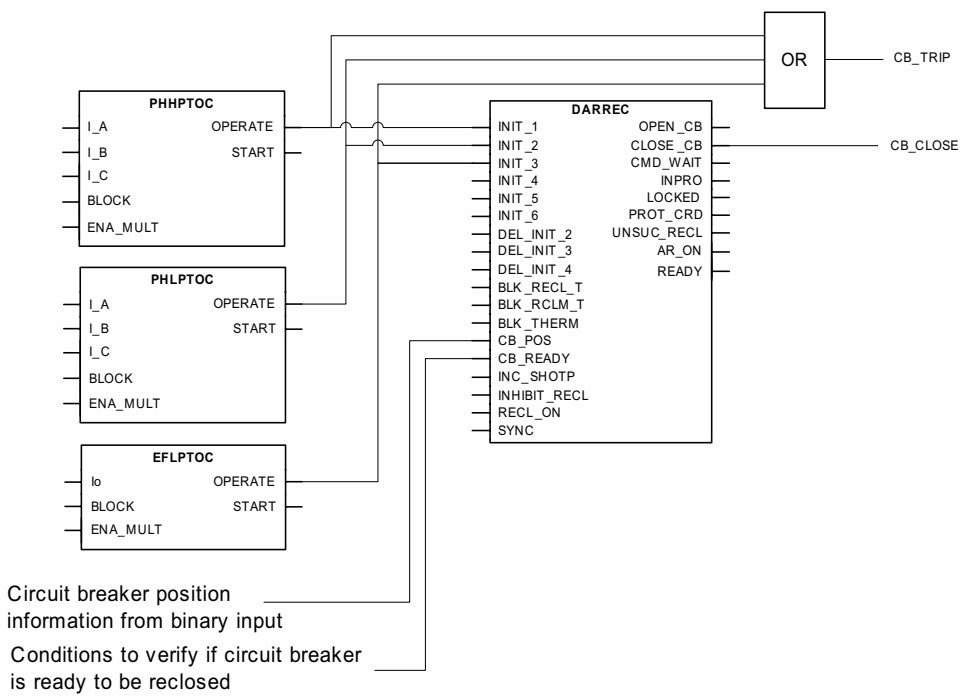



*Figure 804: Example connection between protection and autoreclosing functions in protection relay configuration*

It is possible to create several sequences for a configuration.

Autoreclose sequences for overcurrent and non-directional earth-fault protection applications where high speed and delayed autoreclosings are needed can be as follows:

## Example 1

The sequence is implemented by two shots which have the same reclosing time for all protection functions, namely I>>, I> and Io>. The initiation of the shots is done by activating the operating signals of the protection functions.

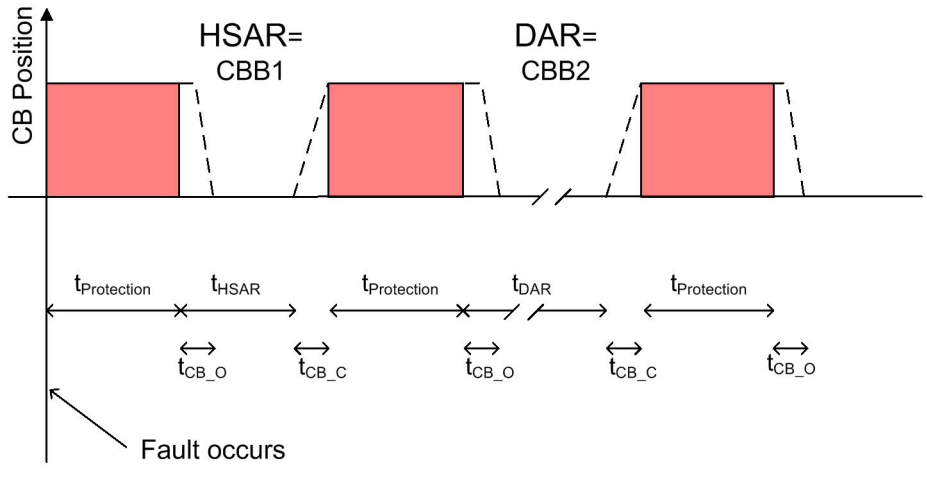



*Figure 805: Autoreclosing sequence with two shots*

| | |
|---|---|
| $t_{HSAR}$ | Time delay of high-speed autoreclosing, here: *First reclose time* |
| $t_{DAR}$ | Time delay of delayed autoreclosing, here: *Second reclose time* |
| $t_{Protection}$ | Operating time for the protection stage to clear the fault |
| $t_{CB_O}$ | Operating time for opening the circuit breaker |
| $t_{CB_C}$ | Operating time for closing the circuit breaker |

In this case, the sequence needs two CBBs. The reclosing times for shot 1 and shot 2 are different, but each protection function initiates the same sequence. The CBB sequence is described in Table 1400 as follows:

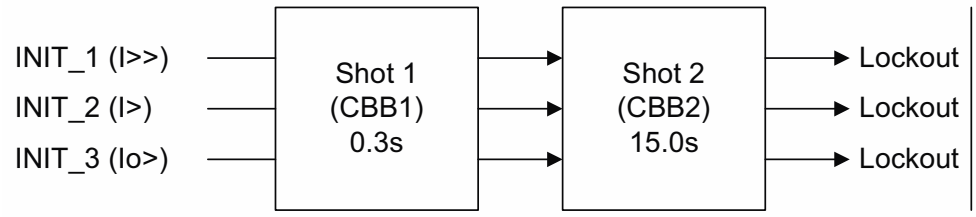



*Figure 806: Two shots with three initiation lines*

***Table 1400: Settings for configuration example 1***

| Setting name | Setting value |
|---|---|
| *Shot number CBB1* | 1 |
| *Init signals CBB1* | 7 (lines 1, 2 and 3 = 1+2+4 = 7) |
| *First reclose time* | 0.3 s (an example) |
| Table continues on next page | |

| Setting name | Setting value |
|---|---|
| *Shot number CBB2* | 2 |
| *Init signals CBB2* | 7 (lines 1, 2 and 3 = 1+2+4 = 7) |
| *Second reclose time* | 15.0 s (an example) |

## Example 2

There are two separate sequences implemented with three shots. Shot 1 is implemented by CBB1 and it is initiated with the high stage of the overcurrent protection (I>>). Shot 1 is set as a high-speed autoreclosing with a short time delay. Shot 2 is implemented with CBB2 and meant to be the first shot of the autoreclose sequence initiated by the low stage of the overcurrent protection (I>) and the low stage of the non-directional earth-fault protection (Io>). It has the same reclosing time in both situations. It is set as a high-speed autoreclosing for corresponding faults. The third shot, which is the second shot in the autoreclose sequence initiated by I> or Io>, is set as a delayed autoreclosing and executed after an unsuccessful high-speed autoreclosing of a corresponding sequence.

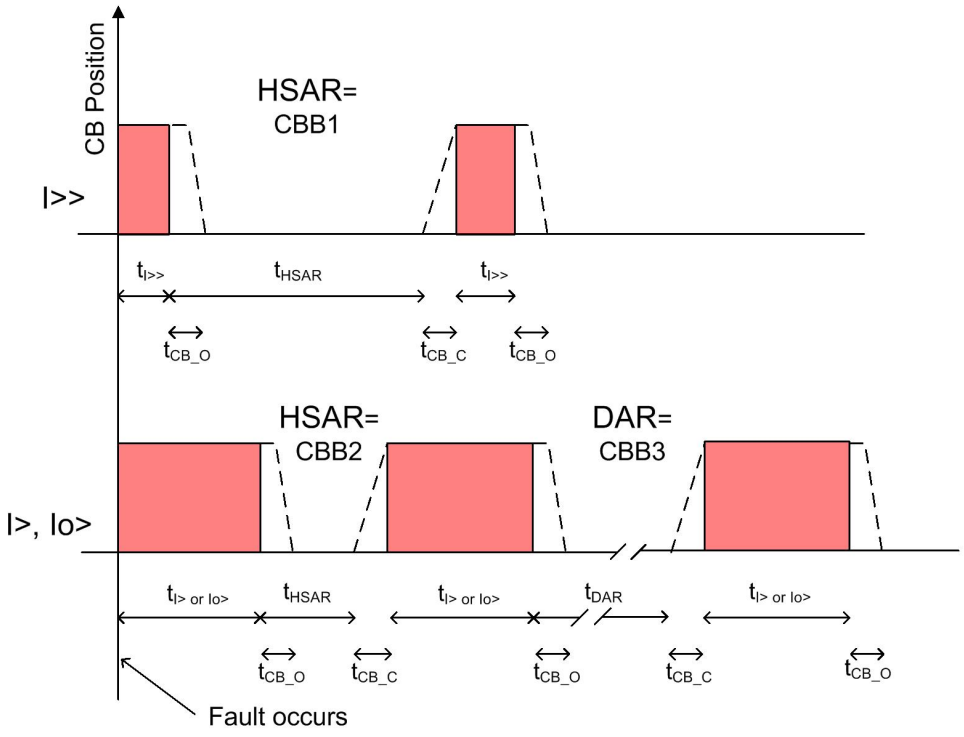



*Figure 807: Autoreclosing sequence with two shots with different shot settings according to initiation signal*

| | |
|---|---|
| $t_{HSAR}$ | Time delay of high-speed autoreclosing, here: *First reclose time* |
| $t_{DAR}$ | Time delay of delayed autoreclosing, here: *Second reclose time* |
| $t_{I>>}$ | Operating time for the I>> protection stage to clear the fault |

| | |
|---|---|
| $t_{I>}$ or $_{Io>}$ | Operating time for the I> or Io> protection stage to clear the fault |
| $t_{CB_O}$ | Operating time for opening the circuit breaker |
| $t_{CB_C}$ | Operating time for closing the circuit breaker |

In this case, the number of needed CBBs is three, that is, the first shot's reclosing time depends on the initiation signal.

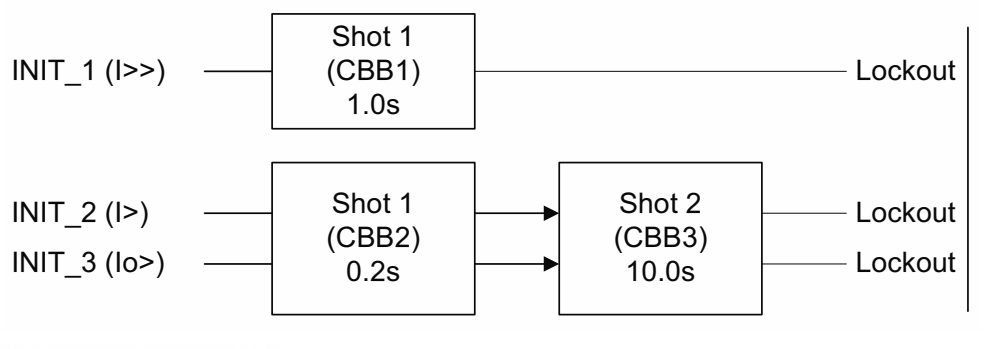



*Figure 808: Three shots with three initiation lines*

If the sequence is initiated from the `INIT_1` line, that is, the overcurrent protection high stage, the sequence is one shot long. If the sequence is initiated from the `INIT_2` or `INIT_3` lines, the sequence is two shots long.

*Table 1401: Settings for configuration example 2*

| Setting name | Setting value |
|---|---|
| *Shot number CBB1* | 1 |
| *Init signals CBB1* | 1 (line 1) |
| *First reclose time* | 0.0 s (an example) |
| *Shot number CBB2* | 1 |
| *Init signals CBB2* | 6 (lines 2 and 3 = 2+4 = 6) |
| *Second reclose time* | 0.2 s (an example) |
| *Shot number CBB3* | 2 |
| *Init signals CBB3* | 6 (lines 2 and 3 = 2+4 = 6) |
| *Third reclose time* | 10.0 s |

### 9.9.6.4 Delayed initiation lines

The autoreclose function consists of six individual autoreclose initiation lines `INIT_1...INIT 6` and three delayed initiation lines:

- `DEL_INIT_2`
- `DEL_INIT_3`
- `DEL_INIT_4`

DEL_INIT_2 and INIT_2 are connected together with an OR-gate, as are inputs 3 and 4. Inputs 1, 5 and 6 do not have any delayed input. From the autoreclosing point of view, it does not matter whether INIT_x or DEL_INIT_x line is used for shot initiation or blocking.

The autoreclose function can also open the circuit breaker from any of the initiation lines. It is selected with the *Tripping line* setting. As a default, all initiation lines activate the OPEN_CB output.

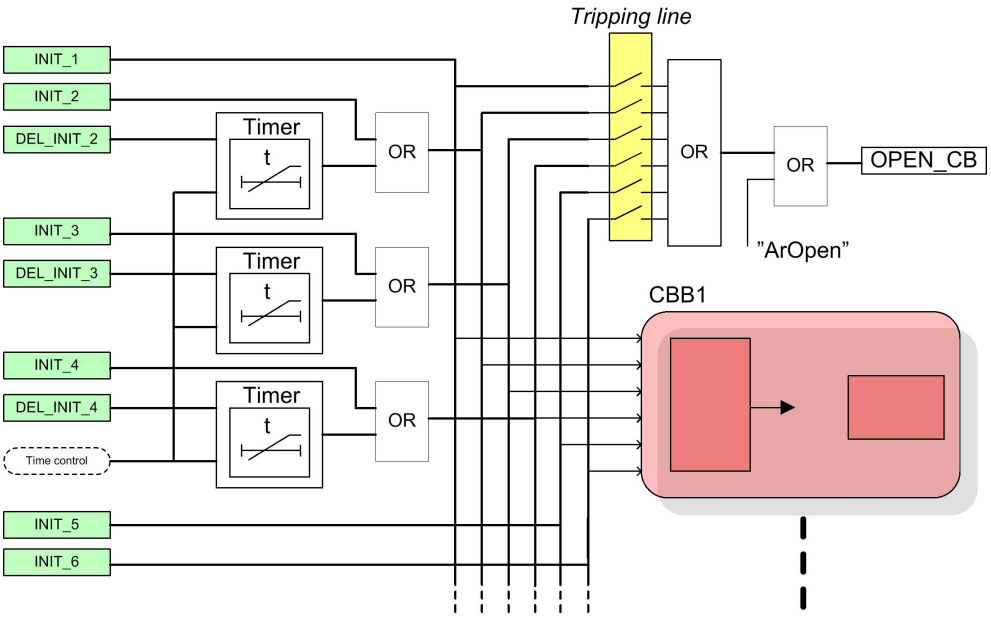



*Figure 809: Simplified logic diagram of initiation lines*

Each delayed initiation line has four different time settings:

***Table 1402: Settings for delayed initiation lines***

| Setting name | Description and purpose |
|---|---|
| *Str x delay shot 1* | Time delay for the DEL_INIT_x line, where x is the number of the line 2, 3 or 4. Used for shot 1. |
| *Str x delay shot 2* | Time delay for the DEL_INIT_x line, used for shot 2. |
| *Str x delay shot 3* | Time delay for the DEL_INIT_x line, used for shot 3. |
| *Str x delay shot 4* | Time delay for the DEL_INIT_x line, used for shots 4 and 5. Optionally, can also be used with SOTF. |

### 9.9.6.5 Shot initiation from protection start signal

In it simplest, all auto-reclose shots are initiated by protection trips. As a result, all trip times in the sequence are the same. This is why using protection trips may not be the

optimal solution. Using protection start signals instead of protection trips for initiating shots shortens the trip times.

### Example 1

When a two-shot-sequence is used, the start information from the protection function is routed to the DEL_INIT 2 input and the operate information to the INIT_2 input. The following conditions have to apply:

- protection operate time = 0.5s
- *Str 2 delay shot 1* = 0.05s
- *Str 2 delay shot 2* = 60s
- *Str 2 delay shot 3* = 60s

Operation in a permanent fault:

1. Protection starts and activates the DEL_INIT 2 input.
2. After 0.05 seconds, the first autoreclose shot is initiated. The function opens the circuit breaker: the OPEN_CB output activates. The total trip time is the protection start delay + 0.05 seconds + the time it takes to open the circuit breaker.
3. After the first shot, the circuit breaker is reclosed and the protection starts again.
4. Because the delay of the second shot is 60 seconds, the protection is faster and trips after the set operation time, activating the INIT 2 input. The second shot is initiated.
5. After the second shot, the circuit breaker is reclosed and the protection starts again.
6. Because the delay of the second shot is 60 seconds, the protection is faster and trips after the set operation time. No further shots are programmed after the final trip. The function is in lockout and the sequence is considered unsuccessful.

### Example 2

The delays can be used also for fast final trip. The conditions are the same as in Example 1, with the exception of *Str 2 delay shot 3* = 0.10 seconds.

The operation in a permanent fault is the same as in Example 1, except that after the second shot when the protection starts again, *Str 2 delay shot 3* elapses before the protection operate time and the final trip follows. The total trip time is the protection start delay + 0.10 seconds + the time it takes to open the circuit breaker.

## 9.9.6.6 Fast trip in Switch on to fault

The *Str _ delay shot 4* parameter delays can also be used to achieve a fast and accelerated trip with SOTF. This is done by setting the *Fourth delay in SOTF* parameter to "1" and connecting the protection start information to the corresponding DEL_INIT_ input.

When the function detects a closing of the circuit breaker, that is, any other closing except the reclosing done by the function itself, it always prohibits shot initiation for

the time set with the *Reclaim time* parameter. Furthermore, if the *Fourth delay in SOTF* parameter is "1", the *Str _ delay shot 4* parameter delays are also activated.

### Example 1

The protection operation time is 0.5 seconds, the *Fourth delay in SOTF* parameter is set to "1" and the *Str 2 delay shot 4* parameter is 0.05 seconds. The protection start signal is connected to the `DEL_INIT_2` input.

If the protection starts after the circuit breaker closes, the fast trip follows after the set 0.05 seconds. The total trip time is the protection start delay + 0.05 seconds + the time it takes to open the circuit breaker.

## 9.9.7 Signals

*Table 1403: DARREC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| INIT_1 | BOOLEAN | 0=False | AR initialization / blocking signal 1 |
| INIT_2 | BOOLEAN | 0=False | AR initialization / blocking signal 2 |
| INIT_3 | BOOLEAN | 0=False | AR initialization / blocking signal 3 |
| INIT_4 | BOOLEAN | 0=False | AR initialization / blocking signal 4 |
| INIT_5 | BOOLEAN | 0=False | AR initialization / blocking signal 5 |
| INIT_6 | BOOLEAN | 0=False | AR initialization / blocking signal 6 |
| DEL_INIT_2 | BOOLEAN | 0=False | Delayed AR initialization / blocking signal 2 |
| DEL_INIT_3 | BOOLEAN | 0=False | Delayed AR initialization / blocking signal 3 |
| DEL_INIT_4 | BOOLEAN | 0=False | Delayed AR initialization / blocking signal 4 |
| BLK_RECL_T | BOOLEAN | 0=False | Blocks and resets reclose time |
| BLK_RCLM_T | BOOLEAN | 0=False | Blocks and resets reclaim time |
| BLK_THERM | BOOLEAN | 0=False | Blocks and holds the reclose shot from the thermal overload |
| CB_POS | BOOLEAN | 0=False | Circuit breaker position input |
| CB_READY | BOOLEAN | 1=True | Circuit breaker status signal |
| INC_SHOTP | BOOLEAN | 0=False | A zone sequence coordination signal |
| INHIBIT_RECL | BOOLEAN | 0=False | Interrupts and inhibits reclosing sequence |
| RECL_ON | BOOLEAN | 0=False | Level sensitive signal for allowing (high) / not allowing (low) reclosing |
| SYNC | BOOLEAN | 0=False | Synchronizing check fulfilled |

*Table 1404: DARREC Output signals*

| Name | Type | Description |
|---|---|---|
| OPEN_CB | BOOLEAN | Open command for circuit breaker |
| CLOSE_CB | BOOLEAN | Close (reclose) command for circuit breaker |
| CMD_WAIT | BOOLEAN | Wait for master command |
| Table continues on next page | | |

| Name | Type | Description |
|---|---|---|
| INPRO | BOOLEAN | Reclosing shot in progress, activated during dead time |
| LOCKED | BOOLEAN | Signal indicating that AR is locked out |
| PROT_CRD | BOOLEAN | A signal for coordination between the AR and the protection |
| UNSUC_RECL | BOOLEAN | Indicates an unsuccessful reclosing sequence |
| AR_ON | BOOLEAN | Autoreclosing allowed |
| READY | BOOLEAN | Indicates that the AR is ready for a new sequence, i.e. the CB_READY input equals TRUE |
| ACTIVE | BOOLEAN | Reclosing sequence is in progress |

## 9.9.8 Settings

*Table 1405: DARREC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off/On |
| Reclosing operation | 1=Off<br>2=External Ctl<br>3=On | | | 1=Off | Reclosing operation (Off, External Ctl / On) |
| Close pulse time | 10...10000 | ms | 10 | 200 | CB close pulse time |
| Reclaim time | 100...1800000 | ms | 100 | 10000 | Reclaim time |
| Terminal priority | 1=None<br>2=Low (follower)<br>3=High (master) | | | 1=None | Terminal priority |
| Synchronisation set | 0...127 | | 1 | 0 | Selection for synchronizing requirement for reclosing |
| Auto initiation cnd | 1=Not allowed<br>2=When sync fails<br>3=CB doesn't close<br>4=Both | | | 2=When sync fails | Auto initiation condition |
| Tripping line | 0...63 | | 1 | 0 | Tripping line, defines INIT inputs which cause OPEN_CB activation |
| Fourth delay in SOTF | 0=False<br>1=True | | | 0=False | Sets 4th delay into use for all DEL_INIT signals during SOTF |
| First reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB1 |
| Second reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB2 |
| Third reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB3 |
| Fourth reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB4 |
| Fifth reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB5 |
| Sixth reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB6 |
| Seventh reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB7 |
| Init signals CBB1 | 0...63 | | 1 | 0 | Initiation lines for CBB1 |
| Init signals CBB2 | 0...63 | | 1 | 0 | Initiation lines for CBB2 |
| Init signals CBB3 | 0...63 | | 1 | 0 | Initiation lines for CBB3 |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Init signals CBB4 | 0...63 | | 1 | 0 | Initiation lines for CBB4 |
| Init signals CBB5 | 0...63 | | 1 | 0 | Initiation lines for CBB5 |
| Init signals CBB6 | 0...63 | | 1 | 0 | Initiation lines for CBB6 |
| Init signals CBB7 | 0...63 | | 1 | 0 | Initiation lines for CBB7 |
| Shot number CBB1 | 0...5 | | 1 | 0 | Shot number for CBB1 |
| Shot number CBB2 | 0...5 | | 1 | 0 | Shot number for CBB2 |
| Shot number CBB3 | 0...5 | | 1 | 0 | Shot number for CBB3 |
| Shot number CBB4 | 0...5 | | 1 | 0 | Shot number for CBB4 |
| Shot number CBB5 | 0...5 | | 1 | 0 | Shot number for CBB5 |
| Shot number CBB6 | 0...5 | | 1 | 0 | Shot number for CBB6 |
| Shot number CBB7 | 0...5 | | 1 | 0 | Shot number for CBB7 |
| Frq Op counter limit | 0...250 | | 1 | 0 | Frequent operation counter lockout limit |
| Frq Op counter time | 1...250 | min | 1 | 1 | Frequent operation counter time |
| Frq Op recovery time | 1...250 | min | 1 | 1 | Frequent operation counter recovery time |
| Auto init | 0...63 | | 1 | 0 | Defines INIT lines that are activated at auto initiation |

*Table 1406: DARREC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Manual close mode | 0=False<br>1=True | | | 0=False | Manual close mode |
| Wait close time | 50...10000 | ms | 50 | 250 | Allowed CB closing time after reclose command |
| Max wait time | 100...1800000 | ms | 100 | 10000 | Maximum wait time for BLK_RECL_T release |
| Max trip time | 100...10000 | ms | 100 | 10000 | Maximum wait time for deactivation of protection signals |
| Max Thm block time | 100...1800000 | ms | 100 | 10000 | Maximum wait time for thermal blocking signal deactivation |
| Cut-out time | 0...1800000 | ms | 100 | 10000 | Cutout time for protection coordination |
| Dsr time shot 1 | 0...10000 | ms | 100 | 0 | Discrimination time for first reclosing |
| Dsr time shot 2 | 0...10000 | ms | 100 | 0 | Discrimination time for second reclosing |
| Dsr time shot 3 | 0...10000 | ms | 100 | 0 | Discrimination time for third reclosing |
| Dsr time shot 4 | 0...10000 | ms | 100 | 0 | Discrimination time for fourth reclosing |
| Auto wait time | 0...60000 | ms | 10 | 2000 | Wait time for reclosing condition fullfilling |
| Auto lockout reset | 0=False<br>1=True | | | 1=True | Automatic lockout reset |
| Protection crd limit | 1...5 | | 1 | 1 | Protection coordination shot limit |
| Protection crd mode | 1=No condition<br>2=AR inoperative<br>3=CB close manual<br>4=AR inop, CB man<br>5=Always | | | 4=AR inop, CB man | Protection coordination mode |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Control line | 0...63 | | 1 | 63 | Control line, defines INIT inputs which are protection signals |
| Enable shot jump | 0=False<br>1=True | | | 1=True | Enable shot jumping |
| CB closed Pos status | 0=False<br>1=True | | | 0=False | Circuit breaker closed position status |
| Blk signals CBB1 | 0...63 | | 1 | 0 | Blocking lines for CBB1 |
| Blk signals CBB2 | 0...63 | | 1 | 0 | Blocking lines for CBB2 |
| Blk signals CBB3 | 0...63 | | 1 | 0 | Blocking lines for CBB3 |
| Blk signals CBB4 | 0...63 | | 1 | 0 | Blocking lines for CBB4 |
| Blk signals CBB5 | 0...63 | | 1 | 0 | Blocking lines for CBB5 |
| Blk signals CBB6 | 0...63 | | 1 | 0 | Blocking lines for CBB6 |
| Blk signals CBB7 | 0...63 | | 1 | 0 | Blocking lines for CBB7 |
| Str 2 delay shot 1 | 0...300000 | ms | 10 | 0 | Delay time for start2, 1st reclose |
| Str 2 delay shot 2 | 0...300000 | ms | 10 | 0 | Delay time for start2 2nd reclose |
| Str 2 delay shot 3 | 0...300000 | ms | 10 | 0 | Delay time for start2 3rd reclose |
| Str 2 delay shot 4 | 0...300000 | ms | 10 | 0 | Delay time for start2, 4th reclose |
| Str 3 delay shot 1 | 0...300000 | ms | 10 | 0 | Delay time for start3, 1st reclose |
| Str 3 delay shot 2 | 0...300000 | ms | 10 | 0 | Delay time for start3 2nd reclose |
| Str 3 delay shot 3 | 0...300000 | ms | 10 | 0 | Delay time for start3 3rd reclose |
| Str 3 delay shot 4 | 0...300000 | ms | 10 | 0 | Delay time for start3, 4th reclose |
| Str 4 delay shot 1 | 0...300000 | ms | 10 | 0 | Delay time for start4, 1st reclose |
| Str 4 delay shot 2 | 0...300000 | ms | 10 | 0 | Delay time for start4 2nd reclose |
| Str 4 delay shot 3 | 0...300000 | ms | 10 | 0 | Delay time for start4 3rd reclose |
| Str 4 delay shot 4 | 0...300000 | ms | 10 | 0 | Delay time for start4, 4th reclose |

## 9.9.9 Monitored data

*Table 1407: DARREC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| DISA_COUNT | BOOLEAN | 0=False<br>1=True | | Signal for counter disabling |
| FRQ_OPR_CNT | INT32 | 0...2147483647 | | Frequent operation counter |
| FRQ_OPR_AL | BOOLEAN | 0=False<br>1=True | | Frequent operation counter alarm |
| Table continues on next page | | | | |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| STATUS | Enum | -1=Not defined<br>1=Ready<br>2=InProgress<br>3=Successful<br>4=WaitingForTrip<br>5=TripFromProtection<br>6=FaultDisappeared<br>7=WaitToComplete<br>8=CBclosed<br>9=CycleUnsuccessful<br>10=Unsuccessful<br>11=Aborted | | AR status signal for IEC61850 |
| INPRO_1 | BOOLEAN | 0=False<br>1=True | | Reclosing shot in progress, shot 1 |
| INPRO_2 | BOOLEAN | 0=False<br>1=True | | Reclosing shot in progress, shot 2 |
| INPRO_3 | BOOLEAN | 0=False<br>1=True | | Reclosing shot in progress, shot 3 |
| INPRO_4 | BOOLEAN | 0=False<br>1=True | | Reclosing shot in progress, shot 4 |
| INPRO_5 | BOOLEAN | 0=False<br>1=True | | Reclosing shot in progress, shot 5 |
| DISCR_INPRO | BOOLEAN | 0=False<br>1=True | | Signal indicating that discrimination time is in progress |
| CUTOUT_INPRO | BOOLEAN | 0=False<br>1=True | | Signal indicating that cut-out time is in progress |
| SUC_RECL | BOOLEAN | 0=False<br>1=True | | Indicates a successful reclosing sequence |
| UNSUC_CB | BOOLEAN | 0=False<br>1=True | | Indicates an unsuccessful CB closing |
| CNT_SHOT1 | INT32 | 0...2147483647 | | Resetable operation counter, shot 1 |
| CNT_SHOT2 | INT32 | 0...2147483647 | | Resetable operation counter, shot 2 |
| CNT_SHOT3 | INT32 | 0...2147483647 | | Resetable operation counter, shot 3 |
| CNT_SHOT4 | INT32 | 0...2147483647 | | Resetable operation counter, shot 4 |
| CNT_SHOT5 | INT32 | 0...2147483647 | | Resetable operation counter, shot 5 |
| COUNTER | INT32 | 0...2147483647 | | Resetable operation counter, all shots |
| SHOT_PTR | INT32 | 1...7 | | Shot pointer value |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| MAN_CB_CL | BOOLEAN | 0=False<br>1=True | | Indicates CB manual closing during reclosing sequence |
| SOTF | BOOLEAN | 0=False<br>1=True | | Switch-onto-fault |
| DARREC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 9.9.10 Technical data

*Table 1408: DARREC Technical data*

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

## 9.10 Tap changer control with voltage regulator OL5ATCC

### 9.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Tap changer control with voltage regulator | OL5ATCC | COLTC | 90V |

### 9.10.2 Function block

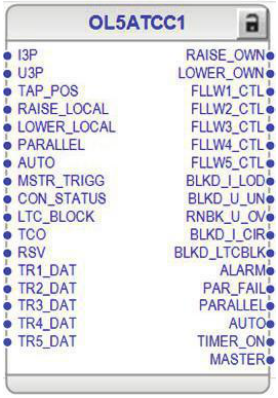



*Figure 810: Function block*

## 9.10.3 Functionality

The tap changer control with voltage regulator function OL5ATCC (on-load tap changer controller) is designed for regulating the voltage of power transformers with on-load tap changers in distribution substations. OL5ATCC provides a manual or automatic voltage control of the power transformer by using the raising or lowering signals to the on-load tap changer.

The automatic voltage regulation can be used in single or parallel transformer applications. The parallel operation can be based on the Master/Follower principle (M/F), Negative Reactance Principle (NRP) or Minimizing Circulating Current (MCC).

OL5ATCC includes the line drop compensation (LDC) functionality, and the load decrease is possible with a dynamic voltage reduction.

Either definite time characteristic (DT) or inverse time characteristic (IDMT) is selectable for delays between the raising and lowering operations.

The function contains a blocking functionality. It is possible to block the voltage control operations with an external signal or with the supervision functionality of the function.

## 9.10.4 Analog channel configuration

OL5ATCC has two analog group inputs which must be properly configured.

*Table 1409: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |



See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1410: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage connected to channel 1, two voltages connected to channels 2 and 3, or all three voltage channels connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks

in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 9.10.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of OL5ATCC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

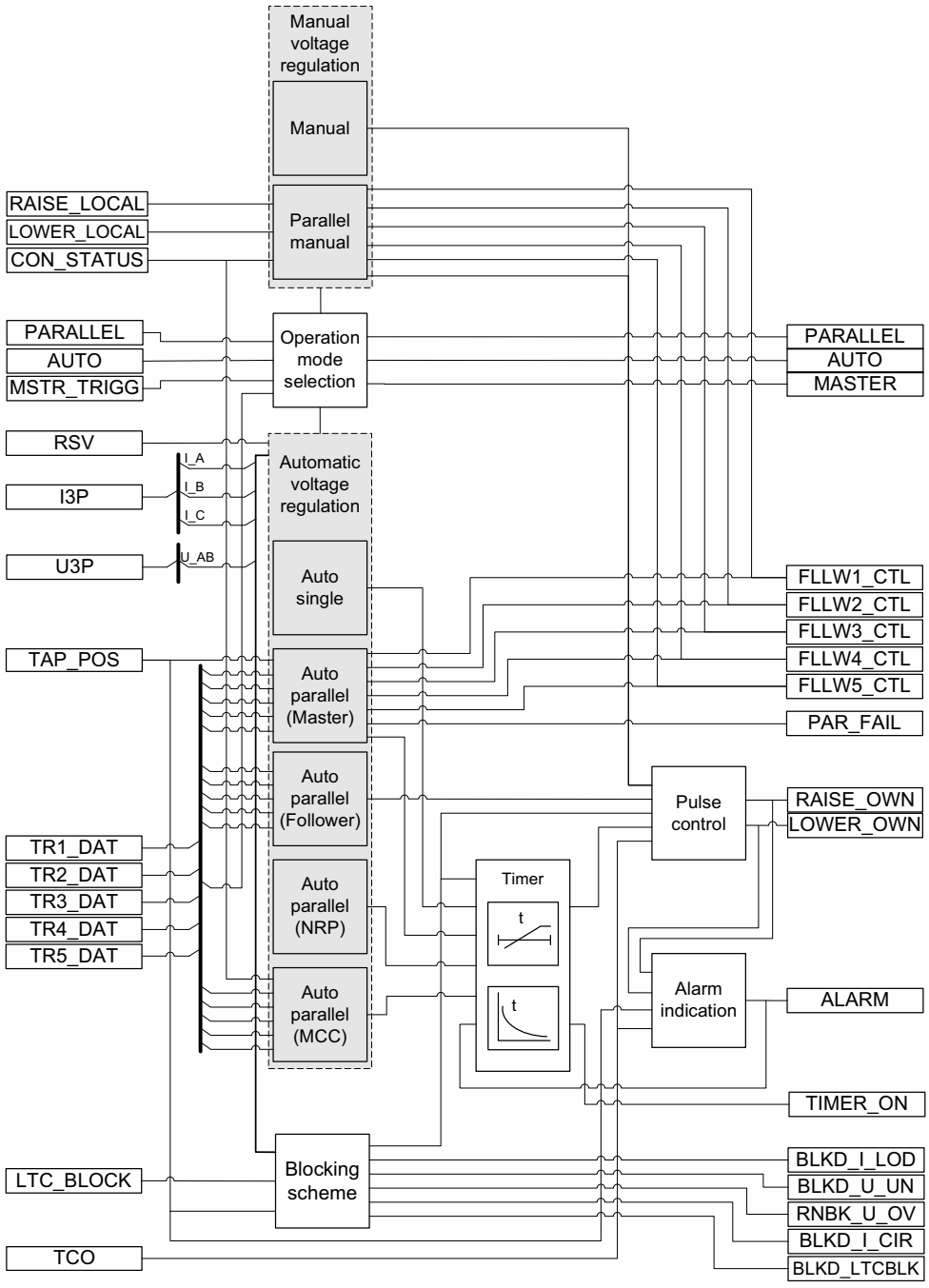



*Figure 811: Functional module diagram*

### 9.10.5.1 Voltage and current measurements

The measured voltage must be a phase-to-phase voltage from the regulated side. Typically, it is the phase-to-phase voltage U_AB from the secondary side of the power

transformer. If the phase voltages are measured, the voltage U_AB is calculated internally in the protection relay.

The currents from the secondary side of the power transformer (I_x, where x is A, B or C) have several uses.

- The highest phase current value is used for overcurrent blocking.
- The currents from the secondary side of the power transformer are used for LDC (average of the connected inputs).
- The currents from the secondary side of the power transformer are used for calculating the circulating current in the NRP and MCC operation modes.

Both voltage U_AB and the phase currents from the secondary side are always measured using the value of the filtered fundamental frequency component (DFT). Hence, the harmonics are always suppressed. Moreover, the measured voltage value is continuously average-filtered with the eight-value-long sliding window. The phase-compensated voltage U_A is always used in calculations, although it is not connected. This averaged value, the parameter $U_m$ in Equation 345, is used for control, and its magnitude can be read from the monitored data U_MEAS.

Similarly, the magnitude of the phase current of the own transformer, I_x, and the phase angle difference between the internally phase-compensated voltage U_A and phase current I_x are also average-filtered by the same fixed-length window. The phase angle value can be read from the monitored data ANGL_UA_IA. These currents and phase angle differences are used solely in circulating current calculations.

The angle difference is used in Equation 341 and Equation 343.

There are minimum limits for the voltage and current magnitudes, so the magnitude and phase angle difference values diverge from zero. The voltage magnitude must exceed three percent of $U_n$ and the current I_A must exceed two percent of $I_n$.

### 9.10.5.2 Tap changer position inputs

The position value of the tap changer can be brought to OL5ATCC as a resistance value, an mA signal or a binary-coded signal. More information on how the resistance value, the mA signal or a binary-coded interface are implemented can be found in TPOSYLTC in this manual.

The indicated tap changer position of the own transformer is internally connected to the TAP_POS input, and the tap changer positions of the parallel transformers are fed to inputs TRx_DAT via data combiner function blocks OLGAPC. This also defines the connection identity so that follower 1 is connected to TR1_DAT, follower 2 is connected to TR2_DAT and follower 3 is connected to TR3_DAT. The own transformer position can be read from the input TAP_POS. The follower tap changer positions can be read from the input data TR_TAP_POS of OLGAPCx.

The tap changer position value is given in parentheses. For example, (0) indicates that there is no tap changer position connected or the quality of the tap changer position value is bad. Typically, if no tap changer position is connected, all the TPOSYLTC binary inputs are FALSE by default and the value shown is (0). A value other than zero indicates bad quality. OL5ATCC treats a bad-quality tap changer position as unconnected tap position information.

### 9.10.5.3 Operation mode selection

OL5ATCC has the *Operation mode* and *Parallel mode* settings for selecting the desired operation mode. The *Operation mode* setting can have any of the following values: "Manual", "Auto single", "Parallel manual", "Auto parallel", "Input control" and "Command". If the *Operation mode* setting is set to "Input control", the active operation mode is determined by the inputs PARALLEL and AUTO.

The PARALLEL input defines if the transformer (voltage regulator) is in parallel or single mode. The AUTO input defines if the operation is in auto or manual mode. The PARALLEL and AUTO outputs represent acting “Parallel or single operation” and “Auto/Manual indication”, respectively.

When the *Operation mode* setting is set to "Command", the active operation mode is determined by the IEC 61850 command data points Auto and ParOp.

Furthermore, if the operation mode has been set to any parallel mode, that is "Parallel manual" or "Auto parallel" via the *Operation mode* setting, binary inputs or commands, the parallel mode is selected by the setting *Parallel mode*.

The *Parallel mode* setting can have any of following values: "Master", "Follower", "NRP", "MCC", "Input control" or "Command".

If the *Parallel mode* setting is set to "Input control", the active operation mode is determined by the input MSTR_TRIGG.

When the *Parallel mode* setting is set to "Command", the active operation mode is determined by the IEC 61850 command data point MstrOp.

MSTR_TRIGG is a rising edge input, that is, the master role is kept even though the MSTR_TRIGG input changes from “true” to “false”. This functionality is used because another parallel transformer must be able to assume the master role even though the MSTR_TRIGG input has remained in “true” state. Switching between operation mode states resets the internal master set. However, switching between Auto master mode and Parallel manual mode keeps the master role.

*Table 1411: Active operation mode when Operation mode setting is "Manual", "Auto single", "Parallel manual" or "Auto parallel"*

| Operation mode | Parallel mode | MSTR_TRIGG | OPR_MODE_STS |
|---|---|---|---|
| Manual | - | - | Manual |
| Auto single | - | - | Auto single |
| Parallel manual | Master | - | Parallel manual |

Table continues on next page

| Operation mode | Parallel mode | MSTR_TRIGG | OPR_MODE_STS |
|---|---|---|---|
| Parallel manual | Input control Command | 0[1)] | Manual |
| Parallel manual | Input control Command | 1[1)] | Parallel manual |
| Auto parallel | Master | - | Auto master |
| Auto parallel | Follower | - | Auto follower |
| Auto parallel | MCC | - | MCC |
| Auto parallel | NRP | - | NRP |
| Auto parallel | Input control Command | 0[1)] | Auto follower |
| Auto parallel | Input control Command | 1[1)] | Auto master |

1) The master role is set on rising edge and internally kept until another parallel transformer assumes the master role, or the operation mode is changed.

*Table 1412: Active operation mode when Operation mode setting is "Input control" or "Command"*

| PARALLEL | AUTO | Parallel mode | MSTR_TRIGG | OPR_MODE_STS |
|---|---|---|---|---|
| 0 | 0 | - | - | Manual |
| 0 | 1 | - | - | Auto single |
| 1 | 0 | Master | - | Parallel manual |
| 1 | 0 | Follower | - | Manual |
| 1 | 0 | MCC | - | Manual |
| 1 | 0 | NRP | - | Manual |
| 1 | 0 | Input control Command | 0[1)] | Manual |
| 1 | 0 | Input control Command | 1[1)] | Parallel manual |
| 1 | 1 | Master | - | Auto master |
| 1 | 1 | Follower | - | Auto follower |
| 1 | 1 | MCC | - | MCC |
| 1 | 1 | NRP | - | NRP |
| 1 | 1 | Input control Command | 0[1)] | Auto follower |
| 1 | 1 | Input control Command | 1[1)] | Auto master |

1) Master role is set on rising edge and internally kept until another parallel transformer overtakes master role, or if operation mode is changed.

The active operation mode can be read from the monitored data OPR_MODE_STS.

## Command exclusion

An active operation mode change using three inputs (PARALLEL, AUTO, MSTR_TRIGG and setting group change either by input or via menu) is needed when

the active operation mode must be changed automatically, that is, there is a logic which drives these three inputs based on the status information from the circuit breakers.

The common Local/Remote (L/R) exclusion concerns the manual raise and lower commands of OL5ATCC, that is, it internally provides the exclusion mechanism to prevent remote commands (from SCADA) when the protection relay is in local mode and vice versa.

### 9.10.5.4 Manual voltage regulation

The manual raising and lowering commands can be given via the configuration inputs LOWER_LOCAL and RAISE_LOCAL, via the HMI of the protection relay or via remote commands. The active operation mode of OL5ATCC must be set to "Manual" or "Parallel manual" and the Local/Remote control LR state monitored data of the protection relay has to be "Local" to execute the control commands manually from HMI or via configuration inputs. If OL5ATCC is set to "Manual" or "Parallel manual" but the LR state is set to "OFF" or "Remote", no manual control commands can be given.

For remote commands, the active operation mode of OL5ATCC must also be set to "Manual" or "Parallel manual" and the LR state monitored data has to be "Remote".

The manual raising or lowering commands can be given locally either via the *Manual control* parameter ("Cancel"/"Lower"/"Raise") located in the HMI menu **Control/ OL5ATCC1** or via the configuration inputs LOWER_LOCAL or RAISE_LOCAL.

A raising command is given by selecting the enumeration value "Raise" and the lowering command is given by selecting the enumeration value "Lower". An accepted manual raising or lowering command activates the corresponding output RAISE_OWN or LOWER_OWN to control the voltage of the own transformer.

#### Parallel manual voltage regulation

While in single manual mode the voltage regulator acts independently, in parallel manual mode the voltage regulator set to "Parallel manual" acts as master and the others follow.

The parallel manual mode is intended for maintenance work and has no permanent settings. When the mode is set again to automatic, the voltage is stepped back to the set value.

Followers not responding to parallel manual command are indicated at output PAR_FAIL and the number of failed followers at monitored data FAIL_FLLW.

In parallel manual mode, the TR_STATUS monitored data indicates "Master" status to the other parallel transformers.

### Voltage control vs. tap changer moving direction

OL5ATCC has the control settings *Lower block tap* and *Raise block tap* which give the tap changer position that results in the lowest and highest controlled voltage value (usually at the LV side of the transformer). *Raise block tap* can be set higher than *Lower block tap* and *Lower block tap* can be set higher than *Raise block tap*.

When the value of *Raise block tap* exceeds the *Lower block tap* value, the raise control activates the RAISE_OWN output. This results in raising the tap changer position, and the measured voltage rises. Furthermore, the RAISE_OWN output value is TRUE. If the own tap changer position is connected (that is, the own tap changer's quality is good), the tap changer alarm is activated if the tap changer does not move upwards within *Cmd error delay time* after the pulse activation. As a result, ALARM_REAS in the monitored data contains a command error value. The default value of the *Cmd error delay time* setting is 20 seconds.

The lowering control works in a similar way, as shown in Figure 812. In the output data, the LOWER_OWN output value is TRUE. An alarm is generated if the tap changer does not move downwards in *Cmd error delay time* after the pulse activation, assuming that the own tap changer position is connected.

In the second case, the parameters are set so that the value of *Lower block tap* exceeds the value of *Raise block tap*. The raising control activates the RAISE_OWN output. The result should be that the tap changer lowers its position and the measured voltage rises. Furthermore, the RAISE_OWN output value is TRUE in the output data. If the own tap changer position is connected, the tap changer alarm is activated if the tap changer does not move downwards in *Cmd error delay time* after the pulse activation, resulting that ALARM_REAS in the monitored data contains a command error value.

The lowering control works in a similar way, as shown in Figure 812. In the output data, the LOWER_OWN output value is TRUE. An alarm is generated if the tap changer does not move upwards in *Cmd error delay time* after the pulse activation, assuming that the own tap changer position is connected.

## 9.10.5.5 Automatic voltage regulation of single transformers (Auto single)

OL5ATCC is intended to control the power transformers with a motor-driven on-load tap changer. The function regulates the voltage at the secondary side of the power transformer. The control method is based on a step-by-step principle, which means that one control pulse at a time is issued to the tap changer mechanism to move it exactly one position upwards or downwards. However, when intermediate steps are not indicated for the tap changer, it does not cause alarm if more than one step change is met.

The purpose of the regulator is to maintain a stable secondary voltage of the power transformer. The basis for this operation is the *Band center voltage* setting. By increasing or decreasing various compensation factors, the regulator calculates a control voltage from the band center voltage as shown in Equation 338. Hence, the control voltage is the desired transformer secondary voltage to be maintained by the

regulator. The control voltage is compared to the measured voltage and the difference between the two forms the regulating process error.

Since the tap changer changes the voltage in steps, a certain error has to be allowed. The error, called *Band width voltage*, is also set by the user. A recommended setting for *Band width voltage* is close to twice the step voltage of the transformer $\Delta U_{step}$ and never below it as a minimum. For example, *Band width voltage* is twice the value of $\Delta U_{step}$ in Figure 812.

If the measured voltage fluctuates within the control voltage ± half the *Band width voltage* setting, the regulator is inactive. If the measured voltage is outside the half-bandwidth voltage limits, an adjustable delay T1 (*Control delay time 1* ) starts, as shown in Figure 812, where the lowering function is an example. The delay T1 remains active as long as the measured voltage is outside the hysteresis limits of half the value of *Band width voltage*. The factory setting for the hysteresis is 10 percent of the set *Band width voltage*.

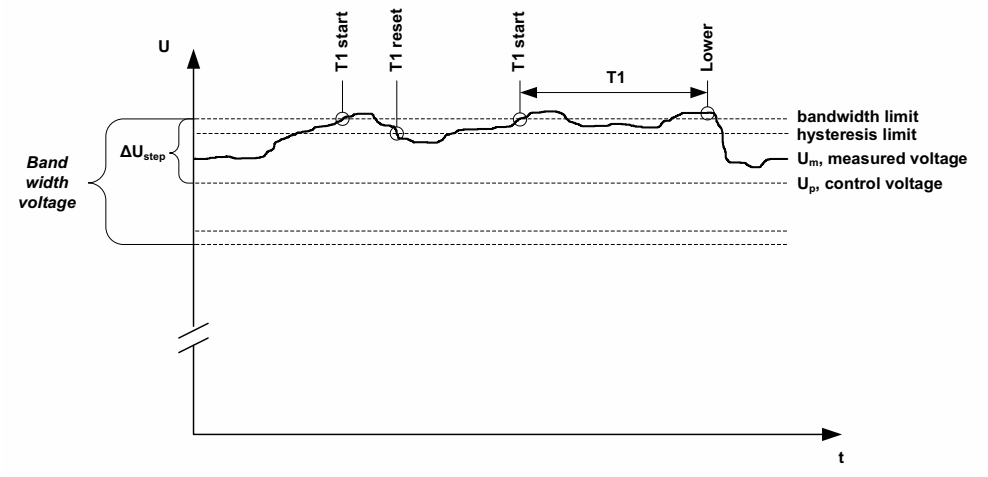



*Figure 812: Voltage-regulating function. A control pulse to lower the voltage is issued after the elapsed T1.*

If the measured voltage is outside the hysteresis when the delay counter T1 reaches its setting value, the raising or lowering output relay is activated. This activates either output pulse RAISE_OWN or LOWER_OWN, and the motor drive of the tap changer operates. The status of these outputs can be read from the output data RAISE_OWN or LOWER_OWN.

If the measured voltage falls or rises within the hysteresis limits during the operating time, the delay counter is reset.

The pulse length can be defined with the *LTC pulse time* setting. The default value is 1.5 seconds.

A short delay, same as the typical tap changer operating time, is active before the start of the next operating timer. For OL5ATCC, the delay is set to 6 seconds. If one tap changer operation is not enough to regulate the transformer voltage within the

hysteresis limits, a second adjustable delay T2 (*Control delay time 2*), usually with a shorter time setting than T1, starts. This delay is used for the control commands within the same sequence until the recovery of voltage occurs. The delays T1 and T2 can be selected either with definite or inverse time characteristics. In the inverse time mode, the operate time depends on the difference between the control voltage and the measured voltage as shown in Equation 345. The bigger the difference in the voltage, the shorter the operating time. More information on the inverse time operation can be found in the Timer characteristics chapter.

## Regulation equation

The simple regulating principle is often complemented by additional features to take the voltage drop of lines into account (line drop compensation), coordinate the regulation of parallel transformers and change the voltage level according to the loading state of the network. The control voltage $U_p$ is calculated according to the equation

$$U_p = U_s + U_z + U_{ci} - U_{rsv}$$

(Equation 338)

| | |
|---|---|
| $U_p$ | Control voltage |
| $U_s$ | Set voltage level (*Band center voltage*) |
| $U_z$ | Line drop compensation term |
| $U_{ci}$ | Circulating current compensation term |
| $U_{rsv}$ | Voltage reduction parameter |

$U_p$ can be directly read in the monitored data U_CTL.

The circulating current compensation term is calculated only in the parallel active operation modes "NRP" and "MCC".

## Line drop compensation (LDC)

The LDC feature is used to compensate the voltage drop along a line or network fed by the transformer. The compensation setting parameters can be either calculated if the resistance and reactance of the line are known or measured from the line drop.

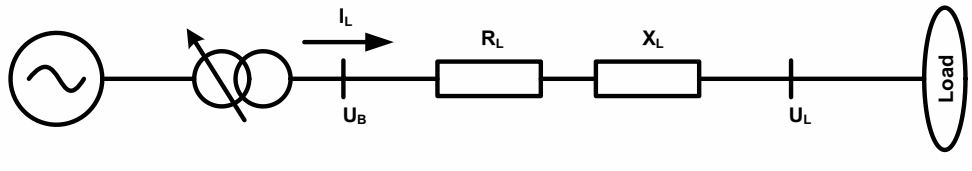



*Figure 813: Equivalent electrical circuit for calculating the LDC term*

The compensation parameters *Line drop V Ris* ($U_r$) and *Line drop V React* ($U_x$) are percentage values of $U_n$ according to the equations

$$Line\ drop\ V\ Ris = U_r[\%] = \frac{\sqrt{3} \cdot I_{CT_n1} \cdot R}{U_{VT_n1}} \cdot 100 \quad [\%U_n]$$

$$Line\ drop\ V\ React = U_x[\%] = \frac{\sqrt{3} \cdot I_{CT_n1} \cdot X}{U_{VT_n1}} \cdot 100 \quad [\%U_n]$$

(Equation 339)

| | |
|---|---|
| $I_{CT_n1}$ | Nominal primary current of the CT |
| $U_{VT_n1}$ | Nominal primary voltage of the VT (phase-to-phase voltage) |
| R | Resistance of the line, Ω/phase |
| X | Reactance of the line, Ω/phase |

The general LDC equation can be calculated.

$$U_z = \frac{I_L}{I_{CT_n1}} \cdot \frac{\left(U_r[\%]\cos\varphi + U_x[\%]\sin\varphi\right)}{100} \quad [xU_n]$$

(Equation 340)

| | |
|---|---|
| $I_L$ | Average of the currents I_A, I_B and I_C |
| $I_{CT_n1}$ | Nominal primary current of the CT |
| $U_r$ | Setting *Line drop V Ris* |
| $U_x$ | Setting *Line drop V React* |
| φ | Phase angle between U_A and I_A (ANGL_UA_IA) |

By default, LDC is not active, but it can be activated by setting *LDC enable* to "True". To keep the LDC term within acceptable limits in all situations, OL5ATCC has a setting parameter *LDC limit*, which has a default value of 0.10 $xU_n$. This gives the maximum value for $U_z$ in Equation 338.

If more than one line is connected to the LV busbar, the equivalent impedance is calculated and given as a parameter setting as shown in Figure 813 for the equivalent electrical circuit for calculating LDC. For example, if there are N number of identical lines with identical loads in the substation, the R and X values needed for the settings *Line drop V React* and *Line drop V Ris* are obtained by dividing the resistance and the reactance of one line by N. Because the voltage drop is different in lines with different impedances and load currents, it is necessary to make a compromise when setting the *Line drop V React* and *Line drop V Ris* settings. Raising the voltage in the point of the lowest voltage must not lead to overvoltage elsewhere.

By default, LDC is effective only on the normal active power flow direction. If the active power flow in the transformer turns opposite, that is, from the regulated side towards the system in the upper level, the LDC term is ignored, that is, it is set to zero. In such a case, it is assumed that the feeding units at the regulated side of the transformers maintain proper voltage levels. This can cause a conflict if the transformer tries to reduce the voltage at the substation. Additionally, it is difficult to

predict the actual voltage levels in the feeder lines in such a case, and lowering the voltage at the substation can have harmful effects in the far end of the network. However, the *Rv Pwr flow allowed* setting allows also negative LDC terms to be taken into equation.

The topology changes in the network can cause changes to the equivalent impedance value of the network. If the change is substantial, the setting groups can be used to switch between different setting values for *Line drop V React* and *Line drop V Ris*. In practice this means that the boolean-type information from the topology change is connected to the active setting group change.

The use of the LDC equation in the case of parallel transformers is described in the Automatic voltage regulation of parallel transformers (Auto parallel) chapter.

### Reduce Set Voltage (RSV) input

The system frequency decreases when the active power production in the network is smaller than its consumption. Either the power supply has to be increased or some loads have to be shed to restore the power balance.

The simplest way to decrease the load is to reduce the voltage level by giving a lower band center voltage value to the regulators. For this purpose, OL5ATCC has the setting group parameter *Band reduction*. The RSV input activation results in reduction. If this input is set to TRUE, a set target voltage value is decreased by *Band reduction*. If more than one RSV reduction steps are desired, the setting group change has to be used where different *Band reduction* values are supported. The decreased value is kept as a target value as long as the RSV input is TRUE.

Because the decrease of frequency indicates a need to reduce the load, it is practical to connect the start signal of an underfrequency function block to the RSV digital input.

It depends on the load characteristics how much the load is reduced when the voltage drops. For instance, purely resistive loads are proportional to the square of the voltage, whereas motor drives based on frequency controllers may draw constant power despite small voltage changes.

The status of the RSV input can be read from the RSV input data.

## 9.10.5.6 Automatic voltage regulation of parallel transformers (Auto parallel)

A circulating current may occur between transformers if two or more transformers with slightly different ratios are energized in parallel. This is due to the unbalanced short circuit impedances of the parallel transformers. To avoid such currents, the tap changers of the transformers should be adjusted to achieve equilibrium. If the transformers are assumed identical, the tap (voltage) steps and tap positions should also match. In this case, the Master/Follower principle can be used. However, unequally rated transformers with different tap steps can be connected in parallel and these configurations can also be managed by OL5ATCC. For these configurations, the Minimizing Circulating Current (MCC) or Negative Reactance Principle (NRP)

should be used. The MCC and NRP principles are also suitable for identical transformers.

The circulating current, which is almost purely inductive, is defined as negative if it flows towards the transformer. $U_{ci}$ in Equation 338 is positive and the control voltage $U_p$ rises as a result of the RAISE_OWN output signal activation if the circulating current level is sufficient (Equation 342 and Equation 344) and the other parameters remain the same. As a result, the voltage rise should diminish the circulating current.

### LDC equation and parallel connection

The additional challenge in the parallel connection regarding LDC is to know the total current which flows through the parallel transformers.

In the Master/Follower mode, it is easier to know the total current than in other parallel modes since the transformers are assumed to have identical ratings, that is, the total current ($I_L$ in Equation 340) is obtained by multiplying the measured load current (the average of the secondary currents I_A, I_B and I_C of the connected own transformer) with the number of parallel transformers. OL5ATCC can internally determine the number of parallel transformers from the connected tap changer position inputs. However, if there is no position information from the other parallel transformers, the correct number of parallel transformers, excluding the own transformer, needs to be set with the *Parallel trafos* setting.

In the MCC mode, the horizontal communication transfers the information from the measured load currents between the regulators so that the total current needed in LDC can be summed accurately. Here, $I_L$ is defined to be the phasor sum of all the parallel transformers' secondary-side currents. The currents from other transformers must be fed via the TR_I_AMPL and TR_I_ANGL inputs of the OLGAPC function.

In the NRP mode, the parallel transformers have different ratings and there is no communication between the regulators. Therefore, when setting *Line drop V React* and *Line drop V Ris*, the $I_{CT_nl}$ used in the equation should be the sum of the rated currents of all the transformers operating in parallel. Here, $I_L$ is also defined as the average of the connected secondary currents (I_A, I_B and I_C). The calculated LDC value can be read from the monitored data LDC.

### Master/Follower principle M/F

The M/F operation principle is suitable for power transformers with identical ratings and step voltages. One voltage regulator (master) measures and controls and the other regulators (followers) follow the master, that is, all the tap changers connected in parallel are synchronized. This parallel operation is obtained by connecting the FLLWx_CTL output of the master to the corresponding OLGAPC function input TR_TAP_FLLW of the followers via horizontal GOOSE communication.

The values for the FLLWx_CTL command are 1=Lower follower x and 2=Raise follower x. Consequently, the values for OLGAPC function TR_TAP_FLLW command are 1=Lower and 2=Raise.

If several regulators act as masters (one at a time), their outputs also have to be routed to the inputs of the other regulators. To start the parallel operation, the master regulator is set to the "Auto master" mode and the followers to the "Auto follower" mode. In input control or command mode, a regulator acting as a follower, can be set to master by activating the MSTR_TRIGG input if the *Master input enabled* setting is activated. The regulator indicates its master status (“Independent”, “Master” or “Follower”) by the TR_STATUS output. A parallel regulator, previously acting as master, receives this signal via the TR_STATUS input of OLGAPC and changes its status to follower.

Connect the TR_STATUS input to the OLGAPC of the parallel transformer and route the TR_DAT output from OLGAPC to OL5ATCC TRx_DAT for proper M/F functionality. If TR_STATUS is left unconnected, that particular parallel transformer is assumed to not be participating even though receiving valid tap position information.

To keep all the tap changers in the same position, the master needs to know the tap positions of the followers. This way, the circulating current is kept at its minimum. The position values of the followers can be brought to the master either via horizontal GOOSE communication or TPOSYLTC.

If it is not possible to use horizontal communication between the protection relays and the position information cannot be wired from the parallel transformers, the M/F principle can still be used to regulate two or an unlimited number of transformers in parallel. Since the master cannot detect the tap positions of parallel transformers, it just activates the lowering and raising outputs for all the followers when it controls its own tap changer. This is called blind control. In this case, a number of parallel transformers are regulated as one unit.

The combined data inputs TRx_DAT must be left unconnected for the master to know that the tap positions of the followers are unknown. The time delay between successive commands can be set by the *Follower delay time* setting. The default value is 6 seconds.

When a disconnected transformer is taken into use and the tap position is unknown, the follower should be manually controlled to the same position as the master. This can also take place in the M/F mode. First, the master gives its own transformer a control command which is echoed to the followers (the follower's tap positions have to be connected). Thereafter, successive control commands to the followers take place until the master and followers have the same tap positions.

## Out-of-step function

The out-of-step function is usually used in the M/F mode only. The out-of-step function means that the master is able to detect the position values of the followers and control them to the same position as the master's. In this case, the master assumes that the followers also have either *Raise block tap* higher than *Lower block tap* or *Lower block tap* higher than *Raise block tap* because this defines what is the given command pulse for a follower. If the master has *Raise block tap* higher than *Lower block tap* and

the follower has *Lower block tap* higher than *Raise block tap*, the corresponding tap changer follow included control signals should be connected crosswise. This requires extra logic where dual point command bits have to be converted, that is, 0=>0, [01]=1=>[10]=2 and [10]=2=>[01]=1.

M/F is the only parallel mode which has an out-of-step functionality. In the MCC and NRP operation modes, the circulating current is minimized, which often means different tap positions in the parallel transformers. Moreover, these modes allow different ratings and step voltages for the parallel transformers. Therefore, it is reasonable to apply the out-of-step function only to the M/F operation mode.

The out-of-step function is triggered when the master detects a difference of at least one step between the tap changer positions in the follower and in the master. The master then sends special raise or lower commands to the diverging follower. If two consecutive commands fail to change the position of the follower to the right direction, the master activates the PAR_FAIL output, that is, PAR_FAIL is set to TRUE, and stops the special recovery efforts. However, every time the master controls its own tap changer later, it sends a controlling pulse to the diverging follower too. Furthermore, if the master notices a correct position change after a sent pulse, it restarts the attempts to drive the follower to the same position and deactivates the PAR_FAIL output, that is, PAR_FAIL is set to FALSE. However, if there still are diverging followers, the reset is not indicated. It is indicated only when no diverging followers exist. Monitoring, and hence the indication of a paralleling failure, is not possible in blind control.

The followers with a parallel failure can be read from the monitored data FAIL_FLLW. For example, if only follower 3 is in the parallel failure state, FAIL_FLLW has the value "T3". If both followers 1 and 2 are in the parallel failure state, FAIL_FLLW has the value "T1+T2". By default, when no failed followers exist, the value is "No failed followers".

### Negative Reactance Principle NRP

This parallel control scheme is suitable for power transformers with different ratings and step voltages. Since no communication between the regulators is needed, this principle can be applied even when the parallel transformers are located at different substations. To start the parallel operation, the active operation mode has to be set to "NRP" for all the regulators of the connection. The active operation mode can be changed via function block inputs or by setting it either locally or remotely.

When applying this principle, each regulator has a phase angle setting $\varphi_{Load}$ (setting parameter *Load phase angle*) towards which it tries to regulate the current. The setting value is chosen according to the expected power factor of the load (positive setting value equals inductive load). When the actual phase angle of the load current is the same as the setting and the transformers and their tap changer positions are identical, the currents of the transformers are in the same phase as the total load current. If the tap changer positions are different, the circulating current flows and the currents of different transformers either lag or lead the load current. Figure 814 shows that the circulating current is the reactive component which separates the measured current vector from the expected angle value.

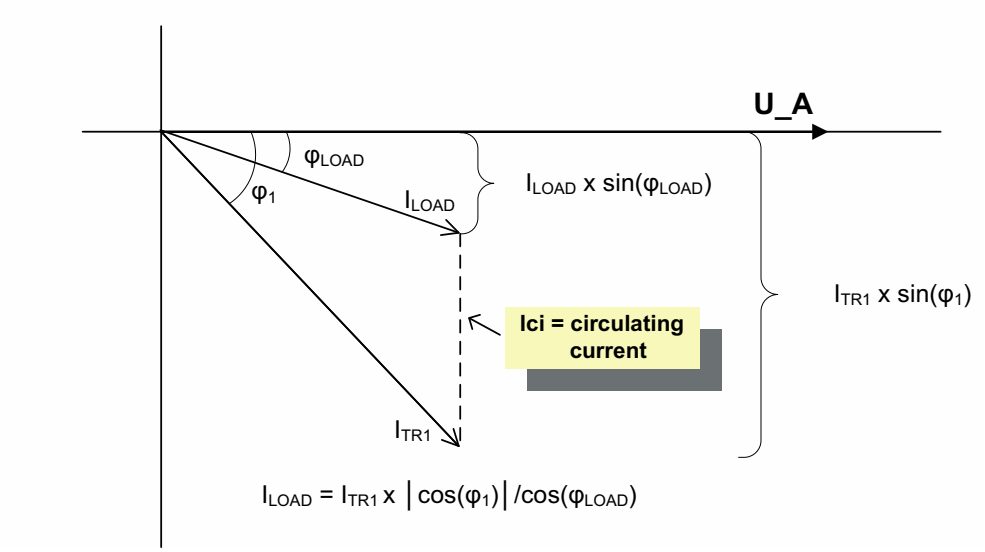



*Figure 814: The expected phase angle of the load supplied by the transformers operating in parallel is entered as a setting value $\varphi_{Load}$*

The regulators calculate the circulating current with the equation

$$I_{ci} = (\sin\varphi_1 - \tan\varphi_{Load} \cdot |\cos\varphi_1|) \cdot I_{TR1}$$

(Equation 341)

| | |
|---|---|
| $I_{TR1}$ | Average of the currents I_A, I_B and I_C |
| $\varphi_1$ | Phase angle between U_A and I_A |
| $\varphi_{Load}$ | Set *Load phase angle* of the load current |

In the negative reactance method, the circulating current is minimized by changing the control voltage according to the measured circulating current. The regulator calculates the circulating current compensation term $U_{ci}$ (Equation 338) as in the MCC

$$U_{ci} = \frac{-I_{ci}}{I_n} \cdot \frac{Stability\ factor}{100} \cdot U_n$$

(Equation 342)

| | |
|---|---|
| $I_{ci}$ | Circulating current |
| *Stability factor* | Stability setting (the recommended value depends on the loop impedance) |

If the transformers operating in parallel have different rated currents, the value of the *Stability factor* setting of the regulator should be proportional to the rated currents, that is, the higher the rated current, the higher the *Stability factor* setting value.

It is possible to find out if the circulating current has been minimized by comparing the reactive components of the currents measured by the different regulators. The circulating current is minimized when the reactive components are equal.

The negative reactance method gives satisfactory results only if the phase angle of the load current is known relatively accurately. If the actual phase angle deviates from the phase angle setting, a regulating error occurs. However, if there is an occasional stepwise change in the phase angle of the load, the regulating error can be suppressed with the logic. This kind of stepwise change can occur, for example, when a capacitor bank is switched on to compensate a reactive power flow. Another possibility is to use an automatic setting group change between setting groups in different loading situations. The setting groups then have different set values for the load phase angle.

### Minimizing Circulating Current MCC

The MCC principle is an optimal solution for controlling parallel transformers of different ratings or step voltages in substations with varying reactive loads. Since this control scheme allows the exchange of data between regulators, the circulating current can be calculated more accurately than with other schemes. However, a maximum of six regulators can be connected in parallel. To start the parallel operation, the active operation mode parameter has to be set to "MCC" for all the regulators of the connection. Furthermore, the signal CON_STATUS must indicate that the transformers are connected to the network. A unit that minimizes the circulating current must have the active operation mode set to "MCC". Units that have the active operation mode set to "Manual" do not perform any circulating current minimization operations themselves.

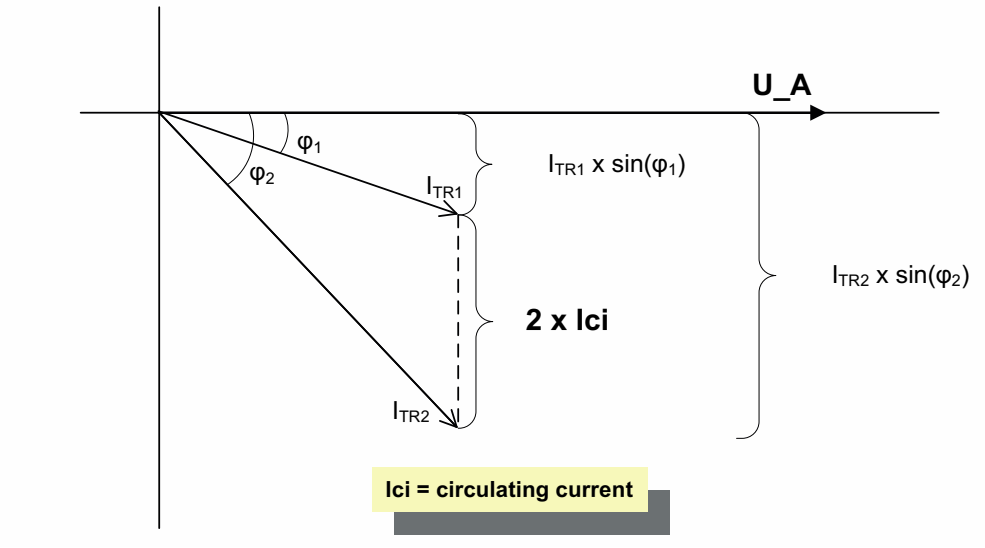



*Figure 815: The circulating current between two parallel transformers*

In this case, the circulating current can be calculated with the equation

$$I_{ci} = \frac{(\sin\phi_1 \cdot I_{TR1} - \sin\phi_2 \cdot I_{TR2})}{2}$$

(Equation 343)

| | |
|---|---|
| $I_{TR1}$ | Current magnitude of regulator 1 |
| $I_{TR2}$ | Current magnitude of regulator 2 |
| $\varphi_1$ | Phase angle between U_A and I_A in regulator 1 |
| $\varphi_2$ | Phase angle between U_A and I_A in regulator 2 |

The circulating current can be read from the monitored data I_CIR.

Using the circulating current, the compensation term $U_{ci}$ can be calculated with the equation

$$U_{ci} = \frac{-I_{ci}}{I_{CT_n1}} \cdot \frac{Stability\ factor}{100} \cdot U_n$$

(Equation 344)

| | |
|---|---|
| $I_{ci}$ | Circulating current |
| $I_{CT_n1}$ | Nominal primary current of the CT |
| *Stability factor* | Stability setting (the recommended value depends on the loop impedance) |

The value of $U_{ci}$, which can be positive or negative, is added to the *Band center voltage* $U_s$ (Equation 338). According to Figure 815 and Equation 343, the phasor information from the other protection relays is needed.

## Parallel unit detection and the MCC mode

The network connection status information is essential for the MCC operation mode. The status FALSE needs to be connected to the CON_STATUS input to ensure a proper operation of the MCC calculation if the transformer is disconnected but OL5ATCC remains in the MCC mode. This way the disconnected transformer is excluded from the circulating current calculations.

The CON_STATUS input is used to identify if a transformer controller can send the current information to other transformer controllers for circulating current minimization purposes. As a result, this input has effect only in the MCC or Manual active operation modes. In these modes, if CON_STATUS is TRUE, the information transmission is started. The circulating current information receiving is allowed only in the MCC active operation mode when CON_STATUS is TRUE. PAR_UNIT_MCC can be seen in the Monitored data view.

### Communication and the MCC mode

The phasor information from the other parallel protection relays is needed for the circulating current calculation. Therefore, horizontal GOOSE communication is needed between protection relays when the MCC principle is used.

The transferred current phasor information contains a primary value of the measured current. The magnitude and angle of the current phasor can be read from the OLGAPC function input data TR_I_AMPL and TR_I_ANGL, respectively.

The sent phasor information always represents the difference between the voltage phasor *U_A* and current phasor *I_A*. The information about the current phasor can be read from the monitored data TR0_I_AMPL and TR0_I_ANGL. The allowed active operation modes for sending data are MCC or Manual, both with the input CON_STATUS activated. The communication is active when the sent and received phasor magnitude is not clamped to zero. The communication phasor magnitude is zero due to a rejected active operation mode or too low signal magnitudes (see Voltage and current measurements chapter). Active CON_STATUS indicates that the corresponding transformer is connected to the network and its current affects the circular current of other transformers even when it is in the manual operating mode.

## 9.10.5.7 Timer characteristics

### Operation timer functionality

The delay times can be set to follow either the definite time characteristic or the inverse time characteristic with the *Delay characteristic* setting. By default, the "Definite time" mode is selected. The timer mode cannot be changed between cycles T1 and T2, but only either before T1 has started or after T2 has elapsed.

*Table 1413: Different timer mode delays*

| Timer mode | Setting | Description |
|---|---|---|
| T1 | *Control delay time 1* | First delay when the measured voltage exceeds or falls below the limit value |
| T2 | *Control delay time 2* | Second delay when the first control did not bring the measured voltage to a desired level |

The delay after the command pulse activation and the restart of the timer is six seconds. The delay is assumed to be the tap changer operating delay. The timer status can also be read from the monitoring data TIMER_STS, where T1 active gives a value "Lower timer1 on" or "Raise timer1 on" while T2 active gives a value "Lower timer2 on" or "Raise timer2 on". Furthermore, the "Fast lower T on" value indicates that the fast lower control functionality is active (Blocking scheme chapter).

Activation of operation timer also activates the TIMER_ON output.

## IDMT type operation

The IDMT timer can be selected by setting *Delay characteristic* to "Inverse time". The minimum time at the inverse time characteristic is limited to 1.0 second. However, the minimum recommended setting of the control delay times T1 and T2 is 10 seconds when the definite time delay is used and 25 seconds when the inverse time delay is used.

The inverse time function is defined by the equations:

$$B = \frac{U_d}{\frac{U_{BW}}{2}}$$

(Equation 345)

| | |
|---|---|
| $U_d$ | $\lvert U_m - U_p \rvert$, differential voltage |
| $U_{BW}$ | Setting parameter *Band width voltage* |

$$t = \frac{T}{2^{(B-1)}}$$

(Equation 346)

| | |
|---|---|
| T | T1 or T2 |

The monitored data UD_CTL shows the differential voltage value $U_m - U_p$. If the value exceeds half of the *Band width voltage* setting and has a negative sign, a raising pulse is issued. The UD_CTL monitored data can also be seen in the DT timer mode.

The hysteresis approach is presented in Figure 812.

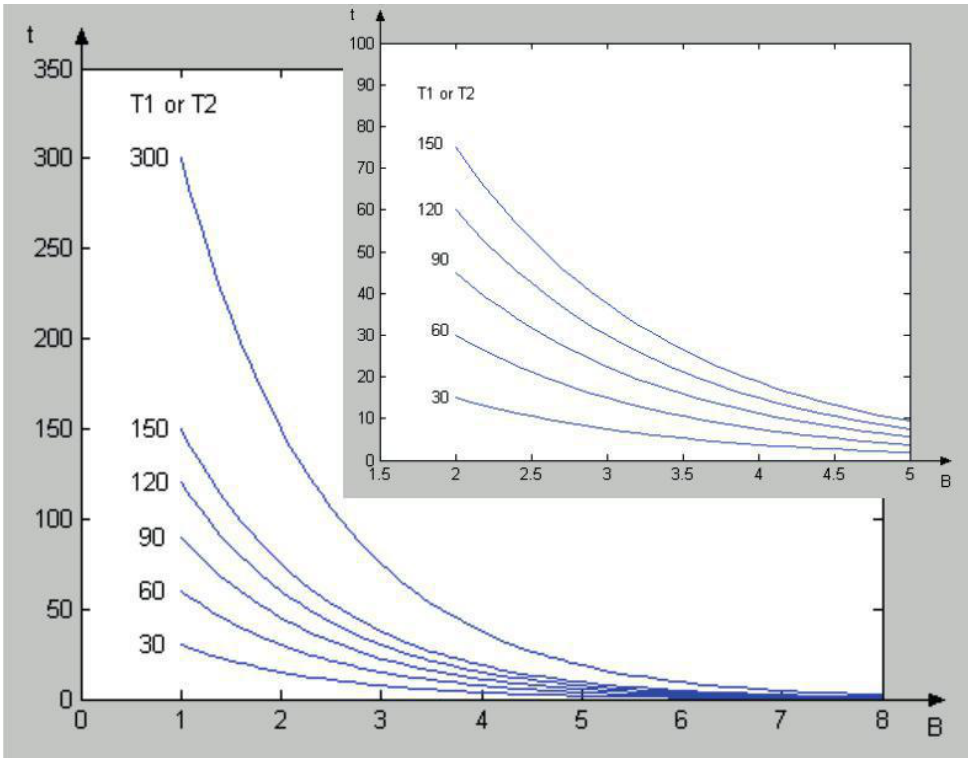



*Figure 816: Inverse time characteristic for different values of T1 or T2 (The smaller figure is a zoom-in of the larger one)*

### 9.10.5.8 Pulse control

The tap changer generates an active operating signal when the tap-changing process is active. This signal is used for alarming purposes and must be connected to the TCO input. If the signal is active (=TRUE) for more than 15 seconds after the control pulse has been deactivated, an alarm is generated (Alarm indication chapter). If the TCO input is not connected, no alarm is generated.

The control operation is disabled when the TCO input signal is active, unless no stuck tap changer is detected (Alarm indication chapter). Thus, the controller cannot send new pulses to the tap changer when this is already operating because tap changers are typically immune to new pulses when they operate. Furthermore, because the pulses are omitted, the tap changer pulse counter of the controller is not incremented.

The commands are not tolerated during an active pulse. Therefore the command pulse length (setting *LTC pulse time*) has to be carefully selected, although an active TCO input is used internally to prevent new commands from reaching the tap changer.

To be more certain that no new pulses are sent when the tap changer is in operation, the tap changer operating signal can be connected to the LTC_BLOCK input. In this case, external blocking is achieved when an automatic pulse is sent to the operating tap

changer. By default, the external LTC_BLOCK has no effect when the active operation mode is set to "Manual" or "Parallel manual".

The status of the TCO input can be read from the TCO input data.

### 9.10.5.9 Blocking scheme

The operation of the voltage regulator can be blocked for several reasons. The purpose of blocking is to prevent the tap changer from operating under conditions that can damage the tap changer or exceed other power system limits. The BLK_STATUS monitored data does not imply actual blocking but reveals if the coming command pulse is issued or not. The blocking itself happens when the corresponding bit in the signal BLK_STATUS is active and the command pulse is started due to a timer elapse or a local command. This is to avoid unnecessary event sending.

The BLK_STATUS monitored data is also packed. It contains information about the blocking status as bit-coded output. The block status output does not indicate the actual blocking but indicates if the coming command is successful. The actual blocking is indicated by the corresponding output (BLKD_I_LOD, BLKD_U_UN, RNBK_U_OV, BLKD_LTCBLK and BLKD_I_CIR) values. Table 1414 illustrates the meaning of different monitored data values. For example, block status value 9 indicates that there are conditional circulating current and load current blockings (8 + 1 = 9) indicated. By default, the status is “0”.

*Table 1414: Bit-coded block status and the meaning of different bits*

| Bit | Active value | Blocking reason |
|---|---|---|
| 6 (msb) | 64 | Lowest position reached |
| 5 | 32 | Highest position reached |
| 4 | 16 | External LTC_BLOCK |
| 3 | 8 | High circuit current |
| 2 | 4 | Overvoltage - Runback raise voltage |
| 1 | 2 | Undervoltage - Block lower voltage |
| 0 (lsb) | 1 | Overcurrent - Load current |

The cross (X) in the table defines when the operation is blocked (if the corresponding bit is active in BLK_STATUS). For example, an overvoltage (runback raising voltage) results in blocking only when the active operation mode is "Manual" and the manual raising command is given.

*Table 1415: Default blocking schema in OL5ATCC*

| Active operation mode | Command | Load current | Block lower voltage | Runback raise voltage | High circulating current | External block | Extreme positions |
|---|---|---|---|---|---|---|---|
| Manual, Parallel manual | Raise | X | | X | | | X |
| | Lower | X | | | | | X |
| Auto follower | Raise | X | X | | | X | X |
| | Lower | X | X | | | X | X |
| Auto single, Auto master, NRP, MCC | Raise | X | X | | X[1)] | X | X[2)] |
| | Lower | X | X | | X[1)] | X | X[2)] |

1) Because the circulating current is calculated only in the NRP and MCC modes, it can have a blocking effect only in these modes.
2) In these cases the automatic operation notices that the extreme position has already been reached and there is no need to activate the signal for data set event sending. The automatic follower case can here be compared to a manual case and an event can be sent, that is, the corresponding output is activated.

In addition to the default blocking, the *Custom Man blocking* setting has been added due to different operation practices of the manual command blocking. The setting can be used to adapt blockings considering the manual overcurrent, undervoltage or external blocking. (The blockings are in Table 1415 in columns Load current, Block lower voltage and External block for the manual operating mode.) The default value for the parameter is "OC". This means that the default blocking schema explained in Table 1415 operates as such. However, there are other alternatives that cause different operations.

*Table 1416: Customized manual blocking schema*

| Manual blocking | Enumeration | Description |
|---|---|---|
| 1 | Custom disabled | No load current, block lower (under) voltage, external blocking has no effect in the manual operation modes |
| 2 | OC | Load current blocking has an effect in the manual operation modes |
| 3 | UV | Block lowering (under) voltage blocking has an effect in the manual operation modes |
| 4 | OC, UV | Conditions 2 and 3 together: Load current and block lowering (under) voltage blocking have effect in the manual operation modes |
| 5 | EXT | External blocking has effect in the manual operation modes |
| 6 | OC, EXT | Conditions 2 and 5 together: Load current and external blocking have effect in the manual operation modes |
| 7 | UV, EXT | Conditions 3 and 5 together: Block lowering (under) voltage and external blocking have effect in the manual operation modes |
| 8 | OC, UV, EXT | All conditions 2, 3 and 5 together: Load current, block lowering (under) voltage and external blocking have effect in the manual operation modes |

If the *Custom Man blocking* setting is "Custom disabled", the blocking schema regarding the active operation mode "Manual" or “Parallel manual” is given in Table 1417. Other operation modes follow the default schema.

*Table 1417: Blocking schema for selection "Custom disabled"*

| Active operation mode | Command | Load current | Block lower voltage | Runback raise voltage | High circulating current | External block | Extreme positions |
|---|---|---|---|---|---|---|---|
| Manual, Parallel manual | Raise | | | x | | | x |
| | Lower | | | | | | x |

*Table 1418: Blocking schema for selection "OC, UV, EXT"*

| Active operation mode | Command | Load current | Block lower voltage | Runback raise voltage | High circulating current | External block | Extreme positions |
|---|---|---|---|---|---|---|---|
| Manual, Parallel manual | Raise | x | x | x | | x | x |
| | Lower | x | x | | | x | x |

*Table 1419: Blocking schema for selection “UV, EXT”*

| Active operation mode | Command | Load current | Block lower voltage | Runback raise voltage | High circulating current | External block | Extreme positions |
|---|---|---|---|---|---|---|---|
| Manual, Parallel manual | Raise | | x | x | | x | x |
| | Lower | | x | | | x | x |

## Load current

The load current blocking is mainly used for preventing the tap changer from operating in an overcurrent situation. For example, if the current is not high enough to activate the protection relay of the substation, it can still be fatal for the diverter switch of the tap changer. This operation can be adjusted with the setting parameter *Load current limit*. The maximum of measurements from the secondary-side current phases is used for blocking. By default, both the automatic operation and the manual operation are blocked (Table 1415) when the set limit is exceeded.

The blocking status can be read from the output `BLKD_I_LOD`.

## Block lowering voltage

The block lowering voltage feature blocks both raise and lower voltage commands if the measured voltage is too low to be corrected by operating the tap changer. Such a situation can occur due to a faulty measuring circuit, an earth fault or an overcurrent situation. By default, only the automatic (also automatic follower) operation is blocked when the undervoltage condition is met (Table 1415). This operation can be adjusted with the setting parameter *Block lower voltage*.

The blocking status can be read from the output BLKD_U_UN.

However, there is no minimum limit for the undervoltage blocking. The blocking is allowed even if the measured voltage is not connected or it temporarily has a very low value. There is a minimum limit for the phase angle calculation based on the voltage phasor magnitude.

### Runback raising voltage

The manual raising command is blocked if the overvoltage limit is exceeded (Table 1415). However, in the automatic operation mode, the overvoltage situation triggers the fast lowering feature. More information can be found in the Manual voltage regulation chapter. This operation can be adjusted with the setting parameter *Runback raise V*.

The blocking status can be read from the output RNBK_U_OV.

### High circulating current

The circulating current value is calculated in the operation modes Negative Reactance Principle (NRP) and Minimizing Circulating Current (MCC). Only the automatic operation in these modes is blocked when the high circulating current is measured (Table 1415). This operation can be adjusted with the setting parameter *Cir current limit*.

The blocking status can be read from the output BLKD_I_CIR.

### LTC_BLOCK – external block input

With the PCM600 tool configuration possibilities, a blocking condition can be built by connecting an outcome to this input. The blocking status can be read from the output BLKD_LTCBLK. When activated, this input blocks only the automatic operation of the regulator by default (Table 1415). For the fully automatic modes, the signal activation resets the timer, and the output BLKD_LTCBLK is not activated.

### Extreme positions

This blocking function supervises the extreme positions of the tap changer. These extreme positions can be adjusted with the setting parameters *Raise block tap* and *Lower block tap*. When the tap changer reaches one of these two positions, the commands in the corresponding direction are blocked (Table 1415). It depends on the comparison between the *Raise block tap* and *Lower block tap* settings, which direction is blocked (Voltage control vs. tap changer moving direction section). This blocking affects both the automatic and manual operation modes.

However, as shown in Table 1415, no blocking indication is generated in the fully automatic modes. Here "Auto follower" is not a fully automatic mode. The unconnected position information does not cause the total block of OL5ATCC; only the extreme position blocking does not work.

The blocking status can be seen in the generated events.

### Fast lowering control

OL5ATCC provides the fast lowering control in the automatic operation modes. When the set *Runback raise V* is exceeded, the regulator gives fast lowering control pulses until the voltage drops below the specified limit. This fast lowering control can be seen with the monitoring data TIMER_STS, where the value "Fast lower T on" indicates this functionality to be active.

To allow the fast lowering operation, *Runback raise V* has to be set always to a value higher than the control voltage (U_CTL) plus half of *Band width voltage*.

Typically, blockings are reset when the corresponding limit with the hysteresis is undershoot or exceeded. Although blocking is reset after undershooting the above-mentioned limit, the fast lowering control operation continues until the measured voltage signal difference undershoots half the *Band width voltage* hysteresis limit (Figure 812). As a result, the normal automatic operation mode is not possible before this happens.

Fast lowering control causes successive LOWER_OWN pulses to be activated. The time between consecutive pulses is the pulse length plus 1.5 seconds.

- There is no tap changer operating delay (otherwise 6 seconds) taken into account in this cycle meaning that some command pulses are ineffective due to tap changer operation, as described in the Pulse control chapter.
- Timer mode set by *Delay characteristic* has no effect here (always the DT timer mode). Because the minimum pulse length (the *LTC pulse time* setting) is 0.5 seconds, the shortest interval between successive pulses can be 2 seconds.

In the automatic follower mode, the fast lowering is not triggered. In this way, the awkward dispersion of position values in different units can be avoided. The master always decides on the fast lowering on behalf of the follower units. Moreover, master and follower should measure an equal voltage level and have similar setting values for the overvoltage blocking limit.

## 9.10.5.10 Alarm indication

### Tap changer monitoring

OL5ATCC supervises the operation of the tap changer and generates alarms if the alarm condition is detected. An alarm activation means that the ALARM output is activated and the alarm reason can be read from the monitored data ALARM_REAS. Alarms are in use by default but they can be set not to be in use by setting *Alarms enabled* to "False". Three different alarm conditions and their combinations can be detected by OL5ATCC.

### Command error

OL5ATCC supervises the tap changer position information of the own transformer when a control pulse is given. If the correct position change (direction depends on the comparison of the settings *Raise block tap* and *Lower block tap*) is not seen by OL5ATCC in *Cmd error delay time* after the pulse start, the alarm is issued.

If the position information is not connected, no alarm is generated. The alarm is reset when the correct change in position value is detected after a given pulse or if a new command pulse is given.

The monitored data ALARM_REAS is set during an alarm. This means that if the alarm reason is active, ALARM_REAS has the value "Cmd error".

### TCO signal fails

If the tap changer operating signal TCO stays active for more than 15 seconds after the output pulse deactivation, OL5ATCC sees this as an abnormal condition and assumes that the tap changer is stuck. The alarm is reset when the TCO input signal deactivates. The monitored data ALARM_REAS is set during the alarm. This means that only if alarm reason is active, ALARM_REAS has the value "TCO error".

If the TCO input signal is not connected (indicated by bad quality), this type of alarm is not possible.

### Regulator pumping

Faulty settings may cause the regulator to give control pulses too frequently. For example, too low a setting for the *Band width voltage* (Figure 812) can result in a pumping condition where the regulator has problems to bring the regulated voltage to a desired level. To detect this, OL5ATCC has a setting *Max operations in 1h*, which defines the allowed number of lowering and raising commands during a one-hour sliding time window. The detection is active both in the manual and automatic operation modes. The alarm is reset after the number of operations during the one-hour time window is less than the set value. The number of executed operations of the last one hour can be read from the monitored data OP_TM_NUM_H. However, this parameter is updated only in three-minute intervals. The monitored data ALARM_REAS is set during an alarm. This means that only if alarm reason is active, ALARM_REAS has the value "Pump error".

The operation of OL5ATCC is not blocked during an alarm situation, but all the alarms mentioned above cause the automatic operation to be delayed, which means that the set delay times T1 and T2 are doubled.

In addition to the alarm detections, OL5ATCC provides a nonvolatile operation counter parameter (monitored data OPR_CNT) for determining the service intervals of the tap changer. The counter gives the total number of raising and lowering commands given in the manual and automatic modes. All commands, even those that are omitted by the tap changer due to its operation sequence, are calculated in a cumulative counter. This data parameter can be reset via the parameter *OL5ATCC counter* on the Clear menu.

## 9.10.6 Application

See the application manual for more information.

## 9.10.7 Signals

*Table 1420: OL5ATCC Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| TAP_POS | INT8 | 0 | Integer value representing tap changer position of own transformer |
| RAISE_LOCAL | BOOLEAN | 0=False | Raise command input from configuration |
| LOWER_LOCAL | BOOLEAN | 0=False | Lower command input from configuration |
| CON_STATUS | BOOLEAN | 0=False | Network connection status of the (own) transformer |
| LTC_BLOCK | BOOLEAN | 0=False | External signal for blocking |
| TCO | BOOLEAN | 0=False | Tap changer operating input |
| RSV | BOOLEAN | 0=False | Reduce set voltage active |
| PARALLEL | BOOLEAN | 0=False | Parallel or single operation |
| AUTO | BOOLEAN | 0=False | Auto/Manual indication |
| MSTR_TRIGG | BOOLEAN | 0=False | Master trigger |
| TR1_DAT | INTEGER | 0 | Combined data from transformer 1 |
| TR2_DAT | INTEGER | 0 | Combined data from transformer 2 |
| TR3_DAT | INTEGER | 0 | Combined data from transformer 3 |
| TR4_DAT | INTEGER | 0 | Combined data from transformer 4 |
| TR5_DAT | INTEGER | 0 | Combined data from transformer 5 |

*Table 1421: OL5ATCC Output signals*

| Name | Type | Description |
|---|---|---|
| RAISE_OWN | BOOLEAN | Raise command for own transformer |
| LOWER_OWN | BOOLEAN | Lower command for own transformer |
| FLLW1_CTL | INT32 | Lower/Raise command for follower transformer 1 in the Master/Follower operation mode |
| FLLW2_CTL | INT32 | Lower/Raise command for follower transformer 2 in the Master/Follower operation mode |
| FLLW3_CTL | INT32 | Lower/Raise command for follower transformer 3 in the Master/Follower operation mode |
| FLLW4_CTL | INT32 | Lower/Raise command for follower transformer 4 in the Master/Follower operation mode |
| FLLW5_CTL | INT32 | Lower/Raise command for follower transformer 5 in the Master/Follower operation mode |
| BLKD_I_LOD | BOOLEAN | Indication of over current blocking |
| BLKD_U_UN | BOOLEAN | Indication of under voltage blocking |

Table continues on next page

| Name | Type | Description |
|---|---|---|
| RNBK_U_OV | BOOLEAN | Indication of raise voltage runback |
| BLKD_I_CIR | BOOLEAN | Indication of high circulating current blocking |
| BLKD_LTCBLK | BOOLEAN | Indication of external blocking |
| ALARM | BOOLEAN | Alarm status |
| PAR_FAIL | BOOLEAN | Parallel failure detected |
| PARALLEL | BOOLEAN | Parallel or single operation |
| AUTO | BOOLEAN | Auto/Manual indication |
| TIMER_ON | BOOLEAN | Timer on |
| MASTER | BOOLEAN | Master indication |

## 9.10.8 Settings

*Table 1422: OL5ATCC Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| LDC limit | 0.00...2.00 | xUn | 0.01 | 0.10 | Maximum limit for line drop compensation term |
| Lower block tap | -36...36 | | 1 | 0 | Tap changer limit position which gives lowest voltage on the regulated side |
| Raise block tap | -36...36 | | 1 | 17 | Tap changer limit position which gives highest voltage on the regulated side |
| LDC enable | 0=False<br>1=True | | | 1=True | Selection for line drop compensation |
| Parallel mode | 2=Master<br>3=Follower<br>5=NRP<br>7=MCC<br>-1=Input control<br>-2=Command | | | 2=Master | Parallel mode selection |
| Band center voltage | 0.000...2.000 | xUn | 0.001 | 1.000 | Band center voltage Us |
| Line drop V Ris | 0.0...25.0 | % | 0.1 | 0.0 | Resistive line-drop compensation factor |
| Line drop V React | 0.0...25.0 | % | 0.1 | 0.0 | Reactive line-drop compensation factor |
| Band reduction | 0.00...9.00 | %Un | 0.01 | 0.00 | Step size for reduce set voltage (RSV) |
| Stability factor | 0.0...70.0 | % | 0.1 | 0.0 | Stability factor in parallel operation |
| Load phase angle | -89...89 | deg | 1 | 0 | Load phase-shift, used only with the negative reactance principle |
| Control delay time 1 | 1000...300000 | ms | 100 | 60000 | Control delay time for the first control pulse |
| Control delay time 2 | 1000...300000 | ms | 100 | 30000 | Control delay time for the following control pulses |

*Table 1423: OL5ATCC Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Rv Pwr flow allowed | 0=False<br>1=True | | | 0=False | Reverse power flow allowed |

*Table 1424: OL5ATCC Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=Manual<br>2=Auto single<br>3=Parallel manual<br>4=Auto parallel<br>5=Input control<br>6=Command | | | 6=Command | The operation mode |
| Custom Man blocking | 1=Custom disabled<br>2=OC<br>3=UV<br>4=OC, UV<br>5=EXT<br>6=OC, EXT<br>7=UV, EXT<br>8=OC, UV, EXT | | | 2=OC | Customized manual blocking |
| Parallel trafos | 0...10 | | 1 | 0 | Number of parallel transformers in addition to own transformer |
| Delay characteristic | 0=Inverse time<br>1=Definite time | | | 1=Definite time | Selection of delay characteristic |
| Band width voltage | 1.20...18.00 | %Un | 0.01 | 3.00 | Allowed deviation of the control voltage |
| Load current limit | 0.10...5.00 | xIn | 0.01 | 2.00 | Load current blocking limit |
| Block lower voltage | 0.10...1.20 | xUn | 0.01 | 0.70 | Voltage limit, where further voltage lowering commands are blocked |
| Runback raise V | 0.80...2.40 | xUn | 0.01 | 1.25 | Voltage limit, where fast lower commands takes place |
| Cir current limit | 0.10...5.00 | xIn | 0.01 | 0.15 | Blocking limit for high circulating current |
| LTC pulse time | 500...10000 | ms | 100 | 1500 | Output pulse duration, common for raise and lower pulses |

*Table 1425: OL5ATCC Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max operations in 1h | 0...10000 | | 1 | 100 | Allowed number of controls per one hour sliding window |
| Cmd error delay time | 10...50 | s | 1 | 20 | Time delay before command error will be activated |
| Follower delay time | 6...20 | s | 1 | 6 | Time delay between successive follower commands by a master |
| Alarms enabled | 0=False<br>1=True | | | 1=True | Alarm selection |

## 9.10.9 Monitored data

*Table 1426: OL5ATCC Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U_MEAS | FLOAT32 | 0.00...5.00 | xUn | Phase-to-phase voltage, average filtered |
| ANGL_UA_IA | FLOAT32 | -180...180 | deg | Measured angle value between phase A voltage and current |
| TIMER_STS | Enum | 0=Timer off<br>1=Lower timer1 on<br>2=Raise timer1 on<br>3=Lower timer2 on<br>4=Raise timer2 on<br>5=Fast lower T on | | Timer T1, T2 or fast lower timer active |
| OPR_MODE_STS | Enum | 0=Not in use<br>1=Manual<br>2=Auto single<br>3=Parallel manual<br>4=Auto master<br>5=Auto follower<br>6=MCC<br>7=NRP | | The acting operation mode of the function block |
| U_CTL | FLOAT32 | 0.000...3.000 | xUn | Control voltage, Up, target voltage level |
| UD_CTL | FLOAT32 | -2.000...2.000 | xUn | Voltage difference between Measured voltage - Control Voltage: Um - Up |
| I_CIR | FLOAT32 | -10.00...10.00 | xIn | Calculated circulating current - calculated in operation modes NRP and MCC |
| LDC | FLOAT32 | -2.00...2.00 | xUn | Calculated line drop compensation |
| BLK_STATUS | INT32 | 0...127 | | Bit-coded output showing the blocking status for the next operation |
| ALARM_REAS | Enum | 0=No alarm<br>1=Cmd error<br>2=TCO error<br>3=Cmd + TCO err<br>4=Pump error<br>5=Pump + cmd err<br>6=Pump + TCO err<br>7=Pmp+TCO +cmd err | | Status and reason for alarm |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| OP_TM_NUM_H | INT32 | 0...2147483647 | | Number of controls for own tap changer during last hour |
| FAIL_FLLW | Enum | 0=No failed followers<br>1=T1<br>2=T2<br>3=T1+T2<br>4=T3<br>5=T1+T3<br>6=T2+T3<br>7=T1+T2+T3<br>8=T4<br>9=T1+T4<br>10=T2+T4<br>11=T1+T2+T4<br>12=T3+T4<br>13=T1+T3+T4<br>14=T2+T3+T4<br>15=T1+T2+T3+T4<br>16=T5<br>17=T1+T5<br>18=T2+T5<br>19=T1+T2+T5<br>20=T3+T5<br>21=T1+T3+T5<br>22=T2+T3+T5<br>23=T1+T2+T3+T5<br>24=T4+T5<br>25=T1+T4+T5<br>26=T2+T4+T5<br>27=T1+T2+T4+T5<br>28=T3+T4+T5<br>29=T1+T3+T4+T5<br>30=T2+T3+T4+T5<br>31=T1+T2+T3+T4+T5 | | Failed followers |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| PAR_UNIT_MCC | Enum | 0=No parallel units<br>1=T1<br>2=T2<br>3=T1+T2<br>4=T3<br>5=T1+T3<br>6=T2+T3<br>7=T1+T2+T3<br>8=T4<br>9=T1+T4<br>10=T2+T4<br>11=T1+T2+T4<br>12=T3+T4<br>13=T1+T3+T4<br>14=T2+T3+T4<br>15=T1+T2+T3+T4<br>16=T5<br>17=T1+T5<br>18=T2+T5<br>19=T1+T2+T5<br>20=T3+T5<br>21=T1+T3+T5<br>22=T2+T3+T5<br>23=T1+T2+T3+T5<br>24=T4+T5<br>25=T1+T4+T5<br>26=T2+T4+T5<br>27=T1+T2+T4+T5<br>28=T3+T4+T5<br>29=T1+T3+T4+T5<br>30=T2+T3+T4+T5<br>31=T1+T2+T3+T4+T5 | | Parallel units included in MCC calculation |
| OPR_CNT | INT32 | 0...2147483647 | | Total number of raise and lower commands given in the manual and automatic modes |
| TR0_I_AMPL | FLOAT32 | 0.00...15000.00 | A | Transmitted current magnitude |
| TR0_I_ANGL | FLOAT32 | -180.00...180.00 | deg | Transmitted current angle |
| TR_STATUS | Enum | 0=Independent<br>1=Master<br>2=Follower | | Transformer status information |
| OL5ATCC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 9.10.10 Technical data

*Table 1427: OL5ATCC Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy[1)] | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Differential voltage $U_d$ = ±0.5% of the measured value or ±0.005 × $U_n$ (in measured voltages <2.0 × $U_n$)<br>Operation value = ±1.5% of the $U_d$ for Us = 1.0 × $U_n$ |
| Operate time accuracy in definite time mode[2)] | +4.0%/-0% of the set value |
| Operate time accuracy in inverse time mode[2)] | +8.5%/-0% of the set value<br>(at theoretical B in range of 1.1…5.0)<br>Also note fixed minimum operate time (IDMT) 1 s |
| Reset ratio for control operation<br>Reset ratio for analog based blockings (except run back raise voltage blocking) | Typically 0.80 (1.20)<br>Typically 0.96 (1.04) |

1) Default setting values used
2) Voltage before deviation = set *Band center voltage*

# 9.11 Petersen coil controller PASANCR

## 9.11.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Petersen coil controller | PASANCR | ANCR | 90 |

## 9.11.2 Function block




*Figure 817: Function block*

## 9.11.3 Functionality

The Petersen coil controller function PASANCR is a numerical automatic controller for the continuously adjustable arc suppression coil (ASC or Petersen coil) and the parallel resistor of the coil. It can be applied to compensated networks where an earth-fault current raising resistor is optionally connected in parallel with the arc suppression coil.

PASANCR is intended for controlling arc suppression coils in networks with natural asymmetry, for example, mixed overhead line and cable networks. The main features of the function are:

- Operation based on forced change in zero-sequence voltage
- Arc suppression coil tuning to the desired position
- Network parameter calculation and displaying of the resonance curve and the fault current estimate curve of the network
- Control of the parallel resistor
- Clear numerical value of the resonance point steady-state zero-sequence voltage, for example, for earth-fault protection purposes

## 9.11.4 Analog channel configuration

PASANCR has three analog group inputs which must be properly configured.

*Table 1428: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |
| IRES[1)] | Residual current (measured or calculated) |
| URES | Residual voltage (measured) |

1) IRES must always be connected irrespective of the setting value of *Position Meas mode*. The possible options are measured IRES from the coil/main transformer neutral point or calculated IRES from the phase CTs of earthing transformer.



See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 9.11.5 Controller connections

### Voltages

PASANCR supports zero-sequence voltage measurement from busbar or from coil. Busbar measurement is, for example, an open-delta connection of phase-to-earth voltage transformers. Coil measurement uses the coil's own secondary measurement winding. *Voltage measurement* setting is used to select the active measurement. Available options are "Busbar" and "Coil".

Phase-to-phase voltage AB must be connected to the controller. If only the phase voltages are measured, the voltage U_AB is calculated internally in the protection relay.

### Coil position

The controller supports two possibilities for the coil position measurement. *Position Meas mode* setting is used to select the active coil position measurement. Available options are:

- "Pos. indication": Using only the RTD input module to measure the resistance value from the arc suppression coil potentiometer with COIL_POS input and to convert it into corresponding coil position according to the linearization table.
- "Pos. ind. and meas.": Using both COIL_POS and IRES signals. IRES is arc suppression coil current measurement using conventional CTs or sensors. Special attention should be paid to the accuracy of the current signals at low amplitudes. Additionally, high accuracy can be ensured by applying measurement class CTs and sensors. Current measurement improves controller speed and accuracy. The recommendation for the CT is a primary current equivalent to the coil's maximum current and accuracy class 0.5S or better. The IRES signal is not sufficient for the controller as it does not allow manual control of the coil if it is disconnected from the network.

All voltage and current signals are measured using the value of the filtered fundamental frequency component (DFT). Hence, the harmonics are always suppressed.

### Status information

The connection status (COIL_STS) information from the adjustable arc suppression coil disconnector or circuit breaker should be wired to the controller. Also, fixed parallel coil status (FIXCOIL_STS) and the parallel resistor status (RESISTOR_STS) should be wired to the controller if they are present in the system. Inactive status information signal means that the device is not connected and active status information signal means that the device is connected.

### Outputs

The following outputs should be considered in order to ensure correct operation of the controller if a fixed parallel coil or parallel resistor is installed in the network:

- FIXCOIL, OP_FIXCOIL and CL_FIXCOIL: Status signal and corresponding open and close command signals for controlling the circuit breaker or disconnector of the fixed parallel coil. These signals are applied if a fixed parallel coil is installed in the system.
- RESISTOR, OP_RESISTOR and CL_RESISTOR: Status signal and corresponding open and close command signals for controlling the contactor, circuit breaker or disconnector of the parallel resistor. These signals are applied if a parallel resistor is installed in the system.

An example configuration of the connections is shown in Figure 818. Controller inputs are indicated with red lines and outputs with green lines. This example shows a simple, one-controller setup without the parallel resistor of the coil.

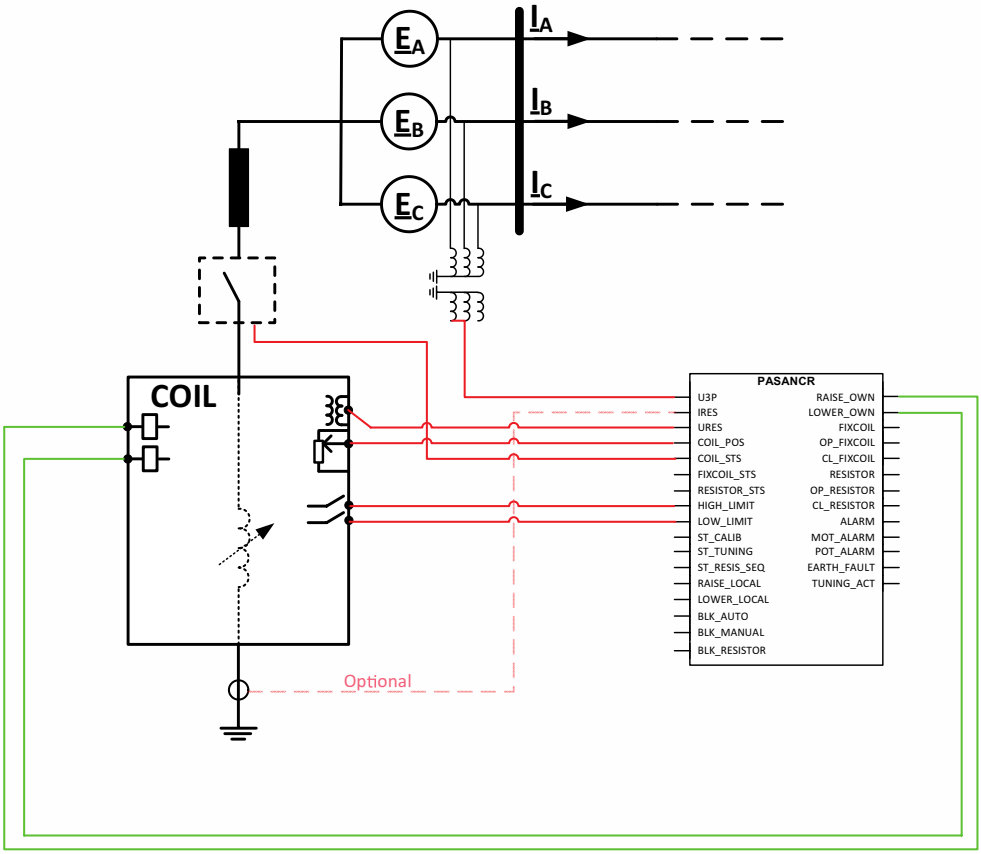



*Figure 818: Example configuration of the controller connections*

## 9.11.6 Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "on" and "off".

The operation of PASANCR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

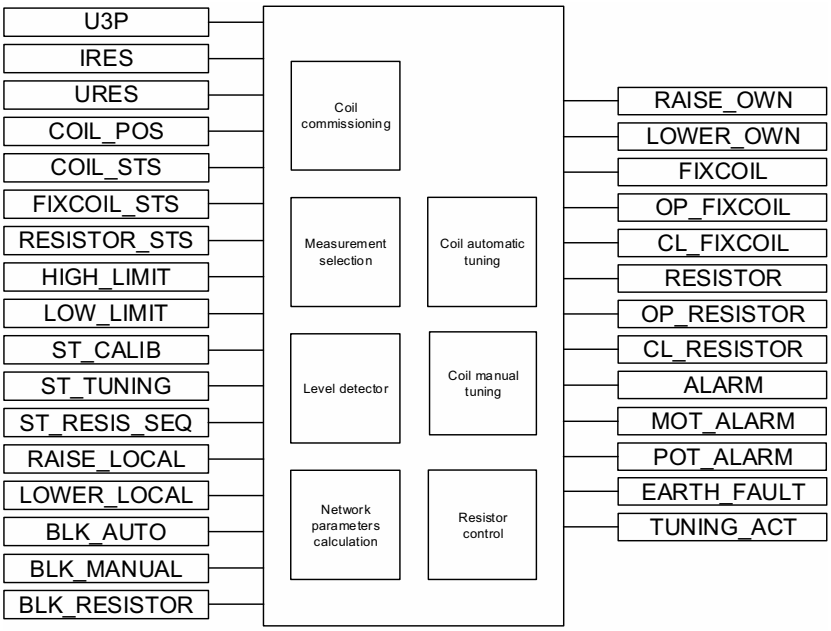



*Figure 819: Functional module diagram*

## Measurement selection

PASANCR supports two possibilities for zero-sequence voltage and coil position measurement.

*Voltage measurement* setting is used to define the location of voltage measurement: from busbar or from coil. Busbar measurement is usually an open-delta connection of phase-to-earth voltage transformers. Coil measurement is available from the arc suppression coil's measurement winding.

*Position Meas mode* setting is used to select the measurement between coil position indication and coil position indication with a CT or sensor. "Pos. indication" option uses the potentiometer-based `COIL_POS` information only. If "Pos. ind. and meas." option is selected, the measured `IRES` is used for the control algorithm. In this case, the `COIL_POS` signal works as a backup and is switched automatically into use if the coil is disconnected from the network.

## Level detector

*Level detector op* setting is used to enable or disable the Level detector module. "Enable" means that the Level detector module is enabled and can be used to start the tuning procedure.

When "Disable" is selected, the automatic coil tuning procedure can be started with input `ST_TUNING`.

Level detector's main task is to release the coil automatic tuning procedure in case of network switching operation. After every successful tuning procedure, the measured

zero-sequence voltage is stored as a new reference voltage $U_{ref}$. Also, the calculated network admittances are stored as new reference admittances $Y_{symm_ref}$ and $Y_{asymm_ref}$ (for more information, see Network parameter calculation in this chapter).

If the change in the measured zero-sequence voltage exceeds the setting *V Res change level* with respect to $U_{ref}$, then a new coil tuning procedure is released. The measured zero-sequence voltage must exceed the threshold at least by the time defined with *Tuning delay* setting, otherwise the start of the tuning procedure is canceled.

Zero-sequence voltage change can be determined considering the voltage amplitude only or a phasor value. Setting *V Res Meas mode* is used to select between these two modes. The available options are "Amplitude" and "Phasor". The phasor triggering mode is explained in Figure 820. Monitored data output TUNING_TRIGG indicates the relation between present zero-sequence voltage and the reference voltage. When TUNING_TRIGG value is below 100%, the controller is at stand-by. When TUNING_TRIGG value is above 100%, that is, Uo vector in Figure 820 enters the red area, the tuning delay is started.

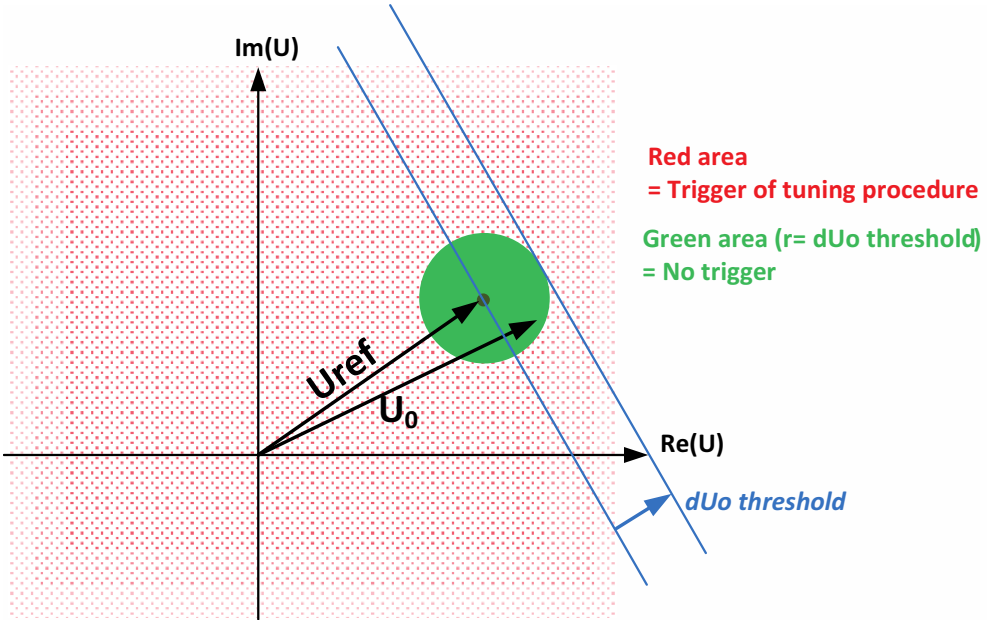



*Figure 820: Phasor triggering mode*

Level detector also includes a threshold-based earth-fault detection functionality. The detection is based on *V Res EF level* voltage threshold setting. If the measured zero-sequence voltage exceeds the threshold at least by the time defined in *Transient time EF* setting, the earth fault is indicated by activating the EARTH_FAULT output and the controller proceeds as described in Operation during earth faults in this chapter.

The delay defined in *Tuning delay* can be bypassed by activating ST_TUNING input, for example, via HMI application. When the rising edge of the signal is detected, the controller skips the tuning delay and proceeds immediately with the coil automatic tuning procedure. The automatic tuning procedure can be started with ST_TUNING

input even without the zero-sequence voltage trigger. The automatic tuning procedure is also released when the controller mode is switched from “manual” to “auto”.

PASANCR has an adaptive $U_{ref}$ feature. The *V Ref adaptive mode* setting is used to enable or disable the functionality. The functionality allows slow changes in measured zero-sequence voltage and therefore reduces unnecessary tuning operations. If the measured zero-sequence voltage does not exceed the *V Res change level* setting during the time defined in *V Ref adaptive delay* setting, the existing measured zero-sequence voltage is stored as a new reference voltage $U_{ref}$ at the end of the adaptive period. The operation principle of the adaptive $U_{ref}$ feature is explained in Figure 821.

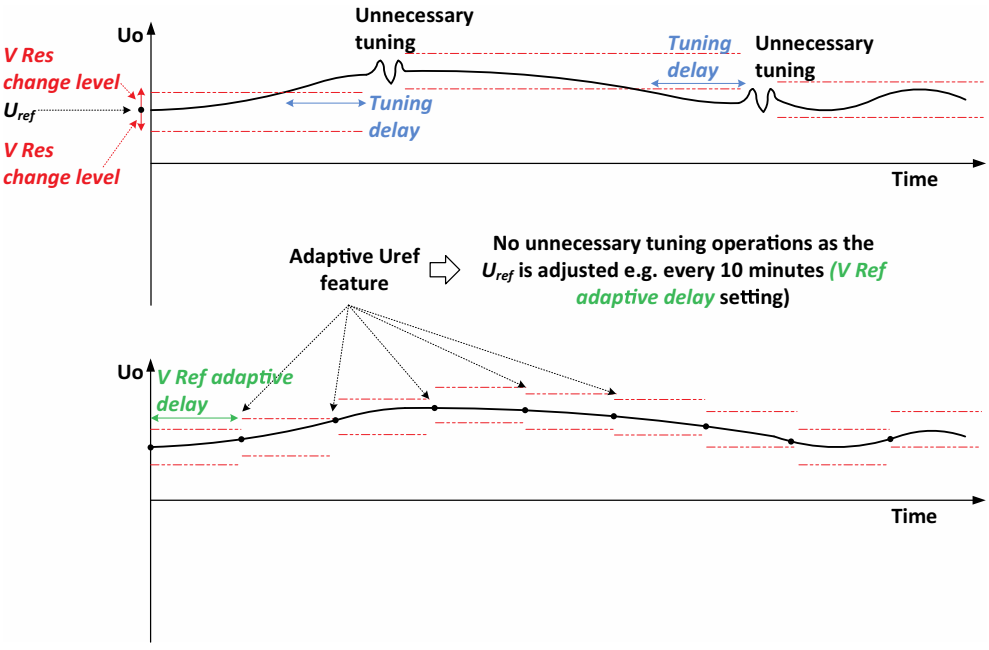



*Figure 821: Example of Uo fluctuation with and without adaptive $U_{ref}$ feature (amplitude triggering mode)*

## Network parameter calculation

To explain the controller, the simplified equivalent circuit of a three-phase distribution network illustrated in Figure 822 is used. The controller assumes that:

- The real network is presented with its shunt admittances neglecting line series impedances as their values are very small compared with the shunt admittances.
- The individual phase admittances of the network are presented with symmetrical phase admittances whose sum equals

$$\underline{Y}_{symm} = G_{symm} + j \cdot B_{symm}$$

(Equation 347)

(one third connected in each phase)

- The natural asymmetry in a real network is due to differences in individual phase admittances and it is presented with an asymmetry admittance concentrated into phase A and presented with admittance

$$\underline{Y}_{asymm} = G_{asymm} + j \cdot B_{asymm}$$

(Equation 348)

(only connected in phase A)

- The single-phase earth fault in the network is presented with admittance $\underline{Y}_f = G_f + j \cdot B_f$. Fault impedance can be assumed to be purely resistive (fault resistance $R_f$) which is connected between phase A, B or C and earth depending on the faulted phase.
- The zero-sequence impedance of the earthing (or main) transformer with the neutral point connected to the coil is represented with impedance $\underline{Z}_{oTr}$ (in the three-phase equivalent scheme one third must be applied).

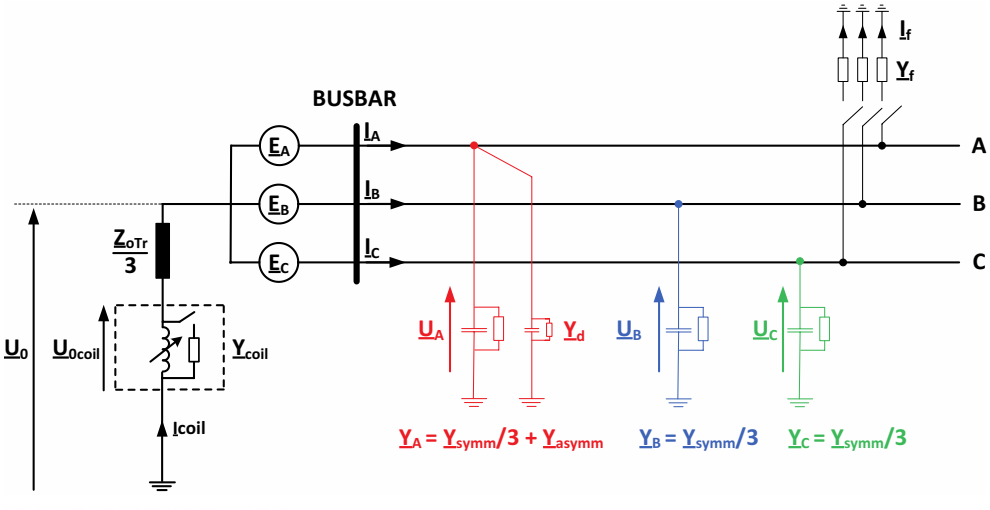



*Figure 822: Simplified three-phase equivalent circuit of a compensated distribution network*

| | |
|---|---|
| $\underline{E}_A$ | Phase A to earth voltage of the source |
| $\underline{E}_B$ | Phase B to earth voltage of the source |
| $\underline{E}_C$ | Phase C to earth voltage of the source |
| $\underline{U}_A$ | Phase A to earth voltage at busbar (=$\underline{E}_A$ + $\underline{U}_o$) |
| $\underline{U}_B$ | Phase B to earth voltage at busbar (=$\underline{E}_B$ + $\underline{U}_o$) |
| $\underline{U}_C$ | Phase C to earth voltage at busbar (=$\underline{E}_C$ + $\underline{U}_o$) |
| $\underline{U}_0$ | Zero-sequence voltage = ($\underline{U}_A$ + $\underline{U}_B$ +$\underline{U}_C$)/3 |
| $\underline{U}_{0coil}$ | Zero-sequence voltage measured at coil |
| $\underline{I}_A$ | Phase A current at the source |
| $\underline{I}_B$ | Phase B current at the source |
| $\underline{I}_C$ | Phase C current at the source |
| $\underline{I}_{coil}$ | Current through the central compensation coil |
| $\underline{Y}_A$ | Phase A to earth admittance of the network |
| $\underline{Y}_B$ | Phase B to earth admittance of the network |
| $\underline{Y}_C$ | Phase C to earth admittance of the network |
| $\underline{Y}_{coil}$ | Admittance of central compensation coil including the parallel resistor |
| $\underline{Z}_{oTr}$ | Zero-sequence impedance of the earthing transformer or the main transformer through which the coil is connected to the network. Settings *R0Transformer* and *X0Transformer* are used to input the zero-sequence impedance of the earthing / main transformer. If the settings are applied, the controller can consider the transformer when calculating network parameters. |

Using this network model, the controller determines network parameters $G_{symm}$, $B_{symm}$, $G_{asymm}$, $B_{asymm}$, $G_{coil}$ and $B_{coil}$.

| | |
|---|---|
| $G_{symm}$ | Real part of symmetrical part of the total network admittance. The sign is positive and it represents the shunt losses of the network (excluding the losses of the central coil and the parallel resistor). If there are distributed compensation coils in the network, their shunt losses are included in this value. |
| $B_{symm}$ | Imaginary part of symmetrical part of the total network admittance. The sign is positive (capacitive) and it represents the capacitive uncompensated earth-fault current of the network. If there are distributed compensation coils in the network, their effect is included in this value. |
| $G_{asymm}$ | Real part of asymmetry admittance. The sign may be positive or negative depending on the actual level of asymmetry. |
| $B_{asymm}$ | Imaginary part of asymmetry admittance. The sign may be positive or negative depending on the actual level of asymmetry. |
| $G_{coil}$ | Real part of the coil admittance. The sign is positive and it represents the resistive losses of the central coil including the parallel resistor. |
| $B_{coil}$ | Imaginary part of the coil admittance. The sign is negative and it represents the inductive current of the central coil, which defines the compensation degree of the network. |

All previous admittance terms can be easily converted into equivalent current values by multiplying them by the system nominal phase-to-earth voltage $U_n$.

| | |
|---|---|
| $I_{ef_network} = (B_{symm} + B_{asymm}) \cdot U_n$ | Uncompensated earth-fault current |
| $I_{loss_network} = (G_{symm} + G_{asymm}) \cdot U_n$ | Network shunt losses |
| $I_{coil} = B_{coil} \cdot U_n$ | Coil inductive current |
| $I_{loss_coil} = G_{coil} \cdot U_n$ | Coil loss current |

Network parameter calculation is based on the forced change in network zero-sequence voltage. This is achieved by changing the coil position or by changing the connection state of the parallel resistor of the coil.

## Coil automatic tuning

Coil automatic tuning mode is enabled with setting *Controller mode* = "Automatic". In this mode, the TUNING_ACT binary output is activated. The coil automatic tuning procedure consists of two parts. First, sufficient zero-sequence voltage variation is obtained using coil movement or resistor switching. Secondly, network parameters are calculated.

The automatic tuning procedure requires a sufficient change to be detected in the measured zero-sequence voltage. This can be achieved by coil movement or switching the parallel resistor of the coil. The mode is selected with *Tuning mode* setting. The available options are "Coil movement" and "Resistor switching".

In the coil movement mode, the controller first moves the coil a little towards the coil's default position and determines the direction of raising Uo voltage. Then the controller moves the coil preferably to the direction of raising zero-sequence voltage until the measured zero-sequence voltage is changed by the amount defined with *V Res variation* setting. *V Res maximum* setting defines the maximum zero-sequence voltage that the controller does not exceed when obtaining the required Uo variation. If the zero-sequence voltage reaches the value defined in *V Res maximum* setting, the

controller seeks the required Uo variation from the direction of decreasing zero-sequence voltage.

The measured zero-sequence voltage level must exceed setting *V Res minimum* during the whole tuning process. If the measured zero-sequence voltage is initially below the *V Res minimum* setting, the controller extends the search range in order to achieve this minimum level. If the minimum required level of zero-sequence voltage cannot be reached, the controller cancels the tuning. If the required zero-sequence voltage variation cannot be reached, the controller moves the coil to *Error position*.

The most accurate tuning is possible when *Pass resonance* setting is enabled: the controller moves the coil over the network resonance point and collects additional measurement points resulting in the most accurate estimate of the network parameters. Particularly passing the resonance point improves the estimate of network losses. Setting *V Res maximum* can deny the resonance point passing functionality.



*V Res EF level* setting should be set to a higher value than *V Res maximum*.

If the coil is equipped with a parallel resistor, the resistor switching mode offers a fast alternative to obtain the change in measured zero-sequence voltage. In the resistor switching mode, the controller switches the connection status of the parallel resistor for three seconds and then switches the resistor back to its original connection status. If the change in the measured zero-sequence voltage exceeds the *V Res variation* setting, the controller can proceed immediately to network parameters calculation. If the change defined in *V Res variation* setting cannot be obtained using resistor switching, the controller automatically uses the coil movement method.



In the case of resistor switching, the setting *V Res maximum* is ineffective.

After sufficient change in the measured zero-sequence voltage is obtained using coil movement or resistor switching, the controller calculates new network parameters and compares them to the reference values. If the network's capacitive earth-fault current has changed, the controller moves the coil to maintain the set compensation level. The active compensation mode is selected with *Compensation mode* setting. The available options are "Absolute" (tuning level selected with *Detuning level* setting) and "Relative" (tuning level selected with *Detuning level Rl* setting). The controller monitors the actual coil current while moving it to the desired tuning position. Taking into account the after-running of the coil motor, it is stopped just before reaching the desired tuning point. If the zero-sequence voltage reaches the voltage level set with *V Res maximum* setting, the controller stops the coil movement.

If the parallel resistor is installed in the system (setting *Parallel resistor* = "True"), PASANCR includes a feature to temporarily connect the parallel resistor into the system while moving the coil to the desired tuning position if the resistor is initially disconnected. The temporary connection of the parallel resistor should lower the zero-sequence voltage and therefore the movement of the coil to the desired tuning position

could be possible. The feature can be enabled with *Temporary damping* setting. The available options are "True" and "False".

An example of the feature is shown in Figure 823 where the initial coil position is at 60 A, the parallel resistor is disconnected and the target position is at 110 A. Before the controller starts moving the coil, it estimates if the zero-sequence voltage at target position is below the *V Res maximum* setting and if the movement is allowed. If the conditions allow, the controller starts moving the coil towards the higher current. While the movement stops at *V Res maximum* (set to 3.5 percent of the system's nominal phase-to-earth voltage in this example), the controller automatically connects the parallel resistor and moves the coil to the desired inductive current position (that is, 110 A). After the coil has reached the target position, the controller automatically disconnects the resistor, that is, returns it to its original connection state while simultaneously obtaining the target position of 110 A with the parallel resistor disconnected.

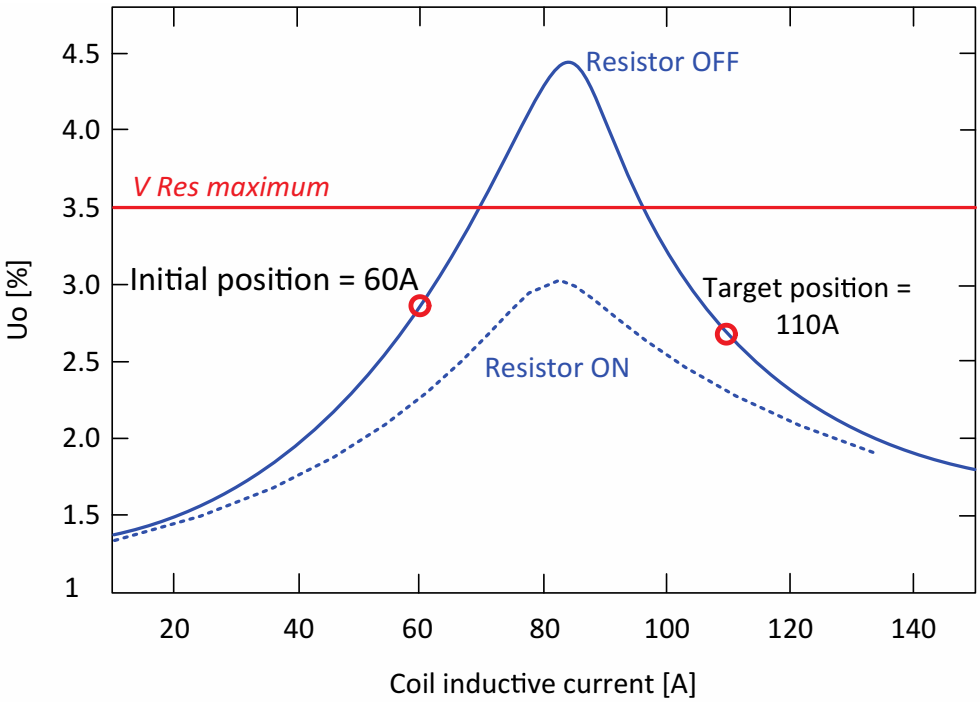



*Figure 823: Damping of the resonance curve by using the parallel resistor*

The number of maximum tuning cycles can be limited with *Tuning cycles* setting. The delay between consecutive tuning cycles is controllable by setting *Tuning cycle delay*. After the maximum number of tuning cycles is reached, the tuning procedure can be started by activating the ST_TUNING input, for example, via HMI application. The counter for maximum tuning cycles is reset after a successful tuning operation.

The ALARM output is a general problem indication during the tuning process. Usually, it is an indication of not obtaining a required minimum level or change of zero-sequence voltage during the coil movement. The reason for this might be, for example, a very symmetrical network. Other reasons for the ALARM indication are coil

movement into wrong direction, maximum number of tuning sequences exceeded or simultaneous indication from both end switches of the coil. There is a dedicated MOT_ALARM output indicating no detected coil movement after activating RAISE_OWN or LOWER_OWN outputs.

After ALARM indication with ALARM_STS “Umin not reached” or “Cannot obtain minimum Uo variation” the coil is moved to a position which is defined with *Error position* setting. The same procedure is executed after CLC_SEQ_WRN indication. The options are to move the coil to the position from where the tuning procedure was started, leave it to its present position or to move the coil to the default position which is settable by the user.

The active tuning range of the arc suppression coil can be limited with *Minimum current* and *Maximum current* settings. Once the operating limits are activated, the controller does not leave the selected range during the tuning procedure. If the operating limits are applied, the limited range of the coil is indicated on the HMI resonance curve view.

**Operation during earth faults**

The controller supports three modes for operation during earth fault. The active mode can be selected with *EF mode* setting. The available modes are "Blocked during EF", "Resonance" and "Tuning during EF".

- Blocked during EF: No coil movement when the earth fault is detected
- Resonance: Coil is moved to the resonance point which is determined during the healthy-state operation of the network.
- Tuning during EF: The controller determines the network parameters during a sustained earth fault and maintains the set compensation level. The controller can also detect network switching operations and tune the ASC correspondingly (for example, disconnecting feeders to isolate the earth fault). Tuning during EF can be performed when the measured zero-sequence voltage is below 80 percent of the system's nominal phase-to-earth voltage. If the measured zero-sequence voltage is over 80 percent of the system's nominal phase-to-earth voltage, the “Blocked during EF” mode is automatically switched into use.

**Fixed parallel coil control**

PASANCR supports the control of the fixed parallel coil. The ampere value and the nominal voltage of the coil can be set with *Fix coil value* and *Fix coil V Nom* settings. The treatment of the fixed parallel coil is selected with *Fix coil type* setting. By applying “OFF” or “ON”, the controller cannot automatically switch the connection status of the fixed parallel coil. If “Automatic” is selected, the controller can change the connection status of the fixed parallel coil to reach the desired compensation level. During the automatic operation, the controller tunes the adjustable ASC first. If the desired compensation level cannot be reached, the fixed parallel coil can be switched on or off. The presence of the fixed parallel coil in the system has effect on correct tuning when the compensation mode is relative.

Absolute detuning current can be calculated:

$$I_v = I_{coil} + I_{fix} - I_{reson}$$

(Equation 349)

The corresponding relative detuning is calculated as:

$$v = \frac{I_{coil} + I_{fix} - I_{reson}}{I_{reson}} \cdot 100\%$$

(Equation 350)

$I_{coil}$ Current of the adjustable ASC

$I_{fix}$ Value of the fixed parallel coil

$I_{reson}$ Current at resonance point

If a fixed parallel coil is introduced in the network (“ON” or “Automatic”), the x axis title of the resonance curve displayed on the HMI can be selected with the *Resonance curve Cur* setting. Available options are:

- Icoil: Only the current of adjustable ASC
- Icoil + Ifix: Total current of adjustable ASC and fixed parallel coil

### Statistics

The controller supports displaying resettable statistics. The statistics can be reset via settings menu using *Clear counters* command.

*Table 1429: Displayed statistics*

| Type | Statistics | Description |
|---|---|---|
| General | Operation time | Controller time in operation |
| | Tuning procedures | Number of started tuning procedures |
| | Tuned | Number of successful tuning operations |
| | Canceled tunings | Number of the canceled tuning procedures, that is, *Tuning delay* has not elapsed |
| | Tuned at Uo max | Number of tuning cases when coil movement has stopped to *V Res maximum* position |
| | Tuned at low limit | Number of cases when coil final position is limited either by low end position indication of the coil or the limited operating range *Minimum current* |
| | Tuned at high limit | Number of cases when coil final position is limited either by high end position indication of the coil or the limited operating range *Maximum current* |
| Earth faults | Transient earth-faults | Number of transient earth faults (that is, fault time shorter than time defined in *Transient time EF* setting) |
| | Permanent earth-faults | Number of permanent earth faults (that is, fault time longer than time defined in *Transient time EF* setting) |

Table continues on next page

| Type | Statistics | Description |
|---|---|---|
| Resistor control | Switch parallel resistor (auto) | Number of parallel resistor switch operations. For example, if the resistor is initially off, then it is switched on and after a defined delay, it is again switched off, this increases the counter by two. |
| | Switch parallel resistor (manual) | Number of manual switch operations for parallel resistor |
| Other | Motor running time | Sum time of RAISE_OWN and LOWER_OWN outputs activated |

## Coil manual tuning

PASANCR supports manual coil tuning when *Controller mode* setting is "Manual". Manual control is achieved by activating RAISE_LOCAL and LOWER_LOCAL inputs which activate the corresponding RAISE_OWN and LOWER_OWN outputs. The manual mode and the corresponding inputs can be activated, for example, via HMI application. Moreover, the manual control of the coil can be achieved via communication by using the *Coil Target Pos* setting. Once the setting is committed, the controller moves to the desired position. Also the activated operating limits can restrict the coil movement. The MOT_ALARM output is activated during manual control if the coil position is not changed due to activated RAISE_OWN and LOWER_OWN commands. The ALARM output is activated when the movement of the coil is in wrong direction or both end switches indicate simultaneously enabled signaling.

Coil manual movement is possible only after calibration.



During the manual control mode the network resonance curve is not updated automatically. The previous automatically detected resonance curve is displayed on the HMI view.

It is possible to manually control the connection status of the fixed parallel coil with *Fix coil type* setting by selecting "ON" or "OFF". The setting can be changed via the settings menu or HMI application.

## Resistor control

Zero-sequence currents in compensated networks are usually very low, making it difficult to select the faulty line. To avoid sensitivity problems, the parallel resistor of the ASC is often used to increase the zero-sequence current allowing a simple earth-fault protection to locate the faulty line. PASANCR contains a functionality to switch the resistor on and off automatically or on user input.

First, the resistor installation status is set with *Parallel resistor* setting. The available options are "True" and "False". If the parallel resistor is installed in the system, the value is selected with *Resistor Nom value* setting. Second, the nominal voltage level of the power auxiliary winding is selected with *Auxiliary Wnd V Nom* setting.

The *Resistor control* setting is used to enable the automatic control sequence or to connect or disconnect the resistor. The automatic control sequence is released if the

functionality is enabled (*Resistor control* = "Automatic") and the EARTH_FAULT output is active. The resistor control sequence after the earth-fault indication depends on the resistor connection status during the healthy state. The healthy-state status is selected with the *Resistor healthy St* setting. The available options are "On" and "Off". The settings affecting the control sequence are explained in Figure 824.

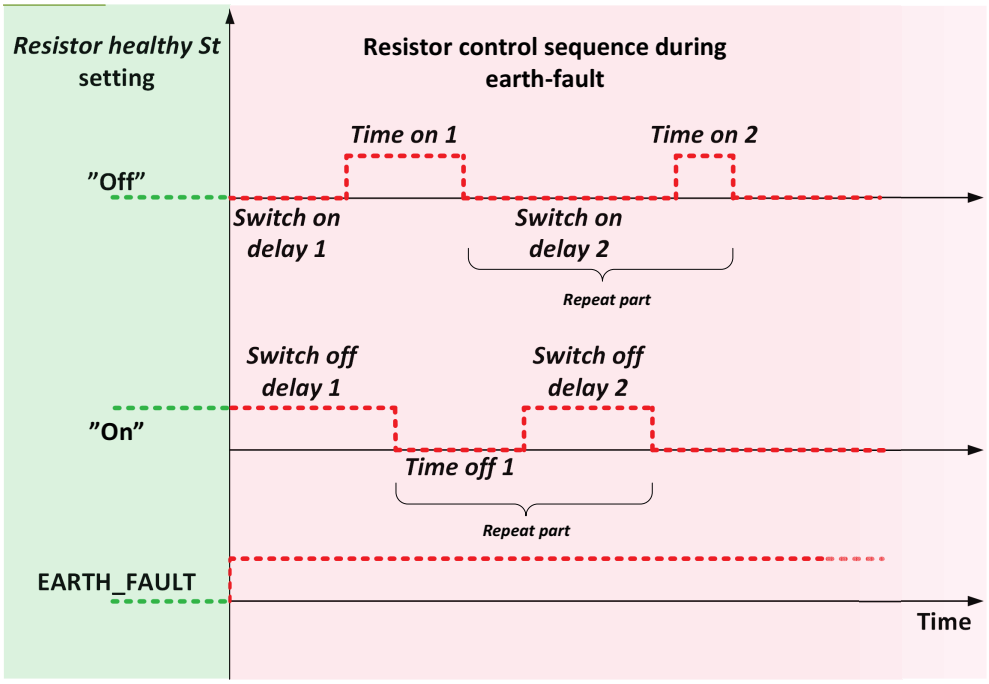



*Figure 824: Resistor control sequence*

When the earth-fault indication becomes inactive, both the single sequence and the repeat sequences are finished and the resistor is switched back to its initial state.

The resistor control sequence contains a repeat part which can be repeated after the whole sequence is executed once. The number of repetitions can be selected with *Resistor repeats* setting. Additionally, the pause between the consecutive repeats can be selected with *Resistor pause* setting. After the sequences are completed, the initial resistor healthy state is restored within 1 s if the *Resistor healthy St* = "On". If the healthy state is "Off", the resistor is already in its healthy-state position after the sequence is completed.

It is also possible to manually trigger the resistor control sequence with ST_RESIS_SEQ binary input.

## Blocking

The BLK_AUTO input blocks the automatic operation of the function. PASANCR's automatic operation is blocked internally if the ASC is disconnected at the substation, that is, COIL_STS signal is low. The BLK_MANUAL input blocks the manual control of the coil. The BLK_RESISTOR input disconnects the parallel resistor and blocks its switching on, for example, due to resistor overheating.

## 9.11.7 Application

PASANCR is a numerical automatic controller for arc suppression coil (Petersen coil) and the parallel resistor. It can be applied to compensated networks where a switched parallel resistor is optionally connected in parallel with the arc-suppression coil. An efficient protecting method against earth faults occurring in a medium-voltage compensated network is the earth-fault compensation. It is carried out by inserting an inductive coil (arc suppression coil or Petersen coil) between the transformer's star point and the earth in order to compensate the zero-sequence capacitive current of the network. It increases the probability of the arc extinction in case of a temporary earth fault. The arc extinction coil is effective only if its value is tuned to the zero-sequence capacity of the network so they are in resonance state and as a consequence the earth-fault current is very low.

## 9.11.8 Commissioning

During the coil setup process, it is not yet needed to connect the ASC to the network. The coil setup consists of two parts:

- Calibration of coil
- Evaluation of coil linearity

The coil calibration procedure is started by activating `ST_CALIB` input which can be done via local HMI application. Before starting the procedure, it must be checked that coil end switches (`HIGH_LIMIT` and `LOW_LIMIT`) are connected to the controller. If end switches are not available, end positions are detected during the calibration process if there was no coil movement for more than 20 s.

First, in the coil calibration procedure the coil is moved automatically from the lower-end switch to the upper-end switch. In both locations, the corresponding potentiometer values are recorded for further use. Also, the coil movement speed is determined during the calibration procedure. Secondly, the coil is moved to its middle position and the after-running and mechanical play of the coil are determined. Finally, the potentiometer gaps are determined. All results from coil calibration (running speed, after running, mechanical play and potentiometer gap locations) are visible in the Monitored data view.

After the calibration, the coil linearity is evaluated. The automatic coil calibration determined the potentiometer ohmic end-switch values. These values are displayed on the HMI and can be entered into the linearization table. The corresponding coil position values (that is, inductive current of the coil) might be entered, for example, from the coil routine test report delivered by the coil manufacturer. The values are entered at coil nominal voltage level which is defined with *Coil V Nom* setting. Moreover, if the potentiometer/coil position relationship is nonlinear, additional eight interpolation points, or part of them, might be applied. This is done by entering the potentiometer and corresponding coil position values into the linearization table. Values which are left to default value of 0.0 are discarded from the actual linearization curve. Both end values of the linearization table are displayed on the HMI view of the

resonance curve. An example of the linearization table is given in Table 1430 and the corresponding linearization curve is plotted in Figure 825.

The values put in ascending order are automatically adjusted so they are in the neighboring positions of the array, irrespective of the position in the linearization table.

*Table 1430: Example of a linearization table*

| Potentiometer value (setting Pot value x, x = 1…10) | Coil position (setting Coil current x, x = 1…10) |
|---|---|
| 100 | 10 |
| 150 | 20 |
| 200 | 30 |
| 250 | 37 |
| 300 | 43 |
| 350 | 48 |
| 400 | 53 |
| 450 | 57 |
| 600 | 68 |
| 1000 | 90 |

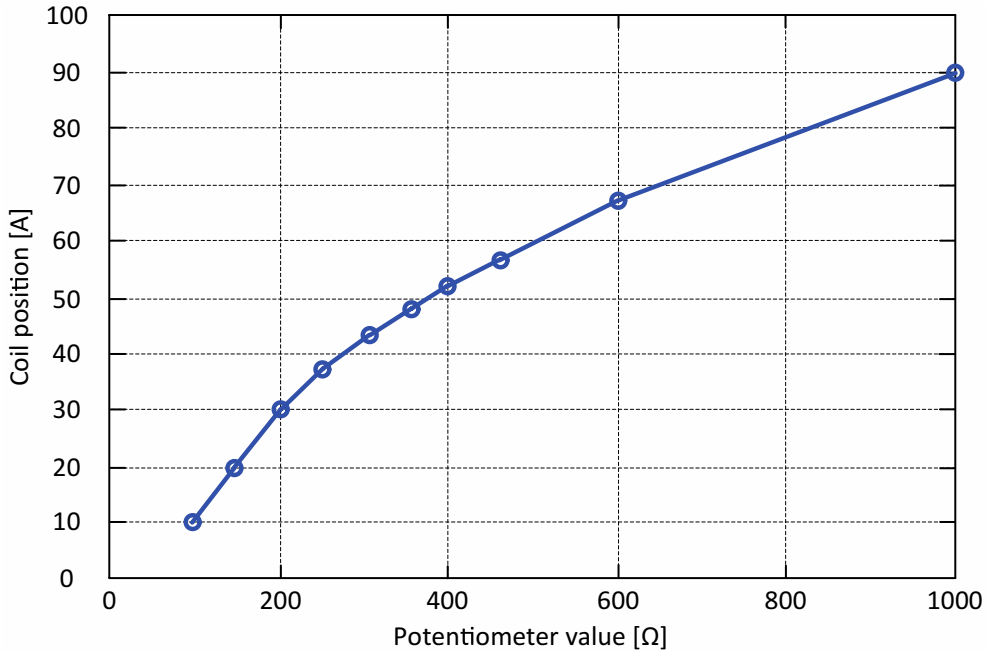



*Figure 825: Example of a linearization curve*

Aged ASCs can suffer from wearing of the position-indicating potentiometer. The potentiometer gaps are identified during the calibration and the number of the gaps is displayed on the HMI after the calibration. Actual gap locations GAP_LO_VAL_x and GAP_HI_VAL_x (x = 1…5, which corresponds to the gap identification number)

are visible in the Monitored data view. If the maximum number of five gap locations is exceeded, the first pair is overwritten.

The coil position should be known and the controller operation should be guaranteed even if no new calibration is done. When potentiometer gaps are present in either both ends or in the middle of the potentiometer range, the potentiometer should be replaced. These are the three critical points of the calibration where ohmic measurements must be precise.

The maximum percentage length of the potentiometer gap can be set with setting *Pot Max gap*. The controller determines a gap length by measuring the distance between both ends of a gap in ohms. A gap is indicated when the ohmic position exceeds 2000 Ω.

If the coil potentiometer enters a gap during the normal operation, the controller estimates the coil position based on its previous known position and coil movement speed. If the actual gap length exceeds the setting *Pot Max gap* or a new gap appears during daily operation, POT_ALARM output is activated. Moreover, TUNING_STS monitored data indicates the reason of alarm. High values of the *Pot Max gap* setting introduce inaccuracy to the coil movement as the coil position is based on a calculated estimate. The purpose of the gap detection functionality is to enable the controller operation even if the potentiometer is worn out during the normal operation. The potentiometer should be replaced during the next service break in order to guarantee accurate operation of the controller. The gap detection functionality can be disabled by setting the *Pot Max gap* value to 0. Potentiometer gaps are illustrated in Figure 826.

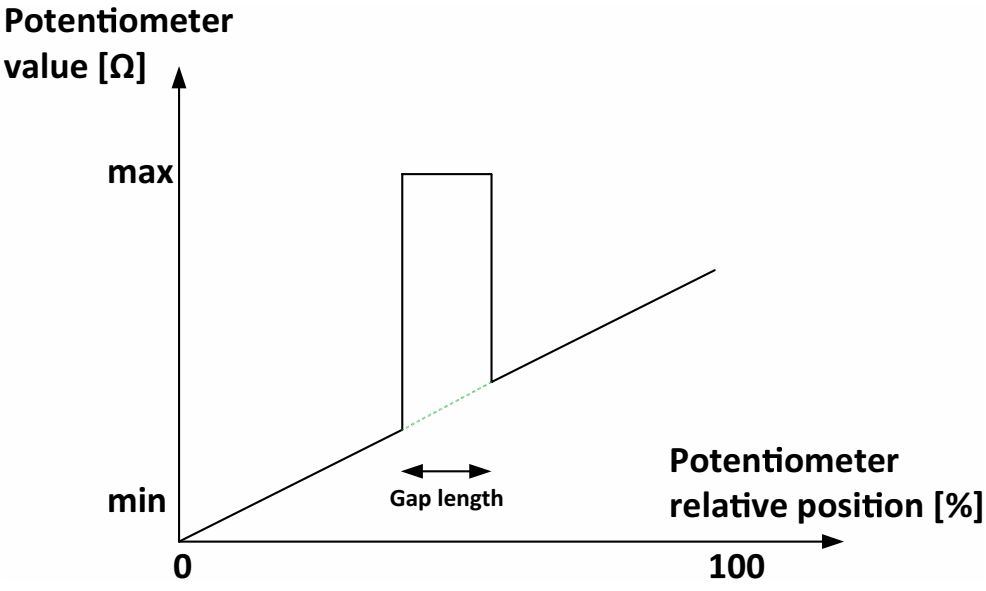



*Figure 826: Potentiometer gaps*

## 9.11.9 Signals

*Table 1431: PASANCR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| IRES | SIGNAL | - | Residual current |
| URES | SIGNAL | - | Residual voltage |
| COIL_POS | FLOAT32 | 0 | Coil position derived from the potentiometer reading |
| COIL_STS | BOOLEAN | 0=False | Connection status of the variable arc suppression coil |
| FIXCOIL_STS | BOOLEAN | 0=False | Connection status of the fixed coil |
| RESISTOR_STS | BOOLEAN | 0=False | Connection status of the parallel current raising resistor |
| HIGH_LIMIT | BOOLEAN | 0=False | High end position reached |
| LOW_LIMIT | BOOLEAN | 0=False | Low end position reached |
| ST_CALIB | BOOLEAN | 0=False | Rising edge of this signal triggers the calibration procedure of the coil |
| ST_TUNING | BOOLEAN | 0=False | Rising edge of this signal triggers the automatic tuning procedure |
| ST_RESIS_SEQ | BOOLEAN | 0=False | Rising edge of this signal triggers the resistor control sequence |
| RAISE_LOCAL | BOOLEAN | 0=False | Increase arc suppression coil current |
| LOWER_LOCAL | BOOLEAN | 0=False | Decrease arc suppression coil current |
| PARALLEL | BOOLEAN | 0=False | Parallel controller has coil movement in progress |
| BLK_AUTO | BOOLEAN | 0=False | Blocking the coil automatic tuning |
| BLK_MANUAL | BOOLEAN | 0=False | Blocking the coil manual operation |
| BLK_RESISTOR | BOOLEAN | 0=False | Disconnect and block switching on the parallel resistor |

*Table 1432: PASANCR Output signals*

| Name | Type | Description |
|---|---|---|
| RAISE_OWN | BOOLEAN | Increase coil current |
| LOWER_OWN | BOOLEAN | Decrease coil current |
| FIXCOIL | BOOLEAN | Status information to control fixed coil on/off |
| OP_FIXCOIL | BOOLEAN | Command to disconnect fix coil |
| CL_FIXCOIL | BOOLEAN | Command to connect fix coil |
| RESISTOR | BOOLEAN | Status information to control parallel current rising resistor on/off |
| OP_RESISTOR | BOOLEAN | Command to disconnect parallel current rising resistor |
| CL_RESISTOR | BOOLEAN | Command to connect parallel current rising resistor |
| ALARM | BOOLEAN | General alarm indication |

Table continues on next page

| Name | Type | Description |
|---|---|---|
| MOT_ALARM | BOOLEAN | Motor alarm: no detected coil movement |
| POT_ALARM | BOOLEAN | Potentiometer alarm |
| EARTH_FAULT | BOOLEAN | Earth-fault indication |
| TUNING_ACT | BOOLEAN | Automatic tuning procedure ongoing |

## 9.11.10 Settings

*Table 1433: PASANCR Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Compensation mode | 1=Absolute<br>2=Relative | | | 1=Absolute | Compensation degree in absolute amperes or relative to the resonance point |
| Detuning level | -100...100 | A | 1 | 0 | Detuning level in amperes |
| Detuning level RI | -100.0...100.0 | % | 0.1 | 0.0 | Detuning level in percents |
| V Res change level | 0.0...1000.0 | %Uref | 0.1 | 10.0 | Zero-sequence voltage change threshold as percent of reference voltage |
| V Res Meas mode | 1=Amplitude<br>2=Phasor | | | 2=Phasor | Uo trigger based on amplitude or phasor measurement |
| Tuning delay | 0...3600 | s | 1 | 60 | Zero-sequence voltage trigger delay to start control procedure |
| V Res variation | 0.1...100.0 | %Un | 0.1 | 2.0 | Req. change in Uo that calc. of net. param. can be executed |
| Tuning mode | 1=Coil movement<br>2=Resistor switching | | | 1=Coil movement | Method for obtaining Uo variation |
| V Ref adaptive mode | 0=Disable<br>1=Enable | | | 1=Enable | Uref adaptive mode |
| V Ref adaptive delay | 0...1000 | min | 1 | 20 | Uref adaptive delay |
| V Res EF level | 0.00...100.00 | %Un | 0.01 | 15.00 | Uo level for detection of earth fault in the network |
| Default position | 0...1000 | A | 1 | 50 | Coil default position |
| V Res minimum | 0.00...20.00 | %Un | 0.01 | 0.10 | Minimum level for zero-sequence voltage to allow coil automatic tuning |
| V Res maximum | 0.00...150.00 | %Un | 0.01 | 10.00 | Maximum level for zero-sequence voltage allowed during automatic tuning process |
| Temporary damping | 0=False<br>1=True | | | 0=False | Resistor switching on/off allowed during the automatic tuning procedure |
| Minimum current | 0...100 | A | 1 | 0 | Minimum current of arc-suppression coil (low operating limit) |
| Maximum current | 0...10000 | A | 1 | 10000 | Maximum current of arc-suppression coil (high operating limit) |
| Error position | 1=Current<br>2=Previous<br>3=Default | | | 2=Previous | Coil position in the case error occured during the automatic tuning process |
| Pass resonance | 0=False<br>1=True | | | 0=False | Pass resonance enabled / disabled |
| Transient time EF | 0...1000000 | ms | 1 | 5 | Transient earth-fault duration threshold |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| EF mode | 1=Blocked during EF<br>2=Resonance<br>3=Tuning during EF | | | 1=Blocked during EF | Operation mode during earth-fault (alarming earth-fault) |
| Resistor healthy St | 0=Off<br>1=On | | | 0=Off | Resistor connection status during healthy state operation |
| Resistor repeats | 0...100 | | 1 | 0 | Number of resistor control sequence repeats |
| Resistor pause | 0...100000000 | ms | 1 | 5 | Time between consecutive resistor control sequence repeats |
| Resonance curve Cur | 1=Icoil<br>2=Icoil + Ifix | | | 2=Icoil + Ifix | Resonance curve x-axis title on HMI |
| Switch on delay 1 | 0...300000 | ms | 1 | 1000 | Resistor switch-on delay time |
| Time on 1 | 0...300000 | ms | 1 | 1000 | Resistor switch on time |
| Switch on delay 2 | 0...300000 | ms | 1 | 1000 | Resistor repetition switch-on delay time |
| Time on 2 | 0...300000 | ms | 1 | 1000 | Resistor repetition switch-on time |
| Switch off delay 1 | 0...300000 | ms | 1 | 1000 | Resistor switch-off delay time |
| Time off 1 | 0...300000 | ms | 1 | 1000 | Resistor switch-off time |
| Switch off delay 2 | 0...300000 | ms | 1 | 1000 | Resistor repetition switch-off delay time |

*Table 1434: PASANCR Group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Tuning cycles | 0...100 | | 1 | 5 | Maximum number of tuning cycles |
| Tuning cycle delay | 0...86400 | s | 1 | 300 | Delay between consecutive tuning cycles |

*Table 1435: PASANCR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Coil V Nom | 0...400000 | V | 1 | 10000 | Adjustable arc suppression coil nominal voltage |
| Fix coil V Nom | 0...400000 | V | 1 | 10000 | Fixed arc suppression coil nominal voltage |
| Auxiliary Wnd V Nom | 0...10000 | V | 1 | 500 | Power auxiliary winding nominal voltage |
| Controller mode | 0=Manual<br>1=Automatic | | | 0=Manual | Coil controller operating in automatic or manual mode |
| Parallel resistor | 0=False<br>1=True | | | 0=False | Parallel resistor installation status |
| R0Transformer | 0...100 | ohm | 1 | 0 | Zero-sequence resistance of the earthing/ main transformer |
| X0Transformer | 0...100 | ohm | 1 | 0 | Zero-sequence reactance of the earthing/ main transformer |
| Voltage measurement | 1=Busbar<br>2=Coil | | | 2=Coil | Residual voltage measurement from busbar or from coil |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Position Meas mode | 1=Pos. indication<br>2=Pos. ind. and meas. | | | 1=Pos. indication | Coil position measurement mode |
| Resistor control | 1=OFF<br>2=ON<br>3=Automatic | | | 1=OFF | Resistor control mode |
| Resistor Nom value | 0.00...100.00 | ohm | 0.01 | 5.00 | Nominal resistance of the parallel resistor at power auxiliary winding secondary voltage level |
| Coil losses | 0.00...20.00 | % | 0.01 | 2.00 | Coil losses |
| Fix coil value | 0...10000 | A | 1 | 0 | Inductive current produced by fixed coil at fixed coil nominal voltage level |
| Fix coil losses | 0.00...20.00 | % | 0.01 | 2.00 | Fix coil losses |
| Pot Max gap | 0...100 | % | 1 | 5 | Potentiometer maximum gap length |
| Fix coil type | 1=OFF<br>2=ON<br>3=Automatic | | | 1=OFF | Fix coil type |
| Level detector op | 0=Disable<br>1=Enable | | | 1=Enable | Enable / disable level detector module |
| Pot value 1 | 0...3000 | ohm | 1 | 0 | Potentiometer value 1 |
| Coil current 1 | 0...10000 | A | 1 | 0 | Coil current 1 |
| Pot value 2 | 0...3000 | ohm | 1 | 0 | Potentiometer value 2 |
| Coil current 2 | 0...10000 | A | 1 | 0 | Coil current 2 |
| Pot value 3 | 0...3000 | ohm | 1 | 0 | Potentiometer value 3 |
| Coil current 3 | 0...10000 | A | 1 | 0 | Coil current 3 |
| Pot value 4 | 0...3000 | ohm | 1 | 0 | Potentiometer value 4 |
| Coil current 4 | 0...10000 | A | 1 | 0 | Coil current 4 |
| Pot value 5 | 0...3000 | ohm | 1 | 0 | Potentiometer value 5 |
| Coil current 5 | 0...10000 | A | 1 | 0 | Coil current 5 |
| Pot value 6 | 0...3000 | ohm | 1 | 0 | Potentiometer value 6 |
| Coil current 6 | 0...10000 | A | 1 | 0 | Coil current 6 |
| Pot value 7 | 0...3000 | ohm | 1 | 0 | Potentiometer value 7 |
| Coil current 7 | 0...10000 | A | 1 | 0 | Coil current 7 |
| Pot value 8 | 0...3000 | ohm | 1 | 0 | Potentiometer value 8 |
| Coil current 8 | 0...10000 | A | 1 | 0 | Coil current 8 |
| Pot value 9 | 0...3000 | ohm | 1 | 0 | Potentiometer value 9 |
| Coil current 9 | 0...10000 | A | 1 | 0 | Coil current 9 |
| Pot value 10 | 0...3000 | ohm | 1 | 0 | Potentiometer value 10 |
| Coil current 10 | 0...10000 | A | 1 | 0 | Coil current 10 |

## 9.11.11 Monitored data

*Table 1436: PASANCR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| COIL_MV_SPD | FLOAT32 | 0.00...100.00 | A/s | Coil movement speed detected during calibration |
| I_AFTER_RUN | FLOAT32 | 0.00...100.00 | A | Coil after-running current |
| I_MCH_PLAY | FLOAT32 | 0.00...100.00 | A | Mechanical play of the coil |
| I_COIL_TOT | FLOAT32 | 0.00...10000.00 | A | Total inductive current of adjustable and fixed arc suppression coil |
| OHM_COIL | FLOAT32 | 0...3000 | ohm | Coil position indicating potentiometer value |
| I_DAMPING | FLOAT32 | 0.00...10000.00 | A | Wattmetric part of the residual current at the fault location |
| I_C_NETWORK | FLOAT32 | 0.00...10000.00 | A | Uncompensated earth-fault current of the network |
| I_EF | FLOAT32 | 0.00...10000.00 | A | Earth-fault current at present operate point |
| I_RESONANCE | FLOAT32 | 0.00...10000.00 | A | Current at the resonance point |
| DAMPING | FLOAT32 | 0.00...100.00 | | Damping of the network |
| I_DETUNING | FLOAT32 | -100.00...100.00 | A | Petersen coil detuning in amperes |
| DETUNING_REL | FLOAT32 | -100.00...100.00 | % | Petersen coil detuning in percents |
| UREF_AMPL | FLOAT32 | 0.00...100.00 | xUn | Reference voltage amplitude |
| UREF_ANG | FLOAT32 | -180.00...180.00 | deg | Reference voltage angle |
| URESO_AMPL | FLOAT32 | 0...100000 | V | Resonance point voltage amplitude without the parallel resistor |
| URESO_REL | FLOAT32 | 0.0...100.0 | % | Resonance point voltage in percent without the parallel resistor |
| URESO_AMPL_R | FLOAT32 | 0...100000 | V | Resonance point voltage amplitude with the parallel resistor connected |
| URESO_REL_R | FLOAT32 | 0.0...100.0 | % | Resonance point voltage in percent with the parallel resistor connected |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TUNING_TRIGG | FLOAT32 | 0...100 | % | Percentage value indicating present deviation in zero-sequence voltage with respect to reference voltage |
| GAP_LO_VAL_1 | FLOAT32 | 0...3000 | ohm | Potentiometer 1st gap low value |
| GAP_HI_VAL_1 | FLOAT32 | 0...3000 | ohm | Potentiometer 1st gap high value |
| GAP_LO_VAL_2 | FLOAT32 | 0...3000 | ohm | Potentiometer 2nd gap low value |
| GAP_HI_VAL_2 | FLOAT32 | 0...3000 | ohm | Potentiometer 2nd gap high value |
| GAP_LO_VAL_3 | FLOAT32 | 0...3000 | ohm | Potentiometer 3rd gap low value |
| GAP_HI_VAL_3 | FLOAT32 | 0...3000 | ohm | Potentiometer 3rd gap high value |
| GAP_LO_VAL_4 | FLOAT32 | 0...3000 | ohm | Potentiometer 4th gap low value |
| GAP_HI_VAL_4 | FLOAT32 | 0...3000 | ohm | Potentiometer 4th gap high value |
| GAP_LO_VAL_5 | FLOAT32 | 0...3000 | ohm | Potentiometer 5th gap low value |
| GAP_HI_VAL_5 | FLOAT32 | 0...3000 | ohm | Potentiometer 5th gap high value |
| CLC_SEQ_WRN | BOOLEAN | 0=False<br>1=True | | Maximum number of tuning cycles is reached |
| DEFAULT_POS | BOOLEAN | 0=False<br>1=True | | Coil has been moved to its default position |
| ERROR_POS | BOOLEAN | 0=False<br>1=True | | Coil has been moved to its error position |
| UMAX_RES_STS | BOOLEAN | 0=False<br>1=True | | Zero-sequence voltage has reached U0 max level |
| UMIN_RES_STS | BOOLEAN | 0=False<br>1=True | | Zero-sequence voltage has reached Uo min level |
| TUNING_DL_ON | BOOLEAN | 0=False<br>1=True | | Tuning delay ongoing |
| TUNING_ST_DELAY | INT32 | 0...3600 | s | Remaining delay time in seconds to start automatic tuning procedure |
| OPR_TIME | INT32 | 0...999999 | h | Controller time in operation (hours) |
| CNT_TUNINGS | INT32 | 0...999999 | | Counter of started tuning procedures |
| CNT_TUNED | INT32 | 0...999999 | | Counter of successful tuning procedures |
| CNT_CNL_TUN | INT32 | 0...999999 | | Counter of cancelled tuning procedures |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| CNT_TUN_UMAX | INT32 | 0...999999 | | Counter of coil final tuning position at Uo max |
| CNT_TUN_HIGH | INT32 | 0...999999 | | Counter of cases when coil final tuning position is at high limit (high end switch or high operating limit) |
| CNT_TUN_LOW | INT32 | 0...999999 | | Counter of cases when coil final tuning position is at low limit (low end switch or low operating limit) |
| CNT_TRNS_EF | INT32 | 0...999999 | | Counter of transient earth-faults |
| CNT_EF | INT32 | 0...999999 | | Counter of earth-faults |
| CNT_RES_SW_A | INT32 | 0...999999 | | Counter of parallel resistor automatic switching operations |
| CNT_RES_SW_M | INT32 | 0...999999 | | Counter of parallel resistor manual switching operations |
| MOT_RUN_TIME | INT32 | 0...999999 | h | Total arc suppression coil motor run time (hours) |
| CALIB_RSL | Enum | 1=Calibration successful<br>2=Calibration ongoing<br>3=Calibration failed<br>4=Not calibrated | | Calibration result |
| CALIB_STS | Enum | 1=Detect end switches<br>2=Move to middle position<br>3=Detect mechanical play<br>4=Detect after running<br>5=Detect potentiometer gaps<br>6=Calibration not ongoing | | Calibration status |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ALARM_STS | Enum | 1=No alarm<br>2=No movement detected<br>3=Movement into wrong direction<br>4=Simultaneously indication from both end-switches<br>5=Potentiometer maximum gap length exceeded<br>6=Potentiometer new gap appeared<br>7=Maximum number of potentiometer gaps exceeded<br>8=Check measurements<br>9=Umin not reached<br>10=Cannot obtain minimum Uo variation | | Alarm status |
| TUNING_STS | Enum | 1=Tuned successfully<br>2=Not tuned<br>3=Tuned at Umax<br>4=Tuned at low limit (low end switch or low operating limit)<br>5=Tuned at high limit (high end switch or high operating limit)<br>6=Tuning delay ongoing<br>7=Tuning ongoing | | Tuning status |
| BSYMM | FLOAT32 | -1000.000...1000.000 | mS | Symmetrical susceptance of network |
| GSYMM | FLOAT32 | -1000.000...1000.000 | mS | Symmetrical conductance of network |
| BASYMM | FLOAT32 | -1000.000...1000.000 | mS | Asymmetrical susceptance of network |
| GASYMM | FLOAT32 | -1000.000...1000.000 | mS | Conductance of network |
| BSYMM_REF | FLOAT32 | -1000.000...1000.000 | mS | Reference value of symmetrical susceptance of network |
| GSYMM_REF | FLOAT32 | -1000.000...1000.000 | mS | Reference value of symmetrical conductance of network |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| BASYMM_REF | FLOAT32 | -1000.000...1000.000 | mS | Reference value of symmetrical conductance of network |
| GASYMM_REF | FLOAT32 | -1000.000...1000.000 | mS | Reference value of asymmetrical susceptance of network |
| BCOIL | FLOAT32 | -1000.000...1000.000 | mS | Coil susceptance |
| GCOIL | FLOAT32 | -1000.000...1000.000 | mS | Coil conductance |
| BFIXCOIL | FLOAT32 | -1000.000...1000.000 | mS | Fixed parallel coil susceptance |
| GFIXCOIL | FLOAT32 | -1000.000...1000.000 | mS | Fixed parallel coil conductance |
| GPARALLEL | FLOAT32 | -1000.000...1000.000 | mS | Parallel resistor conducatance |
| I_COIL_HMI | FLOAT32 | 0.00...10000.00 | A | Coil current value dedicated for HMI purposes (depends on Resonance curve Cur setting) |
| I_COIL | FLOAT32 | 0.00...10000.00 | A | Adjustable arc suppression coil value |
| CALIB_O_MIN | FLOAT32 | 0...3000 | ohm | Low end switch position of the coil (ohms) |
| CALIB_O_MAX | FLOAT32 | 0...3000 | ohm | High end switch position of the coil (ohms) |
| PASANCR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 9.11.12 Technical data

*Table 1437: PASANCR Technical data*

| Characteristic | Value |
|---|---|
| Measuring accuracy | Resistance:<br>±2% or ±1 Ω |
| Operation accuracy[1)] | I_RESONANCE:<br>Typically ±2 A |
| | I_DAMPING:<br>Typically ±2 A |

1) Network resonance point voltage must be at least 0.01 × $U_n$, where $U_n$ = nominal phase-to-earth voltage

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# Section 10 Power quality measurement functions

## 10.1 Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics CHMHAI

### 10.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics | CHMHAI | PQM3IH | PQM ITHD,IDC |

### 10.1.2 Function block

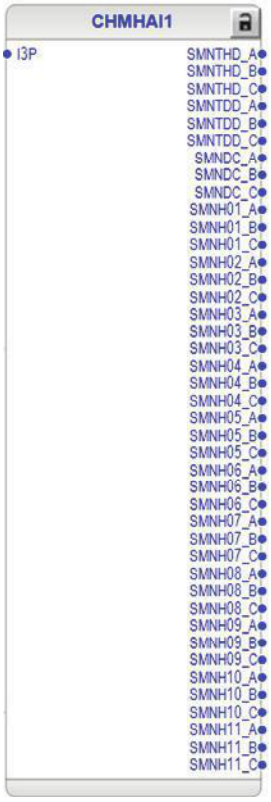



*Figure 827: Function block*

## 10.1.3 Functionality

Harmonic current values are available as measurements for each harmonic, THD and TDD. There are also direct current component and fundamental frequency values. The values of three phases are calculated separately.

There are short-time sliding measurement mean values (3 seconds, 1 minute or 5 minutes). In the configuration tool these values can be connected to other logics. Blocks can be used as limiters, timers and multipurpose analog protection, and alarms can be created when needed.

Non-sliding 10-minute measured mean values are available via communication to substation monitoring products such as COM600S. Only the main function part with an analog signal input must be connected in relay configuration. Data can be collected and stored with the substation monitoring system to the historian database.

These mean values can also be found in the LHMI menus of the protection relay and WHMI.

The applicable power quality standards include EN 50160:2010, IEEE 519-2014, IEC 61000-4-7:2002+A1:2008 and IEC 61000-4-30:2015.

## 10.1.4 Analog channel configuration

CHMHAI has one analog group input which must be properly configured.

*Table 1438: Analog inputs*

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 10.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off". Changes will result to reset the function internal data.

The operation of CHMHAI can be described with a module diagram. All the modules in the diagram are explained in the next sections.

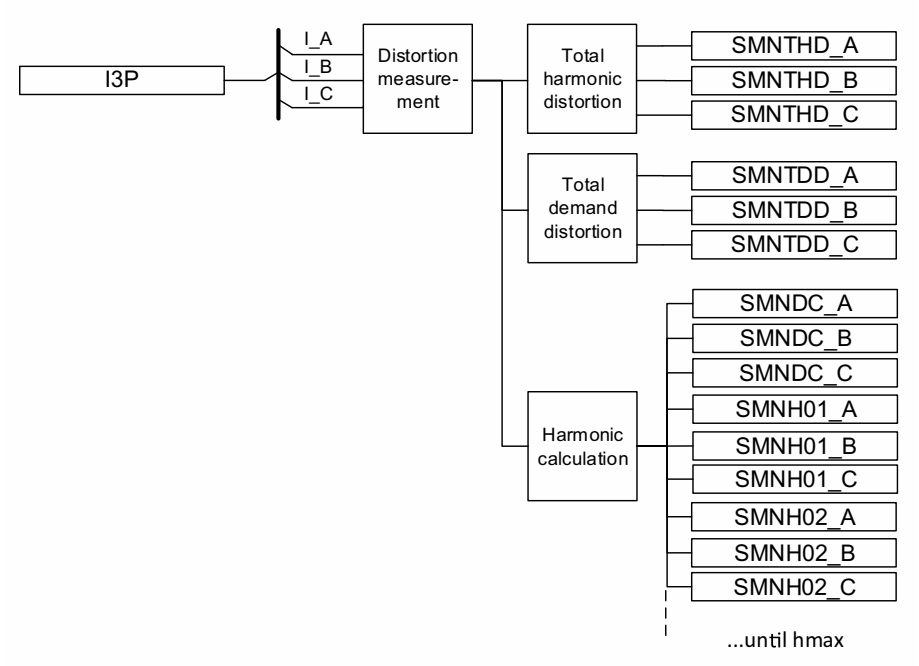



*Figure 828: Functional module diagram*

## Distortion measurement

The Distortion measurement module measures harmonics up to the 11$^{th}$ harmonic.

The filter used for harmonics includes a spectrum of frequencies near each harmonic frequency. FFT for one period is used. The resulting frequency spectrum is wider than in a harmonic subgroup. An anti-aliasing filter is used.

## Total harmonic distortion

The total harmonic distortion THD is calculated from the measured harmonic components with the formula

$$THD = \sqrt{\sum_{h=2}^{n}\left(\frac{I_h}{I_1}\right)^2}$$

(Equation 351)

$I_h$ h$^{th}$ harmonic component

$I_1$ Fundamental frequency current (1$^{st}$ harmonic)

n Number of harmonics

THD sliding mean value outputs are SMNTHD_A, SMNTHD_B and SMNTHD_C. Non-sliding 10-minute mean values LMNTHD_A, LMNTHD_B and LMNTHD_C are seen in the monitored data. These values are always shown as percentage of the fundamental frequency current mean value. The 10-minute mean values follow 10 min ticks. See also Figure 829 and the description for sliding values.

## Total demand distortion

The total demand distortion TDD is calculated from the measured harmonic components with the formula

$$TDD = \sqrt{\sum_{h=2}^{n}\left(\frac{I_h}{I_L}\right)^2}$$

(Equation 352)

$I_h$ $h^{th}$ harmonic component

$I_L$ Maximum demand load current set with *Demand current* setting

n Number of harmonics

The used reference current is the absolute value of the *Demand current* setting. It is typically set according to the maximum load current of the feeder. The TDD value is calculated separately for each phase.

TDD sliding mean value outputs are SMNTDD_A, SMNTDD_B and SMNTDD_C. Non-sliding 10-minute mean values LMNTDD_A, LMNTDD_B and LMNTDD_C are seen in the monitored data. These values are always shown as percentage of the setting *Demand current*. The 10-minute mean values follow 10 min ticks. See also Figure 829 and the description for sliding values.

## Harmonic calculation

Harmonic mean values are calculated for each phase. Also, the mean values of the nominal frequency (fundamental) and direct current component are calculated. The fundamental frequency mean values are shown as percentage of the nominal phase current.

The actual harmonic mean values are shown as percentage of the reference current. By default, the fundamental frequency current is used as reference. This can be selected by setting *Reference Cur Sel* to "fundamental". When amplitude of fundamental frequency current is very low, below 0.02 xIn, calculation is blocked internally. As a result, value zero is used in the mean value calculation. Extremely high harmonic values are limited to 2.0 xIn. This is also used for fundamental mean value, but not for reference.

The value of *Demand current* setting can be used as reference by setting *Reference Cur Sel* to "absolute". Typically, it is set according to the maximum demand load current. That is more typically used when TDD is preferred, but might also be found useful when THD is monitored.

Settings *Reference Cur Sel* and *Demand current* have no effect in THD calculation, but setting *Demand current* is used in TDD calculation.

The calculation window length is set with the *Sliding interval* setting. It has three window lengths ("3 seconds", "1 minute" or "5 minutes") for sliding mean value outputs. Output values can also be seen in monitoring.

The window type used for configuration tool output values is always sliding. Output values are updated once every 0.1 seconds.

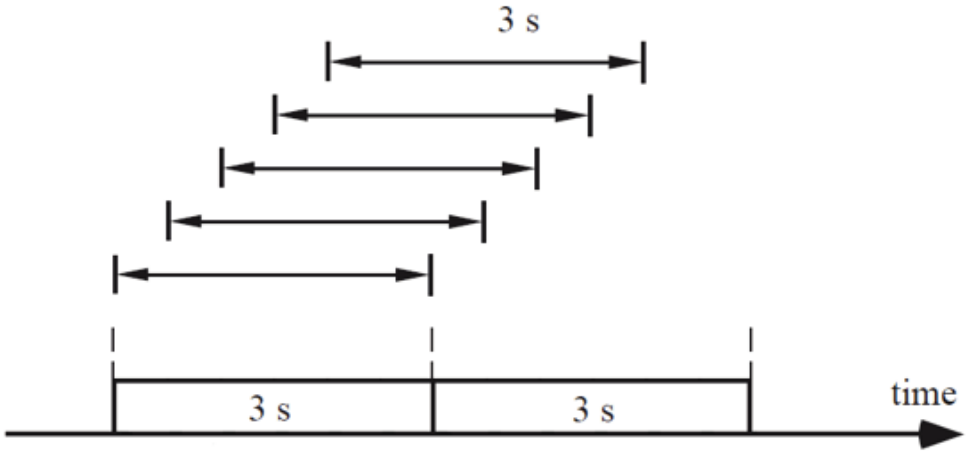



*Figure 829: Sliding 3 seconds value calculation in principle*

The sliding mean values of the fundamental of each phase are SMNH01_A, SMNH01_B and SMNH01_C. Actual harmonics are seen with their number, for example, phase A for second harmonic is SMNH02_A and phase C for 9th harmonic is SMNH09_C. Direct current component outputs are SMNDC_A, SMNDC_B and SMNDC_C.

Intervals that are longer than 3 seconds are calculated using free running 3-second mean values.

The longer 10-minute mean values of the fundamental of each phase are seen in monitored data as LMNH01_A, LMNH01_B and LMNH01_C. Actual harmonics are seen with their number. Direct current components are LMNDC_A, LMNDC_B and LMNDC_C.

Time stamps for ready 10-minute mean value calculation can be seen in the monitored data L time stamp.

The window type used for the 10-minute mean value calculation is always non-sliding. The 10-minute value calculation begins based on the protection relay's internal clock 10 minutes time (for example,11:00, 11:10, 11:20, 11:30, 11:40, 11:50, 12:00…). This is called 10 min tick.

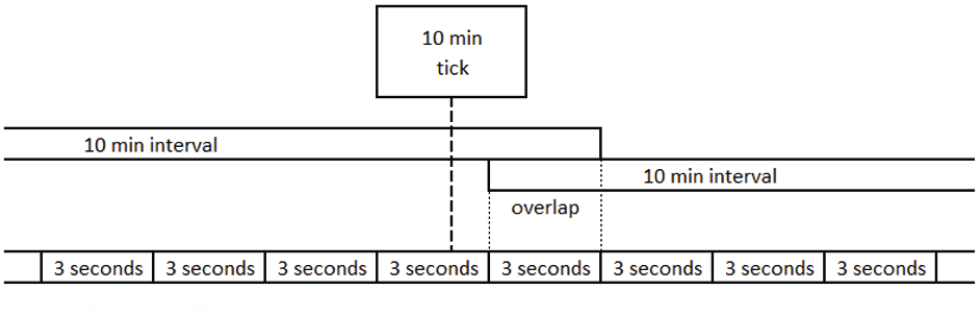



*Figure 830: The 10-minute interval with time synchronization and free running 3 seconds*

The 10-minute mean value is shown in the monitored data until the next 10-minute mean value has been cumulated. Another 10-minute calculation might be started when time synchronization is used to change the protection relay's internal clock. The first calculation continues for 10 minutes and is then seen in the monitored data with a time stamp. An event is sent every time a 10-minute value calculation is ready in the monitored data.

See the Time synchronization chapter in this document.

When the protection relay is powered on, the shown value is zero until the first 10-minute mean value has been cumulated. During this time, the 10-minute output quality is marked questionable in the IEC 61850 data.

When the settings *Reference Cur Sel* or *Demand current* are changed, older data is not cleared. Although older data is calculated based on different setting values, those can still be used as they are used to calculate mean values. The influence might be seen in mean values. These are considered as minor adjustments to the reference current, similar to varying fundamental current.

Changing setting *Sliding interval* has influence on the seen mean values. Sliding values change slowly towards the input value during the time interval. When mean values have not been calculated for a full interval, quality is marked questionable in the IEC 61850 data. Questionable quality is also indicated for a full interval if the protection relay is reset.

## 10.1.6 Application

Typically, the measured short-time 3-second mean values are used with a suitable logic to give alarms. If a more stabilized value is needed, a 1-minute or 5-minute mean value should be selected.

One example of using short-time mean values is to compare the level of THD or TDD and some harmonics, for example, $5^{th}$ and $7^{th}$. The values to be compared to the same limit can be combined with MAX3R and MAPGAPC can be used to test if the settable

limit value is exceeded. Outputs of MAPGAPC can be connected to the needed logic and, for example, an event can be sent with MVGAPC.

The 10-minute mean values can be collected to an external substation monitoring system. Collected data can be used in weekly reporting. If longer mean values are needed, the collected 10-minute mean values can be used to calculate, for example, two-hour mean values.

Typically, 10-minute THD or TDD mean values are collected from all three phases. Individual harmonics and the fundamental frequency component can also be collected.

## 10.1.7 Signals

*Table 1439: CHMHAI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |

*Table 1440: CHMHAI Output signals*

| Name | Type | Description |
|---|---|---|
| SMNTHD_A | FLOAT32 | Mean THD for phase A in 3 s, 1 min or 5 min mean (%) |
| SMNTHD_B | FLOAT32 | Mean THD for phase B in 3 s, 1 min or 5 min mean (%) |
| SMNTHD_C | FLOAT32 | Mean THD for phase C in 3 s, 1 min or 5 min mean (%) |
| SMNTDD_A | FLOAT32 | Mean TDD for phase A in 3 s, 1 min or 5 min mean (%) |
| SMNTDD_B | FLOAT32 | Mean TDD for phase B in 3 s, 1 min or 5 min mean (%) |
| SMNTDD_C | FLOAT32 | Mean TDD for phase C in 3 s, 1 min or 5 min mean (%) |
| SMNDC_A | FLOAT32 | Shorter mean value of DC component for Phase A (%) |
| SMNDC_B | FLOAT32 | Shorter mean value of DC component for Phase B (%) |
| SMNDC_C | FLOAT32 | Shorter mean value of DC component for Phase C (%) |
| SMNH01_A | FLOAT32 | Shorter mean value of basic freq. for Phase A (%) |
| SMNH01_B | FLOAT32 | Shorter mean value of basic freq. for Phase B (%) |
| SMNH01_C | FLOAT32 | Shorter mean value of basic freq. for Phase C (%) |
| SMNH02_A | FLOAT32 | Shorter mean value of 2nd harmonic for Phase A (%) |
| SMNH02_B | FLOAT32 | Shorter mean value of 2nd harmonic for Phase B (%) |
| SMNH02_C | FLOAT32 | Shorter mean value of 2nd harmonic for Phase C (%) |

Table continues on next page

| Name | Type | Description |
|---|---|---|
| SMNH03_A | FLOAT32 | Shorter mean value of 3rd harmonic for Phase A (%) |
| SMNH03_B | FLOAT32 | Shorter mean value of 3rd harmonic for Phase B (%) |
| SMNH03_C | FLOAT32 | Shorter mean value of 3rd harmonic for Phase C (%) |
| SMNH04_A | FLOAT32 | Shorter mean value of 4th harmonic for Phase A (%) |
| SMNH04_B | FLOAT32 | Shorter mean value of 4th harmonic for Phase B (%) |
| SMNH04_C | FLOAT32 | Shorter mean value of 4th harmonic for Phase C (%) |
| SMNH05_A | FLOAT32 | Shorter mean value of 5th harmonic for Phase A (%) |
| SMNH05_B | FLOAT32 | Shorter mean value of 5th harmonic for Phase B (%) |
| SMNH05_C | FLOAT32 | Shorter mean value of 5th harmonic for Phase C (%) |
| SMNH06_A | FLOAT32 | Shorter mean value of 6th harmonic for Phase A (%) |
| SMNH06_B | FLOAT32 | Shorter mean value of 6th harmonic for Phase B (%) |
| SMNH06_C | FLOAT32 | Shorter mean value of 6th harmonic for Phase C (%) |
| SMNH07_A | FLOAT32 | Shorter mean value of 7th harmonic for Phase A (%) |
| SMNH07_B | FLOAT32 | Shorter mean value of 7th harmonic for Phase B (%) |
| SMNH07_C | FLOAT32 | Shorter mean value of 7th harmonic for Phase C (%) |
| SMNH08_A | FLOAT32 | Shorter mean value of 8th harmonic for Phase A (%) |
| SMNH08_B | FLOAT32 | Shorter mean value of 8th harmonic for Phase B (%) |
| SMNH08_C | FLOAT32 | Shorter mean value of 8th harmonic for Phase C (%) |
| SMNH09_A | FLOAT32 | Shorter mean value of 9th harmonic for Phase A (%) |
| SMNH09_B | FLOAT32 | Shorter mean value of 9th harmonic for Phase B (%) |
| SMNH09_C | FLOAT32 | Shorter mean value of 9th harmonic for Phase C (%) |
| SMNH10_A | FLOAT32 | Shorter mean value of 10th harmonic for Phase A (%) |
| SMNH10_B | FLOAT32 | Shorter mean value of 10th harmonic for Phase B (%) |
| SMNH10_C | FLOAT32 | Shorter mean value of 10th harmonic for Phase C (%) |

Table continues on next page

| Name | Type | Description |
|---|---|---|
| SMNH11_A | FLOAT32 | Shorter mean value of 11th harmonic for Phase A (%) |
| SMNH11_B | FLOAT32 | Shorter mean value of 11th harmonic for Phase B (%) |
| SMNH11_C | FLOAT32 | Shorter mean value of 11th harmonic for Phase C (%) |

## 10.1.8 Settings

*Table 1441: CHMHAI Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Sliding interval | 1=3 seconds<br>2=1 minute<br>3=5 minutes | | | 1=3 seconds | Time interval for demand calculation |

*Table 1442: CHMHAI Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reference Cur Sel | 0=fundamental<br>2=absolute | | | 0=fundamental | Selection of reference current used with individual harmonics |
| Demand current | 0.10...1.00 | xIn | 0.01 | 1.00 | Reference current for harmonic demand calculation |

## 10.1.9 Monitored data

*Table 1443: CHMHAI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNTHD_A | FLOAT32 | 0.00...500.00 | % | Mean THD for phase A in 10 min non-sliding mean in % |
| LMNTHD_B | FLOAT32 | 0.00...500.00 | % | Mean THD for phase B in 10 min non-sliding mean in % |
| LMNTHD_C | FLOAT32 | 0.00...500.00 | % | Mean THD for phase C in 10 min non-sliding mean in % |
| LMNTDD_A | FLOAT32 | 0.00...500.00 | % | Mean TDD for phase A in 10 min non-sliding mean in % |
| LMNTDD_B | FLOAT32 | 0.00...500.00 | % | Mean TDD for phase B in 10 min non-sliding mean in % |
| LMNTDD_C | FLOAT32 | 0.00...500.00 | % | Mean TDD for phase C in 10 min non-sliding mean in % |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNDC_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase A in % |
| LMNDC_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase B in % |
| LMNDC_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase C in % |
| LMNH01_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase A in % |
| LMNH01_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase B in % |
| LMNH01_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase C in % |
| LMNH02_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase A in % |
| LMNH02_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase B in % |
| LMNH02_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase C in % |
| LMNH03_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase A in % |
| LMNH03_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase B in % |
| LMNH03_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase C in % |
| LMNH04_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase A in % |
| LMNH04_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase B in % |
| LMNH04_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase C in % |
| LMNH05_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase A in % |
| LMNH05_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase B in % |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNH05_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase C in % |
| LMNH06_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase A in % |
| LMNH06_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase B in % |
| LMNH06_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase C in % |
| LMNH07_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase A in % |
| LMNH07_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase B in % |
| LMNH07_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase C in % |
| LMNH08_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase A in % |
| LMNH08_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase B in % |
| LMNH08_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase C in % |
| LMNH09_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase A in % |
| LMNH09_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase B in % |
| LMNH09_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase C in % |
| LMNH10_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase A in % |
| LMNH10_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase B in % |
| LMNH10_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase C in % |
| LMNH11_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase A in % |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNH11_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase B in % |
| LMNH11_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase C in % |
| L time stamp | Timestamp | | | Time stamp of end of 10 min mean values |

### 10.1.10 Technical data

*Table 1444: CHMHAI Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy[1)] | ±3.0% or ±0.2 |

1) Nominal frequency 50 Hz. Harmonics in the range 0…0.21 × fundamental amplitude

## 10.2 Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics VHMHAI

### 10.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics | VHMHAI | PQM3VH | PQM VTHD,VDC |

## 10.2.2 Function block

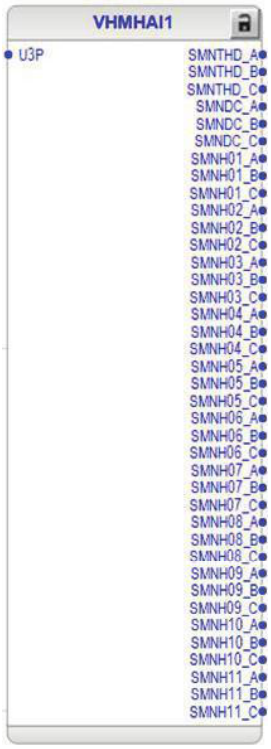



*Figure 831: Function block*

## 10.2.3 Functionality

Harmonic voltage values are available as measurements for each harmonic and THD. There are also direct current component and fundamental frequency values. The values of three phases are calculated separately.

There are short-time sliding measurement mean values (3 seconds, 1 minute or 5 minutes) which can be connected to other logics in the configuration tool. Blocks, such as limiters, timers and multipurpose analog protection, can be used and alarms can be created when needed.

Non-sliding 10-minute measured mean values are available via communication to substation monitoring products such as COM600S. Only the main function part with an analog signal input must be connected in relay configuration. Data can be collected and stored with the substation monitoring system to the historian database.

These mean values can also be found in the LHMI menus of the protection relay and WHMI.

The applicable power quality standards include EN 50160:2010, IEEE 519-2014, IEC 61000-4-7:2002+A1:2008 and IEC 61000-4-30:2015.

## 10.2.4 Analog channel configuration

VHMHAI has one analog group input which must be properly configured.

*Table 1445: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages for voltage harmonic measurement function VHMHAI |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1446: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that all three voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 10.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off". Changes will result to reset the function internal data.

The operation of VHMHAI can be described with a module diagram. All the modules in the diagram are explained in the next sections.

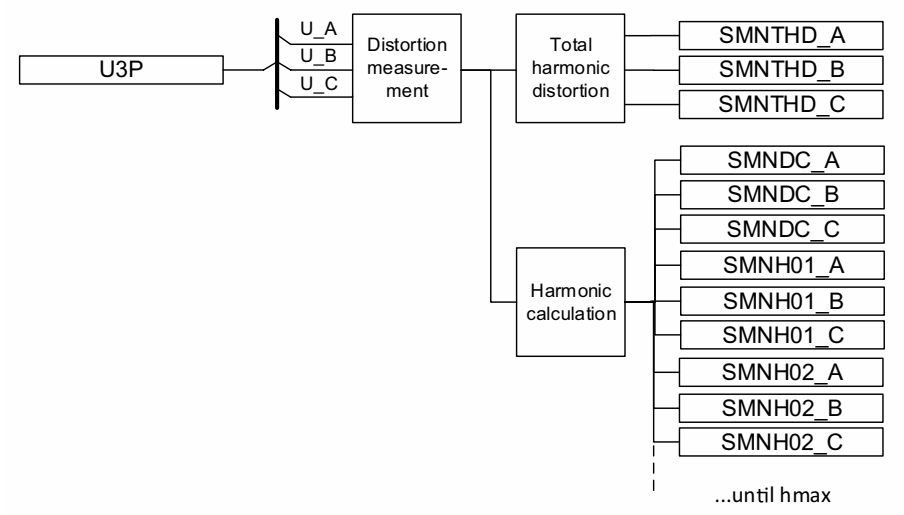



*Figure 832: Functional module diagram*

## Distortion measurement

The Distortion measurement module measures harmonics up to the 11$^{th}$ harmonic.

The filter used for harmonics includes a spectrum of frequencies near each harmonic frequency. FFT for one period is used. The resulting frequency spectrum is wider than in a harmonic subgroup. An anti-aliasing filter is used.

## Total harmonic distortion

The total harmonic distortion THD is calculated from the measured harmonic components with the formula

$$THD = \sqrt{\sum_{h=2}^{n}\left(\frac{U_h}{U_1}\right)^2}$$

(Equation 353)

$U_h$ h$^{th}$ harmonic component

$U_1$ Fundamental voltage (1$^{st}$ harmonic)

n Number of harmonics

THD shorter mean value outputs are SMNTHD_A, SMNTHD_B and SMNTHD_C. These and also the 10-minute mean values LMNTHD_A, LMNTHD_B and LMNTHD_C are seen in the monitored data. These values are always shown as percentage of the fundamental frequency's phase-to-earth voltage 3-second mean value. The 10-minute mean values also follow 10 min ticks. See also Figure 833 and the description for sliding values.

## Harmonic calculation

Harmonic mean values are calculated for each phase. Also, the mean values of the nominal frequency (fundamental) and direct current component are calculated. The fundamental frequency mean values are shown as percentage of the nominal phase-to-earth voltage.

The actual harmonic mean values are shown as percentage of the fundamental voltage. When the reference voltage (the fundamental voltage) is extremely low (below 0.02 xUn), the calculation is blocked internally. As a result, value zero is used in the mean value calculation of individual harmonics. Extremely high harmonic values are limited to 2.0 xUn.

The calculation window length is set with the *Sliding interval* setting. It has three window lengths ("3 seconds", "1 minute" or "5 minutes") for shorter mean value outputs. Output values can also be seen in the monitored data.

The window type used for configuration tool output values is always sliding. Output values are updated once every 0.1 seconds.

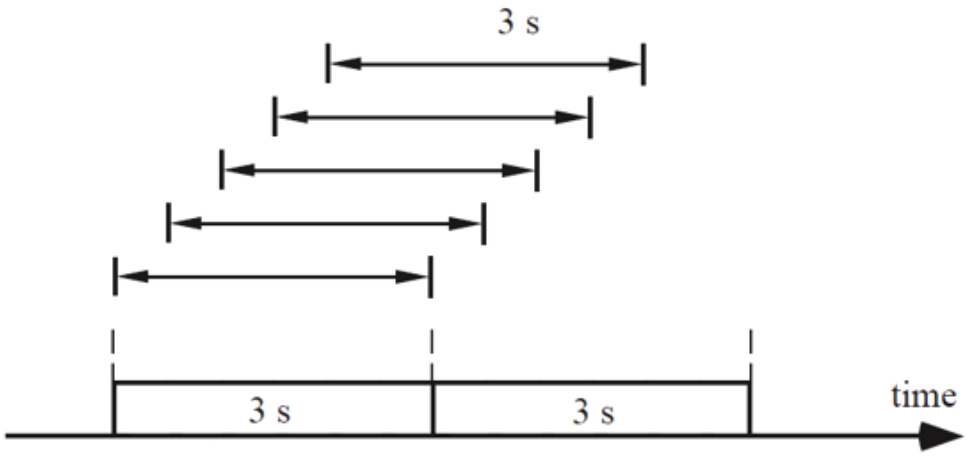



*Figure 833: Sliding 3 seconds value calculation in principle*

The shorter mean values of the fundamental of each phase are SMNH01_A, SMNH01_B and SMNH01_C. Actual harmonics are seen with their number, for example, phase A for second harmonic is SMNH02_A and phase C for 9$^{th}$ harmonic is SMNH09_C. Direct current component outputs are SMNDC_A, SMNDC_B and SMNDC_C.

Intervals that are longer than 3 seconds are calculated using free running 3-second mean values.

The longer 10-minute mean values of the fundamental of each phase are seen in monitored data as LMNH01_A, LMNH01_B and LMNH01_C. Actual harmonics are seen with their number. Direct current components are LMNDC_A, LMNDC_B and LMNDC_C.

The time stamp for the ready 10-minute mean value calculation can be seen in monitored data L time stamp.

The window type used for the 10-minute mean value calculation is always non-sliding. The 10-minute value calculation begins based on the protection relay's internal clock 10 minutes time (for example, 11:00, 11:10, 11:20, 11:30, 11:40, 11:50, 12:00…). This is called 10 min tick.

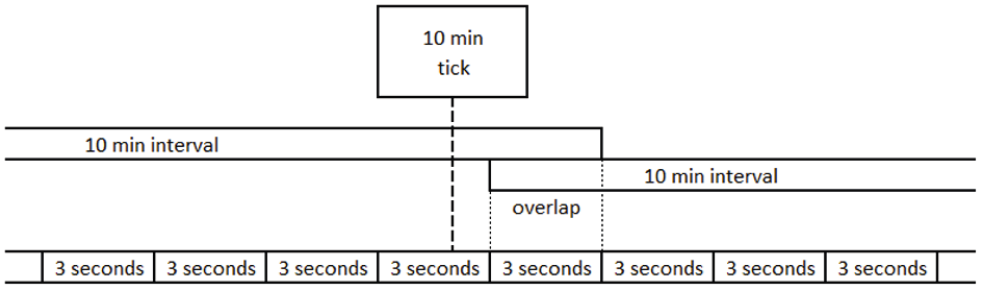



*Figure 834: The 10-minute interval with time synchronization and free running 3 seconds*

The 10-minute mean value is shown in monitored data until the next 10-minute mean value has been cumulated. Another 10-minute calculation can be started when time synchronization is used to change the protection relay's internal clock. The first calculation continues for 10 minutes and is then seen in the monitored data with a time stamp. An event is sent every time a 10-minute value calculation is ready in the monitored data.

See also the Time synchronization chapter in this document.

When the protection relay is powered on, the shown value is zero until the first 10-minute mean value has been cumulated. During this time, the 10-minute output quality is marked as bad in the IEC 61850 data.

Changing setting *Sliding interval* has influence on the seen mean values. Sliding values change slowly towards the input value during the time interval. When mean values have not been calculated for a full interval, quality is marked as bad in the IEC 61850 data. Bad quality is also indicated after the protection relay has been reset.

## 10.2.6 Application

Typically, the measured short-time 3-second mean values are used with a suitable logic to give alarms. If a more stabilized value is needed, a 1-minute or 5-minute mean value should be selected.

One example of using short-time mean values can be to compare the level of THD and some harmonics, for example, $5^{th}$ and $7^{th}$. The values to be compared to the same limit can be combined with MAX3R, and MAPGAPC can be used to test if the settable limit

value is exceeded. Outputs of MAPGAPC can be connected to the needed logic and, for example, an event can be sent with MVGAPC.

The 10-minute mean values can be collected to an external substation monitoring system. Collected data can be used in weekly reporting. If longer mean values are needed, the collected 10-minute mean values can be used to calculate, for example, two-hour mean values.

Typically, 10-minute THD or TDD mean values are collected from all three phases. Individual harmonics and the fundamental frequency component can also be collected.

## 10.2.7 Signals

*Table 1447: VHMHAI Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |

*Table 1448: VHMHAI Output signals*

| Name | Type | Description |
|---|---|---|
| SMNTHD_A | FLOAT32 | Mean THD for phase A in 3 s, 1 min or 5 min mean (%) |
| SMNTHD_B | FLOAT32 | Mean THD for phase B in 3 s, 1 min or 5 min mean (%) |
| SMNTHD_C | FLOAT32 | Mean THD for phase C in 3 s, 1 min or 5 min mean (%) |
| SMNDC_A | FLOAT32 | Shorter mean value of DC component for Phase A (%) |
| SMNDC_B | FLOAT32 | Shorter mean value of DC component for Phase B (%) |
| SMNDC_C | FLOAT32 | Shorter mean value of DC component for Phase C (%) |
| SMNH01_A | FLOAT32 | Shorter mean value of basic freq. for Phase A (%) |
| SMNH01_B | FLOAT32 | Shorter mean value of basic freq. for Phase B (%) |
| SMNH01_C | FLOAT32 | Shorter mean value of basic freq. for Phase C (%) |
| SMNH02_A | FLOAT32 | Shorter mean value of 2nd harmonic for Phase A (%) |
| SMNH02_B | FLOAT32 | Shorter mean value of 2nd harmonic for Phase B (%) |
| SMNH02_C | FLOAT32 | Shorter mean value of 2nd harmonic for Phase C (%) |
| SMNH03_A | FLOAT32 | Shorter mean value of 3rd harmonic for Phase A (%) |
| SMNH03_B | FLOAT32 | Shorter mean value of 3rd harmonic for Phase B (%) |
| SMNH03_C | FLOAT32 | Shorter mean value of 3rd harmonic for Phase C (%) |

Table continues on next page

| Name | Type | Description |
|---|---|---|
| SMNH04_A | FLOAT32 | Shorter mean value of 4th harmonic for Phase A (%) |
| SMNH04_B | FLOAT32 | Shorter mean value of 4th harmonic for Phase B (%) |
| SMNH04_C | FLOAT32 | Shorter mean value of 4th harmonic for Phase C (%) |
| SMNH05_A | FLOAT32 | Shorter mean value of 5th harmonic for Phase A (%) |
| SMNH05_B | FLOAT32 | Shorter mean value of 5th harmonic for Phase B (%) |
| SMNH05_C | FLOAT32 | Shorter mean value of 5th harmonic for Phase C (%) |
| SMNH06_A | FLOAT32 | Shorter mean value of 6th harmonic for Phase A (%) |
| SMNH06_B | FLOAT32 | Shorter mean value of 6th harmonic for Phase B (%) |
| SMNH06_C | FLOAT32 | Shorter mean value of 6th harmonic for Phase C (%) |
| SMNH07_A | FLOAT32 | Shorter mean value of 7th harmonic for Phase A (%) |
| SMNH07_B | FLOAT32 | Shorter mean value of 7th harmonic for Phase B (%) |
| SMNH07_C | FLOAT32 | Shorter mean value of 7th harmonic for Phase C (%) |
| SMNH08_A | FLOAT32 | Shorter mean value of 8th harmonic for Phase A (%) |
| SMNH08_B | FLOAT32 | Shorter mean value of 8th harmonic for Phase B (%) |
| SMNH08_C | FLOAT32 | Shorter mean value of 8th harmonic for Phase C (%) |
| SMNH09_A | FLOAT32 | Shorter mean value of 9th harmonic for Phase A (%) |
| SMNH09_B | FLOAT32 | Shorter mean value of 9th harmonic for Phase B (%) |
| SMNH09_C | FLOAT32 | Shorter mean value of 9th harmonic for Phase C (%) |
| SMNH10_A | FLOAT32 | Shorter mean value of 10th harmonic for Phase A (%) |
| SMNH10_B | FLOAT32 | Shorter mean value of 10th harmonic for Phase B (%) |
| SMNH10_C | FLOAT32 | Shorter mean value of 10th harmonic for Phase C (%) |
| SMNH11_A | FLOAT32 | Shorter mean value of 11th harmonic for Phase A (%) |
| SMNH11_B | FLOAT32 | Shorter mean value of 11th harmonic for Phase B (%) |
| SMNH11_C | FLOAT32 | Shorter mean value of 11th harmonic for Phase C (%) |

## 10.2.8 Settings

*Table 1449: VHMHAI Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Sliding interval | 1=3 seconds<br>2=1 minute<br>3=5 minutes | | | 1=3 seconds | Time interval for demand calculation |

## 10.2.9 Monitored data

*Table 1450: VHMHAI Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNTHD_A | FLOAT32 | 0.00...500.00 | % | Mean THD for phase A in 10 min non-sliding mean in % |
| LMNTHD_B | FLOAT32 | 0.00...500.00 | % | Mean THD for phase B in 10 min non-sliding mean in % |
| LMNTHD_C | FLOAT32 | 0.00...500.00 | % | Mean THD for phase C in 10 min non-sliding mean in % |
| LMNDC_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase A in % |
| LMNDC_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase B in % |
| LMNDC_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase C in % |
| LMNH01_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase A in % |
| LMNH01_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase B in % |
| LMNH01_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase C in % |
| LMNH02_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase A in % |
| LMNH02_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase B in % |
| LMNH02_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase C in % |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNH03_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase A in % |
| LMNH03_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase B in % |
| LMNH03_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase C in % |
| LMNH04_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase A in % |
| LMNH04_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase B in % |
| LMNH04_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase C in % |
| LMNH05_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase A in % |
| LMNH05_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase B in % |
| LMNH05_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase C in % |
| LMNH06_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase A in % |
| LMNH06_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase B in % |
| LMNH06_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase C in % |
| LMNH07_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase A in % |
| LMNH07_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase B in % |
| LMNH07_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase C in % |
| LMNH08_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase A in % |
| LMNH08_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase B in % |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNH08_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase C in % |
| LMNH09_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase A in % |
| LMNH09_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase B in % |
| LMNH09_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase C in % |
| LMNH10_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase A in % |
| LMNH10_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase B in % |
| LMNH10_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase C in % |
| LMNH11_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase A in % |
| LMNH11_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase B in % |
| LMNH11_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase C in % |
| L time stamp | Timestamp | | | Time stamp of end of 10 min mean values |

### 10.2.10 Technical data

*Table 1451: VHMHAI Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy[1)] | ±3.0% or ±0.2 |

1) Nominal frequency 50 Hz. Harmonics in the range 0…0.21 × fundamental amplitude

## 10.3 Voltage variation PHQVVR

### 10.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Voltage variation | PHQVVR | PQMU | PQMV SWE,SAG,INT |

## 10.3.2 Function block




*Figure 835: Function block*

## 10.3.3 Functionality

The voltage variation function PHQVVR is used for measuring the short-duration voltage variations in distribution networks.

Power quality in the voltage waveform is evaluated by measuring voltage swells, dips and interruptions. PHQVVR includes single-phase and three-phase voltage variation modes.

Typically, short-duration voltage variations are defined to last more than half of the nominal frequency period and less than one minute. The maximum magnitude (in the case of a voltage swell) or depth (in the case of a voltage dip or interruption) and the duration of the variation can be obtained by measuring the RMS value of the voltage for each phase. International standard 61000-4-30 defines the voltage variation to be implemented using the RMS value of the voltage. IEEE standard 1159-1995 provides recommendations for monitoring the electric power quality of the single-phase and polyphase ac power systems.

PHQVVR contains a blocking functionality. It is possible to block a set of function outputs or the function itself.

## 10.3.4 Analog channel configuration

PHQVVR has two analog group inputs which must be properly configured.

*Table 1452: Analog inputs*

| Input | Description |
|---|---|
| I3P[1)] | Three-phase currents |
| U3P | Three-phase voltages |

1) Can be connected to GRPOFF

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

*Table 1453: Special conditions*

| Condition | Description |
|---|---|
| U3P connected real measurements | The function can work with one voltage channel connected (A, B or C depending on the *Phase supervision* setting "Ph A", "Ph B" or "Ph C") if *Phase mode* is set to "Single Phase". |
| | The function can work with two voltage channel connected (A-B, B-C or C-A depending on the *Phase supervision* setting "Ph A+B", "Ph B+C" or "Ph A+C") if *Phase mode* is set to "Three Phase". |
| | The function requires that all three voltage channels are connected if *Phase supervision* is set to "Ph A+B+C" and *Phase mode* setting is set to "Three Phase". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 10.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PHQVVR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

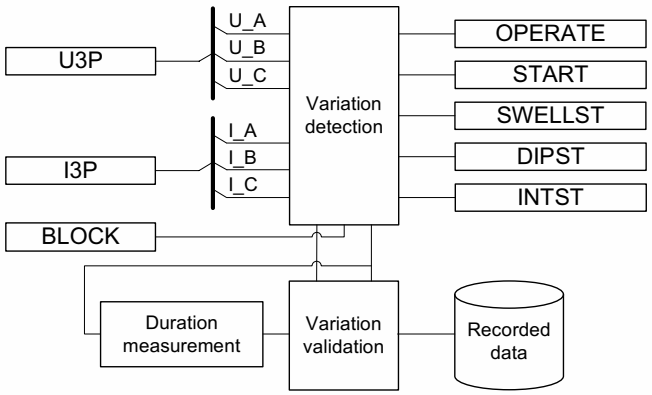



*Figure 836: Functional module diagram*

### 10.3.5.1 Phase mode setting

PHQVVR is designed for both single-phase and polyphase ac power systems, and selection can be made with the *Phase mode* setting, which can be set either to the "Single Phase" or "Three Phase" mode. The default setting is "Single Phase".

The basic difference between these alternatives depends on how many phases are needed to have the voltage variation activated. When the *Phase mode* setting is "Single Phase", the activation is straightforward. There is no dependence between the phases for variation start. The START output and the corresponding phase start are activated when the limit is exceeded or undershot. The corresponding phase start deactivation takes place when the limit (includes small hysteresis) is undershot or exceeded. The START output is deactivated when there are no more active phases.

However, when *Phase mode* is "Three Phase", all the monitored phase signal magnitudes, defined with *Phase supervision*, have to fall below or rise above the limit setting to activate the START output and the corresponding phase output, that is, all the monitored phases have to be activated. Accordingly, the deactivation occurs when the activation requirement is not fulfilled, that is, one or more monitored phase signal magnitudes return beyond their limits. Phases do not need to be activated by the same variation type to activate the START output. Another consequence is that if only one or two phases are monitored, it is sufficient that these monitored phases activate the START output.

### 10.3.5.2 Variation detection

The module compares the measured voltage against the limit settings. If there is a permanent undervoltage or overvoltage, the *Reference voltage* setting can be set to this voltage level to avoid the undesired voltage dip or swell indications. This is accomplished by converting the variation limits with the *Reference voltage* setting in the variation detection module, that is, when there is a voltage different from the nominal voltage, the *Reference voltage* setting is set to this voltage.

The *Variation enable* setting is used for enabling or disabling the variation types. By default, the setting value is "Swell+dip+Int" and all the alternative variation types are indicated. For example, for setting "Swell+dip", the interruption detection is not active and only swell or dip events are indicated.

In a case where *Phase mode* is "Single Phase" and the dip functionality is available, the output DIPST is activated when the measured TRMS value drops below the *Voltage dip set 3* setting in one phase and also remains above the *Voltage Int set* setting. If the voltage drops below the *Voltage Int set* setting, the output INTST is activated. INTST is deactivated when the voltage value rises above the setting *Voltage Int set*. When the same measured TRMS magnitude rises above the setting *Voltage swell set 3*, the SWELLST output is activated.

There are three setting value limits for dip (*Voltage dip set 1..3*) and swell activation (*Voltage swell set 1..3*) and one setting value limit for interruption.

If *Phase mode* is "Three Phase", the DIPST and INTST outputs are activated when the voltage levels of all monitored phases, defined with the parameter *Phase supervision*, drop below the *Voltage Int set* setting value. An example for the detection principle of voltage interruption for "Three Phase" when *Phase supervision* is "Ph A + B + C", and also the corresponding start signals when *Phase mode* is "Single Phase", are as shown in the example for the detection of a three-phase interruption.

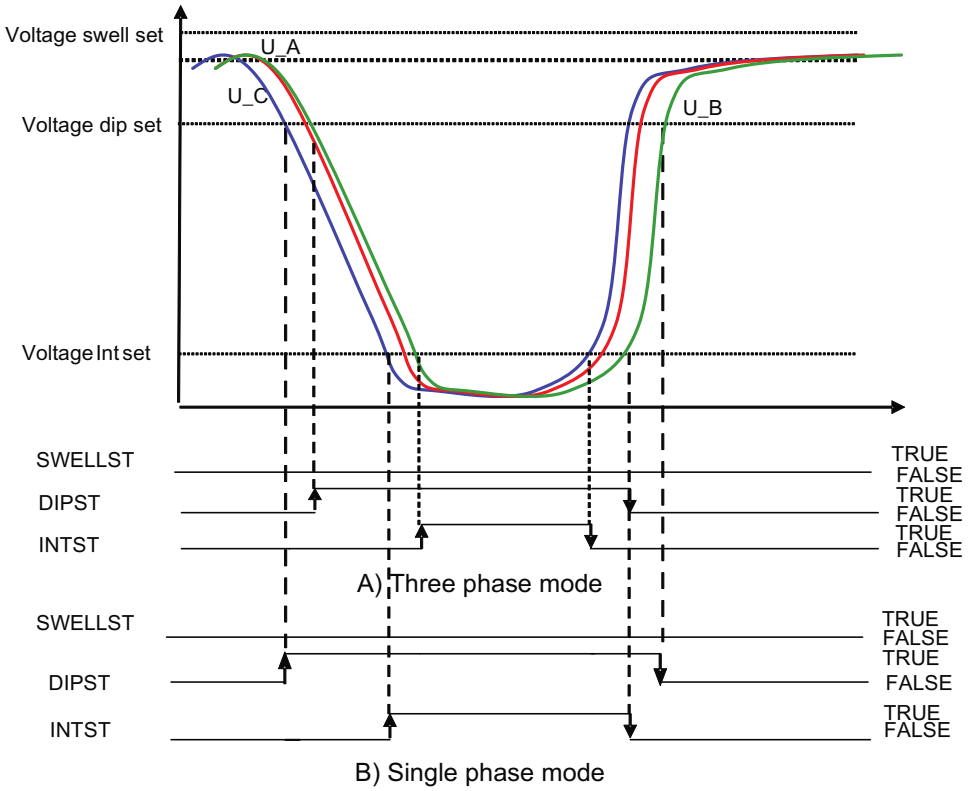



*Figure 837: Detection of three-phase voltage interruption*

The module measures voltage variation magnitude on each phase separately, that is, there are phase-segregated outputs ST_A, ST_B and ST_C for voltage variation indication. The configuration parameter *Phase supervision* defines which voltage phase or phases are monitored. If a voltage phase is selected to be monitored, the function assumes it to be connected to a voltage measurement channel. In other words, if an unconnected phase is monitored, the function falsely detects a voltage interruption in that phase.

The maximum magnitude and depth are defined as percentage values calculated from the difference between the reference and the measured voltage. For example, a dip to 70 percent means that the minimum voltage dip magnitude variation is 70 percent of the reference voltage amplitude.

The activation of the BLOCK input resets the function and outputs.

### 10.3.5.3 Variation validation

The validation criterion for voltage variation is that the measured total variation duration is between the set minimum and maximum durations (Either one of *VVa dip time 1*, *VVa swell time 1* or *VVa Int time 1*, depending on the variation type, and *VVa Dur Max*). The maximum variation duration setting is the same for all variation types.

Figure 838 shows voltage dip operational regions. In Figure 837, only one voltage dip/swell/Int set is drawn, whereas in this figure there are three sub-limits for the dip operation. When *Voltage dip set 3* is undershot, the corresponding ST_x and also the DIPST outputs are activated. When the TRMS voltage magnitude remains between *Voltage dip set 2* and *Voltage dip set 1* for a period longer than *VVa dip time 2* (shorter time than *VVa dip time 3*), a momentary dip event is detected. Furthermore, if the signal magnitude stays between the limits longer than *VVa dip time 3* (shorter time than *VVa Dur max*), a temporary dip event is detected. If the voltage remains below *Voltage dip set 1* for a period longer than *VVa dip time 1* but a shorter time than *VVa dip time 2*, an instantaneous dip event is detected.

For an event detection, the OPERATE output is always activated for one task cycle. The corresponding counter and only one of them (INSTDIPCNT, MOMDIPCNT or TEMPDIPCNT) is increased by one. If the dip limit undershooting duration is shorter than *VVa dip time 1*, *VVa swell time 1* or *VVa Int time 1*, the event is not detected at all, and if the duration is longer than *VVa Dur Max*, MAXDURDIPCNT is increased by one but no event detection resulting in the activation of the OPERATE output and recording data update takes place. These counters are available through the monitored data view on the LHMI or through tools via communications. There are no phase-segregated counters but all the variation detections are registered to a common time/magnitude-classified counter type. Consequently, a simultaneous multiphase event, that is, the variation-type event detection time moment is exactly the same for two or more phases, is counted only once also for single-phase power systems.

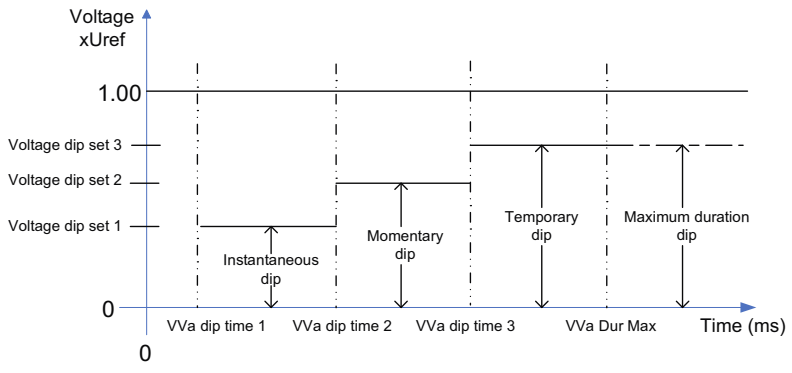



*Figure 838: Voltage dip operational regions*

In Figure 839, the corresponding limits regarding the swell operation are provided with the inherent magnitude limit order difference. The swell functionality principle

is the same as for dips, but the different limits for the signal magnitude and times and the inherent operating zone change (here, *Voltage swell set x* > 1.0 xUn) are applied.

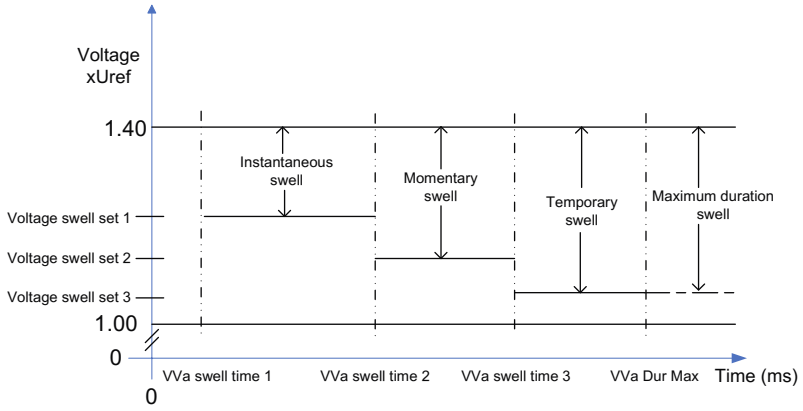



*Figure 839: Voltage swell operational regions*

For interruption, as shown in Figure 840, there is only one magnitude limit but four duration limits for interruption classification. Now the event and counter type depends only on variation duration time.

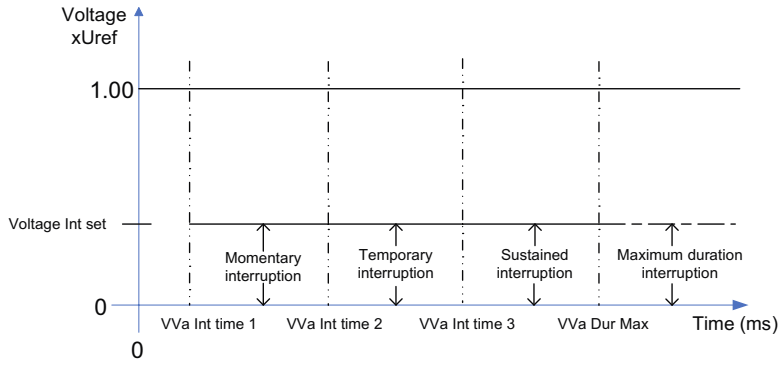



*Figure 840: Interruption operating regions*

Generally, no event detection is done if both the magnitude and duration requirements are not fulfilled. For example, the dip event does not indicate if the TRMS voltage magnitude remains between *Voltage dip set 3* and *Voltage dip set 2* for a period shorter than *VVa dip time 3* before rising back above *Voltage dip set 3*.

The event indication ends and possible detection is done when the TRMS voltage returns above (for dip and interruption) or below (for swell) the activation-starting limit. For example, after an instantaneous dip, the event indication when the voltage magnitude exceeds *Voltage dip set 1* is not detected (and recorded) immediately but only if no longer dip indication for the same dip variation takes place and maximum duration time for dip variation does not exceed before the signal magnitude rises above *Voltage dip set 3*. There is a small hysteresis for all these limits to avoid the oscillation of the output activation. No drop-off approach is applied here due to the hysteresis.

Consequently, only one event detection and recording of the same variation type can take place for one voltage variation, so the longest indicated variation of each variation type is detected. Furthermore, it is possible that another instantaneous dip event replaces the one already indicated if the magnitude again undershoots *Voltage dip set 1* for the set time after the first detection and the signal magnitude or time requirement is again fulfilled. Another possibility is that if the time condition is not fulfilled for an instantaneous dip detection but the signal rises above *Voltage dip set 1*, the already elapsed time is included in the momentary dip timer. Especially the interruption time is included in the dip time. If the signal does not exceed *Voltage dip set 2* before the timer *VVa dip time 2* has elapsed when the momentary dip timer is also started after the magnitude undershooting *Voltage dip set 2*, the momentary dip event instead is detected. Consequently, the same dip occurrence with a changing variation depth can result in several dip event indications but only one detection. For example, if the magnitude has undershot *Voltage dip set 1* but remained above *Voltage Intr set* for a shorter time than the value of *VVa dip time 1* but the signal rises between *Voltage dip set 1* and *Voltage dip set 2* so that the total duration of the dip activation is longer than *VVa dip time 2* and the maximum time is not overshot, this is detected as a momentary dip even though a short instantaneous dip period has been included. In text, the terms "deeper" and "higher" are used for referring to dip or interruption.

Although examples are given for dip events, the same rules can be applied to the swell and interruption functionality too. For swell indication, "deeper" means that the signal rises even more and "higher" means that the signal magnitude becomes lower respectively.

The adjustable voltage thresholds adhere to the relationships:

*VVa dip time 1* ≤ *VVa dip time 2* ≤ *VVa dip time 3*.

*VVa swell time 1* ≤ *VVa swell time 2* ≤ *VVa swell time 3*.

*VVa Int time 1* ≤ *VVa Int time 2* ≤ *VVa Int time 3*.

There is a validation functionality built-in function that checks the relationship adherence so that if *VVa x time 1* is set higher than *VVa x time 2* or *VVa x time 3*, *VVa x time 2* and *VVa x time 3* are set equal to the new *VVa x time 1*. If *VVa x time 2* is set higher than *VVa x time 3*, *VVa x time 3* is set to the new *VVa x time 2*. If *VVa x time 2* is set lower than *VVa x time 1*, the entered *VVa x time 2* is rejected. If *VVa x time 3* is set lower than *VVa x time 2*, the entered *VVa x time 3* is rejected.

### 10.3.5.4 Duration measurement

The duration of each voltage phase corresponds to the period during which the measured TRMS values remain above (swell) or below (dip, interruption) the corresponding limit.

Besides the three limit settings for the variation types dip and swell, there is also a specific duration setting for each limit setting. For interruption, there is only one limit setting common for the three duration settings. The maximum duration setting is common for all variation types.

The duration measurement module measures the voltage variation duration of each phase voltage separately when the *Phase mode* setting is "Single Phase". The phase variation durations are independent. However, when the *Phase mode* setting is "Three Phase", voltage variation may start only when all the monitored phases are active. An example of variation duration when *Phase mode* is "Single Phase" can be seen in Figure 841. The voltage variation in the example is detected as an interruption for the phase B and a dip for the phase A, and also the variation durations are interpreted as independent U_B and U_A durations. In case of single-phase interruption, the DIPST output is active when either ST_A or ST_B is active. The measured variation durations are the times measured between the activation of the ST_A or ST_B outputs and deactivation of the ST_A or ST_B outputs. When the *Phase mode* setting is "Three Phase", the example case does not result in any activation.

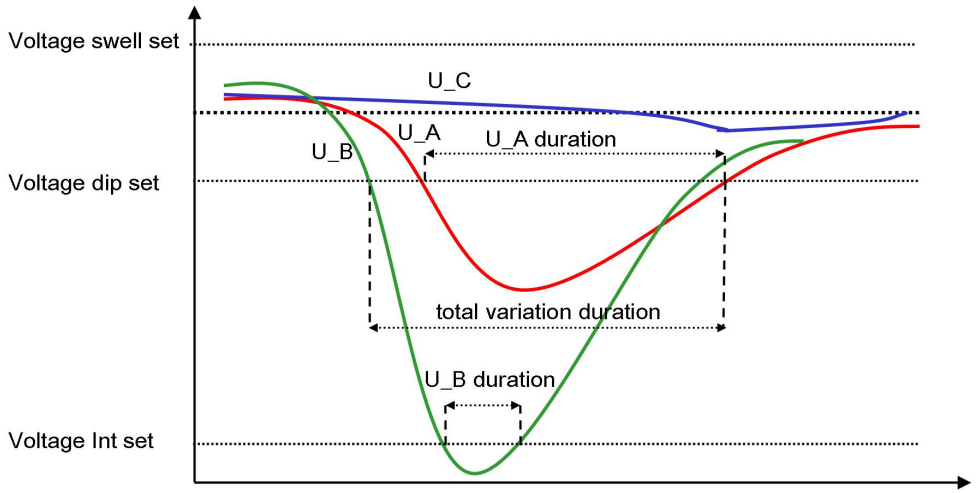



*Figure 841: Single-phase interruption for the Phase mode value "Single Phase"*

### 10.3.5.5 Three/single-phase selection variation examples

The provided rules always apply for single-phase (*Phase mode* is "Single Phase") power systems. However, for three-phase power systems (where *Phase mode* is "Three Phase"), it is required that all the phases have to be activated before the activation of the START output. Interruption event indication requires all three phases to undershoot *Voltage Int set* simultaneously, as shown in Figure 837. When the requirement for interruption for "Three Phase" is no longer fulfilled, variation is indicated as a dip as long as all phases are active.

In case of a single-phase interruption of Figure 841, when there is a dip indicated in another phase but the third phase is not active, there is no variation indication start when *Phase mode* is "Three Phase". In this case, only the *Phase mode* value "Single Phase" results in the ST_B interruption and the ST_A dip.

It is also possible that there are simultaneously a dip in one phase and a swell in other phases. The functionality of the corresponding event indication with one inactive phase is shown in Figure 842. Here, the "Swell + dip" variation type of *Phase mode* is

"Single Phase". For the selection "Three Phase" of *Phase mode*, no event indication or any activation takes place due to a non-active phase.

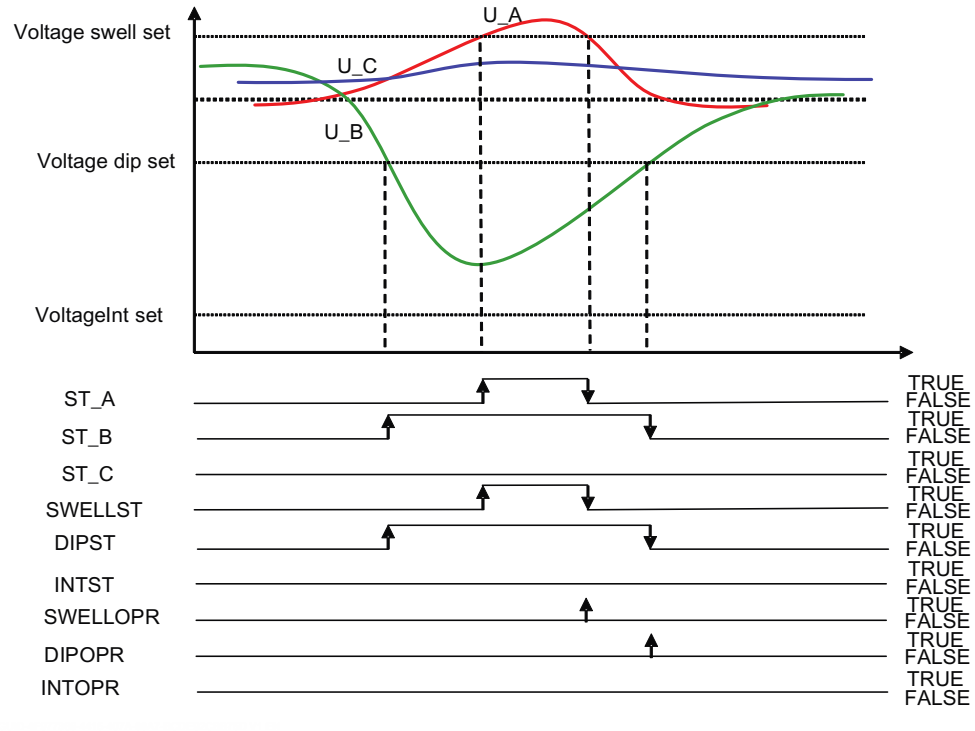



*Figure 842: Concurrent dip and swell when Phase mode is "Single Phase"*

In Figure 843, one phase is in dip and two phases have a swell indication. For the *Phase mode* value "Three Phase", the activation occurs only when all the phases are active. Furthermore, both swell and dip variation event detections take place simultaneously. In case of a concurrent voltage dip and voltage swell, both SWELLCNT and DIPCNT are incremented by one.

Also Figure 843 shows that for the *Phase mode* value "Single Phase", two different time moment variation event swell detections take place and, consequently, DIPCNT is incremented by one but SWELLCNT is totally incremented by two. In bothFigure 842 and Figure 843 it is assumed that variation durations are sufficient for detections to take place.

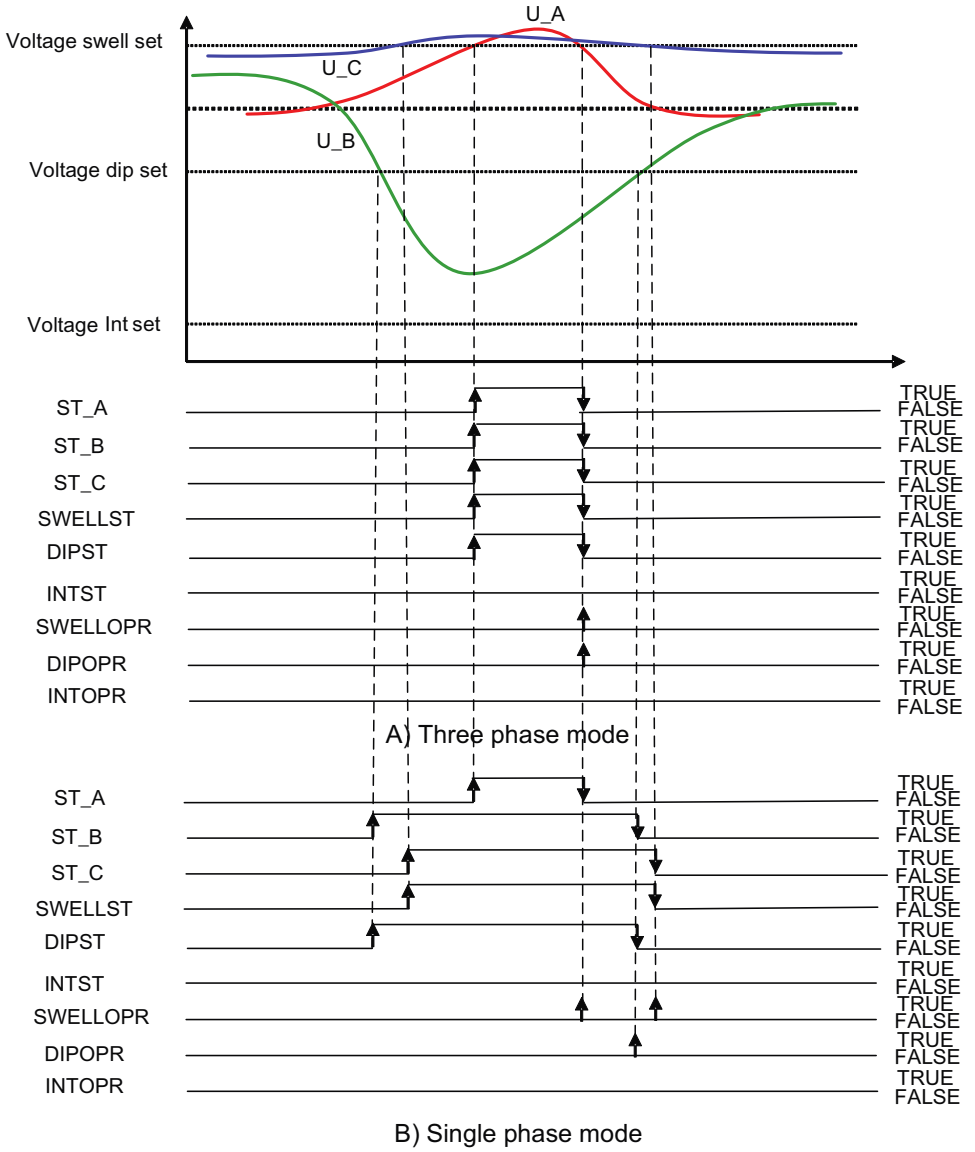



*Figure 843: Concurrent dip and two-phase swell*

## 10.3.6 Recorded data

Besides counter increments, the information required for a later fault analysis is stored after a valid voltage variation is detected.

### Recorded data information

When voltage variation starts, the phase current magnitudes preceding the activation moment are stored. Also, the initial voltage magnitudes are temporarily stored at the variation starting moment. If the variation is, for example, a two-phase voltage dip, the voltage magnitude of the non-active phase is stored from this same moment, as shown in Figure 844. The function tracks each variation-active voltage phase, and the

minimum or maximum magnitude corresponding to swell or dip/interruption during variation is temporarily stored. If the minimum or maximum is found in tracking and a new magnitude is stored, also the inactive phase voltages are stored at the same moment, that is, the inactive phases are not magnitude-tracked. The time instant (time stamp) at which the minimum or maximum magnitude is measured is also temporarily stored for each voltage phase where variation is active. Finally, variation detection triggers the recorded data update when the variation activation ends and the maximum duration time is not exceeded.

The data objects to be recorded for PHQVVR are given in Table 1454. There are totally three data banks, and the information given in the table refers to one data bank content.

The three sets of recorded data available are saved in data banks 1-3. The data bank 1 holds always the most recent recorded data, and the older data sets are moved to the next banks (1→2 and 2→3) when a valid voltage variation is detected. When all three banks have data and a new variation is detected, the newest data are placed into bank 1 and the data in bank 3 are overwritten by the data from bank 2.

Figure 844 shows a valid recorded voltage interruption and two dips for the *Phase mode* value "Single Phase". The first dip event duration is based on the U_A duration, while the second dip is based on the time difference between the dip stop and start times. The first detected event is an interruption based on the U_B duration given in Figure 844. It is shown also with dotted arrows how voltage time stamps are taken before the final time stamp for recording, which is shown as a solid arrow. Here, the U_B timestamp is not taken when the U_A activation starts.

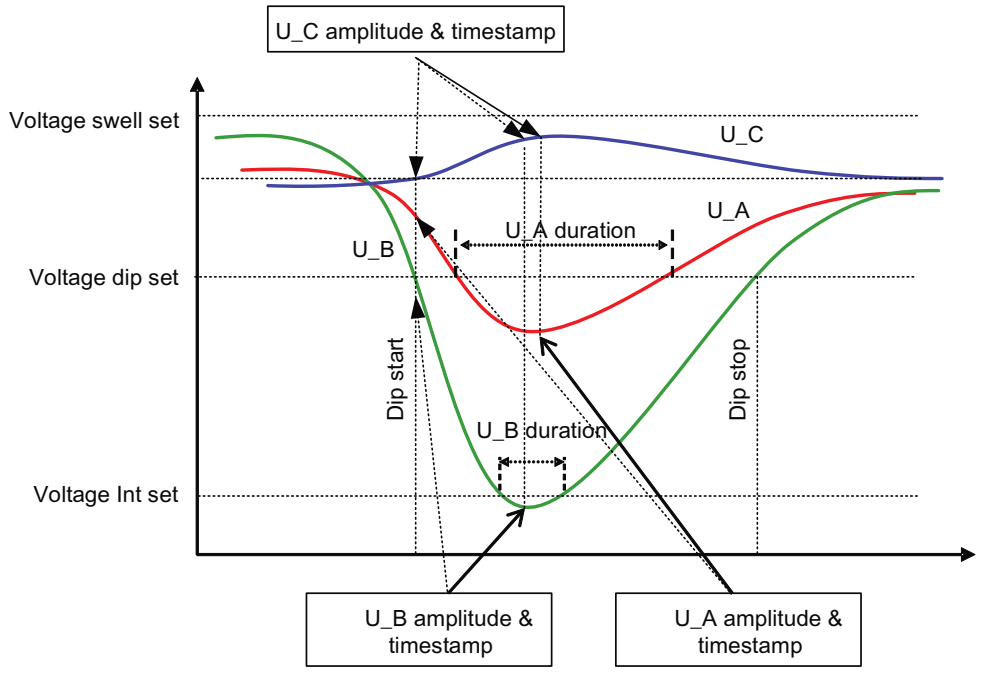



*Figure 844: Valid recorded voltage interruption and two dips*

*Table 1454: PHQVVR recording data bank parameters*

| Parameter description | Parameter name |
|---|---|
| Event detection triggering time stamp | Time |
| Variation type | Variation type |
| Variation magnitude Ph A | Variation Ph A |
| Variation magnitude Ph A time stamp (maximum/minimum magnitude measuring time moment during variation) | Var Ph A rec time |
| Variation magnitude Ph B | Variation Ph B |
| Variation magnitude Ph B time stamp (maximum/minimum magnitude measuring time moment during variation) | Var Ph B rec time |
| Variation magnitude Ph C | Variation Ph C |
| Variation magnitude Ph C time stamp (maximum/minimum magnitude measuring time moment during variation) | Var Ph C rec time |
| Variation duration Ph A | Variation Dur Ph A |
| Variation Ph A start time stamp (phase A variation start time moment) | Var Dur Ph A time |
| Variation duration Ph B | Variation Dur Ph B |
| Variation Ph B start time stamp (phase B variation start time moment) | Var Dur Ph B time |
| Variation duration Ph C | Variation Dur Ph C |
| Variation Ph C start time stamp (phase C variation start time moment) | Var Dur Ph C time |
| Current magnitude Ph A preceding variation | Var current Ph A |
| Current magnitude Ph B preceding variation | Var current Ph B |
| Current magnitude Ph C preceding variation | Var current Ph C |

*Table 1455: Enumeration values for the recorded data parameters*

| Setting name | Enum name | Value |
|---|---|---|
| Variation type | Swell | 1 |
| Variation type | Dip | 2 |
| Variation type | Swell + dip | 3 |
| Variation type | Interruption | 4 |
| Variation type | Swell + Int | 5 |
| Variation type | Dip + Int | 6 |
| Variation type | Swell+dip+Int | 7 |

## 10.3.7 Application

Voltage variations are the most typical power quality variations on the public electric network. Typically, short-duration voltage variations are defined to last more than

half of the nominal frequency period and less than one minute (European Standard EN 50160 and IEEE Std 1159-1995).

These short-duration voltage variations are almost always caused by a fault condition. Depending on where the fault is located, it can cause either a temporary voltage rise (swell) or voltage drop (dip). A special case of voltage drop is the complete loss of voltage (interruption).

PHQVVR is used for measuring short-duration voltage variations in distribution networks. The power quality is evaluated in the voltage waveform by measuring the voltage swells, dips and interruptions.

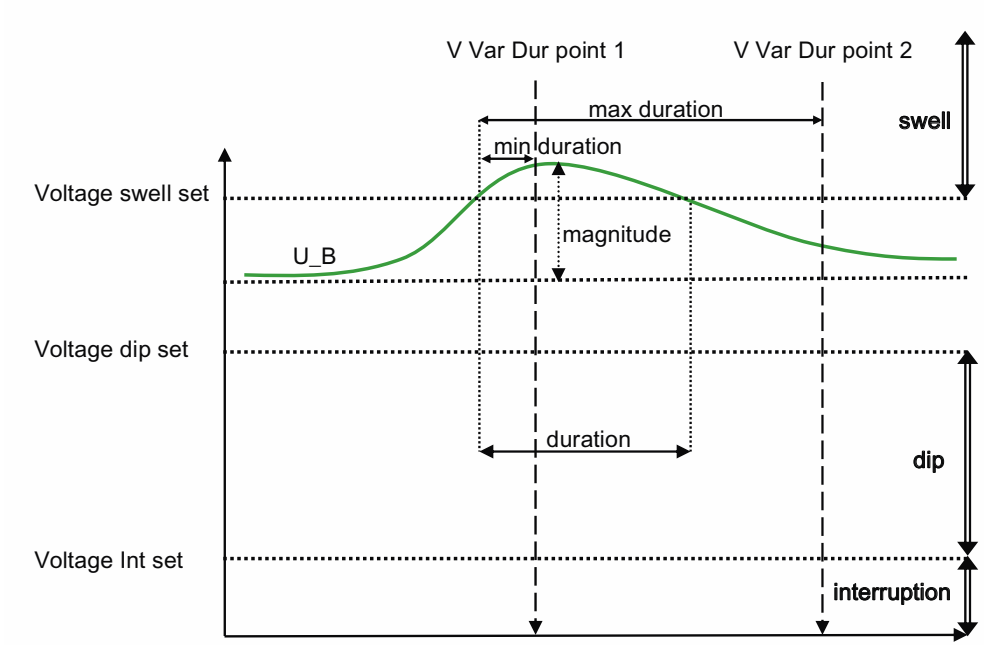



*Figure 845: Duration and voltage magnitude limits for swell, dip and interruption measurement*

Voltage dips disturb the sensitive equipment such as computers connected to the power system and may result in the failure of the equipment. Voltage dips are typically caused by faults occurring in the power distribution system. Typical reasons for the faults are lightning strikes and tree contacts. In addition to fault situations, the switching of heavy loads and starting of large motors also cause dips.

Voltage swells cause extra stress for the network components and the devices connected to the power system. Voltage swells are typically caused by the earth faults that occur in the power distribution system.

Voltage interruptions are typically associated with the switchgear operation related to the occurrence and termination of short circuits. The operation of a circuit breaker disconnects a part of the system from the source of energy. In the case of overhead networks, automatic reclosing sequences are often applied to the circuit breakers that

interrupt fault currents. All these actions result in a sudden reduction of voltages on all voltage phases.

Due to the nature of voltage variations, the power quality standards do not specify any acceptance limits. There are only indicative values for, for example, voltage dips in the European standard EN 50160. However, the power quality standards like the international standard IEC 61000-4-30 specify that the voltage variation event is characterized by its duration and magnitude. Furthermore, IEEE Std 1159-1995 gives the recommended practice for monitoring the electric power quality.

Voltage variation measurement can be done to the phase-to-earth and phase-to-phase voltages. The power quality standards do not specify whether the measurement should be done to phase or phase-to-phase voltages. However, in some cases it is preferable to use phase-to-earth voltages for measurement. The measurement mode is always TRMS.

## 10.3.8 Signals

*Table 1456: PHQVVR Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

*Table 1457: PHQVVR Output signals*

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Voltage variation detected |
| START | BOOLEAN | Voltage variation present |
| SWELLST | BOOLEAN | Voltage swell active |
| DIPST | BOOLEAN | Voltage dip active |
| INTST | BOOLEAN | Voltage interruption active |

## 10.3.9 Settings

*Table 1458: PHQVVR Group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reference voltage | 10.0...200.0 | %Un | 0.1 | 57.7 | Reference supply voltage in % |
| Voltage dip set 1 | 10.0...100.0 | % | 0.1 | 80.0 | Dip limit 1 in % of reference voltage |
| VVa dip time 1 | 0.5...54.0 | cycles | 0.1 | 3.0 | Voltage variation dip duration 1 |
| Voltage dip set 2 | 10.0...100.0 | % | 0.1 | 80.0 | Dip limit 2 in % of reference voltage |
| VVa dip time 2 | 10.0...180.0 | cycles | 0.1 | 30.0 | Voltage variation dip duration 2 |
| Voltage dip set 3 | 10.0...100.0 | % | 0.1 | 80.0 | Dip limit 3 in % of reference voltage |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| VVa dip time 3 | 2000...60000 | ms | 10 | 3000 | Voltage variation dip duration 3 |
| Voltage swell set 1 | 100.0...140.0 | % | 0.1 | 120.0 | Swell limit 1 in % of reference voltage |
| VVa swell time 1 | 0.5...54.0 | cycles | 0.1 | 0.5 | Voltage variation swell duration 1 |
| Voltage swell set 2 | 100.0...140.0 | % | 0.1 | 120.0 | Swell limit 2 in % of reference voltage |
| VVa swell time 2 | 10.0...80.0 | cycles | 0.1 | 10.0 | Voltage variation swell duration 2 |
| Voltage swell set 3 | 100.0...140.0 | % | 0.1 | 120.0 | Swell limit 3 in % of reference voltage |
| VVa swell time 3 | 2000...60000 | ms | 10 | 2000 | Voltage variation swell duration 3 |
| Voltage Int set | 0.0...100.0 | % | 0.1 | 10.0 | Interruption limit in % of reference voltage |
| VVa Int time 1 | 0.5...30.0 | cycles | 0.1 | 3.0 | Voltage variation Int duration 1 |
| VVa Int time 2 | 10.0...180.0 | cycles | 0.1 | 30.0 | Voltage variation Int duration 2 |
| VVa Int time 3 | 2000...60000 | ms | 10 | 3000 | Voltage variation interruption duration 3 |
| VVa Dur Max | 100...3600000 | ms | 100 | 60000 | Maximum voltage variation duration |

*Table 1459: PHQVVR Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Variation enable | 1=Swell<br>2=Dip<br>3=Swell + dip<br>4=Interruption<br>5=Swell + Int<br>6=Dip + Int<br>7=Swell+dip+Int | | | 7=Swell+dip+Int | Enable variation type |

*Table 1460: PHQVVR Non group settings (Advanced)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase supervision | 1=Ph A<br>2=Ph B<br>3=Ph A + B<br>4=Ph C<br>5=Ph A + C<br>6=Ph B + C<br>7=Ph A + B + C | | | 7=Ph A + B + C | Monitored voltage phase |
| Phase mode | 1=Three Phase<br>2=Single Phase | | | 2=Single Phase | Three/Single phase mode |

## 10.3.10 Monitored data

*Table 1461: PHQVVR Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ST_A | BOOLEAN | 0=False<br>1=True | | Start Phase A (Voltage Variation Event in progress) |
| ST_B | BOOLEAN | 0=False<br>1=True | | Start Phase B (Voltage Variation Event in progress) |
| ST_C | BOOLEAN | 0=False<br>1=True | | Start Phase C (Voltage Variation Event in progress) |
| INSTSWELLCNT | INT32 | 0...2147483647 | | Instantaneous swell operation counter |
| MOMSWELLCNT | INT32 | 0...2147483647 | | Momentary swell operation counter |
| TEMPSWELLCNT | INT32 | 0...2147483647 | | Temporary swell operation counter |
| MAXDURSWELLCNT | INT32 | 0...2147483647 | | Maximum duration swell operation counter |
| INSTDIPCNT | INT32 | 0...2147483647 | | Instantaneous dip operation counter |
| MOMDIPCNT | INT32 | 0...2147483647 | | Momentary dip operation counter |
| TEMPDIPCNT | INT32 | 0...2147483647 | | Temporary dip operation counter |
| MAXDURDIPCNT | INT32 | 0...2147483647 | | Maximum duration dip operation counter |
| MOMINTCNT | INT32 | 0...2147483647 | | Momentary interruption operation counter |
| TEMPINTCNT | INT32 | 0...2147483647 | | Temporary interruption operation counter |
| SUSTINTCNT | INT32 | 0...2147483647 | | Sustained interruption operation counter |
| MAXDURINTCNT | INT32 | 0...2147483647 | | Maximum duration interruption operation counter |
| PHQVVR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| Time | Timestamp | | | Time |
| Variation type | Enum | 0=No variation<br>1=Swell<br>2=Dip<br>3=Swell + dip<br>4=Interruption<br>5=Swell + Int<br>6=Dip + Int<br>7=Swell+dip+Int | | Variation type |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Variation Ph A | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase A |
| Var Ph A rec time | Timestamp | | | Variation magnitude Phase A time stamp |
| Variation Ph B | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase B |
| Var Ph B rec time | Timestamp | | | Variation magnitude Phase B time stamp |
| Variation Ph C | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase C |
| Var Ph C rec time | Timestamp | | | Variation magnitude Phase C time stamp |
| Variation Dur Ph A | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase A |
| Var Dur Ph A time | Timestamp | | | Variation Ph A start time stamp |
| Variation Dur Ph B | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase B |
| Var Dur Ph B time | Timestamp | | | Variation Ph B start time stamp |
| Variation Dur Ph C | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase C |
| Var Dur Ph C time | Timestamp | | | Variation Ph C start time stamp |
| Var current Ph A | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase A preceding variation |
| Var current Ph B | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase B preceding variation |
| Var current Ph C | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase C preceding variation |
| Time | Timestamp | | | Time |
| Variation type | Enum | 0=No variation<br>1=Swell<br>2=Dip<br>3=Swell + dip<br>4=Interruption<br>5=Swell + Int<br>6=Dip + Int<br>7=Swell+dip+Int | | Variation type |
| Variation Ph A | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase A |
| Var Ph A rec time | Timestamp | | | Variation magnitude Phase A time stamp |
| Variation Ph B | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase B |
| Var Ph B rec time | Timestamp | | | Variation magnitude Phase B time stamp |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Variation Ph C | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase C |
| Var Ph C rec time | Timestamp | | | Variation magnitude Phase C time stamp |
| Variation Dur Ph A | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase A |
| Var Dur Ph A time | Timestamp | | | Variation Ph A start time stamp |
| Variation Dur Ph B | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase B |
| Var Dur Ph B time | Timestamp | | | Variation Ph B start time stamp |
| Variation Dur Ph C | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase C |
| Var Dur Ph C time | Timestamp | | | Variation Ph C start time stamp |
| Var current Ph A | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase A preceding variation |
| Var current Ph B | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase B preceding variation |
| Var current Ph C | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase C preceding variation |
| Time | Timestamp | | | Time |
| Variation type | Enum | 0=No variation<br>1=Swell<br>2=Dip<br>3=Swell + dip<br>4=Interruption<br>5=Swell + Int<br>6=Dip + Int<br>7=Swell+dip+Int | | Variation type |
| Variation Ph A | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase A |
| Var Ph A rec time | Timestamp | | | Variation magnitude Phase A time stamp |
| Variation Ph B | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase B |
| Var Ph B rec time | Timestamp | | | Variation magnitude Phase B time stamp |
| Variation Ph C | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase C |
| Var Ph C rec time | Timestamp | | | Variation magnitude Phase C time stamp |
| Variation Dur Ph A | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase A |
| Var Dur Ph A time | Timestamp | | | Variation Ph A start time stamp |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Variation Dur Ph B | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase B |
| Var Dur Ph B time | Timestamp | | | Variation Ph B start time stamp |
| Variation Dur Ph C | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase C |
| Var Dur Ph C time | Timestamp | | | Variation Ph C start time stamp |
| Var current Ph A | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase A preceding variation |
| Var current Ph B | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase B preceding variation |
| Var current Ph C | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase C preceding variation |

### 10.3.11 Technical data

*Table 1462: PHQVVR Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.5% of the set value or ±0.2% of reference voltage |
| Reset ratio | Typically 0.96 (Swell), 1.04 (Dip, Interruption) |

## 10.4 Voltage unbalance VSQVUB

### 10.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Voltage unbalance | VSQVUB | PQUUB | PQMV UB |

### 10.4.2 Function block

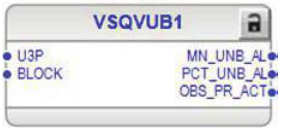



*Figure 846: Function block*

## 10.4.3 Functionality

The voltage unbalance function VSQVUB monitors voltage unbalance conditions in power transmission and distribution networks. It can be applied to identify a network and load unbalance that can cause sustained voltage unbalance. VSQVUB is also used to monitor the commitment of the power supply utility of providing a high-quality, that is, a balanced voltage supply on a continuous basis.

VSQVUB uses five different methods for calculating voltage unbalance. The methods are negative-sequence voltage magnitude, zero-sequence voltage magnitude, ratio of the negative-sequence voltage magnitude to the positive-sequence voltage magnitude, ratio of the zero-sequence voltage magnitude to the positive-sequence voltage magnitude and ratio of maximum phase voltage magnitude deviation from the mean voltage magnitude to the mean of the phase voltage magnitude.

VSQVUB provides statistics which can be used to verify the compliance of the power quality with the European standard EN 50160 (2000). The statistics over selected period include a freely selectable percentile for unbalance. VSQVUB also includes an alarm functionality providing a maximum unbalance value and the date and time of occurrence.

VSQVUB contains a blocking functionality. It is possible to block a set of function outputs or the function itself.

## 10.4.4 Analog channel configuration

VSQVUB has one analog group input which must be properly configured.

*Table 1463: Analog inputs*

| Input | Description |
|---|---|
| U3P | Three-phase voltages |



See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

*Table 1464: Special conditions*

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |
| | Further, if *VT connection* is "Delta" in that particular UTVTR, the *Unb detection method* cannot be set to "Zero Seq" or "Zero to Pos Seq". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 10.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of VSQVUB can be described with a module diagram. All the modules in the diagram are explained in the next sections.

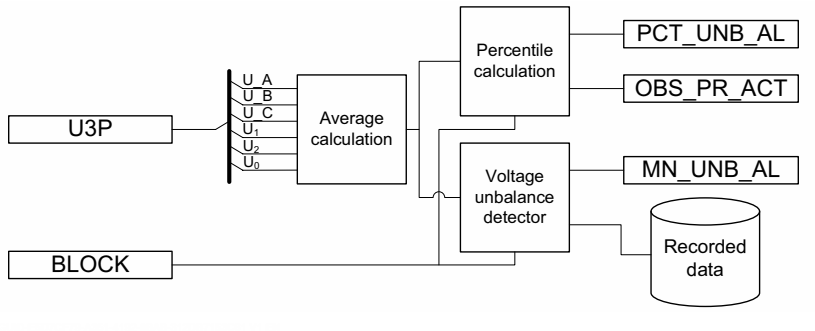



*Figure 847: Functional module diagram*

### Average calculation

VSQVUB calculates two sets of measured voltage unbalance values, a three-second and a ten-minute non-sliding average value. The three-second average value is used for continuous monitoring. The ten-minute average is used for percentile calculation for a longer period.

The Average calculation module uses five different methods for the average calculation. The required method can be selected with the *Unb detection method* parameter.

When the "Neg Seq" mode is selected with *Unb detection method*, the voltage unbalance is calculated based on the negative-sequence voltage magnitude. Similarly, when the "Zero Seq" mode is selected, the voltage unbalance is calculated based on the zero-sequence voltage magnitude. When the "Neg to Pos Seq" mode is selected, the voltage unbalance is calculated based on the ratio of the negative-sequence voltage magnitude to the positive-sequence magnitude. When the "Zero to Pos Seq" mode is selected, the voltage unbalance is calculated based on the ratio of the zero-sequence voltage magnitude to the positive-sequence magnitude. When the "Ph vectors Comp" mode is selected, the ratio of the maximum phase voltage magnitude deviation from the mean voltage magnitude to the mean of the phase voltage magnitude is used for voltage unbalance calculation.

The calculated three-second value and ten-minute value are available in the Monitored data view through the outputs 3S_MN_UNB and 10MIN_MN_UNB.

3S_MN_UNB values are updated every three seconds and 10MIN_MN_UNB is updated every minute.

For VT connection = "Delta", the calculated zero-sequence voltage is always zero, hence, the setting *Unb detection method* = "Zero Seq" is not applicable in this VT configuration.

## Voltage unbalance detector

The three-second average value is calculated and compared to the set value *Unbalance start val*. If the voltage unbalance exceeds this limit, the MN_UNB_AL output is activated.

The activation of the BLOCK input blocks MN_UNB_AL output.

## Percentile calculation

The Percentile calculation module performs the statistics calculation for the level of voltage unbalance value for a settable duration. The operation of the Percentile calculation module can be described with a module diagram.

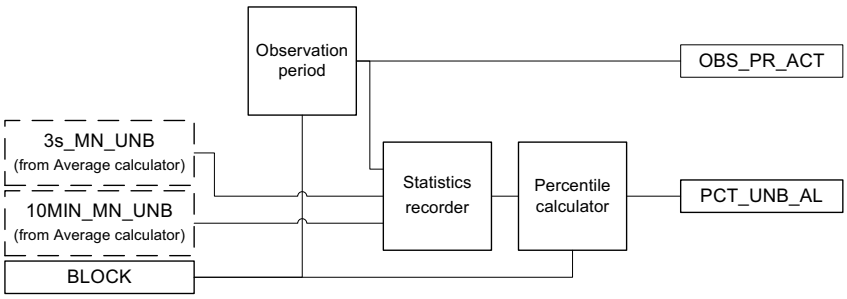



*Figure 848: Percentile calculation*

## Observation period

The Observation period module calculates the length of the observation time for the Statistics recorder sub-module as well as determines the possible start of a new one. A new period can be started by timed activation using calendar time settings *Obs period Str year*, *Obs period Str month*, *Obs period Str day* and *Obs period Str hour*.

The observation period start time settings *Obs period Str year*, *Obs period Str month*, *Obs period Str day* and *Obs period Str hour* are used to set the calendar time in UTC. These settings have to be adjusted according to the local time and local daylight saving time.

A preferable way of continuous statistics recordings can be selected over a longer period (months, years). With the *Trigger mode* setting, the way the next possible observation time is activated after the former one has finished can be selected.

*Table 1465: Trigger mode observation times*

| Trigger mode | Observation time |
|---|---|
| Single | Only one period of observation time is activated. |
| Periodic | The time gap between the two trigger signals is seven days. |
| Continuous | The next period starts right after the previous observation period is completed. |

The length of the period is determined by the settings *Obs period selection* and *User Def Obs period*. The OBS_PR_ACT output is an indication signal which exhibits rising edge (TRUE) when the observation period starts and falling edge (FALSE) when the observation period ends.

If the *Percentile unbalance*, *Trigger mode* or *Obs period duration* settings change when OBS_PR_ACT is active, OBS_PR_ACT deactivates immediately.

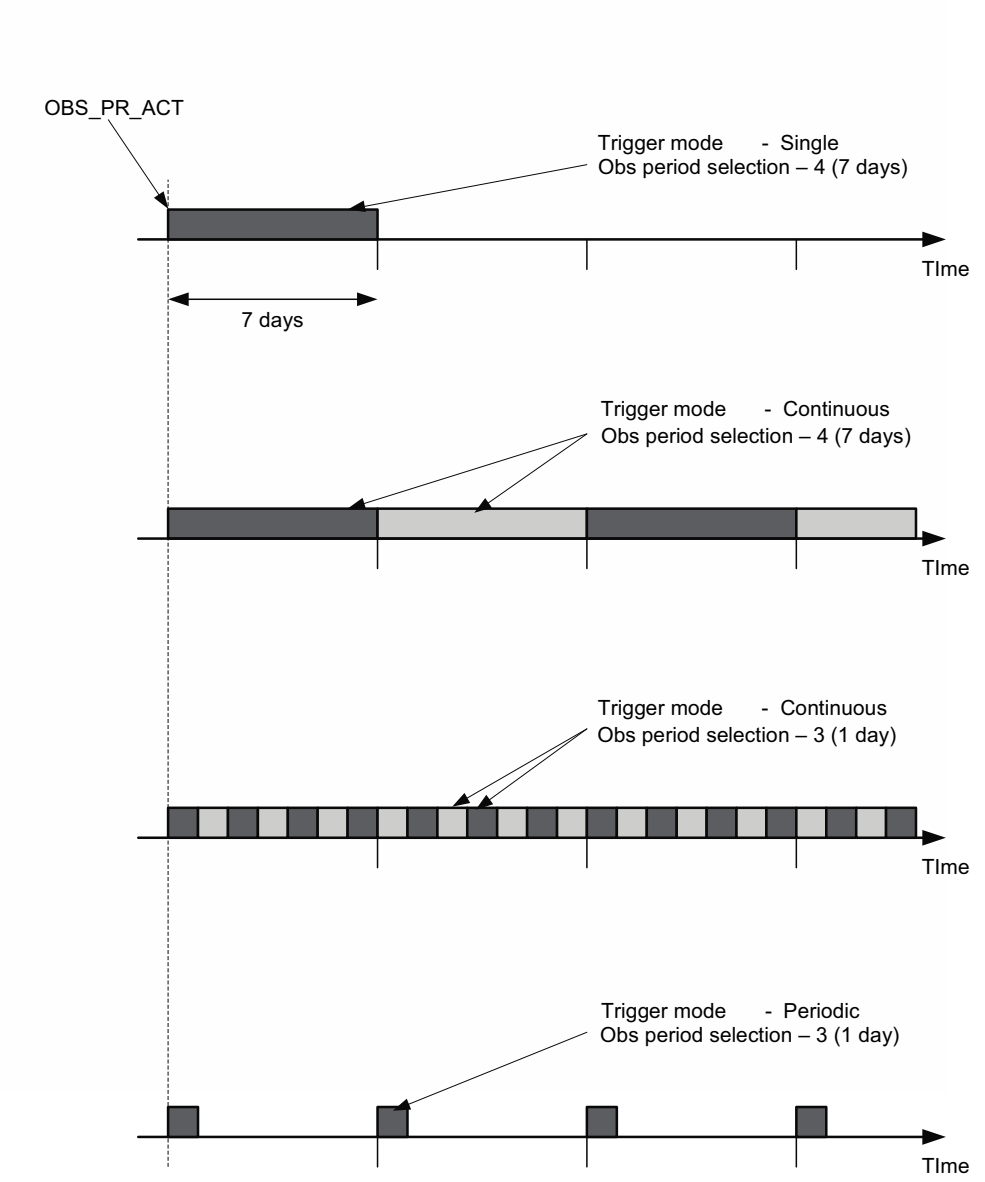



*Figure 849: Periods for statistics recorder with different trigger modes and period settings*

The BLOCK input blocks the OBS_PR_ACT output, which then disables the maximum value calculation of the Statistics recorder module. If the trigger mode is selected "Periodic" or "Continuous" and the blocking is deactivated before the next observation period is due to start, the scheduled period starts normally.

## Statistics recorder

The Statistics recorder module provides readily calculated three-second or ten-minute values of the selected phase to the percentile calculator module based on the length of the active observation period. If the observation period is less than one day, the three-second average values are used. If the observation period is one day or longer, the ten-minute average values are used.

The maximum three-second or ten-minute mean voltage unbalance is recorded during the active observation period. The observation period start time PR_STR_TIME, observation period end time PR_END_TIME, maximum voltage unbalance value during observation period active, MAX_UNB_VAL and time of occurrence MAX_UNB_TIME are available through the Monitored data view. These outputs are updated once OBS_PR_ACT deactivates.

## Percentile calculator

The purpose of the Percentile calculator module is to find the voltage unbalance level so that during the observation time 95 percent (default value of the *Percentile unbalance* setting) of all the measured voltage unbalance amplitudes are less than or equal to the calculated percentile.

The computed output value PCT_UNB_VAL, below which the percentile of the values lies, is available in the Monitored data view. The PCT_UNB_VAL output value is updated at the end of the observation period.

If the output PCT_UNB_VAL is higher than the defined setting *Unbalance start Val* at the end of the observation period, an alarm output PCT_UNB_AL is activated. The PCT_UNB_AL output remains active for the whole period before the next period completes.

The BLOCK input blocks the output PCT_UNB_VAL.

## Recorded data

The information required for a later fault analysis is stored when the Recorded data module is triggered. This happens when a voltage unbalance is detected by the Voltage unbalance detector module.

Three sets of recorded data are available in total. The sets are saved in data banks 1...3. The data bank 1 holds the most recent recorded data. Older data are moved to the subsequent banks (1 to 2 and 2 to 3) when a voltage unbalance is detected. When all three banks have data and a new variation is detected, the latest data set is placed into bank 1 and the data in bank 3 is overwritten by the data from bank 2.

The recorded data can be reset with the RESET binary input signal by navigating to the HMI reset (**Main menu/Clear/Reset recorded data/VSQVUBx**) or through tools via communications.

When a voltage unbalance is detected in the system, VSQVUB responds with the MN_UNB_AL alarm signal. During the alarm situation, VSQVUB stores the maximum magnitude and the time of occurrence and the duration of alarm MN_UNB_AL. The recorded data is stored when MN_UNB_AL is deactivated.

*Table 1466: Recorded data*

| Parameter | Description |
|---|---|
| Alarm high mean Dur | Time duration for alarm high mean unbalance |
| Max unbalance Volt | Maximum three-second voltage |
| Time Max Unb Volt | Time stamp of voltage unbalance |

## 10.4.6 Application

Voltage unbalance is one of the basic power quality parameters.

Ideally, in a three-phase or multiphase power system, the frequency and voltage magnitude of all the phases are equal and the phase displacement between any two consecutive phases is also equal. This is called a balanced source. Apart from the balanced source, usually the power system network and loads are also balanced, implying that network impedance and load impedance in each phase are equal. In some cases, the condition of a balance network and load is not met completely, which leads to a current and voltage unbalance in the system. Providing unbalanced supply voltage has a detrimental effect on load operation. For example, a small magnitude of a negative-sequence voltage applied to an induction motor results in a significant heating of the motor.

A balanced supply, balanced network and balanced load lead to a better power quality. When one of these conditions is disturbed, the power quality is deteriorated. VSQVUB monitors voltage unbalance conditions in power transmission and distribution networks. VSQVUB calculates two sets of measured values, a three-second and a ten-minute non-sliding average value. The three-second average value is used for continuous monitoring while the ten-minute average value is used for percentile calculation for a longer period of time. It can be applied to identify the network and load unbalance that may cause sustained voltage unbalance. A single-phase or phase-to-phase fault in the network or load side can create voltage unbalance but, as faults are usually isolated in a short period of time, the voltage unbalance is not a sustained one. Therefore, the voltage unbalance may not be covered by VSQVUB.

Another major application is the long-term power quality monitoring. This can be used to confirm a compliance to the standard power supply quality norms. The function provides a voltage unbalance level which corresponds to the $95^{th}$ percentile of the ten minutes' average values of voltage unbalance recorded over a period of up to one week. It means that for 95 percent of time during the observation period the voltage unbalance was less than or equal to the calculated percentile. An alarm can be obtained if this value exceeds the value that can be set.

The function uses five different methods for calculating voltage unbalance.

- Negative-sequence voltage magnitude
- Zero-sequence voltage magnitude
- Ratio of negative-sequence to positive-sequence voltage magnitude
- Ratio of zero-sequence to positive-sequence voltage magnitude
- Ratio of maximum phase voltage magnitude deviation from the mean voltage magnitude to the mean of phase voltage magnitude.

Usually, the ratio of the negative-sequence voltage magnitude to the positive-sequence voltage magnitude is selected for monitoring the voltage unbalance. However, other methods may also be used if required.

## 10.4.7 Signals

*Table 1467: VSQVUB Input signals*

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block all outputs except measured values |

*Table 1468: VSQVUB Output signals*

| Name | Type | Description |
|---|---|---|
| MN_UNB_AL | BOOLEAN | Alarm active when 3 sec voltage unbalance exceeds the limit |
| PCT_UNB_AL | BOOLEAN | Alarm active when percentile unbalance exceeds the limit |
| OBS_PR_ACT | BOOLEAN | Observation period is active |

## 10.4.8 Settings

*Table 1469: VSQVUB Non group settings (Basic)*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation On/Off |
| Unb detection method | 1=Neg Seq<br>2=Zero Seq<br>3=Neg to Pos Seq<br>4=Zero to Pos Seq<br>5=Ph vectors Comp | | | 3=Neg to Pos Seq | Set the operation mode for voltage unbalance calculation |
| Unbalance start Val | 1...100 | % | 1 | 1 | Voltage unbalance start value |
| Trigger mode | 1=Single<br>2=Periodic<br>3=Continuous | | | 3=Continuous | Specifies the observation period triggering mode |
| Percentile unbalance | 1...100 | % | 1 | 95 | The percent to which percentile value PCT_UNB_VAL is calculated |
| Obs period selection | 1=1 Hour<br>2=12 Hours<br>3=1 Day<br>4=7 Days<br>5=User defined | | | 5=User defined | Observation period for unbalance calculation |
| User Def Obs period | 1...168 | h | 1 | 168 | User define observation period for statistic calculation |
| Obs period Str year | 2008...2076 | | | 2011 | Calendar time for observation period start year in YYYY |

Table continues on next page

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Obs period Str month | 0=reserved<br>1=January<br>2=February<br>3=March<br>4=April<br>5=May<br>6=June<br>7=July<br>8=August<br>9=September<br>10=October<br>11=November<br>12=December | | | 1=January | Calendar time for observation period start month |
| Obs period Str day | 1...31 | | | 1 | Calendar time for observation period start day |
| Obs period Str hour | 0...23 | h | | 0 | Calendar time for observation period start hour |

## 10.4.9 Monitored data

*Table 1470: VSQVUB Monitored data*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| 3S_MN_UNB | FLOAT32 | 0.00...150.00 | % | Non sliding 3 second mean value of voltage unbalance |
| 10MIN_MN_UNB | FLOAT32 | 0.00...150.00 | % | Sliding 10 minutes mean value of voltage unbalance |
| PCT_UNB_VAL | FLOAT32 | 0.00...150.00 | % | Limit below which percentile unbalance of the values lie |
| MAX_UNB_VAL | FLOAT32 | 0.00...150.00 | % | Maximum voltage unbalance measured in the observation period |
| MAX_UNB_TIME | Timestamp | | | Time stamp at which maximum voltage unbalance measured in the observation period |
| PR_STR_TIME | Timestamp | | | Time stamp of starting of the previous observation period |
| PR_END_TIME | Timestamp | | | Time stamp of end of previous observation period |
| Alarm high mean Dur | FLOAT32 | 0.000...3600.000 | s | Time duration for alarm high mean unbalance |
| Max unbalance Volt | FLOAT32 | 0.00...150.00 | % | Maximum 3 seconds unbalance voltage |
| Time Max Unb Volt | Timestamp | | | Time stamp of maximum voltage unbalance |
| Alarm high mean Dur | FLOAT32 | 0.000...3600.000 | s | Time duration for alarm high mean unbalance |

Table continues on next page

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Max unbalance Volt | FLOAT32 | 0.00...150.00 | % | Maximum 3 seconds unbalance voltage |
| Time Max Unb Volt | Timestamp | | | Time stamp of maximum voltage unbalance |
| Alarm high mean Dur | FLOAT32 | 0.000...3600.000 | s | Time duration for alarm high mean unbalance |
| Max unbalance Volt | FLOAT32 | 0.00...150.00 | % | Maximum 3 seconds unbalance voltage |
| Time Max Unb Volt | Timestamp | | | Time stamp of maximum voltage unbalance |
| VSQVUB | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 10.4.10 Technical data

*Table 1471: VSQVUB Technical data*

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.5% of the set value or ±0.002 × $U_n$ |
| Reset ratio | Typically 0.96 |

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# Section 11 General function block features

## 11.1 Definite time characteristics

### 11.1.1 Definite time operation

The DT mode is enabled when the *Operating curve type* setting is selected either as "ANSI Def. Time" or "IEC Def. Time". In the DT mode, the OPERATE output of the function is activated when the time calculation exceeds the set *Operate delay time*.

The user can determine the reset in the DT mode with the *Reset delay time* setting, which provides the delayed reset property when needed.



The *Type of reset curve* setting has no effect on the reset method when the DT mode is selected, but the reset is determined solely with the *Reset delay time* setting.

The purpose of the delayed reset is to enable fast clearance of intermittent faults, for example self-sealing insulation faults, and severe faults which may produce high asymmetrical fault currents that partially saturate the current transformers. It is typical for an intermittent fault that the fault current contains so called drop-off periods, during which the fault current falls below the set start current, including hysteresis. Without the delayed reset function, the operate timer would reset when the current drops off. In the same way, an apparent drop-off period of the secondary current of the saturated current transformer can also reset the operate timer.

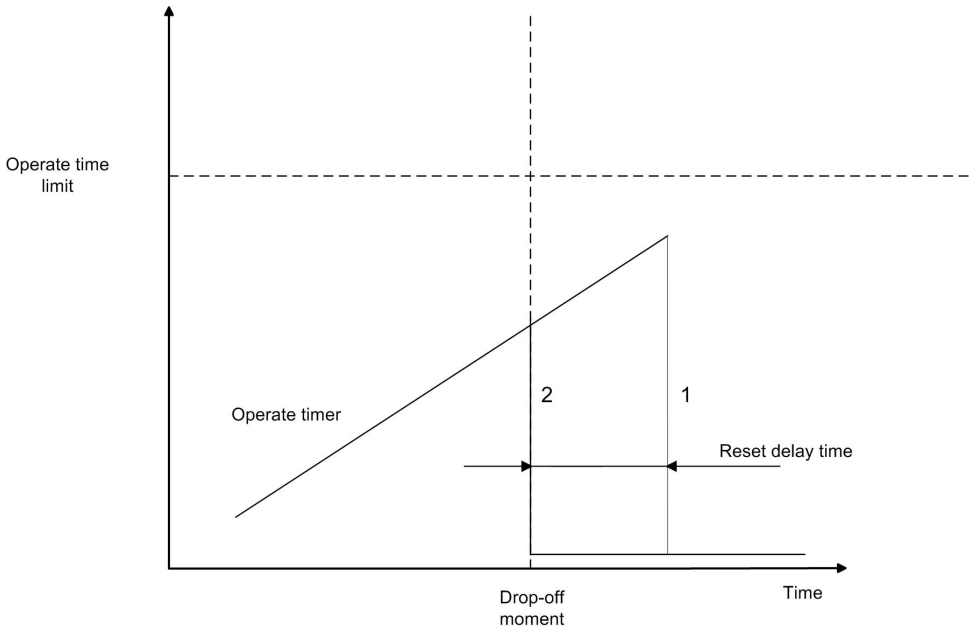



*Figure 850: Operation of the counter in drop-off*

In case 1, the reset is delayed with the *Reset delay time* setting and in case 2, the counter is reset immediately, because the *Reset delay time* setting is set to zero.

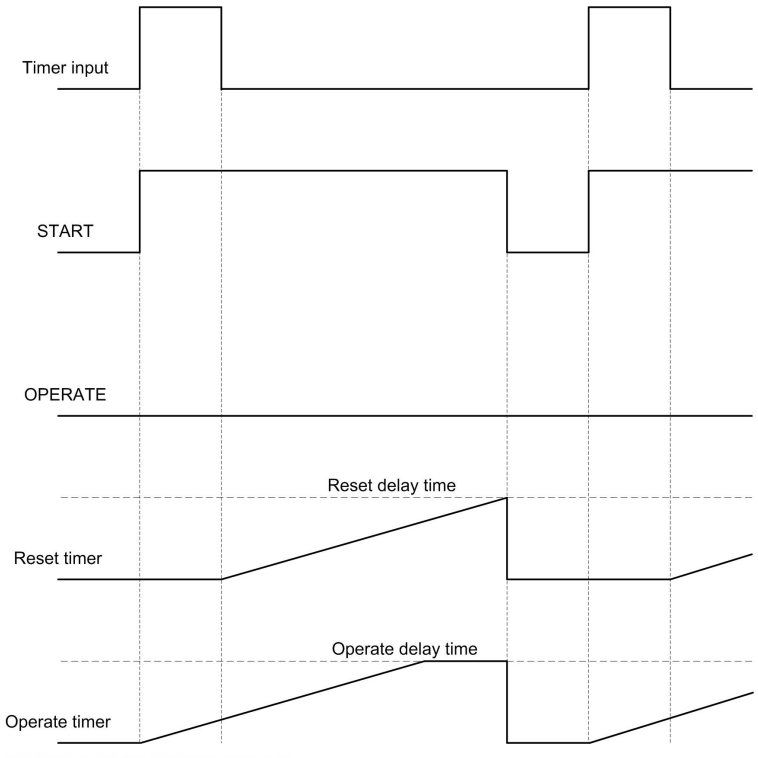



*Figure 851: Drop-off period is longer than the set Reset delay time*

When the drop-off period is longer than the set *Reset delay time*, as described in Figure 851, the input signal for the definite timer (here: timer input) is active, provided that the current is above the set *Start value*. The input signal is inactive when the current is below the set *Start value* and the set hysteresis region. The timer input rises when a fault current is detected. The definite timer activates the START output and the operate timer starts elapsing. The reset (drop-off) timer starts when the timer input falls, that is, the fault disappears. When the reset (drop-off) timer elapses, the operate timer is reset. Since this happens before another start occurs, the OPERATE output is not activated.

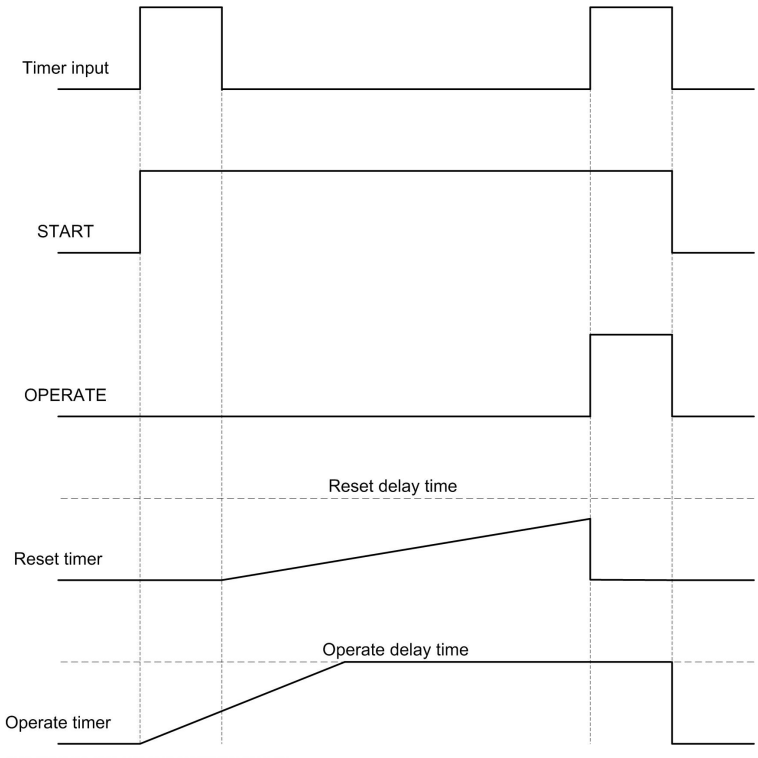



*Figure 852: Drop-off period is shorter than the set Reset delay time*

When the drop-off period is shorter than the set *Reset delay time*, as described in Figure 852, the input signal for the definite timer (here: timer input) is active, provided that the current is above the set *Start value*. The input signal is inactive when the current is below the set *Start value* and the set hysteresis region. The timer input rises when a fault current is detected. The definite timer activates the START output and the operate timer starts elapsing. The Reset (drop-off) timer starts when the timer input falls, that is, the fault disappears. Another fault situation occurs before the reset (drop-off) timer has elapsed. This causes the activation of the OPERATE output, since the operate timer already has elapsed.

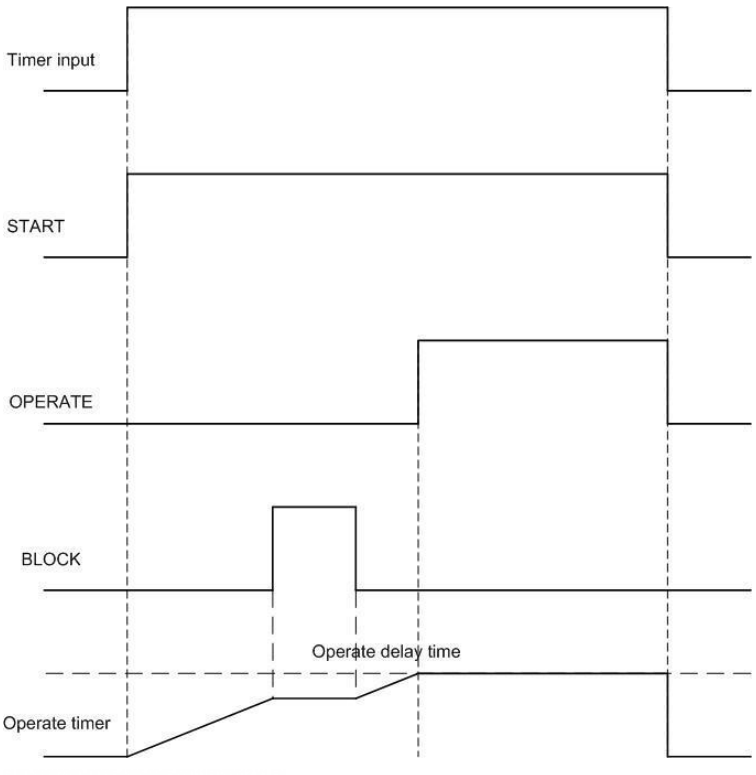



*Figure 853: Operating effect of the BLOCK input when the selected blocking mode is "Freeze timer"*

If the BLOCK input is activated when the operate timer is running, as described in Figure 853, the timer is frozen during the time BLOCK remains active. If the timer input is not active longer than specified by the *Reset delay time* setting, the operate timer is reset in the same way as described in Figure 851, regardless of the BLOCK input .

The selected blocking mode is "Freeze timer".

## 11.2 Current based inverse definite minimum time characteristics

### 11.2.1 IDMT curves for overcurrent protection

In inverse-time modes, the operation time depends on the momentary value of the current: the higher the current, the faster the operation time. The operation time calculation or integration starts immediately when the current exceeds the set *Start value* and the START output is activated.

The OPERATE output of the component is activated when the cumulative sum of the integrator calculating the overcurrent situation exceeds the value set by the inverse-time mode. The set value depends on the selected curve type and the setting values used. The curve scaling is determined with the *Time multiplier* setting.

There are two methods to level out the inverse-time characteristic.

- The *Minimum operate time* setting defines the minimum operating time for the IDMT curve, that is, the operation time is always at least the *Minimum operate time* setting.
- Alternatively, the *IDMT Sat point* is used for giving the leveling-out point as a multiple of the *Start value* setting. (Global setting: **Configuration/System/*IDMT Sat point***). The default parameter value is 50. This setting affects only the overcurrent and earth-fault IDMT timers.



IDMT operation time at currents over 50 x In is not guaranteed.

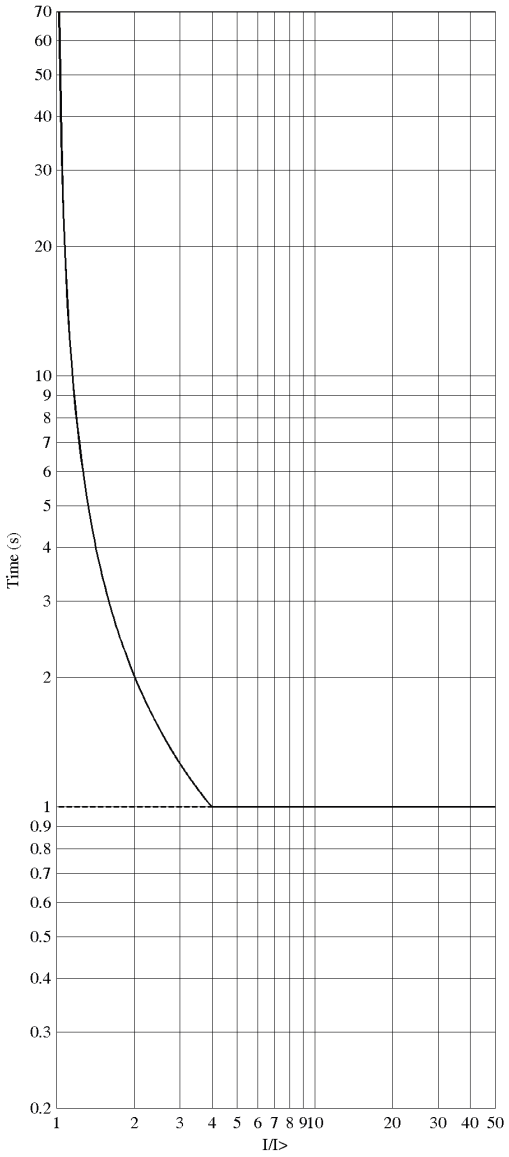



*Figure 854: Operation time curve based on the IDMT characteristic leveled out with the Minimum operate time setting is set to 1000 milliseconds (the IDMT Sat point setting is set to maximum).*

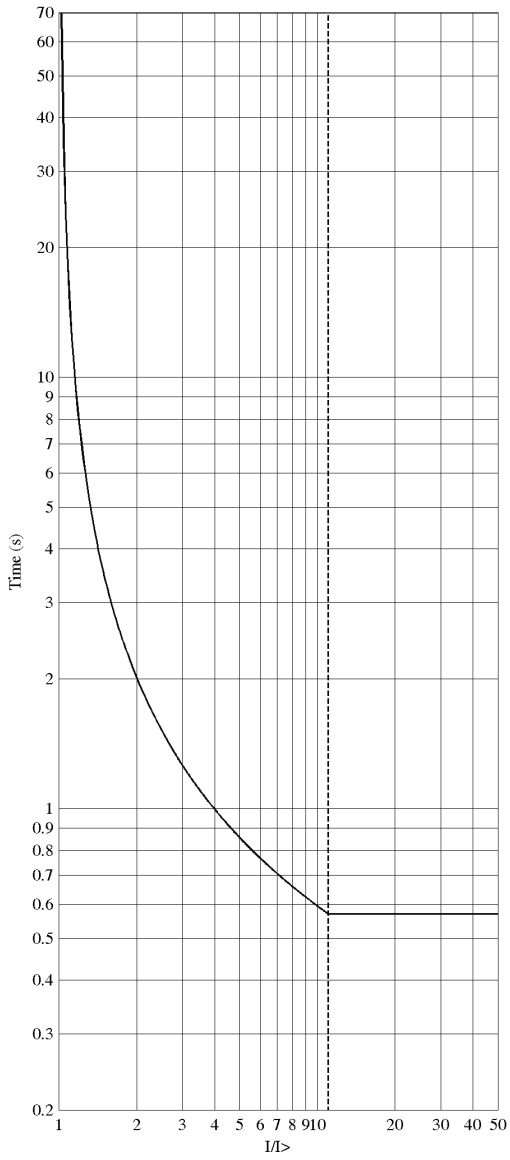



*Figure 855: Operation time curve based on the IDMT characteristic leveled out with IDMT Sat point setting value “11” (the Minimum operate time setting is set to minimum).*

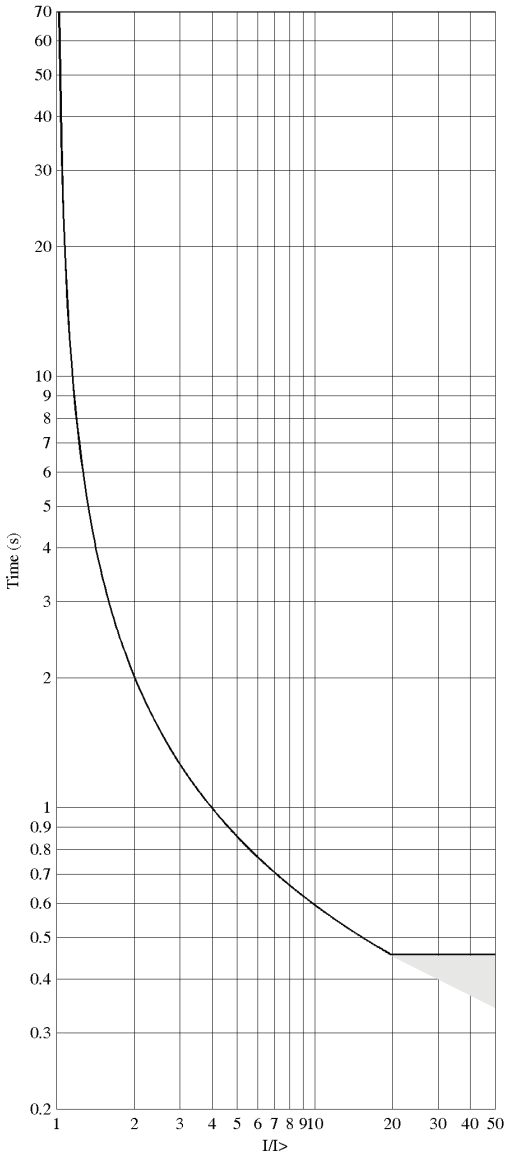



*Figure 856: Example of how the inverse time characteristic is leveled out with currents over 50 x In and the Setting Start value setting "2.5 x In". (the IDMT Sat point setting is set to maximum and the Minimum operate time setting is set to minimum).*

The grey zone in Figure 856 shows the behavior of the curve in case the measured current is outside the guaranteed measuring range. Also, the maximum measured current of 50 x In gives the leveling-out point 50/2.5 = 20 x I/I>.

### 11.2.1.1 Standard inverse-time characteristics

For inverse-time operation, both IEC and ANSI/IEEE standardized inverse-time characteristics are supported.

The operate times for the ANSI and IEC IDMT curves are defined with the coefficients A, B and C.

The values of the coefficients can be calculated according to the formula:

$$t[s] = \left( \frac{A}{\left( \frac{I}{I>} \right)^{c} - 1} + B \right) \cdot k$$

(Equation 354)

t[s] Operate time in seconds

I Measured current

I> Set *Start value*

k Set *Time multiplier*

*Table 1472: Curve parameters for ANSI and IEC IDMT curves*

| Curve name | A | B | C |
|---|---|---|---|
| (1) ANSI Extremely Inverse | 28.2 | 0.1217 | 2.0 |
| (2) ANSI Very Inverse | 19.61 | 0.491 | 2.0 |
| (3) ANSI Normal Inverse | 0.0086 | 0.0185 | 0.02 |
| (4) ANSI Moderately Inverse | 0.0515 | 0.1140 | 0.02 |
| (6) Long Time Extremely Inverse | 64.07 | 0.250 | 2.0 |
| (7) Long Time Very Inverse | 28.55 | 0.712 | 2.0 |
| (8) Long Time Inverse | 0.086 | 0.185 | 0.02 |
| (9) IEC Normal Inverse | 0.14 | 0.0 | 0.02 |
| (10) IEC Very Inverse | 13.5 | 0.0 | 1.0 |
| (11) IEC Inverse | 0.14 | 0.0 | 0.02 |
| (12) IEC Extremely Inverse | 80.0 | 0.0 | 2.0 |
| (13) IEC Short Time Inverse | 0.05 | 0.0 | 0.04 |
| (14) IEC Long Time Inverse | 120 | 0.0 | 1.0 |

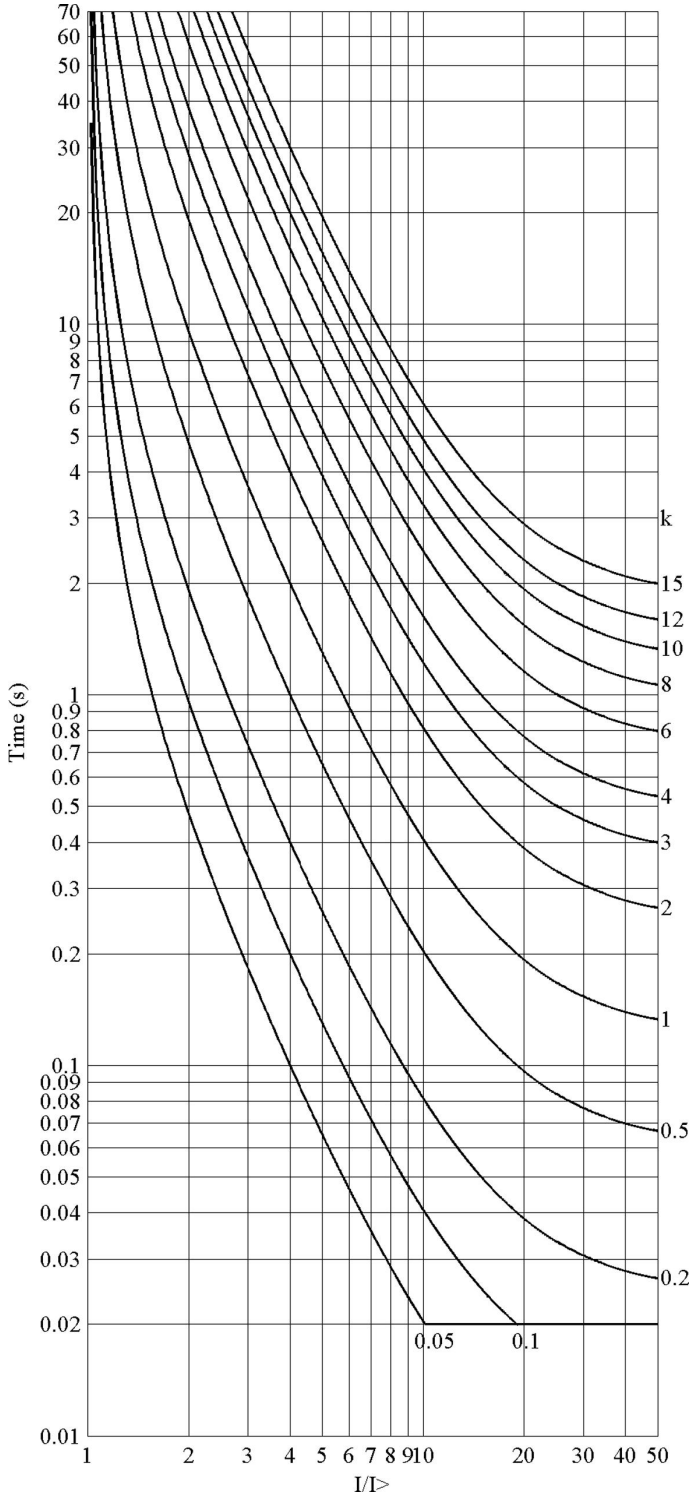



*Figure 857: ANSI extremely inverse-time characteristics*

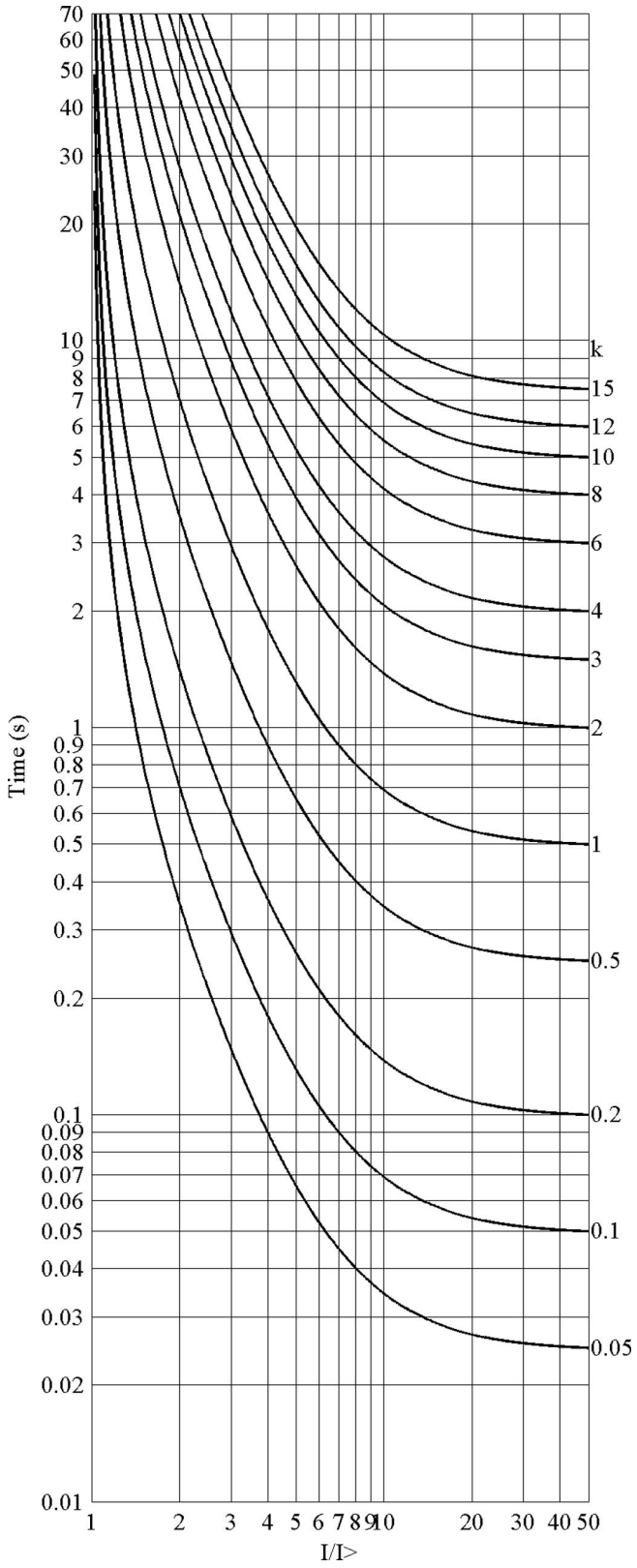



*Figure 858: ANSI very inverse-time characteristics*

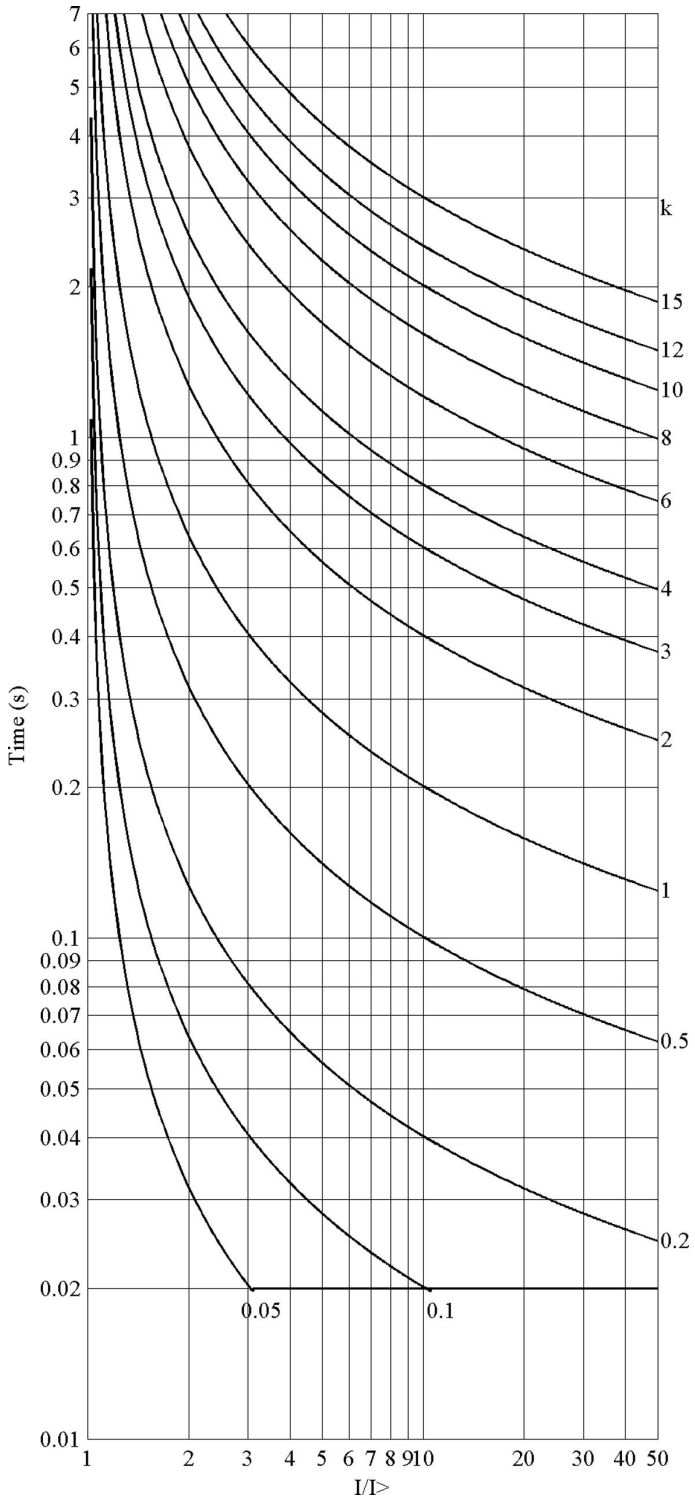



*Figure 859: ANSI normal inverse-time characteristics*

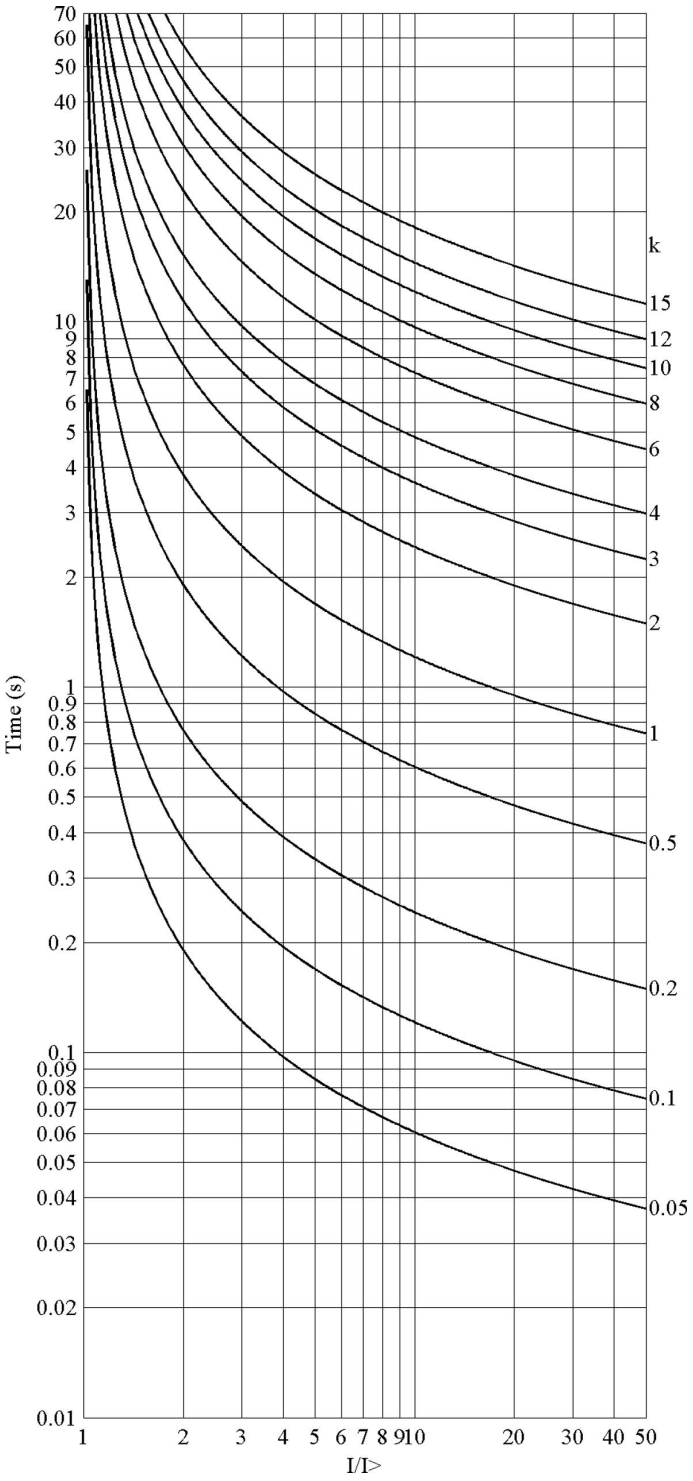



*Figure 860: ANSI moderately inverse-time characteristics*

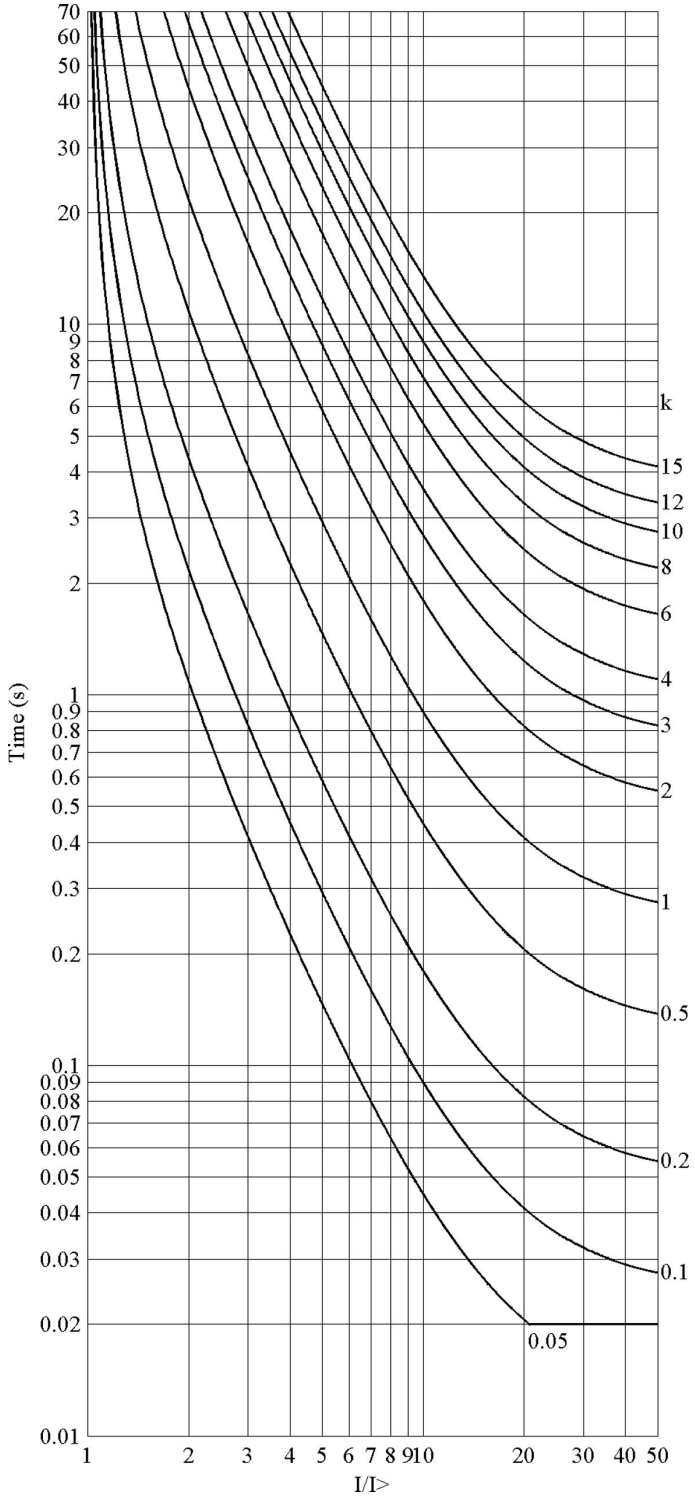



*Figure 861: ANSI long-time extremely inverse-time characteristics*

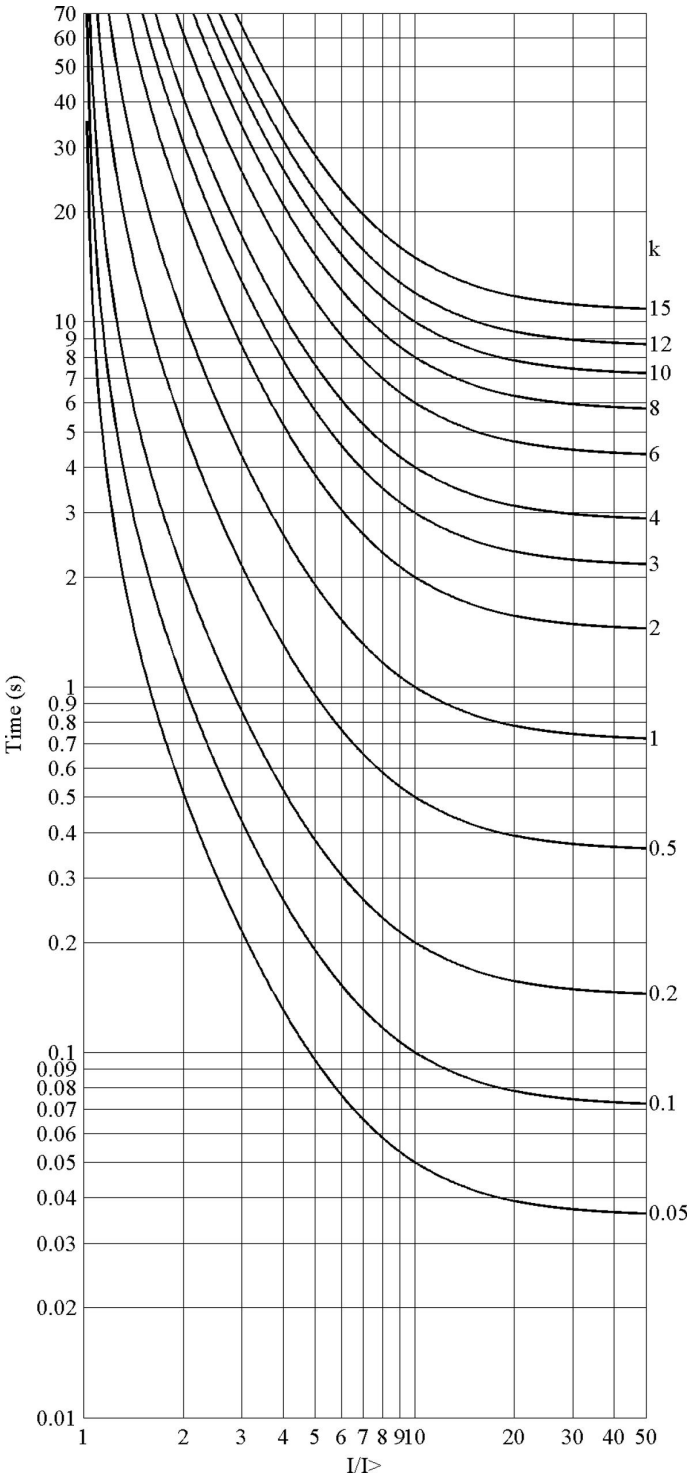



*Figure 862: ANSI long-time very inverse-time characteristics*

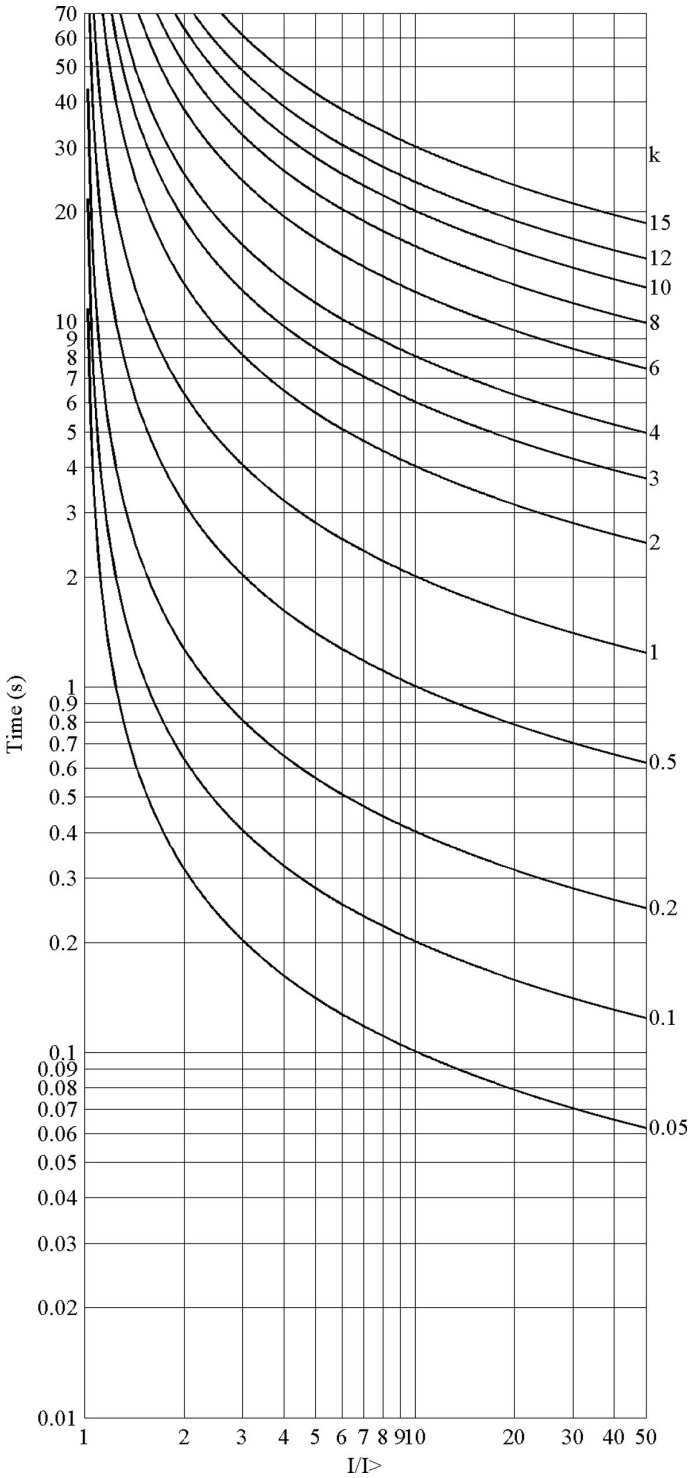



*Figure 863: ANSI long-time inverse-time characteristics*

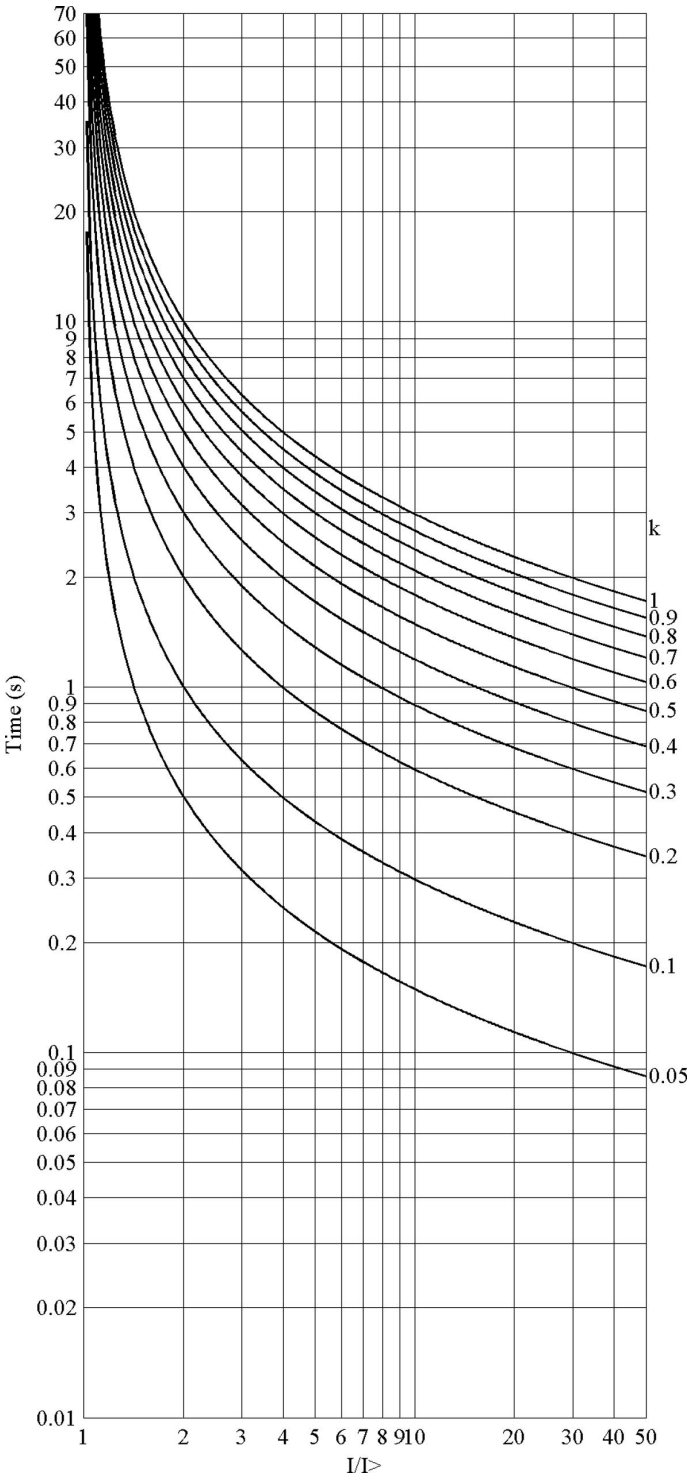



*Figure 864: IEC normal inverse-time characteristics*

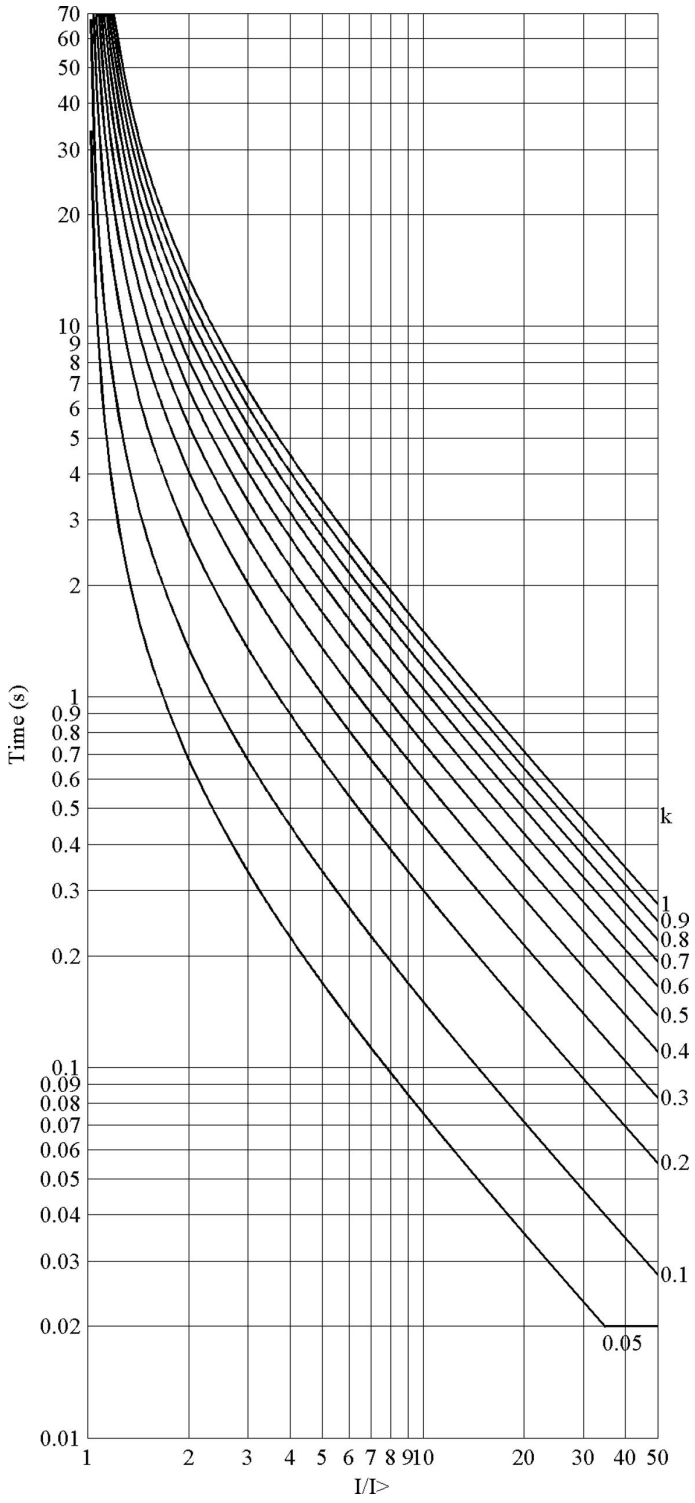



*Figure 865: IEC very inverse-time characteristics*

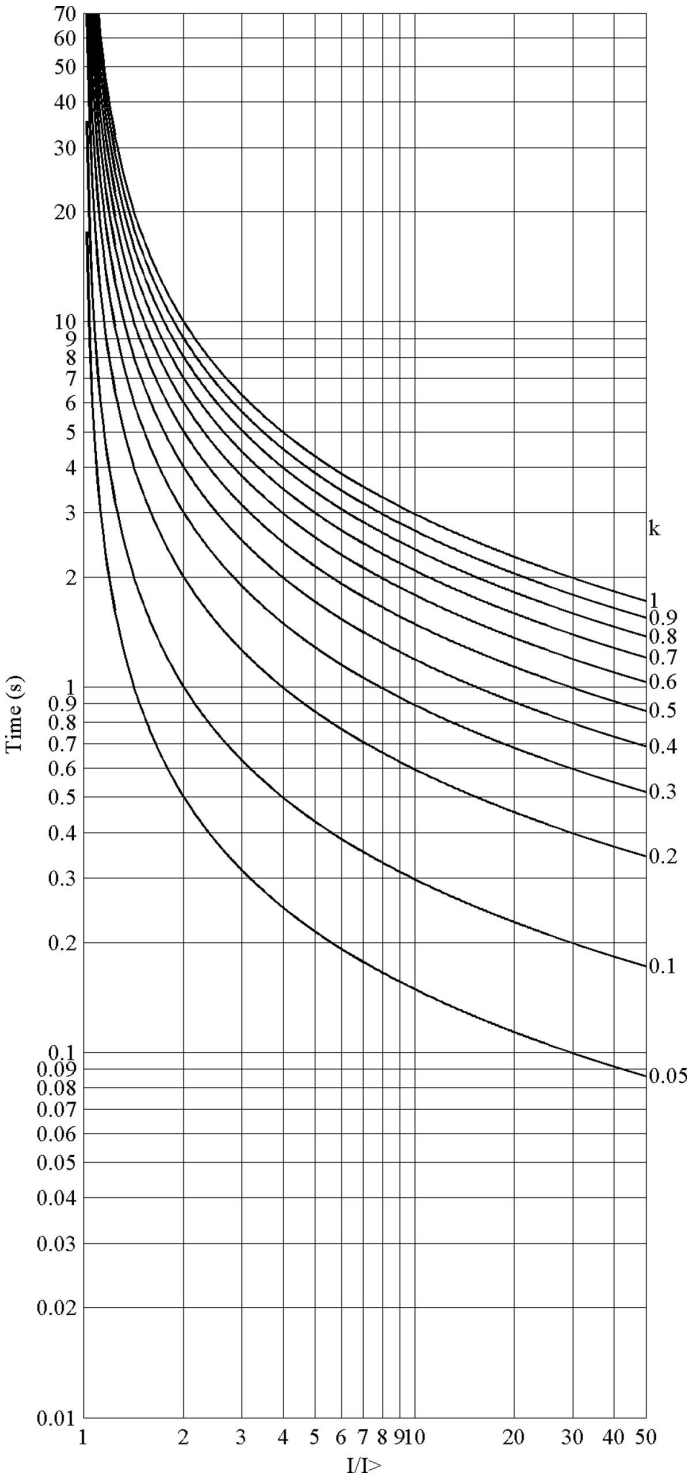



*Figure 866: IEC inverse-time characteristics*

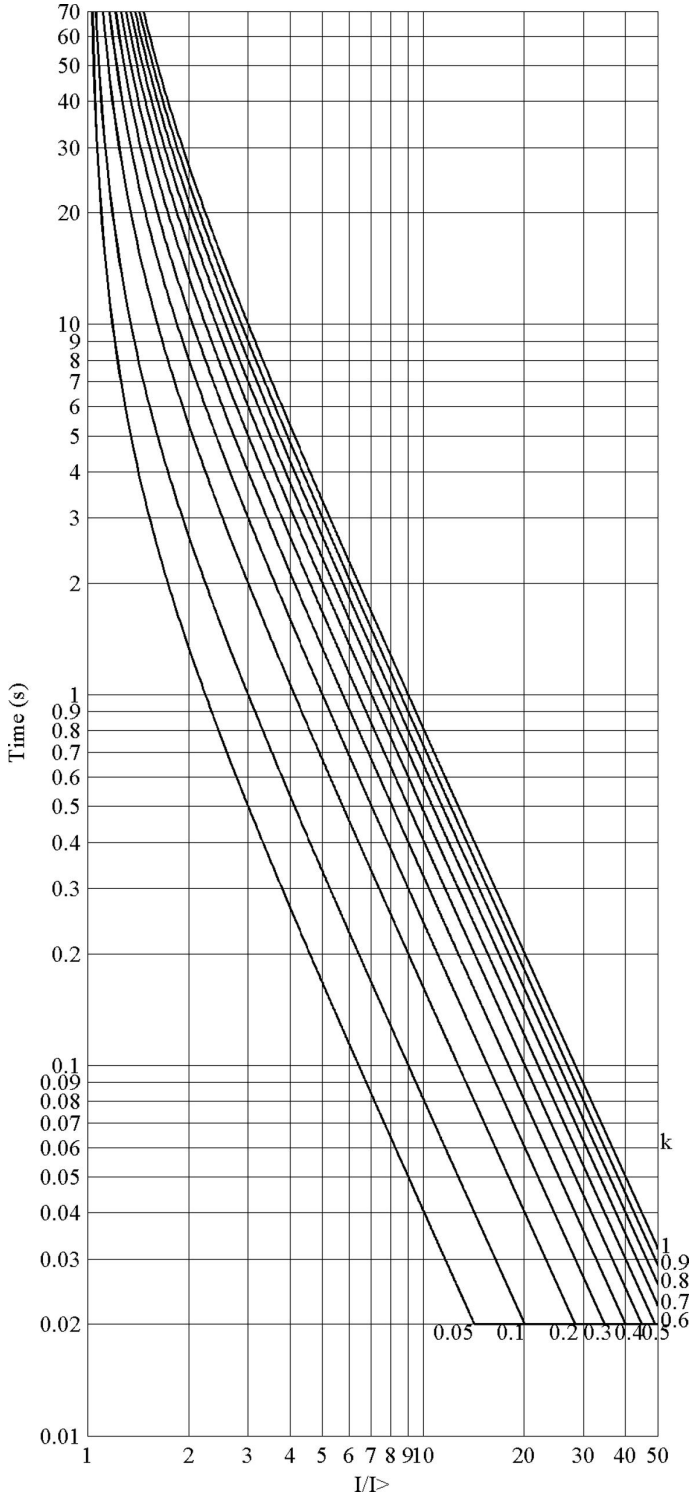



*Figure 867: IEC extremely inverse-time characteristics*

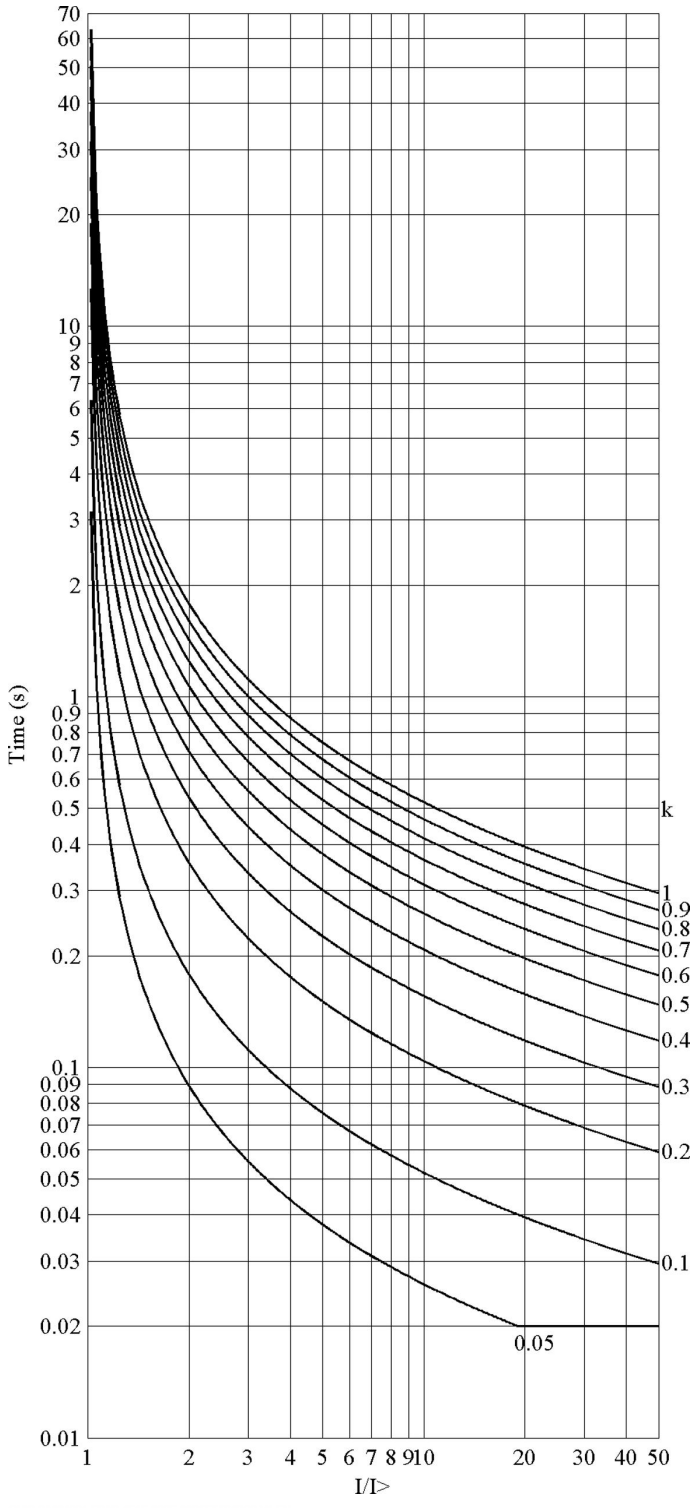



*Figure 868: IEC short-time inverse-time characteristics*

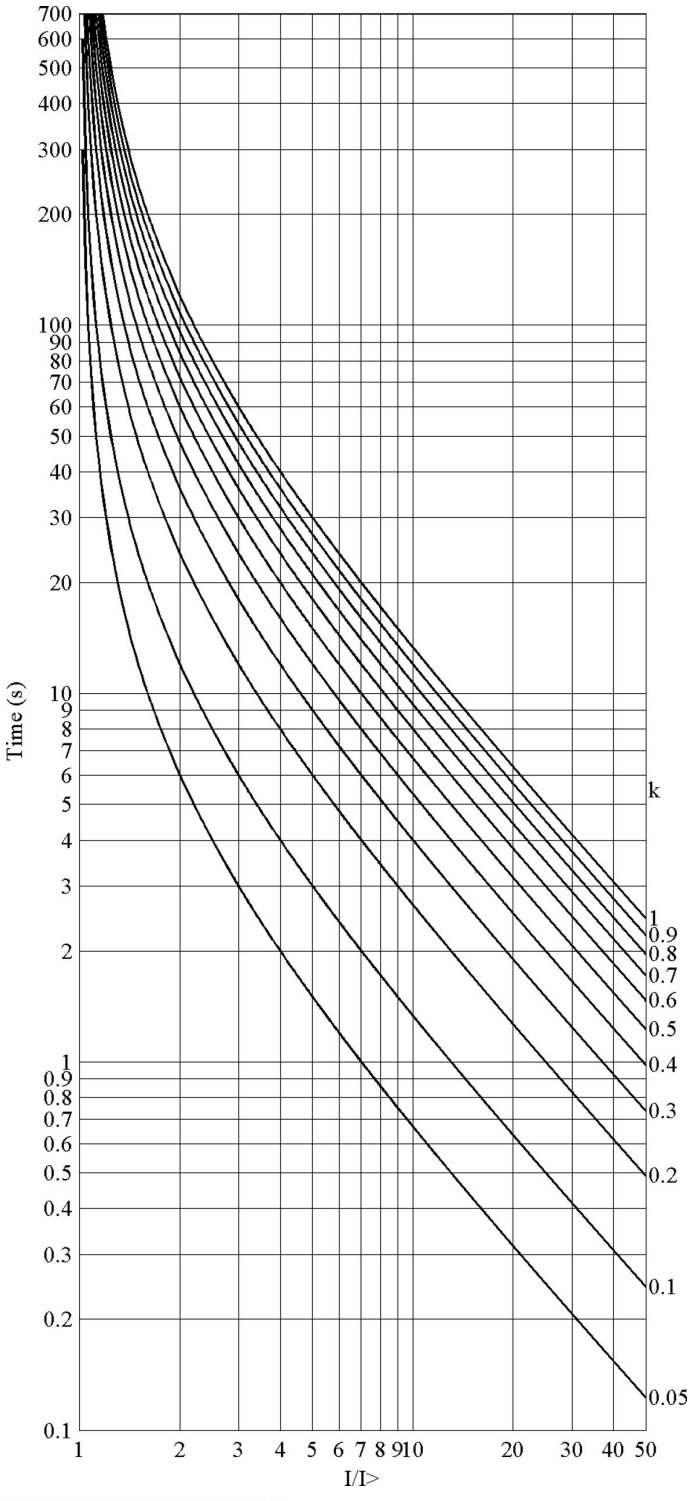



*Figure 869: IEC long-time inverse-time characteristics*

### 11.2.1.2 User-programmable inverse-time characteristics

The user can define curves by entering parameters into the following standard formula:

$$t[s] = \left( \frac{A}{\left( \frac{I}{I>} \right)^{C} - E} + B \right) \cdot k$$

(Equation 355)

t[s] Operate time (in seconds)
A Set *Curve parameter A*
B Set *Curve parameter B*
C Set *Curve parameter C*
E Set *Curve parameter E*
I Measured current
I> Set *Start value*
k Set *Time multiplier*

### 11.2.1.3 RI and RD-type inverse-time characteristics

The RI-type simulates the behavior of electromechanical relays. The RD-type is an earth-fault specific characteristic.

The RI-type is calculated using the formula

$$t[s] = \left( \frac{k}{0.339 - 0.236 \cdot \frac{I>}{I}} \right)$$

(Equation 356)

The RD-type is calculated using the formula

$$t[s] = 5.8 - 1.35 \cdot ln\left( \frac{I}{k \cdot I>} \right)$$

(Equation 357)

t[s] Operate time (in seconds)

k Set *Time multiplier*

I Measured current

I> Set *Start value*

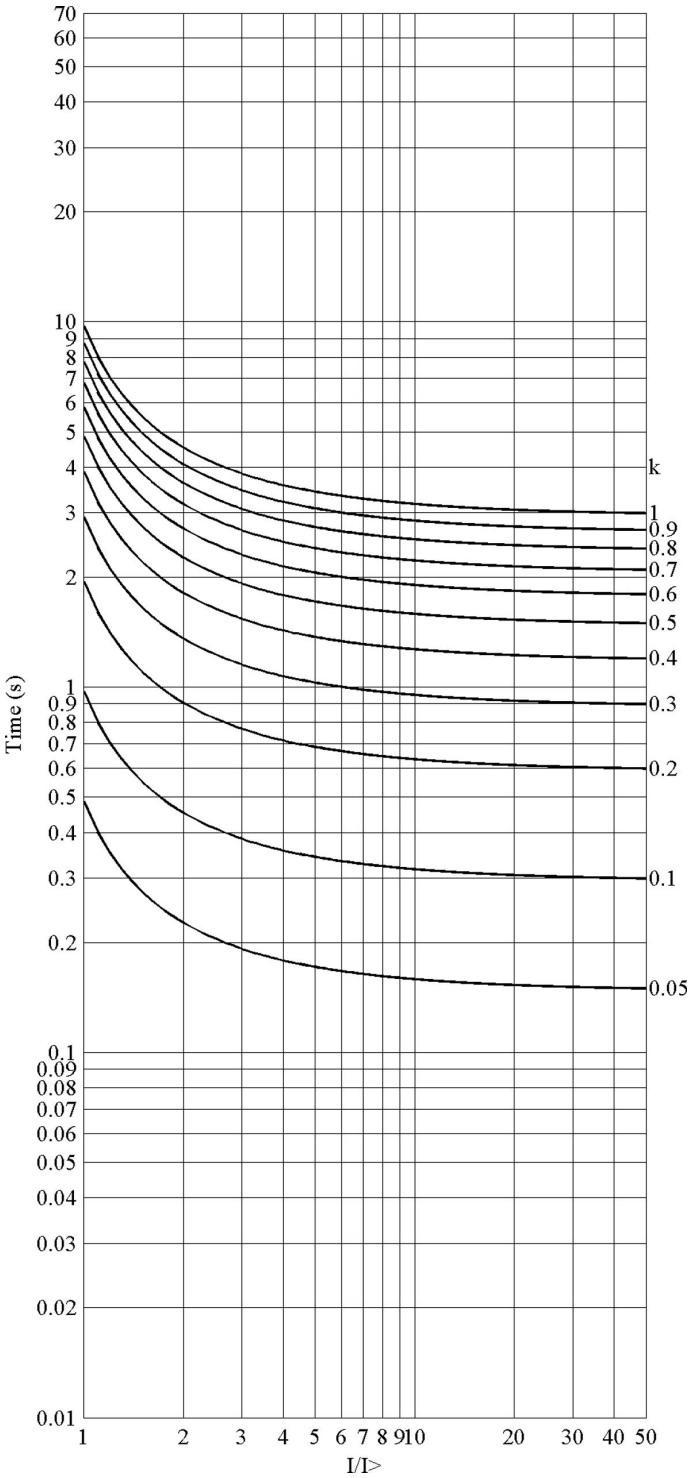



*Figure 870: RI-type inverse-time characteristics*

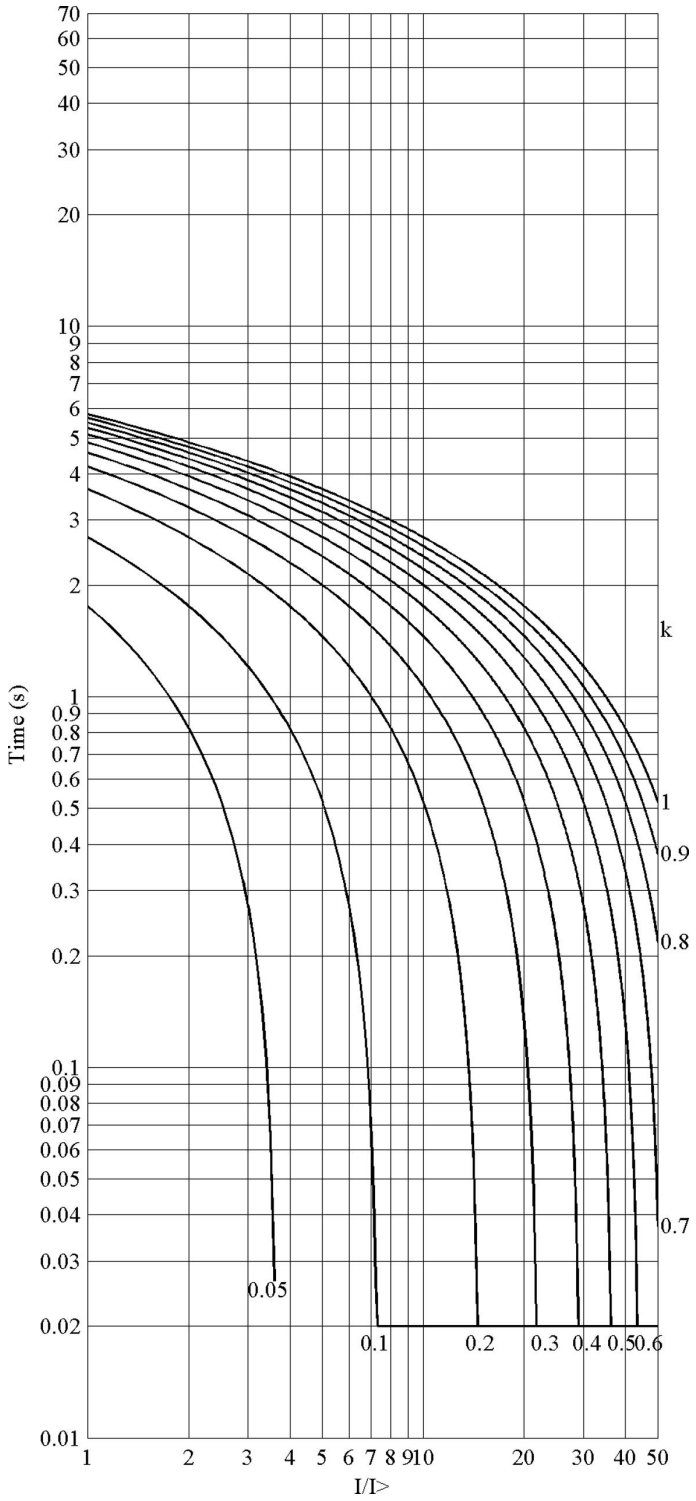



*Figure 871: RD-type inverse-time characteristics*

### 11.2.1.4 UK rectifier inverse-time characteristic

The UK rectifier type simulates the rectifier bridge.

The operate times are defined with the coefficients A, B and C.

The values of the coefficients can be calculated according to the formula

$$t[s] = \left( \frac{A}{\left( \frac{I}{I>} \right)^{c} - 1} + B \right) \cdot k$$

(Equation 358)

t[s] Operate time in seconds

I Measured current

I> Set *Start value*

k Set *Time multiplier*

*Table 1473: Curve parameters for UK rectifier*

| Operating curve type | A | B | C |
|---|---|---|---|
| (20) UK rectifier | 45900 | 0 | 5.6 |

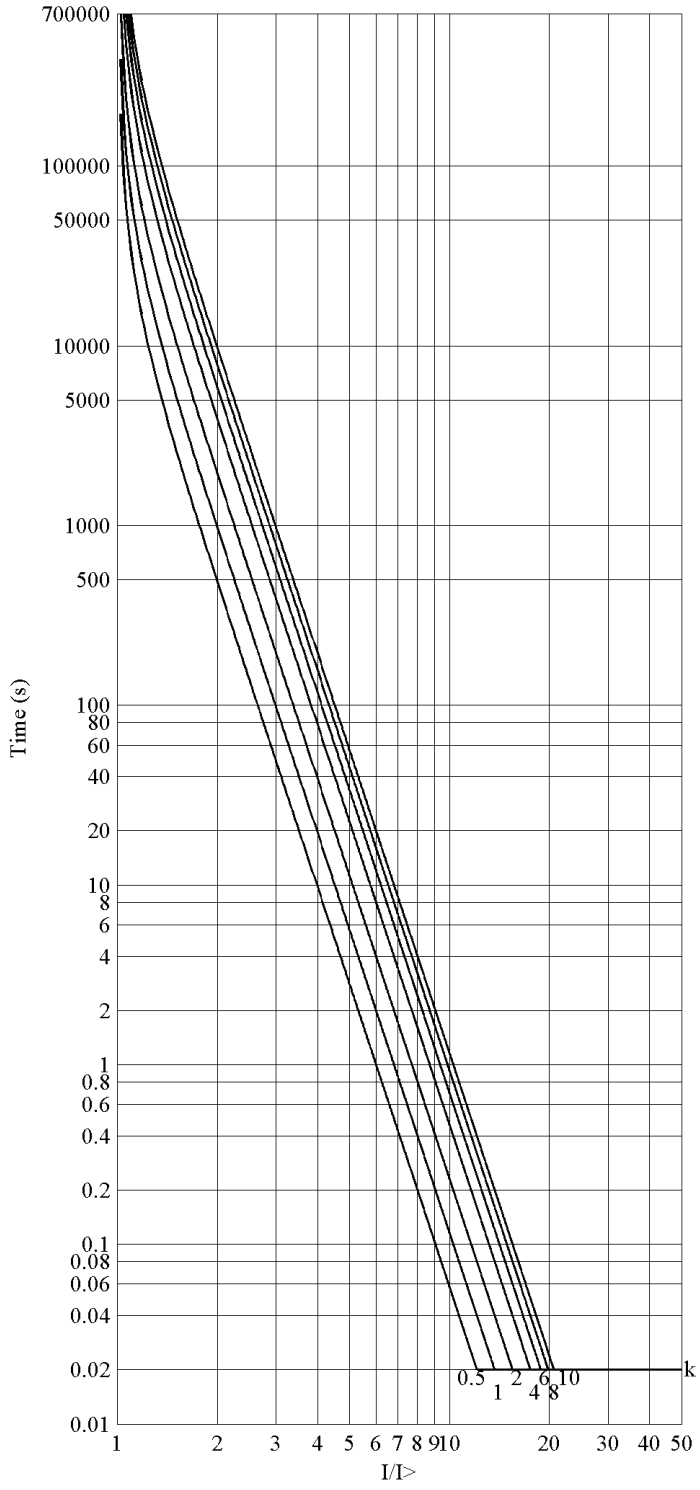



*Figure 872: UK rectifier inverse-time characteristic*

## 11.2.2 Reset in inverse-time modes

The user can select the reset characteristics by using the *Type of reset curve* setting.

*Table 1474: Values for reset mode*

| Setting name | Possible values |
|---|---|
| *Type of reset curve* | 1=Immediate<br>2=Def time reset<br>3=Inverse reset |

### Immediate reset

If the *Type of reset curve* setting in a drop-off case is selected as "Immediate", the inverse timer resets immediately.

### Definite time reset

The definite type of reset in the inverse-time mode can be achieved by setting the *Type of reset curve* parameter to “Def time reset”. As a result, the operate inverse-time counter is frozen for the time determined with the *Reset delay time* setting after the current drops below the set *Start value*, including hysteresis.The integral sum of the inverse-time counter is reset, if another start does not occur during the reset delay.

If the *Type of reset curve* setting is selected as “Def time reset”, the current level has no influence on the reset characteristic.

### Inverse reset

Inverse reset curves are available only for ANSI and user-programmable curves. If you use other curve types, immediate reset occurs.

#### Standard delayed inverse reset

The reset characteristic required in ANSI (IEEE) inverse-time modes is provided by setting the *Type of reset curve* parameter to “Inverse reset”. In this mode, the time delay for reset is given with the following formula using the coefficient D, which has its values defined in the table below.

$$t[s] = \left( \frac{D}{\left( \frac{I}{I>} \right)^2 - 1} \right) \cdot k$$

(Equation 359)

t[s] Reset time (in seconds)

k Set *Time multiplier*

I Measured current

I> Set *Start value*

*Table 1475: Coefficients for ANSI delayed inverse reset curves*

| Curve name | D |
|---|---|
| (1) ANSI Extremely Inverse | 29.1 |
| (2) ANSI Very Inverse | 21.6 |
| (3) ANSI Normal Inverse | 0.46 |
| (4) ANSI Moderately Inverse | 4.85 |
| (6) Long Time Extremely Inverse | 30 |
| (7) Long Time Very Inverse | 13.46 |
| (8) Long Time Inverse | 4.6 |

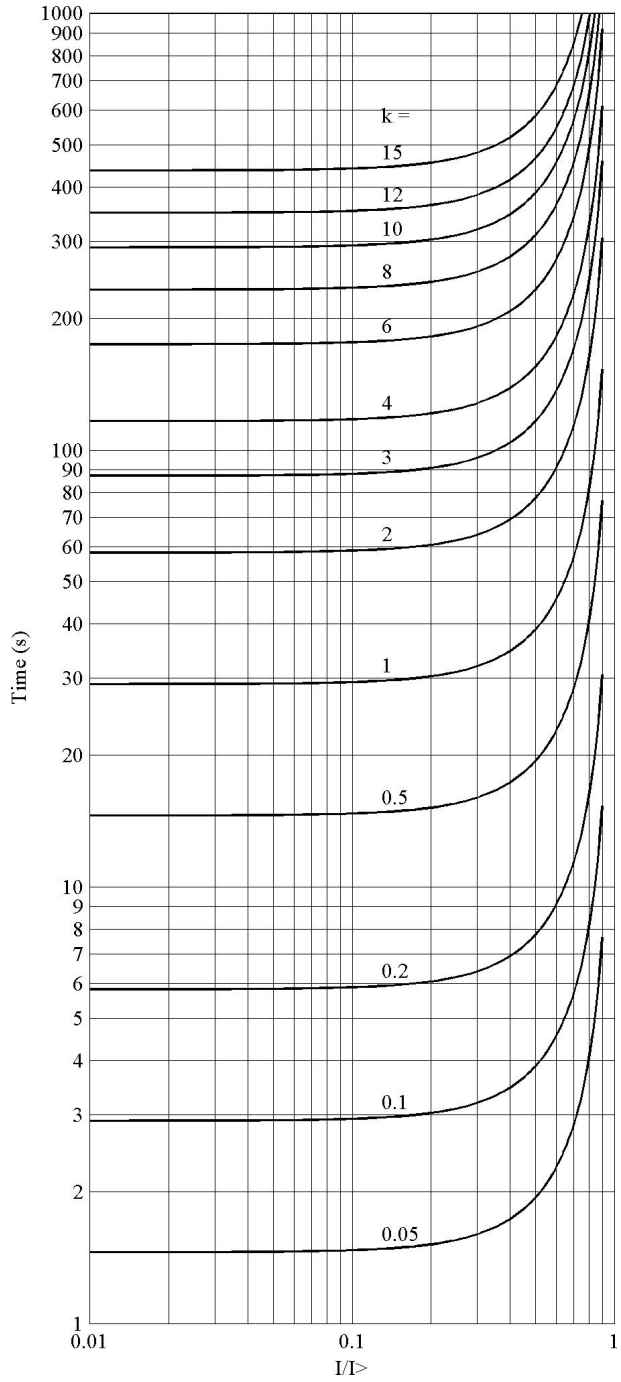
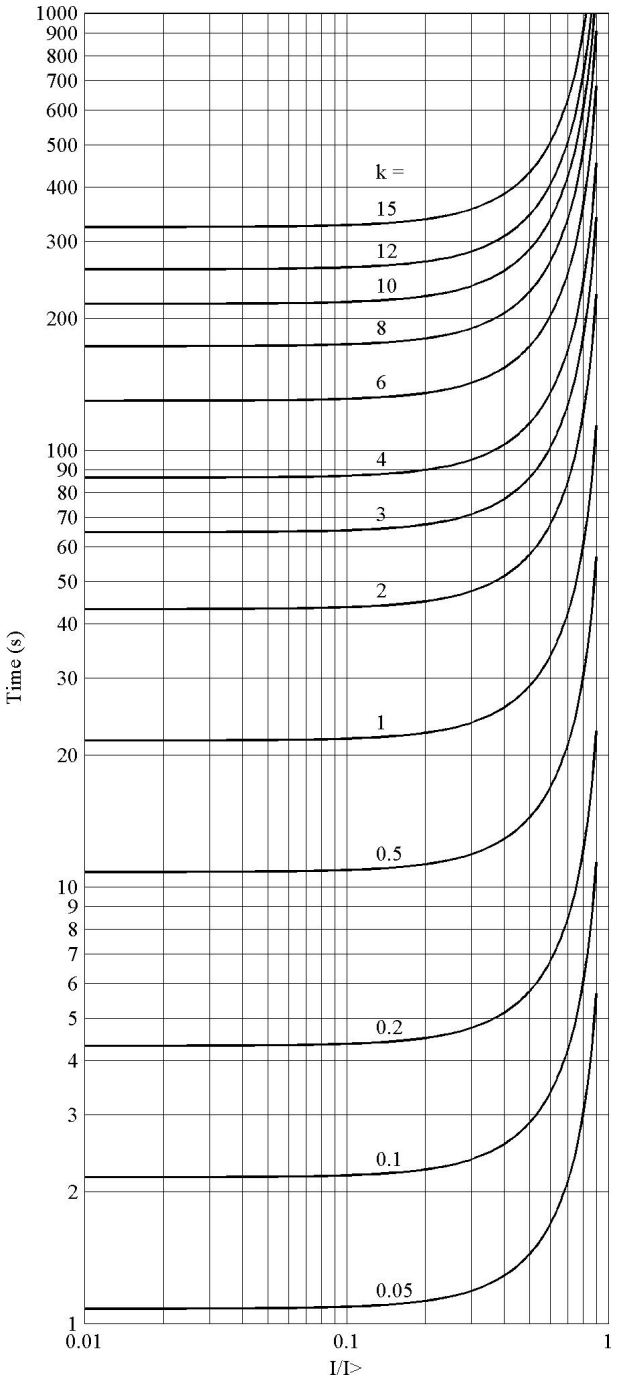



*Figure 873: ANSI extremely inverse reset time characteristics*


1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
k =
15
12
10
8
6
4
3
2
1
0.5
0.2
0.1
0.05
Time (s)
0.01
0.1
1
I/I>
Figure 874: ANSI very inverse reset time characteristics

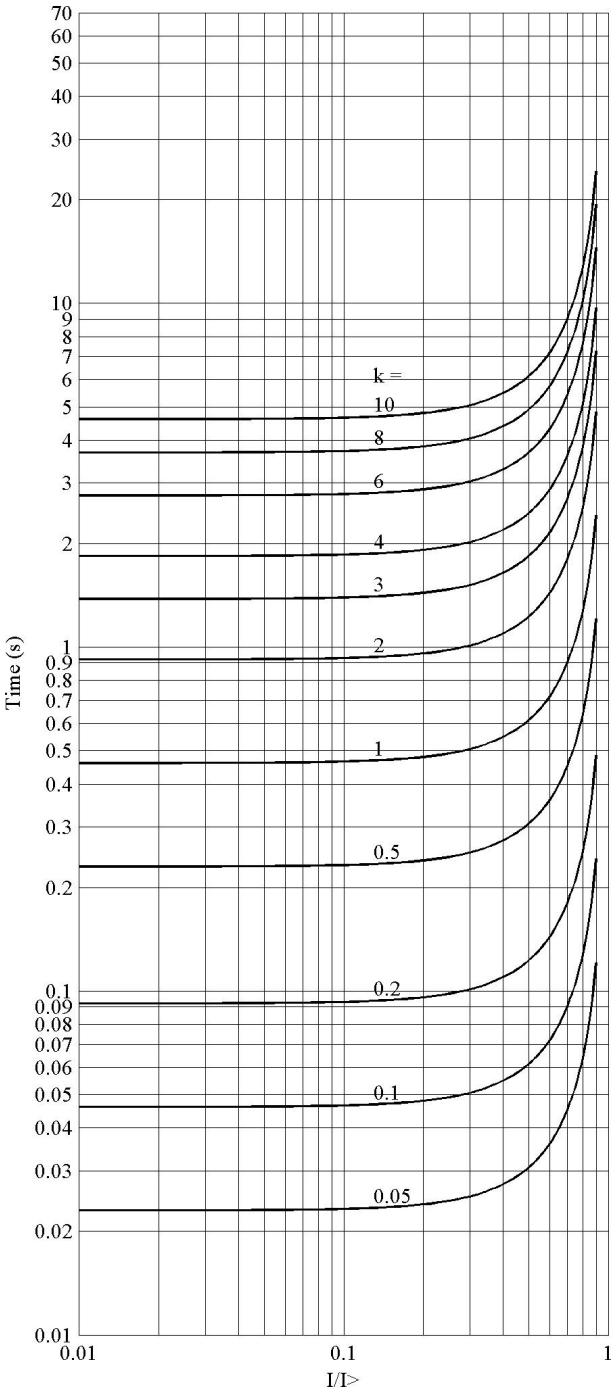



*Figure 875: ANSI normal inverse reset time characteristics*

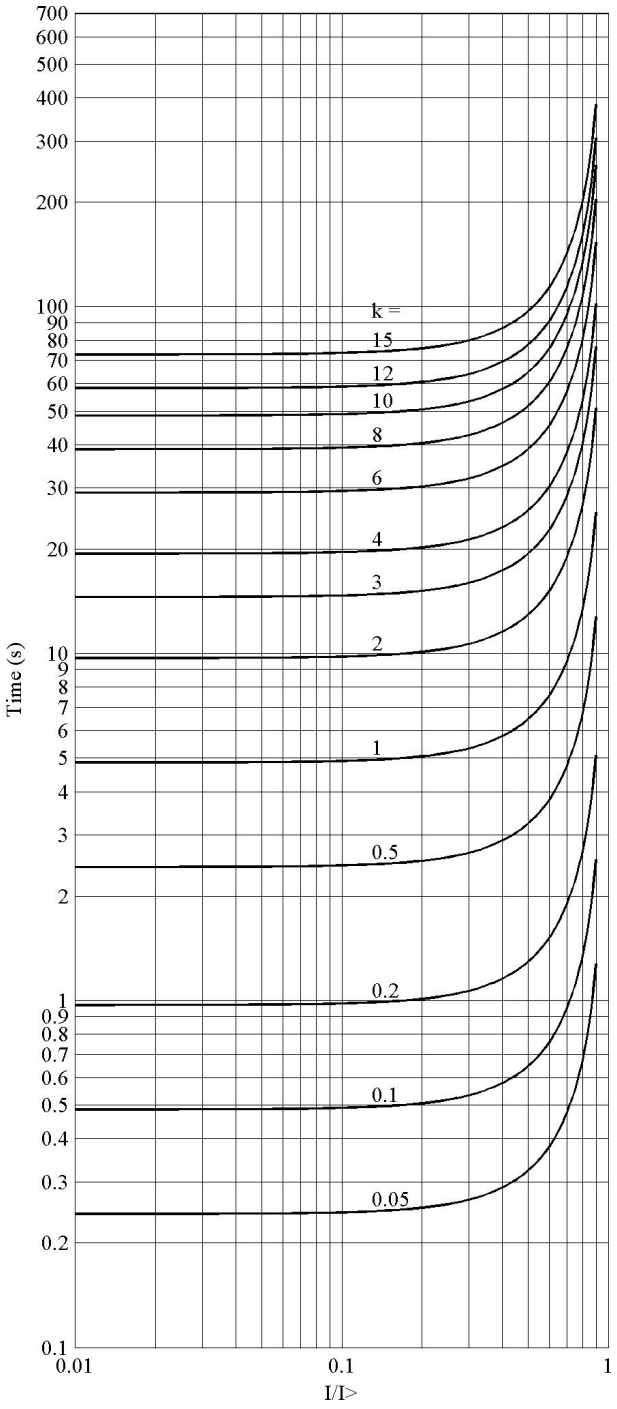



*Figure 876: ANSI moderately inverse reset time characteristics*

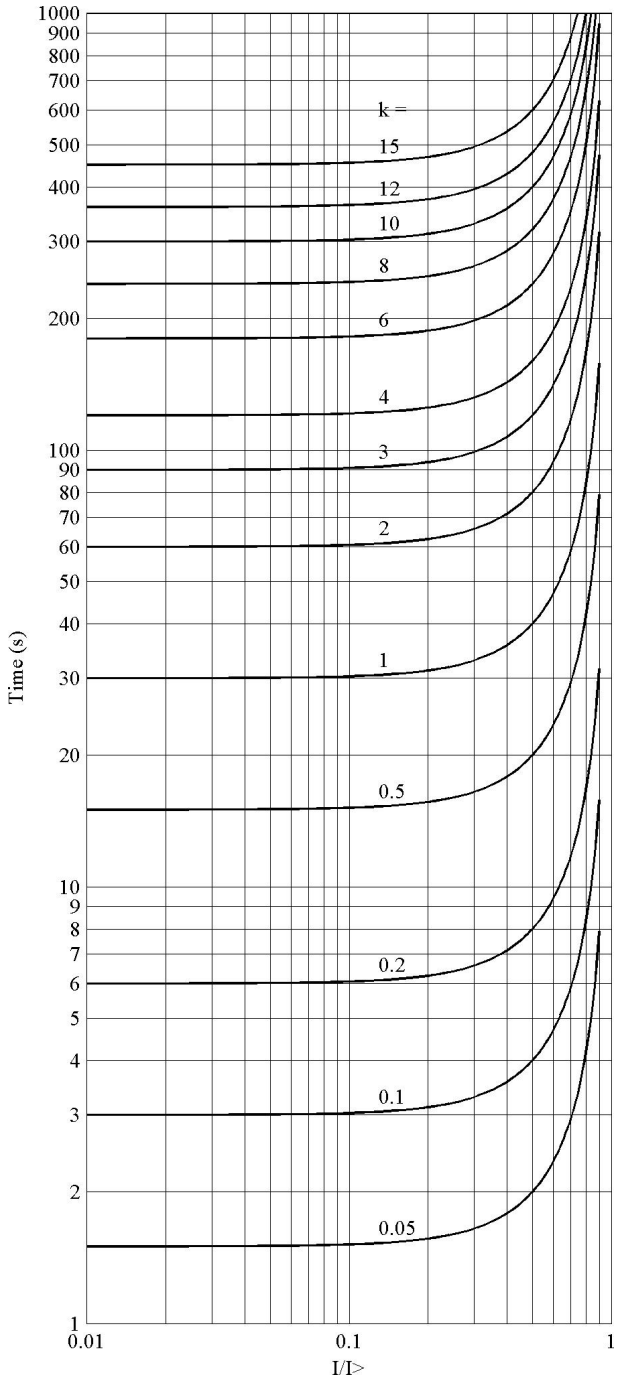



*Figure 877: ANSI long-time extremely inverse reset time characteristics*

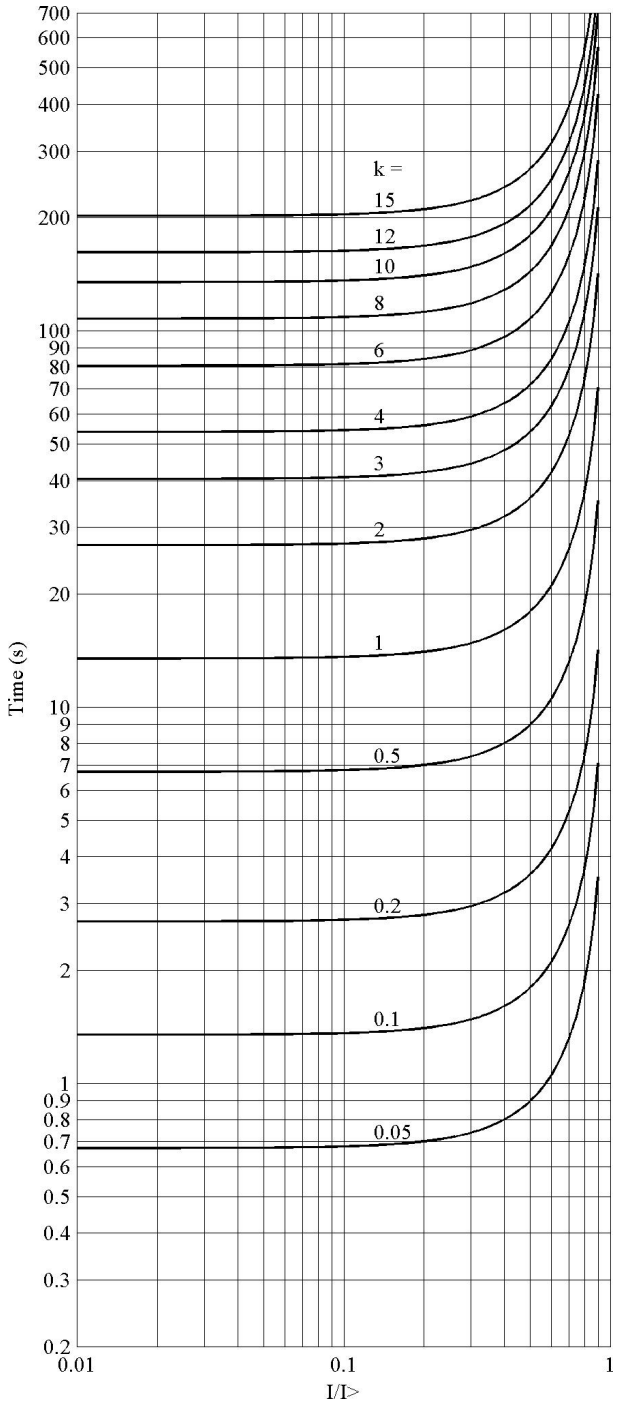



*Figure 878: ANSI long-time very inverse reset time characteristics*

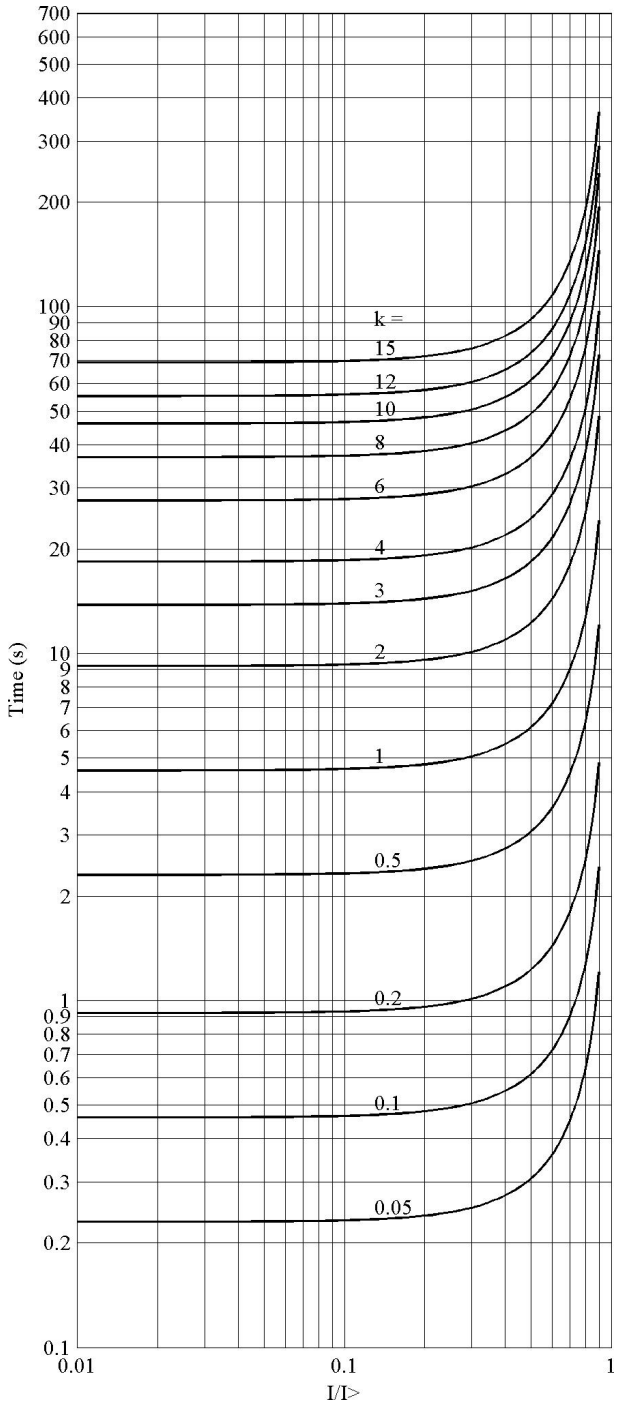



*Figure 879: ANSI long-time inverse reset time characteristics*

The delayed inverse-time reset is not available for IEC-type inverse time curves.

**User-programmable delayed inverse reset**

The user can define the delayed inverse reset time characteristics with the following formula using the set *Curve parameter D*.

$$t[s] = \left( \frac{D}{\left( \frac{I}{I>} \right)^2 - 1} \right) \cdot k$$

(Equation 360)

t[s] Reset time (in seconds)
k Set *Time multiplier*
D Set *Curve parameter D*
I Measured current
I> Set *Start value*

## 11.2.3 Inverse-timer freezing

When the BLOCK input is active, the internal value of the time counter is frozen at the value of the moment just before the freezing. Freezing of the counter value is chosen when the user does not wish the counter value to count upwards or to be reset. This may be the case, for example, when the inverse-time function of a protection relay needs to be blocked to enable the definite-time operation of another protection relay for selectivity reasons, especially if different relaying techniques (old and modern relays) are applied.

The selected blocking mode is "Freeze timer".

The activation of the BLOCK input also lengthens the minimum delay value of the timer.

Activating the BLOCK input alone does not affect the operation of the START output. It still becomes active when the current exceeds the set *Start value*, and inactive when the current falls below the set *Start value* and the set *Reset delay time* has expired.

# 11.3 Voltage based inverse definite minimum time characteristics

## 11.3.1 IDMT curves for overvoltage protection

In inverse-time modes, the operate time depends on the momentary value of the voltage, the higher the voltage, the faster the operate time. The operate time calculation or integration starts immediately when the voltage exceeds the set value of the *Start value* setting and the START output is activated.

The OPERATE output of the component is activated when the cumulative sum of the integrator calculating the overvoltage situation exceeds the value set by the inverse time mode. The set value depends on the selected curve type and the setting values used. The user determines the curve scaling with the *Time multiplier* setting.

The *Minimum operate time* setting defines the minimum operate time for the IDMT mode, that is, it is possible to limit the IDMT based operate time for not becoming too short. For example:

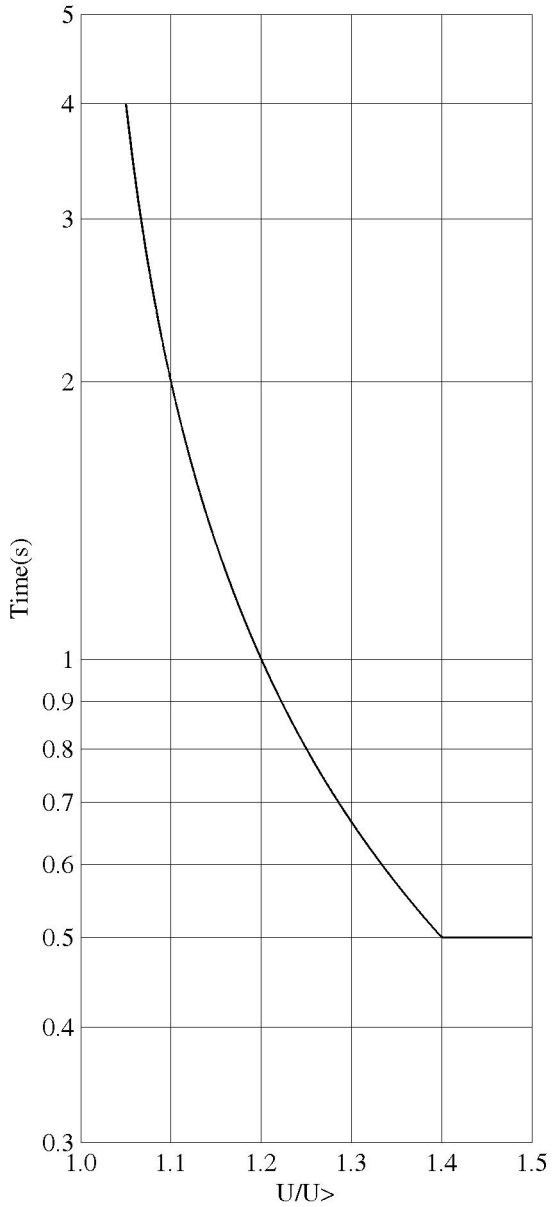



*Figure 880: Operate time curve based on IDMT characteristic with Minimum operate time set to 0.5 second*

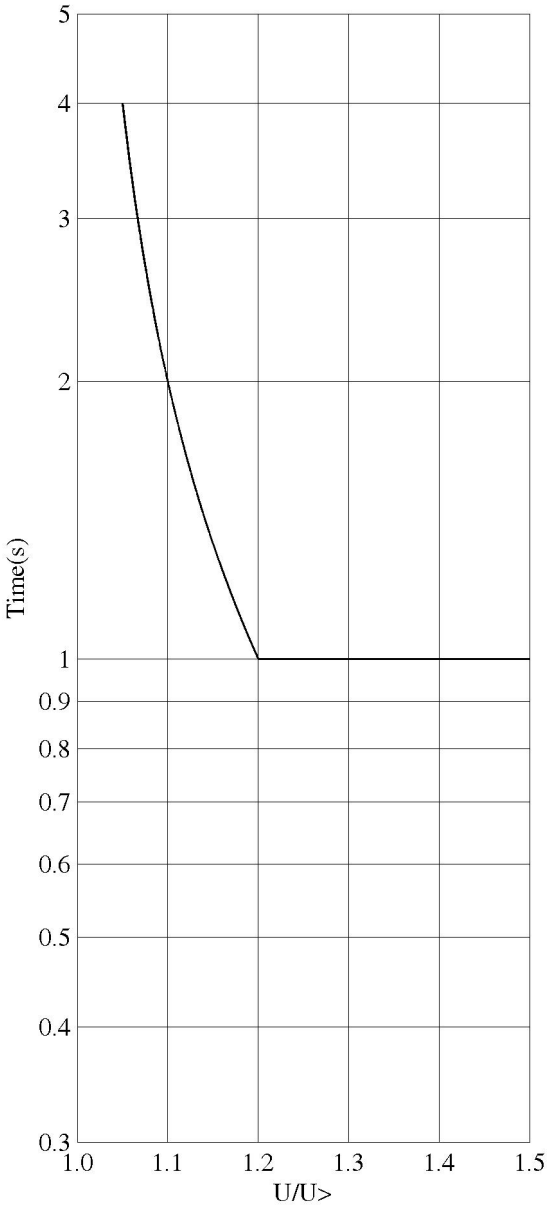



*Figure 881: Operate time curve based on IDMT characteristic with Minimum operate time set to 1 second*

### 11.3.1.1 Standard inverse-time characteristics for overvoltage protection

The operate times for the standard overvoltage IDMT curves are defined with the coefficients A, B, C, D and E.

The inverse operate time can be calculated with the formula:

$$t[s] = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{E}} + D$$

(Equation 361)

t [s] Operate time in seconds

U Measured voltage

U> Set value of *Start value*

k Set value of *Time multiplier*

*Table 1476: Curve coefficients for the standard overvoltage IDMT curves*

| Curve name | A | B | C | D | E |
|---|---|---|---|---|---|
| (17) Inverse Curve A | 1 | 1 | 0 | 0 | 1 |
| (18) Inverse Curve B | 480 | 32 | 0.5 | 0.035 | 2 |
| (19) Inverse Curve C | 480 | 32 | 0.5 | 0.035 | 3 |

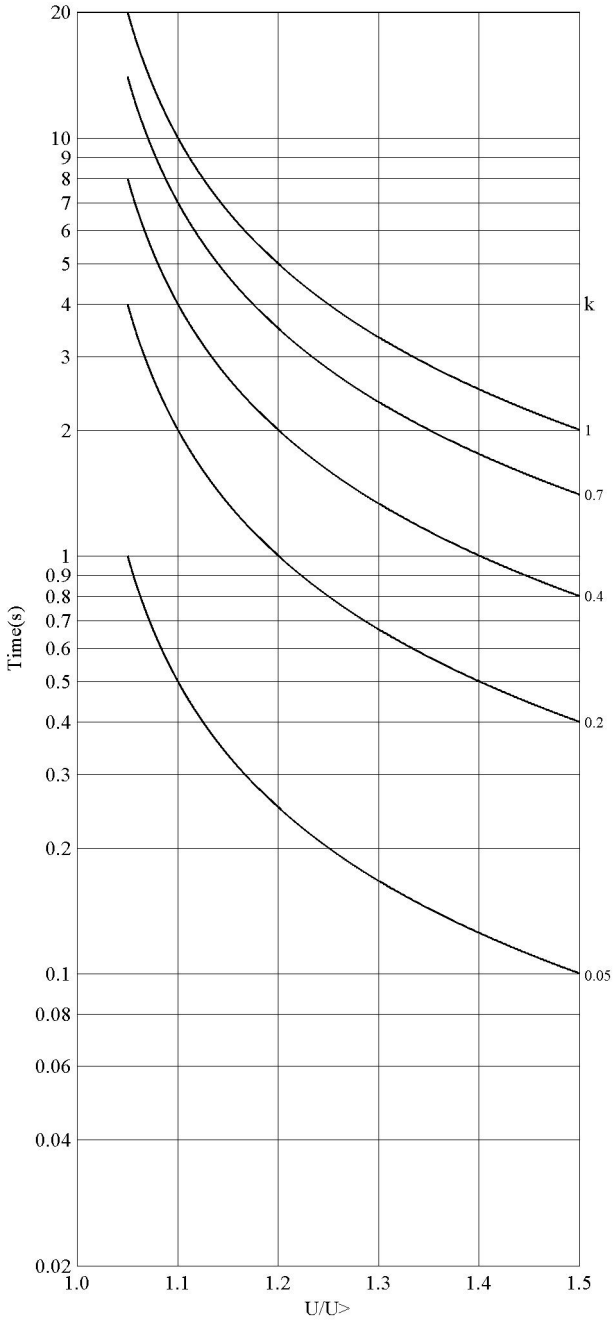



*Figure 882: Inverse curve A characteristic of overvoltage protection*

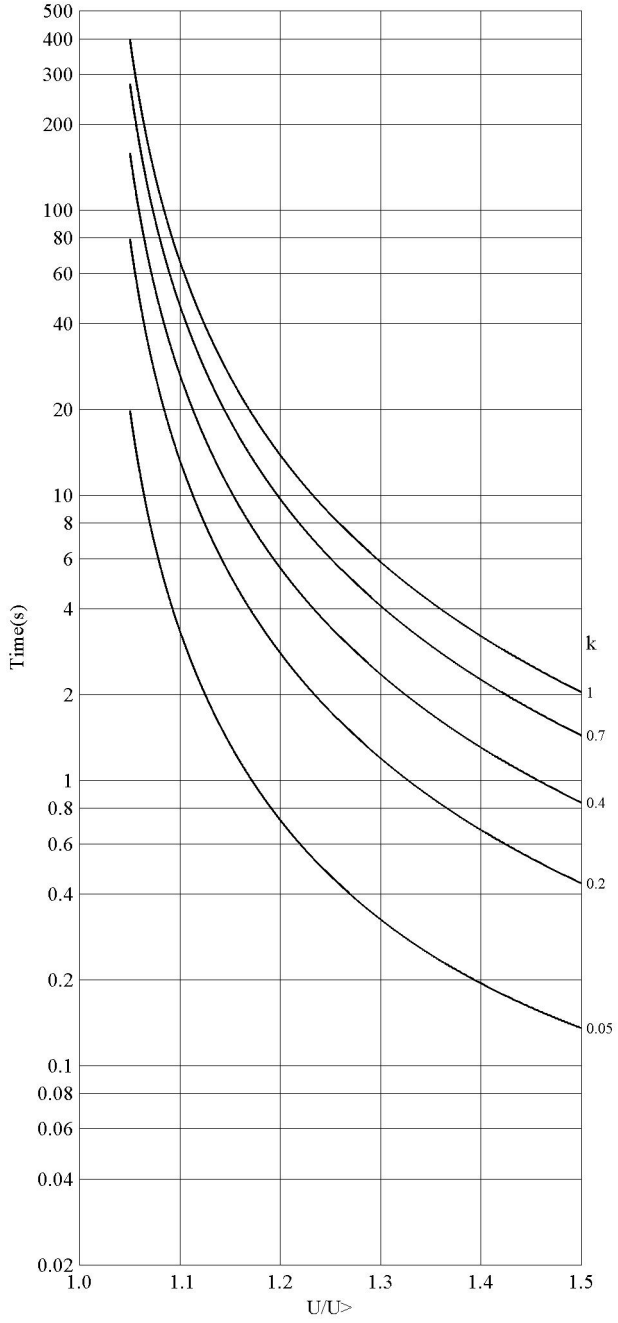



*Figure 883: Inverse curve B characteristic of overvoltage protection*

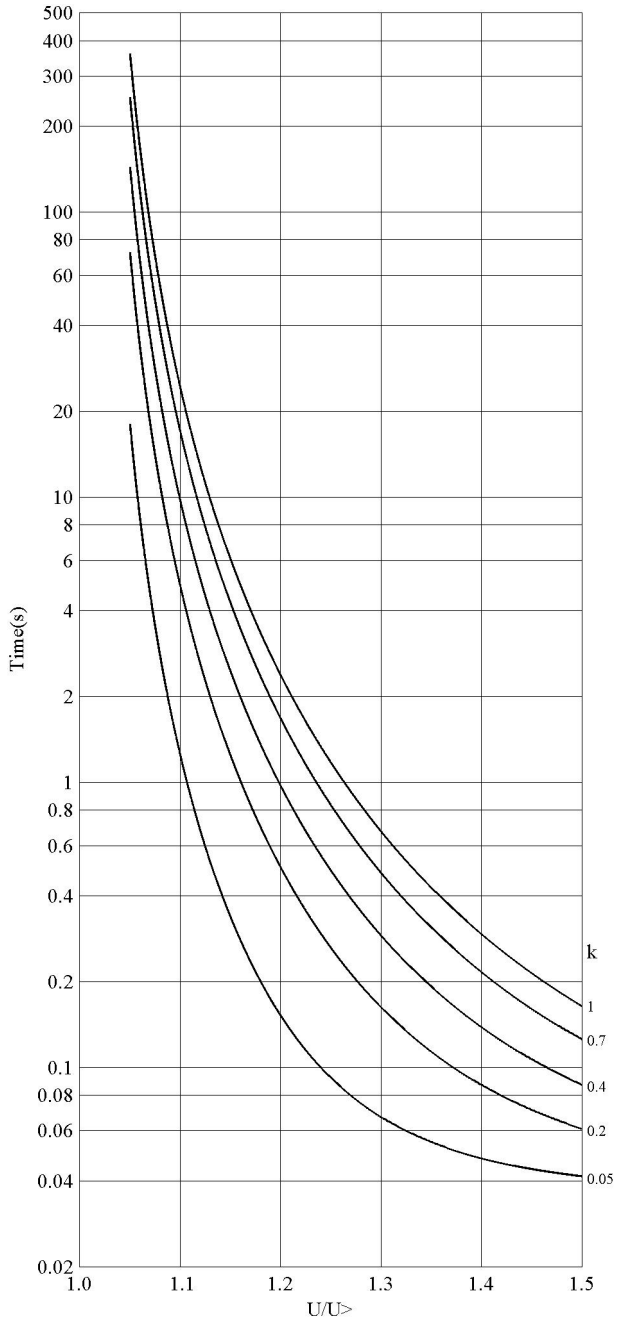



*Figure 884: Inverse curve C characteristic of overvoltage protection*

### 11.3.1.2 User programmable inverse-time characteristics for overvoltage protection

The user can define the curves by entering the parameters using the standard formula:

$$t[s] = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{E}} + D$$

(Equation 362)

t[s] Operate time in seconds
A Set value of *Curve parameter A*
B Set value of *Curve parameter B*
C Set value of *Curve parameter C*
D Set value of *Curve parameter D*
E Set value of *Curve parameter E*
U Measured voltage
U> Set value of *Start value*
k Set value of *Time multiplier*

#### 11.3.1.3 IDMT curve saturation of overvoltage protection

For the overvoltage IDMT mode of operation, the integration of the operate time does not start until the voltage exceeds the value of *Start value*. To cope with discontinuity characteristics of the curve, a specific parameter for saturating the equation to a fixed value is created. The *Curve Sat Relative* setting is the parameter and it is given in percents compared to *Start value*. For example, due to the curve equation B and C, the characteristics equation output is saturated in such a way that when the input voltages are in the range of *Start value* to *Curve Sat Relative* in percent over *Start value*, the equation uses *Start value* * (1.0 + *Curve Sat Relative* / 100 ) for the measured voltage. Although, the curve A has no discontinuities when the ratio U/U> exceeds the unity, *Curve Sat Relative* is also set for it. The *Curve Sat Relative* setting for curves A, B and C is 2.0 percent. However, it should be noted that the user must carefully calculate the curve characteristics concerning the discontinuities in the curve when the programmable curve equation is used. Thus, the *Curve Sat Relative* parameter gives another degree of freedom to move the inverse curve on the voltage ratio axis and it effectively sets the maximum operate time for the IDMT curve because for the voltage ratio values affecting by this setting, the operation time is fixed, that is, the definite time, depending on the parameters but no longer the voltage.

### 11.3.2 IDMT curves for undervoltage protection

In the inverse-time modes, the operate time depends on the momentary value of the voltage, the lower the voltage, the faster the operate time. The operate time calculation or integration starts immediately when the voltage goes below the set value of the *Start value* setting and the START output is activated.

The OPERATE output of the component is activated when the cumulative sum of the integrator calculating the undervoltage situation exceeds the value set by the inverse-

time mode. The set value depends on the selected curve type and the setting values used. The user determines the curve scaling with the *Time multiplier* setting.

The *Minimum operate time* setting defines the minimum operate time possible for the IDMT mode. For setting a value for this parameter, the user should carefully study the particular IDMT curve.

### 11.3.2.1 Standard inverse-time characteristics for undervoltage protection

The operate times for the standard undervoltage IDMT curves are defined with the coefficients A, B, C, D and E.

The inverse operate time can be calculated with the formula:

$$t[s] = \frac{k \cdot A}{\left( B \cdot \frac{U< - U}{U<} - C \right)^{E}} + D$$

(Equation 363)

| | |
|---|---|
| t [s] | Operate time in seconds |
| U | Measured voltage |
| U< | Set value of the *Start value* setting |
| k | Set value of the *Time multiplier* setting |

*Table 1477: Curve coefficients for standard undervoltage IDMT curves*

| Curve name | A | B | C | D | E |
|---|---|---|---|---|---|
| (21) Inverse Curve A | 1 | 1 | 0 | 0 | 1 |
| (22) Inverse Curve B | 480 | 32 | 0.5 | 0.055 | 2 |

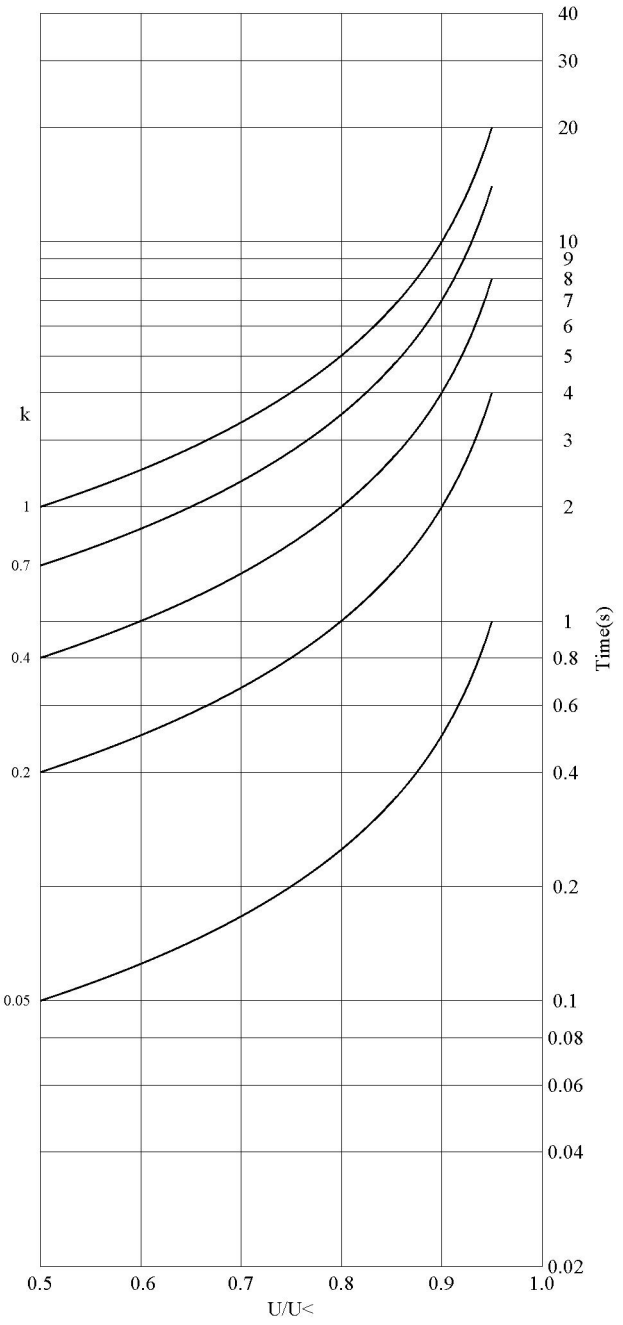



*Figure 885: Inverse curve A characteristic of undervoltage protection*

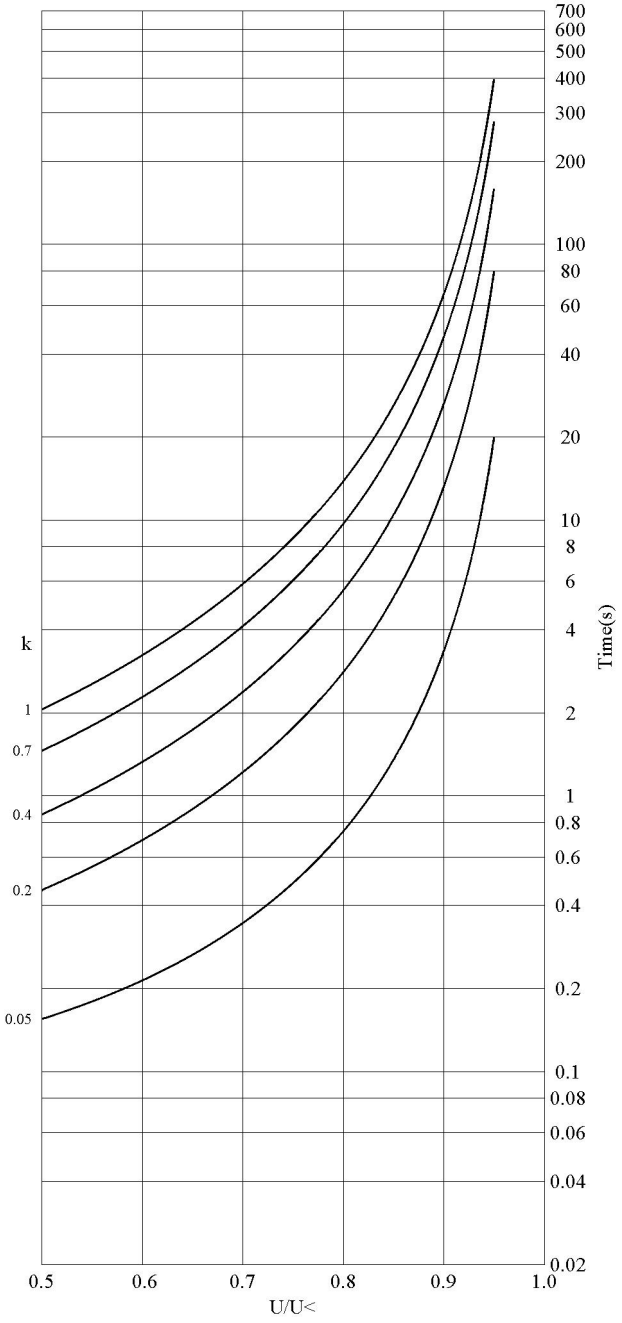



*Figure 886: Inverse curve B characteristic of undervoltage protection*

### 11.3.2.2 User-programmable inverse-time characteristics for undervoltage protection

The user can define curves by entering parameters into the standard formula:

$$t[s] = \frac{k \cdot A}{\left(B \cdot \frac{U<-U}{U<} - C\right)^{E}} + D$$

(Equation 364)

t[s] Operate time in seconds
A Set value of *Curve parameter A*
B Set value of *Curve parameter B*
C Set value of *Curve parameter C*
D Set value of *Curve parameter D*
E Set value of *Curve parameter E*
U Measured voltage
U< Set value of *Start value*
k Set value of *Time multiplier*

#### 11.3.2.3 IDMT curve saturation of undervoltage protection

For the undervoltage IDMT mode of operation, the integration of the operate time does not start until the voltage falls below the value of *Start value*. To cope with discontinuity characteristics of the curve, a specific parameter for saturating the equation to a fixed value is created. The *Curve Sat Relative* setting is the parameter and it is given in percents compared with *Start value*. For example, due to the curve equation B, the characteristics equation output is saturated in such a way that when input voltages are in the range from *Start value* to *Curve Sat Relative* in percents under *Start value*, the equation uses *Start value* * (1.0 - *Curve Sat Relative* / 100 ) for the measured voltage. Although, the curve A has no discontinuities when the ratio U/U> exceeds the unity, *Curve Sat Relative* is set for it as well. The *Curve Sat Relative* setting for curves A, B and C is 2.0 percent. However, it should be noted that the user must carefully calculate the curve characteristics concerning also discontinuities in the curve when the programmable curve equation is used. Thus, the *Curve Sat Relative* parameter gives another degree of freedom to move the inverse curve on the voltage ratio axis and it effectively sets the maximum operate time for the IDMT curve because for the voltage ratio values affecting by this setting, the operation time is fixed, that is, the definite time, depending on the parameters but no longer the voltage.

## 11.4 Frequency measurement and protection

All the function blocks that use frequency quantity as their input signal share the common features related to the frequency measurement algorithm. The frequency estimation is done from one phase (phase-to-phase or phase voltage) or from the positive phase sequence (PPS). The voltage groups with three-phase inputs use PPS as the source. The frequency measurement range is 0.2...1.5 × $F_n$. The df/dt measurement range always starts from 0.6 × $F_n$. When the frequency exceeds these limits, it is regarded as out of range and a minimum or maximum value is held as the measured

value respectively with appropriate quality information. The frequency estimation requires 160 ms to stabilize after a bad quality signal. Therefore, a delay of 160 ms is added to the transition from the bad quality. The bad quality of the signal can be due to restrictions like:

- The source voltage is below 0.02 × $U_n$ at $F_n$.
- The source voltage waveform is discontinuous.
- The source voltage frequency rate of change exceeds 15 Hz/s (including stepwise frequency changes).

When the bad signal quality is obtained, the nominal or zero (depending on the *Def frequency Sel* setting) frequency value is shown with appropriate quality information in the measurement view. The frequency protection functions are blocked when the quality is bad, thus the timers and the function outputs are reset. When the frequency is out of the function block's setting range but within the measurement range, the protection blocks are running. However, the OPERATE outputs are blocked until the frequency restores to a valid range.

## 11.5 Frequency adaptivity and generator start-up protection

Frequency adaptivity enables sensitive and selective protection during the start-up and shutdown phase of the generator when low frequency and low voltage amplitude exist at the same time. Sensitive protection is necessary because, for example, the fault current level in generator internal fault during start-up or shutdown (when field excitation is not present) may not exceed even the nominal current level.

Frequency adaptivity can be enabled by setting *Frequency adaptivity* and setting one UTVTR *Frequency adaptivity* to "Main frequency source". One additional UTVTR or ILTCTR can be set to "Backup frequency source". For main or backup frequency source, all three-phases must be connected. Each TxTR block that is set to Frequency adaptivity mode enable outputs measurements adapted to either main or backup source frequency depending on their availability.



See the Preprocessing blocks chapter for more information.

The frequency adaptivity uses the positive-sequence voltage in the frequency tracking and adapts the DFT, RMS, peak-to-peak and peak measurement accuracies of the current and voltage inputs by using the tracked frequency in the operation range of 0.2...1.5 xFn. Frequency adaptation starts when the generator terminal positive-sequence voltage level exceeds 0.04 xUn (minimum level). If frequency adaptivity backup source is currents their positive sequence must exceed 0.07 xIn to be usable as backup source. Backup source threshold limit is valid at nominal frequency and threshold increases when frequency deviates from nominal (up to 0.35 xIn or 0.2 xUn

at 0.2 xFn or 0.11 xIn or 0.06 xUn at 1.5 xFn). As the Synchronism and energizing check (SECRSYN) bus voltage U12b voltage input always expects *Rated frequency*, the frequency adaptivity does not apply for this input.

If the generator terminal positive-sequence voltage is below the minimum level, the relay is not able to maintain frequency adaptation. The non-adaptive situation is indicated by function Protection output `FRQ_ADP_FAIL`. When frequency adaptivity uses backup frequency source, the `FRQ_ADP_BU` output is activated. The tracked frequency is retained for 3 seconds until the `FRQ_ADP_FAIL` output is activated and *Rated frequency* is expected. Outputs `FRQ_ADP_FAIL`, `FRQ_ADP_BU` and `FRQ_ADP_WARN` can be used in the application configuration, if necessary.



See function block Protection for more information.

The operation accuracy of the protection functions in the range of 0.2...1.5 xFn can be assumed to be according to the technical data given separately for each function. Slight deviations in operation accuracy are possible outside the frequency range specified in technical data. Operate time accuracy and reset times given in technical data are only valid in the frequency range specified for each function.

The specified operate times are expected to increase at lower frequency due to longer network cycles.

Frequency adaptivity depends on the availability of voltages or currents. The generator start-up protection can be also extended by using wide peak-to-peak measurement mode (operational from 2 Hz upward) with designated start-up overcurrent protection function (PHLPTOC). Before the generator is connected with the rest of the network by closing the circuit breaker, the designated start-up overcurrent function should be either blocked or its start value increased, as the *Start value* setting is typically lower than the nominal current.

## 11.6 Measurement modes

In many current or voltage dependent function blocks, there are various alternative measuring principles.

- RMS
- DFT which is a numerically calculated fundamental component of the signal
- Peak-to-peak
- Peak-to-peak with peak backup
- Wide peak-to-peak

Consequently, the measurement mode can be selected according to the application.

In extreme cases, for example with high overcurrent or harmonic content, the measurement modes function in a slightly different way. The operation accuracy is defined with the frequency range of f/fn=0.95...1.05. In peak-to-peak and RMS measurement modes, the harmonics of the phase currents are not suppressed, whereas in the fundamental frequency measurement the suppression of harmonics is at least -50 dB at the frequency range of f= n · fn, where n = 2, 3, 4, 5,...

## RMS

The RMS measurement principle is selected with the *Measurement mode* setting using the value "RMS". RMS consists of both AC and DC components. The AC component is the effective mean value of the positive and negative peak values. RMS is used in applications where the effect of the DC component must be taken into account.

RMS is calculated according to the formula:

$$I_{RMS} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} I_i^2}$$

(Equation 365)

n Number of samples in a calculation cycle

$I_i$ Current sample value

## DFT

The DFT measurement principle is selected with the *Measurement mode* setting using the value "DFT". In the DFT mode, the fundamental frequency component of the measured signal is numerically calculated from the samples. In some applications, for example, it can be difficult to accomplish sufficiently sensitive settings and accurate operation of the low stage, which may be due to a considerable amount of harmonics on the primary side currents. In such a case, the operation can be based solely on the fundamental frequency component of the current. In addition, the DFT mode has slightly higher CT requirements than the peak-to-peak mode, if used with high and instantaneous stages.

## Peak-to-peak

The peak-to-peak measurement principle is selected with the *Measurement mode* setting using the value "Peak-to-Peak". It is the fastest measurement mode, in which the measurement quantity is made by calculating the average from the positive and negative peak values. The DC component is not included. The retardation time is short. The damping of the harmonics is quite low and practically determined by the characteristics of the anti-aliasing filter of the protection relay inputs. Consequently, this mode is usually used in conjunction with high and instantaneous stages, where the suppression of harmonics is not so important. In addition, the peak-to-peak mode allows considerable CT saturation without impairing the performance of the operation.

### Peak-to-peak with peak backup

The peak-to-peak with peak backup measurement principle is selected with the *Measurement mode* setting using the value "P-to-P+backup". It is similar to the peak-to-peak mode, with the exception that it has been enhanced with the peak backup. In the peak-to-peak with peak backup mode, the function starts with two conditions: the peak-to-peak value is above the set start current or the peak value is above two times the set *Start value*. The peak backup is enabled only when the function is used in the DT mode in high and instantaneous stages for faster operation.

### Wide peak-to-peak

The wide peak-to-peak measurement principle is available in products where it is necessary for overcurrent protection to operate already starting from as low frequency as 2 Hz during the generator start-up or shutdown phase. The wide peak-to-peak measurement principle is selected with the *Measurement mode* setting "Wide P-to-P".

The measurement mode calculates the average from the positive and negative peak values over the 500 ms wide measurement window, independently of the *Frequency adaptivity* setting value. Retardation and reset times are longer due to the length of the measurement window. The frequency of the fault current affects the operate time. The damping of the harmonics is quite low and practically determined by the characteristics of the anti-aliasing filter of the protection relay current inputs.

When using measurement mode “Wide P-to-P”, the protection relay accepts only *Operate delay time* setting value 800 ms or longer and *Operating curve type* 5=”ANSI Def. Time” or 15=”IEC Def. Time”. These settings should be used for all six setting groups. If the settings are applied only in the active setting group, the validation is not satisfied and the setting commit fails.

Operation accuracy in the frequency range 2...85 Hz is ±1.5% or ±0.003 x$I_n$. Operate time accuracy in definite time mode is ±1.0% of the set value or ±60 ms when $I_{Fault} = 2 \cdot$ set *Start value* and the fault current frequency is 10...85 Hz.

## 11.7 Calculated measurements

### Calculated residual current and voltage

The residual current is calculated from the phase currents according to equation:

$$\overline{Io} = -(\bar{I}_A + \bar{I}_B + \bar{I}_C)$$

(Equation 366)

The residual voltage is calculated from the phase-to-earth voltages when the VT connection is selected as “Wye” with the equation:

$$\overline{Uo} = \frac{(\overline{U}_A + \overline{U}_B + \overline{U}_C)}{3}$$

(Equation 367)

## Sequence components

The phase-sequence current components are calculated from the phase currents according to:

$$\bar{I}_0 = \frac{(\bar{I}_A + \bar{I}_B + \bar{I}_C)}{3}$$

(Equation 368)

$$\bar{I}_1 = \frac{(\bar{I}_A + a \cdot \bar{I}_B + a^2 \cdot \bar{I}_C)}{3}$$

(Equation 369)

$$\bar{I}_2 = \frac{(\bar{I}_A + a^2 \cdot \bar{I}_B + a \cdot \bar{I}_C)}{3}$$

(Equation 370)

The phase-sequence voltage components are calculated from the phase-to-earth voltages when *VT connection* is selected as “Wye” with the equations:

$$\overline{U}_0 = \frac{(\overline{U}_A + \overline{U}_B + \overline{U}_C)}{3}$$

(Equation 371)

$$\overline{U}_1 = \frac{(\overline{U}_A + a \cdot \overline{U}_B + a^2 \cdot \overline{U}_C)}{3}$$

(Equation 372)

$$\overline{U}_2 = \frac{(\overline{U}_A + a^2 \cdot \overline{U}_B + a \cdot \overline{U}_C)}{3}$$

(Equation 373)

When *VT connection* is selected as “Delta”, the positive and negative phase sequence voltage components are calculated from the phase-to-phase voltages according to the equations:

$$\overline{U}_1 = \frac{(\overline{U}_{AB} - a^2 \cdot \overline{U}_{BC})}{3}$$

(Equation 374)

$$\overline{U}_2 = \frac{(\overline{U}_{AB} - a \cdot \overline{U}_{BC})}{3}$$

(Equation 375)

The phase-to-earth voltages are calculated from the phase-to-phase voltages when *VT connection* is selected as "Delta" according to the equations.

$$\overline{U}_A = \overline{U}_0 + \frac{\left(\overline{U}_{AB} - \overline{U}_{CA}\right)}{3}$$

(Equation 376)

$$\overline{U}_B = \overline{U}_0 + \frac{\left(\overline{U}_{BC} - \overline{U}_{AB}\right)}{3}$$

(Equation 377)

$$\overline{U}_C = \overline{U}_0 + \frac{\left(\overline{U}_{CA} - \overline{U}_{BC}\right)}{3}$$

(Equation 378)

If the $\overline{U}_0$ channel is not valid, it is assumed to be zero.

The phase-to-phase voltages are calculated from the phase-to-earth voltages when *VT connection* is selected as "Wye" according to the equations.

$$\overline{U}_{AB} = \overline{U}_A - \overline{U}_B$$

(Equation 379)

$$\overline{U}_{BC} = \overline{U}_B - \overline{U}_C$$

(Equation 380)

$$\overline{U}_{CA} = \overline{U}_C - \overline{U}_A$$

(Equation 381)

# 11.8 Test mode

## 11.8.1 Functionality

The mode of all the logical nodes in the relay's IEC 61850 data model can be set with *Test mode*. *Test mode* activation method can be changed via parameter **Tests/IED test/Test mode selection**. Available activation methods are "Local", "Local+remote, maintenance", "Local+Remote, all levels" and "Binary input". By default, *Test mode* activation method is "Local" which means the test mode can be activated only via LHMI through parameter **Tests/IED test/Test mode**. The remote activation method via binary input or via IEC 61850 communication is possible (LD0.LLN0.Mod). When the binary input is selected as the test mode activation method, the behavior can be configured with the application configuration.

*Table 1478: Test mode*

| Test mode | Description | Protection BEH_BLK | Protection BEH_TST |
|---|---|---|---|
| Normal mode | Normal operation | FALSE | FALSE |
| IED blocked | Protection works as in “Normal mode” but the ACT configuration can be used to block physical outputs to process. Control function commands are blocked. | TRUE | FALSE |
| IED test | Protection works as in “Normal mode” but protection functions work in parallel with test parameters | FALSE | TRUE |
| IED test and blocked | Protection works as in “Normal mode” but protection functions work in parallel with the test parameter. The ACT configuration can be used to block physical outputs to process. The control function command is blocked. | TRUE | TRUE |



See function block Protection for more details.



The behavior data objects in all logical nodes follow LD0.LLN0.Mod value. If "Normal mode" is selected, the behavior data objects follow the mode (.Mod) data object of the corresponding logical device.



Vertical and horizontal communication is not blocked by the “IED blocked” or “IED test and blocked” modes.

## 11.8.2 Application configuration and Test mode

The physical outputs from control commands to process are blocked with ”IED blocked” and “IED test and blocked” modes. If physical outputs need to be blocked from the protection, the application configuration must be used to block these signals. The blocking scheme needs to use `BEH_BLK` output of PROTECTION function block.

## 11.8.3 Control mode

The mode of all logical nodes located under CTRL logical device can be set with *Control mode*. The *Control mode* parameter is available via the HMI or PCM600 path **Configuration/Control/General**. By default, *Control mode* can only be set locally through LHMI. *Control mode* inherits its value from *Test mode* but *Control mode*

values "On", "Blocked" and "Off" can also be set independently. *Control mode* is also available via IEC 61850 communication (CTRL.LLN0.Mod).

*Table 1479: Control mode*

| Control mode | Description | Control BEH_BLK |
|---|---|---|
| On | Normal operation | FALSE |
| Blocked | Control function commands blocked | TRUE |
| Off | Control functions disabled | FALSE |

See function block Control for more details.

The behavior data objects under CTRL logical device follow CTRL.LLN0.Mod value. If "On" is selected, the behavior data objects follow the mode of the corresponding logical device.

## 11.8.4 Application configuration and Control mode

The physical outputs from commands to process are blocked with “Blocked“ mode. If physical outputs need to be blocked totally, meaning also commands from the binary inputs, the application configuration must be used to block these signals. The blocking scheme uses `BEH_BLK` output of CONTROL function block.

## 11.8.5 Authorization

By default, *Test mode* and *Control mode* can only be changed from LHMI. It is possible to write test mode by remote client if it is needed in configuration. This is done via LHMI by setting parameter *Test mode selection* via **Tests/IED test/Test mode**. Remote operation is possible only when the relay's control position is in remote position. Local and remote control can be selected with R/L button or via Control function block in application configuration

When using the Signal Monitoring tool to force online values, the following conditions need to be met.

- *Remote force* is set to "All levels".
- *Test mode* is enabled.
- The relay's control position is in remote position.

*Table 1480: Test mode selection*

| Test mode selection | LHMI | 61850-8-1-MMS | WHMI | Binary input |
|---|---|---|---|---|
| Local | Yes | No access | No access | No access |
| Local+Remote, Maintenance | Yes | Command originator category maintenance | No access | No access |
| Local+Remote, All levels | Yes | All originator categories | Yes | No access |
| Binary input | No access | No access | No access | Yes |

## 11.8.6 LHMI indications

The yellow Start LED flashes when the relay is in “IED blocked” or “IED test and blocked” mode. The green Ready LED flashes to indicate that the “IED test and blocked” mode or "IED test" mode is activated.

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# Section 12 Requirements for measurement transformers

## 12.1 Current transformers

### 12.1.1 Current transformer requirements for overcurrent protection

For reliable and correct operation of the overcurrent protection, the CT has to be chosen carefully. The distortion of the secondary current of a saturated CT may endanger the operation, selectivity, and co-ordination of protection. However, when the CT is correctly selected, a fast and reliable short circuit protection can be enabled.

The selection of a CT depends not only on the CT specifications but also on the network fault current magnitude, desired protection objectives, and the actual CT burden. The protection settings of the protection relay should be defined in accordance with the CT performance as well as other factors.

#### 12.1.1.1 Current transformer accuracy class and accuracy limit factor

The rated accuracy limit factor ($F_n$) is the ratio of the rated accuracy limit primary current to the rated primary current. For example, a protective current transformer of type 5P10 has the accuracy class 5P and the accuracy limit factor 10. For protective current transformers, the accuracy class is designed by the highest permissible percentage composite error at the rated accuracy limit primary current prescribed for the accuracy class concerned, followed by the letter "P" (meaning protection).

*Table 1481: Limits of errors according to IEC 60044-1 for protective current transformers*

| Accuracy class | Current error at rated primary current (%) | Phase displacement at rated primary current | | Composite error at rated accuracy limit primary current (%) |
|---|---|---|---|---|
| | | minutes | centiradians | |
| 5P | ±1 | ±60 | ±1.8 | 5 |
| 10P | ±3 | - | - | 10 |

The accuracy classes 5P and 10P are both suitable for non-directional overcurrent protection. The 5P class provides a better accuracy. This should be noted also if there are accuracy requirements for the metering functions (current metering, power metering, and so on) of the protection relay.

The CT accuracy primary limit current describes the highest fault current magnitude at which the CT fulfils the specified accuracy. Beyond this level, the secondary current

of the CT is distorted and it might have severe effects on the performance of the protection relay.

In practise, the actual accuracy limit factor ($F_a$) differs from the rated accuracy limit factor ($F_n$) and is proportional to the ratio of the rated CT burden and the actual CT burden.

The actual accuracy limit factor is calculated using the formula:

$$F_a \approx F_n \cdot \frac{|S_{in} + S_n|}{|S_{in} + S|}$$

(Equation 382)

| | |
|---|---|
| $F_n$ | the accuracy limit factor with the nominal external burden $S_n$ |
| $S_{in}$ | the internal secondary burden of the CT |
| S | the actual external burden |

### 12.1.1.2 Non-directional overcurrent protection

#### Current transformer selection

Non-directional overcurrent protection does not set high requirements on the accuracy class or on the actual accuracy limit factor ($F_a$) of the CTs. It is, however, recommended to select a CT with $F_a$ of at least 20.

The nominal primary current $I_{1n}$ should be chosen in such a way that the thermal and dynamic strength of the current measuring input of the protection relay is not exceeded. This is always fulfilled when

$I_{1n} > I_{kmax} / 100$,

$I_{kmax}$ is the highest fault current.

The saturation of the CT protects the measuring circuit and the current input of the protection relay. For that reason, in practice, even a few times smaller nominal primary current can be used than given by the formula.

#### Recommended start current settings

If $I_{kmin}$ is the lowest primary current at which the highest set overcurrent stage is to operate, the start current should be set using the formula:

*Current start value* < $0.7 \times (I_{kmin} / I_{1n})$

$I_{1n}$ is the nominal primary current of the CT.

The factor 0.7 takes into account the protection relay inaccuracy, current transformer errors, and imperfections of the short circuit calculations.

The adequate performance of the CT should be checked when the setting of the high set stage overcurrent protection is defined. The operate time delay caused by the CT saturation is typically small enough when the overcurrent setting is noticeably lower than $F_a$.

When defining the setting values for the low set stages, the saturation of the CT does not need to be taken into account and the start current setting is simply according to the formula.

#### Delay in operation caused by saturation of current transformers

The saturation of CT may cause a delayed protection relay operation. To ensure the time selectivity, the delay must be taken into account when setting the operate times of successive protection relays.

With definite time mode of operation, the saturation of CT may cause a delay that is as long as the time constant of the DC component of the fault current, when the current is only slightly higher than the starting current. This depends on the accuracy limit factor of the CT, on the remanence flux of the core of the CT, and on the operate time setting.

With inverse time mode of operation, the delay should always be considered as being as long as the time constant of the DC component.

With inverse time mode of operation and when the high-set stages are not used, the AC component of the fault current should not saturate the CT less than 20 times the starting current. Otherwise, the inverse operation time can be further prolonged. Therefore, the accuracy limit factor $F_a$ should be chosen using the formula:

$F_a > 20 \cdot$ *Current start value* / $I_{1n}$

The *Current start value* is the primary start current setting of the protection relay.

### 12.1.1.3 Example for non-directional overcurrent protection

The following figure describes a typical medium voltage feeder. The protection is implemented as three-stage definite time non-directional overcurrent protection.

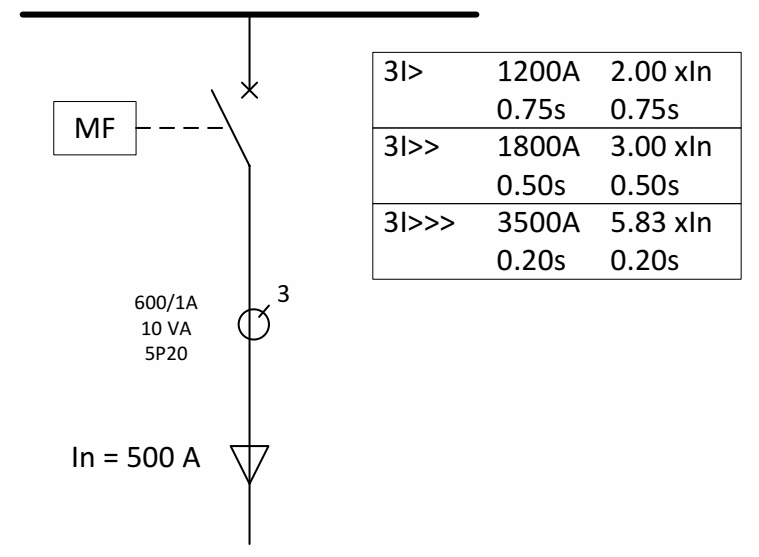



*Figure 887: Example of three-stage overcurrent protection*

The maximum three-phase fault current is 41.7 kA and the minimum three-phase short circuit current is 22.8 kA. The actual accuracy limit factor of the CT is calculated to be 59.

The start current setting for low-set stage (3I>) is selected to be about twice the nominal current of the cable. The operate time is selected so that it is selective with the next protection relay (not visible in Figure 887). The settings for the high-set stage and instantaneous stage are defined also so that grading is ensured with the downstream protection. In addition, the start current settings have to be defined so that the protection relay operates with the minimum fault current and it does not operate with the maximum load current. The settings for all three stages are as in Figure 887.

For the application point of view, the suitable setting for instantaneous stage (I>>>) in this example is 3 500 A (5.83 × $I_n$). $I_n$ is the 1.2 multiple with nominal primary current of the CT. For the CT characteristics point of view, the criteria given by the current transformer selection formula is fulfilled and also the protection relay setting is considerably below the $F_a$. In this application, the CT rated burden could have been selected much lower than 10 VA for economical reasons.

## 12.1.2 Current transformer requirements for transformer differential protection

The more important the object to be protected, the more attention has to be paid to the current transformers. It is not normally possible to dimension the current transformer so that they repeat the currents with high DC components without saturating when the residual flux of the current transformer is high. TR2PTDF and TR3PTDF operate reliably even though the current transformers are partially saturated.

The accuracy class recommended for current transformers to be used with TR2PTDF and TR3PTDF is 5P, in which the limit of the current error at the rated primary current

is 1 percent and the limit of the phase displacement is 60 minutes. The limit of the composite error at the rated accuracy limit primary current is 5 percent.

The approximate value of the accuracy limit factor $F_a$ corresponding to the actual current transformer burden can be calculated on the basis of the rated accuracy limit factor $F_n$ at the rated burden, the rated burden $S_n$, the internal burden $S_{in}$and the actual burden $S_a$ of the current transformer.

$$F_a = F_n \cdot \frac{S_{in} + S_n}{S_{in} + S_a}$$

(Equation 383)

$F_a$ The approximate value of the accuracy limit factor (ALF) corresponding to the actual CT burden

$F_n$ The rated accuracy limit factor at the rated burden of the current transformer

$S_n$ The rated burden of the current transformer

$S_{in}$ The internal burden of the current transformer

$S_a$ The actual burden of the current transformer

## Example 1

The rated burden $S_n$ of the current transformer 5P20 is 10 VA, the secondary rated current is 5A, the internal resistance $R_{in}$= 0.07 Ω and the accuracy limit factor $F_n$ corresponding to the rated burden is 20 (5P20). Thus the internal burden of the current transformer is $S_{in}$= $(5A)^2$ * 0.07 Ω = 1.75 VA. The input impedance of the protection relay at a rated current of 5A is < 20 mΩ. If the measurement conductors have a resistance of 0.113 Ω, the actual burden of the current transformer is $S_a$=$(5A)^2$ * (0.113 + 0.020) Ω = 3.33 VA. Thus the accuracy limit factor $F_a$ corresponding to the actual burden is approximately 46.

The CT burden can grow considerably at the rated current 5A. The actual burden of the current transformer decreases at the rated current of 1A while the repeatability simultaneously improves.

At faults occurring in the protected area, the currents may be very high compared to the rated currents of the current transformers. Due to the instantaneous stage of the differential function block, it is sufficient that the current transformers are capable of repeating the current required for instantaneous tripping during the first cycle.

Thus the current transformers usually are able to reproduce the asymmetric fault current without saturating within the next 10 ms after the occurrence of the fault to secure that the operate times of the protection relay comply with the retardation time.

The accuracy limit factors corresponding to the actual burden of the phase current transformer to be used in differential protection fulfill the requirement.

$$F_a > K_r \times Ik_{\max} \times (T_{dc} \times \omega \times (1 - e^{-T_m/T_{dc}}) + 1)$$

(Equation 384)

| | |
|---|---|
| $Ik_{max}$ | The maximum through-going fault current (in $I_r$) at which the protection is not allowed to operate |
| $T_{dc}$ | The primary DC time constant related to $Ik_{max}$ |
| ω | The angular frequency, that is, 2*π*fn |
| $T_m$ | The time-to-saturate, that is, the duration of the saturation free transformation |
| $K_r$ | The remanence factor 1/(1-r), where r is the maximum remanence flux in p.u. from saturation flux |

The accuracy limit factors corresponding to the actual burden of the phase current transformer is used in differential protection.

The parameter *r* is the maximum remanence flux density in the CT core in p.u. from saturation flux density. The value of the parameter *r* depends on the magnetic material used and on the construction of the CT. For instance, if the value of *r* = 0.4, the remanence flux density can be 40 percent of the saturation flux density. The manufacturer of the CT has to be contacted when an accurate value for the parameter *r* is needed. The value *r* = 0.4 is recommended to be used when an accurate value is not available.

The required minimum time-to-saturate $T_m$ in TR2PTDF and TR3PTDF is half fundamental cycle period (10 ms when fn = 50Hz).

Two typical cases are considered for the determination of the sufficient accuracy limit factor ($F_a$):

1. A fault occurring at the substation bus:
   The protection must be stable at a fault arising during a normal operating situation. Re-energizing the transformer against a bus fault leads to very high fault currents and thermal stress and therefore re-energizing is not preferred in this case. Thus, the remanence can be neglected.
   The maximum through-going fault current $Ik_{max}$ is typically 10 $I_r$ for a substation main transformer. At a short circuit fault close to the supply transformer, the DC time constant ($T_{dc}$) of the fault current is almost the same as that of the transformer, the typical value being 100 ms.

   | | |
   |---|---|
   | $Ik_{max}$ | 10 $I_r$ |
   | $T_{dc}$ | 100 ms |
   | ω | 100π Hz |
   | $T_m$ | 10 ms |
   | $K_r$ | 1 |

   When the values are substituted in Equation 384, the result is:

$$F_a > K_r \times Ik_{\max} \times (T_{dc} \times \omega \times (1 - e^{-T_m / T_{dc}}) + 1) \approx 40$$

2. Re-energizing against a fault occurring further down in the network:
   The protection must be stable also during re-energization against a fault on the line. In this case, the existence of remanence is very probable. It is assumed to be 40 percent here.
   On the other hand, the fault current is now smaller and since the ratio of the resistance and reactance is greater in this location, having a full DC offset is not possible. Furthermore, the DC time constant ($T_{dc}$) of the fault current is now smaller, assumed to be 50 ms here.
   Assuming a maximum fault current being 30 percent lower than in the bus fault and a DC offset 90 percent of the maximum.

| | |
|---|---|
| $Ik_{max}$ | 0.7* 10 = 7 ($I_r$) |
| $T_{dc}$ | 50 ms |
| ω | 100π Hz |
| $T_m$ | 10 ms |
| $K_r$ | 1/(1-0.4) = 1.6667 |

When the values are substituted in the equation, the result is:

$$F_a > K_r \times Ik_{\max} \times 0.9 \times (T_{dc} \times \omega \times (1 - e^{-T_m / T_{dc}}) + 1) \approx 40$$

If the actual burden of the current transformer ($S_a$) in Equation 383 cannot be reduced low enough to provide a sufficient value for $F_a$, there are two alternatives to deal with the situation:

- a CT with a higher rated burden $S_n$ can be chosen (which also means a higher rated accuracy limit $F_n$)
- a CT with a higher nominal primary current $I_{1n}$ (but the same rated burden) can be chosen

## Example 2

Assuming that the actions according to alternative two above are taken in order to improve the actual accuracy limit factor:

$$F_a = \frac{IrCT}{IrTR} \times F_n$$

(Equation 385)

| | |
|---|---|
| IrTR | 1000 A (rated secondary side current of the power transformer) |
| IrCT | 1500 A (rated primary current of the CT on the transformer secondary side) |
| $F_n$ | 30 (rated accuracy limit factor of the CT) |

$F_a$ (IrCT / IrTR) * Fn (actual accuracy limit factor due to oversizing the CT) = (1500/1000) * 30 = 45

In TR2PTDF and TR3PTDF, it is important that the accuracy limit factors $F_a$ of the phase current transformers at both sides correspond with each other, that is, the burdens of the current transformers on both sides are to be as equal as possible. If high inrush or start currents with high DC components pass through the protected object when it is connected to the network, special attention is required for the performance and the burdens of the current transformers and for the settings of the function block.

# Section 13 Protection relay's physical connections

## 13.1 Module diagrams

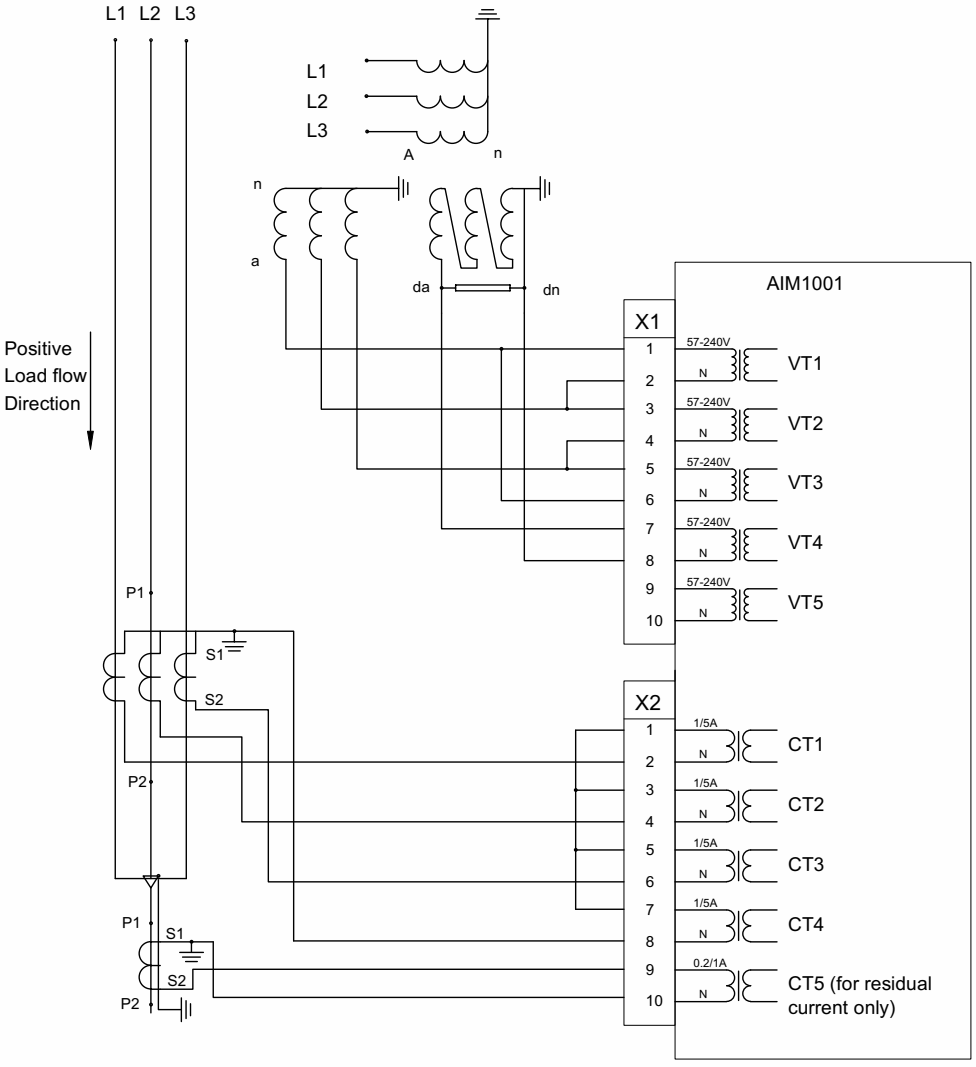



*Figure 888: AIM1001 module*

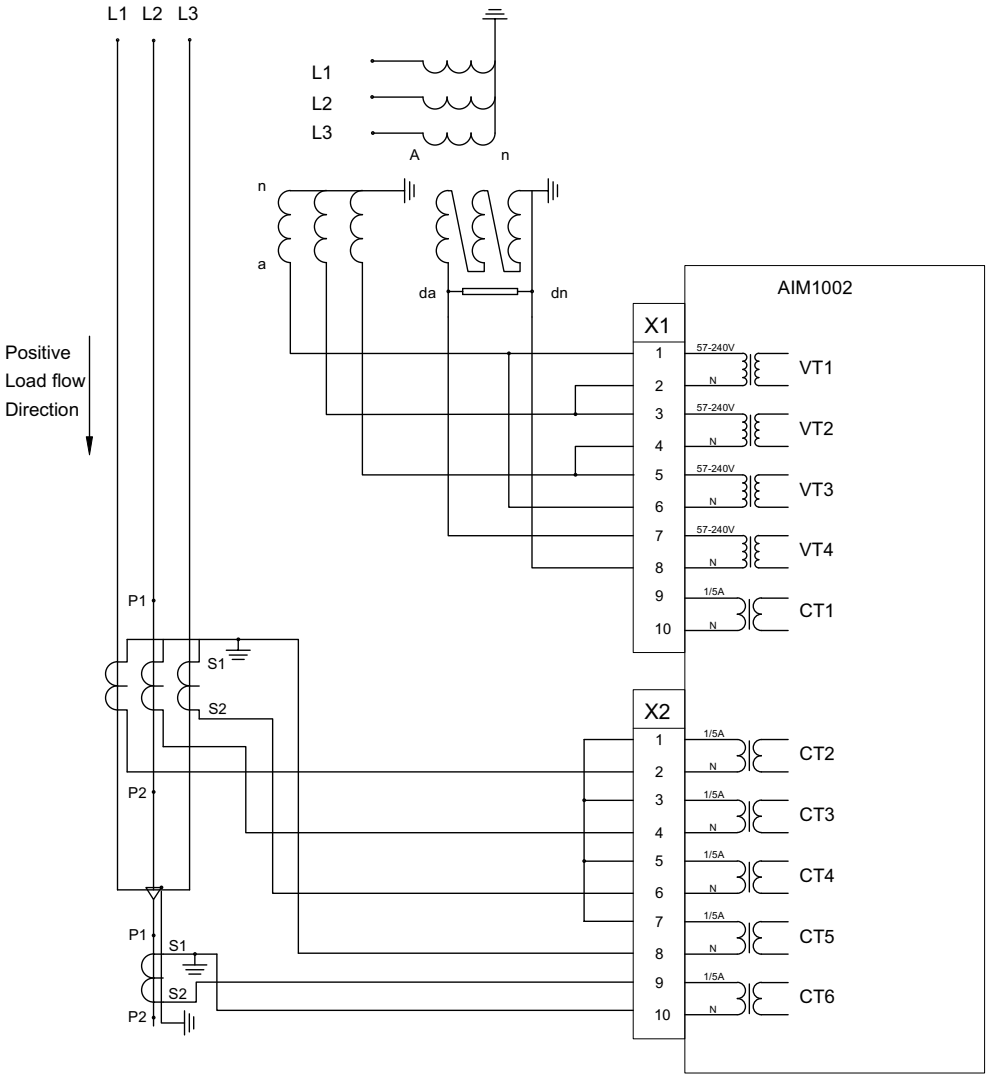



*Figure 889: AIM1002 module*

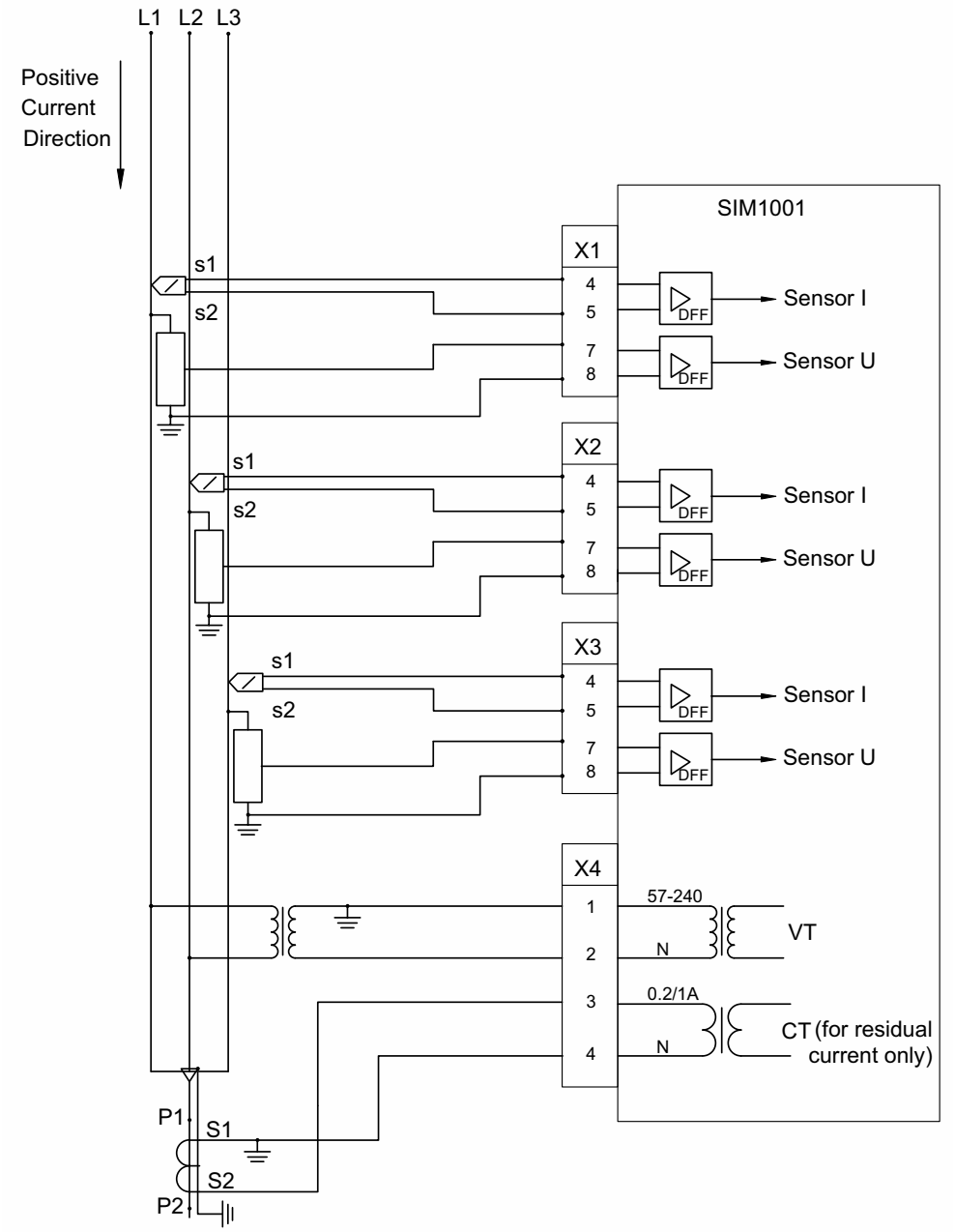



*Figure 890: SIM1001 module*

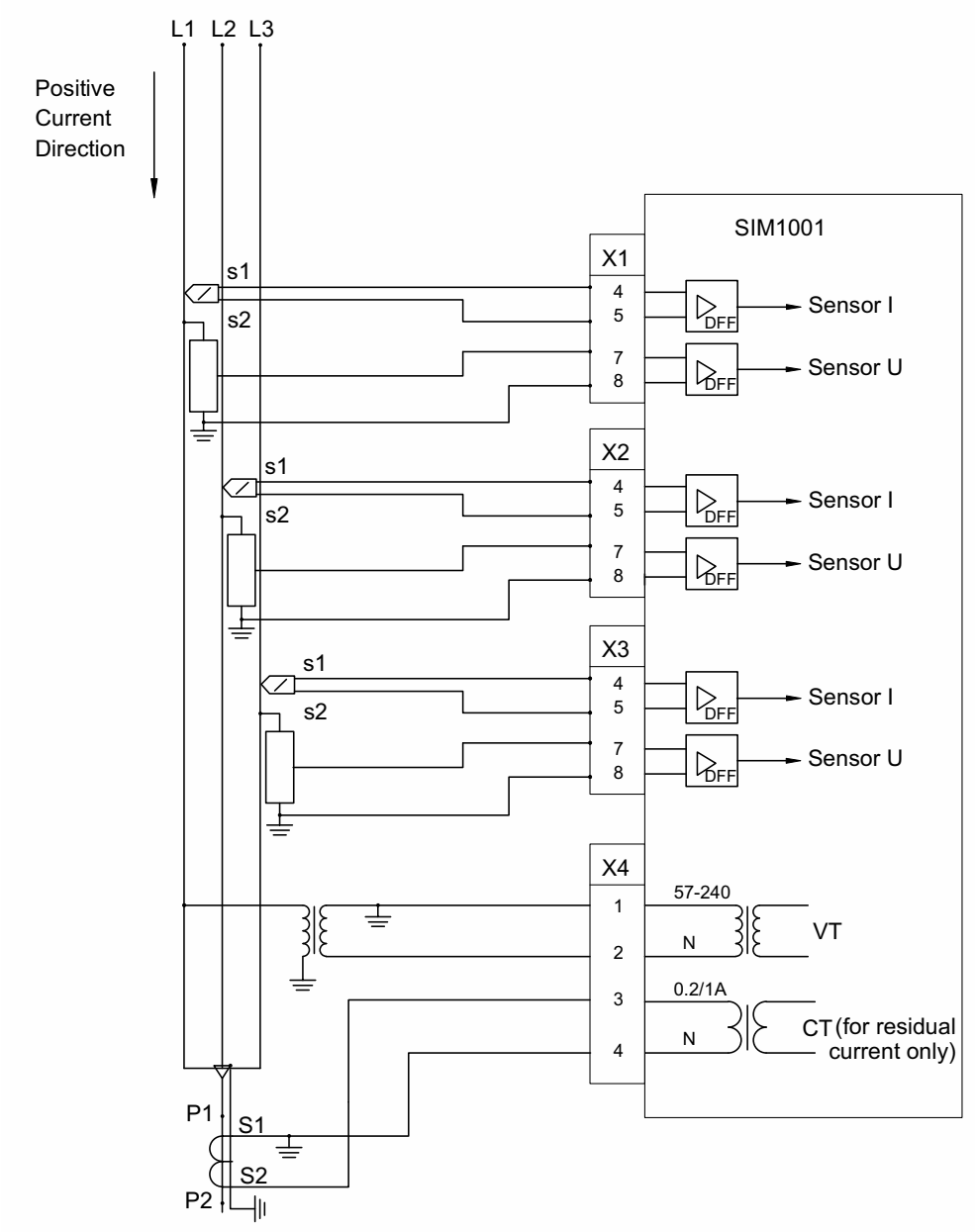



*Figure 891: SIM1001 module*

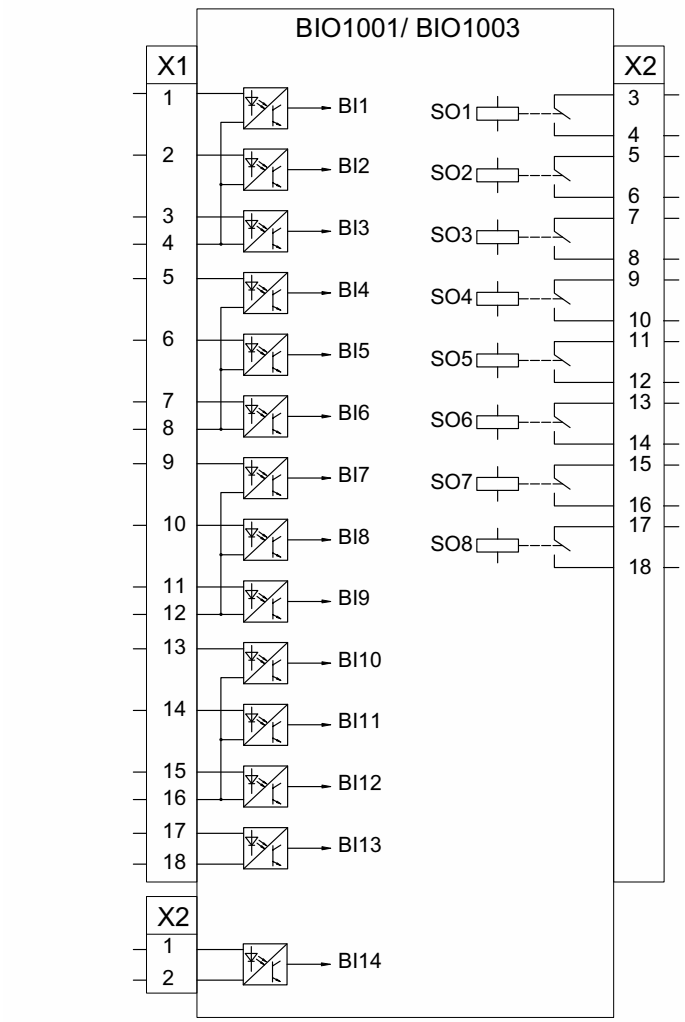



*Figure 892: BIO1001/BIO1003 modules*

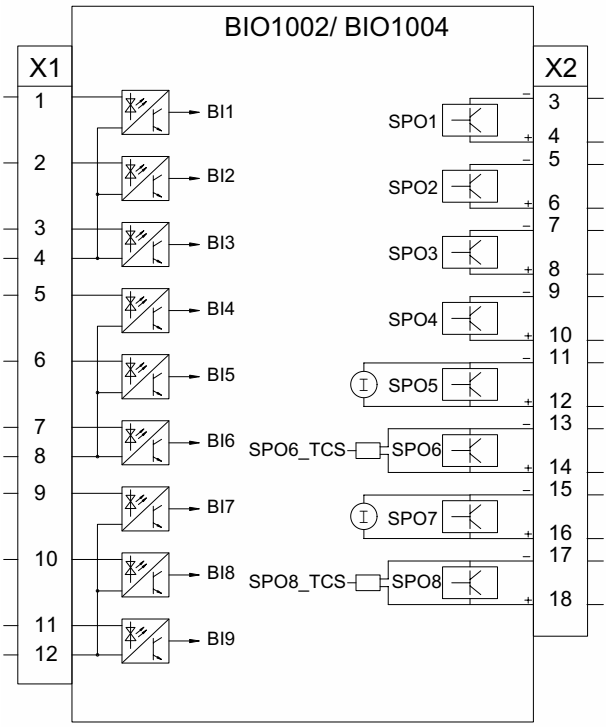



*Figure 893: BIO1002/BIO1004 modules*

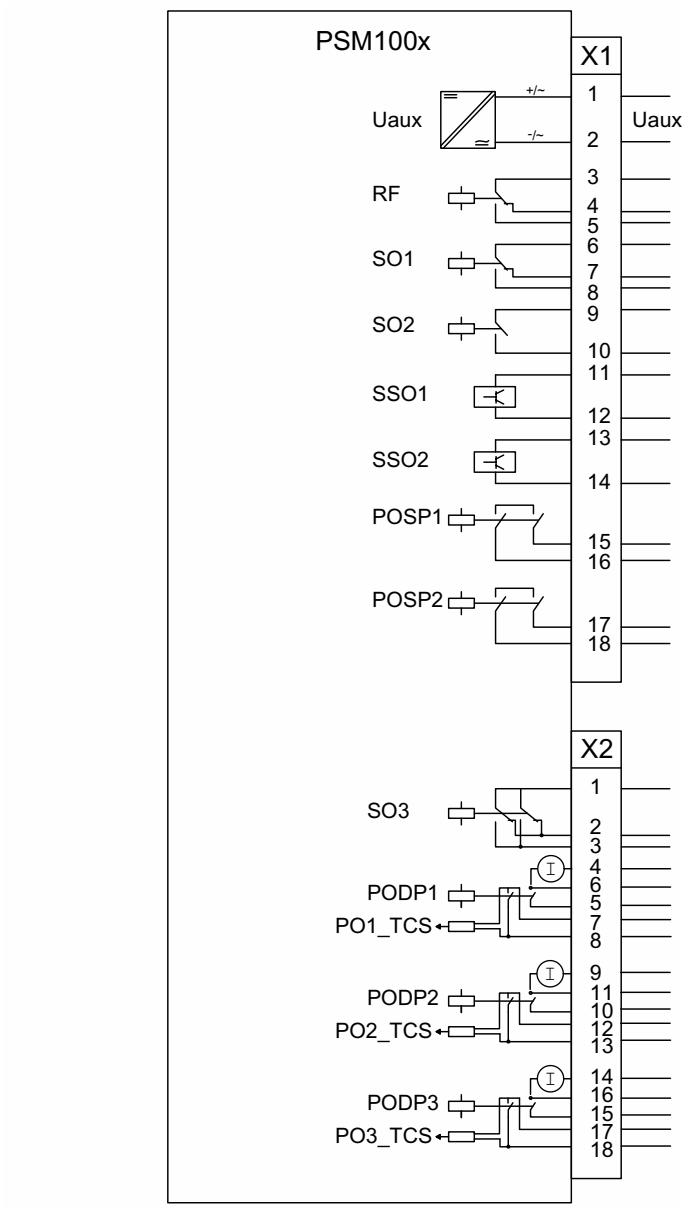



*Figure 894: PSM100x module*

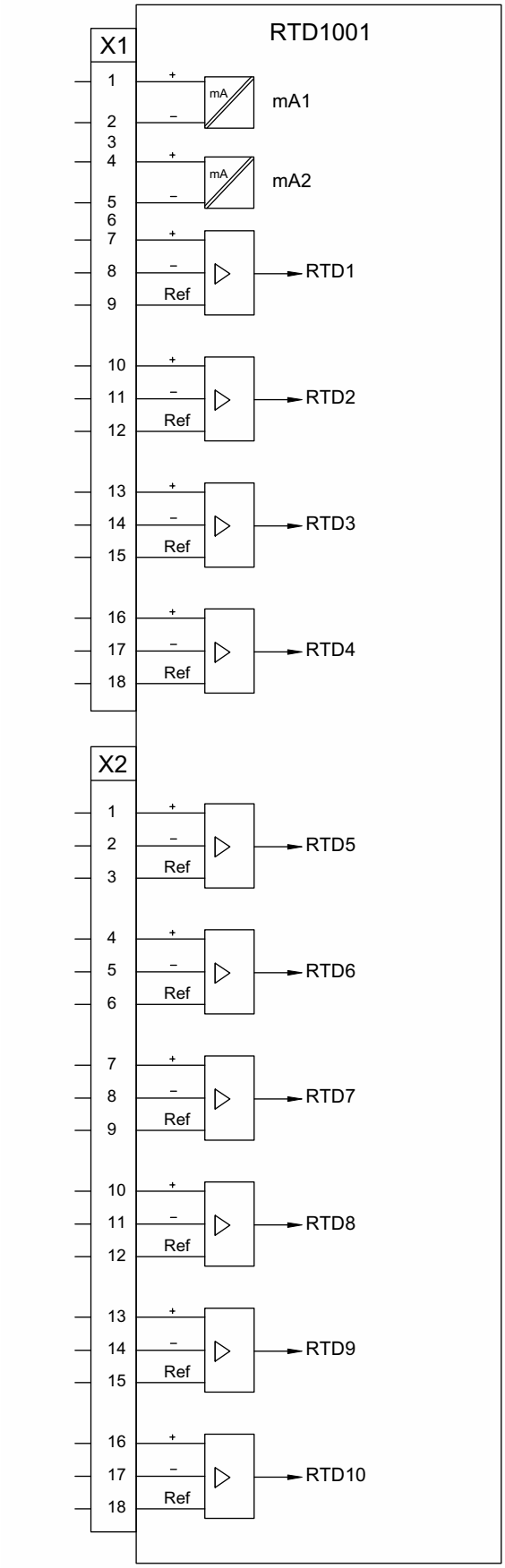

RTD1001
X1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
+
–
mA
mA1
mA2
Ref
RTD1
RTD2
RTD3
RTD4
X2
RTD5
RTD6
RTD7
RTD8
RTD9
RTD10

*Figure 895: RTD1001 module*

## 13.2 Communication modules

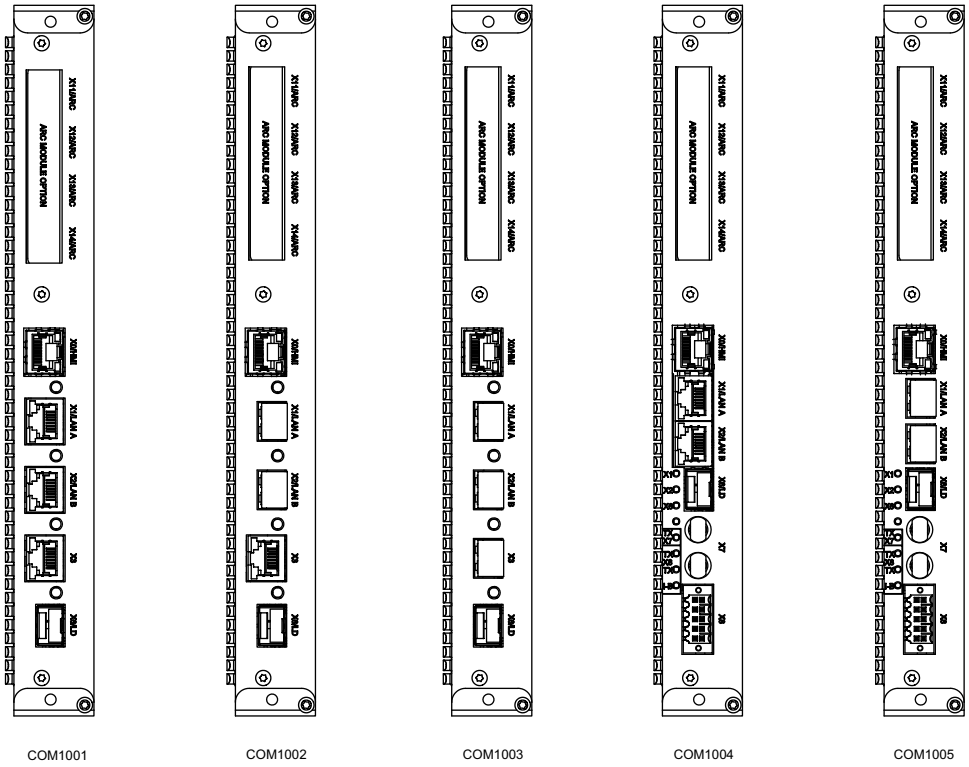



*Figure 896: Communication module options*

The Ethernet ports marked with LAN A and LAN B are used with redundant Ethernet protocols HSR and PRP. The third station bus Ethernet port without the LAN A or LAN B label is an interlink port which is used to connect a device to the common redundant Ethernet channel.

*Table 1482: Ports in communication modules*

| Port | Type | Description |
|---|---|---|
| X0 | RJ-45 | HMI |
| X1 | RJ-45 or LC | Ethernet (LAN A) |
| X2 | RJ-45 or LC | Ethernet (LAN B) |
| X3 | RJ-45 or LC | Ethernet (Interlink) |
| X6 | SFP - LC | Protection communication |
| X7 | FO - ST | Serial communication |
| X8 | TP[1)] | Serial communication/IRIG-B |

1) 2- or 4-wire twisted pair

*Table 1483: Station bus communication interfaces included in communication modules*

| Module ID | RJ-45 | LC | EIA_485 | ST |
|---|---|---|---|---|
| COM1001 | 3 | - | - | - |
| COM1002 | 1 | 2 | - | - |
| COM1003 | - | 3 | - | - |
| COM1004 | 2 | - | 1 | 1 |
| COM1005 | - | 2 | 1 | 1 |

## 13.3 Arc sensor interface

Light sensor input connections for the arc protection are available on the optional hardware module in Slot A1. The module supports connection of up to four sensors. The sensors can be lens or loop types or a free mixture.

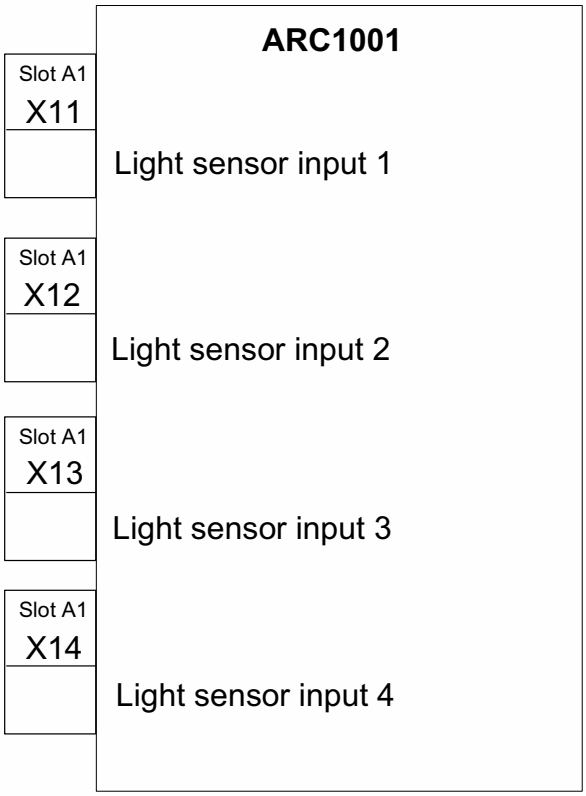



*Figure 897: ARC module*

The ARCSARC function must be instantiated in the application configuration to enable the sensor inputs.

*Table 1484: ARCSARC instances and arc sensor inputs*

| Instance | Sensor input activation |
|---|---|
| ARCSARC1 | Light sensor input 1 |
| ARCSARC2 | Light sensor input 2 |
| ARCSARC3 | Light sensor input 3 |
| ARCSARC4 | Light sensor input 4 |

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# Section 14 Technical data

*Table 1485: Dimensions of the relay*

| Description | | Value |
|---|---|---|
| Width | | 304.0 mm |
| Height | | 264.8 mm |
| Depth | With compression type CT/VT connectors | 242.2 mm |
| | With ring lug type CT/VT connectors | 254.1 mm |
| | With grounding bar | 274.0 mm |
| Weight box | | 6.9...8.8 kg |

*Table 1486: Dimensions of the LHMI*

| Description | Value |
|---|---|
| Width | 212.5 mm |
| Height | 177.5 mm |
| Depth | 57.6 mm |
| Weight | 1.6 kg |

*Table 1487: Power supply for the relay*

| Description | PSM1001 | PSM1002 | PSM1003 |
|---|---|---|---|
| Nominal auxiliary voltage $U_n$ | 24, 30, 48, 60 V DC | 100, 110, 120, 220, 240 V AC, 50 and 60 Hz | 110, 125 V DC |
| | | 48, 60, 110, 125, 220, 250 V DC | |
| Maximum interruption time in the auxiliary DC voltage without resetting the relay | 50 ms at $U_n$ | | |
| Auxiliary voltage variation | 50...120% of $U_n$ (12...72 V DC) | 38...110% of $U_n$ (38...264 V AC) | 70...120% of $U_n$ (77...150 V DC) |
| | | 80...120% of $U_n$ (38.4...300 V DC) | |
| Start-up threshold | 16 V DC (24 V DC × 67%) | | 77 V DC (110 V DC × 70%) |

Table continues on next page

| Description | PSM1001 | PSM1002 | PSM1003 |
|---|---|---|---|
| Burden of auxiliary voltage supply under quiescent ($P_q$)/ operating condition | DC <18.0 W (nominal)/ <25.0 W (max.) | DC <20.0 W (nominal)/ <25.0 W (max.)<br>AC <20.0 W (nominal)/ <25.0 W (max.) | DC <17.0 W (nominal)/ <25.0 W (max.) |
| Ripple in the DC auxiliary voltage | Max 15% of the DC value (at frequency of 100 Hz) | | |
| Fuse type | T8A/250 V | T4A/250 V | |

*Table 1488: Power supply for the LHMI*

| Description | Value |
|---|---|
| Nominal auxiliary voltage $U_n$ | 100, 110, 120, 220, 240 V AC, 50 and 60 Hz |
| | 24, 48, 60, 110, 125, 220, 250 V DC |
| Auxiliary voltage variation | 38...110% of $U_n$ (38...264 V AC) |
| | 80...120% of $U_n$ (19.2...300 V DC) |
| Start-up threshold | 19.2 V DC (24 V DC × 80%) |
| Burden of auxiliary voltage supply under quiescent ($P_q$)/operating condition | DC <6.0 W (nominal)/<14.0 W (max.)<br>AC <7.0 W (nominal)/<12.0 W (max.) |
| Ripple in the DC auxiliary voltage | Max 15% of the DC value (at frequency of 100 Hz) |
| Fuse type | T3.15A/250V |

*Table 1489: Energizing inputs*

| Description | | Value | |
|---|---|---|---|
| Rated frequency | | 50/60 Hz | |
| Current inputs | Rated current, $I_n$ | 0.2/1 A | 1/5 A[1)] |
| | Thermal withstand capability:<br>• Continuously<br>• For 1 s | <br>4 A<br>100 A | <br>20 A<br>500 A |
| | Dynamic current withstand:<br>• Half-wave value | <br>250 A | <br>1250 A |
| | Input impedance | <100 mΩ | <20 mΩ |
| Voltage inputs | Rated voltage | 57...240 V AC | |
| | Voltage withstand:<br>• Continuous<br>• For 10 s | <br>288 V AC<br>360 V AC | |
| | Burden at rated voltage | <0.05 VA | |

1) Residual current and/or phase current

*Table 1490: Energizing inputs (sensors)*

| Description | | Value |
|---|---|---|
| Current sensor input | Rated current voltage (in secondary side) | 75 mV...9000 mV[1)] |
| | Continuous voltage withstand | 125 V |
| | Input impedance at 50/60 Hz | 4 MΩ |
| Voltage sensor input | Rated primary voltage | 6 kV...40.5 kV[2)] |
| | Continuous voltage withstand | 50 V |
| | Input impedance at 50/60 Hz | 8 MΩ |

1) Equals the current range of 40...4000 A with a 80 A, 3 mV/Hz Rogowski
2) This range is covered (up to 2*rated) with sensor division ratio of 10 000:1

*Table 1491: Binary inputs*

| Description | Value |
|---|---|
| Operating range | ±20% of the rated voltage |
| Rated voltage | 24...250 V DC |
| Current drain | 1.6...1.9 mA |
| Power consumption | 31.0...570.0 mW |
| Threshold voltage | 16...176 V DC |
| Ripple in the DC auxiliary voltage | Max 15% of the DC value (at frequency of 100 Hz) |



Adjust the binary input threshold voltage correctly. It is recommended to set the threshold voltage to 70% of the nominal auxiliary voltage. The factory default is 16 V to ensure the binary inputs' operation regardless of the auxiliary voltage used (24, 48, 60, 110, 125, 220 or 250 V DC). However, the default value is not optimal for the higher auxiliary voltages. The binary input threshold voltage should be set as high as possible to prevent any inadvertent activation of the binary inputs due to possible external disturbances. At the same time, the threshold should be set so that the correct operation is not jeopardized in case of undervoltage of the auxiliary voltage.

*Table 1492: RTD/mA inputs and mA outputs*

| Description | | Value | |
|---|---|---|---|
| RTD inputs | Supported RTD sensors | 100 Ω platinum<br>250 Ω platinum<br>100 Ω nickel<br>120 Ω nickel<br>250 Ω nickel | TCR 0.00385 (DIN 43760)<br>TCR 0.00385<br>TCR 0.00618 (DIN 43760)<br>TCR 0.00618<br>TCR 0.00618 |
| | Supported resistance range | 0...4 kΩ | |
| | Maximum lead resistance (three-wire measurement) | 100 Ω per lead | |
| | Isolation | 2 kV (inputs to protective earth) | |
| | Response time | <1 s | |
| | RTD/resistance sensing current | <1 mA rms | |
| | Operation accuracy | Resistance | Temperature |
| | | ± 2.0% or ±1 Ω | ±1°C |
| mA inputs | Supported current range | ±0…20 mA | |
| | Current input impedance | 44 Ω ±0.1% | |
| | Operation accuracy | ±0.5% or ±0.01 mA | |
| mA outputs | Supported current range | ±0…20 mA | |
| | Maximum loop impedance | 700 Ω | |
| | Operation accuracy | ±0.1 mA | |

*Table 1493: Signal outputs and IRF output*

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 1250 VA |
| Continuous contact carry | 5 A |
| Make and carry for 3.0 s | 10 A |
| Make and carry 0.5 s | 15 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC | 1 A/0.25 A/0.15 A |
| Minimum contact load | 10 mA at 5 V AC/DC |

*Table 1494: Single-pole power output relays*

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 2000 VA |
| Continuous contact carry | 8 A |
| Make and carry for 3.0 s | 15 A |
| Make and carry for 0.5 s | 30 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC | 5 A/3 A/1 A |
| Minimum contact load | 100 mA at 24 V AC/DC |

*Table 1495: Static signal output (SSO) relays*

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 250 VA |
| Continuous contact carry | 1 A |
| Make and carry for 3.0 s | 5 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 110 V DC | >0.25 A |
| Minimum load current | 1 mA |
| Maximum operation frequency at 50% duty cycle | 10 Hz |

*Table 1496: Double-pole power output relays with TCS function*

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 2000 VA |
| Continuous contact carry | 8 A |
| Make and carry for 3.0 s | 15 A |
| Make and carry for 0.5 s | 30 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC (two contacts connected in series) | 5 A/3 A/1 A |
| Minimum contact load | 100 mA at 24 V AC/DC |
| Trip-circuit supervision (TCS):<br>• Control voltage range<br>• Current drain through the supervision circuit<br>• Minimum voltage over the TCS contact | <br>20...250 V AC/DC<br>~1.5 mA<br>20 V AC/DC (15...20 V) |

*Table 1497: Static power output (SPO) relays*

| Description | Value |
|---|---|
| Rated voltage | 250 V DC |
| Maximum continuous burden (resistive load, DC) | 2000 VA |
| Continuous contact carry | 5 A (one output at a time)<br>1 A (multiple outputs simultaneously active) |
| Make and carry for 0.2 s | 30 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC two contacts connected in series | 16 A/6 A/3 A |
| Minimum load current | 1 mA |
| Trip-circuit supervision (TCS) SP06 and SP08: | |
| • Control voltage range | 20...250 V DC |
| • Current drain through the supervision circuit | ~1.5 mA |
| • Minimum voltage over the TCS contact | 20 V DC |
| SP05 and SP07: | |
| • Current drain through the circuit | ~3 mA |

*Table 1498: Serial rear interface*

| Type | Counter connector |
|---|---|
| Serial port X8 | 10-pin 2-row counter connector |
| Serial port X7 | Optical ST-connector |

*Table 1499: USB interface, LHMI*

| Type | Description |
|---|---|
| USB | Hi-Speed USB Type A |

*Table 1500: Ethernet interfaces*

| Connector | Media | Reach | Rate | Wavelength | Permitted path attenuation |
|---|---|---|---|---|---|
| RJ-45 | CAT 6 S/FTP | 100 m | 100 mbits/s | - | – |
| LC | MM 62.5/125 or 50/125 µm glass fiber core | 2 km[1)] | 100 mbits/s | 1300 nm | <8 dB[2)] |

1) Maximum length depends on the cable attenuation and quality, the amount of splices and connectors in the path
2) Maximum allowed attenuation caused by connectors and cable togethe

*Table 1501: Protection communication link*

| Connector | Part number | Fiber type | Wave Length | Max. length | Permitted path attenuation |
|---|---|---|---|---|---|
| SFP | 2RCA045621 | MM 62.5/125 or 50/125 µm | 1310 nm | 2 km | <8 dB |
| SFP | 2RCA045622 | SM 9/125 µm | 1310 nm | 20 km | <13 dB |
| SFP | 2RCA045623 | SM 9/125 µm | 1310 nm | 50 km | <26 dB |

*Table 1502: IRIG-B (connector X8)*

| Description | Value |
|---|---|
| IRIG time code format | B004, B005[1)] |
| Isolation | 500V 1 min |
| Modulation | Unmodulated |
| Logic level | 5 V TTL |
| Current consumption | <1.0 mA |
| Power consumption | <0.5 W |

1) According to the 200-04 IRIG standard

*Table 1503: Lens sensor and optical fiber for arc protection*

| Description | Value |
|---|---|
| Fiber optic cable including lens | 1.5 m, 3.0 m or 5.0 m |
| Normal service temperature range of the lens | -40...+100°C |
| Maximum service temperature range of the lens, max 1 h | +140°C |
| Minimum permissible bending radius of the connection fiber | 100 mm |

*Table 1504: Degree of protection of flush-mounted protection relay*

| Description | Value |
|---|---|
| Front/connector side | IP 20 |
| Top and bottom | IP 30 |
| Rear | IP 40 |

*Table 1505: Degree of protection of the LHMI*

| Description | Value |
|---|---|
| Front | IP 54 |
| Other sides | IP 20 |

*Table 1506: Environmental conditions*

| Description | Value |
|---|---|
| Operating temperature range | -25...+55ºC (continuous) |
| Short-time service temperature range | -40...+85ºC (<16 h)[1)2)] |
| Relative humidity | <93%, non-condensing |
| Atmospheric pressure | 86...106 kPa |
| Altitude | Up to 2000 m |
| Transport and storage temperature range | -40...+85ºC |

1) Degradation in MTBF and HMI performance outside the temperature range of -25...+55 ºC
2) For relays with an LC communication interface the maximum operating temperature is +70 ºC

# Section 15 Protection relay and functionality tests

*Table 1507: Electromagnetic compatibility tests*

| Description | Type test value | Reference |
|---|---|---|
| 1 MHz/100 kHz burst disturbance test | | IEC 61000-4-18<br>IEC 60255-26, class III<br>IEEE C37.90.1-2012 |
| • Common mode | 2.5 kV | |
| • Differential mode | 2.5 kV | |
| 3 MHz, 10 MHz and 30 MHz burst disturbance test | | IEC 61000-4-18<br>IEC 60255-26, class III |
| • Common mode | 2.5 kV | |
| Electrostatic discharge test | | IEC 61000-4-2<br>IEC 60255-26<br>IEEE C37.90.3-2001 |
| • Contact discharge | 8 kV | |
| • Air discharge | 15 kV | |
| Radio frequency interference test | | |
| | 10 V (rms)<br>f = 150 kHz...80 MHz | IEC 61000-4-6<br>IEC 60255-26, class III |
| | 10 V/m (rms)<br>f = 80...2700 MHz | IEC 61000-4-3<br>IEC 60255-26, class III |
| | 10 V/m<br>f = 900 MHz | ENV 50204<br>IEC 60255-26, class III |
| | 20 V/m (rms)<br>f = 80...1000 MHz | IEEE C37.90.2-2004 |
| Fast transient disturbance test | | IEC 61000-4-4<br>IEC 60255-26<br>IEEE C37.90.1-2012 |
| • Communication | 2 kV | |
| • Other ports | 4 kV | |
| Surge immunity test | | IEC 61000-4-5<br>IEC 60255-26 |
| • Communication | 1 kV, line-to-earth | |
| • Other ports | 4 kV, line-to-earth<br>2 kV, line-to-line | |
| Power frequency (50 Hz) magnetic field immunity test | | IEC 61000-4-8<br>IEC 60255-26 |

Table continues on next page

| Description | Type test value | Reference |
|---|---|---|
| • Continuous<br>• 1...3 s | 300 A/m<br>1000 A/m | |
| Pulse magnetic field immunity test | 1000 A/m<br>6.4/16 µs | IEC 61000-4-9 |
| Damped oscillatory magnetic field immunity test<br>• 2 s<br>• 1 MHz | <br>100 A/m<br>400 transients/s | IEC 61000-4-10 |
| Voltage dips and short interruptions | 0%/50 ms Criterion A<br>40%/200 ms Criterion C<br>70%/500 ms Criterion C<br>0%/5000 ms Criterion C | IEC 61000-4-11<br>IEC 61000-4-29<br>IEC 60255-26 |
| Power frequency immunity test<br>• Common mode<br>• Differential mode | Binary inputs only<br>300 V rms<br>150 V rms | IEC 61000-4-16<br>IEC 60255-26, class A |
| Emission tests<br>• Conducted<br>0.15...0.50 MHz<br>0.5...30 MHz<br>• Radiated<br>30...230 MHz<br>230...1000 MHz<br>1…3 GHz<br>3…6 GHz | <br><br><79 dB (µV) quasi peak<br><66 dB (µV) average<br><73 dB (µV) quasi peak<br><60 dB (µV) average<br><br><40 dB (µV/m) quasi peak, measured at 10 m distance<br><47 dB (µV/m) quasi peak, measured at 10 m distance<br><76 dB (µV/m) peak<br><56 dB (µV/m) average, measured at 3 m distance<br><80 dB (µV/m) peak<br><60 dB (µV/m) average, measured at 3 m distance | EN 55011, class A<br>IEC 60255-26<br>CISPR 11<br>CISPR 12 |

*Table 1508: Safety-related tests*

| Description | Type test value | Reference |
|---|---|---|
| Overvoltage category | III | IEC 60255-27 |
| Pollution degree | 2 | IEC 60255-27 |
| Insulation class | Class I | IEC 60255-27 |
| Table continues on next page | | |

| Description | Type test value | Reference |
|---|---|---|
| Dielectric tests | 500 V, 50 Hz, 1 min, RS-485 and IRIG-B<br>1 kV, 50 Hz, 1 min, across open contacts<br>1.5 kV, 50 Hz, 1 min, Ethernet RJ-45<br>2 kV, 50 Hz, 1 min, all other circuits | IEC 60255-27 |
| Impulse voltage test | 1 kV, 1.2/50 µs, 0.5 J, RS-485 and IRIG-B<br>2.4 kV, 1.2/50 µs, 0.5 J, Ethernet RJ-45<br>5 kV, 1.2/50 µs, 0.5 J, all other circuits | IEC 60255-27 |
| Insulation resistance measurements | >100 MΩ, 500 V DC | IEC 60255-27 |
| Protective bonding resistance | <0.1 Ω, 4 A, 60 s | IEC 60255-27 |
| Maximum temperature of parts and materials | Tested | IEC 60255-27 |
| Flammability of insulating materials, components and fire enclosures | Evaluated / Tested | IEC 60255-27 |
| Single-fault condition | Tested | IEC 60255-27 |

*Table 1509: Mechanical tests*

| Description | Requirement | Reference |
|---|---|---|
| Vibration tests (sinusoidal) | Class 2 | IEC 60068-2-6 (test Fc)<br>IEC 60255-21-1 |
| Shock and bump test | Class 2 | IEC 60068-2-27 (test Ea shock)<br>IEC 60068-2-29 (test Eb bump)<br>IEC 60255-21-2 |

*Table 1510: Environmental tests*

| Description | Type test value | Reference |
|---|---|---|
| Dry heat test | • 96 h at +55°C<br>• 16 h at +85°C[1)] | IEC 60068-2-2 |
| Dry cold test | • 96 h at -25°C<br>• 16 h at -40°C | IEC 60068-2-1 |
| Damp heat test | • 6 cycles (12 h + 12 h) at +25…+55°C, humidity >93% | IEC 60068-2-30 |
| Change of temperature test | • 5 cycles (3 h + 3 h) at -25...+55°C | IEC60068-2-14 |
| Storage test | • 96 h at -40°C<br>• 96 h at +85°C | IEC 60068-2-1<br>IEC 60068-2-2 |

1) For relays with an LC communication interface the maximum operating temperature is +70°C

*Table 1511: Product safety*

| Description | Reference |
|---|---|
| LV directive | 2006/95/EC |
| Standard | EN 60255-27 (2014)<br>EN 60255-1 (2009) |

*Table 1512: EMC compliance*

| Description | Reference |
|---|---|
| EMC directive | 2004/108/EC |
| Standard | EN 60255-26 (2013) |

*Table 1513: RoHS compliance*

| Description |
|---|
| Complies with RoHS Directive 2011/65/EU |

# Section 16 Applicable standards and regulations

EN 60255-1

EN 60255-26

EN 60255-27

EMC council directive 2004/108/EC

EU directive 2002/96/EC/175

IEC 60255

Low-voltage directive 2006/95/EC

IEC 61850

1746

# Section 17 Glossary

| | |
|---|---|
| 100BASE-FX | A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses fiber optic cabling |
| 100BASE-TX | A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses twisted-pair cabling category 5 or higher with RJ-45 connectors |
| ACT | 1. Application Configuration tool in PCM600<br>2. Trip status in IEC 61850 |
| AD | Active directory |
| AIM | Analog input module |
| AIS | Air-insulated switchgear |
| AR | Autoreclosing |
| ASC | Arc suppression coil |
| AVR | Automatic voltage regulator |
| BCD | Binary coded decimal |
| CAM | Centralized account management |
| CAT 6 | Cable standard for gigabit Ethernet and other network protocols that is backward compatible with CAT 5/5e and CAT 3 cable standards |
| CB | Circuit breaker |
| CBB | Cycle building block |
| CBCT | Core balance current transformer |
| CBFP | Circuit breaker failure protection |
| COM600S | Substation Management Unit. An all-in-one communication gateway, automation platform and user interface solution for utility and industrial distribution substations. |
| COMTRADE | Common format for transient data exchange for power systems. Defined by the IEEE Standard. |
| CR | Carrier receive signal |
| CS | Carrier send signal |
| CT | Current transformer |

| | |
|---|---|
| DAN | Doubly attached node |
| DC | 1. Direct current<br>2. Disconnector<br>3. Double command |
| DCB | Directional comparison blocking scheme |
| DCUB | Directional comparison unblocking scheme |
| DFT | Discrete Fourier transform |
| DG | Distributed generation |
| DIP switch | A set of on-off switches arranged in a standard dual in-line package |
| DNP3 | A distributed network protocol originally developed by Westronic. The DNP3 Users Group has the ownership of the protocol and assumes responsibility for its evolution. |
| DT | Definite time |
| DUTT | Direct underreach transfer trip |
| EEPROM | Electrically erasable programmable read-only memory |
| EMC | Electromagnetic compatibility |
| Ethernet | A standard for connecting a family of frame-based computer networking technologies into a LAN |
| FLC | Full load current |
| FPGA | Field-programmable gate array |
| FTP | File transfer protocol |
| FTPS | FTP Secure |
| GFC | General fault criteria |
| GIS | Gas-insulated switchgear |
| GND | Ground/earth |
| GOOSE | Generic Object-Oriented Substation Event |
| GPS | Global Positioning System |
| HF | High frequency |
| HMI | Human-machine interface |
| HSR | High-availability seamless redundancy |
| HTTPS | Hypertext Transfer Protocol Secure |
| HV | High voltage |
| IDMT | Inverse definite minimum time |
| IEC | International Electrotechnical Commission |

| | |
|---|---|
| IEC 60870-5-103 | 1. Communication standard for protective equipment<br>2. A serial master/slave protocol for point-to-point communication |
| IEC 61850 | International standard for substation communication and modeling |
| IEC 61850-8-1 | A communication protocol based on the IEC 61850 standard series |
| IEC 61850-9-2 | A communication protocol based on the IEC 61850 standard series |
| IEC 61850-9-2 LE | Lite Edition of IEC 61850-9-2 offering process bus interface |
| IED | Intelligent electronic device |
| IRF | 1. Internal fault<br>2. Internal relay fault |
| IRIG-B | Inter-Range Instrumentation Group's time code format B |
| L/R | Local/Remote |
| LAN | Local area network |
| LC | Connector type for glass fiber cable, IEC 61754-20 |
| LDC | Line drop compensation |
| LE | Light Edition |
| LED | Light-emitting diode |
| LF | Low frequency |
| LHMI | Local human-machine interface |
| LOG | Loss of grid |
| LOM | Loss of mains |
| LV | Low voltage |
| M/F | Master/Follower |
| MAC | Media access control |
| MCB | Miniature circuit breaker |
| MCC | Minimizing circulating current |
| MM | 1. Multimode<br>2. Multimode optical fiber |
| MMS | 1. Manufacturing message specification<br>2. Metering management system |

| | |
|---|---|
| **Modbus** | A serial communication protocol developed by the Modicon company in 1979. Originally used for communication in PLCs and RTU devices. |
| **Modbus ASCII** | Link mode using 7-bit ASCII characters |
| **Modbus RTU** | Link mode using 8-bit binary characters |
| **MSB** | Most significant bit |
| **MV** | Medium voltage |
| **NC** | Normally closed |
| **NPS** | Negative phase sequence |
| **NRP** | Negative reactance principle |
| **NSCB** | Non-source circuit breaker |
| **OSB** | Out of step blocking |
| **P2P** | peer-to-peer |
| **PC** | 1. Personal computer<br>2. Polycarbonate |
| **PCL** | Product connectivity level |
| **PCM600** | Protection and Control IED Manager |
| **Peak-to-peak** | 1. The amplitude of a waveform between its maximum positive value and its maximum negative value<br>2. A measurement principle where the measurement quantity is made by calculating the average from the positive and negative peak values without including the DC component. The peak-to-peak mode allows considerable CT saturation without impairing the performance of the operation. |
| **Peak-to-peak with peak backup** | A measurement principle similar to the peak-to-peak mode but with the function starting on two conditions: the peak-to-peak value is above the set start current or the peak value is above two times the set start value |
| **PGU** | Power generating unit |
| **PLC** | Programmable logic controller |
| **PO** | Power output |
| **PODP** | Power output, double pole |
| **POSP** | Power output, single pole |
| **POTT** | Permissive overreach transfer trip |
| **PPS** | Pulse per second |
| **PRP** | Parallel redundancy protocol |
| **PTP** | Precision Time Protocol |

| | |
|---|---|
| PUTT | Permissive underreach transfer trip |
| RAM | Random access memory |
| RCA | Also known as MTA or base angle. Characteristic angle. |
| RIO600 | Remote I/O unit |
| RJ-45 | Galvanic connector type |
| RMS | Root-mean-square (value) |
| ROM | Read-only memory |
| RS-485 | Serial link according to EIA standard RS485 |
| RSTP | Rapid spanning tree protocol |
| RTC | Real-time clock |
| RTD | Resistance temperature detector |
| Rx | Receive/Received |
| SAN | Single attached node |
| SBO | Select-before-operate |
| SCADA | Supervision, control and data acquisition |
| SCB | 1. Shunt capacitor bank<br>2. Source circuit breaker |
| SCL | XML-based substation description configuration language defined by IEC 61850 |
| SCM | Smart control module |
| SDM600 | A software solution for automatic management of service and cyber security relevant data across substations |
| SIM | Subscriber identity module |
| SM | 1. Single mode<br>2. Single-mode optical fiber |
| SMT | Signal Matrix tool in PCM600 |
| SMV | Sampled measured values |
| SNTP | Simple Network Time Protocol |
| SOTF | Switch onto fault |
| SPO | Static power output |
| SSO | Static signal output |
| ST | Connector type for glass fiber cable |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TCS | Trip-circuit supervision |

| | |
|---|---|
| TLV | Type length value |
| TP | Disturbance data recorded with or without trip bit |
| Tx | Transmit/Transmitted |
| UART | Universal asynchronous receiver-transmitter |
| UDP | User datagram protocol |
| USB | Universal serial bus |
| UTC | Coordinated universal time |
| VDR | Voltage-depended resistor |
| VT | Voltage transformer |
| WAN | Wide area network |
| WEI | Weak-end infeed logic |
| WHMI | Web human-machine interface |

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# Exertherm® Alarm Relay Module XL
# ARM XL
# Installation & Setup Manual



MA-131-5-EN

**There are 3 hardware connection options for use with the ARM XL.**

**Instructions detailed in Sections 3 to 8 are generic and applicable to all, and therefore must be adhered to for all hardware selections.**

**Following this please refer to the relevant Section for your selected hardware connection:**

- **8ch Datacard Only Section 9**
- **MMA Only Section 10**
- **Both 8ch Datacard & MMA Section 11**


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# 1. VERSION CHANGE CONTROL RECORD

| Version No | Reason for Change | Created by | Date of Release |
|---|---|---|---|
| MA-131-1-EN | New product | JH/LK | 19th April 2018 |
| MA-131-2-EN | Addition of Exertherm Temp/humidity sensor | JH/LJK | 27th September 2018 |
| MA-131-3-EN | New IO Sheet + drawing updates | JH/LJK | 14th April 2020 |
| MA-131-4-EN | Company name change updates | LJK | 28th April 2021 |
| MA-131-5-EN | Logo and cover updates | JH | 8th April 2024 |
| MA-131-6-EN | Update to register, removal of humidity sensor | JH | 7th May 2024 |


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This document, including all the descriptions within it, assumes that the user is conversant with the operation and uses of basic control and monitoring systems.

In addition, this document does not include any specific documentation concerning the systems with which integration takes place. The user should seek additional information from the supplier's documentation for each of the connected systems.

Where devices such as display panels and personal computers are used, we have assumed that the user will either be familiar with the operation of the devices or will be able to familiarise themselves with the information supplied with the equipment.

The utility, configuration, terminal or stream modes of the connected systems enable all control parameters to be changed. Qualified persons only should carry this out, and it is strongly recommended that any changes made be recorded at the time of the changes. Note that if a change is to be made, a backup of the systems concerned should be made before this where possible.

## 2.1 NOTICES:

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## 2.3 STANDARDS AND APPROVALS

Exertherm ARM XL, MMA, MMD, 8ch Modbus Datacard & IR + Cable Sensors are all CE certified & UL Listed.

Exertherm declare that all our components are produced in accordance with EU Directive 2011/65/EU requirement for RoHS Compliance.

## 2.4 PERSONNEL QUALIFICATION AND TRAINING

It is assumed that the Exertherm ARM XL Product will only be installed in accordance with the instruction contained within this Manual.

Personal responsibilities, competence and supervision must be clearly defined by the commissioner / installer. If the personnel in question are not already in possession of the requisite knowledge, then appropriate training and instruction must be provided.

## 2.5 WARRANTY

Exertherm ARM XL Return/Warranty Policy

Exertherm offers a one year warranty on ARM XL Product from date of sale. We warrant that product will be free of defects in material and workmanship and will repair or replace the returned product at no charge during that one year period. The warranties are void if the product is misused, mishandled or installed incorrectly (not in accordance with the methods and procedures outlined in this document).

Repairs to Exertherm ARM XL Product can only be undertaken by Exertherm. Any repairs or attempted repairs by others will void product warranties.

The warranty is conditional upon the above caveats and strictly limited to the replacement cost of ARM XL Product. Labour costs associated with removal of ARML XL Product and/or re-installation are excluded, as is any consequential loss resulting from the ARM XL Product failure.

Exertherm reserves the right to examine and test any returned products to determine the cause of failure. No returned products will be accepted prior to issue of a Return Material Authorization (RMA) number by Exertherm.

Please contact Exertherm if you have any questions – support@Exertherm.com, current telephone numbers can be found at www.Exertherm.com .

## 2.6 LIVE WORKING



**DO NOT PERFORM ANY ACTIVITY ON A PIECE OF LIVE SWITCHGEAR. FAILURE TO COMPLY WITH THESE AND OTHER NATIONAL, REGIONAL OR LOCAL HEALTH AND SAFETY REGULATIONS/GUIDELINES COULD RESULT IN PERMANENT INJURY OR DEATH.**

Prior to undertaking any work the operator MUST ensure that all busbars, connections and sources of energy are totally isolated and checked prior to any works taking place which should be completed by a competent and suitably qualified person.

All energy sources onto the panel must be isolated, removed and locked out to prevent the panel being re-energised while any works are taking place. If the panel being tested is part of an existing installation then all connections should be bonded to earth.

# 3. TOPOLOGIES

## 3.1 ARM XL & 8CH DATACARD CONNECTION TOPOLOGY

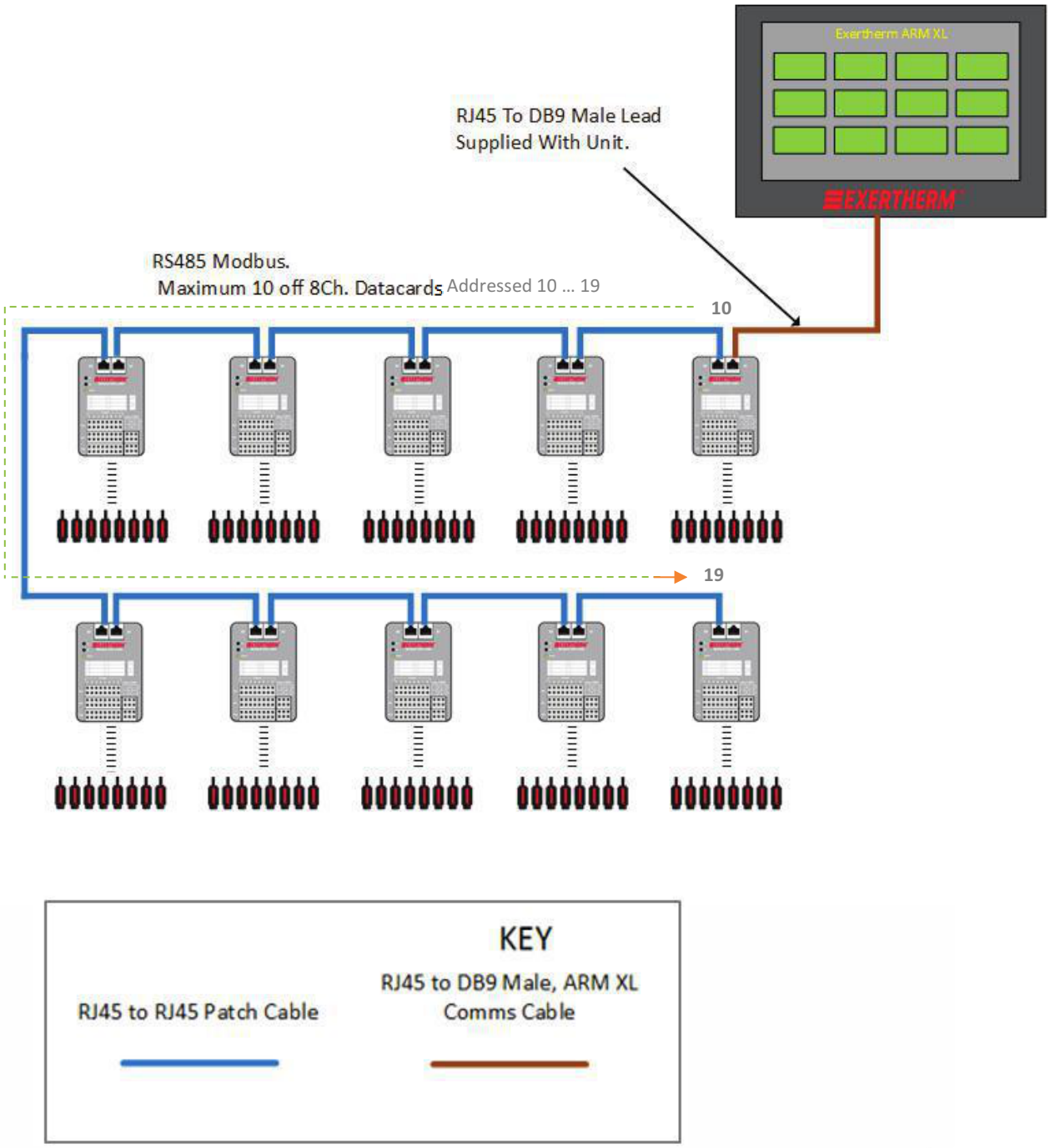



Figure 1 ARM XL & 8ch Datacard Connection Topology


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## 3.2 ARM XL & MMA CONNECTION TOPOLOGY

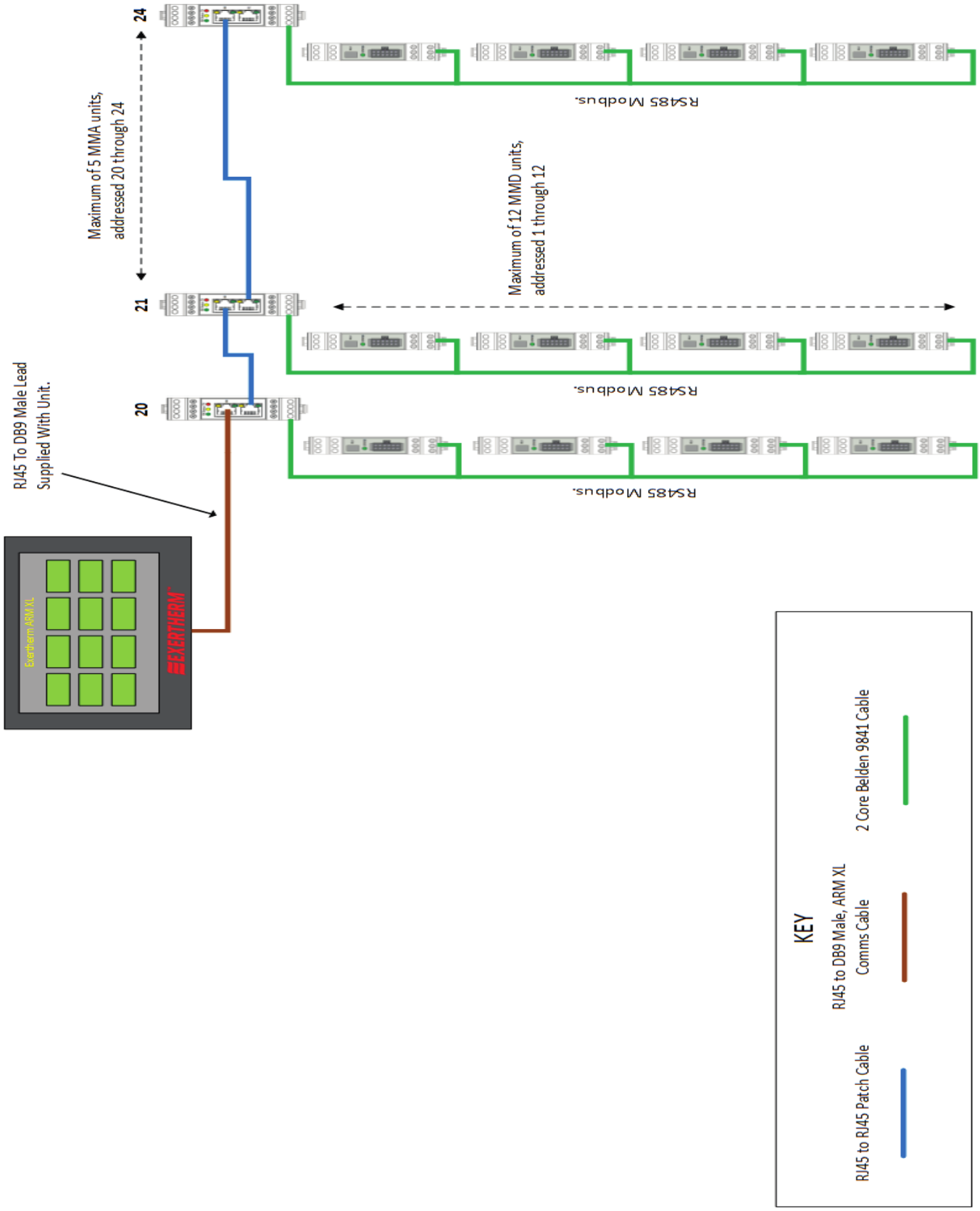



Figure 2 ARM XL & MMA Connection Topology


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## 3.3 ARM XL – 8CH DATACARD & MMA CONNECTION TOPOLOGY

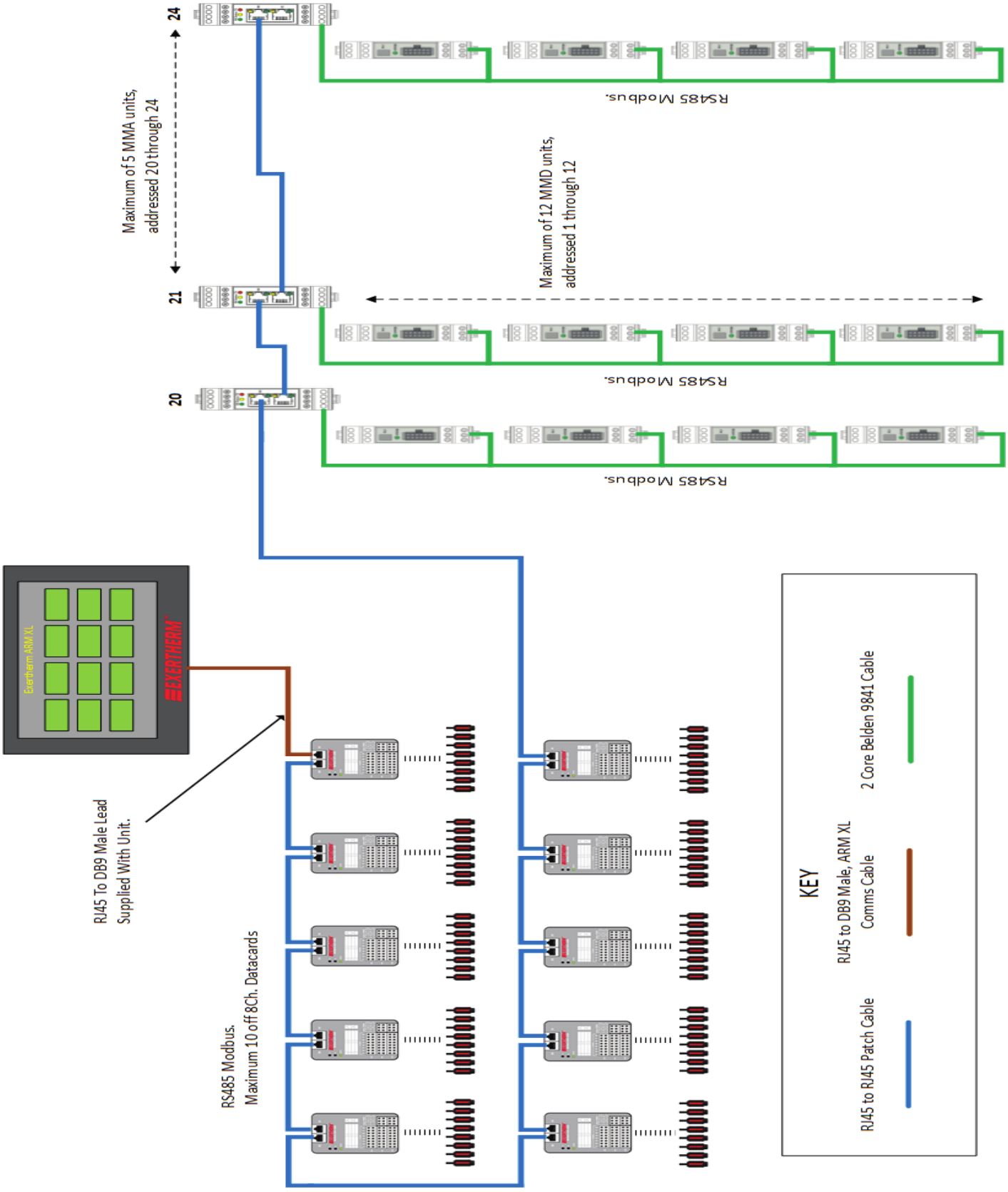



Figure 3 ARM XL - 8ch Datacard & MMA Connection Topology


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# 4. GLOSSARY

| WORD / ACRONYM | DEFINITION |
|---|---|
| ARM XL | Alarm Relay Module XL |
| MMS | MCC Modbus Solution – name for system as a whole |
| MMD | MCC Modbus Datacard |
| MMA | MCC Modbus Aggregator |


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# 5. WHAT'S IN THE BOX?

Part Number & description of box contents below:

**Exertherm Part No. 900451**

1) Exertherm Alarm Relay Module (ARM XL)
2) ARM XL Install & Setup Manual
3) 2 x mounting screws & 1 x power connector
4) Panel cut out Template
5) Comms Cable

**Replacement Parts:**

The following replacement parts can be ordered, part numbers + description below:

1) Comms Cable is – PN 800455
2) 2 x mounting screws & 1 x power connector – PN 800456


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# 6. MOUNTING INSTRUCTIONS

## 6.1 UNIT SIZE

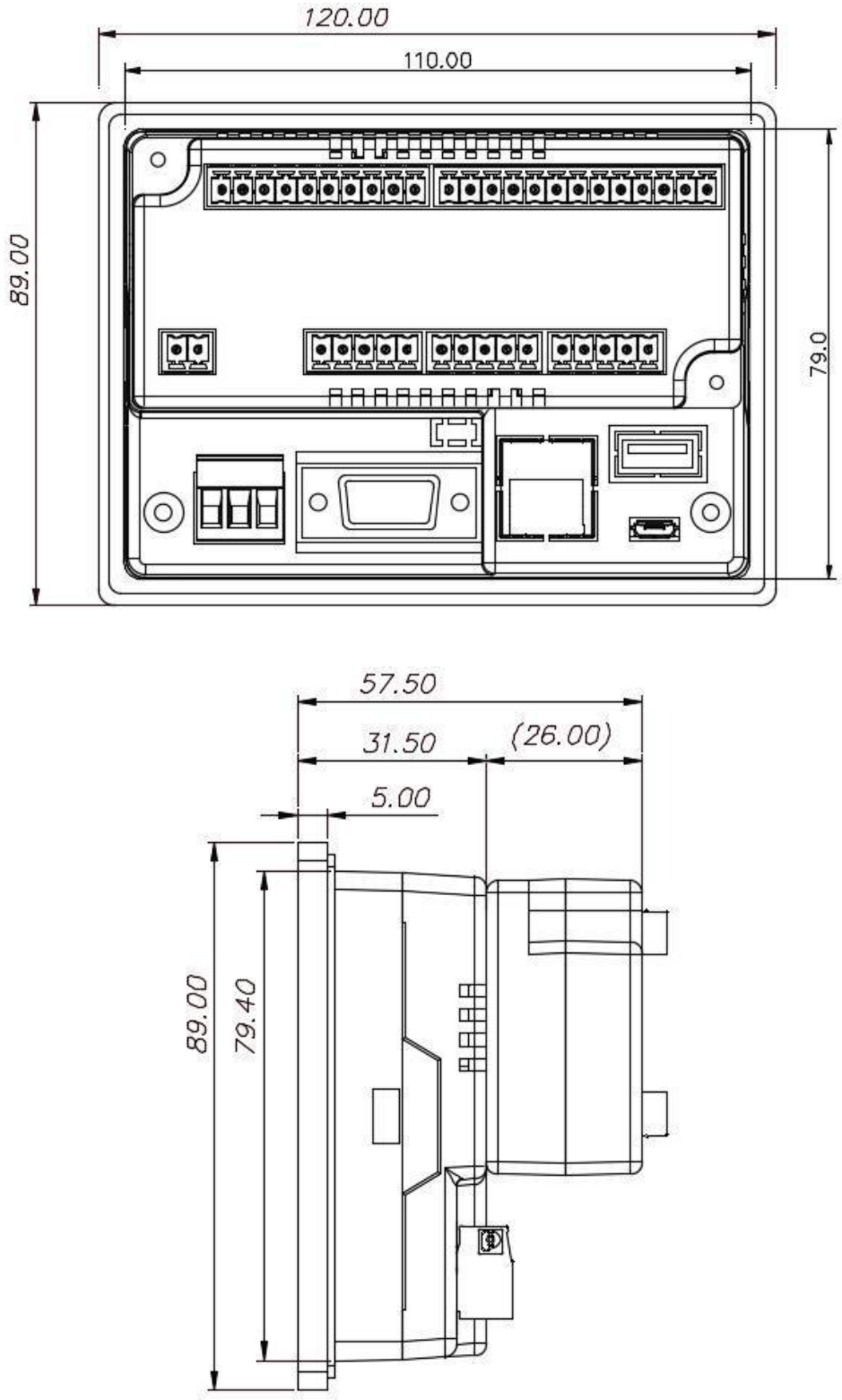



Figure 4 ARM XL Unit Dimensions


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## 6.2 PANEL CUTOUT

The panel which the ARM XL is to mounted in must not be greater than 5 mm (0.2 “) thick.

1. Make a panel cut-out measuring 111.0 x 80.0mm (4.4” x 3.1”)

**Please use the self-adhesive template provided in ARM XL box or create your own template using the measurements above**

2. Slide the ARM XL into the cut-out.
3. Push the mounting brackets into their slots on the side of the unit.
4. Tighten the bracket screws against the panel. Hold the bracket securely against the unit while tightening the screw.
5. When properly mounted, the ARM XL is squarely situated in the panel cut-out.

# 7. CONNECTIONS

## 7.1 CAUTION



**Do not touch live wires.**



Install an external circuit breaker. Guard against short-circuiting in external wiring.

Use appropriate circuit protection devices.

Unused pins should not be connected. Ignoring this directive may damage the ARM XL.

Double-check all wiring before turning on the power supply.

To avoid damaging the wire, do not exceed a maximum torque of 0.5 N·m (5 kgf·cm).

Do not use tin, solder, or any substance on stripped wire that might cause the wire strand to break.

Install at maximum distance from high-voltage cables and power equipment.

## 7.2 POWER SUPPLY

- The ARM XL requires a 24VDC power supply ±15% (20.4 to 27.6) 300mA max
- The power supply must include double insulation. Outputs must be rated as SELV/PELV/Class 2/Limited Power.
- Use separate wires to connect the functional earth line (pin 3) to the system earth ground.
- Do not connect either the 'Neutral' or 'Line' signal of a 110/220 VAC source to the ARM XL
- In the event of voltage fluctuations or non-conformity to power supply voltage specifications, connect the ARM XL to a regulated power supply.

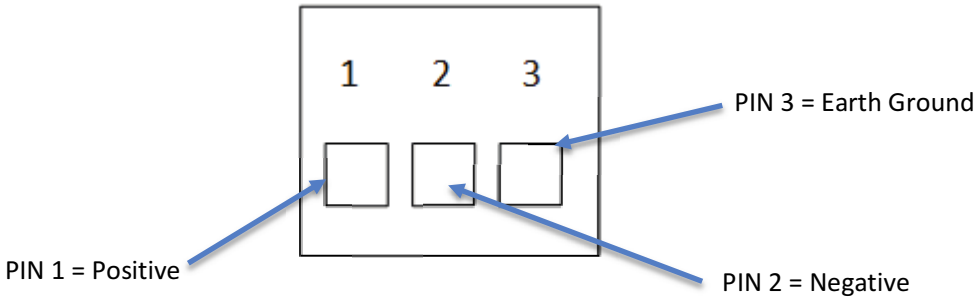



Figure 5 Power Supply Connections


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## 7.3 RELAY OUTPUTS

The ARM XL has 2 sets of relay outputs. These are located on the lower set of terminals on the expansion module on the rear of the ARM XL. Set 1 on terminals Y2, Y3, Y4, Y5 and set 2 on terminals Y6, Y7, Y8, Y9.

Terminals COM1 & COM2 are common inputs for these relays. See Figure 6 Relay Outputs below.

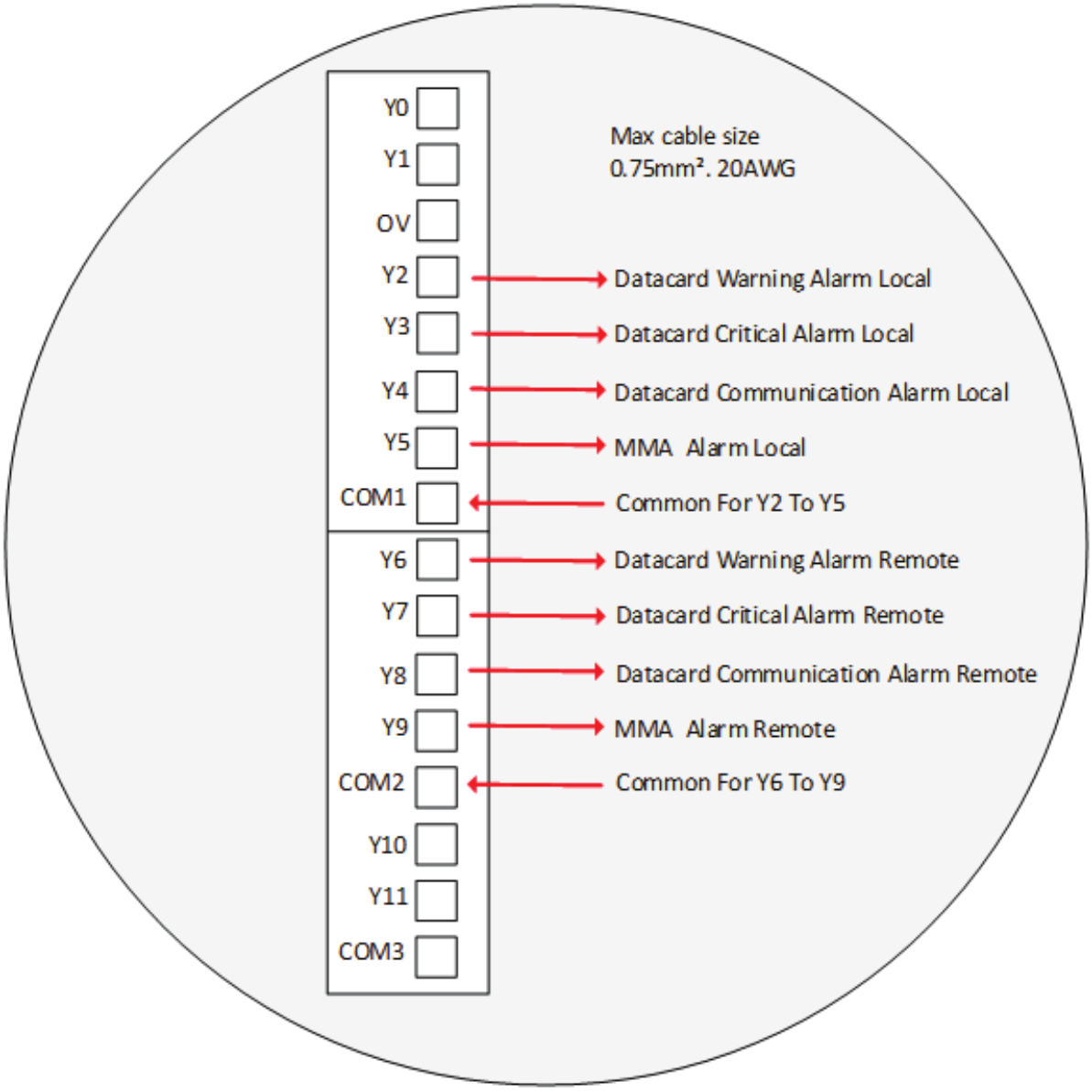



Figure 6 Relay Outputs

These relays are **all** rated to 2Amp at 230v ac.

These 2 sets of relays allow for both local and remote indication of alarms i.e. 1 set for local e.g. klaxon / flashing beacon, and the second for contact inputs to BMS or SCADA systems.


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## 7.4 COMMUNICATION / CONNECTIVITY WITH EXERTHERM DEVICES

The ARM XL allows for the connection of:

- 8ch Datacards - up to a maximum of 10 (80 Exertherm IR or Cable Sensors), and/or
- up to 60 MCC drawer/bucket MMDs via up to 5 MMAs (12 MMDs per MMA).

Both the 8ch Datacard & the MMA connect to the ARM XL via a pre-manufactured cable (part no. 800455) which is supplied as part of the ARM XL.

This cable has a maximum length of 3metres (10 feet) and should not be cut or extended.

This cable has 2 connectors, 1 is an RJ45 for connecting to the port on the 8ch Datacard or MMA labelled 'X0' and the second is a DB9 male for connecting to the ARM XL's port labelled 'COM1' as shown below in Figure 7.

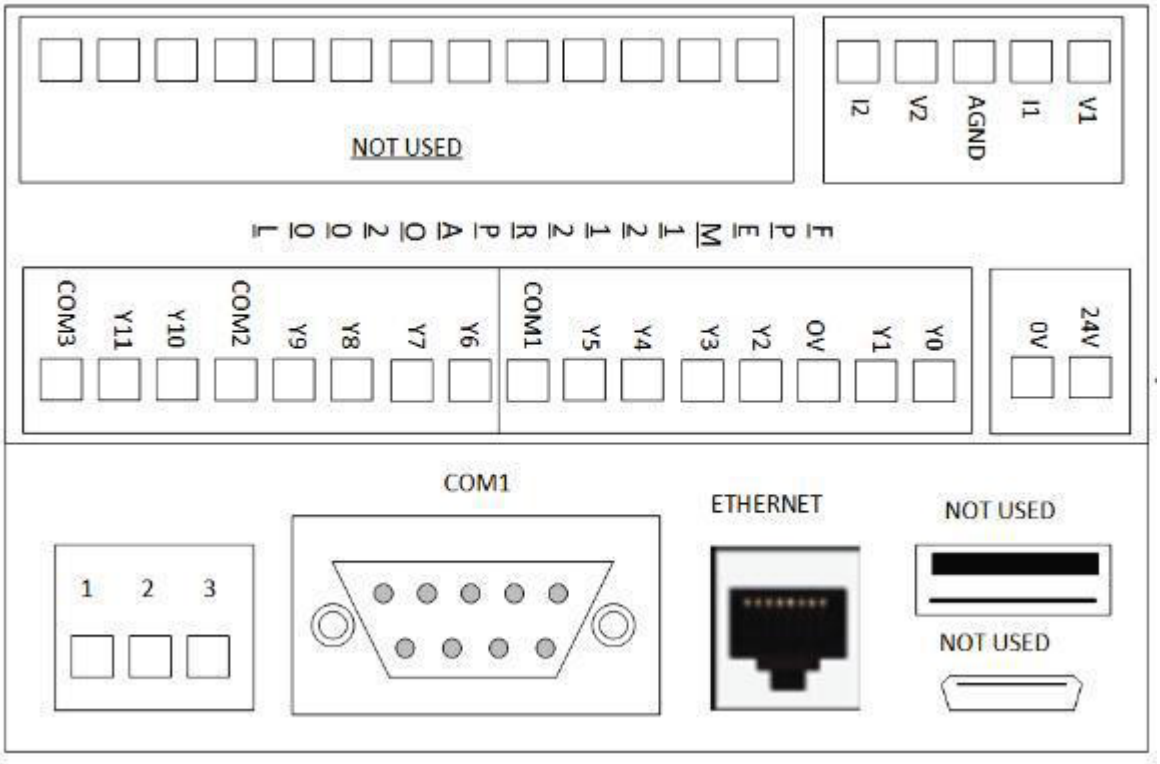



**Figure 7 Communication to Exertherm Devices – RJ45 to COM1**

**All communication is set to operate at 9600 (9k6) baudrate only and cannot be adjusted.**


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### 7.4.1 EXERTHERM DEVICE NUMBERING

8ch Datacards MUST only be numbered from 10 through to 19, MUST be sequential and always start at 10.

MMAs MUST be numbered from 20 through to 24, MUST be sequential and always start at 20.

- There can be a maximum of 12 MMDs connected to any single MMA. The 12 MMDs can only be numbered 1 through to 12 and must be sequential and always start at 1.

**There can be no gaps in the numbering.**

E.g. if we have 4 of the 8ch Datacards in the setup we must use sequential numbering 10, 11, 12, 13

If 8ch Datacard numbers are not sequential, e.g. 10, 11, 13, 14 this will cause communication alarms on 8ch Datacards 13 & 14 (from where the numbering sequence is broken).

E.g. if we have 3 MMAs in the setup we must use sequential numbering 20,21,22

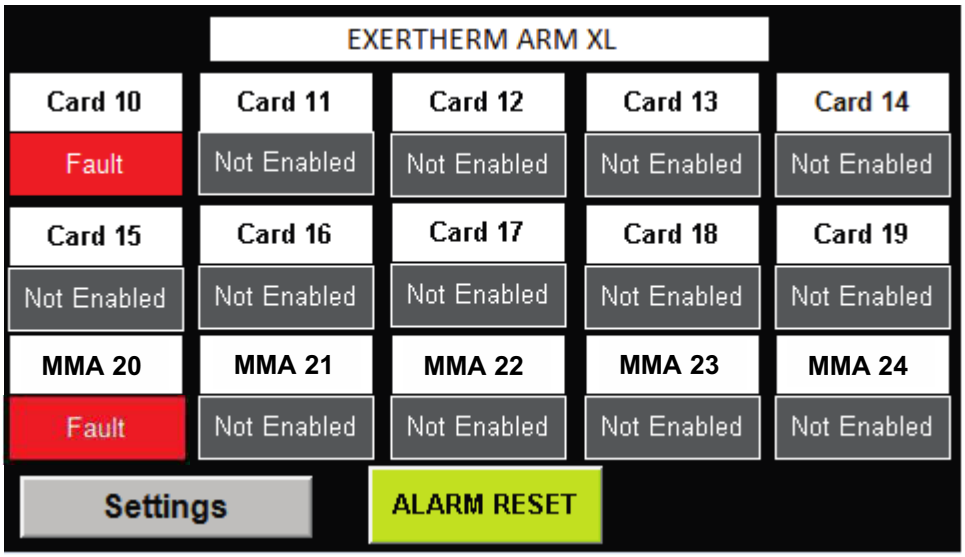
If MMA numbers are not sequential, e.g. 20,21,23 this will cause communication alarms on the MMAs 23,24 (from where the numbering sequence is broken).

### 7.4.2 COMMUNICATION ALARMS

The ARM XL constantly monitors the communication to each 8ch Datacard / MMA and if lost, will recheck this 3 times before reporting a failure.

Once a failure of communication to any of the devices connected is detected, the relevant relays will energise and the Home View screen will identify which devices are in Comms alarm and the yellow 'Alarm Reset' button will appear at the bottom of the screen – e.g. the screen below shows a system with both 8ch Datacards & MMAs in fault, see Figure 8.

This is reporting a communication fault on Card 10 and MMA 20.





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Figure 8 Communication Alarm

**Reason for Comms alarm:**

**Network broken:**

- A broken network will affect the 8ch Datacards / MMAs at the breakpoint and all subsequent enabled devices in the numbered addressing sequence.
    - e.g. if Datacards 10, 11 & 12 and MMA 20 are enabled, and the network was broken at Datacard 11, the system would report a Comms Fault at the network break point Datacard 11.
    - It will then issue a Comms alarm for any enabled 8ch Datacards / MMAs past the break point following on in the numbered addressing sequence e.g. Card 12 & MMA 20 (see Figure 9 below).

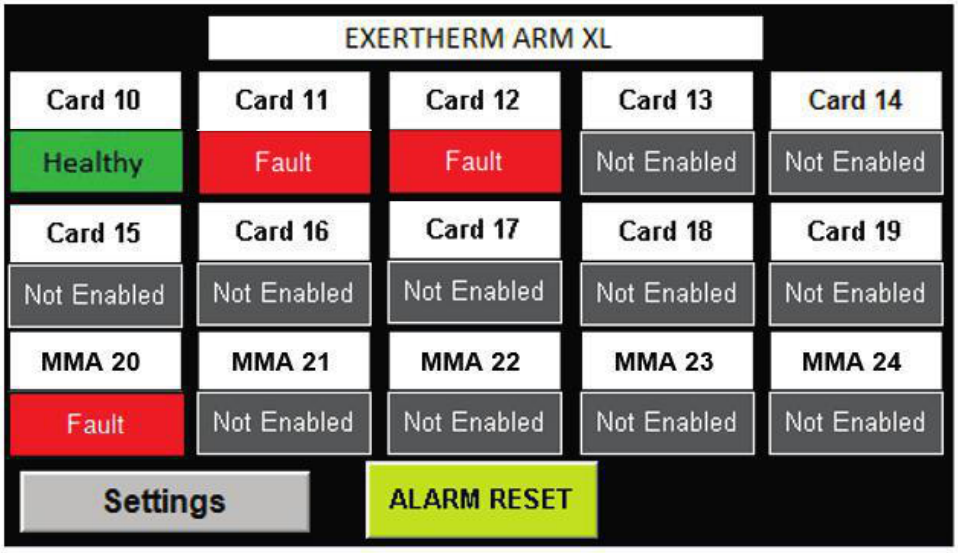



Figure 9 Comms alarm - Network Broken

**Power Failure:**

- Lost power or power failure will only affect the 8ch Datacard / MMA that has power issues.
- Following example in Figure 9, e.g. if Datacard 11 lost power or failed and Datacard 12 was powered and connected, then only Datacard 11 would return a Comms Fault and Datacard 12 & MMA 20 would operate as normal.

Each scan of the program will attempt to regain communication to any failed 8ch Datacards / MMAs until they are either repaired or disabled, at this point the Comms alarm can be reset by pressing the yellow 'Alarm Reset' button, the relays will then de-energise and clear.

**If an 8ch Datacard / MMA is enabled that does not exist, this will generate a Comms alarm.**

**To reset, disable the 8ch Datacard / MMA:**

**- For 8ch Datacard see Section 8.1.1**

**- For MMA see Section 8.1.2**

**- For both 8ch & MMA see Section 8.1.3**


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# 8. CONFIGURATION AND SETUP

The ARM XL is pre-configured with no programming tools or PLC knowledge required. There is a set of basic screen views which are described as follows:

## 8.1 INITIAL SETUP / CONFIGURATION

**On initial setup/configuration you do NOT need to be logged in to select the choice of hardware or to enable/disable devices.**

For first power up, the initial setup/configuration screen will appear.

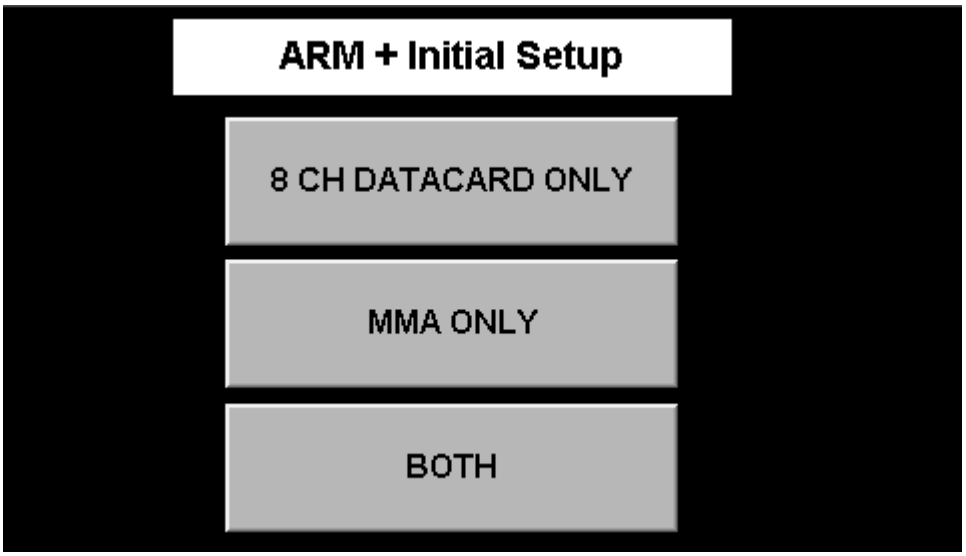



Figure 10 ARM XL Initial Setup/ Configuration

This screen provides the user with the ability to select which hardware they wish the ARM XL to communicate with.

There are 3 options to choose from:

- 8ch Datacard only (this is the correct selection for Exertherm IR & Cable Sensors)
- MMA only (this is the correct selection for MCC drawer/bucket solution - MMDs)
- Both

Pressing the selected hardware button from the 3 options above will take you to the relevant hardware Enabling / Disabling screen. Follow the relevant hardware enabling/disabling device instructions:

- For 8ch Datacard see Section 8.1.1
- For MMA see Section 8.1.2
- For Both see Section 8.1.3

This main configuration screen also has a 'Beep disable/enable' button which mutes the touch screen sound.

**NOTE: As default, sound is disabled.**

**NOTE:**

It is strongly recommended that prior to the ARM XL set up process, the physical location of each 8ch Datacard & Sensor and/or MMA & MMD is recorded as part of the configuration process.

For 8ch Datacard - See Section 9.5

For MMA – See Section 10.4.2

**Only enable 8ch Datacards / MMAs which have already been configured as part of the system commissioning process, and which are connected to the ARM XL.**

**Do not enable 8ch Datacards or MMAs that are not connected, as this will cause false communication alarms.**

### 8.1.1 ENABLING / DISABLING 8CH DATACARDS ONLY

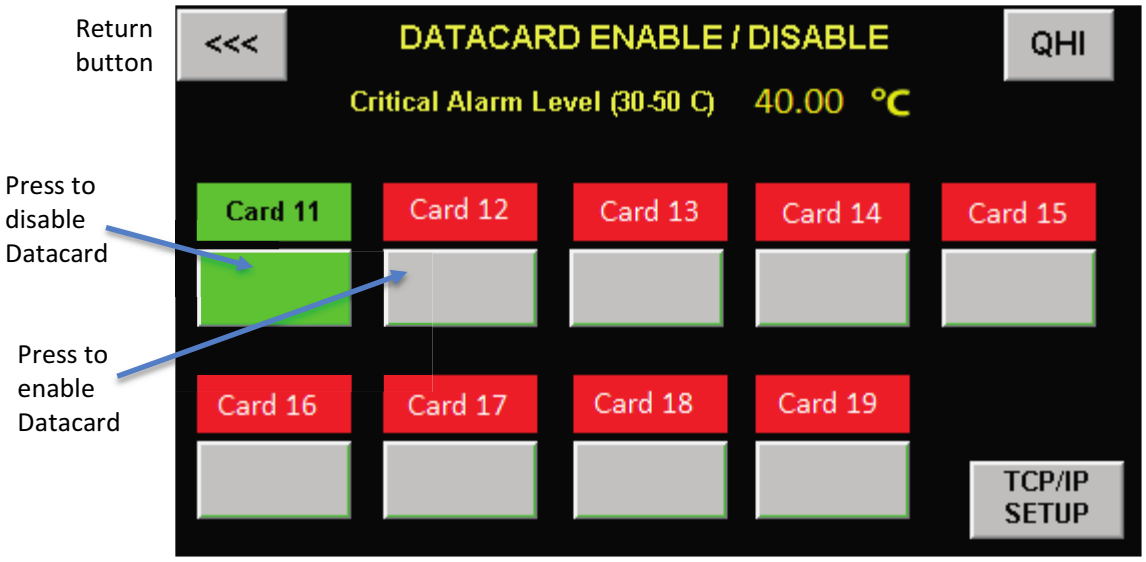



Figure 11 Initial Setup / Config - Enabling/Disabling 8ch Datacards only

On this screen, disabled 8ch Datacards will show with the Card number in a red button, and the button below in grey.

To Enable communication from a 8ch Datacard to the ARM XL, press the grey button under the relevant Card number and both buttons will turn green as shown on Card 11 in Figure 11.

To Disable communication from a 8ch Datacard to the ARM XL, press the green button under the relevant Card number. The Card number button will then turn red, and the button below will be grey.

Once all required 8ch Datacards are enabled continue to the 'Home / 8ch Datacard view' screen by pressing the Return button in the top left corner of the screen.

**IMPORTANT:**

To operate the system, it is essential one 8ch Datacard is enabled.

As 8ch Datacards must be enabled & addressed sequentially, it follows that 'Card 10' must always be enabled.

Therefore, it is not shown on the above screen in Figure 11 so that it cannot be disabled.


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However, 'Card 10' will still show on the 'Home / 8ch Datacard View' screen so that Comms / Temperature alarms remain visible.

### 8.1.2 ENABLING / DISABLING MMA'S ONLY

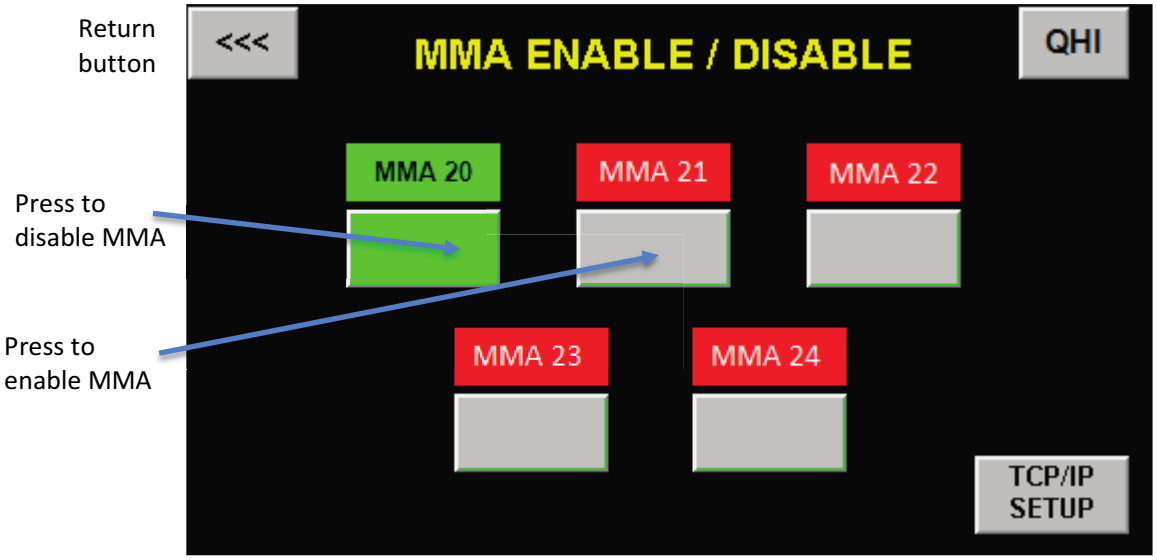



Figure 12 Enabling / Disabling MMA only

On this screen, disabled MMAs will show with the MMA number in a red button, and the button below in grey.

To Enable communication from an MMA to the ARM XL, press the grey button under the relevant MMA number and both buttons will turn green as shown on MMA 20 in Figure 12 above.

To Disable communication from a MMA to the ARM XL, press the green button under the relevant MMA number. The MMA number button will then turn red, and the button below will be grey.

Once all required MMAs are enabled continue to the 'Home / MMA view' screen by pressing the Return button in the top left corner of the screen.

**IMPORTANT:**

All MMAs must be enabled & addressed sequentially, MMAs can only be numbered from 20 through to 24, and always start at 20.

There can be a maximum of 12 MMDs connected to any single MMA. The 12 MMDs can only be numbered 1 through to 12 and must be sequential and always start at 1.


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### 8.1.3 ENABLING / DISABLING BOTH 8CH DATACARDS & MMA'S

On this screen, there is a choice of both 8ch Datacards & MMAs.

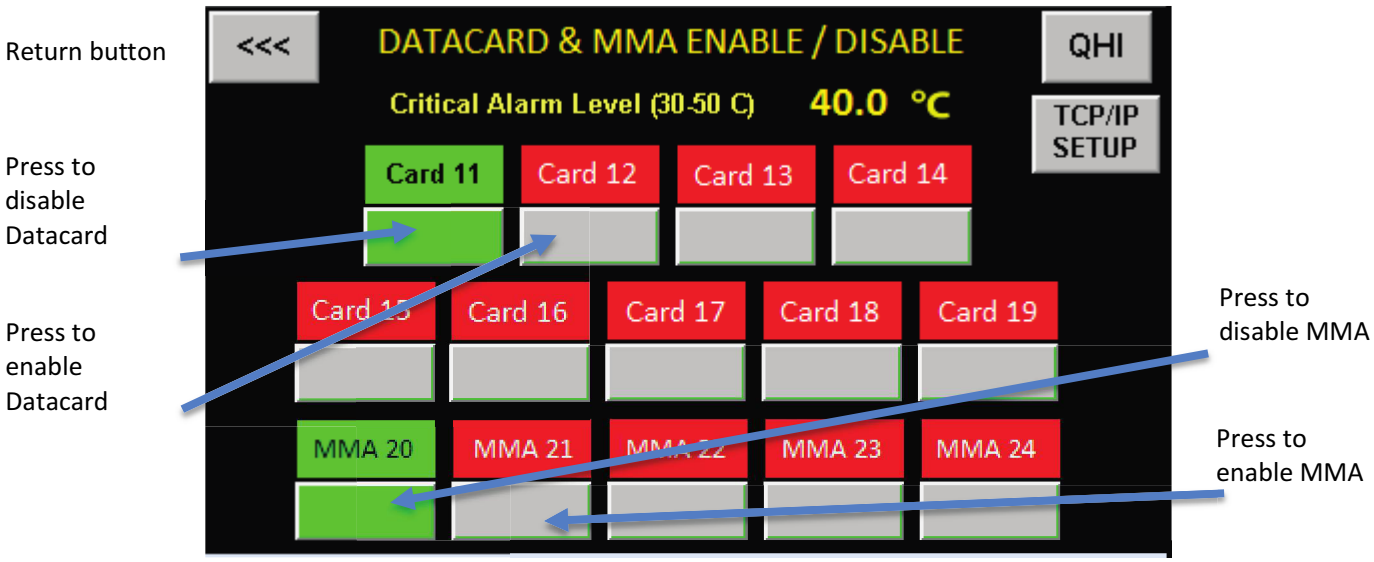



Figure 13 Enabling / Disabling both 8ch Datacards & MMAs

**8ch Datacards**

To Enable communication from a 8ch Datacard to the ARM XL, press the grey button under the relevant Card number and both buttons will turn green as shown on Card 11 in Figure 13.

To Disable communication from a Datacard to the ARM XL, press the green button under the relevant Card number. The Card number button will then turn red, and the button below will be grey.

Once all required 8ch Datacards are enabled continue to the 'Home / 8ch Datacard & MMA view' screen by pressing the Return button in the top left corner of the screen.

**IMPORTANT - DATACARD:**

To operate the system, it is essential one 8ch Datacard is enabled.

As 8ch Datacards must be enabled & addressed sequentially, it follows that 'Card 10' must always be enabled.

Therefore, it is not shown on the above screen in Figure 13 so that it cannot be disabled.

However, 'Card 10' will still show on the 'Home / 8ch Datacard & MMA view' screen so that Comms / Temperature alarms remain visible.

**MMAs**

To Enable communication from an MMA to the ARM XL, press the grey button under the relevant MMA number and both buttons will turn green as shown on MMA 20 in Figure 13.

To Disable communication from a MMA to the ARM XL, press the green button under the relevant MMA number. The MMA number button will then turn red, and the button below will be grey.

Once all required MMAs are enabled continue to the 'Home / 8ch Datacard & MMA view' screen by pressing the Return button in the top left corner of the screen.


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**IMPORTANT - MMA:**

All MMAs must be enabled & addressed sequentially, MMAs can only be numbered from 20 through to 24, and always start at 20.

There can be a maximum of 12 MMDs connected to any single MMA. The 12 MMDs can only be numbered 1 through to 12 and must be sequential and always start at 1.

## 8.2 CHANGING HARDWARE SELECTION

If you wish to change and/or add to the main hardware selection:

- a mistake has been made and you wish to change the hardware selection e.g. 8ch Datacard has been selected, when actually MMA should have been selected.
  **OR**
- you wish to add another hardware option to the existing hardware selected on the system e.g. existing system is 8ch Datacards only, and in addition you wish to add MMAs.

### 8.2.1 CHANGING HARDWARE SELECTION PROCEDURE

To make changes / additions to the hardware selection you must be logged in as a high-level user by following the below steps:

1. From the relevant hardware 'Home' screen, pressing the 'Settings' button in the lower left-hand corner of the screen will take you to the below screen, Figure 14.



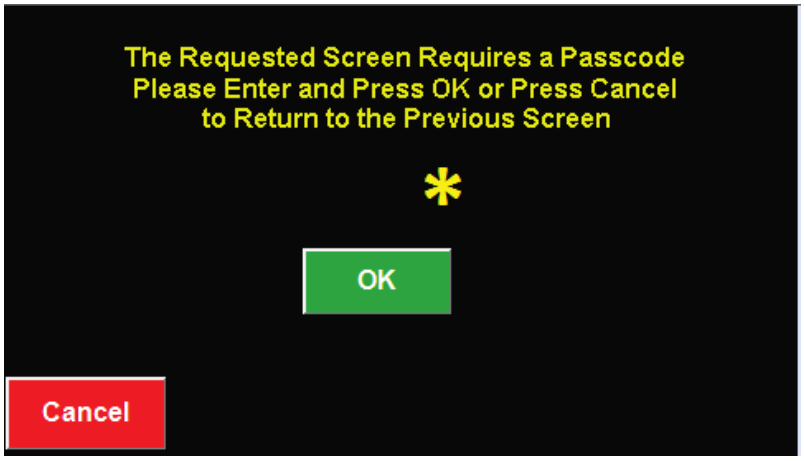
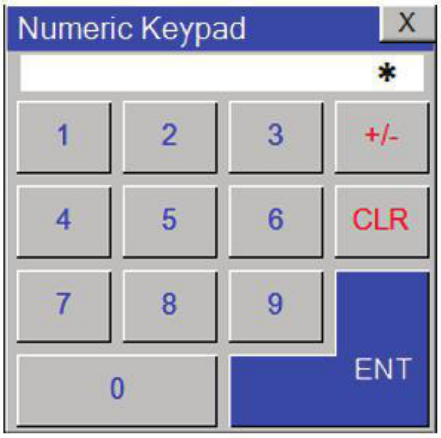




Figure 14 Settings - Initial Password Screen


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2. From the screen shown in Figure 14 above, press the yellow star, a keypad will then appear




3. Using the numeric buttons on the keypad type in the password: 61123.
4. Then press the 'ENT' key – the following screen will appear

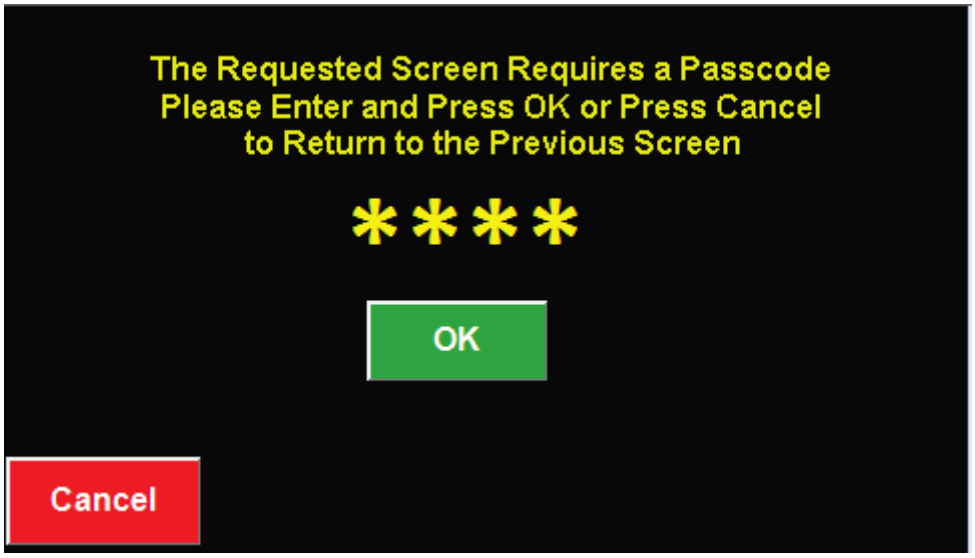



Figure 15 Settings - Password Accepted Screen

5. Then press the green 'OK' button in Figure 15 above
6. You are now logged in as a high-level user. This will then show you the re-configuration version of the 'Enable / Disable' screen for the hardware originally selected
7. Press the 'QHI' button in the top right corner

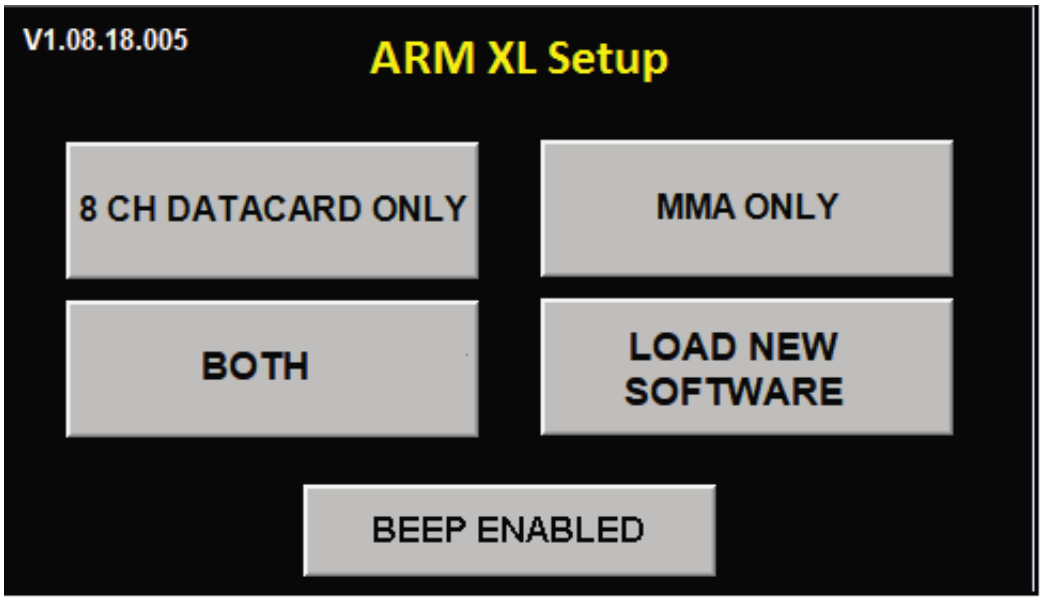




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8. This will then return you to the initial Setup/Configuration screen shown below where you can re-select the choice of hardware from the 3 options.




9. Then follow the relevant hardware enabling/disabling device instructions.
    - For 8ch Datacard see Section 8.1.1
    - For MMA see Section 8.1.2
    - For Both see Section 8.1.3


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## ONCE INITIAL SETUP / CONFIGURATION IS COMPLETE, PLEASE NOW CONTINUE TO THE RELEVANT SECTION TO FOLLOW VIEWING & USING INSTRUCTIONS FOR YOUR SELECTED HARDWARE

**USER GUIDE FOR 8CH DATACARD ONLY – PLEASE GO TO SECTION 9**

**USER GUIDE FOR MMA ONLY – PLEASE GO TO SECTION 10**

**USER GUIDE FOR BOTH 8CH DATACARD & MMA – PLEASE GO TO SECTION 11**


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# 9. USER GUIDE– ARM XL & 8CH DATACARD ONLY

## 9.1 HOME / 8CH DATACARD VIEW SCREEN

Once the system has been configured & required 8ch Datacards enabled, Figure 16 below will be the main user viewing screen. This screen will then appear whenever the ARM XL is powered up.

The Home/ 8ch Datacard view screen shows the status of each 8ch Datacard, including alarms for temperature or communication for each 8ch Datacard enabled on the system.

8ch Datacards not enabled, will show as below e.g. Card 12.

8ch Datacards with no alarms will be displayed as 'Healthy' with a green button as shown below e.g. Card 10 & Card 11.

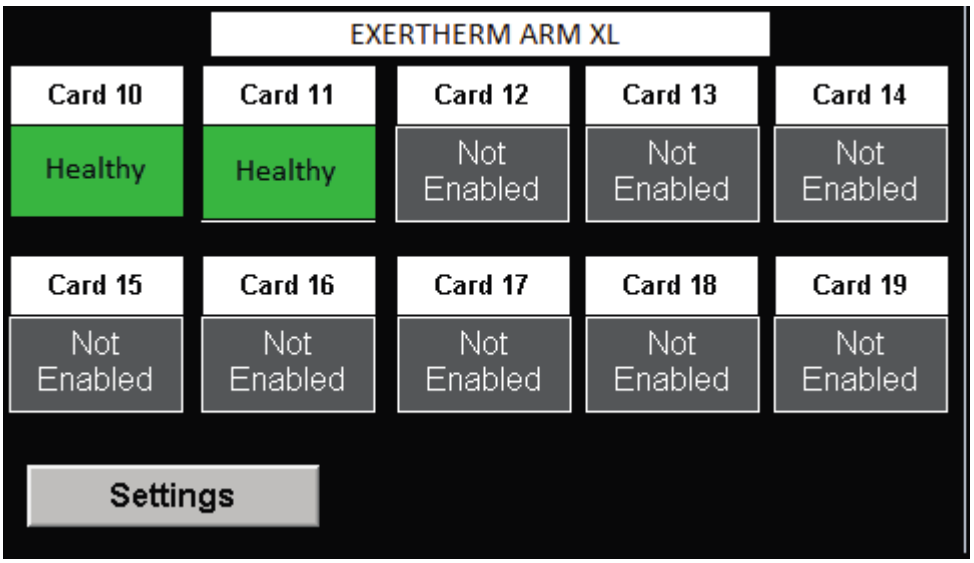



Figure 16 Home / 8ch Datacard View Screen

The 'Alarm Reset' button re-sets the alarm contacts when an alarm condition has been resolved.

**The 'Alarm Reset' button only appears when there is an active alarm condition. This button will be displayed centrally at the bottom of the screen.**

The 'Settings' button takes you to 8ch Datacard Enable / Disable screen (for more detail please see Section 8.1.1).

The 'Home / 8ch Datacard View' screen also provides access to each enabled 8ch Datacard with real-time sensor values and warning alarms.

From the Home / 8ch Datacard view screen, press the button for the 8ch Datacard you wish to view e.g. Card 10.
The screen as shown in Figure 17 will appear.

### 9.1.1 SENSOR VIEW & WARNING ALARMS

Sensor view: Down the left side are the sensor channels, which are numbered 1 through 8. The next column indicates the real-time ΔT temperature values for each Sensor in °C.

Sensor names e.g. Sensor 1, can be edited:

- This is done by pressing on the Sensor name e.g. Sensor 1
- A keypad will then appear (see Figure 18 below)
- Enter the unique Sensor name
    - Sensor names can include letters, numbers and symbols but can only be a maximum of 8 characters long e.g. CB2/A/L1
- Once you have keyed in the new name, press 'ENT' to confirm name

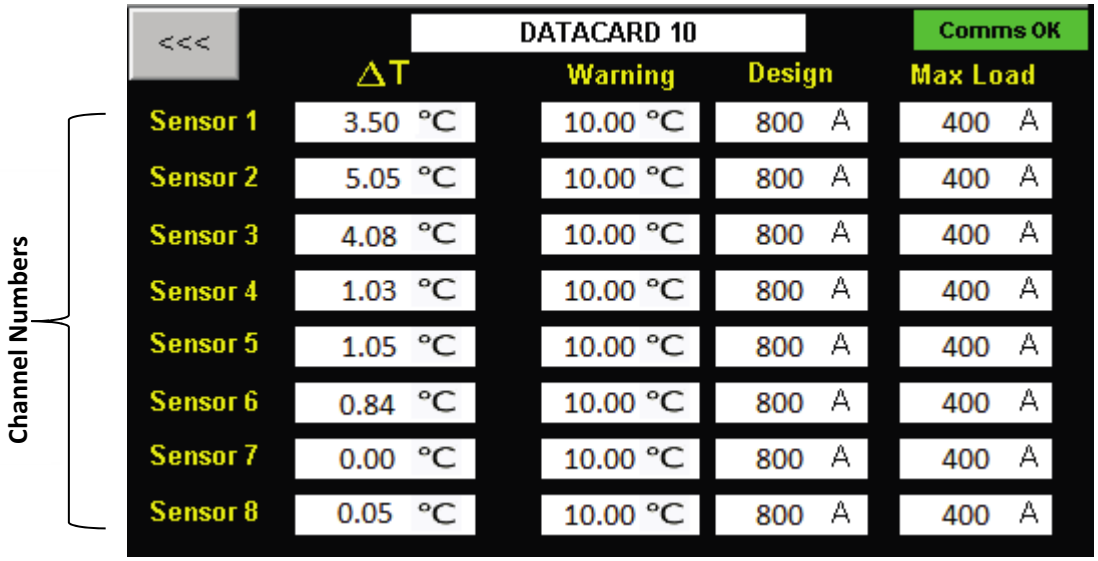



Figure 17 Sensor View & Warning Alarms




Figure 18 8ch Datacard - Sensor name change keypad


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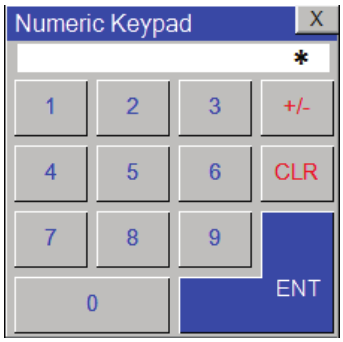
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To change the Design and Maximum load values, you must be logged in as detailed in Section 9.2.

Once logged in, return to the Datacard Home screen, and then select the Datacard which values are to be altered.

Design and Max load values can be edited by:

- Pressing on the white box for the relevant Sensor number for either Design or Max Load
- A keypad will then appear




- Enter the required value
- Once you have keyed in the new value, press 'ENT' to confirm

The column 'Warning' is the load related calculated ΔT alarm threshold from the LoadMap® algorithms. This field is not user adjustable but utilises the Design A & Max Load data to calculate this value.

- Design A – is the design load (Amps) of the circuit on which the joint being monitored resides and should be entered by clicking on the relevant box and entering the appropriate value in Amps.
- Max Load – is the maximum load at which the circuit being monitored is expected to operate at, and should be entered by clicking on the relevant box and entering the appropriate value in Amps.

**The Design A & Max Load values must be entered for each Sensor**

**NOTE: If Load data for any sensor is unknown then a generic alarm threshold of ΔT 22°C can be set by entering in the Design A column a value of 800A and in the Max Load column a value of 600A.**

Press the 'Return' button in the top left corner of the screen to go back to the Home / 8ch Datacard View screen.


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### 9.1.2 VIEWING WARNING ALARMS

If a Sensor value exceeds the warning alarm threshold the Home / 8ch Datacard View screen view will change as in Figure 19 below.

The status indicator below the Card number will change to show 'Fault' on a Red background.

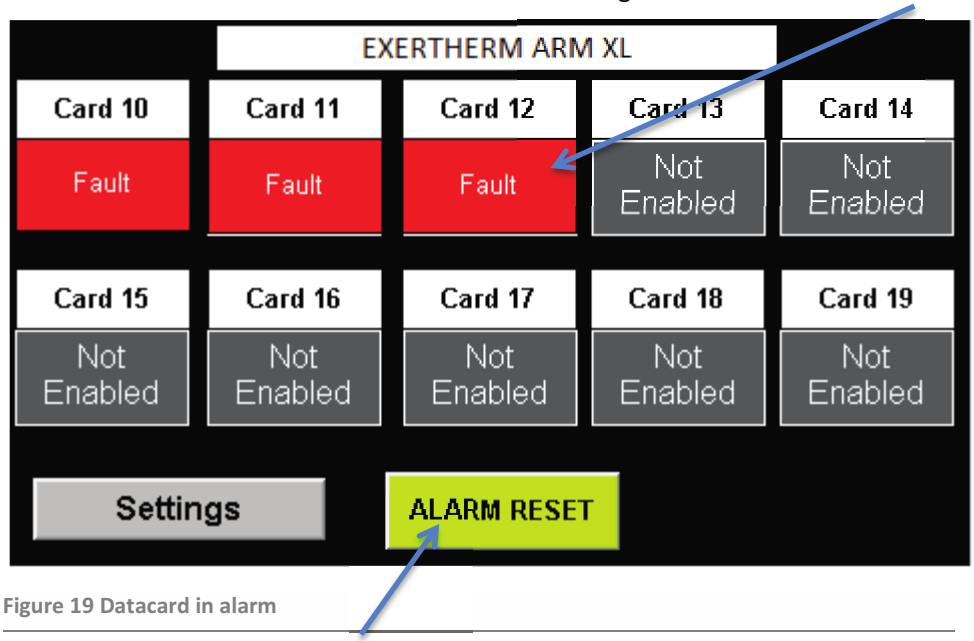



Figure 19 Datacard in alarm

At the same time the 'Alarm Reset' button will appear at the bottom of the screen in Yellow with the word 'Alarm Reset' and the relevant relays will activate.

All alarms are set with a 1 minute time delay to stop the system from 'chattering' and causing false alarms. A Sensor must be in an alarm state for over 1 minute for the relays to operate.

To view the Sensor in alarm – press the red 'Fault' button below the Card number button which is in alarm.
The Sensor View screen will appear as below in Figure 20. A yellow warning indicator box will be shown next to the Sensor in alarm.

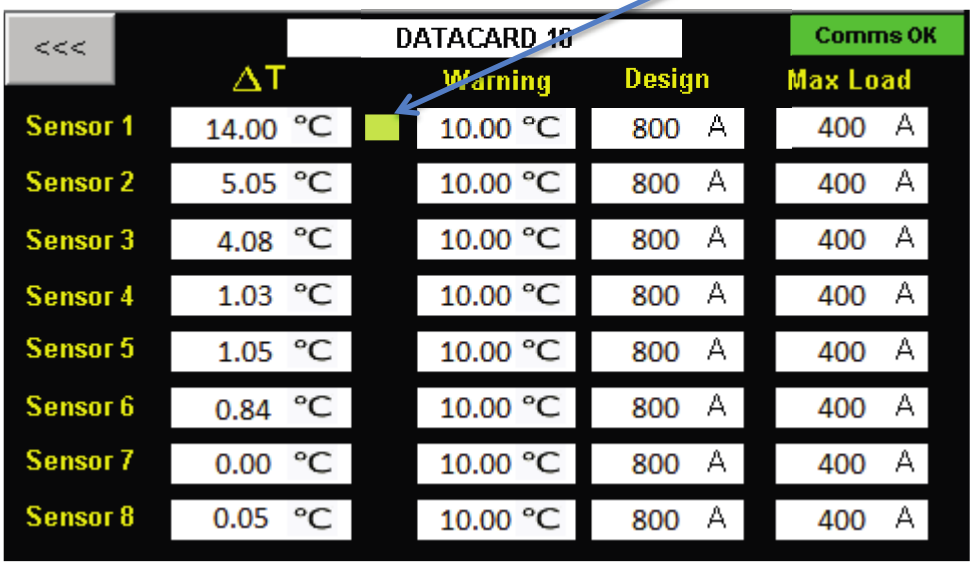



Figure 20 Sensor view - Sensor showing warning alarm


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When the alarm clears and the 8ch Datacard status returns to green & 'Healthy' both the output relays will remain energised until they are reset by pressing the yellow 'Alarm Reset' button on the Home / 8ch Datacard View screen as shown below in Figure 21.

This will reset the relays and the 'Alarm Reset' button will disappear.

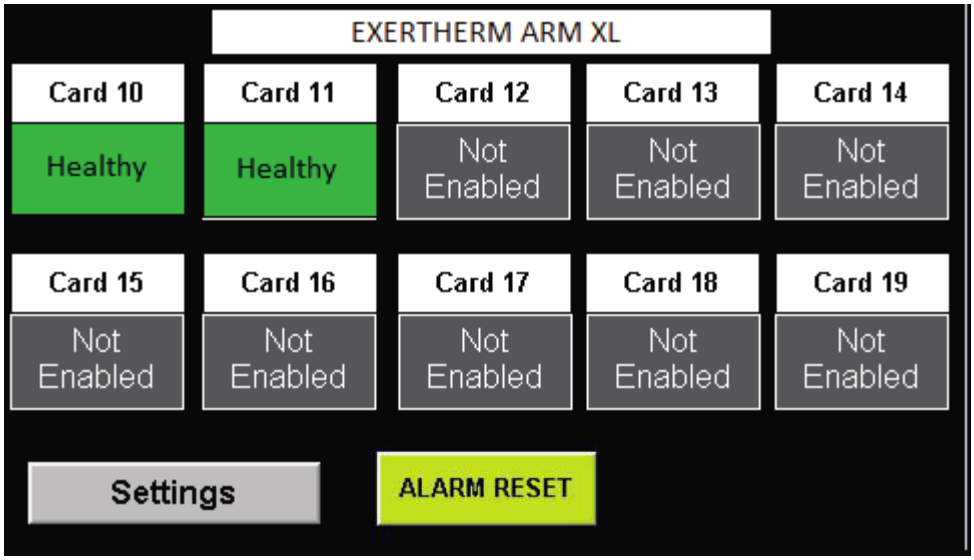



Figure 21 Warning Alarm Reset


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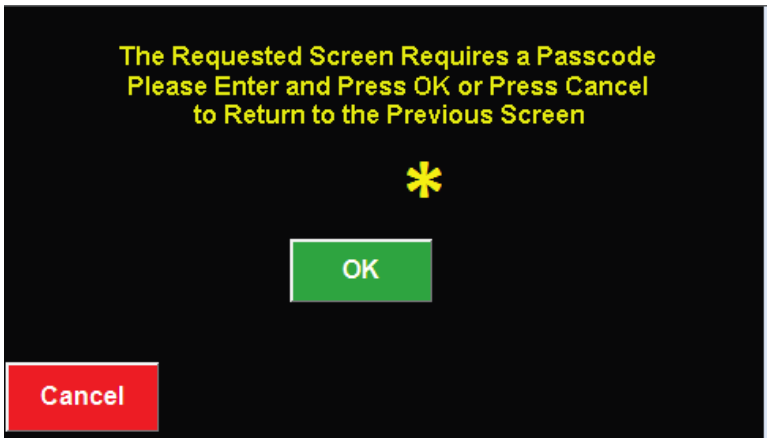
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## 9.2 SYSTEM SETTINGS

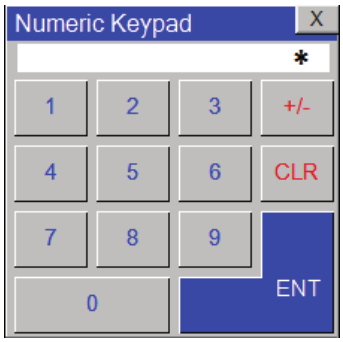
**To access system settings you will need to login.**
**This will allow you to access the following functions:**

- **Enable / Disable 8ch Datacards**
- **Set critical alarm level**
- **Set TCP/IP settings**

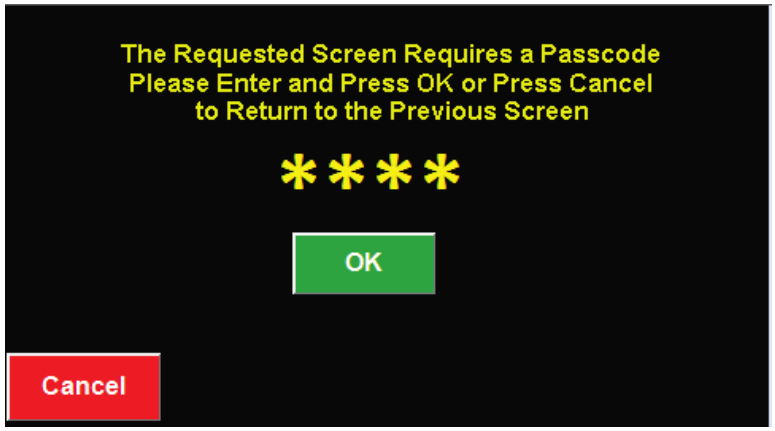
1. From the 'Home / 8ch Datacard view' screen, pressing the 'Settings' button in the lower left-hand corner will take you to the below screen.




2. From the screen shown above press the yellow star, a keypad will then appear




3. Using the numeric buttons on the keypad type in the password: 1582.
4. Then press the 'ENT' key – the following screen will appear




5. Then press the green 'OK' button


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6. You are now logged in as a standard user. This will then show you the Settings version of the '8ch Datacard Enable / Disable' screen as shown in Figure 22 in Section 9.2.1.

### 9.2.1 ENABLE / DISABLE 8CH DATACARDS

**First login as detailed in Section 9.2.**

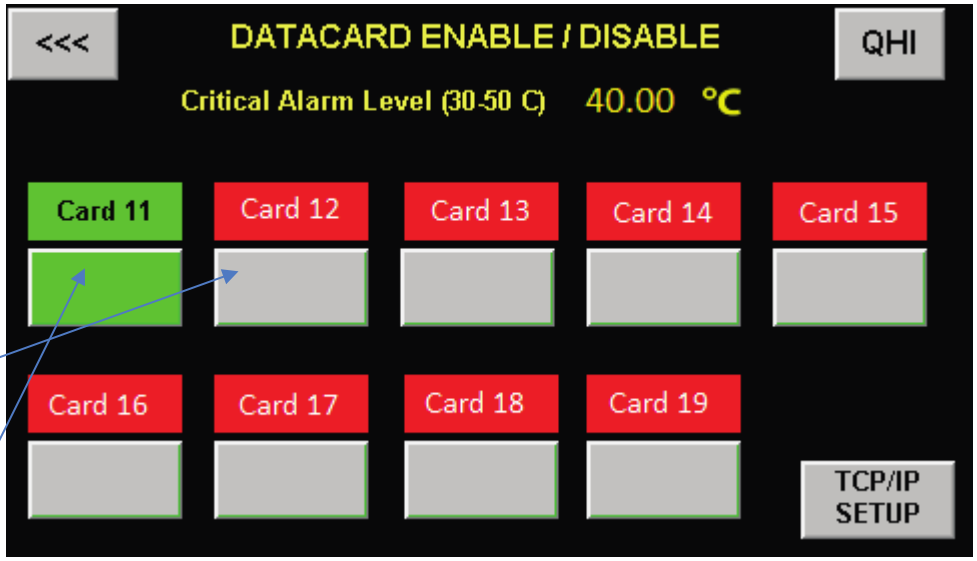



Figure 22 System Settings - Enabling/Disabling 8ch Datacards only

On this screen, disabled 8ch Datacards will show with the Card number in a red button, and the button below in grey.

To Enable communication from a 8ch Datacard to the ARM XL, press the grey button under the relevant Card number and both buttons will turn green as shown on Card 11 in Figure 22.

To Disable communication from a 8ch Datacard to the ARM XL, press the green button under the relevant Card number. The Card number button will then turn red, and the button below will be grey.

Once all required 8ch Datacards are enabled continue to the 'Home / 8ch Datacard view' screen by pressing the Return button in the top left corner of the screen.

**IMPORTANT:**

To operate the system, it is essential one 8ch Datacard is enabled.

As 8ch Datacards must be enabled & addressed sequentially, it follows that 'Card 10' must always be enabled.

Therefore, it is not shown on the above screen in Figure 22 so that it cannot be disabled.

However, 'Card 10' will still show on the 'Home / 8ch Datacard View' screen so that Comms / Temperature alarms remain visible.


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### 9.2.2 SET CRITICAL ALARM LEVEL

**First login as detailed in Section 9.2.**

The Critical alarm has a default threshold of Delta T (ΔT) 40°C which applies to **ALL** sensors.

It is user-configurable between ΔT 30-50°C.

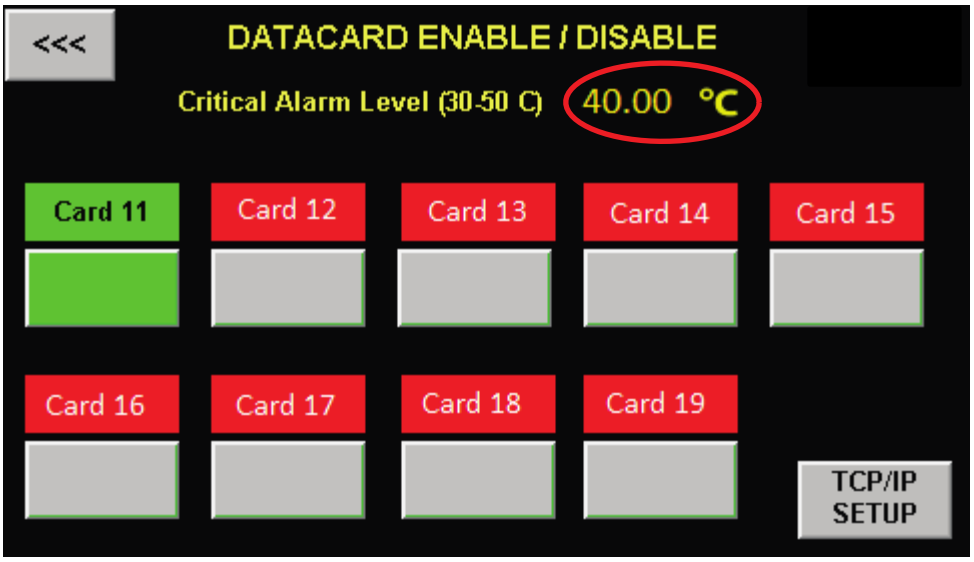
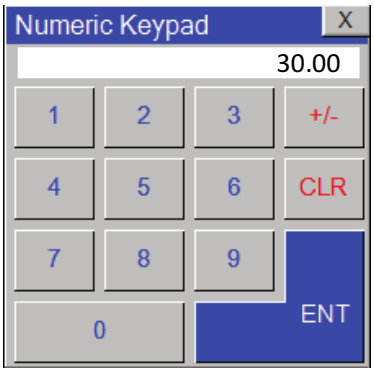



Figure 23 Setting Critical Alarm Level

**IMPORTANT: ALL temperature values are Delta T (ΔT) °C e.g. rise of target temperature above the local ambient**

To edit the critical alarm level, press the alarm threshold value as circled above. The keypad as shown below will then appear:




- Insert the new critical alarm threshold value required e.g. 30.00
- and press the 'ENT' button
- you will then be returned to the '8ch Datacard Enable / Disable' screen
- the new critical alarm threshold will now be applied to all Sensors connected to the ARM XL





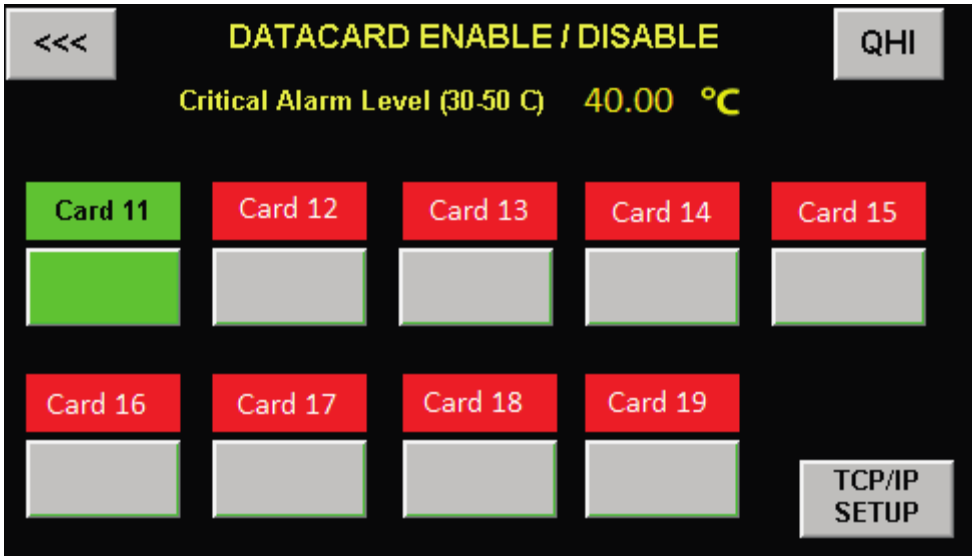
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### 9.2.3 8CH DATACARD - SET TCP / IP SETTINGS

**First login as detailed in Section 9.2.**

1. From the '8ch Datacard Enable / Disable' screen press the 'TCP/IP Setup' button




2. The following address screen will appear (see Figure 24 below), the IP address is split into 4 separate segments.

By touching the relevant segment of the IP address, the keypad will pop up and you can then enter the relevant portion of the IP address individually

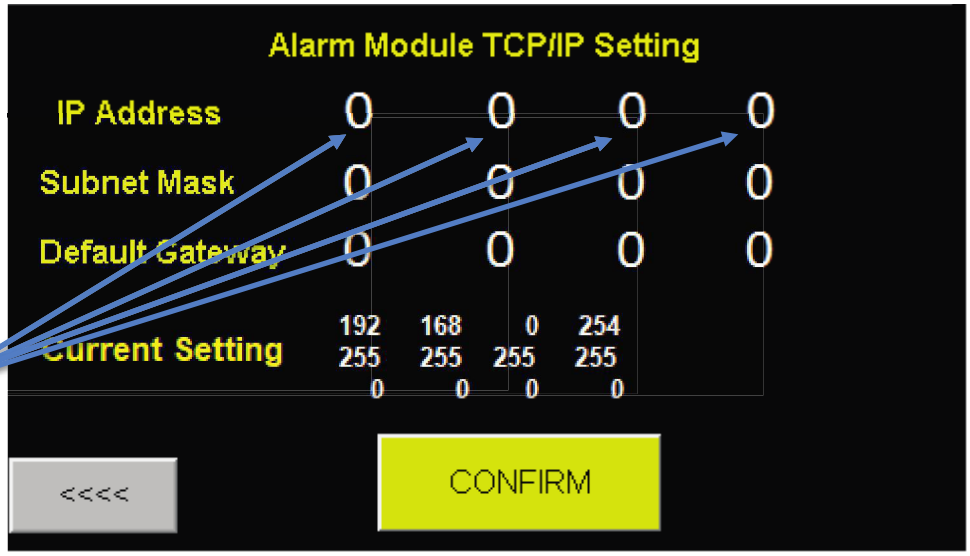


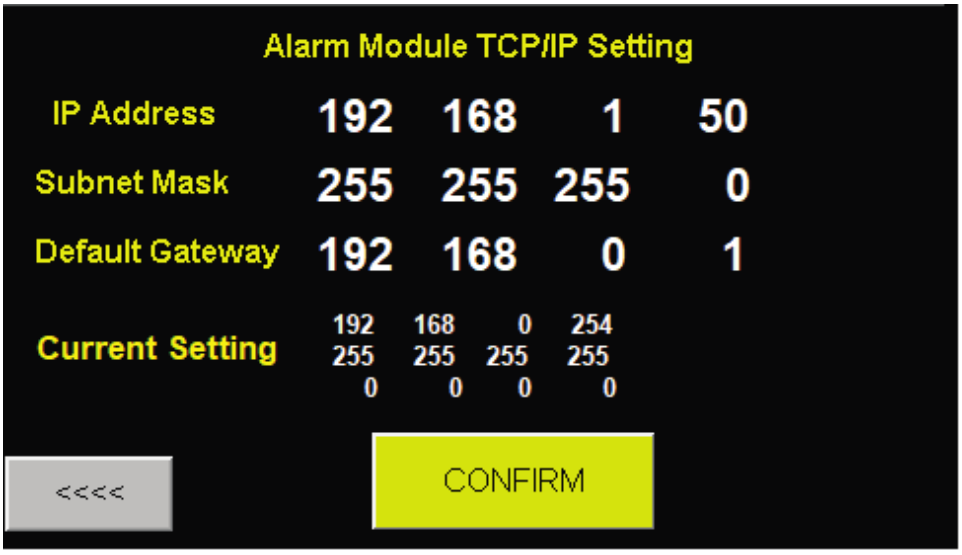

Figure 24 ARM XL TCP/IP Setting

3. Enter the Modbus TCP/IP address by first touching the relevant segment and then enter the relevant portion of the IP address. Existing settings are shown under heading 'Current Setting' as above.


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4. As in the IP address below, an example address has been entered – 192.168.1.50
5. Repeat the same process for the Subnet Mask and IP Gateway.
6. The screen will then show as below (example addresses have also been entered for Subnet Mask & Default Gateway)




7. Once this information has been entered press the yellow 'CONFIRM' button that will then enter the information into system.
8. Then press the 'return' button in the bottom left hand corner to take you back to the '8ch Datacard Enable / Disable' screen.


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## 9.3 OBTAINING RAW DATA FROM THE ARM XL

Raw data in Modbus TCP/IP protocol can be obtained from the ARM XL via the following actions:

1. Ensure TCP/IP settings have been entered as per instruction in 9.2.3
2. Then connect an Ethernet cable into the Port circled in red below on the rear of the ARM XL, as shown in Figure 25 .
3. Then connect the other end of the cable to a suitable host system connection point.

**The Modbus TCP uses standard Port 502 for communication and the ARM XL is set as device 1**

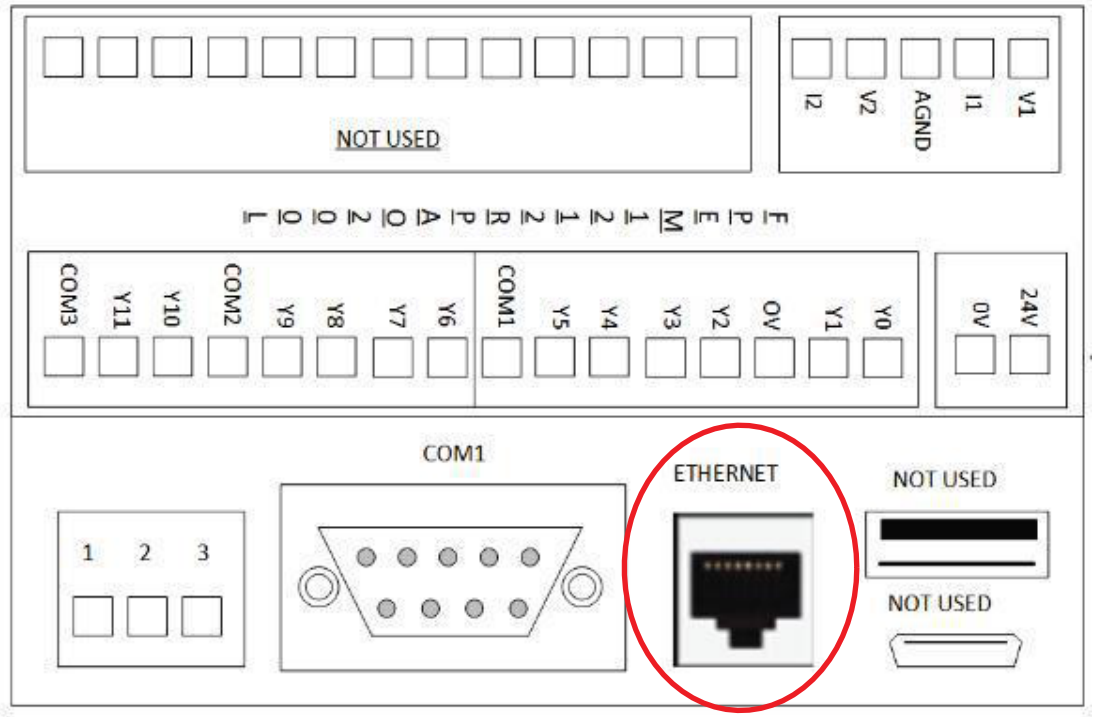



Figure 25 ARM XL Ethernet Port

To read the Sensor registers please refer to Table 1 in Section 9.4 which shows the Modbus holding registers. The registers require a 0.1 multiplier to read the correct value, e.g. if the register reads a raw data value of 150, then use 150 * 0.1 to read the correct register value of 15°C ΔT.

## 9.4 INTERNAL MODBUS TCP REGISTERS FOR 8CH DATACARD

| Sensor No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Card No. | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| TCP Register | 40109 | 40110 | 40111 | 40112 | 40113 | 40114 | 40115 | 40116 |
| | | | | | | | | |
| Card No. | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| TCP Register | 40117 | 40118 | 40119 | 40120 | 40121 | 40122 | 40123 | 40124 |
| | | | | | | | | |
| Card No. | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| TCP Register | 40125 | 40126 | 40127 | 40128 | 40129 | 40130 | 40131 | 40132 |
| | | | | | | | | |
| Card No. | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| TCP Register | 40133 | 40134 | 40135 | 40136 | 40137 | 40138 | 40139 | 40140 |
| | | | | | | | | |
| Card No. | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
| TCP Register | 40141 | 40142 | 40143 | 40144 | 40145 | 40146 | 40147 | 40148 |
| | | | | | | | | |
| Card No. | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| TCP Register | 40149 | 40150 | 40151 | 40152 | 40153 | 40154 | 40155 | 40156 |
| | | | | | | | | |
| Card No. | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| TCP Register | 40157 | 40158 | 40159 | 40160 | 40161 | 40162 | 40163 | 40164 |
| | | | | | | | | |
| Card No. | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 |
| TCP Register | 40165 | 40166 | 40167 | 40168 | 40169 | 40170 | 40171 | 40172 |
| | | | | | | | | |
| Card No. | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| TCP Register | 40173 | 40174 | 40175 | 40176 | 40177 | 40178 | 40179 | 40180 |
| | | | | | | | | |
| Card No. | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 |
| TCP Register | 40181 | 40182 | 40183 | 40184 | 40185 | 40186 | 40187 | 40188 |

Table 1 Internal Modbus TCP Registers for 8ch Datacard

## 9.5 8CH DATACARD IO LIST

| | | | |
|---|---|---|---|
| Project Name: | | | |
| Customer: | | | |
| Section Ref: | | | |
| Modbus Address: | | Serial No.: | |

| DATACARD CHANNELS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **CHANNEL 1** | **CHANNEL 2** | **CHANNEL 3** | **CHANNEL 4** | **CHANNEL 5** | **CHANNEL 6** | **CHANNEL 7** | **CHANNEL 8** |
| Section Reference | | | | | | | | |
| Phase Reference | | | | | | | | |
| **Sensor Type** | | | | | | | | |
| No Sensor | | | | | | | | |
| IR.EM-06.SC – Delta T | | | | | | | | |
| IR-01 Absolute | | | | | | | | |
| Cable EM – Delta T | | | | | | | | |
| Cable – Absolute | | | | | | | | |
| **IR.EM-06.SC Only** | | | | | | | | |
| Busbar Size | | | | | | | | |
| Mounting Distance | | | | | | | | |
| Gain Factor Used | | | | | | | | |
| | | | | | | | | |
| **Factory Acceptance Test** | | | | | | | | |
| Initial Value | | | | | | | | |
| Heat Tested Reading | | | | | | | | |

| **Datacard FAT: Accepted / Signed** | | | |
|---|---|---|---|
| Installer: | | Client Rep. | |
| Date: | | Date: | |
| Sign: | | Sign: | |


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# 10. USER GUIDE – ARM XL & MMA ONLY

## 10.1 HOME / MMA VIEW SCREEN

Once the system has been configured & required MMA's enabled, Figure 26 below will be the main user viewing screen. This screen will then appear whenever the ARM XL is powered up.

The Home/MMA view screen shows the status of each MMA, including alarms for temperature or communication for each MMA enabled on the system.

MMAs not enabled, will show as below e.g. MMA 21.

MMAs with no alarms will be displayed as 'Healthy' with a green button as shown below e.g. MMA 20.

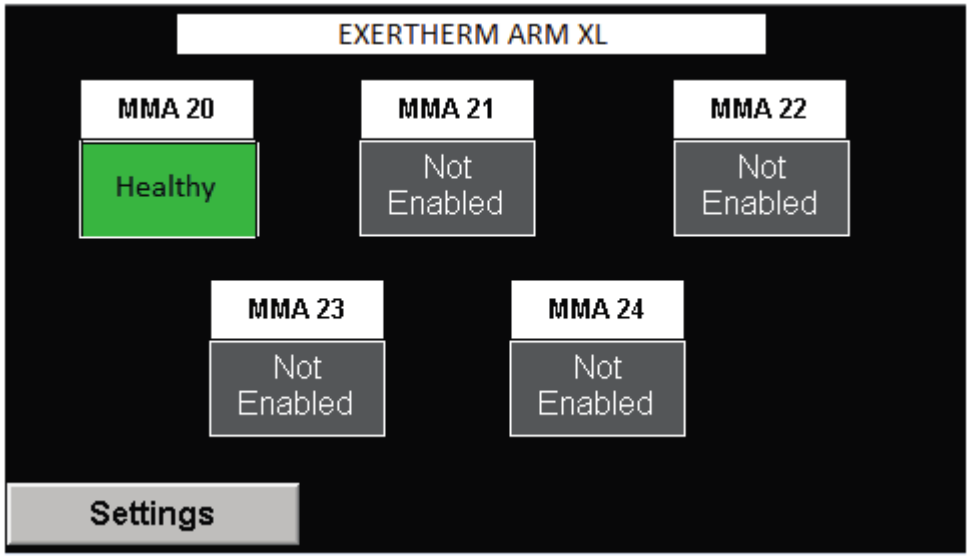



Figure 26 Home / MMA View Screen

The 'Settings' button takes you to MMA Enable / Disable screen. For more detail please see Section 8.1.2.

The Home / MMA view screen also provides access to the status of each MMD on the system, this screen is accessed by pressing on the button below the card number for the relevant enabled MMA.

### 10.1.1 MMD STATUS SCREEN

Once you have pressed the button of the MMA you wish to view, the following screen will appear – see below Figure 27.

Only MMDs installed on the system will show with a green 'healthy' button as shown in MMDs 1-4 below.

Any MMDs in alarm will show with a red 'Fault' button, as show in MMD 3 below.

From the MMD View Screen press the 'Healthy' button for the MMD you wish to view e.g. MMD 1 which will take you to Figure 28 on the next page.

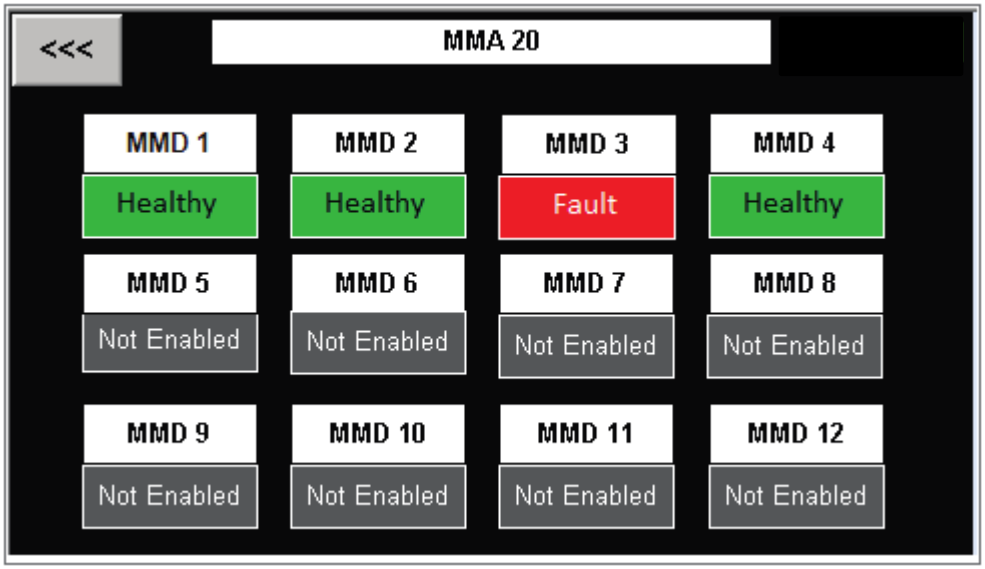



Figure 27 MMD View Screen

Pressing the 'Fault' button of the MMD in alarm will take you to Figure 29 (Section 10.1.2), which will signify which sensor is in alarm and in addition, identify the type of alarm.


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### 10.1.2 MMD SENSOR VIEW & ALARMS

Once you have pressed for the button of the MMD you wish to view as in Figure 27, the following screen will appear – see below Figure 28.

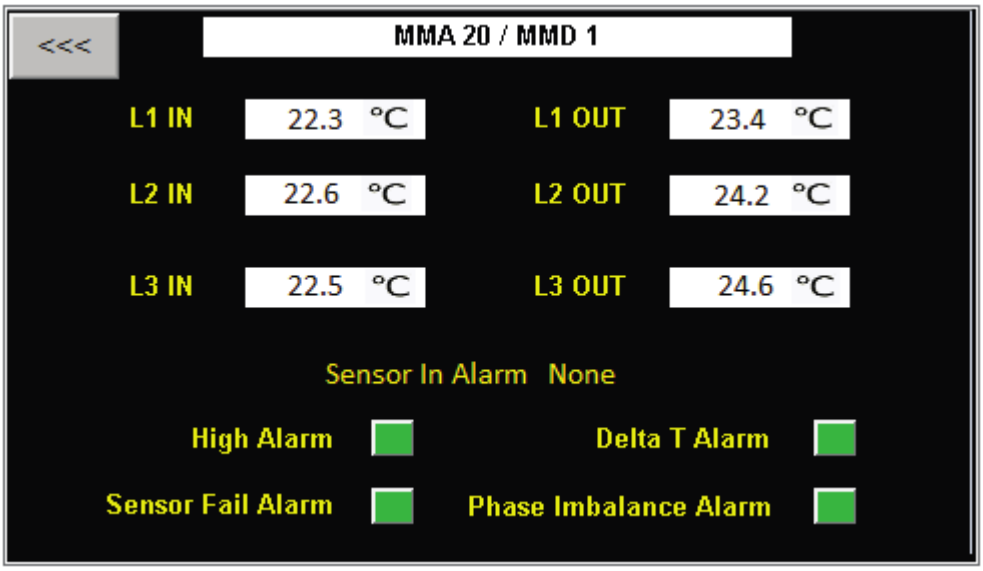



Figure 28 MMD Sensor View & Alarms - Healthy

Sensors are labelled:

- L1 IN, L2 IN, L3 IN
- L1 OUT, L2 OUT, L3 OUT

The white boxes next to the sensor labels indicate the real-time temperature values for each sensor in °C.

**NOTE: These values are absolute temperature values**

At the bottom of the screen, it shows the four alarm types:

- High Alarm
- Sensor Fail Alarm
- Delta T Alarm
- Phase imbalance Alarm

The small box next to each alarm type signifies the status e.g.

- green = no alarm
- red = active alarm


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This screen also indicates which sensor is in alarm, the name of the sensor will appear as circled in yellow in Figure 29.
The type of alarm will be specified by the small box next to it turning red to indicate the active alarm e.g. as shown in Figure 29.

**NOTE: The location of which sensor is in alarm only shows for High alarm and Delta T Alarm.**

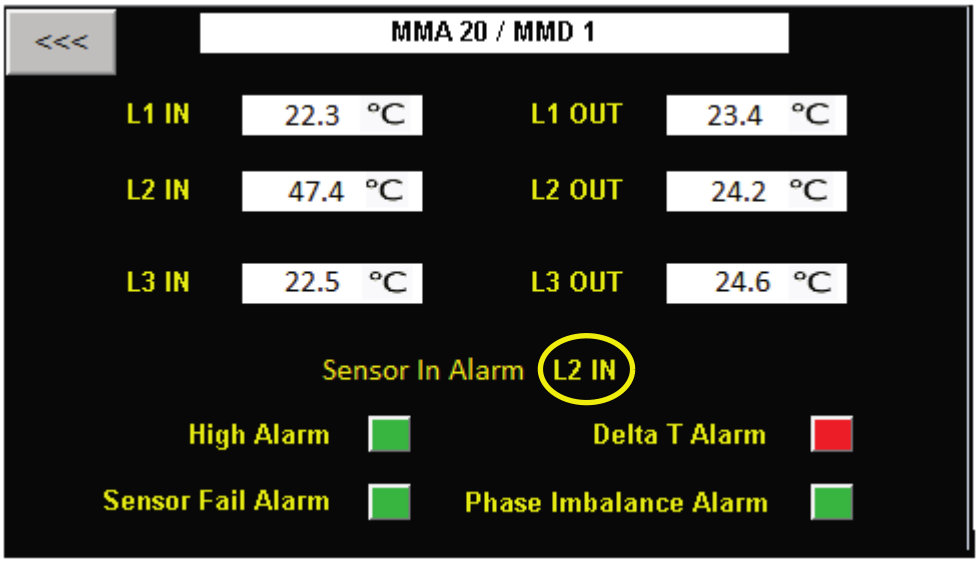



Figure 29 MMD Sensor View & Alarms - Active Alarm

**Alarms will only clear when they are re-set on the MMD itself.**

**NOTE: No re-set for any MMD alarms can be carried out on the ARM XL.**

**For instructions on how to re-set on the MMD, please see Section 9.4 of the MMS & MMA Installation Setup Manual.**

Press the 'Return' button in the top left corner of the screen to go back to the MMD status view (Figure 27 – Section 10.1.1).


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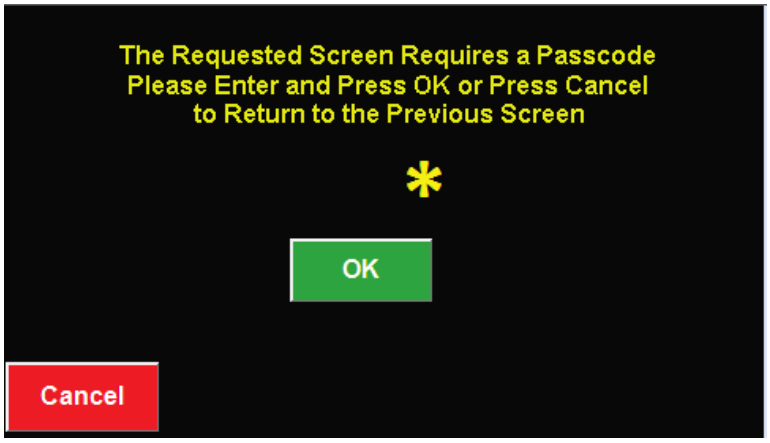
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## 10.2 SYSTEM SETTINGS

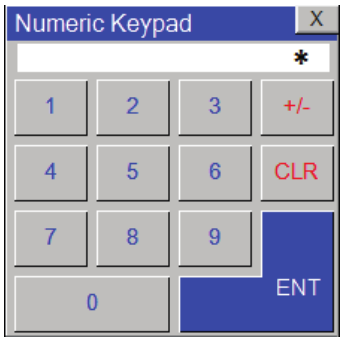
**To access system settings you will need to login.**
**This will allow you to access the following functions:**

- **Disable / Enable MMAs**
- **Set TCP/IP settings**

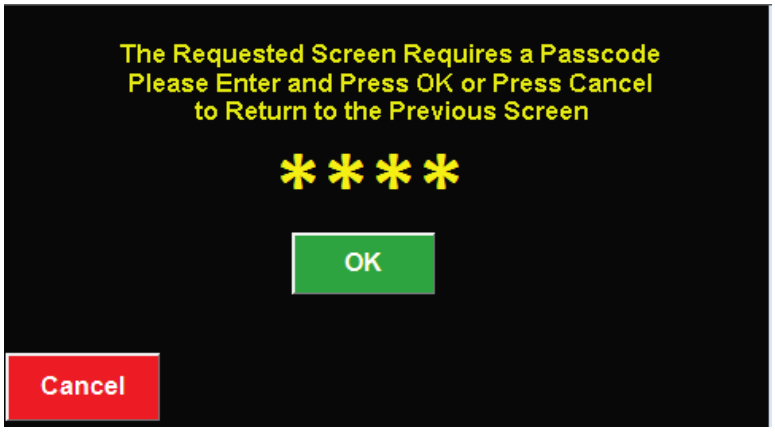
7. From the 'Home / MMA view' screen, pressing the 'Settings' button in the lower left-hand corner will take you to the below screen.




8. From the screen shown above press the yellow star, a keypad will then appear




9. Using the numeric buttons on the keypad type in the password: 1582.
10. Then press the 'ENT' key – the following screen will appear




11. Then press the green 'OK' button
12. You are now logged in as a standard user. This will then show you the Settings version of the 'MMA Enable / Disable' screen as shown in Figure 30 Section 10.2.1 on the following page.


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### 10.2.1 ENABLE / DISABLE MMA

**First login as detailed in Section 10.2.**

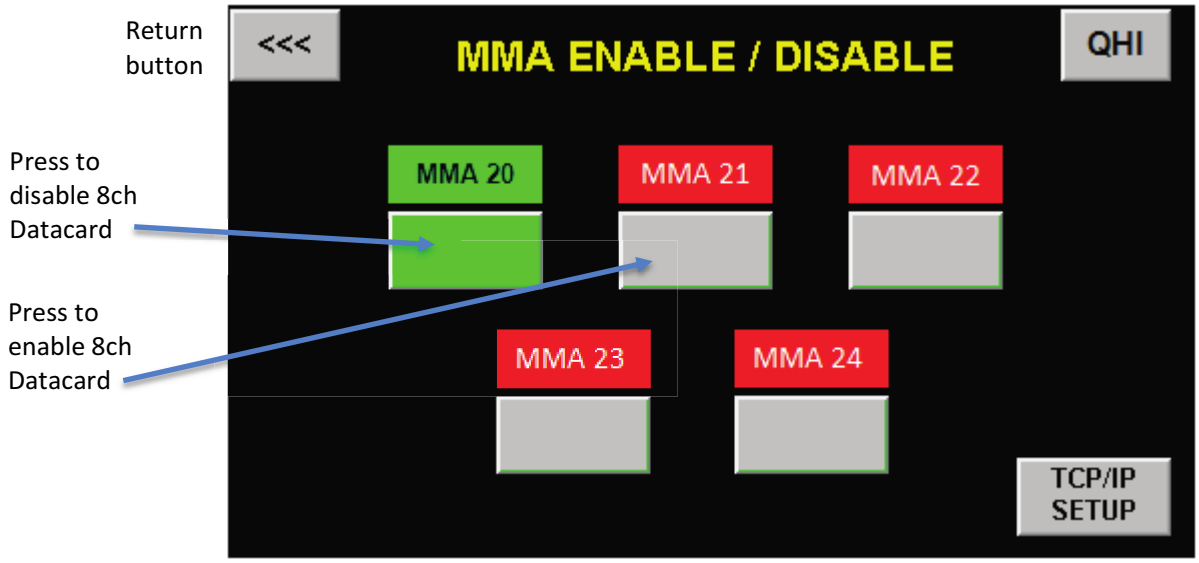



Figure 30 System Settings - Enabling/Disabling MMA only

On this screen, disabled MMAs will show with the MMA number in a red button, and the button below in grey.

To Enable communication from an MMA to the ARM XL, press the grey button under the relevant MMA number and both buttons will turn green as shown on MMA 20 in Figure 30 above.

To Disable communication from a MMA to the ARM XL, press the green button under the relevant MMA number. The MMA number button will then turn red, and the button below will be grey.

Once all required MMAs are enabled continue to the 'Home / MMA view' screen by pressing the Return button in the top left corner of the screen.

**IMPORTANT:**

All MMAs must be enabled & addressed sequentially, MMAs can only be numbered from 20 through to 24, and always start at 20.

There can be a maximum of 12 MMDs connected to any single MMA. The 12 MMDs can only be numbered 1 through to 12 and must be sequential and always start at 1.

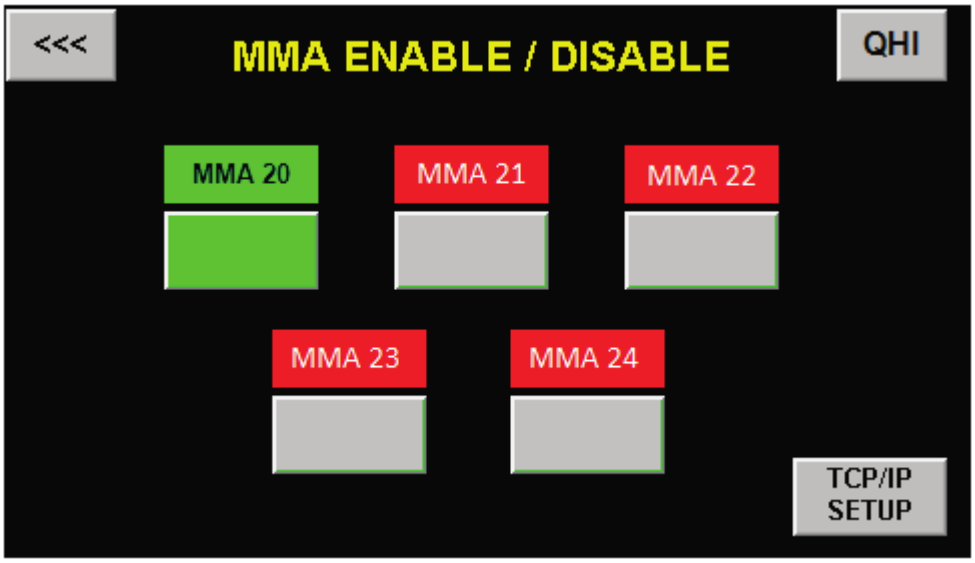

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### 10.2.2 MMA – SET TCP / IP SETTINGS

**First login as detailed in Section 10.2**

9. From the 'MMA Enable / Disable' screen press the 'TCP/IP Setup' button




10. The following address screen will appear (see Figure 31Figure 24 below), the IP address is split into 4 separate segments.

By touching the relevant segment of the IP address, the keypad will pop up and you can then enter the relevant portion of the IP address individually

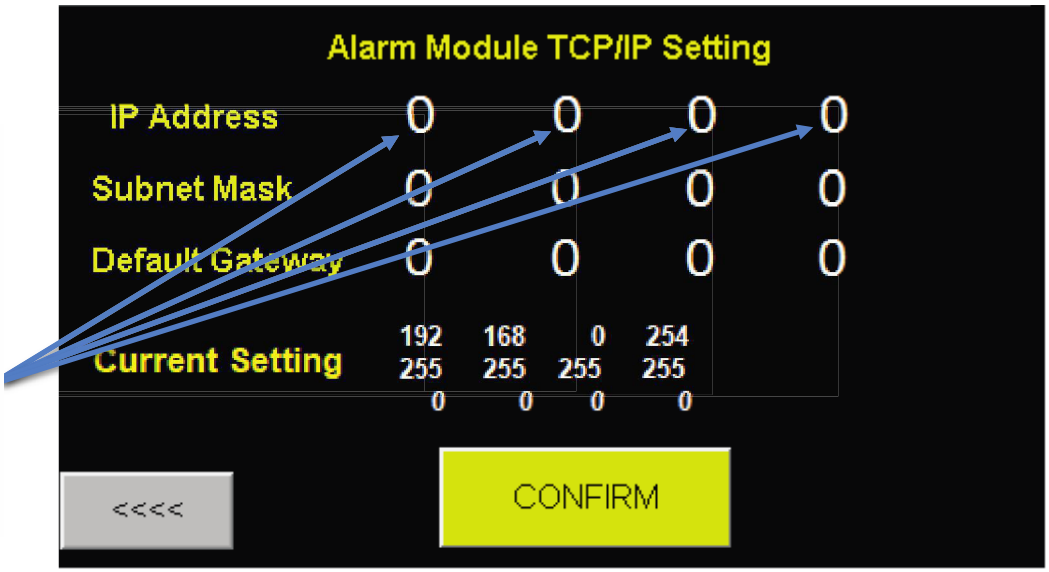


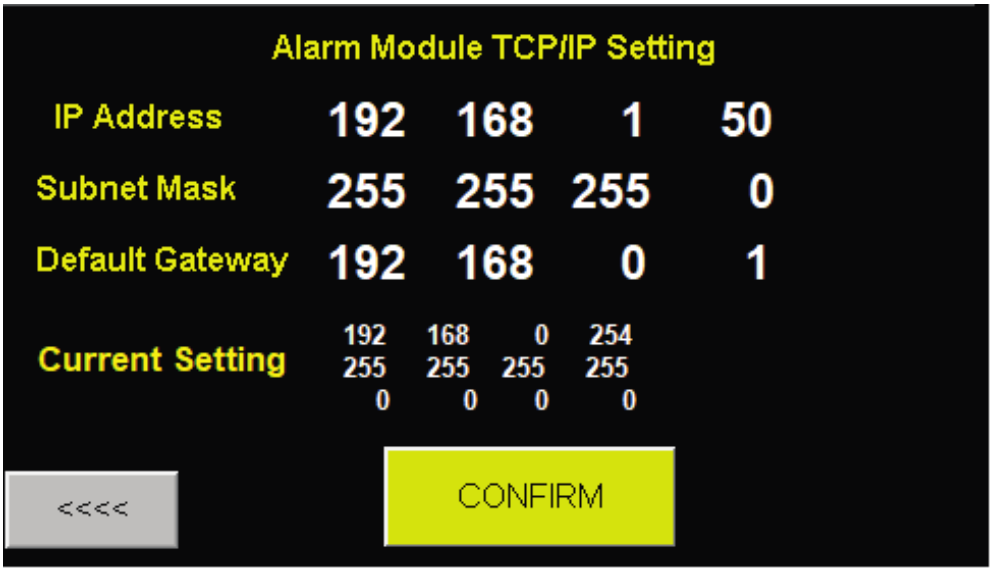

Figure 31 ARM XL TCP/IP Setting

11. Enter the Modbus TCP/IP address by first touching the relevant segment and then enter the relevant portion of the IP address. Existing settings are shown under heading 'Current Setting' as above.


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12. As in the IP address below, an example address has been entered – 192.168.1.50
13. Repeat the same process for the Subnet Mask and IP Gateway.
14. The screen will then show as below (example addresses have also been entered for Subnet Mask & Default Gateway)




15. Once this information has been entered press the yellow 'CONFIRM' button that will then enter the information into system.
16. Then press the 'return' button in the bottom left hand corner to take you back to the 'MMA Enable / Disable' screen.


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## 10.3 OBTAINING RAW DATA FROM THE ARM XL

Raw data in Modbus TCP/IP protocol can be obtained from the ARM XL via the following actions:

1. Ensure TCP/IP settings have been entered as per instruction in 10.2.2
2. Then connect an Ethernet cable into the Port circled in red below on the rear of the ARM XL, as shown in Figure 32 below.
3. Then connect the other end of the cable to a suitable host system connection point.

**The Modbus TCP uses standard Port 502 for communication and the ARM XL is set as device 1**

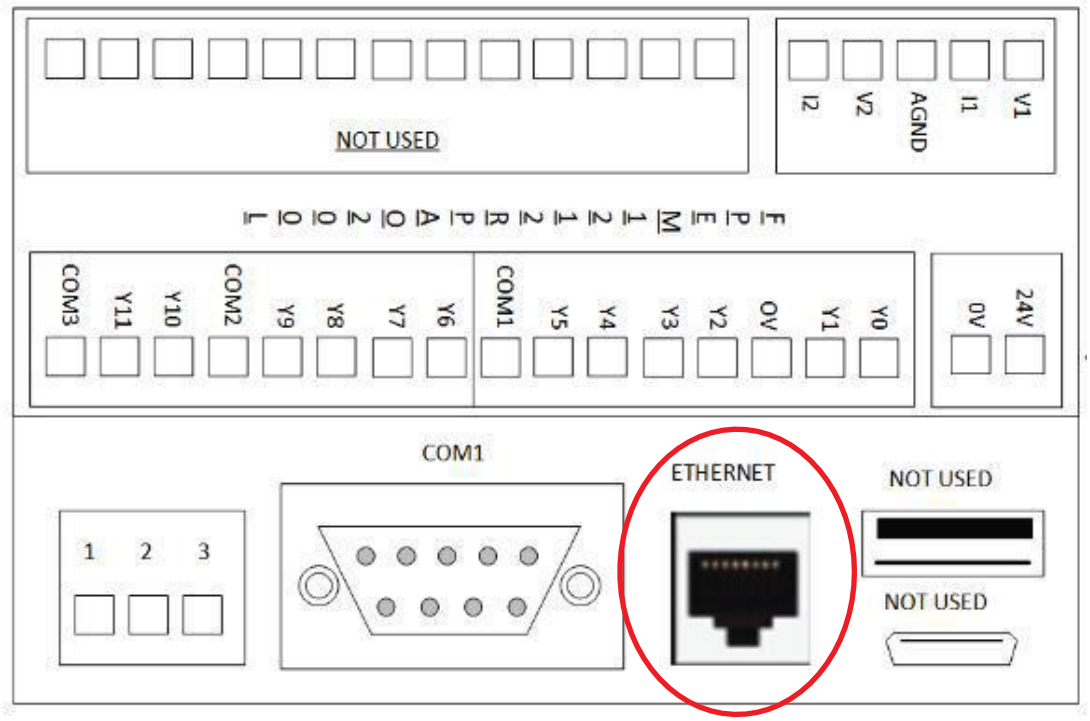



Figure 32 ARM XL TCP/IP Port

To read the Sensor registers please refer to the relevant tables within Section 10.4 on the following page which shows the Modbus holding registers. The registers require a 0.1 multiplier to read the correct value, e.g. if the register reads a raw data value of 150, then use 150 * 0.1 to read the correct register value of 15°C absolute temperature.


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## 10.4 INTERNAL MODBUS TCP REGISTERS FOR MMA

### 10.4.1 INTERNAL MODBUS TCP REGISTERS FOR MMA 20

| Sensor No. | L1 IN | L2 IN | L3 IN | L1 OUT | L2 OUT | L3 OUT |
|---|---|---|---|---|---|---|
| | | | | | | |
| MMD 1 | | | | | | |
| TCP Register | 453501 | 453502 | 453503 | 453504 | 453505 | 453506 |
| | | | | | | |
| MMD 2 | | | | | | |
| TCP Register | 453507 | 453508 | 453509 | 453510 | 453511 | 453512 |
| | | | | | | |
| MMD 3 | | | | | | |
| TCP Register | 453513 | 453514 | 453515 | 453516 | 453517 | 453518 |
| | | | | | | |
| MMD 4 | | | | | | |
| TCP Register | 453519 | 453520 | 453521 | 453522 | 453523 | 453524 |
| | | | | | | |
| MMD 5 | | | | | | |
| TCP Register | 453525 | 453526 | 453527 | 453528 | 453529 | 453530 |
| | | | | | | |
| MMD 6 | | | | | | |
| TCP Register | 453531 | 453532 | 453533 | 453534 | 453535 | 453536 |
| | | | | | | |
| MMD 7 | | | | | | |
| TCP Register | 453537 | 453538 | 453539 | 453540 | 453541 | 453542 |
| | | | | | | |
| MMD 8 | | | | | | |
| TCP Register | 453543 | 453544 | 453545 | 453546 | 453547 | 453548 |
| | | | | | | |
| MMD 9 | | | | | | |
| TCP Register | 453549 | 453550 | 453551 | 453552 | 453553 | 453554 |
| | | | | | | |
| MMD 10 | | | | | | |
| TCP Register | 453555 | 453556 | 453557 | 453558 | 453559 | 453560 |
| | | | | | | |
| MMD 11 | | | | | | |
| TCP Register | 453561 | 453562 | 453563 | 453564 | 453565 | 453566 |
| | | | | | | |
| MMD 12 | | | | | | |
| TCP Register | 453567 | 453568 | 453569 | 453570 | 453571 | 453572 |

Table 2 Internal Modbus TCP Registers for MMA 20


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### 10.4.2 INTERNAL MODBUS TCP REGISTERS FOR MMA 21

| Sensor No. | L1 IN | L2 IN | L3 IN | L1 OUT | L2 OUT | L3 OUT |
|---|---|---|---|---|---|---|
| | | | | | | |
| MMD 1 | | | | | | |
| TCP Register | 453573 | 453574 | 453575 | 453576 | 453577 | 453578 |
| | | | | | | |
| MMD 2 | | | | | | |
| TCP Register | 453579 | 453580 | 453581 | 453582 | 453583 | 453584 |
| | | | | | | |
| MMD 3 | | | | | | |
| TCP Register | 453585 | 453586 | 453587 | 453588 | 453589 | 453590 |
| | | | | | | |
| MMD 4 | | | | | | |
| TCP Register | 453591 | 453592 | 453593 | 453594 | 453595 | 453596 |
| | | | | | | |
| MMD 5 | | | | | | |
| TCP Register | 453597 | 453598 | 453599 | 453600 | 453601 | 453602 |
| | | | | | | |
| MMD 6 | | | | | | |
| TCP Register | 453603 | 453604 | 453605 | 453606 | 453607 | 453608 |
| | | | | | | |
| MMD 7 | | | | | | |
| TCP Register | 453609 | 453610 | 453611 | 453612 | 453613 | 453614 |
| | | | | | | |
| MMD 8 | | | | | | |
| TCP Register | 453615 | 453616 | 453617 | 453618 | 453619 | 453620 |
| | | | | | | |
| MMD 9 | | | | | | |
| TCP Register | 453621 | 453622 | 453623 | 453624 | 453625 | 453626 |
| | | | | | | |
| MMD 10 | | | | | | |
| TCP Register | 453627 | 453628 | 453629 | 453630 | 453631 | 453632 |
| | | | | | | |
| MMD 11 | | | | | | |
| TCP Register | 453633 | 453634 | 453635 | 453636 | 453637 | 453638 |
| | | | | | | |
| MMD 12 | | | | | | |
| TCP Register | 453639 | 453640 | 453641 | 453642 | 453643 | 453644 |

Table 3 Internal Modbus TCP Registers for MMA 21


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### 10.4.3 INTERNAL MODBUS TCP REGISTERS FOR MMA 22

| Sensor No. | L1 IN | L2 IN | L3 IN | L1 OUT | L2 OUT | L3 OUT |
|---|---|---|---|---|---|---|
| | | | | | | |
| **MMD 1** | | | | | | |
| **TCP Register** | 453645 | 453646 | 453647 | 453648 | 453649 | 453650 |
| | | | | | | |
| **MMD 2** | | | | | | |
| **TCP Register** | 453651 | 453652 | 453653 | 453654 | 453655 | 453656 |
| | | | | | | |
| **MMD 3** | | | | | | |
| **TCP Register** | 453657 | 453658 | 453659 | 453660 | 453661 | 453662 |
| | | | | | | |
| **MMD 4** | | | | | | |
| **TCP Register** | 453663 | 453664 | 453665 | 453666 | 453667 | 453668 |
| | | | | | | |
| **MMD 5** | | | | | | |
| **TCP Register** | 453669 | 453670 | 453671 | 453672 | 453673 | 453674 |
| | | | | | | |
| **MMD 6** | | | | | | |
| **TCP Register** | 453675 | 453676 | 453677 | 453678 | 453679 | 453680 |
| | | | | | | |
| **MMD 7** | | | | | | |
| **TCP Register** | 453681 | 453682 | 453683 | 453684 | 453685 | 453686 |
| | | | | | | |
| **MMD 8** | | | | | | |
| **TCP Register** | 453687 | 453688 | 453689 | 453690 | 453691 | 453692 |
| | | | | | | |
| **MMD 9** | | | | | | |
| **TCP Register** | 453693 | 453694 | 453695 | 453696 | 453697 | 453698 |
| | | | | | | |
| **MMD 10** | | | | | | |
| **TCP Register** | 453699 | 453700 | 453701 | 453702 | 453703 | 453704 |
| | | | | | | |
| **MMD 11** | | | | | | |
| **TCP Register** | 453705 | 453706 | 453707 | 453708 | 453709 | 453710 |
| | | | | | | |
| **MMD 12** | | | | | | |
| **TCP Register** | 453711 | 453712 | 453713 | 453714 | 453715 | 453716 |

Table 4 Internal Modbus TCP Registers for MMA 22


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### 10.4.4 INTERNAL MODBUS TCP REGISTERS FOR MMA 23

| Sensor No. | L1 IN | L2 IN | L3 IN | L1 OUT | L2 OUT | L3 OUT |
|---|---|---|---|---|---|---|
| | | | | | | |
| MMD 1 | | | | | | |
| TCP Register | 453717 | 453718 | 453719 | 453720 | 453721 | 453722 |
| | | | | | | |
| MMD 2 | | | | | | |
| TCP Register | 453723 | 453724 | 453725 | 453726 | 453727 | 453728 |
| | | | | | | |
| MMD 3 | | | | | | |
| TCP Register | 453729 | 453730 | 453731 | 453732 | 453733 | 453734 |
| | | | | | | |
| MMD 4 | | | | | | |
| TCP Register | 453735 | 453736 | 453737 | 453738 | 453739 | 453740 |
| | | | | | | |
| MMD 5 | | | | | | |
| TCP Register | 453741 | 453742 | 453743 | 453744 | 453745 | 453746 |
| | | | | | | |
| MMD 6 | | | | | | |
| TCP Register | 453747 | 453748 | 453749 | 453750 | 453751 | 453752 |
| | | | | | | |
| MMD 7 | | | | | | |
| TCP Register | 453753 | 453754 | 453755 | 453756 | 453757 | 453758 |
| | | | | | | |
| MMD 8 | | | | | | |
| TCP Register | 453759 | 453760 | 453761 | 453762 | 453763 | 453764 |
| | | | | | | |
| MMD 9 | | | | | | |
| TCP Register | 453765 | 453766 | 453767 | 453768 | 453769 | 453770 |
| | | | | | | |
| MMD 10 | | | | | | |
| TCP Register | 453771 | 453772 | 453773 | 453774 | 453775 | 453776 |
| | | | | | | |
| MMD 11 | | | | | | |
| TCP Register | 453777 | 453778 | 453779 | 453780 | 453781 | 453782 |
| | | | | | | |
| MMD 12 | | | | | | |
| TCP Register | 453783 | 453784 | 453785 | 453786 | 453787 | 453788 |

Table 5 Internal Modbus TCP Registers for MMA 23


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### 10.4.5 INTERNAL MODBUS TCP REGISTERS FOR MMA 24

| Sensor No. | L1 IN | L2 IN | L3 IN | L1 OUT | L2 OUT | L3 OUT |
|---|---|---|---|---|---|---|
| | | | | | | |
| **MMD 1** | | | | | | |
| **TCP Register** | 453789 | 453790 | 453791 | 453792 | 453793 | 453794 |
| | | | | | | |
| **MMD 2** | | | | | | |
| **TCP Register** | 453795 | 453796 | 453797 | 453798 | 453799 | 453800 |
| | | | | | | |
| **MMD 3** | | | | | | |
| **TCP Register** | 453801 | 453802 | 453803 | 453804 | 453805 | 453806 |
| | | | | | | |
| **MMD 4** | | | | | | |
| **TCP Register** | 453807 | 453808 | 453809 | 453810 | 453811 | 453812 |
| | | | | | | |
| **MMD 5** | | | | | | |
| **TCP Register** | 453813 | 453814 | 453815 | 453816 | 453817 | 453818 |
| | | | | | | |
| **MMD 6** | | | | | | |
| **TCP Register** | 453819 | 453820 | 453821 | 453822 | 453823 | 453824 |
| | | | | | | |
| **MMD 7** | | | | | | |
| **TCP Register** | 453825 | 453826 | 453827 | 453828 | 453829 | 453830 |
| | | | | | | |
| **MMD 8** | | | | | | |
| **TCP Register** | 453831 | 453832 | 453833 | 453834 | 453835 | 453836 |
| | | | | | | |
| **MMD 9** | | | | | | |
| **TCP Register** | 453837 | 453838 | 453839 | 453840 | 453841 | 453842 |
| | | | | | | |
| **MMD 10** | | | | | | |
| **TCP Register** | 453843 | 453844 | 453845 | 453846 | 453847 | 453848 |
| | | | | | | |
| **MMD 11** | | | | | | |
| **TCP Register** | 453849 | 453850 | 453851 | 453852 | 453853 | 453854 |
| | | | | | | |
| **MMD 12** | | | | | | |
| **TCP Register** | 453855 | 453856 | 453857 | 453858 | 453859 | 453860 |

Table 6 Internal Modbus TCP Registers for MMA 24

**EXERTHERM TEMP/HUMIDITY SENSOR: Temperature & humidity can also be read via registers**
**Temperature 453861 Humidity 453862**


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## 10.5 MMA IO LIST

| | | | |
|---|---|---|---|
| Project Name: | | Customer: | |
| Description | | | |
| Revision No. | | Page No. | |
| MMA No. | | | |

| Switchgear Section: | Phase Reference: | Description: | Sensor Type: | Card Address: | Input: |
|---|---|---|---|---|---|
| | **L1IN** | | RTD | | **L1IN** |
| | **L2IN** | | RTD | | **L2IN** |
| | **L3IN** | | RTD | | **L3IN** |
| | **L1OUT** | | RTD | | **L1OUT** |
| | **L2OUT** | | RTD | | **L2OUT** |
| | **L3OUT** | | RTD | | **L3OUT** |
| **Switchgear Section:** | **Phase Reference:** | **Description:** | **Sensor Type:** | **Card Address:** | **Input:** |
| | **L1IN** | | RTD | | **L1IN** |
| | **L2IN** | | RTD | | **L2IN** |
| | **L3IN** | | RTD | | **L3IN** |
| | **L1OUT** | | RTD | | **L1OUT** |
| | **L2OUT** | | RTD | | **L2OUT** |
| | **L3OUT** | | RTD | | **L3OUT** |
| **Switchgear Section:** | **Phase Reference:** | **Description:** | **Sensor Type:** | **Card Address:** | **Input:** |
| | **L1IN** | | RTD | | **L1IN** |
| | **L2IN** | | RTD | | **L2IN** |
| | **L3IN** | | RTD | | **L3IN** |
| | **L1OUT** | | RTD | | **L1OUT** |
| | **L2OUT** | | RTD | | **L2OUT** |
| | **L3OUT** | | RTD | | **L3OUT** |

| Installer: | Date: | Sign: | Client Rep: | Date: | Sign: |
|---|---|---|---|---|---|
| | | | | | |


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# 11. USER GUIDE – ARM XL WITH BOTH 8CH DATACARD + MMA

## 11.1 HOME / 8CH DATACARD & MMA VIEW SCREEN

Once the system has been configured & required 8ch Datacards & MMAs have been enabled, Figure 33 below will be the main user viewing screen. This screen will then appear whenever the ARML XL is powered up.

The Home / 8ch Datacard & MMA view screen shows the status of each enabled device, including alarms for temperature or communication.

**8ch Datacards:**

- 8ch Datacards not enabled, will show was below e.g. Card 12
- 8ch Datacards with no alarms will be displayed as 'Healthy' with a green button as shown below e.g. Card 10.
- 8ch Datacards with alarms with be displayed as 'Fault' with a red button as shown below e.g. Card 11

**MMAs:**

- MMAs not enabled, will show was below e.g. MMA 22
- MMAs with no alarms will be displayed as 'Healthy' with a green button as shown below e.g. MMA 20.
- MMAs with alarms with be displayed as 'Fault' with a red button as shown below e.g. MMA 21

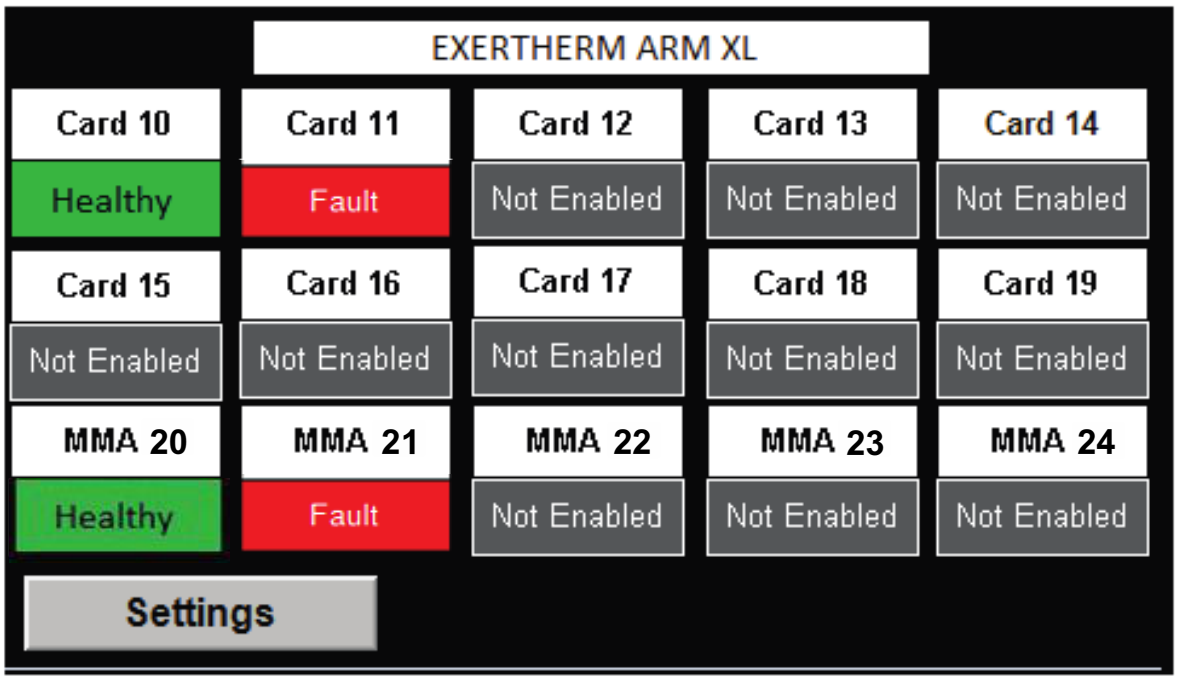



Figure 33 Home / 8ch Datacard & MMA View Screen

The 'Settings' button takes you to the 8ch Datacard & MMA Enable/Disable screen. For more detail please see Section 8.1.3.


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### 11.1.1 8CH DATACARD & MMA STATUS SCREEN

The Home / 8ch Datacard & MMA view screen also provides access to each enabled device with real-time sensor values and warning alarms.

**Datacards**

From the Home / 8ch Datacard & MMA view screen, press the button for the 8ch Datacard you wish to view e.g. Card 10.

For further instructions please refer to Section 9 User Guide– ARM XL & 8ch Datacard Only.

**PLEASE NOTE:**

**Although the screen on the ARM XL**

**Although screens shown in Section 9 only show 8ch Datacards, the screens will show both 8ch Datacards & MMAs – the functionality and instructions remain exactly the same.**

**MMAs**

From the Home / 8ch Datacard & MMA view screen, press the button for the MMA you wish to view e.g. MMA 20.

For further instructions please refer to Section 10 User Guide – ARM XL & MMA Only.

**PLEASE NOTE:**

**Although screens shown in Section 9 only show MMAs, the screens you see will show both 8ch Datacards & MMAs – the functionality and instructions remain exactly the same.**


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# 12. UPGRADING ARM XL SOFTWARE

## 12.1 GETTING STARTED

To begin upgrading the ARM XL Software, you will need a USB memory stick loaded with the latest version of the Software.

Software will be supplied by Exertherm, memory stick must be 4gb or less.

1. Please follow Login instructions detailed in Section 8.2.1
2. When you are then on the relevant hardware's Enable / Disable screen, press the QHI button in the top right hand corner
3. The screen as below will then appear as in Figure 34
4. This screen also shows the current version of the Software in the top left hand corner e.g. V1.08.18.005

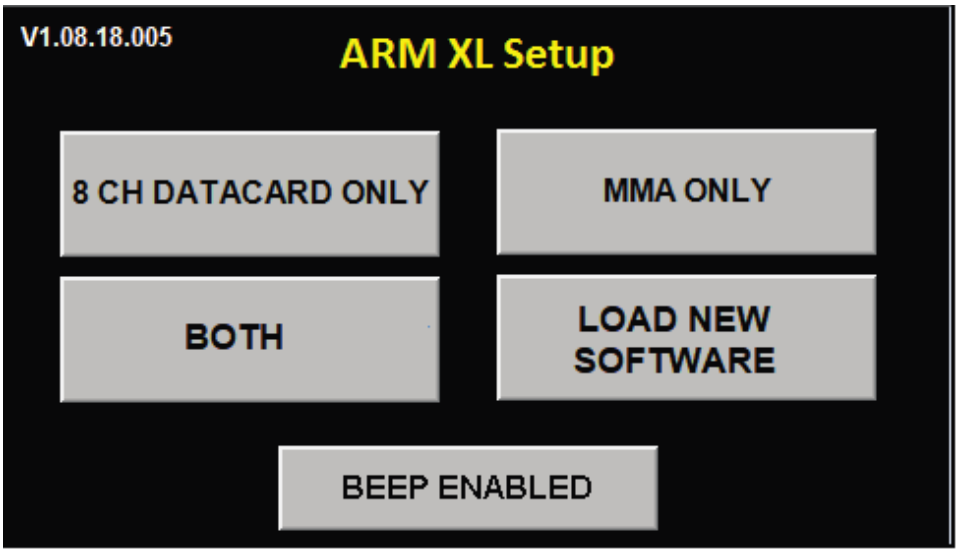



Figure 34 Software Upgrade - ARM XL Setup Screen


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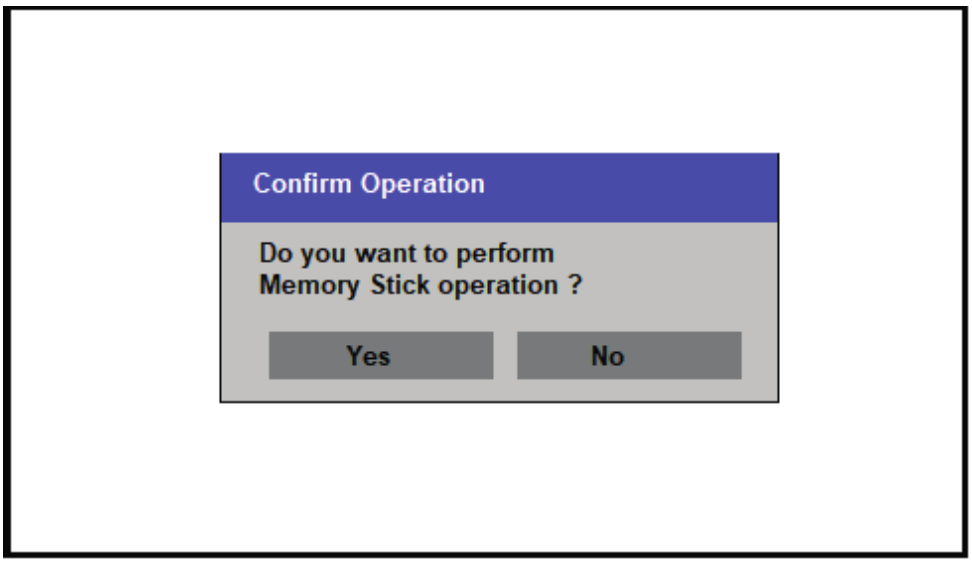
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## 12.2 ARM XL UPGRADE PROCESS

1. Please insert the USB memory stick into the 'Host' port on the reverse of the ARM XL
2. Press the 'Load New Software' button as shown on Figure 39 above.
3. You will then see the following screen – press 'Yes'

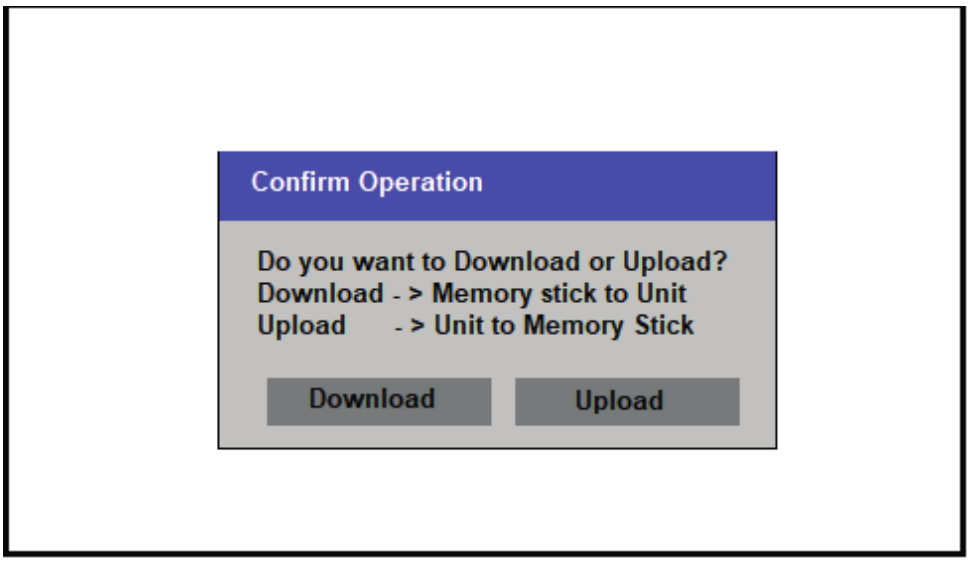
**If you do not press anything the ARM XL will time out and re-start.**

**If you press 'No' the ARM XL will automatically re-start.**




4. Once you have pressed 'Yes' the below screen will appear. Press the 'Download' button.

**IMPORTANT:**
**DO NOT PRESS THE 'UPLOAD' BUTTON OR THE USB MEMORY STICK WILL BE OVERWRITTEN**





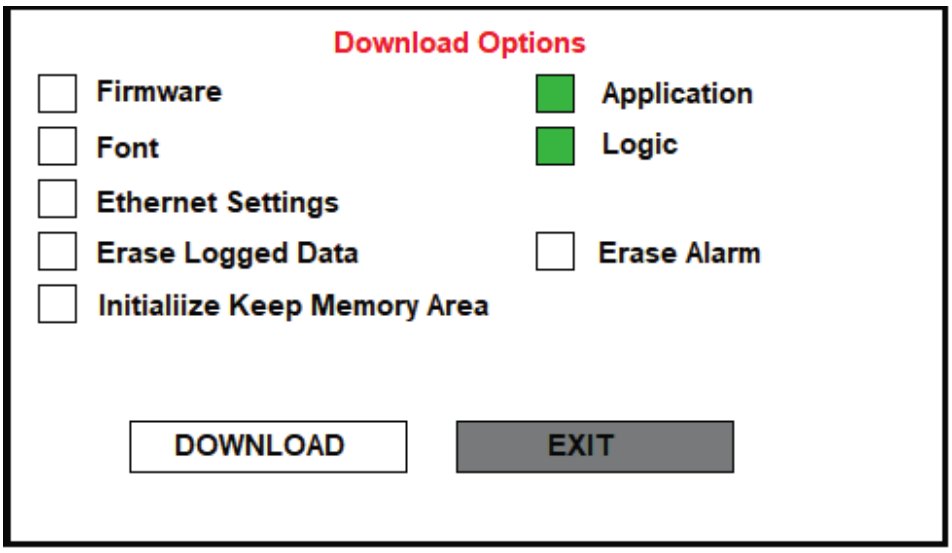
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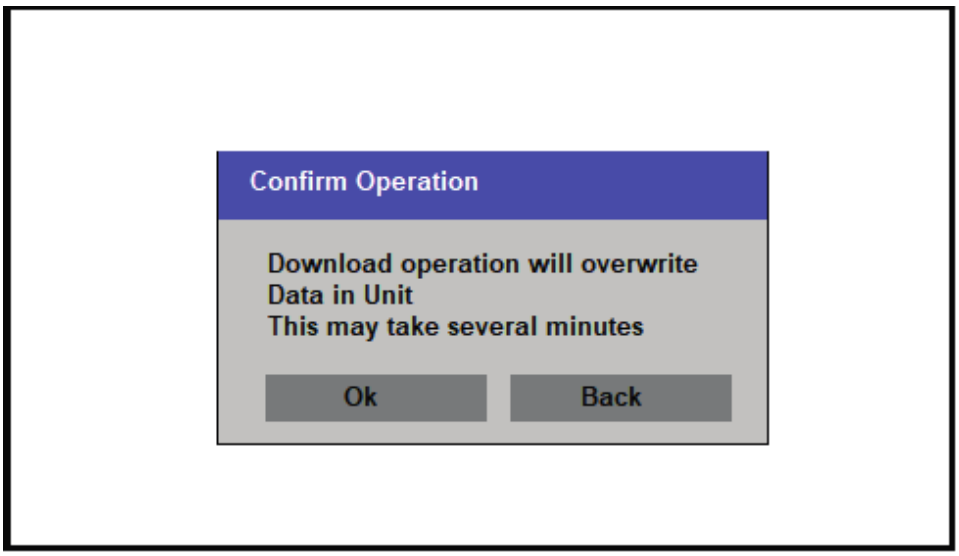
5. The below screen will then appear, you must then select the 'Application' and 'Logic' boxes only – once selected the boxes will turn green as shown below. Then press the 'Download' button.

**IMPORTANT:**

**Do NOT select any other options**




6. This will take you to the following screen, press 'OK'.



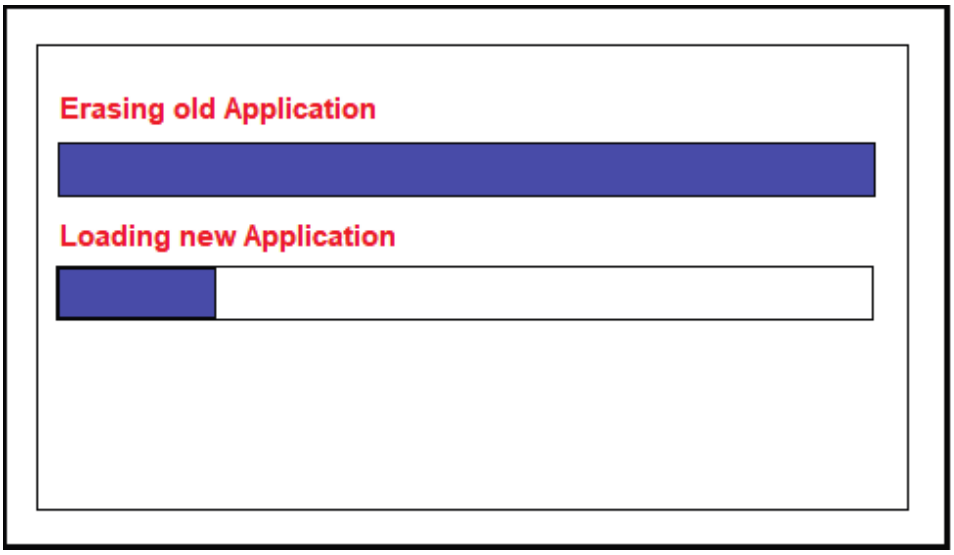


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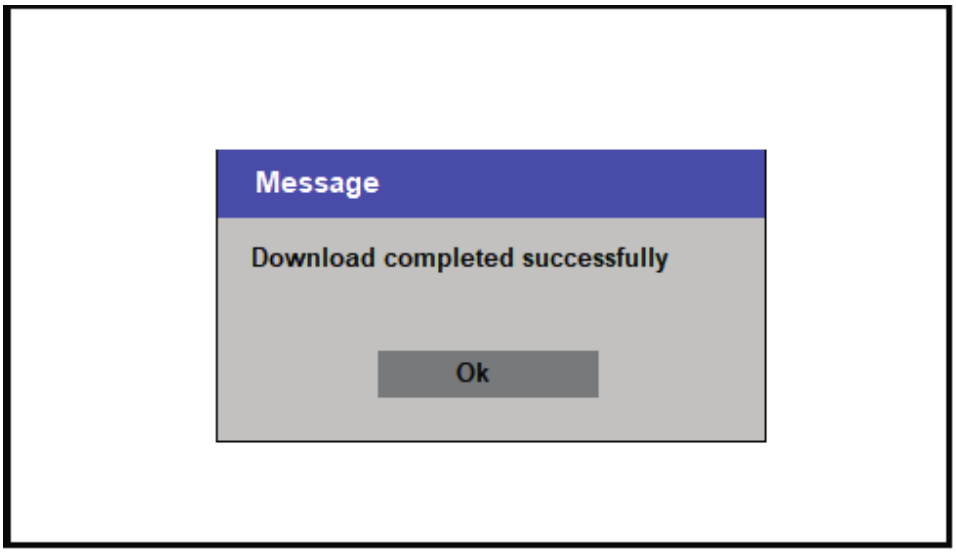
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7. While the Software is downloading you will see the below progress bar screen.

**IMPORTANT:**
**Do NOT unplug the memory stick and do not unplug the ARM XL at any time during the upgrade process.**




8. The following screen will then appear when the download has completed successfully. Then press 'OK'.

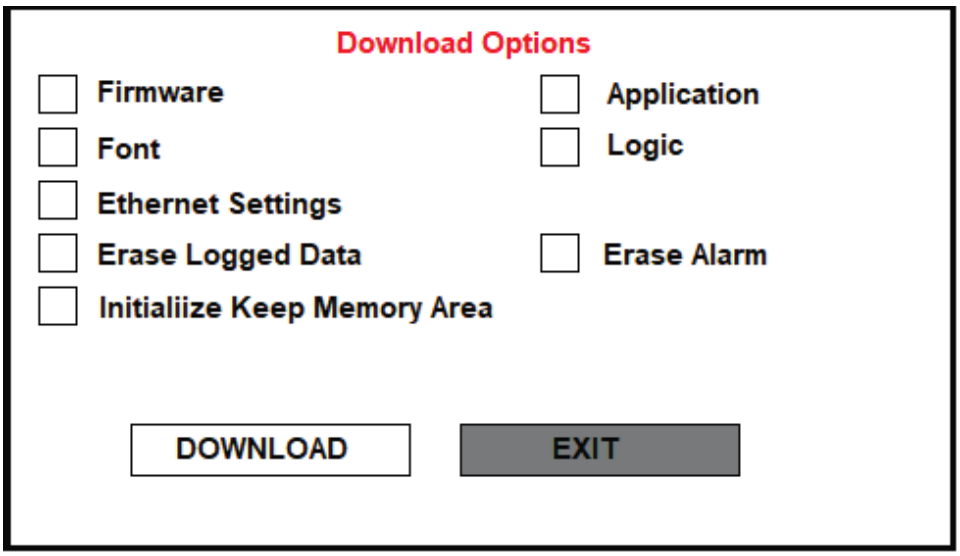




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9. The below screen will then appear. Now remove the USB memory stick and then press ‘Exit’.




10. The ARM XL will then automatically re-start with the new version of Software.


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# 13. ARM XL DATASHEET

The Exertherm Alarm Relay Module XL (ARM XL) device is ideal for those who wish to continuously thermally monitor critical electrical circuits, 100% of operational time, rather than rely on one day per year thermal inspections. It is designed for busy engineers who require a simple monitoring system to just inform when and where a fault is detected, without yet another suite of software.

The Exertherm ARM XL device is designed to provide a complete integral monitoring solution per switchboard, and is suitable for both new build or retro-fit, while being entirely vendor neutral (e.g. can be fitted to any manufacturer's equipment).

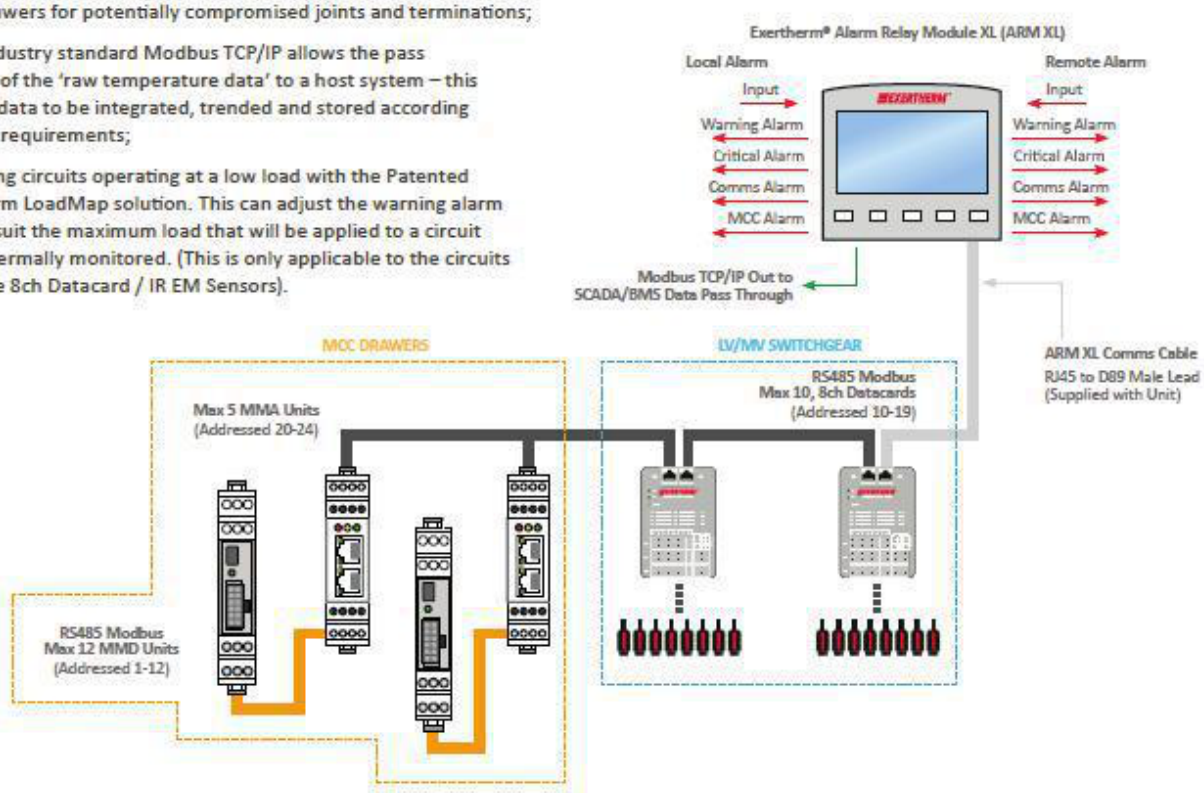
The key benefits of the ARM XL:

- Monitoring 24x7 up to 80 Exertherm Sensors and / or up to 60 MCC Drawers for potentially compromised joints and terminations;
- Using industry standard Modbus TCP/IP allows the pass through of the 'raw temperature data' to a host system – this enables data to be integrated, trended and stored according to client requirements;
- Protecting circuits operating at a low load with the Patented Exertherm LoadMap solution. This can adjust the warning alarm level to suit the maximum load that will be applied to a circuit being thermally monitored. (This is only applicable to the circuits using the 8ch Datacard / IR EM Sensors).

This simple to use, plug and play device, which has 2 sets dry contact relays for connection to a local alarm output and also to a BMS or SCADA system. These relays are a dry contact type.

The ARM XL device connects up to a maximum of 10 Exertherm 8-channel Modbus Datacards (80 Exertherm IR or Cable Sensors) and 5 Exertherm MMA units each of which can connect 12 MMD units (60 MCC Drawers). The ARM XL is supplied with a Comms cable for connection to the 8ch Datacard and MMA.

A simple set up, using the pre-configured screens, provides an easy to use graphical interface to indicate the status of all Sensors, as well as providing both local and remote alarms.







4.3" Touchscreen Display

## Features

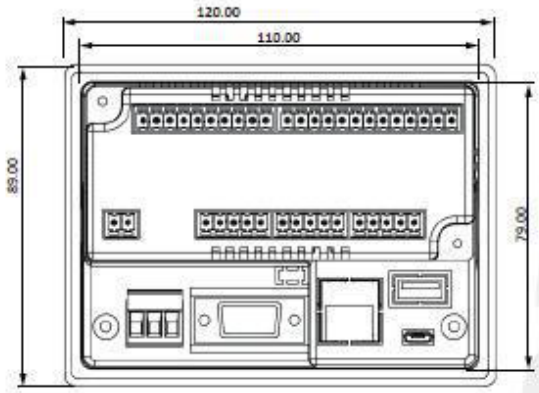
- Panel Mounted HMI
- Plug & Play Solution
- Pre-configured screens allow simple set-up
- 2 sets of Relay Alarm Outputs (Local & Remote)
- Patented LoadMap for load related Warning Alarm threshold (on Exertherm IR Sensors only)
- Transfer of raw temperature data to host system using Modbus TCP/IP
- 4 Different Alarms:
  - Warning Alarm
  - Critical Alarm
  - Communication Failure
  - MCC Alarm

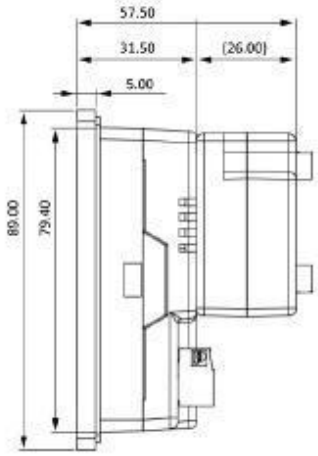

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## Specification

| | |
|---|---|
| **Power Supply** | |
| Input voltage: | 24VDC |
| Permissible range: | 20.4VDC to 27.6VDC with less than 10% ripple |
| Maximum current consumption: | 300mA @ 24VDC |
| **Digital Outputs** | |
| Number of outputs: | 8 relay (in 2 groups) |
| Output type: | SPST-NO (Form A) |
| Isolation: | By relay |
| Output current (resistive load): | 5A maximum per output |
| Minimum load: | 10mA, 5VDC |
| Life expectancy: | 50k operations at maximum load |
| Response time: | 10ms (typical) |




| | |
|---|---|
| **Modbus TCP/IP Output** | |
| TCP / IP Port: | Standard port 502 |
| IP Settings: | User adjustable, IP address, Subnet and Gateway |
| Register type: | Signed Integer |
| Register format: | 16 bit |
| Register Linearisation: | Requires a 0.1 Multiplier on raw value |
| **Graphic Display Screen** | |
| LCD type: | WQVGA Colour TFT, LCD display |
| Illumination backlight: | White LED, software-controlled |
| Display resolution: | 480x272 pixels |
| Viewing area: | 4.3" |
| Colours: | 65,536 (16 bit) |
| Touchscreen: | Resistive, analog |
| Virtual keypad: | Displays virtual keyboard when the application requires data entry |
| **Miscellaneous** | |
| Battery back-up: | Via Super-Cap, for RTC and system data, including variable data |
| Battery replacement: | Not Required |
| **Dimensions** | |
| Size: | 120 x 89 x 57.5mm (4.72 x 3.5 x 2.26") |
| Mounting cut out: | 111 x 80mm (4.37 x 3.14") |
| Weight: | 333g (11.75 oz.) |
| **Environment** | |
| Operational temperature: | 0 to 60°C (32 to 140°F) 0 to 50C (32 to 122°F for UL |
| Storage temperature: | -20 to 85°C (-4 to 185°F) |
| Relative Humidity (RH): | 10% to 90% (non-condensing) |
| Mounting method: | Panel mounted (IP65) using supplied seal |
| Certifications: | CE & cUL Listed. Class 1 Div2 Group A,B,C,D Industrial Control Equipment for use in Hazardous Locations |

## Ordering Information

| QHI Part No. | Product Description |
|---|---|
| 900451 | Exertherm ARM XL, HMI 4.3" Touchscreen Display, 8-ch Datacard + MCC input, Relay & Modbus TCP/IP output (supplied with Comms cable & 2 x Mounting screws + 1 x Power Connector) |
| **Replacement Parts:** | |
| 800445 | Comms cable from Exertherm Alarm Module XL (ARM XL) 8ch Datacard / MMA |
| 800456 | 2 x Mounting screws & 1 x Power Connector for Exertherm Alarm Module XL (ARM XL) |
| **Optional Parts:** | |
| 800457 | Exertherm Humidity Sensor for ARM XL |


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# RMB

SERIES

## INSTANTANEOUS BISTABLE (LATCHING) RELAYS
## 7 TO 20 CONTACTS




RMBE13

## APPLICATIONS

Shipbuilding | Petroleum industry | Heavy industry | Power generation | Power distribution | Railway equipment

## OVERVIEW

- Plug-in instantaneous bistable relay
- Solid and rugged construction for heavy or intensive duty
- Very high electrical life expectancy and exceptional endurance
- Pulsed or permanent power supply, AC or DC
- Self-cleaning knurled contacts
- Fitted with mechanical optical contact status indicator as standard
- Lever for manual operation (optional)
- Wide variety of configurations and customizations
- Transparent cover, fixing/pulling screws
- Label holder in cover for customer's use
- Positive mechanical keying for relay and socket

## DESCRIPTION

RMB relays are multipole bistable types sharing the same basic mechanical design as those of the RGB series, and offering the same specifications and performance.

Available in versions with from 7 to 20 change-over contacts, these highly reliable products provide top performance and are suitable for applications in particularly harsh and unsettled environments, such as high voltage electricity distribution stations and medium voltage substations.

An automatic coil de-energization system ensures that power consumption of the relay reduces to zero once the operating cycle has been completed. Versatility in manufacture allows the production of relays with any voltage from 12 to 250VDC / 440VAC, and with a variety of operating ranges adaptable to different application requirements.

The contacts used are of a type designed to give notable levels of performance both with high and strongly inductive loads, and with particularly low loads; knurled contacts ensure not only better self-cleaning characteristics, but also lower ohmic resistance thanks to multiple points of electrical connection, thereby extending the electrical life expectancy of the component.

All models offer the facility of manual operation, so that tests can be performed even in the absence of electrical power.

To ensure that the relay remains firmly anchored to the sockets, these are equipped with fixing screws, so that there is no need for the use of retaining clips.

A product of proven reliability, as demonstrated by its use for over 40 years in electrical energy transport and distribution systems, and fixed equipment used in the railway sector.

Like all AMRA relays, models of the RMB series are assembled as part of a controlled manufacturing process in which every step of production is verified by the next step in succession. In effect, each relay is calibrated and tested individually, by hand, in such a way as to guarantee top reliability.

## STANDARD COMPLIANCY

EN 60695-2-10
EN 60529
EN 61810-1
EN 61810-2
EN 61810-7

| MODELS | NUMBER OF CONTACTS | POWER INPUT TO COILS |
|---|---|---|
| RMB.x3 | 7 | Common negative |
| RMBZ12 | 8 | Coils galvanically separated |
| RMB.x5 | 11 | Common negative |
| RMBZ13 | 12 | Coils galvanically separated |
| RMB.x7 | 19 | Common negative |
| RMBZ14 | 20 | Coils galvanically separated |

**FOR PRODUCT CODE CONFIGURATION, SEE THE "ORDERING SCHEME" TABLE**

| COIL DATA | RMB.x3 | RMB.x5 - RMB.x7 | RMBZ12 | RMBZ13 - RMBZ14 |
|---|---|---|---|---|
| Nominal voltages at Un [1] | DC / AC: 12 - 24 - 48 - 110 - 125 - 132 - 144 - 230 - 250 - 380 [2] - 440 [2] | | | |
| Consumption at Un (DC/AC) [3] | 15 W / 15 VA | 30 W / 30 VA | 19 W / 19 VA | 36 W / 36 VA |
| Operating range | DC: 80...120% Un - AC: 85...110% Un | | | |
| Type of duty | Continuous | | | |

Minimum control pulse 50ms

(1) Other values on request

(2) Maximum value, AC = 380V 50Hz - 440V 60Hz

(3) Only on latch and unlatch stage. After relay switching, power consumption is zero, as the coil de-energizes automatically

| CONTACT DATA | | RMB.x3 | RMBZ12 | RMB.x5 | RMBZ13 | RMB.x7 | RMBZ14 |
|---|---|---|---|---|---|---|---|
| Number and type | | 7 SPDT, form C | 8 SPDT, form C | 11 SPDT, form C | 12 SPDT, form C | 19 SPDT, form C | 20 SPDT, form C |
| Current | Nominal [1] | 10A | | | | | |
| | Maximum peak [2] | 20A for 1min - 40A for 1s | | | | | |
| | Maximum pulse [2] | 150A for 10ms | | | | | |
| Example of electrical life expectancy [3] | | 0.5A - 110Vdc - L/R 40ms - $10^5$ operations - 1,200 operations/hour | | | | | |
| Minimum load [4] | Standard contacts | 200mW (10V, 10mA) | | | | | |
| | Gold-plated contacts [5] | 50mW (5V, 5mA) | | | | | |
| Maximum breaking voltage | | 350 VDC / 440 VAC | | | | | |
| Contact material | | AgCdO | | | | | |

| | RMB.x3 | RMBZ12 | RMB.x5 | RMBZ13 | RMB.x7 | RMBZ14 |
|---|---|---|---|---|---|---|
| Operating time at Un (ms) [6] | DC - AC | DC - AC | DC - AC | DC - AC | DC - AC | DC - AC |
| Pick-up (NC contact opening) | ≤ 8 - ≤ 20 | ≤ 9 - ≤ 20 | ≤ 9 - ≤ 20 | ≤ 10 - ≤ 20 | ≤ 8 - ≤ 20 | ≤ 8 - ≤ 20 |
| Pick-up (NO contact closing) | ≤ 30 - ≤ 35 | ≤ 26 - ≤ 37 | ≤ 32 - ≤ 37 | ≤ 33 - ≤ 37 | ≤ 25 - ≤ 35 | ≤ 25 - ≤ 36 |
| Drop-out (NO contact opening) | ≤ 9 - ≤ 25 | ≤ 8 - ≤ 25 | ≤ 8 - ≤ 20 | ≤ 9 - ≤ 22 | ≤ 8 - ≤ 25 | ≤ 9 - ≤ 27 |
| Drop-out (NC contact closing) | ≤ 56 - ≤ 65 | ≤ 40 - ≤ 60 | ≤ 50 - ≤ 60 | ≤ 36 - ≤ 57 | ≤ 43 - ≤ 53 | ≤ 43 - ≤ 58 |

(1) On all contacts simultaneously, reduction of 30%

(2) Maximum peak and pulse currents are those currents that can be handled, for a specified time, by the contact. They do not refer to steady or interrupted currents

(3) For other examples, see electrical life expectancy curves

(4) Values referred to a new product, measured in laboratory. The ability to maintain this performance over the time depends on the environmental conditions and the contact' frequency use The use of gold plated contacts is recommended in the case of very low loads. For a correct contact use, refer to the chapter "Installation, operation and maintenance".

(5) A gold contact, if subjected to high loads, degrades superficially. In this case, the characteristics of the standard contact must be considered. This does not affect the operation of the relay

(6) Unless specified otherwise, operating times are understood as comprising stabilization of the contact (inclusive of bounces)

| INSULATION | |
|---|---|
| Insulation resistance (at 500Vdc) | |
| between electrically independent circuits and between these circuits and ground | > 10,000 MΩ |
| between open contact parts | > 10,000 MΩ |
| Withstand voltage at industrial frequency | |
| between electrically independent circuits and between these circuits and ground | 2 kV (1 min) - 2.2 kV (1 s) |
| between open contact parts | 2 kV (1 min) - 2.2 kV (1 s) |
| between adjacent contacts | 2 kV (1 min) - 2.2 kV (1 s) |
| Impulse withstand (1.2/50µs - 0.5J) | |
| between electrically independent circuits and ground | 5 kV |
| between open contact parts | 5 kV |

| MECHANICAL SPECIFICATIONS | | RMB.x3 - RMBZ12 | RMB.x5 - RMBZ13 | RMB.x7 - RMBZ14 |
|---|---|---|---|---|
| Mechanical life expectancy | | 20x10⁶ operations | | |
| Maximum switching rate | Mechanical | 900 operations/hour | | |
| Degree of protection | | IP40 | | |
| Dimensions (mm) | | 132x58x84 (1) | 188x58x84 (1) | 300x58x84 (1) |
| Weight (g) | | 450 | 760 | 1,140 |

(1) Output terminals excluded.

| ENVIRONMENTAL CHARACTERISTICS | |
|---|---|
| Operating temperature<br>Storage and shipping temperature | -25 ÷ +55°C<br>-25 ÷ +70°C |
| Relative humidity | Standard: 75% RH - Tropicalized: 95% RH |
| Fire behaviour | V0 |

| STANDARDS AND REFERENCE VALUES | |
|---|---|
| EN 61810-1, EN 61810-2, EN 61810-7 | Electromechanical elementary relays |
| EN 60695-2-10 | Fire behaviour |
| EN 60529 | Degree of protection provided by enclosures |

Unless otherwise specified, the products are designed and manufactured according to the requirements of the above-mentioned European and International standards.

In accordance with EN 61810-1, all technical data are referred to ambient temperature of 23°C, atmospheric pressure of 96kPa and 50% humidity.

Tolerance for coil resistance and nominal power is ±7%.

| CONFIGURATIONS - OPTIONS | |
|---|---|
| **TROPICALIZATION** | Surface treatment of the coil with protective coating for use with RH 95%. |
| **GOLD PLATING** | Surface treatment of the contacts, with gold-cobalt alloy ≥ 5µ (since 2023, May).<br>This treatment ensures long-term ability of the contact to conduct lower currents. |
| **FLYBACK DIODE** | Component connected in parallel to the coil designed to dampen overvoltages generated by the coil when de-energized. |
| **LEVER FOR MANUAL OPERATION** | Allows manual operation of the relay, with the cover closed, using a screwdriver. |

**ORDERING SCHEME**

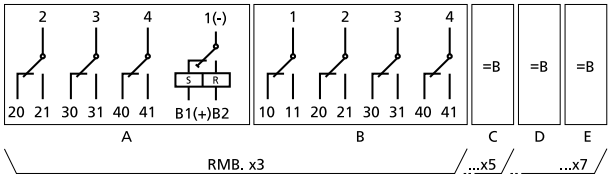
| PRODUCT CODE | APPLICATION (1) | CONFIGURATION A | CONFIGURATION B | TYPE OF POWER SUPPLY | NOMINAL VOLTAGE (V) (2) | FINISH (3) | KEYING POSITION CODE (4) |
|---|---|---|---|---|---|---|---|
| **RMB** | **E:** Energy<br>**F:** Railway Fixed equipment | **1:** Standard<br>**3:** Diode //<br>**4:** Gold plating<br>**6:** Gold plating + Diode // | **3:** 3 SPDT contacts<br>**5:** 11 SPDT contacts<br>**7:** 19 SPDT contacts | **C:** Vdc<br>**A:** Vac 50 Hz<br>**H:** Vac 60 Hz | 012 - 024 - 048<br>110 - 125 - 132<br>144 - 220 - 230<br>250 - 380 - 440 | **T:** Tropicalized coil<br>**M:** Manual operation (6) | XX |
| | Z12 - 8 SPDT contacts (5)<br>Z13 - 12 SPDT contacts (5)<br>Z14 - 20 SPDT contacts (5) | | | | | | |

**Example**

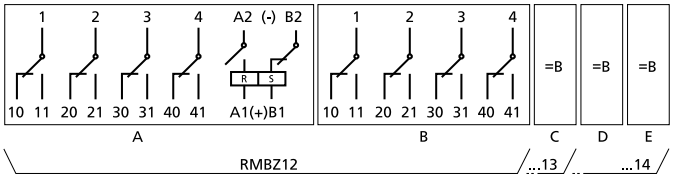
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **RMB** | **E** | **4** | **3** | **C** | **110** | | **SAH** |
| **RMBE43-C110-SAH = ENERGY series relay, with 7 SPDT gold-plated contacts, 110Vdc coil and keying position SAH** | | | | | | | |
| **RMB** | **F** | **1** | **4** | **C** | **110** | | |
| **RMBF15-C110 = RAILWAY series relay, fixed equipment, with 11 SPDT contacts, 110VDC coil** | | | | | | | |
| **RMB** | **Z** | **1** | **2** | **C** | **110** | **T** | |
| **RMBZ12-C220 = Relay with 8 SPDT contacts, 110VDC tropicalized coil** | | | | | | | |

1. **ENERGY:** All applications except for railway.
   **RAILWAYS, FIXED EQUIPMENT:** application on fixed power systems and electrical railway traction.
   For list of RFI compliant and type-approved products, consult dediated catalogue "RAILWAY SERIES - RFI APPROVED".
   Also available is the **STATIONS** series, with ENEL approved material meeting LV15/LV16 specifications.
   For list of ENEL compliant and type-approved products, consult dedicated catalogue "STATIONS SERIES - LV15-LV16-LV20"
2. Other values on request. Voltages 380V and 440V available as Vac only.
3. Optional value. Multiple selection possible (e.g. TM).
4. Option value. The positive mechanical keying is applied according to the manufacturer's model.
5. Suitable for "E" and "F" applications. Gold-plated (2µ) contacts and terminals available on request.
6. With manual operation, no optical indicator.

## WIRING DIAGRAM



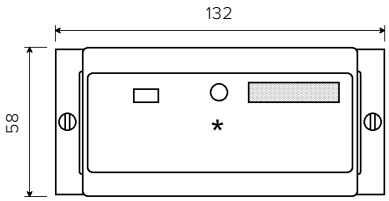

RMB.x3 - RMB.x5 - RMB.x7



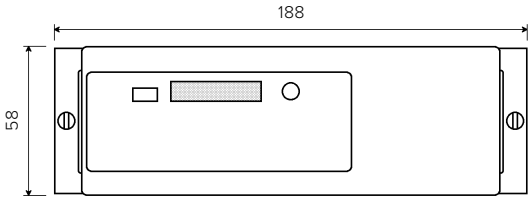

RMBZ12 - RMBZ13 - RMBZ14

**NOTE:**
Coils nomenclature change from 2024/05
**S** = SET (it was C)
**R** = RESET (it was S)

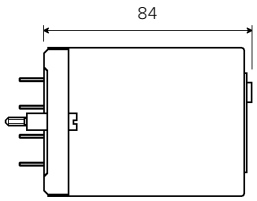
## DIMENSIONS

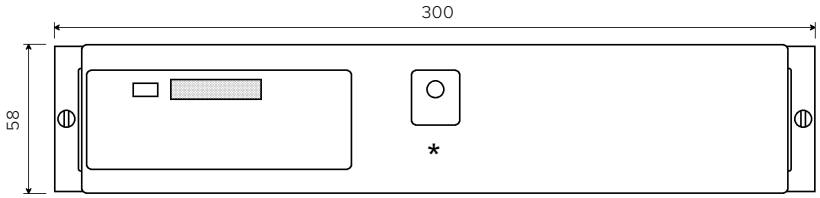



RMB.x3 - RMBZ12




RMB.x5 - RMBZ13

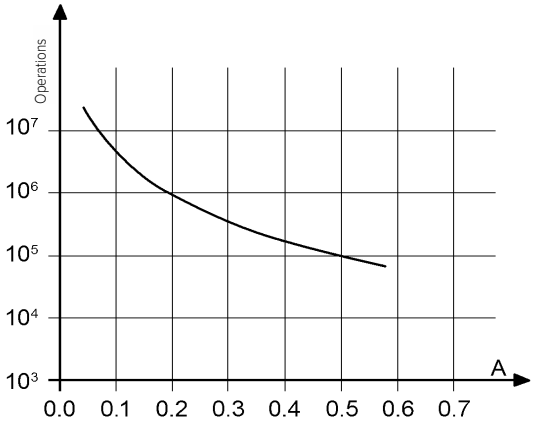



RMB.x7 - RMBZ14

**(*) Models with manual operating lever (optional) are provided with a hole at the front giving access to the lever.**
The position of the data plate holder and the mechanical optical indicator can vary depending on the version.

## ELECTRICAL LIFE EXPECTANCY




**Contact loading: 110Vdc, L/R 40 ms**

**Switching frequency:** 1,200 operations/hour

| U | I (A) | L/R (ms) | Operations |
|---|---|---|---|
| 110Vdc | 0.5 | 40 | 100,000 |
| 110Vdc | 0.6 | 10 | 300,000 |
| 110Vdc | 1 | 40 | 350,000 [1] |
| 120Vdc | 0.7 | 40 | 50,000 |
| 125Vdc | 1.2 | 0 | 1,000,000 |
| 220Vdc | 0.1 | 40 | 100,000 |
| 220Vdc | 0.25 | 10 | 100,000 |
| **U** | **I (A)** | **cosφ** | **Operations** |
| 110Vac | 1 | 1 | 2,000,000 |
| 110Vac | 1 | 0.5 | 1,500,000 |
| 110Vac | 5 | 1 | 1,000,000 |
| 110Vac | 5 | 0.5 | 500,000 |
| 220Vac | 0.5 | 1 | 2,000,000 |
| 220Vac | 1 | 0.5 | 600,000 |
| 220Vac | 5 | 1 | 650,000 |
| 220Vac | 5 | 0.5 | 600,000 |

[1] 2 Series contacts

| SOCKETS AND RETAINING CLIPS | | RMB.x3 - RMBZ12 | RMB.x5 - RMBZ13 | RMB.x7 - RMBZ14 |
|---|---|---|---|---|
| **Type of installation** | **Type of outputs** | **Retaining clip** | | |
| Wall or DIN rail mounting | Screw | PAVM321 | PAVM481 | PAVM801 |
| Flush mounting | Double faston (4.8 x 0.8 mm) | PRDM321 | PRDM481 | PRDM801 |
| | Screw | PRVM321 | PRVM481 | PRVM801 |

## INSTALLATION, OPERATION AND MAINTENANCE

### Installation

Before installing the relay on a wired socket, disconnect the power supply.

The preferential mounting position is on the wall, with the relay positioned horizontally in the “reading orienting” of marking so that the label is readable in the correct sense.

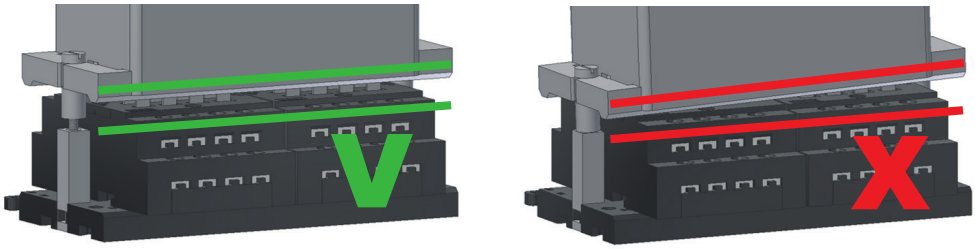
**Spacing:** these relays can be mounted without distance between one relay and the next.

**Mounting of the relay on the socket:**

the relays are equipped at their ends with 2 screws that allow to obtain the correct insertion in the socket and to hold the relay in the correct mounting position.

Place the relay against the socket, making a slight pressure to center the relay terminals over the socket terminals. Screw the two screws progressively and alternately, moving the relay evenly towards the socket.

Avoid screwing/unscrewing completely one screw and then the other one.




### Operation

Before use: if relay is not used, for example after long storage periods, contact resistance may increase due to a natural and slight oxidation or polluting deposits.

In order to restore the optimal conductivity and for standard contacts (NOT gold plated) it is recommended to switch several time a load of at least 110Vdc - 100mA or 24Vdc - 2A. The contacts will be "cleaned" thanks to the electric arc generated during the current interruption and the mechanical self-cleaning action.

The common contact rubs against the fixed poles (NO and NC contacts) both when opening and when closing, which ensures a self-cleaning action.

An increase in contacts' resistance, in most cases, does not represent a problem. Many factors contribute to the correct use of contact and consequently to the relay' long-term reliability:

- **Load:** the current switching generates an electric arc with cleaning effects. For proper electrical cleaning and performance keeping we recommend:
  - o Standard contacts: Minimum current = 20mA (20V)
  - o Gold plated contacts: Minimum current = 10mA (20V)
- **Operating frequency:** relays are components that can operate with a wide range of switching frequency. High frequency operation also allows a continuous cleaning effect by "sliding" (mechanical cleaning). In case of low frequency operation (for example few time a day), we advise:
  - o Use of contact with currents twice compared to those indicated.
  - o For currents lower than 10mA, use gold plated contacts and connect 2 contacts in parallel, in order to reduce the equivalent contact resistance
- **Pollution:** the presence of pollution can cause impurities on contact surface. Electric charges attract organic molecules and impurities that are deposited on the contact surface. Electrical and mechanical cleaning, respectively, burn and remove such impurities. In pollution presence, the minimum recommended currents must be respected. In extreme cases, provide double the cleaning current.

While a contact open high loads, impurities develop inside the relay due to the formation and interruption of the electric arc. These impurities are greater the higher the load and the more frequent the switching operation. These impurities could deposit on the adiacent contacts and alter the initial conductivity characteristics. If all contacts are used with similar loads, this is not a problem.

Please, contact AMRA for further informations.

Condensation is possible inside the relay when energized and the outside ambient temperature is cold; this is quite normal and does not affect the operation of the relay. Plastic materials of relay do not possess hygroscopic properties.

## Maintenance

No maintenance is required.

In case of normal relay wear (reaching the end of electrical or mechanical life), the relay cannot be restored and must be replaced.

**Unmounting of the relay from the socket:**

as for the installation, it is necessary to unscrew the relay on the 2 anchor screws of the product in a progressive and alternating way, extracting the relay evenly from the socket.

Avoid screwing/unscrewing completely one screw and then the other one.

Often the malfunctions are caused by power supply with inverted polarity, by external events or by use with loads exceeding the contact performance.

In case of suspected malfunction, energize relay and observe if mechanical operation of contacts / relay mechanism is performed. Pay attention to the power supply polarity, if relay is equipped with polarized components (example: diode, led).

- In case of expected operation, clean the contacts (see paragraph “OPERATION”) and check if the circuit load ranges within the contact performance. If necessary, replace with relays with gold contacts. Note: the electrical continuity of contacts must be checked with adequate current.
- If it does not work, we recommend to use a relay of the same model and configuration.

If an investigation by AMRA is required, pull-out the relay from the socket, don’t remove the cap, avoid any other manipulation and contact us. You will be asked for the following data: environmental conditions, power supply, switching frequency, contact load, number of operations performed.

The fault can be described through the “TECHNICAL SUPPORT” section of the website www.amra-chauvin-arnoux.it.

In any case, the relay cannot be repaired by the user.

## Storage

Storage conditions must guarantee the environmental conditions (temperature, humidity and pollution) required for the product conservation, in order to avoid deterioration.

The product must be stored in an environment sheltered from atmospheric agents and not polluted, with an ambient temperature between -25 and +70°C with max 75% RH. Humidity can reach peaks of 95%. In any case, there must be no condensation. Before use, please read carefully “OPERATION” section.

ST-GB-666 Ed.04/24 - Non-contractual document - Specifications are to be confirmed at time of ordering and subject to change without notice.

DISTRIBUTION SOLUTIONS

# Medium-voltage fuses
# 3 kV – 40.5 kV, 0.4 A – 315 A




- Continuous protection and reliable operation
- Proven design and compliance with newest fuses standards
- Compatibility with other ABB products

**ABB presents the most effective protective devices – fuses. Our MV fuses are continuously being developed and delivered for more than 90 years.**
**Nowadays, produced in fully automatic process and with greatest care of highest quality and reliable operation fuses are delivered to customers around the world. Millions of ABB MV fuses are now in operation protecting electrical equipment in countless applications.**

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# General information

—
01
Limitation of short--circuit current

The main function of current limiting fuses is to protect electrical apparatus, such as distribution transformers, motors and capacitor banks against overload currents. Fuses can operate as sole devices or can be combined with air/SF6 insulated switch disconnectors. The choice depends on each application requirements and specific network conditions. One of the most critical factors for optimum protection is proper fuse selection. This can be done based on theoretical calculations but in many cases practical knowledge obtained from actual test results could make it easier and even more reliable. ABB, with its extensive apparatus product portfolio, has years of experience in this field. Our current limiting fuses have been designed to ensure safe operation in open air and for limited heat dissipation in installations such as gas insulated switchgears.
Fuse selection principles for the most common situations are presented in the following pages together with common definitions. Moreover we offer our support for each specific case where presented criteria are not sufficient.

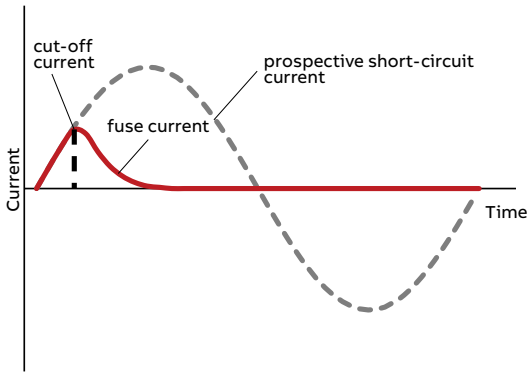
## Definitions
## Current limiting fuses

Current limiting fuse family is generally composed of three different fuse groups:
- back-up fuses
- general-purpose fuses
- full-range fuses

All of them limit the value of prospective short-circuit currents during the interruption process, thereby extending the life time of nearby installed electrical equipment. The main difference is in the minimum breaking current that characterizes the lowest fault current that the fuses are capable of interrupting. This value is generally highest for back-up fuses, slightly smaller for general-purpose fuses and smallest, with the value close to the minimum melting current, for full-range fuses. But reaction time is critical for the protection function. That is why back-up fuses, with an interruption time for the minimum breaking current in the range of a few seconds down to a few tens of milliseconds, are the most commonly used. The total clearing time in cases of high short-circuit currents is even shorter i.e. only a few milliseconds. That is why back-up fuses can be used as typical overload protection elements. General-purpose and full-range fuses capable of interrupting even the smallest values of currents can only be considered as over current devices since the interruption time is greater than one hour. Therefore, these types are used rarely and are usually recognized as a separate element of protection, without any linkage to the opening function of load break switch. ABB current limiting fuses have low minimum breaking currents, i.e. close to three times the rated current $I_r$.

**Current limitation**
All ABB fuse-links presented are current limiting ones. A large short-circuit current will therefore not reach its full value. The cut-off characteristics show the relationship between the prospective short-circuit current and the peak value of the cut-off current. Substantial current limitation results in a considerable reduction in thermal and mechanical stress in a high-voltage installation.

—
01




**Back-up fuses**
All presented in catalog fuse-links are back-up class. That means the operating range in which the fuse-links are able to clear all fault currents is from the minimum breaking current $I_3$ to maximum breaking current $I_1$.

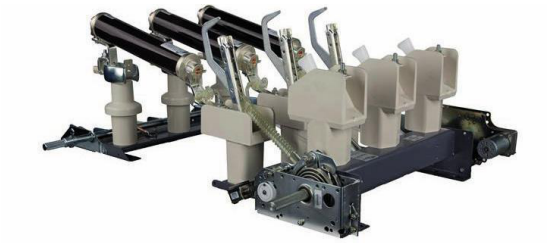
—
02
NALF – switch-fuse combination

—
03
TCU operation diagram

**Switch-fuse combination**

Back-up fuses are commonly used in switch-fuse combinations, both in open air and in gas insulated panels. When a switch-fuse combination operated as a protective device by tripping a system, the fuse assumes two different functions depending on the interrupted current value. When the fault current is greater than the transfer current, the fuse simply extends the breaking capability of the switch ending the interruption operation faster than the incorporated switch. This happens when the fuse clearing time is shorter than the total opening time of the Load Break Switch (LBS). By the time the striker pin pops up, the fuse has already cleared the fault current and the switch opens in almost no load conditions. If the fault currents are less than the nominal transfer current, the fuse then uses the striker pin to activate the switch, which in turn causes the system to trip. In other words, the interruption process is completed by the switch to prevent overloading of the fuses in situations where the fault current is low. Fuses used in switch-fuse combinations have to fulfill conditions specified in IEC 62271-105 (former IEC 60420 and IEC 420). Back-up fuses are specially designed for such application. The use of general-purpose or full-range fuses in switch-fuse combinations are not reasonable due to coordination principles.

—
02



**Temperature Control Unit – TCU**

The Temperature Control Unit is tripping device which is integrated with the striker of high-voltage (HV) fuses. It is activated when the allowable temperature in the switchgear is exceeded. When the temperature is too high the TCU activates the striker by releasing the switch disconnector, which in turn opens the electric circuit and avoids further temperature increases. The high temperatures inside the switchgear interior may be caused by external conditions or by a high current passing through the fuse-link. List of possible reasons of too high temperatures inside fuse compartment:

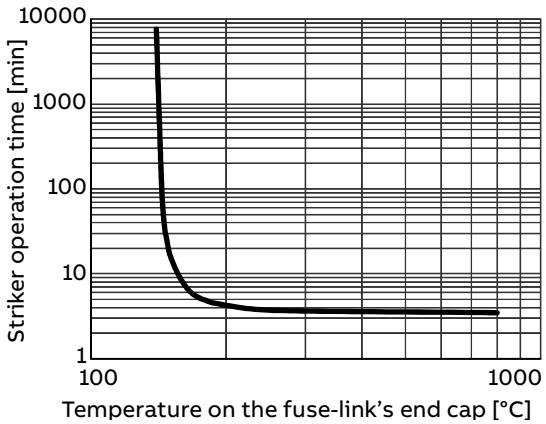
- reduced heat transfer inside the switchgear
- over-heating of degraded conducting contacts
- long-term fuse overloads
- improper selection of the fuse rating
- local melting of fuse elements caused by transformer inrush currents, starting currents of motors etc.

Safety is significantly increased when fuses are equipped with a TCU. This is especially true in devices where fuses are located inside closed fuse compartments, as is the case of SF6 switchgear. In gas insulated switchgear fuse canisters or in narrow panels of air switchgear the risk of overheating is high because cooling is limited. High temperatures in switchgears cause degradation and oxidation of the metal contacts, degradation of switchgear equipment or enclosures, and insulator ageing. Unfavorable effects, i.e. temperature rise inside the switchgear, leads to internal short-circuit and further temperature increases. In case of reaching too high temperature, TCU will be activated, releasing a striker and opening associated switch, thus eliminating the threat. The ABB CEF, CEF-S, CMF and CEF-VT (with striker) are equipped with a TCU as standard design.

Temperature Control Unit features:

- Operation according to diagram presented on Fig. 3
- Operation after approximately one hour at temperature of 150°C on the fuse end-cap
- Withstanding temperatures up to 125°C on the fuse end-cap – without operation
- Withstanding currents not exceeding 110% of fuse rated current – without operation
- Operation time tolerance is ±10% (referred to the temperature)

—
03

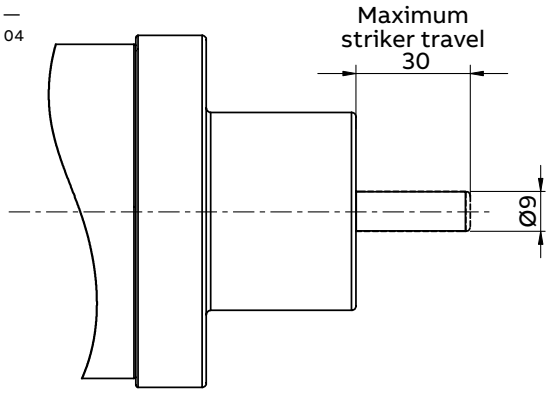



**Indicator and striker pin**

Most of presented in the catalog fuse-links are equipped with a combined indicator and striker system which is activated immediately when the fuse element melts. Information in individual chapters indicate the striker characteristics and its presence or absence for selected type.

—
04
Indicator and striker pin combination, example of design and travel

—
04




—

## General principles for fuse-links selection

**Choice of rated voltage $U_r$:**
The rated voltage of the fuse-links must be equal to, or higher than the operating line voltage.
By choosing the fuse-link rated voltage considerably higher than the line voltage, the maximum arc voltage must not exceed the insulation level of the network.

**Choice of rated current $I_r$:**
To obtain the best possible current limitation and thereby protection, the rated current of fuse-link must be as low as possible compared to the rated current of the object to be protected. However, the following limitations must be taking into consideration:

- the largest load current must not exceed rated current
- cooling conditions (e.g. in compact switchgear)
- inrush current of off load transformers
- starting currents of motor circuits (details in chapter: Fuse-links for motor circuits protection)

**Protection of capacitor banks**
ABB fuses are normally connected in series with capacitor units or banks. They are activated when these units become faulty under normal operating voltages, including the transient voltage as the capacitor are being energized. That is why the chosen fuse-link rated voltage should not be less than 1.1 times that of the rated voltage of the capacitor unit. As recommended in IEC 60549, the rated current of the fuse should be at least 1.43 times that of the capacitor's rated current. In practice it can be distinguished two general cases:

- Only one capacitor bank connected:
  selected rated current ($I_r$) for the fuses should be at least twice the rated current ($I_{rc}$) of the capacitor bank. The rated voltage of fuse-link ($U_r$) should also be at least twice the reated voltage of capacitor ($U_{rc}$).
  $I_r \geq 2 x I_{rc}$
  $U_r \geq 2 x U_{rc}$
  Example: 315 kvar capacitor bank with 10 kV $U_{rc}$.
  $I_{rc}$ = 315 / (10 * √3) = 18.2 A
  Selected fuses: $I_r$ = 40 A; $U_r$ = 24 kV

- More than one capacitor connected in parallel:
  when there is a possibility of reloading i.e. transmitting from a load capacitor bank to the unloaded condition, very high transient currents may occur. The rated current ($I_r$) of the fuses should be selected so that it is more than three times the rated current of capacitor bank ($I_{rc}$). Because a wide variation in transient currents may occur, ABB recommends that the calculation be discussed with the supplier of the capacitors.

**Application in limited heat dissipation conditions**
The setup of interaction between fuses and switch disconnectors in limited heat dissipation conditions can be obtained mainly from practical tests performed under different loading conditions. The maximum allowable power losses should be defined for the fuse so the temperature rise limits are not exceeded according to the referred standard. Therefore, the rated current of fuses with power losses above this limit are de-rated to a safe level. This procedure should be verified by temperature rise and breaking tests of the set.
Above procedure is valid for fuses operating in fuse compartment of switchgears or contactors.

**Replacement of melted fuse-links**
HV fuse-links cannot be regenerated. According to IEC Publication 60282-1, in a three phase system all three fuse-links should be replaced even if only one of them melts. Exceptions are allowed when it can be verified that the fuse-link (s) have not experienced any over current.

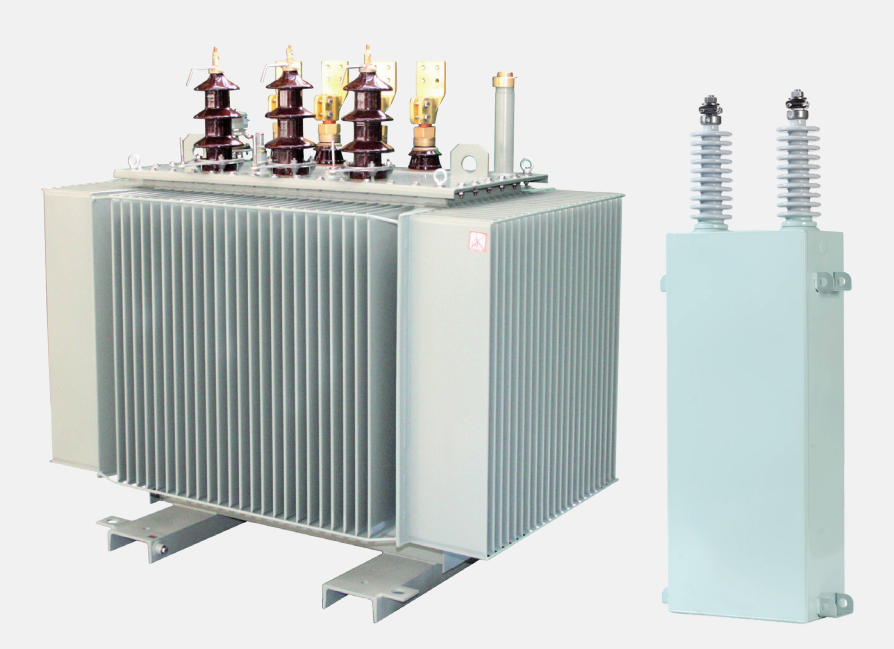
**Fuse selection – detailed procedure**
This catalog is divided into few chapters of various applications of fuse-links. Each of these chapter contains a list of suitable fuses and detailed selection procedure.

# Product list

| Product Group | Rated Voltage [kV] | Rated Current [A] | Class | Length “e” [mm] | Page |
|---|---|---|---|---|---|
| CEF | 3/7.2 | 6.3-125 | Back-up | 192 | 10 |
| CEF | 3/7.2 | 6.3-200 | Back-up | 292 | 10 |
| CEF | 6/12 | 6.3-125 | Back-up | 292 | 10 |
| CEF | 6/12 | 6.3-200 | Back-up | 442 | 10 |
| CEF | 10/17.5 | $6.3\text{-}125_{RC110*}$ | Back-up | 367 | 10 |
| CEF | 10/17.5 | $6.3\text{-}100_{RC87*}$ | Back-up | 292 | 10 |
| CEF | 10/17.5 | 6.3-125 | Back-up | 442 | 10 |
| CEF | 10/24 | $6.3\text{-}125_{RC105*}$ | Back-up | 442 | 10 |
| CEF | 10/24 | 6.3-125 | Back-up | 537 | 10 |
| CEF | 10/25.8 | 40-63 | Back-up | 292 | 10 |
| CEF | 20/36 | 6.3-63 | Back-up | 537 | 10 |
| CEF-S | 6/12 | 10-63 | Back-up „fast“ | 292 | 19 |
| CEF-S | 10/24 | 10-50 | Back-up „fast“ | 442 | 19 |
| CEF-S | 30/40.5 | 6.3-63 | Back-up „fast“ | 537 | 19 |
| CMF | 3.6 | 100-315 | Back-up | 292 | 32 |
| CMF | 7.2 | 63-315 | Back-up | 442 | 32 |
| CMF | 12 | 63-200 | Back-up | 442 | 32 |
| CMF-BS-B | 3.6 | 100-315 | Back-up | 400 | 40 |
| CMF-BS-B | 7.2 | 63-315 | Back-up | 553 | 40 |
| CMF-BS-B | 12 | 63-200 | Back-up | 553 | 40 |
| CMF-BS-C | 3.6 | 100-315 | Back-up | 400 | 40 |
| CMF-BS-C | 7.2 | 63-315 | Back-up | 553 | 40 |
| CMF-BS-C | 12 | 63-200 | Back-up | 553 | 40 |
| CMF-BS-D | 3.6 | 100-315 | Back-up | 419 | 40 |
| CEF-VT | 3/7.2 | 0.5-1 | Back-up | 192/292 | 46 |
| CEF-VT | 6/12 | 0.5-6.3 | Back-up | 192/292 | 46 |
| CEF-VT | 10/17.5 | 0.5-6.3 | Back-up | 192/292 | 46 |
| CEF-VT | 10/24 | 0.5-6.3 | Back-up | 292/442 | 46 |
| WBP, WBP-6 | 7.2 | 0.5-3.15 | Back-up | 210 | 52 |
| WBP, WBP-10 | 12 | 0.5-3.15 | Back-up | 250 | 52 |
| WBP, WBP-20 | 24 | 0.5-3.15 | Back-up | 310 | 52 |
| WBP, WBP-30 | 36 | 0.4-3.15 | Back-up | 385 | 52 |
| WBP | 40.5 | 2, 4 | Back-up | 440 | 52 |

* for fuses with rated current marked with RC (i.e. 125RC110A), maximum application continuous current should not exceed RC value indicated in subscript

# Fuse-links for transformer and capacitor protection



**010** – 018 **CEF** – Essential fuse-links for distribution transformers and capacitor protection

**019** – 025 **CEF-S** – Fast-acting fuse-links for protection of distribution transformers

# CEF

## Essential fuse-links for distribution transformers and capacitor protection

| | |
|---|---|
| **Class, type** | Back-up, current limiting fuse-link |
| **Rated voltages** | 3/7.2 kV – 20/36 kV |
| **Rated currents** | 6.3 A – 200 A |
| **Rated frequency** | 50 Hz |
| **Applicable standard** | IEC 60282-1, VDE 0670-T4 and VDE 0670-T402 |
| **Application** | Indoor/outdoor |
| **Striker** | 80 N (medium), with integrated TCU |



**Lower power losses by average level of 20 % comparing to previous design, generating additional savings during product life-cycle**

**Continuous protection and reliable operation guaranteed by robust design and compliance with newest IEC standards**

**Compatibility with other ABB products provides fast and accurate product selection**

**Outdoor sealing included in standard version, designed and tested for harsh conditions**

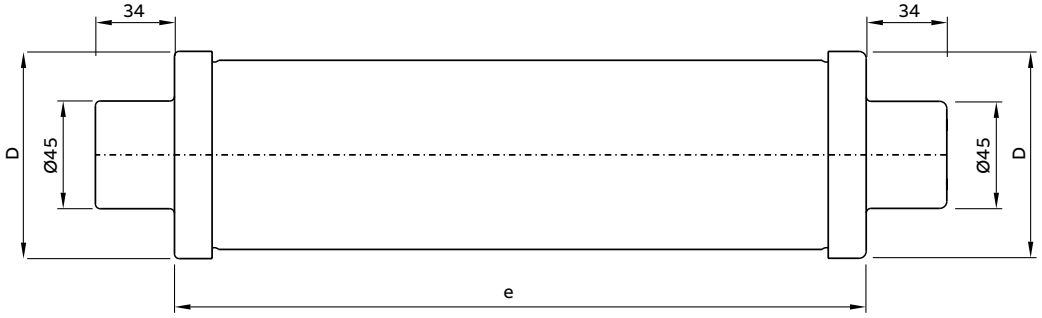
**Fuse-links type CEF are designed to protect distribution transformers, cables, overhead lines and other apparatus against thermal and dynamic effects of short-circuit currents.**

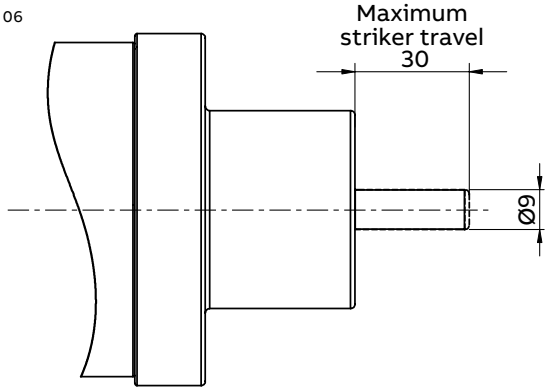
**Key features:**

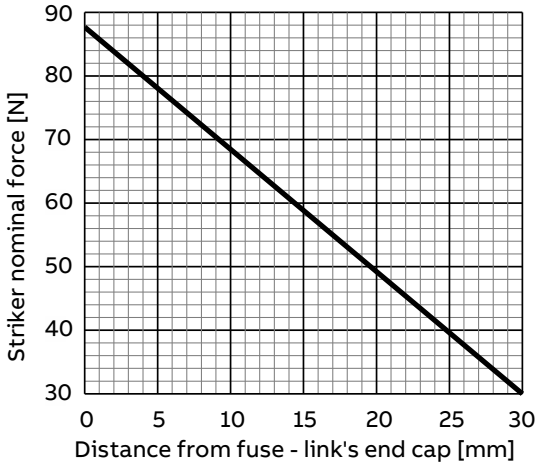
- Rated voltages 3/7.2 kV – 20/36 kV with rated currents of 6.3 A – 200 A
- For indoor and outdoor applications
- Designed and type tested acc. to IEC 602821, VDE 0670-T4 and VDE 0670-T402
- Top level fault current limitation and interruption performance up to 63kA RMS
- Striker 80 N (medium type)
- Equipped with Temperature Control Unit enabling the additional protection against thermal stresses in small enclosures

05
Dimensional drawing of fuse-link type CEF

06
Fuse-link striker force and dimensions




**Ordering and technical table**

| Catalog number | Fuse name | Rated voltage $U_r$ [kV] | Rated current $I_r$ [A] | Rated frequency $f_r$ [Hz] | Breaking capacity $I_1$ [kA] | Minimal breaking current $I_3$ [A] | Diameter D [mm] | Length e [mm] | Rated power $P_w$ [W] | Cold resistance [mΩ] | Pre-arcing integral [$A^2s$] | Total interrupting integral [$A^2s$] | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1YMB710713M1512 | CEF | 3/7.2 | 6.3 | 50 | 63 | 48 | 53 | 192 | 9 | 186.4 | 4.5 | 560 | 1.2 | 5908270806887 |
| 1YMB710716M1512 | CEF | 3/7.2 | 10 | 50 | 63 | 43 | 53 | 192 | 12 | 96.6 | 24 | 1 800 | 1.2 | 5908270806894 |
| 1YMB710718M1512 | CEF | 3/7.2 | 16 | 50 | 63 | 72 | 53 | 192 | 18 | 59.5 | 135 | 6 060 | 1.2 | 5908270806900 |
| 1YMB710719M1512 | CEF | 3/7.2 | 20 | 50 | 63 | 72 | 53 | 192 | 20 | 39.8 | 265 | 10 300 | 1.2 | 5908270806917 |
| 1YMB710721M1512 | CEF | 3/7.2 | 25 | 50 | 63 | 110 | 53 | 192 | 17 | 22.8 | 490 | 17 000 | 1.2 | 5908270806924 |
| 1YMB710724M1512 | CEF | 3/7.2 | 31.5 | 50 | 63 | 115 | 53 | 192 | 23 | 17.1 | 890 | 29 000 | 1.2 | 5908270806931 |
| 1YMB710725M1512 | CEF | 3/7.2 | 40 | 50 | 63 | 143.5 | 53 | 192 | 31 | 14.1 | 1600 | 49 000 | 1.2 | 5908270806948 |
| 1YMB710727M1512 | CEF | 3/7.2 | 50 | 50 | 63 | 215 | 53 | 192 | 32 | 9.4 | 3375 | 99 000 | 1.2 | 5908270806955 |
| 1YMB710729M1612 | CEF | 3/7.2 | 63 | 50 | 63 | 220 | 65 | 192 | 43 | 7.7 | 5150 | 106 000 | 1.6 | 5908270806962 |
| 1YMB710731M1612 | CEF | 3/7.2 | 80 | 50 | 63 | 320 | 65 | 192 | 47 | 5.0 | 7040 | 215 000 | 1.6 | 5908270806979 |
| 1YMB710733M1612 | CEF | 3/7.2 | 100 | 50 | 63 | 380 | 65 | 192 | 62 | 3.9 | 10300 | 319 000 | 1.6 | 5908270806986 |
| 1YMB710735M1812 | CEF | 3/7.2 | 125 | 50 | 63 | 380 | 87 | 192 | 81 | 3.3 | 17200 | 472 000 | 2.6 | 5908270806993 |
| 1YMB710713M2512 | CEF | 3/7.2 | 6.3 | 50 | 63 | 48 | 53 | 292 | 9 | 186.4 | 4.5 | 560 | 1.6 | 5908270807006 |
| 1YMB710716M2512 | CEF | 3/7.2 | 10 | 50 | 63 | 43 | 53 | 292 | 12 | 96.6 | 24 | 1 800 | 1.6 | 5908270807013 |
| 1YMB710718M2512 | CEF | 3/7.2 | 16 | 50 | 63 | 72 | 53 | 292 | 18 | 57.3 | 135 | 6 060 | 1.6 | 5908270807020 |
| 1YMB710719M2512 | CEF | 3/7.2 | 20 | 50 | 63 | 72 | 53 | 292 | 20 | 39.1 | 265 | 10 300 | 1.6 | 5908270807037 |
| 1YMB710721M2512 | CEF | 3/7.2 | 25 | 50 | 63 | 110 | 53 | 292 | 17 | 22.8 | 490 | 17 000 | 1.6 | 5908270807044 |
| 1YMB710724M2512 | CEF | 3/7.2 | 31.5 | 50 | 63 | 115 | 53 | 292 | 23 | 17.1 | 890 | 29 000 | 1.6 | 5908270807051 |
| 1YMB710725M2512 | CEF | 3/7.2 | 40 | 50 | 63 | 143.5 | 53 | 292 | 31 | 14.1 | 1600 | 49 000 | 1.6 | 5908270807068 |
| 1YMB710727M2512 | CEF | 3/7.2 | 50 | 50 | 63 | 215 | 53 | 292 | 32 | 9.4 | 3375 | 99 000 | 1.6 | 5908270807075 |
| 1YMB710729M2612 | CEF | 3/7.2 | 63 | 50 | 63 | 220 | 65 | 292 | 43 | 7.7 | 5150 | 106 000 | 2.3 | 5908270807082 |
| 1YMB710731M2612 | CEF | 3/7.2 | 80 | 50 | 63 | 320 | 65 | 292 | 47 | 5.0 | 7040 | 215 000 | 2.3 | 5908270807099 |
| 1YMB710733M2612 | CEF | 3/7.2 | 100 | 50 | 63 | 380 | 65 | 292 | 62 | 3.9 | 10300 | 319 000 | 2.3 | 5908270807105 |
| 1YMB710735M2812 | CEF | 3/7.2 | 125 | 50 | 63 | 380 | 87 | 292 | 81 | 3.3 | 17200 | 472 000 | 3.6 | 5908270807112 |

| Catalog number | Fuse name | Rated voltage $U_r$ [kV] | Rated current $I_r$ [A] | Rated frequency $f_r$ [Hz] | Breaking capacity $I_1$ [kA] | Minimal breaking current $I_3$ [A] | Diameter D [mm] | Length e [mm] | Rated power $P_w$ [W] | Cold resistance [mΩ] | Pre-arcing integral [A²s] | Total interrupting integral [A²s] | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1YMB710738M2812 | CEF | 3/7.2 | 160 | 50 | 50 | 480 | 87 | 292 | 103 | 2.6 | 35000 | 430 000 | 3.6 | 5908270807129 |
| 1YMB710739M2812 | CEF | 3/7.2 | 200 | 50 | 50 | 650 | 87 | 292 | 109 | 1.7 | 76000 | 750 000 | 3.6 | 5908270807488 |
| 1YMB711213M2512 | CEF | 6/12 | 6.3 | 50 | 63 | 44 | 53 | 292 | 17 | 332.1 | 4.5 | 560 | 1.6 | 5908270806269 |
| 1YMB711216M2512 | CEF | 6/12 | 10 | 50 | 63 | 43.5 | 53 | 292 | 18 | 151.0 | 24 | 1 800 | 1.6 | 5908270806276 |
| 1YMB711218M2512 | CEF | 6/12 | 16 | 50 | 63 | 72.5 | 53 | 292 | 29 | 90.4 | 135 | 6 060 | 1.6 | 5908270806283 |
| 1YMB711219M2512 | CEF | 6/12 | 20 | 50 | 63 | 72.5 | 53 | 292 | 31 | 61.7 | 265 | 10 300 | 1.6 | 5908270806290 |
| 1YMB711221M2512 | CEF | 6/12 | 25 | 50 | 63 | 104 | 53 | 292 | 28 | 35.3 | 490 | 17 000 | 1.6 | 5908270806306 |
| 1YMB711224M2512 | CEF | 6/12 | 31.5 | 50 | 63 | 116 | 53 | 292 | 34 | 27.0 | 890 | 29 000 | 1.6 | 5908270806313 |
| 1YMB711225M2512 | CEF | 6/12 | 40 | 50 | 63 | 150 | 53 | 292 | 51 | 22.3 | 1600 | 49 000 | 1.6 | 5908270806320 |
| 1YMB711227M2612 | CEF | 6/12 | 50 | 50 | 63 | 200 | 65 | 292 | 48 | 14.8 | 3375 | 99 000 | 2.3 | 5908270806337 |
| 1YMB711229M2612 | CEF | 6/12 | 63 | 50 | 63 | 218 | 65 | 292 | 63 | 12.2 | 5150 | 106 000 | 2.3 | 5908270806344 |
| 1YMB711231M2612 | CEF | 6/12 | 80 | 50 | 63 | 330 | 65 | 292 | 72 | 8.0 | 7040 | 215 000 | 2.3 | 5908270806351 |
| 1YMB711233M2612 | CEF | 6/12 | 100 | 50 | 63 | 375 | 65 | 292 | 93 | 6.5 | 10300 | 319 000 | 2.3 | 5908270806368 |
| 1YMB711235M2812 | CEF | 6/12 | 125 | 50 | 63 | 375 | 87 | 292 | 124 | 5.3 | 17200 | 472 000 | 3.6 | 5908270806375 |
| 1YMB711213M4512 | CEF | 6/12 | 6.3 | 50 | 63 | 44 | 53 | 442 | 17 | 332.1 | 4.5 | 560 | 2.3 | 5908270806382 |
| 1YMB711216M4512 | CEF | 6/12 | 10 | 50 | 63 | 43.5 | 53 | 442 | 18 | 151.0 | 24 | 1 800 | 2.3 | 5908270806399 |
| 1YMB711218M4512 | CEF | 6/12 | 16 | 50 | 63 | 72.5 | 53 | 442 | 29 | 90.4 | 135 | 6 060 | 2.3 | 5908270806405 |
| 1YMB711219M4512 | CEF | 6/12 | 20 | 50 | 63 | 72.5 | 53 | 442 | 31 | 61.7 | 265 | 10 300 | 2.3 | 5908270806412 |
| 1YMB711221M4512 | CEF | 6/12 | 25 | 50 | 63 | 104 | 53 | 442 | 28 | 35.3 | 490 | 17 000 | 2.3 | 5908270806429 |
| 1YMB711224M4512 | CEF | 6/12 | 31.5 | 50 | 63 | 116 | 53 | 442 | 34 | 27.0 | 890 | 29 000 | 2.3 | 5908270806436 |
| 1YMB711225M4512 | CEF | 6/12 | 40 | 50 | 63 | 150 | 53 | 442 | 51 | 22.3 | 1600 | 49 000 | 2.3 | 5908270806443 |
| 1YMB711227M4612 | CEF | 6/12 | 50 | 50 | 63 | 200 | 65 | 442 | 48 | 14.8 | 3375 | 99 000 | 3.3 | 5908270806450 |
| 1YMB711229M4612 | CEF | 6/12 | 63 | 50 | 63 | 218 | 65 | 442 | 63 | 12.2 | 5150 | 106 000 | 3.3 | 5908270806467 |
| 1YMB711231M4612 | CEF | 6/12 | 80 | 50 | 63 | 330 | 65 | 442 | 72 | 8.0 | 7040 | 215 000 | 3.3 | 5908270806474 |
| 1YMB711233M4612 | CEF | 6/12 | 100 | 50 | 63 | 375 | 65 | 442 | 93 | 6.5 | 10300 | 319 000 | 3.3 | 5908270806481 |
| 1YMB711235M4612 | CEF | 6/12 | 125 | 50 | 63 | 375 | 65 | 442 | 124 | 5.3 | 17200 | 472 000 | 3.3 | 5908270807877 |
| 1YMB711238M4812 | CEF | 6/12 | 160 | 50 | 63 | 480 | 87 | 442 | 170 | 4.0 | 35000 | 430 000 | 5.3 | 5908270806504 |
| 1YMB711239M4812 | CEF | 6/12 | 200 | 50 | 63 | 700 | 87 | 442 | 166 | 2.7 | 90000 | 860 000 | 5.3 | 5908270806511 |
| 1YMB711713M2512 | CEF | 10/17.5 | 6.3 | 50 | 63 | 44 | 53 | 292 | 23 | 465.2 | 4.5 | 560 | 1.6 | 5908270807136 |
| 1YMB711716M2512 | CEF | 10/17.5 | 10 | 50 | 63 | 46 | 53 | 292 | 26 | 213.0 | 24 | 1 800 | 1.6 | 5908270807143 |
| 1YMB711718M2512 | CEF | 10/17.5 | 16 | 50 | 63 | 76.5 | 53 | 292 | 43 | 130.6 | 135 | 6 060 | 1.6 | 5908270807150 |
| 1YMB711719M2512 | CEF | 10/17.5 | 20 | 50 | 63 | 76.5 | 53 | 292 | 46 | 87.4 | 265 | 10 300 | 1.6 | 5908270807167 |
| 1YMB711721M2512 | CEF | 10/17.5 | 25 | 50 | 63 | 110 | 53 | 292 | 40 | 49.8 | 490 | 17 000 | 1.6 | 5908270807174 |
| 1YMB711724M2612 | CEF | 10/17.5 | 31.5 | 50 | 63 | 122 | 65 | 292 | 49 | 37.4 | 890 | 29 000 | 2.3 | 5908270807181 |
| 1YMB711725M2612 | CEF | 10/17.5 | 40 | 50 | 63 | 160 | 65 | 292 | 70 | 28.4 | 1600 | 49 000 | 2.3 | 5908270807198 |
| 1YMB711727M2812 | CEF | 10/17.5 | 50 | 50 | 63 | 205 | 87 | 292 | 69 | 20.5 | 3375 | 99 000 | 3.6 | 5908270807204 |
| 1YMB711729M2812 | CEF | 10/17.5 | 63 | 50 | 63 | 218 | 87 | 292 | 92 | 16.8 | 5150 | 106 000 | 3.6 | 5908270807211 |
| 1YMB711731M2812 | CEF | 10/17.5 | 80 | 50 | 63 | 330 | 87 | 292 | 110 | 11.0 | 7040 | 215 000 | 3.6 | 5908270807228 |
| 1YMB711733M2812 | CEF | 10/17.5 | $100_{RC87}$ | 50 | 63 | 380 | 87 | 292 | 100 | 8.8 | 10300 | 319 000 | 3.6 | 5908270807235 |
| 1YMB711713M3512 | CEF | 10/17.5 | 6.3 | 50 | 63 | 44 | 53 | 367 | 23 | 465.2 | 4.5 | 560 | 1.9 | 5908270807242 |
| 1YMB711716M3512 | CEF | 10/17.5 | 10 | 50 | 63 | 46 | 53 | 367 | 26 | 213.0 | 24 | 1 800 | 1.9 | 5908270807259 |
| 1YMB711718M3512 | CEF | 10/17.5 | 16 | 50 | 63 | 76.5 | 53 | 367 | 43 | 130.6 | 135 | 6 060 | 1.9 | 5908270807266 |
| 1YMB711719M3512 | CEF | 10/17.5 | 20 | 50 | 63 | 76.5 | 53 | 367 | 46 | 87.4 | 265 | 10 300 | 1.9 | 5908270807273 |
| 1YMB711721M3512 | CEF | 10/17.5 | 25 | 50 | 63 | 110 | 53 | 367 | 40 | 49.8 | 490 | 17 000 | 1.9 | 5908270807280 |
| 1YMB711724M3512 | CEF | 10/17.5 | 31.5 | 50 | 63 | 122 | 53 | 367 | 49 | 37.4 | 890 | 29 000 | 1.9 | 5908270807297 |
| 1YMB711725M3512 | CEF | 10/17.5 | 40 | 50 | 63 | 160 | 53 | 367 | 70 | 28.4 | 1600 | 49 000 | 1.9 | 5908270807303 |
| 1YMB711727M3612 | CEF | 10/17.5 | 50 | 50 | 63 | 205 | 65 | 367 | 69 | 20.5 | 3375 | 99 000 | 2.7 | 5908270807310 |
| 1YMB711729M3612 | CEF | 10/17.5 | 63 | 50 | 63 | 218 | 65 | 367 | 92 | 16.8 | 5150 | 106 000 | 2.7 | 5908270807327 |
| 1YMB711731M3612 | CEF | 10/17.5 | 80 | 50 | 63 | 330 | 65 | 367 | 110 | 11.0 | 7040 | 215 000 | 2.7 | 5908270807334 |
| 1YMB711733M3812 | CEF | 10/17.5 | 100 | 50 | 63 | 380 | 87 | 367 | 137 | 8.8 | 10300 | 319 000 | 4.4 | 5908270807341 |
| 1YMB711735M3812 | CEF | 10/17.5 | $125_{RC110}$ | 50 | 63 | 380 | 87 | 367 | 140 | 7.4 | 17200 | 472 000 | 4.4 | 5908270807358 |
| 1YMB711713M4512 | CEF | 10/17.5 | 6.3 | 50 | 63 | 44 | 53 | 442 | 23 | 465.2 | 4.5 | 560 | 2.3 | 5908270807365 |
| 1YMB711716M4512 | CEF | 10/17.5 | 10 | 50 | 63 | 46 | 53 | 442 | 26 | 213.0 | 24 | 1 800 | 2.3 | 5908270807372 |

| Catalog number | Fuse name | Rated voltage $U_r$ [kV] | Rated current $I_r$ [A] | Rated frequency $f_r$ [Hz] | Breaking capacity $I_1$ [kA] | Minimal breaking current $I_3$ [A] | Diameter D [mm] | Length e [mm] | Rated power $P_w$ [W] | Cold resistance [mΩ] | Pre-arcing integral [$A^2s$] | Total interrupting integral [$A^2s$] | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1YMB711718M4512 | CEF | 10/17.5 | 16 | 50 | 63 | 76.5 | 53 | 442 | 43 | 130.6 | 135 | 6 060 | 2.3 | 5908270807389 |
| 1YMB711719M4512 | CEF | 10/17.5 | 20 | 50 | 63 | 76.5 | 53 | 442 | 46 | 87.4 | 265 | 10 300 | 2.3 | 5908270807396 |
| 1YMB711721M4512 | CEF | 10/17.5 | 25 | 50 | 63 | 110 | 53 | 442 | 40 | 49.8 | 490 | 17 000 | 2.3 | 5908270807402 |
| 1YMB711724M4512 | CEF | 10/17.5 | 31.5 | 50 | 63 | 122 | 53 | 442 | 49 | 37.4 | 890 | 29 000 | 2.3 | 5908270807419 |
| 1YMB711725M4512 | CEF | 10/17.5 | 40 | 50 | 63 | 160 | 53 | 442 | 70 | 28.4 | 1600 | 49 000 | 2.3 | 5908270807426 |
| 1YMB711727M4612 | CEF | 10/17.5 | 50 | 50 | 63 | 205 | 65 | 442 | 69 | 20.5 | 3375 | 99 000 | 3.3 | 5908270807433 |
| 1YMB711729M4612 | CEF | 10/17.5 | 63 | 50 | 63 | 218 | 65 | 442 | 92 | 16.8 | 5150 | 106 000 | 3.3 | 5908270807440 |
| 1YMB711731M4612 | CEF | 10/17.5 | 80 | 50 | 63 | 330 | 65 | 442 | 110 | 11.2 | 7040 | 215 000 | 3.3 | 5908270807457 |
| 1YMB711733M4612 | CEF | 10/17.5 | 100 | 50 | 63 | 380 | 65 | 442 | 136 | 8.5 | 10300 | 319 000 | 3.3 | 5908270807464 |
| 1YMB711735M4812 | CEF | 10/17.5 | 125 | 50 | 63 | 380 | 87 | 442 | 183 | 7.4 | 17200 | 472 000 | 5.3 | 5908270807471 |
| 1YMB712413M4512 | CEF | 10/24 | 6.3 | 50 | 63 | 43 | 53 | 442 | 28 | 572.6 | 4.5 | 560 | 2.3 | 5908270806542 |
| 1YMB712416M4512 | CEF | 10/24 | 10 | 50 | 63 | 46 | 53 | 442 | 33 | 272.2 | 24 | 1 800 | 2.3 | 5908270806559 |
| 1YMB712418M4512 | CEF | 10/24 | 16 | 50 | 63 | 76.5 | 53 | 442 | 55 | 168.9 | 135 | 6 060 | 2.3 | 5908270806566 |
| 1YMB712419M4512 | CEF | 10/24 | 20 | 50 | 63 | 76.5 | 53 | 442 | 59 | 112.5 | 265 | 10 300 | 2.3 | 5908270806573 |
| 1YMB712421M4512 | CEF | 10/24 | 25 | 50 | 63 | 110 | 53 | 442 | 57 | 64.8 | 490 | 17 000 | 2.3 | 5908270806580 |
| 1YMB712424M4512 | CEF | 10/24 | 31.5 | 50 | 63 | 122 | 53 | 442 | 65 | 48.9 | 890 | 29 000 | 2.3 | 5908270806597 |
| 1YMB712425M4512 | CEF | 10/24 | 40 | 50 | 63 | 160 | 53 | 442 | 89 | 40.2 | 1600 | 49 000 | 2.3 | 5908270806603 |
| 1YMB712427M4612 | CEF | 10/24 | 50 | 50 | 63 | 205 | 65 | 442 | 92 | 27.0 | 3375 | 99 000 | 3.3 | 5908270806610 |
| 1YMB712429M4612 | CEF | 10/24 | 63 | 50 | 63 | 215 | 65 | 442 | 127 | 21.9 | 5150 | 106 000 | 3.3 | 5908270806627 |
| 1YMB712431M4612 | CEF | 10/24 | 80 | 50 | 63 | 325 | 65 | 442 | 152 | 15.6 | 7040 | 215 000 | 3.3 | 5908270806634 |
| 1YMB712433M4812 | CEF | 10/24 | 100 | 50 | 63 | 375 | 87 | 442 | 200 | 12.9 | 10300 | 319 000 | 5.3 | 5908270806641 |
| 1YMB712435M4812 | CEF | 10/24 | $125_{RC105}$ | 50 | 40 | 380 | 87 | 442 | 173 | 10.5 | 17200 | 472 000 | 5.3 | 5908270807860 |
| 1YMB712413M5512 | CEF | 10/24 | 6.3 | 50 | 63 | 43 | 53 | 537 | 28 | 572.6 | 4.5 | 560 | 3.1 | 5908270806672 |
| 1YMB712416M5512 | CEF | 10/24 | 10 | 50 | 63 | 46 | 53 | 537 | 33 | 272.2 | 24 | 1 800 | 3.1 | 5908270806689 |
| 1YMB712418M5512 | CEF | 10/24 | 16 | 50 | 63 | 76.5 | 53 | 537 | 55 | 168.9 | 135 | 6 060 | 3.1 | 5908270806696 |
| 1YMB712419M5512 | CEF | 10/24 | 20 | 50 | 63 | 76.5 | 53 | 537 | 59 | 112.5 | 265 | 10 300 | 3.1 | 5908270806702 |
| 1YMB712421M5512 | CEF | 10/24 | 25 | 50 | 63 | 110 | 53 | 537 | 57 | 64.8 | 490 | 17 000 | 3.1 | 5908270806719 |
| 1YMB712424M5512 | CEF | 10/24 | 31.5 | 50 | 63 | 122 | 53 | 537 | 65 | 48.9 | 890 | 29 000 | 3.1 | 5908270806726 |
| 1YMB712425M5512 | CEF | 10/24 | 40 | 50 | 63 | 160 | 53 | 537 | 89 | 40.2 | 1600 | 49 000 | 3.1 | 5908270806733 |
| 1YMB712427M5612 | CEF | 10/24 | 50 | 50 | 63 | 205 | 65 | 537 | 92 | 27.0 | 3375 | 99 000 | 3.9 | 5908270806740 |
| 1YMB712429M5612 | CEF | 10/24 | 63 | 50 | 63 | 215 | 65 | 537 | 127 | 21.9 | 5150 | 106 000 | 3.9 | 5908270806757 |
| 1YMB712431M5612 | CEF | 10/24 | 80 | 50 | 63 | 325 | 65 | 537 | 152 | 15.6 | 7040 | 215 000 | 3.9 | 5908270806764 |
| 1YMB712433M5812 | CEF | 10/24 | 100 | 50 | 63 | 375 | 87 | 537 | 200 | 12.9 | 10300 | 319 000 | 6.4 | 5908270806771 |
| 1YMB712435M5812 | CEF | 10/24 | 125 | 50 | 63 | 375 | 87 | 537 | 234 | 10.6 | 17200 | 472 000 | 6.4 | 5908270806788 |
| 1YMB712525M2811 | CEF | 10/25.8 | 40 | 50 | 16 | 119 | 87 | 292 | 91 | 40.2 | 1446 | 32 538 | 3.6 | 5908270806238 |
| 1YMB712527M2811 | CEF | 10/25.8 | 50 | 50 | 16 | 191 | 87 | 292 | 93 | 26.0 | 4339 | 85 791 | 3.6 | 5908270806245 |
| 1YMB712529M2811 | CEF | 10/25.8 | 63 | 50 | 16 | 278 | 87 | 292 | 97 | 17.2 | 8099 | 155 020 | 3.6 | 5908270806252 |
| 1YMB713613M5512 | CEF | 20/36 | 6.3 | 50 | 40 | 37 | 53 | 537 | 47 | 925.0 | 4.5 | 560 | 3.1 | 5908270806795 |
| 1YMB713616M5512 | CEF | 20/36 | 10 | 50 | 40 | 37.5 | 53 | 537 | 50 | 413.6 | 24 | 1 800 | 3.1 | 5908270806801 |
| 1YMB713618M5512 | CEF | 20/36 | 16 | 50 | 40 | 59 | 53 | 537 | 85 | 254.0 | 135 | 6 060 | 3.1 | 5908270806818 |
| 1YMB713619M5512 | CEF | 20/36 | 20 | 50 | 40 | 62.5 | 53 | 537 | 88 | 162.3 | 265 | 10 300 | 3.1 | 5908270806825 |
| 1YMB713621M5512 | CEF | 20/36 | 25 | 50 | 40 | 100 | 53 | 537 | 87 | 104.0 | 490 | 17 000 | 3.1 | 5908270806832 |
| 1YMB713624M5612 | CEF | 20/36 | 31.5 | 50 | 40 | 158 | 65 | 537 | 118 | 84.0 | 1050 | 20 700 | 3.9 | 5908270806849 |
| 1YMB713625M5612 | CEF | 20/36 | 40 | 50 | 40 | 164 | 65 | 537 | 135 | 57.7 | 1850 | 39 000 | 3.9 | 5908270806856 |
| 1YMB713627M5812 | CEF | 20/36 | 50 | 50 | 40 | 230 | 87 | 537 | 157 | 43.5 | 4040 | 99 600 | 6.4 | 5908270806863 |
| 1YMB713629M5812 | CEF | 20/36 | 63 | 50 | 40 | 299 | 87 | 537 | 225 | 36.6 | 5800 | 89 500 | 6.4 | 5908270806870 |

for fuses with rated current marked with RC (i.e. 125RC110A), maximum application continuous current should not exceed RC value indicated in subscript

**Choice of fuse-links for transformer protection:**

| Line voltage (kV) | Transformer rating (kVA) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | 50 | 75 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3000 |
| | Fuse-link $I_r$ (A) | | | | | | | | | | | | | | | | | | |
| 3 | 10 | 20 | 25 | 31.5 | 40 | 50 | 50 | 63 | 100 | 125 | 160 | 160 | 200 | 250[3] | 315[3] | | | | |
| 5 | 10 | 16 | 20 | 20 | 25 | 31.5 | 31.5 | 50 | 50 | 63 | 100 | 100 | 125 | 160 | 200 | 250[3] | 315[3] | | |
| 6 | 6.3 | 10 | 16 | 20 | 20 | 25 | 31.5 | 40 | 50 | 50 | 63 | 100 | 100 | 125 | 160 | 200 | 250[3] | 315[3] | |
| 10 | 4[2] | 10 | 10 | 16 | 16 | 20 | 20 | 25 | 31.5 | 31.5 | 50 | 50 | 63 | 80 | 100 | 125 | 160 | 200 | |
| 12 | 2.5[2] | 6.3 | 10 | 10 | 16 | 16 | 20 | 20 | 25 | 31.5 | 40 | 50 | 50 | 63 | 80 | 100 | 125 | 160 | 200 |
| 15 | 2.5[2] | 6.3 | 10 | 10 | 10 | 16 | 16 | 20 | 20 | 25 | 31.5 | 40 | 40 | 50 | 63 | 80 | 100 | 125 | |
| 20 | 2[1,2] | 4[2] | 6.3 | 10 | 10 | 10 | 16 | 16 | 20 | 20 | 25 | 31.5 | 31.5 | 40 | 50 | 63 | 80 | 100 | 125 |
| 24 | 2[1,2] | 2.5[2] | 6.3 | 6.3 | 10 | 10 | 10 | 16 | 16 | 20 | 20 | 25 | 25 | 31.5 | 40 | 50 | 63 | 80 | 100 |
| 27 | 6.3[1] | 6.3[1] | 6.3 | 6.3 | 6.3 | 10 | 10 | 10 | 16 | 16 | 20 | 20 | 25 | 31.5 | 40 | 50 | 63 | | |
| 30 | 6.3[1] | 6.3[1] | 6.3[1] | 6.3 | 6.3 | 6.3 | 10 | 10 | 10 | 16 | 20 | 20 | 20 | 25 | 31.5 | 40 | 50 | 63 | |
| 36 | 6.3[1] | 6.3[1] | 6.3[1] | 6.3 | 6.3 | 6.3 | 10 | 10 | 10 | 16 | 16 | 20 | 20 | 25 | 31.5 | 40 | 50 | 63 | 63 |

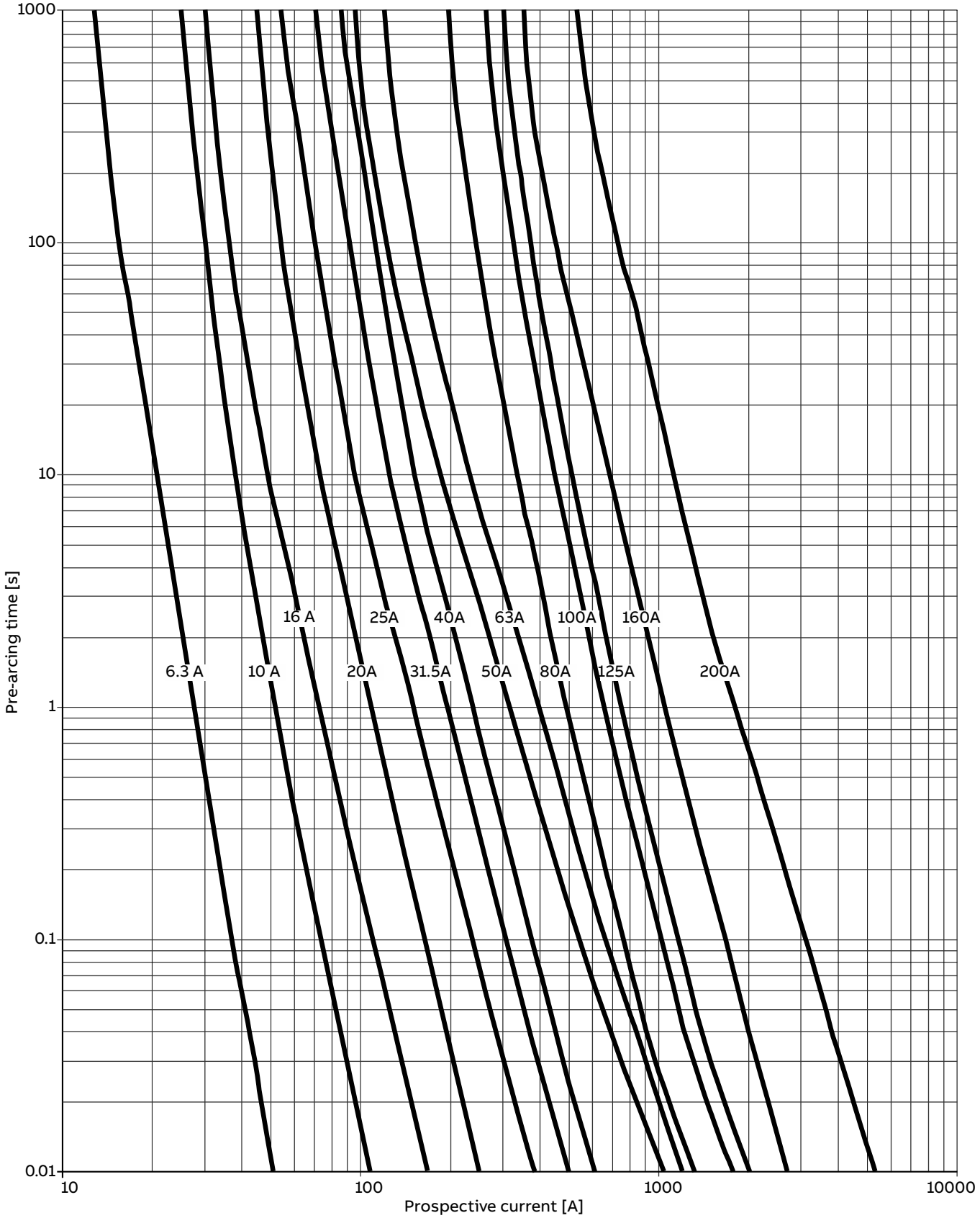
[1] – fuse is not able to clear independently transformer's secondary side terminals short-circuit current; [2] – fuse type CEF-VT; [3] – fuse type CMF

Recommended fuse rating is on the crossing of transformer rating and line voltage. For different line voltage level, please use closest smaller value from the table. The table was calculated according to standards IEC 60787 and IEC 62271-105 with following assumptions:

- Maximum long lasting transformer current overload – 120%
- Magnetizing transformer inrush current – 12 x $I_r$ during 100ms (up to 800 kVA) or 10 x $I_r$ during 100ms (800 kVA and above)
- Transformer short-circuit voltage according to IEC 60076-5
- No fuse derating due to small enclosures assumed

For different working conditions fuse selection has to be recalculated.

—
07

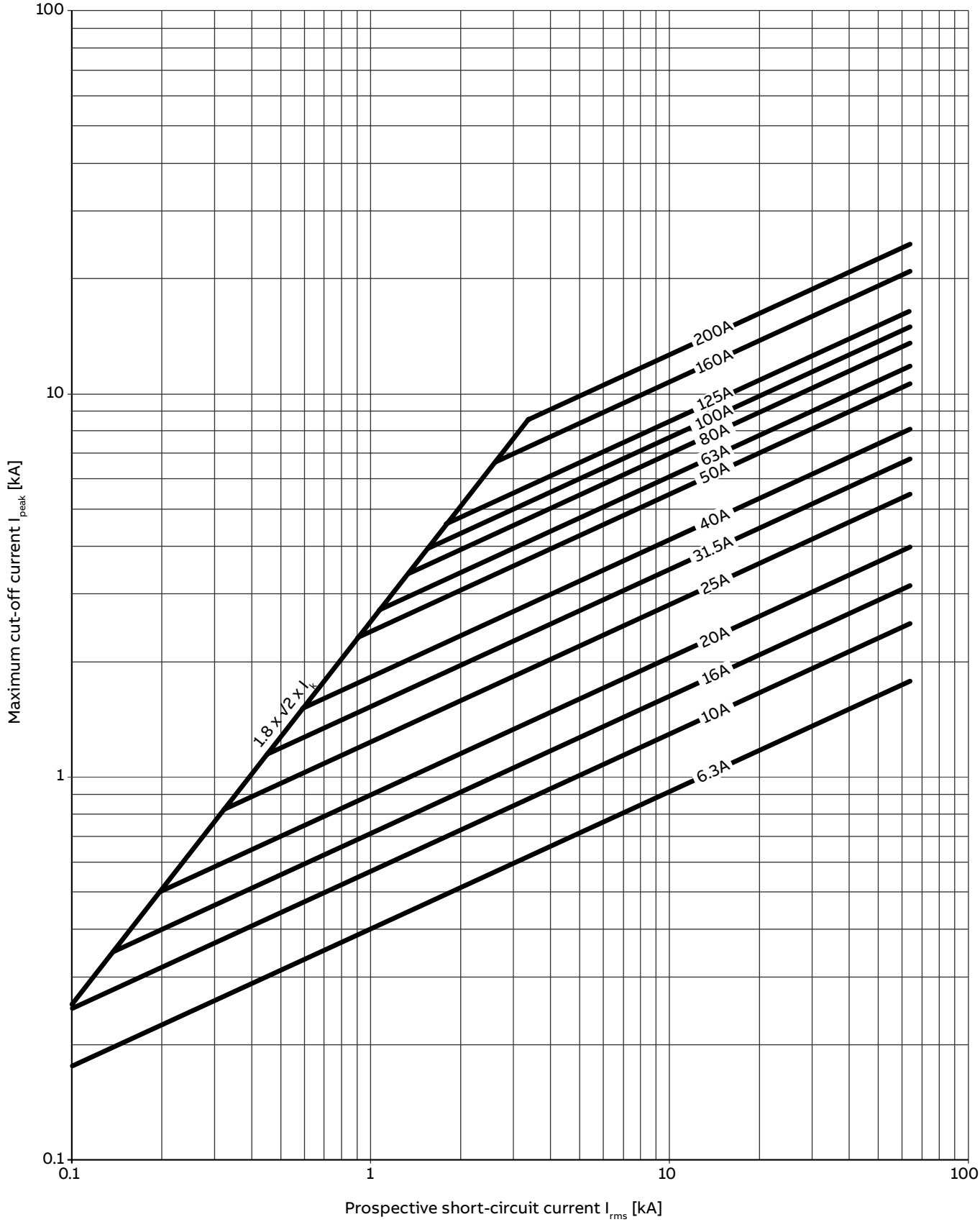



Characteristics show the average melting time as a function of the prospective current and are recorded from cold condition of fuse-link.

The tolerance is ± 10% referred to the current. Characteristics are valid for frequency 50 Hz.

—
07
CEF 3/7.2 kV; 6/12 kV; 10/17.5 kV; 10/24 kV time-current characteristics

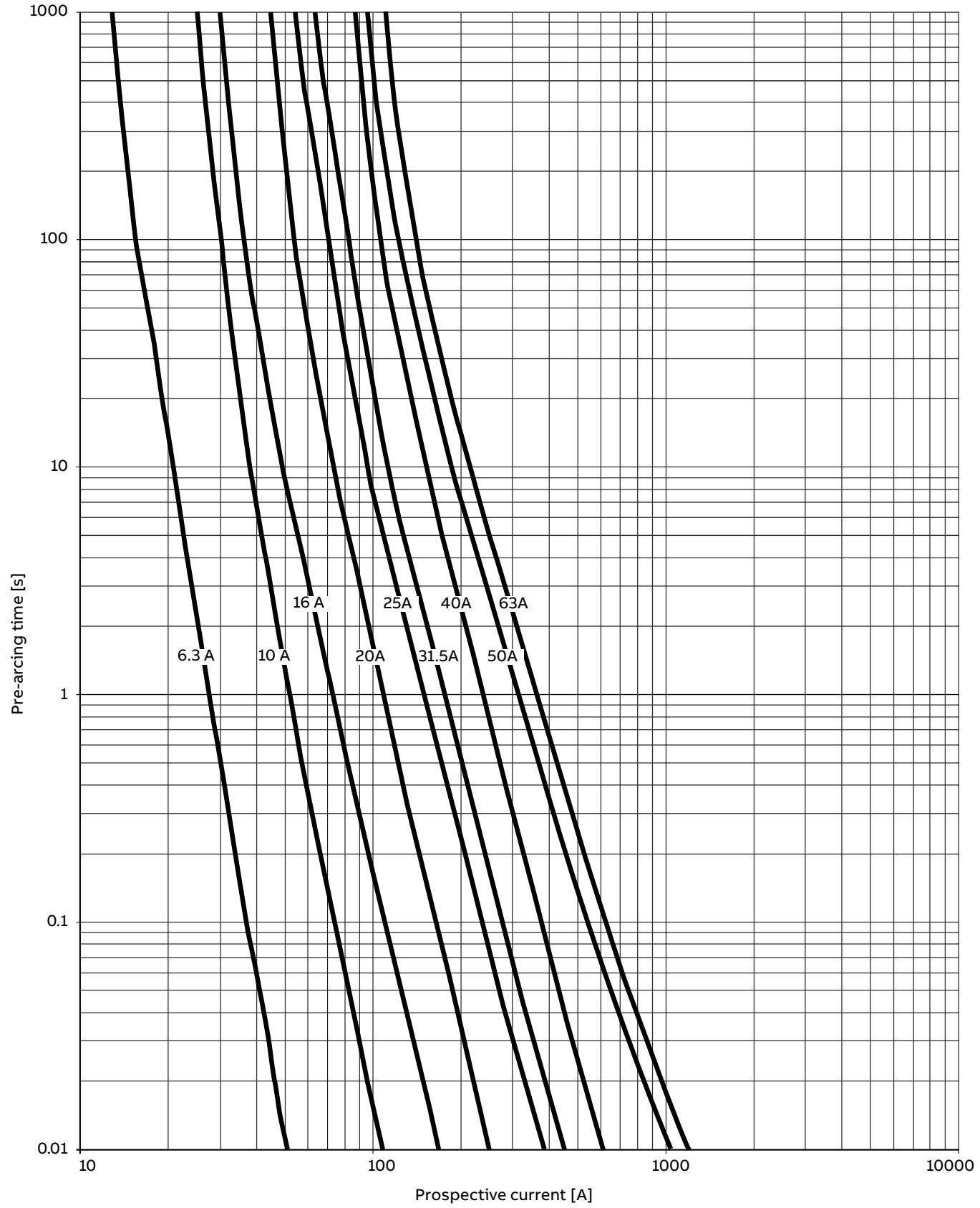
—
08




Characteristics show the cut-off current corresponding to a prospective short-circuit current. Characteristics are valid for frequency 50Hz.

—
08
CEF 3/7.2 kV; 6/12kV; 10/17.5 kV; 10/24 kV cut-off current characteristics

—
09

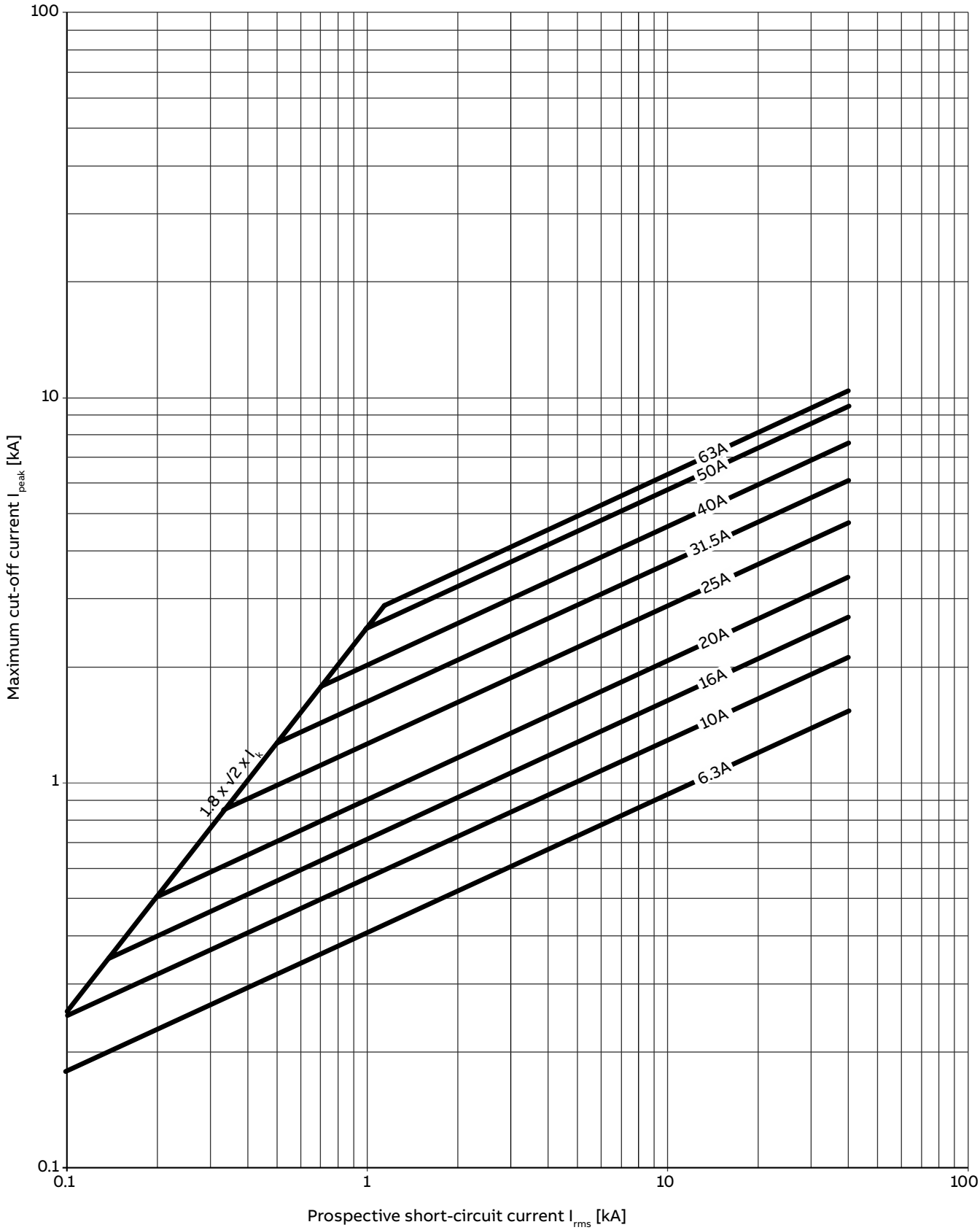



Characteristics show the average melting time as a function of the prospective current and are recorded from cold condition of fuse-link.

The tolerance is ± 10% referred to the current. Characteristics are valid for frequency 50 Hz.

—
09
CEF 20/36 kV
time-current
characteristics

—
10




Characteristics show the cut-off current corresponding to a prospective short-circuit current. Characteristics are valid for frequency 50Hz.

—
10
CEF 20/36kV cut-off characteristics

# CEF-S

## Fast-acting fuse-link for protection of distribution transformers

| | |
|---|---|
| **Class, type** | Back-up, current limiting fuse-link |
| **Rated voltages** | 6/12 kV – 30/40.5 kV |
| **Rated currents** | 6.3 A – 63 A |
| **Rated frequency** | 50 Hz |
| **Applicable standard** | IEC 60282-1 |
| **Application** | Indoor/outdoor |
| **Striker** | 80 N (medium), with integrated TCU |



**Superior performance versus standard fuses ensuring up to 40% faster protection in case of low fault currents**

**Continuous protection and reliable operation guaranteed by robust design and compliance with newest IEC standards**

**Compatibility with other ABB products provides fast and accurate product selection**

**Outdoor sealing included in standard version, designed and tested for harsh conditions**

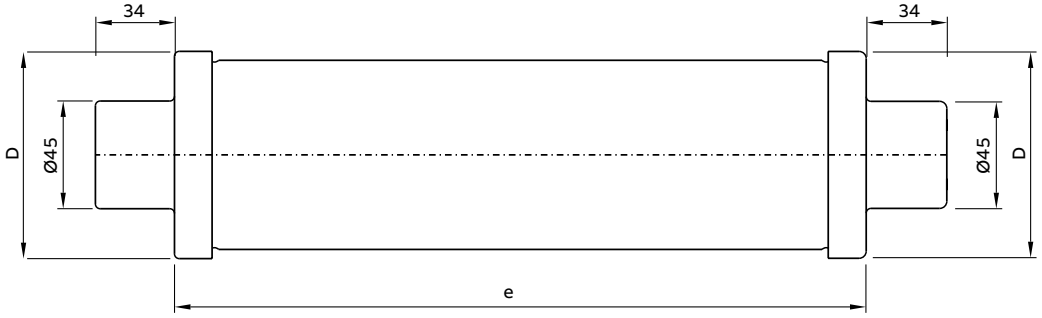
**Fuse-links type CEF-S are designed for fast--acting protection of distribution transformers, increasing safety on low voltage side of the transformer**

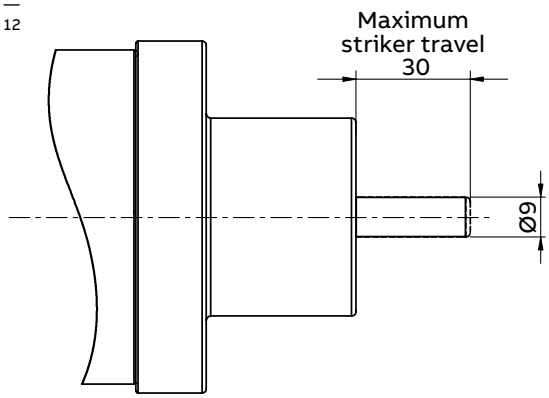
**Key features:**

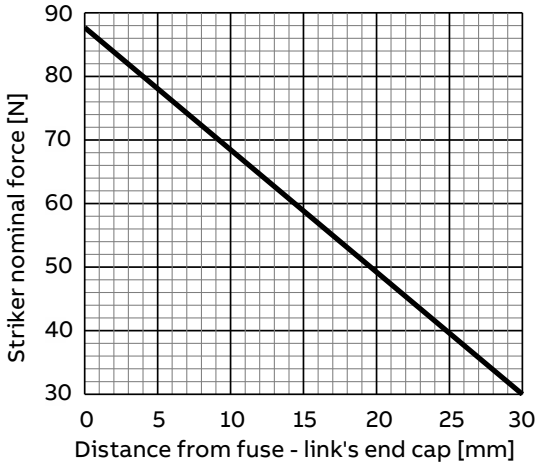
- Rated voltages 6/12 kV – 30/40.5 kV with rated currents of 6.3 A – 63 A
- For indoor and outdoor applications
- Designed and type tested acc. to IEC 60282-1
- Top level fault current limitation and interruption performance up to 63kA RMS
- Striker 80 N (medium type)
- Equipped with Temperature Control Unit enabling the additional protection against thermal stresses in small enclosure

11
Dimensional drawing of fuse-link type CEF-S

12
Fuse-link striker force and dimensions




**Ordering and technical table**

| Catalog number | Fuse name | Rated voltage $U_r$ [kV] | Rated current $I_r$ [A] | Rated frequency $f_r$ [Hz] | Breaking capacity $I_1$ [kA] | Minimal breaking current $I_3$ [A] | Breaking current at 100 ms $I_{0.1s}$ [A] | Diameter D [mm] | Length e [mm] | Rated power $P_w$ [W] | Cold resistance [mΩ] | Pre-arcing integral [$A^2s$] | Total interrupting integral [$A^2s$] | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1YMB741216M2611 | CEF-S | 6/12 | 10 | 50 | 50 | 55 | 48 | 65 | 292 | 25 | 187 | 20 | 2520 | 2.3 | 5908270808034 |
| 1YMB741218M2611 | CEF-S | 6/12 | 16 | 50 | 50 | 55 | 80 | 65 | 292 | 38 | 108.5 | 80 | 2930 | 2.3 | 5908270808041 |
| 1YMB741219M2611 | CEF-S | 6/12 | 20 | 50 | 50 | 72 | 120 | 65 | 292 | 38 | 72.3 | 200 | 3200 | 2.3 | 5908270808058 |
| 1YMB741221M2611 | CEF-S | 6/12 | 25 | 50 | 50 | 72 | 160 | 65 | 292 | 36 | 46.5 | 390 | 7400 | 2.3 | 5908270808065 |
| 1YMB741225M2611 | CEF-S | 6/12 | 40 | 50 | 50 | 100 | 240 | 65 | 292 | 54 | 24.5 | 940 | 17600 | 2.3 | 5908270808072 |
| 1YMB741227M2611 | CEF-S | 6/12 | 50 | 50 | 50 | 190 | 330 | 65 | 292 | 71 | 18.8 | 2030 | 27000 | 2.3 | 5908270808089 |
| 1YMB741229M2611 | CEF-S | 6/12 | 63 | 50 | 63 | 190 | 440 | 65 | 292 | 82 | 14.1 | 4100 | 63500 | 2.3 | 5908270807495 |
| 1YMB742416M4611 | CEF-S | 10/24 | 10 | 50 | 25 | 55 | 48 | 65 | 442 | 54 | 373.2 | 20 | 1450 | 3.3 | 5908270808096 |
| 1YMB742418M4611 | CEF-S | 10/24 | 16 | 50 | 25 | 55 | 80 | 65 | 442 | 58 | 186.6 | 90 | 2910 | 3.3 | 5908270808102 |
| 1YMB742419M4611 | CEF-S | 10/24 | 20 | 50 | 25 | 72 | 120 | 65 | 442 | 66 | 124.4 | 240 | 3960 | 3.3 | 5908270808119 |
| 1YMB742421M4611 | CEF-S | 10/24 | 25 | 50 | 25 | 72 | 160 | 65 | 442 | 74 | 93.3 | 340 | 6140 | 3.3 | 5908270808126 |
| 1YMB742425M4611 | CEF-S | 10/24 | 40 | 50 | 25 | 110 | 240 | 65 | 442 | 107 | 48.7 | 930 | 13300 | 3.3 | 5908270808133 |
| 1YMB742427M4611 | CEF-S | 10/24 | 50 | 50 | 63 | 220 | 330 | 65 | 442 | 125 | 32.5 | 2360 | 57100 | 3.3 | 5908270807501 |
| 1YMB744014M5611 | CEF-S | 30/40.5 | 6.3 | 50 | 20 | 50 | 43 | 65 | 537 | 49 | 927 | 20 | 2350 | 3.9 | 5908270805682 |
| 1YMB744016M5611 | CEF-S | 30/40.5 | 10 | 50 | 20 | 66 | 54 | 65 | 537 | 51 | 615 | 30 | 3000 | 3.9 | 5908270805699 |
| 1YMB744018M5611 | CEF-S | 30/40.5 | 16 | 50 | 20 | 52 | 87 | 65 | 537 | 112 | 313 | 200 | 3400 | 3.9 | 5908270805705 |
| 1YMB744019M5611 | CEF-S | 30/40.5 | 20 | 50 | 20 | 77 | 122 | 65 | 537 | 125 | 207 | 270 | 4620 | 3.9 | 5908270805712 |
| 1YMB744021M5611 | CEF-S | 30/40.5 | 25 | 50 | 20 | 134 | 118 | 65 | 537 | 143 | 175 | 300 | 3880 | 3.9 | 5908270805729 |
| 1YMB744024M5611 | CEF-S | 30/40.5 | 31.5 | 50 | 20 | 265 | 202 | 65 | 537 | 121 | 89.6 | 1050 | 11900 | 3.9 | 5908270805736 |
| 1YMB744025M5811 | CEF-S | 30/40.5 | 40 | 50 | 20 | 172 | 324 | 87 | 537 | 130 | 60.3 | 2480 | 36100 | 6.4 | 5908270805743 |
| 1YMB744027M5811 | CEF-S | 30/40.5 | 50 | 50 | 20 | 251 | 500 | 87 | 537 | 128 | 39.8 | 6600 | 76800 | 6.4 | 5908270805750 |
| 1YMB744029M5811 | CEF-S | 30/40.5 | 63 | 50 | 20 | 334 | 655 | 87 | 537 | 165 | 29.7 | 9460 | 110000 | 6.4 | 5908270805385 |

The breaking current at 100 ms $I_{0.1s}$ values refer to total clearing time. Fuse minimal breaking current $I_3$ data are pre-arcing values.

**Choice of fuse-links for transformer protection**

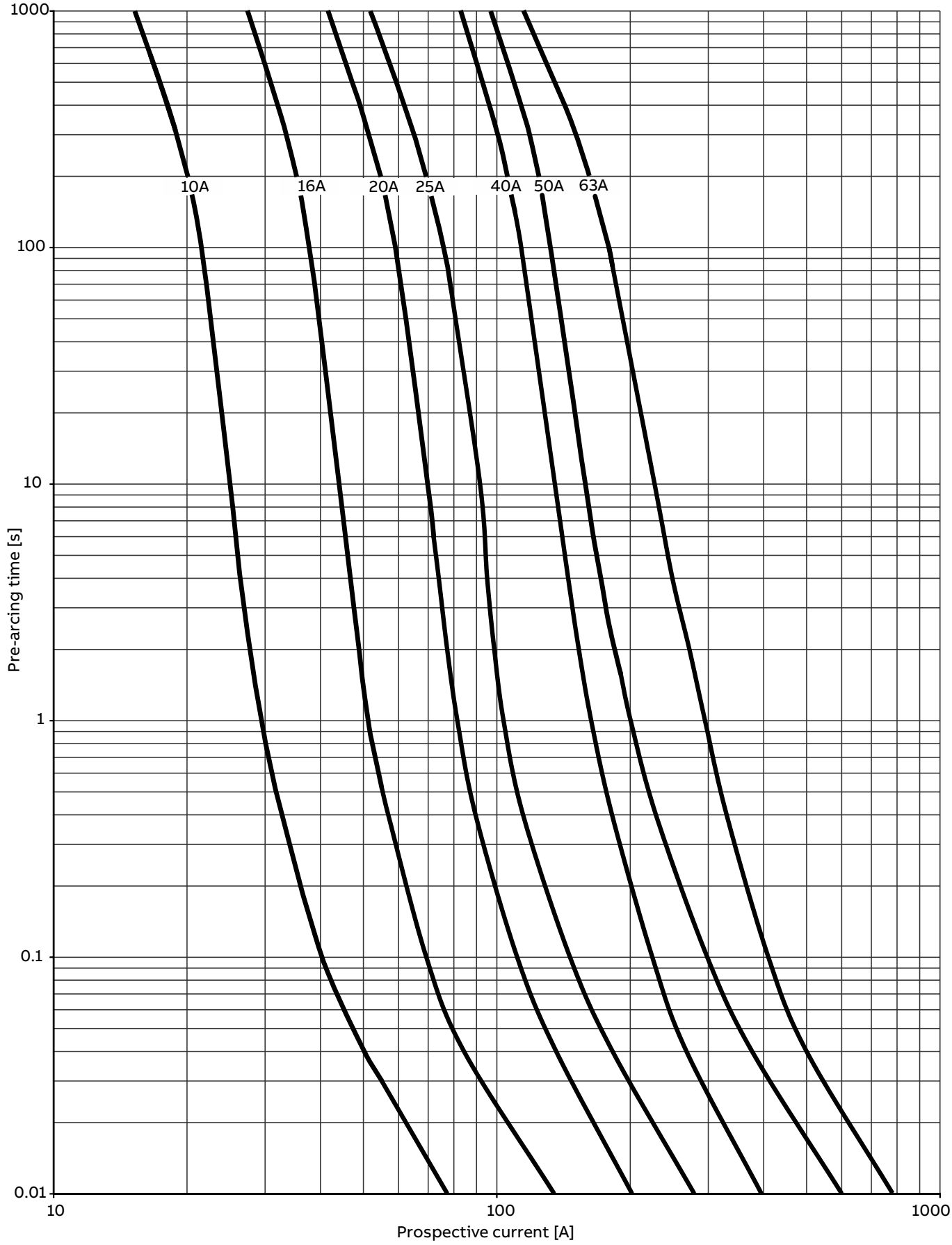
| Transformer rated voltage [kV] | Transformer rating (kVA) | | | | | | | | | | | | | | | | | | | Fuse rated voltage [kV] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | 50 | 75 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3000 | |
| | Fuse-link rating $I_r$ (A) | | | | | | | | | | | | | | | | | | | |
| 6 | 10 | 16 | 20 | 25 | 40 | 40 | 50 | 63 | 63 | | | | | | | | | | | 6/12 |
| 10 | 10* | 10 | 16 | 20 | 20 | 25 | 40 | 40 | 50 | 63 | 63 | | | | | | | | | |
| 11 | 10* | 10 | 16 | 20 | 20 | 25 | 40 | 40 | 40 | 50 | 63 | | | | | | | | | |
| 12 | 10* | 10 | 16 | 16 | 20 | 20 | 25 | 40 | 40 | 50 | 63 | 63 | | | | | | | | |
| 15 | 10* | 10* | 10 | 16 | 16 | 20 | 20 | 25 | 40 | 40 | 50 | | | | | | | | | 10/24 |
| 20 | 10* | 10* | 10* | 10 | 16 | 16 | 20 | 20 | 25 | 40 | 40 | 50 | 50 | | | | | | | |
| 22 | 10* | 10* | 10* | 10 | 16 | 16 | 20 | 20 | 20 | 40 | 40 | 40 | 50 | 50 | | | | | | |
| 24 | 10* | 10* | 10* | 10 | 16 | 16 | 16 | 20 | 20 | 25 | 40 | 40 | 50 | 50 | | | | | | |
| 30 | 6.3* | 6.3* | 6.3* | 6.3* | 6.3 | 10 | 16 | 16 | 20 | 40 | 40 | 40 | 40 | 40 | 40 | 50 | 63 | 63 | | 30/40.5 |
| 36 | 6.3* | 6.3* | 6.3* | 6.3* | 6.3 | 6.3 | 10 | 16 | 16 | 20 | 40 | 40 | 40 | 40 | 40 | 50 | 50 | 63 | 63 | |
| 38.5 | 6.3* | 6.3* | 6.3* | 6.3* | 6.3* | 6.3 | 10 | 16 | 16 | 20 | 20 | 40 | 40 | 40 | 40 | 40 | 50 | 50 | 63 | |
| 40.5 | 6.3* | 6.3* | 6.3* | 6.3* | 6.3* | 6.3 | 10 | 16 | 16 | 20 | 20 | 40 | 40 | 40 | 40 | 40 | 50 | 50 | 63 | |
| Max. gG fuse-link at LV side (A) | 40 | 80 | 125 | 160 | 160 | 200 | 250 | 250 | 300 | 400 | 400 | 800 | 1000 | 1000 | 1000 | 1000 | 1250 | 1250 | 1250 | |

Recommended fuse rating is on the crossing of transformer rating and line voltage. For different line voltage level, please use closest smaller value from the table. The table was calculated according to standards IEC 60787 and IEC 62271-105 with following assumptions:

- Maximum long lasting transformer current overload – 120%
- Magnetizing transformer inrush current – 12 x $I_r$ during 100ms (up to 800 kVA) or 10 x $I_r$ during 100ms (800 kVA and above)
- Transformer short-circuit voltage according to IEC 60076-5
- No fuse derating due to small enclosures assumed
- For ratings marked with "*" fuse is not able to clear independently transformer's secondary side terminals short-circuit current

For different working conditions fuse selection has to be recalculated.
The CEF-S fuse-links can be selected in reference to § 17 STEV-FS requirements that ensure very good protection and prevents many faults in low voltage switchgears. The selection table according to that is available on request.

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13

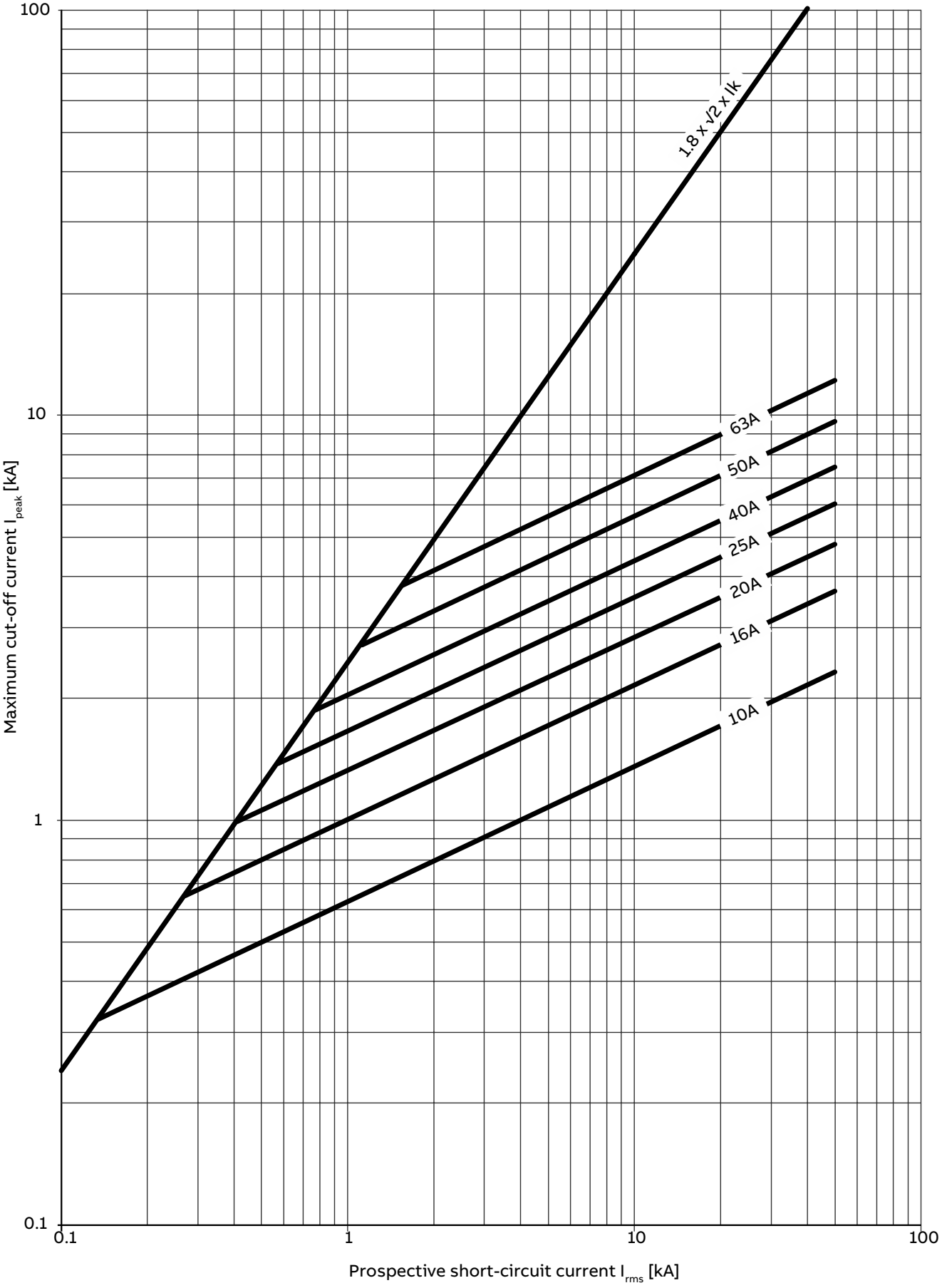



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13
CEF-S 6/12, 10/24 kV fuses time-current characteristic

Characteristics show the average melting time as a function of the prospective current and are recorded from cold condition of fuse-link.

The tolerance is ± 10% referred to the current. Characteristics are valid for frequency 50 Hz.

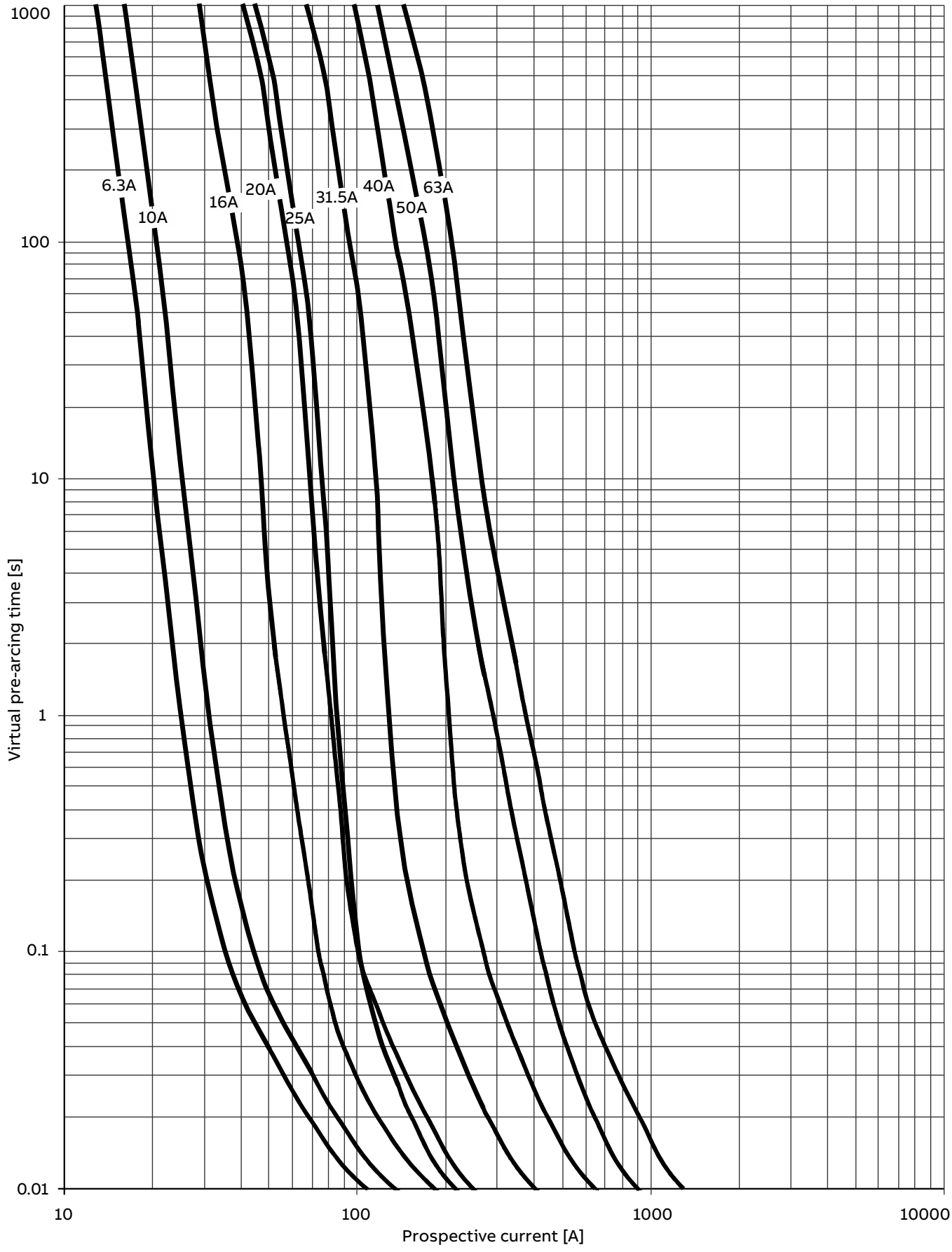
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14




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14
CEF-S 6/12 kV, 10/24 kV cut-off current characteristics

Characteristics show the cut-off current corresponding to a prospective short-circuit current. Characteristics are valid for frequency 50Hz.

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15

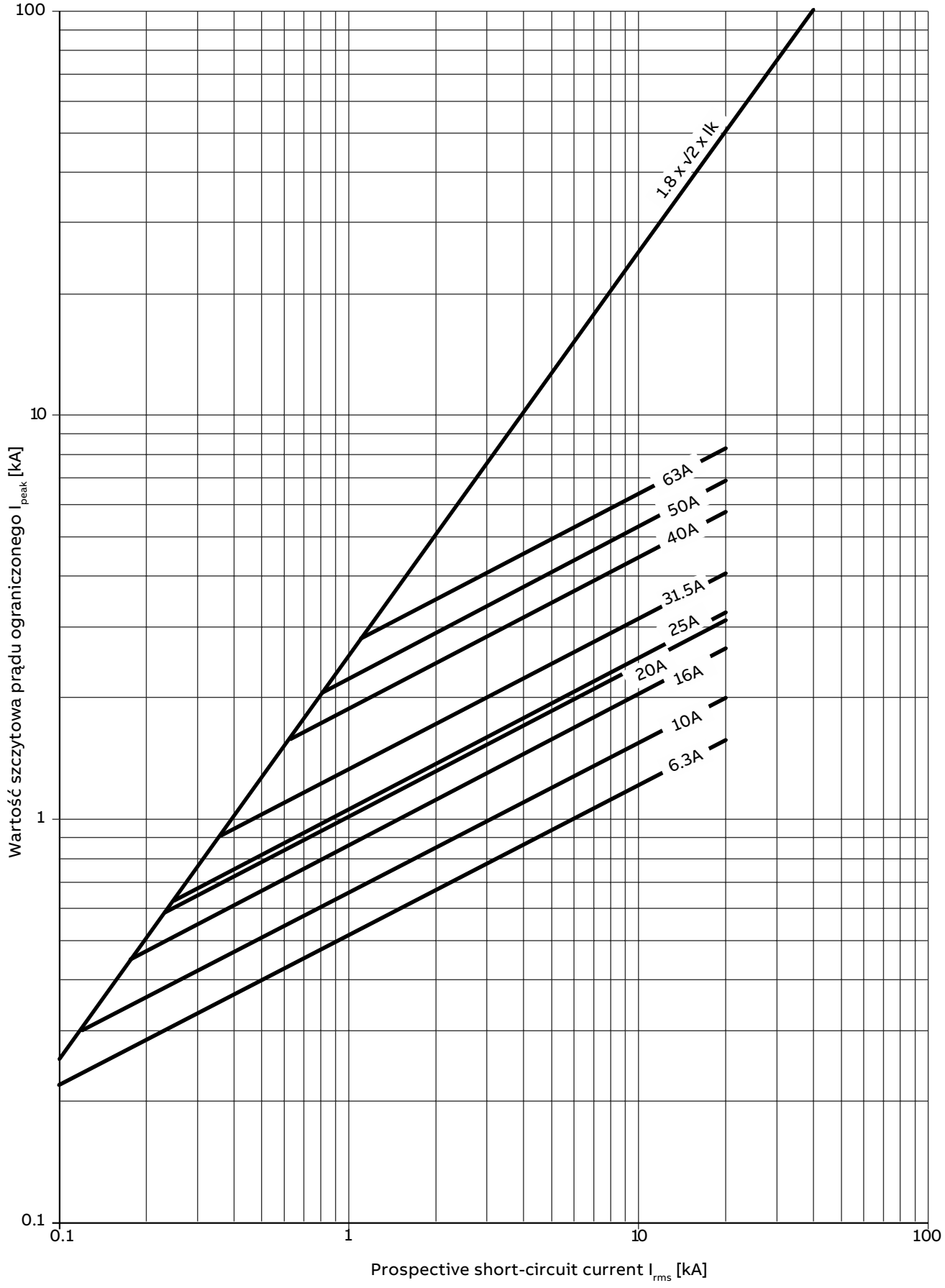



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15
CEF-S 30/40.5 kV time--current characteristics

Characteristics show the average melting time as a function of the prospective current and are recorded from cold condition of fuse-link.

The tolerance is ± 10% referred to the current. Characteristics are valid for frequency 50 Hz.

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16




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16
CEF-S 30/40.5kV cut-off current characteristics

Characteristics show the cut-off current corresponding to a prospective short-circuit current. Characteristics are valid for frequency 50Hz.

# Fuse-links for motor circuits protection



**028** – 035 **CMF** – Essential fuse-links for motor circuit protection

**036** – 039 **CMF-BS** – Fuse-links with tags for motor circuit protection

# CMF

## Essential fuse-links for motor circuit protection

| | |
|---|---|
| **Class, type** | Back-up, current limiting fuse-link |
| **Rated voltages** | 3.6 kV, 7.2 kV, 12 kV |
| **Rated currents** | 63 A – 315 A |
| **Rated frequency** | 50 Hz |
| **Applicable standard** | IEC 60282-1 |
| **Application** | Indoor/outdoor |
| **Striker** | 80 N (medium), with integrated TCU |



**Special design of fuse-links resistant to cyclical load typical for motor applications**

**Continuous protection and reliable operation guaranteed by robust design and compliance with newest IEC standards**

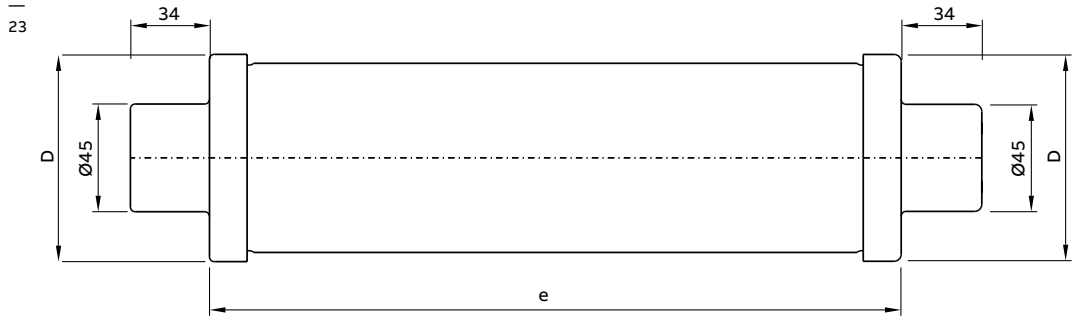
**Compatibility with other ABB products provides fast and accurate product selection**

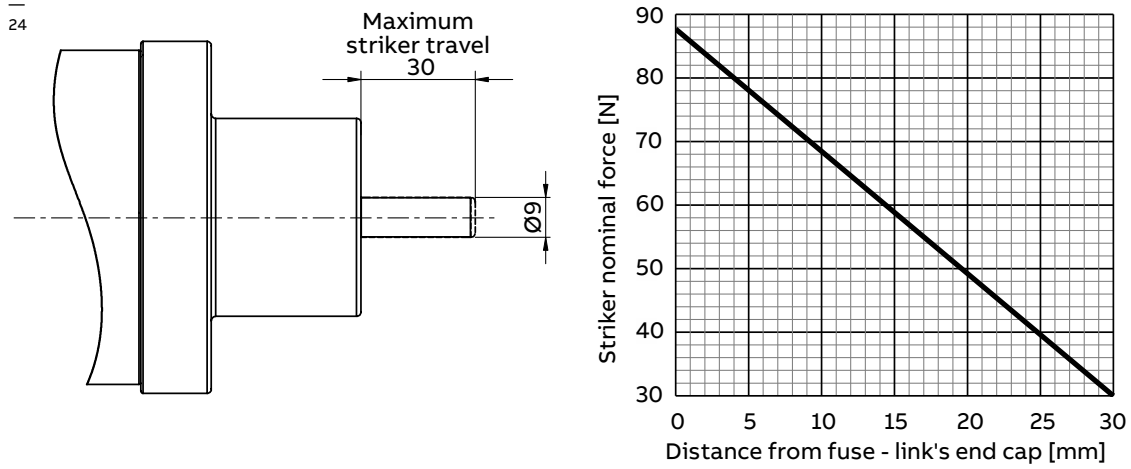
**Outdoor sealing included in standard version, designed and tested for harsh conditions**

**Fuse-links type CMF are designed to protect motor circuits against thermal and dynamic effects of short-circuit currents**

**Key features:**

- Rated voltages up to 12 kV with rated currents of 63 A – 315 A
- For indoor and outdoor applications
- Designed and type tested acc. to IEC 60282-1
- Striker 80 N (medium type)
- Equipped with Temperature Control Unit enabling the additional protection against thermal stresses in small enclosures




— 23
Dimensional drawing of fuse-link type CMF

— 24
Fuse-link striker force and dimensions

**Ordering and technical table**

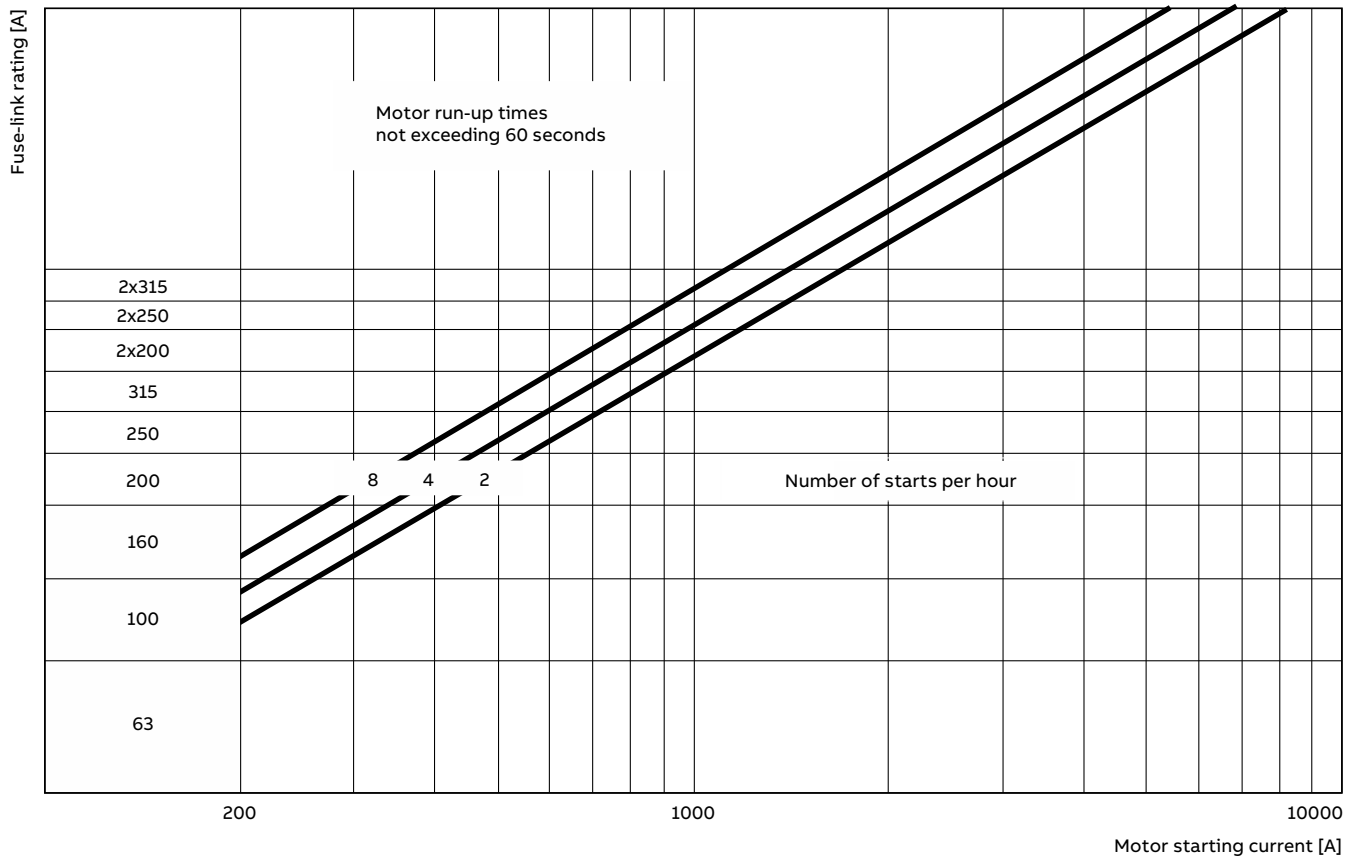
| Catalog number | Fuse name | Rated voltage $U_r$ [kV] | Rated current $I_r$ [A] | Rated frequency $f_r$ [Hz] | Breaking capacity $I_1$ [kA] | Minimal breaking current $I_3$ [A] | K factor | Diameter D [mm] | Length e [mm] | Rated power $P_w$ [W] | Cold resistance [mΩ] | Pre-arcing integral [$A^2s$] | Total interrupting integral [$A^2s$] | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1YMB760333M2611 | CMF | 3.6 | 100 | 50 | 63 | 275 | 0.75 | 65 | 292 | 41 | 3.2 | 14000 | 170000 | 2.3 | 5908270807884 |
| 1YMB760338M2611 | CMF | 3.6 | 160 | 50 | 63 | 400 | 0.7 | 65 | 292 | 70 | 1.9 | 38000 | 500000 | 2.3 | 5908270807891 |
| 1YMB760339M2811 | CMF | 3.6 | 200 | 50 | 63 | 500 | 0.7 | 87 | 292 | 78 | 1.4 | 76000 | 710000 | 3.6 | 5908270807907 |
| 1YMB760341M2811 | CMF | 3.6 | 250 | 50 | 63 | 760 | 0.6 | 87 | 292 | 90 | 1 | 140000 | 1150000 | 3.6 | 5908270807914 |
| 1YMB760342M2811 | CMF | 3.6 | 315 | 50 | 63 | 900 | 0.6 | 87 | 292 | 121 | 0.8 | 210000 | 1800000 | 3.6 | 5908270807921 |
| 1YMB760729M4611 | CMF | 7.2 | 63 | 50 | 63 | 195 | 0.75 | 65 | 442 | 43 | 8.5 | 4800 | 65000 | 3.3 | 5908270807938 |
| 1YMB760733M4611 | CMF | 7.2 | 100 | 50 | 63 | 275 | 0.75 | 65 | 442 | 64 | 4.9 | 14000 | 180000 | 3.3 | 5908270807945 |
| 1YMB760738M4611 | CMF | 7.2 | 160 | 50 | 63 | 400 | 0.7 | 65 | 442 | 109 | 2.9 | 38000 | 540000 | 3.3 | 5908270807952 |
| 1YMB760739M4811 | CMF | 7.2 | 200 | 50 | 63 | 500 | 0.7 | 87 | 442 | 122 | 2.1 | 76000 | 750000 | 5.3 | 5908270807969 |
| 1YMB760741M4811 | CMF | 7.2 | 250 | 50 | 63 | 800 | 0.6 | 87 | 442 | 133 | 1.5 | 140000 | 1200000 | 5.3 | 5908270807976 |
| 1YMB760742M4811 | CMF | 7.2 | 315 | 50 | 63 | 950 | 0.6 | 87 | 442 | 186 | 1.2 | 210000 | 2200000 | 5.3 | 5908270807983 |
| 1YMB761229M4611 | CMF | 12 | 63 | 50 | 63 | 210 | 0.75 | 65 | 442 | 71 | 13.5 | 4800 | 110000 | 3.3 | 5908270807990 |
| 1YMB761233M4811 | CMF | 12 | 100 | 50 | 63 | 275 | 0.75 | 87 | 442 | 88 | 6.6 | 14000 | 200000 | 5.3 | 5908270808003 |
| 1YMB761238M4811 | CMF | 12 | 160 | 50 | 63 | 480 | 0.7 | 87 | 442 | 139 | 3.9 | 38000 | 700000 | 5.3 | 5908270808010 |
| 1YMB761239M4811 | CMF | 12 | 200 | 50 | 63 | 700 | 0.7 | 87 | 442 | 166 | 2.7 | 93000 | 910000 | 5.3 | 5908270808027 |

**Choice of fuse-links for motor protection:**
The minimum permissible current rating of the fuse-links for motor protection may be determined from the selection charts. These three charts are for run-up times of 6, 15 and 60 seconds respectively. Each chart contains different characteristics, depending on the number of starts per hour. With reference to the number of starts per hour, the first two are in immediate succession while the rest are evenly spaced at intervals of one hour. The number of starts per hour indicates the time interval between separated starts. For example, four starts in 15 minutes are represented by 16 starts per hour. The horizontal axis of the selection chart indicates the motor starting current, while the current rating of the fuse-link is found along the vertical axis.

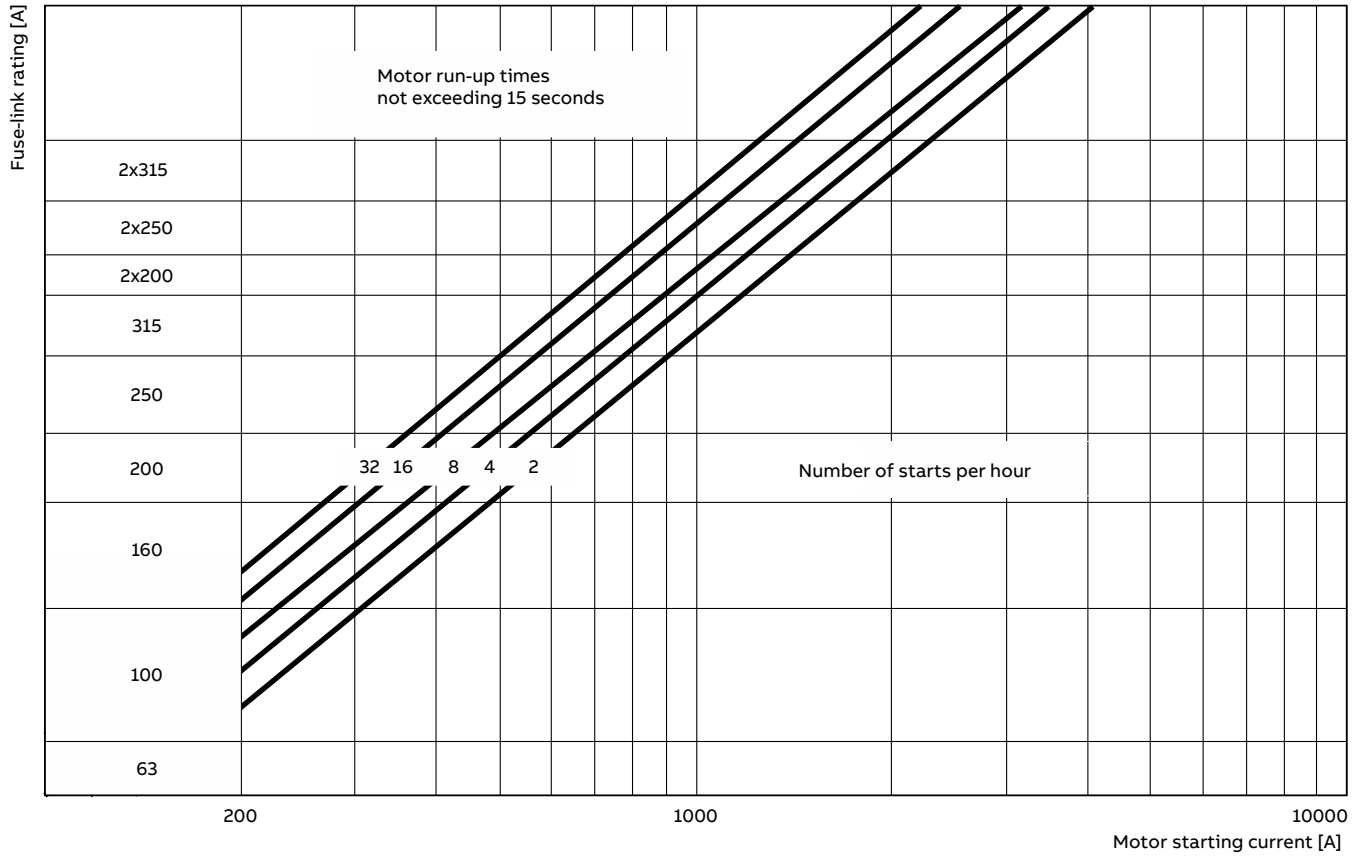
**Selection procedure:**
- Select the chart which is appropriate for the run-up time of the motor
- Select the starting current along the horizontal axis
- Depending on the number of starts per hour, select the correct characteristic (2, 4, 8, 16, 32)
- Read the correct fuse-link rating on the vertical axis.

| Example | A | B |
|---|---|---|
| Starting current of the motor | 850 A | 250 A |
| Run-up time | 6 seconds | 15 seconds |
| Number of starts per hour | 2 | 16 |
| Chart number | 3 | 2 |
| Rated current of fuse link | 250 A | 160 A |

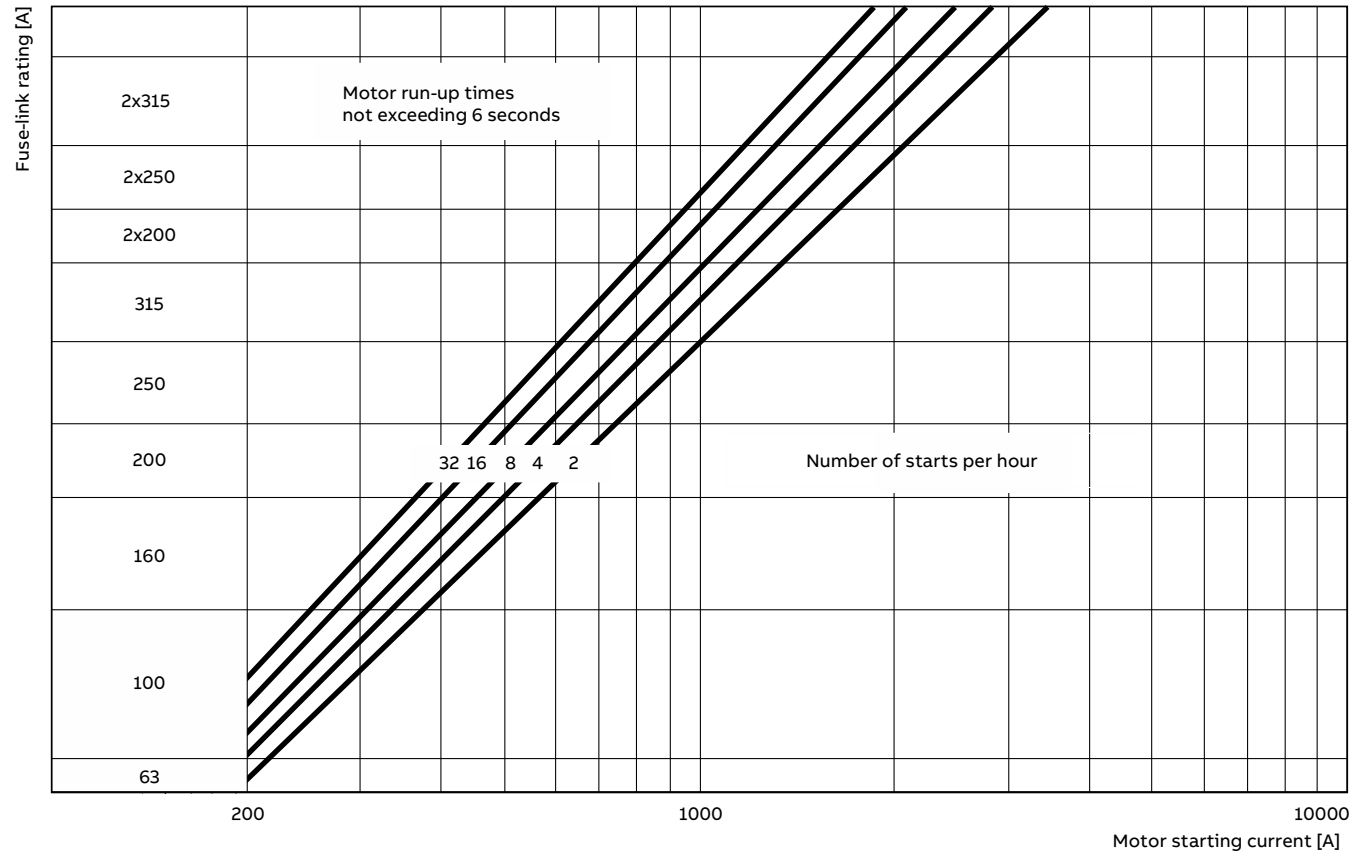
**Selection chart No. 1:**



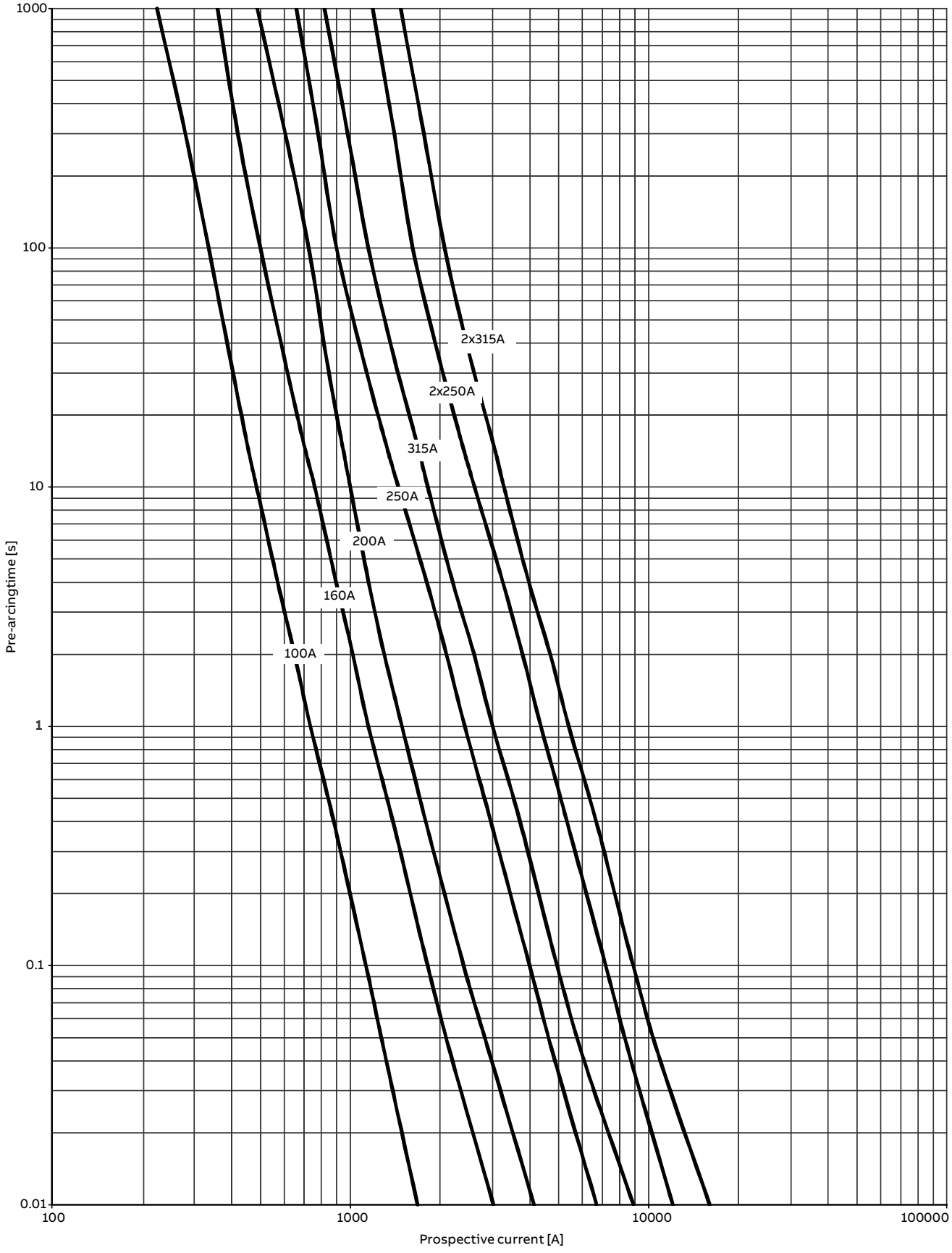
**Selection chart No. 2:**




**Selection chart No. 3:**



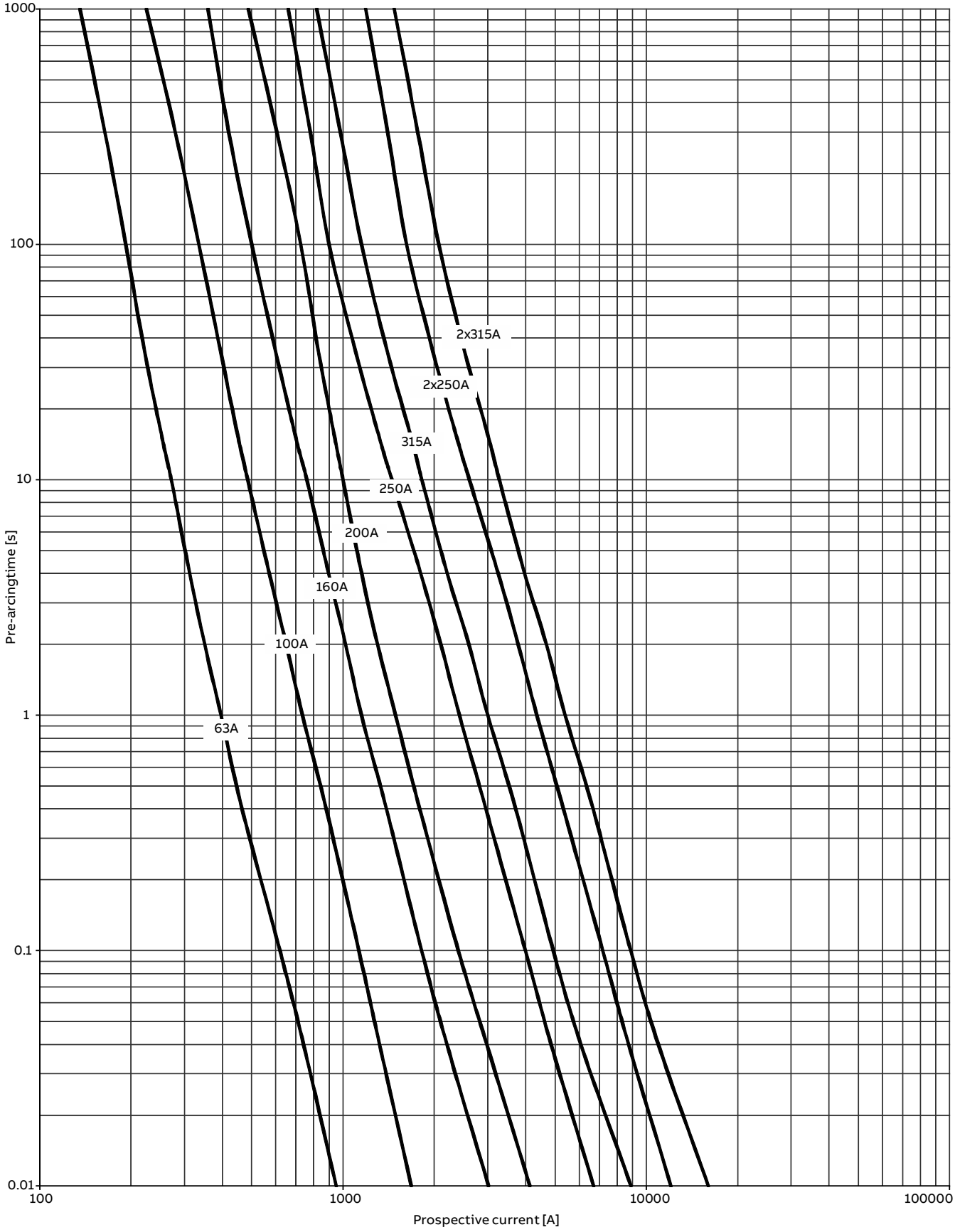
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25




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25
CMF 3.6 kV fuses time-current characteristics

Characteristics show the average melting time as a function of the prospective current and are recorded from cold condition of fuse-link. The tolerance is ± 10% referred to the current for single fuses; ± 20% referred to the current for double fuses. Characteristics are valid for frequency 50Hz.

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26

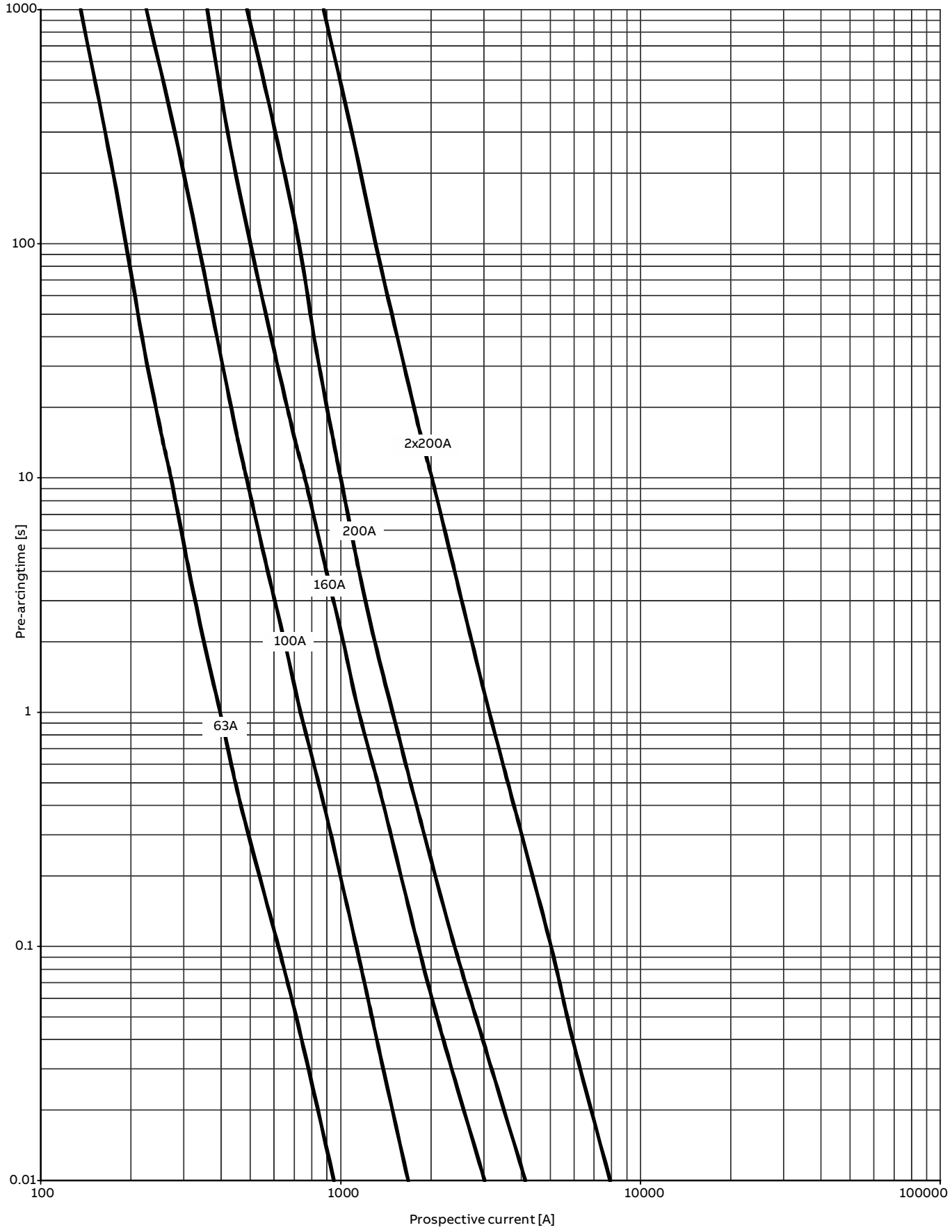



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26
CMF 7.2 kV fuses time-current characteristics

Characteristics show the average melting time as a function of the prospective current and are recorded from cold condition of fuse-link.

The tolerance is ± 10% referred to the current for single fuses; ± 20% referred to the current for double fuses. Characteristics are valid for frequency 50 Hz.

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27

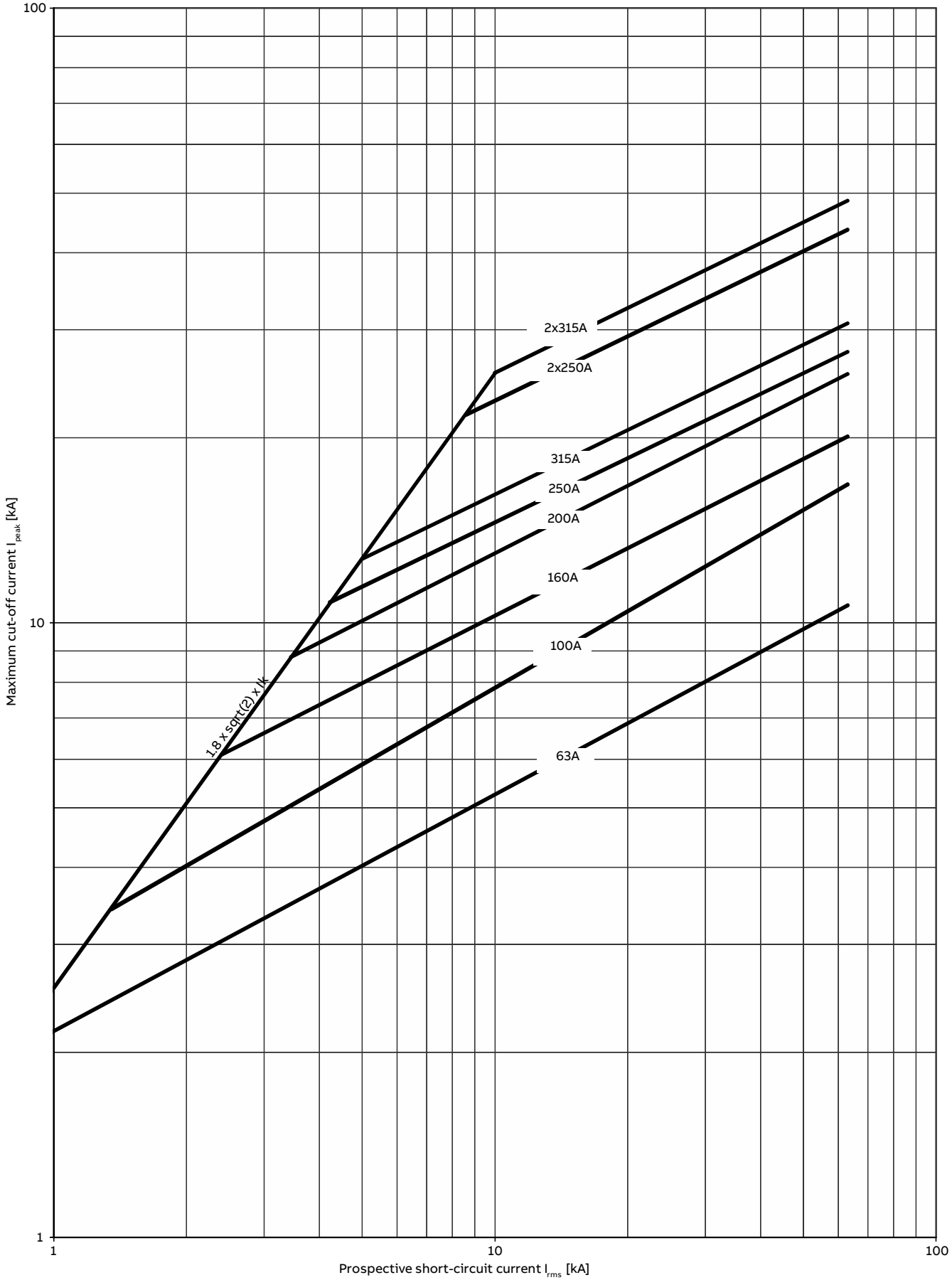



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27
CMF 12 kV fuses
time-current
characteristics

Characteristics show the average melting time as a function of the prospective current and are recorded from cold condition of fuse-link.

The tolerance is ± 10% referred to the current for single fuses; ± 20% referred to the current for double fuses. Characteristics are valid for frequency 50 Hz.

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28




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28
CMF 3.6 kV, 7.2 kV, 12 kV cut-off current characteristics

Characteristics show the cut-off current corresponding to a prospective short-circuit current. Characteristics are valid for frequency 50Hz.

# CMF-BS

## Fuse-links with tags for motor circuit protection

| | |
|---|---|
| **Class, type** | Back-up, current limiting fuse-link |
| **Rated voltages** | 3.6 kV, 7.2 kV, 12 kV |
| **Rated currents** | 63 A – 315 A |
| **Rated frequency** | 50 Hz |
| **Applicable standard** | IEC 60282-1 |
| **Application** | Indoor/outdoor |
| **Striker** | 80 N (medium), with integrated TCU |



**Special design of fuse-links resistant to cyclical load typical for motor applications**

**Continuous protection and reliable operation guaranteed by robust design and compliance with newest IEC standards**

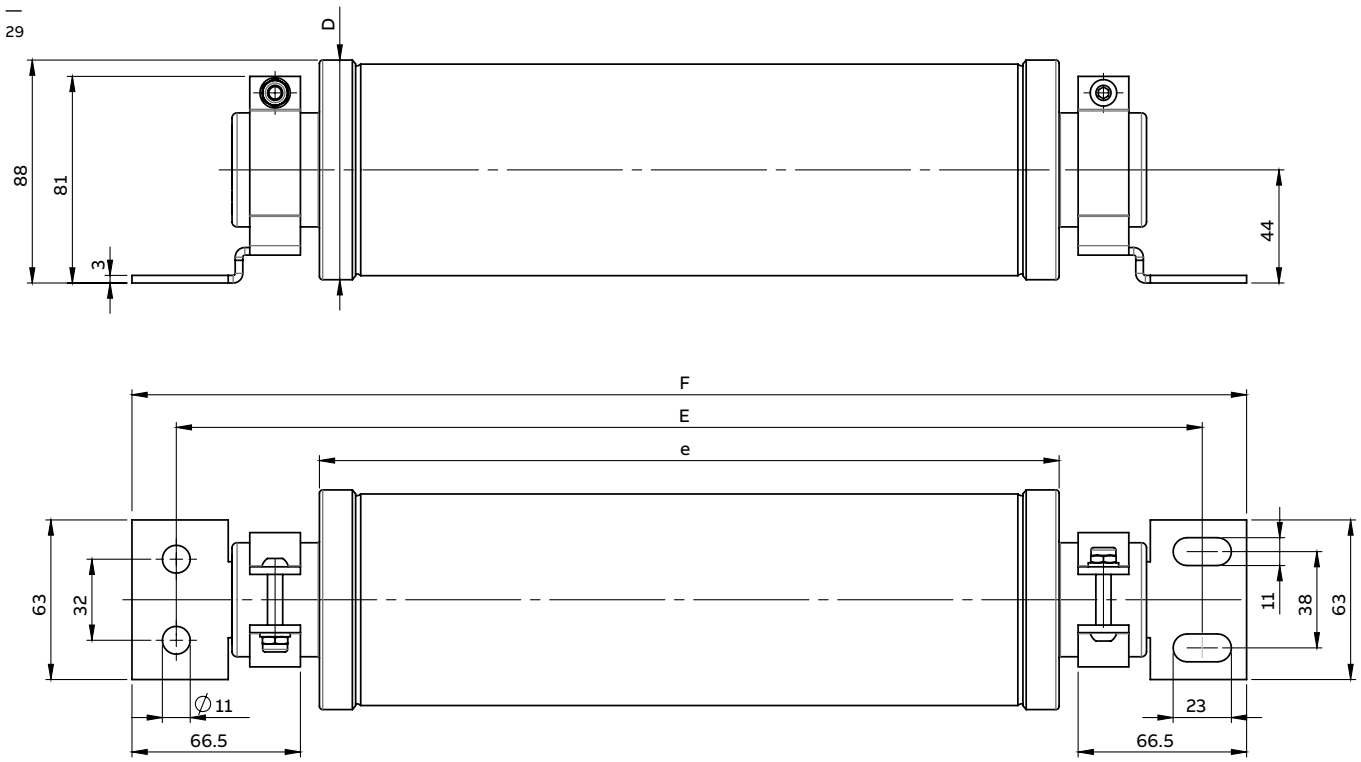
**Outdoor sealing included in standard version, designed and tested for harsh conditions**

**Fuse-links type CMF-BS are designed to protect motor circuits against thermal and dynamic effects of short-circuit currents**

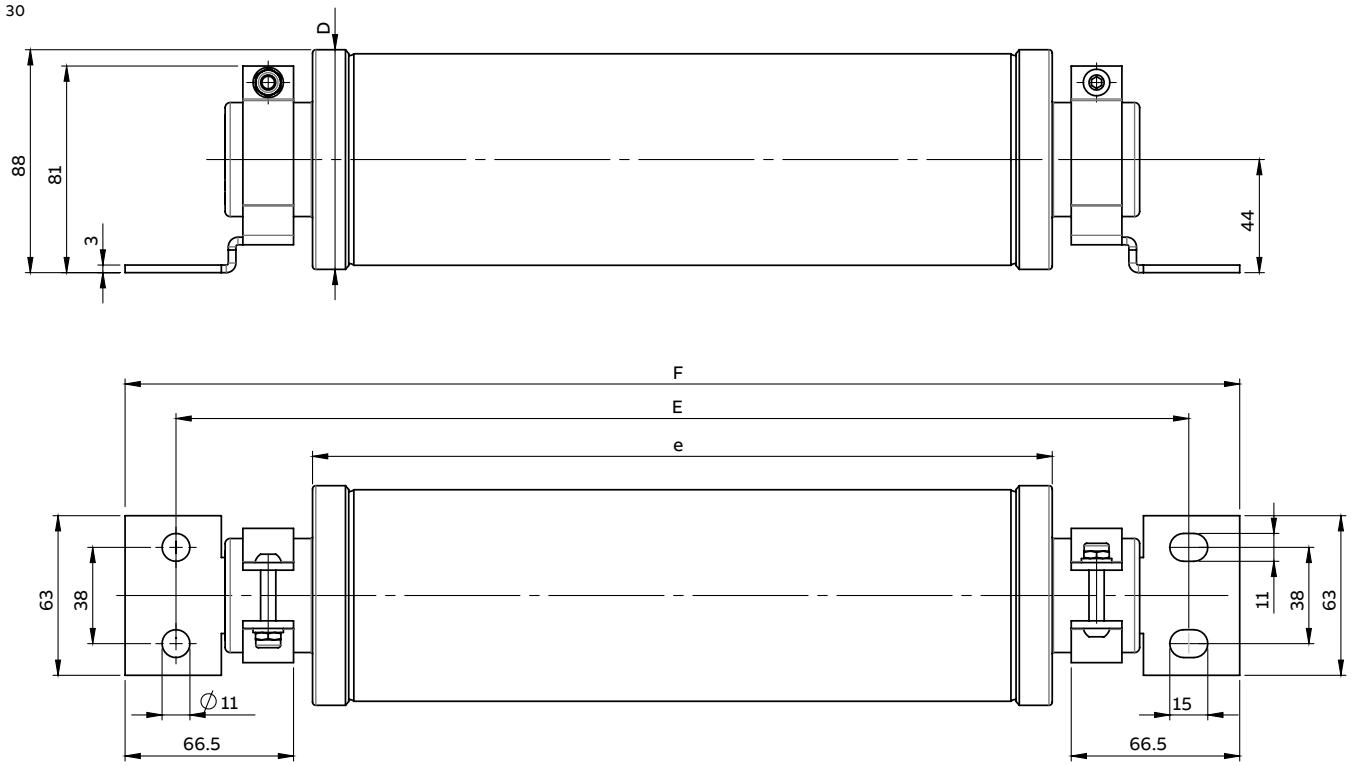
**Key features:**

- Rated voltages up to 12 kV with rated currents of 63 A – 315 A
- Equipped with tags with mounting holes
- For indoor and outdoor applications
- Designed and type tested acc. to IEC 60282-1
- Striker 80 N (medium type)
- Equipped with Temperature Control Unit enabling the additional protection against thermal stresses in small enclosures

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29



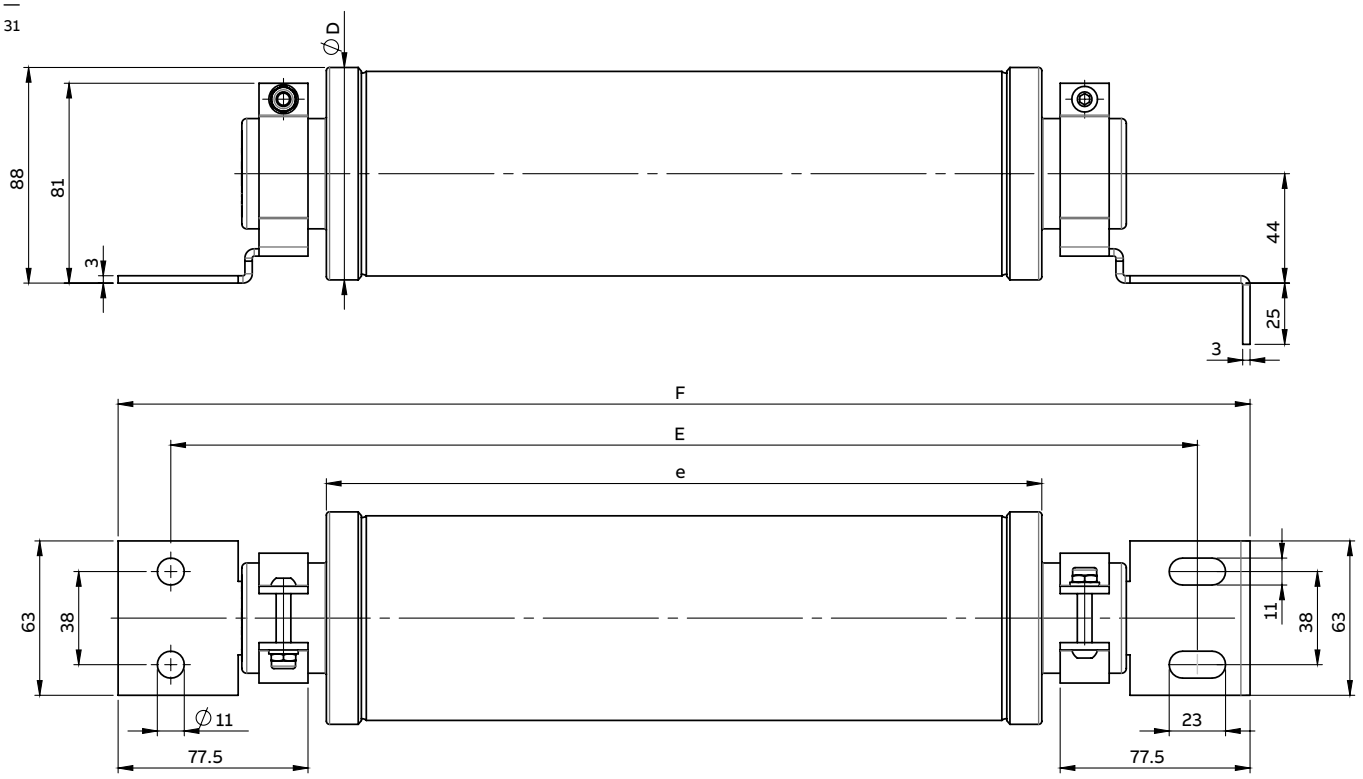

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30



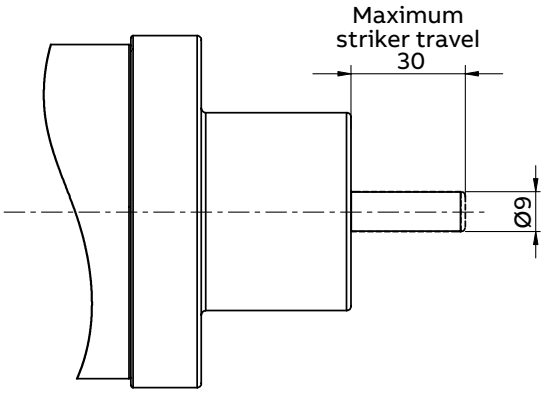

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29
Dimensional drawing of fuse-link type CMF-BS-B

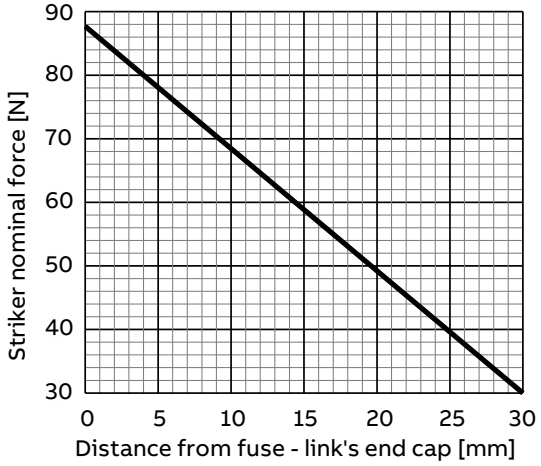
—
30
Dimensional drawing of fuse-link type CMF-BS-C

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31




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32




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31
Dimensional drawing of fuse-link type CMF-BS-D

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32
Fuse-link striker force and dimensions

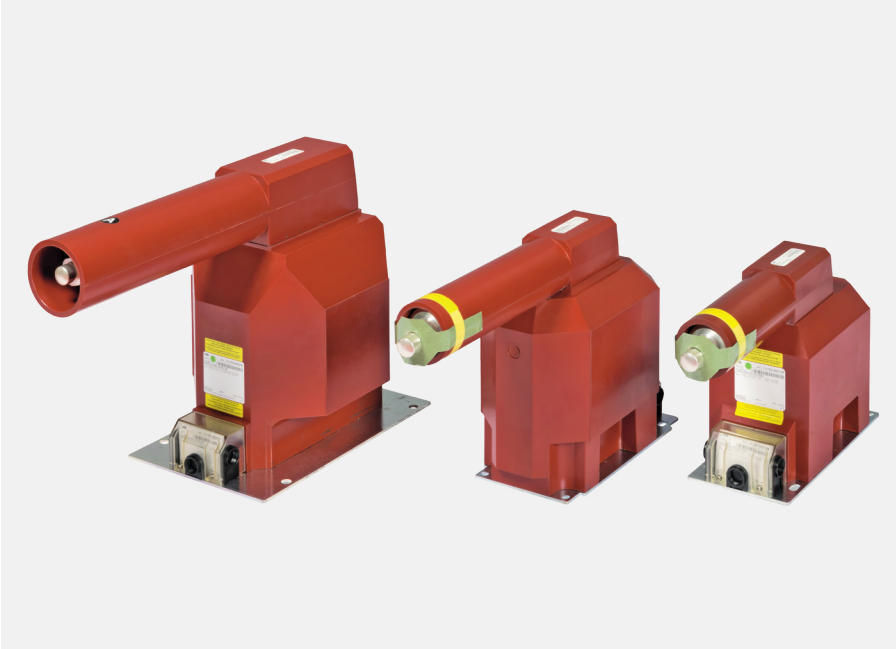
**Ordering and technical table**

| Catalog number | Fuse name | Rated voltage $U_r$ [kV] | Rated current $I_r$ [A] | Rated frequency $f_r$ [Hz] | Breaking capacity $I_1$ [kA] | Minimal breaking current $I_3$ [A] | Diameter D [mm] | Length e [mm] | Length E [mm] | Length F [mm] | Rated power $P_w$ [W] | Cold resistance [mΩ] | Pre-arcing integral [$A^2s$] | Total interrupting integral [$A^2s$] | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1YMB770333M2612 | CMF-BS-B | 3.6 | 100 | 50 | 63 | 275 | 65 | 292 | 400 | 435 | 41 | 3.2 | 14000 | 170000 | 2.5 | 5908270807518 |
| 1YMB770338M2612 | CMF-BS-B | 3.6 | 160 | 50 | 63 | 400 | 65 | 292 | 400 | 435 | 70 | 1.9 | 38000 | 500000 | 2.5 | 5908270807525 |
| 1YMB770339M2812 | CMF-BS-B | 3.6 | 200 | 50 | 63 | 500 | 87 | 292 | 400 | 435 | 78 | 1.4 | 76000 | 710000 | 3.8 | 5908270807532 |
| 1YMB770341M2812 | CMF-BS-B | 3.6 | 250 | 50 | 63 | 760 | 87 | 292 | 400 | 435 | 90 | 1 | 140000 | 1150000 | 3.8 | 5908270807549 |
| 1YMB770342M2812 | CMF-BS-B | 3.6 | 315 | 50 | 63 | 900 | 87 | 292 | 400 | 435 | 121 | 0.8 | 210000 | 1800000 | 3.8 | 5908270807556 |
| 1YMB770729M4612 | CMF-BS-B | 7.2 | 63 | 50 | 63 | 195 | 65 | 442 | 553 | 588 | 43 | 8.5 | 4800 | 65000 | 3.5 | 5908270807563 |
| 1YMB770733M4612 | CMF-BS-B | 7.2 | 100 | 50 | 63 | 275 | 65 | 442 | 553 | 588 | 64 | 4.9 | 14000 | 180000 | 3.5 | 5908270807570 |
| 1YMB770738M4612 | CMF-BS-B | 7.2 | 160 | 50 | 63 | 400 | 65 | 442 | 553 | 588 | 109 | 2.9 | 38000 | 540000 | 3.5 | 5908270807587 |
| 1YMB770739M4812 | CMF-BS-B | 7.2 | 200 | 50 | 63 | 500 | 87 | 442 | 553 | 588 | 122 | 2.1 | 76000 | 750000 | 5.5 | 5908270807594 |
| 1YMB770741M4812 | CMF-BS-B | 7.2 | 250 | 50 | 63 | 800 | 87 | 442 | 553 | 588 | 133 | 1.5 | 140000 | 1200000 | 5.5 | 5908270807600 |
| 1YMB770742M4812 | CMF-BS-B | 7.2 | 315 | 50 | 63 | 950 | 87 | 442 | 553 | 588 | 186 | 1.2 | 210000 | 2200000 | 5.5 | 5908270807617 |
| 1YMB771229M4612 | CMF-BS-B | 12 | 63 | 50 | 63 | 210 | 65 | 442 | 553 | 588 | 71 | 13.5 | 4800 | 110000 | 3.5 | 5908270807624 |
| 1YMB771233M4812 | CMF-BS-B | 12 | 100 | 50 | 63 | 275 | 87 | 442 | 553 | 588 | 88 | 6.6 | 14000 | 200000 | 5.5 | 5908270807631 |
| 1YMB771238M4812 | CMF-BS-B | 12 | 160 | 50 | 63 | 480 | 87 | 442 | 553 | 588 | 139 | 3.9 | 38000 | 700000 | 5.5 | 5908270807648 |
| 1YMB771239M4812 | CMF-BS-B | 12 | 200 | 50 | 63 | 700 | 87 | 442 | 553 | 588 | 166 | 2.7 | 93000 | 910000 | 5.5 | 5908270807655 |
| 1YMB780333M2612 | CMF-BS-C | 3.6 | 100 | 50 | 63 | 275 | 65 | 292 | 400 | 440 | 41 | 3.2 | 14000 | 170000 | 2.5 | 5908270807662 |
| 1YMB780338M2612 | CMF-BS-C | 3.6 | 160 | 50 | 63 | 400 | 65 | 292 | 400 | 440 | 70 | 1.9 | 38000 | 500000 | 2.5 | 5908270807679 |
| 1YMB780339M2812 | CMF-BS-C | 3.6 | 200 | 50 | 63 | 500 | 87 | 292 | 400 | 440 | 78 | 1.4 | 76000 | 710000 | 3.8 | 5908270807686 |
| 1YMB780341M2812 | CMF-BS-C | 3.6 | 250 | 50 | 63 | 760 | 87 | 292 | 400 | 440 | 90 | 1 | 140000 | 1150000 | 3.8 | 5908270807693 |
| 1YMB780342M2812 | CMF-BS-C | 3.6 | 315 | 50 | 63 | 900 | 87 | 292 | 400 | 440 | 121 | 0.8 | 210000 | 1800000 | 3.8 | 5908270807709 |
| 1YMB780729M4612 | CMF-BS-C | 7.2 | 63 | 50 | 63 | 195 | 65 | 442 | 553 | 593 | 43 | 8.5 | 4800 | 65000 | 3.5 | 5908270807716 |
| 1YMB780733M4612 | CMF-BS-C | 7.2 | 100 | 50 | 63 | 275 | 65 | 442 | 553 | 593 | 64 | 4.9 | 14000 | 180000 | 3.5 | 5908270807723 |
| 1YMB780738M4612 | CMF-BS-C | 7.2 | 160 | 50 | 63 | 400 | 65 | 442 | 553 | 593 | 109 | 2.9 | 38000 | 540000 | 3.5 | 5908270807730 |
| 1YMB780739M4812 | CMF-BS-C | 7.2 | 200 | 50 | 63 | 500 | 87 | 442 | 553 | 593 | 122 | 2.1 | 76000 | 750000 | 5.5 | 5908270807747 |
| 1YMB780741M4812 | CMF-BS-C | 7.2 | 250 | 50 | 63 | 800 | 87 | 442 | 553 | 593 | 133 | 1.5 | 140000 | 1200000 | 5.5 | 5908270807754 |
| 1YMB780742M4812 | CMF-BS-C | 7.2 | 315 | 50 | 63 | 950 | 87 | 442 | 553 | 593 | 186 | 1.2 | 210000 | 2200000 | 5.5 | 5908270807761 |
| 1YMB781229M4612 | CMF-BS-C | 12 | 63 | 50 | 63 | 210 | 65 | 442 | 553 | 593 | 71 | 13.5 | 4800 | 110000 | 3.5 | 5908270807778 |
| 1YMB781233M4812 | CMF-BS-C | 12 | 100 | 50 | 63 | 275 | 87 | 442 | 553 | 593 | 88 | 6.6 | 14000 | 200000 | 5.5 | 5908270807785 |
| 1YMB781238M4812 | CMF-BS-C | 12 | 160 | 50 | 63 | 480 | 87 | 442 | 553 | 593 | 139 | 3.9 | 38000 | 700000 | 5.5 | 5908270807792 |
| 1YMB781239M4812 | CMF-BS-C | 12 | 200 | 50 | 63 | 700 | 87 | 442 | 553 | 593 | 166 | 2.7 | 93000 | 910000 | 5.5 | 5908270807808 |
| 1YMB790333M2612 | CMF-BS-D | 3.6 | 100 | 50 | 63 | 275 | 65 | 292 | 419 | 462 | 41 | 3.2 | 14000 | 170000 | 2.5 | 5908270807815 |
| 1YMB790338M2612 | CMF-BS-D | 3.6 | 160 | 50 | 63 | 400 | 65 | 292 | 419 | 462 | 70 | 1.9 | 38000 | 500000 | 2.5 | 5908270807822 |
| 1YMB790339M2812 | CMF-BS-D | 3.6 | 200 | 50 | 63 | 500 | 87 | 292 | 419 | 462 | 78 | 1.4 | 76000 | 710000 | 3.8 | 5908270807839 |
| 1YMB790341M2812 | CMF-BS-D | 3.6 | 250 | 50 | 63 | 760 | 87 | 292 | 419 | 462 | 90 | 1 | 140000 | 1150000 | 3.8 | 5908270807846 |
| 1YMB790342M2812 | CMF-BS-D | 3.6 | 315 | 50 | 63 | 900 | 87 | 292 | 419 | 462 | 121 | 0.8 | 210000 | 1800000 | 3.8 | 5908270807853 |

**Choice of fuse-links for motor protection** – the same selection procedure applies as for CMF fuse-links, see page 34.

**Time-current and cut-off current characteristic** – the same characteristics apply as for the CMF fuse-links, presented on pages 36-39.

# Fuse-links for voltage transformer protection



**042** – 047 **CEF-VT** – Essential fuse-links for voltage transformer protection

**048** – 054 **WBP** – Compact fuse-links for voltage transformer protection

# CEF-VT

## Essential fuse-links for voltage transformer protection

| | |
|---|---|
| **Class, type** | Back-up, current limiting fuse-link |
| **Rated voltages** | 3/7.2 kV - 10/24 kV |
| **Rated currents** | 0.5 A – 6.3 A |
| **Rated frequency** | 50 Hz |
| **Applicable standard** | IEC 60282-1 |
| **Application** | Indoor/outdoor |
| **Striker** | Without / 80 N (medium), with integrated TCU |



**Efficient protection of voltage transformer circuits**

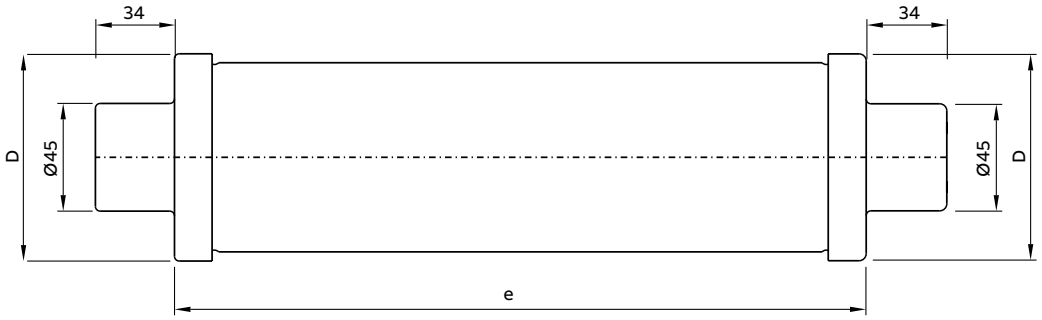
**Extending the lifetime of installed electrical equipment thanks to the limitation of the short-circuit current**

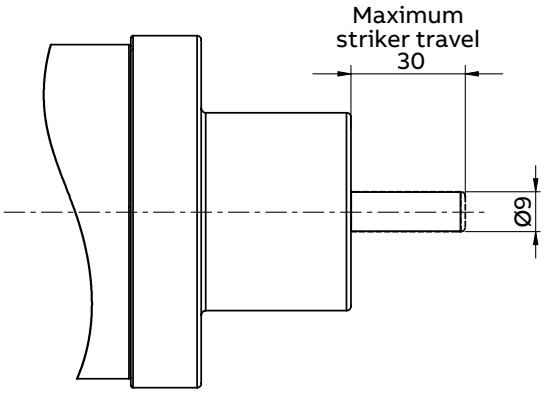
**Outdoor sealing included in standard version, designed and tested for harsh conditions**

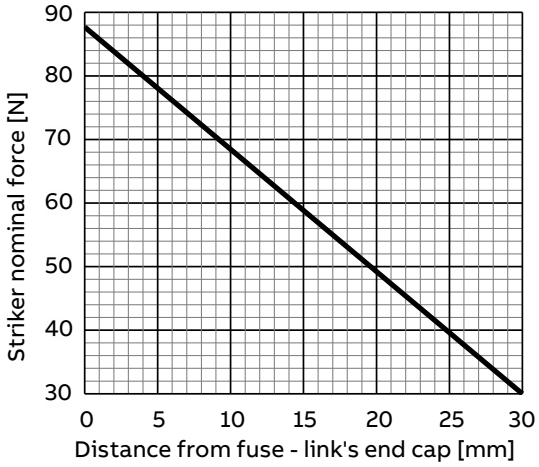
**CEF-VT fuses are designed for protection against faults in voltage transformer installation**

**Key features:**

- Designed and type tested acc. to IEC 60282-1
- Low power losses, generating additional savings during product life-cycle
- Top level fault current limitation and interruption performance up to 63kA RMS
- Outdoor sealing included in standard version, designed and tested for harsh conditions
- Welded current path
- Contacts made from silver coated copper
- Striker 80N (medium type) / without striker
- Equipped with Temperature Control Unit enabling the additional protection against thermal stresses in small enclosures




— 33
Dimensional drawing of fuse-link type CEF-VT

— 34
Fuse-link striker force and dimensions (applies only for types with a striker)

## Ordering and technical table

| Catalog number | Fuse name | Striker force [N] | Rated voltage $U_r$ [kV] | Rated current $I_r$ [A] | Rated frequency $f_r$ [Hz] | Breaking capacity $I_1$ [kA] | Minimal breaking current $I_3$ [A] | Diameter D [mm] | Length e [mm] | Rated power $P_w$ [W] | Cold resistance [mΩ] | Pre-arcing integral [$A^2s$] | Total interrupting integral [$A^2s$] | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1YMB750705M1502 | CEF-VT | - | 3/7.2 | 0.5 | 50 | 63 | 5 | 53 | 192 | 2 | 5957 | 0.05 | 1.4 | 1.2 | 5908270808577 |
| 1YMB750708M1502 | CEF-VT | - | 3/7.2 | 1 | 50 | 63 | 8 | 53 | 192 | 3 | 2149 | 0.09 | 2.4 | 1.2 | 5908270808584 |
| 1YMB750705M2502 | CEF-VT | - | 3/7.2 | 0.5 | 50 | 63 | 5 | 53 | 292 | 2 | 5957 | 0.05 | 1.4 | 1.6 | 5908270808591 |
| 1YMB750708M2502 | CEF-VT | - | 3/7.2 | 1 | 50 | 63 | 8 | 53 | 292 | 3 | 2149 | 0.09 | 2.4 | 1.6 | 5908270808607 |
| 1YMB751205M1502 | CEF-VT | - | 6/12 | 0.5 | 50 | 63 | 5 | 53 | 192 | 3 | 9660 | 0.02 | 0.3 | 1.2 | 5908270808614 |
| 1YMB751208M1502 | CEF-VT | - | 6/12 | 1 | 50 | 63 | 5 | 53 | 192 | 4.5 | 3485 | 0.01 | 0.9 | 1.2 | 5908270808621 |
| 1YMB751209M1512 | CEF-VT | 80 | 6/12 | 2 | 50 | 63 | 21 | 53 | 192 | 6.5 | 1311 | 1.8 | 377 | 1.2 | 5908270808638 |
| 1YMB751209M1502 | CEF-VT | - | 6/12 | 2 | 50 | 63 | 21 | 53 | 192 | 6.5 | 1607 | 1.8 | 377 | 1.2 | 5908270808645 |
| 1YMB751244M1512 | CEF-VT | 80 | 6/12 | 2.5 | 50 | 63 | 26 | 53 | 192 | 9.5 | 1100 | 0.67 | 149 | 1.2 | 5908270808652 |
| 1YMB751244M1502 | CEF-VT | - | 6/12 | 2.5 | 50 | 63 | 26 | 53 | 192 | 9.5 | 1317 | 0.67 | 149 | 1.2 | 5908270808669 |
| 1YMB751245M1512 | CEF-VT | 80 | 6/12 | 3.15 | 50 | 63 | 34 | 53 | 192 | 10.5 | 827 | 0.84 | 186 | 1.2 | 5908270808676 |
| 1YMB751245M1502 | CEF-VT | - | 6/12 | 3.15 | 50 | 63 | 34 | 53 | 192 | 10.5 | 951 | 0.84 | 186 | 1.2 | 5908270808683 |
| 1YMB751211M1512 | CEF-VT | 80 | 6/12 | 4 | 50 | 63 | 34 | 53 | 192 | 16 | 736 | 1.03 | 221 | 1.2 | 5908270808690 |
| 1YMB751211M1502 | CEF-VT | - | 6/12 | 4 | 50 | 63 | 34 | 53 | 192 | 16 | 835 | 1.03 | 221 | 1.2 | 5908270808706 |
| 1YMB751246M1512 | CEF-VT | 80 | 6/12 | 5 | 50 | 63 | 34 | 53 | 192 | 25.5 | 592 | 1.14 | 214 | 1.2 | 5908270808713 |
| 1YMB751246M1502 | CEF-VT | - | 6/12 | 5 | 50 | 63 | 34 | 53 | 192 | 25.5 | 659 | 1.14 | 214 | 1.2 | 5908270808720 |
| 1YMB751214M1512 | CEF-VT | 80 | 6/12 | 6.3 | 50 | 63 | 37 | 53 | 192 | 26 | 421 | 1.44 | 270 | 1.2 | 5908270808737 |
| 1YMB751214M1502 | CEF-VT | - | 6/12 | 6.3 | 50 | 63 | 37 | 53 | 192 | 26 | 458 | 1.44 | 270 | 1.2 | 5908270808744 |
| 1YMB751205M2502 | CEF-VT | - | 6/12 | 0.5 | 50 | 63 | 5 | 53 | 292 | 3 | 9660 | 0.02 | 0.3 | 1.6 | 5908270808751 |
| 1YMB751208M2502 | CEF-VT | - | 6/12 | 1 | 50 | 63 | 5 | 53 | 292 | 4.5 | 3485 | 0.01 | 0.9 | 1.6 | 5908270808768 |
| 1YMB751209M2512 | CEF-VT | 80 | 6/12 | 2 | 50 | 63 | 21 | 53 | 292 | 6.5 | 1311 | 1.8 | 377 | 1.6 | 5908270808775 |
| 1YMB751209M2502 | CEF-VT | - | 6/12 | 2 | 50 | 63 | 21 | 53 | 292 | 6.5 | 1607 | 1.8 | 377 | 1.6 | 5908270808782 |

| Catalog number | Fuse name | Striker force [N] | Rated voltage $U_r$ [kV] | Rated current $I_r$ [A] | Rated frequency $f_r$ [Hz] | Breaking capacity $I_1$ [kA] | Minimal breaking current $I_3$ [A] | Diameter D [mm] | Length e [mm] | Rated power $P_w$ [W] | Cold resistance [mΩ] | Pre-arcing integral [$A^2s$] | Total interrupting integral [$A^2s$] | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1YMB751244M2512 | CEF-VT | 80 | 6/12 | 2.5 | 50 | 63 | 26 | 53 | 292 | 9.5 | 1100 | 0.67 | 149 | 1.6 | 5908270808799 |
| 1YMB751244M2502 | CEF-VT | - | 6/12 | 2.5 | 50 | 63 | 26 | 53 | 292 | 9.5 | 1317 | 0.67 | 149 | 1.6 | 5908270808805 |
| 1YMB751245M2512 | CEF-VT | 80 | 6/12 | 3.15 | 50 | 63 | 34 | 53 | 292 | 10.5 | 827 | 0.84 | 186 | 1.6 | 5908270808812 |
| 1YMB751245M2502 | CEF-VT | - | 6/12 | 3.15 | 50 | 63 | 34 | 53 | 292 | 10.5 | 951 | 0.84 | 186 | 1.6 | 5908270808829 |
| 1YMB751211M2512 | CEF-VT | 80 | 6/12 | 4 | 50 | 63 | 34 | 53 | 292 | 16 | 736 | 1.03 | 221 | 1.6 | 5908270808836 |
| 1YMB751211M2502 | CEF-VT | - | 6/12 | 4 | 50 | 63 | 34 | 53 | 292 | 16 | 835 | 1.03 | 221 | 1.6 | 5908270808843 |
| 1YMB751246M2512 | CEF-VT | 80 | 6/12 | 5 | 50 | 63 | 34 | 53 | 292 | 25.5 | 592 | 1.14 | 214 | 1.6 | 5908270808850 |
| 1YMB751246M2502 | CEF-VT | - | 6/12 | 5 | 50 | 63 | 34 | 53 | 292 | 25.5 | 659 | 1.14 | 214 | 1.6 | 5908270808867 |
| 1YMB751214M2512 | CEF-VT | 80 | 6/12 | 6.3 | 50 | 63 | 37 | 53 | 292 | 26 | 421 | 1.44 | 270 | 1.6 | 5908270808874 |
| 1YMB751214M2502 | CEF-VT | - | 6/12 | 6.3 | 50 | 63 | 37 | 53 | 292 | 26 | 458 | 1.44 | 270 | 1.6 | 5908270808881 |
| 1YMB751705M1502 | CEF-VT | - | 10/17.5 | 0.5 | 50 | 63 | 5 | 53 | 192 | 4 | 12880 | 0.01 | 0.7 | 1.2 | 5908270808898 |
| 1YMB751708M1502 | CEF-VT | - | 10/17.5 | 1 | 50 | 63 | 8 | 53 | 192 | 5.5 | 4716 | 0.02 | 1.3 | 1.2 | 5908270808904 |
| 1YMB751709M1512 | CEF-VT | 80 | 10/17.5 | 2 | 50 | 63 | 24 | 53 | 192 | 9.5 | 1994 | 0.75 | 5.0 | 1.2 | 5908270808911 |
| 1YMB751709M1502 | CEF-VT | - | 10/17.5 | 2 | 50 | 63 | 24 | 53 | 192 | 9.5 | 2410 | 0.75 | 5.0 | 1.2 | 5908270808928 |
| 1YMB751744M1512 | CEF-VT | 80 | 10/17.5 | 2.5 | 50 | 63 | 24 | 53 | 192 | 13.5 | 1618 | 0.16 | 174 | 1.2 | 5908270808935 |
| 1YMB751744M1502 | CEF-VT | - | 10/17.5 | 2.5 | 50 | 63 | 24 | 53 | 192 | 13.5 | 1882 | 0.16 | 174 | 1.2 | 5908270808942 |
| 1YMB751745M1512 | CEF-VT | 80 | 10/17.5 | 3.15 | 50 | 63 | 31 | 53 | 192 | 15.5 | 1174 | 0.2 | 218 | 1.2 | 5908270808959 |
| 1YMB751745M1502 | CEF-VT | - | 10/17.5 | 3.15 | 50 | 63 | 31 | 53 | 192 | 15.5 | 1307 | 0.2 | 218 | 1.2 | 5908270808966 |
| 1YMB751711M1512 | CEF-VT | 80 | 10/17.5 | 4 | 50 | 63 | 31 | 53 | 192 | 23 | 1063 | 0.16 | 170 | 1.2 | 5908270808973 |
| 1YMB751711M1502 | CEF-VT | - | 10/17.5 | 4 | 50 | 63 | 31 | 53 | 192 | 23 | 1171 | 0.16 | 170 | 1.2 | 5908270808980 |
| 1YMB751746M1512 | CEF-VT | 80 | 10/17.5 | 5 | 50 | 63 | 31 | 53 | 192 | 31.5 | 870 | 0.05 | 457 | 1.2 | 5908270808997 |
| 1YMB751746M1502 | CEF-VT | - | 10/17.5 | 5 | 50 | 63 | 31 | 53 | 192 | 31.5 | 941 | 0.05 | 457 | 1.2 | 5908270809000 |
| 1YMB751714M1512 | CEF-VT | 80 | 10/17.5 | 6.3 | 50 | 63 | 37 | 53 | 192 | 38 | 619 | 0.06 | 571 | 1.2 | 5908270809017 |
| 1YMB751714M1502 | CEF-VT | - | 10/17.5 | 6.3 | 50 | 63 | 37 | 53 | 192 | 38 | 654 | 0.06 | 571 | 1.2 | 5908270809024 |
| 1YMB751705M2502 | CEF-VT | - | 10/17.5 | 0.5 | 50 | 63 | 5 | 53 | 292 | 4 | 12880 | 0.01 | 0.7 | 1.6 | 5908270809031 |
| 1YMB751708M2502 | CEF-VT | - | 10/17.5 | 1 | 50 | 63 | 8 | 53 | 292 | 5.5 | 4716 | 0.02 | 1.3 | 1.6 | 5908270809048 |
| 1YMB751709M2512 | CEF-VT | 80 | 10/17.5 | 2 | 50 | 63 | 24 | 53 | 292 | 9.5 | 1994 | 0.75 | 5.0 | 1.6 | 5908270809055 |
| 1YMB751709M2502 | CEF-VT | - | 10/17.5 | 2 | 50 | 63 | 24 | 53 | 292 | 9.5 | 2410 | 0.75 | 5.0 | 1.6 | 5908270809062 |
| 1YMB751744M2512 | CEF-VT | 80 | 10/17.5 | 2.5 | 50 | 63 | 24 | 53 | 292 | 13.5 | 1618 | 0.16 | 174 | 1.6 | 5908270809079 |
| 1YMB751744M2502 | CEF-VT | - | 10/17.5 | 2.5 | 50 | 63 | 24 | 53 | 292 | 13.5 | 1882 | 0.16 | 174 | 1.6 | 5908270809086 |
| 1YMB751745M2512 | CEF-VT | 80 | 10/17.5 | 3.15 | 50 | 63 | 31 | 53 | 292 | 15.5 | 1174 | 0.2 | 218 | 1.6 | 5908270809093 |
| 1YMB751745M2502 | CEF-VT | - | 10/17.5 | 3.15 | 50 | 63 | 31 | 53 | 292 | 15.5 | 1307 | 0.2 | 218 | 1.6 | 5908270809109 |
| 1YMB751711M2512 | CEF-VT | 80 | 10/17.5 | 4 | 50 | 63 | 31 | 53 | 292 | 23 | 1063 | 0.16 | 170 | 1.6 | 5908270809116 |
| 1YMB751711M2502 | CEF-VT | - | 10/17.5 | 4 | 50 | 63 | 31 | 53 | 292 | 23 | 1171 | 0.16 | 170 | 1.6 | 5908270809123 |
| 1YMB751746M2512 | CEF-VT | 80 | 10/17.5 | 5 | 50 | 63 | 31 | 53 | 292 | 31.5 | 870 | 0.05 | 457 | 1.6 | 5908270809130 |
| 1YMB751746M2502 | CEF-VT | - | 10/17.5 | 5 | 50 | 63 | 31 | 53 | 292 | 31.5 | 941 | 0.05 | 457 | 1.6 | 5908270809147 |
| 1YMB751714M2512 | CEF-VT | 80 | 10/17.5 | 6.3 | 50 | 63 | 37 | 53 | 292 | 38 | 619 | 0.06 | 571 | 1.6 | 5908270809154 |
| 1YMB751714M2502 | CEF-VT | - | 10/17.5 | 6.3 | 50 | 63 | 37 | 53 | 292 | 38 | 654 | 0.06 | 571 | 1.6 | 5908270809161 |
| 1YMB752405M2502 | CEF-VT | - | 10/24 | 0.5 | 50 | 63 | 5 | 53 | 292 | 5 | 17709 | 0.01 | 0.3 | 1.6 | 5908270809178 |
| 1YMB752408M2502 | CEF-VT | - | 10/24 | 1 | 50 | 63 | 8 | 53 | 292 | 8 | 6389 | 0.01 | 0.9 | 1.6 | 5908270809185 |
| 1YMB752409M2512 | CEF-VT | 80 | 10/24 | 2 | 50 | 63 | 25 | 53 | 292 | 12 | 2568 | 1.23 | 139 | 1.6 | 5908270809192 |
| 1YMB752409M2502 | CEF-VT | - | 10/24 | 2 | 50 | 63 | 25 | 53 | 292 | 12 | 2962 | 1.23 | 139 | 1.6 | 5908270809208 |
| 1YMB752444M2512 | CEF-VT | 80 | 10/24 | 2.5 | 50 | 63 | 25 | 53 | 292 | 16.5 | 2138 | 3.44 | 98 | 1.6 | 5908270809215 |
| 1YMB752444M2502 | CEF-VT | - | 10/24 | 2.5 | 50 | 63 | 25 | 53 | 292 | 16.5 | 2404 | 3.44 | 98 | 1.6 | 5908270809222 |
| 1YMB752445M2512 | CEF-VT | 80 | 10/24 | 3.15 | 50 | 63 | 30 | 53 | 292 | 19 | 1537 | 4.3 | 123 | 1.6 | 5908270809239 |
| 1YMB752445M2502 | CEF-VT | - | 10/24 | 3.15 | 50 | 63 | 30 | 53 | 292 | 19 | 1670 | 4.3 | 123 | 1.6 | 5908270809246 |

| Catalog number | Fuse name | Striker force [N] | Rated voltage $U_r$ [kV] | Rated current $I_r$ [A] | Rated frequency $f_r$ [Hz] | Breaking capacity $I_1$ [kA] | Minimal breaking current $I_3$ [A] | Diameter D [mm] | Length e [mm] | Rated power $P_w$ [W] | Cold resistance [mΩ] | Pre-arcing integral [$A^2s$] | Total interrupting integral [$A^2s$] | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1YMB752411M2512 | CEF-VT | 80 | 10/24 | 4 | 50 | 63 | 31 | 53 | 292 | 29.5 | 1375 | 2 | 140 | 1.6 | 5908270809253 |
| 1YMB752411M2502 | CEF-VT | - | 10/24 | 4 | 50 | 63 | 31 | 53 | 292 | 29.5 | 1481 | 2 | 140 | 1.6 | 5908270809260 |
| 1YMB752446M2512 | CEF-VT | 80 | 10/24 | 5 | 50 | 63 | 31 | 53 | 292 | 39 | 1132 | 1.54 | 221 | 1.6 | 5908270809277 |
| 1YMB752446M2502 | CEF-VT | - | 10/24 | 5 | 50 | 63 | 31 | 53 | 292 | 39 | 1202 | 1.54 | 221 | 1.6 | 5908270809284 |
| 1YMB752414M2512 | CEF-VT | 80 | 10/24 | 6.3 | 50 | 63 | 36 | 53 | 292 | 46 | 801 | 1.92 | 276 | 1.6 | 5908270809291 |
| 1YMB752414M2502 | CEF-VT | - | 10/24 | 6.3 | 50 | 63 | 36 | 53 | 292 | 46 | 835 | 1.92 | 276 | 1.6 | 5908270809307 |
| 1YMB752405M4502 | CEF-VT | - | 10/24 | 0.5 | 50 | 63 | 5 | 53 | 442 | 5 | 17709 | 0.01 | 0.3 | 2.3 | 5908270809314 |
| 1YMB752408M4502 | CEF-VT | - | 10/24 | 1 | 50 | 63 | 8 | 53 | 442 | 8 | 6389 | 0.01 | 0.9 | 2.3 | 5908270809321 |
| 1YMB752409M4512 | CEF-VT | 80 | 10/24 | 2 | 50 | 63 | 25 | 53 | 442 | 12 | 2568 | 1.23 | 139 | 2.3 | 5908270806528 |
| 1YMB752409M4502 | CEF-VT | - | 10/24 | 2 | 50 | 63 | 25 | 53 | 442 | 12 | 2962 | 1.23 | 139 | 2.3 | 5908270809338 |
| 1YMB752444M4512 | CEF-VT | 80 | 10/24 | 2.5 | 50 | 63 | 25 | 53 | 442 | 16.5 | 2138 | 3.44 | 98 | 2.3 | 5908270809345 |
| 1YMB752444M4502 | CEF-VT | - | 10/24 | 2.5 | 50 | 63 | 25 | 53 | 442 | 16.5 | 2404 | 3.44 | 98 | 2.3 | 5908270809352 |
| 1YMB752445M4512 | CEF-VT | 80 | 10/24 | 3.15 | 50 | 63 | 30 | 53 | 442 | 19 | 1537 | 4.3 | 123 | 2.3 | 5908270809369 |
| 1YMB752445M4502 | CEF-VT | - | 10/24 | 3.15 | 50 | 63 | 30 | 53 | 442 | 19 | 1670 | 4.3 | 123 | 2.3 | 5908270809376 |
| 1YMB752411M4512 | CEF-VT | 80 | 10/24 | 4 | 50 | 63 | 31 | 53 | 442 | 29.5 | 1375 | 2 | 140 | 2.3 | 5908270806535 |
| 1YMB752411M4502 | CEF-VT | - | 10/24 | 4 | 50 | 63 | 31 | 53 | 442 | 29.5 | 1481 | 2 | 140 | 2.3 | 5908270809383 |
| 1YMB752446M4512 | CEF-VT | 80 | 10/24 | 5 | 50 | 63 | 31 | 53 | 442 | 39 | 1132 | 1.54 | 221 | 2.3 | 5908270809390 |
| 1YMB752446M4502 | CEF-VT | - | 10/24 | 5 | 50 | 63 | 31 | 53 | 442 | 39 | 1202 | 1.54 | 221 | 2.3 | 5908270809406 |
| 1YMB752414M4512 | CEF-VT | 80 | 10/24 | 6.3 | 50 | 63 | 36 | 53 | 442 | 46 | 801 | 1.92 | 276 | 2.3 | 5908270809413 |
| 1YMB752414M4502 | CEF-VT | - | 10/24 | 6.3 | 50 | 63 | 36 | 53 | 442 | 46 | 835 | 1.92 | 276 | 2.3 | 5908270809420 |

**Choice of fuse-links for voltage transformer protection:**

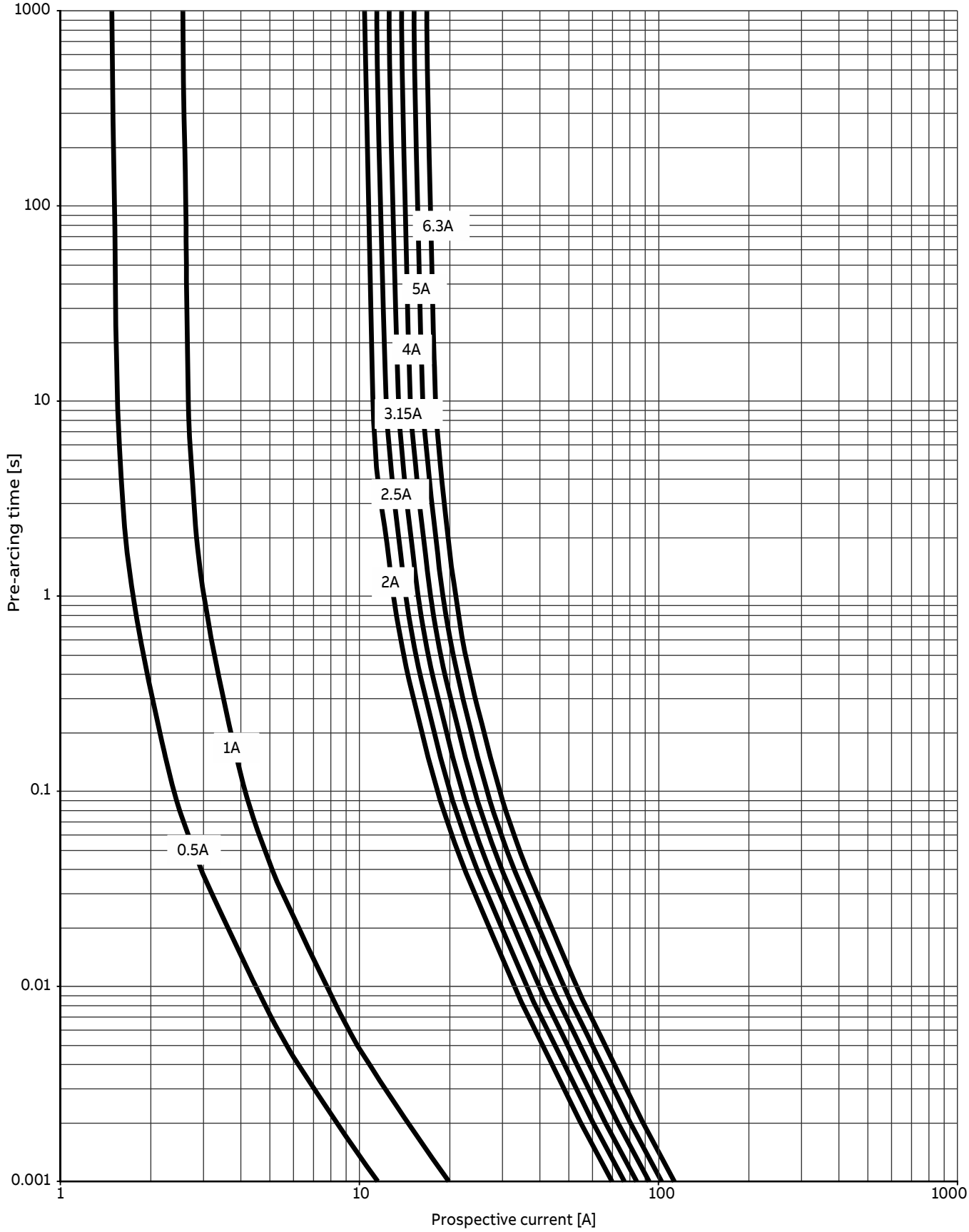
**Rated voltage $U_r$** – should be equal to or higher than the maximum operating system voltage.

**Rated current $I_r$** – should be higher than the maximum continuous current of the voltage transformer.

The following points should be observed:

- Initial starting current of voltage transformer, energizing and operations of installed switching apparatus should not cause fuse tripping under normal working conditions
- Rated breaking capacity of the fuse-links should be higher than the prospective value of the short-circuit in its place of installation
- The ability of the electrical system (switchgear) to withstand impulses should exceed the switching overvoltages generated by the fuse-links

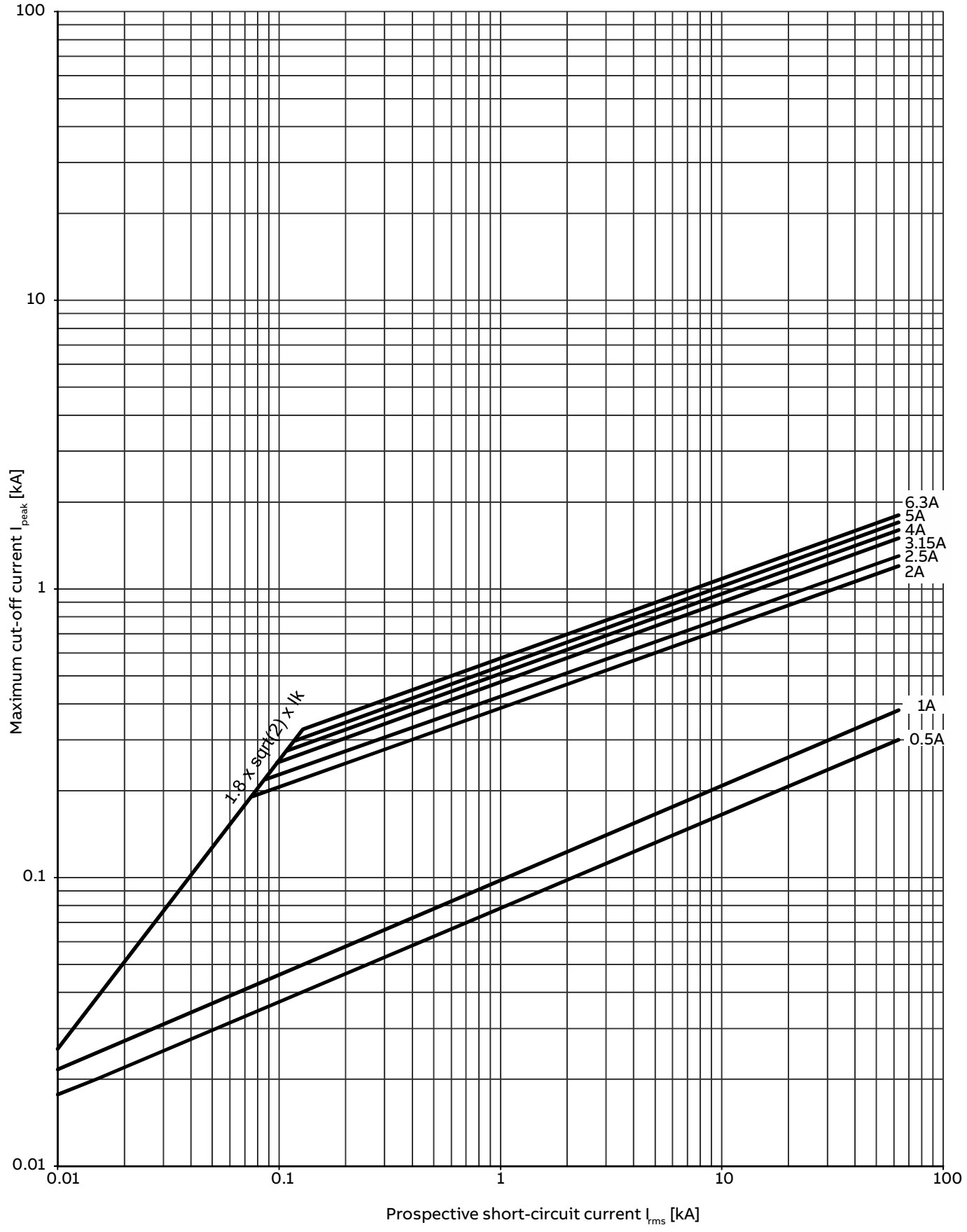
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35




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35
CEF-VT 3/7.2 kV; 6/12 kV; 10/17.5 kV; 10/24 kV time-current characteristics

Characteristic show the average melting time as a function of the prospective current and are recorded from cold condition of fuse-link. The tolerance is ± 20% referred to the current for single fuses. Characteristics are valid for frequency 50 Hz

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36




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36
CEF-VT 3/7.2 kV; 6/12kV; 10/17.5 kV; 10/24 kV cut-off current characteristics

Characteristics show the upper limit of the cut-off current corresponding to a prospective short--circuit current.

Characteristics are valid for frequency 50Hz.

# WBP

## Compact fuse-links for voltage transformer protection

| | |
|---|---|
| **Class, type** | Back-up, current limiting fuse-link |
| **Rated voltages** | 3 kV - 40.5 kV |
| **Rated currents** | 0.4 A - 4 A |
| **Rated frequency** | 50 Hz |
| **Applicable standard** | IEC 60282-1 |
| **Application** | Indoor |
| **Striker** | Without |



**Safe operation of electrical circuit with voltage transformers**

**Reduce cost of service due to extended lifetime of related electrical equipment by effective limitation of short-circuit currents**

**Easier handling thanks to a more durable design comparing to previous generation**

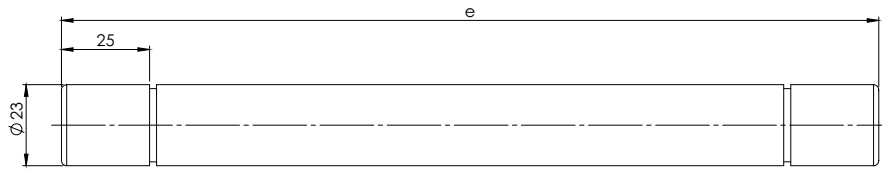
**Fuse-links type WBP are designed for efficient protection of the circuit from faults in voltage transformers (potential transformers)**

**Key features:**

- Designed and type tested acc. to IEC 60282-1
- Low power losses, generating additional savings during product life-cycle
- Designed for indoor applications
- Compact dimensions
- More durable design comparing to previous generation, with the use of porcelain tube
- Top level fault current limitation and interruption performance up to 63kA RMS
- Welded current path
- Contacts made from silver coated copper
- Compatible with ABB voltage transformers type TJC, TDC and other types with suitable fuse holders

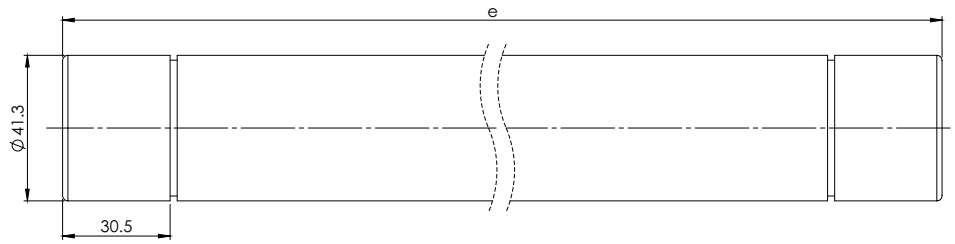
37
Dimensional drawing of fuse-link type WBP 7.2 kV – 36 kV

37




38
Dimensional drawing of fuse-link type WBP 40.5 kV

38




## Ordering and technical table

| Catalog number | Fuse name | Rated voltage $U_r$ [kV] | Rated current $I_r$ [A] | Rated frequency $f_r$ [Hz] | Breaking capacity $I_1$ [kA] | Minimal breaking current $I_3$ [A] | Diameter D [mm] | Length e [mm] | Rated power $P_w$ [W] | Cold resistance [mΩ] | Pre-arcing integral [A²s] | Total interrupting integral [A²s] | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1YMB750705M2202 | WBP | 7.2 | 0.5 | 50 | 63 | 5 | 23 | 210 | 2 | 6057 | 0.05 | 1.36 | 0.2 | 5908270809451 |
| 1YMB750708M2202 | WBP | 7.2 | 1 | 50 | 63 | 8 | 23 | 210 | 3.3 | 2185 | 0.09 | 2.42 | 0.2 | 5908270809468 |
| 1YMB750709M2202 | WBP | 7.2 | 2 | 50 | 63 | 16 | 23 | 210 | 5.2 | 969 | 0.325 | 8.35 | 0.2 | 5908270809475 |
| 1YMB750745M2202 | WBP | 7.2 | 3.15 | 50 | 63 | 16 | 23 | 210 | 7.6 | 546 | 1.23 | 16.3 | 0.2 | 5908270809482 |
| 1YMB751205M2202 | WBP | 12 | 0.5 | 50 | 63 | 5 | 23 | 250 | 3.3 | 9564 | 0.05 | 1.36 | 0.3 | 5908270809499 |
| 1YMB751208M2202 | WBP | 12 | 1 | 50 | 63 | 8 | 23 | 250 | 4.4 | 3451 | 0.09 | 2.42 | 0.3 | 5908270809505 |
| 1YMB751209M2202 | WBP | 12 | 2 | 50 | 63 | 16 | 23 | 250 | 8.3 | 1530 | 0.325 | 8.35 | 0.3 | 5908270809512 |
| 1YMB751245M2202 | WBP | 12 | 3.15 | 50 | 63 | 16 | 23 | 250 | 9.5 | 863 | 1.23 | 16.3 | 0.3 | 5908270809529 |
| 1YMB752405M3202 | WBP | 24 | 0.5 | 50 | 63 | 5 | 23 | 310 | 5.9 | 17534 | 0.05 | 1.36 | 0.3 | 5908270809536 |
| 1YMB752408M3202 | WBP | 24 | 1 | 50 | 63 | 8 | 23 | 310 | 8.4 | 6614 | 0.09 | 2.42 | 0.3 | 5908270809543 |
| 1YMB752409M3202 | WBP | 24 | 2 | 50 | 63 | 16 | 23 | 310 | 11.5 | 2933 | 0.325 | 8.35 | 0.3 | 5908270809550 |
| 1YMB752445M3202 | WBP | 24 | 3.15 | 50 | 63 | 24 | 23 | 310 | 21.2 | 1654 | 1.23 | 16.3 | 0.3 | 5908270809567 |
| 1YMB753605M3202 | WBP | 36 | 0.5 | 50 | 40 | 10 | 23 | 385 | 1.9 | 6074 | 0.02 | 1.85 | 0.4 | 5908270809574 |
| 1YMB753608M3202 | WBP | 36 | 1 | 50 | 40 | 10 | 23 | 385 | 6 | 4727 | 0.1 | 2.82 | 0.4 | 5908270809581 |
| 1YMB753609M3202 | WBP | 36 | 2 | 50 | 40 | 24 | 23 | 385 | 26.6 | 4208 | 0.325 | 8.35 | 0.4 | 5908270809598 |
| 1YMB753645M3202 | WBP | 36 | 3.15 | 50 | 40 | 24 | 23 | 385 | 39 | 2373 | 1.23 | 16.3 | 0.4 | 5908270809604 |
| 1YMB754009M4402 | WBP | 40.5 | 2 | 50 | 40 | 14 | 41.3 | 440 | 26.8 | 4845 | 0.325 | 8.35 | 1.3 | 5908270809611 |
| 1YMB754011M4402 | WBP | 40.5 | 4 | 50 | 40 | 30 | 41.3 | 440 | 38.4 | 2423 | 0.65 | 16.7 | 1.3 | 5908270809628 |
| 1YMB750747M2201 | WBP-6 | 7.2 | 0.7 | 50 | 63 | 8 | 23 | 210 | 2.2 | 2185 | 0.09 | 2.42 | 0.2 | 5908270809635 |
| 1YMB751206M2201 | WBP-10 | 12 | 0.6 | 50 | 63 | 8 | 23 | 250 | 3.1 | 3451 | 0.09 | 2.42 | 0.3 | 5908270809642 |
| 1YMB752405M3201 | WBP-20 | 24 | 0.5 | 50 | 63 | 5 | 23 | 310 | 5.9 | 17534 | 0.05 | 1.36 | 0.3 | 5908270809659 |
| 1YMB753604M3201 | WBP-30 | 36 | 0.4 | 50 | 40 | 10 | 23 | 385 | 1.7 | 6074 | 0.02 | 1.85 | 0.4 | 5908270809666 |

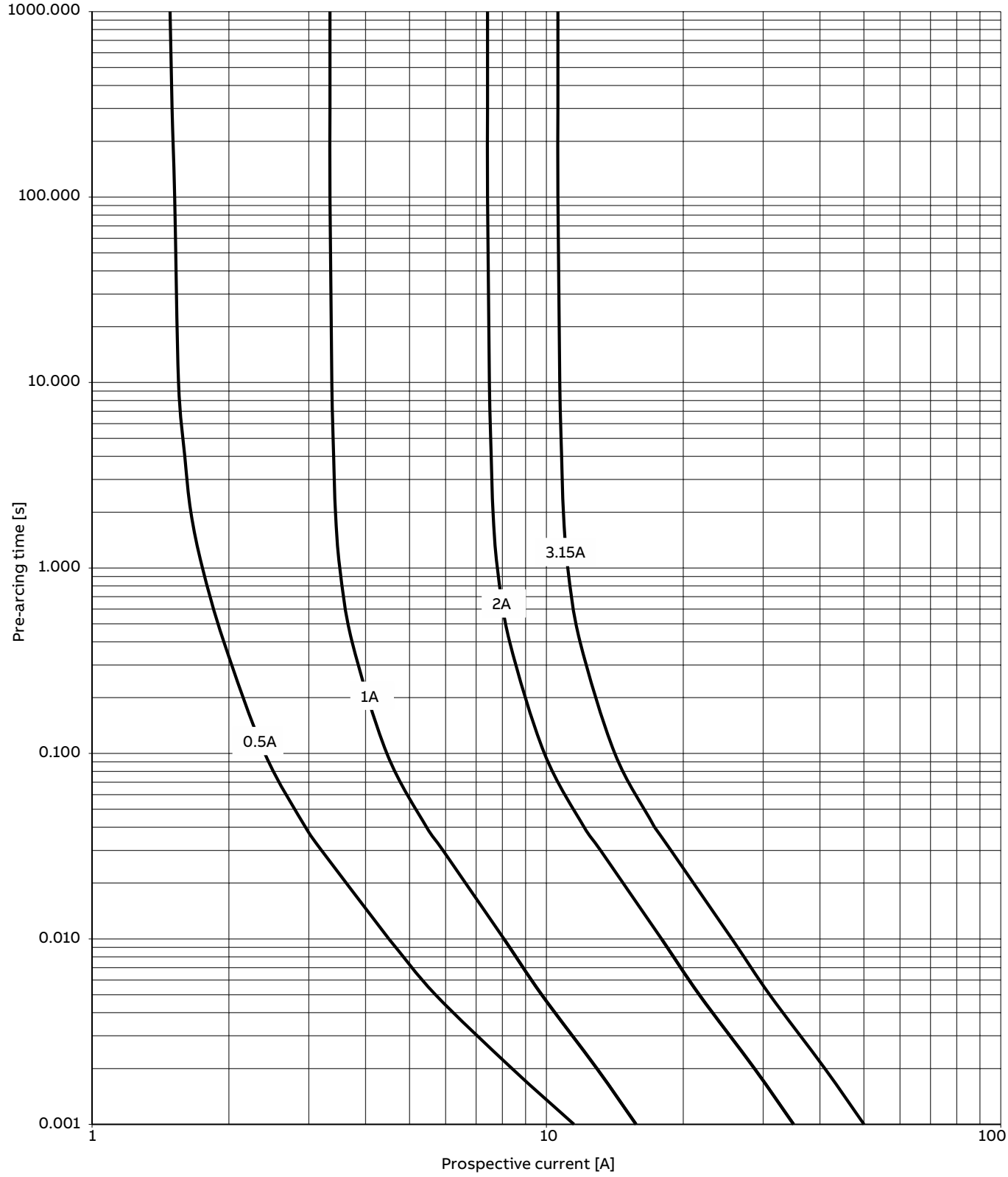
**Choice of fuse-links for voltage transformer protection:**

**Rated voltage $U_r$** - should be equal to or higher than the maximum operating system voltage
**Rated current $I_r$** - should be higher than the maximum continuous current of the voltage transformer

The following points should be observed:

- Initial starting current of voltage transformer, energizing and operations of installed switching apparatus should not cause fuse tripping under normal working conditions
- Rated breaking capacity of the fuse-links should be higher than the prospective value of the short-circuit in its place of installation
- The ability of the electrical system (switchgear) to withstand impulses should exceed the switching overvoltages generated by the fuse-links

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39

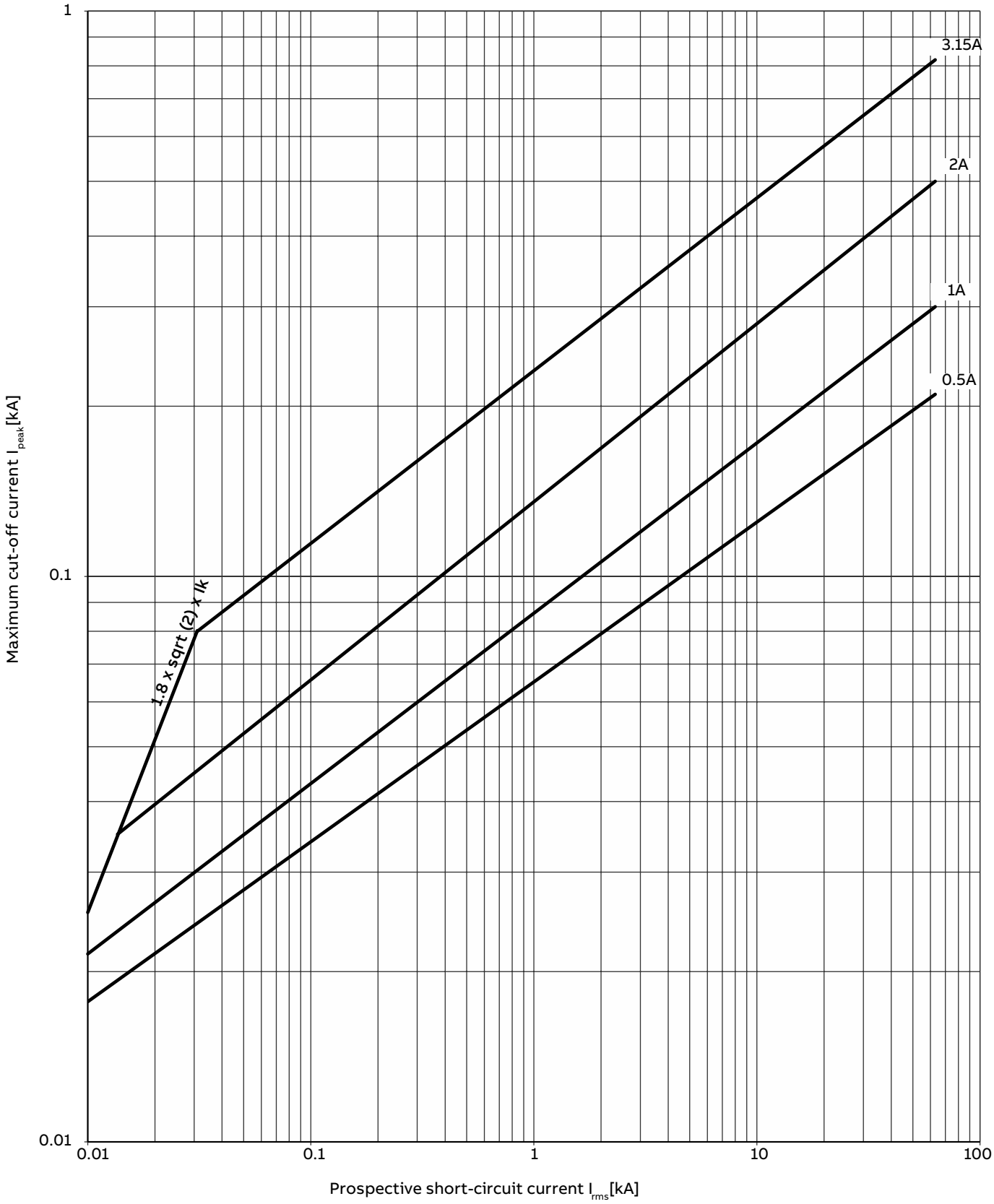



Characteristic show the average melting time as a function of the prospective current and are recorded from cold condition of fuse-link.

The tolerance is ± 20% referred to the current for single fuses. Characteristics are valid for frequency 50 Hz

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39
WBP 7.2 kV, 12 kV, 24 kV fuses time-current characteristics

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40

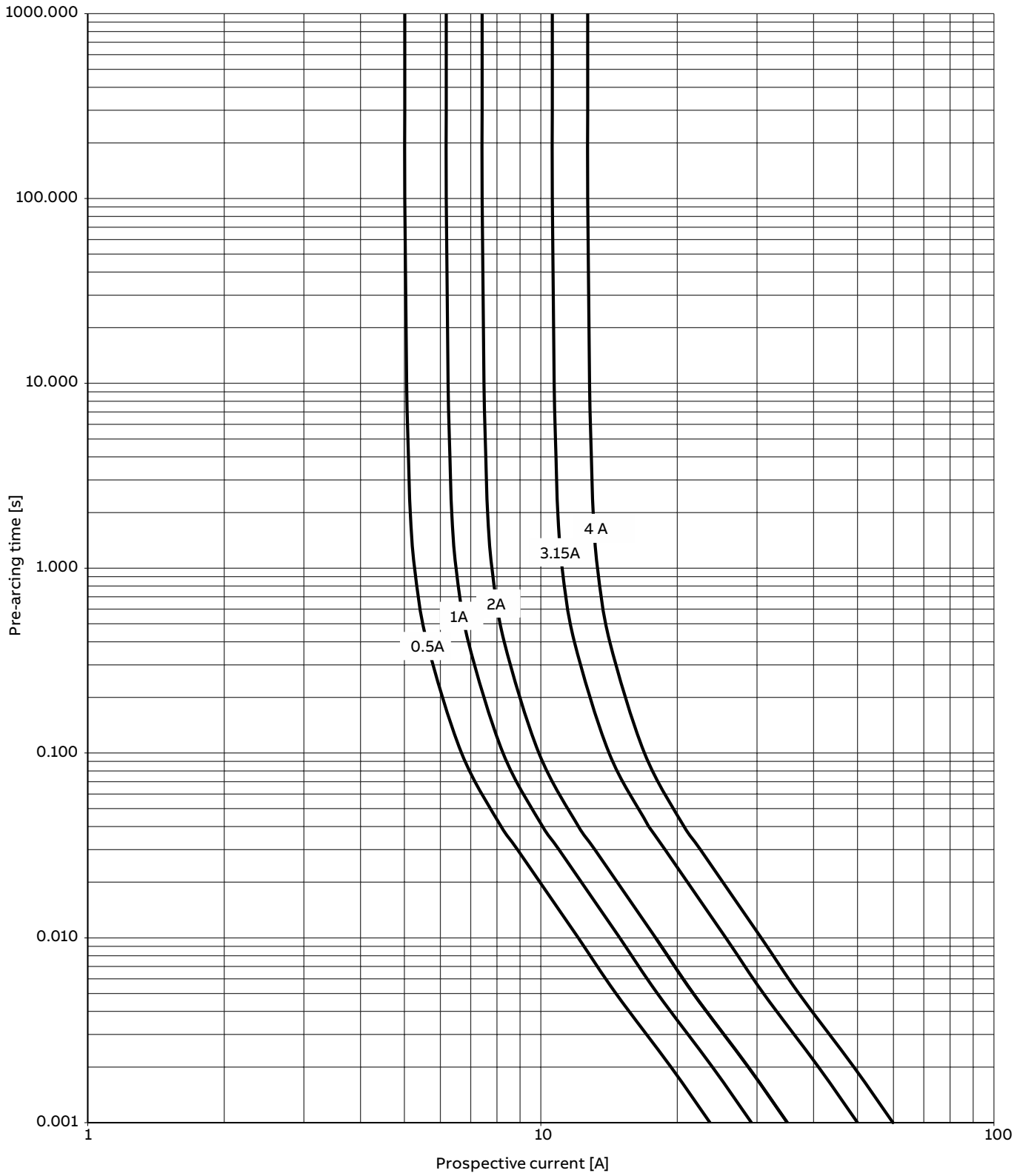



Characteristics show the cut-off current corresponding to a prospective short-circuit current.

Characteristics are valid for frequency 50Hz.

—
40
WBP 7.2 kV, 12 kV, 24 kV cut-off current characteristics

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41

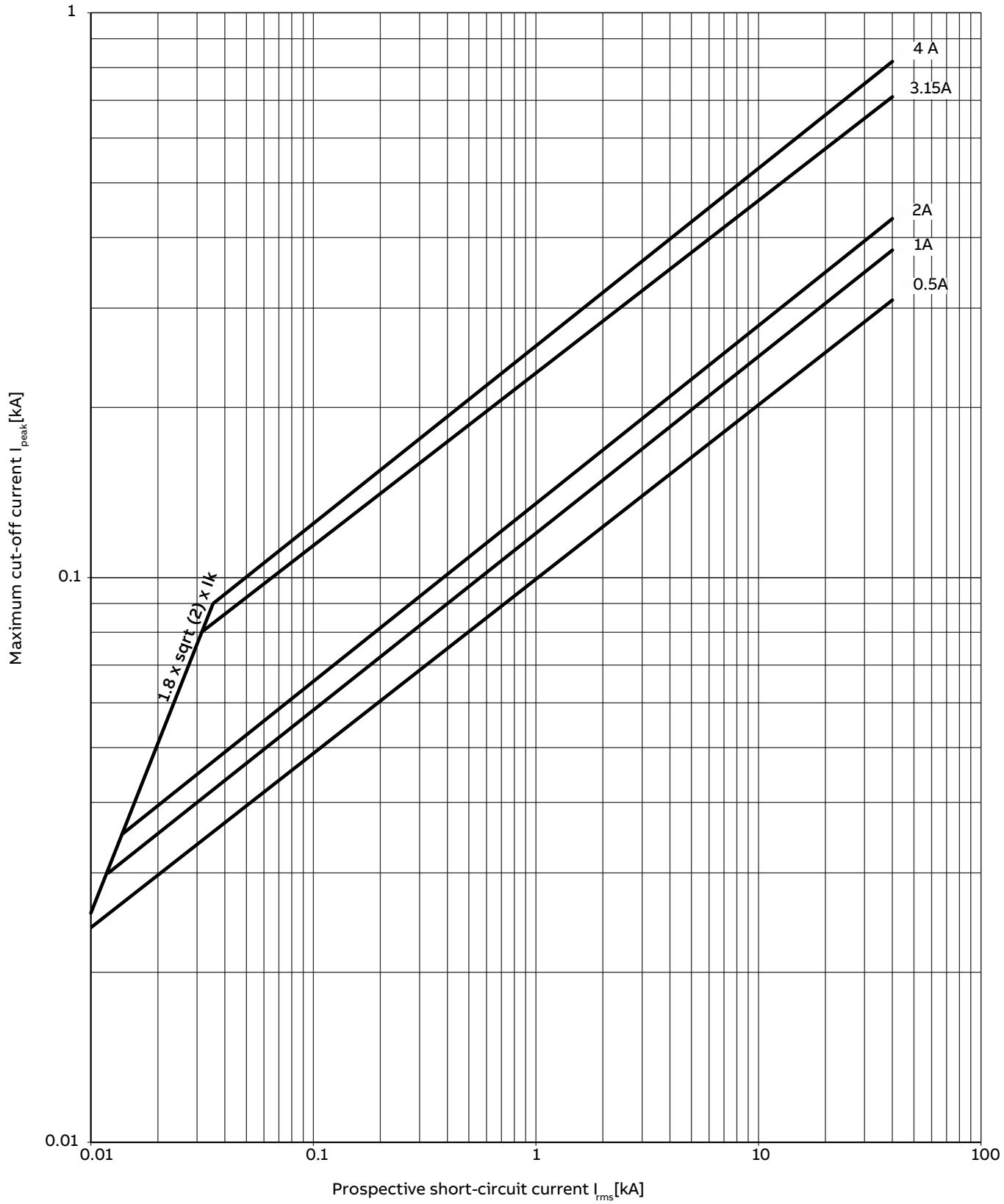



Characteristic show the average melting time as a function of the prospective current and are recorded from cold condition of fuse-link.

The tolerance is ± 20% referred to the current for single fuses. Characteristics are valid for frequency 50 HZ

—
41
WBP 36 kV, 40.5 kV fuses time-current characteristics

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42




Characteristics show the cut-off current corresponding to a prospective short-circuit current.

Characteristics are valid for frequency 50Hz.

—
42
WBP 36 kV, 40.5 kV, cut-off current characteristics

# Fuse-bases and accessories



**058** – 060 **UCE-NI** – Indoor fuse-bases for CEF, CEF-S, CEF-VT, CMF fuse-links

**061** – 063 **PBPM** – Indoor fuse-bases for WBP fuse-links

**064** – 068 **Accessories** – Accessories for fuse-links and fuse-bases

# UCE-NI

## Indoor fuse-bases for CEF, CEF-S, CEF-VT, CMF fuse-links

| | |
|---|---|
| **Application** | Indoor fuse-base |
| **Rated voltages** | 12 kV – 36 kV |
| **Rated currents** | 200 A, 315 A |
| **Rated frequency** | 50 Hz – 60 Hz |
| **Compatible fuse-links** | CEF, CEF-S, CEF-VT, CMF |



**Suitable for all types of DIN-size fuse-links**

**Reliable operation guaranteed by proven design**

**Firm connection with fuse-link secured by locks, allowing any mounting position**

**Fuse-bases type UCE-NI are designed for securing fuse-links in indoor application**

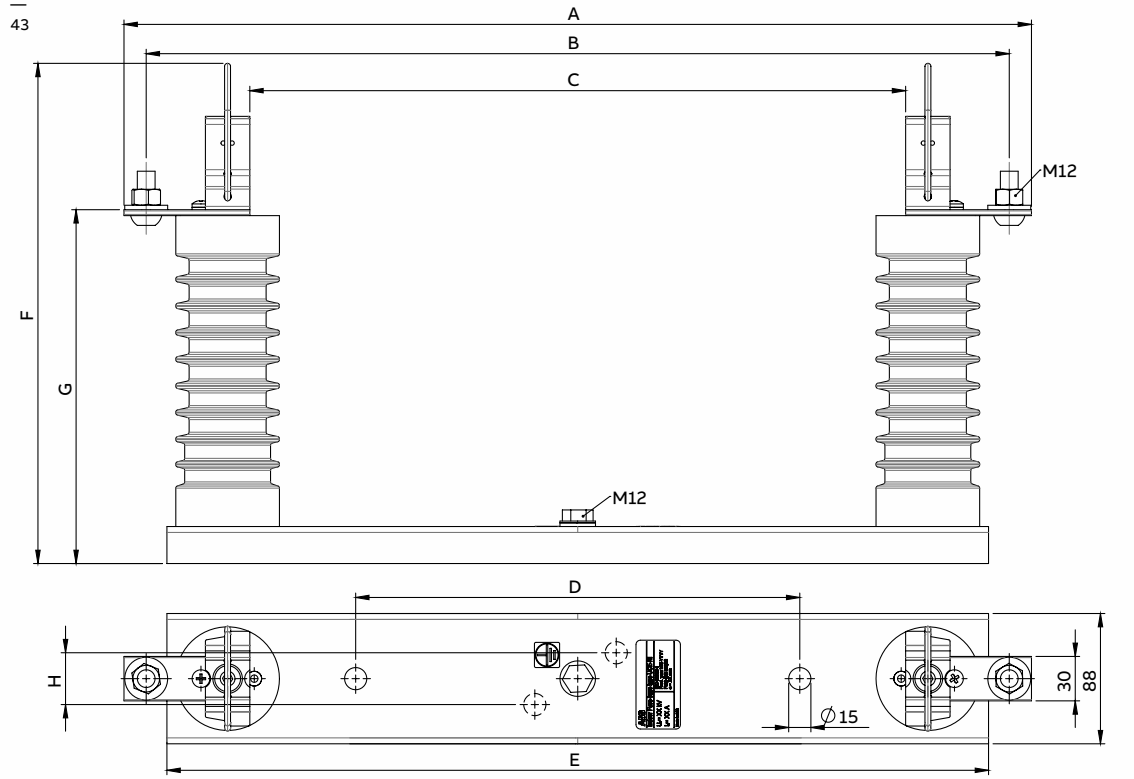
**Key features:**

- Rated voltage 12 kV – 36 kV
- Rated current up to 315 A
- Type tested acc. to IEC 60282-1
- Silver coated contacts

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**Ordering table of fuse-bases UCE-NI**

| Catalog number | Type | Rated voltage [kV] | Rated current [A] | Fuse length e [mm] | Lightning impulse withstand voltage [kV] | | Power-frequency withstand voltage [kV] | | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | To earth and between poles | Across the isolating distance | To earth and between poles | Across the isolating distance | | |
| 1YMB333101M0001 | UCE-NI | 12 | 250 | 192 | 75 | 85 | 28 | 32 | 3 | 5908270808249 |
| 1YMB333101M0002 | UCE-NI | 12 | 250 | 292 | 75 | 85 | 28 | 32 | 3.3 | 5908270808256 |
| 1YMB333101M0003 | UCE-NI | 12 | 250 | 367 | 75 | 85 | 28 | 32 | 3.5 | 5908270808263 |
| 1YMB333101M0004 | UCE-NI | 12 | 250 | 442 | 75 | 85 | 28 | 32 | 3.7 | 5908270808270 |
| 1YMB333101M0005 | UCE-NI | 12 | 250 | 537 | 75 | 85 | 28 | 32 | 4 | 5908270808287 |
| 1YMB333101M0014 | UCE-NI | 12 | 315 | 292 | 75 | 85 | 28 | 32 | 3.4 | 5908270808379 |
| 1YMB333101M0015 | UCE-NI | 12 | 315 | 442 | 75 | 85 | 28 | 32 | 3.8 | 5908270808386 |
| 1YMB333101M0006 | UCE-NI | 17.5 | 250 | 192 | 95 | 110 | 38 | 45 | 4.2 | 5908270808294 |
| 1YMB333101M0007 | UCE-NI | 24 | 250 | 292 | 125 | 145 | 50 | 60 | 4.5 | 5908270808300 |
| 1YMB333101M0008 | UCE-NI | 24 | 250 | 367 | 125 | 145 | 50 | 60 | 4.7 | 5908270808317 |
| 1YMB333101M0009 | UCE-NI | 24 | 250 | 442 | 125 | 145 | 50 | 60 | 4.9 | 5908270808324 |
| 1YMB333101M0010 | UCE-NI | 24 | 250 | 537 | 125 | 145 | 50 | 60 | 5.2 | 5908270808331 |
| 1YMB333101M0011 | UCE-NI | 25.8 | 250 | 292 | 150 | 165 | 60 | 66 | 6.3 | 5908270808348 |
| 1YMB333101M0012 | UCE-NI | 36 | 250 | 442 | 170 | 195 | 70 | 80 | 6.7 | 5908270808355 |
| 1YMB333101M0013 | UCE-NI | 36 | 250 | 537 | 170 | 195 | 70 | 80 | 7 | 5908270808362 |

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**Dimensions of indoor fuse-base type UCE-NI.**

| Type | $U_r$ [kV] | e [mm] | Dimensions in mm ± 3% | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F | G | H |
| UCE-NI | 12 | 192 | 363 | 333 | 193 | 55 | 305 | 258 | 159 | 35 |
| UCE-NI | 12 | 292 | 463 | 433 | 293 | 180 | 405 | 258 | 159 | - |
| UCE-NI | 12 | 367 | 538 | 508 | 368 | 180 | 480 | 258 | 159 | - |
| UCE-NI | 12 | 442 | 613 | 583 | 443 | 300 | 555 | 258 | 159 | - |
| UCE-NI | 12 | 537 | 708 | 678 | 538 | 380 | 650 | 258 | 159 | - |
| UCE-NI | 17.5 | 192 | 363 | 333 | 193 | 55 | 305 | 338 | 239 | 35 |
| UCE-NI | 24 | 292 | 463 | 433 | 293 | 180 | 405 | 338 | 239 | - |
| UCE-NI | 24 | 367 | 538 | 508 | 368 | 180 | 480 | 338 | 239 | - |
| UCE-NI | 24 | 442 | 613 | 583 | 443 | 300 | 555 | 338 | 239 | - |
| UCE-NI | 24 | 537 | 708 | 678 | 538 | 380 | 650 | 338 | 239 | - |
| UCE-NI | 25.8 | 292 | 463 | 433 | 293 | 180 | 405 | 428 | 329 | - |
| UCE-NI | 36 | 442 | 613 | 583 | 443 | 300 | 555 | 428 | 329 | - |
| UCE-NI | 36 | 537 | 708 | 678 | 538 | 380 | 650 | 428 | 329 | - |

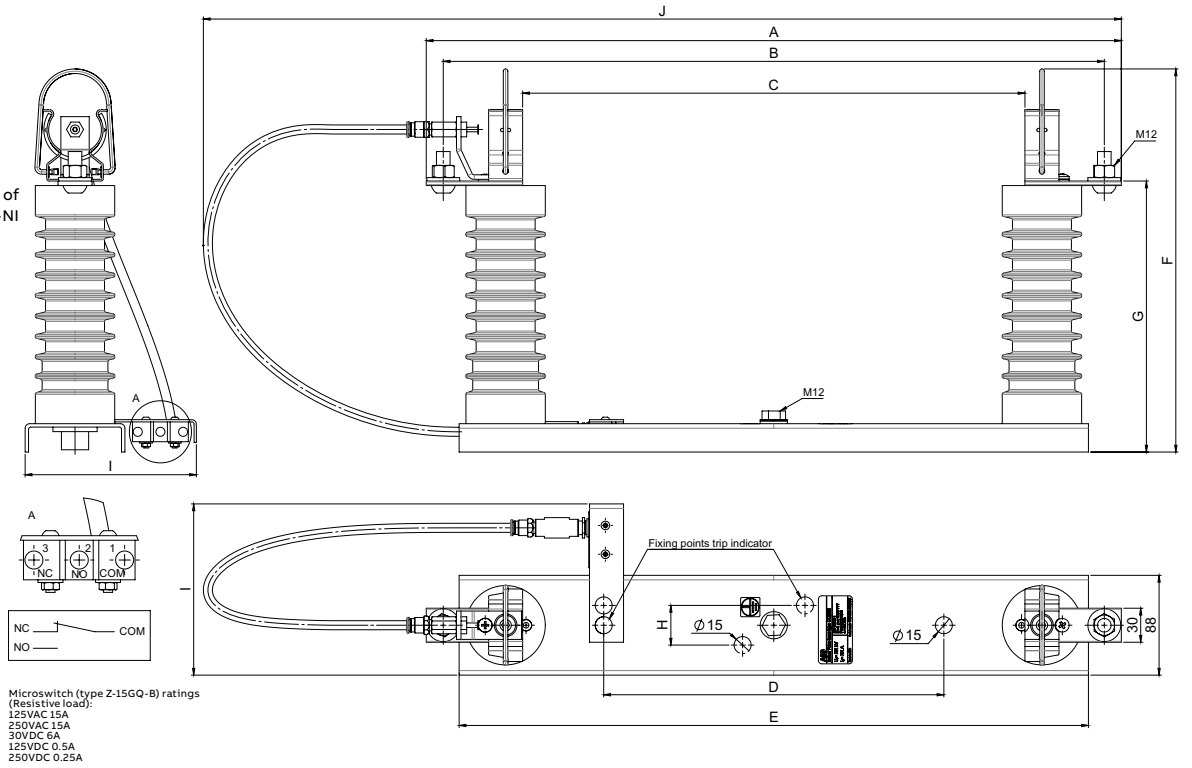
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43
Dimensional drawing of fuse-bases type UCE-NI

**Ordering table of fuse-bases UCE-NI with trip indicator**

| Catalog number | Type | Rated voltage [kV] | Rated current [A] | Fuse length e [mm] | Lightning impulse withstand voltage [kV] | | Power-frequency withstand voltage [kV] | | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | To earth and between poles | Across the isolating distance | To earth and between poles | Across the isolating distance | | |
| 1YMB333101M0101 | UCE-NI | 12 | 250 | 192 | 75 | 85 | 28 | 32 | 3.3 | 5908270846975 |
| 1YMB333101M0102 | UCE-NI | 12 | 250 | 292 | 75 | 85 | 28 | 32 | 3.7 | 5908270846982 |
| 1YMB333101M0103 | UCE-NI | 12 | 250 | 367 | 75 | 85 | 28 | 32 | 3.8 | 5908270846999 |
| 1YMB333101M0104 | UCE-NI | 12 | 250 | 442 | 75 | 85 | 28 | 32 | 4 | 5908270847002 |
| 1YMB333101M0105 | UCE-NI | 12 | 250 | 537 | 75 | 85 | 28 | 32 | 4.3 | 5908270847019 |
| 1YMB333101M0114 | UCE-NI | 12 | 315 | 292 | 75 | 85 | 28 | 32 | 3.7 | 5908270847026 |
| 1YMB333101M0115 | UCE-NI | 12 | 315 | 442 | 75 | 85 | 28 | 32 | 4.1 | 5908270847033 |
| 1YMB333101M0106 | UCE-NI | 17.5 | 250 | 192 | 95 | 110 | 38 | 45 | 4.5 | 5908270847040 |
| 1YMB333101M0107 | UCE-NI | 24 | 250 | 292 | 125 | 145 | 50 | 60 | 4.8 | 5908270847057 |
| 1YMB333101M0108 | UCE-NI | 24 | 250 | 367 | 125 | 145 | 50 | 60 | 5 | 5908270847064 |
| 1YMB333101M0109 | UCE-NI | 24 | 250 | 442 | 125 | 145 | 50 | 60 | 5.2 | 5908270847071 |
| 1YMB333101M0110 | UCE-NI | 24 | 250 | 537 | 125 | 145 | 50 | 60 | 5.5 | 5908270847088 |
| 1YMB333101M0111 | UCE-NI | 25.8 | 250 | 292 | 150 | 165 | 60 | 66 | 6.6 | 5908270847095 |
| 1YMB333101M0112 | UCE-NI | 36 | 250 | 442 | 170 | 195 | 70 | 80 | 7 | 5908270847101 |
| 1YMB333101M0113 | UCE-NI | 36 | 250 | 537 | 170 | 195 | 70 | 80 | 7.3 | 5908270847118 |

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44
Dimensional drawing of fuse-bases type UCE-NI with trip indicator




**Dimensions of indoor fuse-base type UCE-NI with trip indicator**

| Type | Ur [kV] | Ir [A] | Indicator type | e [mm] | Dimensions in mm ± 3% | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | A | B | C | D | E | F | G | H | I | J |
| UCE-NI | 12 | 250 | 500 | 192 | 363 | 333 | 193 | 55 | 305 | 258 | 159 | 35 | 150 | 563 |
| UCE-NI | 12 | 250 | 660 | 292 | 463 | 433 | 293 | 180 | 405 | 258 | 159 | - | 150 | 663 |
| UCE-NI | 12 | 250 | 660 | 367 | 538 | 508 | 368 | 180 | 480 | 258 | 159 | - | 150 | 738 |
| UCE-NI | 12 | 250 | 660 | 442 | 613 | 583 | 443 | 300 | 555 | 258 | 159 | - | 150 | 813 |
| UCE-NI | 12 | 250 | 660 | 537 | 708 | 678 | 538 | 380 | 650 | 258 | 159 | - | 150 | 908 |
| UCE-NI | 12 | 315 | 660 | 292 | 463 | 433 | 293 | 180 | 405 | 258 | 159 | - | 150 | 663 |
| UCE-NI | 12 | 315 | 660 | 442 | 613 | 583 | 443 | 300 | 555 | 258 | 159 | - | 150 | 813 |
| UCE-NI | 17.5 | 250 | 500 | 192 | 363 | 333 | 193 | 55 | 305 | 338 | 239 | 35 | 150 | 563 |
| UCE-NI | 24 | 250 | 660 | 292 | 463 | 433 | 293 | 180 | 405 | 338 | 239 | - | 150 | 663 |
| UCE-NI | 24 | 250 | 660 | 367 | 538 | 508 | 368 | 180 | 480 | 338 | 239 | - | 150 | 738 |
| UCE-NI | 24 | 250 | 660 | 442 | 613 | 583 | 443 | 300 | 555 | 338 | 239 | - | 150 | 813 |
| UCE-NI | 24 | 250 | 660 | 537 | 708 | 678 | 538 | 380 | 650 | 338 | 239 | - | 150 | 908 |
| UCE-NI | 25.8 | 250 | 660 | 292 | 463 | 433 | 293 | 180 | 405 | 428 | 329 | - | 150 | 663 |
| UCE-NI | 36 | 250 | 660 | 442 | 613 | 583 | 443 | 300 | 555 | 428 | 329 | - | 150 | 813 |
| UCE-NI | 36 | 250 | 660 | 537 | 708 | 678 | 538 | 380 | 650 | 428 | 329 | - | 150 | 908 |

# PBPM

## Indoor fuse-bases for WBP fuse-links

| | |
|---|---|
| **Application** | Indoor fuse-base |
| **Rated voltages** | 7.2 kV – 36 kV |
| **Rated currents** | 3.15 A |
| **Rated frequency** | 50 Hz – 60 Hz |
| **Compatible fuse-links** | WBP |



**Reliable operation guaranteed by proven design**

**Flexibility in mounting position**

**Small dimensions support both application and storage**

**Fuse-bases type PBPM are designed for securing WBP fuse-links in indoor application**

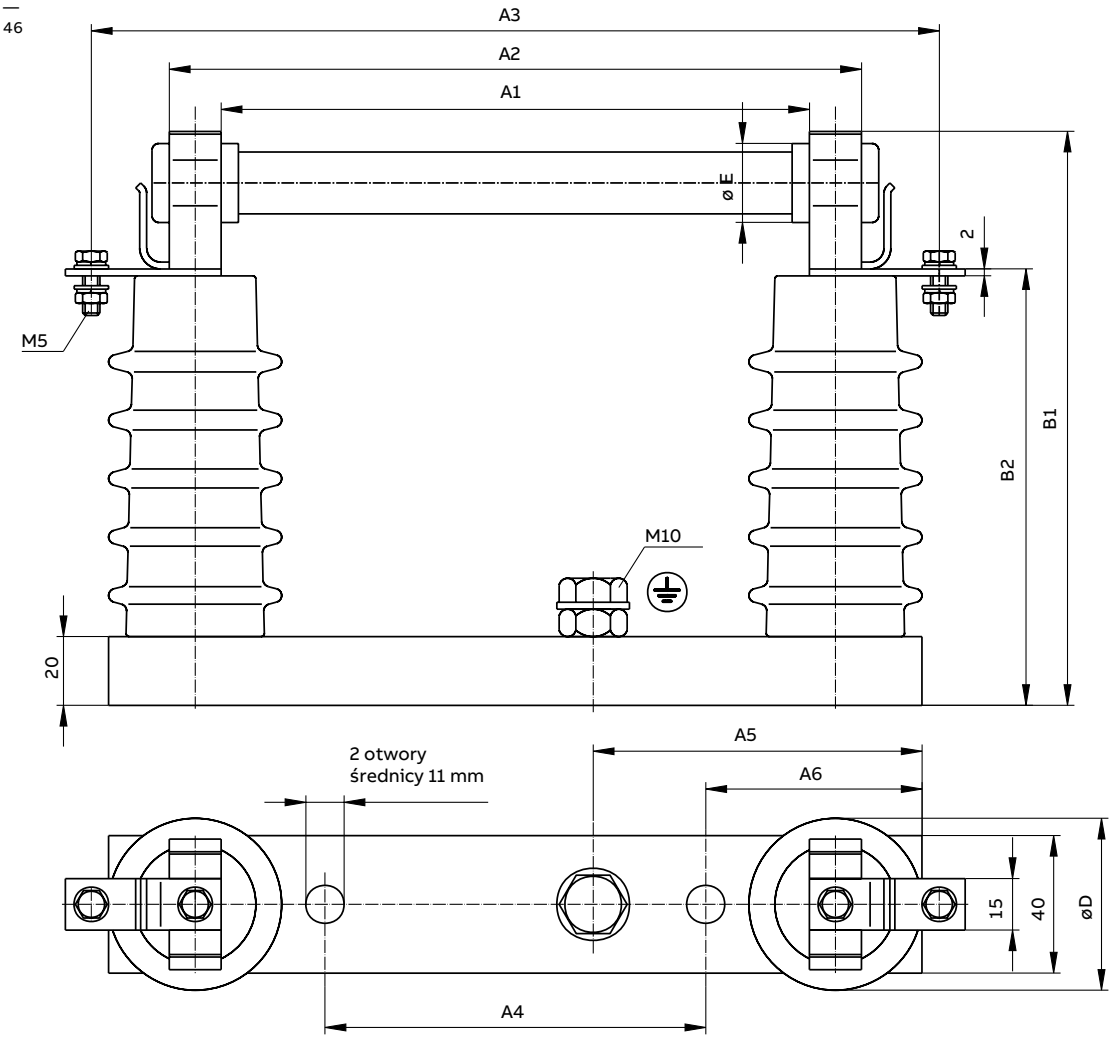
**Key features:**

- Rated voltage 7.2 kV – 36 kV
- Rated current 0.4 A – 3.15 A
- Designed for indoor conditions

**Ordering table of fuse-bases PBPM**

| Catalog number | Type | Rated voltage [kV] | Rated current [A] | Fuse length e [mm] | Lightning impulse withstand voltage [kV] | | Power-frequency withstand voltage [kV] | | Weight [kg] | EAN 13 Code |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | To earth and between poles | Across the isolating distance | To earth and between poles | Across the isolating distance | | |
| 1YMB311101M0001 | PBPM-6 | 7.2 | 3.15 | 210 | 60 | 70 | 20 | 23 | 1.2 | 5908270801929 |
| 1YMB311101M0002 | PBPM-10 | 12 | 3.15 | 250 | 75 | 85 | 28 | 32 | 1.3 | 5908270801936 |
| 1YMB311101M0007 | PBPM-20 | 24 | 3.15 | 310 | 125 | 145 | 50 | 60 | 3.0 | 5908270801950 |
| 1YMB311101M0004 | PBPM-30 | 36 | 3.15 | 385 | 170 | 195 | 70 | 80 | 4.6 | 5908270801943 |

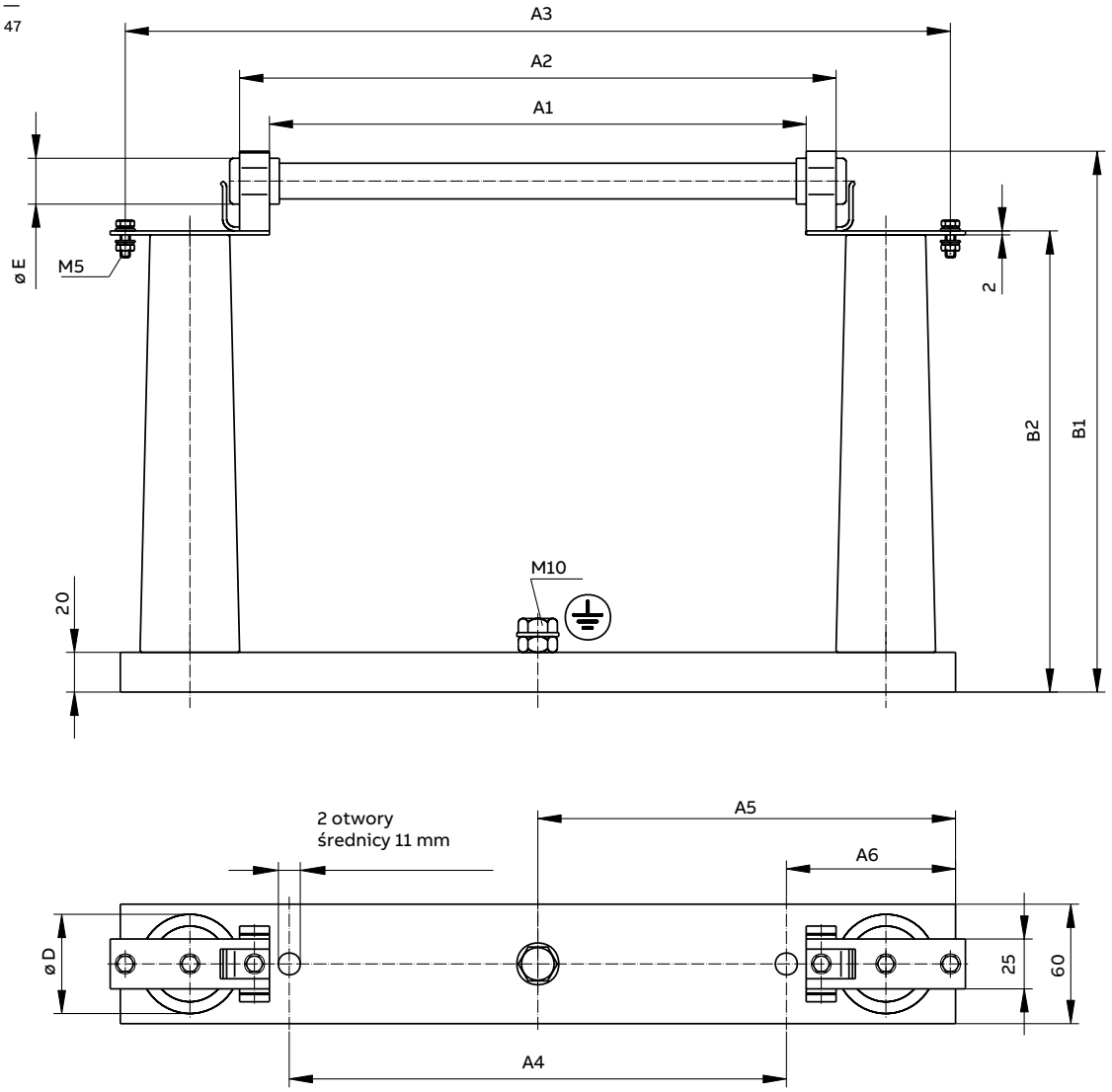
46
Dimensional drawings of fuse-bases type PBPM-6, PBPM-10




| Fuse-base type | Dimensions [mm] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | ØD | ØE |
| PBPM-6 | 170±2 | 200±2 | 245 | 110 | 95 | 62.5 | 165 | 128 | 50 | 23 |
| PBPM-10 | 210±2 | 240±2 | 285 | 150 | 95 | 62.5 | 190 | 153 | 50 | 23 |

—
47
Dimensional drawings of fuse-bases type PBPM-20, PBPM-30

—
47



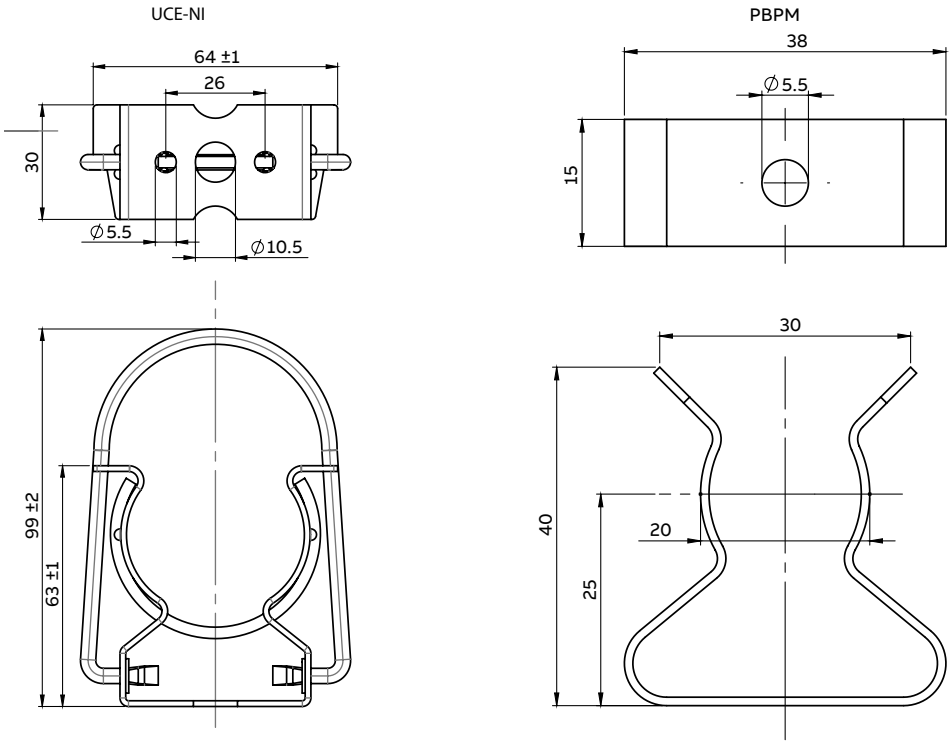

| Fuse-base type | Dimensions [mm] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | ØD | ØE |
| PBPM-20 | 270±2 | 300±2 | 415 | 250 | 210 | 85 | 272 | 232 | 50 | 23 |
| PBPM-30 | 345±2 | 375±2 | 490 | 325 | 247.5 | 85 | 362 | 322 | 70 | 23 |

# Accessories
## List of available accessories

| Catalog number | Accessories | Remarks | Drawing |
|---|---|---|---|
| 1YMB333102M0001 | Fuse-clip UCE-NI | Suitable for CEF/CEF-S/CEF-VT/CMF | 48 |
| 1YMB411002M0001 | Fuse clip PBPM | Suitable for WBP | 48 |
| 1YMB333104M0001 | Fuse extension adapter +150mm, set of 3 pieces | Extension to increase the length of CEF/CEF-S/CEF-VT/CMF fuse-links | 49 |
| 1YMB333104M0002 | Fuse extension adapter +250mm, set of 3 pieces | Extension to increase the length of CEF/CEF-S/CEF-VT/CMF fuse-links | 49 |
| 1YMX304514M0001 | Dummy fuse 192mm | Solid link for other equipment testing purposes | 50 |
| 1YMX304514M0002 | Dummy fuse 292mm | Solid link for other equipment testing purposes | 50 |
| 1YMX304514M0003 | Dummy fuse 367mm | Solid link for other equipment testing purposes | 50 |
| 1YMX304514M0004 | Dummy fuse 442mm | Solid link for other equipment testing purposes | 50 |
| 1YMX304514M0005 | Dummy fuse 537mm | Solid link for other equipment testing purposes | 50 |
| 1YMB333103M0001 | Adapter set BS-B | Adapter set for one fuse-link CEF/CMF/CEF-VT/CEF-S | 51 |
| 1YMB333103M0003 | Adapter set BS-C | Adapter set for one fuse-link CEF/CMF/CEF-VT/CEF-S | 52 |
| 1YMB333103M0002 | Adapter set BS-D | Adapter set for one fuse-link CEF/CMF/CEF-VT/CEF-S | 53 |
| 1YMB333105M0001 | Trip indicator 500mm | Suitable for UCE-NI fuse base | 54 |
| 1YMB333105M0002 | Trip indicator 660mm | Suitable for UCE-NI fuse base | 54 |
| 1YMB333105M0003 | Trip indicator 900mm | Suitable for UCE-NI fuse base | 54 |

## Fuse-clips – equipment of indoor/outdoor fuse-bases used for fuse-link fixing

48

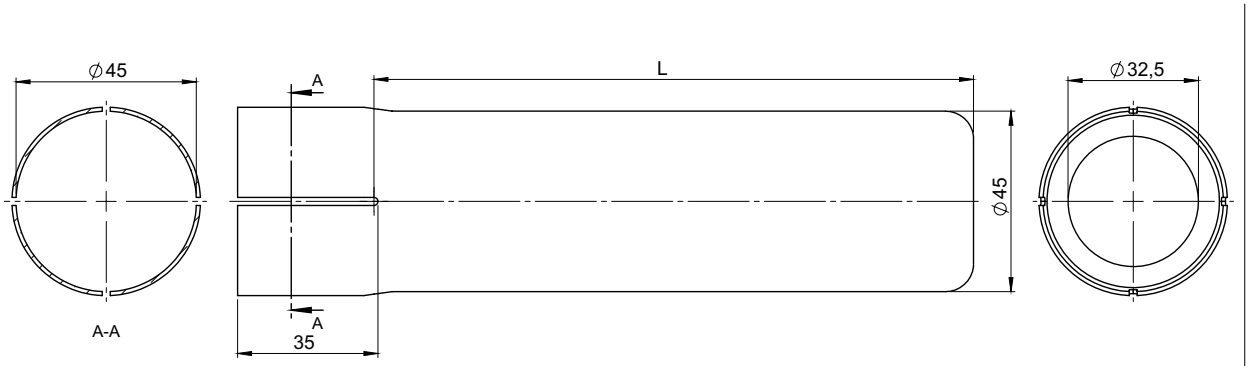



48
Fuse-clips

| Catalog number | Type | Rated current [A] | Weight [kg] | Application | Compatible fuse-links | EAN 13 Code |
|---|---|---|---|---|---|---|
| 1YMB333102M0001 | Fuse-clip UCE-NI | 315 | 0.1 | Indoor | CEF/CEFS/CEFVT/CMF | 5908270808393 |
| 1YMB411002M0001 | Fuse-clip PBPM | 3.15 | 0.1 | Indoor | WBP | 5908270802353 |

## Fuse extension adapter – Extension to increase the length of CEF/ CEF-S/CEF-VT/CMF fuse-links

49



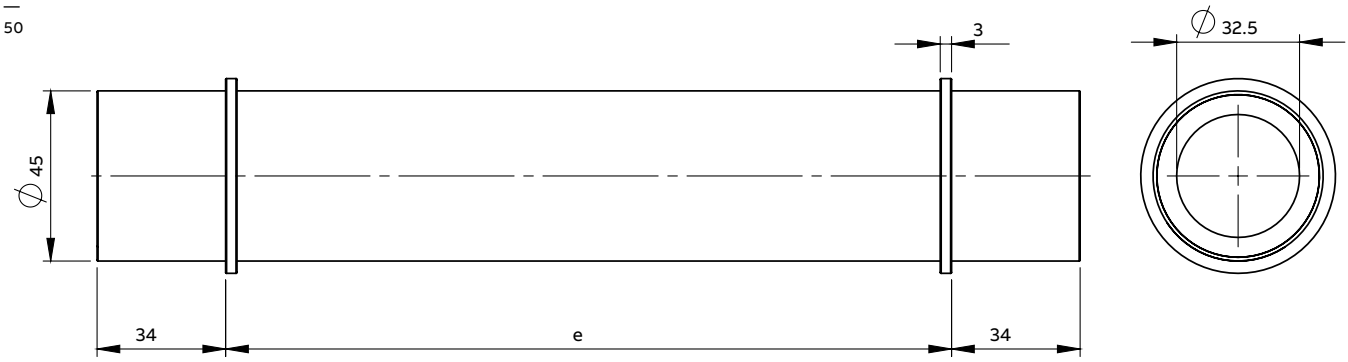

49
Fuse extension adapter

| Catalog number | Type | Extension length L [mm] | Weight [kg] | Compatible fuse-links | EAN 13 Code |
|---|---|---|---|---|---|
| 1YMB333104M0001 | Fuse extension adapter +150mm, set of 3 pieces* | 150 | 0.3 | CEF, CEF-S, CEF-VT, CMF | 5908270809857 |
| 1YMB333104M0002 | Fuse extension adapter +250mm, set of 3 pieces* | 100 | 0.2 | | 5908270809864 |

*3 pieces of hose clamp included. Recommended only for horizontal fuse mounting systems. In vertical systems, possible only for sockets that do not allow the adapter to slide out

## Dummy fuse – solid link for other equipment testing purposes

50

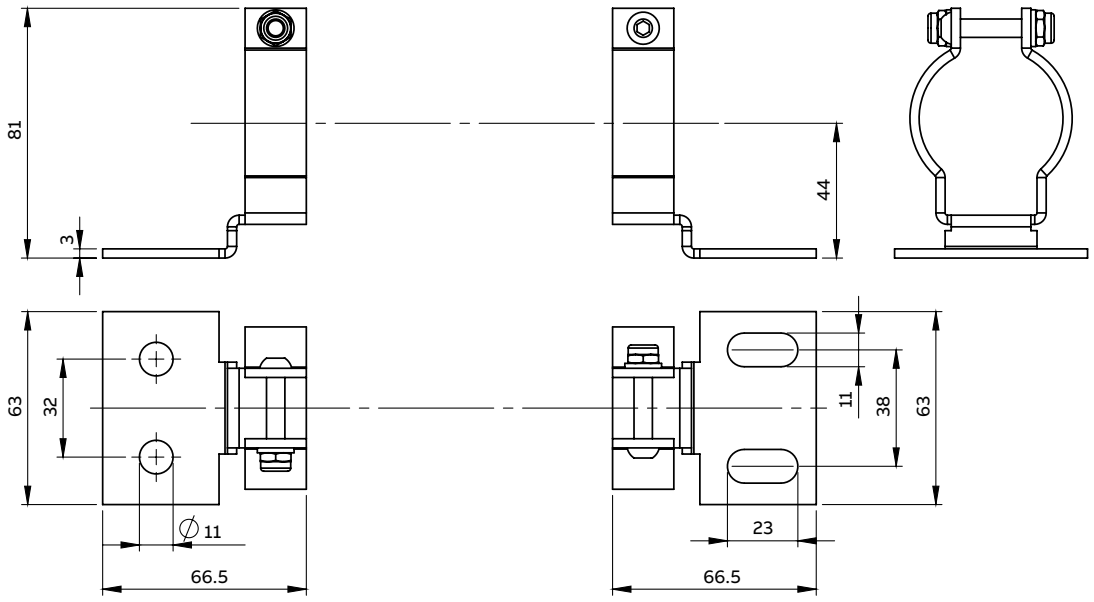



50
Dummy fuse

| Catalog number | Type | Length e [mm] | Weight [kg] | Max. current [A] | Max. voltage [kV] | Material | EAN 13 Code |
|---|---|---|---|---|---|---|---|
| 1YMX304514M0001 | Dummy fuse 192 mm | 192 | 0.4 | 315 | 36 | Cu-ETP, contacts silver plated | 5908270808454 |
| 1YMX304514M0002 | Dummy fuse 292 mm | 292 | 0.5 | 315 | 36 | | 5908270808461 |
| 1YMX304514M0003 | Dummy fuse 367 mm | 367 | 0.6 | 315 | 36 | | 5908270808478 |
| 1YMX304514M0004 | Dummy fuse 442 mm | 442 | 0.7 | 315 | 36 | | 5908270808485 |
| 1YMX304514M0005 | Dummy fuse 537 mm | 537 | 0.9 | 315 | 36 | | 5908270808492 |

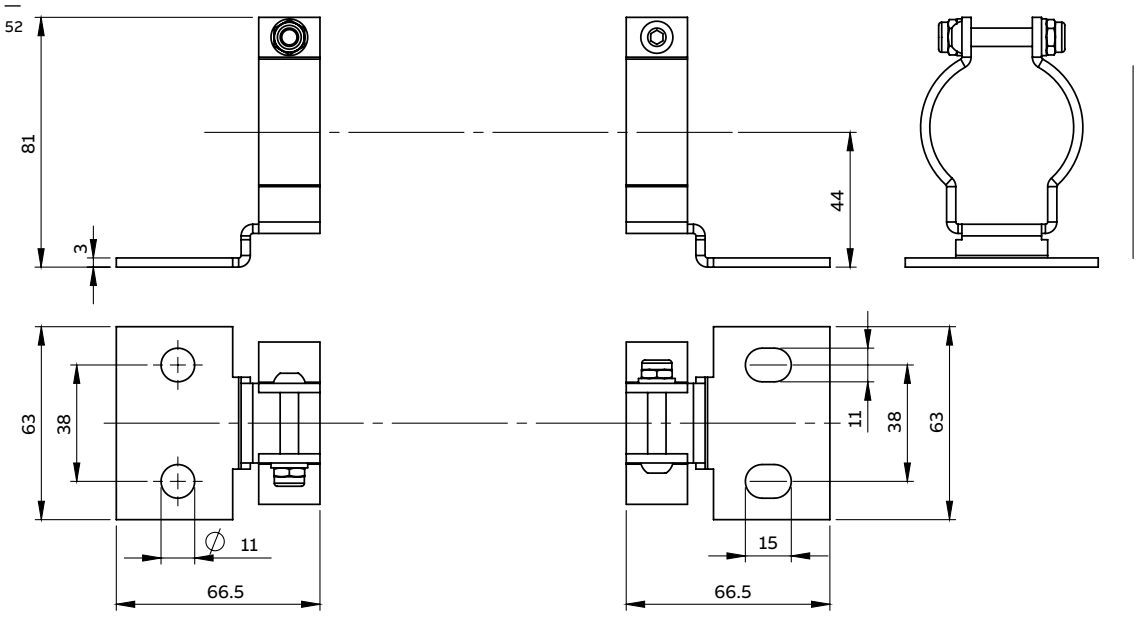
## Adapter sets – connectable tags for fuse-link for fixing adaptation

51

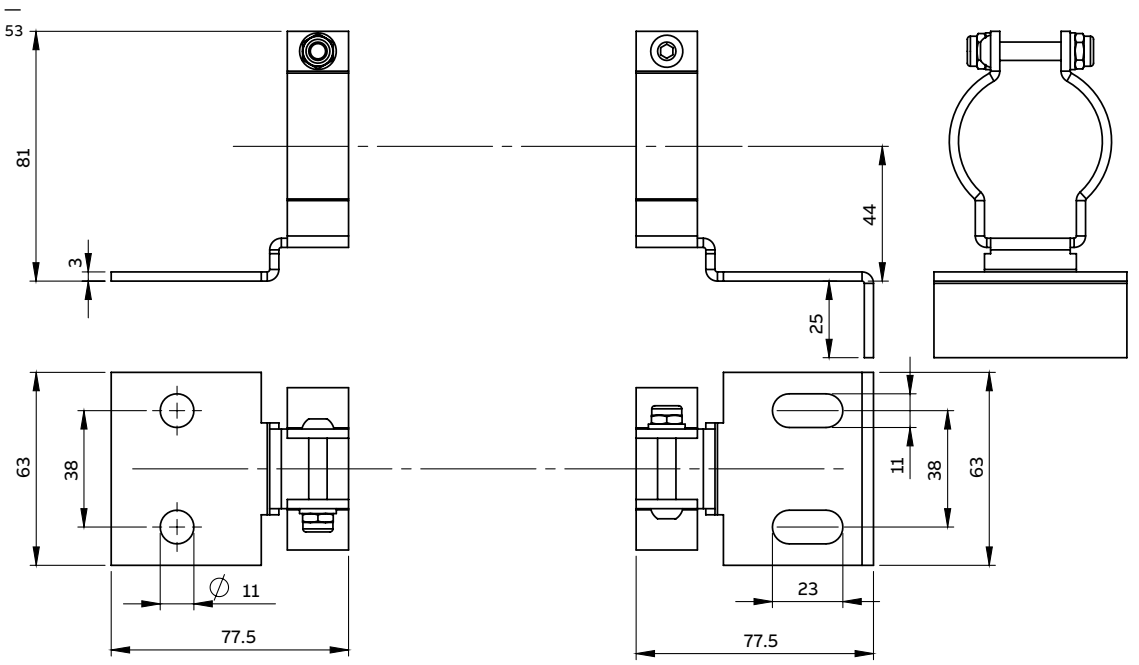



| Catalog number | Type | Weight [kg] | Compatible fuse-links | EAN 13 Code |
|---|---|---|---|---|
| 1YMB333103M0001 | Adapter set BS-B | 0.4 | CEF, CEF-S, CEF-VT, CMF | 5908270808508 |

51
Adapter sets BS-B




| Catalog number | Type | Weight [kg] | Compatible fuse-links | EAN 13 Code |
|---|---|---|---|---|
| 1YMB333103M0003 | Adapter set BS-C | 0.4 | CEF, CEF-S, CEF-VT, CMF | 5908270808515 |



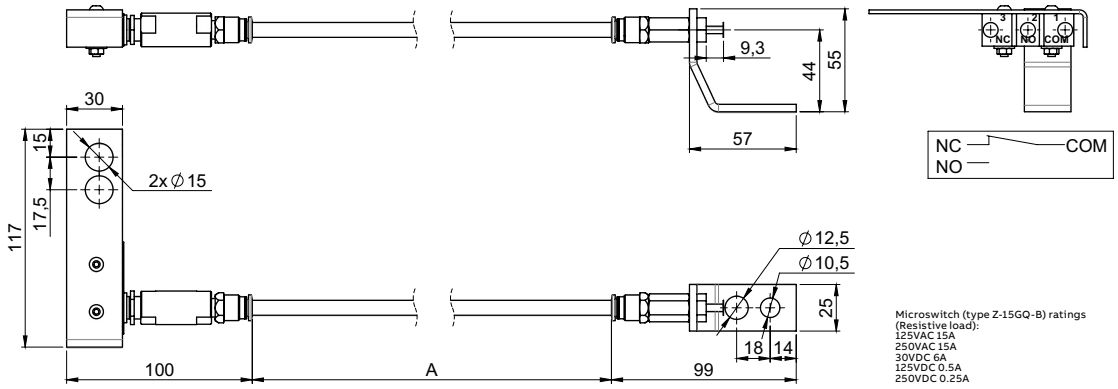

| Catalog number | Type | Weight [kg] | Compatible fuse-links | EAN 13 Code |
|---|---|---|---|---|
| 1YMB333103M0002 | Adapter set BS-D | 0.4 | CEF, CEF-S, CEF-VT, CMF | 5908270808522 |

—
52
Adapter sets BS-C

—
53
Adapter sets BS-D

—
54

# Fuse blown indicator on a flexible link




—

**Trip indicator**

| Number | Type | Bowden length A [mm] | Min. radius [mm] | EAN 13 Code |
|---|---|---|---|---|
| 1YMB333105M0001 | Trip indicator 500mm | 500 | 270 | 5908270847125 |
| 1YMB333105M0002 | Trip indicator 660mm | 660 | 300 | 5908270847132 |
| 1YMB333105M0003 | Trip indicator 900mm | 900 | 300 | 5908270847149 |

—
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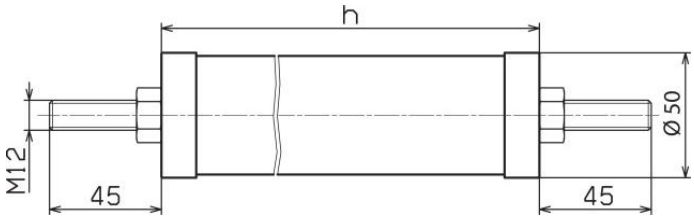
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2401PL1613-W1-en. Edition 03.2024

# ! DMI 9 10 1 L (990 003)



Figure without obligation




Dimension drawing DMI 9 10 1 L

| Type<br>Part No. | DMI 9 10 1 L<br>990 003 |
|---|---|
| Nominal discharge current (8/20 µs) ($I_n$) | 10 kA |
| High current impulse (4/10 µs) | 100 kA |
| Overload capacity | 20 kA |
| Line discharge class (1) | 1 (2.8 kJ/kV $_{Ur}$) |
| Long-duration current impulse (1) | 250 A / 2000 µs |
| Rated voltage (a.c.) ($U_r$) | 9 kV |
| Continuous operating voltage (a.c.) (MCOV) ($U_c$) | 7.2 kV |
| Temporary overvoltage (TOV) at 1 sec. ($U_{1s}$) | 10.4 kV |
| Temporary overvoltage (TOV) at 10 sec. ($U_{10s}$) | 9.8 kV |
| Residual voltage at 10 kA (1/2 µs) ($\hat{u}_{res}$) | 28.9 kV |
| Residual voltage at 5 kA (8/20 µs) ($\hat{u}_{res}$) | 25.1 kV |
| Residual voltage at 10 kA (8/20 µs) ($\hat{u}_{res}$) | 27.0 kV |
| Residual voltage at 20 kA (8/20 µs) ($\hat{u}_{res}$) | 30.0 kV |
| Residual voltage at 40 kA (8/20 µs) ($\hat{u}_{res}$) | 33.8 kV |
| Residual voltage at 125 A (40/100 µs) ($\hat{u}_{res}$) | 19.7 kV |
| Residual voltage at 250 A (40/100 µs) ($\hat{u}_{res}$) | 20.3 kV |
| Residual voltage at 500 A (40/100 µs) ($\hat{u}_{res}$) | 21.1 kV |
| Residual voltage at 1000 A (40/100 µs) ($\hat{u}_{res}$) | 21.9 kV |
| Residual voltage at 2000 A (40/100 µs) ($\hat{u}_{res}$) | 23.0 kV |
| Insulation of arrester housing / nominal power frequency withstand voltage (dry) ($U_{PFWL}$) | 40 kV |
| Insulation of arrester housing / nominal lightning withstand voltage ($U_{LIWL}$) | 58 kV |
| Height (h) | 132 mm |
| Creepage distance (+/- 5%) | 108 mm |
| Torsional strength | 78 Nm |
| Maximum permissible dynamic service load (MPDSL) | 230 Nm |
| Tensile strength | 1400 N |
| Ambient temperature ($T_A$) | -40 °C ... +55 °C |
| Altitude | up to 1000 m above sea level |
| Power frequency ($f_N$) | 16-62 Hz |
| Housing material | HTV silicone housing |
| Colour | auburn, RAL 3013 |
| Fittings | terminals, screws and nuts of stainless steel |
| Conductor clamp | up to Ø16 mm |
| Test standards | IEC 60099-4 |
| Weight | 1 kg |
| Customs tariff number (Comb. Nomenclature EU) | 85354000 |
| GTIN | 4013364102606 |
| PU | 1 pc(s) |

We reserve the right to introduce changes in performance, configuration and technology, dimensions, weights and materials in the course of technical progress. The figures are shown without obligation.

Medium voltage products

# V-Contact VSC
# Installation and service instructions
# 7.2/12 kV - 400 A

## This instruction booklet refers to the following models:
## VSC/F-VSC/FN-VSC/P-VSC/PG-VSC/PN-VSC/PNG
## VSC-S/F-VSC-S/G-VSC-S/PG-VSC-S/PNG


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# For your safety!

- Make sure that the installation room (spaces, divisions and ambient) is suitable for the electrical apparatus.
- Check that all the installation, putting into service and maintenance operations are carried out by qualified personnel with suitable knowledge of the apparatus.
- Make sure that the standard and legal prescriptions are complied with during installation, operation and maintenance, so that installations according to the rules of good working practice and safety in the work place are constructed.
- Strictly follow the information given in this instruction manual.
- Check that the rated performance of the apparatus is not exceeded during service.
- Check that the personnel operating the apparatus have this instruction manual to hand as well as the necessary information for correct intervention.
- Pay special attention to the danger notes indicated in the manual by the following symbol:



**Responsible behaviour safeguards your own and others' safety!**

**For any requests, please contact the ABB Assistance Service.**

# I. Introduction

The instructions in this manual refer to the fixed and withdrawable versions of the VSC series of contactors. For correct use of the product, please read it carefully.

For the electrical and construction characteristics and the overall dimensions of the V-Contact VSC contactors, please also see technical catalogue 1VCP000165.

Like all the apparatus we manufacture, the V-Contact vacuum contactors are designed for different installation configurations. Furthermore, this apparatus allows further technical and construction modifications (at the customer's request) to adapt to special installation requirements. Consequently, this manual may not provide information concerning special configurations of the apparatus.

Apart from this manual, it is therefore always necessary to consult the latest technical documentation (circuit and wiring diagrams, assembly and installation drawings, any protection coordination studies, etc.), especially regarding any variants requested in relation to the standardised configurations.

Only use original spare parts for maintenance operations. The use of non-original spare parts can cause hazardous malfunctions and the apparatus warranty will no longer be valid.

Please refer to the technical sheets of the Kits for correct assembly of the accessories and/or spare parts. For further information, also see the 1VCP000165 technical catalogue of the contactor and the spare parts catalogue.

This manual and all the enclosed drawings must be considered an integral part of the apparatus. They must be easily to hand at all times for revision and reference.

These instructions do not intend to cover all the details, configurations or variants of the apparatus, storage or installation. For this reason, the information given below may sometimes not contain the instructions regarding special configurations. This does not relieve the user from their responsibility for using good technical working practices in application, installation, service and maintenance of the apparatus purchased. Should further information be required, please contact ABB.

**WARNING**



**Dangerous voltages. Risk of death, serious injury to people, damage to the apparatus or other objects.**

**Before carrying out any maintenance operations, turn the power supply off and earth the apparatus.**

**Read and understand this instruction manual before installation, service or maintenance of the apparatus.**

**Maintenance must only be carried out by skilled personnel.**

**The use of unauthorized spare parts for repairs to the apparatus, modification of the apparatus itself, or tampering by unskilled personnel creates hazardous conditions which may cause death or serious injury to people, or damage to the apparatus or other objects. Carefully follow all the safety instructions given in this manual.**

# II. Environmental protection programme

The V-Contact VSC vacuum contactors are manufactured in accordance with the ISO 14000 Standards (Guidelines for environmental management). The production processes are carried out in compliance with the Standards for environmental protection in terms of reduction in energy consumption as well as in raw materials and production of waste materials.
All this is thanks to the medium voltage apparatus manufacturing facility environmental management system.

## III. Application of the X-ray emission Standards

One of the physical properties of vacuum insulation is the possibility of X-ray emission when the interrupter contacts are open. The tests carried out at the PTB laboratories (Physikalisch-Technische Bundesanstalt, in Brunswick - Germany) show that local emission at a distance of 10 cm from the interrupter or pole surface, does not exceed 1 µSv/h. It follows that:

– at the rated service voltage the use of vacuum interrupters is absolutely safe;
– application of the withstand voltage at power frequency, according to the IEC 62271-1 Standard, is safe;
– application of a voltage higher than the withstand voltage at power frequency or of a direct current test voltage, specified in the IEC Standard, cannot be used;
– limitation of the above-mentioned local phenomena, on interrupters with open contacts, depends on keeping the specified distance between the contacts. This condition is intrinsically guaranteed by correct operation of the drive and by transmission system adjustments.

## IV. Safety information

All the installation, putting into service, running and maintenance operations must be carried out by suitably qualified personnel with in-depth knowledge of the apparatus. Make sure that the personnel working on the apparatus have this manual to hand and all the information required for correct intervention.
Strictly follow the information given in this instruction manual. Make sure that during the installation, service and maintenance stages the standard and legal requirements for constructing the installations in accordance with the regulations for safety in the workplace are respected.
Check that the rated performance of the apparatus is not exceeded during service.

## V. Qualified personnel

For the purposes of this manual and the product rating plates, a qualified person is intended as a person who:

1) carefully reads the instruction manual all the way through.
2) has in-depth knowledge of the installation, construction and service of the apparatus and knows about the risks connected with any interventions.
3) is qualified and authorised to energise, de-energise, earth and identify the circuits according to the safety procedures and the local regulations in force.
4) is qualified and authorised to put this apparatus into service, and to carry out maintenance and repair operations on it.
5) is trained in correct use of protective equipment, such as rubber gloves, hard hats, protective goggles, face shields, flameproof clothing, etc. according to the safety procedures and the local regulations in force.
6) is trained in first-aid procedures.

## VI. Interventions in the field

ABB can provide competent and well-trained personnel for assistance in the field to give technical guidance and consultancy regarding installation, full servicing, repair and maintenance of apparatus.

# 1. Description

The medium voltage V-Contact VSC contactors are pieces of apparatus suitable for operating in alternating current and are normally used to control users requiring a high number of hourly operations.

The basic contactors consist of:
- moulded polyester resin monobloc containing the vacuum interrupters
- bistable electromagnet actuator
- multi-voltage feeders
- auxiliary contacts
- mechanical status indicator (open/closed)
- manual emergency opening device.

Apart from what is specified for the fixed contactors, the withdrawable contactors also consist of:
- fuseholders preset for DIN or BS fuses (according to the customer's requirements)
- automatic opening device for intervention of even a single fuse
- truck
- lock which prevents closing during the racking-in/out operation.

The V-Contact VSC contactor introduces the drive with permanent magnets - already widely used, experimented and appreciated in medium voltage circuit-breakers - into the worldwide panorama of medium voltage contactors.
The experience acquired by ABB in the field of medium voltage circuit-breakers fitted with drives with "MABS" permanent magnets, has made it possible to develop an optimised version of the actuator (Bistable MAC drive) for medium voltage contactors.

The drive is operated by means of an electronic feeder able to cover all the power supply voltages required by the major international Standards.

## 1.1. "MAC" magnetic drive

Based on the experience gained in the field of circuit-breakers with magnetic drive, ABB has implemented this technology in the field of contactors.

The magnetic drive adapts perfectly to this type of apparatus thanks to its precise and linear travel.

This means that a simple and direct axial transmission of the movement to the moving contacts of the vacuum interrupter can be realised, with both electrical and mechanical benefits.

The drive, which is of bistable type, is fitted with an opening and a closing coil.

The two coils - individually energised - allow the drive core to be moved from one of the two stable positions to the other.

The drive shaft is solid with an iron core which is immersed and held in position in a field generated by two permanent magnets (fig. A).

Energising the coil opposite to the magnetic latching position (fig. A) of the core, the magnetic field (fig. B) is generated, which attracts and moves the core into the opposite position (fig. C).

Every opening and closing operation creates a magnetic field concordant with the one generated by the permanent magnets, with the advantage, during service, of keeping the intensity of the field itself constant as the number of operations carried out increases.

The energy needed for operation is not supplied directly by the auxiliary power supply, but is always "stored" in the capacitor which acts as an energy accumulator, and therefore operation always takes place with constant speeds and times, regardless of the divergence of the power supply voltage from the rated value.

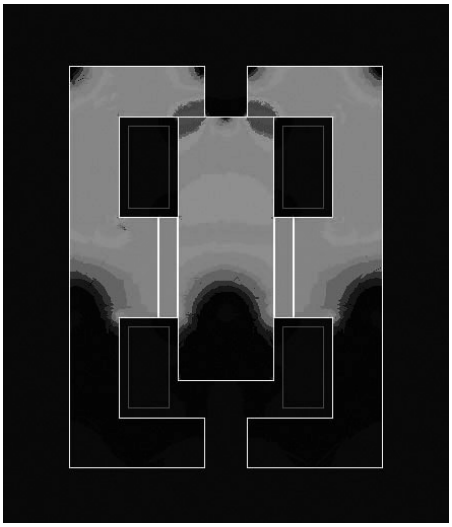


**Fig. A**

**Magnetic circuit in the closed position.**

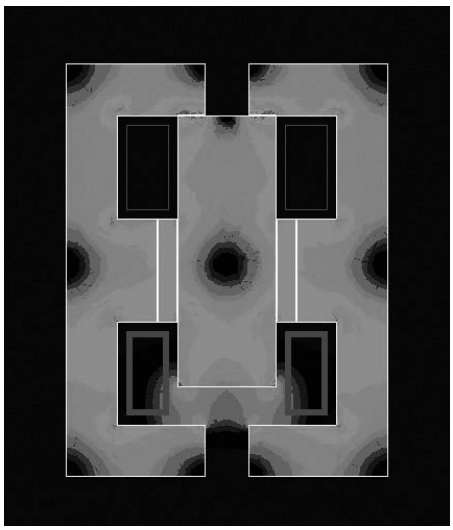


**Fig. B**

**Magnetic circuit with opening coil supplied.**

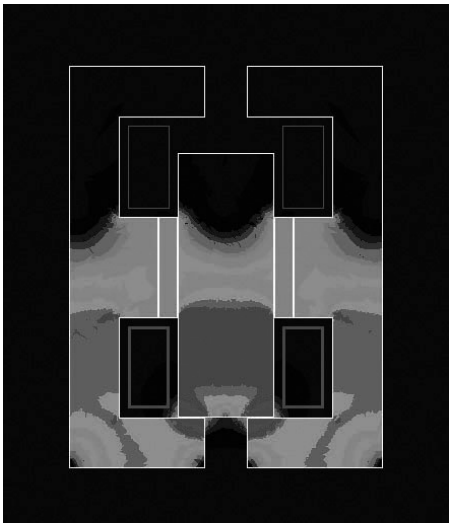


**Fig. C**

**Magnetic circuit in the open position.**

The auxiliary power supply only has the aim of keeping the capacitor charged.
Consumption is therefore minimal.

The power required by the electronic device is indicated in the table below:

| Power supply voltage | Starting (1) | | After closing | After opening | Continuous power consumption |
|---|---|---|---|---|---|
| | Inrush for 2 ms | Inrush for 6 sec | Inrush for 1.2 sec | Inrush for 1.2 sec | |
| 24...60 V DC<br>110...250 V DC<br>110...250 V AC | 42 A (2) | 35 W | 25 W | 30 W | 5 W |

(1) This value refers to a discharged capacitor.
(2) The value drops to 8 A for voltage values between 24...30V

Supply from voltage transformer or from UPS (Uninterrupted Power System) not available.
Use the ABB S282UC-C3 thermal-magnetic circuit-breaker or an equivalent type to protect the secondary circuits.
After powering, the electronic board takes 15 seconds to perform self-diagnosis and then prepares for normal operation, depending on the configuration. Do not operate the contactor during this phase. Contact DO1 will remain open, signal “not ready” and will only close after self-diagnosis has terminated (“ready” state).

Careful selection of the components and a precise design make the electronic multi-voltage feeder extremely reliable, unaffected by electromagnetic interference generated by the surrounding environment and free of any emissions which may affect other apparatus placed in the vicinity.

These characteristics have made it possible for the V-Contact VSC contactors to pass the electromagnetic compatibility tests (EMC).

## 1.2. Versions available

The V-Contact VSC are available in:
– fixed version without fuseholder
– fixed versions with fuseholder: VSC/F e VSC/FN.
– four withdrawable versions with fuseholder:
  - VSC/P (IEC) and VSC/PG or VSC-S/PG (IEC/GB-DL) withdrawable versions for UniGear, PowerCube, CBE and PowerBloc with manual or motorized truck
  - VSC/PN (IEC) and VSC/PG or VSC-S/PNG (IEC/GB-DL) both versions withdrawable for UniGear MCC with manual truck.

## 1.3. Characteristics

| Contactor | | Reference IEC 62271-106 | VSC7<br>VSC7/F (1)<br>VSC7/P (1)<br>VSC7/PN (1)<br>VSC7/FN | VSC12<br>VSC12/F (1)<br>VSC12/P (1)<br>VSC12/PN (1) |
|---|---|---|---|---|
| Rated voltage | [kV] | 4.1 | 7.2 | 12 |
| **Rated insulation voltage** | | | | |
| Withstand voltage at 50 Hz | [kV] | 6.2 | 20 | 28 |
| Impulse withstand voltage | [kVbil] | 6.2 | 60 | 75 |
| Rated frequency | [Hz] | 4.3 | 50-60 | 50-60 |
| Rated service current | [A] | 4.101 | 400 | 400 |
| **Short-time withstand current** | | | | |
| Short-time withstand current for 1 s | [A] | 6.6 | 6,000 | 6,000 |
| Short-time withstand current for 2 s | [A] | | | |
| Short-time withstand current for 4 s | [A] | | | |
| Short-time withstand current for 30 s | [A] | 6.6 | 2,500 | 2,500 |
| Rated peak current | [kA] | 6.6 | 15 | 15 |
| **Rated values** | | | | |
| Operations / hour (SCO - DCO) | [Nr.] | 4.102.4 | 1.200 | 1,200 |
| Rated voltage of the voltage characteristics in category of use | | | | |
| (Category AC4) 100 closing operations | [kA] | 6.102.4 | 4,000 | 4,000 |
| (Category AC4) 25 opening operations | [kA] | 6.102.5 | 4,000 | 4,000 |
| **Switching devices and auxiliary circuits** | | 4.8, 4.9 | | |
| Feeder 1 24÷60 V dc basic | | | ● | ● |
| Feeder 2 24÷60 V dc full option | | | ● | ● |
| Feeder 3 110÷250 V dc/ac basic | | | ● | ● |
| Feeder 4 110÷250 V dc/ac full option | | | ● | ● |
| Normal current | [A] | 6.4.6.5 | 400 | 400 |
| Mechanical life | [Nr.] | 6.101 | 1,000,000 (2) | 1,000,000 (2) |
| Short-circuit breaking capacity (O-3min-CO-3min-CO) | [A] | 6.104 | 5,000 | 5,000 |
| Short-circuit making capacity (O-3min-CO-3min-CO) | [A] | 6.104 | 13,000 | 13,000 |
| Opening time | [ms] | | 35...60 | 35...60 |
| Closing time | [ms] | | 60...90 | 60...90 |
| Tropicalisation | IEC 721-2-1 | | ● | ● |

(1) It is possible to combine current limiting fuses with breaking capacity up to 50 kA (IEC 62271-106 - 4.107) - Damage classification “C” (IEC 62271-106 - 4.107.3).
(2) With replacement of auxiliary contacts every 250,000 closing-opening operations.
(3) 42 kV for fixed versions and in dedicated Unigear switchgear

## 1.4. Weights and overall dimensions

| Contactor | | | VSC7 | VSC12<br>VSC-S/G | VSC7/F | VSC7/FN | VSC12/F<br>VSC-S/F |
|---|---|---|---|---|---|---|---|
| Weight | | [Kg] | 23 | 23 | 35 (1) | 35 (1) | 35 (1) |
| Overall dimensions |  | [mm] H | 371 | 424 | 494 | 598 | 532 |
| | | [mm] W | 350 | 350 | 466 | 466 | 466 |
| | | [mm] D | 215 | 215 | 622 | 623 | 702 |

(1) Without fuses

| | Reference | | VSC7/PNG (1) | VSC12/PNG (1) | VSC-S/G<br>VSC-S/F (1)<br>VSC-S/PG (1)<br>VSC-S/PNG (1) |
|---|---|---|---|---|---|
| | GB/T<br>14808-2001 | DL/T<br>593-2006 | | | |
| | 4.1 | | 7.2 | 12 | 12 |
| | | | | | |
| | 6.2 | ● | 32 | 42 | 28 (3) |
| | 6.2 | | 60 | 75 | 75 |
| | 4.3 | | 50-60 | 50-60 | 50-60 |
| | 4.101 | | 400 | 400 | 250 |
| | | | | | |
| | | | | 6,000 | 600 |
| | 6.6 | | 4,000 | 4,000 | |
| | | ● | 4,000 | 4,000 | |
| | 6.6 | | 2,500 | 2,500 | 2,500 |
| | 6.6 | | 15 | 15 | 15 |
| | | | | | |
| | 4.102.2 | | 1,200 | 1,200 | 1,200 |
| | | | | | |
| | 6.102.4 | | 4,000 | 4,000 | |
| | 6.102.5 | | 4,000 | 4,000 | |
| | 4.8, 4.9 | | | | |
| | | | ● | ● | ● |
| | | | ● | ● | ● |
| | | | ● | ● | ● |
| | | | ● | ● | ● |
| | 6.4, 6.5 | | 400 | 400 | 400 |
| | 6.101 | | 1,000,000 (2) | 1,000,000 (2) | 200,000 |
| | 6.104 | | 5,000 | 5,000 | - |
| | 6.104 | | 13,000 | 13,000 | - |
| | | | 35...60 | 35...60 | 35...60 |
| | | | 60...90 | 60...90 | 60...90 |
| | ● | | ● | ● | ● |

| | VSC7/P | VSC12/P - VSC12/PG<br>VSC-S/PG | VSC7/PN | VSC7/PNG | VSC12/PN | VSC12/PNG<br>VSC-S/PNG |
|---|---|---|---|---|---|---|
| | 52 (1) | 52 (1) | 45 (1) | 45 (1) | 45 (1) | 45 (1) |
| | 636 | 636 | 653 | 653 | 653 | 653 |
| | 531 | 531 | 350 | 350 | 350 | 350 |
| | 657 | 657 | 673 | 673 | 673 | 673 |

## 1.5. Performances

| Contactor | | VSC7<br>VSC7/F<br>VSC7/P<br>VSC7/PN<br>VSC7/PNG<br>VSC7/FN | | | | VSC12<br>VSC12/F<br>VSC12/P<br>VSC12/PN<br>VSC12/PNG |
|---|---|---|---|---|---|---|
| Rated voltage | [kV] | 2.2/2.5 | 3.6 | 3.6/7.2 | 6.2/7.2 | 12 |
| **Ultimate performances for:** | | | | | | |
| Motors | [kW] | 1,000 | 1,500 | 1,500 | 3,000 | 5,000 |
| Transformers | [kVA] | 1,100 | 1,000 | 2,000 | 4,000 | 5,000 |
| Capacitors | [kVAR] | 1,000 | 1,500 | 1,500 | 3,000 | 4,800 (1) |

| Contactor | | VSC-S/G<br>VSC-S/F<br>VSC-S/PG<br>VSC-S/PNG | | | | |
|---|---|---|---|---|---|---|
| Rated voltage | [kV] | 2.2/2.5 | 3.6 | 3.6/7.2 | 6.2/7.2 | 12 |
| **Ultimate performances for back-to-back capacitors banks** | | | | | | |
| Rated current | [A] | 250 | 250 | 250 | 250 | 250 |
| Max. transient current of the capacitor | [kA] | 8 | 8 | 8 | 8 | 8 |
| Max. transient frequency of the capacitor | [kHz] | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |

(1) Overvoltage surge arresters are compulsory between phases and between phase and earth.

## 1.6. Contactor auxiliary circuits

10 auxiliary contacts (5 normally open and 5 normally closed) are available on the contactor for the customer's use, with the following characteristics.

| Auxiliary contacts characteristics | | |
|---|---|---|
| Rated voltage | 24 … 660 | V |
| Rated normal current | 10 | A |
| Rated short time current (30 ms, 20 times) | 100 | A |
| Rated frequency (for AC only) | 50 | Hz |
| Rated insulation voltage (DC) | 800 | V |
| Rated insulation voltage (AC) | 660 | V |
| Insulation test voltage | 2500 | V |
| Number of contacts | 5 | - |
| Stroke | 6 … 7 | mm |
| Maximum contact resistance | 10 | mΩ |
| Storage temperature range | -20 … +120 | °C |
| Operating temperature range | -20 … +70 | °C |
| Emperature rise of contacts | 30 | K |
| Breaking capacity<br>(single contact $\tau$ = 20 ms, 250 V dc) | 250 | W |
| Breaking capacity<br>(single contact $\tau$ = 20 ms, 110 V dc) | 440 | W |
| Breaking capacity<br>(two contacts in series $\tau$ = 20 ms, 250 V dc) | 440 | W |

| Characteristics of the contacts of the “Coil Continuity Control” and “Capacity Survey” devices | |
|---|---|
| Technology | Relay with air-insulated contacts |
| **Breaking characteristics:** | |
| Maximum breaking power | 1200 VA (on resistive load) |
| Maximum breaking voltage | 277 V AC, 30 V DC |
| Maximum breaking current | 3 A |
| Rated current | 5 A @ 4 s |
| **Contact characteristics:** | |
| Maximum resistance with contact open | 150 mohm (measure of voltage drop 6 V DC 1) |
| Maximum capacity | 1.5 pF |
| **Trip times:** | |
| During closing | 5.0 ms |
| During release | 2.0 ms |
| **Insulation:** | |
| Between contacts and coil | 3000 V rms (50 Hz / 1 min.) |
| Between open contacts | 750 V rms (50 Hz / 1 min.) |
| Resistance with contacts open | Min. 103 Mohm at 500 V DC |

## 1.7. Compliance with Standards

V-Contact contactors comply with the Standards of the major industrialised countries and in particular with the following Standards:

– IEC 62271-106 (2011);
– IEC 62271-1 (2007);
– GB/T 14808-2001;
– DL/T 593-2006;
– IEC 60278 replaced by IEC 62271-200;
– IEC 60694 (2002) replaced by IEC 62271-1;
– IEC 60056 (4.104) replaced by IEC 62271-100;
– IEC 60470 replaced by IEC 62271-106.

## 1.8. Protection against short-circuit

The value of the installation short-circuit current could exceed the breaking capacity of the contactor. The contactor must therefore have adequate protection against short-circuit.



**Fuse replacement must only be carried out by qualified personnel.**

# 2. Checking on receipt

**During handling, take great care not to stress the insulating parts of the apparatus and the terminals of the contactor.**

**Any operation carried out on the contactor must be done without the presence of voltage and with the main protection device open: danger of electrocution and/or severe burns.**

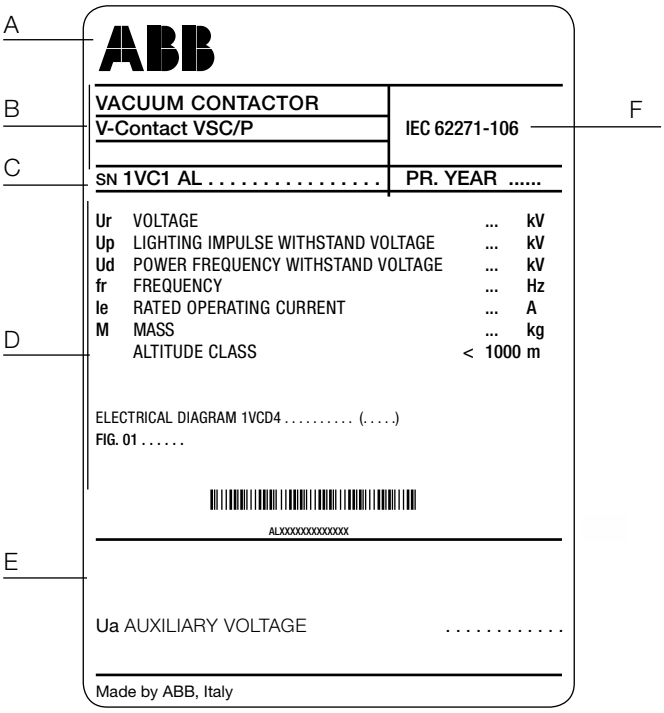
**Make sure that operations are carried out with the main and auxiliary power off.**

On receipt, immediately check integrity of the packing and the colour of the “SHOCKWATCH” indicator (Fig. 1) placed on it.
If the “SHOCKWATCH” impact indicator is WHITE, it means that the packing has not received any notable shocks during transport. Open the packing, remove the contactor as indicated below, and check the state of the apparatus and its correspondence with the nameplate data (see fig. 2) with what is specified in the accompanying shipping note and in the order confirmation sent by ABB.
If the “SHOCKWATCH” impact indicator is RED, follow the instructions indicated on the plate.
Opening the packing does not damage its components and it can therefore be re-instated using the original material.
The contactor is shipped in special packing, in the open position.
Each piece of apparatus is protected by a plastic cover to prevent any infiltration of water during the loading and unloading stages and to keep the dust off during storage.
To remove the contactor from the packing, proceed as follows:
– open the plastic bag
– remove the contactor, avoiding any stress to the functional insulating parts and the terminals of the apparatus.
– use the special lifting plates for the withdrawable version
– check the rating plate characteristics to make sure that the performances are suitable for the destined application and that they are those indicated in the order confirmation.

Should any damage or irregularity be noted in the supply on unpacking, notify ABB (directly or through the agent or supplier) as soon as possible and in any case within five days of receipt.
The apparatus is only supplied with the accessories specified at the time of ordering and validated in the order confirmation sent by ABB.
The accompanying documents inserted in the shipping packing are:
– instruction manual (this document)
– test certification
– identification label
– fiscal copy of the shipping advice note
– electric wiring diagram.




**Fig. 1**




A Trademark
B Type of apparatus
C Serial number
D Characteristics of the apparatus
E Characteristics of the control auxiliaries
F Reference standards

**Fig. 2**

Other documents which are sent prior to shipment of the apparatus are:
– order confirmation
– original shipping advice note
– any drawings or documents referring to special configurations/conditions.

# 3. Handling

The contactor can be lifted using a lifting truck or a fork-lift truck.
The following precautions must be taken during contactor handling:

1. Keep the contactor in the upright position.
2. Make sure that the load is balanced on the truck or on the transport plate/pallet.
3. Interpose protective material between the contactor and the truck to avoid any damage or scratches.
4. Fix the contactor onto the truck or onto the transport plate/pallet to prevent it moving or tilting over.
5. Avoid excessive speed, sudden starts and stops or sharp changes in direction during contactor handling.
6. Only lift the contactor enough to avoid any obstacles on the floor.
7. Take care to avoid any impacts with structures, other apparatus or with personnel when handling the contactor.
8. Never lift a contactor over an area where there are people.
9. During handling of the apparatus, do not stress the insulating parts and the contactor terminals.

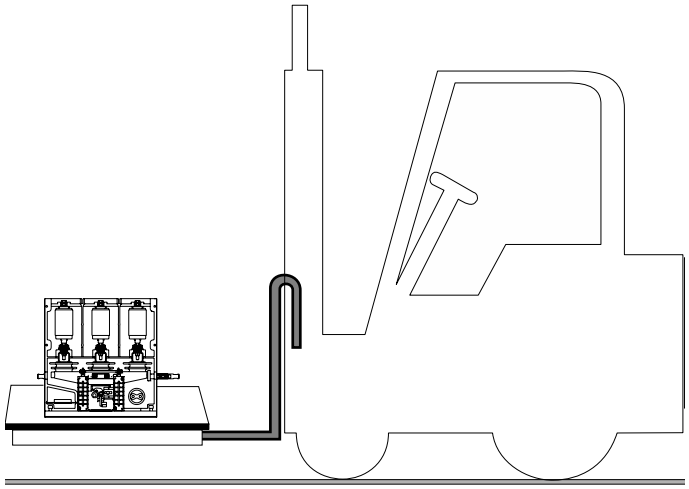
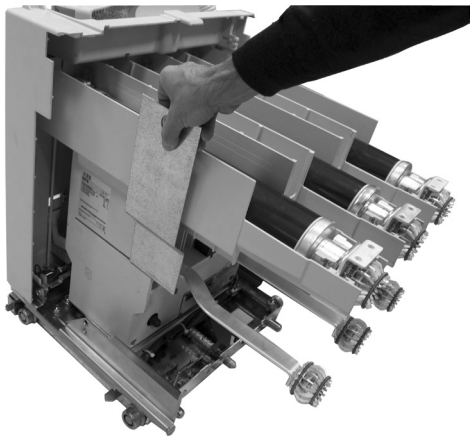
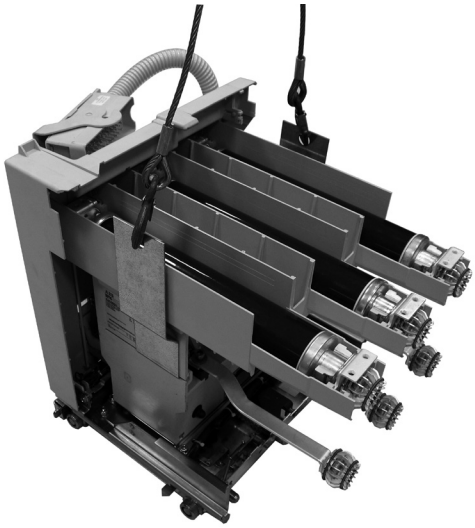


**Fig. 3a - Handling using a lifting or fork-lift truck.**

## 3.1. Handling and lifting using a crane

– Insert the lifting plates
– Lift
– After the unpacking and lifting operations, remove the lifting accessories.
  Warning: with lifting tools, it is mandatory to move the contactors not by pulling them, but by pushing them from the screen





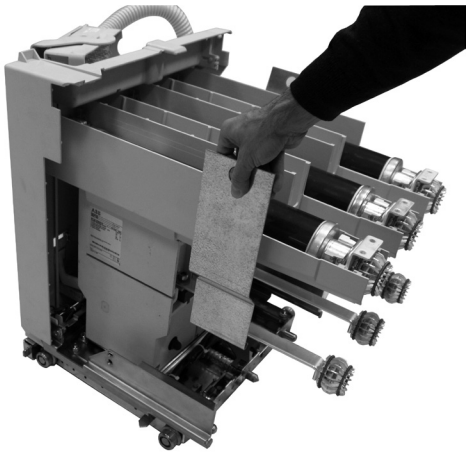


**Fig. 3b - Removal of the contactor from the packing and dismantling the lifting tools.**

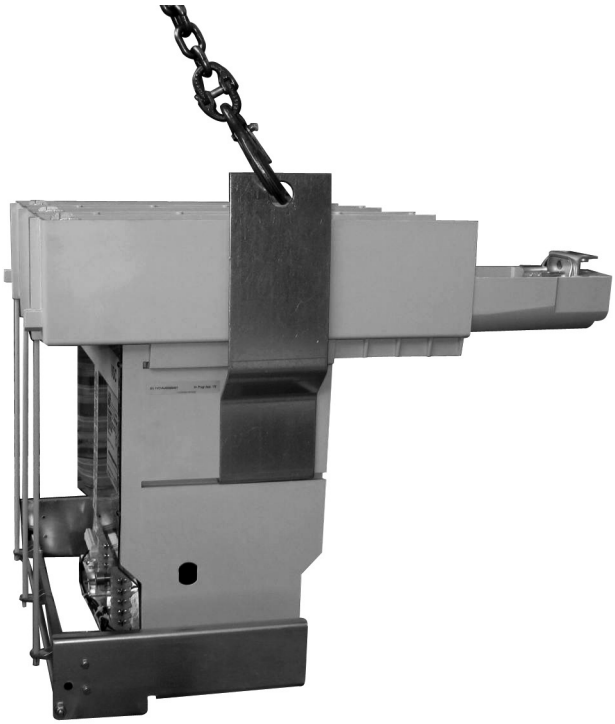


**Fig. 3c - Fixed contactor with fuses**

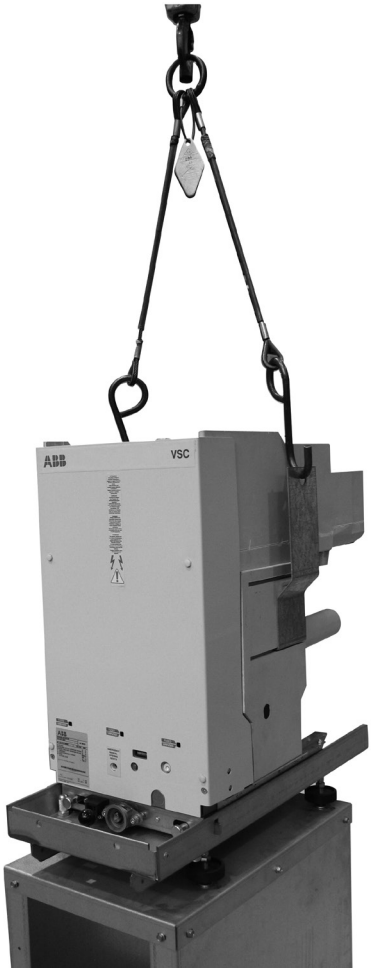



**Fig. 3d - Withdrawable contactor**

# 4. Storage

When a period of storage is foreseen, the original packing must be put back. Store the contactor in a dry dust-free area. It must not be left outside or in adverse micro-climatic conditions: if it is left without protection, rust and deterioration of the insulation can occur.
Insert special hygroscopic packets inside the packing, with at least one standard packet per piece of apparatus. Replace the packets approximately every 6 months.

Should the original packing no longer be available and immediate installation is not possible, store in a covered, well-ventilated, dry, dust-free, non-corrosive ambient, with a dry atmosphere, away from any flammable materials and at a temperature between – 5 °C and + 40 °C.
In any case, avoid any accidental impacts or positioning which stresses the structure of the apparatus.

# 5. Installation

## 5.1. General

Correct installation is of primary importance. The manufacturer's instructions must be carefully studied and followed. It is good practice to use gloves for handling the pieces during installation.

**The areas involved in the passage of power conductors or conductors of auxiliary circuits must be protected against access of any animals which might cause damage or disservices.**

The contactor enclosure must be installed in a clean, dry and heated place with good ventilation. It must be easily accessible for cleaning and inspection, and must be levelled, placed on the supporting foundations and securely fixed into position.
When the contactor is connected to a capacitive load, make sure that there is a heating element to keep the humidity down and of suitable size for the compartment where the contactor is installed. The contactor must always be installed associated with a suitable protection device (e.g.: fuses).

**The fixed version of the V-Contact VSC contactors must be installed by the customer so as to guarantee a minimum degree of protection of IP2X.**

## 5.2. Installation and operating conditions

The following Standards must be taken into particular consideration during installation and service:
- IEC62271-1/DIN VDE 0101
- VDE 0105: Operation of electrical plants
- DIN VDE 0141: Earthing systems for electrical installations with rated voltage higher than 1 kV
- All the accident prevention regulations in force in the relative countries.

## 5.3. Normal conditions

Follow the recommendations in the IEC 62271-1 and 62271-106 Standards. In more detail:

| Ambient temperature | |
|---|---|
| Maximum | + 40 °C |
| Average maximum over 24 hours | + 35 °C |
| Minimum (according to class – 5), apparatus for indoor installation | – 5 °C |

**Humidity**

The average value of the relative humidity, measured for a period longer than 24 hours, must not exceed 95%.
The average value of the water vapour pressure, measured for a period longer than 24 hours, must not exceed 2.2 kPa.
The average value of the relative humidity, measured for a period longer than 1 month, must not exceed 90%.
The average value of the water vapour pressure, measured for a period longer than 1 month, must not exceed 1.8 kPa

**Altitude**

< 1000 m above sea level.

## 5.4. Special conditions

**Installations above 1000 m a.s.l.**

Possible within the limits allowed by reduction of the dielectric resistance of air.
For altitudes over 2000 m ask ABB.

**Climate - Increase in temperature**

In order to avoid the risk of corrosion or other damage in areas with high humidity and/or rapid large fluctuations in temperature, take appropriate measures (for example, using suitable electric heaters) to prevent any condensation phenomena.

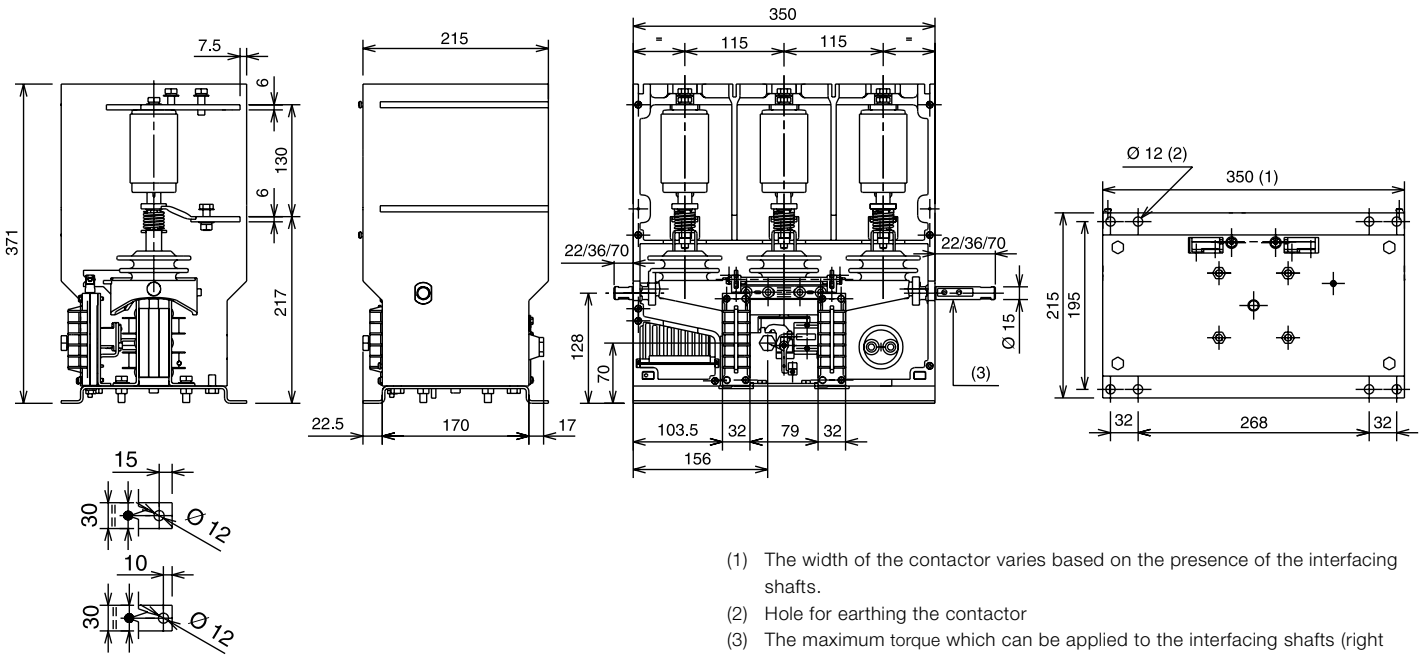
For special installation requirements or other operating conditions, please contact ABB.

# 5.5. Overall dimensions

### 5.5.1. VSC fixed contactor

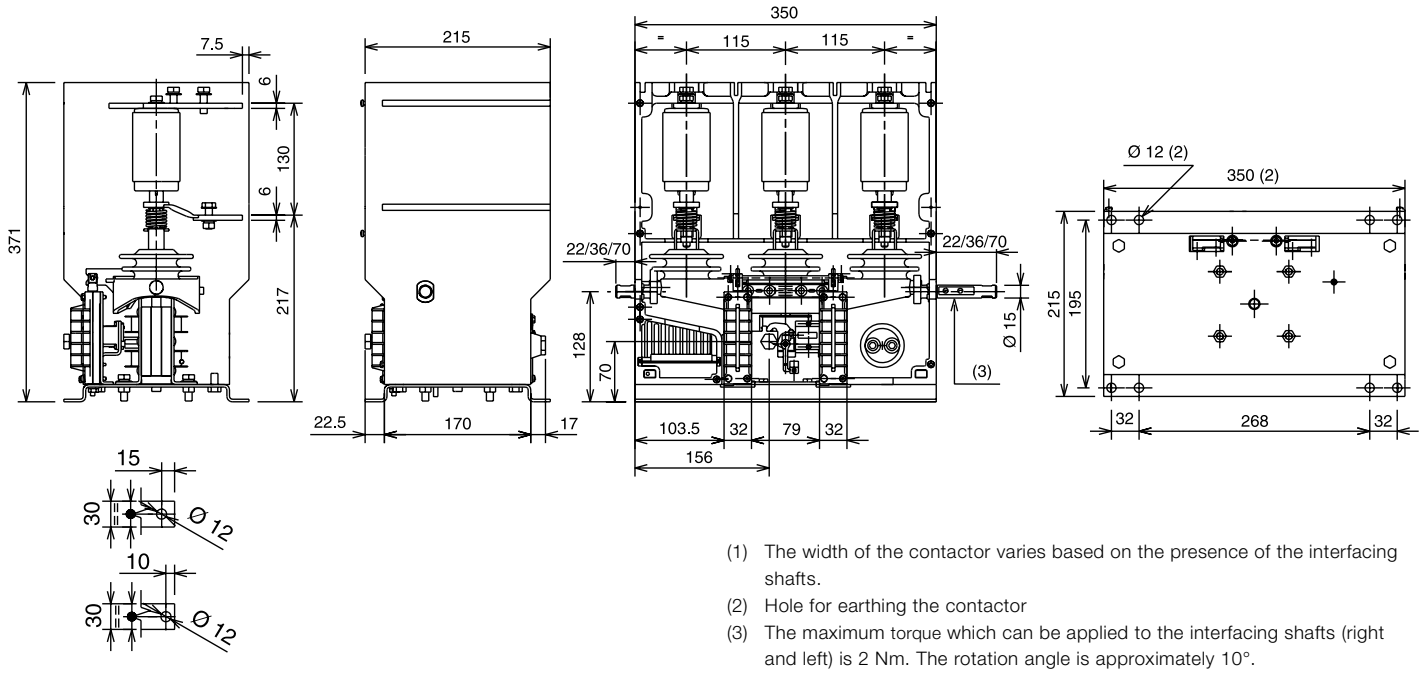
For the overall dimensions and distances between fixing holes, refer to figure 4a.
In any case, avoid stressing the supporting structure of the contactor: if necessary, arrange slots in the fixing area to facilitate correct positioning of the apparatus.
The assembly positions can be selected between the two shown in figure 4b.

**VSC7**




(1) The width of the contactor varies based on the presence of the interfacing shafts.
(2) Hole for earthing the contactor
(3) The maximum torque which can be applied to the interfacing shafts (right and left) is 2 Nm. The rotation angle is approximately 10°.

**VSC12**




(1) The width of the contactor varies based on the presence of the interfacing shafts.
(2) Hole for earthing the contactor
(3) The maximum torque which can be applied to the interfacing shafts (right and left) is 2 Nm. The rotation angle is approximately 10°.

**Fig. 4a**

**Installation of fixed contactors**

The performance of the contactor remains unaltered in the installation positions indicated below:

**VSC 7 - VSC 12**

A) Floor-mounted with moving contacts at the bottom.
B) Wall-mounted with horizontal moving contacts and terminals at the bottom.
C) Wall-mounted with horizontal moving contacts and terminals at the top.
D) Wall-mounted with horizontal moving contacts with interrupters on the front (or rear) with vertical terminals.
E) Ceiling-mounted with moving contacts at the top.

**VSC 7/F - VSC 12/F - VSC 7/FN**

A) Floor-mounted with moving contacts at the bottom.

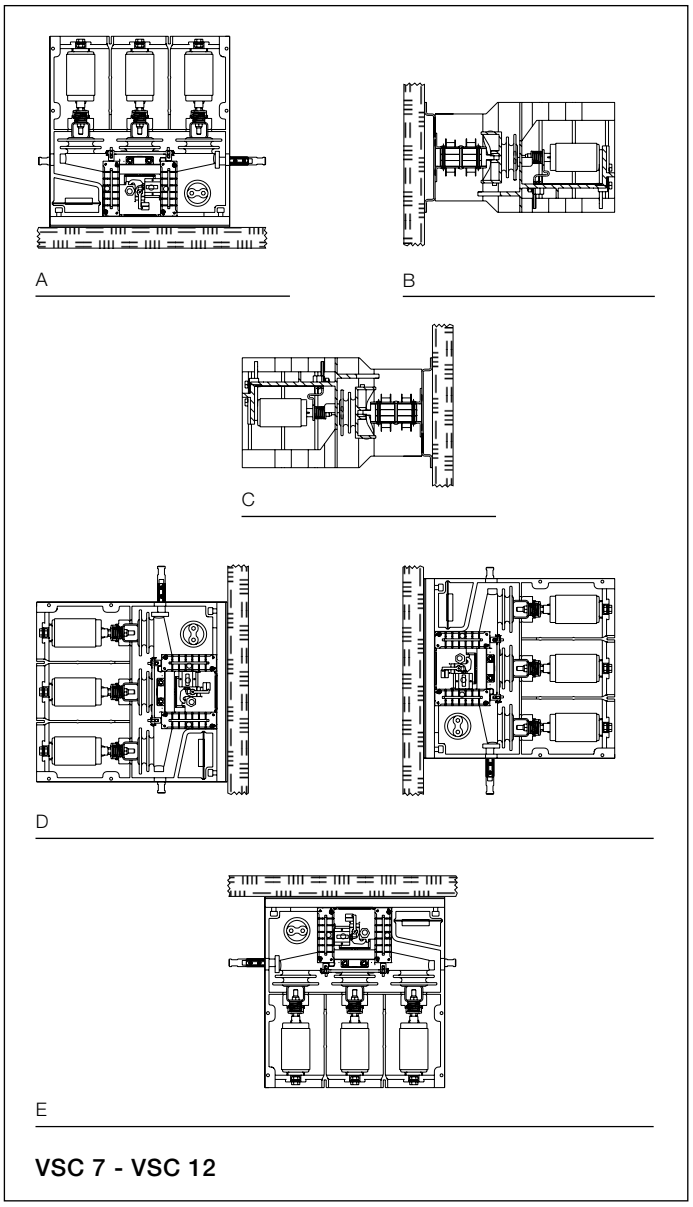
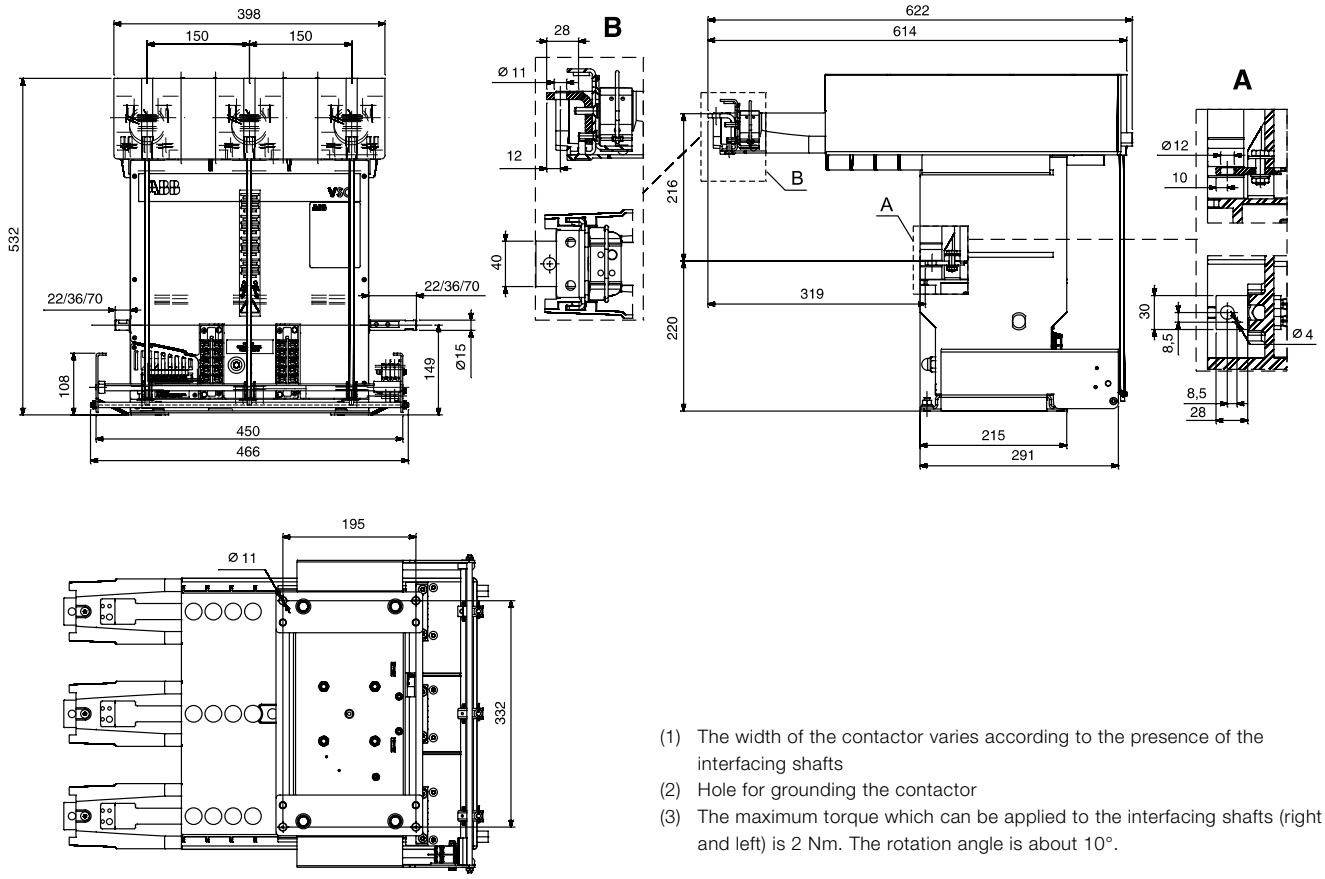



**Fig. 4b**

**5.5.2. VSC/F contactor in fixed version with fuses**

Please refer to figures 5a - 5b for the overall dimensions and the distances between the fixing holes.
In any case, avoid stressing the supporting structure of the contactor: if necessary, prepare slots in the fixing area to facilitate correct positioning of the apparatus.
The contactor must be installed on the floor with moving contacts at the bottom (figure 5c).

## VSC7/F




(1) The width of the contactor varies according to the presence of the interfacing shafts
(2) Hole for grounding the contactor
(3) The maximum torque which can be applied to the interfacing shafts (right and left) is 2 Nm. The rotation angle is about 10°.

Fig. 5a

## VSC7/FN

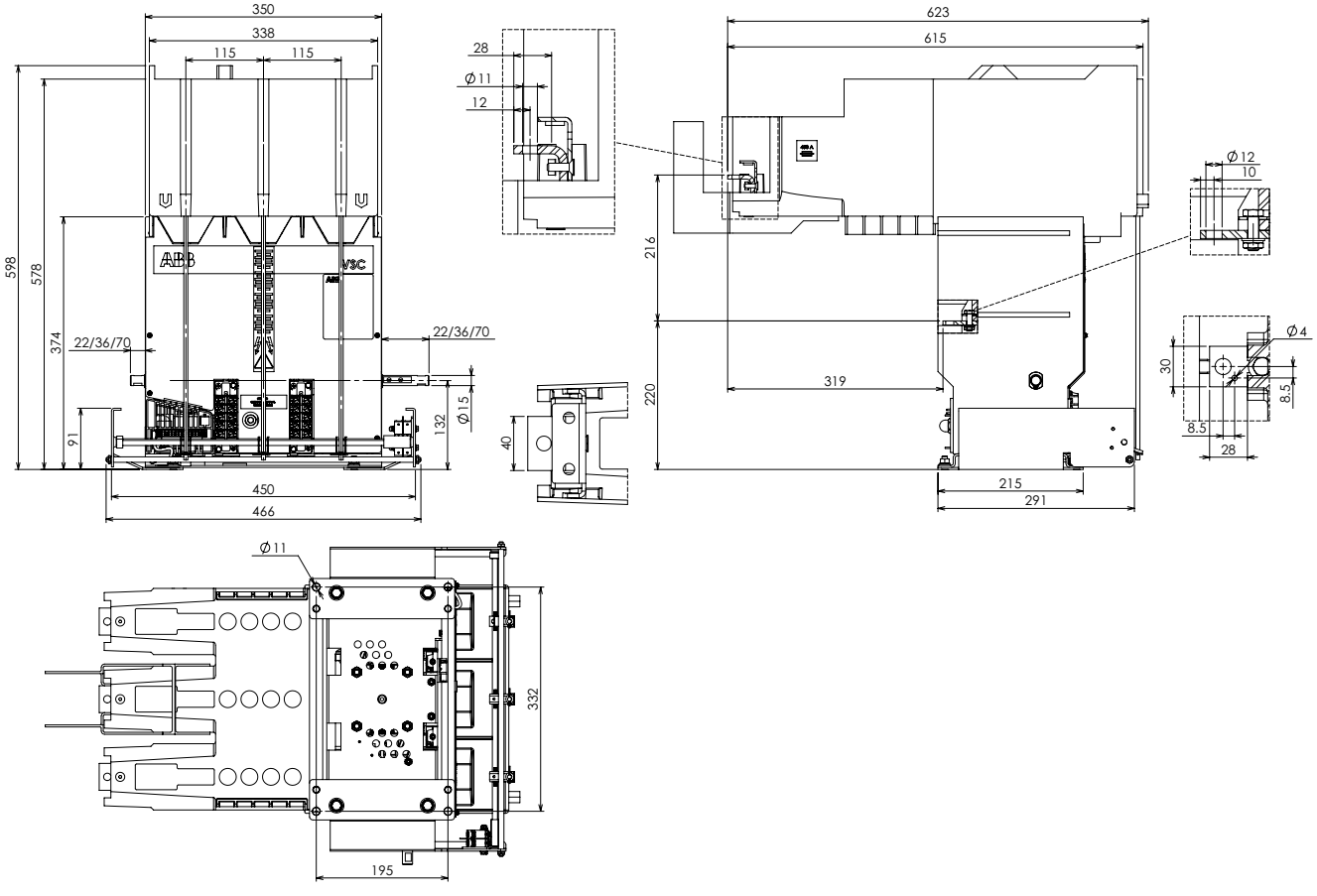
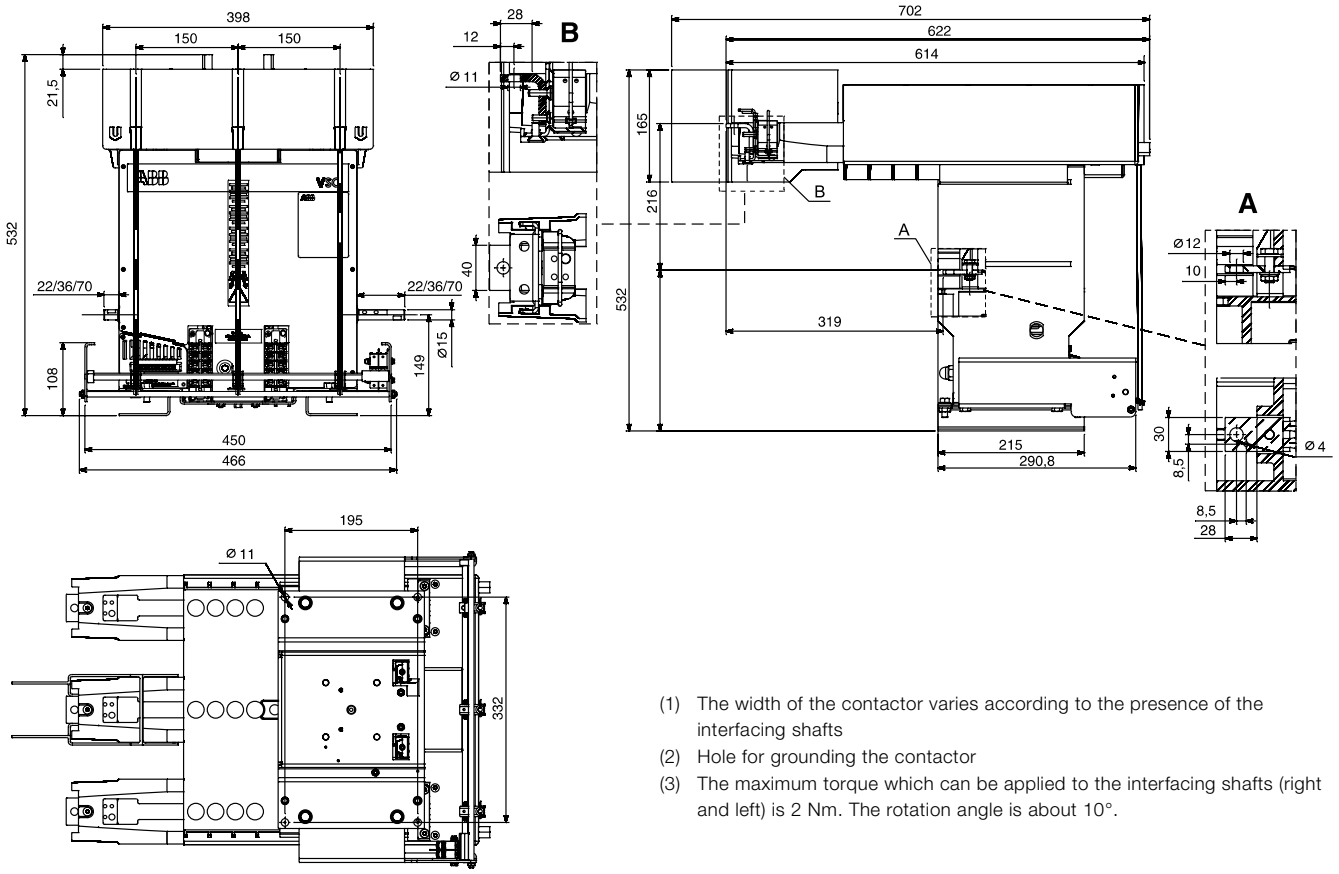



Fig. 5b




(1) The width of the contactor varies according to the presence of the interfacing shafts
(2) Hole for grounding the contactor
(3) The maximum torque which can be applied to the interfacing shafts (right and left) is 2 Nm. The rotation angle is about 10°.

Fig. 5c

## Installation of the fixed contactor with VSC/F - VSC/FN fuses

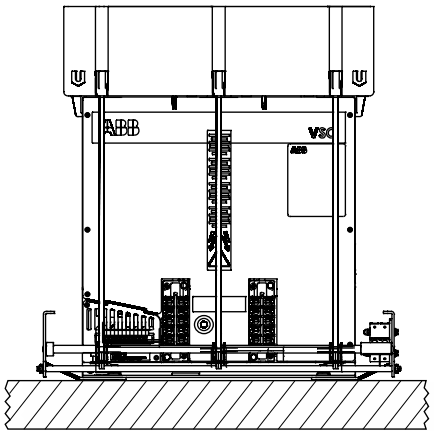


Fig. 5d

### 5.5.3. Withdrawable contactor with VSC/P - VSC/PG - VSC/PN - VSC/PNG fuses

#### VSC7/P - VSC7/PG - VSC12/P - VSC12/PG

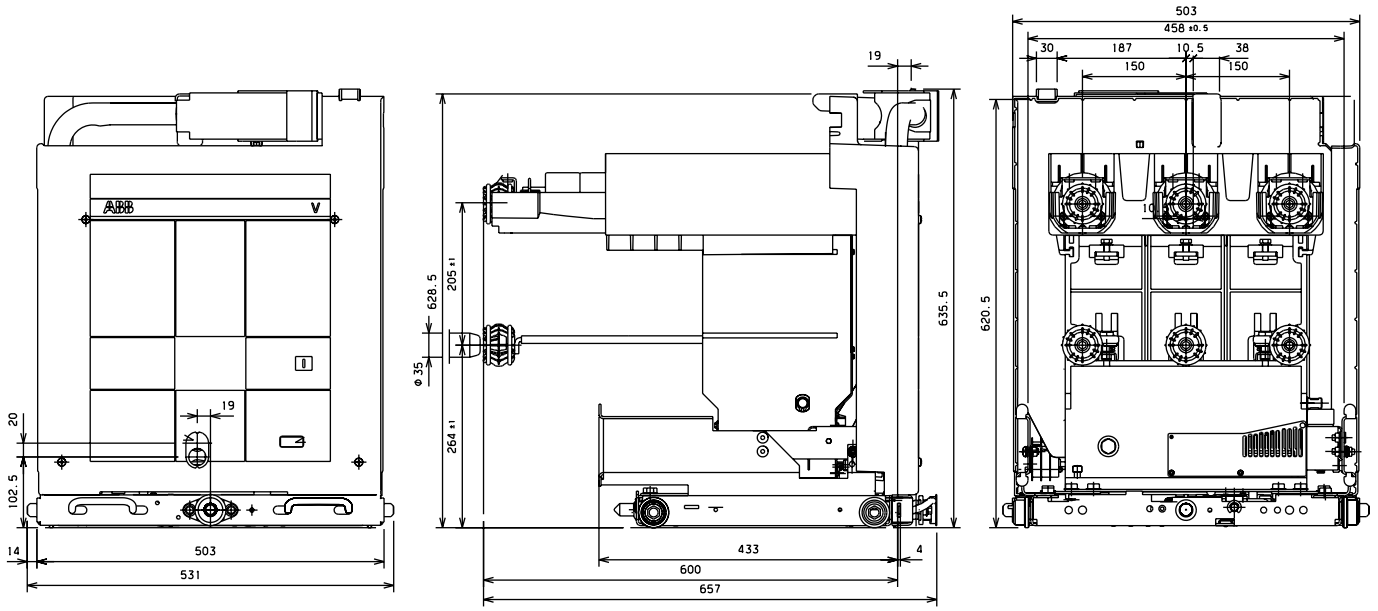



Fig. 6a

#### VSC7/PN

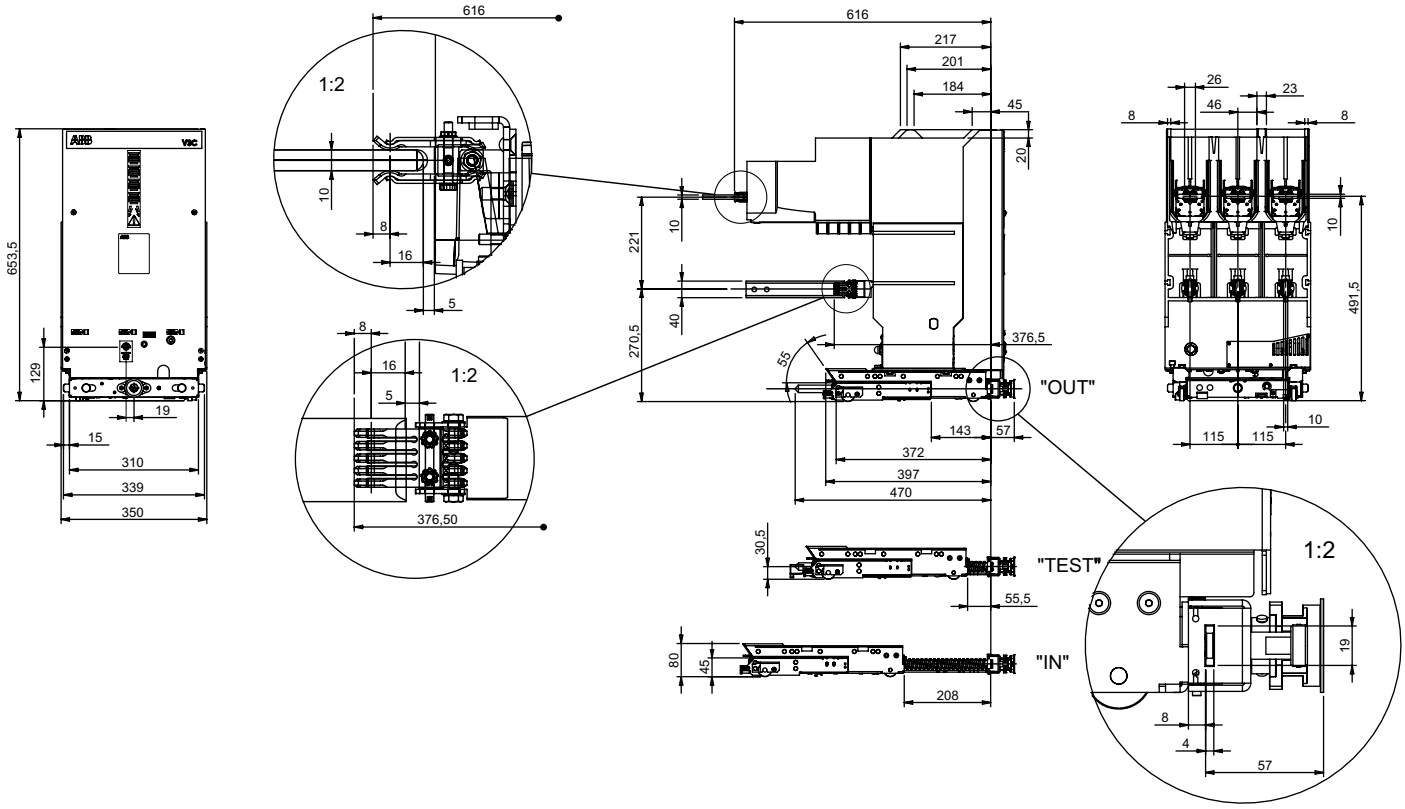
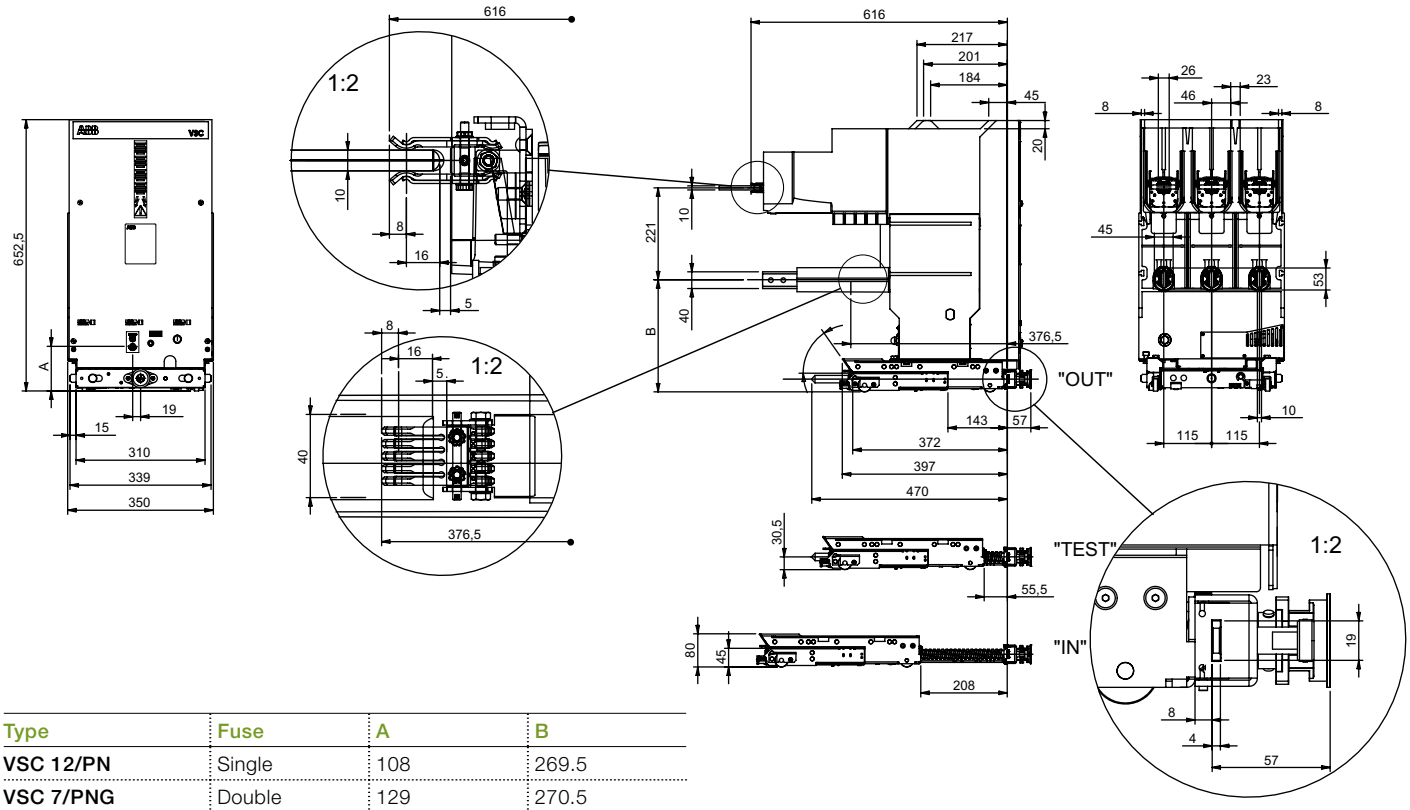



Fig. 6b




| Type | Fuse | A | B |
|---|---|---|---|
| **VSC 12/PN** | Single | 108 | 269.5 |
| **VSC 7/PNG** | Double | 129 | 270.5 |
| **VSC 12/PNG** | Double | 108 | 269.5 |

**Fig. 6c**

## VSC 12/P contactor for marine environments

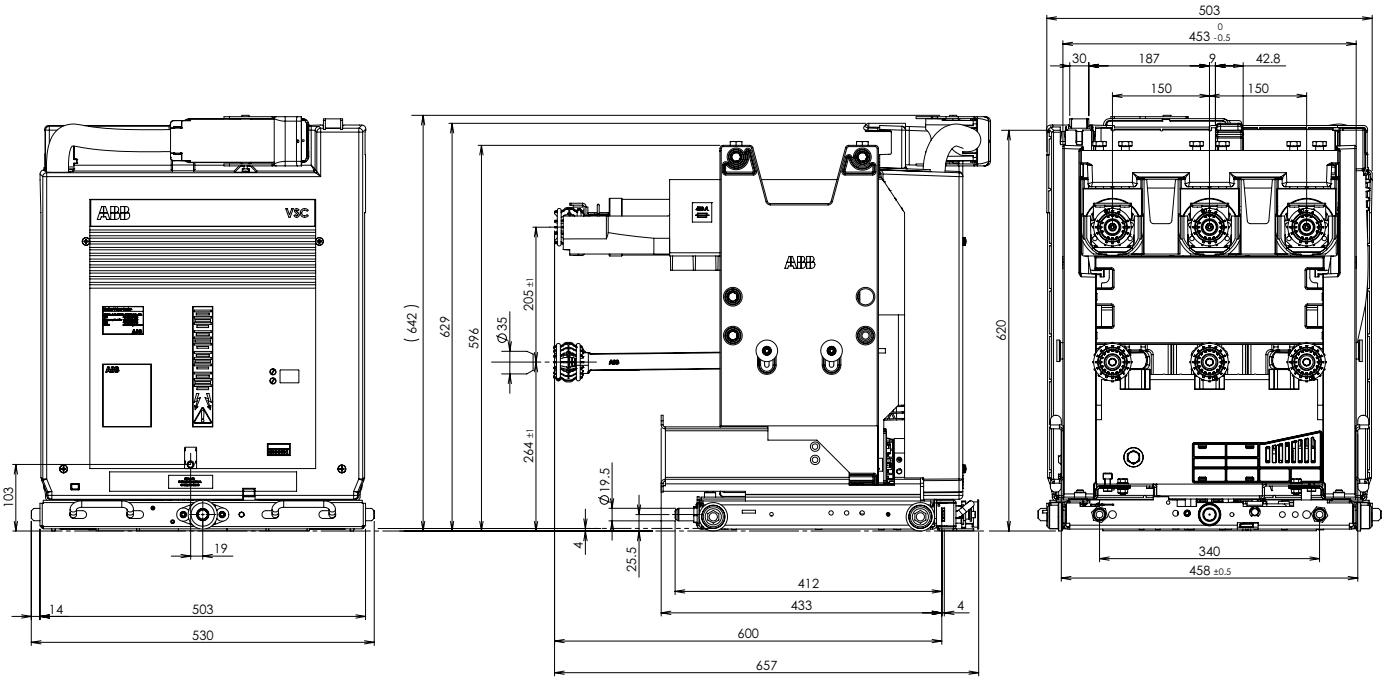



**Fig. 6d**

# 5.6. Assembly and making the connections

### 5.6.1. Fixed contactors



**WARNING**

**Dangerous voltages. Risk of death, serious injury to people, damage to the apparatus or other objects.**

**Remove the power supply, ground and put all the power and control voltage sources under safe conditions before starting the work on this or any other electrical apparauts.**
**Installation must only be carried out by qualified personnel.**

#### Introduction

Before carrying out any installation operations:

- Test all the power terminals to check that they are not supplied with voltage. Only use high voltage testing equipment approved for checking the voltage on the power terminals. **Do not attempt to measure the high voltage (above 600 volt) with a volt-ohm/meter.**
- Check all the control and secondary circuit terminals with a voltmeter to ensure that all the control and secondary input voltage sources have been turned off.
- Connect the safety earthing to the power terminals after having turned the power supply to the system off and before working on the apparatus.
- Carry out all the operations for turning off the voltage and earthing according to the established safety procedures.

#### Power circuit

#### General precautions

– Check that the connections of the fixed contactor or the isolating contacts of the withdrawable contactor are clean and free of any deformation caused by shocks received during transport or storage in the warehouse.
– Select the cross-section of the conductors according to the service current and the short-circuit current of the installation.
– Prepare special pole insulators, near the terminals of the contactor, sized according to the electrodynamic forces deriving from the short-circuit current of the installation and avoid stressing the connections laterally.

#### Surface treatment of the connections

The connections can either be made of bare copper or bare aluminium. In any case, it is always advisable to silver-plate the contact surfaces. The surface treatment must have a constant and even thickness.

#### Assembly procedures for fixed contactors

– Check that the contact surfaces of the connections are flat, and are free of any burrs, traces of oxidation or deformation caused by drilling or impacts received.
– Carry out the operations indicated on the contact surface of the conductor (silver-plated copper):
  - clean with a rough dry cloth
  - only in the case of obstinate traces of oxidation, clean with a very fine grain emery cloth taking care not to remove the surface layer
  - if necessary, restore the surface treatment (consult ABB)
  - put the connections in contact with the contactor terminals, taking care to avoid mechanical stresses produced, for example, by the conductor busbars on the terminals themselves.
– Interpose a spring and a flat washer between the head of the bolt and the connection.
– The use of bolts according to DIN class 8.8 Standards is recommended, also referring to what is indicated in the table.
– In the case of cable connections, strictly follow the manufacturer's instructions for making the terminals.

| Bolt | Recommended tightening torque (1) Without lubricant |
|---|---|
| M6 | 10.5 Nm |
| M8 | 23 Nm |
| M10 | 50 Nm |
| M12 | 86 Nm |

(1) The nominal tightening torque is based on a friction coefficient of the thread of 0.14 (distributed value the thread is subjected to which, in some cases, is not negligible). Take into account the deviations from the general Standards table (for example, for contact systems or terminals) as foreseen in the specific technical documentation. The thread and surfaces in contact with the heads of bolts must be slightly oiled or greased, so as to obtain a correct nominal tightening torque.
The tightening torques indicated can only be applied to metal parts.

#### Earthing and cabling procedures

VSC conforms to level 3 of the IEC 61000-4-x EMC Standards. With regard to medium voltage switchgear, the plants where the VSC contactors are to be installed must conform to the IEC 60694:2002-01 and IEC 62271-1 ed. 1.0 Standards, to ensure adequate electromagnetic immunity. Pay great attention during earthing and cabling operations of the auxiliary circuits. Follow the procedures indicated. For further advice, please contact the ABB Service office.

### Grounding

A good connection to earth guarantees correct operation of all the apparatus installed. However, even earthing carried out correctly is not a sufficient measure to ensure a good connection between the VSC control module and earth. In fact, since the control module of the contactor is connected to the metallic base of the VSC by means of a copper connection (Fig. 7), it is always necessary to check that the connection is intact.
Furthermore, earthing must always be carried out between the VSC frame and the main earthing system of the plant.
Use cables with a suitable cross-section and of the minimum length needed.

### Connection of metallic structures to exposed conductive parts

In the case of painted parts of the supporting structure, the various parts must always be scraped to eliminate the paint and connected with busbars or copper braids so as to guarantee low inductance connections.
To make a low inductance earthing connection, use cables or busbars with an appropriate cross-section, preferably rectangular. Scrape away the paint of the metallic parts over a sufficiently large area, tighten the fixing screws and cover the connected parts with Vaseline grease.
The length of the earthing cables must be as short as possible. Connection to earth of the parts must guarantee the same electric potential and low impedance.

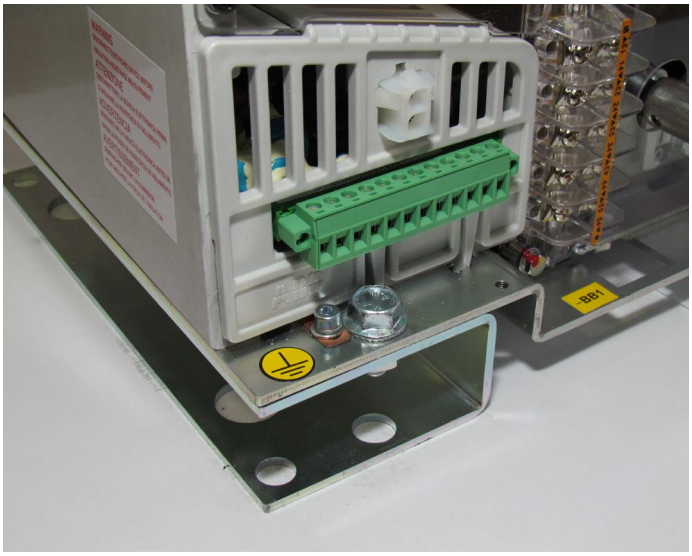


**Fig. 7 - Grounding**

**Figs. 8a - 8b show a grounding operation carried out correctly.**

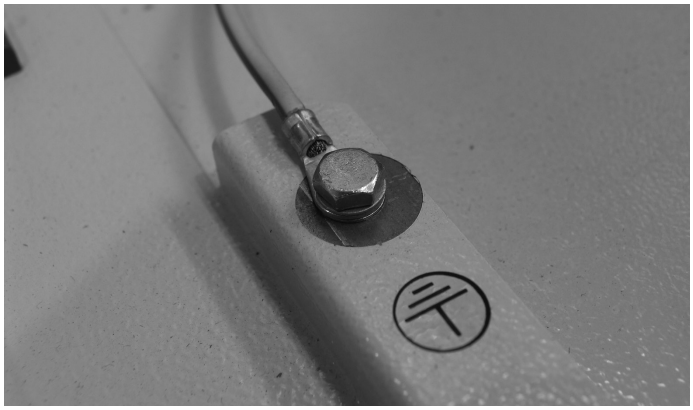


Fig. 8a

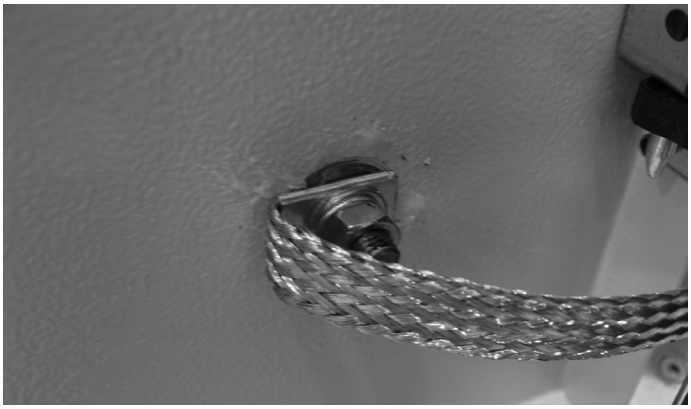


Fig. 8b

**Figs. 8c - 8d show a grounding operation not carried out correctly and which, apart from being dangerous, does not guarantee correct operation of the VSC.**



Fig. 8c

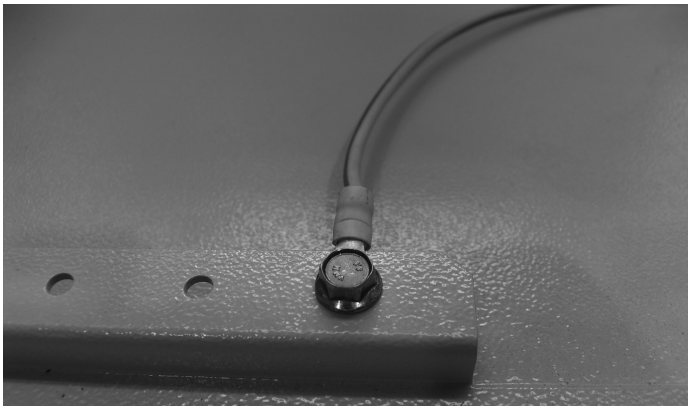


Fig. 8d

### Cabling

Make short connections (maximum 1 metre) inside the medium voltage units and avoid positioning them close to the medium voltage busbars.
All long connections must follow paths as close as possible to the metallic frame. The connections must also be fitted with ferrite rings to suppress high frequency interference.
It is good practice to run the cables inside metallic pipes or ducts (earthed at several points) when they are subject to or may be a cause of interference.
Cabling and earthing procedures according to IEC 61000-5-2 Standards: “Technical report: Installation and mitigation guidelines”.

Where possible, the power supply and auxiliary circuit cables must be braided. Their length must be calculated appropriately to prevent any surplus and the maximum length must be:

- 135 m for 24 to 130 V auxiliary voltage
- 400 m for 220 to 250 V auxiliary voltage

Longer lengths require an additional filter for every operating input used (consult ABB).
In any case, any surplus parts of cables must be wound separately and taken into the low voltage apparatus compartment. Always avoid placing them in the vicinity of the medium voltage cables or close to cables which may generate interference or disturbances, such as current or voltage transformer cables or power supply cables.

### Connection of the auxiliary circuits

The cables to be used for connection of the auxiliary circuits must have a rated voltage Uo/U of 450/750 V and be insulated for 3 kV test.
**Note:** before carrying out the test, disconnect the earthing connection of the electronic feeder.
Also remember that the auxiliary circuits must be checked at the maximum voltage of 2 kV for 1 second in accordance with what is prescribed in the Standards.

The cross-section of the connection cables must not be less than 1.5 $mm^2$.
Connection of the contactor auxiliary circuits must be made by means of the socket with terminal box mounted on the front of the electronic card.
Outside, the wires must run through metallic pipes or ducts suitably earthed.

### Connection to be made by the customer (*)

Pins XDB10-1 and XDB10-2 must always be supplied, both in the SCO and DCO version (also see par. 5.8.). The polarity is not important since the internal circuits take both AC or DC signals. For further details, consult the electric circuit diagram enclosed with the apparatus.

| N. of pin | Connections | Abbr. of binary outputs/inputs | Meaning of each pin (*) | |
|---|---|---|---|---|
| | | | Basic version | "Full option" version |
| -XDB10-1 | Auxiliary power supply | – | Auxiliary power supply AC or DC (pole 1) | Auxiliary power supply AC or DC (pole 1) |
| -XDB10-2 | Auxiliary power supply | – | Auxiliary power supply AC or DC (pole 2) | Auxiliary power supply AC or DC (pole 2) |
| -XDB10-3 | Binary output n° 1 | -PFG | Indication of unit ready and coil continuity control (pole 1) | Indication of unit ready and coil continuity control (pole 1) |
| -XDB10-4 | Binary output n° 1 | | Indication of unit ready and coil continuity control (pole 2) | Indication of unit ready and coil continuity control (pole 2) |
| -XDB10-5 | Binary output n° 2 | -PFR | Not used | Indication of capacitor state (pole 2) |
| -XDB10-6 | Binary output n° 2 | | Not used | Indication of capacitor state (pole 1) |
| -XDB10-7 | Binary input n° 1 | -SFC | Closing (pole 1) | Closing (pole 1) |
| -XDB10-8 | Binary input n° 1 | | Closing (pole 2) | Closing (pole 2) |
| -XDB10-9 | Binary input n° 2 | -SFO | Opening (pole 1) | Opening (pole 1) |
| -XDB10-10 | Binary input n° 2 | | Opening (pole 2) | Opening (pole 2) |
| -XDB10-11 | Binary input n° 3 | -SFL2 | Undervoltage (pole 1) | Undervoltage (pole 1) |
| -XDB10-12 | Binary input n° 3 | | Undervoltage (pole 2) | Undervoltage (pole 2) |

(*) For availability, ask ABB.

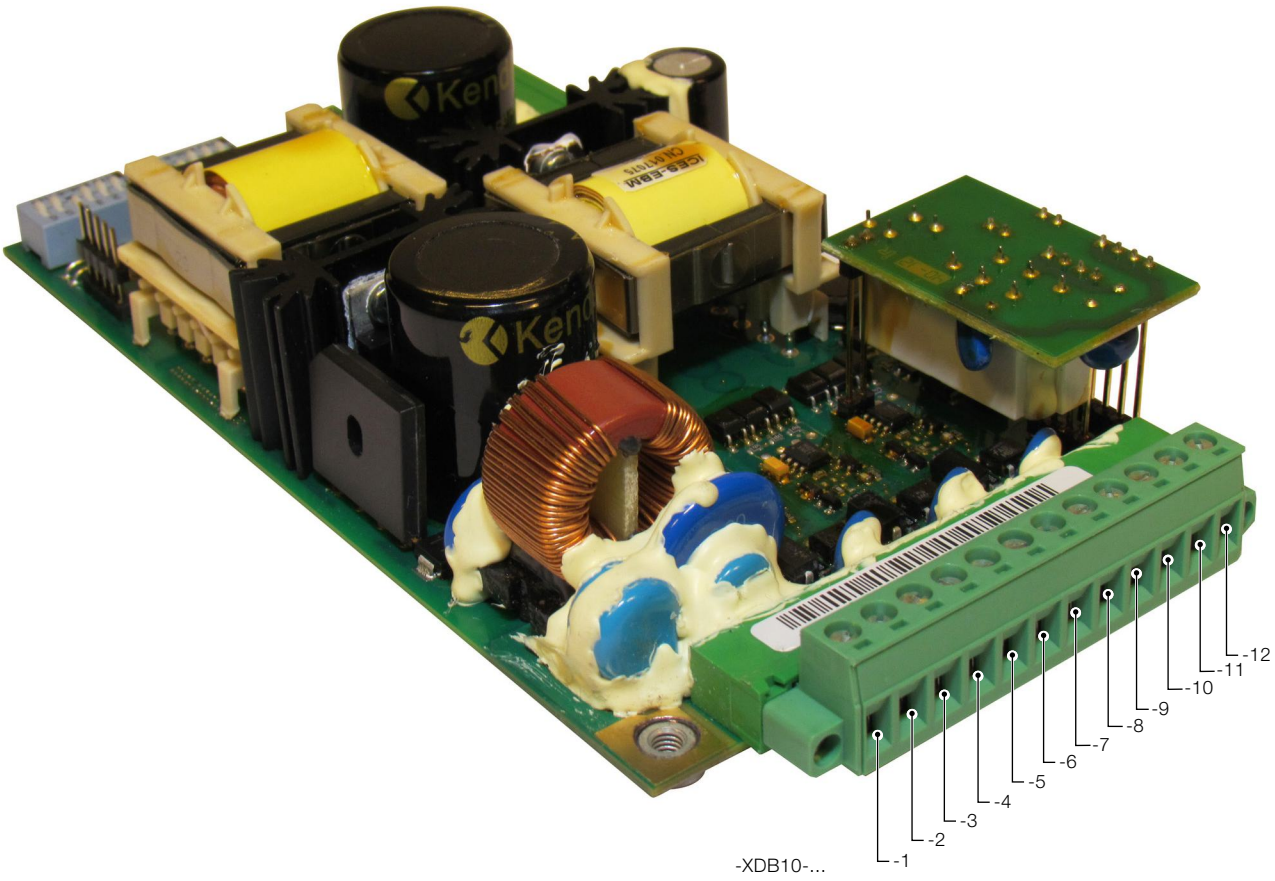



Fig. 9

### Checks

After the above-mentioned operations, carry out the following checks:

– check that the connections do not exert any force on the terminals
– check tightness of the connections.



Fig. 10

### 5.6.2. Withdrawable contactors and enclosures

The withdrawable contactors are used in the UniGear ZS1 type switchgear and in the PowerCube modules. Appropriately fixed together in the configurations defined by the customer, the enclosures build up medium voltage switchgear consisting of various units.

### Rules for designing the switchgear

Arc proofing

The ABB enclosures are supplied with a reinforced door, suitable for making arc proof switchgear.

- **The reinforced enclosure alone cannot guarantee arc proofing of the switchgear designed by the customer. To guarantee this, some representative configurations, selected by the customer, must be subjected to the tests according to the prescriptions indicated in the IEC 62271-200 Standards.**
- **For UniGear ZS1 type switchgear, all the door knurls must be tightened to guarantee arc proofing.**

### Degree of protection

Limited to the front part, the ABB enclosures guarantee the following degree of protection:

- IP30 on the external housing;
- IP20 inside the switchgear with the door open.

Special versions up to IP41.

**The enclosure alone supplied by ABB cannot guarantee the degree of protection of the switchgear designed by the customer. It must undergo the tests according to the prescription indicated in the IEC62271-200 Standards.**

## Heating

Refer to technical catalogue 1VCP000165 for the rated capacity of the contactors, bearing in mind that apparatus heating is affected by the following variables:

- layout of the enclosures in the switchgear designed by the customer;
- degree of protection (ventilation slats);
- current density of the power supply busbars (busbar duct - branches);
- ambient temperature.

For any needs, please contact ABB Service.

### 5.6.2.1. Withdrawable VSC/P contactors

The contactors are used for rated voltages from 7.2 to 12 kV, rated normal currents up to 400 A and fault levels up to 1000 MVA (with suitable protection fuses in series with the contactor).

The VSC/P contactor is made up of:

– a three-pole contactor with SCO or DCO function
– mechanical signalling of open/closed
– two pairs of auxiliary contacts signalling open/closed
– feeder able to operate in DC and AC
– a truck on which the supporting structure of the contactor is fixed, consisting of two supports, closed at the front by the protection with characteristics nameplate.
In the top part of the protection there are strikers 30a and 30b (fig. 11) for actuating the enclosure contacts to signal the connected/isolated position.

The pin (34) for locking contactor racking-in with the earthing switch closed on the enclosure, comes out on the right side of the truck.

The crosspiece for hooking up the contactor to the enclosure for operation of the truck is mounted on the front of the truck (3);

– two supports (102) house the slide for actuation of the segregation shutters of the fixed medium voltage contacts of the enclosure and the locking slide of operation of the switch itself with the contactor in the connected position or during the isolation stage;
– when it is not inserted in the socket located on the enclosure, the plug connector for the auxiliary circuits of the contactor must be hooked up to the pin (101);
– mechanical signalling of open/closed (103);
– fuseholder complete with connections for fuses (104);
– input and output tulip isolating contacts (105);
– locks as per par. 5.6.2.2.;
– three current-limiting fuses (supplied on request) with high breaking capacity connected in series to the contactor, with dimensions according to:
  - DIN 43625 Standard with maximum cartridge length e = 442 mm;
  - BS 2692 Standard with maximum centre fixing distance L = 553 mm;
– an impulse counter (supplied on request) which indicates the number of operations carried out by the contactor (106);
– manual emergency opening device (107)
– device for opening when a fuse blows.

### 5.6.2.2. Description of the locks for withdrawable VSC/P contactors

- Electric lock which prevents the contactor being closed when the truck is not in the racked-in and isolated positions.
- Mechanical lock which prevents the contactor being racked-in and out when it is closed and closing of the contactor when the truck is not in the racked-in and isolated positions.
- Electric lock which prevents closing of the contactor when a fuse is missing or blown.
- Lock which prevents putting a contactor into service in an enclosure preset for a circuit-breaker (*).
- Locking electromagnet on the contactor truck which when there is no voltage, prevents racking-in or racking-out (-RL2).
- Mechanical lock which prevents contactor racking-in if the enclosure door is not closed (requires the same interlock in the fixed part) (108).
- Mechanical interlock with earthing switch placed on the enclosure - with earthing switch closed the contactor cannot be racked-in and with the contactor racked-in or in intermediate positions between racked-in and isolated, it is not possible to close the earthing switch (34).
- Mechanical lock of the shutters when the contactor is racked-out.

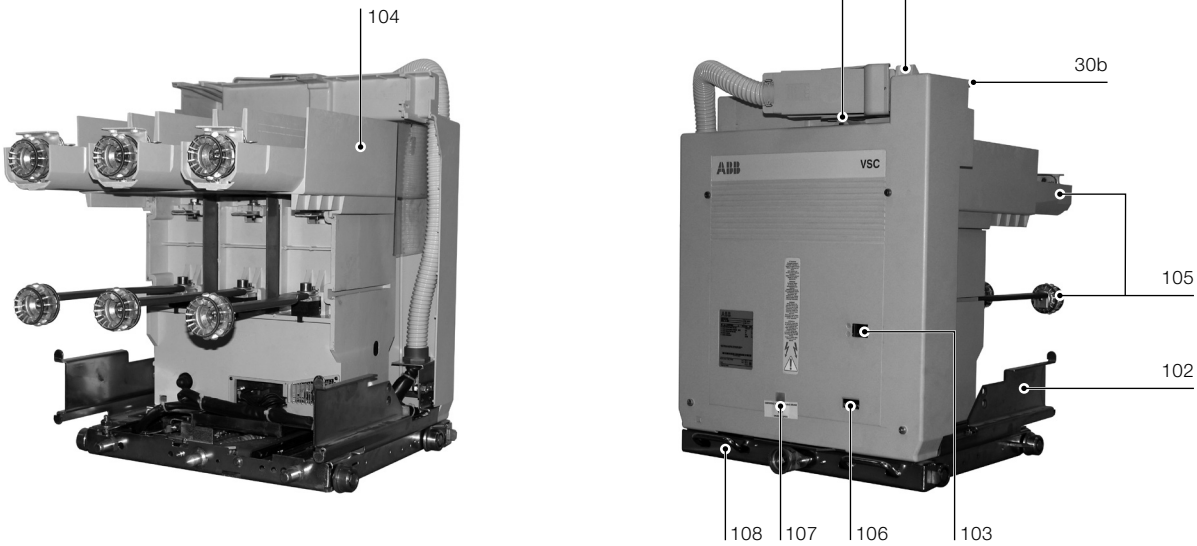



Fig. 11a

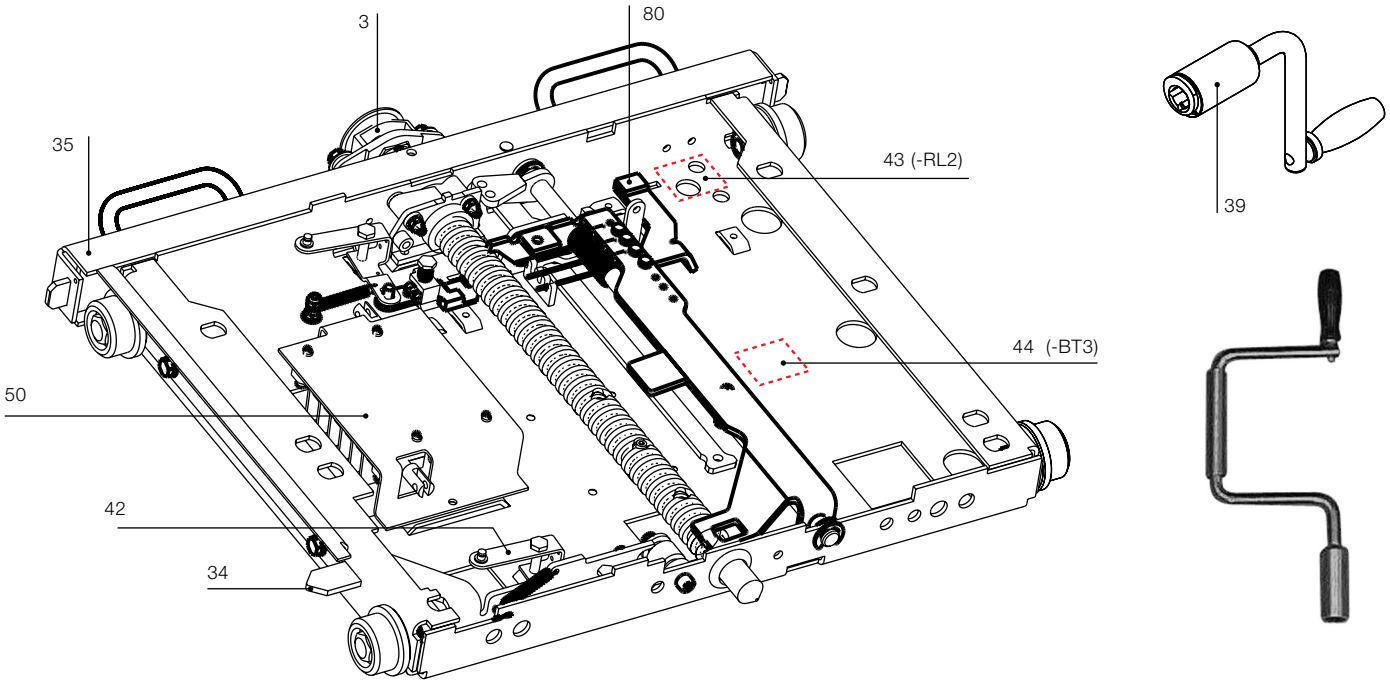



Fig. 11b - Locking devices on the racking-out truck

– Key lock on contactor racking-in - it is only possible to activate the lock and free the key preventing contactor racking-in with the contactor in the isolated position.
– Key lock with earthing switch open - this can only be activated with the earthing switch open. The key can only be removed with the electric lock activated.
– Key lock with earthing switch closed - this can only be activated with the contactor in the isolated position and with the earthing switch closed. The key can only be removed with the lock activated.
– Preset for independent padlocks on the shutters and in the closed and/or open position.
– Electric lock on racking-in and racking-out with the door open (microswitch on the door) of the enclosure connected in series with the locking electromagnet on the contactor truck.
– Key lock on earthing truck racking-in - with the lock activated all the operations with the contactor are possible, but positioning the earthing truck in the isolated position starting from the racked-out position is not allowed.
– Mechanical lock which prevents racking-out of the connector of the auxiliaries when the contactor is racked-in and during racking-in and racking-out.
– Electro-mechanical lock on de-energisation for the earthing switch, which when there is no voltage prevents the earthing switch operations.
– Electro-mechanical lock on the compartment door.

#### 5.6.2.3. VSC/PN and VSC/PNG withdrawable contactors

The VSC/PN contactors are used for rated voltages from 7.2 to 12 kV, rated thermal currents up to 400 A and fault levels up to 1000 MVA (with suitable protection fuses in series with the contactor). In the same way, the VSC/PNG contactor is used for 7.2 kV rated voltage and 400 A rated thermal current.
Both the VSC/PN and the VSC/PNG versions of contactors consist of:
– a three-pole contactor with SCO or DCO operation
– a fuseholder complete with terminals for fuses (121). In the upper part there are strikers 1a, 1b and 1c (fig. 12 - page 29) for activating the enclosure contacts for signalling the connected/test/isolated position
– a mechanical open/closed signalling device (120)
– two pairs of auxiliary contacts signalling open/closed
– feeder able to operate in d.c. and a.c.
– a truck on which the base plate of the contactor is fixed and the front protective screen by means of two supports. At the rear, two pins are positioned on the side walls of the truck for locking contactor racking-in with the earthing switch open on the enclosure, whereas the 45° slides operate the segregation shutters of the medium voltage fixed contacts of the enclosure. The crosspiece for hooking the contactor onto the enclosure for truck operation is mounted on the front of the truck
– the jaw-type input and output isolating contacts (122)
– the locks as per par. 5.6.2.4.
– three current-limiting fuses (supplied on request) with high breaking capacity connected in series with the contactor, with dimensions according to:
  • DIN 43625 Standard with maximum cartridge length e = 442 mm (single cartridge)
  • BS 2692 Standard with maximum fixing distance L = 553 mm (single and/or double cartridge)
– a mechanical operation counter which indicates the number of operations carried out by the contactor (122)
– a manual emergency opening device even when energised with medium voltage (125)
– a device for opening when a fuse blows, with relative fuse blown indication.

#### 5.6.2.4. Description of the locks for VSC/PN and VSC/PNG withdrawable contactors

– Electric lock which prevents the contactor being closed when the truck is not in the “racked-in” (200 mm), “test” (47.5 mm) and “racked-out” (0 mm) positions (-BGT3) (fig. 12a).
– Mechanical lock which prevents the contactor being racked-in and out when it is closed, and contactor closing when the truck is not in the “racked-in”, “test” and “racked-out” positions (1) (fig. 12a).
– Electric lock which prevents contactor closing when a fuse is missing or blown.
– Locking electromagnet on the contactor truck which, when there is no voltage, prevents racking-in or racking-out (-RL2) (fig. 12a).
– Mechanical lock which prevents contactor racking-in if the enclosure door is not closed (requires a reciprocal interlock in the fixed part) (126).
– Mechanical lock for the “test” position (2) (fig. 12a).
– Lock for different currents (5) (fig. 12a).

(*) This lock consists of some pins assembled in the plugs of the auxiliary circuits which, with a suitable code, prevent connection of the plug in the enclosure socket. The lock also foresees compulsory application of the locking magnet in the truck.

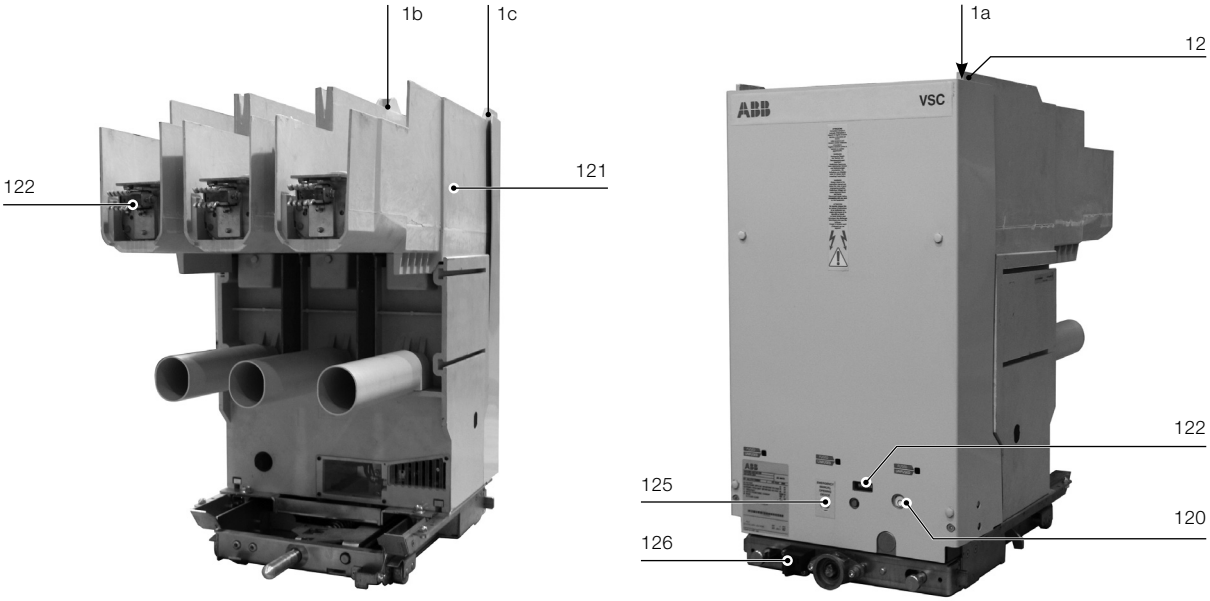



Fig. 12

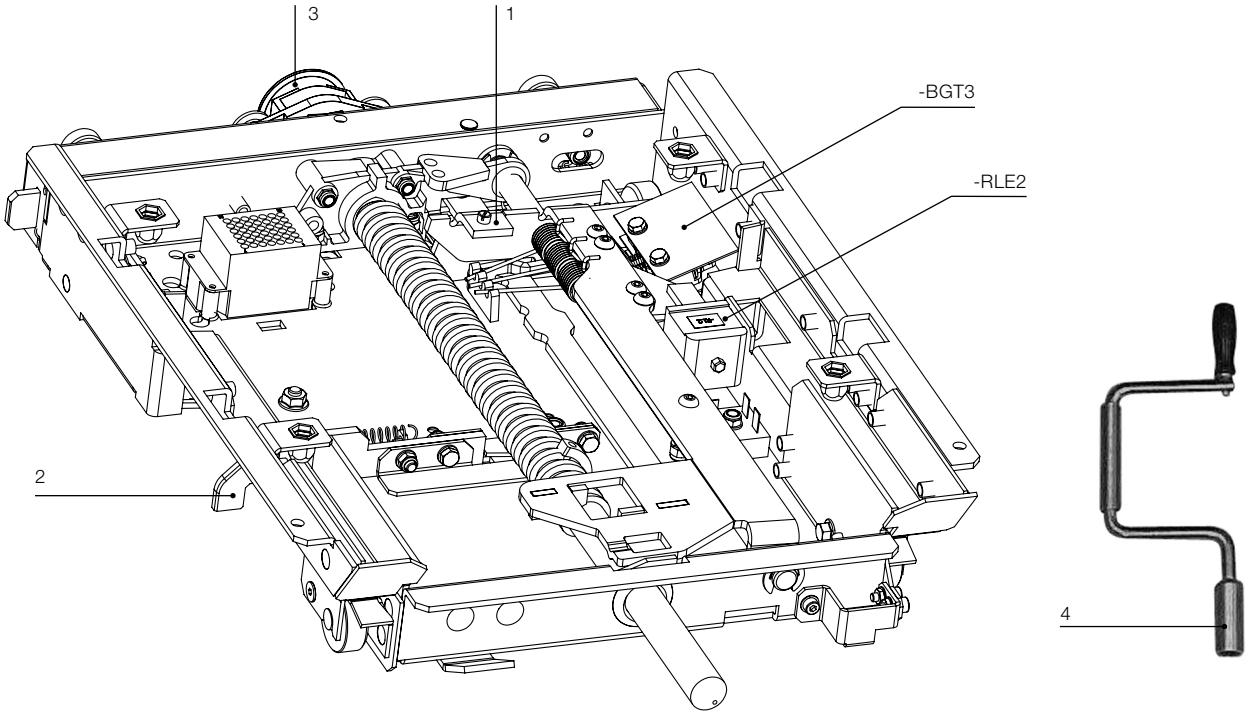



Fig. 12a - Locking devices on withdrawable truck.

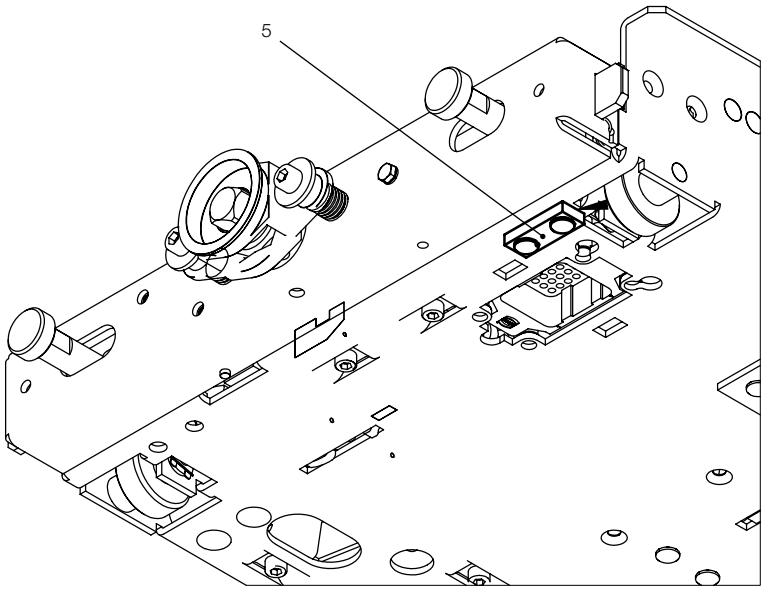



Fig. 12b - Interlocking devices on withdrawable truck.

## 5.7. Description of the closing and opening operations

The contactor drive operates in two different ways as shown in Table 1.

For the DCO version, further personalisation of the apparatus can be made. In fact – the first of its kind – the V-Contact VSC contactor is fitted (on request) with an undervoltage function (UV) with delays which can be set according to the requirements of the installation.

For a more detailed description of the behaviour of the apparatus according to the version, see table 2.

Supply the contactor with auxiliary voltage and operate it several times electrically. The contactor must carry out the opening and closing operations correctly in accordance with the threshold values defined in the IEC 62271-106 Standards.

**TABLE 1**

| Version | Description | Inputs | | |
|---|---|---|---|---|
| | | Closing -XDB10-7, -XDB10-8 | Opening -XDB10-9, -XDB10-10 | Undervoltage -XDB10-11, -XDB10-12 |
| SCO (Single Command Operated) | This version operates according to the state of the command signal at terminals -XDB10-11 and -XDB10-12. Contactor closing takes place when the voltage applied to terminals -XDB10-11 and -XDB10-12 corresponds with the values indicated in Table 2a | Not used | Not used | Used |
| DCO (1) (Double Command Operated) | This version operates by means of two independent signals for closing and opening applied to terminals -XDB10-7 and -XDB10-8 for opening and -XDB10-9 and -XDB10-10 for closing. The values of the signals are indicated in Table 2b. Furthermore, on request, automatic delayed opening of the contactor is available in the case of a drop or lack of voltage at terminals -XDB10-11 and -XDB10-12 (configurable delay filter). See Table 2b. | Used | Used | If the undervoltage function is required (2) |

(1) The contactor is restarted if the supply voltage of the board drops below 18V for more than 300ms.
(2) The undervoltage with time-delay function is guaranteed with 18V minimum residual voltage.

**TABLE 2a**

**SCO (Single Command Operated) version**
**Terminals -XDB10-1 and -XDB10-2 must always be supplied at the rated voltage (tolerance: 85% ... 110%)**

| Closing operation | | Power supply, in continuous mode, to the UV input |
|---|---|---|
| Opening operation (3) | Release voltage (drop out) | A voltage drop occurs at terminals -XDB10-11 and -XDB10-12 for power supply voltage values between 75% and 10% of the rated voltage. |

**TABLE 2b**

**DCO (Double Command Operated) version**
**Terminals -XDB10-1 and -XDB10-2 must always be supplied at the rated voltage (tolerance: 85% ... 110%)**

| | | |
|---|---|---|
| Closing operation | | Supply terminals -XDB10-7 and -XDB10-8 with power. An impulse lasting at least 100 ms is recommended. Note: an impulse lasting a shorter time may also cause contactor closing. |
| Opening operation | Opening operation (switching) | Supply terminals -XDB10-9 and -XDB10-10 with power. An impulse lasting at least 100 ms is recommended.<br>Note: an impulse lasting a shorter time may also cause contactor closing. In the case of simultaneous power supply of terminals -XDB10-7 and -XDB10-8 and terminals -XDB10-9 and -XDB10-10, the opening command prevails. |
| | Release voltage (undervoltage) | – Function available on request (UV = Undervoltage).<br>– Opening takes place for voltage values applied to terminals -XDB10-11 and -XDB10-12, between 70% and 35% of the rated voltage (4) |

(3) The opening operation is only instantaneous.
(4) The opening operation can be instantaneous or delayed (adjusting the daily by means of the special selectors) a 0.3 - 1 - 2 - 3 - 4 - 5 s. It is set to 0 s by default.

**Setting for DCO**

| UV time (s) | S1-3 | S1-4 | S1-5 |
|---|---|---|---|
| Instantaneous (1) | 0 | 0 | 0 |
| 0.3s | 0 | 0 | 1 |
| 1s | 0 | 1 | 0 |
| 2s | 0 | 1 | 1 |
| 3s | 1 | 0 | 0 |
| 4s | 1 | 0 | 1 |
| 5s | 1 | 1 | 1 |

S1-6 → Reserved – (1) See opening time par. 1.3.

### 5.7.1. Diagnostics

Two types of electronic cards are available, “Basic board” and “Full option”, differing from each other in the diagnostic functions they have available.
Both have:
– coil continuity control connected to the card
– capacitor voltage level control.
The “Full option” card also makes the following available:
– control of the state of capacitor efficiency, which is fundamental for correctly carrying out the opening and closing operations
– checking and indicating the temperature inside the contactor.
The alarms corresponding to the above functions are made available to the user by means of two contacts (3-4 and 5-6) of the -XDB10 terminal box.
The cards periodically carry out the controls without preventing the opening and closing operations.
The table below indicates the functions available.

### 5.7.3. Coil continuity control (CCC) and temperature monitoring

The unit checks actuator connection continuity so as to reduce the risk of failure to operate following disconnection. It also monitors the temperature of the board to reduce the risk of operating beyond the board’s design limits.
This function is provided for both the basic MAC R2 board and the “full option” version.
The test is performed:
– Every 2 minutes (irrespective of whether the apparatus is in the open or closed condition)
– 15 seconds after starting
– After each operation
The test is not performed:
If the voltage of the external capacitance is less than 75 V (“not ready” signal already given)
If the ambient temperature is less than -30° (“not ready” signal already given)
An alarm signal is given by opening contact DO1 if errors occur.

| **Basic board - Full option board** | | | | |
|---|---|---|---|---|
| Ready DO1<br>-XDB10 (3-4) | Continuity control | Capacitor voltage level and VSC internal temperature | Anomaly | No anomaly |
| | – After each operation<br>– Start-up<br>– Every 12 hours | Continuously | DO1 open | DO1 closed |

| **Full option only** | | | | |
|---|---|---|---|---|
| CBC DO2<br>-XDB10 (5-6) | Control of state of capacitor efficiency | – | Anomaly | No anomaly |
| | – Start-up<br>– Every 12 hours | – | DO2 open | DO2 closed |

### 5.7.2. Contactor power supply

The contactor has been tested for all the auxiliary operating voltages foreseen and indicated in the table:

| Feeder 1-2 V DC | Feeder 3-4 V DC / V AC (50/60 Hz) | |
|---|---|---|
| 24 | 110 | 220 |
| 30 | 120 | 230 |
| 48 | 125 | 240 |
| 60 | 127 | 250 |
| | 130 | |

The contactor is, however, set with the operating voltage defined in the order confirmation. The power supply voltage is indicated on the contactor rating label.

The tolerances over the voltage values conform to what is defined in the IEC 62271-106 Standard.

### 5.7.4. Capacitor ageing control (CBC)

The unit supervises bulk capacitor discharging so as to check capacitor life.
The unit supervises main capacitor discharging so as to check capacitor life.
This function is only available for the MAC R2 “full option” version.
The test is performed:
– Every 12 hours when the apparatus is in the open condition.
– 15 seconds after starting.
– Two seconds after each opening operation if the contactor has remained closed for 12 hours.
The test is not performed:
– If the voltage of the external capacitance is less than 75 V (“not ready” signal already given).
– If the ambient temperature is less than -5° (“not ready” signal already given).
The “not ready” state is signalled when the CBC function is being performed and the function has priority over the closing operation.
An alarm signal is given by opening contact DO2 if errors occur.

### 5.7.2.1 Changing the supply voltage of the contactor (within the reference range)

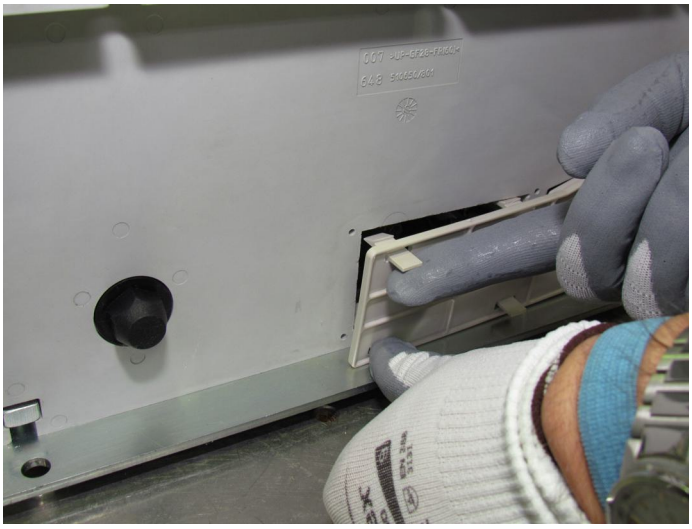


Fig. 13a



Fig. 13b




Fig. 13c

- This operation must be carried out by ABB personnel or by suitably qualified customer personnel with in-depth knowledge of the apparatus (IEC 62271-1, par. 10.4.2.).
- Always check that the apparatus is in the open position before carrying out any activities.
  Check that the medium voltage and auxiliary power supplies have been removed.
  Maintenance of the apparatus must only be carried out with the contactor de-energized, racked-out of the compartment of the enclosure and with the capacitor of the auxiliary circuit discharged. To discharge the capacitor, remove power from the -XDB10 terminal box and connect the mobile two-pole -XDB50 connector to the ABB type CFD device (fig. 13c). Completion of discharging is signalled by the red light going completely off.
- The auxiliary circuit can be configured for all the direct and alternating current voltages within the reference range. To change the voltage value defined during the ordering stage, proceed as follows: 1) remove the rear plastic protection (fig. 13a); 2) access the MAC R2 electronic card (fig. 13b); 3) prepare the dip-switches according to the indications given on the last page of the electric circuit diagram.
- After having set the desired value, the label with the new voltage value must be overlayed the front rating plate of the contactor.

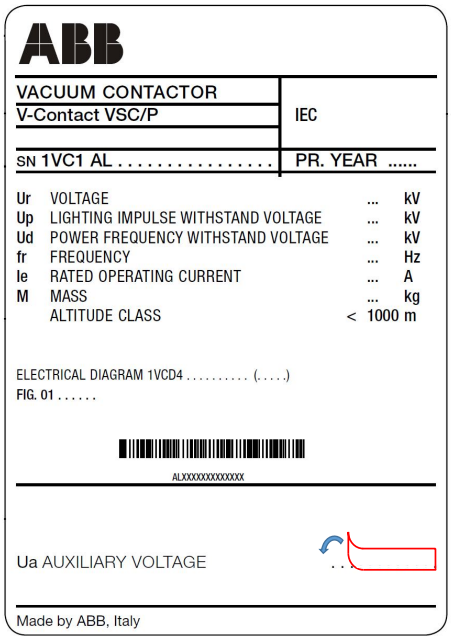



Fig. 13d

- The small plate with the correct voltage value is in the document envelope accompanying the product, along with the electric circuit diagram and this manual.
- Contactor functional check is mandatory after the new voltage setting; the qualified customer's personnel should carry out this check, responsibility for the interventions lies with the customer.

## 5.8. Emergency opening operation

**The contactor is fitted with manual emergency operation which must be carried out by suitably qualified personnel with in-depth knowledge of the apparatus.**

**The following Standards must be taken into particular consideration during installation and service:**

- **IEC 62271-1/DIN VDE 0101**
- **VDE 0105: Operation of electrical plants**
- **DIN VDE 0141: Earthing systems for electrical installations with rated voltage higher than 1 kV**
- **All the accident prevention regulations, in force in the relative countries.**

To manually open the contactor, it is necessary to work on operating part A, consisting of a 8 mm hexagonal-head bolt, working clockwise with a torque of about 20 Nm and at an angle of about 60° (see fig. 14a).
If the contactor (in the fixed version) is placed inside the switchgear, it is necessary to use a transmission made of insulating material of suitable length, which allows safe operation. The transmission device is to be provided by the customer.

For the withdrawable VSC/P contactors placed in UniGear ZS1 switchgear or PowerCube modules and for the withdrawable VSC/PN and VSC/PNG contactors in UniGear MCC switchgear, carry out the emergency operation with the compartment door closed. To carry out the operation, work towards the opening on the compartment door using the special tool provided, fitted on the end with an 8 mm hexagonal spanner. Apply a torque of 20 Nm with an operating angle of about 60° clockwise. The point to operate in is shown by the special plate located on the contactor shield (see detail 1 - fig. 14b and 14c).

**For fixed contactors, if the operations are carried out with the medium voltage protection “B” removed, pay great attention to the moving parts.**

**For withdrawable contactors, do not remove the front shield to carry out the emergency opening operation.**

**In any case, if auxiliary voltage is present, take special care not to remove the protective shield of the stored energy capacitor and not to touch the capacitor itself in any way.**




Fig. 14a

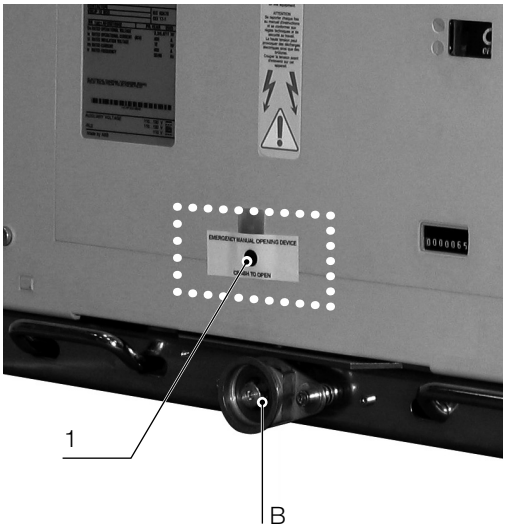



Fig. 14b




Fig. 14c

# 6. Putting into service

## 6.1. General procedures

**All the operations regarding putting into service must be carried out by ABB personnel or by suitably qualified customer personnel with in-depth knowledge of the apparatus and of the installation.**

Before putting the apparatus into service, carry out the following operations as well as those indicated in the table:
- check that the voltage and current applied are within the specified rated values
- check tightness of the power connections of the fixed contactors and integrity of the isolating contacts of the withdrawable contactors
- carefully clean the sheets and insulating parts with brushes and clean dry cloths. Avoid using jets of compressed air
- check the earthing connection of the fixed contactors
- check that no foreign bodies, such as bits of packing, have got into the moving parts
- check that the value of the power supply voltage of the circuits is between 85% and 110% of the rated auxiliary voltage of the apparatus
- check that the contactor vacuum interrupter has not been damaged due to accidental impacts. In case of doubt, carry out the check indicated in paragraph 7.3. Table 4.
- make sure that all the barriers and protective shields are correctly installed
- carry out the inspections indicated in table 3.

On completion of the operations indicated, check that everything is put back in its original position.

**The check can only be considered as passed if all the tests indicated have had a positive outcome.**
**In the case of a negative check, do not put the apparatus into service and, if necessary, contact ABB Service.**

**TAB. 3**

| Item inspected | Procedure | Positive check |
|---|---|---|
| **1** Insulation resistance | Medium voltage circuit With a 2500 V megger, measure the insulation resistance between the phases and the exposed conductive part of the circuit. | The insulation resistance should be at least 50 Mohm. |
| **2** Drive. Open/closed indicator, operation counter (if provided) | Carry out a few closing and opening operations of the contactor. | Operations and signals normal. |
| **3** Auxiliary circuits | Check that the connections to the control circuits are correct: proceed with the relative power supply. | Operations and signals normal. |
| | With the contactor open, check that the thickness between the body of the contact and the stem is 0.5 mm. | Tighten the fixing screws. |
| |  | |

## 6.2. Racking the VSC/P contactor in and out

- **Should operations be carried out with the contactor racked-out of the switchgear, pay great attention to the moving parts.**
- **The contactor must only be racked into the unit in the open position. Racking-in and racking-out must be gradual to avoid shocks which might deform the mechanical interlocks.**

### 6.2.1. Contactor with manual truck

For the racking-in and racking-out operations of the manual contactor, refer to the following manuals:
– PowerCube PBF fixed part – code: 1VCD600530
– PowerCube PBE and PBM module - code: 647652001
– UniGear ZS1 switchgear – code: 1VLM000363.

### 6.2.2. VSC/P contactors with motorised withdrawable truck

Carry out the racking-in/out test of the motorised truck in the same way as for a manual truck, following the instructions below:
– Rack the contactor into the switchgear in the open position. Motor power supply circuit de-energized.
– Supply the truck motor circuit with power.
– Activate the command for the electrical racking-in operation. When racking-in has been done, check correct changeover of the relative auxiliary contact.
– Afterwards, activate the command for the electrical racking-out operation. When racking-out has been done, check correct changeover of the relative auxiliary contact.
– In the case of a fault in the motor during a racking-in or racking-out operation, the truck can be taken to the run end manually in an emergency, first cutting off the voltage to the motor power supply circuit and then using the manual lever (Fig. 15) to operate in the same way as for the manual truck.
– Insert the manual racking-in lever (Fig. 15) in the special coupling (B - Fig. 14b).
The torque needed to carry out truck handling is < 25 Nm.
Checks:
a) clockwise rotation of the motor during circuit-breaker racking-in.
b) anti-clockwise rotation of the motor during circuit-breaker racking-out.
– Remove the manual crank.

**Note**

By means of the chain transmission, truck handling carried out with the manual lever causes rotation of the truck motor rotor which, behaving like a generator, can cause reversal of voltage at the connection terminals. This can damage the permanent magnet of the motor, therefore all the truck racking-in and racking-out operations carried out with the manual lever must be done with the motor circuit de-energized.



**Fig. 15**

# 7. Maintenance

Maintenance operations are aimed at ensuring trouble-free operation of the apparatus for the longest possible time.
The following operations must be carried out in accordance with the IEC 61208/DIN 31051 Standards:

Inspection: Assessment of the actual conditions
Servicing: Measures to be taken to maintain the specified conditions
Repairs: Measures to be taken to restore the specified conditions.

**Notes**

The following rules must be respected for all maintenance operations:

– the relative specifications indicated in the “Standards and specifications” chapter;
– the regulations for safety in the workplace indicated in the “Putting into service and running” chapter;
– the regulations and specifications in the country of installation.

## 7.1. General

It is good practice to keep a maintenance card and a service book where all the operations carried out can be noted down in detail, together with the date, description of the anomaly and the references of data needed to identify the apparatus, etc. (see chapter 2).
Experience gained in use of the apparatus will allow the optimal time intervals for interventions to be established. In any case, inspection of the apparatus not more than one year after it has been put into service is recommended.
In case of need and for further details, please refer to what is prescribed in article 10.4.2 of the Standard (IEC 62271-1).
In any case, for any problems, please do not hesitate to contact us.

## 7.2. Handling the MAC-R2 electronic card

Management of sensitive devices outside protected areas is considered to be “field work” and normally includes product packing, unpacking, installation and maintenance.
In all these cases, handling the devices must be carried out taking care to keep the potential of your hands and that of the work surface earthed, with an equipotential connection to the main grounding branch point.
It is advisable for the operator to wear conductive shoes and overalls and to wear earthed conductive arm bands.
Fig. 13a-13b shows a maintenance kit consisting of an arm band and ground connection, both fitted with a 1 MW integrated resistance.
Using suitable protective means to protect the electronic devices is an indispensable task requiring diligence and attention. Inserting these procedures in the normal service activities allows optimization of resources and underlines their importance.

The main activities which allow an efficient protection system to be maintained are:

- making personnel aware of the problems regarding protection against electrostatic discharges, with reference to the IEC 61340-5-1 Standards (these problems are often unknown or underrated)
- training personnel in correct use of protection equipment and on its perfect working order
- selecting protection materials suitable for the effective production requirements and using them
- marking the protected area and highlighting the presence of sensitive devices so as to attract the attention of operators on correct use of the protection devices
- technicians must always set an example by respecting the rules and using protection devices appropriately

Observe the following basic rules:

- avoid using tools which are unsuitable for removing the electronic cards (e.g. screwdrivers, etc.)
- handling the electronic card during maintenance or replacement operations must be limited to the minimum time possible
- always hold the electronic card at the edges
- avoid touching the components mounted on the card
- pay attention when cables or connectors have to be connected or disconnected
- avoid bending the card while inserting it in its seat or during connector cabling
- avoid damaging the connectors, aligning the pins before connecting the cable

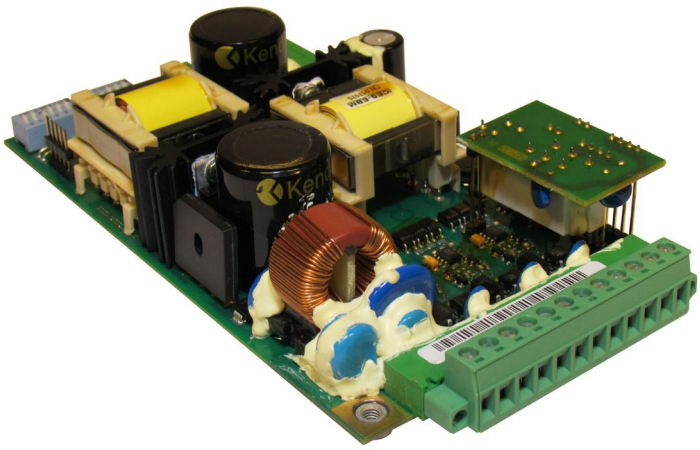
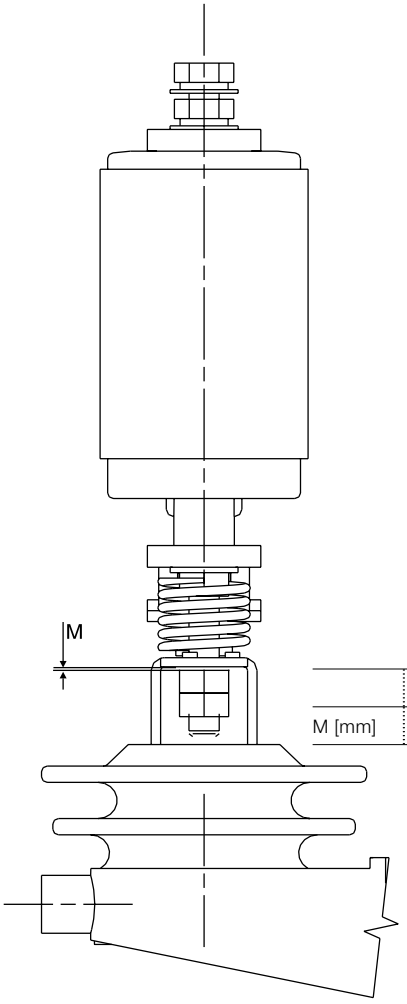


**Fig. 16**

## 7.3. Inspection

– Carry out regular inspections to check that the interruption devices are in good condition.
– The checks must include a visual inspection to find any contamination, traces of corrosion or electrical discharge phenomena (according to what is prescribed in table 4.
– When there are unusual service conditions (including adverse climatic conditions) and/or in the case of environmental pollution (e.g. heavy contamination or an atmosphere with aggressive agents), the frequency of inspections must be increased.
– Visual examination of the main contacts. The contact areas must be cleaned if there are signs of overheating (discoloured surface) (also see the paragraph on “Repairs”).

If any anomalous conditions are found, appropriate maintenance measures must be taken (see the “Servicing” paragraph).




| | VSC 7 | VSC 12 / VSC-S |
|---|---|---|
| M [mm] | 1.5...2 | 1.3...1.7 |

**Fig. 17**

**TABLE 4**

| Item to be inspected | Interval | Operation to be carried out |
|---|---|---|
| **1** Insulating parts. | 1 year or 50,000 operations. | Visual inspection of the insulating parts. The insulating parts must be free of any accumulation of dust, humidity, dirt (clean), cracks, traces of surface discharges or damage. |
| **2** Structure.. | 1 year or 50,000 operations. | Visual inspection of the structure and mechanisms. The components must be free of any deformation, accumulation of dust, dirt or damage. The screws, nuts and bolts must be correctly tightened. Avoid touching the ceramic surface. |
| **3** Interrupter. | 1 year or 50,000 operations. | Check that the interrupter is free of accumulation of dust, dirt (clean), cracks (replace), traces of surface discharges or damage. |
| | In case of accidental impacts. | Carry out a voltage test with the contacts open at 15 kV - 50 Hz for one minute. If there is a discharge during the test, the interrupter must be replaced because this type of phenomenon corresponds to deterioration in the degree of vacuum. In case of need, contact ABB Service. |
| **4** Interrupter contacts. | 1 year or 50,000 interruptions at the rated current. | Refer to fig. 17.<br>The contact material vaporises from the surfaces during each interruption and condenses elsewhere inside the vacuum interrupter. This is a normal process, and is foreseen by the overrun, or by the wear tolerance.<br>As the contacts wear, the overrun distance “M” decreases.<br>When distance “M”, of any pole, goes below 0.5 mm with the contactor in the closed position, all the sub-assemblies must be replaced.<br>Use a fork-shaped gauge 0.5 mm thick to carry out this measurement.<br>**Caution! Never attempt to adjust the nuts of the vacuum interrupters for any reason whatsoever.**<br>The overrun distance must be checked, but not adjusted. |
| **5** Auxiliary contacts. | 1 year or 50,000 operations. | Check correct operation and the signals. Check that there are no burnt or worn contacts (replace). |
| **6** Auxiliary circuit conductors. | 1 year or 50,000 operations. | Check whether any cabling straps are loose or broken and check connection tightness. Examine all the wire or cable connections to make sure that none of them are loose and that there is no overheating. |
| **7** Visual inspection of the isolating contacts (withdrawable contactors) | 5 years. | The isolating contacts must be free of any deformation or erosion.<br>Lubricate the contact elements with 5RX Moly type grease. |

## 7.4. Servicing

Carry out the checks described below.

| Item to be serviced | | Interval | Operation to be carried out |
|---|---|---|---|
| **1** | Contactor. | 2 years or 100,000 operations. | Carry out five mechanical closing and opening operations. The contactor must operate regularly without stopping in intermediate positions. |
| **2** | Contactor springs. | 2 years or 100,000 operations. | Check integrity of the springs. |
| **3** | Power connections. | 2 years or 100,000 operations. | Check tightness: M8 bolt = 23 Nm; M10 bolt = 33 Nm.<br>Check there are no traces of overheating or oxidation. |
| **4** | Earthing contact (fixed contactors) | 2 years or 100,000 operations. | Check tightness of the connections. |
| **5** | Insulation resistance. | 2 years or 100,000 operations. | See par. 6.1. |
| **6** | Racked-in/isolated auxiliary contacts in the truck. | 2 years or 100,000 operations. | Check that the signals are correct. |
| | Furthermore provide: | – replacement of the auxiliary contacts after 250,000 operations. | |

## 7.5. Servicing following a short-circuit or overload

### General

It is foreseen that the VSC contactor be protected by power fuses and/or by a circuit-breaker. In any case, the value of a short-circuit can exceed the threshold of damage to the vacuum bottles.

After interruption of a short-circuit at the maximum rated MVA of the contactor, put the cause of the fault right, inspect all the apparatus and carry out the repairs or replacements necessary before putting the apparatus back into service.

Make sure that all the spare parts (when required) are suitable for the application.

In case of any doubts, please contact ABB.



**Have a complete check of the contactor carried out by ABB personnel after 1,000,000 operations or 10 years of operation.**

**Contact ABB Service Assistance.**

### Vacuum interrupters

A dielectric test by itself cannot be confirmation that the interrupters have to be put back into service after a fault. However, if there is no physical sign of stress and if the distance M exceeds a minimum of 0.5 mm, the interrupters can be tested dielectrically as mentioned in point 3 of table 4. Should this test also be positive, it is reasonable to put the interrupters back into service following a fault.

### Enclosures

External evidence of deformation of the enclosure is usually indicative of damage inside it. Extensive damage will require replacement of the enclosure parts and of the apparatus contained in it.

### Terminals and internal conductors

Replace the damaged parts which show discolouration, melting or damage caused by electric arcs.
Pay special attention to the moving parts.
Carry out the “Checking” procedures indicated in par. 6. of this manual before putting the apparatus back into service.

## 7.6. Repairs

Replacement with spare parts and accessories must only be carried out by ABB personnel or by suitably qualified personnel with appropriate training.
All the power supply sources must be turned off and the capacitor must be discharged.
Always work with the contactor open, with the work area insulated and made safe.



**Should maintenance be carried out by the customer’s personnel, responsibility for the interventions lies with the customer.**

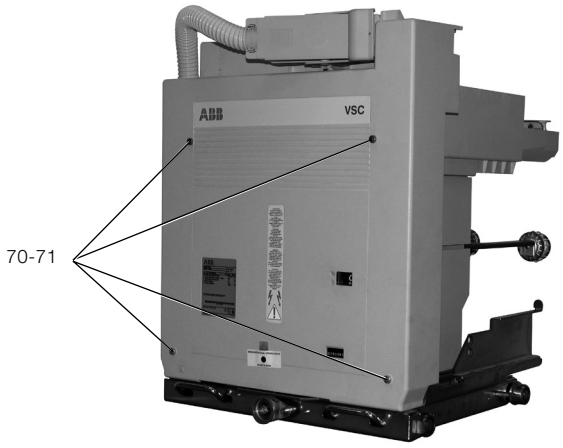



Fig. 18a

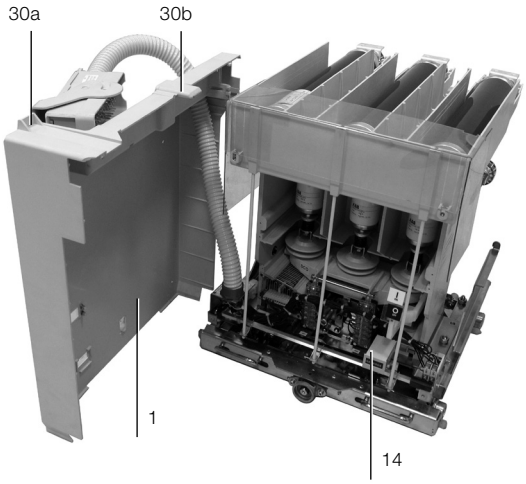



Fig. 18b

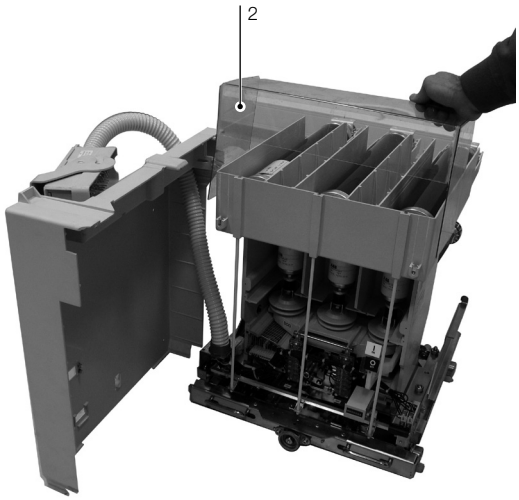



Fig. 18c

# 7.7. Instructions for dismantling and replacing fuses

### 7.7.1. General

- **All the operations described below must be carried out by suitably qualified personnel with in-depth knowledge of the apparatus.**
- **Do not rack the contactor out unless the enclosure is securely fixed in the switchgear or to a stable base.**
- **Check that the contactor is open before proceeding with isolation and its racking-out from the enclosure.**
- **Check that the contactor is open before proceeding with replacement of the fuses.**
- **The contactor is preset to house ABB CMF/BS and ABB CEF/BS fuses.**

The fuseholder is preset for installation of fuses with the dimensions and average type of striker according to DIN 43625 (1983) and BS 2692 (1975) Standards and with electrical characteristics according to IEC 282-1 (1974) Standards.
The fuseholder is always fitted with an automatic opening device for a fuse blowing. This device prevents contactor closing when even a single fuse is missing.

### 7.7.2. Preliminary operations for fuse replacement

**a) VSC/P**

The contactor must be racked out of the enclosure for replacement of the fuses.
The instructions for the racking-out operations are given in the switchgear/enclosure manuals.
With the contactor racked out of the switchgear, unscrew the four fixing screws of the shield and relative DIN washers (fig. 18a) and position it as in fig. 18b. For 12 kV contactors, remove protection (2) and (fig. 18c) proceed to replace the fuses according to the instructions given in par. 7.8.

**b) VSC/PN and VSC/PNG**

To replace the fuses it is necessary to rack the contactor out of the enclosure. The instructions for the racking-out operations are given in the switchgear/enclosure manuals, then proceed to replace the fuses according to the instructions given in par. 7.8.

## 7.8. Replacement of the contactor fuses

**Check that the rated normal current of the fuses to be installed corresponds with the value indicated on the nameplate on the rear of the fuseholder.**

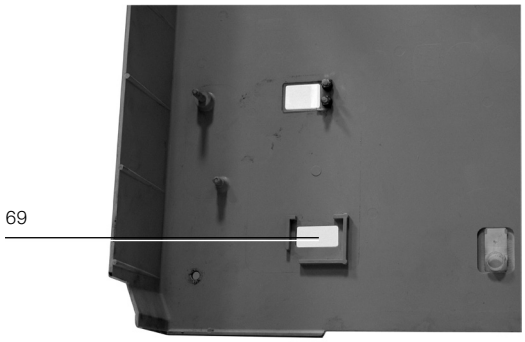



Fig. 18d

**Fuses according to DIN Standards**

**a) Mounting the adapters (fig. 19a)**

The fuseholder is designed to take fuses with a length of 442 mm. For smaller sizes, two adapters are required:
– Adapter (45) for fuses with a length of 192 mm (A)
– Adapter (46) for fuses with a length of 292 mm (B).
Select the type of adapter in relation to the type of fuse to be used, and insert it fully over the fuse contact, opposite to the one of the striker.
Tighten the steel band (47) and fully tighten the screw (48).
To dismantle, proceed in reverse order.
The same instructions are given in the Kit sheet put in the adapter packing.

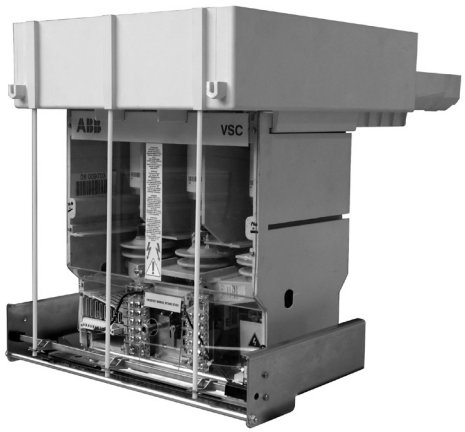



Fig. 18e

**b) Dismantling the fuses (fig. 19b)**

Open the locking rings (49) (fig. 19b) moving them in the direction shown by the arrows using the tool (50), and remove the fuse using the special tool (50).

**c) Mounting the fuses (fig. 19c)**

Open the locking rings (49) moving them in the direction shown by the arrows using the tool (50) (fig. 19b), fully insert the fuses with the contacts fitted with striker on the opposite side to the isolating contacts of the contactor. Close the locking rings again, moving them in the opposite direction to the opening one.

**Fuses according to BS Standards.**

- **Check that the rated normal current of the fuses to be installed corresponds with the value indicated on the nameplate on the rear of the fuseholder.**
- **When tightening the screws, do not force the connections (25 Nm maximum tightening torque).**
- **Fuse mounting and dismantling must only be done with the adapter (if required) already mounted on it.**
- **Only use the material specified, provided by ABB, for assembly.**

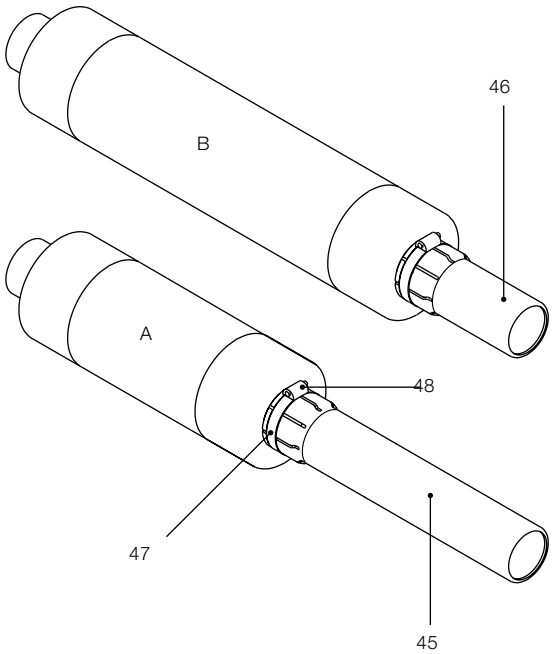
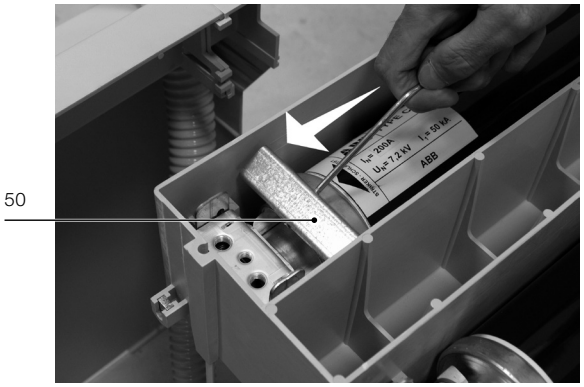
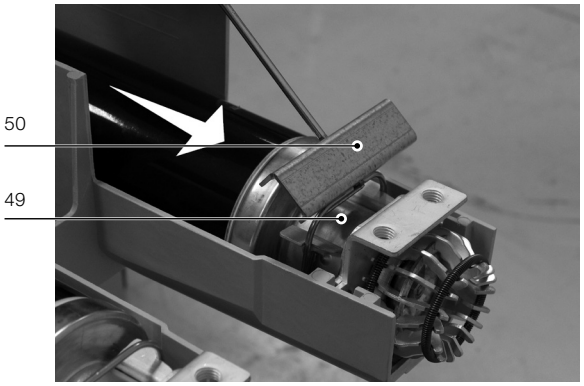
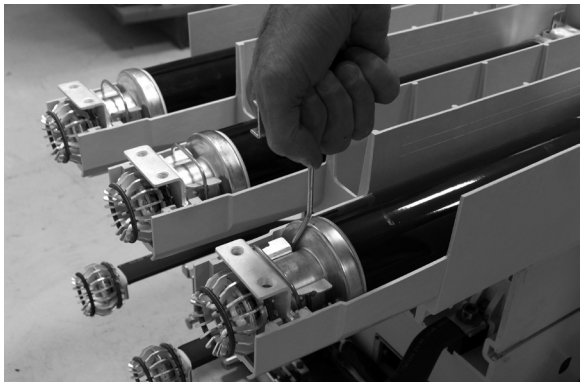
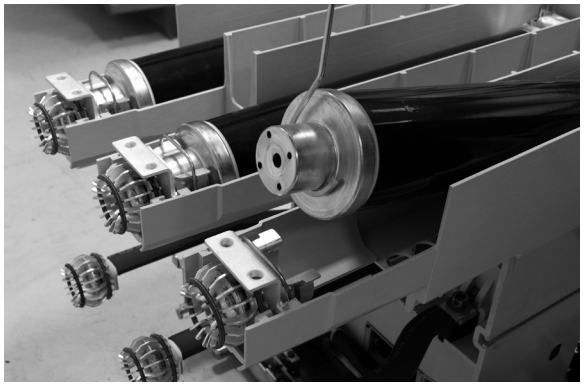



Fig. 19a





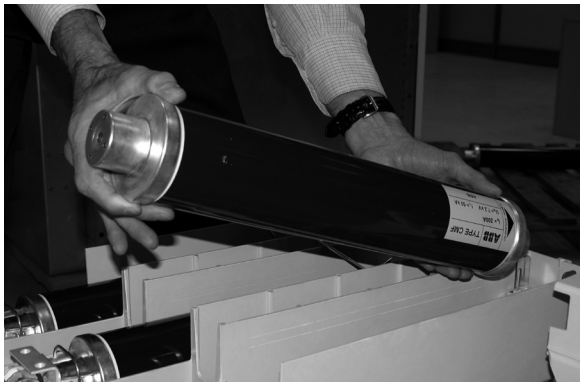
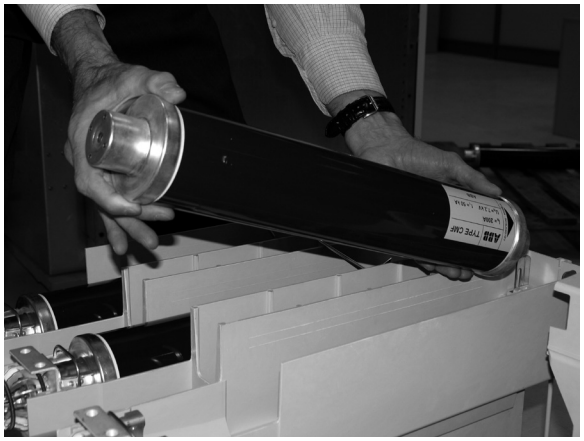
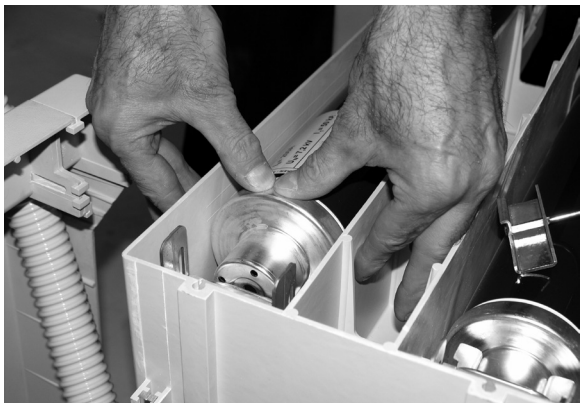


Fig. 19b





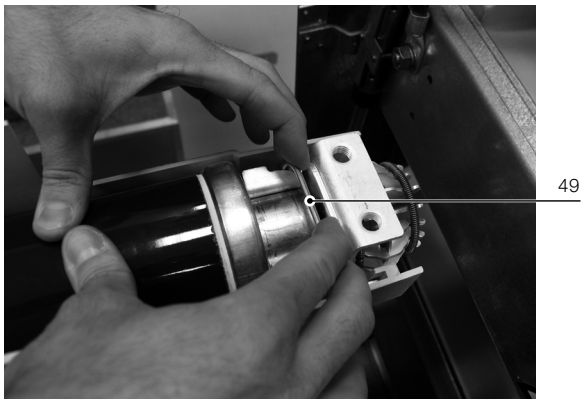



Fig. 19c

### a) Mounting the adapters (fig. 20a)

The fuseholder (32) (fig. 20b) is preset to take fuses with fixing centre distance of 553 mm. For smaller sizes, three adapters are needed, as indicated below:

– adapter (51) for fuses with fixing centre distance
  l = 235 mm
– adapter (52) for fuses with fixing centre distance
  l = 305 mm
– adapter (53) for fuses with fixing centre distance
  l = 454 mm.

Select the type of adapter, fix it onto the fuse on the striker side by means of the grub screws (54), the cup springs (55) and the short nuts (58). Mount the adapter with the extension, with the cap facing the striker.

The same instructions are given in the Kit sheet put in the adapter packing.



**Only position the grub screws (54) as shown in the drawing.**

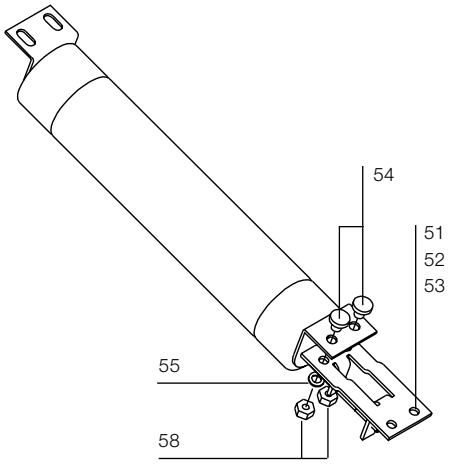



Fig. 20a

### b) Mounting the fuses (fig. 20b)

Mount the fuses or the adapter (preassembled as indicated in par. a) with the striker, (indicated by the arrow) facing the opposite side to the one of the contactor tulips and fix them by means of the screws (56) and the spring washers (57).

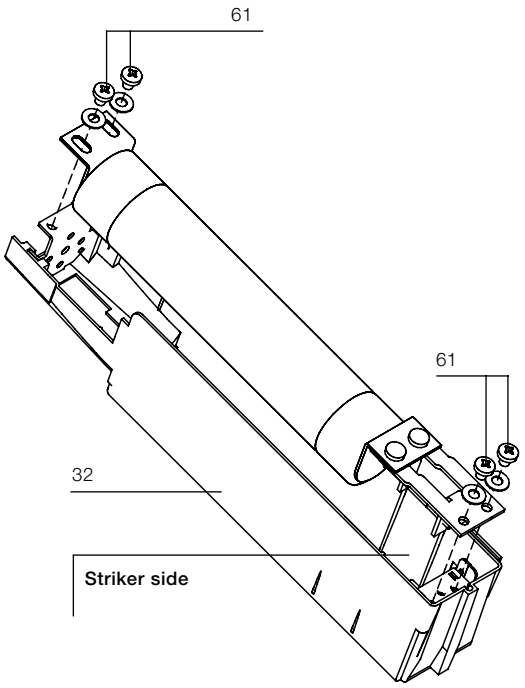



Fig. 20b

### c) Dismantling the fuses

To dismantle the fuses and relative adapters, proceed in reverse order to par. b) and a).

### d) Assembling and dismantling the VSC/PN and VSC/PNG contactor fuses

It is also possible to use BS fuses with double cartridge connected in parallel in the VSC/PN and VSC/PNG contactors (fig. 20c) and therefore in series with the contactor. The assembly and dismantling operations are the same as what is described in sections a) , b) and c) above, with the only difference being to handle a pair of fuses per phase at the same time (fig. 20c) connected by means of a suitable adapter.



Fig. 20c

## 7.9. Mounting and dismantling the short-circuit busbar

**a) Mounting (fig. 21)**

Mount the busbar with the feeler pin (60) on the opposite side to that of the tulips and fix it with the screws (61).

**b) Dismantling (fig. 21)**

To dismantle, proceed in reverse order.

The same instructions are given in the Kit sheet put in the short-circuit busbar packing.

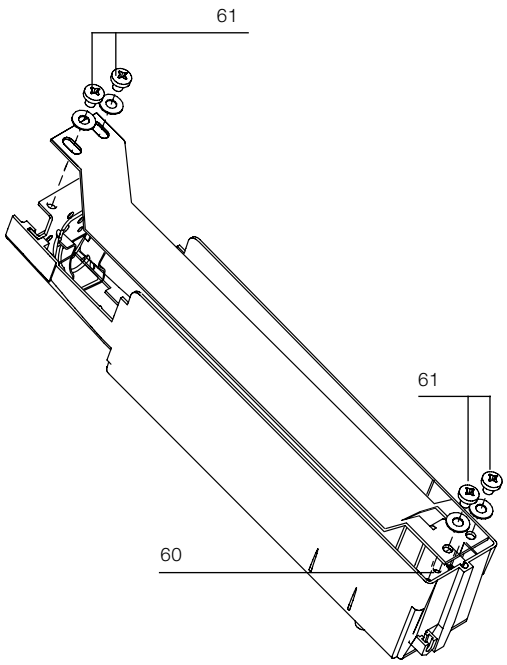



**Fig. 21**

## 7.10. Putting the contactor back into service

### 7.10.1. Mounting the shield and insulating guard (fig. 18)

Reposition the protection (1) (fig. 18b), repeating the operations indicated in par. 7.7.2. in reverse order.
Remount the shield. Check that the impulse counter (14) (fig. 18c) inserts itself into the special seat (69) (fig. 18d) and fix the shield with the screws (70) and DIN washers (71) (fig. 18a).

### 7.10.2. Checking apparatus functions

Rack the contactor into the enclosure, working as indicated in par. 6.
In the “isolated for test” position, check the correctness and functionality of the contactor “open/closed” signalling by carrying out a few operations.

## 7.11. Checking the degree of vacuum of the interrupter

This test is not required for normal maintenance. Should it become necessary for extraordinary maintenance, carry out the test on the interrupter without dismantling it from the contactor and use the VIDAR tester, of the Programma Electric GmbH, Bad Homberg v.d.H. company, for the vacuum test.
To check the vacuum air tightness of the interrupter, prepare the following VIDAR tester test values:

| Contactor rated voltage | DC test voltage |
|---|---|
| 7.2 kV | 16 kV |
| 12 kV | 22.5 kV |

The test must always be carried out with the contactor open, with the contacts at the nominal distance.
Procedure for testing the vacuum of the interrupter of the contactor poles:

- turn off the power and make the working area safe according to the safety regulations of the IEC/DIN VDE standards;
- open the contactor;
- ground a terminal of each contactor pole;
- connect the ground terminal of the VIDAR tester to the structure of the contactor (grounding point of the contactor);
- connect the high voltage terminal of the VIDAR tester to the terminal not connected to ground of the contactor pole (phase L1) and carry out the test. Repeat the test for phases L2 and L3.

**The tester connection cables can produce an indication due to capacitive effect. In this case, the cables must not be removed.**

# 8. Spare parts and accessories

To order contactor spare parts/accessories, refer to technical catalogue 1VCP000165 and always state the following:
– type of contactor
– rated voltage of the contactor
– rated normal current of the contactor
– serial number of the contactor
– rated voltage and frequency of any electrical spare parts.

For availability and to order spare parts, please contact ABB Service.

## 8.1. List of spare parts

– Vacuum interrupter assembly (replacement to be carried out by ABB)
– MAC-R2 electronic card
– Auxiliary contacts (5 normally open and/or 5 normally closed)
– Capacitor
– Interfacing shaft (only fixed contactors)
– 12 kV insulation partitions (only fixed contactors)
– Actuator assembly (replacement to be carried out by ABB).
– Operation counter
– Fuses
– Adapters for fuses
– Fuseholders (replacement to be carried out by ABB)
– Tulip and jaw-type isolating contacts
– Locking magnet in the truck
– Microswitches.

# 9. Product quality and environmental protection

The pieces of apparatus are produced in compliance with the requirements of the international standards regarding quality and environmental management systems. In these fields, the excellent level is proved by availability of the ISO 9001 and ISO 14001 certificates.

**End of product life**

ABB is committed to respecting the requirements and laws for protection of the environment laid down according to the ISO 14001 Standard.

ABB offers its competency and collaboration in facilitating recycling and disposal of the products at the end of their life. It is always necessary to act in compliance with the local regulations in force for disposal of the products.

**Methods of disposal**

Disposal can either be carried out with thermal treatment in an incineration plant or by storage in special areas

| Material | Recommended method of disposal |
|---|---|
| Metals (Fe, Cu, Al, Ag, Zn, W, others) | Separation and recycling |
| Thermoplasts | Recycling or disposal |
| Epoxy resin | Separation of metal parts and disposal of resin parts |
| Rubber | Disposal |
| Dielectric oil (oil for transformers) | Recovery and recycling or disposal |
| Wood for packing | Recycling or disposal |
| Aluminium foil for packing | Recycling or disposal |

For more information please contact:

Your sales contact:
**www.abb.com/contacts**
More product information:
**www.abb.com/productguide**
More service information:
**www.abb.com/service**

Data and illustration are not binding. We reserve the right to make changes in the course of technical development.

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1VCD600943-V8185 - Rev. D, en - Instruction Manual - 2020.11 (V-Contact VSC-F-P-PN-PNG) (gs)

# TJP 4.3, TJP 5.3, TJP 6.3
# Indoor voltage transformers

| | | |
|---|---|---|
| Highest voltage for equipment | [kV] | 3.6 - 24(25) |
| Power frequency test voltage, 1 min. | [kV] | 10 - 50 |
| Lightning impulse test voltage | [kV] | 40 - 125 |
| SesuF | [A] | 2 or 6,3 (IEC) |
| Max. rated burden, classes | [VA/cl] | 25/0.2 - 50/0.5 - 100/1 |
| Residual winding | [VA/cl] | 50 - 200/6P |



## Description

TJP 4.3, TJP 5.3 , TJP 6.3 epoxy insulated voltage transformers are cast in epoxy resin and designed mostly for insulation voltages of
- 3.6 kV to 12 kV....TJP 4.3 type
- 17,5 kV..... TJP 5.3 type
- 24 (25)kV.....TJP 6.3 type

Trasformers are suitable for ABB UNISAFE panel or PowerCube type PB.
If no a different value is required, the transformers are manufactured with a overvoltage factor of 1.9 x Un/8 hrs.
One outlet of the primary winding, including the respective terminal is insulated from the earth to a level which corresponds to the rated insulation value.
Other outlet of primary winding with its terminal is earthed during the operation.
Most of the transformers are equipped with two secondary windings, the first one for either measuring or protection purposes, other for being connected into an open-delta connection in a three-phase system. One terminal of each secondary winding and one of the open delta connected terminals have to be earthed during the transformer operation.
The secondary windings are lead out into a cast-type secondary terminal board. The transformer can be mounted in any position.
Transformer body is fixed by four screws, the bolted M8 earthing clamp is located on the transformer base plate.

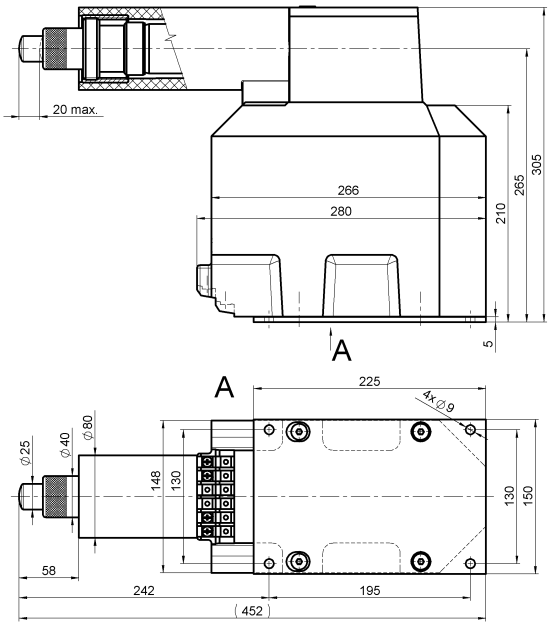
The TJP 4.3, TJP 5.3 , TJP 6.3 transformers are equipped with a fuses conformably to IEC standard.

Rated primary voltages ... 3/V3 kV; 3,3/V3 kV; 6/V3 kV; 6,6/V3 kV; 10/V3 kV; 11/V3 kV, 13,8/V3 kV, 15/V3 kV; 20/V3 kV, 22/V3 kV
Other primary voltages can also be supplied upon request.
Rated secondary voltages... 100/V3 V; 110/V3 V – accuracy classes 0.2; 0.5; 1 (measuring winding) or 3P; 6P (protection winding).
Other secondary voltages can also be supplied upon request.
Rated voltages for open-delta connection: ... 100/3 V; 110/3 V- class 6P. Other voltages for open-delta connection can also be supplied based on customer requirement.
Rated frequency ... 50 Hz; 60 Hz
Based on a discussion with the manufacturer the transformer can also be provided with primary winding designed for two different primary voltages (with secondary side changeover).
Transformers are manufactured conformably to the requirements and recommendations of the following standards and regulations: IEC, VDE, ANSI, BS, GOST, CSN.

## Dimensions

TJP 4.3
TJP 5.3

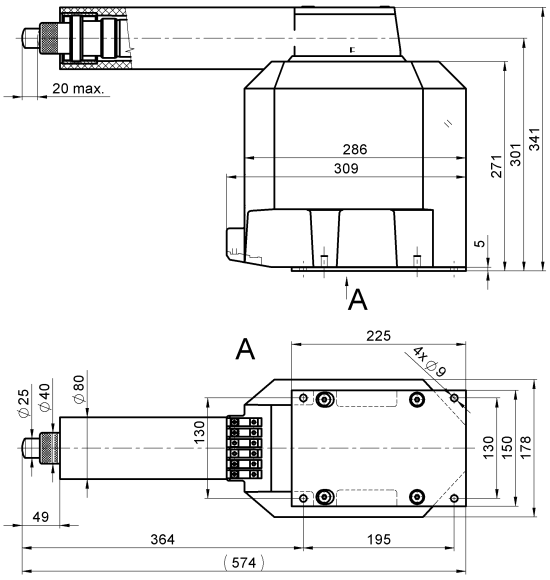
WEIGHT: appr. 28kg
CREP. DISTANCE: 385mm




| Drawing n. |
| --- |
| 1VL4200314R0101 |

TJP 6.3

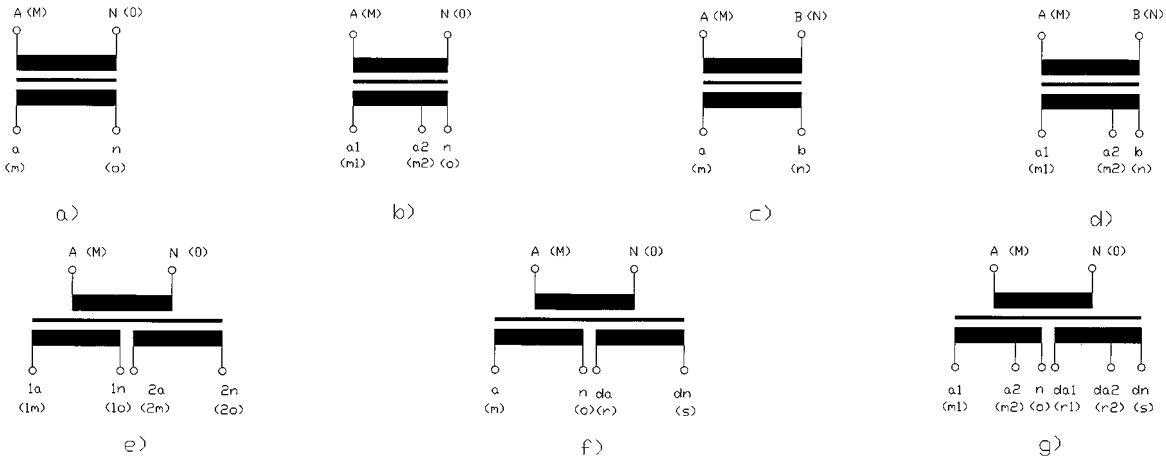
WEIGHT: appr. 42kg
CREP. DISTANCE: 547mm




| Drawing n. |
| --- |
| 1VL4200315R0101 |

1VLC000538 - Rev.-en 2011, 06, 28

## Marking of the voltage transformer outlets




**a) Single-pole insulated transformer | b) Single-pole insulated transformer with a tap | c) Double-pole insulated transformer | d) Double-pole insulated transformer with a tap | e) Single-pole insulated transformer with two secondary windings | f) Single-pole insulated transformer with two secondary windings, with one of which being the auxiliary (residual) winding | g) Single-pole insulated transformer with two secondary, tapped windings, with one which being the auxiliary (residual) winding.**


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# PDCOM
## Installation Manual




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## Disclaimer

The data, examples and diagrams in this manual are included solely for the concept or product description and are not a statement of guaranteed properties. All persons responsible for applying the equipment described in this manual must ensure that each intended application is suitable and acceptable, and that all applicable safety or other operational requirements are complied with. In particular, all risks in applications where a system failure and/or product failure would create a risk of harm to property or persons (including but not limited to personal injuries or death) shall be the sole responsibility of the person or entity who/that applies the equipment, and such parties are hereby requested to ensure that all measures are taken to exclude or mitigate such risks.

This document has been carefully checked by ABB but discrepancies cannot be completely ruled out. If discrepancies are detected, the reader is kindly requested to notify the manufacturer. With the exception of explicit contractual commitments, in no event shall ABB be responsible or liable for any loss or damage resulting from use of this manual or application of the equipment.

## Conformity

The products listed in the document comply with the directive of the Council of the European Communities implemented by the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). Such conformity is the result of tests conducted by ABB in accordance with product standards EN50263 and EN60255-26 for the MEC directive and with product standards EN 60255-1 and EN 60255-27 for the low voltage directive.

# Safety Information



**Dangerous voltages can occur on the connectors, even when the auxiliary voltage has been disconnected.**



**Non-observance can result in death, personal injury or substantial property damage.**



**Only a competent electrician must be allowed to perform the electrical installation tasks.**



**National and local electrical safety regulations must always be followed.**



**SWICOM must be earthed**

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# 1. Introduction

The installation manual contains instructions on how to install PDCOM. The manual describes procedures for mechanical and electrical installation. The chapters are set out in the order in which the device should be installed and connected to the circuit breaker.

## 1.1 Intended recipients

This manual is for use by the personnel responsible for installing the product hardware.
The installation personnel must possess basic knowledge about handling electronic equipment.

## 1.2 Product documentation

The Installation manual contains instructions on how to install PDCOM. The manual describes procedures for mechanical and electrical installation. The chapters are set out in the order in which the device should be installed and connected to the switchgear.

## 1.3 Revision history

| Document revision/ date | Product series version | History |
|---|---|---|
| 2020-09-13 | 2.1 | First release |

**Download the latest documents from the ABB web site**

## 1.4 Related documentation

Product series- and product specific manuals can be downloaded from the ABB web site.

## 1.5 Symbols



**The electrical warning icon indicates the presence of a hazard which could result in electrical shock.**



**The warning icon indicates the presence of a hazard which could result in personal injury**



**The caution icon indicates important information or warnings related to the subject discussed in the text. It might indicate the presence of a hazard which could result in damage to software, equipment or property.**



**The information icon alerts the reader of important facts and conditions.**



**The tip icon indicates advice on, for example, how to design your project or use a certain function.**

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

# 2 Environmental aspects

## 2.1 Sustainable development

Sustainability was taken into account from the time product design began and included the pro-environmental manufacturing process, long life, operation reliability and disposal of PDCOM.
The choice of materials and the suppliers was made in accordance with the EU RoHS directive 2011/65/EU of the European Parliament and of the council of 8 June 2011 on the Restriction of Hazardous Substances in electrical and electronic equipment (RoHS Directive).
PDCOM complies with the maximum values for lead (Pb), mercury, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE) and cadmium.
Pursuant to EU-regulation REACH that came into force on 1 June 2007, the products are solely non-chemical. Moreover, the products supplied will not release any substances under normal and reasonably foreseeable application circumstances.

## 2.2 Disposing of the product

Definitions and regulations concerning hazardous materials are country-specific and change as knowledge of materials increases. The materials used in this product are typical for electric and electronic devices.
All parts used in this product are recyclable. When disposing of PDCOM or its parts contact a local waste handler who is authorized and specialized in disposing of electronic waste. These handlers can sort the material by using dedicated sorting processes and dispose of the product in accordance with local requirements.

**Table 1: Product composition**

| PDCOM | Parts | Material |
|---|---|---|
| Case | Parts and screws | Steel |
| | Case | Metal |
| | Electronic modules | Various |
| Package | Box | Cardboard |
| Attached material | Manuals | Paper |

## 2.3 Applicable directives, standards and compliance

The following directives, standards and compliances are applicable to PDCOM:

- Electrostatic Discharges Immunity test
- Radiated Electromagnetic RF- Field immunity test
- Conducted Low Frequency Immunity test
- EFT Immunity test: EN61000-4-4
- Surge immunity: EN61000-4-5
- Common Mode Conducted RF-Immunity test: EN61000-4-6
- Power frequency magnetic field Immunity test: EN61000-4-8
- Slow Damped Oscillatory Wave Immunity test
- DC Voltage Dips, Interruptions and Variations
- AC component (Ripple) in DC
- Pulse Magnetic Field Immunity test
- Low Frequency conducted disturbances Immunity test
- Conducted Field emission test: CISPR 11
- Radiated Field Emission test

For VPIS systems supported:

- IEC 62271-206: Voltage presence indicating systems for rated voltages above 1 kV and up to and including 52 kV
- IEC 61243-5:1997: Live working - Voltage detectors - Part 5: Voltage detecting systems (VDS)

# 3 Unpacking, inspection and storage

## 3.1 Removal of transport packaging

PDCOM requires careful handling.

1. Examine the delivered products to ensure that they have not been damaged during transport.
2. Remove the transport packing carefully without force.

The cardboard packaging material is 100% recyclable.

## 3.2 Product identification

**The identification label of PDCOM is behind the PDCOM. The label gives the following information: part number, serial number and product code.**

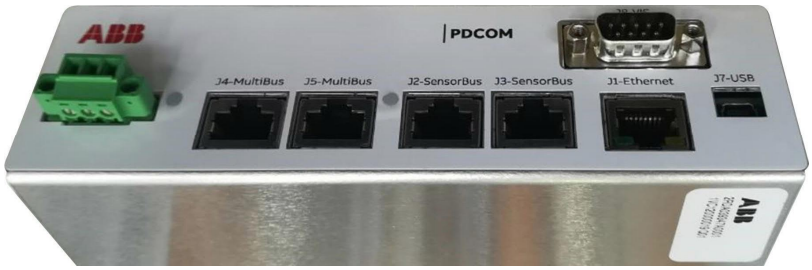



Figure 1: Identification label on backplate

The Serial Number is an important traceability tool for the user and for manufacturer.

## 3.3 Checking delivery items

Check that the items received comply with those listed in the delivery documents.

## 3.4 Inspecting the device

PDCOM requires careful handling before installation on site.

· Check the device to see if any damage occurred during transportation

If the device has been damaged during transportation, lodge a claim with the transport contractor, and notify the local ABB representative.

## 3.5 Returning devices damaged in transit

If damage has occurred during transport, appropriate actions must be taken against the final carrier. Please inform the nearest ABB office or representative. ABB should be notified immediately if there are any discrepancies in relation to the delivery documents.

## 3.6 Storage

If PDCOM is stored before installation, it must be kept in its original transport packaging in a dry and dust free place. Comply with the environmental requirements given in the technical manual.

# 4 Precondition for PDCOM installation

· **VPIS/ VDS tested**

The following table shows which VPIS (also called as VIS) and VDS has been tested.

| ABB ID number | Coupling capacitance (pF) | Nominal Voltage (kV) |
|---|---|---|
| 3WDA020579P0001 | 10:40 | 3:24 |
| 3WDA038144P0001 | 10:40 | 3:24 |

In case VPIS/ VDS used is not present in the table it has to follow the minimum Capacitance Range requirement reported below:

· **Capacitive coupler requirements**
15:250 (pF) - above 50(pF) is preferable

· **SWG shutdown**
Note on safety at work
All relative work and operating procedures must be carefully carried out by trained specialists familiar with the installation, taking into account all the relative safety regulations according to the IEC and other relevant professional bodies, as well as any local and work regulations and instructions.

· **Ground busbars**
Earthing the switchgear
Connect main earthing bar with connections provided in every panel. Ensure protection for the wiring connection of the floor frame or the erected raised false floor. Connect the earthing conductor from the earth electrode, preferably via a removable bolted connection for testing purposes, to the main earthing bar of the switchgear.

· **Case 1: Identification of VPIS/ VDS**

· **Case 2: identification of coupler placement (in case VPIS/ VDS is not present and a dedicated coupler is required)**

## 4.1 Checking environmental conditions and installation space

The mechanical and electrical environmental conditions at the installation site must be within the limits described in the technical manual.

· **Avoid installation in dusty, damp places**
Avoid places susceptible to rapid temperature variations, powerful vibrations and shocks, surge voltages of high amplitude and fast rise time, strong induced magnetic fields or similar extreme conditions.

· **Installation**
The protection class of the device is IP54 from the front side and IP20 from the backside. It is therefore suitable for outdoor installation. The unit is designed to be installed on the front door of the panel, however it can be integrated in an enclosed cabinet too, protected from excessive heat, humidity and dust. The unit can function in any other position.

· **Check that sufficient space is available**
Sufficient space is needed on top and in front to allow access to wires and to enable maintenance and future modifications.

· **Environmental conditions**
The equipment will operate within the specified tolerances only if the following environmental conditions are respected:
Ambient temperature range: -20 °C to +55 °C
Storage temperature range: -30 °C to +70 °C
Ambient humidity: 0 – 95% non-condensing

· **Grounding the device**
Unwanted transients must be eliminated (lightning protection). Comply with EMC requirements.

# 5 PDCOM interface Mounting (with VPIS/ VDS)

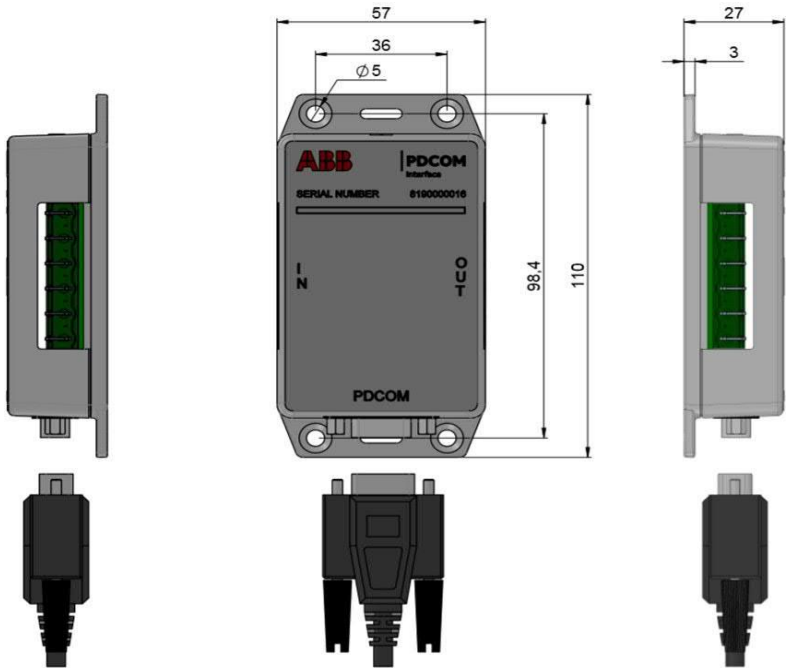
**Hardware interfaces (PDCOM interface)**
The following interfaces are located on the backplate of the device:

- 1 connector for PDCOM (J10)
  - The connector is standard DB9 straight-through
- 1 connector for VPIS/ VDS (J12) (Phoenix connector)
- 1 connector for CAP divider (J11)




Figure 2: PDCOM interface: connection to PDCOM, Dsub9 connector and PDCOM interface: connection to VIS, Phoenix connector

The dimensions of PDCOM interface are the following (mm):



# 5 PDCOM interface Mounting (with VPIS/ VDS)

*Commercial code: 1VCF681000S0104*

If the device is installed inside an enclosed cabinet, please check that there is enough space all round so that the connectors and cables can be fitted.
In case the device is installed in the front door of the panel (low voltage area) the following procedure must be used. It is made by following steps:

· Step 1: Identify the VPIS/ VPIS




Figure 3: VIS

·Step 2: VPIS/ VDS Wires connection options

- Option 1: choose a VIS interface with the same connector of your VPIS/ VDS, so you can connect the wires to the VIS interface and the to the VPIS/ VDS with very short wires or if not possible shielded wires.

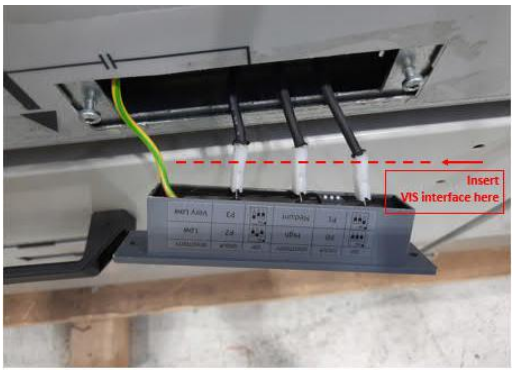



Figure 4: VIS interface connection

- Option 2: if VIS interface connectors are different from your VPIS/ VDS connectors you can make 3 adapter cables. These cables should be very short (3 centimeters maximum).

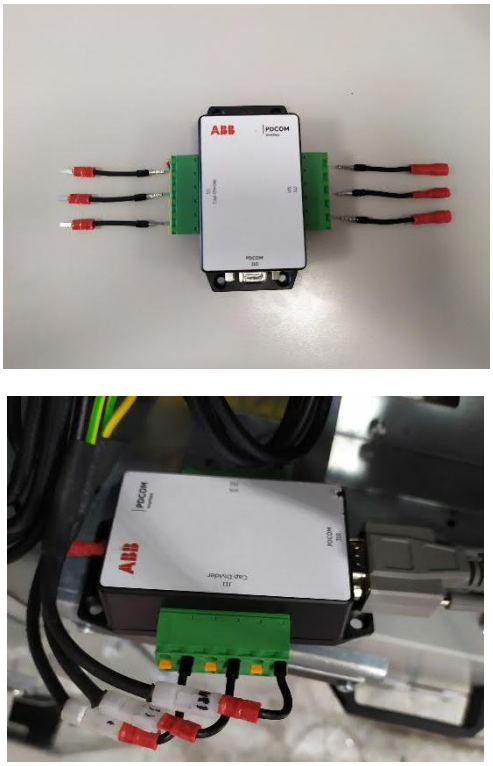


Figure 5: Adapter cables

- Case 3: if adapter cables need to be longer than 3 centimeters a shielded wire must be used and the shield must be connected to the VPIS/ VDS cables earth (see Figure 8 and Figure 10 for hearth connection).

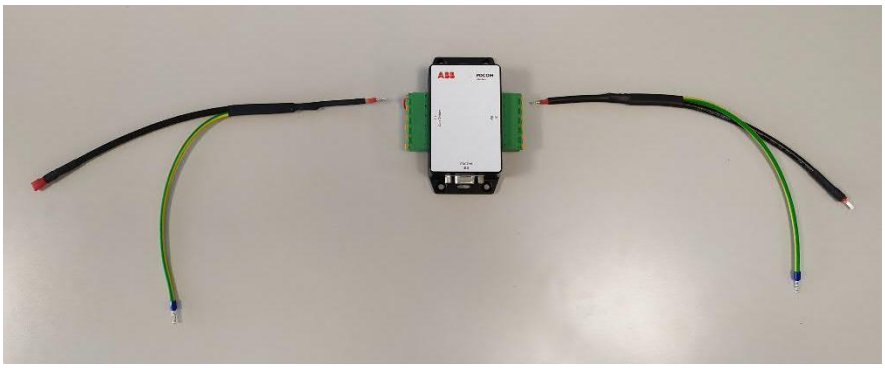


Figure 6: Shielded adapter cables

· Step 3: install the VIS interface:
- Connect the 3 phases (see connector J11 in Figure 18). The VPIS/ VDS should be connected in series, between the capacitor divider (4.1a) and the VPIS/ VDS (4.1b).

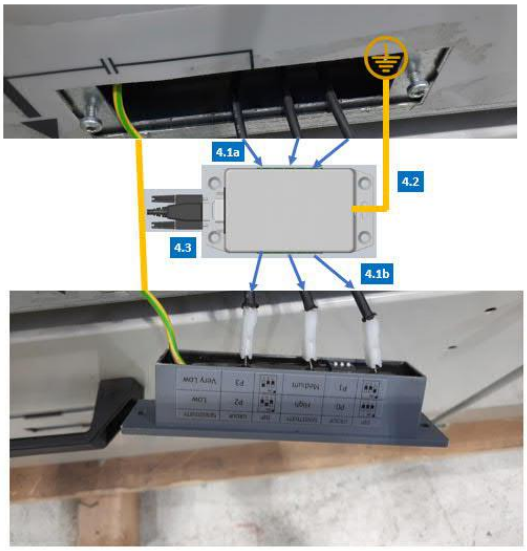



Figure 7: VIS interface connection with VPIS/ VDS

What is key with the grounding in general is to avoid ground loops. For this reason, the shield of the cable connecting the capacitive coupler to the installation kit should be grounded on one side only. We strongly advise to connect the shield to the installation kit.

Option 1: connect wires shields and VIS interface ground to the same hearth

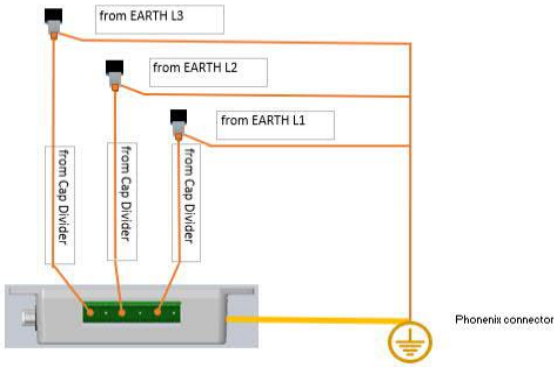



Figure 8: Common hearth

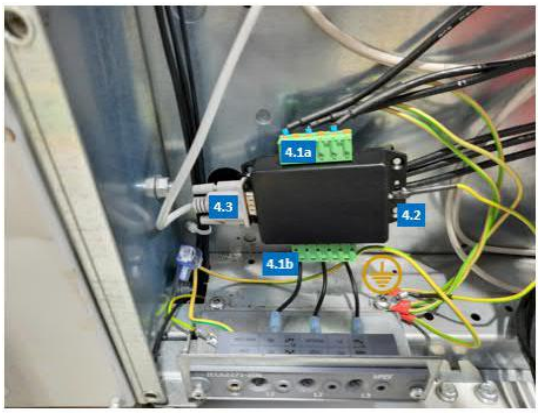



Figure 9: VIS installation with grounding option 1

Option 2: connect wires shields to VIS interface grounds and then the VIS interface to the SWG hearth. In this case be sure to use a wire with an adequate section to ground the VIS interface (it's recommended use cables with section 2,5 $mm^2$).

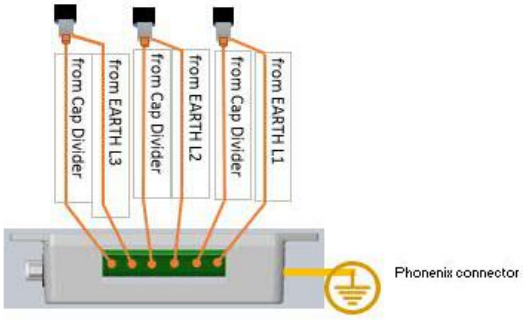



Figure 10: Shields hearth to VIS interface

· Step 4: Install the PCDOM in the LV cabinet, closest to VIS interface and connect the cable between the VIS interface and the PDCOM (5.2).

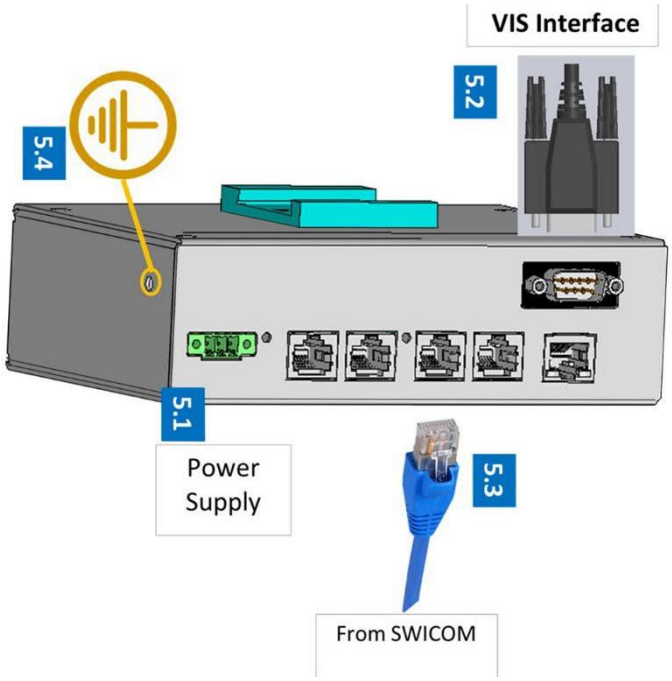



Figure 11: PDCOM connections

- Connect the ethernet cable 5.3 to the SWICOM or to the previous PDCOM if more than one is installed.

· As a general note, the ground connection between the PDCOM, VIS interface and shielded cables should always be as short as possible.

# 6 PDCOM interface Mounting (without VPIS/ VDS)

*Commercial code: 1VCF681000S0105*

· Step 1: Refer to Capacitive divider installation
· Step 2: Install the VIS interface:
- connect the 3 phases. The VIS Interface should be connected to the capacitor divider (4.1a). The connector J12 of the VIS Interface (see Figure *19*: PDCOM electrical scheme without VISFigure 19) should have a dedicated connector with capacitors (4.1b), electrical scheme 1VCD400305.

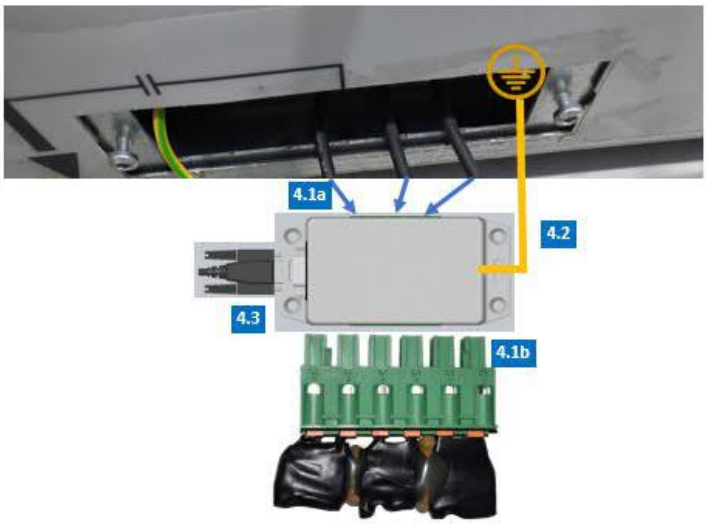



Figure 12: PDCOM connections without VIS

What is key with the grounding in general is to avoid ground loops. For this reason, the shield of the cable connecting the capacitive coupler to the installation kit should be grounded on one side only. We strongly advise to connect the shield to the installation kit.

Option 1: connect wires shields and VIS interface ground to the same hearth

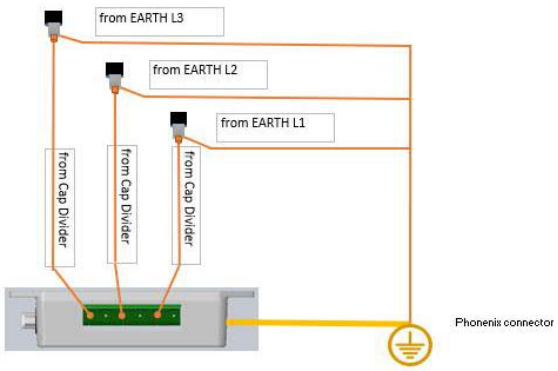



Figure 13: Common hearth

Option 2: connect wires shields to VIS interface grounds and then the VIS interface to the SWG hearth. In this case be sure to use a wire with an adequate section to ground the VIS interface.

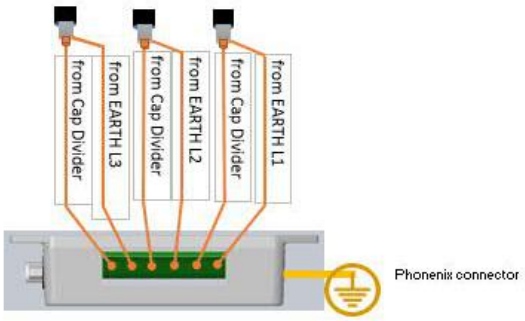



Figure 14: Shields hearth to VIS interface

· Step 3: Install the PCDOM in the LV cabinet, closest to VIS interface and connect the cable between the VIS interface and the PDCOM (5.2).

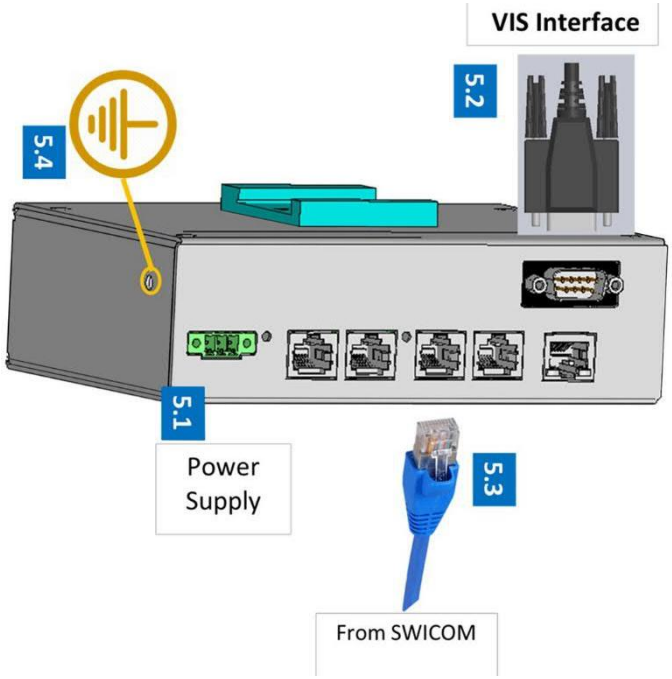



Figure 15: PDCOM connections

- Connect the ethernet cable 5.3 to the SWICOM or to the previous PDCOM if more than one is installed.
- The VIS interface must be the one dedicated with capacitor mounted

# 7 PDCOM Mounting

· Mechanical installation
· Wirings and connections

## 7.1 Checking environmental conditions and installation space

The mechanical and electrical environmental conditions at the installation site must be within the limits described in the technical manual.

· Avoid installation in dusty, damp places.
Avoid places susceptible to rapid temperature variations, powerful vibrations and shocks, surge voltages of high amplitude and fast rise time, strong induced magnetic fields or similar extreme conditions.
· Installation
The protection class of the device is IP2X
· Check that sufficient space is available.
Sufficient space is needed on top and in front to allow access to wires and to enable maintenance and future modifications.
The dimensions of PDCOM are the following:

· Environmental conditions
The equipment will operate within the specified tolerances only if the following environmental conditions are respected:
Ambient temperature range: -20°C to +55°C
Storage temperature range: -30°C to +70°C
Ambient humidity: 0 – 95% non-condensing

· Grounding the device
Unwanted transients must be eliminated (lightning protection). Comply with EMC requirements.

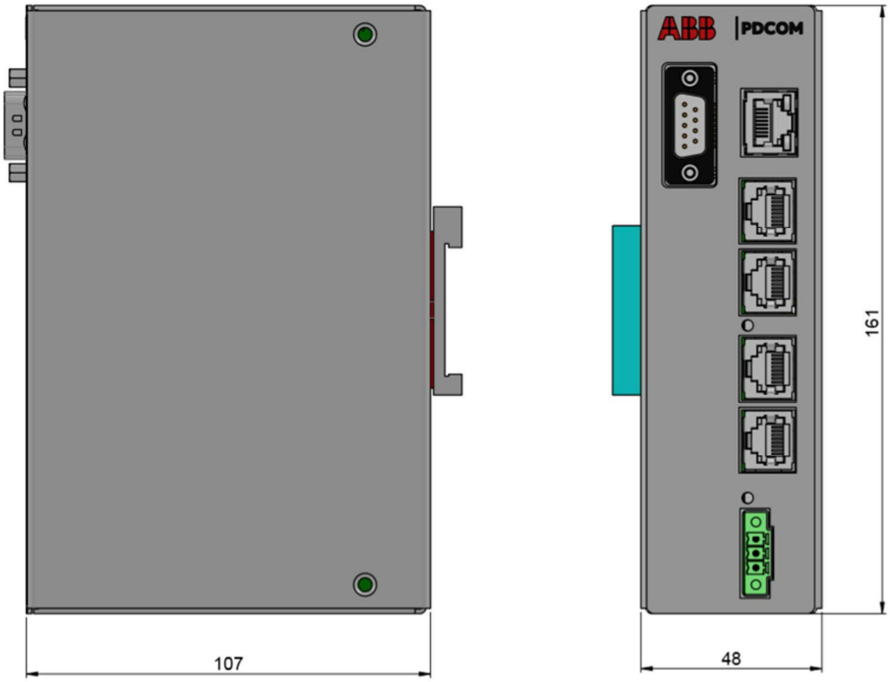


Figure 16: PDCOM dimensions

## 7.2 Hardware interfaces

The following interfaces are located on the backplate of the device:

- 1 connector for multibus (J4 or J5)
- 1 connector for sensor bus (J2) to connect to SWICOM, J3 to connect to other PDCOM with in/out connection
  - The connector is standard RJ45 cable straight-through category 5 or 6
- 1 connector for ethernet (J1)
- 1 connector to PDCOM interface (J8)
  - The connector is standard DB9 straight-through
- 1 connector for USB interface (J7)
- 1 connector for auxiliary power supply (J6)

Refer to electrical scheme (“1VCD400305”).




Figure 17: PDCOM connectors

## 7.3 Electrical Diagrams for connections, 1VCD400305

The following scheme is when VIS is available:

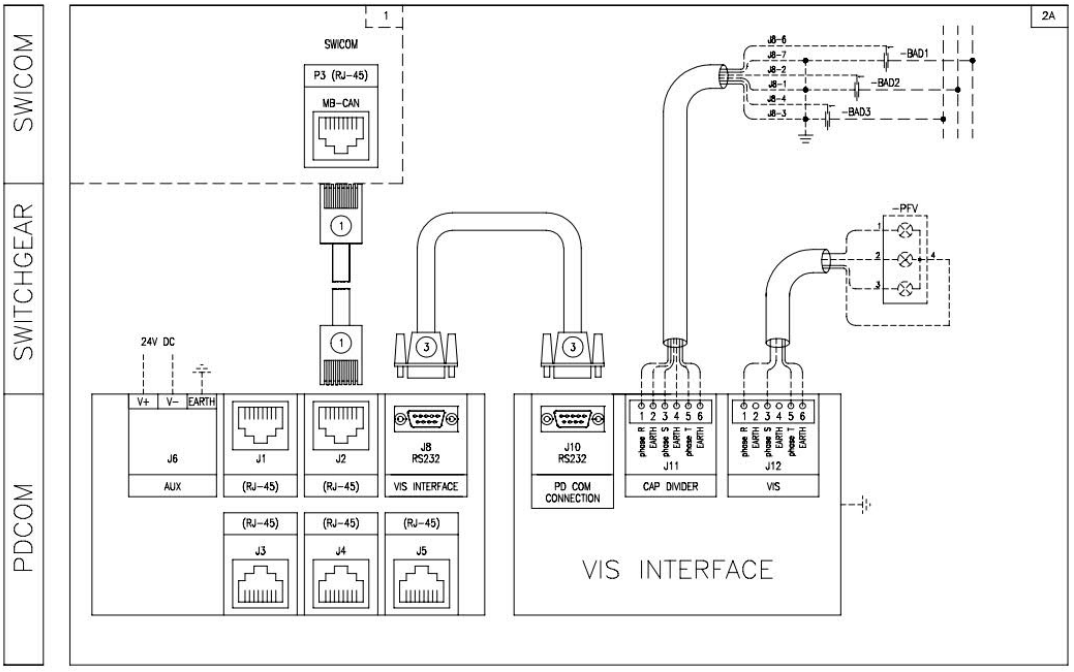



Figure 18: PDCOM electrical scheme with VIS

The following scheme is when VIS is not available:

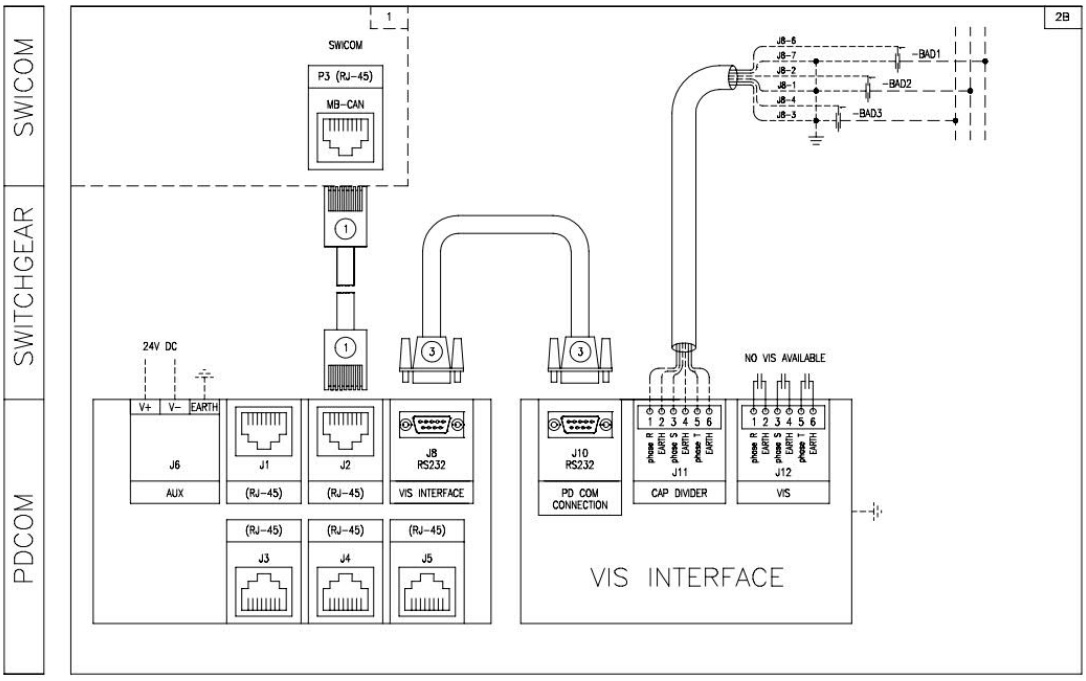



Figure 19: PDCOM electrical scheme without VIS

If the device is installed inside an enclosed cabinet, please check that there is enough space all round so that the connectors and cables can be fitted.

PDCOM installation procedure in the LV cabinet (closest to PDCOM interface):

Step 1: Install the Power Supply (24Vdc) (5.1)
Step 2: Connect the cable coming from PDCOM interface (5.2)
Step 3: Connect the RJ45 form the SWICOM (to the P3 port of SWICOM)
Step 4: Connect the PDCOM to SWG ground
The connect should as short as possible and done by a grounding braid

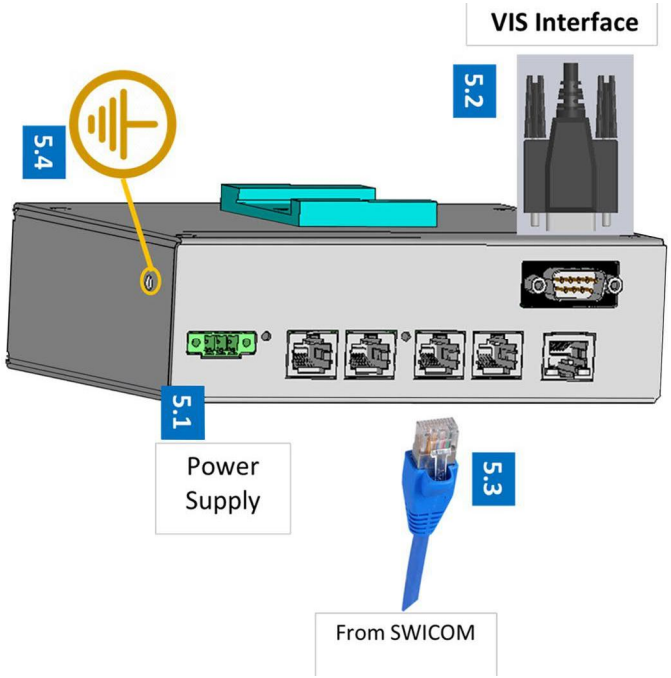



Figure 20: PDCOM connections

Then remove the switchgear ground connection

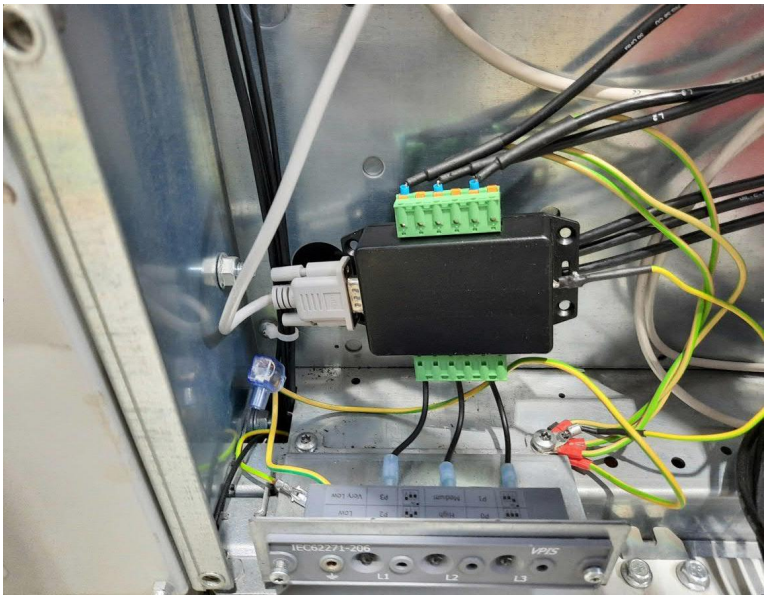


Figure 21: PDCOM installation completed

# 8 Connection

## 8.1 Required tools

The following tools are required:

- A flat tip screwdriver for power supply
- A spanner or wrench for ground nut

## 8.2 Connecting wires

All wire connections are made to the power supply, which is on the backplate. No soldering is needed. Terminals can be connected with 0.5 ... 2.5 $mm^2$ wires.

Use the pre-made cables and connectors for the communication part. Otherwise, use only 0.5 ... 1$mm^2$ twisted and shielded wires.

## 8.3 Protective earth connection

**The earthing tape or wire must be at least 6.0 $mm^2$. Increase the cross section of the tape or wire if the earth lead is very long.**
**Connect the earthing wire from one screw of PDCOM to the earthing point of the switchgear.**

## 8.4 Power supply connection

The external power supply is intended to provide to PDCOM the required 12-24V starting from the switchgear auxiliary voltage.

Please check the Technical Manual carefully

**Table 2: Power supply**

| Description | Voltage |
|---|---|
| Vout | 12-24VDC |
| Vout variation | -15% ... +15% |
| Power consumption | 35.0 W |
| Ripple | Max 12% of the DC value (f=100kHz) |
| Maximum interruption time | 50 ms |
| Conductor material (Mandatory for UL certification) | Copper [(60 -75) °C] |
| Conductor wire size (Mandatory for UL certification) | 28-16 AWG (stranded or solid) |
| Terminal tightening torque (Mandatory for UL certification) | 0.22 Nm |
| Ambient Temperature (Mandatory for UL certification) | > 50 °C |

Ground the unit with the earth screw at the top. This is essential to ensure safety and electro-magnetic compatibility (EMC) of the device.

## 8.5 Serial communication connection

PDCOM use the SWICOM sensor bus that provides the interface for the sensors placed on the switchgear.
PDCOM J2 connector shall have to be connected to the SWICOM P3 through a standard RJ45 cable straight-through category 5 or 6.

# 9 Removal, repair and replacement

## 9.1 Product lifecycle

During the product lifecycle, the time will come when PDCOM must be upgraded to a next generation. Although this will not be required until some 10 years after installation, it is wise to already consider the product lifecycle when investing on the original product.
Specific options are given in the specific Service & Support sheet of the ABB Product Guide.

## 9.2 Device info

The device information includes details about the device, such as version and serial number. PDCOM information is available using the corresponding software tools (Monitoring or Configuration tools). See the Operation Manual for further details.

## 9.3 Removal of the device

1. Turn off the power
2. Detach the power connector
3. Disconnect sensor cables, serial cables and power supply plugs, unscrew the earthing strip.
4. Remove the device from the front door.

## 9.4 Repairs

Contact the nearest ABB or representative for consultation and instructions if the product develops faults.

## 9.5 Replacement of the device

To replace PDCOM with another identical unit, first remove the device itself and then install the new one. The configuration can be copied from the old one. Use the configuration tool as explained in the Engineering Manual.

# 10 Installation Kit

The PDCOM unit can be installed in at least two different places:

- In front of the low voltage compartment (following the procedure in chapter 4)
- In a metal-enclosed box (usually when the low voltage comportment door is already full)

# 11 Accessories and ordering data

**Table 3: Device and sensors**

| Item | Order number |
|---|---|
| PDCOM HV | 1VCF681000S0103 |
| PDCOM HV with VIS | 1VCF681000S0104 |
| PDCOM HV without VIS | 1VCF681000S0105 |

# 12 Glossary

| | |
|---|---|
| **CT** | Current transformer |
| **EMC** | Electromagnetic compatibility |
| **HMI** | Human-machine interface |
| **IEC** | International Electrotechnical Commission |
| **IEC 61850** | International standard for substation communication and modeling |
| **IED** | Intelligent electronic device |
| **LCD** | Liquid crystal display |
| **LCP** | Liquid crystal polymer |
| **LED** | Light-emitting diode |
| **LHMI** | Local human-machine interface |
| **PA** | Polyamide |
| **PBT** | Polybutylene terephthalate |
| **PC** | Personal computer; Polycarbonate |
| **PCM600** | Protection and Control IED Manager |
| **RoHS** | Restriction to the use of certain hazardous substances in electrical and electronic equipment |
| **TCS** | Trip circuit supervision |
| **VT** | Voltage transformer |

# Notes

For further details please contact:

More product information:
www.abb.com/mediumvoltage
Your contact center:
www.abb.com/contactcenters
More service information:
www.abb.com/service

The data and illustrations are not binding. We reserve the right to modify the contents of this document without prior notice following technical and product developments.

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1VCD601688 - Rev. B 0001, en - PDCOM Installation Manual - 2021.12 (PDCOM) (gs)

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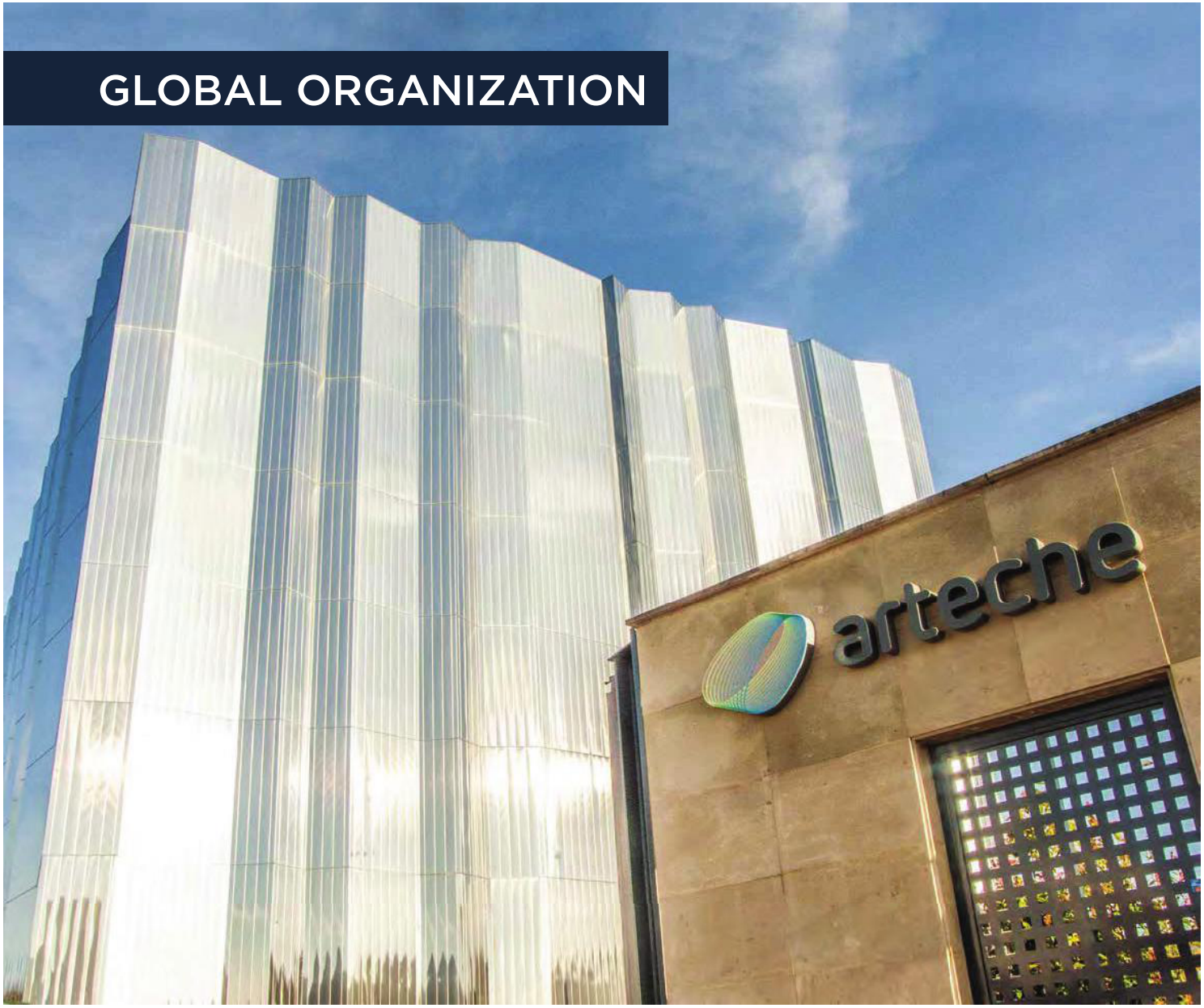
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# MEDIUM VOLTAGE INSTRUMENT TRANSFORMERS

## OUTDOOR / INDOOR



# GLOBAL ORGANIZATION




**Arteche** is a global organization that has manufacturing, technical and trade facilities worldwide, and has **products installed in more than 175 countries** around the world.

This **worldwide presence** allows us to directly meet the local needs of the generation, transmission, and distribution sectors, understanding the local demands and complexities.

In short, we are a global, strong, and stable brand with over 75 years of experience, prepared to respond to any market changes through our main purpose: to respond to energy challenges with agility and responsibility, true to our commitment to people, society and the planet. Always MOVING TOGETHER. Always ADDING ENERGIES.

To this end, **we have the best source of energy on the planet**: **our people**. People have made Arteche the company it is today thanks to their professionalism, knowledge, and commitment to this common project. Our international team has experience and commitment, allowing us to work based on continuous innovation, adapting our answers to the needs of our clients.

**Arteche is a project that is shared** with our people, and clients, and suppliers, and the whole of the society in which we develop our activity.

**Sustainability, ethics, honesty, solidarity, and transparency are the principles that make up our philosophy** and which all of us at Arteche follow, always seeking excellence in quality and service. Our commitment to society is strong, and all of us at Arteche want to participate actively to contribute to social development, and to generate value for our clients and for society as a whole.

In July 2021 **ESITAS company** has been added to Arteche`s project, a company with **over 35 years' experience** in the sector and in the instrumentation and measuring market.

With this acquisition, Arteche reinforces its leadership as it looks to the future challenges around the transformation of the energy sector. We also strengthen our commitment to continue to add energies to move into the future.

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VTB 10-KFP / 20-KFP 93
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VTB 30-F1 / 30-F1B 99
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# M.V. CURRENT TRANSFORMERS





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## General Definitions

General definitions have been given according to International Standarts IEC 61869

## Instrument Transformer

A transformer intended to supply measuring instruments meters, protection relays and other similiar apparatus.

## Applicable Standards

Our transformers comply with applicable national and international standards.

## Current Transformers

An instrument transformer in which the secondary current, in normal conditions of use, is substantially proportional to the primary current and differs in phase from it by angle which is approximately zero for an appropriate direction of the connections. It isolates the instrument and protection circuit from the primary side and protect the devices against overload according to the overcurrent characteristics of the transformer. Current transformers can have several secondary windings with cores of identical of different characteristics completely isolated from each other.

## Measuring Current Transformer

A current transformer intended to supply indicating instruments, integrating meters and similiar apparatus.

## Protective Current Transformer

A current transformer intended to supply protective relays.

## Primary Winding

The winding through which flows the current to be transformed.

## Secondary Winding

The winding, which supplies the current circuits of measuring instruments, meters, relays or similiar devices.

## Secondary Circuit

The external circuit supplied by the secondary winding of a transformer.

## Rated Primary Current

The value of the primary current on which the performance of the transformer is based.

## Rated Secondary Current

The value of the secondary current on which the performance of the transformer is based.

## Rated Transformation Ratio

The ratio of rated primary current to the rated secondary current (I1N/I2N-i.e. 100/5A)

## Current Error (Ratio Error)

The error which a transformer introduces into the measurement of a current and which arises from the fact that the actual transformation ratio is not equal to the rated transformation ratio.
The current error expressed in per cent is given by formula:

$$\text{Current Error}\% = \frac{Kn\ Is - Ip}{Ip} \times 100$$

Where

Kn is the rated transformation ratio;
Ip is the actual primary current
Is is the actual secondary current when Ip is flowing, under the conditions of measurements.

## Accuracy Class

A designation assigned to a current transformer errors of which remain within specified limits under prescribed conditions of use.

## Burden

The impedance of the secondary circuit in ohms and power-factor. The burden is usually expressed as the apparent power in voltamperes absorbed at a specified power-factor and at the rated secondary current.

## Rated Burden

The value of the burden on which the accuracy requirements are based on.

## Rated Output

The value of the apparent power (in voltamperes at a specified power-factor) which the transformer is intended to supply to the secondary circuit at the rated secondary current and with rated burden connected to it.

## Rated Insulation Level

The combination of voltage values which characterizes the insulation of a transformer with regard to its capability to whitstand dielectric stresses.

## Rated Frequency

This is the frequency for which the transformer is designed and given in Hz on the rating plate.

## Rated Short-Time Thermal Current (Ith)

The r.m.s. value of the primary current which a transformer will withstand for one second without suffering harmful effects, the secondary winding being short-circuited.

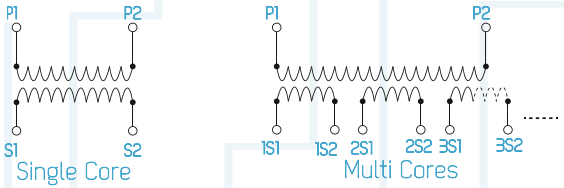
## Rated Dynamic Current (Idyn)

The peak value of the primary current which a transformer will withstand, without being damaged electrically or mechanically by the resulting electromagnetic forces, the secondary winding being short-circuited.

## Rated Continuous Thermal Current

The value of the current which can be permitted to flow continuously in the primary winding, the secondary winding being connected to the rated burden, without temperature rise exceeding the values specified.

## CONNECTION DIAGRAMS
### Single Ratio Current Transformers

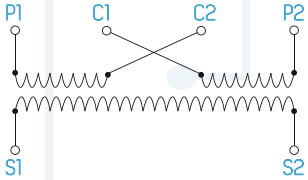



### Reconnection of Current Transformer

In case of changeable ratios, it is possible to design the transformer with primary reconnection or secondary tapping;

### Primary Reconnection

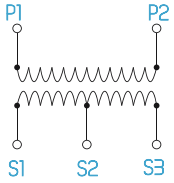
Changeover will be done at the primary side by using joint bars.
Can be used only for primary currents up to 2 x 600A




C1 -C2 short circuited: low rated current
P1 - C1 and P2 - C2 short circuited: high rated current

### Secondary Tapping

Changeover will be done at the secondary side.

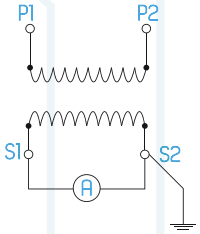



S1 -S2 low rated current
S1 - S3 high rated current

### Safety Operation Conditions for Current Transformers

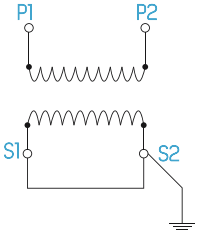
- When the secondary terminals are connected to the measuring or protection devices, one of the terminals should be earthed for safety, as seen in Diagram-1.

Diagram-1



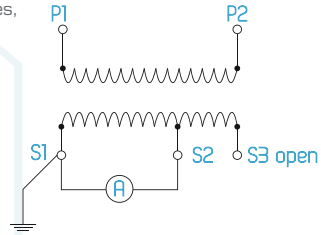

- The secondary circuit of a current transformer must not be operated with an open - circuit.
- The secondary winding of a current transformer which will not be used must be short - circuited and earthed as seen in Diagram-2

Diagram-2



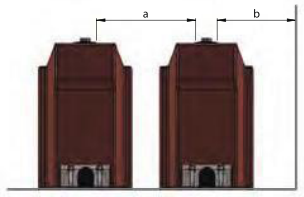

- For the transformer with reconnectable and - or tapped secondaries, unused terminals must be left open as seen in Diagram-3.

Diagram-3




- The current transformers which have capacitive divider tap (Ck) must be connected to the indicator, if the tap will not be used then it must be earthed.

## M.V. CURRENT TRANSFORMERS CONNECTION CLEARENCES




| INSULATION LEVEL | a minimum | b minimum |
|---|---|---|
| 12kV | 100mm | 110mm |
| 24kV | 190mm | 210mm |
| 36kV | 305mm | 325mm |



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV ..... 17,5kV BLOCK TYPES)

Types:
ATB 10-B
ATB 10-B3
ATB 10-2

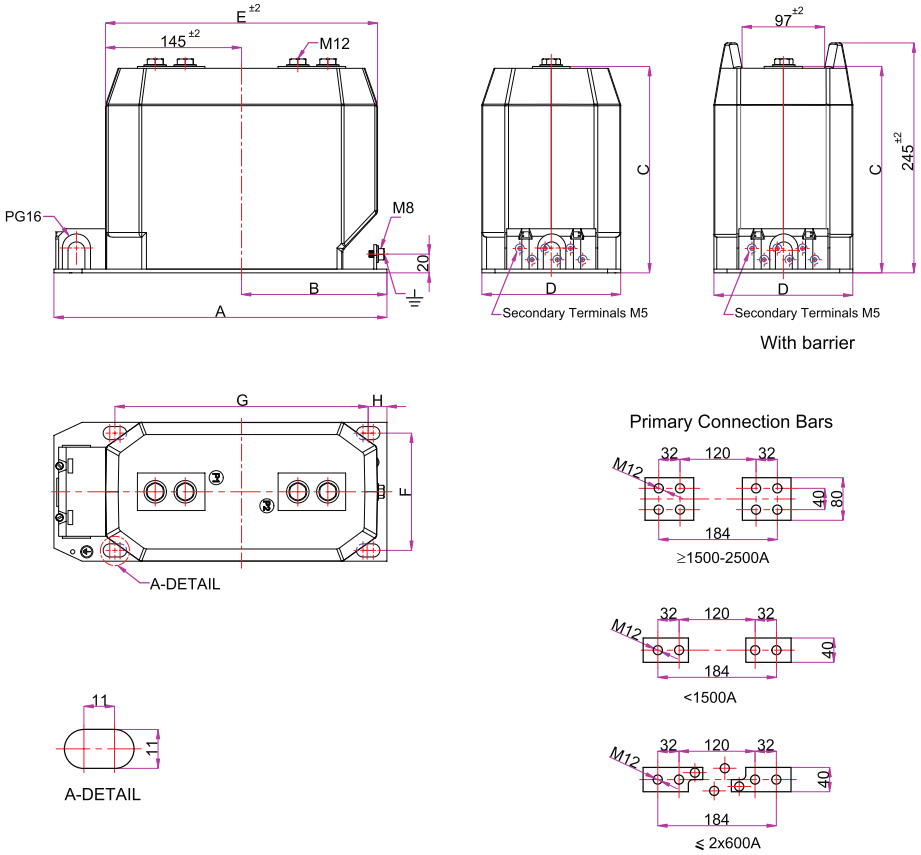
- Up to 3 cores*
- On request with capacitive layer.
- On request with barrier.

| Technical Data | Produced only in Indonesia Factory | | |
|---|---|---|---|
| Types | ATB 10-B | ATB 10-B3 | ATB 10-2 |
| Operating voltage, Um (kV) | 3,6 7,2 12 17,5 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 20 28 38 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 60 75 95 | | |
| Rated frequency (Hz) | 50-60 | | |
| Primary rated current (A) | 5 - 2500 (On request 3000A 1.0xIn / Cont. & Insulation class B) | | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | | |
| Secondary rated current (A) | 1 - 5 | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | | |
| Rated short-time thermal current (Ith) (1s) (kA) | Max. 60 kA or 1000 x In | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | |
| Short-time load (mechanical) (N) | 5000 | | |
| Insulation class | E | | |
| Ambient temperature (°C) | -25 ..... +40** | | |
| Altitude (m) | 1000 | | |
| Standard | According to the customer requirements | | |
| Weight (approx.) (kg) | 20 - 25 | 25 - 33 | 28 - 33 |

*On request operating voltage of 17,5 kV is available.*
** For more cores please contact with ARTECHE for feasibility.*
*** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV ..... 17,5kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATB 10-B | 355 | 155 | 220 | 148 | 290 | 125 | 270 | 20 |
| ATB 10-B3 | 455 | 255 | 220 | 148 | 390 | 125 | 370 | 20 |
| ATB 10-2 | 385 | 170 | 220 | 175 | 290 | 150 | 300 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV ..... 17,5kV NEW BLOCK TYPES)

Types:

| | |
|---|---|
| ATB 10-BS | (With barrier ATB 10-BSB) |
| ATB 10-BS2 | (With barrier ATB 10-BS2B) |
| ATB 10-B3 | (With barrier ATB 10-B3B) |
| ATB 10-B4 | (With barrier ATB 10-B4B) |

- Up to 3 cores*
- On request with capacitive layer.
- On request with barrier.

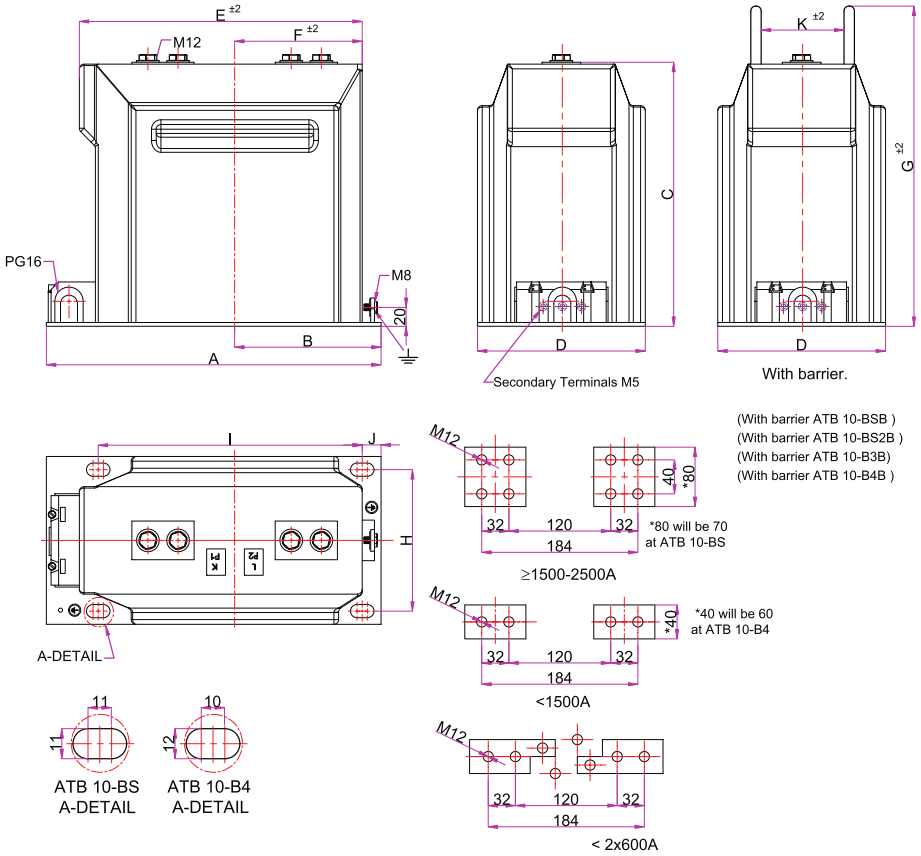
### Technical Data

| Types | ATB 10-BS | ATB 10-BS2 | ATB 10-B3 | ATB 10-B4 |
|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 |
| Rated frequency (Hz) | 50-60 | | | |
| Primary rated current (A) | 5 - 2500 (On request 3000A 1.0xIn / Cont. & Insulation class B) | | | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | | | |
| Secondary rated current (A) | 1 - 5 | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | | |
| Short-time load (mechanical) (N) | 5000 | | | |
| Insulation class | E | | | |
| Ambient temperature (°C) | -25 ..... +40** | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 20 - 25 | 25 - 33 | | 28 - 33 |

* For more cores please contact with ARTECHE for feasibility.
** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.

## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV ..... 17,5kV NEW BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ATB 10-BS | 355 | 155 | 220 | 148 | 299 | 135 | 245 | 125 | 270 | 20 | 88 |
| ATB 10-BS2 | 355 | 155 | 220 | 175 | 300 | 135 | 245 | 150 | 270 | 20 | 115 |
| ATB 10-B3 | 455 | 255 | 220 | 148 | 390 | 245 | 245 | 125 | 370 | 20 | 88 |
| ATB 10-B4 | 355 | 160 | 220 | 184 | 300 | 135 | 280 | 160 | 270 | 25 | 110 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=17,5 ..... 24kV NEW BLOCK TYPES)

Types:

ATB 20-BS (With barrier ATB 20-BSB)

ATB 20-BS2 (With barrier ATB 20-BS2B)

- Up to 3 cores*
- On request with capacitive layer.
- On request with barrier.

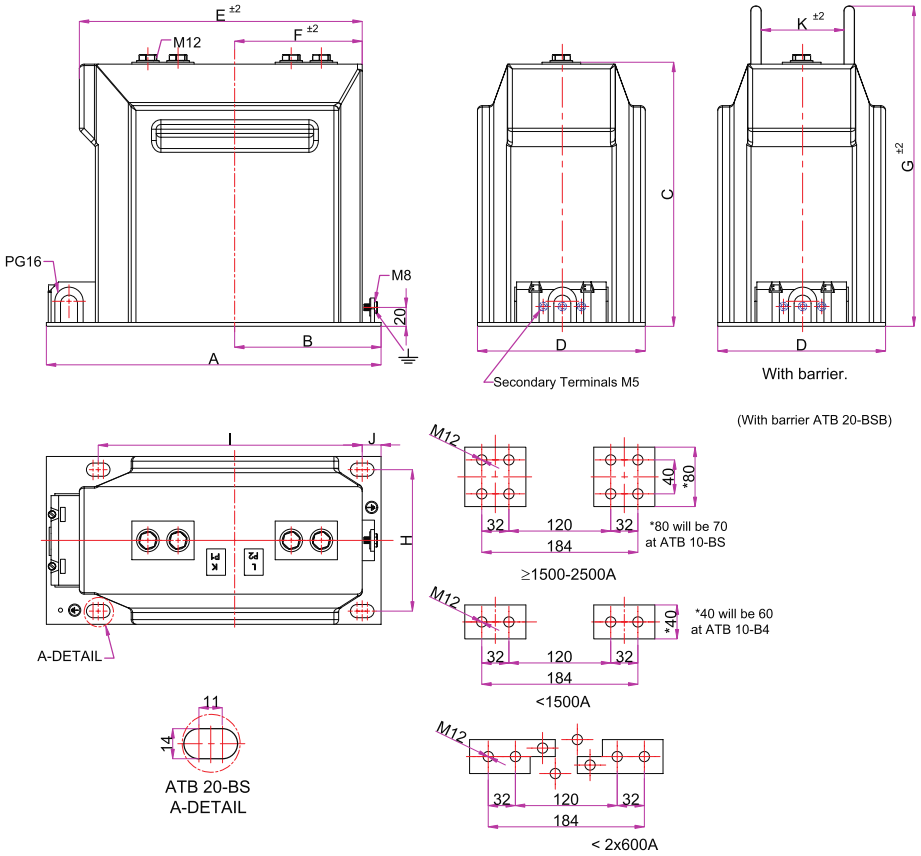
### Technical Data

| Types | ATB 20-BS | ATB 20-BS2 |
|---|---|---|
| Operating voltage, Um (kV) | 17,5 | 24*** |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | 125 |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5 - 2500 (On request 3000A 1.0xIn / Cont. & Insulation class B) | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | |
| Short-time load (mechanical) (N) | 5000 | |
| Insulation class | E | |
| Ambient temperature (°C) | -25 ..... +40** | |
| Altitude (m) | 1000 | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 30 | |

* For more cores please contact with ARTECHE for feasibility.
** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.
*** For more kV, please contact with ARTECHE for feasibility.

## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=17,5 ..... 24kV NEW BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ATB 20-BS | 355 | 155 | 280 | 178 | 300 | 135 | 340 | 150 | 280 | 20 | 88 |
| ATB 20-BS2 | 355 | 155 | 280 | 250 | 300 | 135 | 340 | 150 | 280 | 20 | 88 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV ..... 12kV NARROW BLOCK TYPES)

Types:
ATB 10-10
ATB 10-15

- ATB 10-10, up to 1 core*
- ATB 10-15, up to 2 cores.*

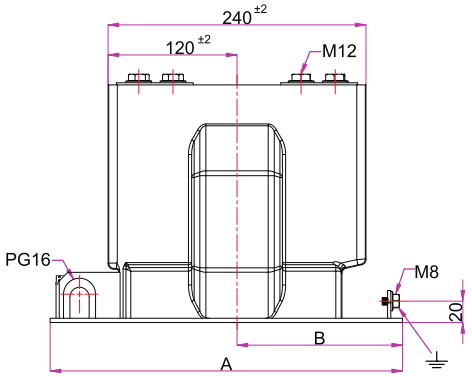
### Technical Data

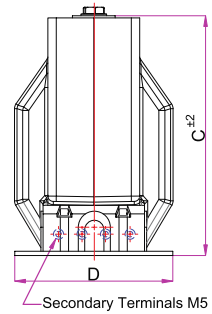
| Types | ATB 10-10 | ATB 10-15 |
|---|---|---|
| Operating voltage, Um (kV) | 3,6 7,2 12 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 20 28 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 60 75 | |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5-up to 1250 | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | (max. 200 x In) ** | |
| Rated dynamic current (Idyn) (kA) | (2,5 x Ith) | |
| Short-time load (mechanical) (N) | 5000 | |
| Insulation class | E | |
| Ambient temperature (°C) | -25 ..... +40 *** | |
| Altitude (m) | 1000 | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 12 | 17 |

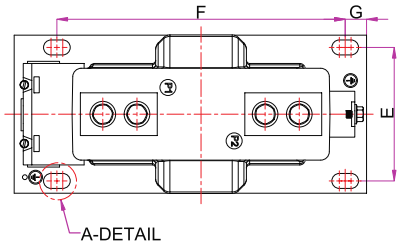
*On request operating voltage of 17,5 kV is available.*
* *For more cores please contact with ARTECHE for feasibility.*
** *May vary according to requested primary current and core values.*
*** *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

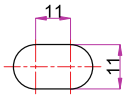
## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV ..... 12kV NARROW BLOCK TYPES)



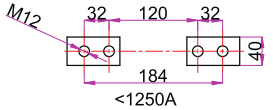



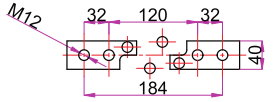




A-DETAIL

Primary Connection Bars




<1250A




≤2x600A

| Types | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| ATB 10-10 | 330 | 155 | 220 | 148 | 125 | 270 | 20 |
| ATB 10-15 | 330 | 155 | 220 | 148 | 125 | 270 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- *All dimensions are in mm.*
- *Tolerances are according to DIN 7168-g when not specified.*
- *Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
- *Customer designed products are also available.*



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=17,5kV ..... 24kV BLOCK TYPES)

### Types:

ATB 20-B (With barrier ATB 20-BR)
ATB 20-B2
ATB 20-3
ATB 20-3B

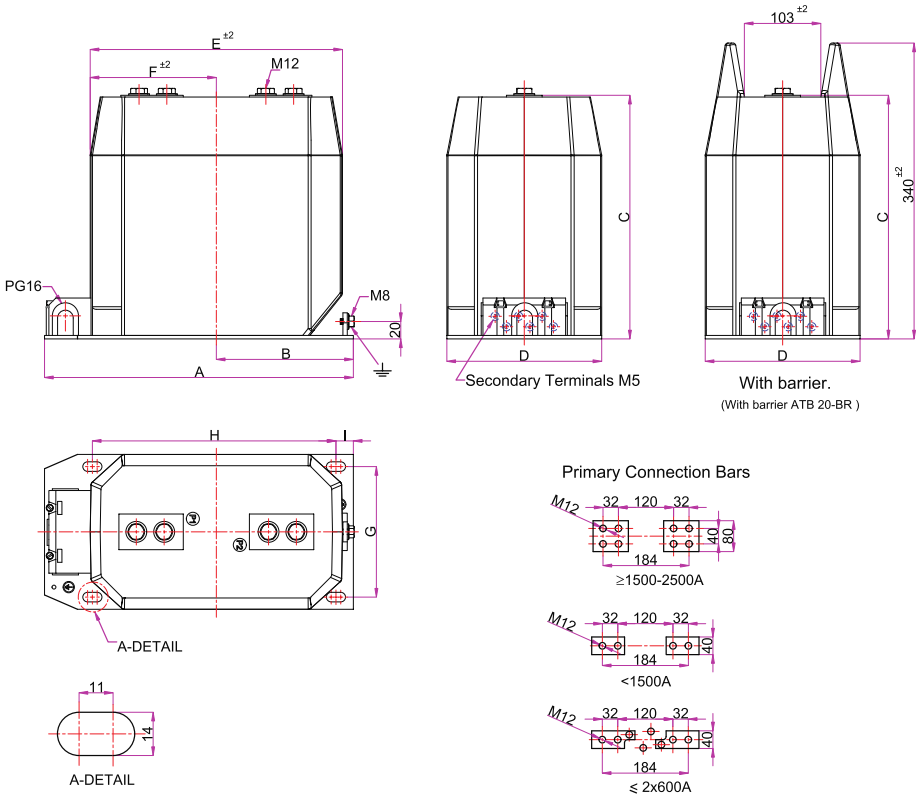
- Up to 3 cores.*
- On request with capacitive layer.
- On request with barrier.

| Technical Data | Produced only in Indonesia Factory | | | |
|---|---|---|---|---|
| Types | ATB 20-B | ATB 20-B2 | ATB 20-3 | ATB 20-3B |
| Operating voltage, Um (kV) | 17,5 | | 24 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | | 50 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | | 125 | |
| Rated frequency (Hz) | 50-60 | | | |
| Primary rated current (A) | 5 - 2500 (On request 3000A 1.0xIn / Cont. & Insulation class B) | | | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | | | |
| Secondary rated current (A) | 1 - 5 | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | Max. 60 kA or 1000 x In | | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | | |
| Short-time load (mechanical) (N) | 5000 | | | |
| Insulation class | E | | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 30 | 42 | 44 | 55 |

* For more cores please contact with ARTECHE for feasibility.
** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.

## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=17,5kV ..... 24kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| ATB 20-B | 355 | 155 | 280 | 178 | 290 | 145 | 150 | 280 | 20 |
| ATB 20-B2 | 355 | 155 | 280 | 205 | 290 | 145 | 180 | 280 | 17 |
| ATB 20-3 | 455 | 197 | 280 | 178 | 390 | 195 | 150 | 300 | 22 |
| ATB 20-3B | 455 | 197 | 280 | 205 | 390 | 195 | 180 | 375 | 22 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=17,5kV ..... 24kV NEW BLOCK TYPES)

### Types:

ATB 20-3A (With barrier ATB 20-3AB)
ATB 20-3B (With barrier ATB 20-3BB)

- Up to 3 cores.*
- On request with capacitive layer.
- On request with barrier.

### Technical Data

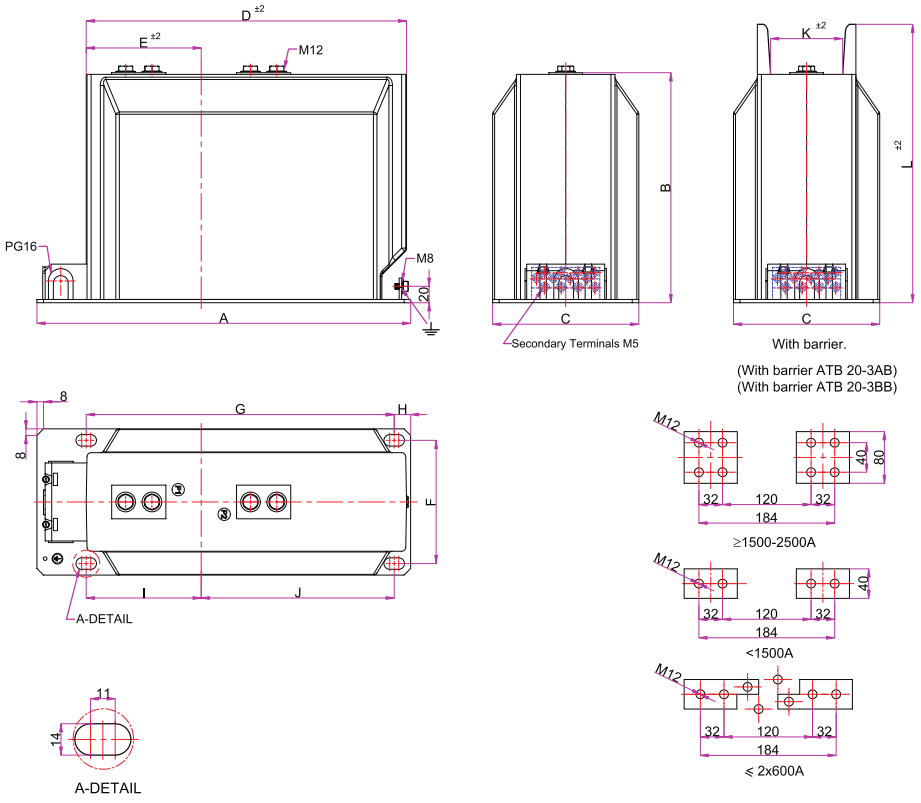
| Types | ATB 20-3A | ATB 20-3B |
|---|---|---|
| Operating voltage, Um (kV) | 17,5 | 24*** |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | 125 |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5 - 2500 (On request 3000A 1.0xIn / Cont. & Insulation class B) | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | |
| Short-time load (mechanical) (N) | 5000 | |
| Insulation class | E | |
| Ambient temperature (°C) | -25 ..... +40 ** | |
| Altitude (m) | 1000 | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 44 | 55 |

* For more cores please contact with ARTECHE for feasibility.
** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.
*** For more kV, please contact with ARTECHE for feasibility.



## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=17,5kV ..... 24kV NEW BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ATB 20-3A | 455 | 280 | 178 | 390 | 140 | 150 | 375 | 20 | 140 | 235 | - | - |
| ATB 20-3B | 455 | 280 | 205 | 390 | 140 | 180 | 375 | 20 | 140 | 235 | 88 | 340 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=17,5kV ..... 24kV NARROW BLOCK TYPES)

Types:
ATB 20-10
ATB 20-15

- ATB 20-10, up to 1 core*
- ATB 20-15, up to 2 cores.*

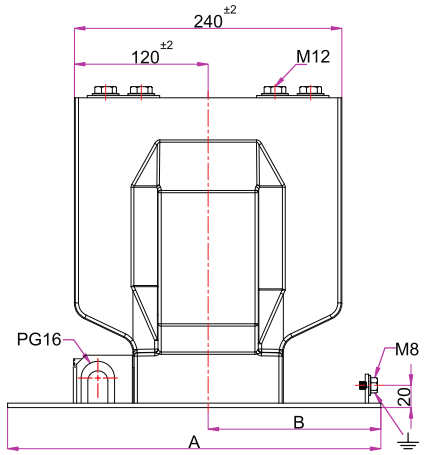
**Technical Data**

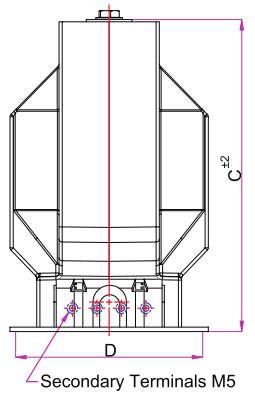
| Types | ATB 20-10 | ATB 20-15 |
|---|---|---|
| Operating voltage, Um (kV) | 17,5 | 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | 125 |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5 up to 1250 | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | (max. 300 x In) ** | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | |
| Short-time load (mechanical) (N) | 5000 | |
| Insulation class | E | |
| Ambient temperature (°C) | -25 ..... +40 *** | |
| Altitude (m) | 1000 | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 20 | 25 |

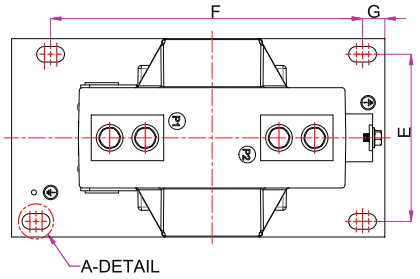
* For more cores please contact with ARTECHE for feasibility.
** May vary according to requested primary current and core values.
*** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.

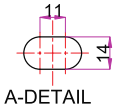
## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=17,5kV ..... 24kV NARROW BLOCK TYPES)

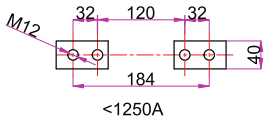


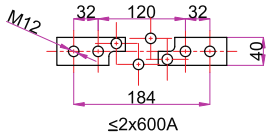




Primary Connection Bars




| Types | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| ATB 20-10 | 335 | 155 | 280 | 178 | 150 | 280 | 20 |
| ATB 20-15 | 335 | 155 | 280 | 178 | 150 | 280 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=36kV BLOCK TYPES)

Types:

ATB 30-S1 (With barrier ATB 30-S1B)
ATB 30-1
ATB 30-2 (With barrier ATB 30-2B)
ATB 30-3 (With barrier ATB 30-3B)

- Up to 3 cores.*
- On request with capacitive layer.
- On request with barrier.
- On request height: 390 mm as ATB 30-S1H
  ATB 30-2H
  ATB 30-3H

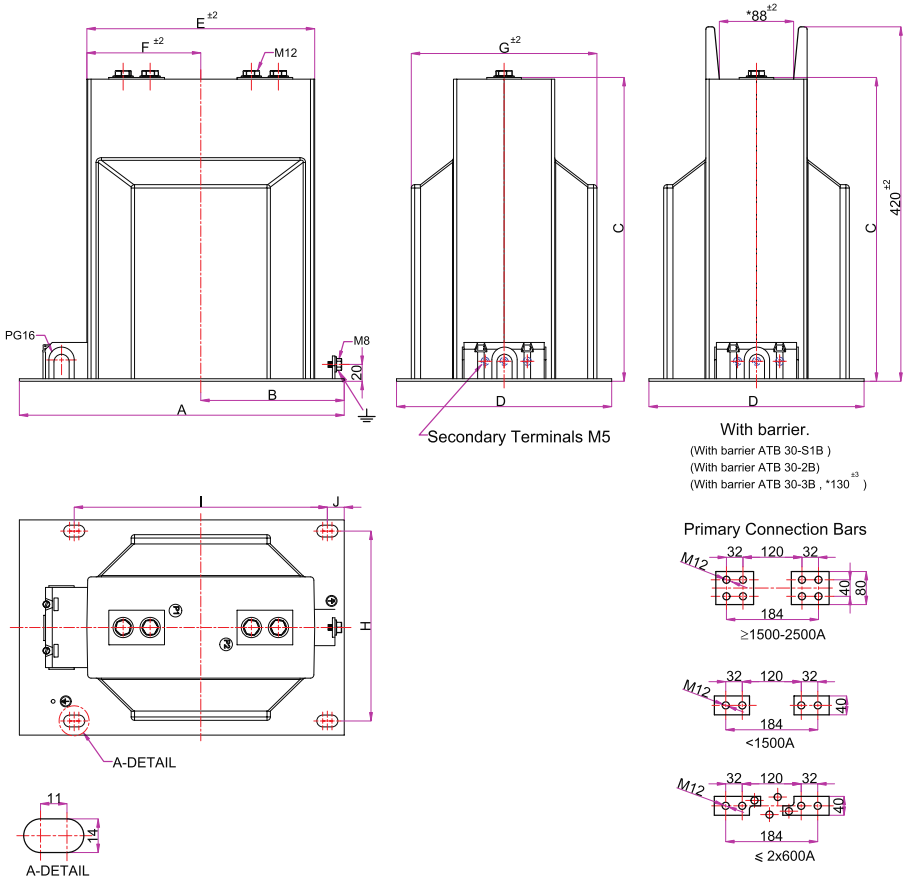
### Technical Data

| Types | ATB 30-S1 | ATB 30-1 | ATB 30-2 | ATB 30-3 |
|---|---|---|---|---|
| Operating voltage, Um (kV) | 36*** | | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | | | |
| Rated frequency (Hz) | 50-60 | | | |
| Primary rated current (A) | 5 - 2500 (On request 3150A 1.0xIn / Cont. & Insulation class B ) | | | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | | | |
| Secondary rated current (A) | 1 - 5 | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | | |
| Short-time load (mechanical) (N) | 5000 | | | |
| Insulation class | E | | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 38-48 | 45-50 | 50-55 | 65 |

* For more cores please contact with ARTECHE for feasibility.
** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.
*** For more kV, please contact with ARTECHE for feasibility.

## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=36kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| ATB 30-S1 | 385 | 170 | 360(390 ATB 30-S1H) | 255 | 270 | 135 | 220 | 225 | 300 | 20 |
| ATB 30-1 | 385 | 170 | 360 | 255 | 270 | 135 | 220 | 225 | 300 | 20 |
| ATB 30-2 | 385 | 170 | 360(390 ATB 30-2H) | 255 | 310 | 155 | 240 | 225 | 300 | 20 |
| ATB 30-3 | 455 | 210 | 360(390 ATB 30-3H) | 255 | 389 | 195 | 249 | 225 | 375 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=36kV NARROW BLOCK TYPES)

Types:

ATB 30-5
ATB 30-10 (With barrier ATB 30-10B)
ATB 30-15 (With barrier ATB 30-15B)

- ATB 30-5, 30-10 up to 1 core.*
- ATB 30-15, up to 2 cores.**
- ATB 30-10 & ATB 30-15 with barrier on request.
- On request height: 390 mm as ATB 30-10H
  ATB 30-15H

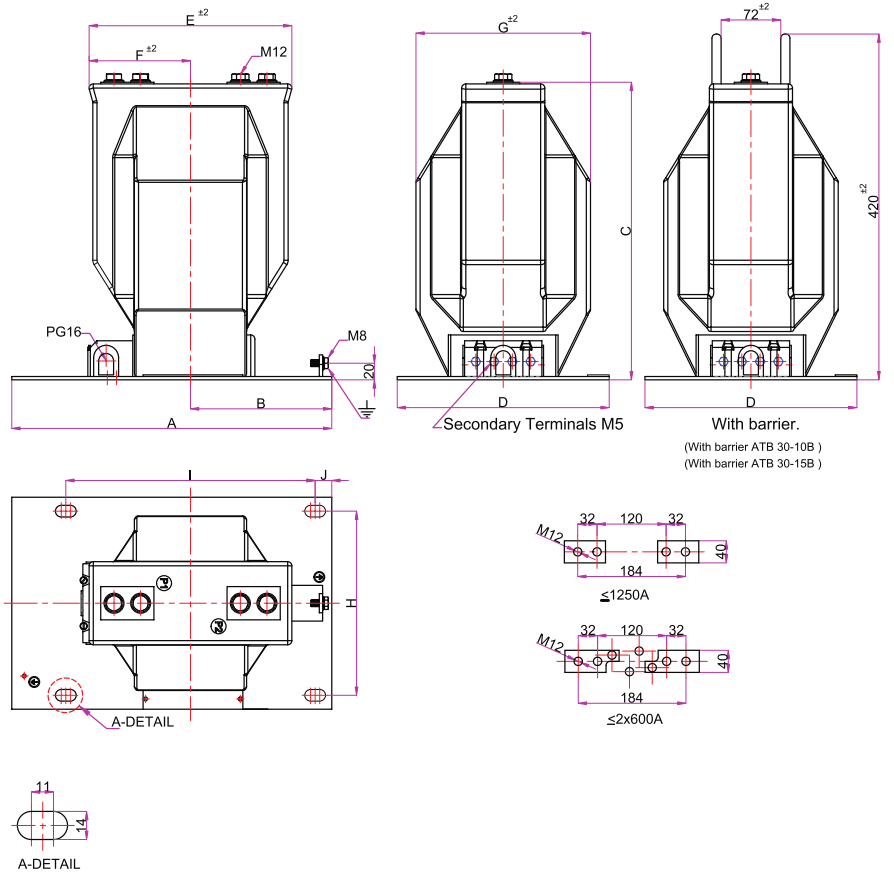
### Technical Data

| Types | ATB 30-5 | ATB 30-10 | ATB 30-15 |
|---|---|---|---|
| Operating voltage, Um (kV) | 36 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | | |
| Rated frequency (Hz) | 50-60 | | |
| Primary rated current (A) | 5 - 1250 | | |
| Primary reconnection (A) | 2x5 - 2x600 | | |
| Secondary rated current (A) | 1 - 5 | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 400xIn ** (for 1 measurement core) | max. 800xIn ** (for 1 measurement core) | max. 300xIn ** (for 2 core) |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | |
| Short-time load (mechanical) (N) | 5000 | | |
| Insulation class | E | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | |
| Altitude (m) | 1000 | | |
| Standard | According to the customer requirements | | |
| Weight (approx.) (kg) | 22 | 30-35 | 35-40 |

* For more cores please contact with ARTECHE for feasibility.
** May vary according to requested primary current and core values.
*** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.

## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=36kV NARROW BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| ATB 30-5 | 385 | 170 | 360 | 255 | 250 | 125 | 210 | 225 | 300 | 20 |
| ATB 30-10 | 385 | 170 | 360(390 ATB 30-10H) | 255 | 250 | 125 | 210 | 225 | 300 | 20 |
| ATB 30-15 | 385 | 170 | 360(390 ATB 30-15H) | 255 | 250 | 125 | 210 | 225 | 300 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Artech reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## INDOOR SUPPORT TYPE CAST RESIN INSULATED NARROW TYPE CURRENT TRANSFORMERS

(Um=7,2kV ..... 24kV BLOCK TYPES)

Types:
ATU 24

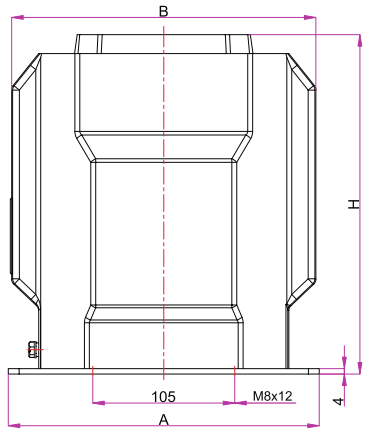
- Up to 2 cores.

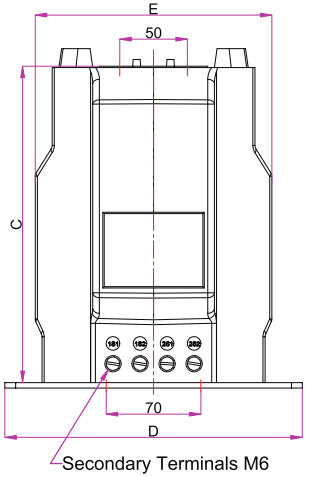
| Technical Data | Produced only in Indonesia Factory | | | |
|---|---|---|---|---|
| Types | ATU 24 | | | |
| Operating voltage, Um (kV) | 7,2 | 12 | 17,5 | 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 20 | 28 | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 60 | 75 | 95 | 125 |
| Rated frequency (Hz) | 50-60 | | | |
| Primary rated current (A) | 10 - 800 | | | |
| Primary reconnection (A) | 2x10 - 2x400 | | | |
| Secondary rated current (A) | 1 - 5 | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | 100 x In* | | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | | |
| Short-time load (mechanical) (N) | 5000 | | | |
| Insulation class | E | | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 24 | | | |

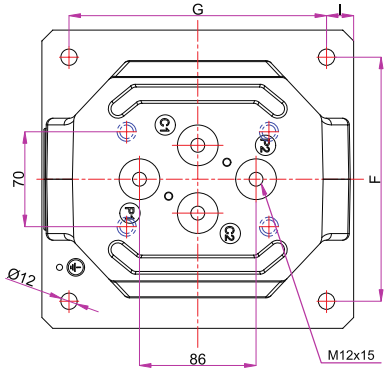
* May vary according to requested primary current and core values.
** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.

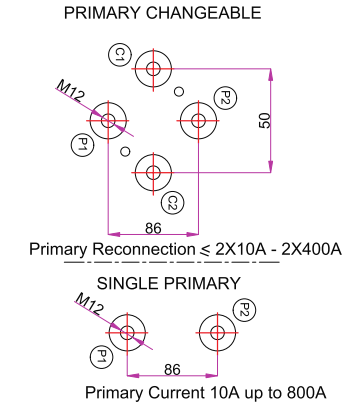
## INDOOR SUPPORT TYPE CAST RESIN INSULATED NARROW TYPE C.T.'S TECHNICAL DRAWING

(Um=7,2kV ..... 24kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| ATU 24 | 230 | 225 | 234 | 220 | 175 | 180 | 190 | 247 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## INDOOR SUPPORT TYPE CAST RESIN INSULATED SPECIAL TYPE CURRENT TRANSFORMERS

(Um=7,2kV ..... 24kV BLOCK TYPES)

Types:
ES 24 C3-B

- Up to 2 cores.

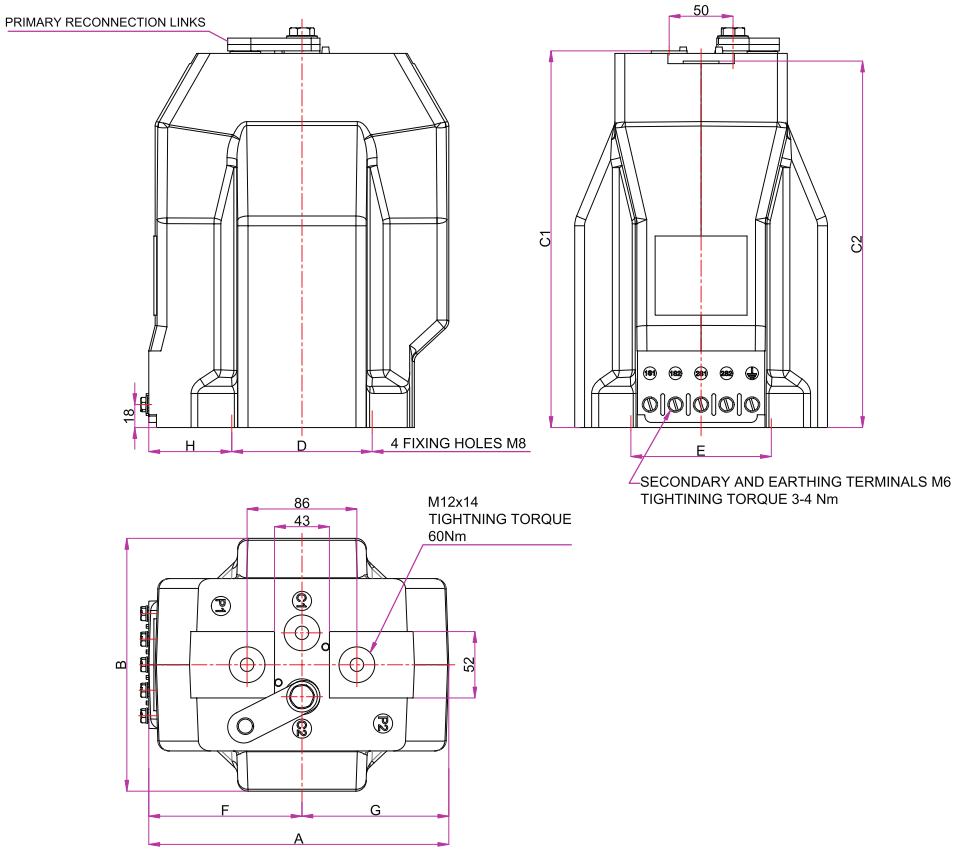
| Technical Data | Produced only in Indonesia Factory | | | |
|---|---|---|---|---|
| Types | ES 24 C3-B | | | |
| Operating voltage, Um (kV) | 7,2 | 12 | 17,5 | 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 20 | 28 | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 60 | 75 | 95 | 125 |
| Rated frequency (Hz) | 50-60 | | | |
| Primary rated current (A) | 10 - 800 | | | |
| Primary reconnection (A) | 2 x 10 - 2 x 400 | | | |
| Secondary rated current (A) | 1 - 5 | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | |
| Protection classes | 5P-10P-PX Acc. to IEC 61869-1&2 | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | Up to 60kA* | | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | | |
| Short-time load (mechanical) (N) | 5000 | | | |
| Insulation class | E | | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 25 | | | |

* May vary according to requested primary current and core values.
** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.



## INDOOR SUPPORT TYPE CAST RESIN INSULATED SPECIAL TYPE C.T.'S TECHNICAL DRAWING

(Um=7,2kV ..... 24kV BLOCK TYPES)




| Types | A | B | C1 | C2 | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|
| ES 24 C3-B | 235 | 198 | 295 | 287 | 110 | 110 | 120 | 115 | 65 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Artechе reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV .....24kV)

Types:
ATD 10
ATD 20

- Up to 2 cores.

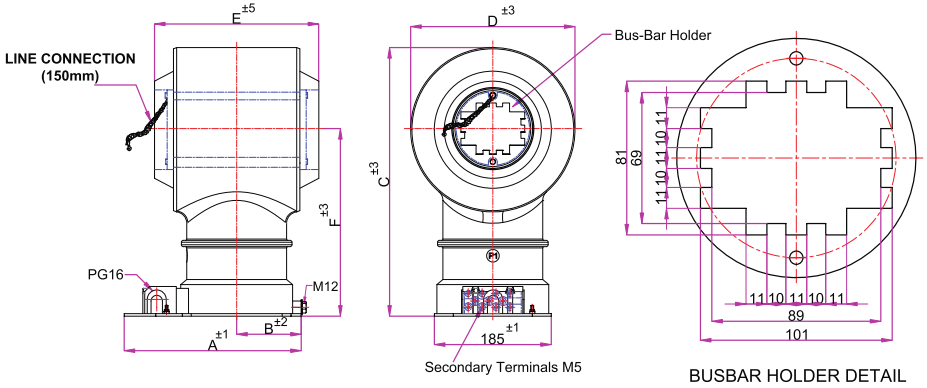
### Technical Data

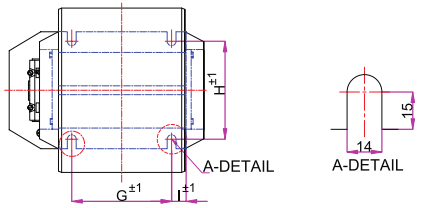
| Types | ATD 10 | | | ATD 20 | |
|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 |
| Rated frequency (Hz) | 50-60 | | | | |
| Primary rated current (A) | 800-3000 | | | 800-4000 | |
| Primary reconnection (A) | 2 x 10 - 2 x 400 | | | | |
| Secondary rated current (A) | 1 - 5 | | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 100 | | | | |
| Rated dynamic current (Idyn) (kA) | Practically Unlimited | | | | |
| Short-time load (mechanical) (N) | 3000 | | | | |
| Insulation class | E | | | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | | | |
| Altitude (m) | 1000 | | | | |
| Standard | According to the customer requirements | | | | |
| Weight (approx.) (kg) | 19 | | | 34 | |

* For more cores please contact with ARTECHE for feasibility.
** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.

## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV .....24kV)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| ATD 10 | 280 | 102 | 342 | 214 | 215 | 235 | 158 | 155 | 23 |
| ATD 20 | 280 | 102 | 427 | 260 | 260 | 295 | 158 | 155 | 23 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

- All dimensions are in mm.
- Tolerance is DIN 7168-g .
- Artache reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.




## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV.....17,5kV)

Types:
ATN 17-1
ATN 17-2
ESO 17 C
ATN 18
ATN 19
AR 01a
AR 03

- Up to 3 cores.*

### Technical Data

| Types | ATN 17-1 | ATN 17-2 | ATN 17 C | ATN 18 | ATN 19 | AR01a / AR 03 |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | | 7,2 | 12 | 17,5 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | | 20 | 28 | 38 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | | 60 | 75 | 95 | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Primary rated current (A) | 800-4000 | | | | | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | | | | | |
| Secondary rated current (A) | 1 - 5 | | | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | | | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | | | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 100 | | | | | |
| Rated dynamic current (Idyn) (kA) | Practically Unlimited | | | | | |
| Short-time load (mechanical) (N) | 3000 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 35 | 30 | 40 | | | 38 |

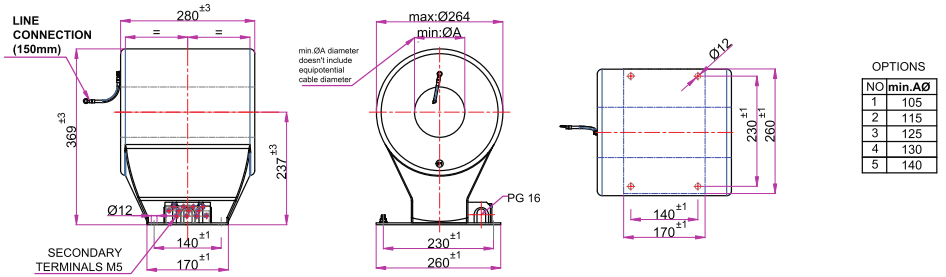
* *For more cores please contact with ARTECHE for feasibility.*
** *It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.*



## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV.....17,5kV)

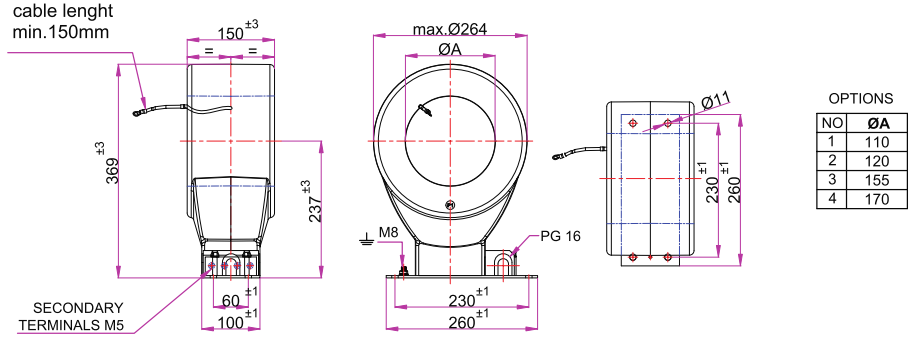
### ATN 17-1




OPTIONS

| NO | min.AØ |
|---|---|
| 1 | 105 |
| 2 | 115 |
| 3 | 125 |
| 4 | 130 |
| 5 | 140 |

### ATN 17-2




OPTIONS

| NO | ØA |
|---|---|
| 1 | 110 |
| 2 | 120 |
| 3 | 155 |
| 4 | 170 |

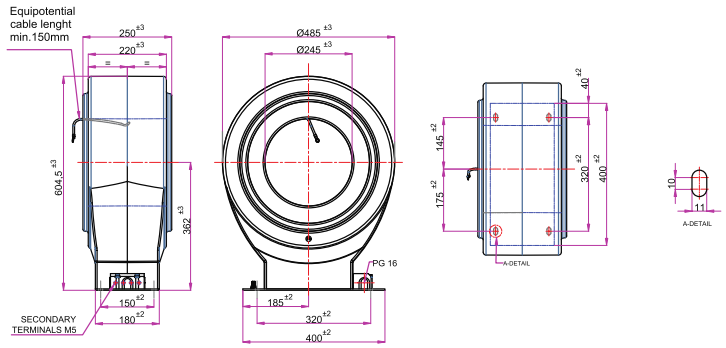
| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

*- All dimensions are in mm.*
*- Tolerance is DIN 7168-g.*
*- Artaeche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*

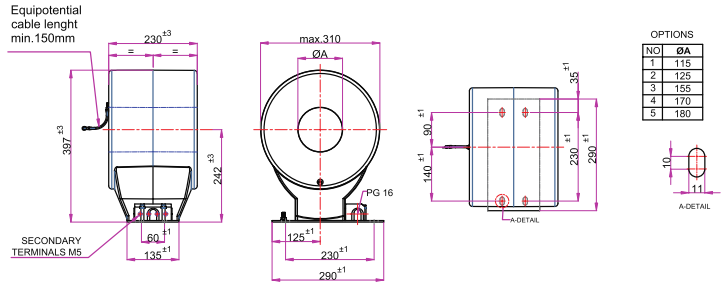
## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV.....17,5kV)

### ATN 18




### ATN 19




| NO | ØA |
|---|---|
| 1 | 115 |
| 2 | 125 |
| 3 | 155 |
| 4 | 170 |
| 5 | 180 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

*- All dimensions are in mm.*
*- Tolerance is DIN 7168-g.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*

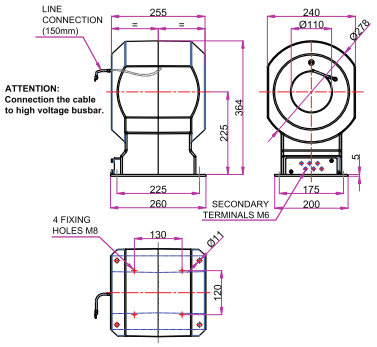




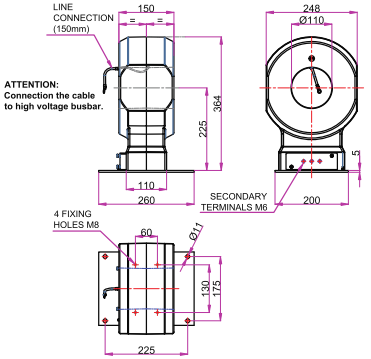
INDOOR POST BUSBAR TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV.....17,5kV)

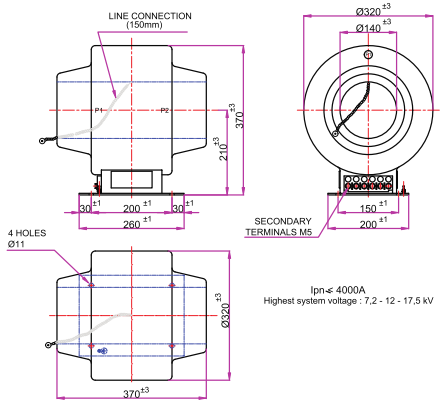
### AR01a




### AR03




### ESO 17 C




| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M6 (Primary Terminal) | 3 | 5 |

*- All dimensions are in mm.*
*- Tolerance is DIN 7168-g.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SUPPORT TYPE CAST RESIN INSULATED SPECIAL TYPE CURRENT TRANSFORMERS

(Um= 3.6kV ..... 24kV BLOCK TYPES)

Types:

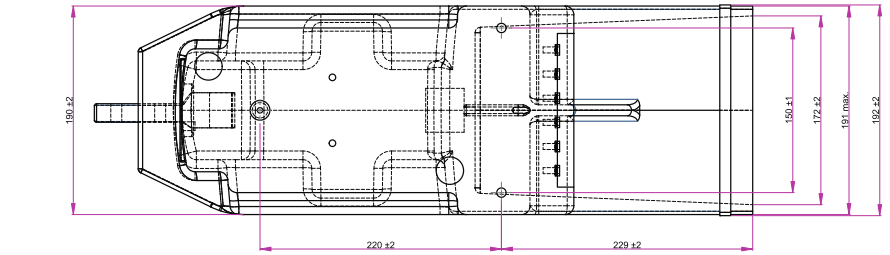
ATSI 24

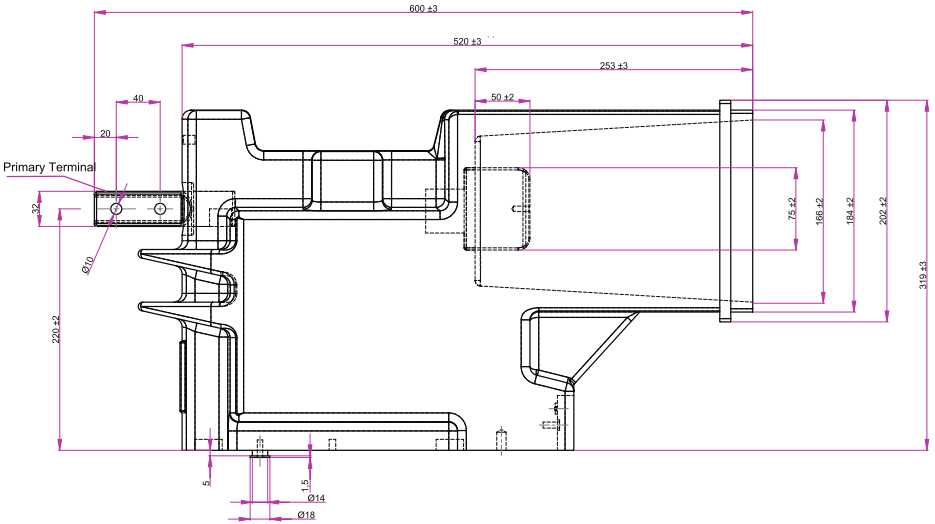
| Technical Data | Produced only in Indonesia Factory |
|---|---|
| Types | ATSI 24 |
| Operating voltage, Um (kV) | 3,6 7,2 12 17,5 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 20 28 38 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 60 75 95 125 |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 300-600 or 400-800 |
| Secondary reconnection (A) | 300-600/5 or 400-800/5 |
| Secondary rated current (A) | 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P-10P- to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | Up to 60kA* |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith |
| Short-time load (mechanical) (N) | 5000 |
| Insulation class | E |
| Ambient temperature (°C) | -25 ..... +40 ** |
| Altitude (m) | 1000 |
| Standard | According to the customer requirements |
| Weight (approx.) (kg) | 25 |

* May vary according to requested primary current and core values.
** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.

## INDOOR SUPPORT TYPE CAST RESIN INSULATED SPECIAL TYPE C.T.'S TECHNICAL DRAWING

(Um= 3.6kV ..... 24kV BLOCK TYPES)




- All dimensions are in mm.
- Tolerance is DIN 7168-g.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.




## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV.....24kV)

### Types:

ATGI 24
ATGI 24-2

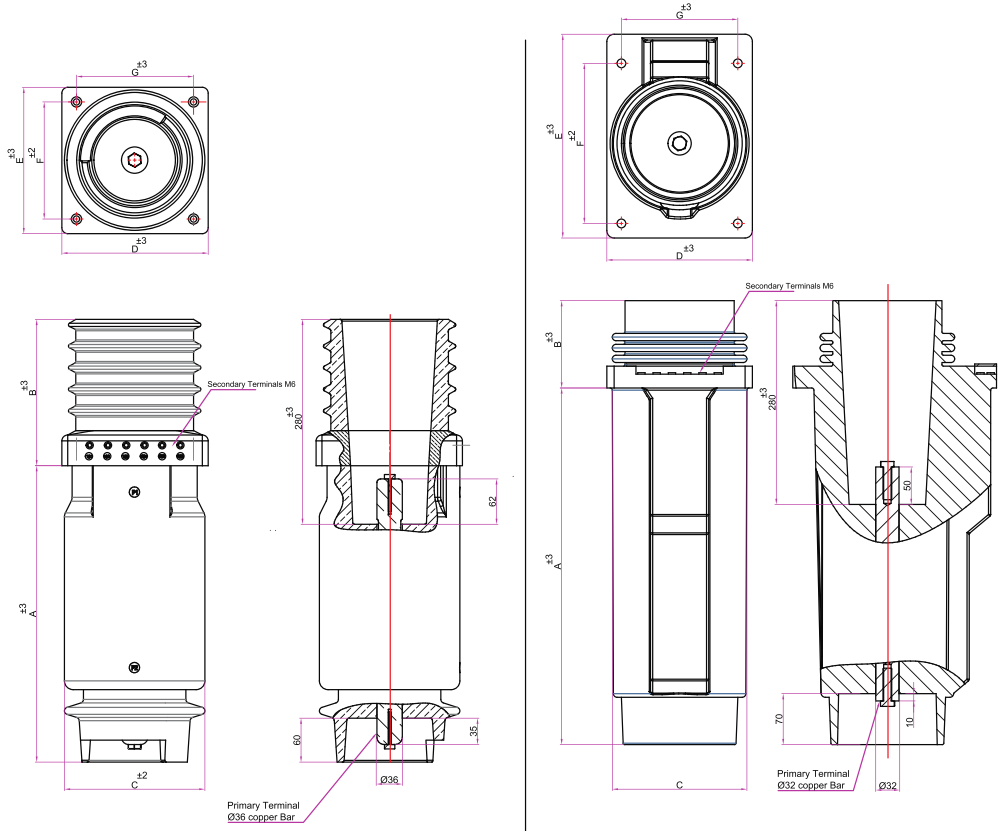
| Technical Data | Produced only in Indonesia Factory |
|---|---|
| Types | ATGI 24 |
| Operating voltage, Um (kV) | 3,6 7,2 12 17,5 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 20 28 38 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 60 75 95 125 |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 300-600 or 400-800 |
| Primary reconnection (A) | 300-600/5 or 400-800/5 |
| Secondary rated current (A) | 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P-10P- to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | Up to 60kA* |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith |
| Short-time load (mechanical) (N) | 5000 |
| Insulation class | E |
| Ambient temperature (°C) | -25 ..... +40 ** |
| Altitude (m) | 1000 |
| Standard | According to the customer requirements |
| Weight (approx.) (kg) | 25 |

* May vary according to requested primary current and core values.
** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.



## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED SPECIAL TYPE C.T.'S TECHNICAL DRAWING

(Um=3,6kV.....24kV)




| Types | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| ATGI 24 | 405 | 200 | Ø190 | 200 | 200 | 160 | 160 |
| ATGI 24-2 | 490 | 120 | Ø185 | 200 | 280 | 220 | 160 |

- All dimensions are in mm.
- Tolerance is DIN 7168-g.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## OUTDOOR DRY TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV .....24kV)

Types:
ATH 20-S
ATH 21
ATH 21-2
ATH 22-N

- ATH 20-S up to 1 core.*
- ATH 21, ATH 21-2 up to 2 cores.*
- ATH 22-N up to 3 cores.*



For the connection of aluminium conductors steel reinforced

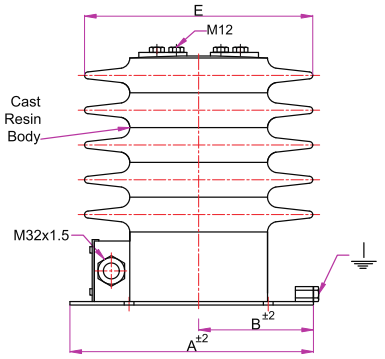
### Technical Data

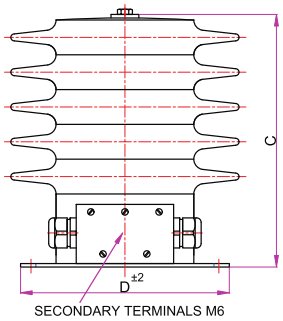
| Types | ATH 20-S | ATH 21 | ATH 21-2 | ATH 22-N |
|---|---|---|---|---|
| Operating voltage, Um (kV) | | 3,6 7,2 12 17,5 24** | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | | 10 20 28 38 50 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | | 40 60 75 95 125 | | |
| Rated frequency (Hz) | | 50-60 | | |
| Primary rated current (A) | 5-1250 | 5-2500 | | |
| Primary reconnection (A) | | 2x5 - 2x400 | | 2x5 - 2x600 |
| Secondary rated current (A) | | 1 - 5 | | |
| Metering classes | | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | |
| Protection classes | | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | | |
| Rated short-time thermal current (Ith) (1s) (kA) | | max. 1000 x In | | |
| Rated dynamic current (Idyn) (kA) | | 2,5 x Ith | | |
| Short-time load (mechanical) (N) | | 2400 | | |
| Insulation class | | E | | |
| Min. creepage distance (mm) | 560 | 825 | | 770 |
| Altitude (m) | | According to the customer requirements | | |
| Standard | | According to the customer requirements | | |
| Weight (approx.) (kg) | 24 | 35 | 38 | 78 |

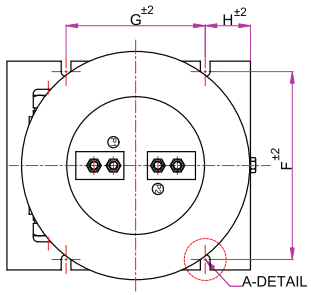
* For more cores please contact with ARTECHE for feasibility.
** For more kV, please contact with ARTECHE for feasibility.

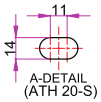
## OUTDOOR DRY TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV .....24kV)



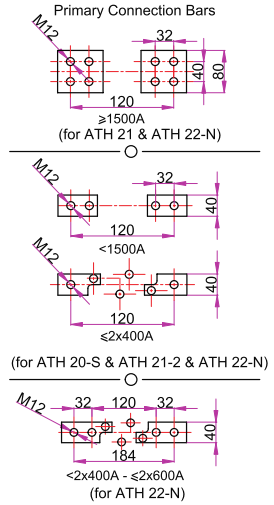










| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATH 20-S | 245 | 105 | max. 350 | 220 | max. ø225 | 178 | 175 | 20 |
| ATH 21 | 350 | 165 | max. 370 | 300 | max. ø340 | 270 | 200 | 65 |
| ATH 21-2 | 350 | 165 | max. 370 | 300 | max. ø340 | 270 | 200 | 65 |
| ATH 22-N | 400 | 195 | max. 380 | 370 | max. ø415 | 340 | 250 | 70 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## OUTDOOR DRY TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=36kV)

Types:
ATH 32

- ATH 32 up to 3 cores.*



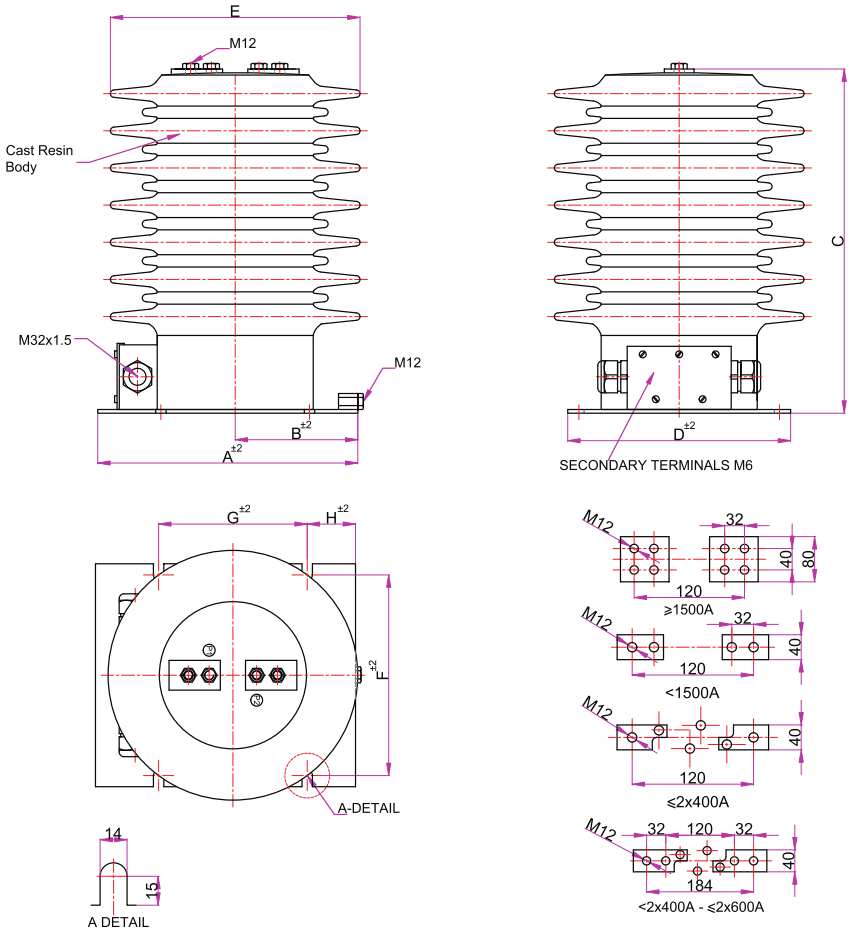
For the connection of aluminium conductors steel reinforced

| Technical Data | Produced only in Indonesia Factory | |
|---|---|---|
| Types | ATH 32 | |
| Operating voltage, Um (kV) | 36 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5-2500 | |
| Primary reconnection (A) | 2x5 - 2x600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | |
| Short-time load (mechanical) (N) | 2500 | |
| Insulation class | E | |
| Min. creepage distance (mm) | 1140 | |
| Altitude (m) | According to the customer requirements | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 47 | 85 |

* *For more cores please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=36kV)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATH 32 | 390 | 190 | max. 477 | 350 | max. ø403 | 320 | 250 | 65 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=36 kV)

Types:
ATH 30-N
ATH 32-N

- ATH 30-N up to 2 cores.*
- ATH 32-N up to 3 cores.*



For the connection of aluminium conductors steel reinforced

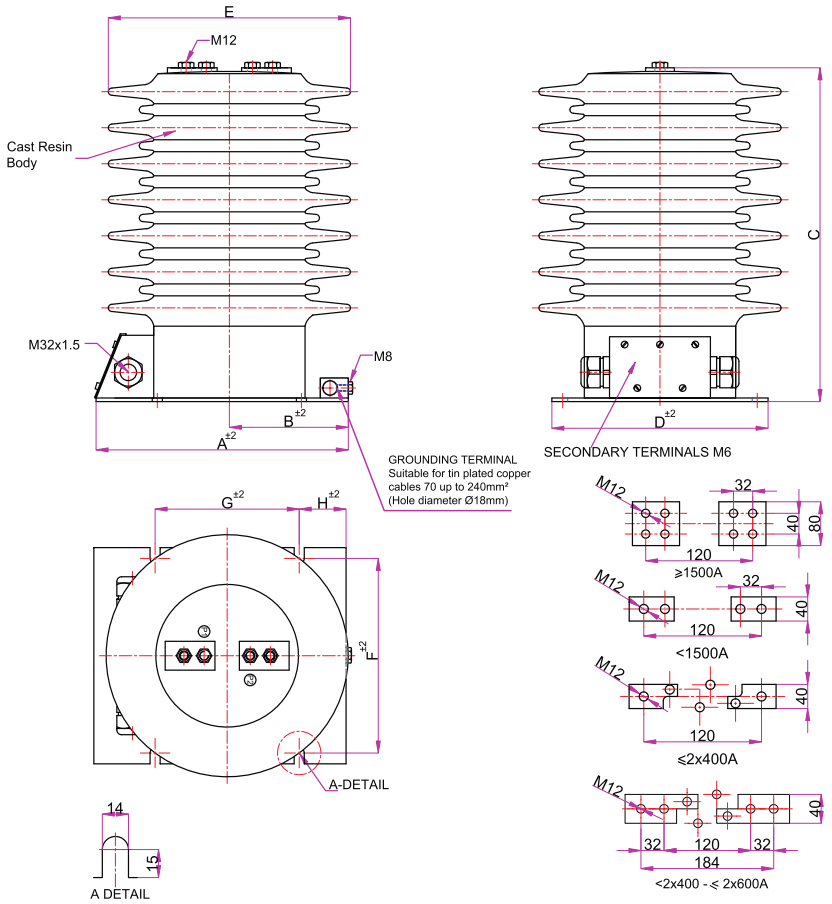
### Technical Data

| Types | ATH 30-N | ATH 32-N |
|---|---|---|
| Operating voltage, Um (kV) | 36** | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5 - 2500 | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | |
| Short-time load (mechanical) (N) | 2500 | |
| Insulation class | E | |
| Min. creepage distance (mm) | 1140 | |
| Altitude (m) | According to the customer requirements | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 47 | 85 |

* *For more cores please contact with ARTECHE for feasibility*
** *For more kV, please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=36kV)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATH 30-N | 350 | 165 | max. 465 | 300 | max. Ø340 | 270 | 200 | 65 |
| ATH 32-N | 390 | 173 | max. 474 | 350 | max. Ø400 | 320 | 250 | 65 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=52kV)

Types:
ATH 52

- Up to 2 cores.*



For the connection of aluminium conductors steel reinforced

## Technical Data

| Types | ATH 52 |
|---|---|
| Operating voltage, Um (kV) | 52 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 95 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 250 |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 5 - 2500 |
| Primary reconnection (A) | 2 x 5 - 2 x 600 |
| Secondary rated current (A) | 1 - 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith |
| Short-time load (mechanical) (N) | 2500 |
| Insulation class | E |
| Min. creepage distance (mm) | 1615 |
| Altitude (m) | According to the customer requirements |
| Standard | According to the customer requirements |
| Weight (approx.) (kg) | 140 |

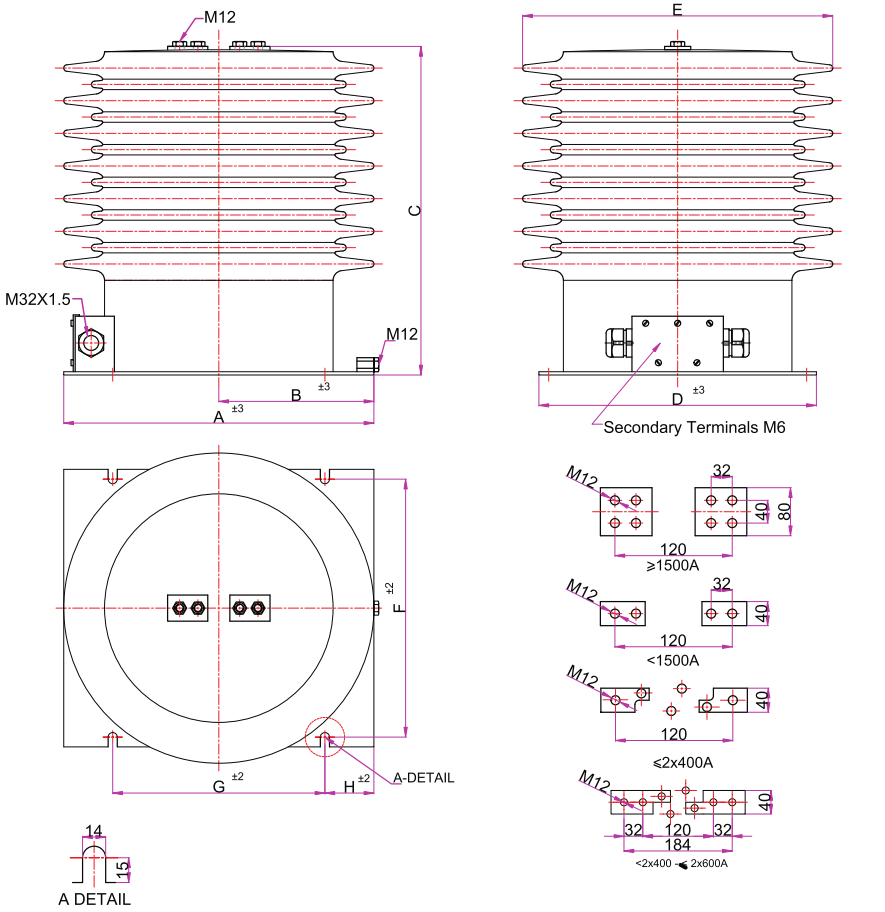
* *For more cores please contact with ARTECHE for feasibility.*





## OUTDOOR DRY TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=52kV )




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATH 52 | 475 | 237,5 | max 510 | 425 | max 480 | 395 | 325 | 75 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=72,5kV)

### Types:

ATH 72-N

| Technical Data | |
|---|---|
| Types | ATH 72-N |
| Operating voltage, Um (kV) | 72,5 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 140 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 325 |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 5 - 2000 |
| Secondary rated current (A) | 1 - 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith |
| Short-time load (mechanical) (N) | 2500 |
| Insulation class | E |
| Min. creepage distance (mm) | 2400 |
| Altitude (m) | According to the customer requirements |
| Standard | According to the customer requirements |
| Weight (approx.) (kg) | 300 |

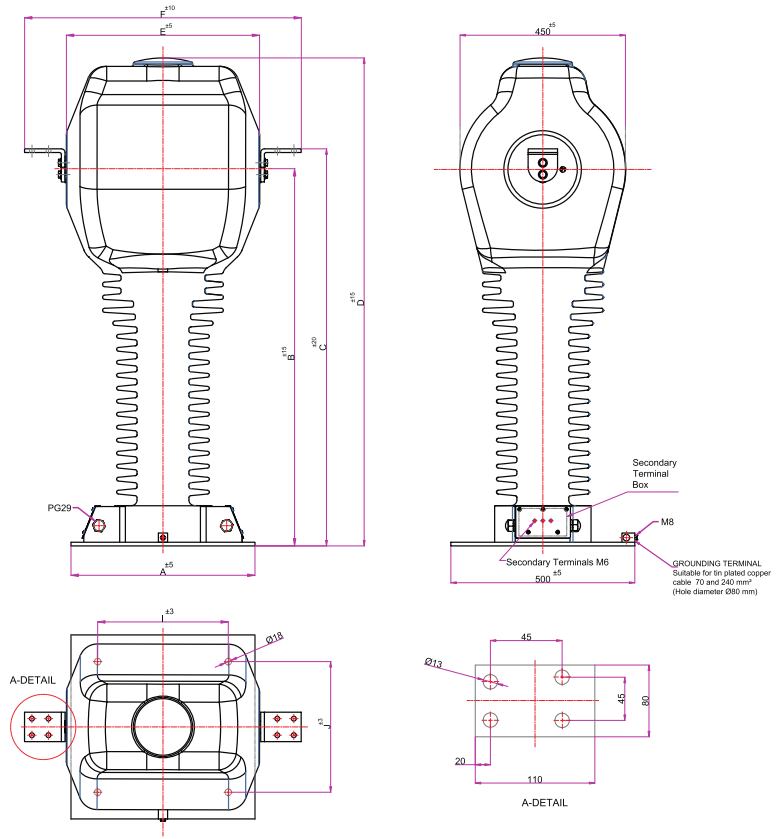
* *For more cores please contact with ARTECHE for feasibility.*



## OUTDOOR DRY TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=72,5 kV)

**ATH 72-N**




| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| ATH 72-N | 500 | 1025 | 1080 | 1325 | 525 | 755 | 500 | 450 | 355 | 355 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE CAST RESIN INSULATED COMBINED TRANSFORMERS (CURRENT & VOLTAGE)

(Um=12kV ..... 36kV)

Types:
ATH 32-C

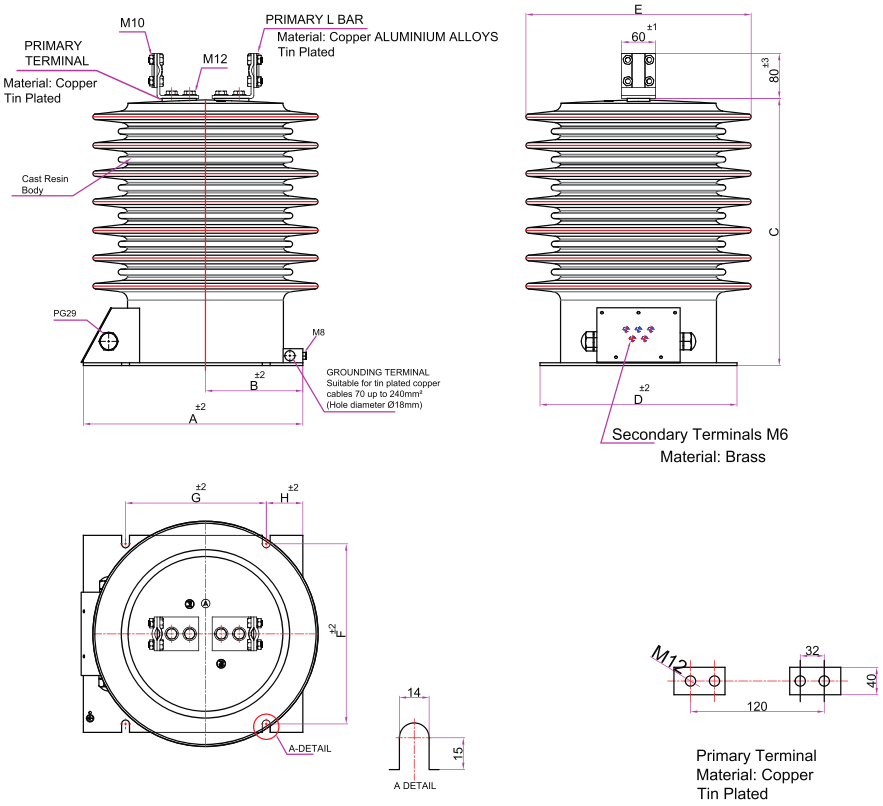
### Technical Data

| Types | ATH 32-C | | | |
|---|---|---|---|---|
| Operating voltage, Um (kV) | 12 | 17,5 | 24 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 28 | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 75 | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | |
| Primary rated current (A) - Rated primary voltage (max)(kv) | 20A-1250A | | 100/√3 110/√3 120/√3 | |
| Secondary rated current (A) - Secondary voltage (V) | 1 - 5 | | | |
| Metering classeses for C.T. | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | |
| Raten burden (max) in class 0,2 (VA) For V.T. | 15 | | | |
| Raten burden (max) in class 0,5 (VA) For V.T. | 25 | | | |
| Raten burden (max) in class 1 (VA) For V.T. | 50 | | | |
| Rated voltage factor (30 sec. or 8h) (Un) (1s) For C.T. (kA) | 1,9 | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 200 x In (25kA) | | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | | |
| Short-time load (mechanical) (N) | 2500 | | | |
| Insulation class | E | | | |
| Min. creepage distance (mm) | 1140 | | | |
| Altitude (m) | According to the customer requirements | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 85 | | | |

* *For more cores please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE CAST RESIN INSULATED COMBINED TRANSFORMERS C.T.'S & V.T.'S TECHNICAL DRAWING

(Um=12kV ..... 36kV)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATH 32-C | 390 | 173 | max 474 | 350 | Ø400 | 320 | 250 | 65 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary Terminal) | 60 | 70 |

- *All dimensions are in mm.*
- *Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
- *Customer designed products are also available.*

# L.V. CURRENT TRANSFORMERS



arteche



## INDOOR KAP TYPE (CABLE TYPE) CAST RESIN INSULATED AND ENCLOSED BY PLASTIC COVER CURRENT TRANSFORMERS

(Um=0,72kV)

Types:
KAP

- Width 35, 55mm up to 1 core.*
- Width 95, 115mm up to 2 cores.*

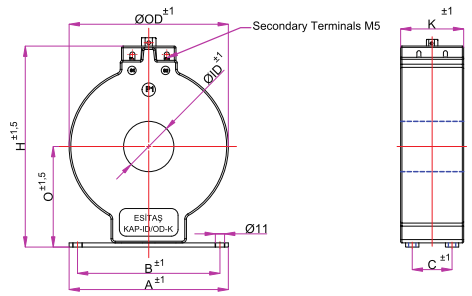
### Technical Data

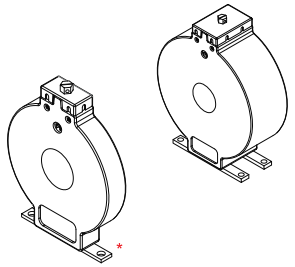
| Types | KAP |
|---|---|
| Operating voltage, Um (kV) | 0,72 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 3 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | - |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 40 ..... 3000 |
| Secondary rated current (A) | 1 - 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P- 10P; Acc. to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 100 |
| Rated dynamic current (Idyn) (kA) | Practically unlimited |
| Insulation class | E |
| Ambient temperature (°C) | -25.....+40** |
| Altitude (m) | 1000 |
| Standard | According to the customer requirements |

* *For more cores, please contact with ARTECHE for feasibility.*
** *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR KAP TYPE (CABLE TYPE) CAST RESIN INSULATED AND ENCLOSED BY PLASTIC COVER C.T.'S TECHNICAL DRAWING

(Um=0,72kV)



* Attention : Transformers which have 35mm height ( K )
There is only one connection plate.

## KAP TYPE ( With Horizontal Mounted Plates) CURRENT TRANSFORMER

As can be seen In the below tables there are various dimensions of KAP Types. Please contact with ARTECHE for feasibility of required transformer's which have different ratio, class, burden and dimensions.

| NO | TYPE | ID | OD | H | K | O | A | B | C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | KAP-40/190-35 | 40 | 190 | 241 | 35 | 119 | 150 | 130 | - |
| 2 | KAP-40/190-55 | 40 | 190 | 241 | 55 | 119 | 150 | 130 | 25 |
| 3 | KAP-40/190-95 | 40 | 190 | 241 | 95 | 119 | 150 | 130 | 40 |
| 4 | KAP-40/190-115 | 40 | 190 | 241 | 115 | 119 | 170 | 150 | 40 |
| 5 | KAP-60/190-35 | 60 | 190 | 241 | 35 | 119 | 150 | 130 | - |
| 6 | KAP-60/190-55 | 60 | 190 | 241 | 55 | 119 | 150 | 130 | 25 |
| 7 | KAP-60/190-95 | 60 | 190 | 241 | 95 | 119 | 150 | 130 | 40 |
| 8 | KAP-60/190-115 | 60 | 190 | 241 | 115 | 119 | 170 | 150 | 40 |
| 9 | KAP-80/190-35 | 80 | 190 | 241 | 35 | 119 | 150 | 130 | - |
| 10 | KAP-80/190-55 | 80 | 190 | 241 | 55 | 119 | 150 | 130 | 25 |
| 11 | KAP-80/190-95 | 80 | 190 | 241 | 95 | 119 | 150 | 130 | 40 |
| 12 | KAP-80/190-115 | 80 | 190 | 241 | 115 | 119 | 170 | 150 | 40 |
| 47 | KAP-100/190-55 | 100 | 190 | 241 | 55 | 119 | 150 | 130 | 25 |
| 48 | KAP-100/190-95 | 100 | 190 | 241 | 95 | 119 | 150 | 130 | 40 |
| 49 | KAP-100/190-115 | 100 | 190 | 241 | 115 | 119 | 170 | 150 | 40 |

| NO | TYPE | ID | OD | H | K | O | A | B | C |
|---|---|---|---|---|---|---|---|---|---|
| 13 | KAP-40/210-35 | 40 | 210 | 261 | 35 | 129 | 150 | 130 | - |
| 14 | KAP-40/210-55 | 40 | 210 | 261 | 55 | 129 | 150 | 130 | 25 |
| 15 | KAP-40/210-95 | 40 | 210 | 261 | 95 | 129 | 150 | 130 | 40 |
| 16 | KAP-40/210-115 | 40 | 210 | 261 | 115 | 129 | 170 | 150 | 40 |
| 17 | KAP-60/210-35 | 60 | 210 | 261 | 35 | 129 | 150 | 130 | - |
| 18 | KAP-60/210-55 | 60 | 210 | 261 | 55 | 129 | 150 | 130 | 25 |
| 19 | KAP-60/210-95 | 60 | 210 | 261 | 95 | 129 | 150 | 130 | 40 |
| 20 | KAP-60/210-115 | 60 | 210 | 261 | 115 | 129 | 170 | 150 | 40 |
| 21 | KAP-80/210-35 | 80 | 210 | 261 | 35 | 129 | 150 | 130 | - |
| 22 | KAP-80/210-55 | 80 | 210 | 261 | 55 | 129 | 150 | 130 | 25 |
| 23 | KAP-80/210-95 | 80 | 210 | 261 | 95 | 129 | 150 | 130 | 40 |
| 24 | KAP-80/210-115 | 80 | 210 | 261 | 115 | 129 | 170 | 150 | 40 |

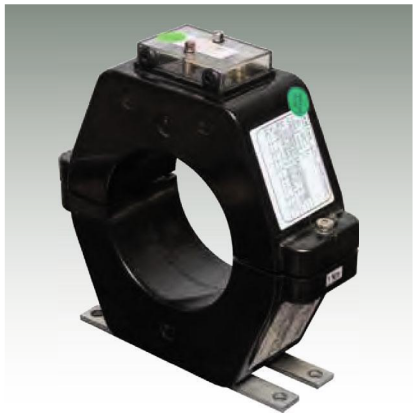
| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

* *All dimensions are in mm.*

| NO | TYPE | ID | OD | H | K | O | A | B | C |
|---|---|---|---|---|---|---|---|---|---|
| 25 | KAP-40/250-35 | 40 | 250 | 301 | 35 | 149 | 150 | 130 | - |
| 26 | KAP-40/250-55 | 40 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 27 | KAP-40/250-95 | 40 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 28 | KAP-40/250-115 | 40 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |
| 29 | KAP-60/250-35 | 60 | 250 | 301 | 35 | 149 | 150 | 130 | - |
| 30 | KAP-60/250-55 | 60 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 31 | KAP-60/250-95 | 60 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 32 | KAP-60/250-115 | 60 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |
| 33 | KAP-80/250-35 | 80 | 250 | 301 | 35 | 149 | 150 | 130 | - |
| 34 | KAP-80/250-55 | 80 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 35 | KAP-80/250-95 | 80 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 36 | KAP-80/250-115 | 80 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |

| NO | TYPE | ID | OD | H | K | O | A | B | C |
|---|---|---|---|---|---|---|---|---|---|
| 37 | KAP-100/250-35 | 100 | 250 | 301 | 35 | 149 | 150 | 130 | - |
| 38 | KAP-100/250-55 | 100 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 39 | KAP-100/250-95 | 100 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 40 | KAP-100/250-115 | 100 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |
| 41 | KAP-120/250-55 | 120 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 42 | KAP-120/250-95 | 120 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 43 | KAP-120/250-115 | 120 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |
| 44 | KAP-150/250-55 | 150 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 45 | KAP-150/250-95 | 150 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 46 | KAP-150/250-115 | 150 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |

| NO | TYPE | ID | OD | H | K | O | A | B | C |
|---|---|---|---|---|---|---|---|---|---|
| 50 | KAP-170/250-55 | 170 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 51 | KAP-170/250-95 | 170 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 52 | KAP-170/250-115 | 170 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |



## INDOOR A-KAP TYPE (SPLIT TYPE) CAST RESIN INSULATED AND ENCLOSED BY PLASTIC COVER CURRENT TRANSFORMERS

(Um=0,72kV)

Types:
A-KAP

- Inside Diameters: Ø80 / Ø100 / Ø120

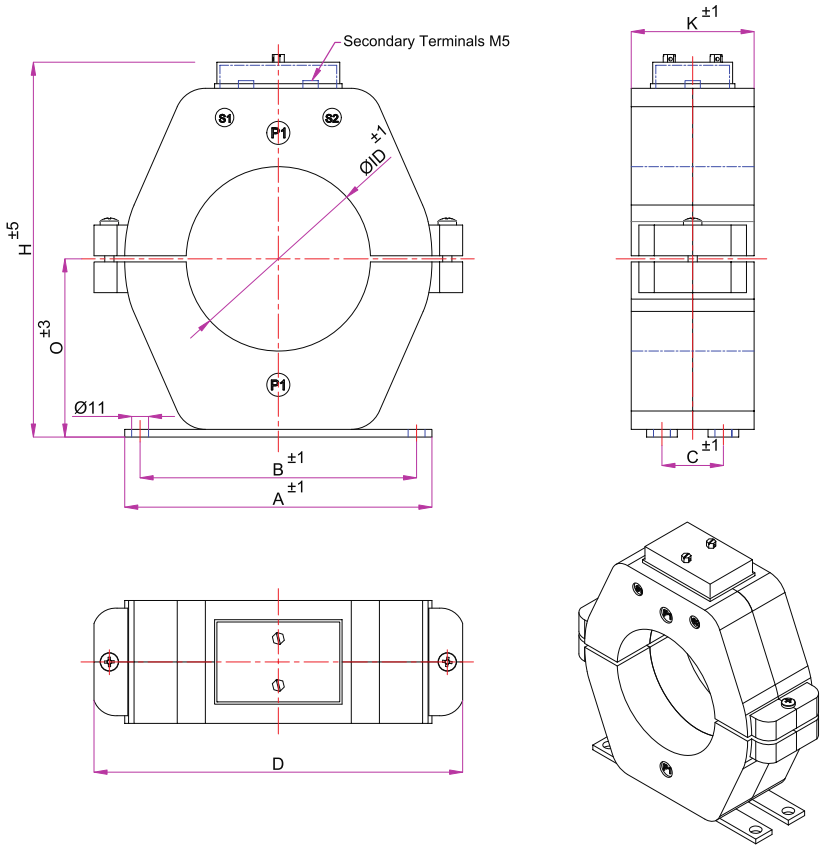
### Technical Data

| Types | A- KAP |
|---|---|
| Operating voltage, Um (kV) | 0,72 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 3 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | - |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 50 ..... 2000 |
| Secondary rated current (A) | 1 - 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P- 10P; Acc. to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 100 |
| Rated dynamic current (Idyn) (kA) | Practically unlimited |
| Insulation class | E |
| Ambient temperature (°C) | -25.....+40** |
| Altitude (m) | 1000 |
| Standard | According to the customer requirements |

*** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR A-KAP TYPE (SPLIT TYPE) CAST RESIN INSULATED AND ENCLOSED BY PLASTIC COVER C.T.'S TECHNICAL DRAWING

(Um=0,72kV)




| Types | Ø | H | K | O | A | B | C | D |
|---|---|---|---|---|---|---|---|---|
| A-KAP | 80/100/120 | 245 | 80 | 116 | 200 | 180 | 40 | max.240 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

** All dimensions are in mm.*

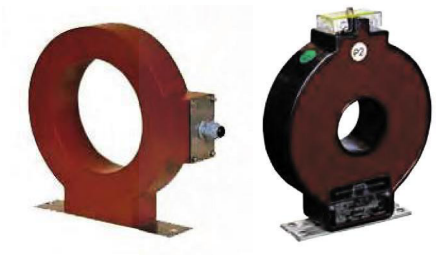
## RING TYPE CURRENT TRANSFORMERS

(Um=0,72kV)

### INDOOR RING TYPES



### OUTDOOR RING TYPES



- Cable type.
- Insulated by cast resin.
- Applicable for measurement and protection purposes.

### BUSHING TYPES



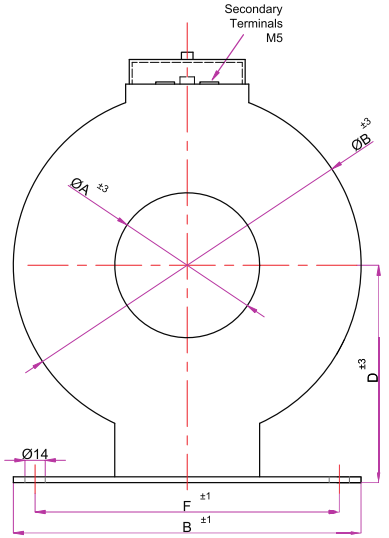


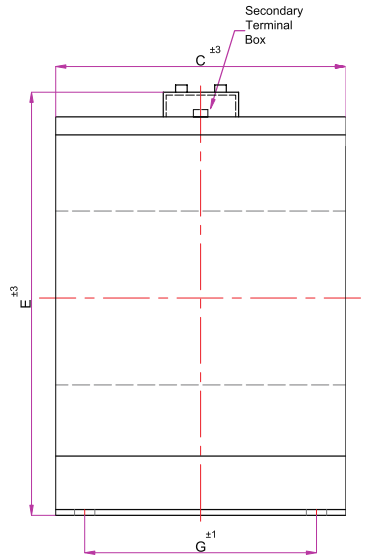
- For power transformers.
- Suitable for operation under oil continuous 130°C.
- Insulated by Insulation paper or Polyester tape.
- Applicable for measurement and protection purposes.



*- Dimensions : According to the customer requirements.*
*- Standards : According to the customer requirements.*
*- Please contact with ARTECHE for feasibility of required transformer's which have different ratio, class, burden and dimensions.*

## C.T.'S TECHNICAL DRAWING









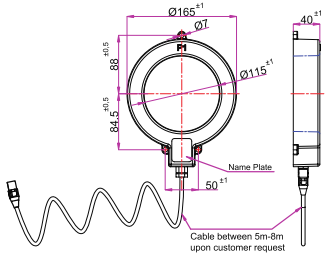
** All dimensions are in mm.*



## INDOOR TYPE LPCT
### (Low Power Current Transformer) (Cable Type)

(Um=0, 72kV)

Types:
LPCT-115




- LPCT-115 is defining low power current transformer with voltage output in compliance with IEC 60044-8.
- It is designed for measuring nominal currents of 5A to 1250 A with ratio 100A / 22,5mV. Thus it should be used with a digital relay which have 100A / 22,5mV input with LPCT.
- Esitas LPCT Set is composed of three LPCT and one digital relay. In case of preffered set without relay, Esitas has to be informed about the relay that will be used.
- The sensor is delivered with cable which is between 5m - 8m upon customer request.

### Advantages :
-Same transformer is usable for nominal currents of 5A to 1250A.
- Accurracy warranty throughout the range :
  • Protection : 5A-40kA ; class 5P
  • Measuring: 100A-1250A; class 0,5 (class 0,75 for 20A, class 1,5 for 5A).

### Simple Assembly :
- Ready for connection secondary cables.
- Simple connection with insulated cable for all types cubicles.

### Safety Operation :
- Openable secondary circuit under load.

**Technical Data**

| Types | LPCT - 115 |
|---|---|
| Standard | IEC 60044-8 |
| Minimum primary curent (A) | 5 |
| Rated primary current (A) | 100 |
| Rated secondary voltage (mV) | 22,5 |
| Rated maximum primary current (A) | 1250 |
| Class of protection | 0,5 (100A - 1250A), 0,75 (20A), 1,5 (5A) |
| Class of measuring | 5P |
| Accuracy limit factor (Kalf) | 150 |
| Rated short - time current (kA / 1s) | 40 |
| Insulation level (kV) | 0,72 / 3 / - |
| Frequency (Hz) | 50 - 60 |
| Burden (Rbr) (kΩ) | 2 |

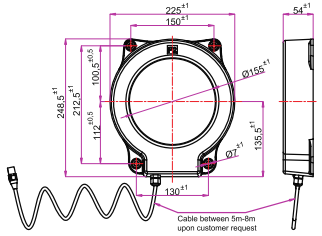




## INDOOR TYPE LPCT
### (Low Power Current Transformer) (Cable Type)

(Um=0, 72kV)

Types:
LPCT-160




- LPCT-160 is defining low power current transformer with voltage output in compliance with IEC 60044-8.
- It is designed for measuring nominal currents of 5A to 2000 A with ratio 100A / 22,5mV. Thus it should be used with a digital relay which have 100A / 22,5mV input with LPCT.
- Esitas LPCT Set is composed of three LPCT and one digital relay. In case of preffered set without relay, Esitas has to be informed about the relay that will be used.
- The sensor is delivered with cable which is between 5m - 8m upon customer request.

### Advantages :
-Same transformer is usable for nominal currents of 5A to 2000A.
- Accurracy warranty throughout the range :
  • Protection : 5A-40kA ; class 5P
  • Measuring: 100A-2000A; class 0,5 (class 0,75 for 20A, class 1,5 for 5A).

### Simple Assembly :
- Ready for connection secondary cables.
- Simple connection with insulated cable for all types cubicles.

### Safety Operation :
- Openable secondary circuit under load.

**Technical Data**

| Types | LPCT - 160 |
|---|---|
| Standard | 60044-8 |
| Minimum primary curent (A) | 5 |
| Rated primary current (A) | 100 |
| Rated secondary voltage (mV) | 22,5 |
| Rated maximum primary current (A) | 2000 |
| Class of protection | 0,5 (100A - 2000A), 0,75 (20A), 1,5 (5A) |
| Class of measuring | 5P |
| Accuracy limit factor (Kalf) | 400 |
| Rated short - time current (kA / 1s) | 40 |
| Insulation level (kV) | 0,72 / 3 / - |
| Frequency (Hz) | 50 - 60 |
| Burden (Rbr) (kΩ) | 2 |

# M.V. VOLTAGE TRANSFORMERS



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## Voltage Transformers

An instrument transformer in which the secondary voltage, in normal conditions of use, is substantially proportional to the primary voltage and differs in phase from it by an angle which is approximately zero for an appropriate direction of the connections.

It isolates the primary side rated voltage from the connected instruments and protection circuits and convert the primary voltage into a measurable secondary voltage, which is true in magnitude and phase.

## Primary Winding

The winding to which the voltage to be transformed is applied.

## Secondary Winding

The winding, which supplies the voltage circuits of measuring instruments, meters, relays or similar apparatus.

## Rated Primary Voltage

The value of the primary voltage, which appears in the designation of the transformer and on which its performance is based.

## Rated Secondary Voltage

The value of the secondary voltage, which appears in the designation of the transformer and on which its performance is based.

## Rated Transformation Ratio

The ratio of the rated primary to the rated secondary voltage.

## Voltage Error (Ratio Error)

The error which a transformer introduces into the measurement of a voltage and which arises when the actual transformation ratio is not equal to the transformation ratio.
The voltage error, expressed in per cent, is given by the formula:

$$\text{Voltage Error } \% = \frac{Kn\ Us - Up}{Up} \times 100$$

Where
Kn is the rated transformation ratio;
Up is the actual primary voltage;
Us is the actual secondary voltage when Up is applied under the conditions of measurement.

## Accuracy Class

A designation assigned to a voltage transformer, the errors of which remain within specified limits under prescribed conditions of use.

## Burden

The admittance of the secondary circuit expressed in siemens and power factor (lagging or leading)

## Rated Burden

The value of the burden on which the accuracy requirements are based on.

## Rated Output

The value of apparent power (in voltamperes at a specified power - factor), which the transformer is intended to supply to the secondary circuit at the rated secondary voltage and with rated burden, connected to it.

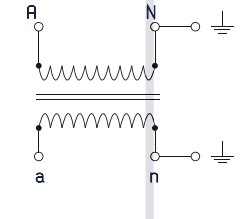
## Rated Insulation Level

The combination of voltage values which characterizes the isolation of a transformer with regard to its capability to withstand dielectric stresses.

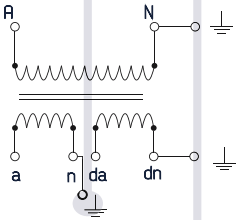
## Rated Voltage Factor

The multiplying factor to be applied to the rated primary voltage to determine the maximum voltage at which a transformer must comply with the relevant thermal requirements for a specified time and with the relevant accuracy requirements.

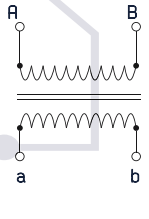
## CONNECTION DIAGRAMS




Single Pole insulated voltage transformer (e.g. 11000/√3: 100/√3V)



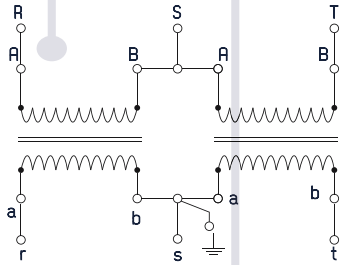

Single Pole insulated voltage transformer with an open delta winding (e.g. 11000/√3: 100/√3V - 100/3V)




Double pole insulated voltage transformer (e.g. 11000: 100V)

It can be required for multi secondary winding and changeable ratios.

## V-Connection of Two Double Pole Insulated Voltage Transformers




## Safety Operation Conditions for Voltage Transformers

-When the Secondary terminals are connected to the measuring or protection devices, one of the terminals should be earthed for safety as seen in Diagram-1.hh

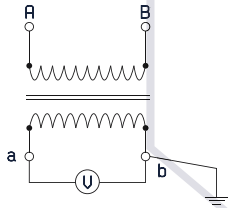
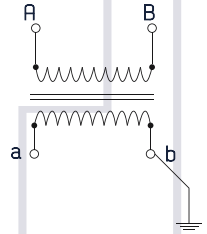



Diagram-1

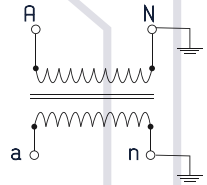
- The base plate must be earthed
- The secondary circuits must not be short-circuited during operation. Otherwise the voltage transformers will be thermally destroyed.
- If any of the secondary windings of a voltage transformer will not be used, then it must be left open with one of the terminals connected to the earth as seen in Diagram-2.

Diagram-2




- For the single phase transformers, the neutral terminal of the primary "N" must be earthed in the earthed (neutral) systems as seen in Diagram-3.

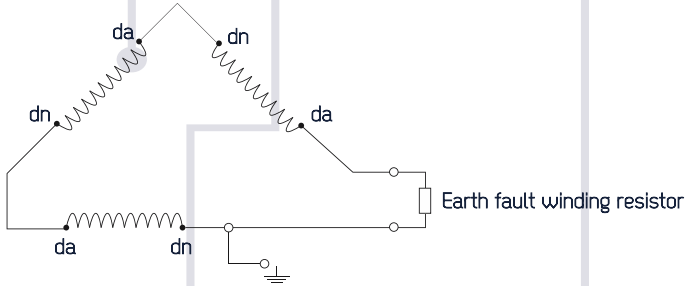
Diagram-3




## Other Important Points and Notes

When using single pole insulated inductive voltage transformers it is very important to understand that, when a circuit is being closed or during the decaying period of an earth fault ferroresonance may occur. Ferroresonance can lead to the overheating and thermal destruction of the voltage transformer or high levels of voltages may be induced. In general, ferroresonance can be eliminated by the use of an appropriate resistor placed as a burden in open-delta circuit formed by three voltage transformers open-delta windings. The open-delta circuit must always be earthed only at one point as seen in Diagram-4. The open-delta connection can also be used for earth-fault monitoring with appropriate devices.

Diagram-4

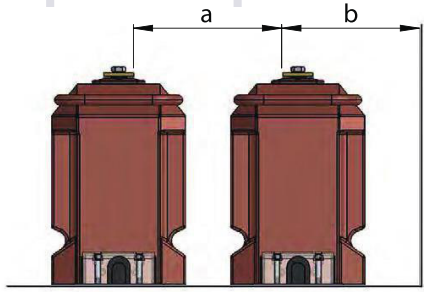



As the number of cable systems is increasing in the energy distribution systems, the protection of voltage transformers have become very important for the uninterrupted operation of the system without any failure and/or down time. For that reason, ARTECHE is always recommending the use of open-delta windings in single phase inductive voltage transformers.



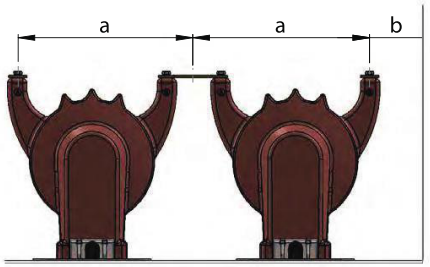
## M.V. VOLTAGE TRANSFORMERS CONNECTION CLEARENCES

SINGLE PHASE VOLTAGE TRANSFORMERS




| INSULATION LEVEL | a minimum | b minimum |
|---|---|---|
| 12kV | 100mm | 110mm |
| 24kV | 190mm | 210mm |
| 36kV | 305mm | 325mm |

PHASE TO PHASE VOLTAGE TRANSFORMERS




| INSULATION LEVEL | a minimum | b minimum |
|---|---|---|
| 12kV | 185mm | 120mm |
| 24kV | 240mm | 220mm |
| 36kV | 340mm | 325mm |



## INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....24kV BLOCK TYPES)

Types:
VTB 10-S
VTB 10-K
VTB 20
VTB 20-K

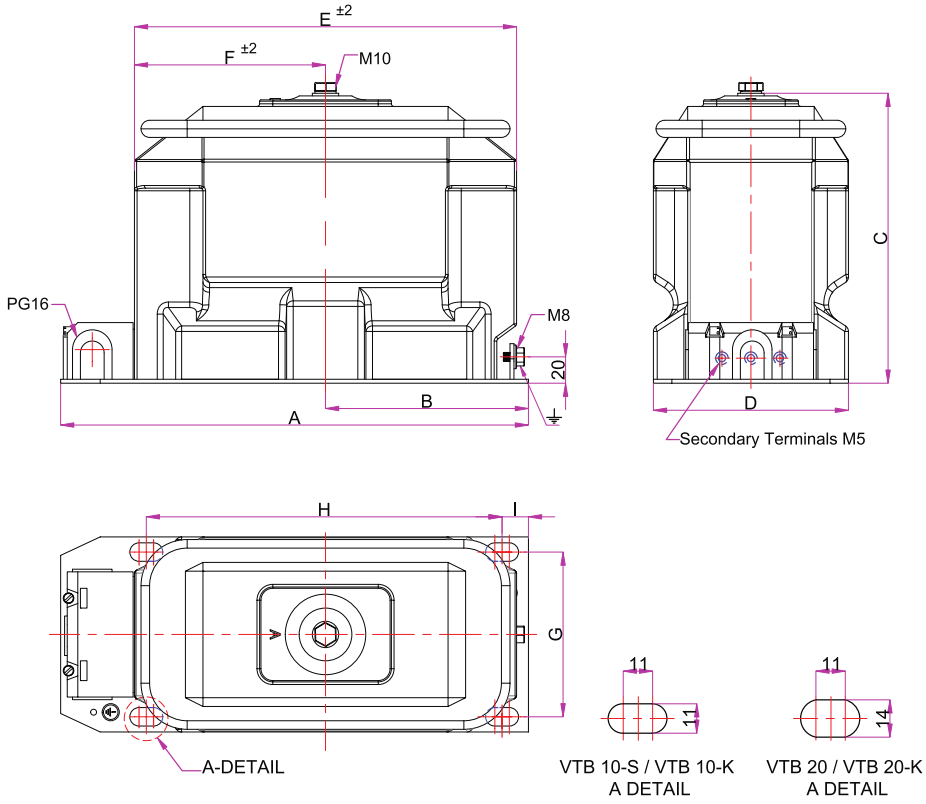
### Technical Data

| Types | VTB 10-S | | VTB 10-K | | VTB 20 | | VTB 20-K |
|---|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 17,5 | | 24** |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 38 | | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 95 | | 125 |
| Rated frequency (Hz) | 50-60 | | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | | 24/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | 50 | | |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | 120 | | |
| Rated burden (max.) in class 1 (VA) | 200 | | | | 250 | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | | |
| Insulation class | E | | | | | | |
| Ambient temperature (°C) | -25.....+40* | | | | | | |
| Altitude (m) | 1000 | | | | | | |
| Standard | According to the customer requirements | | | | | | |
| Weight (approx.) (kg) | 27 | | | | 37 | | |

* It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.
** For more kV, please contact with ARTECHE for feasibility.

## INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....24kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| VTB 10-S | 355 | 155 | 220 | 148 | 290 | 145 | 125 | 270 | 20 |
| VTB 10-K | 355 | 155 | 220 | 148 | 290 | 145 | 125 | 270 | 20 |
| VTB 20 | 355 | 155 | 280 | 178 | 290 | 145 | 150 | 280 | 20 |
| VTB 20-K | 355 | 155 | 280 | 178 | 290 | 145 | 150 | 280 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=36kV Block Types)

Types:
VTB 30-K

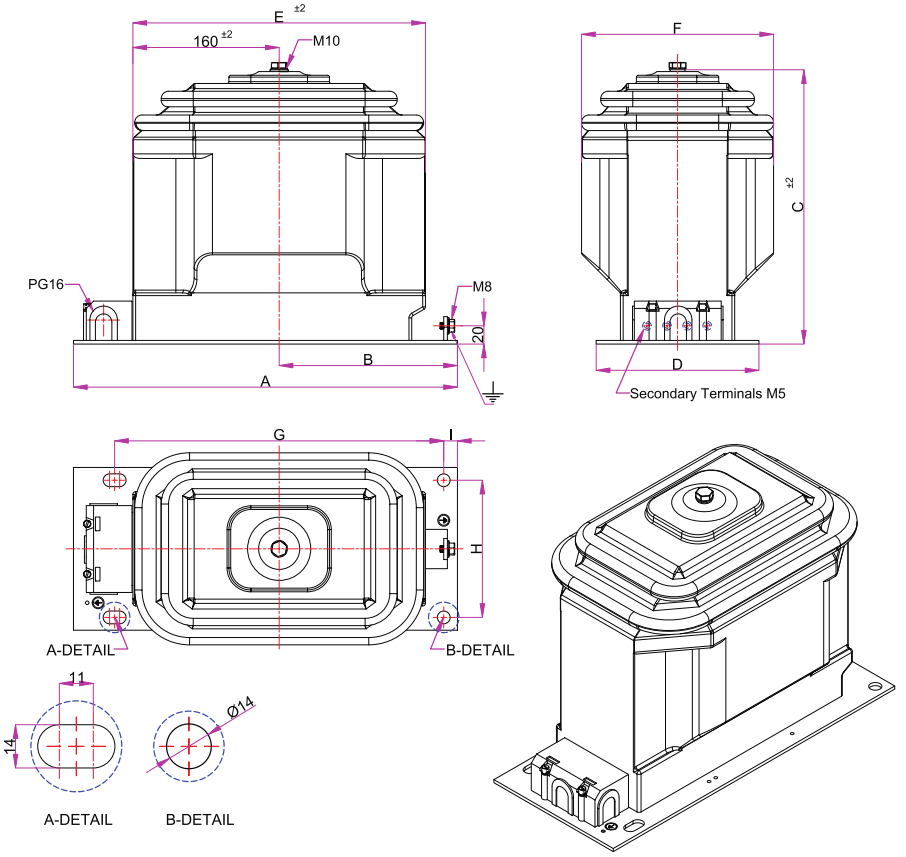
### Technical Data

| Types | VTB 30-K | | | | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 36** | | | | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | | | | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | | | | | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 36/√3 | | | | | |
| Secondary voltage (V) | 100/√3 | 100/3 | 110/√3 | 110/3 | 120/√3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 50 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 120 | | | | | |
| Rated burden (max.) in class 1 (VA) | 250 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25.....+40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 46 | | | | | |

* *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*
** *For more kV, please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=36kV Block Types)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| VTB 30-K | 420 | 195 | 300 | 178 | 320 | 210 | 360 | 150 | 15 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

- *All dimensions are in mm.*
- *Tolerances are according to DIN 7168-g when not specified.*
- *Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
- *Customer designed products are also available.*



## INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=17.5kV ..... 36kV)

Types:
VT 20-B
VTB 30
VTB 30-1
VTB 30-200

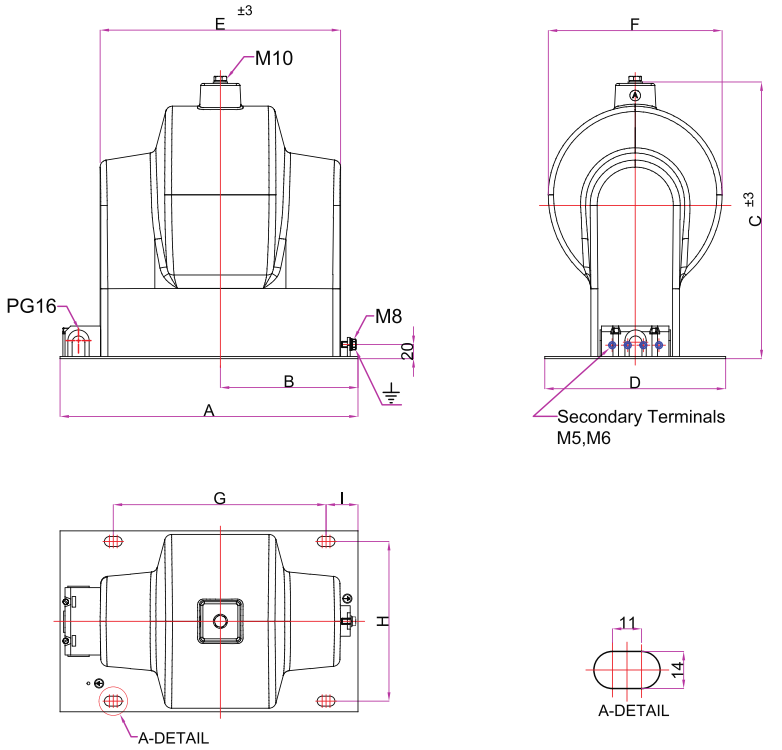
### Technical Data

| Types | VT 20-B | | VTB 30 | VTB 30-1 | VTB 30-200 |
|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 17,5 | 24 | 36 | | 36** |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | 50 | 70 | | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | 125 | 170 | | 200 |
| Rated frequency (Hz) | 50-60 | | | | |
| Rated primary voltage (max.) (kV) | 17,5/√3 | 24/√3 | 36/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 & Suitable for 220V winding | | |
| Rated burden (max.) in class 0,2 (VA) | 50 | | | | |
| Rated burden (max.) in class 0,5 (VA) | 150 | | | | |
| Rated burden (max.) in class 1 (VA) | 300 | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | |
| Rated burden for 220V winding (VA) | 800 | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | |
| Insulation class | E | | | | |
| Ambient temperature (°C) | -25.....+40* | | | | |
| Altitude (m) | 1000 | | | | |
| Standard | According to the customer requirements | | | | |
| Weight (approx.) (kg) | 45 | | 50-60 | | 62 |

* It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.
** For more kV, please contact with ARTECHE for feasibility.

## INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=17.5kV ..... 36kV)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| VTB 30 | 420 | 195 | 390 | 255 | 338 | - | 300 | 225 | 45 |
| VTB 30-1 | 420 | 195 | 390 | 255 | 338 | - | 300 | 225 | 45 |
| VT 20-B | 440 | 205 | 300 | 200 | 360 | 215 | 270 | 170 | 70 |
| VTB 30-200 | 420 | 195 | 445 | 255 | - | - | 300 | 225 | 45 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....17,5kV)

Types:
ES 17 V3

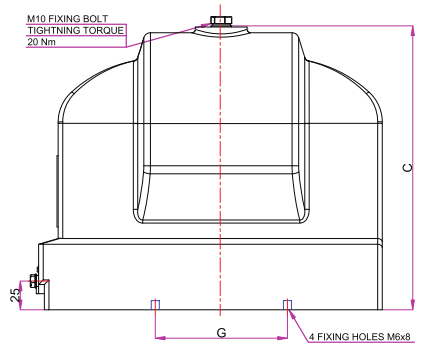
### Technical Data

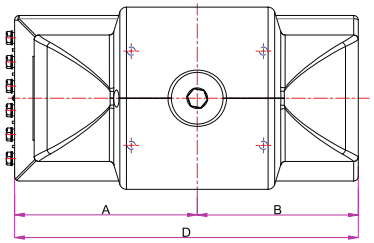
| Types | ES 17 V3 | | | | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 3,6/√3 | | 7,2/√3 | | 12/√3 | 17/√3 |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | 20 |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | | 60 |
| Rated burden (max.) in class 1 (VA) | 200 | | | | | 120 |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 22 | | | | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

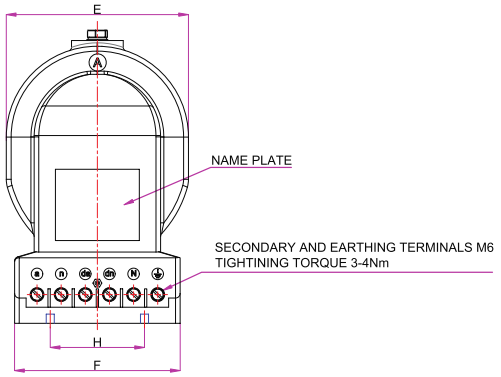
## INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....17,5kV)




Highest system voltage : 7,2-12-17,5kV




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ES 17 V3 | 158 | 139 | 455 | 297 | 158 | 144 | 115 | 82 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS

(Um=7,2kV..... 24kV)

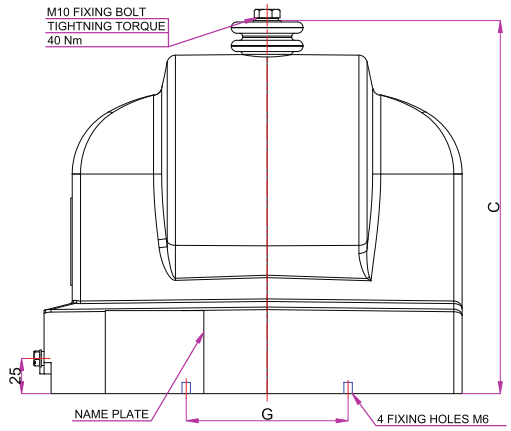
**Types:**
ES 24 V2-B

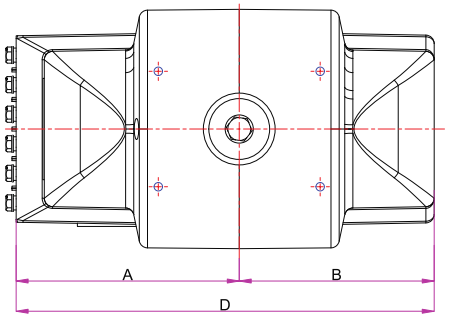
| Technical Data | Produced only in Indonesia Factory | | | | | |
|---|---|---|---|---|---|---|
| Types | ES 24 V2-B | | | | | |
| Operating voltage, Um (kV) | 7,2 | 12 | 17,5 | 24 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 20 | 28 | 38 | 50 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 60 | 75 | 95 | 125 | | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 7,2/√3 | 12/√3 | 17,5/√3 | 24/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 75 | | | | | |
| Rated burden (max.) in class 1 (VA) | 150 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 26 | | | | | |

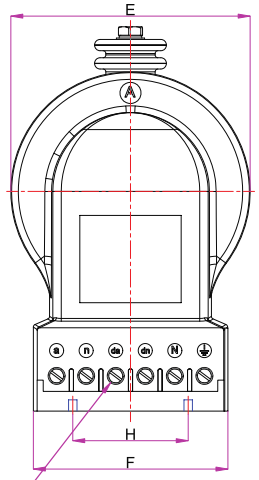
** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=7,2kV..... 24kV)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ES 24 V2-B | 158,5 | 138,5 | 265 | 297 | 170 | 138 | 115 | 82 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS

(Um=24kV)

**Types:**
ES 24 V1

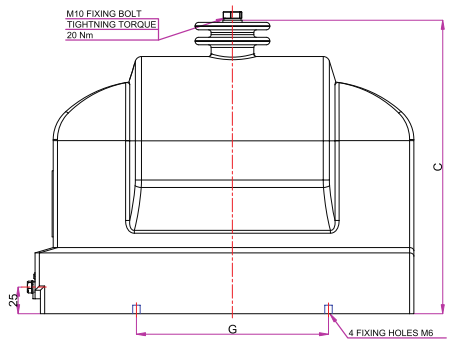
### Technical Data

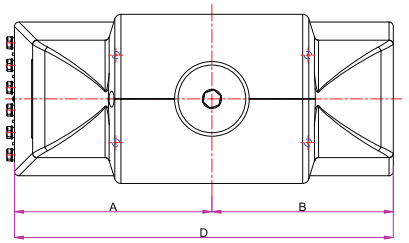
| Types | ES 24 V1 | | | | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 24 | | | | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 50 | | | | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 125 | | | | | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 24/√3 | | | | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | | |
| Rated burden (max.) in class 1 (VA) | 200 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 30 | | | | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

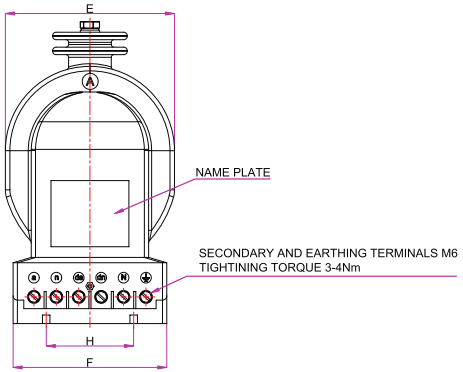
## INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=24kV)




Highest system voltage : 24kV




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ES 24 V1 | 185 | 170 | 275 | 355 | 158 | 144 | 180 | 82 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SINGLE PHASE CAST RESIN INSULATED NARROW TYPE VOLTAGE TRANSFORMERS

(Um=7,2kV.....24kV)

**Types:**
VTU-24

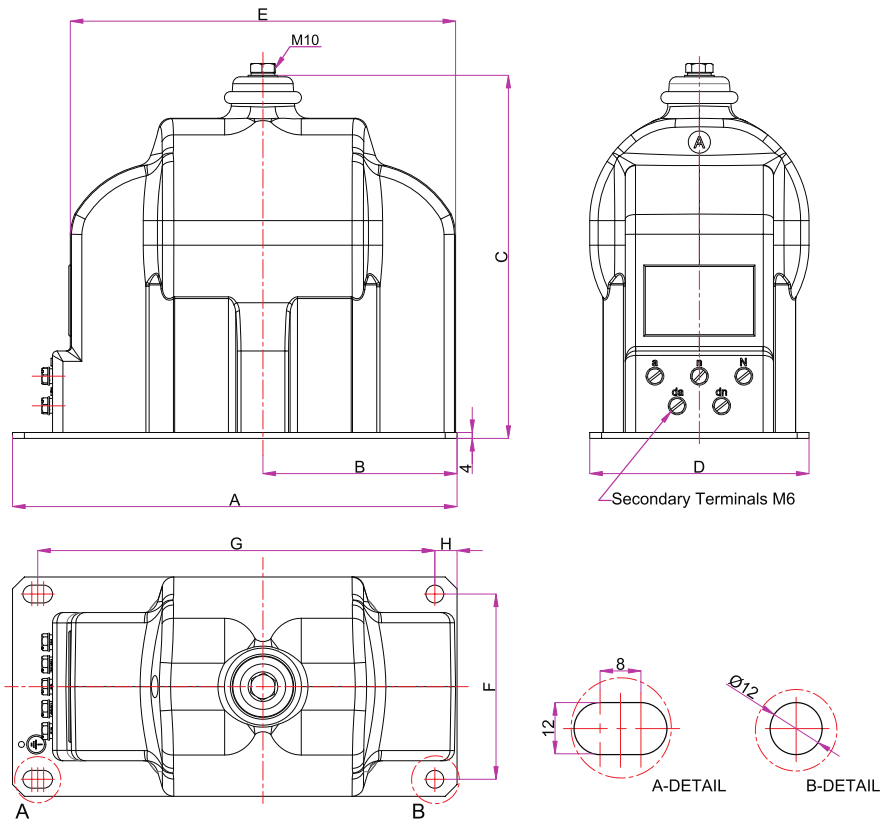
### Technical Data

| Types | VTU-24 | | | | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 7,2 | 12 | 17,5 | 24 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 20 | 28 | 38 | 50 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 60 | 75 | 95 | 125 | | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 7,2/√3 | 12/√3 | 17,5/√3 | 24/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 75 | | | | | |
| Rated burden (max.) in class 1 (VA) | 150 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 28 | | | | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE CAST RESIN INSULATED NARROW TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=7,2kV.....24kV)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| VTU-24 | 300 | 131 | 241 | 148 | 260 | 125 | 268 | 15 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 4 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR PHASE TO PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....24kV BLOCK TYPES)

Types:
2VTB 10
2VTB 20

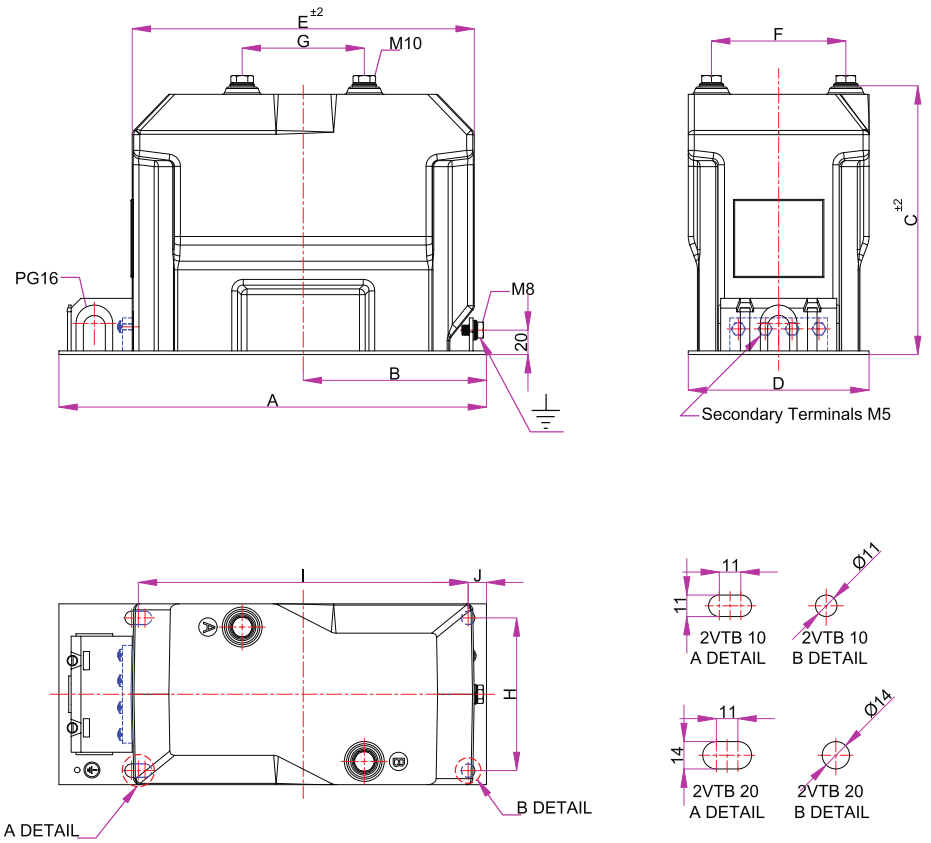
### Technical Data

| Types | 2VTB 10 | | | 2VTB 20 | |
|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 |
| Rated frequency (Hz) | 50-60 | | | | |
| Rated primary voltage (max.) (kV) | 12 | | | 24 | |
| Secondary voltage (V) | 100 | | 110 | 120 | |
| Rated burden (max.) in class 0,2 (VA) | 15 | | | | |
| Rated burden (max.) in class 0,5 (VA) | 60 | | | | |
| Rated burden (max.) in class 1 (VA) | 100 | | | | |
| Rated voltage factor (Cont.) (Un) | 1,2 | | | | |
| Insulation class | E | | | | |
| Ambient temperature (°C) | -25.....+40* | | | | |
| Altitude (m) | 1000 | | | | |
| Standard | According to the customer requirements | | | | |
| Weight (approx.) (kg) | 28 | | | 37 | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR PHASE TO PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....24kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 2VTB 10 | 350 | 150 | 220 | 148 | 280 | 110 | 100 | 125 | 270 | 15 |
| 2VTB 20 | 355 | 155 | 280 | 178 | 290 | 130 | 165 | 150 | 280 | 15 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR PHASE TO PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=17.5kV ..... 36kV LARGE TYPES)

Types:
2VT 20-B
2VTB 30
2VT 40-200

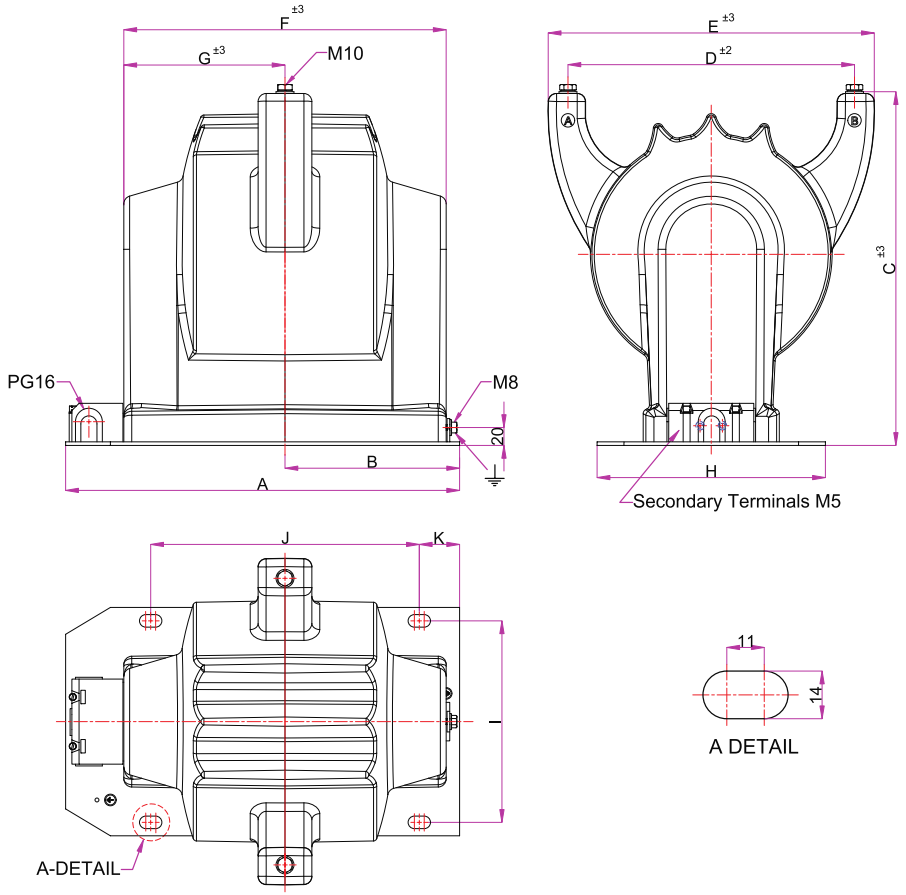
### Technical Data

| Types | 2VT 20-B | | 2VTB 30 | 2VT 40-200 |
|---|---|---|---|---|
| Operating voltage, Um (kV) | 17,5 | 24 | 36 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | 50 | 70 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | 125 | 170 | 200 |
| Rated frequency (Hz) | 50-60 | | | |
| Rated primary voltage (max.) (kV) | | 24 | 36 | 36 |
| Secondary voltage (V) | 100 - 110 - 120 & Suitable for 220V winding | | | |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | |
| Rated burden (max.) in class 0,5 (VA) | 120 | | | |
| Rated burden (max.) in class 1 (VA) | 200 | | | |
| Rated burden for 220V winding (VA) | 800 | | | |
| Rated voltage factor (Cont.) (Un) | 1,2 | | | |
| Insulation class | E | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | | 48 | 65 | 73 |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR PHASE TO PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

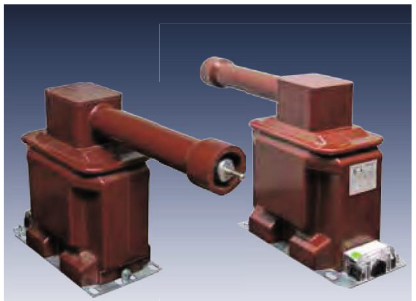
(Um=17.5kV ..... 36kV LARGE TYPES)




| Types | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2VT 20-B | 440 | 205 | 300 | 210 | 250 | 360 | 180 | 200 | 170 | 270 | 70 |
| 2VTB 30 | 440 | 195 | 395 | 320 | 363 | 360 | 180 | 255 | 225 | 300 | 45 |
| 2VT 40-200 | 480 | 220 | 445 | 350 | 390 | 370 | 185 | 255 | 225 | 300 | 70 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV BLOCK TYPES)

Types:
VTB 10-KF1
VTB 20-KF1
VTB 30-KF1

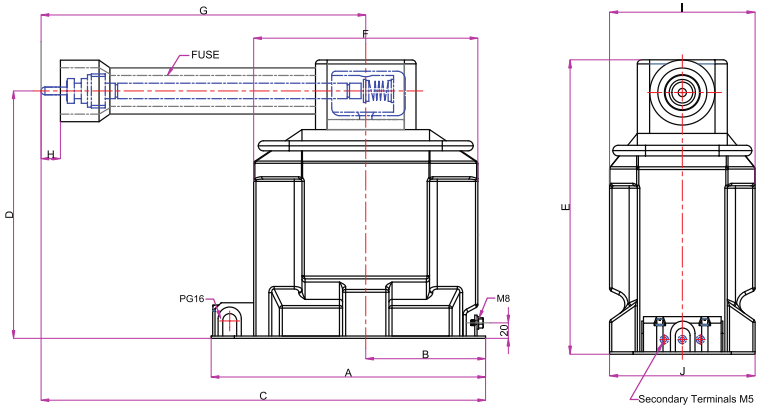
### Technical Data

| Types | VTB 10-KF1 | | | | VTB 20-KF1 | | | | VTB 30-KF1 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 17,5 | 24** | | | 36** | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 38 | 50 | | | 70 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 95 | 125 | | | 170 | |
| Rated frequency (Hz) | 50-60 | | | | | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | | 24/√3 | | | | 36/√3 | |
| Secondary voltage (V) | 100/√3 | | 110/√3 | | 120/√3 | | 100/3 | | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | 50 | | | | 50 | |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | 120 | | | | 120 | |
| Rated burden (max.) in class 1 (VA) | 200 | | | | 250 | | | | 250 | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | | | | | |
| Rated voltage factor (30 sec. or 8 h) (Un) | 1,9 | | | | | | | | | |
| Insulation class | E | | | | | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | | | | | |
| Altitude (m) | 1000 | | | | | | | | | |
| Standard | According to the customer requirements | | | | | | | | | |
| Weight (approx.) (kg) | 30 | | | | 40 | | | | 55 | |

* *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*
** *For more kV, please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

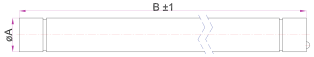
(Um=3,6kV.....36kV BLOCK TYPES)




| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |

| Types | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VTB 10-KF1 | 355 | 155 | 492 | 260 | 299 | 290 | 336 | 25 | 148 | 148 | 125 | 270 | 20 |
| VTB 20-KF1 | 355 | 155 | 575 | 318 | 361 | 290 | 420 | 25 | 178 | 178 | 150 | 280 | 20 |
| VTB 30-KF1 | 395 | 175 | 688 | 364 | 421,5 | 320 | 513 | 75 | 210 | 210 | 180 | 300 | 15 |

Protection Fuses For Voltage Transformer




| NO | V.T. Types | Rated Currents (A) | Rated Voltage (Un) | ØA | B (mm) |
|---|---|---|---|---|---|
| 1 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 7,2 kV | 20 | 190 |
| 2 | | 1 Amper | | | |
| 3 | | 2 Amper | | | |
| 4 | | 3,15 Amper | | | |
| 5 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 12 kV | | 254 |
| 6 | | 1 Amper | | | |
| 7 | | 2 Amper | | | |
| 8 | | 3,15 Amper | | | |
| 9 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 15,5 kV | | |
| 10 | | 1 Amper | | | |
| 11 | | 2 Amper | | | |
| 12 | | 3,15 Amper | | | |
| 13 | VTB 20-KF1 or KF2<br>VTB 30-KF1 or KF2 | 0,5 Amper | 25,5 kV | | 340 |
| 14 | | 1 Amper | | | |
| 15 | | 2 Amper | | | |
| 16 | VTB 30-KF1 or KF2 | 1 Amper | 36 kV | 36 | 400 |
| 17 | | 2 Amper | | | |

- *All dimensions are in mm.*
- *Tolerances are according to DIN 7168-g when not specified.*
- *Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
- *Customer designed products are also available.*



## INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV BLOCK TYPES)

**Types:**
VTB 10-KF2
VTB 10-KFA2
VTB 20-KF2
VTB 30-KF2

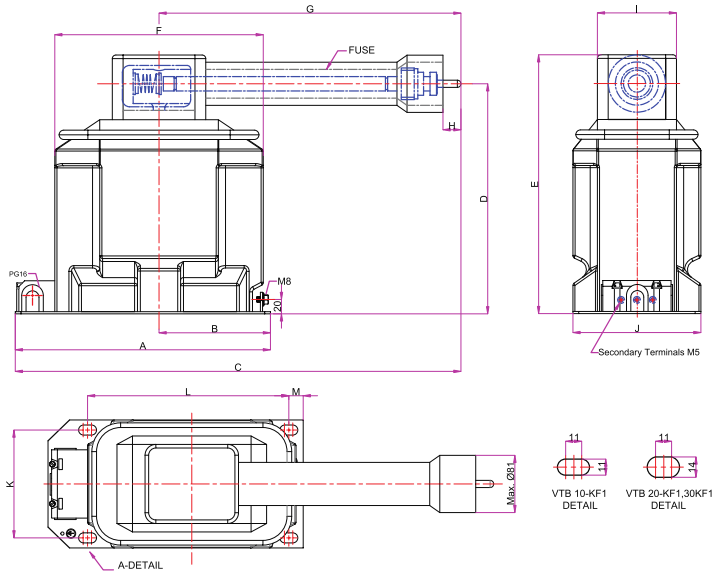
### Technical Data

| Types | VTB 10-KF2 / KFA2 | | | | VTB 20-KF2 | | | | VTB 30-KF2 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 17,5 | 24** | | | 36** | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 38 | 50 | | | 70 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 95 | 125 | | | 170 | |
| Rated frequency (Hz) | 50-60 | | | | | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | | 24/√3 | | | | 36/√3 | |
| Secondary voltage (V) | 100/√3 | | 110/√3 | | 120/√3 | | 100/3 | | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | 50 | | | | 50 | |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | 120 | | | | 120 | |
| Rated burden (max.) in class 1 (VA) | 200 | | | | 250 | | | | 250 | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | | | | | |
| Rated voltage factor (30 sec. or 8 h) (Un) | 1,9 | | | | | | | | | |
| Insulation class | E | | | | | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | | | | | |
| Altitude (m) | 1000 | | | | | | | | | |
| Standard | According to the customer requirements | | | | | | | | | |
| Weight (approx.) (kg) | 30 | | | | 40 | | | | 55 | |

* *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*
** *For more kV, please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

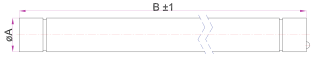
(Um=3,6kV.....36kV BLOCK TYPES)




| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |

| Types | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VTB 10-KFA2 | 350 | 160 | 520 | 285 | 315 | - | - | 25 | - | 160 | 120 | 270 | - |
| VTB 10-KF2 | 355 | 155 | 536 | 260 | 299 | 290 | 336 | 25 | 148 | 148 | 125 | 270 | 20 |
| VTB 20-KF2 | 355 | 155 | 575 | 318 | 361 | 290 | 420 | 25 | 178 | 178 | 150 | 280 | 20 |
| VTB 30-KF2 | 395 | 175 | 733 | 364 | 421,5 | 320 | 513 | 75 | 210 | 210 | 180 | 300 | 15 |

Protection Fuses For Voltage Transformer




| NO | V.T. Types | Rated Currents (A) | Rated Voltage (Un) | Ø A | B (mm) |
|---|---|---|---|---|---|
| 1 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 7,2 kV | 20 | 190 |
| 2 | | 1 Amper | | | |
| 3 | | 2 Amper | | | |
| 4 | | 3,15 Amper | | | |
| 5 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 12 kV | | 254 |
| 6 | | 1 Amper | | | |
| 7 | | 2 Amper | | | |
| 8 | | 3,15 Amper | | | |
| 9 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 15,5 kV | | |
| 10 | | 1 Amper | | | |
| 11 | | 2 Amper | | | |
| 12 | | 3,15 Amper | | | |
| 13 | VTB 20-KF1 or KF2<br>VTB 30-KF1 or KF2 | 0,5 Amper | 25,5 kV | | 340 |
| 14 | | 1 Amper | | | |
| 15 | | 2 Amper | | | |
| 16 | VTB 30-KF1 or KF2 | 1 Amper | 36 kV | 36 | 400 |
| 17 | | 2 Amper | | | |

- *All dimensions are in mm.*
- *Tolerances are according to DIN 7168-g when not specified.*
- *Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
- *Customer designed products are also available.*



## INDOOR SINGLE PHASE CAST RESIN INSULATED WITH STRIKER PIN SIGNALLING BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....24kV BLOCK TYPES)

**Types:**
VTB 10-KFP
VTB 20-KFP

### Technical Data

| Types | VTB 10-KFP | | | VTB 20-KFP | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | |
| Rated impulse test voltage (1.2/50 μs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | 24/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | 50 | | |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | 120 | | |
| Rated burden (max.) in class 1 (VA) | 200 | | | 250 | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8 h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 32 | | | 42 | | |

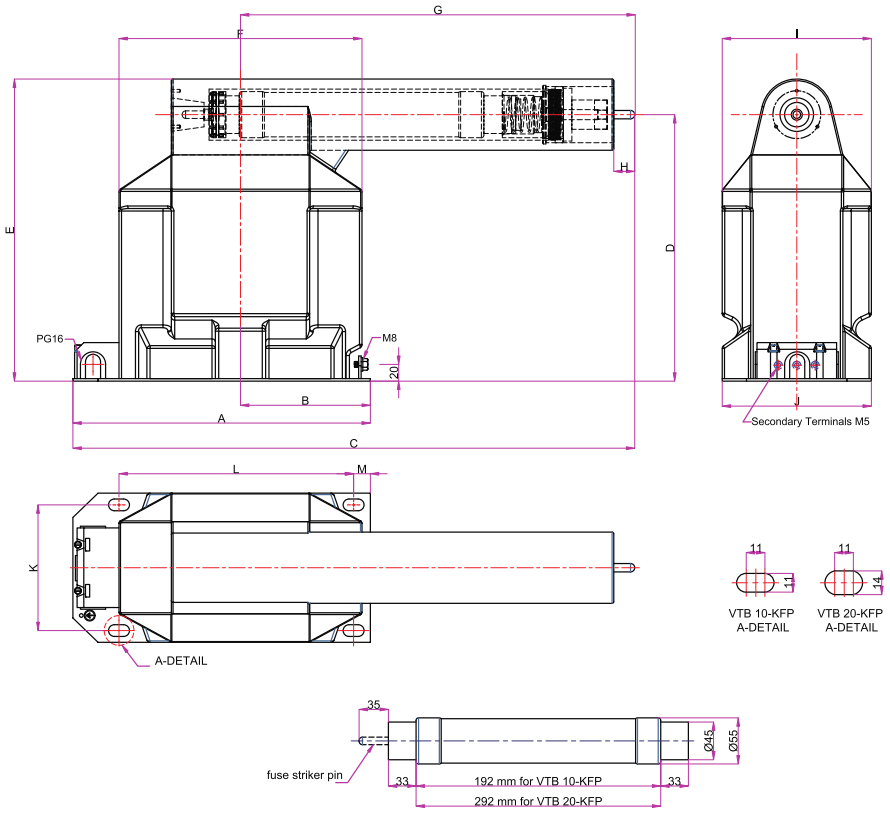
** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*





## INDOOR SINGLE PHASE CAST RESIN INSULATED WITH STRIKER PIN SIGNALLING BUILT IN FUSE WITHDRAWABLE TYPE V.T.'S TECHNICAL DRAWING

(Um=3,6kV .....24kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VTB 10-KFP | 355 | 155 | 560 | 260 | 302 | 290 | 360 | 25 | 148 | 148 | 125 | 270 | 20 |
| VTB 20-KFP | 355 | 155 | 671 | 318 | 361 | 290 | 471 | 25 | 178 | 178 | 150 | 270 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



# INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE SPECIAL TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....24kV BLOCK TYPES)

Types:
ES 12 VR-F
ES 24 V2-F

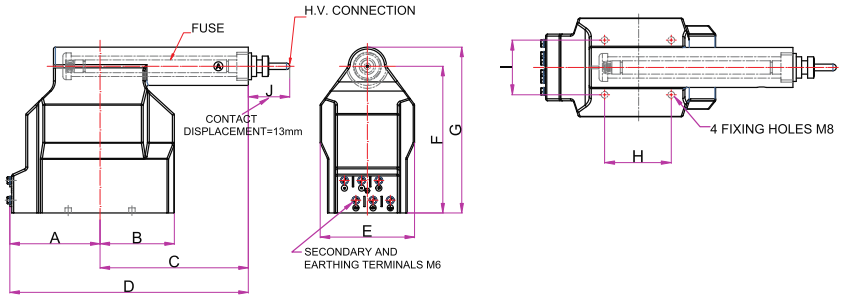
| Technical Data | Produced only in Indonesia Factory | | | | | |
|---|---|---|---|---|---|---|
| Types | ES 12 VR-F | | | ES 24 V2-F | | |
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17.5 | 24 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | 24/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 20 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 60 | | | | | |
| Rated burden (max.) in class 1 (VA) | 120 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 60 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 21 | | | 29 | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

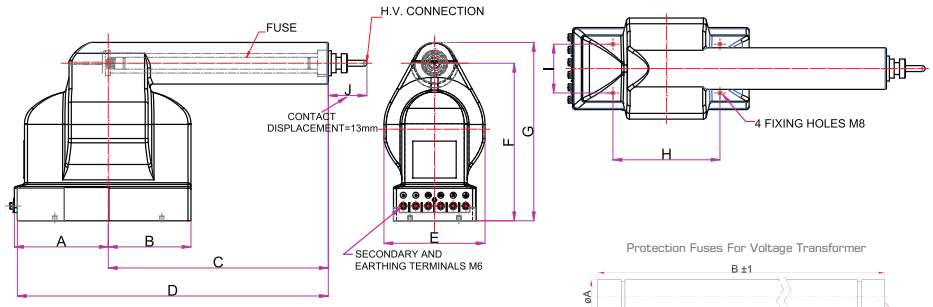
# INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE SPECIAL TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....24kV BLOCK TYPES)

## ES 12 VR-F




## ES 24 V2-F




| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 4 |

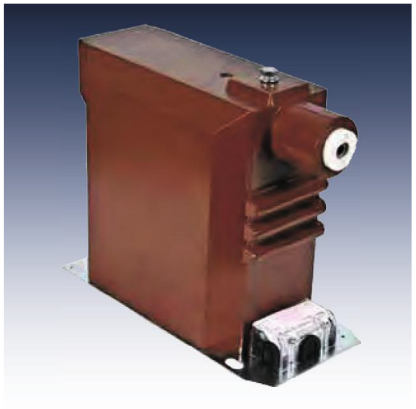
| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| ES 12 VR-F | 141,5 | 116,5 | 232,5 | 374 | 148 | 230 | 260 | 100 | 82 | 65 |
| ES 24 V2-F | 158 | 139 | 370 | 528 | 170 | 265 | 300 | 180 | 82 | 65 |

Protection Fuses For Voltage Transformer




| NO | V.T. Types | Rated Currents (A) | Rated Voltage (Un) | ØA | B (mm) |
|---|---|---|---|---|---|
| 1 | ES 12 VR-F ES 24 V2-F | 0,63 Amper | 7,2 kV | 20 | 190 |
| 2 | | 1 Amper | | | |
| 3 | | 2 Amper | | | |
| 4 | | 3,15 Amper | | | |
| 5 | ES 12 VR-F ES 24 V2-F | 0,63 Amper | 12 kV | | 254 |
| 6 | | 1 Amper | | | |
| 7 | | 2 Amper | | | |
| 8 | | 3,15 Amper | | | |
| 9 | ES 12 VR-F ES 24 V2-F | 0,63 Amper | 15,5 - 17,5 kV | | |
| 10 | | 1 Amper | | | |
| 11 | | 2 Amper | | | |
| 12 | | 3,15 Amper | | | |
| 13 | ES 24 V2-F | 0,5 Amper | 24-25.5 kV | | 340 |
| 14 | | 1 Amper | | | |
| 15 | | 2 Amper | | | |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE FIXED TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....24kV)

**Types:**
VTB 10-SF
VTB 20-F2

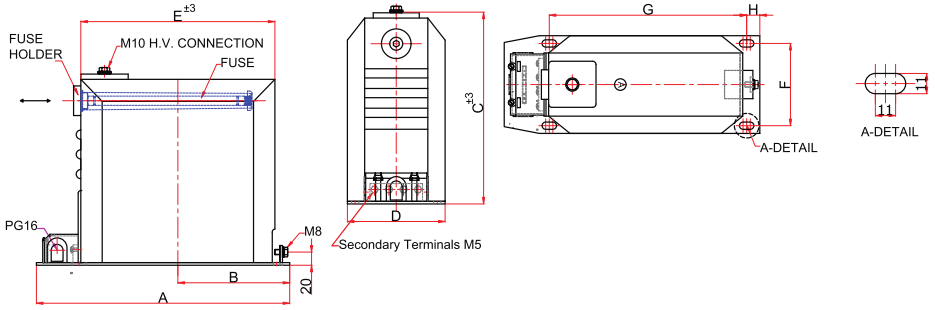
| Technical Data | Produced only in Indonesia Factory | | | | | |
|---|---|---|---|---|---|---|
| Types | VTB 10-SF | | | VTB 20-F2 | | |
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17.5 | 24 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | 24/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | 60 | | 50 |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | 180 | | 120 |
| Rated burden (max.) in class 1 (VA) | 200 | | | 300 | | 250 |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 34 | | | 45 | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

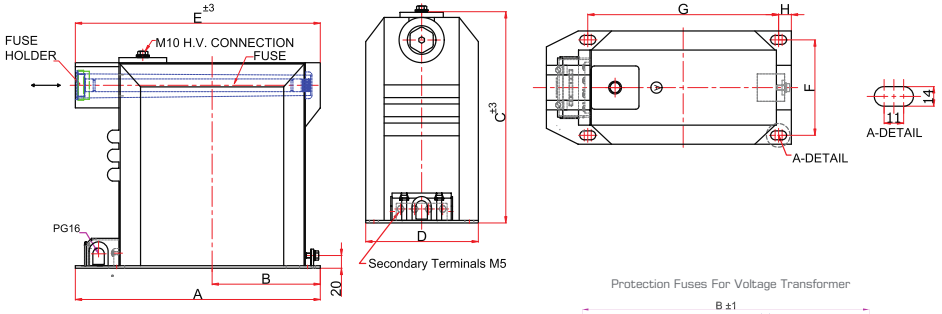
## INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE FIXED TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....24kV)

**VTB 10-SF**



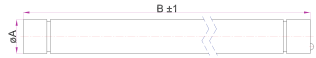

**VTB 20-F2**




| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| VTB 10-SF | 385 | 170 | 290 | 148 | 291 | 125 | 300 | 20 |
| VTB 20-F2 | 385 | 170 | 365 | 178 | 385 | 150 | 300 | 20 |

Protection Fuses For Voltage Transformer




| NO | V.T. Types | Rated Currents (A) | Rated Voltage (Un) | ØA | B (mm) |
|---|---|---|---|---|---|
| 1 | VTB 10-SF VTB 20-F2 | 0,63 Amper | 7,2 kV | 20 | 190 |
| 2 | | 1 Amper | | | |
| 3 | | 2 Amper | | | |
| 4 | | 3,15 Amper | | | |
| 5 | VTB 10-SF VTB 20-F2 | 0,63 Amper | 12 kV | | 254 |
| 6 | | 1 Amper | | | |
| 7 | | 2 Amper | | | |
| 8 | | 3,15 Amper | | | |
| 9 | VTB 10-SF VTB 20-F2 | 0,63 Amper | 15,5- 17,5 kV | | |
| 10 | | 1 Amper | | | |
| 11 | | 2 Amper | | | |
| 12 | | 3,15 Amper | | | |
| 13 | VTB 20-F2 | 0,5 Amper | 24-25,5 kV | | 340 |
| 14 | | 1 Amper | | | |
| 15 | | 2 Amper | | | |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS

(Um=36 kV)

Types:
VTB 30-F1
VTB 30-F1B

### Technical Data

| Types | VTB 30-F1 | | | VTB 30-F1B | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 36** | | | | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | | | | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | | | | | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 36/√3 | | | | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 150 | | | | | |
| Rated burden (max.) in class 1 (VA) | 250 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 70 | | | | | |

* It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.
** For more kV, please contact with ARTECHE for feasibility.

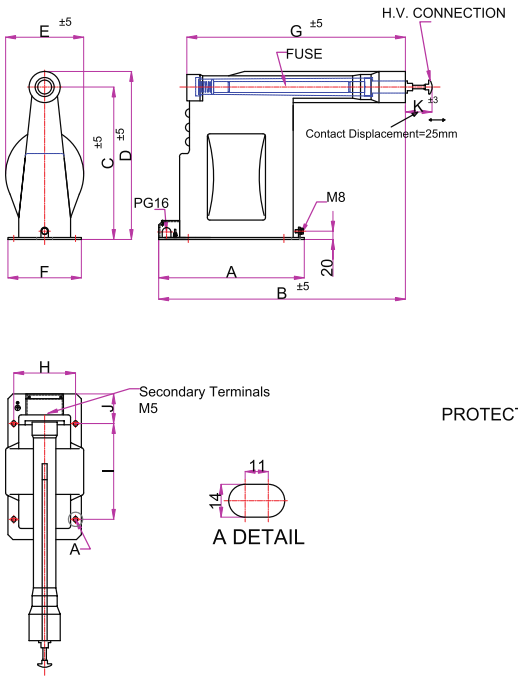




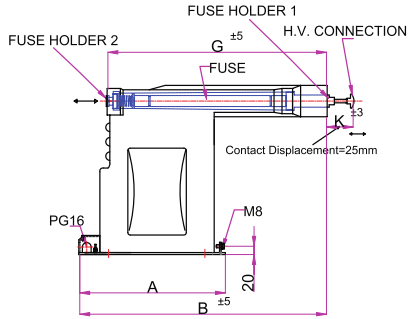
## INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=36kV)

**VTB 30-F1**




**VTB 30-F1B**



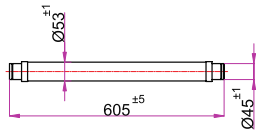







A DETAIL

PROTECTION FUSES FOR VOLTAGE TRANSFORMER




Rated Voltage = 36kV
Rated Current = 2A

| Types | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VTB 30-F1 | 450 | 890 | 455 | 510 | 240 | 220 | 805 | 190 | 240 | 90 | 75 |
| VTB 30-F1B | 450 | 890 | 455 | 510 | 240 | 220 | 805 | 190 | 240 | 90 | 75 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |

- All dimensions are in mm.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV)

Types:
VTH 20
VTH 30



Clamp type terminal
for high voltage connection.

### Technical Data

| Types | VTH 20 | | | | | VTH 30 |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24* | 36* |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 24/√3 | | | | | 36/√3 |
| Secondary voltage (V) | | 100/√3 | 110/√3 | | 120/√3 | & suitable for 220V winding. |
| Rated burden (max.) in class 0,2 (VA) | 40 | | | | | 50 |
| Rated burden (max.) in class 0,5 (VA) | 120 | | | | | 150 |
| Rated burden (max.) in class 1 (VA) | 250 | | | | | 250 |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated burden for 220V winding (VA) | 800 | | | | | |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 | | | | | |
| Short time load (mechanical) (N) | 3750 | | | | | |
| Insulation Class | E | | | | | |
| Min. creepage distance (mm) | 820 | | | | | 1220 |
| Altitude (m) | According to the customer requirements | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 50 | | | | | 65 |

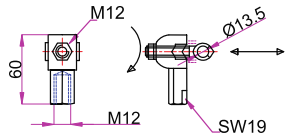
* *For more kV, please contact with ARTECHE for feasibility.*



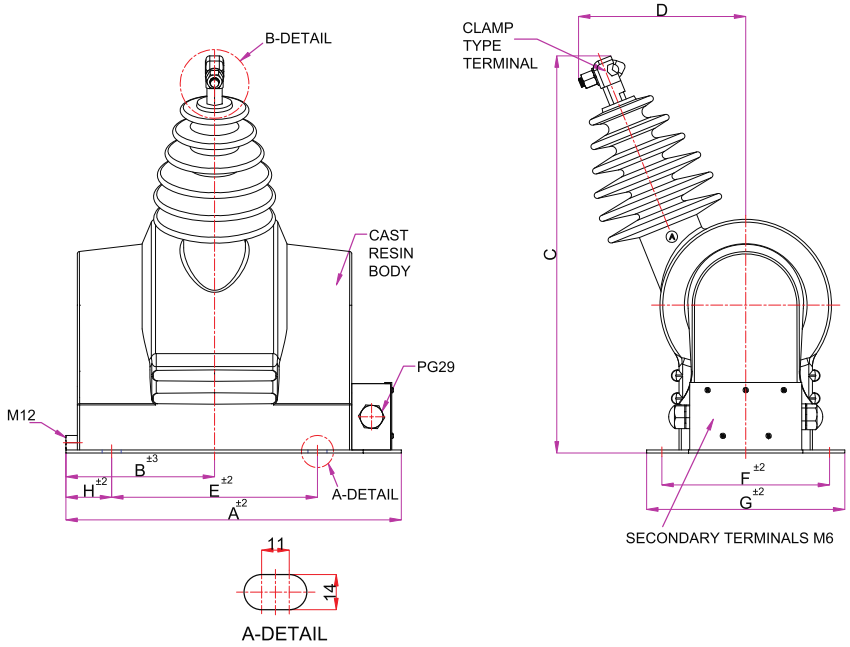


## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....36kV)




B-DETAIL CLAMP TYPE TERMINAL




A-DETAIL

| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| VTH 20 | 440 | 195 | 535 ±5 | 235 ±5 | 270 | 220 | 260 | 60 |
| VTH 30 | 450 | 200 | max.625 | max.295 | 270 | 190 | 220 | 70 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary&Ground Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV)

Types:
VTH 20-N
VTH 30-N



Clamp type terminal
for high voltage connection.

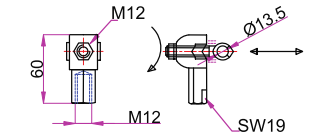
### Technical Data

| Types | VTH 20-N | | | | | VTH 30-N |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24* | 36* |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 24/√3 | | | | | 36/√3 |
| Secondary voltage (V) | 100/√3 | | 110/√3 | | 120/√3 | & suitable for 220V winding. |
| Rated burden (max.) in class 0,2 (VA) | 40 | | | | | 50 |
| Rated burden (max.) in class 0,5 (VA) | 120 | | | | | 150 |
| Rated burden (max.) in class 1 (VA) | 250 | | | | | 250 |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated burden for 220V winding (VA) | 800 | | | | | |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 | | | | | |
| Short time load (mechanical) (N) | 3750 | | | | | |
| Insulation Class | E | | | | | |
| Min. creepage distance (mm) | 820 | | | | | 1220 |
| Altitude (m) | According to the customer requirements | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 55 | | | | | 65 |

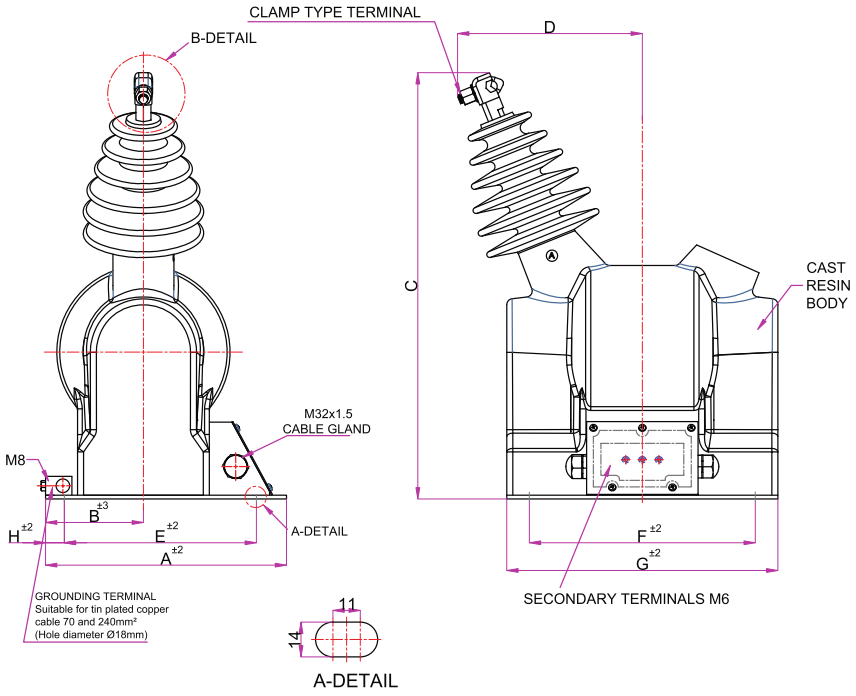
* *For more kV, please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....36kV)




B-DETAIL CLAMP TYPE TERMINAL




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| VTH 20-N | 320 | 130 | max.585 | max.255 | 255 | 300 | 360 | 20 |
| VTH 30-N | 315 | 135 | max.660 | max.275 | 255 | 300 | 360 | 30 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=52kV)

Types:
VTH 52-N



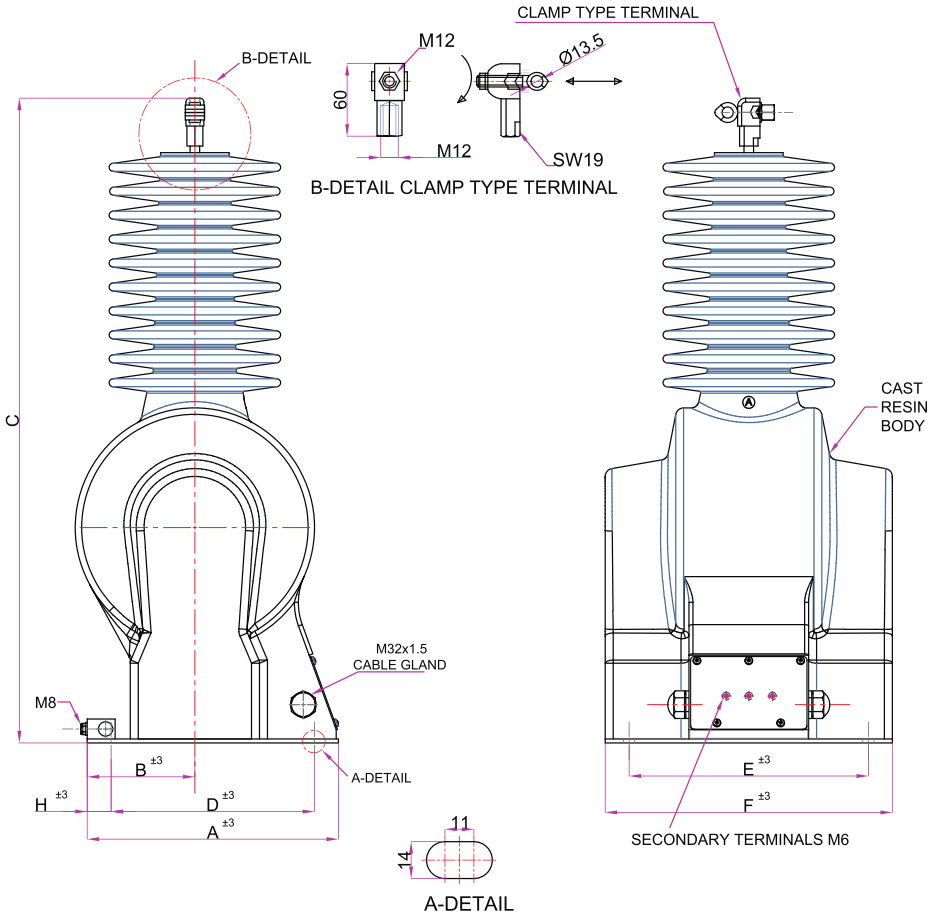
Clamp type terminal
for high voltage connection.

### Technical Data

| Types | VTH 52-N |
|---|---|
| Operating voltage, Um (kV) | 52 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 95 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 250 |
| Rated frequency (Hz) | 50-60 |
| Rated primary voltage (max.) (kV) | 46/√3 |
| Secondary voltage (V) | 100/√3 110/√3 120/√3 & suitable for 220V winding. |
| Rated burden (max.) in class 0,2 (VA) | 50 |
| Rated burden (max.) in class 0,5 (VA) | 150 |
| Rated burden (max.) in class 1 (VA) | 250 |
| Rated burden for protection purpose in class 3P (VA) | 100 |
| Rated burden for 220V winding (VA) | 800 |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 |
| Short time load (mechanical) (N) | 3750 |
| Insulation Class | E |
| Min. creepage distance (mm) | 1650 |
| Altitude (m) | According to the customer requirements |
| Standard | According to the customer requirements |
| Weight (approx.) (kg) | 90 |

## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=52kV)




| Types | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| VTH 20-N | 315 | 135 | max.820 | 255 | 300 | 360 | 30 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE PHASE TO PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV)

Types:
2VTH 20
2VTH 30

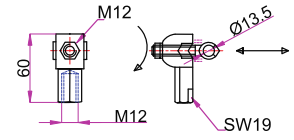


Clamp type terminal
for high voltage connection.

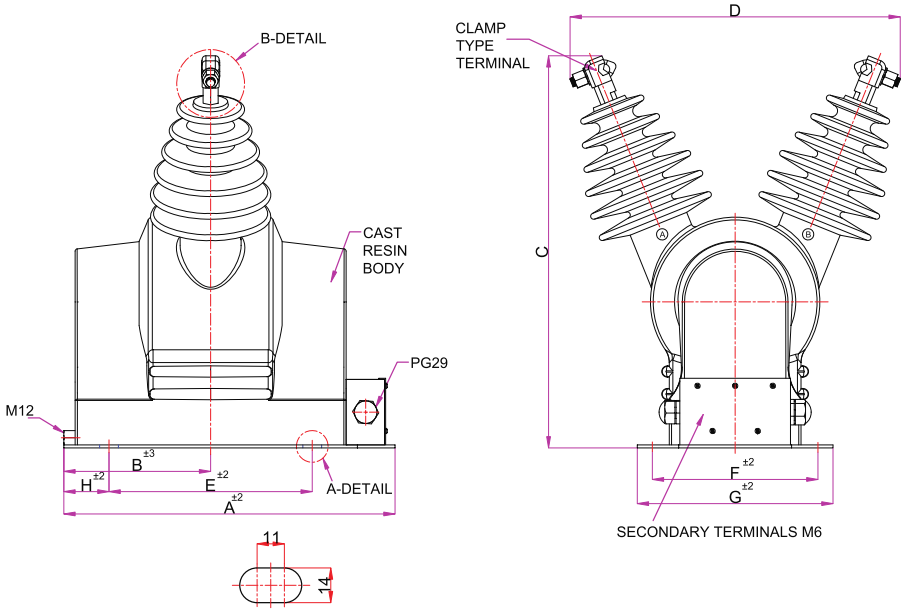
| Technical Data | | | | | | Produced only in Indonesia Factory |
|---|---|---|---|---|---|---|
| Types | 2VTH 20 | | | | | 2VTH 30 |
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 24 | | | | | 36 |
| Secondary voltage (V) | 100, 110, 120 & suitable for 220V winding. | | | | | |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | 40 |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | | 120 |
| Rated burden (max.) in class 1 (VA) | 200 | | | | | 200 |
| Rated burden for 220V winding (VA) | 800 | | | | | |
| Rated voltage factor (30sec. or 8h) (Un) | 1,2 | | | | | |
| Short time load (mechanical) (N) | 3750 | | | | | |
| Min. creepage distance (mm) | 820 | | | | | 1220 |
| Altitude (m) | According to the customer requirements | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 60 | | | | | 70 |

## OUTDOOR DRY TYPE PHASE TO PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....36kV)




B-DETAIL CLAMP TYPE TERMINAL




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 2VTH 20 | 440 | 195 | 535 ±5 | 460 ±5 | 270 | 20 | 260 | 60 |
| 2VTH 30 | 450 | 200 | max.625 | max.580 | 270 | 190 | 220 | 70 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary and Ground Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE PHASE TO PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV)

Types:
2VTH 20-N
2VTH 30-N



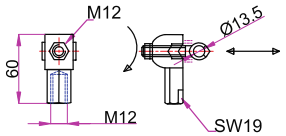
Clamp type terminal
for high voltage connection.

### Technical Data

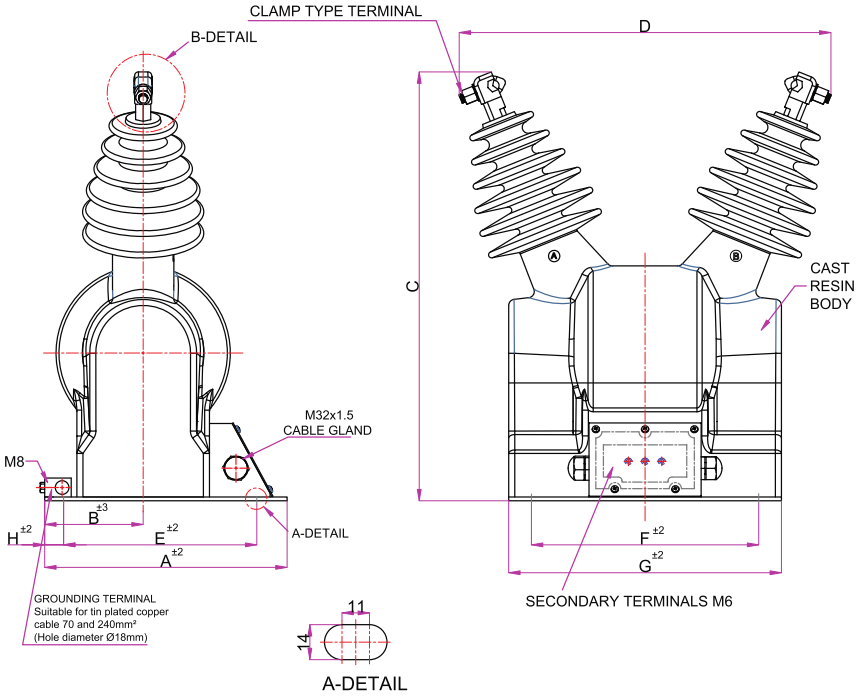
| Types | 2VTH 20-N | | | | | 2VTH 30-N |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 24 | | | | | 36 |
| Secondary voltage (V) | 100, 110, 120 & suitable for 220V winding. | | | | | |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | 40 |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | | 120 |
| Rated burden (max.) in class 1 (VA) | 200 | | | | | 200 |
| Rated burden for 220V winding (VA) | 800 | | | | | |
| Rated voltage factor (30sec. or 8h) (Un) | 1,2 | | | | | |
| Short time load (mechanical) (N) | 3750 | | | | | |
| Insulation Class | E | | | | | |
| Min. creepage distance (mm) | 820 | | | | | 1220 |
| Altitude (m) | According to the customer requirements | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 67 | | | | | 86 |

## OUTDOOR DRY TYPE PHASE TO PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....36kV)




B-DETAIL CLAMP TYPE TERMINAL

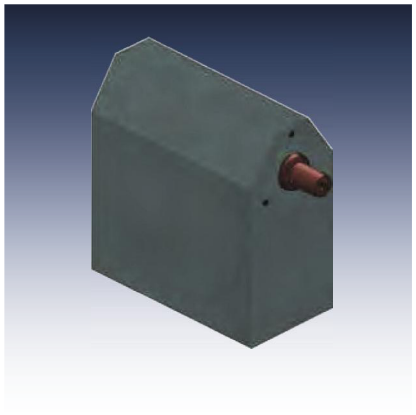



A-DETAIL

| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 2VTH 20-N | 320 | 130 | max.585 | max.510 | 255 | 300 | 360 | 20 |
| 2VTH 30-N | 315 | 135 | max.660 | max.550 | 255 | 300 | 360 | 30 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SINGLE PHASE METAL HOUSING BUSHING TYPE VOLTAGE TRANSFORMERS

(Um=12kV ..... 36kV)

V VMVT 10B
MVT 30B

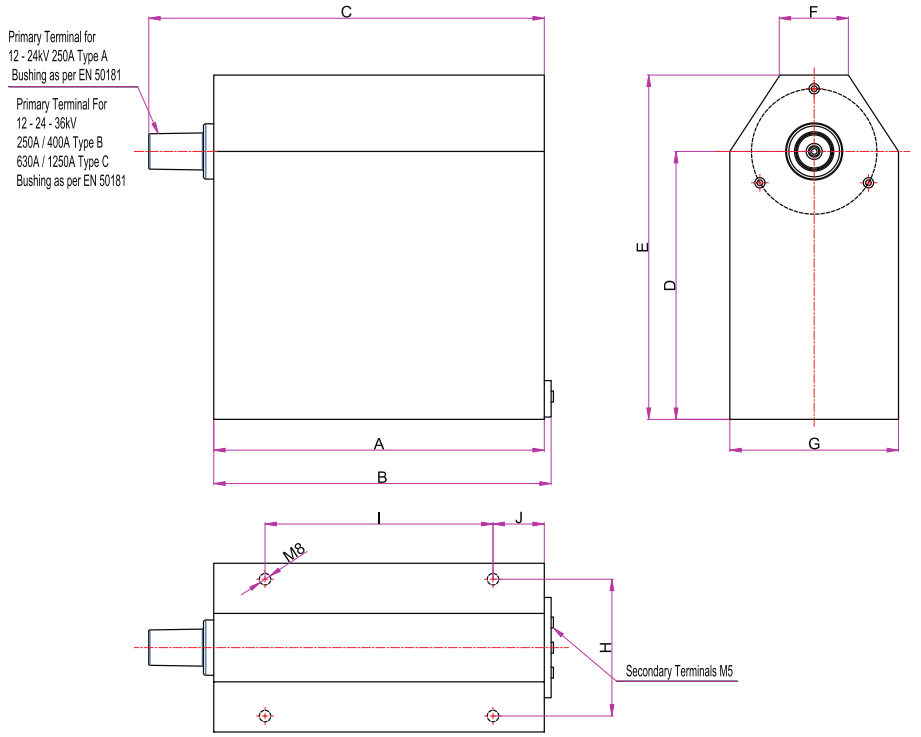
### Technical Data

| Types | MVT 10B | | | MVT 30B | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 12 | | | 17,5 | 24 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 28 | | | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 75 | | | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | 36/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 10 | | | 10 | 10 | 10 |
| Rated burden (max.) in class 0,5 (VA) | 30 | | | 30 | 30 | 30 |
| Rated burden (max.) in class 1 (VA) | 60 | | | 60 | 60 | 60 |
| Rated burden for 220V winding (VA) | 50(Ith 2A) | | | 50 | 50 | 50(Ith 4A) |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation Class | E | | | | | |
| Min. creepage distance (mm) | -25.....+40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 30 | | | 45 | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE METAL HOUSING BUSHING TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=12kV ..... 36kV)




| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| MVT 10B | 290 | 296 | 347 | 235 | 302 | 60 | 148 | 120 | 200 | 45 |
| MVT 30B | 370 | 376 | 482 | - | 306,5 | 95 | 185 | 150 | 250 | 60 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SINGLE PHASE METALISED BUSHING TYPE VOLTAGE TRANSFORMERS

(Um=12kV ..... 36kV)

Types:
MVT 10
MVT 30

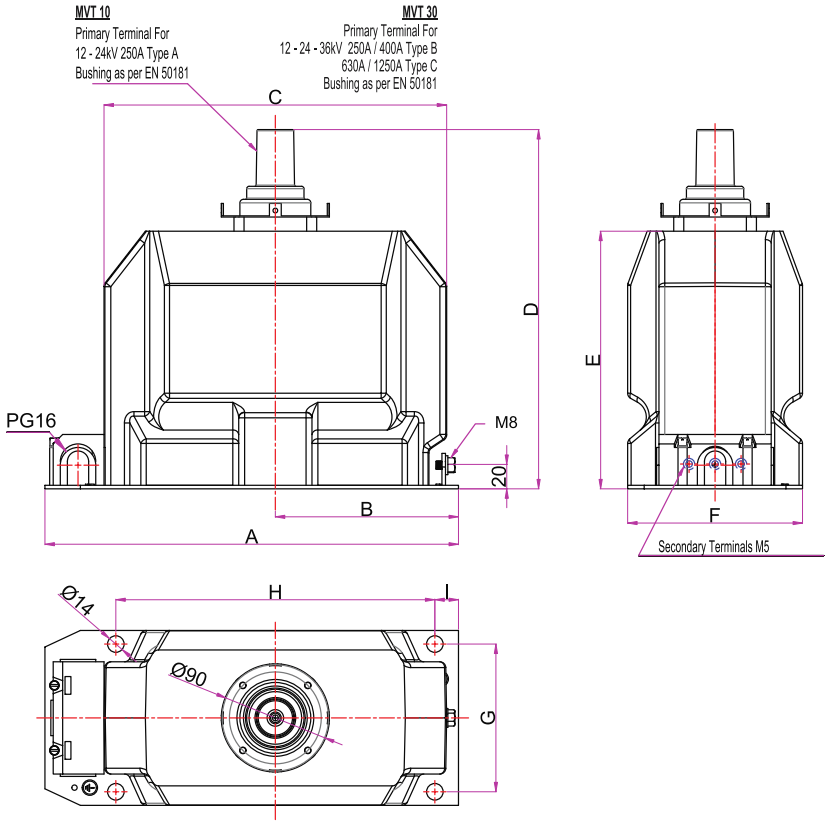
### Technical Data

| Types | MVT 10 | | | MVT 30 | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 12 | | | 17,5 | 24 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 28 | | | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 75 | | | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | 36/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 10 | | | 10 | 10 | 10 |
| Rated burden (max.) in class 0,5 (VA) | 30 | | | 30 | 30 | 30 |
| Rated burden (max.) in class 1 (VA) | 60 | | | 60 | 60 | 60 |
| Rated burden for 220V winding (VA) | 50(Ith 2A) | | | 50 | 50 | 50(Ith 4A) |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation Class | E | | | | | |
| Min. creepage distance (mm) | -25.....+40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 30 | | | 45 | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE METALISED BUSHING TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=12kV ..... 36kV)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| MVT 10 | 350 | 155 | 290 | 304 | 218 | 148 | 125 | 270 | 20 |
| MVT 30 | 430 | 195 | 370 | 429 | 290 | 185 | 150 | 300 | 45 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 ( Ground Terminal) | 15 | 20 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=72,5kV)

Types:
VTH 72-N

### Technical Data

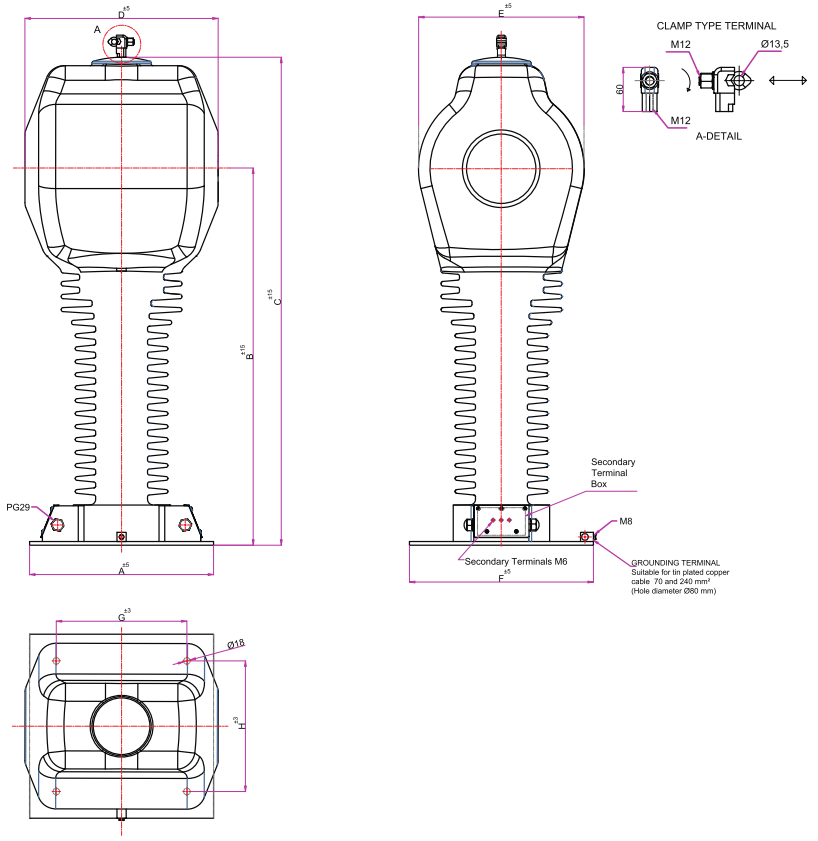
| Types | VTH 72-N | | |
|---|---|---|---|
| Operating voltage, Um (kV) | 72,5 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 140 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 325 | | |
| Rated frequency (Hz) | 50-60 | | |
| Rated primary voltage (max.) (kV) | 66/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 |
| Rated burden (max.) in class 0,2 (VA) | 50 | | |
| Rated burden (max.) in class 0,5 (VA) | 150 | | |
| Rated burden (max.) in class 1 (VA) | 300 | | |
| Rated burden for protection purpose in class 3p (VA) | 100 | | |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 | | |
| Insulation Class | E | | |
| Min. creepage distance (mm) | 2500 | | |
| Altitude (m) | According to the customer requirements | | |
| Standard | According to the customer requirements | | |
| Weight (approx.) (kg) | 300 | | |

** For more cores please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um= 72,5kV)

**VTH 72-N**




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| VTH 72-N | 500 | 1025 | 1325 | 525 | 450 | 500 | 355 | 355 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary and Ground Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*

# INSULATORS





arteche

## INSULATORS

Insulators are insulating and supporting components of the power transmission lines and busbars (distribution centers, switchgears) where they are fixed.

Insulators are intended to be used for 2 reason:
-Separating conductors from the earth in regards to electricity
-Supporting the weight of conductors and additional loads

Arteche Insulators are epoxy cast resin insulated with internal metal fittings.

The insulators are particularly suitable to be used as single support or voltage control.

Arteche MV Insulators are designed for indoor-indoor and outdoor-indoor applications (from 3,6kV to 36kV):

- Bushing Insulators
- Post Insulators
- Capacitive Insulators(voltage divider)

### Post insulators for indoor installation

#### General characteristics
Epoxy resin post insulators, for indoor application, with internal metal fitting.
These insulators are particularly suitable to be used as single supports for conductors, for fuses and for other equipment (as switchgears).

#### Application
For indoor installation with working condition at T° max. 85 °C.

#### Service voltage
Up to 36 kV (40,5 kV available on request)

#### Routine Tests
Visual inspection
Testing of conductive connection of fixing inserts for post insulators
Dry power-frequency withstand voltage
Partial discharge extinction voltage test

#### Standards
IEC 60273 (CEI 36/12) - CENELEC HD 578 S1
IEC 60660

#### General characteristics
Epoxy resin post insulators with capacitive divider for the reading of the voltage.
Manufactured with internal metal fitting, they can be equipped with couplings and low voltage light signal box.
These insulators are mainly suitable to be used as insulated supports of equipment, bus bar or fuses.

#### Application
Max working temperature of 85 °C.

#### Routine Tests
Visual inspection
Testing of conductive connection of fixing inserts for post insulators
Dry power-frequency withstand voltage
Partial discharge extinction voltage test (connected to the voltage indicator)

#### Service voltage
Up to 36 kV (40,5 available on request)

#### Standards
IEC 60660

### Bushing Insulators for indoor-indoor / outdoor-indoor

#### General characteristics
12 - 36 kV epoxy resin bushing insulators. The insulators can be fitted with copper bars designed from 250 up to 1250 A.
They are equipped with internal metal fittings for installation on the relevant frame and with brass nuts and washers for fastening of phase connectors.

#### Application
Indoor/outdoor installation at max working temperature of 85 ºC.

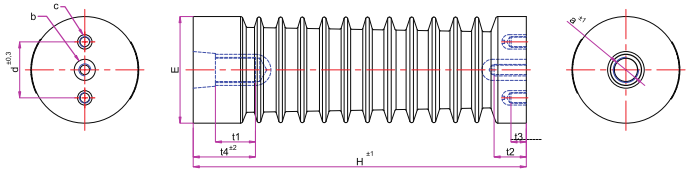
#### Service voltage
Up to 36 kV.

#### Routine Tests
Visual inspection
Dry power-frequency withstand voltage
Measurement of partial discharge quantity

#### Standards
IEC 60137

## INDOOR POST INSULATORS UP TO 36kV






Material Type: Epoxy Resin

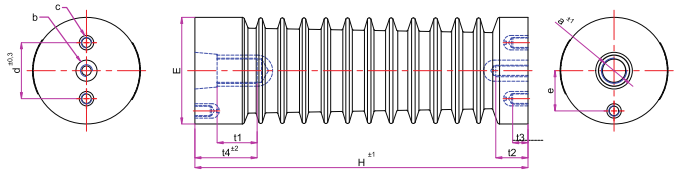
According to IEC 60273 (1990), IEC 60660 (1999)

| TYPES | Um (kV) | Power-frequency withstand voltage, dry (kV) | Falling load bending (N) | Weight app. (kg) | Dimensions (mm) a | b | c | d | E | H | t1 | t2 | t3 | t4 | Min. Creepage Distance (mm) | Number of ribs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J04-75 (10N500) | 12 | 38 | 4000 | 0,60 | M16 | M12 | M6 | 36 | ø | 130 | 25 | 18 | 10 | 37 | 170 | 5 |
| J010-125 (20N1000) | 12/24 | 38/50 | 10000 | 0,97 | M20 | M16 | M10 | 46 | ø | 210 | 27 | 24 | 12 | 42 | 210 | 8 |
| J010-125 (20N1000 EGY) | 24 | 50 | 8000 | 1,80 | M16 | M10 | M6 | 36 | ø | 210 | 45 | 40 | 16 | 63 | 440 | 9 |
| J010-75 (10N1000) | 12 | 38 | 10000 | 0,85 | M20 | M16 | M10 | 46 | ø | 130 | 27 | 24 | 12 | 42 | 190 | 5 |
| J010-75 (10N1000 EGY) | 12 | 38 | 5000 | 0,75 | M16 | M10 | M6 | 36 | ø | 130 | 40 | 20 | 10 | 50 | 240 | 7 |
| J04-95 (15N500) | 17,5 | 50 | 4000 | 0,95 | M16 | M12 | M6 | 36 | ø | 175 | 25 | 18 | 10 | 40 | 250 | 6 |
| J010-95(15N1000) | 17,5 | 50 | 10000 | 1,7 | M20 | M16 | M10 | 46 | ø | 175 | 27 | 24 | 12 | 42 | 270 | 6 |
| J04-125 (20N500) | 24 | 50 | 4000 | 1,30 | M16 | M12 | M6 | 36 | ø | 210 | 25 | 18 | 10 | 40 | 320 | 8 |
| J010-125 (B20N1000) | 24 | 50 | 7500 | 1,6 | M16 | M12 | - | - | ø | 225 | 40 | 32 | - | 60 | 425 | 13 |
| J04-170 (30N500) | 36 | 70 | 4000 | 1,9 | M16 | M12 | M6 | 36 | ø | 300 | 25 | 26 | 12 | 48 | 510 | 11 |
| J010-170 (30N1000) | 36 | 70 | 10000 | 3,00 | M24 | M16 | M10 | 46 | ø | 300 | 38 | 28 | 12 | 56 | 460 | 11 |
| J010-170 (30N1000 ABB) | 36 | 70 | 10000 | 3,9 | M24 | - | M12 | 32 | ø | 390 | 38 | - | 18 | 56 | 550 | 11 |

Tolerance ∓ (Dimensions x 0,01 + 0,2) mm

## INDOOR CAPACITIVE POST INSULATORS UP TO 36kV





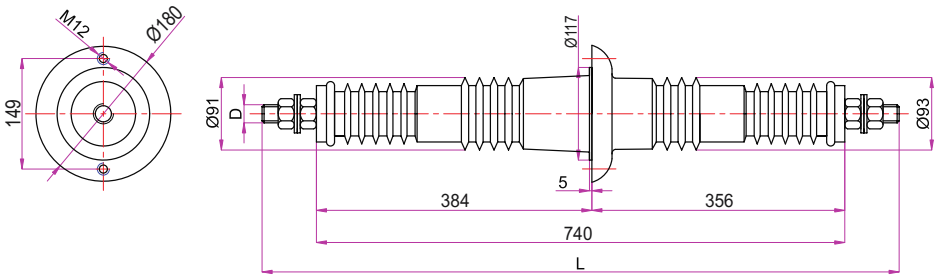

| TYPES | Um (kV) | Power-frequency withstand voltage, dry (kV) | Falling load bending (N) | Weight app. (kg) | Dimensions (mm) a | b | c | d | e | E | H | t1 | t2 | t3 | t4 | Min. Creepage Distance (mm) | Number of ribs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10N1000K | 12 | 38 | 10000 | 0,95 | M20 | M16 | M10 | 46 | 30 | ø 77 | 130 | 27 | 24 | 12 | 42 | 190 | 5 |
| 15N1000K | 17,5 | 50 | 10000 | 1,70 | M20 | M16 | M10 | 46 | 30 | ø 90 | 175 | 27 | 24 | 12 | 42 | 270 | 6 |
| 20N500K | 24 | 50 | 4000 | 1,30 | M16 | M12 | M6 | 36 | 30 | ø 75 | 210 | 25 | 18 | 10 | 40 | 320 | 8 |
| 20N1000K | 24 | 50 | 10000 | 1,90 | M20 | M16 | M10 | 46 | 30 | ø 85 | 210 | 27 | 24 | 12 | 42 | 330 | 8 |
| 30N500K | 36 | 70 | 4000 | 2,00 | M16 | M12 | M6 | 36 | 30 | ø 80 | 300 | 25 | 26 | 12 | 48 | 510 | 11 |
| 30N1000K | 36 | 70 | 10000 | 3,10 | M24 | M16 | M10 | 46 | 34 | ø 96 | 300 | 38 | 28 | 12 | 56 | 460 | 11 |
| 6 KN | 12 | 38 | 6000 | 0,95 | M16 | M4 | M8 | 36 | 20 | ø 75 | 154 | 30 | 5 | 12 | 42 | 255 | 7 |
| 4 KN | 36 | 70 | 4000 | 2,50 | M12 | M10 | M6 | - | - | - | 349 | - | - | - | - | 640 | 13 |

Tolerance ∓ (Dimensions x 0,01 + 0,2) mm



## M.V. INDOOR - INDOOR BOLT BUSHING UP TO 1250A

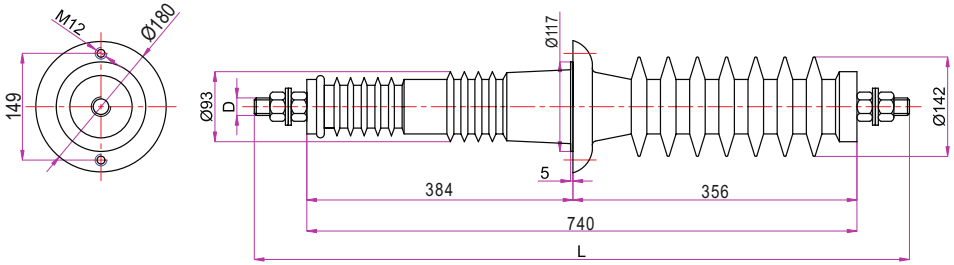
| TYPES | Um (kV) | Falling load bending (N) | In (A) | D | L | Weight (kg) |
|---|---|---|---|---|---|---|
| EDD-36 | 36 | 3750 | 400 | M16 | 840 | 8,6 |
| | | | 630 | M20 | 860 | 9,8 |
| | | | 800 | M24 | 880 | 11,7 |
| | | | 1250 | M30 | 920 | 14,9 |





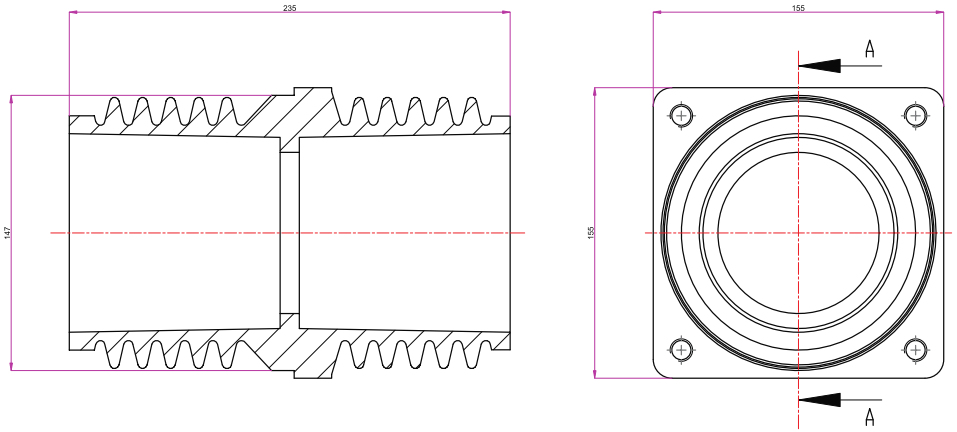

## M.V. OUTDOOR - INDOOR BOLT BUSHING UP TO 1250A

| TYPES | Um (kV) | Falling load bending (N) | In (A) | D | L | Weight (kg) |
|---|---|---|---|---|---|---|
| EDH-36 | 36 | 3750 | 400 | M16 | 840 | 10,8 |
| | | | 630 | M20 | 860 | 12,0 |
| | | | 800 | M24 | 880 | 14,2 |
| | | | 1250 | M30 | 920 | 19,4 |



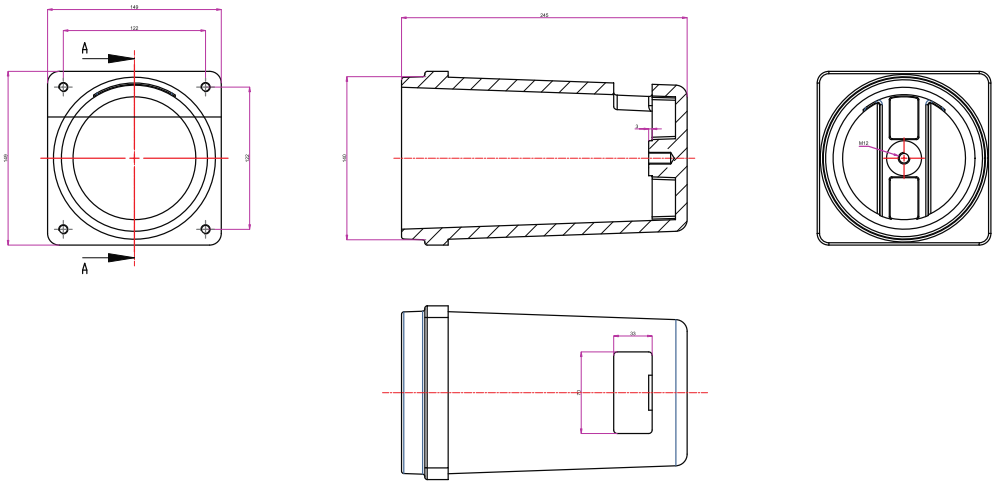
## SPECIAL PRODUCT - I






## SPECIAL PRODUCT - II





## SPECIAL PRODUCTS UPON CUSTOMER REQUEST



## NOTES

NOTES

2. Certification Dossier

2.1. Inspection & Test Plan

2.1.1.INSPECTION AND TEST PLAN - HV Switchgear,

Doc No. 1723002197-QC-ITP-00002

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# Base Load Power Hub (BLPH)

## INSPECTION AND TEST PLAN

## HV Switchgear

## Document Number: 1723002197-QC-ITP-00002

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| | 06/08/2024 |

Document Class: 2

| Rev. | Date | Description | Prepared | Reviewed | Approved |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| 02 | 01/07/2024 | Approved For Construction (AFC) | Santinelli | Mastri | Chiappa |
| 01 | 04/04/2024 | Issue for Review (IFR) | Santinelli | Mastri | Chiappa |
| 00 | 29/01/2024 | Issue for Review (IFR) | Santinelli | Mastri | Chiappa |

IMESA ELECTRICAL ENGINEERING IMESA Doc. n. 231115/SD/002

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*File:* 1723002197-QC-ITP-00002_rev02

## Revision / Change Log

| Rev. | Description |
|---|---|
| 00 | Issue for Review (IFR) |
| 01 | Issue for Review (IFR) |
| 02 | Approved For Construction (AFC) |
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## HOLDS LIST

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|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |

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INSPECTION & TEST PLAN

INTERVENTION CODE:

N = CONTROL PERFORMED BUT CERTIFICATE NO ISSUED
W = WITNESSED
S = MONITORING ACTIVITIES PERFORMED BY CONTRACTOR / COMPANY
C = CONTROL PERFORMED AND CERTIFICATE ISSUED
H = HOLD POINT
R = CHECK OF CERTIFICATES
OP = OPERATING PROCEDURE
WI = WORKING INSTRUCTION
(1) = Spot check
(2) = Sample test

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| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | | Certific. and date | Place of Execution |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Sub-Supplier | IMESA | ROSETTI | CROSSWIND | | |
| INCOMING INSPECTION | | | | | | | | | |
| 1.1 | Raw material, semifinished parts and mechanical components | Certificate (manufacturer)<br>Acceptance check (IMESA) | OP 7.13<br>TAB ACC 02 | C | R | N.A | N.A. | | Supplier Factory<br>IMESA S.p.A. |
| 1.2 | H.V. Circuit Breaker | Test report (manufacturer)<br>Acceptance check (IMESA) | IEC 62271-100<br>OP/WI<br>APPLICABLE | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.3 | L.V. Miniature Circuit Breaker | Certificate (manufacturer)<br>Acceptance check (IMESA) | IEC 60898 – IEC 60947-1/2<br>OP/WI<br>APPLICABLE | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.4 | Command auxiliary and signalling. | Certificate (manufacturer)<br>Acceptance check (IMESA) | IEC 60051-1/60688OP 7.13<br>TAB ACC 01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |

| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | | Certific. and date | Place of Execution |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Sub-Supplier | IMESA | ROSETTI | CROSSWIND | | |
| 1.5 | Protections Relay | Test report (manufacturer)<br>Acceptance check (IMESA) | CEI EN 60255-5<br>CEI EN 60255-27<br>OP 7.13<br>TAB ACC01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.6 | Current Transformer | Test report (manufacturer)<br>Acceptance check (IMESA) | IEC 61869-2<br>IEC 61869-1<br>OP 7.13<br>TAB ACC 01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.7 | Voltage Transformer | Test report (manufacturer)<br>Acceptance check (IMESA) | IEC 61869-3<br>OP 7.13<br>TAB ACC 01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.8 | Measuring transducers (if required) | Certificate (manufacturer)<br>Acceptance check (IMESA) | CEI EN 60688<br>OP 7.13<br>TAB ACC 01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |

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| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | | Certific. and date | Place of Execution |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Sub-Supplier | IMESA | ROSETTI | CROSSWIND | | |
| 1.9 | Metering Instruments (if required) | Certificate (manufacturer)<br>Acceptance check (IMESA) | CEI EN 60688<br>OP 7.13<br>TAB ACC 01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.10 | Auxiliary / Timer relays (if required) | Certificate (manufacturer)<br>Acceptance check (IMESA) | IEC 61810-1<br>OP 7.13<br>TAB ACC01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.11 | Pre inspection meeting | | | | H | W | W | | Supplier Factory<br>IMESA S.p.A. |

| Item N° | Component | Internal activity | Applicable Standard and Documents | Intervention Code | | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Supplier | IMESA | ROSETTI | CROSSWIND | | |
| CHECK & TEST DURING FABRICATION | | | | | | | | | |
| 2 | Mechanical Component | Cut punching | OP 7.08<br>WI 02-03-04 CAR | - | H | R | R | | IMESA factory |
| 3 | Mechanical Component | Bending | OP 7.08<br>WI 06-13 CAR | - | H | R | R | | IMESA factory |
| 4 | Mechanical Component | Welding | OP 7.08<br>WI 15-17-21 | - | H | R | R | | IMESA factory |
| 5 | Mechanical Component | Painting | OP 7.08<br>WI 18 CAR<br>Guide 01_A | - | H | R | R | | IMESA factory |
| 6 | Mechanical Component and semifinished product | Mechanical assembly | OP 7.08<br>WI 19 CAR | - | H | R | R | | IMESA factory |
| 7 | Compartment | Equipment assembly | OP 7.08<br>WI 19 CAR | - | H | R | R | | IMESA factory |
| 8 | Electrical Switchboard | Wiring check | OP 7.08<br>WI 01 CAB | - | H | R | R | | IMESA factory |

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| Item N° | Component | Internal activity | Applicable Standard and Documents | Intervention Code | | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Supplier | IMESA | ROSETTI | CROSSWIND | | |
| 9 | Electrical Switchboard | Accessory assembly and finishing | OP 7.08<br>WI 01 CAB | - | H | R | R | | IMESA factory |
| 10 | Electrical Switchboard | Electrical and Functional Tests<br>(note 1) | OP 7.08<br>WI 01 CAB | - | H | R | R | | IMESA factory |

Note 1: Electrical and Functional Tests will be performed at 100% by IMESA through internal check. Relative test reports will be made available during the FAT for Contractor review.

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| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| CHECK OF DOCUMENTATION BEFORE TESTS | | | | | | | | |
| 11.1 | Electrical Switchboard | Drawings & Data Sheets approval check last revision | IEC 62271-200<br>G.A., SLD, FAT Procedure, Data Sheet, Schematic Diagrams, Logic Diagram<br>OP 7.09<br>WI 08. CQ<br>Technical Specification<br>Doc. 123A90-DDL-EL-SP-20019<br>Technical Data Sheet<br>Doc. 123A90-DDL-EL-DS-20020<br>Supplier master index register<br>1723002197- MD-LIS-00001 | H | R | R | Fat report | IMESA factory |
| 11.2 | | Test procedure approval check | | H | R | R | | |
| 11.3 | | Check of calibration certificates of standard instruments or equipment used for tests | | H | R | R | | |
| 11.4 | | Review ITP schedule | | H | R | R | | |
| 11.5 | | Review Manufacture Schedule | | H | R | R | | |
| 11.6 | | Review of Type Test certificates:<br>• Dielectric Test<br>• IAC<br>• Temperature Rise<br>• Short-time withstand current and peak withstand current.<br>• IP coding | | H | R | R | | |

| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| FAT TEST – DESIGN, VISUAL AND MECHANICAL CHECK | | | | | | | | |
| 12.1 | | Verification of gauging and calibration of instruments used for checks and tests | IEC 62271-200<br>G.A., SLD, FAT Procedure, Data Sheet, Schematic Diagrams, Logic Diagram<br>OP 7.09<br>WI 08. CQ<br>Technical Specification<br>Doc. 123A90-DDL-EL-SP-20019<br>Technical Data Sheet<br>Doc. 123A90-DDL-EL-DS-20020 | H | W | W | | |
| 12.2 | | Check of steel structure (2) | | H | W | W | | |
| 12.3 | | Check of binding dimensions (2) | | H | W | W | | |
| 12.4 | | Check of workmanlike construction (1) | | H | W | W | | |
| 12.5 | | Check of rated data of the equipment installed (1) | | H | W | W | | |
| 12.6 | | Verification of acceptance test documentation on individual power equipments | | H | W | W | | |
| 12.7 | | Check of nameplate and tagging | | H | W | W | | |
| 12.8 | | Rating plate data check | | H | W | W | | |

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| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| 12.9 | | Verification of the clearances and creepage distances | Supplier master index register Doc. 1723002197-MD-LIS-00001 | H | W | W | | |
| 12.10 | | Visual check of IP protection (1) | | H | W | W | | |

| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| FAT TEST – DESIGN, VISUAL AND MECHANICAL CHECK | | | | | | | | |
| 12.11 | FAT Electrical Switchboard | Mechanical operation tests | IEC 62271-200<br>G.A., SLD, FAT Procedure, Data Sheet, Schematic Diagrams, Logic Diagram<br>Supplier master index register<br>Doc. 1723002197-MD-LIS-00001<br>1723002197-MD-LIS-00001<br>OP 7.09<br>WI 08. CQ | H | W | W | Fat report | IMESA factory |
| 12.12 | | Electrical and mechanical interlock functional verification | | H | W | W | | |
| 12.13 | | Check of interchangeability of extractable components (1) | | H | W | W | | |
| 12.14 | | Check of wiring including earthing connection and separation for various level voltage steps (1) | | H | W | W | | |
| 12.15 | | Suitability check of assembled apparatus and of materials at environmental and climatic conditions (conformity declaration) | | H | R | R | | |

| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| 12.16 | | Check of easy accessibility and removal of individual components (1), check assembly layout in accordance with the drawings | Technical Specification<br>Doc. 123A90-DDL-EL-SP-20019<br>Technical Data Sheet<br>Doc. 123A90-DDL-EL-DS-20020<br>Supplier master index register<br>Doc. 1723002197-MD-LIS-00001 | H | W | W | | |
| 12.17 | | Completeness supply check according to the contractor order | | H | W | W | | |
| 12.18 | | Check of the compliance with prototype and contractor requirements | | H | R | R | | |

| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| FAT TEST – DESIGN, VISUAL AND MECHANICAL CHECK | | | | | | | | |
| 12.19 | FAT Electrical Switchboard | Visual check of the condition of painted surfaces | IEC 62271 – 200<br>G.A., SLD, FAT Procedure<br>OP 7.09<br>WI 08. CQ<br>Painting Procedure Doc. n. 1723002197-MAT-PRO-00004 | H | W | W | Fat report painting report or a declaration for painting | IMESA factory |
| 12.20 | | Thickness check (1) | | H | W | W | | |
| 12.21 | | Check of colour | | H | W | W | | |

| Item N° | Component | Internal activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| FAT TEST – ELECTRICAL AND FUNCTIONAL TESTS | | | | | | | | |
| 13.1 | FAT Electrical Switchboard | Power frequency voltage tests | IEC 62271-200<br>G.A., SLD, FAT Procedure, Data Sheet, Schematic Diagrams, Logic Diagram<br>OP 7.09<br>WI 08. CQ<br>Technical Specification<br>Doc. 123A90-DDL-EL-SP-20019<br>Technical Data Sheet<br>Doc. 123A90-DDL-EL-DS-20020<br>Supplier master index register<br>Doc. 1723002197-MD-LIS-00001 | H | W | W | Fat report | IMESA factory |
| 13.2 | | Insulation resistance measurement | | H | W | W | | |
| 13.3 | | Measurement of the resistance of the main circuits | | H | W | W | | |
| 13.4 | | Dielectric test on main, auxiliary and control circuits | | H | W | W | | |
| 13.5 | | Check of protection relay with secondary current injection (1) | | H | W | W | | |
| 13.6 | | CT polarity check with primary current injection (1) | | H | W | W | | |
| 13.7 | | Electrical functional test (typical unit only) | | H | W | W | | |
| 13.8 | | Checking of electrical operation (typical unit only) | | H | W | W | | |

| Item N° | Component | Internal activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| 13.9 | | Grounding circuit check (1) | | H | W | W | | |
| 13.10 | | Cabling check and auxiliary electrical devices (1) | | H | W | W | | |
| 13.11 | | ECMS simulation test | | H | W | W | | |

| Item N° | Component | Internal activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| FINAL INSPECTION | | | | | | | | |
| 14.1 | Electrical Switchboard | Check of type, quantity and labelling of the spare parts | OP/WI APPLICABLE | H | W | R | IMESA certificate | IMESA factory |
| 14.2 | Electrical Switchboard | Check of tools and special tools | OP/WI APPLICABLE | H | W | R | IMESA certificate | IMESA factory |
| 14.3 | Electrical Switchboard | Check of weights, centre of gravity, lifting points | OP/WI APPLICABLE | H | R | R | IMESA certificate | IMESA factory |
| 14.4 | Electrical Switchboard | Weight Report | OP/WI APPLICABLE | H | R | R | IMESA certificate | IMESA factory |
| 14.5 | Electrical Switchboard | Packaging and shipment | OP/WI APPLICABLE | H | R | R | Packing list + shipping invoice | IMESA factory |
| 14.6 | Electrical Switchboard | Certificate review and issue of release note | OP/WI APPLICABLE | H | H | R | Release note issued by ROSETTI | IMESA factory |

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2.1.2.INSPECTION AND TEST PLAN - LV Switchgear,

Doc No. 1723002197-QC-ITP-00003

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# Base Load Power Hub (BLPH)

## INSPECTION AND TEST PLAN

## LV Switchgear

## Document Number: 1723002197-QC-ITP-00003

Document Class: 2

| ROSETTI MARINO | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |
| *NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.* | |
| Sign | Date |
| | 06/08/2024 |

| Rev. | Date | Description | Prepared | Reviewed | Approved |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| 02 | 01/07/2024 | Accepted for construction (AFC) | Santinelli | Mastri | Chiappa |
| 01 | 04/04/2024 | Issue for Review (IFR) | Santinelli | Mastri | Chiappa |
| 00 | 29/01/2024 | Issue for Review (IFR) | Santinelli | Mastri | Chiappa |

IMESA ELECTRICAL ENGINEERING IMESA Doc. n. 231115/SD/003

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*File:* 1723002197-QC-ITP-00003_rev2

## Revision / Change Log

| Rev. | Description |
|---|---|
| 00 | Issue for Review (IFR) |
| 01 | Issue for Review (IFR) |
| 02 | Accepted for construction (AFC) |
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## HOLDS LIST

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| 1 | |
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| 4 | |

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INSPECTION & TEST PLAN

INTERVENTION CODE:

N = CONTROL PERFORMED BUT CERTIFICATE NO ISSUED
W = WITNESSED
S = MONITORING ACTIVITIES PERFORMED BY CONTRACTOR / COMPANY
C = CONTROL PERFORMED AND CERTIFICATE ISSUED
H = HOLD POINT
R = CHECK OF CERTIFICATES
OP = OPERATING PROCEDURE
WI = WORKING INSTRUCTION
(1) = Spot check
(2) = Sample test

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| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | | Certific. and date | Place of Execution |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Sub-Supplier | IMESA | ROSETTI | CROSSWIND | | |
| INCOMING INSPECTION | | | | | | | | | |
| 1.1 | Raw material, semifinished parts and mechanical components | Certificate (manufacturer)<br>Acceptance check (IMESA) | OP 7.13<br>TAB ACC 02 | C | R | N.A | N.A. | | Supplier Factory<br>IMESA S.p.A. |
| 1.2 | L.V. Circuit Breaker | Certificate (manufacturer)<br>Acceptance check (IMESA) | IEC 62271-100<br>OP/WI<br>APPLICABLE | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.3 | L.V. Miniature Circuit Breaker | Certificate (manufacturer)<br>Acceptance check (IMESA) | IEC 60898 – IEC 60947-1/2<br>OP/WI<br>APPLICABLE | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.4 | Command auxiliary and signalling. | Certificate (manufacturer)<br>Acceptance check (IMESA) | IEC 60051-1/60688OP 7.13<br>TAB ACC 01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |

| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | | Certific. and date | Place of Execution |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Sub-Supplier | IMESA | ROSETTI | CROSSWIND | | |
| 1.5 | Protections Relay | Test report (manufacturer)<br>Acceptance check (IMESA) | CEI EN 60255-5<br>CEI EN 60255-27<br>OP 7.13<br>TAB ACC01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.6 | Current Transformer | Test report (manufacturer)<br>Acceptance check (IMESA) | IEC 61869-1<br>IEC 61869-2<br>OP 7.13<br>TAB ACC 01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.7 | Voltage Transformer | Test report (manufacturer)<br>Acceptance check (IMESA) | IEC 61869-3<br>OP 7.13<br>TAB ACC 01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.8 | Measuring transducers | Certificate (manufacturer)<br>Acceptance check (IMESA) | CEI EN 60688<br>OP 7.13<br>TAB ACC 01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |

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| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | | Certific. and date | Place of Execution |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Sub-Supplier | IMESA | ROSETTI | CROSSWIND | | |
| 1.9 | Metering Instruments | Certificate (manufacturer)<br>Acceptance check (IMESA) | CEI EN 60688<br>OP 7.13<br>TAB ACC 01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.10 | Auxiliary / Timer relays | Certificate (manufacturer)<br>Acceptance check (IMESA) | IEC 61810-1<br>OP 7.13<br>TAB ACC01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.11 | Thermal Realys / Contactors | Certificate (manufacturer)<br>Acceptance check (IMESA) | IEC 60947<br>OP 7.13<br>TAB ACC01 | N.A. | R | R | R | | Supplier Factory<br>IMESA S.p.A. |
| 1.12 | Pre inspection meeting | | | | H | W | W | | Supplier Factory<br>IMESA S.p.A. |

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| Item N° | Component | Internal activity | Applicable Standard and Documents | Intervention Code | | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Supplier | IMESA | ROSETTI | CROSSWIND | | |
| CHECK & TEST DURING FABRICATION | | | | | | | | | |
| 2 | Mechanical Component | Cut punching | OP 7.08<br>WI 02-03-04 CAR | - | H | R | R | | IMESA factory |
| 3 | Mechanical Component | Bending | OP 7.08<br>WI 06-13 CAR | - | H | R | R | | IMESA factory |
| 4 | Mechanical Component | Welding | OP 7.08<br>WI 15-17-21 CAR | - | H | R | R | | IMESA factory |
| 5 | Mechanical Component | Painting | OP 7.08<br>WI 18 CAR<br>Guide 01_A | - | H | R | R | | IMESA factory |
| 6 | Mechanical Component and semifinished product | Mechanical assembly | OP 7.08<br>WI 19 CAR | - | H | R | R | | IMESA factory |
| 7 | Compartment | Equipment assembly | OP 7.08<br>WI 19 CAR | - | H | R | R | | IMESA factory |
| 8 | Electrical Switchboard | Wiring check | OP 7.08<br>WI 01 CAB | - | H | R | R | | IMESA factory |

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| Item N° | Component | Internal activity | Applicable Standard and Documents | Intervention Code | | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Supplier | IMESA | ROSETTI | CROSSWIND | | |
| 9 | Electrical Switchboard | Accessory assembly and finishing | OP 7.08<br>WI 01 CAB | - | H | R | R | | IMESA factory |
| 10 | Electrical Switchboard | Electrical and Functional Tests<br>(note 1) | OP 7.08<br>WI 01 CAB | - | H | R | R | | IMESA factory |

Note 1: Electrical and Functional Tests will be performed at 100% by IMESA through internal check. Relative test reports will be made available during the FAT for Contractor review.

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| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| CHECK OF DOCUMENTATION BEFORE TESTS | | | | | | | | |
| 11.1 | Electrical Switchboard | Drawings & Data Sheets approval check last revision | IEC 61439-2<br>G.A., SLD, FAT Procedure, Data Sheet, Schematic Diagrams, Logic Diagram<br>OP 7.09<br>WI 08. CQ<br>Technical Specification<br>Doc. 123A90-DDL-EL-SP-20023<br>Technical Data Sheet<br>Doc. 123A90-DDL-EL-DS-20024<br>Supplier master index register<br>1723002197- MD-LIS-00001 | H | R | R | Fat report | IMESA factory |
| 11.2 | | Test procedure approval check | | H | R | R | | |
| 11.3 | | Check of calibration certificates of standard instruments or equipment used for tests | | H | R | R | | |
| 11.4 | | Review ITP schedule | | H | R | R | | |
| 11.5 | | Review Manufacture Schedule | | H | R | R | | |
| 11.6 | | Review of Type Test certificates:<br>• Dielectric Test<br>• IAC<br>• Temperature Rise<br>• Short-time withstand current and peak withstand current.<br>• IP coding | | H | R | R | | |

| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| FAT TEST – DESIGN, VISUAL AND MECHANICAL CHECK | | | | | | | | |
| 12.1 | | Verification of gauging and calibration of instruments used for checks and tests | IEC 61439-2<br>G.A., SLD, FAT Procedure, Data Sheet, Schematic Diagrams, Logic Diagram<br>OP 7.09<br>WI 08. CQ<br>Technical Specification<br>Doc. 123A90-DDL-EL-SP-20023<br>Technical Data Sheet<br>Doc. 123A90-DDL-EL-DS-20024 | H | W | W | | |
| 12.2 | | Check of steel structure (2) | | H | W | W | | |
| 12.3 | | Check of binding dimensions (2) | | H | W | W | | |
| 12.4 | | Check of workmanlike construction (1) | | H | W | W | | |
| 12.5 | | Check of rated data of the equipment installed (1) | | H | W | W | | |
| 12.6 | | Verification of acceptance test documentation on individual power equipments | | H | W | W | | |
| 12.7 | | Check of nameplate and tagging | | H | W | W | | |
| 12.8 | | Rating plate data check | | H | W | W | | |

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| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| 12.9 | | Verification of the clearances and creepage distances | Supplier master index register Doc. 1723002197-MD-LIS-00001 | H | W | W | | |
| 12.10 | | Visual check of IP protection (1) | | H | W | W | | |

| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| FAT TEST – DESIGN, VISUAL AND MECHANICAL CHECK | | | | | | | | |
| 12.11 | FAT Electrical Switchboard | Mechanical operation tests | IEC 61439-2<br>G.A., SLD, FAT Procedure, Data Sheet, Schematic Diagrams, Logic Diagram<br>OP 7.09<br>WI 08. CQ<br>Technical Specification | H | W | W | Fat report | IMESA factory |
| 12.12 | | Electrical and mechanical interlock functional verification | | H | W | W | | |
| 12.13 | | Check of interchangeability of extractable components (1) | | H | W | W | | |
| 12.14 | | Check of wiring including earthing connection and separation for various level voltage steps (1) | | H | W | W | | |
| 12.15 | | Suitability check of assembled apparatus and of materials at environmental and climatic conditions (conformity declaration) | | H | R | R | | |

| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| 12.16 | | Check of easy accessibility and removal of individual components (1), check assembly layout in accordance with the drawings | Doc. 123A90-DDL-EL-SP-20023 Technical Data Sheet<br>Doc. 123A90-DDL-EL-DS-20024 Supplier master index register<br>Doc. 1723002197-MD-LIS-00001 | H | W | W | | |
| 12.17 | | Completeness supply check according to the contractor order | | H | W | W | | |
| 12.18 | | Check of the compliance with prototype and contractor requirements | | H | R | R | | |

| Item N° | Component | Activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| FAT TEST – DESIGN, VISUAL AND MECHANICAL CHECK | | | | | | | | |
| 12.19 | FAT Electrical Switchboard | Visual check of the condition of painted surfaces | IEC 61439-2<br>G.A., SLD, FAT Procedure<br>OP 7.09<br>WI 08. CQ<br>Painting Procedure Doc. n. 1723002197-MAT-PRO-00004 | H | W | W | Fat report painting report or a declaration for painting | IMESA factory |
| 12.20 | | Thickness check (1) | | H | W | W | | |
| 12.21 | | Check of colour | | H | W | W | | |

| Item N° | Component | Internal activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| FAT TEST – ELECTRICAL AND FUNCTIONAL TESTS | | | | | | | | |
| 13.1 | FAT Electrical Switchboard | Power frequency voltage tests | IEC 61439-2<br>G.A., SLD, FAT Procedure, Data Sheet, Schematic Diagrams, Logic Diagram<br>OP 7.09<br>WI 08. CQ<br>Technical Specification<br>Doc. 123A90-DDL-EL-SP-20023<br>Technical Data Sheet<br>Doc. 123A90-DDL-EL-DS-20024<br>Supplier master index register<br>Doc. 1723002197-MD-LIS-00001 | H | W | W | Fat report | IMESA factory |
| 13.2 | | Insulation resistance measurement | | H | W | W | | |
| 13.3 | | Measurement of the resistance of the main circuits | | H | W | W | | |
| 13.4 | | Dielectric test on main, auxiliary and control circuits | | H | W | W | | |
| 13.5 | | Check of protection relay with secondary current injection (1) | | H | W | W | | |
| 13.6 | | CT polarity check with primary current injection (1) | | H | W | W | | |
| 13.7 | | Electrical functional test (typical unit only) | | H | W | W | | |
| 13.8 | | Checking of electrical operation (typical unit only) | | H | W | W | | |

| Item N° | Component | Internal activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| 13.9 | | Grounding circuit check (1) | | H | W | W | | |
| 13.10 | | Cabling check and auxiliary electrical devices (1) | | H | W | W | | |
| 13.11 | | ECMS simulation test | | H | W | W | | |

| Item N° | Component | Internal activity | Applicable Standard and Documents | Intervention Code | | | Certific. and data | Place of Execution |
|---|---|---|---|---|---|---|---|---|
| | | | | IMESA | ROSETTI | CROSSWIND | | |
| FINAL INSPECTION | | | | | | | | |
| 14.1 | Electrical Switchboard | Check of type, quantity and labelling of the spare parts | OP/WI APPLICABLE | H | W | R | IMESA certificate | IMESA factory |
| 14.2 | Electrical Switchboard | Check of tools and special tools | OP/WI APPLICABLE | H | W | R | IMESA certificate | IMESA factory |
| 14.3 | Electrical Switchboard | Check of weights, centre of gravity, lifting points | OP/WI APPLICABLE | H | R | R | IMESA certificate | IMESA factory |
| 14.4 | Electrical Switchboard | Weight Report | OP/WI APPLICABLE | H | R | R | IMESA certificate | IMESA factory |
| 14.5 | Electrical Switchboard | Packaging and shipment | OP/WI APPLICABLE | H | R | R | Packing list + shipping invoice | IMESA factory |
| 14.6 | Electrical Switchboard | Certificate review and issue of release note | OP/WI APPLICABLE | H | H | R | Release note issued by ROSETTI | IMESA factory |

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2.2. F.A.T. Procedure

2.2.1.FACTORY ACCEPTANCE TEST PROCEDURE - HV Switchgear,

Doc No. 1723002197-QC-PRO-00044

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# Base Load Power Hub (BLPH)

## FACTORY ACCEPTANCE TEST PROCEDURE

## HV Switchgear

## Document Number: 1723002197-QC-PRO-00044

ROSETTI MARINO

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|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Macula | 14/11/2024 |

Document Class: 2

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IMESA ELECTRICAL ENGINEERING IMESA Doc. n. 231115/SD/044

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## Revision / Change Log

| Rev. | Description |
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| 00 | Issue for Review (IFR) |
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## 1 APPLICABILITY AND RESPONSIBILITY

These Job Instructions describe the testing procedures applicable to 6.6 kV Main Electric Switchboard manufactured by IMESA, in accordance with Regulations **IEC 62271-200**.

The Head of Quality Control (CQ) or his collaborators (see list of IMESA qualified testers) are responsible for ensuring the proper implementation of the following Job Instructions.

The tests described on this document will be executed at IMESA factory.

## 2 GENERAL INFORMATION

The switchboard will be placed in a separated area to which access is allowed only to authorised personnel; it should not be possible to isolate the switchboard, the area will be marked off by means of barriers, notices, visible and flashing barriers.

The tester will use the following standards, drawings (switchboard front, overall dimensions, schematic diagrams, etc.) and specifications, as reference:

Applicable standards:

- IEC 62271-200 HV Switchboard
- IEC 62271-100 Circuit breaker
- IEC 62271-102 Earthing switch
- IEC 61869-2 CTs
- IEC 61869-3 VTs
- IEC 60529 Degree of protection

Reference Contractor Documents:

- 123A90-DDL-EL-SP-20019 / Technical Specification, IDS and DDS for 6.6kV Switchgear
- 123A90-DDL-EL-DS-20020/ Technical Data Sheet (TDS) for 6.6kV Switchgear

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Applicable IMESA Documents:

| Document ID | Title |
|---|---|
| 1723002197-EL-DA-00006 | SG-100D1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| 1723002197-EL-DG-00010 | SG-100D1 ELECTRICAL SINGLE LINE DIAGRAM |
| 1723002197-EL-DG-00015 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - INCOMING FEEDER (including Terminals and BOM) |
| 1723002197-EL-DG-00016 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - BUS BAR METERING (including Terminals and BOM) |
| 1723002197-EL-DG-00017 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - BESS FEEDER (including Terminals and BOM) |
| 1723002197-EL-DG-00018 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - ELECTROLYSER FEEDER (including Terminals and BOM) |
| 1723002197-EL-DG-00019 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - FUEL CELL FEEDER (including Terminals and BOM) |
| 1723002197-EL-DG-00020 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - TRANSFORMER TR200ED1 (including Terminals and BOM) |
| 1723002197-EL-DG-00021 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM – TRANSFORMER TR200DE1 (including Terminals and BOM) |
| 1723002197-EL-DG-00022 | SG-100D1 MV SWG INTERCONNECTING AND AUX DISTRIBUTION DIAGRAM (including BOM) |
| 1723002197-EL-DG-00023 | SG-100D1 MV SWG LOGIC DIAGRAM - INCOMING FEEDER |
| 1723002197-EL-DG-00025 | SG-100D1 MV SWG LOGIC DIAGRAM - BESS FEEDER |
| 1723002197-EL-DG-00026 | SG-100D1 MV SWG LOGIC DIAGRAM - ELECTROLYSER FEEDER |
| 1723002197-EL-DG-00027 | SG-100D1 MV SWG LOGIC DIAGRAM - FUEL CELL FEEDER |
| 1723002197-EL-DG-00028 | SG-100D1 MV SWG LOGIC DIAGRAM - TRANSFORMER FEEDER TR200ED1 |
| 1723002197-EL-DG-00029 | SG-100D1 MV SWG LOGIC DIAGRAM - TRANSFORMER FEEDER TR200DE1 |
| 1723002197-COM-LIS-00052 | SPARE PART INDEX REGISTER (COMMISSIONING AND OPERATION) |
| 1723002197-EL-LIS-00053 | SPECIAL TOOLS LIST |
| 1723002197-QC-PRO-00055<br>1723002197-MAT-PRO-00004 | PACKING, SHIPPING, HANDLING AND STORAGE PROCEDURES<br>MV-LV SWG PAINTING PROCEDURE |
| 1723002197-QC-ITP-00002 | INSPECTION AND TEST PLAN - MV Switchgear |

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*3 DESIGN, VISUAL AND MECHANICAL CHECK*

### *3.1 Design, Visual and mechanical check*

1. Check the structural dimensions with respect to those shown by the assembly drawings of the different units.
2. Check that there are no bends and that the sheet plate is perfectly flat
3. Check that assembly has been carried out correctly and that the doors are earthed.
4. Check that ducts have been provided for the auxiliary cables as shown by the foundation drawings.
5. Check the coating or plating If the bus-bars are plated (silver plating, resin coating etc).
6. Check that the Main Equipment has been positioned correctly as per the Mimic Diagrams and Switchboard Front View drawing.
7. Check that the equipment is securely fixed.
8. Check that the equipment is properly earthed, wherever appropriate.
9. Check the equipment for eventual damage caused during assembly.
10. Equipment characteristic and rated data checking
11. Check that the paint colour complies with that indicated on the assembly list and that is has not been damaged during assembly.
12. Check the thickness of the paint by an appropriate instrument insuring that the thickness corresponds to one in specification.
13. Check the required internal form of segregation
14. Equipment accessibility and removability checking
15. Check of nameplate and label legend
16. Bus bar creepage and clearance distances check (phase-earth min 60mm / phase-phase min 90mm)
17. Checking of steel thickness (20/10), steel structure work, welding (if any), sheet metal, lifting tool.

### 3.2 Mechanical structural tests

1. Check that the circuit-breakers can be plugged in and drawn out correctly and possible mechanical interlocking.
2. Check that mechanical locks to prevent the insertion into the unit of similar circuit breakers with rated current inferior to that of the compartment, have been fitted on the mobile section of the circuit breaker and on the fixed section of the unit.
3. Wherever appropriate, check the operating efficiency of the limit switches for racked-in and isolated circuit breaker. To carry out the check, electrically test the switching of the auxiliary contacts both with the circuit-breaker drawn out and the circuit breaker plugged in.
4. Check the operating efficiency of the signalling auxiliary contacts of the open – closed circuit breaker. The check consists of electrically testing the switching of the auxiliary contact both with the circuit breaker in open and closed position.

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5. Check the operating efficiency of the mechanical lock that prevents the manual or electrical closing of the circuit breaker when it is positioned between the plugged in and drawn out positions with the door open. To carry out the check, attempt to close the circuit breaker rack manually and electrically when the circuit breaker is more or less in the plugged in position (or in the case of a HV switchboard, with the door of the box is slightly open).
6. Check the operating efficiency of the key locks and ring the keys if necessary.
7. Check the operating efficiency of all the mechanical interlocks between the circuit-breakers, disconnecting switches and earthing switches.
8. Carry out a number of starting up and stopping sequences as indicated by the table referring to the cell.
9. Check the functional efficiency of the key locks and perform the key ringing when required
10. Check the operating efficiency of all mechanical interlocks between the circuit-breakers, disconnecting switches and earthing switches.
11. Carry out a number of starting up and stopping sequences as indicated by the table referring to the cell.
12. Connections resistor measurement by Voltage Drop Test

### 3.3 Checking the degree of protection

Check that the degree of protection of the Electrical Switchboards complies with the Order Specifications of the Customer and CEI EN 60529 regulation (Classifications of degrees of protection provided by enclosures for electrical equipment).

### 3.4 Checking the cabling

1. Check that the information shown on the switchgear nameplates complies with the project data.
2. Check that the cables and equipment have been correctly marked and tagged whit what is reported on the functional diagrams.
3. Check the section of the bars/cables, as provided by project for the power of switch/utilities.
4. Check that the connections on the main circuits are securely tightened (ensuring that the signs on the bolts are correctly marked, where applicable).

Bus bar tightness check

The table below shows the torque wrench settings to use for the nuts and screws for fixing and connecting the compartments and the busbar. (Tolerance 0 % + 20 %)

| Screws | M6 | M8 | MI0 | M12 | M14 | M16 |
|---|---|---|---|---|---|---|
| Wrench setting (Nm) -Min | 8 | 19 | 40 | 68 | 100 | 160 |
| Wrench setting (Nm) -Nominmal | 9 | 22 | 45 | 75 | 115 | 185 |
| Wrench setting (Nm) -Max | 10 | 25 | 50 | 83 | 130 | 200 |

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Current Transformers tightness check:

| Screw | Max. torque [Nm] | Min. torque [Nm] |
|---|---|---|
| M5 | 3.5 | 2.8 |
| M6 | 4 | 3 |
| M8 | 20 | 16 |
| M10 | 20 | 16 |
| M12 | 70 | 56 |

5. Check that the cables and wires comply with requirements (marine cable SH-W, etc.) and the nominal voltage $U_0/U$.
6. Check that all the wires are installed in suitable ducts or have been grouped in bunches placed so that they do not interfere with moving components or cut the insulating sheath.
7. Carry out sample checks on the cable terminations to ensure that they are properly crimped and marked as shown by the relevant diagram.
8. Check that the terminal boards have been correctly positioned and marked and that the terminal is suited to the required function.
9. Check the terminal board connection to the adjacent units ensuring that it has been marked as shown by the Functional Diagrams and that the terminals and jumpers comply with the schematics.
10. Carry out all the checks indicated by point 4 on terminal boards supplied by the Customer and check that all the contacts requested by the Customer have been cabled (e.g. auxiliary relay contacts, protection relay contacts etc.).

## *4 Electrical and Functional Test*

### 4.1 Functional Test

These tests consist of checking the operating efficiency of all the electric and electromechanical circuits, as shown by the diagrams, by simulating as far as possible different operating conditions. In the case of the **HV** switchboards, the cells must be placed in service position.

1. Check the supply and closing circuit of the spring charging geared motor as follows: set the supply voltage of the circuit to Vn and check the operating efficiency of the spring charging geared motor. With the supply voltage on Vn, place the unit on local operating mode and check compliance of the remote control and lock circuits with the Operating Diagram of the unit. The remote control function must also be simulated by activating on the output terminal boards.
2. Check the opening circuit as follows: set the supply voltage of the circuit on Vn and check the opening circuit of the circuit breaker in the following conditions:

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- **Local**: the circuit breaker must open when the relevant pushbutton or controller is pressed or activated.
- **Remote**: simulate remote operation by activating the relevant output terminal boards.

3. Check the closing circuit as follows: set the supply voltage of the circuit on Vn and check the opening circuit of the circuit breaker in the following conditions:
   - **Local**: the circuit breaker must close when the relevant pushbutton or controller is pressed or activated.
   - **Remote**: simulate remote operation by activating the relevant output terminal boards.
4. Check the signalling circuits as follows:
   - check the operating efficiency of the optical signals on the unit and ensure that they comply with the Operating Diagram;
   - check that the remote signalling circuits on the output terminal boards are suitable.
5. Check that all the logics shown by the diagrams have been complied with and are efficient both in local and remote by simulating electrical commands or locks from the exterior (it depends on the operating philosophy shown on functional and logic diagrams)
   - Check the closing and opening commands in local and remote.
   - Check the intertrip and interlock signals operating.
   - Check the HW remote alarm operating.
   - Check the operating of auxiliary devices.
   - Electrical functional tests on typical single unit including I/O.

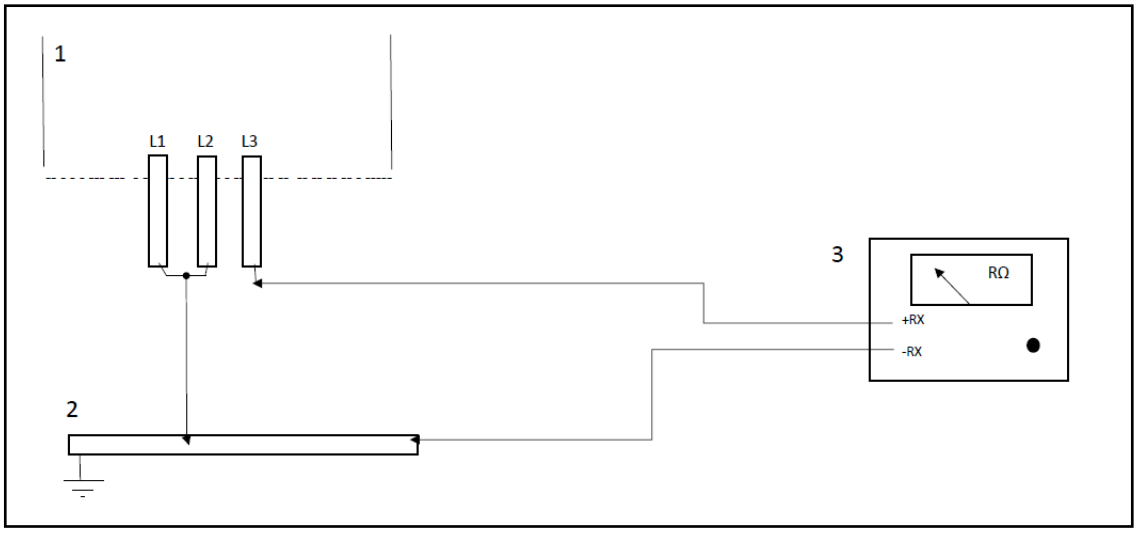
   For the above Tests, please take as reference the Functional and Logis schematic diagrams
6. Measurement of the resistance on the main circuits.
   (100% verification already done my IMESA before FAT. IMESA report can be provided.

   The test is carried out by applying a voltage of 5000 Vdc for 10" between the power circuits (in sequence L1, L2, L3) and ground.
   This Test is carried out to detect the Insulation resistance before and after the test described at item 4.3 (Hi-Pot Test)

   ***Acceptance Criteria:***
   The insulation resistance (based on the cubicles tested) is greater than 10MΩ and the megger does not give an earth fault.

   Resistance Insulation Test on Power Circuit - HV Switchboard Lay-Out
   HV Switchboard Busbar
   Ground Reference
   Megger (-Rx shall be connected with the ground)

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Test lay-out for L1 phase Example

Carrying out the test
Reading of the insulation resistance with a “MEGGER” on the following points:
between phase L1 and the phases L2 and L3 connected to earth (-Rx of instrument);
between phase L2 and the phases L1 and L3 connected to earth (-Rx of instrument);
between phase L3 and the phases L1 and L2 connected to earth (-Rx of instrument).

7. Check the amperometric circuits as follows: apply a primary or secondary current and check the operating efficiency of the current transformers, ammeter, protection relays.
   (100% verification already done my IMESA before FAT. IMESA report can be provided.)
8. Check the voltmeter circuits as follows: applying primary power, check the operating efficiency of the voltmetrical transformers and the protection relays.
9. Check CT Polarity, physical marking of P1, P2 and S1, S2. Through the galvanometer, with the connection cables, connected to primary and secondary terminals of the current transformer, the instrument will indicate if the polarity is "according to" "or" discording "
   (100% verification already done my IMESA before FAT)
10. Check of anti-condensation resistance by means power supply. Check the operating efficiency of thermostat and anti-condensation resistance.
11. Check of the protection relay by means of secondary current/voltage injection to verify some trip functions

These tests consist of checking the operating efficiency of the electrical protective relays, by means of secondary current injection and secondary voltage supply, in terms of:

measurements delivered by the in-built instruments,

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tripping of the relevant protection functions, in accordance with the settings defined in the Selectivity Analysis, proper activation of digital output contacts and optical signals (LED).

### 4.2 VOID

### 4.3 Power Frequency Test and measurement of Insulation resistance

The dielectric tests are carried out to check the insulation distances, the soundness of the insulating materials and that the connections have been made correctly.

Remember to disconnect all current absorbing equipment which would be damaged by the application of voltage (coils, metering instruments, differential circuit breakers etc). A voltage generator at industrial frequency is used to carry out this test.

On agreement between builder and user, operating frequency voltage test, it can be repeated after installation on site; in this case the test voltage shall be equal to 80% the value shown in the table below (CEI EN 62271-200):

| Rated Voltage Efficacy Value (kV) | Test Voltage Efficacy Value (kV) |
|---|---|
| 3,6 | 10 |
| 7,2 | 20 |
| 12 | 28 |
| 17,5 | 38 |
| 24 | 50 |
| 36 | 70 |

Voltage is applied for 60” for each configuration.

In the presence of CTs, they must be short-circuited and the switches closed.

During this time one operator check the activation of voltage indicator of relevant phase

Main busbars will be fully installed, and all MV circuit breakers will be closed and connected.

**Carrying out the test**

To run the test proceed as described:

- Connect to ground the control desk, the VT truck, the foil, the equipment under test;
- Limit the test patch with appropriate barriers;

- Connect the HV pole of VT to the object or to a phase of the electrical panel in test, with the other two phases grounded.
- Connect from table with special cables the lights flashing, the TV and the power plug of the same.
- The operator, before starting the test, must ensure that nobody is within the hurdles.
- Close the main switch of the instrument and work slowly on the rheostat knob until you reach the test voltage read on the voltmeter. (**N.B.** if the rheostat knob is in position zero, the circuit in not closed)

***Acceptance Criteria:***

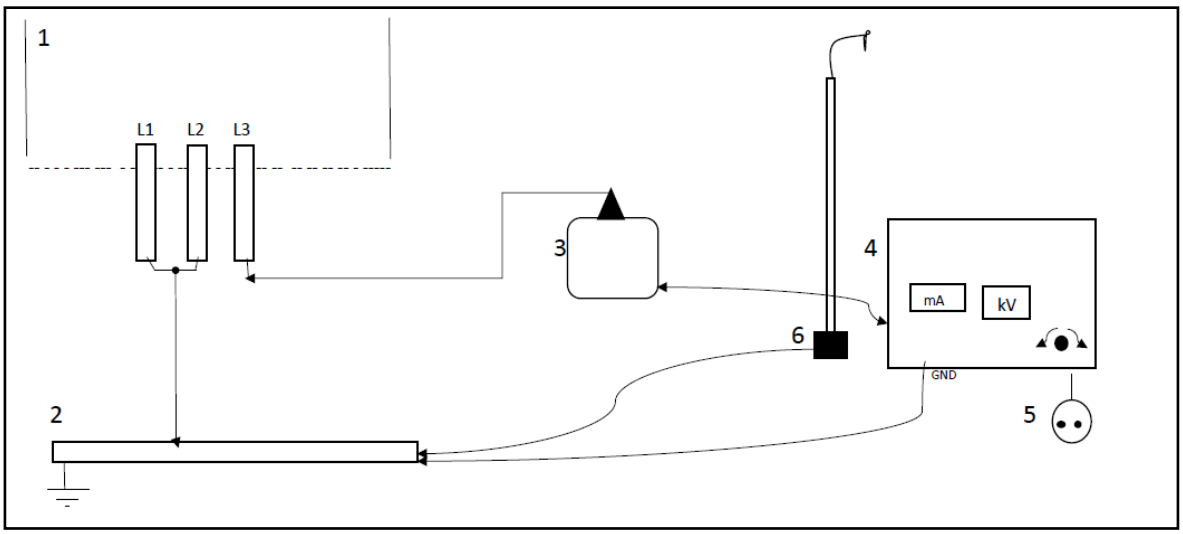
The test is passed if for a minute there is no shock.

**Imesa consider valid the test if the control desk doesn't detect any fault, this shall consider valid also in case if some discharge can be hearded during the test**

- After the test or if there has been a download, return to zero the rheostat, unload with the foil, the pole of VT. In these conditions you can approach the device under test.
- Apply to the other two phases the voltage required by repeating the steps described above for each phase.
- All voltage indicator lamps working properly

HI-Pot Test Lay-Out

1) HV Switchboard Busbar
2) Ground Reference
3) Step-up Transformer
4) Hi-Pot Tester
5) Power supply
6) Ground stick



**Test lay-out for L1 phase Example**

**Carrying out the test**

- between phase L1 and the phases L2 and L3 connected to earth;
- between phase L2 and the phases L1 and L3 connected to earth;
- between phase L3 and the phases L1 and L2 connected to earth.

During the Test a Tester has to check that the indication voltage presence of the main circuit is light on

Between to adjust the circuit for a new test it is necessary to discharge to system by Ground Stick

***After the dielectric Test on each phase, item 6 has been repeated the value detected will be mentioned on the FAT Report.***

### *4.4 Dielectric test on auxiliary circuit and Insulation resistance measurement*

Testing of voltage applied between the auxiliary and control circuits and mass, 1.5kV for 1 min according to RINA rules.

Insulation resistance through Megger device to be checked before and after the here below dielectric Test.

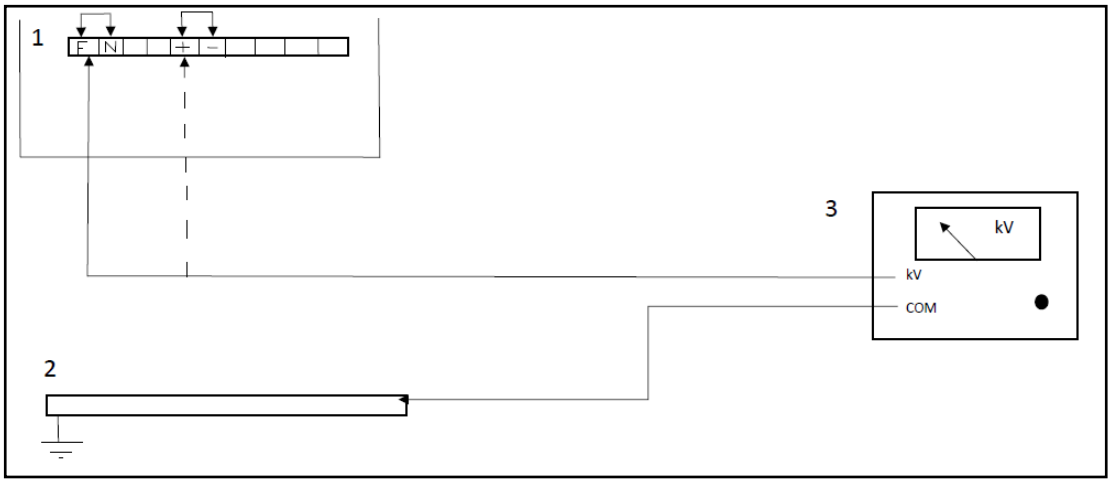
The values detected before and after will be reported in the Test Report.

***Acceptance Criteria:***

The test is passed if for a minute there is no shock detected by the Test Banch.

Resistance Insulation Test on Aux Circuit HV Switchboard Lay-Out

1) HV Switchboard Busbar
2) Ground Reference
3) Megger (-Rx shall be connected with the ground)



*4.4 Applied voltage test on the auxiliary and control circuits*

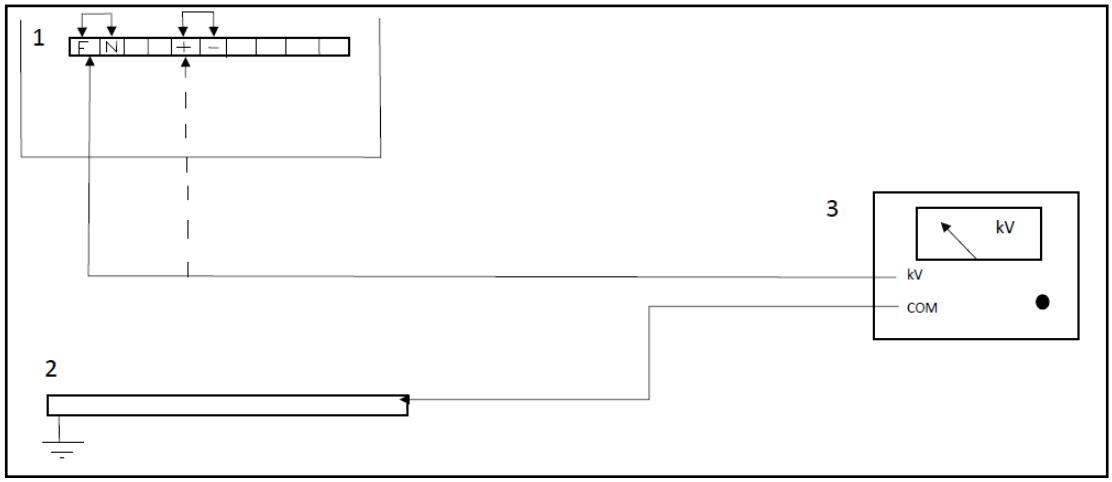
Testing of voltage applied between the auxiliary and control circuits and mass, applying a voltage of 2 kV for 60 seconds (CEI EN 62271-1)

***Acceptance Criteria:***

The test is passed if for a minute there is no shock detected by the Test Banch.

Resistance Insulation Test on Aux Circuit HV Switchboard Lay-Out

1) HV Switchboard Busbar
2) Ground Reference
3) Megger (-Rx shall be connected with the ground)




**Test lay-out for L1 phase Example**

***After the dielectric Test on each phase, item 4.4 has been repeated the value detected will be mentioned on the FAT Report.***

### *4.5 Checking the continuity of the protection circuit*

The purpose of this check is to ensure that the protection circuit has been installed correctly and is carried out with both a visual examination (check that rough contact washers have been fitted) and an electrical test (resistor less than 0,1Ω).
With the multitest instrument we use a measure system with no.4 wires. Switchboard is split into no.2 parts and the measure of the continuity of the protection circuit is carried out as follows:
RPE connectors red and reference black are connected to the earth main busbar in the rear section of the switchboard. To close the circuit others RPE red and reference black connectors are connected to the earthing strap on the auxiliary front door on the opposite side of the first red connector on main earth busbar.
An injection of 25A ac is carried out for 3 sec, and the resistance of the circuit is measured.
Test is considered accepted if the resistance is less than 0,1Ω.

### *4.6 Drop voltage on main busbar*

The drop voltage is performed to check the busbar connections, and is carried out with nr. 2 tests.

First test is carried out as follows:
A current generator 100A dc is connected between the vertical busbar near the upper pole of the circuit breaker and cable connection with main circuit breaker closed and connected. The test is carried out for each phase.
With a digital multimeter the value of the drop voltage is measured in mV.
Consequently it is calculated the value of the contact resistance in microΩ.
Acceptance criteria:
The test is considered accepted if the value of the contact resistance does not deviate each other more than 30%.

Second test is carried out as follows:
A current generator 100A dc is connected between the begin and the end of horizontal main busbar. The test is carried out for each phase.
With a digital multimeter the value of the drop voltage is measured in mV.
Consequently it is calculated the value of the contact resistance in microΩ.
Acceptance criteria:
The test is considered accepted if the value of the contact resistance does not deviate each other more than 30%.

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### 4.7 External Auxiliary Power Supply

Redundancy Test of Incoming supply Lines (110Vdc)

Since there are n.2 incoming line for 110Vdc, the test consists of disconnecting one line at a time verifying that all units continue to be supplied without any unexpected switchgear malfunction.

### 4.8 Check electric arc

Electric arc on busbar compartment, switch compartment and cable compartment

Trial set:

- Connect the test bench with amperometric terminal blocks for secondary current injection.
- Check flash setting (maximum output)

Test procedure:

- Turn on and close the switches of the users involved.
- Carry out the flash test in the absence of power, in the compartment concerned, checking the correct opening of the "light only" trip switches according to the project specifications.
- Close the switches of the users involved.
- Inject the current onto an amperometric input of the protection relay, with a value higher than the threshold limits and check that the relays acquire this value.
- Carry out the flash test in the compartment concerned, checking the correct opening of the "light and power" trip switches according to the project specifications.
- Repeat the tests alternating the amperometric inputs of the three-phase protection relay.

***Acceptance Criteria:***

• The incoming and bus-tie circuit breakers must open and the blocking relay must be activated, depending on the design specifications.

### 4.9 Integrate Test with EMS

(This test will not be held with HV switchgear FAT since it is not in charge of IMESA)

## 5 Final checks

Once all the tests have been carried out on the different units, before sending the switchboard to the packaging department, the following checks must be carried out:

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1. Check that all the jumpers used for the electrical tests of the different circuits have been removed from the terminal boards and the equipment.
2. Clean all the equipment in the unit.
3. Touch up the paintwork if necessary.
4. Check that the foundation bars comply precisely with the drawings.
5. Compile the "Mod. CAR/CAB 04 bill of material for shipment" with an indication of the material to be shipped loose, including material required for installation of the units.
6. Make out the list of missing materials (this list should include materials which are missing because found to be faulty during testing and the equipment to be installed by the Customer).
7. Check that the Manufacturer's data plate showing the characteristics of the switchboard has been fitted.
8. Insert the maintenance manual of the framework
9. CQ deals with the issue the test report and sees to its storage.
10. Check the commissioning spare parts, if any.

N.B In case of acceptance by the customer, it's up to present PM inform RP which involves the planning of production and make it aware of CAB and CQ; PM also defines the exact date that he agreed with the customer and informs the affected functions.

At the end of the test, customer must sign the test report.

## 6 TEST EQUIPMENT

The following test equipment will be used to carry out the above tests:

- Universal power supply for the auxiliary circuits,
- Amperometric power supply for the primary and secondary currents,
- Instrument for the applied voltage test at industrial frequency of the main circuit,
- Instrument for the applied voltage test of the auxiliary and control circuits,
- Digital thickness gauge

## 7 CARRYING OUT THE TESTING ACTIVITIES

The testing activities must be carried out in compliance with the safety requirements of the current regulation by restricting the test area with the special hurdles.

The testing activities must be carried out exclusively by personnel who have received training under the CEI 11-27 anyway the operators must always be at least two.

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If testing is manned by customer (or by those third parties designated by it), this is absolutely not permitted to carry out maneuvers on the switch and are not allowed to stay alone at the IMESA plant.

All electrical parts must be banned from all contact and the area should be well lit and free from hindrances and obstacles.

Operators must be equipment with suitable DPI and certified equipment under current regulations.

During testing must always be at least one first aid worker who has received its education.

When testing the dielectric properties (applied voltage test), remember to wear insulated gloves and shoes with retractable toe caps as well as suitable protection clothing covering body and arms. If the test is suspended even temporarily, the test instrument must be disconnected from the mains.

## 8 ANNEX

- See Annex 1 (Fac-simile Test Report)
- See Annex 2 (Checklist)

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2.2.2.FACTORY ACCEPTANCE TEST PROCEDURE - LV Switchgear,

Doc No. 1723002197-QC-PRO-00045

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# Base Load Power Hub (BLPH)

## FACTORY ACCEPTANCE TEST PROCEDURE

witchgear

723002197-QC-PRO-00045

nent Class: 2

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Andrea Santinelli | 26/03/2025 |

| Rev. | Date | Description | Prepared | Reviewed | Approved |
|---|---|---|---|---|---|
| 03 | 21/03/2025 | Accepted for Construction (AFC) | Santinelli | Mastri | Chiappa |
| 02 | 5/11/2024 | Accepted for Construction (AFC) | Santinelli | Mastri | Chiappa |
| 01 | 15/07/2024 | Issue for Review (IFR) | Santinelli | Mastri | Chiappa |
| 00 | 06/06/2024 | Issue for Review (IFR) | Santinelli | Mastri | Chiappa |

IMESA ELECTRICAL ENGINEERING IMESA Doc. n.231298/SD/045

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## Revision / Change Log

| Rev. | Description |
|---|---|
| 00 | Issue for Review (IFR) |
| 01 | Issue for Review (IFR) |
| 02 | Accepted for Construction (AFC) |
| 03 | Accepted for Construction (AFC) |
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## HOLDS LIST

| No. | Description |
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| 1 | |
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| 4 | |

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## 1 APPLICABILITY AND RESPONSIBILITY

These Job Instructions describe the testing procedures applicable to LV Electric Switchboards manufactured by IMESA, in accordance with Regulation **IEC 61439-1**
The Head of Quality Control (QC), the Head of CAB and the team leader that perform testing are responsible for ensuring the proper implementation of the following Job Instruction.
The tests described on this document will be executed at IMESA factory.

## 2 GENERAL INFORMATION

The switchboards which are ready for tested should be placed in a separated area to which access should be allowed only to authorised personnel; should it not be possible to isolate the switchboard, the area should be marked off by means of barriers, notices, visible and flashing barriers.

The tester must use the diagrams (SLD, Functional, etc) and the drawings (switchboard front, overall dimensions etc.) and eventual special specifications, as reference.

A list of all the checks and tests carried out on both types of switchboards, namely LV Electric Switchboards (unless otherwise indicated) manufactured by IMESA, is provided (see Annex 1).

When testing the dielectric properties (applied voltage test), insulated gloves and shoes with retractable toe caps, as well as suitable protection clothing covering body and arms, to be worn. If the test is suspended even temporarily, the test instrument must be disconnected from the mains.

Applicable standards:

IEC 61439-1:2020 – Low-voltage switchgear and controlgear assemblies – Part 1: General rules.
IEC 61439-2:2020 – Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies.
IEC 60947-2:2016 with Amendment 1:2019 – Low-voltage switchgear and controlgear – Part 2: Circuit-breakers.
IEC 61869-2:2012 – Instrument transformers – Part 2: Additional requirements for current transformers.
IEC 61869-3:2011 – Instrument transformers – Part 3: Additional requirements for voltage transformers.

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IEC 60529:1989 with Amendments 1:1999 and 2:2013 – Degrees of protection provided by enclosures (IP Code).

Reference Contractor Documents:

- 123A90-DDL-EL-SP-20023 / Technical Specification, IDS and DDS for LV Switchgear
- 123A90-DDL-EL-DS-20024 / Technical Data Sheet (TDS) for 6.6kV Switchgear

Applicable IMESA Documents:

| Document ID | Title |
|---|---|
| 1723002197-EL-DA-00007 | SG-200N1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| 1723002197-EL-DA-00008 | SG-200D2 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| 1723002197-EL-DA-00009 | DP-200N1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| 1723002197-EL-DG-00011 | SG-200N1 ELECTRICAL SINGLE LINE DIAGRAM |
| 1723002197-EL-DG-00012 | SG-200D2 ELECTRICAL SINGLE LINE DIAGRAM |
| 1723002197-EL-DG-00013 | DP-200N1 ELECTRICAL SINGLE LINE DIAGRAM |
| 1723002197-EL-DG-00030 | SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - INCOMINGS, INTERCONNECTING AND AUX DISTRIBUTION |
| 1723002197-EL-DG-00031 | SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS |
| 1723002197-EL-DG-00032 | SG-200D2 FUNCTIONAL DIAGRAM |
| 1723002197-EL-DG-00033 | DP-200N1 FUNCTIONAL DIAGRAM |
| 1723002197-COM-LIS-00052 | SPARE PART INDEX REGISTER (COMMISSIONING AND OPERATION) |
| 1723002197-EL-LIS-00053 | SPECIAL TOOLS LIST |
| 1723002197-QC-PRO-00055 | PACKING, SHIPPING, HANDLING AND STORAGE PROCEDURES |
| 1723002197-MAT-PRO-00004 | MV-LV SWG PAINTING PROCEDURE |
| 1723002197-QC-ITP-00003 | INSPECTION AND TEST PLAN - LV Switchgear |

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## *3 DESIGN, VISUAL AND MECHANICAL CHECKS*

### *3.1 Visual and dimensional check*

1. Check of nameplate and label legend
2. Bus bar creepage and clearance distances check
3. Checking of steel thickness, steel structure work, welding, sheet metal, lifting beams (thickness of roofing sheets, plinths, uprights, 3mm; door sheets, segregations, shelves, 2mm)
4. Equipment characteristic and rated data checking
5. Equipment accessibility and removability checking
6. Check the structural dimensions with respect to those shown by the assembly drawings of the different units.
7. Check that there are no bends and that the sheet plate is perfectly flat
8. Check that assembly has been carried out correctly and that the doors are earthed.
9. Check that ducts have been provided for the auxiliary cables as shown by the foundation drawings.
10. Check the coating or plating If the bus-bars are plated (silver plating, resin coating etc).
11. Check that the Main Equipment has been positioned correctly as per the Mimic Diagrams and Switchboard Front View drawing.
12. Check that the equipment is securely fixed.
13. Check that the equipment is properly earthed, wherever appropriate.
14. Check the equipment for eventual damage caused during assembly.
15. Check that the paint colour complies with that indicated on the assembly list and that is has not been damaged during assembly.
16. Check the thickness of the paint by an appropriate instrument insuring that the thickness corresponds to one in specification.
17. Check the required internal form of segregation

### *3.2 Mechanical structural tests*

1. Check that the circuit-breakers can be plugged in and drawn out correctly and possible mechanical interlocking.
2. Check that mechanical locks to prevent the insertion into the unit of similar circuit breakers with rated current inferior to that of the compartment, have been fitted on the mobile section of the circuit breaker and on the fixed section of the unit.
3. Wherever appropriate, check the operating efficiency of the limit switches for racked-in and isolated circuit breaker. To carry out the check, electrically test the switching of the auxiliary contacts both with the circuit-breaker drawn out and the circuit breaker plugged in.
4. Check the operating efficiency of the signalling auxiliary contacts of the open – closed circuit breaker. The check consists of electrically testing the switching of the auxiliary contact both with the circuit breaker in open and closed position.

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5. Check the operating efficiency of the mechanical lock that prevents the manual or electrical closing of the circuit breaker when it is positioned between the plugged in and drawn out positions with the door open. To carry out the check, attempt to close the circuit breaker rack manually and electrically when the circuit breaker is more or less in the plugged in position (or in the case of a MV switchboard, with the door of the box is slightly open).
6. Check the operating efficiency of the key locks and ring the keys if necessary.
7. Check the operating efficiency of all the mechanical interlocks between the circuit-breakers, disconnecting switches and earthing switches.
8. Carry out a number of starting up and stopping sequences as indicated by the table referring to the cell.
9. Check the functional efficiency of the key locks and perform the key ringing when required
10. Check the operating efficiency of all mechanical interlocks between the circuit-breakers, disconnecting switches.
11. Carry out a number of starting up and stopping sequences as indicated by the table referring to the cell.

### *3.3 Checking the degree of protection*

Check that the degree of protection of the Electrical Switchboards complies with the Order Specifications of the Customer and CEI EN 60529 regulation (Classifications of degrees of protection provided by enclosures for electrical equipment).

### *3.4 Checking the wiring*

1. Check that the information shown on the data plates complies with the data shown by the mimic Diagram and apply the setting of caps (when are known).
2. Check that the cables and equipment have been correctly marked and tagged whit what is reported on the operation diagram.
3. Check that the wording on the data plates and positioning of the same comply with the Data Plate and Mimic Diagram List.
4. Check the section of the bars/cables, as provided by project for the power of switch/utilities.
5. Check that the connections on the main circuits are securely tightened (ensuring that the signs on the bolts are correctly marked).
6. Check that the cables and wires comply with requirements (flameproof SH-W) and the nominal voltage $U_0/U$.
7. Check that all the wires are installed in suitable ducts or have been grouped in bunches placed so that they do not interfere with moving components or cut the insulating sheath.
8. Carry out sample checks on the cable terminations to ensure that they are properly crimped and marked as shown by the relevant diagram.
9. Check that the terminal boards have been correctly positioned and marked and that the terminal is suited to the required function.

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10. Check the terminal board connection to the adjacent units ensuring that it has been marked as shown by the Operating Diagram and that the terminals and jumpers comply with the Operating Diagram.
11. Carry out all the checks indicated by point 4 on terminal boards supplied by the Customer and check that all the contacts requested by the Customer have been cabled (e.g. auxiliary relay contacts, protection relay contacts etc.).
12. Verification of thightening of internal circuits and connections / bar connections. * Acceptance criteria as per following table: (see Imesa document TAB 11)

| Type of screw | Tightening torque (Nm) | Tolerance |
|---|---|---|
| M5 | 5 | 5% |
| M6 | 9 | 5% |
| M8 | 22 | 5% |
| M10 | 45 | 5% |
| M12 | 75 | 5% |
| M14 | 115 | 5% |
| M16 | 185 | 5% |

*** for tightening torques regarding insulators, CT's-VT's, refer to the values provided by the manufacturer**

## *4 ELECTRICAL AND FUNCTIONAL TESTS*

### 4.1 Functional Test

These tests consist of checking the operating efficiency of all the electric and electromechanical circuits, as shown by the diagrams, by simulating as far as possible different operating conditions.

In particular:

1. Check the supply and closing circuit of the spring charging geared motor as follows: set the supply voltage of the circuit to Vn and check the operating efficiency of the spring charging geared motor. With the supply voltage on Vn, place the unit on local operating mode and check compliance of the remote control and lock circuits with the Operating Diagram of the unit. The remote control function must also be simulated by activating on the output terminal boards.
2. Check the opening circuit as follows: set the supply voltage of the circuit on Vn and check the opening circuit of the circuit breaker in the following conditions:
   - Local: the circuit breaker must open when the relevant pushbutton or controller is pressed or activated.
   - Remote: simulate remote operation by activating the relevant output terminal boards.
3. Check the closing circuit as follows: set the supply voltage of the circuit on Vn and check the closing circuit of the circuit breaker in the following conditions:

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- Local: the circuit breaker must close when the relevant pushbutton or controller is pressed or activated.
- Remote: simulate remote operation by activating the relevant output terminal boards.

4. Check the signalling circuits as follows:
   - check the operating efficiency of the optical and acoustic signals on the unit and ensure that they comply with the Operating Diagram;
   - check that the remote signalling circuits on the output terminal boards are suitable.
5. Check the amperometric circuits as follows: apply a primary or secondary current and check the operating efficiency of the current transformers, amperometers, amperometric relays and protection relays.
6. Check the voltmeter circuits as follows: applying primary power, check the operating efficiency of the voltmetric relays and the protection relays.
7. Check that all the logics shown by the diagrams have been complied with and are efficient both in automatic and manual by simulating electrical commands or locks from the exterior (it depends on the operating philosophy)
8. Automatic and Manual transfer operating: please refer to the electric tests that will be performed with the helps of relevant approved Schematic Diagrams
9. Intertrip and interlock signals operating: please refer to the electric tests that will be performed witn the helps of relevant approved Schematic Diagrams
10. HW remote alarm operating: please refer to the electric tests that will be performed with the help of relevant approved Schematic Diagrams
11. Check CT Polarity, physical marking of P1, P2 and S1, S2. Through the galvanometer, with the connection cables, connected to primary and secondary terminals of the current transformer, the instrument will indicate if the polarity is "according to" "or" discording " (100% verification ).
12. Check of the Protection Relays by means of secondary current / voltage injection to verify some trip functions

Note: The above tests are carried out on typical feeders only. Hardware and software modification which come out during the FAT can be implemented, if possible, during the FAT on the tested typical units for a prompt verification. After the FAT the software will be prepared for all units including the IED protections settings (out of IMESA scope), however the download and testing of all units will be carried out during the Commissioning activities. Electrical and functional tests will be performed for 100% of the switchgear during fabrication. Relative test reports will be made available during the FAT for Contractor review.

### 4.2 Tests of auxiliary devices

The check of the auxiliary equipment is double. The first, is to check the supplier and other "general" characteristics with the help of SLD & Schematics, the second is to check their "functionality" by the electrical tests that will be performed (please note that all equipment are - in any case - tested during the internal checks before FAT).

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### 4.3 Power Frequency voltage test and measurement of insulation resistance

The dielectric tests are carried out to check the insulation distances, the soundness of the insulating materials and that the connections have been made correctly.

Remember to disconnect all current absorbing equipment which would be damaged by the application of voltage (coils, metering instruments, differential circuit breakers etc). A voltage generator at industrial frequency is used to carry out this test.

Carry out the applied voltage test at industrial frequency on the main circuit between each conductor and the other conductors to earth. The test voltage must comply with that shown by the following table (Table 8 CEI EN 61439-1 pos. 10.9.2.2 + Rina rules) for 1 minute

| Rated insulation voltage Ui | Dielectric test voltage in a.c. (efficacy) |
|---|---|
| Ui ≤ 60 | 1500 |
| 60 < Ui ≤ 300 | 1500 |
| 300 < Ui ≤ 690 | 1890 |
| 690 < Ui ≤ 800 | 2000 |
| 800 < Ui ≤ 1000 | 2200 |

**Carrying out the test :**

To carry out the test, use an insulation reader at a voltage of at least 500V. (as reported by RINA rules PT C – ch2-sec.8 – point 3.4.1)
Measure the insulation resistance of the main circuits.
Read the insulation resistance with a “MEGGER” on the following points:

- between phase L1 and the phases L2 and L3 connected to earth (valid for both tests);
- between phase L2 and the phases L1 and L3 connected to earth (valid for both tests);
- between phase L3 and the phases L1 and L2 connected to earth (valid for both tests).

**Acceptance Criteria:**

Relevant the insulation test, this is considered successful if, for each circuit tested, the insulation resistance is above 1 MΩ as described in the RINA rules (as reported by RINA rules PT C – ch2-sec.8 – point 3.4.2)

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Relevant the industrial frequency test, this is considered successful, if no discharges or perforation occur during the test.

### 4.4 Dielectric test on auxiliary circuit and insulation resistance measurement

Testing of voltage applied between the auxiliary and control circuits and mass, applying a voltage as indicated in the table below, for a period of 1 minute (CEI EN 61439-1+ Rina rules)

| Rated insulated voltage Ui | Dielectric test voltage in a.c. (efficacy) |
|---|---|
| Ui ≤ 12 | 250 |
| 12 < Ui ≤ 60 | 500 |
| Ui > 60 | 2 Ui + 1000 with at least 1500 |

**Carrying out the test:**

To carry out the applied voltage test between the auxiliary and control circuits and earth, apply the voltage highlighted in the above table (checking the insulation between the two short-circuited lines and earth)

**Acceptance Criteria:**

Relevant the insulation test, this is considered successful if, for each circuit tested, the insulation resistance is above 1 MΩ as described in the RINA rules (as reported by RINA rules PT C – ch2-sec.8 – point 3.4.2)

Relevant the auxiliary voltage tests, this is considered to be successful, if no discharges or perforation occur during the test.

### 4.5 Checking the continuity of the protection circuit

The purpose of this check is to ensure that the protection circuit has been installed correctly and is carried out with both a visual examination (check that rough contact washers have been fitted) and an electrical test (resistor less than 0,1Ω).

### 4.6 Integrate Test with EMS

(This test will not be held with HV switchgear FAT since it is not in charge of IMESA)

**5 Final checks**

Once all the tests have been carried out on the different units, before sending the switchboard to the packaging department, the following checks must be carried out:

1. Check that all the jumpers used for the electrical tests of the different circuits have been removed from the terminal boards and the equipment.
2. Clean all the equipment in the unit.
3. Touch up the paintwork if necessary.
4. Check that the foundation bars comply precisely with the drawings.
5. Compile the "Mod. CAR/CAB 04 bill of material for shipment" with an indication of the material to be shipped loose, including material required for installation of the units.
6. Make out the list of missing materials (this list should include materials which are missing because found to be faulty during testing and the equipment to be installed by the Customer).
7. Check that the Manufacturer's data plate showing the characteristics of the switchboard has been fitted.
8. Insert the maintenance manual of the framework
9. CQ deals with the issue the test report and sees to its storage.

N.B In case of acceptance by the customer, it's up to present REC inform RP which involves the planning of production and make it aware of CAB and CQ; REC also defines the exact date that he agreed with the customer and informs the affected functions. At the end of the test, the customer must sign the test report.

## *6 TEST EQUIPMENT*

The following test equipment will be used to carry out the above tests:

- Universal power supply for the auxiliary circuits,
- Amperometric power supply for the primary and secondary currents,
- Instrument for the applied voltage test at industrial frequency of the main circuit,
- Instrument for the applied voltage test of the auxiliary and control circuits,
- Digital thickness gauge

## *7 CARRYING OUT THE TESTING ACTIVITIES*

The testing activities must be carried out in compliance with the safety requirements of the current regulation by restricting the test area with the special hurdles. The testing activities must be carried out

exclusively by personnel who have received proper training, anyway the operators must always be at least two.

If testing is manned by customer (or by those third parties designated by it), this is absolutely not permitted to carry out maneuvers on the switch and are not allowed to stay alone at the IMESA plant.

All electrical parts must be banned from all contact and the area should be well lit and free from hindrances and obstacles.

Operators must be equipment with suitable DPI and certified equipment under current regulations.

During testing must always be at least one first aid worker who has received its education.

When testing the dielectric properties (applied voltage test), remember to wear insulated gloves and shoes with retractable toe caps as well as suitable protection clothing covering body and arms. If the test is suspended even temporarily, the test instrument must be disconnected from the mains.

## *8 ANNEX*

- See Annex 1 (Fac-simile Test Report)
- See Annex 2 (Checklist)

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# RAPPORTO DI PROVA
# TEST REPORT

**Fornitore/ Supplier: IMESA S.p.A.** Via G. Di Vittorio, 14 JESI (Ancona) – ITALIA
Tel.+39 0731 211034 - Fax.+39 0731 211055 - imesa@imesaspa.com - www.imesaspa.com

| | | | |
|---|---|---|---|
| **N° Certificato/ Certificate N°:** | | **Data / Date:** | |
| **Commessa N° / Workorder N°:** | | | |
| **Matricola N° / Serial N°:** | | | |
| **Ordine N° / Order N°:** | | | |
| **Cliente / Customer:** | | | |

Collaudo eseguito alla presenza di: / Test surveyed by:

| Sig. / Mr. | Ditta / Firm | Firma / Signature |
|---|---|---|
| | **IMESA S.p.A.** | |
| | **IMESA S.p.A.** | |
| | **CUSTOMER** | |
| | **CUSTOMER** | |
| | **REGISTER** | |
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Materiale collaudato a Norme: **IEC 61439-2**
Material tested according to
Procedura collaudo Quadri BT :
*Procedure test Switchboards LV* ***FAT procedure- 231298/SD/045***

☐ **register RULES**

| QUADRO ELETTRICO BT<br>SWITCHBOARD LV | Tipologia / Type: | MCC/F |
|---|---|---|
| **Tensione Nominale di Isolamento (Ui):**<br>***Rated Insulation Voltage (Ui)*** | **Rated insulation voltage** | |

**DESCRIZIONE/DESCRIPTION:**

DESCRIPTION OF THE PROJECT AND ELECTRICAL CHARACTERISTICS

**DISEGNI/DRAWINGS**:

| Document ID | Title |
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# RAPPORTO DI PROVA
# TEST REPORT

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**PROVE INDIVIDUALI** (secondo lo standard IEC 61439-1)**:**
*ROUTINE TESTS (according to standard IEC 61439-1):*

■ **= TESTED**

☐ **11.1 GENERALITA'**
**GENERALITY**

☐ CONTROLLO VISIVO E DIMENSIONALE
*VISUAL AND DIMENSIONAL CONTROL* *Point 3.1 FAT proc.*

☐ CONTROLLO OSSERVANZA ALLE SPECIFICHE ED ORDINE
*CHECK OF COMPLIANCE TO SPECS AND ORDER* *Point 3.1 FAT proc*

☐ CONTROLLO CARPENTERIA, SBARRE,CONNESSIONI PRIMARIE
*STRUCTURAL WORKS, BUS-BAR CONTROL*

☐ CONTROLLO VERNICIATURA (**RAL 7035 ≥ 60** µm )
*PAINTING CONTROL* *Point 3.1 FAT proc*

☐ **11.2 GRADO DI PROTEZIONE DEGLI INVOLUCRI**
***PROTECTION DEGREE*** *Point 3.3 FAT proc.*

☐ **11.3 DISTANZE DI ISOLAMENTO IN ARIA E SUPERFICIALI**
***CLEARENCE AND CREPAGE DISTANCES*** *Point 3.1 FAT proc.*

☐ **11.4 PROTEZIONE CONTRO LA SCOSSA ELETTRICA ED INTEGRITA' DEI CIRCUITI DI PROTEZIONE**
***PROTECTION AGAINST ELECTRIC SHOCK AND INTEGRITY OF PROTECTIVE CIRCUITS*** *Point 3.4 FAT proc.*

☐ **11.5 INSTALLAZIONE DEI COMPONENTI**
***INCORPORATION OF BUILT-IN COMPONENTS*** *Point 3.4 FAT proc.*

☐ VERIFICA FONDO SCALA STRUMENTI
*CHECK FULL SCALE OF INSTRUMENTS* *Point 3.4 FAT proc.*

☐ CONTROLLO DATI NOMINALI APPARECCHIATURE
*EQUIPMENT RATED DATA CONTROL* *Point 3.4 FAT proc.*

☐ VERIFICA DEL SERRAGGIO E MARCATURA BULLONERIA
CHECKING THE TIGHTENING AND MARKING OF BOLTS
*Point 3.4 FAT proc.*

☐ **MISURA RESISTENZA D'ISOLAMENTO**
**MEASURE OF INSULATION RESISTANCE** *Point 4.3-4.4 FAT proc.*

CIRCUITI DI POTENZA **L1= MΩ; L2= MΩ**
POWER CIRCUIT **L3= MΩ; N = MΩ**
CIRCUITI AUSILIARI xxx Vdc= **MΩ**
AUXILIARY CIRCUITS xxx Vac = **MΩ**

☐ **11.6 CIRCUITI ELETTRICI INTERNI E COLLEGAMENTI**
***INTERNAL ELECTRICAL CIRCUITS AND CONNECTIONS***
*Point 3.4 FAT proc.*

☐ **11.7 CONTROLLO DEI TERMINALI PER I CONDUTTORI ESTERNI**
***CHECK OF TERMINALS FOR EXTERNAL CONDUCTORS***
*Point 3.4 FAT proc.*

☐ **11.8 CONTROLLO FUNZIONAMENTO MECCANICO**
***MECHANICAL OPERATION TEST*** *Point 3.2 FAT proc.*

☐ **11.9 PROVE DI TENSIONE : f = 50 Hz e t = 1 sec.**
***VOLTAGE TEST : f = 50 Hz and t = 1 sec.*** **(*60 sec)**

CIRCUITI DI POTENZA ..... kV
*MAIN CIRCUITS* *Point 4.3 FAT proc.*
***Leakage curr. L1= mA L2= mA L3= mA* N= mA**
CIRCUITI AUSILIARI ..... kV
*AUXILIARY CIRCUITS* *Point 4.4 FAT proc.*
***Leakage curr. XXXVdc= mA; XXXVac= mA***

☐ **11.10 CONTROLLO CABLAGGIO**
***WIRING CHECK*** *Point 3.4 FAT proc.*

☐ **CONTROLLO DATI DI TARGA**
*PLATE CHECK* *Point 3.4 FAT proc.*

☐ **PROVE DI FUNZIONAMENTO ELETTRICO E SEQUENZE**
*ELECTRICAL OPERATION AND SEQUENCE TESTS*
*Point 4.1 FAT proc.*

☐ ***FUNZIONAMENTO CORRETTO DELLE LOGICHE* DI CONTROLLO**
*RIGHT WORKING OF THE LOGICAL CONTROLS*
**VERIFICA DI FUNZIONAMENTO: CIRCUITI AUSILIARI E DI COMANDO, VERIFICA RAPPORTI TRASFORMAZIONE TV-TA**
CHECKING OF OPERATIONS: AUXILIARY AND CONTROL CIRCUIT, CHECK OF VT's-CT's TRANSFORMATION RATIO
*Point 4.1 FAT proc.*

☐ PROVE SUI DISPOSITIVI AUSILIARI
TEST OF AUXILIARY DEVICE *Point 4.2 FAT proc.*

☐ **CONTROLLO DI CONTINUITA' DEL CIRCUITO DI TERRA**
*CHECKING OF ELECTRICAL CONTINUITY EARTH CIRCUIT*
Max value: **≤0,1Ω (measured: … Ω)** *Point 4.5 FAT proc.*

# RAPPORTO DI PROVA
# TEST REPORT

| N° Certificato/ Certificate N°: | | Data / Date: | |
|---|---|---|---|

**The Equipment is :**

**Compliant** ☐ **/ Non Compliant** ☐

**Referring to the FAT Procedure and relevant documents**

| ***Apparecchiature utilizzate/ Equipment used:*** | ***Scadenza Taratura /Expiration date*** |
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Note/ *Notes:*

FIRMA/ *SIGNATURE*

IMESA SPA ROSETTI MARINO SPA RINA

| Type of switchboard: | LV SWGR / MCC/32 | Comm. : | 231298/SD | ELE Resp. : | SD | Node: | |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex B | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| OPERATING TESTS | | | UNIT: "M1-n Typical" | | | |
| | FUNCTION | DEVICE | *Tested Unit:* | | | |
| 1 | LOCAL OPENING CIRCUIT-BREAKER | QF1 | | | | |
| 2 | LOCAL CLOSING CIRCUIT-BREAKER | QF1 | | | | |
| 3 | TRIPPING CIRCUIT-BREAKER | QF1 | | | | |
| 4 | LOCAL OPENING/CLOSING CONTACTOR IN INSERTED DRAWER POSITION | KM1 | | | | |
| 5 | LOCAL OPENING/CLOSING CONTACTOR IN TESTED DRAWER POSITION | KM1 | | | | |
| 6 | REMOTE OPENING/CLOSING CONTACTOR | KM1 | | | | |
| 7 | TEST FOR SIGNALLING LAMPS / LED | HL1 | | | | |
| 8 | MCB AUX. CONTACTS TEST | / | | | | |
| 9 | TRIPPING "UMC100" | MMU2 | | | | |
| 10 | TEST OF SAFETY RELAY | KSIL | | | | |
| 11 | MECHANICAL TEST FOR INSERTION / DISCONNECTION DRAWER | / | | | | |
| 12 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD | X1 | | | | |
| 13 | READING/WRITING SIGNALS IN ACCORDING TO I//O LIST | MMU4 | | | | |
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| Type of switchboard: | LV SWGR / MCC/32 | Comm. : | 231298/SD | ELE Resp. : | SD | Node: | |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex B | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| OPERATING TESTS) | | | UNIT: "L1-n & L2-n Typical" | | | |
| | FUNCTION | DEVICE | *Tested Unit:* | | | |
| 1 | LOCAL OPENING CIRCUIT-BREAKER | QF1 | | | | |
| 2 | LOCAL CLOSING CIRCUIT-BREAKER | QF1 | | | | |
| 3 | TRIPPING CIRCUIT-BREAKER | QF1 | | | | |
| 4 | OPENING CIRCUIT-BREAKER BY OPEN COIL | YO | | | | |
| 5 | TEST FOR SIGNALLING LAMPS / LED | HL1 | | | | |
| 6 | MCB AUX. CONTACTS TEST | / | | | | |
| 7 | MECHANICAL TEST FOR INSERTION / DISCONNECTION DRAWER | / | | | | |
| 8 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD | X1 | | | | |
| 9 | READING/WRITING SIGNALS IN ACCORDING TO I//O LIST | U2.A | | | | |
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| Type of switchboard: | LV SWGR / MCC/32 | Comm. : | 231298/SD | ELE Resp. : | SD | Node: | |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex B | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| OPERATING TESTS) | | | UNIT: "LK1-n & LK2-n Typical" | | | |
| | FUNCTION | DEVICE | *Tested Unit:* | | | |
| 1 | LOCAL OPENING CIRCUIT-BREAKER | QF1 | | | | |
| 2 | LOCAL CLOSING CIRCUIT-BREAKER | QF1 | | | | |
| 3 | TRIPPING CIRCUIT-BREAKER | QF1 | | | | |
| 4 | LOCAL OPENING/CLOSING CONTACTOR IN INSERTED DRAWER POSITION | KM1 | | | | |
| 5 | LOCAL OPENING/CLOSING CONTACTOR IN TESTED DRAWER POSITION | KM1 | | | | |
| 6 | REMOTE OPENING/CLOSING CONTACTOR | KM1 | | | | |
| 7 | TEST FOR SIGNALLING LAMPS / LED | HL1 | | | | |
| 8 | MCB AUX. CONTACTS TEST | / | | | | |
| 9 | MECHANICAL TEST FOR INSERTION / DISCONNECTION DRAWER | / | | | | |
| 10 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD | X1 | | | | |
| 11 | READING/WRITING SIGNALS IN ACCORDING TO I//O LIST | U2.A | | | | |
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| Type of switchboard: | LV SWGR / MCC/32 | Comm. : | 231298/SD | ELE Resp. : | SD | Node: | |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex B | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| OPERATING TESTS) | | | UNIT: "LE2-320 Typical" | | | |
| | FUNCTION | DEVICE | *Tested Unit:* | | | |
| 1 | LOCAL OPENING CIRCUIT-BREAKER | QF1 | | | | |
| 2 | LOCAL CLOSING CIRCUIT-BREAKER | QF1 | | | | |
| 3 | TRIPPING CIRCUIT-BREAKER | QF1 | | | | |
| 4 | OPENING CIRCUIT-BREAKER BY UNDERVOLTAGE COIL | YU | | | | |
| 5 | TEST FOR SIGNALLING LAMPS / LED | HL1 | | | | |
| 6 | MCB AUX. CONTACTS TEST | / | | | | |
| 7 | MECHANICAL TEST FOR INSERTION / DISCONNECTION DRAWER | / | | | | |
| 8 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD | X1 | | | | |
| 9 | READING/WRITING SIGNALS IN ACCORDING TO I//O LIST | U2.A | | | | |
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| Type of switchboard: | LV SWGR / MCC/32 | Comm. : | 231298/SD | ELE Resp. : | SD | Node: | |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex B | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| OPERATING TESTS) | | | UNIT: "L3-630 Typical" | | | |
| | FUNCTION | DEVICE | *Tested Unit:* | | | |
| 1 | LOCAL OPENING CIRCUIT-BREAKER | QF1 | | | | |
| 2 | LOCAL CLOSING CIRCUIT-BREAKER | QF1 | | | | |
| 3 | REMOTE OPENING CIRCUIT-BREAKER | QF1 | | | | |
| 4 | REMOTE CLOSING CIRCUIT-BREAKER | QF1 | | | | |
| 5 | TRIPPING CIRCUIT-BREAKER | QF1 | | | | |
| 6 | TEST FOR SIGNALLING LAMPS / LED | HL1÷3 | | | | |
| 7 | MCB AUX. CONTACTS TEST | / | | | | |
| 8 | MECHANICAL TEST FOR INSERTION / DISCONNECTION C.B. | QF1 | | | | |
| 9 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD | X1 | | | | |
| 10 | READING/WRITING SIGNALS IN ACCORDING TO I//O LIST | U1.A/QF1 | | | | |
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| Type of switchboard: | LV SWGR / MCC/32 | Comm. : | 231298/SD | ELE Resp. : | SD | Node: | |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex B | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| OPERATING TESTS) | | | UNIT: "INCOMING" | | | |
| | FUNCTION | DEVICE | *Tested Unit:* | | | |
| 1 | LOCAL OPENING CIRCUIT-BREAKER | QF1 | | | | |
| 2 | LOCAL CLOSING CIRCUIT-BREAKER | QF1 | | | | |
| 3 | REMOTE OPENING CIRCUIT-BREAKER | QF1 | | | | |
| 4 | REMOTE CLOSING CIRCUIT-BREAKER | QF1 | | | | |
| 5 | TRIPPING CIRCUIT-BREAKER | QF1 | | | | |
| 6 | LOCK-OUT TEST RELAY | K86 | | | | |
| 7 | MCB AUX. CONTACTS TEST | / | | | | |
| 8 | MECHANICAL TEST FOR INSERTION / DISCONNECTION C.B. | QF1 | | | | |
| 9 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD | X1 | | | | |
| 10 | READING/WRITING SIGNALS IN ACCORDING TO I//O LIST | A1/FP1 | | | | |
| 11 | AUXILIARY VOLTAGE SWITCHING | QU1 | | | | |
| 12 | ARC SURVEY TRIPPING | FP1 | | | | |
| 13 | INTERNAL SPACE HEATER / LIGHTING DISTRIBUTION | BUS-4 | | | | |
| 14 | COMMAND CIRCUITS TO FEEDERS DISTRIBUTION | BUS-1 | | | | |
| 15 | 24VDC VOLTAGE DISTRIBUTION | BUS-2 | | | | |
| 16 | INTERTRIPPING WITH HV SWBD UPSTREAM | FP1 | | | | |
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2.3. S.A.T Procedure

2.3.1.SITE ACCEPTANCE TEST PROCEDURE - HV Switchgear,

Doc No. 1723002197-QC-PRO-00046

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# Base Load Power Hub (BLPH)

SITE ACCEPTANCE TEST PROCEDURE
HV Switchgear
Document Number: 1723002197-QC-PRO-00046

Document Class: 2

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Luca Maeule | 27/11/2024 |

| Rev. | Date | Description | Prepared | Reviewed | Approved |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| 2 | 26/11/24 | Accepted For Construction (AFC) | Del Federico | Giulietti | Santinelli |
| 1 | 06/11/24 | Issue for Review (IFR) | Del Federico | Giulietti | Santinelli |
| 0 | 08/08/24 | Issue for Review (IFR) | Del Federico | Giulietti | Santinelli |

IMESA ELECTRICAL ENGINEERING Doc. n. 231115/SD/046

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# STANDARDIZED H.V. MINIVER/C SWITCHBOARDS

## Site Acceptance Test Procedure



IMESA ELECTRICAL ENGINEERING

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*File:* 1723002197-QC-PRO-00046*_SAT PROCEDURE_Rev02*

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# 1. INTRODUCTION

## 1.1. PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.
Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

### 1.1.1. Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

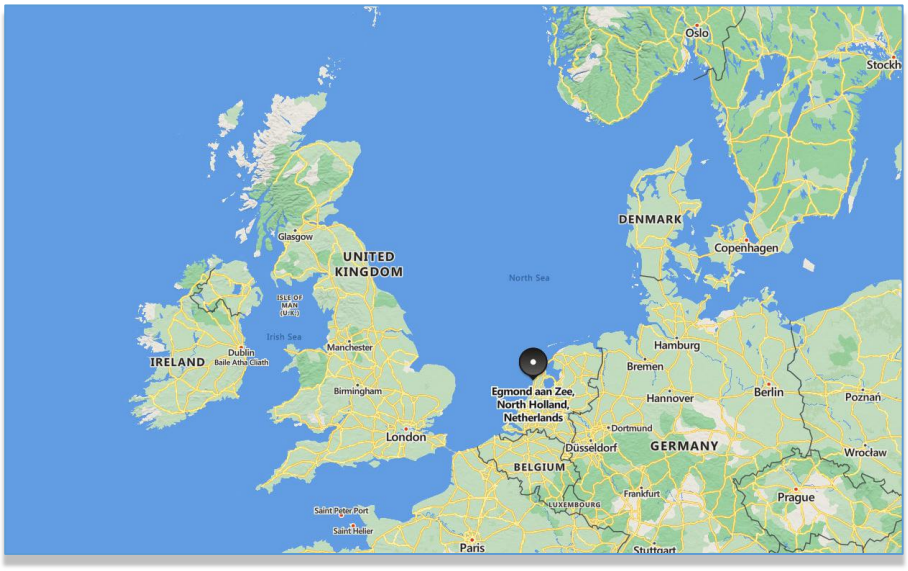



Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

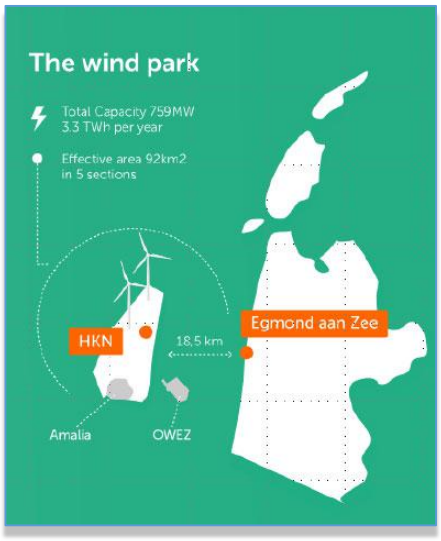



Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

### 1.1.2. Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

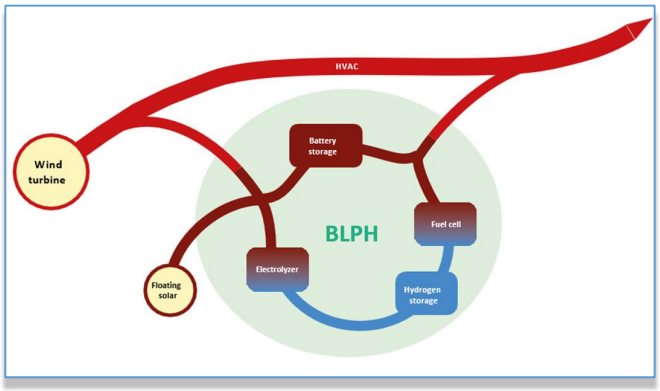



Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.
The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

## 2. SCOPE AND APPLICABILITY

This document provides the commissioning and start-up methods, as well as the testing procedures at site, applicable to H.V. Electrical Switchboards, manufactured by IMESA in compliance to Standard IEC 62271-200 and designated as Miniver-C type.

The procedure is applicable to the following switchgear tag: SG-100D1

## 3. APPLICABLE STANDARDS AND DOCUMENTS

The tester will make reference to Standards IEC 62271-200 and IEC 62271-1 and to the engineering documents listed here below.

| Ref. | Imesa Doc No. | Description |
|---|---|---|
| A1 | **1723002197-EL-DA-00006** | **SG-100D1 General Arrangement DWG and foundation load calculation including COG** |
| A2 | **1723002197-EL-DG-00010** | **SG-100D1 Electrical Single Line Diagram** |
| A3 | **1723002197-EL-DG-00015** | **SG-100D1 MV SWG FUNCTIONAL DIAGRAM - INCOMING FEEDER (including Terminals and BOM)** |
| A4 | **1723002197-EL-DG-00016** | **SG-100D1 MV SWG FUNCTIONAL DIAGRAM - BUS BAR METERING (including Terminals and BOM)** |
| A5 | **1723002197-EL-DG-00017** | **SG-100D1 MV SWG FUNCTIONAL DIAGRAM - BESS FEEDER (including Terminals and BOM)** |
| A6 | **1723002197-EL-DG-00018** | **SG-100D1 MV SWG FUNCTIONAL DIAGRAM - ELECTROLYSER FEEDER (including Terminals and BOM)** |
| A7 | **1723002197-EL-DG-00019** | **SG-100D1 MV SWG FUNCTIONAL DIAGRAM - FUEL CELL FEEDER (including Terminals and BOM)** |
| A8 | **1723002197-EL-DG-00020** | **SG-100D1 MV SWG FUNCTIONAL DIAGRAM - TRANSFORMER FEEDER TR200ED1 (including Terminals and BOM)** |
| A9 | **1723002197-EL-DG-00021** | **SG-100D1 MV SWG FUNCTIONAL DIAGRAM - TRANSFORMER FEEDER TR200DE1 (including Terminals and BOM)** |
| A10 | **1723002197-EL-DG-00022** | **SG-100D1 MV SWG INTERCONNECTING AND AUX DISTRIBUTION DIAGRAM (including BOM)** |
| A11 | **1723002197-EL-DG-00023** | **SG-100D1 MV SWG LOGIC DIAGRAM - INCOMING FEEDER** |
| A12 | **1723002197-EL-DG-00024** | **SG-100D1 MV SWG LOGIC DIAGRAM - BUS BAR METERING** |
| A13 | **1723002197-EL-DG-00025** | **SG-100D1 MV SWG LOGIC DIAGRAM - BESS FEEDER** |
| A14 | **1723002197-EL-DG-00026** | **SG-100D1 MV SWG LOGIC DIAGRAM - ELECTROLYSER FEEDER** |
| A15 | **1723002197-EL-DG-00027** | **SG-100D1 MV SWG LOGIC DIAGRAM - FUEL CELL FEEDER** |
| A16 | **1723002197-EL-DG-00028** | **SG-100D1 MV SWG LOGIC DIAGRAM - TRANSFORMER FEEDER TR200ED1** |
| A17 | **1723002197-EL-DG-00029** | **SG-100D1 MV SWG LOGIC DIAGRAM - TRANSFORMER FEEDER TR200DE1** |
| A18 | **1723002197-EL-DS-00034** | **SG-100D1 EQUIPMENT DATA SHEETS INCLUDING MSDS and WEIGHT DATA SHEET** |
| A19 | **1723002197-EL-CAL-00014** | **SG-100D1 CURRENT and VOLTAGE TRANSFORMER SIZING CALCULATION and CHARACTERISTIC** |
| A20 | | **MV Switchgear - F.A.T. Report** |
| A21 | **1723002197-EL-CAL-00056** | **OPERATION SEQUENCES AND KEY INTERLOCK** |
| A22 | **1723002197-EL-CAL 00054** | **INSTALLATION OPERATING AND MAINTENACE MANUAL** |

Hard copy of the a.m. IMESA documents, properly stamped and signed as "AS BUILT", will be available for the needed testing activities and verifications.

## 4. SAFETY RECOMMENDATIONS

WARNING



- **All the operations of electric maintenance and installation must be performed by qualified technicians**
- **All the standard electric safety procedures must be respected**
- **Never touch inside the switchboard; only after making sure it is out of voltage and grounded**
- **Always wear personal protective equipments (insulating shoes in rubber, protective glasses, safety helmet, etc...)**
- **Never work alone**
- **Never remove safety screens**
- **Always pay maximum attention when handling components or performing measurements inside the panel**
- **It shall be taken in mind that this test procedure is only for the equipment and is to be used together (not instead of) all safety procedures specified by local Laws, rules, regulations and Standards**

People attending the commissioning and testing activities must wear:

**SHOES:** Workers, staff of the Customer, the End User or its representatives (inspectors) present during the tests shall wear safety shoes, ever. The staff of the Customer, the End User or its representatives (inspectors) present during the tests must arrive already equipped with their own shoes. The staff of the Customer, the End User or its representatives (inspectors), present during the tests and not wearing safety shoes, may still access the Safe Area, but not the test area. They will therefore only observe the test from Safe Area and conducting the review of the results in test reports.

**GLASSES:** Workers must wear safety glasses when performing risky for their eyes.

**HELMET:** Workers must wear protective helmets when performing lifting and handling, or when there is a suspended load. When there are suspended loads or handling and lifting the staff of the Customer, the End User or its representatives (inspectors) present during the tests must remain in the Safe Area.

**GLOVES:** Workers must wear gloves when performing risky for the hands or vibrations.

**DRESS:** All workers must wear appropriate safety clothing, forever. Helmet, gloves, glasses, safety clothing are not required to staff of the Customer, the end Customer or his representatives (inspectors) present during the tests.

When testing the dielectric properties (applied voltage test), **insulated gloves** and **shoes with retractable toe caps**, as well as suitable **protection clothing covering body and arms**, to be worn.
If the test is suspended even temporarily, the test instrument must be disconnected from the mains.

Before to start any activity, to thoroughly check that the following points are confirmed:

- the lighting system in the area is suitable and in operation
- phone or radio communication system is available, even temporarily for the present activities
- the fire-fighting system is in operation and provided with valid certification (portable fire extinguishers may be also suitable for purpose)
- earthing plant in the area and earthing connections of the subsystems to be energized have been completed and tested

# 5. GENERAL DESCRIPTION

## 5.1. PURPOSE OF SAT

The purpose of the SAT (Site Acceptance Test) is to inspect the switchboard, after installation at site, to ensure that it is ready for energization and start-up and also that its performance requirements will be met.
Prior to performing any Site Acceptance Testing, all Punch list items have to be rectified and closed.

## 5.2. TESTING TASKS

After completion of the installation phase of the switchboard and in order to prepare it for SAT, pre-commissioning and commissioning are to be first carried out, as further detailed in the next paragraphs.

The overall test activities will be performed by means of the specific test equipment, under the control and responsibility of the test executor, along with some assistants.

The main steps that will be performed are the following:

- Verification of the test procedures and of the related documentation availability.
- Preparation of the test setup
- Execution of the tests according to the Test Procedure and release of the SAT Test Report
- Signing of the SAT Test Report by the test executor and the attending people.

Estimated lead time to carry out all these tests is 3/4 weeks (it depends on site activities conditions, actually).

For additional tests not included in its own scope of work, IMESA will provide technical support, as agreed in advance.

### List of the tests

| Item | Activity | Tool | Support Requested | Type of Test |
|---|---|---|---|---|
| a. | Mechanical check | Torque Wrench | Mech. Engineer<br>Inspection/Quality Officer | Mandatory |
| b. | Testing contact resistance at busbars, CBs & Fused Contactors | Current generator and digital multimeter | Electrical Engineer<br>Inspection/Quality Officer | Mandatory |
| c. | Primary Injection on current transformers | Injection current bench | Electrical Engineer<br>Inspection/Quality Officer | Suggested<br>(to verify that CT is not damaged) |
| d. | Primary Injection on voltage transformers | Apply low voltage to check the functionality of VT (400V) | Electrical Engineer<br>Inspection/Quality Officer | Suggested<br>(to verify that VT is not damaged) |
| e. | Testing of protection relays by secondary injection | Secondary injection bench (Omicron) | Electrical Engineer<br>(Relay specialist)<br>Inspection/Quality Officer | Mandatory |

| Item | Activity | Tool | Support Requested | Type of Test |
|---|---|---|---|---|
| f. | Functional test of IEDs, and interlocks. | Secondary injection bench (Omicron) | Electrical Engineer (Relay specialist)<br>Inspection/Quality Officer | Mandatory |
| g. | High voltage test | Hi pot equipment | Electrical Engineer<br>Inspection/Quality Officer | Mandatory |
| h. | Infrared sensors tests | Non-contact temperature measuring tool | Electrical Engineer (Temperature sensors specialist)<br>Inspection/Quality Officer | Suggested (to verify correct settings) |
| i. | Arc flash detecting system test | Camera Flash<br>Secondary injection bench (Omicron) | Electrical Engineer (Relay specialist)<br>Inspection/Quality Officer | Mandatory |
| j. | Network Goose Messaging system test | Secondary injection bench (Omicron) | Electrical Engineer (Relay specialist)<br>Inspection/Quality Officer | Mandatory |
| k. | ENMC system communication test | Secondary injection bench (Omicron) | Electrical Engineer (Relay specialist)<br>Inspection/Quality Officer<br>ENMC test is intended in charge to PMS vendor (IMESA to only provide assistance, where requested and agreed) | Mandatory |
| l. | Partial discharge detecting system test | Calibration tools | Electrical Engineer (Relay specialist)<br>Inspection/Quality Officer | Suggested (to verify correct settings) |

## 5.3. TEST EQUIPMENT

- Megger (e.g. : Chauvin Arnoux ca 6547)
- Tester / Multimeter
- Testing bench for primary injection (e.g. : Omicron CPC 100)
- Relay Testing System (through current / voltage secondary injection - (e.g. : Omicron CMC 353)
- Torque Wrench (e.g. Dina Beta NM 20÷100)
- Voltage drop test equipment (e.g. : Multimeter + TEIB PP77 100A DC)
- Hi-pot test bench (e.g. : Phenix 650-2P)

NOTES:

- it shall be advised in advance availability of the testing equipment at site or whether those are to be provided by the commissioning engineer himself;
- availability of calibration certificates of the above testing equipment, having valid date, must be ensured.

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### 5.4. TEST PHASE AND PASS/FAIL CRITERIA

For each test a set of pass/fail criteria will be defined (it is also possible that each test has a different criteria) in order to establish an acceptance procedure.
Where acceptance and rejection criteria are not established, they shall be defined according to the best practice, making reference to standards or samples.

The main possibilities are the following:

- All the steps are successfully performed (the test passes)
- Some steps fail but the function under test is verified (the test passes after client approval)
- Some steps fail and the function under test is not verified (the test fails)
- Some steps fail but with a specific corrective action the proper function is recovered (the test must be repeated);

If the test fails, a related NCR will be released.

## 6. PRE-COMMISSIONING PROCEDURE

### 6.1. GENERAL INFORMATION

Locking magnets are installed on the HV circuit breaker / HV Fused contactor compartments, to increase general safety of the H.V. Switchboard.

RLE1
Locking magnet on the operating mechanism.
If de-energized, it mechanically prevents circuit breaker / contactor closure.

RLE2
Locking magnet on the truck.
If de-energized, it mechanically prevents circuit breaker / contactor racking-in and racking-out operations.

RLE3 (provided on request)
Locking magnet on the earthing switch.
If de-energized, it mechanically prevents any earthing switch operation (closing and opening, as well).

RLE4
Locking magnet on the circuit breaker compartment door.
If de-energized, it prevents opening and closing of the circuit breaker compartment door.

Circuit Breaker and contactor status (Open / Close / Tripped) is showed on the HMI panel of the protection relays.

For the programmable indication, assigned to the single LED indicator available on the protection relay's HMI panel, please, refer to the relevant table in the schematic diagrams.

**IT IS RECOMMENDED TO FORESEE THE ATTENDANCE OF AN IMESA TECHNICIAN DURING THE ABOVE MENTIONED ACTIVITIES**

## 6.2. PRE-COMMISIONING ACTIVITIES

Before to start Pre-Commissioning, please, read carefully the I.O.M. document (Installation, Operation and Maintenance manual).
Then proceed with the following checks and actions.

1. Switchboard's cubicles shall be in good and clean status. Make sure that switchboard is clean, free from dust, traces of humidity, installation material debris, cables pieces, tools, provisional connections, etc. , as well as any foreign object.
2. Visually check the interior and exterior of the switchboard for signs of evident damage
3. Make sure that the switchboard is correctly installed according to the General Arrangement Drawings
4. Maintenance clearances shall be according to the General Arrangement Drawings
5. Make sure that any support or protection used to handle the equipment has been removed
6. Make sure that, after completion of the installation, the switchboard overall protection degree is as per General Arrangement Drawings
7. Visual inspection to check that bolted connections of the HV and earthing circuits (at busbars, CBs poles, CTs, VTs, etc. ) are suitably tighten. No disalignment is expected at the marks provided over the bolt, during torque wrench tightening at the factory. In case found, to torque wrench again the connection (see par. 7.1).
8. Cable passages shall be free and unobstructed
9. Couple the auxiliary interpanel connections by the relevant plugs and socket (see schematic diagrams with control voltage distribution loop, panels interconn. wiring and communication network loop)
10. Cabling of control cables from the field in accordance with I/O list / schematics shall be completed
11. Check the incoming / outgoing power cables proper support and earthing screens connections.
12. Make sure that terminals and all the connections have been properly tightened
13. Make sure that all the safety interlock keys (master and copies) have been provided and installed. There are manoeuvres not allowed (forced operations shall be avoided).
14. Remove each H.V. circuit breaker and contactor from its cubicle, by means of the provided lifting / transport trolley, for a visual check of the breaker status and cleaning; including fixed poles of the enclosure and tulip contacts on the removable part.
    Make sure that the breaker is free from dust and traces of humidity and that there are no signs of evident damage.
15. Make sure that all H.V. fuses are correctly installed and that rating is in conformity to the schematic diagrams and parts lists.
16. All necessary warning and caution signs (voltage level indication, warning for live parts, etc.) shall be installed according to the safety standards and procedures.

The results of the a.m. activities shall be recorded on PRE-COMMISSIONING ACTIVITIES REPORT form (see par. 9)

## 7. COMMISIONING ACTIVITIES

Carry out the following checks and actions.

1. To be verified that all HV circuit breakers and HV fused contactors are in open and racked-out position; with charged closing springs.

   N.B. : it is recommended to manually rewind all the circuit breakers closing springs, before to supply the relevant spring motor chargers, with aux. supply voltage 110 V d.c. , in order to prevent concurrent start-up of many motor gears, which may result in excessive load for the supplying circuit.

   As an alternative, it can be taken care that supply to those motors is provided one by one; by separately closing the relevant MCB, provided within the LV compartment of each feeder unit.
2. Check that all the earthing switches are in closed position.
3. Connect all external aux. supplies and check that are at correct voltage value and phase sequence.
4. Check thoroughly the Operating Sequences and the relevant mechanical safety interlocks, by putting in service and then again out of service all the H.V. units.
5. With CBs / Contactors in test position, close and open the same by local command.
6. Make sure that the phase sequence, at the H.V. circuits, is in accordance to the electrical diagrams and that all incoming breakers are connected with the same phase sequence.
7. Check monitoring loops (hardwired status / alarm signals / visual status indications).
8. Check protection relays loops, concerning IEDs' integrated logic functions.
9. Put the HV CBs / HV Contactors in service (racked-in) position and repeat the test for opening / closing the same from local and remote commands, including control loops from / to the field (commands, status, alarm, etc.)

   N.B. : It is necessary to simulate voltage presence at the bus-bars and at the incomers, to enable CBs closing commands. Voltage presence shall be simulated, at voltage and frequency protection relays, to avoid trip commands for "dead bus-bars" function (see relevant schematic diagrams and protective relays selectivity study).
10. Check HV CBs / HV Contactors tripping, locking-out and alarming functions.

The results of the a.m. activities shall be recorded on the COMMISSIONING ACTIVITIES REPORT form (see par. 9)

# 8. SAT TESTING PROCEDURE

## 8.1. MECHANICAL TESTS

1. Bus-bars tightening check

Torque wrench all the bolted joints of the shipping sections, which have been coupled at site, according to the values indicated here below.
After tightening, each bolt is to be marked by red paint to indicated its relative position against the fixed part (as done for the torque wrench tightening provided at the factory).

The table below shows the torque wrench settings to be used for bolted connections fixing the panels and the bus-bars, too.

| Screws | M6 | M8 | MI0 | M12 | M14 | M16 |
|---|---|---|---|---|---|---|
| Wrench setting (Nm) -Min | 8 | 19 | 40 | 68 | 100 | 160 |
| Wrench setting (Nm) - Nominal | 9 | 22 | 45 | 75 | 115 | 185 |
| Wrench setting (Nm) - Max | 10 | 25 | 50 | 83 | 130 | 200 |

2. Tightening at CTs and VTs primary terminals

Primary terminals of the current transformer are made of copper, with threaded screws inserts provided to be used for fastening the primary conductor.

Torque wrench values are to be applied in accordance to the data sheets / to the installation manuals of the Current & Voltage Transformers' manufacturer.

The results of the a.m. activities shall be recorded on SAT REPORT FOR MECHANICAL TEST form (see par. 9)

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## 8.2. MEASUREMENT OF THE RESISTANCE OF THE MAIN CIRCUITS

Measurement of the resistance of the main circuit shall be carried out where joints between shipping sections have been coupled at site. The test is to carried out in accordance to subclause 6.4.1 of Std. IEC 62271-1.
For the routine test, the d.c. voltage drop or resistance of each pole of the main circuit shall be measured under conditions as much as possible similar, with regard to ambient air temperature and point of measurement, to those of the corresponding type test.
The measurement is to be made by volt-ammetrical method with a d.c. current equal to 100 A, across the main circuit of each panel unit phase.

*Acceptance criteria:*
*The measured resistance shall not exceed 1,2 Ru where Ru is equal to the resistance measured before the temperature rise type test.*

The results of the a.m. activities shall be recorded on SAT REPORT FOR MEASUREMENT OF THE RESISTANCE OF THE MAIN CIRCUITS form (see par. 9)

## 8.3. TESTING H.V. CIRCUIT BREAKERS AND H.V. FUSED CONTACTORS

Insulation resistance measurement
When the breaker is closed, measure the insulation resistance, phase to ground, with 5 kV d.c. Megger. The test is to be carried out with the other two phases short-circuited and connected to ground.
Then open the breaker and measure the insulation resistance pole to pole.
The above to be carried out for all the phases.

Minimum value of insulation resistance is to be 50 MΩ.

Contact resistance test
The breaker will be in close position before starting the test.
Then inject d.c. current of 100 A on each pole (from in to out of each phase) and measure the voltage drop across it. The measurement is to be done by multimeter
By applying Ohm's law, the resistance value is then calculated. The obtained value needs to be compared with the value given by the manufacturer. Reference is to be made to the voltage drop value of VD4 Circuit Breakers/VSC Contactors, detailed in the relevant Test Reports.

As an alternative, an apparatus with direct reading (Omicron) can be used.

The results of the a.m. activities shall be recorded on SAT REPORT FOR TESTING H.V. CIRCUIT BREAKERS AND H.V. FUSED CONTACTORS form (see par. 9)

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## 8.4. PRIMARY INJECTION ON CURRENT AND VOLTAGE TRANSFORMERS

1. Testing CTs ratio

   Test the CT for correct ratio with direct current injection to CT primary circuit and reading the measured value from the instruments or protection relays LCD display, provided at the LV compartment front door.

2. Testing VTs ratio

   Test the VT for correct ratio with direct voltage injection to VT primary circuit (low voltage 400 V, for testing purpose) and reading the measured value from the instruments or protection relays LCD display, provided at the LV compartment front door.

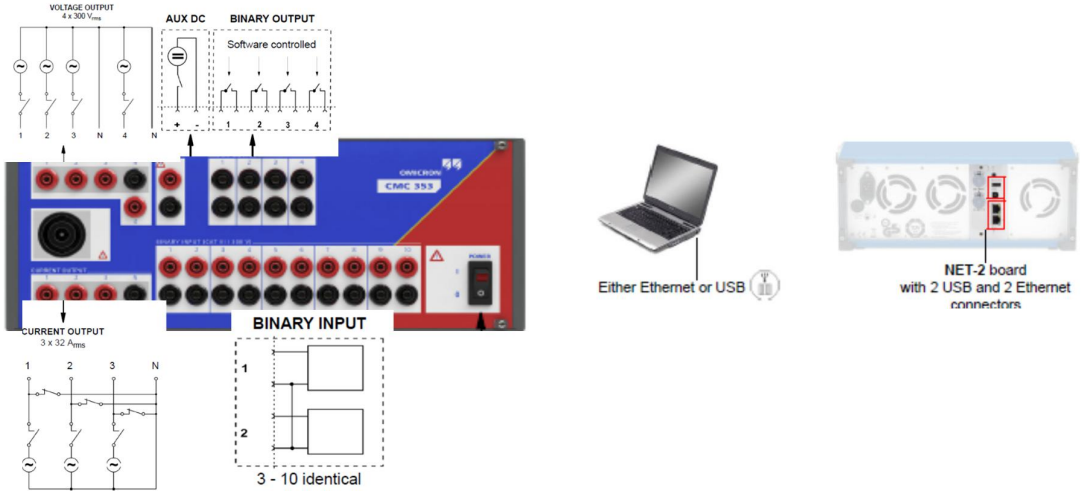
   The results of the a.m. activities shall be recorded on SAT REPORT FOR PRIMARY INJECTION TESTING ON CTs AND VTs form (see par. 9)

## 8.5. SECONDARY INJECTION TESTS ON PROTECTION RELAYS

Refer to the schematic diagrams, for connections and for checking logic functions.
Refer to the selectivity study for the protection relays' setting parameters.
Softwares to be employed for uploading, setting and testing the H.V. Switchgear's protection relays are:

- Interface Software to be used – ABB PCM600 2.9 32 bit / ABB PCM600 2.10 32 bit
- ITT600 Integrated Testing Tool or equivalent

Omicron secondary injection test kit – connection and interface




Example of testing instruments connection

1 – Connection of the test set to the PC (USB Port) for data exchange: output of the data simulation, loading of the binary signal
2 – Connection of the analogue outputs of the test set to the transformer inputs of the test object, to inject the simulated currents and voltages.
3 – Connection of the binary outputs of the test set to the binary inputs of the test object, to send binary input signals to the test object.
4 – Connection of the binary inputs of the test set to the binary outputs of the test object, to receive the binary output signals from the test object.

The recorded tripping values shall be in conformity with the Selectivity study

**N.B. :** Checks on the Partial Discharge detecting systems calibration are also intended within this testing phase.

The results of the a.m. activities shall be recorded on SAT REPORT FOR PROTECTION FUNCTIONS CHECK form (see par. 9)

## 8.6. HI-POT TEST

The dielectric tests are carried out to check that the installation and re-connection activities at site have been made correctly and that no damage occurred to the equipment, during shipment and installation.

These tests shall be performed before to install the power and cables.

### 8.6.1. POWER-FREQUENCY WITHSTAND VOLTAGE TEST AND INSULATION RESISTANCE MEASUREMENT

All the VT's, surge arresters, insulation monitoring devices, etc. must be disconnected before the test. A voltage generator, at industrial power frequency voltage, is to be used to carry out the test.

1. Insulation resistance measurement

Before and after the Hi-pot test, insulation resistance measurement is to be carried out, applying 5 kV d.c. by means of Megger device. The measurement is to be carried out at each phase, while the other two are short-circuited and connected to ground.
The values detected before and after the Hi-pot test will be recorded in the SAT Report.

2. Carrying out the test on the power circuits

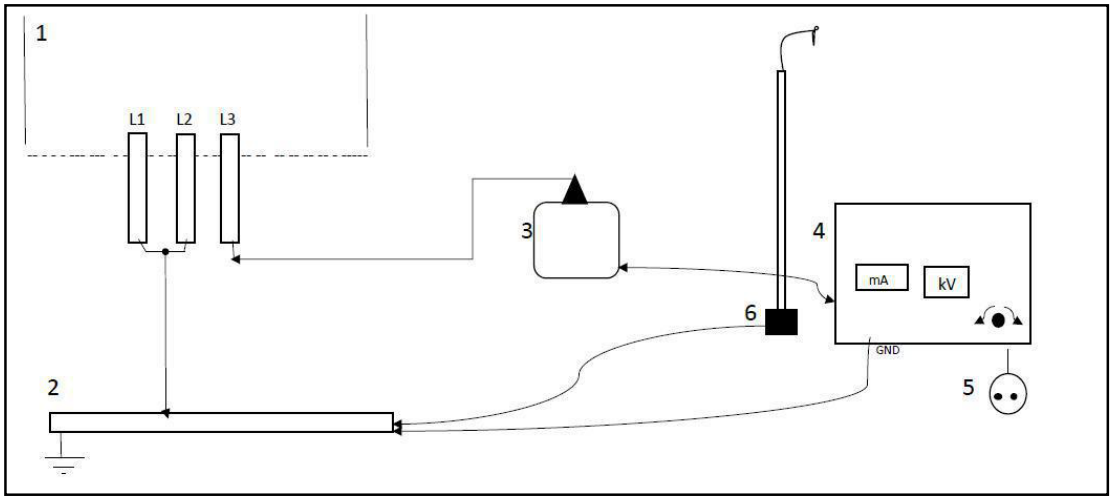
The test voltage to be applied, referring to the rated voltage of the switchboard is as follows (ref. IEC 62271-1, Table 1):

| Rated Voltage<br>kV r.m.s. value) | Test Voltage<br>(kV r.m.s. value) AC<br>(100% during F.A.T.) | Test Voltage<br>(kV r.m.s. value) AC<br>(80% during S.A.T.) | Applicability |
|---|---|---|---|
| 7.2 | 20 | 16 | |

N.B. : the above test voltage value is 80% of the rated power-frequency withstand voltage at FAT, as specified in clause 7.105 of Std. IEC 62271-200.

HI-Pot Test Lay-Out

1) HV Switchboard Busbar
2) Ground Reference
3) Step-up Transformer
4) Hi-Pot Tester
5) Power supply
6) Ground stick




Example: test layout for testing at phase L3

- Connect to ground the control desk, the VT truck, the foil, the equipment under test
- Limit the test area by means of appropriate barriers
- Connect the MV pole of the VT to the phase under test of the panel, while the other two phases are connected together and to ground
- Connect the flashing lights barriers, the VT truck and its power plug
- The operator, before starting the test, must ensure that nobody is within the hurdles
- Close the main switch of the testing bench and rotate slowly the rheostat knob, until reached the test voltage value, read on the voltmeter (**N.B.** if the rheostat knob is in zero position, the circuit is not closed)

All the above indication may be slightly different, depending on the VT truck type, available at site.

Check the dielectric strength of the main circuits by applying the test voltage for 1 minute on the following points:

- between phase L1 and the phases L2 and L3 connected to ground
- between phase L2 and the phases L1 and L3 connected to ground
- between phase L3 and the phases L1 and L2 connected to ground

The test is considered successful when no discharge or perforation occur within 1 minute.
If discharge phenomena are perceived, the test is considered anyway valid if the test bench does not detect this phenomenology.

After the test or if there has been a discharge, return to zero the rheostat and discharge any possible capacitive voltage remained on the VT pole, by means of the foil. After that, it will be allowed to access to the test object.

Apply the same test to the other two phases, in turn, by repeating the steps described here above.

The results of the a.m. dielectric tests shall be recorded on SAT REPORT FOR HI-POT TEST form (see par. 9)

### 8.6.2. DIELECTRIC TEST ON AUXILIARY CIRCUIT AND INSULATION RESISTANCE MEASUREMENT

1. Insulation resistance measurement

Before and after the dielectric test on auxiliary circuits, insulation resistance measurement is to be carried out, applying 500 V d.c. by means of Megger device. The measurement is to be carried out at each pole, while the other one is connected to ground.

The values detected before and after the below test will be recorded in the SAT Report.

2. Carrying out the dielectric test on the auxiliary circuits

The test is to be carried out by applying the voltage test between the single pole of the auxiliary and control circuits and ground (between each conductor and the other conductors connected to ground, in turns).

All current absorbing equipment, which would be damaged by the application of the testing voltage (coils, metering instruments, differential circuit breakers, etc. ) must be disconnected before the test.

The voltage value to be applied is 2000 V, with duration of 1 min. (CEI EN 62271-1, pos. 6.2.10 applies).

The test is considered successful, if no discharge or perforation occur during the test (1 minute).

The results of the a.m. dielectric tests shall be recorded on SAT REPORT FOR DIELECTRIC TEST ON AUX. CIRCUITS form (see par. 9)

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## 8.7. INFRARED SENSORS TESTS

It is here detailed the test method to carry out testing on Exertherm devices, based on infrared thermal sensing.

1. All sensor distance from busbar locations must adhere to standards for clearance from bus bars and cables, depending on circuits rated voltage.

2. Testing must be carried out in a location which provides reasonably stable ambient conditions; i.e. avoid rooms where direct sunlight cannot be prevented, or which are subject to frequent ambient variances.

3. Ambient temperature will be measured on the Exertherm Sensors i.e. at the lens end of the IRT/c using any suitably calibrated non-contact temperature measuring instrument, with certified accuracy. Calibration certificate must be available for scrutiny and up to date.

4. The following method of ambient measurement will be adopted.

   Ambient air temperature is to be between 10°C and 40°C

   - Measurement of ambient air temperature: indoor ambient air temperatures shall be determined by taking the average of the readings of three temperature-measuring devices, such as thermometers or thermocouples, placed as follows:

   a) One level with the top of the structure
   b) One 30 cm above the bottom of the structure
   c) One midway between the two positions a) and b).

   - All temperature-measuring devices shall be placed 30 cm from the structure, not in front of ventilators, and in locations unaffected by drafts caused by the structure or appreciable radiation from the equipment. When the ambient air temperature is subject to variations that might result in errors in measuring the temperature rise, the temperature-measuring devices should be immersed in a suitable liquid, such as oil, in a suitable container, or reliably attached to a suitable mass of metal.

NOTE - A convenient form for such a container consists of a metal cylinder with a hole drilled partly through it. This is filled with liquid and the temperature-measuring device is placed therein. The size of the container should be at least 2.5 cm in diameter and 5.0 cm high.

The ambient temperature used when calculating the connection delta temperature will be the local ambient recorded at the Exertherm Sensor location.

5. All Datacard power supplies will be maintained at 24V d.c. ±10%.

6. All equipment test apparatus and Sensors to be used during these tests will be left to acclimatise in the switchgear for a period of a minimum of 1 hour prior to any tests taking place.

7. It is assumed that all Datacards are programmed and commissioned according to the relevant product instructions.

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### 8.7.1. TEST PROCEDURE – TEST WITH CIRCUITS NOT ENERGISED

1. Ensure all power supplies are set at the correct voltage and within specification i.e. at 110 V d.c. and 24 V d.c. ±10%.

2. Take a reading of room ambient as described in the previous section and note this value on the test check sheet (section Room Ambient)

3. Take a reading of the ambient temperature at the Sensor under test and note this value on the test check sheet (section Ambient Test Reading)

4. Take a reading from the Datacard software on the Sensor under test and note the value on the test check sheet (section Sensor Reading Under Test)

5. Take a reading of absolute temperature from the busbar with a suitably calibrated and certified temperature measurement device and note this reading. This should be an average reading across the connection point and not just one 'spot' temperature and note the value on the test check sheet (section Absolute Reading At Sensor)

6. Subtraction of the ambient temperature (at the sensor) from the connection temperature will result in the Delta T value and note the value on the test check sheet (section Calculated Delta T Reading). This should comply with the IR Sensor reading ±3°C (5.4°F)

7. Note down all these readings for future reference.

Repeat the steps 3 to 7 for all Sensors in the panel.

All these readings should produce a Delta T value of between -3°C (-5.4°F) to +3°C (+5.4°F)

It should be noted that this is not process control and therefore readings will not be exact to the degree. The Exertherm Sensor is 100% repeatable in identical conditions.

### 8.7.2. TEST PROCEDURE – TEST WITH CIRCUITS ENERGISED

1. With the switchgear energised and set in test conditions, with test currents and loading, allow all temperature, including ambient temperature to become stable.
Leave all equipment to again acclimatise to local conditions for a minimum of 30 minutes.

2. Ensure all power supplies are set at the correct voltage and within specification i.e. at 110 V d.c. and 24 V d.c. ±10%.

3. Take a reading of room ambient temperature as described in the previous section and note this value on the test check sheet (section Room Ambient)

4. Take a reading of the ambient temperature at the Sensor under test and note this value on the test check sheet (section Ambient Test Reading)

5. Take a reading from the Datacard software on the Sensor under test and note the value on the test check sheet (section Sensor Reading Under Test)

6. Take a reading of absolute temperature from the busbar with a suitably calibrated and certified temperature measurement device and note this reading. This should be an average reading across the connection point and not just one 'spot' temperature and note the value on the test check sheet (section Absolute Reading At Sensor)

7. Subtraction of the ambient (at the sensor) from the connection temperature will result in the Delta T value and note the value on the test check sheet OEM Design Validation Test Record (section Calculated Delta T Reading). This should comply with the Exertherm IRT/c sensor reading ±3°C (5.4°F)

8. Note all these readings for future reference.

Repeat these steps 4 to 7 for all Sensors in the panel.

All these readings should produce a Delta T value of between -3°C (-5.4°F) to +3°C (+5.4°F).

The results shall be compared to the relevant data sheet for the Sensor's tolerances in terms of accuracy and repeatability.

The results of the a.m. tests shall be recorded on SAT REPORT FOR INFRARED SENSORS TESTS form (see par. 9)

## 8.8. NETWORK and GOOSE TESTING

Preliminary checks

1) Ensure that each IED is set with the right parameter of the network below cited
   - Technical key
   - IP address
   - Subnet Mask (in charge to Network vendor engineer)
   - Main NTP address (in charge to Network vendor engineer)
   - Backup NTP address (in charge to Network vendor engineer)
   - Time clock (in charge to Network vendor engineer)
2) Ensure that Ethernet switch is duly set (in charge to Network vendor engineer)
3) Ensure that the IED is switched ON

### 8.8.1. INTERNAL GOOSE MESSAGING TEST

- Function ANSI 27 block for feeders

Simulate voltage loss from VTs on Busbars metering unit, by opening the distribution MCB, at the secondary circuits of the VTs, or rack-out the VTs trolley, or simulate fuses blown on the VTs' primary circuits.
On different feeder, simulate undervoltage condition with racked-in & closed position of the HV breaker. The HV Circuit Breaker or HV Vacuum Contactor shall remain closed.

- Arc Flash Trip

*CABLE COMPARTMENT*

Arc Flash detected on power cables compartment shall only open the breaker of its own feeder unit, in case of contemporary detection of arc flash light and current flow reading, through the CTs and protection relay.
At the Incoming units, breaker opening is activated by only detecting arc flash light.

Test execution:
Connect the test bench in order to inject a secondary current, according the setting tables, to the unit's protection relay.
Inject the current and simulate a flash light in the cables compartment, from the rear of the Swbd.
The test can be consider passed if the breaker will be opened.

*BUSBARS OR CB COMPARTMENT:*

Arc Flash detected on Busbars chamber or on CB compartment shall result in a complete shutdown of the Switchboard, in case of contemporary detection of arc flash light and current flow reading, through the CTs and protection relay.

Test execution:
Connect the test bench in order to inject a secondary current, according the setting tables, to the protection relay of the Incoming unit.
Choose a CB compartment or Busbar section where to simulate the flash light, inject the current and simulate the flash light in the compartment.
The test can be consider passed if the complete shutdown of the busbars section will be verified.

## 8.8.2. EXTERNAL GOOSE MESSAGING TEST

Scope of these tests is in cooperation with the Network vendor engineer.
The tests can start only if all Ethernet switches have been set from the Network vendor engineer.

- PMS Goose test:

The HVSB receives and transmit goose messages from/to PMS.
For testing purpose of proper communication with PMS, the HVSB vendor can support the PMS vendor or the Network vendor engineer for execution of the following activities:

- opening closing the HV circuit breaker / HV Contactors
- racking-in / racking-out HV circuit breaker / HV Contactors
- opening / closing the earthing switches
- secondary injection tests on the protection relays

This part of the SAT is in charge to the Network Vendor.

## 8.8.3. INFRARED SENSORS MODBUS NETWORK

Scope of these tests is in cooperation with the Network vendor engineer.
The tests can start only if all Ethernet switches have been set from the Network vendor engineer.

These activities can be performed in parallel to IR sensors tests (see paragraph 7.7). This is possible also if the Network is not connected with the PMS, by connecting directly to the switch installed in the HVSB.

This part of the SAT is in charge to the Network Vendor.

The results of the a.m. Goose messaging tests shall be recorded on SAT REPORT FOR GOOSE MESSAGING TESTS form (see par. 9)

## 9. PRE-ENERGIZATION REQUIREMENTS

Before to proceed with energization of the HVSB, the following is to be verified.

- Make sure to pull off the short-circuit jumpers fitted on amperometric terminal boards, to avoid running the units with current transformer (-TI..-L..) short-circuited at secondary windings.
- Make sure to have re-closed the disconnecting terminals fitted on voltmetric terminal boards, to avoid running the units with voltage transformer (-TU-L..) not connected at secondary windings.
- Make sure that all the miniature CBs for aux. and measuring circuits are closed
- All system protections, controls, detectors and monitoring devices shall be reset and ready for operation
- All protections and control logics shall be reset and ready for operation
- All recording equipment, where provided, shall be in operation
- No alarm and/or trip signal shall be active
- Earthing switches shall be locked in open position
- Voltage transformers shall be in service position (racked-in), with primary fuses suitably placed
- H.V. circuit breakers and vacuum contactors shall be in service position (racked-in), open and available
- Fuses at the HV vacuum contactors shall be suitably placed
- Mechanical and electrical interlocks are to be suitably in operation
- All removable protections against direct contacts with accessible parts (panels, grids, plates, doors, etc.), shall be correctly placed and fixed
- All the doors shall be closed and fixed panels are to be correctly positioned and bolted

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## 10. PRE-COMMISSIONING, COMMISSIONING AND SAT REPORT TEMPLATES

The following forms are intended for recording the results of Pre-Commissioning, Commissioning and SAT activities.

Forms provided by the customer may also be employed, on request.

PRE-COMMISSIONING ACTIVITIES REPORT

COMMISSIONING ACTIVITIES REPORT

SAT REPORT FOR MECHANICAL TESTS

SAT REPORT FOR MEASUREMENT OF THE RESISTANCE OF THE MAIN CIRCUIT

SAT REPORT FOR TESTING H.V. CIRCUIT BREAKERS AND H.V. FUSED CONTACTORS

- INSULATION RES. MEASUREMENT -

SAT REPORT FOR TESTING H.V. CIRCUIT BREAKERS AND H.V. FUSED CONTACTORS

- INSULATION RES. MEASUREMENT –

SAT REPORT FOR PRIMARY INJECTION TESTING ON CTs AND VTs

SAT REPORT FOR PROTECTION FUNCTIONS CHECK

SAT REPORT FOR HI-POT TEST

SAT REPORT FOR DIELECTRIC TEST ON AUX. CIRCUITS

SAT REPORT FOR INFRARED SENSORS TESTS

SAT REPORT FOR GOOSE MESSAGING TESTS

# PRE-COMMISSIONING ACTIVITIES REPORT

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

**Legend** **OK** - **N/A** – not applicable **×** SEE NOTE

| **DESCRIPTION** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | |
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**NOTES:**

| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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IMESA ELECTRICAL ENGINEERING

# COMMISSIONING ACTIVITIES REPORT

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

**Legend** **OK** - **N/A** – not applicable **×** SEE NOTE

| **DESCRIPTION** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | | | | | | | |
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**NOTES:**

| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
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| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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# SAT REPORT FOR MECHANICAL TESTS

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

**Legend** **OK** - **N/A** – not applicable × SEE NOTE

| **DESCRIPTION** | **1** | **2** | | | | | | | | | | | | | | | |
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| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
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| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

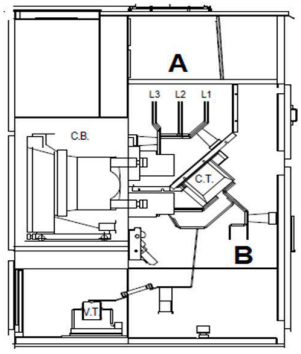
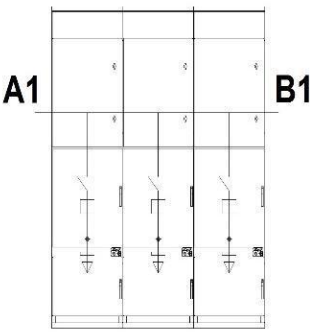
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# SAT REPORT FOR MEASUREMENT OF THE RESISTANCE OF THE MAIN CIRCUIT

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

Value of injected current: 100 A

| ***TYPICAL PANEL ARRANGEMENT DRAWING*** | **Measure =ment between AB or A1/B1** | Phase **L1** *Measured resistance* **(μΩ)*** | Phase **L2** *Measured resistance* **(μΩ)*** | Phase **L3** *Measured resistance* **(μΩ)*** |
|---|---|---|---|---|
|  Panel unit circuit<br> Switchboard's bus-bars | | | | |
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* *To obtain the measured resistance value, in μΩ, is sufficient to multiply by 10 the measured v.d. in mV (e.g. : voltage drop of 1.4 mV = 14 μΩ)*

| **NOTES:** |
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| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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# SAT REPORT FOR TESTING H.V. CIRCUIT BREAKERS AND H.V. FUSED CONTACTORS - INSULATION RES. MEASUREMENT -

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

Megger test with 5 kV d.c.

| **DESCRIPTION** | Phase **L1**<br>*Measured insulation resistance* **(MΩ)*** | Phase **L2**<br>*Measured insulation resistance* **(MΩ)*** | Phase **L3**<br>*Measured insulation resistance* **(MΩ)*** |
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| COLUMN: 3 | | | |
| COLUMN: 4 | | | |
| COLUMN: 5 | | | |
| COLUMN: 6 | | | |
| COLUMN: 7 | | | |
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* *Minimum value of insulation resistance is to be 50 MΩ*

| **NOTES:** |
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| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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IMESA ELECTRICAL ENGINEERING

# SAT REPORT FOR TESTING H.V. CIRCUIT BREAKERS AND H.V. FUSED CONTACTORS - RESISTANCE OF THE MAIN CIRCUIT -

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

Value of injected current: 100 A

| **DESCRIPTION** | Phase **L1**<br>*Measured resistance*<br>**(μΩ)*** | Phase **L2**<br>*Measured resistance*<br>**(μΩ)*** | Phase **L3**<br>*Measured resistance*<br>**(μΩ)*** |
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| COLUMN: 5 | | | |
| COLUMN: 6 | | | |
| COLUMN: 7 | | | |
| | | | |

* *To obtain the measured resistance value, in μΩ, is sufficient to multiply by 10 the measured v.d. in mV (e.g. : voltage drop of 1.4 mV = 14 μΩ)*

| **NOTES:** |
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| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
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| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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# SAT REPORT FOR PRIMARY INJECTION TESTING ON CTs AND VTs

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

**Legend** **OK** - **N/A** – not applicable × SEE NOTE

| **DESCRIPTION** | **1** | **2** | | | | | | | | | | | | | | | |
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| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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# SAT REPORT FOR PROTECTION FUNCTIONS CHECK

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |
| **PROT. RELAYS' COORD. STUDY DOC. :** | **PANEL UNIT:** | **RELAY SERIAL NO. :** |

| ***protection unit setting test values*** | | | | | ***protection unit operation check values*** | | | |
|---|---|---|---|---|---|---|---|---|
| *Protection Function* | *ANSI Code* | *Setting* | | *CT/VT Ratio* | *Phase* | *Test Value* | *Operating Time* | *Result* |
| | | *Value* | Time [s] or K | | | | | |
| | | | | *CT/VT Ratio* | | | | |
| | | | | | | | | |
| | | | | | | | | |

**Notes:**

| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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# SAT REPORT FOR HI-POT TEST

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

| **Legend** | **OK -** | **N/A** – not applicable | | | × SEE NOTE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DESCRIPTION** | **1** | **2** | | | | | | | | | | | | |
| HI-POT TEST ON POWER CIRCUITS | | | | | | | | | | | | | | |

Applied Voltage on the power circuits: 16 kV (80% of the FAT rated value)
Duration Time: 60 s

Measured Insulation Resistance

| BEFORE TEST | AFTER TEST |
|---|---|
| L1= | L1= |
| L2= | L2= |
| L3= | L3= |

| **NOTES:** |
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| Equipment disconnected during Hi-Pot test: |

| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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# SAT REPORT FOR DIELECTRIC TEST ON AUX. CIRCUITS

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

| **Legend** | **OK** - | **N/A** – not applicable | | | × SEE NOTE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DESCRIPTION** | **1** | **2** | | | | | | | | | | | | |
| DIELECTRIC TEST ON AUX. CIRCUITS | | | | | | | | | | | | | | |

Applied Voltage on the power circuits: 2000 V a.c.
Duration Time: 60 s

Measured Insulation Resistance

| BEFORE TEST | AFTER TEST |
|---|---|
| **110 V d.c. =** | **110 V d.c. =** |
| **230 V a.c. =** | **230 V a.c. =** |
| **24 V d.c. =** | **24 V d.c. =** |

| **NOTES:** |
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| Equipment disconnected during dielectric test: |

| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
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| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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# SAT REPORT FOR INFRARED SENSORS TESTS

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

| Modbus Address | | Serial N. | |
|---|---|---|---|

| Data Card Channels (2) | Ch 1 | Ch 2 | Ch 3 | Ch 4 | Ch 5 | Ch 6 | Ch 7 | Ch 8 |
|---|---|---|---|---|---|---|---|---|
| Section Reference (1) | | | | | | | | |
| Phase Reference | | | | | | | | |
| **Sensor Type** | | | | | | | | |
| IR.EM-06.SC – Delta T | | | | | | | | |
| No Sensor | | | | | | | | |
| IR.EM-06.SC ONLY | | | | | | | | |
| Busbar Size | | | | | | | | |
| Mounting Distance | | | | | | | | |
| Gain Factor Used | | | | | | | | |
| **Site Acceptance Test** | | | | | | | | |
| Initial Value | | | | | | | | |
| Heat Tested Reading | | | | | | | | |

(1) Note CB = Cable Compartment BB = Busbar Compartment

(2) See ref. Documents 1723002197-EL-LIS-00041 and 1723002197-EL-DG-00022

| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
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| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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# SAT REPORT FOR GOOSE MESSAGING TESTS

SWBD: **SD-100G1**

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

| | | | | | From | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | SIGNAL Description | BB VT OPEN | ES BB OPEN | CLOSING COMMAND | OPENING COMMAND | |
| | CUBICLE | DEVICE | SIGNAL | GOOSERX N | | 0 | 1 | 2 | 3 | |
| Destination Unit | | | TRIP | | | | | | | |
| | | | ARC FAULT | | | | | | | |
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| **NOTES:** |
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| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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2.3.2.SITE ACCEPTANCE TEST PROCEDURE - LV Switchgear,

Doc No. 1723002197-QC-PRO-00047

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# Base Load Power Hub (BLPH)

SITE ACCEPTANCE TEST PROCEDURE
LV Switchgear
Document Number: 1723002197-QC-PRO-00047

Document Class: 2

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| | 05/02/2025 |

| | | | | | |
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| | | | | | |
| | | | | | |
| 02 | 30/01/25 | Accepted for Construction (AFC) | Flamminio | Martizzi | Chiappa |
| 01 | 19/12/24 | Issue for Review (IFR) | Flamminio | Martizzi | Chiappa |
| 00 | 05/08/24 | Issue for Review (IFR) | Flamminio | Mastri | Chiappa |
| Rev. | Date | Description | Prepared | Reviewed | Approved |

IMESA ELECTRICAL ENGINEERING Doc. n. 231298/SD/047

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*File:* 1723002197-QC-PRO-00047_SAT PROCEDURE_rev02

**Revision / Change Log**

| Rev. | Description |
|---|---|
| 00 | Issue for Review (IFR) |
| 01 | Issue for Review (IFR) |
| 02 | Accepted for Construction (AFC) |
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# 1 INTRODUCTION

## 1.1 PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.
Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

### 1.1.1 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

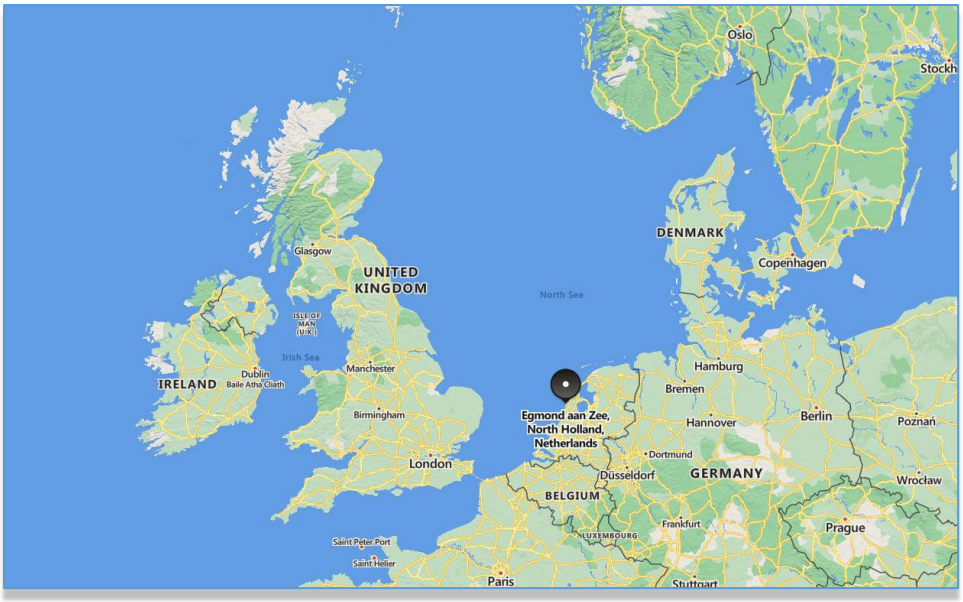



Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map




Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed byVan Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

### 1.1.2 Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

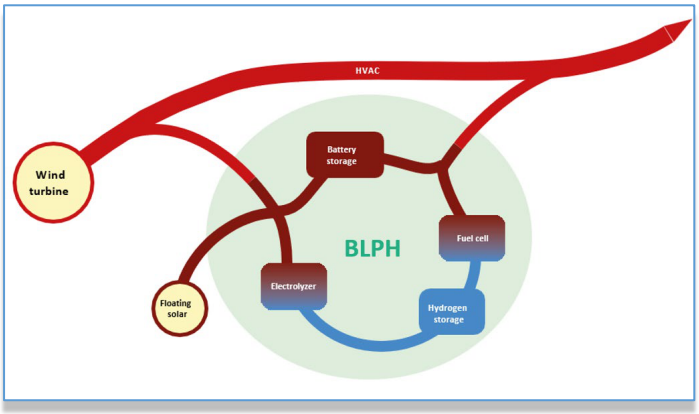



Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.
The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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## 2 SCOPE AND APPLICABILITY

This document provides the commissioning and start-up methods, as well as the testing procedures at site, applicable to L.V. Electrical Switchboards, manufactured by IMESA in compliance to Standard IEC 61439-1 and 61439-2.

The procedure is applicable to the following switchgear tag: SG-200N1, SG-200D2, DP-200N1.

## 3 APPLICABLE STANDARDS AND DOCUMENTS

The tester will make reference to Standards IEC 61439-1 and IEC 61439-2 and to the engineering documents listed here below.

| Ref. | Imesa Doc No. | Description |
|---|---|---|
| A1 | 1723002197-EL-DA-00007 | SG-200N1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| A2 | 1723002197-EL-DA-00008 | SG-200D2 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| A3 | 1723002197-EL-DA-00009 | DP-200N1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| A4 | 1723002197-EL-DG-00011 | SG-200N1 ELECTRICAL SINGLE LINE DIAGRAM |
| A5 | 1723002197-EL-DG-00012 | SG-200D2 ELECTRICAL SINGLE LINE DIAGRAM |
| A6 | 1723002197-EL-DG-00013 | DP-200N1 ELECTRICAL SINGLE LINE DIAGRAM |
| A7 | 1723002197-EL-DG-00030 | SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - INCOMINGS, INTERCONNECTING AND AUX DISTRIBUTION |
| A8 | 1723002197-EL-DG-00031 | SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS |
| A9 | 1723002197-EL-DG-00032 | SG-200D2 FUNCTIONAL DIAGRAM |
| A10 | 1723002197-EL-DG-00033 | DP-200N1 FUNCTIONAL DIAGRAM |
| A11 | 1723002197-EL-DS-00035 | SG-200N1 EQUIPMENT DATA SHEETS INCLUDING MSDS and WEIGHT DATA SHEET |
| A12 | 1723002197-EL-DS-00036 | SG-200D2 EQUIPMENT DATA SHEETS INCLUDING MSDS and WEIGHT DATA SHEET |
| A13 | 1723002197-EL-DS-00037 | DP-200N1 EQUIPMENT DATA SHEETS INCLUDING MSDS and WEIGHT DATA SHEET |
| A14 | 1723002197-EL-CAL 00054 t.b.d. | INSTALLATION OPERATING AND MAINTENACE MANUAL |

Hard copy of the a.m. IMESA documents, properly stamped and signed as “AS BUILT”, will be available for the needed testing activities and verifications.

# 4 SAFETY RECOMMENDATIONS

WARNING



- **All the operations of electric maintenance and installation must be performed by qualified technicians**
- **All the standard electric safety procedures must be respected**
- **Never touch inside the switchboard; only after making sure it is out of voltage and grounded**
- **Always wear personal protective equipment (insulating shoes in rubber, protective glasses, safety helmet, etc...)**
- **Never work alone**
- **Never remove safety screens**
- **Always pay maximum attention when handling components or performing measurements inside the panel**
- **It shall be taken in mind that this test procedure is only for the equipment and is to be used together (not instead of) all safety procedures specified by local Laws, rules, regulations and Standards**

People attending the commissioning and testing activities must wear:

**SHOES:** Workers, staff of the Customer, the End User or its representatives (inspectors) present during the tests shall wear safety shoes, ever. The staff of the Customer, the End User or its representatives (inspectors) present during the tests must arrive already equipped with their own shoes. The staff of the Customer, the End User or its representatives (inspectors), present during the tests and not wearing safety shoes, may still access the Safe Area, but not the test area. They will therefore only observe the test from Safe Area and conducting the review of the results in test reports.

**GLASSES:** Workers must wear safety glasses when performing risky for their eyes.

**HELMET:** Workers must wear protective helmets when performing lifting and handling, or when there is a suspended load. When there are suspended loads or handling and lifting the staff of the Customer, the End User or its representatives (inspectors) present during the tests must remain in the Safe Area.

**GLOVES:** Workers must wear gloves when performing risky for the hands or vibrations.

**DRESS:** All workers must wear appropriate safety clothing, forever. Helmet, gloves, glasses, safety clothing are not required to staff of the Customer, the end Customer or his representatives (inspectors) present during the tests.

When testing the dielectric properties (applied voltage test), **insulated gloves** and **shoes with retractable toe caps**, as well as suitable **protection clothing covering body and arms**, to be worn.
If the test is suspended even temporarily, the test instrument must be disconnected from the mains.

Before to start any activity, to thoroughly check that the following points are confirmed:
- the lighting system in the area is suitable and in operation
- phone or radio communication system is available, even temporarily for the present activities
- the fire-fighting system is in operation and provided with valid certification (portable fire extinguishers may be also suitable for purpose)
- earthing plant in the area and earthing connections of the subsystems to be energized have been completed and tested

# 5 GENERAL DESCRIPTION

## 5.1 LIST OF ABREVIATIONS

| | |
|---|---|
| S.A.T. | Site Acceptance Test |
| VT | Voltage Transformer |
| CT | Current Transformer |
| NCR | Non-Conformity Report |
| IED | Intelligent Electronic Device (like programmable relay) |
| MCB | Miniature Circuit Breaker |
| CB | Circuit Braker |
| MCC | Motor Control Center |
| LV | Low Voltage (Circuit with voltage under 1000Vac or 1500Vdc) |
| I.O.M. | Installation, Operation and Maintenance manual |
| a.m. | above mentioned. |

## 5.2 PURPOSE OF SAT

The purpose of the SAT (Site Acceptance Test) is to inspect the switchboard, after installation at site, to ensure that it is ready for energization and start-up and also that its performance requirements will be met.
Prior to performing any Site Acceptance Testing, all Punch list items have to be rectified and closed.

## 5.3 TESTING TASKS

After completion of the installation phase of the switchboard and in order to prepare it for SAT, pre-commissioning and commissioning are to be first carried out, as further detailed in the next paragraphs.

The overall test activities will be performed by means of the specific test equipment, under the control and responsibility of the test executor, along with some assistants.

The main steps that will be performed are the following:
- Verification of the test procedures and of the related documentation availability.
- Preparation of the test setup
- Execution of the tests according to the Test Procedure and release of the SAT Test Report
- Signing of the SAT Test Report by the test executor and the attending people.

For additional tests not included in its own scope of work, IMESA will provide technical support, as agreed in advance.

**List of the tests**

| Item | Activity | Tool | Support Requested | Type of Test |
|---|---|---|---|---|
| a. | Mechanical check | Torque Wrench | Mech. Engineer<br>Inspection/Quality Officer | Mandatory |
| b. | Primary Injection on current transformers | Injection current bench | Electrical Engineer<br>Inspection/Quality Officer | Suggested<br>(to verify that CT is not damaged) |
| c. | Primary Injection on voltage transformers | Apply low voltage to check the functionality of VT (400V) | Electrical Engineer<br>Inspection/Quality Officer | Suggested<br>(to verify that VT is not damaged) |
| d. | Testing of protection relays by secondary injection | Secondary injection bench (Omicron) | Electrical Engineer<br>(Relay specialist)<br>Inspection/Quality Officer | Mandatory |
| e. | Functional test of IEDs, and interlocks. | Secondary injection bench (Omicron) | Electrical Engineer<br>(Relay specialist)<br>Inspection/Quality Officer | Mandatory |
| f. | Insulating resistance measurement | Megger | Electrical Engineer<br>Inspection/Quality Officer | Mandatory |

### 5.4 TESTING EQUIPMENT

- Megger (e.g. : Chauvin Arnoux ca 6547)
- Tester / Multimeter
- Testing bench for primary injection (e.g. : Omicron CPC 100)
- Relay Testing System ( through current / voltage secondary injection – (e.g. : Omicron CMC 353)
- Testing kit for air circuit breakers type Emax ABB (Ekip T&P)
- Torque Wrench (e.g. Dina Beta NM 20÷100)
- Hi-pot test bench (e.g. : Phenix 650-2P)

NOTES:
- it shall be advised in advance availability of the testing equipment at site or whether those are to be provided by the commissioning engineer himself;
- availability of calibration certificates of the above testing equipment, having valid date, must be ensured.

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### 5.5 TEST PHASE AND PASS/FAIL CRITERIA

For each test a set of pass/fail criteria will be defined (it is also possible that each test has a different criteria) in order to establish an acceptance procedure.
Where acceptance and rejection criteria are not established, they shall be defined according to the best practice, making reference to standards or samples.

The main possibilities are the following:
- All the steps are successfully performed (the test passes)
- Some steps fail but the function under test is verified (the test passes after client approval)
- Some steps fail and the function under test is not verified (the test fails)
- Some steps fail but with a specific corrective action the proper function is recovered (the test must be repeated)

If the test fails, a related NCR will be released.

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# 6 PRE-COMMISSIONING ACTIVITIES

Before to start Pre-Commissioning, please, read carefully the I.O.M. document (Installation, Operation and Maintenance manual).
Then proceed with the following checks and actions.

1. Switchboard's cubicles shall be in good and clean status. Make sure that switchboard is clean, free from dust, traces of humidity, installation material debris, cables pieces, tools, provisional connections, etc. , as well as any foreign object.

2. Visually check the interior and exterior of the switchboard for signs of evident damage or shocks. Protective shields, insulating sheaths, etc.. shall be correctly placed and in good order

3. Painting visual check

4. Make sure that the switchboard is correctly installed according to the General Arrangement Drawings and suitably fixed

5. Maintenance clearances shall be according to the General Arrangement Drawings

6. Make sure that any support or protection used to handle the equipment has been removed

7. Make sure that, after completion of the installation, the switchboard overall protection degree is as per General Arrangement Drawings

8. Visual inspection to check that bolted connections of the LV and earthing circuits (at busbars, CBs poles, etc.) are suitably tighten. No disalignment is expected at the marks provided over the bolt, during torque wrench tightening at the factory. In case found, to torque wrench again the connection (see par. 8.1)

9. Cable passages shall be free and unobstructed

10. Couple the auxiliary interpanel connections by the relevant plugs and socket (see schematic diagrams with control voltage distribution loop, panels interconn. wiring and communication network loop)

11. Cabling of control cables from the field in accordance with I/O list / schematics shall be completed

12. Check the incoming / outgoing power cables proper support

13. Make sure that terminals and all the connections have been properly tightened

14. Make sure that all the safety interlock keys (master and copies) have been provided and installed. Where manoeuvres not allowed (forced operations shall be avoided).

15. Remove each L.V. air circuit breaker and MCC drawer from its cubicle, by means of the provided lifting / transport trolley, for a visual check of the breaker status and cleaning; including poles of the fixed part and the terminals on the removable part.
    Make sure that the breaker and the MCC drawer is free from dust and traces of humidity and that there are no signs of evident damage.
    Check that LV withdrawable circuit brakers and MCC drawers can be racked-in and racked out properly

16. Make sure that all fuses are correctly installed
17. All necessary warning and caution signs (voltage level indication, warning for live parts, etc.) shall be installed according to the safety standards and procedures

The results of the a.m. activities shall be recorded on PRE-COMMISSIONING ACTIVITIES REPORT form (see par. 10).

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## 7 COMMISIONIG ACTIVITIES

Carry out the following checks and actions.

1. To be verified that all LV withdrawable circuit breakers and MCC drawers are in open and racked-out position; with charged closing springs (where present).

   N.B.: it is recommended to manually rewind all the circuit breakers closing springs, before to supply the relevant spring motor chargers, with aux. supply voltage, in order to prevent concurrent start-up of many motor gears, which may result in excessive load for the supplying circuit.

   As an alternative, it can be taken care that supply to those motors is provided one by one; by separately closing the relevant MCB, provided within the LV compartment of each feeder unit.
2. Connect all external aux. supplies and check that are at correct voltage value and phase sequence.
3. Check thoroughly the Operating efficiency and the mechanical locks and key safety interlocks.
4. With CBs in test position, close and open the same by local command.
5. Make sure that the phase sequence is in accordance to the electrical diagrams and that all incoming breakers are connected with the same phase sequence.
6. Check monitoring loops (hardwired status / alarm signals / visual status indications).
7. Check protection relays loops, concerning IEDs' integrated logic functions.
8. Put in service (racked-in) position and repeat the test for opening / closing the same from local and remote commands, including control loops from / to the field (commands, status, alarm, etc.)
9. Check CBs tripping, locking-out and alarming functions.

The results of the a.m. activities shall be recorded on the COMMISSIONING ACTIVITIES REPORT form (see par. 10)

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# 8 SAT TESTING PROCEDURE

## 8.1 MECHANICAL TESTS

**1.** Bus-bars tightening check

Torque wrench all the bolted joints of the shipping sections, which have been coupled at site, according to the values indicated here below.
After tightening, each bolt is to be marked by red paint to indicated its relative position against the fixed part (as done for the torque wrench tightening provided at the factory).

The table below shows the torque wrench settings to be used for bolted connections fixing the panels and the bus-bars, too.

| Type of screw | Tightening torque (Nm) | Tolerance |
|---|---|---|
| M5 | 5 | 5% |
| M6 | 9 | 5% |
| M8 | 22 | 5% |
| M10 | 45 | 5% |
| M12 | 75 | 5% |
| M14 | 115 | 5% |
| M16 | 185 | 5% |

The results of the a.m. activities shall be recorded on SAT REPORT FOR MECHANICAL TEST form (see par. 10)

## 8.2 PRIMARY INJECTION ON CURRENT AND VOLTAGE TRANSFORMER

1. Testing CTs ratio

Test the CT for correct ratio with direct current injection to CT primary circuit and reading the measured value from the instruments or protection relays LCD display, provided at the LV compartment front door.

2. Testing VTs ratio

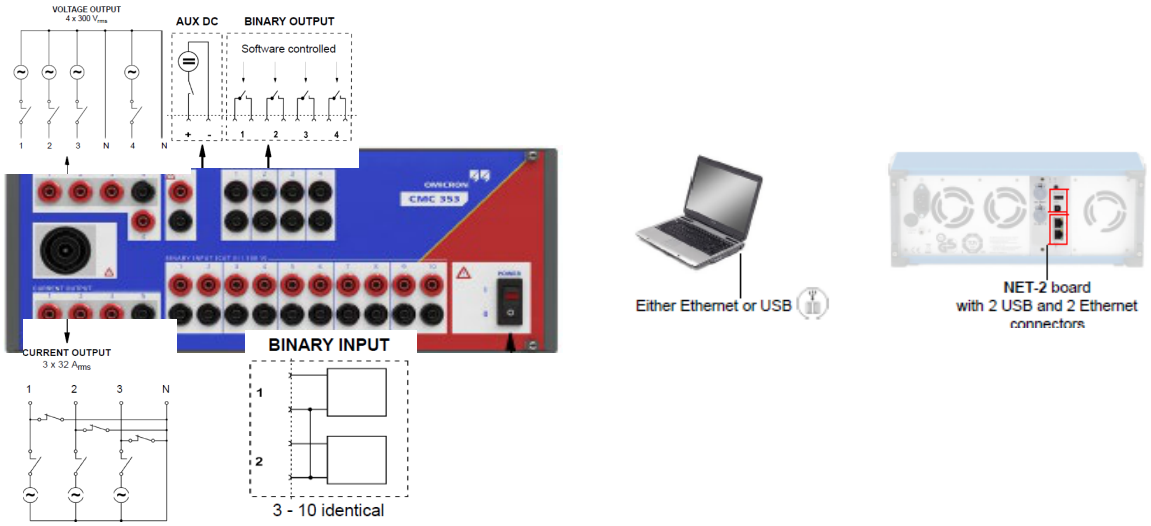
Test the VT for correct ratio with direct voltage injection to VT primary circuit (low voltage 400 V, for testing purpose) and reading the measured value from the instruments or protection relays LCD display, provided at the LV compartment front door.

The results of the a.m. activities shall be recorded on SAT REPORT FOR PRIMARY INJECTION TESTING ON CTs AND VTs form (see par. 10)

## 8.3 SECONDARY INJECTION TESTS ON PROTECTION RELAYS

Refer to the schematic diagrams, for connections and for checking logic functions.
Refer to the selectivity study for the protection relays' setting parameters.

Omicron secondary injection test kit – connection and interface




Example of testing instruments connection

1. Connection of the test set to the PC (USB Port) for data exchange: output of the data simulation, loading of the binary signal
2. Connection of the analogue outputs of the test set to the transformer inputs of the test object, to inject the simulated currents and voltages.
3. Connection of the binary outputs of the test set to the binary inputs of the test object, to send binary input signals to the test object.
4. Connection of the binary inputs of the test set to the binary outputs of the test object, to receive the binary output signals from the test object.

The recorded tripping values shall be in conformity with the Selectivity study

The results of the a.m. activities shall be recorded on SAT REPORT FOR PROTECTION FUNCTIONS CHECK form (see par. 10)

### 8.4 INSULATION RESISTANCE MEASUREMENT

The measurement of the insulation resistance is carried out to check that the installation and re-connection activities at site have been made correctly and that no damage occurred to the equipment, during shipment and installation.
All the VT's, surge arresters, insulation monitoring devices, etc. must be disconnected before the test.

1. Insulation resistance measurement of the main circuits

   It is to be carried out, applying at least 500V d.c. by means of Megger device. The measurement is to be carried out at each phase, while the other two are short-circuited and connected to ground.

   ACCEPTANCE CRITERIA: The test is considered successful if, for each tested circuit, the insulation resistance is above 1MΩ.

The values detected shall be recorded on SAT REPORT FOR INSULATION RESIST MEASUREMENT MAIN CIRCUITS form (see par. 10)

2. Insulation resistance measurement of the auxiliary circuits

   To carry out insulation resistance measurement on auxiliary circuits applying 500V d.c. by means of Megger device. The measurement is to be carried out at each pole, while the other one is connected to ground.

   ACCEPTANCE CRITERIA: The test is considered successful if, for each tested circuit, the insulation resistance is above 1MΩ.

The results of the a.m. dielectric tests shall be recorded on SAT REPORT FOR INSULATION RESIST MEASUREMENT ON AUX CIRCUITS form (see par. 10)

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# 9 PRE-ENERGIZATION REQUIREMENTS

Before to proceed with energization of the LVSB, the following is to be verified.

- Make sure to pull off the short-circuit jumpers fitted on amperometric terminal boards, to avoid running the units with current transformer (-TA) short-circuited at secondary windings.
- Make sure to have re-closed the disconnecting terminals fitted on voltmetric terminal boards, to avoid running the units with voltage transformer (-TV) not connected at secondary windings.
- Make sure that all the miniature CBs for aux. and measuring circuits are closed.
- All system protections, controls, detectors, and monitoring devices shall be reset and ready for operation.
- All protections and control logics shall be reset and ready for operation.
- All recording equipment, where provided, shall be in operation.
- No alarm and/or trip signal shall be active.
- Voltage transformers shall be with fuses suitably placed.
- Circuit breakers shall be in service position (racked-in), open and available.
- Fuses shall be suitably placed.
- Mechanical and electrical interlocks are to be suitably in operation.
- All removable protections against direct contacts with accessible parts (panels, grids, plates, doors, etc.), shall be correctly placed and fixed.
- All the doors shall be closed and fixed panels are to be correctly positioned and bolted.

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# 10 PRE-COMMISSIONING, COMMISSIONING AND SAT REPORT TEMPLATES

The following forms are intended for recording the results of Pre-Commissioning, Commissioning and SAT activities.

Forms provided by the customer may also be employed, on request.

- PRE-COMMISSIONING ACTIVITIES REPORT
- COMMISSIONING ACTIVITIES REPOR
- SAT REPORT FOR MECHANICAL TEST
- SAT REPORT FOR PRIMARY INJECTION TESTING ON CTs AND VT
- SAT REPORT FOR PROTECTION FUNCTIONS CHECK
- SAT REPORT FOR INSULATION RESISTANCE MEASUREMENT ON MAIN CIRCUITS
- SAT REPORT FOR INSULATION RESISTANCE MEASUREMENT ON AUX. CIRCUITs

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IMESA ELECTRICAL ENGINEERING

# PRE-COMMISSIONING ACTIVITIES REPORT

SWBD:

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

**Legend** **OK** - **N/A** – not applicable × SEE NOTE

| DESCRIPTION | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
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**NOTES:**

| TEST PERFORMER | WITNESS | QUALITY OFFICER | |
|---|---|---|---|
| EXECUTED | ACCEPTED / VERIFIED | ACCEPTED / VERIFIED | |
| Sign: | Sign: | Sign: | Sign: |
| Company:<br>Name: | Company:<br>Name: | Company:<br>Name: | Company:<br>Name: |
| Date: | Date: | Date: | Date: |

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IMESA ELECTRICAL ENGINEERING

# COMMISSIONING ACTIVITIES REPORT

SWBD:

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|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

**Legend** **OK** - **N/A** – not applicable **×** SEE NOTE

| **DESCRIPTION** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | | | | | | | | |
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**NOTES:**

| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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IMESA ELECTRICAL ENGINEERING

# SAT REPORT FOR MECHANICAL TESTS

SWBD:

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

**Legend** **OK** - **N/A** – not applicable × SEE NOTE

| **DESCRIPTION** | **1** | | | | | | | | | | | | | | | | | |
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**NOTES:**

| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

# SAT REPORT FOR PRIMARY INJECTION TESTING ON CTs AND VTs

SWBD:

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

**Legend** **OK** - **N/A** – not applicable **×** SEE NOTE

| **DESCRIPTION** | **1** | **2** | | | | | | | | | | | | | | | | |
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**NOTES:**

| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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IMESA ELECTRICAL ENGINEERING

# SAT REPORT FOR PROTECTION FUNCTIONS CHECK

SWBD:

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |
| **PROT. RELAYS' COORD. STUDY DOC. :** | **PANEL UNIT:** | **RELAY SERIAL NO. :** |

| *protection unit setting test values* | | | | | *protection unit operation check values* | | | |
|---|---|---|---|---|---|---|---|---|
| *Protection Function* | *ANSI Code* | *Setting* | | *CT/VT Ratio* | *Phase* | *Test Value* | *Operating Time* | *Result* |
| | | *Value* | Time [s] or K | | | | | |
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**Notes:**

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|---|---|---|---|
| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

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# SAT REPORT FOR INSULATION RESISTANCE MEASUREMENT ON MAIN CIRCUIT

SWBD:

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

**Legend** **OK -** **N/A** – not applicable **×** SEE NOTE

| **DESCRIPTION** | **1** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAIN CIRCUITS | | | | | | | | | | | | | |

| MEASURED INSULATION RESISTANCE |
|---|
| **L1=** |
| **L2=** |
| **L3=** |

| **NOTES:** |
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| |
| Equipment disconnected during Hi-Pot test: |

| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

# SAT REPORT FOR INSULATION RESISTANCE MEASUREMENT ON AUX. CIRCUITS

SWBD:

| | | |
|---|---|---|
| **CUSTOMER:** | **PROJECT DESCRIPTION:** | |
| **SITE:** | **AREA:** | |
| **SWITCHBOARD:** | | |
| **DATE:** | **DOC. N** | **REV:** |

**Legend** **OK** - **N/A** – not applicable ✖ SEE NOTE

| **DESCRIPTION** | **2** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIELECTRIC TEST ON AUX. CIRCUITS | | | | | | | | | | | | | |

| MEASURED INSULATION RESISTANCE |
|---|
| **110 V d.c. =** |
| **230 V a.c. =** |
| **24 V d.c. =** |

| **NOTES:** |
|---|
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| |
| Equipment disconnected during dielectric test: |

| **TEST PERFORMER** | **WITNESS** | **QUALITY OFFICER** | |
|---|---|---|---|
| **EXECUTED** | **ACCEPTED / VERIFIED** | **ACCEPTED / VERIFIED** | |
| **Sign:** | **Sign:** | **Sign:** | **Sign:** |
| **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** | **Company:**<br>**Name:** |
| **Date:** | **Date:** | **Date:** | **Date:** |

2.4. Procedures

2.4.1.MV-LV SWG PAINTING PROCEDURE,

Doc No. 1723002197-MAT-PRO-00004

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# Base Load Power Hub (BLPH)

## HV-LV SWG PAINTING PROCEDURE

## Document Number: 1723002197-MAT-PRO-00004

## Document Class: 3

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Michele Sacchi | 20/05/2024 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| 2 | 12/04/2024 | Issue for Information (IFI) | Santinelli | Mastri | Chiappa |
| 1 | 18/03/2024 | Issue for Information (IFI) | Santinelli | Mastri | Chiappa |
| 0 | 29/01/2024 | Issue for Information (IFI) | Santinelli | Mastri | Chiappa |
| Rev. | Date | Description | Prepared | Reviewed | Approved |

IMESA ELECTRICAL ENGINEERING IMESA Doc. 231151/SD/004

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## Revision / Change Log

| Rev. | Description |
|---|---|
| 00 | Issue for Information (IFI) |
| 01 | Issue for Information (IFI) |
| 02 | Issue for Information (IFI) |
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## HOLDS LIST

| No. | Description |
|---|---|
| 1 | |
| 2 | |
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| 4 | |

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Annex 03 – Paint technical data sheet

Annex 04 – Education course/Training Activity Report

Annex 05 - Technical data sheet Gardobon A4818

Annex 06 – Quality control for painted parts

Annex 07 – Control sheet painting plants



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# 1. GENERAL INFORMATION

NORMATIVE REQUIREMENTS

- Standards series UNI EN ISO 12944: 2018
- ISO 6270-1: 2018 (humidistat)
- ISO 8501.1:2012 (surface preparation for painting treatment)
- DIN EN ISO 9227:2023 (saline fog chamber)
- UNI EN ISO 2813:2014 (Gloss)
- ISO 2409:2020-12
- UNI ISO 2178:2016

IMESA takes painting systems for indoor installations with power paint through electrostatic application.

IMESA defines the correct painting system for HV/LV electrical switchboards according on relevant protection against corrosion in the installation environment.

The installation environments are identified in 6 classes of atmospheric corrosion (C1 ÷ C5-M) and 3 classes of durability (low, medium, high) according to ISO 12944:2018.

IMESA guarantees the systems in the below table, where there are also the relative classes of atmospheric corrosion.

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| **Treatment cycle** | **A** |
|---|---|
| Corrosion - durability class | C3M |
| Installation environment | Unpolluted urban and industrial areas |
| Degreasing | X |
| Phosphatising | X |
| Wash 1 | X |
| Wash 2 | X |
| Passivation in demineralized product with nanotechnology | |
| Drying | X |
| Epoxy polyester powder coating | X |
| Kiln polymerisation | X |

Tables 1

There must be no traces of calamine or soldering slag, lamination etc, on the parts to be painted before the phosphatising treatment, in compliance with Directive ISO 8501.1:2012.

The colours used correspond to the standardised RAL colours.

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# 2. DESCRIPTION AND CHARACTERISTICS OF SYSTEMS

## 2.1 CYCLE A

### 2.1.1 PRETREATMENT

The surfaces to be painted must be prepared in compliance with Directive ISO 8501-1:2012 (rusting and preparation grades of steel surfaces); the part is then chemically prepared according to the following cycle:

HOT DEGREASING (40 ÷ 50°C)

HOT PHOSPHATING (40 ÷ 50°C)

SPRAY WASH

SPRAY RINSE

KILN DRYING (110°C)

The surface must be dry, clean and degreased.

The powder is guaranteed for 24 months since production date whether stored in a temperature not over 30°C and in the original packaging.

### 2.1.2 PAINTING PROCESS

Electrostatic epoxy polyester powder paint coating,

RAL according to the technical specification,

polymerization at 180°C, 60/70 gloss (*),

smooth or orange peel finish according to the technical specification,

minimum thickness 60 micron (dry film).

In this phase the process parameters are monitored in order to obtain an excellent powder paint coating (See Annex 01 - WI 18 Rev. 09).

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(*) The check of gloss is not significant for surface treatment with orange peel finish. Infact the value will be non compliant to what the data sheets because the brilliance depends on the type of surface treatment and the orange peel finish makes impossible a correct evaluation of gloss.

The evaluation of smooth finish is significant

### 2.1.3 CHARACTERISTICS

Exposure in a saline fog chamber in compliance with ISO DIN EN ISO 9227:2023 with resistance more than 240 hours.

Exposure in a humidistat in compliance with ISO 6270 – 1: 2018 with resistance more than 120 hours.

Adhesion: in compliance with Standard ISO 2409:2020-12 (See Annex 02)

N.B. All the characteristics guaranteed by the paint manufacturer must however be complied with.

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# 3. PAINTING CHECKS

Since some of the checks are destructive tests, we recommend painting sheet plate specimens in sizes suitable for the destructive tests, with the same paintwork cycle used for the lot.

The specific modes of the checks that are performed internally are described in Annex 1 IL CAR.18

## 3.1 APPEARANCE

The paint on the painted sheet plate must be uniformly coated. There must be no signs of sagging, local thickening or other paintwork defects.

In any case the thickness' must not be under the minimum values requested. Moreover, the undercut and areas which are difficult to reach with normal painting tools, must be retouched by hand.

Boxed areas (e.g. doors, armour - plated switchboards) must be protected against corrosion with suitable protecting means at the discretion of the manufacturer provided the same ensure a lasting protection.

In cases of small defects in the surface it's possible to make retouches with spray paint or with a hand brush on the same RAL of specification; in case of bigger defects, the surface paint must be removed and a new treatment must be done.

## 3.2 THICKNESS CHECK

This check is carried out by means of magnetic induction readings in compliance with Directive UNI ISO 2178:2016. The readings must be carried out on the diagonal of the part; areas which are difficult to reach during painting, must have at least the minimum values indicated in this specification.

## 3.3 ADHESION CHECK

Carried out in compliance with Standard ISO 2409:2020-12 (See Annex 02).

## 3.4 GLOSS CHECK (THIS TEST WILL BE MADE IF REQUIRED IN AN EXTERNAL LABORATORY)

This check is carried out on smooth surfaces in compliance with UNI EN ISO 2813:2014.

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### 3.5 SALINE FOG TEST (THIS TEST WILL BE MADE IF REQUIRED IN A EXTERNAL LABORATORY)

In compliance with ISO 9227:2023 (duration of the test according to the painting system carried out).

### 3.6 HUMIDISTAT TEST (THIS TEST WILL BE MADE IF REQUIRED IN AN EXTERNAL LABORATORY)

According to ISO 6270-1:2018 (duration of the test according to the painting system carried out).

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## 4. INDICATIONS ON THE DRAWINGS

The painting cycle must be indicated on the drawing by the letter of the system and the thickness to be used. Painting cycle and RAL colour is mentioned on following doc:

- 1723002197-EL-DA-00006 / SG-100D1 GA DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG
- 1723002197-EL-DA-00007 / SG-200N1 GA DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG
- 1723002197-EL-DA-00008 / SG-200D2 GA DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG
- 1723002197-EL-DA-00009 / DP-200N1 GA DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG

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## 5. PAINT TECHNICAL DATA SHEET


EUROPOLVERI S.p.A.
Sede e stabilimento: Via Galvani, 69
36066 Sandrigo (Vicenza) Italy
Telefono: +39.0444.750643
Telefax: +39.0444.750653
www.europolveri.it
info@europolveri.it


### TECHNICAL DATA SHEET

**DURPOL EE 9B2870303T000 (EX 9068A6522) GREY ENEL TEXT HG TS X R7030**

**Composition**

Powder based on polyester saturated carboxylated resins hardened in stoichiometrically relation with epoxy resins and formulated with pigments and inert fillers appropriate to guarantee good resistances in places do not exposed to direct weathering agents

**Recommended uses**

Powder indicated for a wide range of artefacts having excellent aesthetical finishing level and good resistance to yellowing such as: radiators, domestic appliances, tools, metallic furniture, scaffolding, indoor lighting, electric cabinets, office equipment.In order to obtain a good protection, it is necessary to spray an average thickness of 80- 100 micron.

**Substrate pre-treatment**

Powders adhere to most metal surfaces provided these are dry, clean and degreased. A chemical pre-treatment of the surface is required in order to improve the resistance against the corrosion, based on the kind of metallic support.

**Application**

This powder is suitable for use with electrostatic spraying equipments whose voltage is between 40 and 90 KV. Where acronym "TS" is present, our products are working also with triboelectical guns.
A difference of thickness of applied coating can generate modification of the appearance of hardened coating.In case of products having special effects, the use of overspray is not advised except for bonded products.

**Polymerization conditions**

170°C x 25', 180°C x 15', 190°C x 10' (piece temperature)

**Characteristics after polymerization (application on steel panel)**

| | | |
|---|---|---|
| Erichsen Drawing: | >=5 mm | ISO 1520 |
| Mandrel Bend Test: | >= 4 mm | ISO 1519 |
| Impact Resistance: | >= 2,5 Nm | ASTM D2794 |
| Buchholz Hardness: | >= 80 | ISO 2815 |
| Cross Cut Test: | Gt0 | ISO 2409 |
| Gloss 60°: | Not applicable. | ISO 2813 |

**Chemical resistance**

The product has good resistance to most 10% acids and to ethylalcohol at room temperature (25°C).
For specific requests we invite you to contact our technical assistance.

**Corrosion resistance (application on iron-phosphate bonder)**

| | | |
|---|---|---|
| Humidity Chamber: | After 500 hours no change. | ISO 6270 |
| Kesternich: | After 10 cycles no loss of adhesion. | ISO 22479 |
| Salt Spray: | After 1000 hours < 1 mm penetration. | ISO 9227 |

**Accelerated ageing (QUV-B) (313 nm) with QUV/SE cycle 4 hours, condensation at 40°C/4 h irradiation 50°C (0,75 W/m²/nm. Application on aluminium panel)**

| | | |
|---|---|---|
| Test: | Not applicable. | ISO 16474:3 |

**Storage**

The product is guaranteed for 24 months since production date whether stored in a temperature not over 30°C and in the original packaging.

Notes:

* The above data are the results of careful researches and our long experience, nevertheless considering the large number of factors concurring to determine the values in the present technical data sheet, the utilizer will have the duty to effect the best conditions so as to get the best result.
* This product is destined to be used only in industrial plants. The manipulation of the product from the utilizer must be conform to laws concerning the use of powder coatings and to information described in our technical data sheet sent together with the product itself.

*Revision 3/June. 2019*

**EUROPOLVERI S.p.A.**


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| | | |
|---|---|---|
| IMESA ELECTRICAL ENGINEERING | **Work Instruction: powder coating** | IL CAR.18<br>Issue 03/01/2002 |

| Processed and Verified by: Lorenzo Piersigilli | Approved by: Cristiano Stefano Chiappa |
|---|---|
| Lorenzo Piersigilli | |

| Iss./Rev. | Date | Description of modifications made |
|---|---|---|
| First issue | 04/03/2002 | |
| Revision 01 | 04/11/2002 | Adaptation of environmental controls |
| Revision 02 | 06/12/2006 | General revision |
| Revision 03 | 02/07/2007 | Maintenance Sheets Update |
| Revision 04 | 14/09/2011 | Deleted form VER 03 |
| Revision 05 | 27/01/2017 | General revision |
| Revision 06 | 20/11/2020 | Control revision |
| Revision 07 | 06/04/2023 | General revision |
| Revision 08 | 15/05/2023 | Paint operator training |
| Revision 09 | 16/10/2023 | Paint thickness upper limit insertion |

**DISTRIBUTION:** all functions

**ANNEXES:**

- ✓ Form VER 01 – Painted parts control board,
- ✓ Form VER 02 – Painting system control board
- ✓ Form MAN 18 – Painting system periodic maintenance registration sheet
- ✓ Sheet 18 – Periodic maintenance of the Painting Plant

**APPLICABLE DOCUMENTS:**

- ✓ Work order

**APPLICABILITY AND LIABILITY**

The purpose of this Work Instruction is to describe and define the checks and tests to perform during the powder coating work phase, in order to keep this process under control.

The Body responsible for the correct implementation of the following WI is the CAR/LAV Department

**GENERAL INFORMATION**

The automatic powder coating system is described in detail in the manuals of the BIV, CAM and WAGNER manufacturers and consists mainly of:

- **Pre-treatment tunnel;**
- **Cabins and equipment for powder application;**
- **Drying and curing ovens;**
- **Overhead conveyor.**

The process is kept under control by measuring the fundamental parameters (listed below) such as to ensure the desired product quality.

**ACTIVITY SEQUENCE**

1 The department head, according to WO, must communicate to the operators in charge of painting:

- the type of treatment to perform;
- the method of execution of the painting (automatic or manual);
- the pieces to be treated, divided by order/construction;

2 The operator must activate the preheating of the phospho-degreasing tank and ovens, by operating the selectors of the burners and fans, on the control panel.

3 Examine the pieces or the batch to be processed, accompanied by the relative WP and visually verify the absence of defects such as:
- extensive rust or calamine presence;
- unbrushed welds.

4 Check that the colour of the powder in the container is that of the batch to be painted.

5 Operate the overhead conveyor with the appropriate button and start hanging the pieces on the hooks. For each batch, also hang 1 sample of the same material as the first piece .

6 Operate the pumps for phospho-degreasing and the following rinses according to the type of painting cycle when the first piece approaches the entrance of the first tunnel.

7 At the exit of the drying oven, after degreasing, check that the first piece is well cleaned.

If the piece is not clean, stop the conveyor belt and check with the department head the operation of the phospho-degreasing tunnel and the bath titration. After eliminating any inconvenience, repeat the pre-treatment on the pieces made.

8 Activate the suction of the expected painting cabin (automatic or manual) and ensure that the operator is ready on his platform, for painting or only for touch-ups depending on the cabin used.

9 In the case of automatic painting, activate the reciprocators and guns, using the appropriate control panel.

10 As soon as the last piece of each batch has been painted, make a first brief cleaning of the cabin used and move on to the other cabin already prepared for the colour of the second batch of pieces, or clean the manual guns and change the powder with its container.

11 Remove the painted pieces from the hooks and place the WP in the pallet.

12 Store the pieces with their drawings in the dedicated area awaiting collection by the Assembly Department.

13 To turn off the system, deactivate the pretreatment tunnel, turn off the burner of the drying oven just after the last piece has been rinsed; after painting the last piece, turn off the burner of the curing oven and finally stop the conveyor belt.

14 Turn off the air extraction fans 30 minutes after turning off the ovens.

**Quality CHECK of painted parts**

During the unloading phase, at the end of the cycle, perform the following checks:

A. Visually inspect all painted parts;

B. On the sample, at each colour change, check the adhesion of the paint with the UNI EN ISO 2409 DIN 53151 squaring method as indicated on "Guide 01" and record the check on the form VER 01

C. On all the samples, measure the thickness of the paint and record the value detected on the form VER 01

D. The minimum reference thickness is that indicated in the Work Order, if not indicated, use the standard of **60** mμ for "Cycle A" and **90** mμ for "Cycle B" (see Guide 01). In any case, the maximum thickness must not exceed 200 microns unless expressly requested in writing by the Customer in the work order.

E. On the painted pieces make **6 thickness measurements** (3 front and 3 back), the frequency of the control is indicated at the next point.

F. The frequency of thickness control on the painted pieces is as follows

Take measurements on the first 3/4 pieces; then check **one piece every 15** of the batch.

G. If all thickness measurements indicate a value ≥ to the reference value, the piece is **ACCEPTED**

H. If **2 or +** thickness measurements indicate a value < to the reference value, the part must be considered **DEFECTIVE;** in this case, the matter must be submitted to the Department Head, who decides how to proceed.

**CHECKS ON THE SYSTEM**

Checks and tests are performed on the system both before and during the special painting process, in the following ways:

**1. Checks on the degreasing tank**

Before each painting cycle, check the PH of the phospho-degreasing bath by viewing it in the monitor of the degreasing product dosing pump.

The value must be within the range established in the technical data sheet of the product used as a degreaser and check that the tank temperature is between 40 and 50°C.

The values detected must be recorded on the VER 02 form "Painting system control sheet"

**2. Oven temperature control**

The correct curing of paint, being the length of the section travelled inside the oven constant, depends on the curing temperature and the speed of the conveyor belt.

Based on the indications provided by the paint manufacturer, the temperature must be between 180 and 210 °C and the speed must be adjusted between 1 m/min and 1.5 m/min.

For this purpose, it must be verified at each cycle that the actual temperature indicated on the control panel corresponds to that set, with a tolerance of ± 10 °C.

The values detected must be recorded on the form VER 02 "Painting system control sheet".

Check that the temperature set for the drying oven is 90°C and that the temperature actually detected does not deviate by more than ± 10°C.

Record the check performed on the form VER 02

**3. Check of hook cleanliness and bias voltage**

For a correct adhesion of the powder to the piece to be painted (electrostatically biased at a voltage between 60-80 kV managed automatically by the WAGNER equipment), it is necessary to periodically clean the hooks used to hang the pieces on the conveyor belt.

At the points of contact between the hook and the workpiece, the thickness of dry paint present must be less than 2÷4 mm. If there are hooks with more paint attached than indiacted above, the operators must collect these hooks and the department head must send them to the external supplier for cleaning.

**4. Other checks**

Checks to be performed **weekly** taking as reference the values and parameters indicated in the manual or set by the manufacturers:

- check the pressure of the pumps (must be between 0.8 and 2 bar);
- check the correct setting of the paint guns according to the manufacturer's parameters

on board of the painting cabin or near **the manual guns**

Record the operations carried out on the form MAN 18 – Periodic maintenance registration of the painting system.

It is implied that if the system remains stationary for the entire week, the check is postponed to the following week.

If powder paint is used that has exceeded the validity period recommended by the supplier, IMESA reserves the right, before painting the batch in production, to perform adhesion and thickness tests on specific samples. Only after verifying the suitability and goodness of the characteristics of the painting process, can the batch be processed.

## CHECK TOOLS

- Painting Thickness Gauge (magnetic type).
- Cross Hatch Tester for Adhesion Tests.
- Electrode for checking the pH of the phospho-degreasing liquid.
- Instruments for measuring temperature.

## DOCUMENTATION FOR THE VALIDATION OF THE SPECIAL PROCESS

The duly completed forms VER 01 and VER 02 and the storage of the painted samples are the objective evidences that demonstrate the control of the process in question.

The process must be validated by three-year external laboratory tests (See PO 7.17) to verify the salt spray resistance of components made according to the above process parameters and according to the technical data sheets of the products used.

Resistance in salt spray must be at least 100 hours.

## QUALIFICATION OF OPERATORS

The qualification of the painting plant operators takes place through education, handover with more experienced operators and training.
These activities are internal to IMESA and for safety aspects the Competent Physician is also called into question.
The training topics are reported in the relevant form and in any case concern the operation and management of the plant, environmental, safety aspects and practical tests on samples that will be made available in the department.
This qualification activity must be performed for each new operator or, for experienced operators, every three years (See PO 7.17).
If the experienced operator is dedicated to another task for more than one year, he/she must repeat the qualification activity.

## SYSTEM MAINTENANCE

Given that the preventive maintenance is performed by an external company, for the correct operation of the system it is necessary to carry out the operations provided for in Sheets 18 "Maintenance activities of the painting system" and 19 "Maintenance activities of the tanks" and the related records must be indicated in the Form "MAN 18 – Periodic maintenance record sheet for the painting system."

**ENVIRONMENTAL REQUIREMENTS**

The cleaning of the painting system must be performed at the end of each working day, in particular the powder paint deposited on the ground must be carefully collected in the appropriate airtight bags, to be subsequently disposed of according to the regulations in force.

In the same way, proceed with separate collection for other types of waste.

The emissions into the atmosphere of the painting plant are sampled annually by competent external companies and the results obtained communicated to the local authorities responsible for controls.

The disposal of the liquids contained in the pretreatment tunnel, when they are "exhausted", is entrusted to authorised companies.

**SAFETY REQUIREMENTS**

The maintenance operations of the system must always be carried out with the machine stopped and with the power switched off.

During the painting and loading activities of the parts, use the appropriate PPE as indicated in the company Risk Assessment Document.



Do not stand under the conveyor if the pieces are at the top.

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## Elcometer 107 Cross Hatch Cutter



The coating may be continuous and look good, but how well is it connected to the substrate? The Elcometer 107 Cross Hatch Cutter provides an instant assessment of the quality of the bond to the substrate. Due to is rugged construction this gauge is ideal for thin, thick or tough coatings on flat or curved surfaces. An ideal field or laboratory test.

- Low cost
- Robust design
- Easy to change cutters
- Large Non slip grip
- Ideal for thick or hard coatings
- Large selection of cutters, each with four cutting faces
- Can be converted into the Elcometer 141 Paint Inspectors Gauge (P.I.G.)

The Elcometer 107 Cross Hatch Cutter is available in two versions.

- *The Basic Kit comes complete with:*
  Robust handle, the cutter of your choice (see below), Allen Key (wrench), presentation storage case and instructions (together with the Classification of Adhesion Test Results Chart)
- *The Full Kit includes all that is supplied in the Basic Kit, and also includes:*
  An eye glass, brush, and adhesive tape (either ASTM or ISO tape), all in a plastic ABS carrying case.

www.elcometer.com

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**test method** **specifications** **standards** **data sheet**

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specifications

## Elcometer 107 Cross Hatch Cutter

| SELECTING THE APPROPRIATE TEST KIT | | | | |
|---|---|---|---|---|
| Cutter Type | Number of Teeth | Part Number | | |
| | | Full Kit with ISO Tape | Full Kit with ASTM Tape | Basic Kit |
| 1mm | 6 | F10713348-6 | F10713348-1 | F10713222-1 |
| 1mm | 11 | - | F10713348-2 | F10713222-2 |
| 1.5mm | 11 | - | - | F10713222-3 |
| 2mm | 6 | F10713348-9 | F10713348-4 | F10713222-4 |
| 3mm | 6 | - | - | F10713222-5 |

| SELECTING THE APPROPRIATE ELCOMETER 107 CUTTER | | | | | | |
|---|---|---|---|---|---|---|
| Coating Thickness | | Substrate Type | Cutting Teeth | Tooth / Slot Spacing | Test Method | Part Number |
| µm | mils/thou | | | | | |
| 0 - 50 | 0 - 2 | Metal | 11 | 1mm | ASTM D3359B | T10713700-2 |
| 0 - 60 | 0 - 2.4 | Hard | 6 | 1mm | BS EN ISO 2409 | T10713700-1 |
| 0 - 60 | 0 - 2.4 | Medium | 11 | 1.5mm | - | T10713700-3 |
| 0 - 60 | 0 - 2.4 | Soft | 6 | 2mm | BS EN ISO 2409 | T10713700-4 |
| 50 - 125 | 2 - 5 | Hard and Soft | 6 | 2mm | ASTM D3559B | T10713700-4 |
| 61 - 120 | 2.4 - 4.7 | Hard and Soft | 6 | 2mm | BS EN ISO 2409 | T10713700-4 |
| 125 - 250 | 5 - 10 | Hard and Soft | 6 | 3mm | Quick Check Only | T10713700-5 |
| Accessories | | ASTM D3359 Adhesive Tape (2 rolls) | | | | T1078894- |
| | | ASTM D3359 Adhesive Tape (1 roll) | | | | K0001542M001 |
| | | ISO 2409 Adhesive Tape (2 rolls) | | | | T9999358- |
| | | ISO 2409 Adhesive Tape (1 rolls) | | | | K0001542M002 |
| Packing List | | ***Basic Kit:*** Cross Hatch Cutter handle, Cutter blade, Hexagonal wrench, Carry case & Operating instructions<br><br>***Full Kit:*** Cross Hatch Cutter handle, Cutter blade, Hexagonal wrench, Adhesive Tape (ISO or ASTM), Eye Glass, Brush, Carry case & Operating instructions | | | | |

www.elcometer.com

test method standards data sheet product page

elcometer

standards

## Elcometer 107 Cross Hatch Cutter

| Can be used in accordance with: | |
|---|---|
| ASTM D 3359-B | ASTM D 3002 |
| BS 3900-E6 | BS EN ISO 2409 |
| DIN 53151 | ISO 2409 |
| NF T 30-038 | |

www.elcometer.com

test method specifications data sheet product pag

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# Elcometer 107 Cross Hatch Cutter



*Elcometer 107 Cross Hatch Cutter*

## At a glance

- *Ideal for thin, thick or tough coatings.*
- *Available as a basis or a full kit.*
- *ASTM & ISO versions available.*

| Can be used in accordance with: | |
|---|---|
| ASTM D387 | ASTM D332 |
| ISO 8780-5 | ISO 787/16 |
| NFT 30 023 | |

**Elcometer 107 Cross Hatch Cutter**
The coating may be continuous and look good, but how well is it connected to the substrate? The Elcometer 107 Cross Hatch Cutter provides an instant assessment of the quality of the bond to the substrate. Due to is rugged construction this gauge is ideal for thin, thick or tough coatings on flat or curved surfaces. An ideal field or laboratory test.

- Low Cost
- Robust Design
- Easy to change cutters
- Large, non slip grip
- Ideal for thick or hard coatings
- Large selection of cutters, each with four cutting faces
- Can be converted into the Elcometer 141 Paint Inspectors Gauge (P.I.G)

The Elcometer 107 Cross Hatch Cutter is available in two versions.

- *The Basic Kit comes complete with:*
  Robust handle, the cutter of your choice (see below), Allen Key (wrench), presentation storage case and instructions (together with the Classification of Adhesion Test Results Chart)
- *The Full Kit includes all that is supplied in the Basic Kit but also includes:*
  An eye glass, brush, and adhesive tape (either ASTM or ISO tape), all in a plastic ABS carry case.

### Adhesion

From the largest man-made structures to the smallest household appliances, most manufactured products have a protective or cosmetic coating. Premature failure of this coating can, at the very least, result in costly penalties or rework.

Adhesion testing during the coating process will quantify the strength of the bond between substrate and coating, or between different coating layers or the cohesive strength of some substrates. Routine testing is also used as part of inspection and maintenance procedures to help detect potential coating failures.

Elcometer offer a highly comprehensive range of Adhesion Gauges designed specifically to meet your requirements. These gauges can be split into three categories:

Cross Hatch / Cross Cut Method
The coating is cut into small squares, thereby reducing lateral bonding, and the adhesion assessed against ISO, ASTM or Corporate Standards

Pull Off Adhesion Method
Tensile Dollies (or stubs) are glued to the coating and, once the adhesive has cured, the force required to pull the dolly off the surface is measured.

Push Off Adhesion Method
Similar to the Pull Off Adhesion Test, a dolly is glued to the coating, once the adhesive has cured, however, the dolly is pushed off the surface by the adhesion gauge.

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| SELECTING THE APPROPRIATE TEST KIT | | | | |
|---|---|---|---|---|
| Cutter | Number of Teeth | Part Number | | |
| | | Full Kit with ISO Tape | Full Kit with ASTM Tape | Basic Kit |
| 1mm | 6 | F10713348-6 | F10713348-1 | F10713222-1 |
| 1mm | 11 | - | F10713348-2 | F10713222-2 |
| 1.5mm | 11 | - | - | F10713222-3 |
| 2mm | 6 | F10713348-9 | F10713348-4 | F10713222-4 |
| 3mm | 6 | - | - | F10713222-5 |

| SELECTING THE APPROPRIATE ELCOMETER 107 CUTTER | | | | | | |
|---|---|---|---|---|---|---|
| Coating Thickness | | Substrate Type | Cutting Teeth | Tooth / Slot Spacing | Test Method | Part Number |
| µm | mils/thou | | | | | |
| 0 – 50 | 0 - 2 | Metal | 11 | 1mm | ASTM D3359B | T10713700-2 |
| 0 – 60 | 0 - 2.4 | Hard | 6 | 1mm | BS EN ISO 2409 | T10713700-1 |
| 0 – 60 | 0 - 2.4 | Medium | 11 | 1.5mm | - | T10713700-3 |
| 0 – 60 | 0 - 2.4 | Soft | 6 | 2mm | BS EN ISO 2409 | T10713700-4 |
| 50 – 125 | 2 – 5 | Hard and Soft | 6 | 2mm | ASTM D3559B | T10713700-4 |
| 61 – 120 | 2.4 – 4.7 | Hard and Soft | 6 | 2mm | BS EN ISO 2409 | T10713700-4 |
| 125 – 250 | 5- 10 | Hard and Soft | 6 | 3mm | Quick Check Only | T10713700-5 |
| **Accessories** | | ASTM D3359 Adhesive Tape (2 rolls) | | | | T1078894- |
| | | ASTM D3359 Adhesive Tape (1 roll) | | | | K0001542M001 |
| | | ISO 2409 Adhesive Tape (2 rolls) | | | | T9999358- |
| | | ISO 2409 Adhesive Tape (1 roll) | | | | K0001542M002 |
| **Packing List** | | ***Basic Kit:*** Cross Hatch Cutter handle, Cutter blade, Hexagonal wrench, Carry case & Operating instructions | | | | |
| | | ***Full Kit:*** Cross Hatch Cutter handle, Cutter blade, Hexagonal wrench, Adhesive Tape (ISO or ASTM), Eye Glass, Brush, Carry case & Operating instructions | | | | |

## HOW TO SELECT THE CORRECT ADHESION GAUGE

### *Cross Hatch Cutters*

*Advantages:*
A fast, low cost, comparison method

*Possible Limitations:*
A subjective test for flat surfaces for a limited thickness range.

*Applications:*
Paint and powder coating adhesion up to a thickness of 125µm (5 mils).

### *Pull Off Adhesion Testers*

*Advantages:*
Simple to use, quantitative range – giving you a definitive adhesion value

*Possible Limitations:*
Time required for adhesive to cure

*Applications:*
Ideal gauge for the laboratory or field – flat or curved substrate applications

### *Push Off Adhesion Testers*

*Advantages:*
Fast cure time adhesives can be used, ideal for curved surfaces

*Possible Limitations:*
High forces exerted by gauge may cause thin substrates to deform

*Applications:*
Pipelines and metal spray coatings.

# EDUCATION COURSE/TRAINING ACTIVITY REPORT

| | |
|---|---|
| **Location of the course/training** | **IMESA S.p.A. – Via G. Di Vittorio, 14, Zona Industriale JESI (AN), 60035** |
| **Date / Period** | **10/16/2023 2023** |
| **Duration in "h"** | **15 hours – TRAINING** |
| **Title of the course/training** | **Education/training in the use of POWDER COATING SYSTEM** |
| **Name of Speaker/Trainer** | **Cristiano Stefano Chiappa** |
| **Signature Speaker/Trainer** | |
| **Main topics covered** | **Correct use of the system – Environmental and safety regulations – Creation of samples and tests** |
| Illustration of procedures for the safe use of the system (Reference Work Instructions – Risks evaluation document - Risk assessment sheets) | |
| Information on the risks associated with the use of the system and correct use of the PPE/CPE associated with it (Reference Work Instructions - Risks evaluation document - Risk Assessment Sheets) | |
| Examination of the main accident prevention regulations and extracts of specific risks from the company risks evaluation document (Reference Work Instructions - Risks evaluation document - Risk assessment sheets) | |
| Illustration of the Use and maintenance manual (System use and maintenance manual) | |
| Analysis of foreseeable abnormal situations, safety and alarm systems (System use and maintenance manual) | |
| Environmental regulations and methods of disposing of waste products (Reference Work Instructions) | |
| Process control parameters and their recording - Spill test (System use and maintenance manual - paint and chemical products technical data sheets) | |
| Product control parameters and their recording (paint and chemical products technical data sheets) | |
| Technical and safety data sheets of the products used | |
| Training through practical test – see images | |

| **LIST OF PARTICIPANTS** | | | |
|---|---|---|---|
| **Ref.** | **Name** | **Company** | **Signature** |
| **1.** | Andrea Di Re | IMESA | |

| **SAMPLES AND TESTS (if the test is passed, enter an X in the box - otherwise write NO)** | | | |
|---|---|---|---|
| **SAMPLE** | **THICKNESS MEASURE** | **ADHESION** | **NOTE** |
| A | X | X | |
| B | X | X | |

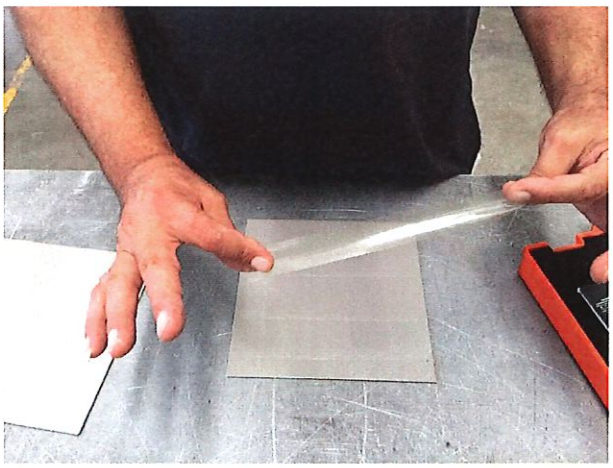
- The thickness must be between 60 and 200 microns
- For adhesion, a classification of at least 1 must be guaranteed according to the UNI EN ISO 16276-2 standard

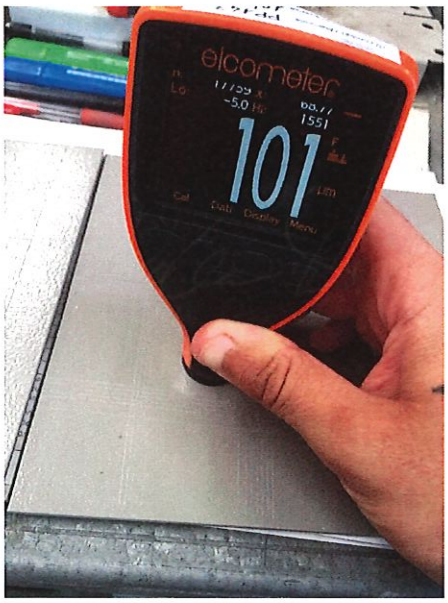
**Speaker Notes:**

## IMAGES









LEARNING TEST

| For each question, tick only one answer | | |
|---|---|---|
| 1. | What is the reference instruction for painting? | 1. WI CAR.17 |
| | | 2. WI CAR.18 |
| | | 3. WI CAB.06 |
| 2. | Are exposed surfaces of the component permitted after painting? | 1. Yes |
| | | 2. No |
| | | 3. Only for a surface area less than 3 cm2 |
| 3. | Which instrument is used for thickness measurement? | 1. Gauge |
| | | 2. Cross hatch |
| | | 3. Thickness gauge |
| 4. | Which instrument is used for adhesion measurement? | 1. Gauge |
| | | 2. Cross hatch |
| | | 3. Thickness gauge |
| 5. | What is the optimal thickness range for an A cycle? | 1. 60-200 microns |
| | | 2. 30-60 microns |
| | | 3. 200 – 400 microns |
| 6. | What is the optimal speed of the painting system chain? | 1. 0.5m/s |
| | | 2. 1.2m/s |
| | | 3. 3 m/s |
| 7. | What temperature should the cooking oven be set at? | 1. 60°C |
| | | 2. 400°C |
| | | 3. 190°C |

**OUTCOME OF EDUCATION AND TRAINING**

**POSITIVE** ☒

**NEGATIVE** ☐

**TRAINER SIGNATURE**



# *Gardobond® A 4818*

## Amorphous iron phosphate pre-treatment

## Scope

***Gardobond A 4818*** is a liquid concentrate, combined cleaner and amorphous iron phosphate solution designed to simultaneously degrease and pre-treat metal ferrous substrates.

The surfaces of parts made of aluminium and zinc materials can be cleaned and slightly tarnished by this process.

***Gardobond A 4818*** is applied by spray.

## Physical properties

| | |
|---|---|
| Appearance: | colourless to bright yellow liquid |
| Density (20ºC): | approx. 1.2 g/cm³ |
| pH value (10 g/l, 20ºC): | approx. 3.0 |
| Flash point (DIN 51755 / 53213): | non-flammable |

## Process sequence

### Combined cleaning and phosphating

Cleaning / phosphating – rinsing – demin rinsing / post rinsing – drying and painting.

### Separate cleaning and phosphating

Cleaning – rinsing – phosphating – rinsing – demin rinsing / post rinsing – drying and painting.

## Chemicals required

***Gardobond A 4818*** (make-up and replenishment solution)

***Gardobond-Additive H 7143*** (to reduce pH), either ***Gardobond-Additive H 7141*** (to increase pH)

CHEMETALL GMBH

**Surface Treatment**

Trakehner Straße 3
D-60487 Frankfurt a. M.
P. O. Box 90 01 70
D-60441 Frankfurt a. M.
Phone: +49 (69) 7165-0
Fax: +49 (69) 7165-3018
Internet: http://www.chemetall.com

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The above data have been compiled to the best of our knowledge on the basis of thorough tests and with regard to the current state of our long practical experience. No liabilities or guarantee deriving from or in connection with this leaflet can be imputed to us. - Reproduction, in whole or in part, only with our express permission.

# Bath make-up

Add per 1.000 litres of working solution:

10 – 30 kg of ***Gardobond A 4818***

Mix and heat to operating temperature. This may be varied dependant on the degree and type of soiling to be removed.

# Bath operation

| | |
|---|---|
| Spray time: | 1 - 3 minutes |
| Spray pressure: | 1 - 2 bar |
| Bath temperature: | 40 - 60 °C |
| Bath concentration: | 1.0 - 3.0 % ***Gardobond A 4818*** |
| pH value: | 4,5 – 5,3 |

These operating limits are for guidance only. Plant conditions will vary and your Chemetall Field Support Engineer may recommend operation close to or even outside the limits quoted under certain circumstances.

# Bath control

### Testing chemicals required

Test Indicator 2 (phenolphthalein)
Testg Solution 1 (0.1 M sodium hydroxide)

## Total acid pointage

Take a 10 ml sample of the working solution, dilute with approx. 50 ml of distilled water add 5 drops of Test Indicator 2 and titrate with Test Solution 1 until the colour changes from colourless to pink. The number of mls of Test Solution 1 required is known as the Total Acid Pointage of the solution.

***Gardobond A 4818*** is normally used in the range of 3.0 to 9.0 Total Acid Points.

## Bath replenishment

An addition of 3.3 kg (2.8 litres)of ***Gardobond A 4818*** per 1000 litres of working solution will raise the Total Acid Pointage by one.

### Pre-treatment

## Separate cleaning and degreasing

Alkali cleaners are well suited for cleaning and degreasing.
Alkali cleaners are supplied by Chemetall under the designation ***Gardoclean***.

### Cleaning additives

In general, the built-in cleaning properties of ***Gardobond A 4818*** will be sufficient for most requirements. Slightly more difficult cleaning jobs can usually be handled by a slight increase in the ***Gardobond A 4818*** pointage.

If, however, difficult cleaning tasks are encountered, use may be made of a Gardobond-Additive surfactant additive. This additive is used to increase the cleaning and degreasing performance of the process without generating excessive amounts of foam.

Gardobond-Additive should be added in increments of 0.5 litres per 1000 litres of working solution, until the cleaning performance is satisfactory.

## Equipment materials

### Tank and Heating element

General-purpose constructional steels to DIN EN 10025, with acid-resistant rubber lining. Chromium nickel steel, material no. 1.4541

## Labour and environmental protection

For transport, storage, use and waste treatment of chemicals in concentrated or diluted form as well as bath solutions, the appropriate local legislation must be followed.

Further specific information on the products can to be obtained from the EC Safety Data Sheets. For the used solutions the hazard code on the label should be followed.

## Waste disposal

All effluent discharge must be treated in accordance with national legislation and local regulations prior to discharge to the sewer.

DES 02 / 10-1

IMESA ELECTRICAL ENGINEERING

# SCHEDA CONTROLLO PEZZI VERNICIATI
## *QUALITY CONTROL FOR PAINTED PARTS*

**Mese**/*Month* : _____ **Anno**/*Year* : _____

| **Giorno** *Day* | **Numero pezzi** *Pieces Number* | **Progetto N°** Project N° | **RAL** | **Controllo visivo** *Visual check* | | **Misura spessore (µm) (a)** *Measurement of thickness (µm) (a)* | | | | | | | **Controllo Spessore** *Thickness Check* | | **Strumento Equipment** | **Controllo aderenza sul provino** *Check adhesion on the specimen* | | **Strumento Equipment** | **Codice operatore operator code** | **Note** *Notes* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **OK** | **KO** | **Richiesto** *Required* | **Valore delle prime 6 misurazioni effettuate** *Value of the first 6 Measurements taken* | | | | | | **OK** | **KO** | **serial number** | **OK** | **KO** | **serial number** | | |
| | | | | | | | | | | | | | | | **PP 127** | | | **PP 160** | | |
| | | | | | | | | | | | | | | | **PP 127** | | | **PP 160** | | |
| | | | | | | | | | | | | | | | **PP 127** | | | **PP 160** | | |
| | | | | | | | | | | | | | | | **PP 127** | | | **PP 160** | | |
| | | | | | | | | | | | | | | | **PP 127** | | | **PP 160** | | |
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| | | | | | | | | | | | | | | | **PP 127** | | | **PP 160** | | |
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| | | | | | | | | | | | | | | | **PP 127** | | | **PP 160** | | |
| | | | | | | | | | | | | | | | **PP 127** | | | **PP 160** | | |
| | | | | | | | | | | | | | | | **PP 127** | | | **PP 160** | | |

**(a)** Effettuare la misura dello spessore sul provino e su un pezzo ogni 15 del lotto (o almeno un pezzo tra i componenti con stesso RAL), indicando il valore misurato sullo spazio apposito, la prova di aderenza va eseguita esclusivamente sul provino (una ogni RAL diverso)

**N.B.** Il provino per commessa deve essere il primo pezzo montato sulla catena, per ogni commessa/costruzione

*(a)Measure the thickness on the specimen and on one piece every 15 of the lot (or at least one piece among the components with the same RAL), indicating the value measured on the space provided, the adhesion test must be performed exclusively on the specimen (one each different RAL)*

*N.B. The order specimen must be the first piece mounted on the chain, for each order / construction*

# SCHEDA CONTROLLO IMPIANTO VERNICIATURA

*CONTROL SHEET PAINTING PLANT*

**Mese**/Month: _____ **Anno**/Year: _____

| **N° Commessa** *Job N°* | **Data** *Date* | **Velocità catena (cm/min)** *Chain Speed (cm/min)* | **Vasca Sgrassaggio** *Degreasing tank* | | **Temperatura forno cottura** *Baking oven temperature* | | **Pulizia ganci** *cleaning hooks* | | **Acqua Demineralizzata** *Demineralized Water* | **Temperatura forno asciugatura** *Drying oven temperature* | | **Firma** *Signature* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **pH** | **Temp. Liq. (°C)** *Liq. Temp. (°C)* | **Impostata** *Set* | **Rilevata** *Detected* | **OK** | **KO** | | **Impostata** *Set* | **Rilevata** *Detected* | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
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**NOTE**

2.4.2.PACKING, SHIPPING, HANDLING AND STORAGE PROCEDURES,

Doc No. 1723002197-QC-PRO-00055

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# Base Load Power Hub (BLPH)

## PACKING, SHIPPING, HANDLING AND STORAGE PROCEDURES

Document Number: 1723002197-QC-PRO-00055

Document Class: 3

ROSETTI MARINO

| | |
|---|---|
| 1 | NO COMMENTS - APPROVED - WORK MAY PROCEED |
| 2 | MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED |
| 3 | MAJOR COMMENTS – REJECTED – DO NOT PROCEED |
| 4 | APPROVAL NOT REQUIRED |

*NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.*

| Sign | Date |
|---|---|
| Vincent Zwaan | 15/07/2024 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 0 | 03/07/2024 | Issue for Information (IFI) | V. Santinelli | Pigliapoco | D. Santinelli |
| Rev. | Date | Description | Prepared | Reviewed | Approved |

IMESA ELECTRICAL ENGINEERING

IMESA Doc. 231115/SD/055

# HIGH VOLTAGE AND LOW VOLTAGE SWITCHBOARDS

## Instructions for Handling and Lifting procedure of High Voltage and Low Voltage prefabricated units with metal enclosure



IMESA® ELECTRICAL ENGINEERING

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# 1 INTRODUCTION

Check that during installation, operation and maintenance, prescriptions relating to technical and safety rules at workplace are complied.

Follow meticulously the indications of this manual.

The switchboards manufactured by IMESA, are designed for different standardized system configurations. Additional technical – structural variations may however be requested by the Customer for particular system requirements.

Remember that you should always refer, not only to this manual, but also to the updated technical documentation forwarded by IMESA (operating diagram, construction drawings etc.); above all, to the instruction manuals of the equipment installed on the switchboard.

# 2 SHIPPING AND CHECKS ON ARRIVAL

In order to facilitate the transport, the switchboard is divided in sections consisting of one or more upright standard units, generally in lengths of no more than 3000 mm.

Each section is packaged according to the shipping and storage requirements, in compliance with the customer's requests.

In general, the switchboards are shipped complete with the mobile parts (circuit breakers, contactors, VT) inserted in the respective cells, unless otherwise agreed with the Customer. The switchboard has its earthing switches in close position while the circuit breakers in open and disconnected position.

On arrival, the compartments and accessories must be unpacked and checked as indicated in the technical documents forwarded before delivery of the switchboard.
If damage or faults (switchboard and equipment) are discovered when the material is unpacked, please inform our sales offices immediately (either directly or through your agent).
Claims for any defects, even after receipt, must show the construction number and year, which are shown on the data plate affixed to the switchboard.

# 3 STANDARD PACKING PROCEDURE

Each switchboard unit/section rests on its own base (not fixed on a wooden pallet).

The following steps are adopted by IMESA for a correct standard packing procedure:

1. covering the protruding parts (lamps, devices, etc.) with bubble wrap with large bubbles and securing them with rubberized paper tape.
2. covering the switchboard with bubble wrap starting from the bottom and climbing up to the top, paying attention to covering the front with at least two layers of bubble wrap.
3. fixing the bubble wrap with IMESA adhesive tape.
4. identifying the unit with the shipping mark.

## 4 LIFTING THE SWITCHBOARD

Each unit rests on its own base (not fixed on a wooden pallet). Since the units contain the apparatus (circuit breaker, contactor, VT service truck) it is compulsory to use proper lifting method, as mentioned in this document.

LIFTING METHOD "A": lifting by using no. 1 spreader bar and no. 2 ropes with hooks (fig. A):

- connect the lifting ropes to the spreader bar coupling points (A).
  The choice of the coupling points must be done in order that the ropes do not compress the switchboard and that lifting occurs in a balanced way.
- connect the other ends of the ropes to the lifting tools in the lower part of switchboard (B)
  Lifting must be carried out according to fig. a – b – c - d

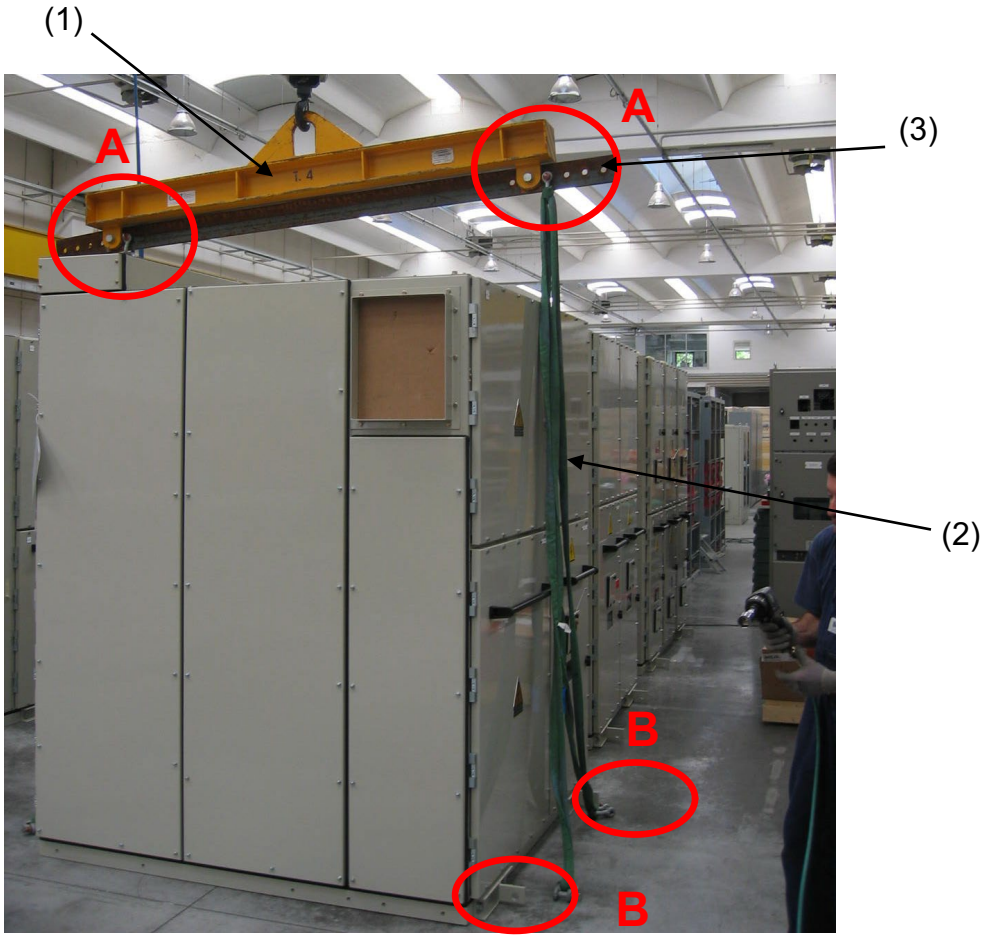



Fig. a

Items out of Swbds scope of supply (can be provided on request):
Spreader bar (1) – lifting ropes (2) – coupling crossbar (3)

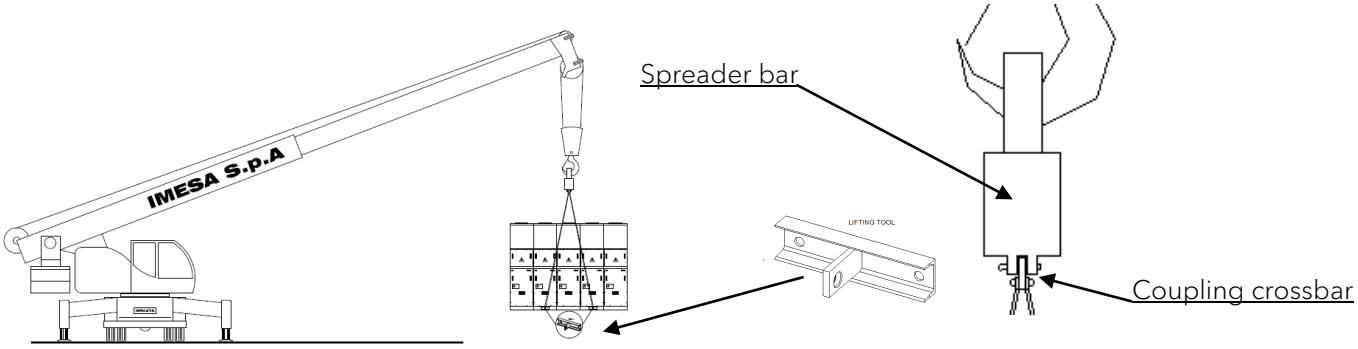



Fig. b

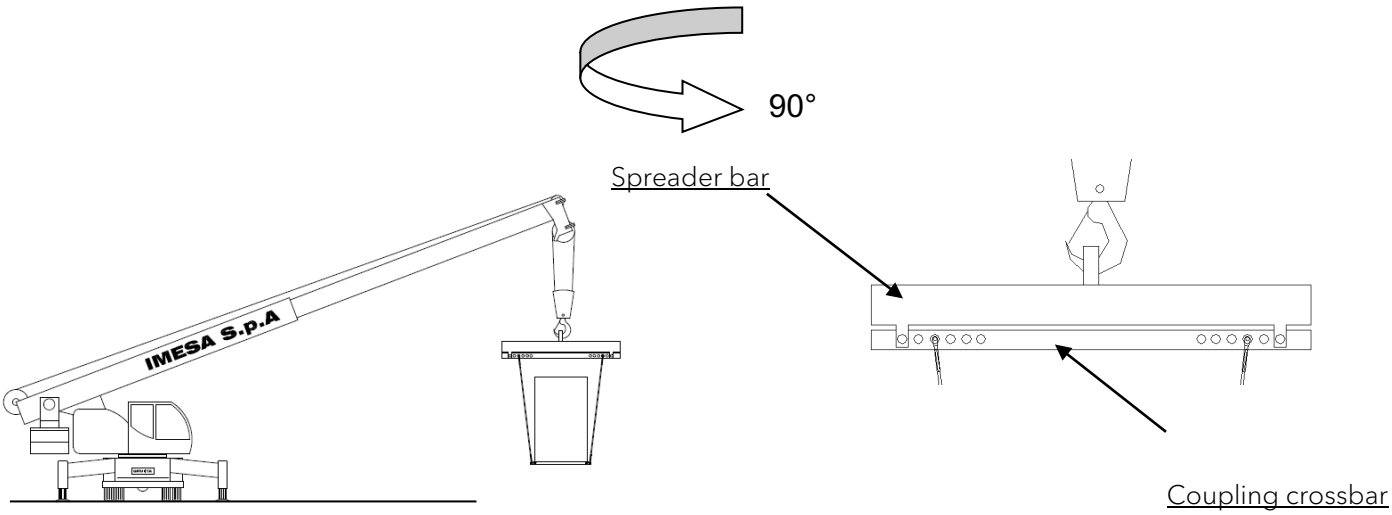



Fig. c

ADJUSTABLE POSITION OF THE COUPLING POINTS (IN CASE THE C.O.G. OF THE SWITCHBOARD IS NOT SYMMETRICAL)

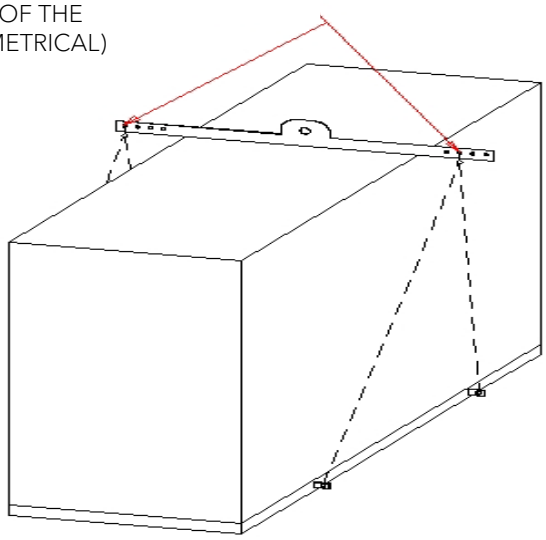


Fig. d

LIFTING METHOD "B": lifting by using no. 2 spacing crossbars bar and no. 8 ropes with hooks (fig. e – f):

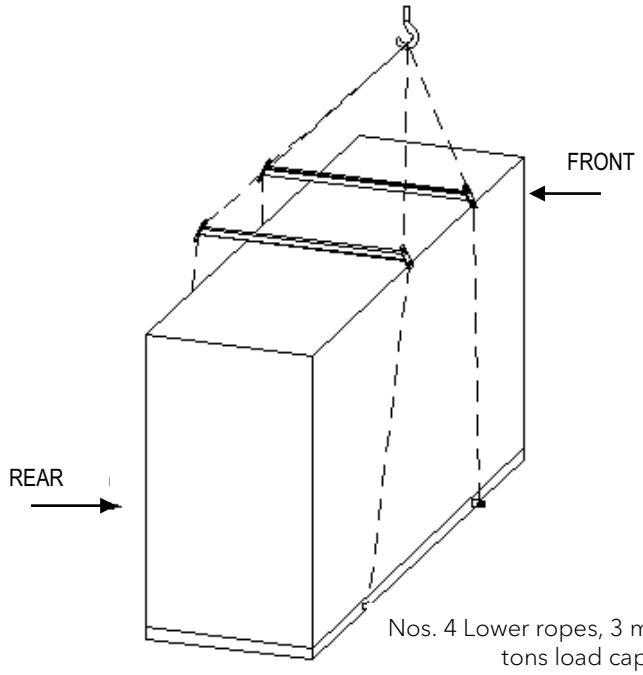
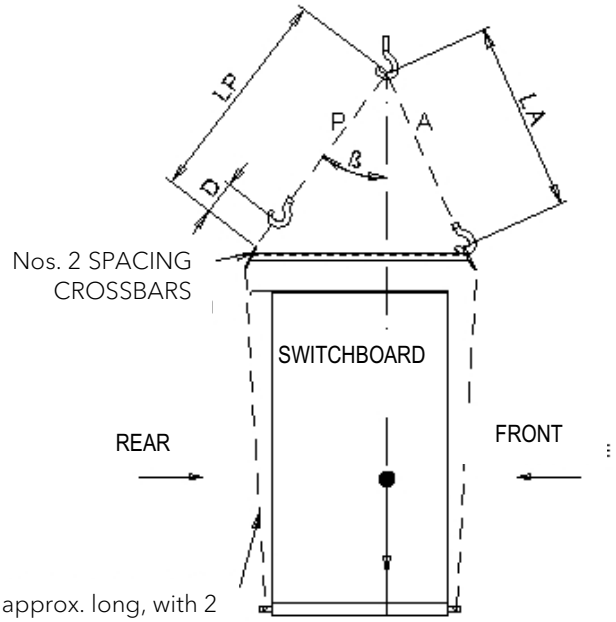


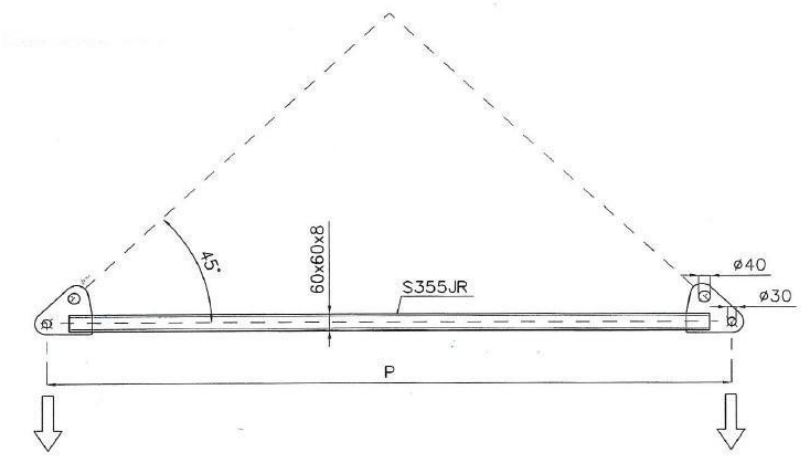

Fig. e




Nos. 4 Lower ropes, 3 m approx. long, with 2 tons load capacity/each
(not included in the Swbds scope of supply)

Fig. f

β = 45° max
A = no. 2 front straps or chains, with one or more closing U-hooks. Load capacity 3 tons each (not included in the Swbds scope of supply)
P = no. 2 rear straps or chains, with one or more closing U-hooks. Load capacity 3 tons each (not included in the Swbds scope of supply)
D = difference between LP and LA, to be defined through a lifting test (min. 50 – max 200 mm)




Spacing Crossbar out of scope of supply (can be provided on request)

LIFTING METHOD "C": lifting the unit using eyebolts and ropes with hooks (fig. G):

Connect the lifting ropes to the 4 eyebolts highlighted in red and lift the switchboard by means of equipments suitable to support the switchboard weight.

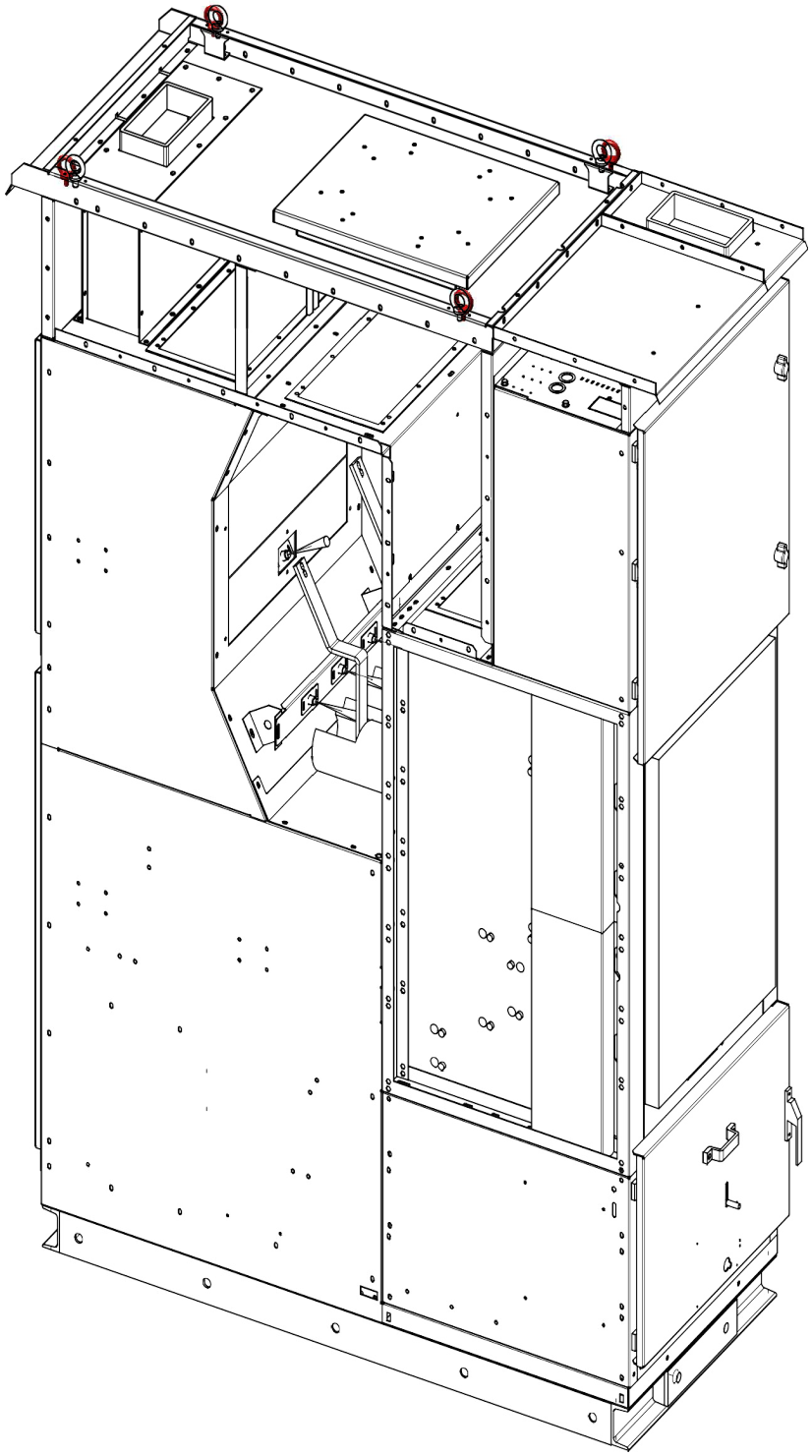


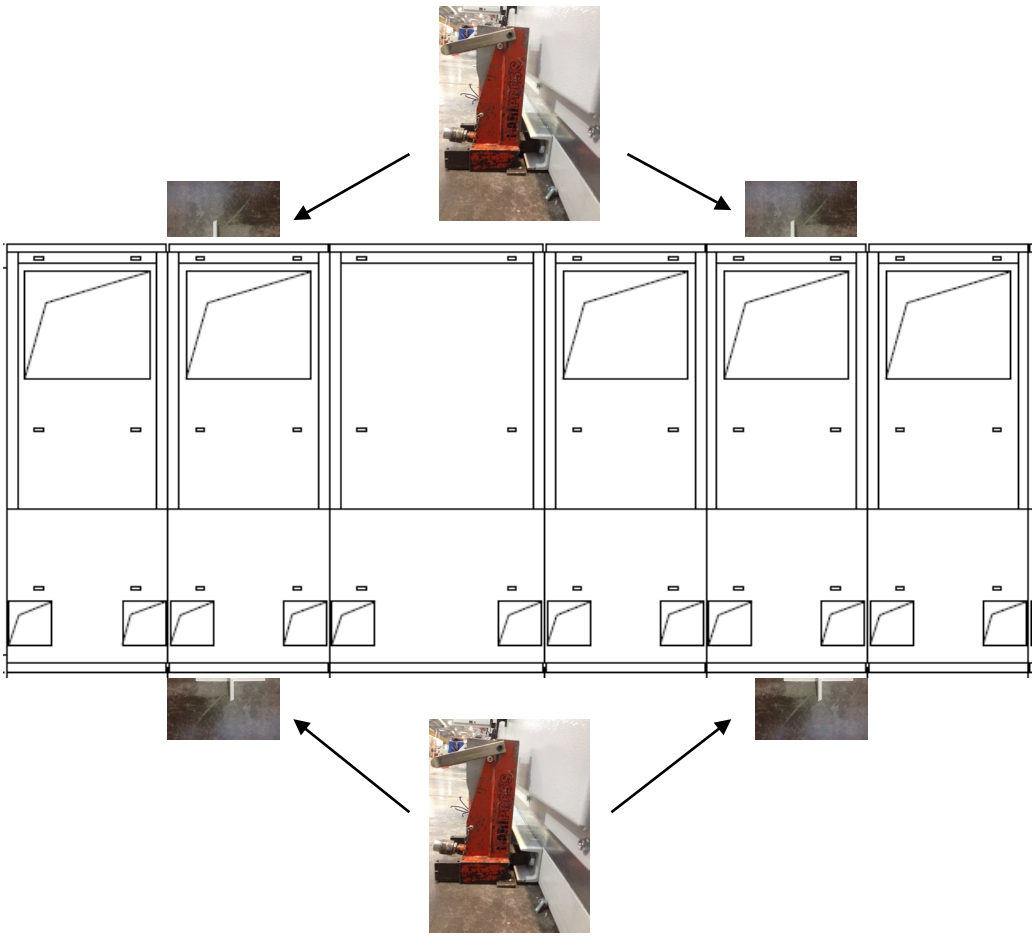
Fig. G

## 5 HANDLING THE SWITCHBOARD

The floor on which the roller slides or machinery skates move shall be completely levelled.

Place no. 4 hydraulic jacks to lift the unit for placing the rollers or the machinery skates and place the panel at the installation location.

Hydraulic Jack-1/2

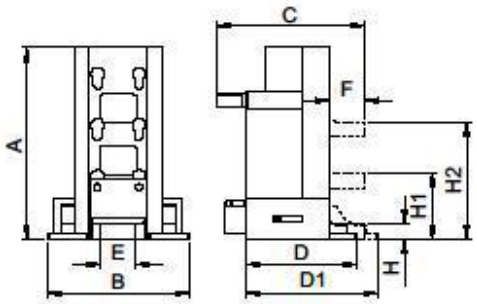


Hydraulic Jack-3/4

## 5.1 Hydraulic Jack (Example)

# UJ

## EUROJACK HEAD AND TOE LIFTING JACK




- Force 10 - 25 t
- Stroke 150 mm
- Max Working Pressure: 700 bar



### FEATURES

Power jack with adjustable lifting toe designed to lift large loads from very low positions.
They are provided with extendable bases for maximum stability. The lifting toe can be positioned at three different levels with only 25 mm minimum clearance needed. The head of the jack may also be used to lift vertically, or if the jack is turned onto its side it can be used for pushing.

### APPLICATIONS

Particularly suitable for lifting, moving and levelling of machinery and heavy equipment from a very low starting height.

Hand Pump model **PL131** is the recommended pump to operate the power jack **UJ** model.

p. 49





HYDRAULIC TOOLS

### SELECTION CHART

| Pushing force | Stroke | Oil volume | MODEL | Dimensions mm | | | | | | | | | | Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| t / kN | mm | cm³ | | A | B | C | D | D1 | E | F | H | H1 | H2 | kg |
| 10 / 111 | 150 | 238 | UJ10 | 280 | 206 | 215 | 160 | 190 | 50 | 50 | 25 | 100 | 175 | 22 |
| 25 / 232 | 150 | 498 | UJ20 | 314 | 271 | 290 | 230 | 265 | 70 | 70 | 30 | 110 | 190 | 45 |



EURO PRESS PACK - Via M. Disma, 87 - 16042 Carasco (GE) ITALY
Tel. 0039 0185 35 271 - Fax 0039 0185 35 11 38

## 5.2 Unit on the skates (Example)



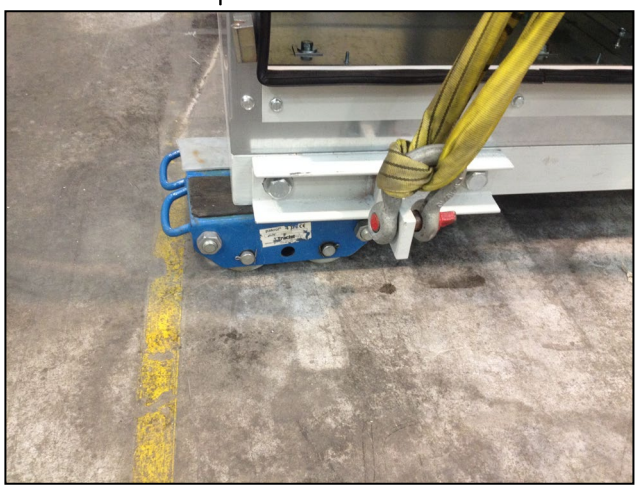
picture 1A



picture 2A




picture 3A



picture 4A



picture 5A



picture6A

# SKATES (PAKROL™)

## LIFTING & HANDLING EQUIPMENT

### 1 OVERVIEW

The PAKROL™ range has been designed to handle and move heavy and rigid loads manually on a flat and resistant floor.

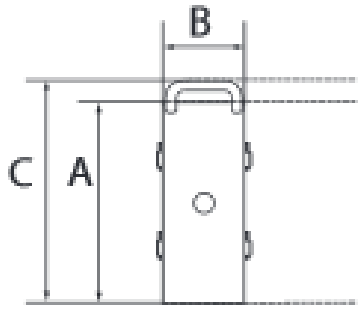


### 2 FEATURES

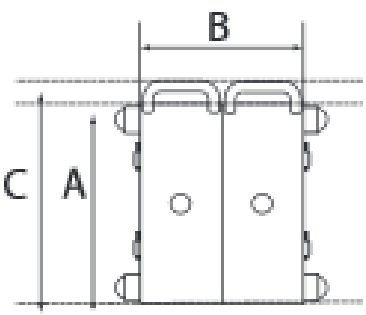
- Unit Consisting Of Steering Handle and Trolley Combinations from 8 to 20 Tons
- A Modular Line to Steer and Move Loads
- Robust Construction
- Trolley Skates Have Turntables
- Skates Can Be Joined Together To Increase Capacity
- Nylon or PU Rollers with Ball Bearings

### 3 PRODUCT SPECIFICATIONS

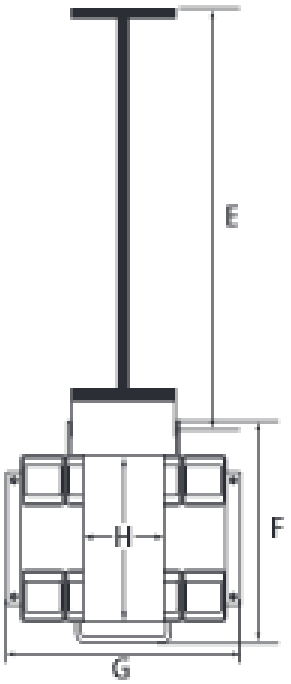


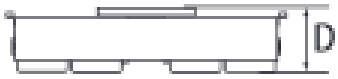




| WEIGHT LOAD LIMIT | | 2t (Skate) |
|---|---|---|
| WEIGHT (kg) | | 5 |
| OPERATING TEMPERATURE RANGE (°C) | | -10à + 30° |
| DIMENSIONS (mm) | A | 270 |
| | B | 108 |
| | C | 308 |
| | D | 110 |




| WEIGHT LOAD LIMIT | | 4t (Skate) |
|---|---|---|
| WEIGHT (kg) | | 11 |
| OPERATING TEMPERATURE RANGE (° C) | | -10à + 30° |
| DIMENSIONS (mm) | A | 270 |
| | B | 232 |
| | C | 308 |
| | D | 110 |




| WEIGHT LOAD LIMIT | | 6/8t (Trolley Skate) |
|---|---|---|
| WEIGHT (kg) | | 50 |
| OPERATING TEMPERATURE RANGE (° C) | | -10à + 30° |
| DIMENSIONS (mm) | D | 110 |
| | E | 1200 |
| | F | 530 |
| | G | 840 |
| | H | 400 x 220 |

# 6 STORAGE OF SWITCHBOARD

## 6.1 Primary considerations

Proper storage must protect items from moisture, environmental contamination and physical damage. This protection must be achieved with adequate:

A. ventilation
B. heat
C. support stand

Storage temperature and humidity ranges are to be considered as follows:

- Maximum environmental temperature: + 40 °C
- Minimum environmental temperature: - 5 °C
- Relative humidity: 85 % max.

## 6.2 Ventilation

To avoid condensation of humidity, the air must be free to circulate through and around the switchboard and on any exhaust ducts:

- The switchgear grids must be free for air circulation.
- Protective covers and shipping packaging must be ventilated to allow air to circulate freely from below through the top of the enclosure.
- Where applicable to guarantee proper covering protection, the electrical panels must be covered with heavy duty polyethylene sheets; taking care that ventilation is anyway adequately assured.
- Enclosed storage areas such as buildings, warehouses, sheds, temporary shelters and similar must be well ventilated.

## 6.3 Heat

To prevent moisture condensation, heating may be required depending upon the warehouse room rate and extremes of temperature change, humidity, etc.
When in doubt, it is recommended to re-heat, by means of the provided space heaters.

Closed storage areas provided with heating system are generally satisfactory, where the temperature of the area is kept at least ten degrees above the outside temperature.

## 6.4 Supporting stand

To prevent distortions and stresses to the switchboards frame structure, the flooring of the storage area must be true and flat.

## 6.5 Internal preservation

The electrical panels of the switchboard are packed and protected in accordance to the Packing Procedure.
All packing materials are of the non-hygroscopic type.

During storage, the equipment must be kept dry, free of dust and protected from mechanical shocks.

### 6.6 Checks on arrival

The switchboard is shipped and delivered with removable parts (HV circuit breakers, HV contactors, VT trolley) racked in, in the respective compartment and with the earthing switches in closed position.

On arrival, the panels must be unpacked and checked, to immediately advise and highlight any possible damage found out.

## 7 STORAGE OF LOOSE MATERIAL AND EQUIPMENT

### 7.1 HV Circuit Breakers / HV Contactors

In case immediate installation is not allowed / not foreseen, the equipment is to be stored kept in the original packaging provided by the manufacturer and warehoused as per instructions further detailed at following par. 3, at a range of ambient air temperature between – 5 °C and + 40 °C.

The switching apparatus is to be left in OFF position and with discharged stored-energy spring mechanism (the latter is applicable to circuit breakers only).

It is to be avoided positioning of the items in risky location, in terms of accidental mechanical impacts or stresses to the structure of the apparatus.

### 7.2 Protection relays

If relays are not to be installed immediately, they shall be stored in a place free from dust and moisture in their original cartons. Where de-humidifier bags have been included in the packing, they should be retained. The action of the de-humidifier crystals will be impaired if the bag has been exposed to ambient conditions and may be restored by gently heating the bag for about an hour, prior to replacing it in the carton.

Dust which collects on a carton may, on subsequent unpacking, find its way into the relay; in damp conditions the carton and packing may become impregnated with moisture and the dehumidifier will lose its efficiency.

Storage temperature: –25°C to +70°C

### 7.3 Current and Voltage Measuring Transformers

In case measuring transformers are not intended for immediate installation, they shall be stored and protected against direct sunshine and rain.

Storage temperature: –5°C to +40°C

## 8 PRESCRIPTIONS

The following prescriptions refer to the equipment, material or switchboard panels stored on site before installation.

- To store the items in closed, weather protected, controlled temperature areas; accessible to authorized personnel, only.
- To keep the equipment, the material and the electrical panels in their original packaging.
- To protect the items from extreme temperatures, humidity and dew accumulation.

Remove packing just before the installation.

- To carefully open the package, in order to avoid any damage to the contents.
- To pay particular attention to corrosion and dirt protection requirements of the equipment.
- To check the status of the protective measures of the panels every 12 months (e.g.: paint, grease, covers, etc.) and, in case found it necessary, to renew them.
- Where necessary, to take additional precautions, based on the local site actual conditions, to avoid damage to the equipment.
- Observe load capacity of cases when piling them up (where applicable)

The equipment, material and switchboard panels, stored as per indications in the present document up to 12 months, can be kept in their original packaging without further storage requirements; where storage temperature and humidity level are maintained as per vendor recommendations.

Packing, boxes and wraps containing loose material must be stored in a closed, covered and unheated location (warehouse), after having checked the integrity of the contents and restored the protection provided by the original packaging.

When a long period of storage in the warehouse of the electrical panels is foreseen (beyond 12 months), the following requirements must be applied:

- to keep the electrical panel in its original packaging and periodically check its preservation.
- to lubricate with non-aggressive lube, grease or protective film, all the unprotected metal parts.

  This is required to prevent corrosion.

## 9 PRESERVATION OF SWITCHBOARD AFTER INSTALLATION

The following prescriptions refer to the switchboard panels preservation, after installation into the electrical room.

- To keep closed/locked all the panels and doors, when the works are not on going.
- To keep thoroughly cleaned the switchboard compartments (e.g. by means of vacuum cleaner), in order to keep the same free from dust and dirt.
- All sensitive items located on the panel doors (e.g.: equipment having glass/plastic panels) shall be mechanically protected by covering with cardboard or polythene sheet and bubble wrap.
- All opening/entries shall be kept closed/sealed to prevent rats or other animals entering within the panels enclosure.

## 2.5. F.A.T. Report

### 2.5.1. LV SWITCHGEAR FAT Report

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# RAPPORTO DI PROVA
# TEST REPORT

**Fornitore/ Supplier:** **IMESA S.p.A.** Via G. Di Vittorio, 14 JESI (Ancona) – ITALIA
Tel.+39 0731 211034 - Fax.+39 0731 211055 - imesa@imesaspa.com - www.imesaspa.com

| | | | |
|---|---|---|---|
| **N° Certificato/ Certificate N°:** | **348** | **Data / Date:** | **17/09/2024** |
| **Commessa N° / Workorder N°:** | **231298/SD** | | |
| **Matricola N° / Serial N°:** | **231298/SD/080** | | |
| **Ordine N° / Order N°:** | **1723002197 item: 80** | | |
| **Cliente / Customer:** | **ROSETTI MARINO S.P.A.** | | |

Collaudo eseguito alla presenza di: / Test surveyed by:

| Sig. / Mr. | Ditta / Firm | Firma / Signature |
|---|---|---|
| FAVA STEFANO | IMESA SPA | IMESA SPA TESTING OFFICE |
| MARTARELLI FERNANDO | IMESA SPA | |
| SANTINELLI DAMIANO | IMESA SPA | |
| TASSINARI GABRIELE | ROSETTI MARINO SPA | |
| CASTELLANI KRISTIAN | ROSETTI MARINO SPA | |
| LINARI STEFANO | ROSETTI MARINO SPA | ROSETTI MARINO SpA Stefano Linari Quality Control Dept. |
| MARANGONI MASSIMILIANO | O.b.o. CROSSWIND | |
| | | |
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# RAPPORTO DI PROVA
# TEST REPORT

| N° Certificato/ Certificate N°: | 348 | Data / Date: | 17/09/2024 |
|---|---|---|---|

Materiale collaudato a Norme: **IEC 61439-2**
Material tested according to

Procedura collaudo Quadri BT : **Document number *FAT procedure:***
*Procedure test Switchboards LV* customer : **1723002197-QC-PRO-00045**; *owner:* **231298/SD/045**

| QUADRO ELETTRICO BT<br>SWITCHBOARD LV | Tipologia / Type: | MCC/F |
|---|---|---|
| Tensione Nominale di Isolamento (Ui):<br>*Rated Insulation Voltage (Ui)* | 0,69 kV | |

**CARATTERISTICHE ELETTRICHE/ELECTRICAL INFORMATION:**

Ue= 0,4/0,23kV; Un= 0,4/0,23kV; F= 50 Hz; In= 63A; Ik= 25kA

**DESCRIZIONE/DESCRIPTION:**

LV SWITCHBOARD 400/230V - BASE LOAD POWER HUB (BLPH)

PROJECT: CROSSWIND HOLLANDSE KUST NOORD WIND PARK

**TAG: "DP-200N1"**

**DISEGNI/DRAWINGS:**

| DOCUMENT ID | TITLE |
|---|---|
| 1723002197-EL-DA-00009 | DP-200N1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| 1723002197-EL-DG-00013 | DP-200N1 ELECTRICAL SINGLE LINE DIAGRAM |
| 1723002197-EL-DG-00033 | DP-200N1 LV SWG FUNCTIONAL DIAGRAMS - |
| | |
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# RAPPORTO DI PROVA
# TEST REPORT

| N° Certificato/ Certificate N°: | 348 | Data / Date: | 17/09/2024 |
|---|---|---|---|

**PROVE INDIVIDUALI** (secondo lo standard IEC 61439-1)**:**
*ROUTINE TESTS (according to standard IEC 61439-1):*

■ = TESTED

■ **11.1 GENERALITA'**
**GENERALITY**

■ **CONTROLLO VISIVO E DIMENSIONALE**
*VISUAL AND DIMENSIONAL CONTROL* *Point 3.1 FAT proc.*

■ **CONTROLLO OSSERVANZA ALLE SPECIFICHE ED ORDINE**
*CHECK OF COMPLIANCE TO SPECS AND ORDER* *Point 3.1 FAT proc.*

■ **CONTROLLO CARPENTERIA, SBARRE,CONNESSIONI PRIMARIE**
*STRUCTURAL WORKS, BUS-BAR CONTROL* *Point 3.4 FAT proc.*

■ **CONTROLLO VERNICIATURA (RAL 7035 ≥ 60 µm )**
*PAINTING CONTROL* *Point 3.1 FAT proc*

■ **11.2 GRADO DI PROTEZIONE DEGLI INVOLUCRI**
*PROTECTION DEGREE* *Point 3.3 FAT proc.*

■ **11.3 DISTANZE DI ISOLAMENTO IN ARIA E SUPERFICIALI**
*CLEARENCE AND CREPAGE DISTANCES* *Point 3.1 FAT proc.*

■ **11.4 PROTEZIONE CONTRO LA SCOSSA ELETTRICA ED INTEGRITA' DEI CIRCUITI DI PROTEZIONE**
*PROTECTION AGAINST ELECTRIC SHOCK AND INTEGRITY OF PROTECTIVE CIRCUITS* *Point 3.4 FAT proc.*

■ **11.5 INSTALLAZIONE DEI COMPONENTI,FISSAGGIO EVENTUALI DANNI IN ASSEMBLAGGIO E COLLEGAMENTI TERRE**
*INCORPORATION OF BUILT-IN COMPONENTS , FIXED,EVENTUAL DAMAGE CAUSED BY ASSEMBLING, EARTHED* *Point 3.1 FAT proc.*

■ **VERIFICA FONDO SCALA STRUMENTI E DATI NOMINALI APPARECCHIATURE**
*CHECK FULL SCALE OF INSTRUMENTS & EQUIPMENT RATED DATA CONTROL* *Point 3.1 FAT proc.*

■ **VERIFICA DEL SERRAGGIO E MARCATURA BULLONERIA**
CHECKING THE TIGHTENING AND MARKING OF BOLTS
*Point 3.4 FAT proc.*

■ **CONTROLLO CABLAGGIO & DATI DI TARGA**
*WIRING CHECK & PLATE CHECK* *Point 3.4 FAT proc.*

■ **MISURA RESISTENZA D'ISOLAMENTO**
MEASURE OF INSULATION RESISTANCE *Point 4.3-4.4 FAT proc.*

**CIRCUITI DI POTENZA** **L1= >500 MΩ; L2= >500 MΩ**
POWER CIRCUIT **L3= >500 MΩ; N = >500 MΩ**
**CIRCUITI AUSILIARI**
AUXILIARY CIRCUITS 230 Vac= **>500 MΩ**

■ **11.6 CIRCUITI ELETTRICI INTERNI E COLLEGAMENTI**
*INTERNAL ELECTRICAL CIRCUITS AND CONNECTIONS*
*Point 3.4 FAT proc.*

■ **11.7 CONTROLLO DEI TERMINALI PER I CONDUTTORI ESTERNI**
*CHECK OF TERMINALS FOR EXTERNAL CONDUCTORS*
*Point 3.4 FAT proc.*

■ **11.8 CONTROLLO FUNZIONAMENTO MECCANICO**
*MECHANICAL OPERATION TEST*
**VERIFICA DI FUNZIONAMENTO: FUNZIONAMENTO DEGLI INTERRUTTORI,PORTE,CHIAVI INTERBLOCCHI SEGNALI E LE PARTI MECCANICHE CHE FORMANO IL QUADRO**
OPERATION TEST: CHECK OPERATION OF C.B. DOORS, SIGNALLING, EFFICIENCY OF KEY LOCKS AND THE MECHANICS PART THAT FORM THE PANEL,INTERLOCKS BETWEEN C.B, CARRY OUT A NUMBER OF STARTING UP AND STOPPING SEQUENCES *Point 3.2 FAT proc.*

■ **11.9 PROVE DI TENSIONE : f = 50 Hz e t = 1 sec.**
***VOLTAGE TEST : f = 50 Hz and t = 1 sec.*** **(*60 sec)**

**CIRCUITI DI POTENZA** **1.89** kV
*MAIN CIRCUITS* *Point 4.3 FAT proc.*
***Leakage curr. L1= 3 mA L2= 3 mA L3= 3 mA*** **N= 5 mA**

**CIRCUITI AUSILIARI** **230Vac= 1,5** kV
*AUXILIARY CIRCUITS* *Point 4.4 FAT proc.*
***Leakage current: 230Vac= <1 mA***

■ **PROVE DI FUNZIONAMENTO ELETTRICO E SEQUENZE, ARC FLASH TEST VANO CAVI, BUSBAR & C.B.**
*ELECTRICAL OPERATION & SEQUENCE TESTS, ARC FLASH TEST ON CABLE COMP. BUSBAR & C.B.* *Point 4.1FAT proc.*
N.A. not applicable

■ ***FUNZIONAMENTO CORRETTO DELLE LOGICHE* DI CONTROLLO**
*RIGHT WORKING OF THE LOGICAL CONTROLS*
**VERIFICA DI FUNZIONAMENTO: CIRCUITI AUSILIARI E DI COMANDO, POLARITA' CIRCUITI VOLTMETRICI/AMPEROM.**
CHECKING OF OPERATIONS: AUXILIARY AND CONTROL CIRCUIT, CHECK VOLTMETRIC/AMPEROMETRIC CIRCUIT & POLARITY,INTERTRIP SIGNAL *Point 4.1 FAT proc.*

■ **PROVE SUI DISPOSITIVI AUSILIARI**
TEST OF AUXILIARY DEVICE *Point 4.2 FAT proc.*

■ **CONTROLLO DI CONTINUITA' DEL CIRCUITO DI TERRA**
*CHECKING OF ELECTRICAL CONTINUITY EARTH CIRCUIT*
**Max = ≤0,1Ω (Max Value Measured: 0,001 Ω)**
*Point 4.5 FAT proc.*

# RAPPORTO DI PROVA
# TEST REPORT

| N° Certificato/ Certificate N°: | 348 | Data / Date: | 17/09/2024 |
|---|---|---|---|

**The Equipment is :**

**Compliant** ☒ **/ Non Compliant** ☐

**Referring to the FAT Procedure and relevant documents**

| ***Apparecchiature utilizzate/ Equipment used:*** | ***Scadenza Taratura /Expiration date*** |
|---|---|
| SP 214 MULTITEST FOR DIELECTRIC TEST | 07/2024 |
| SP 196 MULTIMETER FLUKE | 03/2025 |
| PP 143 DIGITAL THICKNESS GAUGE | 12/2024 |
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Note/ *Notes:*

DUSK SWITCH MISSING (see punch list)

FIRMA/ *SIGNATURE*

IMESA SPA
IMESA SPA
TESTING OFFICE

ROSETTI MARINO SPA
ROSETTI MARINO SpA
Stefano Linari
Quality Control Dept.

O.b.o. CROSSWIND
M MARANGONI
17.09.24

# RAPPORTO DI PROVA
# TEST REPORT

ISO 9001 ISO 14001 ISO 45001

**Fornitore/ Supplier:** **IMESA S.p.A.** Via G. Di Vittorio, 14 JESI (Ancona) – ITALIA
Tel.+39 0731 211034 - Fax.+39 0731 211055 - imesa@imesaspa.com - www.imesaspa.com

| | | | |
|---|---|---|---|
| **N° Certificato/ Certificate N°:** | **347** | **Data / Date:** | **17/09/2024** |
| **Commessa N° / Workorder N°:** | **231298/SD** | | |
| **Matricola N° / Serial N°:** | **231298/SD/070** | | |
| **Ordine N° / Order N°:** | **1723002197 item: 70** | | |
| **Cliente / Customer:** | **ROSETTI MARINO S.P.A.** | | |

Collaudo eseguito alla presenza di: / Test surveyed by:

| Sig. / Mr. | Ditta / Firm | Firma / Signature |
|---|---|---|
| FAVA STEFANO | IMESA SPA | IMESA SPA TESTING OFFICE |
| MARTARELLI FERNANDO | IMESA SPA | |
| SANTINELLI DAMIANO | IMESA SPA | |
| TASSINARI GABRIELE | ROSETTI MARINO SPA | |
| CASTELLANI KRISTIAN | ROSETTI MARINO SPA | |
| LINARI STEFANO | ROSETTI MARINO SPA | ROSETTI MARINO SpA Stefano Linari Quality Control Dept. |
| MARANGONI MASSIMILIANO | O.b.o. CROSSWIND | |
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# RAPPORTO DI PROVA
# TEST REPORT

| N° Certificato/ Certificate N°: | 347 | Data / Date: | 17/09/2024 |
|---|---|---|---|

Materiale collaudato a Norme: **IEC 61439-2**
Material tested according to

Procedura collaudo Quadri BT : **Document number *FAT procedure:***
*Procedure test Switchboards LV* customer **: 1723002197-QC-PRO-00045**; *owner:* **231298/SD/045**

| QUADRO ELETTRICO BT<br>SWITCHBOARD LV | Tipologia / Type: | PC |
|---|---|---|
| Tensione Nominale di Isolamento (Ui):<br>*Rated Insulation Voltage (Ui)* | 1 kV | |

**CARATTERISTICHE ELETTRICHE/ELECTRICAL INFORMATION:**

Ue= 0,8 kV; Un= 0,8 kV; F= 50 Hz; In= 63A @45° C; Ik= 30kA /1s

**DESCRIZIONE/DESCRIPTION:**

LV SWITCHBOARD 800 V - BASE LOAD POWER HUB (BLPH)

PROJECT: CROSSWIND HOLLANDSE KUST NOORD WIND PARK

**TAG: "SG-200D2"**

**DISEGNI/DRAWINGS:**

| DOCUMENT ID | TITLE |
|---|---|
| 1723002197-EL-DA-00008 | SG-200D2 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| 1723002197-EL-DG-00012 | SG-200D2 ELECTRICAL SINGLE LINE DIAGRAM |
| 1723002197-EL-DG-00032 | SG-200D2 LV SWG FUNCTIONAL DIAGRAMS |
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# RAPPORTO DI PROVA
# TEST REPORT

ISO 9001 ISO 14001 ISO 45001

| N° Certificato/ Certificate N°: | 347 | Data / Date: | 17/09/2024 |
|---|---|---|---|

**PROVE INDIVIDUALI** (secondo lo standard IEC 61439-1)**:**
*ROUTINE TESTS (according to standard IEC 61439-1):*

■ = **TESTED**

■ **11.1 GENERALITA'**
**GENERALITY**

■ **CONTROLLO VISIVO E DIMENSIONALE**
*VISUAL AND DIMENSIONAL CONTROL* *Point 3.1 FAT proc.*

■ **CONTROLLO OSSERVANZA ALLE SPECIFICHE ED ORDINE**
*CHECK OF COMPLIANCE TO SPECS AND ORDER* *Point 3.1 FAT proc.*

■ **CONTROLLO CARPENTERIA, SBARRE,CONNESSIONI PRIMARIE**
*STRUCTURAL WORKS, BUS-BAR CONTROL* *Point 3.4 FAT proc.*

■ **CONTROLLO VERNICIATURA (RAL 7035 ≥ 60 µm )**
*PAINTING CONTROL* *Point 3.1 FAT proc*

■ **11.2 GRADO DI PROTEZIONE DEGLI INVOLUCRI**
*PROTECTION DEGREE* *Point 3.3 FAT proc.*

■ **11.3 DISTANZE DI ISOLAMENTO IN ARIA E SUPERFICIALI**
*CLEARENCE AND CREPAGE DISTANCES* *Point 3.1 FAT proc.*

■ **11.4 PROTEZIONE CONTRO LA SCOSSA ELETTRICA ED INTEGRITA' DEI CIRCUITI DI PROTEZIONE**
*PROTECTION AGAINST ELECTRIC SHOCK AND INTEGRITY OF PROTECTIVE CIRCUITS* *Point 3.4 FAT proc.*

■ **11.5 INSTALLAZIONE DEI COMPONENTI,FISSAGGIO EVENTUALI DANNI IN ASSEMBLAGGIO E COLLEGAMENTI TERRE**
*INCORPORATION OF BUILT-IN COMPONENTS , FIXED,EVENTUAL DAMAGE CAUSED BY ASSEMBLING, EARTHED* *Point 3.1 FAT proc.*

■ **VERIFICA FONDO SCALA STRUMENTI E DATI NOMINALI APPARECCHIATURE**
*CHECK FULL SCALE OF INSTRUMENTS & EQUIPMENT RATED DATA CONTROL* *Point 3.1 FAT proc.*

■ **VERIFICA DEL SERRAGGIO E MARCATURA BULLONERIA**
CHECKING THE TIGHTENING AND MARKING OF BOLTS
*Point 3.4 FAT proc.*

■ **CONTROLLO CABLAGGIO & DATI DI TARGA**
*WIRING CHECK & PLATE CHECK* *Point 3.4 FAT proc.*

■ **MISURA RESISTENZA D'ISOLAMENTO**
MEASURE OF INSULATION RESISTANCE *Point 4.3-4.4 FAT proc.*

**CIRCUITI DI POTENZA** **L1= >500 MΩ; L2= >500 MΩ**
POWER CIRCUIT **L3= >500 MΩ; N = / MΩ**
**CIRCUITI AUSILIARI**
AUXILIARY CIRCUITS 230 Vac= **>500 MΩ**

■ **11.6 CIRCUITI ELETTRICI INTERNI E COLLEGAMENTI**
*INTERNAL ELECTRICAL CIRCUITS AND CONNECTIONS*
*Point 3.4 FAT proc.*

■ **11.7 CONTROLLO DEI TERMINALI PER I CONDUTTORI ESTERNI**
*CHECK OF TERMINALS FOR EXTERNAL CONDUCTORS*
*Point 3.4 FAT proc.*

■ **11.8 CONTROLLO FUNZIONAMENTO MECCANICO**
*MECHANICAL OPERATION TEST*
**VERIFICA DI FUNZIONAMENTO: FUNZIONAMENTO DEGLI INTERRUTTORI,PORTE,CHIAVI INTERBLOCCHI SEGNALI E LE PARTI MECCANICHE CHE FORMANO IL QUADRO**
OPERATION TEST: CHECK OPERATION OF C.B. DOORS, SIGNALLING, EFFICIENCY OF KEY LOCKS AND THE MECHANICS PART THAT FORM THE PANEL,INTERLOCKS BETWEEN C.B, CARRY OUT A NUMBER OF STARTING UP AND STOPPING SEQUENCES *Point 3.2 FAT proc.*

■ **11.9 PROVE DI TENSIONE : f = 50 Hz e t = 1 sec.**
***VOLTAGE TEST : f = 50 Hz and t = 1 sec.*** **(*60 sec)**

**CIRCUITI DI POTENZA** **2,2** kV
*MAIN CIRCUITS* *Point 4.3 FAT proc.*
***Leakage curr. L1= <1 mA L2= <1 mA L3= <1 mA*** **N= / mA**

**CIRCUITI AUSILIARI ; 230Vac= 1,5 kV**
*AUXILIARY CIRCUITS* *Point 4.4 FAT proc.*
***Leakage current: 230Vac= 1 mA***

■ **PROVE DI FUNZIONAMENTO ELETTRICO E SEQUENZE, ARC FLASH TEST VANO CAVI, BUSBAR & C.B.**
*ELECTRICAL OPERATION & SEQUENCE TESTS, ARC FLASH TEST ON CABLE COMP. BUSBAR & C.B.* *Point 4.1FAT proc.*
*N.A. not applicable*

■ ***FUNZIONAMENTO CORRETTO DELLE LOGICHE*** **DI CONTROLLO**
*RIGHT WORKING OF THE LOGICAL CONTROLS*
**VERIFICA DI FUNZIONAMENTO: CIRCUITI AUSILIARI E DI COMANDO, POLARITA' CIRCUITI VOLTMETRICI/AMPEROM.**
CHECKING OF OPERATIONS: AUXILIARY AND CONTROL CIRCUIT, CHECK VOLTMETRIC/AMPEROMETRIC CIRCUIT & POLARITY,INTERTRIP SIGNAL *Point 4.1 FAT proc.*

■ **PROVE SUI DISPOSITIVI AUSILIARI**
TEST OF AUXILIARY DEVICE *Point 4.2 FAT proc.*

■ **CONTROLLO DI CONTINUITA' DEL CIRCUITO DI TERRA**
*CHECKING OF ELECTRICAL CONTINUITY EARTH CIRCUIT*
**Max = ≤0,1Ω (Max Value Measured: 0,003 Ω)**
*Point 4.5 FAT proc.*

# RAPPORTO DI PROVA
# TEST REPORT

| N° Certificato/ Certificate N°: | 347 | Data / Date: | 17/09/2024 |
|---|---|---|---|

**The Equipment is :**

**Compliant** ☒ **/ Non Compliant** ☐

**Referring to the FAT Procedure and relevant documents**

| ***Apparecchiature utilizzate/ Equipment used:*** | ***Scadenza Taratura /Expiration date*** |
|---|---|
| SP 214 MULTITEST FOR DIELECTRIC TEST | 07/2024 |
| SP 196 MULTIMETER FLUKE | 03/2025 |
| PP 143 DIGITAL THICKNESS GAUGE | 12/2024 |
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Note/ *Notes:*

Has been performed communication test with breaker.
Communication test with PLC will be performed at site.

Missing Ethernet Switch RSPS25 (see punch list)
EMAX E1.2N 1250A broken - to be replace (see punch list)

FIRMA/ *SIGNATURE*

IMESA SPA
IMESA SPA
TESTING OFFICE

ROSETTI MARINO SPA
ROSETTI MARINO SpA
Stefano Linari
Quality Control Dept.

O.b.o. CROSSWIND
M. MARRONI
17.09.24

# RAPPORTO DI PROVA
# TEST REPORT

**Fornitore/ Supplier:** **IMESA S.p.A.** Via G. Di Vittorio, 14 JESI (Ancona) – ITALIA
Tel.+39 0731 211034 - Fax.+39 0731 211055 - imesa@imesaspa.com - www.imesaspa.com

| | | | |
|---|---|---|---|
| **N° Certificato/ Certificate N°:** | **304** | **Data / Date:** | **29/07 ÷ 01/08/2024** |
| **Commessa N° / Workorder N°:** | **231298/SD** | | |
| **Matricola N° / Serial N°:** | **231298/SD/040** | | |
| **Ordine N° / Order N°:** | **1723002197** | | |
| **Cliente / Customer:** | **ROSETTI MARINO S.P.A.** | | |

Collaudo eseguito alla presenza di: / Test surveyed by:

| Sig. / Mr. | Ditta / Firm | Firma / Signature |
|---|---|---|
| FAVA STEFANO | IMESA SPA | IMESA SPA TESTING OFFICE |
| MARTARELLI FERNANDO | IMESA SPA | |
| SANTINELLI DAMIANO | IMESA SPA | |
| TASSINARI GABRIELE | ROSETTI MARINO SPA | |
| CASTELLANI KRISTIAN | ROSETTI MARINO SPA | |
| MADASCHI ANDREA | ROSETTI MARINO SPA | |
| IVESON ANTHONY | ROSETTI MARINO SPA | |
| MACULAN LUCA | ROSETTI MARINO SPA | |
| LINARI STEFANO | ROSETTI MARINO SPA | |
| MARANGONI MASSIMILIANO | O.b.o. CROSSWIND | |
| | | |

# RAPPORTO DI PROVA
# TEST REPORT

| N° Certificato/ Certificate N°: | 304 | Data / Date: | 29/07 ÷ 01/08/2024 |
|---|---|---|---|

Materiale collaudato a Norme: **IEC 61439-2**
Material tested according to
Procedura collaudo Quadri BT : **Document number *FAT procedure:***
*Procedure test Switchboards LV* customer **: 1723002197-QC-PRO-00045**; *owner:* **231298/SD/045**

| QUADRO ELETTRICO BT<br>SWITCHBOARD LV | Tipologia / Type: | PC/MCC |
|---|---|---|
| **Tensione Nominale di Isolamento (Ui):**<br>***Rated Insulation Voltage (Ui)*** | **0,69 kV** | |

**CARATTERISTICHE ELETTRICHE/ELECTRICAL INFORMATION:**

Ue= 0,4/0,23kV; Un= 0,4/0,23kV; F= 50 Hz; In= 2500A; Ik= 50kA/1s

**DESCRIZIONE/DESCRIPTION:**

LV SWITCHBOARD 400/230V - BASE LOAD POWER HUB (BLPH)

PROJECT: CROSSWIND HOLLANDSE KUST NOORD WIND PARK

**TAG: "SG-200N1"**

**DISEGNI/DRAWINGS:**

| DOCUMENT ID | TITLE |
|---|---|
| 1723002197-EL-DA-00007 | SG-200N1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| 1723002197-EL-DG-00011 | SG-200N1 ELECTRICAL SINGLE LINE DIAGRAM |
| 1723002197-EL-DG-00030 | SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - INCOMINGS, INTERCONNECTING AND AUX DISTRIBUTION |
| 1723002197-EL-DG-00031 | SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS |
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# RAPPORTO DI PROVA
# TEST REPORT

| N° Certificato/ Certificate N°: | 304 | Data / Date: | 29/07 ÷ 01/08/2024 |
|---|---|---|---|

Materiale collaudato a Norme: **IEC 61439-2**
Material tested according to
Procedura collaudo Quadri BT : **Document number *FAT procedure:***
*Procedure test Switchboards LV* customer **: 1723002197-QC-PRO-00045**; *owner:* **231298/SD/045**

| QUADRO ELETTRICO BT<br>SWITCHBOARD LV | Tipologia / Type: | ~~MCC/F~~ PC /MCC<br>~~INTERNAL ARC PROOF (50kA/0,3s)~~ |
|---|---|---|
| **Tensione Nominale di Isolamento (Ui):**<br>***Rated Insulation Voltage (Ui)*** | **0,69 kV** | |

**CARATTERISTICHE ELETTRICHE/ELECTRICAL INFORMATION:**

Ue= 0,4/0,23kV; Un= 0,4/0,23kV; F= 50 Hz; In= 2500A; Ik= 50kA/1s

**DESCRIZIONE/DESCRIPTION:**

LV SWITCHBOARD 400/230V - BASE LOAD POWER HUB (BLPH)

PROJECT: CROSSWIND HOLLANDSE KUST NOORD WIND PARK

**TAG: "SG-200N1"**

**DISEGNI/DRAWINGS:**

| DOCUMENT ID | TITLE |
|---|---|
| 1723002197-EL-DA-00007 | SG-200N1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| 1723002197-EL-DG-00011 | SG-200N1 ELECTRICAL SINGLE LINE DIAGRAM |
| 1723002197-EL-DG-00030 | SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - INCOMINGS, INTERCONNECTING AND AUX DISTRIBUTION |
| 1723002197-EL-DG-00031 | SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS |
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# RAPPORTO DI PROVA
# TEST REPORT

ISO 9001 ISO 14001 ISO 45001

| N° Certificato/ Certificate N°: | 304 | Data / Date: | 29/07 ÷ 01/08/2024 |
|---|---|---|---|

**PROVE INDIVIDUALI** (secondo lo standard IEC 61439-1)**:**
*ROUTINE TESTS (according to standard IEC 61439-1):*

■ **= TESTED**

■ **11.1 GENERALITA'**
**GENERALITY**

■ **CONTROLLO VISIVO E DIMENSIONALE**
*VISUAL AND DIMENSIONAL CONTROL* *Point 3.1 FAT proc.*

■ **CONTROLLO OSSERVANZA ALLE SPECIFICHE ED ORDINE**
*CHECK OF COMPLIANCE TO SPECS AND ORDER* *Point 3.1 FAT proc.*

■ **CONTROLLO CARPENTERIA, SBARRE,CONNESSIONI PRIMARIE**
*STRUCTURAL WORKS, BUS-BAR CONTROL* *Point 3.4 FAT proc.*

■ **CONTROLLO VERNICIATURA (RAL 7035 ≥ 60 µm )**
*PAINTING CONTROL* *Point 3.1 FAT proc*

■ **11.2 GRADO DI PROTEZIONE DEGLI INVOLUCRI**
*PROTECTION DEGREE* *Point 3.3 FAT proc.*

■ **11.3 DISTANZE DI ISOLAMENTO IN ARIA E SUPERFICIALI**
*CLEARENCE AND CREPAGE DISTANCES* *Point 3.1 FAT proc.*

■ **11.4 PROTEZIONE CONTRO LA SCOSSA ELETTRICA ED INTEGRITA' DEI CIRCUITI DI PROTEZIONE**
*PROTECTION AGAINST ELECTRIC SHOCK AND INTEGRITY OF PROTECTIVE CIRCUITS* *Point 3.4 FAT proc.*

■ **11.5 INSTALLAZIONE DEI COMPONENTI,FISSAGGIO EVENTUALI DANNI IN ASSEMBLAGGIO E COLLEGAMENTI TERRE**
*INCORPORATION OF BUILT-IN COMPONENTS , FIXED,EVENTUAL DAMAGE CAUSED BY ASSEMBLING, EARTHED* *Point 3.1 FAT proc.*

■ **VERIFICA FONDO SCALA STRUMENTI E DATI NOMINALI APPARECCHIATURE**
*CHECK FULL SCALE OF INSTRUMENTS & EQUIPMENT RATED DATA CONTROL* *Point 3.1 FAT proc.*

■ **VERIFICA DEL SERRAGGIO E MARCATURA BULLONERIA**
CHECKING THE TIGHTENING AND MARKING OF BOLTS
*Point 3.4 FAT proc.*

■ **CONTROLLO CABLAGGIO & DATI DI TARGA**
*WIRING CHECK & PLATE CHECK* *Point 3.4 FAT proc.*

■ **MISURA RESISTENZA D'ISOLAMENTO**
MEASURE OF INSULATION RESISTANCE *Point 4.3-4.4 FAT proc.*

| | |
|---|---|
| **CIRCUITI DI POTENZA** | **L1= >500 MΩ; L2= >500 MΩ** |
| POWER CIRCUIT | **L3= >500 MΩ; N = >500 MΩ** |
| **CIRCUITI AUSILIARI** | 24 Vdc= **>500 MΩ** |
| AUXILIARY CIRCUITS | 230 Vac = **>500 MΩ** |

■ **11.6 CIRCUITI ELETTRICI INTERNI E COLLEGAMENTI**
*INTERNAL ELECTRICAL CIRCUITS AND CONNECTIONS*
*Point 3.4 FAT proc.*

■ **11.7 CONTROLLO DEI TERMINALI PER I CONDUTTORI ESTERNI**
*CHECK OF TERMINALS FOR EXTERNAL CONDUCTORS*
*Point 3.4 FAT proc.*

■ **11.8 CONTROLLO FUNZIONAMENTO MECCANICO**
*MECHANICAL OPERATION TEST*
**VERIFICA DI FUNZIONAMENTO: FUNZIONAMENTO DEGLI INTERRUTTORI,PORTE,CHIAVI INTERBLOCCHI SEGNALI E LE PARTI MECCANICHE CHE FORMANO IL QUADRO**
OPERATION TEST: CHECK OPERATION OF C.B. DOORS, SIGNALLING, EFFICIENCY OF KEY LOCKS AND THE MECHANICS PART THAT FORM THE PANEL,INTERLOCKS BETWEEN C.B, CARRY OUT A NUMBER OF STARTING UP AND STOPPING SEQUENCES *Point 3.2 FAT proc.*

■ **11.9 PROVE DI TENSIONE : f = 50 Hz e t = 1 sec.**
***VOLTAGE TEST : f = 50 Hz and t = 1 sec.* (*60 sec)**

**CIRCUITI DI POTENZA** **1.89** kV
*MAIN CIRCUITS* *Point 4.3 FAT proc.*
***Leakage curr. L1= 2 mA L2= 2 mA L3= 2 mA* N= 2 mA**

**CIRCUITI AUSILIARI 24Vdc= 0,5**kV; **230Vac= 1,5** kV
*AUXILIARY CIRCUITS* *Point 4.4 FAT proc.*
***Leakage current: 24Vdc= 1 mA; 230Vac= 2 mA***

■ **PROVE DI FUNZIONAMENTO ELETTRICO E SEQUENZE, ARC FLASH TEST VANO CAVI, BUSBAR & C.B.**
*ELECTRICAL OPERATION & SEQUENCE TESTS, ARC FLASH TEST ON CABLE COMP. BUSBAR & C.B.* *Point 4.1FAT proc.*
*CUBICLE TESTED: SEE ANNEX B"*

■ ***FUNZIONAMENTO CORRETTO DELLE LOGICHE* DI CONTROLLO**
*RIGHT WORKING OF THE LOGICAL CONTROLS*
**VERIFICA DI FUNZIONAMENTO: CIRCUITI AUSILIARI E DI COMANDO, POLARITA' CIRCUITI VOLTMETRICI/AMPEROM.**
CHECKING OF OPERATIONS: AUXILIARY AND CONTROL CIRCUIT, CHECK VOLTMETRIC/AMPEROMETRIC CIRCUIT & POLARITY,INTERTRIP SIGNAL *Point 4.1 FAT proc.*

■ **PROVE SUI DISPOSITIVI AUSILIARI**
TEST OF AUXILIARY DEVICE *Point 4.2 FAT proc.*

■ **CONTROLLO DI CONTINUITA' DEL CIRCUITO DI TERRA**
*CHECKING OF ELECTRICAL CONTINUITY EARTH CIRCUIT*
**Max = ≤0,1Ω (Max Value Measured: 0,011 Ω)**
*Point 4.5 FAT proc.*

# RAPPORTO DI PROVA
# TEST REPORT

ISO 9001 ISO 14001 ISO 45001

| N° Certificato/ Certificate N°: | 304 | Data / Date: | 29/07 ÷ 01/08/2024 |
|---|---|---|---|

**The Equipment is :**

**Compliant** ☒ **/ Non Compliant** ☐

**Referring to the FAT Procedure and relevant documents**

***Apparecchiature utilizzate/ Equipment used:*** ***Scadenza Taratura /Expiration date***

| | |
|---|---|
| SP 186 MULTITEST FOR DIELECTRIC TEST | 10/2024 |
| PP 143 DIGITAL THICKNESS GAUGE | 12/2024 |
| SC 05 TEST FINGER IP2X | 07/2025 |
| SC 06 TEST FINGER IP3X | 07/2025 |
| SP 196 DIGITAL MULTIMETER | 03/2025 |
| SCD 61 TORQUE WRENCH (20-100 Nm) | 01/2025 |
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Note/ *Notes:*

See PUNCH list Report : PL - IME - 2197 - 01

FIRMA/ *SIGNATURE*

IMESA SPA
IMESA SPA
TESTING OFFICE

ROSETTI MARINO SPA
LINARI STEFANO
01/08/24

O.b.o. CROSSWIND
MARANGONI

| Type of switchboard: | LV SWGR / MCC/32 | Comm. : | 231298/SD | ELE Resp. : | SD | Node: | 40 |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex B | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| OPERATING TESTS) | | | UNIT: "L1-n & L2-n Typical" | | | |
| | FUNCTION | DEVICE | *Tested Unit:* | | | |
| 1 | LOCAL OPENING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 2 | LOCAL CLOSING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 3 | TRIPPING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 4 | OPENING CIRCUIT-BREAKER BY OPEN COIL | YO | ✓ | | | |
| 5 | TEST FOR SIGNALLING LAMPS / LED | HL1 | ✓ | | | |
| 6 | MCB AUX. CONTACTS TEST | / | | | ✓ | |
| 7 | MECHANICAL TEST FOR INSERTION / DISCONNECTION DRAWER | / | ✓ | | | |
| 8 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD | X1 | | | ✓ | |
| 9 | READING/WRITING SIGNALS IN ACCORDING TO I//O LIST | U2.A | ✓ * | | | |
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*-MODBUS TCP-IP COMMUNICATION SEE I/O LIST

NOTE: TESTED:
UP-200F4 POS.A2/4
UP-200F3 POS. A3/1 LINE A
UP-200F3 POS. A4/1 LINE B
A6/05 "AC UPS F&G LINE A
A6/06 "AC UPS F&G LINE B
A7/02 "UP-200F3-"BYPASS"
A7/03 "DC BATTERY SWTG CONTROL FEEDER A"
A7/04 "DC BATTERY SWTG CONTROL FEEDER B"

ROSETTI MARINO
LIGUARI STEFANO
01/08/24

dott CROSSUNA
MARANGONI

| Type of switchboard: | LV SWGR / MCC/32 | Comm. : | 231298/SD | ELE Resp. : | SD | Node: | 40 |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex B | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| OPERATING TESTS) | | | UNIT: "LK1-n & LK2-n Typical" | | | |
| | FUNCTION | DEVICE | *Tested Unit:* | | | |
| 1 | LOCAL OPENING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 2 | LOCAL CLOSING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 3 | TRIPPING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 4 | LOCAL OPENING/CLOSING CONTACTOR IN INSERTED DRAWER POSITION | KM1 | ✓ | | | |
| 5 | LOCAL OPENING/CLOSING CONTACTOR IN TESTED DRAWER POSITION | KM1 | ✓ | | | |
| 6 | REMOTE OPENING/CLOSING CONTACTOR | KM1 | ✓ | | | |
| 7 | TEST FOR SIGNALLING LAMPS / LED | HL1 | ✓ | | | |
| 8 | MCB AUX. CONTACTS TEST | / | ✓ | | | |
| 9 | MECHANICAL TEST FOR INSERTION / DISCONNECTION DRAWER | / | ✓ | | | |
| 10 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD | X1 | | | ✓ | |
| 11 | READING/WRITING SIGNALS IN ACCORDING TO I//O LIST | U2.A | ✓ * | | | |
| 12 | | | | | | |
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| 21 | | | | | | |

*- MODBUS TCP-IP COMMUNICATION SEE I/O LIST

NOTE: TESTED

POS. A2/05 "SPARE"

POS. A3/02 "SPARE"

POS. A4/02 "HVAC PANELS HV ROOM"

POS. A4/04 "BESS PCS CABINET"

POS. A4/05 "SPARE"

POS. A4/06 "SPARE"

POS. A5/01 "SPARE"

POS. A5/02 "HVAC PANELS LV ROOM"

POS.A5/03 "HVAC PANELS-UPS ROOM"

POS. A5/06 "SPARE"

POS. A6/02 "BESS LV1 CABINET CP-850E1"

POS. A6/03 "BESS LV2 CABINET CP-850E2"

POS. A6/04 "SPARE"

ROSETTI MARINO

ROSETTI MARINO

01/08/24

obo CROSSWIND

| Type of switchboard: | LV SWGR / MCC/32 | Comm. : | 231298/SD | ELE Resp. : | SD | Node: | 40 |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex B | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| OPERATING TESTS) | | | UNIT: "L3-630 Typical" | | | |
| | FUNCTION | DEVICE | *Tested Unit: ELECTROLYZER* | | | |
| 1 | LOCAL OPENING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 2 | LOCAL CLOSING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 3 | REMOTE OPENING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 4 | REMOTE CLOSING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 5 | TRIPPING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 6 | TEST FOR SIGNALLING LAMPS / LED | HL1÷3 | ✓ | | | |
| 7 | MCB AUX. CONTACTS TEST | / | ✓ | | | |
| 8 | MECHANICAL TEST FOR INSERTION / DISCONNECTION C.B. | QF1 | ✓ | | | |
| 9 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD | X1 | ✓ | | | |
| 10 | READING/WRITING SIGNALS IN ACCORDING TO I//O LIST | U1.A/QF1 | ✓ * | | | |
| 11 | | | | | | |
| 12 | | | | | | |
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| 25 | | | | | | |

*- MODBUS TCP-IP ACCORDING TO I/O LIST

ROSETTI MARINO
LINARI STEFANO
01/08/24

obo CROSSWIND

| Type of switchboard: | LV SWGR / MCC/32 | Comm. : | 231298/SD | ELE Resp. : | SD | Node: | 40 |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex B | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| OPERATING TESTS) | | | UNIT: "INCOMING" | | | |
| | FUNCTION | DEVICE | *Tested Unit:* | | | |
| 1 | LOCAL OPENING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 2 | LOCAL CLOSING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 3 | REMOTE OPENING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 4 | REMOTE CLOSING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 5 | TRIPPING CIRCUIT-BREAKER | QF1 | ✓ | | | |
| 6 | LOCK-OUT TEST RELAY | K86 | ✓ | | | |
| 7 | MCB AUX. CONTACTS TEST | / | ✓ | | | |
| 8 | MECHANICAL TEST FOR INSERTION / DISCONNECTION C.B. | QF1 | ✓ | | | |
| 9 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD | X1 | ✓ | | | |
| 10 | READING/WRITING SIGNALS IN ACCORDING TO I//O LIST | A1/FP1 | | | ✓ | |
| 11 | AUXILIARY VOLTAGE SWITCHING | QU1 | ✓ | | | |
| 12 | ARC SURVEY TRIPPING | FP1 | ✓ | | | |
| 13 | INTERNAL SPACE HEATER / LIGHTING DISTRIBUTION | BUS-4 | ✓ | | | |
| 14 | COMMAND CIRCUITS TO FEEDERS DISTRIBUTION | BUS-1 | ✓ | | | |
| 15 | 24VDC VOLTAGE DISTRIBUTION | BUS-2 | | | ✓ | |
| 16 | INTERTRIPPING WITH HV SWBD UPSTREAM | FP1 | | | ✓ | |
| 17 | | | | | | |
| 18 | | | | | | |
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| 24 | | | | | | |
| 25 | | | | | | |

NOTE: ~~K86 RELAY MISSING~~

ROSETTI MARINO
LINARI STEFANO
01/08/24

ABB CROSSWIND

ROSETTI MARINO
KRATTIAN CASTELLANI

# RAPPORTO DI PROVA
# TEST REPORT

ISO 9001 ISO 14001 ISO 45001

**Fornitore/ Supplier:** **IMESA S.p.A.** Via G. Di Vittorio, 14 JESI (Ancona) – ITALIA
Tel.+39 0731 211034 - Fax.+39 0731 211055 - imesa@imesaspa.com - www.imesaspa.com

| | | | |
|---|---|---|---|
| **N° Certificato/ Certificate N°:** | **346** | **Data / Date:** | **17/09/2024** |
| **Commessa N° / Workorder N°:** | **231298/SD** | | |
| **Matricola N° / Serial N°:** | **231298/SD** | | |
| **Ordine N° / Order N°:** | **1723002197 item: 40** | | |
| **Cliente / Customer:** | **ROSETTI MARINO S.P.A.** | | |

Collaudo eseguito alla presenza di: / Test surveyed by:

| Sig. / Mr. | Ditta / Firm | Firma / Signature |
|---|---|---|
| FAVA STEFANO | IMESA SPA | IMESA SPA TESTING OFFICE |
| MARTARELLI FERNANDO | IMESA SPA | |
| SANTINELLI DAMIANO | IMESA SPA | |
| TASSINARI GABRIELE | ROSETTI MARINO SPA | |
| CASTELLANI KRISTIAN | ROSETTI MARINO SPA | |
| LINARI STEFANO | ROSETTI MARINO SPA | ROSETTI MARINO SpA Stefano Linari Quality Control Dept. |
| MARANGONI MASSIMILIANO | O.b.o. CROSSWIND | |
| | | |
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| | | |

# RAPPORTO DI PROVA
# TEST REPORT

| N° Certificato/ Certificate N°: | 346 | Data / Date: | 17/09/2024 |
|---|---|---|---|

Materiale collaudato a Norme: **IEC 61439-2**
Material tested according to

Procedura collaudo Quadri BT : **Document number *FAT procedure:***
*Procedure test Switchboards LV* customer **: 1723002197-QC-PRO-00045**; *owner:* **231298/SD/045**

| QUADRO ELETTRICO BT<br>SWITCHBOARD LV | Tipologia / Type: | MCC DRAWERS COMPLETION |
|---|---|---|
| Tensione Nominale di Isolamento (Ui):<br>*Rated Insulation Voltage (Ui)* | 0,69 kV | |

**CARATTERISTICHE ELETTRICHE/ELECTRICAL INFORMATION:**

Ue= 0,4/0,23kV; Un= 0,4/0,23kV; F= 50 Hz; In= 2500A; Ik= 50kA/1s

**DESCRIZIONE/DESCRIPTION:**

N° 15 DRAWERS COMPLETION FOR LV SWITCHBOARD 400/230V - BASE LOAD POWER HUB (BLPH)

PROJECT: CROSSWIND HOLLANDSE KUST NOORD WIND PARK

DRAWERS TESTED POSITION:

A3/+03; A3/+04; A3/+05; A3/+08; A4/+03; A4/+08; A5/+04; A5/+05; A5/+08; A6/+01; A6/+08;

**TAG: "SG-200N1"**

**DISEGNI/DRAWINGS:**

| DOCUMENT ID | TITLE |
|---|---|
| 1723002197-EL-DA-00007 | SG-200N1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| 1723002197-EL-DG-00011 | SG-200N1 ELECTRICAL SINGLE LINE DIAGRAM |
| 1723002197-EL-DG-00030 | SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - INCOMINGS, INTERCONNECTING AND AUX DISTRIBUTION |
| 1723002197-EL-DG-00031 | SG-200N1 LV SWG FUNCTIONAL DIAGRAMS - TYPICAL FEEDERS |
| | |
| | |

# RAPPORTO DI PROVA
# TEST REPORT

ISO 9001 ISO 14001 ISO 45001

| N° Certificato/ Certificate N°: | 346 | Data / Date: | 17/09/2024 |
|---|---|---|---|

**PROVE INDIVIDUALI** (secondo lo standard IEC 61439-1)**:**
*ROUTINE TESTS (according to standard IEC 61439-1):*

■ = TESTED

■ **11.1 GENERALITA'**
**GENERALITY**

■ **CONTROLLO VISIVO E DIMENSIONALE**
*VISUAL AND DIMENSIONAL CONTROL* *Point 3.1 FAT proc.*

■ **CONTROLLO OSSERVANZA ALLE SPECIFICHE ED ORDINE**
*CHECK OF COMPLIANCE TO SPECS AND ORDER* *Point 3.1 FAT proc.*

■ **CONTROLLO CARPENTERIA, SBARRE,CONNESSIONI PRIMARIE**
*STRUCTURAL WORKS, BUS-BAR CONTROL* *Point 3.4 FAT proc.*

■ **CONTROLLO VERNICIATURA (RAL 7035 ≥ 60 µm )**
*PAINTING CONTROL* *Point 3.1 FAT proc*

■ **11.2 GRADO DI PROTEZIONE DEGLI INVOLUCRI**
*PROTECTION DEGREE* *Point 3.3 FAT proc.*

■ **11.3 DISTANZE DI ISOLAMENTO IN ARIA E SUPERFICIALI**
*CLEARENCE AND CREPAGE DISTANCES* *Point 3.1 FAT proc.*

■ **11.4 PROTEZIONE CONTRO LA SCOSSA ELETTRICA ED INTEGRITA' DEI CIRCUITI DI PROTEZIONE**
*PROTECTION AGAINST ELECTRIC SHOCK AND INTEGRITY OF PROTECTIVE CIRCUITS* *Point 3.4 FAT proc.*

■ **11.5 INSTALLAZIONE DEI COMPONENTI,FISSAGGIO EVENTUALI DANNI IN ASSEMBLAGGIO E COLLEGAMENTI TERRE**
*INCORPORATION OF BUILT-IN COMPONENTS , FIXED,EVENTUAL DAMAGE CAUSED BY ASSEMBLING, EARTHED* *Point 3.1 FAT proc.*

■ **VERIFICA FONDO SCALA STRUMENTI E DATI NOMINALI APPARECCHIATURE**
*CHECK FULL SCALE OF INSTRUMENTS & EQUIPMENT RATED DATA CONTROL* *Point 3.1 FAT proc.*

■ **VERIFICA DEL SERRAGGIO E MARCATURA BULLONERIA**
CHECKING THE TIGHTENING AND MARKING OF BOLTS
*Point 3.4 FAT proc.*

■ **CONTROLLO CABLAGGIO & DATI DI TARGA**
*WIRING CHECK & PLATE CHECK* *Point 3.4 FAT proc.*

■ **MISURA RESISTENZA D'ISOLAMENTO**
MEASURE OF INSULATION RESISTANCE *Point 4.3-4.4 FAT proc.*
**SEE ANNEX CAB06**

**CIRCUITI DI POTENZA** **L1=** **MΩ;** **L2=** **MΩ**
POWER CIRCUIT **L3=** **MΩ;** **N =** **MΩ**
**CIRCUITI AUSILIARI**
AUXILIARY CIRCUITS 230 Vac = **MΩ**

■ **11.6 CIRCUITI ELETTRICI INTERNI E COLLEGAMENTI**
*INTERNAL ELECTRICAL CIRCUITS AND CONNECTIONS*
*Point 3.4 FAT proc.*

■ **11.7 CONTROLLO DEI TERMINALI PER I CONDUTTORI ESTERNI**
*CHECK OF TERMINALS FOR EXTERNAL CONDUCTORS*
*Point 3.4 FAT proc.*

■ **11.8 CONTROLLO FUNZIONAMENTO MECCANICO**
*MECHANICAL OPERATION TEST*
**VERIFICA DI FUNZIONAMENTO: FUNZIONAMENTO DEGLI INTERRUTTORI,PORTE,CHIAVI INTERBLOCCHI SEGNALI E LE PARTI MECCANICHE CHE FORMANO IL QUADRO**
OPERATION TEST: CHECK OPERATION OF C.B. DOORS, SIGNALLING, EFFICIENCY OF KEY LOCKS AND THE MECHANICS PART THAT FORM THE PANEL,INTERLOCKS BETWEEN C.B, CARRY OUT A NUMBER OF STARTING UP AND STOPPING SEQUENCES *Point 3.2 FAT proc.*

■ **11.9 PROVE DI TENSIONE : f = 50 Hz e t = 1 sec.**
***VOLTAGE TEST : f = 50 Hz and t = 1 sec.*** **(*60 sec)**
**SEE ANNEX CAB06**

**CIRCUITI DI POTENZA** **1.89** kV
*MAIN CIRCUITS* *Point 4.3 FAT proc.*

**CIRCUITI AUSILIARI** **230Vac= 1,5** kV
*AUXILIARY CIRCUITS* *Point 4.4 FAT proc.*

■ **PROVE DI FUNZIONAMENTO ELETTRICO E SEQUENZE, ARC FLASH TEST VANO CAVI, BUSBAR & C.B.**
*ELECTRICAL OPERATION & SEQUENCE TESTS, ARC FLASH TEST ON CABLE COMP. BUSBAR & C.B.* *Point 4.1FAT proc.*

■ ***FUNZIONAMENTO CORRETTO DELLE LOGICHE*** **DI CONTROLLO**
*RIGHT WORKING OF THE LOGICAL CONTROLS*
**VERIFICA DI FUNZIONAMENTO: CIRCUITI AUSILIARI E DI COMANDO, POLARITA' CIRCUITI VOLTMETRICI/AMPEROM.**
CHECKING OF OPERATIONS: AUXILIARY AND CONTROL CIRCUIT, CHECK VOLTMETRIC/AMPEROMETRIC CIRCUIT & POLARITY,INTERTRIP SIGNAL *Point 4.1 FAT proc.*

■ **PROVE SUI DISPOSITIVI AUSILIARI**
TEST OF AUXILIARY DEVICE *Point 4.2 FAT proc.*

■ **CONTROLLO DI CONTINUITA' DEL CIRCUITO DI TERRA**
*CHECKING OF ELECTRICAL CONTINUITY EARTH CIRCUIT*
**Max = ≤0,1Ω (Max Value Measured: Ω)**
*Point 4.5 FAT proc.*

# RAPPORTO DI PROVA
# TEST REPORT

| N° Certificato/ Certificate N°: | 346 | Data / Date: | 17/09/2024 |
|---|---|---|---|

**The Equipment is :**

**Compliant** ☒ **/ Non Compliant** ☐

**Referring to the FAT Procedure and relevant documents**

| ***Apparecchiature utilizzate/ Equipment used:*** | ***Scadenza Taratura /Expiration date*** |
|---|---|
| SP 214 MULTITEST FOR DIELECTRIC TEST | 07/2024 |
| SP 196 MULTIMETER FLUKE | 03/2025 |
| PP 143 DIGITAL THICKNESS GAUGE | 12/2024 |
| | |
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Note/ *Notes:*

**DRAWERS TESTED DURING THE FAT (POSITION):**

*A4/+03; A7/+01; A7/+08 ;*

Communication test will be performed after installation at site.

FIRMA/ *SIGNATURE*

IMESA SPA
IMESA SPA
TESTING OFFICE

ROSETTI MARINO SPA
ROSETTI MARINO SpA
Stefano Linari
Quality Control Dept.

O.b.o. CROSSWIND
M MARANGONI
17.09.24

2.5.2.MV SWITCHGEAR FAT Report

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

2.5.2.1. MV SWITCHGEAR FAT Report

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# RAPPORTO DI PROVA
# TEST REPORT

**Fornitore/ Supplier: IMESA S.p.A.** Via G. Di Vittorio, 14 JESI (Ancona) – ITALIA
Tel.+39 0731 211034 - Fax.+39 0731 211055 - imesa@imesaspa.com - www.imesaspa.com

| | | | |
|---|---|---|---|
| **N° Certificato/ Certificate N°:** | **303** | **Data / Date:** | **29/07 ÷ 01/08/2024** |
| **Commessa N° / Workorder N°:** | **231151/SD** | | |
| **Matricola N° / Serial N°:** | **231151/SD/010** | | |
| **Ordine N° / Order N°:** | **1723002197** | | |
| **Cliente / Customer:** | **ROSETTI MARINO S.P.A.** | | |

Collaudo eseguito alla presenza di: / *Test surveyed by:*

| Sig. / Mr. | Azienda / Company | Firma / Signature |
|---|---|---|
| FAVA STEFANO | IMESA SPA | IMESA SPA TESTING OFFICE |
| VINCENZO FRANZESE | IMESA SPA | |
| SANTINELLI DAMIANO | IMESA SPA | |
| TASSINARI GABRIELE | ROSETTI MARINO SPA | |
| CASTELLANI KRISTIAN | ROSETTI MARINO SPA | |
| MADASCHI ANDREA | ROSETTI MARINO SPA | |
| IVESON ANTHONY | ROSETTI MARINO SPA | |
| MACULAN LUCA | ROSETTI MARINO SPA | |
| LINARI STEFANO | ROSETTI MARINO SPA | |
| MARANGONI MASSIMILIANO | O.b.o. CROSSWIND | |
| | | |

| N° Certificato/ Certificate N°: | 303 | Data / Date: | 29/07 ÷ 01/08/2024 |
|---|---|---|---|

Materiale collaudato a Norme: **IEC 62271-200**
Material tested according to

Procedura collaudo Quadri MT : **Document number *FAT procedure:***
*Procedure test Switchboards MT* customer **: 1723002197-QC-PRO-00044** ; owner: **231151/SD/044**

| QUADRO ELETTRICO MT SWITCHBOARD MV | Tipologia / Type: | MINIVER-C INTERNAL ARC PROOF (AFLR 25 kA/1s) |
|---|---|---|
| **Tensione Nominale di Isolamento (Ui):** ***Rated Insulation Voltage (Ui)*** | **7,2 kV** | |

**CARATTERISTICHE ELETTRICHE/ELECTRICAL INFORMATION:**

Ue= **6,6** kV
Up= **60** kV
f= **50** Hz
Ir= **630** A
Ip= **65** kA
Ik= **25** kA / t= **1** s
Vaux= **110** Vdc; **230** Vac

**DESCRIZIONE/DESCRIPTION:**

HV SWITCHBOARD 6,6 Kv - BASE LOAD POWER HUB (BLPH)

PROJECT: CROSSWIND HOLLANDSE KUST NOORD WIND PARK

**TAG: "SG-100D1"**

| N° Certificato/ Certificate N°: | 303 | Data / Date: | 29/07 ÷ 01/08/2024 |
|---|---|---|---|

**DISEGNI/DRAWINGS**

| *DOCUMENT ID* | *TITLE* |
|---|---|
| 1723002197-EL-DA-00006 | SG-100D1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG |
| 1723002197-EL-DG-00010 | SG-100D1 ELECTRICAL SINGLE LINE DIAGRAM |
| 1723002197-EL-DG-00015 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - INCOMING FEEDER (including Terminals and BOM) |
| 1723002197-EL-DG-00016 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - BUS BAR METERING (including Terminals and BOM) |
| 1723002197-EL-DG-00017 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - BESS FEEDER (including Terminals and BOM) |
| 1723002197-EL-DG-00018 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - ELECTROLYSER FEEDER (including Terminals and BOM) |
| 1723002197-EL-DG-00019 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - FUEL CELL FEEDER (including Terminals and BOM) |
| 1723002197-EL-DG-00020 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM - TRANSFORMER TR200ED1 (including Terminals and BOM) |
| 1723002197-EL-DG-00021 | SG-100D1 MV SWG FUNCTIONAL DIAGRAM – TRANSFORMER TR200DE1 (including Terminals and BOM) |
| 1723002197-EL-DG-00022 | SG-100D1 MV SWG INTERCONNECTING AND AUX DISTRIBUTION DIAGRAM (including BOM) |
| 1723002197-EL-DG-00023 | SG-100D1 MV SWG LOGIC DIAGRAM - INCOMING FEEDER |
| 1723002197-EL-DG-00025 | SG-100D1 MV SWG LOGIC DIAGRAM - BESS FEEDER |
| 1723002197-EL-DG-00026 | SG-100D1 MV SWG LOGIC DIAGRAM - ELECTROLYSER FEEDER |
| 1723002197-EL-DG-00027 | SG-100D1 MV SWG LOGIC DIAGRAM - FUEL CELL FEEDER |
| 1723002197-EL-DG-00028 | SG-100D1 MV SWG LOGIC DIAGRAM - TRANSFORMER FEEDER TR200ED1 |
| 1723002197-EL-DG-00029 | SG-100D1 MV SWG LOGIC DIAGRAM - TRANSFORMER FEEDER TR200DE1 |
| | |
| | |

| N° Certificato/ Certificate N°: | 303 | Data / Date: | 29/07 ÷ 01/08/2024 |
|---|---|---|---|

**PROVE INDIVIDUALI** (secondo lo standard IEC 62271-1;200): ■ = OK NA = NOT APPLICABLE
*INDIVIDUAL TESTS* (according to standard IEC 62271-1)*:;200)*

■ **8.2 PROVE DI ISOLAMENTO DEL CIRCUITO PRINCIPALE**
*DIELECTRIC TEST OF THE MAIN CIRCUIT* **(60sec.)**
**PROVA DI TENSIONE A FREQUENZA DI ESERCIZIO**
POWER-FREQUENCY VOLTAGE TEST *point 4.3 FAT Proc*
**CIRCUITI PRINCIPALI** (Ud) **20** kV
MAIN CIRCUITS
**Leakage current: L1= 8 mA; L2= 9 mA; L3= 9 mA**

■ **8.3.1 ISPEZIONE SUI CIRCUITI AUSILIARI**
*TEST ON AUXILIARY CIRCUITS*
**VERIFICA VISIVA: QUALITA' ASSEMBLAGGIO,UBICAZIONE DISPOSITIVI,PERCORSO CAVI,IDENTIFICAZIONE COMPONENTI E MORSETTI**
VISUAL CHECK: ASSEMBLY QUALITY,DEVICE CORRECT LOCATION,CABLES ROUTE,COMPONENTS AND TERMINALS IDENTIFICATION *point 3.4 FAT Proc*

■ **8.3.2 PROVE DI: FUNZIONAMENTO DELLE LOGICHE DI CONTROLLO**
*TESTS OF:CONTROL LOGIC OPERATION,* *point 4.1 FAT Proc*
**VERIFICA DI FUNZIONAMENTO: CIRCUITI AUSILIARI E DI COMANDO, VERIFICA RAPPORTI TRASFORMAZIONE TV-TA**
CHECKING OF OPERATIONS: AUXILIARY AND CONTROL CIRCUIT, CHECK OF VT's-CT's TRANSFORMATION RATIO
CUBICLE TESTED: SEE ANNEX "A"

■ **8.3.3 VERIFICA DELLA PROTEZIONE CONTRO LA SCOSSA ELETTRICA**
*CONTROL OF PROTECTION AGAINST ELECTRIC SHOCK*
**VERIFICA VISIVA SULLE PROTEZIONI CONTRO IL CONTATTO DIRETTO DEL CIRCUITO PRINCIPALE E L'ACCESSIBILITA'IN SICUREZZA ALLE PARTI AUSILIARI E DI COMANDO**
VISUAL CHECK OF THE PROTECTIONS AGAINST DIRECT CONTACT OF THE MAIN CIRCUIT AND SAFE ACCESSIBILITY TO THE AUXILIARY AND CONTROL PARTS *point 3.1 FAT Proc*

■ **8.3.4 PROVE DI ISOLAMENTO (1 sec.)**
*TEST OF INSULATION* (* 60 sec. )
**PROVA DI TENUTA CON TENSIONE A FREQUENZA DI ESERCIZIO DI BREVE DURATA SU CIRCUITI AUSILIARI**
TIGHTNESS TEST WITH SHORT-TERM OPERATING FREQUENCY VOLTAGE ON AUXILIARY CIRCUIT *point 4.4 FAT Proc*
**CIRCUITI AUSILIARI** (Ui)
*AUXILIARY CIRCUITS* :24Vdc= **0,5** kV, 110Vdc=230Vac= **1,5** kV
**Leakage current**; 24Vdc= 1mA; 110Vdc= 9 mA;230Vac=3mA;

■ **8.4 MISURA DELLA RESISTENZA DEL CIRCUITO PRINCIPALE**
*MEASUREMENT OF THE RESISTANCE OF THE MAIN CIRCUIT*
**MISURA CADUTA DI TENSIONE O RESISTENZA SU CIRCUITO PRINCIPALE (DOC.MOD. CQ12)** *point 4.6 FAT Proc*
MEASUREMENT OF VOLTAGE OR RESISTANCE DROP ON THE MAIN CIRCUIT (DOC.MOD. CQ12) **#documental**

■ **8.6 VERIFICHE DI PROGETTO E VISIVE**
**PROJECT AND VISUAL CHECKS**

■ **CONTROLLO VISIVO E DIMENSIONALE**
*VISUAL AND DIMENSIONAL CHECK* *point 3.1 FAT Proc*

■ **CONTROLLO CARPENTERIA, SBARRE E CONNESSIONI**
*STRUCTURAL WORKS, BUS-BAR CONTROL-TIGHTENINGS,GROUND*

■ **CONTROLLO DATI NOMINALI APPARECCHIATURE**
*EQUIPMENT RATED DATA CONTROL* *point 3.4 FAT Proc*

■ **CONTROLLO TARGHETTE/ETICHETTE**
*LABEL / DATA PLATE CONTROL* *point 3.4 FAT Proc*

■ **CONTROLLO OSSERVANZA ALLE SPECIFICHE DI PROGETTO**
*CHECK OF COMPLIANCE TO PROJECT SPECIFICATIONS*
*point 3.1 FAT Proc*

■ **VERIFICA DEL GRADO DI PROTEZIONE**
*CHECK OF IP CODE RATING* *point 3.3 FAT Proc*

■ **VERIFICA SEGREGAZIONI INTERNE**
VERIFY INTERNAL SEGREGATIONS *point 3.1 FAT Proc*

■ **CONTROLLO VERNICIATURA** (RAL **7035 ≥ 60** µm )
*PAINTING CONTROL* *point 3.1 FAT Proc*

■ **CONTROLLO DI CONTINUITA' DEL CIRCUITO DI TERRA**
*CHECKING OF ELECTRICAL CONTINUITY EARTH CIRCUIT* = **≤ 0,1Ω**
**(MAX VALUE MEASURED = 0,007)** *point 4.5 FAT Proc*

■ **VERIFICA HARDWARE E FUNZIONE RELE' DI PROTEZIONE**
VERIFICATIONE OF THE PROTECTIVE RELAYS HARDWARE AND FUNCTIONALITY *point 4.1 FAT Proc*

■ ***TEST RIDONDANZA DELLE LINEE IN INGRESSO***
*EXTERNAL AUXILIARY POWER SUPPLY (REDUNDANCY TEST OF INCOMING SUPPLY)* *point 4.6 FAT Proc*

■ **ARC FLASH TEST VANO CAVI,BUSBAR & C.B.**
ARC FLASH TEST ON CABLE COMP.,BUSBAR &C.B. point 4.8 FAT proc

■ **INTERFACCIA CON SISTEMA AUTOMAZIONE EMS #**
INTERFACE TEST WITH EMS SYSTEM *point 4.9 FAT Proc*
# OUT OF IMESA SCOPE OF SUPPLY

■ **8.102 PROVE DI FUNZIONAMENTO MECCANICO**
*MECHANICAL OPERATION TEST*
**VERIFICA DI FUNZIONAMENTO: SEZIONATORI, INTERRUTTORI,PORTE,CHIAVI E LE PARTI MECCANICHE CHE FORMANO IL QUADRO VERIFICA INTERBLOCCHI INTERRUTTORI E SEZIONATORE DI TERRA,INTERCAMBIABILITA' INTERRUTTORI**
OPERATION TEST:DISCONNECTORS,SWITCHES,DOORS,KEY LOCKS AN INTERCHANGEABILITY *point 3.2 FAT Proc*

RULES :
According to Standard IEC 62271-200

| N° Certificato/ Certificate N°: | 303 | Data / Date: | 29/07 ÷ 01/08/2024 |
|---|---|---|---|

■ MISURA RESISTENZA D'ISOLAMENTO
MEASURE OF INSULATION RESISTANCE
IL TEST SI CONSIDERA SUPERATO SE NON AVVENGONO SCARICHE DISRUPTIVE DURANTE LA PROVA
SI PRENDE IL VALORE PIU' BASSO DI RESISTENZA DI ISOLAMENTO DOPO LA PROVA DIELETTRICA
SI APPLICA UNA TENSIONE DI 5000Vdc PER 10" TRA OGNI FASE E TERRA NEL CASO DEI CIRCUITI DI POTENZA
SI APPLICA UNA TENSIONE DI 500 Vdc PER 5" TRA OGNI CIRCUITO AUSILIARIO VERSO TERRA
APPLYING A VOLTAGE OF 5000 Vdc FOR 10" BETWEEN THE POWER CIRCUITS (IN SEQUENCE L1, L2, L3) AND GROUND.
APPLYING A VOLTAGE OF 500 Vdc FOR 5" BETWEEN THE AUX CIRCUITS AND GROUND
THE TEST IS CONSIDERED PASSED IF NO DISRUPTIVE DISCHARGES OCCUR DURING THE TEST
LOWER INSULATION RESISTANCE VALUE TAKEN AFTER THE DIELECTRIC TEST

CIRCUITI DI POTENZA = 19,2 GΩ *point 4.3 FAT Proc*
POWER CIRCUIT

| BEFORE TEST | AFTER TEST |
|---|---|
| L1= 9,43 GΩ | L1= 28,7 GΩ |
| L2= 17,4 GΩ | L2= 26,8 GΩ |
| L3= 15,3 GΩ | L3= 19,2 GΩ |

CIRCUITI AUSILIARI 24 Vdc= >500 MΩ; 110Vdc = 208 MΩ; 230Vac= >500 MΩ *point 4.4 FAT Proc*
AUXILIARY CIRCUITS

| BEFORE TEST | AFTER TEST |
|---|---|
| 24 Vdc= 498 MΩ | 24 Vdc= >500 MΩ |
| 110 Vdc= 225 MΩ | 110 Vdc= 208 MΩ |
| 230 Vac= >500 MΩ | 230 Vac= >500 MΩ |
| | |

# RAPPORTO DI PROVA
# TEST REPORT

| N° Certificato/ Certificate N°: | 303 | Data / Date: | 29/07 ÷ 01/08/2024 |
|---|---|---|---|

**The Equipment is :**

**Compliant** [X] **/ Non Compliant** [ ]

**Referring to the FAT Procedure and relevant documents**

***Apparecchiature utilizzate/ Equipment used:*** ***Scadenza Taratura /Expiration date***

| | |
|---|---|
| SP 118 INSULATION TESTER | 03/2025 |
| PP 120 AC DIELECTRIC TEST SET | 03/2025 |
| SP 186 MULTITEST FOR DIELCETRIC TEST | 10/2024 |
| PP 143 DIGITAL THICKNESS GAUGE | 12/2024 |
| SC 05 TEST FINGER IP2X | 07/2025 |
| SC 06 TEST FINGER IP3X | 07/2025 |
| SP 158 DIGITAL MULTIMETER | 03/2025 |
| SP 198 OMICRON RELAYS TEST SET | 12/2025 |
| SCD 59 TORQUE WRENCH (20-100Nm) | 01/2025 |
| | |
| | |
| | |

Note/ *Notes:*

SEE PUNCH LIST Report n PL-IME-2197-01

ALL protection test will be performed during SAT activities

FIRMA/ *SIGNATURE*

IMESA SPA

IMESA SPA
TESTING OFFICE

ROSETTI MARINO SPA

Liguori Stefano
01/08/2024

O.b.o. CROSSWIND

M. MARANGONI
01.08.24

| Type of switchboard: | HV SWGR / Miniver-C | Comm. : | 231151/SD | ELE Resp. : | SD | Node: | 10 |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex A | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| ELECTRICAL OPERATING TESTS (CAB) | | | UNIT: C.B. feeders | | | |
| | FUNCTION | DEVICE | *Tested Unit:* Electrolyser Package (A1) | | | |
| 1 | C.B. SPRING CHARGING MOTOR *point 4.1 FAT Proc* | MAS | ✓ | | | |
| 2 | C.B. SHUNT OPENING RELEASE *point 4.1 FAT Proc* | MBO1 MBO2 | ✓ | | | |
| 3 | C.B. CLOSING RELEASE *point 4.1 FAT Proc* | MBC | ✓ | | | |
| 4 | C.B. INHIBIT TO CLOSE *point 4.1 FAT Proc* | RLE1 | ✓ | | | |
| 5 | C.B. LOCAL CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 6 | C.B. LOCAL OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 7 | C.B. REMOTE CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 8 | C.B. REMOTE OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 9 | AUTOMATIC TRANSFER SYSTEM (If applicable) *point 4.1 FAT Proc* | - | | | ✓ | |
| 10 | MECHANICAL/ELECTRICAL TEST FOR INSERTION / DISCONNECTION OF C.B. *point 3.2 FAT Proc* | RLE2 / RLE4 | ✓ | | | |
| 11 | KEY INTERLOCKS CHECKING FOR PUTTING IN SERVICE AND OUT OF SERVICE OF THE UNIT *point 3.2 FAT Proc* | / | ✓ | | | |
| 12 | EARTHING SWITCH OPERATION LOCK (If applicable) *point 3.2 FAT Proc* | RLE3 | ✓ | | | |
| 13 | MCB AUX. CONTACTS TEST *point 3.2 FAT Proc* | / | ✓ | | | |
| 14 | AMMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TI - TO | ✓ | | | |
| 15 | VOLTMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TU | ✓ | | | |
| 16 | TEST FOR SIGNALLING LAMPS / LED *point 4.1 FAT Proc* | H... | ✓ | | | |
| 17 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD *point 3.4 FAT Proc* | XM.. | ✓ | | ✓ | |
| 18 | ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | EH1 - THR | ✓ | | | |
| 19 | EXTERNAL ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | KH / H.. | | | ✓ | |
| 20 | ARC FLASH TEST *point 4.8 FAT Proc* | SF1-2-3 | ✓ | | | |
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06 CROSWIND

ROSETTI MARINO
LANARI STEFANO
01/08/24

| Type of switchboard: | HV SWGR / Miniver-C | Comm. : | 231151/SD | ELE Resp. : | SD | Node: | 10 |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex A | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| ELECTRICAL OPERATING TESTS (CAB) | | | UNIT: Contactor Feeder | | | |
| | FUNCTION | DEVICE | *Tested Unit:* Solar Package (A2) | | | |
| 1 | CONTACTOR SHUNT OPENING/CLOSING RELEASE *point 4.1 FAT Proc* | DI2 | ✓ | | | |
| 2 | CONTACTOR INHIBIT TO CLOSE (THROUGH UNDERVOLTAGE RELEASE) *point 4.1 FAT Proc* | AA | ✓ | | | |
| 3 | CONTACTOR LOCAL CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 4 | C.B. LOCAL OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 5 | C.B. REMOTE CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 6 | C.B. REMOTE OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 7 | MECHANICAL/ELECTRICAL TEST FOR INSERTION / DISCONNECTION OF CONTACTOR *point 4.1 FAT Proc* | RLE2 / RLE4 | ✓ | | | |
| 8 | KEY INTERLOCKS CHECKING FOR PUTTING IN SERVICE AND OUT OF SERVICE OF THE UNIT *point 4.1 FAT Proc* | / | ✓ | | | |
| 9 | EARTHING SWITCH OPERATION LOCK (If applicable) *point 4.1 FAT Proc* | RLE3 | ✓ | | | |
| 10 | MCB AUX. CONTACTS TEST *point 3.2 FAT Proc* | / | ✓ | | | |
| 11 | AMMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TI - TO | ✓ | | | |
| 12 | VOLTMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TU | ✓ | | | |
| 13 | TEST FOR SIGNALLING LAMPS / LED *point 4.1 FAT Proc* | H.. | ✓ | | | |
| 14 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD *point 3.4 FAT Proc* | XM.. | ✓ | | ✓ | |
| 15 | ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | EH1 - THR | ✓ | | | |
| 16 | EXTERNAL ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | KH / HL9 | | | ✓ | |
| 17 | RTD TEST | FP1 / FP6 | ✓ | | | |
| 18 | ARC FLASH TEST *point 4.8 FAT Proc* | SF2-3 | ✓ | | | |
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obo CROSSWIND

KRISTIAN OSTERGAARD

ROSETTI MARINO
NARI STEFANO
01/08/24

| Type of switchboard: | HV SWGR / Miniver-C | Comm. : | 231151/SD | ELE Resp. : | SD | Node: | 10 |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex A | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| ELECTRICAL OPERATING TESTS (CAB) | | | UNIT: Contactor Feeder | | | |
| | FUNCTION | DEVICE | *Tested Unit:* Bess Package (A3) | | | |
| 1 | CONTACTOR SHUNT OPENING/CLOSING RELEASE *point 4.1 FAT Proc* | DI2 | ✓ | | | |
| 2 | CONTACTOR INHIBIT TO CLOSE (THROUGH UNDERVOLTAGE RELEASE) *point 4.1 FAT Proc* | AA | ✓ | | | |
| 3 | CONTACTOR LOCAL CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 4 | C.B. LOCAL OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 5 | C.B. REMOTE CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 6 | C.B. REMOTE OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 7 | MECHANICAL/ELECTRICAL TEST FOR INSERTION / DISCONNECTION OF CONTACTOR *point 4.1 FAT Proc* | RLE2 / RLE4 | ✓ | | | |
| 8 | KEY INTERLOCKS CHECKING FOR PUTTING IN SERVICE AND OUT OF SERVICE OF THE UNIT *point 4.1 FAT Proc* | / | ✓ | | | |
| 9 | EARTHING SWITCH OPERATION LOCK (If applicable) *point 4.1 FAT Proc* | RLE3 | ✓ | | | |
| 10 | MCB AUX. CONTACTS TEST *point 3.2 FAT Proc* | / | ✓ | | | |
| 11 | AMMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TI - TO | ✓ | | | |
| 12 | VOLTMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TU | ✓ | | | |
| 13 | TEST FOR SIGNALLING LAMPS / LED *point 4.1 FAT Proc* | H.. | | | | |
| 14 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD *point 3.4 FAT Proc* | XM.. | ✓ | | | |
| 15 | ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | EH1 - THR | ✓ | | | |
| 16 | EXTERNAL ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | KH / HL9 | | | ✓ | |
| 17 | RTD TEST | FP1 / FP6 | ✓ | | | |
| 18 | ARC FLASH TEST *point 4.8 FAT Proc* | SF2-3 | ✓ | | | |
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Ø60 CROSSWIND

RECUTIAN POSITIVE

ROSETTI MARINO
LUNARI STEFANO
01/08/24

| Type of switchboard: | HV SWGR / Miniver-C | Comm. : | 231151/SD | ELE Resp. : | SD | Node: | 10 |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex A | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| ELECTRICAL OPERATING TESTS (CAB) | | | UNIT: Contactor Feeder | | | |
| | FUNCTION | DEVICE | *Tested Unit:* Transformer TR-200DE1 (A4) | | | |
| 1 | CONTACTOR SHUNT OPENING/CLOSING RELEASE *point 4.1 FAT Proc* | DI2 | ✓ | | | |
| 2 | CONTACTOR INHIBIT TO CLOSE (THROUGH UNDERVOLTAGE RELEASE) *point 4.1 FAT Proc* | AA | ✓ | | | |
| 3 | CONTACTOR LOCAL CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 4 | C.B. LOCAL OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 5 | C.B. REMOTE CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 6 | C.B. REMOTE OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 7 | MECHANICAL/ELECTRICAL TEST FOR INSERTION / DISCONNECTION OF CONTACTOR *point 4.1 FAT Proc* | RLE2 / RLE4 | ✓ | | | |
| 8 | KEY INTERLOCKS CHECKING FOR PUTTING IN SERVICE AND OUT OF SERVICE OF THE UNIT *point 4.1 FAT Proc* | / | ✓ | | | |
| 9 | EARTHING SWITCH OPERATION LOCK (If applicable) *point 4.1 FAT Proc* | RLE3 | ✓ | | | |
| 10 | MCB AUX. CONTACTS TEST *point 3.2 FAT Proc* | / | ✓ | | | |
| 11 | AMMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TI - TO | ✓ | | | |
| 12 | VOLTMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TU | ✓ | | | |
| 13 | TEST FOR SIGNALLING LAMPS / LED *point 4.1 FAT Proc* | H.. | ✓ | | | |
| 14 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD *point 3.4 FAT Proc* | XM.. | ✓ | | | |
| 15 | ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | EH1 - THR | ✓ | | | |
| 16 | EXTERNAL ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | KH / HL9 | | | ✓ | |
| 17 | RTD TEST | FP1 / FP6 | ✓ | | | |
| 18 | ARC FLASH TEST *point 4.8 FAT Proc* | SF2-3 | ✓ | | | |
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obo CROSSWIND

ROSETTI MARINO
LUNARI STEFANO
01/08/24

| Type of switchboard: | HV SWGR / Miniver-C | Comm. : | 231151/SD | ELE Resp. : | SD | Node: | 10 |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex A | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| ELECTRICAL OPERATING TESTS (CAB) | | | UNIT: Contactor Feeder | | | |
| | FUNCTION | DEVICE | *Tested Unit:* METERING UNIT (A5) | | | |
| 1 | MECHANICAL TEST FOR INSERTION / DISCONNECTION OF VT TRUCK *point 4.1 FAT Proc* | - | | | | VT's box damaged |
| 2 | KEY INTERLOCKS CHECKING FOR PUTTING IN SERVICE AND OUT OF SERVICE OF THE UNIT *point 4.1 FAT Proc* | - | ✓ | | | |
| 3 | EARTHING SWITCH OPERATION LOCK *point 4.1 FAT Proc* | RLE3 | ✓ | | | |
| 4 | MCB AUX. CONTACTS TEST *point 3.2 FAT Proc* | / | ✓ | | | |
| 5 | VOLTMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TU | ✓ | | | |
| 6 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD *point 3.4 FAT Proc* | XM.. | ✓ | | | |
| 7 | ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | EH1 - THR | ✓ | | | |
| 8 | TEST FOR SIGNALLING LAMPS / LED *point 4.1 FAT Proc* | H.. | | | ✓ | |
| 9 | EXERTHERM :TEST OF ALL TEMPERATURE SIGNALS point 4.1. FAT proc | | ✓ | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | | | | | |
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ROSETTI, MARINO
LIMANI STEFANO
01/08/24

| Type of switchboard: | HV SWGR / Miniver-C | Comm. : | 231151/SD | ELE Resp. : | SD | Node: | 10 |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex A | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| ELECTRICAL OPERATING TESTS (CAB) | | | UNIT: C.B. feeders | | | |
| | FUNCTION | DEVICE | *Tested Unit:* Incoming (A6) | | | |
| 1 | C.B. SPRING CHARGING MOTOR *point 4.1 FAT Proc* | MAS | ✓ | | | |
| 2 | C.B. SHUNT OPENING RELEASE *point 4.1 FAT Proc* | MBO1 MBO2 | ✓ | | | |
| 3 | C.B. CLOSING RELEASE *point 4.1 FAT Proc* | MBC | ✓ | | | |
| 4 | C.B. INHIBIT TO CLOSE *point 4.1 FAT Proc* | RLE1 | ✓ | | | |
| 5 | C.B. LOCAL CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 6 | C.B. LOCAL OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 7 | C.B. REMOTE CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 8 | C.B. REMOTE OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 9 | AUTOMATIC TRANSFER SYSTEM (If applicable) *point 4.1 FAT Proc* | - | | | ✓ | |
| 10 | MECHANICAL/ELECTRICAL TEST FOR INSERTION / DISCONNECTION OF C.B. *point 3.2 FAT Proc* | RLE2 / RLE4 | ✓ | | | |
| 11 | KEY INTERLOCKS CHECKING FOR PUTTING IN SERVICE AND OUT OF SERVICE OF THE UNIT *point 3.2 FAT Proc* | / | ✓ | | | |
| 12 | EARTHING SWITCH OPERATION LOCK (If applicable) *point 3.2 FAT Proc* | RLE3 | ✓ | | | |
| 13 | MCB AUX. CONTACTS TEST *point 3.2 FAT Proc* | / | ✓ | | | |
| 14 | AMMETRICAL CIRCUITS (Primary Injection) *point 4.1 FAT Proc* | TI - TO | ✓ | | | |
| 15 | VOLTMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TU | ✓ | | | |
| 16 | TEST FOR SIGNALLING LAMPS / LED *point 4.1 FAT Proc* | H... | | | ✓ | |
| 17 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD *point 3.4 FAT Proc* | XM.. | ✓ | | | |
| 18 | ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | EH1 - THR | ✓ | | | |
| 19 | EXTERNAL ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | KH / H.. | | | ✓ | |
| 20 | ARC FLASH TEST *point 4.8 FAT Proc* | SF1-2-3 | ✓ | | | |
| 21 | | | | | | |
| 22 | | | | | | |
| 23 | | | | | | |
| 24 | | | | | | |

***TESTED IEC 61850: C-X1-10, C-X1-15, C-X2-1, C-X1-13, C -X1-9, C-X1-1,D-X1-11,D-X1-3***

p.o. CROSSWIND

KRISTIAN CASTELLAN

ROSETTI MARINO
LUNARI STEFANO
01/08/24

| Type of switchboard: | HV SWGR / Miniver-C | Comm. : | 231151/SD | ELE Resp. : | SD | Node: | 10 |
|---|---|---|---|---|---|---|---|
| Client: | ROSETTI MARINO | | | Annex A | | | |

| Ref. | ACTIVITY (DEPT.) | | YES | NO | N/A | REMARK |
|---|---|---|---|---|---|---|
| ELECTRICAL OPERATING TESTS (CAB) | | | UNIT: Contactor Feeder | | | |
| | FUNCTION | DEVICE | *Tested Unit:* Fuel Cell Package (A7) | | | |
| 1 | CONTACTOR SHUNT OPENING/CLOSING RELEASE *point 4.1 FAT Proc* | DI2 | ✓ | | | |
| 2 | CONTACTOR INHIBIT TO CLOSE (THROUGH UNDERVOLTAGE RELEASE) *point 4.1 FAT Proc* | AA | ✓ | | | |
| 3 | CONTACTOR LOCAL CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 4 | C.B. LOCAL OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 5 | C.B. REMOTE CLOSING *point 4.1 FAT Proc* | - | ✓ | | | |
| 6 | C.B. REMOTE OPENING *point 4.1 FAT Proc* | - | ✓ | | | |
| 7 | MECHANICAL/ELECTRICAL TEST FOR INSERTION / DISCONNECTION OF CONTACTOR *point 4.1 FAT Proc* | RLE2 / RLE4 | ✓ | | | |
| 8 | KEY INTERLOCKS CHECKING FOR PUTTING IN SERVICE AND OUT OF SERVICE OF THE UNIT *point 4.1 FAT Proc* | / | ✓ | | | |
| 9 | EARTHING SWITCH OPERATION LOCK (If applicable) *point 4.1 FAT Proc* | RLE3 | ✓ | | | |
| 10 | MCB AUX. CONTACTS TEST *point 3.2 FAT Proc* | / | ✓ | | | |
| 11 | AMMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TI - TO | ✓ | | | |
| 12 | VOLTMETRICAL CIRCUITS (Secondary Injection) *point 4.1 FAT Proc* | TU | ✓ | | | |
| 13 | TEST FOR SIGNALLING LAMPS / LED *point 4.1 FAT Proc* | H.. | ✓ | | | |
| 14 | AVAILABLE SIGNALS AND CONTACTS AT THE TERMINAL BOARD *point 3.4 FAT Proc* | XM.. | ✓ | | | |
| 15 | ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | EH1 - THR | ✓ | | | |
| 16 | EXTERNAL ANTICONDENSATION HEATING CIRCUIT *point 4.1 FAT Proc* | KH / HL9 | | | ✓ | |
| 17 | RTD TEST | FP1 / FP6 | ✓ | | | |
| 18 | ARC FLASH TEST *point 4.8 FAT Proc* | SF2-3 | ✓ | | | |
| 19 | | | | | | |
| 20 | | | | | | |
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dbo C.ROSSWIND

KRISTIAN CANTELLANI

ROSETTI MARINO
LIVIANI STEFANO
01/08/24

### 2.5.2.2. Circuit Breakers & Contactors Test Reports

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ABB SPA - POWER PRODUCTS DIVISION
Via Vittorio Pisani , 16 - 20124 Milano

| | | | |
|---|---|---|---|
| **CONFIRMATION** | 1240093780 | **ITEM** | 13900 |
| **CUSTOMER** | I.M.E.S.A. SPA | | |
| **CUSTOMER ORDER** | 890 | **QUANTITY** | 1 |

# VACUUM - CIRCUIT BREAKER

| | |
|---|---|
| **TYPE** | VD4/P 12.06.25 |
| **SERIAL NUMBER** | 1VC1CE00021446 |

## RATINGS

| | | | |
|---|---|---|---|
| Rated Voltage | **Ur** | **12** | **KV** |
| Rated insulation Voltage | **Us** | **12** | **KV** |
| Withstand voltage at 50 HZ - 1 min | **Ud** | **28** | **KV** |
| Impulse Withstand voltage | **Up** | **75** | **KV** |
| Rated frequency | **Fr** | **50/60** | **Hz** |
| Rated Normal current (40°C) | **Ir** | **630** | **A** |
| Rated breaking capacity | **Isc** | **25** | **KA** |
| Rated short time withstands current (3s) | **Ik** | **25** | **KA** |
| Making capacity | **Ip** | **63** | **KA** |
| Operation sequence | | **O-0,3S-CO-15S-CO** | |

## Accessories C.B.

| | | | | |
|---|---|---|---|---|
| Spring charging geared motor | **(-MAS)** | **110** | **V** | **AC** |
| Shunt opening release | **(-MBO1)** | **110** | **V** | **DC** |
| Add shunt opening release | **(-MBO2)** | | **V** | |
| Opening solenoid | **(-MBO3)** | | **V** | |
| Shunt closing release | **(-MBC)** | **110...127** | **V** | **AC/DC** |
| Undervoltage release | **(-MBU)** | **110...127** | **V** | **AC/DC** |
| Locking magnet | **(-RLE1)** | **110...127** | **V** | **AC/DC** |
| Add shunt opening release | **(-MBO4)** | | **V** | |

## Accessories On Truck

| | | | | |
|---|---|---|---|---|
| Locking magnet | **(-RLE2)** | **110** | **V** | **DC** |
| Motor moving truck | **(-MAT)** | | **V** | |

## Individual tests according to IEC 62271-100

| | |
|---|---|
| **Design and visual check** | **OK** |

| Mechanical and electrical operating tests | | | | |
|---|---|---|---|---|
| **5 O/C operations at rated supply Voltage** | **5 O/C operations at max. supply Voltage** | **5 O/C operations at min. supply Voltage** | **5 O/C operating cycles with -MC energized** | **5 sequences O-t-C** |
| **OK** | **OK** | **OK** | **OK** | **OK** |

## Power frequency voltage withstand test

| | | |
|---|---|---|
| **Main circuits** | 28 | **KV applied for 1 min** |
| **Auxiliary circuits** | 1 | **KV applied for 1 sec** |

**Voltage drop test with 200A DC**

| | **R** | **S** | **T** | |
|---|---|---|---|---|
| **Drop Voltage Measured (mV)** | **4.8** | **4.7** | **4.8** | **Max 6,7 mV** |

## Contact speed measured

| | | |
|---|---|---|
| **Closing speed** | 1.08 | **Range 0,9 - 1,2 m/sec** |
| **Opening speed** | 1.21 | **Range 1 - 1,3 m/sec** |
| **Main contacts simultaneity check** | 0.20 | Max 2 ms |
| **Direct Envelope Comparison** | **OK** | **Max +/- 2mm from the standard** |

## Operating time at rated voltage applied

| | **Min. Vn** | **Vn** | **Max Vn** | **Range Vn** |
|---|---|---|---|---|
| **Closing Time** | 52 | 50 | 48 | **35 - 60 ms** |
| **Opening Time** | 64 | 37 | 35 | **33 - 60 ms** |

## The circuit breaker has passed the tests

| **Department** | **Date** | **Quality Result** |
|---|---|---|
| **OAQ** | 20240430 | **Passed** |

**Doc n° 1VC1CE00021446**

ABB SPA - POWER PRODUCTS DIVISION
Via Vittorio Pisani , 16 - 20124 Milano

| | | | |
|---|---|---|---|
| **CONFIRMATION** | 1240093780 | **ITEM** | 13900 |
| **CUSTOMER** | I.M.E.S.A. SPA | | |
| **CUSTOMER ORDER** | 890 | **QUANTITY** | 1 |

# VACUUM - CIRCUIT BREAKER

| | |
|---|---|
| **TYPE** | VD4/P 12.06.25 |
| **SERIAL NUMBER** | 1VC1CE00021447 |

## RATINGS

| | | | |
|---|---|---|---|
| Rated Voltage | **Ur** | **12** | **KV** |
| Rated insulation Voltage | **Us** | **12** | **KV** |
| Withstand voltage at 50 HZ - 1 min | **Ud** | **28** | **KV** |
| Impulse Withstand voltage | **Up** | **75** | **KV** |
| Rated frequency | **Fr** | **50/60** | **Hz** |
| Rated Normal current (40°C) | **Ir** | **630** | **A** |
| Rated breaking capacity | **Isc** | **25** | **KA** |
| Rated short time withstands current (3s) | **Ik** | **25** | **KA** |
| Making capacity | **Ip** | **63** | **KA** |
| Operation sequence | | **O-0,3S-CO-15S-CO** | |

## Accessories C.B.

| | | | | |
|---|---|---|---|---|
| Spring charging geared motor | **(-MAS)** | **110** | **V** | **AC** |
| Shunt opening release | **(-MBO1)** | **110** | **V** | **DC** |
| Add shunt opening release | **(-MBO2)** | | **V** | |
| Opening solenoid | **(-MBO3)** | | **V** | |
| Shunt closing release | **(-MBC)** | **110...127** | **V** | **AC/DC** |
| Undervoltage release | **(-MBU)** | **110...127** | **V** | **AC/DC** |
| Locking magnet | **(-RLE1)** | **110...127** | **V** | **AC/DC** |
| Add shunt opening release | **(-MBO4)** | | **V** | |

## Accessories On Truck

| | | | | |
|---|---|---|---|---|
| Locking magnet | **(-RLE2)** | **110** | **V** | **DC** |
| Motor moving truck | **(-MAT)** | | **V** | |

## Individual tests according to IEC 62271-100

| | |
|---|---|
| **Design and visual check** | **OK** |

| **Mechanical and electrical operating tests** | | | | |
|---|---|---|---|---|
| **5 O/C operations at rated supply Voltage** | **5 O/C operations at max. supply Voltage** | **5 O/C operations at min. supply Voltage** | **5 O/C operating cycles with -MC energized** | **5 sequences O-t-C** |
| **OK** | **OK** | **OK** | **OK** | **OK** |

## Power frequency voltage withstand test

| | | |
|---|---|---|
| **Main circuits** | 28 | **KV applied for 1 min** |
| **Auxiliary circuits** | 1 | **KV applied for 1 sec** |

**Voltage drop test with 200A DC**

| | **R** | **S** | **T** | |
|---|---|---|---|---|
| **Drop Voltage Measured (mV)** | **5.7** | **5.8** | **5.9** | **Max 6,7 mV** |

## Contact speed measured

| | | |
|---|---|---|
| **Closing speed** | 1.09 | **Range 0,9 - 1,2 m/sec** |
| **Opening speed** | 1.25 | **Range 1 - 1,3 m/sec** |
| **Main contacts simultaneity check** | 0.10 | Max 2 ms |
| **Direct Envelope Comparison** | **OK** | **Max +/- 2mm from the standard** |

## Operating time at rated voltage applied

| | **Min. Vn** | **Vn** | **Max Vn** | **Range Vn** |
|---|---|---|---|---|
| **Closing Time** | 51 | 49 | 47 | **35 - 60 ms** |
| **Opening Time** | 61 | 38 | 34 | **33 - 60 ms** |

## The circuit breaker has passed the tests

| **Department** | **Date** | **Quality Result** |
|---|---|---|
| **OAQ** | 20240430 | **Passed** |

**Doc n° 1VC1CE00021447**

ABB SPA - POWER PRODUCTS DIVISION
Via Vittorio Pisani , 16 - 20124 Milano

| | | | |
|---|---|---|---|
| **CONFIRMATION** | 1240093780 | **ITEM** | 7200 |
| **CUSTOMER** | I.M.E.S.A. SPA | | |
| **CUSTOMER ORDER** | 890 | **QUANTITY** | 1 |

# Medium Voltage Vacuum Contactor

| | |
|---|---|
| **TYPE** | V-Contact VSC7/P DCO |
| **SERIAL NUMBER** | 1VC1CE00021739 |

## RATINGS

| | | | | |
|---|---|---|---|---|
| Rated Voltage | **Ur** | **7,2** | **KV** | |
| Rated insulation Voltage | **Us** | | **KV** | |
| Withstand voltage at 50 HZ - 1 min | **Ud** | **20** | **KV** | |
| Impulse Withstand voltage | **Up** | **60** | **KV** | |
| Rated frequency | **Fr** | **50/60** | **Hz** | |

## Accessories on Contactor

| | |
|---|---|
| Electronic Device | **110 V DC** |

## Accessories On Truck

| | | | | |
|---|---|---|---|---|
| Locking magnet | **(-RLE2)** | **110** | **V** | **DC** |
| Motor moving truck | **(-MAT)** | | **V** | |

## Individual tests according to IEC 62271-106 or GB/T 14808

| | |
|---|---|
| **Design and visual check** | **OK** |

**Mechanical and electrical operating tests**

| 5 O/C operations at rated supply Voltage | 5 O/C operations at max. supply Voltage | 5 O/C operations at min. supply Voltage | 5 Tripping ops by manual emergency lever | 5 Tripping ops by fuse striker |
|---|---|---|---|---|
| **OK** | **OK** | **OK** | **OK** | **OK** |

## Power frequency voltage withstand test

| | | |
|---|---|---|
| **Main circuits** | 20 | **KV applied for 1 min** |
| **Auxiliary circuits** | 1 | **KV applied for 1 sec** |

**Voltage drop test with 200A DC**

| | R | S | T | |
|---|---|---|---|---|
| **Drop Voltage Measured (mV)** | 47 | 47 | 47 | **Max 56 mV** |

## Contact speed measured

| | | |
|---|---|---|
| **Closing speed** | 0.73 | **Range 0,5 - 0,9 m/sec** |
| **Opening speed** | 0.54 | **Range 0,5 - 0,9 m/sec** |
| **Main cont. simultaneity in closing** | 0.37 | **Max 1 ms** |
| **Direct Envelope Comparison** | **OK** | **Max +/- 5 % from the standard** |

## The Contactor has passed the tests

| Department | Date | Quality Result |
|---|---|---|
| **OAQ** | **23.04.2024** | **Passed** |

**Doc n° 1VC1CE00021739**

ABB SPA - POWER PRODUCTS DIVISION
Via Vittorio Pisani , 16 - 20124 Milano

| | | | |
|---|---|---|---|
| **CONFIRMATION** | 1240093780 | **ITEM** | 7200 |
| **CUSTOMER** | I.M.E.S.A. SPA | | |
| **CUSTOMER ORDER** | 890 | **QUANTITY** | 1 |

# Medium Voltage Vacuum Contactor

| | |
|---|---|
| **TYPE** | V-Contact VSC7/P DCO |
| **SERIAL NUMBER** | 1VC1CE00021740 |

## RATINGS

| | | | | |
|---|---|---|---|---|
| Rated Voltage | **Ur** | **7,2** | **KV** | |
| Rated insulation Voltage | **Us** | | **KV** | |
| Withstand voltage at 50 HZ - 1 min | **Ud** | **20** | **KV** | |
| Impulse Withstand voltage | **Up** | **60** | **KV** | |
| Rated frequency | **Fr** | **50/60** | **Hz** | |

## Accessories on Contactor

| | |
|---|---|
| Electronic Device | **110 V DC** |

## Accessories On Truck

| | | | | |
|---|---|---|---|---|
| Locking magnet | **(-RLE2)** | **110** | **V** | **DC** |
| Motor moving truck | **(-MAT)** | | **V** | |

## Individual tests according to IEC 62271-106 or GB/T 14808

| | |
|---|---|
| **Design and visual check** | **OK** |

**Mechanical and electrical operating tests**

| 5 O/C operations at rated supply Voltage | 5 O/C operations at max. supply Voltage | 5 O/C operations at min. supply Voltage | 5 Tripping ops by manual emergency lever | 5 Tripping ops by fuse striker |
|---|---|---|---|---|
| **OK** | **OK** | **OK** | **OK** | **OK** |

## Power frequency voltage withstand test

| | | |
|---|---|---|
| **Main circuits** | 20 | **KV applied for 1 min** |
| **Auxiliary circuits** | 1 | **KV applied for 1 sec** |

**Voltage drop test with 200A DC**

| | R | S | T | |
|---|---|---|---|---|
| **Drop Voltage Measured (mV)** | **48** | **53** | **47** | **Max 56 mV** |

## Contact speed measured

| | | |
|---|---|---|
| **Closing speed** | 0.84 | **Range 0,5 - 0,9 m/sec** |
| **Opening speed** | 0.59 | **Range 0,5 - 0,9 m/sec** |
| **Main cont. simultaneity in closing** | 0.35 | **Max 1 ms** |
| **Direct Envelope Comparison** | **OK** | **Max +/- 5 % from the standard** |

## The Contactor has passed the tests

| Department | Date | Quality Result |
|---|---|---|
| **OAQ** | **20240423** | **Passed** |

**Doc n° 1VC1CE00021740**

ABB SPA - POWER PRODUCTS DIVISION
Via Vittorio Pisani , 16 - 20124 Milano

| | | | |
|---|---|---|---|
| **CONFIRMATION** | 1240093780 | **ITEM** | 7200 |
| **CUSTOMER** | I.M.E.S.A. SPA | | |
| **CUSTOMER ORDER** | 890 | **QUANTITY** | 1 |

# Medium Voltage Vacuum Contactor

| | |
|---|---|
| **TYPE** | V-Contact VSC7/P DCO |
| **SERIAL NUMBER** | 1VC1CE00021741 |

## RATINGS

| | | | | |
|---|---|---|---|---|
| Rated Voltage | **Ur** | **7,2** | **KV** | |
| Rated insulation Voltage | **Us** | | **KV** | |
| Withstand voltage at 50 HZ - 1 min | **Ud** | **20** | **KV** | |
| Impulse Withstand voltage | **Up** | **60** | **KV** | |
| Rated frequency | **Fr** | **50/60** | **Hz** | |

## Accessories on Contactor

| | |
|---|---|
| Electronic Device | **110 V DC** |

## Accessories On Truck

| | | | | |
|---|---|---|---|---|
| Locking magnet | **(-RLE2)** | **110** | **V** | **DC** |
| Motor moving truck | **(-MAT)** | | **V** | |

## Individual tests according to IEC 62271-106 or GB/T 14808

| | |
|---|---|
| **Design and visual check** | **OK** |

**Mechanical and electrical operating tests**

| 5 O/C operations at rated supply Voltage | 5 O/C operations at max. supply Voltage | 5 O/C operations at min. supply Voltage | 5 Tripping ops by manual emergency lever | 5 Tripping ops by fuse striker |
|---|---|---|---|---|
| **OK** | **OK** | **OK** | **OK** | **OK** |

## Power frequency voltage withstand test

| | | |
|---|---|---|
| **Main circuits** | 20 | **KV applied for 1 min** |
| **Auxiliary circuits** | 1 | **KV applied for 1 sec** |

**Voltage drop test with 200A DC**

| | R | S | T | |
|---|---|---|---|---|
| **Drop Voltage Measured (mV)** | **47** | **51** | **46** | **Max 56 mV** |

## Contact speed measured

| | | |
|---|---|---|
| **Closing speed** | 0.81 | **Range 0,5 - 0,9 m/sec** |
| **Opening speed** | 0.59 | **Range 0,5 - 0,9 m/sec** |
| **Main cont. simultaneity in closing** | 0.33 | **Max 1 ms** |
| **Direct Envelope Comparison** | **OK** | **Max +/- 5 % from the standard** |

## The Contactor has passed the tests

| Department | Date | Quality Result |
|---|---|---|
| **OAQ** | **20240423** | **Passed** |

**Doc n° 1VC1CE00021741**

ABB SPA - POWER PRODUCTS DIVISION
Via Vittorio Pisani , 16 - 20124 Milano

| | | | |
|---|---|---|---|
| **CONFIRMATION** | 1240093780 | **ITEM** | 7200 |
| **CUSTOMER** | I.M.E.S.A. SPA | | |
| **CUSTOMER ORDER** | 890 | **QUANTITY** | 1 |

# Medium Voltage Vacuum Contactor

| | |
|---|---|
| **TYPE** | V-Contact VSC7/P DCO |
| **SERIAL NUMBER** | 1VC1CE00021742 |

## RATINGS

| | | | | |
|---|---|---|---|---|
| Rated Voltage | **Ur** | **7,2** | **KV** | |
| Rated insulation Voltage | **Us** | | **KV** | |
| Withstand voltage at 50 HZ - 1 min | **Ud** | **20** | **KV** | |
| Impulse Withstand voltage | **Up** | **60** | **KV** | |
| Rated frequency | **Fr** | **50/60** | **Hz** | |

## Accessories on Contactor

| | |
|---|---|
| Electronic Device | **110 V DC** |

## Accessories On Truck

| | | | | |
|---|---|---|---|---|
| Locking magnet | **(-RLE2)** | **110** | **V** | **DC** |
| Motor moving truck | **(-MAT)** | | **V** | |

## Individual tests according to IEC 62271-106 or GB/T 14808

| | |
|---|---|
| **Design and visual check** | **OK** |

**Mechanical and electrical operating tests**

| 5 O/C operations at rated supply Voltage | 5 O/C operations at max. supply Voltage | 5 O/C operations at min. supply Voltage | 5 Tripping ops by manual emergency lever | 5 Tripping ops by fuse striker |
|---|---|---|---|---|
| **OK** | **OK** | **OK** | **OK** | **OK** |

## Power frequency voltage withstand test

| | | |
|---|---|---|
| **Main circuits** | 20 | **KV applied for 1 min** |
| **Auxiliary circuits** | 1 | **KV applied for 1 sec** |

**Voltage drop test with 200A DC**

| | R | S | T | |
|---|---|---|---|---|
| **Drop Voltage Measured (mV)** | **53** | **47** | **50** | **Max 56 mV** |

## Contact speed measured

| | | |
|---|---|---|
| **Closing speed** | 0.81 | **Range 0,5 - 0,9 m/sec** |
| **Opening speed** | 0.56 | **Range 0,5 - 0,9 m/sec** |
| **Main cont. simultaneity in closing** | 0.10 | **Max 1 ms** |
| **Direct Envelope Comparison** | **OK** | **Max +/- 5 % from the standard** |

## The Contactor has passed the tests

| Department | Date | Quality Result |
|---|---|---|
| **OAQ** | **20240424** | **Passed** |

**Doc n° 1VC1CE00021742**

| ABB S.p.A.<br>POWER PRODUCTS DIVISION | CERTIFICATO DI COLLAUDO<br>TEST CERTIFICATE | | |
|---|---|---|---|
| | **Nr.** 00075996 | **Data/Date** 16.04.24 | **Page** 1 **of** 2 |

CONFIRMATION 1240093780

ORDER 890

CUSTOMER I.M.E.S.A. SPA

**VIA G.DI VITTORIO,14 60035 JESI**

**GENERAL TESTS AND INSPECTION WITNESSED BY :**

| **MR.** | **FIRM** | **QUALITY RESULT** |
|---|---|---|
| | ABB S.p.A. | PASSED |
| | | |
| | | |

**MATERIAL TESTED ACCORDING TO IEC 62271-200**

**ITEM 004900 NR. 1**

NAMEPLATES IN ENGLISH LANGUAGE
TEST CERTIFICATE FOR PB IN ENGLISH LANGUAGE
PACKING VIA LAND
PB FOR NEW VD4 <= 40 KA
OPENING PUSH-BUTTON PAINTED DOOR
ST-E 17.31 150 EARTHING SWITCH
KEY LOCK PREVENTING CIRCUIT BREAKER RACKING-IN WITH EARTHING SWITCH
KEY LOCK IN CLOSED/OPEN POSITION FOR EARTHING SWITCH
ELECTROMECHANICAL LOCK FOR EARTHING SWITCH 110V DC
5 AUXILIARY CONTACTS FOR EARTHING SWITCH
58 POLE CONNECTOR + SELF-EXTINGUISHING WIRING L=0,8M
5NO+5NC AUXILIARY CONTACTS FOR CIRCUIT BREAKER SERVICE POSITION AND 5NO+5NC AUXILIARY
CONTACTS FOR CIRCUIT BREAKER INSULATED POSITION
FAIL-SAFE F.SHUTTER ELEMENTS
ELECTROMECHANICAL ISOLATING INTERLOCK CIRCUITBREAKER/DOOR 110V DC
INTERLOCK FOR DOOR EARTHING SWITCH
EARTHING SWITCH OPERATING LEVER
QUANTITY OF OPERATING LEVER = QUANTITY OF ENCLOSURES
ELECTRICAL DIAGRAM 1VCD400082 (V5421) FIG.01 FIG.03 FIG.20 FIG.21 FIG.23

SERIAL NUMBER
1VC1CE00020065

**DESIGN AND VISUAL CHECKS**

THE COMPLIANCE WITH THE ORDER SPECIFICATION AND THE RELEVANT STANDARDS WAS CHECKED.
NO DEFECTS IN MATERIAL, TREATMENT AND WORKMANSHIP WERE VERIFIED.

**MECHANICAL WORKING**

THE MECHANICAL WORKING OF THE APPARATUS WAS CHECKED BY CARRING OUT SUCCESSIVELY N. 5 INSERTION AND DRAWOUT OPERATIONS OF THE BREAKER.
DURING THESE OPERATIONS,THE INTERLOCKS WERE CHECKED MAKING 5 ATTEMPTS TO PERFORM THE OPERATION INTENDED TO BE PREVENTED.

| ABB S.p.A.<br>POWER PRODUCTS DIVISION | CERTIFICATO DI COLLAUDO<br>TEST CERTIFICATE | | |
|---|---|---|---|
| | **Nr.** 00075997 | **Data/Date** 16.04.24 | **Page** 1 **of** 2 |

CONFIRMATION 1240093780

ORDER 890

CUSTOMER I.M.E.S.A. SPA

**VIA G.DI VITTORIO,14 60035 JESI**

**GENERAL TESTS AND INSPECTION WITNESSED BY :**

| **MR.** | **FIRM** | **QUALITY RESULT** |
|---|---|---|
| | ABB S.p.A. | PASSED |
| | | |
| | | |

**MATERIAL TESTED ACCORDING TO IEC 62271-200**

**ITEM 002600 NR. 1**

NAMEPLATES IN ENGLISH LANGUAGE
TEST CERTIFICATE FOR PB IN ENGLISH LANGUAGE
PACKING VIA LAND
PB FOR NEW VD4 <= 40 KA
OPENING PUSH-BUTTON PAINTED DOOR
ST-E 17.31 150 EARTHING SWITCH
KEY LOCK PREVENTING CIRCUIT BREAKER RACKING-IN WITH EARTHING SWITCH
KEY LOCK IN CLOSED/OPEN POSITION FOR EARTHING SWITCH
ELECTROMECHANICAL LOCK FOR EARTHING SWITCH 110V DC
10 AUXILIARY CONTACTS FOR EARTHING SWITCH
58 POLE CONNECTOR + SELF-EXTINGUISHING WIRING L=0,8M
5NO+5NC AUXILIARY CONTACTS FOR CIRCUIT BREAKER SERVICE POSITION AND 5NO+5NC AUXILIARY
CONTACTS FOR CIRCUIT BREAKER INSULATED POSITION
FAIL-SAFE F.SHUTTER ELEMENTS
ELECTROMECHANICAL ISOLATING INTERLOCK CIRCUITBREAKER/DOOR 110V DC
INTERLOCK FOR DOOR EARTHING SWITCH
EARTHING SWITCH OPERATING LEVER
QUANTITY OF OPERATING LEVER = QUANTITY OF ENCLOSURES
ELECTRICAL DIAGRAM 1VCD400082 (V5421) FIG.01 FIG.03 FIG.20 FIG.21 FIG.22 FIG.23

SERIAL NUMBER
1VC1CE00020058

**DESIGN AND VISUAL CHECKS**

THE COMPLIANCE WITH THE ORDER SPECIFICATION AND THE RELEVANT STANDARDS WAS CHECKED.
NO DEFECTS IN MATERIAL, TREATMENT AND WORKMANSHIP WERE VERIFIED.

**MECHANICAL WORKING**

THE MECHANICAL WORKING OF THE APPARATUS WAS CHECKED BY CARRING OUT SUCCESSIVELY N. 5 INSERTION AND DRAWOUT OPERATIONS OF THE BREAKER.
DURING THESE OPERATIONS,THE INTERLOCKS WERE CHECKED MAKING 5 ATTEMPTS TO PERFORM THE OPERATION INTENDED TO BE PREVENTED.

CONFIRMATION 1240093780

ORDER 890

CUSTOMER I.M.E.S.A. SPA

**VIA G.DI VITTORIO,14 60035 JESI**

**GENERAL TESTS AND INSPECTION WITNESSED BY :**

| MR. | FIRM | QUALITY RESULT |
|---|---|---|
| | ABB S.p.A. | PASSED |
| | | |
| | | |

**MATERIAL TESTED ACCORDING TO IEC 62271-200**

**ITEM 009500 NR. 4**

NAMEPLATES IN ENGLISH LANGUAGE
TEST CERTIFICATE FOR PB IN ENGLISH LANGUAGE
PACKING VIA LAND
PB FOR VSC
PAINTED DOOR
ST-E 17.31 150 EARTHING SWITCH
KEY LOCK PREVENTING CIRCUIT BREAKER RACKING-IN WITH EARTHING SWITCH
KEY LOCK IN CLOSED/OPEN POSITION FOR EARTHING SWITCH
ELECTROMECHANICAL LOCK FOR EARTHING SWITCH 110V DC
5 AUXILIARY CONTACTS FOR EARTHING SWITCH
58 POLE CONNECTOR + SELF-EXTINGUISHING WIRING L=0,8M
5NO+5NC AUXILIARY CONTACTS FOR CIRCUIT BREAKER SERVICE POSITION AND 5NO+5NC AUXILIARY
CONTACTS FOR CIRCUIT BREAKER INSULATED POSITION
FAIL-SAFE F.SHUTTER ELEMENTS
ELECTROMECHANICAL ISOLATING INTERLOCK CIRCUITBREAKER/DOOR 110V DC
INTERLOCK FOR DOOR EARTHING SWITCH
EARTHING SWITCH OPERATING LEVER
QUANTITY OF OPERATING LEVER = QUANTITY OF ENCLOSURES
ELECTRICAL DIAGRAM 1VCD400082 (V5421) FIG.01 FIG.03 FIG.20 FIG.21 FIG.23

SERIAL NUMBER
1VC1CE00021044 1VC1CE00021045 1VC1CE00021046 1VC1CE00021047

**DESIGN AND VISUAL CHECKS**

THE COMPLIANCE WITH THE ORDER SPECIFICATION AND THE RELEVANT STANDARDS WAS CHECKED.
NO DEFECTS IN MATERIAL, TREATMENT AND WORKMANSHIP WERE VERIFIED.

**MECHANICAL WORKING**

THE MECHANICAL WORKING OF THE APPARATUS WAS CHECKED BY CARRING OUT SUCCESSIVELY N. 5 INSERTION AND DRAWOUT OPERATIONS OF THE BREAKER.
DURING THESE OPERATIONS,THE INTERLOCKS WERE CHECKED MAKING 5 ATTEMPTS TO PERFORM THE OPERATION INTENDED TO BE PREVENTED.

### 2.5.2.3. Protection Relays Test Reports

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# ROUTINE TEST REPORT

**Product type:** REX640
**Date tested:** 10.05.2024
**Serial No:** 1VHR81041854
**Order No:** REX640_1AC2
**Rated frequency:** 50/60 Hz

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   - Dielectric test for binary/analog input module and power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED
   - Dielectric test for communication module at 0,55kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED

2. Final product testing including the relevant tests depending on the hardware composition:
   - Visual inspection — PASSED
   - Current consumption test — PASSED
   - Communication interfaces — PASSED
   - Binary inputs and binary outputs — PASSED
   - Analog inputs — PASSED

3. Product test run
   - Minimum 12h test run in heat cabinet in 55 degree Celsius — PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| Unit type | Serial No | Slot | Type |
|---|---|---|---|
| PSM1003 | 1VH341219384 | G | 2RCA034470A0001H |
| COM1001 | 1VH341254215 | A2 | 2RCA034478A0001L |
| AIM1001 | 1VH341244318 | E | 2RCA034442A0001H |
| AIM1001 | 1VH341244317 | F | 2RCA034442A0001H |
| BIO1001 | 1VH341249632 | B | 2RCA034506A0001G |
| BIO1001 | 1VH341247120 | C | 2RCA034506A0001G |
| BIO1002 | 1VH341253352 | D | 2RCA034536A0001F |
| ARC1001 | 1VH341251229 | A1 | 2RCA032261A0001G |
| BPL1001 | 1VH341244542 | BPL | 2RCA034437A0001H |
| CPU1001 | 1VH341253713 | CPU | 2RCA036414A0001J |

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# ROUTINE TEST REPORT

**Product type:** REX640
**Date tested:** 10.05.2024
**Serial No:** 1VHR81041855
**Order No:** REX640_1AC2
**Rated frequency:** 50/60 Hz

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   - Dielectric test for binary/analog input module and power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED
   - Dielectric test for communication module at 0,55kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED

2. Final product testing including the relevant tests depending on the hardware composition:
   - Visual inspection — PASSED
   - Current consumption test — PASSED
   - Communication interfaces — PASSED
   - Binary inputs and binary outputs — PASSED
   - Analog inputs — PASSED

3. Product test run
   - Minimum 12h test run in heat cabinet in 55 degree Celsius — PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| Unit type | Serial No | Slot | Type |
|---|---|---|---|
| PSM1003 | 1VH341219388 | G | 2RCA034470A0001H |
| COM1001 | 1VH341254199 | A2 | 2RCA034478A0001L |
| AIM1001 | 1VH341244208 | E | 2RCA034442A0001H |
| AIM1001 | 1VH341244319 | F | 2RCA034442A0001H |
| BIO1001 | 1VH341247062 | B | 2RCA034506A0001G |
| BIO1001 | 1VH341247135 | C | 2RCA034506A0001G |
| BIO1002 | 1VH341253348 | D | 2RCA034536A0001F |
| ARC1001 | 1VH341251246 | A1 | 2RCA032261A0001G |
| BPL1001 | 1VH341244550 | BPL | 2RCA034437A0001H |
| CPU1001 | 1VH341253722 | CPU | 2RCA036414A0001J |

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# ROUTINE TEST REPORT

**Product type:** REX640
**Date tested:** 10.05.2024
**Serial No:** 1VHR81041856
**Order No:** REX640_1AC2
**Rated frequency:** 50/60 Hz

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   - Dielectric test for binary/analog input module and power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED
   - Dielectric test for communication module at 0,55kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED

2. Final product testing including the relevant tests depending on the hardware composition:
   - Visual inspection — PASSED
   - Current consumption test — PASSED
   - Communication interfaces — PASSED
   - Binary inputs and binary outputs — PASSED
   - Analog inputs — PASSED

3. Product test run
   - Minimum 12h test run in heat cabinet in 55 degree Celsius — PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| Unit type | Serial No | Slot | Type |
|---|---|---|---|
| PSM1003 | 1VH341219400 | G | 2RCA034470A0001H |
| COM1001 | 1VH341254202 | A2 | 2RCA034478A0001L |
| AIM1001 | 1VH341244843 | E | 2RCA034442A0001H |
| AIM1001 | 1VH341244839 | F | 2RCA034442A0001H |
| BIO1001 | 1VH341247127 | B | 2RCA034506A0001G |
| BIO1001 | 1VH341247119 | C | 2RCA034506A0001G |
| BIO1002 | 1VH341253356 | D | 2RCA034536A0001F |
| ARC1001 | 1VH341251261 | A1 | 2RCA032261A0001G |
| BPL1001 | 1VH341244883 | BPL | 2RCA034437A0001H |
| CPU1001 | 1VH341253721 | CPU | 2RCA036414A0001J |

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# ROUTINE TEST REPORT

**Product type:** REX640
**Date tested:** 10.05.2024
**Serial No:** 1VHR81041857
**Order No:** REX640_1AC2
**Rated frequency:** 50/60 Hz

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   - Dielectric test for binary/analog input module and power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED
   - Dielectric test for communication module at 0,55kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED

2. Final product testing including the relevant tests depending on the hardware composition:
   - Visual inspection — PASSED
   - Current consumption test — PASSED
   - Communication interfaces — PASSED
   - Binary inputs and binary outputs — PASSED
   - Analog inputs — PASSED

3. Product test run
   - Minimum 12h test run in heat cabinet in 55 degree Celsius — PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| Unit type | Serial No | Slot | Type |
|---|---|---|---|
| PSM1003 | 1VH341219369 | G | 2RCA034470A0001H |
| COM1001 | 1VH341254200 | A2 | 2RCA034478A0001L |
| AIM1001 | 1VH341244789 | E | 2RCA034442A0001H |
| AIM1001 | 1VH341244787 | F | 2RCA034442A0001H |
| BIO1001 | 1VH341247121 | B | 2RCA034506A0001G |
| BIO1001 | 1VH341247130 | C | 2RCA034506A0001G |
| BIO1002 | 1VH341253361 | D | 2RCA034536A0001F |
| ARC1001 | 1VH341251244 | A1 | 2RCA032261A0001G |
| BPL1001 | 1VH341244547 | BPL | 2RCA034437A0001H |
| CPU1001 | 1VH341253725 | CPU | 2RCA036414A0001J |

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# ROUTINE TEST REPORT

**Product type:** REX640
**Date tested:** 10.05.2024
**Serial No:** 1VHR81041858
**Order No:** REX640_1AC2
**Rated frequency:** 50/60 Hz

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   - Dielectric test for binary/analog input module and power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED
   - Dielectric test for communication module at 0,55kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED

2. Final product testing including the relevant tests depending on the hardware composition:
   - Visual inspection — PASSED
   - Current consumption test — PASSED
   - Communication interfaces — PASSED
   - Binary inputs and binary outputs — PASSED
   - Analog inputs — PASSED

3. Product test run
   - Minimum 12h test run in heat cabinet in 55 degree Celsius — PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| Unit type | Serial No | Slot | Type |
|---|---|---|---|
| PSM1003 | 1VH341219358 | G | 2RCA034470A0001H |
| COM1001 | 1VH341254193 | A2 | 2RCA034478A0001L |
| AIM1001 | 1VH341244788 | E | 2RCA034442A0001H |
| AIM1001 | 1VH341244337 | F | 2RCA034442A0001H |
| BIO1001 | 1VH341247124 | B | 2RCA034506A0001G |
| BIO1001 | 1VH341254410 | C | 2RCA034506A0001G |
| BIO1002 | 1VH341253310 | D | 2RCA034536A0001F |
| ARC1001 | 1VH341251233 | A1 | 2RCA032261A0001G |
| BPL1001 | 1VH341244982 | BPL | 2RCA034437A0001H |
| CPU1001 | 1VH341253729 | CPU | 2RCA036414A0001J |

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# ROUTINE TEST REPORT

**Product type:** REX640
**Date tested:** 10.05.2024
**Serial No:** 1VHR81041859
**Order No:** REX640_1AC2
**Rated frequency:** 50/60 Hz

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   - Dielectric test for binary/analog input module and power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED
   - Dielectric test for communication module at 0,55kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) — PASSED

2. Final product testing including the relevant tests depending on the hardware composition:
   - Visual inspection — PASSED
   - Current consumption test — PASSED
   - Communication interfaces — PASSED
   - Binary inputs and binary outputs — PASSED
   - Analog inputs — PASSED

3. Product test run
   - Minimum 12h test run in heat cabinet in 55 degree Celsius — PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| Unit type | Serial No | Slot | Type |
|---|---|---|---|
| PSM1003 | 1VH341219364 | G | 2RCA034470A0001H |
| COM1001 | 1VH341254247 | A2 | 2RCA034478A0001L |
| AIM1001 | 1VH341244340 | E | 2RCA034442A0001H |
| AIM1001 | 1VH341244339 | F | 2RCA034442A0001H |
| BIO1001 | 1VH341254400 | B | 2RCA034506A0001G |
| BIO1001 | 1VH341254641 | C | 2RCA034506A0001G |
| BIO1002 | 1VH341253320 | D | 2RCA034536A0001F |
| ARC1001 | 1VH341251259 | A1 | 2RCA032261A0001G |
| BPL1001 | 1VH341244980 | BPL | 2RCA034437A0001H |
| CPU1001 | 1VH341253728 | CPU | 2RCA036414A0001J |

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# ROUTINE TEST REPORT

**Product type:** 2RCA033008A0001V
**Date tested:** 16.05.2024
**Serial No:** 1VHR51024461

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   Dielectric test for power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

   Dielectric test for communication module at 0,5kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

2. Final product testing including the relevant tests:
   Visual inspection PASSED
   Current consumption test PASSED
   Touch screen PASSED
   HOME-button with LEDs PASSED
   Communication interfaces PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| **Modules** | **Serial No** | **Type** |
|---|---|---|
| DIS0100 | 1VH341257175 | 2RCA050396A0001P |

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# ROUTINE TEST REPORT

**Product type:** 2RCA033008A0001V
**Date tested:** 16.05.2024
**Serial No:** 1VHR51024462

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   Dielectric test for power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

   Dielectric test for communication module at 0,5kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

2. Final product testing including the relevant tests:
   Visual inspection PASSED
   Current consumption test PASSED
   Touch screen PASSED
   HOME-button with LEDs PASSED
   Communication interfaces PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| **Modules** | **Serial No** | **Type** |
|---|---|---|
| DIS0100 | 1VH341257186 | 2RCA050396A0001P |

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# ROUTINE TEST REPORT

**Product type:** 2RCA033008A0001V
**Date tested:** 16.05.2024
**Serial No:** 1VHR51024463

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   Dielectric test for power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

   Dielectric test for communication module at 0,5kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

2. Final product testing including the relevant tests:
   Visual inspection PASSED
   Current consumption test PASSED
   Touch screen PASSED
   HOME-button with LEDs PASSED
   Communication interfaces PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| **Modules** | **Serial No** | **Type** |
|---|---|---|
| DIS0100 | 1VH341257180 | 2RCA050396A0001P |

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# ROUTINE TEST REPORT

**Product type:** 2RCA033008A0001V
**Date tested:** 16.05.2024
**Serial No:** 1VHR51024464

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   Dielectric test for power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

   Dielectric test for communication module at 0,5kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

2. Final product testing including the relevant tests:
   Visual inspection PASSED
   Current consumption test PASSED
   Touch screen PASSED
   HOME-button with LEDs PASSED
   Communication interfaces PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| **Modules** | **Serial No** | **Type** |
|---|---|---|
| DIS0100 | 1VH341257179 | 2RCA050396A0001P |

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# ROUTINE TEST REPORT

**Product type:** 2RCA033008A0001V
**Date tested:** 16.05.2024
**Serial No:** 1VHR51024465

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   Dielectric test for power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

   Dielectric test for communication module at 0,5kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

2. Final product testing including the relevant tests:
   Visual inspection PASSED
   Current consumption test PASSED
   Touch screen PASSED
   HOME-button with LEDs PASSED
   Communication interfaces PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| **Modules** | **Serial No** | **Type** |
|---|---|---|
| DIS0100 | 1VH341257183 | 2RCA050396A0001P |

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# ROUTINE TEST REPORT

**Product type:** 2RCA033008A0001V
**Date tested:** 16.05.2024
**Serial No:** 1VHR51024466

This is to certify that the product above has been tested in accordance with the applicable procedures of ABB Oy during production.

The tests performed on the product were:

1. Insulation tests including
   Dielectric test for power supply module at 2,2kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

   Dielectric test for communication module at 0,5kV, 50 Hz, 1sec (IEC 60255-5 and IEC 60255-27) PASSED

2. Final product testing including the relevant tests:
   Visual inspection PASSED
   Current consumption test PASSED
   Touch screen PASSED
   HOME-button with LEDs PASSED
   Communication interfaces PASSED

At the time of shipment the product was in conformance to the specified requirements of the manufacturer.

**Product in details**

| **Modules** | **Serial No** | **Type** |
|---|---|---|
| DIS0100 | 1VH341257170 | 2RCA050396A0001P |

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2.5.2.4. CTs\VTs Test Reports

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-1 | **Serial No<br>Seri No** | 2024/24166-1 |
| **Type / Tip** | KAP-150/250-55 | **Insulation Level<br>Yalıtım Seviyesi** | 0,72/3/- kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 100/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 3 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | (pC) | (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | |
|---|---|---|
| **Kapasitif Değerler** | C1 : | PF |
| *Values Capacitive* | C2 : | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 100 | 1 | 5 | 5P | 5 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **100** | **1** | **0.3130** | **150.7mA** | **26.78V** | | **1,25** | | | **5** | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | **100** | | | | | **0,53** | **26** |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

**Date / Tarih** **16.05.2024**

**Test Operator**
Olcay Han AKDENİZ

**Approved**
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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-1 | **Serial No<br>Seri No** | 2024/24167-1 |
| **Type / Tip** | KAP-150/250-55 | **Insulation Level<br>Yalıtım Seviyesi** | 0,72/3/- kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 100/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 3 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | (pC) | (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | |
|---|---|---|
| **Kapasitif Değerler**<br>*Values Capacitive* | C1 :<br>C2 : | PF<br>PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 100 | 1 | 5 | 5P | 5 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **100** | **1** | **0.3317** | **124.0mA** | **27.42V** | | **1,25** | | | **5** | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | **100** | | | | | **0,02** | **22** |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

**Date / Tarih** 16.05.2024

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-1 | **Serial No<br>Seri No** | 2024/24168-1 |
| **Type / Tip** | KAP-150/250-55 | **Insulation Level<br>Yalıtım Seviyesi** | 0,72/3/- kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 100/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 3 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | (pC) | (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | |
|---|---|---|
| **Kapasitif Değerler** | C1 : | PF |
| *Values Capacitive* | C2 : | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 100 | 1 | 5 | 5P | 5 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **100** | **1** | **0.3204** | **131.0mA** | **27.55V** | | **1,25** | | | **5** | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | **100** | | | | | **-0,1** | **24** |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

**Date / Tarih** **16.05.2024**

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-1 | **Serial No<br>Seri No** | 2024/24169-1 |
| **Type / Tip** | KAP-150/250-55 | **Insulation Level<br>Yalıtım Seviyesi** | 0,72/3/- kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 100/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 3 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | (pC) | (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | |
|---|---|---|
| **Kapasitif Değerler**<br>*Values Capacitive* | C1 :<br>C2 : | PF<br>PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 100 | 1 | 5 | 5P | 5 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **100** | **1** | **0.3221** | **123.3mA** | **28.06V** | | **1,25** | | | **5** | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | **100** | | | | | **0,08** | **23** |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

**Date / Tarih** 16.05.2024

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-1 | **Serial No<br>Seri No** | 2024/24170-1 |
| **Type / Tip** | KAP-150/250-55 | **Insulation Level<br>Yalıtım Seviyesi** | 0,72/3/- kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 100/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 3 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | (pC) | (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | |
|---|---|---|
| **Kapasitif Değerler**<br>*Values Capacitive* | C1 :<br>C2 : | PF<br>PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 100 | 1 | 5 | 5P | 5 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **100** | **1** | **0.3191** | **126.1mA** | **27.33V** | | **1,25** | | | **5** | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | **100** | | | | | **-0** | **23** |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

**Date / Tarih** **16.05.2024**

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-1 | **Serial No<br>Seri No** | 2024/24171-1 |
| **Type / Tip** | KAP-150/250-55 | **Insulation Level<br>Yalıtım Seviyesi** | 0,72/3/- kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 100/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 3 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | (pC) | (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | |
|---|---|---|
| **Kapasitif Değerler**<br>*Values Capacitive* | C1 :<br>C2 : | PF<br>PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 100 | 1 | 5 | 5P | 5 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **100** | **1** | **0.3193** | **128.7mA** | **27.43V** | | **1,25** | | | **5** | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | **100** | | | | | **-0,05** | **23** |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

**Date / Tarih** 16.05.2024

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-2 | **Serial No<br>Seri No** | 2024/24173-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 600/1-1A

**EXPLANATION / Açıklama :**

**Visual and Mechanical Control** (Görsel ve Mekanik Kontrol) — **OK**

**Verification of Terminal Markings** (Terminal İşaretlemeleri Doğrulaması) — **OK**

**Inter-Turn Over Voltage Test -** **Proc. B** (Sarımlar Arası Aşırı Gerilim Testi - Pros. B) (IEC 61869-2 Clause 7.3.204) 150Hz-40sec — **OK**

**Composite Error** (Birleşik Hata) — **OK**

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | 3 kV |
| OK | --- | OK | OK |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 30 | PF |
| *Values Capacitive* | C2 : | 30 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 600 | 1 | 5 | 0,5 /5P | 20 |
| 2 | 600 | 1 | 10 | 5P | 25 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1S1-1S2 | 600 | 1 | 2.978 | 9.937mA | 137.7V | | 1,25 | | | 5 | | |
| | | | | | | 5 | | 0,27 | 4 | | 0,19 | 4 |
| | | | | | | 20 | | 0,3 | 2 | | 0,24 | 2 |
| | | | | | | 100 | | 0,31 | 1 | | 0,26 | 1 |
| | | | | | | 120 | | 0,31 | 1 | | 0,26 | 1 |
| 2S1-2S2 | 600 | 1 | 3.835 | 11.53mA | 350.7V | | 2,5 | | | 10 | | |
| | | | | | | 100 | | | | | 0,44 | 1 |

**Date / Tarih** 14.05.2024

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-2 | **Serial No<br>Seri No** | 2024/24174-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 600/1-1A

**EXPLANATION / Açıklama :**

**Visual and Mechanical Control** (Görsel ve Mekanik Kontrol) — **OK**

**Verification of Terminal Markings** (Terminal İşaretlemeleri Doğrulaması) — **OK**

**Inter-Turn Over Voltage Test -** **Proc. B** (Sarımlar Arası Aşırı Gerilim Testi - Pros. B) (IEC 61869-2 Clause 7.3.204) 150Hz-40sec — **OK**

**Composite Error** (Birleşik Hata) — **OK**

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | 3 kV |
| OK | --- | OK | OK |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 30 | PF |
| *Values Capacitive* | C2 : | 32 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 600 | 1 | 5 | 0,5 /5P | 20 |
| 2 | 600 | 1 | 10 | 5P | 25 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1S1-1S2** | **600** | **1** | **2.994** | **10.01mA** | **137.6V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,28** | **4** | | **0,19** | **4** |
| | | | | | | **20** | | **0,3** | **2** | | **0,24** | **2** |
| | | | | | | **100** | | **0,31** | **1** | | **0,26** | **1** |
| | | | | | | **120** | | **0,31** | **1** | | **0,26** | **1** |
| **2S1-2S2** | **600** | **1** | **3.821** | **11.89mA** | **346.3V** | | **2,5** | | | **10** | | |
| | | | | | | **100** | | | | | **0,44** | **1** |

**Date / Tarih** 14.05.2024

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-3 | **Serial No<br>Seri No** | 2024/24175-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 400/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 28 | PF |
| *Values Capacitive* | C2 : | 30 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 400 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **400** | **1** | **1.608** | **17.67mA** | **132.7V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,03** | **7** | | **-0,16** | **5** |
| | | | | | | **20** | | **0,07** | **3** | | **-0,05** | **3** |
| | | | | | | **100** | | **0,09** | **2** | | **0,01** | **1** |
| | | | | | | **120** | | **0,1** | **2** | | **0,01** | **1** |

**Date / Tarih** 15.05.2024

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-3 | **Serial No<br>Seri No** | 2024/24176-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 400/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 28 | PF |
| *Values Capacitive* | C2 : | 30 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 400 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **400** | **1** | **1.606** | **17.56mA** | **131.5V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,39** | **7** | | **0,19** | **6** |
| | | | | | | **20** | | **0,43** | **3** | | **0,31** | **3** |
| | | | | | | **100** | | **0,45** | **2** | | **0,36** | **1** |
| | | | | | | **120** | | **0,45** | **2** | | **0,37** | **1** |

**Date / Tarih** 15.05.2024

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-3 | **Serial No<br>Seri No** | 2024/24177-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 400/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 28 | PF |
| *Values Capacitive* | C2 : | 30 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 400 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **400** | **1** | **1.558** | **17.44mA** | **132.0V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,28** | **7** | | **0,09** | **5** |
| | | | | | | **20** | | **0,32** | **3** | | **0,2** | **3** |
| | | | | | | **100** | | **0,35** | **2** | | **0,26** | **1** |
| | | | | | | **120** | | **0,35** | **2** | | **0,26** | **1** |

**Date / Tarih** **15.05.2024**

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-4 | **Serial No<br>Seri No** | 2024/24178-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 50/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 26 | PF |
| *Values Capacitive* | C2 : | 26 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 50 | 1 | 2,5 | 0,5 /5P | 15 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **50** | **1** | **0.2667** | **34.31mA** | **42.74V** | | **1** | | | **2,5** | | |
| | | | | | | **5** | | **0,19** | **3** | | **0,15** | **8** |
| | | | | | | **20** | | **0,18** | **2** | | **0,12** | **5** |
| | | | | | | **100** | | **0,17** | **1** | | **0,12** | **2** |
| | | | | | | **120** | | **0,17** | **1** | | **0,12** | **2** |

**Date / Tarih** **15.05.2024**

**Test Operator**
Olcay Han AKDENİZ

**Approved**
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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-4 | **Serial No<br>Seri No** | 2024/24179-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 50/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 27 | PF |
| *Values Capacitive* | C2 : | 26 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 50 | 1 | 2,5 | 0,5 /5P | 15 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **50** | **1** | **0.2648** | **30.67mA** | **42.10V** | | **1** | | | **2,5** | | |
| | | | | | | **5** | | **0,34** | **3** | | **0,32** | **8** |
| | | | | | | **20** | | **0,34** | **2** | | **0,29** | **5** |
| | | | | | | **100** | | **0,33** | **1** | | **0,29** | **2** |
| | | | | | | **120** | | **0,33** | **1** | | **0,29** | **2** |

**Date / Tarih** 15.05.2024

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-4 | **Serial No<br>Seri No** | 2024/24180-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 50/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 30 | PF |
| *Values Capacitive* | C2 : | 28 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 50 | 1 | 2,5 | 0,5 /5P | 15 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **50** | **1** | **0.2680** | **40.30mA** | **39.24V** | | **1** | | | **2,5** | | |
| | | | | | | **5** | | **0,34** | **3** | | **0,32** | **8** |
| | | | | | | **20** | | **0,33** | **2** | | **0,29** | **5** |
| | | | | | | **100** | | **0,32** | **1** | | **0,28** | **2** |
| | | | | | | **120** | | **0,32** | **1** | | **0,29** | **2** |

**Date / Tarih** **14.05.2024**

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-5 | **Serial No<br>Seri No** | 2024/24181-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 150/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 29 | PF |
| *Values Capacitive* | C2 : | 30 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 150 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **150** | **1** | **1.042** | **14.14mA** | **127.7V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,34** | **6** | | **0,19** | **3** |
| | | | | | | **20** | | **0,4** | **2** | | **0,3** | **2** |
| | | | | | | **100** | | **0,42** | **1** | | **0,34** | **1** |
| | | | | | | **120** | | **0,42** | **1** | | **0,34** | **1** |

**Date / Tarih** **14.05.2024**

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-5 | **Serial No<br>Seri No** | 2024/24182-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 150/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 30 | PF |
| *Values Capacitive* | C2 : | 30 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 150 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **150** | **1** | **1.035** | **15.83mA** | **126.3V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,33** | **7** | | **0,14** | **4** |
| | | | | | | **20** | | **0,38** | **3** | | **0,27** | **2** |
| | | | | | | **100** | | **0,41** | **1** | | **0,33** | **1** |
| | | | | | | **120** | | **0,41** | **1** | | **0,33** | **1** |

**Date / Tarih** **14.05.2024**

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-5 | **Serial No<br>Seri No** | 2024/24183-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 150/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 29 | PF |
| *Values Capacitive* | C2 : | 29 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 150 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **150** | **1** | **1.034** | **14.68mA** | **127.6V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,34** | **6** | | **0,18** | **4** |
| | | | | | | **20** | | **0,39** | **2** | | **0,29** | **2** |
| | | | | | | **100** | | **0,42** | **1** | | **0,34** | **1** |
| | | | | | | **120** | | **0,42** | **1** | | **0,34** | **1** |

**Date / Tarih** **14.05.2024**

**Test Operator**
Olcay Han AKDENİZ

**Approved**
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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-5 | **Serial No<br>Seri No** | 2024/24184-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 150/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 30 | PF |
| *Values Capacitive* | C2 : | 30 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 150 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **150** | **1** | **1.041** | **16.83mA** | **123.3V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,33** | **6** | | **0,15** | **4** |
| | | | | | | **20** | | **0,38** | **3** | | **0,27** | **2** |
| | | | | | | **100** | | **0,41** | **2** | | **0,32** | **1** |
| | | | | | | **120** | | **0,41** | **1** | | **0,32** | **1** |

**Date / Tarih** **15.05.2024**

**Test Operator**
Olcay Han AKDENİZ

**Approved**
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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-5 | **Serial No<br>Seri No** | 2024/24185-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 150/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 29 | PF |
| *Values Capacitive* | C2 : | 30 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 150 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **150** | **1** | **1.052** | **14.68mA** | **127.0V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,34** | **6** | | **0,18** | **4** |
| | | | | | | **20** | | **0,39** | **2** | | **0,29** | **2** |
| | | | | | | **100** | | **0,41** | **1** | | **0,34** | **1** |
| | | | | | | **120** | | **0,41** | **1** | | **0,34** | **1** |

**Date / Tarih** **14.05.2024**

**Test Operator**
Olcay Han AKDENİZ

**Approved**
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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-5 | **Serial No<br>Seri No** | 2024/24186-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 150/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 28 | PF |
| *Values Capacitive* | C2 : | 27 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 150 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **150** | **1** | **1.027** | **15.35mA** | **124.0V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,34** | **6** | | **0,16** | **4** |
| | | | | | | **20** | | **0,39** | **3** | | **0,28** | **2** |
| | | | | | | **100** | | **0,42** | **1** | | **0,33** | **1** |
| | | | | | | **120** | | **0,42** | **1** | | **0,34** | **1** |

**Date / Tarih** **15.05.2024**

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-6 | **Serial No<br>Seri No** | 2024/24187-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 200/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 29 | PF |
| *Values Capacitive* | C2 : | 30 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 200 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **200** | **1** | **1.321** | **15.83mA** | **124.5V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,13** | **7** | | **-0,05** | **4** |
| | | | | | | **20** | | **0,19** | **3** | | **0,08** | **2** |
| | | | | | | **100** | | **0,22** | **2** | | **0,13** | **1** |
| | | | | | | **120** | | **0,22** | **2** | | **0,13** | **1** |

**Date / Tarih** **15.05.2024**

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-6 | **Serial No<br>Seri No** | 2024/24188-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 200/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 27 | PF |
| *Values Capacitive* | C2 : | 28 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 200 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **200** | **1** | **1.319** | **15.63mA** | **125.1V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,13** | **7** | | **-0,04** | **4** |
| | | | | | | **20** | | **0,19** | **3** | | **0,08** | **2** |
| | | | | | | **100** | | **0,22** | **2** | | **0,13** | **1** |
| | | | | | | **120** | | **0,22** | **2** | | **0,14** | **1** |

**Date / Tarih** 15.05.2024

**Test Operator**
Olcay Han AKDENİZ

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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-6 | **Serial No<br>Seri No** | 2024/24189-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 200/1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | |
| OK | --- | OK | --- |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 29 | PF |
| *Values Capacitive* | C2 : | 29 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 200 | 1 | 5 | 0,5 /5P | 20 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-S2** | **200** | **1** | **1.312** | **16.03mA** | **127.8V** | | **1,25** | | | **5** | | |
| | | | | | | **5** | | **0,13** | **7** | | **-0,05** | **4** |
| | | | | | | **20** | | **0,19** | **3** | | **0,08** | **2** |
| | | | | | | **100** | | **0,22** | **2** | | **0,13** | **1** |
| | | | | | | **120** | | **0,22** | **2** | | **0,14** | **1** |

**Date / Tarih** **14.05.2024**

**Test Operator**
Olcay Han AKDENİZ

**Approved**
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# CURRENT TRANSFORMER TEST REPORT
## *AKIM TRANSFORMATÖRÜ TEST RAPORU*

| | | | | | |
|---|---|---|---|---|---|
| **Customer/Müşteri** | | **Order No<br>Sipariş No** | 624-0802-2 | **Serial No<br>Seri No** | 2024/26091-1 |
| **Type / Tip** | ATB 10-BS | **Insulation Level<br>Yalıtım Seviyesi** | 7,2/20/60 kV | **Customer P.O. No<br>Müşteri Sip.No** | 1258 |
| **Project Number** | | **Idyn<br>Dinamik Anma Akımı** | 2.5xIth | **FREQUENCY<br>Frekans** | 50Hz |
| **Cust. İtem Code** | | | | | |
| **Shorttime TH.CUR.<br>KI.SÜ.TER.AN. A.(Ith)** | 25kA/1s | **Standard APP.<br>Uygulanan Standart** | IEC 61869-2:2012 | **Insulation Classe<br>İzolasyon Sınıfı** | E |

**Ratio / Çevirme Oranı :** 600/1-1A

**EXPLANATION / Açıklama :**

| | | | |
|---|---|---|---|
| **Visual and Mechanical Control**<br>(Görsel ve Mekanik Kontrol) | **OK** | **Inter-Turn Over Voltage Test - Proc. B**<br>(Sarımlar Arası Aşırı Gerilim Testi - Pros. B)<br>(IEC 61869-2 Clause 7.3.204) 150Hz-40sec | **OK** |
| **Verification of Terminal Markings**<br>(Terminal İşaretlemeleri Doğrulaması) | **OK** | **Composite Error**<br>(Birleşik Hata) | **OK** |

**İzolasyon Testleri / Insulation Test (IEC 61869-1 Clause 7.3.1 ve 7.3.3 / 7.3.4) Yaşta/Wet Test(Clause 7.2.4&IEC**

| Primer Yalıtım Testi<br>Power Frq. On Pri.Winding / (60 sec.) | Primerler Arası Yalıtım Testi<br>Between Primer Wndg. / (60 sec.) | Sekonder Yalıtım Testi<br>Pwr. Frq. On Sec. Wndg. / (60 sec.) | Sekonderler Arası Yalıtım Testi<br>Between Secondary Wndg. / (60 sec.) |
|---|---|---|---|
| 20 kV | | 3 kV | 3 kV |
| OK | --- | OK | OK |

**KISMİ DEŞARJ TESTİ / Partial Discharge Test (IEC 61869-1 Clause 7.3.2)**

| Gerilim / Voltage | 1.2 Um | 1.2 Um/V3 |
|---|---|---|
| Seviye/Level | 1 (pC) | 1 (pC) |

**DIELECTRIC'S CAPACITANCE and POWER FACTOR TEST (Clause 7.4.3)**

| Kapasitans / Capacitance (pf) | Gerilim / Voltage (kV) | tan & (%) |
|---|---|---|
| | | |

**POLARİTE TESTİ/Polarity Test +O.K. (IEC 61869-1 Clause 7.3.6)**

| | | | |
|---|---|---|---|
| **Kapasitif Değerler** | C1 : | 29 | PF |
| *Values Capacitive* | C2 : | 26 | PF |

| Core / Nüve | Primary / Primer (A) | Secondary/Sekonder (A) | Burden / Yük (VA) | Class / Klas | Aşırı Akım Faktörü<br>Over Current Faktor |
|---|---|---|---|---|---|
| 1 | 600 | 1 | 5 | 5P | 20 |
| 2 | 600 | 1 | 10 | 5P | 25 |

**SINIF TESTLERİ / Accuracy Class Tests (IEC 61869-2 Clause 7.3.5)**

| Nüve<br>Core | Primer<br>Primary | Sekonder<br>Second. | Rct<br>(@ 75°C)<br>(Ohm) | Ie (A) | Ek (V) | % | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) | Yük<br>Burden<br>(VA) | Akım Hatası<br>Current Err.<br>(%F) | Faz Hatası<br>Phase Err.<br>(min/dk) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1S1-1S2 | 600 | 1 | 3.131 | 10.06mA | 135.5V | | 1,25 | | | 5 | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | 100 | | | | | 0,26 | 1 |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| 2S1-2S2 | 600 | 1 | 3.969 | 11.24mA | 337.3V | | 2,5 | | | 10 | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | 100 | | | | | 0,44 | 1 |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

**Date**
**Tarih** **22.05.2024**

**Test Operator**
Olcay Han AKDENİZ

**Approved**
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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010781

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 14.05.2024

Ing. Radek Bártek

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Job No.: 983168
Order No.: 4550659971

# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010781

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 14.05.2024 Operator: Krkoška

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.245 | -3.428 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.189 | -5.436 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.188 | -5.595 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.192 | -5.622 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.307 | -3.383 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.359 | -2.493 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.374 | 0.178 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.400 | -0.624 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.401 | -0.671 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.398 | -0.659 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.348 | 0.041 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.323 | 0.606 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.275 | 0.997 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.232 | -1.127 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.229 | -1.343 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.227 | -1.403 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.327 | 1.428 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.363 | 2.450 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.353 | 1.026 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.374 | 0.219 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.373 | 0.185 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.370 | 0.203 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.329 | 1.075 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.309 | 1.733 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.224 | 12.331 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.256 | 9.092 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | 0.168 | 13.405 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.956 | -0.066 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.932 | 0.631 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.922 | 0.973 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010782

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 14.05.2024

Ing. Radek Bártek

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010782

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 14.05.2024 Operator: Krkoška

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.264 | -3.215 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.203 | -5.230 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.202 | -5.386 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.206 | -5.410 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.311 | -3.110 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.354 | -2.341 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.355 | 0.388 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.387 | -0.374 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.387 | -0.407 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.385 | -0.395 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.345 | 0.316 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.328 | 0.836 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.293 | 1.142 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.246 | -0.969 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.245 | -1.115 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.249 | -1.118 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.335 | 1.660 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.373 | 2.660 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.336 | 1.227 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.361 | 0.457 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.361 | 0.429 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.359 | 0.461 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.327 | 1.304 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.314 | 1.831 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.211 | 12.421 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.247 | 9.223 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | 0.166 | 13.455 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.949 | 0.165 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.932 | 0.805 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.928 | 0.986 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010783

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 14.05.2024

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010783

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 14.05.2024 Operator: Krkoška

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.253 | -3.280 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.202 | -5.149 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.201 | -5.303 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.205 | -5.321 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.319 | -3.084 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.366 | -2.340 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.362 | 0.157 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.385 | -0.440 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.385 | -0.472 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.382 | -0.458 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.333 | 0.213 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.313 | 0.674 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.282 | 1.103 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.242 | -0.869 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.242 | -1.005 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.246 | -1.016 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.340 | 1.752 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.379 | 2.770 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.344 | 1.010 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.361 | 0.408 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.361 | 0.383 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.359 | 0.409 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.320 | 1.216 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.304 | 1.805 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.217 | 12.130 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.247 | 9.088 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | 0.159 | 13.302 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.948 | 0.098 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.926 | 0.713 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.920 | 0.993 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010784

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 14.05.2024

Ing. Radek Bártek

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010784

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 14.05.2024 Operator: Krkoška

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.253 | -3.318 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.198 | -5.279 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.197 | -5.431 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.201 | -5.477 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.311 | -3.067 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.358 | -2.225 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.365 | 0.215 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.391 | -0.487 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.392 | -0.530 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.389 | -0.520 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.345 | 0.286 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.325 | 0.833 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.297 | 1.429 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.254 | -0.684 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.253 | -0.843 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.258 | -0.854 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.348 | 2.145 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.387 | 3.216 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.342 | 1.151 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.362 | 0.436 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.362 | 0.403 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.359 | 0.431 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.325 | 1.411 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.310 | 2.063 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.214 | 12.192 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.247 | 9.023 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | 0.163 | 13.354 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.951 | 0.082 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.933 | 0.814 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.927 | 1.070 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010785

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 14.05.2024

Ing. Radek Bártek

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Order No.: 4550659971

# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010785

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 14.05.2024 Operator: Krkoška

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.230 | -3.928 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.168 | -6.010 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.167 | -6.144 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.172 | -6.130 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.283 | -3.627 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.328 | -2.842 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.391 | -0.374 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.422 | -1.258 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.422 | -1.274 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.419 | -1.229 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.371 | -0.250 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.354 | 0.213 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.264 | 0.516 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.217 | -1.726 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.217 | -1.857 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.222 | -1.820 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.314 | 1.174 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.352 | 2.195 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.364 | 0.502 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.388 | -0.402 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.387 | -0.390 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.385 | -0.361 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.347 | 0.722 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.333 | 1.254 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.229 | 11.742 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.265 | 8.477 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | 0.179 | 12.977 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.966 | -0.677 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.945 | 0.192 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.939 | 0.459 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010786

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 14.05.2024

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010786

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 14.05.2024 Operator: Krkoška

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.230 | -3.889 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.179 | -5.608 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.179 | -5.731 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.182 | -5.729 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.285 | -3.453 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.329 | -2.641 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.390 | -0.312 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.411 | -0.828 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.411 | -0.833 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.409 | -0.791 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.371 | -0.081 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.353 | 0.405 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.265 | 0.560 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.226 | -1.333 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.226 | -1.454 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.230 | -1.435 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.315 | 1.346 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.353 | 2.404 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.364 | 0.529 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.380 | -0.007 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.380 | -0.007 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.378 | 0.050 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.348 | 0.892 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.335 | 1.508 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.210 | 12.131 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.240 | 9.102 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | 0.159 | 13.477 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.962 | -0.275 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.947 | 0.364 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.943 | 0.592 | 0 |

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Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010884

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 16.05.2024

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010884

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 16.05.2024 Operator: Tomáš Jelínek

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.235 | -4.031 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.183 | -5.823 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.182 | -5.956 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.188 | -5.959 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.309 | -3.653 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.363 | -2.736 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.387 | -0.451 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.408 | -1.021 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.407 | -1.043 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.404 | -1.021 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.348 | -0.336 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.320 | 0.294 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.269 | 0.408 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.230 | -1.531 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.230 | -1.662 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.234 | -1.643 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.334 | 1.191 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.380 | 2.409 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.361 | 0.420 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.377 | -0.161 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.377 | -0.161 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.374 | -0.131 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.330 | 0.786 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.306 | 1.519 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.052 | 10.558 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.080 | 7.565 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | -0.011 | 11.989 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.959 | -0.363 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.933 | 0.403 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.923 | 0.759 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010885

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 16.05.2024

Ing. Radek Bártek

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010885

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 16.05.2024 Operator: Tomáš Jelínek

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.223 | -3.861 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.178 | -5.547 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.178 | -5.647 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.183 | -5.644 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.288 | -3.267 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.333 | -2.515 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.398 | -0.307 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.413 | -0.740 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.411 | -0.743 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.408 | -0.685 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.368 | 0.072 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.350 | 0.537 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.258 | 0.517 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.223 | -1.284 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.224 | -1.387 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.230 | -1.362 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.318 | 1.474 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.356 | 2.525 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.371 | 0.524 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.383 | 0.093 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.381 | 0.111 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.378 | 0.166 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.345 | 1.059 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.330 | 1.586 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.060 | 10.578 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.084 | 7.792 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | 0.000 | 12.191 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.962 | -0.146 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.943 | 0.551 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.940 | 0.753 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010886

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 16.05.2024

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010886

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 16.05.2024 Operator: Tomáš Jelínek

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.247 | -3.677 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.191 | -5.603 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.190 | -5.746 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.194 | -5.770 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.310 | -3.413 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.361 | -2.550 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.377 | -0.050 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.403 | -0.768 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.402 | -0.796 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.400 | -0.762 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.351 | -0.020 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.329 | 0.586 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.280 | 0.734 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.237 | -1.363 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.236 | -1.497 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.241 | -1.497 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.336 | 1.371 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.378 | 2.448 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.353 | 0.818 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.373 | 0.096 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.373 | 0.061 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.370 | 0.112 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.332 | 1.066 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.312 | 1.642 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.040 | 11.045 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.072 | 7.881 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | -0.016 | 12.331 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.957 | -0.139 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.934 | 0.623 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.925 | 0.948 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010887

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 16.05.2024

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010887

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 16.05.2024 Operator: Tomáš Jelínek

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.234 | -3.869 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.184 | -5.606 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.184 | -5.729 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.189 | -5.734 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.305 | -3.530 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.355 | -2.658 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.388 | -0.253 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.408 | -0.771 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.408 | -0.785 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.404 | -0.736 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.355 | -0.091 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.330 | 0.508 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.266 | 0.577 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.229 | -1.326 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.229 | -1.433 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.234 | -1.415 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.331 | 1.409 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.375 | 2.536 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.363 | 0.576 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.378 | 0.049 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.377 | 0.055 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.374 | 0.113 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.332 | 0.932 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.312 | 1.627 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.051 | 10.739 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.080 | 7.783 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | -0.010 | 12.113 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.958 | -0.228 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.931 | 0.452 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.922 | 0.745 | 0 |

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Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010888

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 16.05.2024

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010888

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 16.05.2024 Operator: Tomáš Jelínek

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.242 | -3.887 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.192 | -5.647 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.192 | -5.792 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.197 | -5.811 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.337 | -3.074 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.393 | -2.015 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.379 | -0.366 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.398 | -0.909 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.397 | -0.930 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.394 | -0.902 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.319 | 0.289 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.288 | 0.934 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.272 | 0.483 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.235 | -1.414 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.235 | -1.550 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.242 | -1.515 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.355 | 1.807 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.403 | 3.035 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.356 | 0.497 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.371 | -0.022 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.370 | -0.050 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.366 | -0.007 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.308 | 1.372 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.283 | 2.170 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.046 | 10.744 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.075 | 7.799 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | -0.028 | 12.591 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.953 | -0.287 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.915 | 0.859 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.903 | 1.260 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010889

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 16.05.2024

Ing. Radek Bártek

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010889

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 16.05.2024 Operator: Tomáš Jelínek

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.284 | -2.938 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.231 | -4.968 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.233 | -5.158 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.241 | -5.237 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.416 | -3.042 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.487 | -1.919 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.338 | 0.730 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.361 | -0.114 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.358 | -0.186 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.352 | -0.210 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.241 | 0.396 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.198 | 1.183 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.306 | 1.557 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.266 | -0.610 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.267 | -0.773 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.276 | -0.800 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.421 | 2.171 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.480 | 3.480 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.323 | 1.627 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.341 | 0.816 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.338 | 0.765 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.333 | 0.762 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.242 | 1.775 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.206 | 2.663 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.022 | 11.807 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.050 | 8.623 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | -0.079 | 13.294 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.930 | 0.620 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.866 | 1.582 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.847 | 2.095 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010941

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 16.05.2024

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010941

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 16.05.2024 Operator: Tomáš Jelínek

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.283 | -3.582 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.233 | -5.411 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.235 | -5.554 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.241 | -5.571 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.396 | -3.105 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.459 | -2.010 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.350 | 0.411 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.368 | -0.207 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.366 | -0.233 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.361 | -0.216 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.272 | 0.705 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.235 | 1.478 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.307 | 0.864 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.269 | -1.087 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.271 | -1.214 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.277 | -1.205 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.405 | 1.890 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.457 | 3.173 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.333 | 1.247 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.347 | 0.646 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.345 | 0.621 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.340 | 0.677 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.269 | 1.830 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.240 | 2.701 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.022 | 11.106 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.049 | 8.120 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | -0.066 | 12.844 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.937 | 0.467 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.889 | 1.502 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.875 | 2.027 | 0 |

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Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010942

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 23.05.2024

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Job No.: 983168
Order No.: 4550659971

# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010942

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 23.05.2024 Operator: Michal Pernica

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.243 | -4.539 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.197 | -6.193 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.197 | -6.295 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.202 | -6.285 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.314 | -3.961 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.362 | -3.102 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.400 | -0.540 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.416 | -0.958 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.414 | -0.951 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.411 | -0.899 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.367 | -0.156 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.347 | 0.347 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.278 | -0.044 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.242 | -1.859 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.242 | -1.966 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.247 | -1.929 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.341 | 0.929 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.385 | 1.985 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.370 | 0.283 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.382 | -0.151 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.381 | -0.132 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.379 | -0.077 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.341 | 0.779 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.323 | 1.408 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.024 | 10.629 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.052 | 7.722 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | -0.037 | 12.183 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.964 | -0.354 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.941 | 0.382 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.935 | 0.613 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010943

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 20.05.2024

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010943

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 20.05.2024 Operator: Michal Vrána

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.261 | -3.849 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.212 | -5.608 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.214 | -5.720 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.221 | -5.711 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.370 | -3.138 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.430 | -2.135 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.371 | -0.089 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.389 | -0.613 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.386 | -0.613 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.381 | -0.557 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.299 | 0.379 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.266 | 1.144 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.285 | 0.579 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.248 | -1.284 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.250 | -1.377 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.256 | -1.341 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.379 | 1.808 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.427 | 3.076 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.349 | 0.752 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.363 | 0.235 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.361 | 0.250 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.357 | 0.316 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.290 | 1.518 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.264 | 2.319 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.023 | 10.473 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.052 | 7.567 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | -0.059 | 12.344 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.948 | 0.074 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.905 | 1.184 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.895 | 1.554 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010944

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 23.05.2024

Ing. Radek Bártek

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010944

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 23.05.2024 Operator: Michal Pernica

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.273 | -3.556 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.222 | -5.343 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.223 | -5.471 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.227 | -5.479 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.340 | -3.124 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.388 | -2.241 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.364 | 0.296 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.383 | -0.253 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.383 | -0.268 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.380 | -0.246 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.334 | 0.531 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.313 | 1.070 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.300 | 0.871 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.261 | -1.061 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.261 | -1.178 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.266 | -1.151 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.359 | 1.746 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.401 | 2.862 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.343 | 1.129 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.358 | 0.579 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.357 | 0.569 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.355 | 0.621 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.317 | 1.550 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.299 | 2.174 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.028 | 11.191 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.057 | 8.223 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | -0.031 | 12.661 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.947 | 0.363 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.925 | 1.107 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.918 | 1.397 | 0 |

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Job No.: 983168
Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010945

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 16.05.2024

Ing. Radek Bártek

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010945

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 16.05.2024 Operator: Tomáš Jelínek

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.262 | -3.464 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.210 | -5.252 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.209 | -5.372 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.213 | -5.387 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.323 | -2.925 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.368 | -2.136 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.377 | 0.351 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.399 | -0.223 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.399 | -0.233 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.396 | -0.202 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.353 | 0.651 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.335 | 1.173 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.292 | 0.976 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.252 | -0.964 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.252 | -1.097 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.257 | -1.087 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.350 | 1.939 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.388 | 2.879 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.353 | 1.188 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.370 | 0.603 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.370 | 0.598 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.367 | 0.645 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.331 | 1.631 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.317 | 2.175 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.028 | 11.336 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.059 | 8.328 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | -0.028 | 12.814 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.955 | 0.363 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.935 | 1.144 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.931 | 1.395 | 0 |

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Order No.: 4550659971

# ROUTINE TESTS REPORT

## VOLTAGE TRANSFORMER

Type: TJP 4.3
Rated frequency: 50/60 Hz
Accuracy class: 0,5(3P)/0,5(3P)/3P
Production number: 1VLT5224010946

Highest voltage: 7.2 kV
Rated ratio: 6600/√3//110/√3/110/√3/110/3 V
Output: 20/30/30 VA
Year of production: 2024

## TESTS:

1. Verification of terminal marking acc. to IEC 61869-1 clause 7.3.6
   Conclusion: Satisfactory
2. Power-frequency voltage withstand tests on primary terminals acc.to IEC 61869-3 clause 7.3.1
   Common mode (separate source) power frequency withstand test acc.to IEC 61869-3 clause 7.3.1.302
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
3. Differential mode (induced) AC voltage test acc. to IEC 61869-3 clause 7.3.1.303
   Test value: 20.0 kV, 100 Hz, 1 minute
   Conclusion: Satisfactory
4. Partial discharge measurment acc. to IEC 61869-3 clause 7.3.2 procedure A
   Conclusion: Satisfactory
5. Power-frequency voltage withstand test on secondary terminals acc.to IEC 61869-3 clause 7.3.4
   Test value: 3 kV, 50/60 Hz, 1 minute
   Conclusion: Satisfactory
6. Tests for accuracy acc.to IEC 61869-3 clause 7.3.5.
   Winding: I: 20 VA/class 0,5(3P)
   Winding: II: 30 VA/class 0,5(3P)
   Winding: III: 30 VA/class 3P
   Conclusion: Satisfactory

The voltage transformer complies with tests required according to IEC Publications 61869-3.

Brno, the: 23.05.2024

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# Measurements with Automatic Transformer Test Set, ZERA

## VOLTAGE TRANSFORMER

Serial No.: 1VLT5224010946

Test Object: TJP 4.3:E404008164
Nominal Freq.: 50 Hz
Date: 23.05.2024 Operator: Michal Pernica

| Winding No. | PXR//SXR(V) | Burden(VA) | COS ß | % Un | ei(%) | di(min) | Burden of other windings (VA) |
|---|---|---|---|---|---|---|---|
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 190 | -0.262 | -3.508 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 120 | -0.212 | -5.236 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 100 | -0.212 | -5.359 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 80 | -0.217 | -5.382 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 5 | -0.326 | -3.169 | 30 |
| 1 | 6600/√3//110/√3 | 20,00 | 0,80 | 2 | -0.376 | -2.292 | 30 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 190 | 0.371 | 0.232 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 120 | 0.391 | -0.281 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 100 | 0.390 | -0.287 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 80 | 0.387 | -0.264 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 5 | 0.343 | 0.364 | 0 |
| 1 | 6600/√3//110/√3 | 5,00 | 0,80 | 2 | 0.320 | 0.885 | 0 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 190 | -0.288 | 0.931 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 120 | -0.250 | -0.947 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 100 | -0.251 | -1.056 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 80 | -0.256 | -1.036 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 5 | -0.349 | 1.794 | 20 |
| 2 | 6600/√3//110/√3 | 30,00 | 0,80 | 2 | -0.392 | 2.887 | 20 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 190 | 0.350 | 1.063 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 120 | 0.365 | 0.547 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 100 | 0.364 | 0.542 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 80 | 0.361 | 0.579 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 5 | 0.323 | 1.403 | 0 |
| 2 | 6600/√3//110/√3 | 7,50 | 0,80 | 2 | 0.306 | 2.074 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 190 | 0.027 | 11.027 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 100 | 0.057 | 8.090 | 0 |
| 3 | 6600/√3//110/3 | 30,00 | 0,80 | 5 | -0.031 | 12.441 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 100 | 0.952 | 0.277 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 5 | 0.933 | 0.915 | 0 |
| 3 | 6600/√3//110/3 | 0,00 | 0,00 | 2 | 0.925 | 1.227 | 0 |

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## 2.6. Fabrication record

### 2.6.1.Raw materials test certificate

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IMESA ELECTRICAL ENGINEERING

# TRACEABILITY LIST - EN10204

| TAG N° | dwg | pos. dwg | component | measure | material | heat/SN | supplier | certificates | type EN 10204 | date | original/copy | page index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SG-100D1 | 1723002197-EL-DA-00006 | | ALUMINIUM ALLOY METAL SHEET | | ALLUMINIUM | | CANTORI | 1020 | EN573-3 EN485-2 | 22/03/2022 | ALL 3X2500X1250 | |
| SG-100D1 | 1723002197-EL-DA-00006 | | PICKLED METAL SHEET | | PICKLED | | ETRUSCA PROFILATI SRL | 411/2023/3 | EN 10025/2-2005 EN 10051:2010 | 17/06/2025 | 411-2023-3_1 | |
| SG-100D1 | 1723002197-EL-DA-00006 | | PICKLED METAL SHEET | | PICKLED | | ETRUSCA PROFILATI SRL | 412/2023/1 | EN 10111:2008 EN1051:2010 | 17/06/2025 | 412-2023-1_1 | |
| SG-100D1 | 1723002197-EL-DA-00006 | | PICKLED METAL SHEET | | PICKLED | | ETRUSCA PROFILATI SRL | 462/2023/3 | EN 10111:2008 EN1051:2010 | 17/06/2025 | 462-2023-3_1 | |
| SG-100D1 | 1723002197-EL-DA-00006 | | PICKLED METAL SHEET | | PICKLED | | ETRUSCA PROFILATI SRL | 1316/2023/3 | EN 10111:2008 EN1051:2010 | 12/06/2023 | DEC 2X2000X1250 | |
| SG-100D1 | 1723002197-EL-DA-00006 | | GALVANIZED METAL SHEET | | GALVANIZED | | ETRUSCA PROFILATI SRL | 3218/2023/1 | EN 10346:2015 EN10143:2006 | 17/06/2025 | 3218-2023-1_1 | |
| SG-100D1 | 1723002197-EL-DA-00006 | | GALVANIZED METAL SHEET | | GALVANIZED | | ARCELORMITTAL CLN | 0001172714 | EN 10346:2015 | 15/09/2021 | ZN 2.5X2000X1250 | |
| SG-100D1 | 1723002197-EL-DA-00006 | | GALVANIZED METAL SHEET | | GALVANIZED | | ARCELORMITTAL CLN | 0001378127 | EN 10346:2015 | 05/04/2024 | ZN 2X2500X1500 | |
| SG-100D1 | 1723002197-EL-DA-00006 | | GALVANIZED METAL SHEET | | GALVANIZED | | ARCELORMITTAL CLN | 0001376435 | EN 10346:2015 | 28/03/2024 | ZN 3X2500X1250 | |
| SG-200N1 SG-200D2 DP-200N1 | 1723002197-EL-DA-00007 1723002197-EL-DA-00008 1723002197-EL-DA-00009 | | GALVANIZED METAL SHEET | | GALVANIZED | | ETRUSCA PROFILATI SRL | 3218/2023/1 | EN 10346:2015 EN10143:2006 | 14/12/2023 | ZN 1.5X900X2400 | |
| SG-200N1 SG-200D2 DP-200N1 | 1723002197-EL-DA-00007 1723002197-EL-DA-00008 1723002197-EL-DA-00009 | | GALVANIZED METAL SHEET | | GALVANIZED | | ARCELORMITTAL CLN | 0001378126 | EN 10346:2015 | 05/04/2024 | ZN 2X1250X1400 | |
| SG-200N1 SG-200D2 DP-200N1 | 1723002197-EL-DA-00007 1723002197-EL-DA-00008 1723002197-EL-DA-00009 | | GALVANIZED METAL SHEET | | GALVANIZED | | ARCELORMITTAL CLN | 0001376434 | EN 10346:2015 | 28/03/2024 | ZN 3X1250X1400 | |

Etrusca Profilati s.r.l.
STEEL SERVICE CENTRE

Loc. Montecaselli, 4 - 57025 PIOMBINO (LI) REA 71068
R.I.L. LI 4 0099232 - C.F. e P.IVA 00712080498
Capitale Sociale € 1.250.000,00 int. vers. www.etruscaprofilati.it

AZIENDA CON
SISTEMA DI GESTIONE QUALITA'
CERTIFICATO DA DNV
ISO 9001

## LAVORAZIONE E COMMERCIO LAMIERE

| | |
|---|---|
| Cliente/Customer: Imesa Spa<br>Zona Ind. Zipa - Via G. Di Vittorio 14<br>60035 Jesi AN | Tipo di documento/Type of document: Certificato di collaudo interno, EQUIVALENTE A 3.1 EN 10204:2004<br>N° Certificato/Certificate N°: 3218/2023/1 |
| N° coil : 202300004623 | DDT n°: 2873 del 13/12/2023 |
| Prodotto/Product : Lamiera Zincata Piana | Norma di rif./Standard: EN 10346:2015 - EN 10143:2006 |
| Rif. collo:<br>1.5x900x2400 Kg.4330 | Qualità + rivestimento/Steel grade + Coating:<br>DX51D + Z200 |

Prova meccanica/Mechanical test

| N° coil | ID provino | $R_{p0.2}$ MPa | $R_{eH}$ MPa | $R_{eL}$ MPa | $R_m$ MPa | $A_{80mm}$ % |
|---|---|---|---|---|---|---|
| 202300004623 | Testa-L1 | 320 | 323 | 317 | 388 | 31,7 |

Analisi chimica/Chemical analysis

| C % | Si % | Mn % | S % | P % | Ti % |
|---|---|---|---|---|---|
| 0.0171 | 0.0110 | 0.2736 | 0.0333 | 0.0215 | 0.0004 |

Controllo marcatura, aspetto superficiale e dimensioni: SODDISFACENTE
Marking, surface aspect and dimension inspection: NO REMARKS

Certifichiamo che il prodotto fornito è conforme ai requisiti dell'ordine - We certify that the material supplied complies with the requirements agreed on the order
Certificato redatto sulla base delle condizioni generali di vendita - This certificate is draw up on the base of our general terms and condition of sale

CERTIFICAZIONE DI SISTEMA QUALITA' DNV ISO 9001

Data di stampa: 17.06.25

Il collaudatore N. Cordini

Etrusca Profilati

LAVORAZIONE E COMMERCIO LAMIERE ZINCATE - PREVERNICIATE E NERE

57025 PIOMBINO (LI) - Loc. Montecaselli, 4
Tel. 0565.220774 - Fax 0565.220253 - CF e PIVA 00712080498
Sito web: www.etruscaprofilati.it - Email: commerciale@etruscaprofilati.it

NUM. ETICH: 0000208316
DATA PROD.: 12/12/2023 15:42
PRODOTTO..: LAMIERA BANDELLATA
TIPO PROD.: Zincato
QUALITA'..: DX51D
ZINCATURA.: Z200

SPESSORE..: 1,50
LARGHEZZA.: 900
LUNGHEZZA.: 2400

PESO.....: 2240 kg
NUM.FOGLI.: 85

IMESA SPA
N. CONFERMA: 2092 del 20/11/2023
ORD CLIENTE: 2929 del 20/11/2023

---------- COIL ORIGINE ----------
8202300004623

TI ALLEGO TIPO LAMIERA USATA PER LAVORAZIONE "ROSETTI MARINO"
C231298 ROTO 40 (CASSETTI)

Guido

ArcelorMittal CLN

**ATTESTATO DI CONTROLLO UNI EN 10204-2.2 - DIN 50049/2.2-ISO 404**

**TEST REPORT UNI EN 10204-2.2 - DIN 50049/2.2-ISO 404**

**N. 0001378126**



**ArcelorMittal CLN Distribuzione Italia srl**
Codice Fiscale e Partita IVA: 11233970018
Registro Imprese TORINO
CEE VAT: IT 11233970018
R.E.A. n. 1197930 Torino

| Organismo di controllo / Checking Entity | Cliente - Customer | Ordine Cliente / Customer Order | Ordine 1003 / Order | Qualità - Steel Grade | Fam. siderurgica - Product group | Disegno N. - Customer Product Code ZN20 |
|---|---|---|---|---|---|---|
| 1003 Produttore / Steelmaker: X | 1096429 I.M.E.S.A. S.P.A Dest.M. S004204 IMESA SPA | 849BOC | 0000572598 | EN 10346 DX51D+Z A Minimizzato 200 2SUP no oliato Passivazione ecologica | LaF Riv<br>Tipo prodotto - Product type: Zincato | |

| Spessore / Thickness | Larghezza / Width | Lunghezza / Length | II Base |
|---|---|---|---|
| 2,00 | 1.250,00 | 1.400,00 | 0,00 |

## IDENTIFICAZIONE DEL PRODOTTO / PRODUCT IDENTIFICATION

## PROVA DI TRAZIONE / TENSILE TEST

Durezza / Hardness — Rugosità / Roughness — Rivestimento - Coating

| N°Partita / SAP ID. | Matricola Prodotto / Coil Number | N. Colata / Heat Number | Peso Partita / Weight (Kg) | Orientamento Test Direction L | T | Provetta Test Sample 20x80 | 5.65 | Re/YS MPa | Rm/UTS MPa | Re/ Rm | A% El% | r | n | Durezza Hardness HRB | Rugosità Roughness Ra Microns | N. Picchi Pics/in. | Faccia-Surf 1 med. | Faccia-Surf 2 med. | Totale-Total medio-avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0011585386 | 24RB019112 | 410322 | 1.675,000 | | | X | | 303,60 | 374,00 | 0,810 | 33,200 | | | | | | | | |
| 0011585397 | 24RB019112 | 410322 | 1.695,000 | | | X | | 303,60 | 374,00 | 0,810 | 33,200 | | | | | | | | |
| 0011585424 | 24RB019112 | 410322 | 1.620,000 | | | X | | 303,60 | 374,00 | 0,810 | 33,200 | | | | | | | | |

## ANALISI CHIMICA DEL PRODOTTO / CHEMICAL ANALYSIS

| N. Colata / Heat Number | C | Mn | P | S | Si | Al | Ni | Cr | Mo | V | Cu | Ti | B | Nb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 410322 | 0,04400 | 0,22400 | 0,00500 | 0,01500 | 0,01600 | 0,04400 | | | | | | 0,00000 | | |

**Hole expansion**

ZINCATI A CALDO - HOT DIP GALVANIZED gr/mq

ELETTROZINCATI - ELECTRO GALVANIZED Micron

Certifichiamo che i prodotti sopra elencati sono conformi ai requisiti dell'ordine
We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order

CONTROLLI VISIVO E DIMENSIONALE: Soddisfacente
Surface and Dimensions Control: OK

Riferimento Bolla(DDT)-Invoice: 15016380

Riferimento Consegna - Delivery: 81319184 / 000010

Data: 05.04.2024

**ArcelorMittal CLN Distribuzione Italia srl**
Corso Susa 13/15
10040 Caselette (T0) Italy
SDI CODE Q1REB9A

T +39 011 9782 111
F +39 011 9688 378
www.arcelormittalcln.com
SDI CODE Q1REB9A

Collaudatore/Tester: Doc. emesso automaticamente


I.M.E.
S.P.A.
ORDINE CLIEN
849BOC
FORNITORE
ArcelorMittalCLN - Div.Osimo
Via Industria 13 60027 Osimo AN
P.LOR(Kg) 1.695
P.NET(Kg)
PEZZI 61
ZN20
2X1250X1400
QUANTITA'
1.69
SVIL. DX51D+Z200 A
LaF Riv EN 10346 no oliato
ORDINE DI PROD.
2001143045
CODICE FORNITORE
DATA
21.03.2024
ORDINE INTERNO
572598/10 – 1096429 – S00 1204
MATRICOLA PRODOTTO
24RB019112
NUMERO COLATA
410322
NS. PARTITA ORIGINE
NS.NUMERO COIL
0011524102
DOCUMENTO MATERIALE
4911596632
0011585207
02.04.2024

ArcelorMittal CLN

**ATTESTATO DI CONTROLLO UNI EN 10204-2.2 - DIN 50049/2.2-ISO 404**

**TEST REPORT UNI EN 10204-2.2 - DIN 50049/2.2-ISO 404**

**N. 0001376434**



**ArcelorMittal CLN Distribuzione Italia srl**
Codice Fiscale e Partita IVA: 11233970018
Registro Imprese TORINO
CEE VAT: IT 11233970018
R.E.A. n. 1197930 Torino

| Organismo di controllo / Checking Entity | Cliente - Customer | Ordine Cliente / Customer Order | Ordine 1007 / Order | Qualità - Steel Grade | Fam. siderurgica - Product group | Disegno N. - Customer Product Code ZN30 |
|---|---|---|---|---|---|---|
| 1007 Produttore / Steelmaker: X | 1096429 I.M.E.S.A. S.P.A Dest.M. S004204 IMESA SPA | 849BOC | 0000572598 | EN 10346 DX51D+Z A Minimizzato 275 2SUP no oliato Passivazione ecologica | LaF Riv<br>Tipo prodotto - Product type: Zincato | |

| Spessore / Thickness | Larghezza / Width | Lunghezza / Length | II Base |
|---|---|---|---|
| 3,00 | 1.250,00 | 1.400,00 | 0,00 |

## IDENTIFICAZIONE DEL PRODOTTO / PRODUCT IDENTIFICATION

## PROVA DI TRAZIONE / TENSILE TEST

Durezza / Hardness — Rugosità / Roughness — Rivestimento - Coating

| N°Partita / SAP ID. | Matricola Prodotto / Coil Number | N. Colata / Heat Number | Peso Partita / Weight (Kg) | Orientamento Test Direction L | Orientamento Test Direction T | Provetta Test Sample 20x80 | Provetta Test Sample 5.65 | Re/YS MPa | Rm/UTS MPa | Re/ Rm | A% El% | r | n | HRB | Ra Microns | N. Picchi Pics/in. | Faccia-Surf 1 med. | Faccia-Surf 1 med. | Faccia-Surf 2 med. | Faccia-Surf 2 med. | Totale-Total medio-avg. | Totale-Total medio-avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0011585590 | 214004263 | 401300 | 1.800,000 | | X | | X | 300 | 400 | 0,750 | 28,00 | | | | | | | | | | | |
| 0011585612 | 214004263 | 401300 | 1.760,000 | | X | | X | 300 | 400 | 0,750 | 28,00 | | | | | | | | | | | |

## ANALISI CHIMICA DEL PRODOTTO / CHEMICAL ANALYSIS

**Hole expansion**

ZINCATI A CALDO - HOT DIP GALVANIZED gr/mq

ELETTROZINCATI - ELECTRO GALVANIZED Micron

| N. Colata / Heat Number | C | Mn | P | S | Si | Al | Ni | Cr | Mo | V | Cu | Ti | B | Nb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 401300 | 0,06000 | 0,45000 | 0,05000 | 0,02300 | 0,02000 | 0,03700 | | | | | | 0,05000 | | |

Certifichiamo che i prodotti sopra elencati sono conformi ai requisiti dell'ordine
We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order

CONTROLLI VISIVO E DIMENSIONALE: Soddisfacente
Surface and Dimensions Control: OK

Riferimento Bolla(DDT)-Invoice: 15015181

Riferimento Consegna - Delivery: 81317548 / 000010

Data: 26.03.2024

**ArcelorMittal CLN Distribuzione Italia srl**
Corso Susa 13/15
10040 Caselette (T0) Italy
SDI CODE Q1REB9A

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F +39 011 9688 378
www.arcelormittalcln.com
SDI CODE Q1REB9A

Collaudatore/Tester: Doc. emesso automaticamente

COMMITTENTE
I.M.E.S.A. S.P.A

ZIONE MATERIALE
A SPA
di Vittorio 14 60035 JESI AN IT

ORDINE CLIENTE
849BOC

FORNITORE
ArcelorM
Via Emil
v.Fontan.
ontenellato PR

P.LOR(Kg)
NET(Kg)
PEZZI 43

ZN30

3X1250X1400

QUANTITA'
1.800

SVIL. DX51D+Z275 A

LaF Riv EN 10346 no oliato

ORDINE DI PROD.
2001143097

CODICE FORNITORE

DATA
21.03.2024

ORDINE INTERNO
572598/30-1096429-S004204

MATRICOLA PRODOTTO
214004263

NUMERO COLATA
401300

NS. PARTITA ORIGINE
0011585509

NS.NUMERO COIL
0011554848

DOCUMENTO MATERIALE
4911596749

0011585590

Cfz:2001558766
IMBFG320
Ubic. 3 PF2

02.04.2024

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metals & solutions
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**CANTORI s.r.l.**
60027 Osimo (AN) - Via Delle Querce 15-21
Tel. 071 7132362 - Fax 071 7230107
Cod. Fisc., Part.IVA e Reg. Impr AN n. 00320860422
R.E.A. AN n. 71933 – Capitale Sociale € 900.000,00
Web: **www.cantorialluminio.it** - E-mail: **info@cantorialluminio.it**

**Intestazione**
**I.M.E.S.A. spa**
**VIA G. DI VITTORIO, 14 - Z.I. ZIPA**
**60035 - JESI (AN) - ITALIA**

**Tel /0731 211034 Tel Fax /0731 211055**

## CERTIFICATO IN ACCORDO ALLA NORMA UNI EN 10204 2.2

| CERTIFICATO NUMERO | DATA CERTIFICATO | RIFERIMENTO DDT | DATA DDT | PAG. |
|---|---|---|---|---|
| **1020** | **22-03-2022** | **1020/ddt** | **22-03-2022** | **1 / 2** |

| N° LOTTO | RIF. ORDINE | DATA ORDINE |
|---|---|---|
| PF-2022-00000844 | 354/ZZORA | 07-02-2022 |

| Codice | Descrizione | N Lastre | U.M. | Quantità |
|---|---|---|---|---|
| ALLA\000026 | LASTRA ALL. LEGA 5754 H111 MF SENZA PVC da mm. 3,00x1250x2500 | 21 | KG | 528,00 |

**COMPOSIZIONE CHIMICA**

| | %Si | %Fe | %Cu | %Mn | %Mg | %Cr | %Zn | %Ti | %Altro | |
|---|---|---|---|---|---|---|---|---|---|---|
| MIN | 0,000 | 0,000 | 0,000 | 0,000 | 2,600 | 0,000 | 0,000 | 0,000 | 0,100 | |
| MAX | 0,400 | 0,400 | 0,100 | 0,500 | 3,600 | 0,300 | 0,200 | 0,500 | 0,600 | |

Norma di riferimento:
EN573-3

**PROPRIETA' MECCANICHE**

| | |
|---|---|
| Allungamento A50%: | 18 |
| Carico di Rottura A Trazione R-N/mmq: | 190-240 N/mm2 |
| Carico di Snervamento S-N/mmq: | 80 |

Norma di riferimento:
EN485-2

:

Cantori s.r.l.
Giordano Cantori


Infinity Zucchetti (www.zucchetti.it)

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**CANTORI s.r.l.**
60027 Osimo (AN) - Via Delle Querce 15-21
Tel. 071 7132362 - Fax 071 7230107
Cod. Fisc., Part.IVA e Reg. Impr AN n. 00320860422
R.E.A. AN n. 71933 – Capitale Sociale € 900.000,00
Web: **www.cantorialluminio.it** - E-mail: **info@cantorialluminio.it**

**ntestazione**
**I.M.E.S.A. spa**
**VIA G. DI VITTORIO, 14 - Z.I ZIPA**
**60035 - JESI (AN) - ITALIA**

**Tel /0731 211034 Tel Fax /0731 211055**

## CERTIFICATO IN ACCORDO ALLA NORM UN EN 10204 2 2

| CERTIFICATO NUMERO | DATA CERTIFICATO | RIFERIMENTO DDT | DATA DDT | PAG. |
|---|---|---|---|---|
| **1020** | **22-03-2022** | **1020/ddt** | **22-03-2022** | **2 / 2** |

| N° LOTTO | RIF. ORDINE | DATA ORDINE |
|---|---|---|
| PF-2022-00001271 | 354/ZZORA | 07-02-2022 |

| Codice | Descrizione | N Lastre | U.M. | Quantità |
|---|---|---|---|---|
| ALLA\000022 | LASTRA ALL. LEGA 5754 H111 MF SENZA PVC da mm. 1,50x1000x2000 | 123 | KG | 1.006,00 |

**COMPOSIZIONE CHIMICA**

| | %Si | %Fe | %Cu | %Mn | %Mg | %Cr | %Zn | %Ti | %Altro | |
|---|---|---|---|---|---|---|---|---|---|---|
| MIN | 0,000 | 0,000 | 0,000 | 0,000 | 2,600 | 0,000 | 0,000 | 0,000 | 0,100 | |
| MAX | 0,400 | 0,400 | 0,100 | 0,500 | 3,600 | 0,300 | 0,200 | 0,500 | 0,600 | |

Norma di riferimento:
EN573-3

**PROPRIETA' MECCANICHE**

| | |
|---|---|
| Allungamento A50%: | 16 |
| Carico di Rottura A Trazione R-N/mmq: | 190-240 N/mm2 |
| Carico di Snervamento S-N/mmq: | 80 |

Norma di riferimento:
EN485-2

:

Cantori s.r.l.
Giordano Cantori


Infinity Zucchetti (www.zucchetti.it)

Etrusca Profilati s.r.l.
STEEL SERVICE CENTRE

Loc. Montecaselli, 4 - 57025 PIOMBINO (LI) REA 71068
R.I.L. LI 4 0099232 - C.F. e P.IVA 00712080498
Capitale Sociale € 1.250.000,00 int. vers. www.etruscaprofilati.it

AZIENDA CON
SISTEMA DI GESTIONE QUALITA'
CERTIFICATO DA DNV
ISO 9001

## LAVORAZIONE E COMMERCIO LAMIERE

| | |
|---|---|
| Cliente/Customer: Imesa Spa<br>Zona Ind. Zipa - Via G. Di Vittorio 14<br>60035 Jesi AN | Tipo di documento/Type of document: Certificato di collaudo interno, EQUIVALENTE A 3.1 EN 10204:2004<br>N° Certificato/Certificate N°: 411/2023/3 |
| N° coil : 202300001394 | DDT n°: 436 del 13/02/2023 |
| Prodotto/Product : Lamiera Decapata Piana | Norma di rif./Standard: EN 10025/2:2005 - EN 10051:2010 |
| Rif. collo:<br>2.0x1000x2000 Kg.4020 | Qualità + rivestimento/Steel grade + Coating:<br>S235JR |

Prova meccanica/Mechanical test

| N° coil | ID provino | $R_{p0.2}$ MPa | $R_{eH}$ MPa | $R_{eL}$ MPa | $R_m$ MPa | $A_{80mm}$ % |
|---|---|---|---|---|---|---|
| 202300001394 | Testa-T1 | 251 | - | - | 372 | 23,8 |

Analisi chimica/Chemical analysis

| C % | Si % | Mn % | S % | P % | Ti % |
|---|---|---|---|---|---|
| 0.0460 | 0.0070 | 0.2370 | 0.0170 | 0.0100 | 0.0000 |

Controllo marcatura, aspetto superficiale e dimensioni: SODDISFACENTE
Marking, surface aspect and dimension inspection: NO REMARKS

Certifichiamo che il prodotto fornito è conforme ai requisiti dell'ordine - We certify that the material supplied complies with the requirements agreed on the order
Certificato redatto sulla base delle condizioni generali di vendita - This certificate is draw up on the base of our general terms and condition of sale

CERTIFICAZIONE DI SISTEMA QUALITÀ DNV ISO 9001

Data di stampa: 17.06.25

Il collaudatore N. Cordini

Etrusca Profilati s.r.l.
STEEL SERVICE CENTRE

Loc. Montecaselli, 4 - 57025 PIOMBINO (LI) REA 71068
R.I.L. LI 4 0099232 - C.F. e P.IVA 00712080498
Capitale Sociale € 1.250.000,00 int. vers. www.etruscaprofilati.it

AZIENDA CON
SISTEMA DI GESTIONE QUALITA'
CERTIFICATO DA DNV
ISO 9001

## LAVORAZIONE E COMMERCIO LAMIERE

| | |
|---|---|
| Cliente/Customer: Imesa Spa<br>Zona Ind. Zipa - Via G. Di Vittorio 14<br>60035 Jesi AN | Tipo di documento/Type of document: Certificato di collaudo interno, EQUIVALENTE A 3.1 EN 10204:2004<br>N° Certificato/Certificate N°: 1316/2023/3 |
| N° coil : 202300005279 | DDT n°: 1360 del 06/06/2023 |
| Prodotto/Product : Lamiera Decapata Piana | Norma di rif./Standard: EN 10111:2008 - EN 10051:2010 |
| Rif. collo:<br>2.0x1250x2000 Kg.8276 | Qualità + rivestimento/Steel grade + Coating:<br>DD11 |

Prova meccanica/Mechanical test

| N° coil | ID provino | $R_{p0.2}$ MPa | $R_{eH}$ MPa | $R_{eL}$ MPa | $R_m$ MPa | $A_{80mm}$ % |
|---|---|---|---|---|---|---|
| 202300005279 | Testa-T1 | 275 | - | - | 394 | 28,6 |

Analisi chimica/Chemical analysis

| C % | Si % | Mn % | S % | P % | Ti % |
|---|---|---|---|---|---|
| 0.0557 | 0.0142 | 0.2993 | 0.0098 | 0.0226 | 0.0141 |

Controllo marcatura, aspetto superficiale e dimensioni: SODDISFACENTE
Marking, surface aspect and dimension inspection: NO REMARKS

Certifichiamo che il prodotto fornito è conforme ai requisiti dell'ordine - We certify that the material supplied complies with the requirements agreed on the order
Certificato redatto sulla base delle condizioni generali di vendita - This certificate is draw up on the base of our general terms and condition of sale

CERTIFICAZIONE DI SISTEMA QUALITÀ DNV ISO 9001

Data di stampa: 12.06.23

Il collaudatore N. Cordini

Etrusca Profilati s.r.l.
STEEL SERVICE CENTRE

Loc. Montecaselli, 4 - 57025 PIOMBINO (LI) REA 71068
R.I.L. LI 4 0099232 - C.F. e P.IVA 00712080498
Capitale Sociale € 1.250.000,00 int. vers. www.etruscaprofilati.it

AZIENDA CON
SISTEMA DI GESTIONE QUALITA'
CERTIFICATO DA DNV
ISO 9001

## LAVORAZIONE E COMMERCIO LAMIERE

| | |
|---|---|
| Cliente/Customer: Imesa Spa<br>Zona Ind. Zipa - Via G. Di Vittorio 14<br>60035 Jesi AN | Tipo di documento/Type of document: Certificato di collaudo interno, EQUIVALENTE A 3.1 EN 10204:2004<br>N° Certificato/Certificate N°: 412/2023/1 |
| N° coil : 202200033051 | DDT n°: 436 del 13/02/2023 |
| Prodotto/Product : Lamiera Decapata Piana | Norma di rif./Standard: EN 10111:2008 - EN 10051:2010 |
| Rif. collo:<br>3.0x1000x1800 Kg.6045 | Qualità + rivestimento/Steel grade + Coating:<br>DD11 |

Prova meccanica/Mechanical test

| N° coil | ID provino | $R_{p0.2}$ MPa | $R_{eH}$ MPa | $R_{eL}$ MPa | $R_m$ MPa | $A_{80mm}$ % |
|---|---|---|---|---|---|---|
| 202200033051 | Testa-T1 | 250 | - | - | 359 | 26,5 |

Analisi chimica/Chemical analysis

| C % | Si % | Mn % | S % | P % | Ti % |
|---|---|---|---|---|---|
| 0.0513 | 0.0153 | 0.2655 | 0.0091 | 0.0033 | 0.0201 |

Controllo marcatura, aspetto superficiale e dimensioni: SODDISFACENTE
Marking, surface aspect and dimension inspection: NO REMARKS

Certifichiamo che il prodotto fornito è conforme ai requisiti dell'ordine - We certify that the material supplied complies with the requirements agreed on the order
Certificato redatto sulla base delle condizioni generali di vendita - This certificate is draw up on the base of our general terms and condition of sale

CERTIFICAZIONE DI SISTEMA QUALITÀ DNV ISO 9001

Data di stampa: 17.06.25

Il collaudatore N. Cordini

Etrusca Profilati s.r.l.
STEEL SERVICE CENTRE

Loc. Montecaselli, 4 - 57025 PIOMBINO (LI) REA 71068
R.I.L. LI 4 0099232 - C.F. e P.IVA 00712080498
Capitale Sociale € 1.250.000,00 int. vers. www.etruscaprofilati.it

AZIENDA CON
SISTEMA DI GESTIONE QUALITA'
CERTIFICATO DA DNV
ISO 9001

## LAVORAZIONE E COMMERCIO LAMIERE

| | |
|---|---|
| Cliente/Customer: Imesa Spa<br>Zona Ind. Zipa - Via G. Di Vittorio 14<br>60035 Jesi AN | Tipo di documento/Type of document: Certificato di collaudo interno, EQUIVALENTE A 3.1 EN 10204:2004<br>N° Certificato/Certificate N°: 462/2023/3 |
| N° coil : 202200023069 | DDT n°: 436 del 13/02/2023 |
| Prodotto/Product : Lamiera Decapata Piana | Norma di rif./Standard: EN 10111:2008 - EN 10051:2010 |
| Rif. collo:<br>3.0x1250x2500 Kg.4225 / 3.0x1250x1800 Kg.2045 | Qualità + rivestimento/Steel grade + Coating:<br>DD11 |

Prova meccanica/Mechanical test

| N° coil | ID provino | $R_{p0.2}$ MPa | $R_{eH}$ MPa | $R_{eL}$ MPa | $R_m$ MPa | $A_{80mm}$ % |
|---|---|---|---|---|---|---|
| 202200023069 | Testa-T1 | 270 | - | - | 371 | 31,8 |

Analisi chimica/Chemical analysis

| C % | Si % | Mn % | S % | P % | Ti % |
|---|---|---|---|---|---|
| 0.0500 | 0.0090 | 0.3330 | 0.0090 | 0.0120 | 0.0000 |

Controllo marcatura, aspetto superficiale e dimensioni: SODDISFACENTE
Marking, surface aspect and dimension inspection: NO REMARKS

Certifichiamo che il prodotto fornito è conforme ai requisiti dell'ordine - We certify that the material supplied complies with the requirements agreed on the order
Certificato redatto sulla base delle condizioni generali di vendita - This certificate is draw up on the base of our general terms and condition of sale

CERTIFICAZIONE DI SISTEMA QUALITA' DNV ISO 9001

Data di stampa: 17.06.25

Il collaudatore N. Cordini

ArcelorMittal CLN

**ArcelorMittal CLN Distribuzione Italia srl**
Codice Fiscale e Partita IVA: 11233970018
Registro Imprese TORINO
CEE VAT: IT 11233970018
R.E.A. n. 1197930 Torino

# ATTESTATO DI CONTROLLO UNI EN 10204-2.2 - DIN 50049/2.2-ISO 404

## TEST REPORT UNI EN 10204-2.2 - DIN 50049/2.2-ISO 404

**N. 0001172714**

Pag. 1 /1

| Organismo di controllo | Cliente - Customer | Ordine Cliente | Ordine 1003 | Qualità - Steel Grade | Fam. siderurgica - Product group | Disegno N. - Customer Product Code MP01000711 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Checking Entity | 1096429 | Customer Order | Order | EN 10346<br>DX51D+Z<br>A<br>Minimizzato<br>200 2SUP<br>no oliato<br>Passivazione ecologica | LaF Riv<br>Tipo prodotto - Product type<br>Zincato | Spessore<br>Thickness | Larghezza<br>Width | Lunghezza<br>Length | II Base |
| 1003 Produttore<br>Steelmaker | I.M.E.S.A. S.P.A<br>Dest.M. S004204 | 4068GS | 0000468580 | | | 2,50 | 1.250,00 | 2.000,00 | 0,00 |
| X | IMESA SPA | | | | | | | | |

## IDENTIFICAZIONE DEL PRODOTTO
## PRODUCT IDENTIFICATION

## PROVA DI TRAZIONE
## TENSILE TEST

| N°Partita<br>SAP ID. | Matricola Prodotto<br>Coil Number | N. Colata<br>Heat Number | Peso Partita<br>Weight (Kg) | Orientamento Test Direction<br>L | <br>T | Provetta Test Sample<br>20x80 | <br>5.65 | Re/YS<br>MPa | Rm/UTS<br>MPa | Re/<br>Rm | A%<br>El% | <br>r | <br>n | Durezza<br>Hardness<br>HRB | Rugosità<br>Roughness<br>Ra<br>Microns | <br>N. Picchi<br>Pics/in. | Rivestimento - Coating<br>Faccia-Surf 1<br>med. | <br>med. | Faccia-Surf 2<br>med. | <br>med. | Totale-Total<br>medio-avg. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0009399546 | 0000006105003 | 012210 | 2.032,000 | | X | X | | 300 | 400 | 0,750 | 28,00 | | | | | | | | | | | |

## ANALISI CHIMICA DEL PRODOTTO
## CHEMICAL ANALYSIS

**Hole expansion**

ZINCATI A CALDO - HOT DIP GALVANIZED gr/mq
ELETTROZINCATI - ELECTRO GALVANIZED Micron

| N. Colata<br>Heat Number | C | Mn | P | S | Si | Al | Ni | Cr | Mo | V | Cu | Ti | B | Nb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 012210 | 0,06000 | 0,45000 | 0,05000 | 0,02300 | 0,02000 | 0,03700 | | | | | | 0,05000 | | |

-MODO DI ELABORAZIONE DELL'ACCIAO:
CONVERTITORE CON OSSIGENO PURO, COLATA CONTINUA
-Steelmaking Process: Converter with pure Oxygen Continuous casting

STATO DI FORNITURA:Laminazione a temperatura controllata
Delivery Conditions: Controlled Rolling Temperature

Certifichiamo che i prodotti sopra elencati sono conformi ai requisiti dell'ordine
We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order

PROVA DI PIEGA: soddisfacente - Bending Test: OK
CONTROLLI VISIVO E DIMENSIONALE: Soddisfacente
Surface and Dimensions Control: OK

**ArcelorMittal CLN Distribuzione Italia srl**
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10040 Caselette (T0) Italy
SDI CODE Q1REB9A

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www.arcelormittalcln.com
SDI CODE Q1REB9A

Riferimento Bolla(DDT)-Invoice:
15051857
Riferimento Consegna - Delivery:
81114479 / 000030

Data: 15.09.2021

Collaudatore/Tester: Doc. emesso automaticamente

ArcelorMittal CLN

**ATTESTATO DI CONTROLLO UNI EN 10204-2.2 - DIN 50049/2.2-ISO 404**

**TEST REPORT UNI EN 10204-2.2 - DIN 50049/2.2-ISO 404**

**N. 0001378127**



**ArcelorMittal CLN Distribuzione Italia srl**
Codice Fiscale e Partita IVA: 11233970018
Registro Imprese TORINO
CEE VAT: IT 11233970018
R.E.A. n. 1197930 Torino

| Organismo di controllo / Checking Entity | Cliente - Customer | Ordine Cliente / Customer Order | Ordine 1003 / Order | Qualità - Steel Grade | Fam. siderurgica - Product group | Disegno N. - Customer Product Code ZN20 |
|---|---|---|---|---|---|---|
| 1003 Produttore / Steelmaker: X | 1096429 I.M.E.S.A. S.P.A Dest.M. S004204 IMESA SPA | 849BOC | 0000572598 | EN 10346 DX51D+Z A Minimizzato 200 2SUP no oliato Passivazione ecologica | LaF Riv<br>Tipo prodotto - Product type: Zincato | Spessore / Thickness: 2,00 — Larghezza / Width: 1.500,00 — Lunghezza / Length: 2.500,00 — II Base: 0,00 |

## IDENTIFICAZIONE DEL PRODOTTO / PRODUCT IDENTIFICATION — PROVA DI TRAZIONE / TENSILE TEST — Durezza / Hardness — Rugosità / Roughness — Rivestimento - Coating

| N°Partita / SAP ID. | Matricola Prodotto / Coil Number | N. Colata / Heat Number | Peso Partita / Weight (Kg) | Orientamento Test Direction L | Orientamento Test Direction T | Provetta Test Sample 20x80 | Provetta Test Sample 5.65 | Re/YS MPa | Rm/UTS MPa | Re/ Rm | A% El% | r | n | HRB | Ra Microns | N. Picchi Pics/in. | Faccia-Surf 1 med. | Faccia-Surf 2 med. | Totale-Total medio-avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0011584948 | 0000006454617 | 331984 | 2.300,000 | | X | X | | 300 | 400 | 0,750 | 28,00 | | | | | | | | |
| 0011585004 | 0000006454617 | 331984 | 2.295,000 | | X | X | | 300 | 400 | 0,750 | 28,00 | | | | | | | | |

## ANALISI CHIMICA DEL PRODOTTO / CHEMICAL ANALYSIS

**Hole expansion**

ZINCATI A CALDO - HOT DIP GALVANIZED gr/mq

ELETTROZINCATI - ELECTRO GALVANIZED Micron

| N. Colata / Heat Number | C | Mn | P | S | Si | Al | Ni | Cr | Mo | V | Cu | Ti | B | Nb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 331984 | 0,06000 | 0,45000 | 0,05000 | 0,02300 | 0,02000 | 0,03700 | | | | | | 0,05000 | | |

Certifichiamo che i prodotti sopra elencati sono conformi ai requisiti dell'ordine
We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order

CONTROLLI VISIVO E DIMENSIONALE: Soddisfacente
Surface and Dimensions Control: OK

Riferimento Bolla(DDT)-Invoice: 15016380

Riferimento Consegna - Delivery: 81319184 / 000020

Data: 05.04.2024

**ArcelorMittal CLN Distribuzione Italia srl**
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www.arcelormittalcln.com
SDI CODE Q1REB9A

Collaudatore/Tester: Doc. emesso automaticamente

ArcelorMittal CLN

**ATTESTATO DI CONTROLLO UNI EN 10204-2.2 - DIN 50049/2.2-ISO 404**

**TEST REPORT UNI EN 10204-2.2 - DIN 50049/2.2-ISO 404**

**N. 0001376435**



**ArcelorMittal CLN Distribuzione Italia srl**
Codice Fiscale e Partita IVA: 11233970018
Registro Imprese TORINO
CEE VAT: IT 11233970018
R.E.A. n. 1197930 Torino

| Organismo di controllo / Checking Entity | Cliente - Customer | Ordine Cliente / Customer Order | Ordine 1007 / Order | Qualità - Steel Grade | Fam. siderurgica - Product group | Disegno N. - Customer Product Code ZN30 |
|---|---|---|---|---|---|---|
| 1007 Produttore / Steelmaker: X | 1096429 I.M.E.S.A. S.P.A Dest.M. S004204 IMESA SPA | 849BOC | 0000572598 | EN 10346 DX51D+Z A Minimizzato 275 2SUP no oliato Passivazione ecologica | LaF Riv<br>Tipo prodotto - Product type: Zincato | Spessore / Thickness: 3,00 — Larghezza / Width: 1.250,00 — Lunghezza / Length: 2.500,00 — II Base: 0,00 |

## IDENTIFICAZIONE DEL PRODOTTO / PRODUCT IDENTIFICATION — PROVA DI TRAZIONE / TENSILE TEST — Durezza / Hardness — Rugosità / Roughness — Rivestimento - Coating

| N°Partita / SAP ID. | Matricola Prodotto / Coil Number | N. Colata / Heat Number | Peso Partita / Weight (Kg) | Orientamento Test Direction L | Orientamento Test Direction T | Provetta Test Sample 20x80 | Provetta Test Sample 5.65 | Re/YS MPa | Rm/UTS MPa | Re/ Rm | A% El% | r | n | HRB | Ra Microns | N. Picchi Pics/in. | Faccia-Surf 1 med. | Faccia-Surf 1 med. | Faccia-Surf 2 med. | Faccia-Surf 2 med. | Totale-Total medio-avg. | Totale-Total medio-avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0011585649 | 214004263 | 401300 | 1.895,000 | | X | | X | 300 | 400 | 0,750 | 28,00 | | | | | | | | | | | |
| 0011587792 | 214004263 | 401300 | 980,000 | | X | | X | 300 | 400 | 0,750 | 28,00 | | | | | | | | | | | |

## ANALISI CHIMICA DEL PRODOTTO / CHEMICAL ANALYSIS

**Hole expansion**

ZINCATI A CALDO - HOT DIP GALVANIZED gr/mq

ELETTROZINCATI - ELECTRO GALVANIZED Micron

| N. Colata / Heat Number | C | Mn | P | S | Si | Al | Ni | Cr | Mo | V | Cu | Ti | B | Nb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 401300 | 0,06000 | 0,45000 | 0,05000 | 0,02300 | 0,02000 | 0,03700 | | | | | | 0,05000 | | |

Certifichiamo che i prodotti sopra elencati sono conformi ai requisiti dell'ordine
We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order

CONTROLLI VISIVO E DIMENSIONALE: Soddisfacente
Surface and Dimensions Control: OK

Riferimento Bolla(DDT)-Invoice: 15015181

Riferimento Consegna - Delivery: 81317548 / 000020

Data: 26.03.2024

**ArcelorMittal CLN Distribuzione Italia srl**
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SDI CODE Q1REB9A

Collaudatore/Tester: Doc. emesso automaticamente

2.6.2.Painting record

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IMESA ELECTRICAL ENGINEERING

# SCHEDA CONTROLLO PEZZI VERNICIATI
## *QUALITY CONTROL FOR PAINTED PARTS*

**Mese/*Month*:** APRILE **Anno/*Year*:** 2024

| Giorno *Day* | Numero pezzi *Pieces Number* | Progetto N° Project N° | RAL | Controllo visivo *Visual check* | | Misura spessore (µm) (a) *Measurement of thickness (µm) (a)* | | | | | | | Controllo Spessore *Thickness Check* | | Strumento Equipment | Controllo aderenza sul provino *Check adhesion on the specimen* | | Strumento Equipment | Codice operatore operator code | Note *Notes* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | OK | KO | Richiesto *Required* | Valore delle prime 6 misurazioni effettuate *Value of the first 6 Measurements taken* | | | | | | OK | KO | serial number | OK | KO | serial number | | |
| 4/4 | 485 | 500020 | 7035 | X | | 60 | 98 | 112 | 135 | 106 | 97 | 92 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 4/4 | 4 | MAG. | 5019 | X | | 60 | 103 | 87 | 116 | 122 | 109 | 97 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 4/4 | 4 | 231074 | 7035 | X | | 90 | 128 | 136 | 118 | 133 | 120 | 118 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 5/4 | 730 | 231074 | / | X | | 10 | GO | AI | WA | TO | RA | BAR | RE OK | | PP 127 | | | PP 160 | 101 | |
| 11/4 | 74 | 500020 | 7030 | X | | 60 | 110 | 115 | 88 | 92 | 110 | 118 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 11/4 | 115 | 500020 | 7035 | X | | 60 | 115 | 91 | 127 | 118 | 93 | 105 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 17/4 | 363 | 500020 | 7030 | X | | 60 | 117 | 131 | 118 | 95 | 103 | 112 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 17/4 | 71 | 500020 | 7035 | X | | 60 | 101 | 95 | 118 | 121 | 130 | 106 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 24/4 | 615 | 500020 | 7035 | X | | 60 | 105 | 108 | 127 | 97 | 117 | 96 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 24/4 | 120 | 231151 | 7035 | X | | 60 | 101 | 100 | 110 | 104 | 98 | 105 | OK | | PP 127 | OK | | PP 160 | 101 | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
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| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |

**(a)** Effettuare la misura dello spessore sul provino e su un pezzo ogni 15 del lotto (o almeno un pezzo tra i componenti con stesso RAL), indicando il valore misurato sullo spazio apposito, la prova di aderenza va eseguita esclusivamente sul provino (una ogni RAL diverso)

**N.B.** Il provino per commessa deve essere il primo pezzo montato sulla catena, per ogni commessa/costruzione

*(a)Measure the thickness on the specimen and on one piece every 15 of the lot (or at least one pièce among the components with the same RAL), indicating the value measured on the space provided, the adhesion test must be performed exclusively on the specimen (one each different RAL)*

*N.B. The order specimen must be the first piece mounted on the chain, for each order / construction*

IMESA ELECTRICAL ENGINEERING

# SCHEDA CONTROLLO PEZZI VERNICIATI
## *QUALITY CONTROL FOR PAINTED PARTS*

**Mese/*Month*:** MAGGIO **Anno/*Year*:** 2024

| Giorno *Day* | Numero pezzi *Pieces Number* | Progetto N° Project N° | RAL | Controllo visivo *Visual check* | | Misura spessore (µm) (a) *Measurement of thickness (µm) (a)* | | | | | | | Controllo Spessore *Thickness Check* | | Strumento Equipment | Controllo aderenza sul provino *Check adhesion on the specimen* | | Strumento Equipment | Codice operatore operator code | Note *Notes* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | OK | KO | Richiesto *Required* | Valore delle prime 6 misurazioni effettuate *Value of the first 6 Measurements taken* | | | | | | OK | KO | serial number | OK | KO | serial number | | |
| 7/5 | 275 | 500020 | 7012 | OK | | 60 | 85 | 98 | 110 | 96 | 124 | 102 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 8/5 | 195 | 220812 | 7035 | OK | | 60 | 93 | 102 | 88 | 116 | 98 | 106 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 8/5 | 260 | 230925 | 7035 | OK | | 60 | 106 | 118 | 102 | 97 | 91 | 101 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 9/5 | 430 | 230924 | | OK | | IN | GU | AI | UA | TU | RA | | | | PP 127 | | | PP 160 | 101 | |
| 15/5 | 528 | 500020 | 7035 | OK | | 60 | 100 | 97 | 113 | 106 | 88 | 92 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 16/5 | 474 | 231012 | 7035 | OK | | 60 | 91 | 118 | 106 | 93 | 102 | 85 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 20/5 | 396 | 500020 | 7030 | OK | | 60 | 106 | 118 | 122 | 107 | 98 | 93 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 29/5 | 280 | 230924 | 7035 | OK | | 60 | 100 | 97 | 112 | 88 | 95 | 104 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 29/5 | 170 | 500020 | 7035 | OK | | 60 | 95 | 91 | 103 | 108 | 117 | 101 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 30/5 | 150 | 230924 | 7035 | OK | | 60 | 118 | 87 | 95 | 102 | 127 | 103 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 30/5 | 68 | 500020 | 7030 | OK | | 60 | 85 | 98 | 107 | 102 | 117 | 108 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 31/5 | 90 | 231151 | 7035 | OK | | 60 | 91 | 99 | 86 | 84 | 91 | 105 | OK | | PP 127 | OK | | PP 160 | 101 | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |

**(a)** Effettuare la misura dello spessore sul provino e su un pezzo ogni 15 del lotto (o almeno un pezzo tra i componenti con stesso RAL), indicando il valore misurato sullo spazio apposito, la prova di aderenza va eseguita esclusivamente sul provino (una ogni RAL diverso)

**N.B.** Il provino per commessa deve essere il primo pezzo montato sulla catena, per ogni commessa/costruzione

*(a)Measure the thickness on the specimen and on one piece every 15 of the lot (or at least one piece among the components with the same RAL), indicating the value measured on the space provided, the adhesion test must be performed exclusively on the specimen (one each different RAL)*

*N.B. The order specimen must be the first piece mounted on the chain, for each order / construction*

IMESA ELECTRICAL ENGINEERING

# SCHEDA CONTROLLO PEZZI VERNICIATI
## *QUALITY CONTROL FOR PAINTED PARTS*

**Mese/*Month*** GIUGNO **Anno/*Year*:** 2024

| Giorno *Day* | Numero pezzi *Pieces Number* | Progetto N° *Project N°* | RAL | Controllo visivo *Visual check* | | Misura spessore (µm) (a) *Measurement of thickness (µm) (a)* | | | | | | | Controllo Spessore *Thickness Check* | | Strumento Equipment | Controllo aderenza sul provino *Check adhesion on the specimen* | | Strumento Equipment | Codice operatore operator code | Note *Notes* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | OK | KO | Richiesto *Required* | Valore delle prime 6 misurazioni effettuate *Value of the first 6 Measurements taken* | | | | | | OK | KO | serial number | OK | KO | serial number | | |
| 6/6 | 180 | 500020 | 7035 | OK | | 60 | 92 | 97 | 106 | 113 | 125 | 91 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 7/6 | 175 | 230925 | 7035 | OK | | 60 | 104 | 117 | 88 | 93 | 102 | 95 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 13/6 | 120 | 231298 | 7035 | OK | | 60 | 110 | 97 | 114 | 91 | 88 | 102 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 13/6 | 150 | 500020 | 7035 | OK | | 60 | 96 | 85 | 102 | 125 | 111 | 88 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 13/6 | 3 | 231244 | 7032 | OK | | 60 | 127 | 118 | 99 | 88 | 106 | 97 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 13/6 | 78 | 231131 | 7035 | OK | | 60 | 86 | 102 | 118 | 96 | 104 | 81 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 18/6 | 295 | 210965 | 7030 | OK | | 60 | 102 | 93 | 115 | 113 | 98 | 121 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 18/6 | 250 | 500020 | 7030 | OK | | 60 | 108 | 106 | 98 | 87 | 102 | 106 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 24/6 | 190 | 500020 | 7030 | OK | | 60 | 105 | 115 | 95 | 88 | 106 | 88 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 27/6 | 315 | 500020 | 7035 | OK | | 60 | 118 | 102 | 100 | 92 | 100 | 85 | OK | | PP 127 | OK | | PP 160 | 101 | |
| 28/6 | 140 | 231298 | 7035 | OK | | 60 | 96 | 101 | 91 | 94 | 98 | 90 | OK | | PP 127 | OK | | PP 160 | 101 | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |
| | | | | | | | | | | | | | | | PP 127 | | | PP 160 | | |

**(a)** Effettuare la misura dello spessore sul provino e su un pezzo ogni 15 del lotto (o almeno un pezzo tra i componenti con stesso RAL), indicando il valore misurato sullo spazio apposito, la prova di aderenza va eseguita esclusivamente sul provino (una ogni RAL diverso)

**N.B.** Il provino per commessa deve essere il primo pezzo montato sulla catena, per ogni commessa/costruzione

*(a)Measure the thickness on the specimen and on one piece every 15 of the lot (or at least one piece among the components with the same RAL), indicating the value measured on the space provided, the adhesion test must be performed exclusively on the specimen (one each different RAL)*

*N.B. The order specimen must be the first piece mounted on the chain, for each order / construction*

## 2.6.3.Mechanical & Electrical completion checklist

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IMESA ELECTRICAL ENGINEERING

# SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO BT
## *LV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | |
|---|---|---|---|
| **CLIENTE** *CUSTOMER* | Rosetti M. | **PROGETTO** *PROJECT* | 231298 "SG-200 N1" |
| **TIPO QUADRO** *SWITCHBOARD TYPE* | L.V. | **N. CELLA** *N UNIT* | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Caratteristiche elettriche** *Electrical characteristics* | $U_r$ (kV): | | $I_r$ (A): | | $I_k$ (kA): | | $t_k$(s) | |

## ASSEMBLAGGIO SCOMPARTO – COMPARTMENT *ASSEMBLY*

| Attività/ *Activity* | II/ *WI* | Rif/ *Ref* | *Strumento Equipment* | *data date* | Codice oper. i.d. code |
|---|---|---|---|---|---|
| Preparazione contro basamento (molle / gomma)<br>*Preparation of the bottom-base(springs/rubber)* | CAR 26 | 01 | / | / | / |
| Preparazione della base e montaggio dei fianchi anteriori,posteriori e tetti<br>*Preparation of the base and assembly of the front, rear and roof sides* | CAR 26 | 02 | | 6/6/2024 | 849 |
| Controllo dello squadro struttura<br>*Structure squaring control* | CAR 26 | 03 | | 13/6/24 | 849 |
| Montaggio degli accessori su tetto<br>*Mounting of accessories on the roof* | CAR 26 | 04 | | 13/6/24 | 849 |
| Montaggio dei ripiani, segregazioni per interruttori e piastre di fondo<br>*Assembly of shelves, dividers for switches and bottom plates* | CAR 26 | 05 | | 14/6/24 | 849 |
| Montaggio parti fisse interruttori<br>*Assembly of the circuit breakers fixed parts* | CAR 26 | 06 | | 21/6/24 | 849 |
| Montaggio dei montanti struttura per alloggio accessori(rame,TA,TO,segregazioni..)<br>*Mounting the supports for the accessory frame (copper,CT's,VT's,TO,segregations)* | CAR 26 | 07 | | 25/06/24 | 849 |
| Montaggio rame di parallelo, TA e serraggio<br>*Mounting of copper parallel, CT and tightening* | CAR 26 | 08 | | 2/07/24 | 849 |
| Montaggio rame di alimentazione,TA e serraggio<br>*Mounting of power supply's copper,CT and tightening* | CAR 26 | 10 | | 4/07/24 | 849 |
| Montaggio rame di uscita, TA e serraggio<br>Mounting of copper output, CT and tightening | CAR 26 | 11 | | 9/07/24 | 849 |
| Montaggio rame di terra e serraggio<br>*Assembly of ground copper and tightening* | CAR 26 | 12 | | 9/07/24 | 849 |
| Montaggio apparecchiature di potenza (contattori, termiche, fusibili ecc)<br>*Assembly of power equipments (contactors, thermal, fuses etc.)* | CAB 01 | 02 | | 01/07/24 | 275 |
| Cablaggio ausiliari<br>*Auxiliary cable* | CAB 01 | 02 | | 01/07/24 | 275 |
| Cablaggio potenza in cavo<br>*Underground power cable* | CAB 01 | 03 | | 01/07/24 | 275 |
| Montaggio segregazioni<br>*Assembly of segregations* | CAR 26 | 13 | | 18/07/24 | 849 |
| Montaggio porte anteriori e centraggio<br>*Assembly and centering of the front door* | CAR 26 | 14 | | 25/07/24 | 849 |
| Montaggio porte posteriori e tamponature<br>*Assembly of rear doors and closing panels* | CAR 26 | 15 | | 25/07/24 | 849 |
| Pulizia finale<br>*Cleaning* | CAR 26 | 16 | | 26/07/24 | 849 |
| | | | | | |
| | | | | | |

## CABLAGGIO – *WIRING*

| Attività/ *Activity* | Il/ *WI* | Rif/ *Ref* | *Strumento Equipment* | *data date* | Codice oper. i.d. code |
|---|---|---|---|---|---|
| Controllo materiali cella aux. e interruttore<br>*Auxiliary cell materials control and circuit breaker* | CQ 11 | 01.1 | | 08/07 Zu | 275 |
| Controllo cablaggio (sigla numerini, morsetti, serraggio viti, targhette, ecc..)<br>*Wiring check (code numbers, terminals, screw tightening, labels, etc.)* | CQ 11 | 01.2 | | u | u |
| Apertura serrande cella interruttore e pulizia<br>*Open the circuit breaker cell shutters, blow and vacuum the whole box well* | CQ 11 | 01.3 | | / | / |
| Controllo delle alimentazioni dei vari strumenti, sulla spina dell'interruttore/contattore e collaudo dei circuiti ausiliari seguendo la logica dello schema<br>*Power supplies check of the various instruments on the plug of contactor/circuit breaker and auxiliary circuits test following the functional diagram* | CQ 11 | 01.4 | | 08/07 | 275 |
| Controllare caratteristiche TA, Toroidi e relativi circuiti<br>*Check CT, toroidal and characteristics and related circuits* | CQ 11 | 02 | | 12/07 | 275 |
| Controllare caratteristiche TV e relativi circuiti<br>*Check VT characteristics and related circuits* | CQ 11 | 03 | | u | u |
| Controllo targhette<br>*Control of plates* | CQ 11 | 04 | | u | u |
| Verifica delle matricole delle parti fisse e mobili degli interruttori<br>*Write the serial numbers of the fixed and moving parts of the switches* | CQ 11 | 05 | | u | u |
| Controllo del grado di protezione (IP)<br>Check protection degree | CQ 11 | 06 | | u | u |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

# SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CLIENTE *CUSTOMER* | ROSETTI MARINO | N. PROGETTO *N. PROJECT* | 231151 | | | | | |
| TIPO QUADRO *SWITCHBOARD TYPE* | MINIVER-C | N. CELLA *N UNIT* | A1 | | | | | |
| Caratteristiche elettriche *Electrical characteristics* | $U_r$ (kV): | | $I_r$ (A): | $I_k$ (kA): | | $t_k$(s) | | Arco interno SI ☐ NO☐ |

## ASSEMBLAGGIO SCOMPARTO – COMPARTMENT *ASSEMBLY*

| Attività/ *Activity* | II/ *WI* | Rif/ *Ref* | Data /*Date*-- *Strumento/Equip* | Codice operator./ *i.d. operator* |
|---|---|---|---|---|
| Preparazione contenitore, prove di funzionamento meccanico e montaggio vano ausiliari<br>*Enclosure preparation and mechanical functional test and* Auxiliary compartment assembly | CAR 19 | 01 | 27/6/24 | 724 |
| Montaggio guarnizioni anteriori, barre derivate superiori<br>*Assembly of front gaskets, upper branch bars* | CAR 19 | 02 | 28/6/24 | 724 |
| Montaggio parte posteriore inferiore, barre di terra<br>*Bottom rear mounting, ground bars* | CAR 19 | 03 | 27/6/24 | 724 |
| Montaggio parte posteriore superiore, TA e barratura rame attacco cavi<br>*Assembly of upper rear part, CT and copper bar for cable connection* | CAR 19 | 04 | 28/6/24<br>SCD TILTI 500 48 | 724 |
| Controllo verniciatura e montaggio portelle anteriori<br>Paint check and front door assembly | CAR 19 | 05 | 28/6/24<br>■ PP143 ☐ PP157 | 443 |
| S.P.Montaggio del tetto<br>D.P. trasferimento contenitore superiore su quello inferiore e montaggio del tetto<br>*S.P. Roof assembly*<br>*D.P. transfer of the upper container to the lower one and assembly of the roof* | CAR 19 | 06 | 28/6/24 | 443 |
| Montaggio apparecchiature di potenza (contattori, termiche, fusibili, scaricatori, ecc)<br>*Assembly of power equipments (contactors, thermal, fuses etc.)* | CAB 01 | 02 | / | / |
| Cablaggio ausiliari<br>*Auxiliary cable* | CAB 01 | 02 | 01/07/24 | 541 |
| Cablaggio potenza in cavo<br>*Underground power cable* | CAB 01 | 03 | / | / |
| Montaggio e controllo targhette<br>*Assembly and control of data plates* | CAB 01 | 04 | 22/07/24 | 535 |
| Verifica completamento montaggio guarnizioni scomparto e coperture canale varie<br>Check completion of assembly of compartment gaskets and various duct covers | CAR 19 | 07 | 25/07/24 | 535 |
| Staffaggio toroide<br>Toroidal transformer bracket | CAR 19 | 08 | 26/07/24 | 441 |

### MATRICOLE APPARECCHIATURE MT MONTATE SULLA CELLA
*Serial number of the equipments mounted in MV switchgear*

| | L1 | L2 | L3 | TO |
|---|---|---|---|---|
| TA *CT* | SIGLA TIL1<br>S/N 24175 | SIGLA TIL2<br>S/N 24176 | SIGLA TIL3<br>S/N 24177 | SIGLA<br>S/N |
| TA *CT* | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N |



SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | | | |
|---|---|---|---|---|---|
| N. PROGETTO *N. PROJECT* | 231251 | TIPO QUADRO *SWITCHBOARD TYPE* | | N. CELLA *N. UNIT* | BOX A1 |

| | | | | |
|---|---|---|---|---|
| TV *VT* | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N |

## VERIFICA ELETTRICA E MECCANICA'- *ELECTRICAL MECHANICAL VERIFICATION*

| Attività/ Activity | II/ *WI* | Rif/ *Ref* | Data/*Date* *Strumento/Equip* | Codice operatore *i.d. operator* |
|---|---|---|---|---|
| Controllo materiali della cella aux e interruttore<br>*Control of materials od Auxiliary cell and circuit breaker* | CQ 10 | 01.1 | 05.07.24 | 614 |
| Controllo cablaggio (sigla numerini, morsetti, serraggio viti, targhette, ecc..)<br>*Wiring check (code numbers, terminals, screw tightening, labels, etc.)* | CQ 10 | 01.2 | 11 | 11 |
| Controllo cablaggio carrello trasformatori di tensione<br>Check the wiring of the voltage transformer track | CQ 10 | 01.3 | 11 | 11 |
| Prova apertura serrande cella interruttore<br>*Open test of the circuit breaker cell shutters* | CQ 10 | 01.4 | 11 | 11 |
| Controllo serraggio dei poli<br>*Tightening check of the poles* | CQ 10 | 01.5 | /<br>SCD..... | / |
| Chiusura serrande, posizionamento fianchi e ripiano, inserimento interruttore<br>*Shutters closing, position of the sides, the shelf and circuit breaker insertion* | CQ 10 | 01.6 | 05.07.24 | 614 |
| Controllo delle alimentazioni degli strumenti, sulla spina dell'interruttore/contattore e collaudo dei circuiti ausiliari<br>*Power supplies check of the various instruments on the plug of contactor/circuit breaker and auxiliary circuits test* | CQ 10 | 01.7 | 11<br>SP.222 | 11 |
| Controllo scaldiglia e luce box<br>*Check heater and light box* | CQ 10 | 01.8 | 11 | 11 |
| Impostazione capacitivi e Collaudo capacitivi<br>*Capacitive setting and Capacitive testing* | CQ 10 | 01.9 | 11 | 11 |
| Controllo targhette<br>*Control of plates* | CQ 10 | 01.10 | | |
| Controllo sezionatore di terra, contattore, interruttore<br>*Control of earthing switch, contactor, circuit breaker insertion* | CQ 10 | 02 | 05.07.24 | 614 |
| Controllo chiavi<br>Key control | Operating sequences | | 11 | 11 |
| Prova con iniezione primaria su TA con generatore di corrente e controllo circuiti; verifica della polarità<br>*Test with primary injection on CT with current generator and circuit control; polarity check* | CQ 10 | 03 | 11<br>SP.222 PP.633 | 11 |
| Prova TV con tensione sui primari e relativi circuiti e controllo rapporto trasf.<br>*Check VT characteristics and related circuits and check the ratio* | CQ 10 | 04 | SP.222 11 | 11 |
| Controllo finale della verniciatura (VISIVO)<br>*Painting final check (VISUAL)* | CQ 10 | 05 | | |
| Prova iniezione primaria su Toroidi con generatore di corr. e controllo circuiti<br>*Test with primary injection on Toroids with current generator and circuit control;* | CQ 10 | 04 | SP.633 | 535 |
| EXERTHERM | | | 25/07/24 | 535 |

## SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CLIENTE *CUSTOMER* | ROSETTI MARINO | N. PROGETTO *N. PROJECT* | 231151 | | | | | |
| TIPO QUADRO *SWITCHBOARD TYPE* | MINIVER -C | N. CELLA *N UNIT* | A 2 | | | | | |
| Caratteristiche elettriche *Electrical characteristics* | $U_r$ (kV): | | $I_r$ (A): | $I_k$ (kA): | | $t_k$(s) | | Arco interno SI ☐ NO☐ |

### ASSEMBLAGGIO SCOMPARTO – COMPARTMENT *ASSEMBLY*

| Attività/ *Activity* | II/ *WI* | Rif/ *Ref* | Data /*Date*-- *Strumento/Equip* | Codice operator./ *i.d. operator* |
|---|---|---|---|---|
| Preparazione contenitore, prove di funzionamento meccanico e montaggio vano ausiliari<br>*Enclosure preparation and mechanical functional test and* Auxiliary compartment assembly | CAR 19 | 01 | 25/6/24 | 724 |
| Montaggio guarnizioni anteriori, barre derivate superiori<br>*Assembly of front gaskets, upper branch bars* | CAR 19 | 02 | 26/6/24 | 724 |
| Montaggio parte posteriore inferiore, barre di terra<br>*Bottom rear mounting, ground bars* | CAR 19 | 03 | 25/6/24 | 724 |
| Montaggio parte posteriore superiore, TA e barratura rame attacco cavi<br>*Assembly of upper rear part, CT and copper bar for cable connection* | CAR 19 | 04 | 26/6/24<br>SCD 1141 T1/SCD148 | 724 |
| Controllo verniciatura e montaggio portelle anteriori<br>Paint check and front door assembly | CAR 19 | 05 | 26/6/24<br>■ PP143 ☐ PP157 | 724 |
| S.P.Montaggio del tetto<br>D.P. trasferimento contenitore superiore su quello inferiore e montaggio del tetto<br>*S.P. Roof assembly*<br>*D.P. transfer of the upper container to the lower one and assembly of the roof* | CAR 19 | 06 | 27/6/24 | 643 |
| Montaggio apparecchiature di potenza (contattori, termiche, fusibili, scaricatori, ecc)<br>*Assembly of power equipments (contactors, thermal, fuses etc.)* | CAB 01 | 02 | / | / |
| Cablaggio ausiliari<br>*Auxiliary cable* | CAB 01 | 02 | 02/07/24 | 434 |
| Cablaggio potenza in cavo<br>*Underground power cable* | CAB 01 | 03 | / | / |
| Montaggio e controllo targhette<br>*Assembly and control of data plates* | CAB 01 | 04 | 22/07/24 | 535 |
| Verifica completamento montaggio guarnizioni scomparto e coperture canale varie<br>Check completion of assembly of compartment gaskets and various duct covers | CAR 19 | 07 | 25/07/24 | 535 |
| Staffaggio toroide<br>Toroidal transformer bracket | CAR 19 | 08 | 26/7/24 | 441 |

### MATRICOLE APPARECCHIATURE MT MONTATE SULLA CELLA
*Serial number of the equipments mounted in MV switchgear*

| | L1 | L2 | L3 | TO |
|---|---|---|---|---|
| TA *CT* | SIGLA TIL1<br>S/N 24178 | SIGLA TIL2<br>S/N 24179 | SIGLA TIL3<br>S/N 24180 | SIGLA<br>S/N |
| TA *CT* | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N |



## SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | | | |
|---|---|---|---|---|---|
| N. PROGETTO *N. PROJECT* | 231151 | TIPO QUADRO *SWITCHBOARD TYPE* | | N. CELLA *N. UNIT* | BOX A2 |

| | | | | |
|---|---|---|---|---|
| TV *VT* | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N |

### VERIFICA ELETTRICA E MECCANICA'- *ELECTRICAL MECHANICAL VERIFICATION*

| Attività/ Activity | II/ *WI* | Rif/ *Ref* | Data/*Date* *Strumento/Equip* | Codice operatore *i.d. operator* |
|---|---|---|---|---|
| Controllo materiali della cella aux e interruttore<br>*Control of materials od Auxiliary cell and circuit breaker* | CQ 10 | 01.1 | 09.07.24 | 614 |
| Controllo cablaggio (sigla numerini, morsetti, serraggio viti, targhette, ecc..)<br>*Wiring check (code numbers, terminals, screw tightening, labels, etc.)* | CQ 10 | 01.2 | 〃 | 〃 |
| Controllo cablaggio carrello trasformatori di tensione<br>Check the wiring of the voltage transformer track | CQ 10 | 01.3 | 〃 | 〃 |
| Prova apertura serrande cella interruttore<br>*Open test of the circuit breaker cell shutters* | CQ 10 | 01.4 | 〃 | 〃 |
| Controllo serraggio dei poli<br>*Tightening check of the poles* | CQ 10 | 01.5 | SCD..... | |
| Chiusura serrande, posizionamento fianchi e ripiano, inserimento interruttore<br>*Shutters closing, position of the sides, the shelf and circuit breaker insertion* | CQ 10 | 01.6 | 09.07.24 | 614 |
| Controllo delle alimentazioni degli strumenti, sulla spina dell'interruttore/contattore e collaudo dei circuiti ausiliari<br>*Power supplies check of the various instruments on the plug of contactor/circuit breaker and auxiliary circuits test* | CQ 10 | 01.7 | 〃<br>SP.222 | 〃 |
| Controllo scaldiglia e luce box<br>*Check heater and light box* | CQ 10 | 01.8 | 〃 | 〃 |
| Impostazione capacitivi e Collaudo capacitivi<br>*Capacitive setting and Capacitive testing* | CQ 10 | 01.9 | 〃 | 〃 |
| Controllo targhette<br>*Control of plates* | CQ 10 | 01.10 | | |
| Controllo sezionatore di terra, contattore, interruttore<br>*Control of earthing switch, contactor, circuit breaker insertion* | CQ 10 | 02 | 09.07.24 | 614 |
| Controllo chiavi<br>Key control | Operating sequences | | 09.07.24 | 614 |
| Prova con iniezione primaria su TA con generatore di corrente e controllo circuiti; verifica della polarità<br>*Test with primary injection on CT with current generator and circuit control; polarity check* | CQ 10 | 03 | 09.07.24<br>SP.222 PP.G33 | 614 |
| Prova TV con tensione sui primari e relativi circuiti e controllo rapporto trasf.<br>*Check VT characteristics and related circuits and check the ratio* | CQ 10 | 04 | SP.222 09.07 | 614 |
| Controllo finale della verniciatura (VISIVO)<br>*Painting final check (VISUAL)* | CQ 10 | 05 | | |
| Prova iniezione primaria su Toroidi con generatore di corr. e controllo circuiti<br>*Test with primary injection on Toroids with current generator and circuit control;* | CQ 10 | 04 | SP.G33 | 535 |
| EXERTHERM | | | 25/07/25 | 535 |

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# SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CLIENTE *CUSTOMER* | ROSETTI MARINO | N. PROGETTO *N. PROJECT* | 231151 | | | | | |
| TIPO QUADRO *SWITCHBOARD TYPE* | MINER-C | N. CELLA *N UNIT* | A3 | | | | | |
| Caratteristiche elettriche *Electrical characteristics* | $U_r$ (kV): | | $I_r$ (A): | $I_k$ (kA): | | $t_k$(s) | | Arco interno SI ☐ NO☐ |

## ASSEMBLAGGIO SCOMPARTO – COMPARTMENT *ASSEMBLY*

| Attività/ *Activity* | II/ *WI* | Rif/ *Ref* | Data /*Date*-- *Strumento/Equip* | Codice operator./ *i.d. operator* |
|---|---|---|---|---|
| Preparazione contenitore, prove di funzionamento meccanico e montaggio vano ausiliari<br>*Enclosure preparation and mechanical functional test and* Auxiliary compartment assembly | CAR 19 | 01 | 1/7/24 | 724 |
| Montaggio guarnizioni anteriori, barre derivate superiori<br>*Assembly of front gaskets, upper branch bars* | CAR 19 | 02 | 1/7/24 | 724 |
| Montaggio parte posteriore inferiore, barre di terra<br>*Bottom rear mounting, ground bars* | CAR 19 | 03 | 1/7/24 | 724 |
| Montaggio parte posteriore superiore, TA e barratura rame attacco cavi<br>*Assembly of upper rear part, CT and copper bar for cable connection* | CAR 19 | 04 | 1/7/24<br>SCD H1.2-T1/48 | 724 |
| Controllo verniciatura e montaggio portelle anteriori<br>Paint check and front door assembly | CAR 19 | 05 | ■ PP143 ☐ PP157 | |
| S.P.Montaggio del tetto<br>D.P. trasferimento contenitore superiore su quello inferiore e montaggio del tetto<br>*S.P. Roof assembly*<br>*D.P. transfer of the upper container to the lower one and assembly of the roof* | CAR 19 | 06 | 2/7/24 | 724 |
| Montaggio apparecchiature di potenza (contattori, termiche, fusibili, scaricatori, ecc)<br>*Assembly of power equipments (contactors, thermal, fuses etc.)* | CAB 01 | 02 | / | / |
| Cablaggio ausiliari<br>*Auxiliary cable* | CAB 01 | 02 | 4/07/24 | 541 |
| Cablaggio potenza in cavo<br>*Underground power cable* | CAB 01 | 03 | / | / |
| Montaggio e controllo targhette<br>*Assembly and control of data plates* | CAB 01 | 04 | 22/07/24 | 535 |
| Verifica completamento montaggio guarnizioni scomparto e coperture canale varie<br>Check completion of assembly of compartment gaskets and various duct covers | CAR 19 | 07 | 25/07/24 | 535 |
| Staffaggio toroide<br>Toroidal transformer bracket | CAR 19 | 08 | 26/7/24 | 441 |

### MATRICOLE APPARECCHIATURE MT MONTATE SULLA CELLA
*Serial number of the equipments mounted in MV switchgear*

| | L1 | L2 | L3 | TO |
|---|---|---|---|---|
| TA *CT* | SIGLA TIL1<br>S/N 24183 | SIGLA TIL2<br>S/N 24184 | SIGLA TIL3<br>S/N 24185 | SIGLA<br>S/N |
| TA *CT* | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N |



SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | | | |
|---|---|---|---|---|---|
| N. PROGETTO *N. PROJECT* | 231151 | TIPO QUADRO *SWITCHBOARD TYPE* | | N. CELLA *N. UNIT* | A3 |

| | | | | |
|---|---|---|---|---|
| TV *VT* | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N |

## VERIFICA ELETTRICA E MECCANICA'- *ELECTRICAL MECHANICAL VERIFICATION*

| Attività/ Activity | II/ *WI* | Rif/ *Ref* | Data/*Date* *Strumento/Equip* | Codice operatore *i.d. operator* |
|---|---|---|---|---|
| Controllo materiali della cella aux e interruttore<br>*Control of materials od Auxiliary cell and circuit breaker* | CQ 10 | 01.1 | 12.07.24 | 614 |
| Controllo cablaggio (sigla numerini, morsetti, serraggio viti, targhette, ecc..)<br>*Wiring check (code numbers, terminals, screw tightening, labels, etc.)* | CQ 10 | 01.2 | 11 | 11 |
| Controllo cablaggio carrello trasformatori di tensione<br>Check the wiring of the voltage transformer track | CQ 10 | 01.3 | | |
| Prova apertura serrande cella interruttore<br>*Open test of the circuit breaker cell shutters* | CQ 10 | 01.4 | 12.07.24 | 614 |
| Controllo serraggio dei poli<br>*Tightening check of the poles* | CQ 10 | 01.5 | SCD..... | |
| Chiusura serrande, posizionamento fianchi e ripiano, inserimento interruttore<br>*Shutters closing, position of the sides, the shelf and circuit breaker insertion* | CQ 10 | 01.6 | 12.07.24 | 614 |
| Controllo delle alimentazioni degli strumenti, sulla spina dell'interruttore/contattore e collaudo dei circuiti ausiliari<br>*Power supplies check of the various instruments on the plug of contactor/circuit breaker and auxiliary circuits test* | CQ 10 | 01.7 | 11<br>SP.....222 | 11 |
| Controllo scaldiglia e luce box<br>*Check heater and light box* | CQ 10 | 01.8 | 11 | 11 |
| Impostazione capacitivi e Collaudo capacitivi<br>*Capacitive setting and Capacitive testing* | CQ 10 | 01.9 | 11 | 11 |
| Controllo targhette<br>*Control of plates* | CQ 10 | 01.10 | | |
| Controllo sezionatore di terra, contattore, interruttore<br>*Control of earthing switch, contactor, circuit breaker insertion* | CQ 10 | 02 | 12.07.24 | 614 |
| Controllo chiavi<br>Key control | Operating sequences | | 11 | 11 |
| Prova con iniezione primaria su TA con generatore di corrente e controllo circuiti; verifica della polarità<br>*Test with primary injection on CT with current generator and circuit control; polarity check* | CQ 10 | 03 | 12.07.24<br>SP..... PP.....G33 | 614 |
| Prova TV con tensione sui primari e relativi circuiti e controllo rapporto trasf.<br>*Check VT characteristics and related circuits and check the ratio* | CQ 10 | 04 | 13.07.24<br>SP..... | 614 |
| Controllo finale della verniciatura (VISIVO)<br>*Painting final check (VISUAL)* | CQ 10 | 05 | | |
| Prova iniezione primaria su Toroidi con generatore di corr. e controllo circuiti<br>*Test with primary injection on Toroids with current generator and circuit control;* | CQ 10 | 04 | SP.G33 | 535 |
| EXERTHERM | | | | |

# SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | |
|---|---|---|---|
| CLIENTE *CUSTOMER* | ROSETTI MARINO | N. PROGETTO *N. PROJECT* | 231151 |
| TIPO QUADRO *SWITCHBOARD TYPE* | MINIVER-C | N. CELLA *N UNIT* | A4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Caratteristiche elettriche *Electrical characteristics* | $U_r$ (kV): | | $I_r$ (A): | $I_k$ (kA): | | $t_k$(s) | | Arco interno SI ☐ NO☐ |

## ASSEMBLAGGIO SCOMPARTO – COMPARTMENT *ASSEMBLY*

| Attività/ *Activity* | II/ *WI* | Rif/ *Ref* | Data /*Date*-- *Strumento/Equip* | Codice operator./ *i.d. operator* |
|---|---|---|---|---|
| Preparazione contenitore, prove di funzionamento meccanico e montaggio vano ausiliari *Enclosure preparation and mechanical functional test and* Auxiliary compartment assembly | CAR 19 | 01 | 2/7/24 | 724 |
| Montaggio guarnizioni anteriori, barre derivate superiori *Assembly of front gaskets, upper branch bars* | CAR 19 | 02 | 2/7/24 | 724 |
| Montaggio parte posteriore inferiore, barre di terra *Bottom rear mounting, ground bars* | CAR 19 | 03 | 2/7/24 | 724 |
| Montaggio parte posteriore superiore, TA e barratura rame attacco cavi *Assembly of upper rear part, CT and copper bar for cable connection* | CAR 19 | 04 | 2/7/24 SCD HILTI/SD48 | 724 |
| Controllo verniciatura e montaggio portelle anteriori Paint check and front door assembly | CAR 19 | 05 | 2/7/24 ■ PP143 ☐ PP157 | 443 |
| S.P.Montaggio del tetto D.P. trasferimento contenitore superiore su quello inferiore e montaggio del tetto *S.P. Roof assembly D.P. transfer of the upper container to the lower one and assembly of the roof* | CAR 19 | 06 | 2/7/24 | 443 |
| Montaggio apparecchiature di potenza (contattori, termiche, fusibili, scaricatori, ecc) *Assembly of power equipments (contactors, thermal, fuses etc.)* | CAB 01 | 02 | / | / |
| Cablaggio ausiliari *Auxiliary cable* | CAB 01 | 02 | 4/07/24 | 434 |
| Cablaggio potenza in cavo *Underground power cable* | CAB 01 | 03 | / | / |
| Montaggio e controllo targhette *Assembly and control of data plates* | CAB 01 | 04 | 22/07/24 | 535 |
| Verifica completamento montaggio guarnizioni scomparto e coperture canale varie Check completion of assembly of compartment gaskets and various duct covers | CAR 19 | 07 | 25/07/24 | 535 |
| Staffaggio toroide Toroidal transformer bracket | CAR 19 | 08 | 26/07/24 | 421 |

### MATRICOLE APPARECCHIATURE MT MONTATE SULLA CELLA
*Serial number of the equipments mounted in MV switchgear*

| | L1 | L2 | L3 | TO |
|---|---|---|---|---|
| TA CT | SIGLA T1L1 S/N 24187 | SIGLA T1L2 S/N 24188 | SIGLA T1L3 S/N 24189 | SIGLA S/N |
| TA CT | SIGLA S/N | SIGLA S/N | SIGLA S/N | SIGLA S/N |



SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE

| | | | | | |
|---|---|---|---|---|---|
| N. PROGETTO *N. PROJECT* | 231151 | TIPO QUADRO *SWITCHBOARD TYPE* | | N. CELLA *N. UNIT* | BOX A4 |

| | | | | |
|---|---|---|---|---|
| TV *VT* | SIGLA S/N | SIGLA S/N | SIGLA S/N | SIGLA S/N |

## VERIFICA ELETTRICA E MECCANICA'- *ELECTRICAL MECHANICAL VERIFICATION*

| Attività/ Activity | II/ *WI* | Rif/ *Ref* | Data/*Date* *Strumento/Equip* | Codice operatore *i.d. operator* |
|---|---|---|---|---|
| Controllo materiali della cella aux e interruttore *Control of materials od Auxiliary cell and circuit breaker* | CQ 10 | 01.1 | 11.07.24 | 614 |
| Controllo cablaggio (sigla numerini, morsetti, serraggio viti, targhette, ecc..) *Wiring check (code numbers, terminals, screw tightening, labels, etc.)* | CQ 10 | 01.2 | 11 | 11 |
| Controllo cablaggio carrello trasformatori di tensione Check the wiring of the voltage transformer track | CQ 10 | 01.3 | / | / |
| Prova apertura serrande cella interruttore *Open test of the circuit breaker cell shutters* | CQ 10 | 01.4 | 11.07.24 | 614 |
| Controllo serraggio dei poli *Tightening check of the poles* | CQ 10 | 01.5 | SCD..... | |
| Chiusura serrande, posizionamento fianchi e ripiano, inserimento interruttore *Shutters closing, position of the sides, the shelf and circuit breaker insertion* | CQ 10 | 01.6 | 11.07.24 | 614 |
| Controllo delle alimentazioni degli strumenti, sulla spina dell'interruttore/contattore e collaudo dei circuiti ausiliari *Power supplies check of the various instruments on the plug of contactor/circuit breaker and auxiliary circuits test* | CQ 10 | 01.7 | 11 SP.....222 | 11 |
| Controllo scaldiglia e luce box *Check heater and light box* | CQ 10 | 01.8 | 11.07.24 | 614 |
| Impostazione capacitivi e Collaudo capacitivi *Capacitive setting and Capacitive testing* | CQ 10 | 01.9 | 11 | 11 |
| Controllo targhette *Control of plates* | CQ 10 | 01.10 | | |
| Controllo sezionatore di terra, contattore, interruttore *Control of earthing switch, contactor, circuit breaker insertion* | CQ 10 | 02 | 11.07.24 | 614 |
| Controllo chiavi Key control | Operating sequences | | 11 | 11 |
| Prova con iniezione primaria su TA con generatore di corrente e controllo circuiti; verifica della polarità *Test with primary injection on CT with current generator and circuit control; polarity check* | CQ 10 | 03 | 11.07.24 SP.222 PP.633 | 614 |
| Prova TV con tensione sui primari e relativi circuiti e controllo rapporto trasf. *Check VT characteristics and related circuits and check the ratio* | CQ 10 | 04 | SP.222 11.07 | 614 |
| Controllo finale della verniciatura (VISIVO) *Painting final check (VISUAL)* | CQ 10 | 05 | | |
| Prova iniezione primaria su Toroidi con generatore di corr. e controllo circuiti *Test with primary injection on Toroids with current generator and circuit control;* | CQ 10 | 04 | SP.633 | 535 |
| EXERTHERM | | | 25/07/24 | 535 |

# SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CLIENTE *CUSTOMER* | ROSETTI MARINO | N. PROGETTO *N. PROJECT* | 231151 | | | | | |
| TIPO QUADRO *SWITCHBOARD TYPE* | MINIVER-C | N. CELLA *N UNIT* | A 5 | | | | | |
| Caratteristiche elettriche *Electrical characteristics* | $U_r$ (kV): | | $I_r$ (A): | $I_k$ (kA): | | $t_k$(s) | | Arco interno SI ☐ NO☐ |

## ASSEMBLAGGIO SCOMPARTO – COMPARTMENT *ASSEMBLY*

| Attività/ *Activity* | II/ *WI* | Rif/ *Ref* | Data /*Date*-- *Strumento/Equip* | Codice operator./ *i.d. operator* |
|---|---|---|---|---|
| Preparazione contenitore, prove di funzionamento meccanico e montaggio vano ausiliari<br>*Enclosure preparation and mechanical functional test and* Auxiliary compartment assembly | CAR 19 | 01 | 3/7/24 | 724 |
| Montaggio guarnizioni anteriori, barre derivate superiori<br>*Assembly of front gaskets, upper branch bars* | CAR 19 | 02 | 4/7/24 | 443 |
| Montaggio parte posteriore inferiore, barre di terra<br>*Bottom rear mounting, ground bars* | CAR 19 | 03 | 3/7/24 | 724 |
| Montaggio parte posteriore superiore, TA e barratura rame attacco cavi<br>*Assembly of upper rear part, CT and copper bar for cable connection* | CAR 19 | 04 | 4/7/24<br>SCD.69 | 443 |
| Controllo verniciatura e montaggio portelle anteriori<br>Paint check and front door assembly | CAR 19 | 05 | 4/7/24<br>■ PP143 ☐PP157 | 443 |
| S.P.Montaggio del tetto<br>D.P. trasferimento contenitore superiore su quello inferiore e montaggio del tetto<br>*S.P. Roof assembly*<br>*D.P. transfer of the upper container to the lower one and assembly of the roof* | CAR 19 | 06 | 4/7/24 | 443 |
| Montaggio apparecchiature di potenza (contattori, termiche, fusibili, scaricatori, ecc)<br>*Assembly of power equipments (contactors, thermal, fuses etc.)* | CAB 01 | 02 | / | / |
| Cablaggio ausiliari<br>*Auxiliary cable* | CAB 01 | 02 | 10/7/24 | 434 |
| Cablaggio potenza in cavo<br>*Underground power cable* | CAB 01 | 03 | / | / |
| Montaggio e controllo targhette<br>*Assembly and control of data plates* | CAB 01 | 04 | 22/07/24 | 535 |
| Verifica completamento montaggio guarnizioni scomparto e coperture canale varie<br>Check completion of assembly of compartment gaskets and various duct covers | CAR 19 | 07 | 22/07/24 | 535 |
| Staffaggio toroide<br>Toroidal transformer bracket | CAR 19 | 08 | | |

### MATRICOLE APPARECCHIATURE MT MONTATE SULLA CELLA
*Serial number of the equipments mounted in MV switchgear*

| | L1 | L2 | L3 | TO |
|---|---|---|---|---|
| TA *CT* | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N |
| TA *CT* | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N |



SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | | | |
|---|---|---|---|---|---|
| N. PROGETTO *N. PROJECT* | 231151 | TIPO QUADRO *SWITCHBOARD TYPE* | | N. CELLA *N. UNIT* | A 5 |

| | | | | |
|---|---|---|---|---|
| TV *VT* | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N |

## VERIFICA ELETTRICA E MECCANICA'- *ELECTRICAL MECHANICAL VERIFICATION*

| Attività/ Activity | II/ *WI* | Rif/ *Ref* | Data/*Date* *Strumento/Equip* | Codice operatore *i.d. operator* |
|---|---|---|---|---|
| Controllo materiali della cella aux ~~e interruttore~~<br>*Control of materials od Auxiliary cell and circuit breaker* | CQ 10 | 01.1 | 16.07.24 | 614 |
| Controllo cablaggio (sigla numerini, morsetti, serraggio viti, targhette, ecc..)<br>*Wiring check (code numbers, terminals, screw tightening, labels, etc.)* | CQ 10 | 01.2 | 11 | 11 |
| Controllo cablaggio carrello trasformatori di tensione<br>Check the wiring of the voltage transformer track | CQ 10 | 01.3 | 11 | 11 |
| Prova apertura serrande cella interruttore<br>*Open test of the circuit breaker cell shutters* | CQ 10 | 01.4 | / | / |
| Controllo serraggio dei poli<br>*Tightening check of the poles* | CQ 10 | 01.5 | SCD..... | |
| ~~Chiusura serrande~~, posizionamento fianchi e ripiano, ~~inserimento interruttore~~<br>*Shutters closing, position of the sides, the shelf and circuit breaker insertion* | CQ 10 | 01.6 | 16.07.24 | 614 |
| Controllo delle alimentazioni degli strumenti, sulla spina dell'interruttore/contattore e collaudo dei circuiti ausiliari<br>*Power supplies check of the various instruments on the plug of contactor/circuit breaker and auxiliary circuits test* | CQ 10 | 01.7 | 11<br>SP.222 | 11 |
| Controllo scaldiglia e luce box<br>*Check heater and light box* | CQ 10 | 01.8 | 11 | 11 |
| Impostazione capacitivi e Collaudo capacitivi<br>*Capacitive setting and Capacitive testing* | CQ 10 | 01.9 | 11 | 11 |
| Controllo targhette<br>*Control of plates* | CQ 10 | 01.10 | | |
| Controllo sezionatore di terra, ~~contattore, interruttore~~<br>*Control of earthing switch, contactor, circuit breaker insertion* | CQ 10 | 02 | 16.07.24 | 614 |
| Controllo chiavi<br>Key control | Operating sequences | | 11 | 11 |
| Prova con iniezione primaria su TA con generatore di corrente e controllo circuiti; verifica della polarità<br>*Test with primary injection on CT with current generator and circuit control; polarity check* | CQ 10 | 03 | SP..... PP..... | / |
| Prova TV con tensione sui primari e relativi circuiti e controllo rapporto trasf.<br>*Check VT characteristics and related circuits and check the ratio* | CQ 10 | 04 | SP.222 16.07 | 614 * |
| Controllo finale della verniciatura (VISIVO)<br>*Painting final check (VISUAL)* | CQ 10 | 05 | | |
| Prova iniezione primaria su Toroidi con generatore di corr. e controllo circuiti<br>*Test with primary injection on Toroids with current generator and circuit control;* | CQ 10 | 04 | SP..... | |
| * PROVARE VOLTMETRO E SELETTORE EXERTHERM | | | 25/07/24<br>11 | 535<br>535 |

## SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| CLIENTE *CUSTOMER* | ROSETTI MARINO | N. PROGETTO *N. PROJECT* | 231151 | | | | | |
|---|---|---|---|---|---|---|---|---|
| TIPO QUADRO *SWITCHBOARD TYPE* | MINIVER -C | N. CELLA *N UNIT* | A6 | | | | | |
| Caratteristiche elettriche *Electrical characteristics* | $U_r$ (kV): | | $I_r$ (A): | $I_k$ (kA): | | $t_k$(s) | | Arco interno SI ☐ NO☐ |

### ASSEMBLAGGIO SCOMPARTO – COMPARTMENT *ASSEMBLY*

| Attività/ *Activity* | II/ *WI* | Rif/ *Ref* | Data /*Date*-- *Strumento/Equip* | Codice operator./ *i.d. operator* |
|---|---|---|---|---|
| Preparazione contenitore, prove di funzionamento meccanico e montaggio vano ausiliari<br>*Enclosure preparation and mechanical functional test and* Auxiliary compartment assembly | CAR 19 | 01 | 4/7/24 | 724 |
| Montaggio guarnizioni anteriori, barre derivate superiori<br>*Assembly of front gaskets, upper branch bars* | CAR 19 | 02 | 5/7/24 | 724 |
| Montaggio parte posteriore inferiore, barre di terra<br>*Bottom rear mounting, ground bars* | CAR 19 | 03 | 4/7/24 | 724 |
| Montaggio parte posteriore superiore, TA e barratura rame attacco cavi<br>*Assembly of upper rear part, CT and copper bar for cable connection* | CAR 19 | 04 | 5/7/24<br>SCD. ITALTI/48 | 724 |
| Controllo verniciatura e montaggio portelle anteriori<br>Paint check and front door assembly | CAR 19 | 05 | 5/7/24<br>■ PP143 ☐ PP157 | 724 |
| S.P.Montaggio del tetto<br>D.P. trasferimento contenitore superiore su quello inferiore e montaggio del tetto<br>*S.P. Roof assembly*<br>*D.P. transfer of the upper container to the lower one and assembly of the roof* | CAR 19 | 06 | 5/7/24 | 724 |
| Montaggio apparecchiature di potenza (contattori, termiche, fusibili, scaricatori, ecc)<br>*Assembly of power equipments (contactors, thermal, fuses etc.)* | CAB 01 | 02 | / | / |
| Cablaggio ausiliari<br>*Auxiliary cable* | CAB 01 | 02 | 10/7/24 | 541 |
| Cablaggio potenza in cavo<br>*Underground power cable* | CAB 01 | 03 | / | / |
| Montaggio e controllo targhette<br>*Assembly and control of data plates* | CAB 01 | 04 | 22/7/24 | 535 |
| Verifica completamento montaggio guarnizioni scomparto e coperture canale varie<br>Check completion of assembly of compartment gaskets and various duct covers | CAR 19 | 07 | 22/07/24 | 535 |
| Staffaggio toroide<br>Toroidal transformer bracket | CAR 19 | 08 | 26/7/24 | 441 |

### MATRICOLE APPARECCHIATURE MT MONTATE SULLA CELLA
*Serial number of the equipments mounted in MV switchgear*

| | L1 | L2 | L3 | TO |
|---|---|---|---|---|
| TA *CT* | SIGLA TIL1<br>S/N 24173 | SIGLA TIL2<br>S/N 24174 | SIGLA TIL3<br>S/N ~~24175~~ 26091 | SIGLA<br>S/N |
| TA *CT* | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N |



## SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| N. PROGETTO *N. PROJECT* | 231151 | TIPO QUADRO *SWITCHBOARD TYPE* | MINIVER C | N. CELLA *N. UNIT* | A6 |
|---|---|---|---|---|---|

| TV *VT* | SIGLA TV-L1 | SIGLA TV-L2 | SIGLA TV-L3 | SIGLA |
|---|---|---|---|---|
| | S/N 1VLT622010 ~~796~~ | S/N – 888 | S/N – 783 | S/N |

### VERIFICA ELETTRICA E MECCANICA'- *ELECTRICAL MECHANICAL VERIFICATION*

| Attività/ Activity | II/ *WI* | Rif/ *Ref* | Data/*Date* *Strumento/Equip* | Codice operatore *i.d. operator* |
|---|---|---|---|---|
| Controllo materiali della cella aux e interruttore<br>*Control of materials od Auxiliary cell and circuit breaker* | CQ 10 | 01.1 | 17/07 | 777 |
| Controllo cablaggio (sigla numerini, morsetti, serraggio viti, targhette, ecc..)<br>*Wiring check (code numbers, terminals, screw tightening, labels, etc.)* | CQ 10 | 01.2 | 17/07 | 777 |
| Controllo cablaggio carrello trasformatori di tensione<br>Check the wiring of the voltage transformer track | CQ 10 | 01.3 | 17/07 | 777 |
| Prova apertura serrande cella interruttore<br>*Open test of the circuit breaker cell shutters* | CQ 10 | 01.4 | 17/07 | 777 |
| Controllo serraggio dei poli<br>*Tightening check of the poles* | CQ 10 | 01.5 | SCD..... | |
| Chiusura serrande, posizionamento fianchi e ripiano, inserimento interruttore<br>*Shutters closing, position of the sides, the shelf and circuit breaker insertion* | CQ 10 | 01.6 | 17/07 | 777 |
| Controllo delle alimentazioni degli strumenti, sulla spina dell'interruttore/contattore e collaudo dei circuiti ausiliari<br>*Power supplies check of the various instruments on the plug of contactor/circuit breaker and auxiliary circuits test* | CQ 10 | 01.7 | 1707<br>SP.....230 | 777 |
| Controllo scaldiglia e luce box<br>*Check heater and light box* | CQ 10 | 01.8 | 17/07 | 777 |
| Impostazione capacitivi e Collaudo capacitivi<br>*Capacitive setting and Capacitive testing* | CQ 10 | 01.9 | 17/07 | 777 |
| Controllo targhette<br>*Control of plates* | CQ 10 | 01.10 | | |
| Controllo sezionatore di terra, contattore, interruttore<br>*Control of earthing switch, contactor, circuit breaker insertion* | CQ 10 | 02 | 17/07 | 777 |
| Controllo chiavi<br>Key control | Operating sequences | | 17/07 | 777 |
| Prova con iniezione primaria su TA con generatore di corrente e controllo circuiti; verifica della polarità<br>*Test with primary injection on CT with current generator and circuit control; polarity check* | CQ 10 | 03 | 17/07<br>633<br>SP..... PP..... | 777 |
| Prova TV con tensione sui primari e relativi circuiti e controllo rapporto trasf.<br>*Check VT characteristics and related circuits and check the ratio* | CQ 10 | 04 | 17/07<br>SP.....230 | 777 |
| Controllo finale della verniciatura (VISIVO)<br>*Painting final check (VISUAL)* | CQ 10 | 05 | | |
| Prova iniezione primaria su Toroidi con generatore di corr. e controllo circuiti<br>*Test with primary injection on Toroids with current generator and circuit control;* | CQ 10 | 04 | SP.....633 | 535 |
| EXERTHERM | | | 25/07/24 | 535 |

# SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | |
|---|---|---|---|
| CLIENTE *CUSTOMER* | ROSETTI MARINO | N. PROGETTO *N. PROJECT* | 231151 |
| TIPO QUADRO *SWITCHBOARD TYPE* | MINIVER - C | N. CELLA *N UNIT* | A7 |

| Caratteristiche elettriche *Electrical characteristics* | $U_r$ (kV): | | $I_r$ (A): | $I_k$ (kA): | | $t_k$(s) | | Arco interno SI ☐ NO☐ |
|---|---|---|---|---|---|---|---|---|

## ASSEMBLAGGIO SCOMPARTO – COMPARTMENT *ASSEMBLY*

| Attività/ *Activity* | Il/ *Wi* | Rif/ *Ref* | Data /*Date*-- *Strumento/Equip* | Codice operator./ *i.d. operator* |
|---|---|---|---|---|
| Preparazione contenitore, prove di funzionamento meccanico e montaggio vano ausiliari<br>*Enclosure preparation and mechanical functional test and* Auxiliary compartment assembly | CAR 19 | 01 | 4/7/24 | 724 |
| Montaggio guarnizioni anteriori, barre derivate superiori<br>*Assembly of front gaskets, upper branch bars* | CAR 19 | 02 | 5/7/24 | 443 |
| Montaggio parte posteriore inferiore, barre di terra<br>*Bottom rear mounting, ground bars* | CAR 19 | 03 | 4/7/24 | 724 |
| Montaggio parte posteriore superiore, TA e barratura rame attacco cavi<br>*Assembly of upper rear part, CT and copper bar for cable connection* | CAR 19 | 04 | 5/7/24<br>SCD.....48 + HILTI | 443 |
| Controllo verniciatura e montaggio portelle anteriori<br>Paint check and front door assembly | CAR 19 | 05 | 5/7/24<br>■ PP143 ☐ PP157 | 443 |
| S.P.Montaggio del tetto<br>D.P. trasferimento contenitore superiore su quello inferiore e montaggio del tetto<br>*S.P. Roof assembly*<br>*D.P. transfer of the upper container to the lower one and assembly of the roof* | CAR 19 | 06 | 8/7/24 | 443 |
| Montaggio apparecchiature di potenza (contattori, termiche, fusibili, scaricatori, ecc)<br>*Assembly of power equipments (contactors, thermal, fuses etc.)* | CAB 01 | 02 | | |
| Cablaggio ausiliari<br>*Auxiliary cable* | CAB 01 | 02 | 10/7/24 | 434 |
| Cablaggio potenza in cavo<br>*Underground power cable* | CAB 01 | 03 | | |
| Montaggio e controllo targhette<br>*Assembly and control of data plates* | CAB 01 | 04 | 22/7/24 | 535 |
| Verifica completamento montaggio guarnizioni scomparto e coperture canale varie<br>Check completion of assembly of compartment gaskets and various duct covers | CAR 19 | 07 | 22/07/24 | 535 |
| Staffaggio toroide<br>Toroidal transformer bracket | CAR 19 | 08 | 26/7/24 | 441 |

### MATRICOLE APPARECCHIATURE MT MONTATE SULLA CELLA
*Serial number of the equipments mounted in MV switchgear*

| | L1 | L2 | L3 | TO |
|---|---|---|---|---|
| TA *CT* | SIGLA TI-L1<br>S/N 2024/24181 | SIGLA TI-L2<br>S/N 2024/24182 | SIGLA TI-L3<br>S/N 2024/24186 | SIGLA<br>S/N |
| TA *CT* | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N | SIGLA<br>S/N |



SCHEDA DI AVANZAMENTO E CONTROLLO QUADRO MT MINIVER C
*MINIVER C HV SWITCHBOARD PROGRESS AND CHECK MODULE*

| | | | |
|---|---|---|---|
| N. PROGETTO *N. PROJECT* | 231151 | TIPO QUADRO *SWITCHBOARD TYPE* | |
| N. CELLA *N. UNIT* | 07 | | |

| TV *VT* | SIGLA / S/N | SIGLA / S/N | SIGLA / S/N | SIGLA / S/N |
|---|---|---|---|---|

## VERIFICA ELETTRICA E MECCANICA'- *ELECTRICAL MECHANICAL VERIFICATION*

| Attività/ Activity | Il/ *Wi* | Rif/ *Ref* | Data/*Date* *Strumento/Equip* | Codice operatore *i.d. operator* |
|---|---|---|---|---|
| Controllo materiali della cella aux e interruttore<br>*Control of materials od Auxiliary cell and circuit breaker* | CQ 10 | 01.1 | 17.07.24 | 614 |
| Controllo cablaggio (sigla numerini, morsetti, serraggio viti, targhette, ecc..)<br>*Wiring check (code numbers, terminals, screw tightening, labels, etc.)* | CQ 10 | 01.2 | 17.07.24 | 614 |
| Controllo cablaggio carrello trasformatori di tensione<br>Check the wiring of the voltage transformer track | CQ 10 | 01.3 | 〃 | 〃 |
| Prova apertura serrande cella interruttore<br>*Open test of the circuit breaker cell shutters* | CQ 10 | 01.4 | 〃 | 〃 |
| Controllo serraggio dei poli<br>*Tightening check of the poles* | CQ 10 | 01.5 | SCD..... | |
| Chiusura serrande, posizionamento fianchi e ripiano, inserimento interruttore<br>*Shutters closing, position of the sides, the shelf and circuit breaker insertion* | CQ 10 | 01.6 | 17.07.24 | 614 |
| Controllo delle alimentazioni degli strumenti, sulla spina dell'interruttore/contattore e collaudo dei circuiti ausiliari<br>*Power supplies check of the various instruments on the plug of contactor/circuit breaker and auxiliary circuits test* | CQ 10 | 01.7 | SP.....222 17.04 | 〃 |
| Controllo scaldiglia e luce box<br>*Check heater and light box* | CQ 10 | 01.8 | 〃 | 〃 |
| Impostazione capacitivi e Collaudo capacitivi<br>*Capacitive setting and Capacitive testing* | CQ 10 | 01.9 | 〃 | 〃 |
| Controllo targhette<br>*Control of plates* | CQ 10 | 01.10 | | |
| Controllo sezionatore di terra, contattore, interruttore<br>*Control of earthing switch, contactor, circuit breaker insertion* | CQ 10 | 02 | 17.07.24 | 614 |
| Controllo chiavi<br>Key control | Operating sequences | | 〃 | 〃 |
| Prova con iniezione primaria su TA con generatore di corrente e controllo circuiti; verifica della polarità<br>*Test with primary injection on CT with current generator and circuit control; polarity check* | CQ 10 | 03 | 17.07.24<br>SP..... PP.....G33 | 614 |
| Prova TV con tensione sui primari e relativi circuiti e controllo rapporto trasf.<br>*Check VT characteristics and related circuits and check the ratio* | CQ 10 | 04 | SP..... | |
| Controllo finale della verniciatura (VISIVO)<br>*Painting final check (VISUAL)* | CQ 10 | 05 | | |
| Prova iniezione primaria su Toroidi con generatore di corr. e controllo circuiti<br>*Test with primary injection on Toroids with current generator and circuit control;* | CQ 10 | 04 | SP.....G33 | 535 |
| EXERTHERM | | | 25/07/24 | 535 |

2.6.4.Welding/NDE

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Organismo Notificato/*Notified body* N./*No.*
0474
RINA Services S.p.A.
Via Corsica, 12 – 16128 Genova (GE)
Italy

# CERTIFICATO DI CONFORMITÀ DEL CONTROLLO DELLA PRODUZIONE IN FABBRICA / *CERTIFICATE OF CONFORMITY OF THE FACTORY PRODUCTION CONTROL*

## N./*No.* 0474-CPR-2451

In conformità al Regolamento (UE) N. 305/2011 del Parlamento Europeo e del Consiglio del 9 marzo 2011 (Regolamento Prodotti da Costruzione o CPR), questo certificato si applica al prodotto da costruzione /

*In compliance with Regulation (EU) No. 305/2011 of the European Parliament and of the Council of 9 March 2011 (the Construction Products Regulation or CPR), this certificate applies to the construction product*

**Componenti strutturali e kit per strutture di acciaio /**
***Structural components and kits for steel structures***

come descritto nell'allegato al presente certificato / *as described in the annex to this certificate*

immesso sul mercato con il nome o con il marchio di / *placed on the market under the name or trade mark of*

**EUROMETAL S.R.L.**

**Via Ciro Amedeo Moriconi, 4 - 60035 Jesi (AN)**

e fabbricato nello stabilimento di produzione / *and produced in the manufacturing plant*

**Via Ciro Amedeo Moriconi, 4 - 60035 Jesi (AN)**

Il presente certificato attesta che tutte le disposizioni riguardanti la valutazione e la verifica della costanza della prestazione descritte nell'Allegato ZA della norma /

*This certificate attests that all provisions concerning the assessment and verification of constancy of performance described in Annex ZA of the standard*

**EN 1090-1:2009+A1:2011**

nell'ambito del sistema 2+ sono applicate e che / *under system 2+ are applied and that*

**il controllo della produzione in fabbrica è valutato conforme ai requisiti applicabili /**
***the factory production control is assessed to be in conformity with the applicable requirements***

Il presente certificato è stato emesso la prima volta il 16/12/2021 ed ha validità sino a che né la norma armonizzata, il prodotto da costruzione, i metodi AVCP né le condizioni di produzione nell'impianto sono significativamente modificati, a meno che non sia sospeso o ritirato dall'organismo notificato di certificazione del controllo della produzione in fabbrica /

*This certificate was first issued on 16/12/2021 and will remain valid as long as neither the harmonised standard, the construction product, the AVCP methods nor the manufacturing conditions in the plant are modified significantly, unless suspended or withdrawn by the notified factory production control certification body*

Genova, 16/12/2021

Revisione n. / Revision *no.*: 1

RINA Services S.p.A.
Il Direttore Tecnico / Technical Manager

(Ing. Andrea ALLOISIO)

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*IQNet, the association of the world's first class certification bodies, is the largest provider of management System Certification in the world. IQNet is composed of more than 30 bodies and counts over 150 subsidiaries all over the globe.*

# CERTIFICATO N. 3834-1091/21/S

# *CERTIFICATE No.*

SI CERTIFICA CHE IL SISTEMA DI GESTIONE DI
*IT IS HEREBY CERTIFIED THAT THE MANAGEMENT SYSTEM OF*

Per informazioni sulla validità del certificato, visitare il sito www.rina.org

*For information concerning validity of the certificate, you can visit the site www.rina.org*

## EUROMETAL S.R.L.

VIA CIRO AMEDEO MORICONI 4 60035 JESI (AN) ITALIA

NELLE SEGUENTI UNITÀ OPERATIVE */ IN THE FOLLOWING OPERATIONAL UNITS*

VIA CIRO AMEDEO MORICONI 4 60035 Jesi (AN) ITALIA

PER IL CAMPO DI APPLICAZIONE DI CUI ALL'ALLEGATO */ FOR THE SCOPE SPECIFIED IN THE ANNEX*

È CONFORME ALLA NORMA
*IS IN COMPLIANCE WITH THE STANDARD*

## ISO 3834-2:2005

PER I SEGUENTI CAMPI DI ATTIVITÀ / *FOR THE FOLLOWING FIELD(S) OF ACTIVITIES* *IAF:17*

REALIZZAZIONE DI CARPENTERIE SALDATA IN ACCIAIO AL CARBONIO, IN AMBITO CIVILE ED INDUSTRIALE.

*CONSTRUCTION OF WELDED CARPENTRY IN CARBON STEEL, IN CIVIL AND INDUSTRIAL APPLICATION.*

La validità del presente certificato è subordinata a sorveglianza periodica annuale / semestrale ed al riesame completo del sistema di gestione con periodicità triennale
*The validity of this certificate is dependent on an annual / six monthly audit and on a complete review, every three years, of the management system*
L'uso e la validità del presente certificato sono soggetti al rispetto del documento RINA: Regolamento per la Certificazione di Sistemi di Gestione per la Qualità
*The use and validity of this certificate are subject to compliance with the RINA document : Rules for the certification of Quality Management Systems*

Prima emissione
*First Issue* 13.12.2021

Data scadenza
*Expiry Date* 12.12.2024

Data revisione
*Revision date* 13.12.2021

Filippo Lago

Italy Welding & Pressure Equipments, Personnel Certification & Laboratories, Director

**RINA Services S.p.A.**
Via Corsica 12 - 16128 Genova Italy

ACCREDIA L'ENTE ITALIANO DI ACCREDITAMENTO
SGQ N° 002 A
PRD N° 002 B

Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC
*Signatory of EA, IAF and ILAC Mutual Recognition Agreements*

FEDERAZIONE CISQ
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*CISQ is the Italian Federation of management system Certification Bodies*

Form CERSISGE-01/2018

# WELDER APPROVAL CERTIFICATE
## ACCORDING TO UNI EN ISO 9606-1:2017

No. **21FI00494PW7**

| | | | | | |
|---|---|---|---|---|---|
| Designation | **UNI EN ISO 9606-1 135-D/135-S P BW FM1/FM1 S/S t12 PA ss nb** | | | | |
| Welder | **ENCARNACION GARCIA MARIO EDUARDO** | | | | |
| Born in | **VILLA TAPIA-DOMINICAN REPUBLIC** | | | on | **09/04/1997** |
| Identification | **AX8475000** | Method of Identification | **C.I.** | Stamp No. | **EGME** |
| Employed by | **EUROMETAL S.R.L. - Jesi (AN)** | | | | |

WPS used by welder during welding of test coupon: **01/21** Job knowledge: **not tested**

| Welding variables | Test piece | Range of qualification |
|---|---|---|
| Welding process(es) | 135-D / 135-S | 135; 138 |
| Transfer mode | Short-arc / Spray-arc | Short, spray, globular and pulsed-arc |
| Product type | Plate | Plates and pipes |
| Type of weld | BW | Butt weld |
| Parent Metal group (ISO/TR 15608) | 1.2 | 1 to 11 |
| Filler material group(s) | FM1 | FM1, FM2 |
| Filler material type | 135-D | Root: Solid wire<br>Fill/Cap: Solid wire/electrode core: M |
| | 135-S | Solid wire/electrode core: M |
| Shielding gas (EN ISO 14175) | M20 | All compatible |
| Type of current and polarity | 135-D: DC EP; 135-S: DC EP | All compatible |
| Deposited thickness (mm) | 12 | 135-D: 3 to 6<br>135-S: 3 to 18<br>135-D / 135-S: >= 3 |
| Pipe outside diameter (mm) | N.A. | 75 and over |
| Welding position(s) | PA | PA |
| Weld details / Layer technique | ss nb | 135-D: ss nb, ss mb, bs, ss gb, ss fb<br>135-S: ss mb, bs |

| Type of test | | | | | | | |
|---|---|---|---|---|---|---|---|
| Visual | **Acceptable** | Radiographic | **Not tested** | Magnetic particle | **Not tested** | Penetrant | **Not tested** |
| Macro | **Not tested** | Fracture | **Not tested** | Bend | **Acceptable** | | |

| | | | |
|---|---|---|---|
| This certificate is valid from | **27 September 2021** | to | **27 September 2024** |
| Issued at | **GENOVA** | on | **28 October 2021** |

This certificate consist of 2 pages

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ACCREDIA
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**PRD N° 002 B**
Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC
*Signatory of EA, IAF and ILAC Mutual Recognition Agreements*

Filippo Lago
(Italy Welding & Pressure Equipments, Personnel Certification & Laboratories, Director)

**RINA Services S.p.A.**
**PED No. Bo. 0474**
**Via Corsica 12 - 16128 Genova**

# WELDER APPROVAL CERTIFICATE
## ACCORDING TO UNI EN ISO 9606-1:2017

No. **21FI00494PW11**

| | | | | | |
|---|---|---|---|---|---|
| Designation | **UNI EN ISO 9606-1 135-S T FW FM1 S t5 D60.3 PB ml** | | | | |
| Welder | **ENCARNACION GARCIA MARIO EDUARDO** | | | | |
| Born in | **VILLA TAPIA-DOMINICAN REPUBLIC** | | | on | **09/04/1997** |
| Identification | **AX8475000** | Method of Identification | **C.I.** | Stamp No. | **EGME** |
| Employed by | **EUROMETAL S.R.L. - Jesi (AN)** | | | | |

WPS used by welder during welding of test coupon: **04/21** Job knowledge: **not tested**

| Welding variables | Test piece | Range of qualification |
|---|---|---|
| Welding process(es) | 135-S | 135; 138 |
| Transfer mode | Spray-arc | Spray, globular and pulsed-arc |
| Product type | Pipes | Plates and pipes |
| Type of weld | FW | Fillet weld |
| Parent Metal group (ISO/TR 15608) | 1.2 | 1 to 11 |
| Filler material group(s) | FM1 | FM1, FM2 |
| Filler material type | Solid wire | Solid wire/electrode core: M |
| Shielding gas (EN ISO 14175) | M20 | All compatible |
| Type of current and polarity | DC EP | All compatible |
| Material thickness (mm) | 5 | >= 3 |
| Pipe outside diameter (mm) | 60.3 | 30,15 and over |
| Welding position(s) | PB | PA, PB |
| Weld details / Layer technique | ml | sl, ml |

| Type of test | | | | | | | |
|---|---|---|---|---|---|---|---|
| Visual | **Acceptable** | Radiographic | **Not tested** | Magnetic particle | **Not tested** | Penetrant | **Not tested** |
| Macro | **Acceptable** | Fracture | **Not tested** | Bend | **Not tested** | | |

| | | | |
|---|---|---|---|
| This certificate is valid from | **27 September 2021** | to | **27 September 2024** |
| Issued at | **GENOVA** | on | **28 October 2021** |

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**PED No. Bo. 0474**
**Via Corsica 12 - 16128 Genova**

PRD N° 002 B

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# WELDING PROCEDURE QUALIFICATION RECORD (WPQR)

## LEVEL 2

N. 21FI00494PW2/A

Manufacturer **EUROMETAL S.R.L. – Jesi (AN)**

WPQR No. **02/21-A** Dated **27/10/2021**

Manufacturer's welding procedure (WPS) No. **02/21** Dated **27/09/2021**

**RANGE OF QUALIFICATION**

Welding process **135** Type **Partly mechanized**

Joint type **Plates and Pipes and build-up FW**

Single/Multiple pass **Multiple** (**Impact properties not applied**)

Parent material group(s) **1-1** ISO/TR 15608; ISO/TR20172; ISO/TR 20173; ISO/TR20174 with a specified minimum yield strength ≤ 355 MPa

Parent material thickness (mm) Butt Joint = **N.A.** Fillet Joint $t_1$ **= 5 and over** $t_2$ **= 5 and over**

Throat thickness (mm) **No restriction**

Weld deposit thickness (mm) **N.A.**

Outside pipe diameter (mm) **>150 (PA, PB, PF rotated position); >500 (all other qualified positions)**

Filler metal make **N.A.** Nr. of wires for process 12: **N.A.**

Flux make **N.A.** Flux Designation: **N.A.**

Filler metal designation **Solid wire EN ISO 14341-A: G 42 4 M 3Si1**

Shielding gas (ISO 14175) **M20 with CO2% min. 6,4 max. 9,6** Backing gas (ISO 14175) **N.A.**

Type of welding current **DCEP** **Heat Input** kJ/cm **Min. 7,6**

Welding position **PB** Transfer Mode **Spray, Pulse, Globular transfer**

Preheat min. (°C) **30** (if ISO/TR 17671-2 requirements are fulfilled)

Interpass temp. Max. (°C) **250** Postheat min. (°C) **N.A.** Time (minutes) **N.A.**

Post weld heat treatment / Ageing **None** Time (minutes) **N.A.**

Other information **-**

Welder's/Operator's name **Marini Federico** Stamp No. **MF**

Welding test conducted by **EUROMETAL S.R.L. – Jesi (AN)**

Mechanical test conducted by **Meccano Spa - Fabriano (AN)** Laboratory test No. **RPLMA 023121/03 dated 20/10/2021**

At presence of RINA Surveyor **M. Giacomini**

We confirm that statements in this record are correct and that the test welds were prepared, welded and tested and have fulfilled the requirements in accordance with **UNI EN ISO 15614-1: 2019** Standard

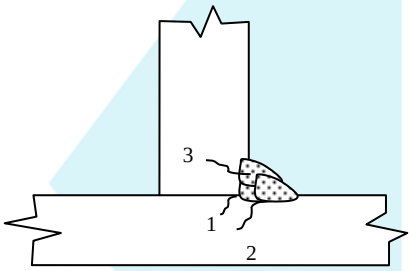
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RINA Services S.p.A.
PED No. Bo. 0474

**Certificate No. 21FI00494PW2/A**

**RECORD OF WELD TEST**

| JOINT DETAILS AND WELDING SEQUENCES | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| PLATE TO PLATE FILLET WELD IN MULTIPASS | | | | | | | | | |
| Pass No. | Process | Filler metal diam. (mm) | Amps | Volt | Type of Current/ Polarity | Travel speed (cm/min) | Heat input (kJ/cm) | Metal Transfer mode | Other |
| 1 | **135** | 1,0 | 242 | 29 | **DCEP** | 30 | 11,2 | **Spray Arc** | - |
| 2-3 | **135** | 1,0 | 255 | 29 | **DCEP** | 35 | 10,1 | **Spray Arc** | - |




**PARENT MATERIAL**

| | |
|---|---|
| Material specification | **EN 10025-2 to EN 10025-2** |
| Type or grade | **S355J2+AR to S355J2+AR** |
| Group(s)/Subgroup(s) No. (ISO/TR 15608; ISO/TR20172; ISO/TR 20173; ISO/TR20174) | **1.2 to 1.2** |
| Thickness (mm) | **t1: 30 ; t2: 30** Throat thickness (mm) **5,9** |
| Diameter (mm) | **N.A.** |
| Branch connection angle | **N.A.** |
| Other | **-** |

**WELDING CONSUMABLES**

| | |
|---|---|
| Process | **135** |
| Trade name(s) | **ELBOR SG2** |
| Specification | **EN ISO 14341-A** |
| Classification / designation | **G 42 4 M 3Si1** |
| Size (mm) | **1,0** |
| Deposited metal thickness | |
| Groove | **N.A.** |
| Throat | **5,9 mm** |
| Flux trade name | **N.A.** |
| Consumable insert | **N.A.** |
| Other | **-** |

**GAS**

| | Gas | Mixture | Flow rate (l/min.) |
|---|---|---|---|
| Shielding | - | **92% Ar +8% CO2** | **15** |
| Trailing | - | - | - |
| Backing | - | - | - |

**POSITION**

Welding position **PB**

Other -

**PREHEAT**

Preheat temperature **80°C**

Interpass temperature **Max. 250°C**

Postheat temperature **N.A.** Time **N.A.**

**POSTWELD HEAT TREATMENT**

Temperature **N.A.** Time **N.A.**

Method **N.A.**

Other -

**ELECTRICAL CHARACTERISTICS**

Current **DCEP**

Ampere (range) **See table** Volts (Range) **See table**

Mode of metal transfer **Spray arc**

Tungsten electrode size and type **N.A.**

Pulse welding details **N.A.**

Plasmawelding details **N.A.**

Waveform controlled welding machine **N.A.** Waveform control mode **N.A.**

Power source **KEMPPI FAST MIG 320** Welding mode Pulse ☐ Non pulse ☑

Other -

**TECHNIQUE**

Travel speed (range) **See table**

String or weave bead **String** Maximum width of run **12 mm**

Oscillation (*) **N.A.** (Amplitude/Frequency/Dwell time)

Method of groove/edge preparation **Machining/Grinding**

Interpass cleaning **Grinding / Brushing**

Method of back gouging **N.A.**

Orifice or gas cup size **19 mm**

Distance contact tube/worpiece (*) **N.A.**

Multiple or single pass **Multiple**

Multiple or single electrodes **Single**

Torch angle (*) **N.A.**

Other (*) for fully mechanized/robotic only

| HARDNESS TEST | | |
|---|---|---|
| Location | Type/load | Maximum value |
| Parent metal(s) | **HV10** | **140** |
| H.A.Z.(s) | **HV10** | **247** |
| Weld metal | **HV10** | **202** |

**OTHER TEST**

| | |
|---|---|
| MACROGRAPHIC EXAMINATION | **Acceptable** |
| MICROGRAPHIC EXAMINATION | **Not required** |

**NON DESTRUCTIVE EXAMINATION**

| | |
|---|---|
| VISUAL EXAMINATION | **Acceptable** |
| RADIOGRAPHIC EXAMINATION | **Not required** |
| PENETRANT TEST | **Not required** |
| MAGNETIC PARTICLE | **Acceptable** |
| ULTRASONIC TEST | **Not required** |

Issued at: Genova on 27 October 2021

RINA Services S.p.A.
PED No. Bo. 0474

# WELDING PROCEDURE QUALIFICATION RECORD (WPQR)

## LEVEL 2

N. 21FI00494PW1/A

Manufacturer **EUROMETAL S.R.L. – Jesi (AN)**

WPQR No. **01/21-A** Dated **27/10/2021**

Manufacturer's welding procedure (WPS) No. **01/21** Dated **27/09/2021**

**RANGE OF QUALIFICATION**

Welding process **135** Type **Partly mechanized**

Joint type **Plates and Pipes and build-up BW ssnb-ssmb-bs/FW**

Single/Multiple pass **Multiple** (**Impact properties apply**)

Parent material group(s) **1-1** ISO/TR 15608; ISO/TR20172; ISO/TR 20173; ISO/TR20174 with a specified minimum yield strength ≤ 355 MPa

Parent material thickness (mm) Butt Joint = **3 to 24** Fillet Joint $t_1$ **: 3 to 24** Fillet Joint $t_2$ **: 3 to 24**

Throat thickness (mm) **No restriction**

Weld deposit thickness (mm) **Max. 24** **Max. 6 135-D** **Max. 18 135-S**

Outside pipe diameter (mm) **>150 (PA, PB, PF rotated position); >500 (all other qualified positions)**

Filler metal make **N.A.** Nr. of wires for process 12: **N.A.**

Flux make **N.A.** Flux Designation: **N.A.**

Filler metal designation **Solid wire EN ISO 14341-A: G 42 4 M 3Si1**

Shielding gas (ISO 14175) **M20 with CO2% min. 6,4 max. 9,6** Backing gas (ISO 14175) **With and without ( I, N1, N2, N3 )**

Type of welding current **DCEP** **Heat Input** kJ/cm **4,9 to 15,2**

Welding position **PA** Transfer Mode **Short Arc (root pass only); Spray, Pulse, Globular transfer (other passes)**

Preheat min. (°C) **15** (if ISO/TR 17671-2 requirements are fulfilled)

Interpass temp. Max. (°C) **250** Postheat min. (°C) **N.A.** Time (minutes) **N.A.**

Post weld heat treatment / Ageing **None** Time (minutes) **N.A.**

Other information **-**

Welder's/Operator's name **Marini Federico** Stamp No. **MF**

Welding test conducted by **EUROMETAL S.R.L. – Jesi (AN)**

Mechanical test conducted by **Meccano Spa - Fabriano (AN)** Laboratory test No. **RPLMA 023121/01/02/05/06 dated 20-22/10/2021**

At presence of RINA Surveyor **M. Giacomini**

We confirm that statements in this record are correct and that the test welds were prepared, welded and tested and have fulfilled the requirements in accordance with **UNI EN ISO 15614-1: 2019** Standard

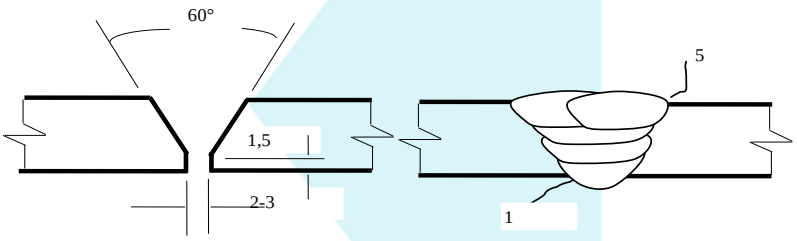
Issued at: Genova on 27 October 2021

RINA Services S.p.A.
PED No. Bo. 0474

**Certificate No. 21FI00494PW1/A**

**RECORD OF WELD TEST**

| JOINT DETAILS AND WELDING SEQUENCES<br>PLATE TO PLATE SINGLE-V BUTT JOINT; ONE SIDE WELDING WITHOUT BACKING | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pass No. | Process | Filler metal diam. (mm) | Amps | Volt | Type of Current/ Polarity | Travel speed (cm/min) | Heat input (kJ/cm) | Metal Transfer mode | Other |
| 1 | **135** | 1,0 | 145 | 17 | **DCEP** | 18 | 6,6 | **Short Arc** | - |
| 2 | **135** | 1,0 | 225 | 27 | **DCEP** | 27 | 10,8 | **Spray Arc** | - |
| 3 | **135** | 1,0 | 235 | 27 | **DCEP** | 25 | 12,2 | **Spray Arc** | - |
| 4-5 | **135** | 1,0 | 220 | 26 | **DCEP** | 32 | 8,6 | **Spray Arc** | - |




**PARENT MATERIAL**

| | |
|---|---|
| Material specification | **EN 10025-2** |
| Type or grade | **S355J2+AR** |
| Group(s)/Subgroup(s) No. (ISO/TR 15608; ISO/TR20172; ISO/TR 20173; ISO/TR20174) | **1.2** |
| Thickness (mm) | **12** |
| Throat thickness (mm) | **N.A.** |
| Diameter (mm) | **N.A.** |
| Branch connection angle | **N.A.** |
| Other | **-** |

**WELDING CONSUMABLES**

| | |
|---|---|
| Process | **135** |
| Trade name(s) | **ELBOR SG2** |
| Specification | **EN ISO 14341-A** |
| Classification / designation | **G 42 4 M 3Si1** |
| Size (mm) | **1,0** |
| Deposited metal thickness | |
| Groove | **12 mm** |
| Throat | **N.A.** |
| Flux trade name | **N.A.** |
| Consumable insert | **N.A.** |
| Other | **-** |

**GAS**

| | Gas | Mixture | Flow rate (l/min.) |
|---|---|---|---|
| Shielding | - | **92% Ar +8% CO2** | **15** |
| Trailing | - | - | - |
| Backing | - | - | - |

**POSITION**

Welding position **PA**

Other -

**PREHEAT**

Preheat temperature **15°C**

Interpass temperature **250 °C**

Postheat temperature **N.A.** Time **N.A.**

**POSTWELD HEAT TREATMENT**

Temperature **N.A.** Time **N.A.**

Method **N.A.**

Other -

**ELECTRICAL CHARACTERISTICS**

Current **DCEP**

Ampere (range) **See table** Volts (Range) **See table**

Mode of metal transfer **Short arc (root pass only) ; Spray arc (other passes)**

Tungsten electrode size and type **N.A.**

Pulse welding details **N.A.**

Plasmawelding details **N.A.**

Waveform controlled welding machine **N.A.** Waveform control mode **N.A.**

Power source **KEMPPI FAST MIG 320** Welding mode Pulse ☐ Non pulse ☑

Other -

**TECHNIQUE**

Travel speed (range) **See table**

String or weave bead **String** Maximum width of run **15 mm**

Oscillation (*) **N.A.** (Amplitude/Frequency/Dwell time)

Method of groove/edge preparation **Machining/Grinding**

Interpass cleaning **Grinding/Brushing**

Method of back gouging **N.A.**

Orifice or gas cup size **19 mm**

Distance contact tube/worpiece (*) **N.A.**

Multiple or single pass **Multiple**

Multiple or single electrodes **Single**

Torch angle (*) **N.A.**

Other (*) for fully mechanized/robotic only

| TRANSVERSE TENSILE TEST | | | | | | |
|---|---|---|---|---|---|---|
| Spec. (No.) | Width (mm) | Thickness (mm) | Area ($mm^2$) | Total load (N) | $R_m$. ($N/mm^2$) | Fracture location |
| **023121/01/01** | **25,001** | **12,019** | **300,487** | **158789** | **528** | **Ductile failure out of weld** |
| **023121/01/02** | **25,036** | **12,042** | **301,483** | **158818** | **527** | **Ductile failure out of weld** |

| BEND TEST | | | |
|---|---|---|---|
| Type | No. | Bend Angle | Result |
| **SIDE TRANSVERSE** | **4 OFF** | **180°** | **Acceptable** |

**IMPACT TEST**

**Sub-size specimens 7,5x10x55 mm**

| Spec No. | Notch location | Notch type | Test Temp. (°C) | Impact values (J) | Average (J) |
|---|---|---|---|---|---|
| **VWT** 0/1 | **WELD** | **ISO-V** | **-20** | **113,0 - 111,4 - 111,7** | **112,0** |
| **VHT** 1/1 | **H.A.Z.** | **ISO-V** | **-20** | **81,1 - 34,7 - 58,3** | **58,0** |

| HARDNESS TEST | | |
|---|---|---|
| Location | Type/load | Maximum value |
| Parent metal(s) | **HV10** | **133** |
| H.A.Z.(s) | **HV10** | **153** |
| Weld metal | **HV10** | **163** |

**OTHER TEST**

| | |
|---|---|
| MACROGRAPHIC EXAMINATION | **Acceptable** |
| MICROGRAPHIC EXAMINATION | **Not required** |

**NON DESTRUCTIVE EXAMINATION**

| | |
|---|---|
| VISUAL EXAMINATION | **Acceptable** |
| RADIOGRAPHIC EXAMINATION | **Acceptable** |
| PENETRANT TEST | **Not required** |
| MAGNETIC PARTICLE | **Acceptable** |
| ULTRASONIC TEST | **Not required** |

Issued at: Genova on 27 October 2021

RINA Services S.p.A.
PED No. Bo. 0474

EUROMETAL SRL

# CERTIFICATO DI CONTROLLO VISIVO
*VISUAL EXAMINATION CONTROL*



**CERTIFICATO**
DOCUMENT
N° 01/2024

| | |
|---|---|
| **Cliente** / Customer : | **IMESA SPA** |
| **Ordine** / Order : | **798BOC DEL 12-03-2024** |
| **Commessa** / Shop order : | **798BOC** |
| **Oggetto** / Object : | **COSTRUZIONE BASAMENTI** |
| **Disegno** / Drawing : | **C231151701 ; C231151702** |
| **Materiale** / Material : | ACCIAIO AL CARBONIO |

| | |
|---|---|
| **Estensione** / Extension : 100% | **Proc. saldatura** / Welding process : 135 |

| | |
|---|---|
| **Specifica di rif.** / Specification Ref. : **EN ISO 17637** | **Classe accettabilità** / Acceptance Criteria : **EN 5817** ☐ **B** ☒ **C** |

**TECNICA E PROCEDURA DEL CONTROLLO** / Test method and procedure

| | | |
|---|---|---|
| **PREPARAZIONE DELLA SUPERFICIE** SURFACE PREPARATION | **Di tipo meccanico** / Mechanical precleaning | **SPAZZOLATURA** |
| | **Di tipo chimico** / Chemical precleaning | **N.A.** |
| | **Temperatura d'esame** / Test temperature | **20°C** |

| | |
|---|---|
| **Illuminamento:** Illuminance: | **500 LUX MIN.** |
| **angolazione visiva:** visual angle: | **90°** |
| **misuratori di forma delle saldature:** weld gauge: | **CALIBRO** |

| **IDENTIFICAZIONE** Identification | **N° PEZZI** | **AREA - TRATTO** Area - section | **TIPO DISCONTINUITA'** Discontinuity | **LARGHEZZA** Width | **LUNGHEZZA** Length | **NOTE** Notes | **RISULTATO DELL'ESAME** Examination result |
|---|---|---|---|---|---|---|---|
| C231151701 | 1 | SALDATA | NESSUNA | | | | OK |
| C231151702 | 6 | SALDATA | NESSUNA | | | | OK |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

| | | |
|---|---|---|
| **RISULTATO DELL'ESAME :** TEST RESULT : | **X** | **Conforme / Satisfactory** |
| | | **Non conforme / Unsatisfactory** |

| ESAMINATORE - EXAMINER | DATE - DATA | APPROVATO - APPROVED |
|---|---|---|
| MARINI FEDERICO<br>EUROMETAL s.r.l.<br>Via Ciro Amedeo Moriconi, 4 - 60035 JESI (AN)<br>Cod. Fisc. e P.Iva 02803020425<br>Tel. e Fax 0731.60954<br>Pec: eurometalsrl@cert.cna.it<br>e-mail: eurometals2008@gmail.com | 07-04-24 | |

| | | | |
|---|---|---|---|
| 1 | 03/04/2024 | aggiornate note | andrea.bonci |

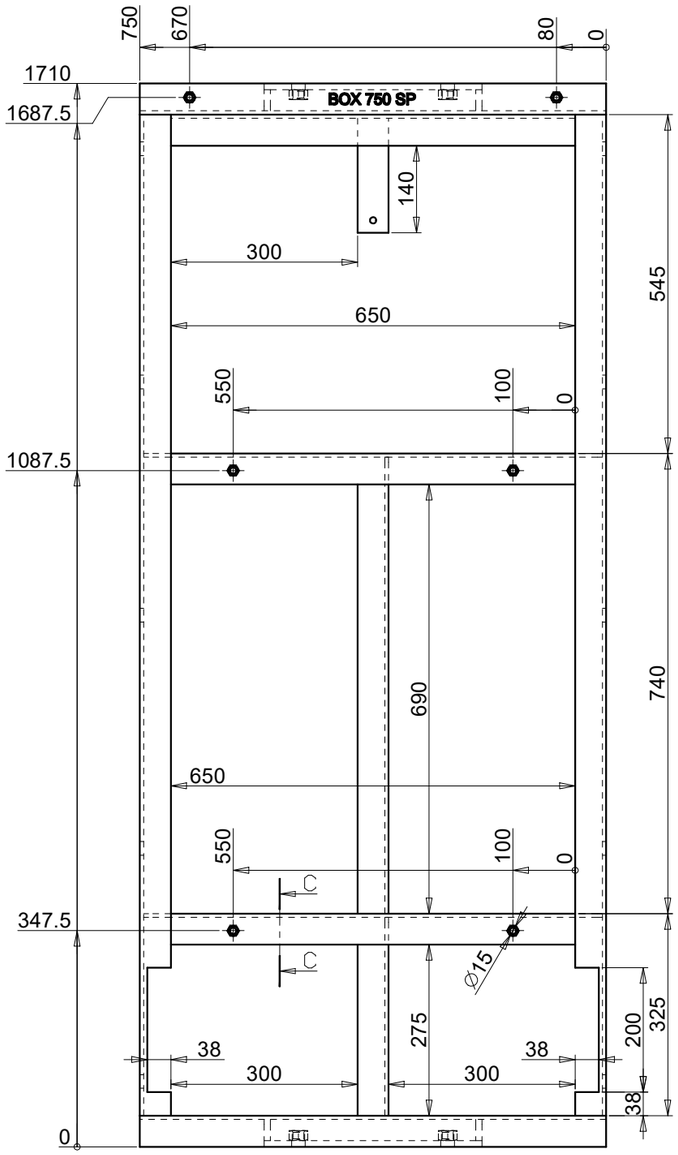
D-D
(4x)

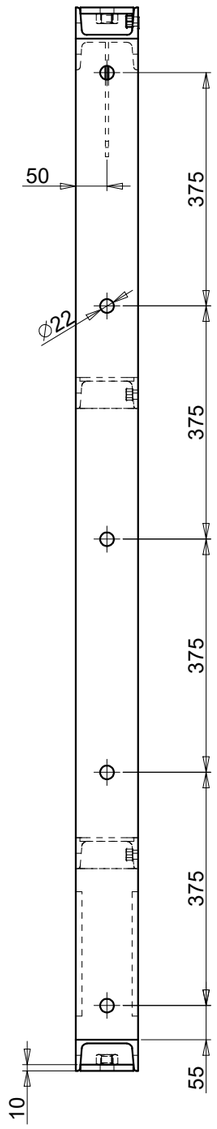
PUNTI DI SOLLEVAMENTO



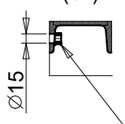

DADO SALDATO M20
Acciaio I8I DIN 934 DADO ESAG. CL.8 UNI5588 GR. M20

PIATTO 85X10 IN ACCIAIO S235JR O SUPERIORE

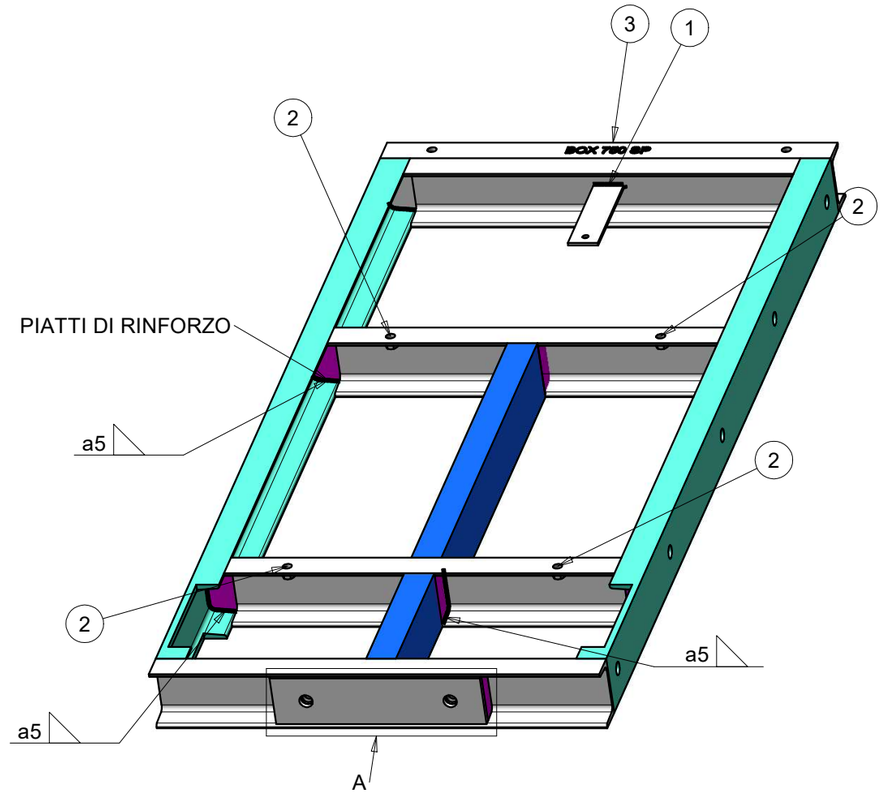


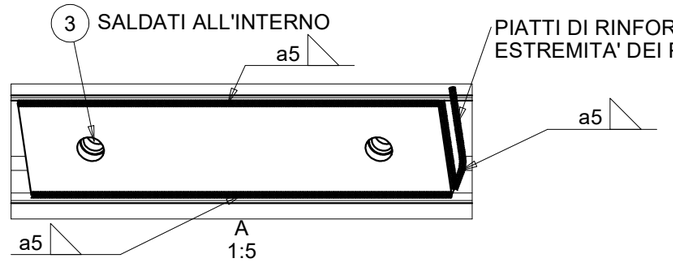




C-C
(6x)




DADO SALDATO M12
Acciaio I8I DIN 934 DADO ESAG. CL.8 UNI5588 GR. M12




NOTE :
- Saldature non quotate a=7/10 dello spessore minimo o superiori
- Classe di esecuzione delle saldature EXC2
- Si richiede prove non distruttive:
  - Esame visivo dei giunti saldati secondo UNI EN 5817:2014

| Pos. | Codice | Descrizione | U.M. | Q.ta |
|---|---|---|---|---|
| 3 | MP0402306 | DADI ESAGONALI MEDI PG 6S M20 ZINCATO BIANCO 5588-934 | NR | 4 |
| 2 | MP0402302 | DADI ESAGONALI MEDI PG 6S M12 ZINCATO BIANCO 5588-934 | NR | 6 |
| 1 | C231151703 | PIASTRA DI MESSA A TERRA PER CONTROBASAMENTI | NR | 1 |

GENERAL TOLERANCES UNI ISO 22768

| | | | | | |
|---|---|---|---|---|---|
| Linear Dim. / Angles : | f | m | c | Class |
| Geometric Tolerances : | H | K | L | |

Stato Superfici : 3.2
Surfaces State :

Projection Method
UNI EN ISO 5456-2 :

All edges and corners derived by mechanical processing must be carefully deburred.

The supplier is required to know the supply specifications of IMESA S.p.A. materials.

Materiale / Sezione / Spessore : PROFILATO U 100X50X6 IN ACCIAIO S235JR O SUPERIORE
Material / Section / Thickness :

Finitura : VERNICIATURA ÷ PAINTING
Finish :

Part. Critico : NO
Critical Part :

Tratt. Termico :
Heat Treatm. :

Scala : 1:10
Scale :

Descrizione / Description :
CONTROBASAMENTO DA 750 PER 1800 PER 100 FERRO A C

Rilascio : FOR MANUFACTURING
Release :

Formato : A3
Size :

| | | | |
|---|---|---|---|
| Dis. : Drw. : | andrea.bonci | 01/03/2024 | Peso kg : Weight : 85.885 |
| Contr. : Check : | Sigismondi P. | 01/03/2024 | Sup. $dm^2$ : Surf : 307.405 |

IMESA® ELECTRICAL ENGINEERING

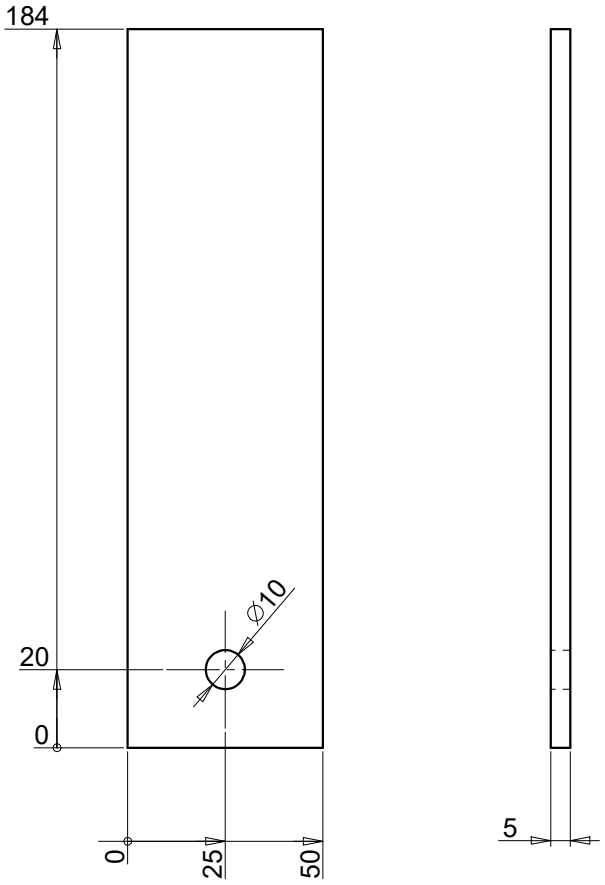
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Gli sviluppi dei particolari in lamiera e delle barre di rame, indicate nel disegno, sono solo di riferimento per il reparto di produzione interna Imesa
The unfolded sheet metal sketch, of copper bars or other components indicated in the technical drawings, are only for Imesa internal production department

Codice / Code : C231151702

Rev. : 1

Fo. / Sh. : 1/1




| | | | | | |
|---|---|---|---|---|---|
| GENERAL TOLERANCES UNI ISO 22768 | | | | Materiale / Sezione / Spessore :<br>Material / Section / Thickness : | LAMIERA DECAPATA ÷ PICKLING SHEET FE P11 50/10 |
| Linear Dim. / Angles : | f | m | c | Finitura :<br>Finish : | Part. Critico :<br>Critical Part : NO |
| Geometric Tolerances : | H | K | L | Tratt. Termico :<br>Heat Treatm. : | Scala :<br>Scale : 1:2 |
| Class | | | | | |
| Stato Superfici :<br>Surfaces State : 3.2 | | | | | |
| Projection Method<br>UNI EN ISO 5456-2 : | | | | Descrizione / Description :<br>PIASTRA DI MESSA A TERRA PER CONTROBASAMENTI | Rilascio :<br>Release : FOR MANUFACTURING<br>Formato :<br>Size : A4 |
| All edges and corners derived by mechanical processing must be carefully deburred. | | | | | Dis. :<br>Drw. : andrea.bonci 06/03/2024<br>Peso kg :<br>Weight : 0.358 |
| The supplier is required to know the supply specifications of IMESA S.p.A. materials. | | | | | Contr. :<br>Check : Sigismondi P. 06/03/2024<br>Sup. dm$^2$ :<br>Surf : 2.074 |

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Gli sviluppi dei particolari in lamiera e delle barre di rame, indicate nel disegno, sono solo di riferimento per il reparto di produzione interna Imesa
The unfolded sheet metal sketch, of copper bars or other components indicated in the technical drawings are only for Imesa internal production department

Codice / Code : C231151703 | Rev. : 0 | Fo. / Sh. : 1/1

# FILO PER LA SALDATURA MIG
## WIRE FOR GMAW

| | |
|---|---|
| Denominazione<br>Product name | **ELB-SG2** |
| Classificazioni<br>Classification | UNI EN ISO 14341-A: 2011 - G 42 4 M21 3Si1 / G 38 2 C1 3Si1<br>SFA - 5.18/5.18M : 2005 AWS ER 70S-6 |

| | |
|---|---|
| Approvazioni<br>Approvals | CE, DB, LR, ABS, TUV, NAKS, DNV, GL, CWB |

| | |
|---|---|
| Corrente<br>Current | DC+ |

Caratteristiche principali - Main characteristics

Filo pieno ramato usato per la saldatura sotto protezione di gas CO2 o miscela di Ar/CO2.
Di impiego generale, indicato per l'unione di acciai al carbonio tipo S355 A516 Gr60, ecc. Arco stabile, cordoni di ottimo aspetto, ridotta formazione di spruzzi. Da impiegarsi nella carpenteria in generale, serbatoi, carrozzerie, ecc.

*Copper-plated solid wire for welding under protection of CO2 gas or Ar/ CO2 mixture. Suitable for the joint of unalloyed carbon steels S355, A516 Gr60, and similar. Stable arc, bead of excellent appearance, extremely reduced spatter. To be used for steel structures in general, coachwork, etc.*

| Diam.<br>mm | A |
|---|---|
| 0,8 | 50-170 |
| 1,0 | 80-250 |
| 1,2 | 120-280 |
| 1,6 | 180-350 |

Analisi chimica tipica del deposito% - Typical weld chemical composition %

| C | Mn | Si | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0,09 | 1,60 | 0,85 | | | | | | | | | |

Caratteristiche meccaniche tipiche - Typical mechanical characteristics

| GAS<br>ISO 14175 | Rm<br>N/mm ² | Rs<br>N/mm² | A5d (%) | KV | C° |
|---|---|---|---|---|---|
| M21 | 500-640 | ≥420 | ≥22 | ≥47 J | -40 |
| C1 | 480-600 | ≥400 | ≥22 | ≥47 J | -20 |

Posizioni di saldatura - Welding positions



| EN | PA | PB | PC | PF | PG | PE | PF | PG | |
|---|---|---|---|---|---|---|---|---|---|
| AWS | 1G | 2F | 2G | 3G | 3F | 4G | 5G | 5G | |

**ELBOR SPA** - Via Nazionale Arcella 12 bis - MONTEFREDANE - AV - ITALY
Tel: +39 0825 607171 - Fax: +39 0825 670012 - email: info@elbor.it
P.IVA: IT 01828680643 - CCIAA Avellino n° 106845 - REG SOC n° 6770

EUROMETAL SRL

# CERTIFICATO DI CONTROLLO VISIVO
*VISUAL EXAMINATION CONTROL*



**CERTIFICATO**
DOCUMENT
N° 01/2024

| | |
|---|---|
| **Cliente** / Customer : | **IMESA SPA** |
| **Ordine** / Order : | **798BOC DEL 12-03-2024** |
| **Commessa** / Shop order : | **798BOC** |
| **Oggetto** / Object : | **COSTRUZIONE BASAMENTI** |
| **Disegno** / Drawing : | **C231151701 ; C231151702** |
| **Materiale** / Material : | ACCIAIO AL CARBONIO |

**Estensione** / Extension : 100%

**Proc. saldatura** / Welding process : 135

**Specifica di rif.** / Specification Ref. : **EN ISO 17637**

**Classe accettabilità** / Acceptance Criteria : **EN 5817** ☐ **B** ☒ **C**

**TECNICA E PROCEDURA DEL CONTROLLO** / Test method and procedure

| | | |
|---|---|---|
| **PREPARAZIONE DELLA SUPERFICIE** SURFACE PREPARATION | **Di tipo meccanico** / Mechanical precleaning | **SPAZZOLATURA** |
| | **Di tipo chimico** / Chemical precleaning | **N.A.** |
| | **Temperatura d'esame** / Test temperature | **20°C** |

| | |
|---|---|
| **Illuminamento:** Illuminance: | **500 LUX MIN.** |
| **angolazione visiva:** visual angle: | **90°** |
| **misuratori di forma delle saldature:** weld gauge: | **CALIBRO** |

| **IDENTIFICAZIONE** Identification | **N° PEZZI** | **AREA - TRATTO** Area - section | **TIPO DISCONTINUITA'** Discontinuity | **LARGHEZZA** Width | **LUNGHEZZA** Length | **NOTE** Notes | **RISULTATO DELL'ESAME** Examination result |
|---|---|---|---|---|---|---|---|
| C231151701 | 1 | SALDATA | NESSUNA | | | | OK |
| C231151702 | 6 | SALDATA | NESSUNA | | | | OK |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

| | | |
|---|---|---|
| **RISULTATO DELL'ESAME :** TEST RESULT : | **X** | **Conforme / Satisfactory** |
| | | **Non conforme / Unsatisfactory** |

| ESAMINATORE - EXAMINER | DATE - DATA | APPROVATO - APPROVED |
|---|---|---|
| MARINI FEDERICO<br>EUROMETAL s.r.l.<br>Via Ciro Amedeo Moriconi, 4 - 60035 JESI (AN)<br>Cod. Fisc. e P.Iva 02803020425<br>Tel. e Fax 0731.60954<br>Pec: eurometalsrl@cert.cna.it<br>e-mail: eurometals2008@gmail.com | 07-04-24 | |

2.6.5.Weight Report

*This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy*

# WEIGHT REPORT

**By the present, the manufacturer and vendor IMESA SPA, here by certifies the following packaging and weight details:**

**VENDOR:**
**I.M.E.S.A. S.p.A.**
VIA G. DI VITTORIO, 14
60035 JESI (AN), ITALY

**Weight Report No.: 231298_231151**
**REF.: ROSETTI MARINO S.p.A. Purchase Order No.: 1723002197 123A90A**
REF.: IMESA SPA Delivery Notes No. 1068 dated 20/09/2024, No. 968 and No. 936 dated 06/08/2024
Total No. of Packages: 18
Total Net Weight: 13.085 kgs
Total Gross Weight: 13.180 kgs
Total Volume: 44,18 cbm

| Pkg No. | PO Item | Description of goods | TAG No. | Q.TY | Package Type | Dimension CM | | | | | Volume CBM | Net Wt KG | Gross Wt KG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lenght | x | Width | x | Height | | | |
| 1 OF 18 | 10 Rev.4<br>100 Rev4<br>110 Rev.4<br>190 Rev.4<br>220 | 1EQP078<br>MV IN AIR SEGREGATE SWITCHBOARD (COLUMN A1) | SG-100D1 | 1 | AT SIGHT | 80,00 | x | 190,00 | x | 255,00 | 3,88 | 1.185,00 | 1.187,00 |
| 2 OF 18 | | 1EQP078<br>MV IN AIR SEGREGATE SWITCHBOARD (COLUMN A7) | SG-100D1 | 1 | AT SIGHT | 80,00 | x | 190,00 | x | 255,00 | 3,88 | 1.180,00 | 1.182,00 |
| 3 OF 18 | | 1EQP078<br>MV IN AIR SEGREGATE SWITCHBOARD (COLUMN A4) | SG-100D1 | 1 | AT SIGHT | 60,00 | x | 190,00 | x | 255,00 | 2,91 | 730,00 | 732,00 |
| 4 OF 18 | | 1EQP078<br>MV IN AIR SEGREGATE SWITCHBOARD (COLUMN A2) | SG-100D1 | 1 | AT SIGHT | 75,00 | x | 190,00 | x | 255,00 | 3,63 | 980,00 | 982,00 |
| 5 OF 18 | | 1EQP078<br>MV IN AIR SEGREGATE SWITCHBOARD (COLUMN A3) | SG-100D1 | 1 | AT SIGHT | 75,00 | x | 190,00 | x | 255,00 | 3,63 | 980,00 | 982,00 |
| 6 OF 18 | | 1EQP078<br>MV IN AIR SEGREGATE SWITCHBOARD (COLUMN A5) | SG-100D1 | 1 | AT SIGHT | 75,00 | x | 190,00 | x | 255,00 | 3,63 | 640,00 | 642,00 |
| 7 OF 18 | | 1EQP078<br>MV IN AIR SEGREGATE SWITCHBOARD (COLUMN A6) | SG-100D1 | 1 | AT SIGHT | 75,00 | x | 190,00 | x | 255,00 | 3,63 | 1.020,00 | 1.022,00 |
| 8 OF 18 | 20 Rev.4 | 2SPAREEQPVAL - SPARE PARTS<br>(MV 6.6kV Switchgear - Commissioning spare parts) | SG-100D1 | 1 / SET | PALLET | 80,00 | x | 120,00 | x | 95,00 | 0,91 | 77,00 | 87,00 |
| | 30 Rev.4 | 1EQP011 - MV SWGR - Special tools<br>(MV 6.6kV Switchgear - Special tools) | SG-100D1 | 1 / SET | | | | | | | | | |
| | 50 Rev.4 | 1EQP075 - LV SWGR - Commissioning Spare Part<br>LV 0,4kV Switchgear - Commissioning spare parts | SG-200N1 | 1 / SET | | | | | | | | | |
| 9 OF 18 | 40 Rev.4<br>160 Rev.4<br>190 Rev.4<br>230 Rev.4 | 1EQP070 - MCC LV SWITCHBOARD<br>LV 0,4kV Switchgear (COLUMNS A6, A7) | SG-200N1 | 1 | AT SIGHT | 75,00 | x | 245,00 | x | 235,00 | 4,32 | 1.290,00 | 1.292,00 |
| 10 OF 18 | | 1EQP070 - MCC LV SWITCHBOARD<br>LV 0,4kV Switchgear (COLUMNS A4, A5) | SG-200N1 | 1 | AT SIGHT | 75,00 | x | 245,00 | x | 235,00 | 4,32 | 1.350,00 | 1.352,00 |
| 11 OF 18 | | 1EQP070 - MCC LV SWITCHBOARD<br>LV 0,4kV Switchgear (COLUMNS A1, A2, A3) | SG-200N1 | 1 | AT SIGHT | 75,00 | x | 340,00 | x | 235,00 | 6,00 | 2.120,00 | 2.122,00 |

# WEIGHT REPORT

ELECTRICAL ENGINEERING
1972 50 ANNIVERSARIO 2022

**By the present, the manufacturer and vendor IMESA SPA, here by certifies the following packaging and weight details:**

**VENDOR:**
**I.M.E.S.A. S.p.A.**
VIA G. DI VITTORIO, 14
60035 JESI (AN), ITALY

**Weight Report No.: 231298_231151**
**REF.: ROSETTI MARINO S.p.A. Purchase Order No.: 1723002197 123A90A**
REF.: IMESA SPA Delivery Notes No. 1068 dated 20/09/2024, No. 968 and No. 936 dated 06/08/2024
Total No. of Packages: 18
Total Net Weight: 13.085 kgs
Total Gross Weight: 13.180 kgs
Total Volume: 44,18 cbm

| Pkg No. | PO Item | Description of goods | TAG No. | Q.TY | Package Type | Dimension CM | | | | | Volume CBM | Net Wt KG | Gross Wt KG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lenght | x | Width | x | Height | | | |
| 12 OF 18 | 60 Rev.4 | 1EQP011 - LV SWGR - Special tools<br>LV 0,4kV Switchgear - Special tools | SG-200N1 | 1 / SET | PALLET | 80,00 | x | 120,00 | x | 220,00 | 2,11 | 140,00 | 150,00 |
| 13 OF 18 | N.A. | COPPER BARS, BOLTS AND NUTS | SG-100D1 | 1 / SET | PALLET | 80,00 | x | 120,00 | x | 55,00 | 0,53 | 78,00 | 88,00 |
| 14 OF 18 | 70 | 1EQP070<br>MCC LV SWITCHBOARD<br>LV 0,4kV Switchgear (Solar) | SG-200D2 | 1 | AT SIGHT | 112,00 | x | 90,00 | x | 235,00 | 2,37 | 450,00 | 455,00 |
| 15 OF 18 | 80 | 1EQP072<br>ELECTRIC DISTRIBUTION LV SWITCHBOARD<br>LV 400/230V Distribution board | DP-200N1 | 1 | AT SIGHT | 116,00 | x | 60,00 | x | 235,00 | 1,64 | 360,00 | 365,00 |
| 16 OF 18 | 40 | DRAWERS | SG-200N1 | 8 | PALLET | 120,00 | x | 80,00 | x | 110,00 | 1,06 | 200,00 | 210,00 |
| 17 OF 18 | 40 | DRAWERS | SG-200N1 | 4 | PALLET | 120,00 | x | 80,00 | x | 110,00 | 1,06 | 200,00 | 210,00 |
| 18 OF 18 | 40 | DRAWERS | SG-200N1 | 3 | PALLET | 120,00 | x | 80,00 | x | 70,00 | 0,67 | 105,00 | 120,00 |
| **TOTAL** | | | | | | | | | | | **44,18** | **13.085,00** | **13.180,00** |

Jesi, 25/06/2025

I.M.E.S.A. S.p.A.
Via G. Di Vittorio, 14 - 60035 JESI
☎0731/211034 - Fax 0731/211055
Cod. Fisc. e P.IVA 0015563 042 9

## 2.7. SWBDs Declaration of Conformity

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Doc. N. 26-606-GZ-6850

# EU DECLARATION OF CONFORMITY

This declaration of conformity is issued under the sole responsibility of the manufacturer

**I.M.E.S.A. S.p.A. - Via G. di Vittorio, 14 - Zona industriale ZIPA - 60035 Jesi (AN) Italy**

and are in conformity with the following harmonized standards

**CEI EN 62271-200 "A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV"**

| | |
|---|---|
| **Purchaser** | Rosetti Marino S.p.A. |
| **Purchase Order** | 1723002197 date:21.12.2023 |
| **Consignee** | Base Load Power Hub (BLPH) HOLLANDSE KUST NOORD WIND PARK |
| **I.M.E.S.A. job no.** | 231151 |

| | |
|---|---|
| **Description of the switchboards** | HV SWITCHGEARS AIS TYPE – 6.6kV 630A 25kA "SG-100D1" |
| **Serial numbers** | 231151/SD/010/2024 |

*Jesi, 7-Aug-2024*

**IMESA Spa**
*Technical Manager*
*Maurizio Martizzi*

**IMESA Spa**
*Legal Representative*
*Marco Achilli*

I.M.E.S.A. S.p.A.
Via G. Di Vittorio, 14 – 60035 JESI
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Cod. Fisc. e P.IVA 00155630429

# EU DECLARATION OF CONFORMITY

## REQUIREMENTS COMPLYING WITH STANDARDS IEC 61439-2

| | |
|---|---|
| **Purchaser:** | Rosetti Marino S.p.A. |
| **Purchase Order:** | 1723002197 date:21.12.2023 |
| **Consignee:** | Base Load Power Hub (BLPH) HOLLANDSE KUST NOORD WIND PARK |
| **I.M.E.S.A. job no.:** | 231298 |

| | |
|---|---|
| **Description of the switchboards:** | "DP-200N1" LV SWBD 400/230V 63A 25kA |
| **Serial number::** | 231298/080/2024 |

We hereby declare under our full responsibility that the above switchboard has been manufactured to good workmanship standards and complies in full with the specifications of Standards IEC 61439-2 “low-voltage switchgear and controlgear assemblies”.

We declare that all the test provided by the EU Directive were successfully performed.

*Jesi, 20-Sep-2024*

**IMESA Spa**
*Technical Manager*
*Maurizio Martizzi*

**IMESA Spa**
*Legal Representative*
*Marco Achilli*

I.M.E.S.A. S.p.A.
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# EU DECLARATION OF CONFORMITY

## REQUIREMENTS COMPLYING WITH STANDARDS IEC 61439-2

| | |
|---|---|
| **Purchaser:** | Rosetti Marino S.p.A. |
| **Purchase Order:** | 1723002197 date:21.12.2023 |
| **Consignee:** | Base Load Power Hub (BLPH) HOLLANDSE KUST NOORD WIND PARK |
| **I.M.E.S.A. job no.:** | 231298 |

| | |
|---|---|
| **Description of the switchboards:** | "SG-200D2" LV SWBD 800V 630A 30kA |
| **Serial number::** | 231298/SD/070/2024 |

We hereby declare under our full responsibility that the above switchboard has been manufactured to good workmanship standards and complies in full with the specifications of Standards IEC 61439-2 “low-voltage switchgear and controlgear assemblies”.

We declare that all the test provided by the EU Directive were successfully performed.

*Jesi, 20-Sep-2024*

**IMESA Spa**
*Technical Manager*
*Maurizio Martizzi*

**IMESA Spa**
*Legal Representative*
*Marco Achilli*

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# EU DECLARATION OF CONFORMITY

## REQUIREMENTS COMPLYING WITH STANDARDS IEC 61439-2

| | |
|---|---|
| **Purchaser:** | Rosetti Marino S.p.A. |
| **Purchase Order:** | 1723002197 date:21.12.2023 |
| **Consignee:** | Base Load Power Hub (BLPH) HOLLANDSE KUST NOORD WIND PARK |
| **I.M.E.S.A. job no.:** | 231298 |

| | |
|---|---|
| **Description of the switchboards:** | "SG-200N1" LV SWBD 400/230V 2500A 50kA |
| **Serial number::** | 231298/SD/040/2024 |

We hereby declare under our full responsibility that the above switchboard has been manufactured to good workmanship standards and complies in full with the specifications of Standards IEC 61439-2 “low-voltage switchgear and controlgear assemblies”.

We declare that all the test provided by the EU Directive were successfully performed.

*Jesi, 20-Sep-2024*

**IMESA Spa**
*Technical Manager*
*Maurizio Martizzi*

**IMESA Spa**
*Legal Representative*
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## 2.8. Release Note

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| ROSETTI MARINO | RELEASE NOTE | Nr. RN-2197-IMS-01 | Sheet 1 of 1 |
|---|---|---|---|
| | | Date 19/06/2024 | Rev. 00 |

| PROGETTO *Project* | CLIENTE *Client* | COMMESSA *Job* |
|---|---|---|
| HOLLANDSE KUST NOORD WIND PARK | CROSSWIND | *123A90* |

| FORNITORE *Vendor* | NUMERO D' ORDINE *Purchase Order No.* |
|---|---|
| IMESA S.p.A. | *1723002197* |

| Release Note | ☒ FOR PAYMENT | ☐ FOR SHIPMENT |
|---|---|---|

**RELEASE NOTE FOR PAYMENT**

| PO Art. | | **"MAIN MATERIALS RECEIPT INSTALLMENT"** |
|---|---|---|
| 9.2.1 | **b)** | 30 % of the PURCHASE ORDER TOTAL AMOUNT at delivery of main materials at CONTRACTOR's premises ("MAIN MATERIALS RECEIPT INSTALLMENT") , against presentation of the following ;<br>(i) Receipt by COMPANY of the correct invoice;<br>(ii) Release note issued by COMPANY's Supply Management Department, relevant to the arrival at CONTRACTOR's premises<br>of following main materials :<br>- Circuits breakers and fixed parts, iron, copper of all Switchgears;<br>accompanied by the Delivery note and relevant Material/Testing certificates.<br>COMPANY reserves the right to verify receipt of the above. |

**RELEASE NOTE FOR SHIPMENT**

| POS. Item | Q.TA' Quantity | DESCRIZIONE Description | Nr. TAG TAG No. | TIPO DI ISPEZIONE / Kind of Inspection | ESITO / Result |
|---|---|---|---|---|---|
| | | | | | |

**DOCUMENTI APPLICABILI /** *APPLICABLE DOCUMENTS*

| POSIZIONE *Items* | TIPO DI DOCUMENTO *Type of Document* | NUMERO DI DOCUMENTO *Document Number* | Rev. | COD. DI APPROV. *Approv. Code* |
|---|---|---|---|---|
| | | | | |

**PUNCH LIST:** ☐ SI / *YES* VEDI PUNCH LIST ALLEGATA N° / *REFER TO ATTACHED PUNCH LIST N°*
☒ NO/ *NO*

**CONTROLLO VALIDITA' FIDEJUSSIONE / *PERFORMANCE or WARRANTY BOND expiration date check***
Estensione Fidejussione Richiesta *(Performance or Warranty Bond Extension of Validity required)*
☐ SI / *YES* ☒ NO/ *NO*
***Acceptance Method:*** *Performance or Warranty Bond valid if actually delivery date it's not greater than two weeks from contractual delivery date.*

**RELEASE NOTE**

| RISULTATO / *RESULT* | FORNITURA / *SUPPLY* | DISTRIBUZIONE A: / *DISTRIBUTION TO:* | |
|---|---|---|---|
| ☒ POSITIVO / *POSITIVE* | ☐ COMPLETA / *COMPLETE* | ☒ Project Manager | ☒ Administration |
| ☐ NEGATIVO / *NEGATIVE* | ☐ PARZIALE / *PARTIAL* | ☒ Project Quality Manager | ☒ Project Eng-/Procurement Coord |
| ☐ PUNTI PENDENTI / *PUNCH-LIST* | ☐ ULTIMA / *FINAL* | ☐ Warehouse | ☐ Supplier |

**NOTE /** *NOTES*

**Note:**
Attached DDTs

| L' INCARICATO /*Person in charge* ROSETTI MARINO *Supply Management dept.* | | IL RAPPR. DEL CLIENTE / *Client Representative* | IL FORNITORE /*Vendor* | CONSTRUCTION MANAGER *Only requested for Punch List to be closed at Yard* |
|---|---|---|---|---|
| **Nome Cognome** *Name Surname* | **Firma** *Signature* | | | |
| *Vincent Zwaan* |  | N.A. | N.A. | N.A. |

QUESTO DOCUMENTO NON SOLLEVA IL FORNITORE DALLA RESPONSABILITA' DI EVENTUALI DIFETTI E/O MALFUNZIONAMENTI RILEVATI DURANTE L'USO / *The present RELEASE NOTE does not relieve the Supplier of the responsibility of any possible defects and/or malfunctioning arising during the utilisation.*
MOD-PRO-18-Rev. 2016-02 Release Note Report

| ROSETTI MARINO | RELEASE NOTE | Nr. RN-2197-IMS-02 | Sheet 1 of 2 |
|---|---|---|---|
| | | Date 01/08/2024 | Rev. 00 |

| PROGETTO *Project* | CLIENTE *Client* | COMMESSA *Job* |
|---|---|---|
| HOLLANDSE KUST NOORD WIND PARK | CROSSWIND | *123A90* |

| FORNITORE *Vendor* | NUMERO D' ORDINE *Purchase Order No.* |
|---|---|
| IMESA S.p.A | *1723002197* |

| Release Note | ☐ FOR PAYMENT | ☒ FOR SHIPMENT |
|---|---|---|

**RELEASE NOTE FOR PAYMENT**

| PO Art. | |
|---|---|
| | |

**RELEASE NOTE FOR SHIPMENT**

| POS. Item | Q.TA' Quantity | DESCRIZIONE Description | Nr. TAG TAG No. | TIPO DI ISPEZIONE / Kind of Inspection | ESITO / Result |
|---|---|---|---|---|---|
| 10<br>100<br>110<br>190<br>220 | 7 | 1EQP078<br>MV IN AIR SEGREGATE SWITCHBOARD (COLUMN A1 to A7) | SG-100D1 | FAT | Positive |
| 20 | '1 / SET | 2SPAREEQPVAL - SPARE PARTS<br>(MV 6.6kV Switchgear - Commissioning spare parts) | SG-100D1 | FAT | Positive |
| 30 | '1 / SET | 1EQP011 - MV SWGR - Special tools<br>(MV 6.6kV Switchgear - Special tools) | SG-100D1 | FAT | Positive |
| 50 | '1 / SET | 1EQP075 - LV SWGR - Commissioning Spare Part<br>LV 0,4kV Switchgear - Commissioning spare parts | SG-200N1 | FAT | Positive |
| 40<br>160<br>190<br>230 | 7 | 1EQP070 - MCC LV SWITCHBOARD<br>LV 0,4kV Switchgear (COLUMNS A1 to A7) | SG-200N1 | FAT | Positive |
| 60 | '1 / SET | 1EQP011 - LV SWGR - Special tools<br>LV 0,4kV Switchgear - Special tools | SG-200N1 | FAT | Positive |
| NA | '1 / SET | COPPER BARS, BOLTS AND NUTS | SG-100D1 | FAT | Positive |

**Warehouse open Monday to Friday From 08.00 to12.00 and from 13.00 to 17.00.**
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| POSIZIONE *Items* | TIPO DI DOCUMENTO *Type of Document* | NUMERO DI DOCUMENTO *Document Number* | Rev. | COD. DI APPROV. *Approv. Code* |
|---|---|---|---|---|
| | | | | |

**PUNCH LIST:** ☐ SI / *YES* VEDI PUNCH LIST ALLEGATA N° / *REFER TO ATTACHED PUNCH LIST N°*
☐ NO/ *NO*

**CONTROLLO VALIDITA' FIDEJUSSIONE / *PERFORMANCE or WARRANTY BOND expiration date check***
Estensione Fidejussione Richiesta *(Performance or Warranty Bond Extension of Validity required)*
☐ SI / *YES* ☐ NO/ *NO*
***Acceptance Method:*** *Performance or Warranty Bond valid if actually delivery date it's not greater than two weeks from contractual delivery date.*

**RELEASE NOTE**

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|---|---|---|---|
| ☒ POSITIVO / *POSITIVE* | ☐ COMPLETA / *COMPLETE* | ☒ Project Manager | ☒ Administration |

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|---|---|---|---|---|
| **Nome Cognome** *Name Surname* | **Firma** *Signature* | | | |
| *Vincent Zwaan* | | N.A. | N.A. | N.A. |

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| ROSETTI MARINO | RELEASE NOTE | Nr. RN-2197-IMS-02 | Sheet 2 of 2 |
|---|---|---|---|
| | | Date 01/08/2024 | Rev. 00 |

| PROGETTO *Project* | CLIENTE *Client* | COMMESSA *Job* |
|---|---|---|
| HOLLANDSE KUST NOORD WIND PARK | CROSSWIND | *123A90* |

| FORNITORE *Vendor* | NUMERO D' ORDINE *Purchase Order No.* |
|---|---|
| IMESA S.p.A | *1723002197* |

| ☐ NEGATIVO / *NEGATIVE* | ☒ PARZIALE / *PARTIAL* | ☒ Project Quality Manager | ☒ Project Eng-/Procurement Coord |
|---|---|---|---|
| ☐ PUNTI PENDENTI / *PUNCH-LIST* | ☐ ULTIMA / *FINAL* | ☐ Warehouse | ☐ Supplier |

**NOTE /** *NOTES*

**Note:**
Refer to attached PL

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|---|---|---|---|---|
| **Nome Cognome** *Name Surname* | **Firma** *Signature* | | | |
| *Vincent Zwaan* | | N.A. | N.A. | N.A. |

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MOD-PRO-18-Rev. 2016-02 Release Note Report

| ROSETTI MARINO | RELEASE NOTE | Nr. RN-2197-IMS-03 | Sheet 1 of 2 |
|---|---|---|---|
| | | Date 20/09/2024 | Rev. 00 |

| PROGETTO *Project* | CLIENTE *Client* | COMMESSA *Job* |
|---|---|---|
| HOLLANDSE KUST NOORD WIND PARK | CROSSWIND | *123A90* |

| FORNITORE *Vendor* | IMESA S.p.A | NUMERO D' ORDINE *Purchase Order No.* | *1723002197* |
|---|---|---|---|

| Release Note | ☐ FOR PAYMENT | ☒ FOR SHIPMENT |
|---|---|---|

**RELEASE NOTE FOR PAYMENT**

| PO Art. | |
|---|---|
| | |

**RELEASE NOTE FOR SHIPMENT**

| POS. Item | Q.TA' Quantity | DESCRIZIONE Description | Nr. TAG TAG No. | TIPO DI ISPEZIONE / Kind of Inspection | ESITO / Result |
|---|---|---|---|---|---|
| 70 | 1 | 1EQP070<br>MCC LV SWITCHBOARD<br>LV 0,4kV Switchgear (Solar) | SG-200D2 | FAT | Positive |
| 80 | 1 | 1EQP072<br>ELECTRIC DISTRIBUTION LV SWITCHBOARD<br>LV 400/230V Distribution board | DP-200N1 | FAT | Positive |
| 40 | 8 | DRAWERS | SG-200N1 | FAT | Positive |
| 40 | 4 | DRAWERS | SG-200N1 | FAT | Positive |
| 40 | 3 | DRAWERS | SG-200N1 | FAT | Positive |
| | | | | | |
| | | | | | |

**Warehouse open Monday to Friday From 08.00 to12.00 and from 13.00 to 17.00.**
**Contact Mr Rota +39 3451608099**

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**PUNCH LIST:** ☐ SI / *YES* VEDI PUNCH LIST ALLEGATA N° / *REFER TO ATTACHED PUNCH LIST N°*
☐ NO/ *NO*

**CONTROLLO VALIDITA' FIDEJUSSIONE / *PERFORMANCE or WARRANTY BOND expiration date check***
Estensione Fidejussione Richiesta *(Performance or Warranty Bond Extension of Validity required)*
☐ SI / *YES* ☐ NO/ *NO*
***Acceptance Method:*** *Performance or Warranty Bond valid if actually delivery date it's not greater than two weeks from contractual delivery date.*

## RELEASE NOTE

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| ☐ PUNTI PENDENTI / *PUNCH-LIST* | ☐ ULTIMA / *FINAL* | ☐ Warehouse | ☐ Supplier |

**NOTE /** *NOTES*

| L' INCARICATO /*Person in charge* ROSETTI MARINO *Supply Management dept.* | | IL RAPPR. DEL CLIENTE / *Client Representative* | IL FORNITORE /*Vendor* | CONSTRUCTION MANAGER *Only requested for Punch List to be closed at Yard* |
|---|---|---|---|---|
| **Nome Cognome** *Name Surname* | **Firma** *Signature* | | | |
| *Vincent Zwaan* | | N.A. | N.A. | N.A. |

QUESTO DOCUMENTO NON SOLLEVA IL FORNITORE DALLA RESPONSABILITA' DI EVENTUALI DIFETTI E/O MALFUNZIONAMENTI RILEVATI DURANTE L'USO / *The present RELEASE NOTE does not relieve the Supplier of the responsibility of any possible defects and/or malfunctioning arising during the utilisation.*

MOD-PRO-18-Rev. 2016-02 Release Note Report

| ROSETTI MARINO | RELEASE NOTE | Nr. RN-2197-IMS-03 | Sheet 2 of 2 |
|---|---|---|---|
| | | Date 20/09/2024 | Rev. 00 |

| PROGETTO *Project* | CLIENTE *Client* | COMMESSA *Job* |
|---|---|---|
| HOLLANDSE KUST NOORD WIND PARK | CROSSWIND | *123A90* |

| FORNITORE *Vendor* | | NUMERO D' ORDINE *Purchase Order No.* | |
|---|---|---|---|
| | IMESA S.p.A | | *1723002197* |

**Note:**
Refer to attached PL

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|---|---|---|---|---|
| **Nome Cognome** *Name Surname* | **Firma** *Signature* | | | |
| *Vincent Zwaan* | | N.A. | N.A. | N.A. |

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| ROSETTI MARINO | RELEASE NOTE | Nr. RN-2197-IMS-04 | Sheet 1 of 1 |
|---|---|---|---|
| | | Date 10/03/2025 | Rev. 00 |

| PROGETTO *Project* | CLIENTE *Client* | COMMESSA *Job* |
|---|---|---|
| HOLLANDSE KUST NOORD WIND PARK | CROSSWIND | *123A90* |

| FORNITORE *Vendor* | NUMERO D' ORDINE *Purchase Order No.* |
|---|---|
| IMESA S.p.A | *1723002197* |

| Release Note | ☐ FOR PAYMENT | ☒ FOR SHIPMENT |
|---|---|---|

**RELEASE NOTE FOR PAYMENT**

| PO Art. | |
|---|---|
| | |

**RELEASE NOTE FOR SHIPMENT**

| POS. Item | Q.TA' Quantity | DESCRIZIONE Description | Nr. TAG TAG No. | TIPO DI ISPEZIONE / Kind of Inspection | ESITO / Result |
|---|---|---|---|---|---|
| 280 | | Sensore mod 011.03 + Relè 11.31 | | NA | NA |
| | | | | | |

**Warehouse open Monday to Friday From 08.00 to12.00 and from 13.00 to 17.00.**
**Contact Mr Rota +39 3451608099**

**DOCUMENTI APPLICABILI /** *APPLICABLE DOCUMENTS*

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**PUNCH LIST:** ☐ SI / *YES* VEDI PUNCH LIST ALLEGATA N° / *REFER TO ATTACHED PUNCH LIST N°*
☐ NO/ *NO*

**CONTROLLO VALIDITA' FIDEJUSSIONE / *PERFORMANCE or WARRANTY BOND expiration date check***
Estensione Fidejussione Richiesta *(Performance or Warranty Bond Extension of Validity required)*
☐ SI / *YES* ☐ NO/ *NO*
***Acceptance Method:*** *Performance or Warranty Bond valid if actually delivery date it's not greater than two weeks from contractual delivery date.*

## RELEASE NOTE

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|---|---|---|---|
| ☒ POSITIVO / *POSITIVE* | ☐ COMPLETA / *COMPLETE* | ☒ Project Manager | ☒ Administration |
| ☐ NEGATIVO / *NEGATIVE* | ☒ PARZIALE / *PARTIAL* | ☒ Project Quality Manager | ☒ Project Eng-/Procurement Coord |
| ☐ PUNTI PENDENTI / *PUNCH-LIST* | ☐ ULTIMA / *FINAL* | ☐ Warehouse | ☐ Supplier |

**NOTE /** *NOTES*

**Note:**
Refer to attached DDT 359

| L' INCARICATO /*Person in charge* ROSETTI MARINO *Supply Management dept.* | | IL RAPPR. DEL CLIENTE / *Client Representative* | IL FORNITORE /*Vendor* | CONSTRUCTION MANAGER *Only requested for Punch List to be closed at Yard* |
|---|---|---|---|---|
| **Nome Cognome** *Name Surname* | **Firma** *Signature* | | | |
| *Vincent Zwaan* | | N.A. | N.A. | N.A. |

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## 2.9. Main component Manual/Catalogue

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2.9.1.Circuit breakers

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DISTRIBUTION SOLUTIONS

# VD4

## Medium voltage vacuum circuit breakers 12...40.5 kV - 630...4000 A - 16...63 kA



VD4 medium voltage circuit breakers use vacuum interrupters embedded in the poles. This construction method makes the poles particularly sturdy and protects the interrupter from shocks, dust and condensation.
VD4 circuit breakers are the best choice for the majority of modern electricity distribution applications and are used in transformer and distribution substations to control and protect motors, transformers, capacitor banks and for protecting cables.

# Table of contents


**004** – 007 **VD4: its strengths, your benefits**

**008** – 017 **Description**

**018** – 097 **Selection and ordering**

**098** – 101 **Specific product characteristics**

**102** – 137 **Overall dimensions**

**138** – 161 **Electric circuit diagram**

# **VD4:**
# its strengths, your benefits

**Global availability**

**Safety and protection**

**Reliable in extreme conditions**



# Productivity
## Maximize your output



### Services and training
- Dedicated training for installation and maintenance
  - Specialized ABB personnel for installation and maintenance
- Backup at your location and analysis for special applications
  - ABB technical support helps you choose the best solution for your specific application



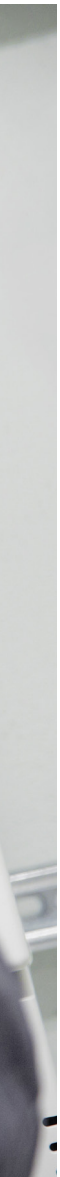
### Easy to install
- Withdrawable version available
  - Circuit breaker can be rapidly racked-in/out for maintenance
  - The complete circuit breaker is ready for installation in the switchgear



### Speed up your projects
- Breaker+cassette proposal
  - Speedier engineering thanks to tried-and-tested ABB design
- Technical collaboration agreements
  - New switchgear configurations take less time to develop



### Continuous operation
- Excellent quality product thanks to high process automation
  - Reliable, high quality product



# Reliability
## Protect your assets



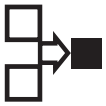
### Safety and protection
- Motor-driven truck for remote circuit breaker racking-in/out
  – The breaker can be safely put into the service or test position without the need for an operator in front of the switchgear
- Truck interlocking magnet: prevents breaker from being racked into switchgear with different rated current or without the auxiliary circuit plug connected
  – No risk of installing the wrong breaker in the switchgear or without its protection functions having been activated.



### Reliable in extreme conditions
- Vacuum interrupters embedded in the poles
  – The core components of the breaker are completely protected against mechanical shocks, dust and condensation



### Global availability
- The world’s best-selling circuit breaker
  – Our worldwide presence means you can rely on us for any type of support you may require



**Optimized interface**

- Standardized product family up to 40.5 kV, 4000A
  - A common, simplified interface and accessories for the whole product family
- Mechanically Interchangeable with HD4
  - The same switchgear configuration is used to host breakers with both interruption technologies
- Fixed version with truck assembled and ready to be customized
  - The contact system most suited to your switchgear can be designed and created thanks to the already assembled interlocking system

## Efficiency
Optimize your investments



**Affordable Range**

- Technical collaboration agreements
  - Allow you to cut investment costs when new switchgears are designed



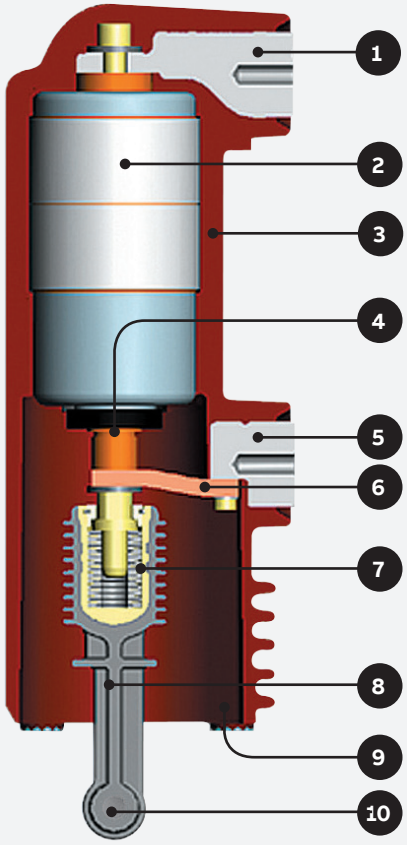
**Optimized logistics**

- Poles in thermoplastic material make the breaker lighter
  - Easily handled breakers and reduced transport charges

# Description

**These new VD4 circuit breakers exemplify ABB's proven vacuum interrupter engineering and manufacturing technology, as well as the superior design standards employed in the production of circuit breakers.**
**VD4 medium voltage circuit breakers use vacuum interrupters embedded in the poles. This construction technique makes the poles of the circuit breaker particularly sturdy and protects the interrupter from shocks, dust and condensation. The vacuum interrupter houses the contacts and forms the interruption chamber.**

**Vacuum current interruption**
The vacuum circuit breaker does not require an interrupting and insulating medium. Interrupters do not, in fact, contain ionizable material.
The electric arc that generates when the contacts separate is merely formed by melted and vaporized contact material.
Supported by the external energy, the electric arc persists until the current annuls near natural zero crossing. In that instant, the dielectric properties are very rapidly restored by the sharp reduction in the density of the conveyed load and rapid condensation of the metallic vapor.
Thus the vacuum interrupter recovers insulating capacity and the ability to withstand transient recovery voltage, thereby definitively extinguishing the arc.




1 Upper terminal
2 Vacuum interrupter
3 Enclosure/pole
4 Stem of moving contact
5 Lower terminal
6 Flexible connection
7 Tie-rod spring fork
8 Tie-rod
9 Pole fixing
10 Connection to operating mechanism

Vacuum interrupter embedded in the pole

- **Vacuum interruption technique**
- **Vacuum contacts protected against oxidation and contamination**
- **Vacuum interrupter embedded in the pole**
- **Interrupter protected against shocks, dust and condensation**
- **Operation under different climatic conditions**
- **Limited switching energy**
- **Stored energy operating mechanism with anti-pumping device supplied as standard**
- **Simple customizing with a complete range of accessories**
- **Fixed and withdrawable version**
- **Compact dimensions**
- **Sealed-for-life poles**
- **Sturdy and reliable**
- **Limited maintenance**
- **Circuit breaker racked in and out with door closed**
- **Incorrect and hazardous operations are prevented thanks to special locks in the operating mechanism and truck**
- **High environmental compatibility**

Since high dielectric strength can be reached in the vacuum, even with minimum distances, circuit breaking is also guaranteed when the contacts separate a few milliseconds before natural current zero crossing.
The special shape of the contacts, the material used, as well as the limited duration and low voltage of the arc, guarantee minimum contact wear and long life. In addition, the vacuum also prevents contact oxidation and contamination.

**Operating mechanism**
The low speed of the contacts, their reduced travel and exposed conductive part, limit the energy required for the operation and therefore guarantee extremely low wear on the system.
This means that the circuit breaker only requires very little maintenance.

VD4 circuit breakers have mechanical operating mechanisms with stored energy and free trip. These characteristics allow opening and closing operations to be performed independently of the operator. The operating mechanism is of a simple design, easy to use and can be customized with a wide range of accessories which are straightforward and rapidly installed. This simplicity enhances the reliability of the apparatus.

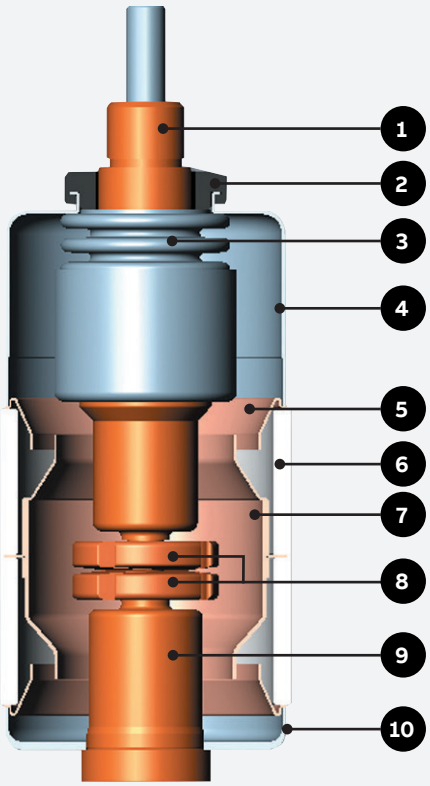
**The structure**
The operating mechanism and the poles are fixed to a metal frame which also acts as the support for the fixed version of the circuit breaker.
The compact structure is sturdy and ensures mechanical reliability.
Apart from the isolating contacts and the cord with plug for connecting the auxiliary circuits, the withdrawable version is complete with truck for racking it in and out of the switchgear or enclosure with the door closed.



# Description

## Interruption principle of ABB interrupters

In a vacuum interrupter, the electric arc begins the instant in which the contacts separate. It persists until zero current is reached and can be influenced by the magnetic field.




1. Stem/terminal
2. Twist protection
3. Metal bellows
4. Interrupter enclosure
5. Centring ring
6. Ceramic insulator
7. Shield
8. Contacts
9. Terminal
10. Interrupter enclosure

Vacuum interrupter

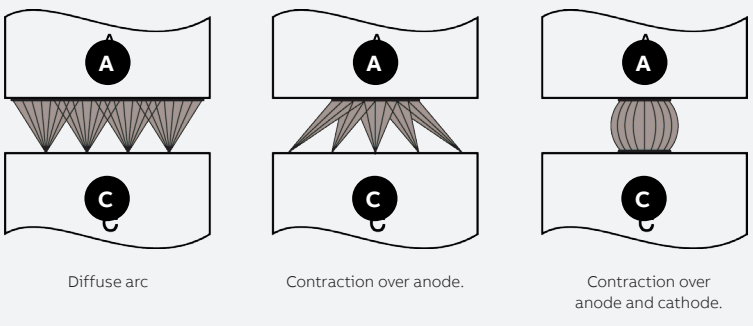



Diagram of transition from diffuse arc to contracted arc in a vacuum interrupter.

**Vacuum arc – diffuse or contracted**

Individual melting points form on the surface of the cathode after the contacts separate. This leads to the formation of metallic vapors which support the arc itself.

The diffuse vacuum arc is characterized by expansion over the contact surface itself and by evenly distributed thermal stress.

At the rated current of the vacuum interrupter, the electric arc is always of the diffuse type. Contact erosion is very limited and the number of current interruptions very high.

As the interrupted current value increases (beyond rated value), the electric arc tends to change from the diffuse to contracted type, owing to the Hall effect.

Starting out from the anode, the arc contracts and tends to concentrate as the current increases. There is a temperature rise on a level with the affected area and the contact is consequently subjected to thermal stress.

To prevent the contacts from overheating and becoming eroded, the arc is made to rotate. By turning, the arc becomes similar to a moving conductor through which current passes.

**The spiral shape of ABB vacuum interrupter contacts**

The special spiral shape of the contacts generates a radial magnetic field in all parts of the arc column, concentrated around the circumferences of the contacts.

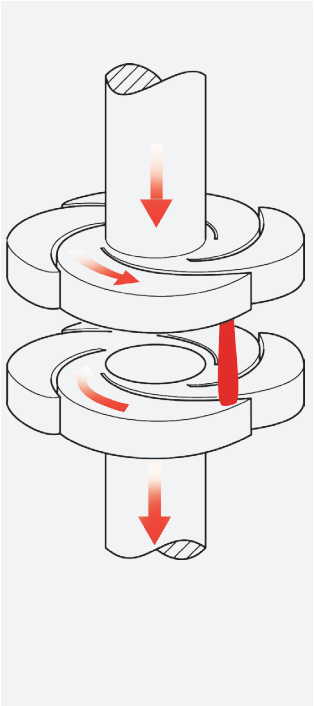
The electromagnetic force that self-generates, acts tangentially and causes the arc to spin rapidly around the axis of the contacts.

This forces the arc to turn and affect a larger area than that of a fixed contracted arc.

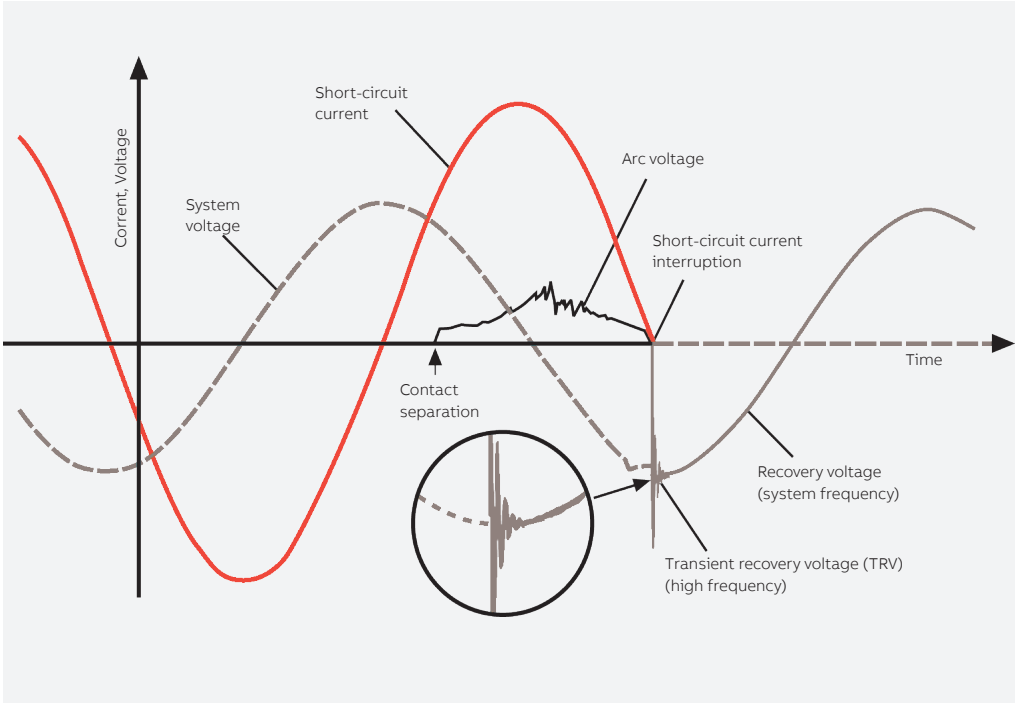
Besides minimizing the thermal stress to which the contacts are subjected, all this ensures that these latter are only eroded to a negligible extent and, above all, allows the interruption process to be controlled even with very high short-circuit current values.

ABB vacuum interrupters interrupt at natural current zero crossing, thereby preventing the arc from restriking after this has occurred.

Rapid reduction in current density at the same time as the zero current instant allow maximum dielectric strength to be re-established between the interrupter contacts within a few microseconds.



Geometry of radial magnetic field contact with a rotating vacuum arc.




Development of current and voltage trends during a single phase vacuum interruption process.

# Description

## Versions available

VD4 circuit breakers are available in the fixed and withdrawable versions with front operating mechanism.
The withdrawable version is available for UniGear ZS1, ZS2, ZS8.4 and UniSec switchgear and for PowerCube and Powerbloc enclosures.

## Fields of application

VD4 circuit breakers are used in power distribution systems for controlling and protecting cables, transformer and distribution substations, motors, transformers and capacitor banks.

## Standards

VD4 circuit breakers comply with IEC 62271-100 Standards and those of the major industrialized countries.
VD4 circuit breakers undergo the tests indicated below and guarantee the safety and reliability of apparatus in service in every installation.

- **Type tests:** temperature rise, tests to verify the insulation level (tests with rated lightning impulse withstand voltage and power frequency withstand voltage), peak and short-time withstand current tests, mechanical life, shortcircuit current making and breaking capacity.
- **Individual tests:** insulation of the main circuits with voltage at power frequency, auxiliary and operating circuit insulation, measurement of the main circuit resistance, mechanical and electrical operation.

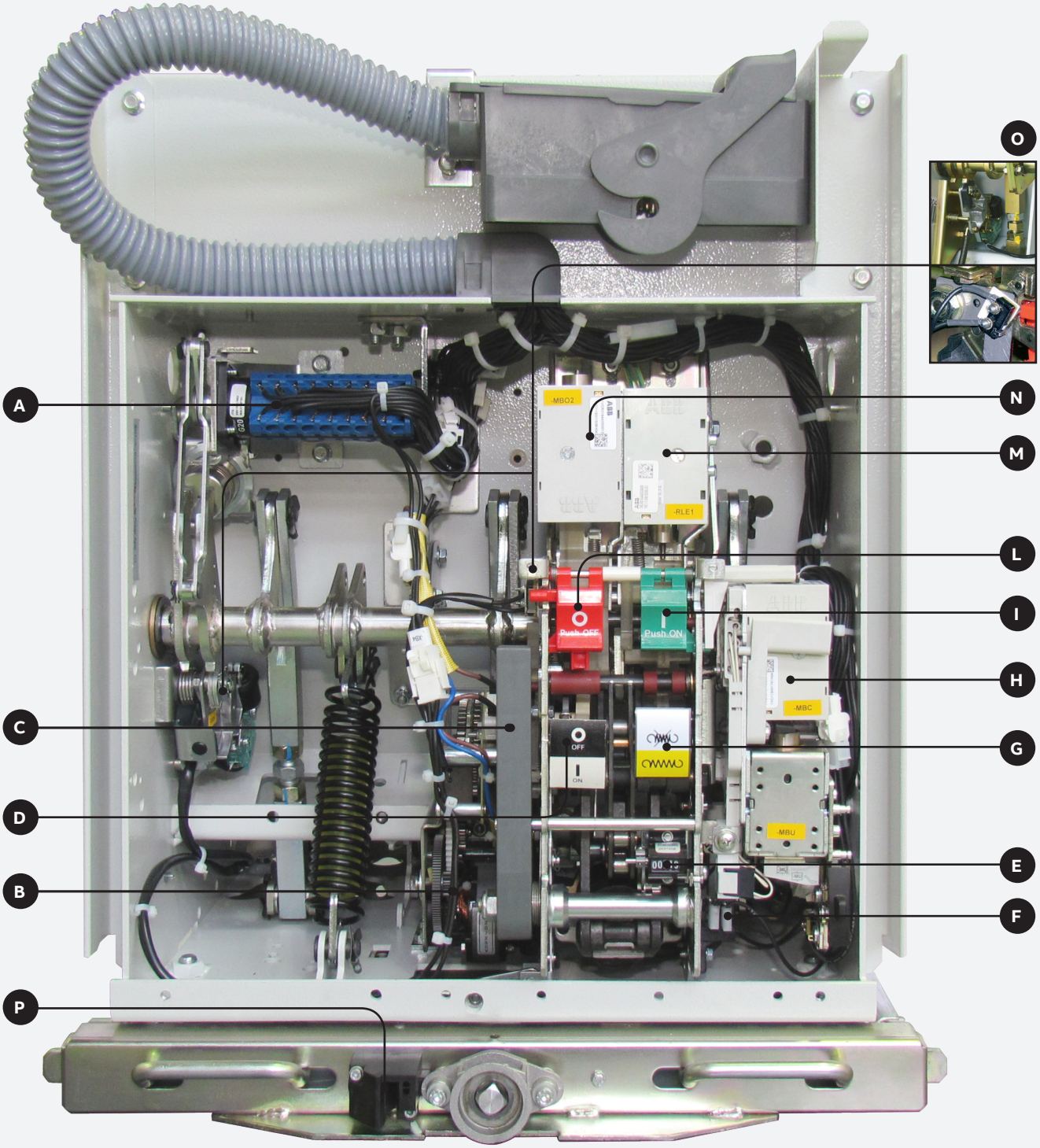
## Safe service

Thanks to the complete range of mechanical and electrical locks (available on request), VD4 circuit breakers can be used to create reliable distribution switchgear.
The locking devices are designed to prevent incorrect operations and allow the installations to be inspected in conditions of operator safety.
Key locks or padlocks enable the opening and closing and/or racking in and out operations.
The device for racking-out with the door closed only allows the circuit breaker to be racked in or out of the switchgear with the door closed.
Anti-racking-in locks prevent circuit breakers with different rated currents from being racked in, and racking-in and out operations with the circuit breaker closed.

- **Highly reliable operating mechanisms since they have very few components**
- **Extremely limited, simple maintenance**
- **Accessories common to the entire range**
- **Electrical accessories that can be easily and quickly installed or replaced thanks to wiring pre-engineered with plug-socket connectors**
- **Mechanical anti-pumping device supplied as standard equipment**
- **Built-in closing spring loading lever**
- **Circuit breaker open key lock**
- **Protective covering over the opening and closing pushbuttons that can only operated with a special tool**
- **Padlock  device on the operating pushbuttons**

## Accessories

VD4 circuit breakers have a complete range of accessories able to meet all installation requirements.
The operating mechanism has a standardized range of accessories and replacement parts which are easy to identify and order.
The accessories are installed conveniently from the front of the circuit breaker. Electrical connection is performed with plug-socket connectors.
Use, maintenance and operation of the apparatus are simple and require limited use of resources.




## Circuit breaker operating mechanism

A Open/closed auxiliary contacts
B Geared motor for loading closing spring
C Built-in closing spring loading lever
D Mechanical signaling device for circuit breaker open/closed
E Mechanical operation counter
F Contacts for signaling spring loaded/discharged
G Signaling device for closing springs loaded/discharged
H Service releases
I Closing pushbutton
L Opening pushbutton
M Operating mechanism locking electromagnet
N Additional shunt opening release
O Transient contact
P Lock that prevents racking-in when door is open

# Description

## VD4 evo
Evolution that Empowers



**Complete health status assessment for intelligent operation and maintenance**

**30%**

Reduction of unexpected outages

Reliability

**60%**

Operation and maintenance efficiency increase

Efficiency

**15%**

Footprint optimization and time savings

Productivity

**Improve your OpEx by cutting outages and maintenance cost with the future of medium voltage circuit breakers**

VD4 is now available with the new VD4 evo series of accessories and configuration coming from the ABB family of Digital components.

The primary components of the circuit breaker are the same assuring full interchangeably with previous version and keeping same reliability and performance, but enhancing Digital features.

Such new accessories can be equipped on the new units recognizable from the new cover design, that will be available on all the VD4 family very soon.

VD4 evo can be ordered with different configurations specific for your need: either fully equipped device option for Advanced Monitor & Diagnostic features or as a standard configuration, but with possibility of future upgrade. Check the accessories section of the catalogue for the full list and the rating table section for the available ratings.

**Digital transformation starts from breaker evolution**



**Available versions**

VD4 in VD4 evo version evo is available in either Standard or Digital configurations, depending on customer application needs.

The Digital version is available in 3 main packages:

- **Basic,** offers a basic yet comprehensive health and status management of the main circuit breaker components like the actuator and conductor integrity via thermal monitoring;
- **Advanced,** in addition to basic offering it is possible to get more comprehensive mechanical checks with travel curve monitoring, dynamic thermal monitoring and VI life check;
- **Flexible,** features can be selected individually depending on the application needs.

The Standard VD4 evo offers the possibility of upgrade to Digital version with the “Digital upgrade” kits, but does not provide monitoring and diagnostic features by default.

| Features | Digital | | | Standard |
|---|---|---|---|---|
| | VD4 evo Basic | VD4 evo Advanced | VD4 evo Flexible | VD4 evo |
| Warnings and alarms with suggestions from expert | • | • | • | Upgradable |
| Environmental temperature and humidity monitoring | • | • | • | |
| Basic mechanical kinematic chain anomalies detection | • | • | • | |
| Accessories monitoring and replacement suggestions | • | • | | |
| Loose connections detection and CB contacts monitoring | • | • | | |
| Predict CB mechanical failures | | • | • | |
| Advanced thermal checks & VI life | | • | • | |
| Advanced mechanical chain and travel curve monitor | | • | | |

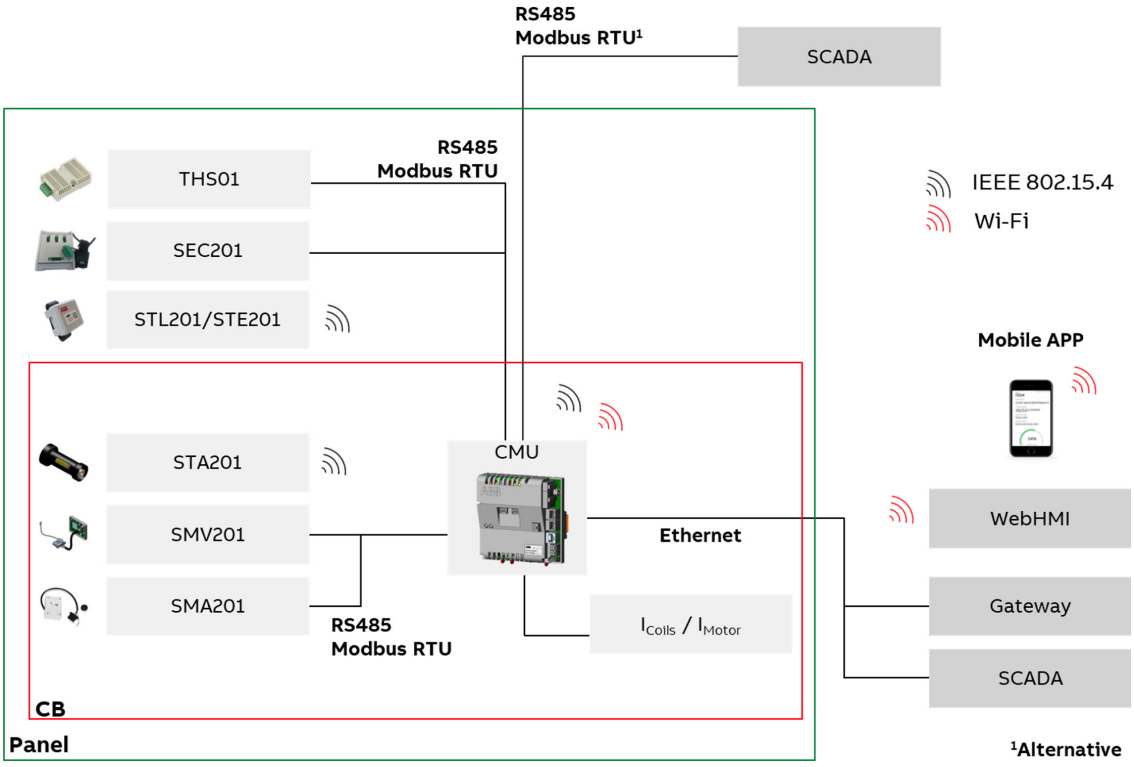
See the accessories section of the catalogue for more information on the available sensors and kits.

**Interfaces**

You have access to the circuit breaker information from the new dedicated WebHMI, that was designed to be intuitive and familiar as other ABB products. To access the Digital features, there are different connectivity options:

- Locally in site using the breaker hotspot Wi-Fi connection, with the option of using the Mobile APP RXplore for one-click connection via QR-CODE
- Via ethernet cable included in the breaker plug (if selected)
- Connecting the breaker to a SCADA system through Modbus TCP

For connections details and instruction see the dedicated Configuration Manual.




*SMV201 Vibration sensor coming soon

# Description

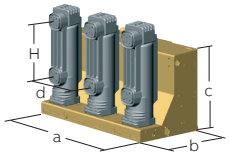
**General characteristics of the VD4 series**

The VD4 series of vacuum circuit breakers conform to the specifications of the following standards:

- IEC 62271-1
- IEC 62271-100




| **Rated voltage (1)** | **kV** | **12** | | | |
|---|---|---|---|---|---|
| Rated frequency | Hz | 50 - 60 | | | |
| Rated thermal current | A | 630 . . . 4000 (2) | | | |
| Short-time withstand current and breaking capacity | kA | 16 ... 31.5 | 40 | 50 | 63 |
| Making capacity | kA | 40 ... 80 | 100 | 125 (3) | 164 |
| Admissible short-time withstand current | s | 3 | 3 | 3 | 3 (8) |
| Fixed / withdrawable version | | •/• | •/• | •/• | •/• |
| Maximum overall dimensions (fixed version) | d (mm) | 150 - 275 | 150 - 210 - 275 - 275 | 210 - 275 | 275 |
| | H (mm) | 205 - 310 | 310 | 310 | 310 |
| | a (mm) | 450 - 700 | 450 - 570 - 700 | 600 - 750 | 750 |
| | b (mm) | 424 | 424 | 459 | 459 |
| | c (mm) | 461 - 599 | 599 (5) | 608 (7) | 677 |
| Weight | kg | 73 - 105 | 94 - 180 | 147 - 260 | 260 |
| Embedded poles | | • | • | • | - |
| Assembled poles | | - | - | - | • |



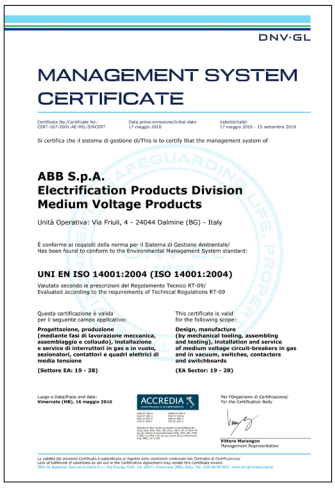

(1) Test voltage according to IEC 62271-1 Standards table 1a, VDE 0670, - part 1000, list 2
(2) With forced ventilation
(3) Higher values on request
(4) 360 mm for fixed version, 280 mm for withdrawable version
(5) Circuit breaker with heat sink 616 mm (2500 A)
(6) Withdrawable version
(7) Circuit breaker with heat sink 634 mm (3150 A)
(8) 1s for withdrawable version
(9) 40.5kV up to 2000A
(10) Withdrawable only up to 36kV

**Technical documentation**

Order the following publications for more details about the technical aspects and applications of VD4 circuit breakers:

- PowerCube modules code 1VCP000091
- Powerbloc modules code BA441/03E
- UniGear ZS1 switchgear code 1VCP000138
- ZS8.4 switchgear code L2288
- REF542*plus* unit code 1VTA100001
- UniSec cod. 1VFM200003


DNV·GL
MANAGEMENT SYSTEM CERTIFICATE
ABB S.p.A.
Electrification Products Division
Medium Voltage Products
UNI EN ISO 9001:2008 (ISO 9001:2008)


DNV·GL
MANAGEMENT SYSTEM CERTIFICATE
ABB S.p.A.
Electrification Products Division
Medium Voltage Products
UNI EN ISO 14001:2004 (ISO 14001:2004)


DNV·GL
MANAGEMENT SYSTEM CERTIFICATE
ABB S.p.A.
Electrification Products Division
Medium Voltage Products
BS OHSAS 18001:2007


ACCREDIA
CERTIFICATO DI ACCREDITAMENTO
Accreditation Certificate
ABB S.p.A. Power Products Division












| | | | | | |
|---|---|---|---|---|---|
| **17.5** | | | **24** | **36/40.5** | **36/40.5** |
| 50 - 60 | | | 50 - 60 | 50-60 | 50-60 |
| 630 . . . 4000 ([2]) | | | 630 . . . 3150 ([2]) | 630 ... 3150 ([9]) | 630 ... 3150 |
| 16 ... 31.5 | 40 ... 50 | 63 | 16 ... 31.5 | 16 ... 31.5 | 16 ... 40 |
| 40 ... 80 | 100 ... 125 | 164 | 40 ... 80 | 40 ... 80 | 40 ... 100 |
| 3 | 3 | 3 ([8]) | 3 | 3 | 3 |
| •/• | •/• | •/• | •/• | •/• ([10]) | •/• |
| 150 - 275 | 150 - 210 - 275 | 275 | 210 - 275 | 275 | 280 - 360 ([4]) |
| 205 - 310 | 310 | 310 | 310 | 328 | 328 |
| 450 - 700 | 450 - 570 - 700 | 750 | 570 - 700 | 786 / 853 ([6]) | 895 ([6]) - 1000 |
| 424 | 424 | 459 | 424 | 492 / 789 ([6]) | 555 - 686 ([6]) |
| 461 - 599 ([5]) | 599 ([5]) ([7]) | 677 | 631 - 661 | 876 / 973 ([6]) | 1575 |
| 73 - 105 | 94 - 180 | 260 | 100 - 110 | 170 / 210 | 290 - 350 |
| • | • | - | • | • | • |
| - | - | • | - | • | • |

**Quality System**
Complies with EN ISO 9001 Standards, certified by an independent organisation.

**Environmental Management System**
Complies with EN ISO 14001 Standards, certified by an independent organisation.

**Test Laboratory**
Complies with EN ISO/IEC 17025 Standards, accredited by an independent organisation.

**Health and Safety Management System**
Complies with OHSAS 18001 Standards, certified by an independent organisation.


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**High-Voltage Switchgear and Controlgear,**
**Current and Voltage Transformers,**
**Power Transformers and Busbar Systems**

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**PEHLA Testing Laboratories Ratingen**
**Oberhausener Str. 33**
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**Strom- und Spannungswandler, Transformatoren und**
**Sammelschienensysteme**

nach den in der Anlage aufgeführten Normen und Spezifikationen auszuführen.
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Leiter der Akkreditierungsstelle

Akkreditierungsstelle in der TGA – Trägergemeinschaft für Akkreditierung GmbH

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**Niederspannungs-Schaltgerätekombinationen,**
**Strom- und Spannungswandler, Transformatoren und**
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Leiter der Akkreditierungsstelle

Akkreditierungsstelle in der TGA – Trägergemeinschaft für Akkreditierung GmbH

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**Calor Emag Medium Voltage Products**
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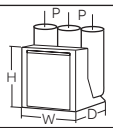
Member in EA, ILAC, IAF

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# Selection and ordering
## Fixed circuit breakers

### VD4 fixed circuit breaker (12 kV) ([3])




| **Circuit breaker** | | **VD4 12** | | | | |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | |
| Rated voltage | Ur [kV] | 12 ([2]) | | | | |
| Rated insulation voltage | Us [kV] | 12 | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | | | |
| Impulse withstand voltage | Up [kV] | 75 | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | |
| Rated thermal current (40 °C) | Ir [A] | 630 | 630 | 630 | 1250 | 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| | | – | – | – | – | – |
| | | – | – | – | – | – |
| | | – | – | – | – | – |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| | | – | – | – | – | – |
| | | – | – | – | – | – |
| | | – | – | – | – | – |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 |
| | | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 |
| | | 80 | 80 | 80 | 80 | 80 |
| | | – | – | – | – | – |
| | | – | – | – | – | – |
| | | – | – | – | – | – |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | – | – |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 |
| Maximum overall dimensions   | H [mm] | 461 | 461 | 461 | 461 | 461 |
| | W [mm] | 450 | 570 | 700 | 450 | 570 |
| | D [mm] | 424 | 424 | 424 | 424 | 424 |
| | Pole center distance P [mm] | 150 | 210 | 275 | 150 | 210 |
| Weight | [kg] | 73 | 75 | 79 | 73 | 75 |
| Standardized dimensions table | TN | 7405 ([1]) | 7406 ([1]) | – | 7405 ([1]) | 7406 ([1]) |
| | 1VCD | – | – | 000051 ([1]) | – | – |
| | 2RDA | – | – | – | – | – |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |
| VD4 evo ([4]) | | | | | | |

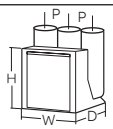
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **VD4 12** | | | | | | | |
| • | | | | | | | |
| 12 (2) | | | | | | | |
| 12 | | | | | | | |
| 28 | | | | | | | |
| 75 | | | | | | | |
| 50-60 | | | | | | | |
| 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 |
| 16 | – | – | – | – | – | – | – |
| 20 | – | – | – | – | – | – | – |
| 25 | – | – | – | – | – | – | – |
| 31.5 | – | – | – | – | – | – | – |
| – | 40 | 40 | 40 | 40 | – | – | – |
| – | – | – | – | – | 50 | 50 | – |
| – | – | – | – | – | – | – | 63 |
| 16 | – | – | – | – | – | – | – |
| 20 | – | – | – | – | – | – | – |
| 25 | – | – | – | – | – | – | – |
| 31.5 | – | – | – | – | – | – | – |
| – | 40 | 40 | 40 | 40 | – | – | – |
| – | – | – | – | – | 50 | 50 | – |
| – | – | – | – | – | – | – | 63 |
| 40 | – | – | – | – | – | – | – |
| 50 | – | – | – | – | – | – | – |
| 63 | – | – | – | – | – | – | – |
| 80 | – | – | – | – | – | – | – |
| – | 104 | 100 | 100 | 100 | – | – | – |
| – | – | – | – | – | 125 | 125 | – |
| – | – | – | – | – | – | – | 164 |
| • | • | • | • | • | • | • | – |
| – | – | – | – | – | – | – | • |
| 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 28...40 |
| 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10...15 |
| 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 38...55 |
| 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | ≤55 |
| 461 | 589 | 589 | 589 | 589 | 610 | 610 | 615 |
| 700 | 450 | 570 | 570 | 700 | 600 | 750 | 750 |
| 424 | 424 | 424 | 424 | 424 | 459 | 459 | 459 |
| 275 | 150 | 210 | 210 | 275 | 210 | 275 | 275 |
| 79 | 81 | 84 | 84 | 84 | 146 | 158 | 265 |
| – | – | – | – | – | – | – | – |
| 000051 (1) | – | 003282 (1) | 003282 (1) | 003285 (1) | 003440 | 003441 | 003945 |
| – | 043108A0001 | – | – | – | – | – | – |
| - 5 ... + 40 | | | | | | | |
| • | | | | | | | |
| • | | | | | | | |
| | • | | | | | | |

(1) Poles in polyamide
(2) Available at 10kV according to GOST R 52565 standard with Ud=42kV
(3) On request, the closing spring can be loaded by means of a removable crank handle outside operating mechanism (instead of linear loading by a lever built into the front of operating mechanism)
(4) Refer to chapter "Description" for more details

# Selection and ordering
## Fixed circuit breakers

### VD4 fixed circuit breaker (12 kV) ([3])




| **Circuit breaker** | | **VD4 12** | | | | |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | |
| Rated voltage | Ur [kV] | 12 ([2]) | | | | |
| Rated insulation voltage | Us [kV] | 12 | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | | | |
| Impulse withstand voltage | Up [kV] | 75 | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | |
| Rated thermal current (40 °C) | Ir [A] | 1600 | 1600 | 1600 | 1600 | 1600 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | – | – | – | – | – |
| | | 20 | 20 | 20 | – | – |
| | | 25 | 25 | 25 | – | – |
| | | 31.5 | 31.5 | 31.5 | – | – |
| | | – | – | – | 40 | 40 |
| | | – | – | – | – | – |
| | | – | – | – | – | – |
| Admissible rated short-time withstand current (3s) | Ik [kA] | – | – | – | – | – |
| | | 20 | 20 | 20 | – | – |
| | | 25 | 25 | 25 | – | – |
| | | 31.5 | 31.5 | 31.5 | – | – |
| | | – | – | – | 40 | 40 |
| | | – | – | – | – | – |
| | | – | – | – | – | – |
| Making capacity | Ip [kA] | – | – | – | – | – |
| | | 50 | 50 | 50 | – | – |
| | | 63 | 63 | 63 | – | – |
| | | 80 | 80 | 80 | – | – |
| | | – | – | – | 100 | 100 |
| | | – | – | – | – | – |
| | | – | – | – | – | – |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | – | – |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 |
| Maximum overall dimensions   | H [mm] | 599 | 599 | 599 | 589 | 589 |
| | W [mm] | 450 | 570 | 700 | 570 | 700 |
| | D [mm] | 424 | 424 | 424 | 424 | 424 |
| | Pole center distance P [mm] | 150 | 210 | 275 | 210 | 275 |
| Weight | [kg] | 93 | 98 | 105 | 84 | 84 |
| Standardized dimensions table | TN | – | 7407 ([1]) | 7408 ([1]) | – | – |
| | 1VCD | 000050 | – | – | 003282([1]) | 003285([1]) |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

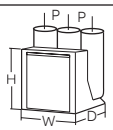
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **VD4 12** | | | | | | | |
| • | | | | | | | |
| 12 (2) | | | | | | | |
| 12 | | | | | | | |
| 28 | | | | | | | |
| 75 | | | | | | | |
| 50-60 | | | | | | | |
| 1600 | 1600 | 1600 | 2000 | 2000 | 2000 | 2000 | 2000 |
| – | – | – | – | – | – | – | – |
| – | – | – | 20 | 20 | – | – | – |
| – | – | – | 25 | 25 | – | – | – |
| – | – | – | 31.5 | 31.5 | – | – | – |
| – | – | – | 40 | 40 | – | – | – |
| 50 | 50 | – | – | – | 50 | 50 | – |
| – | – | 63 | – | – | – | – | 63 |
| – | – | – | – | – | – | – | – |
| – | – | – | 20 | 20 | – | – | – |
| – | – | – | 25 | 25 | – | – | – |
| – | – | – | 31.5 | 31.5 | – | – | – |
| – | – | – | 40 | 40 | – | – | – |
| 50 | 50 | – | – | – | 50 | 50 | – |
| – | – | 63 | – | – | – | – | 63 |
| – | – | – | – | – | – | – | – |
| – | – | – | 50 | 50 | – | – | – |
| – | – | – | 63 | 63 | – | – | – |
| – | – | – | 80 | 80 | – | – | – |
| – | – | – | 100 | 100 | – | – | – |
| 125 | 125 | – | – | – | 125 | 125 | – |
| – | – | 164 | – | – | – | – | 164 |
| • | • | – | • | • | • | • | – |
| – | – | • | – | – | – | – | • |
| 33 ... 60 | 33...60 | 28...40 | 33...60 | 33...60 | 33...60 | 33...60 | 28...40 |
| 10 ... 15 | 10...15 | 10...15 | 10...15 | 10...15 | 10...15 | 10...15 | 10...15 |
| 43 ... 75 | 43...75 | 38...55 | 43...75 | 43...75 | 43...75 | 43...75 | 38...55 |
| 30 ... 60 | 30...60 | ≤55 | 30...60 | 30...60 | 30...60 | 30...60 | ≤55 |
| 610 | 610 | 677.5 | 599 | 599 | 610 | 610 | 615 |
| 600 | 750 | 750 | 570 | 700 | 600 | 750 | 750 |
| 459 | 459 | 459 | 424 | 424 | 459 | 459 | 459 |
| 210 | 275 | 265 | 210 | 275 | 210 | 275 | 275 |
| 146 | 158 | 265 | 98 | 105 | 146 | 158 | 265 |
| – | – | – | 7407 (1) | 7408 (1) | – | – | – |
| 003440 | 003441 | 003945 | – | – | 003440 | 003441 | 003945 |
| | - 5 ... + 40 | | | | | | |
| | • | | | | | | |
| | • | | | | | | |

(1) Poles in polyamide
(2) Available at 10kV according to GOST R 52565 standard with Ud=42kV
(3) On request, the closing spring can be loaded by means of a removable crank handle outside operating mechanism (instead of linear loading by a lever built into the front of operating mechanism)

# Selection and ordering
## Fixed circuit breakers

### VD4 fixed circuit breaker (12 kV) ([3])




| **Circuit breaker** | | **VD4 12** | | | |
|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | |
| Rated voltage | Ur [kV] | 12 ([2]) | | | |
| Rated insulation voltage | Us [kV] | 12 | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | | |
| Impulse withstand voltage | Up [kV] | 75 | | | |
| Rated frequency | fr [Hz] | 50-60 | | | |
| Rated thermal current (40 °C) | Ir [A] | 2500 | 2500 | 2500 | 2500 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | – | – | – | – |
| | | 20 | 20 | – | – |
| | | 25 | 25 | – | – |
| | | 31.5 | 31.5 | – | – |
| | | 40 | 40 | – | – |
| | | – | – | 50 | – |
| | | – | – | – | 63 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | – | – | – | – |
| | | 20 | 20 | – | – |
| | | 25 | 25 | – | – |
| | | 31.5 | 31.5 | – | – |
| | | 40 | 40 | – | – |
| | | – | – | 50 | – |
| | | – | – | – | 63 |
| Making capacity | Ip [kA] | – | – | – | – |
| | | 50 | 50 | – | – |
| | | 63 | 63 | – | – |
| | | 80 | 80 | – | – |
| | | 100 | 100 | – | – |
| | | – | – | 125 | – |
| | | – | – | – | 164 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | – |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | • |
| Opening time | [ms] | 33...60 | 33...60 | 33...60 | 28...40 |
| Arcing time | [ms] | 10...15 | 10...15 | 10...15 | 10...15 |
| Total breaking time | [ms] | 43...75 | 43...75 | 43...75 | 38...55 |
| Closing time | [ms] | 30...60 | 30...60 | 30...60 | ≤55 |
| Maximum overall dimensions   | H [mm] | 599 | 599 | 610 | 615 |
| | W [mm] | 570 | 700 | 750 | 750 |
| | D [mm] | 424 | 424 | 459 | 459 |
| | Pole center distance P [mm] | 210 | 275 | 275 | 275 |
| Weight | [kg] | 98 | 105 | 163 | 265 |
| Standardized dimensions table | TN | 7407 ([1]) | 7408 ([1]) | – | – |
| | 1VCD | – | – | 003441 | 003945 |
| Operating temperature | [°C] | - 5 ... + 40 | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | |

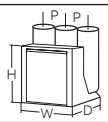
| | | |
|---|---|---|
| **VD4 12** | | |
| • | | |
| 12 (2) | | |
| 12 | | |
| 28 | | |
| 75 | | |
| 50-60 | | |
| 3150 (4) | 3150 (4) | 3150 (4) |
| – | – | – |
| 20 | – | – |
| 25 | – | – |
| 31.5 | – | – |
| 40 | – | – |
| – | 50 | – |
| – | – | 63 |
| – | – | – |
| 20 | – | – |
| 25 | – | – |
| 31.5 | – | – |
| 40 | – | – |
| – | 50 | – |
| – | – | 63 |
| – | – | – |
| 50 | – | – |
| 63 | – | – |
| 80 | – | – |
| 100 | – | – |
| – | 125 | – |
| – | – | 164 |
| • | • | – |
| – | – | • |
| 33...60 | 33...60 | 28...40 |
| 10...15 | 10...15 | 10...15 |
| 43...75 | 43...75 | 38...55 |
| 30...60 | 30...60 | ≤55 |
| 635 | 636 | 637 |
| 700 | 750 | 750 |
| 424 | 459 | 459 |
| 275 | 275 | 275 |
| 140 | 177 | 265 |
| – | – | – |
| 000149 (1) | 003443 | 003945 |
| - 5 ... + 40 | | |
| • | | |
| • | | |

(1) Poles in polyamide
(2) Available at 10kV according to GOST R 52565 standard with Ud=42kV
(3) On request, the closing spring can be loaded by means of a removable crank handle outside operating mechanism (instead of linear loading by a lever built into the front of operating mechanism)
(4) Up to 4000 A with forced ventilation (*)

# Selection and ordering
## Fixed circuit breakers

### VD4 fixed circuit breaker (17.5 kV) (2)




| Circuit breaker | | VD4 17 | | | | | |
|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | |
| Rated voltage | Ur [kV] | 17.5 | | | | | |
| Rated insulation voltage | Us [kV] | 17.5 | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 38 | | | | | |
| Impulse withstand voltage | Up [kV] | 95 | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | |
| Rated thermal current (40 °C) | Ir [A] | 630 | 630 | 630 | 1250 | 1250 | 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| | | – | – | – | – | – | – |
| | | – | – | – | – | – | – |
| | | – | – | – | – | – | – |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| | | – | – | – | – | – | – |
| | | – | – | – | – | – | – |
| | | – | – | – | – | – | – |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 | 40 |
| | | 50 | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 | 63 |
| | | 80 | 80 | 80 | 80 | 80 | 80 |
| | | – | – | – | – | – | – |
| | | – | – | – | – | – | – |
| | | – | – | – | – | – | – |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | – | – | – |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 |
| Maximum overall dimensions   | H [mm] | 461 | 461 | 461 | 461 | 461 | 461 |
| | W [mm] | 450 | 570 | 700 | 450 | 570 | 700 |
| | D [mm] | 424 | 424 | 424 | 424 | 424 | 424 |
| | Pole center distance P [mm] | 150 | 210 | 275 | 150 | 210 | 275 |
| Weight | [kg] | 73 | 75 | 79 | 73 | 75 | 79 |
| Standardized dimensions table | TN | 7405 (1) | 7406 (1) | – | 7405 (1) | 7406 (1) | – |
| | 1VCD | – | – | 000051 (1) | – | – | 000051 (1) |
| | 2RDA | – | – | – | – | – | – |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | |
| VD4 evo (2) | | | | | | | |

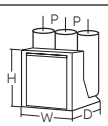
(1) Poles in polyamide
(2) Refer to chapter “Description” for more details

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VD4 17** | | | | | | | | | | | | |
| • | | | | | | | | | | | | |
| 17.5 | | | | | | | | | | | | |
| 17.5 | | | | | | | | | | | | |
| 38 | | | | | | | | | | | | |
| 95 | | | | | | | | | | | | |
| 50-60 | | | | | | | | | | | | |
| 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 |
| – | – | – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | 20 | 20 | – | – | – | – | – |
| – | – | – | – | – | – | 25 | 25 | – | – | – | – | – |
| – | – | – | – | – | – | 31.5 | 31.5 | – | – | – | – | – |
| 40 | 40 | 40 | – | – | – | – | – | 40 | 40 | – | – | – |
| – | – | – | 50 | 50 | – | – | – | – | – | 50 | 50 | – |
| – | – | – | – | – | 63 | – | – | – | – | – | – | 63 |
| – | – | – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | 20 | 20 | – | – | – | – | – |
| – | – | – | – | – | – | 25 | 25 | – | – | – | – | – |
| – | – | – | – | – | – | 31.5 | 31.5 | – | – | – | – | – |
| 40 | 40 | 40 | – | – | – | – | – | 40 | 40 | – | – | – |
| – | – | – | 50 | 50 | – | – | – | – | – | 50 | 50 | – |
| – | – | – | – | – | – | – | – | – | – | – | | 63 |
| – | – | – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | 50 | 50 | – | – | – | – | – |
| – | – | – | – | – | – | 63 | 63 | – | – | – | – | – |
| – | – | – | – | – | – | 80 | 80 | – | – | – | – | – |
| 104 | 100 | 100 | – | – | – | – | – | 100 | 100 | – | – | – |
| – | – | – | 125 | 125 | – | – | – | – | – | 125 | 125 | – |
| – | – | – | – | – | 164 | – | – | – | – | – | – | 164 |
| • | • | • | • | • | – | • | • | • | • | • | • | – |
| – | – | – | – | – | • | – | – | – | – | – | – | • |
| 33 … 60 | 33 … 60 | 33 … 60 | 33 … 60 | 33 … 60 | 28 … 60 | 33 … 60 | 33 … 60 | 33 … 60 | 33 … 60 | 33 … 60 | 33 … 60 | 28 … 40 |
| 10 … 15 | 10 … 15 | 10 … 15 | 10 … 15 | 10 … 15 | 10 … 15 | 10 … 15 | 10 … 15 | 10 … 15 | 10 … 15 | 10 … 15 | 10 … 15 | 10 … 15 |
| 43 … 75 | 43 … 75 | 43 … 75 | 43 … 75 | 43 … 75 | 38 … 55 | 43 … 75 | 43 … 75 | 43 … 75 | 43 … 75 | 43 … 75 | 43 … 75 | 38 … 55 |
| 30 … 60 | 30 … 60 | 30 … 60 | 30 … 60 | 30 … 60 | ≤55 | 30 … 60 | 30 … 60 | 30 … 60 | 30 … 60 | 30 … 60 | 30 … 60 | ≤55 |
| 589 | 589 | 589 | 610 | 610 | 677.5 | 599 | 599 | 589 | 589 | 610 | 610 | 615 |
| 450 | 570 | 700 | 600 | 750 | 750 | 570 | 700 | 570 | 700 | 600 | 750 | 750 |
| 424 | 424 | 424 | 459 | 459 | 459 | 424 | 424 | 424 | 424 | 459 | 459 | 459 |
| 150 | 210 | 275 | 210 | 275 | 275 | 210 | 275 | 210 | 275 | 210 | 275 | 265 |
| 81 | 84 | 84 | 146 | 158 | 265 | 98 | 105 | 84 | 84 | 146 | 158 | 265 |
| – | – | – | – | – | – | 7407 (1) | 7408 (1) | – | – | – | – | – |
| – | 003282 (1) | 003285 (1) | 003440 | 003441 | 003945 | – | – | 003282 (1) | 003285 (1) | 003440 | 003441 | 003945 |
| 043108A0001 | – | – | – | – | – | – | – | – | – | – | – | – |
| | - 5 … + 40 | | | | | | | | | | | |
| | • | | | | | | | | | | | |
| | • | | | | | | | | | | | |
| • | | | | | | | | | | | | |

# Selection and ordering
## Fixed circuit breakers

### VD4 fixed circuit breaker (17.5 kV) (2)




| Circuit breaker | | VD4 17 | | | | |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | |
| Rated voltage | Ur [kV] | 17.5 | | | | |
| Rated insulation voltage | Us [kV] | 17.5 | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 38 | | | | |
| Impulse withstand voltage | Up [kV] | 95 | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | |
| Rated thermal current (40 °C) | Ir [A] | 2000 | 2000 | 2000 | 2000 | 2000 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | – | – | – | – | – |
| | | 20 | 20 | – | – | – |
| | | 25 | 25 | – | – | – |
| | | 31.5 | 31.5 | – | – | – |
| | | 40 | 40 | – | – | – |
| | | – | – | 50 | 50 | – |
| | | – | – | – | – | 63 |
| Rated short-time withstand current (3s) | Ik [kA] | – | – | – | – | – |
| | | 20 | 20 | – | – | – |
| | | 25 | 25 | – | – | – |
| | | 31.5 | 31.5 | – | – | – |
| | | 40 | 40 | – | – | – |
| | | – | – | 50 | 50 | – |
| | | – | – | – | – | 63 |
| Making capacity | Ip [kA] | – | – | – | – | – |
| | | 50 | 50 | – | – | – |
| | | 63 | 63 | – | – | – |
| | | 80 | 80 | – | – | – |
| | | 100 | 100 | – | – | – |
| | | – | – | 125 | 125 | – |
| | | – | – | – | – | 164 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | – |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | – | • |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 28 ... 40 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 38 ... 55 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | ≤55 |
| Maximum overall dimensions   | H [mm] | 599 | 599 | 610 | 610 | 615 |
| | W [mm] | 570 | 700 | 600 | 750 | 750 |
| | D [mm] | 424 | 424 | 459 | 459 | 459 |
| | Pole center distance P [mm] | 210 | 275 | 210 | 275 | 275 |
| Weight | [kg] | 98 | 105 | 146 | 158 | 265 |
| Standardized dimensions table | TN | 7407 (1) | 7408 (1) | – | – | – |
| | 1VCD | – | – | 003440 | 003441 | 003945 |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

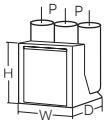
| | | | | | |
|---|---|---|---|---|---|
| **VD4 17** | | | | | |
| • | | | | | |
| 17.5 | | | | | |
| 17.5 | | | | | |
| 38 | | | | | |
| 95 | | | | | |
| 50-60 | | | | | |
| 2500 | 2500 | 2500 | 3150 (3) | 3150 (3) | 3150 (3) |
| – | – | – | – | – | – |
| 20 | – | – | 20 | – | – |
| 25 | – | – | 25 | – | – |
| 31.5 | – | – | 31.5 | – | – |
| 40 | – | – | 40 | – | – |
| – | 50 | – | – | 50 | – |
| – | – | 63 | – | – | 63 |
| – | – | – | – | – | – |
| 20 | – | – | 20 | – | – |
| 25 | – | – | 25 | – | – |
| 31.5 | – | – | 31.5 | – | – |
| 40 | – | – | 40 | – | – |
| – | 50 | – | – | 50 | – |
| – | – | 63 | – | – | 63 |
| – | – | – | – | – | – |
| 50 | – | – | 50 | – | – |
| 63 | – | – | 63 | – | – |
| 80 | – | – | 80 | – | – |
| 100 | – | – | 100 | – | – |
| – | 125 | – | – | 125 | – |
| – | – | 164 | – | – | 164 |
| • | • | – | • | • | – |
| – | – | • | – | – | • |
| 33 ... 60 | 33 ... 60 | 28 ... 40 | 33 ... 60 | 33 ... 60 | 28 ... 40 |
| 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| 43 ... 75 | 43 ... 75 | 38 ... 55 | 43 ... 75 | 43 ... 75 | 38 ... 55 |
| 30 ... 60 | 30 ... 60 | ≤55 | 30 ... 60 | 30 ... 60 | ≤55 |
| 599 | 610 | 677.5 | 635 | 636 | 637 |
| 700 | 750 | 750 | 700 | 750 | 750 |
| 424 | 459 | 459 | 424 | 459 | 459 |
| 275 | 275 | 275 | 275 | 275 | 275 |
| 105 | 163 | 265 | 140 | 177 | 265 |
| 7408 (1) | – | – | – | – | – |
| – | 003441 | 003945 | 000149 (1) | 003443 | 003945 |
| - 5 ... + 40 | | | | | |
| • | | | | | |
| • | | | | | |

(1) Poles in polyamide
(2) On request, the closing spring can be loaded by means of a removable crank handle outside operating mechanism (instead of linear loading by a lever built into the front of operating mechanism)
(3) Up to 4000 A with forced ventilation

# Selection and ordering
## Fixed circuit breakers

### VD4 fixed circuit breaker (24 kV) (2)

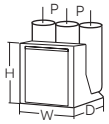



| Circuit breaker | | VD4 24 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | | |
| Rated voltage | Ur [kV] | 24 | | | | | | |
| Rated insulation voltage | Us [kV] | 24 | | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 50 | | | | | | |
| Impulse withstand voltage | Up [kV] | 125 | | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | | |
| Rated thermal current (40 °C) | Ir [A] | 630 | 630 | 1250 | 1250 | 1600 | 2000 | 2500 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| | | – | – | 31.5 | – | 31.5 | 31.5 | 31.5 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| | | – | – | 31.5 | – | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 | 40 | – |
| | | 50 | 50 | 50 | 50 | 50 | 50 | – |
| | | 63 | 63 | 63 | 63 | 63 | 63 | 63 |
| | | – | – | 80 | – | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 |
| Maximum overall dimensions   | H [mm] | 631 | 631 | 631 | 631 | 642 | 642 | 642 |
| | W [mm] | 570 | 700 | 570 | 700 | 700 | 700 | 700 |
| | D [mm] | 424 | 424 | 424 | 424 | 424 | 424 | 424 |
| | Pole center distance P [mm] | 210 | 275 | 210 | 275 | 275 | 275 | 275 |
| Weight | [kg] | 100 | 104 | 100/106 (1) | 104 | 110 | 110 | 110 |
| Standardized table of dimensions | TN | 7409 | 7410 | 7409 | 7410 | 7411 | 7411 | 7411 |
| | 1VCD | – | – | 000172 (1) | – | – | – | – |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | | |

(1) 31.5 kA version
(2) On request, the closing spring can be loaded by means of a removable crank handle outside operating mechanism (instead of linear loading by a lever built into the front of operating mechanism)

# VD4 fixed circuit breaker (36 kV)

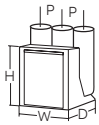



| Circuit breaker | | VD4 36 | | | |
|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | |
| Rated voltage | Ur [kV] | 36 | | | |
| Rated insulation voltage | Us [kV] | 36 | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 70 | | | |
| Impulse withstand voltage | Up [kV] | 170 | | | |
| Rated frequency | fr [Hz] | 50 | | | |
| Rated thermal current (40 °C) | Ir [A] | 1250 | 1600 | 2000 | 2500 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 |
| | | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | | | |
| Opening time | [ms] | 35 ... 60 | 35 ... 60 | 35 ... 60 | 35 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 45 ... 75 | 45 ... 75 | 45 ... 75 | 45 ... 75 |
| Closing time | [ms] | 50 ... 65 | 50 ... 65 | 50 ... 65 | 50 ... 65 |
| Maximum overall dimensions   | H [mm] | 884 | 884 | 884 | 884 |
| | W [mm] | 796 | 796 | 796 | 796 |
| | D [mm] | 501 | 501 | 501 | 501 |
| | Pole center distance P [mm] | 275 | 275 | 275 | 275 |
| Weight | [kg] | 170 | 170 | 170 | 210 |
| Standardized dimensions table | TN | 2RDA040578 | 2RDA040578 | 2RDA040578 | 2RDA040578 |
| Operating temperature | [°C] | - 5 ... + 40 | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | |

# Selection and ordering
## Fixed circuit breakers

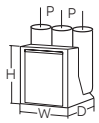
### VD4 fixed circuit breaker (40.5 kV)



| **Circuit breaker** | | **VD4 40** | | |
|---|---|---|---|---|
| Standards | IEC 62271-100 & GOST 52565 R2006 | • | | |
| Rated voltage | Ur [kV] | 40.5 | | |
| Rated insulation voltage | Us [kV] | 40.5 | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 95 | | |
| Impulse withstand voltage | Up [kV] | 190 | | |
| Rated frequency | fr [Hz] | 50 | | |
| Rated thermal current (40 °C) | Ir [A] | 1250 | 1600 | 2000 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 20 | 20 | 20 |
| | | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 20 | 20 | 20 |
| | | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 50 | 50 | 50 |
| | | 63 | 63 | 63 |
| | | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 3 min - CO] | • | | |
| Opening time | [ms] | 35 ... 60 | | |
| Arcing time | [ms] | 10 ... 15 | | |
| Total breaking time | [ms] | 45 ... 75 | | |
| Closing time | [ms] | 50 ... 65 | | |
| Maximum overall dimensions   | H [mm] | 884 | | |
| | W [mm] | 796 | | |
| | D [mm] | 501 | | |
| | Pole center distance P [mm] | 275 | | |
| Weight | [kg] | 170 | | |
| Standardized dimensions table | TN | 2RDA043326A0001 | | |
| Operating temperature | [°C] | - 20 ... + 40 | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | |

# VD4 fixed circuit breaker in floor rolling version (36 kV)

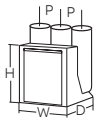


| Circuit breaker | | VD4 36 | | | | |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | |
| Rated voltage | Ur [kV] | 36 | | | | |
| Rated insulation voltage | Us [kV] | 36 | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 95 | | | | |
| Impulse withstand voltage | Up [kV] | 185 | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | |
| Rated thermal current (40 °C) | Ir [A] | 630 | 1250 | 1600 | 2000 | 2500 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | – | – | – |
| | | 20 | 25 | – | – | – |
| | | – | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 |
| | | – | 40 | 40 | 40 | 40 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | – | – | – |
| | | 20 | 25 | – | – | – |
| | | – | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 |
| | | – | 40 | 40 | 40 | 40 |
| Making capacity | Ip [kA] | 40 | 40 | – | – | – |
| | | 50 | 50 | – | – | – |
| | | – | 63 | 63 | 63 | 63 |
| | | – | 80 | 80 | 80 | 80 |
| | | – | 100 | 100 | 100 | 100 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| Opening time | [ms] | ≤45 | ≤45 | ≤45 | ≤45 | ≤45 |
| Arcing time | [ms] | ≤15 | ≤15 | ≤15 | ≤15 | ≤15 |
| Total breaking time | [ms] | ≤60 | ≤60 | ≤60 | ≤60 | ≤60 |
| Closing time | [ms] | approx. 60 | approx. 60 | approx. 60 | approx. 60 | approx. 60 |
| Maximum overall dimensions  | H [mm] | 1575 | 1575 | 1575 | 1575 | 1575 |
| | W [mm] | 1000 | 1000 | 1000 | 1000 | 1000 |
| | D [mm] | 555 | 555 | 555 | 555 | 555 |
| | Pole distance P [mm] | 360 | 360 | 360 | 360 | 360 |
| Weight | [kg] | 320 | 320 | 320 | 355 | 355 |
| Standardized dimensions table | TN | GCEM 700198 | GCEM 700198 | GCEM 700198 | GCEM 700198 | GCEM 700198 |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

# Selection and ordering
## Fixed circuit breakers

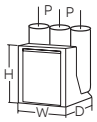
VD4 fixed circuit breaker (38 kV) - IEEE C37.09 Standards




| **Circuit breaker** | | **VD4 38** | |
|---|---|---|---|
| Standards | IEEE C37.09 | • | |
| Rated voltage | Ur [kV] | 38 | |
| Rated insulation voltage | Us [kV] | 38 | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 80 | |
| Impulse withstand voltage | Up [kV] | 150 | |
| Rated frequency | fr [Hz] | 60 | |
| Rated thermal current (40 °C) | Ir [A] | 1200 | 2000 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 82 | 82 |
| Operation sequence | [O - 0.3 s - CO - 3 min - CO] | • | • |
| Opening time | [ms] | 30 ... 35 | 30 ... 35 |
| Arcing time | [ms] | 5 ... 15 | 5 ... 15 |
| Total breaking time | [ms] | 35 ... 50 3-cycle | 35 ... 50 3-cycle |
| Closing time | [ms] | 50 ... 65 | 50 ... 65 |
| Maximum overall dimensions   | H [mm] | 884 | 884 |
| | W [mm] | 796 | 796 |
| | D [mm] | 501 | 501 |
| | Pole center distance P [mm] | 275 | 275 |
| Weight | [kg] | 170 | 170 |
| Standardized dimensions table | TN | 2RDA040578 | 2RDA040578 |
| Operating temperature | [°C] | - 5 ... + 40 | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | |
| Electromagnetic compatibility | IEC 62271-1 | • | |

# VD4 fixed circuit breaker in floor rolling version (40 kV)



| **Circuit breaker** | | **VD4 40** (1) | | | | |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | |
| Rated voltage | Ur [kV] | 40.5 | | | | |
| Rated insulation voltage | Us [kV] | 40.5 | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 95 | | | | |
| Impulse withstand voltage | Up [kV] | 185-200 | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | |
| Rated thermal current (40 °C) | Ir [A] | 630 | 1250 | 1600 | 2000 | 2500 (2) |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | – | – | – |
| | | 20 | 20 | – | – | – |
| | | – | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 (2) | 31.5 (2) | 31.5 (2) |
| | | – | 40 | 40 | 40 | 40 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | – | – | – |
| | | 20 | 20 | – | – | – |
| | | – | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 |
| | | – | 40 | 40 | 40 | 40 |
| Making capacity | Ip [kA] | 40 | 40 | – | – | – |
| | | 50 | 50 | – | – | – |
| | | – | 63 | 63 | 63 | 63 |
| | | – | 80 | 80 | 80 | 80 |
| | | – | 100 | 100 | 100 | 100 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| Opening time | [ms] | ≤45 | ≤45 | ≤45 | ≤45 | ≤45 |
| Arcing time | [ms] | ≤15 | ≤15 | ≤15 | ≤15 | ≤15 |
| Total breaking time | [ms] | ≤60 | ≤60 | ≤60 | ≤60 | ≤60 |
| Closing time | [ms] | approx. 60 | approx. 60 | approx. 60 | approx. 60 | approx. 60 |
| Maximum overall dimensions  | H [mm] | 1575 | 1575 | 1575 | 1575 | 1575 |
| | W [mm] | 1000 | 1000 | 1000 | 1000 | 1000 |
| | D [mm] | 555 | 555 | 555 | 555 | 555 |
| | Pole center distance P [mm] | 360 | 360 | 360 | 360 | 360 |
| Weight | [kg] | 320 | 320 | 290 | 340 | 340 |
| Standardized dimensions table | TN | GCEM 700198 | GCEM 700198 | GCEM 700198 | GCEM 700198 | GCEM 700198 |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

(1) GOST version available on request.
(2) Version for capacity banks available on request.

# Selection and ordering
## Fixed circuit breakers

### Types of fixed circuit breakers available

Complete the circuit breaker selected with the optional accessories indicated on the following pages.

**VD4 fixed circuit breaker without bottom and top terminals (12 kV)**

| Ur | Isc | Rated thermal current (40°C) [A] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H=461 | | | H=589 | | | H=599 | | | H=610 | | H=636 | |
| | | D=424 | | | D=424 | | | D=424 | | | D=459 | | D=459 | |
| kV | kA | u/l=205 | | | u/l=310 | | | u/l=310 | | | u/l=310 | | u/l=310 | Circuit breaker type |
| | | l/g=217.5 | | | l/g=238 | | | l/g=237.5 | | | l/g=237 | | l/g=237 | |
| | | P=150 | P=210 | P=275 | P=150 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | |
| | | W=450 | W=570 | W=700 | W=450 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | |
| 12 | 16 | 630 | | | | | | | | | | | | VD4 12.06.16 p150 |
| | 20 | 630 | | | | | | | | | | | | VD4 12.06.20 p150 |
| | 25 | 630 | | | | | | | | | | | | VD4 12.06.25 p150 |
| | 31.5 | 630 | | | | | | | | | | | | VD4 12.06.32 p150 |
| | 16 | 1250 | | | | | | | | | | | | VD4 12.12.16 p150 |
| | 20 | 1250 | | | | | | | | | | | | VD4 12.12.20 p150 |
| | 25 | 1250 | | | | | | | | | | | | VD4 12.12.25 p150 |
| | 31.5 | 1250 | | | | | | | | | | | | VD4 12.12.32 p150 |
| | 20 | | | | | | | 1600 | | | | | | VD4 12.16.20 p150 |
| | 25 | | | | | | | 1600 | | | | | | VD4 12.16.25 p150 |
| | 31.5 | | | | | | | 1600 | | | | | | VD4 12.16.32 p150 |
| | 16 | | 630 | | | | | | | | | | | VD4 12.06.16 p210 |
| | 20 | | 630 | | | | | | | | | | | VD4 12.06.20 p210 |
| | 25 | | 630 | | | | | | | | | | | VD4 12.06.25 p210 |
| | 31.5 | | 630 | | | | | | | | | | | VD4 12.06.32 p210 |
| | 16 | | 1250 | | | | | | | | | | | VD4 12.12.16 p210 |
| | 20 | | 1250 | | | | | | | | | | | VD4 12.12.20 p210 |
| | 25 | | 1250 | | | | | | | | | | | VD4 12.12.25 p210 |
| | 31.5 | | 1250 | | | | | | | | | | | VD4 12.12.32 p210 |
| | 40 | | | | 1250 | | | | | | | | | VD4 12.12.40 p150 |
| | 40 | | | | | 1250 | | | | | | | | VD4 12.12.40 p210 |
| | 50 | | | | | | | | | | 1250 | | | VD4 12.12.50 p210 |
| | 20 | | | | | | | | 1600 | | | | | VD4 12.16.20 p210 |
| | 25 | | | | | | | | 1600 | | | | | VD4 12.16.25 p210 |
| | 31.5 | | | | | | | | 1600 | | | | | VD4 12.16.32 p210 |
| | 40 | | | | | 1600 | | | | | | | | VD4 12.16.40 p210 |
| | 50 | | | | | | | | | | 1600 | | | VD4 12.16.50 p210 |
| | 20 | | | | | | | | 2000 | | | | | VD4 12.20.20 p210 |
| | 25 | | | | | | | | 2000 | | | | | VD4 12.20.25 p210 |
| | 31,5 | | | | | | | | 2000 | | | | | VD4 12.20.32 p210 |
| | 40 | | | | | | | | 2000 | | | | | VD4 12.20.40 p210 |
| | 50 | | | | | | | | | | 2000 | | | VD4 12.20.50 p210 |
| | 20 | | | | | | | | 2500 | | | | | VD4 12.25.20 p210 |
| | 25 | | | | | | | | 2500 | | | | | VD4 12.25.25 p210 |
| | 31.5 | | | | | | | | 2500 | | | | | VD4 12.25.32 p210 |
| | 40 | | | | | | | | 2500 | | | | | VD4 12.25.40 p210 |

H = Height of circuit breaker.
W = Width of circuit breaker.
D = Depth of circuit breaker.
u/l = Distance between bottom and top terminals.
l/g = Distance between bottom terminal and bearing surface of circuit breaker.
P = Horizontal center distance of poles.

## VD4 fixed circuit breaker without bottom and top terminals (12 kV)

| Ur | Isc | Rated thermal current (40°C) [A] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H=461 | | | H=589 | | H=599 | | | H=610 | | H=636 | H=677,5 | |
| | | D=424 | | | D=424 | | D=424 | | | D=459 | | D=459 | D=459 | |
| kV | kA | u/l=205 | | | u/l=310 | | u/l=310 | | | u/l=310 | | u/l=310 | u/l=310 | Circuit breaker type |
| | | l/g=217.5 | | | l/g=238 | | l/g=237.5 | | | l/g=237 | | l/g=237 | l/g=237 | |
| | | P=150 | P=210 | P=275 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | P=275 | |
| | | W=450 | W=570 | W=700 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | W=750 | |
| | 16 | | | 630 | | | | | | | | | | VD4 12.06.16 p275 |
| | 20 | | | 630 | | | | | | | | | | VD4 12.06.20 p275 |
| | 25 | | | 630 | | | | | | | | | | VD4 12.06.25 p275 |
| | 31.5 | | | 630 | | | | | | | | | | VD4 12.06.32 p275 |
| | 16 | | | 1250 | | | | | | | | | | VD4 12.12.16 p275 |
| | 20 | | | 1250 | | | | | | | | | | VD4 12.12.20 p275 |
| | 25 | | | 1250 | | | | | | | | | | VD4 12.12.25 p275 |
| | 31.5 | | | 1250 | | | | | | | | | | VD4 12.12.32 p275 |
| | 40 | | | | | 1250 | | | | | | | | VD4 12.12.40 p275 |
| | 50 | | | | | | | | | | 1250 | | | VD4 12.12.50 p275 |
| | 63 | | | | | | | | | | | | 1250 | VD4 12.12.63 p275 |
| | 20 | | | | | | | | 1600 | | | | | VD4 12.16.20 p275 |
| | 25 | | | | | | | | 1600 | | | | | VD4 12.16.25 p275 |
| | 31.5 | | | | | | | | 1600 | | | | | VD4 12.16.32 p275 |
| | 40 | | | | | 1600 | | | | | | | | VD4 12.16.40 p275 |
| | 50 | | | | | | | | | | 1600 | | | VD4 12.16.50 p275 |
| | 63 | | | | | | | | | | | | 1600 | VD4 12.16.63 p275 |
| 12 | 20 | | | | | | | | 2000 | | | | | VD4 12.20.20 p275 |
| | 25 | | | | | | | | 2000 | | | | | VD4 12.20.25 p275 |
| | 31.5 | | | | | | | | 2000 | | | | | VD4 12.20.32 p275 |
| | 40 | | | | | | | | 2000 | | | | | VD4 12.20.40 p275 |
| | 50 | | | | | | | | | | 2000 | | | VD4 12.20.50 p275 |
| | 63 | | | | | | | | | | | | 2000 | VD4 12.20.63 p275 |
| | 20 | | | | | | | | 2500 | | | | | VD4 12.25.20 p275 |
| | 25 | | | | | | | | 2500 | | | | | VD4 12.25.25 p275 |
| | 31.5 | | | | | | | | 2500 | | | | | VD4 12.25.32 p275 |
| | 40 | | | | | | | | 2500 | | | | | VD4 12.25.40 p275 |
| | 50 | | | | | | | | | | 2500 | | | VD4 12.25.50 p275 |
| | 63 | | | | | | | | | | | | 2500 | VD4 12.25.63 p275 |
| | 20 | | | | | | | | | | | 3150 (1) | | VD4 12.32.20 p275 |
| | 25 | | | | | | | | | | | 3150 (1) | | VD4 12.32.25 p275 |
| | 31.5 | | | | | | | | | | | 3150 (1) | | VD4 12.32.32 p275 |
| | 40 | | | | | | | | | | | 3150 (1) | | VD4 12.32.40 p275 |
| | 50 | | | | | | | | | | | 3150 (1) | | VD4 12.32.50 p275 |
| | 63 | | | | | | | | | | | | 3150 (1) | VD4 12.32.63 p275 |

H = Height of circuit breaker.
W = Width of circuit breaker.
D = Depth of circuit breaker.
u/l = Distance between bottom and top terminals.
l/g = Distance between bottom terminal and bearing surface of circuit breaker.
P = Horizontal center distance of poles.
(1) Up to 4000 A with forced ventilation.

# Selection and ordering
## Fixed circuit breakers

### VD4 fixed circuit breaker without bottom and top terminals (17.5 kV)

| Ur | Isc | Rated thermal current (40 °C) [A] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H=461 | | | H=589 | | | H=599 | | | H=610 | | H=635 | |
| | | D=424 | | | D=424 | | | D=424 | | | D=459 | | D=459 | |
| kV | kA | u/l=205 | | | u/l=310 | | | u/l=310 | | | u/l=310 | | u/l=310 | Circuit breaker type |
| | | l/g=217.5 | | | l/g=238 | | | l/g=237.5 | | | l/g=237 | | l/g=237.5 | |
| | | P=150 | P=210 | P=275 | P=150 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | |
| | | W=450 | W=570 | W=700 | W=450 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | |
| | 16 | 630 | | | | | | | | | | | | VD4 17.06.16 p150 |
| | 20 | 630 | | | | | | | | | | | | VD4 17.06.20 p150 |
| | 25 | 630 | | | | | | | | | | | | VD4 17.06.25 p150 |
| | 31.5 | 630 | | | | | | | | | | | | VD4 17.06.32 p150 |
| | 16 | 1250 | | | | | | | | | | | | VD4 17.12.16 p150 |
| | 20 | 1250 | | | | | | | | | | | | VD4 17.12.20 p150 |
| | 25 | 1250 | | | | | | | | | | | | VD4 17.12.25 p150 |
| | 31.5 | 1250 | | | | | | | | | | | | VD4 17.12.32 p150 |
| | 16 | | 630 | | | | | | | | | | | VD4 17.06.16 p210 |
| | 20 | | 630 | | | | | | | | | | | VD4 17.06.20 p210 |
| | 25 | | 630 | | | | | | | | | | | VD4 17.06.25 p210 |
| | 31.5 | | 630 | | | | | | | | | | | VD4 17.06.32 p210 |
| | 16 | | 1250 | | | | | | | | | | | VD4 17.12.16 p210 |
| | 20 | | 1250 | | | | | | | | | | | VD4 17.12.20 p210 |
| 17.5 | 25 | | 1250 | | | | | | | | | | | VD4 17.12.25 p210 |
| | 31.5 | | 1250 | | | | | | | | | | | VD4 17.12.32 p210 |
| | 40 | | | | 1250 | | | | | | | | | VD4 17.12.40 p150 |
| | 40 | | | | | 1250 | | | | | | | | VD4 17.12.40 p210 |
| | 50 | | | | | | | | | | 1250 | | | VD4 17.12.50 p210 |
| | 20 | | | | | | | | 1600 | | | | | VD4 17.16.20 p210 |
| | 25 | | | | | | | | 1600 | | | | | VD4 17.16.25 p210 |
| | 31.5 | | | | | | | | 1600 | | | | | VD4 17.16.32 p210 |
| | 40 | | | | | 1600 | | | | | | | | VD4 17.16.40 p210 |
| | 50 | | | | | | | | | | 1600 | | | VD4 17.16.50 p210 |
| | 20 | | | | | | | | 2000 | | | | | VD4 17.20.20 p210 |
| | 25 | | | | | | | | 2000 | | | | | VD4 17.20.25 p210 |
| | 31.5 | | | | | | | | 2000 | | | | | VD4 17.20.32 p210 |
| | 40 | | | | | | | | 2000 | | | | | VD4 17.20.40 p210 |
| | 50 | | | | | | | | | | 2000 | | | VD4 17.20.50 p210 |

H = Height of circuit breaker.
W = Width of circuit breaker.
D = Depth of circuit breaker.
u/l = Distance between bottom and top terminals.
l/g = Distance between bottom terminal and bearing surface of circuit breaker.
P = Horizontal center distance of poles.

## VD4 fixed circuit breaker without bottom and top terminals (17.5 kV)

| Ur | Isc | Rated thermal current (40 °C) [A] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H=461 | | | H=589 | | H=599 | | | H=610 | | H=635 | H=677,5 | |
| | | D=424 | | | D=424 | | D=424 | | | D=459 | | D=459 | D=459 | |
| kV | kA | u/l=205 | | | u/l=310 | | u/l=310 | | | u/l=310 | | u/l=310 | u/l=310 | Circuit breaker type |
| | | l/g=217.5 | | | l/g=238 | | l/g=237.5 | | | l/g=237 | | l/g=237.5 | l/g=237 | |
| | | P=150 | P=210 | P=275 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | P=275 | |
| | | W=450 | W=570 | W=700 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | W=750 | |
| | 16 | | | 630 | | | | | | | | | | VD4 17.06.16 p275 |
| | 20 | | | 630 | | | | | | | | | | VD4 17.06.20 p275 |
| | 25 | | | 630 | | | | | | | | | | VD4 17.06.25 p275 |
| | 31.5 | | | 630 | | | | | | | | | | VD4 17.06.32 p275 |
| | 16 | | | 1250 | | | | | | | | | | VD4 17.12.16 p275 |
| | 20 | | | 1250 | | | | | | | | | | VD4 17.12.20 p275 |
| | 25 | | | 1250 | | | | | | | | | | VD4 17.12.25 p275 |
| | 31.5 | | | 1250 | | | | | | | | | | VD4 17.12.32 p275 |
| | 40 | | | | | 1250 | | | | | | | | VD4 17.12.40 p275 |
| | 50 | | | | | | | | | | 1250 | | | VD4 17.12.50 p275 |
| | 63 | | | | | | | | | | | | 1250 | VD4 17.12.63 p275 |
| | 20 | | | | | | | | 1600 | | | | | VD4 17.16.20 p275 |
| | 25 | | | | | | | | 1600 | | | | | VD4 17.16.25 p275 |
| | 31.5 | | | | | | | | 1600 | | | | | VD4 17.16.32 p275 |
| | 40 | | | | | 1600 | | | | | | | | VD4 17.16.40 p275 |
| | 50 | | | | | | | | | | 1600 | | | VD4 17.16.50 p275 |
| | 63 | | | | | | | | | | | | 1600 | VD4 17.16.63 p275 |
| 17.5 | 20 | | | | | | | | 2000 | | | | | VD4 17.20.20 p275 |
| | 25 | | | | | | | | 2000 | | | | | VD4 17.20.25 p275 |
| | 31.5 | | | | | | | | 2000 | | | | | VD4 17.20.32 p275 |
| | 40 | | | | | | | | 2000 | | | | | VD4 17.20.40 p275 |
| | 50 | | | | | | | | | | 2000 | | | VD4 17.20.50 p275 |
| | 63 | | | | | | | | | | | | 2000 | VD4 17.20.63 p275 |
| | 20 | | | | | | | | 2500 | | | | | VD4 17.25.20 p275 |
| | 25 | | | | | | | | 2500 | | | | | VD4 17.25.25 p275 |
| | 31.5 | | | | | | | | 2500 | | | | | VD4 17.25.32 p275 |
| | 40 | | | | | | | | 2500 | | | | | VD4 17.25.40 p275 |
| | 50 | | | | | | | | | | 2500 | | | VD4 17.25.50 p275 |
| | 63 | | | | | | | | | | | | 2500 | VD4 17.25.63 p275 |
| | 20 | | | | | | | | | | | 3150 (1) | | VD4 17.32.20 p275 |
| | 25 | | | | | | | | | | | 3150 (1) | | VD4 17.32.25 p275 |
| | 31.5 | | | | | | | | | | | 3150 (1) | | VD4 17.32.32 p275 |
| | 40 | | | | | | | | | | | 3150 (1) | | VD4 17.32.40 p275 |
| | 50 | | | | | | | | | | | 3150 (1) | | VD4 17.32.50 p275 |
| | 63 | | | | | | | | | | | | 3150 (1) | VD4 17.32.63 p275 |

H = Height of circuit breaker
W = Width of circuit breaker
D = Depth of circuit breaker
u/l = Distance between bottom and top terminals
l/g = Distance between bottom terminal and bearing surface of circuit breaker
P = Horizontal center distance of poles
(1) Up to 4000 A with forced ventilation.

# Selection and ordering
## Fixed circuit breakers

**VD4 fixed circuit breaker without bottom and top terminals (24 kV)**

| Ur | Isc | Rated thermal current (40 °C) [A] | | | Circuit breaker type |
|---|---|---|---|---|---|
| | | H=631 | | H=642 | |
| | | D=424 | | D=424 | |
| | | u/l=310 | | u/l=310 | |
| kV | kA | l/g=282.5 | | l/g=282.5 | |
| | | P=210 | P=275 | P=275 | |
| | | W=570 | W=700 | W=700 | |
| | 16 | 630 | | | VD4 24.06.16 p210 |
| | 20 | 630 | | | VD4 24.06.20 p210 |
| | 25 | 630 | | | VD4 24.06.25 p210 |
| | 16 | 1250 | | | VD4 24.12.16 p210 |
| | 20 | 1250 | | | VD4 24.12.20 p210 |
| | 25 | 1250 | | | VD4 24.12.25 p210 |
| | 31.5 | 1250 | | | VD4 24.12.32 p210 |
| | 16 | | 630 | | VD4 24.06.16 p275 |
| | 20 | | 630 | | VD4 24.06.20 p275 |
| | 25 | | 630 | | VD4 24.06.25 p275 |
| | 16 | | 1250 | | VD4 24.12.16 p275 |
| 24 | 20 | | 1250 | | VD4 24.12.20 p275 |
| | 25 | | 1250 | | VD4 24.12.25 p275 |
| | 16 | | | 1600 | VD4 24.16.16 p275 |
| | 20 | | | 1600 | VD4 24.16.20 p275 |
| | 25 | | | 1600 | VD4 24.16.25 p275 |
| | 31.5 | | | 1600 | VD4 24.16.32 p275 |
| | 16 | | | 2000 | VD4 24.20.16 p275 |
| | 20 | | | 2000 | VD4 24.20.20 p275 |
| | 25 | | | 2000 | VD4 24.20.25 p275 |
| | 31,5 | | | 2000 | VD4 24.20.32 p275 |
| | 25 | | | 2500 | VD4 24.25.25 p275 |
| | 31.5 | | | 2500 | VD4 24.25.32 p275 |

H = Height of circuit breaker.
W = Width of circuit breaker.
D = Depth of circuit breaker.
u/l = Distance between bottom and top terminals.
l/g = Distance between bottom terminal and bearing surface of circuit breaker.
P = Horizontal center distance of poles.

### VD4 fixed circuit breaker without bottom and top terminals (36 kV)

| Ur | Isc | Rated thermal current (40 °C) [A] | | | | Circuit breaker type |
|---|---|---|---|---|---|---|
| kV | kA | H = 884<br>W = 796<br>D = 501<br>u/l = 328<br>l/g = 428.5<br>P = 275 | | | | |
| 36 | 20 | 1250 A | | | | VD4 36.12.20 p275 |
| | 25 | 1250 A | | | | VD4 36.12.25 p275 |
| | 31.5 | 1250 A | | | | VD4 36.12.32 p275 |
| | 20 | | 1600 A | | | VD4 36.16.20 p275 |
| | 25 | | 1600 A | | | VD4 36.16.25 p275 |
| | 31.5 | | 1600 A | | | VD4 36.16.32 p275 |
| | 20 | | | 2000 A | | VD4 36.20.20 p275 |
| | 25 | | | 2000 A | | VD4 36.20.25 p275 |
| | 31.5 | | | 2000 A | | VD4 36.20.32 p275 |
| | 20 | | | | 2500 A | VD4 36.25.20 p275 |
| | 25 | | | | 2500 A | VD4 36.25.25 p275 |
| | 31.5 | | | | 2500 A | VD4 36.25.32 p275 |
| 40 | 20 | 1250 A | | | | VD4 40.12.20 p275 |
| | 25 | 1250 A | | | | VD4 40.12.25 p275 |
| | 31.5 | 1250 A | | | | VD4 40.12.32 p275 |
| | 20 | | 1600 A | | | VD4 40.16.20 p275 |
| | 25 | | 1600 A | | | VD4 40.16.25 p275 |
| | 31.5 | | 1600 A | | | VD4 40.16.32 p275 |
| | 20 | | | 2000 A | | VD4 40.20.20 p275 |
| | 25 | | | 2000 A | | VD4 40.20.25 p275 |
| | 31.5 | | | 2000 A | | VD4 40.20.32 p275 |

H = Height of circuit breaker.
W = Width of circuit breaker.
D = Depth of circuit breaker.
u/l = Distance between bottom and top terminals.
l/g = Distance between bottom terminal and bearing surface of circuit breaker.
P = Horizontal center distance of poles

# Selection and ordering
## Fixed circuit breakers

### VD4 (36 kV) fixed circuit breaker

| Ur | Isc | Rated thermal current (40 °C) [A] | Circuit breaker type |
|---|---|---|---|
| kV | kA | H= 1575<br>W= 555<br>D= 1000<br>u/l=328<br>l/g=900<br>P=360 | |
| 36 | 16 | 630A | VD4 36.06.16 p360 |
| | 20 | 630A | VD4 36.06.20 p360 |
| | 16 | 1250A | VD4 36.12.16 p360 |
| | 20 | 1250A | VD4 36.12.20 p360 |
| | 25 | 1250A | VD4 36.12.25 p360 |
| | 31.5 | 1250A | VD4 36.12.31 p360 |
| | 40 | 1250A | VD4 36.12.40 p360 |
| | 25 | 1600A | VD4 36.16.25 p360 |
| | 31.5 | 1600A | VD4 36.16.31 p360 |
| | 40 | 1600A | VD4 36.16.40 p360 |
| | 25 | 2000A | VD4 36.20.25 p360 |
| | 31.5 | 2000A | VD4 36.20.31 p360 |
| | 40 | 2000A | VD4 36.20.40 p360 |
| | 25 | 2500A | VD4 36.25.25 p360 |
| | 31.5 | 2500A | VD4 36.25.31 p360 |
| | 40 | 2500A | VD4 36.25.40 p360 |

H = Height of circuit breaker
W = Width of circuit breaker.
D = Depth of circuit breaker.
u/l = Distance between bottom and top terminals.
l/g = Distance between bottom terminal and bearing surface of circuit breaker.
P = Horizontal center distance of poles.

### VD4 (38 kV) fixed circuit breaker

| Ur | Isc | Rated thermal current (40 °C) [A] | Circuit breaker type |
|---|---|---|---|
| kV | kA | H = 884<br>W = 796<br>P = 501<br>u/l = 328<br>l/g = 490<br>l = 275 | |
| 38 | 31.5 | 1200 A | VD4 38.12.32 p275 |
| | 31.5 | 2000 A | VD4 38.20.32 p275 |

H = Height of circuit breaker
W = Width of circuit breaker.
D = Depth of circuit breaker.
u/l = Distance between bottom and top terminals.
l/g = Distance between bottom terminal and bearing surface of circuit breaker.
P = Horizontal center distance of poles.

## VD4 (40 kV) fixed circuit breaker

| Ur | Isc | Rated thermal current (40 °C) [A] | | | | | Circuit breaker type |
|---|---|---|---|---|---|---|---|
| | | H= 1575 | | | | | |
| | | W= 555 | | | | | |
| kV | kA | D= 1000 | | | | | Circuit breaker type |
| | | u/l=328 | | | | | |
| | | l/g=900 | | | | | |
| | | P=360 | | | | | |
| 40 | 16 | 630A | | | | | VD4 40.06.16 p360 |
| | 20 | 630A | | | | | VD4 40.06.20 p360 |
| | 16 | | 1250A | | | | VD4 40.12.16 p360 |
| | 20 | | 1250A | | | | VD4 40.12.20 p360 |
| | 25 | | 1250A | | | | VD4 40.12.25 p360 |
| | 31.5 | | 1250A | | | | VD4 40.12.31 p360 |
| | 40 | | 1250A | | | | VD4 40.12.40 p360 |
| | 25 | | | 1600A | | | VD4 40.16.25 p360 |
| | 31.5 | | | 1600A | | | VD4 40.16.31 p360 |
| | 40 | | | 1600A | | | VD4 40.16.40 p360 |
| | 25 | | | | 2000A | | VD4 40.20.25 p360 |
| | 31.5 | | | | 2000A | | VD4 40.20.31 p360 |
| | 40 | | | | 2000A | | VD4 40.20.40 p360 |
| | 25 | | | | | 2500A | VD4 40.25.25 p360 |
| | 31.5 | | | | | 2500A | VD4 40.25.31 p360 |
| | 40 | | | | | 2500A | VD4 40.25.40 p360 |

H = Height of circuit breaker
W = Width of circuit breaker.
D = Depth of circuit breaker.
u/l = Distance between bottom and top terminals.
l/g = Distance between bottom terminal and bearing surface of circuit breaker.
P = Horizontal center distance of poles.

**Standard equipment of fixed circuit breakers**
The basic versions of the fixed circuit breakers are three-pole and equipped with:

- EL or Classic manual operating mechanism
- mechanical signaling device for closing springs loaded/discharged
- mechanical signaling device for circuit breaker open/closed
- closing pushbutton, opening pushbutton and operation counter
- set of ten auxiliary circuit breaker break/make contacts
  Note: three break contacts (signaling circuit breaker open) and five make contacts (signaling circuit breaker closed) are available with the group of ten auxiliary contacts supplied as standard and the maximum number of electrical applications.
- lever built into operating mechanism for linear loading of closing spring.




VD4 - up to 24 kV

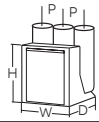



VD4 - 36 kV

# Selection and ordering
## Withdrawable circuit breakers

### Withdrawable circuit breakers for UniGear ZS1 switchgear (12 kV) (4)




| **Circuit breaker** | | **VD4/P 12** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | | |
| Rated voltage | Ur [kV] | 12 (2) | | | | | | |
| Rated insulation voltage | Us [kV] | 12 | | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | | | | | |
| Impulse withstand voltage | Up [kV] | 75 | | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | | |
| Rated thermal current (40 °C) (1) | Ir [A] | 630 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | – | – | – | – | – |
| | | 20 | 20 | – | – | – | – | – |
| | | 25 | 25 | – | – | – | – | – |
| | | 31.5 | 31.5 | – | – | – | – | – |
| | | – | – | 40 | 40 | 40 | – | – |
| | | – | – | – | – | – | 50 | – |
| | | – | – | – | – | – | – | 63 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | – | – | – | – | – |
| | | 20 | 20 | – | – | – | – | – |
| | | 25 | 25 | – | – | – | – | – |
| | | 31.5 | 31.5 | – | – | – | – | – |
| | | – | – | 40 | 40 | 40 | – | – |
| | | – | – | – | – | – | 50 | – |
| | | – | – | – | – | – | – | 63 (5) |
| Making capacity | Ip [kA] | 40 | 40 | – | – | – | – | – |
| | | 50 | 50 | – | – | – | – | – |
| | | 63 | 63 | – | – | – | – | – |
| | | 80 | 80 | – | – | – | – | – |
| | | – | – | 104 | 100 | 100 | – | – |
| | | – | – | – | – | – | 125 | – |
| | | – | – | – | – | – | – | 164 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | – |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | – | – | – | • |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 28 ... 40 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 38 ... 55 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | ≤55 |
| Maximum overall dimensions   | H [mm] | 628 | 628 | 693 | 691 | 691 | 691 | 735 |
| | W [mm] | 503 | 503 | 503 | 653 | 853 | 681 | 851 |
| | D [mm] | 662 | 662 | 651 | 641 | 642 | 643 | 650 |
| | Pole center distance P [mm] | 150 | 150 | 150 | 210 | 275 | 210 | 275 |
| Weight | [kg] | 116 | 116 | 111 | 174 | 176 | 180 | 270 |
| Standardized dimensions table | TN | 7412 (3) | 7412 (3) | – | – | – | – | – |
| | 1VCD | – | – | – | 003284 (3) | 003286 (3) | 003444 | 003943 |
| | 2RDA | – | – | 040163A0001 | – | – | – | – |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | | |
| VD4 evo (6) | | | | • | | | | |

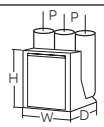
| | | | | | | |
|---|---|---|---|---|---|---|
| **VD4/P 12** | | | | | | |
| • | | | | | | |
| 12 (2) | | | | | | |
| 12 | | | | | | |
| 28 | | | | | | |
| 75 | | | | | | |
| 50-60 | | | | | | |
| 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 |
| – | – | – | – | – | – | – |
| 20 | 20 | – | – | – | – | – |
| 25 | 25 | – | – | – | – | – |
| 31.5 | 31.5 | – | – | – | – | – |
| – | – | 40 | 40 | – | – | – |
| – | – | – | – | 50 | 50 | – |
| – | – | – | – | – | – | 63 |
| – | – | – | – | – | – | – |
| 20 | 20 | – | – | – | – | – |
| 25 | 25 | – | – | – | – | – |
| 31.5 | 31.5 | – | – | – | – | – |
| – | – | 40 | 40 | – | – | – |
| – | – | – | – | 50 | 50 | – |
| – | – | – | – | – | – | 63 (5) |
| – | – | – | – | – | – | – |
| 50 | 50 | – | – | – | – | – |
| 63 | 63 | – | – | – | – | – |
| 80 | 80 | – | – | – | – | – |
| – | – | 100 | 100 | – | – | – |
| – | – | – | – | 125 | 125 | – |
| – | – | – | – | – | – | 164 |
| • | • | • | • | • | • | – |
| – | – | – | – | – | – | • |
| 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 28 ... 40 |
| 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 38 ... 55 |
| 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | ≤55 |
| 691 | 691 | 691 | 691 | 691 | 691 | 735 |
| 653 | 853 | 653 | 853 | 681 | 853 | 851 |
| 642 | 642 | 641 | 642 | 643 | 643 | 650 |
| 210 | 275 | 210 | 275 | 210 | 275 | 275 |
| 160 | 166 | 174 | 176 | 180 | 193 | 270 |
| 7415(3) | 7416(3) | – | – | – | – | – |
| – | – | 003284(3) | 003286(3) | 003444 | 003445 | 003943 |
| – | – | – | – | – | – | – |
| - 5 ... + 40 | | | | | | |
| • | | | | | | |
| • | | | | | | |

(1) Rated current guaranteed with circuit breaker installed in UniGear ZS1 switchgear and with 40 °C ambient temperature.
(2) Available at 10kV according to GOST R 52565 standard with Ud=42kV
(3) Poles in polyamide
(4) On request, the closing spring can be loaded by means of a removable crank handle outside the operating mechanism (instead of linear loading, only possible with the door open, by means of a lever built into the front of the operating mechanism).
(5) For 1s
(6) Refer to chapter “Description” for more details

# Selection and ordering
## Withdrawable circuit breakers

### Withdrawable circuit breakers for UniGear ZS1 switchgear (12 kV) (4)




| **Circuit breaker** | | **VD4/P 12** | | | | |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | |
| Rated voltage | Ur [kV] | 12 (2) | | | | |
| Rated insulation voltage | Us [kV] | 12 | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | | | |
| Impulse withstand voltage | Up [kV] | 75 | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | |
| Rated thermal current (40 °C) (1) | Ir [A] | 2000 | 2000 | 2000 | 2000 | 2000 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | – | – | – | – | – |
| | | 20 | 20 | – | – | – |
| | | 25 | 25 | – | – | – |
| | | 31.5 | 31.5 | – | – | – |
| | | 40 | 40 | – | – | – |
| | | – | – | 50 | 50 | – |
| | | – | – | – | – | 63 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | – | – | – | – | – |
| | | 20 | 20 | – | – | – |
| | | 25 | 25 | – | – | – |
| | | 31.5 | 31.5 | – | – | – |
| | | 40 | 40 | – | – | – |
| | | – | – | 50 | 50 | – |
| | | – | – | – | – | 63 (5) |
| Making capacity | Ip [kA] | – | – | – | – | – |
| | | 50 | 50 | – | – | – |
| | | 63 | 63 | – | – | – |
| | | 80 | 80 | – | – | – |
| | | 100 | 100 | – | – | – |
| | | – | – | 125 | 125 | – |
| | | – | – | – | – | 164 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | – |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | – | • |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 28 ... 40 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 38 ... 55 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | ≤55 |
| Maximum overall dimensions   | H [mm] | 691 | 691 | 691 | 691 | 735 |
| | W [mm] | 653 | 853 | 681 | 853 | 851 |
| | D [mm] | 642 | 642 | 643 | 643 | 650 |
| | Pole center distance P [mm] | 210 | 275 | 210 | 275 | 275 |
| Weight | [kg] | 160 | 166 | 190 | 205 | 270 |
| Standardized dimensions table | TN | 7415 (3) | 7416 (3) | – | – | – |
| | 1VCD | – | – | 003444 | 003445 | 003943 |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

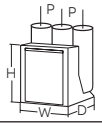
| | | | | | |
|---|---|---|---|---|---|
| **VD4/P 12** | | | | | |
| • | | | | | |
| 12 (4) | | | | | |
| 12 | | | | | |
| 28 | | | | | |
| 75 | | | | | |
| 50-60 | | | | | |
| 2500 | 2500 | 2500 | 3150 (6) | 3150 (6) | 3150 (6) |
| – | – | – | – | – | – |
| 20 | – | – | 20 | – | – |
| 25 | – | – | 25 | – | – |
| 31.5 | – | – | 31.5 | – | – |
| 40 | – | – | 40 | – | – |
| – | 50 | – | – | 50 | – |
| – | – | 63 | – | – | 63 |
| – | – | – | – | – | – |
| 20 | – | – | 20 | – | – |
| 25 | – | – | 25 | – | – |
| 31.5 | – | – | 31.5 | – | – |
| 40 | – | – | 40 | – | – |
| – | 50 | – | – | 50 | – |
| – | – | 63 (5) | – | – | 63 (5) |
| – | – | – | – | – | – |
| 50 | – | – | 50 | – | – |
| 63 | – | – | 63 | – | – |
| 80 | – | – | 80 | – | – |
| 100 | – | – | 100 | – | – |
| – | 125 | – | – | 125 | – |
| – | – | 164 | – | – | 164 |
| • | • | – | • | • | – |
| – | – | • | – | – | • |
| 33 ... 60 | 33 ... 60 | 28 ... 40 | 33 ... 60 | 33 ... 60 | 28 ... 40 |
| 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| 43 ... 75 | 43 ... 75 | 38 ... 55 | 43 ... 75 | 43 ... 75 | 38 ... 55 |
| 30 ... 60 | 30 ... 60 | ≤55 | 30 ... 60 | 30 ... 60 | ≤55 |
| 691 | 691 | 735 | 730 | 742 | 735 |
| 853 | 853 | 851 | 853 | 853 | 851 |
| 640 | 643 | 650 | 640 | 643 | 650 |
| 275 | 275 | 275 | 275 | 275 | 275 |
| 186 | 225 | 270 | 221 | 240 | 270 |
| 7417(3) | – | – | – | – | – |
| – | 003446 | 003943 | 000153(3) | 003447 | 003943 |
| - 5 ... + 40 | | | | | |
| • | | | | | |
| • | | | | | |

(1) Rated current guaranteed with circuit breaker installed in UniGear ZS1 switchgear and with 40 °C ambient temperature.
(2) Available at 10kV according to GOST R 52565 standard with Ud=42kV
(3) Poles in polyamide
(4) On request, the closing spring can be loaded by means of a removable crank handle outside the operating mechanism (instead of linear loading, only possible with the door open, by means of a lever built into the front of the operating mechanism).
(5) For 1s
(6) Up to 4000 A with forced ventilation

# Selection and ordering
## Withdrawable circuit breakers

### Withdrawable circuit breakers for UniGear ZS1 switchgear (17.5 kV) (4)




| **Circuit breaker** | | **VD4/P 17** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | | |
| Rated voltage | Ur [kV] | 17.5 | | | | | | |
| Rated insulation voltage | Us [kV] | 17.5 | | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 38 | | | | | | |
| Impulse withstand voltage | Up [kV] | 95 | | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | | |
| Rated thermal current (40 °C) (1) | Ir [A] | 630 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | – | – | – | – | – |
| | | 20 | 20 | – | – | – | – | – |
| | | 25 | 25 | – | – | – | – | – |
| | | 31.5 | 31.5 | – | – | – | – | – |
| | | – | – | 40 | 40 | 40 | – | – |
| | | – | – | – | – | – | 50 | – |
| | | – | – | – | – | – | – | 63 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | – | – | – | – | – |
| | | 20 | 20 | – | – | – | – | – |
| | | 25 (2) | 25 (2) | – | – | – | – | – |
| | | 31.5 (2) | 31.5 (2) | – | – | – | – | – |
| | | – | – | 40 | 40 | 40 | – | – |
| | | – | – | – | – | – | 50 | – |
| | | – | – | – | – | – | – | 63 (5) |
| Making capacity | Ip [kA] | 40 | 40 | – | – | – | – | – |
| | | 50 | 50 | – | – | – | – | – |
| | | 63 | 63 | – | – | – | – | – |
| | | 80 | 80 | – | – | – | – | – |
| | | – | – | 104 | 100 | 100 | – | – |
| | | – | – | – | – | – | 125 | – |
| | | – | – | – | – | – | – | 164 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | – |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | – | – | – | • |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 28 ... 40 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 38 ... 55 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | ≤55 |
| Maximum overall dimensions   | H [mm] | 632 | 632 | 693 | 691 | 691 | 691 | 735 |
| | W [mm] | 503 | 503 | 503 | 653 | 853 | 681 | 851 |
| | D [mm] | 664 | 664 | 651 | 641 | 642 | 643 | 650 |
| | Pole center distance P [mm] | 150 (2) | 150 (2) | 150 | 210 | 275 | 210 | 275 |
| Weight | [kg] | 116 | 116 | 111 | 174 | 176 | 180 | 270 |
| Standardized dimensions table | TN | 7412(3) | 7412(3) | – | – | – | – | – |
| | 1VCD | – | – | – | 003284(3) | 003286(3) | 003444 | 003943 |
| | 2RDA | – | – | 040163A0001 | – | – | – | – |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | | |
| VD4 evo (6) | | | | • | | | | |

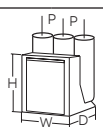
| | | | | | | |
|---|---|---|---|---|---|---|
| **VD4/P 17** | | | | | | |
| • | | | | | | |
| 17.5 | | | | | | |
| 17.5 | | | | | | |
| 38 | | | | | | |
| 95 | | | | | | |
| 50-60 | | | | | | |
| 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 |
| – | – | – | – | – | – | – |
| 20 | 20 | – | – | – | – | – |
| 25 | 25 | – | – | – | – | – |
| 31.5 | 31.5 | – | – | – | – | – |
| – | – | 40 | 40 | – | – | – |
| – | – | – | – | 50 | 50 | – |
| – | – | – | – | – | – | 63 |
| – | – | – | – | – | – | – |
| 20 | 20 | – | – | – | – | – |
| 25 | 25 | – | – | – | – | – |
| 31.5 | 31.5 | – | – | – | – | – |
| – | – | 40 | 40 | – | – | – |
| – | – | – | – | 50 | 50 | – |
| – | – | – | – | – | – | 63 ([5]) |
| – | – | – | – | – | – | – |
| 50 | 50 | – | – | – | – | – |
| 63 | 63 | – | – | – | – | – |
| 80 | 80 | – | – | – | – | – |
| – | – | 100 | 100 | – | – | – |
| – | – | – | – | 125 | 125 | – |
| – | – | – | – | – | – | 164 |
| • | • | • | • | • | • | – |
| – | – | – | – | – | – | • |
| 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 28 ... 40 |
| 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 38 ... 55 |
| 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | ≤55 |
| 691 | 691 | 691 | 691 | 691 | 691 | 735 |
| 653 | 853 | 653 | 853 | 681 | 853 | 851 |
| 642 | 642 | 641 | 642 | 643 | 643 | 650 |
| 210 | 275 | 210 | 275 | 210 | 275 | 275 |
| 160 | 166 | 174 | 176 | 180 | 193 | 270 |
| 7415([3]) | 7416([3]) | – | – | – | – | – |
| – | – | 003284([3]) | 003286([3]) | 003444 | 003445 | 003943 |
| – | – | – | – | – | – | – |
| - 5 ... + 40 | | | | | | |
| • | | | | | | |
| • | | | | | | |

([1]) Rated current guaranteed with circuit breaker installed in UniGear ZS1 switchgear and with 40 °C ambient temperature.
([2]) Please consult drawing 2RDA032149 of “Overall dimensions” section for 210 mm pole center distance.
([3]) Poles in polyamide
([4]) On request, the closing spring can be loaded by means of a removable crank handle outside the operating mechanism (instead of linear loading, only possible with the door open, by means of a lever built into the front of the operating mechanism).
([5]) For 1s
([6]) Refer to chapter “Description” for more details

# Selection and ordering
## Withdrawable circuit breakers

### Withdrawable circuit breakers for UniGear ZS1 switchgear (17.5 kV) ([4])




| **Circuit breaker** | | **VD4/P 17** | | | | |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | |
| Rated voltage | Ur [kV] | 17.5 | | | | |
| Rated insulation voltage | Us [kV] | 17.5 | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 38 | | | | |
| Impulse withstand voltage | Up [kV] | 95 | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | |
| Rated thermal current (40 °C) ([1]) | Ir [A] | 2000 | 2000 | 2000 | 2000 | 2000 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | – | – | – | – | – |
| | | 20 | 20 | – | – | – |
| | | 25 | 25 | – | – | – |
| | | 31.5 | 31.5 | – | – | – |
| | | 40 | 40 | – | – | – |
| | | – | – | 50 | 50 | – |
| | | – | – | – | – | 63 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | – | – | – | – | – |
| | | 20 | 20 | – | – | – |
| | | 25 | 25 | – | – | – |
| | | 31.5 | 31.5 | – | – | – |
| | | 40 | 40 | – | – | – |
| | | – | – | 50 | 50 | – |
| | | – | – | – | – | 63 ([5]) |
| Making capacity | Ip [kA] | – | – | – | – | – |
| | | 50 | 50 | – | – | – |
| | | 63 | 63 | – | – | – |
| | | 80 | 80 | – | – | – |
| | | 100 | 100 | – | – | – |
| | | – | – | 125 | 125 | – |
| | | – | – | – | – | 164 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | – |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | – | • |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 28 ... 40 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 38 ... 55 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | ≤55 |
| Maximum overall dimensions   | H [mm] | 691 | 691 | 691 | 691 | 735 |
| | W [mm] | 653 | 853 | 681 | 853 | 851 |
| | D [mm] | 642 | 642 | 643 | 643 | 650 |
| | Pole center distance P [mm] | 210 | 275 | 210 | 275 | 275 |
| Weight | [kg] | 160 | 166 | 190 | 205 | 270 |
| Standardized dimensions table | TN | 7415 ([3]) | 7416 ([3]) | – | – | – |
| | 1VCD | – | – | 003444 | 003445 | 003943 |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

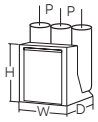
| | | | | | |
|---|---|---|---|---|---|
| **VD4/P 17** | | | | | |
| • | | | | | |
| 17.5 | | | | | |
| 17.5 | | | | | |
| 38 | | | | | |
| 95 | | | | | |
| 50-60 | | | | | |
| 2500 | 2500 | 2500 | 3150 (2) | 3150 (2) | 3150 (2) |
| – | – | – | – | – | – |
| 20 | – | – | 20 | – | – |
| 25 | – | – | 25 | – | – |
| 31.5 | – | – | 31.5 | – | – |
| 40 | – | – | 40 | – | – |
| – | 50 | – | – | 50 | – |
| – | – | 63 | – | – | 63 |
| – | – | – | – | – | – |
| 20 | – | – | 20 | – | – |
| 25 | – | – | 25 | – | – |
| 31.5 | – | – | 31.5 | – | – |
| 40 | – | – | 40 | – | – |
| – | 50 | – | – | 50 | – |
| – | – | 63 (5) | – | – | 63 (5) |
| – | – | – | – | – | – |
| 50 | – | – | 50 | – | – |
| 63 | – | – | 63 | – | – |
| 80 | – | – | 80 | – | – |
| 100 | – | – | 100 | – | – |
| – | 125 | – | – | 125 | – |
| – | – | 164 | – | – | 164 |
| • | • | – | • | • | – |
| – | – | • | – | – | • |
| 33 ... 60 | 33 ... 60 | 28 ... 40 | 33 ... 60 | 33 ... 60 | 28 ... 40 |
| 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| 43 ... 75 | 43 ... 75 | 38 ... 55 | 43 ... 75 | 43 ... 75 | 38 ... 55 |
| 30 ... 60 | 30 ... 60 | ≤55 | 30 ... 60 | 30 ... 60 | ≤55 |
| 691 | 691 | 735 | 730 | 742 | 735 |
| 853 | 853 | 851 | 853 | 853 | 851 |
| 640 | 643 | 650 | 640 | 643 | 650 |
| 275 | 275 | 275 | 275 | 275 | 275 |
| 186 | 225 | 270 | 221 | 240 | 270 |
| 7417 (3) | – | – | – | – | – |
| – | 003446 | 003943 | 000153 (3) | 003447 | 003943 |
| - 5 ... + 40 | | | | | |
| • | | | | | |
| • | | | | | |

(1) Rated current guaranteed with circuit breaker installed in UniGear ZS1 switchgear and with 40 °C ambient temperature.
(2) Up to 4000 A with forced ventilation.
(3) Poles in polyamide
(4) On request, the closing spring can be loaded by means of a removable crank handle outside the operating mechanism (instead of linear loading, only possible with the door open, by means of a lever built into the front of the operating mechanism).
(5) For 1s

# Selection and ordering
## Withdrawable circuit breakers

### Withdrawable circuit breakers for UniGear ZS1 switchgear (24 kV) ([5])

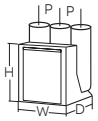



| **Circuit breaker** | | **VD4/P 24** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | | | |
| Rated voltage | Ur [kV] | 24 | | | | | | | |
| Rated insulation voltage | Us [kV] | 24 | | | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 50 | | | | | | | |
| Impulse withstand voltage | Up [kV] | 125 | | | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | | | |
| Rated thermal current (40 °C) ([1]) | Ir [A] | 630 | 630 | 1250 | 1250 | 1600 ([6]) | 2000 ([6]) | 2500 ([2]) ([6]) | 3150 ([3]) ([6]) |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 ([6]) | 25 ([6]) | 25 ([6]) | 25 ([6]) | 25 | 25 | 25 | – |
| | | – | – | 31.5 ([6]) | 31.5 ([6]) | 31.5 | 31.5 | 31.5 | 31.5 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | – |
| | | – | – | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 | 40 | 40 | – |
| | | 50 | 50 | 50 | 50 | 50 | 50 | 50 | – |
| | | 63 | 63 | 63 | 63 | 63 | 63 | 63 | – |
| | | – | – | 80 | 80 | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • | • |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 |
| Maximum overall dimensions   | H [mm] | 794 | 794 | 794 | 794 | 838 | 838 | 838 | 838 |
| | W [mm] | 653 | 853 | 653 | 853 | 853 | 853 | 853 | 853 |
| | D [mm] | 802 | 802 | 802 | 802 | 790 | 790 | 790 | 790 |
| | Pole center distance P [mm] | 210 | 275 | 210 | 275 | 275 | 275 | 275 | 275 |
| Weight | [kg] | 140 | 148 | 140/146 ([4]) | 148 | 228 | 228 | 228 | 277 |
| Standardized dimensions table | TN | 7413 | 7414 | 7413 | 7414 | 7418 | 7418 | 7418 | – |
| | 1VCD | – | – | 000173 ([4]) | 000174 ([4]) | – | – | – | 000177 |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | | | |

([1]) Rated current guaranteed with circuit breaker installed in UniGear ZS1 switchgear and with 40 °C ambient temperature.
([2]) 2300 A rated current guaranteed with natural ventilation; 2500 A rated current guaranteed with forced ventilation.
([3]) 2700 A rated current guaranteed with natural ventilation; 3150 A rated current guaranteed with forced ventilation.
([4]) 31.5 kA version.
([5]) On request, the closing spring can be loaded by means of a removable crank handle outside the operating mechanism (instead of linear loading, only possible with the door open, by means of a lever built into the front of the operating mechanism).
([6]) Contact ABB for the 27 kV version

# Withdrawable circuit breakers for UniGear ZS2 switchgear and Powerbloc modules (36 kV)



| Circuit breaker | | VD4/W 36 | | | | |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | |
| Rated voltage | Ur [kV] | 36 | | | | |
| Rated insulation voltage | Us [kV] | 36 | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 70 | | | | |
| Impulse withstand voltage | Up [kV] | 170 | | | | |
| Rated frequency | fr [Hz] | 50 | | | | |
| Rated thermal current (40 °C) (1) | Ir [A] | 1250 | 1600 | 2000 | 2500 (1) | 3150 (2) |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 |
| | | 80 | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| Opening time | [ms] | 35 ... 60 | 35 ... 60 | 35 ... 60 | 35 ... 60 | 35 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 45 ... 75 | 45 ... 75 | 45 ... 75 | 45 ... 75 | 45 ... 75 |
| Closing time | [ms] | 50 ... 65 | 50 ... 65 | 50 ... 65 | 50 ... 65 | 50 ... 65 |
| Maximum overall dimensions   | H [mm] | 974 | 974 | 974 | 974 | 974 |
| | W [mm] | 880 | 880 | 880 | 880 | 880 |
| | D [mm] | 789 | 789 | 789 | 789 | 789 |
| | Pole center distance P [mm] | 275 | 275 | 275 | 275 | 275 |
| Weight | [kg] | 230 | 245 | 275 | 275/315 | 315 |
| Standardized dimensions table | TN | 2RDA040543 | 2RDA040565 | 2RDA040565 | 2RDA040565 (1) 2RDA040573 | 2RDA040573 |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

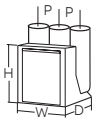
(1) 2500 A with forced ventilation and 79 mm diameter tulip contacts TN 2RDA040565.
2500A without forced ventilation and 109 mm diameter tulip contacts TN 2RDA040573 available for UniGear ZS2 only.
(2) 3150 A with forced ventilation.
Available for UniGear ZS2 only.

# Selection and ordering
## Withdrawable circuit breakers

Withdrawable circuit breakers in floor rolling version for UniGear ZS3.2 switchgear and Powerbloc modules (36 kV)(*)

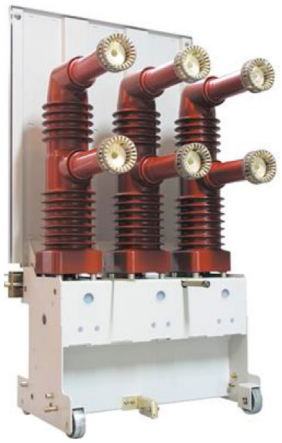


(*) Up to 31.5 kA for UniGear ZS3.2.

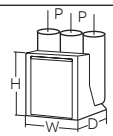
| **Circuit breaker** | | **VD4/P 36** | | | | | |
|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | |
| Rated voltage | Ur [kV] | 36 | | | | | |
| Rated insulation voltage | Us [kV] | 36 | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 95 | | | | | |
| Impulse withstand voltage | Up [kV] | 185 | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | |
| Rated thermal current (40 °C) | Ir [A] | 630 | 1250 | 1600 | 2000 | 2500 (2) | 3150 (1) |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | – | – | – | – |
| | | 20 | 25 | – | – | – | – |
| | | – | 25 | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| | | – | 40 | 40 | 40 | 40 | – |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | – | – | – | – |
| | | 20 | 25 | – | – | – | – |
| | | – | 25 | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| | | – | 40 | 40 | 40 | 40 | – |
| Making capacity | Ip [kA] | 40 | 40 | – | – | – | – |
| | | 50 | 50 | – | – | – | – |
| | | – | 63 | 63 | 63 | 63 | 63 |
| | | – | 80 | 80 | 80 | 80 | 80 |
| | | – | 100 | 100 | 100 | 100 | – |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • |
| Opening time | [ms] | ≤45 | ≤45 | ≤45 | ≤45 | ≤45 | ≤45 |
| Arcing time | [ms] | ≤15 | ≤15 | ≤15 | ≤15 | ≤15 | ≤15 |
| Total breaking time | [ms] | ≤60 | ≤60 | ≤60 | ≤60 | ≤60 | ≤60 |
| Closing time | [ms] | approx. 60 | approx. 60 | approx. 60 | approx. 60 | approx. 60 | approx. 60 |
| Maximum overall dimensions  | H [mm] | 1575 | 1575 | 1575 | 1575 | 1575 | 1575 |
| | W [mm] | 840 | 840 | 840 | 840 | 840 | 840 |
| | D [mm] | 685 | 685 | 685 | 685 | 685 | 685 |
| | Pole center distance P [mm] | 280 | 280 | 280 | 280 | 280 | 280 |
| Weight | [kg] | 290 | 290 | 340 | 340 | 340 | 380 |
| Standardized dimensions table | TN | GCEM 700198 | | | | | |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | |

(1) version only available with forced ventilation and assembled pole

# General characteristics of withdrawable circuit breakers for UniGear ZS3.2 and Powerbloc modules (40 kV)(*)



(*) Up to 31.5 kA for UniGear ZS3.2.

| Circuit breaker | | VD4/P 40 | | | | | |
|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | |
| Rated voltage | Ur [kV] | 40.5 | | | | | |
| Rated insulation voltage | Us [kV] | 40.5 | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 95 | | | | | |
| Impulse withstand voltage | Up [kV] | 200 | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | |
| Rated thermal current (40 °C) | Ir [A] | 630 | 1250 | 1600 | 2000 | 2500 | 3150 (1) |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | – | – | – | – |
| | | 20 | 20 | – | – | – | – |
| | | – | 25 | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| | | – | 40 | 40 | 40 | 40 | |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | – | – | – | – |
| | | 20 | 20 | – | – | – | – |
| | | – | 25 | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| | | – | 40 | 40 | 40 | 40 | |
| Making capacity | Ip [kA] | 40 | 40 | – | – | – | – |
| | | 50 | 50 | – | – | – | – |
| | | – | 63 | 63 | 63 | 63 | 63 |
| | | – | 80 | 80 | 80 | 80 | 80 |
| | | – | 100 | 100 | 100 | 100 | – |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | – | – | – | – | • |
| Opening time | [ms] | ≤45 | ≤45 | ≤45 | ≤45 | ≤45 | ≤45 |
| Arcing time | [ms] | ≤15 | ≤15 | ≤15 | ≤15 | ≤15 | ≤15 |
| Total breaking time | [ms] | ≤60 | ≤60 | ≤60 | ≤60 | ≤60 | ≤60 |
| Closing time | [ms] | approx. 60 | approx. 60 | approx. 60 | approx. 60 | approx. 60 | approx. 60 |
| Maximum overall dimensions  | H [mm] | 1575 | 1575 | 1575 | 1575 | 1575 | 1575 |
| | W [mm] | 840 | 840 | 840 | 840 | 840 | 840 |
| | D [mm] | 685 | 685 | 685 | 685 | 685 | 685 |
| | Pole center distance P [mm] | 280 | 280 | 280 | 280 | 280 | 280 |
| Weight | [kg] | 290 | 290 | 340 | 340 | 340 | 380 |
| Standardized dimensions table | TN | GCEM 700198 | | | | | |
| Operating temperature | [°C] | - 5° ... + 40° | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | |

(1) version only available with forced ventilation and assembled pole

# Selection and ordering
## Withdrawable circuit breakers

### Types of withdrawable circuit breakers available for UniGear ZS1 switchgear

Complete the circuit breaker selected with the optional accessories indicated on the following pages.

**VD4 (12 kV) withdrawable circuit breaker**

| Ur | Isc | Rated thermal current (40 °C) [A] | | | | | |
|---|---|---|---|---|---|---|---|
| | | W=650 | W=650 | W=800 | W=1000 | W=1000 | |
| | | P=150 | P=150 | P=210 | P=275 | P=275 | |
| kV | kA | u/l=205 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | Circuit breaker type |
| | | ø=35 | ø=45 | ø=79 | ø=79 | ø=109 | |
| | 16 | 630 | | | | | VD4/P 12.06.16 p150 |
| | 20 | 630 | | | | | VD4/P 12.06.20 p150 |
| | 25 | 630 | | | | | VD4/P 12.06.25 p150 |
| | 31.5 | 630 | | | | | VD4/P 12.06.32 p150 |
| | 16 | 1250 | | | | | VD4/P 12.12.16 p150 |
| | 20 | 1250 | | | | | VD4/P 12.12.20 p150 |
| | 25 | 1250 | | | | | VD4/P 12.12.25 p150 |
| | 31.5 | 1250 | | | | | VD4/P 12.12.32 p150 |
| | 40 | | 1250 | | | | VD4/P 12.12.40 p150 |
| | 40 | | | 1250 | | | VD4/P 12.12.40 p210 |
| | 50 | | | 1250 | | | VD4/P 12.12.50 p210 |
| | 20 | | | 1600 | | | VD4/P 12.16.20 p210 |
| | 25 | | | 1600 | | | VD4/P 12.16.25 p210 |
| | 31.5 | | | 1600 | | | VD4/P 12.16.32 p210 |
| | 40 | | | 1600 | | | VD4/P 12.16.40 p210 |
| | 50 | | | 1600 | | | VD4/P 12.16.50 p210 |
| | 20 | | | 2000 | | | VD4/P 12.20.20 p210 |
| | 25 | | | 2000 | | | VD4/P 12.20.25 p210 |
| | 31.5 | | | 2000 | | | VD4/P 12.20.32 p210 |
| | 40 | | | 2000 | | | VD4/P 12.20.40 p210 |
| | 50 | | | 2000 | | | VD4/P 12.20.50 p210 |
| | 40 | | | | 1250 | | VD4/P 12.12.40 p275 |
| | 63 | | | | | 1250 | VD4/P 12.12.63 p275 |
| 12 | 20 | | | | 1600 | | VD4/P 12.16.20 p275 |
| | 25 | | | | 1600 | | VD4/P 12.16.25 p275 |
| | 31.5 | | | | 1600 | | VD4/P 12.16.32 p275 |
| | 40 | | | | 1600 | | VD4/P 12.16.40 p275 |
| | 50 | | | | 1600 | | VD4/P 12.16.50 p275 |
| | 63 | | | | | 1600 | VD4/P 12.16.63 p275 |
| | 20 | | | | 2000 | | VD4/P 12.20.20 p275 |
| | 25 | | | | 2000 | | VD4/P 12.20.25 p275 |
| | 31.5 | | | | 2000 | | VD4/P 12.20.32 p275 |
| | 40 | | | | 2000 | | VD4/P 12.20.40 p275 |
| | 50 | | | | 2000 | | VD4/P 12.20.50 p275 |
| | 63 | | | | | 2000 | VD4/P 12.20.63 p275 |
| | 20 | | | | | 2500 | VD4/P 12.25.20 p275 |
| | 25 | | | | | 2500 | VD4/P 12.25.25 p275 |
| | 31.5 | | | | | 2500 | VD4/P 12.25.32 p275 |
| | 40 | | | | | 2500 | VD4/P 12.25.40 p275 |
| | 50 | | | | | 2500 | VD4/P 12.25.50 p275 |
| | 63 | | | | | 2500 | VD4/P 12.25.63 p275 |
| | 20 | | | | | 3150 (1) | VD4/P 12.32.20 p275 |
| | 25 | | | | | 3150 (1) | VD4/P 12.32.25 p275 |
| | 31.5 | | | | | 3150 (1) | VD4/P 12.32.32 p275 |
| | 40 | | | | | 3150 (1) | VD4/P 12.32.40 p275 |
| | 50 | | | | | 3150 (1) | VD4/P 12.32.50 p275 |
| | 63 | | | | | 3150 (1) | VD4/P 12.32.63 p275 |

W = Switchgear width.
P = Horizontal center distance of poles.
u/l = Distance between bottom and top terminals.
ø = Diameter of isolating contact.
(1) Up to 4000 A with forced ventilation.

## VD4 (17.5 kV) withdrawable circuit breaker for UniGear ZS1 switchgear

| Ur | Isc | Rated thermal current (40 °C) [A] | | | | | |
|---|---|---|---|---|---|---|---|
| | | W=650 | W=650 | W=800 | W=1000 | W=1000 | |
| | | P=150 | P=150 | P=210 | P=275 | P=275 | |
| kV | kA | u/l=205 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | Circuit breaker type |
| | | ø=35 | ø=45 | ø=79 | ø=79 | ø=109 | |
| | 16 | 630 | | | | | VD4/P 17.06.16 p150 |
| | 20 | 630 | | | | | VD4/P 17.06.20 p150 |
| | 25 | 630 | | | | | VD4/P 17.06.25 p150 |
| | 31.5 | 630 | | | | | VD4/P 17.06.32 p150 |
| | 16 | 1250 | | | | | VD4/P 17.12.16 p150 |
| | 20 | 1250 | | | | | VD4/P 17.12.20 p150 |
| | 25 | 1250 | | | | | VD4/P 17.12.25 p150 |
| | 31.5 | 1250 | | | | | VD4/P 17.12.32 p150 |
| | 40 | | 1250 | | | | VD4/P 17.12.40 p150 |
| | 40 | | | 1250 | | | VD4/P 17.12.40 p210 |
| | 50 | | | 1250 | | | VD4/P 17.12.50 p210 |
| | 20 | | | 1600 | | | VD4/P 17.16.20 p210 |
| | 25 | | | 1600 | | | VD4/P 17.16.25 p210 |
| | 31.5 | | | 1600 | | | VD4/P 17.16.32 p210 |
| | 40 | | | 1600 | | | VD4/P 17.16.40 p210 |
| | 50 | | | 1600 | | | VD4/P 17.16.50 p210 |
| | 20 | | | 2000 | | | VD4/P 17.20.20 p210 |
| | 25 | | | 2000 | | | VD4/P 17.20.25 p210 |
| | 31.5 | | | 2000 | | | VD4/P 17.20.32 p210 |
| | 40 | | | 2000 | | | VD4/P 17.20.40 p210 |
| | 50 | | | 2000 | | | VD4/P 17.20.50 p210 |
| | 40 | | | | 1250 | | VD4/P 17.12.40 p275 |
| | 63 | | | | | 1250 | VD4/P 17.12.63 p275 |
| 17.5 | 20 | | | | 1600 | | VD4/P 17.16.20 p275 |
| | 25 | | | | 1600 | | VD4/P 17.16.25 p275 |
| | 31.5 | | | | 1600 | | VD4/P 17.16.32 p275 |
| | 40 | | | | 1600 | | VD4/P 17.16.40 p275 |
| | 50 | | | | 1600 | | VD4/P 17.16.50 p275 |
| | 63 | | | | | 1600 | VD4/P 17.16.63 p275 |
| | 20 | | | | 2000 | | VD4/P 17.20.20 p275 |
| | 25 | | | | 2000 | | VD4/P 17.20.25 p275 |
| | 31.5 | | | | 2000 | | VD4/P 17.20.32 p275 |
| | 40 | | | | 2000 | | VD4/P 17.20.40 p275 |
| | 50 | | | | 2000 | | VD4/P 17.20.50 p275 |
| | 63 | | | | | 2000 | VD4/P 17.20.63 p275 |
| | 20 | | | | | 2500 | VD4/P 17.25.20 p275 |
| | 25 | | | | | 2500 | VD4/P 17.25.25 p275 |
| | 31.5 | | | | | 2500 | VD4/P 17.25.32 p275 |
| | 40 | | | | | 2500 | VD4/P 17.25.40 p275 |
| | 50 | | | | | 2500 | VD4/P 17.25.50 p275 |
| | 63 | | | | | 2500 | VD4/P 17.25.63 p275 |
| | 20 | | | | | 3150 (1) | VD4/P 17.32.20 p275 |
| | 25 | | | | | 3150 (1) | VD4/P 17.32.25 p275 |
| | 31.5 | | | | | 3150 (1) | VD4/P 17.32.32 p275 |
| | 40 | | | | | 3150 (1) | VD4/P 17.32.40 p275 |
| | 50 | | | | | 3150 (1) | VD4/P 17.32.50 p275 |
| | 63 | | | | | 3150 (1) | VD4/P 17.32.63 p275 |

W = Switchgear width.
P = Horizontal center distance of poles.
u/l = Distance between bottom and top terminals.
ø = Diameter of isolating contact.
(1) Up to 4000 A with forced ventilation.

# Selection and ordering
## Withdrawable circuit breakers

**VD4 (24 kV) withdrawable circuit breaker for UniGear ZS1 switchgear**

| Ur | Isc | Rated thermal current (40 °C) [A] | | | | |
|---|---|---|---|---|---|---|
| | | W=800 | W=1000 | W=1000 | W=1000 | |
| | | P=210 | P=275 | P=275 | P=275 | |
| kV | kA | u/l=310 | u/l=310 | u/l=310 | u/l=310 | Circuit breaker type |
| | | ø=35 | ø=35 | ø=79 | ø=109 | |
| | 16 | 630 | | | | VD4/P 24.06.16 p210 |
| | 20 | 630 | | | | VD4/P 24.06.20 p210 |
| | 25 | 630 | | | | VD4/P 24.06.25 p210 |
| | 16 | 1250 | | | | VD4/P 24.12.16 p210 |
| | 20 | 1250 | | | | VD4/P 24.12.20 p210 |
| | 25 | 1250 | | | | VD4/P 24.12.25 p210 |
| | 31.5 | 1250 | | | | VD4/P 24.12.32 p210 |
| | 16 | | 630 | | | VD4/P 24.06.16 p275 |
| | 20 | | 630 | | | VD4/P 24.06.20 p275 |
| | 25 | | 630 | | | VD4/P 24.06.25 p275 |
| | 16 | | 1250 | | | VD4/P 24.12.16 p275 |
| | 20 | | 1250 | | | VD4/P 24.12.20 p275 |
| | 25 | | 1250 | | | VD4/P 24.12.25 p275 |
| 24 | 31.5 | | 1250 | | | VD4/P 24.12.32 p275 |
| | 16 | | | 1600 | | VD4/P 24.16.16 p275 |
| | 20 | | | 1600 | | VD4/P 24.16.20 p275 |
| | 25 | | | 1600 | | VD4/P 24.16.25 p275 |
| | 31.5 | | | 1600 | | VD4/P 24.16.32 p275 |
| | 16 | | | 2000 | | VD4/P 24.20.16 p275 |
| | 20 | | | 2000 | | VD4/P 24.20.20 p275 |
| | 25 | | | 2000 | | VD4/P 24.20.25 p275 |
| | 31.5 | | | 2000 | | VD4/P 24.20.32 p275 |
| | 16 | | | 2300 (1) | | VD4/P 24.25.16 p275 |
| | 20 | | | 2300 (1) | | VD4/P 24.25.20 p275 |
| | 25 | | | 2300 (1) | | VD4/P 24.25.25 p275 |
| | 31.5 | | | 2300 (1) | | VD4/P 24.25.32 p275 |
| | 31.5 | | | | 2700 (2) | VD4/P 24.32.32 p275 |

W = Switchgear width.
P = Horizontal center distance of poles.
u/l = Distance between bottom and top terminals.
ø = Diameter of isolating contact.
(1) 2500 A rated current guaranteed with forced ventilation.
(2) 3150 A rated current guaranteed with forced ventilation.

## VD4 withdrawable circuit breaker in floor rolling version (36 kV)

| Ur | Isc | Rated thermal current (40 °C) [A] | | | | | Circuit breaker type |
|---|---|---|---|---|---|---|---|
| kV | kA | H= 1575<br>W= 840<br>D= 685<br>u/l=328<br>l/g=900<br>P=280 | | | | | |
| 36 | 16 | 630A | | | | | VD4/P 36.06.16 p280 |
| | 20 | 630A | | | | | VD4/P 36.06.20 p280 |
| | 16 | | 1250A | | | | VD4/P 36.12.16 p280 |
| | 20 | | 1250A | | | | VD4/P 36.12.20 p280 |
| | 25 | | 1250A | | | | VD4/P 36.12.25 p280 |
| | 31.5 | | 1250A | | | | VD4/P 36.12.31 p280 |
| | 40 | | 1250A | | | | VD4/P 36.12.40 p280 |
| | 25 | | | 1600A | | | VD4/P 36.16.25 p280 |
| | 31.5 | | | 1600A | | | VD4/P 36.16.31 p280 |
| | 40 | | | 1600A | | | VD4/P 36.16.40 p280 |
| | 25 | | | | 2000A | | VD4/P 36.20.25 p280 |
| | 31.5 | | | | 2000A | | VD4/P 36.20.31 p280 |
| | 40 | | | | 2000A | | VD4/P 36.20.40 p280 |
| | 25 | | | | | 2500A | VD4/P 36.25.25 p280 |
| | 31.5 | | | | | 2500A | VD4/P 36.25.31 p280 |
| | 40 | | | | | 2500A | VD4/P 36.25.40 p280 |
| | 25 | | | | | 3150A | VD4/P 36.31.25 p280 ([1]) |
| | 31.5 | | | | | 3150A | VD4/P 36.31.31 p280 ([1]) |

H = Height of circuit breaker
W = Switchgear width.
D = Depth of circuit breaker.
u/l = Distance between bottom and top terminals.
l/g = Distance between bottom terminal and bearing surface of circuit breaker.
P = Horizontal center distance of poles.
([1]) version only available with forced ventilation and assembled pole

# Selection and ordering
## Withdrawable circuit breakers

### VD4 (36 kV) withdrawable circuit breaker

| Ur | Isc | Rated thermal current (40 °C) [A] | |
|---|---|---|---|
| kV | kA | H = 951 - W = 788 - D = 778 - u/l = 380 - l/g = 399 - P = 275 | Circuit breaker type |
| 36 | 20 | 1250 A | VD4/W 36.12.20 p275 |
| | 25 | 1250 A | VD4/W 36.12.25 p275 |
| | 31.5 | 1250 A | VD4/W 36.12.32 p275 |
| | 20 | 1600 A | VD4/W 36.16.20 p275 |
| | 25 | 1600 A | VD4/W 36.16.25 p275 |
| | 31.5 | 1600 A | VD4/W 36.16.32 p275 |
| | 20 | 2000 A | VD4/W 36.20.20 p275 |
| | 25 | 2000 A | VD4/W 36.20.25 p275 |
| | 31.5 | 2000 A | VD4/W 36.20.32 p275 |
| | 20 | 2500 A (1) | VD4/W 36.25.20 p275 |
| | 25 | 2500 A (1) | VD4/W 36.25.25 p275 |
| | 31.5 | 2500 A (1) | VD4/W 36.25.32 p275 |
| | 20 | 3150 A (2) | VD4/W 36.32.20 p275 |
| | 25 | 3150 A (2) | VD4/W 36.32.25 p275 |
| | 31.5 | 3150 A (2) | VD4/W 36.32.32 p275 |

H = Height of circuit breaker.
D = Depth of circuit breaker.
W = Width of circuit breaker.
u/l = Distance between bottom and top terminals.
l/g = Distance between bottom terminal and bearing surface of circuit breaker.
P = Horizontal center distance of poles.
(1) 2500 A rated current guaranteed with forced ventilation and 79 mm diameter tulip contacts (TN 1VYN300901-RA)
2500 A without forced ventilation and 109 mm diameter tulip contacts TN 1VYN300901-RB available for UniGear ZS2 only.
(2) 3150 A rated current guaranteed with forced ventilation. Available for UniGear ZS2 only.

### VD4 withdrawable circuit breaker in floor rolling version (40 kV)

| Ur | Isc | Rated thermal current (40 °C) [A] | |
|---|---|---|---|
| kV | kA | H= 1575<br>W= 840<br>D= 685<br>u/l=328<br>l/g=900<br>P=280 | Circuit breaker type |
| 40 | 16 | 630A | VD4/P 40.06.16 p280 |
| | 20 | 630A | VD4/P 40.06.20 p280 |
| | 16 | 1250A | VD4/P 40.12.16 p280 |
| | 20 | 1250A | VD4/P 40.12.20 p280 |
| | 25 | 1250A | VD4/P 40.12.25 p280 |
| | 31.5 | 1250A | VD4/P 40.12.31 p280 |
| | 40 | 1250A | VD4/P 40.12.40 p280 |
| | 25 | 1600A | VD4/P 40.16.25 p280 |
| | 31.5 | 1600A | VD4/P 40.16.31 p280 |
| | 40 | 1600A | VD4/P 40.16.40 p280 |
| | 25 | 2000A | VD4/P 40.20.25 p280 |
| | 31.5 | 2000A | VD4/P 40.20.31 p280 |
| | 40 | 2000A | VD4/P 40.20.40 p280 |
| | 25 | 2500A | VD4/P 40.25.25 p280 |
| | 31.5 | 2500A | VD4/P 40.25.31 p280 |
| | 40 | 2500A | VD4/P 40.25.40 p280 |
| | 25 | 3150A | VD4/P 40.31.25 p280 (1) |
| | 31.5 | 3150A | VD4/P 40.31.31 p280 (1) |

H = Height of circuit breaker.
D = Depth of circuit breaker.
W = Width of circuit breaker.
u/l = Distance between bottom and top terminals.
l/g = Distance between bottom terminal and bearing surface of circuit breaker.
P = Horizontal center distance of poles
(1) Version only available with forced ventilation and assembled pole

**Standard equipment of withdrawable circuit breakers for UniGear ZS1, ZS2, ZS3.2 switchgear and similar panels**

The basic versions of the withdrawable circuit breakers are three-pole and equipped with:

- EL manual operating mechanism
- mechanical signaling device for closing springs loaded/discharged
- mechanical signaling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten circuit breaker open/closed auxiliary contacts

  Note: three break contacts (signaling circuit breaker open) and four make contacts (signaling circuit breaker closed) are available with the group of ten auxiliary contacts supplied as standard and the maximum number of electrical applications.
- lever built into operating mechanism for linear loading of closing spring
- isolating contacts
- cord with connector (plug only) for auxiliary circuits, with striker pins which prevent the plug from being inserted into the socket if the rated current of the circuit breaker is lower than the rated current of the panel
- racking-out/in lever (the quantity depends on the number of apparatuses ordered)
- locking electromagnet in the truck (mandatory for ABB switchgear). This device prevents the circuit breaker from being racked into the switchgear when the auxiliary circuits are not connected (plug not in in the socket)
- door interlock (mandatory for ABB switchgear). This device prevents the circuit breaker from being racked into the switchgear when the switchgear door is open.



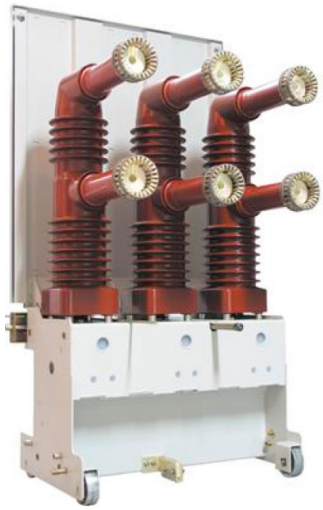

VD4 with poles in polyamide




VD4 - 36 kV




VD4 - up to 24 kV

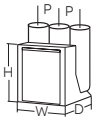


VD4 - 36/40 kV in floor rolling version

# Selection and ordering
## Withdrawable circuit breakers

### Withdrawable circuit breakers for PowerCube modules (12 kV) ([5])




| **Circuit breaker** | | **VD4/P 12** | | **VD4/W 12 ([6])** | | | |
|---|---|---|---|---|---|---|---|
| | **PowerCube module** | **PB1** | | **PB2** | | | |
| Standards | IEC 62271-100 | • | | • | | | |
| Rated voltage | Ur [kV] | 12 ([4]) | | 12 | | | |
| Rated insulation voltage | Us [kV] | 12 | | 12 | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | 28 | | | |
| Impulse withstand voltage | Up [kV] | 75 | | 75 | | | |
| Rated frequency | fr [Hz] | 50-60 | | 50-60 | | | |
| Rated thermal current (40 °C) ([1]) | Ir [A] | 630 | 1250 | 630 | 1250 | 1250 | 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | 16 | 16 | – | – |
| | | 20 | 20 | 20 | 20 | – | – |
| | | 25 | 25 | 25 | 25 | – | – |
| | | 31.5 | 31.5 | 31.5 | 31.5 | – | – |
| | | – | – | – | – | 40 | – |
| | | – | – | – | – | – | 50 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | – | – |
| | | 20 | 20 | 20 | 20 | – | – |
| | | 25 | 25 | 25 | 25 | – | – |
| | | 31.5 | 31.5 | 31.5 | 31.5 | – | – |
| | | – | – | – | – | 40 | – |
| | | – | – | – | – | – | 50 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | – | – |
| | | 50 | 50 | 50 | 50 | – | – |
| | | 63 | 63 | 63 | 63 | – | – |
| | | 80 | 80 | 80 | 80 | – | – |
| | | – | – | – | – | 100 | – |
| | | – | – | – | – | – | 125 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | | • | | • | |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 |
| Maximum overall dimensions   | H [mm] | 628 | 628 | 691 | 691 | 691 | 691 |
| | W [mm] | 503 | 503 | 653 | 853 | 653 | 681 |
| | D [mm] | 662 | 662 | 642 | 642 | 641 | 643 |
| | Pole center distance P [mm] | 150 | 150 | 210 | 210 | 210 | 210 |
| Weight | [kg] | 116 | 116 | 135 | 135 | 174 | 180 |
| Standardized dimensions table | TN | 7412 ([3]) | 7412 ([3]) | 7420 ([3]) | 7420 ([3]) | – | – |
| | 1VCD | – | – | – | – | 601243 ([3]) | 003444 |
| Operating temperature | [°C] | - 5 ... + 40 | | - 5 ... + 40 | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | • | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | • | | | |

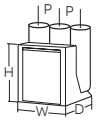
| VD4/P 12 | | | | | | | VD4/W 12 | |
|---|---|---|---|---|---|---|---|---|
| PB2 | | | | | PB3 | | PB3 | |
| • | | | | | • | | • | |
| 12 (4) | | | | | 12 (4) | | 12 | |
| 12 | | | | | 12 | | 12 | |
| 28 | | | | | 28 | | 28 | |
| 75 | | | | | 75 | | 75 | |
| 50-60 | | | | | 50-60 | | 50-60 | |
| 1600 | 1600 | 1600 | 2000 | 2000 | 2500 | 2500 | 3150 (2) | 3150 (2) |
| – | – | – | – | – | – | – | – | – |
| 20 | – | – | 20 | – | 20 | – | 20 | – |
| 25 | – | – | 25 | – | 25 | – | 25 | – |
| 31.5 | – | – | 31.5 | – | 31.5 | – | 31.5 | – |
| – | 40 | – | 40 | – | 40 | – | 40 | – |
| – | – | 50 | – | 50 | – | 50 | – | 50 |
| – | – | – | – | – | – | – | – | – |
| 20 | – | – | 20 | – | 20 | – | 20 | – |
| 25 | – | – | 25 | – | 25 | – | 25 | – |
| 31.5 | – | – | 31.5 | – | 31.5 | – | 31.5 | – |
| – | 40 | – | 40 | – | 40 | – | 40 | – |
| – | – | 50 | – | 50 | – | 50 | – | 50 |
| – | – | – | – | – | – | – | – | – |
| 50 | – | – | 50 | – | 50 | – | 50 | – |
| 63 | – | – | 63 | – | 63 | – | 63 | – |
| 80 | – | – | 80 | – | 80 | – | 80 | – |
| – | 100 | – | 100 | – | 100 | – | 100 | – |
| – | – | 125 | – | 125 | – | 125 | – | 125 |
| • | | | | | • | | • | |
| 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 |
| 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 |
| 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 |
| 691 | 691 | 691 | 690 | 691 | 691 | 691 | 730 | 691 |
| 653 | 653 | 681 | 653 | 681 | 853 | 853 | 853 | 853 |
| 642 | 641 | 643 | 642 | 643 | 640 | 643 | 640 | 643 |
| 210 | 210 | 210 | 210 | 210 | 275 | 275 | 275 | 275 |
| 160 | 174 | 180 | 160 | 190 | 186 | 225 | 221 | 240 |
| 7415 (3) | – | – | 7415 (3) | – | 7417 (3) | – | – | – |
| – | 003284 (3) | 003444 | – | 003444 | – | 003445 | 000152 (3) | 003596 |
| - 5 ... + 40 | | | | | - 5 ... + 40 | | - 5 ... + 40 | |
| • | | | | | • | | • | |
| • | | | | | • | | • | |

(1) Rated current guaranteed with circuit breaker installed in PowerCube enclosure and with 40 °C ambient temperature
(2) Up to 4000 A with forced ventilation.
(3) Poles in polyamide
(4) Available in 10 kV voltage version to GOST standards
(5) On request, the closing spring can be loaded by means of a removable crank handle outside the operating mechanism(instead of linear loading, only possible with the door open, by means of a lever built into the front of the operating mechanism).
(6) VD4/W does not need insulation for the feed-through and tulip contacts in module PB2. On request, the same circuit breaker with insulated feed-through and tulip contacts is available for installation in enclosures not produced by ABB (version VD4/PW)

# Selection and ordering
## Withdrawable circuit breakers

### Withdrawable circuit breakers for PowerCube modules (17.5 kV) ([4])




| **Circuit breaker** | | **VD4/P 17** | | **VD4/W 17 ([5])** | | | |
|---|---|---|---|---|---|---|---|
| | **PowerCube module** | **PB1** | | **PB2** | | | |
| Standards | IEC 62271-100 | • | | • | | | |
| Rated voltage | Ur [kV] | 17.5 | | 17.5 | | | |
| Rated insulation voltage | Us [kV] | 17.5 | | 17.5 | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 38 | | 38 | | | |
| Impulse withstand voltage | Up [kV] | 95 | | 95 | | | |
| Rated frequency | fr [Hz] | 50-60 | | 50-60 | | | |
| Rated thermal current (40 °C) ([1]) | Ir [A] | 630 | 1250 | 630 | 1250 | 1250 | 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | 16 | 16 | – | – |
| | | 20 | 20 | 20 | 20 | – | – |
| | | 25 | 25 | 25 | 25 | – | – |
| | | 31.5 | 31.5 | 31.5 | 31.5 | – | – |
| | | – | – | – | – | 40 | – |
| | | – | – | – | – | – | 50 |
| Admissible rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | – | – |
| | | 20 | 20 | 20 | 20 | – | – |
| | | 25 | 25 | 25 | 25 | – | – |
| | | 31.5 | 31.5 | 31.5 | 31.5 | – | – |
| | | – | – | – | – | 40 | – |
| | | – | – | – | – | – | 50 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | – | – |
| | | 50 | 50 | 50 | 50 | – | – |
| | | 63 | 63 | 63 | 63 | – | – |
| | | 80 | 80 | 80 | 80 | – | – |
| | | – | – | – | – | 100 | – |
| | | – | – | – | – | – | 125 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 |
| Maximum overall dimensions   | H [mm] | 628 | 628 | 691 | 691 | 691 | 691 |
| | W [mm] | 503 | 503 | 653 | 653 | 653 | 681 |
| | D [mm] | 662 | 662 | 642 | 642 | 641 | 643 |
| | Pole center distance P [mm] | 150 | 150 | 210 | 210 | 210 | 210 |
| Weight | [kg] | 116 | 116 | 135 | 135 | 174 | 180 |
| Standardized dimensions table | TN | 7412 ([3]) | 7412 ([3]) | 7420 ([3]) | 7420 ([3]) | – | – |
| | 1VCD | – | – | – | – | 601243 ([3]) | 003444 |
| Operating temperature | [°C] | - 5 ... + 40 | | - 5 ... + 40 | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | • | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | • | | | |

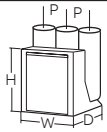
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **VD4/P 17** | | | | | | | **VD4/W 17** | |
| **PB2** | | | | | **PB3** | | **PB3** | |
| • | | | | | • | | • | |
| 17.5 | | | | | 17.5 | | 17.5 | |
| 17.5 | | | | | 17.5 | | 17.5 | |
| 38 | | | | | 38 | | 38 | |
| 95 | | | | | 95 | | 95 | |
| 50-60 | | | | | 50-60 | | 50-60 | |
| 1600 | 1600 | 1600 | 2000 | 2000 | 2500 | 2500 | 3150 (2) | 3150 (2) |
| – | – | – | – | – | – | – | – | – |
| 20 | – | – | 20 | – | 20 | – | 20 | – |
| 25 | – | – | 25 | – | 25 | – | 25 | – |
| 31.5 | – | – | 31.5 | – | 31.5 | – | 31.5 | – |
| – | 40 | – | 40 | – | 40 | – | 40 | – |
| – | – | 50 | – | 50 | – | 50 | – | 50 |
| – | – | – | – | – | – | – | – | – |
| 20 | – | – | 20 | – | 20 | – | 20 | – |
| 25 | – | – | 25 | – | 25 | – | 25 | – |
| 31.5 | – | – | 31.5 | – | 31.5 | – | 31.5 | – |
| – | 40 | – | 40 | – | 40 | – | 40 | – |
| – | – | 50 | – | 50 | – | 50 | – | 50 |
| – | – | – | – | – | – | – | – | – |
| 50 | – | – | 50 | – | 50 | – | 50 | – |
| 63 | – | – | 63 | – | 63 | – | 63 | – |
| 80 | – | – | 80 | – | 80 | – | 80 | – |
| – | 100 | – | 100 | – | 100 | – | 100 | – |
| – | – | 125 | – | 125 | – | 125 | – | 125 |
| • | • | • | • | • | • | • | • | • |
| 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 |
| 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 |
| 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 |
| 691 | 691 | 691 | 690 | 691 | 691 | 691 | 730 | 691 |
| 653 | 653 | 681 | 653 | 681 | 853 | 853 | 853 | 853 |
| 642 | 641 | 643 | 642 | 643 | 640 | 643 | 640 | 643 |
| 210 | 210 | 210 | 210 | 210 | 275 | 275 | 275 | 275 |
| 160 | 174 | 180 | 160 | 190 | 186 | 225 | 221 | 240 |
| 7415 (3) | – | – | 7415 (3) | – | 7417 (3) | – | – | – |
| – | 003284 (3) | 003444 | – | 003444 | – | 003445 | 000152 (3) | 003596 |
| - 5 ... + 40 | | | | | - 5 ... + 40 | | - 5 ... + 40 | |
| • | | | | | • | | • | |
| • | | | | | • | | • | |

(1) Rated current guaranteed with circuit breaker installed in PowerCube enclosure and with 40 °C ambient temperature.
(2) Up to 4000 A with forced ventilation.
(3) Poles in polyamide.
(4) On request, the closing spring can be loaded by means of a removable crank handle outside the operating mechanism (instead of linear loading, only possible with the door open, by means of a lever built into the front of the operating mechanism).
(5) VD4/W does not need insulation for the feed-through and tulip contacts in module PB2. On request, the same circuit breaker with insulated feed-through and tulip contacts is available for installation in enclosures not produced by ABB (version VD4/PW).

# Selection and ordering
## Withdrawable circuit breakers

### Withdrawable circuit breakers for PowerCube modules (24 kV) ([4])




| **Circuit breaker** | | **VD4/P 24** | | | | |
|---|---|---|---|---|---|---|
| | **PowerCube module** | **PB4** | | **PB5** | | |
| Standards | IEC 62271-100 | • | | • | | |
| Rated voltage | Ur [kV] | 24 | | 24 | | |
| Rated insulation voltage | Us [kV] | 24 | | 24 | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 50 | | 50 | | |
| Impulse withstand voltage | Up [kV] | 125 | | 125 | | |
| Rated frequency | fr [Hz] | 50-60 | | 50-60 | | |
| Rated thermal current (40 °C) ([1]) | Ir [A] | 630 | 1250 | 1600 | 2000 | 2500 ([2]) |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 |
| | | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 |
| | | – | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| Opening time | [ms] | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 | 33 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 | 43 ... 75 |
| Closing time | [ms] | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 | 30 ... 60 |
| Maximum overall dimensions   | H [mm] | 794 | 794 | 838 | 838 | 838 |
| | W [mm] | 653 | 653 | 853 | 853 | 853 |
| | D [mm] | 802 | 802 | 790 | 790 | 790 |
| | Pole center distance P [mm] | 210 | 210 | 275 | 275 | 275 |
| Weight | [kg] | 140 | 140/146 ([3]) | 228 | 228 | 228 |
| Standardized dimensions table | TN | 7413 | 7413 | 7418 | 7418 | 7418 |
| | 1VCD | – | 000173 ([3]) | – | – | – |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

([1]) Rated current guaranteed with circuit breaker installed in PowerCube enclosure and with 40 °C ambient temperature.
([2]) 2300 A rated uninterrupted current guaranteed with natural ventilation; 2500 A rated uninterrupted current guaranteed with forced ventilation.
([3]) 31.5 kA version.
([4]) On request, the closing spring can be loaded by means of a removable crank handle outside the operating mechanism (instead of linear loading, only possible with the door open, by means of a lever built into the front of the operating mechanism).



# Selection and ordering
## Withdrawable circuit breakers

### Types of withdrawable circuit breakers available for PowerCube modules

Complete the circuit breaker selected with the optional accessories indicated on the following pages.

**VD4 (12 kV) withdrawable circuit breaker**

| Ur | Isc | Rated thermal current (40 °C) [A] | | | | Circuit breaker type |
|---|---|---|---|---|---|---|
| | | W=650 | W=750 | W=750 | W=1000 | |
| | | P=150 | P=210 | P=210 | P=275 | |
| kV | kA | u/l=205 | u/l=310 | u/l=310 | u/l=310 | |
| | | ø=35 | ø=35 | ø=79 | ø=109 | |
| | 16 | 630 | | | | VD4/P 12.06.16 p150 |
| | 20 | 630 | | | | VD4/P 12.06.20 p150 |
| | 25 | 630 | | | | VD4/P 12.06.25 p150 |
| | 31,5 | 630 | | | | VD4/P 12.06.32 p150 |
| | 16 | 1250 | | | | VD4/P 12.12.16 p150 |
| | 20 | 1250 | | | | VD4/P 12.12.20 p150 |
| | 25 | 1250 | | | | VD4/P 12.12.25 p150 |
| | 31,5 | 1250 | | | | VD4/P 12.12.32 p150 |
| | 16 | | 630 | | | VD4/W 12.06.16 p210 |
| | 20 | | 630 | | | VD4/W 12.06.20 p210 |
| | 25 | | 630 | | | VD4/W 12.06.25 p210 |
| | 31,5 | | 630 | | | VD4/W 12.06.32 p210 |
| | 16 | | 1250 | | | VD4/W 12.12.16 p210 |
| | 20 | | 1250 | | | VD4/W 12.12.20 p210 |
| | 25 | | 1250 | | | VD4/W 12.12.25 p210 |
| | 31,5 | | 1250 | | | VD4/W 12.12.32 p210 |
| | 40 | | 1250 | | | VD4/W 12.12.40 p210 |
| | 40 | | | 1250 | | VD4/P 12.12.40 p210 |
| | 50 | | | 1250 | | VD4/P 12.12.50 p210 |
| 12 | 20 | | | 1600 | | VD4/P 12.16.20 p210 |
| | 25 | | | 1600 | | VD4/P 12.16.25 p210 |
| | 31,5 | | | 1600 | | VD4/P 12.16.32 p210 |
| | 40 | | | 1600 | | VD4/P 12.16.40 p210 |
| | 50 | | | 1600 | | VD4/P 12.16.50 p210 |
| | 20 | | | 2000 | | VD4/P 12.20.20 p210 |
| | 25 | | | 2000 | | VD4/P 12.20.25 p210 |
| | 31,5 | | | 2000 | | VD4/P 12.20.32 p210 |
| | 40 | | | 2000 | | VD4/P 12.20.40 p210 |
| | 50 | | | 2000 | | VD4/P 12.20.50 p210 |
| | 20 | | | | 2500 | VD4/P 12.25.20 p275 |
| | 25 | | | | 2500 | VD4/P 12.25.25 p275 |
| | 31,5 | | | | 2500 | VD4/P 12.25.32 p275 |
| | 40 | | | | 2500 | VD4/P 12.25.40 p275 |
| | 50 | | | | 2500 | VD4/P 12.25.50 p275 |
| | 20 | | | | 3150 (1) | VD4/W 12.32.20 p275 |
| | 25 | | | | 3150 (1) | VD4/W 12.32.25 p275 |
| | 31,5 | | | | 3150 (1) | VD4/W 12.32.32 p275 |
| | 40 | | | | 3150 (1) | VD4/W 12.32.40 p275 |
| | 50 | | | | 3150 (1) | VD4/W 12.32.50 p275 |

W = Enclosure width.
P = Horizontal center distance of poles.
u/l = Distance between bottom and top terminal.
ø = Diameter of isolating contact.
(1) Up to 4000 A with forced ventilation.

## VD4 (17.5 kV) withdrawable circuit breaker

| Ur | Isc | Rated thermal current (40 °C) [A] | | | | |
|---|---|---|---|---|---|---|
| | | W=650 | W=750 | W=750 | W=1000 | |
| | | P=150 | P=210 | P=210 | P=275 | |
| kV | kA | u/l=205 | u/l=310 | u/l=310 | u/l=310 | Circuit breaker type |
| | | ø=35 | ø=35 | ø=79 | ø=109 | |
| 17.5 | 16 | 630 | | | | VD4/P 17.06.16 p150 |
| | 20 | 630 | | | | VD4/P 17.06.20 p150 |
| | 25 | 630 | | | | VD4/P 17.06.25 p150 |
| | 31.5 | 630 | | | | VD4/P 17.06.32 p150 |
| | 16 | 1250 | | | | VD4/P 17.12.16 p150 |
| | 20 | 1250 | | | | VD4/P 17.12.20 p150 |
| | 25 | 1250 | | | | VD4/P 17.12.25 p150 |
| | 31.5 | 1250 | | | | VD4/P 17.12.32 p150 |
| | 16 | | 630 | | | VD4/W 17.06.16 p210 |
| | 20 | | 630 | | | VD4/W 17.06.20 p210 |
| | 25 | | 630 | | | VD4/W 17.06.25 p210 |
| | 31.5 | | 630 | | | VD4/W 17.06.32 p210 |
| | 16 | | 1250 | | | VD4/W 17.12.16 p210 |
| | 20 | | 1250 | | | VD4/W 17.12.20 p210 |
| | 25 | | 1250 | | | VD4/W 17.12.25 p210 |
| | 31.5 | | 1250 | | | VD4/W 17.12.32 p210 |
| | 40 | | | 1250 | | VD4/P 17.12.40 p210 |
| | 50 | | | 1250 | | VD4/P 17.12.50 p210 |
| | 20 | | | 1600 | | VD4/P 17.16.20 p210 |
| | 25 | | | 1600 | | VD4/P 17.16.25 p210 |
| | 31.5 | | | 1600 | | VD4/P 17.16.32 p210 |
| | 40 | | | 1600 | | VD4/P 17.16.40 p210 |
| | 50 | | | 1600 | | VD4/P 17.16.50 p210 |
| | 20 | | | 2000 | | VD4/P 17.20.20 p210 |
| | 25 | | | 2000 | | VD4/P 17.20.25 p210 |
| | 31.5 | | | 2000 | | VD4/P 17.20.32 p210 |
| | 40 | | | 2000 | | VD4/P 17.20.40 p210 |
| | 50 | | | 2000 | | VD4/P 17.20.50 p210 |
| | 20 | | | | 2500 | VD4/P 17.25.20 p275 |
| | 25 | | | | 2500 | VD4/P 17.25.25 p275 |
| | 31.5 | | | | 2500 | VD4/P 17.25.32 p275 |
| | 40 | | | | 2500 | VD4/P 17.25.40 p275 |
| | 50 | | | | 2500 | VD4/P 17.25.50 p275 |
| | 20 | | | | 3150 (1) | VD4/W 17.32.20 p275 |
| | 25 | | | | 3150 (1) | VD4/W 17.32.25 p275 |
| | 31.5 | | | | 3150 (1) | VD4/W 17.32.32 p275 |
| | 40 | | | | 3150 (1) | VD4/W 17.32.40 p275 |
| | 50 | | | | 3150 (1) | VD4/W 17.32.50 p275 |

W = Enclosure width.
P = Horizontal center distance of poles.
u/l = Distance between bottom and top terminals.
ø = Diameter of isolating contact.
(1) Up to 4000 A with forced ventilation.

# Selection and ordering
## Withdrawable circuit breakers

### VD4 (24 kV) withdrawable circuit breaker

| Ur | Isc | Rated thermal current (40 °C) [A] | | |
|---|---|---|---|---|
| | | W=800 | W=1000 | |
| kV | kA | P=210 | P=275 | Circuit breaker type |
| | | u/l=310 | u/l=310 | |
| | | ø=35 | ø=79 | |
| | 16 | 630 | | VD4/P 24.06.16 p210 |
| | 20 | 630 | | VD4/P 24.06.20 p210 |
| | 25 | 630 | | VD4/P 24.06.25 p210 |
| | 16 | 1250 | | VD4/P 24.12.16 p210 |
| | 20 | 1250 | | VD4/P 24.12.20 p210 |
| | 25 | 1250 | | VD4/P 24.12.25 p210 |
| | 31.5 | 1250 | | VD4/P 24.12.32 p210 |
| | 16 | | 1600 | VD4/P 24.16.16 p275 |
| | 20 | | 1600 | VD4/P 24.16.20 p275 |
| 24 | 25 | | 1600 | VD4/P 24.16.25 p275 |
| | 31.5 | | 1600 | VD4/P 24.16.32 p275 |
| | 16 | | 2000 | VD4/P 24.20.16 p275 |
| | 20 | | 2000 | VD4/P 24.20.20 p275 |
| | 25 | | 2000 | VD4/P 24.20.25 p275 |
| | 31.5 | | 2000 | VD4/P 24.20.32 p275 |
| | 16 | | 2300 (1) | VD4/P 24.25.16 p275 |
| | 20 | | 2300 (1) | VD4/P 24.25.20 p275 |
| | 25 | | 2300 (1) | VD4/P 24.25.25 p275 |
| | 31.5 | | 2300 (1) | VD4/P 24.25.32 p275 |

W = Enclosure width.
P = Horizontal center distance of poles.
u/l = Distance between bottom and top terminals.
ø = Diameter of isolating contact.
(1) Up to 2500 A rated current guaranteed with forced ventilation.

**Standard equipment of withdrawable circuit breakers for PowerCube modules**

The basic versions of the withdrawable circuit breakers are always three-pole and equipped with:

- EL manual operating mechanism
- mechanical signaling device for closing springs loaded/discharged
- mechanical signaling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten circuit breaker open/closed auxiliary contacts

  Note: three break contacts (signaling circuit breaker open) and four make contacts (signaling circuit breaker closed) are available with the group of ten auxiliary contacts supplied as standard and the maximum number of electrical applications.
- lever built into the operating mechanism for linear loading of closing spring
- isolating contacts
- cord with connector (plug only) for auxiliary circuits, with striker pins which prevent the plug from being inserted into the socket if the rated current of the circuit breaker is different from the rated current of the switchgear
- racking-in/out lever (the quantity depends on the number of apparatuses ordered)
- locking electromagnet in the truck. This prevents the circuit breaker from being racked into the switchgear when the auxiliary circuits are not connected (plug not in in the socket).
- door interlock (mandatory for ABB switchgear); this device prevents the circuit breaker from being racked into the switchgear when the switchgear door is open.

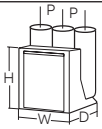





# Selection and ordering
## Withdrawable circuit breakers

Withdrawable circuit breakers for ZS8.4 switchgear (12 - 17.5 - 24 kV)




| Circuit breaker | | VD4/Z8 | | | | | |
|---|---|---|---|---|---|---|---|
| | Panel without partitions | • | • | • | • | • | • |
| | Panel with partitions | – | – | – | – | – | – |
| | Preussen Elektra - EON (2) | – | – | – | – | – | – |
| | Width [mm] | 650 | 650 | 650 | 650 | 800 | 800 |
| | Depth [mm] | 1000 | 1000 | 1000 | 1000 | 1200 | 1200 |
| Standards | IEC 62271-100 | • | | | | | |
| Rated voltage | Ur [kV] | 12 | 12 | 17.5 | 17.5 | 24 | 24 |
| Rated insulation voltage | Us [kV] | 12 | 12 | 17.5 | 17.5 | 24 | 24 |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | 28 | 38 | 38 | 50 | 50 |
| Impulse withstand voltage | Up [kV] | 75 | 75 | 95 | 95 | 125 | 125 |
| Rated frequency | fr [Hz] | 50-60 | | | | | |
| Rated thermal current (40 °C) (1) | Ir [A] | 630 | 1250 | 630 | 1250 | 630 | 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | – | – | – | – | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 | 25 |
| Admissible rated short-time withstand current(3 s) | Ik [kA] | – | – | – | – | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 | 25 |
| Making capacity | Ip [kA] | – | – | – | – | 40 | 40 |
| | | 50 | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 | 63 |
| Operation sequence | [O-0.3s-CO-15s-CO] | • | • | • | • | • | • |
| Opening time | [ms] | 33...60 | 33...60 | 33...60 | 33...60 | 33...60 | 33...60 |
| Arcing time | [ms] | 10...15 | 10...15 | 10...15 | 10...15 | 10...15 | 10...15 |
| Total breaking time | [ms] | 43...75 | 43...75 | 43...75 | 43...75 | 43...75 | 43...75 |
| Closing time | [ms] | 30...60 | 30...60 | 30...60 | 30...60 | 30...60 | 30...60 |
| Maximum overall dimensions   | H [mm] | 579 | 579 | 579 | 579 | 680 | 680 |
| | W [mm] | 503 | 503 | 503 | 503 | 653 | 653 |
| | D [mm] | 548 | 548 | 548 | 548 | 646 | 646 |
| | Pole center distance P [mm] | 150 | 150 | 150 | 150 | 210 | 210 |
| Weight | [kg] | 116 | 116 | 116 | 116 | 140 | 140 |
| Standardized dimensions table | 1VCD | 000092 | 000137 | 000137 | 000137 | 000089 | 000138 |
| Operating temperature | [°C] | – 5 ... + 40 | | | | | |
| Tropicalization | IEC 60068-2-30 | • | • | • | • | • | • |
| | IEC 60721-2-1 | • | • | • | • | • | • |
| Electromagnetic compatibility | IEC 62271-1 | • | • | • | • | • | • |

(1) Rated current guaranteed with circuit breaker installed in switchgear with 40 °C air temperature.
(2) Special type with device for loading the closing spring by means of a crank handle outside the operating mechanism.

| VD4/ZT8 | | | | | | VD4/ZS8 | | | |
|---|---|---|---|---|---|---|---|---|---|
| – | – | – | – | – | – | – | – | – | – |
| • | • | • | • | • | • | – | – | – | – |
| – | – | – | – | – | – | • | • | • | • |
| 650 | 650 | 650 | 650 | 800 | 800 | 650 | 650 | 800 | 800 |
| 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| • | | | | | | • | | | |
| 12 | 12 | 17.5 | 17.5 | 24 | 24 | 12 | 12 | 24 | 24 |
| 12 | 12 | 17.5 | 17.5 | 24 | 24 | 12 | 12 | 24 | 24 |
| 28 | 28 | 38 | 38 | 50 | 50 | 28 | 28 | 50 | 50 |
| 75 | 75 | 95 | 95 | 125 | 125 | 75 | 75 | 125 | 125 |
| 50-60 | | | | | | 50-60 | | | |
| 630 | 1250 | 630 | 1250 | 630 | 1250 | 630 | 1250 | 630 | 1250 |
| – | – | – | – | 16 | 16 | – | – | 16 | 16 |
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| – | – | – | – | 16 | 16 | – | – | 16 | 16 |
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| – | – | – | – | 40 | 40 | – | – | 40 | 40 |
| 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 |
| • | • | • | • | • | • | • | • | • | • |
| 33...60 | 33...60 | 33...60 | 33...60 | 33...60 | 33...60 | 33...60 | 33...60 | 33...60 | 33...60 |
| 10...15 | 10...15 | 10...15 | 10...15 | 10...15 | 10...15 | 10...15 | 10...15 | 10...15 | 10...15 |
| 43...75 | 43...75 | 43...75 | 43...75 | 43...75 | 43...75 | 43...75 | 43...75 | 43...75 | 43...75 |
| 30...60 | 30...60 | 30...60 | 30...60 | 30...60 | 30...60 | 30...60 | 30...60 | 30...60 | 30...60 |
| 579 | 579 | 579 | 579 | 680 | 680 | 579 | 579 | 680 | 680 |
| 503 | 503 | 503 | 503 | 653 | 653 | 503 | 503 | 653 | 653 |
| 638 | 638 | 638 | 638 | 646 | 646 | 638 | 638 | 646 | 646 |
| 150 | 150 | 150 | 150 | 210 | 210 | 150 | 150 | 210 | 210 |
| 116 | 116 | 116 | 116 | 140 | 140 | 116 | 116 | 140 | 140 |
| 000093 | 000134 | 000134 | 000134 | 000090 | 000136 | 000091 | 000133 | 000088 | 000135 |
| – 5 ... + 40 | | | | | | – 5 ... + 40 | | | |
| • | • | • | • | • | • | • | • | • | • |
| • | • | • | • | • | • | • | • | • | • |
| • | • | • | • | • | • | • | • | • | • |

# Selection and ordering
## Withdrawable circuit breakers

### VD4/ZS8 - VD4/ZT8 - VD4/Z8 withdrawable circuit breakers for ZS8.4 switchgear

| Ur | Isc | Rated uninterrupted current (40°C) [A] | | | | | | Circuit breaker type |
|---|---|---|---|---|---|---|---|---|
| | | Panel without partition | | Panel with partition | | Special EON panel | | |
| | | W = 650 | W = 800 | W = 650 | W = 800 | W = 650 | W = 800 | |
| kV | kA | P = 150 | P = 210 | P = 150 | P = 210 | P = 150 | P = 210 | |
| | | u/l = 205 | u/l = 310 | u/l = 205 | u/l = 310 | u/l = 205 | u/l = 310 | |
| | | ø = 35 | ø = 35 | ø = 35 | ø = 35 | ø = 35 | ø = 35 | |
| 12 | 20 | 630 | | | | | | VD4/Z8 12.06.20 p150 |
| | 25 | 630 | | | | | | VD4/Z8 12.06.25 p150 |
| | 20 | 1250 | | | | | | VD4/Z8 12.12.20 p150 |
| | 25 | 1250 | | | | | | VD4/Z8 12.12.25 p150 |
| | 20 | | | 630 | | | | VD4/ZT8 12.06.20 p150 |
| | 25 | | | 630 | | | | VD4/ZT8 12.06.25 p150 |
| | 20 | | | 1250 | | | | VD4/ZT8 12.12.20 p150 |
| | 25 | | | 1250 | | | | VD4/ZT8 12.12.25 p150 |
| | 20 | | | | | 630 | | VD4/ZS8 12.06.20 p150 |
| | 25 | | | | | 630 | | VD4/ZS8 12.06.25 p150 |
| | 20 | | | | | 1250 | | VD4/ZS8 12.12.20 p150 |
| | 25 | | | | | 1250 | | VD4/ZS8 12.12.25 p150 |
| 17.5 | 20 | 630 | | | | | | VD4/Z8 17.06.20 p150 |
| | 25 | 630 | | | | | | VD4/Z8 17.06.25 p150 |
| | 20 | 1250 | | | | | | VD4/Z8 17.12.20 p150 |
| | 25 | 1250 | | | | | | VD4/Z8 17.12.25 p150 |
| | 20 | | | 630 | | | | VD4/ZT8 17.06.20 p150 |
| | 25 | | | 630 | | | | VD4/ZT8 17.06.25 p150 |
| | 20 | | | 1250 | | | | VD4/ZT8 17.12.20 p150 |
| | 25 | | | 1250 | | | | VD4/ZT8 17.12.25 p150 |
| 24 | 16 | | 630 | | | | | VD4/Z8 24.06.16 p210 |
| | 20 | | 630 | | | | | VD4/Z8 24.06.20 p210 |
| | 25 | | 630 | | | | | VD4/Z8 24.06.25 p210 |
| | 16 | | 1250 | | | | | VD4/Z8 24.12.16 p210 |
| | 20 | | 1250 | | | | | VD4/Z8 24.12.20 p210 |
| | 25 | | 1250 | | | | | VD4/Z8 24.12.25 p210 |
| | 16 | | | | 630 | | | VD4/ZT8 24.06.16 p210 |
| | 20 | | | | 630 | | | VD4/ZT8 24.06.20 p210 |
| | 25 | | | | 630 | | | VD4/ZT8 24.06.25 p210 |
| | 16 | | | | 1250 | | | VD4/ZT8 24.12.16 p210 |
| | 20 | | | | 1250 | | | VD4/ZT8 24.12.20 p210 |
| | 25 | | | | 1250 | | | VD4/ZT8 24.12.25 p210 |
| | 16 | | | | | | 630 | VD4/ZS8 24.06.16 p210 |
| | 20 | | | | | | 630 | VD4/ZS8 24.06.20 p210 |
| | 25 | | | | | | 630 | VD4/ZS8 24.06.25 p210 |
| | 16 | | | | | | 1250 | VD4/ZS8 24.12.16 p210 |
| | 20 | | | | | | 1250 | VD4/ZS8 24.12.20 p210 |
| | 25 | | | | | | 1250 | VD4/ZS8 24.12.25 p210 |

W = Switchgear width.
P = Horizontal center distance of poles.
u/l = Distance between bottom and top terminals.
Ø = Diameter of isolating contact.

**Standard equipment of withdrawable circuit breakers for ZS8.4 switchgear**

The basic versions of the withdrawable circuit breakers are three-pole and equipped with:

- EL manual operating mechanism
- mechanical signaling device for closing springs loaded/discharged
- mechanical signaling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten circuit breaker open/closed auxiliary contacts

  Note: three break contacts (signaling circuit breaker open) and four make contacts (signaling circuit breaker closed) are available with the group of ten auxiliary contacts supplied as standard and the maximum number of electrical applications.

- lever built into the operating mechanism for linear loading of closing spring for VD4/Z8 and VD4/ZT8, external with crank operation for VD4/ZS8
- racking in/out lever (the quantity depends on the number of apparatuses ordered)

**VD4/ZS8**

- device for loading the closing springs with the door closed, by means of a removable crank handle outside the operating mechanism and the switchgear
- Harting 64-pin socket with mechanical interlock which prevents the circuit breaker from being moved when the plug is not in in the socket
- door interlock, which prevents the spring loading lever from being inserted when the circuit breaker is closed
- door interlock and Harting 64-pin socket, which prevent the door from closing when the plug is not in in the socket.

**VD4/Z8 - VD4/ZT8**

- Harting 64-pin socket with mechanical interlock which prevents the circuit breaker from being moved when the plug is not in in the socket.

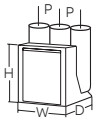



Key
1) Device with crank handle for loading closing spring (only version VD4/ZS8)
2) Harting 64 plus socket with mechanical interlock which prevents circuit breaker from being moved when socket is not inserted
3) Interlock that prevents door from closing if plug is not in socket (only version VD4/ZS8)

# Selection and ordering
## Withdrawable circuit breakers

General characteristics of withdrawable circuit breakers for UniSec switchgear (units WBC and WBS)




| Circuit breaker | | VD4/P 12 | | VD4/P 17 | | VD4/SEC |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | • | | • |
| Rated voltage | Ur [kV] | 12 | | 17.5 | | 24 |
| Rated insulation voltage | Us [kV] | 12 | | 17.5 | | 24 |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | 38 | | 50 |
| Impulse withstand voltage | Up [kV] | 75 | | 95 | | 125 |
| Rated frequency | fr [Hz] | 50-60 | | 50-60 | | 50-60 |
| Rated thermal current (40 °C) (1) | Ir [A] | 630 | 1250 | 630 | 1250 | 630 - 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| Admissible rated short-time withstand current (3 s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 |
| | | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | | • | | • |
| Opening time | [ms] | 33 ... 60 | | 33 ... 60 | | 33 ... 60 |
| Arcing time | [ms] | 10 ... 15 | | 10 ... 15 | | 10 ... 15 |
| Total breaking time | [ms] | 43 ... 75 | | 43 ... 75 | | 43 ... 75 |
| Closing time | [ms] | 30 ... 60 | | 30 ... 60 | | 30 ... 60 |
| Maximum overall dimensions   | H [mm] | 628 | 628 | 632 | 632 | 743 |
| | W [mm] | 503 | 503 | 503 | 503 | 653 |
| | D [mm] | 662 | 662 | 664 | 664 | 742 |
| | Pole center distance P [mm] | 150 | 150 | 150 | 150 | 210 |
| Weight | [kg] | 116 | 116 | 116 | 116 | 133 |
| Standardized dimensions table | 1VCD | 7412 (2) | 7412 (2) | 7412 (2) | 7412 (2) | 000190 |
| Operating temperature | [°C] | - 5 ... + 40 | | - 5 ... + 40 | | - 5 ... + 40 |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | • | | • |
| Electromagnetic compatibility | IEC 62271 | • | | • | | • |

(1) Rated current guaranteed with withdrawable circuit breaker installed in switchgear with 40 °C ambient temperature.
(2) Poles in polyamide.

**Withdrawable circuit breaker for UniSec switchgear**

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | Circuit breaker type |
|---|---|---|---|---|---|
| | | P=150 | P=150 | P=210 | |
| kV | kA | u/l=205 | u/l=205 | u/l=310 | |
| | | ø=35 | ø=35 | ø=79 | |
| 12 | 16 | 630 | | | VD4/P 12.06.16 p150 |
| | 20 | 630 | | | VD4/P 12.06.20 p150 |
| | 25 | 630 | | | VD4/P 12.06.25 p150 |
| | 16 | 1250 | | | VD4/P 12.12.16 p150 |
| | 20 | 1250 | | | VD4/P 12.12.20 p150 |
| | 25 | 1250 | | | VD4/P 12.12.25 p150 |
| 17 | 16 | | 630 | | VD4/P 17.06.16 p150 |
| | 20 | | 630 | | VD4/P 17.06.20 p150 |
| | 25 | | 630 | | VD4/P 17.06.25 p150 |
| | 16 | | 1250 | | VD4/P 17.12.16 p150 |
| | 20 | | 1250 | | VD4/P 17.12.20 p150 |
| | 25 | | 1250 | | VD4/P 17.12.25 p150 |
| 24 | 16 | | | 630 | VD4/SEC 24.06.16 p210 |
| | 20 | | | 630 | VD4/SEC 24.06.20 p210 |
| | 25 | | | 630 | VD4/SEC 24.06.25 p210 |
| | 16 | | | 1250 | VD4/SEC 24.12.16 p210 |
| | 20 | | | 1250 | VD4/SEC 24.12.20 p210 |
| | 25 | | | 1250 | VD4/SEC 24.12.25 p210 |

P = Horizontal center distance between poles.
u/l = Distance between top and bottom terminals.
Ø = Diameter of isolating contacts.

**Standard equipment of withdrawable circuit breakers for UniSec switchgear**

The basic versions of the withdrawable circuit breakers are three-pole and equipped with:

- EL manual operating mechanism
- mechanical signaling device for closing springs loaded/discharged
- mechanical signaling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten circuit breaker open/closed auxiliary contacts

  Note: three break contacts (signaling circuit breaker open) and four make contacts (signaling circuit breaker closed) are available with the group of ten auxiliary contacts supplied as standard and the maximum number of electrical applications.
- lever built into the operating mechanism for linear loading of closing spring
- isolating contacts
- cord with connector (plug only) for auxiliary circuits, with striker pins which prevent the plug from being inserted into the socket if the rated current of the circuit breaker is different from the rated current of the switchgear
- racking-in/out lever (the quantity depends on apparatuses ordered)

# Selection and ordering
## Optional accessories

### For circuit breakers up to 36 kV, 50 kA with EL operating mechanism
Accessories with the same number are alternative to each other.

**1 Shunt opening release (-MBO1)**
Allows the opening command of the apparatus to be enabled by remote control.
This release is suitable for both instantaneous and permanent duty. However, there is always an auxiliary contact, -BGB1, that de-energizes it after the circuit breaker has opened. In the case of instantaneous service, the current impulse must last at least 100 ms.
This release can be controlled by the following devices: coil continuity control (CCC), opening circuit supervision (TCS)(*) or the ABB STU functionality control device (see accessory 21, supplied on request).

| Characteristics | |
|---|---|
| Un | 24-30-48-60-110...132-220...250 V DC |
| Un | 48-60-110...127-220...250 V AC 50-60 Hz |
| Operating limits | 65 ... 120% Un |
| Inrush power (Ps) | 60...100 W / VA |
| Continuous power consumption (Pc) | 1.5 W |
| Electronics self-consumption (no coil supplied); value independent of voltage applied | 1.5 mA |
| Opening time | 33...60 ms |
| Insulation voltage | 2000 V 50 Hz (for 1 min) |

**2 Additional shunt opening release (-MBO2)**
Similarly to shunt opening release -MBO1, this allows the opening command of the apparatus to be transmitted by remote control. It can be supplied by the same circuit as main shunt opening release -MBO1 or by a circuit that is completely separate from release -MBO1.
This release is suitable for both instantaneous and permanent duty. However, there is always an auxiliary contact, -BGB1, that de-energizes it after the circuit breaker has opened.
To guarantee the release action, the current impulse must last at least 100 ms.
Continuity functionality can be checked with a continuity control device (CCC), opening circuit supervision (TCS)(*) or the STU functionality control device (see accessory 21, supplied on request).
-MBO2 has the same electrical and operating characteristics as release -MBO1.

(*) The minimum current that the relay with TCS function (used for monitoring coil continuity) detects as a condition denoting that the trip circuit is operating correctly (specified for each relay in the relative manual), must be sensibly higher than the self-consumption current of the actual coil (~1.5 mA).
If this fails to occur, always add, in parallel to the TCS, a circuit able to absorb sufficient current to compensate the gap while preventing the total current in the TCS circuit from rising above the maximum threshold up to 100mA.
A simple resistor can be sized for the purpose, depending on the parameters of the TCS and the auxiliary voltage range used.
For further details consult the Guidelines for use of the Smart Coil 1VCD601416






### 3 Opening solenoid (-MBO3)

The opening solenoid (-MBO3) is a special demagnetization release to be used in conjunction with an overcurrent protection relay of the self-supplied type.
It is situated in the operating mechanism (in the left side) and is not an alternative to the additional shunt opening release **(-MBO2).**
**It is not available for 40 and 50 kA circuit breakers.**
**Should this accessory be required, specify at the time of order since it cannot be installed later on by the customer.**
Note: ask ABB for info for use in conjunction with the protection relay.

The opening solenoid (-MBO3) is available in two versions:

- For DC (release by discharging the energy stored in protection relay against overcurrents of the self-supplied type)
- For AC (release by means of the energy supplied by an summation current transformer on the secondaries of the protection current transformers (the transformer is at customer's charge)

### 4 Shunt closing release (-MBC)

Allows the closing command of apparatus to be transmitted by remote control.
This release is suitable for both instantaneous and permanent duty. An auxiliary contact that de-energizes it after the circuit breaker has closed is not envisaged.
The permanently supplied release provides the electrical anti-pumping function with both electrical opening and re-closing commands maintained. To guarantee the closing action, the current impulse must last at least 100 ms.
If there is the same supply voltage for shunt closing release -MBC and under-voltage release -MBU and the circuit breaker must close automatically when auxiliary voltage returns, there must be a delay of at least 50 ms between under-voltage release energizing and energizing of the shunt closing release to allow the closing operation to take place. Continuity functionality can be checked with a continuity control device (CCC), opening circuit supervision (TCS)(*) or the STU functionality control device (see accessory 21, supplied on request).

| Characteristics | |
|---|---|
| Un | 24-30-48-60-110...132-220...250 V DC |
| Un | 48-60-110...127-220...250 V AC 50-60 Hz |
| Operating limits | 65 … 120% Un |
| Inrush power (Ps) | 60...100 W / VA |
| Continuous power consumption (Pc) | 1.5 W |
| Electronics self-consumption (no coil supplied; value independent of voltage applied | 1.5 mA |
| Closing time | 30...60 ms |
| Insulation voltage | 2000 V 50 Hz (for 1 min) |

(*) The minimum current that the relay with TCS function (used for monitoring coil continuity) detects as a condition denoting that the trip circuit is operating correctly (specified for each relay in the relative manual), must be sensibly higher than the current consumption of the actual coil (~1.5 mA).
If this fails to occur, always add, in parallel to the TCS, a circuit able to absorb sufficient current to compensate the gap while preventing the total current in the TCS circuit from rising above the maximum threshold up to 100mA.
A simple resistor can be sized for the purpose, depending on the parameters of the TCS and the auxiliary voltage range used.
For further details, consult the Guidelines for use of the Smart Coil 1VCD601416





# Selection and ordering
## Optional accessories

**5 Undervoltage release (-MBU)**
The undervoltage release opens the circuit breaker when there is a sensible reduction or lack of the voltage that powers it. The circuit breaker can only close when the release is energized (the closing lock is obtained mechanically).
It can be used for remote release (by means of a pushbutton of the normally closed type) and for locking on automatic closing/opening in the absence of voltage in the auxiliary circuits.
Supplied by means of the secondary output of a voltage transformer, it provides locking upon automatic closing/opening in the absence of voltage in the Medium Voltage main circuit.
If there is the same supply voltage for shunt closing release -MBC and undervoltage release -MBU and the circuit breaker must close automatically when auxiliary voltage returns, there must be a delay of at least 50 ms between under-voltage release energizing and energizing of the shunt closing release to allow the closing operation to take place.

The undervoltage release is available in the following versions:

**5A** Undervoltage release (with supply shunted from a transformer on the supply side of the circuit breaker or from an auxiliary power supply, regardless of the state in which the circuit breaker is to be found).

**5B** Undervoltage release with -KFT electronic time-lag device (0.5 - 1 - 1.5 - 2 - 3 s) (with power supply as indicated for 5A); this device is supplied with a 0.5 s setting (the adjustments are described in the Circuit diagrams chapter)

| **Characteristics** | |
|---|---|
| Un | 24-30-48-60-110...132-220...250 V DC |
| Un | 48-60-110...127-220...250 V AC 50-60 Hz |
| Operating limits | – circuit breaker opening: 35-70% Un |
| | – circuit breaker closing: 85-110% Un |
| Inrush power (Ps) | 150 W / VA |
| Continuous power consumption (Pc) | 1.55 W |
| Electronics self-consumption (no coil supplied); value independent of voltage applied | 1.5 mA |
| Insulation voltage | 2000 V 50 Hz (for 1 min) |

Note
As an alternative to the undervoltage release, an additional shunt opening release (-MBO4) with the same electrical and operating specifications as shunt opening release (-MBO1) can be installed on request (only for 12..17.5 kV circuit breakers up to 40 kA and 24 kV up to 31.5 kA).
Warning! Since installation of the additional shunt opening release (-MBO4) requires a special mounting plate for releases, ask for application (-MBO4) when ordering and not after delivery.



**5C Electronic time-lag device (-KFT)**

The electronic time-lag device must be installed outside the circuit breaker. It allows release tripping to be delayed by preset and adjustable times.

Use of the undervoltage release is recommended for the purpose of preventing trips when the power supply network of the release may be subject to interruptions or voltage drops of short duration.

If it is not being energized, circuit breaker closing is inhibited.

The time-lag device must be used in conjunction with an undervoltage release for d.c.

The voltage of the undervoltage release must be within the operating range of the electronic time-lag device.

| Characteristics of the time-lag device | |
|---|---|
| Un | 24...30 - 48 - 60 - 110...127 - 220...250 V– |
| Un | 48 - 60 - 110...127 - 220...240 - V~ 50/60 Hz |
| Adjustable opening time (release + time-lag device): | 0.5-1-1.5-2-3 s |

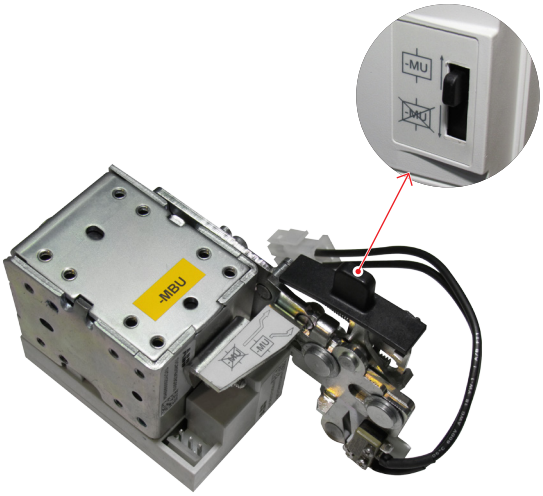
**6 Mechanical override of the undervoltage release**

This is a mechanical device which allows the undervoltage release trip to be temporarily excluded.

It is always equipped with electrical signaling.

If this accessory is required, it must be specified at the time of order since it cannot be installed later on by the customer.



# Selection and ordering
## Optional accessories

**7a Auxiliary contacts of the circuit breaker (-BGB1) for 12 to 24 kV versions**

Electrical signaling of circuit breaker open/closed can be obtained with a group of 10, 16, 20 or 24 auxiliary contacts for the fixed version and 10 or 16 auxiliary contacts for the withdrawable version. The standard equipment comprises 10 auxiliary contacts.

**Note**

The following are available using the standard group of ten auxiliary contacts and the maximum number of electrical accessories:

- for fixed circuit breakers: three closing contacts “a” for signaling circuit breaker open and five opening contacts “b” for signaling circuit breaker closed;
- for withdrawable circuit breakers: three closing contacts “a” for signaling circuit breaker open and four opening contacts “b” for signalling circuit breaker closed.

Circuit breakers in the fixed version are available with two finishing accessories (to be specified when ordering):

- non-wired auxiliary contacts; wiring to the terminals of the contacts is at the customer’s charge (photo at left; the terminal box to which the other electrical accessories are wired is at the top); ask for instructions 1VCD601204 (available in the main languages) which describe how to remove, wire the auxiliary contacts more easily and fit the auxiliary contact unit back into its housing;
- auxiliary contacts already wired to the terminal box (see photo at right)

Consult circuit diagrams 1VCD400151 for fixed circuit breakers and 1VCD400155 for withdrawable circuit breakers.

**Note:** The main shunt opening release and/or the additional shunt opening release use 1 and/or 2 closing contacts “a”, thereby reducing the number of auxiliary contacts available. Always check the maximum number of contacts available with non-standard equipment.

The new diagrams are interchangeable with the existing ones, with the following exceptions:

- diagram 1VCD400151 (substitutes 1VCD400046 and 1VCD400099)
  - fig. 34 on the previous diagrams is represented by fig. 31 + fig. 32 on the new diagram;
  - fig. 33 and fig. 35 on the previous diagrams are not available with the new layout
- diagram 1VCD400155 (substitutes 1VCD400047)

Auxiliary contacts –BGB1 conform to the following standards/regulations/directives:

- IEC 62271-100
- IEEE C37.54
- EN 61373 cat. 1 class B / impact and vibration test
- Germanish Loyd regulation / vibrations envisaged by the shipping registers
- UL 508
- EN 60947 (DC-21A DC-22A DC-23A AC-21A)
- RoHS Directive







| General characteristics | |
|---|---|
| Insulation voltage to standard VDE 0110, Group C | 660 V AC<br>800 V DC |
| Rated voltage | 24 V ... 660 V |
| Test voltage | 2 kV for 1 min |
| Maximum rated current | 10 A - 50/60 Hz |
| Breaking capacity | Class 1 (IEC 62271-1) |
| Number of contacts | 5 |
| Groups of contacts | 10 / 16 / 20 |
| Contact travel | 90° |
| Actuating force | 0.66 Nm |
| Resistance | <6.5 mΩ |
| Storage temperature | –30 °C ... +120 °C |
| Operating temperature | –20 °C ... +70 °C<br>(-30° ref. ANSI 37.09) |
| Contact overtemperature | 10 K |
| Mechanical life | 30.000 mechanical operations |
| Protection class | IP20 |
| Cable section | 1 $mm^2$ |

| Electrical characteristics (according to IEC 60947) | | |
|---|---|---|
| Rated current Un | | Breaking capacity (10000 interruptions) |
| 220 V AC | Cosφ = 0.70 | 20 A |
| 220 V AC | Cosφ = 0.45 | 10 A |
| 24 V DC | 1 ms (*) | 12 A |
| | 15 ms | 9 A |
| | 50 ms | 6 A |
| 60 V DC | 1 ms | 10 A |
| | 15 ms | 6 A |
| | 50 ms | 4.6 A |
| 110 V DC | 1 ms | 7 A |
| | 15 ms | 4.5 A |
| | 50 ms | 3.5 A |
| 220 V DC | 1 ms | 2 A |
| | 15 ms | 1.7 A |
| | 50 ms | 1.5 A |
| 250 V DC | 1 ms | 2 A |
| | 15 ms | 1.4 A |
| | 50 ms | 1.2 A |

| Electrical characteristics (according to IEC 62271-100 class 1) | |
|---|---|
| Rated voltage Un | Breaking capacity |
| 24 V DC 20 ms | 18.8 mA |
| 60 V DC 20 ms | 7.4 mA |
| 110 V DC 20 ms | 4.2 mA |
| 250 V DC 20 ms | 1.8 mA |

(*) For application at 24Vdc and with currents lower than 2,5mA golden contacts are recommended.

### 8 Transient contact (-BGB4)

This contact closes momentarily (duration > 30 ms) upon circuit breaker opening controlled remotely with a shunt opening release.
The indication is not provided when opening is manual and local. In this case, a contact (–BGB11) is activated by the manual pushbutton and cuts off the transient contact closing signal (–BGB4).
The transient contact is activated directly from the main operating shaft, thus the indication is provided only on actual opening of the main circuit breaker contacts.



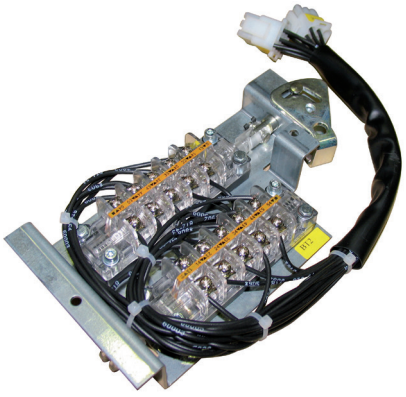
# Selection and ordering
## Optional accessories

**9 Position contact (-BGT3)**
This contact is used, together with the locking magnet in the operating mechanism **(-RLE1)**, to prevent remote closing as the circuit breaker is racked into the compartment.
It is only supplied for withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube modules.
It cannot be supplied when transmitted contacts in the truck are requested **(-BGT1; -BGT2)**.

**10 Transmitted contacts (*) in the truck (-BGT1; -BGT2)**
Transmitted contacts of withdrawable circuit breakers (installed in the circuit breaker truck - only for VD4/P withdrawable circuit breakers). These contacts are either in addition or alternatives to the position contacts (for signaling circuit breaker racked out). They also act as position contacts **(-BGT3)**.

(*) For application at 24Vdc and with currents lower than 10mA golden contacts are recommended.



### 11 Motor operator (-MAS)

Automatically loads the closing springs of the circuit breaker operating mechanism. After circuit breaker closing, the geared motor immediately reloads the closing springs.
If there is a power cut or during maintenance work, the closing spring can be loaded in the manual mode (by means of the special crank handle built into in the operating mechanism).

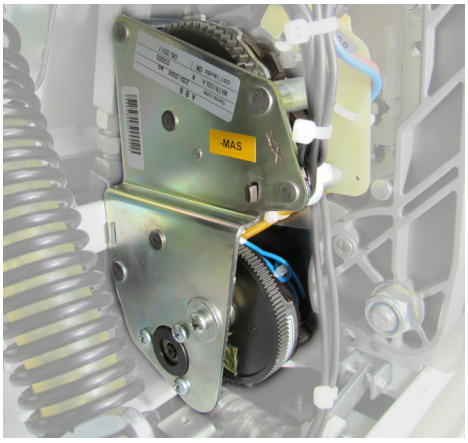
| Characteristics | | |
|---|---|---|
| Un | 24...30 - 48...60 - 110...130 - 220...250 V– | |
| Un | 100...130 - 220...250 V~ 50/60 Hz | |
| Operating limits | 85 ... 110% Un | |
| Inrush power (Ps) | ≤ 40 kA | 50 kA |
| | DC = 600 W;<br>AC = 600 VA | DC = 900 W;<br>AC = 900 VA |
| Rated power (Pn) | DC = 200 W;<br>AC = 200 VA | DC = 350 W;<br>AC = 350 VA |
| Inrush duration | 0.2 s | 0.2 s |
| Loading time | 6-7 s | 6-7 s |
| Insulation voltage | 2000 V 50 Hz<br>(for 1 min) | 2000 V 50 Hz<br>(for 1 min) |

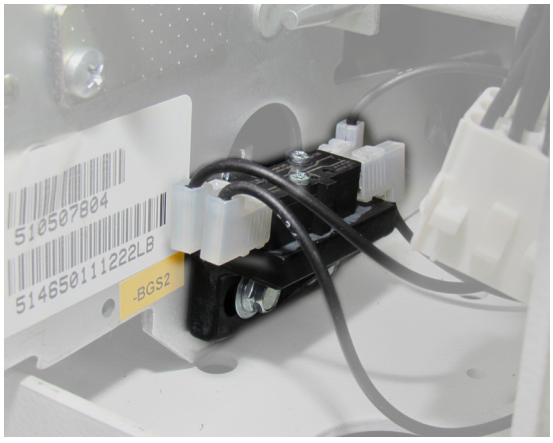
### 12 Contact for signaling closing spring loaded/ discharged (-BGS2)

Consists of a microswitch which allows the state of the closing spring of the circuit breaker operating mechanism to be remotely signaled.
The following signals are possible:
- contact open: spring loaded signal
- contact closed: spring discharged signal.

The two signals must be used for circuits with the same power supply voltage.

| | | |
|---|---|---|
| Rated voltage (a.c.) | 250 | V |
| Rated current | 10 | A |
| Thermal capacity | 17 | A |
| Short-time withstand current | 20 | A for 30 sec |
| Withstand voltage at 50 Hz for 1 minute between live parts and ground | >2000 | V |
| Distance between open contacts | 0.5 | mm |



# Selection and ordering
## Optional accessories

### Protections and locks

Various mechanical and electromechanical locking and protection devices are available.

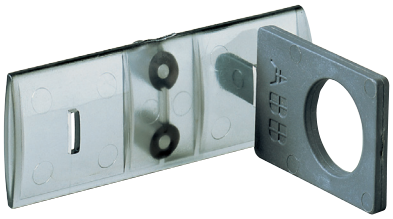
**13 Opening and closing pushbutton protection**
The protection only allows the opening and closing pushbuttons to be operated using a special tool.

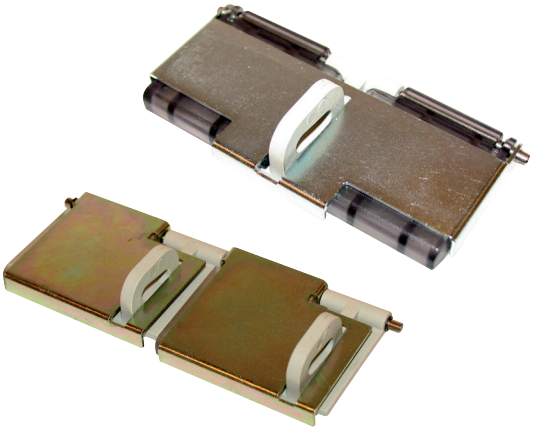
**14 Opening and closing pushbutton padlock**
The device allows the opening and closing pushbuttons to be locked using up to three ø 4 mm diameter padlocks (not supplied).
The padlock is available in two versions:

**14A** Possibility of padlocking both the pushbuttons without distinction

**14B** Separate padlocking of the opening and/or closing pushbutton.

N.B. Lock 14A prevents closing by remote control; lock 14B does not prevent closing by remote control.



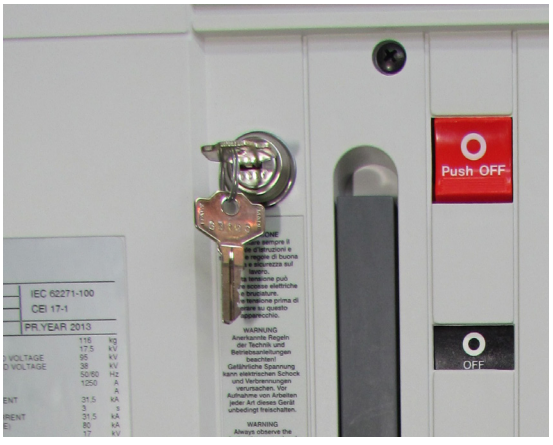


**15 Key lock in open position**

The lock is activated by a special circular lock. Different keys (for a single circuit breaker), or the same keys (for several circuit breakers) are available.
To activate the lock, keep the opening pushbutton pressed down, turn the key and remove it.
With the key removed, the opening pushbutton automatically remains in the pressed position, thereby preventing local manual closing and remote electrical closing.
Different keys(for the same breaker) or same keys (for different breakers) are available, Ronis type.

**16 Locking magnet on the operating mechanism (-RLE1)**

Only allows the command to be activated when the electromagnet is energized.
The locking electromagnet in the operating mechanism has the same electrical characteristics as shunt closing release -MBC.



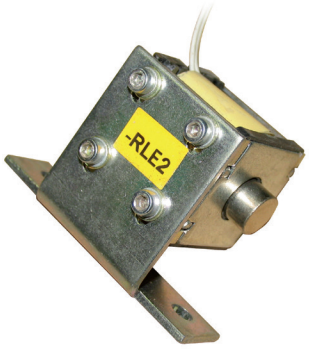


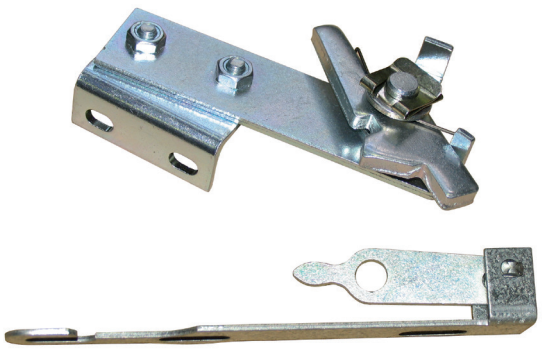

# Selection and ordering
## Optional accessories

**17 Locking magnet on the truck (-RLE2)**
Mandatory accessory for withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube modules. Prevents the circuit breaker from racking into the switchgear when the auxiliary circuit plug is disconnected.
The plug also acts as an anti-insertion lock if the rated current is different. Special striker pins prevent the plug from being inserted into the socket if the rated current of the circuit breaker is lower than the rated current of the panel.
**Note: a specific version for the circuit breakers of ZS8.4 switchgear is available on request. This accessory is not available when the motor-operated truck is required**

| Characteristics | |
|---|---|
| Un | 24 - 30 - 48 - 60 - 110 - 125 - 127 - 132 - 220 - 240 V– |
| Un | 24 - 30 - 48 - 60 - 110 - 125 - 127 - 220 - 230 ... 240 V~ 50/60 Hz |
| Operating limits | 85 ... 110% Un |
| Inrush power (Pn) | DC 250 W; AC = 250 VA |
| Continuous power (Pc) | DC = 5 W; AC = 5 VA |
| Inrush duration | 150 ms |
| Insulation voltage | 2000 V 50 Hz (for 1 min) |

**18 Interlock for fixed circuit breakers**
Device for fixed circuit breakers which have been converted into withdrawable ones by the customer. It allows a mechanical lock to be created by the customer to prevent racking-out/in with the circuit breaker closed and prevents circuit breaker closing while moving.
**Note: The device must be requested when ordering since it must be assembled and tested in the factory.**



**19 Mechanical interlock with door**

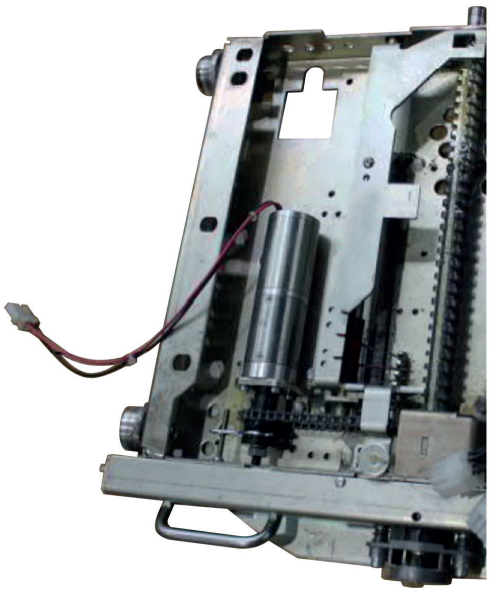
This device prevents the circuit breaker from being racked-in when the switchgear door is open. It is only provided for circuit breakers used in UniGear ZS1 switchgear and PowerCube modules equipped with a special actuator on the door.
It is not available for circuit breakers with motor-driven truck (-MAT).

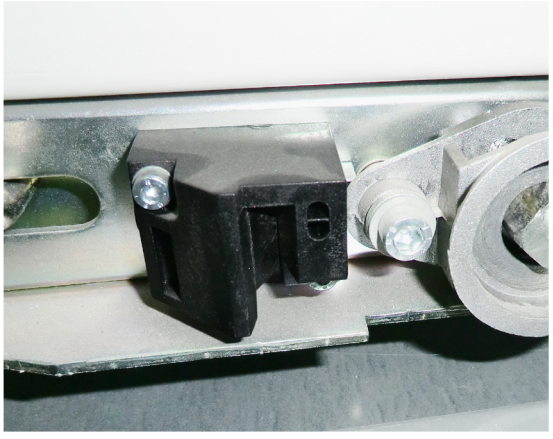
**20 Motor-driven truck (-MAT)**

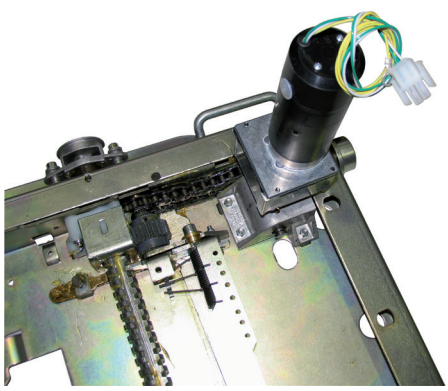
Allows the circuit breaker to be remotely racked-in and out of the switchgear (only for withdrawable circuit breakers for UniGear ZS1 and ZS8.4 switchgear and PowerCube modules).
The motor-driven version with clutch can be ordered on request. It enables the circuit breaker to be racked-in/out in an emergency if the truck motor fails to operate.

| Characteristics | |
|---|---|
| Un | 24 - 30 - 48 - 60 - 110 - 220 V– |
| Operating limits | 85 ... 110% Un |
| Rated power (Pn) | 40 W |

It is also possible to order the magnetothermic micro circuit breaker protect the motor from over current and temperature. Provided as loose part.







# Selection and ordering
## Optional accessories

**21 STU Shunt Test Unit**
Device which monitors the functionality and continuity of opening/closing shunt releases. Owing to their particular construction, checking the functionality of closing (-MBC) and opening (-MBO1, -MBO2) shunt releases cannot be performed by dedicated relays (e.g. TCS Test Control Supervision, CCC Control Coil Continuity) or with the REF control and protection unit. The only device able to monitor the functionality of these releases is the STU device. Please contact us if this function must be provided by devices other than STU.
The STU Shunt Test Unit can be used in conjunction with the shunt opening release **(-MBO1; -MBO2)** or shunt closing release **(-MBC)** to check their functionality and continuity.
The Shunt Test Unit allows the continuity of releases with rated operating voltage between 24 V and 250 V (AC and DC) to be monitored, as well as the functionality of the electronic circuit of the release.
Continuity is monitored cyclically with intervals of 20 seconds between one test and the next.
The unit has optical signals with LEDs on the front. The following information is given:
- POWER ON: power supply present
- (-MO) TESTING: test in progress
- TEST FAILED: signal following a failed test or in the absence of auxiliary power supply
- ALARM: signal after three failed tests.

Two relays and a changeover are also available on the unit and allow the following two events to be remotely signaled:
- failure of a test (with automatic reset when alarm ceases)
- failure of three tests (resetting can only be obtained by means of the manual - RESET – from the front of the unit).

There is also a manual - RESET – key on the front of the unit.

| **Characteristics** | |
|---|---|
| Un | 24 ... 250 V AC/DC |
| Maximum interrupted current | 6 A |
| Maximum interrupted voltage | 250 V AC |

**22 Extension cord for 58 pins plug**
The extension cord with 58 pins available in two lengths 1.5m and 3m, in addition to the standard plug.



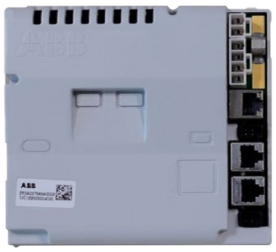
# Digital accessories for VD4 evo

**23 CMU**

The CMU is an embedded Monitoring & Diagnostic unit, capable of advanced local data analytics. It also embeds sensors for basic breaker monitoring features. It can be ordered stand alone or in combination with a range of Sensors from ABB sensors portfolio, depending on the monitoring needs (see next section).

For more details please see the CMU datasheet 2RDA044111 6 and CMU Dashboard Manual 2RDA044113.

| Parameter | Unit | Min Value | Max Value |
|---|---|---|---|
| AUX Rated voltage | AC (V)<br>DC (V) | 85<br>110 | 250<br>370 |
| Working temperature range | °C | -20 | +55 |
| Storage temperature | °C | -30 | +80 |



**24 Monitor & Diagnostic Sensors**

**24a STA201 Primary contacts thermal monitoring**

The STA201 sensors embedded in the primary contact arms allow direct measurement of the temperature in one of the most critical points of the circuit breaker. The measurement is shared through wireless to the concentrator unit for Monitor & Diagnostic features.

For installation or replacements please consult dedicated device documentation.



**24b SMA201 Smart Angle sensor**

The SMA201 sensor is assembled on the breaker kinematic chain to allow direct measurement of the most important characteristic of a proper Opening or Closing operation. The measurement is shared to with the concentrator unit for Monitor & Diagnostic features.

For installation or replacements please consult dedicated device documentation.



**24c STE201/STL201 Cables/BusBars thermal monitoring**

The STE201/STL201 Temperature monitoring devices are key components in ABB's switchgear and apparatus monitoring & diagnostic solutions. The devices are battery-free, self-powered smart temperature sensors, using wireless communication technology for connecting to ABB's monitoring and diagnostics data concentrators. The sensor devices can be installed directly on high-voltage parts, inside medium-voltage switchgear.

For installation or replacements please consult dedicated device documentation.



# Selection and ordering
## Optional accessories

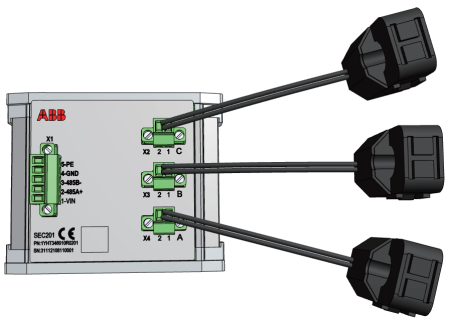
**24d THS01 Environmental monitoring**
The THS01 senors allows the monitoring of the circuit breaker at room parameters for monitor and diagnostic purposes.
For installation or replacements please consult dedicated device documentation.

**25 Digital upgrade KIT**
It is available a complete kit to upgrade a VD4 evo with Digital feature for monitor and diagnostic.
It includes the necessary connectors, concentrator unit CMU, and a flexible selection of ABB sensors.
Please contact your sales representative for more information.
Please contact ABB for more details based on your needs.



**24e SEC201 Primary Current Sensor**
The SEC201 sensor allows the measurement of primary currents for monitor and diagnostic of the circuit breaker from the current transformer secondary circuit. It allows electrical life monitoring and in combination with the thermal sensors enables advanced thermal monitoring and diagnostic features.
For installation or replacements please consult dedicated device documentation.

**26 Serial Hub**
The Serial communication hub is automatically delivered when more than one sensor with serial communication embedded in the CB has been ordered.
To be purchased separately in case of sensors upgrade after the ordering of the circuit breaker.



# For circuit breakers up to 40.5 kV, 40 kA with Classic operating mechanism

**Accessories with the same number are alternatives to each other.**

### 1 Shunt opening release -MO1 (-Y2)

The shunt opening release allows the apparatus to be opened by remote control.
An auxiliary contact -BB2 (-S4) always de-energizes it after opening.

| Characteristics | |
|---|---|
| Ua: 24 - 30 - 48 - 60 - 110 - 125 - 220 - 240 V- | |
| Ua: 100 - 110 - 125 - 220 - 230 - 240 V ~ 50 … 60 Hz | |
| Service tolerances: | DC 70 … 110% Ua |
| | AC 85 … 110% Ua |
| Short-term power consumption: | approx. DC 250 W; approx. AC 250 VA |
| Admissible maximum operating time: | 8 s |

### 2 Additional shunt opening release -MO2 (-Y9)

The additional shunt opening release has the same function as shunt opening release -MO1 (-YO2).
The additional shunt opening release is available on request and requires use of auxiliary contact -BB1 (-S3), which is part of the standard equipment.

| Characteristics | |
|---|---|
| Ua: 24 - 30 - 48 - 60 - 110 - 125 - 220 - 240 V- | |
| Ua: 100 - 110 - 125 - 220 - 230 - 240 V ~ 50 … 60 Hz | |
| Service tolerances: | DC 70 … 110% Ua |
| | AC 85 … 110% Ua |
| Short-term power consumption: | approx. DC 250 W; approx. AC 250 VA |
| Admissible maximum operating time: | 8 s |





# Selection and ordering
## Optional accessories

**3 Shunt closing release -MC (-Y3)**

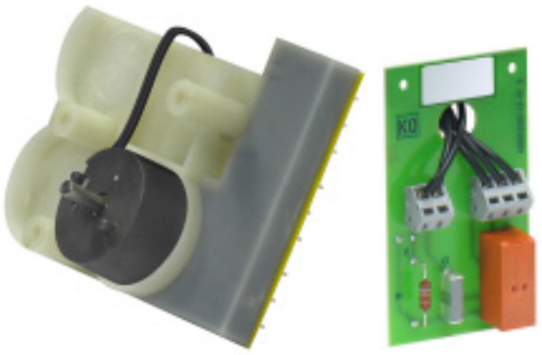
The shunt closing release allows the circuit breaker to be closed by remote control.
Auxiliary contact -BS1 (-S1) cuts off the power supplied to the release after the closing springs have been loaded, while auxiliary contact -BB1 (-S3) cuts off the power supplied to the release after the circuit breaker has closed.
Both are required and are part of the standard equipment.
The shunt closing release is optional in circuit breakers with manual opening mechanisms but mandatory for circuit breakers with motor-operated drives.
Application of the shunt closing release includes anti-pumping relay -K0.
The permanently supplied release provides the electrical anti-pumping function with both electrical opening and re-closing commands maintained.
Circuit breaker closing is only re-enabled once the active closing command has been interrupted.

| Characteristics | |
|---|---|
| Ua: 24 - 30 - 48 - 60 - 110 - 125 - 220 - 240 V- | |
| Ua: 100 - 110 - 125 - 220 - 230 - 240 V ~ 50 ... 60 Hz | |
| Service tolerances: | DC 70 ... 110% Ua |
| | AC 70 ... 110% Ua |
| Short-term power consumption: | approx. DC 250 W; approx. AC 250 VA |
| Admissible maximum operating time: | 8 s |

**4 Locking magnet on operating mechanism RL1 (-Y1) with auxiliary contacts -BL1 (-S2)**

Only allows the operating mechanism to be activated when the electromagnet is energized.
To enable the circuit breaker to close, the locking magnet must be energized for at least 100 ms before the circuit breaker closing command.
Auxiliary contact -BL1 (-S2) is required and is part of the standard equipment.

| Characteristics | |
|---|---|
| Ua: 24 - 30 - 48 - 60 - 110 - 125 - 220 - 240 V- | |
| Ua: 100 - 110 - 125 - 220 - 230 - 240 V ~ 50 ... 60 Hz | |
| Service tolerances: | DC 85 ... 110% Ua |
| | AC 85 ... 110% Ua |
| Short-term power consumption: | approx. DC 10 W; approx. AC 10 VA |
| Admissible maximum operating time: | unlimited |






## 5 Undervoltage release -MU (-Y4)

The undervoltage release opens the circuit breaker when there is an appreciable drop or lack of the voltage that supplies it.
It trips when the auxiliary voltage is between 70% and 30% of its rated value.
The circuit breaker can only close again when the voltage reaches 85% of its rated value.
The undervoltage release trips instantaneously, but can also be accompanied by an electronic time-lag device.

| **Characteristics of the non-delayed version** | |
|---|---|
| Ua: 24 - 30 - 48 - 60 - 110 - 125 - 220 V- | |
| Ua: 100 - 110 - 125 - 220 V ~ 50 … 60 Hz | |
| Power consumption: | approx. DC 10 W |
| | approx. AC 11 VA |
| Maximum service tolerance: | 110% Ua |
| Voltage for readiness closing: | > 85% UN |
| Trip voltage: | 30 … 70% Ua |
| Operating time: | immediate |
| Admissible maximum operating time: | none |

### 5.1 Electronic time-lag device -KT (-RN3U)

Use of the delayed undervoltage release is useful for preventing trips when the supply network of the release may be subject to power cuts or brief voltage dips.
The voltage of the undervoltage release must be within the operating range of the electronic time-lag device (a coupler transformer must be connected in series for rated voltages other than 100-110 V AC).
The electronic time-lag device must be assembled externally in relation to the circuit breaker. It allows the tripping action of the release to be delayed on the basis of preset and adjustable time settings.

| **Characteristics** | |
|---|---|
| Ua: 100 - 110 V ~ 50 … 60 Hz | |
| Power consumption: | approx. AC 10 VA |
| Service tolerances: | 110% Ua |
| Voltage for readiness closing: | > 70% Ua |
| Trip voltage: | < 70% Ua |
| a) standard: operating time 0.5... 4 s, adjustable in 0.5 s steps | |
| b) when closing is performed by means of auxiliary contacts: operating time is 0.5... 2s, adjustable in 0.5s steps with suitable coil | |
| Admissible maximum operating time: | none |





# Selection and ordering
## Optional accessories

### 6 Opening solenoid -MO3 (-Y7)

Use of the overcurrent release may be advisable in systems where the auxiliary voltage is unable to provide reliable continuity of service.
The release must receive the opening pulse on the basis of the current from the secondary winding of an intermediate current transformer or a delayed overvoltage relay.
During continuous service, the secondary winding of the MO3 is short-circuited by an auxiliary contact.

| Characteristics | |
|---|---|
| Power consumption in continuous service mode: | connection to 2 phases 35 VA<br>connection to 3 phases 2 VA |
| Trippping power consumption: | approx. 15 VA |
| Readiness tripping: | 70% IN |
| Power consumption of intermediate current transformer at IN = 5 A and continuous operation (short-circuited secondary winding): | Winding A 1 VA<br>Winding B 1 VA<br>Winding C 1.5 VA |
| Power consumption of intermediate current transformer at IN = 5 A and continuous operation (open secondary winding): | Winding A 15 VA<br>Winding B 15 VA<br>Winding C 25 VA |
| Primary current of intermediate current transformer: | 3 x 5 |
| Secondary current of intermediate current transformer: | ~ 0.4 A |

### 7 Auxiliary contacts of circuit breaker -BS1, -BB1, -BB2, -BB3 (S1, S3, S4, S5)

The circuit breaker can be equipped with five-pole auxiliary contacts for monitoring, interlocking and signaling. Auxiliary contact -BB2 (-S4) is part of the basic equipment of all circuit breakers with motor-driven operating mechanisms.
Auxiliary contact -BB3 (-S5) is optional.
Also consult the circuit-diagram.

| Characteristics | |
|---|---|
| Ua: | 24 (*) ... 250 V |
| Test voltage: | 2.5 kV |
| Rated current: | $Ith^2$ = 10 A |

(*) For application at 24Vdc and with currents lower than 10 mA golden contacts are recommended.







### 8 Auxiliary contact for signaling effective opening -BB4 (-S7)

Auxiliary contact -BB4 (-S7), also known as transient contact, is part of the basic equipment of all circuit breakers.
It is used for signaling effective opening of the circuit breaker (the transient signal lasts 30ms).

| Characteristics | |
|---|---|
| Ua: | 24 (*) ... 250 V |
| Test voltage: | 2.5 kV |
| Rated current: | $Ith^2$ = 10 A |

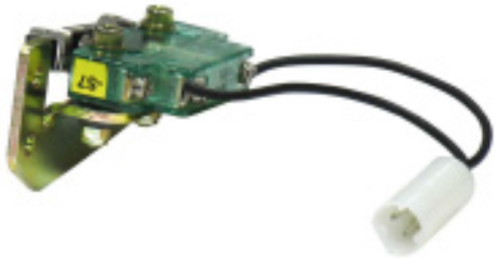
(*) For application at 24Vdc and with currents lower than 10 mA golden contacts are recommended.

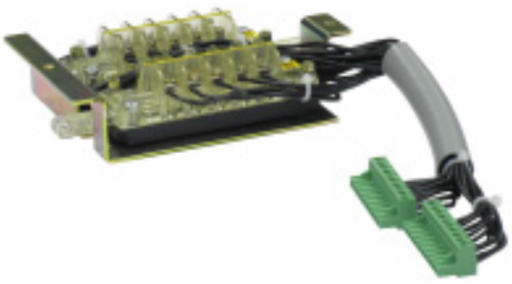
### 9 Transmitted contacts in truck -BT1, -BT2 (-S8, -S9)

The auxiliary contacts signal whether the circuit breaker is racked in or out.
In the intermediate position, the circuit breaker is mechanically interlocked.

| Characteristics | |
|---|---|
| Ua: | 24 (*) ... 250 V |
| Test voltage: | 2.5 kV |
| Rated current: | $Ith^2$ = 10 A |

(*) For application at 24Vdc and with currents lower than 10 mA golden contacts are recommended.





# Selection and ordering
## Optional accessories

### 10 Motor-operated drive -MS (-M0)

The spiral spring of circuit breakers with motor-operated drive is automatically loaded by an electric motor installed in the actual drive on the load side of each closing operation.

| **Characteristics** | |
|---|---|
| Ua: | 24 - 30 - 48 - 60 - 110 - 125 - 220 - 240 V- |
| Ua: | 110 - 240 V ~ 50 ... 60 Hz |
| Loading time: | max. 15 s |
| Reloading time: | max. 15 s |
| Service tolerances: | 85 ... 110% Ua |
| Power consumption during loading: | approx. DC 230 ... 260 W; approx. AC 260 VA |
| Weight: | 1.5 kg |

**Fuse motor:**

| rated supply voltage | power consumption | Fuse motor (ABB-Stotz mcb) | loading time (maximum) |
|---|---|---|---|
| V | VA/W | A | S |
| AC 110 | 260 | 1.6 S 281 UC-K | 10 |
| 220 | 260 | 0.75 | 10 |
| 240 | 260 | 0.75 | 10 |
| DC 110 | 230 | 1.60 | 10 |
| 125 | 260 | 1.60 | 10 |
| 220 | 240 | 0.75 | 10 |
| 240 | 260 | 0.75 | 10 |
| 24 | | | 15 |
| 30 | | | 15 |
| 48 | | | 15 |
| 60 | | | 15 |

| **Properties of Gefeg motor** | |
|---|---|
| Ua: | 24 - 48 - 60 - 110 - 125 - 220 - 240 V- |
| Ua: | 110 - 240 V ~ 50 ... 60 Hz |
| Loading time: | max. 15 s |
| Reloading time: | max. 15 s |
| Service tolerances: | 85 ... 110% Ua |
| Power consumption during loading: | app. DC 130 ... 140 W; app. AC 150 – 170 VA |
| Weight: | 1.5 kg |

**Fuse motor:**

| rated supply voltage | power consumption | Fuse motor (ABB-Stotz mcb) | loading time (maximum) |
|---|---|---|---|
| V | VA/W | A | S |
| AC 110 | 150 | 1.6 S 281 UC-K | 15 |
| 220 | 150 | 0.75 | 15 |
| 240 | 170 | 0.75 | 15 |
| DC 24 | 130 | 4.0 S 282 UC-K | 15 |
| 48 | 130 | 3.00 | 15 |
| 60 | 130 | 2.00 | 15 |
| 110 | 140 | 1.00 / 1.60 * | 10 |
| 125 | 160 | 1.00 / 1.60 * | 15 |
| 220 | 140 | 0.75 | 15 |
| 240 | 150 | 0.75 | 15 |

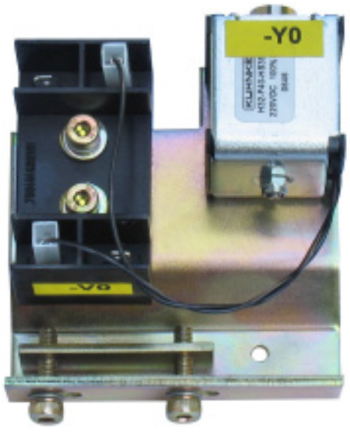
* VD4 63 kA motor



### 11 Locking magnet on truck -RL2 (-Y0)

The locking magnet on the truck prevents circuit breaker travel in the absence of auxiliary voltage.

| Characteristics | |
|---|---|
| Ua: 24 - 30 - 48 - 60 - 110 - 125 - 220 - 240 V- | |
| Ua: 100 - 110 - 125 - 220 - 230 - 240 V ~ 50 … 60 Hz | |
| Service tolerances: | DC; AC 85 … 110% Ua |
| Power consumption: | approx. DC 10 W;<br>approx. AC 10 VA |
| Admissible maximum operating time: | unlimited |



# Specific product characteristics








## Vibration resistance

VD4 circuit breakers are designed to provide high levels of resistance to stress caused by mechanical vibrations.
Many versions comply with the type-approval criteria of the major International Shipping Registers (DNV, Lloyd's Register, RINA) and the qualification criteria of the International Seismic Standards (IEEE 344, IEEE 323 and IEC 60980).
Please contact us if you wish to know which versions have been type-approved by the shipping registers.

## Tropicalization

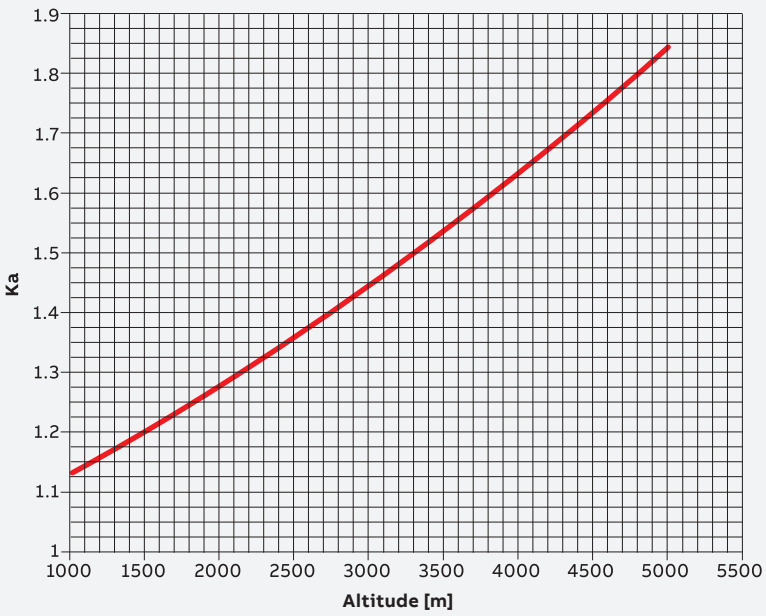
VD4 circuit breakers are manufactured in compliance with the most stringent specifications concerning their use in hot-humid-saline climates.
All the more important metal parts are treated against corrosive substances in compliance with atmospheric **corrosivity class C5 of standard BS EN 12500.**
Galvanizing treatment is applied in accordance with ISO 2081 Standards, classification code Fe/Zn 12, thickness $12x10^{-6}$ m, protected by a conversion layer formed mainly by chromates in compliance with ISO 4520 Standards.



## Altitude

The insulating property of air decreases as the altitude increases, therefore this must always be considered with regard to the external insulation of the apparatus (the internal insulation of the interrupters is not liable to change since it is guaranteed by the vacuum).
Altitude must always be taken into account when the insulating components of apparatus to be installed over 1000 m above sea level is designed. In these cases a correction coefficient must be applied. This can be found from the graph on the next page, which has been created on the basis of the indications in Standard IEC 62271-1.
The following example provides a clear interpretation of the indications given above.

**Graph for determining the Ka correction factor according to altitude, Example (IEC):**




**Ka** = $e^{mH/8150}$ with m=1
**H** = altitude in meters
**m** = value with reference to power frequency test voltage and lightning impulse withstand voltage as well as line-to-line voltage. Value defined for m = 1

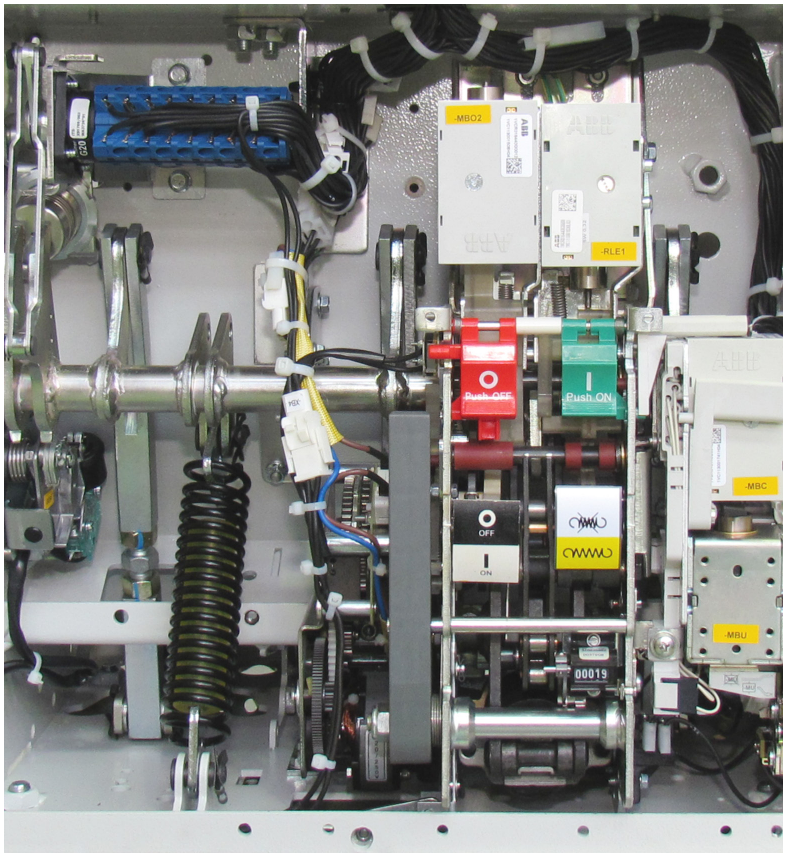
- Installation altitude: 2000 m
- Service at 7 kV rated voltage
- Power frequency withstand voltage 20 kV rms
- Impulse withstand voltage 60 kVp
- Ka Factor = 1.28 (see graph).

On the basis of the parameters above, the apparatus must ensure the following withstand values (test performed at zero altitude i.e. at sea level):

- power frequency withstand voltage equal to: 20 x 1.28 = 25.6 kVrms
- impulse withstand voltage equal to: 60 x 1.28 = 76.8 kVp.

It will be apparent from the above that apparatus with 17 kV rated voltage characterized by 38 kV rms power frequency insulation levels and 95 kVp impulse withstand voltage must be provided for installations at an altitude of 2000 m above sea level with 12 kV service voltage.

# Specific product characteristics




## Anti-pumping device

The EL operating mechanism of VD4 circuit breakers (in all versions) is equipped with a mechanical anti-pumping device which prevents re-closing due to both electrical and mechanical commands.
Should both the closing command and any one of the opening commands (local or remote) be active at the same time, there would be a continuous succession of opening and closing commands.
The anti-pumping device prevents this situation by ensuring that each closing operation is only followed by an opening operation and that there is no other closing operation after this. To obtain a further closing operation, the closing command must be released and then enabled again.
Furthermore, the anti-pumping device only allows the circuit breaker to be closed if the following conditions are present at the same time:

- operating mechanism spring fully loaded
- opening pushbutton and/or shunt opening release (-MBO1/-MBO2) not activated
- circuit breaker open.

## REF 601 protection device

On request, the REF 601 switchgear protection device is available for protecting the installations. It requires an auxiliary power supply in order to operate, unlike the previous PR512 which was a self-supplied relay.
REF 601 has protections and trip curves that conform to IEC 255-3 Standards. It protects against overloads (51), against instantaneous and delayed short-circuits (50-51) and against instantaneous and delayed homopolar earth faults (50N and 51N). It also detects the second harmonic component to prevent unwarranted tripping when a transformer is switched-in (68).

The unit has 3 inputs from current sensors of the Rogowsky coil type and one input from an external ring-type CT. 4 rated currents can be set via the keyboard: 40, 80, 250 and 1250 A.
If the unit is connected to 3 current sensors, the 50N and 51N protection functions are obtained by means of the vectorial sum of the phase currents.
If only 2 current sensors are used, an external ring-type current transformer must be provided for functions 50N and 51N.
The external ring-type current transformer can have an openable or closed core and any transformation ratio so long as the secondary current is 1 A.
The ABB current sensors of the Rogowsky coil type provided for REF 601 are only suitable for installation on MV insulated cables.
The characteristics of the device are:

- trip precision
- broad adjustment ranges
- single and simultaneous adjustment of the three phases
- no limitation (due to the current sensors) to the rated breaking capacity or short-time withstand current of the circuit breaker
- pushbuttons for local electrical operation of the circuit breaker (opening and closing pushbutton
- 5 distinct indicators: “relay operating”, “relay in trip threshold”, “relay tripped”, “relay tripped due to phase current having been exceeded”, “relay tripped for earth fault current having been exceeded”
- interface consisting of an LCD display and “arrow”, “enter” and “esc” keys for facilitated navigation in the “measurement” menu, “data recording”, “event recording”, “settings”, “configuration” and “test” menus




- three user levels: “operator” (display only, with free access by keeping this key pressed for at least 5 sec.), “configurator” (same as the previous level) but also with authorization to set the protection parameters (i.e. times and thresholds), and communication if present (access limited by a password), “administrator” (same as the previous levels), but also with authorization to set the password and configure the basic settings of the device, such as the rated current (access limited by a password)
- continuous display of the current on the most highly loaded phase and of the earth current
- recording of the value of the currents which caused the device to trip
- storage of the number of openings carried out by the device
- event log (storage of the parameters described above in the last 5 trips of the device) in a non-volatile memory
- curves “ß = 1” or “ß = 5” and curve “RI” specifically designed for the Belgian market (only REF 601 IEC)
- circuit breaker opening by means of an undervoltage release (only REF 601 CEI)
- version, on request, with RS485 4-wire serial communication
- MODBUS RTU full duplex protocol
- multi-voltage feeder 24 … 240 V AC- DC
- REF 601 is also available in a version specifically designed for the Italian market to CEI 0-16 standards (see brochure entitled “Solutions for upgrading to CEI 0-16 standards”) , with 80 or 250 A rated current which can be selected via the keyboard. It is always supplied with 3 sensors for installation on insulated MV cable, a 40/1 A ring-type CT for homopolar protection and undervoltage release for the circuit breaker opening operation.

## Environmental protection programme

VD4 circuit breakers are manufactured in accordance with the ISO 14000 Standards (Guidelines for environmental management).
The production processes are implemented in accordance with the environmental protection standards as to the reduction of energy consumption and the production of waste.
All this is achieved thanks to the environmental management system applied in the medium voltage apparatus manufacturing facility.
Assessment of the environmental impact during the life-cycle of the product obtained by reducing the overall energy consumption and use of raw materials to the minimum, is put into effect during the design engineering stage through an accurate choice of materials, processes and packaging.
This to allow the products and components to be recycled to the utmost degree at the end of their useful life.

## Spare parts

- Shunt opening release
- Additional shunt opening release
- Undervoltage release
- Time-lag device for undervoltage release
- Shunt closing release
- Spring loading geared motor with electrical signaling of spring loaded
- Contact signaling geared motor protection circuit breaker open/closed
- Contact signaling closing spring loaded/ discharged
- Transient contact with momentary closing during circuit breaker opening
- Circuit breaker auxiliary contacts
- Locking electromagnet on the operating mechanism
- Position contact of the withdrawable truck
- Contacts signaling connected/isolated
- Opening solenoid
- Open position key lock
- Isolation interlock with door
- Protection for opening pushbutton
- Protection for closing pushbutton
- Locking electromagnet on withdrawable truck
- Set of six isolating contacts.

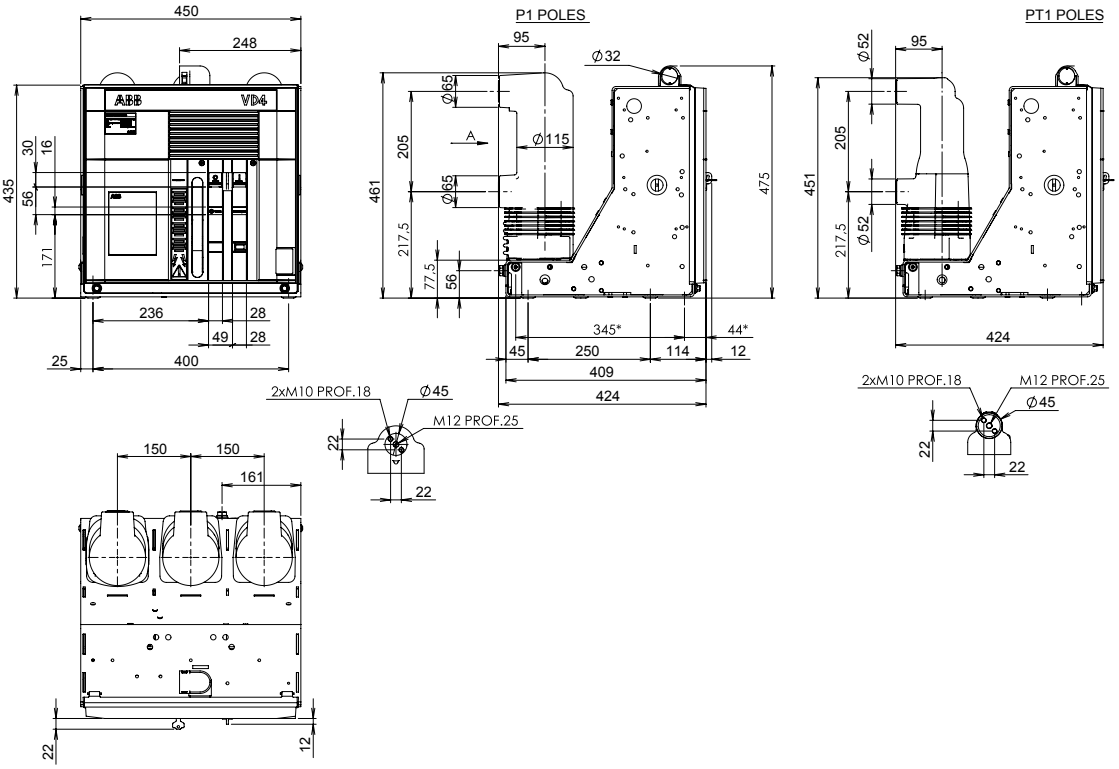
## Ordering

For availability and to order spare parts, please contact our Service department, specifying the circuit breaker serial number.

# Overall dimensions

### Fixed circuit breakers

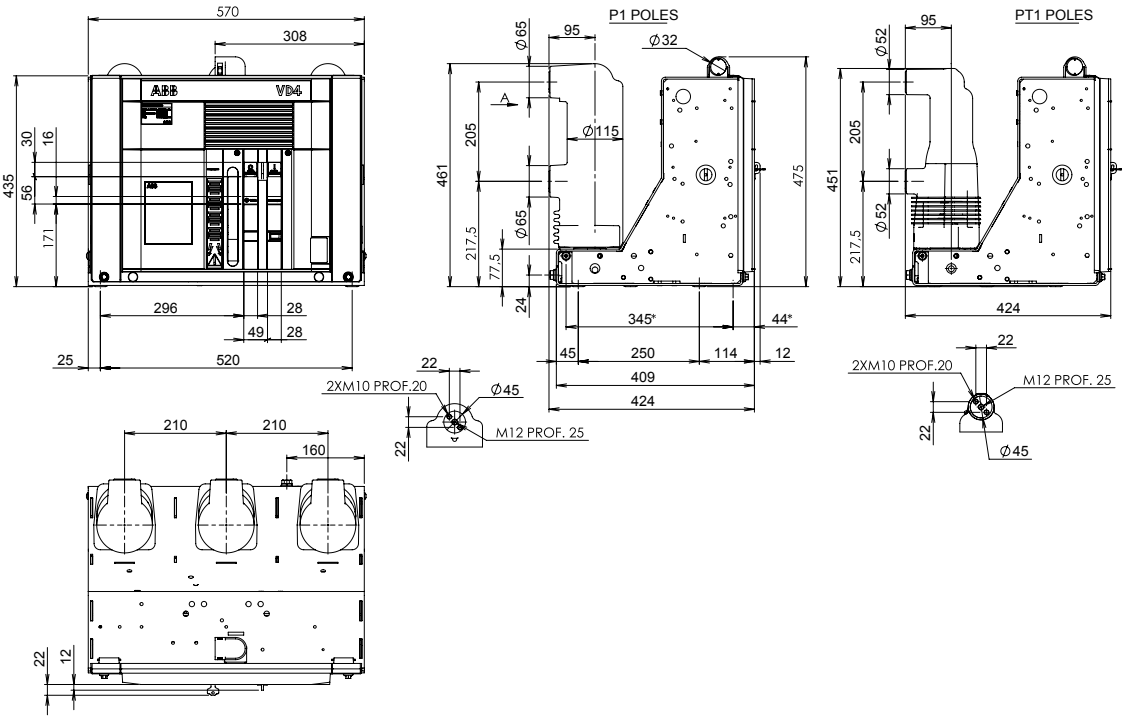
| VD4 | | |
|---|---|---|
| TN | 7405 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




(*) Fixing interchangeability with previous series (345 x 400).

### Fixed circuit breakers

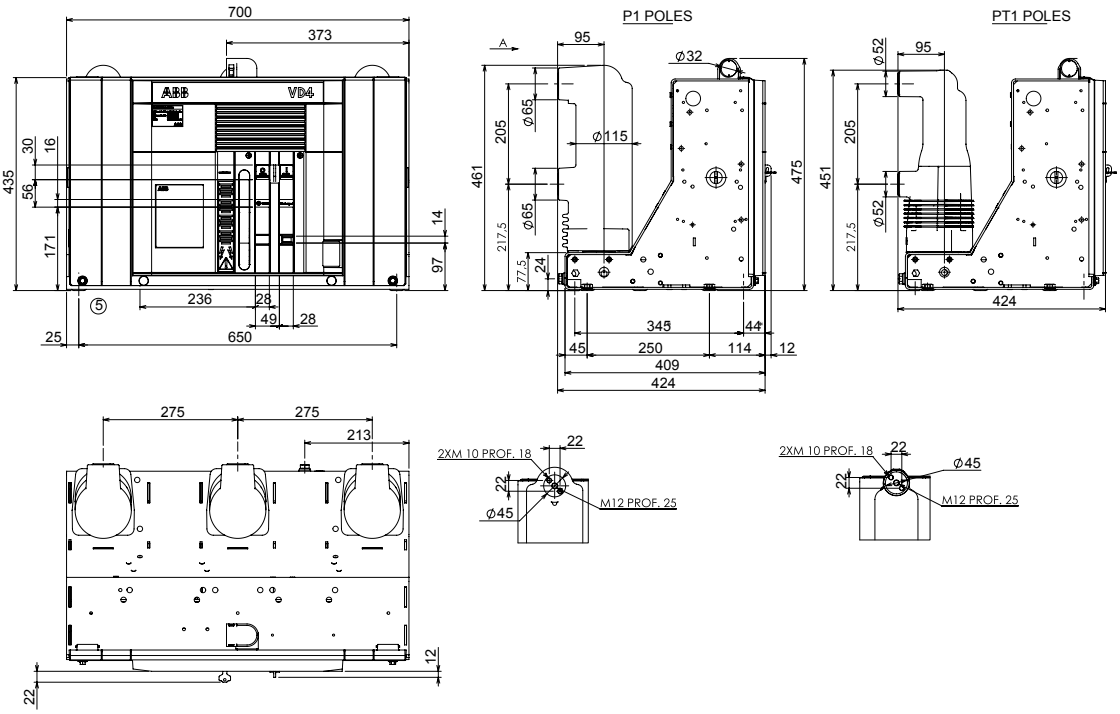
| VD4 | | |
|---|---|---|
| TN | 7406 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




(*) Fixing interchangeability with previous series (345 x 520).

## Fixed circuit breakers

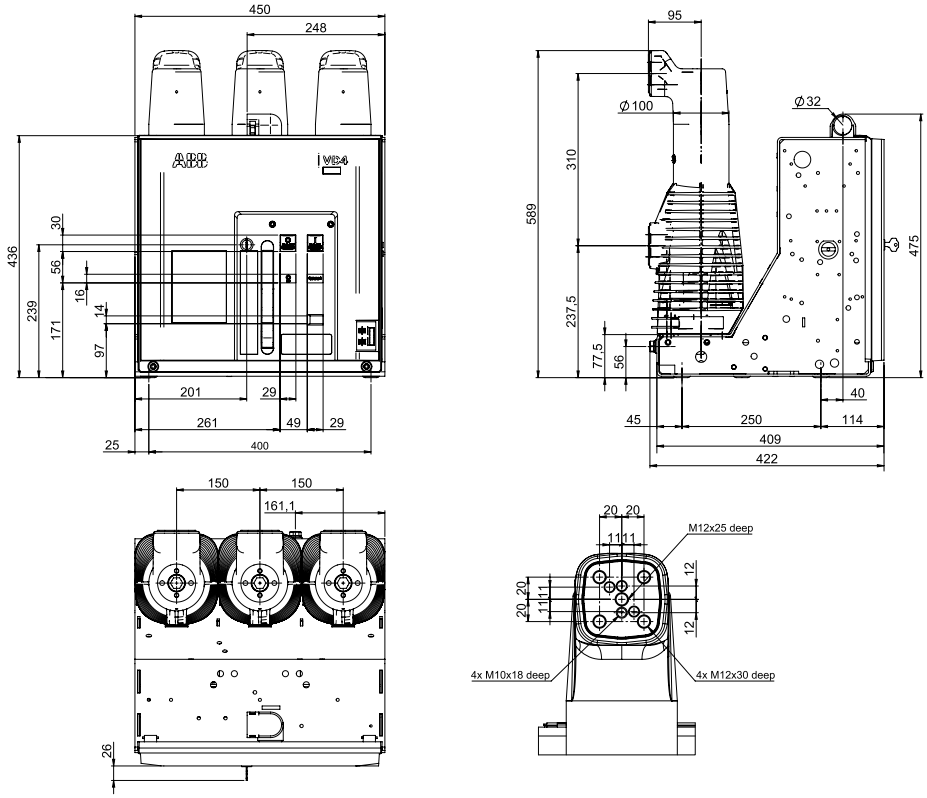
| VD4 | | |
|---|---|---|
| TN | 1VCD000051 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




(*) Fixing interchangeability with previous series (345 x 650).

## Fixed circuit breakers

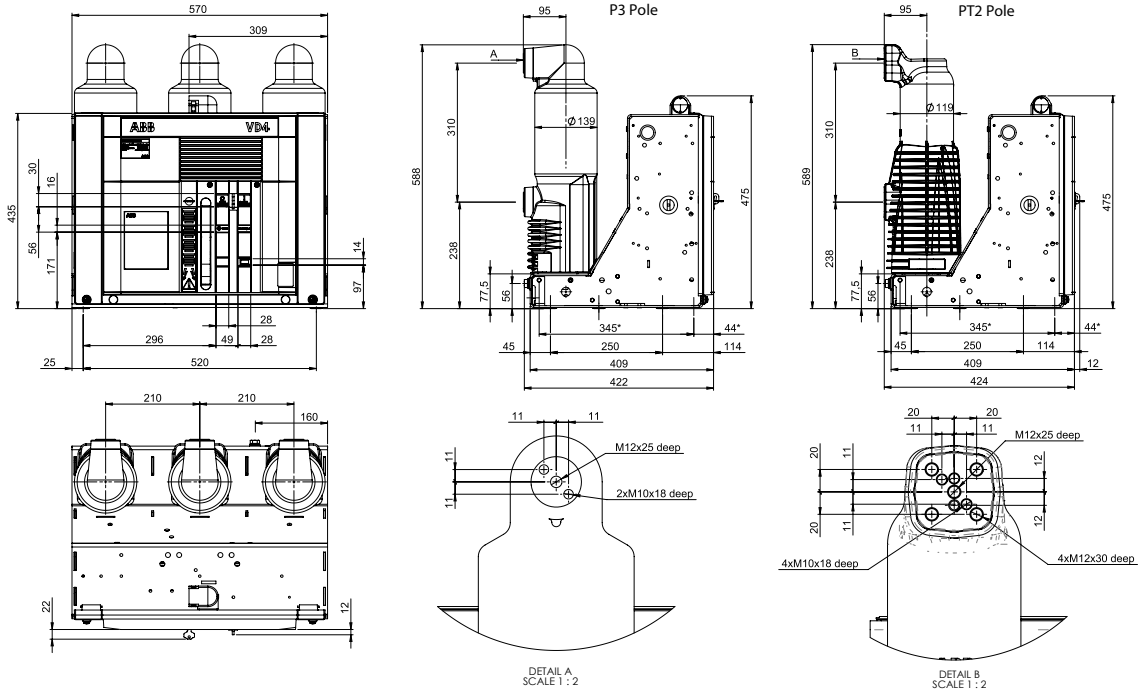
| VD4 | | |
|---|---|---|
| TN | 2RDA043108 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| In | 1250 | A |
| Isc | 40 | kA |



# Overall dimensions

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003282 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |

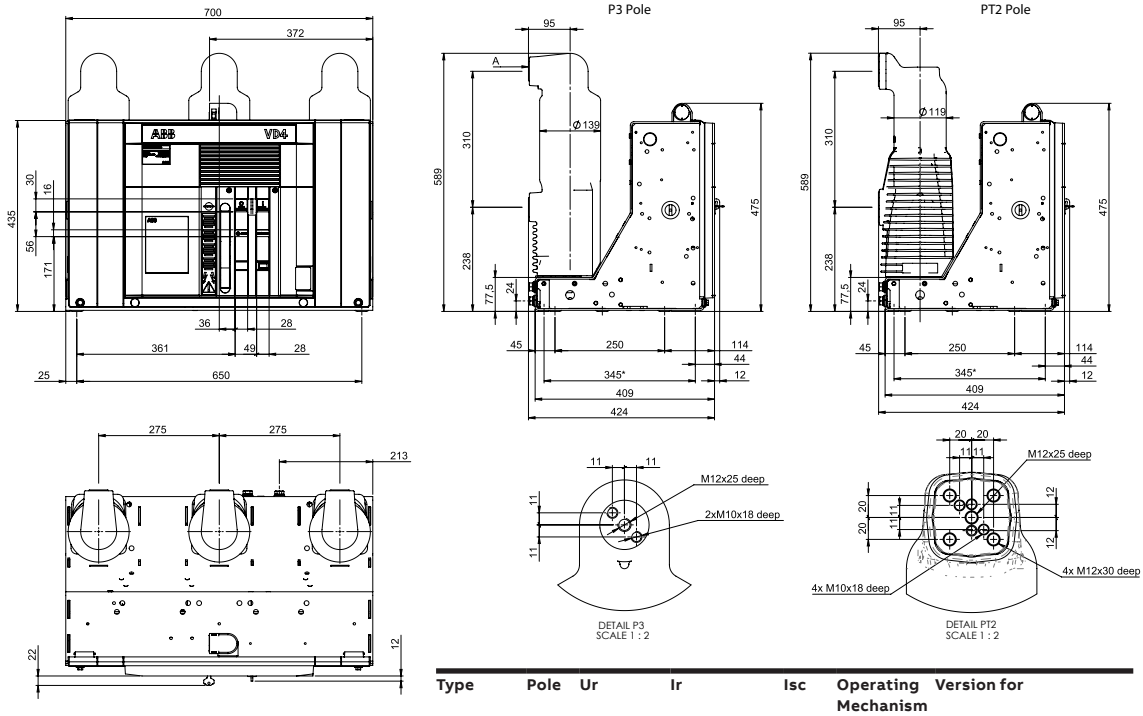



| Type | Pole | Ur | Ir | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p210 | P3 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |
| VD4 p210 | PT2 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |

(*) Fixing interchangeability with previous series (345 x 650).

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003285 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |

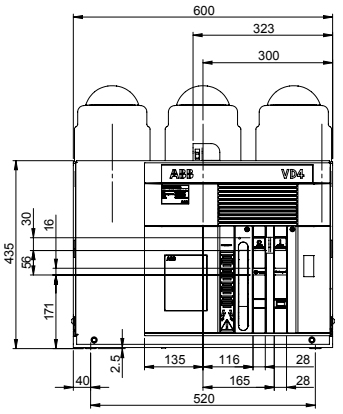


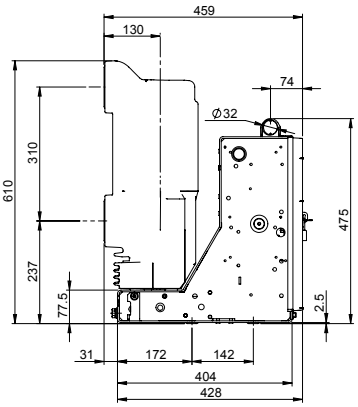

| Type | Pole | Ur | Ir | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p275 | P3 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |
| VD4 p275 | PT2 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |

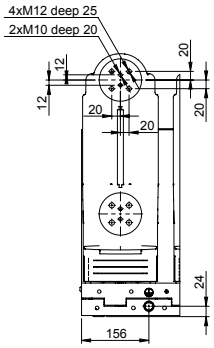
(*) Fixing interchangeability with previous series (345 x 650).

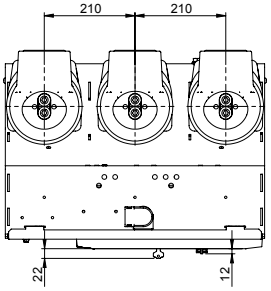
## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003440 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| Isc | 50 | kA |



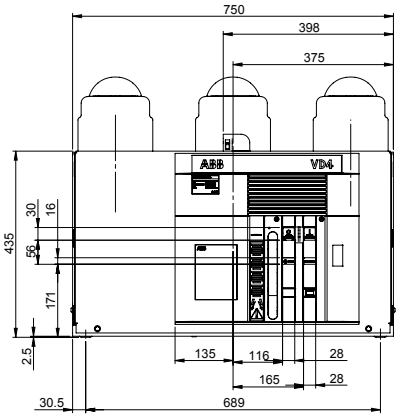



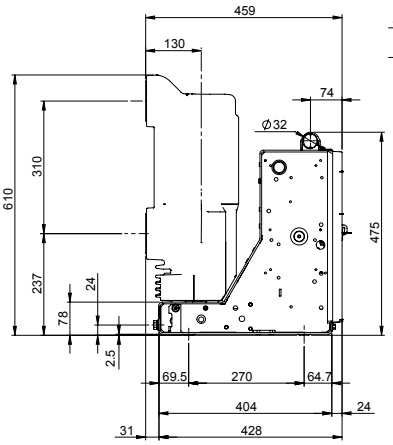



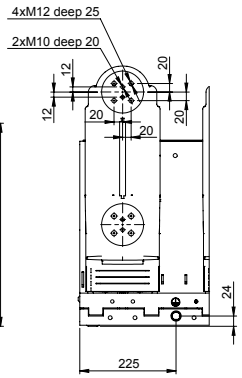



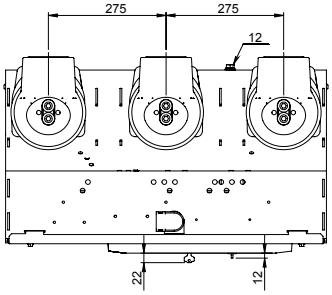

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003441 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 50 | kA |



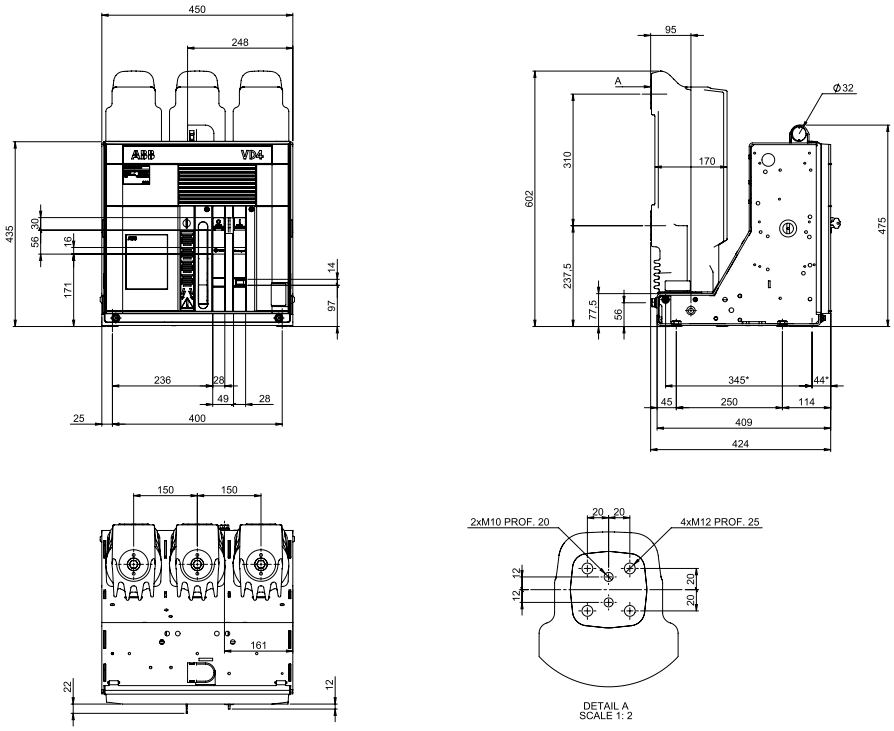



# Overall dimensions

### Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD000050 | |
| Ur | 12 | kV |
| Ir | 1600 | A |
| | 20 | kA |
| Isc | 25 | kA |
| | 31.5 | kA |



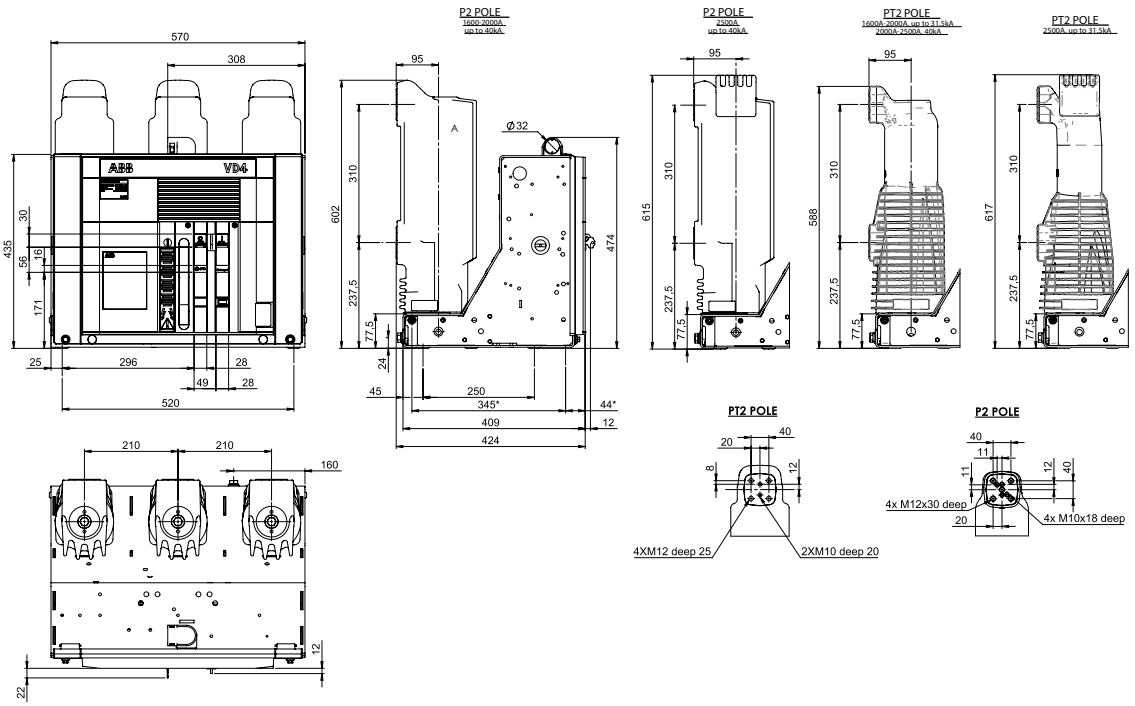

(*) Fixing interchangeability with previous series (345 x 400).

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 7407 | |
| Ur | 12-17.5 | kV |
| Ir | 1600 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4 | | |
|---|---|---|
| TN | 7407 | |
| Ur | 12-17.5 | kV |
| Ir | 2000 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |

| VD4 | | |
|---|---|---|
| TN | 7407 | |
| Ur | 12 | kV |
| Ir | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |




| Type | Pole | Un | In | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p.210 | P2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | free standing version |
| | | 12-17.5kV | 2000A | 40kA | EL3 | |
| | | 12kV | 2500A | 40kA | EL3 | |
| VD4 12/**/**/G p.210 | | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | |
| VD4 p.210 | P2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |
| | | 12-17.5kV | 2000A | 40kA | EL3S | |
| | | 12kV | 2500A | 40kA | EL3S | |
| VD4 12/**/**/G p.210 | | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |

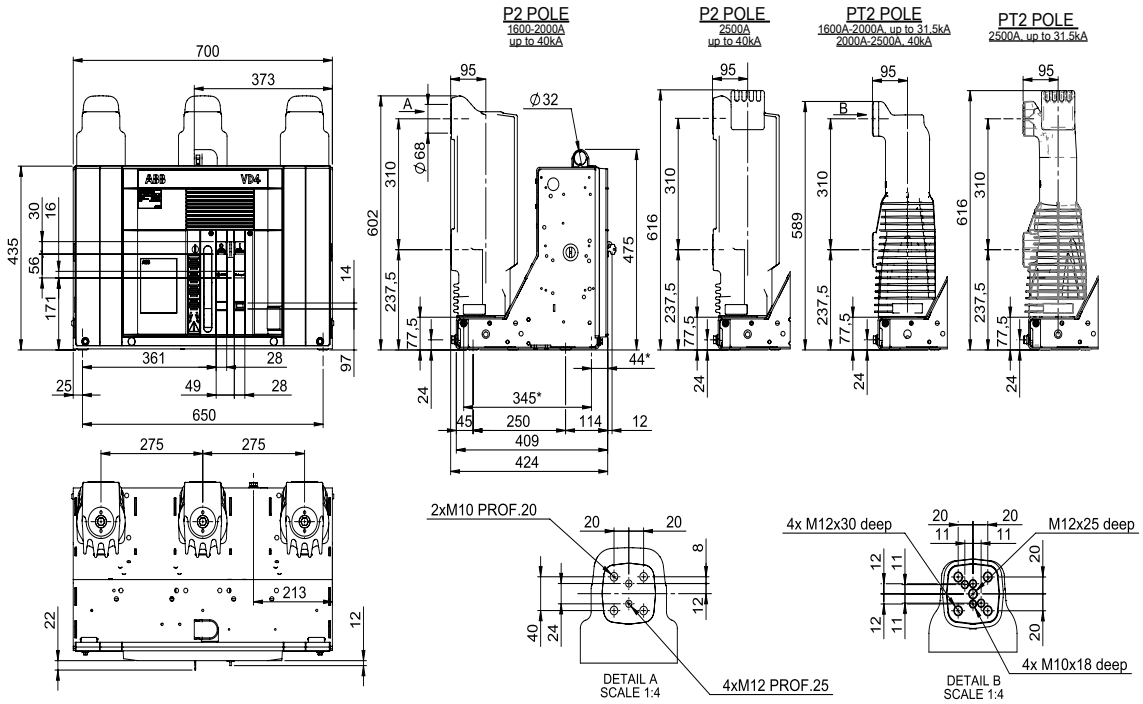
(*) Fixing interchangeability with previous series (345 x 650).

# Overall dimensions

### Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 7408 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4 | | |
|---|---|---|
| TN | 7408 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2000 | A |
| | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |

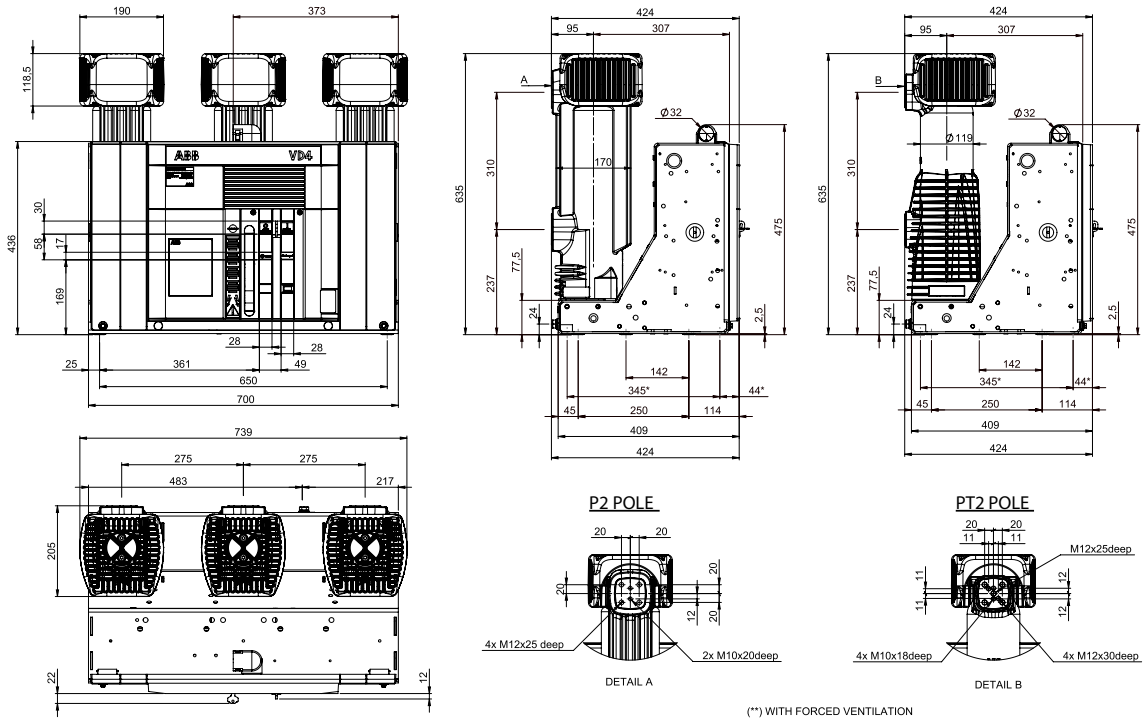



| Type | Poles | Un | In | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p.275 | P2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | free standing version |
| | | 12-17.5kV | 2000-2500A | 40kA | EL3 | |
| VD4 12/**/**/G p.275 | P2 | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | |
| | | 12kV | 2000-2500A | 40kA | EL3 | |
| VD4 p.275 | PT2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |
| | | 12-17.5kV | 2000-2500A | 40kA | EL3S | |
| VD4 12/**/**/G p.275 | PT2 | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |
| | | 12kV | 2000-2500A | 40kA | EL3S | |

(*) Fixing interchangeability with previous series (345 x 650).

## Fixed circuit breakers

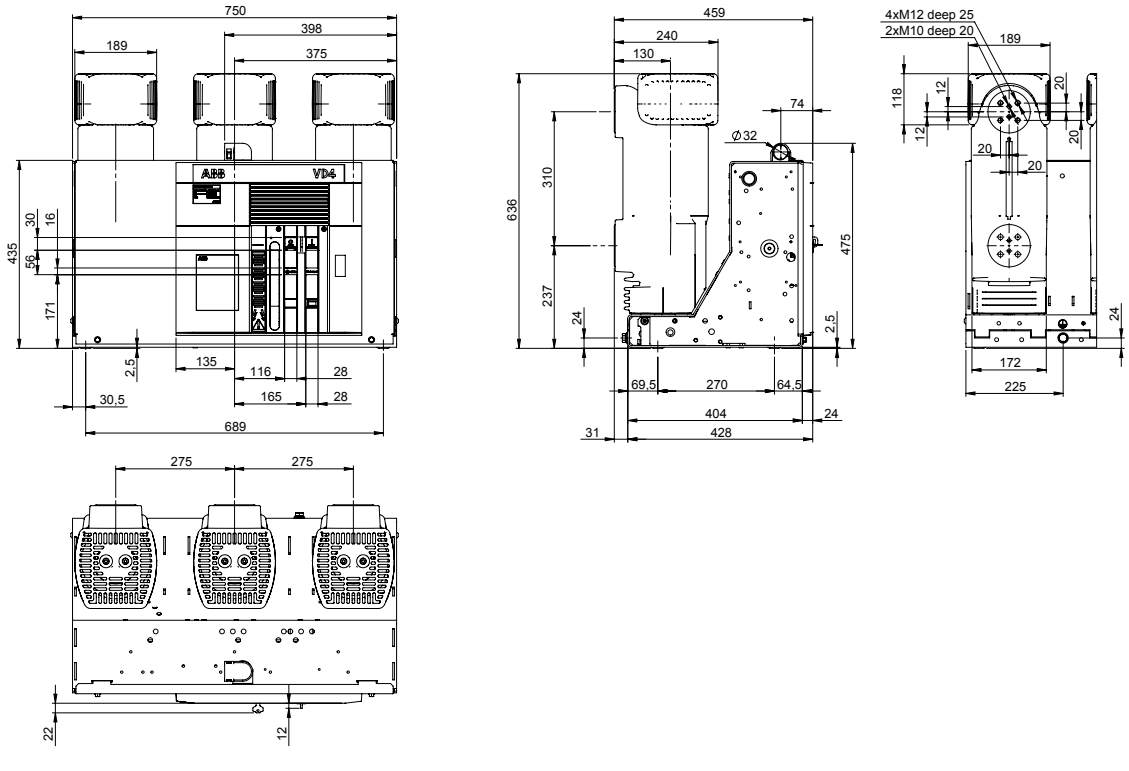
| VD4 | | |
|---|---|---|
| TN | 1VCD000149 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |




(*) Fixing interchangeability with previous series (345 x 650).

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003443 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 50 | kA |

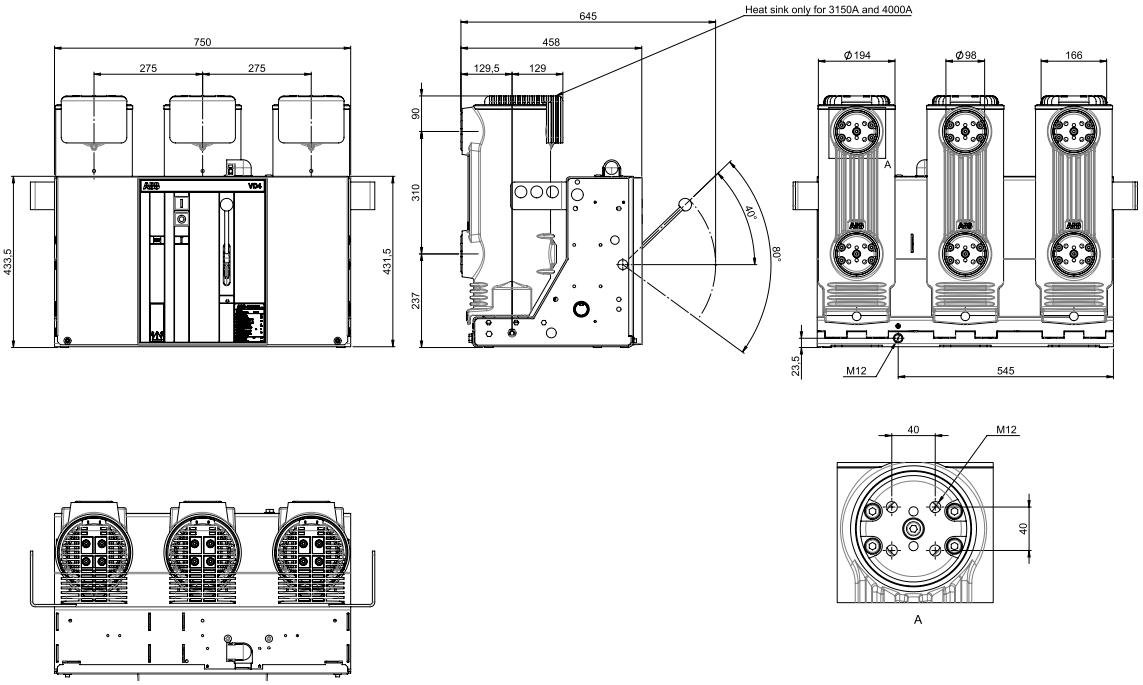



(*) 4000 A with forced ventilation.

# Overall dimensions

### Fixed circuit breakers

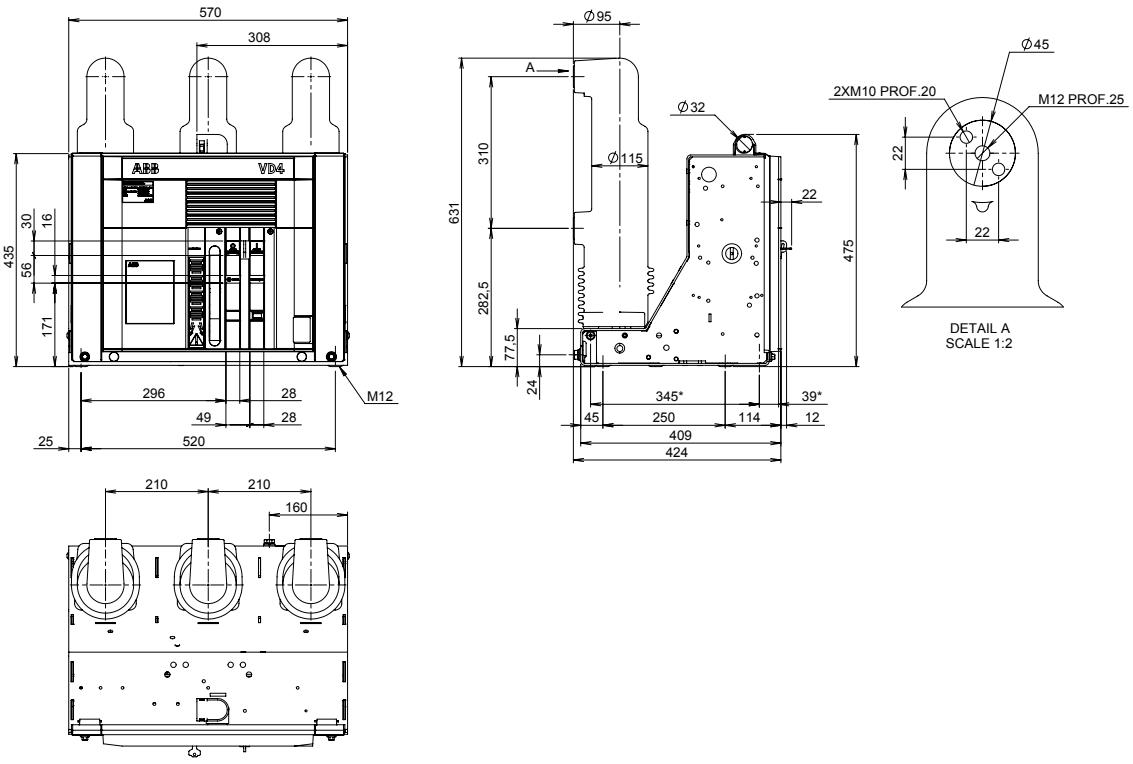
| VD4 | | |
|---|---|---|
| TN | 1VCD003945 | |
| Ur | 12 | kV |
| | 17 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| | 3150 | A (*) |
| Isc | 63 | kA |




(*) with forced ventilation

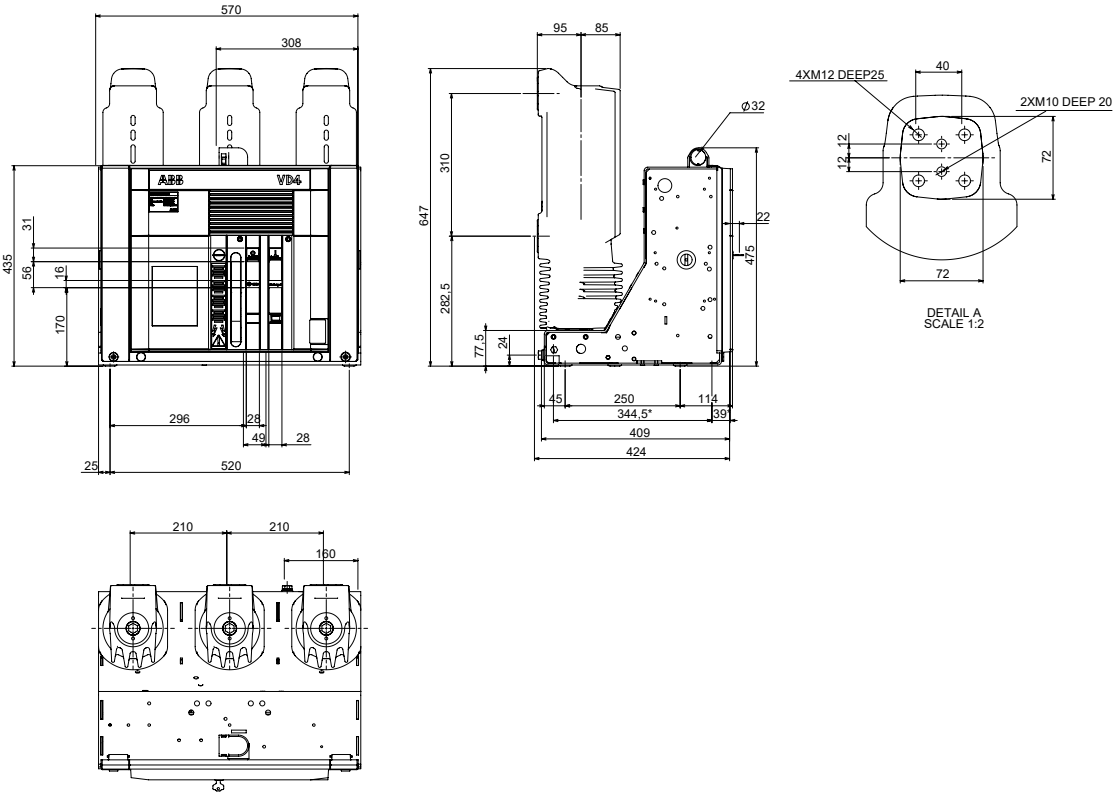
### Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 7409 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |



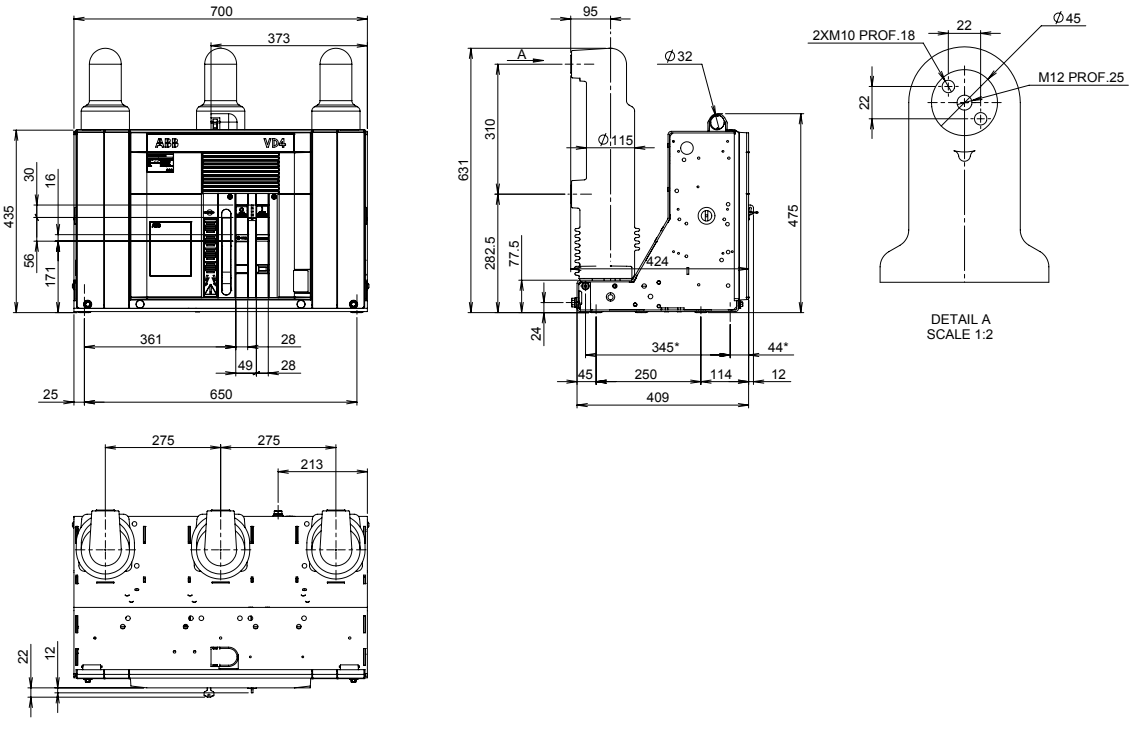
## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD000172 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 31,5 | kA |




## Fixed circuit breakers

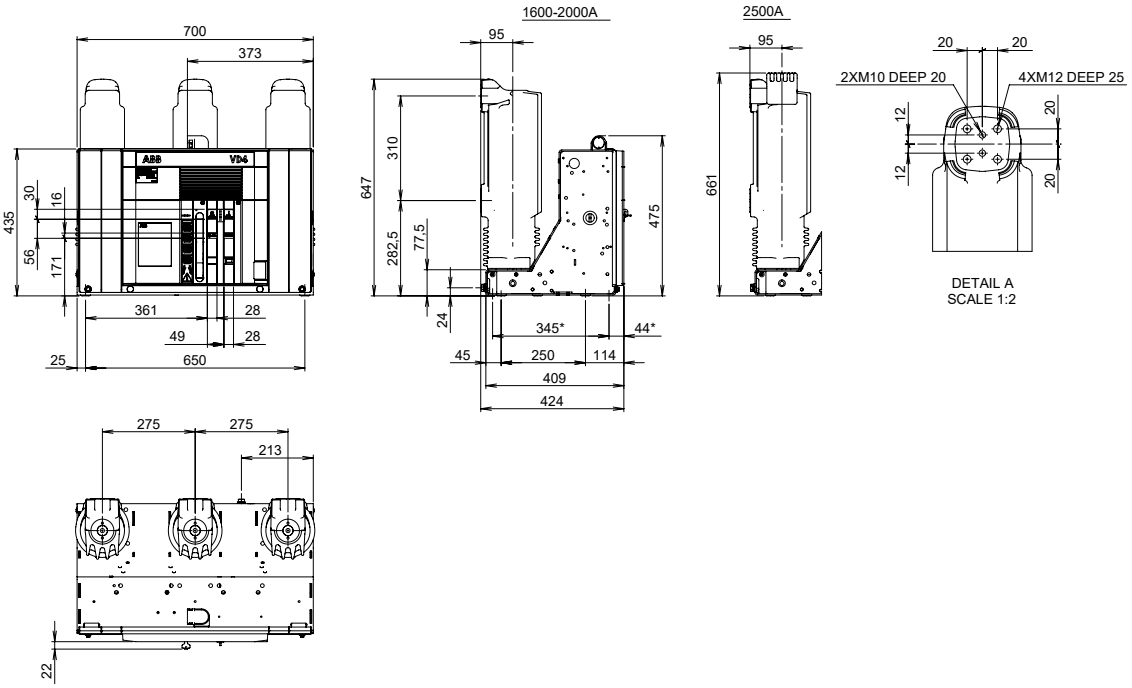
| VD4 | | |
|---|---|---|
| TN | 7410 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |



# Overall dimensions

### Fixed circuit breakers

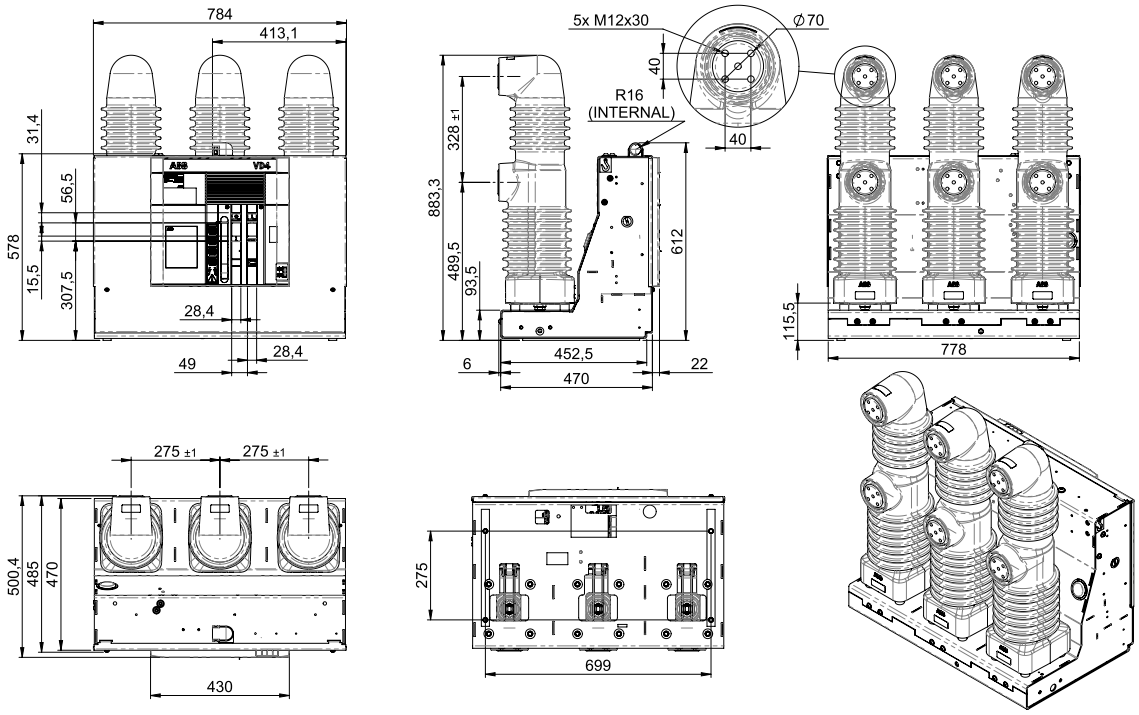
| VD4 | | |
|---|---|---|
| TN | 7411 | |
| Ur | 24 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




### Fixed circuit breakers

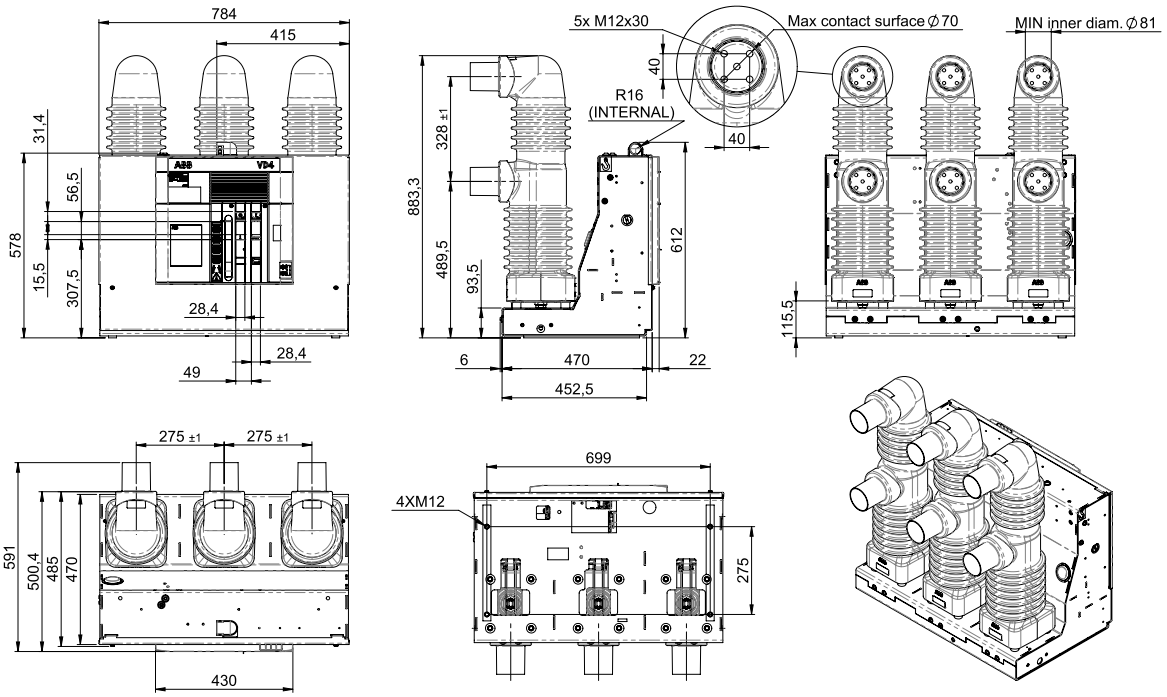
| VD4 | | |
|---|---|---|
| TN | 2RDA040578 | |
| Ur | 36 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4 | | |
|---|---|---|
| TN | 2RDA040578 | |
| Ur | 38 | kV |
| Ir | 1200 | A |
| | 2000 | A |
| Isc | 31.5 | kA |



## Fixed circuit breakers

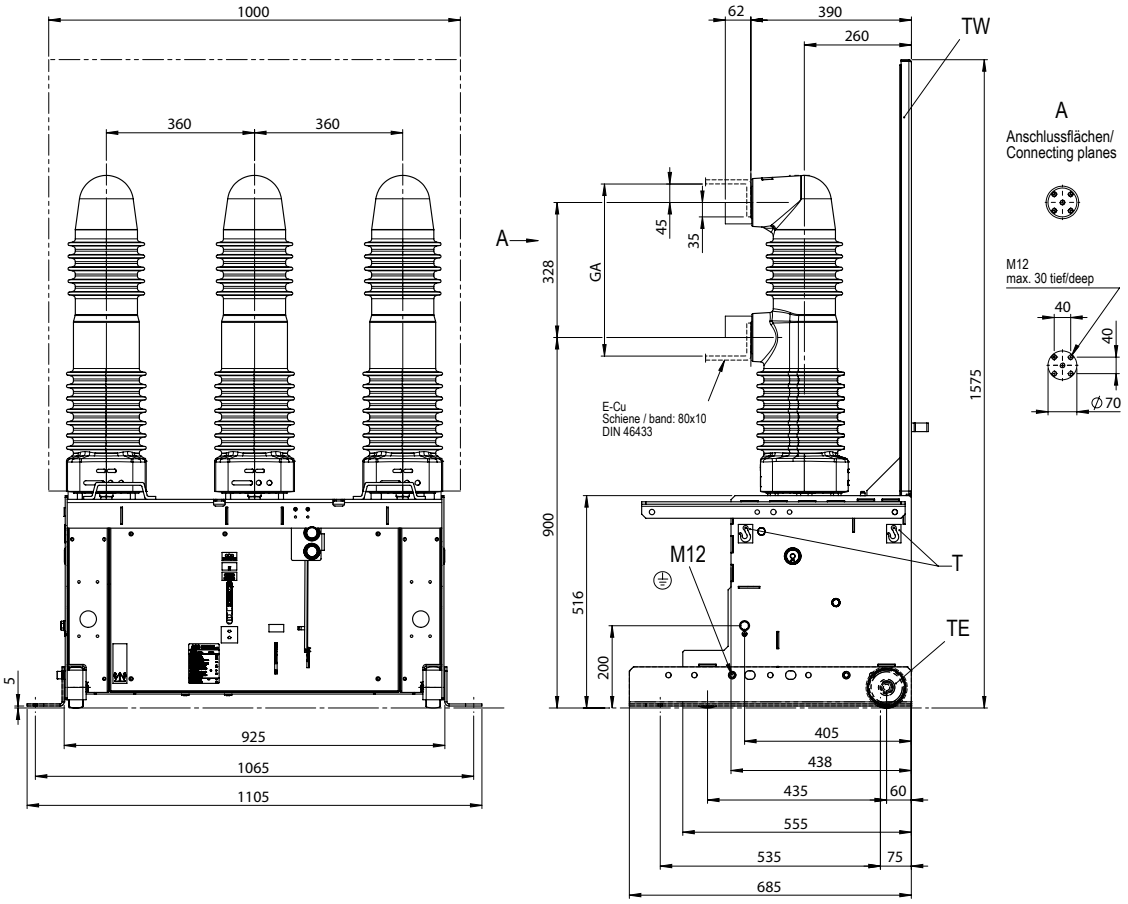
| VD4 | | |
|---|---|---|
| TN | 2RDA043326A | |
| Ur | 40 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |



# Overall dimensions

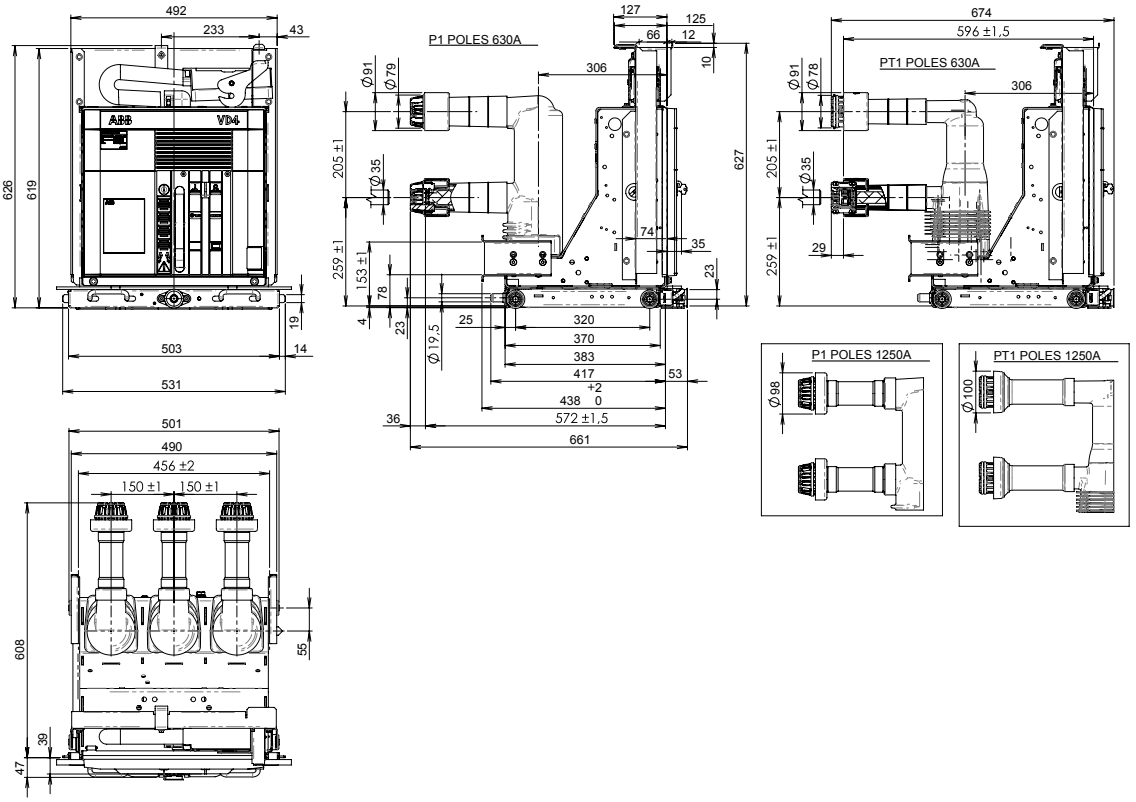
### Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | GCEM700198 | |
| Ur | 36-40.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



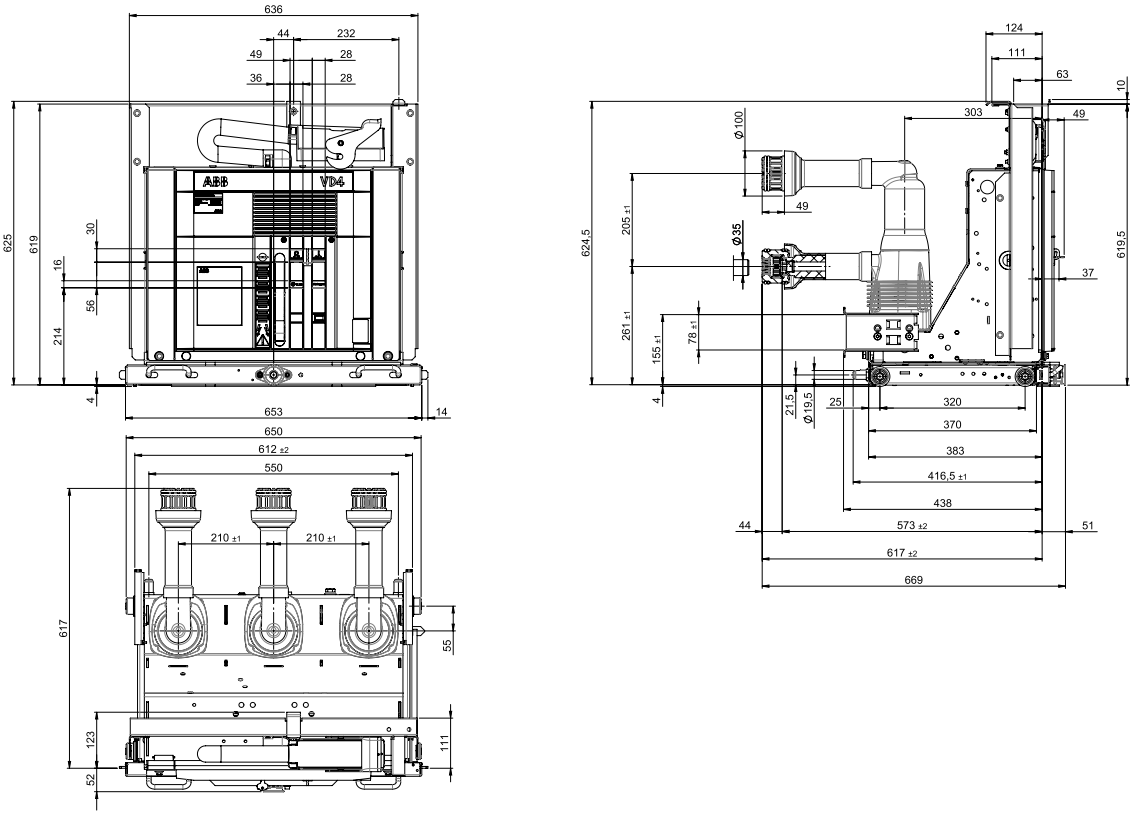
### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB1 modules

| VD4/P | | |
|---|---|---|
| TN | 7412 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




### Withdrawable circuit breakers for UniGear ZS1 switchgear

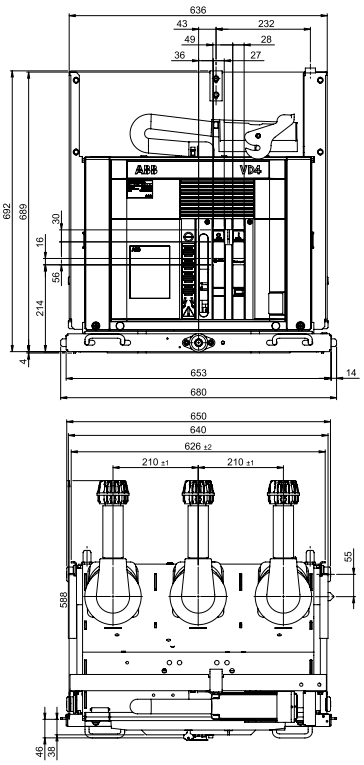
| VD4/P | | |
|---|---|---|
| TN | 2RDA032149 | |
| Ur | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 25 | kA |
| | 31.5 | kA |



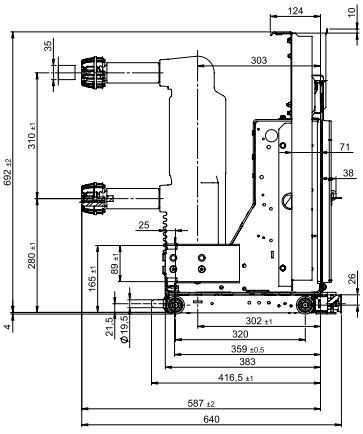
# Overall dimensions

### Withdrawable circuit breakers for PowerCube PB2 modules

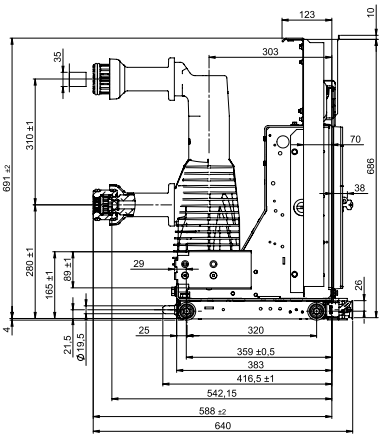
| VD4/W | | |
|---|---|---|
| TN | 7420 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




**P3 POLE**



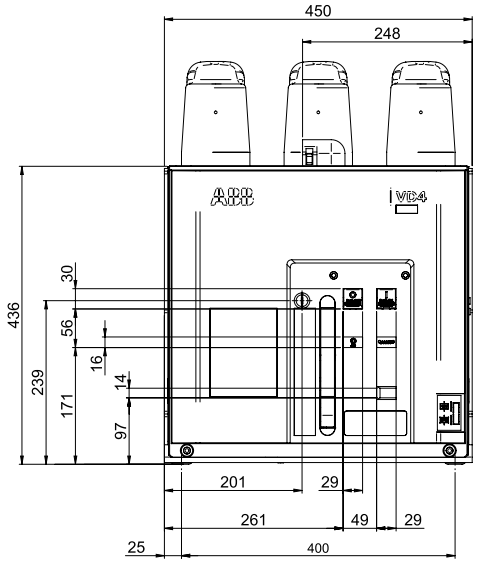

**PT2 POLE**

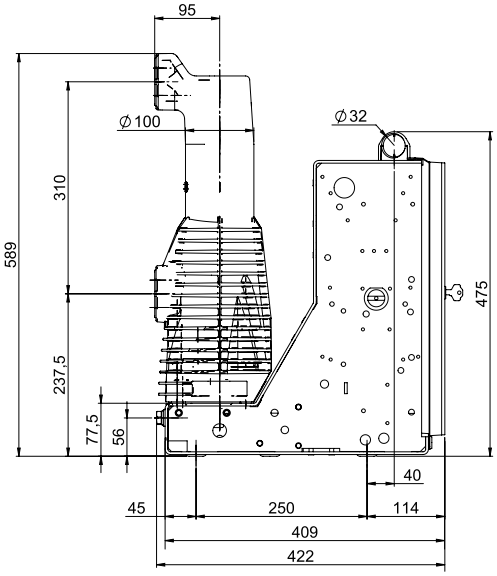


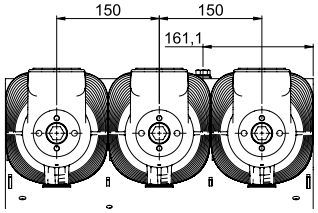

| Type | Pole | Un | In | Isc | Operating mechanism | Panel |
|---|---|---|---|---|---|---|
| VD4/W p.210 | P3 | 12-17.5 kV | 630-1250A | 16-25-31.5 kA | | |
| VD4/W 12/**/** G p.210 | | 12 kV | 12 kV | 16-25-31.5 kA | | |
| VD4/W xx.xx.xx. SA p.210 | | 12 kV | 630A | 16-20-25-31.5 kA | EL | UniSafe |
| VD4/W p.210 | PT2 | 12-17.5 kV | 630-1250A | 16-25-31.5 kA | | |
| VD4/W 12/**/** G p.210 | | 12 kV | 12 kV | 16-25-31.5 kA | | |

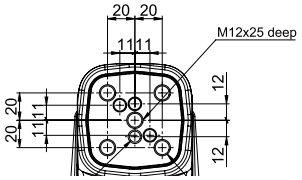
### Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 2RDA040163A | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| Isc | 40 | kA |



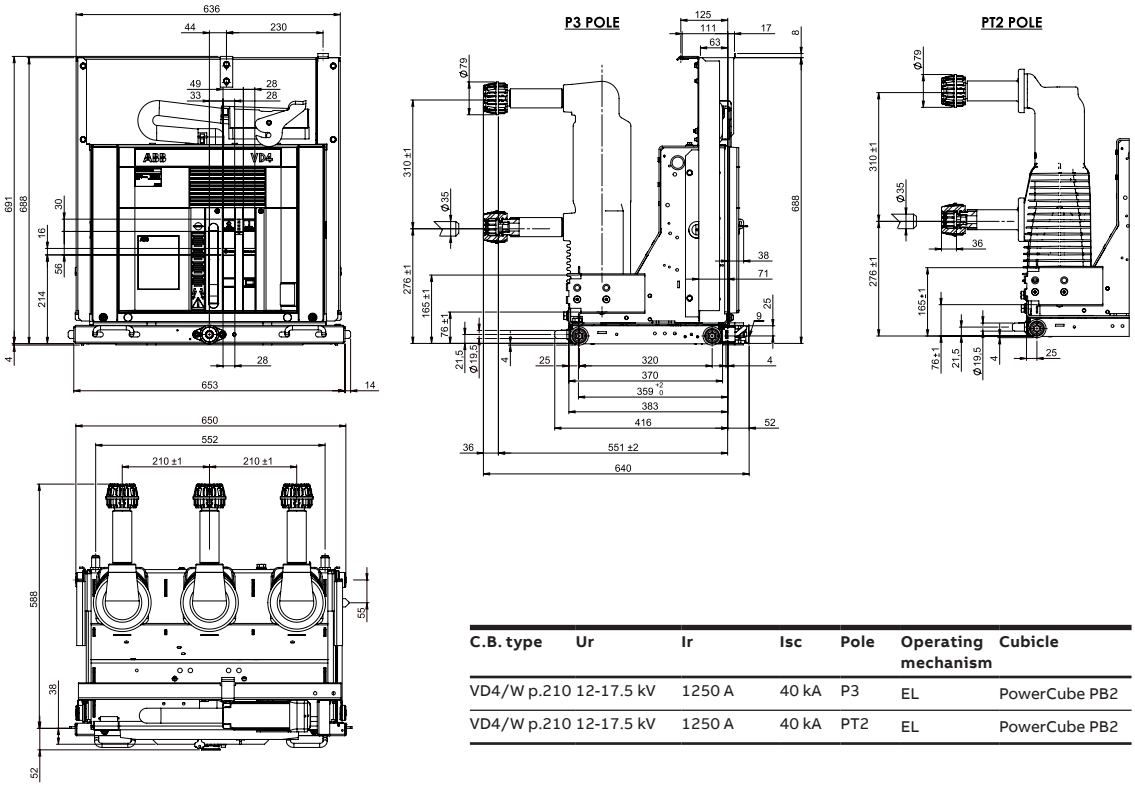



## Withdrawable circuit breakers for PowerCube PB2 modules

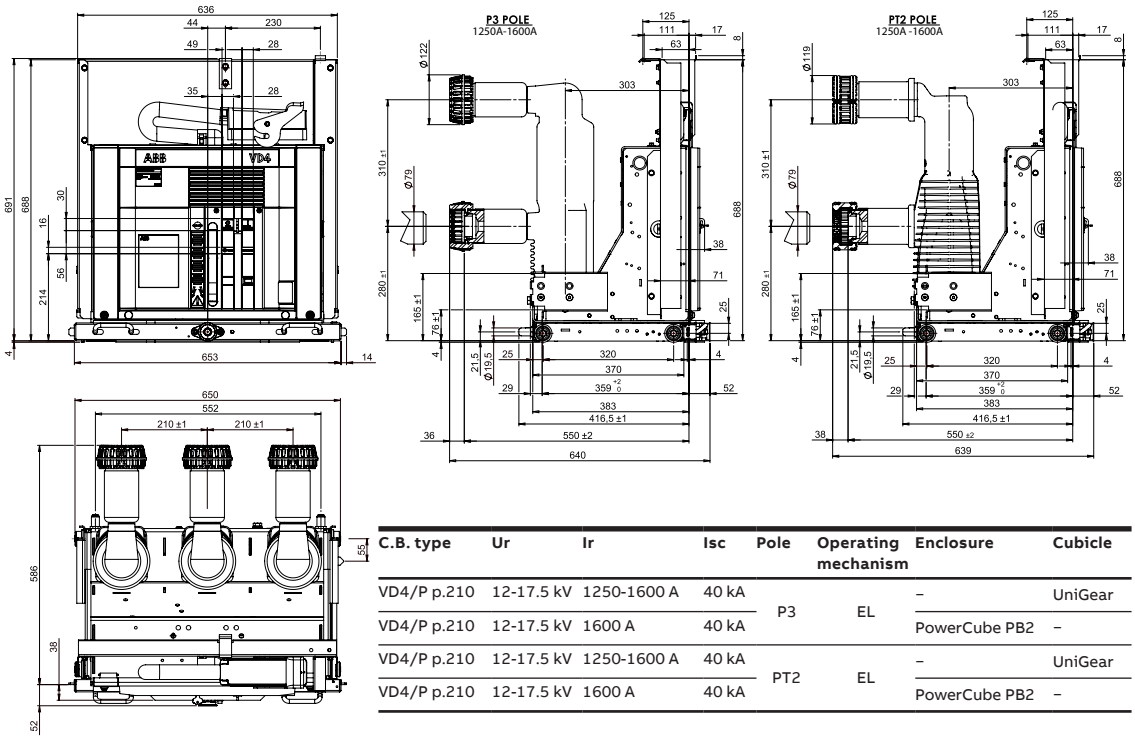
| VD4/W | | |
|---|---|---|
| TN | 1VCD601243 | |
| Ur | 12 | kV |
| | 17 | kV |
| Ir | 1250 | A |
| Isc | 40 | kA |




| C.B. type | Ur | Ir | Isc | Pole | Operating mechanism | Cubicle |
|---|---|---|---|---|---|---|
| VD4/W p.210 | 12-17.5 kV | 1250 A | 40 kA | P3 | EL | PowerCube PB2 |
| VD4/W p.210 | 12-17.5 kV | 1250 A | 40 kA | PT2 | EL | PowerCube PB2 |

## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB2 modules

| VD4/P | | |
|---|---|---|
| TN | 1VCD003284 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |

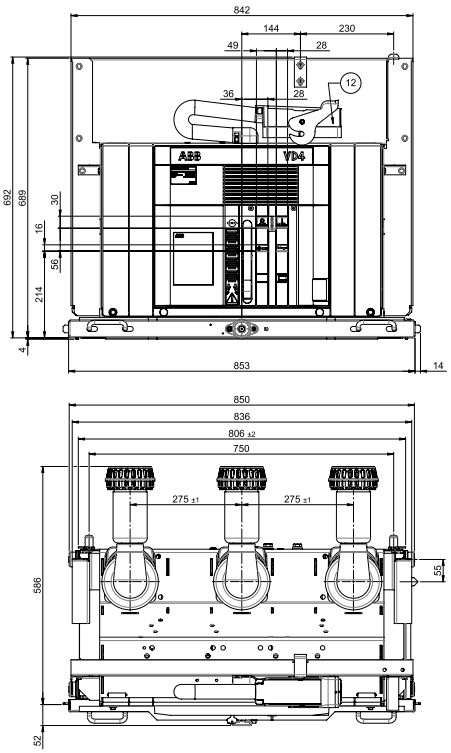


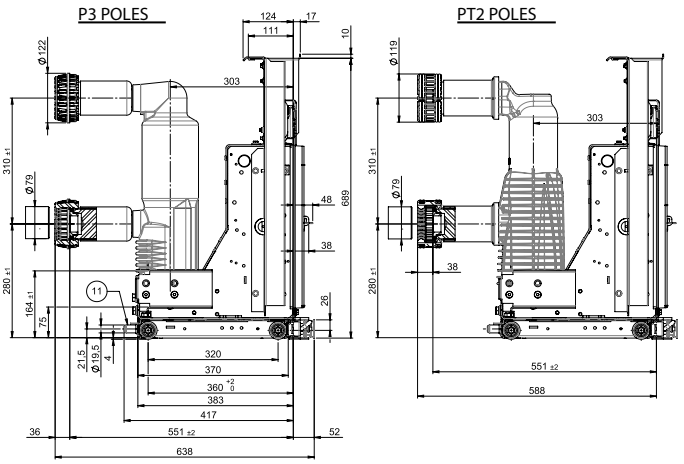

| C.B. type | Ur | Ir | Isc | Pole | Operating mechanism | Enclosure | Cubicle |
|---|---|---|---|---|---|---|---|
| VD4/P p.210 | 12-17.5 kV | 1250-1600 A | 40 kA | P3 | EL | – | UniGear |
| VD4/P p.210 | 12-17.5 kV | 1600 A | 40 kA | | | PowerCube PB2 | – |
| VD4/P p.210 | 12-17.5 kV | 1250-1600 A | 40 kA | PT2 | EL | – | UniGear |
| VD4/P p.210 | 12-17.5 kV | 1600 A | 40 kA | | | PowerCube PB2 | – |

# Overall dimensions

### Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD003286 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |

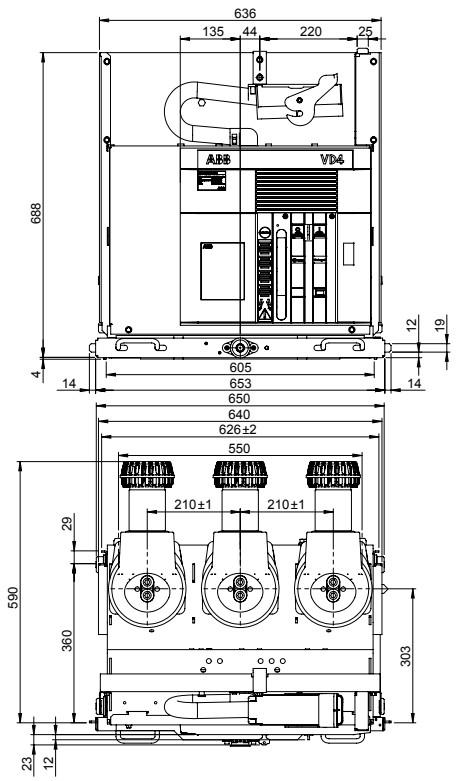


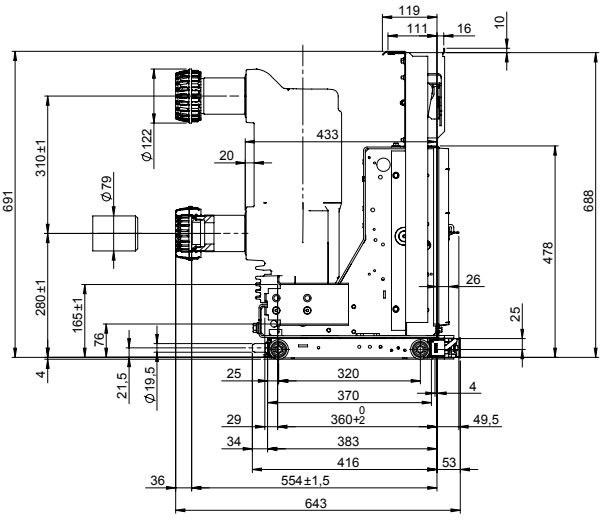




| C.B. type | Ur | Ir | Isc | Pole | Operating mechanism | Cubicle |
|---|---|---|---|---|---|---|
| VD4 p.275 | 12-17.5 kV | 1250-1600 | 40 kA | P | EL | UniGear ZS1 |
| VD4 p.275 | 12-17.5 kV | 1250-1600 A | 40 kA | PT2 | EL | UniGear ZS1 |

### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB2 modules

| VD4/P | | |
|---|---|---|
| TN | 1VCD 003444 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| Isc | 50 | kA |

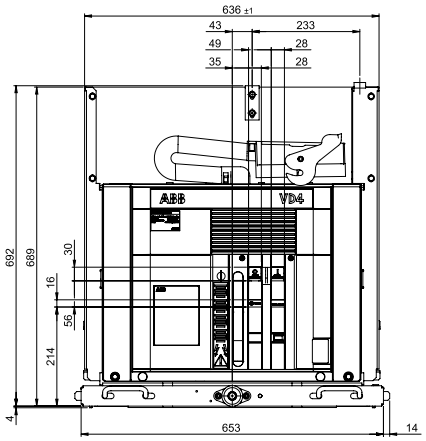


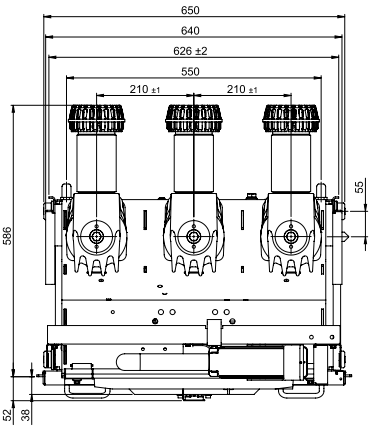



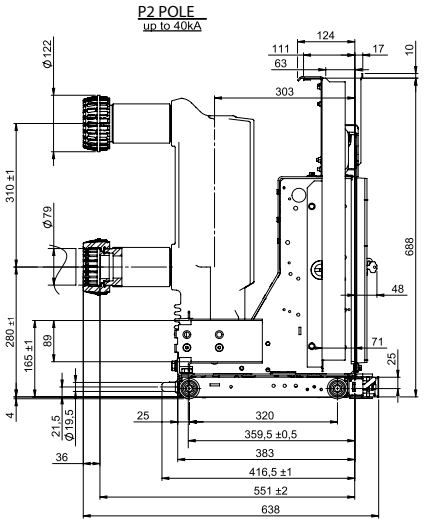
## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB2 modules

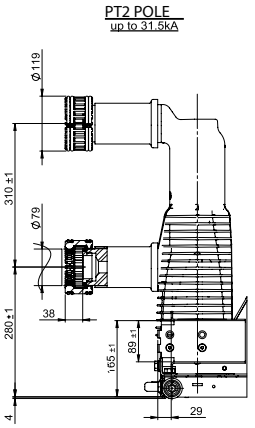
| VD4/P | | |
|---|---|---|
| TN | 7415 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4/P | | |
|---|---|---|
| TN | 7415 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2000 | A |
| Isc | 40 | kA |



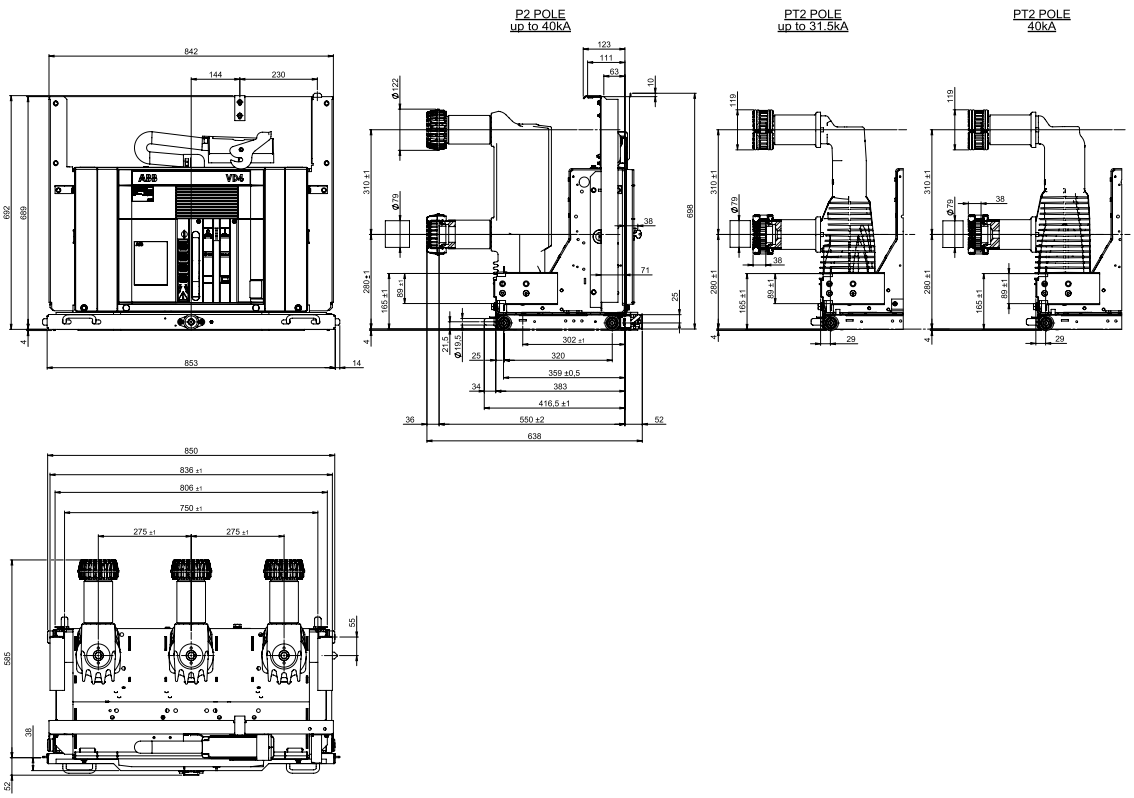

| Type | Un | In | Isc | Pole | O.M. | Enclosure | Cubide |
|---|---|---|---|---|---|---|---|
| VD4/P p.210 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | P2 | EL | CBE2-CBF2 PowerBloc-PowerCube PB2 | UniGear UniGear ZS1 |
| | 12-17.5kV | 2000A | 40kA | | | | UniGear |
| VD4/P 12/**/**/G p.210 | 12kV | 1600A-2000A | 20-25-31.5kA | | | | UniGear UniGear ZS1 |
| VD4/P XX.XX.XX.SA p.210 | 12-17.5kV | 1600A | 20-25kA | P2 | EL | PowerCube PB2 | UniGear |
| | | 2000A | 20-25-31.5kA | | | | |
| VD4/P p.210 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | PT2 | EL | PowerCube PB2 | UniGear |
| | | 2000A | 40kA | | | | |
| VD4/P 12/**/**/G p.210 | 12kV | 1600A-2000A | 20-25-31.5kA | | | | |

# Overall dimensions

### Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 7416 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

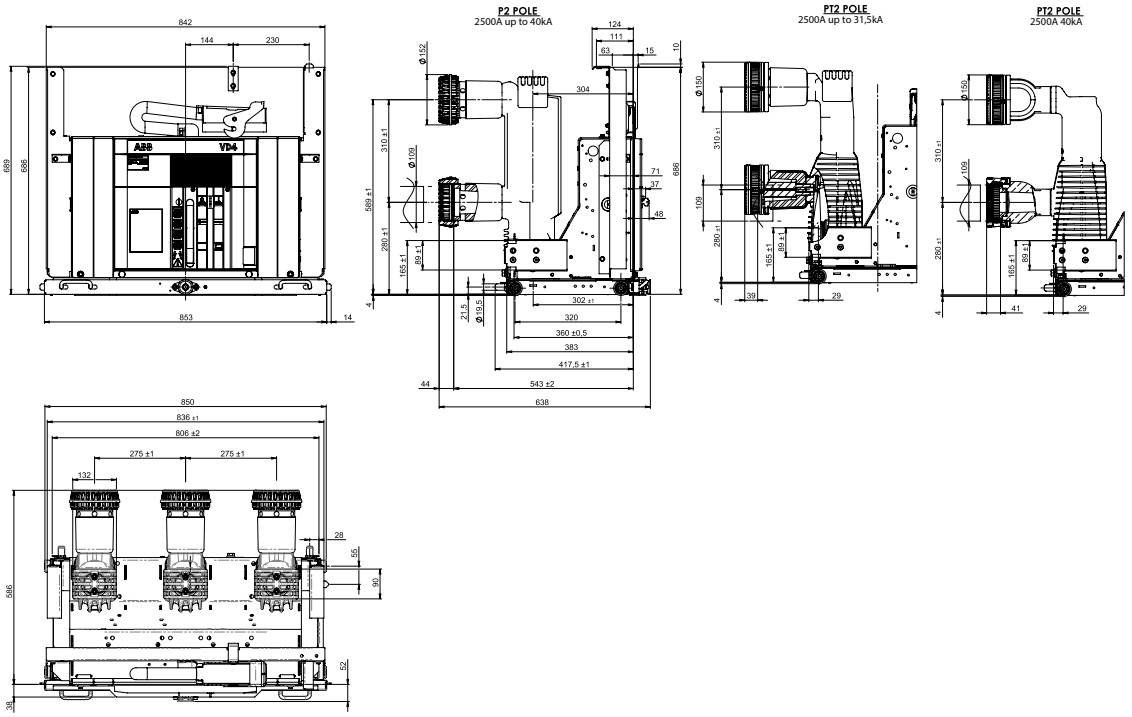
| VD4/P | | |
|---|---|---|
| TN | 7416 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2000 | A |
| Isc | 40 | kA |




| Type | Un | In | Isc | Pole | O.M. | Enclosure | Cubide |
|---|---|---|---|---|---|---|---|
| VD4/P p.275 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | P2 | EL | PowerBloc CBF3 | UniGear ZS1 |
| VD4/P 12/**/**/G p.275 | 12kV | 1600A-2000A | 20-25-31.5kA | | | PowerCube | |
| VD4/P p.275 | 12-17.5kV | 2000A | 40kA | | | PowerBloc CBF3 | |
| VD4/P p.275 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | P2 | EL | PowerBloc PowerCube | UniGear ZS1 |
| VD4/P 12/**/**/G p.275 | 12kV | 1600A-2000A | 20-25-31.5kA | | | | |
| VD4/P p.275 | 12-17.5kV | 2000A | 40kA | | | | |
| VD4/P XX.XX.XX.SA p.210 | 12kV | 1600A | 20-25kA | PT2 | EL | PowerCube PB2 | UniGear |
| | | 2000A | 20-25-31.5kA | | | | |
| | 17.5kV | 1600A | 20-25kA | | | | |
| | | 2000A | 20-25-31.5kA | | | | |

## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB3 modules

| VD4/P | | |
|---|---|---|
| TN | 7417 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |

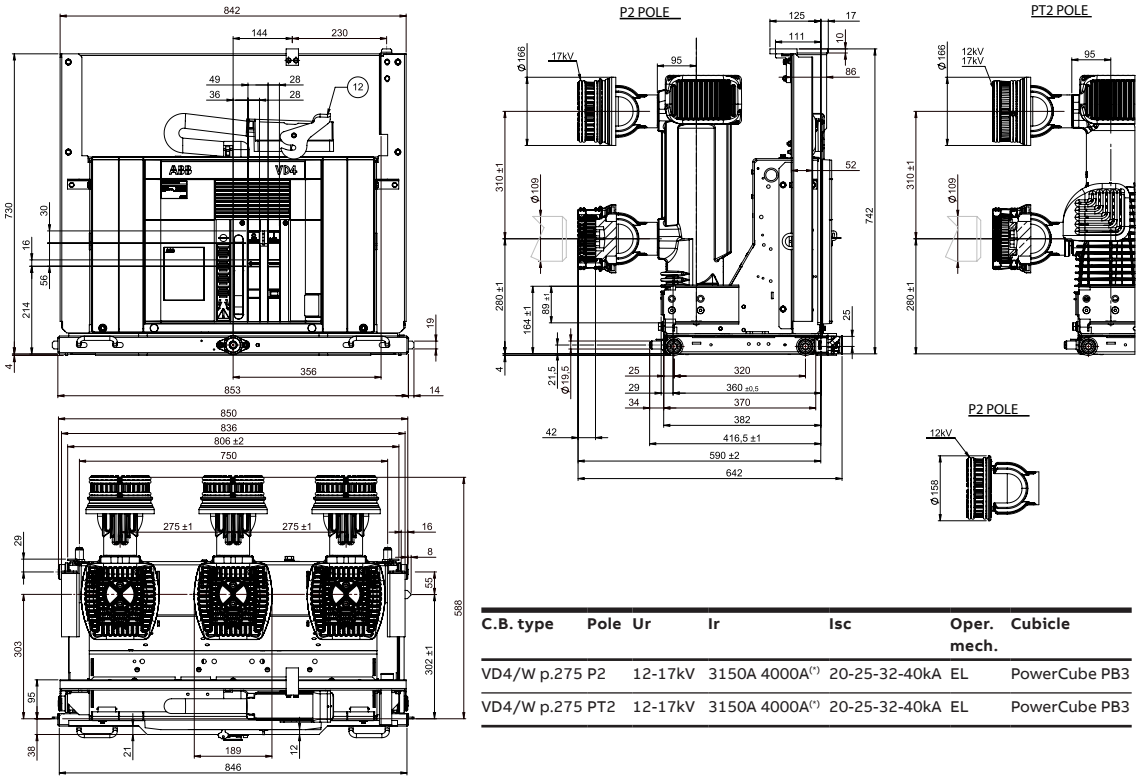



| Type | Un | In | Isc | Pole | O.M. | Enclosure | Cubide |
|---|---|---|---|---|---|---|---|
| VD4/P p.275 | 12-17.5kV | 2500A | 20-25-31.5-40kA | P2 | EL | PowerBloc CBF3 PowerCube | UniGear ZS1 UniSafe |
| VD4/P 12/**/**/G p.275 | 12kV | 2500A | 20-25-31.5kA | | | | |
| VD4/P XX.XX.XX.SA p.210 | 12-17.5kV | 2500A | 40kA | | | PowerCube | |
| VD4/P p.275 | 12-17.5kV | 2500A | 20-25-31.5kA | P2 | EL | PowerCube | UniGear ZS1 UniSafe |
| VD4/P 12/**/**/G p.275 | 12kV | 2500A | 20-25-31.5kA | | | | |
| VD4/P p.275 | 12-17.5kV | 2500A | 40kA | | | | |

# Overall dimensions

### Withdrawable circuit breakers for PowerCube PB3 modules

| VD4/W | | |
|---|---|---|
| TN | 1VCD000152 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |

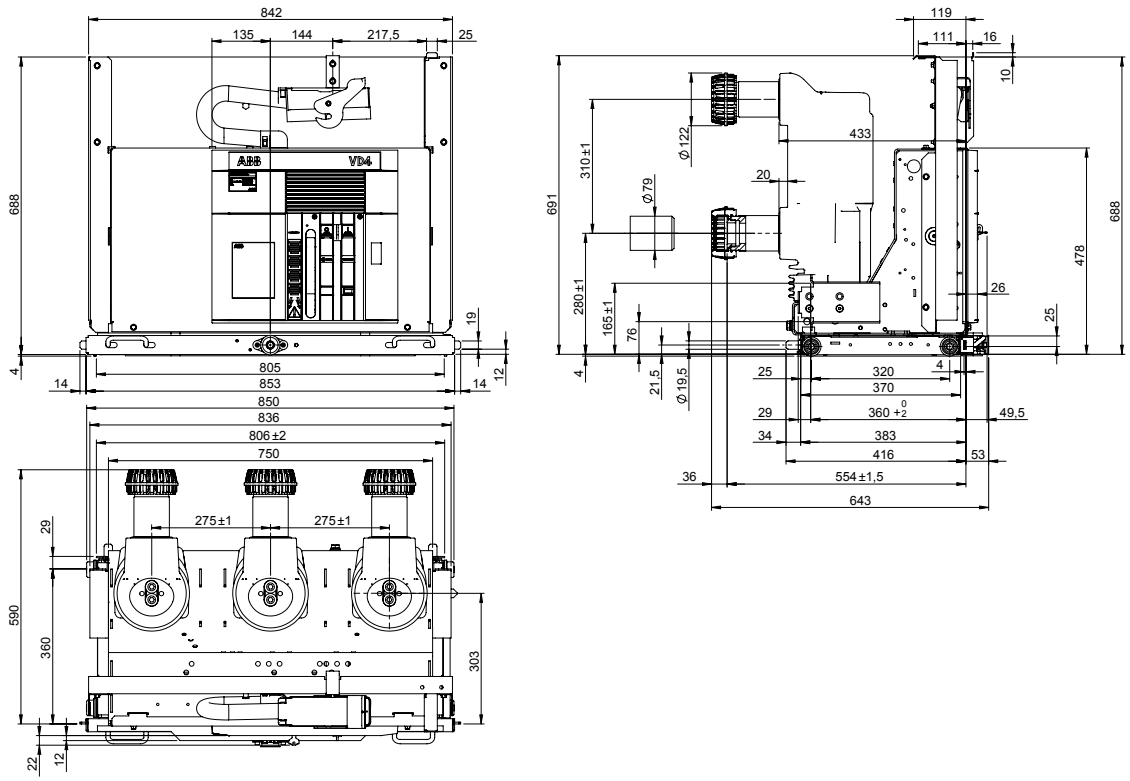



| C.B. type | Pole | Ur | Ir | Isc | Oper. mech. | Cubicle |
|---|---|---|---|---|---|---|
| VD4/W p.275 P2 | | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | PowerCube PB3 |
| VD4/W p.275 PT2 | | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | PowerCube PB3 |

(*) 4000 A with forced ventilation.

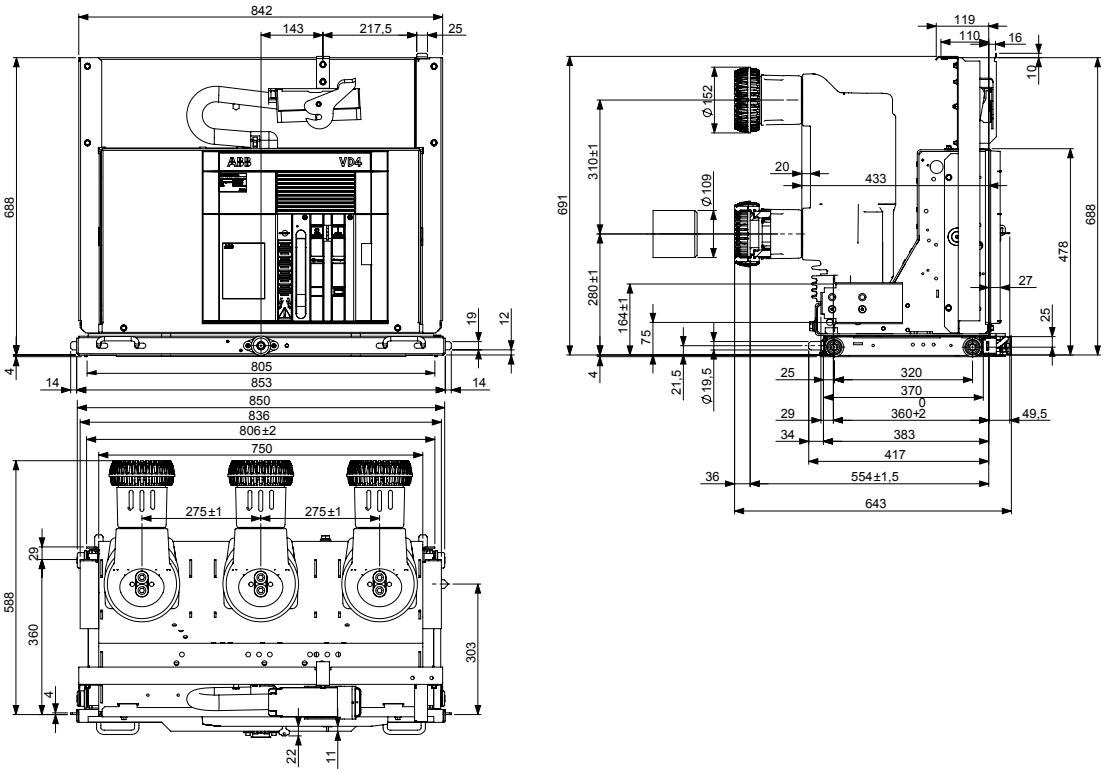
### Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD003445 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| Isc | 50 | kA |



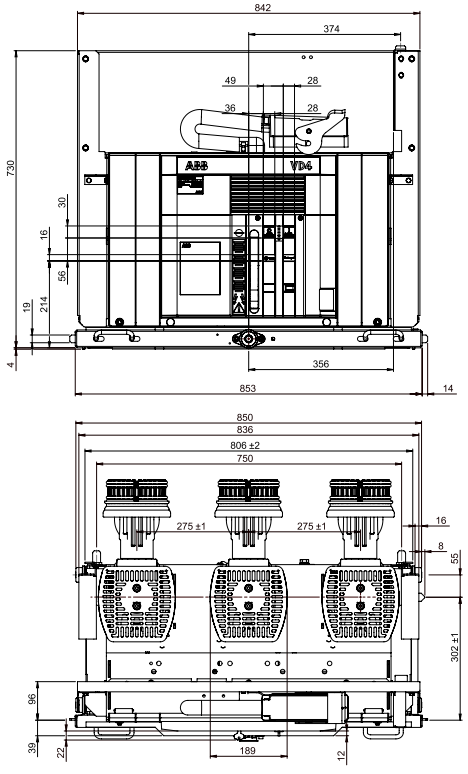
## Withdrawable circuit breakers for UniGear ZS1 switchgear

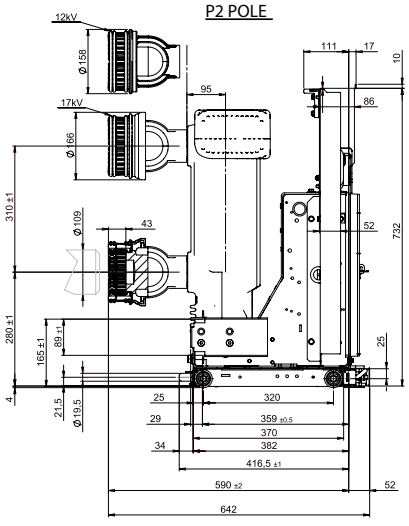
| VD4/P | | |
|---|---|---|
| TN | 1VCD003446 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2500 | A |
| Isc | 50 | kA |

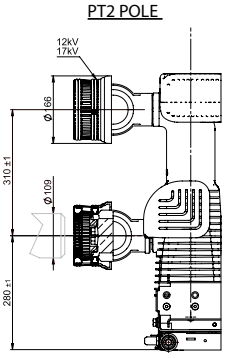



## Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD000153 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



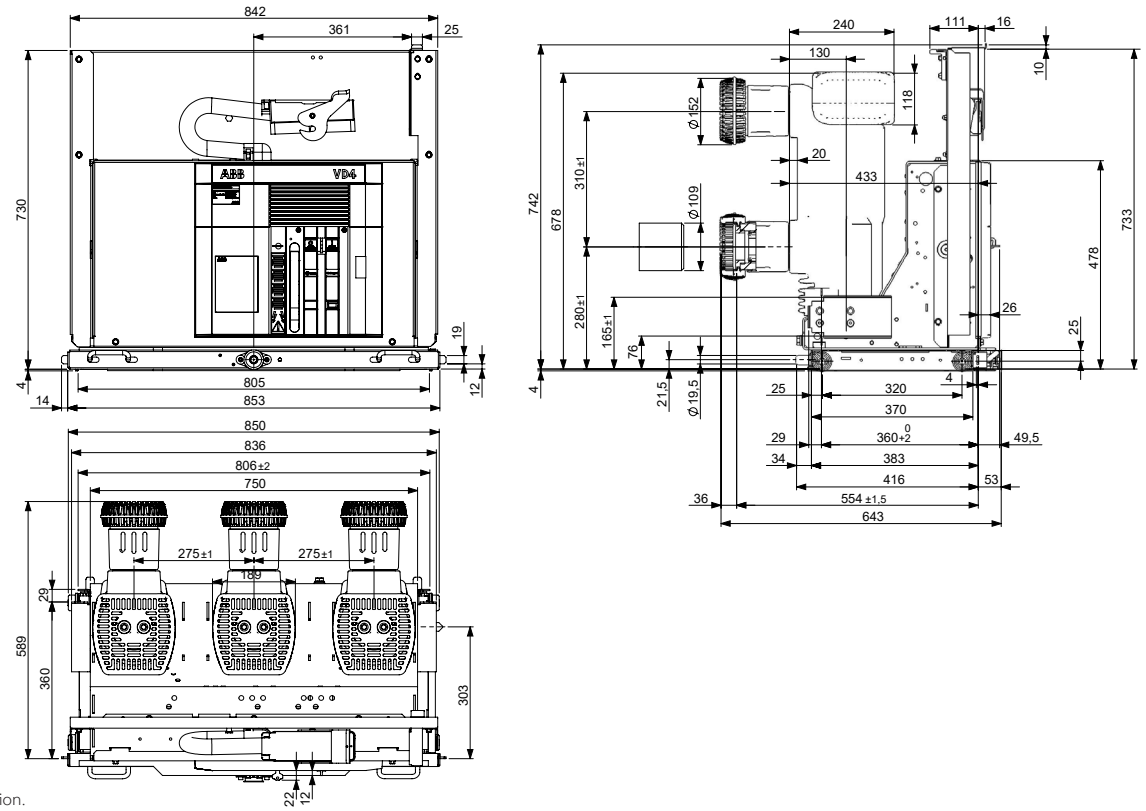

| C.B. type | Pole | Ur | Ir | Isc | Oper. mech. | Cubicle |
|---|---|---|---|---|---|---|
| VD4/P p.275 | P2 | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | UniGear |
| VD4/P p.275 | PT2 | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | UniGear |

(*) 4000 A with forced ventilation.

# Overall dimensions

### Withdrawable circuit breakers for UniGear ZS1 switchgear

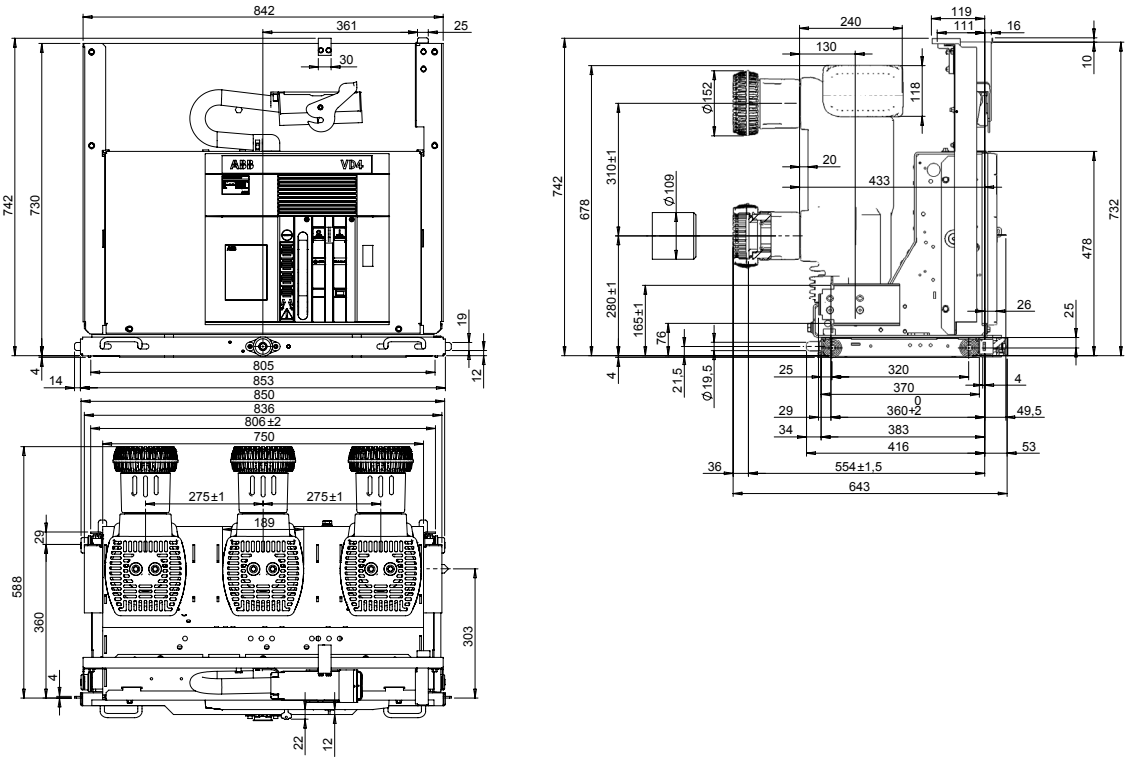
| VD4/P | | |
|---|---|---|
| TN | 1VCD003447 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 50 | kA |




(*) 4000 A with forced ventilation.

### Withdrawable circuit breakers for PowerCube PB3 modules

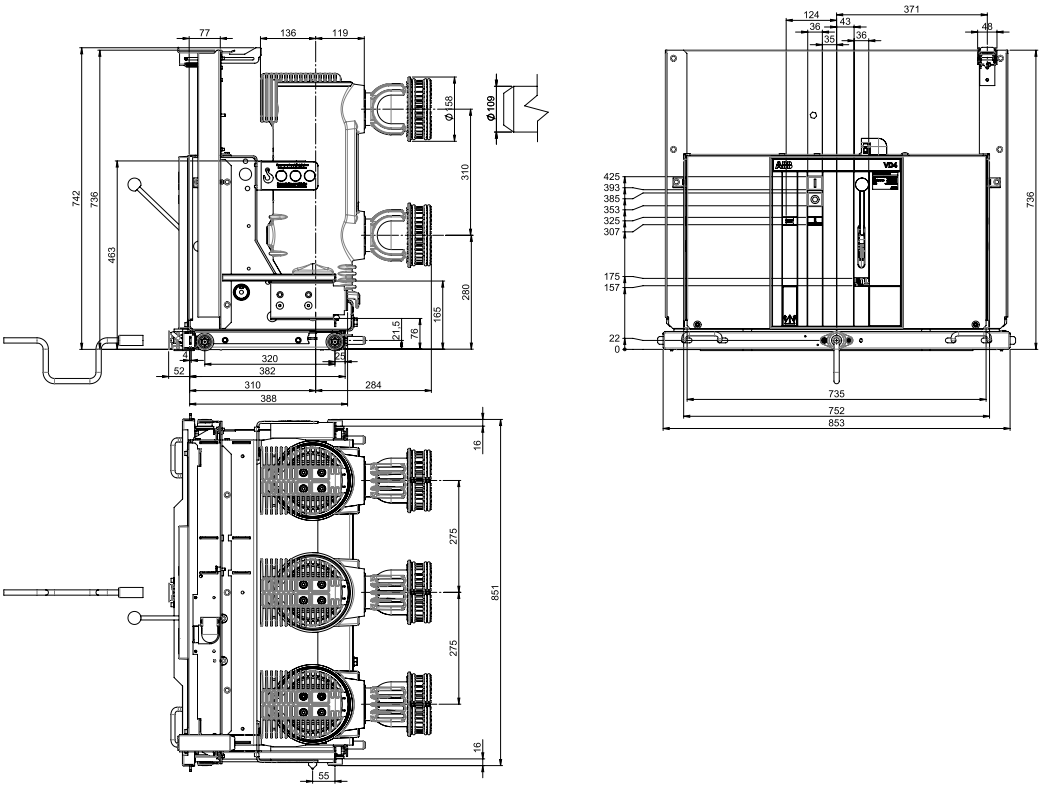
| VD4/W | | |
|---|---|---|
| TN | 1VCD003596 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 50 | kA |




(*) 4000 A with forced ventilation.

### Withdrawable circuit breakers for UniGear ZS1 switchgear

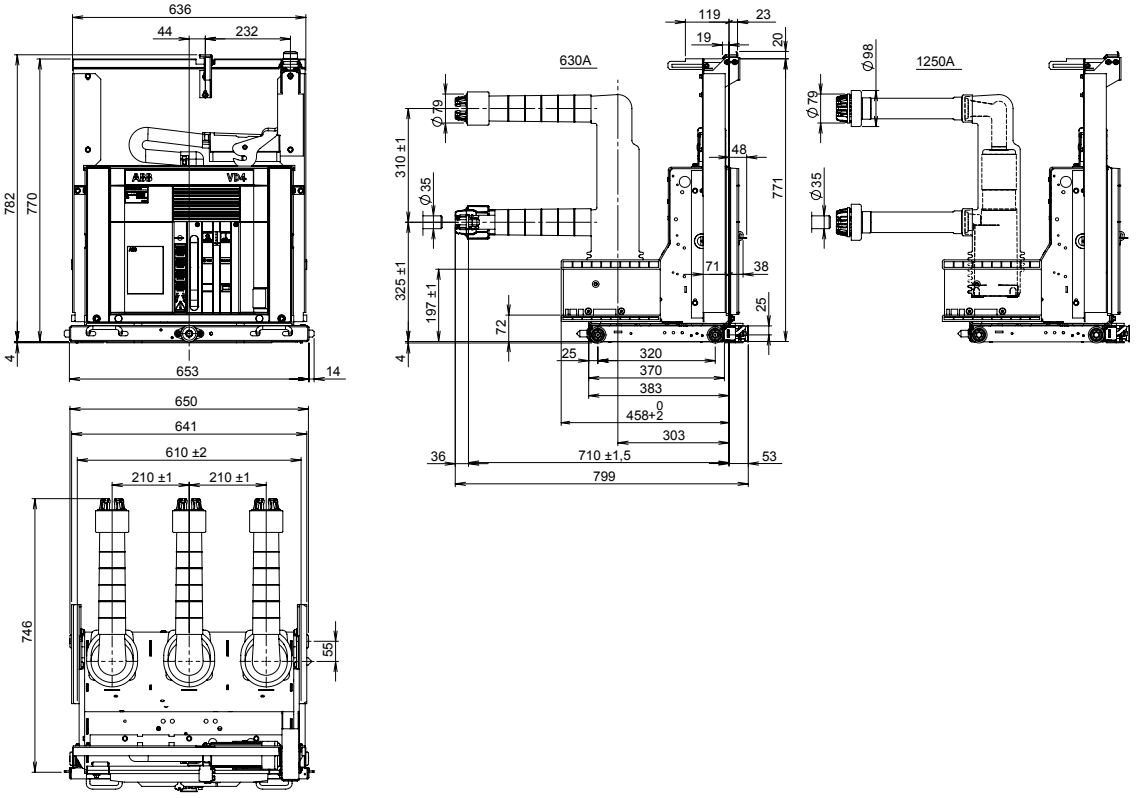
| VD4/P | | |
|---|---|---|
| TN | 1VCD003943 | |
| Ur | 12 | kV |
| | 17 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| | 3150 | A (*) |
| Isc | 63 | kA |




(*) 4000 A with forced ventilation.

### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB4 modules

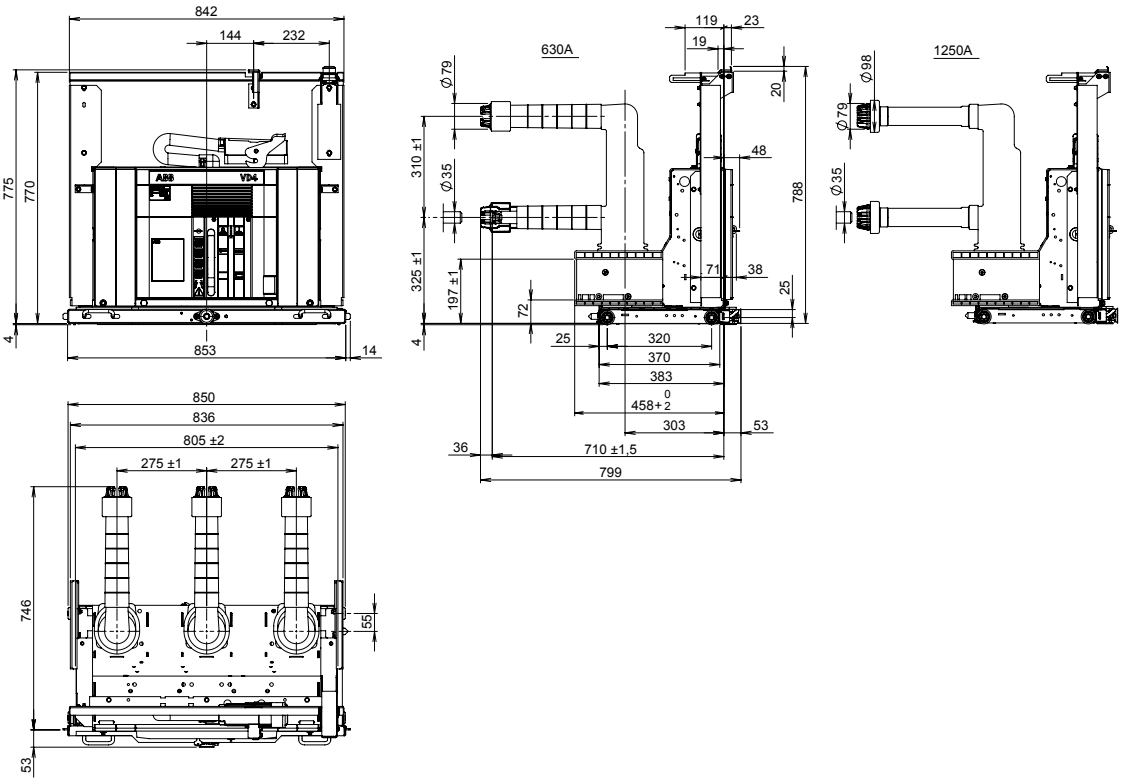
| VD4/P | | |
|---|---|---|
| TN | 7413 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |



# Overall dimensions

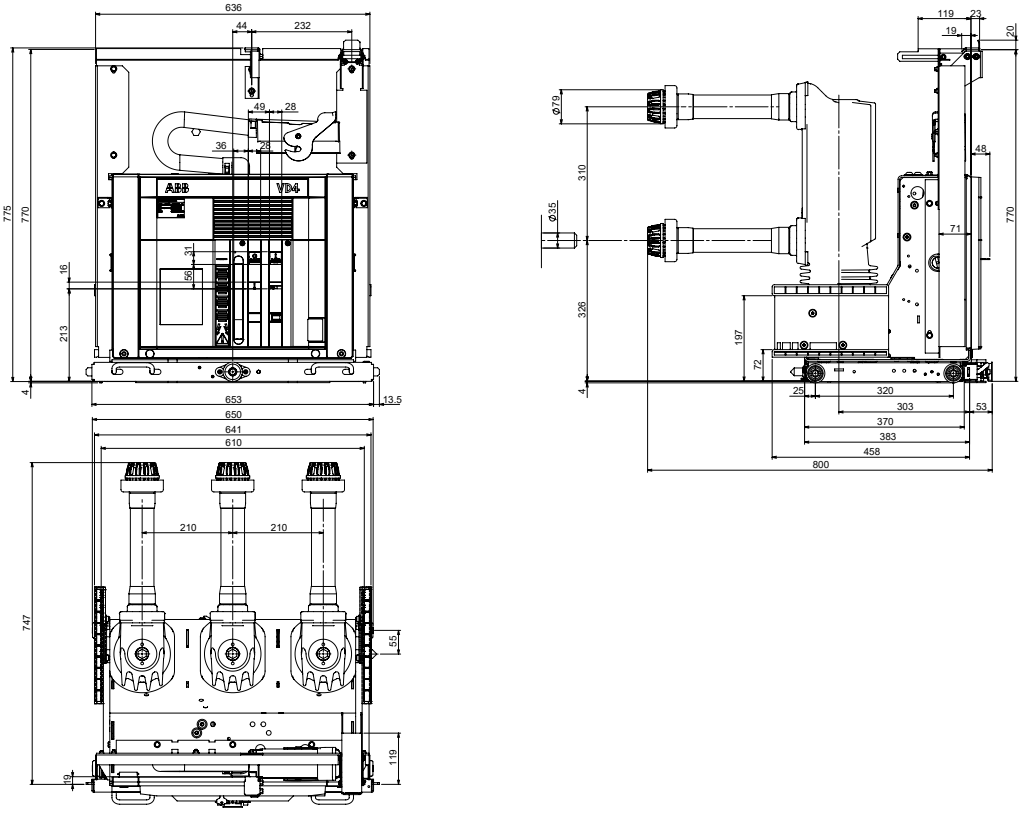
### Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 7414 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |



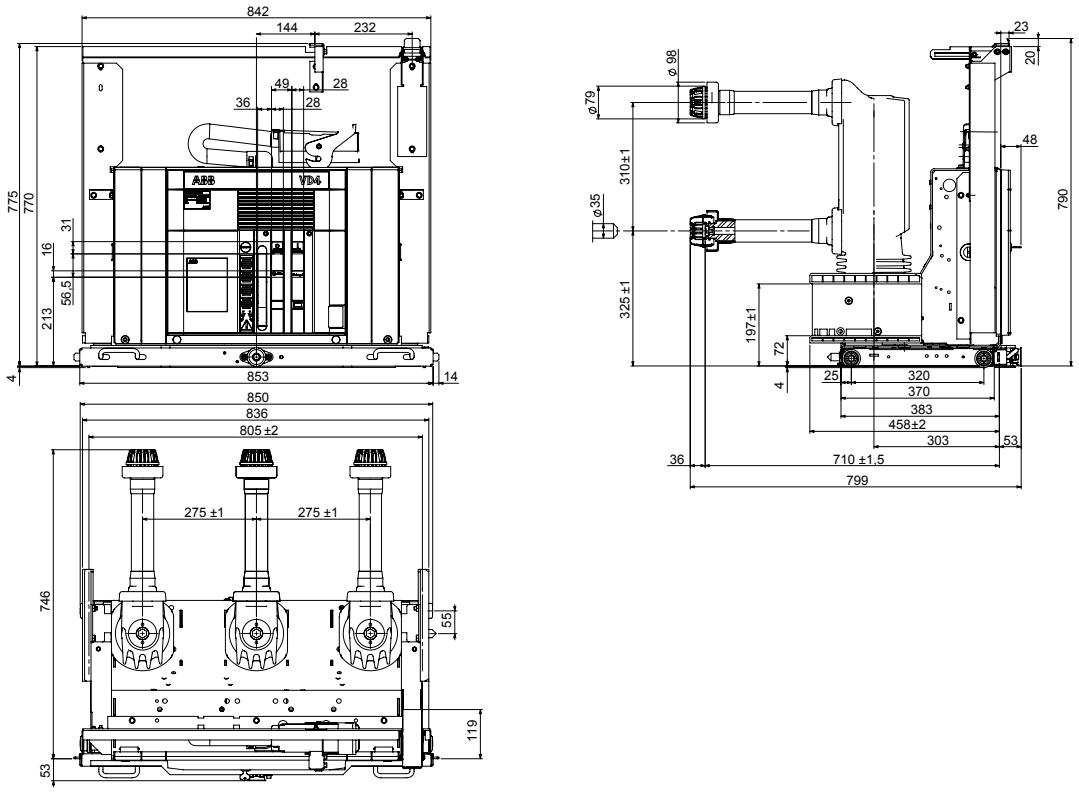

### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB4 modules

| VD4/P | | |
|---|---|---|
| TN | 1VCD000173 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| Isc | 31.5 | kA |



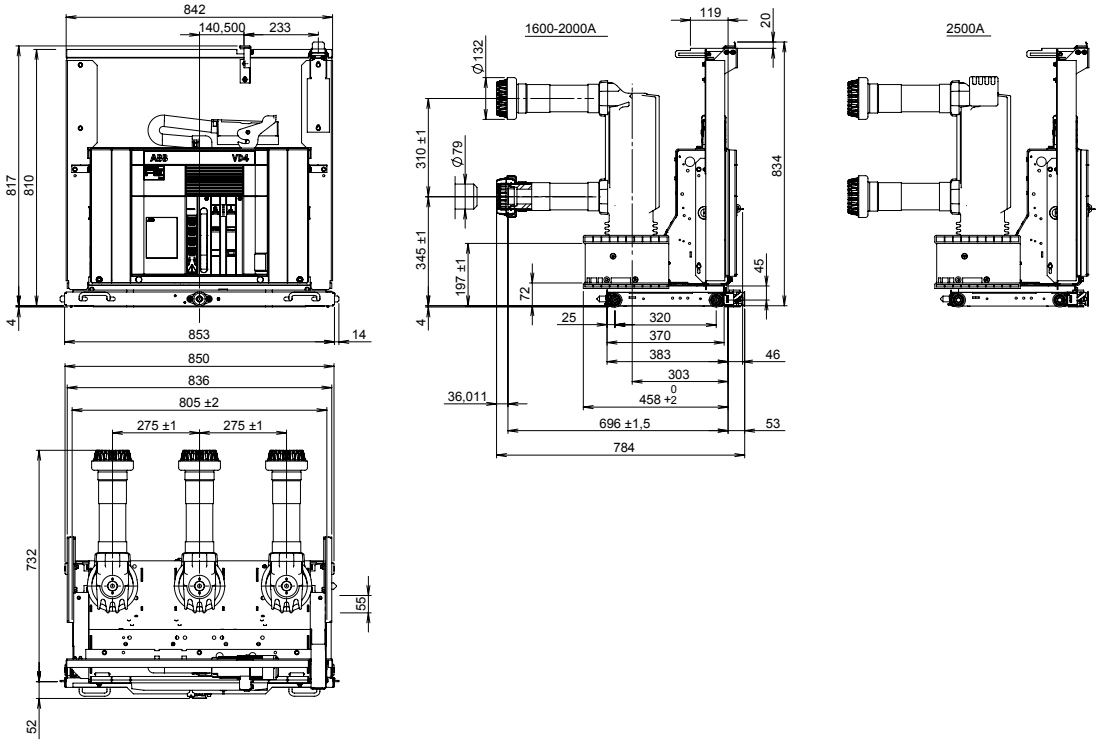
### Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD000174 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| Isc | 31.5 | kA |




### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB5 modules

| VD4/P | | |
|---|---|---|
| TN | 7418 | |
| Ur | 24 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| | 2500 | A (1) |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

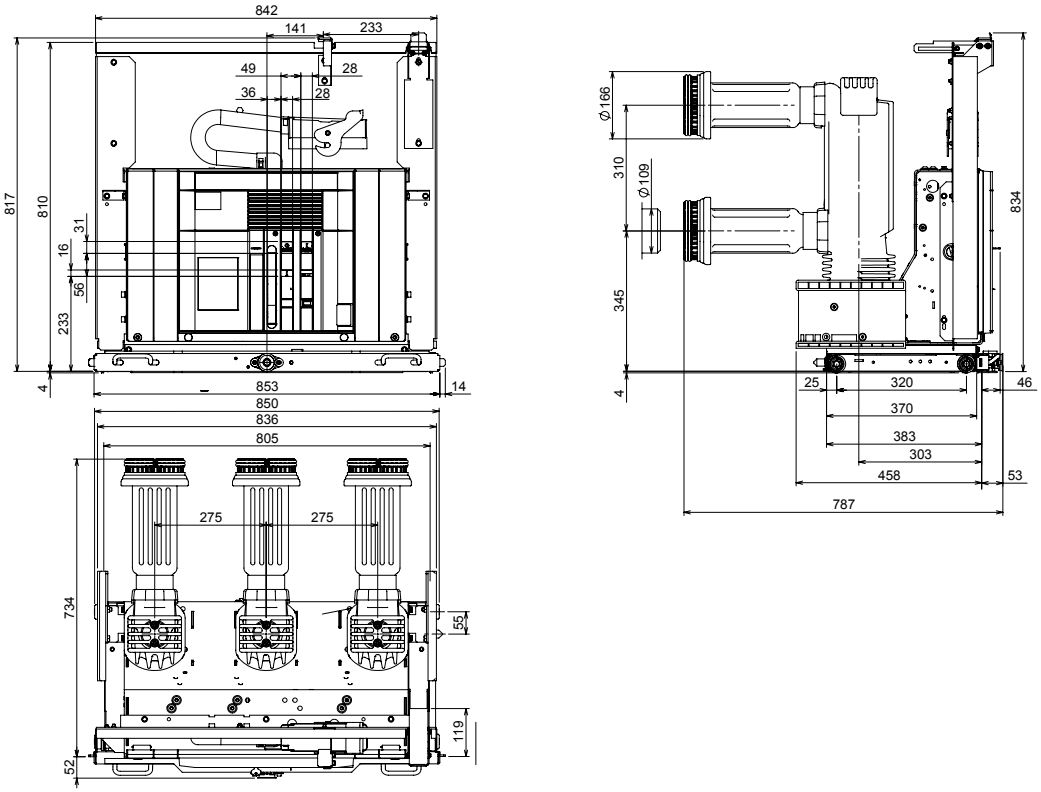



(1) 2300 A rated uninterrupted current is guaranteed with natural ventilation. 2500 A rated uninterrupted current is guaranteed with forced ventilation.

# Overall dimensions

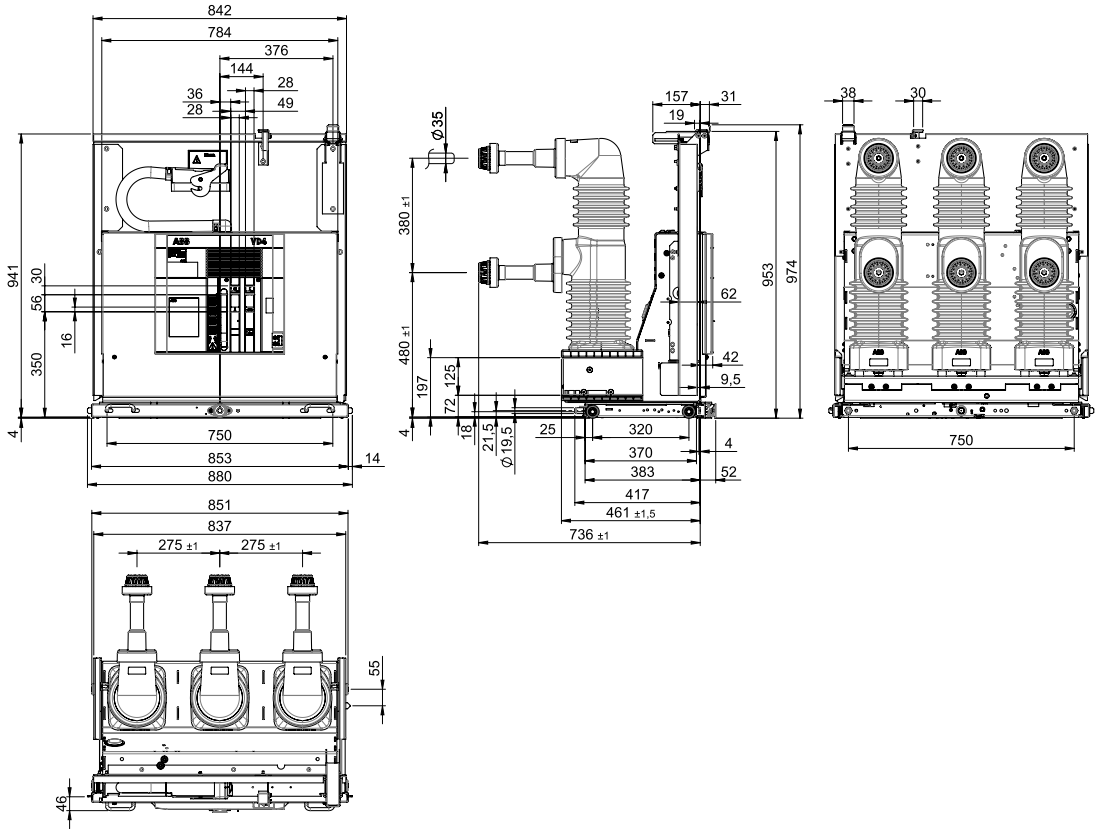
### Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD000177 | |
| Ur | 24 | kV |
| | 3150 | A |
| Isc | 31.5 | kA |



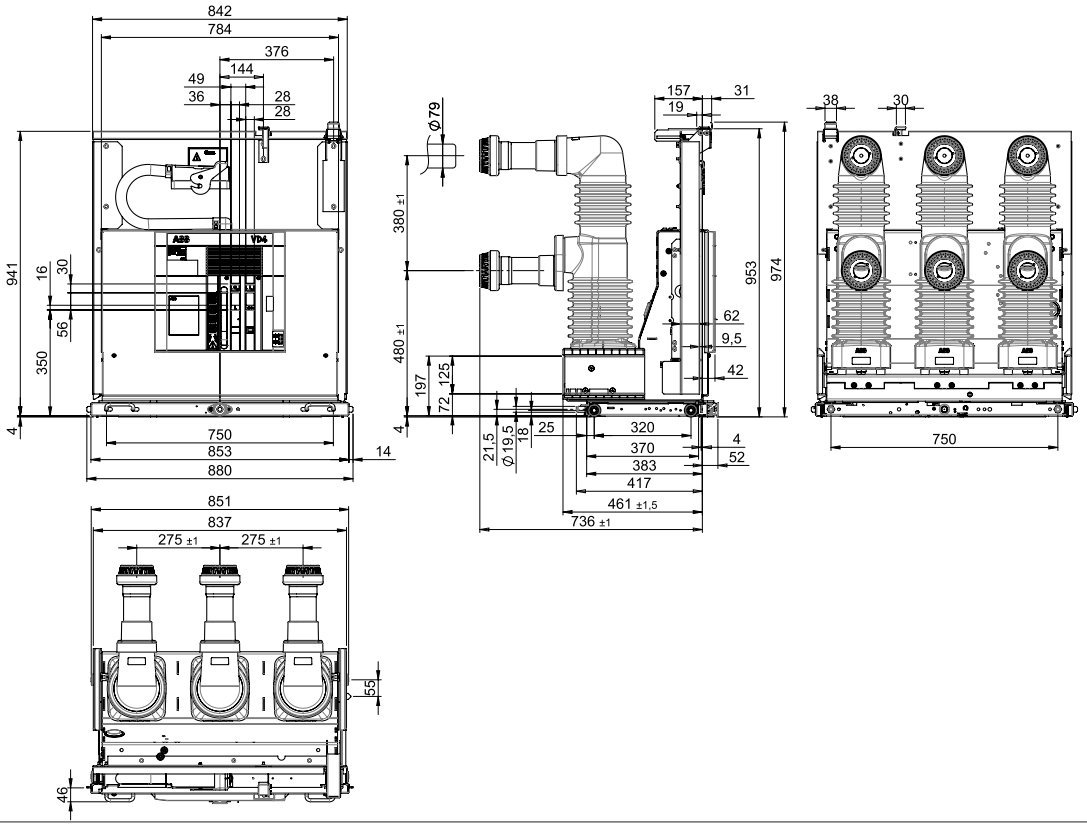

### Withdrawable circuit breakers for UniGear ZS2 switchgear and PowerCube PB6

| VD4/W | | |
|---|---|---|
| TN | 2RDA040543 | |
| Ur | 36 | kV |
| Ir | 1250 | A |
| | 20 | kA |
| Isc | 25 | kA |
| | 31.5 | kA |



## Withdrawable circuit breakers for UniGear ZS2 switchgear and PowerCube PB6

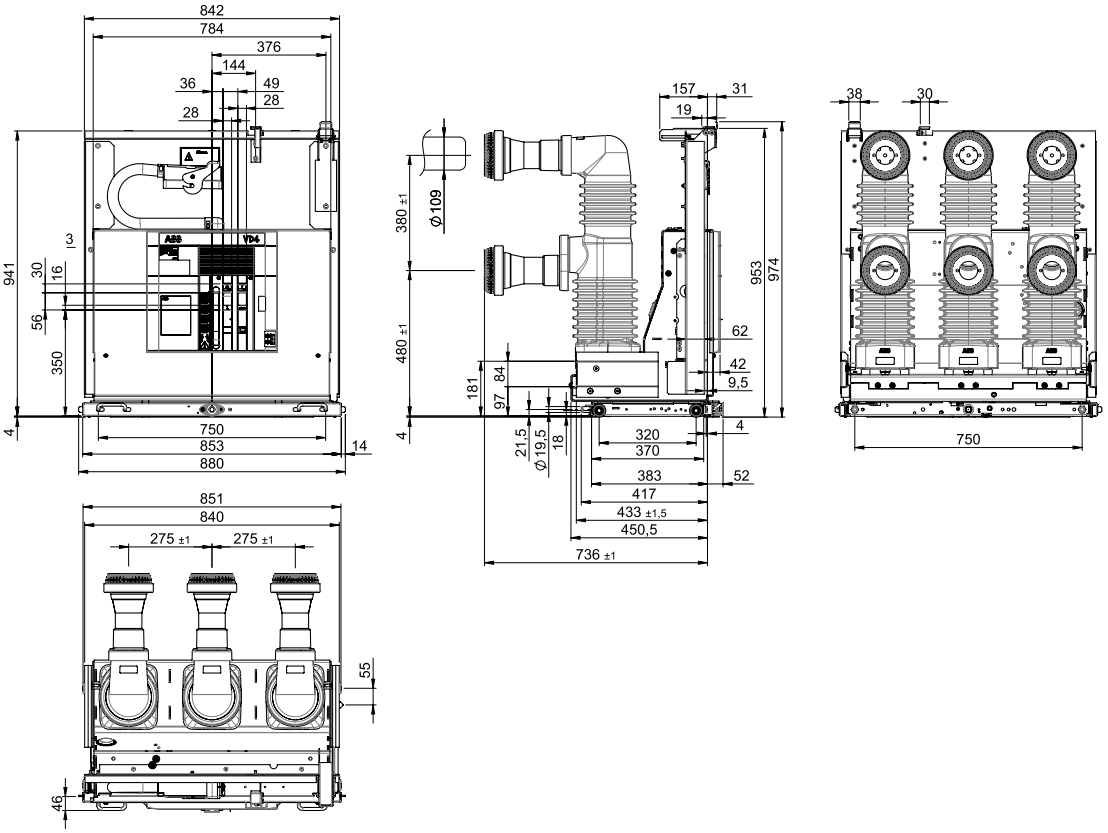
| VD4/W | | |
|---|---|---|
| TN | 2RDA040565 | |
| Ur | 36 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| | 2500 | A (*) |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




(*) 2000 A rated uninterrupted current is guaranteed with natural ventilation. 2500 A rated uninterrupted current is guaranteed with forced ventilation.

## Withdrawable circuit breakers for UniGear ZS2 switchgear

| VD4/W | | |
|---|---|---|
| TN | 2RDA040573 | |
| Ur | 36 | kV |
| Ir | 2500 | A (*) |
| | 20 | kA |
| Isc | 25 | kA |
| | 31.5 | kA |

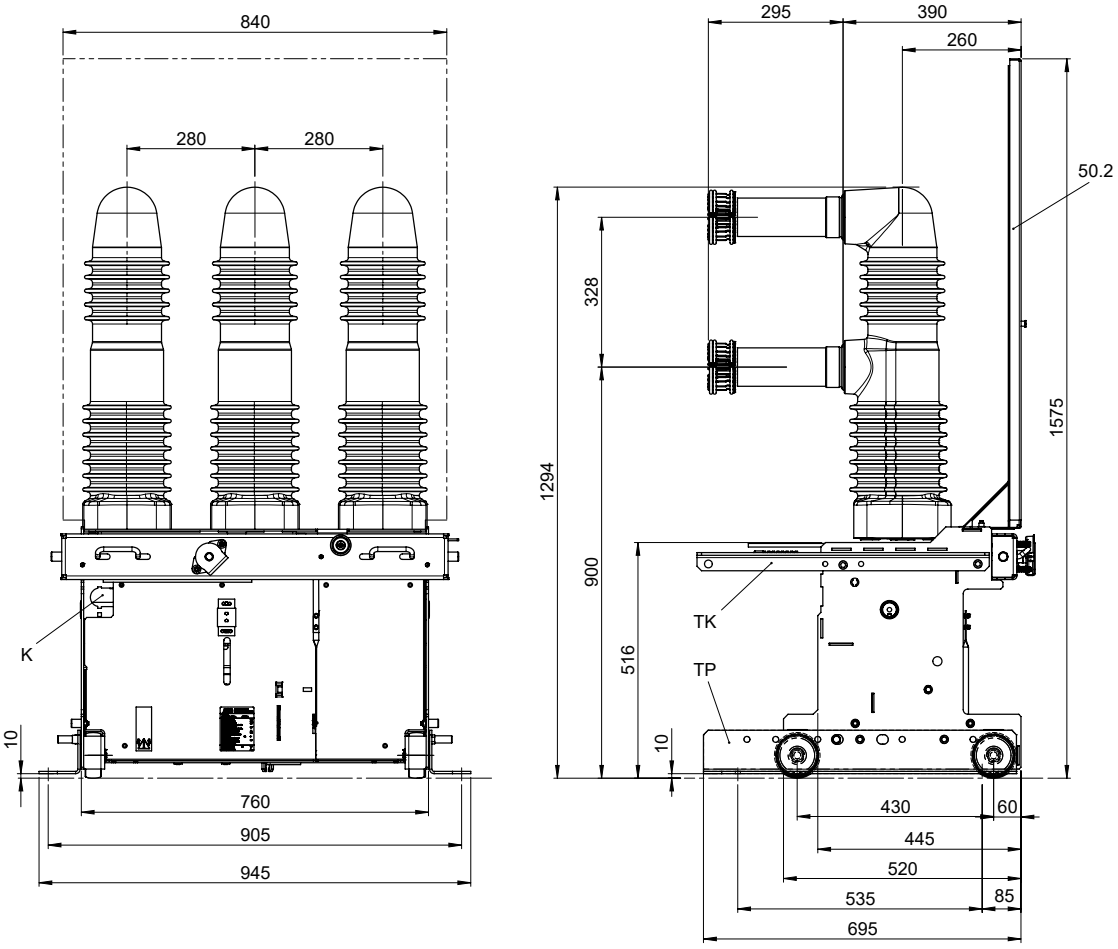



(*) 3150 A rated uninterrupted current is guaranteed with forced ventilation.

# Overall dimensions

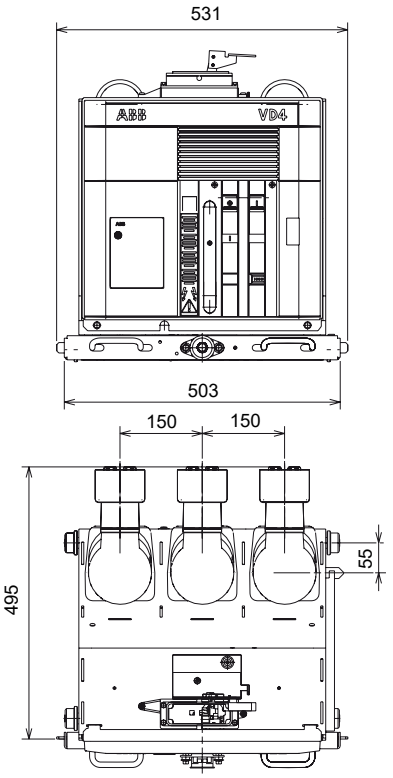
**Withdrawable circuit breakers for ZS3.2 switchgear**

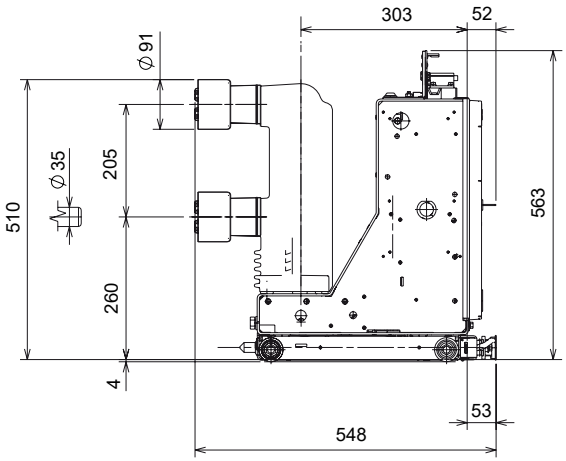
| **VD4** | | |
|---|---|---|
| TN | GCEM700198 | |
| Ur | 36-40.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| | 3150 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/Z8 | | |
|---|---|---|
| TN | 1VCD000092 | |
| Ur | 12 | kV |
| Ir | 630 | A |
| Isc | 20 | kA |
| | 25 | kA |

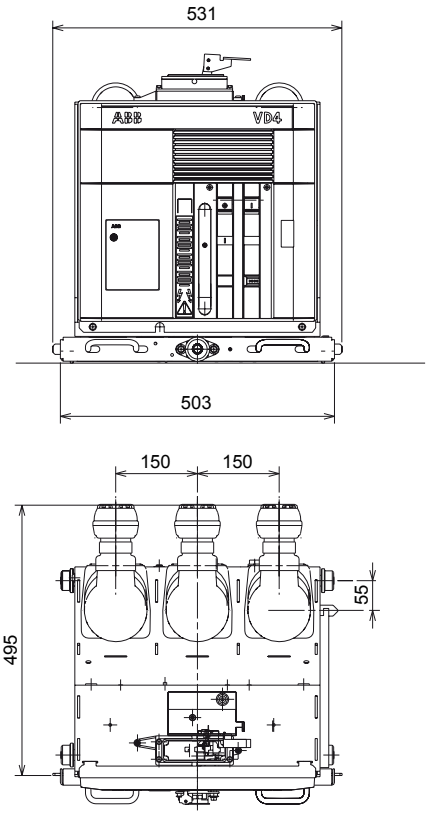


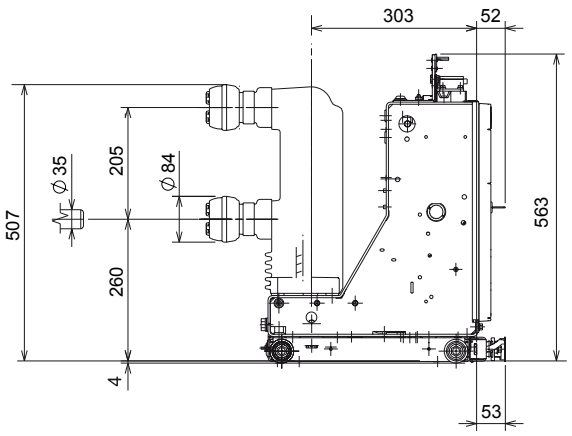




### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/Z8 | | |
|---|---|---|
| TN | 1VCD000137 | |
| Ur | 12 | kV |
| Ir | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |

| | | |
|---|---|---|
| TN | 1VCD000137 | |
| Ur | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |

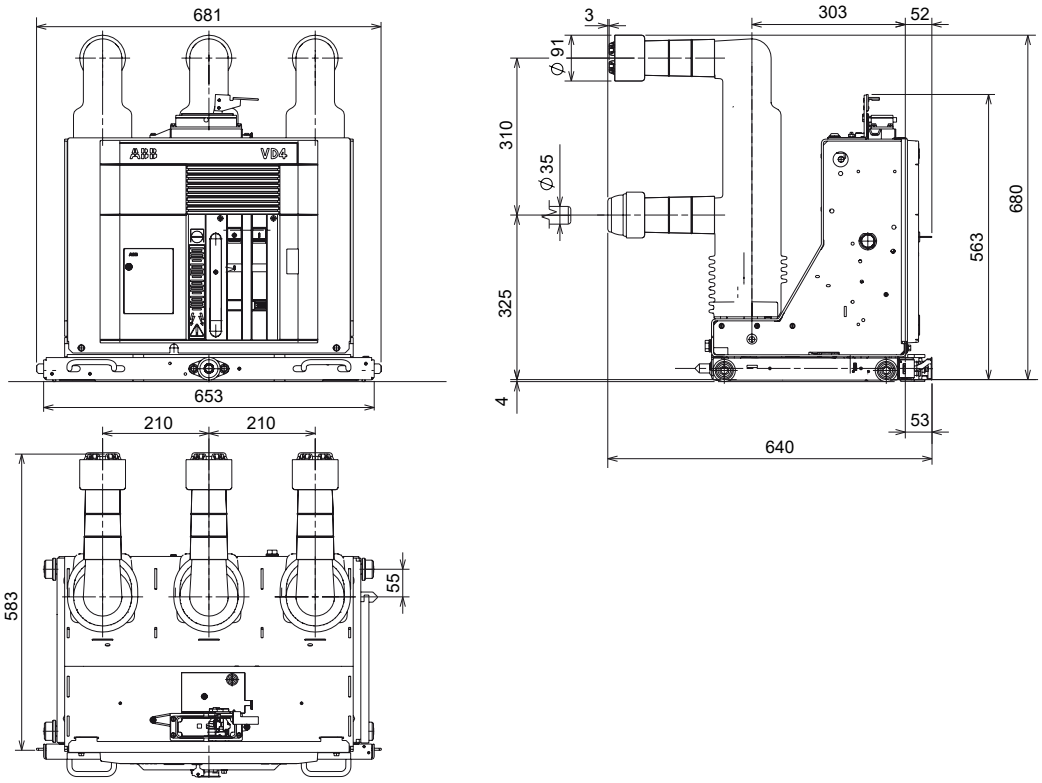


# Overall dimensions

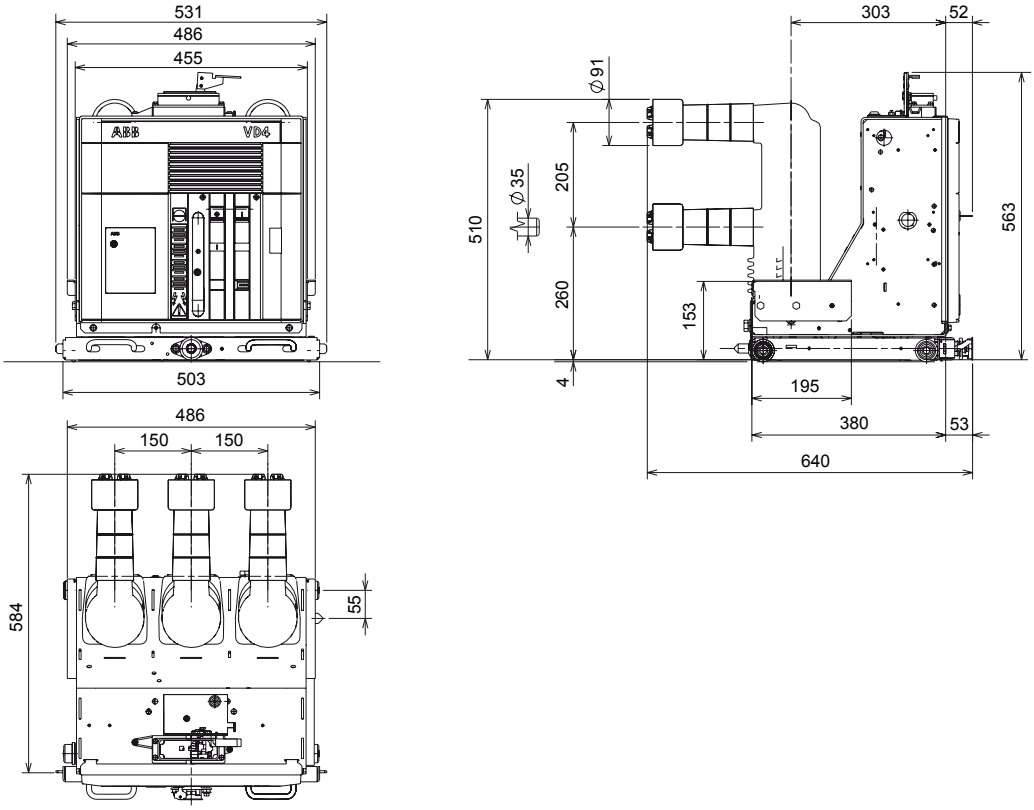
### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/Z8 | | |
|---|---|---|
| TN | 1VCD000089 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |



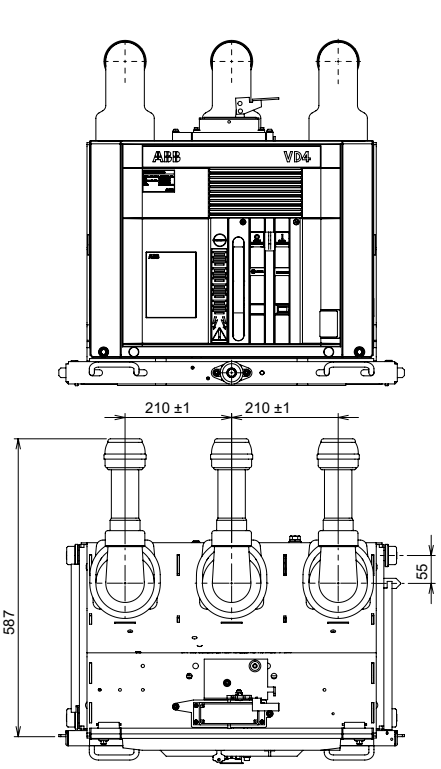

### Withdrawable circuit breakers for ZS8.4 switchgear

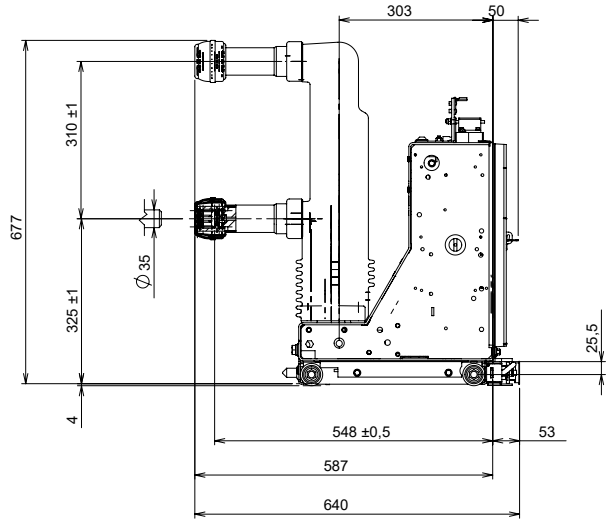
| VD4/ZT8 | | |
|---|---|---|
| TN | 1VCD000093 | |
| Ur | 12 | kV |
| Ir | 630 | A |
| Isc | 20 | kA |
| | 25 | kA |



### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/Z8 | | |
|---|---|---|
| TN | 1VCD000138 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |

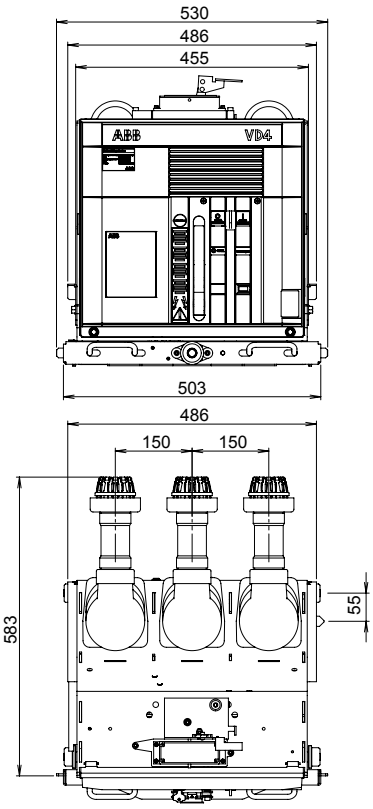


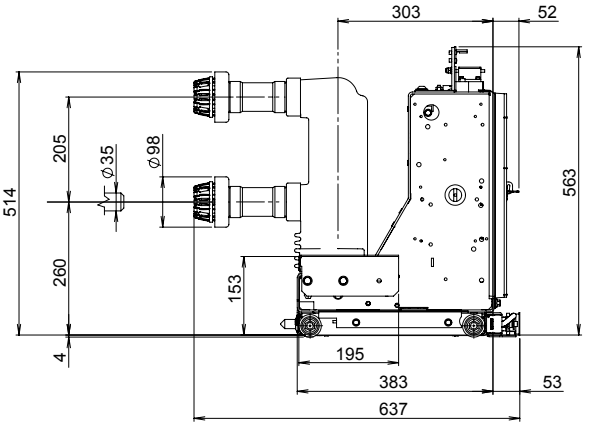




### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/ZT8 | | |
|---|---|---|
| TN | 1VCD000134 | |
| Ur | 12 | kV |
| Ir | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |

| VD4/ZT8 | | |
|---|---|---|
| TN | 1VCD000134 | |
| Ur | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |

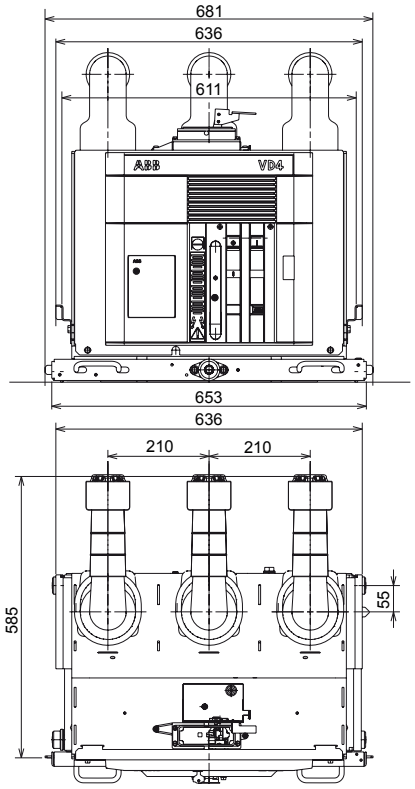


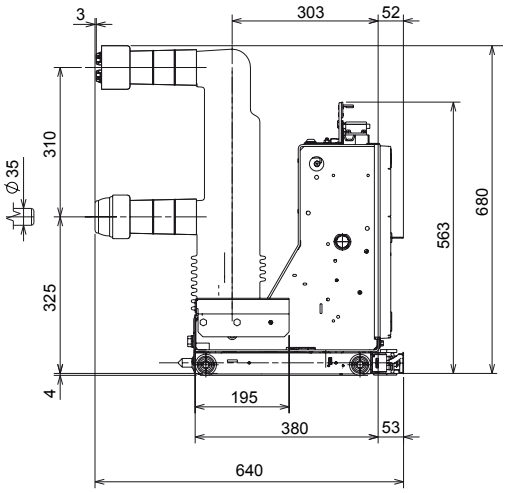



# Overall dimensions

### Withdrawable circuit breakers for ZS8.4 switchgear

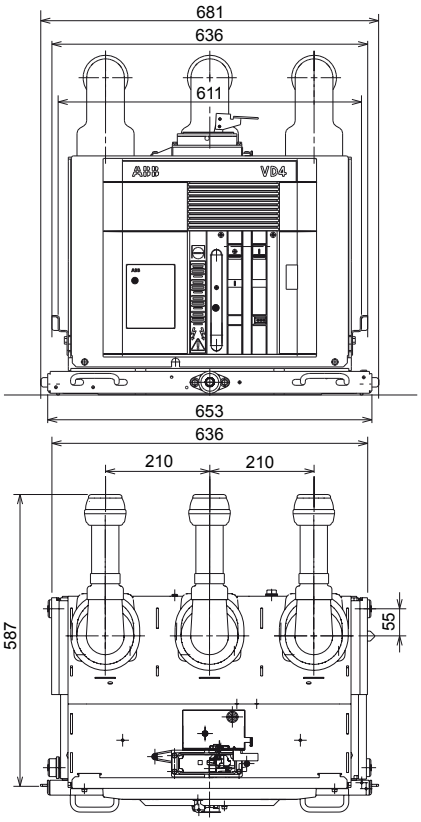
| VD4/ZT8 | | |
|---|---|---|
| TN | 1VCD000090 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 16 | kA |
| Isc | 20 | kA |
| | 25 | kA |

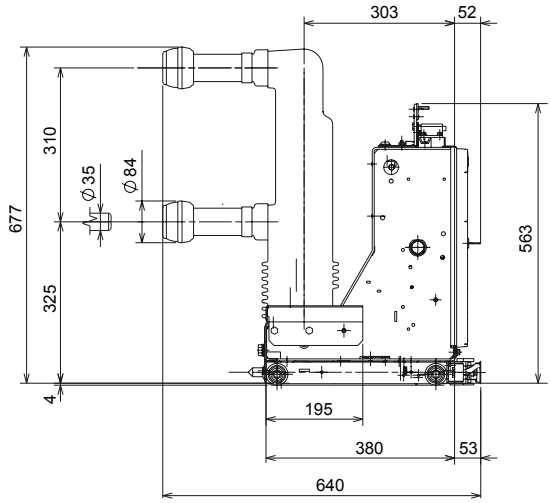



### Withdrawable circuit breakers for ZS8.4 switchgear

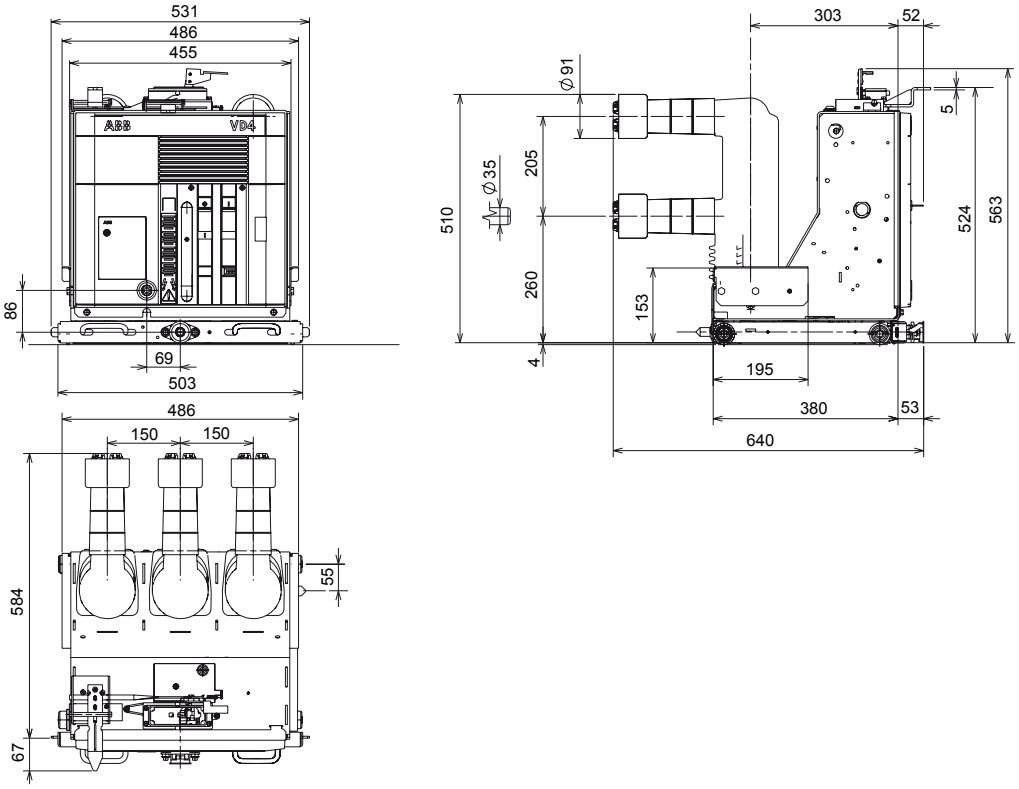
| VD4/ZT8 | | |
|---|---|---|
| **TN** | 1VCD000136 | |
| **Ur** | 24 | kV |
| **Ir** | 1250 | A |
| | 16 | kA |
| **Isc** | 20 | kA |
| | 25 | kA |



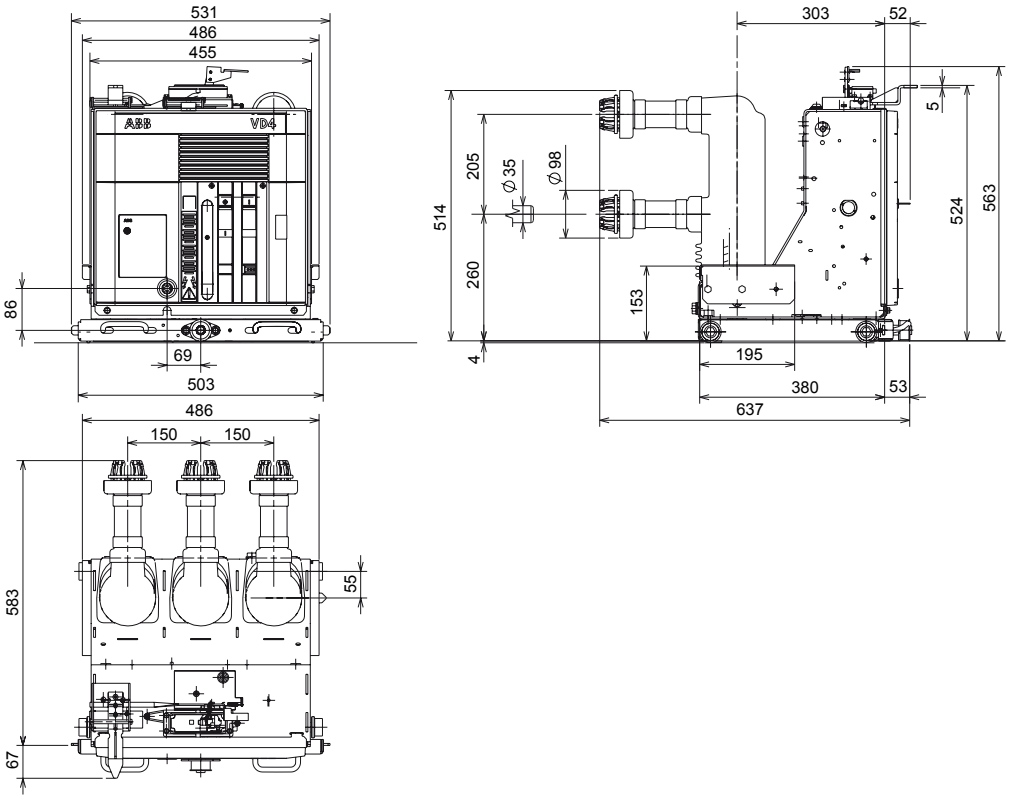
### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000091 | |
| Ur | 12 | kV |
| Ir | 630 | A |
| Isc | 20 | kA |
| | 25 | kA |




### Withdrawable circuit breakers for ZS8.4 switchgear

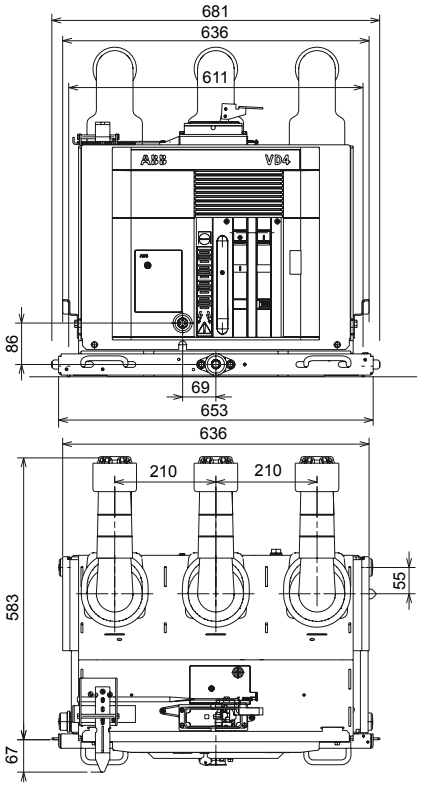
| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000133 | |
| Ur | 12 | kV |
| Ir | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |

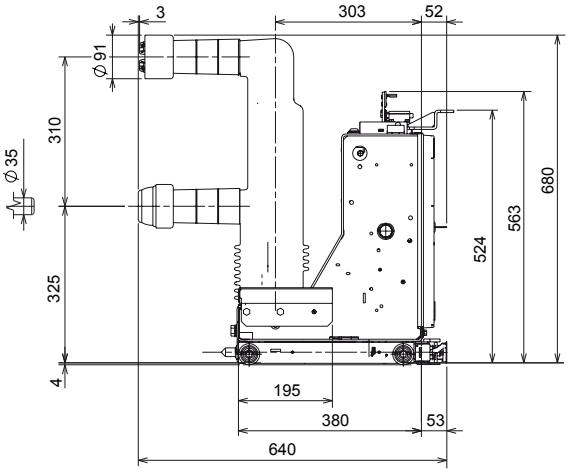


# Overall dimensions

### Withdrawable circuit breakers for ZS8.4 switchgear

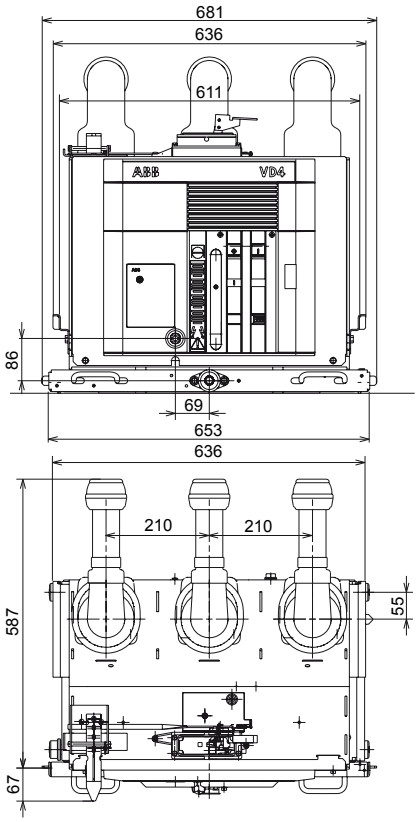
| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000088 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 16 | kA |
| Isc | 20 | kA |
| | 25 | kA |

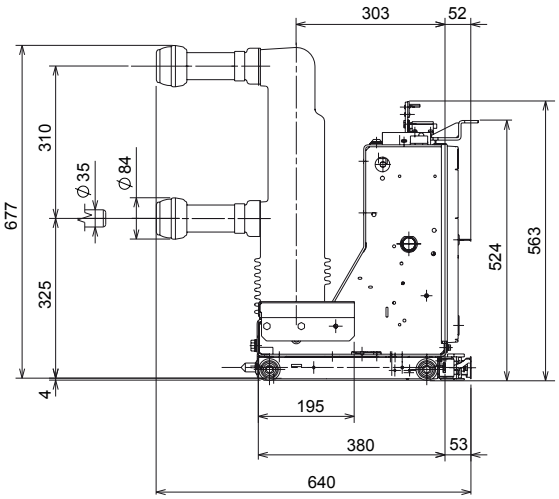



### Withdrawable circuit breakers for ZS8.4 switchgear

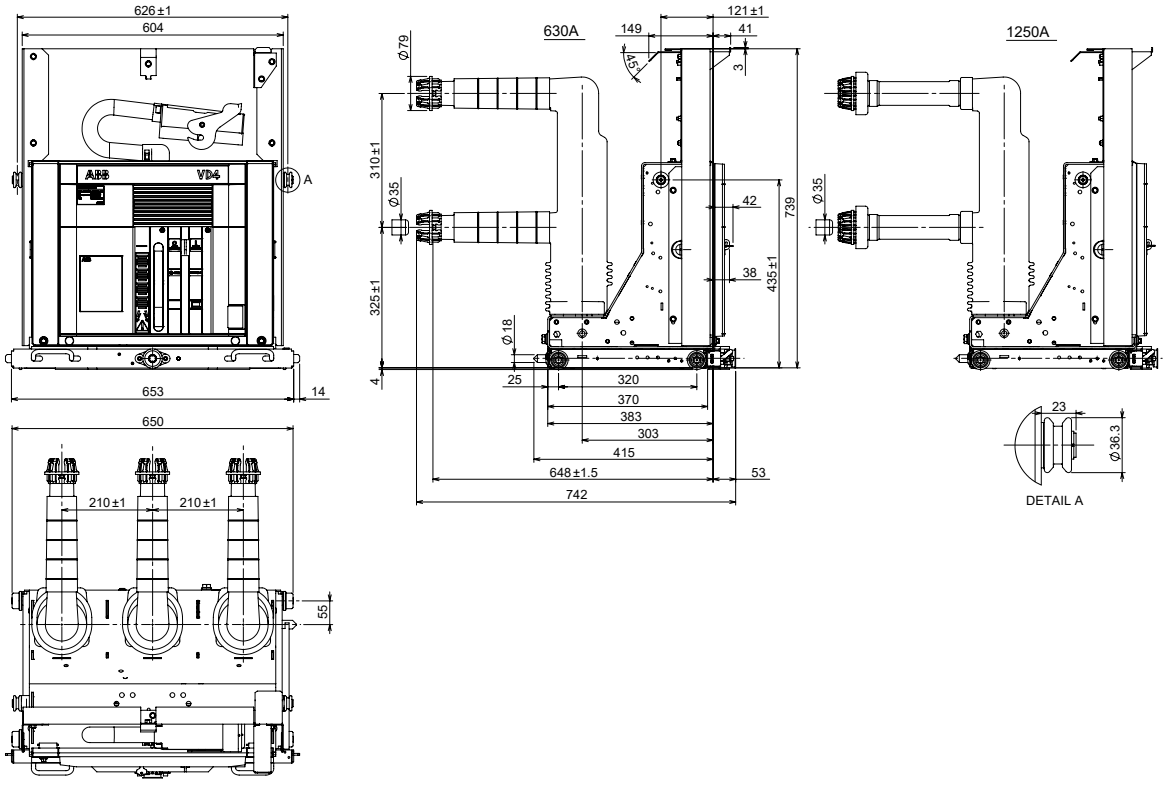
| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000135 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| | 16 | kA |
| Isc | 20 | kA |
| | 25 | kA |



**Withdrawable circuit breakers for UniSec (WBC and WBS) switchgear**

| VD4/Sec | | |
|---|---|---|
| TN | 1VCD000190 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |

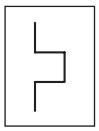


# Electric circuit diagram

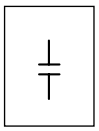
**Note**
The wiring diagrams in this section might not be the latest versions and are shown as exemplary of possible electrical wiring configurations. The wiring diagram depends on the specific circuit breaker configuration selected during ordering phase.
For VD4 evo Digital version refer please refer to documents 1VCD400316, 1VCD400311 and 1VCD400312

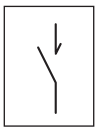
**Operating state shown**
The diagrams are shown the following conditions:
- Circuit breaker open and connected (only withdrawable circuit breaker)
- Circuits de-energized
- Closing springs discharged

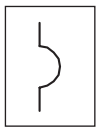
**Graphical symbols for electric diagrams**

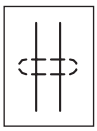

Thermal effect

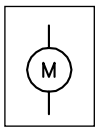

Exposed conductive part, frame


Capacitor (general symbol)

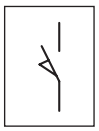

Passing make contact closing momentarily during release

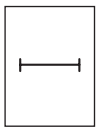

Electromagnetic effect

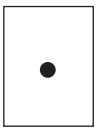

Conductors in shielded cable (e.g. two conductors)

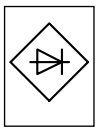


Motor (general symbol)

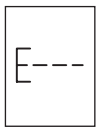

Closing position contact (limit switch)

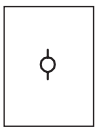

Timing

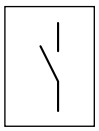

Connection of conductors

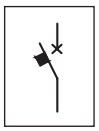

Rectifier with two half-waves (bridge)

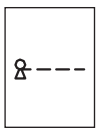

Opening position contact (limit switch)


Pushbutton control

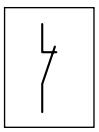

Terminal or clamp

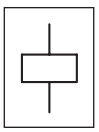

Make contact

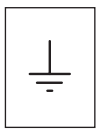

Power circuit breaker with automatic opening

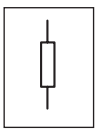

Key control

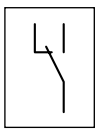

Socket and plug (female and male)

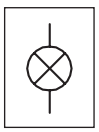

Break contact


Control coil (general symbol)


Earth (general symbol)

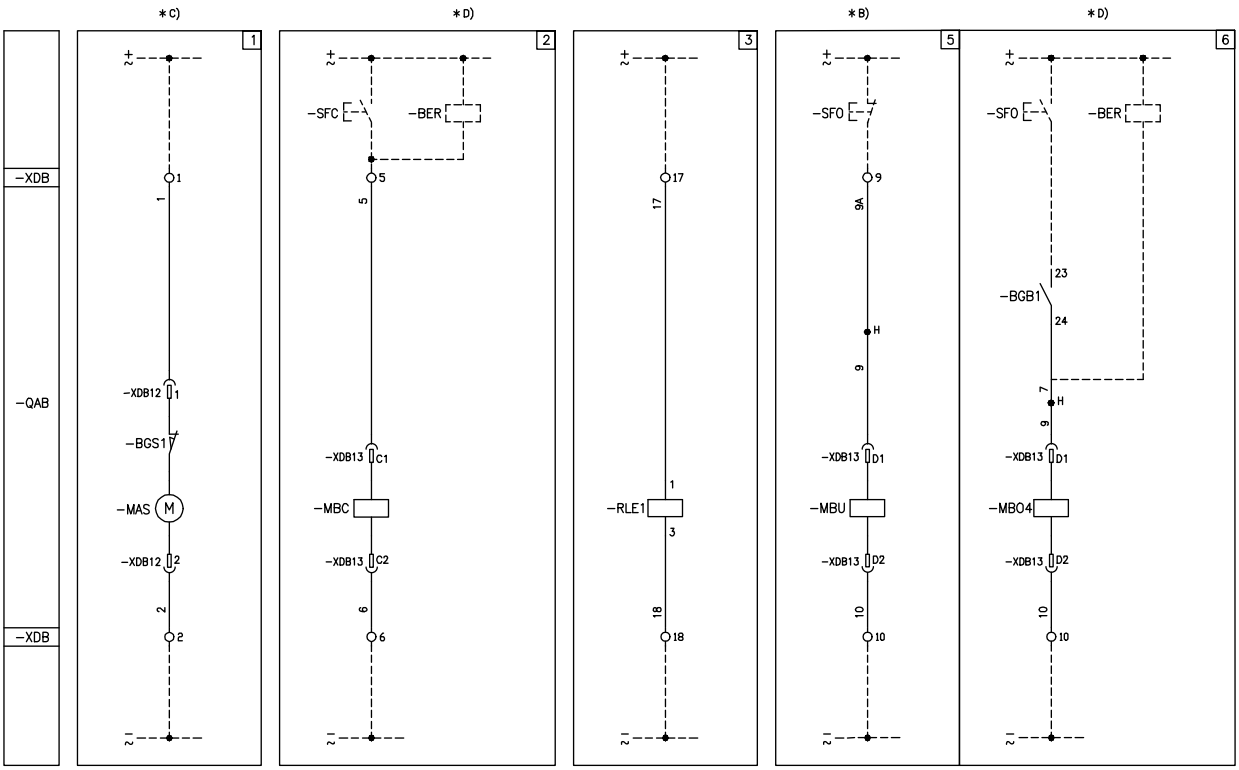

Resistor (general symbol)

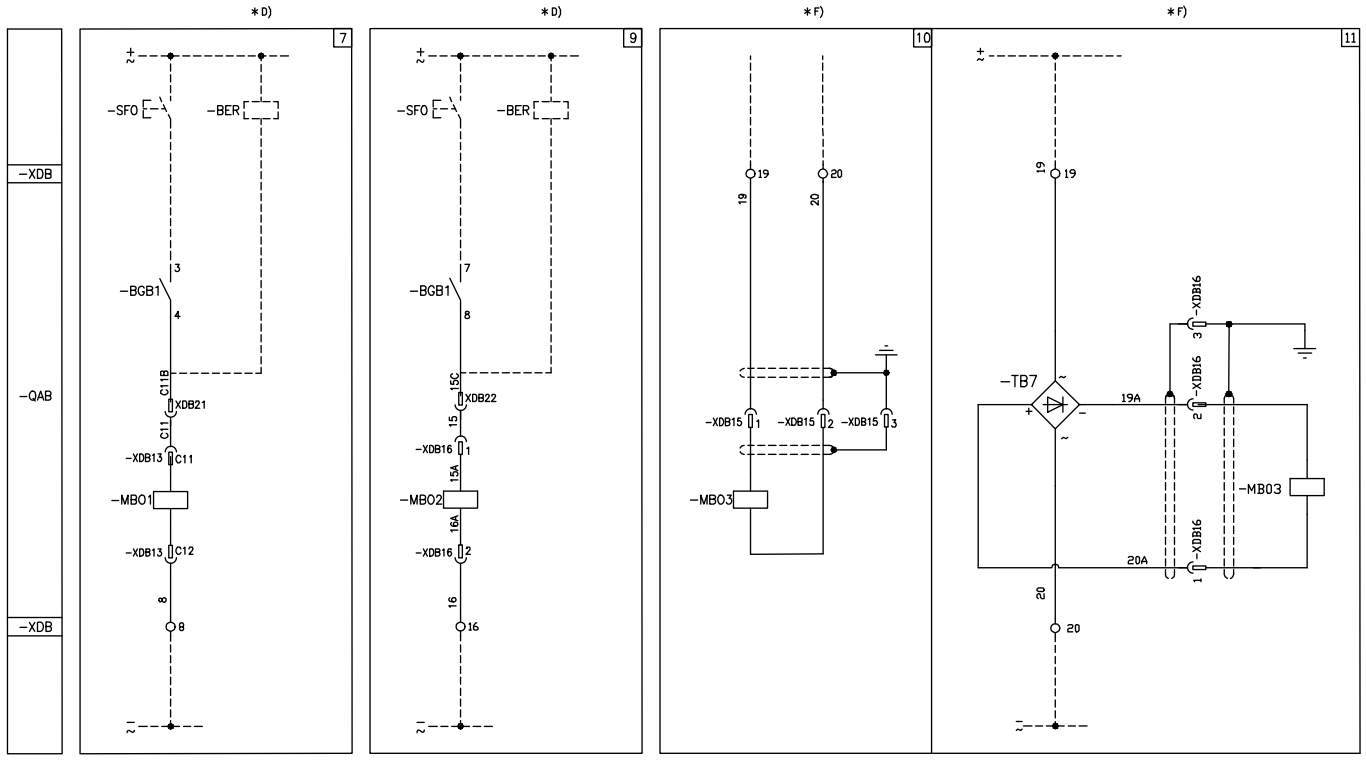

Change-over break before make contact


Lamp (general symbol)

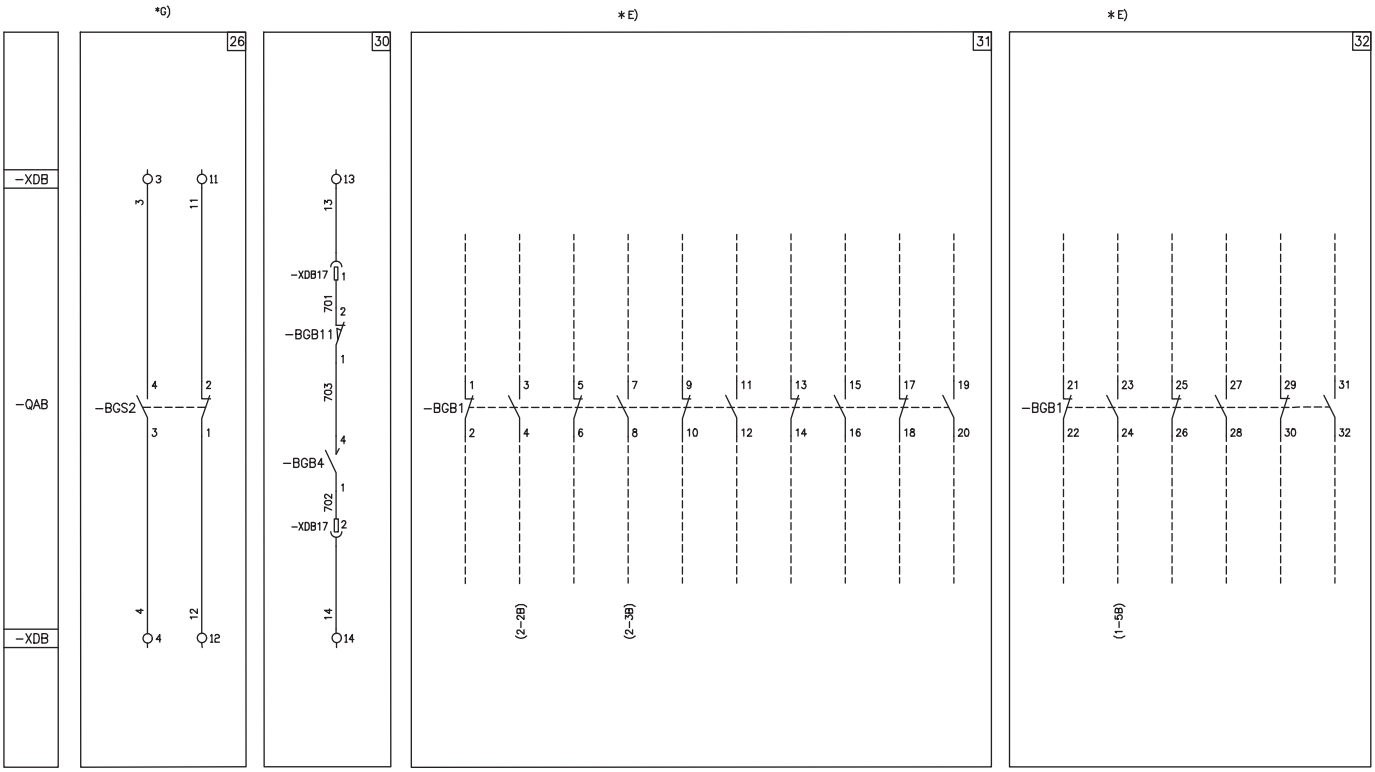
# Electric circuit diagram of 12 .. 40.5 kV fixed circuit breakers 1VCD400151

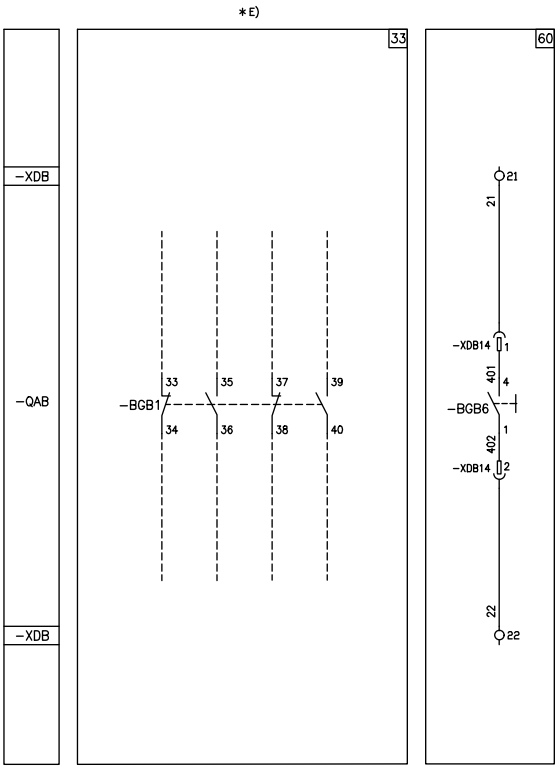
**The electric circuit diagram in this section concerns 12 .. 40.5 kV fixed circuit breakers.**

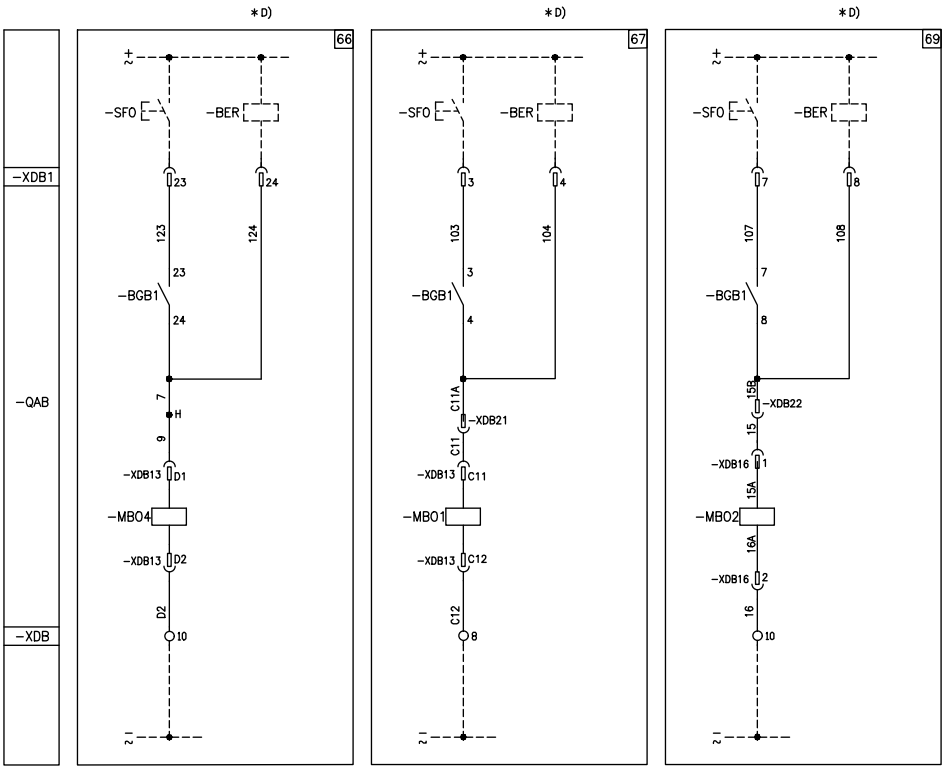


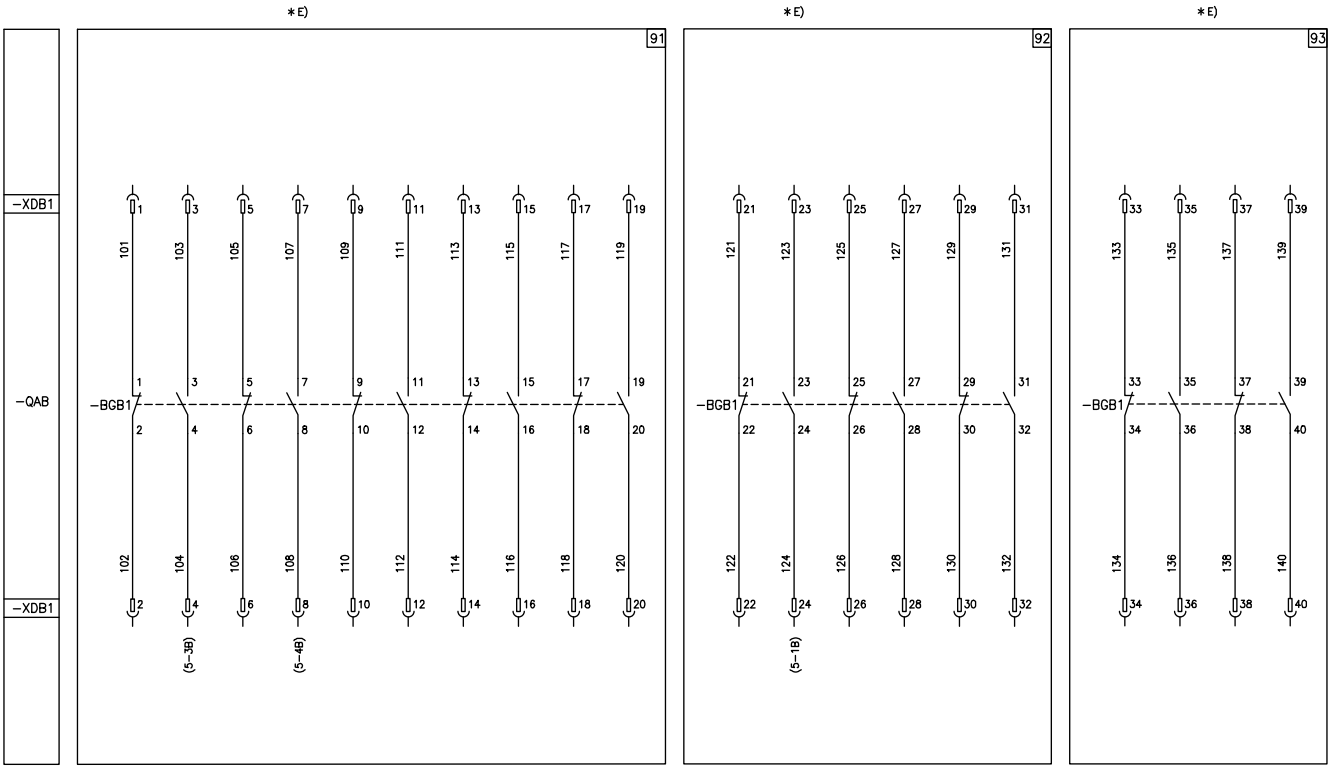



# Electric circuit diagram




*D)
66
67
69
-SF0
-BER
-XDB1
-QAB
-XDB
-BGB1
-MBO4
-MBO1
-MBO2
-XDB13
-XDB21
-XDB22
-XDB16
D1
D2
C11
C11A
C12
15B
15
15A
16A
16
H


*E)
91
92
93
-XDB1
-QAB
-BGB1
(5-3B)
(5-4B)
(5-1B)

# Electric circuit diagram

| Key | | |
|---|---|---|
| □ | = | Figure number of the diagram. |
| * | = | See note indicated by the letter. |
| -BER | = | SOR Test Unit device for monitoring continuity of shunt opening and closing release winding (see note D) |
| -BGB1 | = | Auxiliary contacts of circuit breaker. |
| -BGB4 | = | Auxiliary let-through contact of circuit breaker with momentary closing during circuit breaker opening. |
| -BGB6 | = | Contact for electrical signaling of undervoltage release de-energized. |
| -BGB11 | = | Contact for cutting off electrical signal -BGB4 if opening operation is performed in the manual mode. |
| -BGS1 | = | Limit contact of spring loading motor. |
| -BGS2 | = | Contact for signaling closing springs loaded-discharged. |
| -MAS | = | Motor for loading closing springs (see note C). |
| -MBC | = | Shunt closing release (see note D). |
| -MBO1 | = | First shunt opening release (see note D). |
| -MBO2 | = | Second shunt opening release (see note D). |
| -MBO3 | = | Opening solenoid for release outside circuit breaker (see note F). |
| -MBO4 | = | Third shunt opening release (see note D). |
| -MBU | = | Under-voltage release (see note B). |
| -QAB | = | Circuit breaker applications. |
| -RLE1 | = | Locking magnet. Mechanically inhibits circuit breaker closing if de-energized. (Consumption can be limited by connecting a delayed operation enabling pushbutton in series). |
| -SFC | = | Pushbutton or contact for closing circuit breaker. |
| -SFO | = | Pushbutton or contact for opening circuit breaker. |
| -TB7 | = | Rectifier for release -MBO3. |
| -XDB | = | Terminal box of circuit breaker circuits. |
| -XDB1 | = | Connector of circuit breaker circuits. |
| -XDB10, ...,17 | = | Connectors of applications. |

| Description of the figures | | |
|---|---|---|
| Fig. 1 | = | Circuit of motor for loading closing springs (see note C). |
| Fig. 2 | = | Shunt closing release (anti-pumping is achieved mechanically), (see note D). |
| Fig. 3 | = | Locking magnet. Mechanically inhibits circuit breaker closing if de-energized. Consumption can be limited by connecting a delayed operation enabling pushbutton in series. |
| Fig. 5 | = | Instantaneous undervoltage release (see note B). |
| Fig. 6, 66 | = | Circuit of third shunt opening release with possibility of continuous control of winding (see note D). |
| Fig. 7, 67 | = | Circuit of first shunt opening release with possibility of continuous control of winding (see note D). |
| Fig. 9, 69 | = | Circuit of second shunt opening release with possibility of continuous control of winding (see note D). |
| Fig. 10 | = | Opening solenoid for release outside circuit breaker. |
| Fig. 11 | = | Opening solenoid for release outside circuit breaker with AC supply. |
| Fig. 26 | = | Electrical signaling of closing springs loaded and discharged. |
| Fig. 30 | = | Auxiliary let-through contact of circuit breaker with momentary closing during circuit breaker opening. |
| Fig. 31, 91 | = | Available auxiliary contacts of circuit breaker (see note E). |
| Fig. 32, 92 | = | Available auxiliary contacts of circuit breaker (see note E). |
| Fig. 33, 93 | = | Available auxiliary contacts of circuit breaker (see note E). |
| Fig. 60 | = | Contact for electrical signaling of undervoltage release de-energized. |

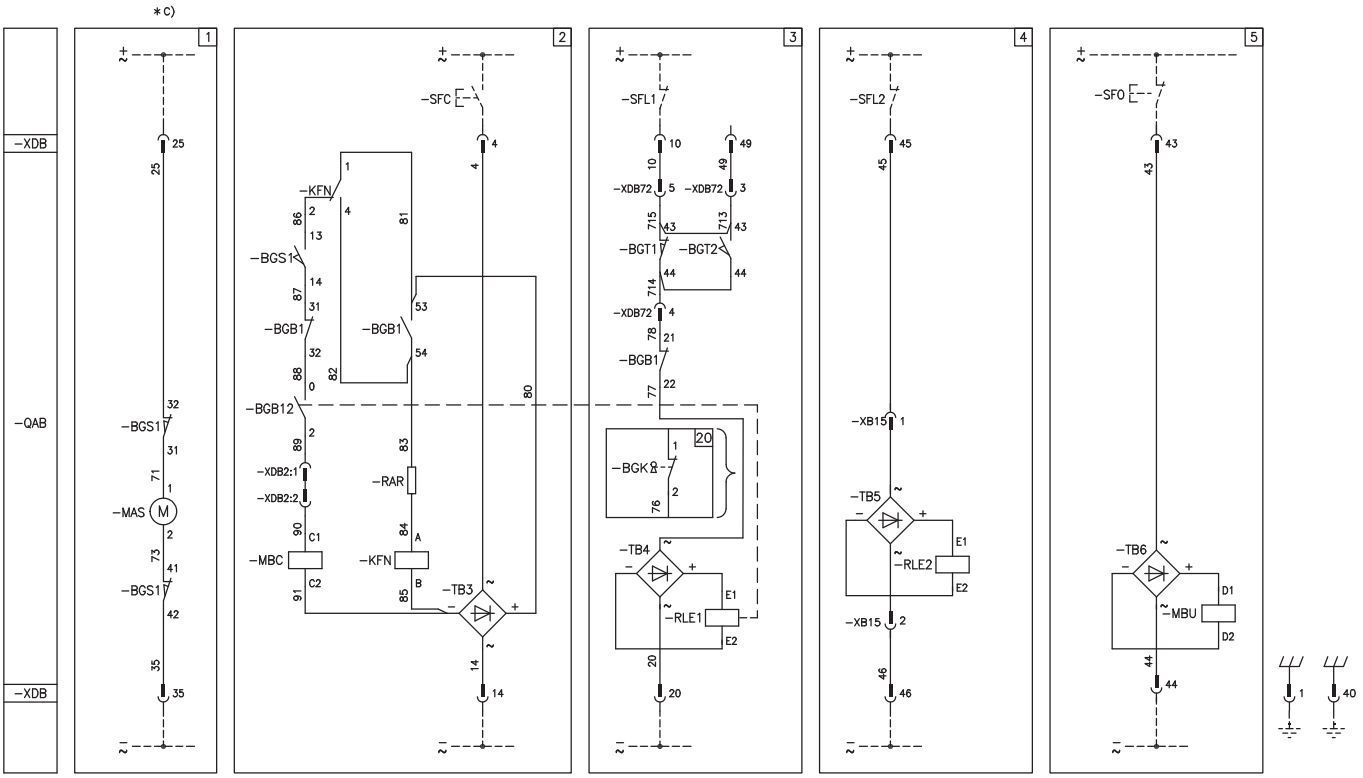
| Incompatibility | | | |
|---|---|---|---|
| The circuits indicated in the following figures cannot be supplied at the same time in the same circuit breaker: | | | |
| 5-6-66 | 7-67 | 9-69 | 31-91 |
| 32-92 | 33-93 | 10-11 | |

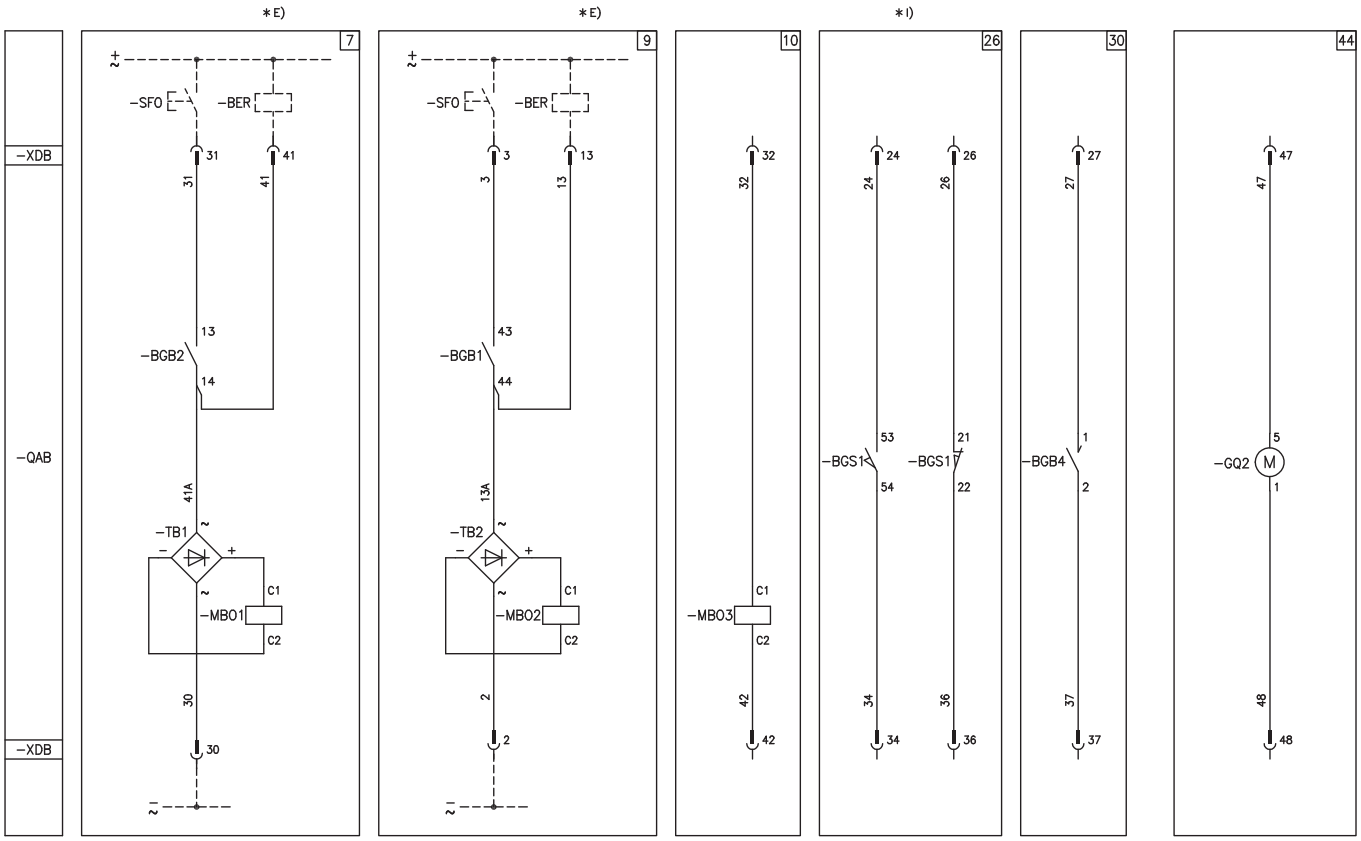
| Notes | |
|---|---|
| A) | The circuit breaker is equipped solely with the applications specified in the order confirmation. Consult this catalog for information about how to make out an order. |
| B) | The undervoltage release can be supplied for energizing with voltage derived from the supply side of the circuit breaker or from an independent source.<br>Circuit breaker closing is only allowed when the release is energized (closing lock is obtained mechanically). If there is the same power supply for the shunt closing and undervoltage releases and the circuit breaker must close automatically when auxiliary voltage returns, there must be a 50 ms delay between the under-voltage release's enabling instant and energizing of the shunt closing release.<br>Incompatible with -MBO4. |
| C) | Check power of auxiliary circuit to find out whether several motors for loading the closing springs can be started at the same time. To prevent excessive power draw, the springs must be loaded by hand before the auxiliary circuit is powered. |
| D) | The circuit for monitoring the continuity of the release winding must only be used for that purpose. The SOR Test Unit can be used for checking the continuity of the various different releases.<br>-MBO4 incompatible with -MBU.<br>-MBO4 not available for VD4 50 kA. |
| E) | When fig. 6 is required, contact -BGB1 (23-24) of fig.32 is not available.<br>When fig. 7 is required, contact -BGB1 (3-4) of fig. 31 is not available.<br>When fig. 9 is required, contact -BGB1 (7-8) of fig. 31 is not available.<br>When fig. 32 is required, it is obligatory to supply the auxiliary contacts of fig. 31.<br>When fig. 33 is required, it is obligatory to supply the auxiliary contacts of fig. 32.<br>When fig. 66 is required, contact -BGB1 (23-24) of fig. 92 is not available.<br>When fig. 67 is required, contact -BGB1 (3-4) of fig. 91 is not available.<br>When fig. 69 is required, contact -BGB1 (7-8) of fig. 91 is not available.<br>When fig. 92 is required, it is obligatory to supply the auxiliary contacts of fig. 91.<br>When fig. 93 is required, it is obligatory to supply the auxiliary contacts of fig. 92.<br>Figs. 33 and 93 are not available for VD4 50 kA. |
| F) | Figs. 10 and 11 are only available for VD4 up to 31.5 kA. |
| G) | The energizing voltage must be the same for both signals. |

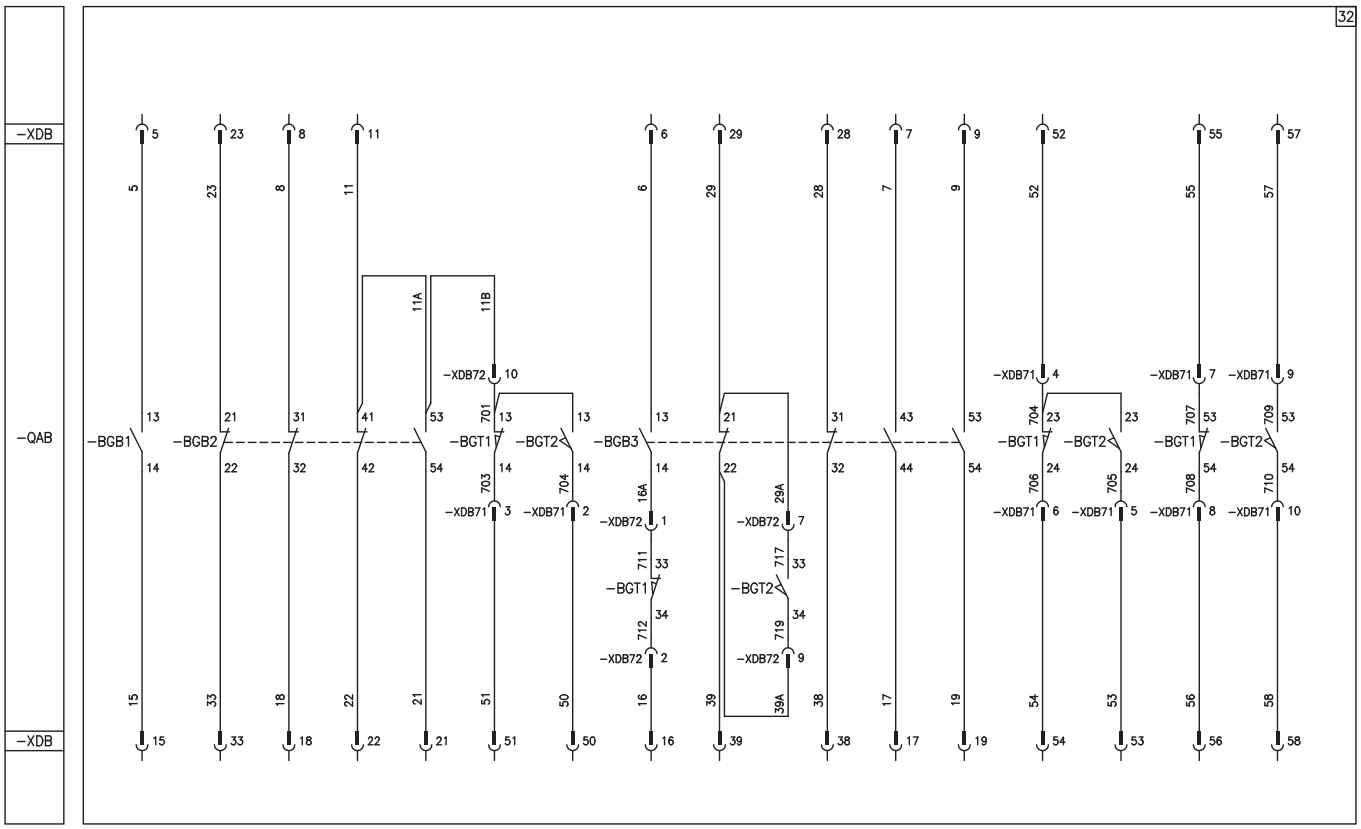
# Electric circuit diagram

## Electric circuit diagram of 36-40.5 kV fixed circuit breakers with Classic operating mechanism 1VCD400231

**The electric circuit diagram in this section concerns 36 - 40.5 kV fixed circuit breakers with Classic operating mechanism.**




*E)
*E)
*I)
7
9
10
26
30
44
-XDB
-QAB
-XDB
-SF0
-BER
-BGB2
-BGB1
-TB1
-TB2
-MBO1
-MBO2
-MBO3
-BGS1
-BGS1
-BGB4
-GQ2
M
C1
C2


32
-XDB
-QAB
-XDB
-BGB1
-BGB2
-BGT1
-BGT2
-BGB3
-BGT1
-BGT2
-XDB72
-XDB71
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-XDB71
-XDB71
-XDB71

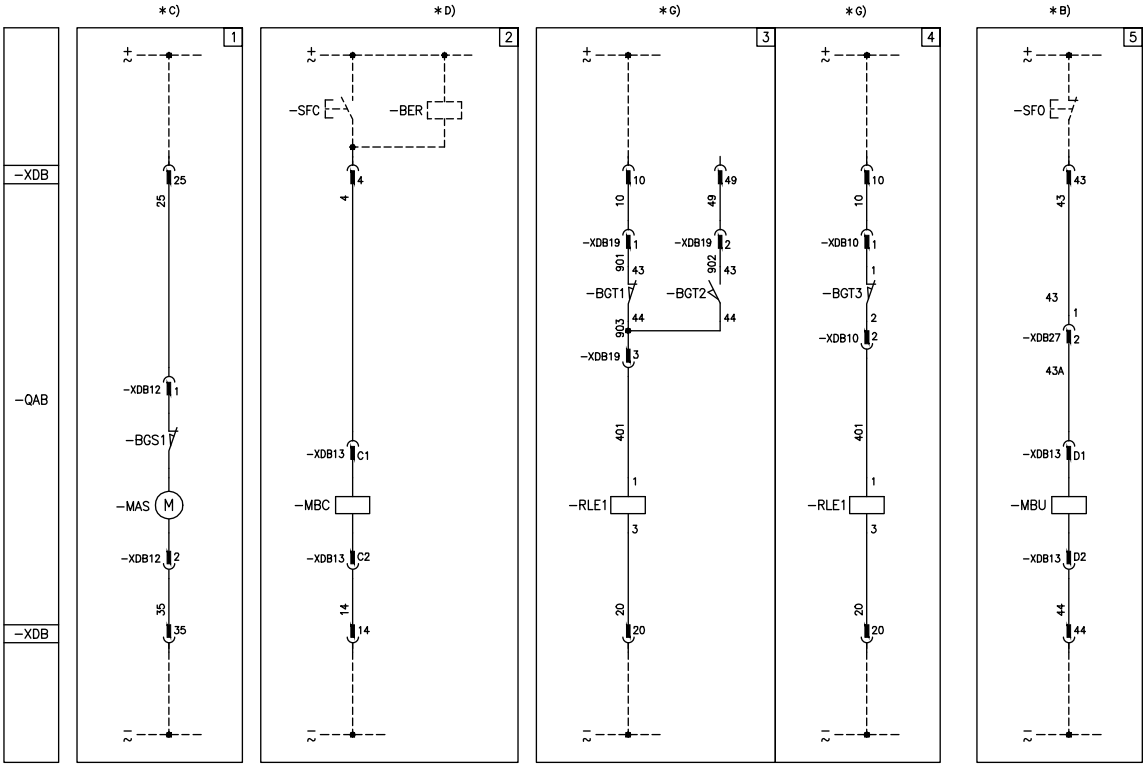
# Electric circuit diagram

| Key | | |
|---|---|---|
| □ | = | Reference number of diagram figure |
| * | = | See note indicoted by the letter |
| -BER | = | Device for the supervision of shunt opening release coil continuity (see note E) |
| -BGB1,..., -BGB3 | = | Circuit breaker auxiliary contacts |
| -BGB4 | = | Auxiliary passing contact (closing momentarily when circuit breaker opens) |
| -BGB12 | = | Auxiliary contact for block closing of the circuit breaker |
| -BGK | = | Contact operated by the key lock preventing the c. breaker closing |
| -BGS | = | Umit switch signalling closing springs charged or discharged |
| -BGT1 | = | Contacts signalling c. breaker in the connected position |
| -BGT2 | = | Contacts signalling c. breaker in the isolated position |
| -MAS | = | Motor for the closing charging springs (see note C) |
| -MBC | = | Shunt closing release |
| -MB01 | = | First shunt opening release (see note E) |
| -MB02 | = | Second shunt opening release (see note E) |
| -MB03 | = | Indirect overcurrent relay |
| -MBU | = | Instantaneous undervoltoge release |
| -KFN | = | Antipumping relay |
| -QAB | = | Main circuit breaker |
| -RAR | = | Resistor |
| -RLE1 | = | Locking magnel If de-energized it prevents the c. breaker closing |
| -RLE2 | = | Locking magnet an the truck. If de-energized it prevents the c. breaker racking-in and racking-out mechanically |
| -SFC | = | Pushbutton or contact for the circuit breaker closing |
| -SFO | = | Pushbutton or contact for the circuit breaker opening |
| -SFL1 | = | Contact locking the c. breaker closing |
| -SFL2 | = | Contact locking the c. breaker rocking-in and rocking-out |
| -TB1 | = | Rectifier for -M01 |
| -TB2 | = | Rectifier for -M02 |
| -TB3 | = | Rectifier for -MBC and -KFN |
| -TB4 | = | Rectifier for -RLE1 |
| -TB6 | = | Rectifier for -MBU |
| -GQ2 | = | Ventilator |
| -XDB | = | Connector for the c. breaker circuits |
| -XDB2 | = | Connector of the accessories |
| -XDB71, -XDB72 | = | Connectors of the accessories |

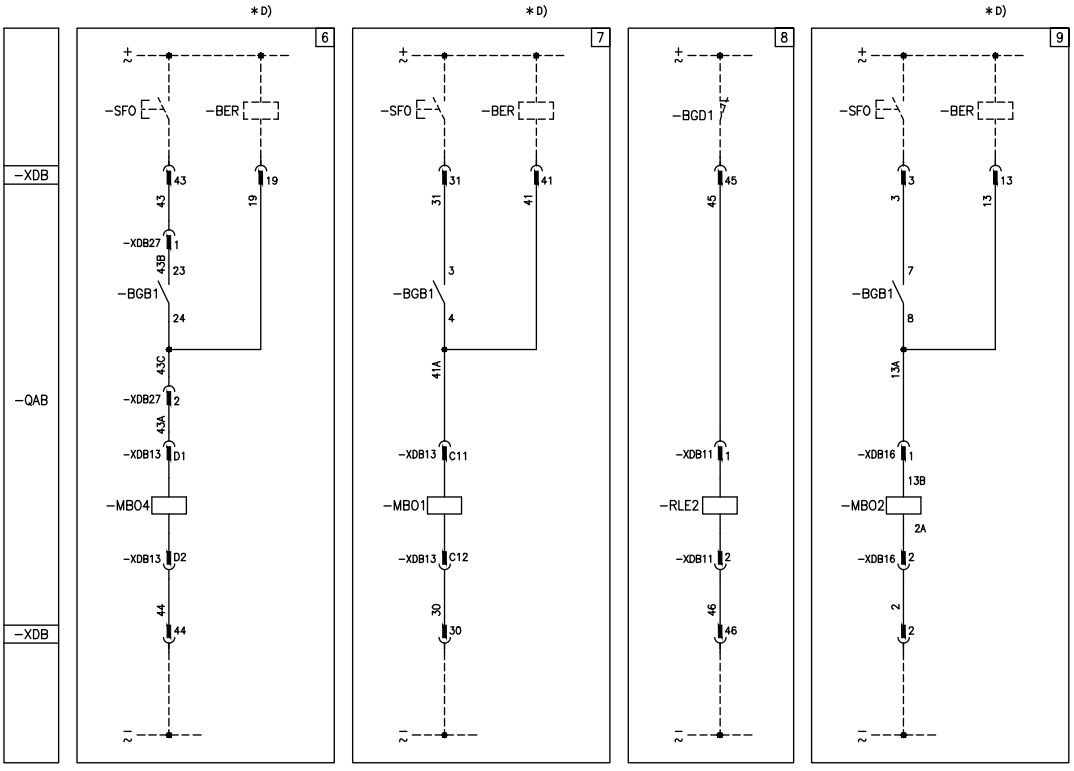
| Description of the figures | | |
|---|---|---|
| Fig. 1 | = | Springs charging-motor circuit (see note C) |
| Fig. 2 | = | Shunt closing release |
| Fig. 3 | = | Locking magnet on the operating mechanism. If de-energized it prevents the c. breaker closing |
| Fig. 4 | = | Locking magnet on the truck. If de-energized it prevents the c. breaker racking-in and racking-out mechanically. |
| Fig. 5 | = | Instantaneous undervoltoge release |
| Fig. 7 | = | First shunt opening release circuit with possibility of permanent supervision of coil continuity (see note E) |
| Fig. 9 | = | Second shunt opening release circuit with possibility of permanent supervision of coil continuity (see note E) |
| Fig. 10 | = | Indirect overcurrent relay |
| Fig. 26 | = | Contact signalling charged or discharged closing springs (see note I) |
| Fig. 30 | = | Wiping contact 35ms for C.B. tripped indication |
| Fig. 32 | = | C. breaker available auxiliary contacts |
| Fig. 44 | = | Ventilation circuit |

| Notes | |
|---|---|
| A) | The circuit breaker is delivered complete with the accessories listed in the order aknowledgement only. To draw up the order examine the apparatus catalogue. |
| C) | Check the power supply available on the auxiliary circuit to verify if it is odeguate to start several closing spring-charging motors simultaneously. To prevent excessive consumption the closing springs must be charged manually before energizing the auxiliary circuit. |
| E) | The circuit for the supervision of shunt opening release coil continuity shall be used for this function only. |
| I) | Both limit switches signalling must be working at the same supply voltage. |

# Electric circuit diagram of 12 .. 24 kV withdrawable circuit breakers for UniGear switchgear and PowerCube enclosure 1VCD400155





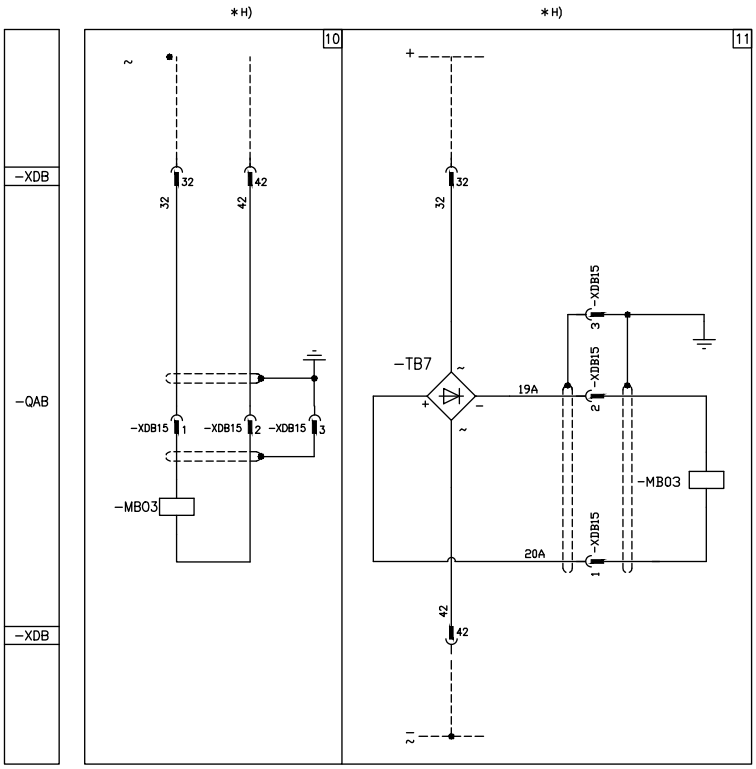



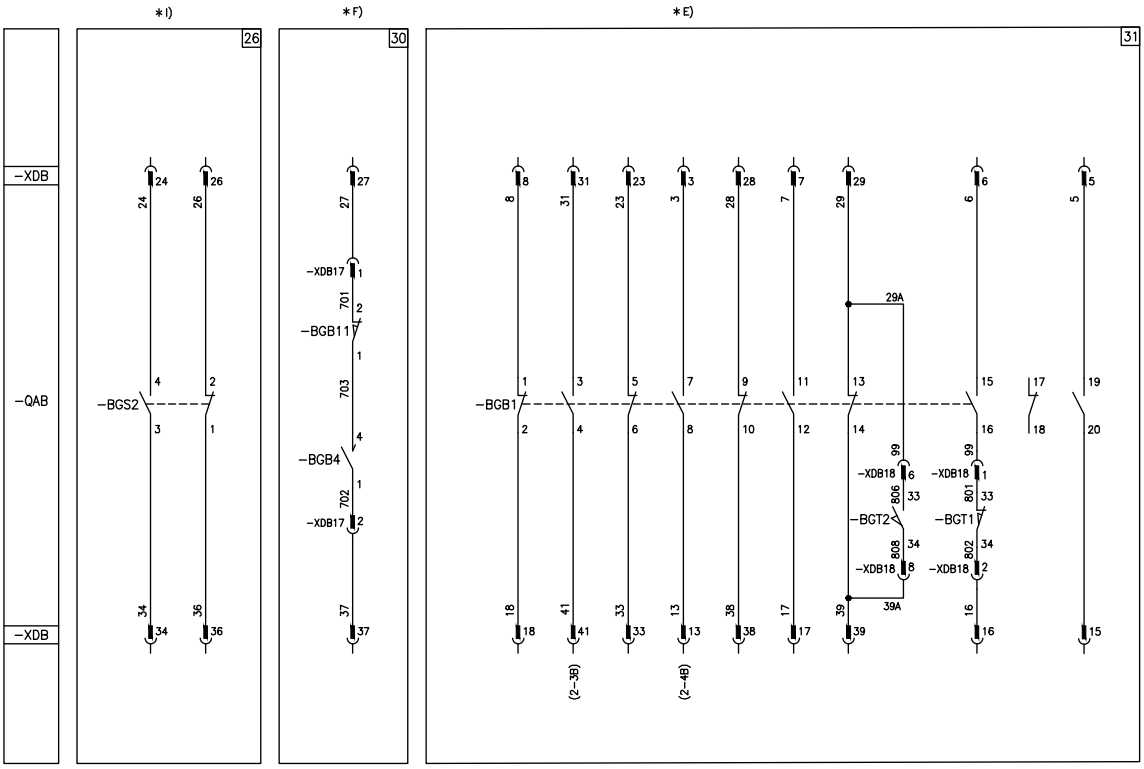
# Electric circuit diagram

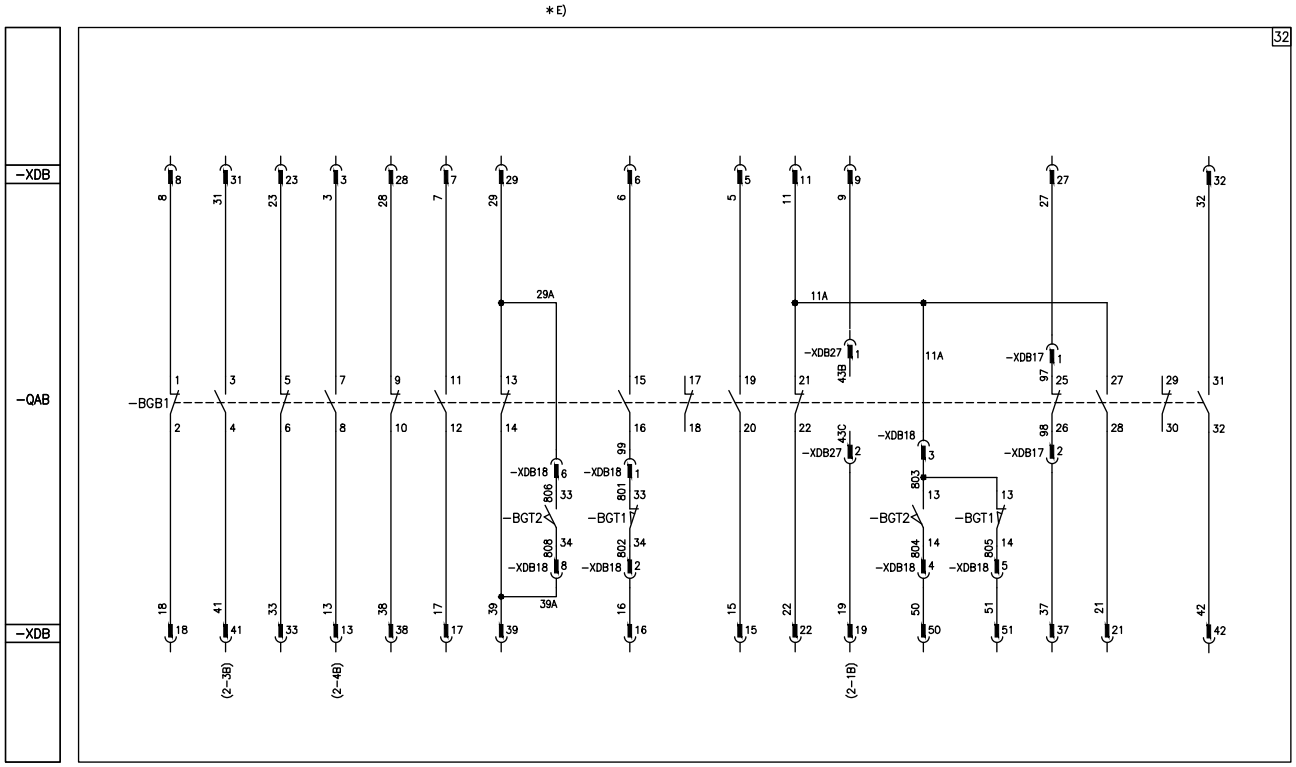
The electric circuit diagram in this section concerns 12 .. 24 kV withdrawable circuit breakers for UniGear switchgear and PowerCube enclosures. See diagram 1VCD400156 for withdrawable circuit breakers with motor-driven truck.

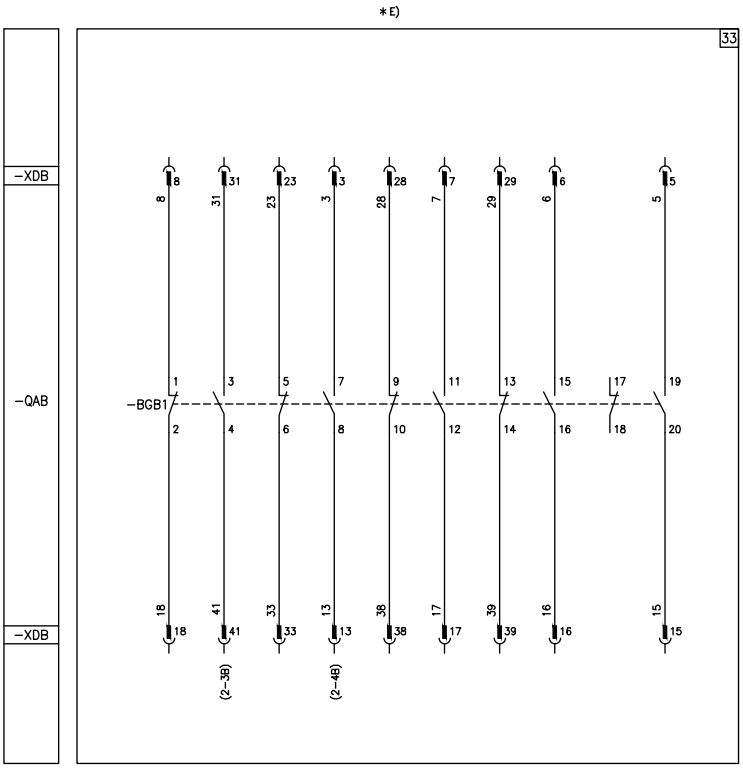
The following diagrams are available for circuit breakers for ZS8.4 switchgear:

- **1VCD400158** Standard version
- **1VCD400159** Version with motorized truck.

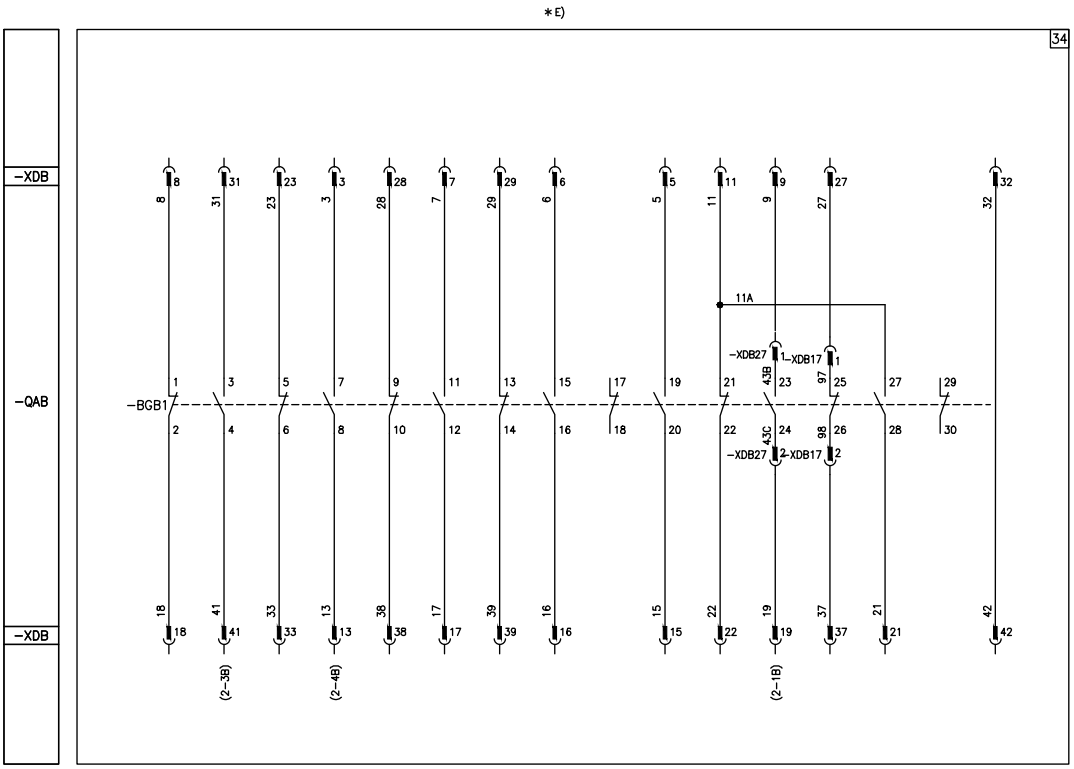


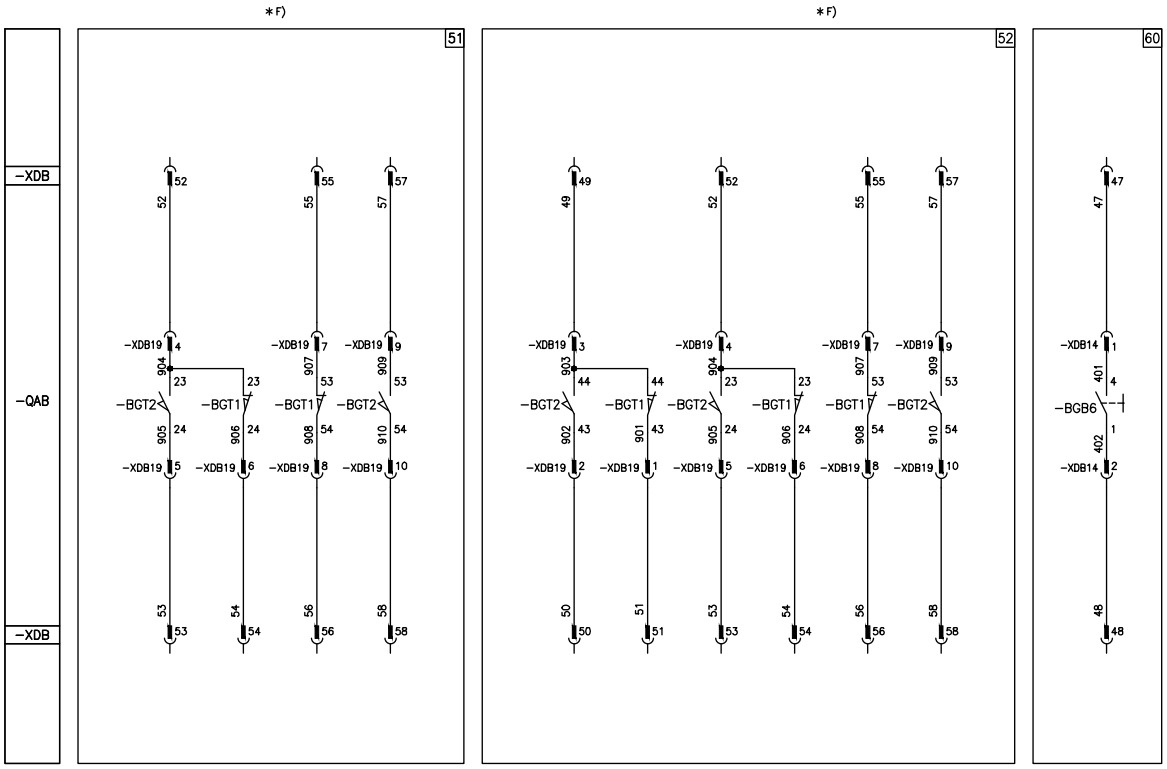




*E)
32
-XDB
-QAB
-XDB
-BGB1
29A
39A
11A
-XDB27
43B
43C
-XDB17
-XDB18
-BGT2
-BGT1
(2-3B)
(2-4B)
(2-1B)


*E)
33
-XDB
-QAB
-XDB
-BGB1
(2-3B)
(2-4B)

# Electric circuit diagram



| Key | | |
|---|---|---|
| □ | = | Figure number of the diagram. |
| * | = | See note indicated by the letter. |
| -BER | = | SOR Test Unit device for monitoring continuity of shunt opening and closing release winding (see note D). |
| -BGB1 | = | Auxiliary contacts of circuit breaker. |
| -BGB4 | = | Auxiliary let-through contact of circuit breaker with momentary closing during circuit breaker opening. |
| -BGB6 | = | Contact for electrical signaling of undervoltage release de-energized. |
| -BGB11 | = | Contact for cutting off electrical signal -BGB4 if opening operation is performed in the manual mode. |
| -BGD1 | = | Enclosure door position contact. |
| -BGS1 | = | Limit contact of spring loading motor. |
| -BGS2 | = | Contact for signaling closing springs loaded-discharged. |
| -BGT1 | = | Electrical signalling contacts for circuit breaker in racked-in position (see note F) |
| -BGT2 | = | Electrical signaling contacts for circuit breaker in isolated position (see note F). |
| -BGT3 | = | Circuit breaker position contact, open during isolating travel. |
| -MAS | = | Motor for loading closing springs (see note C). |
| -MBC | = | Shunt closing release (see note D). |
| -MBO1 | = | First shunt opening release (see note D). |
| -MBO2 | = | Second shunt opening release (see note D). |
| -MBO3 | = | Opening solenoid for release outside circuit breaker. |
| -MBO4 | = | Third shunt opening release (see note D). |
| -MBU | = | Undervoltage release (see note B). |
| -QAB | = | Circuit breaker applications. |
| -RLE1 | = | Locking magnet. Mechanically inhibits circuit breaker closing if de-energized. (Consumption can be limited by connecting a delayed pushbutton in series so as to enable the operation). |
| -RLE2 | = | Locking magnet (on truck). Mechanically inhibits circuit breaker racking-in and isolating if de-energized. (Consumption can be limited by connecting a delayed pushbutton in series so as to enable the operation). |
| -SFC | = | Pushbutton or contact for closing circuit breaker. |
| -SFO | = | Pushbutton or contact for opening circuit breaker. |
| -TB7 | = | Rectifier for release -MBO3. |
| -XDB | = | Terminal box of circuit breaker circuits. |
| -XDB10, ... , 27 | = | Connectors of applications. |
| -XDB28 | = | Connectors of applications. |

| Description of the figures | | |
|---|---|---|
| Fig. 1 | = | Circuit of motor for loading closing springs (see note C). |
| Fig. 2 | = | Shunt closing release (anti-pumping is achieved mechanically). (see note D). |
| Fig. 3 | = | Locking magnet. Mechanically inhibits circuit breaker closing if de-energized. (If -RLE1 is required, provide this figure when fig.31 or 32 are selected). Consumption can be limited by connecting a delayed pushbutton in series so as to enable the operation. |
| Fig. 4 | = | Locking magnet. Mechanically inhibits circuit breaker closing if de-energized. (If -RLE1 is required, provide this figure when fig.33 or 34 are selected). Consumption can be limited by connecting a delayed pushbutton in series so as to enable the operation. |
| Fig. 5 | = | Instantaneous undervoltage release (see note B). |
| Fig. 6 | = | Circuit of third opening release with continuous control of winding (see note D). |
| Fig. 7 | = | Circuit of first opening release with continuous control of winding (see note D). |
| Fig. 8 | = | Locking magnet (on truck). Mechanically inhibits circuit breaker racking-in and isolating if de-energized. (Consumption can be limited by connecting a delayed pushbutton in series so as to enable the operation). |
| Fig. 9 | = | Circuit of second opening release with continuous control of winding (see note D). |
| Fig. 10 | = | Opening solenoid for release outside circuit breaker. |
| Fig. 11 | = | Opening solenoid for release outside circuit breaker with AC supply. |
| Fig. 26 | = | Electrical signalling of closing springs loaded and discharged. |
| Fig. 30 | = | Auxiliary let-through contact of circuit breaker with momentary closing during circuit breaker opening. |
| Fig. 31, ... , 34 | = | Available auxiliary contacts of circuit breaker (see note E). |
| Fig. 51 | = | Contacts for electrical signaling of circuit breaker in racked-in and isolated positions located on circuit breaker truck (obligatory when fig. 31 or 32 are required). |
| Fig. 52 | = | Contacts for electrical signaling of circuit breaker in racked-in and isolated positions located on circuit breaker truck (supplied on request when fig. 33 to 34 are required). |
| Fig. 60 | = | Contact for electrical signaling of undervoltage release de-energized. |

# Electric circuit diagram

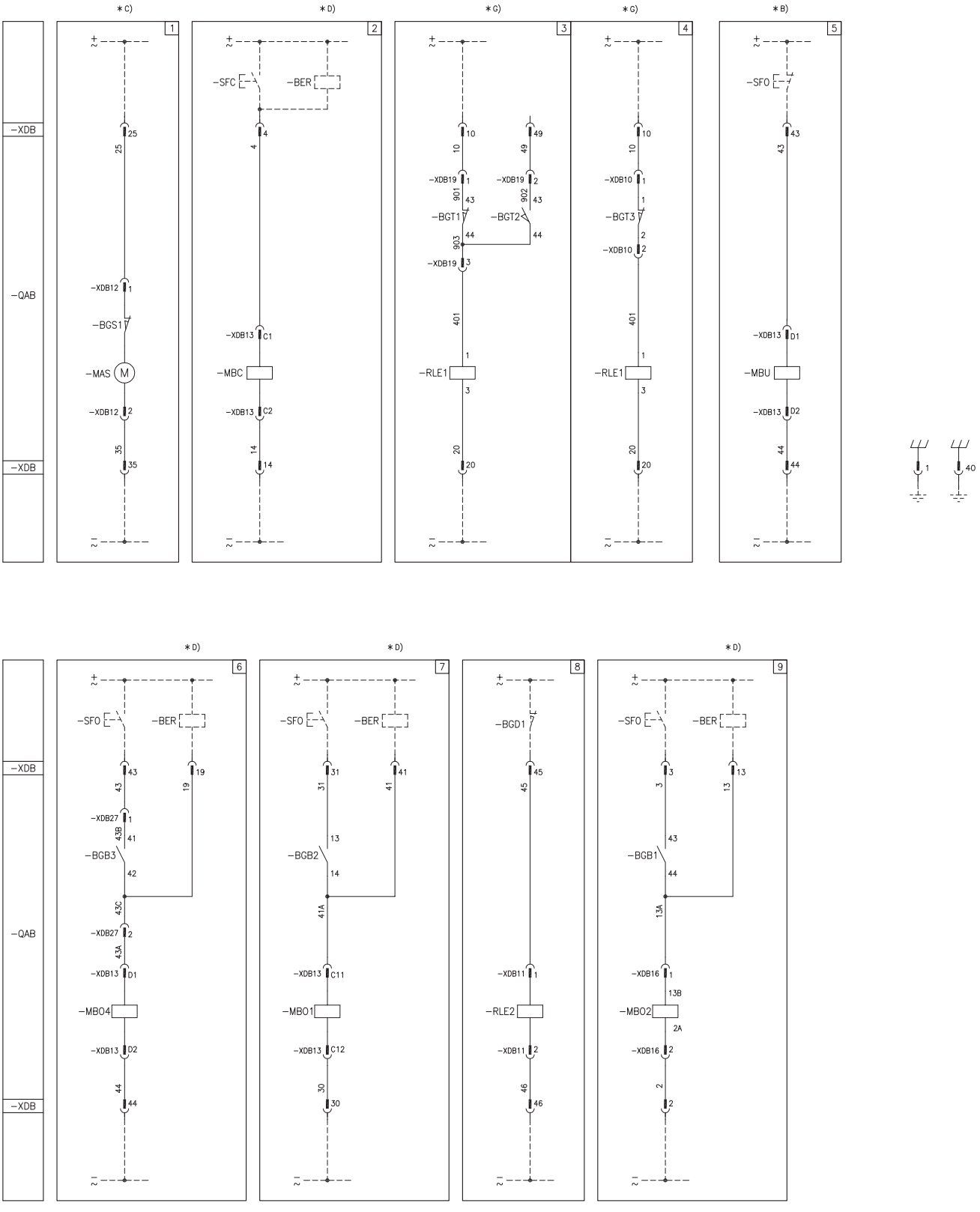
| **Incompatibility** | | | | |
|---|---|---|---|---|
| The circuits indicated in the following figures cannot be supplied at the same time in the same circuit breaker: | | | | |
| **3-4** | **3-33-34** | **4-31-32** | **5-6** | **10-11** |
| **31-32-33-34** | **31-32-52** | **33-34-51** | **51-52** | |

| **Notes** | |
|---|---|
| A) | Circuit breaker is equipped solely with the applications specified in the order confirmation. Consult this catalog for information about how to make out an order. |
| B) | The undervoltage release can be supplied for energizing with voltage derived from the supply side of the circuit breaker or from an independent source. Circuit breaker closing is only allowed when the release is energized (closing lock is obtained mechanically). If there is the same power supply for the shunt closing and undervoltage releases and the circuit breaker must close automatically when auxiliary voltage returns, there must be a 50 ms delay between the undervoltage release's enabling instant and energizing of the shunt closing release.<br>Incompatible with -MBO4. |
| C) | Check power of auxiliary circuit to find out whether several motors for loading the closing springs can be operated at the same time. To prevent excessive power draw, the springs must be loaded by hand before auxiliary circuit is powered. |
| D) | The circuit for monitoring the continuity of the release windings must only be used for that purpose. The SOR Test Unit can be used for checking the continuity of the various different releases:<br>-MBO4 incompatible with -MBU.<br>-MBO4 not available on Vmax and VD4 50kA. |
| E) | When fig. 6 is required, contact -BGB1 (23-24) of fig. 32-34 is not available.<br>When fig. 7 is required, contact -BGB1 (3-4) of fig. 31-32-33-34 is not available.<br>When fig. 9 is required, contact -BGB1 (7-8) of fig. 31-32-33-34 is not available.<br>When fig. 10 or 11 are required, contact -BGB1 (31-32) of fig. 32 and 34 is not available.<br>When fig. 30 is required, contact -BGB1 (25-26) of fig. 32 and 34 is not available. |
| F) | The contacts for electrical signaling of circuit breaker in isolated and racked-in position (-BGT1 and BGT2) shown in fig. 51-52 are installed on circuit breaker truck (movable part). |
| G) | Fig. 3 is supplied when fig. 31 or 32 are required.<br>Fig. 4 is supplied when fig. 33 or 34 are required (in this case, it is obligatory to supply –BGT3). |
| H) | Fig. 10 is only available for VD4 up to 31.5 kA and Vmax.<br>Fig. 11 is only available for VD4 up to 31.5 kA. |
| I) | The energizing voltage must be the same for both signals. |

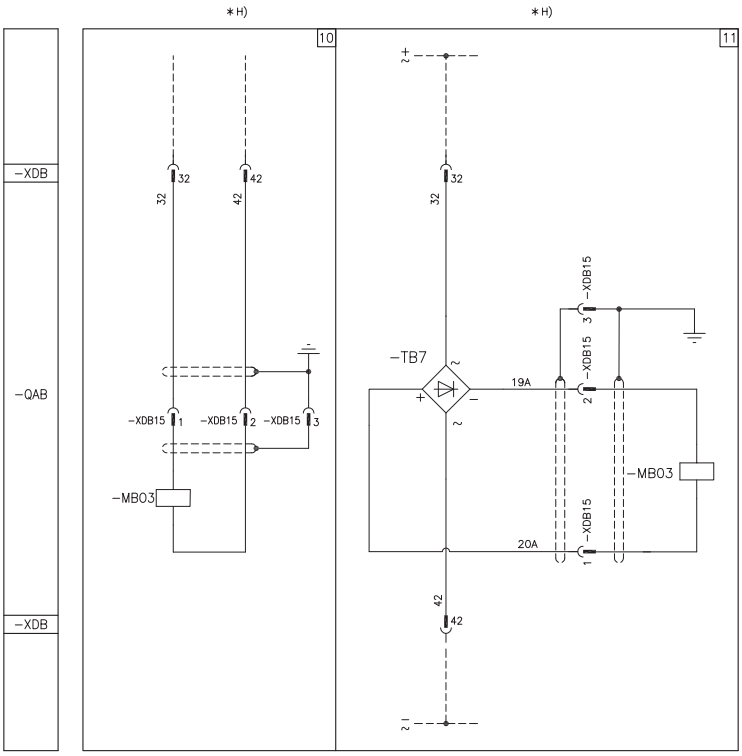
# Electric circuit diagram of 36 kV withdrawable circuit breakers 1VCD400237

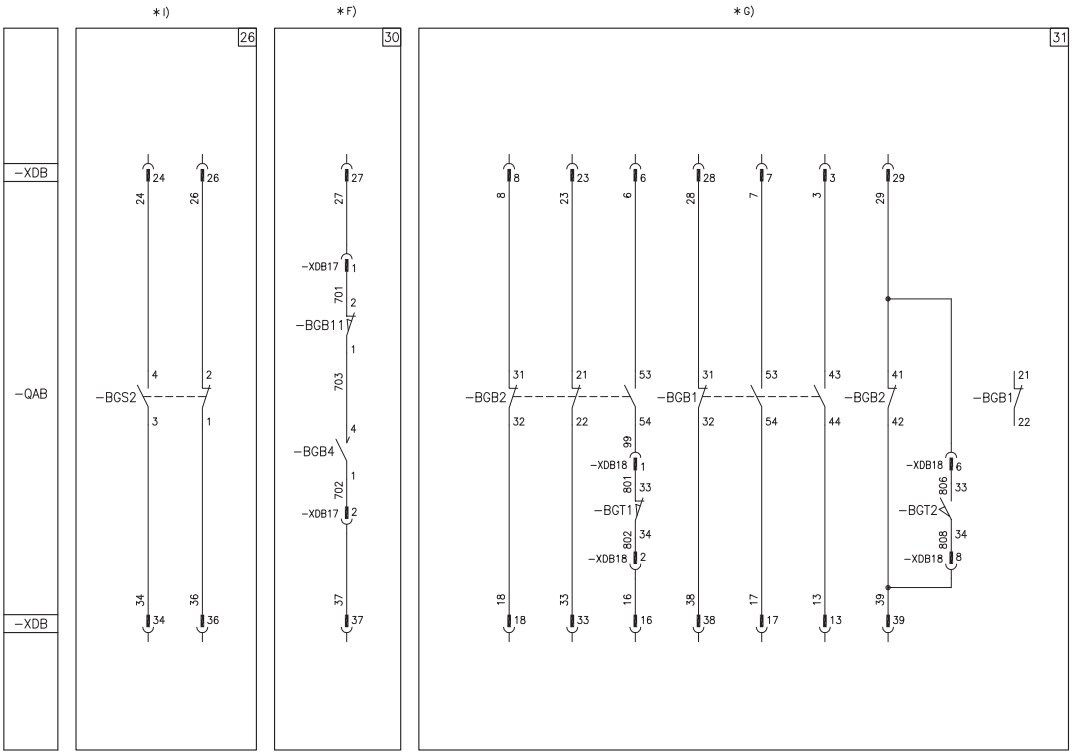
The electric circuit diagram in this section concerns 36 kV withdrawable circuit breakers.

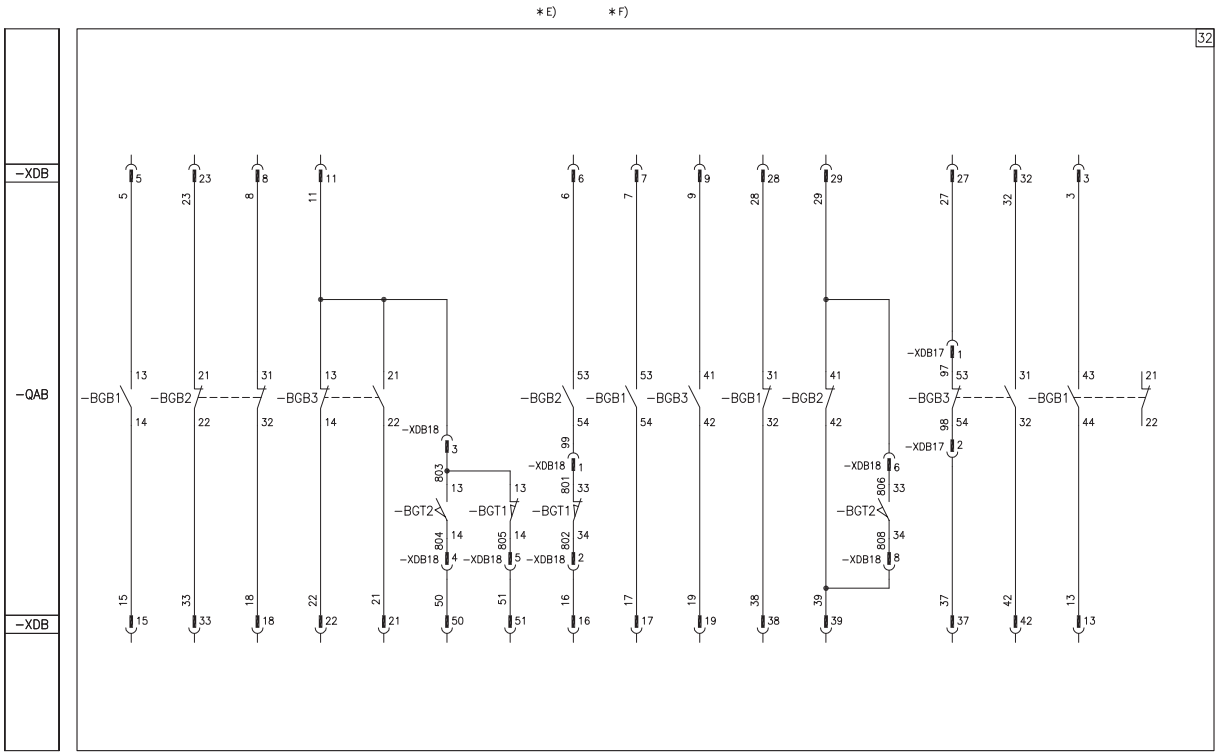
**Version with motor-driven truck 1VCD 400240**

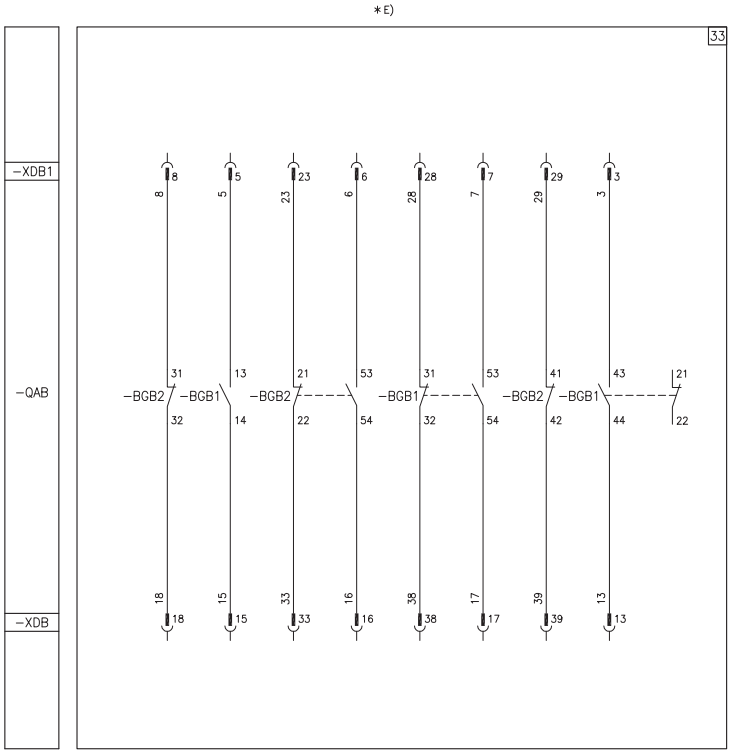


# Electric circuit diagram

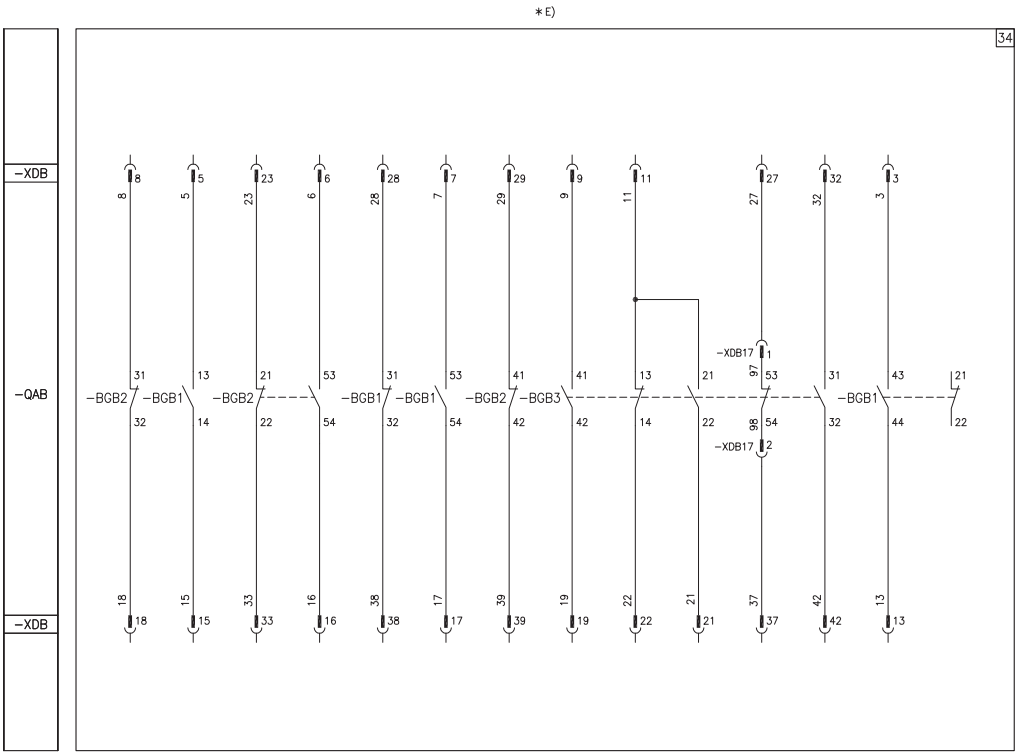


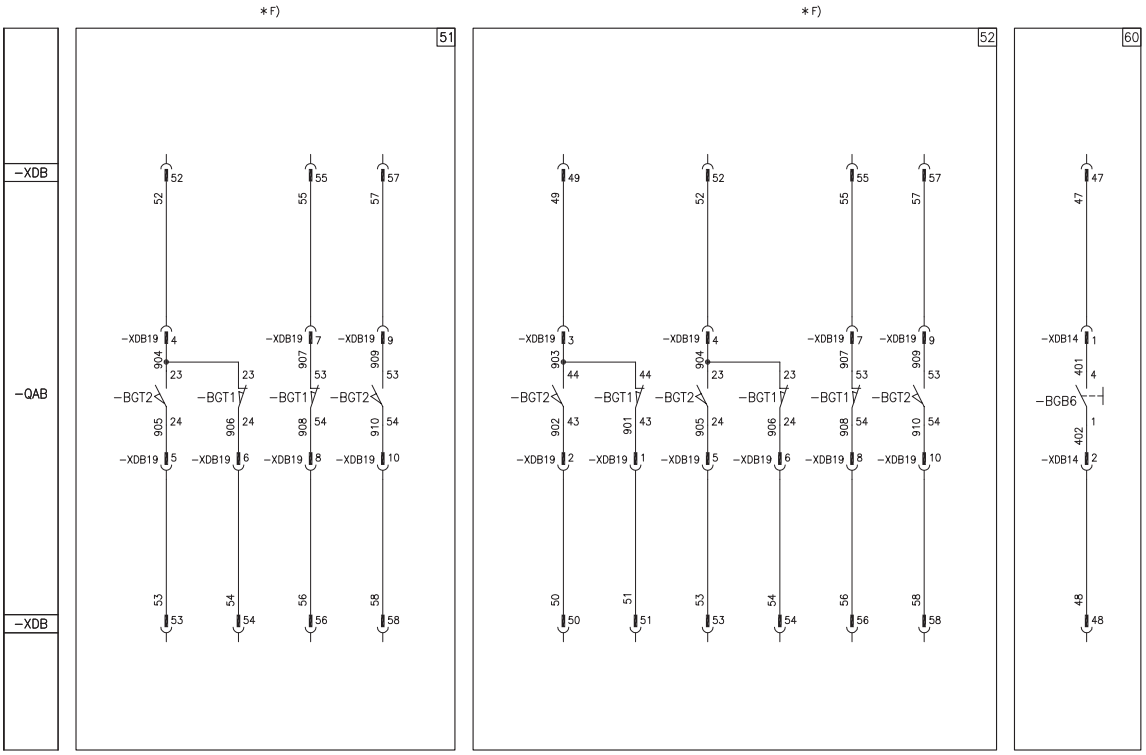




*E)
*F)
32
-XDB
-QAB
-XDB
-BGB1
-BGB2
-BGB3
-BGT1
-BGT2
-XDB18
-XDB17


*E)
33
-XDB1
-QAB
-XDB
-BGB1
-BGB2

# Electric circuit diagram



| Key | | |
|---|---|---|
| □ | = | Figure number of the diagram |
| * | = | See note indicated by the letter. |
| -BER | = | SOR Test Unit device for monitoring continuity of shunt opening and closing release winding (see note D) |
| -BGB1, ... ,3 | = | Auxiliary contacts of circuit breaker. |
| -BGB4 | = | Auxiliary let-through contact of circuit breaker with momentary closing during circuit breaker opening. |
| -BGB6 | = | Contact for electrical signaling of undervoltage release de-energized. |
| -BGB11 | = | Contact for cutting off electrical signal -BGB4 if opening operation is performed in the manual mode |
| -BGD1 | = | Enclosure door position contact. |
| -BGS1 | = | Limit contact of spring loading motor. |
| -BGS2 | = | Contact for signaling closing springs loaded-discharged. |
| -BGT1 | = | Electrical signalling contacts for circuit breaker in racked-in position (see note F). |
| -BGT2 | = | Contacts for electrical signaling of circuit-breaker in isolated position (see note F). |
| -BGT3 | = | Circuit breaker position contact, open during isolating travel. |
| -MAS | = | Motor for loading closing springs (see note C). |
| -MBC | = | Shunt closing release (see note D). |
| -MBO1 | = | First shunt opening release (see note D). |
| -MBO2 | = | Second shunt opening release (see note D). |
| -MBO3 | = | Opening solenoid for release outside circuit breaker. |
| -MBO4 | = | Third shunt opening release (see note D). |
| -MBU | = | Undervoltage release (see note B). |
| -QAB | = | Circuit breaker applications. |
| -RLE1 | = | Locking magnet. Mechanically inhibits circuit breaker closing if de-energized. (Consumption can be limited by connecting a delayed operation enabling pushbutton in series). |
| -RLE2 | = | Locking magnet (on truck). Mechanically inhibits circuit breaker racking-in and isolating if de-energized. (Consumption can be limited by connecting a delayed pushbutton in series so as to enable the operation). |
| -SFC | = | Pushbutton or contact for closing circuit breaker. |
| -SFO | = | Pushbutton or contact for opening circuit breaker. |
| -TB7 | = | Rectifier for release -MBO3. |
| -XDB | = | Terminal box of circuit breaker circuits. |
| -XDB10, ... , 27 | = | Connectors of applications. |
| -XDB28 | = | Connector of applications. |

| Description of the figures | | |
|---|---|---|
| Fig. 1 | = | Circuit of motor for loading closing springs (see note C). |
| Fig. 2 | = | Shunt closing release (anti-pumping is achieved mechanically), (see note D). |
| Fig. 3 | = | Locking magnet. Mechanically inhibits circuit breaker closing if de-energized. (If -RLE1 is required, provide this figure when fig. 31 or 32 are selected). Consumption can be limited by connecting a delayed pushbutton in series so as to enable the operation. |
| Fig. 4 | = | Locking magnet. Mechanically inhibits circuit breaker closing if de-energized. (If -RLE1 is required, provide this figure when fig.33 or 34 are selected). Consumption can be limited by connecting a delayed pushbutton in series so as to enable the operation. |
| Fig. 5 | = | Instantaneous undervoltage release (see note B). |
| Fig. 6 | = | Circuit of third shunt opening release with continuous control of winding (see note D). |
| Fig. 7 | = | Circuit of first opening release with continuous control of winding (see note D). |
| Fig. 8 | = | Locking magnet (on truck). Mechanically inhibits circuit breaker racking-in and isolating if de-energized. (Consumption can be limited by connecting a delayed pushbutton in series so as to enable the operation). |
| Fig. 9 | = | Circuit of second shunt opening release with continuous control of winding (see note D). |
| Fig. 10 | = | Opening solenoid for release outside circuit breaker. |
| Fig. 11 | = | Opening solenoid for release outside circuit breaker with AC supply. |
| Fig. 26 | = | Electrical signaling of closing springs loaded and discharged. |
| Fig. 30 | = | Auxiliary let-through contact of circuit breaker with momentary closing during circuit breaker opening. |
| Fig. 31, ... , 34 | = | Available auxiliary contacts of circuit breaker (see note E). |
| Fig. 51 | = | Contacts for electrical signaling of circuit breaker in racked-in and isolated positions located on circuit breaker truck (obligatory when fig.31 or 32 are required). |
| Fig. 52 | = | Contacts for electrical signaling of circuit breaker in racked-in and isolated positions located on circuit breaker truck (supplied on request when fig.33 to 34 are required). |
| Fig. 60 | = | Contact for electrical signaling of undervoltage release de-energized. |

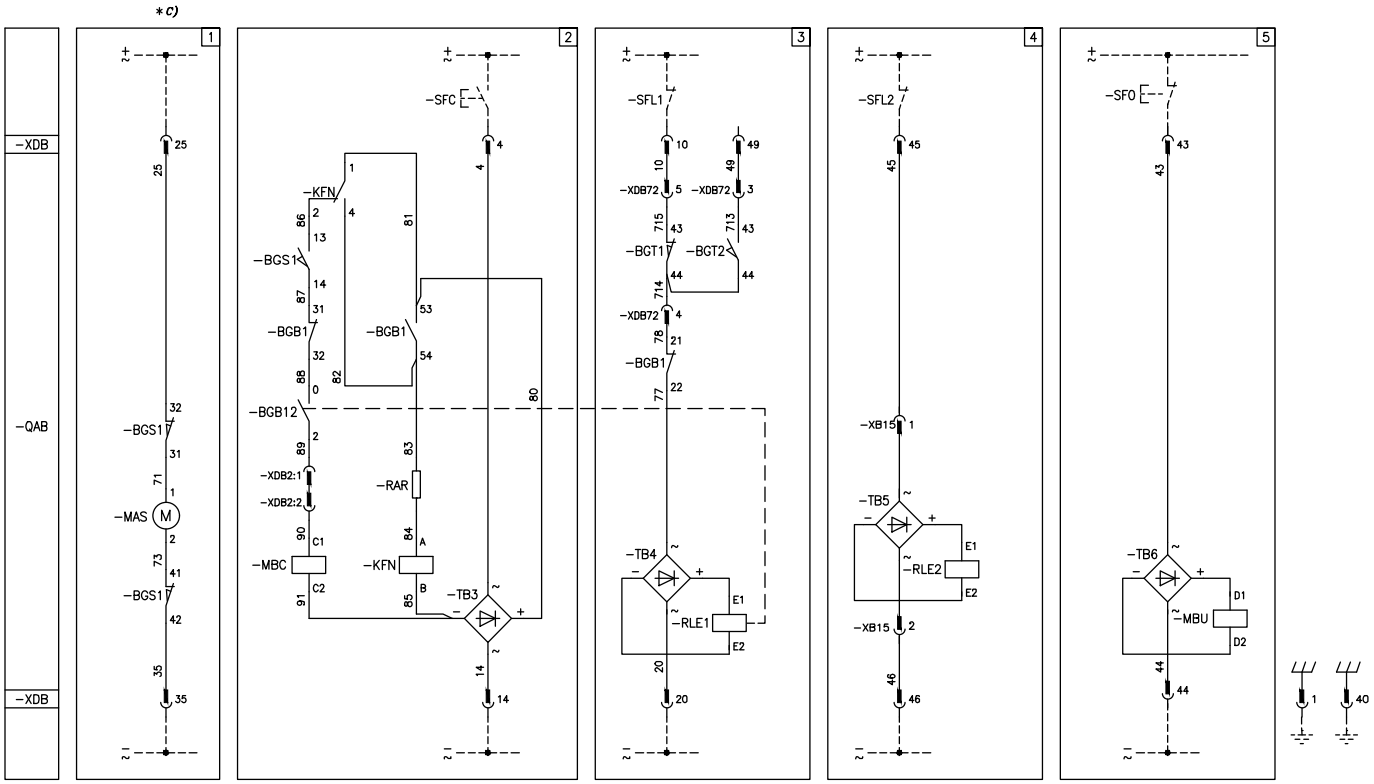
# Electric circuit diagram

| **Incompatibility** | | | | |
|---|---|---|---|---|
| The circuits indicated in the following figures cannot be supplied at the same time in the same circuit breaker: | | | | |
| **3-4** | **3-33-34** | **4-31-32** | **5-6** | **10-11** |
| **31-32-33-34** | **31-32-52** | **33-34-51** | **51-52** | |

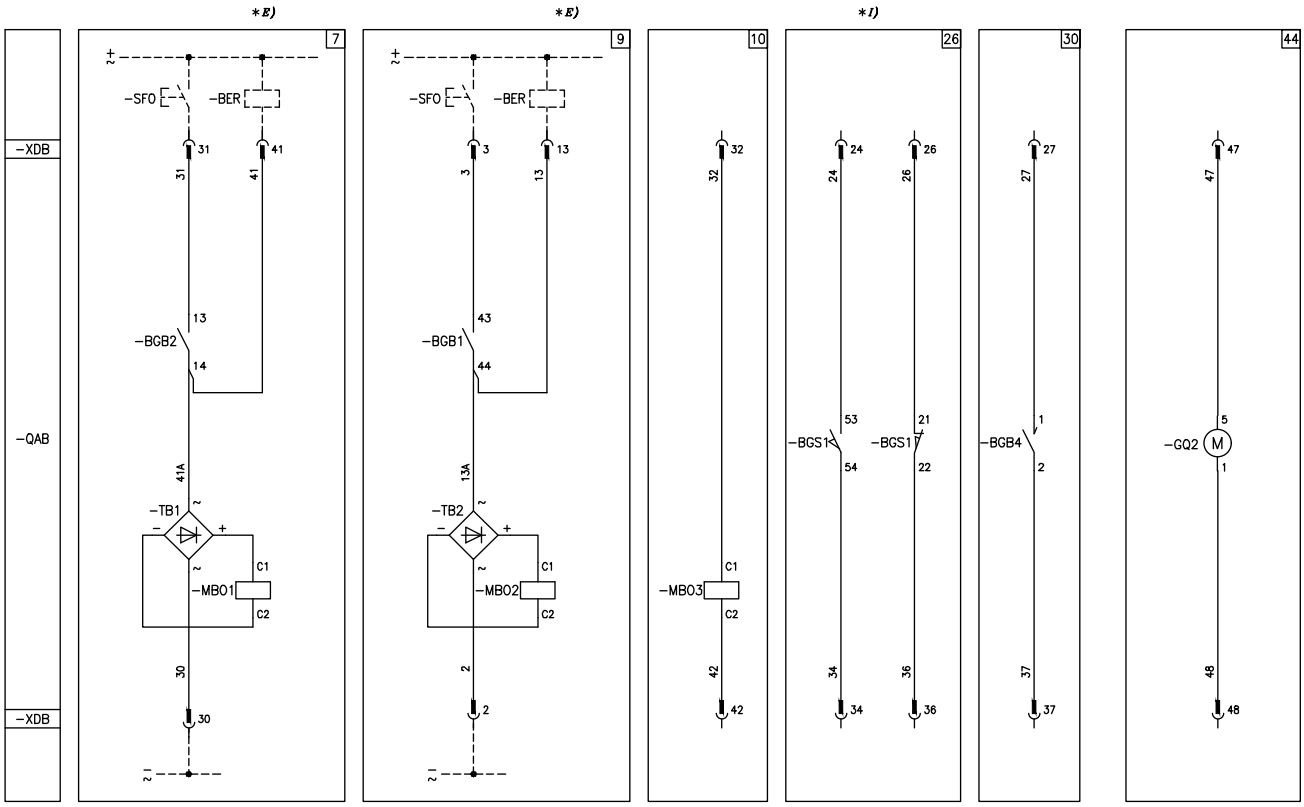
| **Notes** | |
|---|---|
| A) | The circuit breaker is equipped solely with the applications specified in the order confirmation. Consult this catalog for information about how to make out an order. |
| B) | The undervoltage release can be supplied for energizing with voltage derived from the supply side of the circuit breaker or from an independent source.<br>Circuit breaker closing is only allowed when the release is energized (closing lock is obtained mechanically). If there is the same power supply for the shunt closing and under-voltage releases and the circuit breaker must close automatically when auxiliary voltage returns, there must be a 50 ms delay between the undervoltage release's enabling instant and energizing of the shunt closing release.<br>Incompatible with -MBO4. |
| C) | Check power of auxiliary circuit to find out whether several motors for loading the closing springs can be operated at the same time. To prevent excessive power draw, springs must be loaded by hand before auxiliary circuit is powered. |
| D) | The circuit for monitoring the continuity of the release windings must only be used for that purpose. The SOR Test Unit can be used for checking the continuity of the various different releases.<br>-MBO4 incompatible with -MBU. |
| E) | When fig. 6 is required, contact -BGB3 (41-42) of fig. 32-34 is not available.<br>When fig. 9 is required, contact -BGB1 (43-44) of fig. 31-32-33-34 is not available.<br>When fig. 10 or 11 are required, contact -BGB3 (31-32) of fig. 32 and 34 is not available.<br>When fig. 30 is required, contact -BGB3 (53-54) of fig. 32 and 34 is not available. |
| F) | The contacts for electrical signaling of circuit breaker in racked-in and isolated positions (-BGT1 and -BGT2) shown in fig. 51-52 are located on circuit breaker truck (moving part). |
| G) | Fig. 3 is supplied when fig. 31 or 32 are required. Fig. 4 is supplied when fig. 33 or 34 are required (in this case, it is obligatory for -BGT3 to be supplied). |
| H) | Fig. 10 is only available for VD4 up to 31.5 kA.<br>Fig. 11 is only available for VD4 up to 31.5 kA. |
| I) | The energizing voltage must be the same for both signals. |

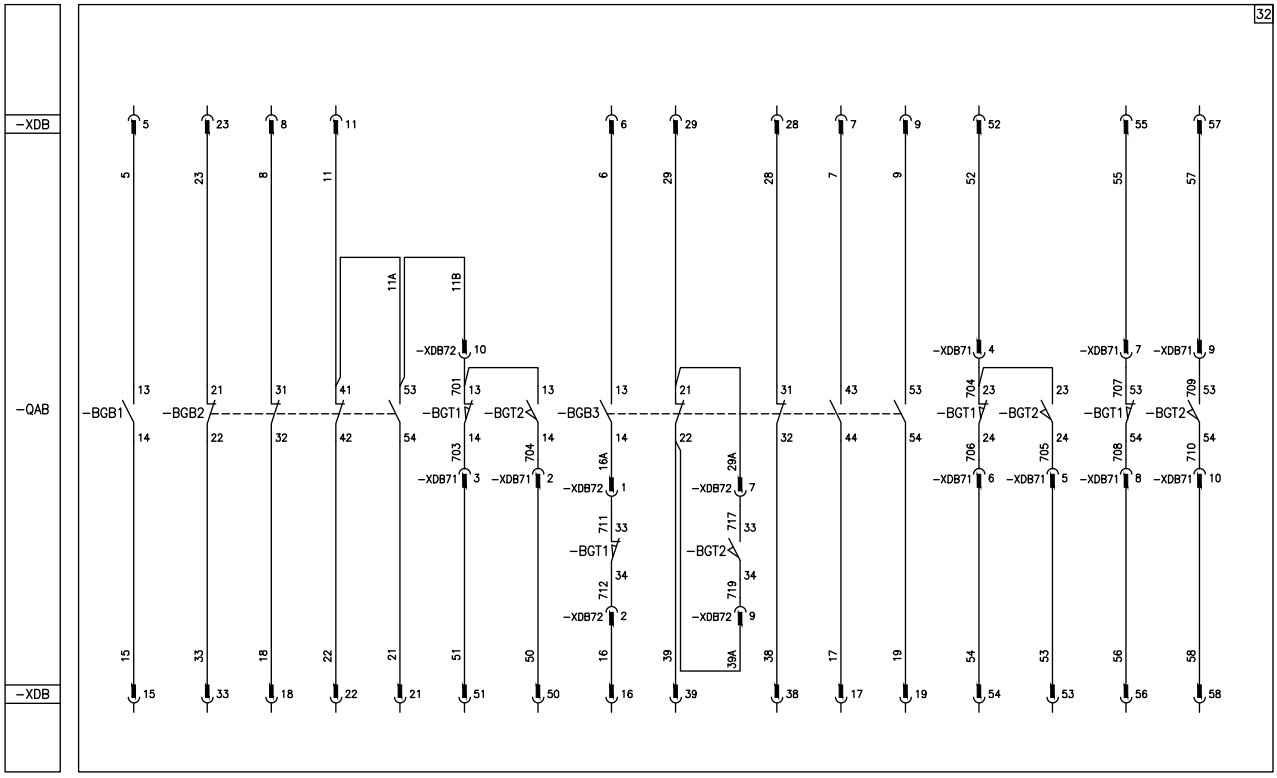
# Electric circuit diagram for 36-40.5 kV and 63 kA withdrawable circuit breakers with Classic operating mechanisms 1VCD400231

**The circuit diagram in this section concerns 36-40.5 kV plug-in circuit breakers with Classic operating mechanism.**



# Electric circuit diagram



| Key | | |
|---|---|---|
| ☐ | = | Reference number of diagram figure |
| * | = | See note indicated by the letter |
| -BER | = | Device for the supervision of shunt opening release coil continuity (see note E) |
| -BGB1, ..., -BGB3 | = | Circuit breaker auxiliary contacts |
| -8GB4 | = | Auxiliary passing contact (closing momentarily when circuit breaker opens) |
| -8GB12 | = | Auxiliary contact for block closing of the circuit breaker |
| -BGS | = | Limit switch signalling closing springs charged or discharged |
| -BGT1 | = | Contacts signalling circuit breaker in the connected position |
| -BGT2 | = | Contacts signalling circuit breaker in the isolated position |
| -MAS | = | Motor for the closing charging springs {see note C) |
| -MBC | = | Shunt closing release |
| -MBO1 | = | First shunt opening release (see note E) |
| -MBO2 | = | Second shunt opening release (see note E) |
| -MBO3 | = | Indirect overcurrent relay |
| -MBU | = | Instantaneous undervoltoge release |
| -KFN | = | Antipumping relay |
| -QAB | = | Main circuit breaker |
| -RAR | = | Resistor |
| -RLE1 | = | Locking magnet. If de-energized it prevents the circuit breaker closing |
| -RLE2 | = | Locking magnet on the truck. If de-energized it prevents the circuit breaker racking-in and racking-out mechanically |
| -SFC | = | Pushbutton or contact for the circuit breaker closing |
| -SFO | = | Pushbutton or contact for the circuit breaker opening |
| -SFL1 | = | Contact locking the circuit breaker closing |
| -SFL2 | = | Contact locking the circuit breaker racking-in and racking-out |
| -TB1 | = | Rectifier for -MO1 |
| -TB2 | = | Rectifier for -MO2 |
| -TB3 | = | Rectifier for -MBC and -KFN |
| -TB4 | = | Rectifier for -RLE1 |
| -TB6 | = | Rectifier for -MBU |
| -GQ2 | = | Ventilator |
| -XDB | = | Connector for the circuit breaker circuits |
| -XDB2 | = | Connector of the accessories |
| -XDB71, -XDB72 | = | Connectors of the accessories |

| Description of the figures | | |
|---|---|---|
| Fig. 1 | = | Springs charging-motor circuit {see note C) |
| Fig. 2 | = | Shunt closing release |
| Fig. 3 | = | Locking magnet on the operating mechanism. If de-energized it prevents the circuit breaker closing |
| Fig. 4 | = | Locking magnet on the truck. If de-energized it prevents the circuit breaker racking-in and racking-out mechanically |
| Fig. 5 | = | Instantaneous undervoltage release |
| Fig. 7 | = | First shunt opening release circuit with possibility of permanent supervision of coil continuity (see note E) |
| Fig. 9 | = | Second shunt opening release circuit with possibility of permanent supervision of coil continuity (see note E) |
| Fig. 10 | = | Indirect overcurrent relay |
| Fig. 26 | = | Contact signalling charged or discharged closing springs (see note I) |
| Fig. 30 | = | Wiping contact 35ms for C.B. tripped indication |
| Fig. 32 | = | Circuit breaker available auxiliary contacts |
| Fig. 44 | = | Ventilation circuit |

| Notes | |
|---|---|
| A) | The circuit breaker is delivered complete with the accessories listed in the order aknowledgement only. To draw up the order examine the apparatus catalogue. |
| C) | Check the power eupply available on the auxiliary circuit to verify if it is adeguate to start several closing spring-charging motors simultaneously. To prevent excessive consumption the closing springs must be charged manually before energizing the auxiliary circuit. |
| E) | The circuit for the supervision of shunt opening release coil continuity shall be used for this function only. |
| I) | Both limit switches signalling must be working at the same supply voltage. |

# Notes

More product information:
abb.com/mediumvoltage
Your contact center:
abb.com/contactcenters
More service information:
abb.com/service

**www.abb.com/VD4**

Data and illustration are not binding. We reserve the right to make changes in the course of technical development.

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1VCP000001_A - Rev. AB - en - Technical catalog - 2023-09 (VD4-63 kA) (gs)

DISTRIBUTION SOLUTIONS

# VD4

## Installation and service instructions
## 12 ... 40.5 kV - 630 ... 3150 A - 16 ... 50 kA




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# I. For your safety!

- **Make sure that the installation room (spaces, divisions and ambient) is suitable for the electrical apparatus.**
- **Check that all the installation, putting into service and maintenance operations are carried out by qualified personnel with suitable knowledge of the apparatus.**
- **Make sure that the standard and legal prescriptions are complied with during installation, putting into service and maintenance, so that installations according to the rules of good working practice and safety in the work place are constructed.**
- **Strictly follow the information given in this instruction manual.**
- **Check that the rated performance of the apparatus is not exceeded during service.**
- **Check that the personnel operating the apparatus have this instruction manual to hand as well as the necessary information for correct intervention.**
- **Pay special attention to the danger notes indicated in the manual by the following symbol:**

**Responsible behaviour safeguards your own and others' safety!**
**For any requests, please contact the ABB Assistance Service.**

# II. Introduction

This publication contains the information needed to install medium voltage VD4 circuit breakers and put them into service.
For correct use of the product, please read it carefully.
Like all the apparatus we manufacture, the VD4 circuit breakers are designed for different installation configurations.
However, this apparatus allows further technical-construction modifications (at the customer's request) to adapt to special installation requirements.
Consequently, the information given below may sometimes not contain instructions concerning special configurations.
Apart from this manual, it is therefore always necessary to consult the latest technical documentation (electric circuit and wiring diagrams, assembly and installation drawings, any protection coordination studies, etc.), especially regarding any variants requested in relation to the standardised configurations.
Only use original spare parts for maintenance operations.
For further information, please also see the technical catalogue of the circuit breaker and the spare parts catalogue.



**All the installation, putting into service, running and maintenance operations must be carried out by skilled personnel with in-depth knowledge of the apparatus.**

# III. Environmental protection programme

The VD4 circuit breakers are manufactured in accordance with the ISO 14000 Standards (Guidelines for environmental management).
The production processes are carried out in compliance with the Standards for environmental protection in terms of reduction in energy consumption as well as in raw materials and production of waste materials. All this is thanks to the medium voltage apparatus manufacturing facility environmental management system.

# 1. Packing and transport

The circuit breaker is shipped in special packing, in the open position and with the spring discharged. Each piece of apparatus is protected by a plastic cover to prevent any infiltration of water during the loading and unloading stages and to keep the dust off during storage.

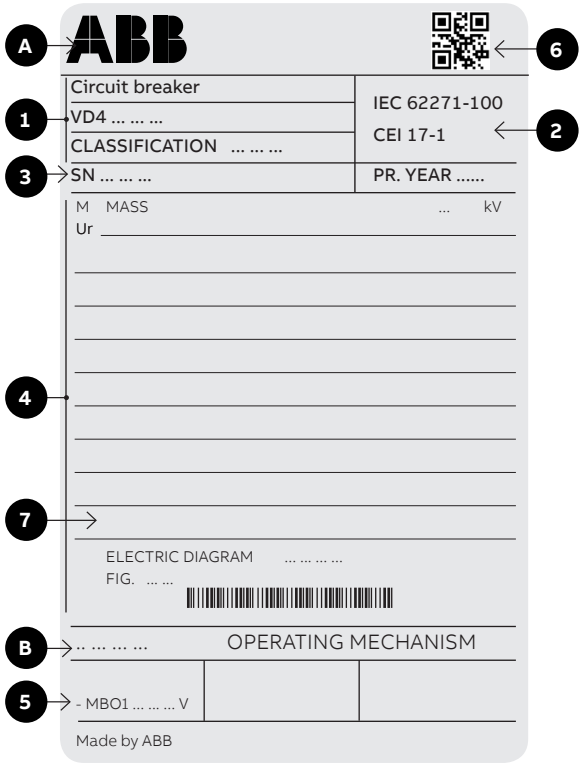
# 2. Checking on receipt

**Before carrying out any operation, always make sure that the operating mechanism spring is discharged and that the apparatus is in the open position.**

On receipt, check the state of the apparatus, integrity of the packing and correspondence with the nameplate data (see fig. 1) with what is specified in the order confirmation and in the accompanying shipping note.
Also make sure that all the materials described in the shipping note are included in the supply.
Should any damage or irregularity be noted in the supply on unpacking, notify ABB (directly or through the agent or supplier) as soon as possible and in any case within five days of receipt.
The apparatus is only supplied with the accessories specified at the time of ordering and validated in the order confirmation sent by ABB.

The accompanying documents inserted in the shipping packing are:
- instruction manual (this document)
- test certification
- identification label
- copy of the shipping documents
- electric wiring diagram.

Other documents which are sent prior to shipment of the apparatus are:
- order confirmation
- original shipping advice note
- any drawings or documents referring to special configurations/conditions.




Caption
A Circuit breaker rating plate
B Operating mechanism rating plate
1 Type of apparatus
2 Symbols of compliance with Standards
3 Serial number
4 Circuit breaker characteristics
5 Characteristics of the operating mechanism auxiliaries
6 QR code
7 CMU power supply (VD4 evo only)

Fig. 1

# 3. Storage

When a period of storage is foreseen, our workshops can (on request) provide suitable packing for the specified storage conditions.
On receipt the apparatus must be carefully unpacked and checked as described in Checking on receipt (chap. 2).
If immediate installation is not possible, the packing must be replaced, using the original material supplied.
Insert packets of special hygroscopic substances inside the packing, with at least one standard packet for piece of apparatus.
Should the original packing not be available and immediate installation is not possible, store in a covered, well-ventilated, dry, dust-free, non-corrosive ambient, away from any easily flammable materials and at a temperature between – 5 °C and + 45 °C.
In any case, avoid any accidental impacts or positioning which stresses the structure of the apparatus.

# 4. Handling

Before carrying out any operations, always make sure that the operating mechanism spring is discharged and that the apparatus is in the open position.
To lift and handle the circuit breaker, proceed as follows (fig. 2):

- use a special lifting tool (1) (not supplied) fitted with ropes with safety hooks (2);
- insert the hooks (2) in the supports (3) fixed to the frame of the circuit breaker and lift. Put the hooks (2) into the support holes (3) according to the type of apparatus (see table);
- on completion of the operation (and in any case before putting into service) unhook the lifting tool (1) and dismantle the supports (3) from the frame.

During handling, take great care not to stress the insulating parts and the terminals of the circuit breaker.

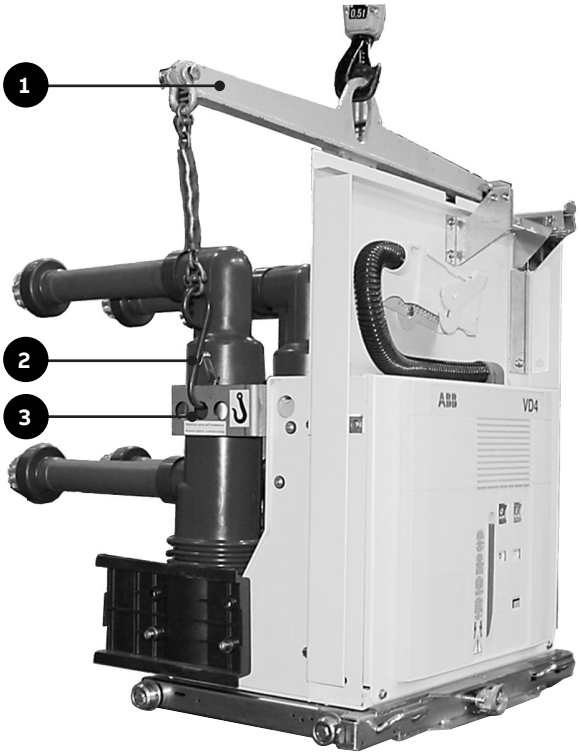



Fig. 2

**The apparatus must not be handled by putting lifting devices directly under the apparatus itself.**
**Should it be necessary to use this technique, put the circuit breaker onto a pallet or a sturdy supporting surface (see fig. 3).**
**In any case, it is always advisable to carry out lifting using the supports (3).**

| Version | Pole centre distance | Rated current | Hole |
|---|---|---|---|
| Fixed | 150-210 mm | up to 1250 A | A |
| Fixed | 275 mm | from 1600 to 3150 A | A |
| Fixed | 210 mm | from 1600 to 2000 A | A |
| Fixed | 210-275 mm | up to 4000 A | C |
| Withdrawable | 150 mm | up to 1250 A | A |
| Withdrawable | 210 mm | from 1600 to 2500 A | B |
| Withdrawable | 275 mm | up to 1250 A | B |
| Withdrawable | 275 mm | from 1600 to 3150 A | C |
| Withdrawable | 210 mm | up to 1250 A | C |
| Withdrawable | 210-275 mm | up to 4000 A | C |

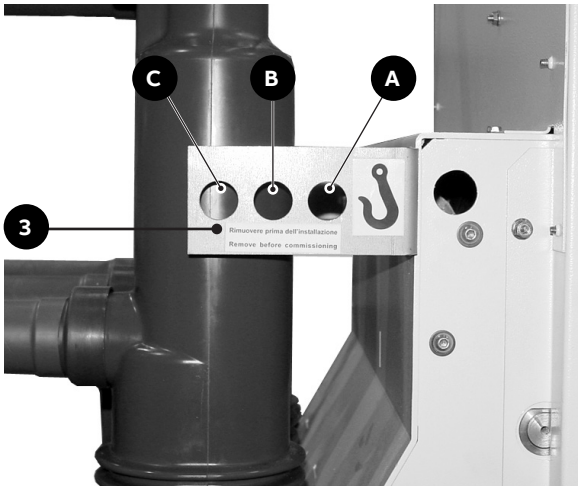



Fig. 2a Lifting support

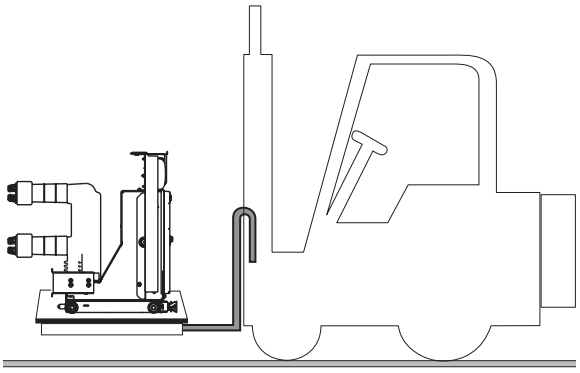


Fig. 3

# 5. Description

## 5.1. General

The VD4 are vacuum circuit breaker for indoor installation.
For the electrical performances, please refer to the corresponding technical catalogue code 1VCP000001.
For special installation requirements, please contact ABB.
The following versions are available:

- fixed
- withdrawable for UniGear ZS1 switchgear and PowerCube modules.

## 5.2. Reference Standards

The VD4 circuit breakers conform to the IEC 62271-100, CEI - VDE - BS Standards are equivalent to IEC Standards due to harmonization with IEC.
Some ratings are qualified also according to ANSI/ IEEE standards.

## 5.3. EL operating mechanism

VD4 circuit breakers are equipped with modular EL spring operating mechanisms. The operating mechanism is designed to cover the whole range of performances as shown in the following table:

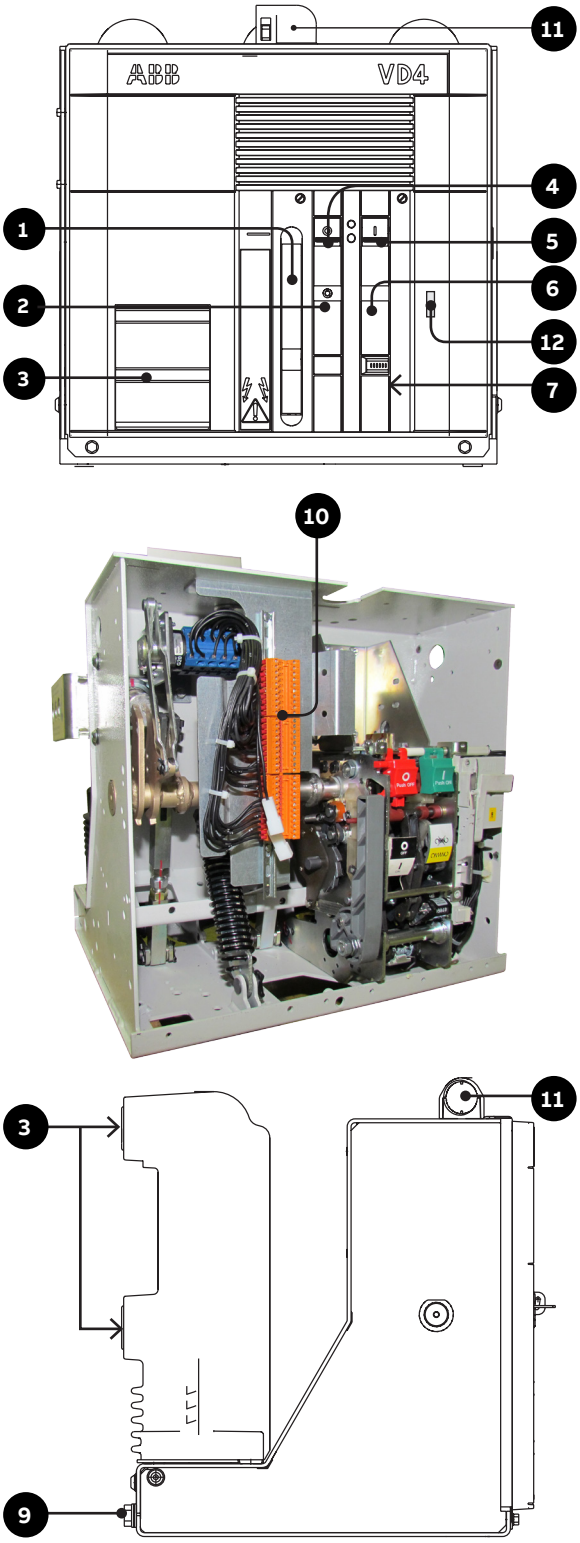
| Type of operating mechanism | Rated short-circuit current |
|---|---|
| EL1 - EL2 | Up to 31.5 kA |
| EL3 - EL3 | Up to 40 kA - 24 kV, 31.5 kA |
| EL3 - EL3-S | 40.5 kV up to 31.5 kA<br>40 kA up to 17.5 kV |
| EL1 TWIN | Up to 50 kA (rated current up to 2000 A) |
| EL2 TWIN | Up to 50 kA (rated current ≥ 2500 A) |

## 5.4. VD4 evo

VD4 evo availablen with digital capabilities and sensors.

## 5.5. Fixed circuit breakers

The fixed circuit breaker (fig. 4) is the basic version complete with structure and front protection screen. The fixing holes are made in the lower part of the structure.
For the electrical connections of the circuit breaker auxiliary circuits, the terminal box (10) is available (also see par. 7.8.1.).
The earthing screw is placed in the rear part of the circuit breaker. For further details please see the caption to figure 4.




Caption
1 Lever for manual closing spring charging
2 Signalling device for circuit breaker open/closed
3 Rating plate
4 Opening pushbutton
5 Closing pushbutton
6 Signalling device for closing spring charged/discharged
7 Operation counter
8 Terminals
9 Earthing screw
10 Delivery terminal box
11 Cabling connection
12 Mechanical override of the undervoltage release (on request)

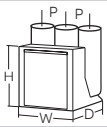
Fig. 4

# 5. Description

### 5.5.1. General characteristics of fixed circuit breakers

**General characteristics of fixed circuit breakers (12 kV)**




| Circuit breaker | | VD4 12 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | | |
| Rated voltage | Ur [kV] | 12 (2) | | | | | | |
| Rated insulation voltage | Us [kV] | 12 | | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | | | | | |
| Impulse withstand voltage | Up [kV] | 75 | | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | | |
| Rated normal current (40 °C) | Ir [A] | 630 | 630 | 630 | 1250 | 1250 | 1250 | 1250 (5) |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 | 25 | 25 | 25 | 25 | 25 | – |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | – |
| | | – | – | – | – | – | – | 40 (5) |
| | | – | – | – | – | | – | – |
| | | – | – | – | – | – | – | – |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 | 25 | 25 | 25 | 25 | 25 | – |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | – |
| | | – | – | – | – | – | – | 40 (5) |
| | | – | – | – | – | – | – | – |
| | | – | – | – | – | – | – | – |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 | 40 | – |
| | | 50 | 50 | 50 | 50 | 50 | 50 | – |
| | | 63 | 63 | 63 | 63 | 63 | 63 | – |
| | | 80 | 80 | 80 | 80 | 80 | 80 | – |
| | | – | – | – | – | – | – | 104 (5) |
| | | – | – | – | – | – | – | – |
| | | – | – | – | – | – | – | – |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | | | | | | |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | – | – | – | – |
| Opening time | [ms] | 33 ... 60 | | | | | | |
| Arcing time | [ms] | 10 ... 15 | | | | | | |
| Total breaking time | [ms] | 43 ... 75 | | | | | | |
| Closing time | [ms] | 30 ... 60 | | | | | | |
| Maximum overall dimensions   | H [mm] | 461 | 461 | 461 | 461 | 461 | 461 | 589 |
| | W [mm] | 450 | 570 | 700 | 450 | 570 | 700 | 450 |
| | D [mm] | 424 | 424 | 424 | 424 | 424 | 424 | 424 |
| | Pole distance P [mm] | 150 | 210 | 275 | 150 | 210 | 275 | 150 |
| Weight | [kg] | 73 | 75 | 79 | 73 | 75 | 79 | 81 |
| Standardised table of dimensions | TN | 7405(1) | 7406(1) | – | 7405(1) | 7406(1) | – | 2RDA043108 |
| | 1VCD | – | – | 000051(1) | – | – | 000051(1) | |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | | |

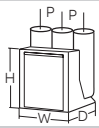
(1) Poles in polyamide
(2) Available in 10 kV voltage version in accordance with GOST standards up to 50 kA
(3) Up to 4000 A with forced ventilation
(4) On request, the closing spring can be loaded by means of a removable crank handle outside operating mechanism (instead of linear loading by a lever built into the front of operating mechanism)
(5) Available in VD4 evo only
*) Consult ABB for the 4000 A version with natural ventilation

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **VD4 12** | | | | | | | | |
| • | | | | | | | | |
| 12 (²) | | | | | | | | |
| 12 | | | | | | | | |
| 28 | | | | | | | | |
| 75 | | | | | | | | |
| 50-60 | | | | | | | | |
| 1250 | 1250 | 1250 | 1250 | 1250 | 1600 | 1600 | 1600 | 1600 |
| – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | 20 | 20 | 20 | – |
| – | – | – | – | – | 25 | 25 | 25 | – |
| – | – | – | – | – | 31.5 | 31.5 | 31.5 | – |
| 40 | 40 | – | – | – | – | – | – | 40 |
| – | – | 50 | 50 | – | – | – | – | – |
| – | – | – | – | 63 | – | – | – | – |
| – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | 20 | 20 | 20 | – |
| – | – | – | – | – | 25 | 25 | 25 | – |
| – | – | – | – | – | 31.5 | 31.5 | 31.5 | – |
| 40 | 40 | – | – | – | – | – | – | 40 |
| – | – | 50 | 50 | – | – | – | – | – |
| – | – | – | – | 63 | – | – | – | – |
| – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | 50 | 50 | 50 | – |
| – | – | – | – | – | 63 | 63 | 63 | – |
| – | – | – | – | – | 80 | 80 | 80 | – |
| 100 | 100 | – | – | – | – | – | – | 100 |
| – | – | 125 | 125 | – | – | – | – | – |
| – | – | – | – | 158 | – | – | – | – |
| • | | | | | | | | |
| – | – | – | – | – | – | – | – | – |
| 33 ... 60 | | | | ≤45 | 33 ... 60 | | | |
| 10 ... 15 | | | | ≤15 | 10 ... 15 | | | |
| 43 ... 75 | | | | ≤60 | 43 ... 75 | | | |
| 30 ... 60 | | | | approx. 60 | 30 ... 60 | | | |
| 589 | 589 | 610 | 610 | 677.5 | 599 | 599 | 599 | 589 |
| 570 | 700 | 600 | 750 | 750 | 450 | 570 | 700 | 570 |
| 424 | 424 | 459 | 459 | 459 | 424 | 424 | 424 | 424 |
| 210 | 275 | 210 | 275 | 275 | 150 | 210 | 275 | 210 |
| 84 | 84 | 146 | 158 | 265 | 93 | 98 | 105 | 84 |
| – | – | – | – | – | – | 7407 (¹) | 7408 (¹) | – |
| 003282(¹) | 003285(¹) | 003440 | 003441 | GCEM370562 | 000050 | – | – | 003282(¹) |
| - 5 ... + 40 | | | | | | | | |
| • | | | | | | | | |
| • | | | | | | | | |

# 5. Description

### General characteristics of fixed circuit breakers (12 kV)




| Circuit breaker | | VD4 12 | | | | | |
|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | |
| Rated voltage | Ur [kV] | 12 (2) | | | | | |
| Rated insulation voltage | Us [kV] | 12 | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | | | | |
| Impulse withstand voltage | Up [kV] | 75 | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | |
| Rated normal current (40 °C) | Ir [A] | 1600 | 1600 | 1600 | 1600 | 2000 | 2000 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | – | – | – | – | – | – |
| | | – | – | – | – | 20 | 20 |
| | | – | – | – | – | 25 | 25 |
| | | – | – | – | – | 31.5 | 31.5 |
| | | 40 | – | – | – | 40 | 40 |
| | | – | 50 | 50 | – | – | – |
| | | – | – | – | 63 | – | – |
| Rated short-time withstand current (3s) | Ik [kA] | – | – | – | – | – | – |
| | | – | – | – | – | 20 | 20 |
| | | – | – | – | – | 25 | 25 |
| | | – | – | – | – | 31.5 | 31.5 |
| | | 40 | – | – | – | 40 | 40 |
| | | – | 50 | 50 | – | – | – |
| | | – | – | – | 63 | – | – |
| Making capacity | Ip [kA] | – | – | – | – | – | – |
| | | – | – | – | – | 50 | 50 |
| | | – | – | – | – | 63 | 63 |
| | | – | – | – | – | 80 | 80 |
| | | 100 | – | – | – | 100 | 100 |
| | | – | 125 | 125 | – | – | – |
| | | – | – | – | 158 | – | – |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | – | • | • |
| | [O - 0.3 s - CO - 3 min - CO] | – | – | – | • | – | – |
| Opening time | [ms] | 33...60 | | | ≤45 | 33...60 | |
| Arcing time | [ms] | 10...15 | | | ≤15 | 10...15 | |
| Total breaking time | [ms] | 43...75 | | | ≤60 | 43...75 | |
| Closing time | [ms] | 30...60 | | | approx. 60 | 30...60 | |
| Maximum overall dimensions   | H [mm] | 589 | 610 | 610 | 677.5 | 599 | 599 |
| | W [mm] | 700 | 600 | 750 | 750 | 570 | 700 |
| | D [mm] | 424 | 459 | 459 | 459 | 424 | 424 |
| | Pole distance P [mm] | 275 | 210 | 275 | 265 | 210 | 275 |
| Weight | [kg] | 84 | 146 | 158 | 265 | 98 | 105 |
| Standardised table of dimensions | TN | – | – | – | – | 7407 (1) | 7408 (1) |
| | 1VCD | 003285(1) | 003440 | 003441 | GCEM370562 | – | – |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | |

(1) Poles in polyamide
(2) Available in 10 kV voltage version in accordance with GOST standards up to 50 kA
(3) Up to 4000 A with forced ventilation
(4) On request, the closing spring can be loaded by means of a removable crank handle outside operating mechanism (instead of linear loading by a lever built into the front of operating mechanism)
*) Consult ABB for the 4000 A version with natural ventilation

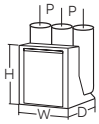
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **VD4 12** | | | | | | | | |
| • | | | | | | | | |
| 12 (²) | | | | | | | | |
| 12 | | | | | | | | |
| 28 | | | | | | | | |
| 75 | | | | | | | | |
| 50-60 | | | | | | | | |
| 2000 | 2000 | 2000 | 2500 | 2500 | 2500 | 2500 | 3150 (³) | 3150 (³) |
| – | – | – | – | – | – | – | – | – |
| – | – | – | 20 | 20 | – | – | 20 | – |
| – | – | – | 25 | 25 | – | – | 25 | – |
| – | – | – | 31.5 | 31.5 | – | – | 31.5 | – |
| – | – | – | 40 | 40 | – | – | 40 | – |
| 50 | 50 | – | – | – | 50 | – | – | 50 |
| – | – | 63 | – | – | – | 63 | | |
| – | – | – | – | – | – | – | – | – |
| – | – | – | 20 | 20 | – | – | 20 | – |
| – | – | – | 25 | 25 | – | – | 25 | – |
| – | – | – | 31.5 | 31.5 | – | – | 31.5 | – |
| – | – | – | 40 | 40 | – | – | 40 | – |
| 50 | 50 | – | – | – | 50 | – | – | 50 |
| – | – | 63 | – | – | – | 63 | – | – |
| – | – | – | – | – | – | – | – | – |
| – | – | – | 50 | 50 | – | – | 50 | – |
| – | – | – | 63 | 63 | – | – | 63 | – |
| – | – | – | 80 | 80 | – | – | 80 | – |
| – | – | – | 100 | 100 | – | – | 100 | – |
| 125 | 125 | – | – | – | 125 | – | – | 125 |
| – | – | 158 | – | – | – | 158 | – | – |
| • | • | – | • | • | • | – | • | • |
| – | – | • | – | – | – | • | – | – |
| | | ≤45 | 33...60 | | | ≤45 | 33...60 | |
| | | ≤15 | 10...15 | | | ≤15 | 10...15 | |
| | | ≤60 | 43...75 | | | ≤60 | 43...75 | |
| | | approx. 60 | 30...60 | | | approx. 60 | 30...60 | |
| 610 | 610 | 677.5 | 599 | 599 | 610 | 677.5 | 635 | 636 |
| 600 | 750 | 750 | 570 | 700 | 750 | 750 | 700 | 750 |
| 459 | 459 | 459 | 424 | 424 | 459 | 459 | 424 | 459 |
| 210 | 275 | 275 | 210 | 275 | 275 | 275 | 275 | 275 |
| 146 | 158 | 265 | 98 | 105 | 163 | 265 | 140 | 177 |
| – | – | – | 7407 (¹) | 7408 (¹) | – | – | – | – |
| 003440 | 003441 | GCEM370562 | – | – | 003441 | GCEM370562 | 000149 (¹) | 003443 |
| - 5 ... + 40 | | | | | | | | |
| • | | | | | | | | |
| • | | | | | | | | |



# 5. Description

**General characteristics of fixed circuit breakers (15kV)**

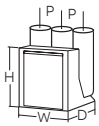



| Circuit breaker | | | VD4/N 15 | | VD4 15 | |
|---|---|---|---|---|---|---|
| Standard | | IEEE C37.04 | • | | • | |
| Rated voltage | | [kV] | 15 | | 15 | |
| Rated frequency | | [Hz] | 60 | | 50/60 | |
| Short-circuit breaking current Isc | | [kA] | 31.5 | | 40 | |
| Rated current Ir | | [A] | 1200 | 2000 | 1200 | 2000 |
| Short-time withstand current | | [A] | 31.5 | | 40 | |
| Short circuit withstand | | [A] | 3 | | 2 | |
| Close and latch capability | | [kA] | 82 | | 104 | |
| Operation sequence | | [O - 0,3 s - CO - 3 min - CO] | • | | • | |
| % DC component | | [%] | 40 | | 30 | |
| Interrupting time | | [ms] | 50 | | 50 | |
| Closing time | | [ms] | 30...60 | | 30...60 | |
| Mechanical endurance class | | [M2] | 10k | | 10k | |
| Lightning impulse withstand voltage Up | | [kV] | 95 | | 95 | |
| Power frequency withstand voltage Ud | | [kV] | 36 | | 36 | |
| Operating temperature | | [°C] | -5…+40 | | -20…+40 | |
| Maximum overall dimensions   | Height | [mm] | 461 | 599 | 599 | |
| | Width | [mm] | 450 | 570 | 570 | |
| | Depth | [mm] | 424 | 424 | 424 | |
| | Pole distance | [mm] | 150 | 210 | 210 | |
| Standard table of dimensions | | TN | 7407 | 7405 | 7407 | |
| Weight | | [kg] | 73 | 80 | 75 | |

# 5. Description

### General characteristics of fixed circuit breakers (17.5 kV)




| Circuit breaker | | | VD4 17 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Standards | | IEC 62271-100 | • | | | | | | | | | | |
| | | VDE 0671; CEI EN 62271-100 File 7642 | • | | | | | | | | | | |
| Rated voltage | | Ur [kV] | 17.5 | | | | | | | | | | |
| Rated insulation voltage | | Us [kV] | 17.5 | | | | | | | | | | |
| Withstand voltage at 50 Hz | | Ud (1 min) [kV] | 38 | | | | | | | | | | |
| Impulse withstand voltage | | Up [kV] | 95 | | | | | | | | | | |
| Rated frequency | | fr [Hz] | 50-60 | | | | | | | | | | |
| Rated normal current (40 °C) | | Ir [A] | 630 | 630 | 630 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 (2) |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | | Isc [kA] | 16 | 16 | 16 | 16 | 16 | 16 | - | - | - | - | - |
| | | | 20 | 20 | 20 | 20 | 20 | 20 | - | - | - | - | - |
| | | | 25 | 25 | 25 | 25 | 25 | 25 | - | - | - | - | - |
| | | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | - | - | - | - | - |
| | | | - | - | - | - | - | - | 40 | 40 | - | - | 40 (2) |
| | | | - | - | - | - | - | - | - | - | 50 | 50 | - |
| Rated short-time withstand current (3s) | | Ik [kA] | 16 | 16 | 16 | 16 | 16 | 16 | - | - | - | - | - |
| | | | 20 | 20 | 20 | 20 | 20 | 20 | - | - | - | - | - |
| | | | 25 | 25 | 25 | 25 | 25 | 25 | - | - | - | - | - |
| | | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | - | - | - | - | - |
| | | | - | - | - | - | - | - | 40 | 40 | - | - | 40 (2) |
| | | | - | - | - | - | - | - | - | - | 50 | 50 | - |
| Making capacity | | Ip [kA] | 40 | 40 | 40 | 40 | 40 | 40 | - | - | - | - | - |
| | | | 50 | 50 | 50 | 50 | 50 | 50 | - | - | - | - | - |
| | | | 63 | 63 | 63 | 63 | 63 | 63 | - | - | - | - | - |
| | | | 80 | 80 | 80 | 80 | 80 | 80 | - | - | - | - | - |
| | | | - | - | - | - | - | - | 100 | 100 | - | - | 104 (2) |
| | | | - | - | - | - | - | - | - | - | 125 | 125 | - |
| Operation sequence | | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • | • | • | • | • |
| Opening time | | [ms] | 33 ... 60 | | | | | | | | | | |
| Arcing time | | [ms] | 10 ... 15 | | | | | | | | | | |
| Total breaking time | | [ms] | 43 ... 75 | | | | | | | | | | |
| Closing time | | [ms] | 30 ... 60 | | | | | | | | | | |
| Maximum overall dimensions |  | H [mm] | 461 | 461 | 461 | 461 | 461 | 461 | 589 | 589 | 610 | 610 | 589 |
| | | W [mm] | 450 | 570 | 700 | 450 | 570 | 700 | 570 | 700 | 600 | 750 | 450 |
| | | D [mm] | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 459 | 459 | 424 |
| | | Pole distance P [mm] | 150 | 210 | 275 | 150 | 210 | 275 | 210 | 275 | 210 | 275 | 150 |
| Weight | | [kg] | 73 | 75 | 79 | 73 | 75 | 79 | 84 | 84 | 146 | 158 | 81 |
| Standardised table of dimensions | | TN | 7405 (1) | 7406 (1) | - | 7405 (1) | 7406 (1) | - | - | - | - | - | 2RDA043108 |
| | | 1VCD | - | - | 000051 (1) | - | - | 000051 (1) | 003282 (1) | 003285 (1) | 003440 | 003441 | |
| Operating temperature | | [°C] | - 5 ... + 40 | | | | | | | | | | |
| Tropicalization | | IEC: 60068-2-30, 60721-2-1 | • | | | | | | | | | | |
| Electromagnetic compatibility | | IEC: 62271 | • | | | | | | | | | | |

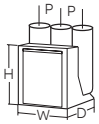
(1) Poles in polyamide
(2) Available in VD4 evo only

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VD4 17** | | | | | | | | | | | | | | |
| • | | | | | | | | | | | | | | |
| • | | | | | | | | | | | | | | |
| 17.5 | | | | | | | | | | | | | | |
| 17.5 | | | | | | | | | | | | | | |
| 38 | | | | | | | | | | | | | | |
| 95 | | | | | | | | | | | | | | |
| 50-60 | | | | | | | | | | | | | | |
| 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 2000 | 2000 | 2000 | 2000 | 2500 | 2500 | 2500 | 3150 | 3150 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 20 | 20 | - | - | - | - | 20 | 20 | - | - | 20 | 20 | - | 20 | - |
| 25 | 25 | - | - | - | - | 25 | 25 | - | - | 25 | 25 | - | 25 | - |
| 31.5 | 31.5 | - | - | - | - | 31.5 | 31.5 | - | - | 31.5 | 31.5 | - | 31.5 | - |
| - | - | 40 | 40 | - | - | 40 | 40 | - | - | - | 40 | - | 40 | - |
| - | - | - | - | 50 | 50 | - | - | 50 | 50 | - | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 20 | 20 | - | - | - | - | 20 | 20 | - | - | 20 | 20 | - | 20 | - |
| 25 | 25 | - | - | - | - | 25 | 25 | - | - | 25 | 25 | - | 25 | - |
| 31.5 | 31.5 | - | - | - | - | 31.5 | 31.5 | - | - | 31.5 | 31.5 | - | 31.5 | - |
| - | - | 40 | 40 | - | - | 40 | 40 | - | - | - | 40 | - | 40 | - |
| - | - | - | - | 50 | 50 | - | - | 50 | 50 | - | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 50 | 50 | - | - | - | - | 50 | 50 | - | - | 50 | 50 | - | 50 | - |
| 63 | 63 | - | - | - | - | 63 | 63 | - | - | 63 | 63 | - | 63 | - |
| 80 | 80 | - | - | - | - | 80 | 80 | - | - | 80 | 80 | - | 80 | - |
| - | - | 100 | 100 | - | - | 100 | 100 | - | - | - | 100 | - | 100 | - |
| - | - | - | - | 125 | 125 | - | - | 125 | 125 | - | - | 125 | - | 125 |
| • | • | • | • | • | • | • | • | • | • | • | • | • | • | - |
| 33 ... 60 | | | | | | | | | | | | | | |
| 10 ... 15 | | | | | | | | | | | | | | |
| 43 ... 75 | | | | | | | | | | | | | | |
| 30 ... 60 | | | | | | | | | | | | | | |
| 599 | 599 | 589 | 589 | 610 | 610 | 599 | 599 | 610 | 610 | 599 | 599 | 610 | 635 | 636 |
| 570 | 700 | 570 | 700 | 600 | 750 | 570 | 700 | 600 | 750 | 570 | 700 | 750 | 700 | 750 |
| 424 | 424 | 424 | 424 | 459 | 459 | 424 | 424 | 459 | 459 | 424 | 424 | 459 | 424 | 459 |
| 210 | 275 | 210 | 275 | 210 | 275 | 210 | 275 | 210 | 275 | 210 | 275 | 275 | 275 | 275 |
| 98 | 105 | 84 | 84 | 146 | 158 | 98 | 105 | 146 | 158 | 98 | 105 | 163 | 140 | 177 |
| 7407 (1) | 7408 (1) | - | - | - | - | 7407 (1) | 7408 (1) | - | - | 7407 (1) | 7408 (1) | - | - | - |
| - | - | 003282 (1) | 003285 (1) | 003440 | 003441 | - | - | 003440 | 003441 | - | - | 003441 | 000149 (1) | 003443 |
| - 5 ... + 40 | | | | | | | | | | | | | | |
| • | | | | | | | | | | | | | | |
| • | | | | | | | | | | | | | | |

# 5. Description

### General characteristics of fixed circuit breakers (24 kV)

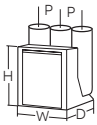



| Circuit breaker | | | VD4 24 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Standards | | IEC 62271-100 | • | | | | | | |
| | | VDE 0671; CEI EN 62271-100 File 7642 | • | | | | | | |
| Rated voltage | | Ur [kV] | 24 | | | | | | |
| Rated insulation voltage | | Us [kV] | 24 | | | | | | |
| Withstand voltage at 50 Hz | | Ud (1 min) [kV] | 50 | | | | | | |
| Impulse withstand voltage | | Up [kV] | 125 | | | | | | |
| Rated frequency | | fr [Hz] | 50-60 | | | | | | |
| Rated normal current (40 °C) | | Ir [A] | 630 | 630 | 1250 | 1250 | 1600 | 2000 | 2500 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | | Isc [kA] | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| | | | – | – | 31.5 | – | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | | Ik [kA] | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| | | | – | – | 31.5 | – | 31.5 | 31.5 | 31.5 |
| Making capacity | | Ip [kA] | 40 | 40 | 40 | 40 | 40 | 40 | – |
| | | | 50 | 50 | 50 | 50 | 50 | 50 | – |
| | | | 63 | 63 | 63 | 63 | 63 | 63 | 63 |
| | | | – | – | 80 | – | 80 | 80 | 80 |
| Operation sequence | | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • |
| Opening time | | [ms] | 33 ... 60 | | | | | | |
| Arcing time | | [ms] | 10 ... 15 | | | | | | |
| Total breaking time | | [ms] | 43 ... 75 | | | | | | |
| Closing time | | [ms] | 30 ... 60 | | | | | | |
| Maximum overall dimensions |  | H [mm] | 631 | 631 | 631 | 631 | 642 | 642 | 642 |
| | | W [mm] | 570 | 700 | 570 | 700 | 700 | 700 | 700 |
| | | D [mm] | 424 | 424 | 424 | 424 | 424 | 424 | 424 |
| | | Pole distance P [mm] | 210 | 275 | 210 | 275 | 275 | 275 | 275 |
| Weight | | [kg] | 100 | 104 | 100/106 (1) | 104 | 110 | 110 | 110 |
| Standardised table of dimensions | | TN | 7409 | 7410 | 7409 | 7410 | 7411 | 7411 | 7411 |
| | | 1VCD | – | – | 000172 (1) | – | – | – | – |
| Operating temperature | | [°C] | - 5 ... + 40 | | | | | | |
| Tropicalization | | IEC: 60068-2-30, 60721-2-1 | • | | | | | | |
| Electromagnetic compatibility | | IEC: 62271-1 | • | | | | | | |

(1) 31.5 kA version.

## General characteristics of fixed circuit breakers (36 kV)

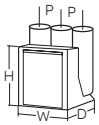



| Circuit breaker | | VD4 36 | | | |
|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | |
| Rated voltage | Ur [kV] | 36 | | | |
| Rated insulation voltage | Us [kV] | 36 | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 70 | | | |
| Impulse withstand voltage | Up [kV] | 170 | | | |
| Rated frequency | fr [Hz] | 50 | | | |
| Rated normal current (40 °C) | Ir [A] | 1250 | 1600 | 2000 | 2500 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 |
| | | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • |
| Opening time | [ms] | 35 ... 60 | | | |
| Arcing time | [ms] | 5 ... 15 | | | |
| Total breaking time | [ms] | 40 ... 75 | | | |
| Closing time | [ms] | 50 ... 65 | | | |
| Maximum overall dimensions   | H [mm] | 884 | 884 | 884 | 884 |
| | W [mm] | 796 | 796 | 796 | 796 |
| | D [mm] | 501 | 501 | 501 | 501 |
| | Pole distance P [mm] | 275 | 275 | 275 | 275 |
| Weight | [kg] | 170 | 170 | 170 | 210 |
| Standardised table of dimensions | TN | 1VYN300901-RF | 1VYN300901-RF | 1VYN300901-RF | 1VYN300901-RF |
| Operating temperature | [°C] | - 5 ... + 40 | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | |

# 5. Description

### General characteristics of fixed circuit breakers (40.5 kV)



| Circuit breaker | | VD4 40.5 | | |
|---|---|---|---|---|
| Standards | IEC 62271-100 | • (1) | | |
| Rated voltage | Ur [kV] | 40.5 | | |
| Rated insulation voltage | Us [kV] | 40.5 | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 95 | | |
| Impulse withstand voltage | Up [kV] | 190 | | |
| Rated frequency | fr [Hz] | 50 | | |
| Rated normal current (40 °C) | Ir [A] | 1250 | 1600 | 2000 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 20 | 20 | 20 |
| | | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 20 | 20 | 20 |
| | | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 50 | 50 | 50 |
| | | 63 | 63 | 63 |
| | | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 3 min - CO] | • | • | • |
| Opening time | [ms] | 35 ... 60 | 35 ... 60 | 35 ... 60 |
| Arcing time | [ms] | 10 ... 15 | 10 ... 15 | 10 ... 15 |
| Total breaking time | [ms] | 45 ... 75 | 45 ... 75 | 45 ... 75 |
| Closing time | [ms] | 50 ... 65 | 50 ... 65 | 50 ... 65 |
| Maximum overall dimensions   | H [mm] | 884 | 884 | 884 |
| | W [mm] | 796 | 796 | 796 |
| | D [mm] | 501 | 501 | 501 |
| | Pole distance P [mm] | 275 | 275 | 275 |
| Weight | [kg] | 170 | 170 | 170 |
| Standardised table of dimensions | TN | 2RDA043326A001 | 2RDA043326A001 | 2RDA043326A001 |
| Operating temperature | [°C] | - 20 ... + 40 | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | |

(1) GOST version available on request.

### 5.5.2. Types of circuit breakers available in the fixed version

#### VD4 fixed circuit breaker without bottom and top terminals (12 kV)

| Ur | Isc | Rated uninterrupted current (40°C) [A] | | | | | | | | | | | | Circuit breaker type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kV | kA | H=461 | | | H=589 | | H=599 | | | H=610 | | H=636 | H=589 | |
| | | D=424 | | | D=424 | | D=424 | | | D=459 | | D=459 | D=424 | |
| | | u/l=205 | | | u/l=310 | | u/l=310 | | | u/l=310 | | u/l=310 | u/l=310 | |
| | | l/g=217.5 | | | l/g=238 | | l/g=237.5 | | | l/g=237 | | l/g=237 | l/g=237.5 | |
| | | P=150 | P=210 | P=275 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | P=150 | |
| | | W=450 | W=570 | W=700 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | W=450 | |
| 12 | 16 | 630 | | | | | | | | | | | | VD4 12.06.16 p150 |
| | 20 | 630 | | | | | | | | | | | | VD4 12.06.20 p150 |
| | 25 | 630 | | | | | | | | | | | | VD4 12.06.25 p150 |
| | 31.5 | 630 | | | | | | | | | | | | VD4 12.06.32 p150 |
| | 16 | 1250 | | | | | | | | | | | | VD4 12.12.16 p150 |
| | 20 | 1250 | | | | | | | | | | | | VD4 12.12.20 p150 |
| | 25 | 1250 | | | | | | | | | | | | VD4 12.12.25 p150 |
| | 31.5 | 1250 | | | | | | | | | | | | VD4 12.12.32 p150 |
| | 40 | | | | | | | | | | | | 1250 | VD4 12.12.40 p150 |
| | 20 | | | | | | 1600 | | | | | | | VD4 12.16.20 p150 |
| | 25 | | | | | | 1600 | | | | | | | VD4 12.16.25 p150 |
| | 31.5 | | | | | | 1600 | | | | | | | VD4 12.16.32 p150 |
| | 16 | | 630 | | | | | | | | | | | VD4 12.06.16 p210 |
| | 20 | | 630 | | | | | | | | | | | VD4 12.06.20 p210 |
| | 25 | | 630 | | | | | | | | | | | VD4 12.06.25 p210 |
| | 31.5 | | 630 | | | | | | | | | | | VD4 12.06.32 p210 |
| | 16 | | 1250 | | | | | | | | | | | VD4 12.12.16 p210 |
| | 20 | | 1250 | | | | | | | | | | | VD4 12.12.20 p210 |
| | 25 | | 1250 | | | | | | | | | | | VD4 12.12.25 p210 |
| | 31.5 | | 1250 | | | | | | | | | | | VD4 12.12.32 p210 |
| | 40 | | | | 1250 | | | | | | | | | VD4 12.12.40 p210 |
| | 50 | | | | | | | | | 1250 | | | | VD4 12.12.50 p210 |
| | 20 | | | | | | | 1600 | | | | | | VD4 12.16.20 p210 |
| | 25 | | | | | | | 1600 | | | | | | VD4 12.16.25 p210 |
| | 31.5 | | | | | | | 1600 | | | | | | VD4 12.16.32 p210 |
| | 40 | | | | 1600 | | | | | | | | | VD4 12.16.40 p210 |
| | 50 | | | | | | | | | 1600 | | | | VD4 12.16.50 p210 |
| | 20 | | | | | | | 2000 | | | | | | VD4 12.20.20 p210 |
| | 25 | | | | | | | 2000 | | | | | | VD4 12.20.25 p210 |
| | 31.5 | | | | | | | 2000 | | | | | | VD4 12.20.32 p210 |
| | 40 | | | | | | | 2000 | | | | | | VD4 12.20.40 p210 |
| | 50 | | | | | | | | | 2000 | | | | VD4 12.20.50 p210 |
| | 20 | | | | | | | 2500 | | | | | | VD4 12.25.20 p210 |
| | 25 | | | | | | | 2500 | | | | | | VD4 12.25.25 p210 |
| | 31.5 | | | | | | | 2500 | | | | | | VD4 12.25.32 p210 |
| | 40 | | | | | | | 2500 | | | | | | VD4 12.25.40 p210 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.

# 5. Description

### VD4 fixed circuit breaker without bottom and top terminals (12 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H=461 | | | H=589 | | H=599 | | | H=610 | | H=636 | |
| | | D=424 | | | D=424 | | D=424 | | | D=459 | | D=459 | |
| kV | kA | u/l=205 | | | u/l=310 | | u/l=310 | | | u/l=310 | | u/l=310 | Circuit breaker type |
| | | l/g=217.5 | | | l/g=238 | | l/g=237.5 | | | l/g=237 | | l/g=237 | |
| | | P=150 | P=210 | P=275 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | |
| | | W=450 | W=570 | W=700 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | |
| 12 | 16 | | | 630 | | | | | | | | | VD4 12.06.16 p275 |
| | 20 | | | 630 | | | | | | | | | VD4 12.06.20 p275 |
| | 25 | | | 630 | | | | | | | | | VD4 12.06.25 p275 |
| | 31.5 | | | 630 | | | | | | | | | VD4 12.06.32 p275 |
| | 16 | | | 1250 | | | | | | | | | VD4 12.12.16 p275 |
| | 20 | | | 1250 | | | | | | | | | VD4 12.12.20 p275 |
| | 25 | | | 1250 | | | | | | | | | VD4 12.12.25 p275 |
| | 31.5 | | | 1250 | | | | | | | | | VD4 12.12.32 p275 |
| | 40 | | | | | 1250 | | | | | | | VD4 12.12.40 p275 |
| | 50 | | | | | | | | | | 1250 | | VD4 12.12.50 p275 |
| | 20 | | | | | | | | 1600 | | | | VD4 12.16.20 p275 |
| | 25 | | | | | | | | 1600 | | | | VD4 12.16.25 p275 |
| | 31.5 | | | | | | | | 1600 | | | | VD4 12.16.32 p275 |
| | 40 | | | | | 1600 | | | | | | | VD4 12.16.40 p275 |
| | 50 | | | | | | | | | | 1600 | | VD4 12.16.50 p275 |
| | 20 | | | | | | | | 2000 | | | | VD4 12.20.20 p275 |
| | 25 | | | | | | | | 2000 | | | | VD4 12.20.25 p275 |
| | 31.5 | | | | | | | | 2000 | | | | VD4 12.20.32 p275 |
| | 40 | | | | | | | | 2000 | | | | VD4 12.20.40 p275 |
| | 50 | | | | | | | | | | 2000 | | VD4 12.20.50 p275 |
| | 20 | | | | | | | | 2500 | | | | VD4 12.25.20 p275 |
| | 25 | | | | | | | | 2500 | | | | VD4 12.25.25 p275 |
| | 31.5 | | | | | | | | 2500 | | | | VD4 12.25.32 p275 |
| | 40 | | | | | | | | 2500 | | | | VD4 12.25.40 p275 |
| | 50 | | | | | | | | | | 2500 | | VD4 12.25.50 p275 |
| | 20 | | | | | | | | | | | 3150 (1) | VD4 12.32.20 p275 |
| | 25 | | | | | | | | | | | 3150 (1) | VD4 12.32.25 p275 |
| | 31.5 | | | | | | | | | | | 3150 (1) | VD4 12.32.32 p275 |
| | 40 | | | | | | | | | | | 3150 (1) | VD4 12.32.40 p275 |
| | 50 | | | | | | | | | | | 3150 (1) | VD4 12.32.50 p275 |

### VD4 fixed circuit breaker without bottom and top terminals (15 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | |
|---|---|---|---|---|
| | | H=461 | H=599 | |
| | | D=424 | D=424 | |
| kV | kA | u/l=205 | u/l=310 | Circuit breaker type |
| | | l/g=217.5 | l/g=237.5 | |
| | | P=150 | P=210 | |
| | | W=450 | W=570 | |
| 15 | 31.5 | 1200 | | VD4/N 15.12.32 p150 |
| | 40 | | 1200 | VD4 15.12.40 p210 |
| | 31.5 | | 2000 | VD4/N 15.20.32 p210 |
| | 40 | | 2000 | VD4 15.20.40 p210 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.
(1) Up to 4000 A with forced ventilation

## VD4 fixed circuit breaker without bottom and top terminals (17.5 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H=461 | | | H=589 | | H=599 | | | H=610 | | H=635 | H=589 | |
| | | D=424 | | | D=424 | | D=424 | | | D=459 | | D=459 | D=424 | |
| kV | kA | u/l=205 | | | u/l=310 | | u/l=310 | | | u/l=310 | | u/l=310 | u/l=310 | Circuit breaker type |
| | | l/g=217.5 | | | l/g=238 | | l/g=237.5 | | | l/g=237 | | l/g=237.5 | l/g=237.5 | |
| | | P=150 | P=210 | P=275 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | P=150 | |
| | | W=450 | W=570 | W=700 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | W=450 | |
| | 16 | 630 | | | | | | | | | | | | VD4 17.06.16 p150 |
| | 20 | 630 | | | | | | | | | | | | VD4 17.06.20 p150 |
| | 25 | 630 | | | | | | | | | | | | VD4 17.06.25 p150 |
| | 31.5 | 630 | | | | | | | | | | | | VD4 17.06.32 p150 |
| | 16 | 1250 | | | | | | | | | | | | VD4 17.12.16 p150 |
| | 20 | 1250 | | | | | | | | | | | | VD4 17.12.20 p150 |
| | 25 | 1250 | | | | | | | | | | | | VD4 17.12.25 p150 |
| | 31.5 | 1250 | | | | | | | | | | | | VD4 17.12.32 p150 |
| | 40 | | | | | | | | | | | | 1250 | VD4 17.12.40 p150 |
| | 16 | | 630 | | | | | | | | | | | VD4 17.06.16 p210 |
| | 20 | | 630 | | | | | | | | | | | VD4 17.06.20 p210 |
| | 25 | | 630 | | | | | | | | | | | VD4 17.06.25 p210 |
| | 31.5 | | 630 | | | | | | | | | | | VD4 17.06.32 p210 |
| | 16 | | 1250 | | | | | | | | | | | VD4 17.12.16 p210 |
| 17.5 | 20 | | 1250 | | | | | | | | | | | VD4 17.12.20 p210 |
| | 25 | | 1250 | | | | | | | | | | | VD4 17.12.25 p210 |
| | 31.5 | | 1250 | | | | | | | | | | | VD4 17.12.32 p210 |
| | 40 | | | | 1250 | | | | | | | | | VD4 17.12.40 p210 |
| | 50 | | | | | | | | | 1250 | | | | VD4 17.12.50 p210 |
| | 20 | | | | | | | 1600 | | | | | | VD4 17.16.20 p210 |
| | 25 | | | | | | | 1600 | | | | | | VD4 17.16.25 p210 |
| | 31.5 | | | | | | | 1600 | | | | | | VD4 17.16.32 p210 |
| | 40 | | | | 1600 | | | | | | | | | VD4 17.16.40 p210 |
| | 50 | | | | | | | | | 1600 | | | | VD4 17.16.50 p210 |
| | 20 | | | | | | | 2000 | | | | | | VD4 17.20.20 p210 |
| | 25 | | | | | | | 2000 | | | | | | VD4 17.20.25 p210 |
| | 31.5 | | | | | | | 2000 | | | | | | VD4 17.20.32 p210 |
| | 40 | | | | | | | 2000 | | | | | | VD4 17.20.40 p210 |
| | 50 | | | | | | | | | 2000 | | | | VD4 17.20.50 p210 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.

# 5. Description

### VD4 fixed circuit breaker without bottom and top terminals (17.5 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | | | | | | Circuit breaker type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kV | kA | H=461 | | | H=589 | | H=599 | | | H=610 | | H=635 | |
| | | D=424 | | | D=424 | | D=424 | | | D=459 | | D=459 | |
| | | u/l=205 | | | u/l=310 | | u/l=310 | | | u/l=310 | | u/l=310 | |
| | | l/g=217.5 | | | l/g=238 | | l/g=237.5 | | | l/g=237 | | l/g=237.5 | |
| | | P=150 | P=210 | P=275 | P=210 | P=275 | P=150 | P=210 | P=275 | P=210 | P=275 | P=275 | |
| | | W=450 | W=570 | W=700 | W=570 | W=700 | W=450 | W=570 | W=700 | W=600 | W=750 | W=750 | |
| 17.5 | 16 | | | 630 | | | | | | | | | VD4 17.06.16 p275 |
| | 20 | | | 630 | | | | | | | | | VD4 17.06.20 p275 |
| | 25 | | | 630 | | | | | | | | | VD4 17.06.25 p275 |
| | 31.5 | | | 630 | | | | | | | | | VD4 17.06.32 p275 |
| | 16 | | | 1250 | | | | | | | | | VD4 17.12.16 p275 |
| | 20 | | | 1250 | | | | | | | | | VD4 17.12.20 p275 |
| | 25 | | | 1250 | | | | | | | | | VD4 17.12.25 p275 |
| | 31.5 | | | 1250 | | | | | | | | | VD4 17.12.32 p275 |
| | 40 | | | | | 1250 | | | | | | | VD4 17.12.40 p275 |
| | 50 | | | | | | | | | | 1250 | | VD4 17.12.50 p275 |
| | 20 | | | | | | | | 1600 | | | | VD4 17.16.20 p275 |
| | 25 | | | | | | | | 1600 | | | | VD4 17.16.25 p275 |
| | 31.5 | | | | | | | | 1600 | | | | VD4 17.16.32 p275 |
| | 40 | | | | | 1600 | | | | | | | VD4 17.16.40 p275 |
| | 50 | | | | | | | | | | 1600 | | VD4 17.16.50 p275 |
| | 20 | | | | | | | | 2000 | | | | VD4 17.20.20 p275 |
| | 25 | | | | | | | | 2000 | | | | VD4 17.20.25 p275 |
| | 31.5 | | | | | | | | 2000 | | | | VD4 17.20.32 p275 |
| | 40 | | | | | | | | 2000 | | | | VD4 17.20.40 p275 |
| | 50 | | | | | | | | | | 2000 | | VD4 17.20.50 p275 |
| | 20 | | | | | | | | 2500 | | | | VD4 17.25.20 p275 |
| | 25 | | | | | | | | 2500 | | | | VD4 17.25.25 p275 |
| | 31.5 | | | | | | | | 2500 | | | | VD4 17.25.32 p275 |
| | 40 | | | | | | | | 2500 | | | | VD4 17.25.40 p275 |
| | 50 | | | | | | | | | | 2500 | | VD4 17.25.50 p275 |
| | 20 | | | | | | | | | | | 3150 (1) | VD4 17.32.20 p275 |
| | 25 | | | | | | | | | | | 3150 (1) | VD4 17.32.25 p275 |
| | 31.5 | | | | | | | | | | | 3150 (1) | VD4 17.32.32 p275 |
| | 40 | | | | | | | | | | | 3150 (1) | VD4 17.32.40 p275 |
| | 50 | | | | | | | | | | | 3150 (1) | VD4 17.32.50 p275 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.
(1) Up to 4000 A with forced ventilation

## VD4 fixed circuit breaker without bottom and top terminals (24 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | |
|---|---|---|---|---|---|
| | | H=631 | | H=642 | |
| | | D=424 | | D=424 | |
| | | u/l=310 | | u/l=310 | Circuit breaker type |
| kV | kA | l/g=282.5 | | l/g=282.5 | |
| | | P=210 | P=275 | P=275 | |
| | | W=570 | W=700 | W=700 | |
| | 16 | 630 | | | VD4 24.06.16 p210 |
| | 20 | 630 | | | VD4 24.06.20 p210 |
| | 25 | 630 | | | VD4 24.06.25 p210 |
| | 16 | 1250 | | | VD4 24.12.16 p210 |
| | 20 | 1250 | | | VD4 24.12.20 p210 |
| | 25 | 1250 | | | VD4 24.12.25 p210 |
| | 31.5 | 1250 | | | VD4 24.12.32 p210 |
| | 16 | | 630 | | VD4 24.06.16 p275 |
| | 20 | | 630 | | VD4 24.06.20 p275 |
| | 25 | | 630 | | VD4 24.06.25 p275 |
| | 16 | | 1250 | | VD4 24.12.16 p275 |
| 24 | 20 | | 1250 | | VD4 24.12.20 p275 |
| | 25 | | 1250 | | VD4 24.12.25 p275 |
| | 16 | | | 1600 | VD4 24.16.16 p275 |
| | 20 | | | 1600 | VD4 24.16.20 p275 |
| | 25 | | | 1600 | VD4 24.16.25 p275 |
| | 31.5 | | | 1600 | VD4 24.16.32 p275 |
| | 16 | | | 2000 | VD4 24.20.16 p275 |
| | 20 | | | 2000 | VD4 24.20.20 p275 |
| | 25 | | | 2000 | VD4 24.20.25 p275 |
| | 31.5 | | | 2000 | VD4 24.20.32 p275 |
| | 25 | | | 2500 | VD4 24.25.25 p275 |
| | 31.5 | | | 2500 | VD4 24.25.32 p275 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.

# 5. Description

**VD4 fixed circuit breaker without bottom and top terminals (36-40.5 kV)**

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | Circuit breaker type |
|---|---|---|---|---|---|---|
| kV | kA | H = 884<br>W = 796<br>D = 501<br>u/l = 328<br>l/g = 428.5<br>P = 275 | | | | |
| 36 | 20 | 1250 A | | | | VD4 36.12.20 p275 |
| | 25 | 1250 A | | | | VD4 36.12.25 p275 |
| | 31.5 | 1250 A | | | | VD4 36.12.32 p275 |
| | 20 | | 1600 A | | | VD4 36.16.20 p275 |
| | 25 | | 1600 A | | | VD4 36.16.25 p275 |
| | 31.5 | | 1600 A | | | VD4 36.16.32 p275 |
| | 20 | | | 2000 A | | VD4 36.20.20 p275 |
| | 25 | | | 2000 A | | VD4 36.20.25 p275 |
| | 31.5 | | | 2000 A | | VD4 36.20.32 p275 |
| | 20 | | | | 2500 A | VD4 36.25.20 p275 |
| | 25 | | | | 2500 A | VD4 36.25.25 p275 |
| | 31.5 | | | | 2500 A | VD4 36.25.32 p275 |
| 40.5 | 20 | 1250 A | | | | VD4 40.12.20 p275 |
| | 25 | 1250 A | | | | VD4 40.12.25 p275 |
| | 31.5 | 1250 A | | | | VD4 40.12.32 p275 |
| | 20 | | 1600 A | | | VD4 40.16.20 p275 |
| | 25 | | 1600 A | | | VD4 40.16.25 p275 |
| | 31.5 | | 1600 A | | | VD4 40.16.32 p275 |
| | 20 | | | 2000 A | | VD4 40.20.20 p275 |
| | 25 | | | 2000 A | | VD4 40.20.25 p275 |
| | 31.5 | | | 2000 A | | VD4 40.20.32 p275 |

H = Height of the circuit breaker.
W = Width of the circuit breaker.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.

### 5.5.3. Standard fittings for fixed circuit breakers

The basic versions of the fixed circuit breakers are three-pole and fitted with:

- EL type manual operating mechanism
- mechanical signalling device for closing spring charged/ discharged
- mechanical signalling device for circuit breaker open/closed
- closing pushbutton, opening pushbutton and operation counter
- set of ten circuit breaker open/closed auxiliary contacts

  Note: with the set of ten auxiliary contacts supplied as standard and the maximum number of electrical applications possible, three make contacts (signalling circuit breaker open) and five break contacts (signalling circuit breaker closed) are available.

- lever for manual closing spring charging




VD4 evo - up to 17 kV




VD4 - up to 24 kV




VD4 - 36 kV

## 5.6. Withdrawable circuit breakers

The withdrawable circuit breakers up to 24 kV are available for UniGear ZS1 and UniSec switchgear, PowerCube modules (see fig. 5a) and for ZS8.4 switchgear (see fig. 5b).
The 36 kV circuit breakers are available for ZS2 switchgear.
They consist of a truck on which the supporting structure of the circuit breaker is fixed.

**Circuit breakers for UniGear ZS1 and UniSec switchgear and for PowerCube modules (fig. 5a)**

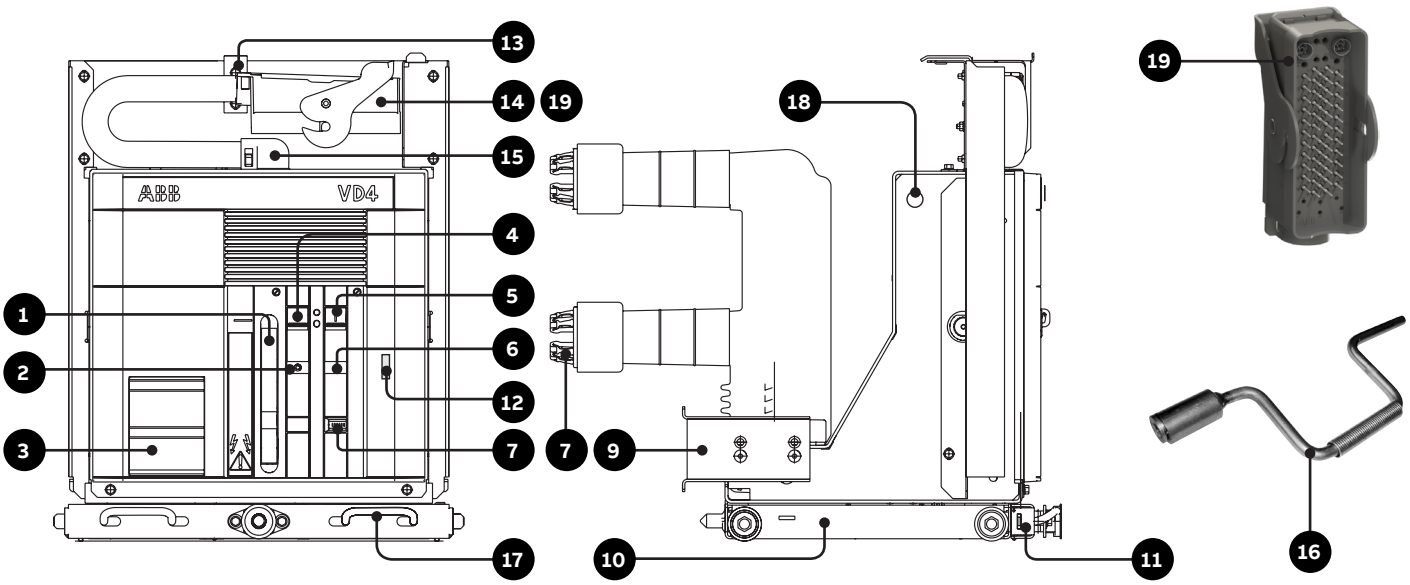
The cord with the connector (14) (plug) for connection of the operating mechanism electrical accessories comes out of the connection (15).
The strikers for operating the contacts (connected/ isolated) placed in the switchgear are fixed in the top part of the circuit breaker.
The shutter actuator (9) (roller (18) for UniSec version) are provided for operating the segregation shutters of the medium voltage contacts of the enclosure or of the switchgear are fixed on the sides of the circuit breaker.
The crosspiece with the handles (17) for hooking up the circuit breaker for the racking-in/out operations by means of the special operating lever (16) is mounted on the front part of the circuit breaker truck.
The circuit breaker is completed with the isolating contacts (8).

# 5. Description

The withdrawable circuit breaker is fitted with special locks on the front crosspiece, which allow hooking up into the corresponding couplings of the switchgear.
The locks can only be activated by the handles with the truck fully resting against the crosspiece.
The operating lever (16) must be fully inserted (also see par. 7.5.). A lock prevents the truck from advancing into the enclosure or fixed part when the earthing switch is closed.
Another lock prevents racking-in and racking-out with the circuit breaker closed. With the truck in an intermediate position between isolated and connected, a further lock prevents circuit breaker closing (either mechanical or electrical).
A locking magnet is also mounted on the truck which, when de-energised, prevents the truck racking-in operation.

On request, an interlock is available which prevents racking-in of the circuit breaker with the door open, and door opening with the circuit breaker closed.
The lever for loading the closing spring (1) in the manual mode is built into the operating mechanism.
The spring is loaded by repeatedly lowering the lever with linear movements until the yellow indicator (6) appears to show that loading is complete.
The spring can only be loaded with the switchgear door open.
Comply with the instructions in the UniGear switchgear manual for the operations that can be performed with the door open.

Note: on request, the closing spring loading device for withdrawable circuit breakers for UniGear switchgear can be supplied with the lever outside the operating mechanism and a rotary loading movement. This device is part of the standard equipment for VD4/ZS8 withdrawable circuit breakers only (see detail 1 of Fig. 5b on the next page). This rotary loading device allows the closing spring to be loaded with the switchgear door closed.




Caption
1 Lever for manually charging the closing spring
2 Signalling device for circuit breaker open/closed
3 Rating plate
4 Opening pushbutton
5 Closing pushbutton
6 Signalling device for closing spring charged/discharged
7 Operation counter
8 Isolating contacts
9 Slide for operating the switchgear shutters (UniGear ZS1, PowerCube, ZS8.4)
10 Truck
11 Locks for hooking into the fixed part
12 Mechanical override of the undervoltage release (on request)
13 Strikers for activating the contacts placed in the enclosure
14 Connector (plug)
15 Cabling connection
16 Operating lever for circuit breaker racking-in/out
17 Handles for activating the locks (11)
18 Shutters actuator (for UniSec version only)
19 Connector (plug) with two Harting connectors - VD4 evo only

Fig. 5a

**Circuit breakers for ZS8.4 switchgear (fig. 5b)**
The socket (13) takes the connector (plug) placed in the switchgear.
The slides (9) for operating the segregation shutters of the medium voltage contacts of the switchgear are fixed on the sides of the circuit breaker.
The crosspiece with the handles (17) for hooking up the circuit breaker for the racking-in/out operations by means of the special operating lever (16) is mounted on the front part of the circuit breaker truck.
The circuit breaker is completed with the isolating contacts (8).
The withdrawable circuit breaker is fitted with special locks, described below (see fig. 5c - 5d).

**1) Prevention of traverse with circuit breaker closed**

With the circuit breaker closed, the feeler pin (16 - fig. 5c) prevents the shutter sliding (19 - fig. 5c) and therefore insertion of the lever (20 - fig. 5c) for traverse of the apparatus.

**2) Prevention of traverse with socket-plug disconnected**

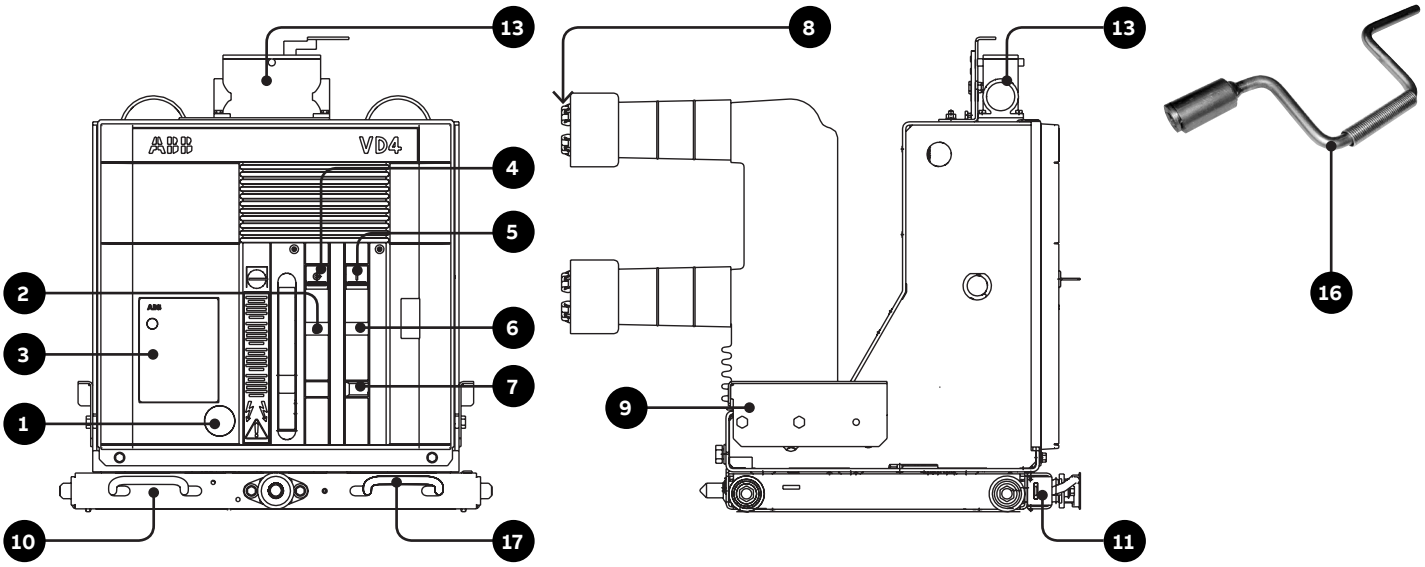
When the plug is not inserted in the socket (13), the stem (21 - fig. 5c) prevents the plate (22 - fig. 5c) lifting and traverse of the apparatus.

**3) Prevention of switchgear door closing with socketplug disconnected (*)**

When the plug is not inserted in the socket (13), the feeler pin (23 - fig. 5d) prevents door closing.

**4) Prevention of circuit breaker racking-out with the socket-plug connected (*)**

When the plug is inserted in the socket (13), the lock bolt (29 - fig. 5d) hits the pin (30 - fig. 5d) preventing the apparatus from being racked out of the switchgear.




Caption
1 Coupling for the manual closing spring charging lever (*)
2 Signalling device for circuit breaker open/closed
3 Rating plate
4 Opening pushbutton
5 Closing pushbutton
6 Signalling device for closing spring charged/discharged
7 Operation counter
8 Isolating contacts
9 Slide for operating the switchgear shutters
10 Truck
11 Locks for hooking into the fixed part
13 Connector (plug)
16 Operating lever for circuit breaker racking-in/out (a special version is provided for VD4/ZS8 Preussen Elektra EON circuit breakers)
17 Handles for activating the locks (11)
(*) Only VD4/ZS8 Preussen - Elektra EON version.

Fig. 5b

# 5. Description

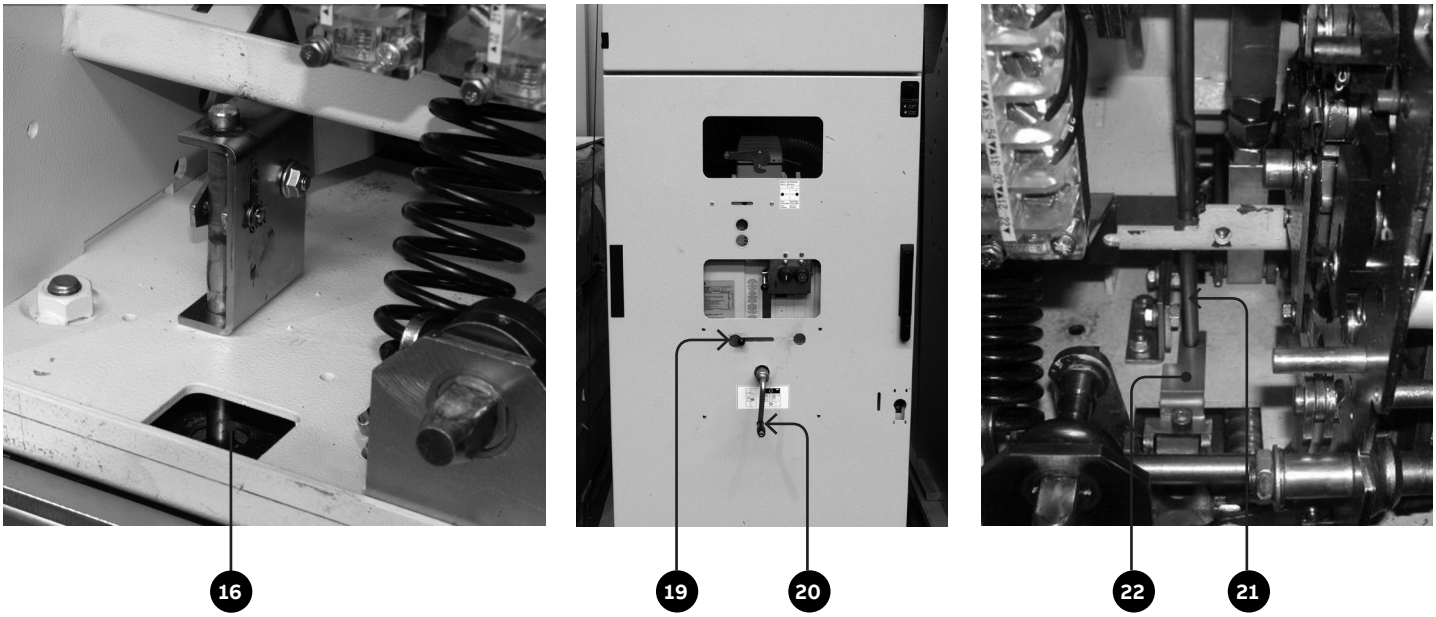



Fig. 5c

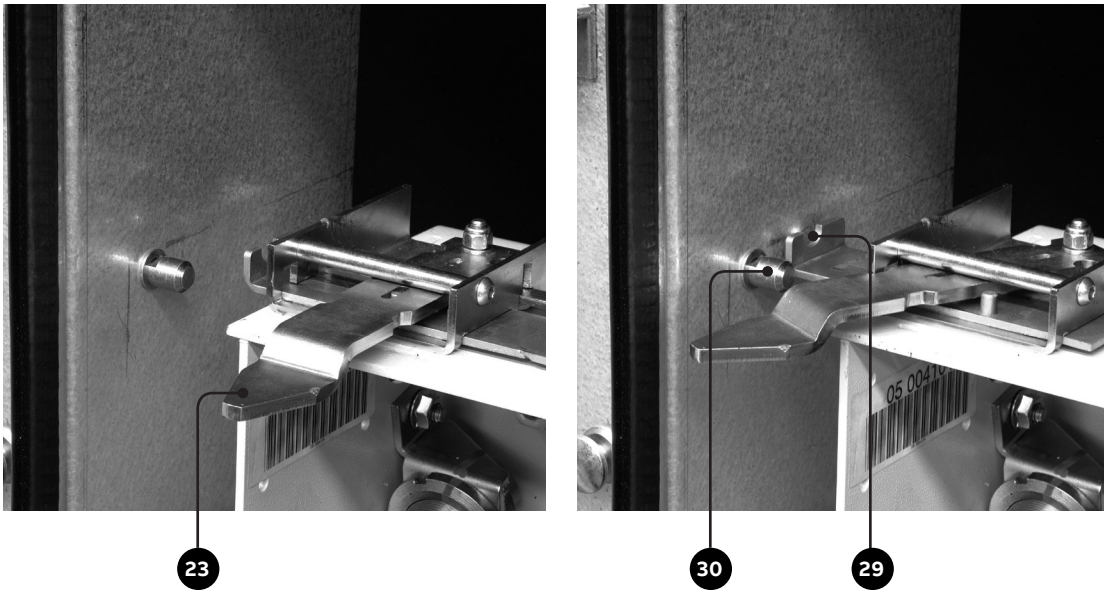


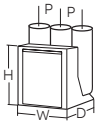

Fig. 5d

# 5. Description

### 5.6.1. General characteristics of withdrawable circuit breakers for UniGear ZS1 switchgear




**General characteristics of withdrawable circuit breakers for UniGear ZS1 switchgear (12 kV)**

| **Circuit breaker** | | **VD4/P 12** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | | | |
| Rated voltage | Ur [kV] | 12 | | | | | | | |
| Rated insulation voltage | Us [kV] | 12 | | | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | | | | | | |
| Impulse withstand voltage | Up [kV] | 75 | | | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | | | |
| Rated normal current (40 °C) (1) | Ir [A] | 630 | 1250 | 1250 (4) | 1250 | 1250 | 1250 | 1600 | 1600 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | - | - | - | - | - | - |
| | | 20 | 20 | - | - | - | - | 20 | 20 |
| | | 25 | 25 | - | - | - | - | 25 | 25 |
| | | 31.5 | 31.5 | - | - | - | - | 31.5 | 31.5 |
| | | - | - | 40 (4) | 40 | 40 | - | - | - |
| | | - | - | - | - | - | 50 | - | - |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | - | - | - | - | - | - |
| | | 20 | 20 | - | - | - | - | 20 | 20 |
| | | 25 | 25 | - | - | - | - | 25 | 25 |
| | | 31.5 | 31.5 | - | - | - | - | 31.5 | 31.5 |
| | | - | - | 40 (4) | 40 | 40 | - | - | - |
| | | - | - | - | - | - | 50 | - | - |
| Making capacity | Ip [kA] | 40 | 40 | - | - | - | - | - | - |
| | | 50 | 50 | - | - | - | - | 50 | 50 |
| | | 63 | 63 | - | - | - | - | 63 | 63 |
| | | 80 | 80 | - | - | - | - | 80 | 80 |
| | | - | - | 104 (4) | 100 | 100 | - | - | - |
| | | - | - | - | - | - | 125 | - | - |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • | • |
| Opening time | [ms] | 33 ... 60 | | | | | | | |
| Arcing time | [ms] | 10 ... 15 | | | | | | | |
| Total breaking time | [ms] | 43 ... 75 | | | | | | | |
| Closing time | [ms] | 30 ... 60 | | | | | | | |
| Maximum overall dimensions   | H [mm] | 628 | 628 | 693 | 691 | 691 | 691 | 691 | 691 |
| | W [mm] | 503 | 503 | 503 | 653 | 853 | 681 | 653 | 853 |
| | D [mm] | 662 | 662 | 651 | 641 | 642 | 643 | 642 | 642 |
| | Pole distance P [mm] | 150 | 150 | 150 | 210 | 275 | 210 | 210 | 275 |
| Weight | [kg] | 116 | 116 | 111 | 174 | 176 | 180 | 160 | 166 |
| Standardised table of dimensions | TN | 7412 (3) | 7412 (3) | 2RDA040163 | - | - | - | 7415 (3) | 7416 (3) |
| | 1VCD | - | - | | 003284 (3) | 003286 (3) | 003444 | - | - |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | | | |

(1) Rated current guaranteed with circuit breaker installed in UniGear ZS1 switchgear and with 40 °C ambient temperature.
(2) Up to 4000 A with forced ventilation
(3) Poles in polyamide
(4) Available in VD4 evo only

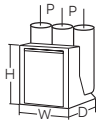
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **VD4/P 12** | | | | | | | | | | | |
| • | | | | | | | | | | | |
| 12 | | | | | | | | | | | |
| 12 | | | | | | | | | | | |
| 28 | | | | | | | | | | | |
| 75 | | | | | | | | | | | |
| 50-60 | | | | | | | | | | | |
| 1600 | 1600 | 1600 | 1600 | 2000 | 2000 | 2000 | 2000 | 2500 | 2500 | 3150 (2) | 3150 (2) |
| – | – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | 20 | 20 | – | – | 20 | – | 20 | – |
| – | – | – | – | 25 | 25 | – | – | 25 | – | 25 | – |
| – | – | – | – | 31.5 | 31.5 | – | – | 31.5 | – | 31.5 | – |
| 40 | 40 | – | – | 40 | 40 | – | – | 40 | – | 40 | – |
| – | – | 50 | 50 | – | – | 50 | 50 | – | 50 | – | 50 |
| – | – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | 20 | 20 | – | – | 20 | – | 20 | – |
| – | – | – | – | 25 | 25 | – | – | 25 | – | 25 | – |
| – | – | – | – | 31.5 | 31.5 | – | – | 31.5 | – | 31.5 | – |
| 40 | 40 | – | – | 40 | 40 | – | – | 40 | – | 40 | – |
| – | – | 50 | 50 | – | – | 50 | 50 | – | 50 | – | 50 |
| – | – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | 50 | 50 | – | – | 50 | – | 50 | – |
| – | – | – | – | 63 | 63 | – | – | 63 | – | 63 | – |
| – | – | – | – | 80 | 80 | – | – | 80 | – | 80 | – |
| 100 | 100 | – | – | 100 | 100 | – | – | 100 | – | 100 | – |
| – | – | 125 | 125 | – | – | 125 | 125 | – | 125 | – | 125 |
| • | • | • | • | • | • | • | • | • | • | • | • |
| 33 ... 60 | | | | | | | | | | | |
| 10 ... 15 | | | | | | | | | | | |
| 43 ... 75 | | | | | | | | | | | |
| 30 ... 60 | | | | | | | | | | | |
| 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 730 | 742 |
| 653 | 853 | 681 | 853 | 653 | 853 | 681 | 853 | 853 | 853 | 853 | 853 |
| 641 | 642 | 643 | 643 | 642 | 642 | 643 | 643 | 640 | 643 | 640 | 643 |
| 210 | 275 | 210 | 275 | 210 | 275 | 210 | 275 | 275 | 275 | 275 | 275 |
| 174 | 176 | 180 | 193 | 160 | 166 | 190 | 205 | 186 | 225 | 221 | 240 |
| – | – | – | – | 7415 (3) | 7416 (3) | – | – | 7417 (3) | – | – | – |
| 003284 (3) | 003286 (3) | 003444 | 003445 | – | – | 003444 | 003445 | – | 003446 | 000153 (3) | 003447 |
| - 5 ... + 40 | | | | | | | | | | | |
| • | | | | | | | | | | | |
| • | | | | | | | | | | | |


ABB

# 5. Description

**General characteristics of withdrawable circuit breakers for OeM switchgear (15kV)**

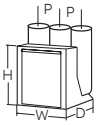



| Circuit breaker | | OeM panel | VD4/N/P 15 | |
|---|---|---|---|---|
| Standard | | IEEE C37.04 | • | |
| Rated voltage | | [kV] | 15 | |
| Rated frequency | | [Hz] | 60 | |
| Short-circuit breaking current Isc | | [kA] | 31.5 | |
| Rated current Ir | | [A] | 1200 | 2000 |
| Short-time withstand current | | [A] | 31.5 | |
| Short circuit withstand | | [A] | 3 | |
| Close and latch capability | | [kA] | 82 | |
| Operation sequence | | [O - 0,3 s - CO - 3 min - CO] | • | |
| % DC component | | [%] | 40 | |
| Interrupting time | | [ms] | 50 | |
| Closing time | | [ms] | 30…60 | |
| Mechanical endurance class | | [M2] | 10k | |
| Lightning impulse withstand voltage Up | | [kV] | 95 | |
| Power frequency withstand voltage Ud | | [kV] | 36 | |
| Operating temperature | | [°C] | -5…+40 | |
| Maximum overall dimensions   | Height | [mm] | 632 | 691 |
| | Width | [mm] | 503 | 653 |
| | Depth | [mm] | 664 | 642 |
| | Pole distance | [mm] | 150 | 210 |
| Standard table of dimensions | | TN | 7412 | 7415 |
| Weight | | [kg] | 116 | 160 |

# 5. Description

**General characteristics of withdrawable circuit breakers for UniGear ZS1 switchgear (17.5 kV)**




| Circuit breaker | | | VD4/P 17 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Standards | | IEC 62271-100 | • | | | | | | |
| Rated voltage | | Ur [kV] | 17.5 | | | | | | |
| Rated insulation voltage | | Us [kV] | 17.5 | | | | | | |
| Withstand voltage at 50 Hz | | Ud (1 min) [kV] | 38 | | | | | | |
| Impulse withstand voltage | | Up [kV] | 95 | | | | | | |
| Rated frequency | | fr [Hz] | 50-60 | | | | | | |
| Rated normal current (40 °C) (1) | | Ir [A] | 630 | 1250 | 1250 (4) | 1250 | 1250 | 1250 | 1600 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | | Isc [kA] | 16 | 16 | - | - | - | - | - |
| | | | 20 | 20 | - | - | - | - | 20 |
| | | | 25 | 25 | - | - | - | - | 25 |
| | | | 31.5 | 31.5 | - | - | - | - | 31.5 |
| | | | - | - | 40 (4) | 40 | 40 | - | - |
| | | | - | - | - | - | - | 50 | - |
| Rated short-time withstand current (3s) | | Ik [kA] | 16 | 16 | - | - | - | - | - |
| | | | 20 | 20 | - | - | - | - | 20 |
| | | | 25 | 25 | - | - | - | - | 25 |
| | | | 31.5 | 31.5 | - | - | - | - | 31.5 |
| | | | - | - | 40 (4) | 40 | 40 | - | - |
| | | | - | - | - | - | - | 50 | - |
| Making capacity | | Ip [kA] | 40 | 40 | - | - | - | - | - |
| | | | 50 | 50 | - | - | - | - | 50 |
| | | | 63 | 63 | - | - | - | - | 63 |
| | | | 80 | 80 | - | - | - | - | 80 |
| | | | - | - | 104 (4) | 100 | 100 | - | - |
| | | | - | - | - | - | - | 125 | - |
| Operation sequence | | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • |
| Opening time | | [ms] | 33 ... 60 | | | | | | |
| Arcing time | | [ms] | 10 ... 15 | | | | | | |
| Total breaking time | | [ms] | 43 ... 75 | | | | | | |
| Closing time | | [ms] | 30 ... 60 | | | | | | |
| Maximum overall dimensions |  | H [mm] | 632 | 632 | 693 | 691 | 691 | 691 | 691 |
| | | W [mm] | 503 | 503 | 503 | 653 | 853 | 681 | 653 |
| | | D [mm] | 664 | 664 | 651 | 641 | 642 | 643 | 642 |
| | | Pole distance P [mm] | 150 | 150 | 150 | 210 | 275 | 210 | 210 |
| Weight | | [kg] | 116 | 116 | 111 | 174 | 176 | 180 | 160 |
| Standardised table of dimensions | | TN | 7412 (3) | 7412 (3) | 2RDA040163- | | - | - | 7415 (3) |
| | | 1VCD | - | - | - | 003284 (3) | 003286 (3) | 003444 | - |
| Operating temperature | | [°C] | - 5 ... + 40 | | | | | | |
| Tropicalization | | IEC: 60068-2-30, 60721-2-1 | • | | | | | | |
| Electromagnetic compatibility | | IEC: 62271-1 | • | | | | | | |

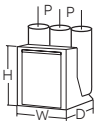
(1) Rated current guaranteed with circuit breaker installed in UniGear ZS1 switchgear and with 40 °C ambient temperature.
(2) Up to 4000 A with forced ventilation.
(3) Poles in polyamide
(4) Available in VD4 evo only

| VD4/P 17 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| • | | | | | | | | | | | | |
| 17.5 | | | | | | | | | | | | |
| 17.5 | | | | | | | | | | | | |
| 38 | | | | | | | | | | | | |
| 95 | | | | | | | | | | | | |
| 50-60 | | | | | | | | | | | | |
| 1600 | 1600 | 1600 | 1600 | 1600 | 2000 | 2000 | 2000 | 2000 | 2500 | 2500 | 3150 (2) | 3150 (2) |
| - | – | – | – | – | – | – | – | – | – | – | – | – |
| 20 | – | – | – | – | 20 | 20 | – | – | 20 | – | 20 | – |
| 25 | – | – | – | – | 25 | 25 | – | – | 25 | – | 25 | – |
| 31.5 | – | – | – | – | 31.5 | 31.5 | – | – | 31.5 | – | 31.5 | – |
| - | 40 | 40 | – | – | 40 | 40 | – | – | 40 | – | 40 | – |
| - | – | – | 50 | 50 | – | – | 50 | 50 | – | 50 | – | 50 |
| - | – | – | – | – | – | – | – | – | – | – | – | – |
| 20 | – | – | – | – | 20 | 20 | – | – | 20 | – | 20 | – |
| 25 | – | – | – | – | 25 | 25 | – | – | 25 | – | 25 | – |
| 31.5 | – | – | – | – | 31.5 | 31.5 | – | – | 31.5 | – | 31.5 | – |
| - | 40 | 40 | – | – | 40 | 40 | – | – | 40 | – | 40 | – |
| - | – | – | 50 | 50 | – | – | 50 | 50 | – | 50 | – | 50 |
| - | – | – | – | – | – | – | – | – | – | – | – | – |
| 50 | – | – | – | – | 50 | 50 | – | – | 50 | – | 50 | – |
| 63 | – | – | – | – | 63 | 63 | – | – | 63 | – | 63 | – |
| 80 | – | – | – | – | 80 | 80 | – | – | 80 | – | 80 | – |
| - | 100 | 100 | – | – | 100 | 100 | – | – | 100 | – | 100 | – |
| - | – | – | 125 | 125 | – | – | 125 | 125 | – | 125 | – | 125 |
| • | • | • | • | • | • | • | • | • | • | • | • | • |
| 33 ... 60 | | | | | | | | | | | | |
| 10 ... 15 | | | | | | | | | | | | |
| 43 ... 75 | | | | | | | | | | | | |
| 30 ... 60 | | | | | | | | | | | | |
| 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 691 | 730 | 742 |
| 853 | 653 | 853 | 681 | 853 | 653 | 853 | 681 | 853 | 853 | 853 | 853 | 853 |
| 642 | 641 | 642 | 643 | 643 | 642 | 642 | 643 | 643 | 640 | 643 | 640 | 643 |
| 275 | 210 | 275 | 210 | 275 | 210 | 275 | 210 | 275 | 275 | 275 | 275 | 275 |
| 166 | 174 | 176 | 180 | 193 | 160 | 166 | 190 | 205 | 186 | 225 | 221 | 240 |
| 7416 (3) | – | – | – | – | 7415 (3) | 7416 (3) | – | – | 7417 (3) | – | – | – |
| - | 003284 (3) | 003286 (3) | 003444 | 003445 | – | – | 003444 | 003445 | – | 003446 | 000153 (3) | 003447 |
| - 5 ... + 40 | | | | | | | | | | | | |
| • | | | | | | | | | | | | |
| • | | | | | | | | | | | | |

# 5. Description

**General characteristics of withdrawable circuit breakers for UniGear ZS1 switchgear (24 kV)**

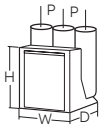



| Circuit breaker | | VD4/P 24 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | | | | |
| Rated voltage | Ur [kV] | 24 | | | | | | | |
| Rated insulation voltage | Us [kV] | 24 | | | | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 50 | | | | | | | |
| Impulse withstand voltage | Up [kV] | 125 | | | | | | | |
| Rated frequency | fr [Hz] | 50-60 | | | | | | | |
| Rated normal current (40 °C) (1) | Ir [A] | 630 | 630 | 1250 | 1250 | 1600 | 2000 | 2500 (2) | 3150 (3) |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | – |
| | | – | – | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 | 16 | 16 | – |
| | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | – |
| | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | – |
| | | – | – | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 | 40 | 40 | – |
| | | 50 | 50 | 50 | 50 | 50 | 50 | 50 | – |
| | | 63 | 63 | 63 | 63 | 63 | 63 | 63 | – |
| | | – | – | 80 | 80 | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • | • | • | • |
| Opening time | [ms] | 33 ... 60 | | | | | | | |
| Arcing time | [ms] | 10 ... 15 | | | | | | | |
| Total breaking time | [ms] | 43 ... 75 | | | | | | | |
| Closing time | [ms] | 30 ... 60 | | | | | | | |
| Maximum overall dimensions   | H [mm] | 794 | 794 | 794 | 794 | 838 | 838 | 838 | 838 |
| | W [mm] | 653 | 853 | 653 | 853 | 853 | 853 | 853 | 853 |
| | D [mm] | 802 | 802 | 802 | 802 | 790 | 790 | 790 | 790 |
| | Pole distance P [mm] | 210 | 275 | 210 | 275 | 275 | 275 | 275 | 275 |
| Weight | [kg] | 140 | 148 | 140/146 (4) | 148 | 228 | 228 | 228 | 277 |
| Standardised table of dimensions | TN | 7413 | 7414 | 7413 | 7414 | 7418 | 7418 | 7418 | – |
| | 1VCD | – | – | 000173 (4) | | – | – | – | 000177 |
| Operating temperature | [°C] | - 5 ... + 40 | | | | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | | | | |

(1) Rated current guaranteed with circuit breaker installed in UniGear ZS1 switchgear and with 40 °C ambient temperature.
(2) 2300 A rated current guaranteed with natural ventilation; 2500 A rated current guaranteed with forced ventilation.
(3) 2700 A rated current guaranteed with natural ventilation; 3150 A rated current guaranteed with forced ventilation.
(4) 31.5 kA version.

## Withdrawable circuit breakers for UniGear ZS2 switchgear (36 kV)



| Circuit breaker | | VD4/W 36 | | | | |
|---|---|---|---|---|---|---|
| Standards | IEC 62271-100 | • | | | | |
| Rated voltage | Ur [kV] | 36 | | | | |
| Rated insulation voltage | Us [kV] | 36 | | | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 70 | | | | |
| Impulse withstand voltage | Up [kV] | 170 | | | | |
| Rated frequency | fr [Hz] | 50 | | | | |
| Rated normal current (40 °C) | Ir [A] | 1250 | 1600 | 2000 | 2500 (1) | 3150 (2) |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 |
| | | 80 | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| Opening time | [ms] | 35 ... 60 | | | | |
| Arcing time | [ms] | 10 ... 15 | | | | |
| Total breaking time | [ms] | 45 ... 75 | | | | |
| Closing time | [ms] | 50 ... 65 | | | | |
| Maximum overall dimensions   | H [mm] | 974 | 974 | 974 | 974 | 974 |
| | W [mm] | 880 | 880 | 880 | 880 | 880 |
| | D [mm] | 789 | 789 | 789 | 789 | 789 |
| | Pole distance P [mm] | 275 | 275 | 275 | 275 | 275 |
| Weight | [kg] | 230 | 245 | 275 | 275/315 | 315 |
| Standardised table of dimensions | TN | 1VYN300901-KG | 1VYN300901-RA | 1VYN300901-RA | 1VYN300901-RA (1) 1VYN300901-RB | 1VYN300901-RB |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

(1) 2500 A with forced ventilation and tulip contacts diameter 79 mm (TN 1VYN300901-RA).
(2) 3150 A with forced ventilation.

# 5. Description

### 5.6.2. Types of withdrawable circuit breakers available for UniGear ZS1 switchgear

**VD4 withdrawable circuit breaker (12 kV)**

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | W=650 | W=800 | W=1000 | W=1000 | W=1000 | W=650 | |
| | | P=150 | P=210 | P=275 | P=275 | P=275 | P=150 | |
| kV | kA | u/l=205 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | Circuit breaker type |
| | | ø=35 | ø=79 | ø=79 | ø=109 | ø=109 | ø=45 | |
| 12 | 16 | 630 | | | | | | VD4/P 12.06.16 p150 |
| | 20 | 630 | | | | | | VD4/P 12.06.20 p150 |
| | 25 | 630 | | | | | | VD4/P 12.06.25 p150 |
| | 31.5 | 630 | | | | | | VD4/P 12.06.32 p150 |
| | 16 | 1250 | | | | | | VD4/P 12.12.16 p150 |
| | 20 | 1250 | | | | | | VD4/P 12.12.20 p150 |
| | 25 | 1250 | | | | | | VD4/P 12.12.25 p150 |
| | 31.5 | 1250 | | | | | | VD4/P 12.12.32 p150 |
| | 40 | | | | | | 1250 | VD4/P 12.12.40 p150 |
| | 40 | | 1250 | | | | | VD4/P 12.12.40 p210 |
| | 50 | | 1250 | | | | | VD4/P 12.12.50 p210 |
| | 20 | | 1600 | | | | | VD4/P 12.16.20 p210 |
| | 25 | | 1600 | | | | | VD4/P 12.16.25 p210 |
| | 31.5 | | 1600 | | | | | VD4/P 12.16.32 p210 |
| | 40 | | 1600 | | | | | VD4/P 12.16.40 p210 |
| | 50 | | 1600 | | | | | VD4/P 12.16.50 p210 |
| | 20 | | 2000 | | | | | VD4/P 12.20.20 p210 |
| | 25 | | 2000 | | | | | VD4/P 12.20.25 p210 |
| | 31.5 | | 2000 | | | | | VD4/P 12.20.32 p210 |
| | 40 | | 2000 | | | | | VD4/P 12.20.40 p210 |
| | 50 | | 2000 | | | | | VD4/P 12.20.50 p210 |
| | 40 | | | 1250 | | | | VD4/P 12.12.40 p275 |
| | 20 | | | 1600 | | | | VD4/P 12.16.20 p275 |
| | 25 | | | 1600 | | | | VD4/P 12.16.25 p275 |
| | 31.5 | | | 1600 | | | | VD4/P 12.16.32 p275 |
| | 40 | | | 1600 | | | | VD4/P 12.16.40 p275 |
| | 50 | | | 1600 | | | | VD4/P 12.16.50 p275 |
| | 20 | | | 2000 | | | | VD4/P 12.20.20 p275 |
| | 25 | | | 2000 | | | | VD4/P 12.20.25 p275 |
| | 31.5 | | | 2000 | | | | VD4/P 12.20.32 p275 |
| | 40 | | | 2000 | | | | VD4/P 12.20.40 p275 |
| | 50 | | | 2000 | | | | VD4/P 12.20.50 p275 |
| | 20 | | | | 2500 | | | VD4/P 12.25.20 p275 |
| | 25 | | | | 2500 | | | VD4/P 12.25.25 p275 |
| | 31.5 | | | | 2500 | | | VD4/P 12.25.32 p275 |
| | 40 | | | | 2500 | | | VD4/P 12.25.40 p275 |
| | 50 | | | | 2500 | | | VD4/P 12.25.50 p275 |
| | 20 | | | | | 3150 (1) | | VD4/P 12.32.20 p275 |
| | 25 | | | | | 3150 (1) | | VD4/P 12.32.25 p275 |
| | 31.5 | | | | | 3150 (1) | | VD4/P 12.32.32 p275 |
| | 40 | | | | | 3150 (1) | | VD4/P 12.32.40 p275 |
| | 50 | | | | | 3150 (1) | | VD4/P 12.32.50 p275 |

W = Width of the switchgear..
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) Up to 4000 A rated current guaranteed with forced ventilation.

## VD4 withdrawable circuit breaker (17.5 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | W=650 | W=800 | W=1000 | W=1000 | W=1000 | W=650 | |
| | | P=150 | P=210 | P=275 | P=275 | P=275 | P=150 | |
| kV | kA | u/l=205 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | Circuit breaker type |
| | | ø=35 | ø=79 | ø=79 | ø=109 | ø=109 | ø=45 | |
| 17.5 | 16 | 630 | | | | | | VD4/P 17.06.16 p150 |
| | 20 | 630 | | | | | | VD4/P 17.06.20 p150 |
| | 25 | 630 | | | | | | VD4/P 17.06.25 p150 |
| | 31.5 | 630 | | | | | | VD4/P 17.06.32 p150 |
| | 16 | 1250 | | | | | | VD4/P 17.12.16 p150 |
| | 20 | 1250 | | | | | | VD4/P 17.12.20 p150 |
| | 25 | 1250 | | | | | | VD4/P 17.12.25 p150 |
| | 31.5 | 1250 | | | | | | VD4/P 17.12.32 p150 |
| | 40 | | | | | | 1250 | VD4/P 17.12.40 p150 |
| | 40 | | 1250 | | | | | VD4/P 17.12.40 p210 |
| | 50 | | 1250 | | | | | VD4/P 17.12.50 p210 |
| | 20 | | 1600 | | | | | VD4/P 17.16.20 p210 |
| | 25 | | 1600 | | | | | VD4/P 17.16.25 p210 |
| | 31.5 | | 1600 | | | | | VD4/P 17.16.32 p210 |
| | 40 | | 1600 | | | | | VD4/P 17.16.40 p210 |
| | 50 | | 1600 | | | | | VD4/P 17.16.50 p210 |
| | 20 | | 2000 | | | | | VD4/P 17.20.20 p210 |
| | 25 | | 2000 | | | | | VD4/P 17.20.25 p210 |
| | 31.5 | | 2000 | | | | | VD4/P 17.20.32 p210 |
| | 40 | | 2000 | | | | | VD4/P 17.20.40 p210 |
| | 50 | | 2000 | | | | | VD4/P 17.20.50 p210 |
| | 40 | | | 1250 | | | | VD4/P 17.12.40 p275 |
| | 20 | | | 1600 | | | | VD4/P 17.16.20 p275 |
| | 25 | | | 1600 | | | | VD4/P 17.16.25 p275 |
| | 31.5 | | | 1600 | | | | VD4/P 17.16.32 p275 |
| | 40 | | | 1600 | | | | VD4/P 17.16.40 p275 |
| | 50 | | | 1600 | | | | VD4/P 17.16.50 p275 |
| | 20 | | | 2000 | | | | VD4/P 17.20.20 p275 |
| | 25 | | | 2000 | | | | VD4/P 17.20.25 p275 |
| | 31.5 | | | 2000 | | | | VD4/P 17.20.32 p275 |
| | 40 | | | 2000 | | | | VD4/P 17.20.40 p275 |
| | 50 | | | 2000 | | | | VD4/P 17.20.50 p275 |
| | 20 | | | | 2500 | | | VD4/P 17.25.20 p275 |
| | 25 | | | | 2500 | | | VD4/P 17.25.25 p275 |
| | 31.5 | | | | 2500 | | | VD4/P 17.25.32 p275 |
| | 40 | | | | 2500 | | | VD4/P 17.25.40 p275 |
| | 50 | | | | 2500 | | | VD4/P 17.25.50 p275 |
| | 20 | | | | | 3150 (1) | | VD4/P 17.32.20 p275 |
| | 25 | | | | | 3150 (1) | | VD4/P 17.32.25 p275 |
| | 31.5 | | | | | 3150 (1) | | VD4/P 17.32.32 p275 |
| | 40 | | | | | 3150 (1) | | VD4/P 17.32.40 p275 |
| | 50 | | | | | 3150 (1) | | VD4/P 17.32.50 p275 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) Up to 4000 A rated current guaranteed with forced ventilation

# 5. Description

### VD4 withdrawable circuit breaker (24 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | |
|---|---|---|---|---|---|---|
| | | W=800 | W=1000 | W=1000 | W=1000 | |
| | | P=210 | P=275 | P=275 | P=275 | |
| kV | kA | u/l=310 | u/l=310 | u/l=310 | u/l=310 | Circuit breaker type |
| | | ø=35 | ø=35 | ø=79 | ø=109 | |
| | 16 | 630 | | | | VD4/P 24.06.16 p210 |
| | 20 | 630 | | | | VD4/P 24.06.20 p210 |
| | 25 | 630 | | | | VD4/P 24.06.25 p210 |
| | 16 | 1250 | | | | VD4/P 24.12.16 p210 |
| | 20 | 1250 | | | | VD4/P 24.12.20 p210 |
| | 25 | 1250 | | | | VD4/P 24.12.25 p210 |
| | 31.5 | 1250 | | | | VD4/P 24.12.32 p210 |
| | 16 | | 630 | | | VD4/P 24.06.16 p275 |
| | 20 | | 630 | | | VD4/P 24.06.20 p275 |
| | 25 | | 630 | | | VD4/P 24.06.25 p275 |
| | 16 | | 1250 | | | VD4/P 24.12.16 p275 |
| | 20 | | 1250 | | | VD4/P 24.12.20 p275 |
| | 25 | | 1250 | | | VD4/P 24.12.25 p275 |
| 24 | 31.5 | | 1250 | | | VD4/P 24.12.32 p275 |
| | 16 | | | 1600 | | VD4/P 24.16.16 p275 |
| | 20 | | | 1600 | | VD4/P 24.16.20 p275 |
| | 25 | | | 1600 | | VD4/P 24.16.25 p275 |
| | 31.5 | | | 1600 | | VD4/P 24.16.32 p275 |
| | 16 | | | 2000 | | VD4/P 24.20.16 p275 |
| | 20 | | | 2000 | | VD4/P 24.20.20 p275 |
| | 25 | | | 2000 | | VD4/P 24.20.25 p275 |
| | 31.5 | | | 2000 | | VD4/P 24.20.32 p275 |
| | 16 | | | 2300 (1) | | VD4/P 24.25.16 p275 |
| | 20 | | | 2300 (1) | | VD4/P 24.25.20 p275 |
| | 25 | | | 2300 (1) | | VD4/P 24.25.25 p275 |
| | 31.5 | | | 2300 (1) | | VD4/P 24.25.32 p275 |
| | 31.5 | | | | 2700 (2) | VD4/P 24.32.32 p275 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) 2500 A rated current guaranteed with forced ventilation.
(2) 3150 A rated current guaranteed with forced ventilation.

### VD4 withdrawable circuit breaker (36 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | |
|---|---|---|---|---|---|---|
| kV | kA | H = 951 - W = 788 - D = 778 - u/l = 380 - l/g = 399 - P = 275 | | | | Circuit breaker type |
| | 20 | 1250 A | | | | VD4/W 36.12.20 p275 |
| | 25 | 1250 A | | | | VD4/W 36.12.25 p275 |
| | 31.5 | 1250 A | | | | VD4/W 36.12.32 p275 |
| | 20 | | 1600 A | | | VD4/W 36.16.20 p275 |
| | 25 | | 1600 A | | | VD4/W 36.16.25 p275 |
| | 31.5 | | 1600 A | | | VD4/W 36.16.32 p275 |
| | 20 | | | 2000 A | | VD4/W 36.20.20 p275 |
| 36 | 25 | | | 2000 A | | VD4/W 36.20.25 p275 |
| | 31.5 | | | 2000 A | | VD4/W 36.20.32 p275 |
| | 20 | | | | 2500 A (1) | VD4/W 36.25.20 p275 |
| | 25 | | | | 2500 A (1) | VD4/W 36.25.25 p275 |
| | 31.5 | | | | 2500 A (1) | VD4/W 36.25.32 p275 |
| | 20 | | | | 3150 A (2) | VD4/W 36.32.20 p275 |
| | 25 | | | | 3150 A (2) | VD4/W 36.32.25 p275 |
| | 31.5 | | | | 3150 A (2) | VD4/W 36.32.32 p275 |

H = Height of the circuit breaker.
W = Width of the switchgear.
D = Depth of the circuit breaker.
u/l = Distance between bottom and top terminal.
l/g = Distance between the bottom terminal and the resting surface of the circuit breaker.
P = Pole horizontal centre distance.
(1) 2500 A rated current guaranteed with forced ventilation and tulip contacts diameter 79 mm (TN 1VYN300901-RA).
(2) 3150 A rated current guaranteed with forced ventilation.

### 5.6.3. Standard fittings of withdrawable circuit breakers for UniGear ZS1 switchgear (up to 24 kV) - UniGear ZS2 and PowerCube modules (VD4 36 kV)

The basic versions of the withdrawable circuit breakers are three-pole and fitted with:

- EL type manual operating mechanism
- mechanical signalling device for closing spring charged/discharged
- mechanical signalling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten auxiliary circuit breaker open/closed contacts

  Note: with the set of ten auxiliary contacts supplied as standard and the maximum number of electrical applications possible, three make contacts (signalling circuit breaker open) and four break contacts (signalling circuit breaker closed) are available.
- lever for manually charging the closing spring
- isolating contacts
- cord with connector (plug only) for auxiliary circuits, withstriker pin which does not allow connection of the plugin the socket if the rated current of the circuit breaker isdifferent from the rated current of the panel
- racking-in/out lever (the quantity must be defined according to the number of pieces of apparatus ordered)
- locking electromagnet in the truck. This prevents the circuit breaker from being racked into the panel with auxiliary circuits not connected (plug not inserted in the socket).




VD4 with poles in polyamide




VD4 - 36 kV




VD4 - up to 24 kV



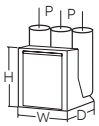

VD4 evo - up to 17 kV

# 5. Description

### 5.6.4. General characteristics of withdrawable circuit breakers for PowerCube modules

**General characteristics of withdrawable circuit breakers for PowerCube modules (12 kV)**




| Circuit breaker | | VD4/P 12 | | VD4/W 12 | | VD4/P 12 | |
|---|---|---|---|---|---|---|---|
| | PowerCube module | PB1 | | PB2 | | PB2 | |
| Standards | IEC 62271-100 | • | | • | | • | |
| Rated voltage | Ur [kV] | 12 | | 12 | | 12 | |
| Rated insulation voltage | Us [kV] | 12 | | 12 | | 12 | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | | 28 | | 28 | |
| Impulse withstand voltage | Up [kV] | 75 | | 75 | | 75 | |
| Rated frequency | fr [Hz] | 50-60 | | 50-60 | | 50-60 | |
| Rated normal current (40 °C) (1) | Ir [A] | 630 | 1250 | 630 | 1250 | 1250 | 1250 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | 16 | 16 | - | - |
| | | 20 | 20 | 20 | 20 | - | - |
| | | 25 | 25 | 25 | 25 | - | - |
| | | 31.5 | 31.5 | 31.5 | 31.5 | - | - |
| | | - | - | - | - | 40 | - |
| | | - | - | - | - | - | 50 |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | - | - |
| | | 20 | 20 | 20 | 20 | - | - |
| | | 25 | 25 | 25 | 25 | - | - |
| | | 31.5 | 31.5 | 31.5 | 31.5 | - | - |
| | | - | - | - | - | 40 | - |
| | | - | - | - | - | - | 50 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | - | - |
| | | 50 | 50 | 50 | 50 | - | - |
| | | 63 | 63 | 63 | 63 | - | - |
| | | 80 | 80 | 80 | 80 | - | - |
| | | - | - | - | - | 100 | - |
| | | - | - | - | - | - | 125 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | | • | | • | |
| Opening time | [ms] | 33 ... 60 | | 33 ... 60 | | 33 ... 60 | |
| Arcing time | [ms] | 10 ... 15 | | 10 ... 15 | | 10 ... 15 | |
| Total breaking time | [ms] | 43 ... 75 | | 43 ... 75 | | 43 ... 75 | |
| Closing time | [ms] | 30 ... 60 | | 30 ... 60 | | 30 ... 60 | |
| Maximum overall dimensions   | H [mm] | 628 | 628 | 691 | 691 | 691 | 691 |
| | W [mm] | 503 | 503 | 653 | 853 | 653 | 681 |
| | D [mm] | 662 | 662 | 642 | 642 | 641 | 643 |
| | Pole distance P [mm] | 150 | 150 | 210 | 210 | 210 | 210 |
| Weight | [kg] | 116 | 116 | 135 | 135 | 174 | 180 |
| Standardised table of dimensions | TN | 7412 (3) | 7412 (3) | 7420 (3) | 7420 (3) | - | - |
| | 1VCD | - | - | - | - | 003284 (3) | 003444 |
| Operating temperature | [°C] | - 5 ... + 40 | | - 5 ... + 40 | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | • | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | • | | | |

(1) Rated current guaranteed with circuit breaker installed in PowerCube enclosure and with 40 °C ambient temperature
(2) Up to 4000 A with forced ventilation.
(3) Poles in polyamide

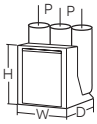
| VD4/P 12 | | | | | | | VD4/W 12 | |
|---|---|---|---|---|---|---|---|---|
| PB2 | | | | | PB3 | | PB3 | |
| • | | | | | • | | • | |
| 12 | | | | | 12 | | 12 | |
| 12 | | | | | 12 | | 12 | |
| 28 | | | | | 28 | | 28 | |
| 75 | | | | | 75 | | 75 | |
| 50-60 | | | | | 50-60 | | 50-60 | |
| 1600 | 1600 | 1600 | 2000 | 2000 | 2500 | 2500 | 3150 (²) | 3150 (²) |
| - | - | - | - | - | - | - | - | - |
| 20 | - | - | 20 | - | 20 | - | 20 | - |
| 25 | - | - | 25 | - | 25 | - | 25 | - |
| 31.5 | - | - | 31.5 | - | 31.5 | - | 31.5 | - |
| - | 40 | - | 40 | - | 40 | - | 40 | - |
| - | - | 50 | - | 50 | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - |
| 20 | - | - | 20 | - | 20 | - | 20 | - |
| 25 | - | - | 25 | - | 25 | - | 25 | - |
| 31.5 | - | - | 31.5 | - | 31.5 | - | 31.5 | - |
| - | 40 | - | 40 | - | 40 | - | 40 | - |
| - | - | 50 | - | 50 | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - |
| 50 | - | - | 50 | - | 50 | - | 50 | - |
| 63 | - | - | 63 | - | 63 | - | 63 | - |
| 80 | - | - | 80 | - | 80 | - | 80 | - |
| - | 100 | - | 100 | - | 100 | - | 100 | - |
| - | - | 125 | - | 125 | - | 125 | - | 125 |
| • | | | | | • | | • | |
| 33 ... 60 | | | | | 33 ... 60 | | 33 ... 60 | |
| 10 ... 15 | | | | | 10 ... 15 | | 10 ... 15 | |
| 43 ... 75 | | | | | 43 ... 75 | | 43 ... 75 | |
| 30 ... 60 | | | | | 30 ... 60 | | 30 ... 60 | |
| 691 | 691 | 691 | 690 | 691 | 691 | 691 | 730 | 691 |
| 653 | 653 | 681 | 653 | 681 | 853 | 853 | 853 | 853 |
| 642 | 641 | 643 | 642 | 643 | 640 | 643 | 640 | 643 |
| 210 | 210 | 210 | 210 | 210 | 275 | 275 | 275 | 275 |
| 160 | 174 | 180 | 160 | 190 | 186 | 225 | 221 | 240 |
| 7415 (³) | - | - | 7415 (³) | - | 7417 (³) | - | - | - |
| - | 003284 (³) | 003444 | - | 003444 | - | 003445 | 000152 (³) | 003596 |
| - 5 ... + 40 | | | | | - 5 ... + 40 | | - 5 ... + 40 | |
| • | | | | | • | | • | |
| • | | | | | • | | • | |


ABB

# 5. Description

**General characteristics of withrawable circuit breakers for PowerCube modules (15kV)**

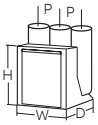



| Circuit breaker | | | VD4/P 15 | |
|---|---|---|---|---|
| | | PowerCube module | PB2/E & PB2/FL | |
| Standard | | IEEE C37.04 | • | |
| Rated voltage | | [kV] | 15 | |
| Rated frequency | | [Hz] | 50/60 | |
| Short-circuit breaking current Isc | | [kA] | 40 | |
| Rated current Ir | | [A] | 1200 | 2000 |
| Short-time withstand current | | [A] | 40 | |
| Short circuit withstand | | [A] | 2 | |
| Close and latch capability | | [kA] | 104 | |
| Operation sequence | | [O - 0,3 s - CO - 3 min - CO] | • | |
| % DC component | | [%] | 30 | |
| Interrupting time | | [ms] | 50 | |
| Closing time | | [ms] | 30…60 | |
| Mechanical endurance class | | [M2] | 10k | |
| Lightning impulse withstand voltage Up | | [kV] | 95 | |
| Power frequency withstand voltage Ud | | [kV] | 36 | |
| Operating temperature | | [°C] | -20…+40 | |
| Maximum overall dimensions   | Height | [mm] | 691 | |
| | Width | [mm] | 653 | |
| | Depth | [mm] | 642 | |
| | Pole distance | [mm] | 210 | |
| Standard table of dimensions | | TN | 7415 | |
| Weight | | [kg] | 160 | |

# 5. Description

**General characteristics of withdrawable circuit breakers for PowerCube modules (17.5 kV)**




| **Circuit breaker** | | **VD4/P 17** | | **VD4/W 17** | | **VD4/P 17** | |
|---|---|---|---|---|---|---|---|
| | **PowerCube module** | PB1 | | PB2 | | PB2 | |
| Standards | IEC 62271-100 | • | | • | | • | |
| Rated voltage | Ur [kV] | 17.5 | | 17.5 | | 17.5 | |
| Rated insulation voltage | Us [kV] | 17.5 | | 17.5 | | 17.5 | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 38 | | 38 | | 38 | |
| Impulse withstand voltage | Up [kV] | 95 | | 95 | | 95 | |
| Rated frequency | fr [Hz] | 50-60 | | 50-60 | | 50-60 | |
| Rated normal current (40 °C)(1) | Ir [A] | 630 | 1250 | 630 | 1250 | 1250 | 1250 |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | 16 | 16 | - | - |
| | | 20 | 20 | 20 | 20 | - | - |
| | | 25 | 25 | 25 | 25 | - | - |
| | | 31.5 | 31.5 | 31.5 | 31.5 | - | - |
| | | - | - | - | - | 40 | - |
| | | - | - | - | - | - | 50 |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | - | - |
| | | 20 | 20 | 20 | 20 | - | - |
| | | 25 | 25 | 25 | 25 | - | - |
| | | 31.5 | 31.5 | 31.5 | 31.5 | - | - |
| | | - | - | - | - | 40 | - |
| | | - | - | - | - | - | 50 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | - | - |
| | | 50 | 50 | 50 | 50 | - | - |
| | | 63 | 63 | 63 | 63 | - | - |
| | | 80 | 80 | 80 | 80 | - | - |
| | | - | - | - | - | 100 | - |
| | | - | - | - | - | - | 125 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | | • | | | |
| Opening time | [ms] | 33 ... 60 | | 33 ... 60 | | | |
| Arcing time | [ms] | 10 ... 15 | | 10 ... 15 | | | |
| Total breaking time | [ms] | 43 ... 75 | | 43 ... 75 | | | |
| Closing time | [ms] | 30 ... 60 | | 30 ... 60 | | | |
| Maximum overall dimensions   | H [mm] | 628 | 628 | 691 | 691 | 691 | 691 |
| | W [mm] | 503 | 503 | 653 | 653 | 653 | 681 |
| | D [mm] | 662 | 662 | 642 | 642 | 641 | 643 |
| | Pole distance P [mm] | 150 | 150 | 210 | 210 | 210 | 210 |
| Weight | [kg] | 116 | 116 | 135 | 135 | 174 | 180 |
| Standardised table of dimensions | TN | 7412 (3) | 7412 (3) | 7420 (3) | 7420 (3) | - | - |
| | 1VCD | - | - | - | - | 003284 (3) | 003444 |
| Operating temperature | [°C] | - 5 ... + 40 | | - 5 ... + 40 | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | • | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | • | | | |

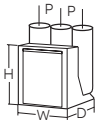
(1) Rated current guaranteed with circuit breaker installed in PowerCube enclosure and with 40 °C ambient temperature.
(2) Up to 4000 A with forced ventilation.
(3) Poles in polyamide.

| VD4/P 17 | | | | | | | VD4/W 17 | |
|---|---|---|---|---|---|---|---|---|
| PB2 | | | | | PB3 | | PB3 | |
| • | | | | | • | | • | |
| 17.5 | | | | | 17.5 | | 17.5 | |
| 17.5 | | | | | 17.5 | | 17.5 | |
| 38 | | | | | 38 | | 38 | |
| 95 | | | | | 95 | | 95 | |
| 50-60 | | | | | 50-60 | | 50-60 | |
| 1600 | 1600 | 1600 | 2000 | 2000 | 2500 | 2500 | 3150 (²) | 3150 (²) |
| - | - | - | - | - | - | - | - | - |
| 20 | - | - | 20 | - | 20 | - | 20 | - |
| 25 | - | - | 25 | - | 25 | - | 25 | - |
| 31.5 | - | - | 31.5 | - | 31.5 | - | 31.5 | - |
| - | 40 | - | 40 | - | 40 | - | 40 | - |
| - | - | 50 | - | 50 | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - |
| 20 | - | - | 20 | - | 20 | - | 20 | - |
| 25 | - | - | 25 | - | 25 | - | 25 | - |
| 31.5 | - | - | 31.5 | - | 31.5 | - | 31.5 | - |
| - | 40 | - | 40 | - | 40 | - | 40 | - |
| - | - | 50 | - | 50 | - | 50 | - | 50 |
| - | - | - | - | - | - | - | - | - |
| 50 | - | - | 50 | - | 50 | - | 50 | - |
| 63 | - | - | 63 | - | 63 | - | 63 | - |
| 80 | - | - | 80 | - | 80 | - | 80 | - |
| - | 100 | - | 100 | - | 100 | - | 100 | - |
| - | - | 125 | - | 125 | - | 125 | - | 125 |
| • | | | | | • | | • | |
| 33 ... 60 | | | | | 33 ... 60 | | 33 ... 60 | |
| 10 ... 15 | | | | | 10 ... 15 | | 10 ... 15 | |
| 43 ... 75 | | | | | 43 ... 75 | | 43 ... 75 | |
| 30 ... 60 | | | | | 30 ... 60 | | 30 ... 60 | |
| 691 | 691 | 691 | 690 | 691 | 691 | 691 | 730 | 691 |
| 653 | 653 | 681 | 653 | 681 | 853 | 853 | 853 | 853 |
| 642 | 641 | 643 | 642 | 643 | 640 | 643 | 640 | 643 |
| 210 | 210 | 210 | 210 | 210 | 275 | 275 | 275 | 275 |
| 160 | 174 | 180 | 160 | 190 | 186 | 225 | 221 | 240 |
| 7415 (³) | - | - | 7415 (³) | - | 7417 (³) | - | - | - |
| - | 003284 (³) | 003444 | - | 003444 | - | 003445 | 000152 (³) | 003596 |
| - 5 ... + 40 | | | | | - 5 ... + 40 | | - 5 ... + 40 | |
| • | | | | | • | | • | |
| • | | | | | • | | • | |

# 5. Description

**General characteristics of withdrawable circuit breakers for PowerCube modules (24 kV)**




| **Circuit breaker** | | **VD4/P 24** | | | | |
|---|---|---|---|---|---|---|
| | **PowerCube module** | **PB4** | | **PB5** | | |
| Standards | IEC 62271-100 | • | | • | | |
| Rated voltage | Ur [kV] | 24 | | 24 | | |
| Rated insulation voltage | Us [kV] | 24 | | 24 | | |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 50 | | 50 | | |
| Impulse withstand voltage | Up [kV] | 125 | | 125 | | |
| Rated frequency | fr [Hz] | 50-60 | | 50-60 | | |
| Rated normal current (40 °C) (1) | Ir [A] | 630 | 1250 | 1600 | 2000 | 2500 (2) |
| Rated breaking capacity (rated short-circuit breaking current symmetrical) | Isc [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 |
| Rated short-time withstand current (3s) | Ik [kA] | 16 | 16 | 16 | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 |
| | | – | 31.5 | 31.5 | 31.5 | 31.5 |
| Making capacity | Ip [kA] | 40 | 40 | 40 | 40 | 40 |
| | | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 |
| | | – | 80 | 80 | 80 | 80 |
| Operation sequence | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| Opening time | [ms] | 33 ... 60 | | 33 ... 60 | | |
| Arcing time | [ms] | 10 ... 15 | | 10 ... 15 | | |
| Total breaking time | [ms] | 43 ... 75 | | 43 ... 75 | | |
| Total breaking time | [ms] | 30 ... 60 | | 30 ... 60 | | |
| Maximum overall dimensions   | H [mm] | 794 | 794 | 838 | 838 | 838 |
| | W [mm] | 653 | 653 | 853 | 853 | 853 |
| | D [mm] | 802 | 802 | 790 | 790 | 790 |
| | Pole distance P [mm] | 210 | 210 | 275 | 275 | 275 |
| Weight | [kg] | 140 | 140/146 (3) | 228 | 228 | 228 |
| Standardised table of dimensions | TN | 7413 | 7413 | 7418 | 7418 | 7418 |
| | 1VCD | – | 000173 (3) | – | – | – |
| Operating temperature | [°C] | - 5 ... + 40 | | | | |
| Tropicalization | IEC: 60068-2-30, 60721-2-1 | • | | | | |
| Electromagnetic compatibility | IEC: 62271-1 | • | | | | |

(1) Rated current guaranteed with circuit breaker installed in PowerCube enclosure and with 40 °C ambient temperature.
(2) 2300 A rated uninterrupted current guaranteed with natural ventilation; 2500 A rated current guaranteed with forced ventilation.
(3) 31.5 kA version.

### 5.6.5. Types of withdrawable circuit breakers available for PowerCube modules

#### VD4 withdrawable circuit breaker (12 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | Circuit breaker type |
|---|---|---|---|---|---|---|---|
| | | W=650 | W=800 | W=1000 | W=1000 | W=1000 | |
| kV | kA | P=150 | P=210 | P=275 | P=275 | P=275 | |
| | | u/l=205 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | |
| | | ø=35 | ø=79 | ø=79 | ø=109 | ø=109 | |
| 12 | 16 | 630 | | | | | VD4/P 12.06.16 p150 |
| | 20 | 630 | | | | | VD4/P 12.06.20 p150 |
| | 25 | 630 | | | | | VD4/P 12.06.25 p150 |
| | 31.5 | 630 | | | | | VD4/P 12.06.32 p150 |
| | 16 | 1250 | | | | | VD4/P 12.12.16 p150 |
| | 20 | 1250 | | | | | VD4/P 12.12.20 p150 |
| | 25 | 1250 | | | | | VD4/P 12.12.25 p150 |
| | 31.5 | 1250 | | | | | VD4/P 12.12.32 p150 |
| | 16 | | 630 | | | | VD4/W 12.06.16 p210 |
| | 20 | | 630 | | | | VD4/W 12.06.20 p210 |
| | 25 | | 630 | | | | VD4/W 12.06.25 p210 |
| | 31.5 | | 630 | | | | VD4/W 12.06.32 p210 |
| | 16 | | 1250 | | | | VD4/W 12.12.16 p210 |
| | 20 | | 1250 | | | | VD4/W 12.12.20 p210 |
| | 25 | | 1250 | | | | VD4/W 12.12.25 p210 |
| | 31.5 | | 1250 | | | | VD4/W 12.12.32 p210 |
| | 40 | | 1250 | | | | VD4/P 12.12.40 p210 |
| | 50 | | 1250 | | | | VD4/P 12.12.50 p210 |
| | 20 | | | 1600 | | | VD4/P 12.16.20 p210 |
| | 25 | | | 1600 | | | VD4/P 12.16.25 p210 |
| | 31.5 | | | 1600 | | | VD4/P 12.16.32 p210 |
| | 40 | | | 1600 | | | VD4/P 12.16.40 p210 |
| | 50 | | | 1600 | | | VD4/P 12.16.50 p210 |
| | 20 | | | 2000 | | | VD4/P 12.20.20 p210 |
| | 25 | | | 2000 | | | VD4/P 12.20.25 p210 |
| | 31.5 | | | 2000 | | | VD4/P 12.20.32 p210 |
| | 40 | | | 2000 | | | VD4/P 12.20.40 p210 |
| | 50 | | | 2000 | | | VD4/P 12.20.50 p210 |
| | 20 | | | | 2500 | | VD4/P 12.25.20 p275 |
| | 25 | | | | 2500 | | VD4/P 12.25.25 p275 |
| | 31.5 | | | | 2500 | | VD4/P 12.25.32 p275 |
| | 40 | | | | 2500 | | VD4/P 12.25.40 p275 |
| | 50 | | | | 2500 | | VD4/P 12.25.50 p275 |
| | 20 | | | | | 3150 (1) | VD4/W 12.32.20 p275 |
| | 25 | | | | | 3150 (1) | VD4/W 12.32.25 p275 |
| | 31.5 | | | | | 3150 (1) | VD4/W 12.32.32 p275 |
| | 40 | | | | | 3150 (1) | VD4/W 12.32.40 p275 |
| | 50 | | | | | 3150 (1) | VD4/W 12.32.50 p275 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) Up to 4000 A rated current guaranteed with forced ventilation. Available on request.

# 5. Description

### VD4 withdrawable circuit breakers (15kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | Circuit breaker type |
|---|---|---|---|---|
| | | W=650 | W=800 | |
| | | P=150 | P=210 | |
| kV | kA | u/l=205 | u/l=310 | |
| | | Ø=35 | Ø=79 | |
| 15 | 31.5 | 1200 | | VD4/N/P 15.12.32 p150 |
| | 40 | | 1200 | VD4/P 15.12.40 p210 |
| | 31.5 | | 2000 | VD4/N/P 15.20.32 p210 |
| | 40 | | 2000 | VD4/P 15.20.40 p210 |

### VD4 withdrawable circuit breaker (17.5 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | Circuit breaker type |
|---|---|---|---|---|---|---|---|
| | | W=650 | W=800 | W=1000 | W=1000 | W=1000 | |
| | | P=150 | P=210 | P=275 | P=275 | P=275 | |
| kV | kA | u/l=205 | u/l=310 | u/l=310 | u/l=310 | u/l=310 | |
| | | ø=35 | ø=79 | ø=79 | ø=109 | ø=109 | |
| 17.5 | 16 | 630 | | | | | VD4/P 17.06.16 p150 |
| | 20 | 630 | | | | | VD4/P 17.06.20 p150 |
| | 25 | 630 | | | | | VD4/P 17.06.25 p150 |
| | 31.5 | 630 | | | | | VD4/P 17.06.32 p150 |
| | 16 | 1250 | | | | | VD4/P 17.12.16 p150 |
| | 20 | 1250 | | | | | VD4/P 17.12.20 p150 |
| | 25 | 1250 | | | | | VD4/P 17.12.25 p150 |
| | 31.5 | 1250 | | | | | VD4/P 17.12.32 p150 |
| | 16 | | 630 | | | | VD4/W 17.06.16 p210 |
| | 20 | | 630 | | | | VD4/W 17.06.20 p210 |
| | 25 | | 630 | | | | VD4/W 17.06.25 p210 |
| | 31.5 | | 630 | | | | VD4/W 17.06.32 p210 |
| | 16 | | 1250 | | | | VD4/W 17.12.16 p210 |
| | 20 | | 1250 | | | | VD4/W 17.12.20 p210 |
| | 25 | | 1250 | | | | VD4/W 17.12.25 p210 |
| | 31.5 | | 1250 | | | | VD4/W 17.12.32 p210 |
| | 40 | | 1250 | | | | VD4/P 17.12.40 p210 |
| | 50 | | 1250 | | | | VD4/P 17.12.50 p210 |
| | 20 | | | 1600 | | | VD4/P 17.16.20 p210 |
| | 25 | | | 1600 | | | VD4/P 17.16.25 p210 |
| | 31.5 | | | 1600 | | | VD4/P 17.16.32 p210 |
| | 40 | | | 1600 | | | VD4/P 17.16.40 p210 |
| | 50 | | | 1600 | | | VD4/P 17.16.50 p210 |
| | 20 | | | 2000 | | | VD4/P 17.20.20 p210 |
| | 25 | | | 2000 | | | VD4/P 17.20.25 p210 |
| | 31.5 | | | 2000 | | | VD4/P 17.20.32 p210 |
| | 40 | | | 2000 | | | VD4/P 17.20.40 p210 |
| | 50 | | | 2000 | | | VD4/P 17.20.50 p210 |
| | 20 | | | | 2500 | | VD4/P 17.25.20 p275 |
| | 25 | | | | 2500 | | VD4/P 17.25.25 p275 |
| | 31.5 | | | | 2500 | | VD4/P 17.25.32 p275 |
| | 40 | | | | 2500 | | VD4/P 17.25.40 p275 |
| | 50 | | | | 2500 | | VD4/P 17.25.50 p275 |
| | 20 | | | | | 3150 (1) | VD4/W 17.32.20 p275 |
| | 25 | | | | | 3150 (1) | VD4/W 17.32.25 p275 |
| | 31.5 | | | | | 3150 (1) | VD4/W 17.32.32 p275 |
| | 40 | | | | | 3150 (1) | VD4/W 17.32.40 p275 |
| | 50 | | | | | 3150 (1) | VD4/W 17.32.50 p275 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) Up to 4000 A rated current guaranteed with forced ventilation. Available on request.

## VD4 withdrawable circuit breaker (24 kV)

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | Circuit breaker type |
|---|---|---|---|---|
| | | W=800 | W=1000 | |
| | | P=210 | P=275 | |
| kV | kA | u/l=310 | u/l=310 | |
| | | ø=35 | ø=79 | |
| 24 | 16 | 630 | | VD4/P 24.06.16 p210 |
| | 20 | 630 | | VD4/P 24.06.20 p210 |
| | 25 | 630 | | VD4/P 24.06.25 p210 |
| | 16 | 1250 | | VD4/P 24.12.16 p210 |
| | 20 | 1250 | | VD4/P 24.12.20 p210 |
| | 25 | 1250 | | VD4/P 24.12.25 p210 |
| | 31.5 | 1250 | | VD4/P 24.12.32 p210 |
| | 16 | | 1600 | VD4/P 24.16.16 p275 |
| | 20 | | 1600 | VD4/P 24.16.20 p275 |
| | 25 | | 1600 | VD4/P 24.16.25 p275 |
| | 31.5 | | 1600 | VD4/P 24.16.32 p275 |
| | 16 | | 2000 | VD4/P 24.20.16 p275 |
| | 20 | | 2000 | VD4/P 24.20.20 p275 |
| | 25 | | 2000 | VD4/P 24.20.25 p275 |
| | 31.5 | | 2000 | VD4/P 24.20.32 p275 |
| | 16 | | 2300 (1) | VD4/P 24.25.16 p275 |
| | 20 | | 2300 (1) | VD4/P 24.25.20 p275 |
| | 25 | | 2300 (1) | VD4/P 24.25.25 p275 |
| | 31.5 | | 2300 (1) | VD4/P 24.25.32 p275 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
ø = Diameter of the isolating contact.
(1) Up to 2500 A rated current guaranteed with forced ventilation.

### Standard fittings of withdrawable circuit breakers for PowerCube modules

The basic versions of the withdrawable circuit breakers are always three-pole and fitted with:

- EL type manual operating mechanism
- mechanical signalling device for closing springs charged/discharged
- mechanical signalling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten circuit breaker open/closed auxiliary contacts
  Note: with the group of ten auxiliary contacts supplied as standard and the maximum number of electrical applications, three break contacts (signalling circuit breaker open) and four make contacts (signalling circuit breaker closed) are available.
- lever built into operating mechanism for linear loading of closing spring
- isolating contacts
- cord with connector (plug only) for auxiliary circuits, with striker pin which does not allow the plug to be inserted into the socket if the rated current of the circuit breaker is different from the rated current of the panel
- racking-in/out lever (the quantity must be defined according to the number of pieces of apparatus ordered)
- electromagnet lock in the truck. Prevents the circuit breaker from being racked into the panel when the auxiliary circuits are not connected (plug not in socket)
- door interlock (compulsory for ABB switchgear); this device prevents racking the circuit breaker into the switchgear when the switchgear door is open.



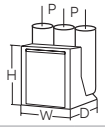

VD4 with poles in polyamide



# 5. Description

### 5.6.6. General characteristics of withdrawable circuit breakers for ZS8.4 switchgear




| Circuit breaker | | VD4/Z8 | | | | | |
|---|---|---|---|---|---|---|---|
| | Panel without partitions | • | | | | | |
| | Panel with partitions | - | | | | | |
| | Preussen Elektra - EON (2) | - | | | | | |
| | Width [kV] | 650 | 650 | 650 | 650 | 800 | 800 |
| | Depth [kV] | 1000 | 1000 | 1000 | 1000 | 1200 | 1200 |
| Standards | IEC 62271-100 | • | | | | | |
| | VDE 0671 | • | | | | | |
| Rated voltage | Ur [kV] | 12 | 12 | 17.5 | 17.5 | 24 | 24 |
| Rated insulation voltage | Us [kV] | 12 | 12 | 17.5 | 17.5 | 24 | 24 |
| Withstand voltage at 50 Hz | Ud (1 min) [kV] | 28 | 28 | 38 | 38 | 50 | 50 |
| Impulse withstand voltage | Up [kV] | 75 | 75 | 95 | 95 | 125 | 125 |
| Rated frequency | fr [Hz] | 50-60 | | | | | |
| Rated normal current (40 °C) (1) | Ir [A] | 630 | 1250 | 630 | 1250 | 630 | 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | Isc [kA] | - | - | - | - | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 | 25 |
| Rated short-time withstand current (3 s) | Ik [kA] | - | - | - | - | 16 | 16 |
| | | 20 | 20 | 20 | 20 | 20 | 20 |
| | | 25 | 25 | 25 | 25 | 25 | 25 |
| Making capacity | Ip [kA] | - | - | - | - | 40 | 40 |
| | | 50 | 50 | 50 | 50 | 50 | 50 |
| | | 63 | 63 | 63 | 63 | 63 | 63 |
| Operation sequence | [O-0.3s-CO-15s-CO] | • | | | | | |
| Opening time | [ms] | 33...60 | | | | | |
| Arcing time | [ms] | 10...15 | | | | | |
| Total breaking time | [ms] | 43...75 | | | | | |
| Closing time | [ms] | 60...80 | | | | | |
| Maximum overall dimensions   | H [mm] | 579 | 579 | 579 | 579 | 680 | 680 |
| | W [mm] | 503 | 503 | 503 | 503 | 653 | 653 |
| | D [mm] | 548 | 548 | 548 | 548 | 646 | 646 |
| | Pole distance P [mm] | 150 | 150 | 150 | 150 | 210 | 210 |
| Weight | [kg] | 116 | 116 | 116 | 116 | 140 | 140 |
| Standardised table of dimensions | 1VCD | 000092 | 000137 | 000137 | 000137 | 000089 | 000138 |
| Operating temperature | [°C] | – 5 ... + 40 | | | | | |
| Tropicalisation | IEC 60068-2-30 | • | | | | | |
| | IEC 60721-2-1 | • | | | | | |
| Electromagnetic compatibility | IEC 62271-1 | • | | | | | |

(1) Rated current guaranteed with circuit breaker installed in switchgear with 40 °C ambient temperature.
(2) Special type with device for charging the closing spring by means of a rotary handle outside the operating mechanism.

| VD4/ZT8 | | | | | | VD4/ZS8 | | | |
|---|---|---|---|---|---|---|---|---|---|
| - | | | | | | - | | | |
| • | | | | | | - | | | |
| - | | | | | | • | | | |
| 650 | 650 | 650 | 650 | 800 | 800 | 650 | 650 | 800 | 800 |
| 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| • | | | | | | • | | | |
| • | | | | | | • | | | |
| 12 | 12 | 17.5 | 17.5 | 24 | 24 | 12 | 12 | 24 | 24 |
| 12 | 12 | 17.5 | 17.5 | 24 | 24 | 12 | 12 | 24 | 24 |
| 28 | 28 | 38 | 38 | 50 | 50 | 28 | 28 | 50 | 50 |
| 75 | 75 | 95 | 95 | 125 | 125 | 75 | 75 | 125 | 125 |
| 50-60 | | | | | | 50-60 | | | |
| 630 | 1250 | 630 | 1250 | 630 | 1250 | 630 | 1250 | 630 | 1250 |
| - | - | - | - | 16 | 16 | - | - | 16 | 16 |
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| - | - | - | - | 16 | 16 | - | - | 16 | 16 |
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| - | - | - | - | 40 | 40 | - | - | 40 | 40 |
| 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 |
| • | | | | | | • | | | |
| 33...60 | | | | | | 40...60 | | | |
| 10...15 | | | | | | 10...15 | | | |
| 43...75 | | | | | | 50...75 | | | |
| 60...80 | | | | | | 60...80 | | | |
| 579 | 579 | 579 | 579 | 680 | 680 | 579 | 579 | 680 | 680 |
| 503 | 503 | 503 | 503 | 653 | 653 | 503 | 503 | 653 | 653 |
| 638 | 638 | 638 | 638 | 646 | 646 | 638 | 638 | 646 | 646 |
| 150 | 150 | 150 | 150 | 210 | 210 | 150 | 150 | 210 | 210 |
| 116 | 116 | 116 | 116 | 140 | 140 | 116 | 116 | 140 | 140 |
| 000093 | 000134 | 000134 | 000134 | 000090 | 000136 | 000091 | 000133 | 000088 | 000135 |
| – 5 ... + 40 | | | | | | – 5 ... + 40 | | | |
| • | | | | | | • | | | |
| • | | | | | | • | | | |
| • | | | | | | • | | | |

# 5. Description

### 5.6.7. General characteristics of withdrawable circuit breakers for ZS8.4 switchgear

**VD4/ZS8 - VD4/ZT8 - VD4/Z8 withdrawable circuit breaker for ZS8.4 switchgear**

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | | | | Circuit breaker type |
|---|---|---|---|---|---|---|---|---|
| | | Panel without partition | | Panel with partition | | Special panel EON | | |
| | | W = 650 | W = 800 | W = 650 | W = 800 | W = 650 | W = 800 | |
| kV | kA | P = 150 | P = 210 | P = 150 | P = 210 | P = 150 | P = 210 | |
| | | u/l = 205 | u/l = 310 | u/l = 205 | u/l = 310 | u/l = 205 | u/l = 310 | |
| | | ø = 35 | ø = 35 | ø = 35 | ø = 35 | ø = 35 | ø = 35 | |
| 12 | 20 | 630 | | | | | | VD4/Z8 12.06.20 p150 |
| | 25 | 630 | | | | | | VD4/Z8 12.06.25 p150 |
| | 20 | 1250 | | | | | | VD4/Z8 12.12.20 p150 |
| | 25 | 1250 | | | | | | VD4/Z8 12.12.25 p150 |
| | 20 | | | 630 | | | | VD4/ZT8 12.06.20 p150 |
| | 25 | | | 630 | | | | VD4/ZT8 12.06.25 p150 |
| | 20 | | | 1250 | | | | VD4/ZT8 12.12.20 p150 |
| | 25 | | | 1250 | | | | VD4/ZT8 12.12.25 p150 |
| | 20 | | | | | 630 | | VD4/ZS8 12.06.20 p150 |
| | 25 | | | | | 630 | | VD4/ZS8 12.06.25 p150 |
| | 20 | | | | | 1250 | | VD4/ZS8 12.12.20 p150 |
| | 25 | | | | | 1250 | | VD4/ZS8 12.12.25 p150 |
| 17.5 | 20 | 630 | | | | | | VD4/Z8 17.06.20 p150 |
| | 25 | 630 | | | | | | VD4/Z8 17.06.25 p150 |
| | 20 | 1250 | | | | | | VD4/Z8 17.12.20 p150 |
| | 25 | 1250 | | | | | | VD4/Z8 17.12.25 p150 |
| | 20 | | | 630 | | | | VD4/ZT8 17.06.20 p150 |
| | 25 | | | 630 | | | | VD4/ZT8 17.06.25 p150 |
| | 20 | | | 1250 | | | | VD4/ZT8 17.12.20 p150 |
| | 25 | | | 1250 | | | | VD4/ZT8 17.12.25 p150 |
| 24 | 16 | | 630 | | | | | VD4/Z8 24.06.16 p210 |
| | 20 | | 630 | | | | | VD4/Z8 24.06.20 p210 |
| | 25 | | 630 | | | | | VD4/Z8 24.06.25 p210 |
| | 16 | | 1250 | | | | | VD4/Z8 24.12.16 p210 |
| | 20 | | 1250 | | | | | VD4/Z8 24.12.20 p210 |
| | 25 | | 1250 | | | | | VD4/Z8 24.12.25 p210 |
| | 16 | | | | 630 | | | VD4/ZT8 24.06.16 p210 |
| | 20 | | | | 630 | | | VD4/ZT8 24.06.20 p210 |
| | 25 | | | | 630 | | | VD4/ZT8 24.06.25 p210 |
| | 16 | | | | 1250 | | | VD4/ZT8 24.12.16 p210 |
| | 20 | | | | 1250 | | | VD4/ZT8 24.12.20 p210 |
| | 25 | | | | 1250 | | | VD4/ZT8 24.12.25 p210 |
| | 16 | | | | | | 630 | VD4/ZS8 24.06.16 p210 |
| | 20 | | | | | | 630 | VD4/ZS8 24.06.20 p210 |
| | 25 | | | | | | 630 | VD4/ZS8 24.06.25 p210 |
| | 16 | | | | | | 1250 | VD4/ZS8 24.12.16 p210 |
| | 20 | | | | | | 1250 | VD4/ZS8 24.12.20 p210 |
| | 25 | | | | | | 1250 | VD4/ZS8 24.12.25 p210 |

W = Width of the switchgear.
P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
Ø = Diameter of the isolating contact.

### 5.6.8. Standard fittings for withdrawable circuit breakers for ZS8.4 switchgear

The basic versions of the withdrawable circuit breakers are always three-pole and fitted with:

- EL type manual operating mechanism
- mechanical signalling device for closing spring charged/ discharged
- mechanical signalling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten auxiliary circuit breaker open/closed contacts

  Note: with the set of ten auxiliary contacts supplied as standard and the maximum number of electrical applications possible, three make contacts (signalling circuit breaker open) and four break contacts (signalling circuit breaker closed) are available.
- lever for manually charging the closing springs incorporatedin the operating mechanism for VD4/ Z8 and VD4/ZT8,external with rotary movement for VD4/ZS8
- isolating contacts
- cord with connector (only plug) for auxiliary circuits, withstriker pin which does not allow connection of the plugin the socket if the rated current of the circuit breaker isdifferent from the rated current of the panel
- racking-in/out lever (the quantity must be defined accordingto the number of pieces of apparatus ordered)

### 5.6.9. VD4/ZS8 (Preussen Elektra-EON version)

- Device for recharging the closing spring, with door closed, by means of removable rotary handle and outside the operating mechanism and the switchgear
- 64-pin Harting socket with mechanical interlock which prevents traverse of the circuit breaker when the plug is not inserted in the socket
- Interlock with the door which prevents insertion of the spring charging lever when the circuit breaker is closed
- Interlock with the door and the 64-pin Harting socket which prevents door closure when the plug is not inserted in the socket.

### 5.6.10. VD4/Z8 - VD4/ZT8

- Harting 64-pin socket with mechanical interlock which prevents traverse of the circuit breaker when the plug is not inserted in the socket.



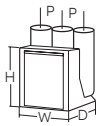

Caption

1) Device for spring charging with rotary handle
2) Harting 64-pin socket with mechanical interlock which prevents traverse when the socket is not inserted
3) Door-socket-spring charging device interlock (only VD4/ZS8 version)

# 5. Description

### 5.6.11. General characteristics of withdrawable circuit breakers for UniSwitch switchgear and UniMix (24 kV) switchgear




| Circuit breaker | | | VD4/SEC | VD4/P 12 | | VD4/P 17 | |
|---|---|---|---|---|---|---|---|
| Standards | | IEC 62271-100 | • | • | | • | |
| Rated voltage | | Ur [kV] | 24 | 12 | | 17.5 | |
| Rated insulation voltage | | Us [kV] | 24 | 12 | | 17.5 | |
| Withstand voltage at 50 Hz | | Ud (1 min) [kV] | 50 | 28 | | 38 | |
| Impulse withstand voltage | | Up [kV] | 125 | 75 | | 95 | |
| Rated frequency | | fr [Hz] | 50-60 | 50-60 | | 50-60 | |
| Rated normal current (40 °C) (1) | | Ir [A] | 630 - 1250 | 630 | 1250 | 630 | 1250 |
| Rated breaking capacity (rated symmetrical short-circuit current) | | Isc [kA] | 16 | 16 | 16 | 16 | 16 |
| | | | 20 | 20 | 20 | 20 | 20 |
| | | | 25 | 25 | 25 | 25 | 25 |
| Rated short-time withstand current (3 s) | | Ik [kA] | 16 | 16 | 16 | 16 | 16 |
| | | | 20 | 20 | 20 | 20 | 20 |
| | | | 25 | 25 | 25 | 25 | 25 |
| Making capacity | | Ip [kA] | 40 | 40 | 40 | 40 | 40 |
| | | | 50 | 50 | 50 | 50 | 50 |
| | | | 63 | 63 | 63 | 63 | 63 |
| Operation sequence | | [O - 0.3 s - CO - 15 s - CO] | • | • | • | • | • |
| Opening time | | [ms] | 33 ... 60 | 33 ... 60 | | 33 ... 60 | |
| Arcing time | | [ms] | 10 ... 15 | 10 ... 15 | | 10 ... 15 | |
| Total breaking time | | [ms] | 43 ... 75 | 43 ... 75 | | 43 ... 75 | |
| Closing time | | [ms] | 30 ... 60 | 30 ... 60 | | 30 ... 60 | |
| Maximum overall dimensions |  | H [mm] | 743 | 628 | 628 | 632 | 632 |
| | | W [mm] | 653 | 503 | 503 | 503 | 503 |
| | | D [mm] | 742 | 662 | 662 | 664 | 664 |
| | | Pole distance P [mm] | 210 | 150 | 150 | 150 | 150 |
| Weight | | [kg] | 133 | 116 | 116 | 116 | 116 |
| Standardised table of dimensions | | 1VCD | 000190 | 7412 (2) | 7412 (2) | 7412 (2) | 7412 (2) |
| Operating temperature | | [°C] | - 5 ... + 40 | - 5 ... + 40 | | - 5 ... + 40 | |
| Tropicalization | | IEC: 60068-2-30, 60721-2-1 | • | • | • | • | • |
| Electromagnetic compatibility | | IEC 62271 | • | • | • | • | • |



(1) Rated current guaranteed with circuit breaker installed in switchgear with 40 °C ambient temperature.
(2) Poles in polyamide.

**Withdrawable circuit breakers for UniSec switchgear**

| Ur | Isc | Rated uninterrupted current (40 °C) [A] | | | Circuit breaker type |
|---|---|---|---|---|---|
| | | P=150 | P=150 | P=210 | |
| kV | kA | u/l=205 | u/l=205 | u/l=310 | |
| | | ø=35 | ø=35 | ø=79 | |
| 12 | 16 | 630 | | | VD4/P 12.06.16 p150 |
| | 20 | 630 | | | VD4/P 12.06.20 p150 |
| | 25 | 630 | | | VD4/P 12.06.25 p150 |
| | 16 | 1250 | | | VD4/P 12.12.16 p150 |
| | 20 | 1250 | | | VD4/P 12.12.20 p150 |
| | 25 | 1250 | | | VD4/P 12.12.25 p150 |
| 17 | 16 | | 630 | | VD4/P 17.06.16 p150 |
| | 20 | | 630 | | VD4/P 17.06.20 p150 |
| | 25 | | 630 | | VD4/P 17.06.25 p150 |
| | 16 | | 1250 | | VD4/P 17.12.16 p150 |
| | 20 | | 1250 | | VD4/P 17.12.20 p150 |
| | 25 | | 1250 | | VD4/P 17.12.25 p150 |
| 24 | 16 | | | 630 | VD4/SEC 24.06.16 p210 |
| | 20 | | | 630 | VD4/SEC 24.06.20 p210 |
| | 25 | | | 630 | VD4/SEC 24.06.25 p210 |
| | 16 | | | 1250 | VD4/SEC 24.12.16 p210 |
| | 20 | | | 1250 | VD4/SEC 24.12.20 p210 |
| | 25 | | | 1250 | VD4/SEC 24.12.25 p210 |

P = Pole horizontal centre distance.
u/l = Distance between bottom and top terminal.
Ø = Diameter of the isolating contact.

### 5.6.12. Standard fittings of withdrawable circuit breakers for UniSec

The basic versions of the withdrawable circuit breakers are three-pole and fitted with:

- EL type manual operating mechanism
- mechanical signalling device for closing springs charged/discharged
- mechanical signalling device for circuit breaker open/closed
- closing pushbutton
- opening pushbutton
- operation counter
- set of ten circuit breaker open/closed auxiliary contacts

Note: with the group of ten auxiliary contacts supplied as standard and the maximum number of electrical applications, three break contacts (signalling circuit breaker open) and four make contacts (signalling circuit breaker closed) are available.

- lever built into operating mechanism for linear loading of closing spring
- isolating contacts
- cord with connector (plug only) for auxiliary circuits, with striker pin which does not allow the plug to be inserted into the socket if the rated current of the circuit breaker is different from the rated current of the panel
- racking-in/out lever (the quantity must be defined according to the number of pieces of apparatus ordered)

# 5. Description

## 5.7. Characteristics of the electrical accessories

**The accessories identified with the same number are alternative to each other.**

### 1 Shunt opening release (-MBO1)

Allows opening command of apparatus to be enabled by remote control.
This release is suitable for both instantaneous and permanent duty. However, an auxiliary contact -BGB1 de-energizes it after circuit breaker has opened. In the case of instantaneous service, the current impulse must last at least 100 ms.
This release can be controlled by the following devices: coil continuity control (CCC), opening circuit supervision (TCS)(*) or the ABB STU functionality control device (see accessory 21, supplied on request).

| Characteristics | |
|---|---|
| Un | 24-30-48-60-110...132-220...250 V DC |
| Un | 48-60-110...127-220...250 V AC 50-60 Hz |
| Operating limits | 65 ... 120% Un |
| Inrush power (Ps) | 60...100 W / VA |
| Continuous power consumption (Pc) | 1.5 W |
| Electronics self-consumption (no coil supplied); value independent of voltage applied | 1.5 mA |
| Opening time | 33...60 ms |
| Insulation voltage | 2000 V 50 Hz (for 1 min) |

(*) The minimum current that the relay with TCS function (used for monitoring coil continuity) detects as a condition denoting that the trip circuit is operating correctly (specified for each relay in the relative manual), must be sensibly higher than the current consumption of the actual coil (~1.5 mA).
If this fails to occur, always add, in parallel to the TCS, a circuit able to absorb sufficient current to compensate the gap while preventing the total current in the TCS circuit from rising above the maximum threshold (Itcs < 10 mA for High Voltage coils - from 110V to 250V, and Itcs < 50 mA for Low Voltage coils from 24 V to 60 V).
A simple resistor can be sized for the purpose, depending on the parameters of the TCS and the auxiliary voltage range used.

### 2 Additional shunt opening release (-MBO2)

Similarly to shunt opening release -MBO1, this allows the opening command of the apparatus to be transmitted by remote control. It can be powered by the same circuit as main shunt opening release -MBO1 or by a circuit that is completely separate from release -MBO1.
This release is suitable for both instantaneous and permanent duty. However, an auxiliary contact -BGB1 de-energizes it after the circuit breaker has opened.
To guarantee the release action, the current impulse must last at least 100 ms.
Continuity functionality can be checked with a continuity control device (CCC), opening circuit supervision (TCS)(*) or the STU functionality control device (see accessory 21, supplied on request).
-MBO2 has the same electrical and operating characteristics as release -MBO1.






## 3 Opening solenoid (-MO3)

The opening solenoid (-MO3) is a special release with demagnetisation to be combined with an overcurrent protection relay of the self-supplied type.
It is located in the operating mechanism (in the left side piece) and is not alternative to the additional shunt opening release (-MO2).
It is not available for 40 and 50 kA circuit breakers.
Should the application of this accessory be required, specify the request at the time of order since subsequent application by the customer is not possible.

Note: for combination with the protection relays, please ask for the document: Data sheet 1VCD600854.

The opening solenoid (-MBO3) is available in two versions:

- For DC (release by discharging energy stored in protection relay against overcurrent of the self-supplied type)
- For AC (release by means of the energy supplied by an adder transformer on the secondaries of the protection current transformers (the TA is at customer's charge)

(*) The minimum current that the relay with TCS function (used for monitoring coil continuity) detects as a condition denoting that the trip circuit is operating correctly (specified for each relay in the relative manual), must be sensibly higher than the current consumption of the actual coil (~1.5 mA).
If this fails to occur, always add, in parallel to the TCS, a circuit able to absorb sufficient current to compensate the gap while preventing the total current in the TCS circuit from rising above the maximum threshold (Itcs < 10 mA for High Voltage coils - from 110V to 250V, and Itcs < 50 mA for Low Voltage coils from 24 V to 60 V).
A simple resistor can be sized for the purpose, depending on the parameters of the TCS and the auxiliary voltage range used.

## 4 Shunt closing release (-MC)

Allows closing command of apparatus to be transmitted by remote control.
This release is suitable for both instantaneous and permanent duty. An auxiliary contact that de-energizes it after the circuit breaker has closed is not envisaged.
The permanently supplied release provides the electrical anti-pumping function with both electrical opening and re-closing commands maintained. To guarantee the closing action, the current impulse must last at least 100 ms.
If there is the same supply voltage for shunt closing release -MBC and under-voltage release -MBU and the circuit breaker must close automatically when auxiliary voltage returns, there must be a delay of at least 50 ms between under-voltage release energizing and energizing of the shunt closing release to allow the closing operation to take place.Continuity functionality can be checked with a continuity control device (CCC), opening circuit supervision (TCS)(*) or the STU functionality control device (see accessory 21, supplied on request).

| Characteristics | |
|---|---|
| Un | 24-30-48-60-110...132-220...250 V DC |
| Un | 48-60-110...127-220...250 V AC 50-60 Hz |
| Operating limits | 65 ... 120% Un |
| Inrush power (Ps) | 60...100 W / VA |
| Continuous power consumption (Pc) | 1.5 W |
| Electronics self-consumption (no coil supplied); value independent of voltage applied | 1.5 mA |
| Opening time | 33...60 ms |
| Insulation voltage | 2000 V 50/60 Hz (for 1 min) |





# 5. Description

### 5 Undervoltage release (-MBU)

The undervoltage release opens the circuit breaker when there is a sensible reduction or lack of the voltage that powers it. The circuit breaker can only close when the release is energized (the closing lock is obtained mechanically).
It can be used for remote release (by means of a pushbutton of the normally closed type), for locking on automatic closing/opening in the absence of voltage in the auxiliary circuits. Supplied by means of the secondary output of a voltage transformer, it provides locking upon automatic closing/opening in the absence of voltage in the Medium Voltage main circuit.
If there is the same supply voltage for shunt closing release -MBC and under-voltage release -MBU and the circuit breaker must close automatically when auxiliary voltage returns, there must be a delay of at least 50 ms between under-voltage release energizing and energizing of the shunt closing release to allow the closing operation to take place.

The undervoltage release is available in the following versions:

**5A** Undervoltage release (with supply shunted from a transformer on the supply side of the circuit breaker or from an auxiliary power supply, regardless of the state in which the circuit breaker is to be found).

**5B** Undervoltage release with -KFT electronic time-lag device (0.5 - 1 - 1.5 - 2 - 3 s) (with power supply as indicated for 5A); this device is supplied with a 0.5 s setting (the adjustments are described in the Circuit diagrams chapter)

| Characteristics | |
|---|---|
| Un | 24-30-48-60-110...132-220...250 V DC |
| Un | 48-60-110...127-220...250 V AC 50-60 Hz |
| Operating limits | – circuit breaker opening: 35-70% Un |
| | – circuit breaker closing: 85-110% Un |
| Inrush power (Ps) | 150 W / VA |
| Continuous power consumption (Pc) | 1.55 W |
| Electronics self-consumption (no coil supplied); value independent of voltage applied | 1.5 mA |
| Opening time | 60...80 ms |
| Insulation voltage | 2000 V 50/60 Hz (for 1 min) |

Note
As an alternative to the undervoltage release, an additional shunt opening release (-MBO4) with the same electrical and operating specifications as shunt opening release (-MBO1) can be installed on request (only for circuit breakers 12..17.5 kV up to 40 kA and 24 kV up to 31.5 kA).
Warning! Since installation of the additional shunt opening release (-MBO4) requires a special mounting plate for releases, ask for application (-MBO4) when ordering and not after delivery.



### 5a Electronic time delay device (-KFT)

The electronic time delay device must be mounted externally in relation to the circuit breaker. It allows release trip delay with established and adjustable times.
The use of the undervoltage release is recommended in order to prevent trips when the power supply network of the release may be subject to cuts or voltage drops of short duration.
If it is not supplied, circuit breaker closing is disabled.
The time delay device must be combined with an undervoltage release for d.c.
Rated voltage of the undervoltage release must be within the selected range of working of the time-delay device.

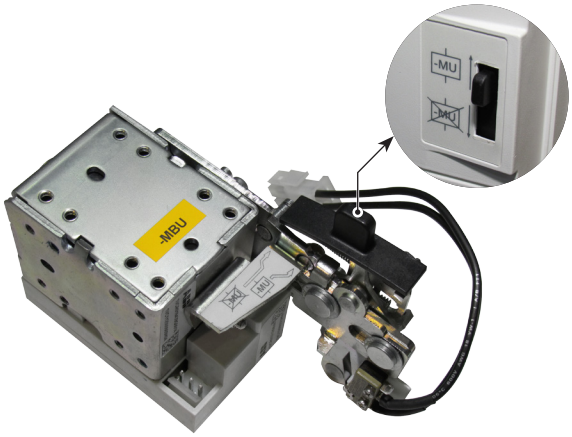
| Characteristics of the time-delay device | |
|---|---|
| Un | 24...30 - 48 - 60 - 110...127 - 220...250 V– |
| Un | 48 - 60 - 110...127 - 220...240 - V~ 50/60 Hz |
| Adjustable opening time (release + time delay device): 0.5-1-1.5-2-3 s | |

### 6 Undervoltage release mechanical override

This is a mechanical device which allows the undervoltage release trip to be temporarily excluded.
It is always fitted with electrical signalling.

**Should the application of this accessory be required, specify the request at the time of order since subsequent application by the customer is not possible.**



# 5. Description

### 7a Auxiliary contacts of the circuit breaker (-BGB1) for 12 to 24 kV versions

Electrical signalling of circuit breaker open/closed can be obtained with a group of 10, 16 or 20 auxiliary contacts for the fixed version and 10 or 16 auxiliary contacts for the withdrawable version. The standard equipment comprises 10 auxiliary contacts.

**Note**

The following are available using the standard group of ten auxiliary contacts and the maximum number of electrical accessories:

- for fixed circuit breakers: three closing contacts "a" for signalling circuit breaker open and five opening contacts "b" for signalling circuit breaker closed;
- for withdrawable circuit breakers: three closing contacts "a" for signalling circuit breaker open and four opening contacts "b" for signalling circuit breaker closed;

Circuit breakers in the fixed version are available with two finishing accessories (to be specified when ordering):

- non-wired auxiliary contacts; wiring to the terminals of the contacts is at the customer's charge (photo below left; the terminal box to which the other electrical accessories are wired is at the top); ask for instructions 1VCD601204 (available in the main languages) which describe how to remove, wire auxiliary contacts more easily and fit auxiliary contacts unit back into its housing;
- auxiliary contacts already wired to the terminal box (see photo at top right).

Consult circuit diagrams 1VCD400151 for fixed circuit breakers and 1VCD400155 for withdrawable circuit breakers.

**Note:** The main shunt opening release and/or the additional shunt opening release use 1 and/or 2 closing contacts "a", thereby reducing the number of auxiliary contacts available. Always check the maximum number of contacts available with non-standard equipment.

The new diagrams are interchangeable with the existing ones, with the following exceptions:

- diagram 1VCD400151 (substitutes 1VCD400046 and 1VCD400099)
- fig. 34 on the previous diagrams is represented by fig. 31 + fig. 32 on the new diagram;
- fig. 33 and fig. 35 on the previous diagrams are not available with the new layout
- diagram 1VCD400155 (substitutes 1VCD400047)







Auxiliary contacts –BGB1 conform to the following standards/regulations/directives:

- IEC 62271-100
- IEEE C37.54
- EN 61373 cat.1 class B / impact and vibration test
- Germanish Loyd regulation / vibrations envisaged by the shipping registers
- UL 508
- EN 60947 (DC-21A DC-22A DC-23A AC-21A)
- RoHS Directive

| General characteristics | |
|---|---|
| Insulation voltage to standard VDE 0110, Group C | 660 V AC<br>800 V DC |
| Rated voltage | 24 V ... 660 V |
| Test voltage | 2 kV for 1 min |
| Maximum rated current | 10 A - 50/60 Hz |
| Breaking capacity | Class 1 (IEC 62271-1) |
| Number of contacts | 5 |
| Groups of contacts | 10 / 16 / 20 |
| Contact travel | 90° |
| Actuating force | 0.66 Nm |
| Resistance | <6.5 mΩ |
| Storage temperature | –30 °C ... +120 °C |
| Operating temperature | –20 °C ... +70 °C<br>(-30° ref. ANSI 37.09) |
| Contact overtemperature | 10 K |
| Mechanical life | 30.000 mechanical operations |
| Protection class | IP20 |
| Cable section | 1 mm² |

| Electrical characteristics (according to IEC 60947) | | |
|---|---|---|
| Rated current Un | | Breaking capacity (10000 interruptions) |
| 220 V AC | Cosφ = 0.70 | 20 A |
| 220 V DC | Cosφ = 0.45 | 10 A |
| 24 V DC | 1 ms | 12 A |
| | 15 ms | 9 A |
| | 50 ms | 6 A |
| 60 V DC | 1 ms | 10 A |
| | 15 ms | 6 A |
| | 50 ms | 4.6 A |
| 110 V DC | 1 ms | 7 A |
| | 15 ms | 4.5 A |
| | 50 ms | 3.5 A |
| 220 V DC | 1 ms | 2 A |
| | 15 ms | 1.7 A |
| | 50 ms | 1.5 A |
| 250 V DC | 1 ms | 2 A |
| | 15 ms | 1.4 A |
| | 50 ms | 1.2 A |

| Electrical characteristics (according to IEC 62271-100 class 1) | |
|---|---|
| Rated current Un | Breaking capacity |
| 24 V DC 20 ms | 18.8 A |
| 60 V DC 20 ms | 7.4 A |
| 110 V DC 20 ms | 4.2 A |
| 250 V DC 20 ms | 1.8 A |

# 5. Description

### 7b Auxiliary contacts of the circuit breaker (-BGB1, -BGB2, -BGB3 ) for 36 kV version

As an alternative to the standard 10 contacts, electrical signaling of circuit breaker open/closed can be obtained with a group of 15 auxiliary contacts.
Consult the following circuit diagrams for VD4 36 kV series with “7b” auxiliary contacts:

- for fixed circuit breakers: 1VCD400236
- for withdrawable circuit breakers: 1VCD400237

**Note**

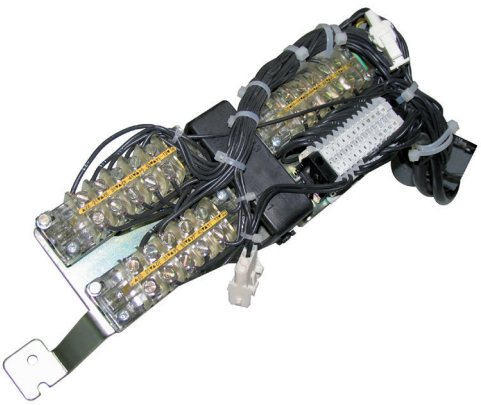
The following are available with the standard group of ten contacts and maximum electrical applications:
- three make contacts (circuit breaker open signal) and five break contacts (circuit breaker closed signal), and five break contacts (circuit breaker closed signal) for fixed circuit breakers, four break contacts (circuit breaker closed signal) for withdrawable circuit breakers.

Depending on the electrical applications required, the following are available with the group of 15 auxiliary circuits:

- for fixed circuit breakers: thirteen auxiliary contacts comprising the numbers of break contacts and make contacts established by the required wiring configuration;
- for withdrawable circuit breakers, since the plug of the auxiliary circuits has a limited number of pins: five make contacts (circuit breaker open signal) and five break contacts (circuit breaker closed signal).

| **General characteristics** | |
|---|---|
| Insulation voltage to standard VDE 0110, Group C | 660 V AC<br>800 V DC |
| Rated voltage | 24 V ... 660 V AC |
| Test voltage | 2 kV 50 Hz (for 1 min) |
| Maximum rated current | 10 A |
| Number of contacts | 5 |
| Contact travel | 6 mm ... 7 mm |
| Actuating force | 26 N |
| Resistance | 3 mΩ |
| Storage temperature | –20 °C ... +120 °C |
| Operating temperature | –20 °C ... +70 °C |
| Contact overtemperature | 20 K |
| Number of cycles | 30.000 |
| Unlimited breaking capacity if used with 10 A fuse in series | |

| **Electrical characteristics** | | | |
|---|---|---|---|
| Un | | Rated current | Breaking capacity |
| 220 V AC | Cosφ = 0.7 | 2.5 A | 25 A |
| 380 V AC | Cosφ = 0.7 | 1.5 A | 15 A |
| 500 V AC | Cosφ = 0.7 | 1.5 A | 15 A |
| 660 V AC | Cosφ= 0.7 | 1.2 A | 12 A |
| 24 V DC | 1 ms | 10 A | 12 A |
| | 15 ms | 10 A | 12 A |
| | 50 ms | 8 A | 10 A |
| | 200 ms | 6 A | 7.7 A |
| 60 V DC | 1 ms | 8 A | 10 A |
| | 15 ms | 6 A | 8 A |
| | 50 ms | 5 A | 6 A |
| | 200 ms | 4 A | 5.4 A |
| 110 V DC | 1 ms | 6 A | 8 A |
| | 15 ms | 4 A | 5 A |
| | 50 ms | 2 A | 4.6 A |
| | 200 ms | 1 A | 2.2 A |
| 220 V DC | 1 ms | 1.5 A | 2 A |
| | 15 ms | 1 A | 1.4 A |
| | 50 ms | 0.75 A | 1.2 A |
| | 200 ms | 0.5 A | 1 A |



### 8 Transient contact (-BGB4)

This contact closes momentarily (duration > 30 ms) on circuit breaker opening controlled remotely with a shunt opening release.
The indication is not provided when opening is manual and local. In fact, a contact (–BGB11) is activated by the manual pushbutton and cuts off the transient contact closure (–BGB4).
The transient contact is activated directly from the main operating shaft when the indication is provided only on actual opening of the main circuit breaker contacts.

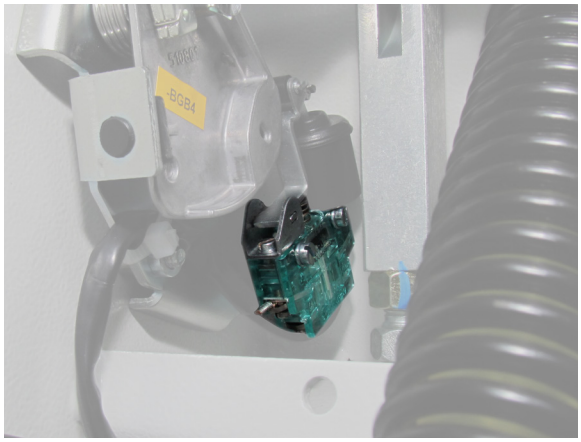
### 9 Position contact (-BGT3)

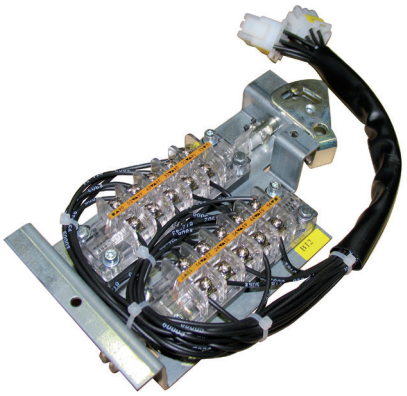
This contact is used, together with the locking magnet in the operating mechanism **(-RLE1)** to prevent remote closing during traverse into the unit.
It is only supplied for the withdrawable version circuit breakers for UniGear ZS1 switchgear and PowerCube modules.
It cannot be supplied when the transmitted contacts are requested in the truck **(-BGT1; -BGT2)**.




### 10 Transmitted contacts in the truck (-BGT1; -BGT2)

Transmitted contacts of the withdrawable circuit breaker (installed in the circuit breaker truck - only for VD4/P withdrawable circuit breaker).
These contacts are either in addition or as an alternative to the position contacts (for signalling circuit breaker racked out) located in the unit. They also carry out the function of the position contact **(-BGT3)**.
Contacts -BGT1 and BGT2 have the same general and electrical characteristics as auxiliary contacts "7b. -BGB1, -BGB2, -BGB3".



# 5. Description

### 11 Motor operator (-MAS)

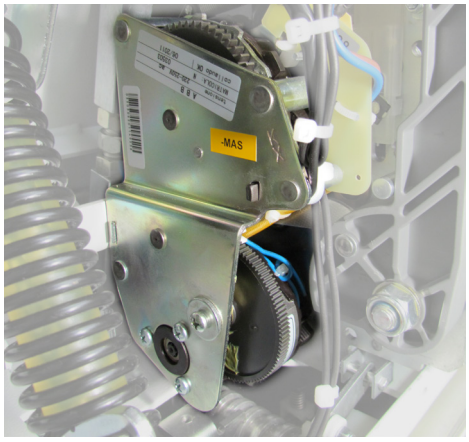
This carries out automatic charging of the circuit breaker operating mechanism closing spring. After circuit breaker closing, the geared motor immediately recharges the closing springs.
In the case of a power cut or during maintenance work, the closing spring can be charged manually in any case (by means of the special crank handle incorporated in the operating mechanism).

| **Characteristics** | | |
|---|---|---|
| Un | 24...30 - 48...60 - 110...130 - 220...250 V– | |
| Un | 100...130 - 220...250 V~ 50/60 Hz | |
| Operating limits | 85 ... 110% Un | |
| Power on inrush (Ps) | ≤ 40 kA | 50 kA |
| | DC = 600 W;<br>AC = 600 VA | DC = 900 W;<br>AC = 900 VA |
| Rated power (Pn) | DC = 200 W;<br>AC = 200 VA | DC = 350 W;<br>AC = 350 VA |
| Inrush duration | 0.2 s | 0.2 s |
| Charging time | 6-7 s | 6-7 s |
| Insulating voltage | 2000 V 50/60 Hz<br>(for 1 min) | 2000 V 50 Hz<br>(for 1 min) |

### 12 Contact for signalling closing spring charged/ discharged (-BGS2)

This consists of a microswitch which allows remote signalling of the state of the circuit breaker operating mechanism closing pring.
The following signals are possible:
- contact open: signalling spring charged
- contact closed: signalling spring discharged.

The two signals must be used for circuits which have the same power supply voltage.






# Protections and locks

Various mechanical and electromechanical locking and protection devices are available.

**13 Opening and closing pushbutton protection**

The protection only allows the opening and closing pushbuttons to be operated using a special tool.

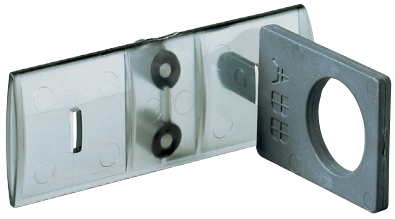
**14 Opening and closing pushbutton padlock**

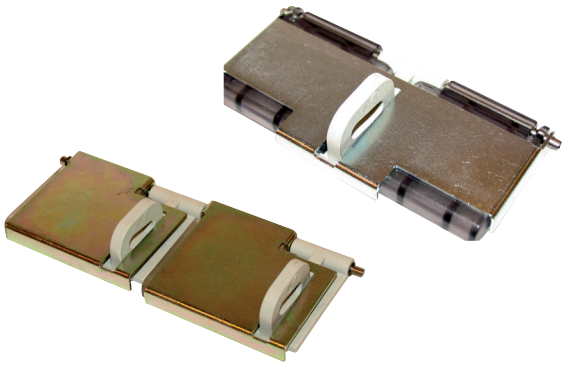
The device allows the opening and closing pushbuttons to be locked using a maximum of three padlocks (not supplied): ø 4 mm. Also prevents closing using remote control.
This lock is available in two versions:

**14A** Possibility of padlocking both the pushbuttons without distinction

**14B** Separate padlocking of the opening and/or closing pushbutton.

N.B. Lock 14A prevents closure by remote control; lock 14B does not prevent closure by remote control.





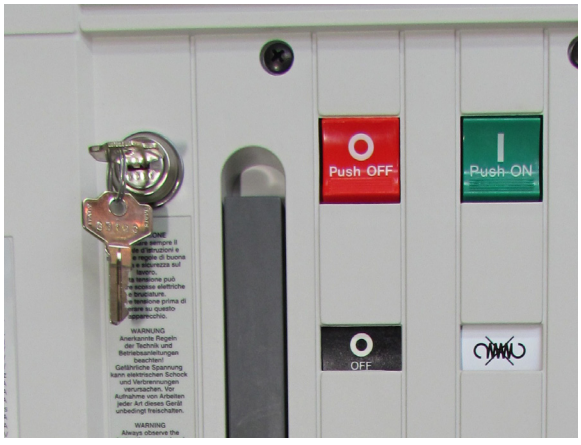
# 5. Description

**15 Key lock in open position**

The lock is activated by a special circular lock. Different keys (for a single circuit breaker) are available, or the same keys (for several circuit breakers).
To activate the lock, keep the opening pushbutton pressed down, turn the key and remove it.
With the key removed, the opening pushbutton automatically remains in the pressed position preventing local manual closing and remote electrical closing.

**16 Locking magnet on the operating mechanism (-RLE1)**

Only allows activation of the command with the electromagnet supplied.
The locking electromagnet in the operating mechanism has the same electrical characteristics as shunt closing release -MBC.






### 17 Locking magnet on the truck (-RLE2)

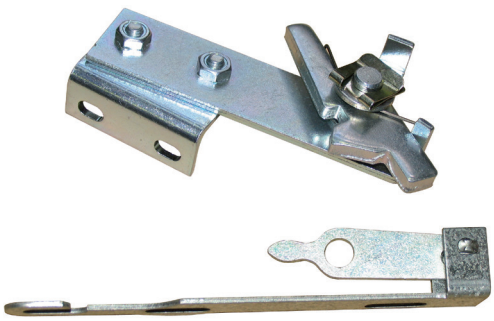
Compulsory accessory for the withdrawable versions for UniGear ZS1 switchgear and PowerCube modules, to prevent circuit breaker racking into the switchgear with the auxiliary circuit plug disconnected.
The plug also makes the anti-insertion lock for a different rated current. Special striker pins do not allow insertion of the plug in the socket if the rated current of the circuit breaker is lower than the rated current of the panel.
**Note: a specific version for the circuit breakers of ZS8.4 switchgear is available on request. This accessory is not available when the motor-operated truck is required.**

| Characteristics | |
|---|---|
| Un | 24 - 30 - 48 - 60 - 110 - 125 - 127 - 132 - 220 - 240 V– |
| Un | 24 - 30 - 48 - 60 - 110 - 125 - 127 - 220 - 230 ... 240 V~ 50/60 Hz |
| Operating limits | 85 ... 110% Un |
| Power on inrush (Ps) | d.c. 250 W; a.c. = 250 VA |
| Continuous power (Pc) | d.c. = 5 W; a.c. = 5 VA |
| Inrush duration | 150 ms |
| Insulating voltage | 2000 V 50/60 Hz (for 1 min) |

### 18 Interlock for fixed circuit breaker

Device for fixed circuit breakers which are converted into withdrawable ones by the customer. It allows a mechanical lock to be made, by the customer, which prevents racking-out/in with the circuit breaker closed and prevents circuit breaker closing during translation.
**Note: The device must be requested when ordering since it must be assembled and tested in the factory.**



# 5. Description

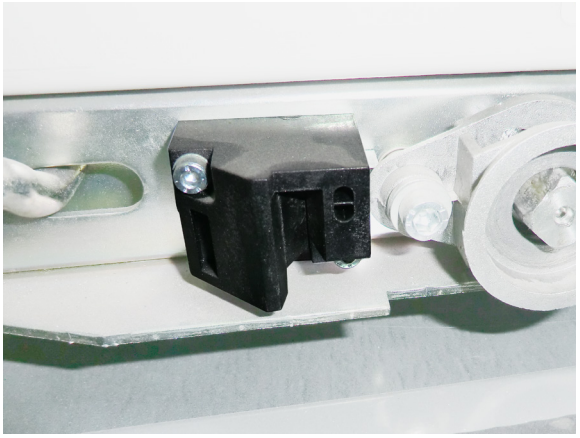
### 19 Mechanical interlock with the door

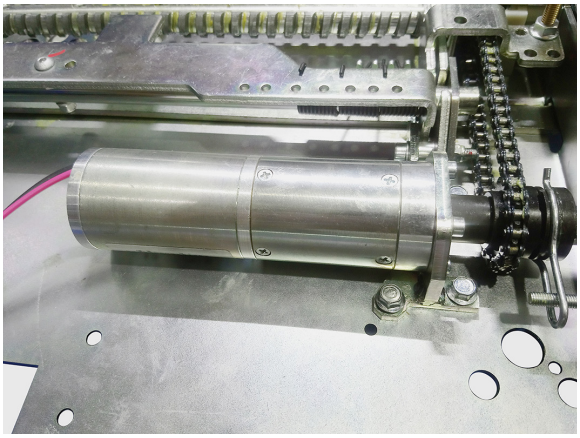
This device prevents circuit breaker racking-in when the switchgear door is open. It is only provided for circuit breakers used in switchgear UniGear ZS1 and PowerCube modules, fitted with a special actuator on the door.

### 20 Motorised truck (-MAT)

It allows racking-in and racking-out of the circuit breaker in the switchgear to be carried out remotely, (only for circuit breaker in withdrawable version for UniGear ZS1 and ZS8.4 switchgear and PowerCube modules).
The motor version with clutch is supplied as standard, so that racking-in/ out can be performed in an emergency if the truck motor fails to operate.

| **Characteristics** | |
|---|---|
| Un | 24 - 30 - 48 - 60 - 110 - 220 V– |
| Operating limits | 85 ... 110% Un |
| Nominal power (Pn) | 40 W |





## 21 STU Shunt Test Unit

Due to the particular construction of these releases, checking the functionality of the shunt closing (-MBC) and opening (-MBO1, -MBO2) releases is not possible with dedicated relays (e.g. TCS Test Control Supervision, CCC Control Coil Continuity) or with the REF control and protection unit. The only device able to carry out a check of the functionality is the STU device. Please contact us if you want to carry out this control with devices other than STU.
This device can be combined with the shunt opening release **(-MBO1; -MBO2)** or with the shunt closing release **(-MBC)** to check functionality and continuity.

The control/monitoring Shunt Test Unit allows the continuity of releases with a rated operating voltage between 24 V and 250 V (AC and DC) to be checked, as well as the functionality of the electronic circuit of the release.
Checking continuity is carried out cyclically with an interval of 20 seconds between one test and the next.
The unit has optical signals by means of LEDs on the front. In particular the following information is indicated:

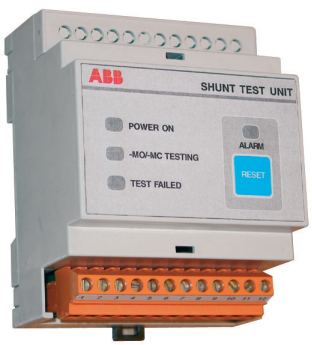
- POWER ON: power supply present
- (-MO) TESTING: test being carried out
- TEST FAILED: signal following a failed test or in the absence of auxiliary power supply
- ALARM: signal after three failed tests.

Two relays and a changeover are also available on board the unit, which allow remote signalling of the following two events:

- failure of a test (resetting is carried out automatically when the alarm stops)
- failure of three tests (resetting is only carried out by means of the manual - RESET – from the front of the unit).

There is also a manual - RESET – button on the front of the unit.

| Characteristics | |
|---|---|
| Un | 24 ... 250 V AC/DC |
| Maximum interrupted current | 6 A |
| Maximum interrupted voltage | 250 V AC |




## 22 Digital accessories for VD4 evo CMU

The CMU is an embedded unit with Monitor & Diagnostic capabilities. It also embeds sensors for basic breaker monitoring features. It can be ordered stand alone or in combination with a range of Sensors from ABB sensors portfolio, depending on the monitoring needs (see next section).
For more details please see the CMU datasheet 2RDA044111 6 CMU Dashboard Manual 2RDA044113.

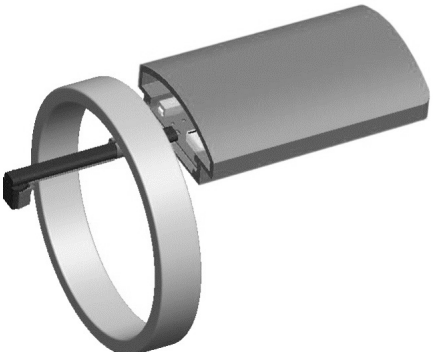
| Parameter | Unit | Min Value | Max Value |
|---|---|---|---|
| AUX Rated voltage | AC (V) | 85 | 250 |
| Working temperature range | °C | -20 | +55 |
| Storage temperature | °C | -30 | +80 |



# 5. Description

### 23 Monitor & Diagnostic Sensors

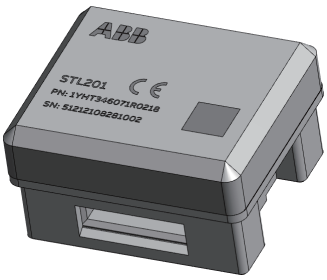
**23a STA201 Primary contacts thermal monitoring**
The STA201 sensors embedded in the primary contact arms allow direct measurement of the temperature in one of the most critical points of the circuit breaker. The measurement is shared through wireless to the concentrator unit for Monitor & Diagnostic features.
For installation or replacements please consult dedicated device documentation.



**23b SMA201 Smart Angle sensor**
The SMA201 sensor is assembled on the breaker kinematic chain to allow direct measurement of the most important characteristic of a proper Opening or Closing operation. The measurement is shared to with the concentrator unit for Monitor & Diagnostic features.
For installation or replacements please consult dedicated device documentation.



**23c STE201/STL201 Cables/BusBars thermal monitoring**
The STE201/STL201 Temperature monitoring devices are key components in ABB's switchgear and apparatus monitoring & diagnostic solutions. The devices are battery-free, self-powered smart temperature sensors, using wireless communication technology for connecting to ABB's monitoring and diagnostics data concentrators. The sensor devices can be installed directly on high-voltage parts, inside medium-voltage switchgear.
For installation or replacements please consult dedicated device documentation.

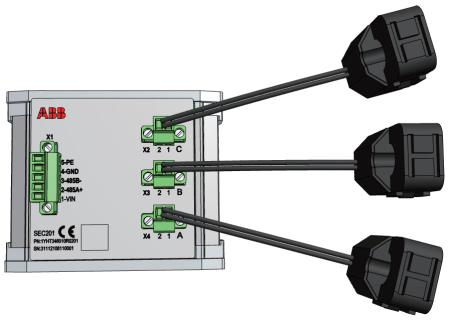



**23d THS01 Environmental monitoring**
The THS01 senors allows the monitoring of the circuit breaker at room parameters for monitor and diagnostic purposes.
For installation or replacements please consult dedicated device documentation.



### 23e SEC201 Primary Current Sensor

The SEC201 sensor allows the measurement of primary currents for monitor and diagnostic of the circuit breaker from the current transformer secondary circuit. It allows electrical life monitoring and in combination with the thermal sensors enables advanced thermal monitoring and diagnostic features.
For installation or replacements please consult dedicated device documentation.




### 24 Digital upgrade KIT

It is available a complete kit to upgrade a VD4 evo with Digital feature for monitor and diagnostic.
It includes the necessary connectors, concentrator unit CMU, and a flexible selection of ABB sensors.
Please contact your sales representative for more information.
Please contact ABB for more details based on your needs.

### 25 Serial Hub

The Serial communication hub is automatically delivered when more than one sensor with serial communication embedded in the CB has been ordered.
To be purchased separately in case of sensors upgrade after the ordering of the circuit breaker.

# 6. Instructions for operating the circuit breaker

## 6.1. Safety indications

**The VD4 circuit breakers guarantee a minimum IP2X degree of protection when installed in the following conditions:**

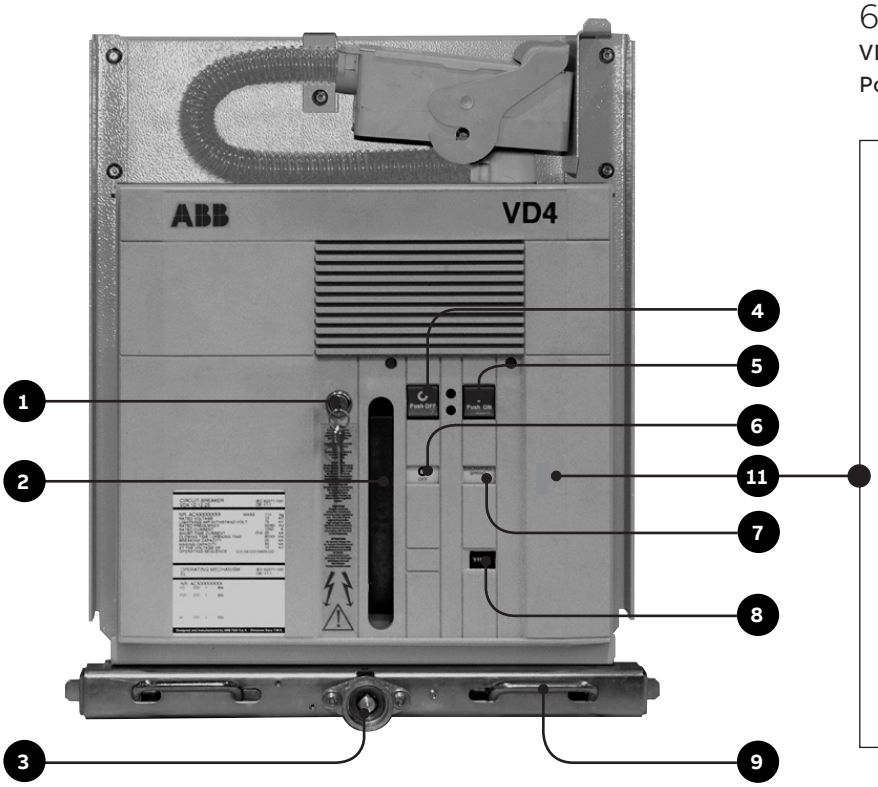
- **fixed circuit breaker, installed behind a protective metal net**
- **withdrawable circuit breaker, installed in switchgear.**

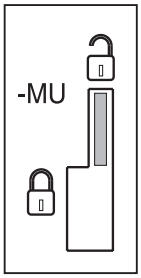
**Under these conditions the operator is totally guaranteed against accidental contact with moving parts.**
**Should mechanical operations be carried out on the circuit breaker outside of the switchgear, take great care of the moving parts.**

**If the operations are prevented, do not force the mechanical interlocks and check that the operating sequence is correct.**
**Racking the circuit breaker in and out of the switchgear must be done gradually to avoid shocks which may deform the mechanical interlocks.**
**Due to safety reasons, the circuit breaker has to be treated as "switched on" if the switching position cannot be clearly determined.**
**In this case all high voltage connections to the circuit breaker have to be de-energized and zero potential on the primary side of the circuit breaker has to be confirmed prior to commissioning, operation, maintenance or repair work.**

## 6.2. Switching and signalling parts

VD4 circuit breakers for UniGear switchgear and PowerCube modules (fig. 6a)




**Mechanical override of the undervoltage release (on request)**

Undervoltage release enabled. The circuit breaker can only be closed if the undervoltage release is supplied with power.

Undervoltage release disabled. The circuit breaker can also be closed if the undervoltage release is not supplied with power.

Caption
1 Key lock (if provided) (*)
2 Lever for manually charging the closing spring (except version VD4/ZS8 - see figure 6b)
3 Coupling lever for racking-out operation (withdrawable circuit breakers only)
4 Opening pushbutton
5 Closing pushbutton
6 Signalling device for circuit breaker open/closed
7 Signalling device for closing springs charged/discharged
8 Operation counter.
9 Handles for operating the truck locks (only for withdrawable circuit breakers)
10 Operating lever for circuit breaker racking-in/out (there is a special version for VD4/ZS8)
11 Mechanical undervoltage release override (on request).
(*) Warning! To activate the key lock: open the circuit breaker, keep the opening pushbutton depressed, then turn the key and remove it from the housing.

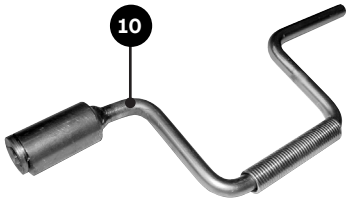



Fig. 6a

## 6.3. Circuit breaker closing and opening operations

Circuit breaker operation can be either manual or electrical (fig. 6 - fig. 7).

**a1) Manual closing spring charging for VD4 circuit breakers for UniGear switchgear and PowerCube modules (fig. 7a)**

Repeatedly activate the charging lever (2) (maximum rotation angle of the lever: about 90°) until the yellow indicator (7) appears.
The maximum forces which can normally be applied to the lever are < 150 N for the EL1operating mechanism, < 200 N for the EL2 operating mechanism and < 250 N for EL3 operating mechanism.
EL1 Twin and EL2 Twin type operating mechanisms are provided for circuit breakers with 50 kA breaking capacity.
For manual charging, the additional lever (1) should be inserted fully, as indicated in fig. 7c. In this way, the maximum force to be applied is < 200 N. For the type of operating mechanism, please refer to the rating plate in fig. 1.

**a2) Closing spring loading in the manual mode for withdrawable VD4 circuit breakers for UniGear switchgear equipped with a hand-operated rotaryc loading device for the closing spring (refer to fig. 6b for indicative details)**

Rotate the charging lever (2) (rotate about 12 times) until the yellow indicator (7) appears. The maximum force which can normally be applied to the lever is < 150 N for the EL1 operating mechanism and < 230 N for the EL3 operating mechanism.
The operation can be carried out with the door either open or closed and the circuit breaker either withdrawn or connected.
WARNING (fig. 6b): Fit the hand-operated loading lever of the closing spring (2b) into its housing (2a). Turn the lever clockwise (about 12 times) until the yellow indicator (7) appears to show that loading is complete. Once this happens, the lever will continue for half a turn without loading (without exercising any force), after which it will lock owing to a sudden load increase. Do not exercise force or try to continue loading as this will damage the device.

**VD4 circuit breakers for ZS8.4 switchgear (fig. 6b)**

**a3) Manual closing spring charging for VD4 circuit breakers (fig. 7b)**

Ruotare la leva di carica (2) fino alla comparsa del
Rotate the charging lever (2) until the yellow indicator (7) appears. The maximum force which can normally be applied to the lever is < 150 N for the EL1 operating mechanism and < 230 N for the EL3 operating mechanism.
The operation can be carried out with the door either open or closed and the circuit breaker either withdrawn or connected.

WARNING (fig. 6b): Fit the hand-operated loading lever of the closing spring (2b) into its housing (2a). Turn the lever clockwise (about 12 times) until the yellow indicator (7) appears to show that loading is complete. Once this happens, the lever will continue for half a turn without loading (without exercising any force), after which it will lock owing to a sudden load increase. Do not exercise force or try to continue loading as this will damage the device.

**b) Electrical spring charging operation**

On request, the circuit breaker can be fitted with the following accessories for electrical operation:
- geared motor for automatic closing spring charging
- shunt closing release
- shunt opening release.

The geared motor automatically recharges the spring after each closing operation until the yellow indicator (7) appears. If the power is cut off during charging, the geared motor stops and automatically starts recharging the springs again when the power returns.
In any case, it is always possible to complete the charging operation manually.

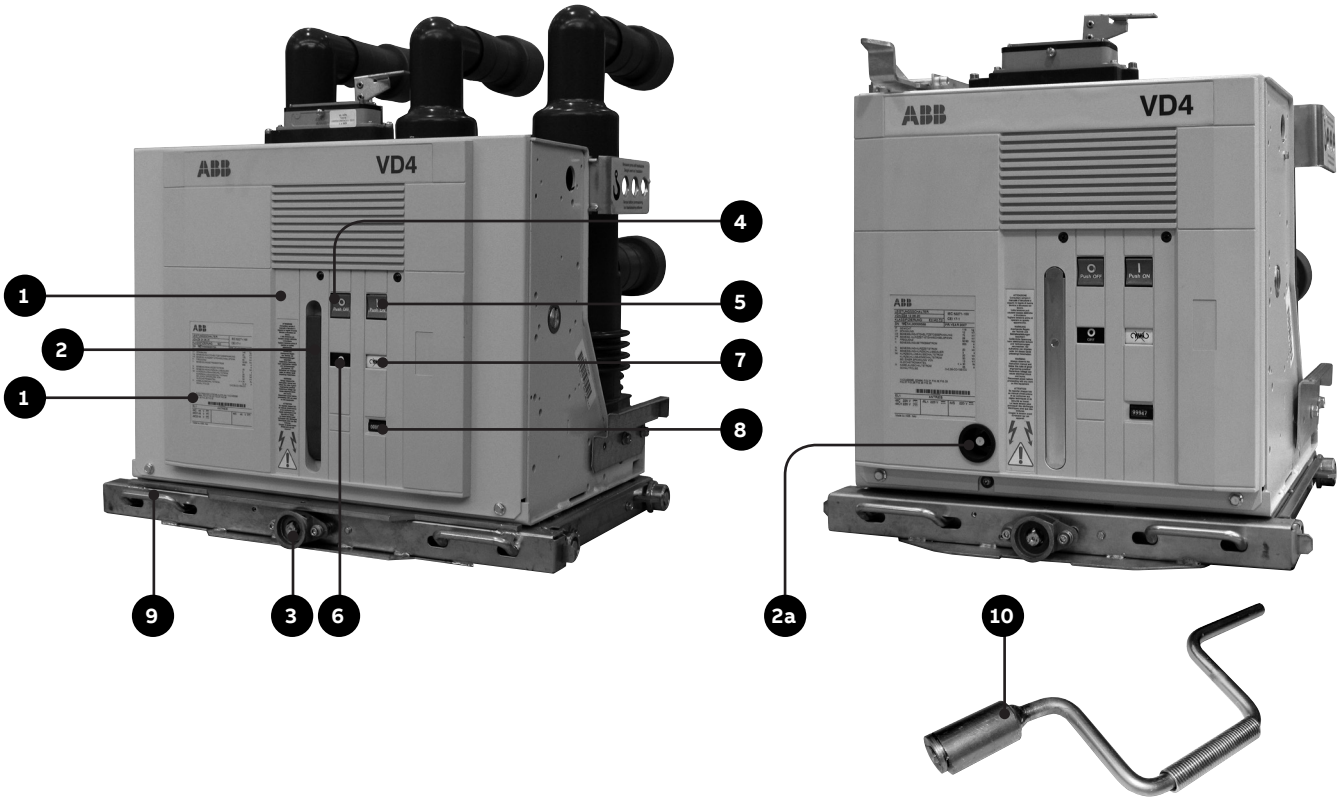
**c) Circuit breaker closing**

The operation can only be carried out with the closing spring completely charged.
For manual closing, press the pushbutton (5 - fig. 6b).
When there is a shunt closing release, the operation can also be carried out remotely by means of a special control circuit. Closing having taken place is indicated by the signalling device (6 - fig. 6b).

**d) Circuit breaker opening**

The operation can only be carried out with the closing spring completely charged.
For manual closing, press the pushbutton (5 - fig. 6b).
When there is a shunt closing release, the operation can also be carried out remotely by means of a special control circuit.
Closing having taken place is indicated by the signalling device (6 - fig. 6b).

# 6. Instructions for operating the circuit breaker




Caption
1 Key lock (if provided)
2 Lever for manually charging the closing spring
2a Coupling for manual closing spring charging (when lever 2 is not provided)
2b Lever for manual closing spring charging for rotary charging device
3 Coupling for racking-out operation lever (only for withdrawable circuit breakers)
4 Opening pushbutton
5 Closing pushbutton
6 Signalling device for circuit breaker open/closed
7 Signalling device for closing spring charged/discharged
8 Operation counter.
9 Handles for operating the truck locks (only for withdrawable circuit breakers)
10 Operating lever for circuit breaker racking-in/out.

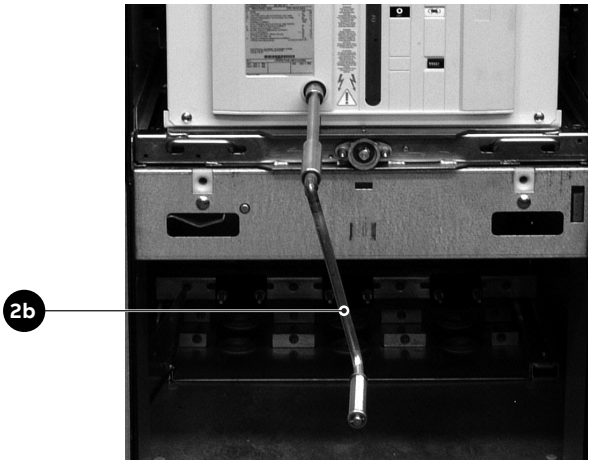



Fig. 6b

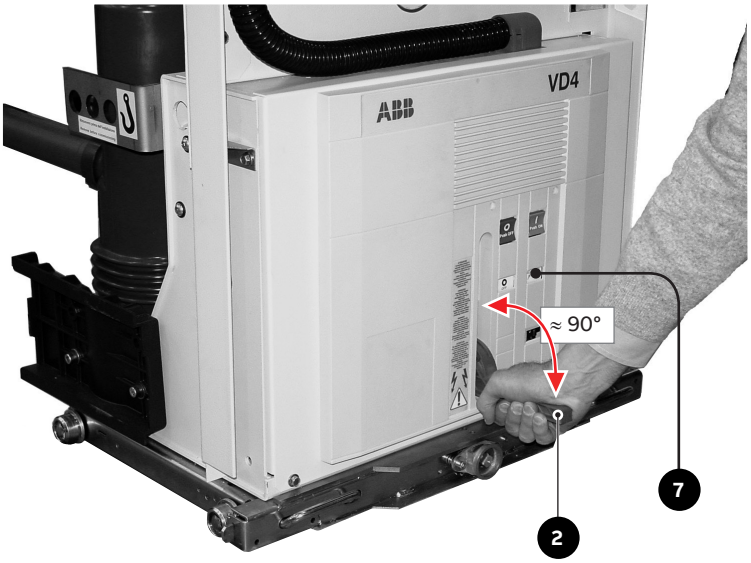
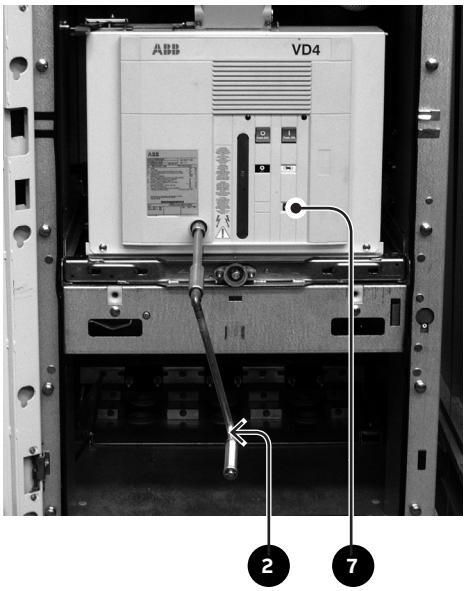



Fig. 7a



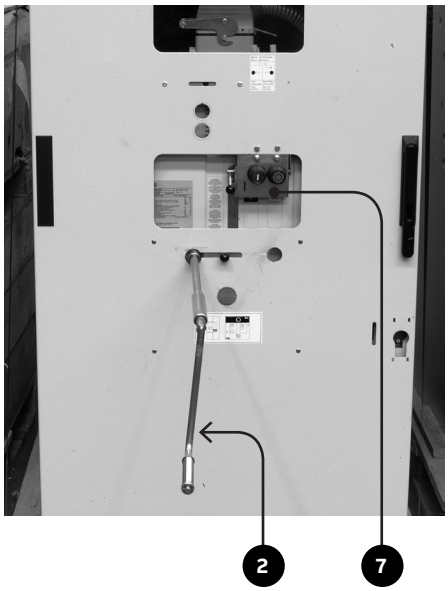
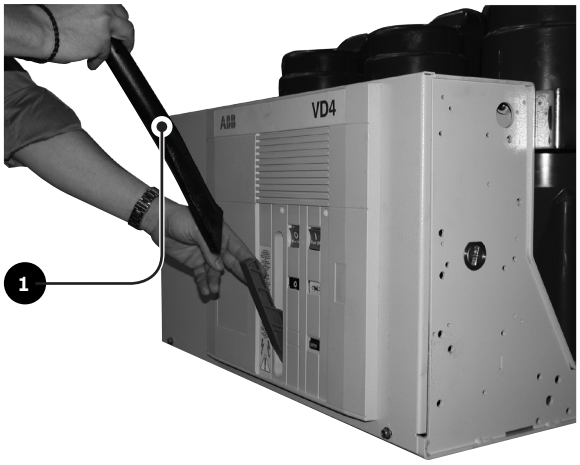




Fig. 7b



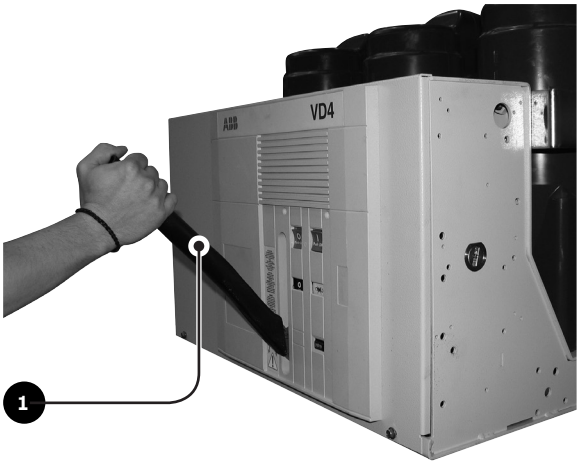




Fig. 7c

6.4 Detailed instruction of sensors and CMU Usage is in 2RDA044113 &2RDA044114. only for VD4 evo

# 7. Installation

## 7.1. General

**Correct installation is of primary importance. The manufacturer's instructions must be carefully studied and followed. It is good practice to use gloves for handling the pieces during installation.**

## 7.2. Installation and operating conditions

The following Standards must be taken into particular consideration during installation and service:

- IEC 62271-1/DIN VDE 0101
- VDE 0105: Electrical installation service
- DIN VDE 0141: Earthing systems for installations with rated voltage above 1 kV
- All the accident prevention regulations in force in the relative countries.

### 7.2.1. Normal conditions

Follow the recommendations in the IEC 62271-1 and 62271- 100 Standards. In more detail:

| **Ambient temperature** | |
|---|---|
| Maximum | + 40 °C |
| Average maximum over 24 hours | + 35 °C |
| Minimum (according to class – 5), apparatus for indoor installation | – 5° |

| **Humidity** |
|---|
| The average value of the relative humidity, measured for a period longer than 24 hours, must not exceed the 95%. |
| The average value of the pressure of the water vapour, measured for a period longer than 24 hours, must not exceed 2.2 kPa. |
| The average value of the relative humidity, measured for a period longer than 1 month, must not exceed the 90%. |
| The average value of the pressure of the water vapour, measured for a period longer than 1 month, must not exceed 1.8 kPa. |

| **Altitude** |
|---|
| ≤ 1000 m above sea level. |

### 7.2.2. Special conditions

| Installations over 1000 m a.s.l. |
|---|
| Possible within the limits permitted by reduction of the dielectric resistance of the air. |

| **Increase in the ambient temperature** |
|---|
| Reduction in the rated current. |
| Encourage heat dissipation with appropriate additional ventilation. |

| **Climate** |
|---|
| To avoid the risk of corrosion or other damage in areas: |
| • with a high level of humidity, and/or |
| • with rapid and big temperature variations, take appropriate steps (for example, by using suitable electric heaters) to prevent condensation phenomena. |

For special installation requirements or other operating conditions, please contact ABB.

**The areas involved by the passage of power conductors or auxiliary circuit conductors must be protected against access of any animals which might cause damage or disservices.**

### 7.2.3. Trip curves

The following graphs show the number of closing-opening cycles (No.) allowed, of the vacuum interrupters, according to the breaking capacity (Ia).

Caption (Figs. 8...)
No. Number of closing-opening cycles allowed for the vacuum interrupters.
Ia: Breaking capacity of the vacuum interrupters.

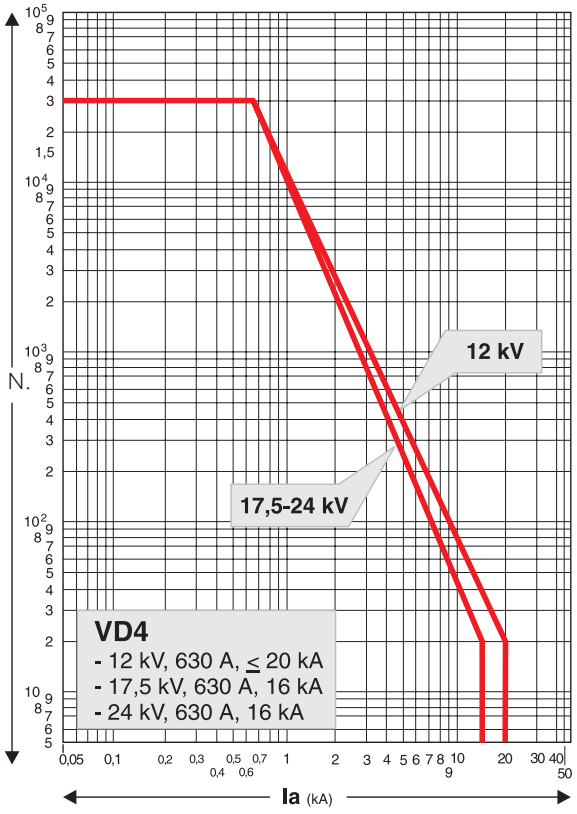



Fig. 8a

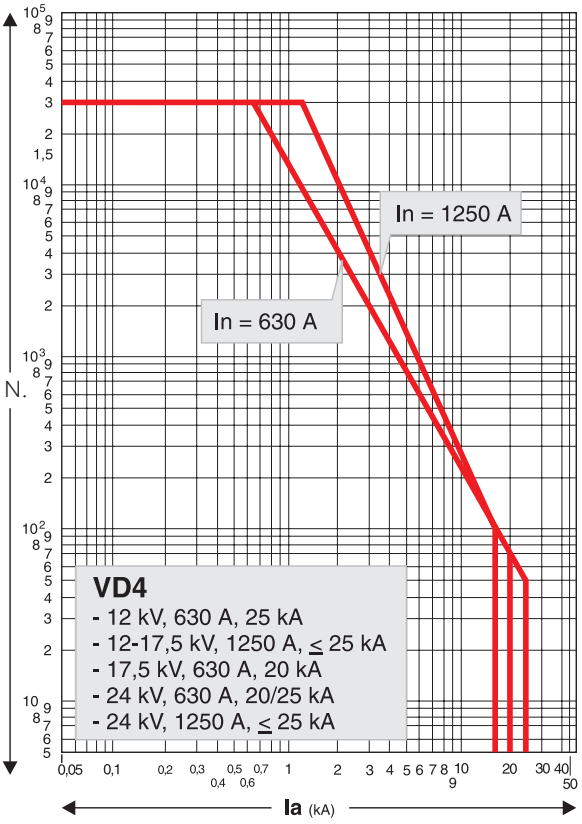



Fig. 8b

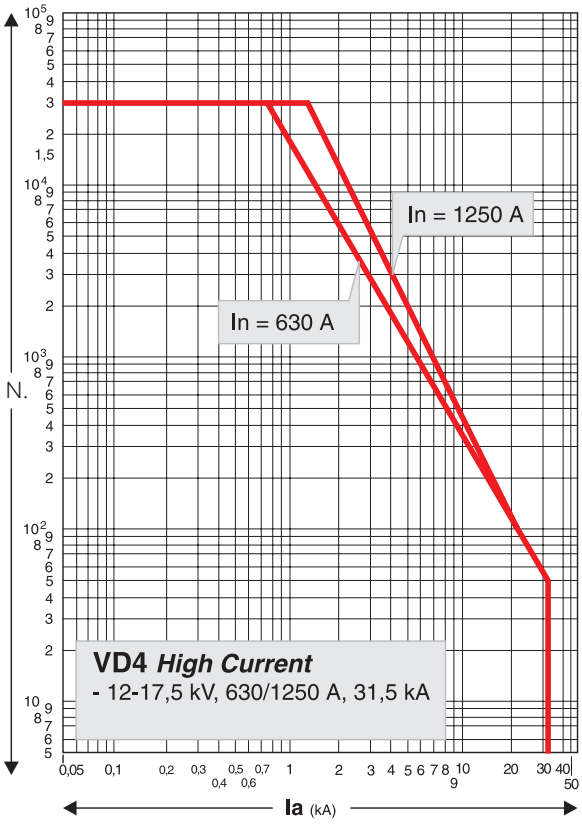



Fig. 8c

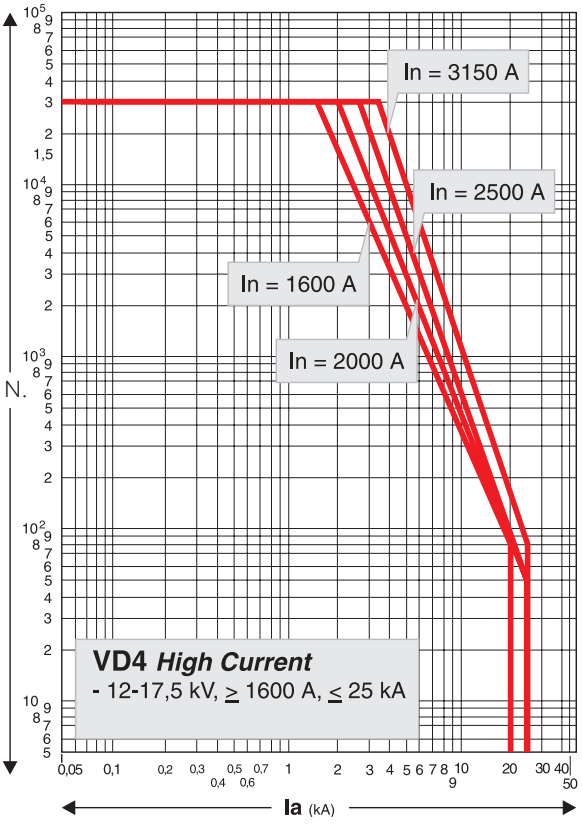



Fig. 8d

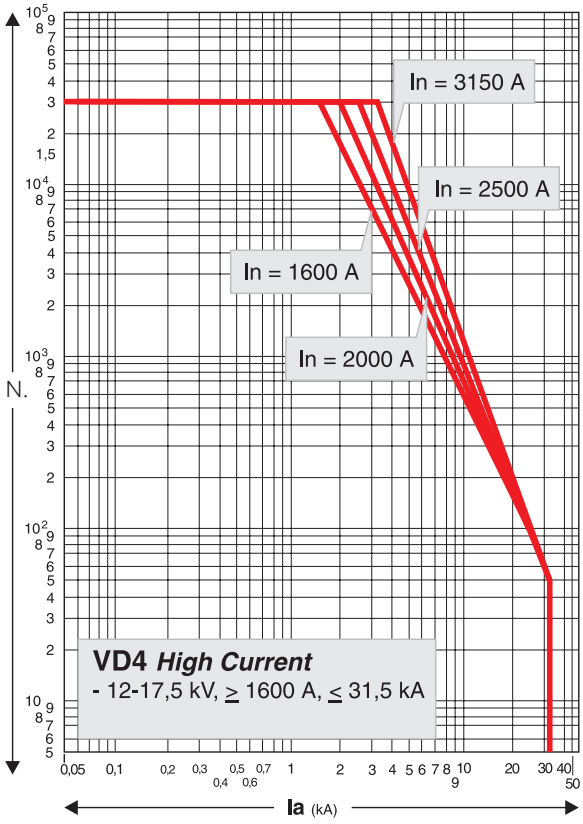



Fig. 8e

# 7. Installation

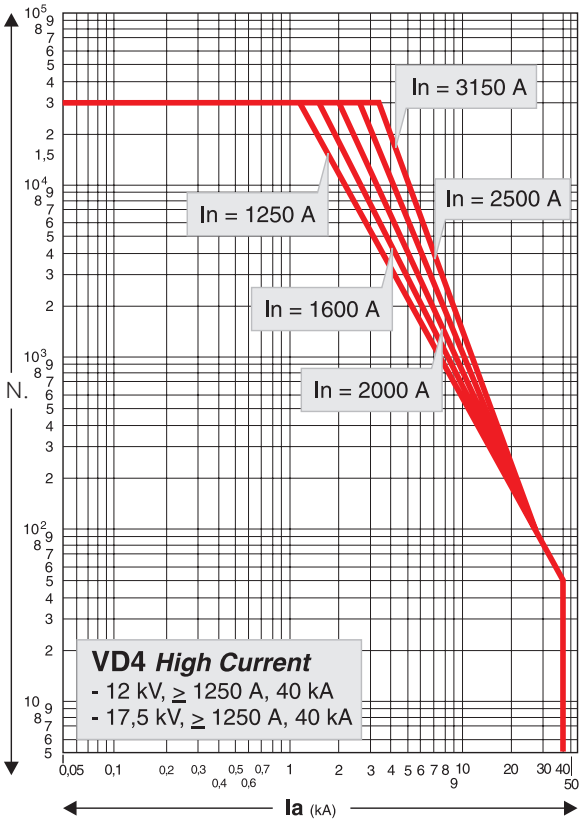



Fig. 8f

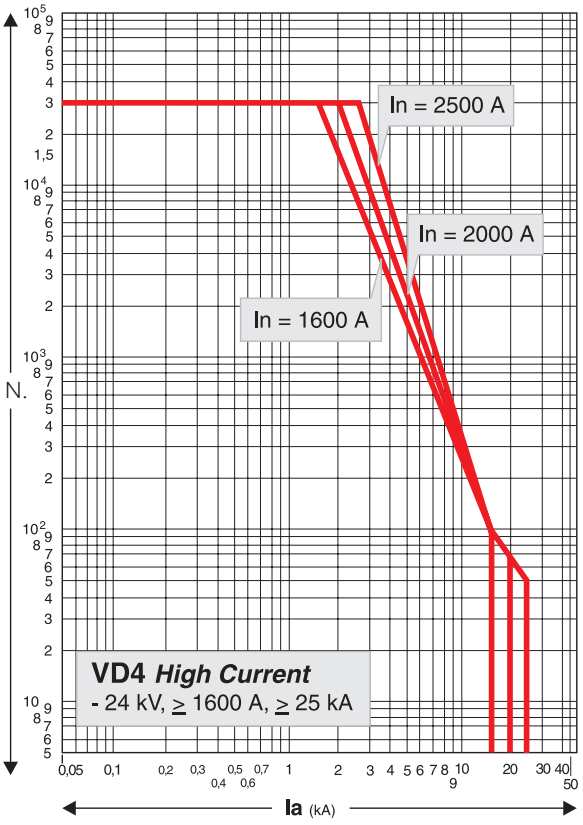



Fig. 8g

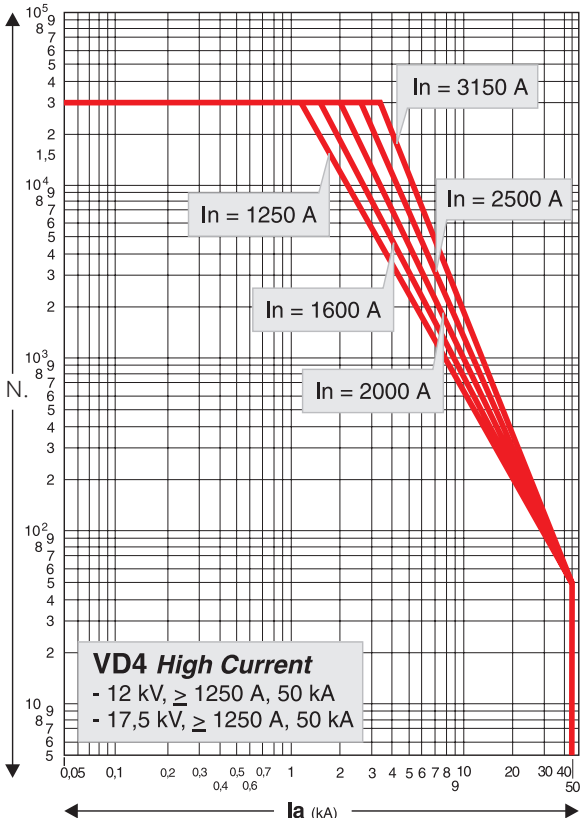



Fig. 8h

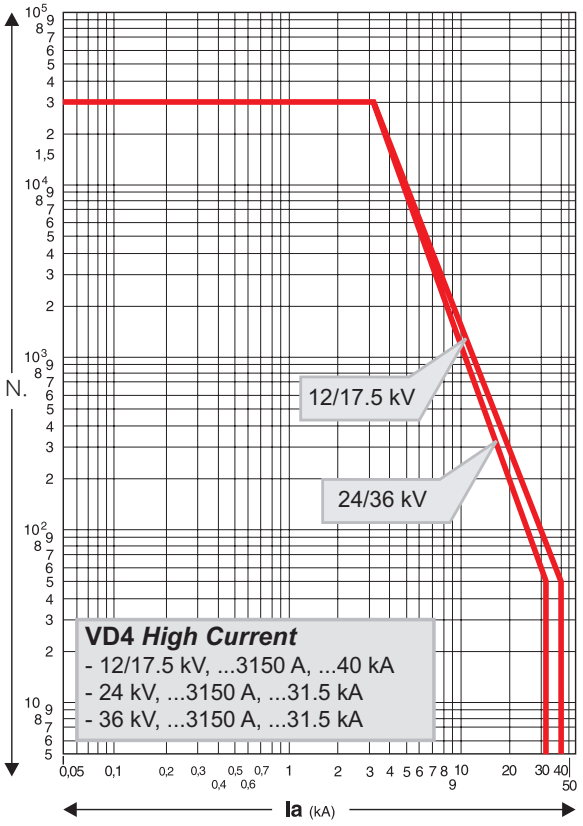



Fig. 8i

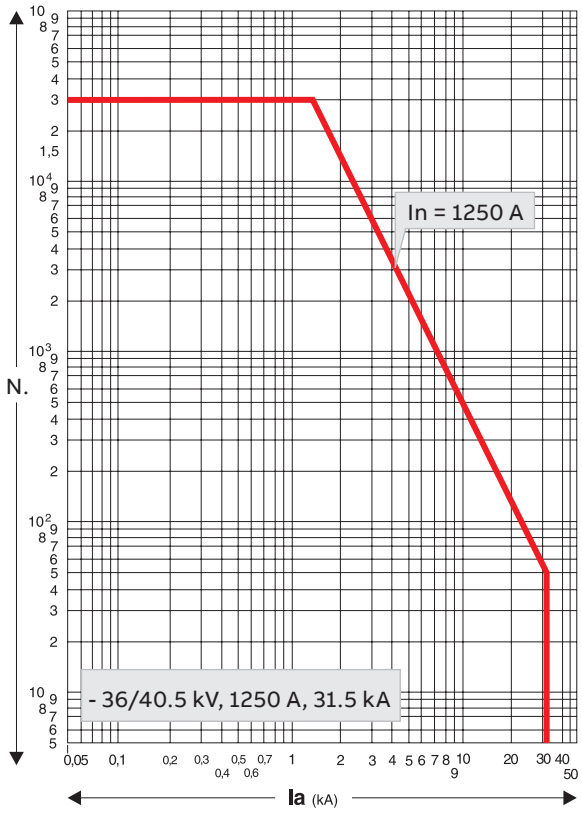



Fig. 8l

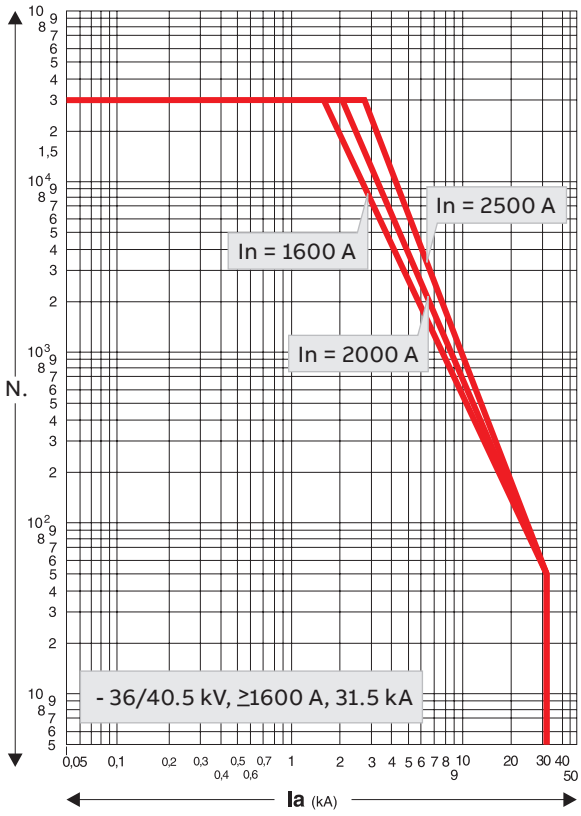



Fig. 8m

**Breaking curves for vacuum interrupters embedded in thermoplastic poles for VD4 High Current:**

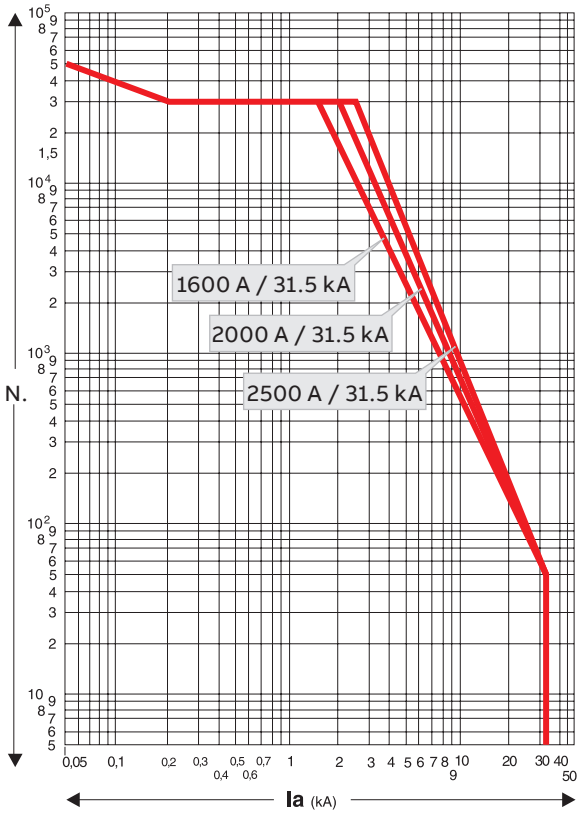



Fig. 8n

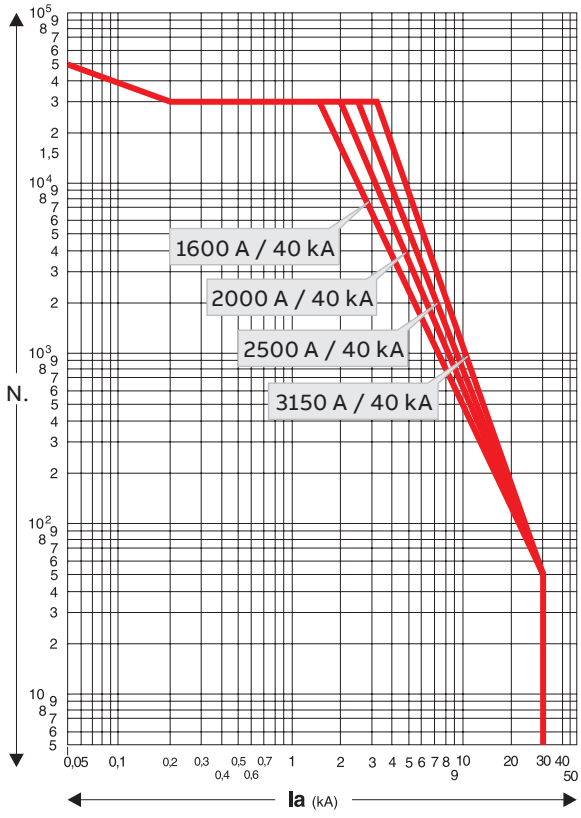



Fig. 8o

# 7. Installation

## 7.3. Preliminary operations

- Clean the insulating parts with clean dry cloths.
- Check that the top and bottom terminals are clean and free of any deformation caused by shocks received during transport or storage.

## 7.4. Installation of fixed circuit breakers

The circuit breaker can be mounted directly on supporting frames to be provided by the customer, or on a special supporting truck (available on request).
The circuit breaker, with supporting truck, must be suitably fixed to the floor of its own compartment by the customer.
The floor surface in correspondence with the truck wheels must be carefully levelled.
A minimum degree of protection (IP2X) must be guaranteed from the front towards live parts.

### 7.4.1. Mounting the circuit breaker on a truck made by other manufacturers

The VD4 circuit breakers which are not installed on ABB trucks, but on trucks made by the customer, must be fitted with one or two additional auxiliary contacts (activated by the mechanical lock and by the circuit breaker release device) to carry out the function of interrupting the shunt closing release circuit (-MBC) during traverse from isolated and vice versa.
In ABB trucks, this function is carried out by the -BGT1 and -BGT2 auxiliary contacts which cut of the release power supply during and before activation of the mechanical lock of the screw truck racking-in device. This means that the shunt closing release power supply can only by applied at the end of activation of the mechanical lock. In this way it is certain that no electrical impulse can activate the shunt closing release with the circuit breaker in an intermediate position.

## 7.5. Installation of withdrawable circuit breaker

The withdrawable circuit breakers are preset for use in UniGear ZS1, UniGear ZS2, UniSec switchgear and PowerCube modules.
For racking-in/racking-out of the switchgear, fully insert the lever (1) (fig. 9) in the appropriate seat (2) and work it clockwise for racking-in, and anti-clockwise for racking-out, until the limit switch positions are reached.
Circuit breaker racking-in/-out must be carried out gradually to avoid shocks which may deform the mechanical interlocks and the limit switches.
The torque normally required to carry out racking-in and racking-out is <25 Nm.
This value must not be exceeded. If operations are prevented or difficult, do not force them and check that the operating sequence is correct.

Note
To complete the racking-in/out operation, about 20 rotations of the lever are required for circuit breakers up to 17.5 kV, and about 30 rotations for 24 kV circuit breakers.

When the circuit breaker has reached the isolated for test/ isolated position, it can be considered racked into the switchgear and, at the same time, earthed by means of the truck wheels.
Withdrawable circuit breakers of the same version, and therefore with the same dimensions, are interchangeable.
However, when, for example, different electrical accessory fittings are provided, a different code for the plug of the auxiliary circuits does not allow incorrect combinations between panels and circuit breakers.
For the circuit breaker installation operations, also refer to the technical documentation of the above-mentioned switchgear.



- **The racking-in/-out operations must always be carried out with the circuit breaker open.**
- **When putting into service for the first time, it is advisable to charge the circuit breaker operating mechanisms manually so as not to overload the auxiliary power suply circuit.**

### 7.5.1. Circuit breakers with withdrawable motorized truck

Carry out the racking-in/racking-out test of the motorized truck in the same way as for a manual truck, following the instructions below:

- Rack the circuit breaker into the switchgear in the open and isolated position, with the power supply to the motor circuit cut off and with the enclosure door closed.
- Insert the manual racking-in lever (1) in the special coupling (2) Fig. 9, and take the motorized truck to about half its run between the isolated for test and the connected position. The torque needed to carry out truck handling is < 25 Nm.
- In the case of accidental inversion of the truck motor power supply polarity, this operation allows a possible error in direction to be dealt with without any damage. Verification checks:
  a) motor rotation clockwise during circuit breaker racking-in.
  b) motor rotation anticlockwise during circuit breaker racking-out.
- Remove the manual lever (1) from the coupling (2) Fig. 9
- Supply the truck motor circuit.
- Activate the control for the electrical racking-in operation. When racking-in has taken place, check correct changeover of the relative auxiliary contact.
- On completion, activate the control for the electrical racking-out operation. When racking-out has taken place, check correct changeover of the relative auxiliary contact.
- In the case of a motor fault during a racking-in or rackingout operation, in an emergency the truck can be taken to the end of its run manually, after first cutting off the power supply to the motor power supply circuit and then, using the manual lever, work in the same way as with the manual truck.

Note
The clutch has to mechanically disconnect the motor to operate the truck by manual lever in the right way. To do it, perform one turn by manual lever in the opposite direction compared to the last motorized truck movement, before to operate by manual lever in the needed direction.

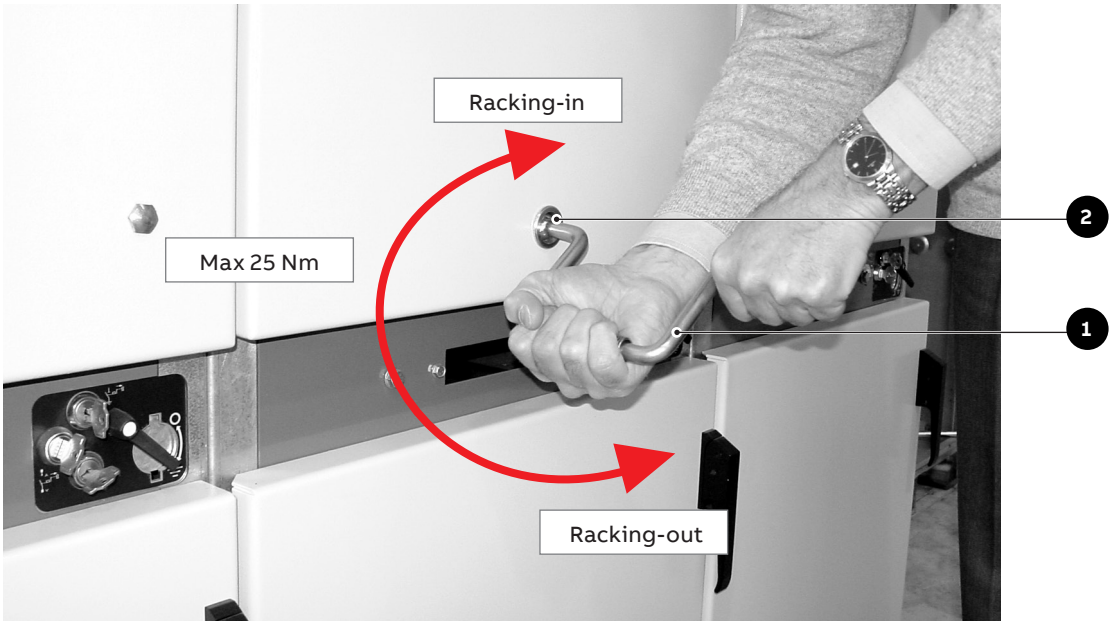



Fig. 9

# 7. Installation

## 7.6. Power circuit connections of fixed circuit breakers

### 7.6.1. General recommendations

- Select the cross-section of the conductors according to the service current and the short-circuit current of the installation.
- Prepare special pole insulators, near the terminals of the fixed circuit breaker or of the enclosure, sized according to the electrodynamic forces deriving from the short-circuit current of the installation.

### 7.6.2. Assembly of the connections

- Check that the contact surfaces of the connections are flat, and are free of any burrs, traces of oxidation or deformation caused by drilling or impacts received.
- According to the conductor material and the surface treatment used, carry out the operations indicated in table T1 on the contact surface of the conductor.

**Assembly procedure**

- Put the connections in contact with the circuit breaker terminals, taking care to avoid mechanical stresses (traction / compression) on, for example, the conducting busbars on the terminals.
- Interpose a spring washer and a flat washer between the head of the bolt and the connection.
- It is advisable to use bolts according to DIN class 8.8 Standards, also referring to what is indicated in table T2.
- In the case of cable connections, strictly follow the manufacturer's instructions to make the terminals.

**T1**

| **Bare copper** |
|---|
| • Clean with a fine file or emery cloth. |
| • Tighten fully and cover the contact surfaces with 5RX Moly type grease |

| **Copper or silver-plated aluminium** |
|---|
| • Clean with a rough dry cloth. |
| • Only in the case of obstinate traces of oxidation, clean with a very fine grain emery cloth taking care not to remove the surface layer. |
| • If necessary, restore the surface treatment. |

| **Bare aluminium** |
|---|
| • Clean with a metal brush or emery cloth. |
| • Cover the contact surfaces again immediately with neutral grease |
| • Insert the copper-aluminium bimetal with surfaces shined (copper side in contact with the terminal; aluminium side in contact with the connection) between the aluminium connection and the copper terminal. |

**T2**

| **Bolt** | **Recommended tightening torque (1)** | |
|---|---|---|
| | Without lubricant | With lubricant (2) |
| M6 | 10.5 Nm | 4.5 Nm |
| M8 | 26 Nm | 10 Nm |
| M10 | 50 Nm | 20 Nm |
| M12 | 86 Nm | 40 Nm |
| M16 | 200 Nm | 80 Nm |

(1) The nominal tightening torque is based on a friction coefficient of the thread of 0.14 (distributed value the thread is subjected to which, in some cases, is not negligible). The nominal tightening torque with lubricant is according to the DIN 43673 Standards.

(2) Oil or grease. The thread and surfaces in contact with the lubricated heads. Take into account the deviations from the general Standards table (for example, for systems in contact or terminals) as foreseen in the specific technical documentation. The thread and surfaces in contact with the heads of bolts must be slightly oiled or greased, so as to obtain a correct nominal tightening torque.

## 7.7. Earthing

For the fixed version circuit breaker, carry out earthing by means of the special screw marked with the relative symbol.
Clean and degrease the area around the screw to a diameter of about 30 mm and, on completion of assembly, cover the joint again with Vaseline grease.
Use a conductor (busbar or braid) with a cross-section conforming to the Standards in force.

## 7.8. Connection of the auxiliary circuits

Note: the minimum cross-section of the wires used for the auxiliary circuits must not be less than the one used for the internal cabling. Furthermore, they must be insulated for 3 kV of test.

### 7.8.1. Fixed circuit breaker

The customer can choose between two types of auxiliary circuit connections in the circuit breaker. The first type is supplied as the standard version. In this case, the auxiliary contacts must be disassembled from the structure of the circuit breaker, since their terminals cannot be directly accessed (fig. 10) (consult the installation manual). Part of the wiring is made during the production phase for the second type. This means that the customer can wire up by directly accessing the terminal boxes in the front part of the circuit breaker. In this case, the wiring operation is much faster and immediate.

To prevent the cabling wires outside the circuit breaker (carried out by the customer) from accidentally coming into contact with moving parts and therefore undergoing damage to the insulation, it is recommended to fix the wires as shown in fig. 10a.
In both types of connection, the wires must pass through connection (2) while outside the circuit breaker, the cables must be screened by an appropriate sort of metallic protection (tube, duct, ...), which must be earthed.

### 7.8.2. Withdrawable circuit breakers

The auxiliary circuits of withdrawable circuit breakers are fully cabled in the factory as far as the connector (fig. 11).
For the external connections, refer to the electric wiring diagram of the switchgear.

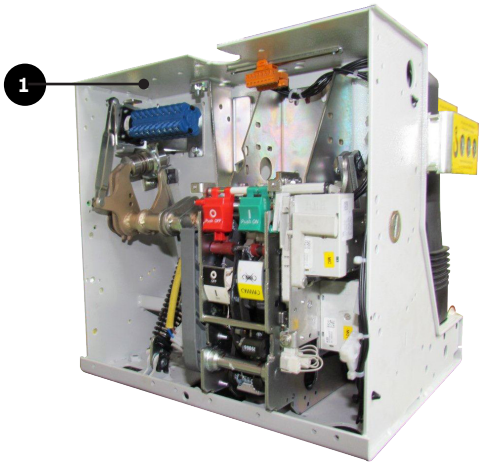



Fig. 10

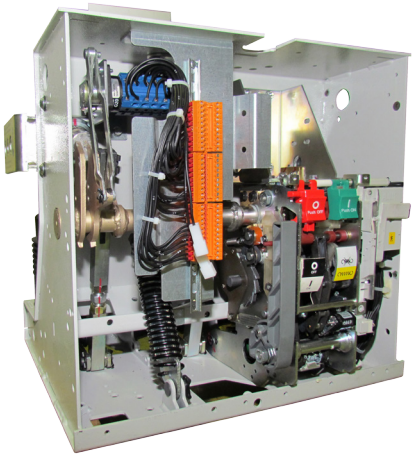


Fig. 10a

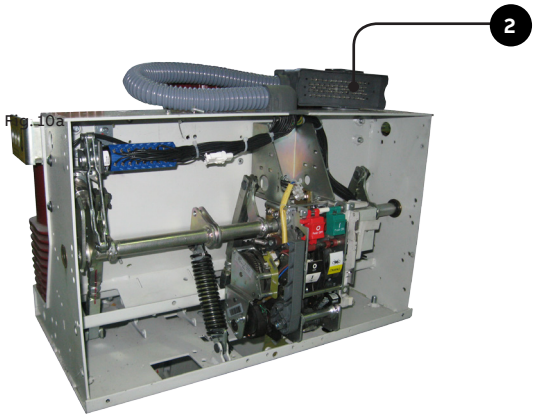



Fig. 11

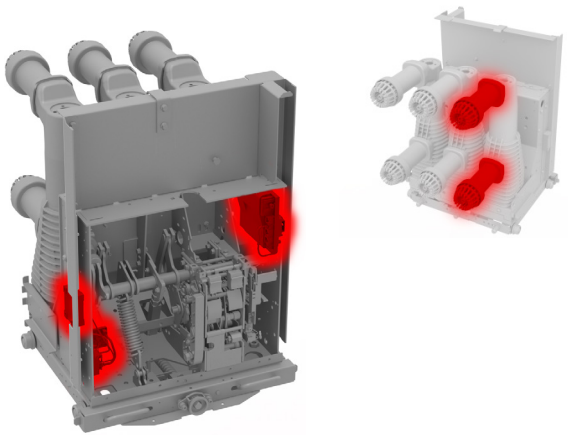


Fig. 12 VD4 evo with sensors

# 7. Installation

## 7.9. Sensors installation

Please refer to manual 2RDA044114 for sensor configuration.

### 7.9.1. Installation of CMU

Detailed instructions for installing CMU are available in 1VCD601733R0001

### 7.9.2. Installation of Serial Hub

Detailed instructions for installing Serial Hub are available in 1VCD601734R0001

### 7.9.3. Installation of Temperature Sensor

Detailed instructions for installing Temperature Sensor are available in 1VCD601730R0001

### 7.9.4. Installation of Angle Sensor

Detailed instructions for installing Angle Sensor are available in 1VCD601731R0001

# 8. Putting into service

## 8.1. General procedures



**All the operations regarding putting into service must be carried out by ABB personnel or by suitably qualified customer personnel with in-depth knowledge of the apparatus and of the installation.**
**Should the operations be prevented, do not force the mechanical interlocks and check that the operating sequence is correct.**
**The operating forces which can be applied for racking-in withdrawable circuit breakers are indicated in paragraph 7.5.**

Before putting the circuit breaker into service, carry out the following operations:

- check tightness of the power connections to the circuit breaker terminals;
- establish the setting of the primary electronic overcurrent release (if provided);
- check that the value of the power supply voltage of the auxiliary circuits is between 85% and 110% of the rated voltage of the electrical accessories;
- check that no foreign bodies, such as bits of packing, have got into the moving parts;
- check that there is a sufficient exchange of air in the installation place to avoid overtemperatures;
- also carry out the checks indicated in table T3.

**Detailed instruction for putting sensors and CMU into service are available in 2RDA044114**

# 8. Putting into service

**T3**

| ITEM | INSPECTED | PROCEDURE | POSITIVE CHECK |
|---|---|---|---|
| **1** | Insulation resistance. | **Medium voltage circuit** | |
| | | With a 2500 V megger, measure the insulation resistance between the phases and the exposed conductive part of the circuit. | The insulation resistance should be at least 50 Mohm and in any case constant over time. |
| | | **Auxiliary circuits** | |
| | | With a 500 V megger (if the apparatus installed allows this), measure the insulation resistance between the auxiliary circuits and the exposed conductive part. | The insulation resistance should be a few Mohm and in any case constant over time. |
| **2** | Auxiliary circuits. | Check that the connections to the control circuit are correct: proceed at the relative power supply. | Operations and signals normal. |
| **3** | Manual operating mechanism. | Carry out a few closing and opening operations (see cap. 6).<br>N.B. Supply the undervoltage release and the locking magnet on the operating mechanism at the relative rated voltage (if provided). | The operations and relative signals take place normally. |
| **4** | Motor operator (if provided). | Supply the spring charging geared motor at the relative rated voltage. | The spring is charged normally.<br>The signals are normal.<br>With the spring charged, the geared motor stops. |
| | | Carry out a few closing and opening operations.N.B. Supply the undervoltage release and the locking magnet on the operating mechanism at the relative rated voltage (if provided). | The geared motor recharges the spring after each closing operation. |
| **5** | Undervoltage release (if provided). | Supply the undervoltage release at the relative rated voltage and carry out the circuit breaker closing operation. | The circuit breaker closes normally.<br>The signals are normal. |
| | | Cut off power to the release. | The circuit breaker opens.<br>The signalling changes over. |
| **6** | Shunt opening release and additional shunt opening release (if provided). | Close the circuit breaker and supply the shunt opening release at the relative rated voltage. | The circuit breaker opens normally.<br>The signals are normal. |
| **7** | Shunt closing release (if provided). | Open the circuit breaker and supply the shunt closing release at the relative rated voltage. | The circuit breaker opens normally.<br>The signals are normal |
| **8** | Key lock (if provided). | Open the circuit breaker, keep the opening pushbutton depressed, then turn the key and remove it from the housing. Attempt the circuit breaker closing operation. | Neither manual nor electrical closing takes place. |
| | | Put the key back in and turn it 90°.<br>Carry out the closing operation. | Both electrical and manual closing take place normally; in this position the key cannot be removed. |
| **9** | Locking electromagnet (-RLE1) (if provided). | With the circuit breaker open, spring charged and locking electromagnet not supplied, attempt circuit breaker closing both manually and electrically. | Closing is not possible. |
| **10** | Auxiliary contacts in the operating mechanism. | Insert the auxiliary contacts in suitable signalling circuits.<br>Carry out a few closing and opening operations. | Signals take place normally. |
| **11** | Locking electromagnet on the truck circuit breaker (-RLE2) (if provided). | With the circuit breaker open, in the isolated for test position and the locking electromagnet not supplied, attempt racking-in of the circuit breaker. | Racking-in is not possible. |
| | | Supply the locking electromagnet and carry out the racking-in operation. | Racking-in takes place correctly. |
| **12** | Auxiliary transmitted contacts for signalling circuit breaker racked-in, isolated (UniGear switchgear or PowerCube modules). | Insert the auxiliary contacts in suitable signalling circuits.<br>With the circuit breaker racked into the enclosure, carry out a few traverse operations from the isolated for test position to the connected position.<br>Take the circuit breaker to the racked-out position. | The signals due to the relative operations take place normally. |
| **13** | CMU and Sensors | Perform 5O & 5C to check if the CMU and Sensors are communicating. | Curves on dashboard as per the standard. |

# 9. Maintenance

The maintenance operations are aimed at keeping the apparatus in good working condition for as long as possible.
In accordance with what is specified in the IEC 61208 / DIN 31 051 Standards, the following operations must be carried out.

| | |
|---|---|
| Inspection: | Finding out the actual conditions |
| Overhauling: | Measures to be taken to maintain the specific conditions |
| Repairs: | Measures to be taken to restore the specific conditions. |

## 9.1. General

ABB Advises you to refer to the SWAPs maintenance program to get a customized maintenance plan according to your specific environmental and operational conditions. Use the QR code below to access the SWAPs webpage and related creation tool.

Vacuum interruption does not produce any harmful effects even when there are frequent interruptions at the rated and short-circuit current.
The interventions during service and their aim are determined by the ambient conditions, by the sequence of operations and by the short-circuit interruptions.

Note
Respect the following Standards for maintenance work:
the relative specifications given in the chapter on “Standards and Specifications”;
– work safety regulations in the chapter on “Putting into service and operations”;
– standards and specifications of the country where the apparatus is installed.

The maintenance operations must only be carried out by trained personnel and who follow all the safety regulations.
Furthermore, it is advisable to call on ABB personnel, at least in cases for checking the performances in service and for repairs.
Cut the power supply off and put the apparatus under safe conditions during the maintenance operations.

**Before carrying out any operations, check that the circuit breaker is open, with the spring discharged and that it is not supplied (medium voltage circuit and auxiliary circuits).**

### 9.1.1. Operating life expectancy

The operating life expectancy for the VD4 circuit breakers is as follows:

- vacuum interrupters: up to 30.000 operations, according to their type (see par. 7.2.3. Trip curves);
- switching device, actuator and transmission system: up to 30.000 operations, under normal operating conditions, according to the type of circuit breaker and with regular
- with operations correctly executed it is possible to carry outup to 1000 racking-out/in operations (as prescribed in theIEC 60271-200 Standards);
- with operations correctly executed it is possible to carry out up to 500 racking-out/in operations (as prescribed in the IEEE/ANSI C37.20.2 Standards);
- the data regarding the operating life are basically applicable to all the components which cannot be directly affected by operator activity. The manually operated components (moving parts of isolatable parts, etc.) can vary their behaviour.

# 9. Maintenance

## 9.2. Inspections and functionality tests

### 9.2.1. Interruption devices in general

- Check the conditions of the interruption devices with regular inspections.
- Inspection at fixed intervals can be avoided when the apparatus is permanently under the control of qualified personnel.
- The checks must, first of all, include visual inspection to check for any contamination, traces of corrosion or electrical discharge phenomena.
- Carry out more frequent inspections when there are unusual operating conditions (including severe climatic conditions) and in the case of environmental pollution (e.g. high level of contamination or an atmosphere with aggressive agents).
- Visual inspection of the isolating contacts. It is recommended to turn the contact system alternately in order to keep the internal surface of the contact areas clean. The contact areas must be cleaned when there are signs of overheating (discoloured surface) (also see Repairs).



- In the case of abnormal conditions, take suitable overhauling measures (see Overhauling par.).

### 9.2.2. Stored energy operating mechanism

Carry out the functional test of the operating mechanism after 5.000 operations or during ordinary maintenance operations as specified in par. 9.2.1. and service the release devices at least every 5 years (see par. 9.3.2.).
Before doing the test, open the circuit breaker and carry out the following operations:

- in the case of withdrawable circuit breakers, take the circuit breaker to the isolated for test position
- in the case of fixed circuit breakers: cut off the power supply to the medium voltage circuit.

Note
Insulate the work area and make it safe, following the safety regulations specified in the IEC/DIN VDE Standards.

**Functional test**

- With the circuit breaker not connected to the load, carry out a few opening and closing operations.
- If foreseen, cut the power supply to the spring charging motor off. Discharge the spring by closing and opening the circuit breaker by means of the closing and opening pushbuttons.
- Visually inspect the lubrication conditions of the tulip isolating contacts, of the sliding surfaces, etc.
- Check correct electrical and mechanical operation of the various devices, with particular attention to the interlocks.
- The screws and nuts are tightened in the factory and correct tightening is marked with a collared sign. No further tightening operations are foreseen during the operating life of the circuit breaker. However, following any maintenance interventions, should it be necessary to re-tighten the screws or nuts, it is recommended to always replace the screws and nuts and to keep to the values indicated in fig. 12.

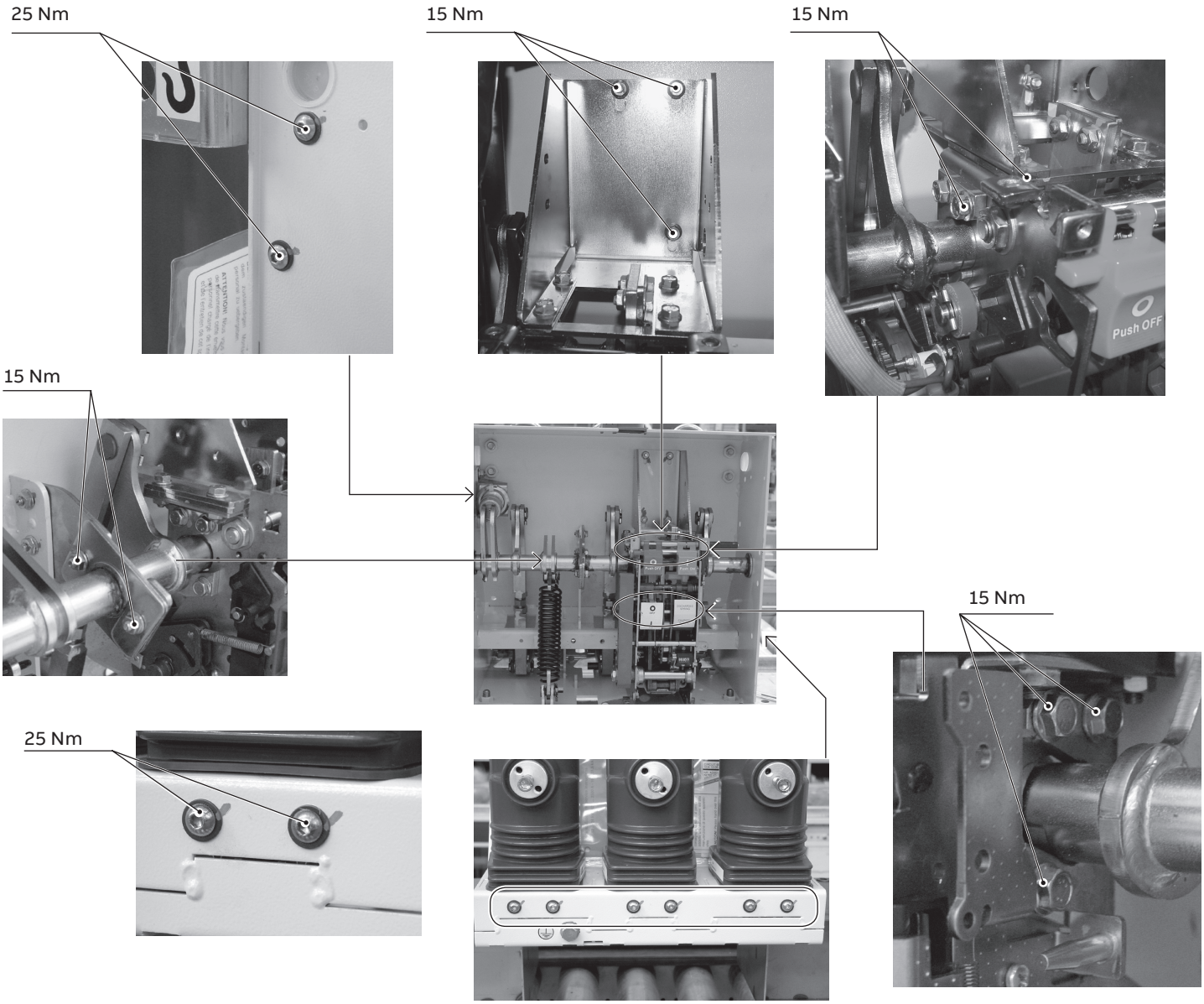
### 9.2.3. Circuit breaker pole

No other check except what has already been specified in par. 9.2.1. is necessary.

### 9.2.4. Withdrawable assembly (truck and circuit-breaker)

Visually inspect the components, especially those which may be damaged by incorrect operations (also see table in chap. 8).
Visually inspect the isolating contacts and that all the contact elements are clean, especially in cases where signs of overheating are found (also see par. 9.4.).
Visually inspect and carry out the functional tests of the locks, checking their correct operation and activation without abnormal force – maximum 25 N (also see table in chap. 8).

**Checking tightness of the screws**




**EL Twin actuator - 50 kA**

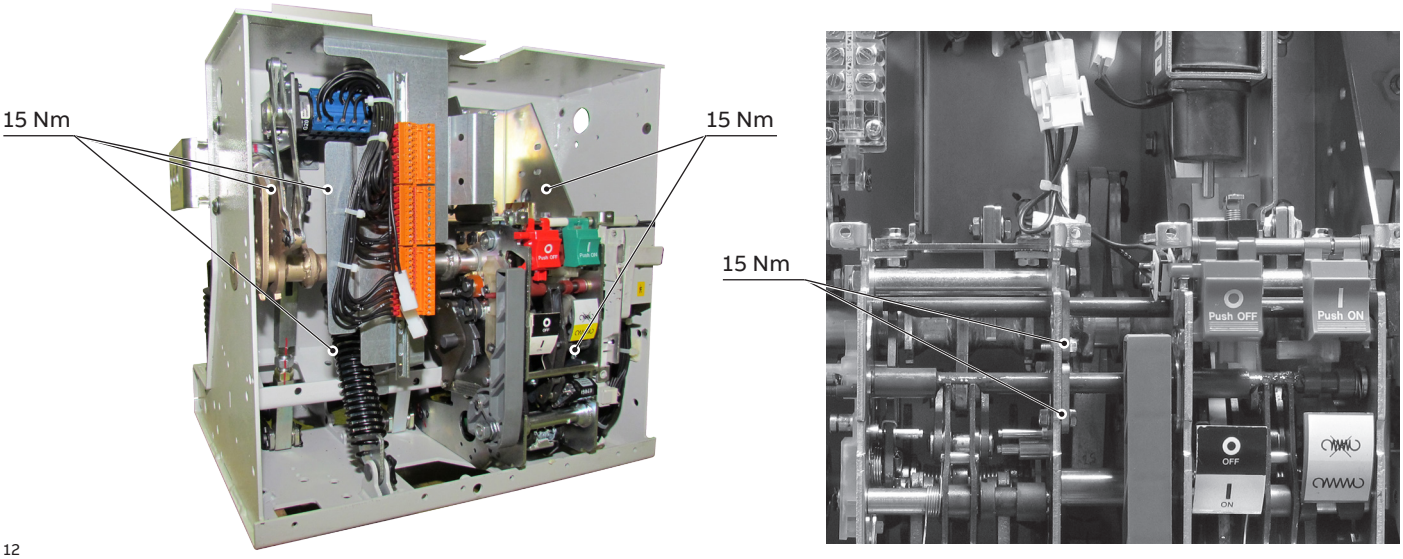



Fig. 12

# 9. Maintenance

## 9.3. Overhauling

### 9.3.1. Interruption devices in general

Should it have been necessary to clean the devices during the inspections, according to what is specified in par. 9.2.1., use the following procedure:

- insulate the work ar ea and make it safe, following the safety regulations specified in the IEC/DIN VDE Standards;
- general cleaning of the surfaces:
  - dry and eliminate light deposits of dirt with a soft dry cloth;
  - more resistant deposits of dirt can be removed using slightly alkaline domestic type detergent or Rivolta BWR 210 type detergent;
- cleaning insulating surfaces and conductive parts.

After cleaning, rinse thoroughly with clean water and dry carefully.

Note
Only use detergents without halogens and never 1.1.1-trichloroethane, trichloroethylene or carbon tetrachloride!

### 9.3.2. Tripping device: actuator and transmission system

**Circuit breakers up to 17.5 kV, 1250 A, 31.5 kA and up to 24 kV, 2500 A, 25 kA**

To ensure correct operation of the circuit breaker, inspection and maintenance of the tripping devices is recommended every 10.000 operations. For this purpose, please contact the ABB Service office.
Complete replacement of the actuator, shock absorber and of the other transmission system parts (shaft, main levers, safety rings, etc.) must be carried out after 30.000 operations.

**IEEE circuit breakers 15kV up to 2000A, 40kA**

To ensure correct operation of the circuit breaker, inspection and maintenance of the tripping devices must be carried out every 2.000 operations. For this purpose, please contact the ABB Service office.
Replacement of spring charging motor (-MAS) must be carried out every 5.000 operations.
Complete replacement of the shock absorber and of the other parts of the transmission system (shaft, main levers, safety rings, etc.) must be carried out every 10.000 operations.

**Circuit breakers up to 17.5 kV, 40 kA and 24 kV, 31.5 kA**

To ensure correct operation of the circuit breaker, inspection and maintenance of the tripping devices is recommended every 5.000 operations. For this purpose, please contact the ABB Service office.
Complete replacement of the actuator must be carried out every 10.000 operations.
Complete replacement of the shock absorber and of the other transmission system parts (shaft, main levers, safety rings, etc.) must be carried out after 30.000 operations.

**Circuit breakers up to 17.5 kV, 3150 A , 40 kA and 36/40.5 kV**

To ensure correct operation of the circuit breaker, inspection and maintenance of the tripping devices must be carried out every 5.000 operations. For this purpose, please contact the ABB Service office.
Complete replacement of the shock absorber and of the other part of the transmission system (shaft, main levers, safety rings, etc.) must be carried out after 10.000 operations.

**Circuit breakers up to 17.5 kV, 50 kA and EL twin actuator**

To ensure correct operation of the circuit breaker, inspection and maintenance of the tripping devices must be carried out every 5.000 operations. For this purpose, please contact ABB Service.
Complete replacement of the shock-absorber and of the other parts of the transmission system (shaft, main levers, safety rings, etc.) must be carried out every 10.000 operations.

Note
Dismantling and replacement of the operating mechanism (trip box) can only be carried out by ABB personnel or by skilled and specially trained personnel, particularly for the necessary adjustments.

**Details regarding overhauling**

- When foreseen, cut of the power supply to the spring charging motor and manually discharge the operating mechanism spring by closing and opening the circuit breaker.
- Replace the parts subjected to mechanical str ess or stress due to particular environmental conditions, (contact and ABB service centre).
- Consult maintenance instruction manual 1VCP000558 for further details.

Note
These operations can only be carried out by ABB personnel or by skilled and specially trained personnel.

### 9.3.3. Circuit breaker pole

The circuit breaker pole and relative vacuum interrupter are maintenance-free until the maximum number of electrical operations for the type of interrupter is reached (see par. 7.2.3. Trip curves). The operating life of the vacuum interrupter is defined by the sum of the ultimate currents corresponding to the specific type of interrupter in accordance with what is indicated in the graphs of par. 7.2.3. Trip curves: when the sum of the ultimate currents is reached, the whole pole must be replaced.

Note
Dismantling and replacement of the pole can only be carried out by ABB personnel or by skilled and specially trained personnel, particularly for the necessary adjustments.

To carry out the interrupter test without dismantling the circuit breaker pole, use:

- the VIDAR vacuum tester, made by the company Programma Electric GmbH, Bad Homberg v.d.H.

To check vacuum tightness of the interrupter, the following test values must be set on the VIDAR tester:

| Rated voltage of the circuit breaker | d.c. test voltage |
|---|---|
| 12 kV | 40 kV |
| 17.5 kV | 40 kV |
| 24 kV - 36 kV - 40.5 kV | 60 kV |

CMU and Sensors The expected life expectancy for CMU and sensors is 10 years. After 10 years please get in touch with ABB Service for the replacement. For VD4 evo customers can replace the sensors themselves without any intervention from ABB Service.
Detailed instructions for installing the sensors is available .Please see section.7 -Installation for more details.
ABB shall provide the software updates from time to time.

The test must always be carried out with the circuit breaker open with the contacts at the nominal distance.

**Procedure for testing the degree of vacuum of the interrupter of the circuit breaker poles:**

- **turn the power supply off and make the working area safe by following the safety regulations specified in the IEC/ DIN VDE Standards;**
- **open the circuit breaker;**
- **earth a terminal of each circuit breaker pole;**
- **connect the earth terminal of the VIDAR tester to the circuit breaker structure;**
- **connect the high voltage terminal of the VIDAR tester to the terminal of the circuit breaker pole not connected to earth (L1 phase) and carry out the test. Repeat the test for phases L2 and L3.**

Note
The tester connection cables can produce an indication due to the capacitive effect. In this case the cables must not be removed.

## 9.4. Repairs

Replacement of spare parts and accessories must only be carried out by ABB personnel or suitably qualified and specially trained personnel.
Always work with the circuit breaker open and locked so that it cannot be closed again, with the work area insulated and made safe.
The operating mechanism spring must be discharged.
All power supply sources must be disconnected and made safe against any reclosing during removal and installation work.

**Should maintenance be carried out by the customer's personnel, responsibility for the interventions remains with the customer.**
**The replacement of parts not included in the "List of spare parts/accessories" (par. 12.1.) must only be carried out by ABB personnel. In particular:**

- **complete pole with bushings/ connections**
- **actuator and transmission system**
- **closing spring set**
- **opening spring**
- **shock-absorber.**

# 10. Application of the X-ray emission Standards

One of the physical properties of vacuum insulation is the possibility of X-ray emission when the interrupter contacts are open.
The specific tests carried out at the PTB laboratories (Physikalisch-Technische Bundesanstalt, in Brunswick - Germany) show that local emission at a distance of 10 cm from the interrupter or pole surface, does not exceed 1 μSv/h.

**It follows that:**

- at the rated service voltage the use of vacuum interrupters is absolutely safe;
- application of the withstand voltage at power frequency, according to the IEC 62271-100 and VDE 0670 Standards, is safe;
- application of a voltage higher than the withstand voltage at power frequency or of a test voltage in direct current, specified in the IEC and VDE Standards, cannot be used;
- limitation of the above-mentioned local phenomena, with interrupters with open contacts, depends on keeping the specific distance between the contacts.
  This condition is intrinsically guaranteed by correct operation of the operating mechanism and by the adjustments of the transmission system.

# 11. Spare parts and accessories



**All assembly operations of spare parts/ accessories must be carried out following the instructions enclosed with the spare parts, by ABB personnel or by suitably qualified customer personnel with in-depth knowledge of the apparatus (IEC 60694) and of all the Standards aimed at carrying out these interventions in safe conditions. Should the maintenance be carried out by the customer's personnel, responsibility for the interventions remains with the customer. Before carrying out any operation, always make sure that the circuit breaker is open, the spring discharged and that it is not energised (medium voltage circuit and auxiliary circuits).**

To order circuit breaker spare parts/accessories, refer to the ordering sales codes indicated in the technical catalogue and always state the following:
- type of circuit breaker
- rated voltage of the circuit breaker
- rated normal current of the circuit breaker
- breaking capacity of the circuit breaker
- serial number of the circuit breaker
- rated voltage of any electrical spare parts.

For availability and to order spare parts, please contact our Service office.

## 11.1. List of spare parts

- Shunt opening release
- Additional shunt opening release
- Undervoltage release
- Contact for signalling undervoltage release energised/deenergised
- Time delay device for undervoltage release
- Mechanical override for undervoltage release
- Shunt closing release
- Spring charging geared motor with electrical signalling of spring charged
- Contact signalling protection circuit breaker of the geared motor open/closed
- Contact signalling closing spring charged/ discharged
- Transient contact with momentary closing during circuit breaker opening
- Circuit breaker auxiliary contacts
- Locking electromagnet on the operating mechanism
- Position contact of the withdrawable truck
- Contacts signalling connected/isolated
- Opening solenoid
- Key lock in open position
- Isolation interlock with the door
- Protection for opening pushbutton
- Protection for closing pushbutton
- Locking electromagnet on the withdrawable truck
- Set of six tulip contacts
- CMU (for VD4 evo only)
- Temperature sensor with Smart Arm (for VD4 evo only)
- Angle sensor (for VD4 evo only)

# 12. Electric circuit diagrams

The standard VD4 circuit breaker electric circuit diagrams are as follows:

Free standing version:
- 1VCD400151: Fixed circuit breakers
- 1VCD400152: Fixed circuit breakers with 64-pole connector
- 1VCD400153: Fixed circuit breakers with 58-pole connector
- 1VCD400154: Fixed circuit breakers with truck

Withdrawable version
- 1VCD400155: Withdrawable circuit breakers
- 1VCD400156: Withdrawable motorized circuit breakers
- 1VCD400158 Withdrawable circuit breakers for ZS8.4 switchgear VD4/ZS8, ZT8 and Z8 with circuit breaker
- 1VCD400159: Withdrawable circuit breakers for ZS8.4 switchgear with VD4/ZS8, ZT8 and Z8 circuit breaker with motorized truck

50kA version
- 1VCD400166: Fixed circuit breakers 50 kA
- 1VCD400167: Withdrawable circuit breakers 50 kA
- 1VCD400168: Withdrawable circuit breakers 50 kA with motorized truck.

Each circuit breaker is always provided with the standard electric diagram or with a specific diagram in the case of a circuit breaker with non-standard cabling.

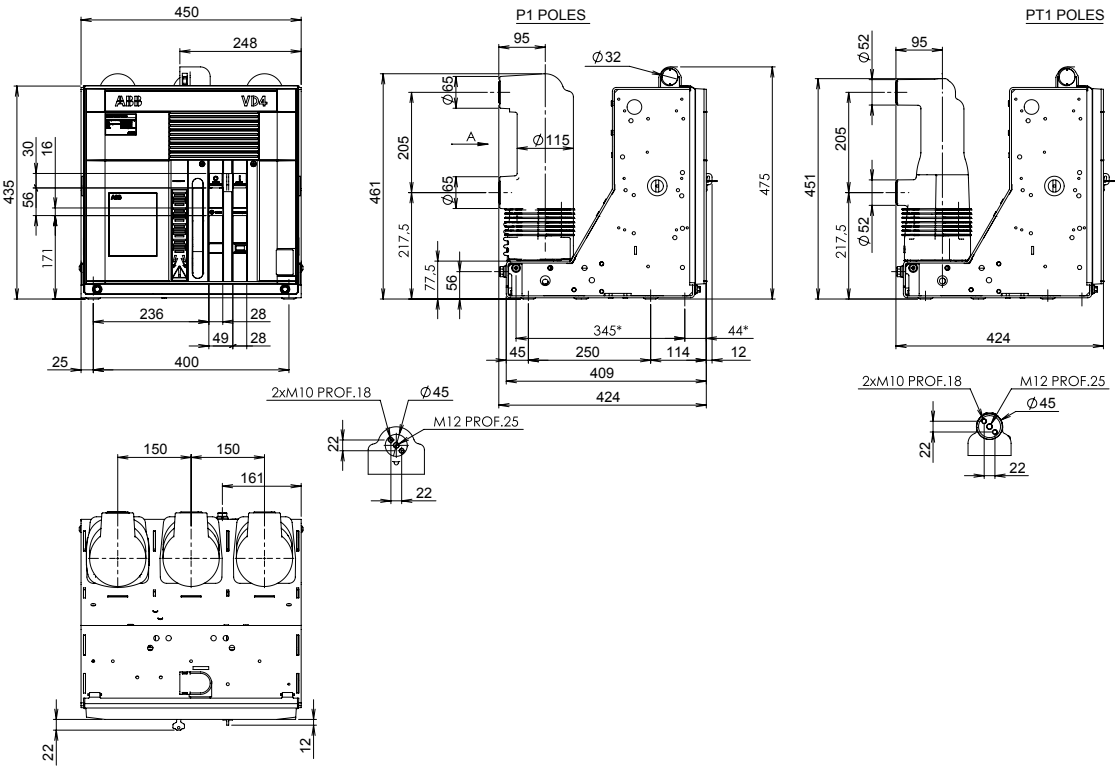
Free standing version VD4 evo 40 kA:
- 1VCD400316: Fixed circuit breakers

Withdrawable version VD4 evo 40 kA:
- 1VCD400311: Withdrawable circuit breakers
- 1VCD400312: Withdrawable motorized circuit breakers

# 13. Overall dimensions

## Fixed circuit breakers

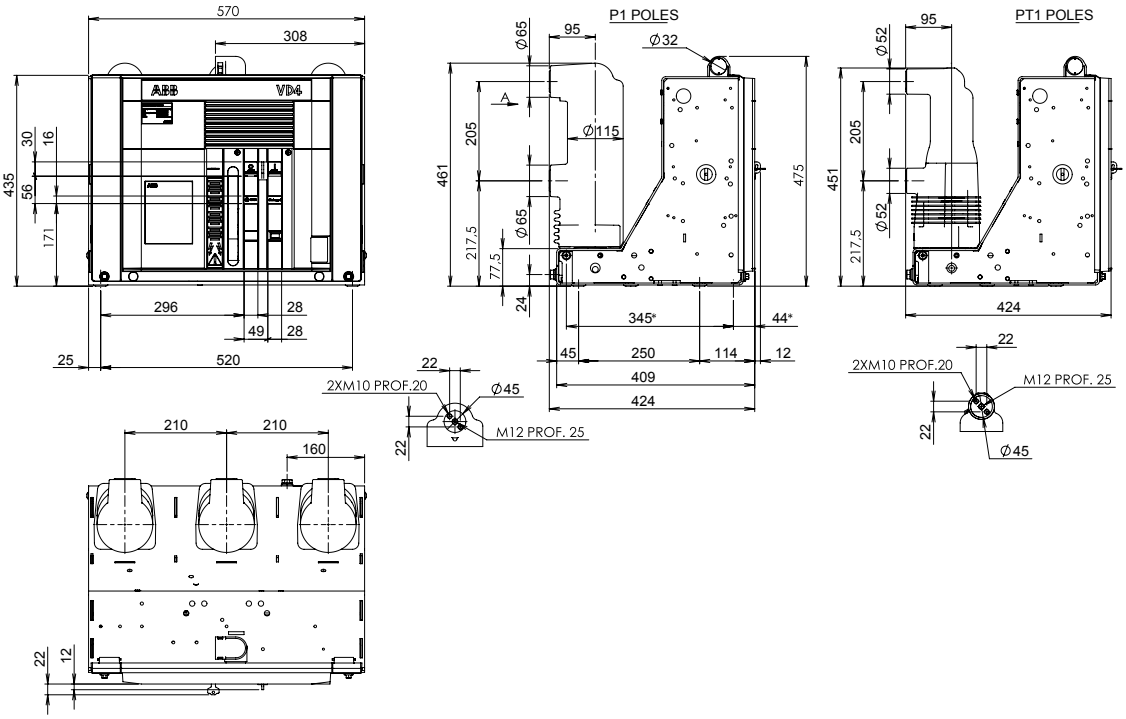
| VD4 | | |
|---|---|---|
| TN | 7405 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1200 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




(*) Fixing interchangeability with previous series (345 x 400).

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 7406 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

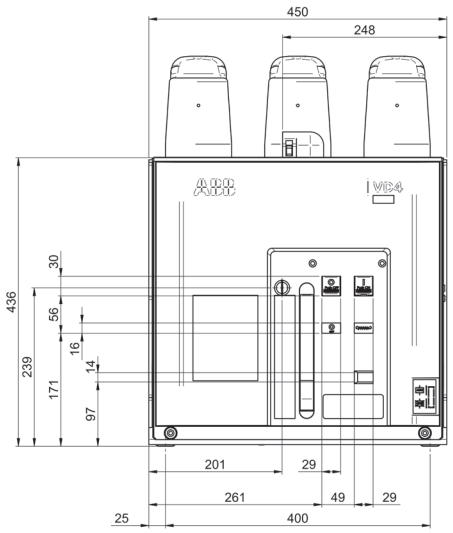


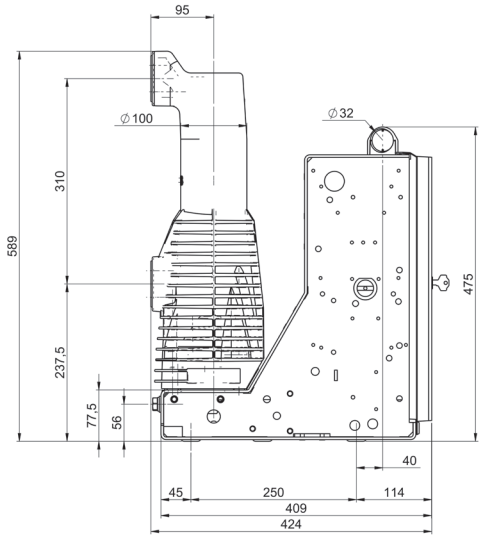

(*) Fixing interchangeability with previous series (345 x 520).

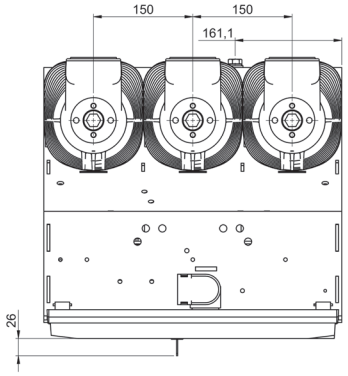
# 13. Overall dimensions

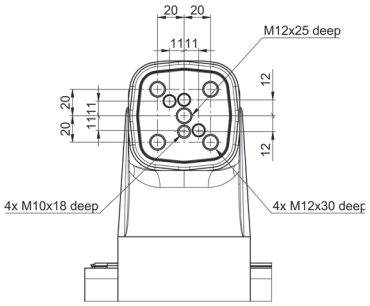
### Fixed circuit breakers

| **VD4** | | |
|---|---|---|
| TN | 2RDA043108 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



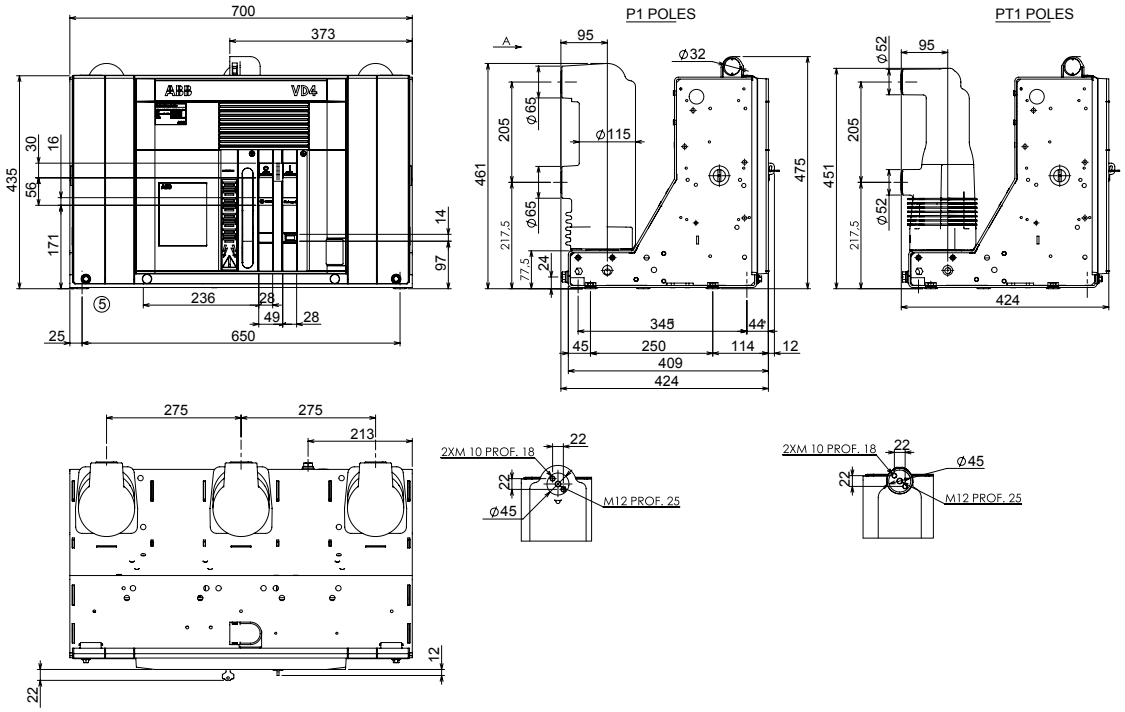



## Fixed circuit breakers

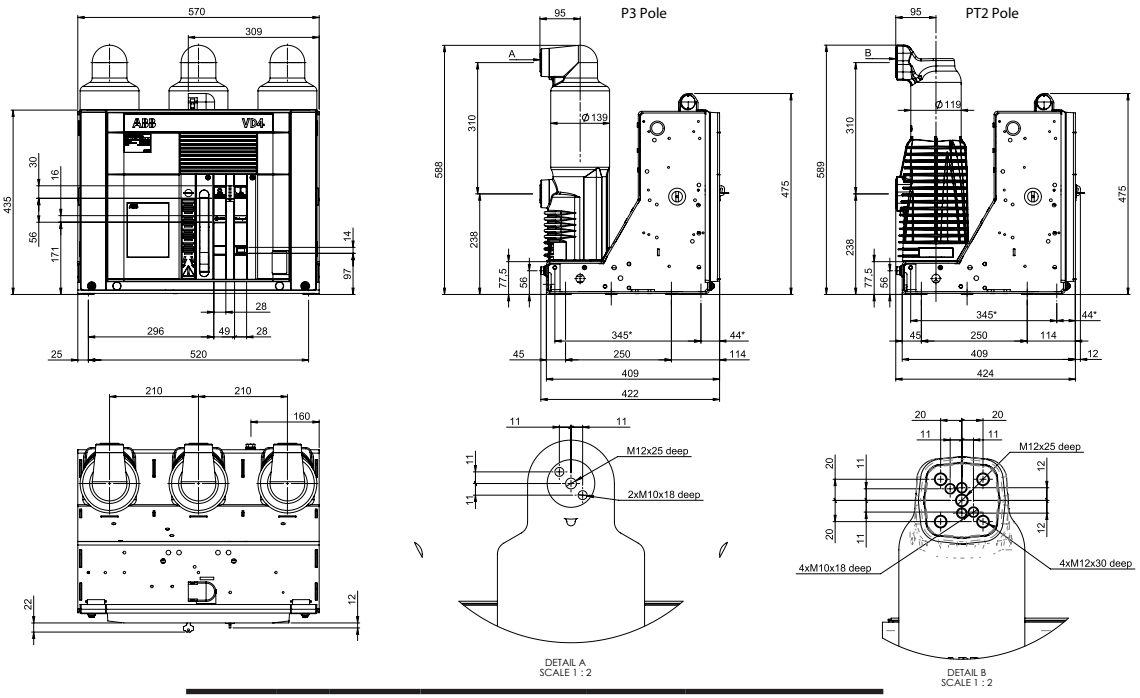
| VD4 | | |
|---|---|---|
| TN | 1VCD000051 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




(*) Fixing interchangeability with previous series (345 x 650).

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003282 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |



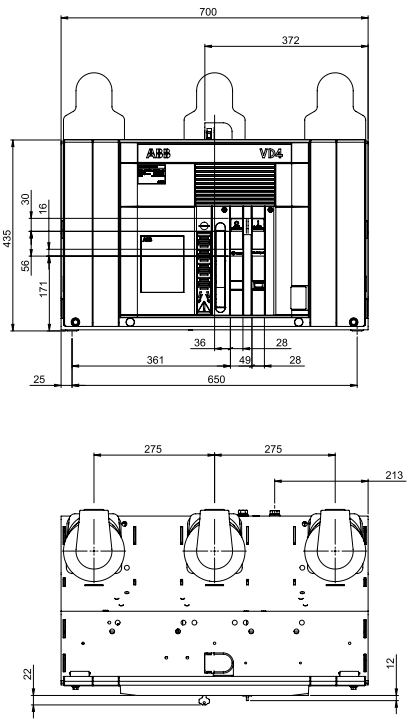

| Type | Pole | Ur | Ir | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p210 | P3 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |
| VD4 p210 | PT2 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |

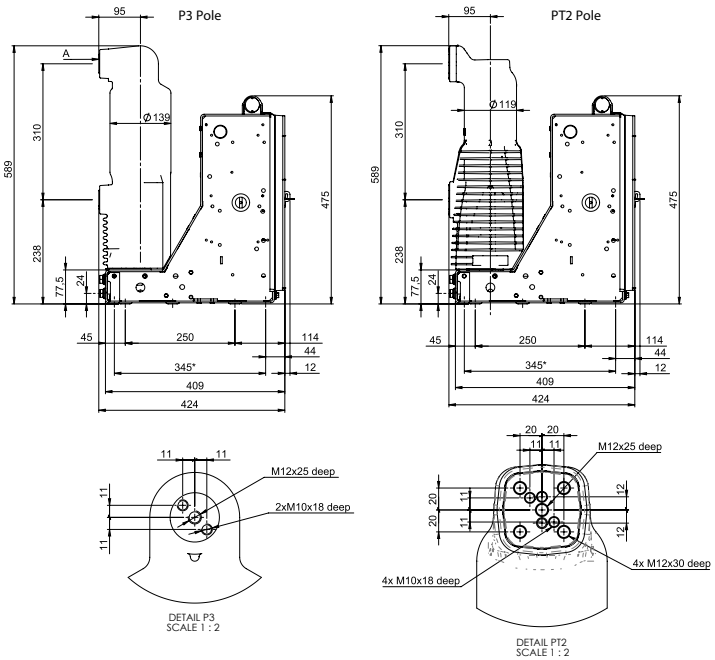
(*) Fixing interchangeability with previous series (345 x 650).

# 13. Overall dimensions

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003285 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |



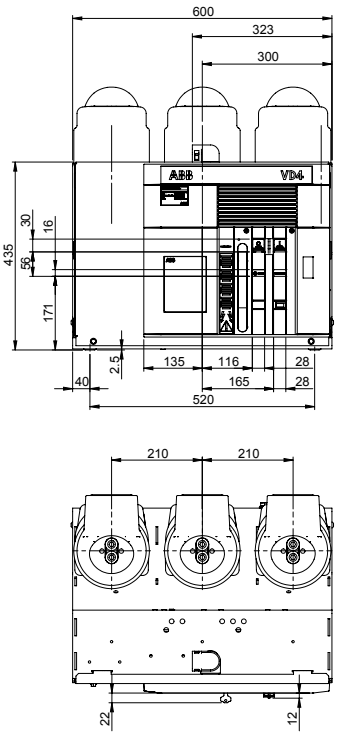



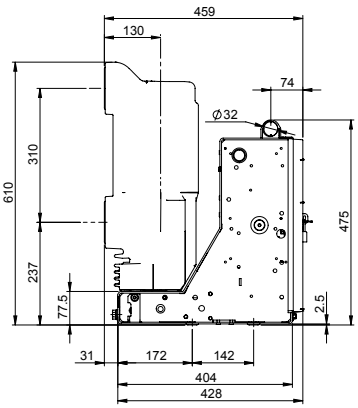

| Type | Pole | Ur | Ir | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p275 | P3 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |
| VD4 p275 | PT2 | 12-17.5 kV | 1250A-1600A | 40kA | EL | free standing installation |

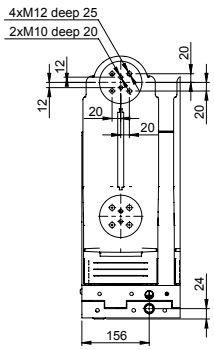
(*) Fixing interchangeability with previous series (345 x 650).

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003440 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| Isc | 50 | kA |

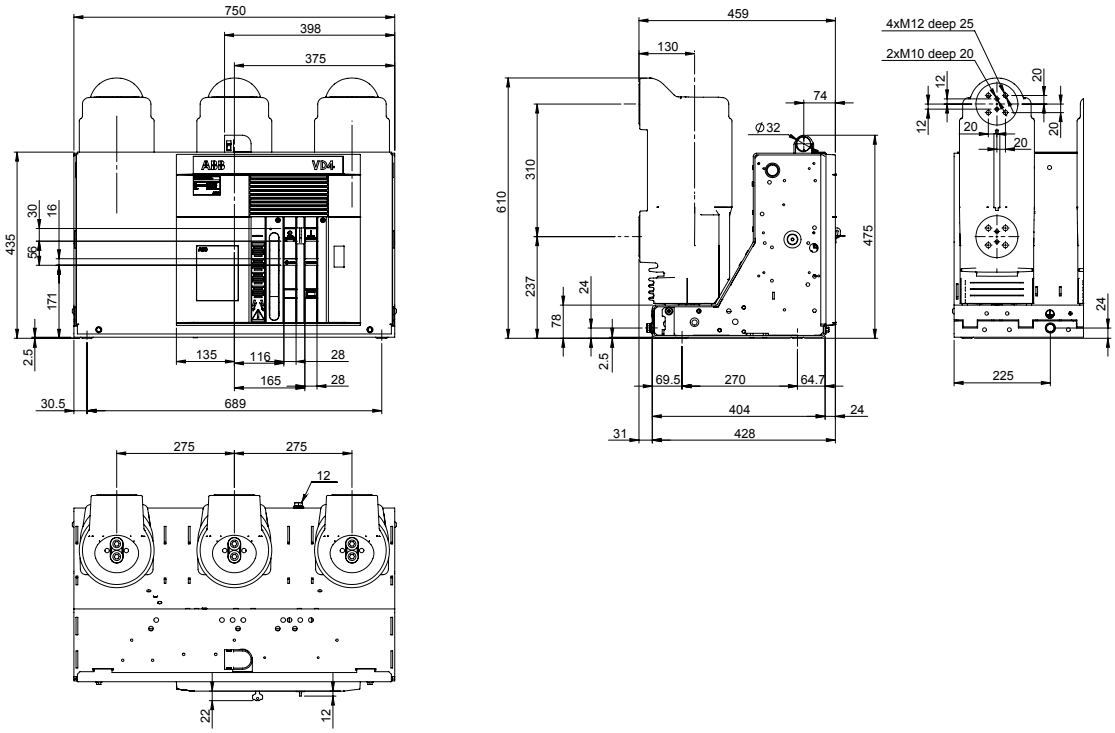


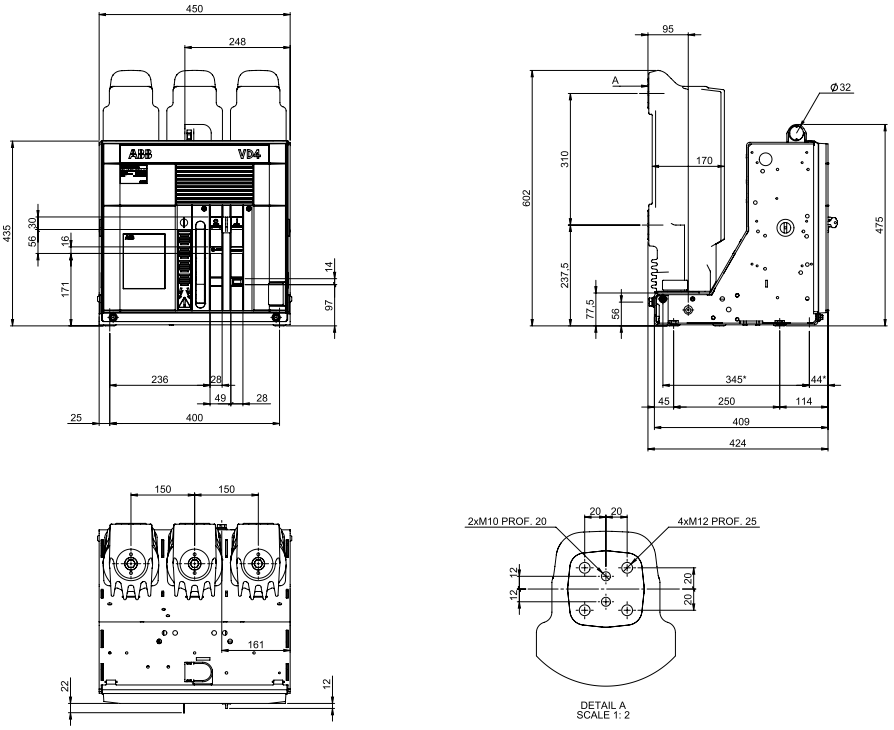
## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD003441 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 50 | kA |




## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 1VCD000050 | |
| Ur | 12 | kV |
| Ir | 1600 | A |
| | 20 | kA |
| Isc | 25 | kA |
| | 31.5 | kA |




(*) Fixing interchangeability with previous series (345 x 400).

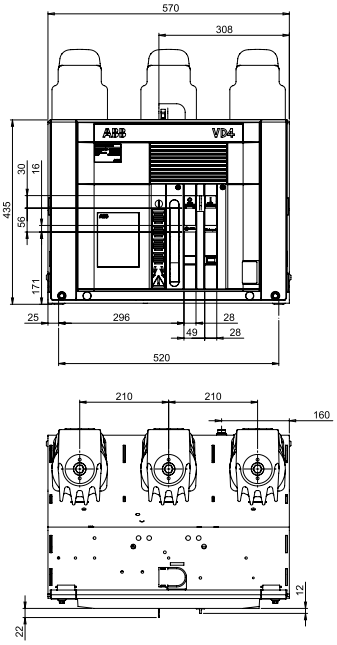
# 13. Overall dimensions

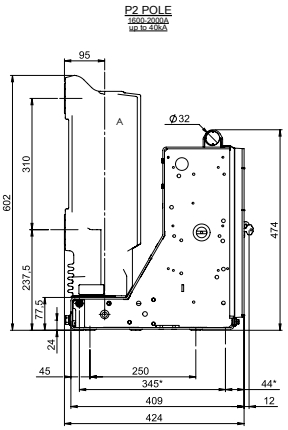
### Fixed circuit breakers

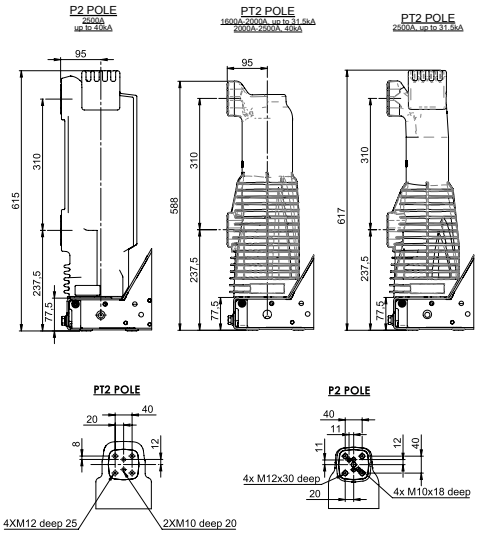
| VD4 | | |
|---|---|---|
| TN | 7407 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 1200 | A |
| | 1600 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4 | | |
|---|---|---|
| TN | 7407 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 1200 | A |
| | 2000 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |

| VD4 | | |
|---|---|---|
| TN | 7407 | |
| Ur | 12 | kV |
| Ir | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |









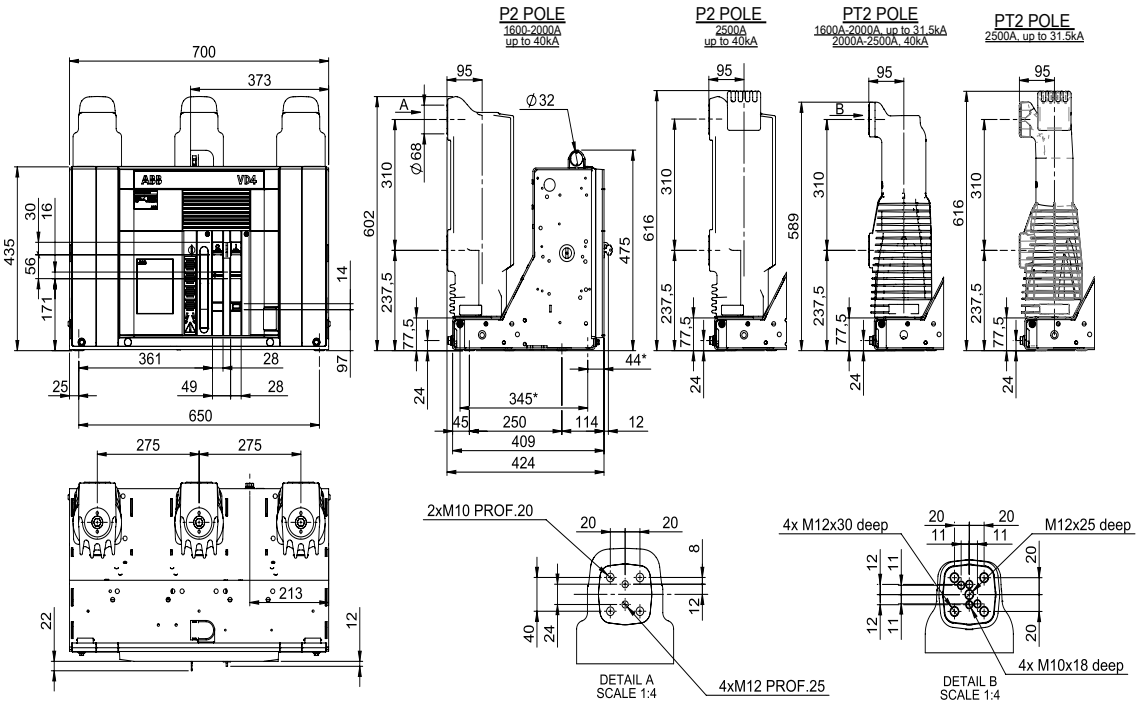

| Type | Pole | Un | In | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p.210 | P2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | free standing version |
| | | 12-17.5kV | 2000A | 40kA | EL3 | |
| | | 12kV | 2500A | 40kA | EL3 | |
| | | 15kV | 2000A | 31,5kA | EL3 | |
| VD4 12/**/**/G p.210 | | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | |
| VD4 p.210 | P2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |
| | | 12-17.5kV | 2000A | 40kA | EL3S | |
| | | 12kV | 2500A | 40kA | EL3S | |
| | PT2 | 15kV | 1200A-2000A | 40kA | EL3S | |
| VD4 12/**/**/G p.210 | | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |

(*) Fixing interchangeability with previous series (345 x 650).

## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 7408 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4 | | |
|---|---|---|
| TN | 7408 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2000 | A |
| | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



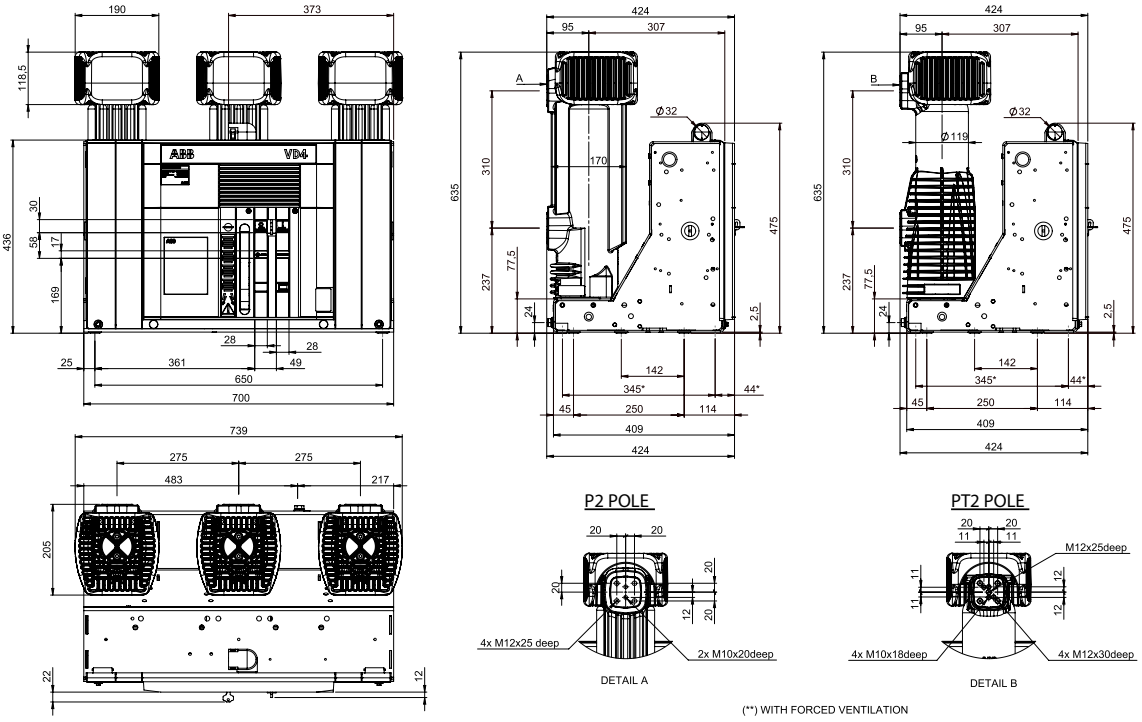

| Type | Poles | Un | In | Isc | Operating Mechanism | Version for |
|---|---|---|---|---|---|---|
| VD4 p.275 | P2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | free standing version |
| | | 12-17.5kV | 2000-2500A | 40kA | EL3 | |
| VD4 12/**/**/G p.275 | P2 | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL2 | |
| | | 12kV | 2000-2500A | 40kA | EL3 | |
| VD4 p.275 | PT2 | 12-17.5kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |
| | | 12-17.5kV | 2000-2500A | 40kA | EL3S | |
| VD4 12/**/**/G p.275 | PT2 | 12kV | 1600A-2000-2500A | 20-25-31.5kA | EL3 | |
| | | 12kV | 2000-2500A | 40kA | EL3S | |

(*) Fixing interchangeability with previous series (345 x 650).

# 13. Overall dimensions

### Fixed circuit breakers

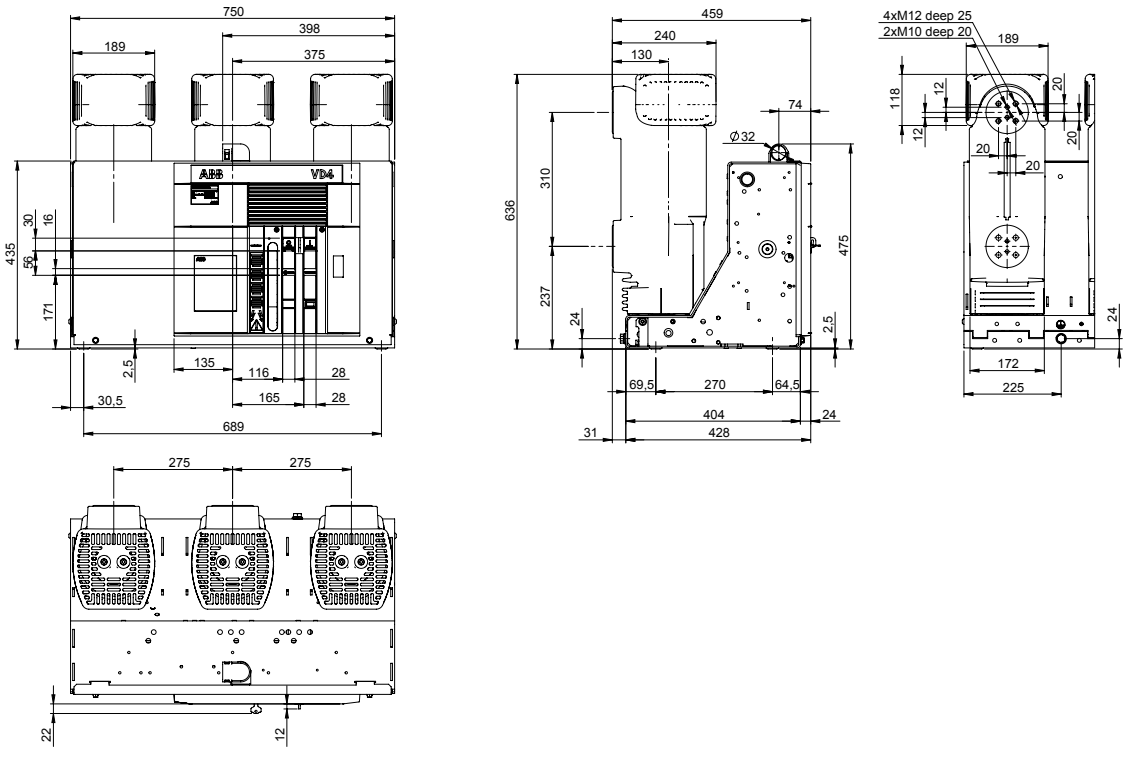
| VD4 | | |
|---|---|---|
| TN | 1VCD000149 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |




(*) Fixing interchangeability with previous series (345 x 650).

### Fixed circuit breakers

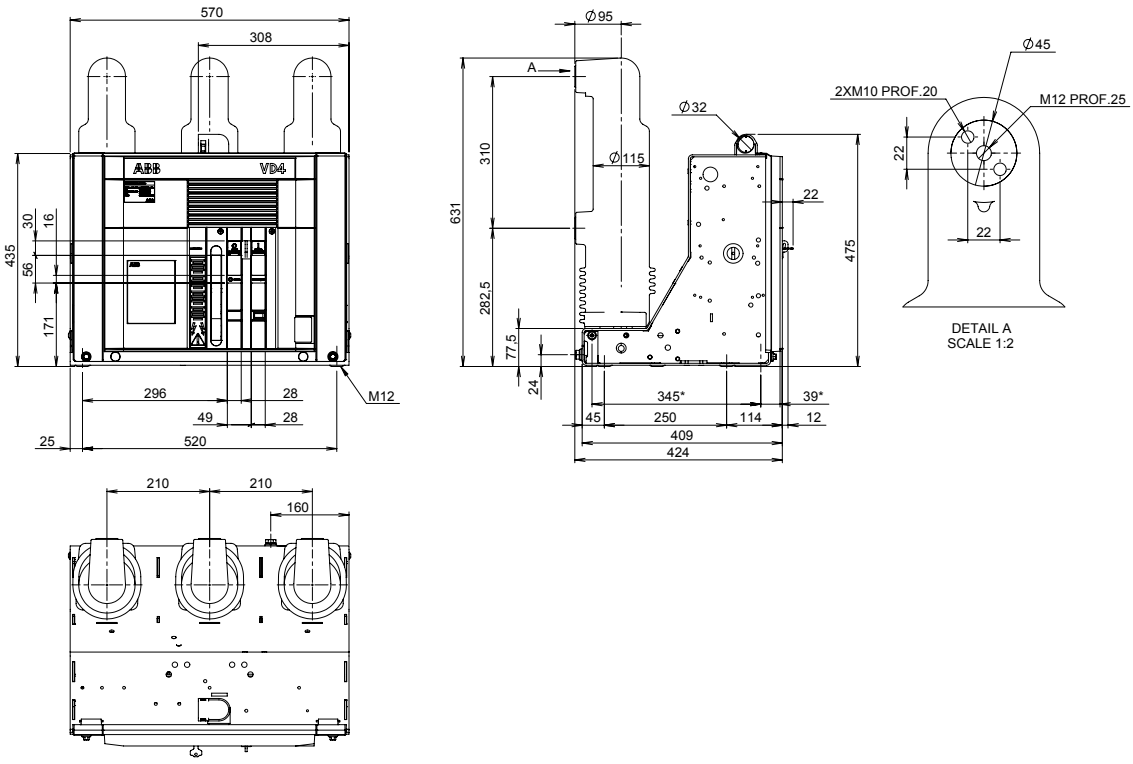
| VD4 | | |
|---|---|---|
| TN | 1VCD003443 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 50 | kA |



(*) 4000 A with forced ventilation.

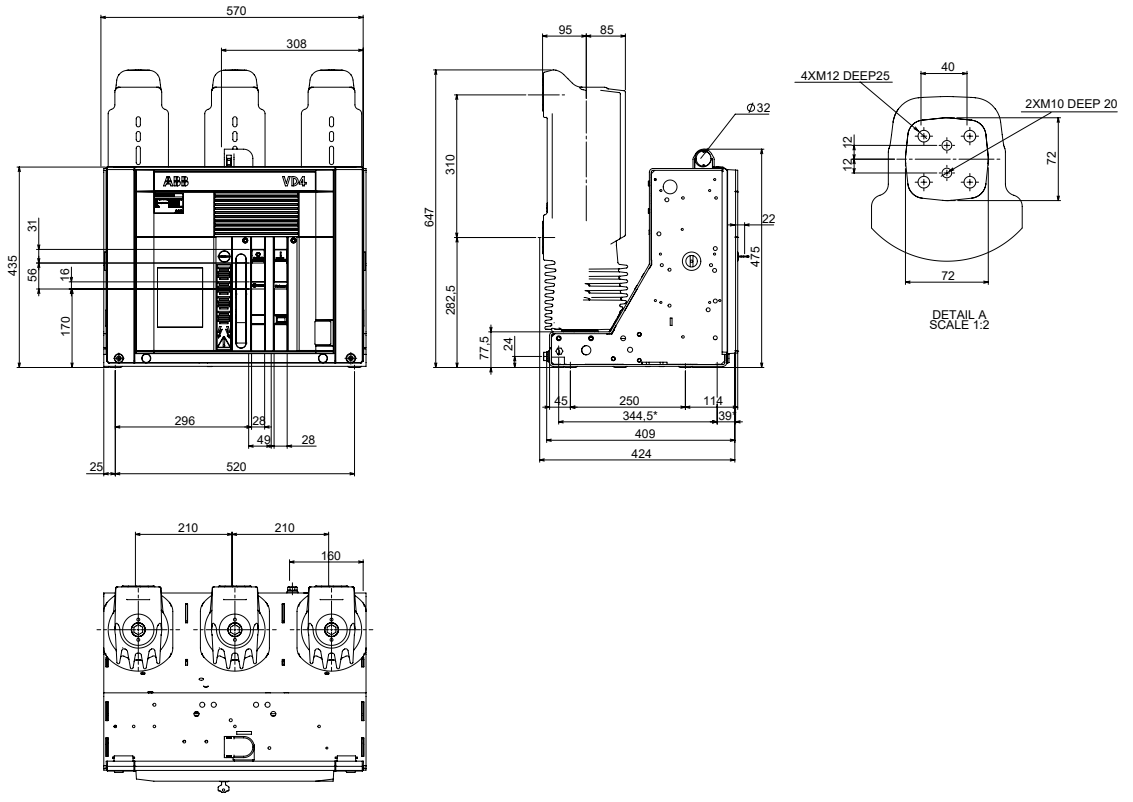
## Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 7409 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |




## Fixed circuit breakers

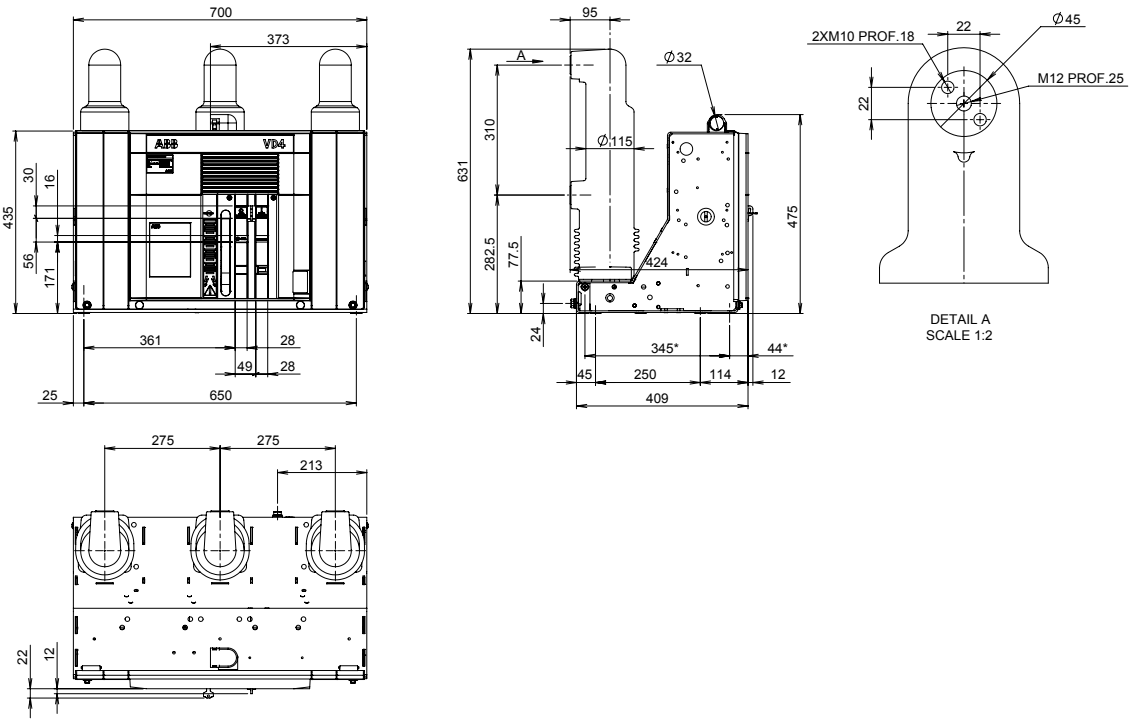
| VD4 | | |
|---|---|---|
| TN | 1VCD000172 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 31,5 | kA |



# 13. Overall dimensions

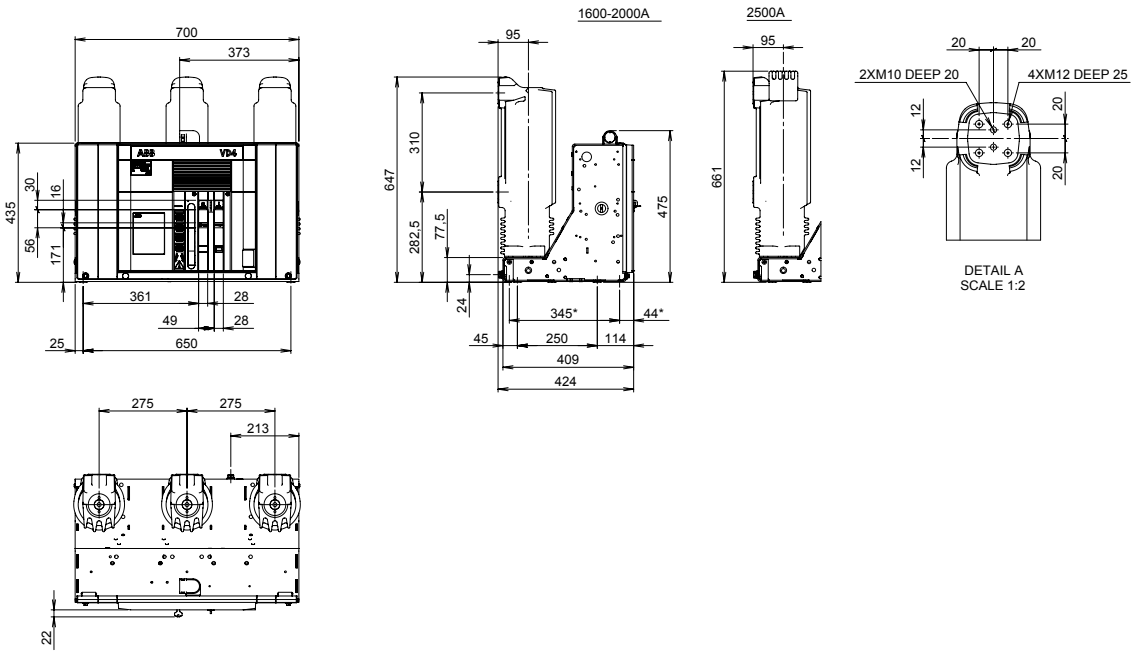
### Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | 7410 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |




### Fixed circuit breakers

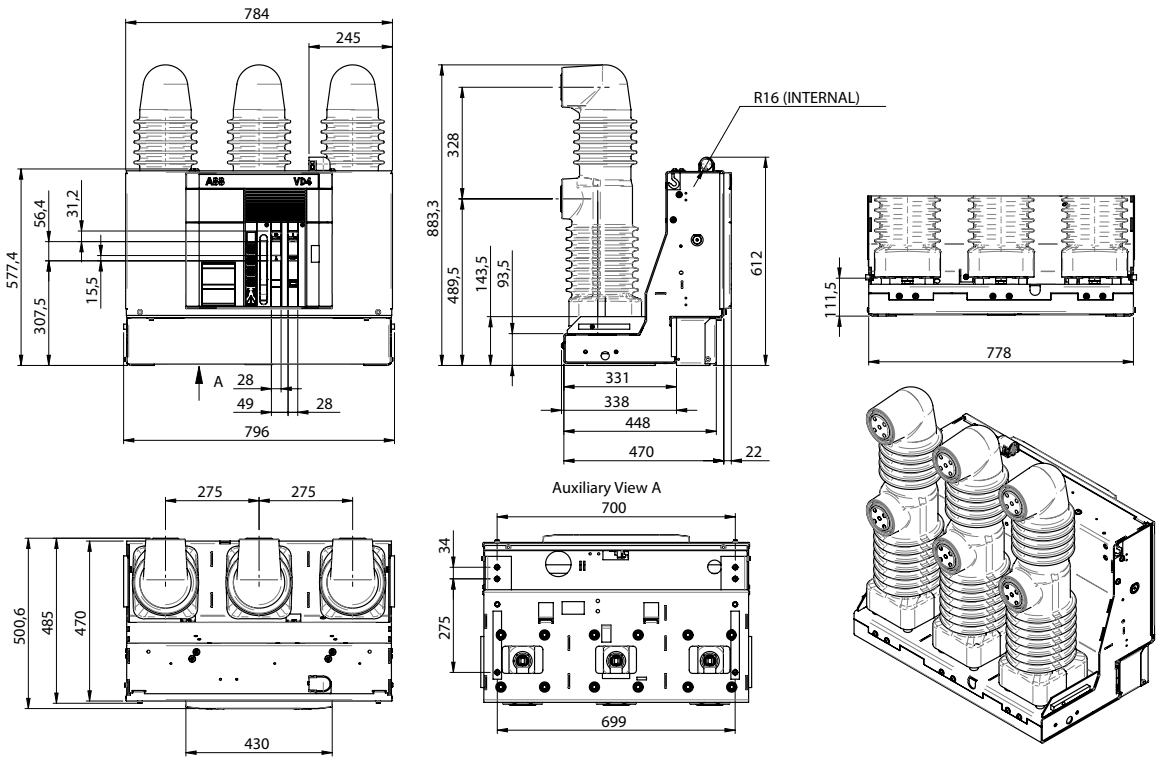
| VD4 | | |
|---|---|---|
| TN | 7411 | |
| Ur | 24 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |



## Fixed circuit breakers

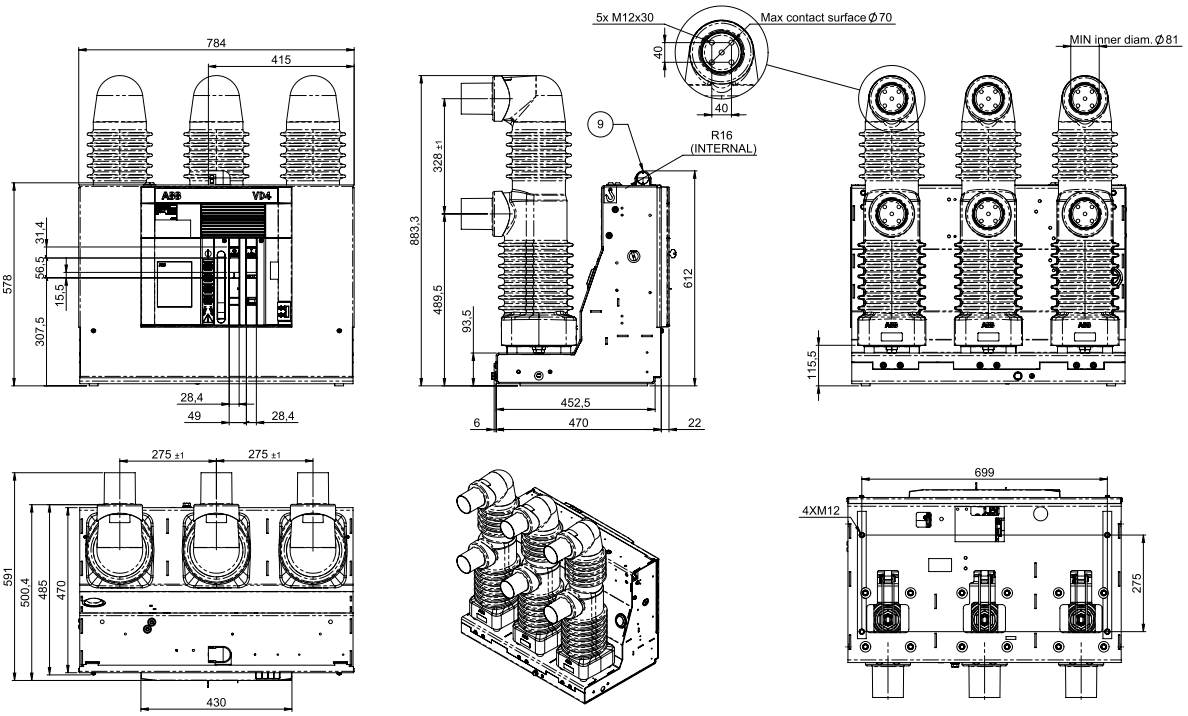
| VD4 | | |
|---|---|---|
| TN | 1VYN300901-RF | |
| Ur | 36 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4 | | |
|---|---|---|
| TN | 1VYN300901-RF | |
| Ur | 38 | kV |
| Ir | 1200 | A |
| | 2000 | A |
| Isc | 31.5 | kA |




## Fixed circuit breakers

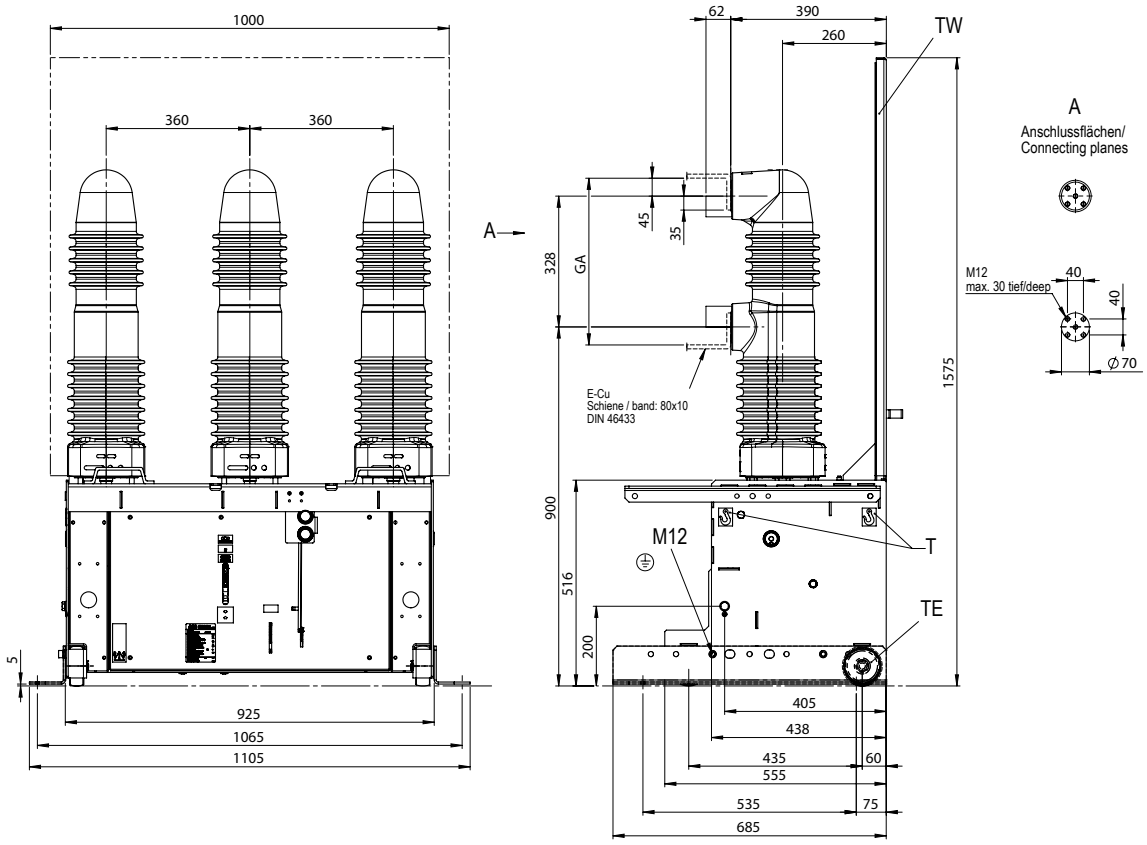
| VD4 | | |
|---|---|---|
| TN | 2RDA043326A | |
| Ur | 40.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| Isc | 31.5 | kA |



# 13. Overall dimensions

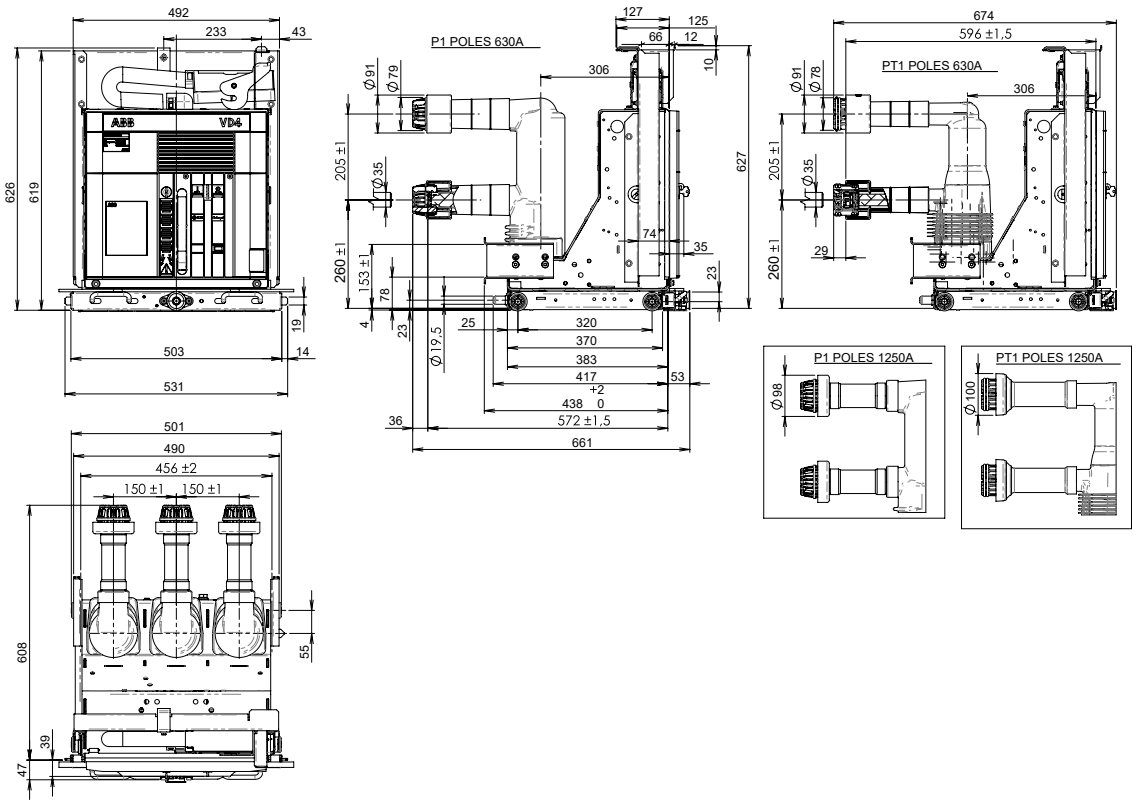
### Fixed circuit breakers

| VD4 | | |
|---|---|---|
| TN | GCEM700198 | |
| Ur | 36-40.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



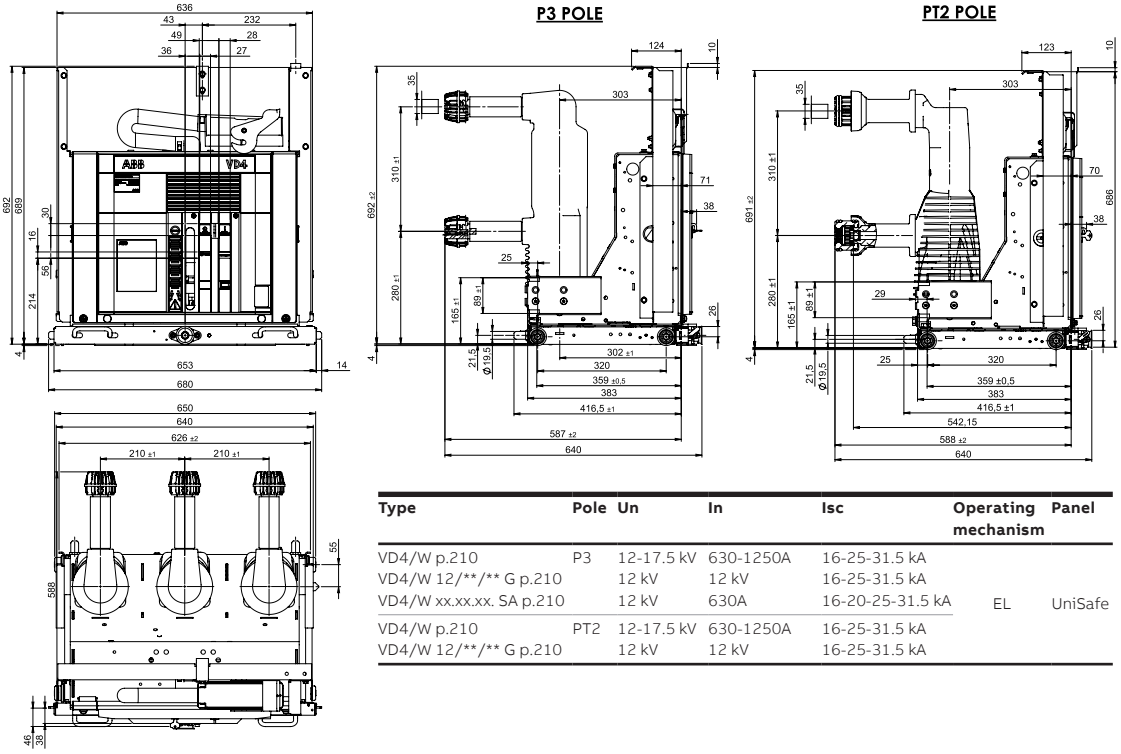
## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB1 modules

| VD4/P | | |
|---|---|---|
| TN | 7412 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1200 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




## Withdrawable circuit breakers for PowerCube PB2 modules

| VD4/W | | |
|---|---|---|
| TN | 7420 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

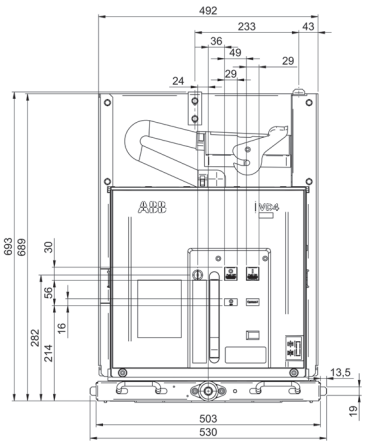


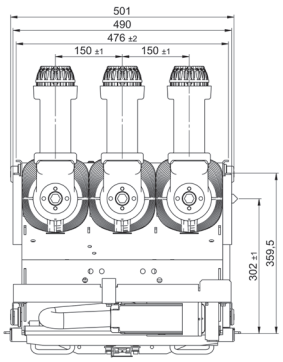

| Type | Pole | Un | In | Isc | Operating mechanism | Panel |
|---|---|---|---|---|---|---|
| VD4/W p.210 | P3 | 12-17.5 kV | 630-1250A | 16-25-31.5 kA | EL | UniSafe |
| VD4/W 12/**/** G p.210 | | 12 kV | 12 kV | 16-25-31.5 kA | | |
| VD4/W xx.xx.xx. SA p.210 | | 12 kV | 630A | 16-20-25-31.5 kA | | |
| VD4/W p.210 | PT2 | 12-17.5 kV | 630-1250A | 16-25-31.5 kA | | |
| VD4/W 12/**/** G p.210 | | 12 kV | 12 kV | 16-25-31.5 kA | | |

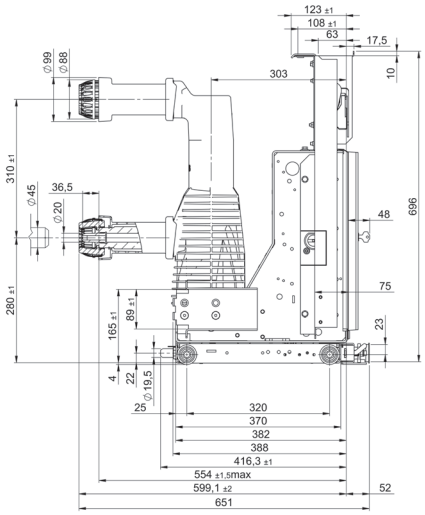
# 13. Overall dimensions

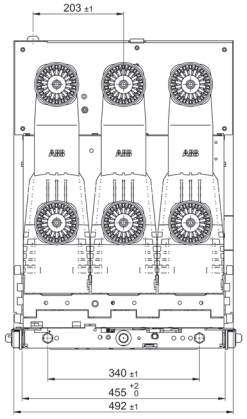
### Withdrawable circuit breakers for UniGear ZS1 switchgear

| **VD4** | | |
|---|---|---|
| TN | 2RDA040163 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |



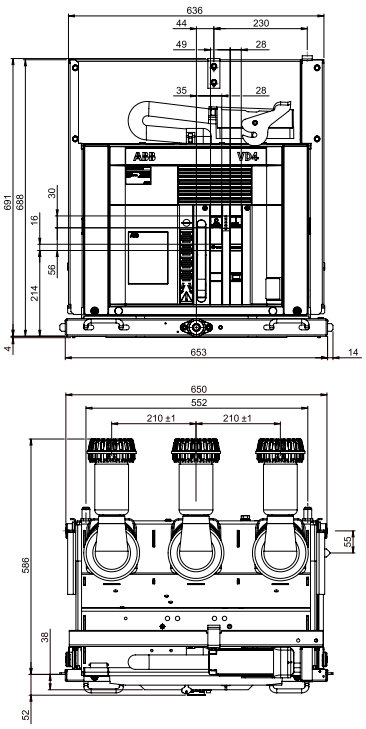



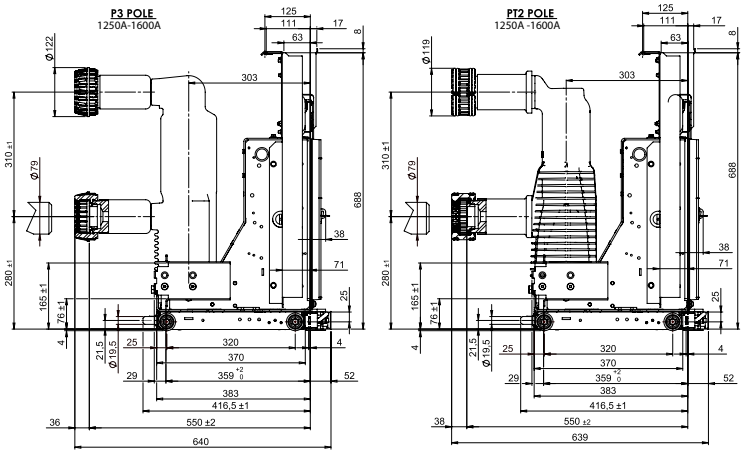



## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB2 modules

| VD4/P | | |
|---|---|---|
| TN | 1VCD003284 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |

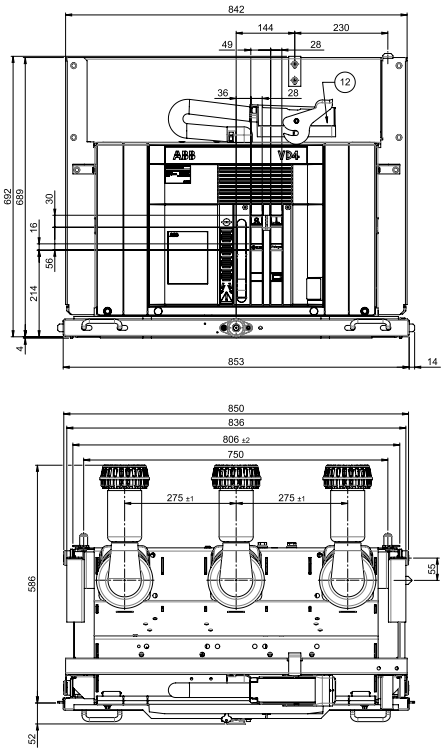


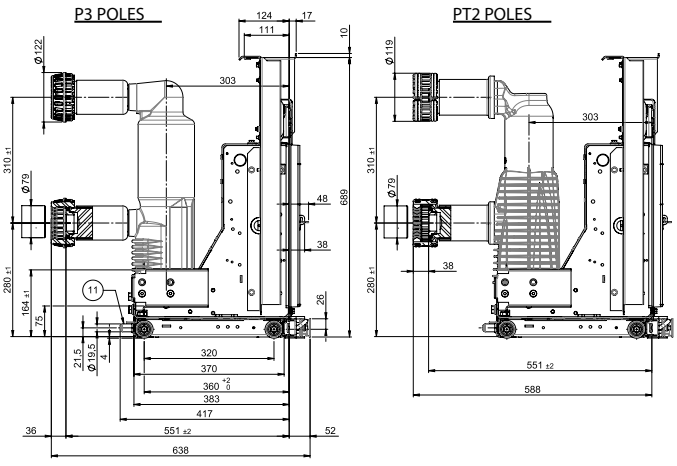




| C.B. type | Ur | Ir | Isc | Pole | Operating mechanism | Enclosure | Cubicle |
|---|---|---|---|---|---|---|---|
| VD4/P p.210 | 12-17.5 kV | 1250-1600 A | 40 kA | P3 | EL | – | UniGear |
| VD4/P p.210 | 12-17.5 kV | 1600 A | 40 kA | | | PowerCube PB2 | – |
| VD4/P p.210 | 12-17.5 kV | 1250-1600 A | 40 kA | PT2 | EL | – | UniGear |
| VD4/P p.210 | 12-17.5 kV | 1600 A | 40 kA | | | PowerCube PB2 | – |

## Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD003286 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| Isc | 40 | kA |



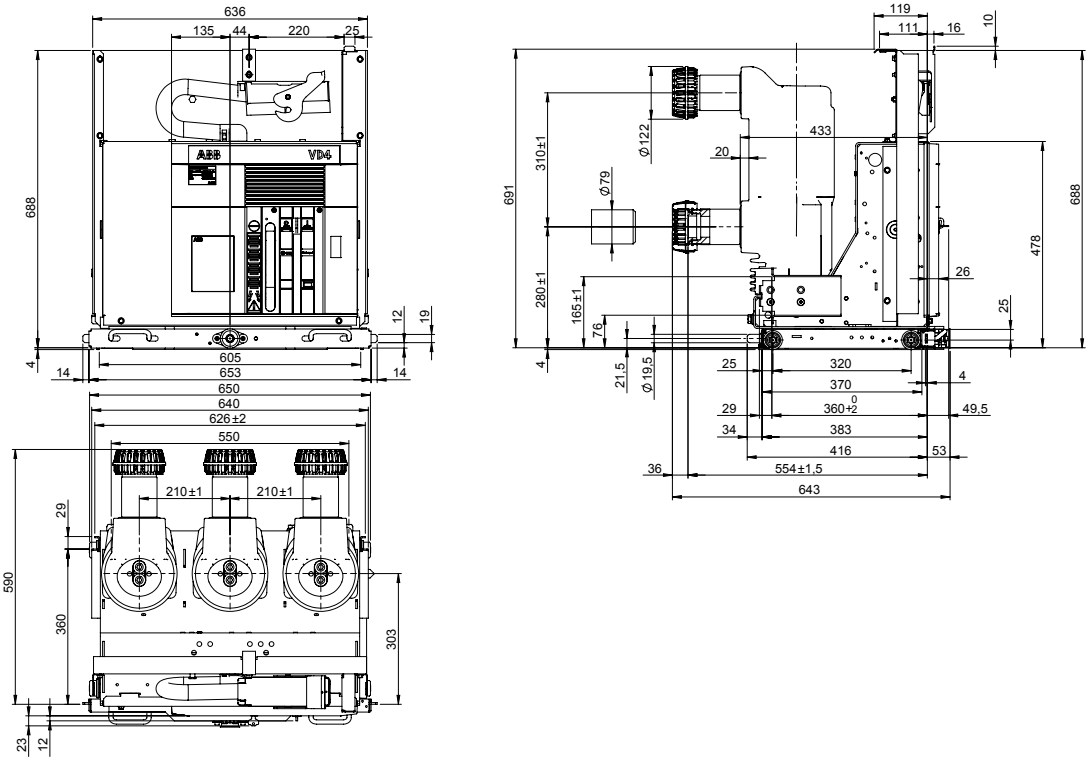




| C.B. type | Ur | Ir | Isc | Pole | Operating mechanism | Cubicle |
|---|---|---|---|---|---|---|
| VD4 p.275 | 12-17.5 kV | 1250-1600 | 40 kA | P | EL | UniGear ZS1 |
| VD4 p.275 | 12-17.5 kV | 1250-1600 A | 40 kA | PT2 | EL | UniGear ZS1 |

# 13. Overall dimensions

### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB2 modules

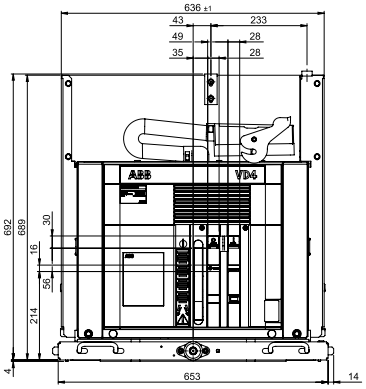
| VD4/P | | |
|---|---|---|
| TN | 1VCD 003444 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1250 | A |
| | 1600 | A |
| | 2000 | A |
| Isc | 50 | kA |

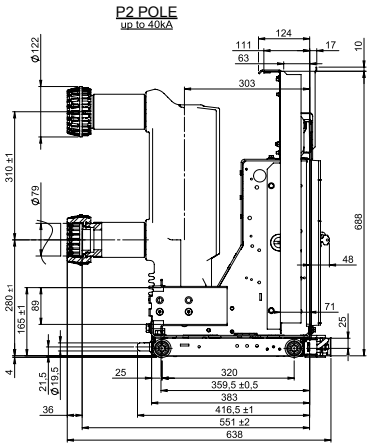


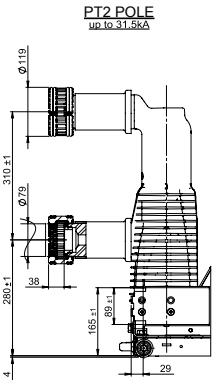

### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB2 modules

| VD4/P | | |
|---|---|---|
| TN | 7415 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4/P | | |
|---|---|---|
| TN | 7415 | |
| Ur | 12 | kV |
| | 15 | kV |
| | 17.5 | kV |
| Ir | 1200 | A |
| | 2000 | A |
| Isc | 40 | kA |



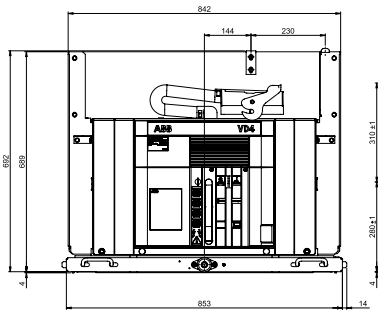



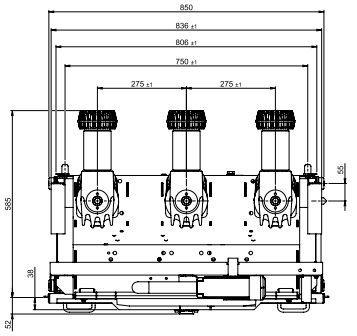

| Type | Un | In | Isc | Pole | O.M. | Enclosure | Cubide |
|---|---|---|---|---|---|---|---|
| VD4/P p.210 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | P2 | EL | CBE2-CBF2 PowerBloc-PowerCube PB2 | UniGear UniGear ZS1 |
| | 12-17.5kV | 2000A | 40kA | | | | UniGear |
| VD4/P 12/**/**/G p.210 | 12kV | 1600A-2000A | 20-25-31.5kA | | | | UniGear UniGear ZS1 |
| VD4/P XX.XX. XX.SA p.210 | 12-17.5kV | 1600A | 20-25kA | P2 | EL | PowerCube PB2 | UniGear |
| | | 2000A | 20-25-31.5kA | | | | |
| VD4/P p.210 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | PT2 | EL | PowerCube PB2 | UniGear |
| | | 2000A | 40kA | | | | |
| VD4/P 12/**/**/G p.210 | 12kV | 1600A-2000A | 20-25-31.5kA | | | | |
| VD4/P p.210 | 15kV | 1200A-2000A | 40kA | PT2 | EL | PowerCube **PB2/E-PB2/FL** | |
| **VD4/N/P** p.210 | 15kV | 2000A | 31.5kA | P2 | EL | | OeM panel |

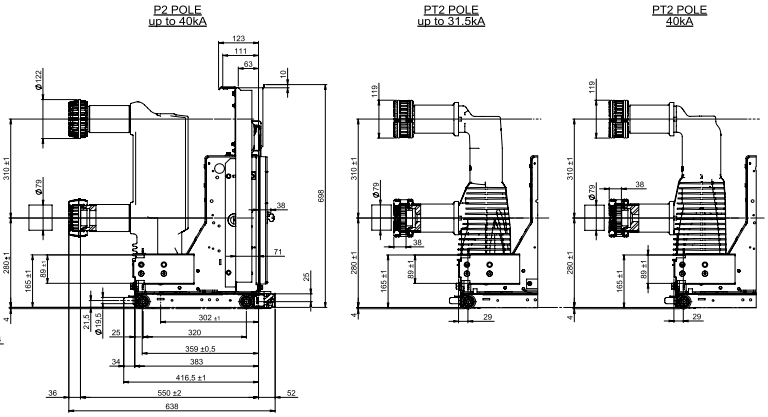
## Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 7416 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |

| VD4/P | | |
|---|---|---|
| TN | 7416 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2000 | A |
| Isc | 40 | kA |



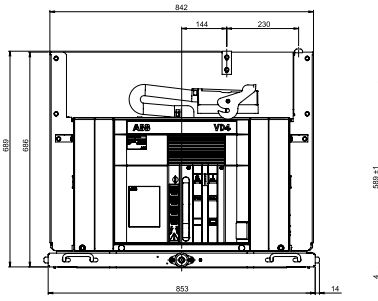


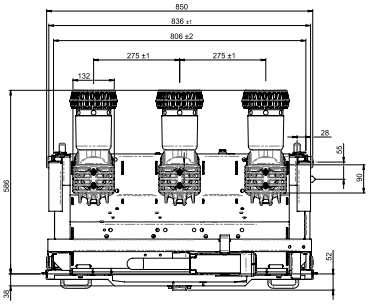


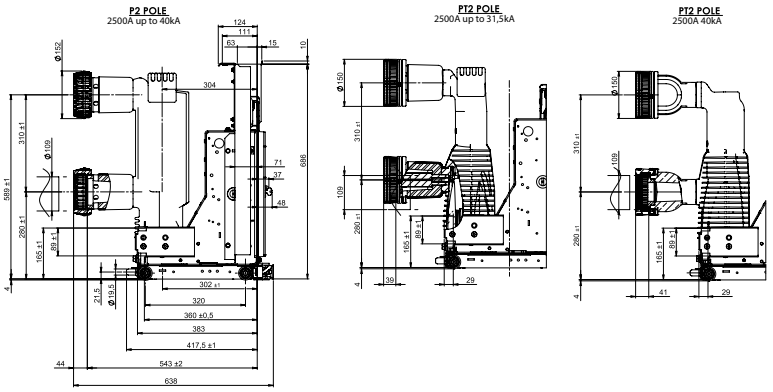

| Type | Un | In | Isc | Pole | O.M. | Enclosure | Cubide |
|---|---|---|---|---|---|---|---|
| VD4/P p.275 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | P2 | EL | PowerBloc CBF3 PowerCube | UniGear ZS1 |
| VD4/P 12/**/**/G p.275 | 12kV | 1600A-2000A | 20-25-31.5kA | | | | |
| VD4/P p.275 | 12-17.5kV | 2000A | 40kA | | | PowerBloc CBF3 | |
| VD4/P p.275 | 12-17.5kV | 1600A-2000A | 20-25-31.5kA | P2 | EL | PowerBloc PowerCube | UniGear ZS1 |
| VD4/P 12/**/**/G p.275 | 12kV | 1600A-2000A | 20-25-31.5kA | | | | |
| VD4/P p.275 | 12-17.5kV | 2000A | 40kA | | | | |
| VD4/P XX.XX.XX.SA p.210 | 12kV | 1600A | 20-25kA | PT2 | EL | PowerCube PB2 | UniGear |
| | | 2000A | 20-25-31.5kA | | | | |
| | 17.5kV | 1600A | 20-25kA | | | | |
| | | 2000A | 20-25-31.5kA | | | | |

## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB3 modules

| VD4/P | | |
|---|---|---|
| TN | 7417 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2500 | A |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |





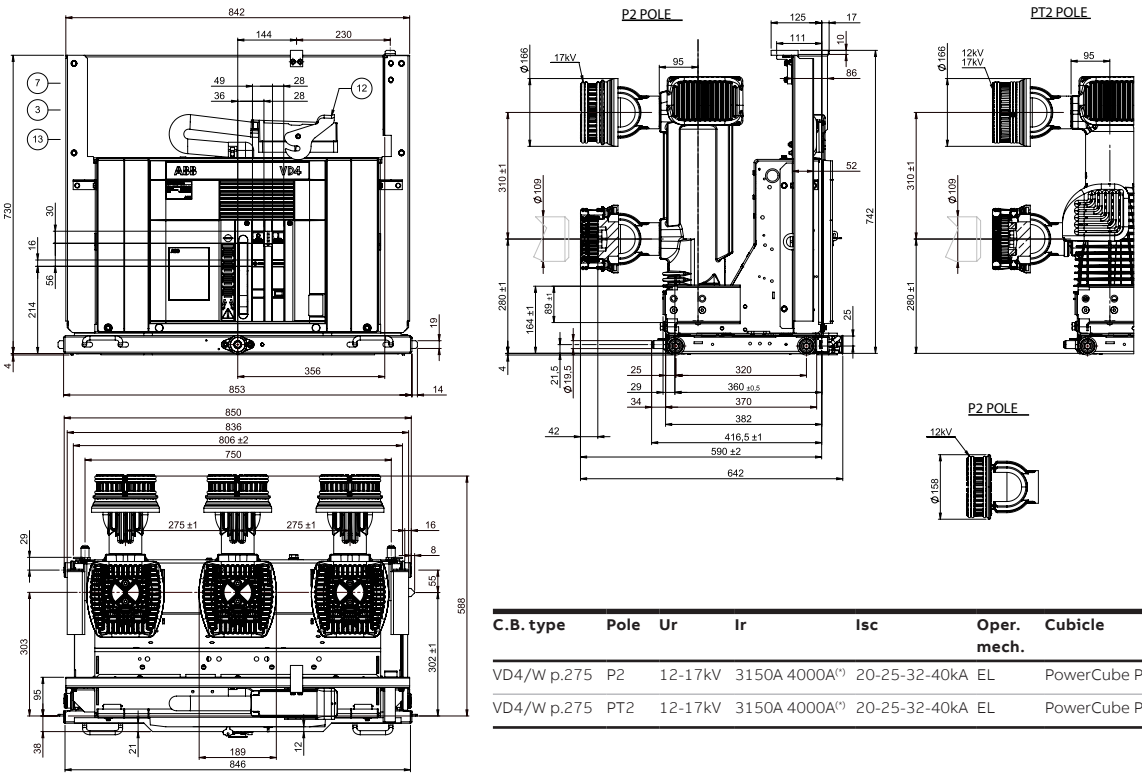



| Type | Un | In | Isc | Pole | O.M. | Enclosure | Cubide |
|---|---|---|---|---|---|---|---|
| VD4/P p.275 | 12-17.5kV | 2500A | 20-25-31.5-40kA | P2 | EL | PowerBloc CBF3 PowerCube | UniGear ZS1 UniSafe |
| VD4/P 12/**/**/G p.275 | 12kV | 2500A | 20-25-31.5kA | | | | |
| VD4/P XX.XX.XX.SA p.210 | 12-17.5kV | 2500A | 40kA | | | PowerCube | |
| VD4/P p.275 | 12-17.5kV | 2500A | 20-25-31.5kA | P2 | EL | PowerCube | UniGear ZS1 UniSafe |
| VD4/P 12/**/**/G p.275 | 12kV | 2500A | 20-25-31.5kA | | | | |
| VD4/P p.275 | 12-17.5kV | 2500A | 40kA | | | | |

# 13. Overall dimensions

### Withdrawable circuit breakers for PowerCube PB3 modules

| VD4/W | | |
|---|---|---|
| TN | 1VCD000152 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |
| | 40 | kA |

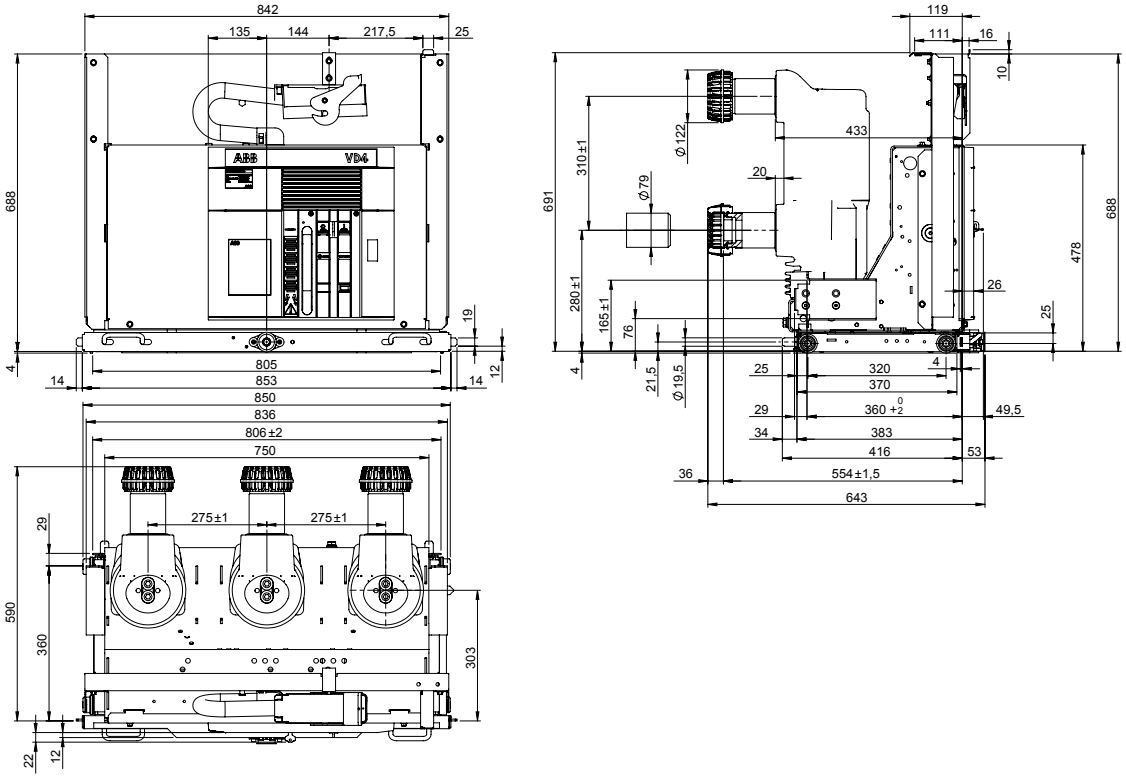



| C.B. type | Pole | Ur | Ir | Isc | Oper. mech. | Cubicle |
|---|---|---|---|---|---|---|
| VD4/W p.275 | P2 | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | PowerCube PB3 |
| VD4/W p.275 | PT2 | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | PowerCube PB3 |

(*) 4000 A con ventilazione forzata.

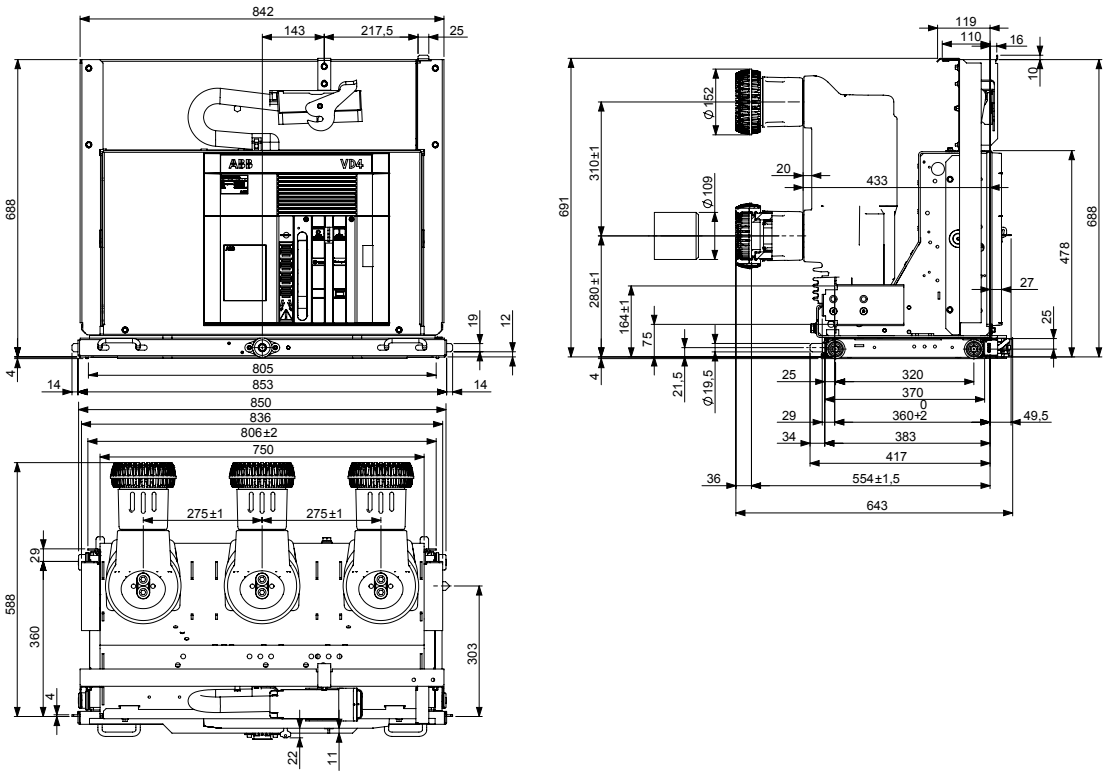
### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB3 modules

| VD4/P | | |
|---|---|---|
| TN | 1VCD003445 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| Isc | 50 | kA |



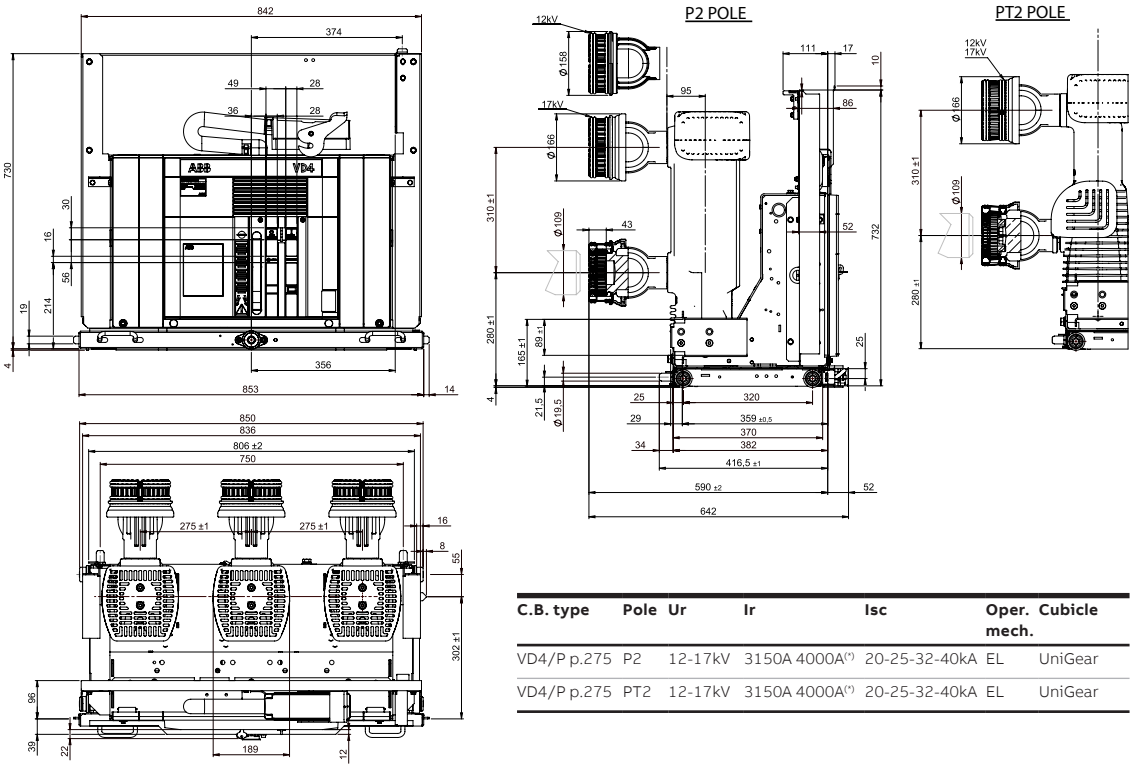
## Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD003446 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 2500 | A |
| Isc | 50 | kA |




## Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD000153 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 40 | kA |



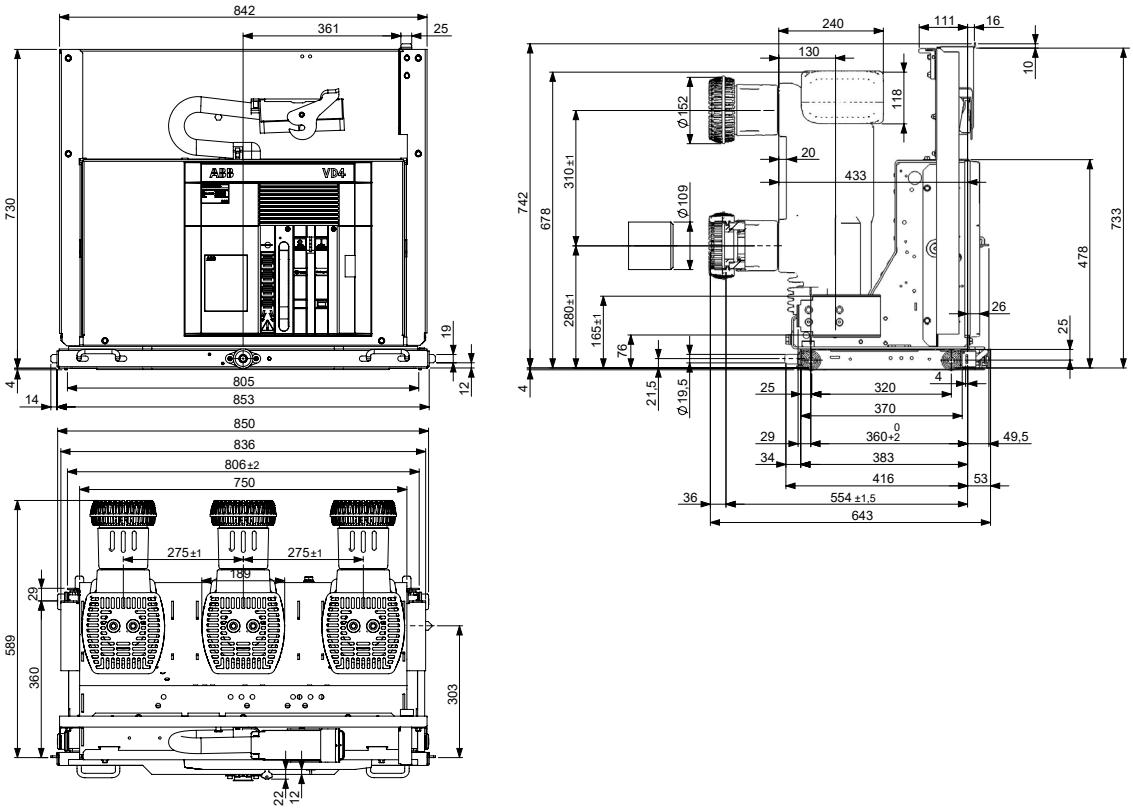

| C.B. type | Pole | Ur | Ir | Isc | Oper. mech. | Cubicle |
|---|---|---|---|---|---|---|
| VD4/P p.275 | P2 | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | UniGear |
| VD4/P p.275 | PT2 | 12-17kV | 3150A 4000A(*) | 20-25-32-40kA | EL | UniGear |

(*) 4000 A with forced ventilation.

# 13. Overall dimensions

### Withdrawable circuit breakers for UniGear ZS1 switchgear

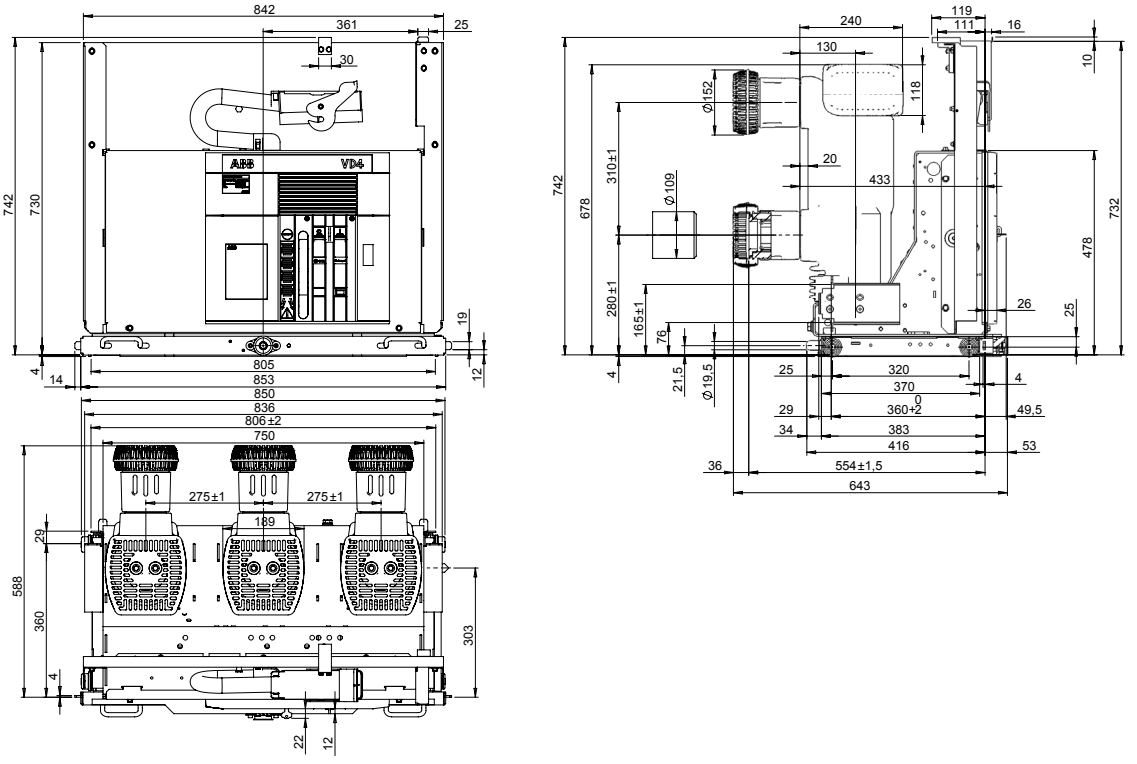
| VD4/P | | |
|---|---|---|
| TN | 1VCD003447 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 50 | kA |




(*) 4000 A with forced ventilation.

### Withdrawable circuit breakers for PowerCube PB3 modules

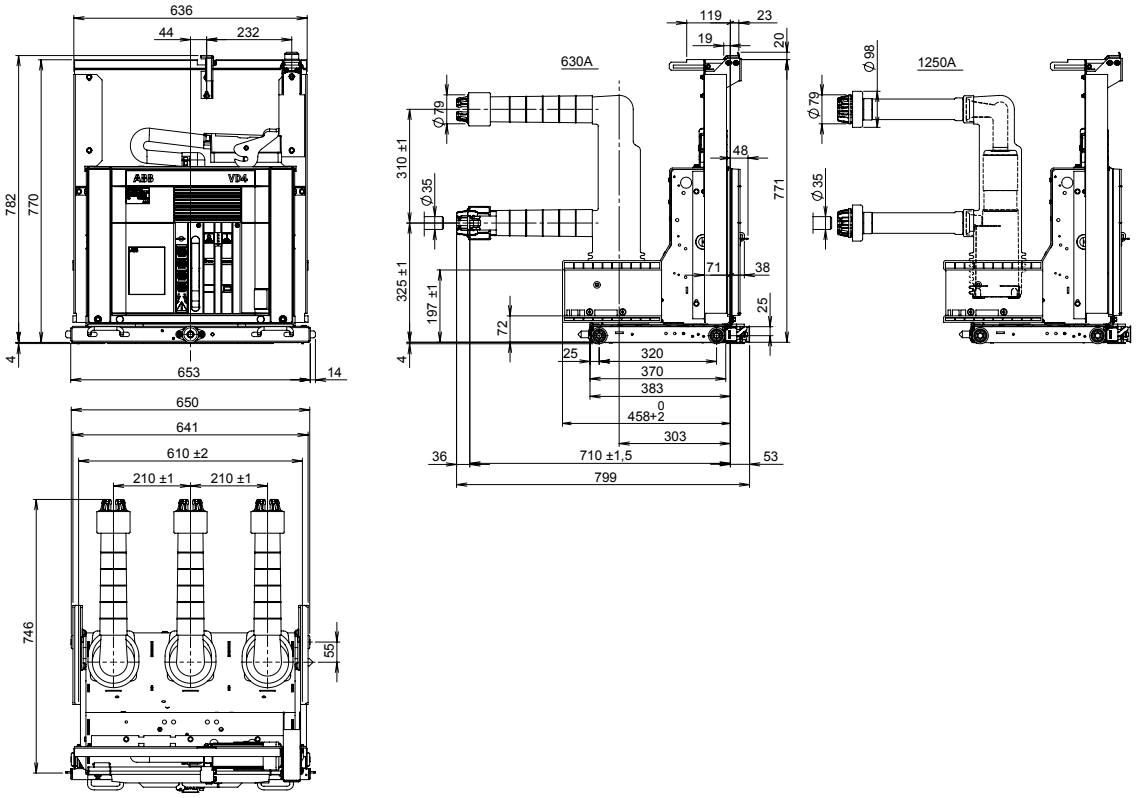
| VD4/W | | |
|---|---|---|
| TN | 1VCD003596 | |
| Ur | 12 | kV |
| | 17.5 | kV |
| Ir | 3150 | A (*) |
| Isc | 50 | kA |




(*) 4000 A with forced ventilation.

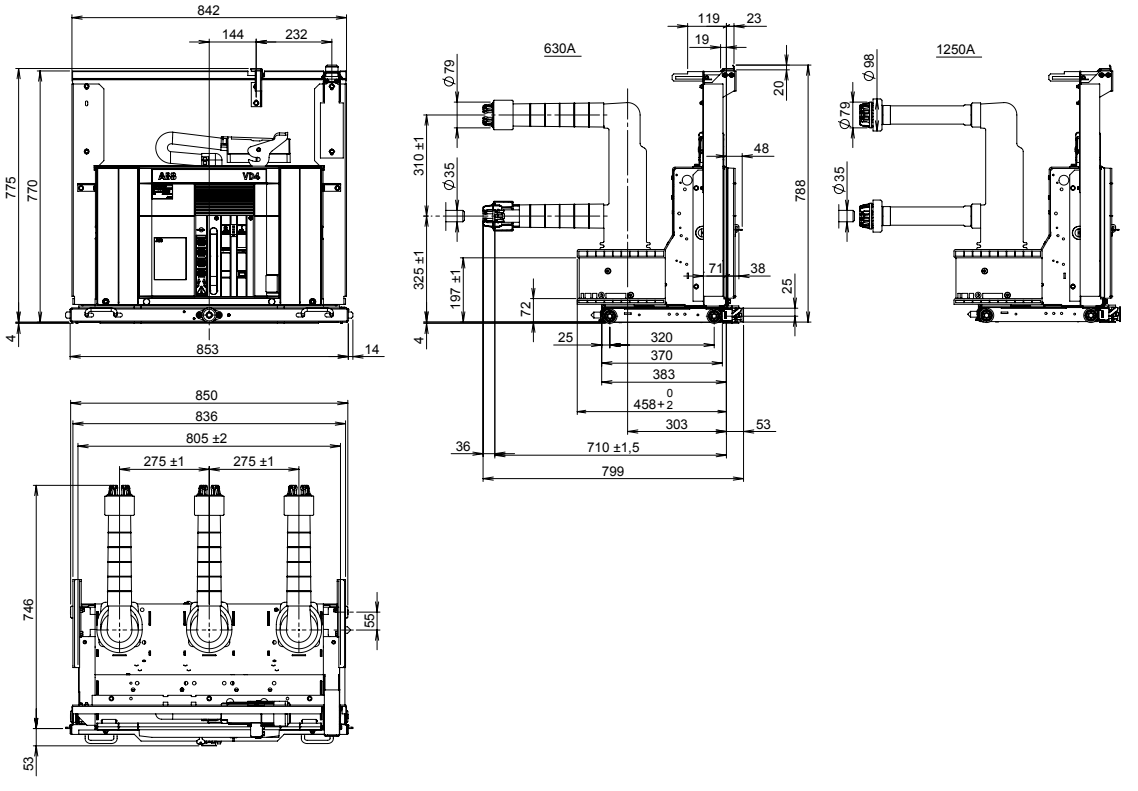
## Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB4 modules

| VD4/P | | |
|---|---|---|
| TN | 7413 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |




## Withdrawable circuit breakers for UniGear ZS1 switchgear

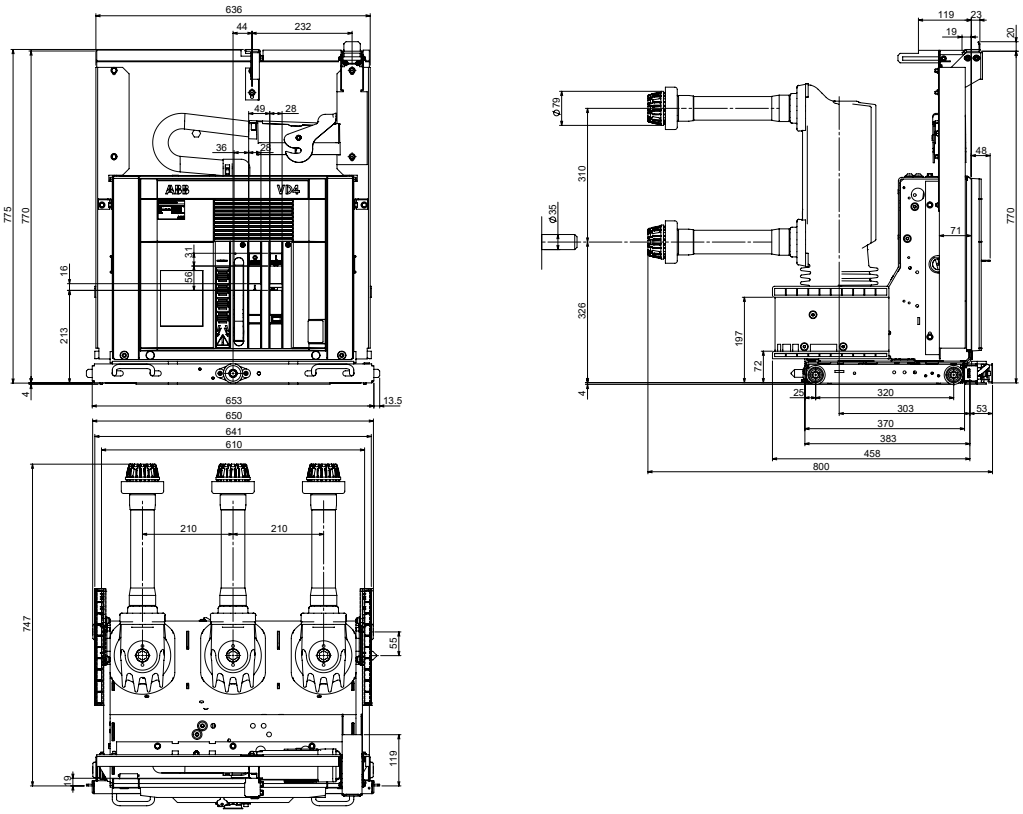
| VD4/P | | |
|---|---|---|
| TN | 7414 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |



# 13. Overall dimensions

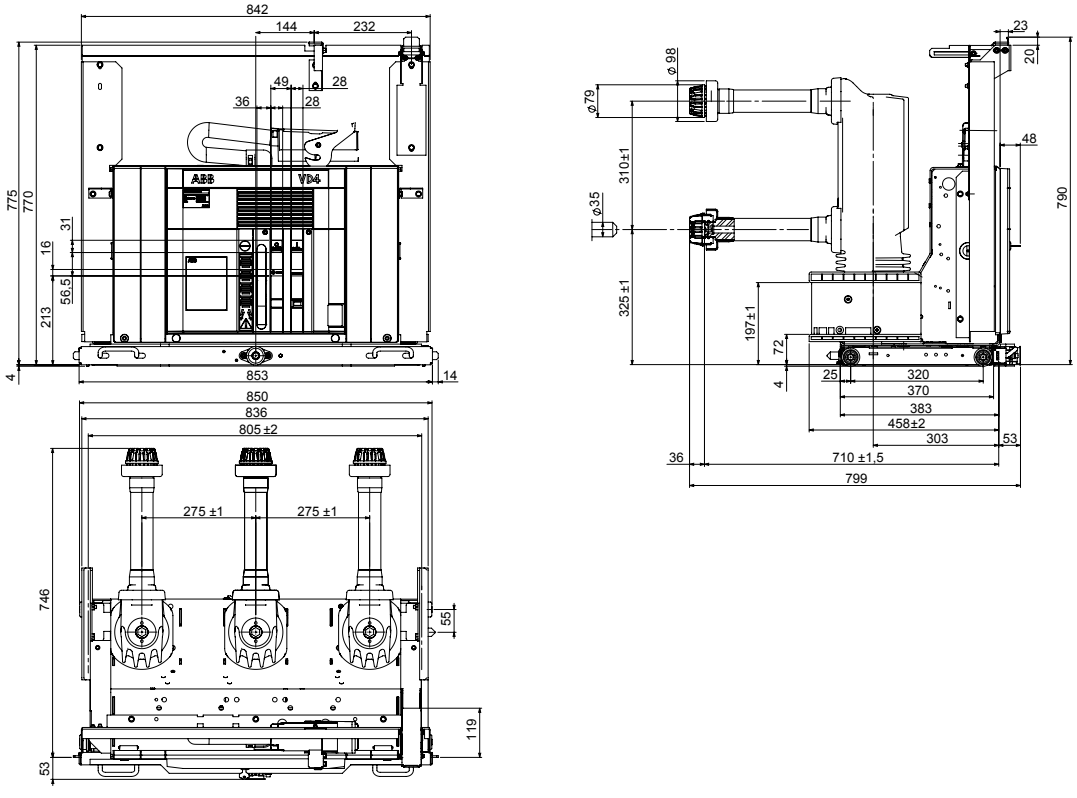
### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB4 modules

| VD4/P | | |
|---|---|---|
| TN | 1VCD000173 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| Isc | 31.5 | kA |



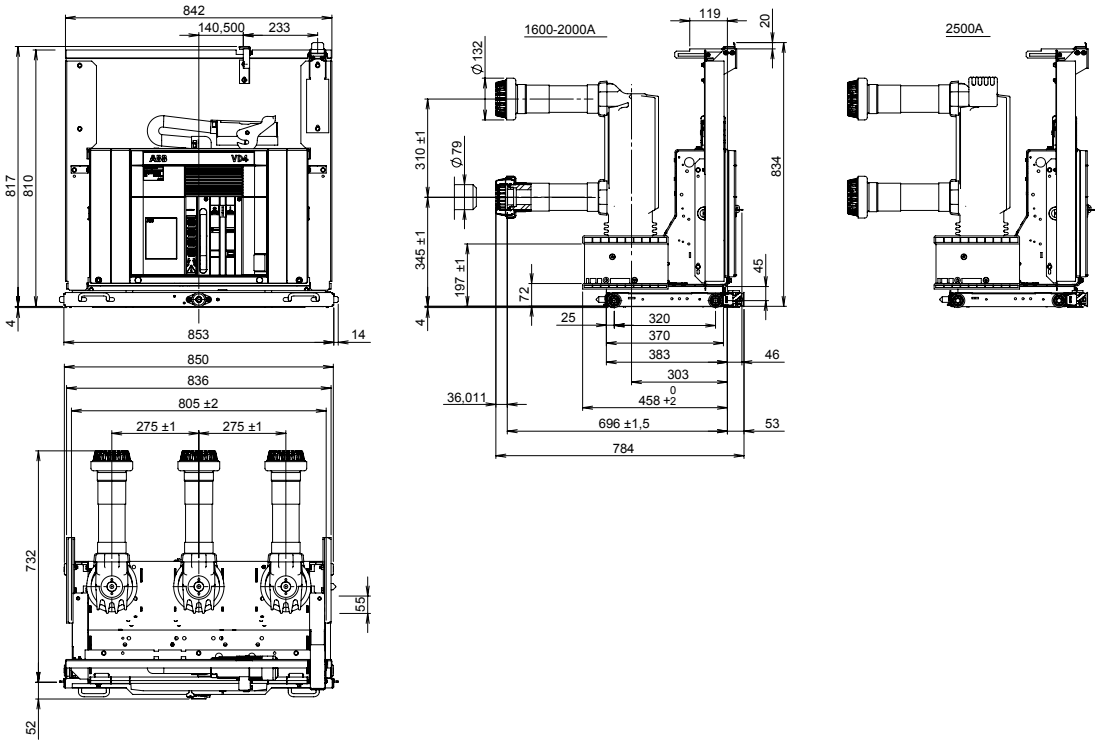

### Withdrawable circuit breakers for UniGear ZS1 switchgear

| VD4/P | | |
|---|---|---|
| TN | 1VCD000174 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| Isc | 31.5 | kA |



### Withdrawable circuit breakers for UniGear ZS1 switchgear and PowerCube PB5 modules

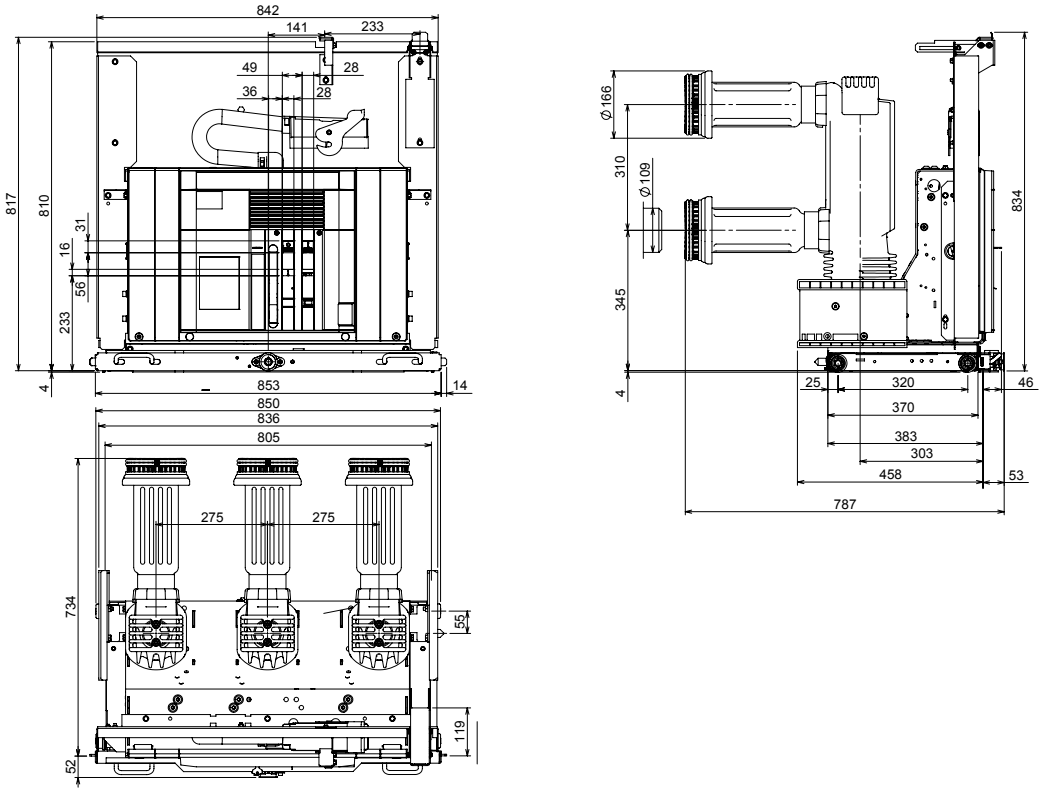
| VD4/P | | |
|---|---|---|
| TN | 7418 | |
| Ur | 24 | kV |
| Ir | 1600 | A |
| | 2000 | A |
| | 2500 | A (1) |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |
| | 31.5 | kA |




(1) The rated uninterrupted current of 2300 A is guaranteed with natural ventilation. The rated uninterrupted current of 2500 A is guaranteed with forced ventilation.

### Withdrawable circuit breakers for UniGear ZS1 switchgear

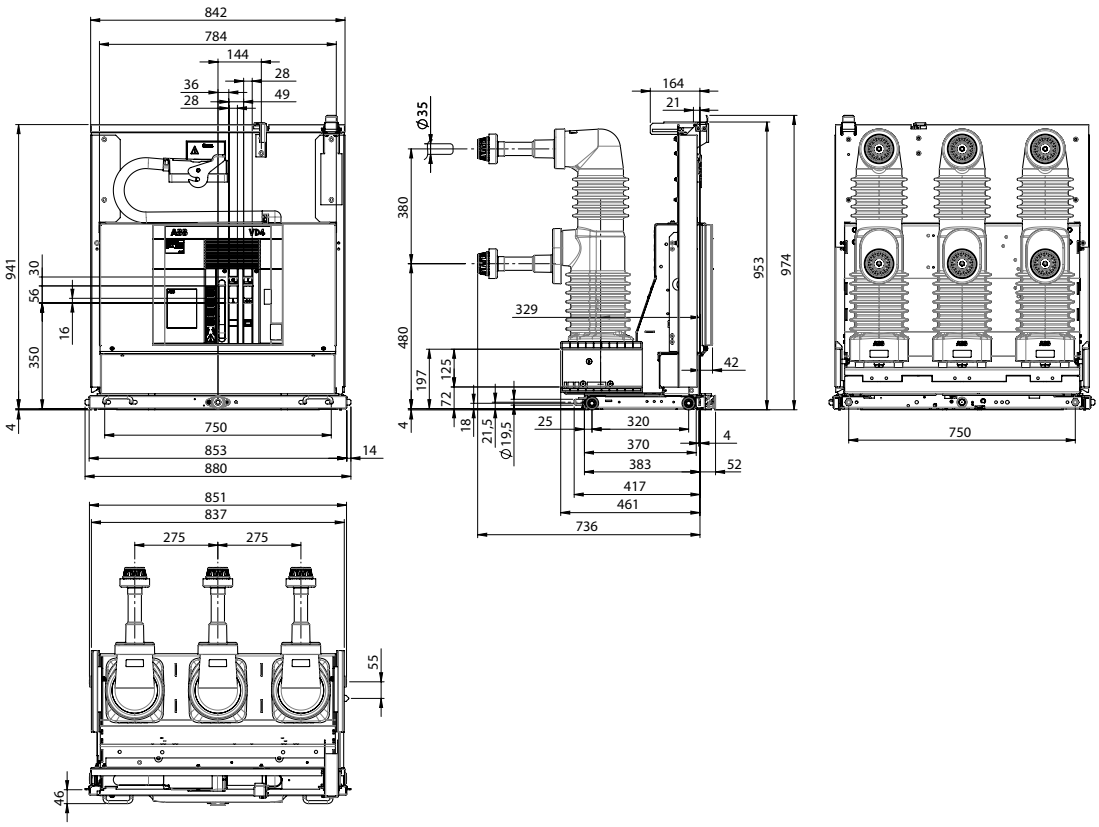
| VD4/P | | |
|---|---|---|
| TN | 1VCD000177 | |
| Ur | 24 | kV |
| | 3150 | A |
| Isc | 31.5 | kA |



# 13. Overall dimensions

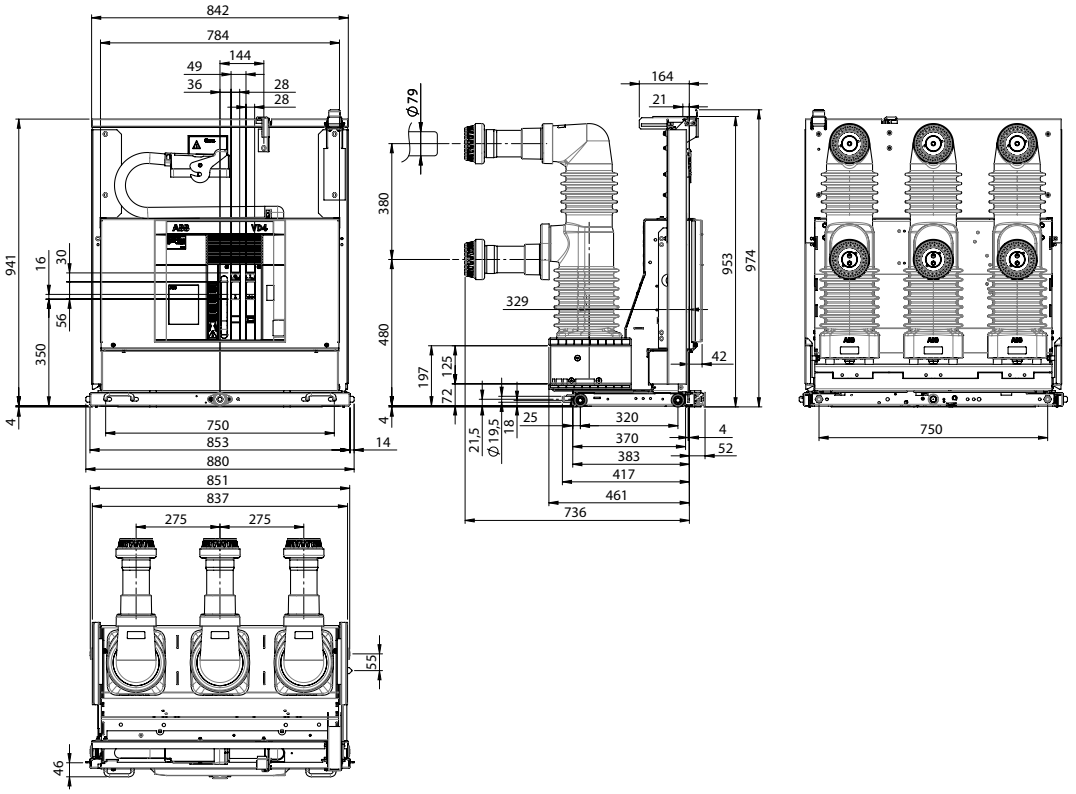
### Withdrawable circuit breakers for UniGear ZS2 switchgear

| VD4/W | | |
|---|---|---|
| TN | 1VYN300901-KG | |
| Ur | 36 | kV |
| Ir | 1250 | A |
| | 20 | kA |
| Isc | 25 | kA |
| | 31.5 | kA |




### Withdrawable circuit breakers for UniGear ZS2 switchgear

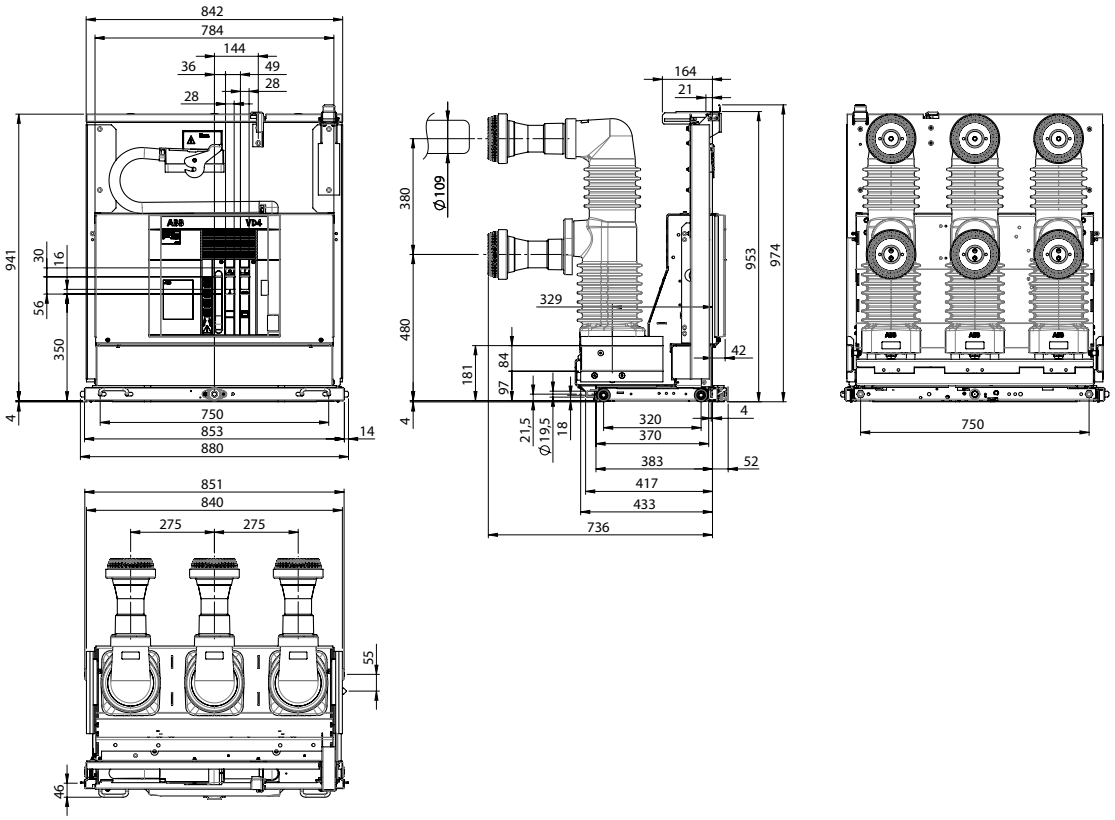
| VD4/W | | |
|---|---|---|
| TN | 1VYN300901RA | |
| Ur | 36 | kV |
| | 1600 | A |
| Ir | 2000 | A |
| | 2500 | A (*) |
| | 20 | kA |
| Isc | 25 | kA |
| | 31.5 | kA |




(1) The rated uninterrupted current of 2300 A is guaranteed with natural ventilation. The rated uninterrupted current of 2500 A is guaranteed with forced ventilation.

## Withdrawable circuit breakers for UniGear ZS2 switchgear

| VD4/W | | |
|---|---|---|
| TN | 1VYN300901RB | |
| Ur | 36 | kV |
| Ir | 2500 | A (*) |
| | 20 | kA |
| Isc | 25 | kA |
| | 31.5 | kA |

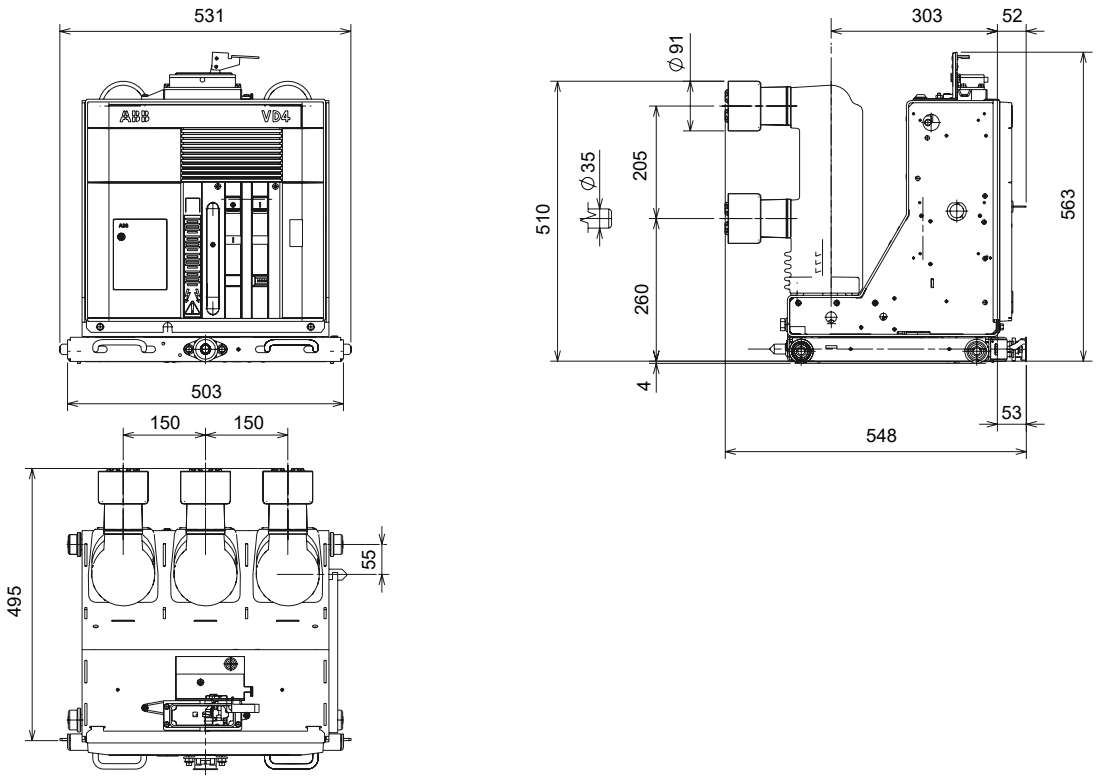



(*) The rated uninterrupted current of 3150 A is guaranteed with forced ventilation.

# 13. Overall dimensions

### Withdrawable circuit breakers for ZS8.4 switchgear

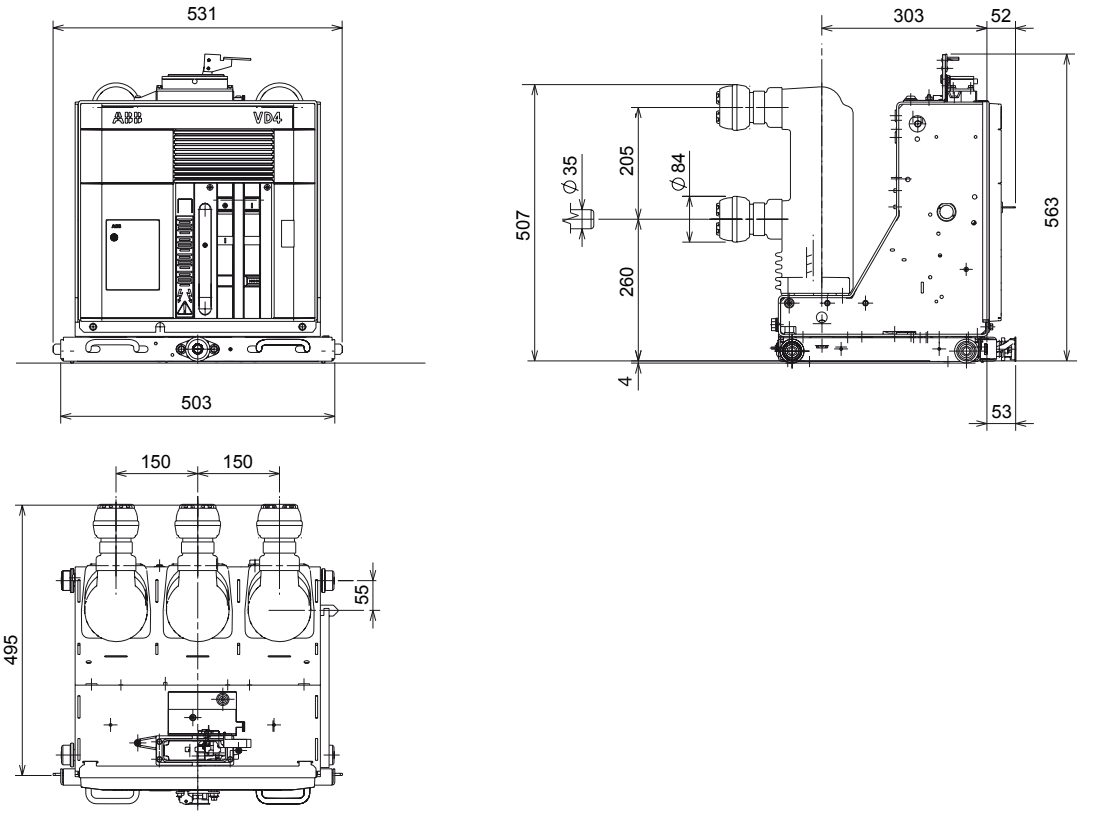
| VD4/Z8 | | |
|---|---|---|
| TN | 1VCD000092 | |
| Ur | 12 | kV |
| Ir | 630 | A |
| Isc | 20 | kA |
| | 25 | kA |




### Withdrawable circuit breakers for ZS8.4 switchgear

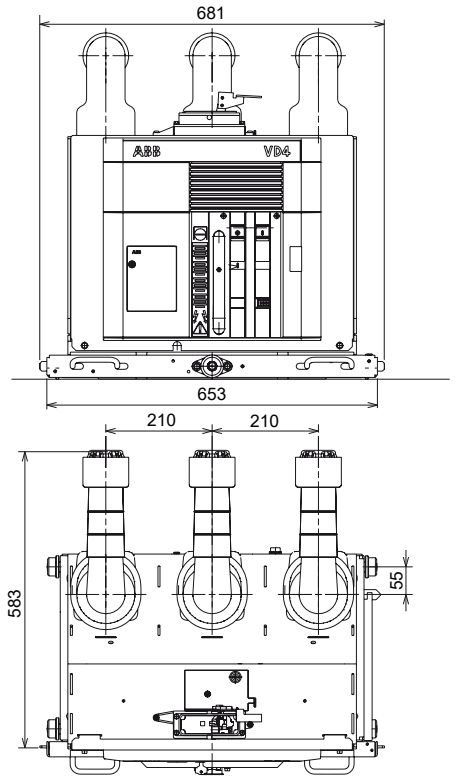
| VD4/Z8 | | |
|---|---|---|
| TN | 1VCD000137 | |
| Ur | 12 | kV |
| Ir | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |

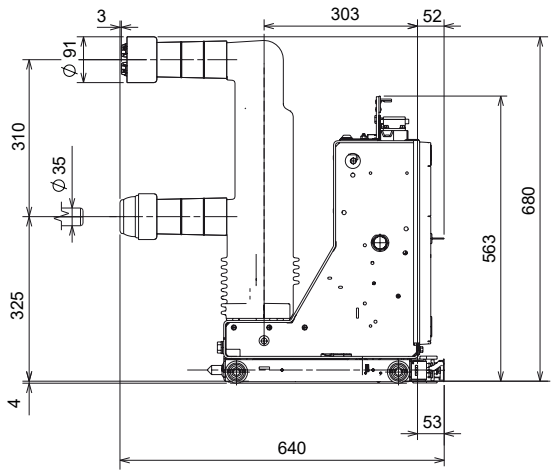
| | | |
|---|---|---|
| TN | 1VCD000137 | |
| Ur | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |



### Withdrawable circuit breakers for ZS8.4 switchgear

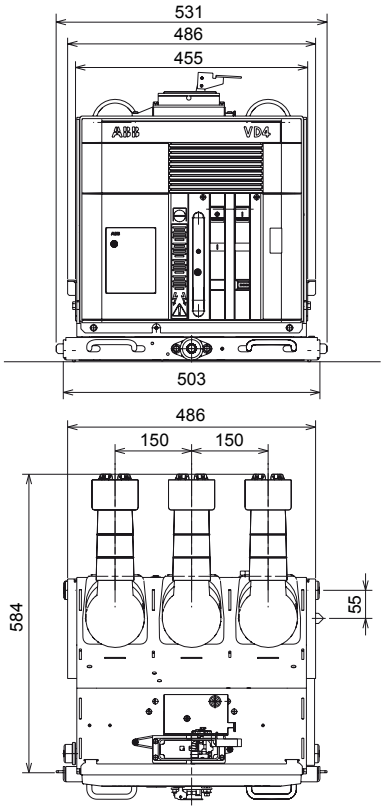
| VD4/Z8 | | |
|---|---|---|
| TN | 1VCD000089 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |

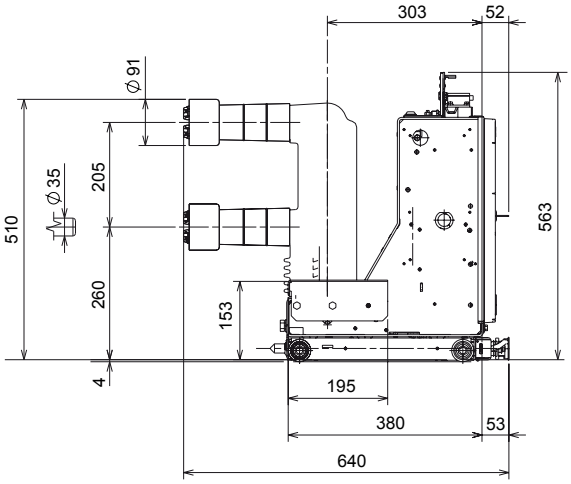



### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/ZT8 | | |
|---|---|---|
| TN | 1VCD000093 | |
| Ur | 12 | kV |
| Ir | 630 | A |
| Isc | 20 | kA |
| | 25 | kA |

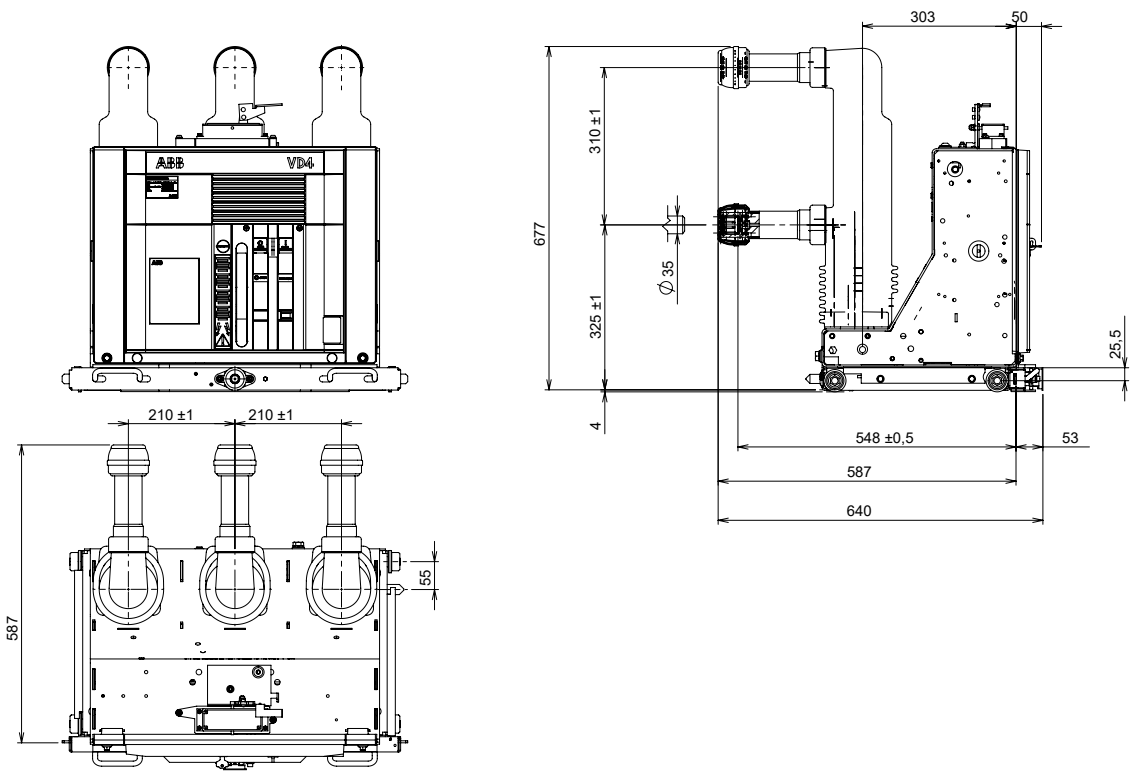


# 13. Overall dimensions

### Withdrawable circuit breakers for ZS8.4 switchgear

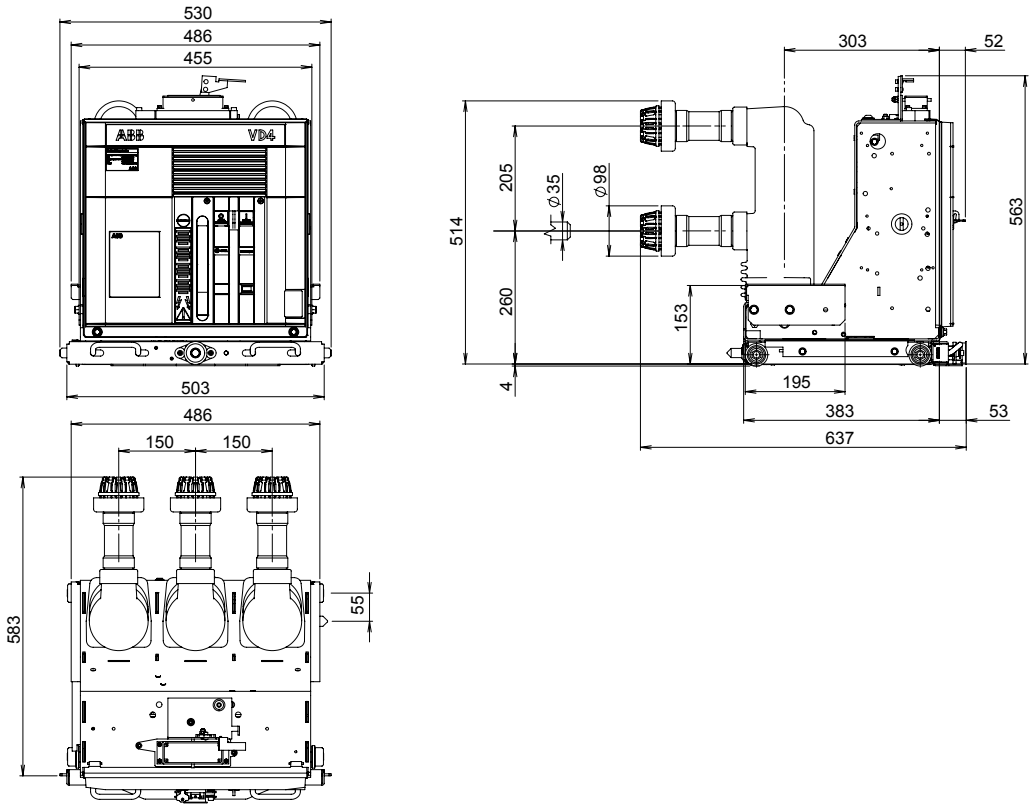
| VD4/Z8 | | |
|---|---|---|
| TN | 1VCD000138 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |
| | 25 | kA |




### Withdrawable circuit breakers for ZS8.4 switchgear

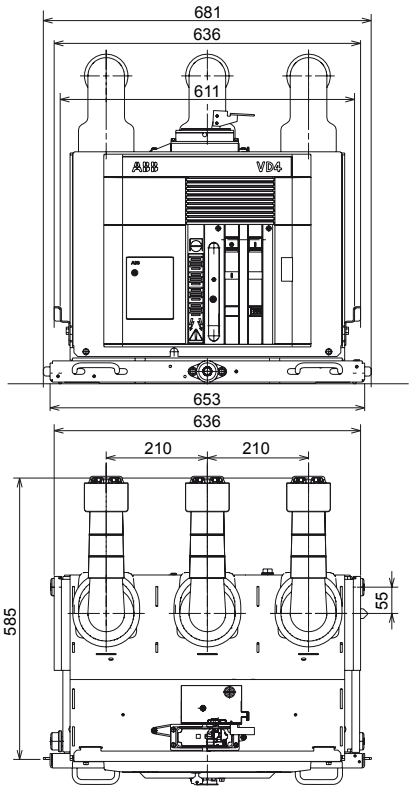
| VD4/ZT8 | | |
|---|---|---|
| TN | 1VCD000134 | |
| Ur | 12 | kV |
| Ir | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |

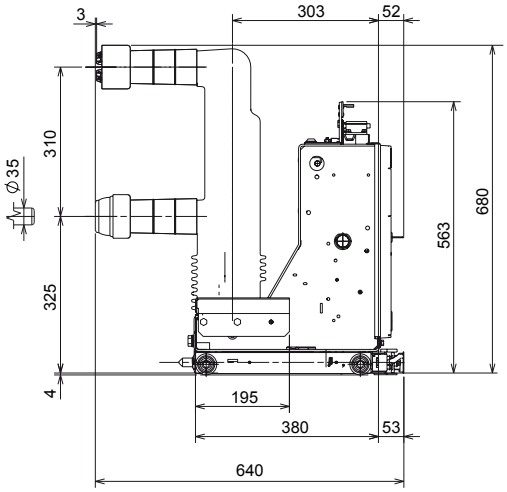
| VD4/ZT8 | | |
|---|---|---|
| TN | 1VCD000134 | |
| Ur | 17.5 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |



### Withdrawable circuit breakers for ZS8.4 switchgear

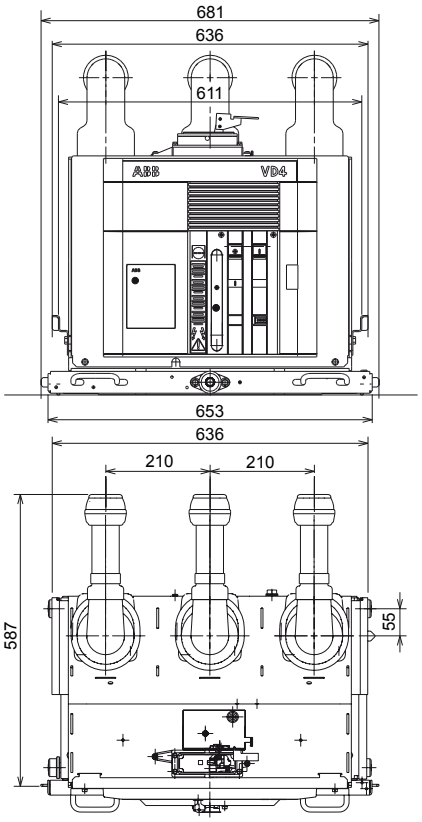
| VD4/ZT8 | | |
|---|---|---|
| TN | 1VCD000090 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 16 | kA |
| Isc | 20 | kA |
| | 25 | kA |

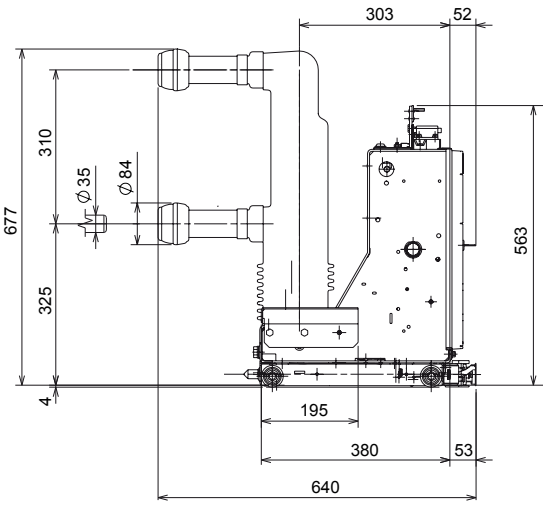



### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/ZT8 | | |
|---|---|---|
| **TN** | 1VCD000136 | |
| **Ur** | 24 | kV |
| **Ir** | 1250 | A |
| | 16 | kA |
| **Isc** | 20 | kA |
| | 25 | kA |

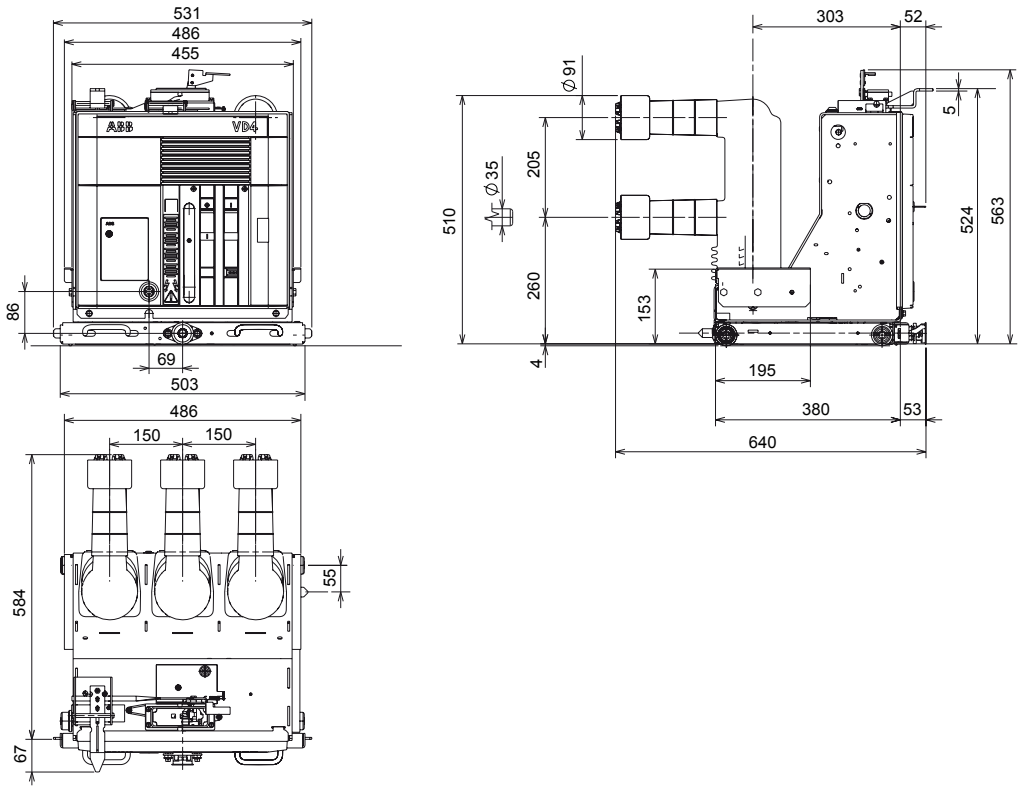


# 13. Overall dimensions

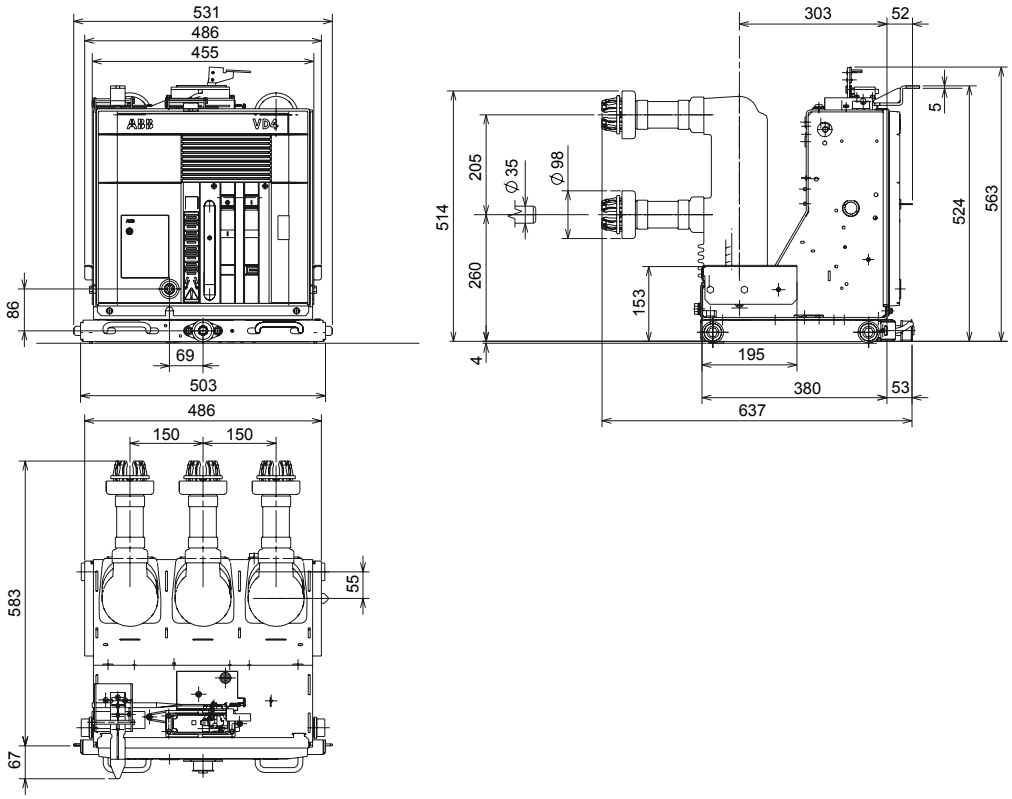
### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000091 | |
| Ur | 12 | kV |
| Ir | 630 | A |
| Isc | 20 | kA |
| | 25 | kA |



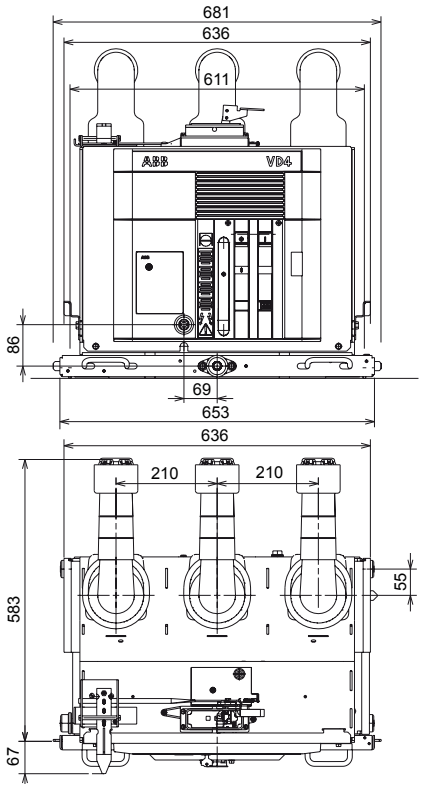

### Withdrawable circuit breakers for ZS8.4 switchgear

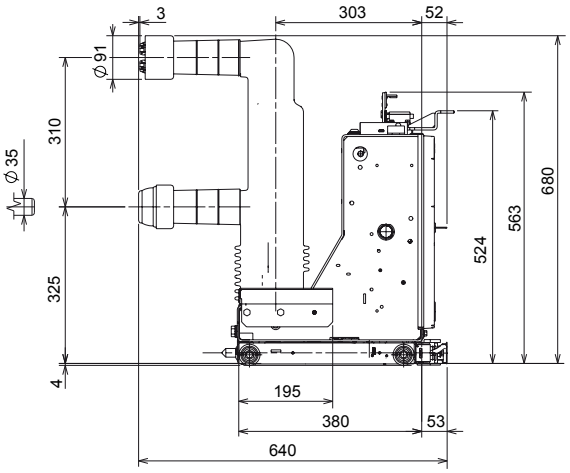
| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000133 | |
| Ur | 12 | kV |
| Ir | 1250 | A |
| Isc | 20 | kA |
| | 25 | kA |



### Withdrawable circuit breakers for ZS8.4 switchgear

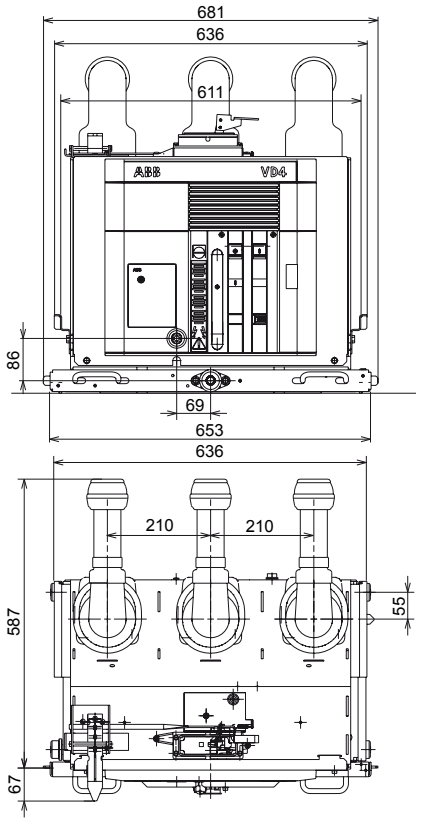
| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000088 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 16 | kA |
| Isc | 20 | kA |
| | 25 | kA |

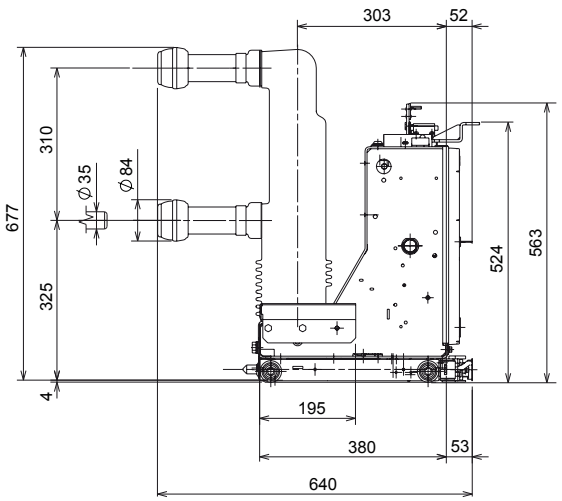



### Withdrawable circuit breakers for ZS8.4 switchgear

| VD4/ZS8 | | |
|---|---|---|
| TN | 1VCD000135 | |
| Ur | 24 | kV |
| Ir | 1250 | A |
| | 16 | kA |
| Isc | 20 | kA |
| | 25 | kA |

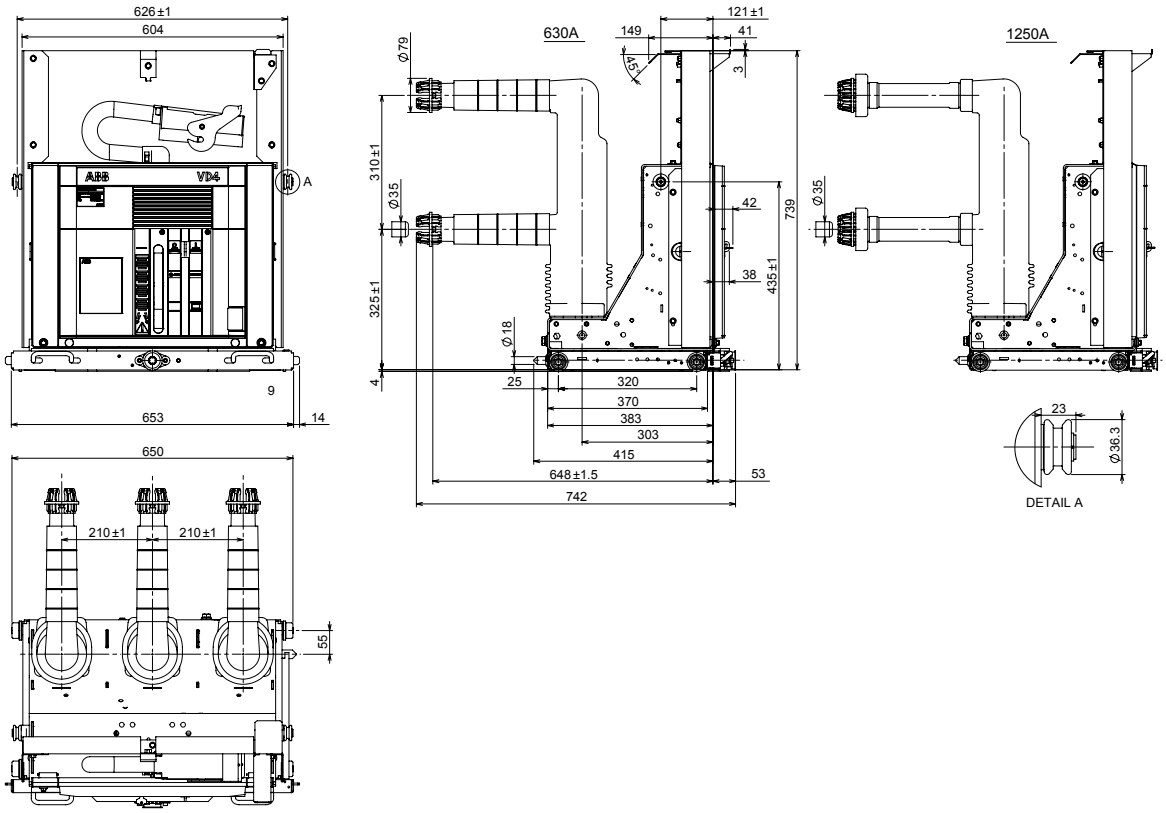


# 13. Overall dimensions

**Withdrawable circuit breakers for UniSec (WBC and WBS) switchgear**

| VD4/Sec | | |
|---|---|---|
| TN | 1VCD000190 | |
| Ur | 24 | kV |
| Ir | 630 | A |
| | 1250 | A |
| Isc | 16 | kA |
| | 20 | kA |



# 14. Product quality and environmental protection

The apparatus are produced in compliance with the requirements of international standards for the quality management system and environmental management system. In these fields, the excellent level is proved by quality certificates according to ISO 9001 and by the EMS according to ISO 14 001.

## End of life of product

The ABB company is committed to complying with the relevant legal and other requirements for environment protection according to the ISO 14 001 standard.
The duty of company is to facilitate subsequent recycling or disposal at the end of product life. During disposal of the product, it is always necessary to act in accordance with local legal requirements in force.

## Methods of disposal

Disposal can either be carried out thermally in an incineration plant or by storing on a waste site.

| Raw material | Recommended method of disposal |
|---|---|
| Metal material (Fe, Cu, Al, Ag, Zn, W, others) | Separation and recycling |
| Thermoplasts | Recycling or disposal |
| Epoxy resin | Separation of metal material and the disposal of rest |
| Rubber | Disposal |
| Oil as dielectric (transformer oil) | Draining from equipment and further recycling or disposal |
| Packing material – wood | Recycling or disposal |

# Notes

# Notes

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More product information:
abb.com/mediumvoltage
Your contact center:
abb.com/contactcenters
More service information:
abb.com/service

—

The data and illustrations are not binding. We reserve the right to make changes without notice in the course of technical development of the product.

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647654/001 - Rev. AB, en - Instruction Manual - 2022.09 (VD4 up to 12 ... 40.5 kA) (gs)

DISTRIBUTION SOLUTIONS

# PowerCube type PB

## Pre-assembled modules, enclosures and L-frames for medium voltage switchgears



—

# ABB PowerCube, A brick to build your solution.

Medium voltage preassembled units to be used as components for primary distribution air-insulated switchgears, from enclosures to modules with complete apparatus and cable access compartments. A flexible portfolio of solutions for panel builders and OEMs to design their own customized panel configurations. Maximize your added value, depending on the needs and specific requirements, with flexibility in hosting different types of apparatus and quenching techniques to fulfill customer specifications.

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# 1. General characteristics



PowerCube module type PB/M



PowerCube enclosure type PB/E



PowerCube L-frame type PB/F

Scan o Tap on QR code
to visit PowerCube website

## General information

PowerCube modules can be used to develop and assemble metalclad medium voltage air-insulated switchgear with the same rated current values as the enclosure.
The rated currents of the enclosures refer to versions tested in ABB UniSafe switchgear.
Use of the 4000 A PB3 enclosure allows a switchgear with the same rated current to be made so long as a suitable fan is installed in the rear part of the switchgear itself (consult ABB for further details).
PowerCube units type PB are available in three different versions: PB/M, PB/E and PB/F or PB/FL.
PB/M: complete module that also includes the cable access cubicle, which can also be pre-engineered to house the withdrawable TV compartment.
PB/E: enclosure without cable access compartment thus unable to house the withdrawable VT which, being smaller in size, is more flexible and suitable for creating double-deck switchgear.
PB/F: L-frame without door and cable access compartment thus unable to house the withdrawable VT cell or truck, which, being smaller in size, is more flexible and suitable for creating double-deck switchgear.
PB/FL: it is a compact version of PB/F which does not allow usage of the earthing switch
PowerCube modules are pre-assembled and tested in the factory. They can be used to make switchgear conforming to Standards IEC 62271-200, IEC 62271-1.

They are available with the following specifications:

| | | |
|---|---|---|
| Rated voltage (kV) | ... 17.5 | 24 |
| Rated current (A) | ... 4000 | ... 2500 |
| Rated short-time withstand current of main circuit (kA) | ... 40 x 3s | ... 31.5 x 3s |
| | ... 50 x 1s | |

The following apparatus can be installed in PowerCube modules:
- series VD4, VM1 and VD4-G vacuum circuit breakers
- series ConVac vacuum contactors

All the switching operations are carried out from the front of the module/enclosure.

## Protection class

PowerCube PB/M and PB/E units can guarantee a degree of protection IP4X according IEC 60529 from front and with door closed.
The degree of protection from top, bottom, left and right side is dependent on complete panel design and therefore at customer care, this is in general applicable to PB/F and PB/FL units as are open L-frames

## Interlocks

The PowerCube module is equipped with interlocks in order to prevent incorrect operations that could put the operators' safety at risk and compromise the efficiency and reliability of the actual equipment. These interlocks inhibit the following operations:

- closing of the circuit-breaker unless the connected or isolated positions are reached.
- rack-out of the closed circuit-breaker.
- rack-in of the closed circuit-breaker
- door opening if the circuit-breaker is in rack-in position or halfway between rack-in and isolated position.
- rack-in of the circuit-breaker when the compartment door is open
- manual opening of the shutters.

Moreover, if the unit is equipped with an earthing switch:

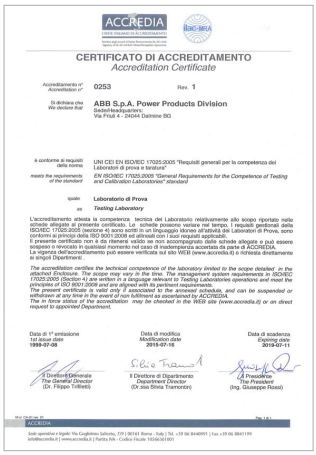
- closing of the earthing switch if the circuit-breaker is in rack-in position or halfway between rack-in and isolated position
- rack-in of the circuit-breaker with the earthing switch closed.
- opening of the feeder compartment door with the earthing switch open (PowerCube PB/M module only)
- opening of the earthing switch with the feeder compartment door open (PowerCube PB/M module only).

Note: some of the above mentioned interlocks are available on request or only available for certain versions.


DNV·GL
MANAGEMENT SYSTEM CERTIFICATE
ABB
ABB S.p.A.
Electrification Products Division
Medium Voltage Products
UNI EN ISO 9001:2008 (ISO 9001:2008)


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ABB
ABB S.p.A.
Electrification Products Division
Medium Voltage Products
UNI EN ISO 14001:2004 (ISO 14001:2004)


DNV·GL
MANAGEMENT SYSTEM CERTIFICATE
ABB S.p.A. - EPDS Electrification Products - Distribution Solutions
ISO 45001:2018


ACCREDIA
CERTIFICATO DI ACCREDITAMENTO
Accreditation Certificate

## Quality System

Conforms to ISO 9001 Standards, certified by an independent body.

## Test laboratory

Conforms to ISO 45001 Standards, certified by an independent body.

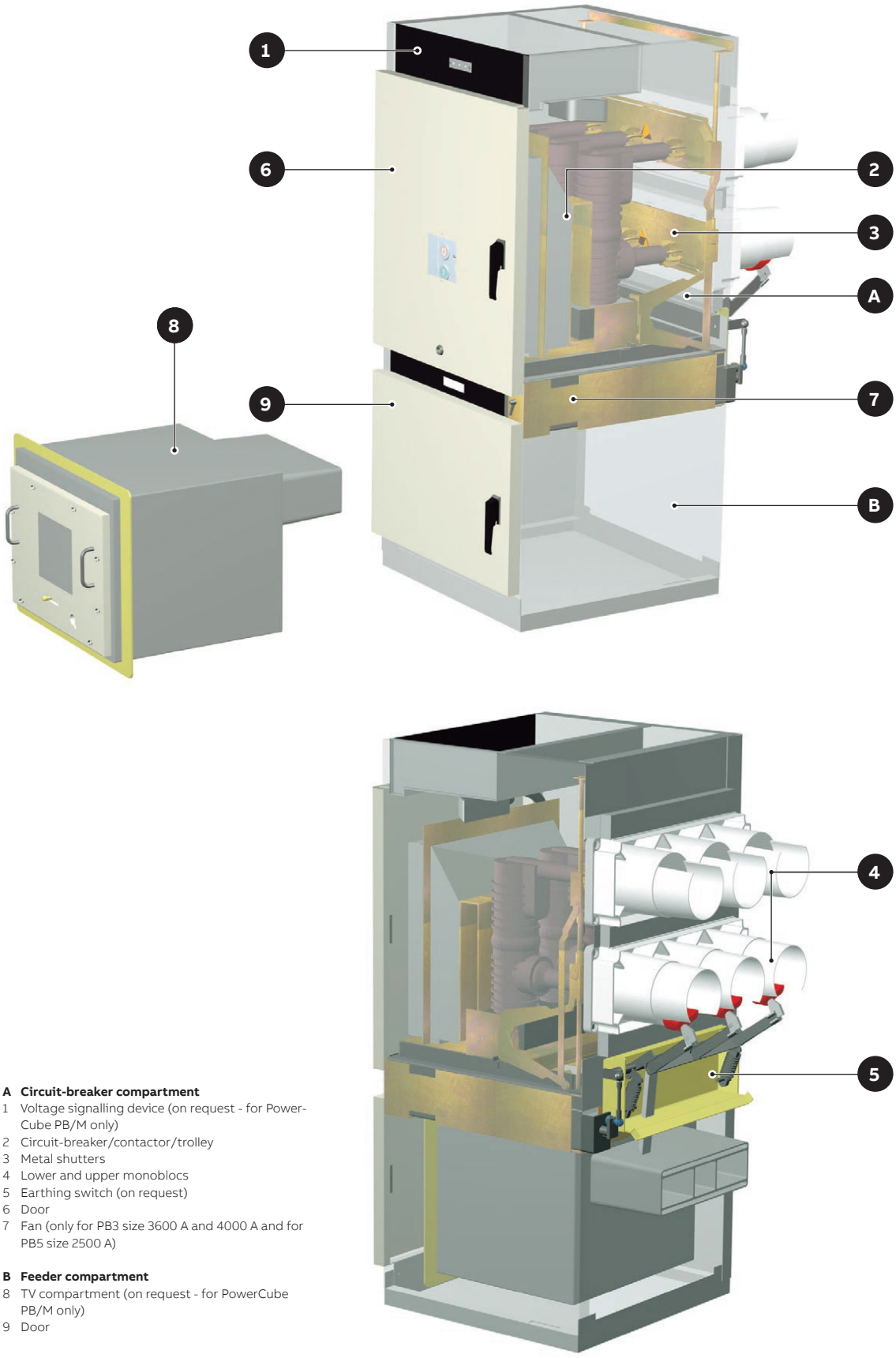
## Environmental Management System

Conforms to ISO 14001 Standards, certified by an independent body.

## Health and Safety Management System

Conforms to ISO 45001: 2018 Standards, certified by an independent body.

# 1. General characteristics




**A Circuit-breaker compartment**

1 Voltage signalling device (on request - for PowerCube PB/M only)
2 Circuit-breaker/contactor/trolley
3 Metal shutters
4 Lower and upper monoblocs
5 Earthing switch (on request)
6 Door
7 Fan (only for PB3 size 3600 A and 4000 A and for PB5 size 2500 A)

**B Feeder compartment**

8 TV compartment (on request - for PowerCube PB/M only)
9 Door

## Electrical specifications of PowerCube unit

| PowerCube type | | | PB1 | PB2 | PB3 [3] | PB4 | PB5 [2] | PB1/R [2] | PB2/R [2] | PB3/R [2] | PB4/R [2] | PB5/R [2] | PB1/T | PB2/T | PB4/T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Module width | | mm | 600 | 750 | 1000 | 750 | 1000 | 600 | 750 | 1000 | 750 | 1000 | 600 | 750 | 750 |
| Rated voltage | 12 | kV | • | • | • | | | • | • | • | | | • | • | |
| | 17.5 | kV | • | • | • | | | • | • | • | | | • | • | |
| | 24 | kV | | | | • | • | | | | • | • | | | • |
| Test Voltage at industrial frequency | 28 | kV | • | • | • | | | • | • | • | | | • | • | |
| | 38 | kV | • | • | • | | | • | • | • | | | • | • | |
| | 50 | kV | | | | • | • | | | | • | • | | | • |
| Impulse withstand voltage | 75 | kV | • | • | • | | | • | • | • | | | • | • | |
| | 95 | kV | • | • | • | | | • | • | • | | | • | • | |
| | 125 | kV | | | | • | • | | | | • | • | | | • |
| Short-time withstand current | 25 | kA (3s) | • | • | • | • | • | | | | | | | | |
| | 31.5 | kA (3s) | • | • | • | • | • | | | | | | | | |
| | 40 | kA (3s) | | • | • | | | | | | | | | | |
| | 50 | kA (1s) | | • | • | | | | | | | | | | |
| Peak current | 63 | kA | • | • | • | • | • | | | | | | | | |
| | 79 | kA | • | • | • | • | • | | | | | | | | |
| | 100 | kA | | • | • | | | | | | | | | | |
| | 125 | kA | | • | • | | | | | | | | | | |
| Rated currents | 630 | A | • | • | | • | | | | | | | | | |
| | 1250 | A | • | • | | • | | | | | | | | | |
| | 1600 | A | | • | | | • | | | | | | | | |
| | 2000 | A | | • | | | • | | | | | | | | |
| | 2500 | A | | | • | | • (1) | | | | | | | | |
| | 3150 | A | | | • | | | | | | | | | | |
| | 3600 | A | | | • (1) | | | | | | | | | | |
| | 4000 | A | | | • (1) | | | | | | | | | | |

**Not applicable**

## Electrical specifications of the earthing switch (on request)

| PowerCube Module/Enclosure | | | PB1 | PB2 | PB3 | PB4 | PB5 | PB1/R | PB2/R | PB3/R | PB4/R | PB5/R | PB1/T | PB2/T | PB4/T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Module width | | mm | 600 | 750 | 1000 | 750 | 1000 | 600 | 750 | 1000 | 750 | 1000 | 600 | 750 | 750 |
| Short-time withstand current | 25 | kA (3s) | • | • | • | • | • | • | • | • | • | • | • | • | • |
| | 31.5 | kA (3s) | • | • | • | • | • | • | • | • | • | • | • | • | • |
| | 40 | kA (1s) | | • | • | | | | • | • | | | | • | |
| | 50 | kA (1s) | | • | • | | | | • | • | | | | • | |
| Peak current | 63 | kA | • | • | • | • | • | • | • | • | • | • | • | • | • |
| | 79 | kA | • | • | • | • | • | • | • | • | • | • | • | • | • |
| | 100 | kA | | • | • | | | | • | • | | | | • | |
| | 125 | kA | | • | • | | | | • | • | | | | • | |

(1) With forced ventilation in the circuit-breaker compartment: a further fan is required at the rear of the switchgear for 4000 A versions.
(2) PB/F and PB/FL not available
(3) PB/FL not available

# 2. Available types and apparatus

## Circuit breakers

**Note: see relevant apparatus catalogue for rating and versions suitable for PB untis**




VD4 series vacuum circuit breaker.

Scan o Tap on QR code to visit ABB VD4 website.



VM1 series vacuum circuit breaker

Scan o Tap on QR code to visit ABB VM1 website.




VD4G series Vacuum circuit breaker.

Scan o Tap on QR code to visit ABB VD4G website.

PowerCube Units can be equipped with VD4, VM1 and VD4G series withdrawable vacuum circuit-breakers.
The circuit breakers are fitted with a truck which allows their racking-in and out of the switchgear with the door closed.
They have a compact and light structure which ensures great sturdiness and excellent mechanical reliability.
The operating mechanism and poles are fixed to the metal structure which also acts as a support for the moving contact actuation kinematics

**Series VD4, VM1 and VD4G vacuum circuit-breakers**
The VD4, VD4G and VM1 circuit breakers use vacuum as interruption and insulating medium.
Thanks to the advanced techniques used for their manufacturing, the vacuum circuit breakers ensure high performances under all service conditions.
The vacuum interrupters are embedded in thermoplastic or epoxy resin poles.
This construction protect the vacuum interrupters which are unaffected by shocks, humidity and environmental pollution.
The circuit breaker poles, constitute the interrupting part, they are sealed for life pressure systems (IEC 62271-100 Standards) and maintenance-free.
The VD4 and VD4G circuit breakers use a mechanical type of operating mechanism while VM1 circuit breakers use an operating mechanism with a magnetic actuator.
VD4G circuit breakers are designed to meet the most demanding plant requirements for generator applications as for IEEE C37.013 and the new revision of IEC/IEEE 62271-C37-013 standards (dual logo).




Series ConVac vacuum contactor

Scan o Tap on QR code to visit ABB ConVac website.

**Series ConVac vacuum contactors**

ConVac series withdrawable contactors are used in PowerCube PB1 Units up to 12 kV. The contactors are suitable for controlling a.c. devices that need to a considerable number of operations with an extremely low chopping current.

The Contactor is characterized by a monostable linear actuator and available in two basic configuration, Electrical latching and mechanical latching. Close operation is always performed supplying the multi-voltage electronic feeded which reduce automatically power consumption after the close operation without the need of added resistances.

In electrically latched units, when auxiliary power supply is not present, open operation is guaranteed by springs. In mechanically latched units, after the closing operation is performed, the power supply is removed and a mechanical device lock the contactor in close position until a trip coil is energized. When this happen the mechanical lock disengage and the contactor open by springs.

The contactor is suitable to install both DIN and BS fuses (type to be specified at order stage) with different lenghts.

ConVac contactors are also characterized by an extreme flexibility in term of configuration, for instance it is possible for the customer to switch from electrical to mechanical latching, or to change contactor auxiliary voltage level, without ABB intervention by means of a simple kit. This allow to optimize and reduce spare contactors units and spare parts management and to fast adapt to changes in specifications.

# 2. Available types and apparatus



PB/TM PB1/MWL

**VT trucks**

PTT/W is the VT truck used in PB/T measuring unit (see table 1).
VT truck is supplied without voltage transformers (separately available from ABB)
ABB Voltage Transformers suitable for these units are:

- ABB TJP-F 4.0 (12 kV)
- ABB TJP-F 5.0 (17,5 kV)
- ABB TJP 6.0 (24 kV)

PTT/WL is the VT truck used in PB1/MWL measuring unit (see table 2).
VT truck is supplied without voltage transformers (separately available from ABB)
ABB Voltage Transformers suitable for these units are:

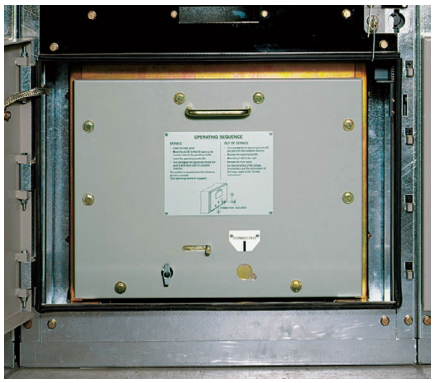
- ABB TJP-F 4.0 (12 kV)
- ABB TJP-F 5.0 (17,5 kV)

**Tab. 1 – VT trucks for PB/TM, PB/TE and PB/TF**

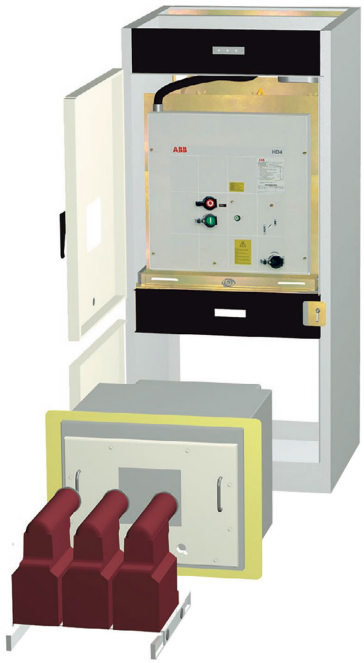
| kV | Isc/ Icw (kA) | Dimensions | Truck type | PowerCube |
|---|---|---|---|---|
| 12<br>17.5 | 16<br>20<br>25<br>31.5 | W=600 mm (panel width)<br>P=150 mm (pole distance VT) | PTT1/W | PB1/TM<br>PB1/TE<br>PB1/TF |
| 12<br>17.5 | 40<br>50 | W=750 mm (panel width)<br>P=210 mm (pole distance VT) | PTT2/W | PB2/TM<br>PB2/TE<br>PB2/TF |
| 24 | 16<br>20<br>25<br>31.5 | W=750 mm (panel width)<br>P=210 mm (pole distance VT) | PTT4/W | PB4/TM<br>PB4/TE<br>PB4/TF |

**Tab. 2 – VT trucks for PB/MWL**

| kV | Isc/ Icw (kA) | Dimensions | Truck type | PowerCube |
|---|---|---|---|---|
| 12<br>17.5 | 16<br>20<br>25<br>31.5 | W=600 mm (panel width)<br>P=160 mm (pole distance VT) | PTT1/WL | PB1/MWL |



TV cell



**VT Cell**

TV-F and TV-W are cells for VT placed in PB/M and PB/RM cable compartment

VT truck is fit inside the cell without voltage transformers (separately available from ABB)

ABB Voltage Transformers suitable for these units are:

- ABB TJP 4.3 (12 kV)
- ABB TJP 5.3 (17,5 kV)
- ABB TJP 6.3 (24 kV)

The voltage transformers are are protected by fuses. The fuses can be replaced when the switchgear is in service since the fuse compartment is segregated from the other compartments by metal partitions.

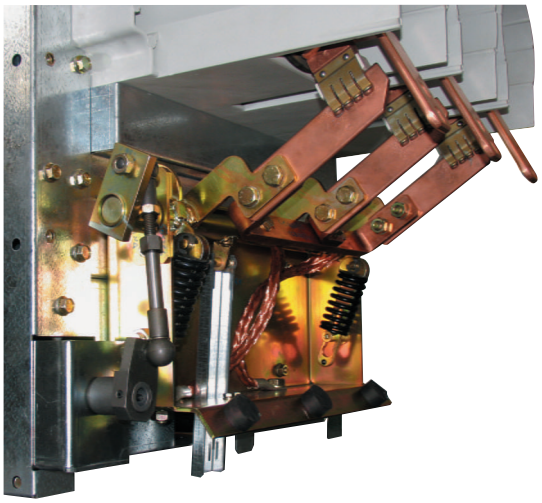
**Tab. 3 – VT trucks for PB/M - PB/RM**

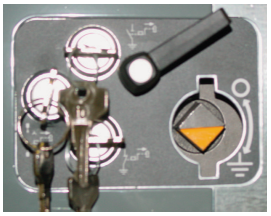
| kV | Isc/ Icw (kA) | Dimensions | Cell type | PowerCube |
|---|---|---|---|---|
| 12<br>17.5 | 16<br>20<br>25<br>31.5 | W=750 mm (panel width)<br>W=1000 mm (panel width)<br>P=150 mm (pole distance VT) | Type F | PB2/M<br>PB2/RM<br>PB3/M<br>PB3/RM |
| 24 | 16<br>20<br>25<br>31.5 | W=750 mm (panel width)<br>W=1000 mm (panel width)<br>P=200 mm (pole distance VT) | Type/W | PB4/M<br>PB4/RM<br>PB5/M<br>PB5/RM |

# 3. Main components

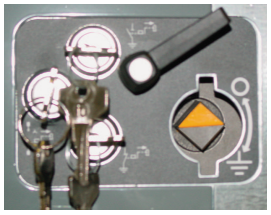
## Earth switches

PowerCube units type PB can be equipped with an earthing switch. The earthing switch possesses short-circuit making capacity. On request, the opening and closing operations can be inhibited by means of key locks. The earthing switch is operated from the front of the module by means of a manual operation appropriately interlocked with the circuit-breaker's position.
Not available on PB/FL



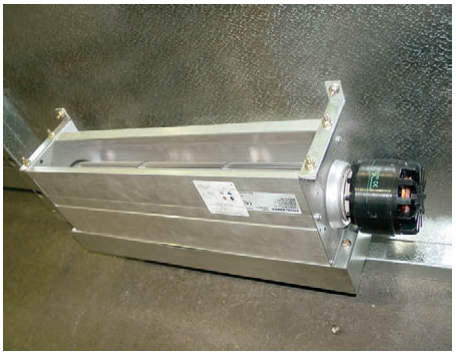


Earthing switch closed



Earthing switch open

Indication of the earthing switch (open/closed) visible from the front of the enclosure.



A fan for forced ventilation is pre-installed in PB3 units size 3600 A and PB5 units size 2500 A. To reach 4000A with PB3 a second fan (in the picture) shall be installed, according with ABB prescriptions, in the rear of the panel (at the customer's charge).

## Monoblocks and shutters

The spout consist of an insulated monoblock containing the upper and lower power connections of the Circuit breaker or contactor compartment.
Branches for busbars connection are from upper monoblock while connections towards the cable compartment are from the lower one.
The metallic shutters are automatically actuated when the circuit-breaker moves from the test/isolated position to the connected position and vice versa.
They are always equipped with a fail-safe safety device to prevent them from being manually open by an operator when the apparatus compartment is empty. Shutters can be locked by means of padlocks. (optional).



Insulating monoblocks with contacts for rated current up to 2500 A.



Insulating monoblocks with contacts for rated current of up to 4000 A.



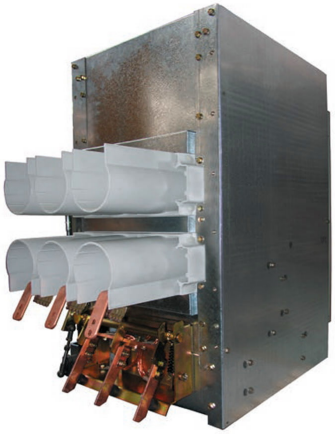
Segregating shutters with metal partitions

## Notes for use of PowerCube Units type PB

- **PowerCube Units type PB1 ... PB5** are recommended for incoming, outgoing and bus-tie panels.

Example of a PowerCube Unit type PB1 ... PB5 (front and rear views)





- **PowerCube Units type PB1/R ... PB5/R** are recommended for riser, metering and direct busbar incoming panels.

Example of a PowerCube Unit type PB1/R ... PB5/R (front and rear views)





**Tab. 4 - PowerCube units without apparatus (PB/RM, PB/RE)**

| **Characteristics of the enclosure/module** | | | | | |
|---|---|---|---|---|---|
| Rated voltage (kV) | Width (mm) | Rated current (A) | Isc (kA) (1) | Icw (kA x 3s/1s) (1) | PowerCube |
| 12-17.5 | 600 (2) | 1250 | 31.5 | 31.5 | PB1/RE - PB1/RM |
| 12-17.5 | 750 | 2000 | 31.5 | 31.5 | PB2/RE - PB2/RM |
| 12-17.5 | 750 | 2000 | 40-50 | 40-50 | PB2/RE - PB2/RM |
| 12-17.5 | 1000 | 4000 | 31.5 | 31.5 | PB3/RE - PB3/RM |
| 12-17.5 | 1000 | 4000 | 40-50 | 40-50 | PB3/RE - PB3/RM |
| 24 | 750 | 1250 | 31.5 | 31.5 | PB4/RE - PB4/RM |
| 24 | 1000 | 2500 | 31.5 | 31.5 | PB5/RE - PB5/RM |

(1) On earthing switch, if requested.
(2) VT Cell not available

# 3. Main components

## Accessories

**1a Signalling contacts for circuit-breaker/ contactor in connected/isolated position**

Standard fitting is 10 contacts (5 normally open and 5 normally closed in change-over configuration) to signal connected position and another ten to signal the isolated position. A second group of 10 contacts is available on request for both signals. Not available on PB/F - PB/FL.

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



| | | | | |
|---|---|---|---|---|
| **Specifications** | Rated voltage | V | up to 250 a.c. (50-60 Hz)/d.c. |
| | Insulation voltage 50 Hz/1 min | V | 2000 (towards earth) |
| | Rated current | A | 5 |
| | Rated thermal current | A | 17.5 |
| **Breaking capacity of auxiliary contacts** | 48 V (d.c.) | A | 3 |
| | 110 V (d.c.) | A | 0.8 |
| **Resistive load** | 220 V (d.c.) | A | 0.5 |
| **Inductive load: L/R = 5 ms** | 48 V (d.c.) | A | 1.5 |
| | 110 V (d.c.) | A | 0.5 |
| | 220 V (d.c.) | A | 0.3 |

**1b Anti-racking-in lock for circuit-breakers / contactors with a rated current lower than the cubicle or for apparatus not envisaged for the cubicle itself**

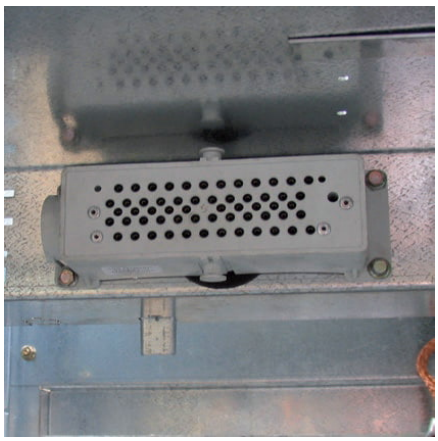
Consists of a code on the socket that prevents the plug from being inserted if the rated current of the apparatus is incompatible with the one of the PowerCube.

In order to work correctly, this lock requires a counterpart on the circuit-breaker or contactor, a combination of a coding on the apparatus plug and the locking magnet on the truck (-RL2).

The plug cannot be removed when the apparatus is in connected position or halfway between rack-in and isolated position.

Not available on PB/F - PB/FL.

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



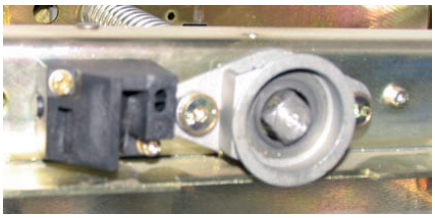
### 1c Lock to prevent rack-in with the door open

Prevents withdrawable apparatus from being moved from the test/isolated position to the connected position (and vice versa) with the door open. In order to function correctly, this lock requires a counterpart on the circuit-breaker. Not available on PB/F - PB/FL.

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



Lock installed in internal part of door

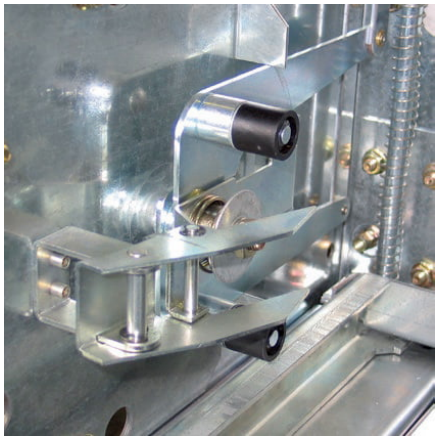


Counterpart on the apparatus

### 1d Safety device for shutters (fail-safe)

It is a mechanical device that is always supplied and that prevents manual open of a shutter by an operator when the apparatus compartment is empty

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F PB/FL | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |

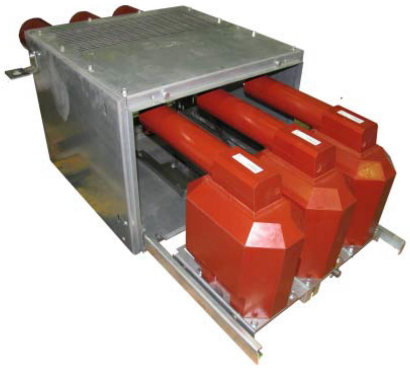


# 3. Main components

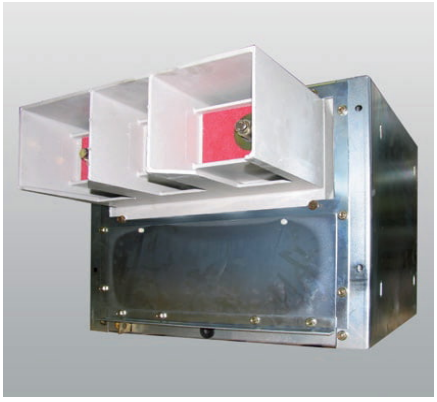
## Accessories that must be obligatorily indicated when ordering

**2 Withdrawable VT compartment (includes VT truck)**

Can only be applied to module units (PB/M - PB/RM) for which the necessary presetting must be requested.
The VT compartment is equipped with 2 normally open and 2 normally closed auxiliary position contacts for the VT truck.



24kV cell



12÷17kV cell

**3 Earthing switch ST/E with making capacity**

Not available on PB/FL

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | yes |
| PB2/R | 750 | • | • | | | • | yes |
| PB3/R | 1000 | • | • | | | • | yes |
| PB4/R | 750 | | | • | | • | yes |
| PB5/R | 1000 | | | • | | • | yes |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



## 4 Key locks on earthing switches

Two key locks are available on request for the earthing switch, 3 options are available:

a) Key lock with free key with earthing switch open.

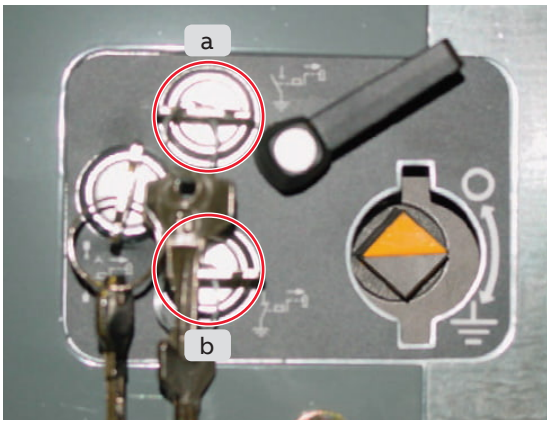
b) Key lock with free key with earthing switch closed.

c) Key lock with free key with earthing switch open and Key lock with free key with earthing switch closed.

The application is available also with a reinforced key .

Not available on PB/FL

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | yes |
| PB2/R | 750 | • | • | | | • | yes |
| PB3/R | 1000 | • | • | | | • | yes |
| PB4/R | 750 | | | • | | • | yes |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |

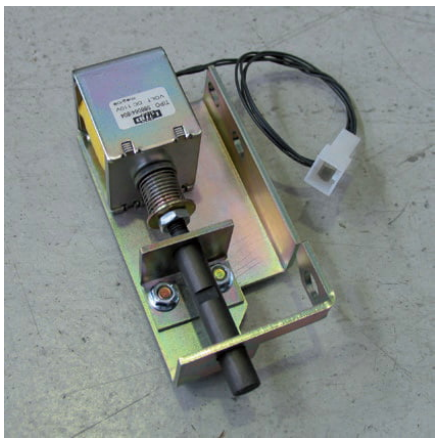



## 5 Electromechanical lock on the earthing switch (BED)

Lock the earthing switch if auxiliary power is voluntarily cut or is missing: de-energization electromechanical lock connected to the earthing switch actuator operating shaft.

Not available on PB/FL

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | yes |
| PB2/R | 750 | • | • | | | • | yes |
| PB3/R | 1000 | • | • | | | • | yes |
| PB4/R | 750 | | | • | | • | yes |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



| Rated voltage | | |
|---|---|---|
| d.c. | V | 24-30-48-60-110-125-220-250 |
| a.c. 50 Hz | V | 110-220 |
| a.c. 60 Hz | A | 110-220 |
| **Breaking capacity of auxiliary contacts** | | |
| d.c. | W | 10.5 ± 1.5 |
| a.c. | VA | 20 ± 3 |

# 3. Main components

### 6 Auxiliary contacts for the earthing switch

Units equipped with earthing switches are available:

a) Pack of 5 auxiliary contacts

b) Pack of 10 auxiliary contacts.

The customer can easily change the settings of the auxiliary contacts from normally open to normally closed and vice versa.

Not available on PB/FL

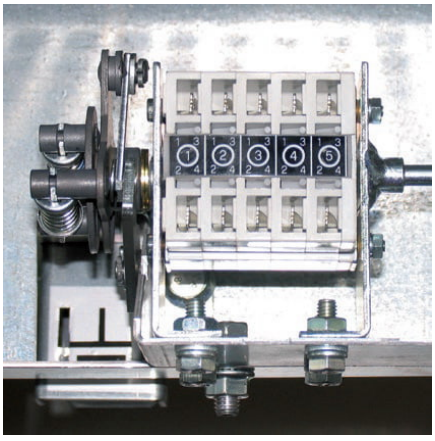
### 7 Circuit-breaker anti-racking-in lock

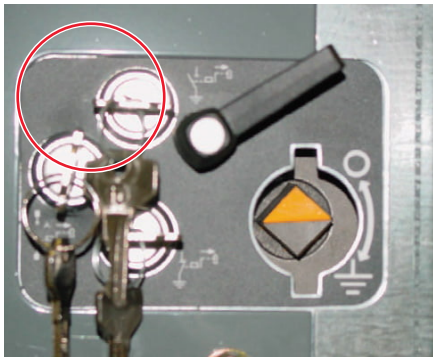
(the apparatus cannot be switched from the isolated position to the racked-in position when the key has been removed).

Not available on PB/FL

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | yes |
| PB2/R | 750 | • | • | | | • | yes |
| PB3/R | 1000 | • | • | | | • | yes |
| PB4/R | 750 | | | • | | • | yes |
| PB5/R | 1000 | | | • | | • | yes |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |





| Specifications | | Hz)/d.c. |
|---|---|---|
| Specifications | V | 24-500 a.c. (50-60 |
| Insulation voltage 50 Hz/1 min | V | 2500 |
| Rated thermal current | A | 10 |
| **Breaking capacity of auxiliary contacts** | | |
| 500 V (a.c. 50/60 Hz); cos=0.4 | A | 6 |
| 220 V (a.c. 50/60 Hz); cos=0.4 | A | 10 |
| 220 V (d.c.); L/R=10 ms | A | 1 |
| **Number of operations** | op/N° | 8 |

## 8 Voltage signalling lamps (VDIS)

These lamps indicate presence of primary voltage. VDIS can be pre-assembled on request on PB/M modules with the appropriate presetting while for PB/E, PB/F and PB/FL units, they can be supplied loose and assembled by the customer in the low voltage compartment.
VPIS can receive the signal from post insulators with capacitive dividers, by combi-sensors or by current transformers.




## 9 Opening or closing operations with the door closed

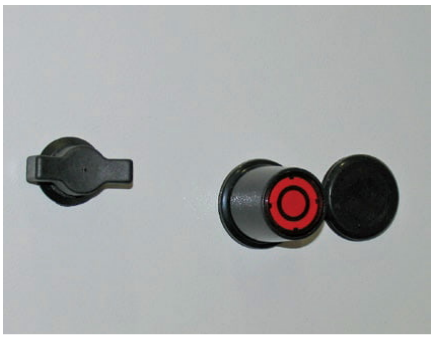
This accessory is available on request for circuit-breakers and contactors; available options are as below.
VD4 and VD4-G circuit breakers:
- open push-button.
- open and close push-buttons.

VM1, VSC and mechanically latched ConVac:
- Slot to operate with emergency open rod (provided with the apparatus).

This accessory requires different and specific doors for the different type of apparatus.
This accessory is not available for PB/F and PB/FL units.
This accessory is not available for:
- 50 kA circuit breakers.
- PB/F and PB/FL units

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F PB/FL | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | yes |
| PB2/R | 750 | • | • | | | • | yes |
| PB3/R | 1000 | • | • | | | • | yes |
| PB4/R | 750 | | | • | | • | yes |
| PB5/R | 1000 | | | • | | • | yes |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/measure-ments | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | no |
| PB2/T | 750 | • | • | | | • | no |
| PB4/T | 750 | | | • | | • | no |



# 3. Main components

### 10 Position contacts for earthing truck

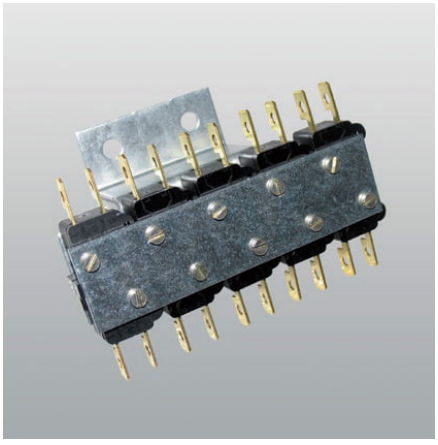
Signal when the earthing truck is in connected position. Two kits are available:

a) Group of 5 contacts

b) Group of 10 contacts

This accessory it is not available on PB/F and PB/FL

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | no |
| PB2/T | 750 | • | • | | | • | no |
| PB4/T | 750 | | | • | | • | no |



| Specifications | | |
|---|---|---|
| Rated voltage | V | up to 250 a.c. (50-60 Hz)/d.c. |
| Insulation voltage 50 Hz/1 min | V | 2000 (towards earth) |
| Rated current | A | 5 |
| Rated thermal current | A | 17.5 |
| **Breaking capacity of auxiliary contacts** | | |
| **Resistive load** | | |
| 48 V (d.c.) | A | 3 |
| 110 V (d.c.) | A | 0.8 |
| 220 V (d.c.) | A | 0.5 |
| **Inductive load: L/R = 5 ms** | | |
| 48 V (d.c.) | A | 1.5 |
| 110 V (d.c.) | A | 0.5 |
| 220 V (d.c.) | A | 0.3 |

### 11 Electromechanical door lock

The lock only allows the door to be opened if the locking device is energized.

This accessory it is not available on PB/F and PB/FL

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



| Rated voltage | | |
|---|---|---|
| d.c. | V | 24-30-48-60-110-125-220-250 |
| a.c. 50 Hz | V | 110-220 |
| a.c. 60 Hz | A | 110-220 |
| **Rated power** | | |
| d.c. | W | 10.5 ± 1.5 |
| a.c. | VA | 20 ± 3 |
| **Operation** | | Unsuitable for continuous service (Energize to open door and normally leave de-energized) |

## 12 Anti-condensation heaters

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F PB/FL | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | yes |
| PB2/R | 750 | • | • | | | • | yes |
| PB3/R | 1000 | • | • | | | • | yes |
| PB4/R | 750 | | | • | | • | yes |
| PB5/R | 1000 | | | • | | • | yes |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



| Rated voltage | | |
|---|---|---|
| a.c. 50 Hz | V | 110-220 |
| a.c. 60 Hz | A | 110-220 |
| **Rated power** | | |

## 13 Shutter padlocks

Can be fitted to the upper, lower shutters, or both.

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F PB/FL | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |





# 3. Main components

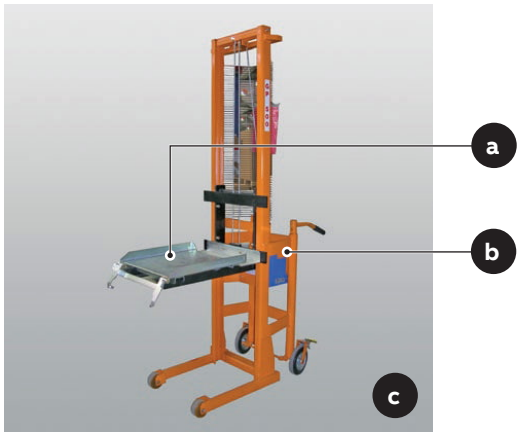
**14 Earthing switch operating lever**
Standard fitting if Earthing switch is required: 1 lever on each order confirmation or on each group of enclosures for each position of the order confirmation.
Extra levers are supplied on request as accessories.
Not available for PB/FL

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/measure-ments | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | yes |
| PB2/R | 750 | • | • | | | • | yes |
| PB3/R | 1000 | • | • | | | • | yes |
| PB4/R | 750 | | | • | | • | yes |
| PB5/R | 1000 | | | • | | • | yes |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



**16 Circuit-breaker lifting and transporting unit**
Allows the withdrawable apparatus to be safely lifted to plug it into the PowerCube unit.
Available options are:
a) Plate for lifting trolley
b) Lifting trolley
c) Complete kit (plate installed on trolley).

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F PB/FL | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



# 3. Main components

### 15 Transport trolley

With fixed height proportional to the height of PB/M modules. Allows the apparatus to be plugged into the module.

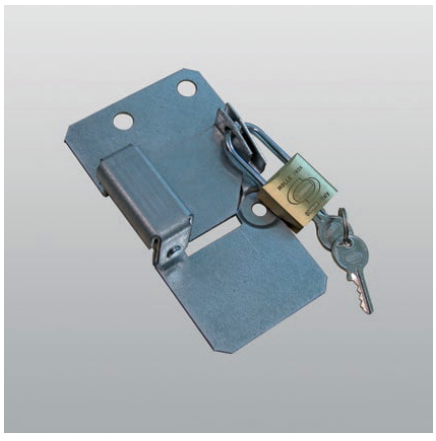
| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F PB/FL | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



### 17 Padlock on earth switch

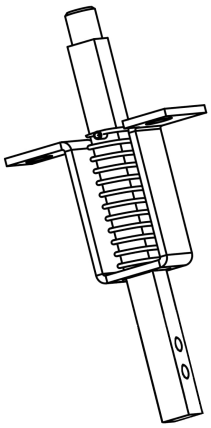
Prevents insertion of earthing switch operating lever by means of a padlocked device.
The device is to be assembled on the operating slot of the earthing switch actuator.

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/mea-surements | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | yes |
| PB2/R | 750 | • | • | | | • | yes |
| PB3/R | 1000 | • | • | | | • | yes |
| PB4/R | 750 | | | • | | • | yes |
| PB5/R | 1000 | | | • | | • | yes |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



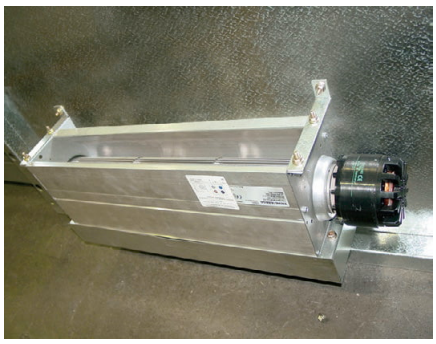
**18 Mechanical lock for cable access compartment door.**
Prevent opening of cable access compartment door with the earthing switch in open position. For PB/E and PB/F it is provided loose. It is responsibility of the customet to assemble it and check functionality of the lock with his door.
Not available on PB/FL

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/measure-ments | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | yes |
| PB2/R | 750 | • | • | | | • | yes |
| PB3/R | 1000 | • | • | | | • | yes |
| PB4/R | 750 | | | • | | • | yes |
| PB5/R | 1000 | | | • | | • | yes |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |



**19 Rear fan to install at rear of switchgear**
When installed according to the instructions in the PowerCube manual, this fan can allows to reach 4000 A rated thermal current in panels based on a PowerCube PB3 3600 A.

| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M PB/F PB/FL | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/measure-ments | |
| PB1 | 600 | • | • | | • | | no |
| PB2 | 750 | • | • | | • | | no |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | no |
| PB5 | 1000 | | | • | • | | no |
| PB1/R | 600 | • | • | | | • | no |
| PB2/R | 750 | • | • | | | • | no |
| PB3/R | 1000 | • | • | | | • | no |
| PB4/R | 750 | | | • | | • | no |
| PB5/R | 1000 | | | • | | • | no |
| PB1/T | 600 | • | • | | | • | no |
| PB2/T | 750 | • | • | | | • | no |
| PB4/T | 750 | | | • | | • | no |



**20 Key locks for the earthing truck**

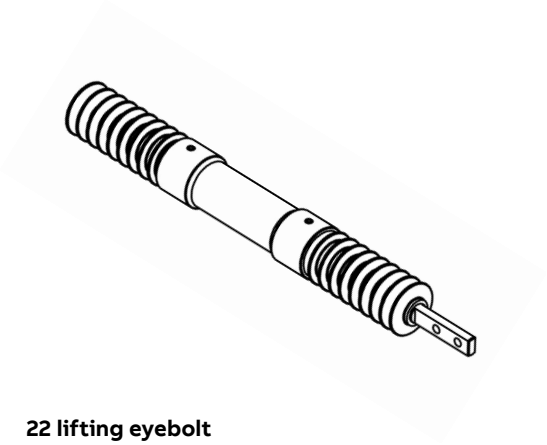
It is used to inhibit the rack-in operation of the Earthing truck. Two locks are supplied:
One lock for earthing truck to earth busbars (truck with upper phases)
one lock earthing truck to earth cables (truck with lower phases).
Both key locks can be installed in the same enclosure. Not available for PB/F and PB/FL



| PowerCube unit | | Rated voltage | | | Type of Unit | | Available accessory |
|---|---|---|---|---|---|---|---|
| PB/E PB/M | Width (mm) | 12 kV | 17.5 kV | 24 kV | Bus tie/ incoming/ outgoing | Direct incoming/ riser/measure-ments | |
| PB1 | 600 | • | • | | • | | yes |
| PB2 | 750 | • | • | | • | | yes |
| PB3 | 1000 | • | • | | • | | yes |
| PB4 | 750 | | | • | • | | yes |
| PB5 | 1000 | | | • | • | | yes |
| PB1/R | 600 | • | • | | | • | yes |
| PB2/R | 750 | • | • | | | • | yes |
| PB3/R | 1000 | • | • | | | • | yes |
| PB4/R | 750 | | | • | | • | yes |
| PB5/R | 1000 | | | • | | • | yes |
| PB1/T | 600 | • | • | | | • | yes |
| PB2/T | 750 | • | • | | | • | yes |
| PB4/T | 750 | | | • | | • | yes |

**21 CT rods**

Allow usage of CT rods for metering and protection. Installation, testing and functional verifications are at customer care



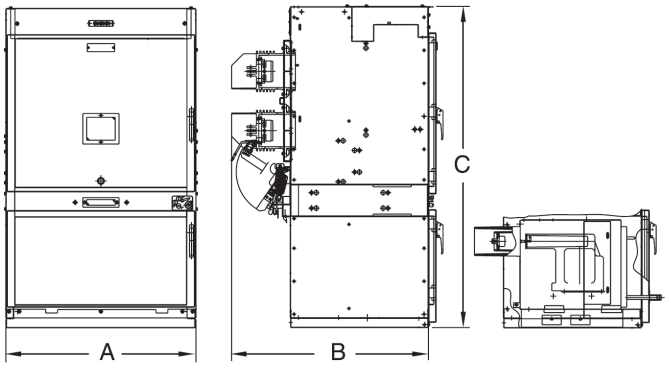
**22 lifting eyebolt**

Allow to lift with a crane PowerCube modules
It is available only for PB/M units

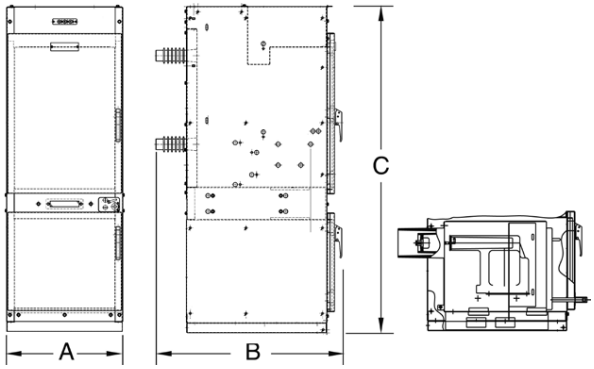


# 4. Overall dimensions and weights

## Type PB/M units




## Type PB/RM units

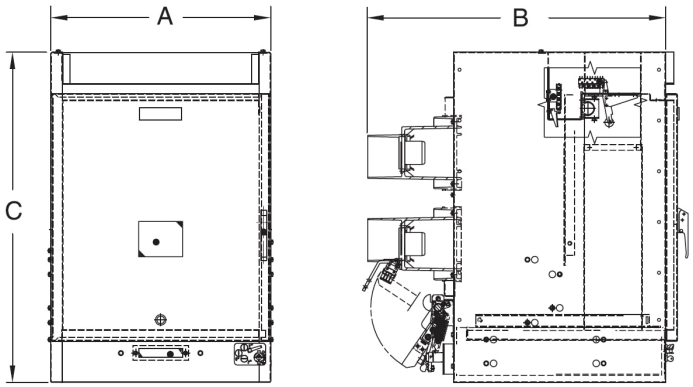



| Module | Rated voltage [kV] | Rated current [A] | Isc Icw [kA] | Dimension table | A [mm] | B [mm] | C [mm] | Weight [kg] (1) |
|---|---|---|---|---|---|---|---|---|
| **PB1/M** | 12 | 630 - 1250 | 31.5 | 1VCD000023 | 600 | 1016 | 1680 | 200 |
| | 17.5 | 630 - 1250 | 31.5 | 1VCD000028 | 600 | 1016 | 1680 | 200 |
| **PB2/M** | 12 | 630...2000 | 31.5 | 1VCD000024 | 750 | 1016 | 1680 | 200...260 |
| | 12 | 1250...2000 | 40-50 | 1VCD000027 | 750 | 1016 | 1680 | 200...260 |
| | 17.5 | 630...2000 | 31.5 | 1VCD000029 | 750 | 1016 | 1680 | 200...260 |
| | 17.5 | 1250...2000 | 40-50 | 1VCD000030 | 750 | 1016 | 1680 | 200...260 |
| **PB3/M** | 12-17.5 | 2500 | 31.5 | 1VCD000025 | 1000 | 1030 | 1680 | 320 |
| | 12-17.5 | 3150 | 31.5 | 1VCD000026 | 1000 | 1030 | 1680 | 344 |
| | 12-17.5 | 3600...4000 | 31.5 | 1VCD000043 | 1000 | 1030 | 1680 | 370...400 |
| | 12-17.5 | 2500 | 40-50 | 1VCD000037 | 1000 | 1030 | 1680 | 320 |
| | 12-17.5 | 3150 | 40-50 | 1VCD000038 | 1000 | 1030 | 1680 | 344 |
| | 12-17.5 | 3600 - 4000 | 40-50 | 1VCD000039 | 1000 | 1030 | 1680 | 370...400 |
| **PB4/M** | 24 | 630 - 1250 | 31.5 | 1VCD000031 | 750 | 1246 | 1745 | 270 |
| **PB5/M** | 24 | 1600 - 2000 | 31.5 | 1VCD000032 | 1000 | 1246 | 1745 | 330 |
| | 24 | 2500 | 31.5 | 1VCD000044 | 1000 | 1246 | 1745 | 360 |

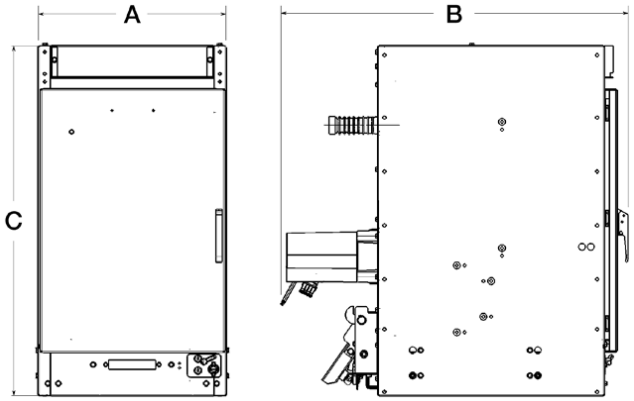
| Module | Rated voltage [kV] | Rated current [A] | Isc Icw [kA] | Dimension table | A [mm] | B [mm] | C [mm] | Weight [kg] (1) |
|---|---|---|---|---|---|---|---|---|
| **PB1/RM** | 17.5 | not applicable | 31.5 | 1VCD000033 | 600 | 1016 | 1745 | 185 |
| **PB2/RM** | 12 | | 31.5 | 1VCD000034 | 750 | 1016 | 1745 | 185...235 |
| | 17.5 | | 40-50 | 1VCD000040 | 750 | 1016 | 1745 | 185...235 |
| **PB3/RM** | 12-17.5 | | 31.5 | 1VCD000041 | 1000 | 1030 | 1680 | 290 |
| | 12-17.5 | | 40-50 | 1VCD000042 | 1000 | 1030 | 1680 | 290 |
| **PB4/RM** | 24 | | 31.5 | 1VCD000035 | 750 | 1246 | 1745 | 270 |
| **PB5/RM** | 24 | | 31.5 | 1VCD000036 | 1000 | 1246 | 1745 | 270 |
| **PB1/TM** | 12-17.5 | not applicable | 31.5 | 1VCD003639 | 600 | 1016 | 1745 | 185 |
| **PB2/TM** | 12-17.5 | | 40-50 | 1VCD003640 | 750 | 1016 | 1745 | 185...235 |
| **PB3/TM** | 24 | | 31.5 | 1VCD003641 | 1000 | 1016 | 1745 | 270 |

(1) Weight without earth switch and without TV compartment.
(2) Dimension with earth switch applied.

## Type PB/E units




## Type PB/RE units

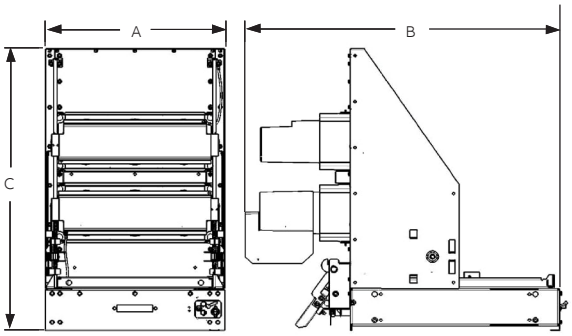



| Module | Rated voltage [kV] | Rated current [A] | Isc Icw [kA] | Dimension table | A [mm] | B [mm] | C [mm] | Weight [kg] (1) |
|---|---|---|---|---|---|---|---|---|
| **PB1/E** | 12 | 630 - 1250 | 31.5 | 1VCD003369 | 600 | 1016 | 1120 | 180 |
| | 17.5 | 630 - 1250 | 31.5 | 1VCD003369 | 600 | 1016 | 1120 | 180 |
| **PB2/E** | 12 | 630...2000 | 31.5 | 1VCD003370 | 750 | 1016 | 1120 | 200...240 |
| | 12 | 1250...2000 | 40-50 | 1VCD003370 | 750 | 1016 | 1120 | 200...240 |
| | 17.5 | 630...2000 | 31.5 | 1VCD003370 | 750 | 1016 | 1120 | 200...240 |
| | 17.5 | 1250...2000 | 40-50 | 1VCD003370 | 750 | 1016 | 1120 | 200...240 |
| **PB3/E** | 12-17.5 | 2500 | 31.5 | 1VCD003371 | 1000 | 1030 | 1120 | 300 |
| | 12-17.5 | 3150 | 31.5 | 1VCD003372 | 1000 | 1030 | 1120 | 320 |
| | 12-17.5 | 3600...4000 | 31.5 | 1VCD003373 | 1000 | 1030 | 1120 | 350...380 |
| | 12-17.5 | 2500 | 40-50 | 1VCD003371 | 1000 | 1030 | 1120 | 300 |
| | 12-17.5 | 3150 | 40-50 | 1VCD003372 | 1000 | 1030 | 1120 | 320 |
| | 12-17.5 | 3600 - 4000 | 40-50 | 1VCD003373 | 1000 | 1030 | 1120 | 350...380 |
| **PB4/E** | 24 | 630 - 1250 | 31.5 | 1VCD003374 | 750 | 1246 | 1230 | 250 |
| **PB5/E** | 24 | 1600 - 2000 | 31.5 | 1VCD003375 | 1000 | 1246 | 1230 | 310 |
| | 24 | 2500 | 31.5 | 1VCD003376 | 1000 | 1246 | 1230 | 340 |
| **PB1/RE** | 17.5 | not applicable | 31.5 | 1VCD003377 | 600 | 1016 (2) | 1120 | 165 |
| **PB2/RE** | 17.5 | | 31.5 | 1VCD003378 | 750 | 1016 (2) | 1120 | 165...215 |
| | 17.5 | | 40-50 | 1VCD003378 | 750 | 1016 (2) | 1120 | 165...215 |
| **PB3/RE** | 12-17.5 | | 31.5 | 1VCD003379 | 1000 | 1030 (2) | 1120 | 270 |
| | 12-17.5 | | 40-50 | 1VCD003379 | 1000 | 1030 (2) | 1120 | 270 |
| **PB4/RE** | 24 | | 31.5 | 1VCD003380 | 750 | 1246 (2) | 1230 | 215 |
| **PB5/RE** | 24 | | 31.5 | 1VCD003381 | 1000 | 1246 (2) | 1230 | 250 |
| **PB1/TE** | 12-17.5 | not applicable | 31.5 | 1VCD003636 | 600 | 1016 | 1120 | 165 |
| **PB1/TE** | 12-17.5 | | 40-50 | 1VCD003637 | 750 | 1016 | 1120 | 200 |
| **PB1/TE** | 24 | | 31.5 | 1VCD003638 | 750 | 1246 | 1230 | 220 |

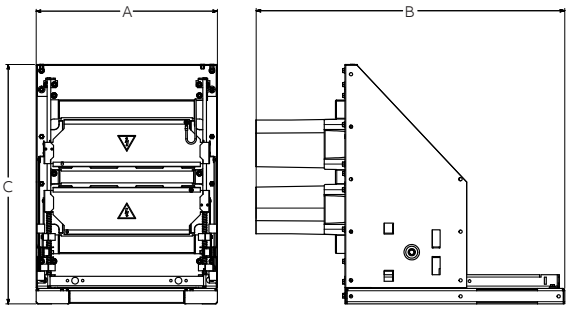
(1) Weight without earth switch.
(2) Dimension with earth switch applied.

# 4. Overall dimensions and weights

## Type PB/F units




## Type PB/FL units

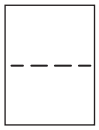


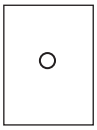

| Module | Rated voltage [kV] | Rated current [A] | Isc Icw [kA] | Dimension table | A [mm] | B [mm] | C [mm] | Weight [kg] (1) |
|---|---|---|---|---|---|---|---|---|
| **PB1/F** | 12÷17.5 | 630 ÷1250 | 31.5 | 1VCD003382 | 596 | 1016 | 900 | (*) |
| **PB2/F** | 12 | 630÷2000 | 31.5 | 1VCD003383 | 746 | 1016 | 1096 | (*) |
| | 12 | 1250÷2000 | 40÷50 | 1VCD003383 | 746 | 1016 | 1096 | (*) |
| | 17.5 | 630÷2000 | 31.5 | 1VCD003383 | 746 | 1016 | 1096 | (*) |
| | 17.5 | 1250÷2000 | 40-50 | 1VCD003383 | 746 | 1016 | 1096 | (*) |
| **PB3/F** | 12÷17.5 | 2500 | 31.5 | 1VCD003893 | 996 | 1030 | 1096 | **(*)** |
| | 12÷17.5 | 2500 | 40÷50 | 1VCD003893 | 996 | 1030 | 1096 | (*) |
| | 12÷17.5 | 3150 | 31.5 | 1VCD003914 | 996 | 1030 | 1096 | (*) |
| | 12÷17.5 | 3150 | 40÷50 | 1VCD003914 | 996 | 1030 | 1096 | (*) |
| | 12÷17.5 | 3600÷4000 | 31.5 | 1VCD003928 | 996 | 1030 | 1096 | (*) |
| | 12÷17.5 | 3600÷4000 | 40÷50 | 1VCD003928 | 996 | 1030 | 1096 | (*) |
| **PB4/F** | 24 | 630 ÷1250 | 31.5 | 1VCD003384 | 746 | 1338 | 1236 | (*) |
| **PB1/FL** | 12÷17.5 | 630 ÷1250 | **31.5** | 1VCD003614 | 596 | 1015 | 787 | (*) |
| **PB2/FL** | 12÷17.5 | 630÷2000 | 31.5 | 1VCD000210 | 746 | 1015 | 983 | (*) |
| | 12÷17.5 | 1250÷2000 | 40÷50 | 1VCD000210 | 746 | 1015 | 983 | (*) |
| **PB1/TF** | 12÷17.5 | not applicable | 31.5 | 1VCD003642 | 596 | 1016 | 900 | (*) |
| **PB2/TF** | 12÷17.5 | | 31.5 | 1VCD003643 | 746 | 1016 | 1096 | (*) |
| **PB4/TF** | 24 | | 31.5 | 1VCD003644 | 746 | 1334 | 1226 | (*) |

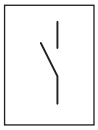
(*) Ask ABB.

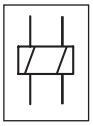
# 5. Wiring diagrams

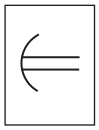
## Symbols (in compliance with Standards IEC 60617 and CEI EN 60617)

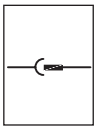

Mechanical, pneumatic or hydraulic connection

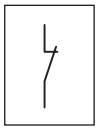

Terminal

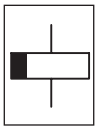

Make contact

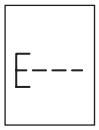

Control coil with two separate windings

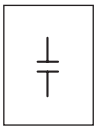

Delayed movement (in the movement of the arc towards its center)

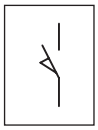

Socket and plug (female and male)

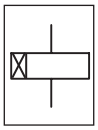

Break contact

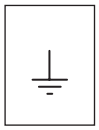

Control coil of a slow-releasing relay

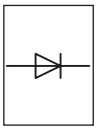

Pushbutton actuaor


Capacitor (general symbol)

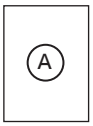

Make position contact (limit)


Control coil of a slow-operating relay


Earth, (general symbol)

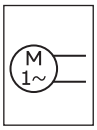

Semiconductor diode (general symbol)


Break position contact (limit)

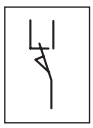


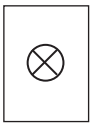
Ammeter

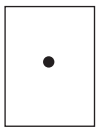

Earth, frame

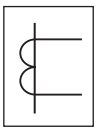


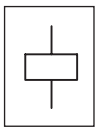
Single-phase asynchro-nous otor, short-circuited rotor, terminals for aux. phase routed outside


Position change-over break before make contact (limit)


Lamp (general symbol)


Conductor connections


Current transformer

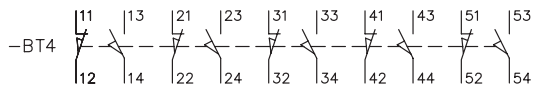

Control coil (general symbol)

# 5. Wiring diagrams

## Application diagrams

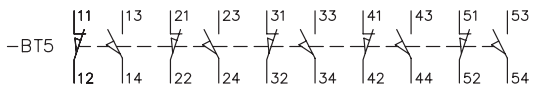
*C)

1



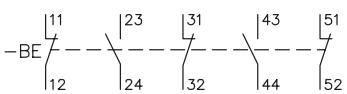

*C) D)

3



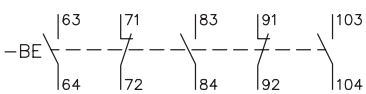

*B)

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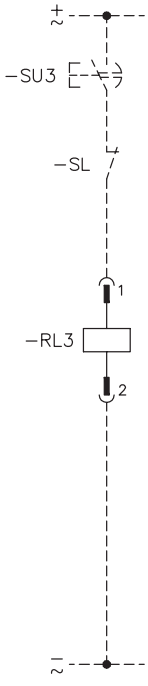



*B)

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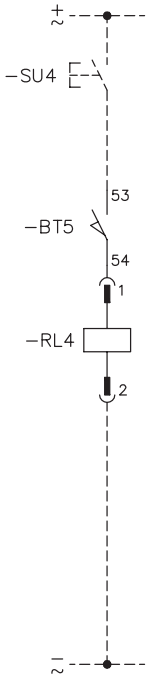


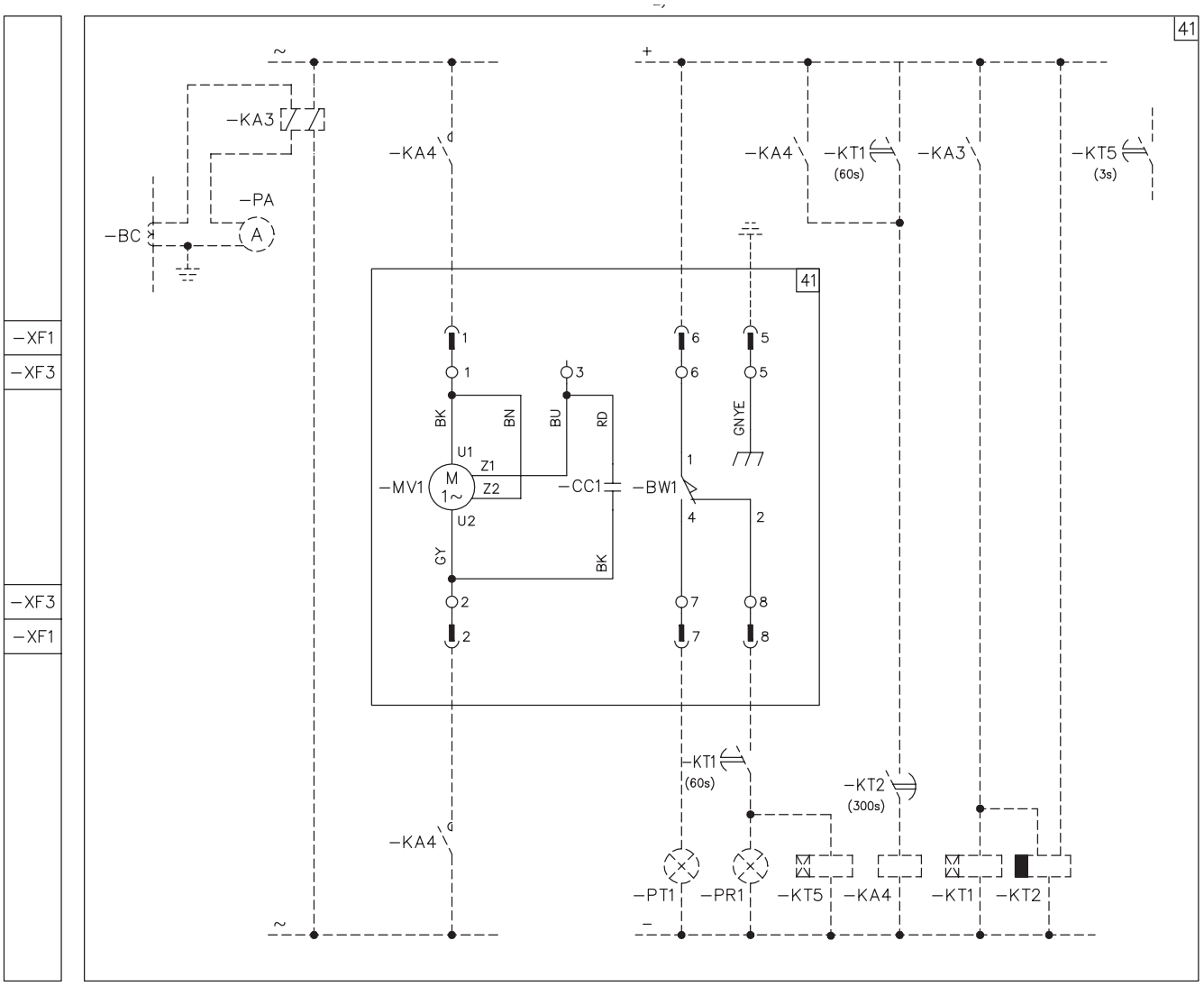

20



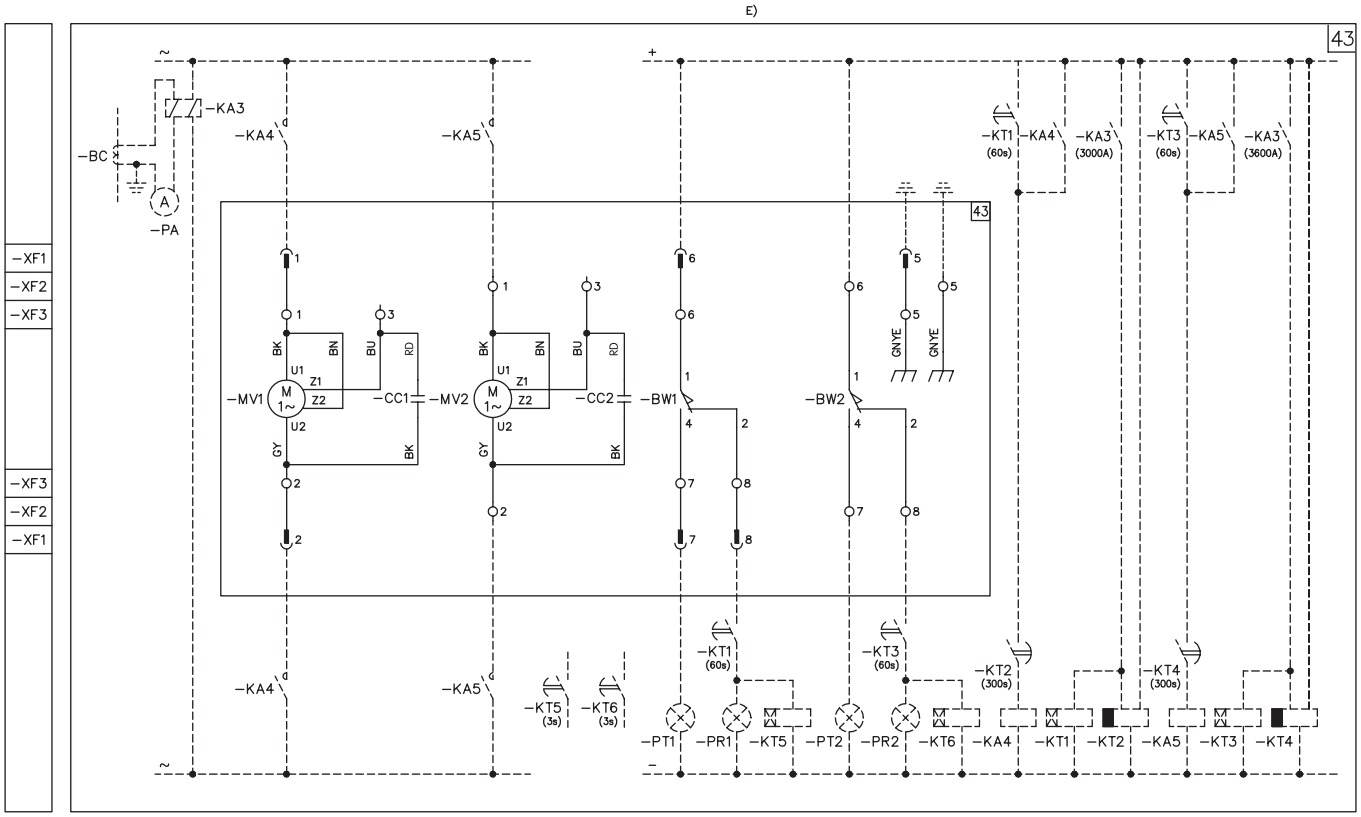

*D)

23




41
~
+
−KA3
−KA4
−KA4
−KT1
(60s)
−KA3
−KT5
(3s)
−PA
−BC
A
41
−XF1
−XF3
−XF3
−XF1
1
1
3
6
6
5
5
BK
BN
BU
RD
GNYE
U1
Z1
−MV1
M
1~
Z2
−CC1
−BW1
1
U2
4
2
GY
BK
2
2
7
7
8
8
−KT1
(60s)
−KT2
(300s)
−KA4
−PT1
−PR1
−KT5
−KA4
−KT1
−KT2
~
−

# 5. Wiring diagrams



## Reference designations

(in compliance with standard IEC 61346-2 and technical standard ABB 2NBA000001).

| Description | Figure number of the diagram |
|---|---|
| -BC | Current transformer |
| -BE | Auxiliary contacts of the earth switch (see note B) |
| -BT4 | Contacts on switchgear for signalling trolley in racked-in position (see note C) |
| -BT5 | Contacts on switchgear for signalling trolley in isolated position (see note C) |
| -BW1 | Front fan position contact |
| -BW2 | Rear fan position contact |
| -CC1 | Capacitor for front fan |
| -CC2 | Capacitor for rear fan |
| -KA3 | Current metering relay |
| -KA4 | Auxiliary contact for front fan operation |
| -KA5 | Auxiliary contact for rear fan operation |
| -KT1, -KT2 | Timed auxiliary relays for forced front fan operation |
| -KT3, -KT4 | Timed auxiliary relays for forced rear fan operation |
| -KT5 | Timed auxiliary relay for forced front ventilation failure alarm signal |
| -KT6 | Timed auxiliary relay for forced rear ventilation failure alarm signal |
| -MV1 | Front fan (see note E) |
| -MV2 | Rear fan (see note E) |
| -PA | Ammeter |
| -PR1 | Red lamp for forced front ventilation failure alarm signal |
| -PR2 | Red lamp for forced rear ventilation failure alarm signal |
| -PT1 | White lamp for forced front ventilation operation alarm signal |
| -PT2 | White lamp for forced rear ventilation operation alarm signal |
| -RL3 | Electromechanical lock on earth switch closing operation |
| -RL4 | Locking magnet. Mechanically inhibits door opening if de-energized |
| -SL | Contact for locking earth switch operation |
| -SU3 | Delay button for enabling earth switch operation (maximum permissible delay 1 minute) |
| -SU3 | Door release button |
| -XF1 | Connector for disconnecting the forced front ventilation circuits |
| -XF2 | Connector for the forced rear ventilation circuits |
| -XF3 | Connector for the forced front ventilation circuits |

| Figure | Description |
|---|---|
| Fig. 1 | Electrical signalling contacts for switch in plugged-in position (see note C) |
| Fig. 3 | Electrical signalling contacts for switch in isolated position (see note C) |
| Fig. 20 | Circuit of electromechanical lock on earth switch closing operation: the operation is only permitted with coil -RL3 energized |
| Fig. 21 | First pack of auxiliary contacts of the earth switch (see note B) |
| Fig. 22 | Second pack of auxiliary contacts of the earth switch (see note B) |
| Fig. 23 | Circuit of electromechanical door opening lock: opening is only permitted with coil -RL3 energized |
| Fig. 41 | Forced front ventilation circuit |
| Fig. 43 | Forced front and rear ventilation circuit |

**Notes**

A) The switchgear comes solely equipped with the specific applications in the order confirmation

B) The auxiliary contacts -BE are supplied in the position indicated in the diagram. However, the user can easily convert them from make contacts to break contacts or vice versa.

C) Position contacts -BT4 and BT5 are switch contacts. This means that the make contact and the break contact belonging to the same position contact cannot be powered with different voltage values.

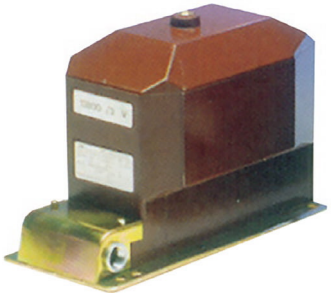
D) When fig. 23 is required, the contact -BT5 (terminals 51-52-53-54) of fig. 3 is not available
Symbols (in compliance with Standards IEC 60617 and CEI EN 60617)

E) The fans must activate when at least one phase exceeds the following thresholds for 60 seconds:
- UniSafe 12-17.5 kV 3600 A = 3000 A (front fan)
- UniSafe 12-17.5 kV 4000 A = 3000 A (front fan) and 3600 A (rear fan)
- UniSafe 24 kV 2500 A = 2250 A (front fan).

The fans must disconnect when the current of all three phases is lower than the following values for 300 seconds:
- UniSafe 12-17.5 kV 3600 A = 2900 A (front fan)
- UniSafe 12-17.5 kV 4000 A = 2900 A (front fan) and 3500 A (rear fan)
- UniSafe 24 kV 2500 A = 2150 A (front fan).

# 6. Switchgear completion

## Voltage transformers



The voltage transformers are insulated in resin and are used for powering measuring devices and protections. They are available for fixed assembly or for istallation on withdrawable trolleys.
They conform to standard IEC 60044-2.
The dimensions normally comply with Standard DIN 42600,
while the transformers designed for installation on withdrawable trolleys are the dedicated type.
These transformers can have one or two poles and possess performance and accuracy classes that suit the functional requirements of the instruments to which they are connected.
When they are installed on withdrawable trolleys, they are equipped with medium voltage protection fuses. The fuses can be replaced whilst the switchgear is in service.

## Current transformers



The current transformers are insulated in resin and are used for powering measuring devices and protections. These transformers can have a wound core or bushing bar with one or more cores and come with performance and accuracy classes that suit the requirements of the installation.
They conform to standard IEC 60044-1.
The dimensions normally comply with standard DIN 42600.
The current transformers can also be supplied with a capacitive socket for connection to voltage signalling lamps.

## Measuring sensors (for applications with microprocessor protection units)

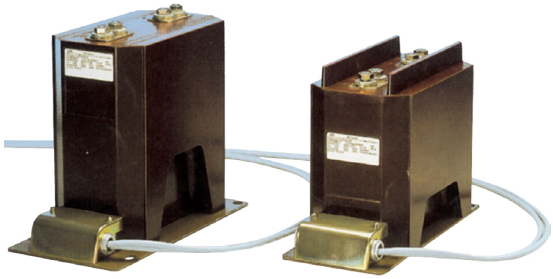


ABB KEDCD voltage-current combi-sensors

Use of digital technologies for electrical protection and measuring instruments has deeply modified the performance that transformers must provide.
The analog input levels of the instruments have become significantly lower than those of conventional systems.
This is why ABB has introduced a new range of sensors that meets the specifications of the new generation instruments in an optimal way.
The switchgear can be equipped with up to 24 kV ABB KEVCD Block Type sensors.
The current sensors comply with standards IEC 60044-8 (CDV), while the voltage sensors comply with standard IEC 60044-7.
The dimensions normally comply with standard DIN 42600 Narrow Type.
The resin casing can house current sensors and voltage sensors at the same time, or just the current sensor. A capacitive divider is also installed for connection to the voltage signalling lamps.
ABB multifunction units and measuring sensors comply with accuracy class CI.1.

# 6. Switchgear completion

## Current sensor

The current sensor consists of a Rogowski coil without ferromagnetic core, thus unaffected by saturation phenomena. If a core is formed by a uniform winding over a non-magnetic closed core with a constant section, the voltage indiced in the secondary circuit will be directly proportional to the variations in the let-through current. This voltage must be integrated in order to obtain a signal proportional to the current provided. The multifunction devices accomplish this function and use the signal obtained for both the measurements and protections.

**Main features of the current sensors**

- Linear response over the entire measuring range;
- no saturation;
- no hysteresis;
- one single instrument for both protections and measurements;
- high accuracy class;
- high degree of immunity to electromagnetic disturbances;
- the output signal is a voltage (150 mV) proportional to the current variation over time. The current measurement is obtained by integrating the signal;
- two single coils cover the range from 0 to 3200 rated A;
- the winding can remain open even when the switchgear is under service conditions.



Scan o Tap on QR code to visit ABB instrument transformers and sensors website

## Voltage sensor

The voltage sensor consists of a resistive divider through which the signal is taken. This sensor is also the non-saturable type and gives a linear response for the entire measuring range.
The output signal is a voltage directly proportional to the primary voltage. The resistive element consists of a bar of ceramic material. Voltage sensors are used at the same time to make measurements and energize the protections.

**Main features of the voltage sensors**

- Linear response over the entire measuring range;
- no saturation;
- no ferroresonance;
- one single instrument for both protections and measurements;
- high accuracy class;
- high degree of immunity to electromagnetic disturbances;
- the output signal is a voltage directly proportional to the primary voltage;
- the division ratio is 10000/1;
- one single divider covers the range from 0 to 24 rated kV.

# 6. Switchgear completion

## REF 601 switchgear protection device

ABB can also supply the following components to complete the switchgear.
Please consult ABB for further details.




Relay REF 601 is a device that protects against overcurrents, with tripping curves in compliance with standard IEC 255-3. It protects against overload (51), instantaneous and delayed short-circuits (50-51), instantaneous and delayed homopolar earth faults (50N and 51N). It also detects the magnetizing current of a threephase transformer to prevent it from tripping in an untimely way when a transformer switches in (68). elay REF 601 must be energized in order to function.
The REF 601 relay can operate with up to 3 inputs from current sensors of the Rogowsky coil type and an input from an external toroidal current transformer. 4 rated current values can be entered via the keyboard: 40, 80, 250, 1250 A.
If the circuit-breaker is equipped with 3 current sensors, the 50N and 51N protection functions are accomplished with the vector sum of the phase currents. On the other hand, the external toroidal current transformer must be installed for the 50N and 51N functions if 2 current sensors are used. The external toroidal transformer can have either an openable or closed core and any transformer ratio, so long as there is 1 A secondary current.

Specific features of the REF 601 relay:
- Accurate interventions
- Wide setting ranges
- Single and contemporaneous adjustment of the three phases
- No limitation (due to the current sensors) to the rated breaking capacity or to the short-time withstand current of the circuit-breaker
- Local electric operating buttons
- 5 separate indicators: “relay operating”, “relay at tripping threshold”, “relay tripped”, “relay tripped due to phase over-current”, “relay tripped due to earth fault over-current”
- Interface consisting of an LCD display and by “arrow”, “enter” and “esc” keys for user-friendly browsing among the “measuring”, “data recording”, “event recording”, “settings”, “configuration” and “test” menus
- Three user levels: “Operator” (display only, free access), “configurator” (same as the previous level, but with the ability to enter the protection parameters and, if applicable, the communication parameters - access limited by a password), “administrator” (same as the previous level but with the ability to enter the passwords and configure the settings according to the device - access limited by a password)
- Continuous display of the current in the most loaded phase and the earth current
- Recording of the values of the currents that caused the device to trip
- Storage of the number of openings caused by the device
- Event recording (storage of the previously described parameters in the last 5 tripping actions of the device) in a non-volatile memory
- On request, version with RS485 serial link, 4 wires - MODBUS RTU full duplex protocol
- 24…240 V AC/DC multi-voltage feeder.

Relay REF 601 is also available in a specific version, in accordance with standard CEI 0-16 (for the Italian market), with reference to the point where MV energy is delivered to the distribution user.

## Relion® protection and control relays

The Relion® product family offers the widest range of products for the protection, control, measurement and supervision of power systems for IEC and ANSI applications – from generation and interconnected transmission grids over primary distribution to secondary distribution kiosks.

The Relion® protection relays are deeply rooted in ABB's vast experience of developing successful protection and control relays. These relays have been developed during many years and are built on the experience gathered from wide ranging application and functionality requirements of ABB's customers globally.
To ensure interoperable and future-proof solutions, Relion® products have been designed to implement the core values of the IEC 61850 standard.

The genuine implementation of the IEC 61850 substation modelling and communication standard covers both vertical and horizontal information exchange between protection relays and external systems.
The protection and control IED manager PCM600 provides versatile functionality throughout the life cycle of all Relion® protection and control relays. PCM600 is IEC 61850 compliant, which ensures smooth engineering of the relays and enables information exchange with other IEC 61850 compliant tools.
With these products, you benefit from ABB's leading-edge technology, global application knowledge and experienced support network.
The Relion technology is leading the way and setting the future trends in the field of protection and control systems.



Relion protection and control product family

Scan o Tap on QR code to visit ABB protection relay website

# 6. Switchgear completion

## Fuses

ABB CMF and CEF fuses can be supplied for use with the contactor, to protect lines, motors, capacitors, voltage transformers, etc.
The fuses shall be DIN standard.



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to visit ABB fuses website

## Surge arresters

**MWD**
Over-voltage protective device:
- Transformers
- Motors
- Cables
- Cable sheath.

Medium voltage switchgear:
- Alternating current applications (AC)
- For indoor use.

**Technical specifications**
Surge arrester against over-voltage with metal oxide resistor without stark-gap (MO surge arresters), enclosure in moulded silicone rubber, grey colour, designed and tested in accordance with standard IEC 60099-4.



More product information:
abb.com/mediumvoltage
Your contact center:
abb.com/contactcenters
More service information:
abb.com/service

Data and illustration are not binding. We reserve the right to make changes in the course of technical development.

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1VCP000091 – Rev. I, en – Technical catalogue – 2024.11

**Medium voltage products**

# PowerCube PB
# Installation and maintenance instructions

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Power and productivity
for a better world™

# For your safety!

- Make sure that the room is suitable for the installation of electrical apparatus.
- Make sure that all the installation, putting into service and maintenance operations are carried out by skilled personnel with in-depth knowledge of the apparatus.
- Make sure that all the installation, service and maintenance operations comply with standard and legal requirements for constructing the installations in accordance with the regulations for safety in the workplace.
- Strictly follow this instruction manual.
- Make sure that the ratings are not exceeded while the apparatus is in service.
- Pay the utmost attention to the notes shown in the manual by the following symbol:



- Make sure that the personnel working on the apparatus have this manual to hand and all the information required for correct intervention.



Responsible behaviour safeguards your own and others' safety!

For any requests, place contact the ABB Assistance Service.

# Introduction

The instructions in this manual refer to standardised PowerCube type medium voltage modules.
The instructions applicable to both the PowerCube PB/M modules and to the PowerCube PB/E enclosures will refer to these as PowerCube “Units”.
For correct use of the apparatus, please read the manual carefully.
PowerCube modules are designed for a large number of installation configurations.
However, they do allow further technical and constructional modifications to satisfy special installation requirements.
Consequently, the information given below may sometimes not contain instructions concerning special configurations requested by the customer.
Apart from to the manual, it is therefore always necessary to consult the latest technical documentation (circuit and wiring diagrams, foundation plans, any protection coordination studies, etc.), especially regarding any variants requested in relation to the standardised configurations.
For maintenance use only original spare parts. For any further information, refer to Technical Catalogue 1VCP000091.
For instructions regarding the apparatus (circuit-breakers, contactors …), refer to the relative instruction booklets.

# 1. Packing and transport

**Follow the symbols and instructions shown on the packing carefully**

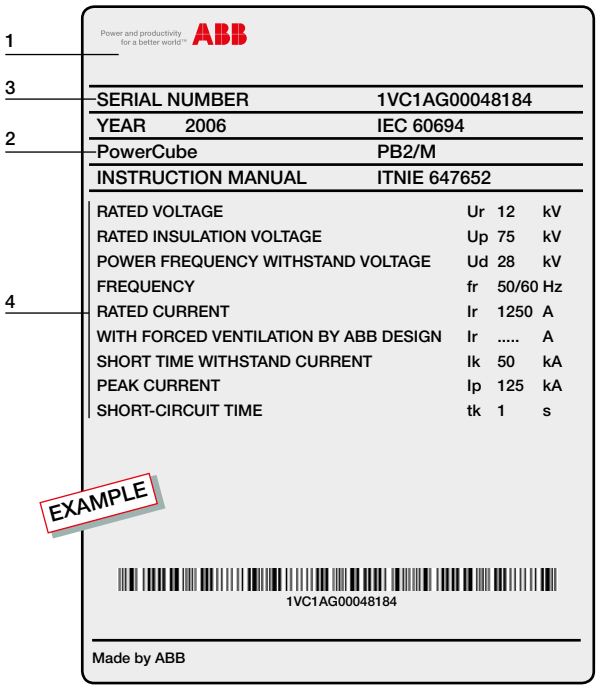
The PowerCube modules are shipped complete with trucks (voltage transformers) inserted in the relative compartments, except where otherwise agree with
the customer.
Each module is packed according to the shipping and storage requirements of the customer.
Each module is protected by a plastic cover to prevent any water entering during the loading and unloading stages and to keep it free of dust during storage.
The vehicle to be used to transport must have a loading platform not higher than 1.5 m from the ground so as to come within the maximum height of 4 metres. The loading platform must be slip-proof with a high friction coefficient.
The modules must be placed on the transport vehicle platform back-to-back and transversely, placing materials between them suitable for absorbing any compression and to avoid any direct contact between the surfaces of the various groups.
Special longitudinal members must be placed on the platform to space each module and prevent it moving either longitudinally or transversely.
The modules must be anchored to the structure of the vehicle with ropes, so that there is not deformation and to prevent tilting on bends or in the case of sudden stops.
The transport vehicle must also have a tarpaulin cover over the whole load.
The resting points of the lifting means must have a specific capacity to ensure proper weight distribution.
To unload the modules, there must be an area at the same level and with dimensions not less than 3 x 2 m in front of the access to the warehouse or switchboard room.
See paragraph 4 for handling.
Small differences in level can be compensated with temporary structures made using wooden boards.
Unloading must be carried out with the utmost care using suitable lifting equipment.
Special attention must be paid and the specific risks analysed for working in areas with live overhead lines.

# 2. Control on receipt

- **While handling the unit do not put stress on the insulating parts.**
- **Before performing any operation make sure that the operating device springs are discharged and the apparatus is in the open position.**

On receipt, immediately check the packing and the state of the apparatus.
Open the packing as shown in para. 4., taking care not to damage its materials. Check that no damage has occurred during transport and make sure that the nameplate data (fig. 1) corresponds to what is specified in the ABB order acknowledgement and in the shipping note.
Should any damage or irregularity be found in the supply, immediately notify ABB (directly, through the agent or the supplier) and the carrier who delivered the goods.
Notification of any irregularity, even after receipt, must indicate the module serial number shown on the nameplate located on the module itself.
The modules are only supplied complete with the accessories specified at the time of ordering and confirmed in the order acknowledgement sent by ABB.
The documents enclosed in the shipping packing are:
– adhesive labels showing the addressee and product type;
– this instruction manual;
– the test report;
– the electrical diagram.

## 2.1. Nameplate data




Caption
1 Trade mark
2 Enclosure type
3 Serial number
4 Electrical characteristics
5 Standards

**Fig. 1**

# 3. Storage

- **Please contact ABB in case of special storage conditions.**
- **If the gas pressure of the circuit-breaker (due to the altitude) has been reduced for shipping purposes, the nominal value the SF6 level must be restored (see para. 12.2.2) with SF6 gas in compliance with CEI 10-7 and IEC 60376 Standards.**
- **Gas recovery must be carried out either by our personnel or suitably qualified customer personnel with in-depth knowledge of the apparatus.**

If the apparatus has to be stored before installation, on request suitable packing for the conditions specified can be provided.
On receipt, the module must be unpacked and checked as described in “Control on receipt” (chapter 2), and then put back in the packing again using the original materials.
PowerCube modules must be stored in a dry, dust-free, non-corrosive place, at a temperature ranging from – 5 °C to + 45 °C without significant changes. If this is not possible, store the modules in a well-ventilated room, cover them with tarpaulins or waterproof sheets (e.g.: polyethylene) and supply the anti-condensation heaters to prevent any condensation.
The package contains dehydrating bags that must be replaced every six months.
For special requirements, please contact us.

# 4. Handling

## 4.1. Modules/enclosures

Each unit is usually fixed onto a wooden platform.
Handling should preferably be carried out by means of bridge or mobile cranes. Otherwise, use rollers or fork lift trucks.
Weights and dimensions of the various sections are indicated in the shipping documents and on the plant drawings.

### 4.1.1. Handling

**To handle the modules containing the apparatus (circuit-breaker, contactor or service truck), it is compulsory to use the proper lifting eyebolts.**

#### 4.1.1.1. Handling with bridge or mobile crane and unpacking

**Handling the wood packing**

Lifting by means of a crane must be carried out using the circular slings (1) (fig. 2).
The slings must be inserted according to the lifting symbols marked on the crate.
Weight and lifting opening angle must be taken into account when choosing the circular slings.

**Unpacking**

- Remove the nails and crate lid and sides;
- open the door of the units and loosen the screws fixing the module to the pallet (if present);
- lift the module by means of the crane following the instructions below;
- slide the pallet out from under the unit;
- position the unloading shims;
- lower the unit onto the shims using the crane.

**Only use a suitable balance lifting system of the type shown in the picture.**

After unpacking it, lift the unit by means of a crane, using the special eyebolts (1) (fig. 3) and the ropes fitted with safety spring catches, following this procedure:
- take hold of the lifting eyebolts by the handle (3);
- insert the hooking irons (5) in the slots (4) made on the side of the unit and marked with self-adhesive labels;
- push the lifting bolts against the module and make them slide upwards until the hooking irons (5) hit the top of the slot (4);
- fully tighten the positioning screw (6);
- hook the rope spring catches to the unit eyebolts and lift.

After installation, remove the eyebolts used for lifting by proceeding in reverse order.

**Handling the unit in the wooden crate**

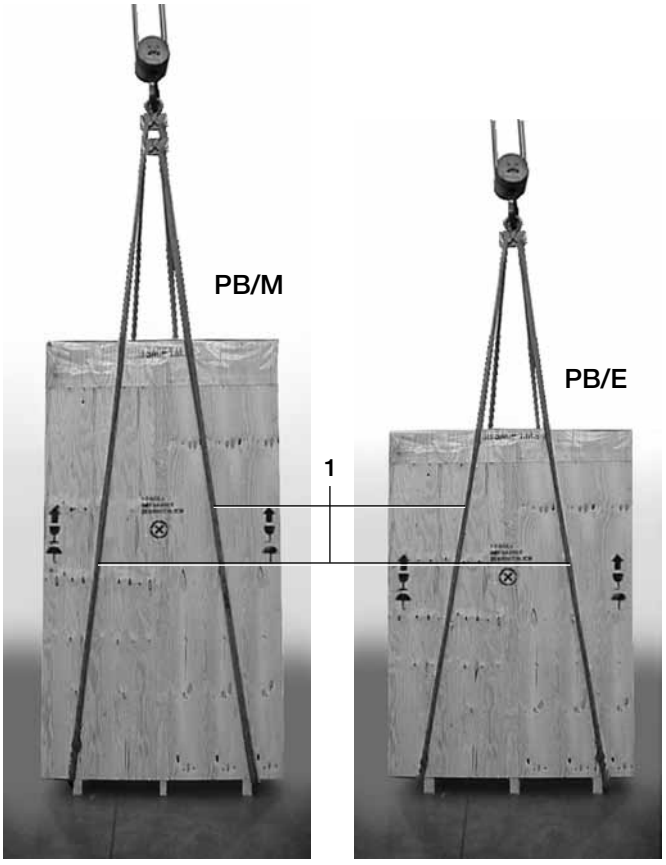



Fig. 2

**Module handling**

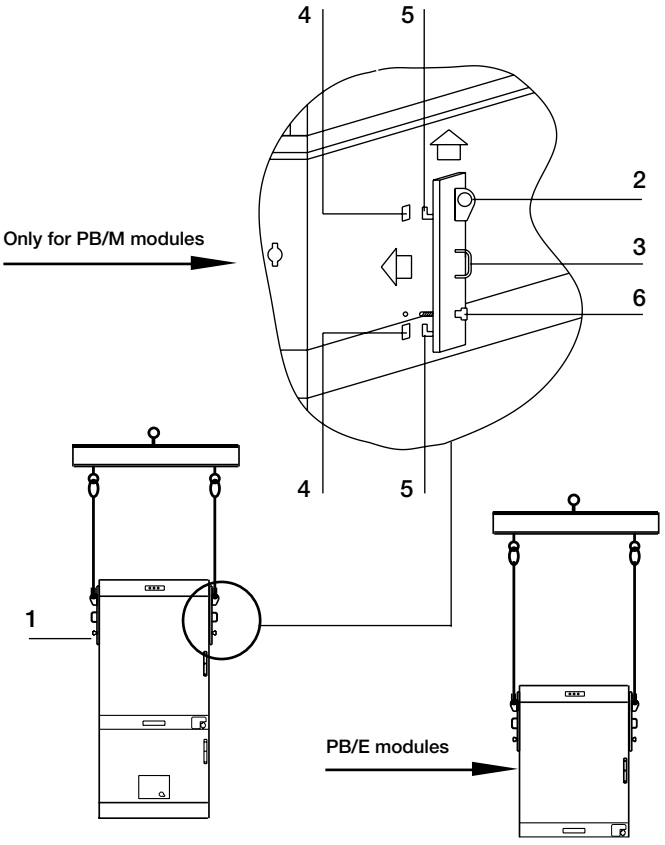



Fig. 3

#### 4.1.1.2. Handling by means of rollers

- **The floor on which the rollers slide must be completely level.**
- **Move the module, avoiding any bumps which might turn it over.**

Lift the unit by means of a bridge or mobile crane or using jacks (fig. 3).
Remove the wooden pallet, loosening the screws fixing it to the switchboard section base.
Put a sturdy metal sheet between the rollers and the base of the units and place the unit on the sliding rollers (fig. 4).

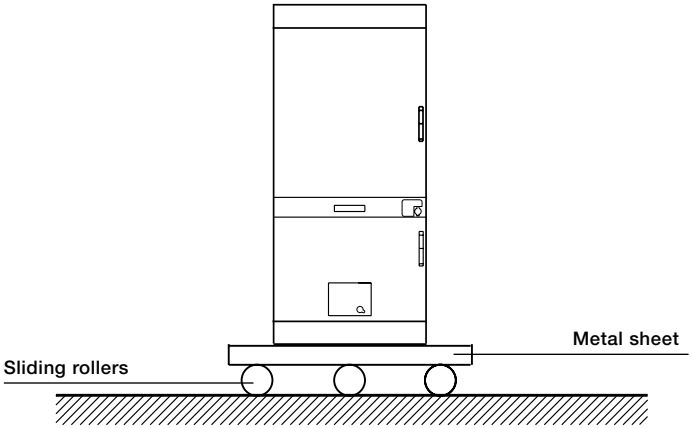



**Fig. 4**

#### 4.1.1.3. Handling by means of transpallets or fork lift trucks

- **The floor on which the transpallets or fork lift trucks run must be completely**
- **Move the unit, avoiding any bumps which might turn it over.**

For greater stability, only lift the unit enough to allow handling.
Also check levelness of the forks.

**Lifting a unit packed in a wooden crate.**



## 4.2. Apparatus

The apparatus can be handled by means of cranes, fork lift trucks or using the special truck provided by ABB.
For each apparatus follow the instructions given in the relative booklet.

**Unit handling.**

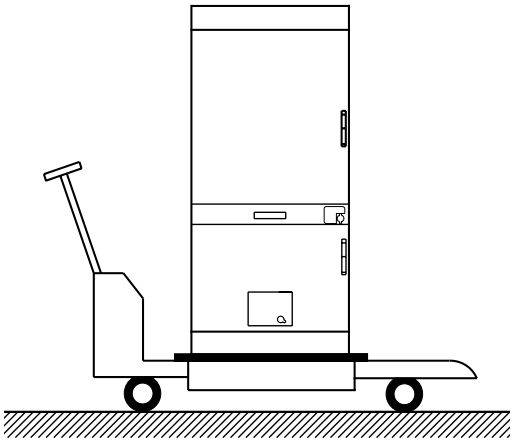


**Fig. 5**

# 5. Description

## 5.1. Unit construction features

The PowerCube units allow MV metal-clad switchboards with metal enclosure to be built, suitable for indoor installation.
The PowerCube units are pre-assembled and tested in the factory.
The PowerCube units are suitable for all primary distribution requirements with service voltages up to 24 kV and can take on different configurations according to customer requests.
For the instructions regarding the apparatus please refer to the relative manuals.
All normal service operations are carried out from the front of the unit with the doors closed. The doors on the front only need to be opened for maintenance operations and replacement of spare parts.

The circuit-breaker unit can be fitted with withdrawable circuit-breakers or contactors.
The switchgears built up with Power Cube units can be installed against walls since they are fully accessible from the front for the operations, maintenance and installation operations.
The PowerCube units allow arc-proof switchboards to be constructed in compliance with the prescriptions of the IEC 62271 - App. AA Standards, class of access (A) criteria (1 - 5).

The PowerCube units are designed with the following degrees of protection:

| | |
|---|---|
| Degree of protection with doors open | IP2X |
| Degree of protection on the external enclosure | IP4X |

Each unit (fig. 6) is divided internally into a circuit-breaker compartment and a feeder compartment.

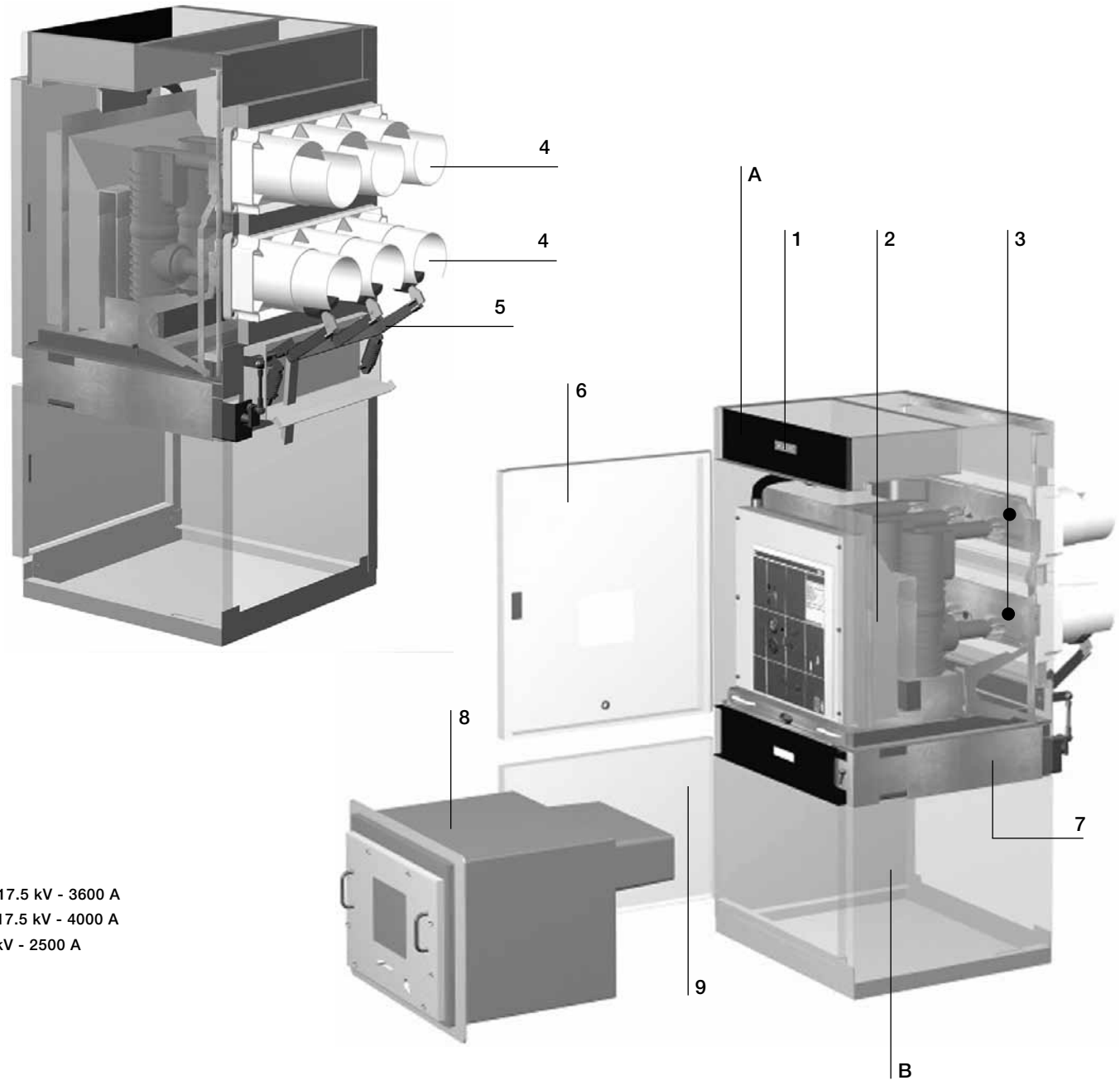
**A Circuit-breaker compartment**

1 Voltage signalling device (on request for PB/M only)
2 Circuit-breaker/contactor
3 Shutters
4 Lower and upper monoblocks
5 Earthing switch (on request)
6 Door
7 Fan (*)

**B Feeder compartment (PB/M-PB/RM)**

8 VT compartment on request (non available PB1/M - PB1/RM)
9 Door.

**Standard cross-section**

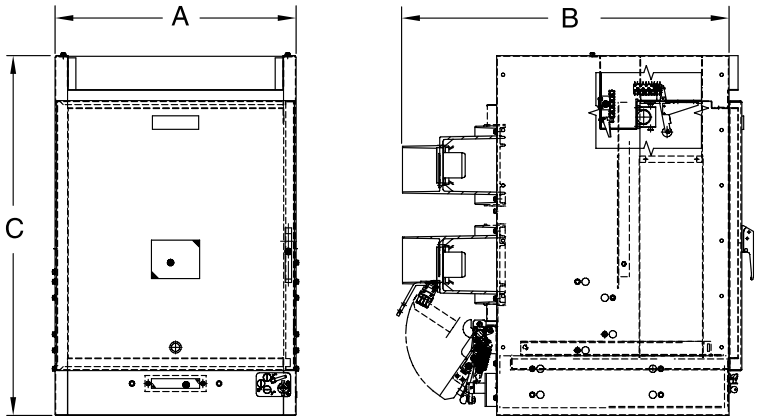



**(*)12/17.5 kV - 3600 A**
**12/17.5 kV - 4000 A**
**24 kV - 2500 A**

**Fig. 6**

# 5.2. Dimensions and weights

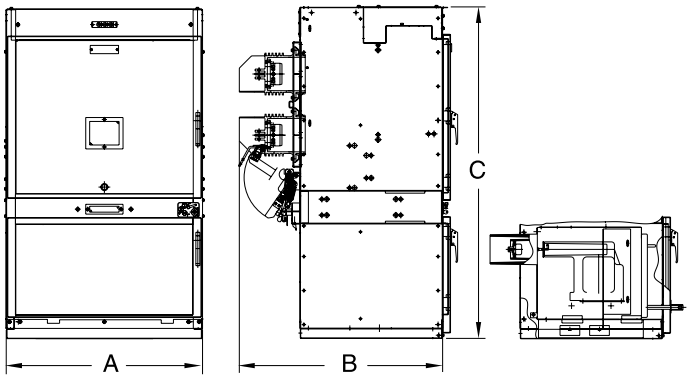
## PB/E



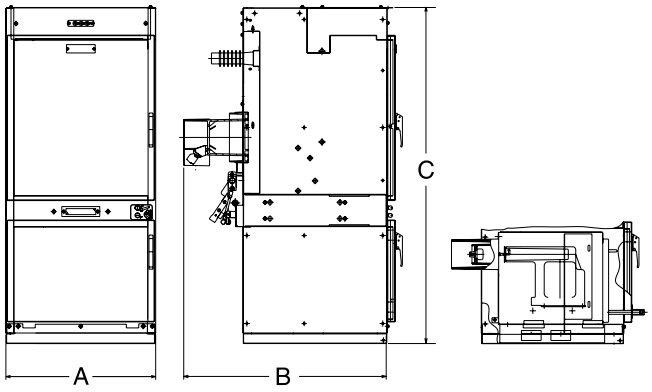

| Unit | Rated voltage [kV] | Rated current [A] | Isc Icw [kV] | Table of dimensions | A [mm] | B [mm] | C [mm] | Weight [kg] (1) |
|---|---|---|---|---|---|---|---|---|
| PB1/E | 12 | 630 - 1250 | 31.5 | 1VCD003369 | 600 | 1016 | 1120 | 180 |
| | 17.5 | 630 - 1250 | 31.5 | 1VCD003369 | 600 | 1016 | 1120 | |
| PB2/E | 12 | 630...2000 | 31.5 | 1VCD003370 | 750 | 1016 | 1120 | 200...240 |
| | 12 | 1250...2000 | 40-50 | 1VCD003370 | 750 | 1016 | 1120 | |
| | 17,5 | 630...2000 | 31.5 | 1VCD003370 | 750 | 1016 | 1120 | |
| | 17.5 | 1250...2000 | 40-50 | 1VCD003370 | 750 | 1016 | 1120 | |
| PB3/E | 12-17.5 | 2500 | 31.5 | 1VCD003371 | 1000 | 1030 | 1120 | 300 |
| | 12-17.5 | 3150 | 31.5 | 1VCD003372 | 1000 | 1030 | 1120 | 320 |
| | 12-17.5 | 3600...4000 | 31.5 | 1VCD003373 | 1000 | 1030 | 1120 | 350...380 |
| | 12-17.5 | 2500 | 40-50 | 1VCD003371 | 1000 | 1030 | 1120 | 300 |
| | 12-17.5 | 3150 | 40-50 | 1VCD003372 | 1000 | 1030 | 1120 | 320 |
| | 12-17.5 | 3600 - 4000 | 40-50 | 1VCD003373 | 1000 | 1030 | 1120 | 350...380 |
| PB4/E | 24 | 630 - 1250 | 31.5 | 1VCD003374 | 750 | 1246 | 1230 | 250 |
| PB5/E | 24 | 1600 - 2000 | 31.5 | 1VCD003376 | 1000 | 1246 | 1230 | 310 |
| | 24 | 2500 | 31.5 | 1VCD003376 | 1000 | 1246 | 1230 | 340 |
| PB1/RE | 17.5 | NOT APPLICABLE | 31.5 | 1VCD003377 | 600 | 1016 (2) | 1120 | 165 |
| PB2/RE | 17.5 | | 31.5 | 1VCD003378 | 750 | 1016 (2) | 1120 | 165...215 |
| | 17.5 | | 40-50 | 1VCD003378 | 750 | 1016 (2) | 1120 | 165...215 |
| PB3/RE | 12-17.5 | | 31.5 | 1VCD003379 | 1000 | 1030 (2) | 1120 | 270 |
| | 12-17.5 | | 40-50 | 1VCD003379 | 1000 | 1030 (2) | 1120 | 270 |
| PB4/RE | 24 | | 31.5 | 1VCD003380 | 750 | 1310 (2) | 1230 | 215 |
| PB5/RE | 24 | | 31.5 | 1VCD003381 | 1000 | 1246 (2) | 1230 | 250 |

(1) Weight without earthing switch.
(2) Dimension with earthing switch.

## PB/M




## PR/M




| Unit | Rated voltage [kV] | Rated current [A] | Isc Icw [kV] | Table of dimensions | A [mm] | B [mm] | C [mm] | Weight [kg] (1) |
|---|---|---|---|---|---|---|---|---|
| PB1/M | 12 | 630 - 1250 | 31.5 | 1VCD000023 | 600 | 1016 | 1680 | |
| | 17.5 | 630 - 1250 | 31.5 | 1VCD000028 | 600 | 1016 | 1680 | 200 |
| PB2/M | 12 | 630...2000 | 31.5 | 1VCD000024 | 750 | 1016 | 1680 | |
| | 12 | 1250...2000 | 40-50 | 1VCD000027 | 750 | 1016 | 1680 | |
| | 17.5 | 630...2000 | 31.5 | 1VCD000029 | 750 | 1016 | 1680 | 220...260 |
| | 17.5 | 1250...2000 | 40-50 | 1VCD000030 | 750 | 1016 | 1680 | |
| PB3/M | 12-17.5 | 2500 | 31.5 | 1VCD000025 | 1000 | 1030 | 1680 | 320 |
| | 12-17.5 | 3150 | 31.5 | 1VCD000026 | 1000 | 1030 | 1680 | 344 |
| | 12-17.5 | 3600...4000 | 31.5 | 1VCD000043 | 1000 | 1030 | 1680 | 370...400 |
| | 12-17.5 | 2500 | 40-50 | 1VCD000037 | 1000 | 1030 | 1680 | 320 |
| | 12-17.5 | 3150 | 40-50 | 1VCD000038 | 1000 | 1030 | 1680 | 344 |
| | 12-17.5 | 3600 - 4000 | 40-50 | 1VCD000039 | 1000 | 1030 | 1680 | 370...400 |
| PB4/M | 24 | 630 - 1250 | 31.5 | 1VCD000031 | 750 | 1310 | 1745 | 270 |
| PB5/M | 24 | 1600 - 2000 | 31.5 | 1VCD000032 | 1000 | 1246 | 1745 | 330 |
| | 24 | 2500 | 31.5 | 1VCD000044 | 1000 | 1246 | 1745 | 360 |

| Unit | Rated voltage [kV] | Rated current [A] | Isc Icw [kV] | Table of dimensions | A [mm] | B [mm] | C [mm] | Weight [kg] (1) |
|---|---|---|---|---|---|---|---|---|
| PB1/RM | 17.5 | NOT APPLICABLE | 31.5 | 1VCD000033 | 600 | 1016 | 1745 | 185 |
| PB2/RM | 12 | | 31.5 | 1VCD000034 | 750 | 1016 | 1745 | 185...235 |
| | 17,5 | | 40-50 | 1VCD000040 | 750 | 1016 | 1745 | 185...235 |
| PB3/RM | 12-17.5 | | 31.5 | 1VCD000041 | 1000 | 1030 | 1680 | 290 |
| | 12-17.5 | | 40-50 | 1VCD000042 | 1000 | 1030 | 1680 | 290 |
| PB4/RM | 24 | | 31.5 | 1VCD000035 | 750 | 1310 | 1745 | 270 |
| PB5/RM | 24 | | 31.5 | 1VCD000036 | 1000 | 1246 | 1745 | 270 |

(1) Weight without earthing switch and without VT compartment.
(2) Dimension with earthing switch.

# 5.3. Possibility of combining PowerCube units with ABB apparatus

**Table 1 - VD4 withdrawable circuit-breakers for PowerCube type PB units (*)**
**Rated current of the VD4 circuit-breakers (A - 40 °C)**



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12-17.5 | 16 | 16 | 630 | | | | | | VD4/P 12.06.16 p150 | VD4/P 17.06.16 p150 | PB 1/E PB 1/M |
| | 20 | 20 | 630 | | | | | | VD4/P 12.06.20 p150 | VD4/P 17.06.20 p150 | |
| | 25 | 25 | 630 | | | | | | VD4/P 12.06.25 p150 | VD4/P 17.06.25 p150 | |
| | 31.5 | 31.5 | 630 | | | | | | VD4/P 12.06.32 p150 | VD4/P 17.06.32 p150 | |
| | 16 | 16 | 1250 | | | | | | VD4/P 12.12.16 p150 | VD4/P 17.12.16 p150 | |
| | 20 | 20 | 1250 | | | | | | VD4/P 12.12.20 p150 | VD4/P 17.12.20 p150 | |
| | 25 | 25 | 1250 | | | | | | VD4/P 12.12.25 p150 | VD4/P 17.12.25 p150 | |
| | 31.5 | 31.5 | 1250 | | | | | | VD4/P 12.12.32 p150 | VD4/P 17.12.32 p150 | |
| | 16 | 16 | | 630 | | | | | VD4/W 12.06.16 p210 | VD4/W 17.06.16 p210 | PB 2/E PB 2/M |
| | 20 | 20 | | 630 | | | | | VD4/W 12.06.20 p210 | VD4/W 17.06.20 p210 | |
| | 25 | 25 | | 630 | | | | | VD4/W 12.06.25 p210 | VD4/W 17.06.25 p210 | |
| | 31.5 | 31.5 | | 630 | | | | | VD4/W 12.06.32 p210 | VD4/W 17.06.32 p210 | |
| | 16 | 16 | | 1250 | | | | | VD4/W 12.12.16 p210 | VD4/W 17.12.16 p210 | |
| | 20 | 20 | | 1250 | | | | | VD4/W 12.12.20 p210 | VD4/W 17.12.20 p210 | |
| | 25 | 25 | | 1250 | | | | | VD4/W 12.12.25 p210 | VD4/W 17.12.25 p210 | |
| | 31.5 | 31.5 | | 1250 | | | | | VD4/W 12.12.32 p210 | VD4/W 17.12.32 p210 | |
| | 40 | 40 | | 1250 | | | | | – | – | |
| | 50 | 50 | | 1250 | | | | | – | – | |
| | 40 | 40 | | | 1250 | | | | VD4/P 12.12.40 p210 (3) | VD4/P 17.12.40 p210 (3) | |
| | 50 | 50 | | | 1250 | | | | VD4/P 12.12.50 p210 (3) | VD4/P 17.12.50 p210 (3) | |
| | 20 | 20 | | | 1600 | | | | VD4/P 12.16.20 p210 | VD4/P 17.16.20 p210 | |
| | 25 | 25 | | | 1600 | | | | VD4/P 12.16.25 p210 | VD4/P 17.16.25 p210 | |
| | 31.5 | 31.5 | | | 1600 | | | | VD4/P 12.16.32 p210 | VD4/P 17.16.32 p210 | |
| | 40 | 40 | | | 1600 | | | | VD4/P 12.16.40 p210 (3) | VD4/P 17.16.40 p210 (3) | |
| | 50 | 50 | | | 1600 | | | | VD4/P 12.16.50 p210 (3) | VD4/P 17.16.50 p210 (3) | |
| | 20 | 20 | | | 2000 | | | | VD4/P 12.20.20 p210 | VD4/P 17.20.20 p210 | |
| | 25 | 25 | | | 2000 | | | | VD4/P 12.20.25 p210 | VD4/P 17.20.25 p210 | |
| | 31.5 | 31.5 | | | 2000 | | | | VD4/P 12.20.32 p210 | VD4/P 17.20.32 p210 | |
| | 40 | 40 | | | 2000 | | | | VD4/P 12.20.40 p210 (3) | VD4/P 17.20.40 p210 (3) | |
| | 50 | 50 | | | 2000 | | | | VD4/P 12.20.50 p210 (3) | VD4/P 17.20.50 p210 (3) | |
| | 20 | 20 | | | | 2500 | | | VD4/P 12.25.20 p275 | VD4/P 17.25.20 p275 | PB 3/E PB 3/M |
| | 25 | 25 | | | | 2500 | | | VD4/P 12.25.25 p275 | VD4/P 17.25.25 p275 | |
| | 31.5 | 31.5 | | | | 2500 | | | VD4/P 12.25.32 p275 | VD4/P 17.25.32 p275 | |
| | 40 | 40 | | | | 2500 | | | VD4/P 12.25.40 p275 (3) | VD4/P 17.25.40 p275 (3) | |
| | 50 | 50 | | | | 2500 | | | VD4/P 12.25.50 p275 (3) | VD4/P 17.25.50 p275 (3) | |
| | 31.5 | 31.5 | | | | 3150 | | | VD4/P 12.32.32 p275 (3) | VD4/P 17.32.32 p275 (3) | |
| | 40 | 40 | | | | 3150 | | | VD4/W 12.32.40 p275 (3) | VD4/W 17.32.40 p275 (3) | |
| | 50 | 50 | | | | 3150 | | | VD4/P 12.32.50 p275 (3) | VD4/P 17.32.50 p275 (3) | |
| | 31.5 | 31.5 | | | | 3600 (1) | | | VD4/P 12.32.32 p275 (3) | VD4/P 17.32.32 p275 (3) | |
| | 40 | 40 | | | | 3600 (1) | | | VD4/W 12.32.40 p275 (3) | VD4/W 17.32.40 p275 (3) | |
| | 50 | 50 | | | | 3600 (1) | | | VD4/P 12.32.50 p275 (3) | VD4/P 17.32.50 p275 (3) | |
| | 31.5 | 31.5 | | | | 4000 (1) | | | VD4/P 12.32.32 p275 (3) | VD4/P 17.32.32 p275 (3) | |
| | 40 | 40 | | | | 4000 (1) | | | VD4/W 12.32.40 p275 (3) | VD4/W 17.32.40 p275 (3) | |
| | 50 | 50 | | | | 4000 (1) | | | VD4/P 12.32.50 p275 (3) | VD4/P 17.32.50 p275 (3) | |



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 16 | | | | | 630 | | VD4/P 24.06.16 p210 | – | |
| | 20 | 20 | | | | | 630 | | VD4/P 24.06.20 p210 | – | |
| | 25 | 25 | | | | | 630 | | VD4/P 24.06.25 p210 | – | PB 4/E |
| | 16 | 16 | | | | | 1250 | | VD4/P 24.12.16 p210 | – | PB 4/M |
| | 20 | 20 | | | | | 1250 | | VD4/P 24.12.20 p210 | – | |
| | 25 | 25 | | | | | 1250 | | VD4/P 24.12.25 p210 | – | |
| | 16 | 16 | | | | | | 1600 | VD4/P 24.16.16 p275 | – | |
| 24 | 20 | 20 | | | | | | 1600 | VD4/P 24.16.20 p275 | – | |
| | 25 | 25 | | | | | | 1600 | VD4/P 24.16.25 p275 | – | |
| | 16 | 16 | | | | | | 2000 | VD4/P 24.20.16 p275 | – | |
| | 20 | 20 | | | | | | 2000 | VD4/P 24.20.20 p275 | – | PB 5/E |
| | 25 | 25 | | | | | | 2000 | VD4/P 24.20.25 p275 | – | PB 5/M |
| | 16 | 16 | | | | | | 2500 (2) | VD4/P 24.25.16 p275 | – | |
| | 20 | 20 | | | | | | 2500 (2) | VD4/P 24.25.20 p275 | – | |
| | 25 | 25 | | | | | | 2500 (2) | VD4/P 24.25.25 p275 | – | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monbloc.
(*) The PowerCube units are not prepared for application of the “motorised truck” for VD4 circuit-breakers
(1) 3600 A with fan pre-installed in the PB3 units. For 4000 A it is necessary to install another fan in the back of the switchgear (by the customer).
(2) 2500 A with fan pre-installed in the PB5 units.
(3) Please ask ABB for availability.

## Table 2 - Withdrawable HD4 circuit-breakers for PowerCube type PB units

### Rated current of the HD4 circuit-breakers (A - 40 °C)



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12-17.5 | 16 | 16 | 630 | | | | | | HD4/W 12.06.16 p150 | HD4/W 17.06.16 p150 | PB 1/E PB 1/M |
| | 25 | 25 | 630 | | | | | | HD4/W 12.06.25 p150 | HD4/W 17.06.25 p150 | |
| | 31.5 | 31.5 | 630 | | | | | | HD4/W 12.06.32 p150 | HD4/W 17.06.32 p150 | |
| | 16 | 16 | 1250 | | | | | | HD4/W 12.12.16 p150 | HD4/W 17.12.16 p150 | |
| | 25 | 25 | 1250 | | | | | | HD4/W 12.12.25 p150 | HD4/W 17.12.25 p150 | |
| | 31.5 | 31.5 | 1250 | | | | | | HD4/W 12.12.32 p150 | HD4/W 17.12.32 p150 | |
| | 16 | 16 | | 630 | | | | | HD4/W 12.06.16 p210 | HD4/W 17.06.16 p210 | PB 2/E PB 2/M |
| | 25 | 25 | | 630 | | | | | HD4/W 12.06.25 p210 | HD4/W 17.06.25 p210 | |
| | 31.5 | 31.5 | | 630 | | | | | HD4/W 12.06.32 p210 | HD4/W 17.06.32 p210 | |
| | 16 | 16 | | 1250 | | | | | HD4/W 12.12.16 p210 | HD4/W 17.12.16 p210 | |
| | 25 | 25 | | 1250 | | | | | HD4/W 12.12.25 p210 | HD4/W 17.12.25 p210 | |
| | 31.5 | 31.5 | | 1250 | | | | | HD4/W 12.12.32 p210 | HD4/W 17.12.32 p210 | |
| | 40 | 40 | | 1250 | | | | | HD4/W 12.12.40 p210 | HD4/W 17.12.40 p210 | |
| | 50 | 50 | | 1250 | | | | | HD4/W 12.12.50 p210 | HD4/W 17.12.50 p210 | |
| | 40 | 40 | | | 1250 | | | | – | – | |
| | 50 | 50 | | | 1250 | | | | – | – | |
| | 16 | 16 | | | 1600 | | | | HD4/W 12.16.16 p210 | HD4/W 17.16.16 p210 | |
| | 25 | 25 | | | 1600 | | | | HD4/W 12.16.25 p210 | HD4/W 17.16.25 p210 | |
| | 31.5 | 31.5 | | | 1600 | | | | HD4/W 12.16.32 p210 | HD4/W 17.16.32 p210 | |
| | 40 | 40 | | | 1600 | | | | HD4/P 12.16.40 p210 | HD4/P 17.16.40 p210 | |
| | 50 | 50 | | | 1600 | | | | HD4/P 12.16.50 p210 | HD4/P 17.16.50 p210 | |
| | 16 | 16 | | | 2000 | | | | HD4/W 12.20.16 p210 | HD4/W 17.20.16 p210 | |
| | 25 | 25 | | | 2000 | | | | HD4/W 12.20.25 p210 | HD4/W 17.20.25 p210 | |
| | 31.5 | 31.5 | | | 2000 | | | | HD4/W 12.20.32 p210 | HD4/W 17.20.32 p210 | |
| | 40 | 40 | | | 2000 | | | | HD4/P 12.20.40 p210 | HD4/P 17.20.40 p210 | |
| | 50 | 50 | | | 2000 | | | | HD4/P 12.20.50 p210 | HD4/P 17.20.50 p210 | |
| | 25 | 25 | | | | 2500 | | | HD4/P 12.25.25 p275 | HD4/P 17.25.25 p275 | PB 3/E PB 3/M |
| | 31.5 | 31.5 | | | | 2500 | | | HD4/P 12.25.32 p275 | HD4/P 17.25.32 p275 | |
| | 40 | 40 | | | | 2500 | | | HD4/P 12.25.40 p275 | HD4/P 17.25.40 p275 | |
| | 50 | 50 | | | | 2500 | | | HD4/P 12.25.50 p275 | HD4/P 17.25.50 p275 | |
| | 31.5 | 31.5 | | | | 3150 | | | HD4/W 12.32.32 p275 | HD4/W 17.32.32 p275 | |
| | 40 | 40 | | | | 3150 | | | HD4/W 12.32.40 p275 | HD4/W 17.32.40 p275 | |
| | 50 | 50 | | | | 3150 | | | HD4/W 12.32.50 p275 | HD4/W 17.32.50 p275 | |
| | 31.5 | 31.5 | | | | 3600 (1) | | | HD4/W 12.32.32 p275 | HD4/W 17.32.32 p275 | |
| | 40 | 40 | | | | 3600 (1) | | | HD4/W 12.32.40 p275 | HD4/W 17.32.40 p275 | |
| | 50 | 50 | | | | 3600 (1) | | | HD4/W 12.32.50 p275 | HD4/W 17.32.50 p275 | |
| | 31.5 | 31.5 | | | | 4000 (1) | | | HD4/W 12.32.32 p275 | HD4/W 17.32.32 p275 | |
| | 40 | 40 | | | | 4000 (1) | | | HD4/W 12.32.40 p275 | HD4/W 17.32.40 p275 | |
| | 50 | 50 | | | | 4000 (1) | | | HD4/W 12.32.50 p275 | HD4/W 17.32.50 p275 | |



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 16 | | | | | 630 | | HD4/W 24.06.16 p210 | – | |
| | 20 | 20 | | | | | 630 | | HD4/W 24.06.20 p210 | – | |
| | 25 | 25 | | | | | 630 | | HD4/W 24.06.25 p210 | – | |
| | 16 | 16 | | | | | 1250 | | HD4/W 24.12.16 p210 | – | PB 4/E PB 4/M |
| | 20 | 20 | | | | | 1250 | | HD4/W 24.12.20 p210 | – | |
| | 25 | 25 | | | | | 1250 | | HD4/W 24.12.25 p210 | – | |
| | 31.5 | 31.5 | | | | | 1250 (3) | | HD4/P 24.12.32 p275 | – | |
| | 16 | 16 | | | | | | 1600 | HD4/P 24.16.16 p275 | – | |
| | 20 | 20 | | | | | | 1600 | HD4/P 24.16.20 p275 | – | |
| 24 | 25 | 25 | | | | | | 1600 | HD4/P 24.16.25 p275 | – | |
| | 31.5 | 31.5 | | | | | | 1600 (3) | HD4/P 24.16.32 p275 | – | |
| | 16 | 16 | | | | | | 2000 | HD4/P 24.20.16 p275 | – | |
| | 20 | 20 | | | | | | 2000 | HD4/P 24.20.20 p275 | – | PB 5/E PB 5/M |
| | 25 | 25 | | | | | | 2000 | HD4/P 24.20.25 p275 | – | |
| | 31.5 | 31.5 | | | | | | 2000 (3) | HD4/P 24.20.32 p275 | – | |
| | 16 | 16 | | | | | | 2500 (2) | HD4/P 24.25.16 p275 | – | |
| | 20 | 20 | | | | | | 2500 (2) | HD4/P 24.25.20 p275 | – | |
| | 25 | 25 | | | | | | 2500 (2) | HD4/P 24.25.25 p275 | – | |
| | 31.5 | 31.5 | | | | | | 2500 (2)(3) | HD4/P 24.25.32 p275 | – | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monbloc.
(1) 3600 A with fan pre-installed in the PB3 modules. For 4000 A it is necessary to install another fan in the back of the switchgear (by the customer).
(2) 2500 A with fan pre-installed in the PB5 modules.
(3) Please ask ABB for availability. Not available for PB/M.

## Table 3 - Withdrawable VM1 circuit-breakers for PowerCube type PB units

### Rated current of the VM1 circuit-breakers (A - 40 °C)



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12-17.5 | 16 | 16 | 630 | | | | | | VM1/P 12.06.16 p150 | VM1/P 17.06.16 p150 | PB 1/E PB 1/M |
| | 20 | 20 | 630 | | | | | | VM1/P 12.06.20 p150 | VM1/P 17.06.20 p150 | |
| | 25 | 25 | 630 | | | | | | VM1/P 12.06.25 p150 | VM1/P 17.06.25 p150 | |
| | 31.5 | 31.5 | 630 | | | | | | VM1/P 12.06.32 p150 | VM1/P 17.06.32 p150 | |
| | 16 | 16 | 1250 | | | | | | VM1/P 12.12.16 p150 | VM1/P 17.12.16 p150 | |
| | 20 | 20 | 1250 | | | | | | VM1/P 12.12.20 p150 | VM1/P 17.12.20 p150 | |
| | 25 | 25 | 1250 | | | | | | VM1/P 12.12.25 p150 | VM1/P 17.12.25 p150 | |
| | 31.5 | 31.5 | 1250 | | | | | | VM1/P 12.12.32 p150 | VM1/P 17.12.32 p150 | |
| | 16 | 16 | | 630 | | | | | VM1/W 12.06.16 p210 | VM1/W 17.06.16 p210 | PB 2/E PB 2/M |
| | 20 | 20 | | 630 | | | | | VM1/W 12.06.20 p210 | VM1/W 17.06.20 p210 | |
| | 25 | 25 | | 630 | | | | | VM1/W 12.06.25 p210 | VM1/W 17.06.25 p210 | |
| | 31.5 | 31.5 | | 630 | | | | | VM1/W 12.06.32 p210 | VM1/W 17.06.32 p210 | |
| | 16 | 16 | | 1250 | | | | | VM1/W 12.12.16 p210 | VM1/W 17.12.16 p210 | |
| | 20 | 20 | | 1250 | | | | | VM1/W 12.12.20 p210 | VM1/W 17.12.20 p210 | |
| | 25 | 25 | | 1250 | | | | | VM1/W 12.12.25 p210 | VM1/W 17.12.25 p210 | |
| | 31.5 | 31.5 | | 1250 | | | | | VM1/W 12.12.32 p210 | VM1/W 17.12.32 p210 | |
| | 40 | 40 | | 1250 | | | | | – | – | |
| | 50 | 50 | | 1250 | | | | | – | – | |
| | 40 | 40 | | | 1250 | | | | – | – | |
| | 50 | 50 | | | 1250 | | | | – | – | |
| | 20 | 20 | | | 1600 | | | | VM1/P 12.16.20 p210 | VM1/P 17.16.20 p210 | |
| | 25 | 25 | | | 1600 | | | | VM1/P 12.16.25 p210 | VM1/P 17.16.25 p210 | |
| | 31.5 | 31.5 | | | 1600 | | | | VM1/P 12.16.32 p210 | VM1/P 17.16.32 p210 | |
| | 40 | 40 | | | 1600 | | | | – | – | |
| | 50 | 50 | | | 1600 | | | | – | – | |
| | 20 | 20 | | | 2000 | | | | VM1/P 12.20.20 p210 | VM1/P 17.20.20 p210 | |
| | 25 | 25 | | | 2000 | | | | VM1/P 12.20.25 p210 | VM1/P 17.20.25 p210 | |
| | 31.5 | 31.5 | | | 2000 | | | | VM1/P 12.20.32 p210 | VM1/P 17.20.32 p210 | |
| | 40 | 40 | | | 2000 | | | | – | – | |
| | 50 | 50 | | | 2000 | | | | – | – | |
| | 20 | 20 | | | | 2500 | | | VM1/P 12.25.20 p275 | VM1/P 17.25.20 p275 | PB 3/E PB 3/M |
| | 25 | 25 | | | | 2500 | | | VM1/P 12.25.25 p275 | VM1/P 17.25.25 p275 | |
| | 31.5 | 31.5 | | | | 2500 | | | VM1/P 12.25.32 p275 | VM1/P 17.25.32 p275 | |
| | 40 | 40 | | | | 2500 | | | – | – | |
| | 50 | 50 | | | | 2500 | | | – | – | |
| | 31.5 | 31.5 | | | | 3150 | | | – | – | |
| | 40 | 40 | | | | 3150 | | | – | – | |
| | 50 | 50 | | | | 3150 | | | – | – | |
| | 31.5 | 31.5 | | | | 3600 (1) | | | – | – | |
| | 40 | 40 | | | | 3600 (1) | | | – | – | |
| | 50 | 50 | | | | 3600 (1) | | | – | – | |
| | 31.5 | 31.5 | | | | 4000 (1) | | | – | – | |
| | 40 | 40 | | | | 4000 (1) | | | – | – | |
| | 50 | 50 | | | | 4000 (1) | | | – | – | |



| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 16 | | | | | 630 | | VM1/P 24.06.16 p210 | – | |
| | 20 | 20 | | | | | 630 | | VM1/P 24.06.20 p210 | – | |
| | 25 | 25 | | | | | 630 | | VM1/P 24.06.25 p210 | – | PB 4/E |
| | 16 | 16 | | | | | 1250 | | VM1/P 24.12.16 p210 | – | PB 4/M |
| | 20 | 20 | | | | | 1250 | | VM1/P 24.12.20 p210 | – | |
| | 25 | 25 | | | | | 1250 | | VM1/P 24.12.25 p210 | – | |
| | 16 | 16 | | | | | | 1600 | VM1/P 24.16.16 p275 | – | |
| 24 | 20 | 20 | | | | | | 1600 | VM1/P 24.16.20 p275 | – | |
| | 25 | 25 | | | | | | 1600 | VM1/P 24.16.25 p275 | – | |
| | 16 | 16 | | | | | | 2000 | VM1/P 24.20.16 p275 | – | |
| | 20 | 20 | | | | | | 2000 | VM1/P 24.20.20 p275 | – | PB 5/E |
| | 25 | 25 | | | | | | 2000 | VM1/P 24.20.25 p275 | – | PB 5/M |
| | 16 | 16 | | | | | | 2500 (2) | VM1/P 24.25.16 p275 (3) | – | |
| | 20 | 20 | | | | | | 2500 (2) | VM1/P 24.25.20 p275 (3) | – | |
| | 25 | 25 | | | | | | 2500 (2) | VM1/P 24.25.25 p275 (3) | – | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monbloc.
(1) 3600 A with fan pre-installed in the PB3 units. For 4000 A it is necessary to install another fan in the back of the switchgear (by the customer).
(2) 2500 A with fan pre-installed in the PB5 units.
(3) Please ask ABB for availability.

## Table 4 - Withdrawable eVM1 circuit-breakers for PowerCube type PB units



| | | | Rated current of the eVM1 circuit-breakers inserted in the PowerCube units (40°C) [A] | | | | | | Withdrawable eVM1 for PowerCube unit | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| kV | Isc [kA] 3s | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker type | Circuit-breaker type | PowerCube |
| 7.2 | 16 | 16 | 630 | | | | | | eVM1/P 12.06.16 p150 | eVM1/P 17.06.16 p150 | PB1/E PB1/M |
| | 20 | 20 | 630 | | | | | | eVM1/P 12.06.20 p150 | eVM1/P 17.06.20 p150 | |
| | 25 | 25 | 630 | | | | | | eVM1/P 12.06.25 p150 | eVM1/P 17.06.25 p150 | |
| | 31.5 | 31.5 | 630 | | | | | | eVM1/P 12.06.32 p150 | eVM1/P 17.06.32 p150 | |
| 12 | 16 | 16 | 1250 | | | | | | eVM1/P 12.12.16 p150 | eVM1/P 17.12.16 p150 | |
| | 20 | 20 | 1250 | | | | | | eVM1/P 12.12.20 p150 | eVM1/P 17.12.20 p150 | |
| | 25 | 25 | 1250 | | | | | | eVM1/P 12.12.25 p150 | eVM1/P 17.12.25 p150 | |
| | 31.5 | 31.5 | 1250 | | | | | | eVM1/P 12.12.32 p150 | eVM1/P 17.12.32 p150 | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monobloc.
* Please contact us for availability.

## Table 5 - Withdrawable Vmax circuit-breakers for PowerCube type PB units



| | | | Rated current of the circuit-breakers Vmax inserted in the PowerCube units (40°C) [A] | | | | | | Withdrawable Vmax for PowerCube units | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| kV | Isc [kA] 3s | Icw [kA] | W=600 p=150 ul=205 H=260 ø=35 | W=750 p=210 ul=310 H=280 ø=35 | W=750 p=210 ul=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 ul=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Circuit-breaker type | Circuit-breaker type | PowerCube |
| 7.2 | 16 | 16 | 630 | | | | | | Vmax/W 12.06.16 p150 | Vmax/W 17.06.16 p150 * | PB1/E PB1/M |
| | 20 | 20 | 630 | | | | | | Vmax/W 12.06.20 p150 | Vmax/W 17.06.20 p150 * | |
| | 25 | 25 | 630 | | | | | | Vmax/W 12.06.25 p150 | Vmax/W 17.06.25 p150 * | |
| | 31.5 | 31.5 | 630 | | | | | | Vmax/W 12.06.32 p150 | Vmax/W 17.06.32 p150 * | |
| 12 | 16 | 16 | 1250 | | | | | | Vmax/W 12.12.16 p150 | Vmax/W 17.12.16 p150 * | |
| | 20 | 20 | 1250 | | | | | | Vmax/W 12.12.20 p150 | Vmax/W 17.12.20 p150 * | |
| | 25 | 25 | 1250 | | | | | | Vmax/W 12.12.25 p150 | Vmax/W 17.12.25 p150 * | |
| | 31.5 | 31.5 | 1250 | | | | | | Vmax/W 12.12.32 p150 | Vmax/W 17.12.32 p150 * | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monobloc.
* Please contact us for availability.

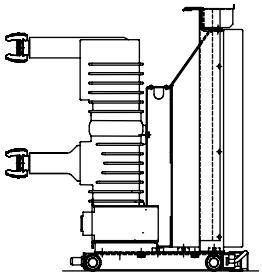
## Table 6 - V-Contact withdrawable contactors for PowerCube type PB units



| | | | Rated current of the V-Contact contactors (A - 40 °C) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| kV | Isc [kA] (3) | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Contactor | PowerCube |
| 7.2 | 16 | 6 | 400 (4) | | | | | | V7/W VSC7/P | PB 1/E PB 1/M |
| | 20 | 6 | 400 (4) | | | | | | | |
| | 25 | 6 | 400 (4) | | | | | | | |
| | 31.5 | 6 | 400 (4) | | | | | | | |
| 12 | 16 | 6 | 400 (4) | | | | | | V12/W VSC12/P | |
| | 20 | 6 | 400 (4) | | | | | | | |
| | 25 | 6 | 400 (4) | | | | | | | |
| | 31.5 | 6 | 400 (4) | | | | | | | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monobloc.
(1) 3600 A with fan pre-installed in the PB3 modules. For 4000 A it is necessary to install another fan in the back of the switchgear (by the customer).
(2) 2500 A with fan pre-installed in the PB5 modules.
(3) Guaranteed using suitable fuses.
(4) The rated current is subject to derating according to the rated current of the fuses.

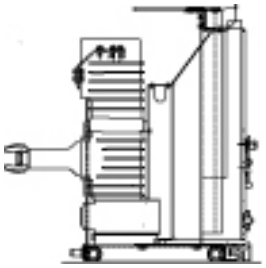
## Table 7 – Isolating trucks for PowerCube type PB units



| kV | Isc [kA] | Icw [kA] | Rated current of the isolating trucks (A - 40 °C) W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Isolating truck | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|
| 12-17.5 | 16 | 16 | ...1250 | | | | | | S-HD4/W 17.12.32 p150 | PB 1/E PB 1/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 16 | 16 | | ...1250 | | | | | S-HD4/W 17.12.32 p210 | PB 2/E PB 2/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | S-HD4/W 17.12.50 p210 | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | ...2000 | | | | S-HD4/W 17.20.32 p210 | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | S-HD4/P 17.20.50 p210 | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | | ...2500 | | | S-HD4/P 17.25.50 p275 | PB 3/E PB 3/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | | ...3150 | | | S-HD4/P 17.32.50 p275 | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| | 31.5 | 31.5 | | | | ...3600 (1) | | | S-HD4/P 17.32.50 p275 | |
| | 40 | 40 | | | | ...3600 (1) | | | | |
| | 50 | 50 | | | | | | | | |
| | 31.5 | 31.5 | | | | ...4000 (1) | | | S-HD4/P 17.32.50 p275 | |
| | 40 | 40 | | | | ...4000 (1) | | | | |
| | 50 | 50 | | | | | | | | |
| 24 | 16 | 16 | | | | | ...1250 | | S-HD4/W 24.12.25 p210 | PB 4/E PB 4/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2000 | S-HD4/P 24.20.25 p275 | PB 5/E PB 5/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2500 (2) | S-HD4/P 24.25.25 p275 | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monobloc.
(1) 3600 A with fan pre-installed in the PB3 modules. For 4000 A it is necessary to install another fan in the back of the switchgear (by the customer).
(2) 2500 A with fan pre-installed in the PB5 modules.
(3) Guaranteed using suitable fuses.
(4) The rated current is subject to derating according to the rated current of the fuses.

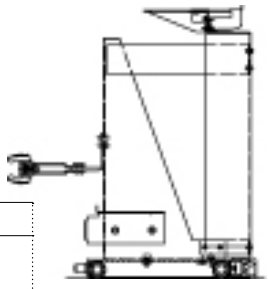
## Table 8 – Earthing trucks with making capacity for PowerCube type PB units



| kV | Isc [kA] | Icw [kA] | Rated current of the earthing trucks (A - 40 °C) W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Earthing truck (1) | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|
| 12-17.5 | 16 | 16 | ...1250 | | | | | | | |
| | 20 | 20 | | | | | | | EM-U/W 17.12.32 p150 | PB 1/E<br>PB 1/M |
| | 25 | 25 | | | | | | | EM-L/W 17.12.32 p150 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 16 | 16 | | ...1250 | | | | | | |
| | 20 | 20 | | | | | | | EM-L/W 17.12.32 p210 | |
| | 25 | 25 | | | | | | | EM-U/W 17.12.32 p210 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | EM-L/W 17.12.50 p210 (2) | |
| | 50 | 50 | | | | | | | EM-U/W 17.12.50 p210 (2) | PB 2/E<br>PB 2/M |
| | 16 | 16 | | | ...2000 | | | | | |
| | 20 | 20 | | | | | | | EM-L/W 17.20.32 p210 | |
| | 25 | 25 | | | | | | | EM-U/W 17.20.32 p210 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | EM-L/P 17.20.50 p210 | |
| | 50 | 50 | | | | | | | EM-U/P 17.20.50 p210 | |
| | 16 | 16 | | | | ...2500 | | | | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | EM-L/P 17.25.50 p275 | |
| | 31.5 | 31.5 | | | | | | | EM-U/P 17.25.50 p275 | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | PB 3/E<br>PB 3/M |
| | 16 | 16 | | | | ....3150 | | | | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | EM-L/P 17.32.50 p275 | |
| | 31.5 | 31.5 | | | | | | | EM-U/P 17.32.50 p275 | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| 24 | 16 | 16 | | | | | ...1250 | | EM-L/W 24.12.25 p210 | |
| | 20 | 20 | | | | | | | EM-U/W 24.12.25 p210 | PB 4/E<br>PB 4/M |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2000 | EM-L/P 24.20.25 p275 | |
| | 20 | 20 | | | | | | | EM-U/P 24.20.25 p275 | |
| | 25 | 25 | | | | | | | EM-L/P 24.25.25 p275 | |
| | 16 | 16 | | | | | | ...2500 (2) | EM-U/P 24.25.25 p275 | PB 5/E |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube type PB unit monobloc.
(1) - EM-L... = Earthing truck with making capacity with bottom bushings (for cable earthing).
- EM-U... = Earthing truck with making capacity with top bushings (for earthing the busbar system).
(2) Ask ABB.

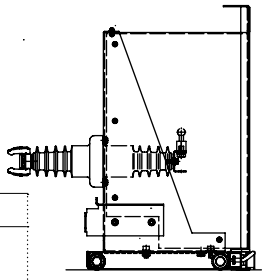
## Table 9 - Earthing trucks without making capacity for PowerCube type PB units



| | | | Rated current of the earthing trucks (A - 40 °C) | | | | | | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|
| kV | Isc [kA] | Icw [kA] | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Earthing truck (1) | |
| 12-17.5 | 16 | 16 | ...1250 | | | | | | | PB 1/E PB 1/M |
| | 20 | 20 | | | | | | | E-U/W 17.12.32 p150 | |
| | 25 | 25 | | | | | | | E-L/W 17.12.32 p150 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 16 | 16 | | ...1250 | | | | | | PB 2/E PB 2/M |
| | 20 | 20 | | | | | | | E-L/W 17.12.32 p210 | |
| | 25 | 25 | | | | | | | E-U/W 17.12.32 p210 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | E-L/W 17.12.50 p210 (2) | |
| | 50 | 50 | | | | | | | E-U/W 17.12.50 p210 (2) | |
| | 16 | 16 | | | ...2000 | | | | | |
| | 20 | 20 | | | | | | | E-L/W 17.20.32 p210 | |
| | 25 | 25 | | | | | | | E-U/W 17.20.32 p210 | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | E-L/P 17.20.50 p210 | |
| | 50 | 50 | | | | | | | E-U/P 17.20.50 p210 | |
| | 16 | 16 | | | | ...2500 | | | | PB 3/E PB 3/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | E-L/P 17.25.50 p275 | |
| | 31.5 | 31.5 | | | | | | | E-U/P 17.25.50 p275 | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | | ...3150 | | | | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | E-L/P 17.32.50 p275 | |
| | 31.5 | 31.5 | | | | | | | E-U/P 17.32.50 p275 | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| 24 | 16 | 16 | | | | | ...1250 | | E-L/W 24.12.25 p210 | PB 4/E PB 4/M |
| | 20 | 20 | | | | | | | E-U/W 24.12.25 p210 | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2000 | E-L/P 24.20.25 p275 | PB 5/E PB 5/M |
| | 20 | 20 | | | | | | | E-U/P 24.20.25 p275 | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2500 | E-L/P 24.25.25 p275 | |
| | 20 | 20 | | | | | | | E-U/P 24.25.25 p275 | |
| | 25 | 25 | | | | | | | | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth.
Ø = Diameter of the contacts in the PowerCube unit monobloc.
(1) - EM-L... = Earthing truck without making capacity with bottom bushings (for cable earthing).
- EM-U... = Earthing truck without making capacity with top bushings (for earthing the busbar system).
(2) Ask ABB..

## Table 10 – Cable testing trucks for PowerCube type PB units



| | | | Rated current of the cable testing trucks (A - 40 °C) | | | | | | | PowerCube |
|---|---|---|---|---|---|---|---|---|---|---|
| kV | Isc [kA] | Icw (kAx3s) | W=600 p=150 u/l=205 H=260 ø=35 | W=750 p=210 u/l=310 H=280 ø=35 | W=750 p=210 u/l=310 H=280 ø=79 | W=1000 p=275 u/l=310 H=280 ø=109 | W=750 p=210 u/l=310 H=325 ø=35 | W=1000 p=275 u/l=310 H=345 ø=79 | Cable testing truck | |
| 12-17.5 | 16 | 16 | ...1250 | | | | | | T/W 17.12 p150 | PB 1/E PB 1/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 16 | 16 | | ...1250 | | | | | T/W 17.12 p210 | PB 2/E PB 2/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | T/W 17.12 p210 (1) | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | ...2000 | | | | T/P 17.20 p210 | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | T/P 17.20 p210 | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | | 2500 | | | T/P 17.32 p275 | PB 3/E PB 3/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| | 16 | 16 | | | | 3150 | | | | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 31.5 | 31.5 | | | | | | | | |
| | 40 | 40 | | | | | | | | |
| | 50 | 50 | | | | | | | | |
| 24 | 16 | 16 | | | | | ...1250 | | T/W 24.12 p210 | PB 4/E PB 4/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2000 | T/W 24.20 p275 | PB 5/E PB 5/M |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |
| | 16 | 16 | | | | | | ...2500 (1) | T/P 24.25 p275 | |
| | 20 | 20 | | | | | | | | |
| | 25 | 25 | | | | | | | | |

W = Width of PowerCube unit.
P = Horizontal centre distance between circuit-breaker poles.
U/L = Distance between top and bottom terminal.
H = Distance between bottom terminal and earth
Ø = Diameter of the contacts in the PowerCube unit monobloc.
(1) Ask ABB.

**Table 11 - PowerCube type PB units without apparatus**

| Enclosure characteristics | | | | Configuration | | | | |
|---|---|---|---|---|---|---|---|---|
| Rated voltage [kV] | Width (mm) | Rated current (A) | Isc [kA] (1) | Icw (kA x 3s/1s) (1) | Bus riser or direct incoming feeder with earthing switch | Bus riser or direct incoming feeder | Measuring (2) | Measuring (2) |
| 12-17.5 | 600 | 1250 | 31.5 | 31.5 | PB1/RE - PB1/RM | PB1/RE - PB1/RM | PB1/RE - PB1/RM | PB1/RE - PB1/RM |
| | 750 | 2000 | 31.5 | 31.5 | PB2/RE - PB2/RM | PB2/RE - PB2/RM | PB2/RE - PB2/RM | PB2/RE - PB2/RM |
| | 750 | 2000 | 40-50 | 40-50 | PB2/RE - PB2/RM | PB2/RE - PB2/RM | PB2/RE - PB2/RM | PB2/RE - PB2/RM |
| | 1000 | 4000 | 31.5 | 31.5 | PB3/RE - PB3/RM | PB3/RE - PB3/RM | PB3/RE - PB3/RM | PB3/RE - PB3/RM |
| | 1000 | 4000 | 40-50 | 40-50 | PB3/RE - PB3/RM | PB3/RE - PB3/RM | PB3/RE - PB3/RM | PB3/RE - PB3/RM |
| 24 | 750 | 1250 | 25 | 25 | PB4/RE - PB4/RM | PB4/RE - PB4/RM | PB4/RE - PB4/RM | PB4/RE - PB4/RM |
| | 1000 | 2500 | 25 | 25 | PB5/RE - PB5/RM | PB5/RE - PB5/RM | PB5/RE - PB5/RM | PB5/RE - PB5/RM |

(1) On earthing switch, if provided.
(2) For units PB/RE end for PB1/RM, the VT compartment is not available. Construction at customer care.

## 5.4. Main components

### 5.4.1. Switchgear

PowerCube units can be equipped with the following switchgear:
– HD4 series SF6 circuit-breaker;
– VD4 and VM1 series vacuum circuit-breaker;
– V-Contact series vacuum contactor;
– operational trucks.
The apparatus is always the withdrawable version, mounted on a truck that allows the following positions in relation to the compartment:

CONNECTED: – main and auxiliary circuits connected;
ISOLATED: – partially isolated with main circuits disconnected and auxiliary circuits (plug connector connected);
– totally isolated with main and auxiliary circuits disconnected, (plug connector withdrawn);
WITHDRAWN: – main and auxiliary circuits disconnected and apparatus racked out of the switchboard.

In the connected and isolated positions the apparatus remains in the unit with the door closed is visible through switchboard inspection window.
The apparatus is equipped with special locks, located on the front crosspiece which allow their hooking into the corresponding slots of the unit. The front hooking crosspiece also allows the connecting/isolating operation, with the door closed, by means of the special operating lever.
A lock prevents truck insertion into the switchboard (for example when the earthing switch is closed).
If the truck is in the indefinite position (between connected and isolated), the lock prevents both mechanical and electrical circuit-breaker closing.
The truck is equipped with a locking magnet which, if deenergised, prevents its operation.
The connector (plug) for connection of the operating mechanism electrical accessories comes out of the front protection of the apparatus.
The strikers for actuating the contacts (connected/isolated) located in the switchboard are fixed in the upper part of the apparatus.
The slides for activating the segregation shutters of the medium voltage contacts are placed on the sides of the apparatus.
Please refer to the relative instruction booklet for further details.

### 5.4.2. Earthing switch

The earthing switch (1) (fig. 8) with making capacity is placed in the rear part whereas the front houses the operating mechanism (2).
The switch position is indicated in the flange of the operating seat (2).

**The certain position of the earthing switch is indicated by the graphic symbols at the operating seat (2). The position of the earthing switch is indicated by the yellow arrow made directly on the operating shaft (5).**
**For enclosures up to 17 kV and rated current up to 3150 A, or enclosures of 24 kV and rated currents up to 2000 A, the position of the earthing switch can be checked either by means of the indicator (3), located inside the enclosure and visible through the inspection window (4) positioned on the bottom front part of the unit.**

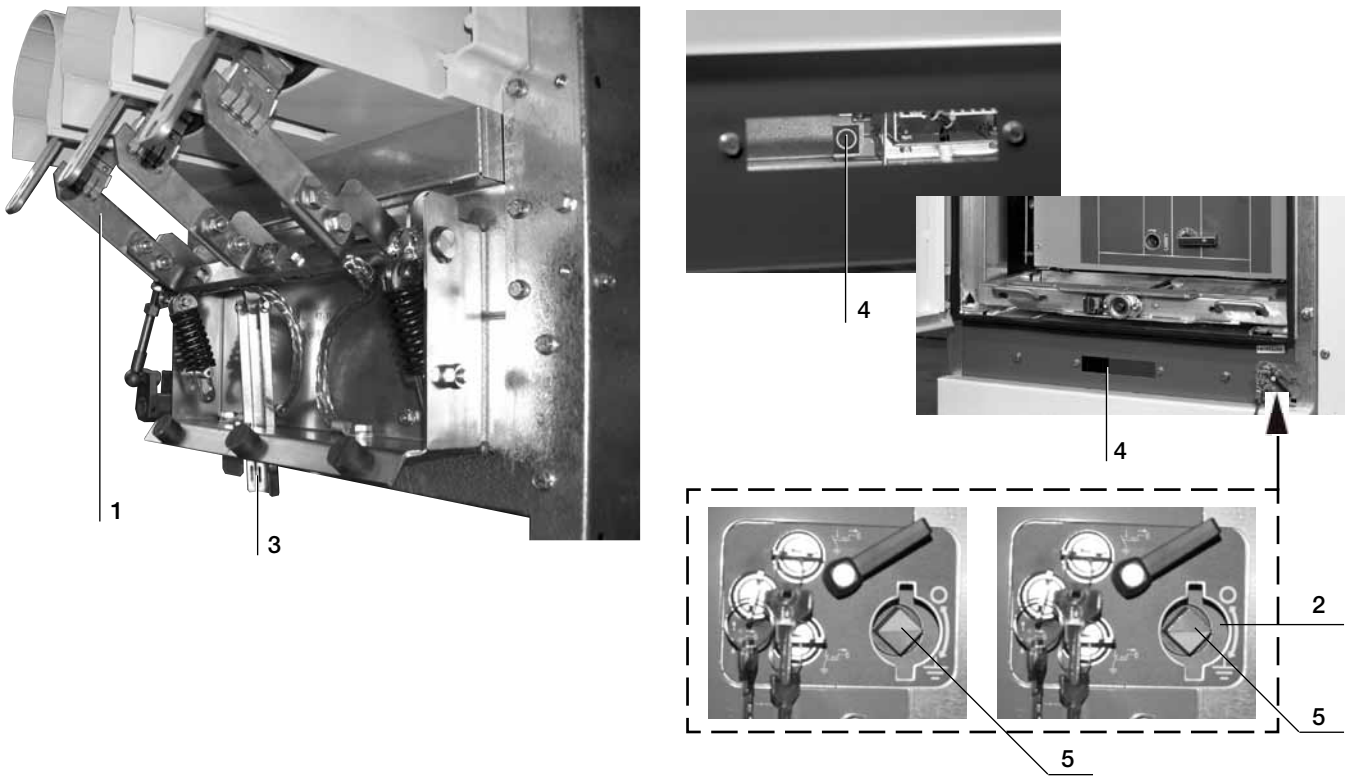



Fig. 8

### 5.4.3. Module units

#### 5.4.3.1. Circuit-breaker and/or contactor unit

The parallelepiped metal structure is fitted with a front door and operating and control mechanisms on the external front side (fig. 9).
The apparatus must only be isolated and connected with the door closed.
The earthing switch control panel on the lower front part is fitted with:
– the earthing switch operating mechanism seat (10);
– the actuator (9) for operating the shutter (11) of the earthing switch operating mechanism seat;
– key lock with earthing switch open (8);
– key lock with earthing switch closed (12);
– key lock for preventing apparatus racking in (7).
The voltage indicator lamps (4) are mounted in the upper part of the unit (for PB/M only).
The door is fitted with:
– an opening-closing handle (5);
– an inspection window to see the apparatus position (3);
– a coupling (2) for the removable lever for apparatus racking in/ out with the door closed;
– screw for emergency unlock of the door lock (6).

The compartment houses the following components:
– truck guides (15);
– segregating shutters (18) of the fixed isolating contacts inside the monoblocks and the shutter operating mechanisms (16);
– socket for the mobile connector (22);
– mechanical lock (23) for preventing racking out of the auxiliary circuit connector when the circuit-breaker is connected;
– microswitch kinematics (21) for signalling circuit-breaker connected position;
– microswitch kinematics (24) for signalling the apparatus isolated position;
– mechanical lock for preventing either circuit-breaker racking in when the earthing switch is closed or earthing switch closing if the circuit-breaker is connected (27);
– on request, anti-condensation heater (25);
– on request, key lock for the earthing truck fitted with upper bushings (19);
– on request, earthing truck fitted with lower bushings (20);
– lock for preventing insertion of apparatus of different size than foreseen for the compartment (22).
The insulating monoblocks (14) for the power connections are on the rear of the compartment.

### 5.4.3.2. Feeder unit (PB/M-PB/RM units)

The feeder unit contains the earthing switch and relative auxiliary contacts. It allows access to the cable area working from the front.
The live components can be segregated by means of (fig. 10) earthing switch interlock (22) - in this case the door can only be opened when the earthing switch is closed.

**Before accessing the cable terminals, make sure that the earthing switch position indicators (3) fig. 8, visible through the inspection window (4) and (5) fig. 8, visible from the operating seat of the earthing switch, confirm that closing has taken place.**

### 5.4.3.3. VT unit and withdrawable truck (PB/M-PB/RM units)

The voltage transformer unit (fig. 11) consists of an enclosure (fig. 11d) where a withdrawable truck is inserted (fig. 11f), with the transformers on board (53) (fig. 11f) and the relative protection fuses.

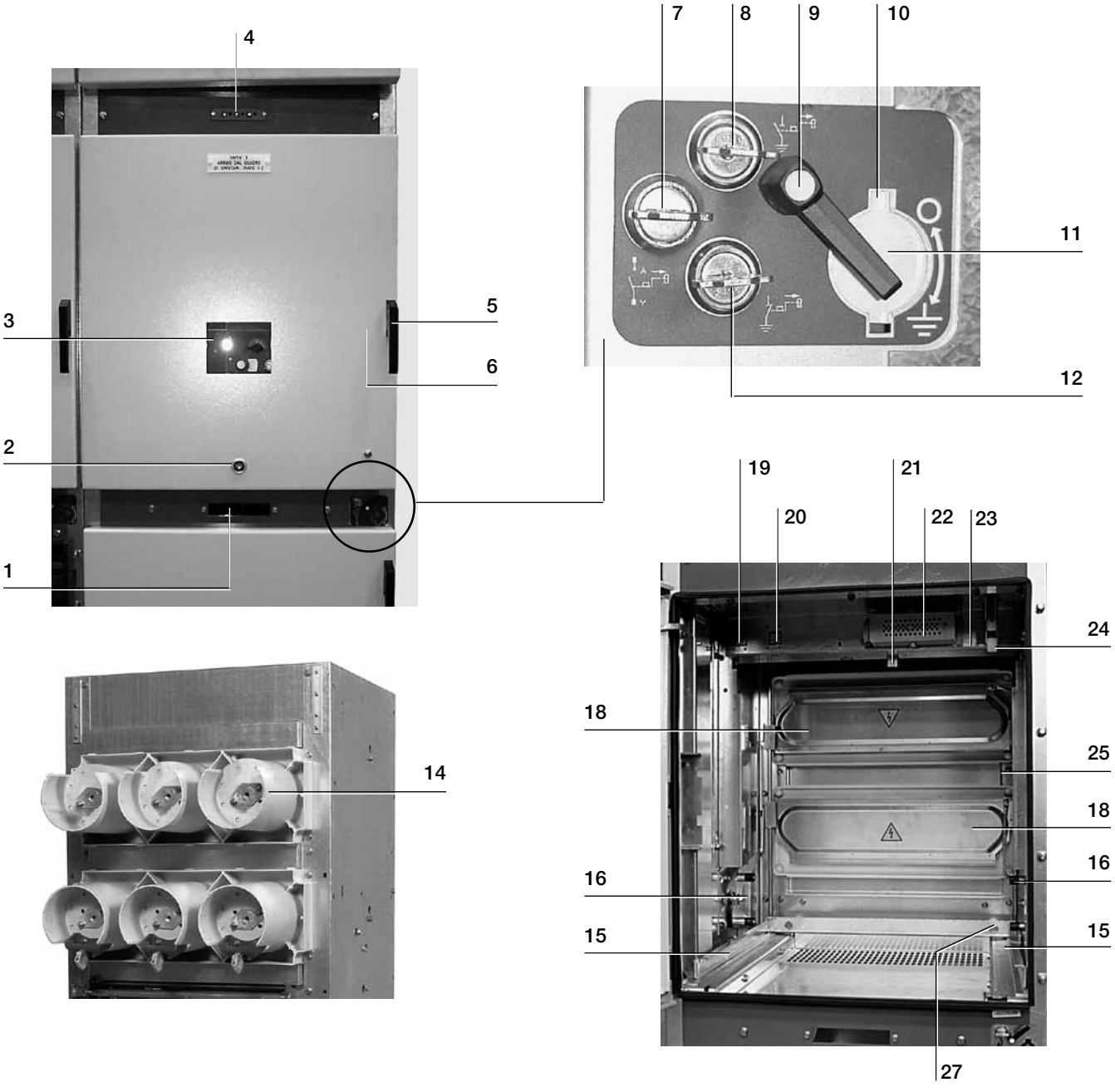



**Fig. 9**




**Fig. 10**

The withdrawable truck (fig. 11f) can be fully withdrawn from the unit and allows safe fuse replacement.
A special metallic shutter (57) (fig. 11b) prevents contact with the medium voltage terminals when the truck is withdrawn.
The main measurement compartment features are:
– VTs mounted on a withdrawable truck inside the unit
– isolation of the VTs and relative fuses is by means of an operating handle outside the compartment;
– when the VTs are isolated the VT auxiliary circuits are also isolated automatically;
– travel of the VT truck automatically operates the metallic shutter;
– the fuses can be replaced opening the door, after VT isolation and its withdrawal from the compartment;
– the VTs can be replaced only after the truck is withdrawn from the compartment;
– on request, electrical signalling of VT inserted and withdrawn can be supplied.

The VT truck can take up the following positions:

| | |
|---|---|
| INSERTED: | VT main and auxiliary circuits connected; |
| ISOLATED: | VT main and auxiliary circuits disconnected. The VT truck remains inside the compartment. |
| WITHDRAWN: | VT main and auxiliary circuits disconnected: VT truck withdrawn. |

The voltage transformers insulated in resin for supplying power to instruments and protection devices, have the performances and precision classes normally provided by instrument transformer manufacturers. VT auxiliary circuits are connected by means of sliding contacts (58) (fig. 11c).
The cable area of wall-standing switchboards can be accessed by withdrawing the whole measurement compartment.

The following components are mounted in the VT compartment:

**VT Compartment:**

– door (41) (fig. 11a);
– operation sequence plate (42) (fig. 11a);
– operating seat of lever for VT truck racking in/out (43) (fig. 11a);
– truck guides (55) (fig. 11b);
– metallic shutter (57) (fig. 11b) for segregating the isolating contacts inside the monoblocks and segregation actuating kinematics (56) (fig. 11b);
– sliding contacts of the VT auxiliary circuits (58) (fig. 11c);
– contacts for signalling VT truck inserted (60) (fig. 11c);
– contacts for signalling VT truck isolated (61) (fig. 11c).

**VT truck:**

– actuator of the door closing bolt (45) (fig. 11d);
– operating seat of the racking in/out lever (46) (fig. 11d);
– pin for unlocking the door closing bolt (47) (fig. 11d);
– door closing screws (48) (fig. 11d);
– door locking bolt (50) (fig. 11e);
– pin plate for releasing the door closing bolt (49) (fig. 11e);
– voltage transformers (VTs) (53) (fig. 11f);
– left and right supplementary guides (52) (fig. 11f).

VT compartment

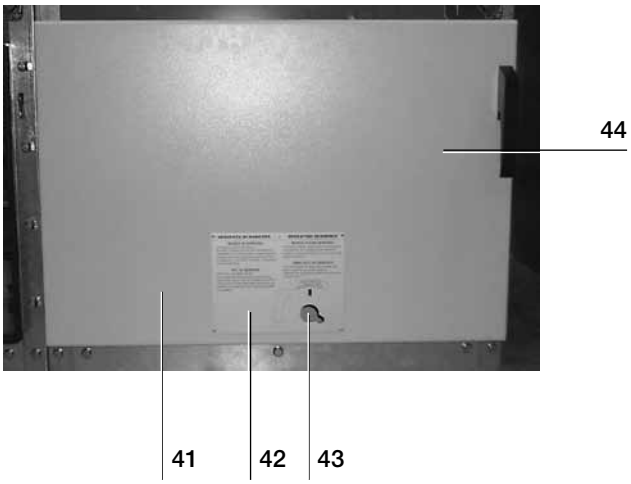



Fig. 11a

VT compartment (internal view)

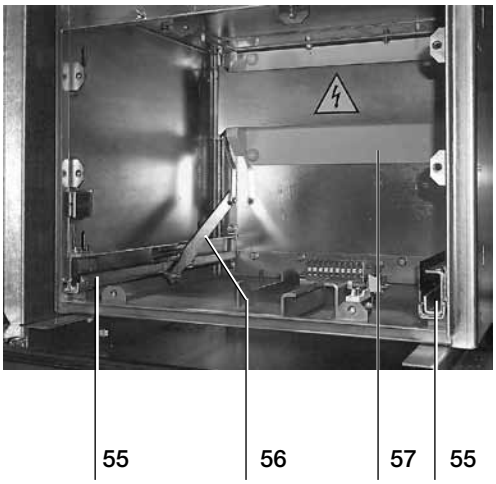



Fig. 11b

VT compartment (internal view)

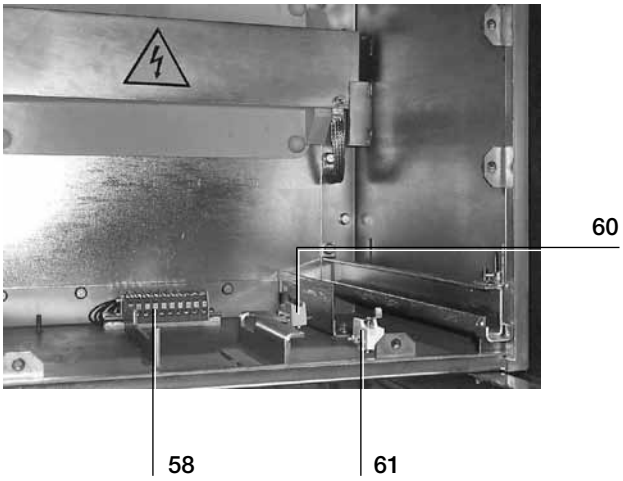



Fig.11c

VT truck

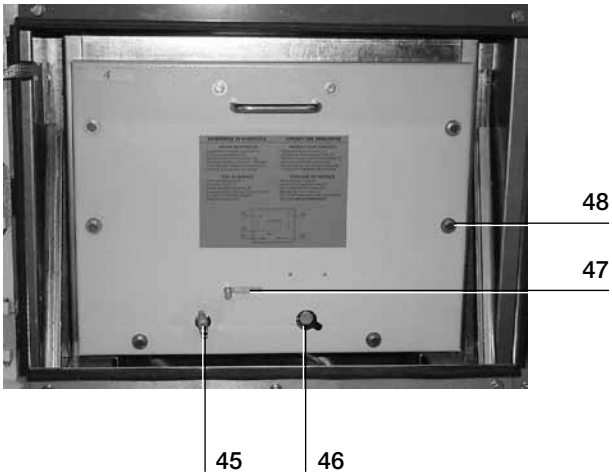



Fig. 11d

VT truck door

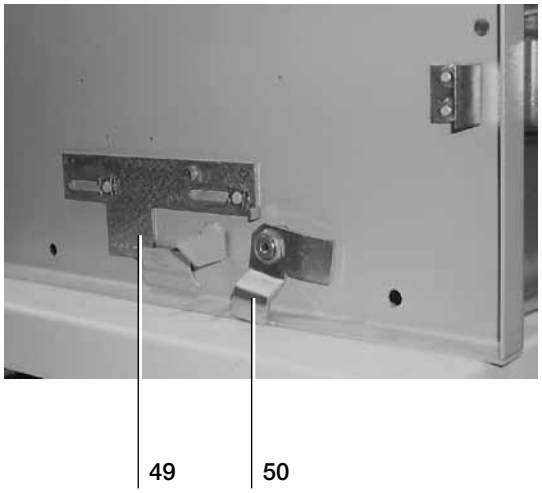



Fig.11e

VT truck

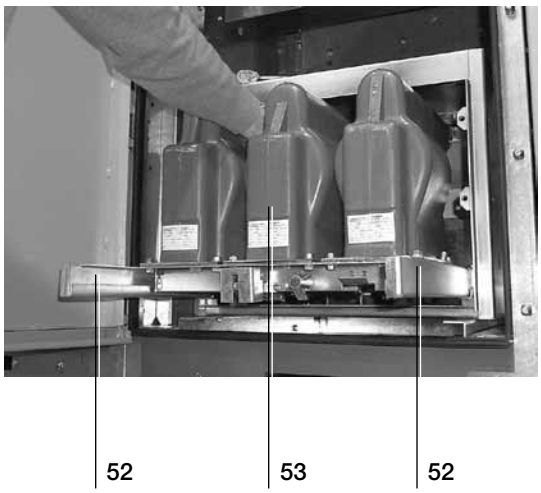



Fig. 11f

### 5.4.3.4. Voltage indicator and phase concordance device

- **Just indication of the device is not sufficient to prove that the system is out of service.**
- **Before accessing the indicator connections, make sure that the relative line is disconnected and the cables earthed.**

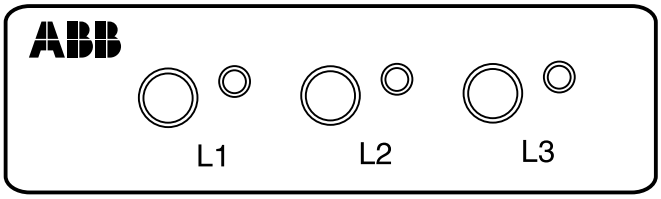
#### Voltage indicator

The voltage indicator (fig. 12) consists of capacitive dividers made of capacitors incorporated in insulators or in the CTs. They are connected to a device containing the signalling lamps and the bushings for checking phase concordance. The presence of voltage is indicated by the lamps either flashing or lit continuously.

#### Phase concordance checking device (on request)

The device consists of electronic apparatus with which phase concordance can be checked using the voltage indicator. The instructions are included in the kit.

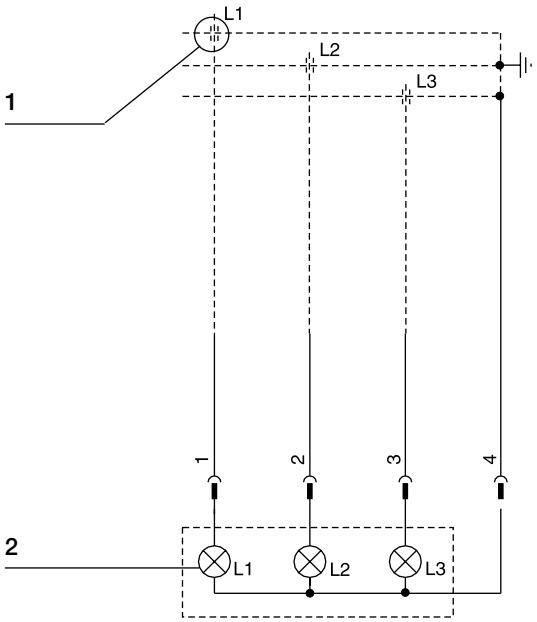
**Voltage indicator**




**Phase concordance checking device**



**Electrical diagram**




Caption

1 Capacitive socket shunted either from the insulator or from the current transformers with capacitive socket.

2 Voltage indicator lamps.

**Fig. 12**

## 5.5. Interlocks/locks

- **The operations must be carried out using normal operating force (not more than 200 N) only using the special levers.**
  **Should the operations be prevented, do not force the mechanical interlocks and check that the operations are correct.**
- **The locks can be activated with a maximum force of 400 N, using the special operating tools.**

The locks used in the PowerCube units are mechanical and electrical with microswitches for circuit continuity or interruption.
The mechanical locks are divided into:
– force locks;
– prevention locks;
– electromechanical locks;
– safety locks (padlocks/keys).
PowerCube modules can be equipped with the locks shown in the following table.

| Lock description | Apparatus (1) | Apparatus compartment | Feeder compartment PB/M-PB/RM | compartment PB/M-PB/RM |
|---|---|---|---|---|
| Electric lock to prevent apparatus closing when the truck is not in the connected/isolated position. | ■ (fig. 13r - det. 44) | | | |
| Mechanical lock to prevent apparatus racking in/out in the closed position. | ■ | | | |
| Mechanical lock which prevents closing the apparatus when the truck is not in the racked-in and isolated positions. | ■ (not available for VM1 and eVM1) | | | |
| Lock to prevent racking-in apparatus in an enclosure preset for another type or size of apparatus. The lock is located in the connector. | ■ (fig. 13a - det. 4) | ■ (fig. 13a - det. 4) | | |
| Locking electromagnet on the apparatus truck to prevent racking-in/out without power. | ■ (fig. 13r - det. 43) | | | |
| Electromechanical lock to prevent door opening if the apparatus is not in the isolated position. | | ☐ (fig. 13c - det. 8) | | |
| Mechanical lock to prevent apparatus racking-in with the door open. | ☐ (fig. 13q - det. 17) | ☐ (fig. 13d - det. 17) | | ■ (fig. 13m - det. 61) |
| Mechanical interlock with earthing switch:<br>– the apparatus cannot be inserted when the earthing switch is closed;<br>– the earthing switch cannot be closed when the apparatus is inserted or in the intermediate positions between connected and isolated. | ■ (fig. 13n - det. 12) (fig. 13r - det. 12)<br>■ (fig. 13n - det. 60) | ■ (fig. 13b - det. 12)<br>■ (fig. 13b - det. 12) | | |
| Mechanical lock to prevent the manual opening of the shutters when the apparatus is withdrawn. (Fail-Safe). | ☐ (fig. 13n - det. 3) (fig. 13o - det. 3) | ☐ (fig. 13b - det. 3) | | ■ (fig. 11b - det. 56) |
| Key lock to prevent apparatus insertion. Only when the apparatus is in the isolated position can the lock be operated and the key released thus preventing apparatus insertion. | ☐ (fig.13n - det. 12) (fig. 13r - det. 12) | ☐ (fig. 13e - det. 35) | | |
| Key lock with open earthing switch. It can only be operated when the earthing switch is open. The key can only be withdrawn with the lock activated. | | ☐ (fig. 13e - det. 33) | | |
| Key lock with closed earthing switch. It can only be operated when the apparatus is isolated and the earthing switch is closed. The key can only be removed with the lock activated. | | ☐ (fig. 13e - det. 34) | | |
| Padlock on the shutters in the closed position. | | ☐ (fig. 13g - det. 52) | | |
| Key lock to prevent placing the earthing truck in the switchboard. | | ☐ (fig. 13a - det. 19) | | |
| Mechanical lock to prevent the racking out of the auxiliarycircuit connector when the apparatus is connected and during apparatus racking in/out. | | ■ (fig. 13a - det. 20) | | |
| Padlock for the door handles. | | ☐ (fig. 13h) | | |
| Earthing switch electromechanical lock to prevent earthing switch opening and closing once the coil (BED) is deenergised. | | ☐ (fig. 13i - det. 53) | | |
| Door lock with earthing switch open. | | | ■ (fig. 13f - det. 22) | |
| Padlock lock to prevent manual apparatus closing. | ☐ (fig. 13s) | | | |

(1) HD4, VD4, V-Contact.
■ Standard
☐ On request

### 5.5.1. Locks in the apparatus compartment (circuit-breaker, contactor, VT compartment)

**Positions of the locks with reference to the figures.**




**Fig. 13**

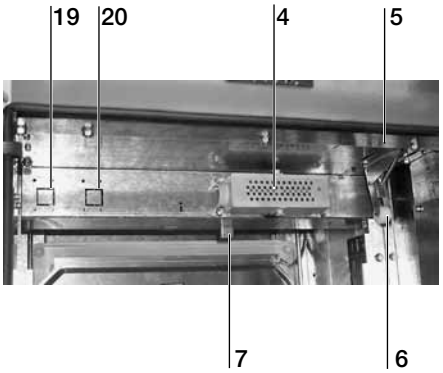



Fig. 13a

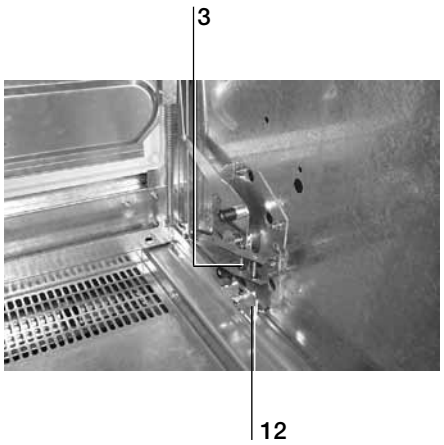



Fig. 13b

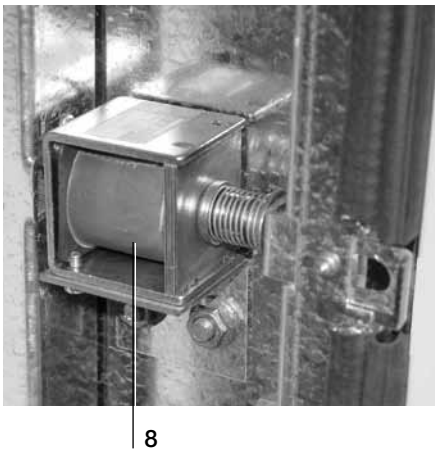



Fig. 13c

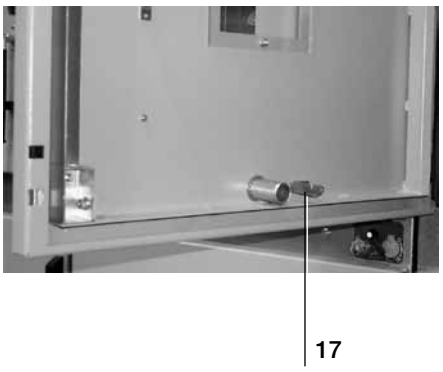



Fig. 13d

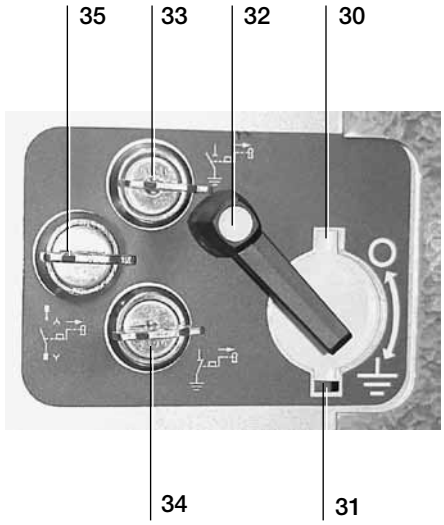



Fig. 13e

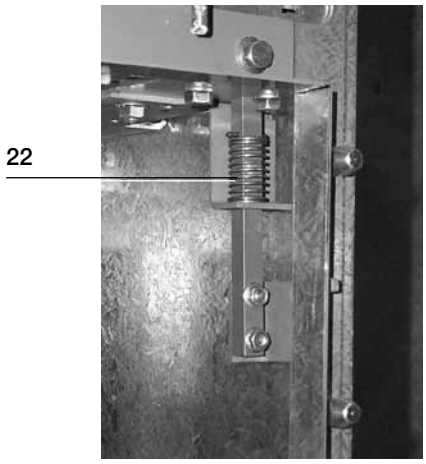



Fig. 13f

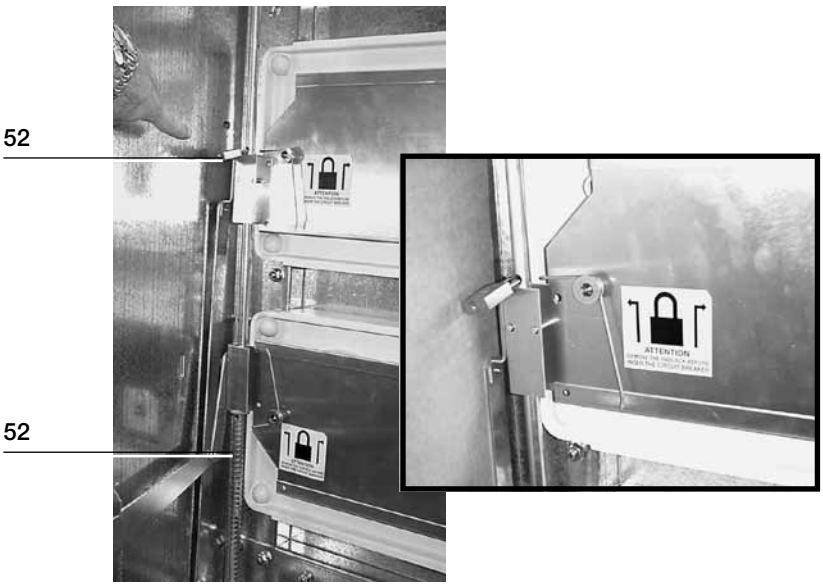



Fig. 13g



Fig. 13h

VT compartment door.

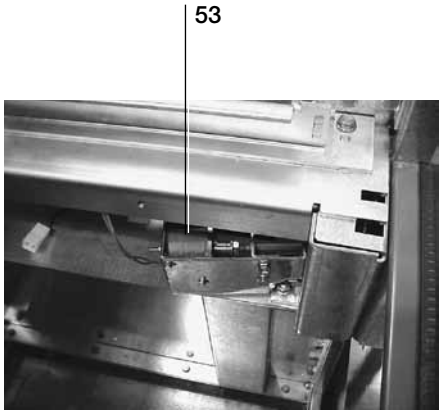



Fig. 13i

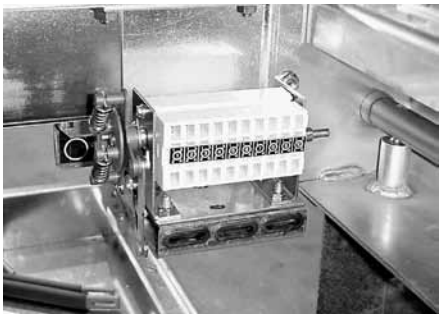


Fig. 13l

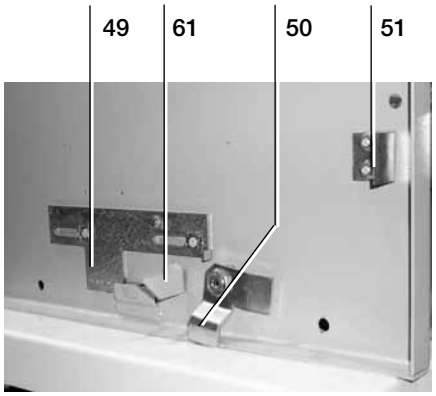



Fig. 13m

Apparatus locks

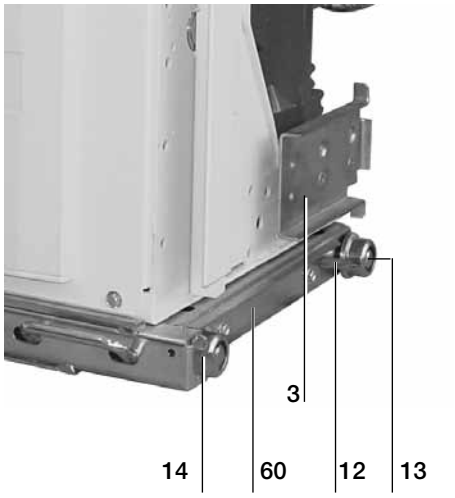



Fig. 13n

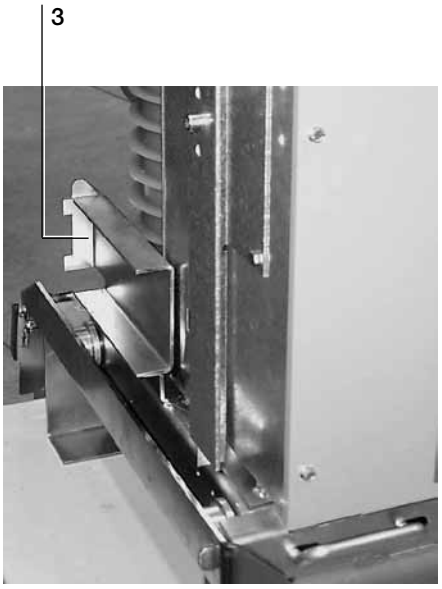



Fig. 13o

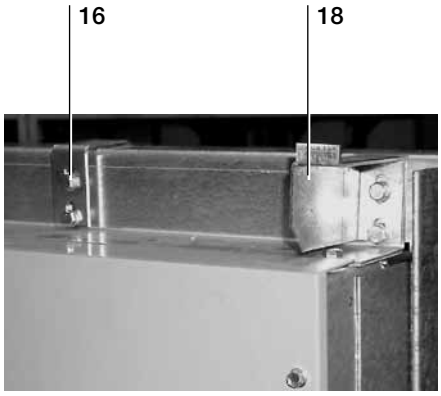



Fig. 13p

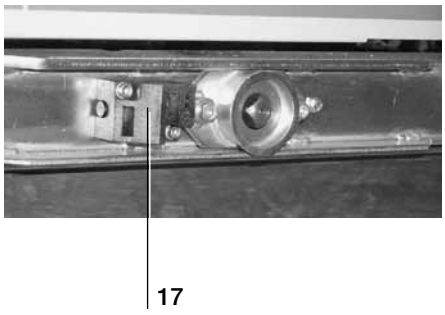



Fig. 13q

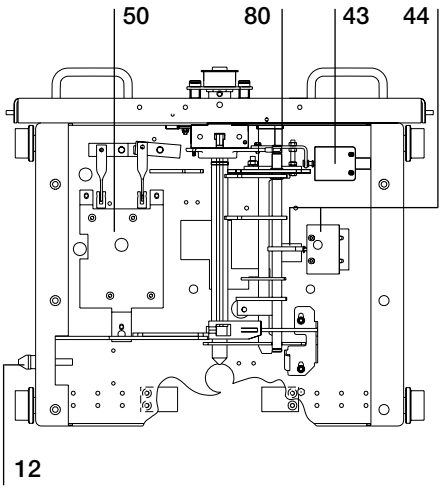



Fig. 13r



Fig. 13s

**Coding the plug-socket connector of the auxiliary circuits**

Coding the plug-socket connector of the auxiliary circuits allows the apparatus to be electrically combined with its panel.
For example, it only allows apparatus with different rated current to be combined with the panels they are destined for.
The operating mechanism cabling coding pins are inserted in the sockets, and must couple with the corresponding seats of the plug-socket connector.
Coding the plug-socket connector depends on the final configuration of the switchgear and must be carried out by the customer by closing the holes not used with the special plugs, according to the coding enclosed with this manual.

Socket references:
B1 - B2 - B3 - B4 - B5 - B6.

Plug references:
(B1) - (B2) - (B3) - (B4) - (B5) - (B6).

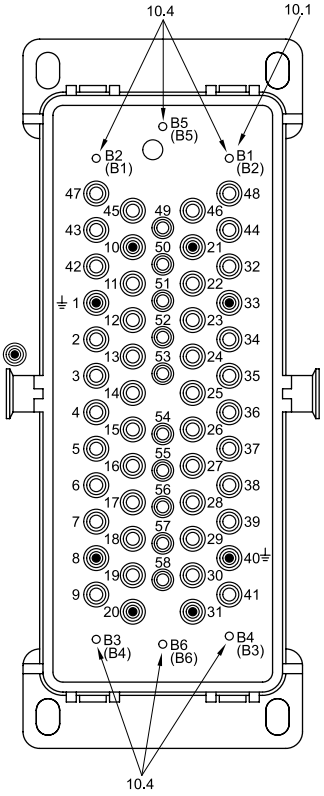



**Fig. 13t**

Application of locks on plug-socket

| Ir | Apparatus | Pole center line | Isc | Ø contacts | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|---|---|---|---|
| 400A | V-CONTACT | 150 | 31.5 kA | 35 | | | ■ | ■ | | |
| 630A | HD4-VD4-VM1 | | | | ■ | | | ■ | | |
| 1250A | HD4-VD4-VM1 | | | | ■ | | | | | |
| 1250A | HD4 isolating truck | | | | | ■ | | ■ | | |
| 1250A | HD4-VD4-VM1 | 210 | 31.5 kA | 35 | ■ | | | | | |
| 1250A | HD4 (UniSafe/PowerCube) | | 50 kA | 35 | ■ | | | | | |
| 1250A | VD4 | | 50 kA | 79 | | | ■ | ■ | ■ | |
| 1250A | HD4 isolating truck | | 31.5-50 kA | 79 | ■ | | | ■ | | |
| 1600A | HD4-VD4-VM1 | | | | | | | ■ | ■ | |
| 2000A | HD4-VD4-VM1 | | | | | | | | ■ | |
| 1250A | HD4 isolating truck | | | | | ■ | ■ | | | |
| 2500A | HD4-VD4-VM1 | 275 | 31.5-50 kA | 109 | | | | | | ■ |
| 2000A | HD4 isolating truck | | | | | | | | | ■ |
| 3150-3600-4000A | HD4-VD4 | | | | | | | | | |
| 2500A | HD4 isolating truck | | | | | | | | | |
| 2500A | HD4 (UniSafe) | 210 | 31.5 kA | 35 | | | | ■ | | ■ |
| 2500A | HD4 isolating truck (UniSafe) | | | | | | ■ | | | ■ |
| 1600A | HD4-HXB/P p210 | 210 | – | – | | | | | ■ | |
| The white boxes in the correspond with the assembly position of the rivets on the switchgear side socket. | | | | | B2 | B1 | B4 | B3 | B5 | B6 |

Pin position in the plug (apparatus)

Hole position in the socket (switchgear)

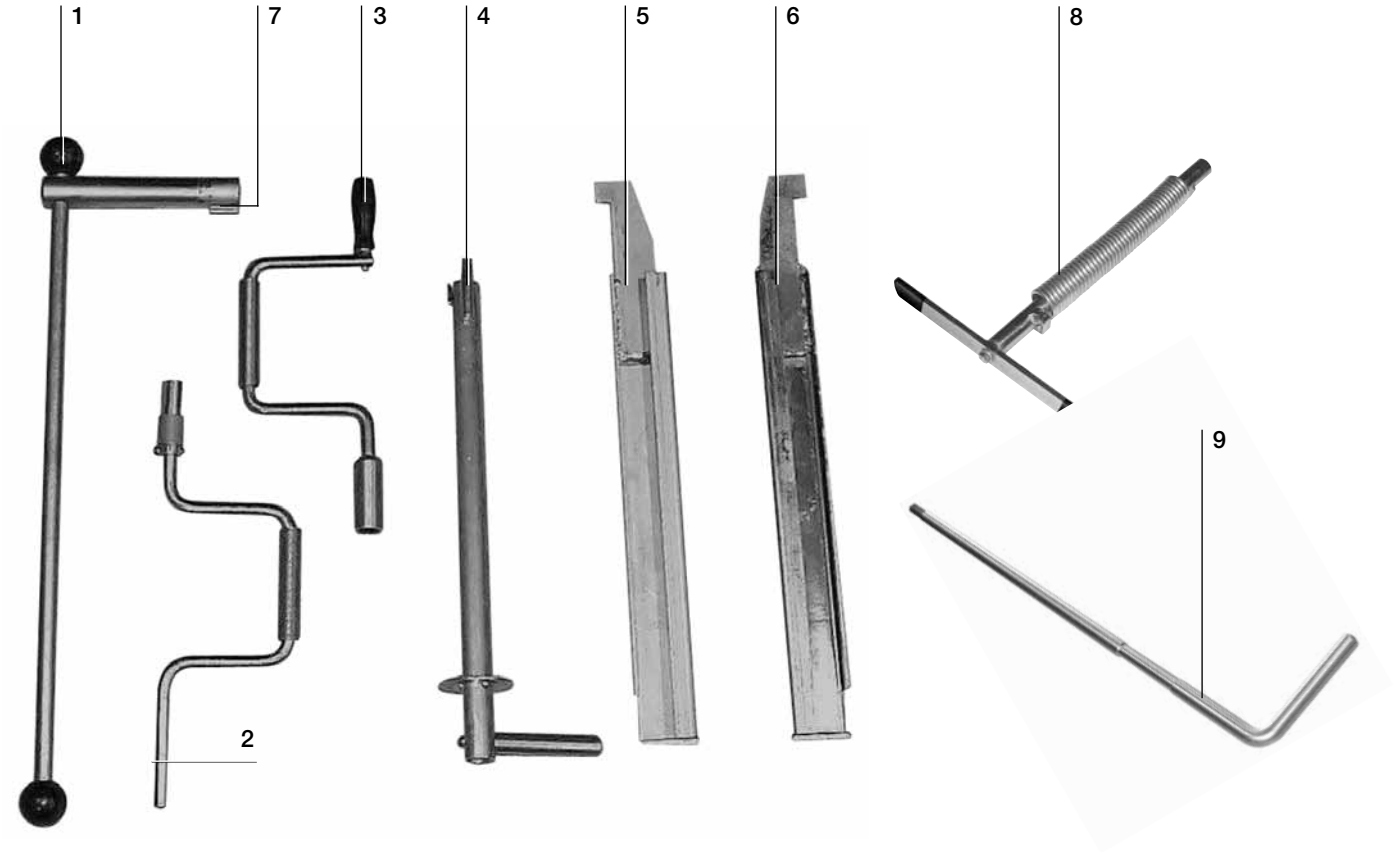
## 5.6. Reference Standards

| | |
|---|---|
| **IEC 60694** | for general application |
| **IEC 62271-200** | for the switchgear |
| **IEC 62271-102** | for the earthing switch |
| **IEC 60071-2** | coordination of insulation |
| **IEC 62271-100** | for the circuit-breakers |
| **IEC 60470** | for the contactor |
| **IEC 60265-1** | for the switch-disconnector |
| **CEI EN 60529** | degrees of protection for the housings Classification. |

# 6. Instructions for operating the apparatus and operation sequence of the units

- **Do not remove the circuit-breaker covering panels; if necessary, keep a safe distance during apparatus opening and closing operations to avoid any contact with moving parts.**
- **The operations must be carried out with normal activating force (not more than 200 Nm), only using the special tools (see para. 6.1). Should they be prevented, make sure that the operating sequence is correct.**

## 6.1. Operating accessories and devices




Caption

1 Earthing switch operating lever
2 Circuit-breaker charging-spring lever
3 Circuit-breaker racking in/out lever
4 VT truck racking in/out lever
5 Additional left guide for VT truck racking in/out
6 Additional right guide for VT truck racking in/out
7 Operating lever raised part
8 Emergency operating lever of VM1circuit-breakers
9 Emergency operating lever of VSC contactors

**Fig. 14**

## 6.2. Apparatus racking in/out

- **Should any operation be carried out while the apparatus is withdrawn from the switchboard, pay the utmost attention to the moving parts.**
- **The apparatus must be inserted into the unit only in the open position; its racking in/out must be gradual, so as to safeguard the mechanical interlocks against any deforming impact.**

### 6.2.1. Apparatus (circuit-breakers and contactors)

The following instructions refer to HD4 circuit-breakers but they are valid for VD4 circuit-breakers and V-Contact contactors as well.

**a) Racking in**

(1) Switching from circuit-breaker withdrawn to “isolated” position

– lift the apparatus (2) (fig. 15a) and place it on the handling truck (1) (fig. 15a), following the instructions in par. 4.2. “Circuit-breaker handling by means of truck”;
– open the door of the circuit-breaker compartment;
– draw the truck close to the switchboard (fig. 15a);
– insert the hooking bracket (4) (fig. 44b - c), and block the wheels (3) (fig. 15a);
– release the circuit-breaker from the truck by moving the handles (5) at the same time (fig. 15d) towards the circuitbreaker centre axis and at the same time gradually pushing the circuit-breaker handles towards the back of the module until the circuit-breaker locks with the handles (5) (fig. 15e) clicking laterally, inserting themselves into the slots (6) (fig. 15b);
– unlock the wheels (3) (fig. 15a), lift the hooking bracket (4) (fig. 15f) and remove the truck from the switchboard.

**Make sure that the handles have tripped sideways (horizontal locks of the truck inserted in the enclosure)**

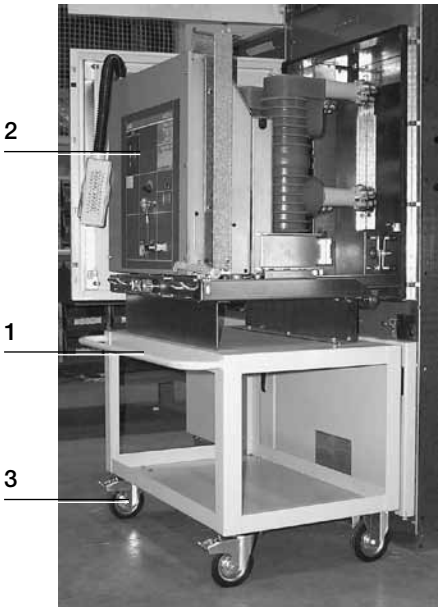



Fig. 15a

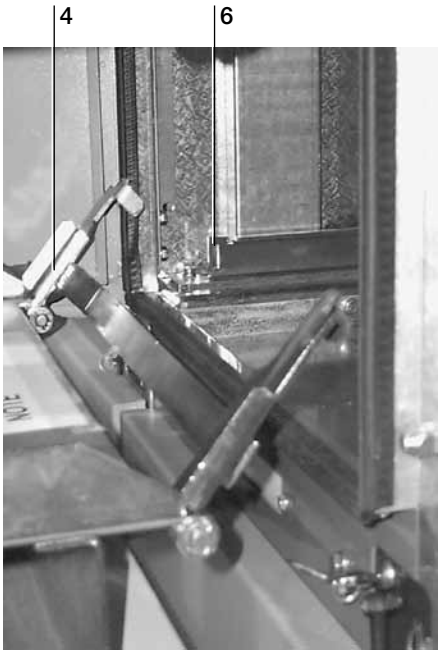



Fig. 15b

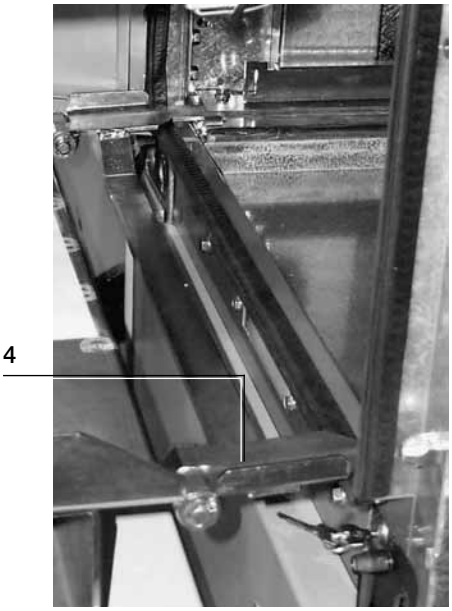



Fig. 15c

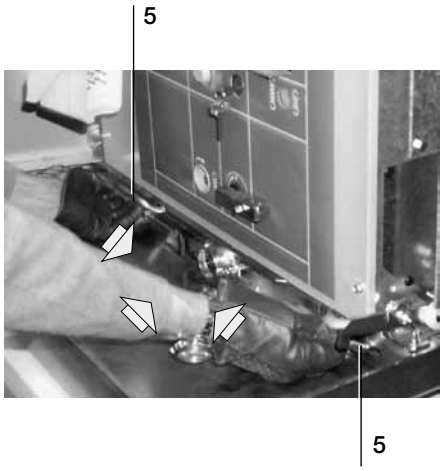



Fig. 15d

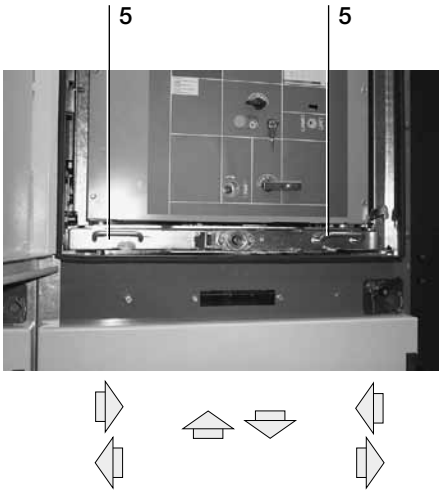



Fig. 15e

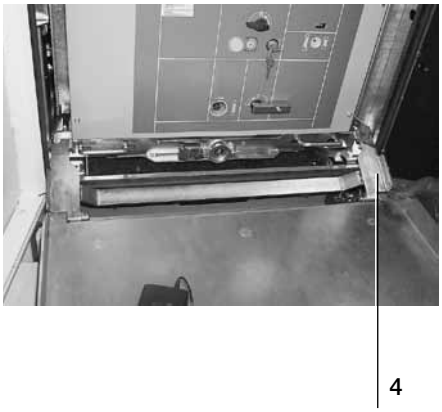



Fig. 15f

(2) Switching from “isolated” to “test” position (connection of auxiliary circuits).

– Insert and hook the mobile connector (1) (fig. 17) in the enclosure fixed socket (2) (fig. 16).

**Make sure that the lever (3) (fig. 17) is fully pushed against the connector (1) (fig. 17).**

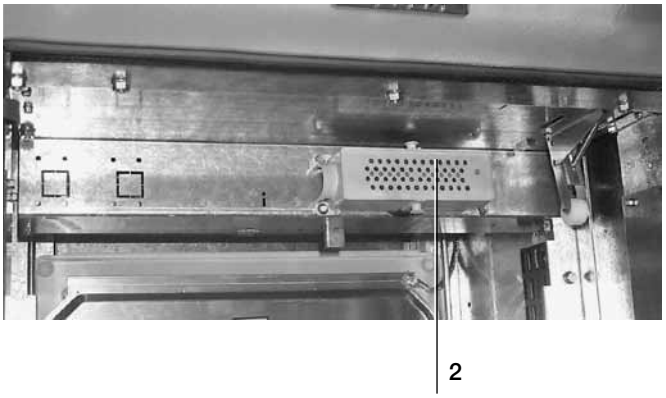



**Fig. 16**

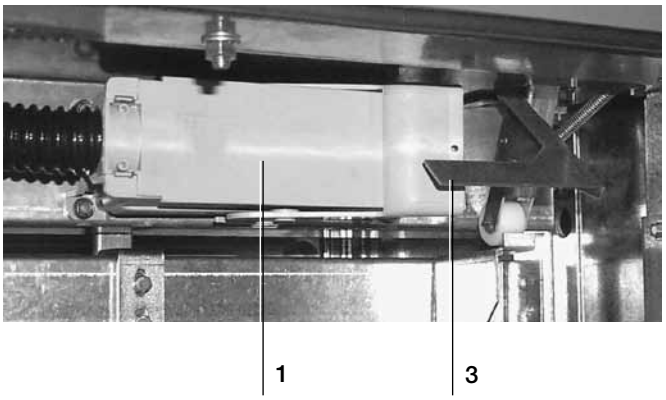



**Fig. 17**

(3) Switching from “test” to “connected” position (with earthing switch closed) (fig. 18)

– close the circuit-breaker compartment door (1) pushing the handle downwards;
– close the feeder compartment door (2) pushing the handle downwards;
– make sure that:
  • the locking electromagnet of the earthing switch is energised (if supplied);
  • the key locks (7-8-9) are disabled, if supplied;
– insert operating lever (13) into the seat of the earthing switch making the raised piece (12) coincide with one of the two slots (11);
– open the earthing switch, turning the operating lever anticlockwise (13);
– withdraw the operating lever (13) from the earthing switch seat;
– through the inspection window (6) and/or the operating seat (2 - fig. 8) for version without forced ventilation make sure that the earthing switch is open (indicator in the “O” position);

**Make sure that the feeder unit door (2) is locked (PB/M-PB/RM).**

– close the cover of the earthing switch seat by turning the actuator (10) clockwise; this operation unlocks the circuit-breaker and trips a lock for preventing insertion of the operating lever into the earthing switch;
– make sure that the locking magnet on the circuit-breaker truck (if supplied) is energised and check that the key lock for preventing insertion (if supplied) is disabled;
– fully insert the operating lever of the circuit-breaker/truck (3) (fig. 14) in the corresponding coupling (5) and turn it clockwise until the circuit-breaker is fully connected;
– through the inspection window (4) make sure that the circuitbreaker is connected.

**b) Racking out operation (only with circuit-breaker open)**

(1) Switching from “connected” to “isolated for test” position (with circuit-breaker open) (fig. 18)

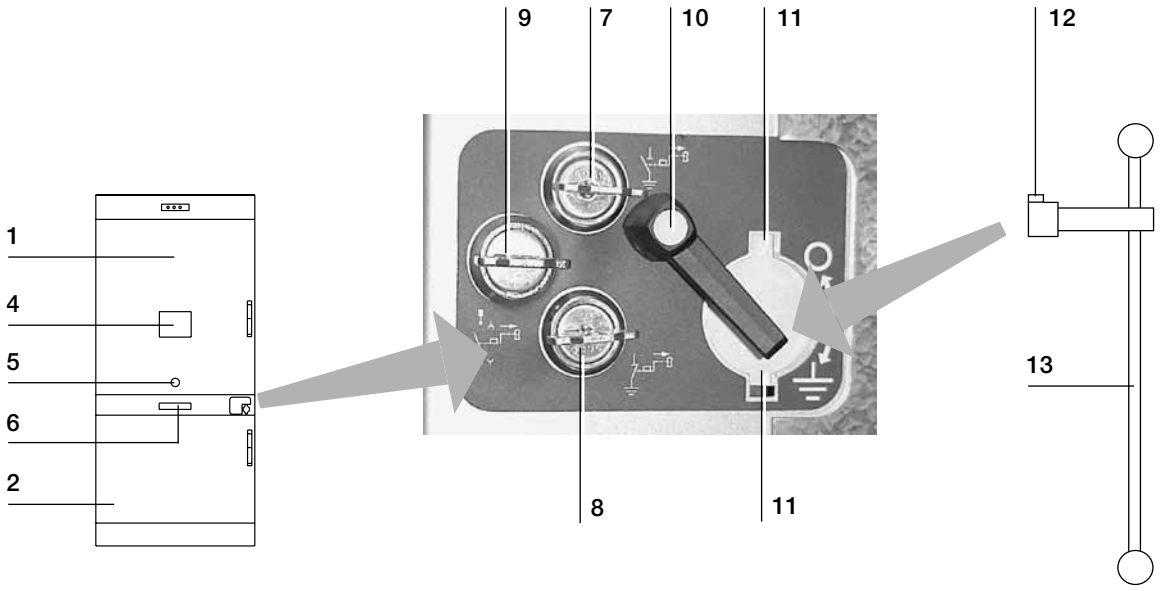
– through the inspection window (4) make sure that the earthing switch is open (indicator in the “O” position);
– fully insert the circuit-breaker truck/racking in/out lever (3) (fig. 14) in the relative coupling (5 - fig. 18) and turn it anticlockwise until the circuit-breaker stops;
– open the cover of the earthing switch operating seat by turning the actuator anticlockwise (10);
– insert the operating lever (13) in the earthing switch seat making the raised part (12) coincide with one of the two slots (11);
– close the earthing switch turning the operating lever clockwise;
– withdraw the operating lever (13) from the earthing switch seat;
– through the inspection window (6 - fig. 18) (for modules without forced ventilation) and the operating seat (2 - fig. 8) make sure that the earthing switch position indicator is in the “I” position showing closing;
– open the circuit-breaker compartment door (1) pulling the handle upwards.

(2) Switching from “isolated for test” to “isolated” position (auxiliary circuit disconnection)

– unlock the mobile connector (1) (fig. 17) and withdraw the latter from the enclosure fixed socket (2) (fig. 16);

(3) Switching from “isolated” to “withdrawn” position

– draw the truck close to the switchboard (fig. 15a);
– insert the hooking bracket (4) (fig. 15b-c) and block the wheels (3) (fig. 15a);
– move the two handles (5) (fig. 15d) at the same time towards the circuit-breaker centre and by means of the handles gradually pull the circuit-breaker outside on the truck;
– release the handles and continue withdrawal until the circuitbreaker stops (fig. 15a) and the handles trip sideways thus locking the circuit-breaker on the truck;
– unlock the wheels (3) (fig. 15a) and lift the hooking bracket (4) (fig. 15f);
– lift the hooking bracket (4) (fig. 15f) and remove the truck from the switchboard.




Caption of the earthing switch key locks

7 Lock with earthing switch open
8 lock with earthing switch closed
9 lock for preventing circuit-breaker insertion.

**Fig. 18**

### 6.2.2. VT unit (PB/M-PB/RM)

**Putting the VT truck in and out of service must be carried out with the door closed**

**a) Racking truck into the unit**

– open the unit door pulling the handle (3) (fig. 20m) upwards;
– insert the left and right additional guides (fig. 419a) in the lateral slots as in fig. 19b;
– lift the VT truck front part and insert the front wheels in the additional guides (fig. 19c);
– push the truck backwards, lift the rear part and insert the rear wheels in the additional guide slots (fig. 19d);
– push the truck backwards until it is blocked (fig. 19e);
– remove the left and right additional guides (fig. 19f);
– hook the door (fig. 20a) and insert the door earthing connection;
– tighten the door fixing screws (fig. 20b-fig. 20c);
– move the pin leftwards removing it from the slot of the operating lever (2) (fig. 20d);
– turn the lever of the door locking bolt clockwise (1) (fig. 20d);
– close the compartment door pushing the handle (3) (fig. 20e) downwards.

**b) Truck racking out operation (with compartment unit deenergised)**

– open the unit door pulling the handle upwards (3) (fig. 20e);
– move the pin rightwards to unlock the closing bolt of the VT truck front door (2) (fig. 20d);
– turn the actuator anticlockwise to lock the door bolt (1) (fig. 20d);
– loosen the door fixing screws (fig. 20b);
– remove the door (fig. 20a);
– insert through the inspection window (6) make sure that the earthing switch position indicator is in the “I” position showing closing; the left and right additional guides (fig. 19a) into the slots (fig. 19b);
– pull the truck outside until it is blocked;
– lift the truck rear part and remove the rear wheels from the additional guides (fig. 19c);
– pull the truck outside until it is blocked;
– lift the VT truck front part and remove the front wheels from the additional guides (fig. 19c);
– remove the left and right additional guides (fig. 19f);
– close the compartment door pushing the handle (3) downwards (fig. 20e).

**Note**

Use a lifting truck (fig. 20i), always positioning and moving the VT truck in the rotated position indicated in fig. 20m.

**Operation for racking the truck in/out of the unit**



**Fig. 19a**

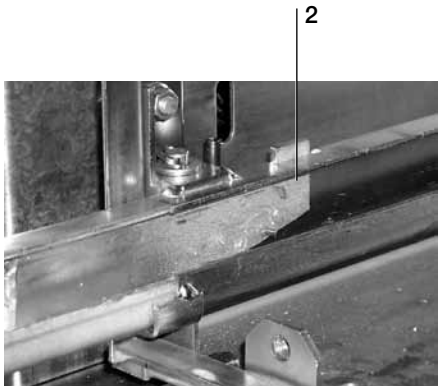



**Fig. 19b**



**Fig. 19c**

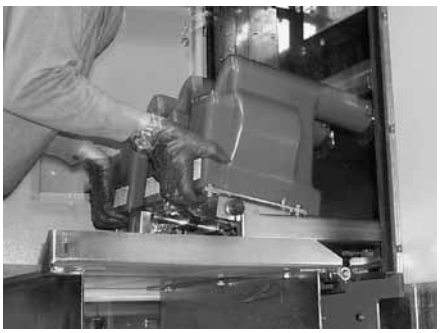


**Fig. 19d**

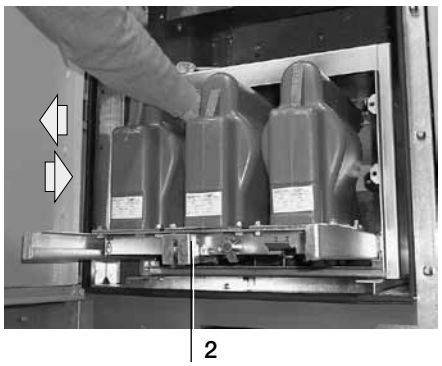



**Fig. 19e**



**Fig. 19f**

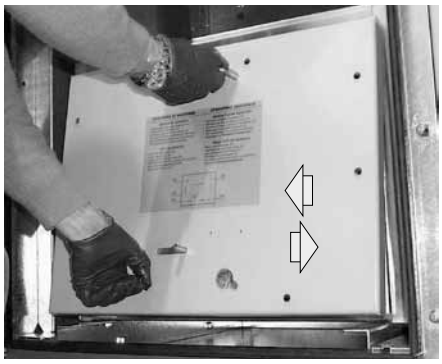


Fig. 20a

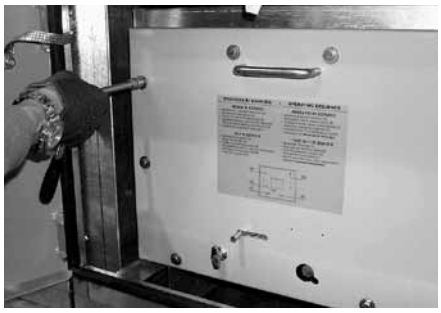


Fig. 20b

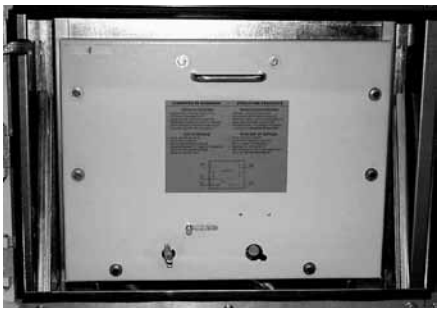


Fig. 20c

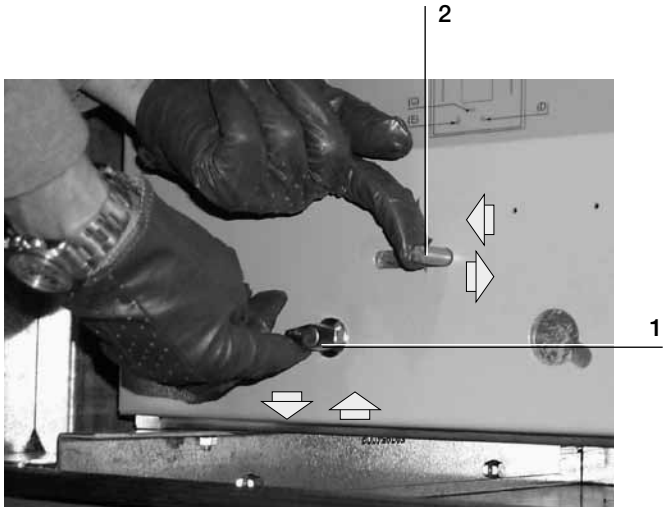



Fig. 20d




Fig. 20e



Fig. 20f



Fig. 20g



Fig. 20h



Fig. 20i



Fig.20l



Fig. 20m

## 6.3. Disabling the apparatus unit door lock

**Skilled personnel with suitable knowledge of the apparatus and installation must carry out this operation only in case of emergency.**

Should the door lock of the apparatus unit be activated and the switchboard door must be unlocked, loosen the screw (1), insert a 2-3 mm diameter rod in the hole, push the lever (2) and at the same time open the door, pulling the handle upwards.

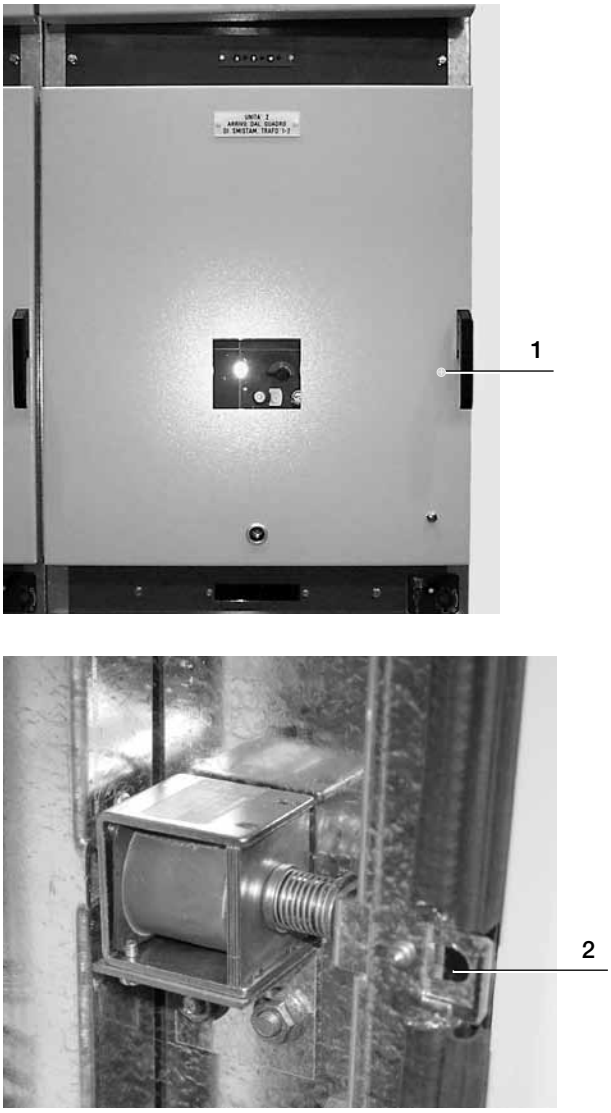



**Fig. 21**

## 6.4. Operating the apparatus

### 6.4.1. Earthing switch

- **Make sure that the earthing switch key locks (if supplied) are disabled and that the electromagnetic lock of the earthing switch (if supplied) is energised.**
- **The earthing switch can only be operated with the circuit-breaker in the isolated or withdrawn position.**
- **Once started, the operations must be completed.**

**Closing (fig. 22)**

– Make sure that the circuit-breaker is either in the isolated or withdrawn position;
– open the cover of the earthing switch operating seat by turning the operating actuator (10) anticlockwise; the earthing switch operating seat is freed;
– insert the operating lever (13) in the earthing switch seat making the raised part (12) coincide with one of the two slots (11);
– close the earthing switch by turning (13) the lever clockwise;
– remove the operating lever;
– check on the operating seat (5) and through the inspection window (6) (version without forced ventilation) that the earthing switch is closed (indicator in the "⏚" position).

**Opening**

– Insert the operating lever (13) in the earthing switch seat making the raised part (12) coincide with one of the two slots (11);
– open the earthing switch turning the operating lever anticlockwise (13);
– remove the operating lever (13) from the earthing switch seat;
– through the operation seat (5) and the inspection window (6) (version without forced ventilation) make sure that the earthing switch is open (indicator in the "O" position);
– close the cover of the earthing switch turning the actuator (10) clockwise; the circuit-breaker is thus unlocked while a lock for preventing operating lever insertion into the earthing switch is activated.

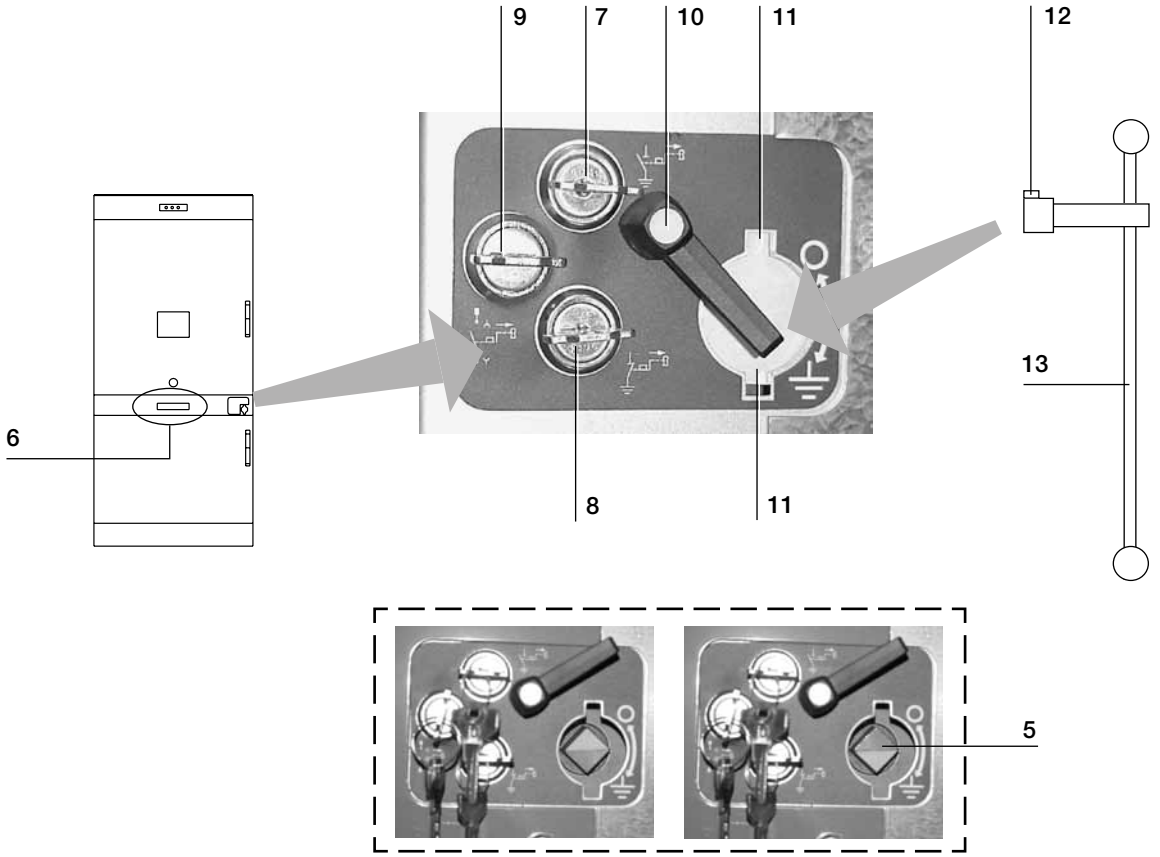
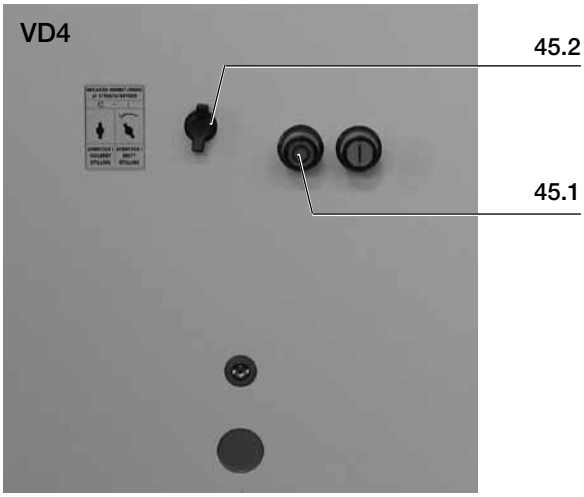
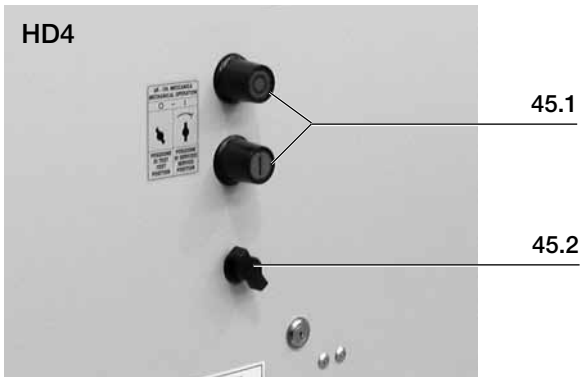



Fig. 22

### 6.4.2. Operation of HD4 - VD4 circuit-breakers with the door closed (application on request) (PB/E)

For operation of the apparatus, please also refer to the relative instruction manuals.
Pushbutton for circuit-breaker opening and closing operation with the door closed (on request). If the circuit-breaker is in the service position, the operation is carried out by rotating the knob 45.2 which takes the extension of operating rod 45.3 into position, allowing the operation by means of pressing the mechanical opening and closing pushbuttons (45.1).





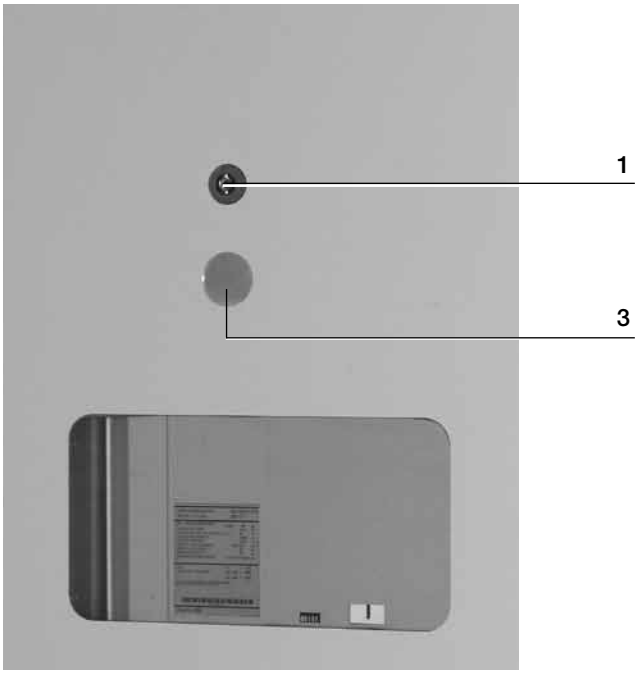

### 6.4.3. Emergency opening of VM1 circuit-breakers with the door closed

For operation of the apparatus, please also refer to the relative instruction manuals.

Opening due to fault on the auxiliary feeder:
– electrical opening is still possible within the first 200 s;
– after a period of 200 s, manual emergency opening is necessary.

Turn the small handle 1 to free the operating seat; insert operating lever 2 in the special opening so as to insert it in seat 3 and turn lever 2 until the apparatus opens.

Just before reaching the run end, a little resistance on the emergency shaft must be overcome.



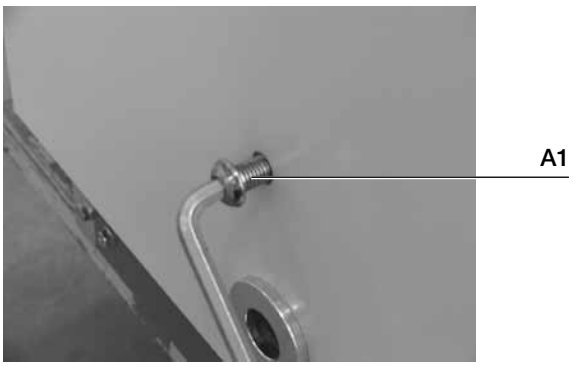




### 6.4.4. Emergency opening of VSC/P contactors with the door closed

For operation of the contactors, please also refer to the relative instruction manuals.
Unscrew screw A1 on the door using an 8 mm socket head wrench or the emergency operating lever of the contactor. Put the screw in a safe place and put the operating lever into the opening left by the screw (A1.1) inserting it in the special opening A2 on the contactor shield.
Turn the lever clockwise until the apparatus opens. Once opening has taken place, withdraw the lever and screw up the dome-headed screw on the door again.

**CAUTION!**
– Do not screw up the closing screw A1 – this would jeopardise the arc proofing of the door.









### 6.4.5. VT unit (PB/M-PB/RM)

**Putting the VT truck in and out of service must be performed with door closed.**

**a) Putting into service**

– Insert the operating lever (1) (fig. 23b) into the seat (2) (fig. 23a) making the raised piece (2) (fig. 23b) of the lever coincide with the slot (3) (fig. 23a);
– turn the lever clockwise (fig. 23c) and push hard until it is fully inserted;
– from the inserted position, turn the lever anticlockwise until the reference indicators coincide (4) and the operating lever is coupled (fig. 23d);
– make sure that by pulling the handle upwards the door does not open (fig. 23e).

**b) Putting out of service**

– Turn the lever (1) in fig. 23d clockwise and pull it outwards until the isolated position click;
– withdraw the operating lever (1) (fig. 23b) from the seat (fig. 23a) making the raised piece (2) (fig. 23b) of the lever coincide with the slot (3) (fig. 23a);
– open the door pulling the handle upwards. In this condition the VT truck is isolated and earthed and the VT auxiliary circuits are also isolated.

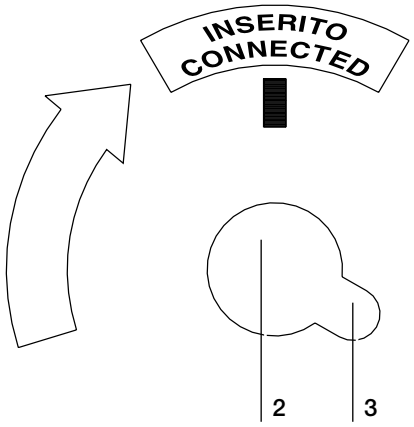



Fig. 23a

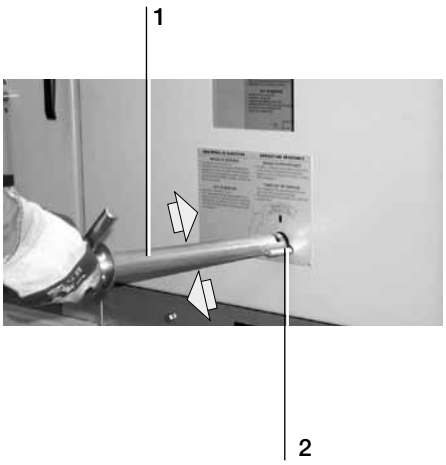



Fig. 23b



Fig. 23c

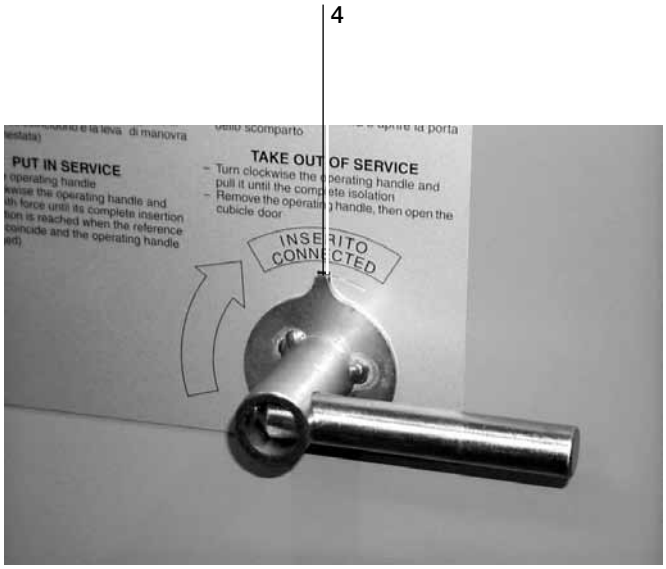



Fig. 23d



Fig. 23e

# 7. VT fuse replacement (PB/M-PB/RM)

- **All the operations below must only be carried out by qualified and skilled personnel with in-depth knowledge of the apparatus.**
- **Make sure that the rated normal current value of the fuses to be installed is the same as the one shown on the fuse-holder nameplate.**
- **Only use fuses indicated by ABB.**

**Procedure**

– Open the unit door pulling the handle (3) (fig. 24a) upwards;
– move the pin (2) (fig. 24q) right so as to unlock the closing lock bolt of the VT compartment door;
– turn the actuator of the door locking bolt anticlockwise (1) (fig. 24q);
– loosen the door fixing screws (fig. 24c);
– remove the door (fig. 24d);
– insert the left and right supplementary guides (fig. 24e);
– pull the truck outwards until it is blocked (fig. 24f);
– turn the fuse contact ring nut (fig. 24g) clockwise and remove it;
– remove the fuse and replace it (fig. 24h);
– insert the ring nut and turn it anticlockwise (fig. 24i);
– push the VT truck backwards until it is blocked (fig. 24l);
– remove the left and right supplementary guides (fig. 24m);
– hook the door (fig. 24n) and insert the door earthing connection;
– tighten the door fixing screws (fig. 24o - fig. 24p);
– move the pin leftwards thus freeing the coupling slot of the operating lever (2) (fig. 24q);
– turn the actuator of the door locking bolt clockwise (1) (fig. 24q);
– close the compartment door pushing the handle (3) (fig. 24a) downwards.

**Replacing the VT compartment fuses**

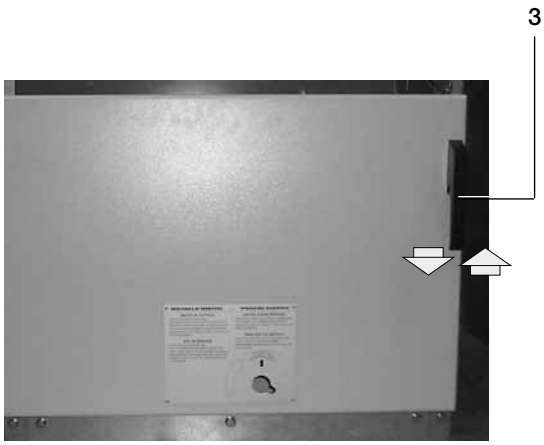



**Fig. 24a**



**Fig. 24b**

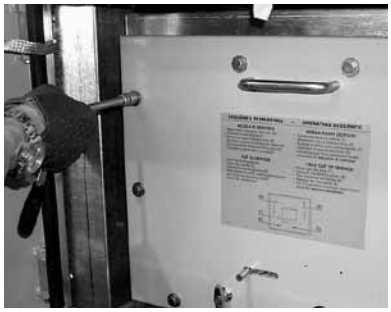


**Fig. 24c**

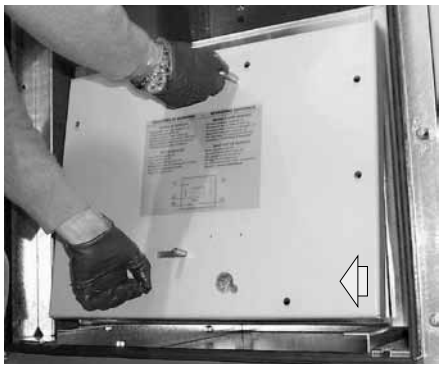


Fig. 24d



Fig. 24e



Fig. 24f



Fig. 24g

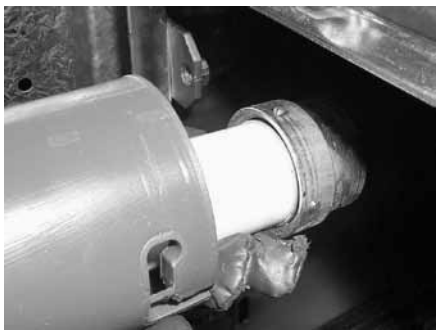


Fig. 24h



Fig. 24i



Fig. 24l



Fig. 24m

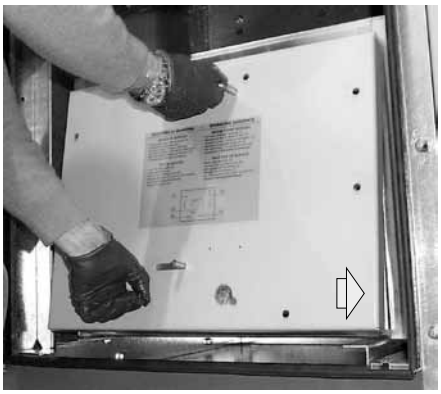


Fig. 24n

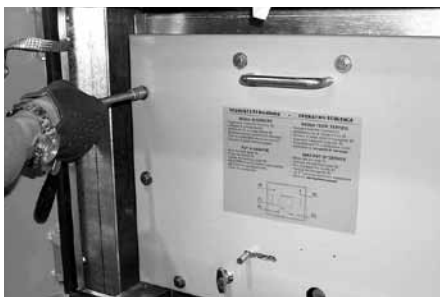


Fig. 24o



Fig. 24p

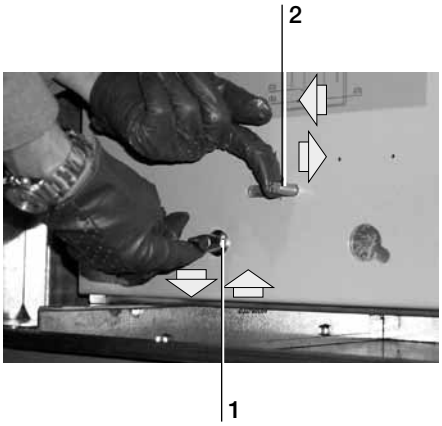



Fig. 24q

# 8. Installation

## 8.1. General information

- **Correct installation is of paramount importance. The instructions given by the manufacturer must be thoroughly studied and followed.**
- **Installation must be carried out by skilled personnel with in-depth knowledge of the apparatus.**
- **It is advisable to wear gloves for handling the components.**
- **Before removing the operating mechanism cover make sure that the circuit-breaker is open and the closing springs discharged.**

## 8.2. Normal installation room conditions

| | |
|---|---|
| Maximum air temperature | + 40 °C |
| Minimum air temperature | – 5 °C |
| Relative humidity | % ≤ 95 |
| Altitude | ≤ 1000 |

**For shipping reasons, the gas pressure in the HD4 circuit-breakers can be reduced. In this case, before putting the apparatus into service recover the pressure using SF6 gas in compliance with the CEI 10-7 - IEC 60376 Standards.**
**Filling with gas must be carried out by ABB personnel or by suitably qualified customer personnel with indepth knowledge of the apparatus.**

For any special conditions, please contact us.
For other installation room characteristics, please refer to the product standards (IEC 60694).
For any special conditions, please contact us.

## 8.3. Foundations and fixing surface (PB/M-PB/RM)

The floor or the foundation must be strong enough to bear the weight of the module (plus all the apparatus) without any deformation.
The general foundation drawing is shown in fig. 25a.
The switchboard can be fixed (fig. 25b) either to the floor or to special base irons (supplied on request):
– for floor fixing put the expansion and anchoring bolts in the fixing holes;
– special bolt blocks are supplied for base iron fixing. The base irons must be fixed and buried in concrete.

The base of each module is prepared with four fixing holes. For switchgear positioning, the planarity of the fixing surface must be checked, with special attention paid to longitudinal levelling (maximum planarity: 2/1000).

### 8.3.1. Module fixing systems (fig. 25b)

**Fixing with base irons and masonry floor**

The base irons, which can be supplied on request, must be installed in the slab before finishing the floor:
– rest the irons on the floor and line them up so that they are parallel and are spaced from each other as shown in the foundation drawing;
– level the irons both longitudinally and transversally;
– fix the base irons in this position with expansion anchor bolts, using the holes provided in the irons;
– complete the flooring so that the base irons extend out at least 0.5 mm from the finished floor surface.

**Fixing to floor with anchoring and masonry floor**

**Procedure**

– Clean the installation area;
– on the slab, visibly trace the perimeter of all the cubicles making up the switchboard, taking the minimum wall and obstacle clearances into account;
– level the floor both longitudinally and transversally;
– drill the floor at the fixing points foreseen, referring to our slab drilling drawings. To make the holes, use a hammer drill with a Ø = 16 mm bit;
– insert the expansion anchoring bolts in the holes.

**Fixing to a floating floor**

**Procedure**

– Clean the installation area;
– on the slab, visibly trace the perimeter of all the cubicles making up the switchboard, taking the minimum wall and obstacle clearances into account;
– drill the floor at the fixing points foreseen, referring to our slab drilling drawings. To make the holes, use a drill with a suitable bit for the type of fixing to be made (through or threaded hole).

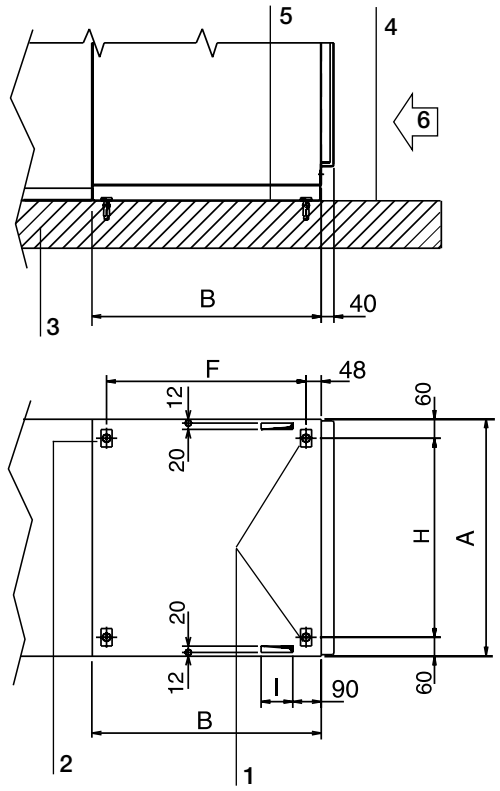
## 8.4. Tightening torque

The screw and nut tightening torque values for fixing and coupling switchboards and busbars are given in the table below.

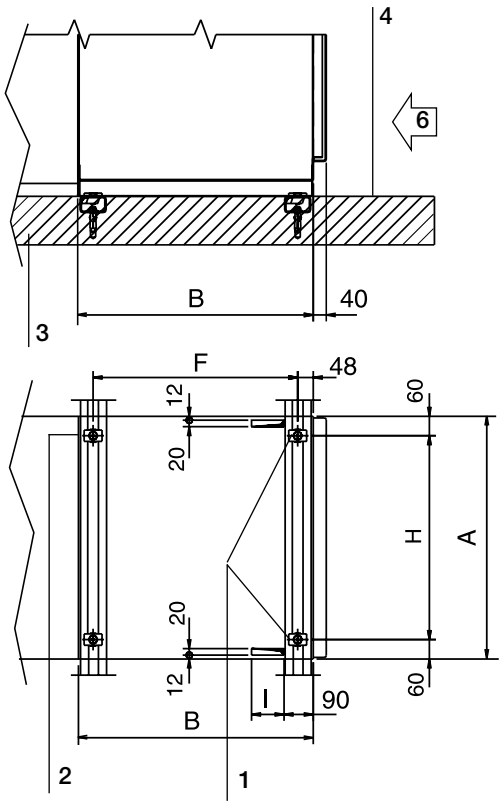
| Nut or screw | Tightening torque (Nm) | | Key for exhagonal nut or screw |
|---|---|---|---|
| | Acc. 4.8 | Acc. 8.8 | |
| M3 | 0.5 | 1.2 | 5.5 |
| M4 | 1.1 | 2.7 | 7 |
| M5 | 2 | 5 | 8 |
| M6 | 3.7 | 9 | 10 |
| M8 | 9 | 22 | 13 |
| M10 | 18 | 45 | 17 |
| M12 | 30 | 75 | 19 |
| M16 | 75 | 185 | 24 |
| M18 | 104 | 260 | 27 |
| M20 | 148 | 370 | 30 |

### Foundations

**Version with anchoring bolts**




**Version with base irons**




| Module | A | B | F | H | I |
|---|---|---|---|---|---|
| 12-17.5 kV | 600 | 723 | 630 | 480 | 200 |
| | 750 | 723 | 630 | 630 | 200 |
| | 1000 | 723 | 630 | 880 | 200 |
| 24 kV | 750 | 873 | 770 | 630 | 200 |
| | 1000 | 873 | 770 | 880 | 200 |

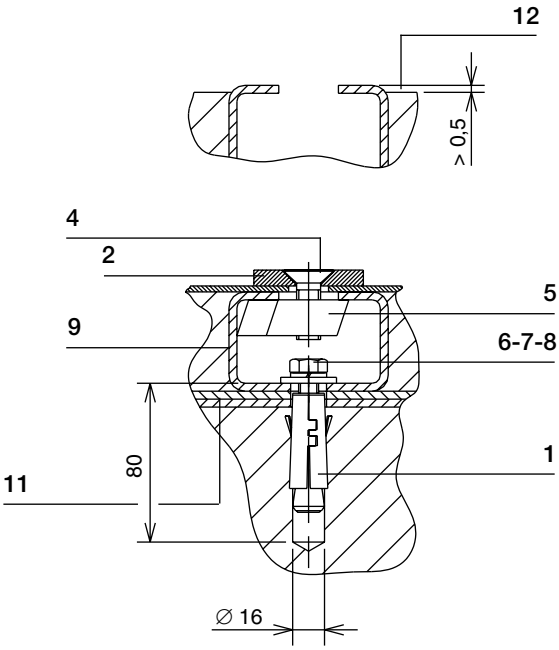
Caption

1 Passage of auxiliary circuit cables
2 Slot for module fixing
3 Slab
4 Finished floor surface
5 Module base sheet
6 Module front

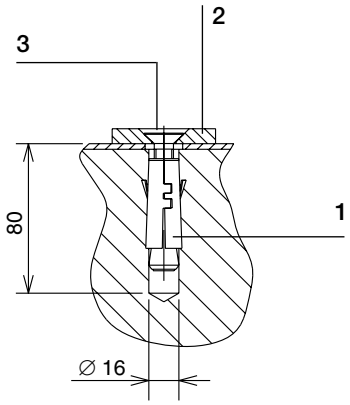
**Fig. 25a**

## Masonry floor

**Version with base iron**

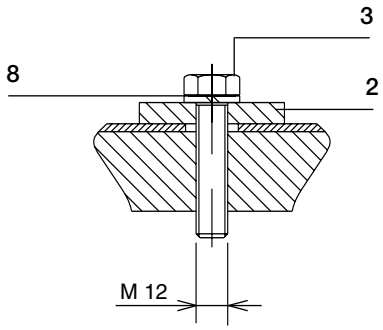



**Version with anchoring bolts**

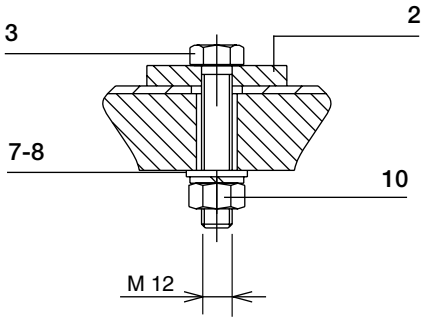



## Metal structure

**Version with threaded hole**




**Version with through hole**




Caption

1 Anchoring bolt
2 Plate
3 Screw
4 Screw
5 Block
6 Hexagonal-head screw
7 Washer
8 Spring washer
9 Steel section
10 Nut
11 Level by means of suitable shims (not supplied)
12 Floor level

**Fig. 25b**

## 8.5. Access from the front to the cable connection area (PB/M)

### 8.5.1. Access through the feeder unit

**Circuit-breaker racking out**

Follow the instructions given in para. 6.2.

**Dismantling the panels**

**Disconnect the fan power supply in the case of units with forced ventilation.**

**Procedure**

– Loosen the fixing screws of the front panel (fig. 26a)
– loosen the two fixing screws (right side) of the circuit-breaker compartment panel (fig. 26b)
– loosen the two fixing screws (left side) of the circuit-breaker unit panel (fig. 26c)
– lift and remove the circuit-breaker unit panel (fig. 26d)
– access the cable connection area of the unit (fig. 26e).

### 8.5.2. Access through the VT unit

**Racking the VT truck out**

Follow the instructions in para. 6.2.

**VT compartment dismantling**

– Loosen the fixing screws (right and left side) of the VT unit (fig. 27b-27c);
– move the guides (right and left) against the switchboard walls (fig. 27d);
– loosen the panel fixing screws on the switchboard base (fig. 27e).
– loosen the fixing screws of the VT unit base (fig. 27f-27g);
– withdraw the VT unit as in fig. 27h;
– position the VT unit as in fig. 27i.

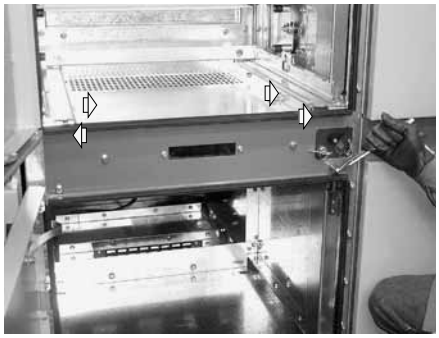


Fig. 26a



Fig. 26b



Fig. 26c



Fig. 26d



Fig. 26e



Fig. 27a

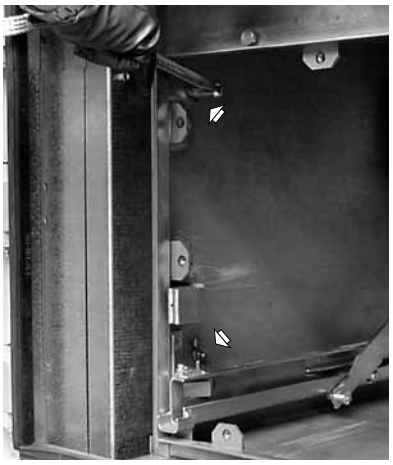


Fig. 27b



Fig. 27c

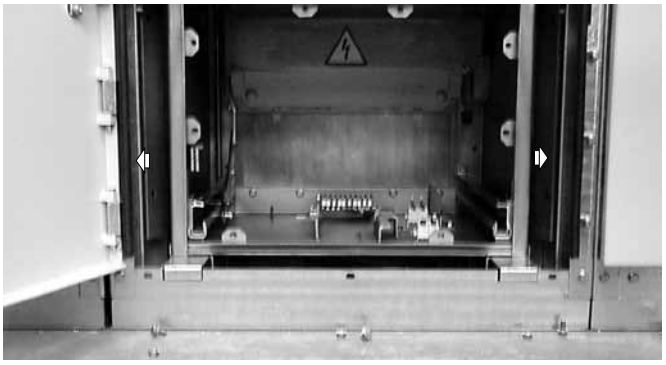


Fig. 27d

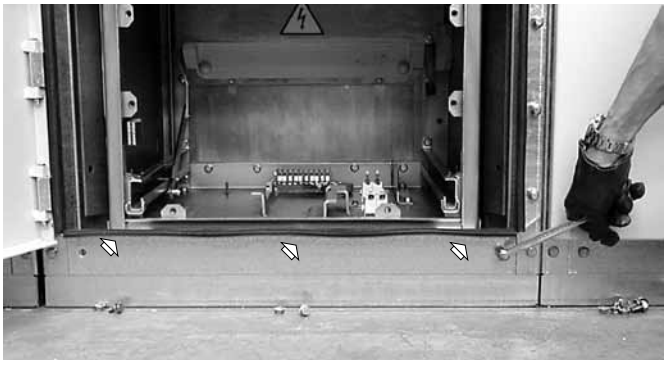


Fig. 27e



Fig. 27f

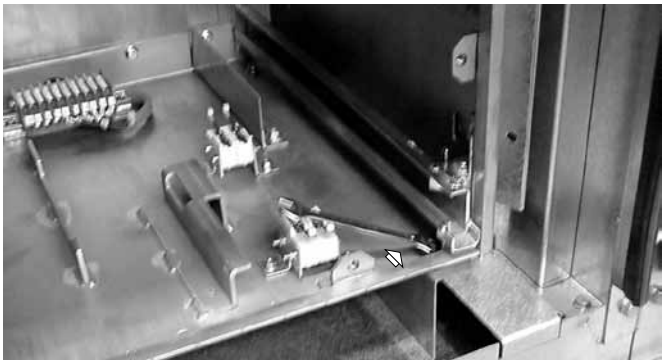


Fig. 27g



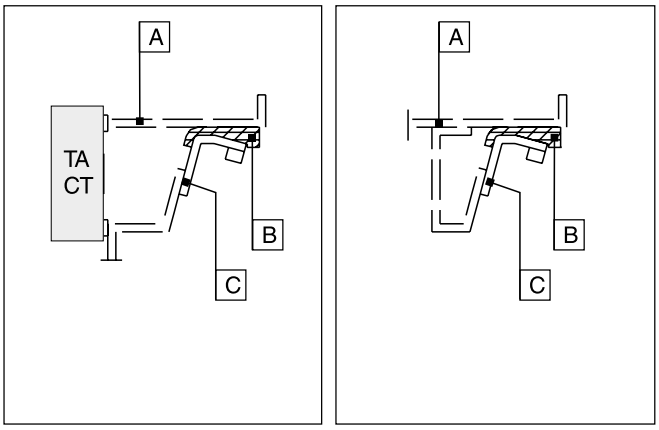
Fig. 27h



Fig. 27i

### 8.5.3. Connection of the lower terminals for units with earthing switch (with and without CT).

**The PowerCube units are preset for connection of the CTs between the A and C contacts of the lower terminals.**
**If this is not done, connect contacts A and C to each other using a conductor with the same cross-section as the one in detail C.**
**In both cases, the connection must be made - by the customer - respecting the geometry indicated in the figure so that the making capacity of the earthing switch is guaranteed.**




Caption
A = Lower terminal
B = Insulating support
C = Fixed contact

**Fig. 27I**

## 8.6. Hints on constructing switchgear units with 4000 A rated current

The PowerCube modules are provided for rated currents up to 3600 A, but can also be used to construct switchgear units with rated current up to 4000 A.
This can be done thanks to applying a special fan in the rear part of the unit.
The characteristics of the fan used are listed below. This fan can be ordered as an accessory for the 3600 A enclosure. Assembly is to be carried out by the customer. In any case, certification of the completed switchgear remains the responsibility of the customer.

### Fan characteristics

| | | | 50 Hz | 60 Hz |
|---|---|---|---|---|
| Frequency | f | Hz | 50 | 60 |
| Rated voltage | U | V | 230 | 230 |
| Power consumption | $P_1$ | W | 270 | 280 |
| Speed | n | $min^{-1}$ | 2470 | 2600 |
| Capacity | C | µF | 6 | 6 |
| Max air volume | V | $m^3/h$ | 1180 | 1240 |
| Minimum pressure | | | 80Pa | 80Pa |

### Performance curve

We suggest putting the fan in the position shown in the figure 28b.

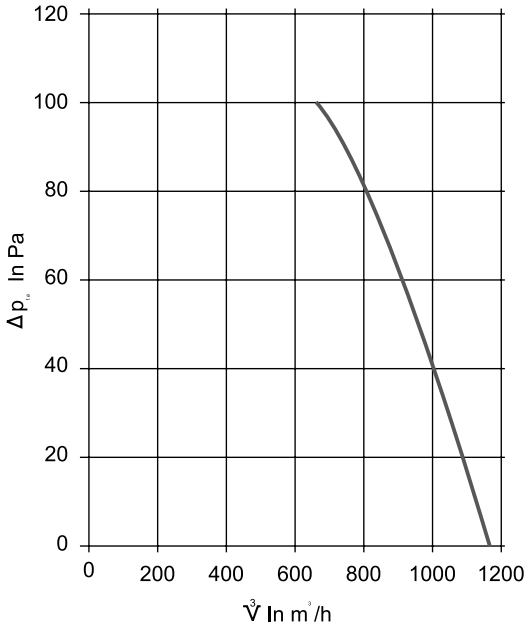
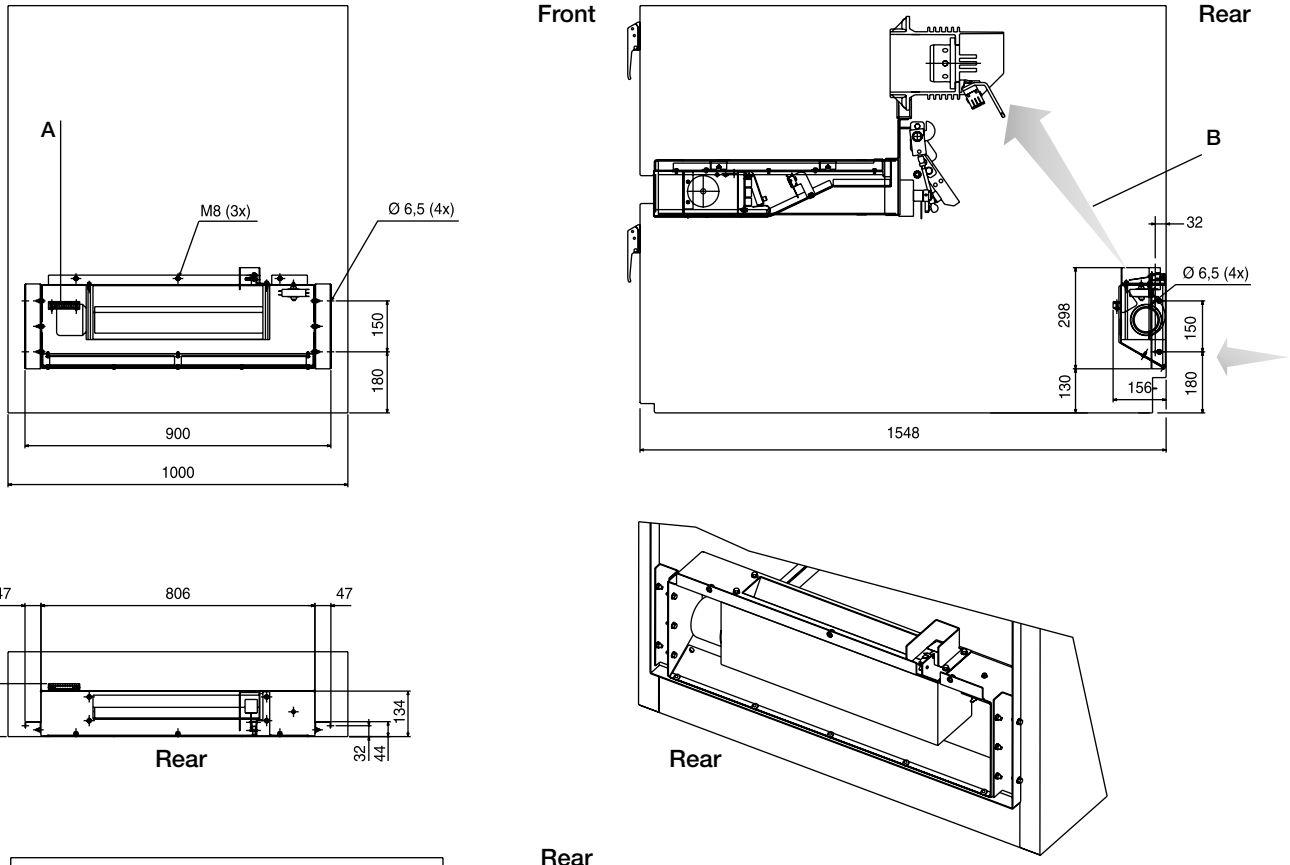



**Fig. 28a**




**Note**

The back of the switchgear shown in the figure is purely indicative and refers to the ABB PowerCube version. The arrows indicate the recommended direction for the air flow.

A Auxiliary circuits connector

B Air flow

C No. 4 slots

D No. 80 slots

E Rear sheet steel cut out of the panel

**Note**

We recommend the following procedures for turning the fans fitted on the PowerCube modules on and off.

**PowerCube Modules PB3 12-17 kV / 3600-4000 A**

Turning fans on if at least one phase exceeds the following current thresholds:

– 3000 A: delay of 60 s and consequent turning on of just the front fan
– 3600 A: delay of 60 s and consequent turning on of the rear fan as well as the front one

Turning fans off if all the phases drop below the following current thresholds:

– 3500 A: delay of 300 s and consequent turning off of just the rear fan
– 2900 A: delay of 300 s and consequent turning off of the front fan.

**PowerCube Modules PB5 24 kV / 2500 A**

Turning the fans on if at least one phase exceeds the 2250 A threshold: delay of 60 s and consequent turning on of the front fan.

Turning fans off if all the phases drop below the 2150 A threshold: delay of 300 s and consequent turning off of the front fan.

**Fig. 28b**

# 9. Putting into service

- **All operations for putting into service must be carried out by skilled personnel.**
- **Should the operations be prevented, do not force the mechanical interlocks but make sure that the operating sequence is correct.**
- **Before opening the door check the apparatus position through the inspection windows.**

Before putting into service, all the apparatus installed must be checked and tested as prescribed below, bearing in mind that in case of special installation configurations, **the tests indicated in the table may have to be integrated with others which are to be established by the plant technical manager.**

## 9.1. Preliminary operations

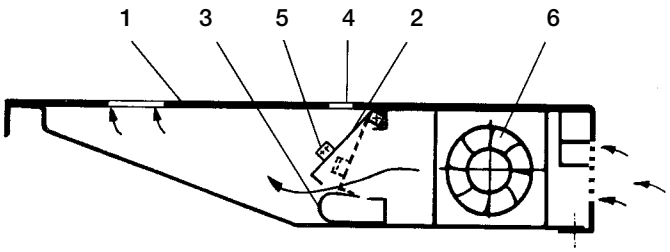
– Make sure there is no evident damage and remove any foreign bodies;
– make sure that the internal metal segregations (if supplied) are present;
– make sure that any insulating barriers or hoods previously removed have been remounted;
– check connection tightness;
– make sure that the sheets have been properly mounted and have not been deformed;
– make sure that all the metallic frame screws have been properly tightened;
– thoroughly clean the sheets and the insulating components by means of brushes and clean, dry cloths. Avoid any compressed air blasts unless they are dry and free of lubricating oil;
– remove dust and dirt from any air vent grids and ventilation ducts;
– for the units with 3600 A and 4000 A circuit-breaker up to 17.5 kV and 2500 A up to 24 kV, check operation of the fan and the free movement of the internal flap (see fig. 29);
– make sure that the vacuum interrupters of the V-Contact contactor and VD4, Vmax, VM1, eVM1 circuit-breaker have not been accidentally damaged, **in case of doubt do not hesitate to contact us;**
– insert the apparatus into the compartments in the isolated position with the apparatus open and insert the auxiliary instrument connectors;
– power the auxiliary circuits;
– make sure that the value of the circuit power supply ranges between 85% and 110% of the apparatus rated voltage value.

If all the above tests have been successful, carry out the inspection and testing procedures indicated in para. 11.2. **Should any problem arise, do not hesitate to contact us.**

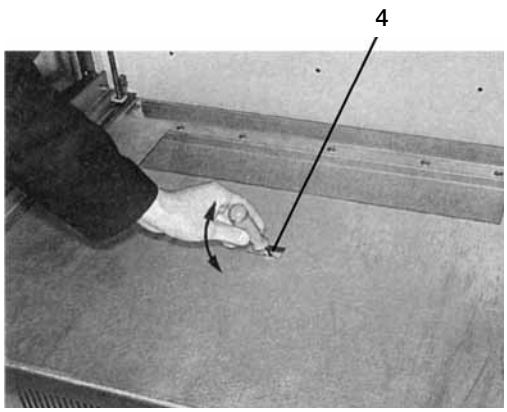
## 9.2. Measurements and tests

Carry out the tests indicated below only after performing the preliminary operations prescribed in para. 9.1.

- **The check is only successful if all the above tests have been passed successfully.**
- **If the inspection gives negative results, do not put the apparatus into service but contact us if necessary.**
- **Only supply the module with circuit-breakers open and doors closed.**




1 Horizontal surface
2 Flap
3 Spring hook
4 Opening for inspection
5 Stop
6 Centrifugal fan




**Lateral view of fan application.**
**The internal flap is shown in the service position (open).**

**Fig. 29**

| Subject of inspection | | Procedure | Positive test |
|---|---|---|---|
| 1 | Insulation resistance. | Main circuit: by means of a 5000 V Megger, measure the insulating resistance between phases as well as between phases and the exposed conductive part. | The insulation resistance value should not be lower than 1000 MΩ and constant in time. |
| 2 | Industrial frequency voltage test. | Main circuit: the voltage test is performed after installation in order to check the busbar duct connection insulation. The voltage test value must reach 80% of the test value prescribed for the individual tests (IEC 60271-200) | No electrical discharges should occur. |
| 3 | Electrical functionality test. | Supply the auxiliary circuits and perform some operations. | Normal operations and signals. |
| 4 | Open/closed control indicator. Operation counter (if supplied). | Put the apparatus in the isolated for test position and perform a few openings and closings. | Normal operations and signals. |
| 5 | Apparatus operations. | With the apparatus open, close the enclosure door and perform racking in, carry out a few openings and closings. | Normal operations and signals. |
| 6 | Electromechanical door interlock with apparatus in the inserted and intermediate positions (if supplied). | With the door closed, insert the apparatus first partially and then fully.i. | The door must not open after about two handle turns. |
| | | Isolate the truck and try to open the door. | The door opens. |
| 7 | Mechanical and electrical lock for preventing apparatus closing in the position between connected and isolated. | Put the truck in the intermediate position between isolated and connected. Attempt contactor closing. | Closing is not possible. |
| 8 | Lock for preventing racking in between apparatus with different characteristics. | From the withdrawn position, try to insert the plug into the socket. | Insertion is not possible. |
| 9 | Truck locking electromagnet. | De-energise the electromagnet and try to move it using the relevant handle. | The truck does not move. |
| 10 | Mechanical lock for preventing apparatus racking in/out when closed. | Put the truck in the isolated position, close the apparatus and try the racking in operation. | The operation is not possible. |
| 11 | Key lock for preventing racking in (if supplied). | With the contactor in the isolated position, turn the key 90° | Apparatus racking-in is prevented after about two handle turns.<br>The key can be removed. |
| 12 | IEC lock with plug-socket. | With apparatus racked in and in the positions between connected and isolated. | The plug-socket cannot be removed. |
| 13 | Shutter mechanical lock when the apparatus is withdrawn (if supplied). | With apparatus withdrawn try to manually move the shutters. | It is not possible to open the shutters. |
| 14 | Key lock for preventing earthing truck racking in (if supplied). | Trip the lock turning the key 180° and remove it. | The earthing truck cannot be inserted switching from the withdrawn to the isolated position. |
| 15 | Earthing switch (if supplied). | With isolated apparatus, close the earthing switch and re-open it. | The operation is possible. Check that the position signalled on the circuit-breaker front is correct. |
| | | Try to close the earthing switch with the apparatus inserted. | The earthing switch cannot be closed. |
| | | Try to insert the apparatus with isolated apparatus and earthing switch closed. | The operation is prevented after about two handle turns. |
| | | Try to operate the earthing switch with the apparatus in the intermediate position between isolated and connected. | The earthing switch operating lever cannot be inserted. |
| 16 | Key lock for earthing switch open (if supplied). | Turn the key 90° with apparatus isolated, earthing switch open and lever withdrawn. | The earthing switch operating lever cannot be inserted. |
| 17 | Key lock for earthing switch closed (if supplied). | Turn the key 90° with apparatus isolated, earthing switch closed and lever withdrawn. | The earthing switch operating lever cannot be inserted. |
| 18 | Double key lock for earthing switch open and closed (if supplied). | Turn the key 90° with apparatus isolated, earthing switch closed and lever withdrawn. | The earthing switch operating lever cannot be inserted. |
| 19 | Earthing switch electromechanical lock (if supplied). | With earthing switch open or closed and lock deenergised. | The earthing switch operations are not possible. |
| 20 | Operating pushbuttons with the apparatus door closed (if provided). | For HD4 and VD4, carry out the opening and closing operations using the pushbuttons.<br>For VM1 and contactors carry out the emergency opening operation. | The operations are normal. |

After performing the tests, make sure that all normal service conditions are restored.
Check that all the mechanical and electrical locks, (if deenergised to carry out the putting into service tests with switchboard disconnected) have been restored.

# 10. Periodic checks

- **The periodic checks must be carried out by skilled personnel.**
- **Before carrying out any operation, make sure that the apparatus is open with springs discharged.**
- **Before opening the door check the apparatus and earthing switch positions through the inspection windows.**

## 10.1. General information

During normal service the modules are maintenance-free. Any possible intervention depends on specific installation aspects such as operation frequency, interrupted current value, power factor and ambient conditions.
As a precaution, the paragraph below shows the inspection programme table with the relevant periodic checks. At least for the first check, it is advisable to follow what is specified in the table.
According to the results obtained, establish the best interval for subsequent operations.
It is advisable to keep a maintenance card and a service book containing all the operations performed along with date, description of possible anomalies, reference to the data needed to identify the apparatus (see chapter 2) etc.
For further information, refer to article 10 of IEC 60694 Standards.
In any case, should there be any problems, do not hesitate to contact us.
It is recommendable to perform an inspection within one year from putting the apparatus into service.

## 10.2. Inspection programme

| Subject of inspection | | Time intervals | Procedure |
|---|---|---|---|
| 1 | Carry out two mechanical closing and opening operations of the apparatus. | 3 years and in any case after a time not exceeding the one specified. | Check operation and transmission functionality. The apparatus must work normally without stopping in intermediate positions and the torque applied must not exceed 200 Nm. |
| 2 | Visual inspection of insulating parts. | 3 years and in any case in relation to the environmental pollution. | Insulating parts must be free from dust, dirt, cracks, traces of surface discharges and damage. Remove any dust and dirt by means of a vacuum cleaner and dry, clean cloths. |
| 3 | Auxiliary contacts. | 3 years. In any case, refer to the specific manuals of the apparatus. | Check functionality and signals. |
| 4 | Auxiliary circuit conductors. | 5 years. | Check whether any cabling strap is loose or broken and connection tightness. |
| 5 | Interlocks. | 3 years. | Check device functionality. |
| 6 | Visual inspection of earthing switch contacts. | 5 years. | Check that contacts are not deformed, eroded or oxidised. Lubricate the contacts with Molydal EL/5 (Industrial Service) grease or Vaseline. |
| 7 | Apparatus springs. | 5 years. In any case, refer to the specific manuals of the apparatus. | Check that the seal placed on the spring register is intact. |
| 8 | Power connections. | 3 years. | The connections must be tight and have no traces of overheating or oxidisation. |
| 9 | Insulation resistance measurement. | 3 years. | See para. 9.2. (table). |

**For the routine checks and maintenance of apparatus and protection devices, please refer to the relative instruction manuals.**

# 11. Maintenance operations

- **Maintenance must be carried out either by our personnel or by qualified skilled personnel. Should the customer's personnel be in charge of maintenance, the customer is responsible for any operation performed on the apparatus.**
- **While performing routine checks and maintenance operations, de-energise all the components.**
- **The spare parts shown in the table "List of spare parts/accessories" can only be replaced by our personnel. For the apparatus, consult the relevant manuals.**
- **Use original spare parts only.**

## 11.1. General information

Thanks to their simple design, PowrBox modules do not require any particular maintenance except for the "Periodic checks" in paragraph 10.
In order to avoid any hazardous deterioration of the insulating level, it is advisable to perform the first inspection six months after putting into service so as to establish the routine check intervals and the maintenance card.
Moreover, it is recommendable to follow the instructions for the single items according to the instruction manuals supplied with the apparatus.
It is advisable to keep a maintenance card and a service book containing all the operations performed along with date, description of possible anomalies, reference to the data needed to identify the apparatus (see chapter 2) etc.
For further information, refer to article 10 of the IEC 60694 Standards.
Should you have any problems, do not hesitate to contact us.
The electrical apparatus is easily affected by ambient conditions and can be damaged by abnormal service conditions.
Dust, heat, humidity, corrosive atmosphere, chemical residues, fumes, vibrations and other elements can influence apparatus and the life of the electrical apparatus.
Especially when combined, these conditions cause premature faults.
The most important rules to follow are:
– keep clean;
– keep dry;
– tighten bolts and connections;
– preserve the mechanical parts from excessive friction.

The instructions concerning the operations to be carried out on the various parts of the module, excluding the apparatus for which the relevant instruction manuals should be referred to.

## 11.2. Metallic structure

This comprises the supporting construction complete with removable panels, vertical and horizontal segregating sheets, hinges, doors and locks.
These parts can either be galvanised or painted.

### Painted parts

The module doors are painted using epoxy powder paints whose minimum thickness is more than 40 µm.

### Painting

Any damage, scratches or scrapes caused to the module external paint during installation can be touched up using the paint supplied with the special paint.

### Touching up

On request, sufficient paint for touching up after installation can be supplied with the module. For its use follow the paint supplier's instructions. If these are not available, proceed as follows:

– clean the part to be touched up with damp abrasive paper and smooth off the edges of the damaged area;
– prepare the necessary amount of paint adding some catalyst (30% of the paint by weight);
– try the paint on a piece of sheet first and see the result. Any brush marks can be reduced by adding more solvent to the paint, which can be kept in the fridge for about 24 hours before it solidifies.

### Cleaning

The painted components can be cleaned using either a cloth with water and soap or a paint solvent when very dirty. In this case, try the solvent on a surface out of sight to make sure it doesn't remove the paint coating.

### Galvanised components

The galvanised and passivated components can be cleaned by means of a dry cloth.
Oil and grease can be removed using a cloth soaked in a suitable solvent. To polish the surface, repeat the previous operation.

## 11.3. Mechanical actuators

The mechanical actuators comprise all the mechanical parts of the module for carrying out the operations, locks and safety devices. The force, prevention and safety locks are all considered mechanical actuators.
The moving components are lubricated and tested while assembling the switchboard. Contact our personnel for mounting any accessories on a switchboard already installed.

**The mechanical interlocks must not be ignored, but used properly so as to avoid any hazardous situations.**

The mechanical interlocks must reach the final locked/unlocked positions without any intermediate stops.
They must be tested several times to check that they operate perfectly. The operating force required must also be checked.
Always make sure that the mechanical interlock position corresponds with the position of both the part controlled device and with the interlocked apparatus.
If excessive force is required to activate the device it means that the mechanism is prevented from moving.
In this case, please contact us.

# 12. Accessories and spare parts

- **Either our personnel or qualified skilled customer personnel must mount the spare parts and/or the accessories carefully following the instructions enclosed.**
- **Before performing any operation make sure that all the apparatus is open and de-energised (main circuit and auxiliary circuits).**

To order spare parts or accessories, always specify the serial number of the modules in which the spare parts are to be installed.
For any enquiry about spare part availability and ordering, please contact us.

## 12.1. Accessories and tools for operations

**Standard completion accessories:**

The module is usually supplied complete with:
– operating lever for any earthing switches;
– emergency opening lever for VM1circuit-breaker and VSC contactor.
– handle for circuit-breaker racking in/out;
– project diagrams and drawings;
– instructions for installation, service and maintenance;
– auxiliary position contacts (5 isolated changeover contacts plus 5 connected changeover contacts).

**Completion items and accessories on request**

On request, the module can be completed with supply of the following accessories:
– lifting eyebolts;
– truck for transporting the circuit-breaker out of switchboard;
– auxiliary contacts for signalling earthing switch open/closed (5-10 closing contacts plus 5-10 opening contacts);
– voltage indicators;
– anti-condensation heaters and thermostat (rated voltage values: 110-220 V);
– opening and closing pushbutton for VD4-HD4 circuit-breakers (to be specified at the time of ordering because they cannot be applied afterwards (only for PB/E);
– rear fan;
– electro-mechanical lock on the earthing switch

**Other components**

– shutter Fail-safe device;
– contact for signalling connected and key lock on earthing truck insertion
– electromechanical interlock on circuit-breaker unit door.

## 12.2 . Spare parts

For the apparatus, refer to the relative installation, service and maintenance instructions.
The module spare parts normally supplied as a rule are listed in the table below.

| Description of spare part | Assembly by the customer |
|---|---|
| Earthing switch | No |
| Auxiliary contacts for limit switch inserted | Yes |
| Auxiliary contacts for limit switch isolated | Yes |

For more information please contact:

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1VCD601263 -Rev. -, en - Instruction Manual - 2013.09 (PowerCube) (gs)

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# V-Contact VSC

## Medium voltage vacuum contactors



V-Contact VSC are the motor and capacitor switching solution, suitable for controlling electrical apparatus in industry, service, marine sector, etc.
The V-Contact VSC contactor uses the drive with permanent magnets, widely used, experimented and appreciated in medium voltage circuit breakers. Thanks to the breaking technique with vacuum interrupters, they can operate in particularly difficult environments.

# Table of contents


**004**–007 **V-Contact VSC: its strengths, your benefits**

**008**–013 **Description**

**014**–021 **Contactor selection and ordering**

**022**–036 **Specific product characteristics**

**037**–041 **Overall dimensions**

**042**–052 **Electric circuit diagram**

# **V-Contact VSC:**
# its strengths, your benefits

**Easy to install**

**Affordable range**

**Safety and protection**



# Productivity
## Maximizing your output



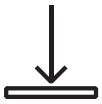
### Continuous operation
- Low chopping current in VI
  – Minimize the risk of switching over voltages and therefore maintenance intervention on your assets
- UV to detect MV loss and stop the motor
  – Increase service continuity thanks to insensibility to voltage dips that would normally lead to a restart of the motor

### Easy to install
- Possibility to assemble free standing version in all orthogonal solution
– Have flexibility and the easiest connection and interface with the panel

### Speed up your projects
- Free standing version with fuse holder
  – Avoid the study of fuse installation and have guaranteed coordination and functionality
- Technical and license cooperation agreement
  – Rely on ABB technical support to reduce development time

### Services and training
- Field application support and analysis
  – Rely on ABB technical support for choosing the best solution fitting your specific application

# Efficiency
## Optimize your investment



### Space saving
- Free standing version with fuse holder
  – Save footprint and overall height compared to a design with external fuse holder



### Affordable range
- Higher dielectric performances with G version
  – Save the cost of a circuit breaker with a 12 kV solution valid over 1000 m above the sea level
- Capacitor switch version
  – Have a competitive solution in C2 class
- Technical cooperation agreement
  – Rely on ABB technical support to reduce your investment for your panel design



### Energy efficiency
- Low power consumption compared to traditional solutions
  – Reduce the cost of ownership and reduce the overall $CO_2$ consumption

# Reliability
## Protecting your assets

### Safety and protection
- Embedded control coil continuity
  – Avoid TCS on open coil and closing coil monitoring
- Temperature and capacitor monitoring (on request)
  – Provide “predictive” function as when the capacitor start ageing the warning is sent but contactor is still operative: this allows to program an intervention without LSC
- Guaranteed coordination with fuses
  – Increase your safety: guaranteed coordination with SCPD

### Global availability
- ABB by your side
  – Count on a worldwide presence for any support you may need



# Description

## General

The medium voltage V-Contact VSC contactors are apparatus suitable for operating in alternating current and are normally used to control users requiring a high number of hourly operations.
The V-Contact VSC contactor introduces the drive with permanent magnets, already widely used, experimented and appreciated in medium voltage circuit breakers, into the worldwide panorama of medium voltage contactors.
The experience acquired by ABB in the field of medium voltage circuit breakers fitted with drives with “MABS” permanent magnets, has made it possible to develop an optimised version of the actuator (bistable MAC drive) for medium voltage contactors.
The drive with permanent magnets is activated by means of an electronic multi-voltage feeder.
The feeders differ according to the integrated functions and to the auxiliary power supply voltage.
Each feeder is able to take any voltage value within its own operating band.

**Versions available**

The V-Contact VSC contactors are available in the following versions:

| Version | Rated voltage | Type |
|---|---|---|
| Fixed | 7,2 kV | VSC 7 - VSC 7/F - VSC 7/G |
| | 12 kV | VSC 12 - VSC 12/F - VSC 12/G - VSC S/G - VSC S/F |
| Withdrawable | 7,2 kV | VSC 7/P - VSC 7/PN - VSC 7/PG - VSC 7/PNG |
| | 12 kV | VSC 12/P - VSC 12/PN - VSC 12/PG - VSC S/PG - VSC S/PNG |

The withdrawable versions are foreseen for use with UniGear ZS1 and UniSec WBC switchgears, PowerCube units and CBE1 enclosures. For use with the CBE11 enclosures, please contact ABB.
All the contactors mentioned above are available, on request, in one of the two following versions.

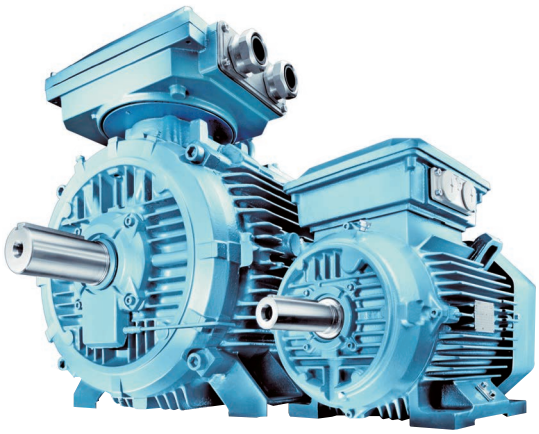
- **SCO** (Single Command Operated): closing takes place by supplying auxiliary power to the special input of the multi-voltage feeder. On the other hand, opening takes place when the auxiliary power is either voluntarily cut off (by means of a command) or involuntarily (due to lack of auxiliary power in the installation).
- **DCO** (Double Command Operated): closing takes place by supplying the input of the closing command of the apparatus in an impulsive way. On the other hand, opening takes place when the input of the opening command of the contactor is supplied in an impulsive way.




## Fields of application

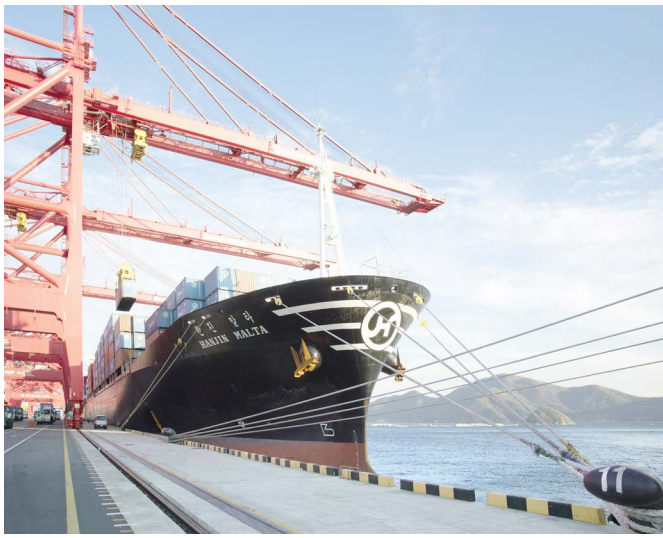
The V-Contact VSC contactors are suitable for controlling electrical apparatus in industry, in the service sector, in the marine sector, etc. Thanks to the breaking technique with vacuum interrupters, they can operate in particularly difficult environments.
They are suitable for control and protection of motors, transformers, power factor correction banks, switching systems, etc.
Fitted with suitable fuses, they can be used in circuits with fault levels up to 1000 MVA (VSC7 - VSC12).





## Compliance with Standards

V-Contact VSC contactors comply with the Standards of the major industrialised countries and in particular with the IEC 62271-106 (2011).



## Type approvals

Type approval by Shipping Register DNV, GL, LLRR, ABS, BV.
Before the order check with ABB if applicable to the specific VSC version requested and certificate expiration date

## Operating characteristics

- Ambient temperature: – 5 °C ... + 40 °C
- Relative humidity: < 95% (without condensation)
- Altitude: < 1000 m s.l.m.

For other conditions, please contact us.

## Main technical characteristics

- Maintenance-free
- Suitable for installation in prefabricated substations and switchgear both of the card (slim line) and traditional type
- High number of operations
- Direct checking of contact wear
- Long electrical and mechanical life
- Remote control
- Multi-voltage feeder
- Bistable drive of the type with permanent magnets.



# Description

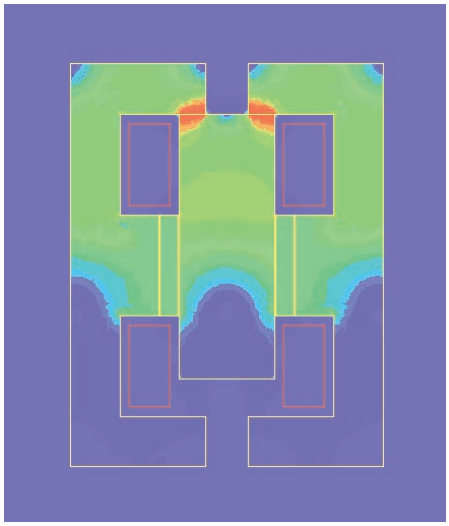


Fig. A - Magnetic circuit in the closed position.

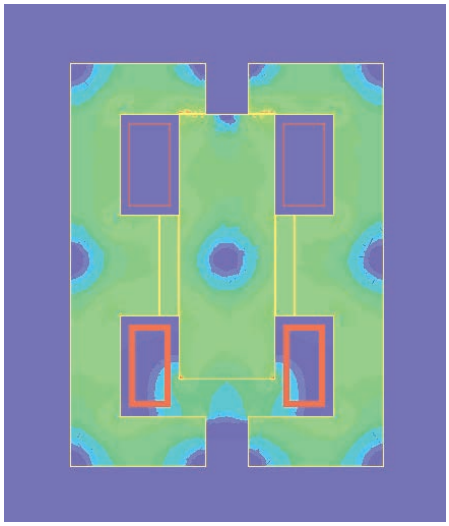


Fig. B - Magnetic circuit with the opening coil supplied.

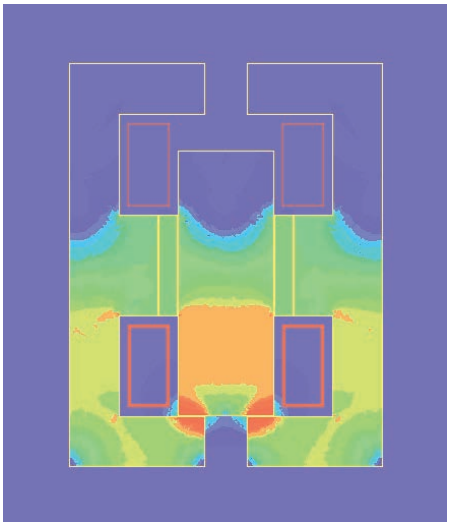


Fig. C - Magnetic circuit in the open position.

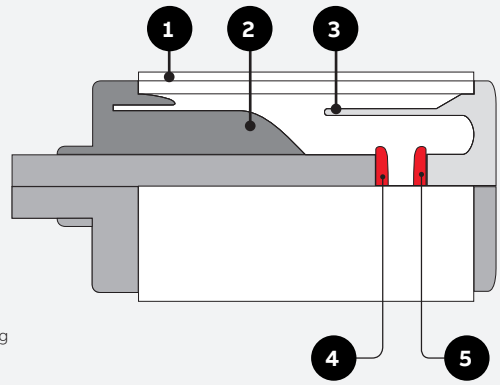
## “MAC” magnetic drive

ABB has implemented this technology in the field of contactors on the basis of experience gained in the field of circuit breakers with magnetic drive.
The magnetic drive adapts perfectly to this type of apparatus thanks to its precise and linear travel.
The drive, which is of bistable type, is fitted with an opening and a closing coil.
The two coils - individually energised - allow the drive mobile armature to be moved from one of the two stable positions to the other.
The drive shaft is solid with the mobile armature and held in position in a field generated by two permanent magnets (fig. A).
Energising the coil opposite to the magnetic latching position (fig. A) of the core, the magnetic field is generated (fig. B), which attracts and moves the mobile armature into the opposite position (fig. C).
Every opening and closing operation creates a magnetic field concordant with the one generated by the permanent magnets, with the advantage of keeping the intensity of the field itself constant during service, regardless of the number of operations carried out.

The energy needed for operation is not supplied directly by the auxiliary power supply, but is always “stored” in the capacitor which acts as an energy accumulator, and therefore operation always takes place with constant speeds and times, independently of the divergence of the power supply voltage from the rated value.
The auxiliary power supply has the only aim of keeping the capacitor charged.
Consumption is therefore minimal.
For the reasons indicated above, both for the DCO and for the SCO version it is necessary to supply the auxiliary circuits which recharge the capacitor with a continuous auxiliary power supply.

## Technical documentation

For more in-depth technical and application aspects of the VSC contactors, also consult the publication on the REF542plus multi-function control and protection unit - code 1VTA100001.




1. Ceramic housing
2. Seal diaphragm
3. Metal screen
4. Moving contact
5. Fixed contact

Schematic cross-section of the vacuum interrupter.




## Test laboratory

Conforms to the UNI CEI EN ISO/IEC 17025 Standards.

## Environmental Management System

Conforms to the ISO 14001 Standards, certified by an external independent organization.

## Health and Safety Management System

Conforms to the OHSAS 18001 Standards, certified by an external independent organization.

## Breaking principle

The main contacts operate inside the vacuum interrupters (the level of vacuum is extremely high: 13 x $10^{-5}$ Pa).
On opening, there is rapid separation of the fixed and moving contacts in each contactor interrupter.
Overheating of the contacts, generated at the moment they separate, causes formation of metallic vapours which allow the electric arc to be sustained up to the first passage through zero current.
On passage of zero current, cooling of the metallic vapours allows recovery of high dielectric resistance able to withstand high values of the return voltage.

**Power rating of electronic device**

| Supply voltage | Starting (1) | After closing | After opening | Continuous power consumption |
|---|---|---|---|---|
| | Inrush for 6 sec | Inrush for 1.2 sec | Inrush for 1.2 sec | |
| 24...250 V d.c.<br>110...250 V a.c. | 35 W | 25 W | 30 W | 5 W |

(1) This value refers to a discharged capacitor; 42 A are required for 2 ms upon start up.

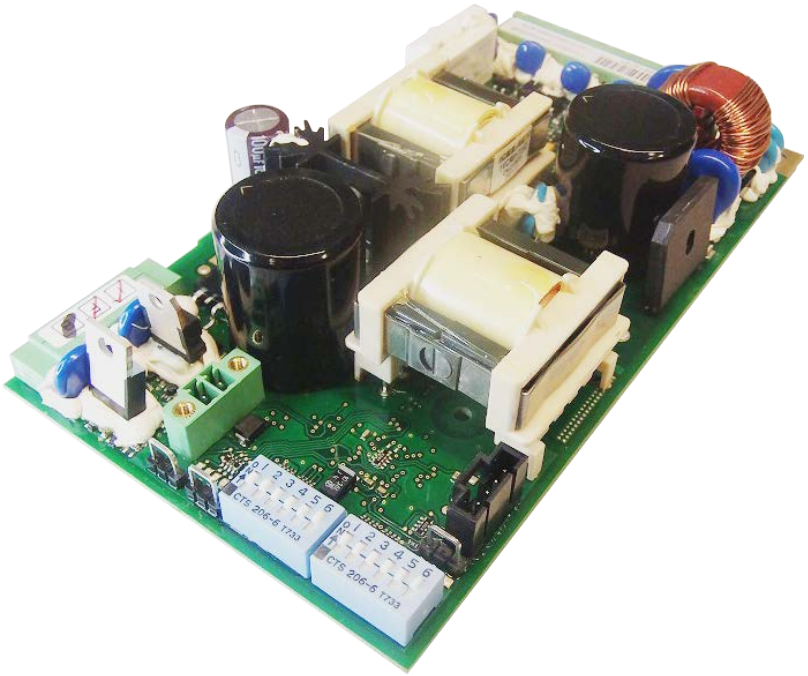
# Description

## Control module/feeder

The careful selection of components and precise design make the electronic multi-voltage feeder extremely reliable, immune to electromagnetic interference generated by the surrounding environment and free of emissions able to influence other apparatus in the vicinity.
These characteristics have allowed the V-Contact VSC contactors to pass the electromagnetic compatibility tests (EMC).

As standard, the electronic control module is fitted with:

- a connector with screw terminal box for connection of the auxiliary circuits of the fixed versions
- a signalling contact for controlling the closing and opening coil continuity
- the possibility, only at the time of ordering, of defining the reference Standard for the operating thresholds of the auxiliary voltage (available: IEC - GB)
- a dedicated input for opening the contactor regardless of the functionality of the electronics by means o fan external accessory which directly controls the opening coil.






## Technical documentation

**For more in-depth technical and application aspects of the VSC contactors, also consult the publication on the REF542plus multi-function control and protection unit - code 1VTA100001.**

## Test laboratory

**Conforms to the UNI CEI EN ISO/IEC 17025 Standards.**

## Environmental Management System

**Conforms to the ISO 14001 Standards, certified by an external independent organization.**

## Health and Safety Management System

**Conforms to the OHSAS 18001 Standards, certified by an external independent organization.**


DNV

MANAGEMENT SYSTEM CERTIFICATE

This is to certify that the management system of
**ABB S.p.A.**
Via Friuli, 4 - 24044 Dalmine (BG) - Italy

has been found to conform to the Quality Management System standard:
**ISO 9001:2015**

This certificate is valid for the following scope:
**Design, manufacturing, repair and service of low and medium voltage electrical products and applications for electrical distribution systems. On-site maintenance, repair, retrofitting and supervision (IAF: 19, 28)**


DNV

MANAGEMENT SYSTEM CERTIFICATE

This is to certify that the management system of
**ABB S.p.A.**
Via Friuli, 4 - 24044 Dalmine (BG) - Italy

has been found to conform to the Environmental Management System standard:
**ISO 14001:2015**

This certificate is valid for the following scope:
**Design, manufacturing, repair and service of low and medium voltage electrical products and applications for electrical distribution systems. On-site installation, maintenance, repair and supervision (IAF: 19, 28)**
Evaluated according to the requirements of Technical Regulations RT-09


DNV

MANAGEMENT SYSTEM CERTIFICATE

This is to certify that the management system of
**ABB S.p.A.**
Via Friuli, 4 - 24044 Dalmine (BG) - Italy

has been found to conform to the Occupational Health and Safety Management System standard:
**ISO 45001:2018**

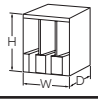
This certificate is valid for the following scope:
**Design, manufacturing, repair and service of low and medium voltage electrical products and applications for electrical distribution systems. On-site installation, maintenance, repair and supervision (IAF: 19, 28)**

# Contactor selection and ordering

| General characteristics | | | Ref. to the IEC 62271-106 Standard |
|---|---|---|---|
| Rated voltage | | [kV] | 4.1 |
| Rated insulation voltage | | [kV] | – |
| Withstand voltage at 50 Hz | | (1 min) [kV] | 6.2 |
| Impulse withstand voltage | | [kVp] | 6.2 |
| Rated frequency | | [Hz] | 4.3 |
| Rated service current | | [A] | 4.101 |
| Short-time withstand current for 1 s | | [A] | 6.6 |
| Rated peak current | | [kA peak] | 6.6 |
| Breaking capacity up to | | [kA] | 4.107 |
| Short-circuit making capacity up to | | [kA] | 4.107 |
| Number of operations (rated values) | Contactor SCO | [op./hour] | 4.102.2 |
| | Contactor DCO | [op./hour] | 4.102.2 |
| Maximum rated admissible overcurrent for ½ period (peak value) | | [kA] | – |
| Rated load and overload characteristics in category of use: | | | |
| (Category AC4) 100 closing operations | | [A] | 6.102.4 |
| (Category AC4) 25 opening operations | | [A] | 6.102.5 |
| Rated voltage of the switching devices and auxiliary circuits | | | 4.8,4.9 |
| Feeder type 1: 24÷60 V dc (basic version) | | | – |
| Feeder type 2: 24÷60 V dc (full option version) | | | – |
| Feeder type 3: 110÷250 V ac/dc (basic version) | | | – |
| Feeder type 4: 110÷250 V ac/dc (full option version) | | | – |
| Normal current | | [A] | 4.4.101 |
| Mechanical life - number of cycles / number of operations ([6]) | | [op.] | 6.101 |
| Apparatus wear classification (type) | | [op.] | 4.107.3 |
| Short-circuit breaking capacity (O-3min-CO-3min-CO) | | [A] | 6.104 |
| Short-circuit making capacity (O-3min-CO-3min-CO) | | [A peak] | 6.104 |
| Limit above which the fuse blows ([5]) | | [A] | 4.107.3 |
| Switching times | Opening time (lower and upper limit) [ms] | | – |
| | Closing time (lower and upper limit) [ms] | | – |
| Tropicalisation | | (IEC 721-2-1) | – |

| **Ultimate performances for (value refers to fixed versions without fuseholder)** | |
|---|---|
| Rated voltage | [kV] |
| Motors | [kW] |
| Transformers | [kVA] |
| **Ultimate performances for single and back-to-back capacitor banks** | |
| Rated voltage | [kV] |
| Rated current | [A] |
| Maximum transient current of the capacitor | [kA] |
| Maximum transient frequency of capacitor connection | [kHz] |

**Weights and overall dimensions**

| | | | |
|---|---|---|---|
| Weight (excluding the fuses) | | | [kg] |
| Overall dimensions |  | Height | H [mm] |
| | | Width | W [mm] |
| | | Depth | D [mm] |

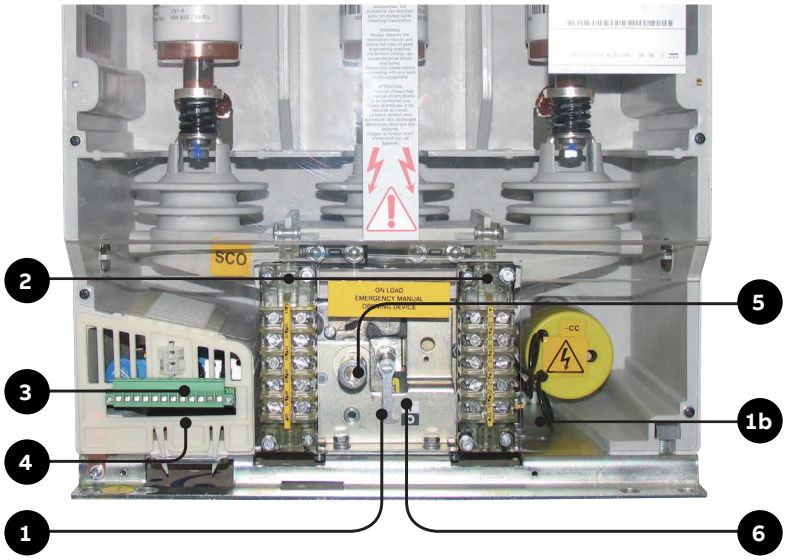
([1]) Version for 42 kV 50 Hz x 1 min. between phases and between phase and earth available on request - (only fixed VSC12/G contactors without fuseholders and withdrawable VSC12/PG for UniGear panels I = 650 mm).
([2]) Depending on the capacity of the coordinated fuse.
([3]) Value linked to the breaking capacity of the fuse: refer to the fuse manufacturer's documentation.
([4]) Indicate the reference fuses.
([5]) This is the current value determined by intersection of the time-current trip curves of two protection devices - in this case the fuse and any thermal protection relay.
([6]) Not applicabile for VSC-S versions.
([7]) Version with 32 kV -50Hz x 1 min between phases and between phase and earth available on request - (only fixed VSC7/G contactors without fuseholders, withdrawable VSC7/PG for UniGear panels I = 650 mm and VSC7/PNG for UniGear MCC).

| VSC 7 - VSC 7/F - VSC 7/P - VSC 7/PN 400A<br>VSC 7/G 400A - VSC 7/PG 400A - VSC 7/PNG 400A | | | VSC 12 - VSC 12/F - VSC 12/P - VSC 12/PN - VSC 12/G -<br>VSC 12/PG - VSC S/G - VSC S/F - VSC S/PG - VSC S/PNG | | |
|---|---|---|---|---|---|
| **Contactor** | **Starter** | **Combined with fuses** | **Contactor** | **Starter** | **Combined with fuses** |
| **3.4.105** | **3.4.110** | **3.4.110.5** | **3.4.105** | **3.4.110** | **3.4.110.5** |
| 7.2 | 7.2 | 7.2 | 12 | 12 | 12 |
| 7.2 | 7.2 | 7.2 | 12 | 12 | 12 |
| 20 ([7]) | 20 ([7]) | 20 ([7]) | 28 ([1]) | 28 ([1]) | 28 ([1]) |
| 60 | 60 | 60 | 75 | 75 | 75 |
| 50-60 | 50-60 | 50-60 | 50-60 | 50-60 | 50-60 |
| 400 | 400 | – ([2]) | 400 ([6]) | 400 ([6]) | – ([2]) |
| 6,000 | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 |
| 15 | 15 | 15 | 15 | 15 | 15 |
| – | – | 50 ([3]) | – | – | 50 ([3]) |
| – | – | 50 ([3]) | – | – | 50 ([3]) |
| 1,200 | 1,200 | 1,200 | 1,200 | 1,200 | 1,200 |
| 1,200 | 1,200 | 1,200 | 1,200 | 1,200 | 1,200 |
| 55 | – | – | 55 | – | – |
| | | | | | |
| 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 |
| 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 |
| | | | | | |
| • | • | • | • | • | • |
| • | • | • | • | • | • |
| • | • | • | • | • | • |
| • | • | • | • | • | • |
| 400 | 400 | – ([2]) | 400 ([6]) | 400 ([6]) | – ([2]) |
| 1,000,000 / 2,000,000 | 1,000,000 / 2,000,000 | 1,000,000 / 2,000,000 | 1,000,000 / 2,000,000 | 1,000,000 / 2,000,000 | 1,000,000 / 2,000,000 |
| C | C | C | C | C | – |
| 5,000 | 5,000 | – | 5,000 | 5,000 | – |
| 13,000 | 13,000 | – | 13,000 | 13,000 | – |
| – | – | 5,000 | – | – | 4,000 |
| 35...60 | 35...60 | 35...60 | 35...60 | 35...60 | 35...60 |
| 60...90 | 60...90 | 60...90 | 60...90 | 60...90 | 60...90 |
| • | • | • | • | • | • |

| VSC 7 - 400A | | | | VSC 12 - 400 A |
|---|---|---|---|---|
| 2.2/2.5 | 3.3 | 3.6/5 | 6.2/7.2 | 12 |
| 1.000 | 1.500 | 1.500 | 3.000 | 5.000 |
| 1.100 | 1.600 | 2.000 | 4.000 | 5.000 |
| **VSC-S/G - VSC-S/F - VSC-S/PG - VSC-S/PNG (limit refers to unfused contactors, rated current limit can change depending on the fuses rating)** | | | | |
| 2.2/2.5 | 3.3 | 3.6/5 | 6.2/7.2 | 12 |
| 250 | 250 | 250 | 250 | 250 |
| 8 | 8 | 8 | 8 | 8 |
| 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |

| Fixed contactor | | | | | Withdrawable contactor | | | |
|---|---|---|---|---|---|---|---|---|
| **VSC 7<br>VSC 7/G** | **VSC 12** | **VSC 12/G** | **VSC S/G** | **VSC 12/F<br>VSC S/F** | **VSC 7/P<br>VSC 7/PG** | **VSC 12/P<br>VSC 12/PG<br>VSC S/PG** | **VSC 7/PN<br>VSC 7/PNG** | **VSC 12/PN<br>VSC S/PNG** |
| 20 | 20 | 35 | 35 | 35 | 52 | 52 | 54 | 54 |
| 371 | 424 | 494 | 598 | 532 | 636 | 636 | 653 | 653 |
| 350 | 350 | 466 | 466 | 466 | 531 | 531 | 350 | 350 |
| 215 | 215 | 622 | 623 | 702 | 657 | 657 | 673 | 673 |

# Contactor selection and ordering




VSC 7 - VSC 12




VSC/F

**Standard fittings**

**1** MAC Drive with permanent magnets with capacitor for storing energy (1b)

**2** Auxiliary contacts available to the customer

| Contactor | Normally open | Normally closed |
|---|---|---|
| VSC 7 400 A | 5 | 5 |
| VSC 12 | 5 | 5 |
| VSC 7/P<br>VSC 7/PN<br>VSC 7/F | 5 (SCO) - 4 (DCO) | 5 |
| VSC 12/P<br>VSC 12/PN<br>VSC 12/F | 5 (SCO) - 4 (DCO) | 5 |

**3** Feeder

- The contactor has been tested for all the auxiliary operating voltages foreseen, indicated in the table:

| Feeder type 1 and 2<br>V d.c. | Feeder type 3 and 4<br>V d.c. / V a.c. (50/60 Hz) | |
|---|---|---|
| 24 | 110 | 220 |
| 30 | 120 | 230 |
| 48 | 125 | 240 |
| 60 | 127 | 250 |
| | 130 | |

- The contactor is, however, preset with the operating voltage defined in the order confirmation. The power supply voltage is indicated on the nameplate of the contactor itself. Should it be indispensible to change the power supply voltage, please contact ABB.
- The voltage value tolerances conform to what is defined by the IEC 62271-106 or GB 14808 depending on customer's requirements.
- The card is guaranteed to become operational 15 seconds after the power supply voltage is applied because the card controls functionality during this time interval.
- The feeder is available in either the "Standard" or "Full option" version. Apart from the functions indicated on page 12, the "Full option" version also ensures:
  - control of capacitor operating conditions
  - verification of operating temperature of electronic board

**4** Socket/plug with terminal at terminal box

**5** Manual emergency opening operation

**6** Mechanical Open/Closed indicator

**7** Fuseholders (only VSC/F and withdrawable versions).

- The VSC/F or VSC/P contactor is fitted with fuseholders able to hold DIN or BS type fuses according to what the customer requests.
- The fuses must have the dimensions and striker of average type according to DIN 43625 Standards with maximum cartridge size e=442mm and BS 2692 (1975) with maximum cartridge size L=553mm.
- The electrical characteristics must conform to the IEC 282-1 (1974) Standards.
- ABB fuses type CMF-BS cannot be installed on V-Contact VSC contactor.




VSC/P




VSC/PN

- The fuseholder is fitted with a special kinematics mechanism which automatically opens the contactor when even a single fuse blows and prevents contactor closing when even a single fuse is missing.

**8** Isolation interlock with the truck (only withdrawable contactor). This prevents isolation or racking-in the contactor into the switchgear if the apparatus is in the closed position, and also prevents contactor closing during the isolation run.

| **"Control Coil Continuity" and "Capacity Survey" contacts characteristics** | |
|---|---|
| **Technology** | Wipe contacts relay |
| **Switching characteristics:** | |
| Maximum switching power | 1200 VA (on resistive load) |
| Maximum switching voltage | 277 V AC, 30 V DC |
| Maximum switching current | 3 A |
| Maximum rated current | 5 A @ 4 s |
| **Contacts characteristics:** | |
| Maximum on resistance (Ron) | 150 m (measured by voltage drop 6 V DC 1 A) |
| Maximum capacity | 1.5 pF |
| **Timing characteristics:** | |
| Maximum actuating time | 5.0 ms |
| Maximum releasing time | 2.0 ms |
| **Insulation:** | |
| Between contacts and coil | 3000 V rms (50 Hz / 1 min.) |
| Between open contacts | 750 V rms (50 Hz / 1 min.) |
| Resistance (Roff) | Min. 103 M at 500 V DC |

| **Characteristics of the auxiliary contacts of the contactor** | |
|---|---|
| Rated voltage: | 24 ... 250 V AC-DC |
| Rated current $Ith^2$: | 10 A |
| Insulation voltage: | 2500 V 50 Hz (1 min) |
| Electric resistance: | 3 mOhm |

The rated current and breaking capacity values in category AC11 and DC11 are indicated below.

| **Un** | **Cosφ** | **T** | **In** | **Icu** |
|---|---|---|---|---|
| 220 V ~ | 0.7 | — | 2.5 A | 25 A |
| 24 V – | — | 15 ms | 10 A | 12 A |
| 60 V – | — | 15 ms | 6 A | 8 A |
| 110 V – | — | 15 ms | 4 A | 5 A |
| 220 V – | — | 15 ms | 1 A | 2 A |

# Contactor selection and ordering
## Optional accessories

**The table below indicates availability of the accessories in relation to the various types of contactor.**

| Table of accessory availability | | VSC 7<br>VSC 7/G | VSC 7/F | VSC 7/P<br>VSC 7/PG | VSC 7/PN<br>VSC 7/PNG |
|---|---|---|---|---|---|
| 1a | Interfacing shaft on feeder side | • | • | - | - |
| 1b | Interfacing shaft on capacitor side | • | • | - | - |
| 2 | Electric operation counter (impulse counter) | • | • | • | • |
| 3 | Undervoltage function (only DCO version) | • | • | • | • |
| 4 | Adapter for fuses | - | • | • | • |
| 5 | Connection alternative to the fuses | - | • | • | • |
| 6 | Position contacts for connected isolated position in the truck | - | - | • | - |
| 7 | Isolation lock | - | - | • | • |
| 8 | Locking magnet in the withdrawable truck | - | - | • | • |
| 9 | Anti-insertion lock for different currents (1) | - | - | • | • |
| 10 | Motorisation of the truck (2) | - | - | • | - |
| 11 | Sliding earthing contact | - | - | • | • |
| 12 | ETR (Emergency Trip Release) device | • | • | • | • |

(1) Compulsory for UniGear and UniSec WBC switchgears.
(2) Assembly at a later stage is not possible.

### 1 Interfacing shafts

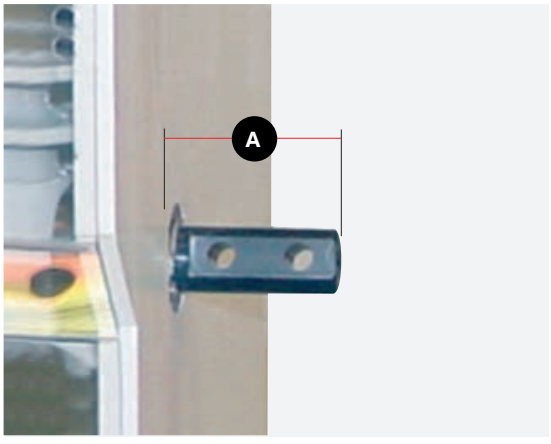
These can be used to interface the apparatus with the kinematics of the switchgear to make interlocks and/or signals.
The interfacing shafts are available in two different lengths (A = 22 mm and 70 mm) and can be mounted on one or both sides of the contactor (as indicated in the following table).

| Lenght A | 22/70 mm | |
|---|---|---|
| Position | Feeder side | Capacitor side |
| VSC 7 400 A -<br>VSC 7/F 400 A | • | • |
| VSC 12 400 A -<br>VSC 12/F 400 A | – | • |

Note: for the utilisation parameters (angles and forces applicable), please refer to the instruction manual.

### 2 Impulse counter

This is a device which counts the contactor closing cycles.






| VSC 12<br>VSC 12/G<br>VSC S/G | VSC 12/F<br>VSC S/F | VSC 12/P<br>VSC 12/PG<br>VSC S/PG | VSC 12/PN<br>VSC S/PNG |
|---|---|---|---|
| - | - | - | - |
| • | • | - | - |
| • | • | • | • |
| • | • | • | • |
| - | • | • | • |
| - | • | • | • |
| - | - | • | - |
| - | - | • | • |
| - | - | • | • |
| - | - | • | • |
| - | - | • | - |
| - | - | • | • |
| • | • | • | • |

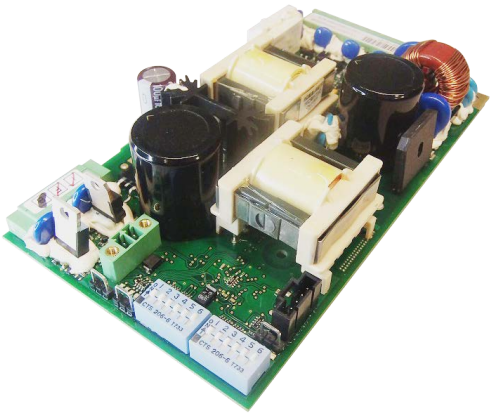
### 3 Undervoltage function (only available for DCO)

First of its type, the V-Contact VSC contactor is fitted with an undervoltage function with selectable delays of 0; 0,3; 1; 2; 3; 4; 5 s.
This accessory must be specified at the time of order because it cannot be mounted at a later stage.
The undervoltage function cannot be deactivated in boards with the undervoltage function.

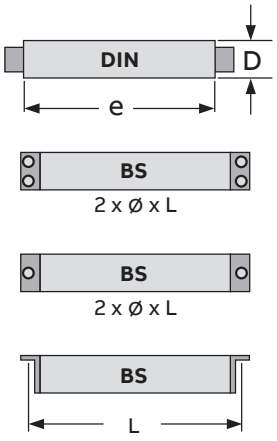
### 4 Adapter for application of fuses

The kit includes all the accessories needed to adapt and mount three fuses (according to DIN Standards with dimension **e less than 442** mm; according to BS Standards with dimension **L less than 553** mm).
The kit can be installed directly onto the fuseholder supports. The fuses must have dimensions and striker of average type according to DIN 43625 and BS 2692 (1975) Standards.
The electrical characteristics must conform to the IEC 282-1 (1974) Standards.
To select the fuses, see “Conditions of use according to the load” - chapter 3.
The adaptation kits are available in the following types:

**4A** For fuses according to DIN Standards with distance **e** = 192 mm
**4B** For fuses according to DIN Standards with distance **e** = 292 mm
**4C** For fuses according to BS Standards (2 x 8 x **L** = 235 mm)
**4D** For fuses according to BS Standards (4 x 10 x **L** = 305 mm)
**4E** For fuses according to BS Standards (4 x 10 x **L** = 410 mm)
**4F** For fuses according to BS Standards (4 x 10 x **L** = 454 mm)
**4G** For fuses in parallel according to BS Standards (4 x 10 x **L** = 410 mm)

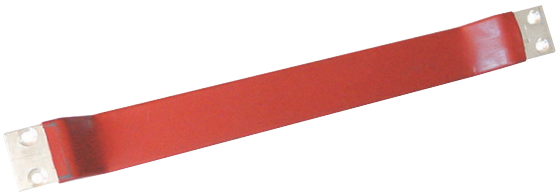






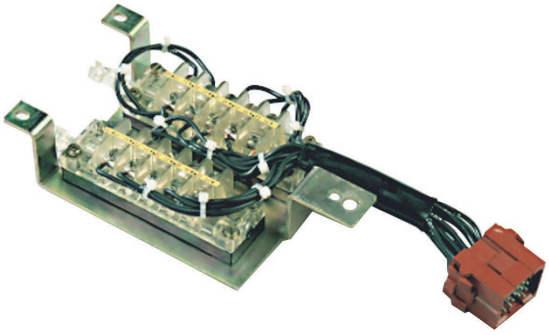
# Contactor selection and ordering
## Optional accessories

**5 Connections alternative to the fuses**
The kit includes three flat copper busbars and fixing screws to be installed when the fuses are not needed.
The kit can be installed directly onto the fuseholder supports.

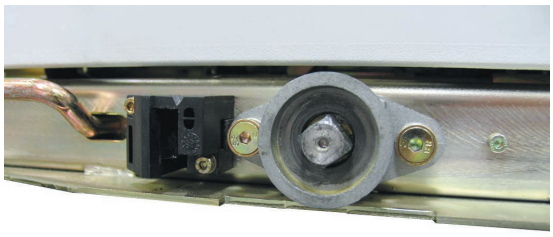


**6 Position contacts for connected/isolated position in the withdrawable truck**
These signal the position of the truck (accessory not available for V-Contact VSC/PN contactors). The kit includes a set of 10 auxiliary contacts. This accessory must always be requested for contacts to be used in UniGear type ZS1 switchgear if the same application is not already present on the fixed part.
**6A** Standard diagram
**6B** Calor Emag diagram.

| Electrical characteristics of the contact | | | |
|---|---|---|---|
| Un | Icu | cosφ | T |
| 220 V~ | 10 A | 0.4 | – |
| 220 V~ | 5 A | 0.4 | – |
| 220 V– | 1 A | – | 10 ms |

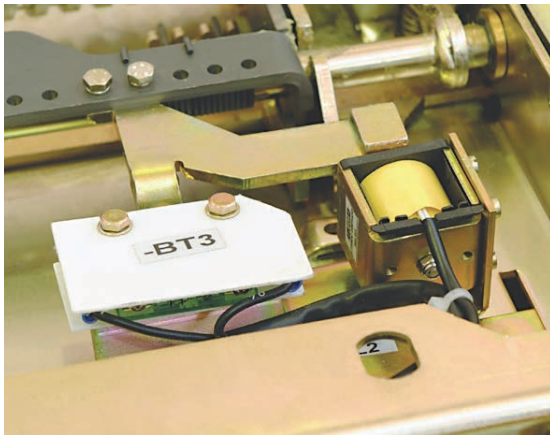


**7 Isolation lock**
Isolation lock for UniGear and UniSec WBC switchgears and PowerCube units. It prevents the apparatus from being racked-in if the unit door is open.
This lock only works if the door of the switchgear/ enclosure is also fitted with the corresponding lock.
This accessory is not compatible with use in CBE enclosures.



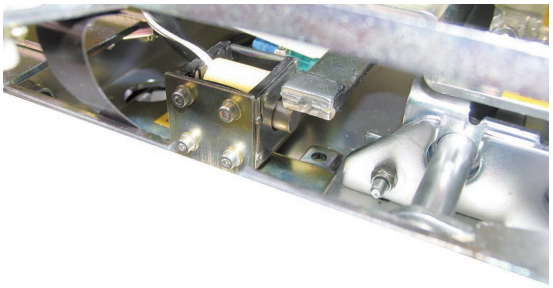
**8 Locking magnet in the truck**
This only allows the withdrawable contactor to be racked into/out of the enclosure with the electromagnet energised and the contactor open. The table below shows the power supply voltages available.

| Un | Un | F | Un | F |
|---|---|---|---|---|
| 24 V – | 24 V ~ | 50 Hz | 110 V ~ | 60 Hz |
| 30 V – | 48 V ~ | 50 Hz | 120 V ~ | 60 Hz |
| 48 V – | 60 V ~ | 50 Hz | 127 V ~ | 60 Hz |
| 60 V – | 110 V ~ | 50 Hz | 220 V ~ | 60 Hz |
| 110 V – | 120 V ~ | 50 Hz | 230 V ~ | 60 Hz |
| 125 V – | 127 V ~ | 50 Hz | 240 V ~ | 60 Hz |
| 220 V – | 220 V ~ | 50 Hz | | |
| | 230 V ~ | 50 Hz | | |
| | 240 V ~ | 50 Hz | | |



**9 Lock for different rated currents (only withdrawable versions)**

In the VSC/P contactors, it prevents insertion of the plug-socket and therefore apparatus closing, in a panel provided for a circuit breaker.
This lock, which is compulsory for UniGear and UniSec WBC switchgears, requires the same lock provided on the enclosure / switchgear, and is associated with the presence of the locking magnet on the truck.



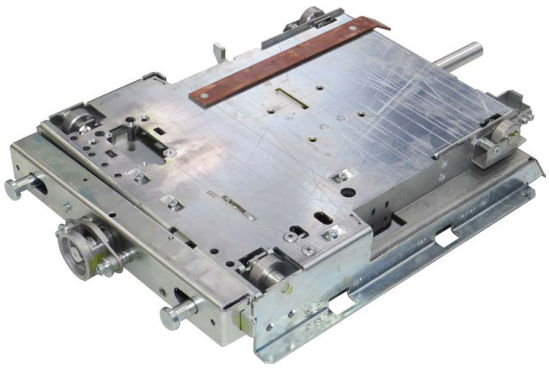
**10 Motorised truck**

Only available for VSC/P for use in UniGear type ZS1 and UniSec WBC switchgears and PowerCube units. This application must be specified at the time of ordering the contactor and cannot be mounted at a later stage.
Not available on VSC/PN.

| Characteristics | |
|---|---|
| Un: | 110 / 220V– |
| Operating limits: | 85...110% Un |
| Rated power (Pn): | 40 W |

**11 Sliding earthing contact**

Available on request for VSC/PN.
This application must be specified at the time of ordering the contactor and cannot be mounted at a later stage.



**12 ETR (Elecrical Emergency Opening) device**

Beside the mechanical opening operation, which is anyway always provided, it is available as accessory on request, the ETR device.
The ETR device (Emergency Trip Release) is an optional accessory that can be provided with the VSC contactor and installed in the switchgear auxiliary compartment.
Purpose of ETR is to give to the customer the opportunity to perform a remote electrical open of the apparatus in emergency conditions.
ETR device is design to provide an additional opportunity to open locally or remotely the contactor for the identified faulty conditions.
In the event of a power loss in the auxiliary circuit, ETR can still be actuated, locally or remotely, within 5 minutes.

| Characteristics | |
|---|---|
| Rated voltage: | 110V AC-DC (J1: terminal 1-2)<br>220V AC-DC (J1: terminal 1-3) |
| Rated voltage tolerance | 75%...1105 |
| Insulation | No isolation from Power supply to input command channel |
| Common mode overvoltage protection | 4 kV |
| Voltage deep immunity LV and HV | 1 min @ 100% |
| Operational temperature | -5...+40 °C |
| Minimum diameter of wiring | Ø 1.5mm² |
| Start up time | 6 MIN |
| Ready contact | One contact available for customer use |

# Specific product characteristics



## Altitude

It is well-known that the insulating properties of air decrease as the altitude increases.
This phenomenon must always be taken into account during the design stage of insulating parts of equipment which is to be installed over 1000 m above sea level.
In this case a correction coefficient must be applied, which can be taken from the graph drawn up according to the indications given in the IEC 62272-1.
The following example gives a clear interpretation of the indications given above.
For altitude higher than 3000mt please contact ABB.



## Electromagnetic compatibility

The V-Contact VSC vacuum contactors ensure operation without unwarranted trips when there are interferences caused by electronic apparatus, by atmospheric disturbances or by discharges of electrical type. Moreover they do not produce any interference with electronic apparatus in the vicinity of the apparatus.
The above is in compliance with IEC 62271-1, 62271-106, 61000-6-2, 61000-6-4, Standards, as well as with the EEC 89/336 European Directive regarding electromagnetic compatibility (EMC).

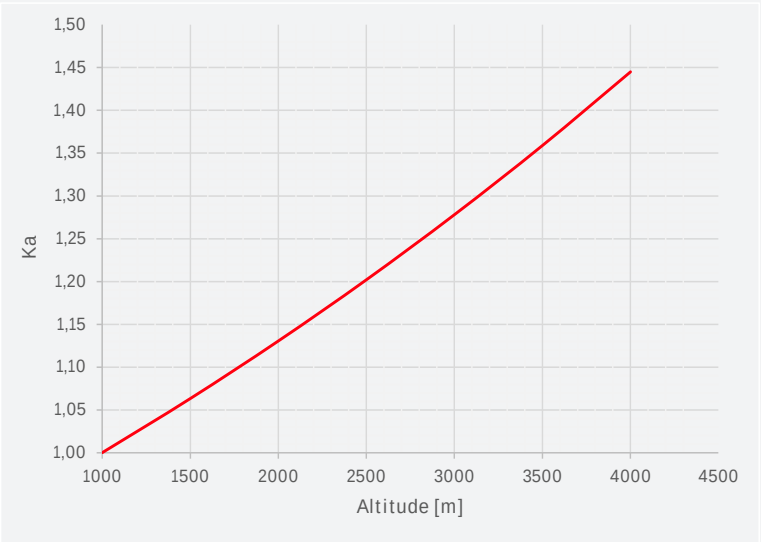
## Tropicalisation

V-Contact vacuum contactors are manufactured in compliance with the prescriptions regarding use in hot-humid-saline climates. All the most important metal parts are treated against corrosive factors corresponding to class C in compliance with the UNI 3564-65 Standards.
Galvanization is carried out in compliance with the UNI ISO 2081 Standard, classification code Fe/Zn 12, with thickness of $12x10^{-6}$ m, protected by a layer of conversion mainly consisting of chromates in compliance with the UNI ISO 4520 Standard.
These construction characteristics mean that all the V-Contact VSC series apparatus and their accessories comply with climate graph no. 8 of the IEC 721-2-1 and IEC 68-2-2 (Test B: Dry Heat) / IEC 68-2-30 (Test Db: Damp Heat, cyclic) Standards.





**Graph for determining the Ka correction factor according to the altitude**




**Ka** = $e^{mH/8150}$ with m=1
**H** = altitude in metres
**m** = value referred to industrial frequency and the atmospheric impulse withstand voltages and those between phase and phase. Defined value for m = 1

**Example**

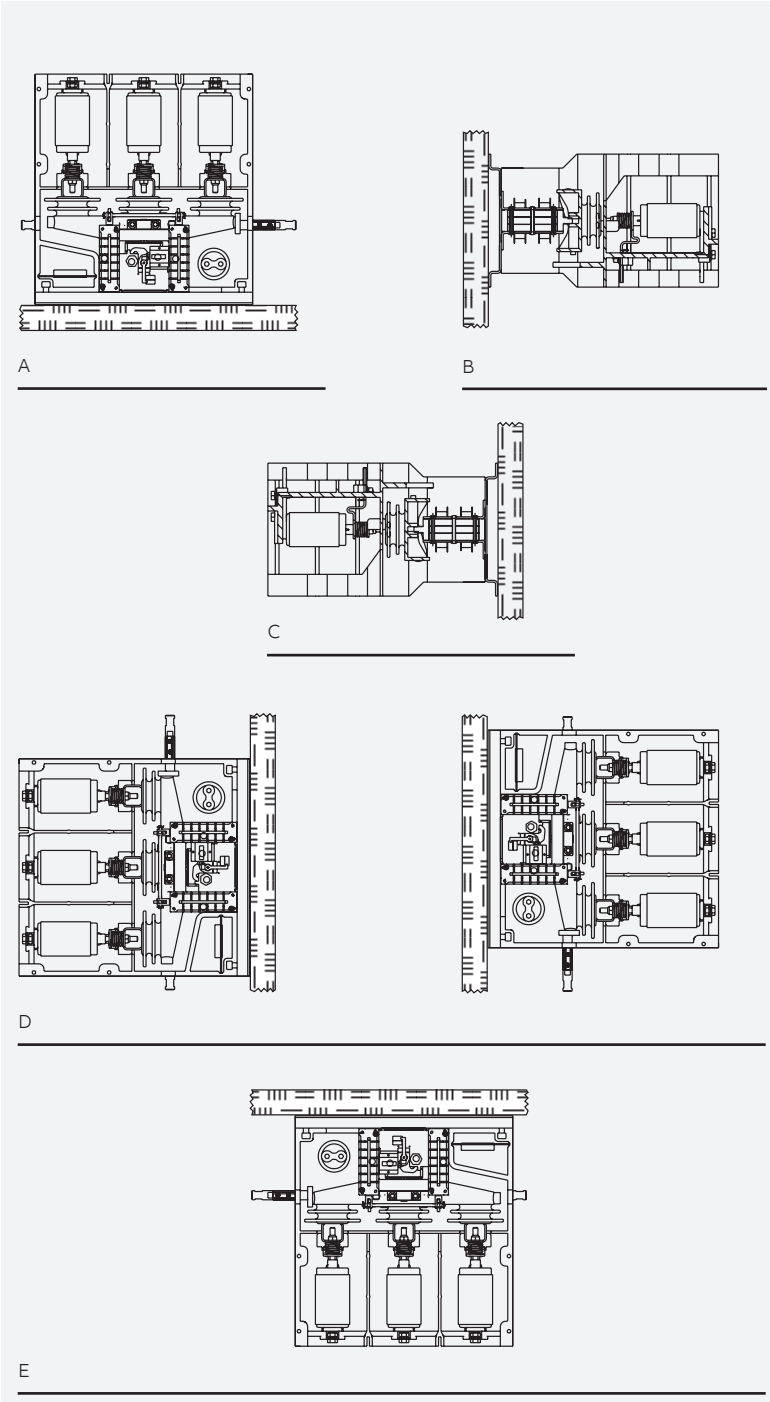
- Installation altitude: 2000 m
- Service at a rated voltage of 7 kV
- Withstand voltage at power frequency 20 kV rms
- Impulse withstand voltage 60 kVp
- Ka Factor = 1.13 (see graph).

Taking the above parameters into consideration, the apparatus will have to withstand the following values (under test at zero altitude i.e. at sea level):

- withstand voltage at power frequency equal to:
  - 20 x 1.13; 22,6 kVrms
- impulse withstand voltage equal to:
  - 60 x 1.13 = 67,8 kVp.

From the above, it can be deduced that for installations at an altitude of 2000 m above sea level, with a service voltage of 7 kV, an apparatus with a rated voltage of 12 kV must be provided, as it is characterized by an insulation levels at power frequency of 28 kV rms and an impulse withstand voltage of 75 kVp.

# Specific product characteristics




**VSC 7 - VSC 12**

## Installation of fixed contactors

The performance of the contactor remains unaltered in the installation positions indicated:

**VSC 7 - VSC 12**

A) Floor-mounted with moving contacts at the bottom.
B) Wall-mounted with horizontal moving contacts and terminals at the bottom.
C) Wall-mounted with horizontal moving contacts and terminals at the top.
D) Wall-mounted with horizontal moving contacts with interrupters on the front (or rear) with vertical terminals.
E) Ceiling-mounted with moving contacts at the top.

**VSC 7/F - VSC 12/F**

A) Floor-mounted with moving contacts at the bottom.

## Use of fuses according to the load

**Motor control and protection**

The motors are supplied in low voltage, normally up to a power of 630 kW. Over the latter power, medium voltage power supply is preferable (from 3 to 12 kV) with the aim of reducing costs and dimensions of all the apparatus which are part of the circuit. The V-Contact can be used for voltages from 2.2 kV up to 12 kV and for motors up to a power of 5000 kW, thanks to the simplicity and sturdiness of the control mechanisms and the long life of the main contacts.

To ensure protection against short-circuit, it is necessary to combine the contactors with appropriate current-limiting fuses. This solution allows the costs of the load-side apparatus (cables, current transformers, busbar and cable anchoring devices, etc.) to be further reduced and to make the user practically independent of any subsequent enlargements of the plant and of the consequent increased in network power.

**Motor protection fuses**

**How to choose motor protection fuses**

V-Contact VSC contactors can be used with fuses with dimensions and striker of the medium type in accordance with Standards DIN 43625 and BS 2692 (1975).

The electrical characteristics must conform to Standard IEC 282-1 (1974).

The customer is responsible for choosing a brand of fuse that conforms to the specifications above and for selecting the fuse, which must be done on the basis of the trip curves supplied by the manufacturer and the characteristics of the contactor.

Consult chapter 2 section 4 of this publication for maximum fuse length and availability of adapters for installing fuses that are smaller than the maximum length.

Among the vast array of applicable fuses, ABB has tested two brands of fuses for coordination in class C, in accordance with standard IEC62271-106:

- Fuses to DIN standards: ABB type CMF
- Fuses to BS standards: SIBA type HHBM-BM

Instructions on how to correctly select the fuses tested by ABB are given below.

**DIN fuses**

ABB fuses type CMF for protecting motors must be chosen by assessing the service conditions. Consider the following parameters:

- supply voltage
- starting current
- starting time
- number of starts/hour
- full load current of motor
- short circuit current of installation.

One of the criteria to bear in mind when choosing is trip coordination with the other protection relays so as to adequately protect the contactor, current transformers, cables, the motor itself and all the other equipment in the circuit that could be damaged by prolonged overloads or by specific let-through energy (I2t) that exceeds the withstand rating.

Protection against short-circuit is carried out by the fuses, always selected with a rated current higher than that of the motor to prevent their intervention on start-up. This method of selection does not, however, allow their use as protection against repeated overloads - a function already not guaranteed by them, especially with current values included up to the end of the initial asymptotic stretch of the characteristic curve.

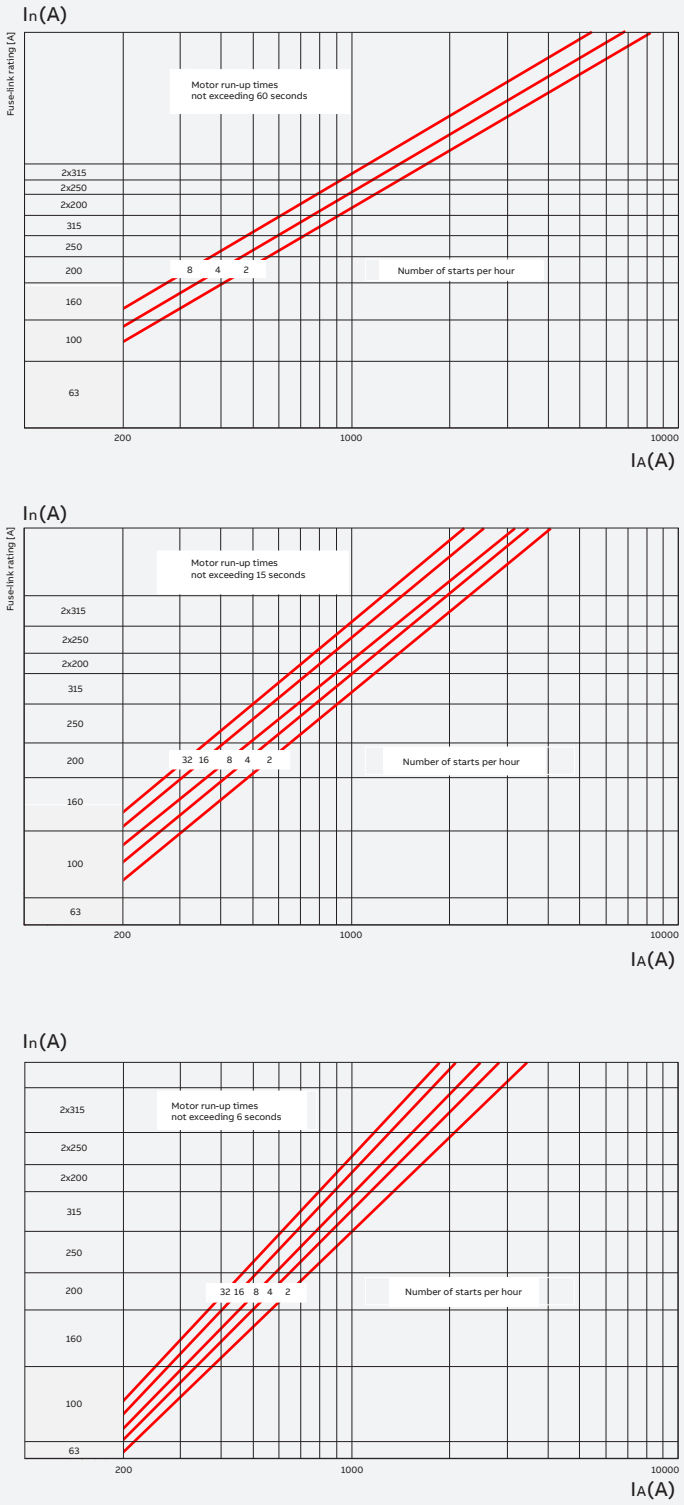
A release with inverse or independent time is therefore always needed for protection against overloads. This protection must be coordinated with the one carried out by the fuse, working so that the release and fuse curves intersect at a point to allow the following:

1) Motor protection against overcurrents due to overloads, single-phase running, blocked rotor and repeated start-ups. Protection entrusted to an indirect relay with inverse or definite time delay trip which acts on the contactor.
2) Protection of the circuit against fault currents, between phases and towards earth, of low value, entrusted to a release with inverse or definite time delay trip, which must only intervene for the short-circuit values which can be interrupted by the contactor.
3) Protection of the circuit against fault currents higher than the breaking capacity of the contactor up to the maximum fault withstand current. Protection entrusted to the fuse.

To verify the service conditions, proceed as follows:

- **Rated voltage Un.** This must be equal to or higher than the service voltage of the installation. Check that the level of insulation of the network is higher than the switching overvoltage value generated by the fuses, which for the fuses used by ABB is widely below the limit fixed by the IEC 282-1 Standards.

# Specific product characteristics




**In** = rated current of the fuse
**IA** = motor start-up current
**Nh** = number of motor start-ups in one hour
**tA** = maximum motor start-up time

Fig. A - Fuse selection curves for motor start-up. ABB CMF type fuses.

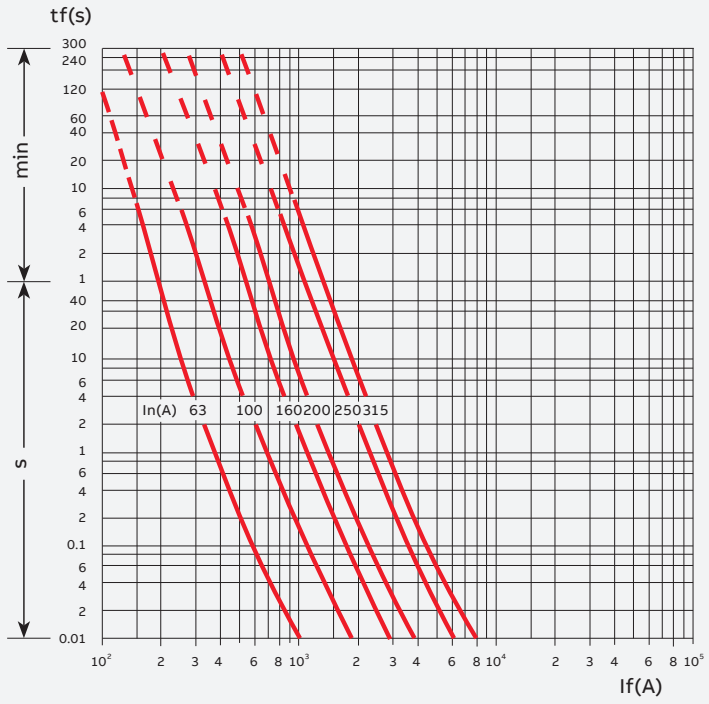
- **Rated current In.** This must be selected by consulting the diagrams indicated in fig. A which refer to the case of starting at regular time intervals, except for the first two start-ups of each hourly cycle which can take place in immediate succession.
  Each diagram refers to a different starting time: 6 s - 15 s - 60 s, respectively.
  In the case of start-ups close together, it must be checked that the starting current does not exceed the value of If x K, where If is the fuse blowing current in correspondence with the starting time of the motor, and K is a minor factor of the unit, a function of the In of the fuse and which can be taken from the table given in figure B.
- **Full load motor current.** The rated current of the fuse must be of a value equal to or higher than 1.33 times the rated current value of full motor load.
  This condition is, in any case, always obtained for motors started at full voltage for which the procedure described for selection of the rated fuse current necessarily imposes values which are always higher than 1.33 In.
- **Short-circuit current.** The short-circuit current limiting curves in fig. C allow the short-circuit current limitation on the load side of the fuses involved in the fault to be appreciated. And this implies smaller sizing of the load side apparatus.

**Example of coordination for overload of a fuse-relay with inverse time delay trip**

| **Motor characteristics:** | | |
|---|---|---|
| Pn | = | 1000 kW |
| Un | = | 6 kV |
| $I_{start}$ | ≈ | 5 In = 650 A |
| $T_{start}$ | = | 6 s |
| No. hourly operations | = | 16. |

In the curve with starting time of 6 s in fig. A, in correspondence with the 650 A starting current value, the straight line, traced for 16 hourly start-ups, intersects in the range of the 315 A fuse.

In the fuse blowing time curve, it can be noted that the 315 A fuse blows in 6 s (starting time) when it is passed through by a current of 2000 A.



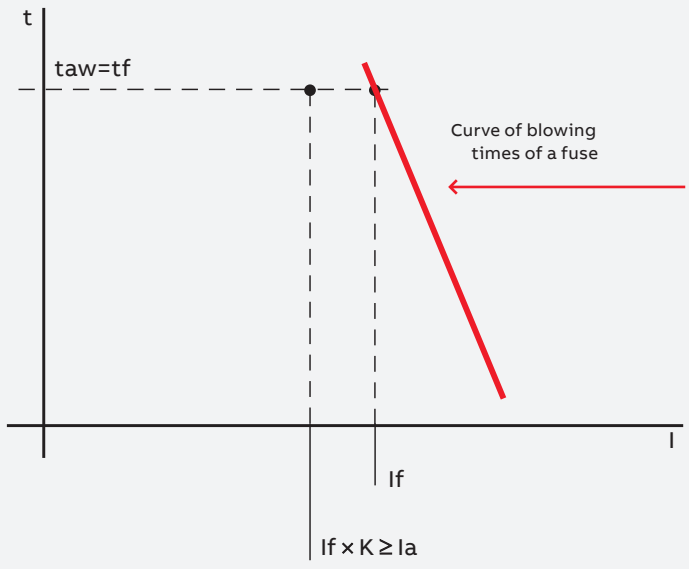



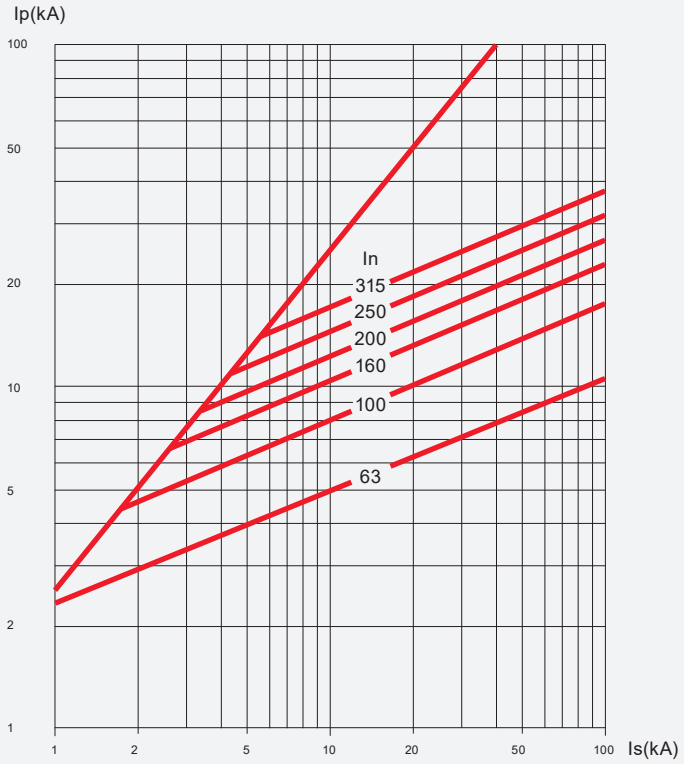

**Table for selection of factor K**

| Un [kV] | In [A] | | | | | |
|---|---|---|---|---|---|---|
| 3.6 | 63 | 100 | 160 | 200 | 250 | 315 |
| 7.2 | 63 | 100 | 160 | 200 | 250 | 315 |
| 12 | 63 | 100 | 160 | 200 | – | – |
| K | 0.75 | 0.75 | 0.7 | 0.7 | 0.6 | 0.6 |

Fig. B - Curve of fuse blowing times and table for selection of factor K ABB CMF type fuses.

In the table in fig. B, the K coefficient for the 315 A size is 0.6, from which the value If x K = 1200 A is taken, which is higher than the start-up current (650 A), so use of the 315 A fuse is also legitimate in respect of this condition, which regards the possibility of start-ups close together.
By observing the blowing curve of the 315 A fuse, the need to use a relay with inverse time delay trip, or a relay with definite time delay trip for protection against overloads can be noted.
It must be remembered that prolonged overheating, above the temperature foreseen for the class of insulating materials, is harmful and strongly prejudices the life of electric machines.

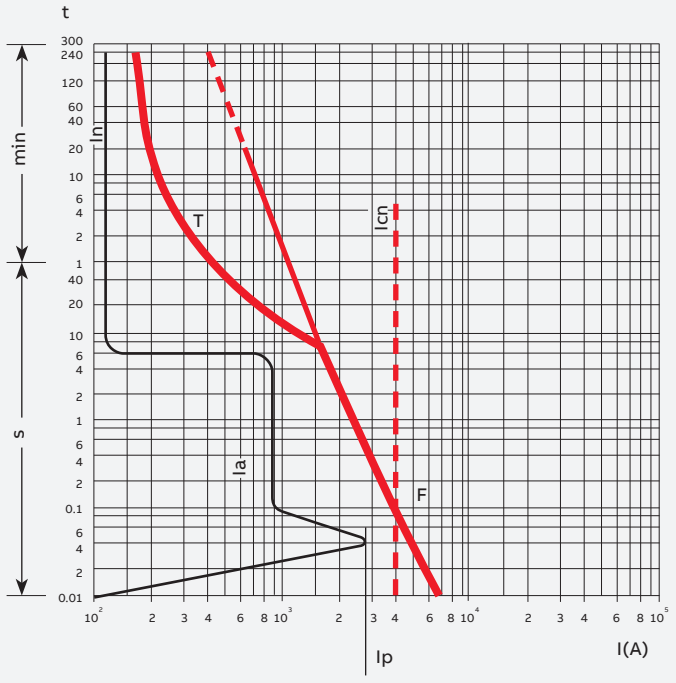
# Specific product characteristics

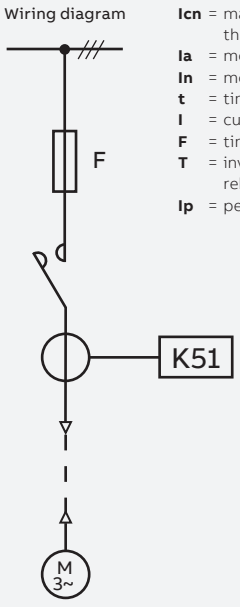



**Is** = prospective short-circuit symmetrical current
**Ip** = current limited by the fuse (peak value)

Fig. C - Short-circuit current limitation curves. ABB CMF type fuses.

Fig. D shows the graph relative to the motor considered in the example.




**Icn** = maximum short-circuit current in amperes that the contactor can interrupt
**Ia** = motor start-up current in amperes
**In** = motor rated current in amperes
**t** = time in seconds
**I** = current in amperes
**F** = time-current characteristic of the 250 A fuse
**T** = inverse time characteristics of the indirect relay for protection against overloads (K51)
**Ip** = peak value of the motor connection current

Fig. D - Graph showing the coordination between 250 A ABB CMF fuse and relay with inverse time delay trip.

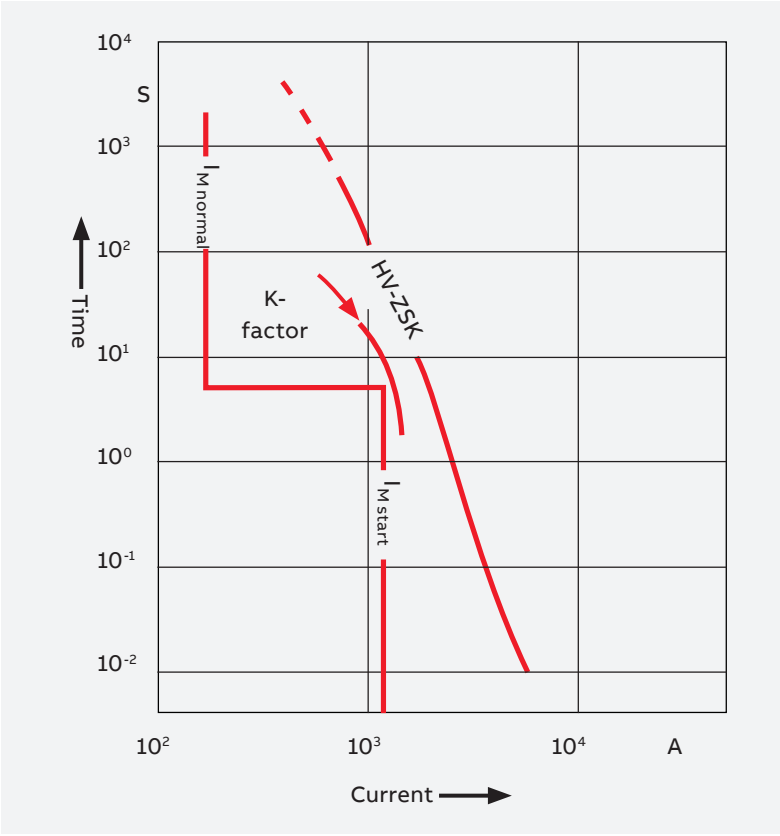



Fig. E - Motor circuit protection as specified in the relevant standards

**BS fuses**

The HHBM-BM fuse produced by SIBA has been tested.

An important parameter is the magnetic inrush. The magnetic inrush current of a motor is significantly smaller than that of a transformer and of shorter duration, which is due to the fact that there is much less copper and iron in a motor than in a (power-wise) comparable transformer. The main stress criteria applicable to a motor and the accompanying fuse are therefore the starting time $t_{start}$ and the starting current $I_{start}$. The stress to the fuse is at its maximum when the motor is starting. Consequently, special attention must be paid to these parameters.

The number of starts per hour is determined by the system and shall in any case be specified by the user. The normal operating current must of course also be taken into account for dimensioning. This is required in order to be able to ensure thermal stability in continuous operation. For this, the environmental conditions and the technical data of the switchgear (heat dissipation) need to be considered.

An important requirement for fuses installed in motor circuits is to be highly resistant to repeated motor start-ups. Therefore, the fuse must be designed and dimensioned in order to be insensitive to this type of cyclic stresses.

Depending on the starting frequency, the possible operating current of the fuses decreases as shown in the following table.

It is permissible to have two starts immediately following each other.

| Start-up/h | Reduction factor |
|---|---|
| 2 | 0.59 |
| 4 | 0.53 |
| 8 | 0.48 |
| 16 | 0.43 |
| 32 | 0.39 |

The diagram shows the motor starting current and the motor starting time.

It is easy to see that the time-current curve of the fuse needs to be on the right-hand side of the motor starting curve, otherwise the fuse would operate and switch-off the current during the run-up period.

The distance between motor and fuse curve represents the safety factor for two consecutive starts. The curve for the K-factor is therefore always within the area limited by the fuse and motor curves.

# Specific product characteristics

## K-factor

The K-factor (K < 1) is based on the following assumptions:

- Starting time $t_{start}$ < 10 seconds
- Max. 6 starts per hour
- Max. 2 consecutive starts (immediately following each other)

The K-factor is essentially a safety margin for the heat dissipation during consecutive starts.
It can be seen that the factor K is not a constant.
In case of intention to deviate from these assumptions, the fuse manufacturer should be consulted in order to ensure proper fuse selection.
The K- factor is therefore integrated into the selection diagrams with means that the safety factor provided by the fuse standard is already included in order to simplify matters for the user.
HV fuse-links, determined for the protection of motor-circuits, are distinguished by their particular low power-losses.
They also respond relatively slow in the time range between 1 s up to approx. 30 s in order to withstand starting currents repeatedly without changing their characteristic.
Selection diagrams are available for determination of the rated fuse current.
Using the motor starting current, starting time, and starting frequency the rated fuse current can be read out directly.
It is important to use the right diagram fitting to the fuse system selected, because only in this case the K-factor, provided by the fuse standard, is taken into account “automatically.” In the following example the selection diagram (Figure E) represents high-voltage fuses with motor circuit protection characteristics.

## Selection in three steps

**Step 1:**

- The following information is required:
- Rated voltage $U_r$ of the system
- Motor data:
  - Rated power $P_n$ of the motor
  - Power factor cosφ
  - Efficiency ($\eta_M$)

  or
  - Rated current Ir of the motor
- Maximum starting current $I_{start}$
- Maximum starting time $t_{start}$
- Maximum number of starts per hour

For motors reference is made to the mechanical power at the shaft. Therefore, if the rated current Ir of the motor is not indicated, the actual motor current is to be derived from the stated rated power taking into consideration the power factor as well as the efficiency.
This information and additional data will always be indicated by the motor manufacturer because they are essential for design and dimensioning of the system.

**Step 2:**
The motor starting current is plotted into the selection diagram and the rated fuse current may be read out taking into consideration the starting time and starting frequency (see the example). In limit cases, the next higher nominal fuse current should be chosen, which has the advantage of lower ohmic losses in nominal operation and improved withstand capability in the event of unusual or more frequent starts.

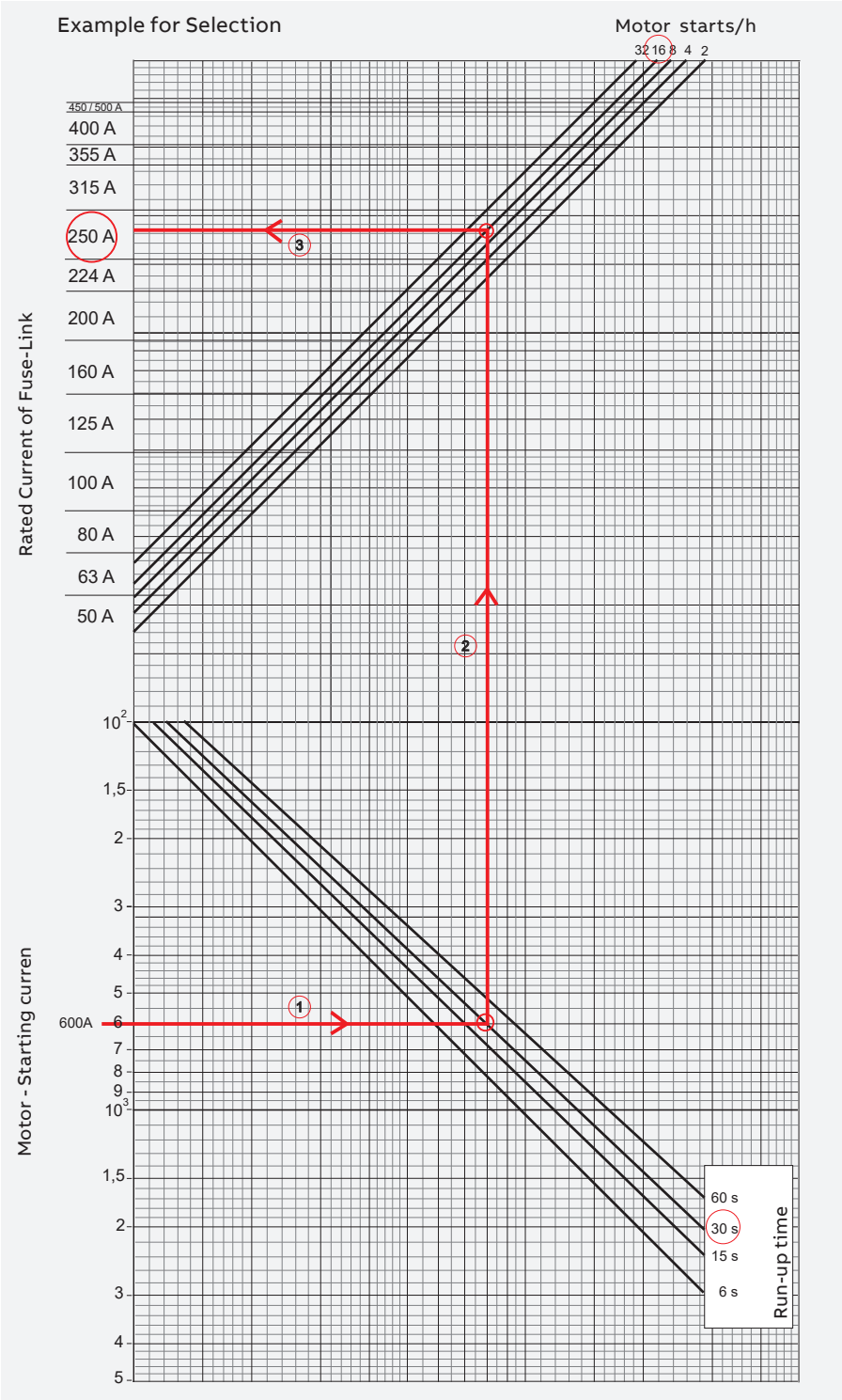
**Step 3:**
It is mandatory to check whether the rated current of the motor will not lead to inadmissible temperature-rise inside the enclosure. According to actual fuse standards the temperature-rise at the metal contact parts is limited to 75 Kelvin at a maximum ambient temperature of 40 °C. This is required in order to ensure that neither the fuse nor the switchgear is subjected to thermal overload.

**Example:**

1. Motor data:
- $U_r$ = 7.2 kV
- $P_n$ = 1 100 kW
- cosφ = 0.93
- $\eta_M$ = 0.95

2. Calculation of rated current Ir of motor:

$$Ir = \frac{P_n}{\sqrt{3} * Ur * \cos\varphi * \eta_M} = \frac{1100\ kW}{\sqrt{3} * 7.2\ kV * 0.93 * 0.95} = 99.84\ A \approx 100\ A$$




3. Additional system data:
- Starting current
  $I_{start}$ = 6 × Ir = 600 A
- Starting time $t_{start}$ = 30 s
- Number of starts/h = 16

Plot into the diagram in Fig. E the starting current of 600 A, go to the right (1) up to the intersection with the 30 s line, then go upwards (2) to the intersection with the 16 starts/h line, then read off 250 A for the rated fuse current on the left (3).
The 7.2 kV – 250 A HV fuse-link is the correct type for this application.

**Special conditions:**

Consult ABB about the contactor and fuse manufacturer if there are special operating conditions, such as:
- Ambient temperature > 40 °C
- $T_{start}$ time > 60 s
- Number of trips > 32/hour

# Specific product characteristics

## Motor starting

Motor starting poses the problem of the high current consumption on inrush.
In most cases, since these are asynchronous motors, the start-up current can take on the following values:

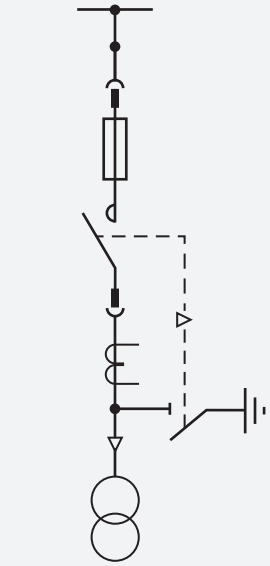
- asynchronous with simple squirrel cage 4.5 ... 5.5 In
- asynchronous with double squirrel cage 5 ... 7 In
- asynchronous with wound motor: low values, dependent on selection of the starting resistances.

This current cannot be available if the short-circuit power of the network is not sufficiently high and, in any case, can give rise to a drop in voltage for the whole duration of starting, which cannot be tolerated, from the loads derived from the network itself. Normally a voltage drop between 15 and 20% is considered acceptable except for verification needed in the case of special users.

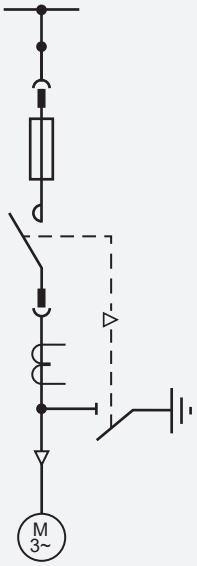
The full voltage start-up condition can be checked analytically and turns out to be possible in most cases.
If the calculations show that the start-up power causes a voltage drop higher than the admissible one, starting with reduced voltage must be used, with consequent reduction in the start-up current. For this purpose, starting with a step-down autotransformer is generally used.
For large motors it may be more convenient to use a transformer, whose sizing can be a little higher than the power required by the motor, dedicated exclusively to the machine: start-up therefore takes place with reduced voltage without the rest of the plant being affected.

By suitably combining different enclosures, with withdrawable contactors appropriately fitted with accessories, any motor starting, control, protection  and measurement diagram can be made.

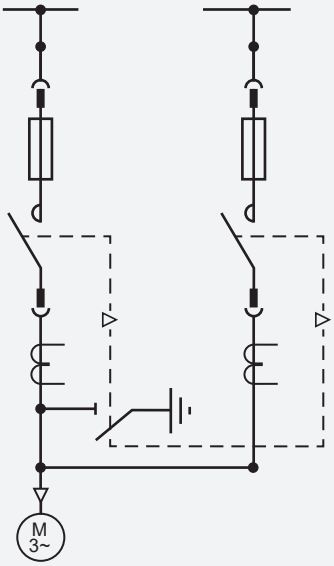
Fig. F shows some typical electric diagrams which can be made with withdrawable contactors.



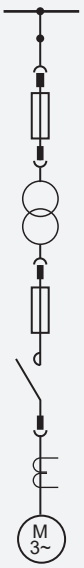
Transformer power supply



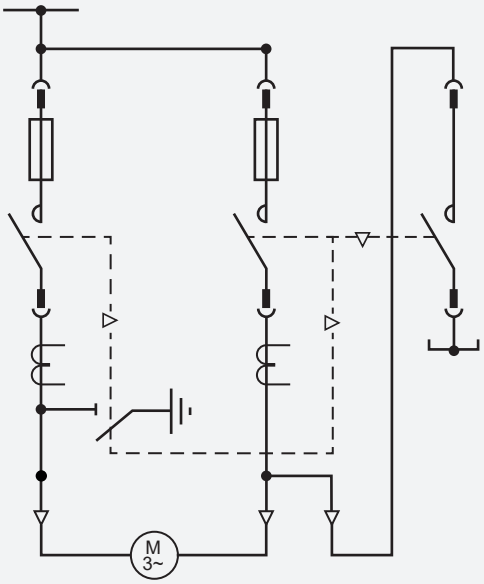

Motor starting with full voltage



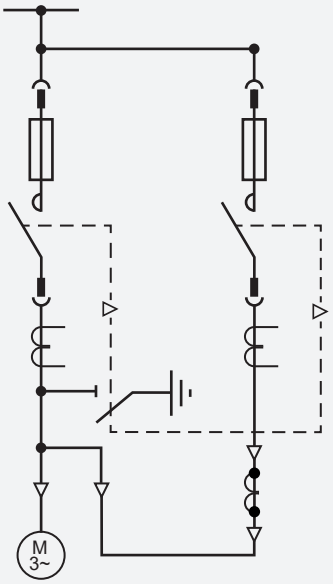

Reversal of motor running



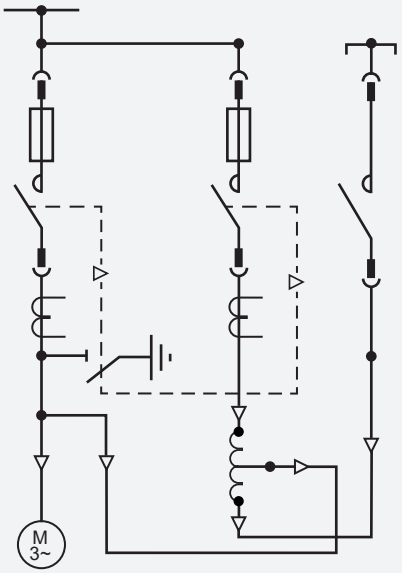

Motor starting with dedicated transformer




Star-delta motor starting




Motor starting with reactor




Motor starting with autotransformer

Fig. F - Typical diagrams of transformer power supply and motor starting

# Specific product characteristics

## Transformer protection and fuse selection ([1])

When contactors are used for transformer control and protection, they are fitted with special types of current-limiting fuses which guarantee selectivity with other protection devices and which can take the high transformer connection currents without deterioration.
Unlike what has been seen for motors, in this case protection against overcurrents on the medium voltage side of the transformer is not indispensable since this task is carried out by the protection provided on the low voltage side. The protection on the medium voltage side can be entrusted to the fuse alone, which must be selected taking into account the no-load connection current, which can reach values up to 10 times the rated current for smaller transformers built with orientated crystal core laminations.
The maximum connection current is reached when circuit breaker closing takes place in correspondence with passage through zero of the voltage.
Another result to be guaranteed is protection against faults in the low voltage winding and in the connection stretch from this to the circuit breaker located on the secondary winding, avoiding the use of fuses with rated current which is too high, to be able to ensure tripping within a short time even under these fault conditions.
A rapid check of the short-circuit current at the secondary terminals of the transformer and on the supply side of the circuit breaker on the secondary, if placed at a significant distance, allows the trip time to be verified on the fuse blowing curve.
The table of use given below takes both the required conditions into account, i.e. rated current sufficiently high to prevent unwarranted blowing during the no-load connection phase and, in any case, of a value which guarantees protection of the machine against faults on the low voltage side.

## Connection of capacitors

The presence of current transients, which occur during switching-in of a capacitor bank, requires attention during the calculation procedures. In fact, assessment of the size of the phenomenon provides the elements for selecting the switching apparatus suitable for connecting/disconnecting the bank and for guaranteeing its protection in the case of overload.
To make this calculation, the power factor correction installations must be divided into two types:

1) installations with a single three-phase capacitor bank (single bank installations)
2) installations with several three-phase capacitor banks, which can be connected separately (multiple bank installations).

In the first type of installations there is only one type of switching-in transient, called switching-in transient of a single capacitor bank to the network. An example of a typical current transient is shown in fig. A.
In the second type of installations there are two types of switching-in transients:

- on connection of the first capacitor bank there is the switching-in transient of a capacitor bank to the network
- on connection of the other banks there is a switching-in transient of a capacitor bank to the network with other banks already supplied in parallel. In this case, the current transient is the type shown in fig. B.

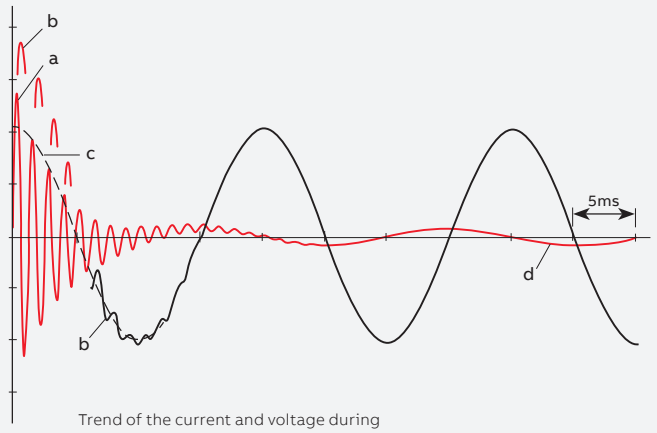
**Selection of contactors suitable for connection of capacitor banks**
The CEI 33-7 and IEC 871-1/2 Standards specify that the capacitor banks "... must be able to operate correctly under overload with an effective line current value up to 1.3 In, not taking into account the transients".

([1]) Selection criteria relative to ABB CEF type fuses.

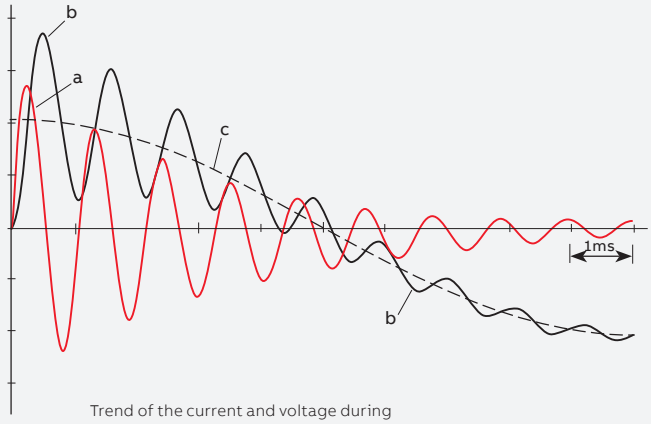
## Selection table for fuses for transformers

| Rated voltage of the transformer | Rated transformer power [kVA] | | | | | | | | | | | | | | | | | | Rated voltage of the fuse |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | 50 | 75 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | |
| [kV] | Rated current of fuse CEF [A] | | | | | | | | | | | | | | | | | | [kV] |
| 3 | 16 | 25 | 25 | 40 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 2x250 (1) | 2x315 (1) | | | 3.6/7.2 |
| 5 | 10 | 16 | 25 | 25 | 25 | 40 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 2x250 (1) | 2x315 (1) | |
| 6 | 6 | 16 | 16 | 25 | 25 | 25 | 40 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 2x250 (1) | |
| 10 | 6 | 10 | 16 | 16 | 16 | 20 | 20 | 25 | 31.5 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 2x160 (1) | 12 |
| 12 | 6 | 6 | 10 | 16 | 16 | 16 | 20 | 20 | 25 | 40 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 | |

Use CMF fuses.
(1) External fuse carrier required.



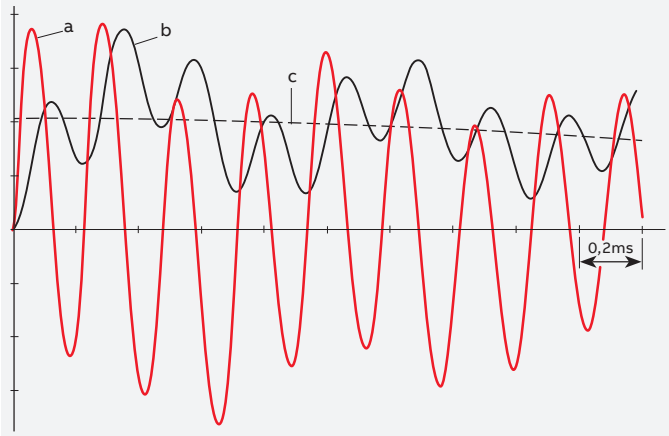

Trend of the current and voltage during and after the switching-in transient.



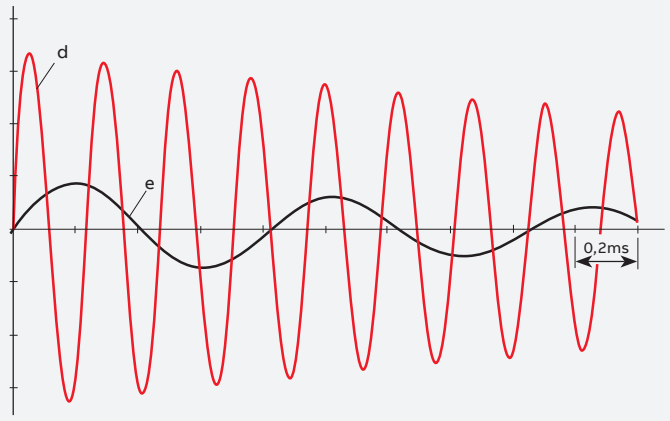

Trend of the current and voltage during the first 10 ms of the switching-in transient.

**a** = Transient switching-in current: first peak at 600 A peak and 920 Hz frequency.
**b** = Transient voltage at the 400 kVAR bank terminals.
**c** = Power supply phase voltage 10/÷3 = 5.8 kV.
**d** = Rated bank current at 50 Hz: 23.1 A.

Fig. A - Example of a current transient during connection of a single capacitor bank.




Trend of the current and voltage during the first 2 ms of the switching-in transient.




Trend of the two components of the total current (see graph above).

**a** = Transient switching-in current: 1800 A peak and 4280 Hz frequency.
**b** = Transient voltage at the 400 kVAR bank terminals
**c** = Power supply phase voltage: 10/÷3 = 5.8 kV.
**d** = Component at 4280 Hz frequency of the transient switching-in current.
**e** = Component at 1260 Hz frequency of the transient switching-in current.

Fig. B - Example of a current transient during connection of a capacitor bank with another one already supplied with voltage.

# Specific product characteristics

The switching, protection and connection devices must therefore be designed to withstand continuously a current 1.3 times the current there would be at the rated sinusoidal voltage and at the rated frequency.
According to the effective value of the capacity, which may also be 1.10 times the rated value, this current can have a maximum value of 1.3 x 1.10 = 1.43 times the rated current.
It is therefore advisable to select the rated normal current of the contactor for operating the capacitor bank at least equal to 1.43 times the rated current of the bank.
The V-Contact VSC contactors completely fulfil the requirements of the Standards, particularly those regarding connection and disconnection operations of banks and the overvoltages which, in any case, do not exceed three times the peak value of the rated phase voltage of the installation.

**Single bank**
The parameters of the current transient, peak values and own frequency, which are present in the case of connection of the bank to the network, are usually of notably smaller size than those in the case of multiple banks.

**Two or more banks (back-to-back)**
In the case of several capacitor banks, it is necessary to make the calculations regarding the installation, considering operation of a single bank with the other capacitor banks already connected. Under these conditions, it is necessary to check that:
- maximum switching-in current does not exceed the value given below (see table);
- switching-in current frequency does not exceed the value given below (see table)..

| Contactor | Peak current | Maximum switching-in frequency | Ip (ka) x f (Hz) |
|---|---|---|---|
| VSC-S | 8 kAp | 2.500 Hz | 20000 |

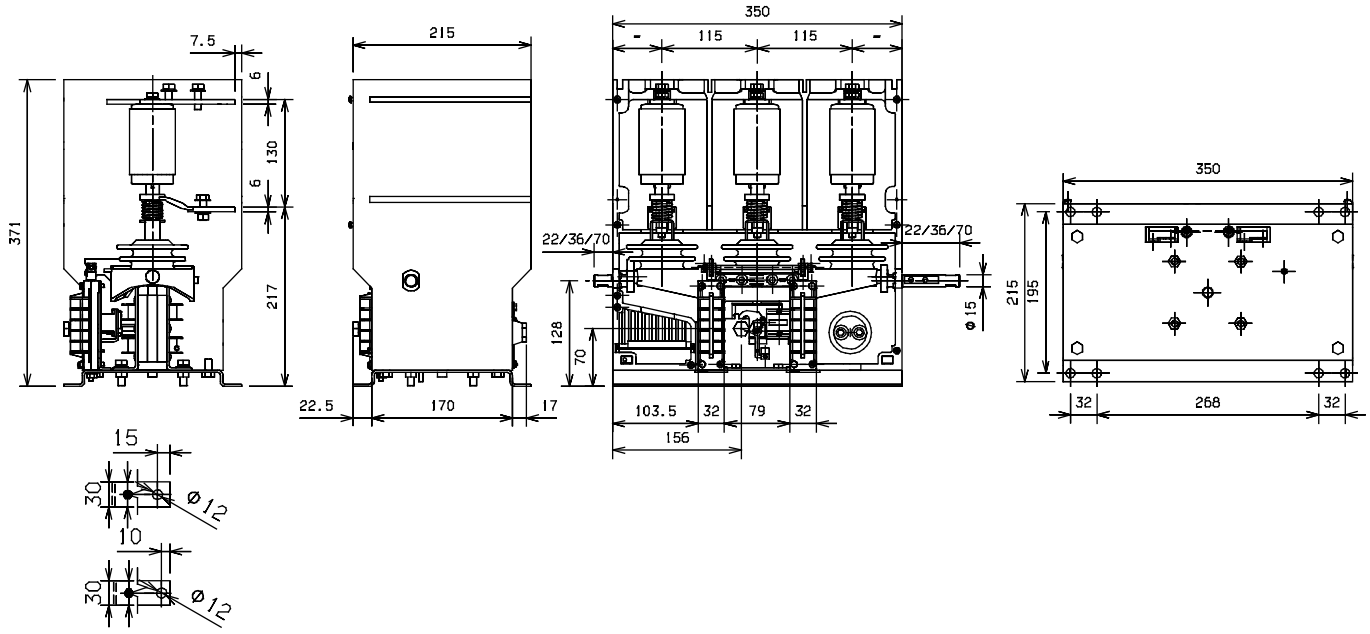
If the maximum switching-in current is lower than 8kA than the switching in frequency can be higher, provided that multiplying the current for the frequency the result is lower than
Ip (kA) x f (Hz) = 8 x 2,500 = 20.000
for instance:
Ip (kA) = 5kA the maximum allowed switching-in frequency become
f (Hz) = 20.000 / 5 = 4.000Hz
This rule is applicable for switching currents lower than 8kAp thet is the maximum value not to be exceeded even if the frequency is lower than 2500Hz.
To calculate the switching-in current and frequency, refer to the ANSI C37.012 Standards or to the IEC 62271-100 Annex H Standards.
If the result of calculation is a switching-in current and frequency higher than the maximum allowed than is necessary to connect air reactors of suitable value in the circuit taking into account also cables connected.
In case of frequent operations with high switching-in frequencies use of reactors is recommended.

## Environmental protection programme

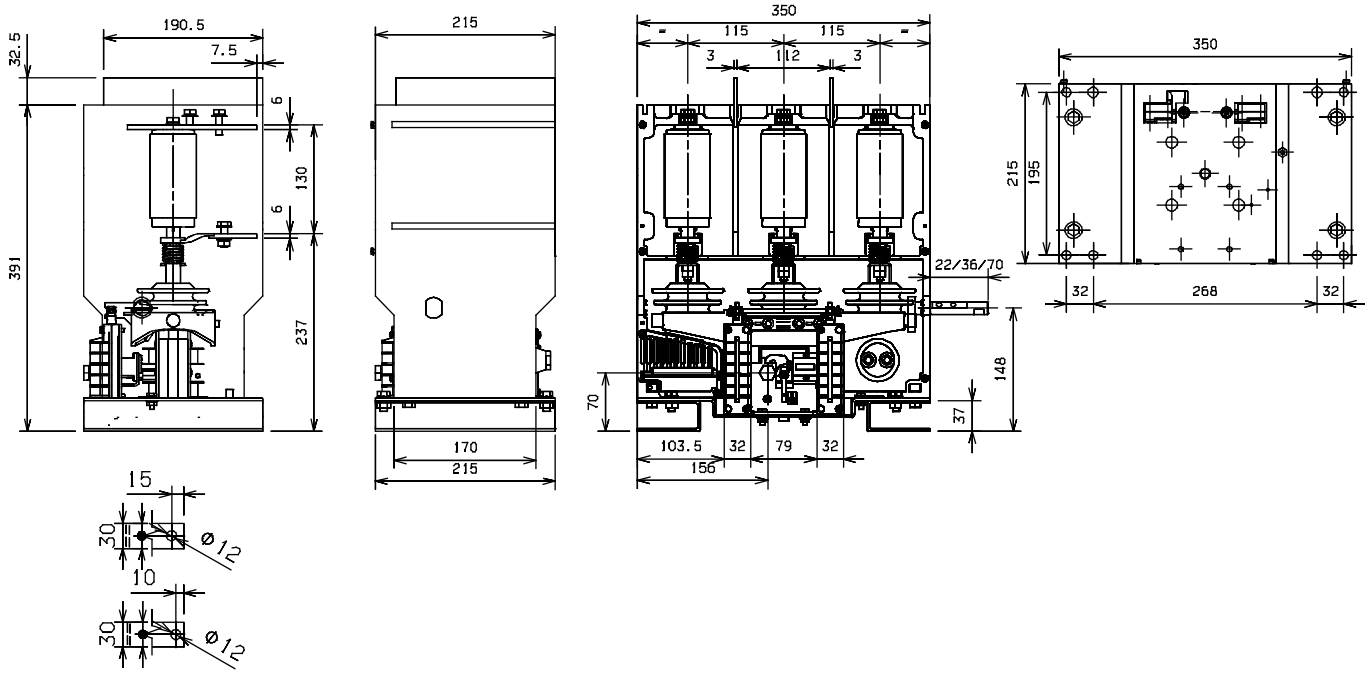
The V-Contact VSC contactors are constructed in compliance with the ISO 14000 Standards (Guidelines for environmental management).
The production processes are carried out in compliance with the Standards for environmental protection both in terms of reduction of energy consumption and raw materials and of production of waste. All this is thanks to the environmental management system in the production facility conforming to what is certified by the certifying Organisation.
The minimal environmental impact during the life cycle of the product (LCA - Life Cycle Assessment), is obtained by targeted selection of materials, processes and packing made during the design stage.
The production techniques prepare the products for easy dismantling and easy separation of the components to allow maximum recycling at the end of the useful life cycle of the apparatus.
For this purpose, all the plastic components are marked according to ISO 11469 (2nd ed. 15.05.2000).
When compared with a contactor fitted with a traditional operating mechanism, V-Contact VSC contactors allow an energy saving which prevents emission into the atmosphere of about 7000 kg of carbon dioxide ($CO_2$).

# Overall dimensions

### VSC 7 - VSC 7/G fixed contactor

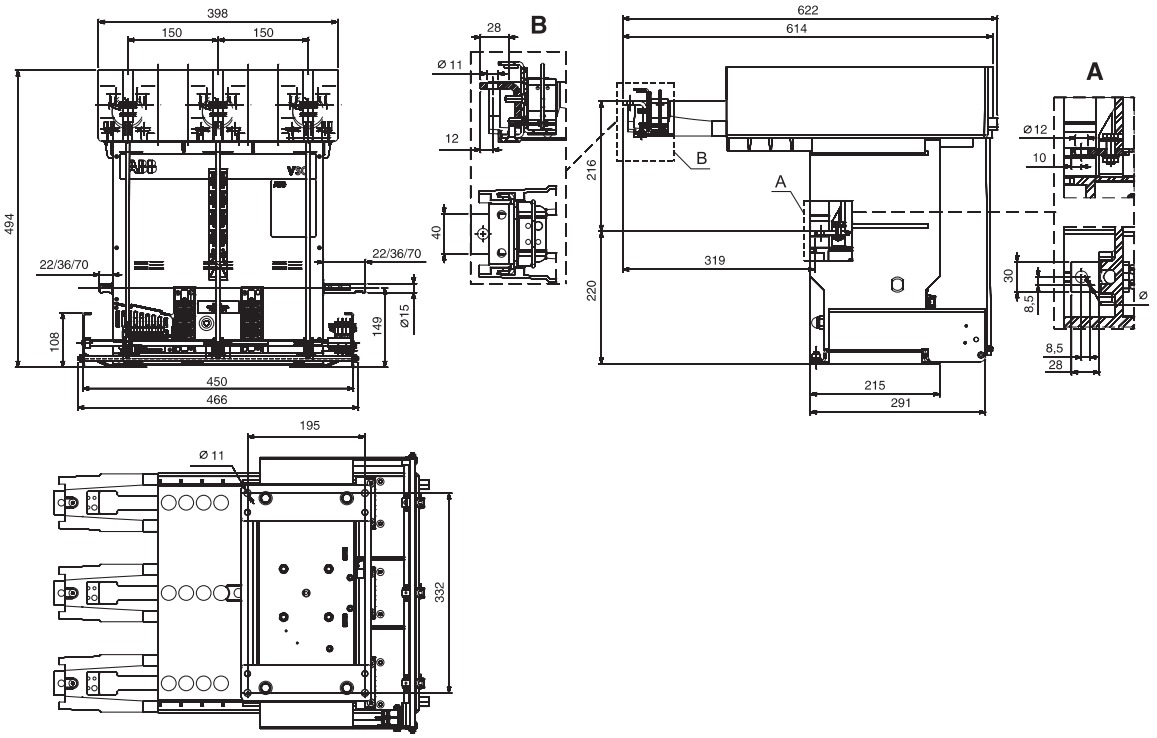



### VSC 12 - VSC 12/G - VSC-S/G fixed contactor

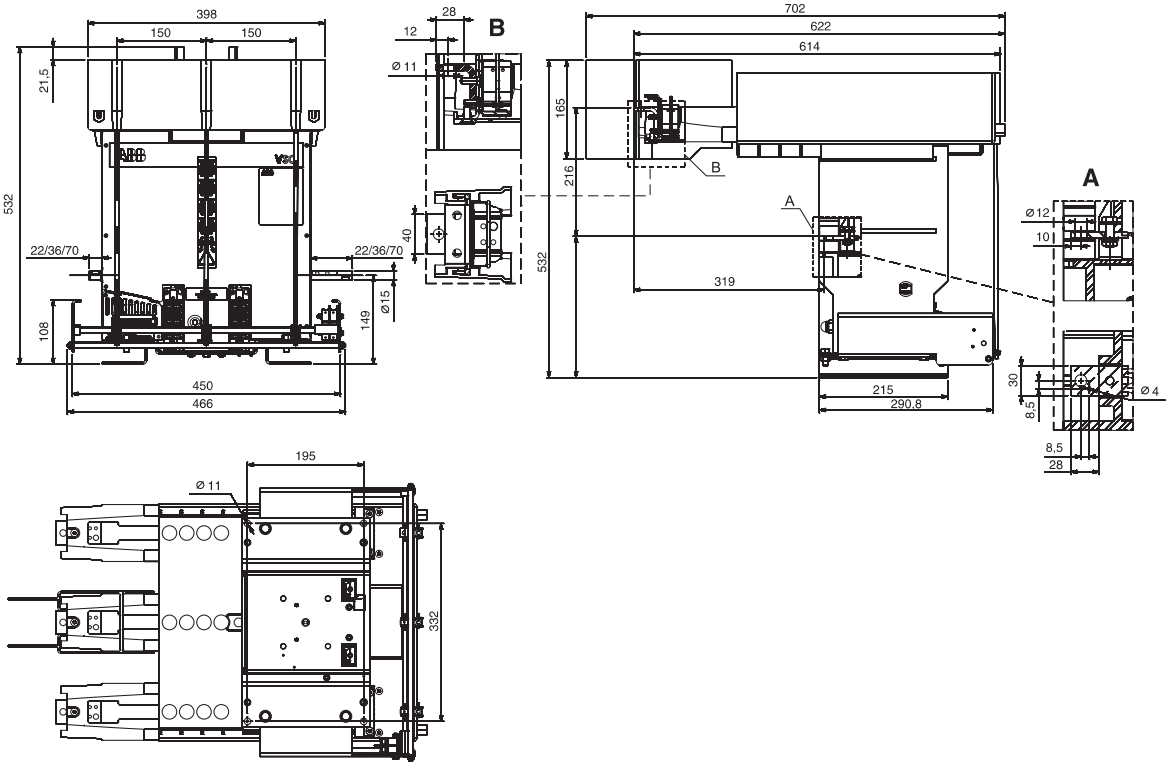


# Overall dimensions

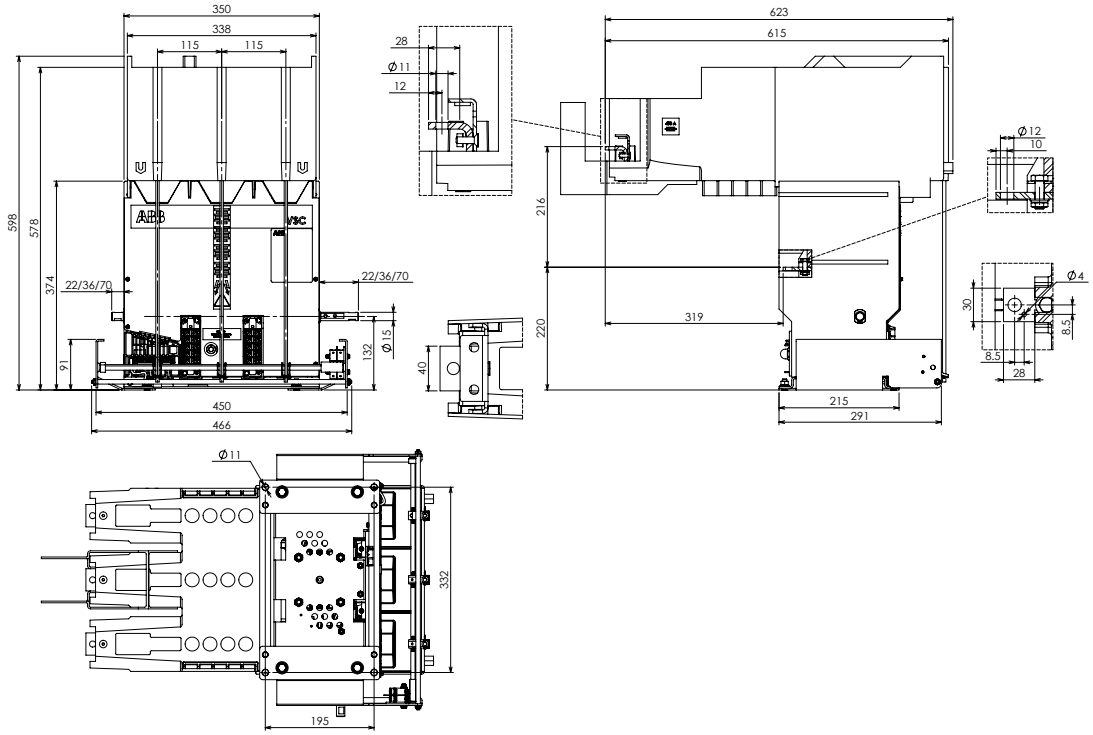
### VSC 7/F fixed contactor with fuses



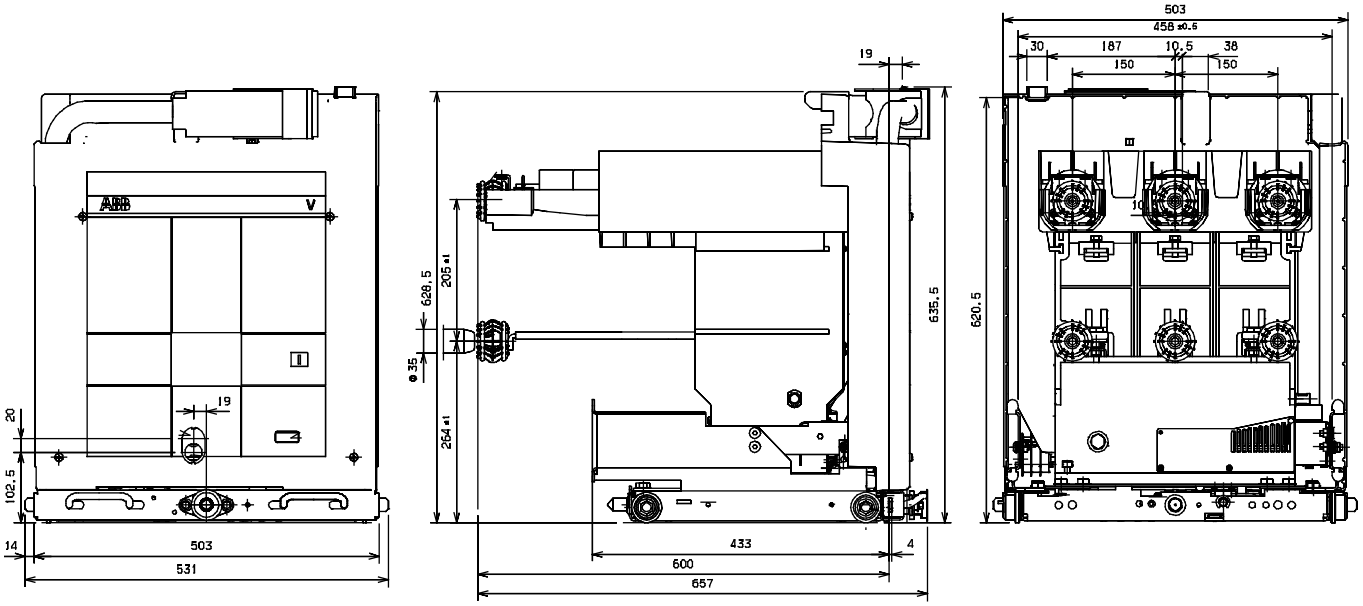

### VSC 12/F - VSC-S/F fixed contactor with fuses



**VSC 7/FN Contactor preset for 2 BS fuses in parallel**

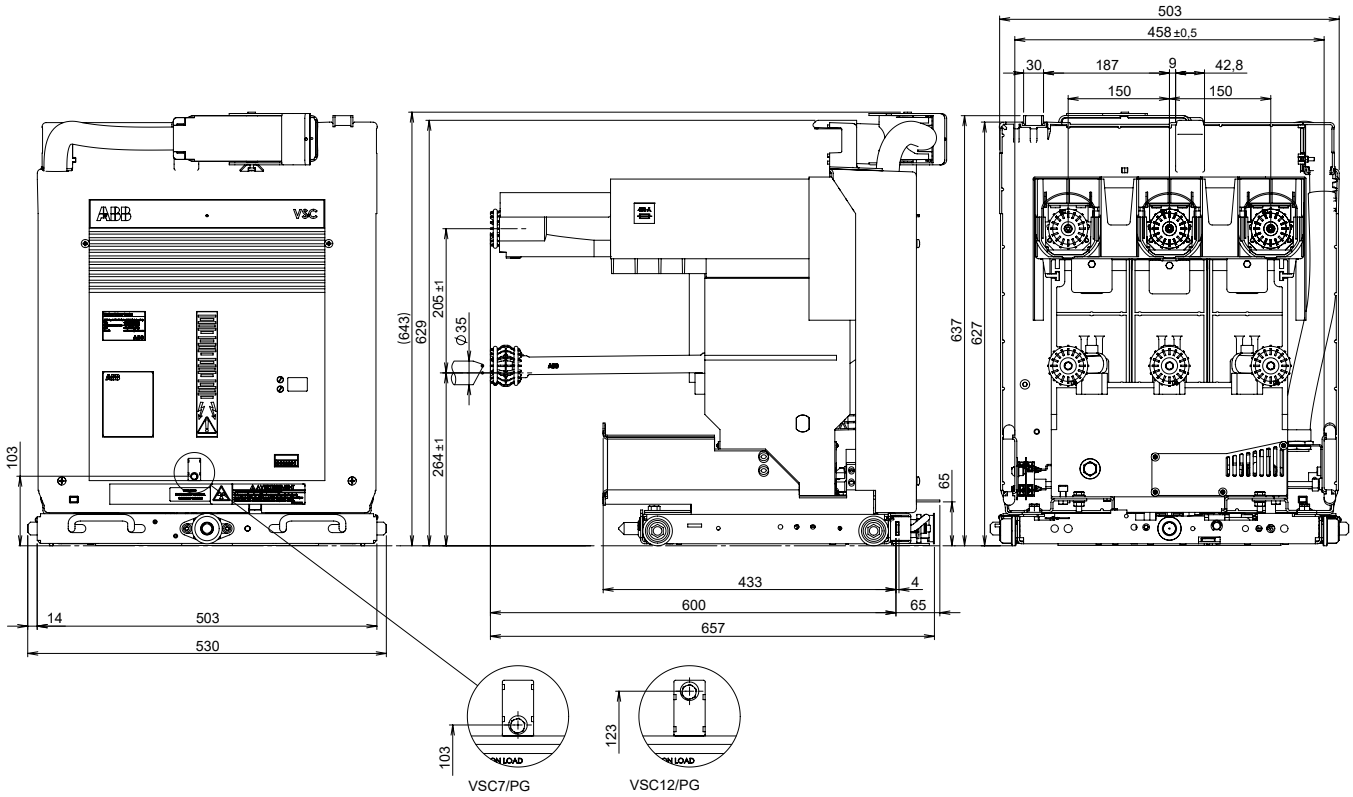



**VSC 7/P - VSC 12/P withdrawable contactor**

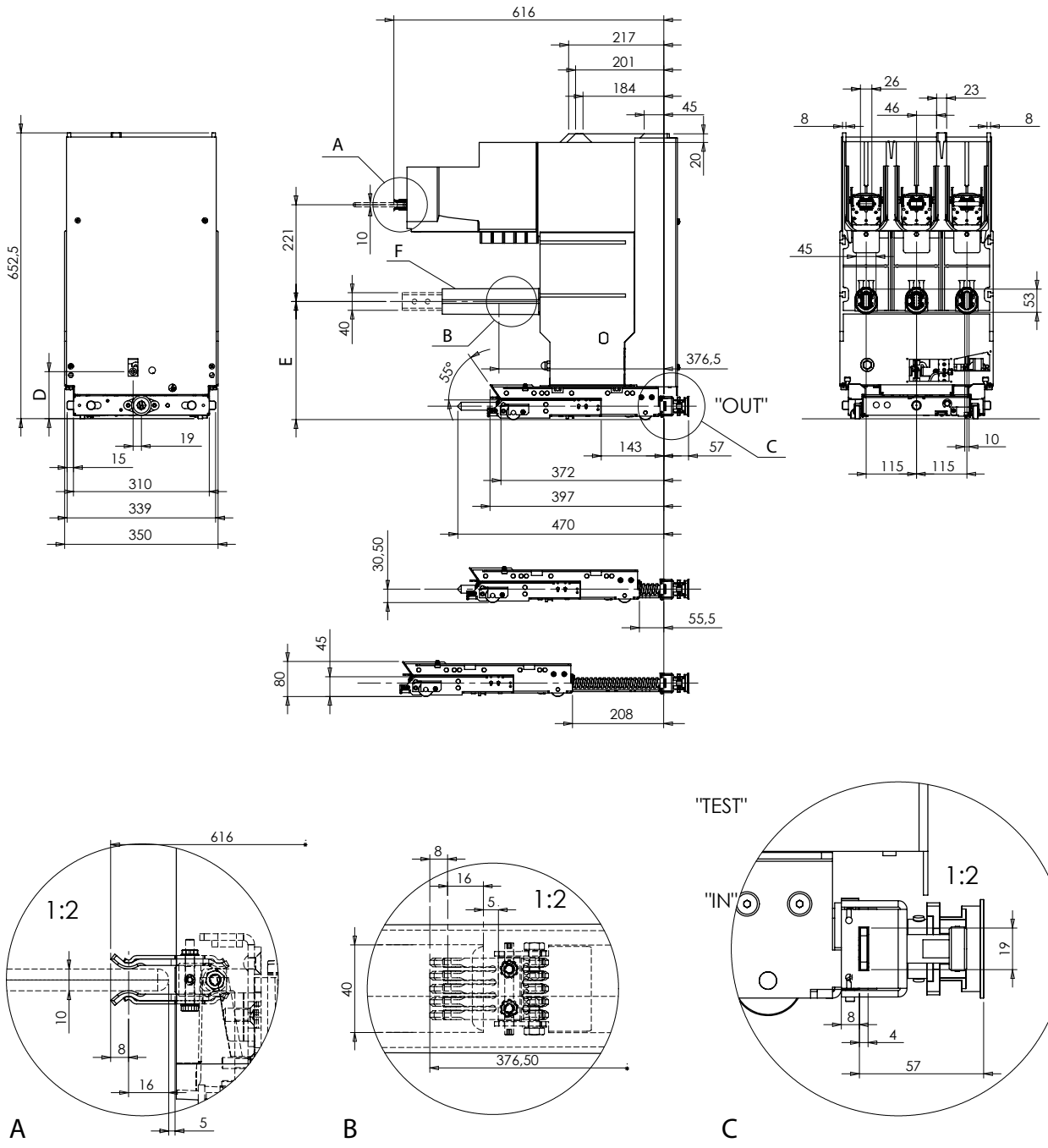


# Overall dimensions

**VSC7/PG - VSC12/PG - VSC-S/PG withdrawable contactor**



**VSC 7/PN - VSC 12/PN - VSC-S/PNG withdrawable contactor**



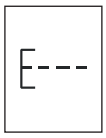

| Contactor | D | E | Protection “F” |
|---|---|---|---|
| **VSC 7/PN** | 270.5 | 108 | Not present |
| **VSC 7/PNG** | 269.5 | 108 | Present |
| **VSC 12/PN** | 269.5 | 129 | Present |

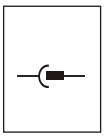
# Electric circuit diagram

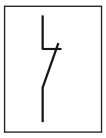
The diagrams given below show, as an example, the contactor circuits.
In any case, to take into account product development and for specific applications, it is always useful refer to the electric circuit diagram provided with each piece of apparatus.

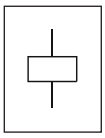
**State of operation represented**
The diagram indicates the following conditions:
- circuit breaker open
- circuits de-energized
- in service position (withdrawable contactor).

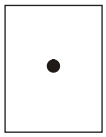
**Graphic symbols for electric diagrams (IEC Standards)**

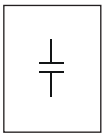

Operated by pushingl

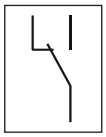

Plug and socket (male and female)

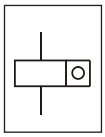

Break contact

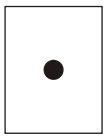

Operating device (general symbol)

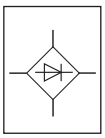

Connections of conductors

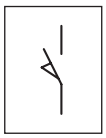

Capacitor (general symbol)

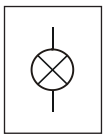

Change-over break before make contact

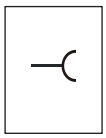

Pulse meter (electrically-operated counting device)

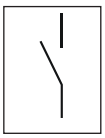

Borne

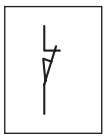

Rectifier in full wave (bridge) connection

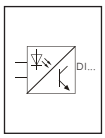

Position switch (limit switch), make contact


Lamp (general symbol)

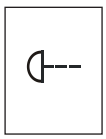

Socket


Make contact

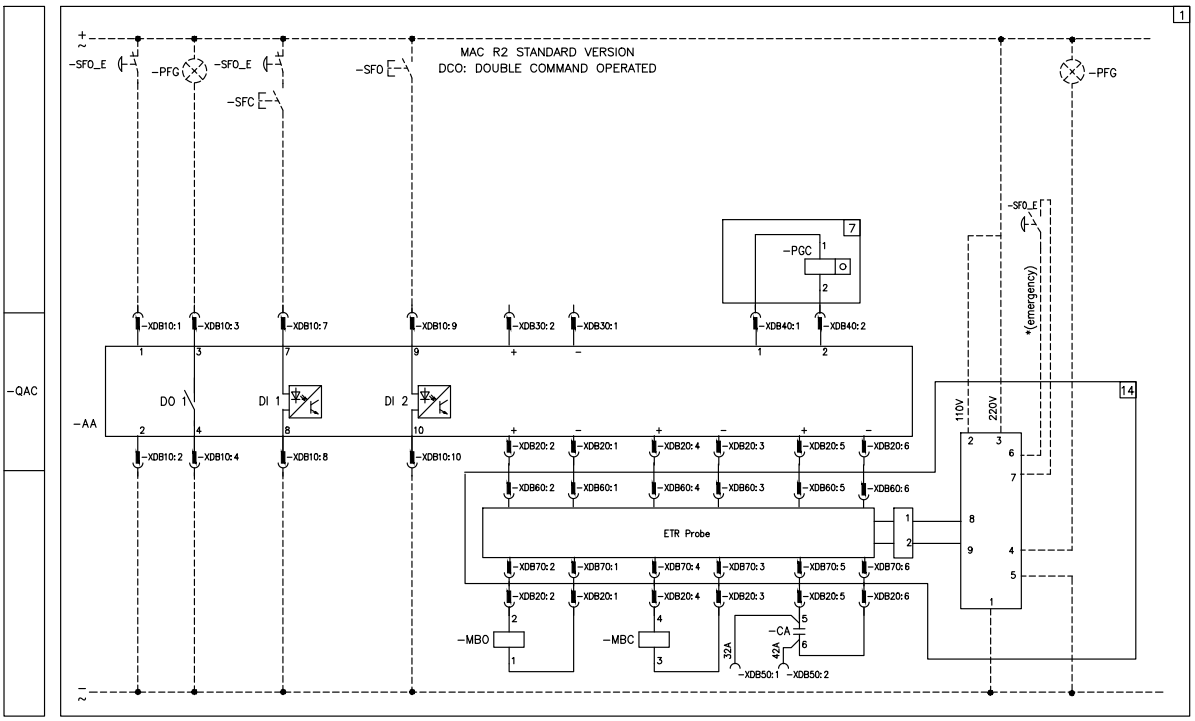

Position switch (limit switch), break contact



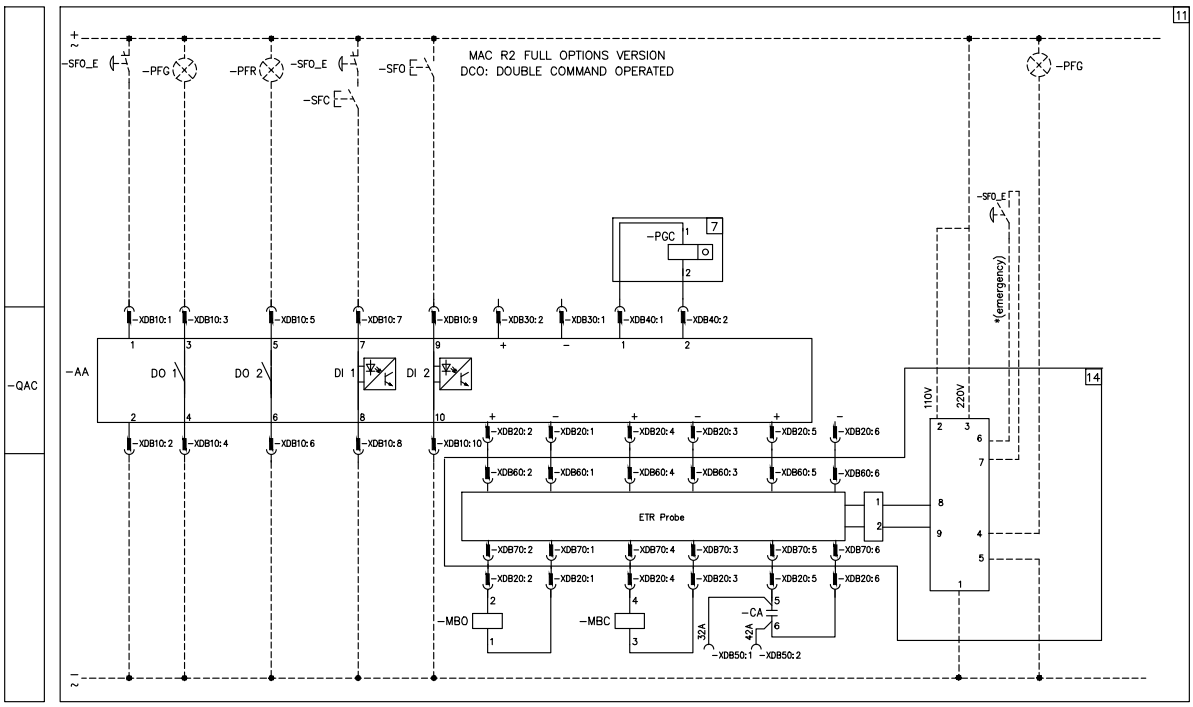
Isolated binary digital input


Emergency pushbutton

**Circuit diagram for fixed contactors VSC - 1VCD400138 - V8871**



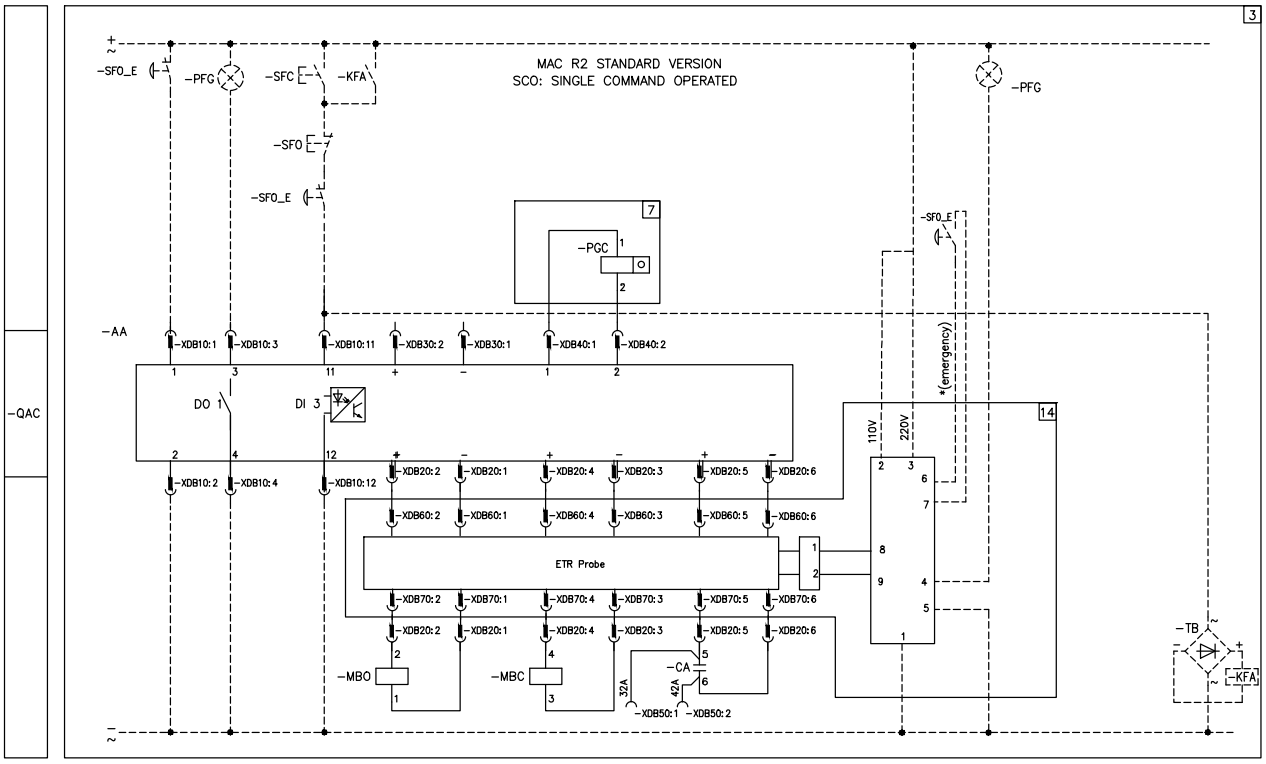

WARNING: the voltage at the feeder clamps of the electronic card and the command circuit (clamps 1-3-7-9, 2-4-8-10 of fig. 1 and clamps 11, 12 of fig. 2) must come from an unique auxiliary circuit supply and the same circuit breaker.



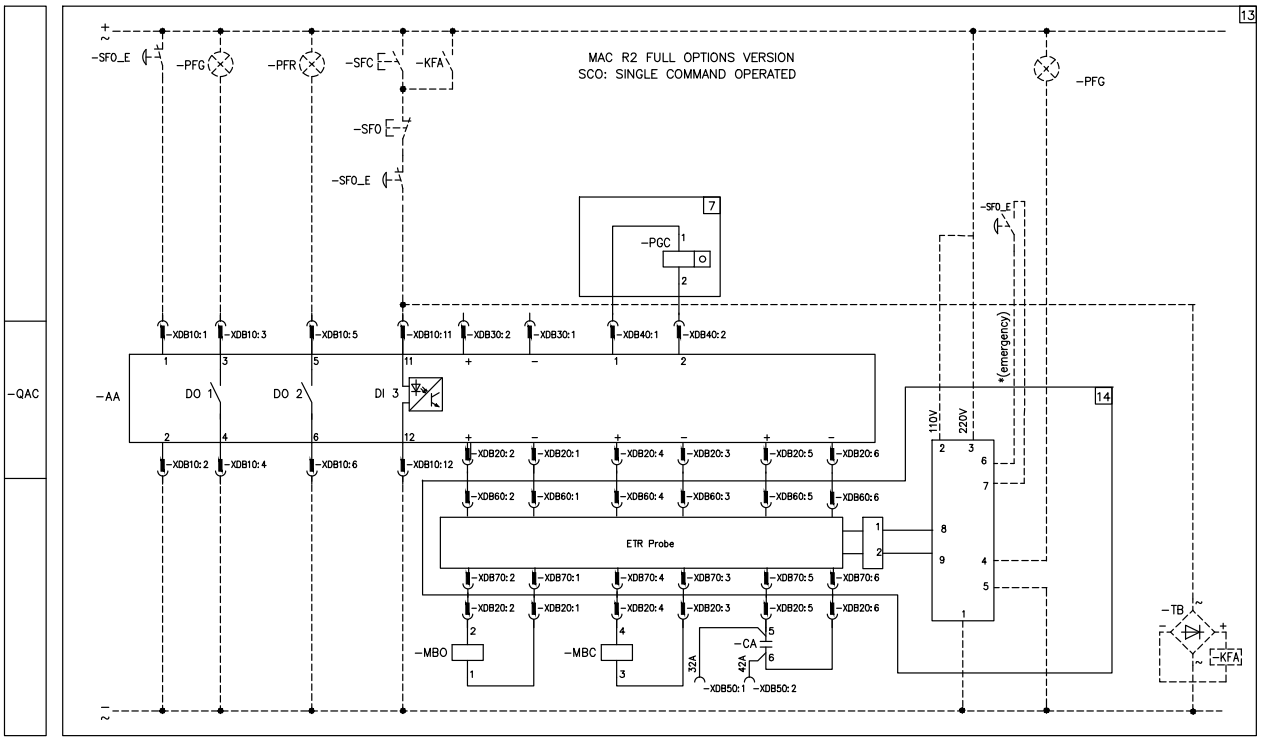

WARNING: the voltage at the feeder clamps of the electronic card and the command circuit (clamps 1-3-7-9, 2-4-8-10 of fig. 11 and clamps 11, 12 of fig. 2) must come from an unique auxiliary circuit supply and the same circuit breaker.

# Electric circuit diagram

### Circuit diagram for fixed contactors VSC - 1VCD400138 - V8871

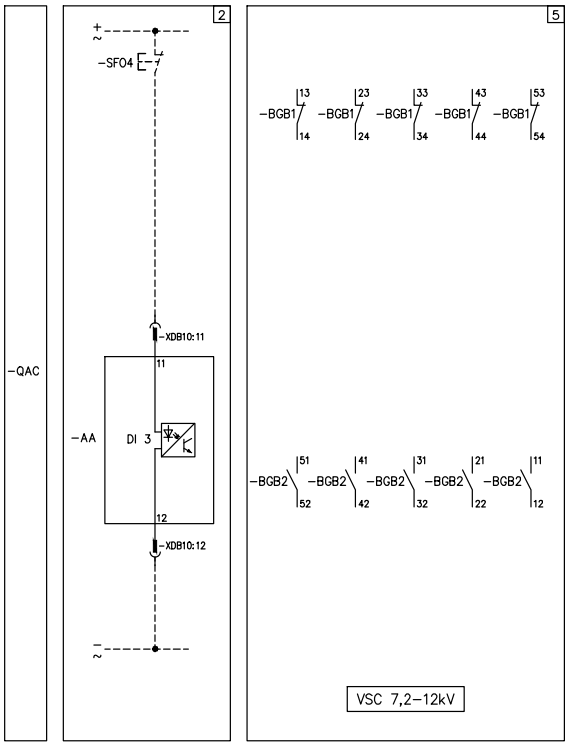



WARNING: the voltage at the feeder clamps of the electronic card and the command circuit (clamps 1-3-11 and 2-4-12) must come from an unique auxiliary circuit supply and the same circuit breaker.



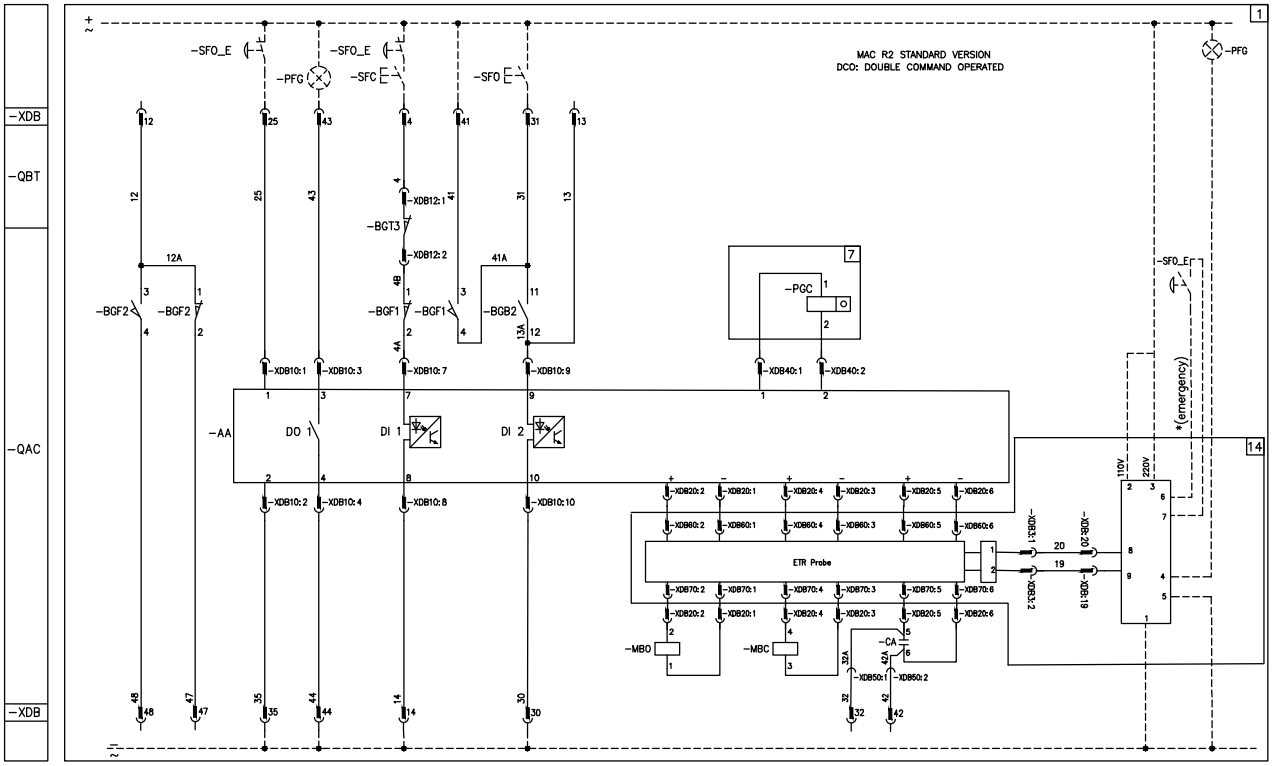

WARNING: the voltage at the feeder clamps of the electronic card and the command circuit (clamps 1-3-5-11 and 2-4-6-12)must come from an unique auxiliary circuit supply and the same circuit breaker.

**Circuit diagram for fixed contactors VSC - 1VCD400138 - V8871**

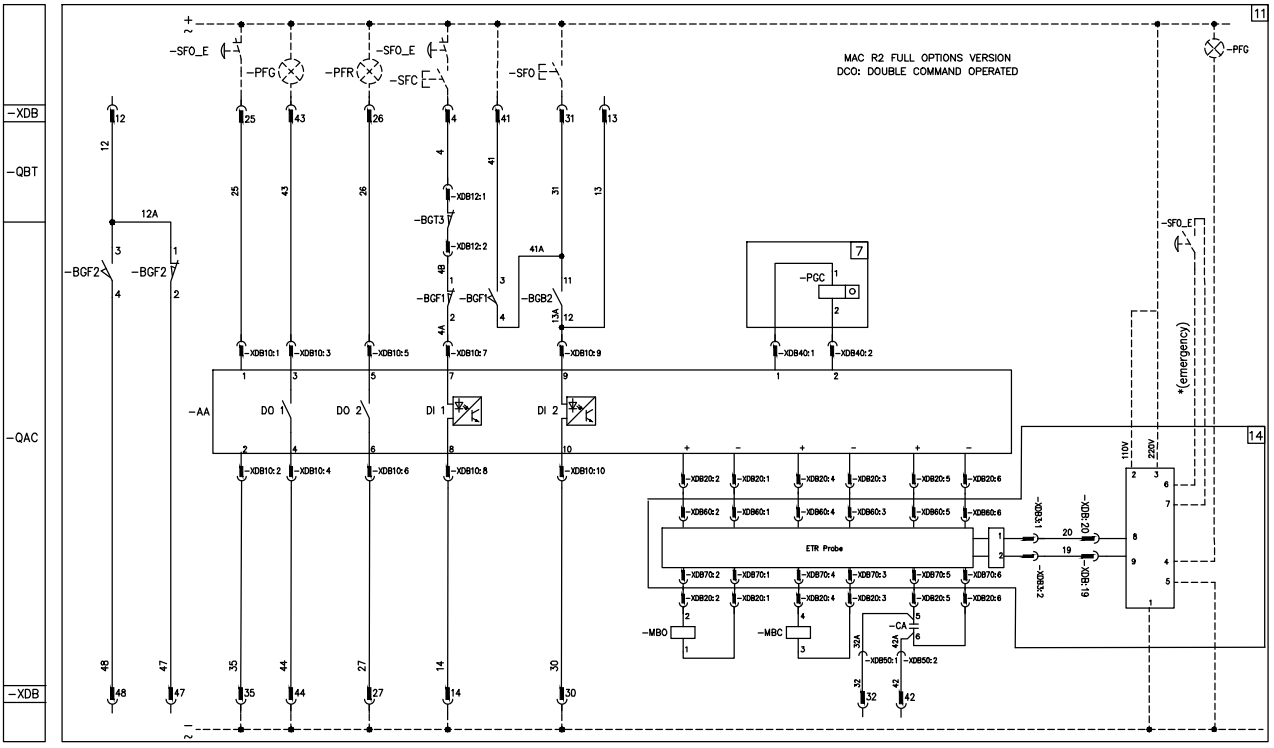


# Electric circuit diagram

### Circuit diagram for withdrawable contactors VSC/P-PG - 1VCD400139 - V8917

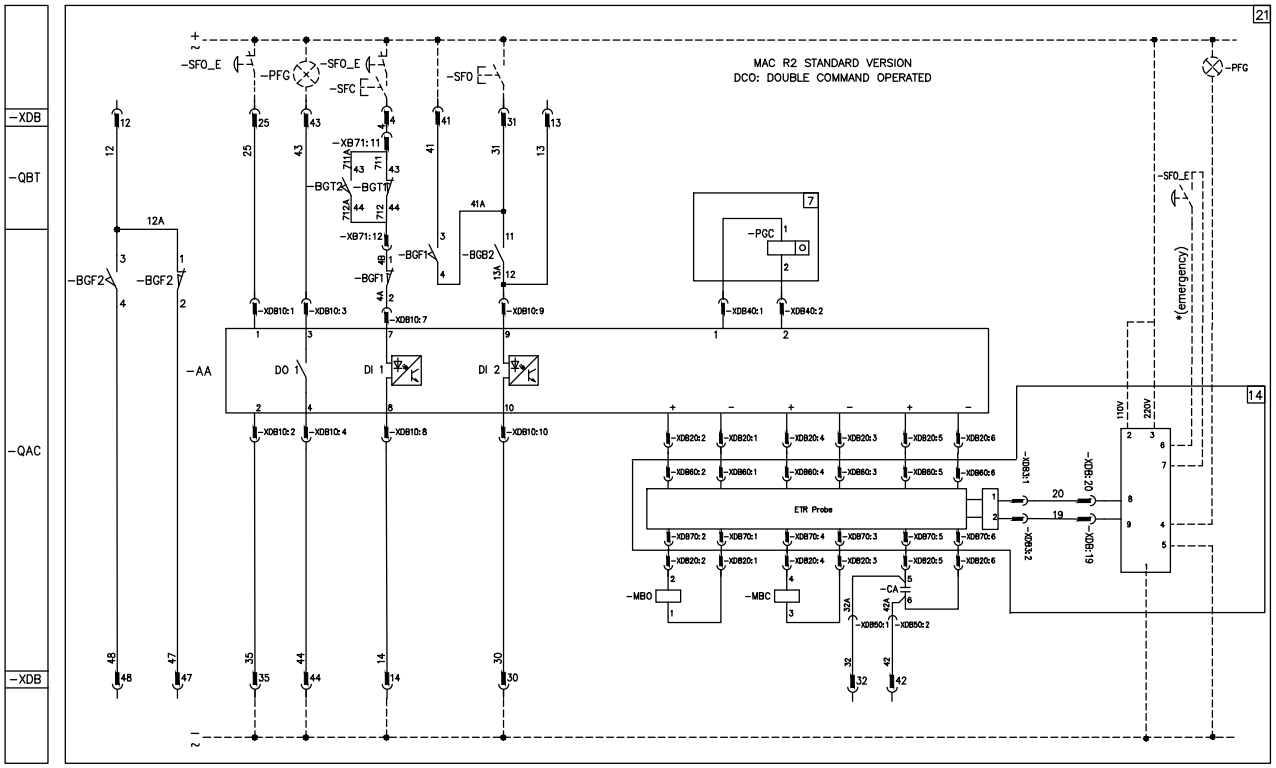



WARNING: the voltage at the feeder clamps of the electronic card and the command circuit (clamps 1-3-7-9, 2-4-8-10 of fig. 1 and clamps 11, 12 of fig. 2) must come from an unique auxiliary circuit supply and the same circuit breaker.

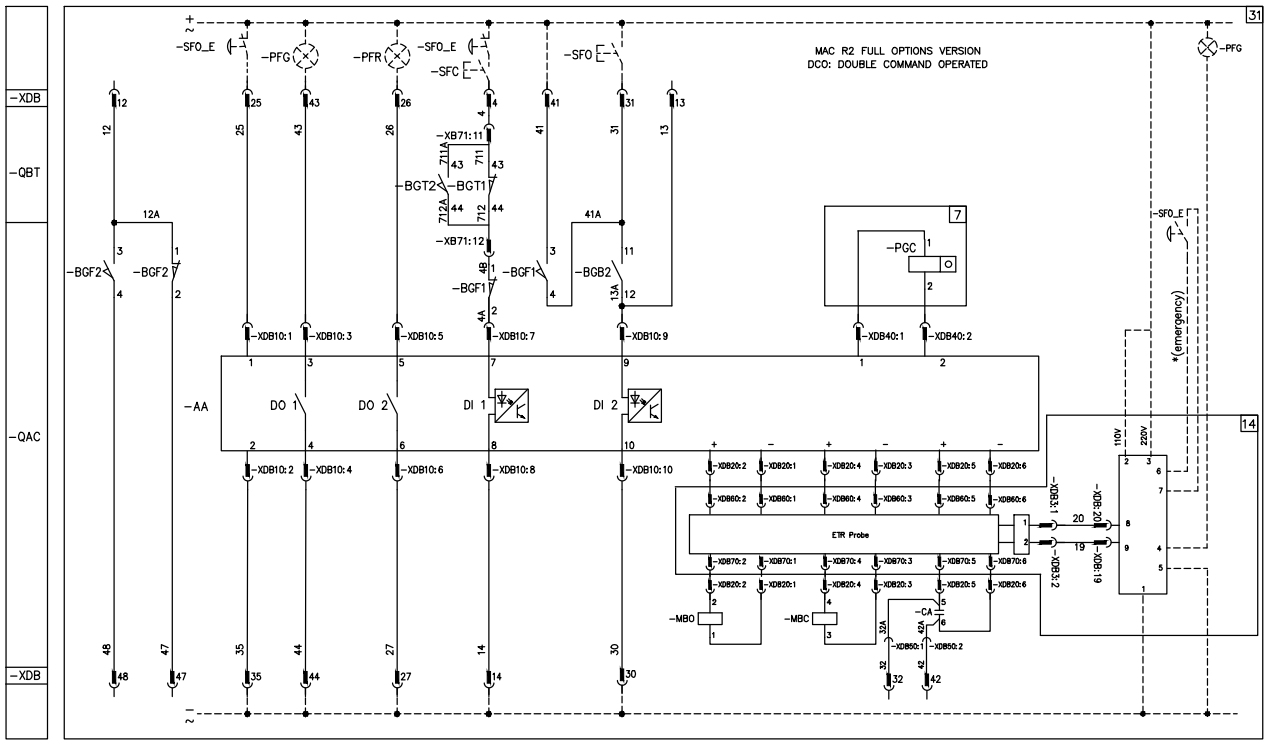



WARNING: the voltage at the feeder clamps of the electronic card and the command circuit (clamps 1-3-7-9, 2-4-8-10 of fig. 11 and clamps 11, 12 of fig. 2) must come from an unique auxiliary circuit supply and the same circuit breaker.

## Circuit diagram for withdrawable contactors VSC/P-PG - 1VCD400139 - V8917



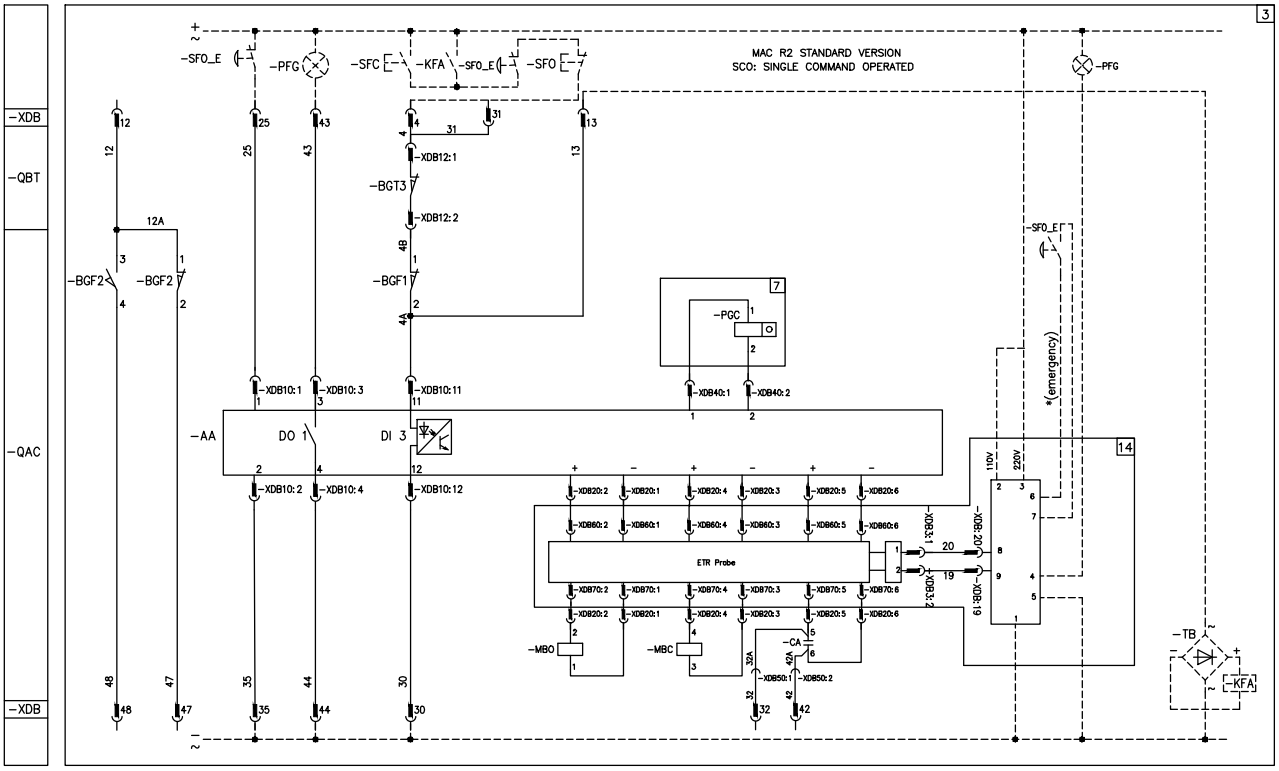

WARNING: the voltage at the feeder clamps of the electronic card and the command circuit (clamps 1-3-7-9, 2-4-8-10 of fig. 1 and clamps 11, 12 of fig. 2) must come from an unique auxiliary circuit supply and the same circuit breaker.



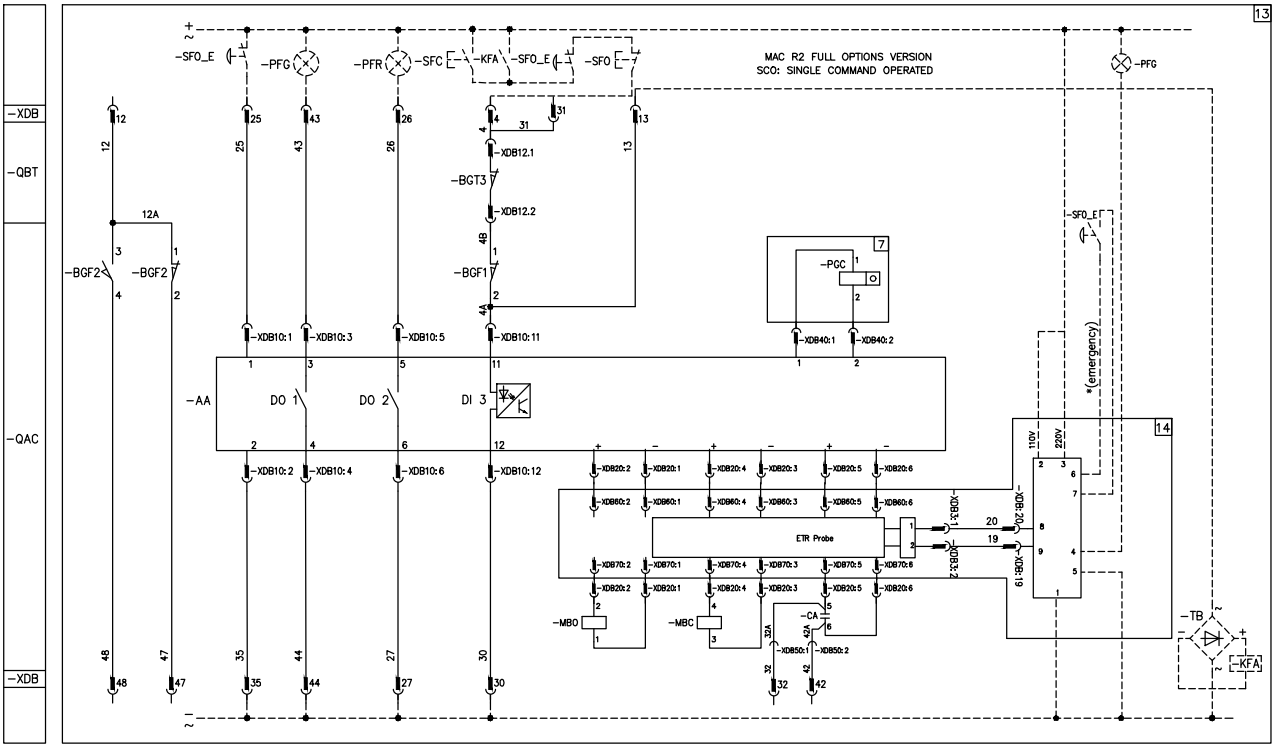

WARNING: the voltage at the feeder clamps of the electronic card and the command circuit (clamps 1-3-7-9, 2-4-8-10 of fig. 1 and clamps 11, 12 of fig. 2) must come from an unique auxiliary circuit supply and the same circuit breaker.

# Electric circuit diagram

### Circuit diagram for withdrawable contactors VSC/P-PG - 1VCD400139 - V8917

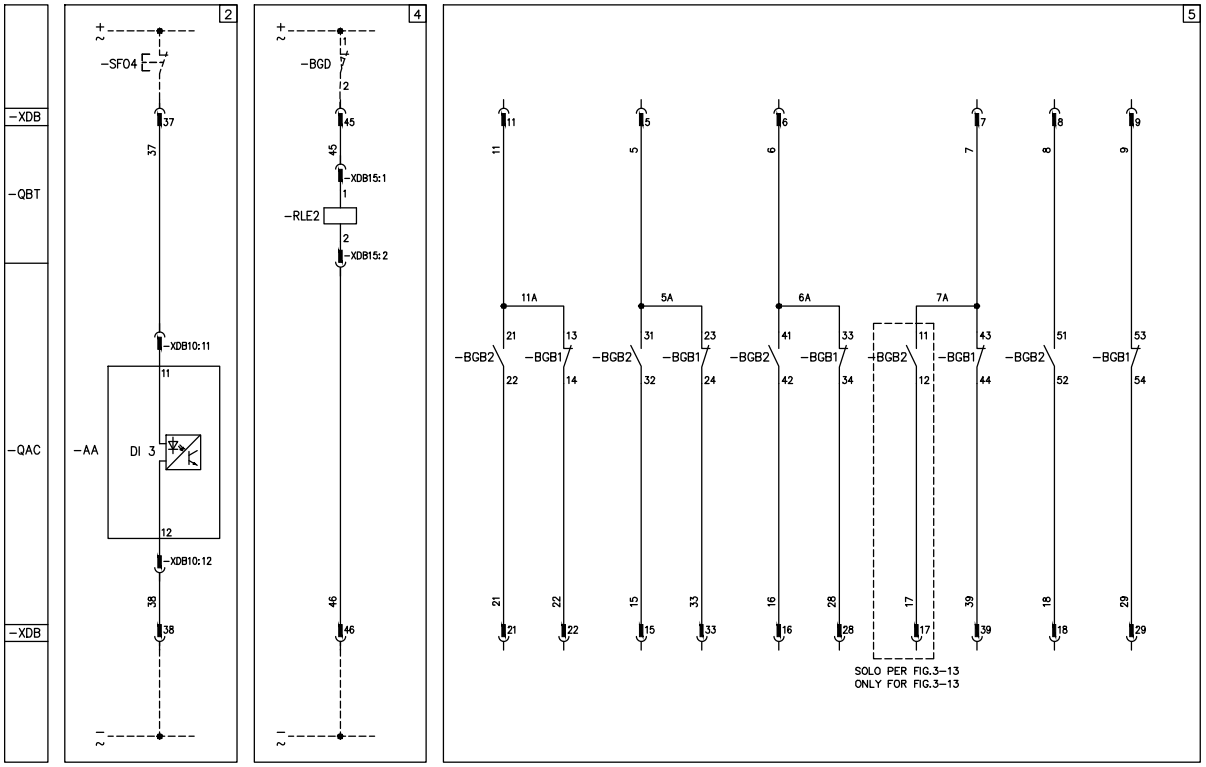


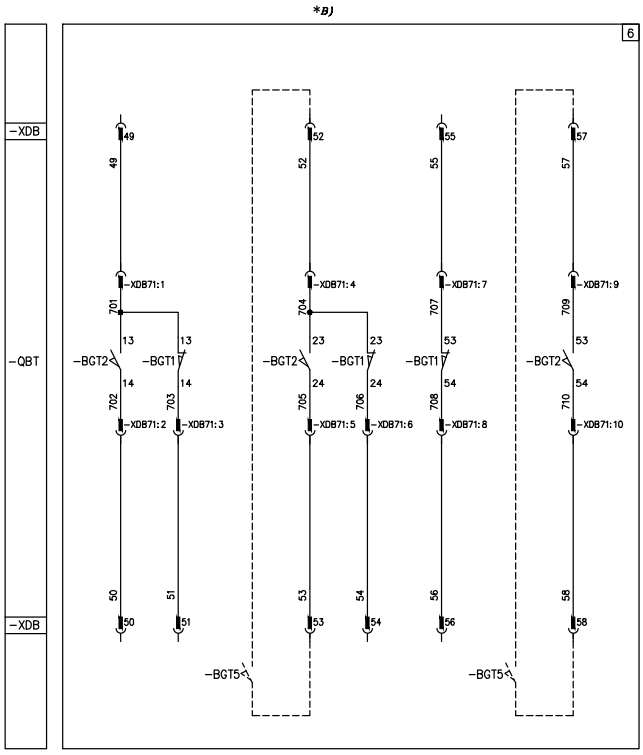

WARNING: the voltage at the feeder clamps of the electronic card and the command circuit (clamps 1-3-11 and 2-4-12) must come from an unique auxiliary circuit supply and the same circuit breaker.




WARNING: the voltage at the feeder clamps of the electronic card and the command circuit (clamps 1-3-5-11 and 2-4-6-12) must come from an unique auxiliary circuit supply and the same circuit breaker.

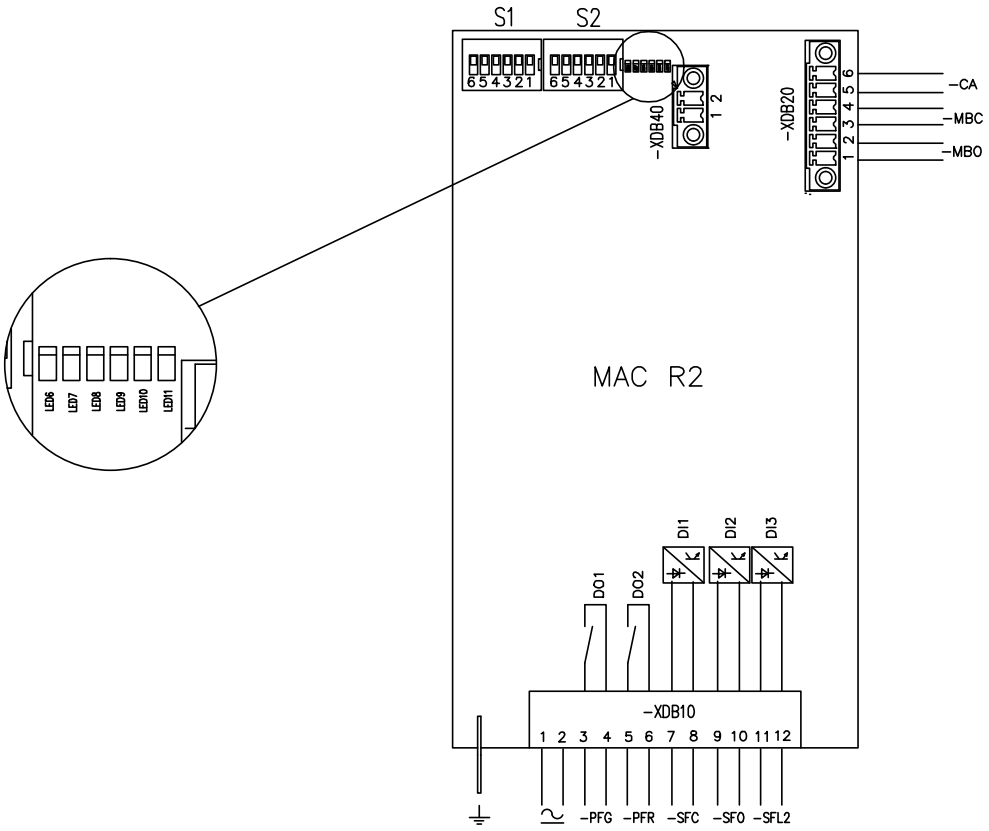
**Circuit diagram for withdrawable contactors VSC/P-PG - 1VCD400139 - V8917**



# Electric circuit diagram

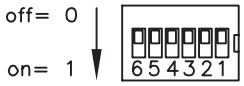
**Board MAC R2**



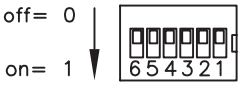

| Caption | |
|---|---|
| S1-1 | ⟶ Reserved |
| S1-2 | ⟶ Reserved |
| S1-3 ÷ 5 | ⟶ Setting undervoltage time |
| S2-1 ÷ 5 | ⟶ Setting group |
| S2-1 ÷ 6 | ⟶ Reserved |
| **Digital imput** | |
| DI1 | closed command (DCO) |
| DI2 | open command (DCO) |
| DI3 | under voltage (DCO); DROP OUT (SCO) |
| **Digital output** | |
| DO1 | Unit ready |
| | - electronic device in working conditions |
| | - capacitor working voltage |
| | - coil continuity |
| D02 | System status information |
| | - control bank capacitor status |
| | - temperature status (full options version only) |

| Signalling information | |
|---|---|
| Led 6 | Normal operation (blink->0.3s) fail or start-up procedure (fixed->ON) |
| Led 7 | Comunication thresholds (FAIL COMMUNICATION ->ON) |
| Led 8 | Over temperature (FAIL->ON) |
| Led 9 | Working voltage capacitor (FAIL->ON) |
| Led 10 | Coil connection status (FAIL->ON) |
| Led 11 | Capacitor bank status (FAIL->ON) |

**Board MAC R2**




S2–1 ÷ 5 –> setting group




| Signalling information | |
|---|---|
| S1–1 | Reserved |
| S1–1 | Reserved |
| S1–3 ÷ 6 | Under voltage time conf. (DCO) –Dropout (SCO) |
| S1–6 | Reserved |

| Setting for SCO | | | |
|---|---|---|---|
| Time UV (s) | S1–3 | S1–4 | S1–5 |
| Instantaneous | 0 | 0 | 0 |
| | 0 | 0 | 1 |
| | 0 | 1 | 0 |
| | 0 | 1 | 1 |
| | 1 | 0 | 0 |
| | 1 | 0 | 1 |
| | 1 | 1 | 1 |

| Setting for DCO | | | |
|---|---|---|---|
| Time UV (s) | S1–3 | S1–4 | S1–5 |
| Instantaneous | 0 | 0 | 0 |
| 0.3s | 0 | 0 | 1 |
| 1s | 0 | 1 | 0 |
| 2s | 0 | 1 | 1 |
| 3s | 1 | 0 | 0 |
| 4s | 1 | 0 | 1 |
| 5s | 1 | 1 | 1 |

| Feeders 1 and 2 | | | | | |
|---|---|---|---|---|---|
| Working group | S2–1 | S2–2 | S2–3 | S2–4 | S2–5 |
| 24V dc | 0 | 0 | 0 | 0 | 0 |
| 30V dc | 0 | 0 | 0 | 0 | 1 |
| 48V dc | 0 | 0 | 0 | 1 | 0 |
| 60V dc | 0 | 0 | 0 | 1 | 1 |

| Feeders 3 and 4 | | | | | |
|---|---|---|---|---|---|
| Working group | S2–1 | S2–2 | S2–3 | S2–4 | S2–5 |
| 110V dc | 0 | 0 | 1 | 0 | 1 |
| 110V ac | 0 | 0 | 1 | 1 | 0 |
| 120V dc | 0 | 0 | 1 | 1 | 1 |
| 120V ac | 0 | 1 | 0 | 0 | 0 |
| 125V dc | 0 | 1 | 0 | 0 | 1 |
| 125V ac | 0 | 1 | 0 | 1 | 0 |
| 127V dc | 0 | 1 | 0 | 1 | 1 |
| 127V ac | 0 | 1 | 1 | 0 | 0 |
| 130V dc | 0 | 1 | 1 | 0 | 1 |
| 130V ac | 0 | 1 | 1 | 1 | 0 |
| 220V dc | 0 | 1 | 1 | 1 | 1 |
| 220V ac | 1 | 0 | 0 | 0 | 0 |
| 230V dc | 1 | 0 | 0 | 0 | 1 |
| 230V ac | 1 | 0 | 0 | 1 | 0 |
| 240V dc | 1 | 0 | 0 | 1 | 1 |
| 240V ac | 1 | 0 | 1 | 0 | 0 |
| 250V dc | 1 | 0 | 1 | 0 | 1 |
| 250V ac | 1 | 0 | 1 | 1 | 0 |

# Electric circuit diagram

**Reference designations in compliance with Standards IEC 81346**

**Represented operational state**

The diagram indicates the following conditions:

- contactor off and connected
- circuits de-energized.

| Caption | | |
|---|---|---|
| -AA | = | Control unit MAC R2 |
| -BGB1, 2 | = | Auxiliary contacts |
| -BGD | = | Position contact of the enclosure door |
| -BGF1, 2 | = | Position contacts of medium voltage fuses |
| -BGT1 | = | Contacts signalling contactor in the connected position (see note B) |
| -BGT2 | = | Contacts signalling contactor in the isolated position (see note B) |
| -BGT3 | = | Contactor position contact. It is open during the isolating travel of the contactor |
| -CA | = | Capacitor |
| -KFA | = | Auxiliary relay |
| -MBC | = | Shunt closing release |
| -MBO | = | Shunt opening release |
| -PFG | = | Green lamp for signalling control and actuating circuits ready.<br>The following conditions are fulfilled:<br>– electronic dervice in working conditions<br>– capacitor level tension<br>– continuity of command coil |
| -PFR | = | Red lamp for signalling anomalies on contactor operational parameters |
| -PFG | = | Electrical operations counter |
| -QAC | = | Contactor |
| -QBT | = | Accessories of withdrawable truck |
| -RLE2 | = | Locking magnet on the truck. If de-energized it prevents the contactor racking-in and racking-out mechanically |
| -SFC | = | Closing push-button |
| -SFO | = | Opening push-button |
| -SFO_E | = | Emergency opening push-button - by ETR device only |
| -SFO4 | = | Undervolatge push button or contact for contactor opening |
| -TB | | Rectifier in full waves (bridge) connection type KBPC 1008 380V 10A RBL2 |
| -XDB | = | Connector or contactor circuits |
| -XDB12, 15 | = | Connectors of the accessories |
| -XDB10 | = | Delivery terminal board of contactor circuits available for customer |
| -XDB20 | = | Interface terminal board with magnetic actuator |
| -XDB40 | = | Interface terminal board with electrical operations counter |
| -XDB50 | = | Safety connector for discharge capacitor |
| -XDB60 | = | ETR probe - input |
| -XDB70 | = | ETR probe - output |
| -XDB71 | = | Connector of the accessories |

| Diagram figures description | | |
|---|---|---|
| Fig. 1 | = | MAC R2 Standard DCO version |
| Fig. 2 | = | “Undervoltage” at request only for DCO version |
| Fig. 3 | = | MAC R2 Standard SCO version |
| Fig. 4 | = | Locking magnet on the truck. If de-energized it prevents the contactor racking-in and racking-out mechanically |
| Fig. 5 | = | Auxiliary contacts of contactor |
| Fig. 6 | = | Contacts signalling contactor in the connected and isolated positions, located on the truck |
| Fig. 7 | = | Circuit of the electrical operations counter |
| Fig. 11 | = | MAC R2 Full options DCO version |
| Fig. 13 | = | MAC R2 Full options SCO version |
| Fig. 21 | = | MAC R2 Standard DCO version with -BGT1 and -BGT2 |
| Fig. 31 | = | MAC R2 Full options DCO version with -BGT1 and -BGT2 |

**Incompatibility**

The combinations of circuits given in the figures below are not possible on the same contactor:

| | | | | |
|---|---|---|---|---|
| 1VCD400138 | | | | |
| 2 - 3 | \| | 2 - 13 | \| | 1-3-11-13 |
| 1VCD400139 | | | | |
| 2 - 3 | \| | 2 - 13 | \| | 1-3-11-13 -21-31 \| 6-21-31 |

**Notes**

A) The contactor is delivered complete with the accessories listed in the order acknowledgement only. To draw up the order examine the apparatus caytalogue.

B) Contacts signalling contactor in the connected and isolated positions (-BGT1 and -BGT2) given in fig. 6 are located on the contactor (moving part). Usually the application of these contacts is carried out on the enclosure (fixed part): see diagram 1VCD400036.

# Notes

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For more information please contact:

—

More product information:
abb.com/mediumvoltage
Your contact center:
abb.com/contactcenters
More service information:
abb.com/service

Data and illustration are not binding. We reserve the right to make changes in the course of technical development.

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1VCP000532 - Rev. E, en - Technical catalogue - 2024.10 - (V-Contact VSC-series 2)

Medium voltage products

# V-Contact VSC
# Installation and service instructions
# 7.2/12 kV - 400 A

## This instruction booklet refers to the following models:
## VSC/F-VSC/FN-VSC/P-VSC/PG-VSC/PN-VSC/PNG
## VSC-S/F-VSC-S/G-VSC-S/PG-VSC-S/PNG


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# For your safety!

- Make sure that the installation room (spaces, divisions and ambient) is suitable for the electrical apparatus.
- Check that all the installation, putting into service and maintenance operations are carried out by qualified personnel with suitable knowledge of the apparatus.
- Make sure that the standard and legal prescriptions are complied with during installation, operation and maintenance, so that installations according to the rules of good working practice and safety in the work place are constructed.
- Strictly follow the information given in this instruction manual.
- Check that the rated performance of the apparatus is not exceeded during service.
- Check that the personnel operating the apparatus have this instruction manual to hand as well as the necessary information for correct intervention.
- Pay special attention to the danger notes indicated in the manual by the following symbol:



**Responsible behaviour safeguards your own and others' safety!**

**For any requests, please contact the ABB Assistance Service.**

# I. Introduction

The instructions in this manual refer to the fixed and withdrawable versions of the VSC series of contactors. For correct use of the product, please read it carefully.

For the electrical and construction characteristics and the overall dimensions of the V-Contact VSC contactors, please also see technical catalogue 1VCP000165.

Like all the apparatus we manufacture, the V-Contact vacuum contactors are designed for different installation configurations. Furthermore, this apparatus allows further technical and construction modifications (at the customer's request) to adapt to special installation requirements. Consequently, this manual may not provide information concerning special configurations of the apparatus.

Apart from this manual, it is therefore always necessary to consult the latest technical documentation (circuit and wiring diagrams, assembly and installation drawings, any protection coordination studies, etc.), especially regarding any variants requested in relation to the standardised configurations.

Only use original spare parts for maintenance operations. The use of non-original spare parts can cause hazardous malfunctions and the apparatus warranty will no longer be valid.

Please refer to the technical sheets of the Kits for correct assembly of the accessories and/or spare parts. For further information, also see the 1VCP000165 technical catalogue of the contactor and the spare parts catalogue.

This manual and all the enclosed drawings must be considered an integral part of the apparatus. They must be easily to hand at all times for revision and reference.

These instructions do not intend to cover all the details, configurations or variants of the apparatus, storage or installation. For this reason, the information given below may sometimes not contain the instructions regarding special configurations. This does not relieve the user from their responsibility for using good technical working practices in application, installation, service and maintenance of the apparatus purchased. Should further information be required, please contact ABB.



**WARNING**



**Dangerous voltages. Risk of death, serious injury to people, damage to the apparatus or other objects.**

**Before carrying out any maintenance operations, turn the power supply off and earth the apparatus.**

**Read and understand this instruction manual before installation, service or maintenance of the apparatus.**

**Maintenance must only be carried out by skilled personnel.**

**The use of unauthorized spare parts for repairs to the apparatus, modification of the apparatus itself, or tampering by unskilled personnel creates hazardous conditions which may cause death or serious injury to people, or damage to the apparatus or other objects. Carefully follow all the safety instructions given in this manual.**

# II. Environmental protection programme

The V-Contact VSC vacuum contactors are manufactured in accordance with the ISO 14000 Standards (Guidelines for environmental management). The production processes are carried out in compliance with the Standards for environmental protection in terms of reduction in energy consumption as well as in raw materials and production of waste materials.
All this is thanks to the medium voltage apparatus manufacturing facility environmental management system.

## III. Application of the X-ray emission Standards

One of the physical properties of vacuum insulation is the possibility of X-ray emission when the interrupter contacts are open. The tests carried out at the PTB laboratories (Physikalisch-Technische Bundesanstalt, in Brunswick - Germany) show that local emission at a distance of 10 cm from the interrupter or pole surface, does not exceed 1 µSv/h. It follows that:

– at the rated service voltage the use of vacuum interrupters is absolutely safe;
– application of the withstand voltage at power frequency, according to the IEC 62271-1 Standard, is safe;
– application of a voltage higher than the withstand voltage at power frequency or of a direct current test voltage, specified in the IEC Standard, cannot be used;
– limitation of the above-mentioned local phenomena, on interrupters with open contacts, depends on keeping the specified distance between the contacts. This condition is intrinsically guaranteed by correct operation of the drive and by transmission system adjustments.

## IV. Safety information

All the installation, putting into service, running and maintenance operations must be carried out by suitably qualified personnel with in-depth knowledge of the apparatus. Make sure that the personnel working on the apparatus have this manual to hand and all the information required for correct intervention.
Strictly follow the information given in this instruction manual. Make sure that during the installation, service and maintenance stages the standard and legal requirements for constructing the installations in accordance with the regulations for safety in the workplace are respected.
Check that the rated performance of the apparatus is not exceeded during service.

## V. Qualified personnel

For the purposes of this manual and the product rating plates, a qualified person is intended as a person who:

1) carefully reads the instruction manual all the way through.
2) has in-depth knowledge of the installation, construction and service of the apparatus and knows about the risks connected with any interventions.
3) is qualified and authorised to energise, de-energise, earth and identify the circuits according to the safety procedures and the local regulations in force.
4) is qualified and authorised to put this apparatus into service, and to carry out maintenance and repair operations on it.
5) is trained in correct use of protective equipment, such as rubber gloves, hard hats, protective goggles, face shields, flameproof clothing, etc. according to the safety procedures and the local regulations in force.
6) is trained in first-aid procedures.

## VI. Interventions in the field

ABB can provide competent and well-trained personnel for assistance in the field to give technical guidance and consultancy regarding installation, full servicing, repair and maintenance of apparatus.

# 1. Description

The medium voltage V-Contact VSC contactors are pieces of apparatus suitable for operating in alternating current and are normally used to control users requiring a high number of hourly operations.

The basic contactors consist of:

- moulded polyester resin monobloc containing the vacuum interrupters
- bistable electromagnet actuator
- multi-voltage feeders
- auxiliary contacts
- mechanical status indicator (open/closed)
- manual emergency opening device.

Apart from what is specified for the fixed contactors, the withdrawable contactors also consist of:

- fuseholders preset for DIN or BS fuses (according to the customer's requirements)
- automatic opening device for intervention of even a single fuse
- truck
- lock which prevents closing during the racking-in/out operation.

The V-Contact VSC contactor introduces the drive with permanent magnets - already widely used, experimented and appreciated in medium voltage circuit-breakers - into the worldwide panorama of medium voltage contactors.
The experience acquired by ABB in the field of medium voltage circuit-breakers fitted with drives with "MABS" permanent magnets, has made it possible to develop an optimised version of the actuator (Bistable MAC drive) for medium voltage contactors.

The drive is operated by means of an electronic feeder able to cover all the power supply voltages required by the major international Standards.

## 1.1. "MAC" magnetic drive

Based on the experience gained in the field of circuit-breakers with magnetic drive, ABB has implemented this technology in the field of contactors.

The magnetic drive adapts perfectly to this type of apparatus thanks to its precise and linear travel.

This means that a simple and direct axial transmission of the movement to the moving contacts of the vacuum interrupter can be realised, with both electrical and mechanical benefits.

The drive, which is of bistable type, is fitted with an opening and a closing coil.

The two coils - individually energised - allow the drive core to be moved from one of the two stable positions to the other.

The drive shaft is solid with an iron core which is immersed and held in position in a field generated by two permanent magnets (fig. A).

Energising the coil opposite to the magnetic latching position (fig. A) of the core, the magnetic field (fig. B) is generated, which attracts and moves the core into the opposite position (fig. C).

Every opening and closing operation creates a magnetic field concordant with the one generated by the permanent magnets, with the advantage, during service, of keeping the intensity of the field itself constant as the number of operations carried out increases.

The energy needed for operation is not supplied directly by the auxiliary power supply, but is always "stored" in the capacitor which acts as an energy accumulator, and therefore operation always takes place with constant speeds and times, regardless of the divergence of the power supply voltage from the rated value.

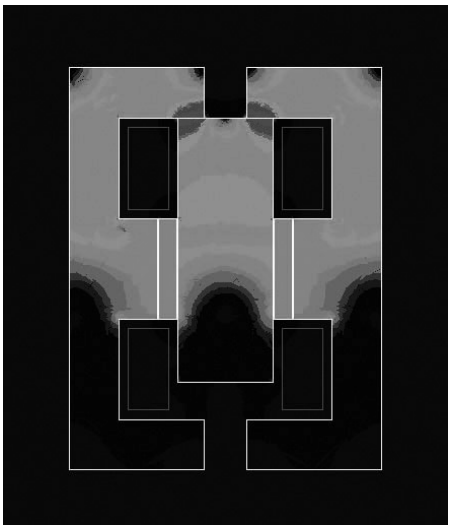


**Fig. A**
**Magnetic circuit in the closed position.**

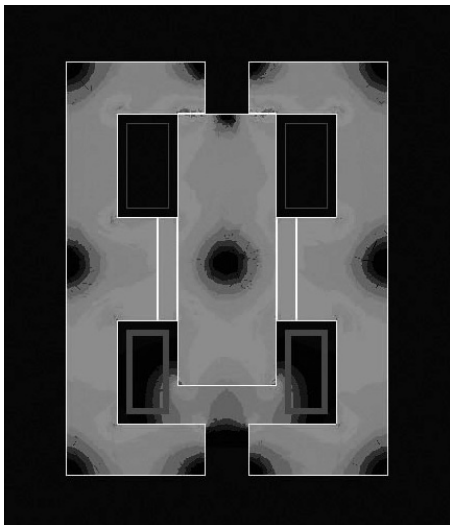


**Fig. B**
**Magnetic circuit with opening coil supplied.**

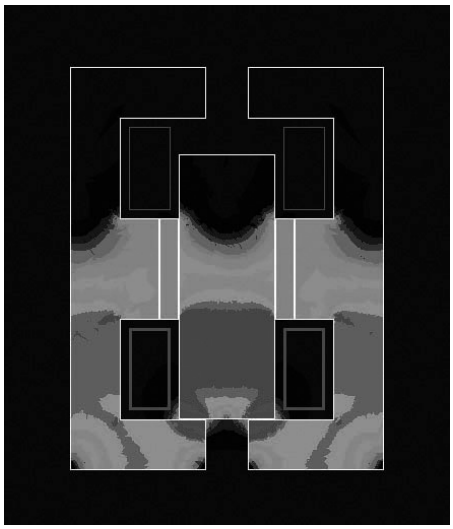


**Fig. C**
**Magnetic circuit in the open position.**

The auxiliary power supply only has the aim of keeping the capacitor charged.
Consumption is therefore minimal.

The power required by the electronic device is indicated in the table below:

| Power supply voltage | Starting (1) | | After closing | After opening | Continuous power consumption |
|---|---|---|---|---|---|
| | Inrush for 2 ms | Inrush for 6 sec | Inrush for 1.2 sec | Inrush for 1.2 sec | |
| 24...60 V DC<br>110...250 V DC<br>110...250 V AC | 42 A (2) | 35 W | 25 W | 30 W | 5 W |

(1) This value refers to a discharged capacitor.
(2) The value drops to 8 A for voltage values between 24...30V

Supply from voltage transformer or from UPS (Uninterrupted Power System) not available.
Use the ABB S282UC-C3 thermal-magnetic circuit-breaker or an equivalent type to protect the secondary circuits.
After powering, the electronic board takes 15 seconds to perform self-diagnosis and then prepares for normal operation, depending on the configuration. Do not operate the contactor during this phase. Contact DO1 will remain open, signal “not ready” and will only close after self-diagnosis has terminated (“ready” state).

Careful selection of the components and a precise design make the electronic multi-voltage feeder extremely reliable, unaffected by electromagnetic interference generated by the surrounding environment and free of any emissions which may affect other apparatus placed in the vicinity.

These characteristics have made it possible for the V-Contact VSC contactors to pass the electromagnetic compatibility tests (EMC).

## 1.2. Versions available

The V-Contact VSC are available in:
– fixed version without fuseholder
– fixed versions with fuseholder: VSC/F e VSC/FN.
– four withdrawable versions with fuseholder:
  - VSC/P (IEC) and VSC/PG or VSC-S/PG (IEC/GB-DL) withdrawable versions for UniGear, PowerCube, CBE and PowerBloc with manual or motorized truck
  - VSC/PN (IEC) and VSC/PG or VSC-S/PNG (IEC/GB-DL) both versions withdrawable for UniGear MCC with manual truck.

## 1.3. Characteristics

| Contactor | | Reference IEC 62271-106 | VSC7<br>VSC7/F (1)<br>VSC7/P (1)<br>VSC7/PN (1)<br>VSC7/FN | VSC12<br>VSC12/F (1)<br>VSC12/P (1)<br>VSC12/PN (1) |
|---|---|---|---|---|
| Rated voltage | [kV] | 4.1 | 7.2 | 12 |
| **Rated insulation voltage** | | | | |
| Withstand voltage at 50 Hz | [kV] | 6.2 | 20 | 28 |
| Impulse withstand voltage | [kVbil] | 6.2 | 60 | 75 |
| Rated frequency | [Hz] | 4.3 | 50-60 | 50-60 |
| Rated service current | [A] | 4.101 | 400 | 400 |
| **Short-time withstand current** | | | | |
| Short-time withstand current for 1 s | [A] | 6.6 | 6,000 | 6,000 |
| Short-time withstand current for 2 s | [A] | | | |
| Short-time withstand current for 4 s | [A] | | | |
| Short-time withstand current for 30 s | [A] | 6.6 | 2,500 | 2,500 |
| Rated peak current | [kA] | 6.6 | 15 | 15 |
| **Rated values** | | | | |
| Operations / hour (SCO - DCO) | [Nr.] | 4.102.4 | 1.200 | 1,200 |
| Rated voltage of the voltage characteristics in category of use | | | | |
| (Category AC4) 100 closing operations | [kA] | 6.102.4 | 4,000 | 4,000 |
| (Category AC4) 25 opening operations | [kA] | 6.102.5 | 4,000 | 4,000 |
| **Switching devices and auxiliary circuits** | | 4.8, 4.9 | | |
| Feeder 1 24÷60 V dc basic | | | ● | ● |
| Feeder 2 24÷60 V dc full option | | | ● | ● |
| Feeder 3 110÷250 V dc/ac basic | | | ● | ● |
| Feeder 4 110÷250 V dc/ac full option | | | ● | ● |
| Normal current | [A] | 6.4.6.5 | 400 | 400 |
| Mechanical life | [Nr.] | 6.101 | 1,000,000 (2) | 1,000,000 (2) |
| Short-circuit breaking capacity (O-3min-CO-3min-CO) | [A] | 6.104 | 5,000 | 5,000 |
| Short-circuit making capacity (O-3min-CO-3min-CO) | [A] | 6.104 | 13,000 | 13,000 |
| Opening time | [ms] | | 35...60 | 35...60 |
| Closing time | [ms] | | 60...90 | 60...90 |
| Tropicalisation | IEC 721-2-1 | | ● | ● |

(1) It is possible to combine current limiting fuses with breaking capacity up to 50 kA (IEC 62271-106 - 4.107) - Damage classification "C" (IEC 62271-106 - 4.107.3).
(2) With replacement of auxiliary contacts every 250,000 closing-opening operations.
(3) 42 kV for fixed versions and in dedicated Unigear switchgear

## 1.4. Weights and overall dimensions

| Contactor | | | VSC7 | VSC12<br>VSC-S/G | VSC7/F | VSC7/FN | VSC12/F<br>VSC-S/F |
|---|---|---|---|---|---|---|---|
| Weight | | [Kg] | 23 | 23 | 35 (1) | 35 (1) | 35 (1) |
| Overall dimensions |  | [mm] H | 371 | 424 | 494 | 598 | 532 |
| | | [mm] W | 350 | 350 | 466 | 466 | 466 |
| | | [mm] D | 215 | 215 | 622 | 623 | 702 |

(1) Without fuses

| | Reference | | VSC7/PNG (1) | VSC12/PNG (1) | VSC-S/G<br>VSC-S/F (1)<br>VSC-S/PG (1)<br>VSC-S/PNG (1) |
|---|---|---|---|---|---|
| | GB/T<br>14808-2001 | DL/T<br>593-2006 | | | |
| | 4.1 | | 7.2 | 12 | 12 |
| | | | | | |
| | 6.2 | ● | 32 | 42 | 28 (3) |
| | 6.2 | | 60 | 75 | 75 |
| | 4.3 | | 50-60 | 50-60 | 50-60 |
| | 4.101 | | 400 | 400 | 250 |
| | | | | | |
| | | | | 6,000 | 600 |
| | 6.6 | | 4,000 | 4,000 | |
| | | ● | 4,000 | 4,000 | |
| | 6.6 | | 2,500 | 2,500 | 2,500 |
| | 6.6 | | 15 | 15 | 15 |
| | | | | | |
| | 4.102.2 | | 1,200 | 1,200 | 1,200 |
| | | | | | |
| | 6.102.4 | | 4,000 | 4,000 | |
| | 6.102.5 | | 4,000 | 4,000 | |
| | 4.8, 4.9 | | | | |
| | | | ● | ● | ● |
| | | | ● | ● | ● |
| | | | ● | ● | ● |
| | | | ● | ● | ● |
| | 6.4, 6.5 | | 400 | 400 | 400 |
| | 6.101 | | 1,000,000 (2) | 1,000,000 (2) | 200,000 |
| | 6.104 | | 5,000 | 5,000 | - |
| | 6.104 | | 13,000 | 13,000 | - |
| | | | 35…60 | 35…60 | 35…60 |
| | | | 60…90 | 60…90 | 60…90 |
| | ● | | ● | ● | ● |

| | VSC7/P | VSC12/P - VSC12/PG<br>VSC-S/PG | VSC7/PN | VSC7/PNG | VSC12/PN | VSC12/PNG<br>VSC-S/PNG |
|---|---|---|---|---|---|---|
| | 52 (1) | 52 (1) | 45 (1) | 45 (1) | 45 (1) | 45 (1) |
| | 636 | 636 | 653 | 653 | 653 | 653 |
| | 531 | 531 | 350 | 350 | 350 | 350 |
| | 657 | 657 | 673 | 673 | 673 | 673 |

## 1.5. Performances

| Contactor | | VSC7<br>VSC7/F<br>VSC7/P<br>VSC7/PN<br>VSC7/PNG<br>VSC7/FN | | | | VSC12<br>VSC12/F<br>VSC12/P<br>VSC12/PN<br>VSC12/PNG |
|---|---|---|---|---|---|---|
| Rated voltage | [kV] | 2.2/2.5 | 3.6 | 3.6/7.2 | 6.2/7.2 | 12 |
| **Ultimate performances for:** | | | | | | |
| Motors | [kW] | 1,000 | 1,500 | 1,500 | 3,000 | 5,000 |
| Transformers | [kVA] | 1,100 | 1,000 | 2,000 | 4,000 | 5,000 |
| Capacitors | [kVAR] | 1,000 | 1,500 | 1,500 | 3,000 | 4,800 (1) |

| Contactor | | VSC-S/G<br>VSC-S/F<br>VSC-S/PG<br>VSC-S/PNG | | | | |
|---|---|---|---|---|---|---|
| Rated voltage | [kV] | 2.2/2.5 | 3.6 | 3.6/7.2 | 6.2/7.2 | 12 |
| **Ultimate performances for back-to-back capacitors banks** | | | | | | |
| Rated current | [A] | 250 | 250 | 250 | 250 | 250 |
| Max. transient current of the capacitor | [kA] | 8 | 8 | 8 | 8 | 8 |
| Max. transient frequency of the capacitor | [kHz] | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |

(1) Overvoltage surge arresters are compulsory between phases and between phase and earth.

## 1.6. Contactor auxiliary circuits

10 auxiliary contacts (5 normally open and 5 normally closed) are available on the contactor for the customer's use, with the following characteristics.

| Auxiliary contacts characteristics | | |
|---|---|---|
| Rated voltage | 24 … 660 | V |
| Rated normal current | 10 | A |
| Rated short time current (30 ms, 20 times) | 100 | A |
| Rated frequency (for AC only) | 50 | Hz |
| Rated insulation voltage (DC) | 800 | V |
| Rated insulation voltage (AC) | 660 | V |
| Insulation test voltage | 2500 | V |
| Number of contacts | 5 | - |
| Stroke | 6 … 7 | mm |
| Maximum contact resistance | 10 | mΩ |
| Storage temperature range | -20 … +120 | °C |
| Operating temperature range | -20 … +70 | °C |
| Emperature rise of contacts | 30 | K |
| Breaking capacity<br>(single contact $\tau$ = 20 ms, 250 V dc) | 250 | W |
| Breaking capacity<br>(single contact $\tau$ = 20 ms, 110 V dc) | 440 | W |
| Breaking capacity<br>(two contacts in series $\tau$ = 20 ms, 250 V dc) | 440 | W |

| Characteristics of the contacts of the “Coil Continuity Control” and “Capacity Survey” devices | |
|---|---|
| Technology | Relay with air-insulated contacts |
| **Breaking characteristics:** | |
| Maximum breaking power | 1200 VA (on resistive load) |
| Maximum breaking voltage | 277 V AC, 30 V DC |
| Maximum breaking current | 3 A |
| Rated current | 5 A @ 4 s |
| **Contact characteristics:** | |
| Maximum resistance with contact open | 150 mohm (measure of voltage drop 6 V DC 1) |
| Maximum capacity | 1.5 pF |
| **Trip times:** | |
| During closing | 5.0 ms |
| During release | 2.0 ms |
| **Insulation:** | |
| Between contacts and coil | 3000 V rms (50 Hz / 1 min.) |
| Between open contacts | 750 V rms (50 Hz / 1 min.) |
| Resistance with contacts open | Min. 103 Mohm at 500 V DC |

## 1.7. Compliance with Standards

V-Contact contactors comply with the Standards of the major industrialised countries and in particular with the following Standards:

– IEC 62271-106 (2011);
– IEC 62271-1 (2007);
– GB/T 14808-2001;
– DL/T 593-2006;
– IEC 60278 replaced by IEC 62271-200;
– IEC 60694 (2002) replaced by IEC 62271-1;
– IEC 60056 (4.104) replaced by IEC 62271-100;
– IEC 60470 replaced by IEC 62271-106.

## 1.8. Protection against short-circuit

The value of the installation short-circuit current could exceed the breaking capacity of the contactor. The contactor must therefore have adequate protection against short-circuit.



**Fuse replacement must only be carried out by qualified personnel.**

# 2. Checking on receipt

**During handling, take great care not to stress the insulating parts of the apparatus and the terminals of the contactor.**

**Any operation carried out on the contactor must be done without the presence of voltage and with the main protection device open: danger of electrocution and/or severe burns.**

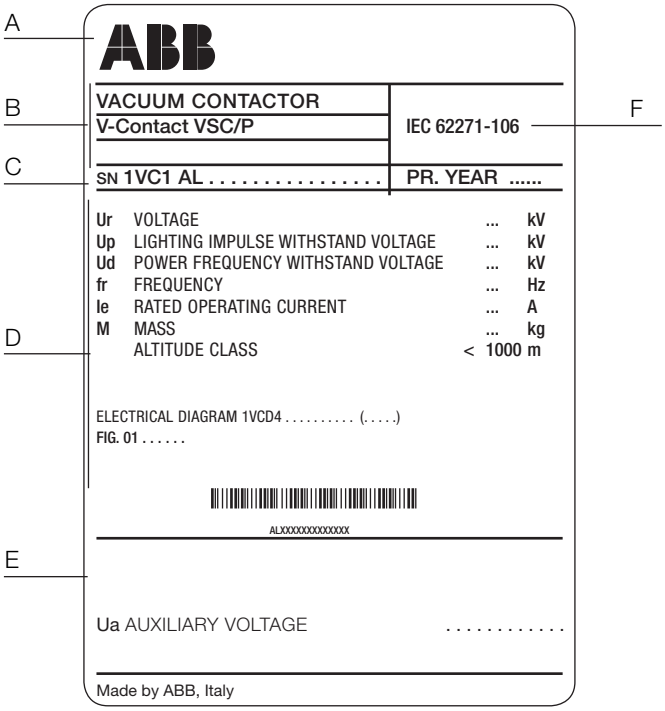
**Make sure that operations are carried out with the main and auxiliary power off.**

On receipt, immediately check integrity of the packing and the colour of the “SHOCKWATCH” indicator (Fig. 1) placed on it. If the “SHOCKWATCH” impact indicator is WHITE, it means that the packing has not received any notable shocks during transport. Open the packing, remove the contactor as indicated below, and check the state of the apparatus and its correspondence with the nameplate data (see fig. 2) with what is specified in the accompanying shipping note and in the order confirmation sent by ABB.
If the “SHOCKWATCH” impact indicator is RED, follow the instructions indicated on the plate.
Opening the packing does not damage its components and it can therefore be re-instated using the original material.
The contactor is shipped in special packing, in the open position.
Each piece of apparatus is protected by a plastic cover to prevent any infiltration of water during the loading and unloading stages and to keep the dust off during storage.
To remove the contactor from the packing, proceed as follows:
– open the plastic bag
– remove the contactor, avoiding any stress to the functional insulating parts and the terminals of the apparatus.
– use the special lifting plates for the withdrawable version
– check the rating plate characteristics to make sure that the performances are suitable for the destined application and that they are those indicated in the order confirmation.

Should any damage or irregularity be noted in the supply on unpacking, notify ABB (directly or through the agent or supplier) as soon as possible and in any case within five days of receipt.
The apparatus is only supplied with the accessories specified at the time of ordering and validated in the order confirmation sent by ABB.
The accompanying documents inserted in the shipping packing are:
– instruction manual (this document)
– test certification
– identification label
– fiscal copy of the shipping advice note
– electric wiring diagram.




**Fig. 1**




A Trademark
B Type of apparatus
C Serial number
D Characteristics of the apparatus
E Characteristics of the control auxiliaries
F Reference standards

**Fig. 2**

Other documents which are sent prior to shipment of the apparatus are:
– order confirmation
– original shipping advice note
– any drawings or documents referring to special configurations/conditions.

# 3. Handling

The contactor can be lifted using a lifting truck or a fork-lift truck.
The following precautions must be taken during contactor handling:

1. Keep the contactor in the upright position.
2. Make sure that the load is balanced on the truck or on the transport plate/pallet.
3. Interpose protective material between the contactor and the truck to avoid any damage or scratches.
4. Fix the contactor onto the truck or onto the transport plate/pallet to prevent it moving or tilting over.
5. Avoid excessive speed, sudden starts and stops or sharp changes in direction during contactor handling.
6. Only lift the contactor enough to avoid any obstacles on the floor.
7. Take care to avoid any impacts with structures, other apparatus or with personnel when handling the contactor.
8. Never lift a contactor over an area where there are people.
9. During handling of the apparatus, do not stress the insulating parts and the contactor terminals.

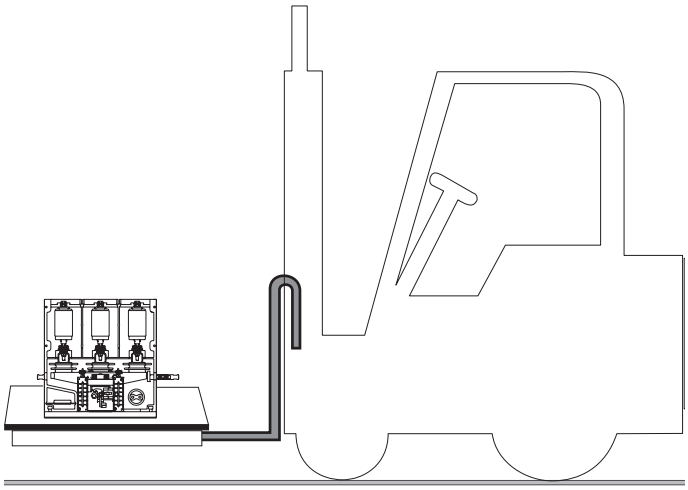
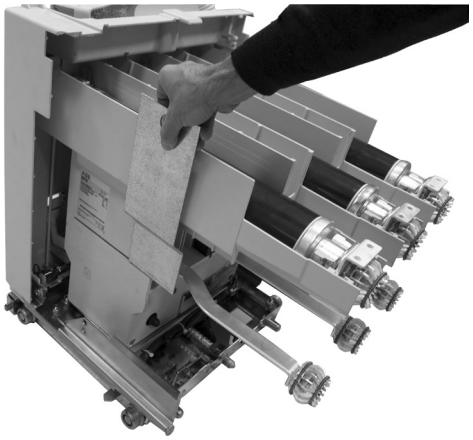
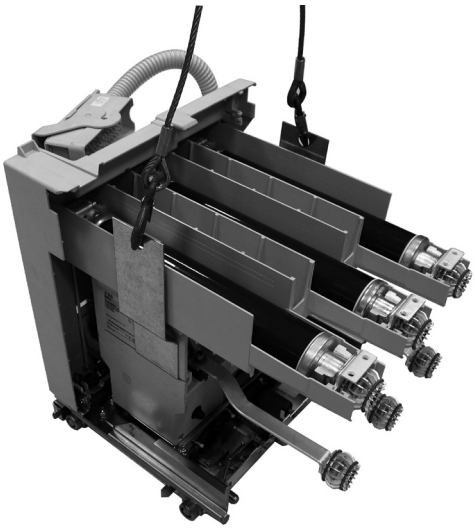


**Fig. 3a - Handling using a lifting or fork-lift truck.**

## 3.1. Handling and lifting using a crane

– Insert the lifting plates
– Lift
– After the unpacking and lifting operations, remove the lifting accessories.
  Warning: with lifting tools, it is mandatory to move the contactors not by pulling them, but by pushing them from the screen





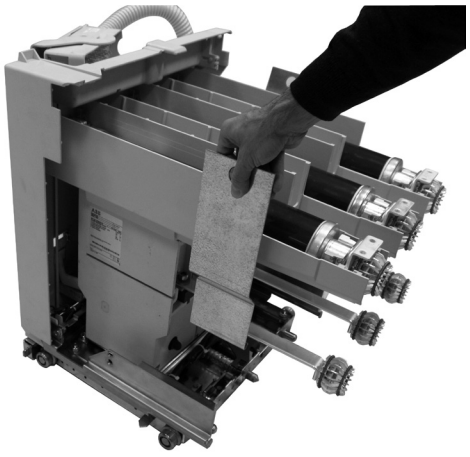


Fig. 3b - Removal of the contactor from the packing and dismantling the lifting tools.

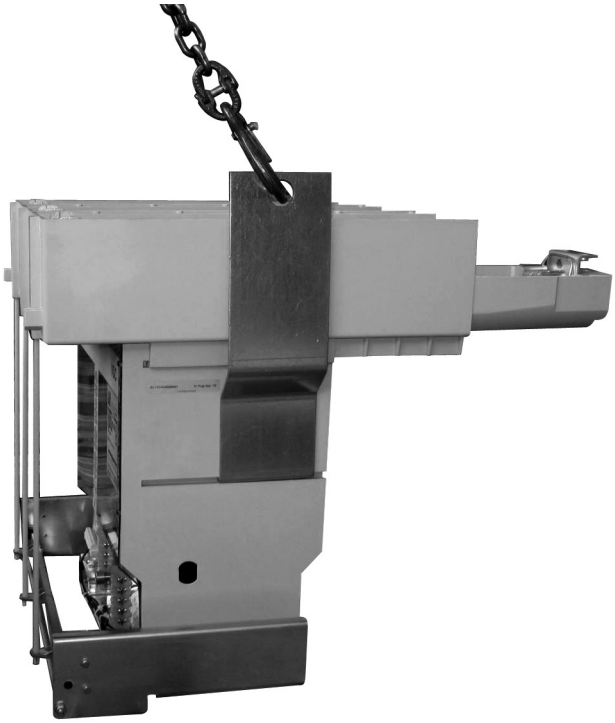


Fig. 3c - Fixed contactor with fuses

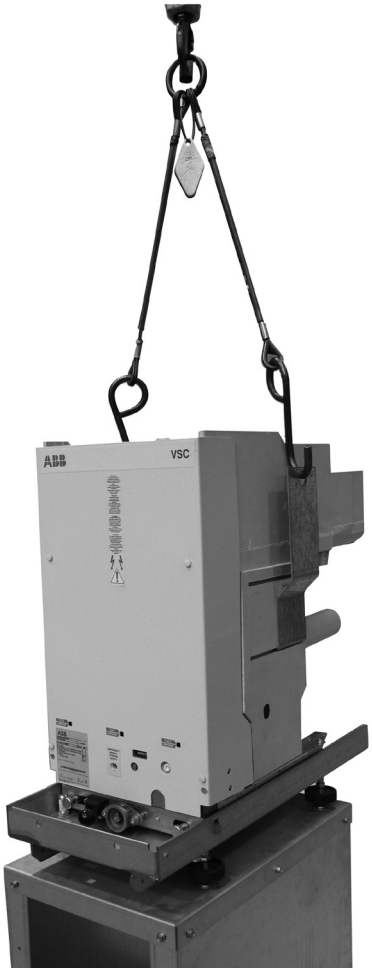



Fig. 3d - Withdrawable contactor

# 4. Storage

When a period of storage is foreseen, the original packing must be put back. Store the contactor in a dry dust-free area. It must not be left outside or in adverse micro-climatic conditions: if it is left without protection, rust and deterioration of the insulation can occur.
Insert special hygroscopic packets inside the packing, with at least one standard packet per piece of apparatus. Replace the packets approximately every 6 months.

Should the original packing no longer be available and immediate installation is not possible, store in a covered, well-ventilated, dry, dust-free, non-corrosive ambient, with a dry atmosphere, away from any flammable materials and at a temperature between – 5 °C and + 40 °C.
In any case, avoid any accidental impacts or positioning which stresses the structure of the apparatus.

# 5. Installation

## 5.1. General

Correct installation is of primary importance. The manufacturer's instructions must be carefully studied and followed. It is good practice to use gloves for handling the pieces during installation.

**The areas involved in the passage of power conductors or conductors of auxiliary circuits must be protected against access of any animals which might cause damage or disservices.**

The contactor enclosure must be installed in a clean, dry and heated place with good ventilation. It must be easily accessible for cleaning and inspection, and must be levelled, placed on the supporting foundations and securely fixed into position.
When the contactor is connected to a capacitive load, make sure that there is a heating element to keep the humidity down and of suitable size for the compartment where the contactor is installed. The contactor must always be installed associated with a suitable protection device (e.g.: fuses).

**The fixed version of the V-Contact VSC contactors must be installed by the customer so as to guarantee a minimum degree of protection of IP2X.**

## 5.2. Installation and operating conditions

The following Standards must be taken into particular consideration during installation and service:
- IEC62271-1/DIN VDE 0101
- VDE 0105: Operation of electrical plants
- DIN VDE 0141: Earthing systems for electrical installations with rated voltage higher than 1 kV
- All the accident prevention regulations in force in the relative countries.

## 5.3. Normal conditions

Follow the recommendations in the IEC 62271-1 and 62271-106 Standards. In more detail:

| Ambient temperature | |
|---|---|
| Maximum | + 40 °C |
| Average maximum over 24 hours | + 35 °C |
| Minimum (according to class – 5), apparatus for indoor installation | – 5 °C |

### Humidity

The average value of the relative humidity, measured for a period longer than 24 hours, must not exceed 95%.
The average value of the water vapour pressure, measured for a period longer than 24 hours, must not exceed 2.2 kPa.
The average value of the relative humidity, measured for a period longer than 1 month, must not exceed 90%.
The average value of the water vapour pressure, measured for a period longer than 1 month, must not exceed 1.8 kPa

### Altitude

< 1000 m above sea level.

## 5.4. Special conditions

### Installations above 1000 m a.s.l.

Possible within the limits allowed by reduction of the dielectric resistance of air.
For altitudes over 2000 m ask ABB.

### Climate - Increase in temperature

In order to avoid the risk of corrosion or other damage in areas with high humidity and/or rapid large fluctuations in temperature, take appropriate measures (for example, using suitable electric heaters) to prevent any condensation phenomena.

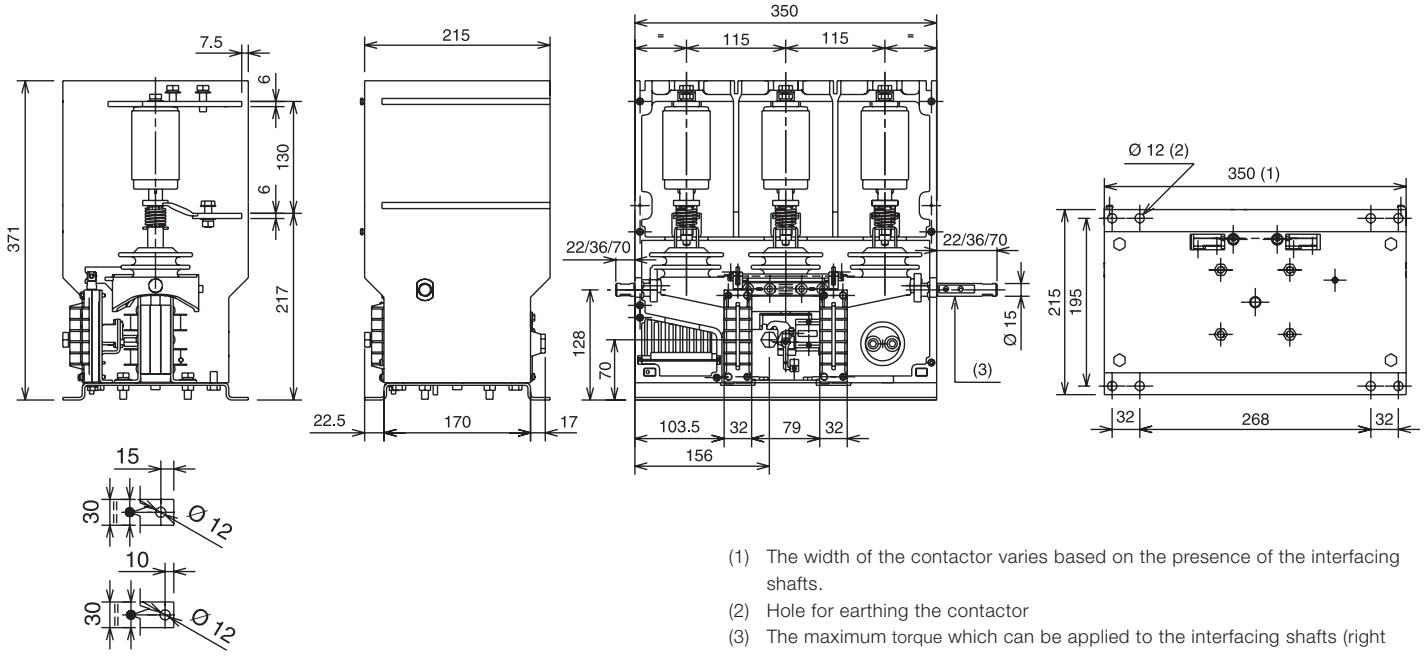
For special installation requirements or other operating conditions, please contact ABB.

# 5.5. Overall dimensions

### 5.5.1. VSC fixed contactor

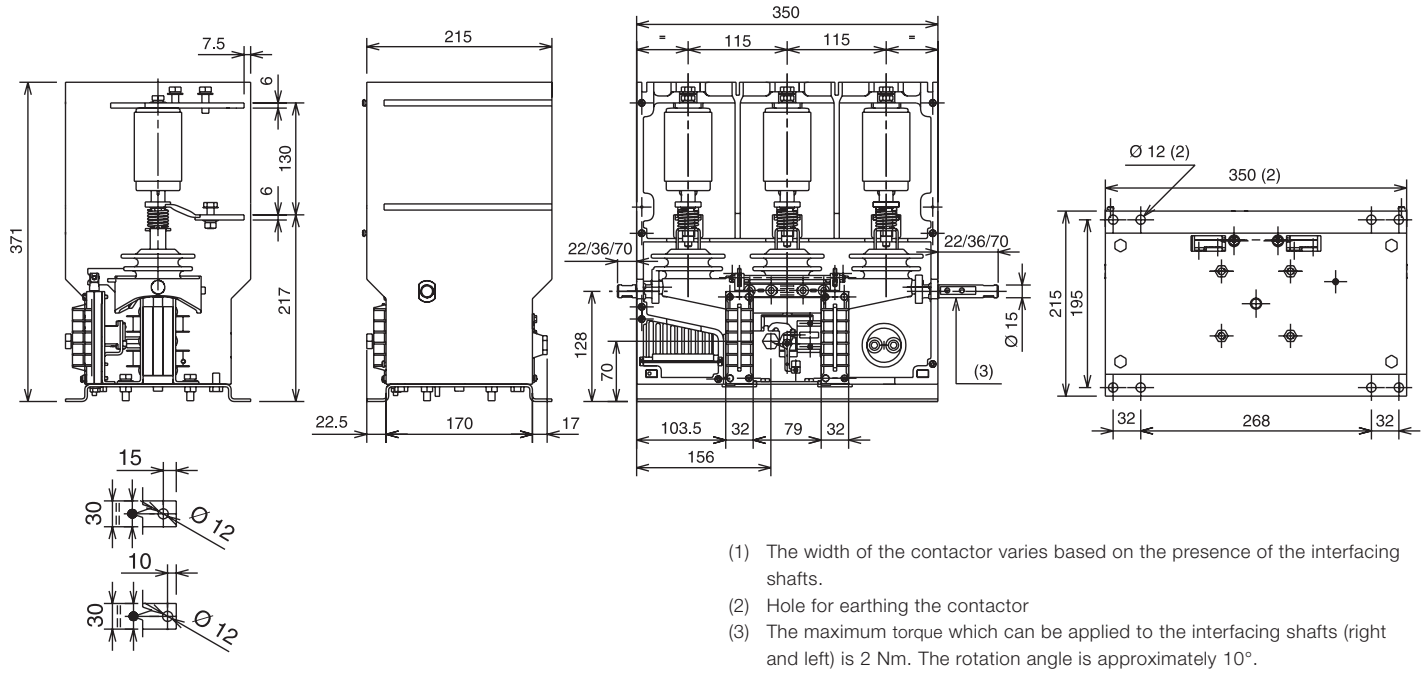
For the overall dimensions and distances between fixing holes, refer to figure 4a.
In any case, avoid stressing the supporting structure of the contactor: if necessary, arrange slots in the fixing area to facilitate correct positioning of the apparatus.
The assembly positions can be selected between the two shown in figure 4b.

**VSC7**




(1) The width of the contactor varies based on the presence of the interfacing shafts.
(2) Hole for earthing the contactor
(3) The maximum torque which can be applied to the interfacing shafts (right and left) is 2 Nm. The rotation angle is approximately 10°.

**VSC12**




(1) The width of the contactor varies based on the presence of the interfacing shafts.
(2) Hole for earthing the contactor
(3) The maximum torque which can be applied to the interfacing shafts (right and left) is 2 Nm. The rotation angle is approximately 10°.

**Fig. 4a**

**Installation of fixed contactors**

The performance of the contactor remains unaltered in the installation positions indicated below:

**VSC 7 - VSC 12**

A) Floor-mounted with moving contacts at the bottom.
B) Wall-mounted with horizontal moving contacts and terminals at the bottom.
C) Wall-mounted with horizontal moving contacts and terminals at the top.
D) Wall-mounted with horizontal moving contacts with interrupters on the front (or rear) with vertical terminals.
E) Ceiling-mounted with moving contacts at the top.

**VSC 7/F - VSC 12/F - VSC 7/FN**

A) Floor-mounted with moving contacts at the bottom.

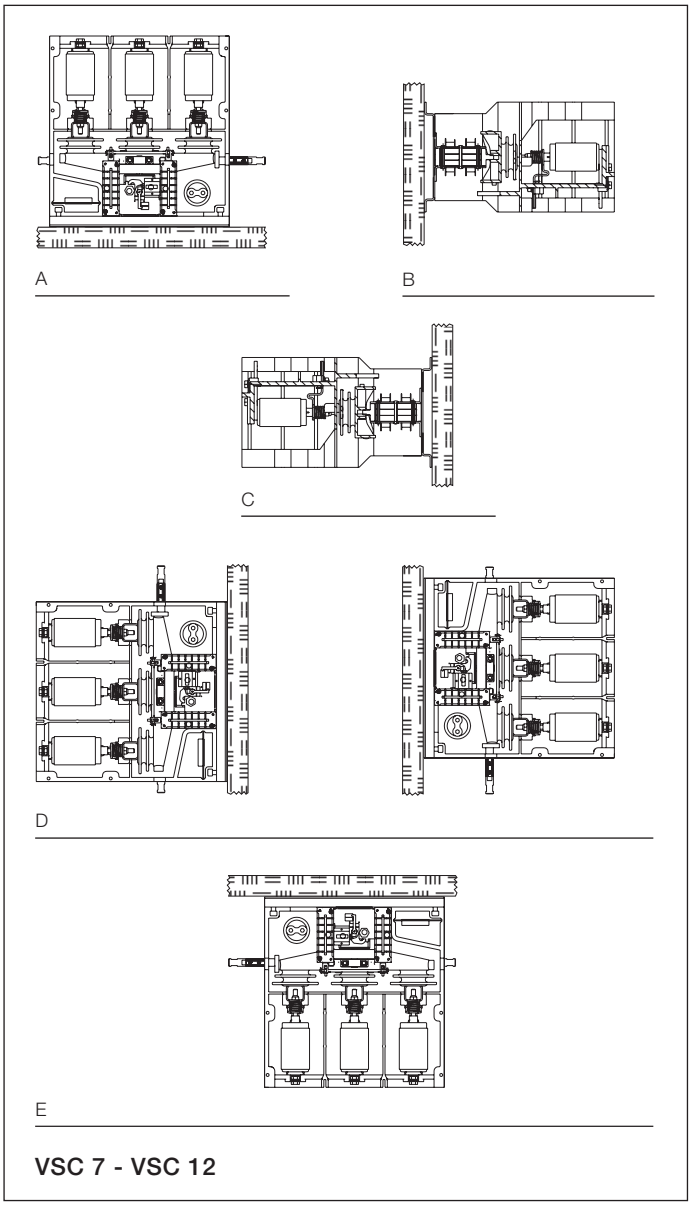
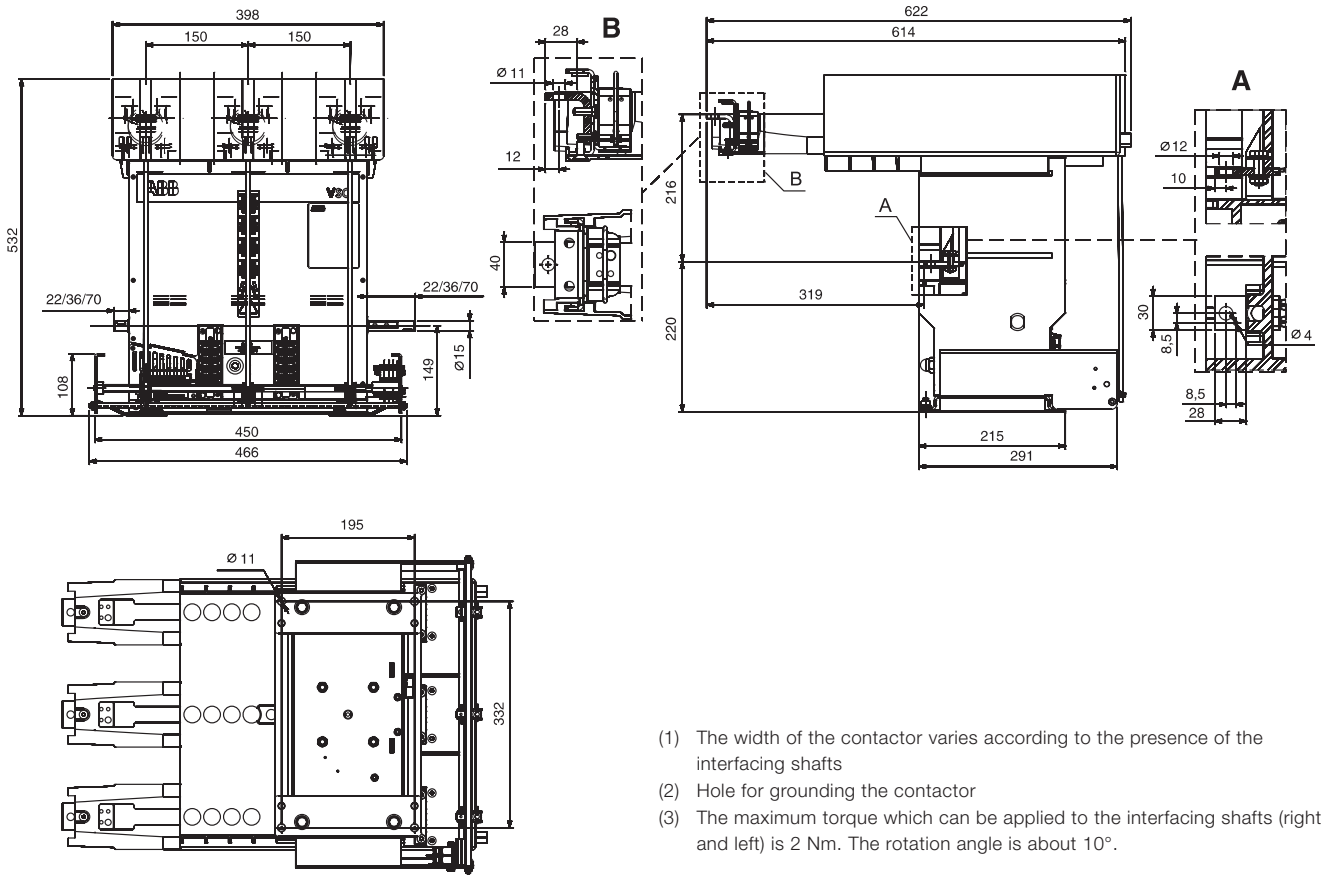



**Fig. 4b**

**5.5.2. VSC/F contactor in fixed version with fuses**

Please refer to figures 5a - 5b for the overall dimensions and the distances between the fixing holes.
In any case, avoid stressing the supporting structure of the contactor: if necessary, prepare slots in the fixing area to facilitate correct positioning of the apparatus.
The contactor must be installed on the floor with moving contacts at the bottom (figure 5c).

## VSC7/F




(1) The width of the contactor varies according to the presence of the interfacing shafts
(2) Hole for grounding the contactor
(3) The maximum torque which can be applied to the interfacing shafts (right and left) is 2 Nm. The rotation angle is about 10°.

Fig. 5a

## VSC7/FN

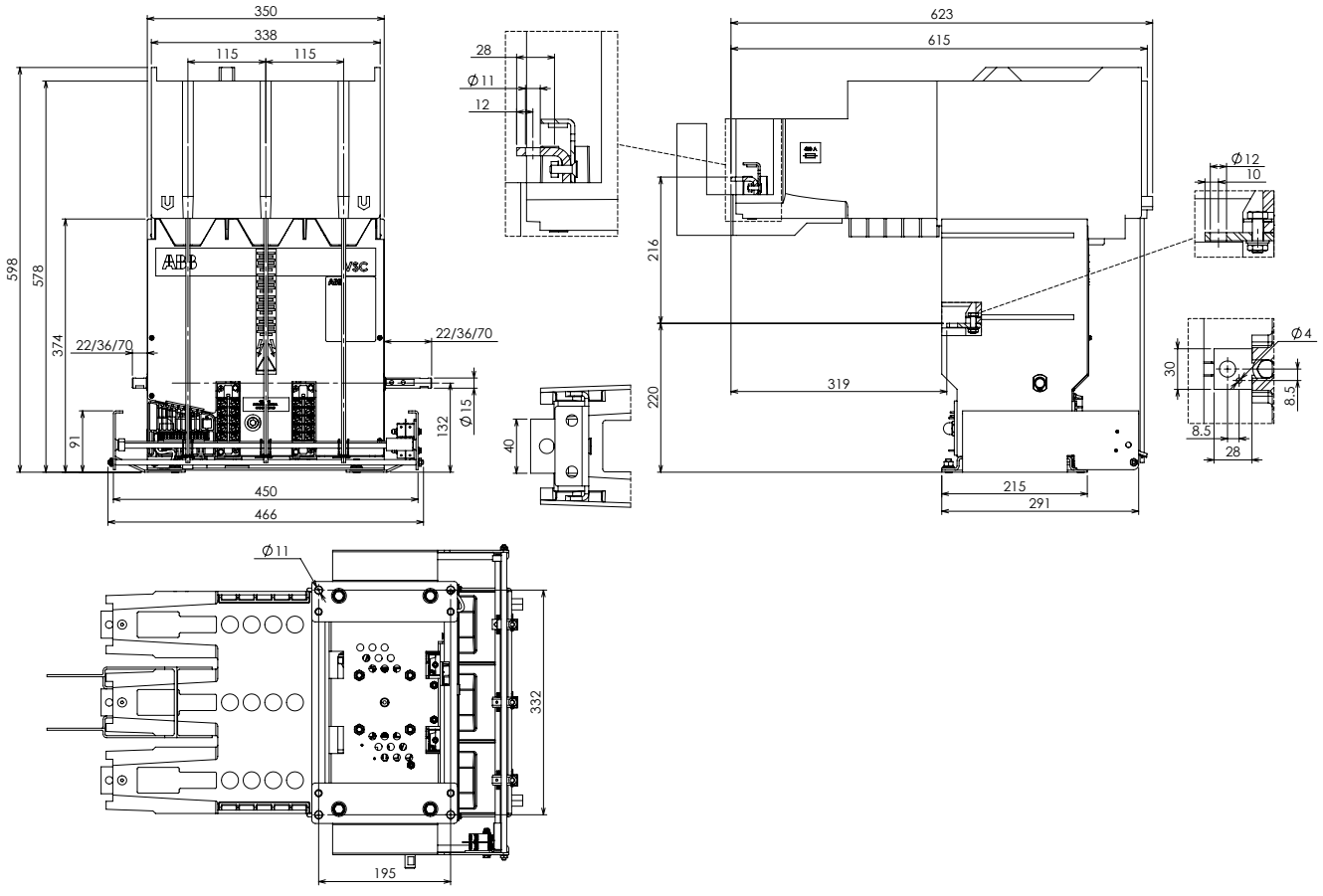
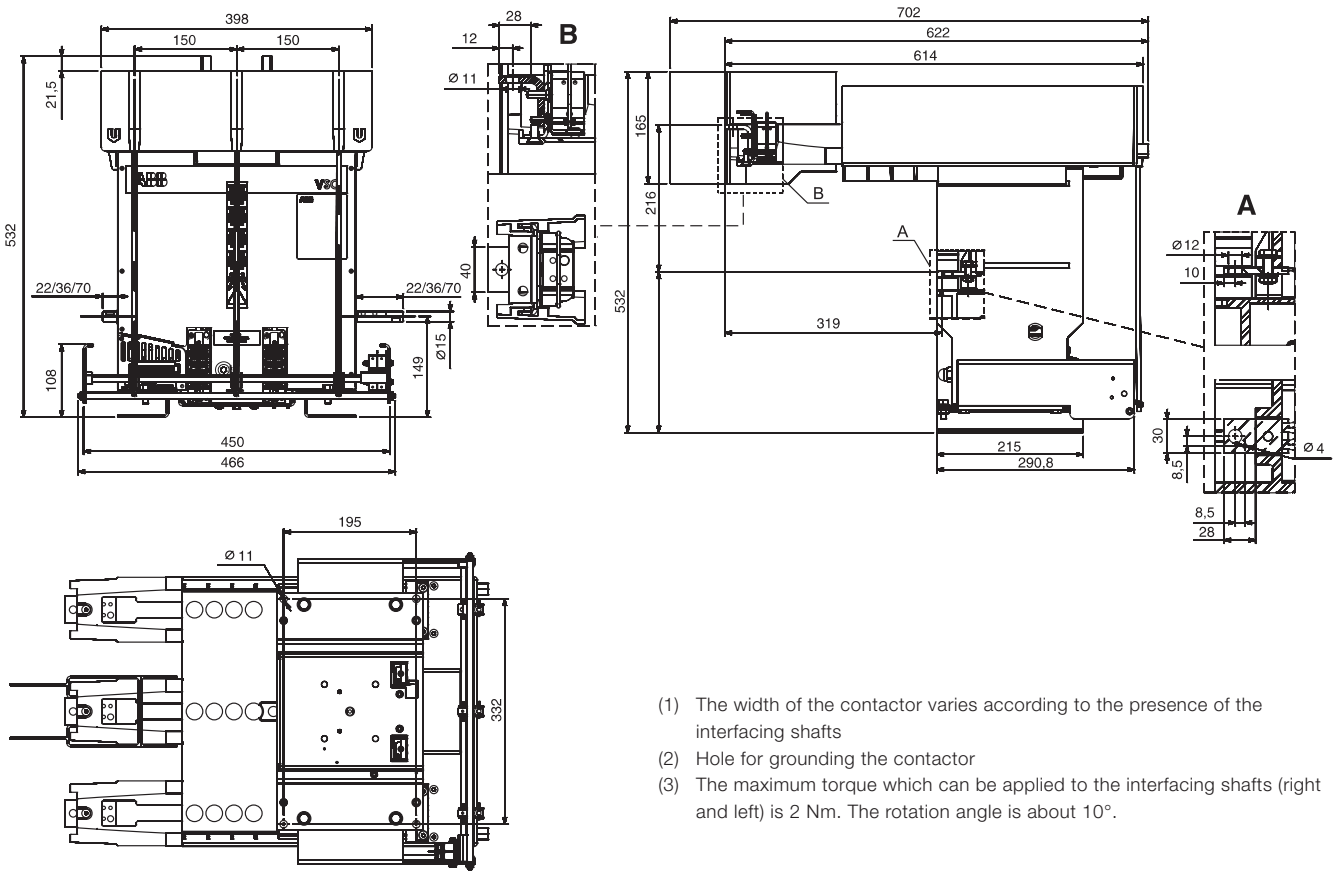



Fig. 5b




(1) The width of the contactor varies according to the presence of the interfacing shafts
(2) Hole for grounding the contactor
(3) The maximum torque which can be applied to the interfacing shafts (right and left) is 2 Nm. The rotation angle is about 10°.

Fig. 5c

## Installation of the fixed contactor with VSC/F - VSC/FN fuses

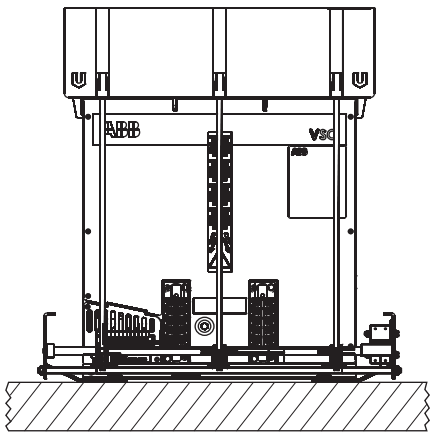


Fig. 5d

### 5.5.3. Withdrawable contactor with VSC/P - VSC/PG - VSC/PN - VSC/PNG fuses

#### VSC7/P - VSC7/PG - VSC12/P - VSC12/PG

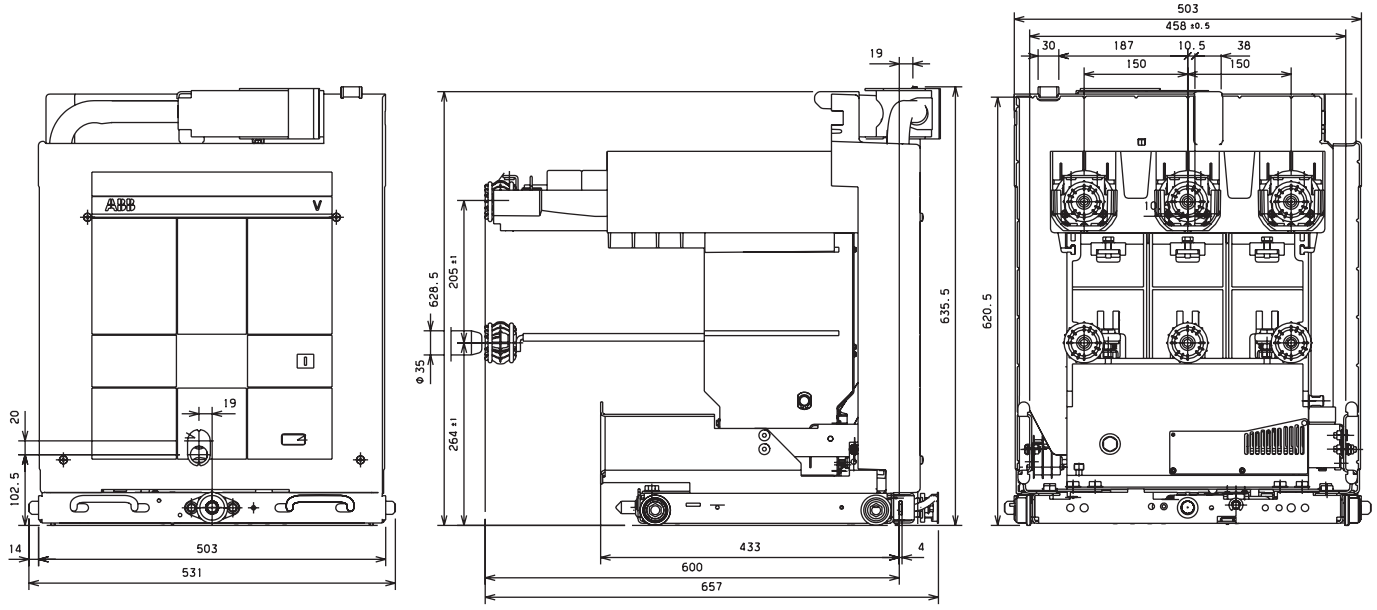



Fig. 6a

#### VSC7/PN

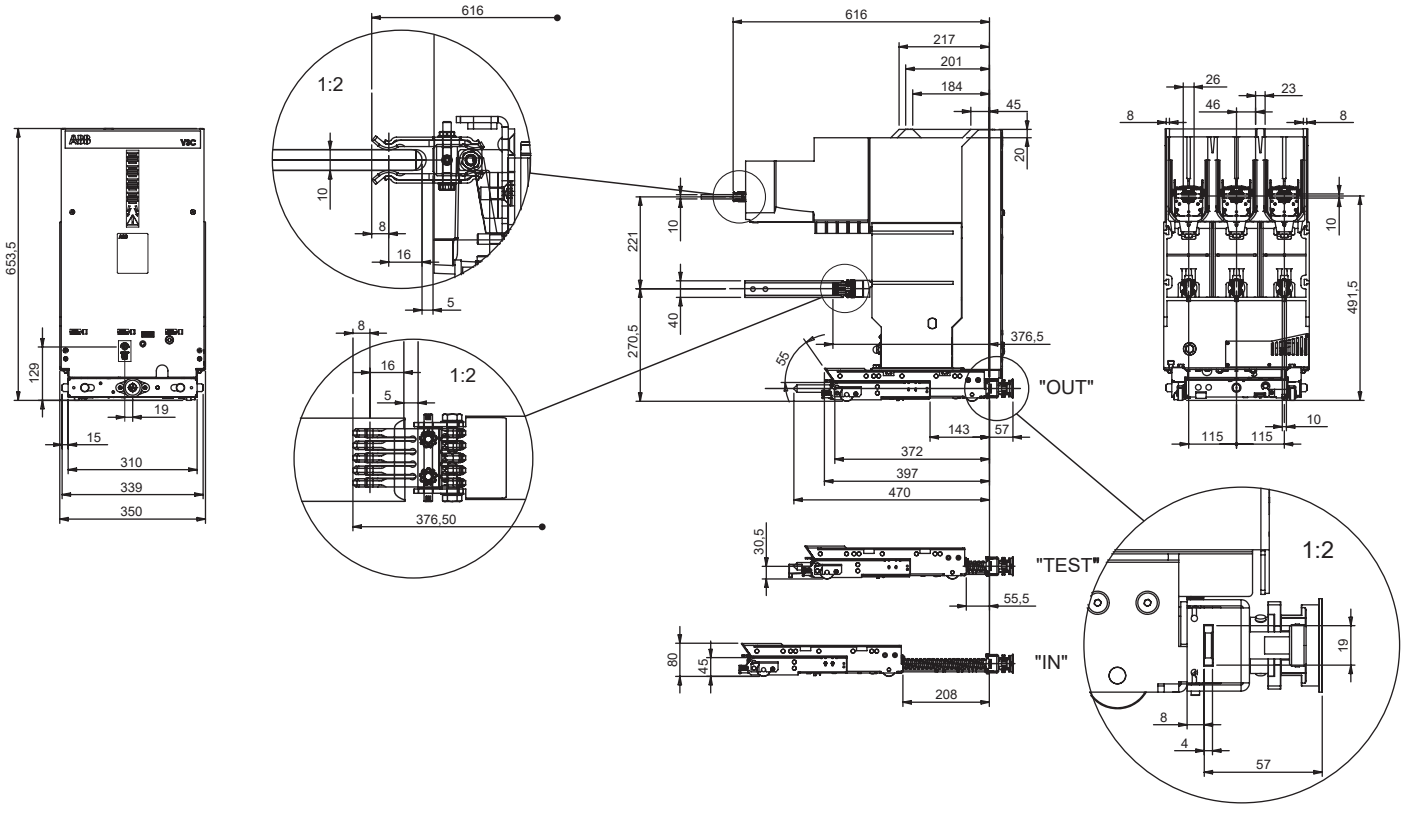
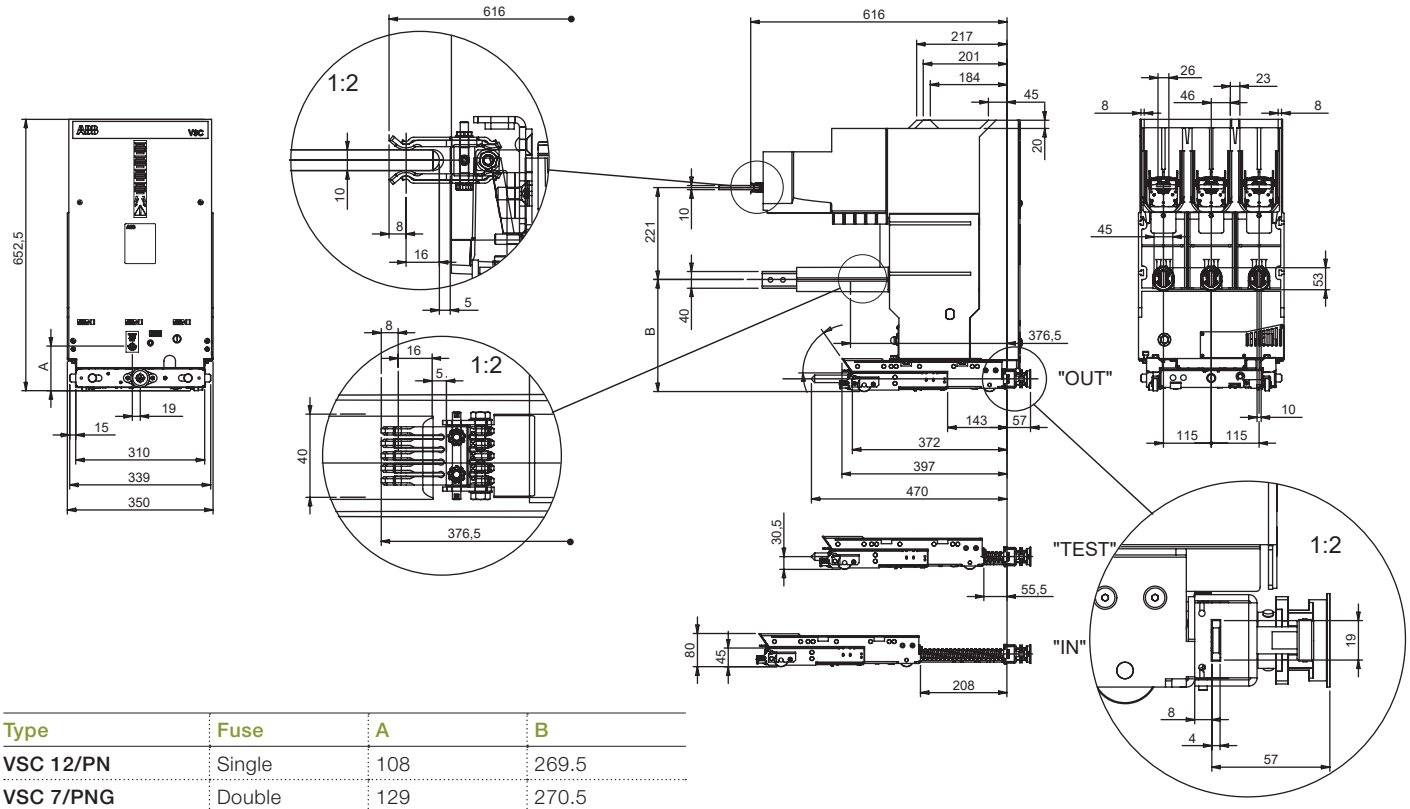



Fig. 6b




| Type | Fuse | A | B |
|---|---|---|---|
| **VSC 12/PN** | Single | 108 | 269.5 |
| **VSC 7/PNG** | Double | 129 | 270.5 |
| **VSC 12/PNG** | Double | 108 | 269.5 |

**Fig. 6c**

## VSC 12/P contactor for marine environments

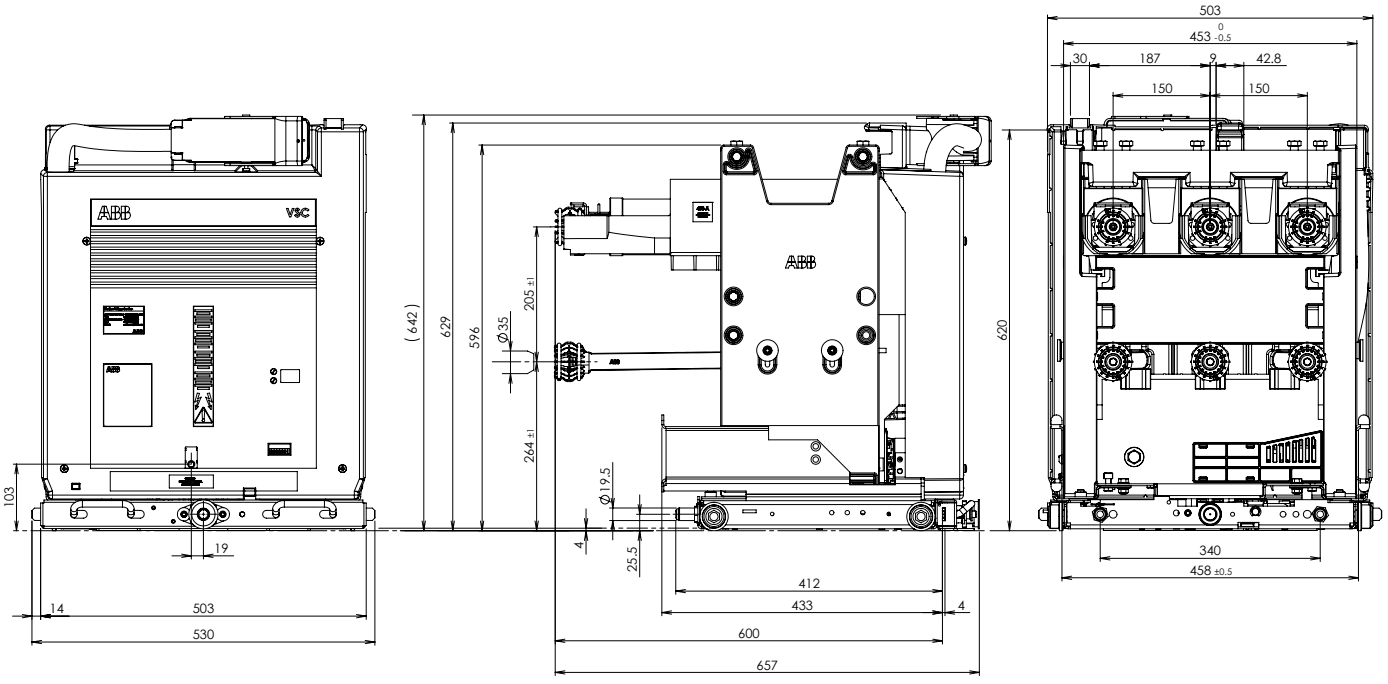



**Fig. 6d**

# 5.6. Assembly and making the connections

### 5.6.1. Fixed contactors



**WARNING**



**Dangerous voltages. Risk of death, serious injury to people, damage to the apparatus or other objects.**

**Remove the power supply, ground and put all the power and control voltage sources under safe conditions before starting the work on this or any other electrical apparauts.**
**Installation must only be carried out by qualified personnel.**

#### Introduction

Before carrying out any installation operations:

- Test all the power terminals to check that they are not supplied with voltage. Only use high voltage testing equipment approved for checking the voltage on the power terminals. **Do not attempt to measure the high voltage (above 600 volt) with a volt-ohm/meter.**
- Check all the control and secondary circuit terminals with a voltmeter to ensure that all the control and secondary input voltage sources have been turned off.
- Connect the safety earthing to the power terminals after having turned the power supply to the system off and before working on the apparatus.
- Carry out all the operations for turning off the voltage and earthing according to the established safety procedures.

#### Power circuit

#### General precautions

– Check that the connections of the fixed contactor or the isolating contacts of the withdrawable contactor are clean and free of any deformation caused by shocks received during transport or storage in the warehouse.
– Select the cross-section of the conductors according to the service current and the short-circuit current of the installation.
– Prepare special pole insulators, near the terminals of the contactor, sized according to the electrodynamic forces deriving from the short-circuit current of the installation and avoid stressing the connections laterally.

#### Surface treatment of the connections

The connections can either be made of bare copper or bare aluminium. In any case, it is always advisable to silver-plate the contact surfaces. The surface treatment must have a constant and even thickness.

#### Assembly procedures for fixed contactors

– Check that the contact surfaces of the connections are flat, and are free of any burrs, traces of oxidation or deformation caused by drilling or impacts received.
– Carry out the operations indicated on the contact surface of the conductor (silver-plated copper):
  - clean with a rough dry cloth
  - only in the case of obstinate traces of oxidation, clean with a very fine grain emery cloth taking care not to remove the surface layer
  - if necessary, restore the surface treatment (consult ABB)
  - put the connections in contact with the contactor terminals, taking care to avoid mechanical stresses produced, for example, by the conductor busbars on the terminals themselves.
– Interpose a spring and a flat washer between the head of the bolt and the connection.
– The use of bolts according to DIN class 8.8 Standards is recommended, also referring to what is indicated in the table.
– In the case of cable connections, strictly follow the manufacturer's instructions for making the terminals.

| Bolt | Recommended tightening torque (1) Without lubricant |
|---|---|
| M6 | 10.5 Nm |
| M8 | 23 Nm |
| M10 | 50 Nm |
| M12 | 86 Nm |

(1) The nominal tightening torque is based on a friction coefficient of the thread of 0.14 (distributed value the thread is subjected to which, in some cases, is not negligible). Take into account the deviations from the general Standards table (for example, for contact systems or terminals) as foreseen in the specific technical documentation. The thread and surfaces in contact with the heads of bolts must be slightly oiled or greased, so as to obtain a correct nominal tightening torque.
The tightening torques indicated can only be applied to metal parts.

#### Earthing and cabling procedures

VSC conforms to level 3 of the IEC 61000-4-x EMC Standards. With regard to medium voltage switchgear, the plants where the VSC contactors are to be installed must conform to the IEC 60694:2002-01 and IEC 62271-1 ed. 1.0 Standards, to ensure adequate electromagnetic immunity. Pay great attention during earthing and cabling operations of the auxiliary circuits. Follow the procedures indicated. For further advice, please contact the ABB Service office.

### Grounding

A good connection to earth guarantees correct operation of all the apparatus installed. However, even earthing carried out correctly is not a sufficient measure to ensure a good connection between the VSC control module and earth. In fact, since the control module of the contactor is connected to the metallic base of the VSC by means of a copper connection (Fig. 7), it is always necessary to check that the connection is intact.
Furthermore, earthing must always be carried out between the VSC frame and the main earthing system of the plant.
Use cables with a suitable cross-section and of the minimum length needed.

### Connection of metallic structures to exposed conductive parts

In the case of painted parts of the supporting structure, the various parts must always be scraped to eliminate the paint and connected with busbars or copper braids so as to guarantee low inductance connections.
To make a low inductance earthing connection, use cables or busbars with an appropriate cross-section, preferably rectangular. Scrape away the paint of the metallic parts over a sufficiently large area, tighten the fixing screws and cover the connected parts with Vaseline grease.
The length of the earthing cables must be as short as possible. Connection to earth of the parts must guarantee the same electric potential and low impedance.

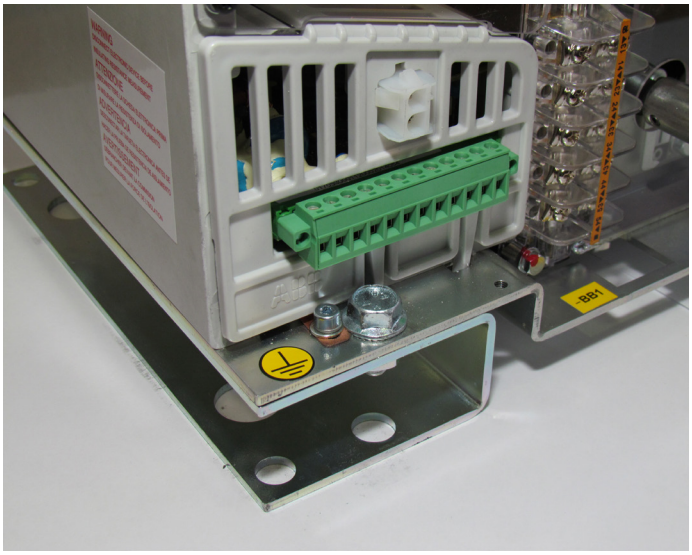



Fig. 7 - Grounding

**Figs. 8a - 8b show a grounding operation carried out correctly.**

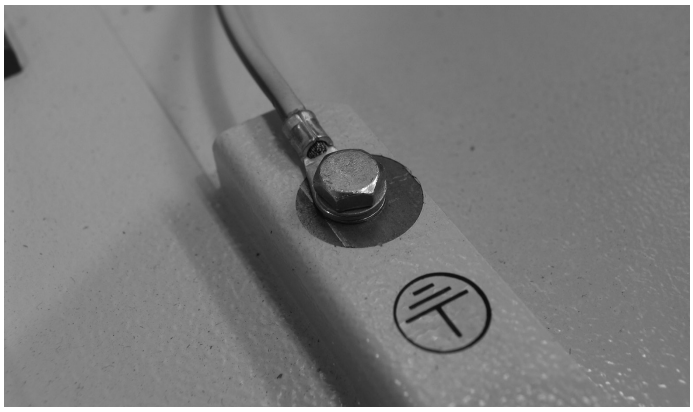


Fig. 8a

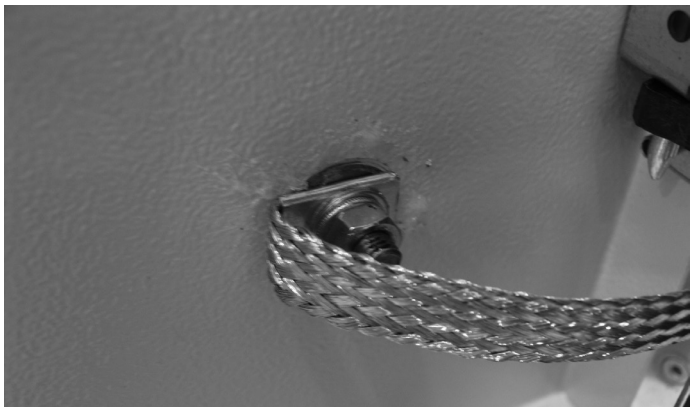


Fig. 8b

**Figs. 8c - 8d show a grounding operation not carried out correctly and which, apart from being dangerous, does not guarantee correct operation of the VSC.**



Fig. 8c

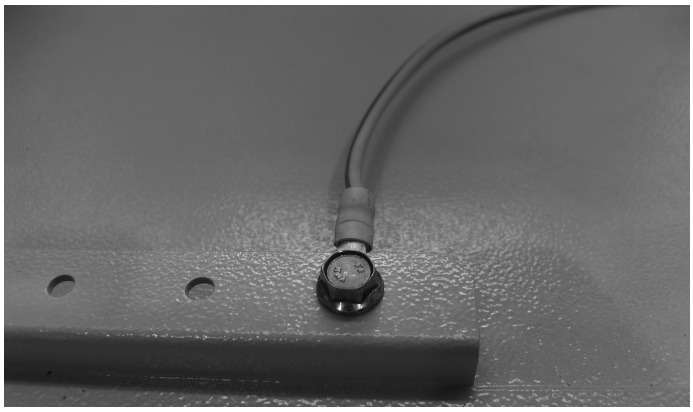


Fig. 8d

## Cabling

Make short connections (maximum 1 metre) inside the medium voltage units and avoid positioning them close to the medium voltage busbars.
All long connections must follow paths as close as possible to the metallic frame. The connections must also be fitted with ferrite rings to suppress high frequency interference.
It is good practice to run the cables inside metallic pipes or ducts (earthed at several points) when they are subject to or may be a cause of interference.
Cabling and earthing procedures according to IEC 61000-5-2 Standards: “Technical report: Installation and mitigation guidelines”.

Where possible, the power supply and auxiliary circuit cables must be braided. Their length must be calculated appropriately to prevent any surplus and the maximum length must be:

- 135 m for 24 to 130 V auxiliary voltage
- 400 m for 220 to 250 V auxiliary voltage

Longer lengths require an additional filter for every operating input used (consult ABB).
In any case, any surplus parts of cables must be wound separately and taken into the low voltage apparatus compartment. Always avoid placing them in the vicinity of the medium voltage cables or close to cables which may generate interference or disturbances, such as current or voltage transformer cables or power supply cables.

### Connection of the auxiliary circuits

The cables to be used for connection of the auxiliary circuits must have a rated voltage Uo/U of 450/750 V and be insulated for 3 kV test.
**Note:** before carrying out the test, disconnect the earthing connection of the electronic feeder.
Also remember that the auxiliary circuits must be checked at the maximum voltage of 2 kV for 1 second in accordance with what is prescribed in the Standards.

The cross-section of the connection cables must not be less than 1.5 $mm^2$.
Connection of the contactor auxiliary circuits must be made by means of the socket with terminal box mounted on the front of the electronic card.
Outside, the wires must run through metallic pipes or ducts suitably earthed.

### Connection to be made by the customer (*)

Pins XDB10-1 and XDB10-2 must always be supplied, both in the SCO and DCO version (also see par. 5.8.). The polarity is not important since the internal circuits take both AC or DC signals. For further details, consult the electric circuit diagram enclosed with the apparatus.

| N. of pin | Connections | Abbr. of binary outputs/inputs | Meaning of each pin (*) | |
|---|---|---|---|---|
| | | | Basic version | "Full option" version |
| -XDB10-1 | Auxiliary power supply | – | Auxiliary power supply AC or DC (pole 1) | Auxiliary power supply AC or DC (pole 1) |
| -XDB10-2 | Auxiliary power supply | – | Auxiliary power supply AC or DC (pole 2) | Auxiliary power supply AC or DC (pole 2) |
| -XDB10-3 | Binary output n° 1 | -PFG | Indication of unit ready and coil continuity control (pole 1) | Indication of unit ready and coil continuity control (pole 1) |
| -XDB10-4 | Binary output n° 1 | | Indication of unit ready and coil continuity control (pole 2) | Indication of unit ready and coil continuity control (pole 2) |
| -XDB10-5 | Binary output n° 2 | -PFR | Not used | Indication of capacitor state (pole 2) |
| -XDB10-6 | Binary output n° 2 | | Not used | Indication of capacitor state (pole 1) |
| -XDB10-7 | Binary input n° 1 | -SFC | Closing (pole 1) | Closing (pole 1) |
| -XDB10-8 | Binary input n° 1 | | Closing (pole 2) | Closing (pole 2) |
| -XDB10-9 | Binary input n° 2 | -SFO | Opening (pole 1) | Opening (pole 1) |
| -XDB10-10 | Binary input n° 2 | | Opening (pole 2) | Opening (pole 2) |
| -XDB10-11 | Binary input n° 3 | -SFL2 | Undervoltage (pole 1) | Undervoltage (pole 1) |
| -XDB10-12 | Binary input n° 3 | | Undervoltage (pole 2) | Undervoltage (pole 2) |

(*) For availability, ask ABB.

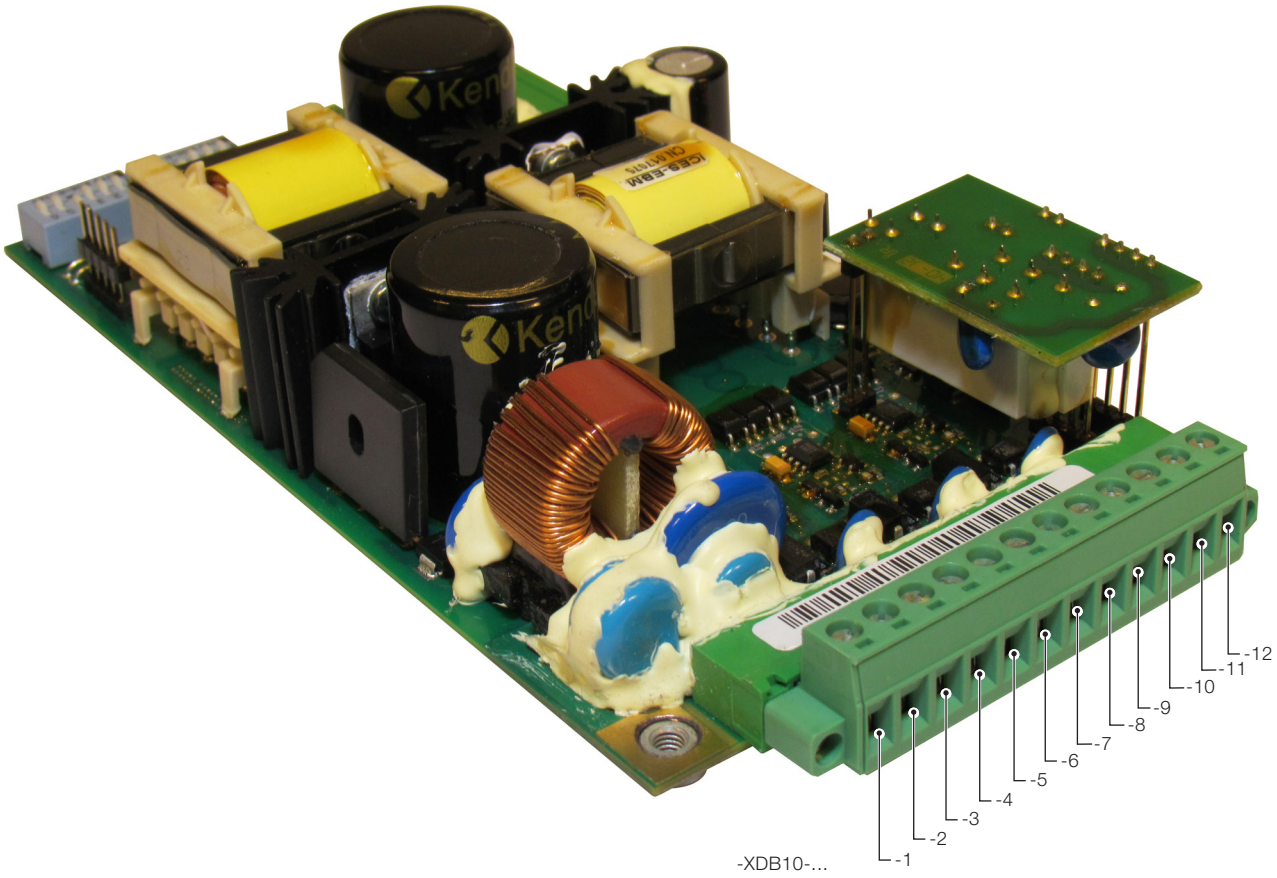



Fig. 9

### Checks

After the above-mentioned operations, carry out the following checks:

– check that the connections do not exert any force on the terminals
– check tightness of the connections.



Fig. 10

### 5.6.2. Withdrawable contactors and enclosures

The withdrawable contactors are used in the UniGear ZS1 type switchgear and in the PowerCube modules. Appropriately fixed together in the configurations defined by the customer, the enclosures build up medium voltage switchgear consisting of various units.

### Rules for designing the switchgear

Arc proofing

The ABB enclosures are supplied with a reinforced door, suitable for making arc proof switchgear.

- **The reinforced enclosure alone cannot guarantee arc proofing of the switchgear designed by the customer. To guarantee this, some representative configurations, selected by the customer, must be subjected to the tests according to the prescriptions indicated in the IEC 62271-200 Standards.**
- **For UniGear ZS1 type switchgear, all the door knurls must be tightened to guarantee arc proofing.**

### Degree of protection

Limited to the front part, the ABB enclosures guarantee the following degree of protection:

- IP30 on the external housing;
- IP20 inside the switchgear with the door open.

Special versions up to IP41.

**The enclosure alone supplied by ABB cannot guarantee the degree of protection of the switchgear designed by the customer. It must undergo the tests according to the prescription indicated in the IEC62271-200 Standards.**

## Heating

Refer to technical catalogue 1VCP000165 for the rated capacity of the contactors, bearing in mind that apparatus heating is affected by the following variables:

- layout of the enclosures in the switchgear designed by the customer;
- degree of protection (ventilation slats);
- current density of the power supply busbars (busbar duct - branches);
- ambient temperature.

For any needs, please contact ABB Service.

### 5.6.2.1. Withdrawable VSC/P contactors

The contactors are used for rated voltages from 7.2 to 12 kV, rated normal currents up to 400 A and fault levels up to 1000 MVA (with suitable protection fuses in series with the contactor).

The VSC/P contactor is made up of:

– a three-pole contactor with SCO or DCO function
– mechanical signalling of open/closed
– two pairs of auxiliary contacts signalling open/closed
– feeder able to operate in DC and AC
– a truck on which the supporting structure of the contactor is fixed, consisting of two supports, closed at the front by the protection with characteristics nameplate.
  In the top part of the protection there are strikers 30a and 30b (fig. 11) for actuating the enclosure contacts to signal the connected/isolated position.

The pin (34) for locking contactor racking-in with the earthing switch closed on the enclosure, comes out on the right side of the truck.

The crosspiece for hooking up the contactor to the enclosure for operation of the truck is mounted on the front of the truck (3);

– two supports (102) house the slide for actuation of the segregation shutters of the fixed medium voltage contacts of the enclosure and the locking slide of operation of the switch itself with the contactor in the connected position or during the isolation stage;
– when it is not inserted in the socket located on the enclosure, the plug connector for the auxiliary circuits of the contactor must be hooked up to the pin (101);
– mechanical signalling of open/closed (103);
– fuseholder complete with connections for fuses (104);
– input and output tulip isolating contacts (105);
– locks as per par. 5.6.2.2.;
– three current-limiting fuses (supplied on request) with high breaking capacity connected in series to the contactor, with dimensions according to:
  - DIN 43625 Standard with maximum cartridge length e = 442 mm;
  - BS 2692 Standard with maximum centre fixing distance L = 553 mm;
– an impulse counter (supplied on request) which indicates the number of operations carried out by the contactor (106);
– manual emergency opening device (107)
– device for opening when a fuse blows.

### 5.6.2.2. Description of the locks for withdrawable VSC/P contactors

- Electric lock which prevents the contactor being closed when the truck is not in the racked-in and isolated positions.
- Mechanical lock which prevents the contactor being racked-in and out when it is closed and closing of the contactor when the truck is not in the racked-in and isolated positions.
- Electric lock which prevents closing of the contactor when a fuse is missing or blown.
- Lock which prevents putting a contactor into service in an enclosure preset for a circuit-breaker (*).
- Locking electromagnet on the contactor truck which when there is no voltage, prevents racking-in or racking-out (-RL2).
- Mechanical lock which prevents contactor racking-in if the enclosure door is not closed (requires the same interlock in the fixed part) (108).
- Mechanical interlock with earthing switch placed on the enclosure - with earthing switch closed the contactor cannot be racked-in and with the contactor racked-in or in intermediate positions between racked-in and isolated, it is not possible to close the earthing switch (34).
- Mechanical lock of the shutters when the contactor is racked-out.

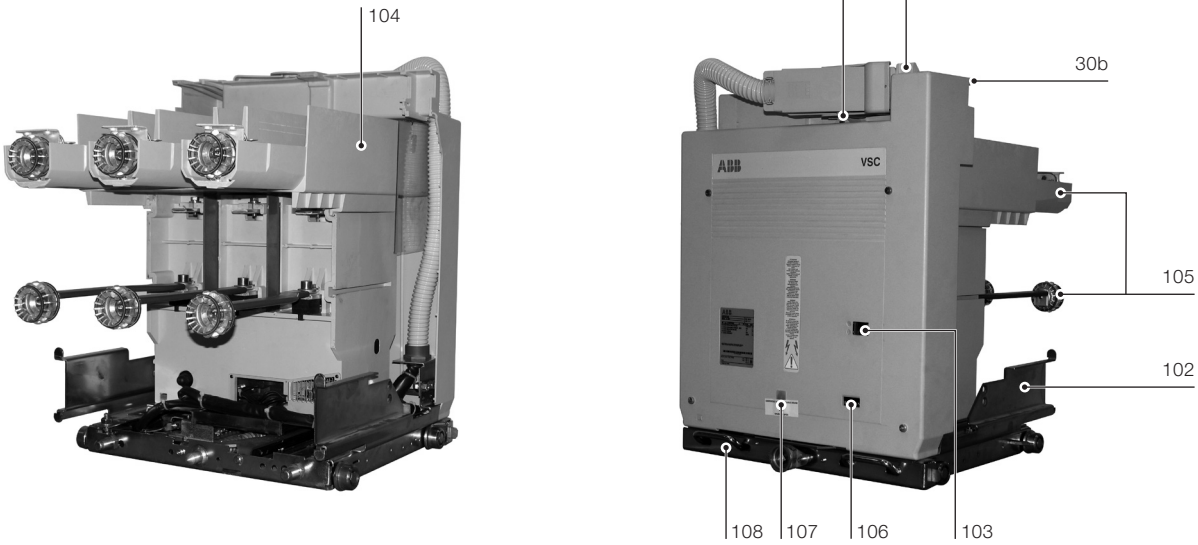



Fig. 11a

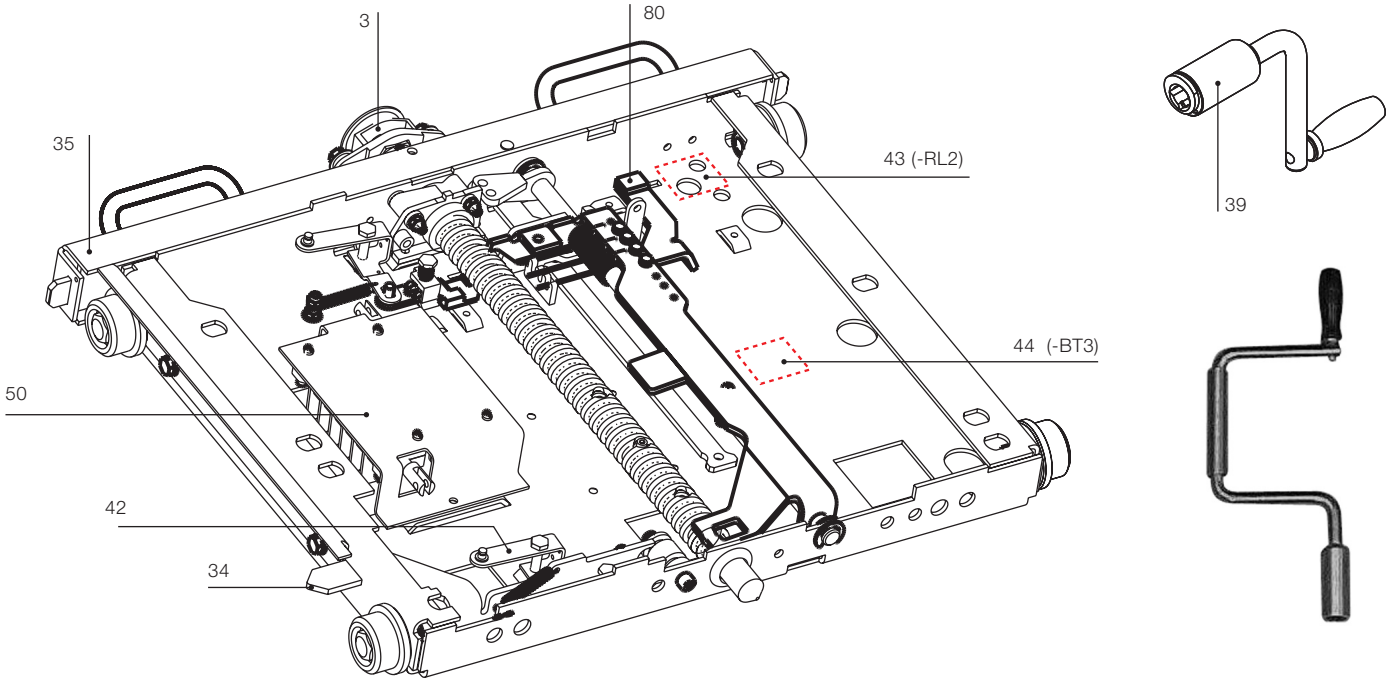



Fig. 11b - Locking devices on the racking-out truck

– Key lock on contactor racking-in - it is only possible to activate the lock and free the key preventing contactor racking-in with the contactor in the isolated position.
– Key lock with earthing switch open - this can only be activated with the earthing switch open. The key can only be removed with the electric lock activated.
– Key lock with earthing switch closed - this can only be activated with the contactor in the isolated position and with the earthing switch closed. The key can only be removed with the lock activated.
– Preset for independent padlocks on the shutters and in the closed and/or open position.
– Electric lock on racking-in and racking-out with the door open (microswitch on the door) of the enclosure connected in series with the locking electromagnet on the contactor truck.
– Key lock on earthing truck racking-in - with the lock activated all the operations with the contactor are possible, but positioning the earthing truck in the isolated position starting from the racked-out position is not allowed.
– Mechanical lock which prevents racking-out of the connector of the auxiliaries when the contactor is racked-in and during racking-in and racking-out.
– Electro-mechanical lock on de-energisation for the earthing switch, which when there is no voltage prevents the earthing switch operations.
– Electro-mechanical lock on the compartment door.

#### 5.6.2.3. VSC/PN and VSC/PNG withdrawable contactors

The VSC/PN contactors are used for rated voltages from 7.2 to 12 kV, rated thermal currents up to 400 A and fault levels up to 1000 MVA (with suitable protection fuses in series with the contactor). In the same way, the VSC/PNG contactor is used for 7.2 kV rated voltage and 400 A rated thermal current.
Both the VSC/PN and the VSC/PNG versions of contactors consist of:
– a three-pole contactor with SCO or DCO operation
– a fuseholder complete with terminals for fuses (121). In the upper part there are strikers 1a, 1b and 1c (fig. 12 - page 29) for activating the enclosure contacts for signalling the connected/test/isolated position
– a mechanical open/closed signalling device (120)
– two pairs of auxiliary contacts signalling open/closed
– feeder able to operate in d.c. and a.c.
– a truck on which the base plate of the contactor is fixed and the front protective screen by means of two supports. At the rear, two pins are positioned on the side walls of the truck for locking contactor racking-in with the earthing switch open on the enclosure, whereas the 45° slides operate the segregation shutters of the medium voltage fixed contacts of the enclosure. The crosspiece for hooking the contactor onto the enclosure for truck operation is mounted on the front of the truck
– the jaw-type input and output isolating contacts (122)
– the locks as per par. 5.6.2.4.
– three current-limiting fuses (supplied on request) with high breaking capacity connected in series with the contactor, with dimensions according to:
  • DIN 43625 Standard with maximum cartridge length e = 442 mm (single cartridge)
  • BS 2692 Standard with maximum fixing distance L = 553 mm (single and/or double cartridge)
– a mechanical operation counter which indicates the number of operations carried out by the contactor (122)
– a manual emergency opening device even when energised with medium voltage (125)
– a device for opening when a fuse blows, with relative fuse blown indication.

#### 5.6.2.4. Description of the locks for VSC/PN and VSC/PNG withdrawable contactors

– Electric lock which prevents the contactor being closed when the truck is not in the “racked-in” (200 mm), “test” (47.5 mm) and “racked-out” (0 mm) positions (-BGT3) (fig. 12a).
– Mechanical lock which prevents the contactor being racked-in and out when it is closed, and contactor closing when the truck is not in the “racked-in”, “test” and “racked-out” positions (1) (fig. 12a).
– Electric lock which prevents contactor closing when a fuse is missing or blown.
– Locking electromagnet on the contactor truck which, when there is no voltage, prevents racking-in or racking-out (-RL2) (fig. 12a).
– Mechanical lock which prevents contactor racking-in if the enclosure door is not closed (requires a reciprocal interlock in the fixed part) (126).
– Mechanical lock for the “test” position (2) (fig. 12a).
– Lock for different currents (5) (fig. 12a).

(*) This lock consists of some pins assembled in the plugs of the auxiliary circuits which, with a suitable code, prevent connection of the plug in the enclosure socket. The lock also foresees compulsory application of the locking magnet in the truck.

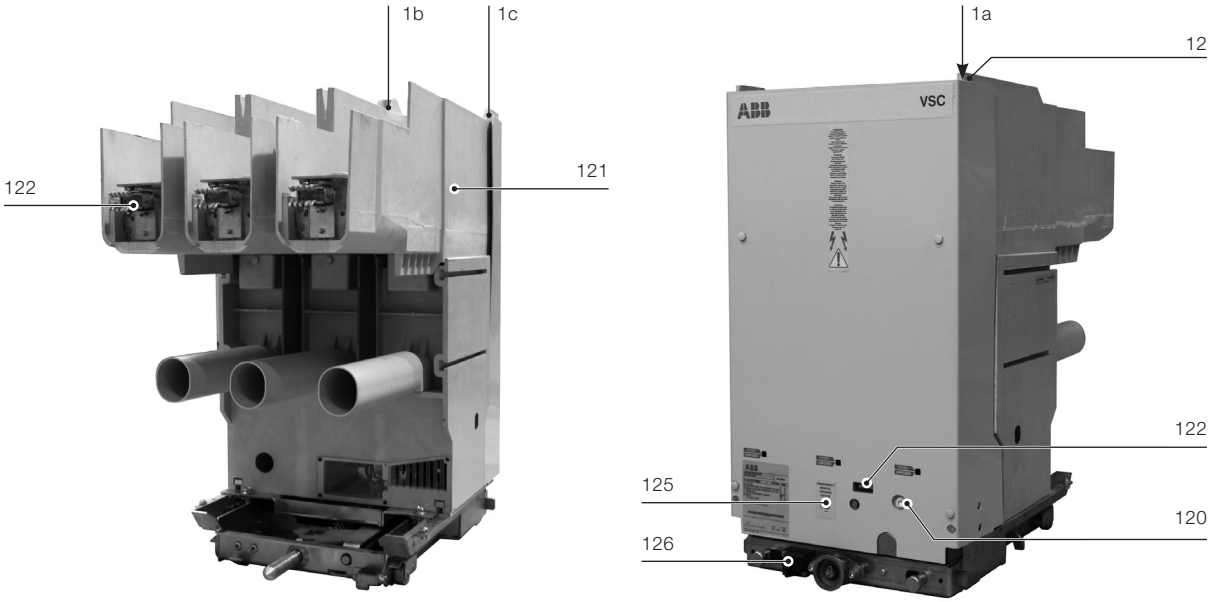



Fig. 12

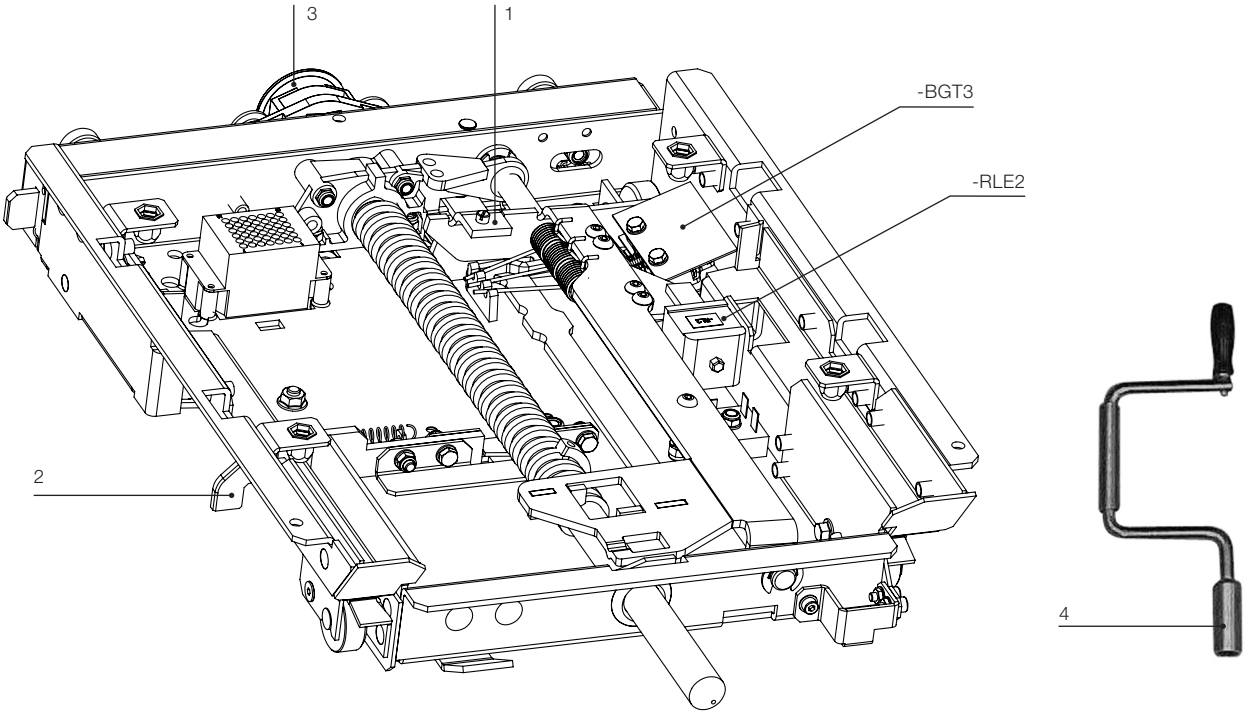



Fig. 12a - Locking devices on withdrawable truck.

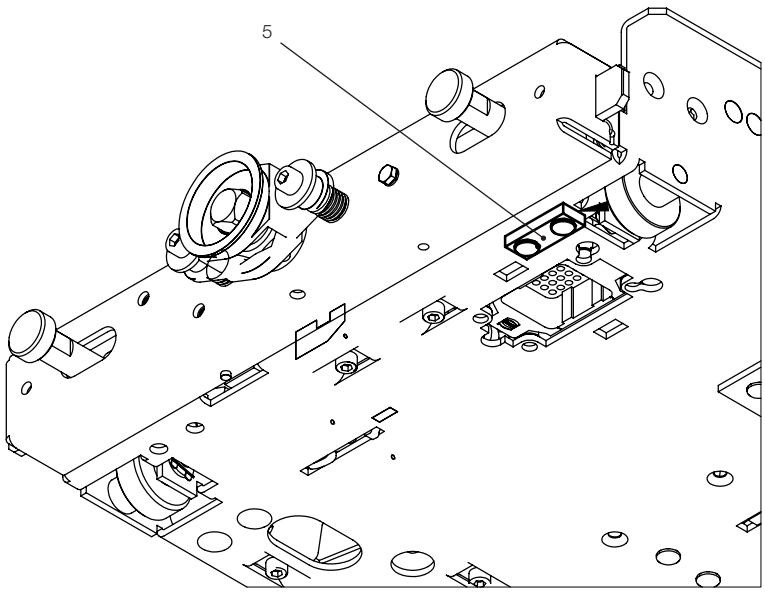



Fig. 12b - Interlocking devices on withdrawable truck.

## 5.7. Description of the closing and opening operations

The contactor drive operates in two different ways as shown in Table 1.

For the DCO version, further personalisation of the apparatus can be made. In fact – the first of its kind – the V-Contact VSC contactor is fitted (on request) with an undervoltage function (UV) with delays which can be set according to the requirements of the installation.

For a more detailed description of the behaviour of the apparatus according to the version, see table 2.

Supply the contactor with auxiliary voltage and operate it several times electrically. The contactor must carry out the opening and closing operations correctly in accordance with the threshold values defined in the IEC 62271-106 Standards.

**TABLE 1**

| Version | Description | Inputs | | |
|---|---|---|---|---|
| | | Closing -XDB10-7, -XDB10-8 | Opening -XDB10-9, -XDB10-10 | Undervoltage -XDB10-11, -XDB10-12 |
| SCO (Single Command Operated) | This version operates according to the state of the command signal at terminals -XDB10-11 and -XDB10-12. Contactor closing takes place when the voltage applied to terminals -XDB10-11 and -XDB10-12 corresponds with the values indicated in Table 2a | Not used | Not used | Used |
| DCO (1) (Double Command Operated) | This version operates by means of two independent signals for closing and opening applied to terminals -XDB10-7 and -XDB10-8 for opening and -XDB10-9 and -XDB10-10 for closing. The values of the signals are indicated in Table 2b. Furthermore, on request, automatic delayed opening of the contactor is available in the case of a drop or lack of voltage at terminals -XDB10-11 and -XDB10-12 (configurable delay filter). See Table 2b. | Used | Used | If the undervoltage function is required (2) |

(1) The contactor is restarted if the supply voltage of the board drops below 18V for more than 300ms.
(2) The undervoltage with time-delay function is guaranteed with 18V minimum residual voltage.

**TABLE 2a**

**SCO (Single Command Operated) version**
**Terminals -XDB10-1 and -XDB10-2 must always be supplied at the rated voltage (tolerance: 85% ... 110%)**

| Closing operation | | Power supply, in continuous mode, to the UV input |
|---|---|---|
| Opening operation (3) | Release voltage (drop out) | A voltage drop occurs at terminals -XDB10-11 and -XDB10-12 for power supply voltage values between 75% and 10% of the rated voltage. |

**TABLE 2b**

**DCO (Double Command Operated) version**
**Terminals -XDB10-1 and -XDB10-2 must always be supplied at the rated voltage (tolerance: 85% ... 110%)**

| | | |
|---|---|---|
| Closing operation | | Supply terminals -XDB10-7 and -XDB10-8 with power. An impulse lasting at least 100 ms is recommended. Note: an impulse lasting a shorter time may also cause contactor closing. |
| Opening operation | Opening operation (switching) | Supply terminals -XDB10-9 and -XDB10-10 with power. An impulse lasting at least 100 ms is recommended.<br>Note: an impulse lasting a shorter time may also cause contactor closing. In the case of simultaneous power supply of terminals -XDB10-7 and -XDB10-8 and terminals -XDB10-9 and -XDB10-10, the opening command prevails. |
| | Release voltage (undervoltage) | – Function available on request (UV = Undervoltage).<br>– Opening takes place for voltage values applied to terminals -XDB10-11 and -XDB10-12, between 70% and 35% of the rated voltage (4) |

(3) The opening operation is only instantaneous.
(4) The opening operation can be instantaneous or delayed (adjusting the daily by means of the special selectors) a 0.3 - 1 - 2 - 3 - 4 - 5 s. It is set to 0 s by default.

**Setting for DCO**

| UV time (s) | S1-3 | S1-4 | S1-5 |
|---|---|---|---|
| Instantaneous (1) | 0 | 0 | 0 |
| 0.3s | 0 | 0 | 1 |
| 1s | 0 | 1 | 0 |
| 2s | 0 | 1 | 1 |
| 3s | 1 | 0 | 0 |
| 4s | 1 | 0 | 1 |
| 5s | 1 | 1 | 1 |

S1-6 → Reserved – (1) See opening time par. 1.3.

### 5.7.1. Diagnostics

Two types of electronic cards are available, “Basic board” and “Full option”, differing from each other in the diagnostic functions they have available.
Both have:
– coil continuity control connected to the card
– capacitor voltage level control.
The “Full option” card also makes the following available:
– control of the state of capacitor efficiency, which is fundamental for correctly carrying out the opening and closing operations
– checking and indicating the temperature inside the contactor.
The alarms corresponding to the above functions are made available to the user by means of two contacts (3-4 and 5-6) of the -XDB10 terminal box.
The cards periodically carry out the controls without preventing the opening and closing operations.
The table below indicates the functions available.

### 5.7.3. Coil continuity control (CCC) and temperature monitoring

The unit checks actuator connection continuity so as to reduce the risk of failure to operate following disconnection. It also monitors the temperature of the board to reduce the risk of operating beyond the board’s design limits.
This function is provided for both the basic MAC R2 board and the “full option” version.
The test is performed:
– Every 2 minutes (irrespective of whether the apparatus is in the open or closed condition)
– 15 seconds after starting
– After each operation
The test is not performed:
If the voltage of the external capacitance is less than 75 V (“not ready” signal already given)
If the ambient temperature is less than -30° (“not ready” signal already given)
An alarm signal is given by opening contact DO1 if errors occur.

| **Basic board - Full option board** | | | | |
|---|---|---|---|---|
| Ready DO1<br>-XDB10 (3-4) | Continuity control | Capacitor voltage level and VSC internal temperature | Anomaly | No anomaly |
| | – After each operation<br>– Start-up<br>– Every 12 hours | Continuously | DO1 open | DO1 closed |

| **Full option only** | | | | |
|---|---|---|---|---|
| CBC DO2<br>-XDB10 (5-6) | Control of state of capacitor efficiency | – | Anomaly | No anomaly |
| | – Start-up<br>– Every 12 hours | – | DO2 open | DO2 closed |

### 5.7.2. Contactor power supply

The contactor has been tested for all the auxiliary operating voltages foreseen and indicated in the table:

| Feeder 1-2 V DC | Feeder 3-4 V DC / V AC (50/60 Hz) | |
|---|---|---|
| 24 | 110 | 220 |
| 30 | 120 | 230 |
| 48 | 125 | 240 |
| 60 | 127 | 250 |
| | 130 | |

The contactor is, however, set with the operating voltage defined in the order confirmation. The power supply voltage is indicated on the contactor rating label.

The tolerances over the voltage values conform to what is defined in the IEC 62271-106 Standard.

### 5.7.4. Capacitor ageing control (CBC)

The unit supervises bulk capacitor discharging so as to check capacitor life.
The unit supervises main capacitor discharging so as to check capacitor life.
This function is only available for the MAC R2 “full option” version.
The test is performed:
– Every 12 hours when the apparatus is in the open condition.
– 15 seconds after starting.
– Two seconds after each opening operation if the contactor has remained closed for 12 hours.
The test is not performed:
– If the voltage of the external capacitance is less than 75 V (“not ready” signal already given).
– If the ambient temperature is less than -5° (“not ready” signal already given).
The “not ready” state is signalled when the CBC function is being performed and the function has priority over the closing operation.
An alarm signal is given by opening contact DO2 if errors occur.

### 5.7.2.1 Changing the supply voltage of the contactor (within the reference range)

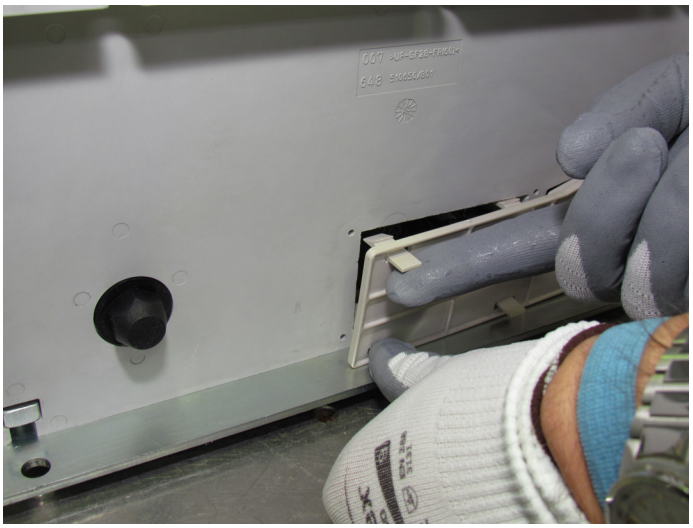


Fig. 13a



Fig. 13b




Fig. 13c

- This operation must be carried out by ABB personnel or by suitably qualified customer personnel with in-depth knowledge of the apparatus (IEC 62271-1, par. 10.4.2.).
- Always check that the apparatus is in the open position before carrying out any activities.
  Check that the medium voltage and auxiliary power supplies have been removed.
  Maintenance of the apparatus must only be carried out with the contactor de-energized, racked-out of the compartment of the enclosure and with the capacitor of the auxiliary circuit discharged. To discharge the capacitor, remove power from the -XDB10 terminal box and connect the mobile two-pole -XDB50 connector to the ABB type CFD device (fig. 13c). Completion of discharging is signalled by the red light going completely off.
- The auxiliary circuit can be configured for all the direct and alternating current voltages within the reference range. To change the voltage value defined during the ordering stage, proceed as follows: 1) remove the rear plastic protection (fig. 13a); 2) access the MAC R2 electronic card (fig. 13b); 3) prepare the dip-switches according to the indications given on the last page of the electric circuit diagram.
- After having set the desired value, the label with the new voltage value must be overlayed the front rating plate of the contactor.

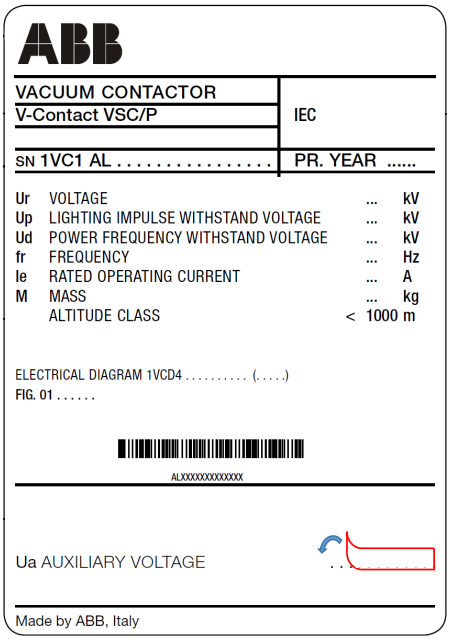



Fig. 13d

- The small plate with the correct voltage value is in the document envelope accompanying the product, along with the electric circuit diagram and this manual.
- Contactor functional check is mandatory after the new voltage setting; the qualified customer's personnel should carry out this check, responsibility for the interventions lies with the customer.

## 5.8. Emergency opening operation

**The contactor is fitted with manual emergency operation which must be carried out by suitably qualified personnel with in-depth knowledge of the apparatus.**

**The following Standards must be taken into particular consideration during installation and service:**

- **IEC 62271-1/DIN VDE 0101**
- **VDE 0105: Operation of electrical plants**
- **DIN VDE 0141: Earthing systems for electrical installations with rated voltage higher than 1 kV**
- **All the accident prevention regulations, in force in the relative countries.**

To manually open the contactor, it is necessary to work on operating part A, consisting of a 8 mm hexagonal-head bolt, working clockwise with a torque of about 20 Nm and at an angle of about 60° (see fig. 14a).
If the contactor (in the fixed version) is placed inside the switchgear, it is necessary to use a transmission made of insulating material of suitable length, which allows safe operation. The transmission device is to be provided by the customer.

For the withdrawable VSC/P contactors placed in UniGear ZS1 switchgear or PowerCube modules and for the withdrawable VSC/PN and VSC/PNG contactors in UniGear MCC switchgear, carry out the emergency operation with the compartment door closed. To carry out the operation, work towards the opening on the compartment door using the special tool provided, fitted on the end with an 8 mm hexagonal spanner. Apply a torque of 20 Nm with an operating angle of about 60° clockwise. The point to operate in is shown by the special plate located on the contactor shield (see detail 1 - fig. 14b and 14c).

**For fixed contactors, if the operations are carried out with the medium voltage protection “B” removed, pay great attention to the moving parts.**

**For withdrawable contactors, do not remove the front shield to carry out the emergency opening operation.**

**In any case, if auxiliary voltage is present, take special care not to remove the protective shield of the stored energy capacitor and not to touch the capacitor itself in any way.**

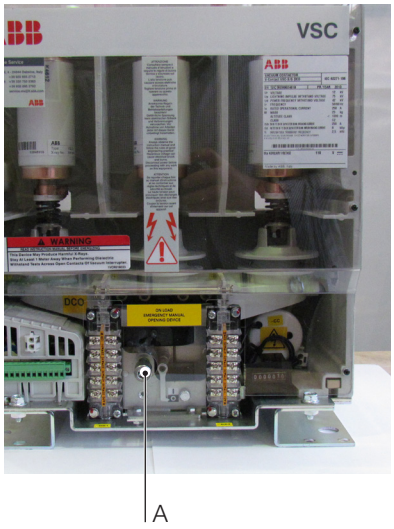



Fig. 14a

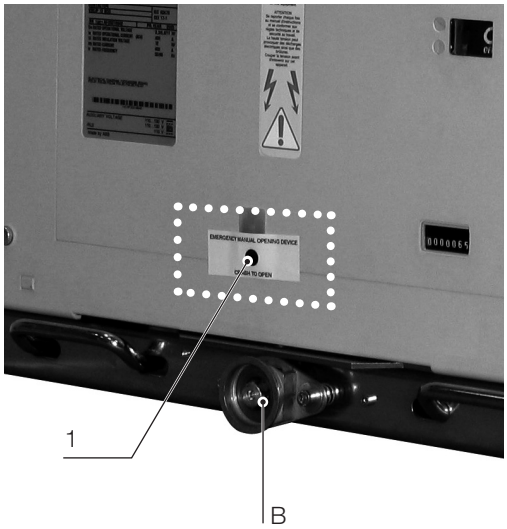



Fig. 14b




Fig. 14c

# 6. Putting into service

## 6.1. General procedures

**All the operations regarding putting into service must be carried out by ABB personnel or by suitably qualified customer personnel with in-depth knowledge of the apparatus and of the installation.**

Before putting the apparatus into service, carry out the following operations as well as those indicated in the table:
- check that the voltage and current applied are within the specified rated values
- check tightness of the power connections of the fixed contactors and integrity of the isolating contacts of the withdrawable contactors
- carefully clean the sheets and insulating parts with brushes and clean dry cloths. Avoid using jets of compressed air
- check the earthing connection of the fixed contactors
- check that no foreign bodies, such as bits of packing, have got into the moving parts
- check that the value of the power supply voltage of the circuits is between 85% and 110% of the rated auxiliary voltage of the apparatus
- check that the contactor vacuum interrupter has not been damaged due to accidental impacts. In case of doubt, carry out the check indicated in paragraph 7.3. Table 4.
- make sure that all the barriers and protective shields are correctly installed
- carry out the inspections indicated in table 3.

On completion of the operations indicated, check that everything is put back in its original position.

**The check can only be considered as passed if all the tests indicated have had a positive outcome.**
**In the case of a negative check, do not put the apparatus into service and, if necessary, contact ABB Service.**

**TAB. 3**

| Item inspected | Procedure | Positive check |
|---|---|---|
| **1** Insulation resistance | Medium voltage circuit With a 2500 V megger, measure the insulation resistance between the phases and the exposed conductive part of the circuit. | The insulation resistance should be at least 50 Mohm. |
| **2** Drive. Open/closed indicator, operation counter (if provided) | Carry out a few closing and opening operations of the contactor. | Operations and signals normal. |
| **3** Auxiliary circuits | Check that the connections to the control circuits are correct: proceed with the relative power supply. | Operations and signals normal. |
| | With the contactor open, check that the thickness between the body of the contact and the stem is 0.5 mm. | Tighten the fixing screws. |
| |  | |

## 6.2. Racking the VSC/P contactor in and out

- **Should operations be carried out with the contactor racked-out of the switchgear, pay great attention to the moving parts.**
- **The contactor must only be racked into the unit in the open position. Racking-in and racking-out must be gradual to avoid shocks which might deform the mechanical interlocks.**

### 6.2.1. Contactor with manual truck

For the racking-in and racking-out operations of the manual contactor, refer to the following manuals:
– PowerCube PBF fixed part – code: 1VCD600530
– PowerCube PBE and PBM module - code: 647652001
– UniGear ZS1 switchgear – code: 1VLM000363.

### 6.2.2. VSC/P contactors with motorised withdrawable truck

Carry out the racking-in/out test of the motorised truck in the same way as for a manual truck, following the instructions below:
– Rack the contactor into the switchgear in the open position. Motor power supply circuit de-energized.
– Supply the truck motor circuit with power.
– Activate the command for the electrical racking-in operation. When racking-in has been done, check correct changeover of the relative auxiliary contact.
– Afterwards, activate the command for the electrical racking-out operation. When racking-out has been done, check correct changeover of the relative auxiliary contact.
– In the case of a fault in the motor during a racking-in or racking-out operation, the truck can be taken to the run end manually in an emergency, first cutting off the voltage to the motor power supply circuit and then using the manual lever (Fig. 15) to operate in the same way as for the manual truck.
– Insert the manual racking-in lever (Fig. 15) in the special coupling (B - Fig. 14b).
The torque needed to carry out truck handling is < 25 Nm.
Checks:
a) clockwise rotation of the motor during circuit-breaker racking-in.
b) anti-clockwise rotation of the motor during circuit-breaker racking-out.
– Remove the manual crank.

**Note**

By means of the chain transmission, truck handling carried out with the manual lever causes rotation of the truck motor rotor which, behaving like a generator, can cause reversal of voltage at the connection terminals. This can damage the permanent magnet of the motor, therefore all the truck racking-in and racking-out operations carried out with the manual lever must be done with the motor circuit de-energized.



**Fig. 15**

# 7. Maintenance

Maintenance operations are aimed at ensuring trouble-free operation of the apparatus for the longest possible time.
The following operations must be carried out in accordance with the IEC 61208/DIN 31051 Standards:

Inspection: Assessment of the actual conditions
Servicing: Measures to be taken to maintain the specified conditions
Repairs: Measures to be taken to restore the specified conditions.

**Notes**

The following rules must be respected for all maintenance operations:

– the relative specifications indicated in the “Standards and specifications” chapter;
– the regulations for safety in the workplace indicated in the “Putting into service and running” chapter;
– the regulations and specifications in the country of installation.

## 7.1. General

It is good practice to keep a maintenance card and a service book where all the operations carried out can be noted down in detail, together with the date, description of the anomaly and the references of data needed to identify the apparatus, etc. (see chapter 2).
Experience gained in use of the apparatus will allow the optimal time intervals for interventions to be established. In any case, inspection of the apparatus not more than one year after it has been put into service is recommended.
In case of need and for further details, please refer to what is prescribed in article 10.4.2 of the Standard (IEC 62271-1).
In any case, for any problems, please do not hesitate to contact us.

The main activities which allow an efficient protection system to be maintained are:

- making personnel aware of the problems regarding protection against electrostatic discharges, with reference to the IEC 61340-5-1 Standards (these problems are often unknown or underrated)
- training personnel in correct use of protection equipment and on its perfect working order
- selecting protection materials suitable for the effective production requirements and using them
- marking the protected area and highlighting the presence of sensitive devices so as to attract the attention of operators on correct use of the protection devices
- technicians must always set an example by respecting the rules and using protection devices appropriately

Observe the following basic rules:

- avoid using tools which are unsuitable for removing the electronic cards (e.g. screwdrivers, etc.)
- handling the electronic card during maintenance or replacement operations must be limited to the minimum time possible
- always hold the electronic card at the edges
- avoid touching the components mounted on the card
- pay attention when cables or connectors have to be connected or disconnected
- avoid bending the card while inserting it in its seat or during connector cabling
- avoid damaging the connectors, aligning the pins before connecting the cable

## 7.2. Handling the MAC-R2 electronic card

Management of sensitive devices outside protected areas is considered to be “field work” and normally includes product packing, unpacking, installation and maintenance.
In all these cases, handling the devices must be carried out taking care to keep the potential of your hands and that of the work surface earthed, with an equipotential connection to the main grounding branch point.
It is advisable for the operator to wear conductive shoes and overalls and to wear earthed conductive arm bands.
Fig. 13a-13b shows a maintenance kit consisting of an arm band and ground connection, both fitted with a 1 MW integrated resistance.
Using suitable protective means to protect the electronic devices is an indispensable task requiring diligence and attention. Inserting these procedures in the normal service activities allows optimization of resources and underlines their importance.

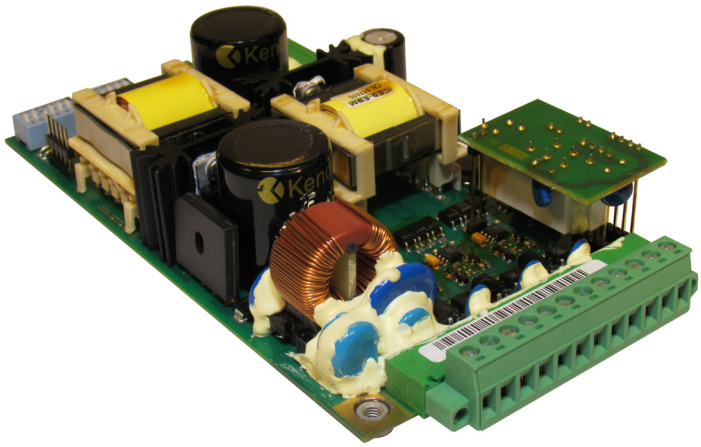
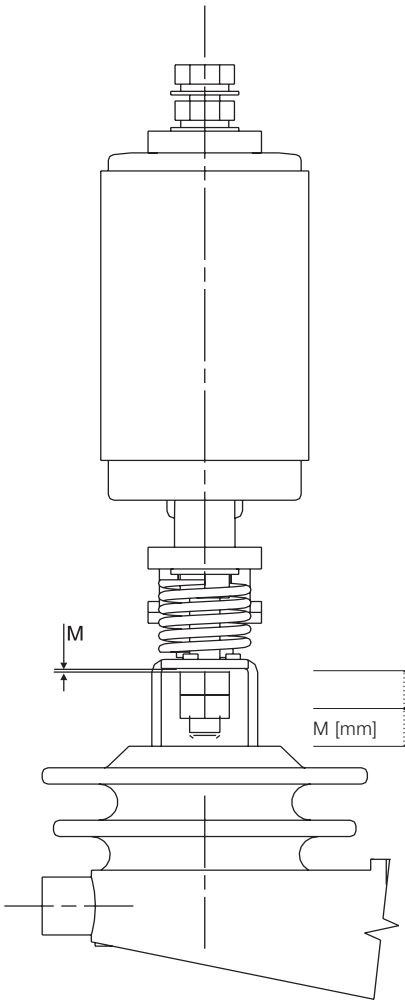


**Fig. 16**

## 7.3. Inspection

– Carry out regular inspections to check that the interruption devices are in good condition.
– The checks must include a visual inspection to find any contamination, traces of corrosion or electrical discharge phenomena (according to what is prescribed in table 4.
– When there are unusual service conditions (including adverse climatic conditions) and/or in the case of environmental pollution (e.g. heavy contamination or an atmosphere with aggressive agents), the frequency of inspections must be increased.
– Visual examination of the main contacts. The contact areas must be cleaned if there are signs of overheating (discoloured surface) (also see the paragraph on “Repairs”).

If any anomalous conditions are found, appropriate maintenance measures must be taken (see the “Servicing” paragraph).




| | VSC 7 | VSC 12 / VSC-S |
|---|---|---|
| M [mm] | 1.5...2 | 1.3...1.7 |

Fig. 17

**TABLE 4**

| Item to be inspected | Interval | Operation to be carried out |
|---|---|---|
| **1** Insulating parts. | 1 year or 50,000 operations. | Visual inspection of the insulating parts. The insulating parts must be free of any accumulation of dust, humidity, dirt (clean), cracks, traces of surface discharges or damage. |
| **2** Structure.. | 1 year or 50,000 operations. | Visual inspection of the structure and mechanisms. The components must be free of any deformation, accumulation of dust, dirt or damage. The screws, nuts and bolts must be correctly tightened. Avoid touching the ceramic surface. |
| **3** Interrupter. | 1 year or 50,000 operations. | Check that the interrupter is free of accumulation of dust, dirt (clean), cracks (replace), traces of surface discharges or damage. |
| | In case of accidental impacts. | Carry out a voltage test with the contacts open at 15 kV - 50 Hz for one minute. If there is a discharge during the test, the interrupter must be replaced because this type of phenomenon corresponds to deterioration in the degree of vacuum. In case of need, contact ABB Service. |
| **4** Interrupter contacts. | 1 year or 50,000 interruptions at the rated current. | Refer to fig. 17.<br>The contact material vaporises from the surfaces during each interruption and condenses elsewhere inside the vacuum interrupter. This is a normal process, and is foreseen by the overrun, or by the wear tolerance.<br>As the contacts wear, the overrun distance “M” decreases.<br>When distance “M”, of any pole, goes below 0.5 mm with the contactor in the closed position, all the sub-assemblies must be replaced.<br>Use a fork-shaped gauge 0.5 mm thick to carry out this measurement.<br>**Caution! Never attempt to adjust the nuts of the vacuum interrupters for any reason whatsoever.**<br>The overrun distance must be checked, but not adjusted. |
| **5** Auxiliary contacts. | 1 year or 50,000 operations. | Check correct operation and the signals. Check that there are no burnt or worn contacts (replace). |
| **6** Auxiliary circuit conductors. | 1 year or 50,000 operations. | Check whether any cabling straps are loose or broken and check connection tightness. Examine all the wire or cable connections to make sure that none of them are loose and that there is no overheating. |
| **7** Visual inspection of the isolating contacts (withdrawable contactors) | 5 years. | The isolating contacts must be free of any deformation or erosion.<br>Lubricate the contact elements with 5RX Moly type grease. |

## 7.4. Servicing

Carry out the checks described below.

| Item to be serviced | | Interval | Operation to be carried out |
|---|---|---|---|
| 1 | Contactor. | 2 years or 100,000 operations. | Carry out five mechanical closing and opening operations. The contactor must operate regularly without stopping in intermediate positions. |
| 2 | Contactor springs. | 2 years or 100,000 operations. | Check integrity of the springs. |
| 3 | Power connections. | 2 years or 100,000 operations. | Check tightness: M8 bolt = 23 Nm; M10 bolt = 33 Nm.<br>Check there are no traces of overheating or oxidation. |
| 4 | Earthing contact (fixed contactors) | 2 years or 100,000 operations. | Check tightness of the connections. |
| 5 | Insulation resistance. | 2 years or 100,000 operations. | See par. 6.1. |
| 6 | Racked-in/isolated auxiliary contacts in the truck. | 2 years or 100,000 operations. | Check that the signals are correct. |
| | Furthermore provide: | – replacement of the auxiliary contacts after 250,000 operations. | |

## 7.5. Servicing following a short-circuit or overload

### General

It is foreseen that the VSC contactor be protected by power fuses and/or by a circuit-breaker. In any case, the value of a short-circuit can exceed the threshold of damage to the vacuum bottles.

After interruption of a short-circuit at the maximum rated MVA of the contactor, put the cause of the fault right, inspect all the apparatus and carry out the repairs or replacements necessary before putting the apparatus back into service.

Make sure that all the spare parts (when required) are suitable for the application.

In case of any doubts, please contact ABB.



**Have a complete check of the contactor carried out by ABB personnel after 1,000,000 operations or 10 years of operation.**

**Contact ABB Service Assistance.**

### Vacuum interrupters

A dielectric test by itself cannot be confirmation that the interrupters have to be put back into service after a fault. However, if there is no physical sign of stress and if the distance M exceeds a minimum of 0.5 mm, the interrupters can be tested dielectrically as mentioned in point 3 of table 4. Should this test also be positive, it is reasonable to put the interrupters back into service following a fault.

### Enclosures

External evidence of deformation of the enclosure is usually indicative of damage inside it. Extensive damage will require replacement of the enclosure parts and of the apparatus contained in it.

### Terminals and internal conductors

Replace the damaged parts which show discolouration, melting or damage caused by electric arcs.
Pay special attention to the moving parts.
Carry out the “Checking” procedures indicated in par. 6. of this manual before putting the apparatus back into service.

## 7.6. Repairs

Replacement with spare parts and accessories must only be carried out by ABB personnel or by suitably qualified personnel with appropriate training.
All the power supply sources must be turned off and the capacitor must be discharged.
Always work with the contactor open, with the work area insulated and made safe.



**Should maintenance be carried out by the customer’s personnel, responsibility for the interventions lies with the customer.**

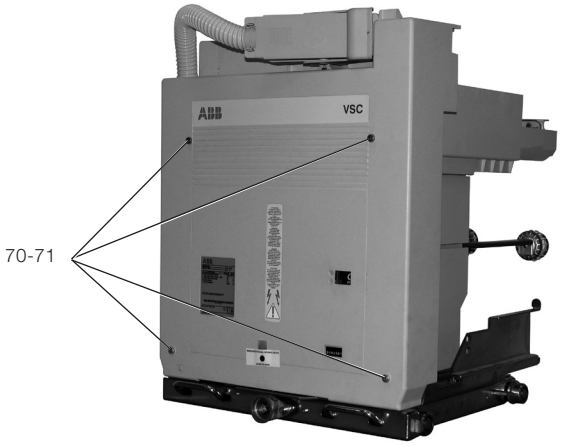



Fig. 18a

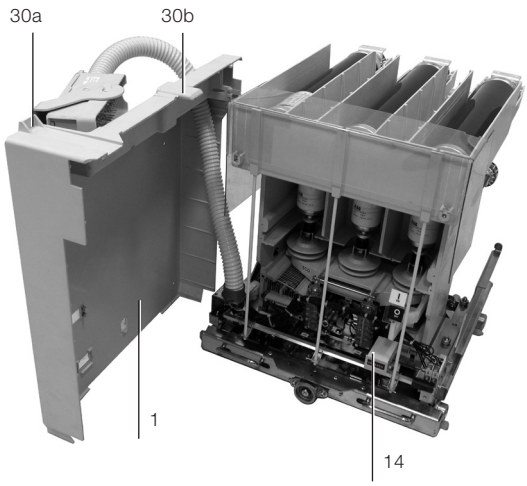



Fig. 18b

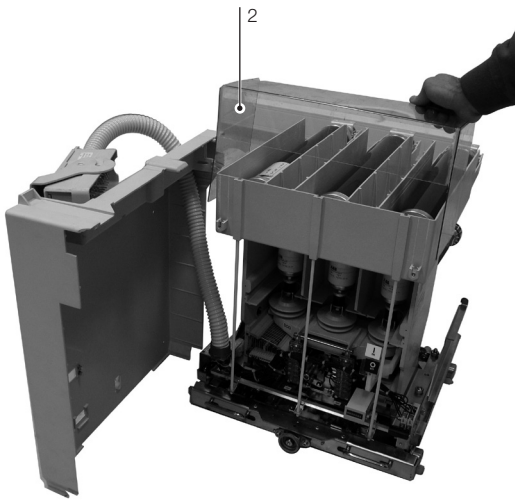



Fig. 18c

# 7.7. Instructions for dismantling and replacing fuses

### 7.7.1. General

- **All the operations described below must be carried out by suitably qualified personnel with in-depth knowledge of the apparatus.**
- **Do not rack the contactor out unless the enclosure is securely fixed in the switchgear or to a stable base.**
- **Check that the contactor is open before proceeding with isolation and its racking-out from the enclosure.**
- **Check that the contactor is open before proceeding with replacement of the fuses.**
- **The contactor is preset to house ABB CMF/BS and ABB CEF/BS fuses.**

The fuseholder is preset for installation of fuses with the dimensions and average type of striker according to DIN 43625 (1983) and BS 2692 (1975) Standards and with electrical characteristics according to IEC 282-1 (1974) Standards.
The fuseholder is always fitted with an automatic opening device for a fuse blowing. This device prevents contactor closing when even a single fuse is missing.

### 7.7.2. Preliminary operations for fuse replacement

**a) VSC/P**

The contactor must be racked out of the enclosure for replacement of the fuses.
The instructions for the racking-out operations are given in the switchgear/enclosure manuals.
With the contactor racked out of the switchgear, unscrew the four fixing screws of the shield and relative DIN washers (fig. 18a) and position it as in fig. 18b. For 12 kV contactors, remove protection (2) and (fig. 18c) proceed to replace the fuses according to the instructions given in par. 7.8.

**b) VSC/PN and VSC/PNG**

To replace the fuses it is necessary to rack the contactor out of the enclosure. The instructions for the racking-out operations are given in the switchgear/enclosure manuals, then proceed to replace the fuses according to the instructions given in par. 7.8.

## 7.8. Replacement of the contactor fuses

**Check that the rated normal current of the fuses to be installed corresponds with the value indicated on the nameplate on the rear of the fuseholder.**

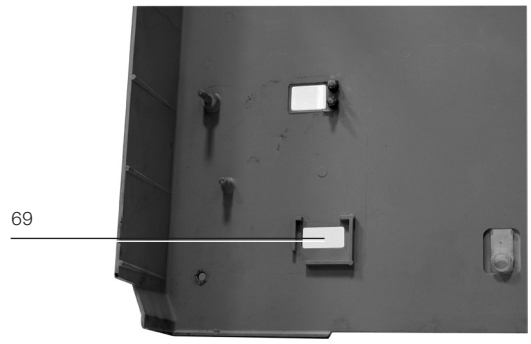



Fig. 18d

**Fuses according to DIN Standards**

**a) Mounting the adapters (fig. 19a)**

The fuseholder is designed to take fuses with a length of 442 mm. For smaller sizes, two adapters are required:
– Adapter (45) for fuses with a length of 192 mm (A)
– Adapter (46) for fuses with a length of 292 mm (B).
Select the type of adapter in relation to the type of fuse to be used, and insert it fully over the fuse contact, opposite to the one of the striker.
Tighten the steel band (47) and fully tighten the screw (48).
To dismantle, proceed in reverse order.
The same instructions are given in the Kit sheet put in the adapter packing.




Fig. 18e

**b) Dismantling the fuses (fig. 19b)**

Open the locking rings (49) (fig. 19b) moving them in the direction shown by the arrows using the tool (50), and remove the fuse using the special tool (50).

**c) Mounting the fuses (fig. 19c)**

Open the locking rings (49) moving them in the direction shown by the arrows using the tool (50) (fig. 19b), fully insert the fuses with the contacts fitted with striker on the opposite side to the isolating contacts of the contactor. Close the locking rings again, moving them in the opposite direction to the opening one.

**Fuses according to BS Standards.**

- **Check that the rated normal current of the fuses to be installed corresponds with the value indicated on the nameplate on the rear of the fuseholder.**
- **When tightening the screws, do not force the connections (25 Nm maximum tightening torque).**
- **Fuse mounting and dismantling must only be done with the adapter (if required) already mounted on it.**
- **Only use the material specified, provided by ABB, for assembly.**

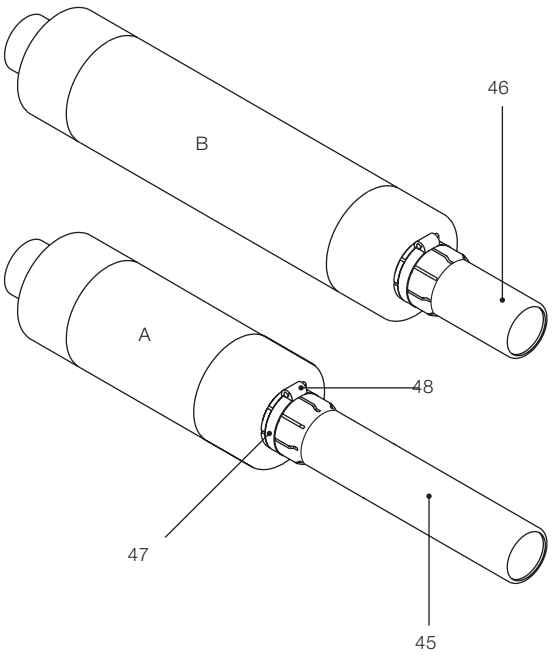
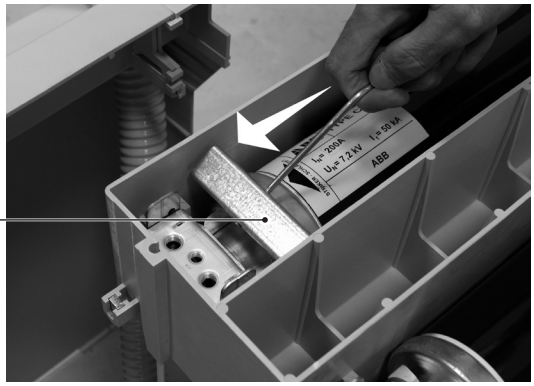
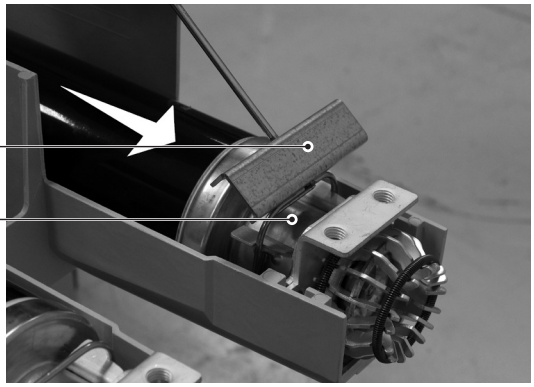
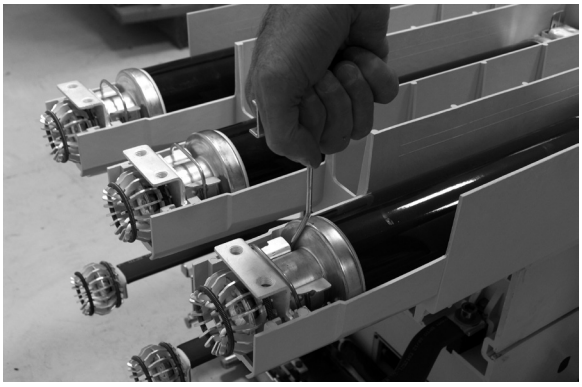



Fig. 19a



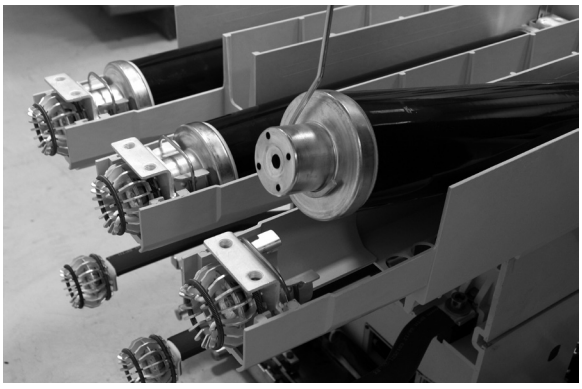
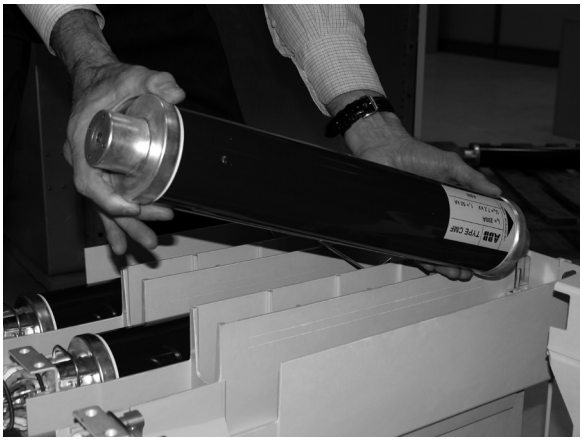
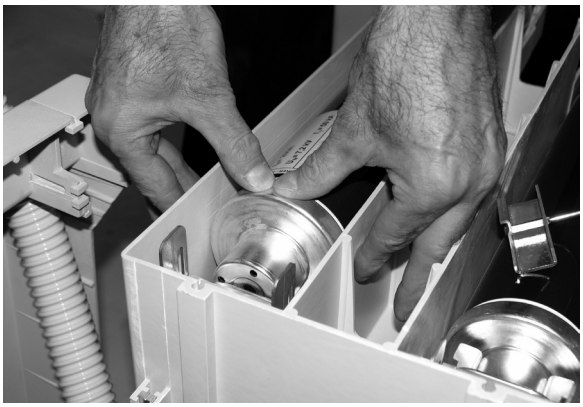




Fig. 19b





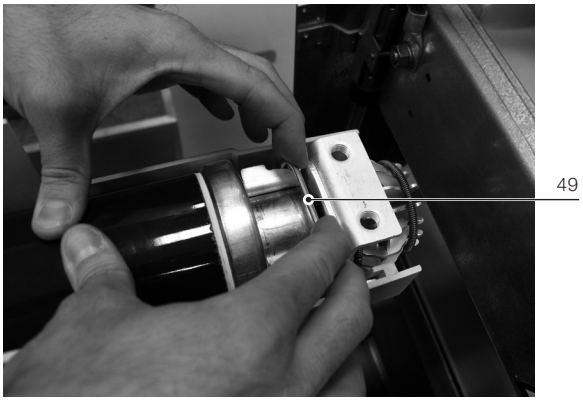



Fig. 19c

### a) Mounting the adapters (fig. 20a)

The fuseholder (32) (fig. 20b) is preset to take fuses with fixing centre distance of 553 mm. For smaller sizes, three adapters are needed, as indicated below:

– adapter (51) for fuses with fixing centre distance
  l = 235 mm
– adapter (52) for fuses with fixing centre distance
  l = 305 mm
– adapter (53) for fuses with fixing centre distance
  l = 454 mm.

Select the type of adapter, fix it onto the fuse on the striker side by means of the grub screws (54), the cup springs (55) and the short nuts (58). Mount the adapter with the extension, with the cap facing the striker.

The same instructions are given in the Kit sheet put in the adapter packing.



**Only position the grub screws (54) as shown in the drawing.**

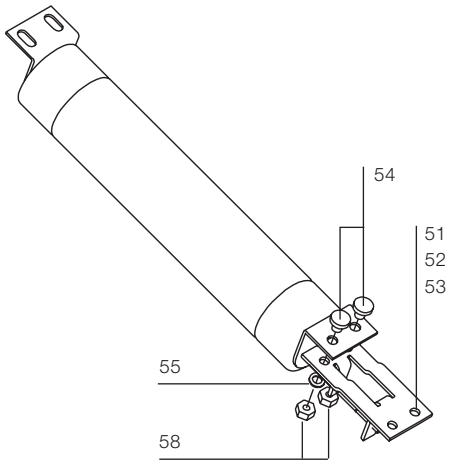



Fig. 20a

### b) Mounting the fuses (fig. 20b)

Mount the fuses or the adapter (preassembled as indicated in par. a) with the striker, (indicated by the arrow) facing the opposite side to the one of the contactor tulips and fix them by means of the screws (56) and the spring washers (57).

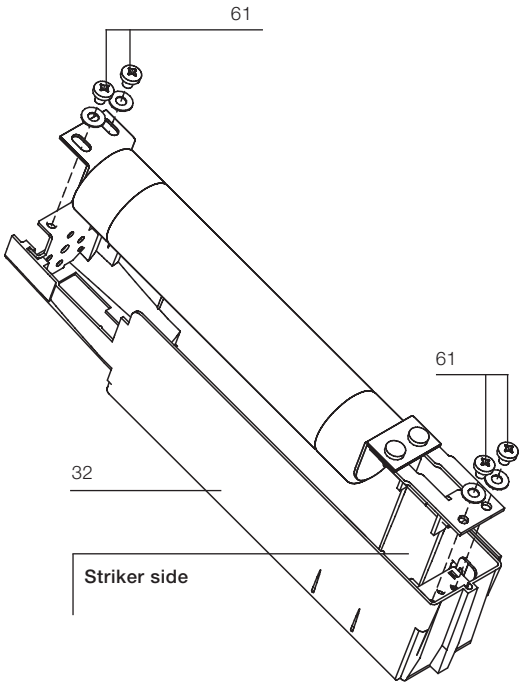



Fig. 20b

### c) Dismantling the fuses

To dismantle the fuses and relative adapters, proceed in reverse order to par. b) and a).

### d) Assembling and dismantling the VSC/PN and VSC/PNG contactor fuses

It is also possible to use BS fuses with double cartridge connected in parallel in the VSC/PN and VSC/PNG contactors (fig. 20c) and therefore in series with the contactor. The assembly and dismantling operations are the same as what is described in sections a) , b) and c) above, with the only difference being to handle a pair of fuses per phase at the same time (fig. 20c) connected by means of a suitable adapter.

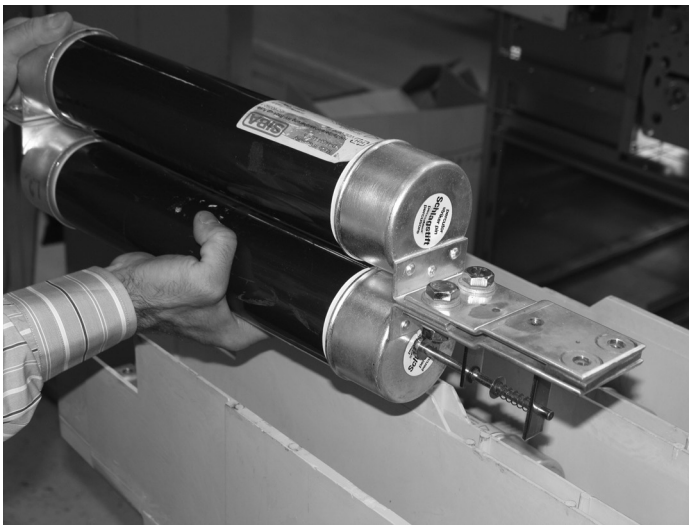


Fig. 20c

## 7.9. Mounting and dismantling the short-circuit busbar

**a) Mounting (fig. 21)**

Mount the busbar with the feeler pin (60) on the opposite side to that of the tulips and fix it with the screws (61).

**b) Dismantling (fig. 21)**

To dismantle, proceed in reverse order.

The same instructions are given in the Kit sheet put in the short-circuit busbar packing.

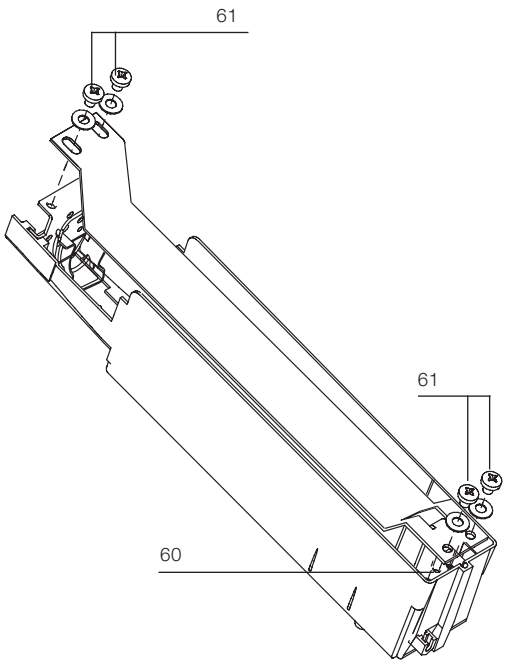



**Fig. 21**

## 7.10. Putting the contactor back into service

### 7.10.1. Mounting the shield and insulating guard (fig. 18)

Reposition the protection (1) (fig. 18b), repeating the operations indicated in par. 7.7.2. in reverse order.
Remount the shield. Check that the impulse counter (14) (fig. 18c) inserts itself into the special seat (69) (fig. 18d) and fix the shield with the screws (70) and DIN washers (71) (fig. 18a).

### 7.10.2. Checking apparatus functions

Rack the contactor into the enclosure, working as indicated in par. 6.
In the “isolated for test” position, check the correctness and functionality of the contactor “open/closed” signalling by carrying out a few operations.

## 7.11. Checking the degree of vacuum of the interrupter

This test is not required for normal maintenance. Should it become necessary for extraordinary maintenance, carry out the test on the interrupter without dismantling it from the contactor and use the VIDAR tester, of the Programma Electric GmbH, Bad Homberg v.d.H. company, for the vacuum test.
To check the vacuum air tightness of the interrupter, prepare the following VIDAR tester test values:

| Contactor rated voltage | DC test voltage |
|---|---|
| 7.2 kV | 16 kV |
| 12 kV | 22.5 kV |

The test must always be carried out with the contactor open, with the contacts at the nominal distance.
Procedure for testing the vacuum of the interrupter of the contactor poles:

- turn off the power and make the working area safe according to the safety regulations of the IEC/DIN VDE standards;
- open the contactor;
- ground a terminal of each contactor pole;
- connect the ground terminal of the VIDAR tester to the structure of the contactor (grounding point of the contactor);
- connect the high voltage terminal of the VIDAR tester to the terminal not connected to ground of the contactor pole (phase L1) and carry out the test. Repeat the test for phases L2 and L3.

**The tester connection cables can produce an indication due to capacitive effect. In this case, the cables must not be removed.**

# 8. Spare parts and accessories

To order contactor spare parts/accessories, refer to technical catalogue 1VCP000165 and always state the following:
– type of contactor
– rated voltage of the contactor
– rated normal current of the contactor
– serial number of the contactor
– rated voltage and frequency of any electrical spare parts.

For availability and to order spare parts, please contact ABB Service.

## 8.1. List of spare parts

– Vacuum interrupter assembly (replacement to be carried out by ABB)
– MAC-R2 electronic card
– Auxiliary contacts (5 normally open and/or 5 normally closed)
– Capacitor
– Interfacing shaft (only fixed contactors)
– 12 kV insulation partitions (only fixed contactors)
– Actuator assembly (replacement to be carried out by ABB).
– Operation counter
– Fuses
– Adapters for fuses
– Fuseholders (replacement to be carried out by ABB)
– Tulip and jaw-type isolating contacts
– Locking magnet in the truck
– Microswitches.

# 9. Product quality and environmental protection

The pieces of apparatus are produced in compliance with the requirements of the international standards regarding quality and environmental management systems. In these fields, the excellent level is proved by availability of the ISO 9001 and ISO 14001 certificates.

**End of product life**

ABB is committed to respecting the requirements and laws for protection of the environment laid down according to the ISO 14001 Standard.

ABB offers its competency and collaboration in facilitating recycling and disposal of the products at the end of their life. It is always necessary to act in compliance with the local regulations in force for disposal of the products.

**Methods of disposal**

Disposal can either be carried out with thermal treatment in an incineration plant or by storage in special areas

| Material | Recommended method of disposal |
|---|---|
| Metals (Fe, Cu, Al, Ag, Zn, W, others) | Separation and recycling |
| Thermoplasts | Recycling or disposal |
| Epoxy resin | Separation of metal parts and disposal of resin parts |
| Rubber | Disposal |
| Dielectric oil (oil for transformers) | Recovery and recycling or disposal |
| Wood for packing | Recycling or disposal |
| Aluminium foil for packing | Recycling or disposal |

For more information please contact:

Your sales contact:
**www.abb.com/contacts**
More product information:
**www.abb.com/productguide**
More service information:
**www.abb.com/service**

Data and illustration are not binding. We reserve the right to make changes in the course of technical development.

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1VCD600943-V8185 - Rev. D, en - Instruction Manual - 2020.11 (V-Contact VSC-F-P-PN-PNG) (gs)

## 2.9.2.Protection Relays

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RELION® PROTECTION AND CONTROL

# REX640

## Engineering Manual







Document ID: 1MRS759117
Issued: 2023-02-13
Revision: D

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*www.abb.com/mediumvoltage*

## Disclaimer

The data, examples and diagrams in this manual are included solely for the concept or product description and are not to be deemed as a statement of guaranteed properties. All persons responsible for applying the equipment addressed in this manual must satisfy themselves that each intended application is suitable and acceptable, including that any applicable safety or other operational requirements are complied with. In particular, any risks in applications where a system failure and/or product failure would create a risk for harm to property or persons (including but not limited to personal injuries or death) shall be the sole responsibility of the person or entity applying the equipment, and those so responsible are hereby requested to ensure that all measures are taken to exclude or mitigate such risks.

This product has been designed to be connected and communicate data and information via a network interface which should be connected to a secure network. It is the sole responsibility of the person or entity responsible for network administration to ensure a secure connection to the network and to take the necessary measures (such as, but not limited to, installation of firewalls, application of authentication measures, encryption of data, installation of anti virus programs, etc.) to protect the product and the network, its system and interface included, against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. ABB is not liable for any such damages and/or losses.

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In case of discrepancies between the English and any other language version, the wording of the English version shall prevail.

## Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2014/35/EU). This conformity is the result of tests conducted by the third party testing laboratory Intertek in accordance with the product standard EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The product is designed in accordance with the international standards of the IEC 60255 series.

## Safety information



Dangerous voltages can occur on the connectors, even though the auxiliary voltage has been disconnected.



Non-observance can result in death, personal injury or substantial property damage.



Only a competent electrician is allowed to carry out the electrical installation.



National and local electrical safety regulations must always be followed.



The frame of the protection relay has to be carefully earthed.



The protection relay contains components which are sensitive to electrostatic discharge. Unnecessary touching of electronic components must therefore be avoided.



Whenever changes are made in the protection relay, measures should be taken to avoid inadvertent tripping.

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# 1 Introduction

## 1.1 This manual

The engineering manual contains instructions on how to engineer the protection relays using the different tools in PCM600. The manual provides instructions on how to set up a PCM600 project and insert relays to the project structure. The manual also recommends a sequence for engineering of protection and control functions, LHMI functions as well as communication engineering for IEC 61850 and other supported protocols.

## 1.2 Intended audience

This manual addresses system and project engineers involved in the engineering process of a project, and installation and commissioning personnel, who use technical data during engineering, installation and commissioning, and in normal service.

The system engineer must have a thorough knowledge of the application, protection and control equipment and the configured functional logic in the relays. The installation and commissioning personnel must have a basic knowledge of handling electronic equipment.

# 1.3 Product documentation

## 1.3.1 Product documentation set

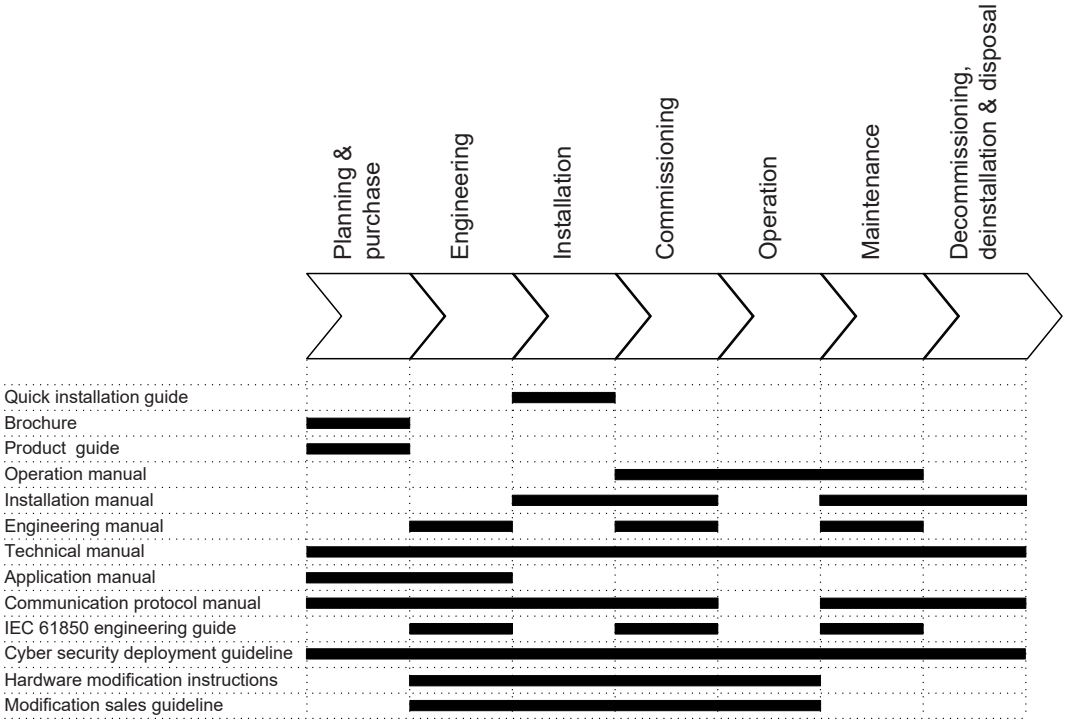



*Figure 1: The intended use of documents during the product life cycle*

### 1.3.2 Document revision history

| Document revision/ date | Product connectivity level | History |
|---|---|---|
| A/2019-05-08 | PCL1 | First release |
| B/2020-02-13 | PCL2 | Content updated to correspond to the product connectivity level |
| C/2020-12-09 | PCL3 | Content updated to correspond to the product connectivity level |
| D/2023-02-13 | PCL4 | Content updated to correspond to the product connectivity level |

### 1.3.3 Related documentation

| Name of the document | Document ID |
|---|---|
| TISSUES Implementation Conformance Statement (TICS) for the IEC 61850 interface in REX640 | 1MRS759027 |
| Protocol Implementation extra Information for Testing (PIXIT) for the IEC 61850 interface in REX640 | 1MRS759030 |
| Protocol Implementation extra Information for Testing (PIXIT) for the IEC 61850 9–2LE interface in REX640 | 1MRS759037 |
| Protocol Implementation Conformance Statement (PICS) for the IEC 61850 interface in REX640 | 1MRS759029 |
| IEC 61850 Ed2 Model Implementation Conformance Statement (MICS) for REX640 | 1MRS759028 |

Download the latest documents from the ABB Web site *www.abb.com/mediumvoltage*.

## 1.4 Symbols and conventions

### 1.4.1 Symbols

The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

The information icon alerts the reader of important facts and conditions.



The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

## 1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms are spelled out in the glossary. The glossary also contains definitions of important terms.
- Menu paths are presented in bold.

  Select **Main menu** > **Settings**.
- Parameter names are shown in italics.

  The function can be enabled and disabled with the *Operation* setting
- Parameter values are indicated with quotation marks.

  The corresponding parameter values are "On" and "Off".
- Input/output messages and monitored data names are shown in Courier font.

  When the function starts, the `START` output is set to TRUE.
- Values of quantities are expressed with a number and an SI unit. The corresponding imperial units may be given in parentheses.
- This document assumes that the parameter setting visibility is "Advanced".

## 1.4.3 Functions, codes and symbols

**Table 1: Functions included in the relay**

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| **Protection** | | | |
| Distance protection | DSTPDIS | Z< | 21P,21N |
| Local acceleration logic | DSTPLAL | LAL | 21LAL |
| Scheme communication logic | DSOCPSCH | CL | 85 21SCHLGC |
| Current reversal and weak-end infeed logic | CRWPSCH | CLCRW | 85 21CREV,WEI |
| Communication logic for residual overcurrent | RESCPSCH | CLN | 85 67G/N SCHLGC |
| Current reversal and weak-end infeed logic for residual overcurrent | RCRWPSCH | CLCRWN | 85 67G/N CREV,WEI |
| Power swing detection | DSTRPSB | Zpsb | 68 |
| Line differential protection with inzone power transformer | LNPLDF | 3Id/I> | 87L |
| Binary signal transfer | BSTGAPC | BST | BST |
| Switch-onto-fault protection | CVPSOF | CVPSOF | SOTF |
| Three-phase non- directional overcurrent protection, low stage | PHLPTOC | 3I> | 51P-1 |
| Three-phase non- directional overcurrent protection, high stage | PHHPTOC | 3I>> | 51P-2 |
| Three-phase non- directional overcurrent protection, instantaneous stage | PHIPTOC | 3I>>> | 50P |
| Three-phase directional overcurrent protection, low stage | DPHLPDOC | 3I>-> | 67P/51P-1 |
| Three-phase directional overcurrent protection, high stage | DPHHPDOC | 3I>>-> | 67P/51P-2 |
| Non-directional earth-fault protection, low stage | EFLPTOC | Io> | 51G/51N-1 |
| Non-directional earth-fault protection, high stage | EFHPTOC | Io>> | 51N-2 |
| Non-directional earth-fault protection, instantaneous stage | EFIPTOC | Io>>> | 50G/50N |
| Directional earth-fault protection, low stage | DEFLPDEF | Io>-> | 67G/N-1 51G/N-1 |
| Directional earth-fault protection, high stage | DEFHPDEF | Io>>-> | 67G/N-1 51G/N-2 |
| Three-phase power directional element | DPSRDIR | I1 -> | 67P-TC |
| Neutral power directional element | DNZSRDIR | I2->,Io-> | 67N-TC |
| Admittance-based earth-fault protection | EFPADM | Yo>-> | 21YN |
| Multifrequency admittance-based earth-fault protection | MFADPSDE | Io>->Y | 67NYH |
| Wattmetric-based earth-fault protection | WPWDE | Po>-> | 32N |
| Transient/intermittent earth-fault protection | INTRPTEF | Io>->IEF | 67NTEF/NIEF |
| Harmonics-based earth-fault protection | HAEFPTOC | Io>HA | 51NH |
| Touch voltage based earth-fault current protection | IFPTOC | IF>/UT> | 46SNQ/59N |
| Negative-sequence overcurrent protection | NSPTOC | I2>M | 46M |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Phase discontinuity protection | PDNSPTOC | I2/I1> | 46PD |
| Residual overvoltage protection | ROVPTOV | Uo> | 59G/59N |
| Three-phase undervoltage protection | PHPTUV | 3U< | 27 |
| Three-phase overvoltage variation protection | PHVPTOV | 3Urms> | 59.S1 |
| Three-phase overvoltage protection | PHPTOV | 3U> | 59 |
| Positive-sequence overvoltage protection | PSPTOV | U1> | 59PS |
| Positive-sequence undervoltage protection | PSPTUV | U1< | 27PS |
| Negative-sequence overvoltage protection | NSPTOV | U2> | 47,59NS |
| Frequency protection | FRPFRQ | f>/f<,df/dt | 81 |
| Three-phase voltage-dependent overcurrent protection | PHPVOC | 3I(U)> | 51V |
| Overexcitation protection | OEPVPH | U/f> | 24 |
| Three-phase thermal protection for feeders, cables and distribution transformers | T1PTTR | 3Ith>F | 49F |
| Three-phase thermal overload protection, two time constants | T2PTTR | 3Ith>T/G/C | 49T/G/C |
| Three-phase overload protection for shunt capacitor banks | COLPTOC | 3I>3I< | 51,37,86C |
| Current unbalance protection for shunt capacitor banks | CUBPTOC | dI>C | 60N |
| Three-phase current unbalance protection for shunt capacitor banks | HCUBPTOC | 3dI>C | 60P |
| Shunt capacitor bank switching resonance protection, current based | SRCPTOC | TD> | 55ITHD |
| Compensated neutral unbalance voltage protection | CNUPTOV | CNU> | 59NU |
| Directional negative- sequence overcurrent protection | DNSPDOC | I2>-> | 67Q |
| Low-voltage ride- through protection | LVRTPTUV | UU | 27RT |
| Voltage vector shift protection | VVSPPAM | VS | 78VS |
| Directional reactive power undervoltage protection | DQPTUV | Q>-> ,3U< | 32Q,27 |
| Reverse power/ directional overpower protection | DOPPDPR | P>/Q> | 32R/32O |
| Underpower protection | DUPPDPR | P< | 32U |
| Three-phase under impedance protection | UZPDIS | ZZ | 21G |
| Directional negative sequence impedance protection | DNZPDIS | Z2-> | Z2Q |
| Three-phase under excitation protection | UEXPDIS | X< | 40 |
| Third harmonic-based stator earth-fault protection | H3EFPSEF | dUo>/Uo3H | 64TN |
| Rotor earth-fault protection (injection method) | MREFPTOC | Io>R | 64R |
| Generator shaft leakage current | GSLPTOC | I>,GS | 38, 51 |
| Thermal overload protection for rotors | RPTTR | 3Ith>R | 49R |
| High-impedance or flux-balance based differential protection | MHZPDIF | 3dIHi>M | 87HIM |
| Out-of-step protection with double blinders | OOSRPSB | OOS | 78PS |
| Negative-sequence overcurrent protection for machines | MNSPTOC | I2>M | 46M |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Loss of phase, undercurrent | PHPTUC | 3I< | 37 |
| Loss of load supervision | LOFLPTUC | 3I< | 37 |
| Motor load jam protection | JAMPTOC | Ist> | 50TDJAM |
| Motor start-up supervision | STTPMSU | Is2t n< | 49,66,48,50TDLR |
| Motor start counter | MSCPMRI | n< | 66 |
| Phase reversal protection | PREVPTOC | I2>> | 46R |
| Thermal overload protection for motors | MPTTR | 3Ith>M | 49M |
| Stabilized and instantaneous differential protection for machines | MPDIF | 3dI>M/G | 87M/87G |
| Underpower factor protection | MPUPF | PF< | 55U |
| Stabilized and instantaneous differential protection for two- or three- winding transformers | TR3PTDF | 3dI>3W | 87T3 |
| Stabilized and instantaneous differential protection for two-winding transformers | TR2PTDF | 3dI>T | 87T |
| Numerical stabilized low-impedance restricted earth-fault protection | LREFPNDF | dIoLo> | 87NLI |
| High-impedance based restricted earth- fault protection | HREFPDIF | dIoHi> | 87NHI |
| High-impedance differential protection for phase A | HIAPDIF | dHi_A> | 87_A |
| High-impedance differential protection for phase B | HIBPDIF | dHi_B> | 87_B |
| High-impedance differential protection for phase C | HICPDIF | dHi_C> | 87_C |
| Circuit breaker failure protection | CCBRBRF | 3I>/Io>BF | 50BF |
| Three-phase inrush detector | INRPHAR | 3I2f> | 68HB |
| Master trip | TRPPTRC | Master Trip | 94/86 |
| Arc protection | ARCSARC | ARC | AFD |
| High-impedance fault detection | PHIZ | HIF | HIZ |
| Cable Fault Detection | RCFD | CFD | CFD |
| Fault locator | SCEFRFLO | FLOC | FLOC |
| Load-shedding and restoration | LSHDPFRQ | UFLS/R | 81LSH |
| Multipurpose protection | MAPGAPC | MAP | MAP |
| Accidental energization protection | GAEPVOC | U<,I> | 50/27 |
| Load blinder | LBRDOB | LB | 21LB |
| **Control** | | | |
| Circuit-breaker control | CBXCBR | I <-> O CB | 52 |
| Three-state disconnector control | P3SXSWI | I<->O P3S | 29DS/GS |
| Disconnector control | DCXSWI | I <-> O DCC | 29DS |
| Earthing switch control | ESXSWI | I <-> O ESC | 29GS |
| Three-state disconnector position indication | P3SSXSWI | I<->O P3SS | 29DS/GS |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Disconnector position indication | DCSXSWI | I <-> O DC | 29DS |
| Earthing switch position indication | ESSXSWI | I <-> O ES | 29GS |
| Motor controlled earthing switch and disconnector supervision | ESDCSSWI | ESDCCM | 29CM |
| Emergency start-up | ESMGAPC | ESTART | EST,62 |
| Autoreclosing | DARREC | O->I | 79 |
| Autosynchronizer for generator breaker | ASGCSYN | AUTOSYNCG | 25AUTOSYNCG |
| Autosynchronizer for network breaker | ASNSCSYN | AUTOSYNC | 25AUTOSYNCBT/T |
| Autosynchronizer co-ordinator | ASCGAPC | AUTOSYNC | 25AUTOSYNC |
| Synchronism and energizing check | SECRSYN | SYNC | 25 |
| Tap changer control with voltage regulator | OL5ATCC | COLTC | 90V |
| Transformer data combiner | OLGAPC | OLGAPC | OLGAPC |
| Petersen coil controller | PASANCR | ANCR | 90 |
| High speed bus transfer | HSABTC | I<->O BT | HSBT |
| **Condition monitoring and supervision** | | | |
| Circuit-breaker condition monitoring | SSCBR | CBCM | 52CM |
| Hot-spot and insulation ageing rate monitoring for transformers | HSARSPTR | 3Ihp>T | 26/49HS |
| Trip circuit supervision | TCSSCBR | TCS | TCM |
| Current circuit supervision | CCSPVC | MCS 3I | CCM |
| Current circuit supervision for transformers | CTSRCTF | MCS 3I,I2 | CCM 3I,I2 |
| Current transformer supervision for high- impedance protection scheme for phase A | HZCCASPVC | MCS I_A | CCM_A |
| Current transformer supervision for high- impedance protection scheme for phase B | HZCCBSPVC | MCS I_B | CCM_B |
| Current transformer supervision for high- impedance protection scheme for phase C | HZCCCSPVC | MCS I_C | CCM_C |
| Fuse failure supervision | SEQSPVC | FUSEF | VCM, 60 |
| Protection communication supervision | PCSITPC | PCS | PCS |
| Runtime counter for machines and devices | MDSOPT | OPTS | OPTM |
| Three-phase remanent undervoltage supervision | MSVPR | 3U<R | 27R |
| Diesel Generator Monitoring | DGMGAPC | P><,U/f >< | 32/40G |
| **Measurement** | | | |
| Three-phase current measurement | CMMXU | 3I | IA, IB, IC |
| Sequence current measurement | CSMSQI | I1, I2, I0 | I1, I2, I0 |
| Residual current measurement | RESCMMXU | Io | IG |
| Three-phase voltage measurement | VMMXU | 3U | VA, VB, VC |
| Single-phase voltage measurement | VAMMXU | U_A | V_A |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Phase voltage measurement | VPHMMXU | 3UL | VL |
| Residual voltage measurement | RESVMMXU | Uo | VG/VN |
| Sequence voltage measurement | VSMSQI | U1, U2, U0 | V1, V2, V0 |
| Three-phase power and energy measurement | PEMMXU | P, E | P, E |
| Load profile recorder | LDPRLRC | LOADPROF | LOADPROF |
| Frequency measurement | FMMXU | f | f |
| Tap changer position indication | TPOSYLTC | TPOSM | 84T |
| **Power quality** | | | |
| Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics | CHMHAI | PQM3IH | PQM ITHD,IDC |
| Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics | VHMHAI | PQM3VH | PQM VTHD,VDC |
| Voltage variation | PHQVVR | PQMU | PQMV SWE,SAG,INT |
| Voltage unbalance | VSQVUB | PQUUB | PQMV UB |
| **Traditional LED indication** | | | |
| LED indication control | LEDPTRC | LEDPTRC | LEDPTRC |
| Individual virtual LED control | LED | LED | LED |
| **Logging functions** | | | |
| Disturbance recorder (common functionality) | RDRE | DR | RDRE |
| Disturbance recorder, analog channels 1...12 | A1RADR | A1RADR | A1RADR |
| Disturbance recorder, analog channels 13...24 | A2RADR | A2RADR | A2RADR |
| Disturbance recorder, binary channels 1...32 | B1RBDR | B1RBDR | B1RBDR |
| Disturbance recorder, binary channels 33...64 | B2RBDR | B2RBDR | B2RBDR |
| Fault recorder | FLTRFRC | FAULTREC | FR |
| **Other functionality** | | | |
| Parameter setting groups | PROTECTION | PROTECTION | PROTECTION |
| Time master supervision | GNRLLTMS | TSYNC | TSYNC |
| Serial port supervision | SERLCCH | SERLCCH | SERLCCH |
| IEC 61850-1 MMS | MMSLPRT | MMS | MMS |
| IEC 61850-1 GOOSE | GSELPRT | GSE | GSE |
| IEC 60870-5-103 protocol | I3CLPRT | I3C | I3C |
| IEC 60870-5-104 protocol | I5CLPRT | I5C | I5C |
| DNP3 protocol | DNPLPRT | DNP 3.0 | DNP 3.0 |
| Modbus protocol | MBSLPRT | MBS | MBS |
| OR gate with two inputs | OR | OR | OR |
| OR gate with six inputs | OR6 | OR6 | OR6 |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| OR gate with twenty inputs | OR20 | OR20 | OR20 |
| AND gate with two inputs | AND | AND | AND |
| AND gate with six inputs | AND6 | AND6 | AND6 |
| AND gate with twenty inputs | AND20 | AND20 | AND20 |
| XOR gate with two inputs | XOR | XOR | XOR |
| NOT gate | NOT | NOT | NOT |
| Real maximum value selector | MAX3R | MAX3R | MAX3R |
| Real minimum value selector | MIN3R | MIN3R | MIN3R |
| Rising edge detector | R_TRIG | R_TRIG | R_TRIG |
| Falling edge detector | F_TRIG | F_TRIG | F_TRIG |
| Real switch selector | SWITCHR | SWITCHR | SWITCHR |
| Integer 32-bit switch selector | SWITCHI32 | SWITCHI32 | SWITCHI32 |
| SR flip-flop, volatile | SR | SR | SR |
| RS flip-flop, volatile | RS | RS | RS |
| Minimum pulse timer, two channels | TPGAPC | TP | 62TP |
| Minimum pulse timer second resolution, two channels | TPSGAPC | TPS | 62TPS |
| Minimum pulse timer minutes resolution, two channels | TPMGAPC | TPM | 62TPM |
| Pulse counter for energy measurement | PCGAPC | PCGAPC | PCGAPC |
| Pulse timer, eight channels | PTGAPC | PT | 62PT |
| Time delay off, eight channels | TOFGAPC | TOF | 62TOF |
| Time delay on, eight channels | TONGAPC | TON | 62TON |
| Daily timer | DTMGAPC | DTM | DTM |
| Calendar function | CALGAPC | CAL | CAL |
| SR flip-flop, eight channels, nonvolatile | SRGAPC | SR | SR |
| Boolean value event creation | MVGAPC | MV | MV |
| Integer value event creation | MVI4GAPC | MVI4 | MVI4 |
| Analog value event creation with scaling | SCA4GAPC | SCA4 | SCA4 |
| Generic control points | SPCGAPC | SPC | SPCG |
| Generic up-down counter | UDFCNT | UDCNT | UDCNT |
| Local/Remote control | CONTROL | CONTROL | CONTROL |
| External HMI wake-up | EIHMI | EIHMI | EIHMI |
| Real addition | ADDR | ADDR | ADDR |
| Real subtraction | SUBR | SUBR | SUBR |
| Real multiplication | MULR | MULR | MULR |
| Real division | DIVR | DIVR | DIVR |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Real equal comparator | EQR | EQR | EQR |
| Real not equal comparator | NER | NER | NER |
| Real greater than or equal comparator | GER | GER | GER |
| Real less than or equal comparator | LER | LER | LER |
| Voltage switch | VMSWI | VSWI | VSWI |
| Current sum | CMSUM | CSUM | CSUM |
| Current switch | CMSWI | CMSWI | CMSWI |
| Phase current preprocessing | ILTCTR | ILTCTR | ILTCTR |
| Residual current preprocessing | RESTCTR | RESTCTR | RESTCTR |
| Phase and residual voltage preprocessing | UTVTR | UTVTR | UTVTR |
| Residual current preprocessing, current measured as voltage | RESUTCTR | Io(U) | Io(U) |
| SMV stream receiver (IEC 61850-9-2LE) | SMVRCV | SMVRCV | SMVRCV |
| SMV stream sender (IEC 61850-9-2LE) | SMVSENDER | SMVSENDER | SMVSENDER |
| Redundant Ethernet channel supervison | RCHLCCH | RCHLCCH | RCHLCCH |
| Ethernet channel supervision | SCHLCCH | SCHLCCH | SCHLCCH |
| HMI Ethernet channel supervision | HMILCCH | HMILCCH | HMILCCH |
| Received GOOSE binary information | GOOSERCV_BIN | GOOSERCV_BIN | GOOSERCV_BIN |
| Received GOOSE double binary information | GOOSERCV_DP | GOOSERCV_DP | GOOSERCV_DP |
| Received GOOSE measured value information | GOOSERCV_MV | GOOSERCV_MV | GOOSERCV_MV |
| Received GOOSE 8- bit integer value information | GOOSERCV_INT8 | GOOSERCV_INT8 | GOOSERCV_INT8 |
| Received GOOSE 32- bit integer value information | GOOSERCV_INT32 | GOOSERCV_INT32 | GOOSERCV_INT32 |
| Received GOOSE interlocking information | GOOSERCV_INTL | GOOSERCV_INTL | GOOSERCV_INTL |
| Received GOOSE measured value (phasor) information | GOOSERCV_CMV | GOOSERCV_CMV | GOOSERCV_CMV |
| Received GOOSE enumerator value information | GOOSERCV_ENUM | GOOSERCV_ENUM | GOOSERCV_ENUM |
| Bad signal quality | QTY_BAD | QTY_BAD | QTY_BAD |
| Good signal quality | QTY_GOOD | QTY_GOOD | QTY_GOOD |
| Received GOOSE Test mode | QTY_GOOSE_TEST | QTY_GOOSE_TEST | QTY_GOOSE_TEST |
| GOOSE communication quality | QTY_GOOSE_COMM | QTY_GOOSE_COMM | QTY_GOOSE_COMM |
| GOOSE data health | T_HEALTH | T_HEALTH | T_HEALTH |
| Fault direction evaluation | T_DIR | T_DIR | T_DIR |
| Enumerator to boolean conversion | T_TCMD | T_TCMD | T_TCMD |
| 32-bit integer to binary command conversion | T_TCMD_BIN | T_TCMD_BIN | T_TCMD_BIN |
| Binary command to 32-bit integer conversion | T_BIN_TCMD | T_BIN_TCMD | T_BIN_TCMD |
| Switching device status decoder - CLOSE position | T_POS_CL | T_POS_CL | T_POS_CL |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Switching device status decoder - OPEN position | T_POS_OP | T_POS_OP | T_POS_OP |
| Switching device status decoder - OK status | T_POS_OK | T_POS_OK | T_POS_OK |
| Controllable gate, 8 Channels | GATEGAPC | GATEGAPC | GATEGAPC |
| Security application | GSAL | GSAL | GSAL |
| Hotline tag | HLTGAPC | HLTGAPC | HLTGAPC |
| 16 settable 32-bit integer values | SETI32GAPC | SETI32GAPC | SETI32GAPC |
| 16 settable real values | SETRGAPC | SETRGAPC | SETRGAPC |
| Boolean to integer 32- bit conversion | T_B16_TO_I32 | T_B16_TO_I32 | T_B16_TO_I32 |
| Integer 32-bit to boolean conversion | T_I32_TO_B16 | T_I32_TO_B16 | T_I32_TO_B16 |
| Integer 32-bit to real conversion | T_I32_TO_R | T_I32_TO_R | T_I32_TO_R |
| Real to integer 8-bit conversion | T_R_TO_I8 | T_R_TO_I8 | T_R_TO_I8 |
| Real to integer 32-bit conversion | T_R_TO_I32 | T_R_TO_I32 | T_R_TO_I32 |
| Constant FALSE | FALSE | FALSE | FALSE |
| Constant TRUE | TRUE | TRUE | TRUE |

# 2 Relay engineering process

PCM600 is used for various tasks in the protection relay engineering process.

- Relay engineering management
  - Organizing the bay protection relays in the structure of the substation by defining voltage levels and bays below the substation. PCM600 manages the project.
  - Configuring the protection relay functions (for example, protection and control functions) by using Application Configuration.
  - Configuring the parameters and setting values for the protection relay and for the process functions by using Parameter Setting.
  - Configuring LHMI pages, drawing single-line diagrams and making links to dynamic process values by using Graphical Display Editor. The single-line diagrams are displayed on the LHMI and the WHMI on the bay protection relay.
  - Configuring connections between the application configuration function blocks and physical hardware inputs and outputs by using Signal Matrix or Application Configuration.
  - Configuring the events shown on the LHMI using HMI Event Filtering.
- Communication management
  - IEC 61850 station communication engineering is done using the internal IEC 61850 Configuration tool or the separate IET600. PCM600 interacts with IET600 by importing and exporting SCL files.
  - Configuring the GOOSE receiving data connections to the protection relay's application configuration function blocks by using the Application Configuration tool and the Signal Matrix tool.
  - Configuring protocol data mapping for Modbus, DNP3, IEC 60870-5-103 or IEC 60870-5-104 with the Communication Management tool.
  - Configuring the sampled values (process bus) between the devices using Application Configuration, IEC 61850 Configuration and Signal Matrix.
  - Configuring Ethernet ports and other network settings using Ethernet Configuration.
- Record management
  - Generating overviews of the available disturbance recordings in all connected protection relays by using Disturbance Handling.
  - Manually reading the recording files (in the COMTRADE format) from the protection relays by using Disturbance Handling or automatically by using PCM600 Scheduler.
  - Managing recording files with Disturbance Handling.
  - Creating overview reports for fast evaluation of the recording file content by using Disturbance Handling.
  - Reading fault records from the protection relay, saving records to a PC and clearing old records with Fault Record.
  - Reading load profile records from the protection relay, saving records to a PC and clearing old records using Load Profile.
- Service management

- Monitoring the selected signals of a protection relay for commissioning or service purposes by using Application Configuration, Parameter Setting and Event Viewer (including security logs)

There are also additional functions for managing projects and organizing user rights.

- PCM600 user management
  - Organizing users regarding their rights, profiles and passwords to use different tools and functions in the tools.
  - Defining allowed activities for user profiles to use tools in PCM600.
- Relay user management
  - Supporting user account management and role-based access control
  - Using IED Users for local user accounts and Account Management for central account management

Once the engineering of the protection relay is finished, the results must be written to the protection relay.

The connection between the physical IED and PCM600 is established via an Ethernet link on the HMI or LAN port of the protection relay.

## 2.1 Monitoring and control system structure

The monitoring and control system can be divided into three main parts which require specific engineering and configuration.

- Bay level devices
- Station communication
- Station level devices

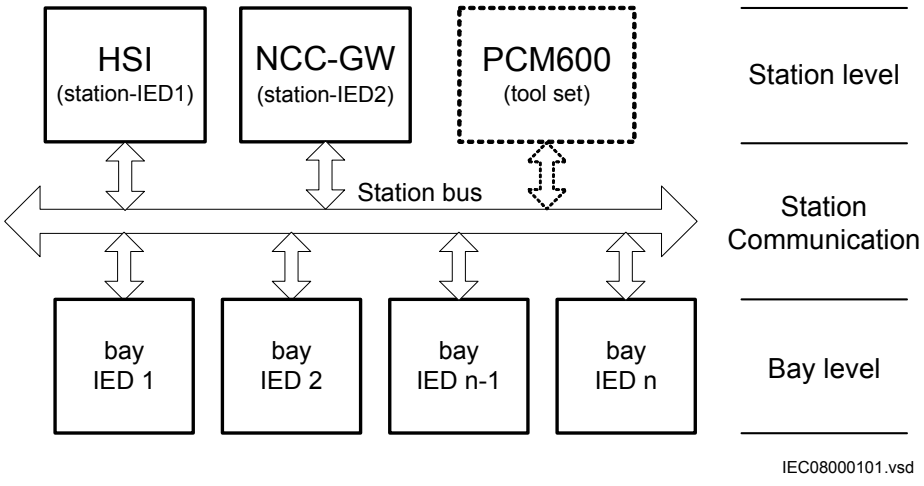



*Figure 2: Principle structure of a monitoring and control system for a substation*

A plant structure is used to identify each device in its location within the substation organization. The plant structure is a logical image of the substation and the bays within the substation. The device organization may differ from the structure of the primary equipment in the substation.

In PCM600 it is possible to set up a hierarchical structure of five levels for the device identification.

- Project
- Substation = name of the substation
- Voltage level = identifies to which grid type or part the device belongs in the substation
- Bay = bay within the voltage level
- IED = selection of the IED that is used in the bay; several IEDs can be inserted in a bay, for example, one control device and two protection relays

## 2.2 Default configuration

The protection relay contains a default configuration when delivered. The default configuration contains a simple application configuration and an LHMI configuration which can be used as a basis when the actual application configuration is created for the protection relay installation. The default configuration does not have output relays connected in the application configuration, so the relay and its configuration must not be used in installation as they are; modification of the application configuration is always required before commissioning.

The default configuration is available for IEC 61850 Edition 2 only, though the relay supports the IEC 61850 Edition 1 as well. For instructions on how to enable Edition 1 for the relay, see chapter IED insertion.

## 2.3 Workflow

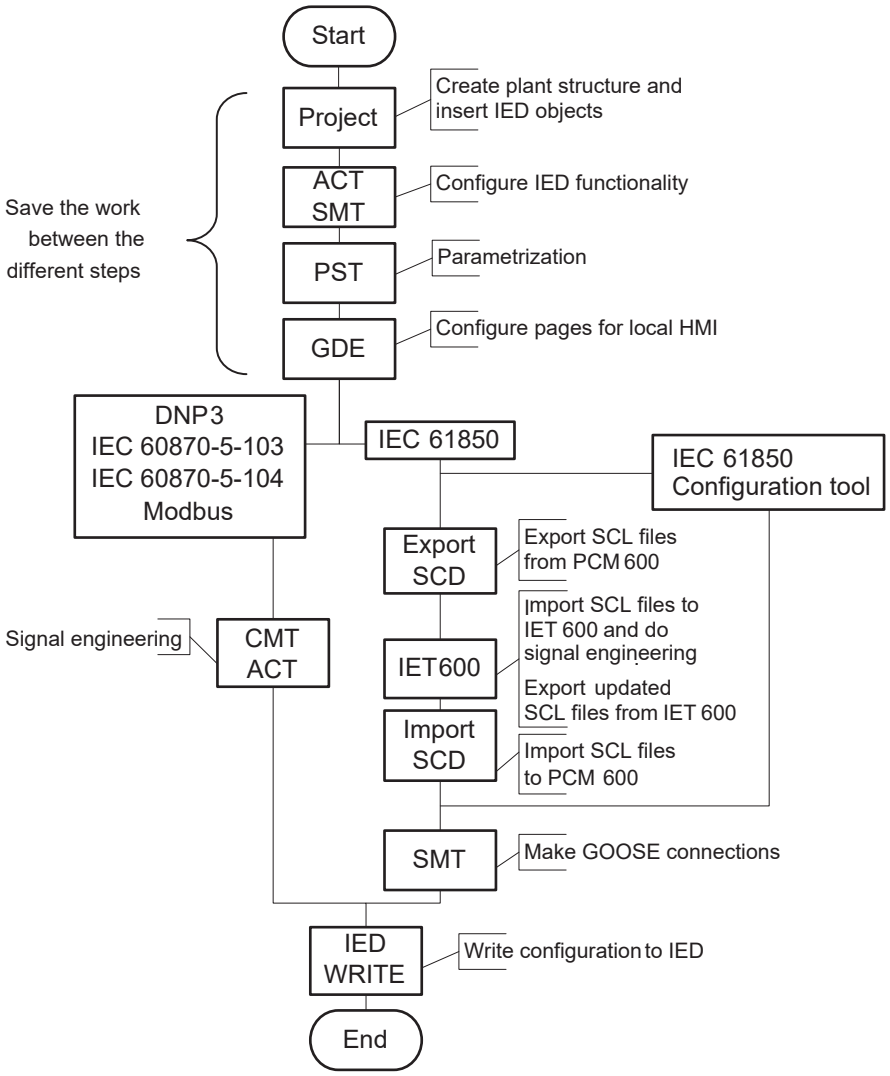



*Figure 3: Protection relay engineering workflow proposal based on practical experience and dependencies of the steps*

It is possible to follow a different sequence based on the information available at the start of the project. This means that several iterations may be needed to complete the project.

**PCM600 project setup**

- The plant structure is built according to the substation structure.
- To add a protection relay to a project, a suitable connectivity package is needed. Protection relays can be added either while connected or disconnected or through other means such as an IED template.
- IED objects are uniquely named within the PCM600 project.

**Application configuration in the Application Configuration tool**

- Protection and control functions can be configured as needed.

- The configuration made in Application Configuration is saved to make the interfaces and signals available for other engineering tools within PCM600, for example, for Parameter Setting.

**Parameter setting and configuration in the Parameter Setting tool**

- The setting values are checked and adjusted with the Parameter Setting tool.

**HMI engineering in Graphical Display Editor**

- It is possible to create new pages, configure pages by adding widgets, set page visibility to different user categories, create single-line diagrams (shown on the LHMI and the WHMI) and symbols, and to provide language translations for the LHMI elements.

**Communication protocol engineering**

- The communication engineering details are protocol-dependent.
- The connectivity package creates the IEC 61850 configuration for vertical communication automatically and it is often directly suitable for IEC 61850 client configuration. Either IEC 61850 Configuration tool or IET600 is needed for configuring horizontal and vertical communication.
- The Communication Management tool is used for other protocols; for example Modbus.



The protection relay restarts automatically when writing a relay configuration where changes have been made. It is not possible to communicate with the protection relay during restart.

# 3 PCM600

Protection and Control IED Manager PCM600 offers all the necessary functionality to work throughout all stages of the protection relay's life cycle.

- Planning
- Engineering
- Commissioning
- Operation and disturbance handling
- Functional analysis

The whole substation configuration can be controlled and different tasks and functions can be performed with the individual tool components. PCM600 can operate with many different topologies, depending on the project needs.

PCM600 is used to conduct complete engineering and configuration activities needed for the bay-level protection relays.

Connectivity packages are separate software packages that provide type and version information to PCM600 and assist the tool with communications.

PCM600 communicates with devices over Ethernet using either IEC 61850 or the FTP/FTPS protocols. This communication allows PCM600 to configure and monitor the devices. In addition to IEC 61850, the devices have optional communication protocols and hardware to connect to station engineering tools. PCM600 provides the ability to export the configuration of the devices or an entire substation in a standard file format which enables station engineering in separate IEC 61850 system configuration tools.

A PC with PCM600 can be connected to any Relion protection relay within a station by using the Ethernet connection. The connection can also be used for service and maintenance purposes and to handle disturbance records from the protection relays.

The modern protection relays are designed using the concept of the IEC 61850 standard. This is mainly visible in how functions within the protection relay are modelled and how the protection relay is represented in the substation. The list of logical nodes available in the protection relay reflects the IEC 61850 parameter list. The logical nodes follow the structure and rules defined in part 7 of the standard.

The communication protocol engineering is a separate task and an addition to the engineering of protection and control functions.

As PCM600 can be used for different purposes throughout the protection relay life cycle, a set of tools is available for different applications.

The applications can be organized into groups.

- Relay engineering
- Communication engineering
- Record management
- Device monitoring and diagnostic
- User management

For more information, see the PCM600 documentation.

## 3.1 Connectivity packages

A connectivity package is a software component that consists of executable code and data which enable system tools to communicate with a protection relay. Connectivity packages are used to create configuration structures in PCM600. The latest PCM600 and connectivity packages are backward compatible with older protection relay versions.

A connectivity package includes all the data which is used to describe the protection relay. For example, it contains a list of the existing parameters, data format used, units, setting range, access rights and visibility of the parameters. In addition, it contains code which allows the software packages that use the connectivity package to properly communicate with the protection relay.

## 3.2 PCM600 and relay connectivity package version

- Protection and Control IED Manager PCM600 Ver. 2.12 or later
- REX640 Connectivity Package Ver. 1.3.0 or later

Download connectivity packages from the ABB Web site *www.abb.com/mediumvoltage* or directly with Update Manager in PCM600.

### 3.2.1 Installing connectivity packages

- Install connectivity packages either by running the installer which can be downloaded on the ABB Web site or by using Update Manager when a network connection is available.

Download connectivity packages from the ABB Web site *www.abb.com/mediumvoltage* or directly with Update Manager in PCM600.

#### 3.2.1.1 Installing connectivity packages by using the connectivity package installer

1. Close PCM600.
2. Run the connectivity package installer.
   - ABB IED Connectivity Package REX640 Ver. n.msi
   - ABB IED Connectivity Package REX640 Ver. n. User Documentation.msi (optional)

   (n = version number)

3. Follow the steps in the connectivity package installation wizard.

### 3.2.1.2 Installing connectivity packages by using Update Manager

1. In PCM600, click **Help** and select **Update Manager**.
   Run Update Manager with administrator rights.

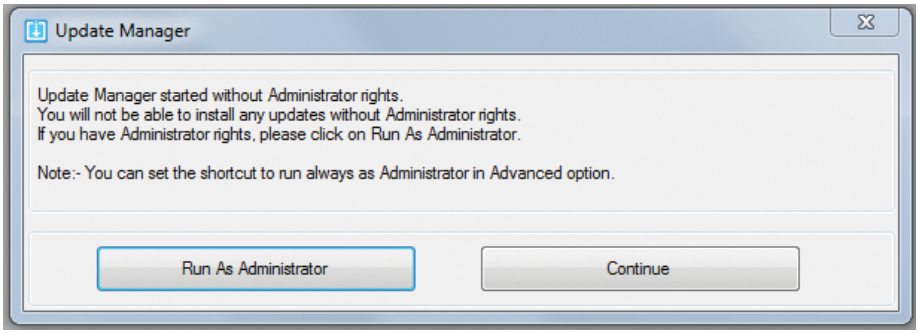



*Figure 4: Running Update Manager as an administrator*

2. Select **Get Connectivity Packages** from the menu on the left column.
3. Select all the required connectivity packages.
4. Click **Download and Install**.
   The status bar shows the installation status.

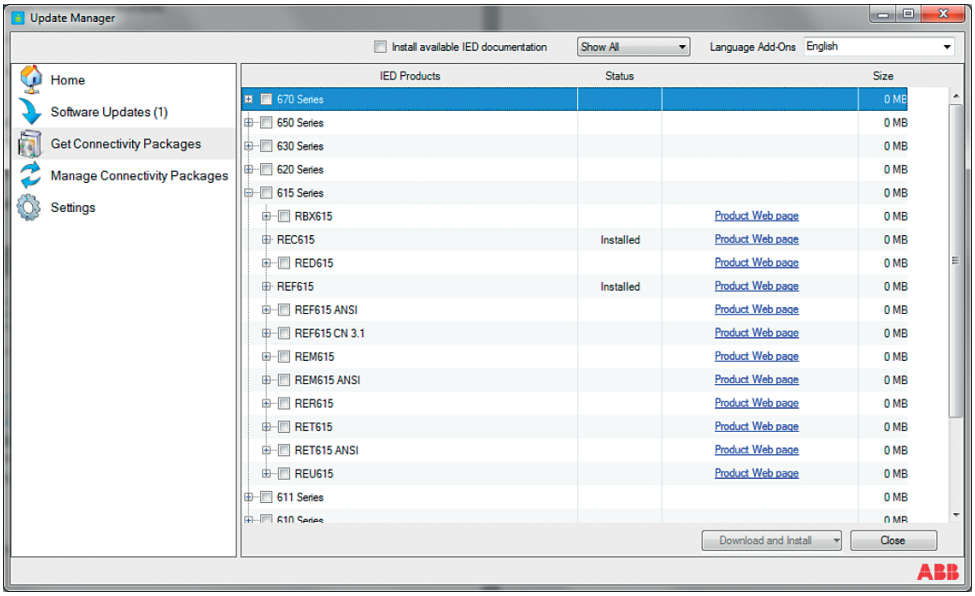



*Figure 5: Selecting the connectivity packages*

## 3.2.2 Activating connectivity packages

The relay connectivity package has to be installed before it can be activated in Update Manager.

1. Select **Manage Connectivity Packages** from the menu on the left column to access the installed connectivity packages.
2. Browse the tree structure to find the correct product.
3. Select the connectivity package version from the drop-down list beside the product name.

Always use the latest version of the connectivity package.

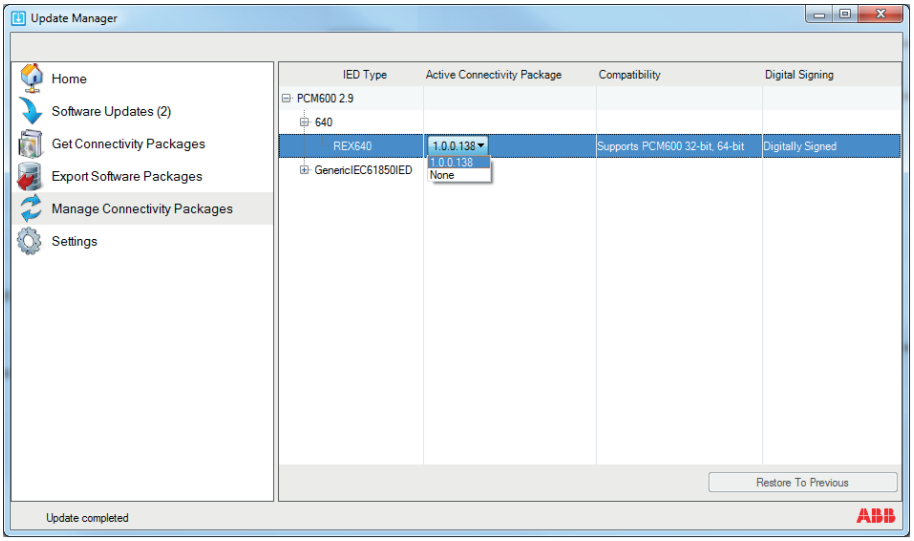



*Figure 6: Selecting the connectivity package versions*

PCM600 recognizes the installed connectivity packages during start-up, and the corresponding IED types are available in PCM600 when starting a new project.

## 3.3 PCM600 projects

A typical project in PCM600 contains a plant structure including one or several IED objects, where each IED object contains the engineering data created or modified using the different PCM600 tools.

Several projects can be created and managed by PCM600, but only one project can be active at a time.

Regardless of the protocol used in installation for each project, it is possible to have Edition1 and Edition2 relays configured in the same PCM600 project. The PCM600 project's SCL edition is the highest SCL edition relay in the project. If IEC 61850 is not used for station bus, either version can be applied. The protection relay's IEC 61850 version is by default Edition 2.

With PCM600, it is possible to do various tasks.

- Open existing projects
- Import projects
- Create new projects
- Export projects

- Delete projects
- Rename projects
- Copy and paste projects

The extension of the exported project file is .pcmp. The files are only used for exporting and importing projects between PCM600s.

## 3.4 Technical key

Both a physical IED and an IED object in PCM600 have a technical key. The technical key in the protection relay and PCM600 must be the same, otherwise it is not possible to download a configuration.

Each IED in a PCM600 project and in an entire substation must have a unique technical key. Therefore, it is not possible to set the same technical key for several IEDs in the same PCM600 project.

The protection relay is delivered with a factory default technical key. The validation of the technical keys between PCM600 and the protection relay does not occur if the protection relay contains the factory default technical key.

The technical key property in PCM600 corresponds to the IED name attribute in SCL files. Avoid changing the IED name attribute outside PCM600, because data in PCM600 may get lost when importing the SCL files.

When writing a configuration to the protection relay, PCM600 checks for a mismatch between the IED object and the physical IED technical key. The technical key can be read from the protection relay and updated to PCM600, or the PCM600 technical key can be written to the protection relay. Alternatively, a user-defined technical key can be defined.

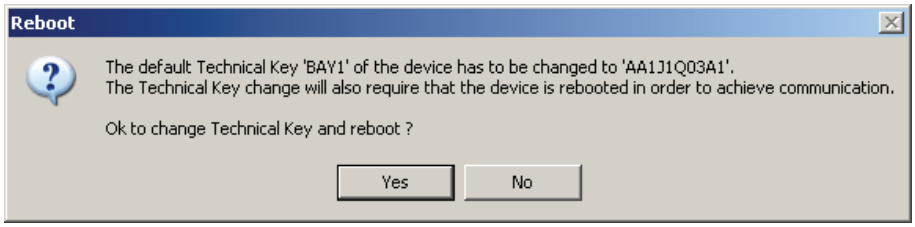



*Figure 7: Reboot suggestion*

Ensure that the IED object in PCM600 has the same IP address as the physical IED to be connected through the technical key.

Change the technical key for an IED object in the **Object Properties** dialog box in PCM600.

### 3.4.1 IEC 61850 naming conventions for an IED

The IEC 61850 naming conventions to identify an IED are valid only when the IEC 61850 standard is used for station bus communication. According to IEC 61850-6, the SCL model allows two kinds of project designations in the object properties: a technical key and a user-oriented textual designation.

- The technical key is used in engineering drawings and for signal identifications. This is contained in the attribute name as an identification of each object. If the value is used as a reference to an object, it is contained in an attribute name starting with a string denoting the reference target object type and ending with the string *Name*. The technical key is used within SCL for referencing other objects. The name is a relative identification within a hierarchy of objects. The maximum length of the technical key is 28 characters for Edition 1 and 60 characters for Edition 2.
- User-oriented textual designation is contained in the *desc* attribute. Attributes are not allowed to contain carriage return, line feed, tab, greater than, less than, double quotes or ampersand characters. The semantics of *desc* must also be relative within an object hierarchy. The maximum length is 100.

PCM600 supports both possibilities. The two signal designations are available per object in Object Properties for all the hierarchical levels beginning with the station as the highest level.

The technical key is automatically generated based on the rules and type specifications of IEC 61346 and the extended definitions assigned for substations by a technical committee. The technical key is shown in the Object Properties dialog box under SCL Technical Key or Technical Key.

- The station is predefined by “AA1" where 1 is the index. To get the real station name that is used, it is possible to rename the SCL Technical Key for the station as the name used by the project. To minimize the word length, a short form should be used because this name is also used in the transmitted messages to identify the events, for example.
- The voltage level. In *Figure 8* it is 20 kV and J1 is selected from the list below SCL Technical Key in the Object Properties dialog box.
- The bay and the IED are appended with the coding defined in the IEC 61346 standard and the substation definition lists. In the example, the bay SCL Technical Key part is Q03 and IED is A1.

The user-oriented textual designation is visible in the Plant structure view for each object. It is the name given by default or changed by with the Rename function.

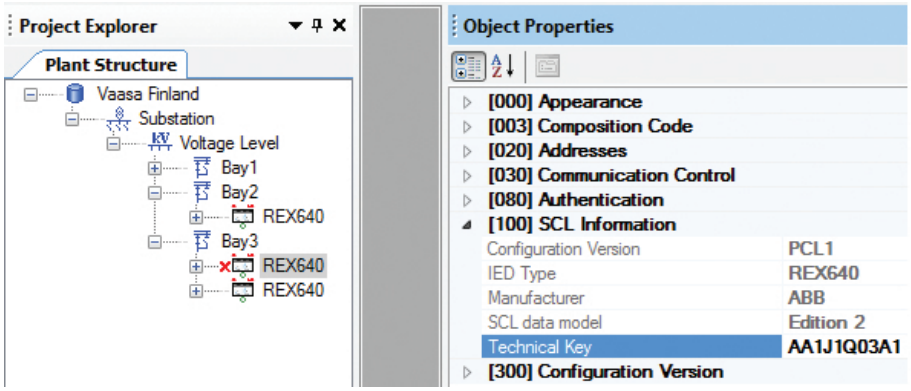



*Figure 8: IEC 61850 signal designation concept in PCM600*

The created technical key for the full path name of the IED would be: AA1J1Q03A1.

- AA1 = substation in the project
- J1 = voltage level from 20 to 30 kV
- Q03 = third bay in the voltage level
- A1 = first IED in bay Q03

## 3.4.2 Setting technical key



The maximum length of the technical key is 28 characters for Edition 1 and 60 characters for Edition 2.

1. In the **Plant Structure** view, right-click the IED and select **Set Technical Key in IED**.

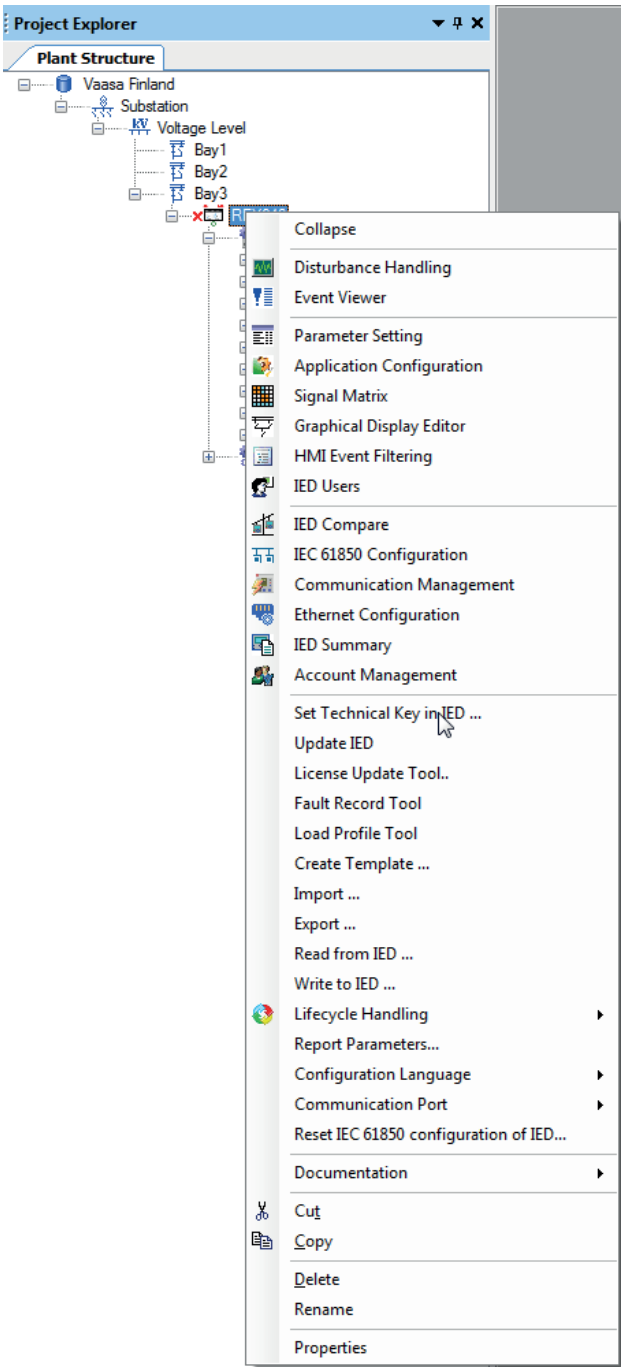



*Figure 9: PCM600: Setting the technical key on the IED level*

A dialog box opens to inform about the technical key concept.

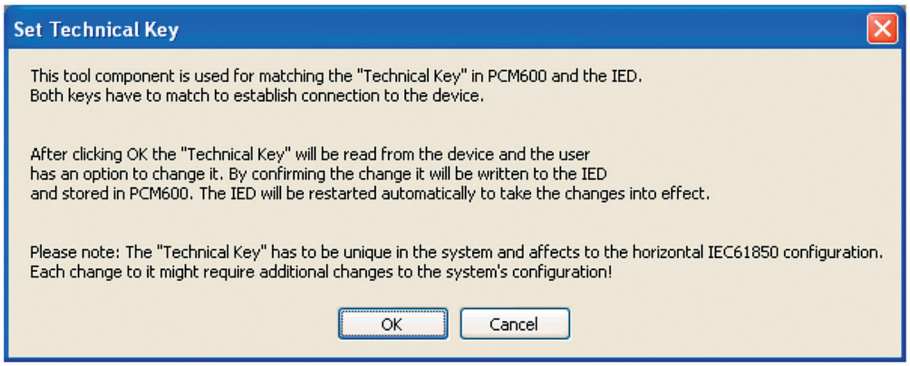



*Figure 10: Technical key information*

2. Click **OK**.

   The technical key is read from the IED and the **Set Technical Key** dialog box opens.

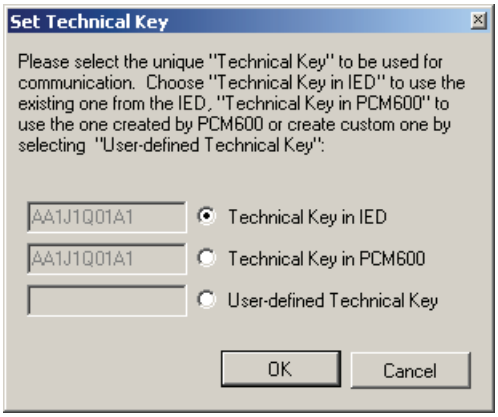



*Figure 11: Setting the technical key*

3. In the **Set Technical Key** dialog box, select the technical key to be used. There are three alternatives.
   - Use the technical key in the IED
   - Use the technical key defined for the IED object in PCM600
   - Set a user-defined technical key, which changes the technical key for both the physical IED and IED object in PCM600
4. Click **OK** to confirm the selection.

It is not possible to set a user-defined name or select **Technical key in IED** if the value is already given to another IED object in the PCM600 project. An error message is displayed if this happens.

## 3.5 Communication between PCM600 and the protection relay

The communication between the protection relay and PCM600 is independent of the used communication protocol within the substation or to the NCC.

All communication is done over Ethernet using either IEC 61850 or the FTP/FTPS protocol.

When an Ethernet-based station protocol is used, the same Ethernet port and IP address can be used for PCM600 communication.

Two basic variants have to be considered for the connection between PCM600 and the protection relay.

- Direct point-to-point link between PCM600 and service port X1.2 on the protection relay's LHMI or, if an LHMI is not used, the HMI port X0 of the communication module
- Indirect link via station LAN or remotely via network

1. If needed, the IP address for the protection relay is set.
2. A PC or workstation is set up for a direct link (point-to-point), or the PC or workstation is connected to the LAN/WAN network.
3. The protection relays' IP addresses in the PCM600 project are configured to match the IP addresses of the physical IEDs.
4. Technical keys of the IEDs in the PCM600 project are configured to match the technical keys of the physical IEDs.

For successful protection relay engineering and usage, the workstation firewall TCP and UDP port configurations should be checked, especially for IEC 61850 and FTP. Other protocols are not used for engineering or they are optional.

### 3.5.1 Setting up IP addresses

The IP address and the corresponding subnet mask can be set via LHMI for the Ethernet interface in the protection relay. Each Ethernet interface has a default factory IP address when the protection relay is delivered. The configured Ethernet interface IP address is preserved if the communication card is replaced.

1. Set the IP address for the protection relay's rear port and the corresponding subnet mask via the LHMI paths **Configuration** > **Communication** > **Ethernet** > **Network1 address** and **Configuration** > **Communication** > **Ethernet** > **Network2 address**.

   Only the Network1 interface is enabled by default. See the cyber security deployment guideline for more information.

   **Table 2: Default IP addresses for the LAN port interfaces and the corresponding subnet masks**

| Interface | IP address | Subnet mask | Default mode |
|---|---|---|---|
| Network1 | 192.168.2.10 | 255.255.255.0 | Enabled |
| Network2 | 192.168.3.10 | 255.255.255.0 | Disabled |

When using redundant Ethernet (HSR or PRP), configure all devices in the network before connecting cables to ports LAN A and LAN B. Avoid using the LAN A or LAN B ports on redundant communication modules while changing the *Switch mode* parameter.

## 3.6 IED Update

The firmware update tool is used for updating the following:

- IED firmware
- HW module firmware
- LHMI firmware and application
- License in case of Modifications Sales related update

The tool can also be used for adding or replacing IED languages. Update packages are provided by Customer Support.

The update tool can be used either locally or remotely.

Separate update packages are needed for updating the communication card, the LHMI and license and default configuration files. If the new communication card firmware, LHMI firmware or application need new IED firmware, it is updated at the same time, otherwise a second update with the same package is needed to update the IED firmware.

### 3.6.1 Prerequisites for local and remote updates

Local update

- It is recommended to use the LHMI's service port X1.2 or, if an LHMI is not used, the HMI port X0 of the communication module. The IED should be removed from the network especially with redundant network topologies (HSR or PRP).

Remote update

- Communication should be secured either by setting up a VPN connection or by enabling secure communication in the IED via LHMI (**Configuration** > **Communication** > **Protocols** > **Network1**FTP or **Configuration** > **Communication** > **Protocols** > **Network2** > **FTP**).
- Remote update can be enabled in the IED either via the LHMI (**Configuration** > **Authorization** > **Security** > **Remote Update**) or by an administrator in Parameter Setting in PCM600 (**IED Configuration** > **Configuration** > **Authorization** > **Remote Update**. If the IED is in local control mode, remote update proceeds only after a confirmation is received from the user.
- Remote update can be disabled manually after the update.
- Remote update only works when the IED is connected from the Ethernet interface connector of the communication module with a custom IP address.
- Remote update via a network gateway can be assigned either to Network 1 or Network 2.

### 3.6.2 Updating firmware or language

1. Select the update mode.
   - Firmware
   - Language
2. Select the update package and click **Next**.

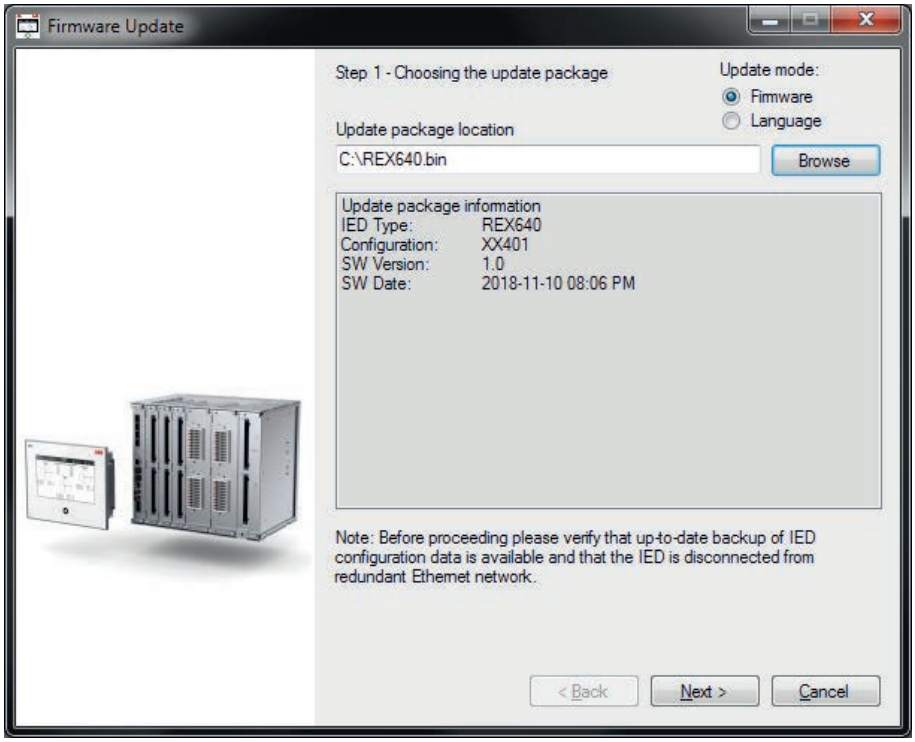



*Figure 12: Choosing the update mode and package*

3. Select the relay to be updated and click **Next**.

   Currently only one relay can be selected.

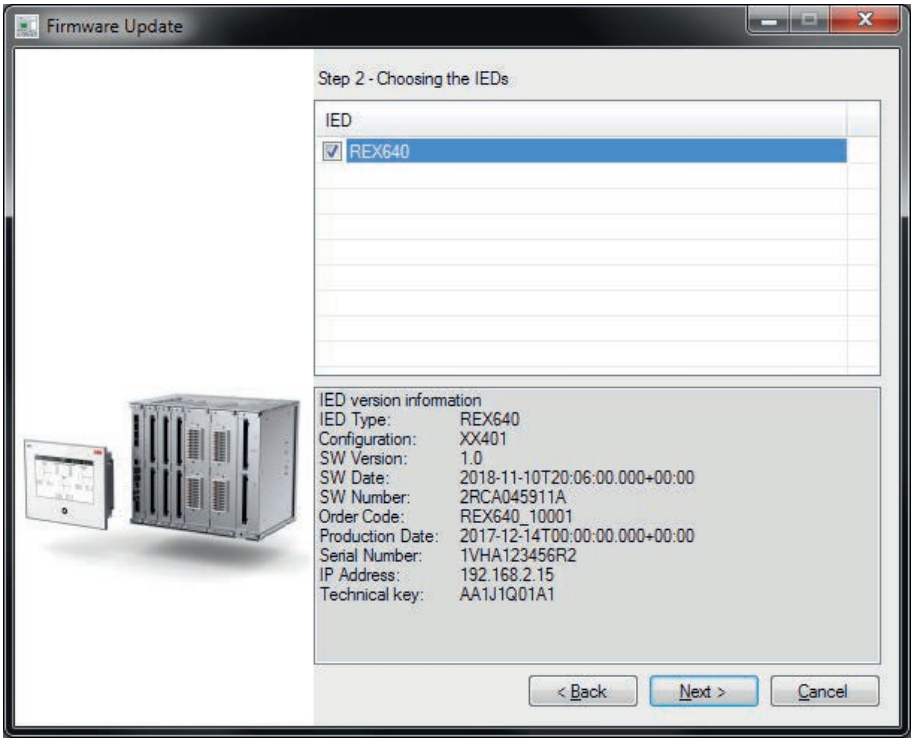



*Figure 13: Choosing the relay for the update*

4. If required, clear the life cycle handling indication by selecting the **Clear Lifecycle Handling indication on Local HMI after update** check box.

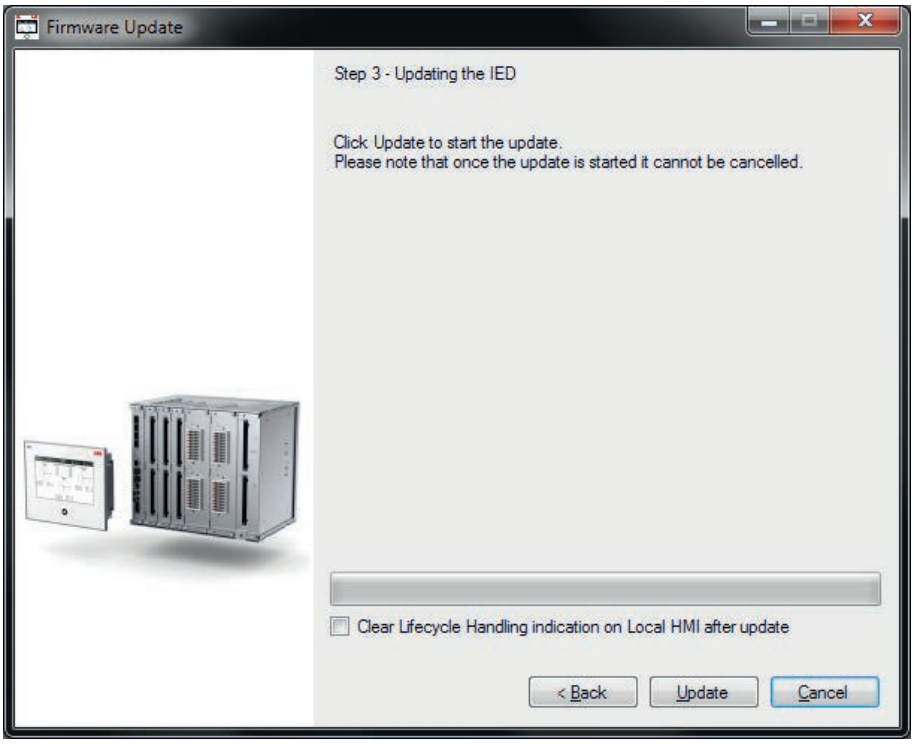



*Figure 14: Clearing lifecycle handling indication*

5. When updating remotely, wait for 30 seconds for the local user confirmation before proceeding with the update.
   - The local user can cancel the update via the LHMI by pressing Cancel Update during the 30-second window.
   - IED use is allowed after the update is completed successfully.

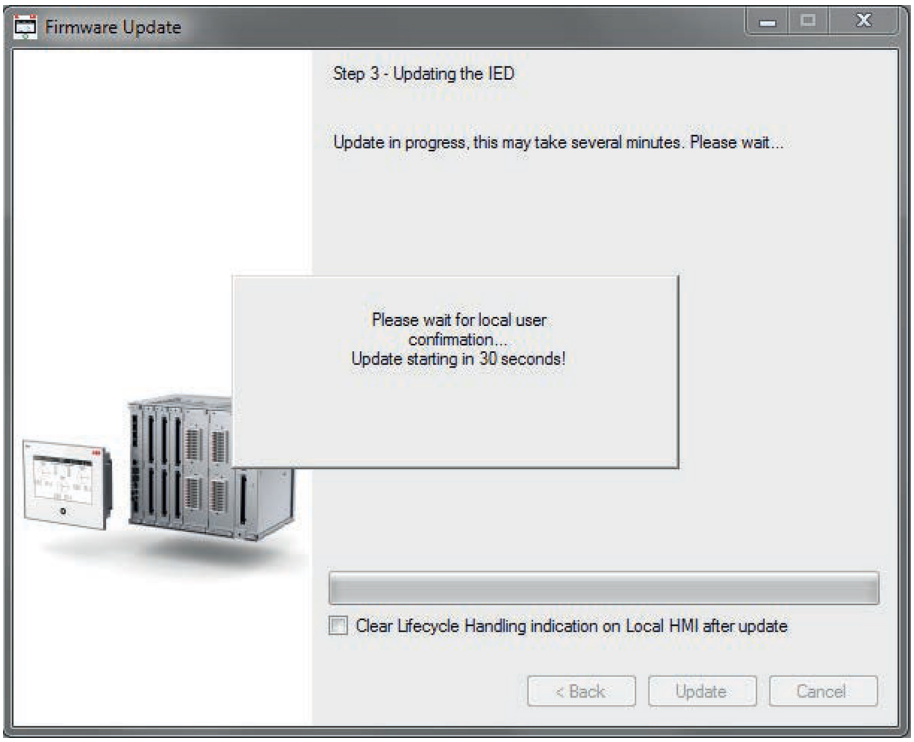



*Figure 15: Waiting for local user confirmation with remote update*

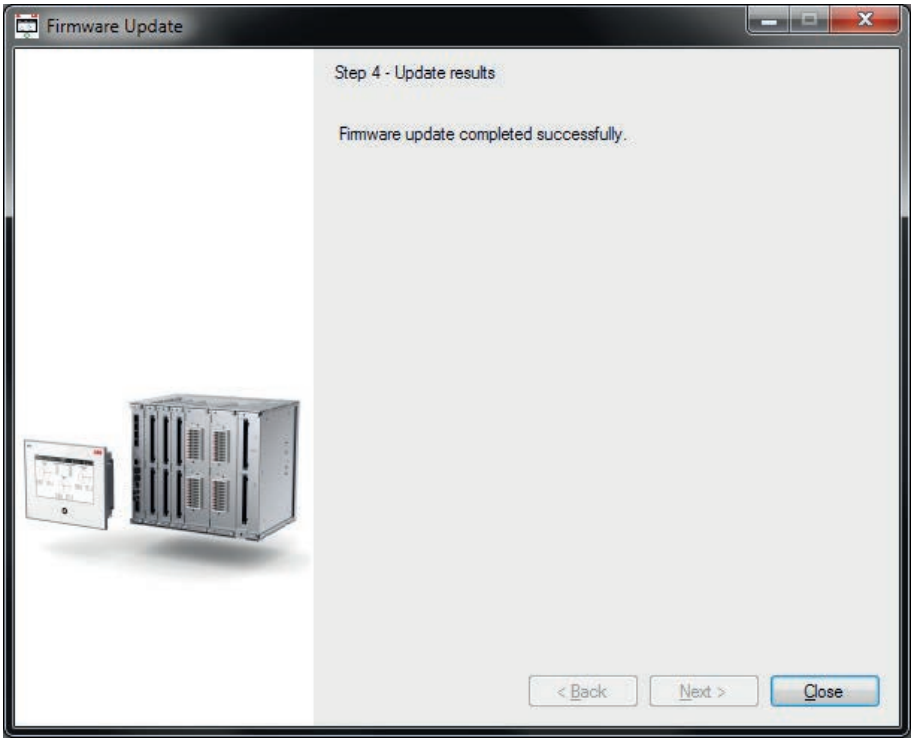



*Figure 16: Completing the update*

# 4 Setting up a project

## 4.1 Creating a new project

1. Start PCM600.
2. To see the projects that are available in the PCM databases, click **File** and select **Open** > **Manage Project** on the menu bar.
3. In the **Open** > **Manage Project** window, click **Projects on my computer**.
4. Click **New Project**.
5. If there are projects or object tools open, a confirmation dialog box opens.

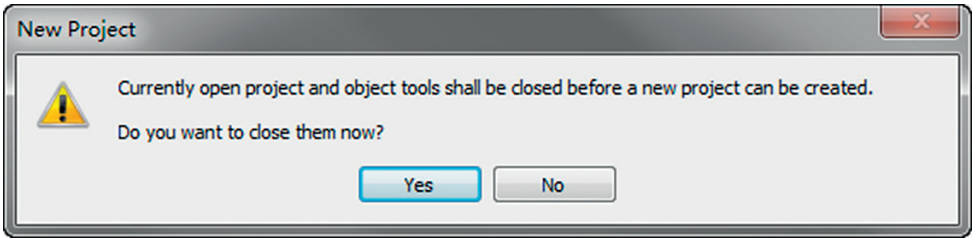



*Figure 17: Confirming project and object tool closing*

6. In the **Create New Project** dialog box, fill in the project name and optional description.
   - In the **Project Name** box, type a unique name for the project.
   - In the **Description** box, type a description of the project.

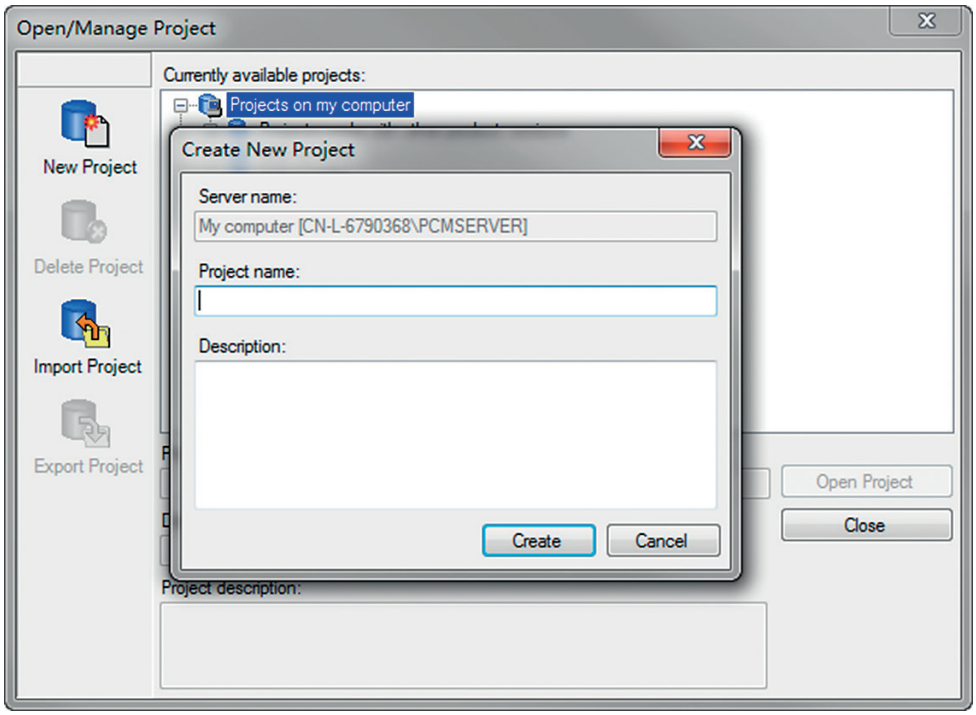



*Figure 18: Creating a new project*

7. Click **Create**.

PCM600 sets up a new project that is listed under **Projects on my computer**.

## 4.2 Building plant structure

1. Create a new plant structure in one of the alternative ways.
   - Right-click the **Plant Structure** view, point to **New** and select **Create from Template**.
   - Right-click the **Plant Structure** view, point to **New**, select **General** and select either **IED Group** or **Substation**.
2. On the **View** menu, select **Object Types**.

3. Select the needed elements and drag them into the plant structure.

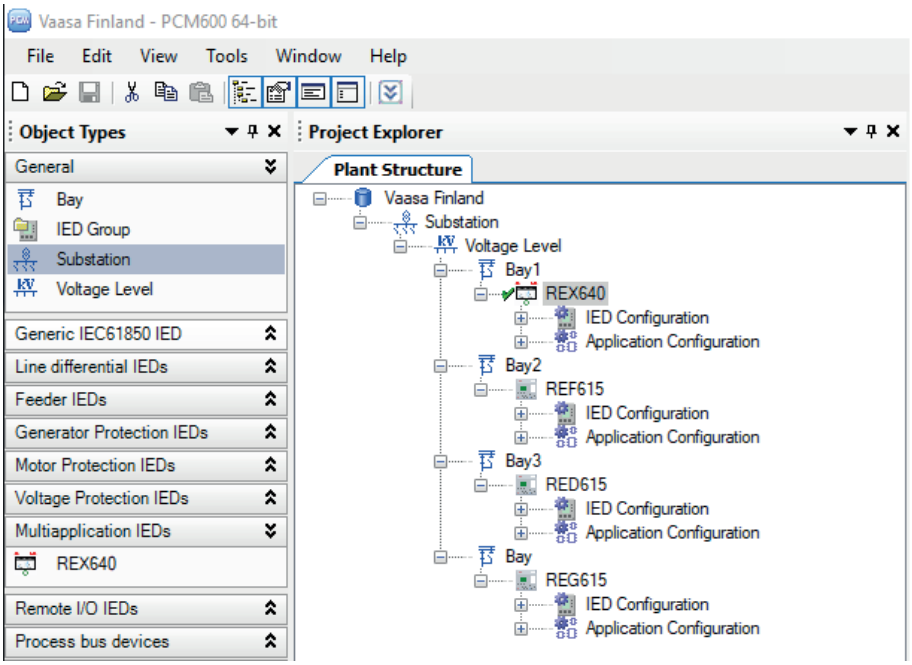



*Figure 19: Project with IEDs placed but not renamed*

4. Rename each level in the structure by the names or identifications used in the grid.

   Use one of the alternative ways.

   - Right-click the level and select **Rename**.
   - Rename the levels in the **Object Properties** view.

## 4.3 IED insertion

The context menu or the **Object Types** view shows the available IEDs that can be inserted on the bay level of the plant structure according to the installed connectivity package.

It is possible to do various tasks in the plant structure.

- Insert either an offline or an online IED
- Import a template IED that is available in the template library as a .pcmt file
- Import a preconfigured IED available as a .pcmi file

PCM600 uses two kinds of IED files: .pcmt and .pcmi. Both files include the complete IED configuration but their usage differs. The .pcmt files are always accessed through the PCM600 template manager while the .pcmi files are meant for sharing the IED instances between different PCM600 users enabling quick import and export from the plant structure context menu.

### 4.3.1 Inserting an IED in online mode

To set up an IED online, the protection relay must be connected to PCM600.

When the protection relay is connected to PCM600, PCM600 can read the composition code directly from the relay. It is possible to read the full configuration from the relay by using the Read from IED function.

1. In the **Plant Structure** view, right-click the bay, point to **New**, point to the relay application area such as **Multiapplication IEDs** and select the protection relay type to be inserted.



Alternatively, drag an IED from the **Object Types** view to the bay level.

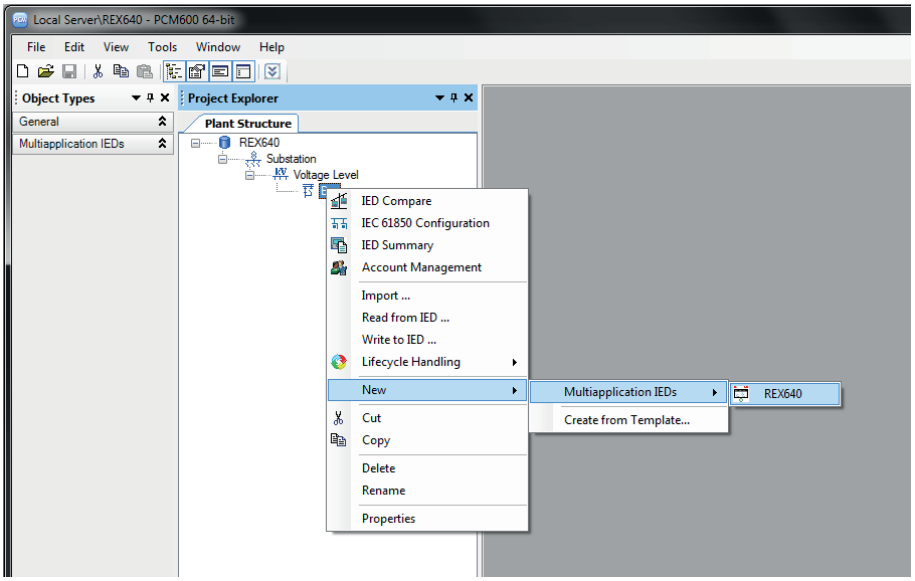



*Figure 20: Selecting the protection relay type*

2. On the **Configuration mode selection** page, select **Online Configuration** and click **Next**.

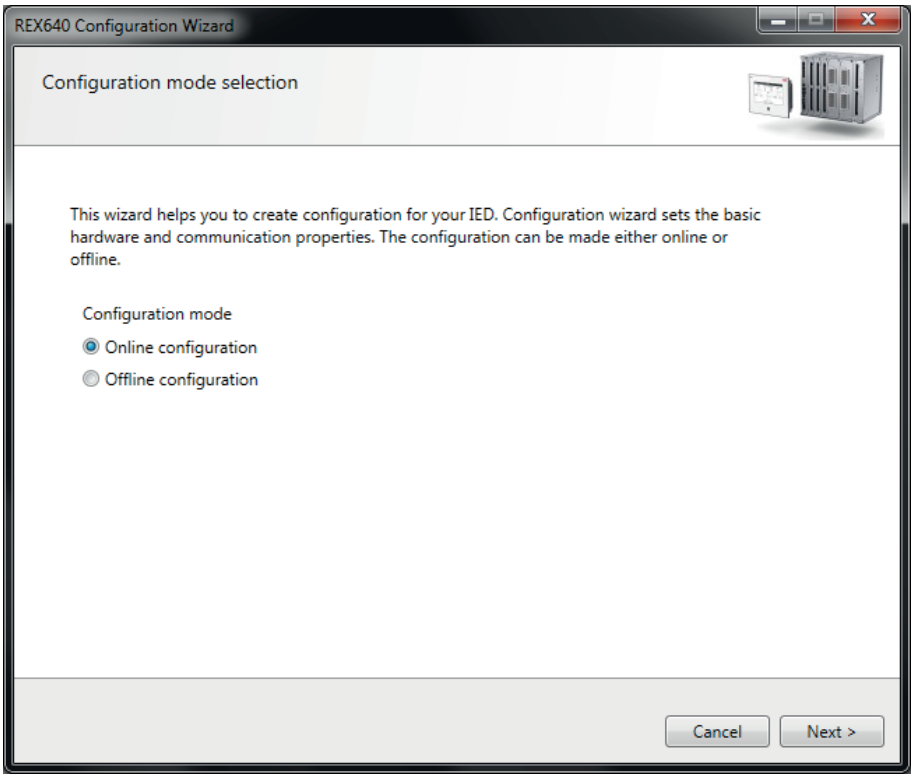



*Figure 21: Selecting the configuration mode*

3. On the **Communication protocol** page, select the communication protocol from the **IED Protocol** list and click **Next**.

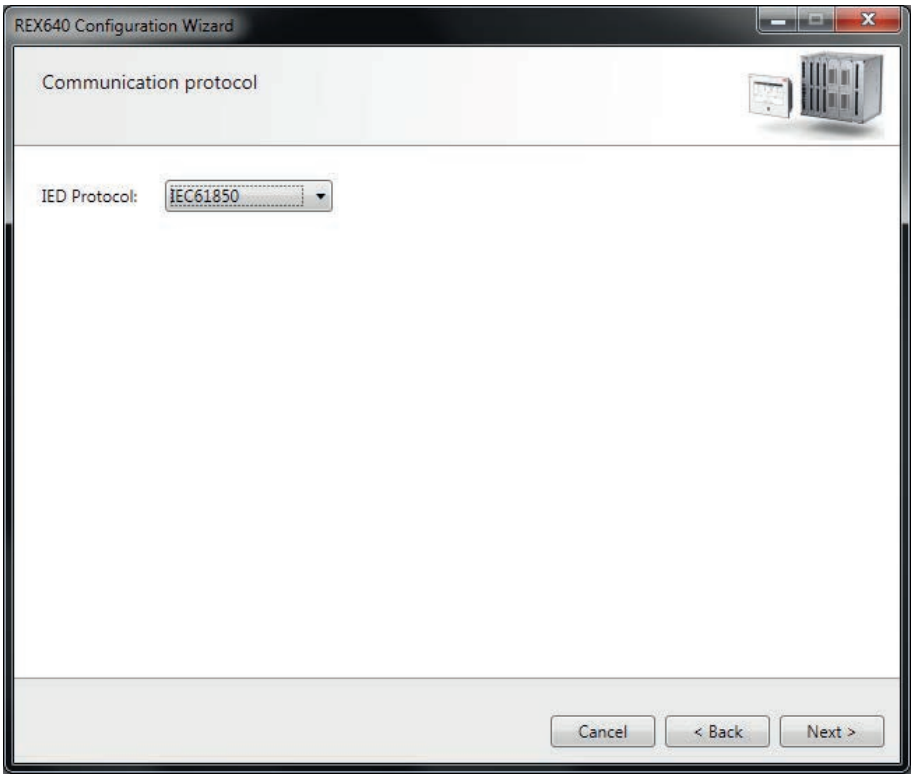



*Figure 22: Selecting the communication protocol*

4. On the **IEC61850 communication protocol** page, select the port from the **Port** list.
   - If the LAN port is selected, type the correct IP address (of the physical protection relay to be configured) to the **IP address** box.

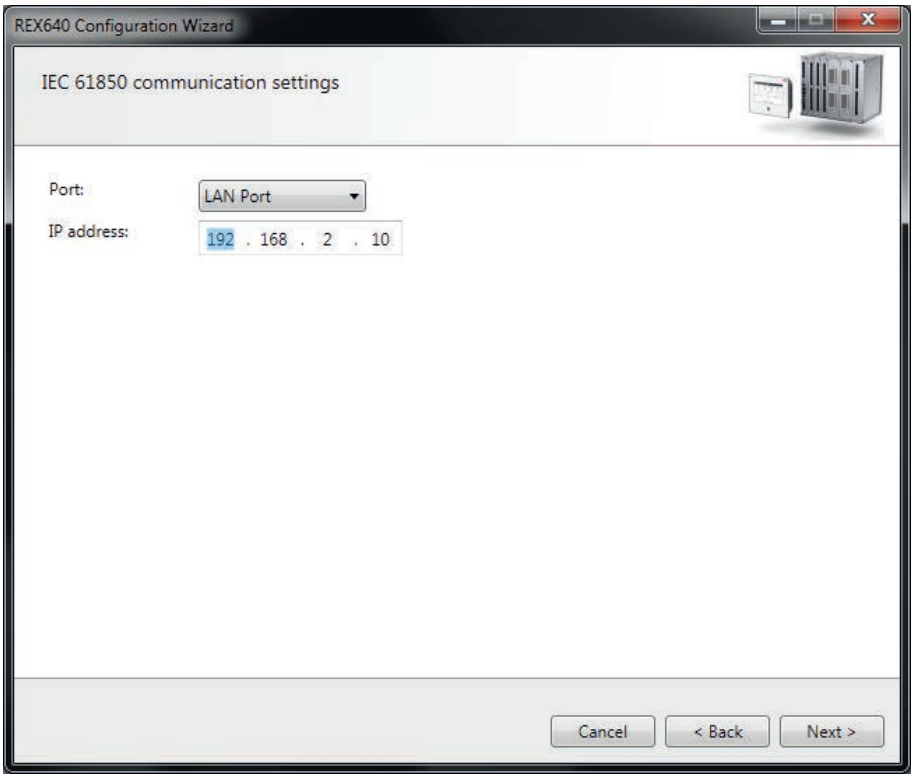



*Figure 23: Selecting the communication port and IP address*

Communication configuration is now defined.

5. Click **Next** to scan/read the composition code of the protection relay.
6. On the **Composition code detection** page, click **Next**.

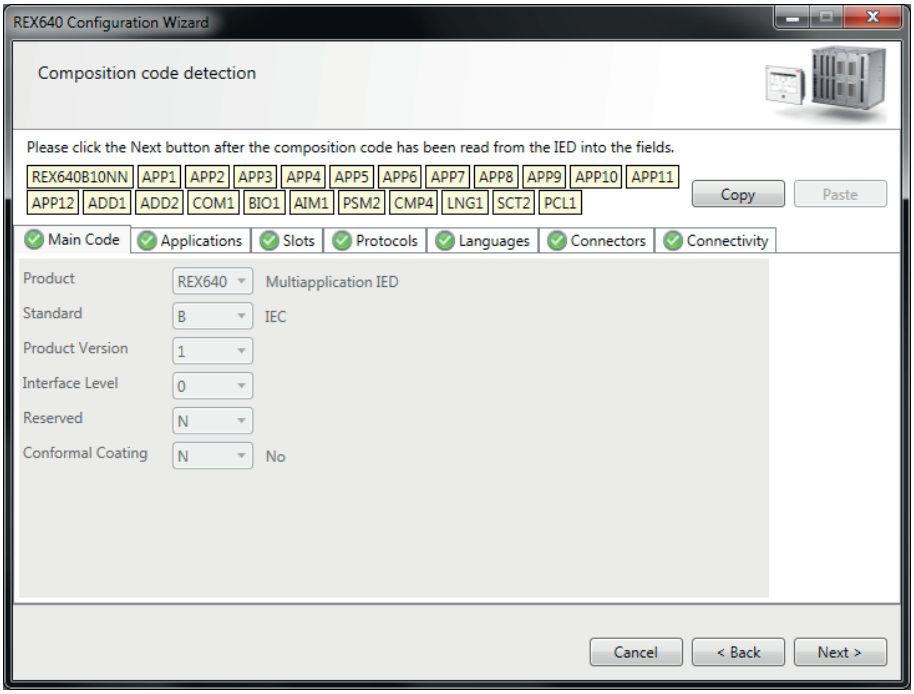



*Figure 24: Detecting the composition code*

7. On the **Configuration selection** page, select the configuration type and click **Next**.
   - Select **Empty Configuration** to create an empty configuration.
   - Select **Import configuration from file (PCMI/PCMT)** to import any existing example configuration.

     Click **Browse** to select the .pcmi or .pcmt file that has the example configuration.
   - Select **Default configuration (available only for IEC 61850 Edition 2)** to generate a default configuration.

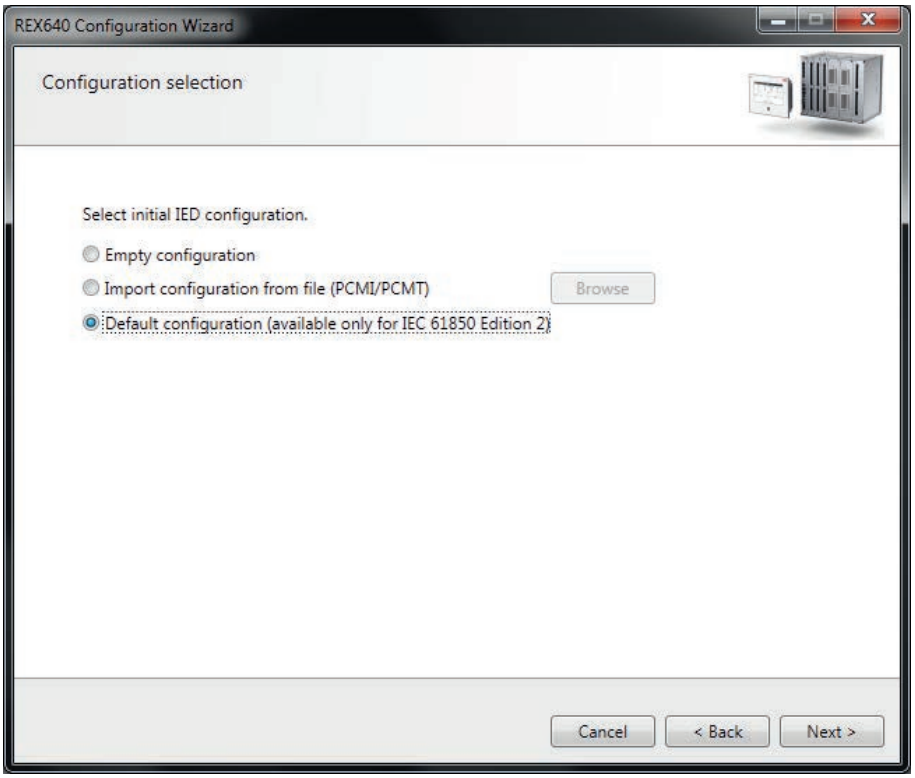



*Figure 25: Selecting the configuration type*

If a default configuration is selected, the next page is skipped as default configuration is only supported for the IEC 61850 Edition 2 IEDs. To configure an IEC 61850 Edition 1 IED, select empty or example configuration and make the proper selections on the next page.

8. On the **Version Selection** page, select the IEC 61850 version and click **Next**.

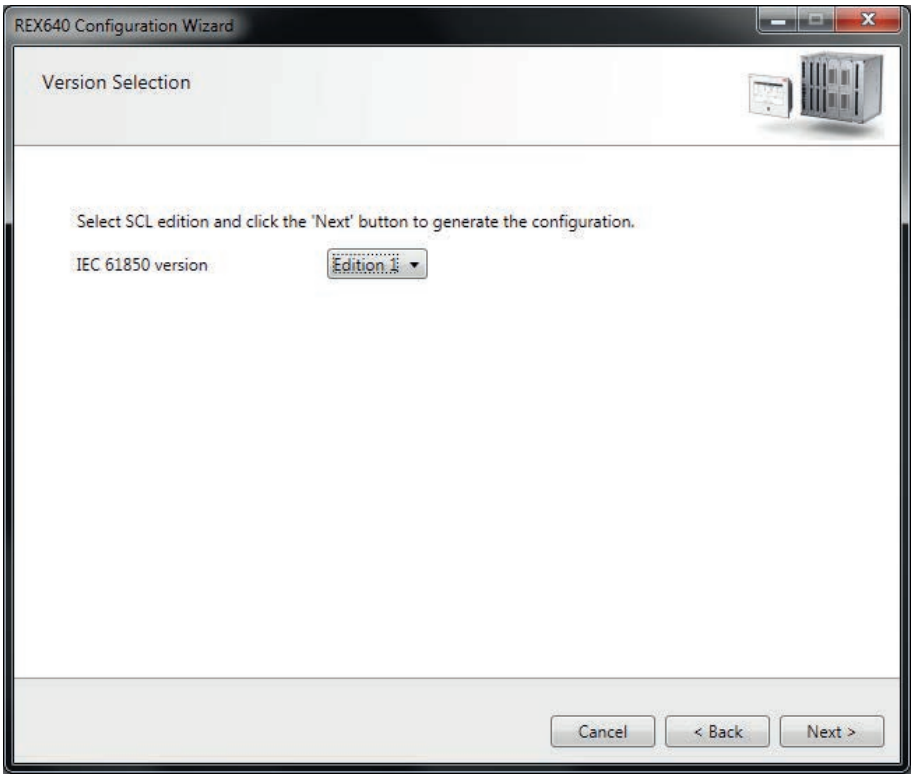



*Figure 26: Selecting the IEC 61850 version*

Regardless of the protocol used in the installation for each project, it is possible to have Edition1 and Edition2 relays configured in the same PCM600 project. The PCM600 project's SCL edition is the highest SCL edition relay in the project.

9. On the **Summary** page, click **Finish** to confirm the configuration and insert the IED.

   The **Summary** page shows the protection relay's IED type, IP address and the selected composition code.

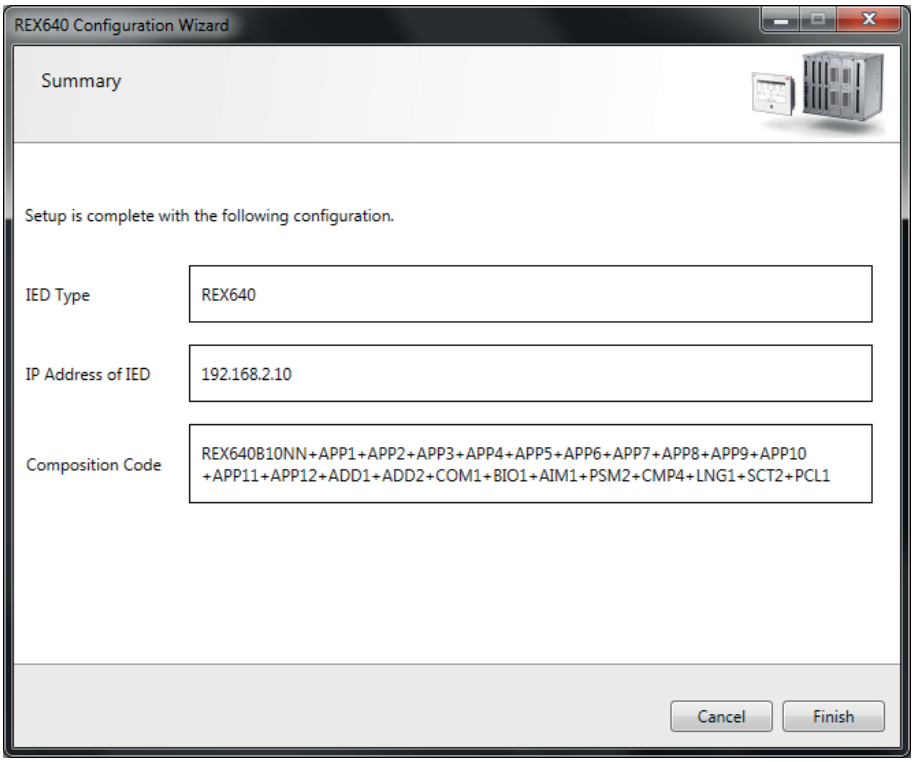



*Figure 27: Confirming the configuration*

If an error is shown on the **Summary** page, it is not possible to go back and make modifications. If an error is detected, cancel the insertion by clicking **Cancel** and insert the IED again.

## 4.3.2 Inserting an IED in offline mode

When the protection relay is not available or is not connected to PCM600, engineering can be done offline. The offline configuration in PCM600 can be written to the protection relay later when it is connected.

Working in the offline mode has an advantage over the online mode because the preparation for the configuration can be started even though the protection relay is not available.

1. In the **Plant Structure** view, right-click the bay, point to **New**, point to the relay application area such as **Multiapplication IEDs** and select the protection relay type to be inserted.

   Alternatively, drag an IED from the **Object Types** view to the bay level.

2. On the **Configuration mode selection** page, select **Offline configuration** and click **Next**.

   Setting up an IED in the offline mode is similar to the online mode; however, with the offline mode it is not necessary to type the correct IP address in the **IP address** box.

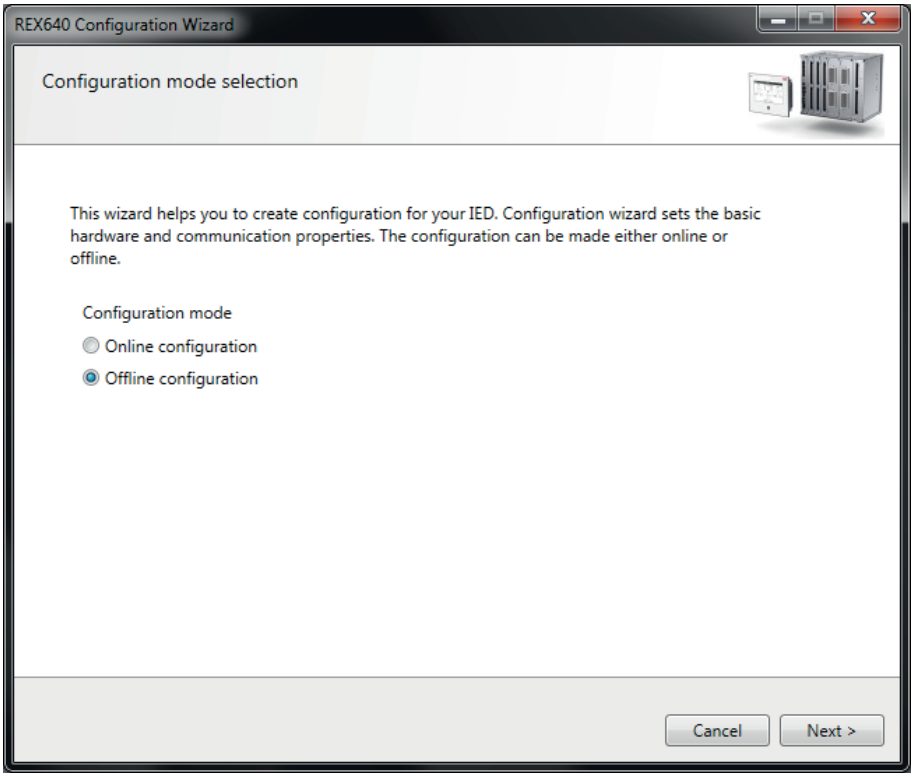



*Figure 28: Selecting the configuration mode*

3. On the **Composition code selection** page, select the correct composition codes and click **Next**.

   Ensure that the composition code is correct. PCM600 verifies that the composition code matches the relay. If the composition code digits related to the configuration, I/O or version do not match the relay, PCM600 does not allow writing the configuration to the relay. If other digits in the composition code do not match, PCM600 informs about the mismatch with a dialog box.

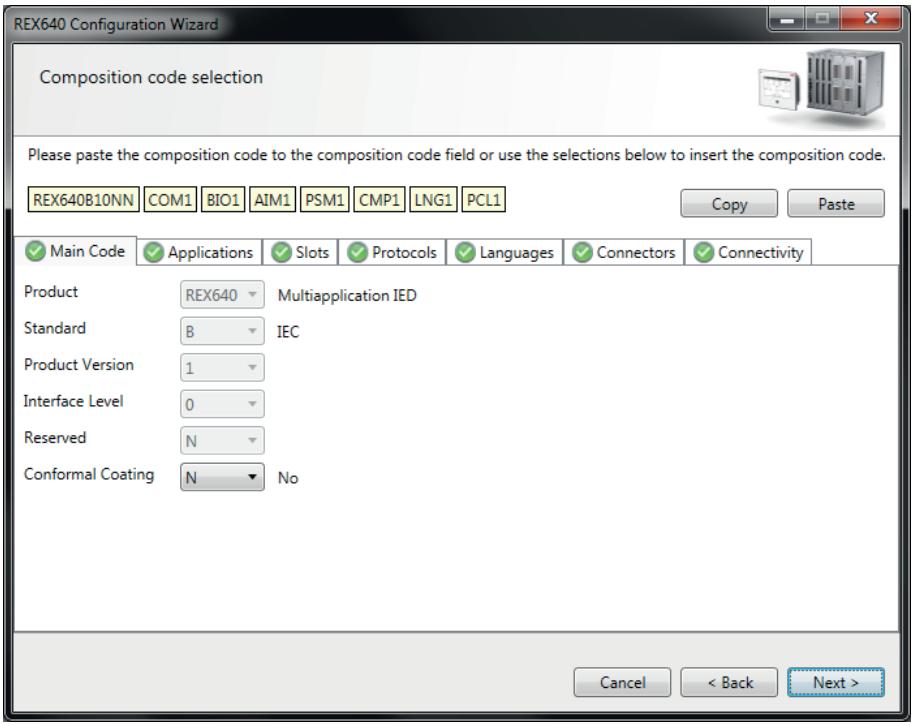



*Figure 29: Selecting the composition code*

4. On the **Configuration Selection Page**, select the configuration type and click **Next**.

   - Select **Empty configuration** to create an empty configuration.
   - Select **Import configuration from file (PCMI/PCMT)** to import an example configuration.

     Click **Browse** to select the .pcmi/.pcmt file that has the example configuration.
   - Select **Default configuration (available only for IEC 61850 Edition 2)** to generate a default configuration.

     If a default configuration is selected, the next page is skipped as default configuration is only supported for the IEC 61850 Edition 2 IEDs. To configure an IEC 61850 Edition 1 IED, select empty or example configuration and make the proper selection on the next page.

5. On the **Version Selection page**, select the IEC 61850 version and click **Next** to generate the functions.

6. The **Summary** page shows the summary of the IED type, IP address and the selected composition code. Click **Finish** to confirm the configuration and conduct the insertion.

## 4.3.3 Inserting an IED from the template directory

IED templates can be used to replicate IEDs with the same order code in PCM600 projects. The template includes an IED application configuration, graphical display configuration (single-line diagram), communication protocol mappings and parameters. An IED in the plant structure can be exported as a template (.pcmt file). The template library can be built from all the exported IED templates.

It is also possible to insert an IED from the template library to create a new IED in the plant structure. After a template IED has been imported, *IP address* and *Caption* in IED's **Object Properties** and *Technical Key* of the physical IED have to be changed.

1. In the **Plant Structure** view, select the bay or IED group, right-click, point to **New** and select **Create from template**.
2. In the **Create New Object from Template** dialog box, select the IED under **Available Object Types**.

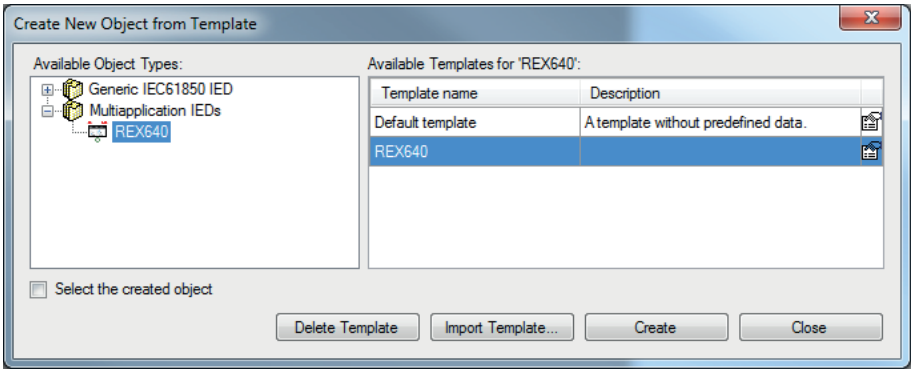



*Figure 30: PCM600: Selecting an IED from the template library*

3. Click the icon on the rightmost column in the list of available templates.

4. In the **Template Properties** dialog box, verify the template information and click **Close**.

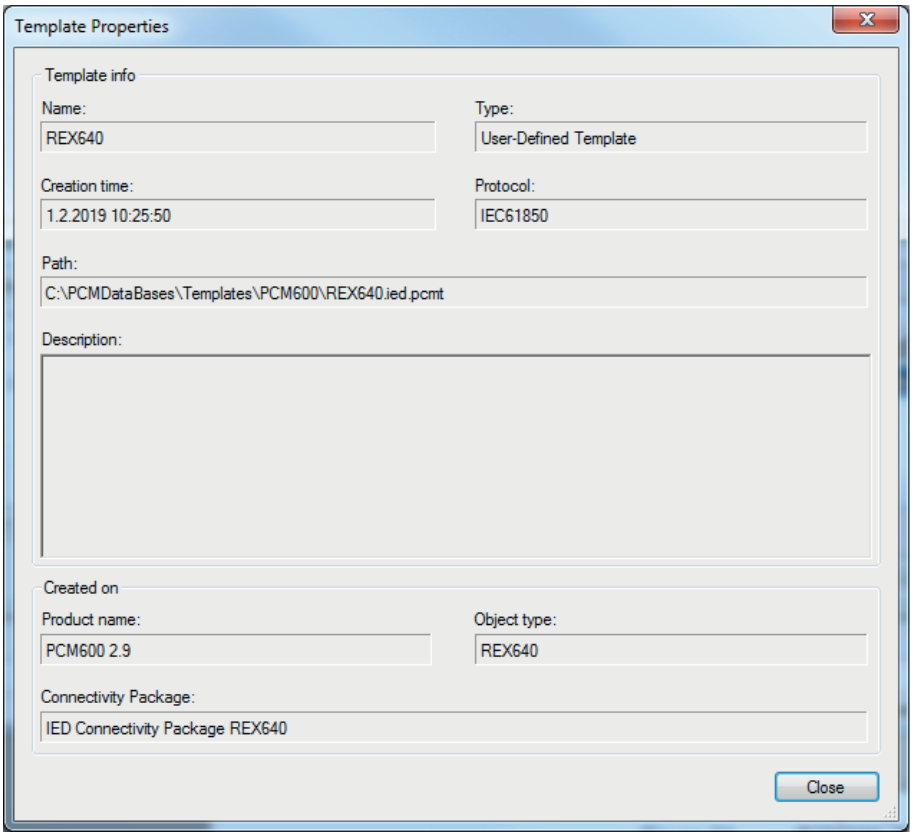



*Figure 31: PCM600: Template information*

5. In the **Create New Object from Template** dialog box, delete, import or create a template by clicking the corresponding button.
   - To delete the selected template, click **Delete Template**.
   - To import a template from the selection window, click **Import Template**.
   - To insert the selected IED to the bay, click **Create**.

   It is possible to insert more than one IED from the **Create New Object from Template** dialog box. The dialog box remains open until **Close** is clicked.

6. Click **Close** when finished.

### 4.3.4 Inserting an IED by importing a .pcmi file

1. In the **Plant Structure** view, right-click the bay and select **Import**.

A .pcmi file can be imported only when the bay is selected in the plant structure.

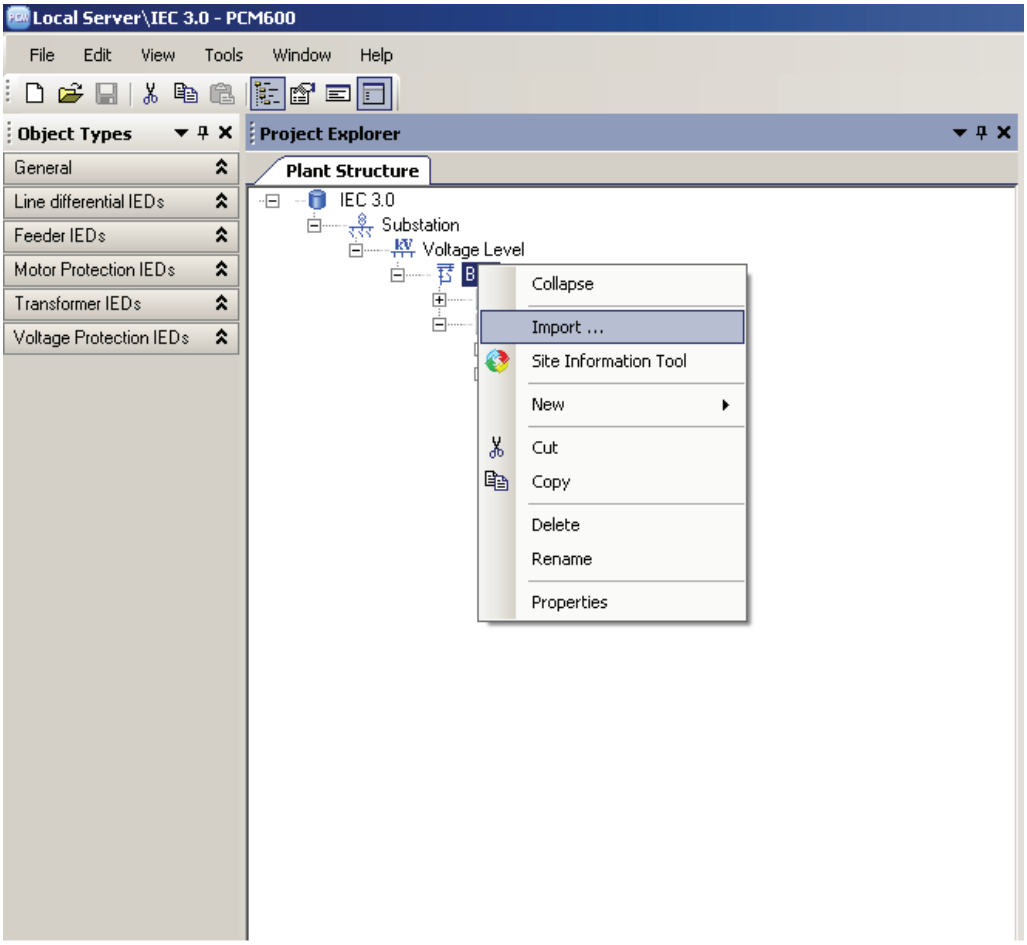



*Figure 32: Importing IED configuration*

2. In the **Import** dialog box, select the .pcmi file to be imported and click **Open**. After importing, the IED object is created in the plant structure.

After the .pcmi file has been imported, the IP address, the name and the technical key of the physical IED have to be changed.

## 4.4 Setting IED's IP address in a project

The IP address and subnet mask of the IED object in PCM600 must match the HMI and LAN ports of the protection relay (physical IED) to which the PC is connected. The IP address of the protection relay can only be set via the LHMI or Parameter Setting in PCM600. The PC and protection relay need to be on the same subnet.

There are two ways to set the IP address of an IED object in PCM600: on the first page of the wizard when including a new IED into a project or in the IP address box of the IED's Object Properties pane.

Choosing between the two ways depends on when the IP address is set. Typing the IP address via the IED's Object Properties pane is possible at any time while entering it via the configuration wizard can only be done when inserting the IED in online or offline mode.

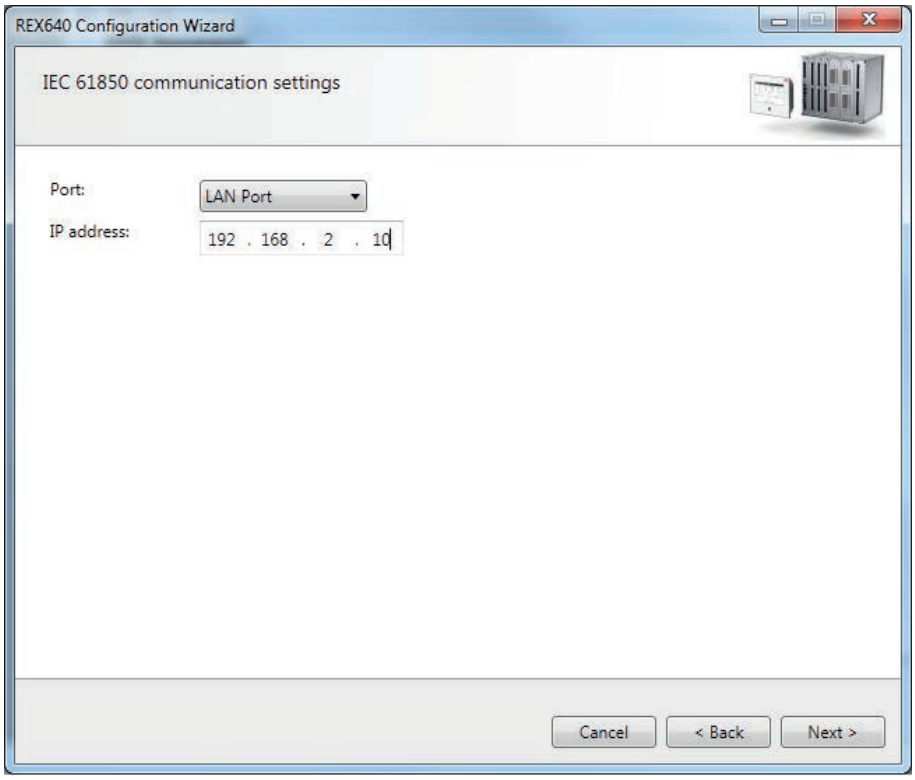



*Figure 33: Alternative 1: Setting the IP address on the first wizard page*

1. In the **Plant Structure** view, select the IED whose IP address must be entered.
2. On the **View** menu, select **Object Properties**.

3. In the **Object Properties** pane, type the IP address in the **IP Address** box.

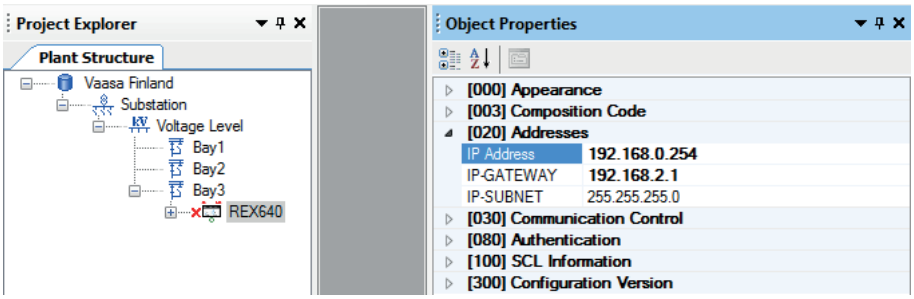



*Figure 34: Alternative 2: Setting the IP address in the IED's Object Properties pane*

## 4.5 Using the Web HMI

Connection to WHMI can be established using different communication card ports or the LHMI service port. WHMI is disabled by default and can be enabled with a setting parameter. As only secure communication is supported for the WHMI, it must be accessed from a Web browser using the HTTPS protocol. Three simultaneous LHMI and WHMI sessions are supported.

1. To enable the WHMI, select **Configuration** > **HMI** > **Web HMI mode** and set the parameter to "On".
2. Reboot the relay for the change to take effect.
3. Log in with the proper user rights to use the WHMI.

   If the WHMI is accessed through the LHMI service port, use the corresponding IP address of the relay communication port. The IP address can be obtained via the Engineer pages. Tap the relay's name on the LHMI menu bar to open the Relay address dialog box.

To establish a remote WHMI connection to the protection relay, contact the network administrator to check the company rules for IP and remote connections.

HTTPS is enabled for all ports by default. To disable the HTTPS for station ports, select **Communication** > **Protocols** > **Network1** > **HTTPS** or **Communication** > **Protocols** > **Network2** > **HTTPS** and set the parameter to "Off". HTTPS is always enabled for the X0/HMI port.

The WHMI write access can be limited with the parameter HTTPS write access in **Configuration** > **Authorization** > **Network1** or **Configuration** > **Authorization** > **Network2**.

Disable the Web browser proxy settings or make an exception to the proxy rules to allow the protection relay's WHMI connection, for example, by including the relay's

IP address in **Internet Options** > **Connections** > **LAN Settings** > **Advanced** > **Exceptions**.

## 4.6 Relay user management

The user account management and role-based access control in the protection relay have been handled as specified in IEC 62351-8. The relay supports both local user account and central account management. For information on how to set up user account management, see user management in the cyber security deployment guideline.

## 4.7 PCM600 project's IEC 61850 version identification

The IEC 61850 version of a PCM600 project can be identified from the Object Properties pane of the project.

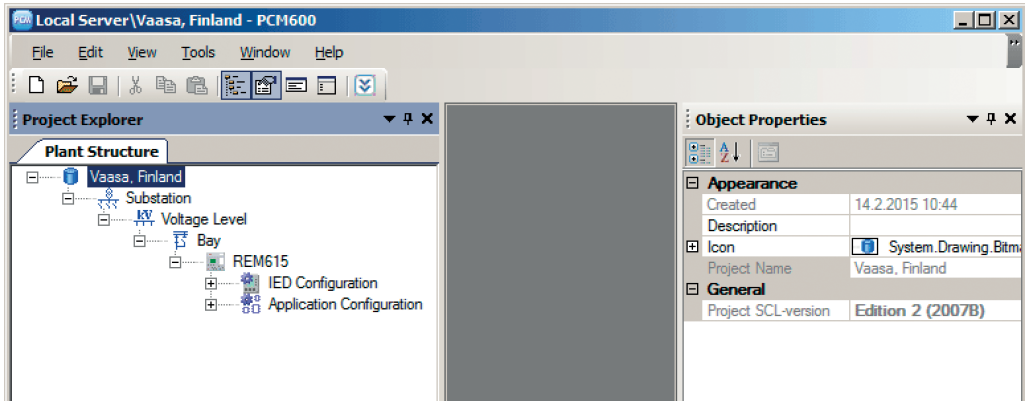



*Figure 35: Project's IEC 61850 version*

To change IEC 61850 version Edition 1 of an IED to Edition 2, the configuration has to be written to the IED from a PCM600 project that has IEC 61850 version Edition 2. A dialog box notifies of the version difference.

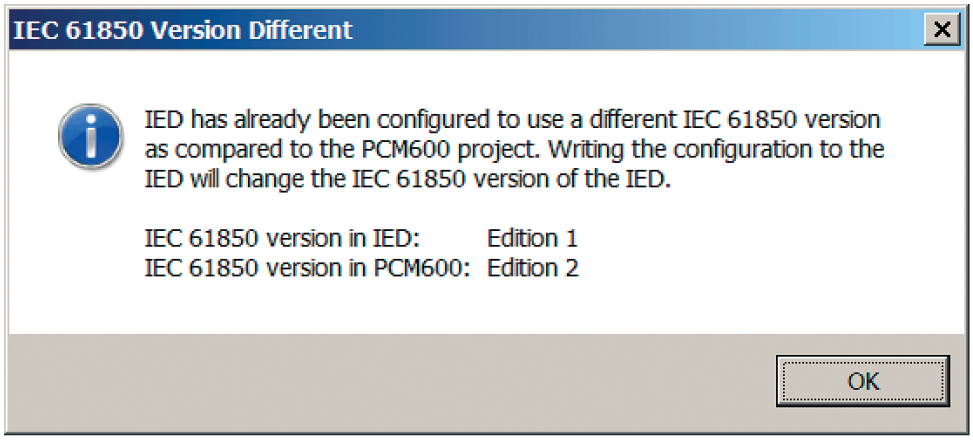



*Figure 36: IEC 61850 version change*

# 5 Protection and control engineering

## 5.1 Application Configuration

Application Configuration is used to modify an application configuration for a protection relay and is based on IEC 61131-3 Function Block Diagrams.

The function blocks are dedicated to different functions such as control related, protection related, monitoring or communication functions. For more information on the function blocks, see the technical manual.

Most function blocks are mapped as logical nodes according to the IEC 61850 standard. See the IEC 61850 parameter list for more information.

If a function block is removed with Application Configuration, the function-related data disappears from the menus as well as from the IEC 61850 data model, with the exception of some basic function blocks, which are mandatory and thus cannot be removed from the relay configuration by removing them from Application Configuration. The mandatory function blocks are: ETHLDEV1, ETHLDEV2, FTPLPRT1, GNRLLTIM1, GNRLLTMS1, GSAL1, GSELPRT1, HMILCCH1, HMILDEV1, HTTPLPRT1, LDEV1, LEDPTRC1, LINF1, LLN0, LPHD1, MMSLPRT1, RCHLCCH1, SA2LINF1, SBBIGGIO1, SBBOGGIO1, SBLINF1, SCHLCCH1, SCHLCCH2, SCHLCCH3, SCHLCCH6, SFAIGGIO1, SFLINF1, SGBOGGIO1 and SGLINF1.

Some of the protocol-related LPRT function blocks contain outputs which can be used to monitor protocol status. For example, the `CHLIV` output can be used to monitor if protocol-related messages are received from the client. However, all function blocks do not have outputs as they may just be visual objects to indicate protocol support when the sheet is printed out. This applies also to the PKIGSAL and LDEV function blocks. Security related function block GSAL has the `DOS_ALARM` and `DOS_WARNING` outputs for indicating denial of service warning and alarm event.

Other function blocks are not mapped as logical nodes; for example, logical gates.

The basic features of Application Configuration include the ability to organize a configuration into several MainApplications as well as providing different application programming features.

- Organizing an application configuration
  - Organizing an application configuration into a number of logical parts (MainApplication)
  - Organizing a MainApplication over a number of pages
- Features for programming an application configuration
- Inserting function blocks, making connections and creating variables
- Including the hardware I/O channels directly in the application configuration
- Calculating the execution order automatically by clicking Calculate execution order on the toolbar
- Documenting the application configuration, for example, by making printouts
- Saving application configurations as templates in an application library to reuse them in other protection relays. Function blocks and the related logic can be

fully or partially reused depending on the functionality available in the other protection relay.

- Validating the application configuration during the configuration process on demand and while writing the application configuration to the protection relay

For instructions on how to perform the different tasks in PCM600, see PCM600 online help.

## 5.1.1 Function blocks

Function blocks are the main elements of an application configuration. They are designed for a various number of functions and organized into groups according to type. The different function block types are shown in the Object Types view. Function block data can be modified with Application Configuration in PCM600.

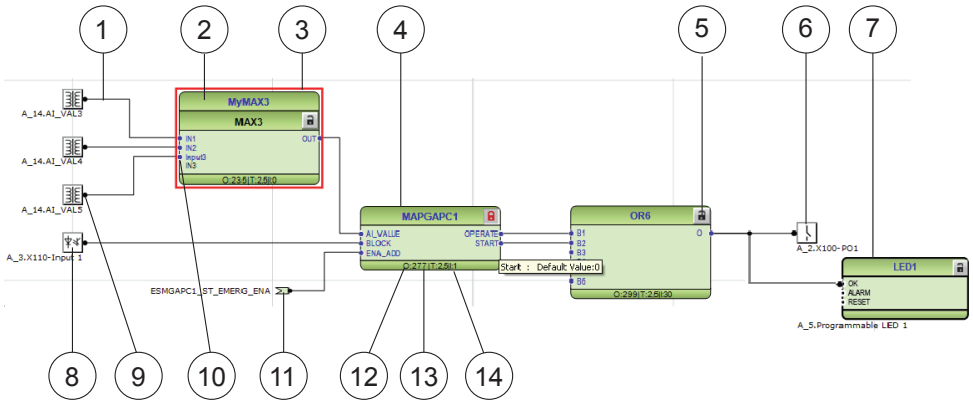
- User-defined names can be given for function blocks and signals.

Signals that have a user-defined name created with Application Configuration are visible in Parameter Setting in PCM600 only if the relay configuration is written to the protection relay and read back to PCM600. Otherwise, only the default signal name is shown in Parameter Setting.

Restart the relay to ensure that all user-defined names for the disturbance recorder's Channel id texts are updated on the LHMI, WHMI and Parameter Setting menus.

If possible, set the user-defined name to a signal before connecting the signal to other function blocks.

- IEC 61850, ANSI or IEC 60617 symbol standard can be set.
- IEC or ANSI naming style can be set.
- Function blocks can be locked.
- Visibility for execution order, cycle time and instance number can be set.
- Signals can be managed.
- Boolean inputs and outputs can be inverted.




1 Connections
2 User-defined function block name
3 Function block, selected (red)
4 Function block name
5 Function block, locked
6 Hardware, binary output channel
7 Hardware, programmable LED

8 Hardware, binary input channel
9 Hardware, analog input channel
10 User-defined signal name
11 User-defined input variable
12 Execution order
13 Cycle time
14 Instance number

*Figure 37: Application Configuration: function block overview*

## 5.1.2 Signals and signal management

The function block has a set of input and output signals. The placement of function block signals is from left to right. Input signals are placed on the left and output signals on the right.

Function blocks can contain more signals than needed in an application part. Unused signals can be hidden to get a clear picture.

Signals are located up and down on both sides of the middle position. When there is space left, some signals may be moved up or down for better visibility and connection routing.

Boolean input and output signals may need to be inverted to fulfil the logic. The Application Configuration tool supports the adding of inversion logic to a binary signal.

All input signals have a default value that is used when the signals are not connected in the configuration.



The input signal on glue logic function blocks can be inverted only if a glue logic function block with lower execution order in the same cycle time is available. Similarly, the output signal can only be inverted if a glue logic function block with higher execution order in the same cycle time is available. Up to two input signals and two output signals can be inverted for glue logic blocks in the same cycle time.

## 5.1.3 Function block execution parameters

Three function block execution parameters influence the runtime execution of the function block within the application configuration.

- Execution order
- Cycle time
- Instance number

When a new function block is inserted, these parameters are shown in the Function Block Instance dialog box in Application Configuration. The three parameters are selectable or not selectable depending on the function block type. The cycle time is predefined to one value. The instance number is a counter for the total possible number of function blocks of that type used within the application configuration.

*Execution Order* and *Instance Number* are a combination that is predefined within a product. It is possible to select a pair out of the list.

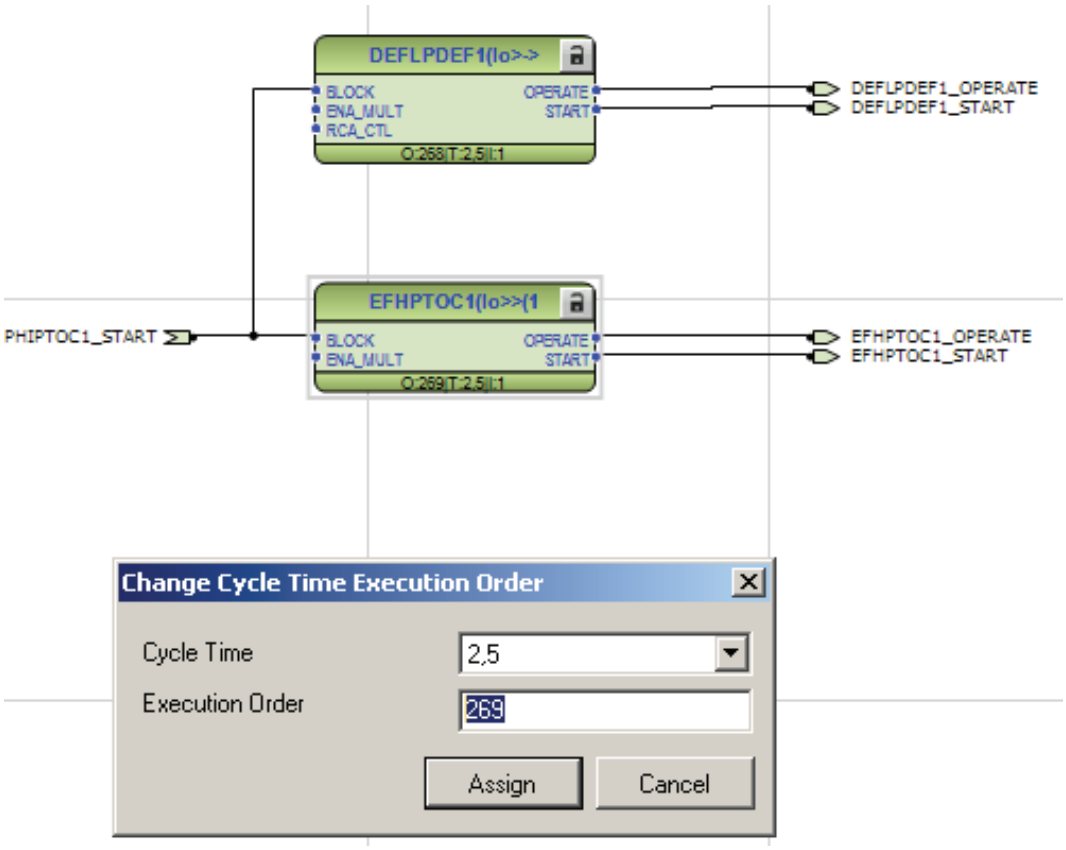



*Figure 38: Application Configuration tool: an example of function block organization parameters*

*Cycle Time* is automatically set and it cannot be modified.

To automatically calculate the execution order, click **Calculate Execution Order** on the tool bar.

## 5.1.4 Execution order and feedback loops

It is possible to draw a multi-layer configuration logic that contains feedback loops with the Application Configuration tool. The execution order of logic functions is calculated automatically in the Application Configuration tool, but it can also be set manually. If the automatically calculated value causes the function to be executed one task cycle time after the other logic functions in the same loop, the execution order number can be set manually to prevent delays, for example, in output activation.

To perceive accurate time stamps from binary input signals to function blocks, direct logic connection should be used in the Application Configuration tool. Due to the internal execution order, time stamps may not be accurate if an additional logic is used to connect priority signals to function blocks.

*Figure 39* shows a simple situation where the execution order causes one cycle time delay if the NOT gate is executed in the order determined by the automatic calculation.

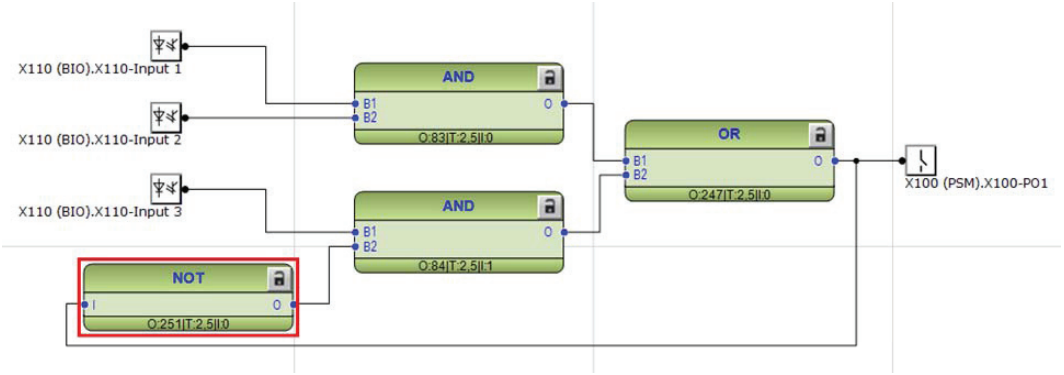



*Figure 39: Feedback loop situation with automatically calculated execution orders*

By setting a smaller execution number than in the AND port to where the NOT port is connected, it is possible to fix the execution order of all functions in a loop so that they are handled in the same task.

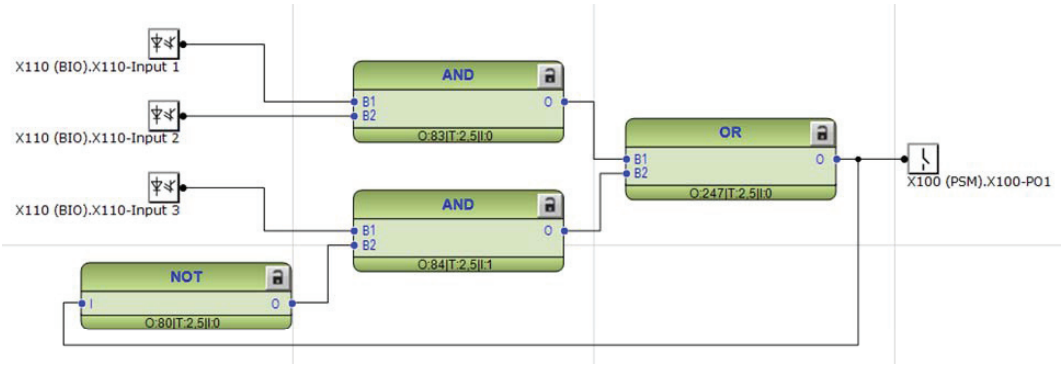



*Figure 40: Feedback loop situation with manually fixed execution order for NOT port*

The execution number can be changed by right-clicking the function and selecting Change CycleTime ExecOrder.

After manually defining the execution number, the function is excluded from the automatic execution order calculation. The function can be included back to the automatic calculation by right-clicking the function and selecting Include FB in calculation.

## 5.1.5 Connections and variables

A connection is the link or "wire" between function block outputs and inputs.

Connections can be made in two ways.

- Dragging a line between two signals
- Linking two signals by using variables

It is possible to search and replace variable names in Application Configuration tool.

Connect the variables to a destination, for example to a function block or a hardware output channel. The connectivity package automatically

removes the orphan variables which are not connected to any destination.

Connect at least one analog input signal from AIM or SMVRCV.

**Connection validation**

A connection is only useful or even possible between two signals of the same base attribute type.

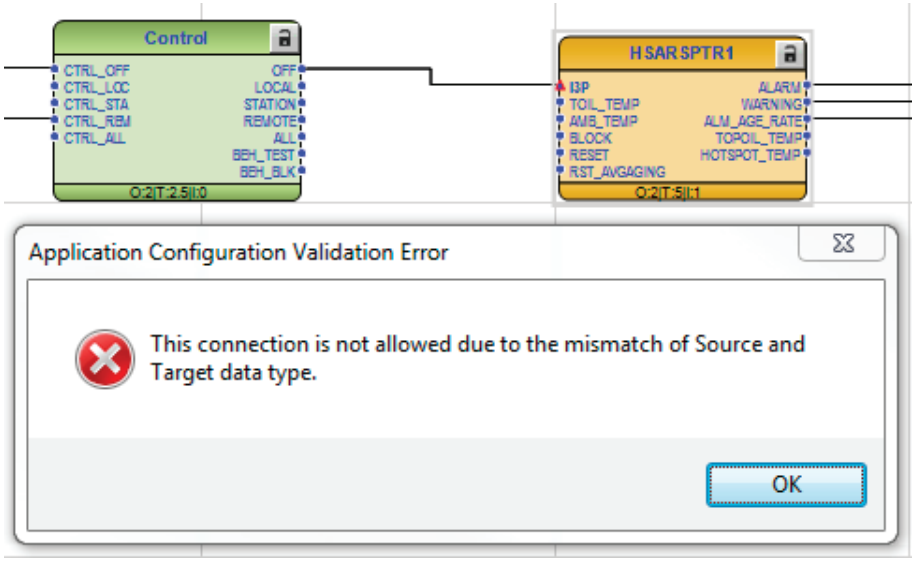



*Figure 41: Application Configuration tool: an error message of a signal mismatch for a connection*

## 5.1.6 Hardware channels

Hardware channels can be connected only to a function block input or output. A hardware connection can be established with Application Configuration or Signal Matrix.

When a hardware channel is connected, a graphical symbol appears in Application Configuration. The connection is also indicated in Signal Matrix with a cross mark. All hardware channels are always visible in Signal Matrix.

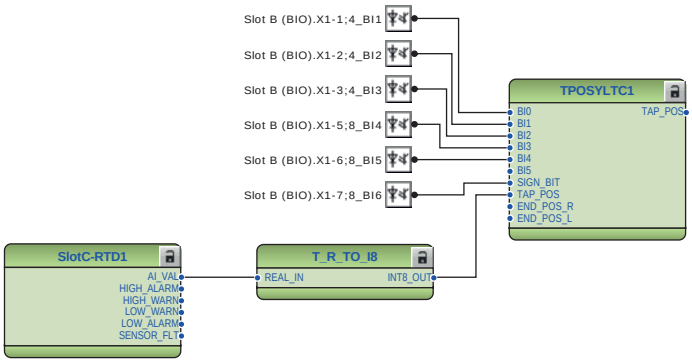



*Figure 42: Application Configuration: HW signal channels*

There are three types of supported hardware channels.

- Binary input channels
- Binary output channels
- Analog input channels

Hardware binary input channels may have multiple connections. A hardware binary output channel is taken from the list of available channels when a new channel is requested. This prevents using the same hardware binary output channel twice.

### 5.1.6.1 Hardware channel configuration

Instead of pre-configured I/O channel connections to pre-processing function blocks, user-customized configurations can be used. There are some rules which must be followed to create a working configuration. Application Configuration automatically checks if configuration is valid and results are shown in the output pane. See the technical manual for the minimum I/O requirement per application function block.

**Example 1**

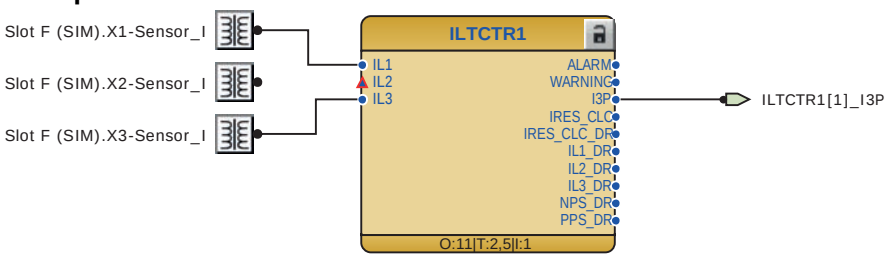



*Figure 43: Missing required input connection for output*

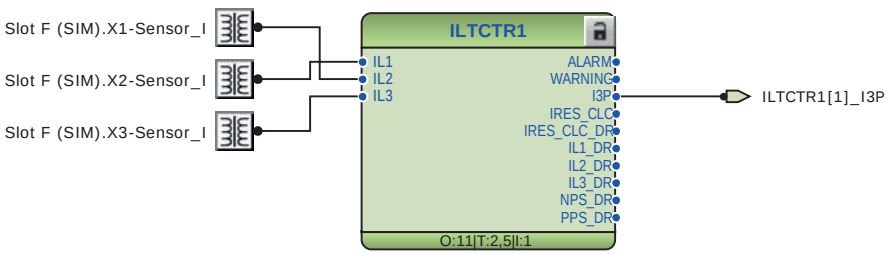



*Figure 44: All required input connections configured for output*

In *Figure 43*, the output connection requires more input channels to be connected. *Figure 44* has correction for *Figure 43* where all required inputs are configured and the input order is according to installation.

When an output is not connected to any function block, Application Configuration considers the configuration valid. Check validation warnings from the output pane for possible missing connections. Once the output is connected, the complete configuration is validated again.

**Example 2**

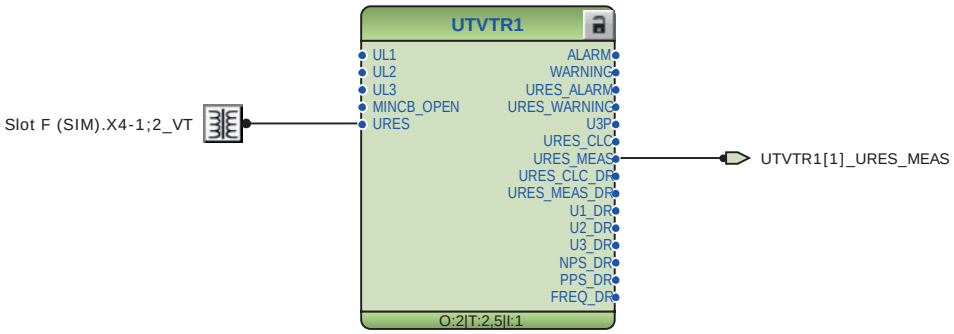



*Figure 45: Output connection requiring only one input*

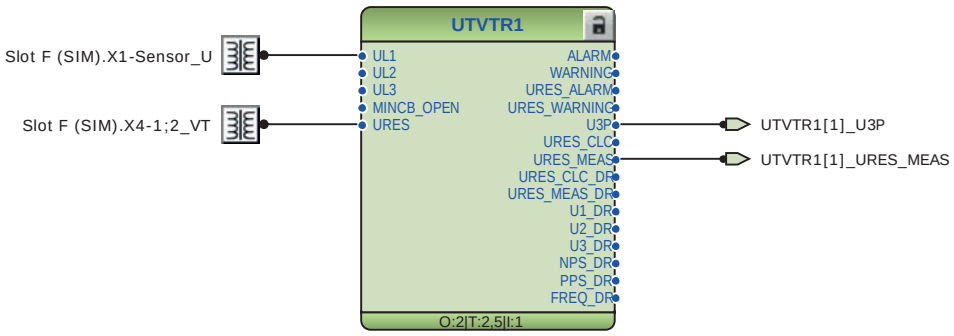



*Figure 46: Two output connections requiring two inputs*

UTVTR ULx inputs can be used as one-, two- or three-phase connection. The ACT blocks connected to `U3P` may further demand two- or three-phase connection. `URES` input must be connected if `URES_MEAS` output is used. *Figure 45* illustrates the use case of only residual voltage being used in UTVTR1. *Figure 46* illustrates a case where one residual voltage and one phase voltage are sufficient.

**Example 3**

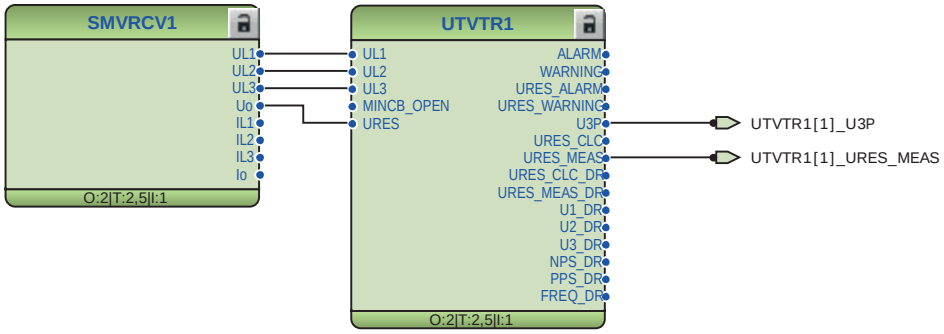



*Figure 47: Remote samples as input connections*

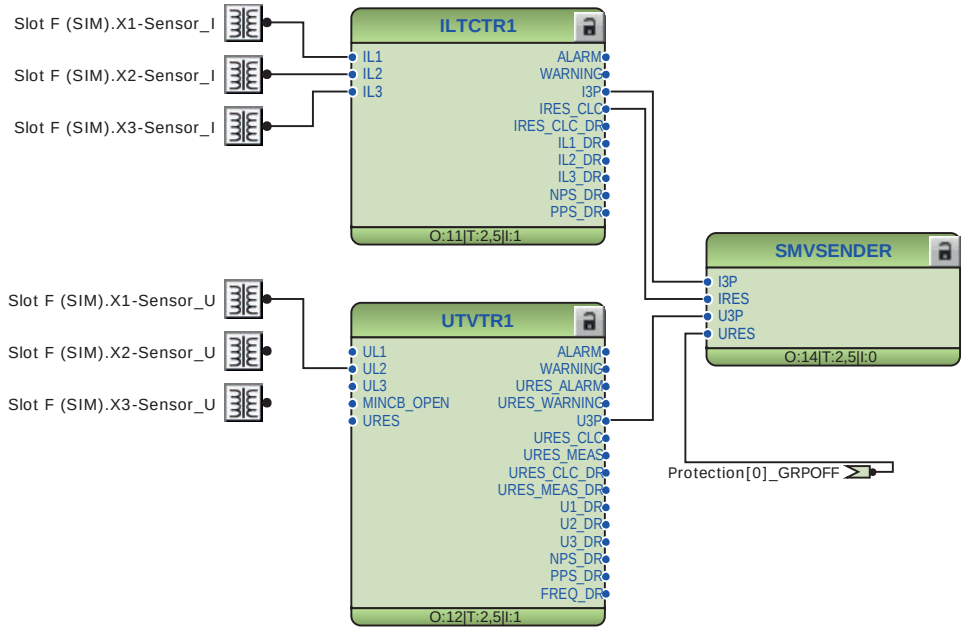



*Figure 48: Local inputs sent out as remote samples*

Instead of local hardware inputs in *Figure 47*, remote samples can be used by local function blocks. Remote samples sender can also be configured as described in *Figure 48*, where GRP_OFF is used to indicate that channel is not available locally. See the technical manual for details about GRP_OFF.

TVTR and TCTR function blocks accept analog channels connected only either from local or remote, that is, local and remote channels cannot be mixed within a TVTR/TCTR function block.

It is not possible to forward the received remote analog channels.

An analog input can only be connected to one function block. Triplets (for example, U3P and I3P) should be used instead in the application to connect analog inputs to other function blocks.

**Example 4**

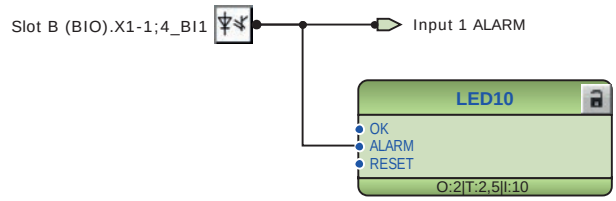



*Figure 49: Hardware binary input channel shared by function blocks*

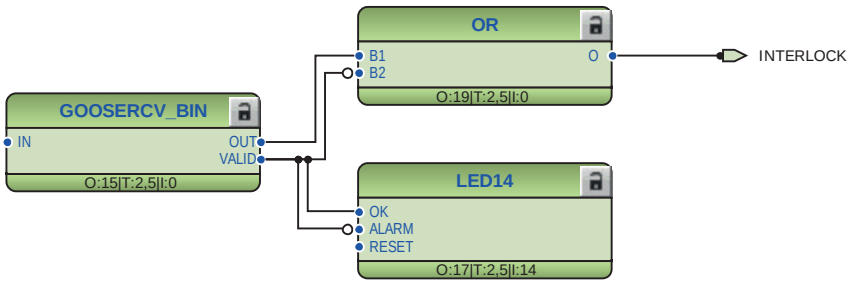



*Figure 50: GOOSE input shared by function blocks*

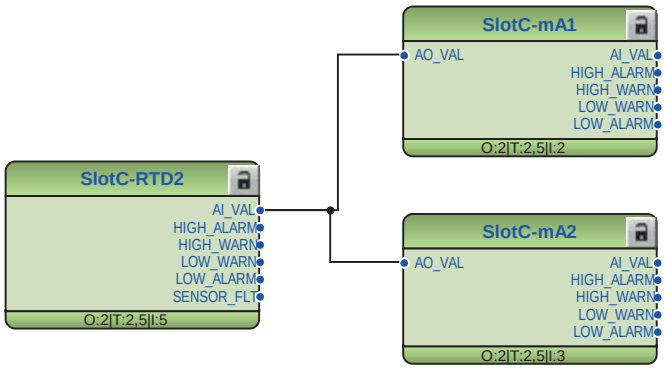



*Figure 51: RTD input shared by function blocks*

GOOSE, RTD and binary inputs can be shared by multiple function blocks.

## 5.1.7 Online monitoring

Online monitoring enables the continuous monitoring of the signal or channel values in the configuration. In the Online monitoring mode, the configuration cannot be edited in the Application Configuration tool.

Online monitoring can be started by clicking the Work online button in the toolbar. If the application configurations in the IED and PCM600 are the same, the online monitoring starts. The online monitoring ends and the tool returns to the configuration mode if the Work Offline button is clicked.

Online monitoring cannot be started if the application configurations in IED and PCM600 are different.

In some cases when the function block input is directly mapped to the function block output, the input is internally forced to the correct value

depending on the function block's settings. This function block design is present in control blocks, setting group handling and tap changer.

## 5.1.8 Validation

Validation checks the application configuration for errors based on the rules that govern the application creation at three different times.

- During the logic creation, while making a connection or placing a function block
- On demand by starting the validation
- When writing the application configuration to the protection relay

### 5.1.8.1 Validation when creating application configuration

Certain conditions require the validation to be made when creating the application configuration.

- A connection between two input or two output signals is not possible
- A connection between two different data types is not possible: for example, from a binary output to an analog input

### 5.1.8.2 Validation on demand

The validity of an application configuration can be checked by clicking **Validate Configuration** in the toolbar. The Application Configuration tool checks the application configuration for formal correctness. The found problems are divided into warnings and errors.

- Warnings, marked with a yellow warning icon
  - Example: a variable connected to an output signal that is not connected
  - Example: if an output from a higher execution order function is connected to the inputs of a lower execution order function
- Errors, marked with a red circle with a cross
  - Example: unconnected hardware output

Warnings do not prevent writing to the protection relay. However, errors must be corrected before writing the application configuration to the protection relay. The application configuration can be saved and the Application Configuration tool can be closed with open errors, but the application configuration cannot be written to the protection relay.

These problems are listed in the **Output** view under the **Application Configuration** tab. Double-clicking the error or warning row navigates to the **MainApplication** > **Page** > **Area**, where the problem was identified.

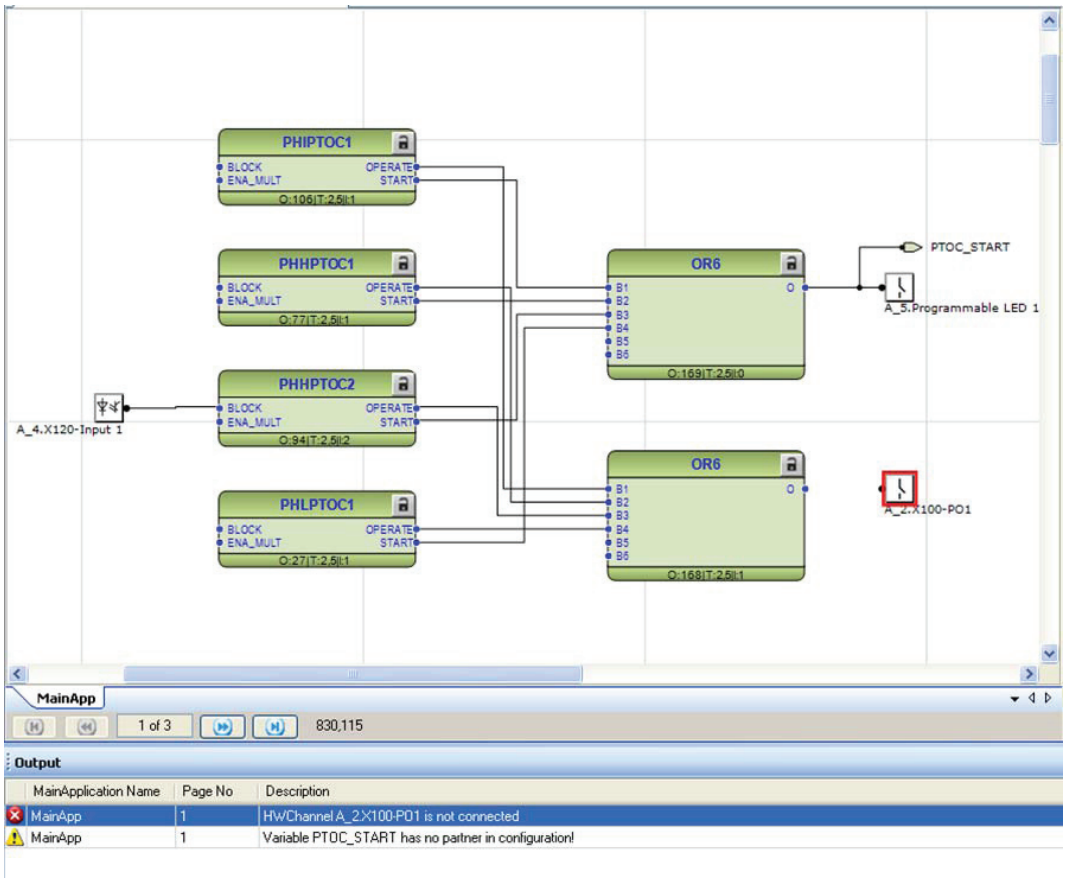



*Figure 52: Application Configuration tool: validation on demand*

### 5.1.8.3 Validation when writing to protection relay

When writing the application configuration to the protection relay, an automatic validation is performed. Errors abort the writing.

## 5.1.9 Configuration load calculation

The connectivity package calculates an estimated application configuration load every time it is saved in Application Configuration or written to the IED. This functionality prevents too complex configurations from being used and possibly risking IED protection functionality.

Calculation results are divided into two different sections: OK and Error. At 100 percent, PCM600 can give either an OK or an error message because the connectivity package rounds the actual limit to the closest percentage. If the calculation result is above 100 percent, PCM600 always gives an error message and prevents writing the configuration to the IED as the configuration is too large for the IED to handle. The configuration is written to the IED if the result is below the error range.

The calculation result is visible only in PCM600 output window on the Logging tab.

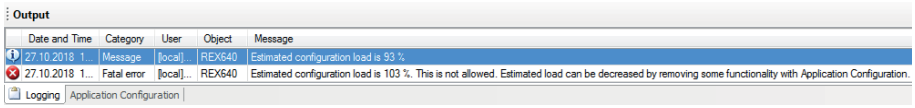



*Figure 53: Configuration load result: an example of different messages shown in PCM600*

## 5.2 Parameter Setting

Configuration and setting parameters can be changed with LHMI, WHMI or with the Parameter Setting tool in PCM600.

Some parameters are only visible in the Parameter Setting tool and some only on the LHMI.

The Write to IED command from PCM600 to the protection relay overwrites any parameter changes made with the HMI.

All parameters displayed in the parameter list can be sorted into two groups.

- Configuration parameters
- Setting parameters

### 5.2.1 Configuration parameter

The configuration parameter specifies the operation mode of an application function or of the protection relay. These are basic configurations that are normally configured only once and then not modified again. The protection relay configures itself during start-up according to the given configuration parameter values.

### 5.2.2 Setting parameter

Setting parameter (short form: “setting”) is a parameter that can be changed in the protection relay at runtime.

### 5.2.3 Setting group

Nearly all settings used by the protection relay for protection application functions are organized into a group of settings. Up to six setting groups can be configured with different values.

The protection relay supports the selection of a setting group at runtime.

### 5.2.4 Parameter import and export

The parameter export and import function can be used, for example, when the protection relay's parameters are set using the WHMI instead of PCM600. The relay

settings engineered with PCM600 can be exported to XRIO files and imported to the WHMI, which can be used to write the settings to the protection relays. The WHMI can also be used to read the relay setting parameters and to export those to files, which can be used by PCM600.

The setting export and import are sensitive to the protection relay's content. Settings are exported and imported for one protection relay at a time. The export files of a protection relay can be exchanged between PCM600, WHMI and the actual physical IED. To avoid errors and to efficiently manage the setting export and import, for example, in a substation with several protection relays, ensure that the names of the export files identify the protection relay to which the file should be imported.

The parameter import and export functionality is available via the File menu when the Parameter Setting tool is open.

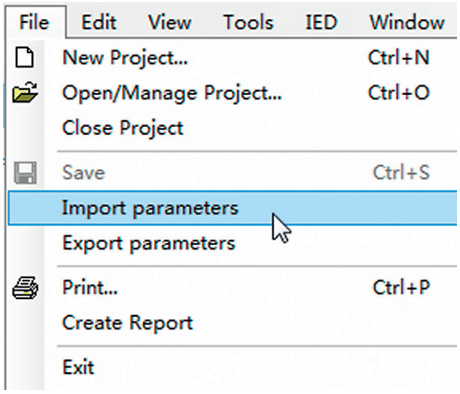



*Figure 54: Parameter import and export*

### 5.2.5 Parameter organization

The organization of parameters into a tree structure can be seen in the **Plant Structure** by expanding the setting tree.

## 5.3 Configure Autosynchronization

Manual configuration of the autosynchronization scheme in PCM600 is time-consuming and complex in case the system contains both generator circuit breakers and non-generator circuit breakers, that is, non-source circuit breakers. Configure Autosynchronization in PCM600 can be used to simplify the configuration process. The autosynchronization scheme for a given project can be configured via user-understandable terminologies regarding the system to understand the network topology.

The relay supports synchronizing of GCBs and NSCBs, such as grid connection or bus coupler circuit breakers, by providing dedicated function blocks to perform the synchronization process.

- ASGCSYN is used for GCB synchronization.
- ASNSCSYN is used for NSCB synchronization.

- ASCGAPC is a coordination function that handles the control request and allows communication among the relays connected to the autosynchronization system.

Configure Autosynchronization generates a configuration with IEC61850-8-1 GOOSE engineering, function block parameters in Parameter Setting and relevant connections in Application Configuration for ASGCSYN, ASNSCSYN and ASCGAPC. Further, the tool displays the configured network topology as an SLD preview.

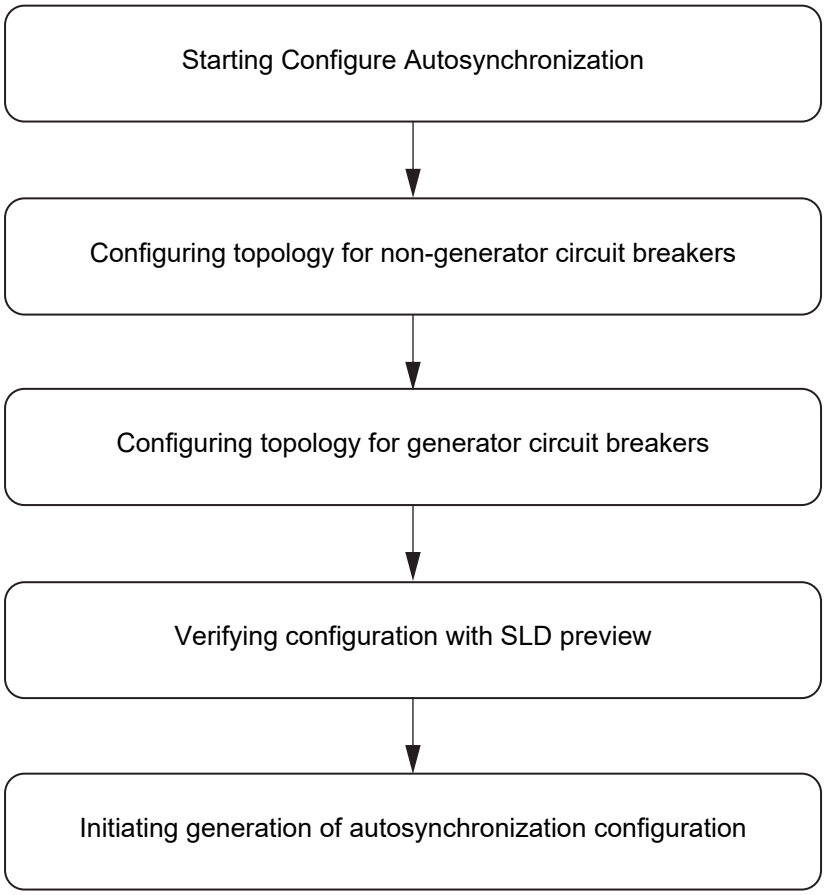



*Figure 55: Simple engineering flow for Configure Autosynchronization*

After using Configure Autosynchronization, manually handle the connections for voltage measurements, inputs and outputs to ASGCSYN, ASNSCSYN and ASCGAPC in Application Configuration. For functional details, see the technical and application manuals.

## 5.3.1 Example case

*Figure 56* presents a 11 kV network with a generator, grid connection, bus sectionalizers, local power generation and two feeder loads to illustrate a more realistic application. The target is to create a complete autosynchronization system were each of the breakers, except for CB1 and CB2, are capable of performing synchronized closing. The system is continuously aware of the relevant primary objects' switching status as well as the availability of the generator. Depending on which circuit breaker is selected for synchronization, the system checks the conditions and proceeds only if the selected circuit breaker is viable. As the feeder relays do not have any dependency on the autosynchronization system, they are not

explained further in this example. This example case is used in the selections made in the following chapters.

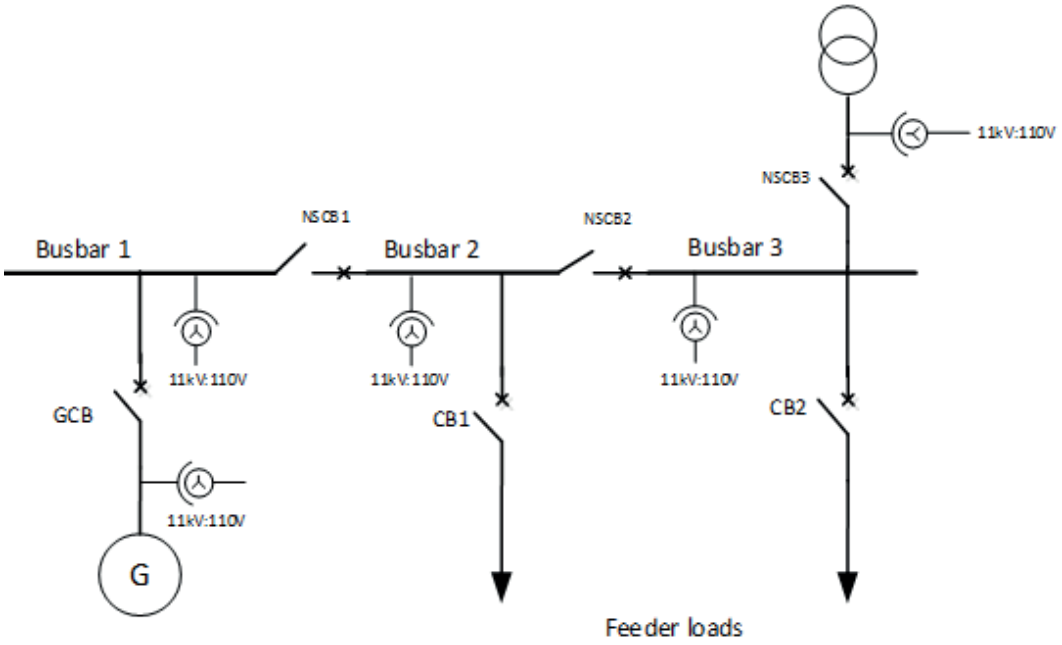



*Figure 56: Example case for the autosynchronization scheme*

*Figure 57* presents the terminology used in a typical topology for different busbar arrangements containing an NSCB. It only depicts the logical connections and does not represent any primary network.

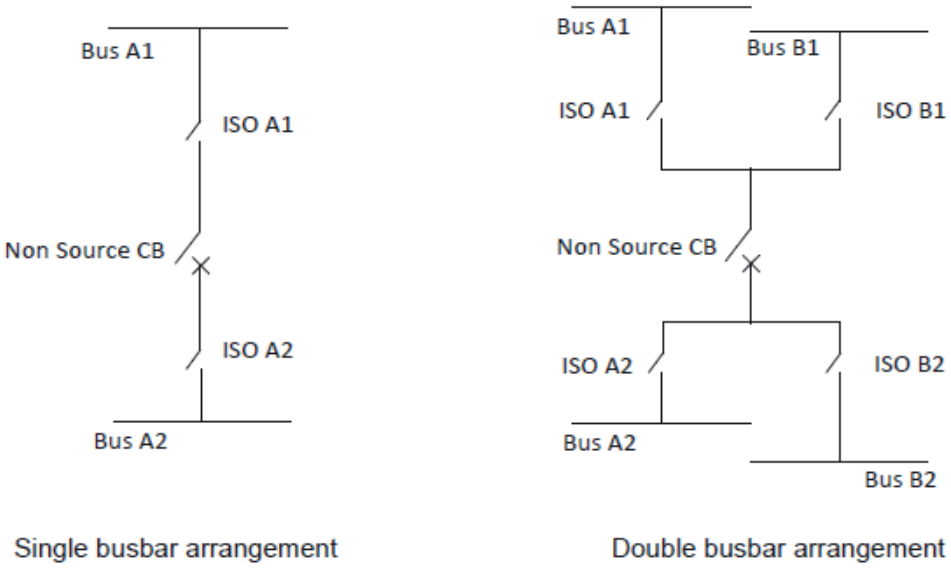



*Figure 57: Terminology used in a typical topology containing a non-generator circuit breaker*

*Figure 58* presents the terminology used in a typical topology for different busbar arrangements containing a GCB. It only depicts the logical connections and does not represent any primary network.

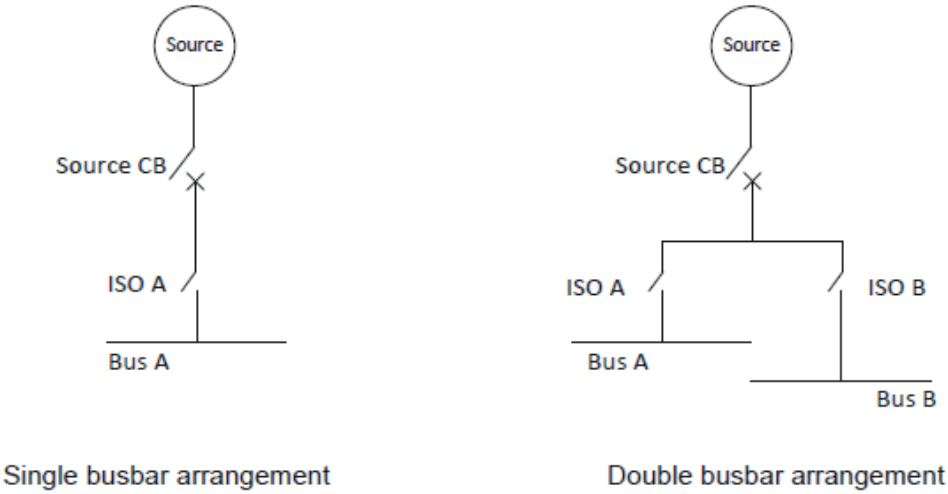



*Figure 58: Terminology used in a topology containing a generator circuit breaker*

## 5.3.2 Configuring autosynchronization scheme

If Autosynchronization Configuration has already been used to successfully generate an autosynchronization configuration, relaunching the tool loads the previously made configuration to the respective pages. Any existing connections in Application Configuration or settings in Parameter Setting made to ASGCSYN, ASNSCSYN or ASCGAPC must be reconfigured as they are removed from the configurations of the respective relays after relaunching Autosynchronization Configuration.

1. In the **Plant Structure**, right-click **Substation** or **IED Group** and select **Configure Autosynchronization**.

   Configure Autosynchronization can be opened only if there are at least two relays in the PCM600 project: one with the Generator autosynchronizer application package and the other with the Network autosynchronizer application package. No other tools should be open in PCM600.

2. On **Welcome Page** , click **Next** to configure first the topology for NSCBs and then for GCBs.
3. On the **Non-generator Configuration** page, configure the topology by adding, removing or clearing NSCBs.

   The page displays the relays from the PCM600 project setup that support the Network autosynchronizer application package. It is possible to synchronize up to 17 NSCBs in the configuration.

   - **IED Name**: Shows a list of relays with non-generator capabilities that can be selected and added to the configuration
   - **IP Address**: Shows the IP address of the selected non-generator (read only)
   - **Non-generator CB ID**: Shows an autogenerated non-generator circuit breaker ID to identify the breaker in the SLD preview controlled by the relay (read only)
   - **Breakers**: Used to specify the number of breakers a relay can control

- **Bus A1**: Used to specify the Bus A1 value for a non-generator in a single bus system
- **Bus A2**: Used to specify the Bus A2 value for a non-generator in a single bus system
- **Bus B1**: Used to specify the Bus B1 value for a non-generator in a double bus system
- **Bus B2**: Used to specify the Bus B2 value for a non-generator in a double bus system

Bus A1 and Bus A2 are mandatory to configure for non-generators. Use unique values in Bus A1, Bus A2, Bus B1 and Bus B2 for a given non-generator.

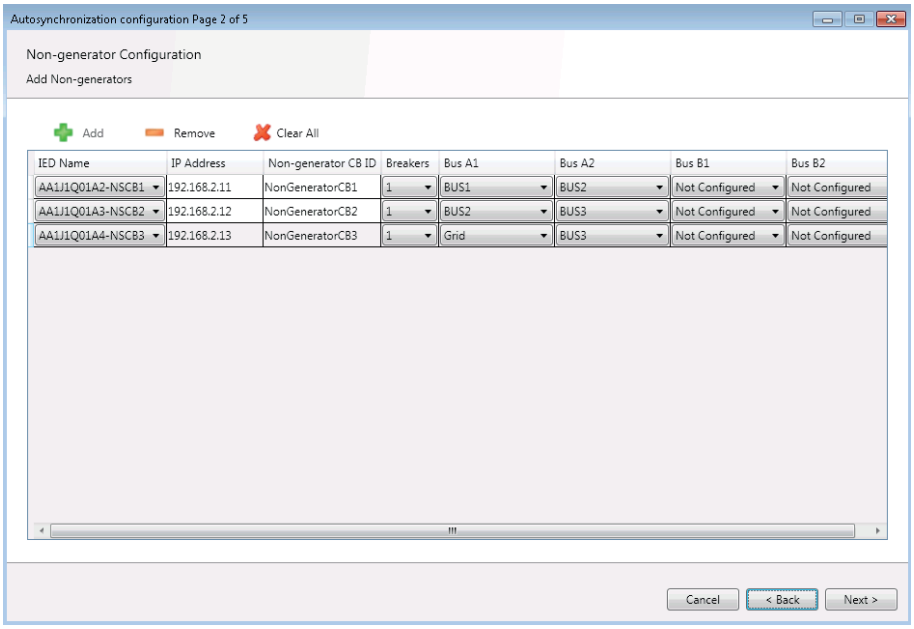



*Figure 59: Configuring the topology for non-generator circuit breakers*

4. Correct any invalid selections highlighted in yellow to be able to proceed and click **Next**.

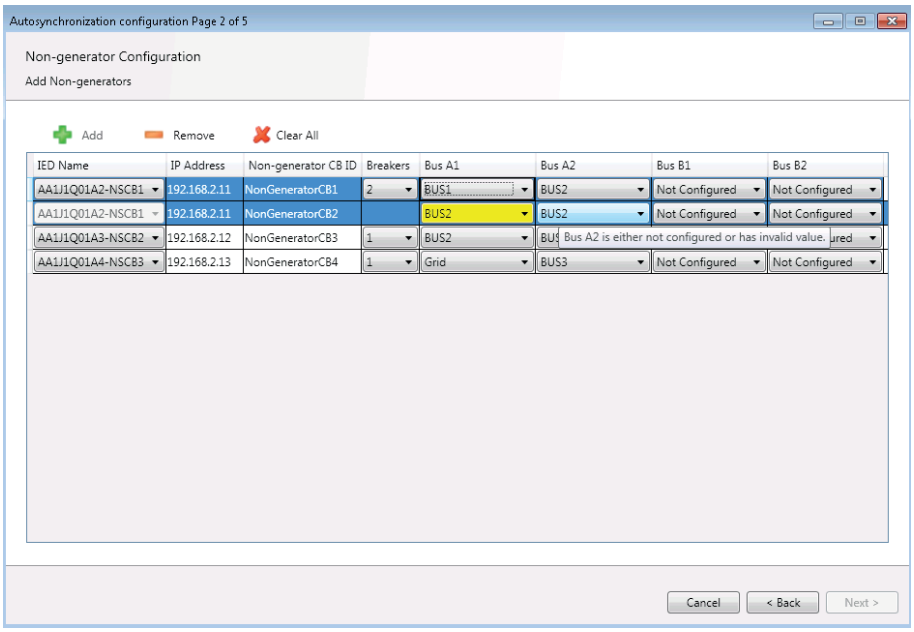



*Figure 60: Correcting invalid non-generator circuit breaker selections*

5. On the **Generator Configuration** page, configure the topology by adding, removing or clearing GCBs.

   The page displays the relays from the PCM600 project setup that support the Generator autosynchronizer application package. It is possible to synchronize up to eight GCBs to the configuration.

   - **IED Name**: Shows a list of relays with generator capabilities that can be selected and added to the configuration
   - **IP Address**: Shows the IP address of the selected generator (read only)
   - **Generator Name**: Used to specify a user-defined name for the generator
   - **Bus A**: Used to specify the Bus A value for a generator in a single bus system
   - **Bus B**: Used to specify the Bus B value for a generator in a double bus system

   Bus A and Generator Name are mandatory to configure for generators. Use unique values in Bus A and Bus B for a given generator.

   The value in Generator Name is later shown in the SLD preview and the REX640 LHMI dialog where the synchronization for NSCBs is initiated. The generator name can be modified in this field only.

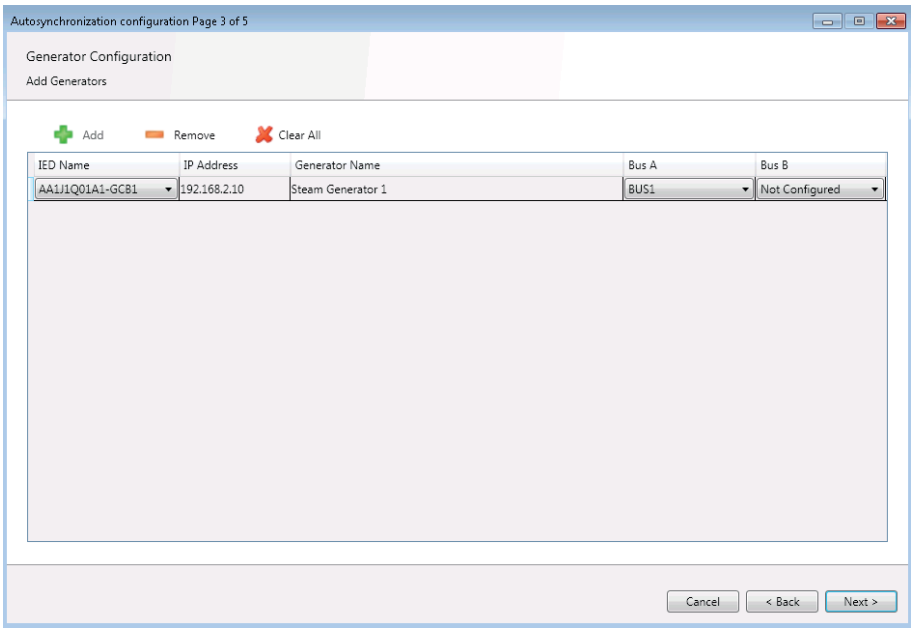



*Figure 61: Configuring the topology for generator circuit breakers*

6. Correct any invalid selections highlighted in yellow to be able to proceed and click **Next**.

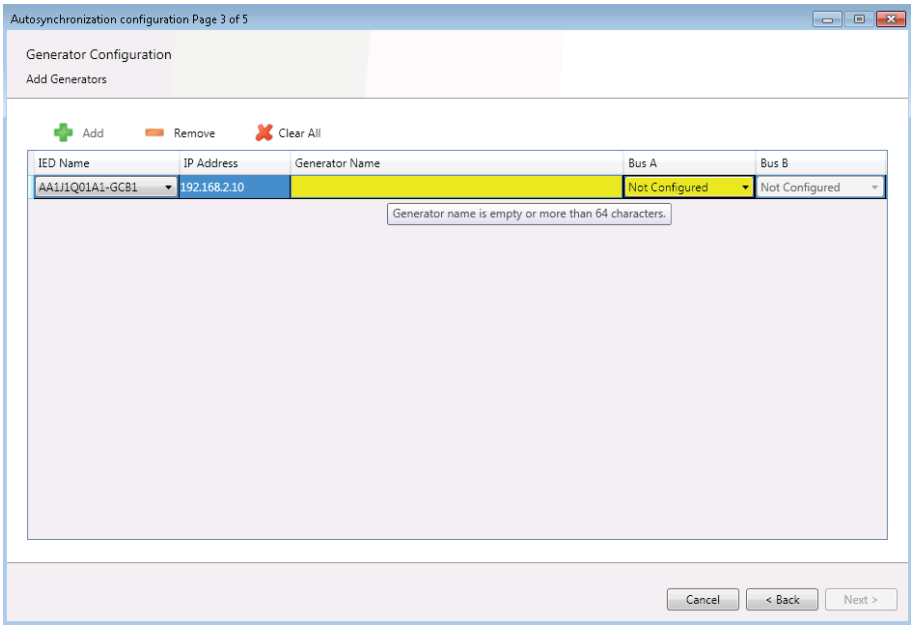



*Figure 62: Correcting invalid generator circuit breaker selections*

7. On **Summary Page**, verify the configuration with the SLD preview and click **Next**.

   The page shows an SLD based on the network topology entered in the previous pages and a report regarding the configuration changes made along with their impact on the relays. *Figure 63* shows a part of the page which displays the SLD generated based on the case presented in the *Chapter 5.3.1 Example case*.

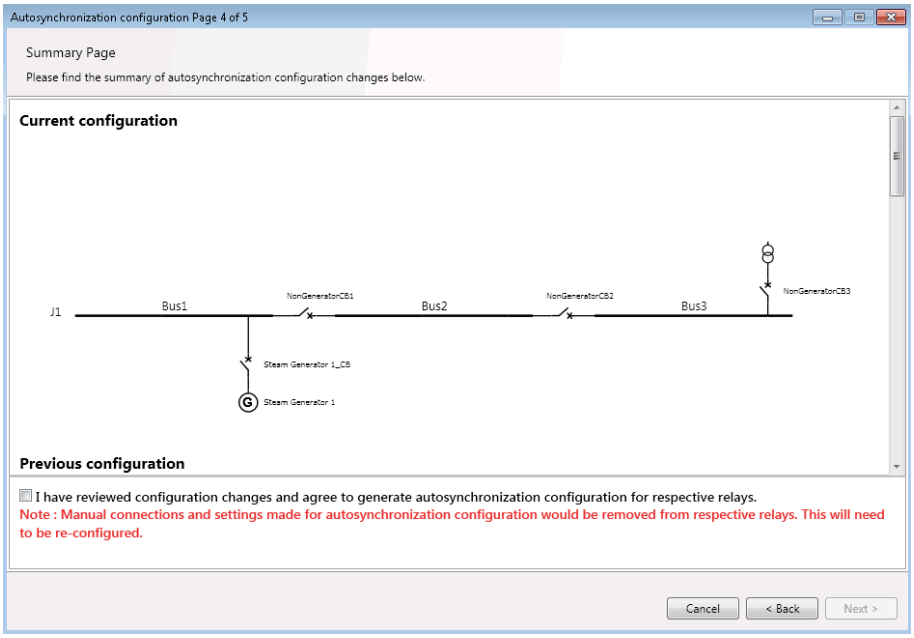



*Figure 63: SLD preview for the example case*

If the SLD preview is compressed and not properly visible, double-click the SLD to open the preview in a separate dialog with zoom buttons and scroll bars.

The autosynchronization configuration for ASGCSYN, ASNSCSYN and ASCGAPC is modified in Application Configuration, Parameter Setting and GOOSE engineering.

8. Verify the configuration made against the SLD preview and click **Next** to initiate the generation of autosynchronization configuration for the respective relays.

In case Autosynchronization Configuration has already been used to complete the configuration, the impact of configuration changes for each relay is shown on Summary Page. Review the configuration changes by comparing the SLDs of the current and previous configurations before initiating the configuration generation.

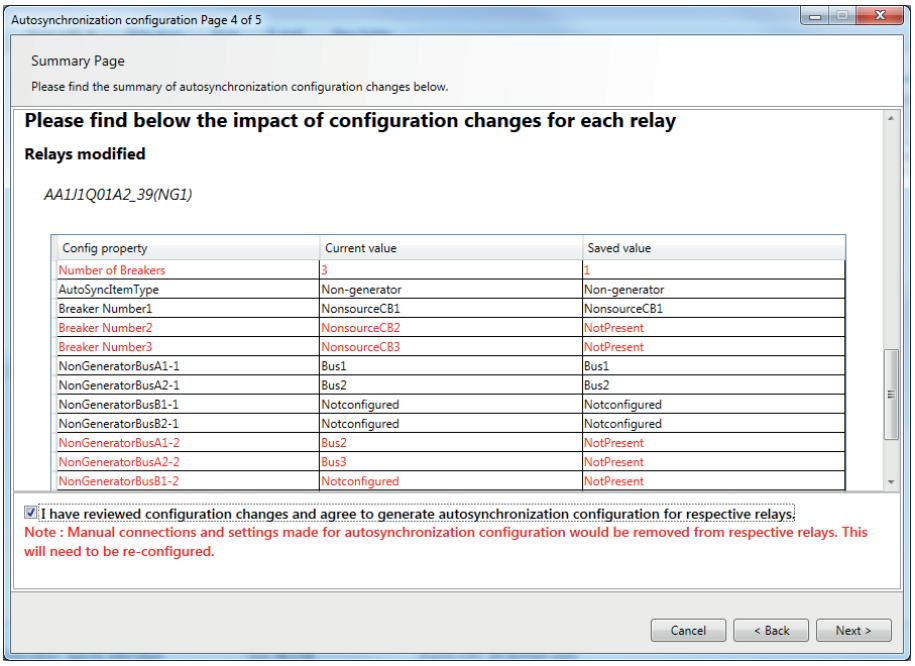



*Figure 64: Reviewing configuration changes*

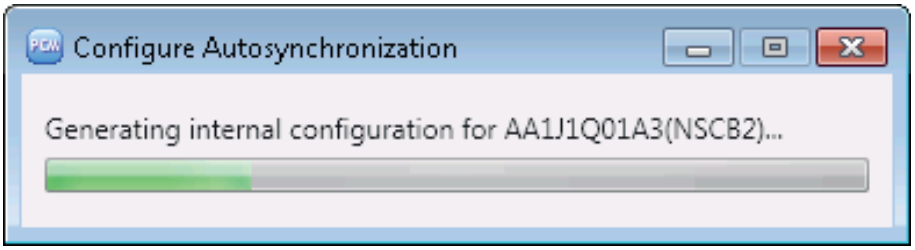



*Figure 65: Generating configuration*

9. On **Finish Page**, click **Finish** to close the tool.

   The page displays the configuration created as an SLD and the status of the autosynchronization configuration generation.

*Figure 66: Finish Page*

## 5.3.3 Finalizing of generated autosynchronization configuration

Configure Autosynchronization generates a partial configuration in Application Configuration and Parameter Setting and a complete GOOSE engineering for the

function blocks ASGCSYN, ASNSCSYN and ASCGAPC. The remaining connections for voltage measurements and other inputs and outputs need to be handled manually in PCM600.

For functional details, see the technical and application manuals.

With reference to the example given in the *Chapter 5.3.1 Example case* chapter, the following figures show the partial configuration generated by the tool in PCM600.

*Figure 67* shows the Application Configuration view of the relay controlling NSCB1. Similar connections are also generated for the other relays. The connections for the function blocks shown in the figure should be completed next.

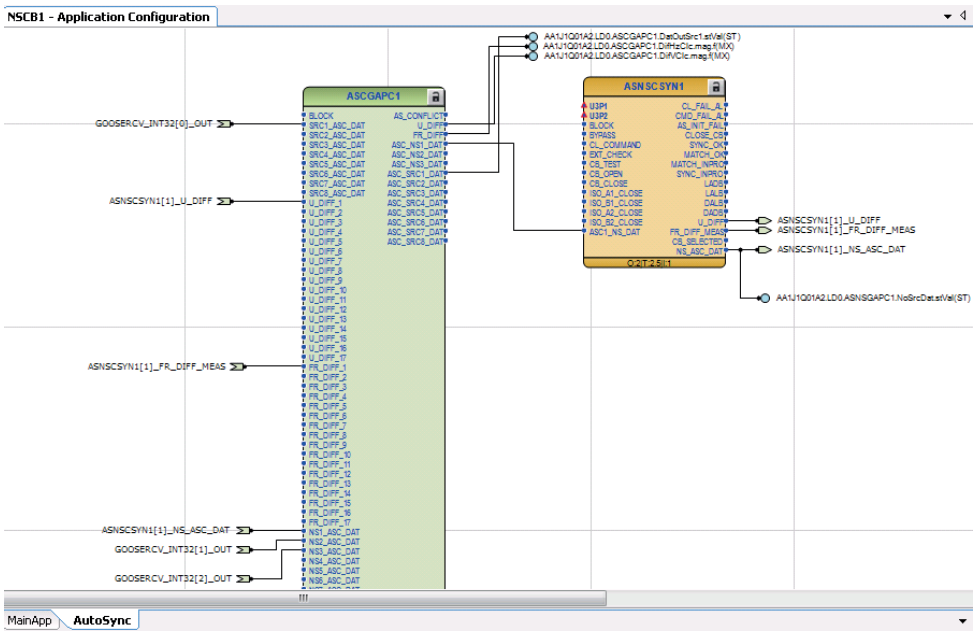



*Figure 67: Application Configuration view of relay controlling NSCB1*

*Figure 68* shows part of the Parameter Setting view of ASCGAPC of the relay controlling NSCB1. Similar settings are also made for ASCGAPC in other relays. The other settings for ASGCSYN, ASNSCSYN and ASCGAPC should be checked and modified, if needed.

NSCB1 - Parameter Setting

| Group / Parameter Name | IED Value | PC Value | Unit | Min | Max |
|---|---|---|---|---|---|
| Operation | | on | | | |
| ASC CB Num1 | | Non source CB 1 | | | |
| ASC CB Num2 | | Not Configured | | | |
| ASC CB Num3 | | Not Configured | | | |
| Max matching time | | 60000 | ms | 100 | 6000000 |
| Central PMS present | | No | | | |
| Double busbar | | False | | | |
| Setting Group 1 | | | | | |
| Number of sources | | 1 | | 1 | 8 |
| Number of NonSrc CB | | 3 | | 1 | 17 |
| Src1 bus A Num | | Bus 1 | | | |
| Src1 bus B Num | | Not Configured | | | |
| NonSrc1 bus A1 Num | | Bus 1 | | | |
| NonSrc1 bus A2 Num | | Bus 2 | | | |
| NonSrc1 bus B1 Num | | Not Configured | | | |
| NonSrc1 bus B2 Num | | Not Configured | | | |
| NonSrc2 bus A1 Num | | Bus 2 | | | |
| NonSrc2 bus A2 Num | | Bus 3 | | | |
| NonSrc2 bus B1 Num | | Not Configured | | | |
| NonSrc2 bus B2 Num | | Not Configured | | | |
| NonSrc3 bus A1 Num | | Grid | | | |
| NonSrc3 bus A2 Num | | Bus 3 | | | |

*Figure 68: Partial Parameter Setting view of ASCGAPC in the relay controlling NSCB1*

*Figure 69* shows the GOOSE data sets generated by the tool containing all the entries required to be exchanged among the relays for the autosynchronization process. No further user actions are required regarding the GOOSE engineering for the autosynchronization process. However, GOOSE data exchange for any other logic or scheme may be handled manually.

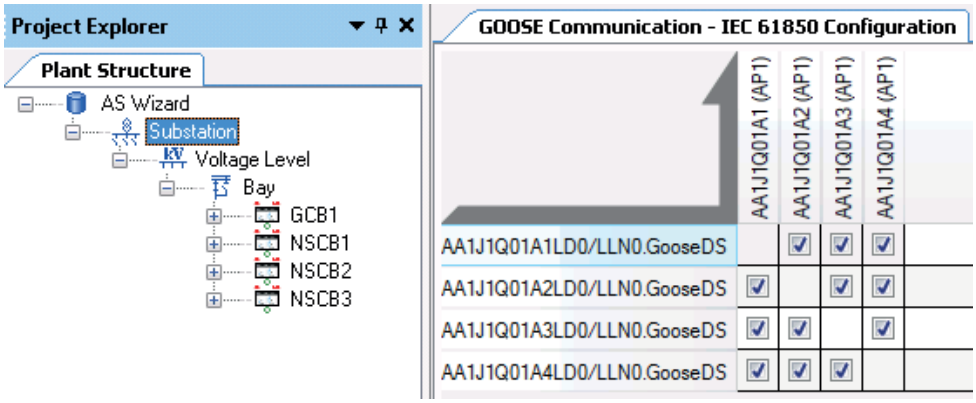



*Figure 69: GOOSE data sets in IEC 61850 Configuration*

## 5.4 Signal Matrix

Signal Matrix is used to make cross-references between the physical I/O signals, function blocks and SMV and for the GOOSE signal input engineering.

Application Configuration is used for adding or removing function blocks, for example, GOOSE receiving function blocks.

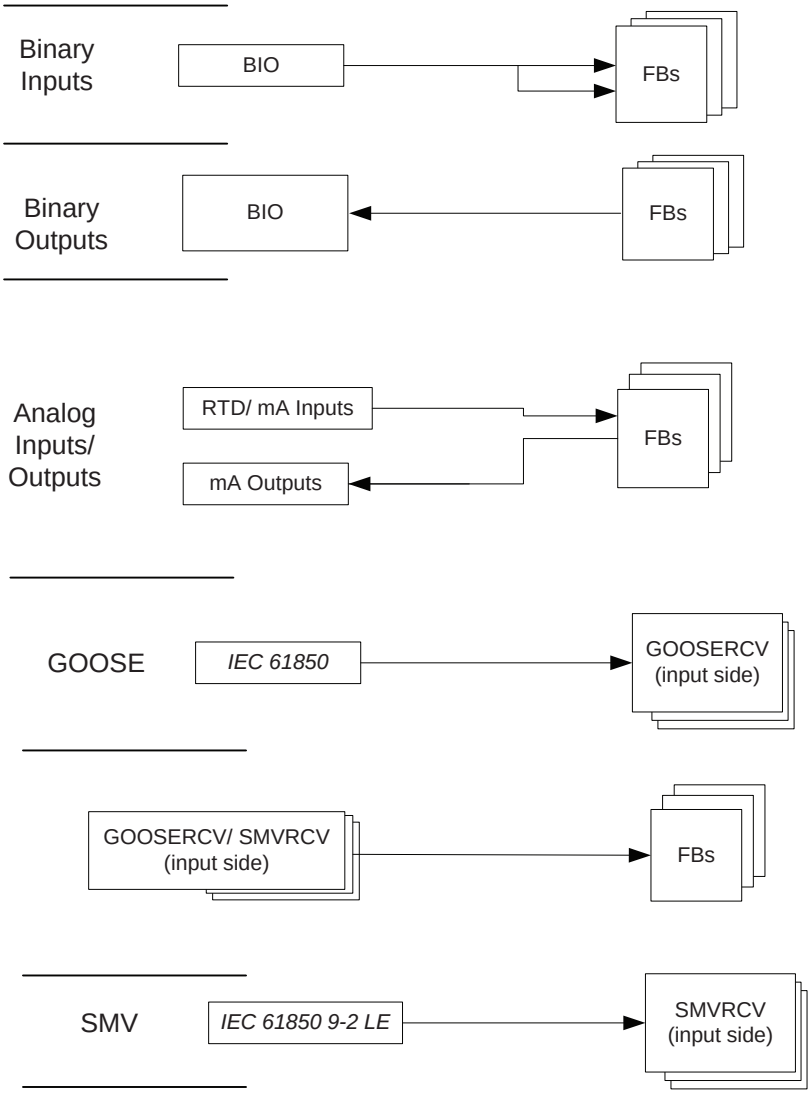



*Figure 70: Signal Matrix: operation principles*

A binary input channel can be connected to one or more function block inputs. If a binary input channel is connected to several different function blocks in the Application Configuration tool, the connection appears as glue logic in Signal Matrix.

A binary output channel can only be activated from one function block output. If it is activated from more than one function block output, the glue logic has to be used.

Glue logic means inserting a logical gate (OR and AND blocks) between the binary input and the function blocks or between the function blocks and the binary output channel. This can be engineered with the Signal Matrix.

Connections made with Signal Matrix are automatically shown in Application Configuration.

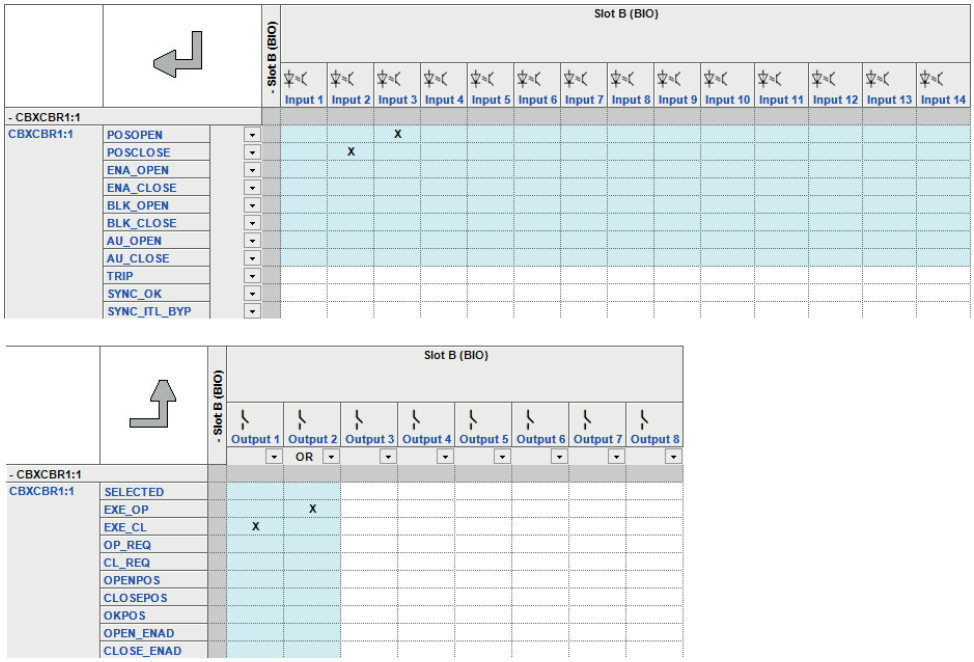



*Figure 71: Signal Matrix: a connection between binary input channels to binary input signals*

Each SMVRCV block used in Application Configuration needs to be connected to the desired SMV stream in Signal Matrix. Connections need to be one-to-one and unconnected SMVRCV blocks are not allowed.

Signal Matrix has a separate sheet for each possible combination.

- Binary inputs
- Binary outputs
- Analog inputs
- GOOSE
- SMV

## 5.5 Load Profile tool

Load Profile tool is used for reading load profile records of COMTRADE format from a protection relay, clearing old records and viewing records via an external COMTRADE viewer. The default viewer included with PCM600 is Wavewin, but a third-party viewer can be used.

### 5.5.1 Opening and closing Load Profile tool

- To open the Load Profile tool, right-click an IED in the PCM600 project tree and select **Load Profile Tool**.
- To close the Load Profile tool, click Close in the tool. The Load Profile tool runs in the same process as PCM600 but in a separate window. Multiple instances of the tool can be run at the same time. Any open tool instances are closed without confirmation when PCM600 is closed.

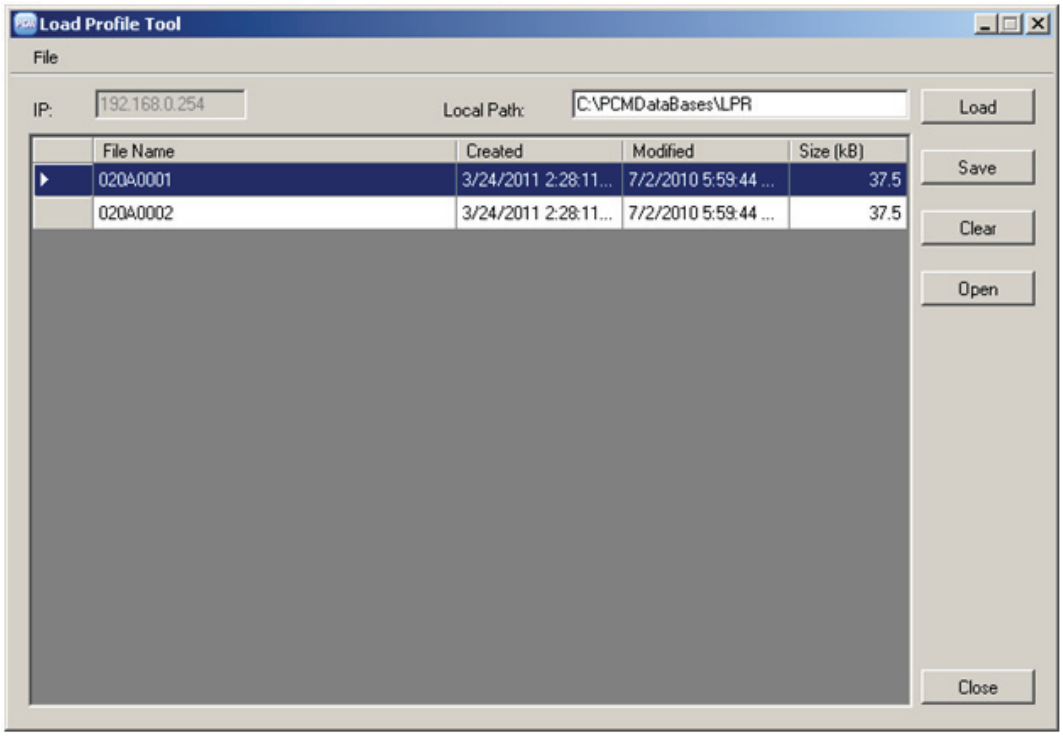



*Figure 72: Load Profile tool*

By default, the Load Profile tool uses the `\PCMDataBases\LPR` directory as a saving target directory.

## 5.5.2 Load Profile tool user interface

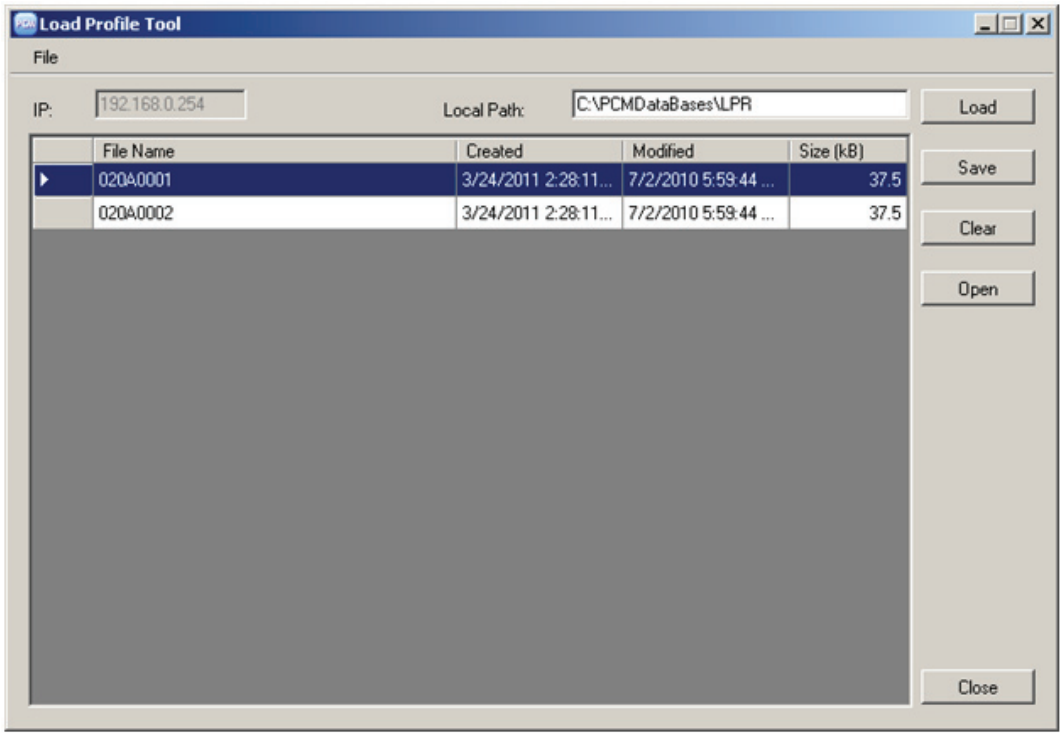



*Figure 73: Load Profile tool interface*

**Table 3: Available actions on the user interface**

| Action | Description |
|---|---|
| Local Path | Default local path (`C:\PCMDataBases\LPR`) is the location from which the records are shown on the Load Profile tool. It is also the default path for saving records. The location where the records are saved can be changed in the Local Path field. The grid of the Load Profile tool shows only the records in the default local path including any unsaved records in `C:\Temp\Load\Profile Tool`. Therefore records can be saved at a user-specified location on the local machine but those records are not visible in the grid of the Load Profile tool. |
| Load | Clicking Load downloads all available records from `C:\LDP\COMTRADE` directory in the protection relay to a temporary folder `C:\Temp\Load-ProfileTool` on the local machine. In this temporary folder, the target file name is constant, and loading again overwrites the file. An unsaved record is deleted when the tool is closed. |
| Save | Clicking **Save** moves the records to the default or specified local path, **Load** transfers the records to a temporary folder. Each load profile record comprises two files with file extensions .dat and .cfg.<br>Clicking **Save** adds a time stamp to the file names and moves the two files pertaining to the record to the default or specified folder. Saving another record creates a new record in addition to the old ones. |
| Clear | Clicking **Clear** clears the record from either the Load Profile tool or protection relay or both. Before deleting the records, a confirmation dialog box is shown. |

*Table continues on the next page*

| Action | Description |
|---|---|
| Open | Clicking **Open** opens any selected record to be viewed in Wavewin, provided that this external software is installed. Additionally, any record row can be double-clicked to view that record. |
| Sort | Record rows can be sorted by any column by clicking the column header. |
| Close | Clicking **Close** closes the tool instance. All open tool instances are closed when PCM600 is closed. |
| File | All the actions are also available on the **File** menu. |

### 5.5.3 Information fields

The **IP** box shows the IP address of the selected IED and the **Local Path** box shows the selected location for reading or viewing records.

The record grid shows the name, creation time, modification time and size of each record. The times and dates shown in the grid are the times when the files have been read rather than the original date stamps in the device.

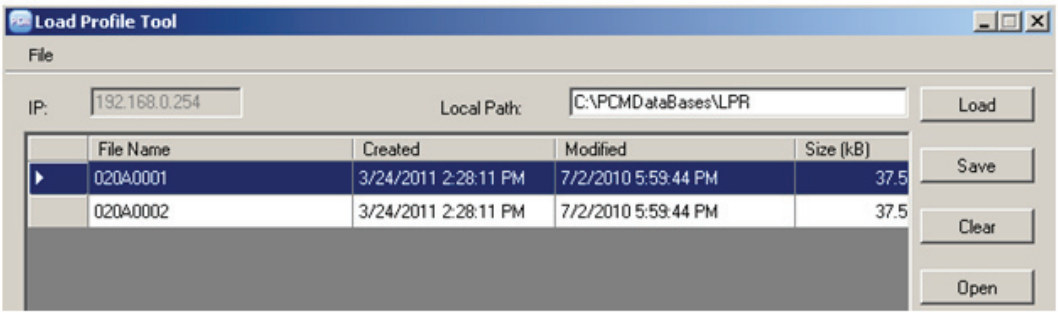



*Figure 74: Information fields*

## 5.6 Fault Record tool

The Fault Record tool is used for reading the fault records from the protection relay. The tool makes analyzing the fault records easier by showing them separately in their own user control components. It also includes save, copy and clear functions where all the fault records are saved or copied in text format for later viewing or cleared from the protection relay or the tool.

The fault record is saved to a local PC with the default name `FaultRecords.txt`. Rename the file before saving it to avoid overriding the old record.

### 5.6.1 Opening and closing Fault Record tool

- To open the Fault Record tool, right-click an IED node in the PCM600 project tree and select **Fault Record Tool**.

- To close the Fault Record tool, click the **Close** button in the tool.

  The Fault Record tool runs in the same process as PCM600 but in a separate window. Multiple instances of the tool can be run at the same time. Any open tool instances are closed without confirmation when PCM600 is closed.

The main functionality is divided into three parts: reading the fault record parameters from the protection relay, displaying their names, values and units on the user interface and saving them to a text file. It is also possible to clear all the fault records from both the tool and the protection relay and copy the fault records either individually or all at once to a word processor.

## 5.6.2 Fault Record tool interface

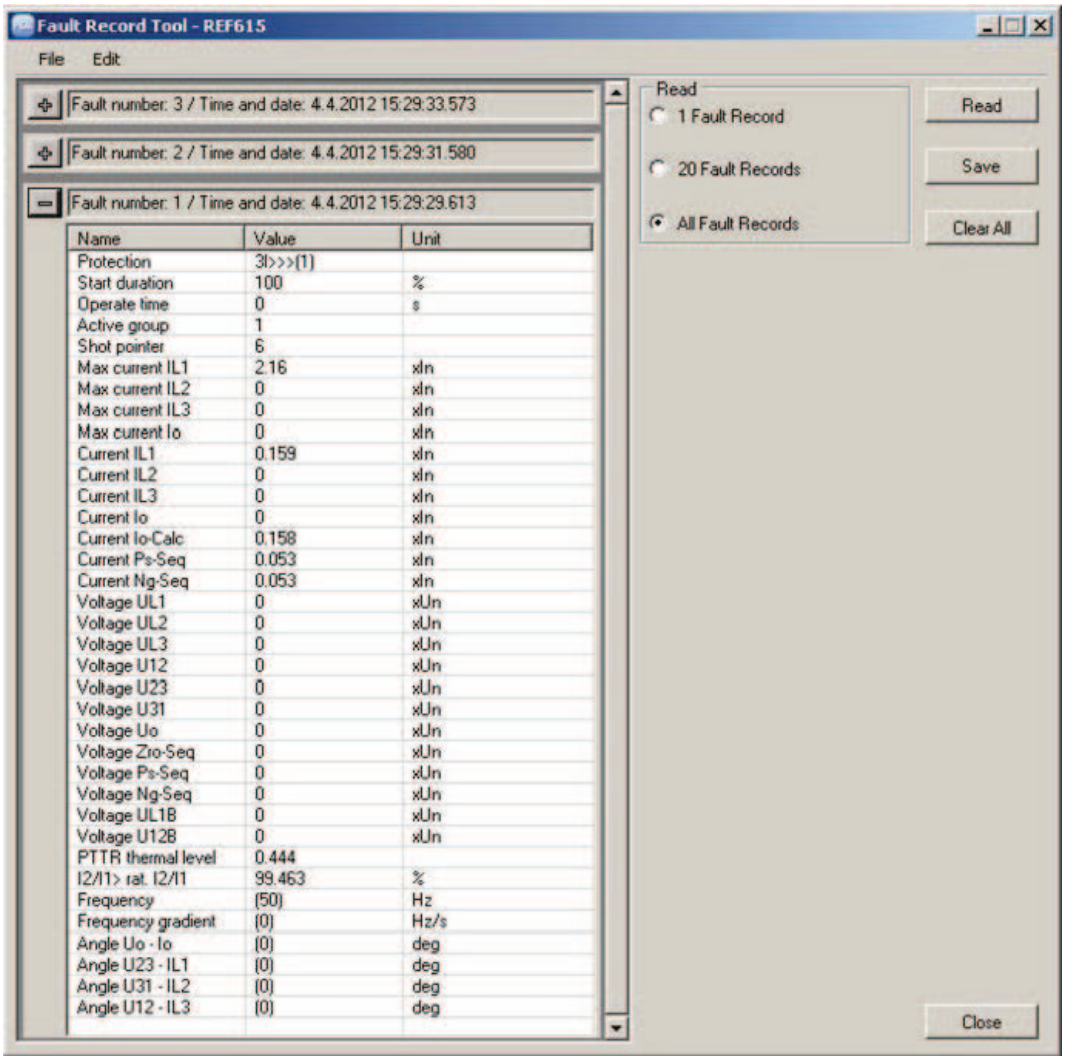



*Figure 75: Fault record tool*

**Table 4: Available actions on the user interface**

| Action | Description |
|---|---|
| Read | Clicking **Read** reads all available fault records from the protection relay into the tool. One fault record, 20 fault records or all fault records can be read. The **Read** button opens up a progress bar to indicate an ongoing read operation.<br>Clicking **Cancel** on the Read progress bar cancels the read operation. On operation completion, the available fault records are shown in the record grid.<br>Click the **+** icon to expand and view record details.<br>Clicking the **+** icon expands the record details for viewing. |
| Save | Clicking **Save** saves the fault records on the local machine as .txt file. |
| Clear | A record can be cleared from the Fault Record tool, the protection relay or both. Before deleting the records, a confirmation dialog box is shown. |
| Close | Clicking **Close** closes this instance of the Fault Record tool. All open instances are closed when PCM600 is closed. |
| File | **File** menu for **Save** and **Exit** actions. |
| Edit | **Copy All** in the **Edit** menu allows to copy all the fault records which can then be pasted to a word processor and saved on the local machine without having to save the records as a .txt file.<br>Additionally the user can select any particular fault record and right-click to copy the selected record. |

## 5.7 IED Compare

IED Compare is used to compare the IED configurations of two IEDs of the same type. It generates a text report which lists the differences between the IED configurations. IED Compare provides an option to compare an IED configuration stored in PCM600, IED or .pcmi file. IED Compare can compare certain types of IED configurations and parameters.

- Application configuration
- Display configuration
- GOOSE receive configuration
- Parameters



Application comparison also compares the system function blocks.



Display comparison compares the LHMI page configurations.



Detailed instructions are shown in PCM600 documentation.

## 5.7.1 Starting IED Compare

- Start **IED Compare** in the shortcut menu in plant structure.
  a) In the PCM600 plant structure, right-click **Substation**, **Voltage level**, **Bay** or **IED**.
  b) Select **IED Compare**.
- Start **IED Compare** from the PCM600 main menu.
  a) Select **Substation**, **Voltage level**, **Bay** or **IED** in the PCM600 plant structure.
  b) On the PCM600 menu bar, point to **Tools** and select **IED Compare**.

## 5.7.2 IED Compare tool interface

The comparison report shows differences in the configuration of two IEDs. Hardware, application, display, GOOSE and parameter configuration differences are grouped and listed under the corresponding headings.

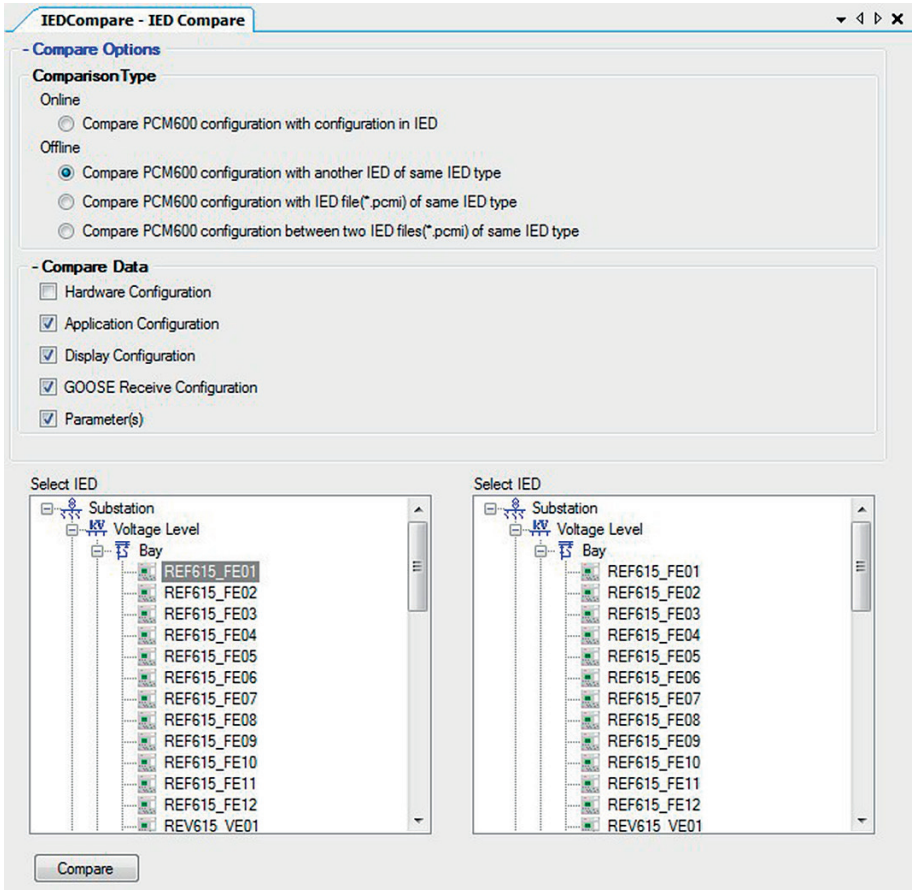



*Figure 76: Compare options*

Each configuration group can be expanded or collapsed by clicking the plus (+) or minus (-) button next to it in the result grid.

The reports must be read from left to right row-wise.

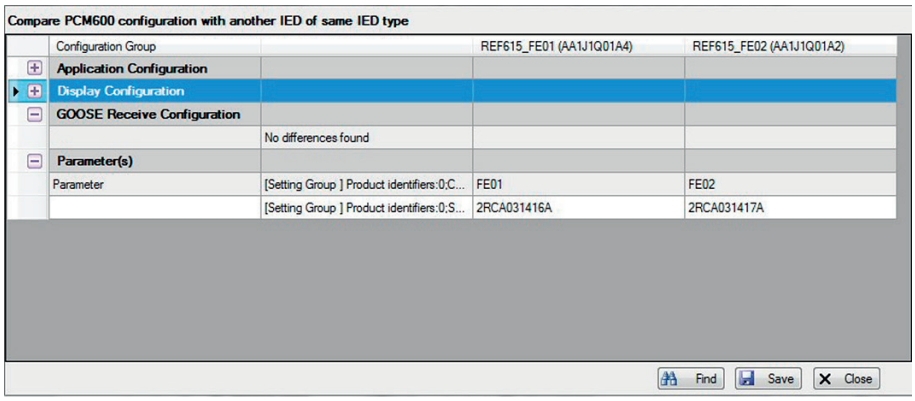



*Figure 77: Compare report*

**Table 5: Acronyms used in a report**

| Acronym | Description |
|---|---|
| DA | Data attribute |
| DO | Data object |
| IED | Intelligent electronic device |
| LN | Logical node |
| SIG | Signal |

## 5.8 Protection and control blocking examples

*Test mode* is selected through one common parameter via the HMI path **Tests** > **IED test**. By default, *Test mode* can only be set locally through LHMI. *Test mode* is also available via IEC 61850 communication (LD0.LLN0.Mod).

**Table 6: Test mode**

| Test mode | Description | Protection BEH_BLK |
|---|---|---|
| Normal mode | Normal operation | FALSE |
| IED blocked | Protection working as in Normal mode but ACT configuration can be used to block physical outputs to process. Control function commands are blocked. | TRUE |
| IED test | Protection working as in Normal mode but protection functions work in parallel with test parameters. | FALSE |
| IED test and blocked | Protection working as in Normal mode but protection functions work in parallel with test parameters. ACT configuration can be used to block physical outputs to process. Control function commands are blocked. | TRUE |

The mode of all logical nodes located under the CTRL logical device is set with *Control mode*. *Control mode* is selected via the HMI or PCM600 path **Configuration** > **Control** > **General**. By default, *Control mode* can only be set

locally through LHMI. *Control mode* inherits its value from *Test mode* but *Control mode* "On", "Blocked" and "Off" can also be independently set. *Control mode* is also available via IEC 61850 communication (CTRL.LLN0.Mod).

**Table 7: Control mode**

| Control mode | Description | Control BEH_BLK |
|---|---|---|
| On | Normal operation | FALSE |
| Blocked | Control function commands blocked | TRUE |
| Off | Control functions disabled | FALSE |

According to IEC 61850, the physical outputs to process should be blocked when the device is set to blocked or test blocked mode. The blocking logic must be implemented in the ACT configuration. In the protection blocking example the main trip from TRPPTRC1 is blocked, and in the control blocking example CBXCBR1 is blocked. Both comply with IEC 61850. In real applications some PTRCs might also be used for signalling purposes (GOOSE) and blocking and interlocking via I/O.

## 5.8.1 Protection blocking example

The physical outputs to process can be blocked with "IED blocked" and "IED test and blocked" modes. If physical outputs need to be blocked, the application configuration must block the signals or the function blocks that affect primary apparatuses. The blocking scheme needs to use the `BEH_BLK` output of the PROTECTION function block.

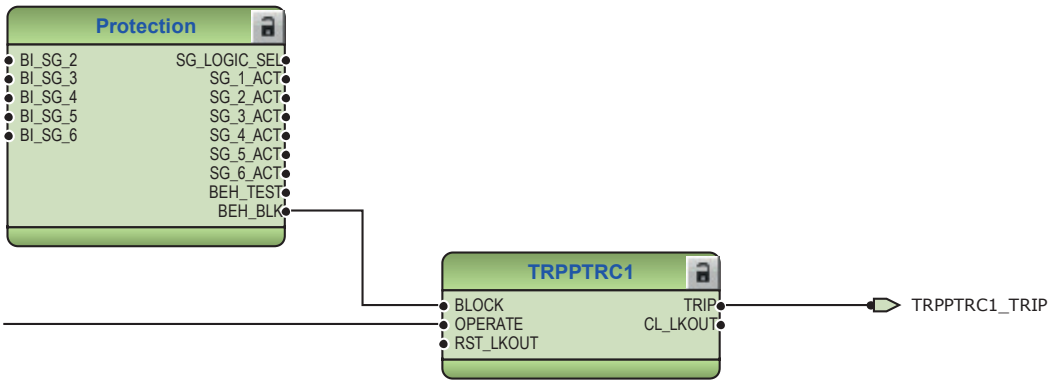



*Figure 78: Master trip TRPPTRC blocked using Protection function block `BEH_BLK` output*

## 5.8.2 Control blocking example

The physical outputs to process can be blocked with "Blocked" mode. If physical outputs need to be blocked, the application configuration must block signals or function blocks that affect primary apparatuses. Blocking scheme needs to use `BEH_BLK` output of CONTROL function block.

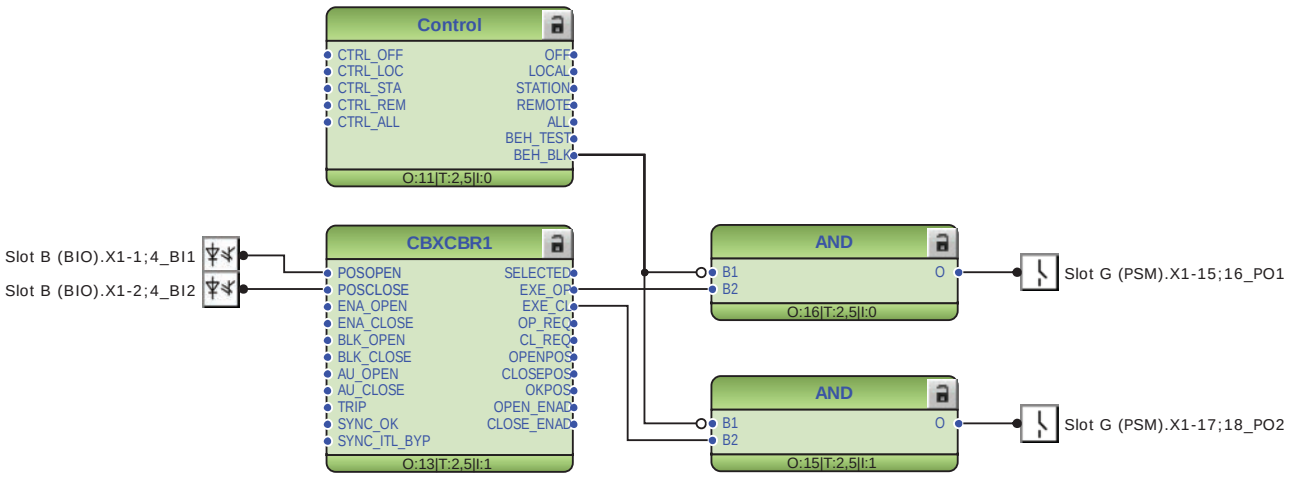



*Figure 79: Circuit breaker control CBXCBR1 blocked using Protection function block BEH_BLK output*

# 6 HMI engineering

## 6.1 Graphical Display Editor

Graphical Display Editor is used to configure the protection relay's HMI pages.

Graphical Display Editor can be used to create new pages, configure pages by adding widgets, set page visibility to different user categories, create single-line diagrams and symbols and provide language translations.

### 6.1.1 Creating complete local HMI page configuration

- Configure the protection relay functions such as protection, measurements and control functions with Application Configuration. The configuration made in Application Configuration can be saved to make the interfaces and signals available for other engineering tools within PCM600 such as Parameter Setting or Graphical Display Editor.
- Make connections between the application configuration function blocks and physical hardware inputs and outputs by using Signal Matrix or Application Configuration.
- Configure HMI pages by using Graphical Display Editor. Create new pages, configure the pages by adding widgets, set page visibility to different user categories, create single-line diagrams shown on the LHMI and WHMI and symbols, and provide language translations for the added LHMI elements.

  1. To configure the single-line diagram, check if any new symbols are required in addition to the default symbols in SLD Editor. Use Symbol Editor to create the missing symbols.
  2. Use SLD Editor to create a single-line diagram. Add bus bars, symbols and texts and create links between the symbols. Link the dynamic symbols to the corresponding function blocks in the application configuration. The function blocks control the objects represented by symbols on the HMI. Add 10 SLD pages at the maximum.
  3. Use Page Organizer to configure the main screen of HMI and to create main pages and linked pages by using the predefined ABB built-in pages and template pages. Set also the page visibility to Basic or Advanced access rights and define unique page names.
  4. Use Page Editor to configure the main and linked pages and, for example, to add widgets.
  5. Use Language Translation to translate the configuration data text into different languages. Configuration data includes widget properties, page properties and symbol captions. If needed, add a new language from the list of languages supported by the relay and set the translated text for the language for available configuration.
  6. Save the configuration.
  7. Preview the configuration before writing it to the relay.
  8. Write the configuration to the relay.

### 6.1.2 Creating complete switchgear HMI configuration

- Configure HMI pages for all the relays that are intended to be connected to the SHMI. These steps are described separately.
- Configure bay overview for each relay by using Graphical Display Editor. Create SHMI pages, configure SLDViewPort or Image widgets, and create single-line diagrams shown on the SHMI navigation page.
  1. To configure a single-line diagram for the bay overview, create a single-line diagram in Switchgear HMI SLD Editor. Create an SHMI page in Page Organizer, add an SLDViewPort widget to the SHMI page, and select the previously drawn SHMI SLD to be shown.
  2. To configure an image for the bay overview, create an SHMI page in Page Organizer. Add an Image widget to the SHMI page, and select the image to be shown in the bay overview.
  3. Save the configuration and write the bay overview configuration to the relay.
  4. Close Graphical Display Editor.
- Create an SHMI object in the plant structure.
- Start Switchgear HMI Configuration from the SHMI object to configure the navigation page for the SHMI.
  1. Set the substation name, voltage level and switchgear name according to the project requirements.
  2. Ensure that all bay overviews under the Switchgear HMI Navigation Page Configuration section are presented as intended in the SHMI navigation page. The order of bays can be changed and any bay overviews unintended for the SHMI can be moved to the Unallocated bays overview section.
  3. Preview the navigation page to ensure that the result is correct.
- Set up a connection to the relays through a station network so that all the relays are reachable.
- Write the SHMI configuration to all allocated relays.

### 6.1.3 ABB built-in pages

The ABB built-in pages contain information and functionality which are common to most of the applications. Widget properties are usually fixed on these pages but some, such as measurement page and phasors page contents, can be modified.

#### 6.1.3.1 Measurements page

The Measurements page contains two configurable measurement lists. The buttons at the bottom of the page are used to navigate to other measurement-related pages: **Phasors**, **Load Profile**, **Harmonics** and **Temperatures**.

Only the **Measurements** and **Phasors** pages are user-configurable.

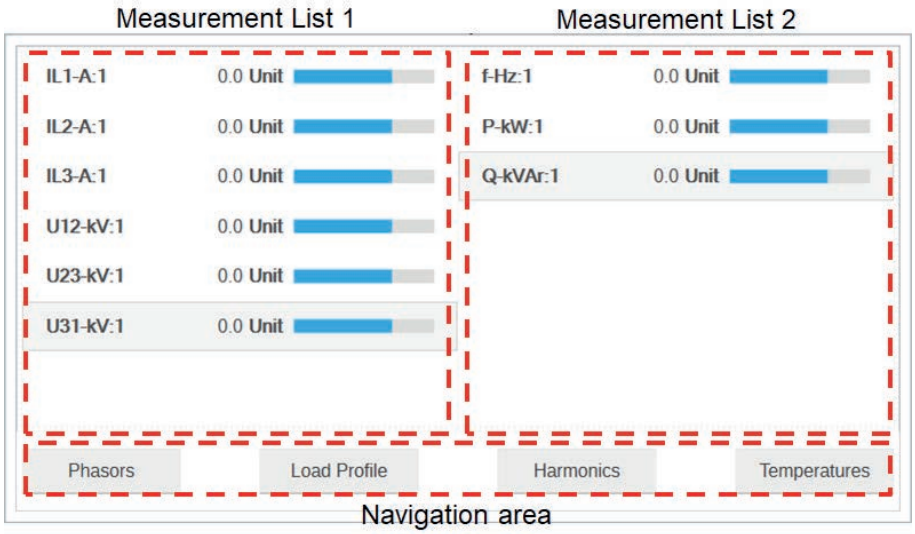



*Figure 80: Measurements page*

The **Measurements** page configuration data is also used by the WHMI, that is, even if the LHMI is not used with the relay, if the measurements need to be seen on the WHMI, the **Measurements** page configuration must be created in Graphical Display Editor.

**Adding and removing measurements**

1. In Page Editor, select the **Measurements** page and then select a measurement list by clicking it.
2. In the **Object Properties** pane, click **...** on the **listId** row to browse the available signals.

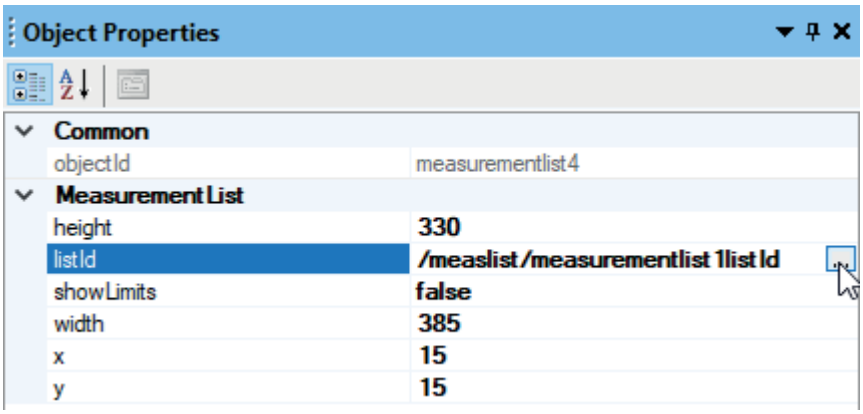



*Figure 81: Accessing the signals*

3. In the **Signal Group Selection** dialog, select check boxes to add the required signals or clear them to remove any unused signals.

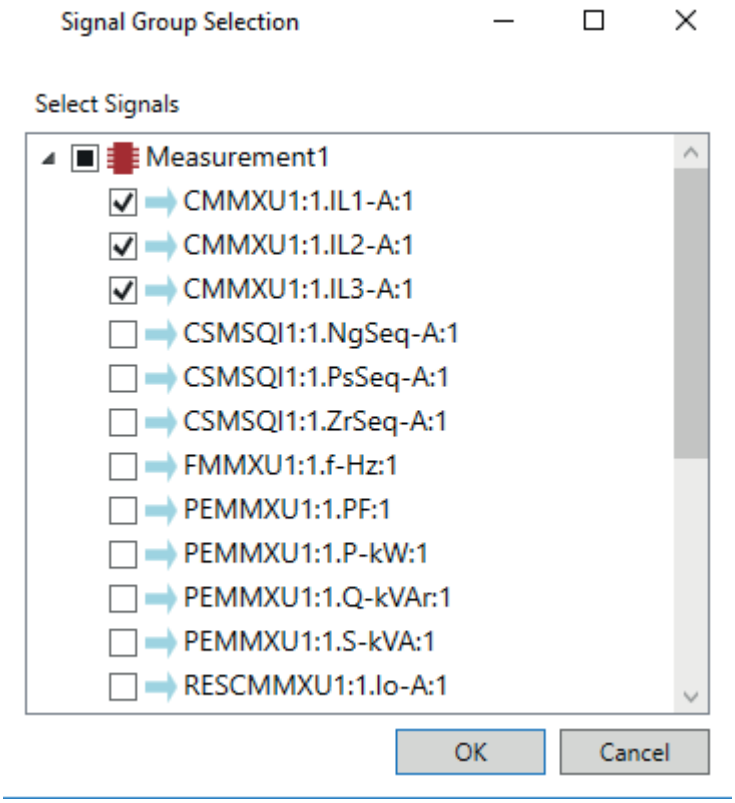



*Figure 82: Selecting signals*

4. Click **OK**.

### Configuring measurement items

The measurement limits, scaling and order can be independently configured in the Object Properties pane.

Click a measurement to select the measurement item. Then click the same item again to select the measurement list.

- Set the measurement properties.

  If the property value is set to "Automatic", the LHMI uses the value defined by the data model.

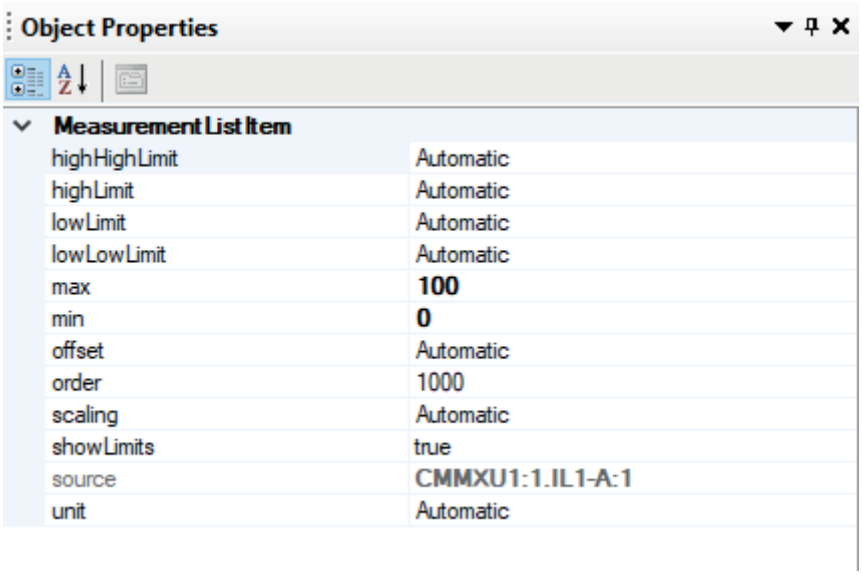



*Figure 83: Configuring measurement items*

- Apply custom scaling, if needed.
  1. In the **scaling** box, define the correct value which is a coefficient applied to the measurement value. The supported scaling is linear: new_value = read_measurement_value × scaling_property + offset_property.
  2. In the **offset** box, define the offset value.
  3. In the **unit** box, define the unit (string).
  4. Adjust the other limit properties to better fit the scaled measurement value.
- In the **order** box, define custom order for the measurements, if needed. The smaller the order property, the higher the measurement's position in the measurement list.

  By default, all measurement list items are arranged in alphabetical order. Modifying the order property overrides the default behavior.

### 6.1.3.2 Phasors page

By default, the Phasors page template available in Page Organizer contains an empty Custom signal group. Measurements can be added to the Custom signal group or new signal groups can be added and removed by opening the **Phasors** page in Page Editor.

#### Opening Signal Grouping Editor

1. In Page Editor, open the **Phasors** page.
2. Click  in the lower-right corner of the Phasors page.

   The **Signal Grouping Editor** dialog opens.

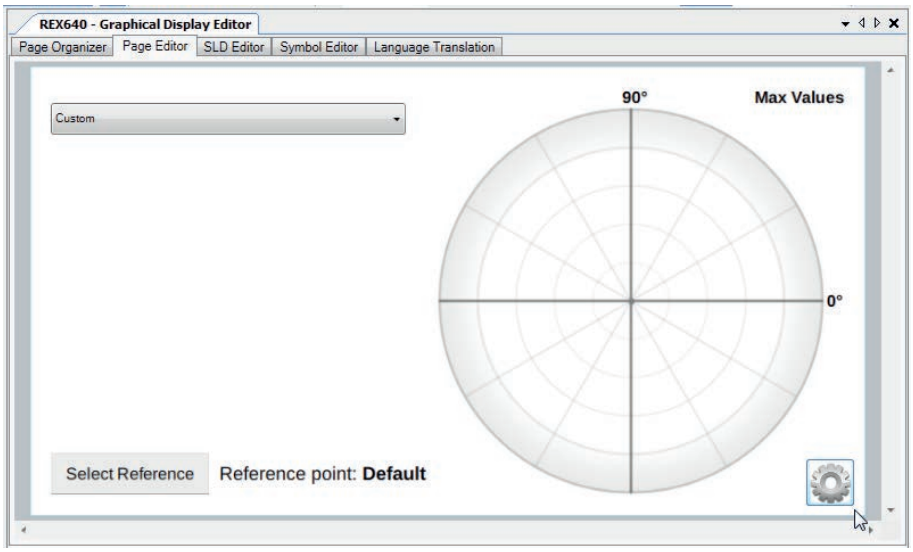



*Figure 84: Opening Signal Grouping Editor*

### Adding and removing signal groups

- Add a new signal group.
  1. In **Signal Grouping Editor** dialog, click **Add**.
  2. In **Enter Group Name** dialog, type the signal group name.
  3. Click **OK**.

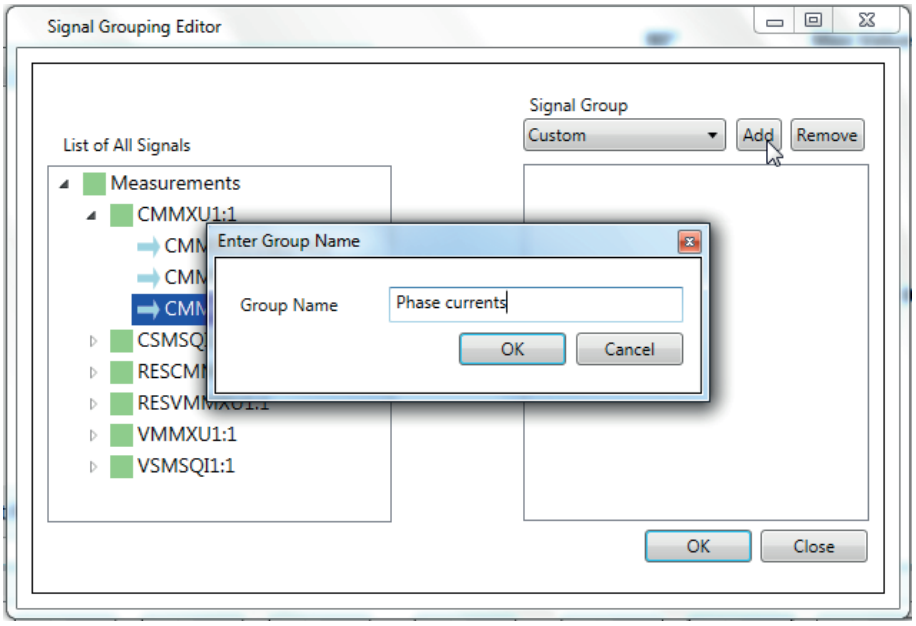



*Figure 85: Adding a signal group*

- Remove an existing signal group.
  1. In **Signal Grouping Editor** dialog, select a group from the **Signal Group** drop-down list.
  2. Click **Remove**.

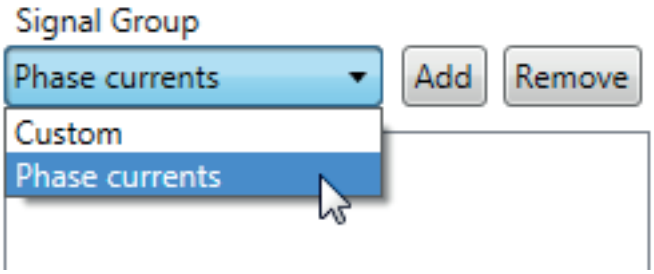



*Figure 86: Removing a signal group*

**Adding and removing signals**

- Add new signals.
  1. In **Signal Grouping Editor** dialog, select a group from the **Signal Group** drop-down list.
  2. In List of All Signals list, select the required signals and click .

     Add seven signals at the maximum to a single group.
  3. Click **OK**.

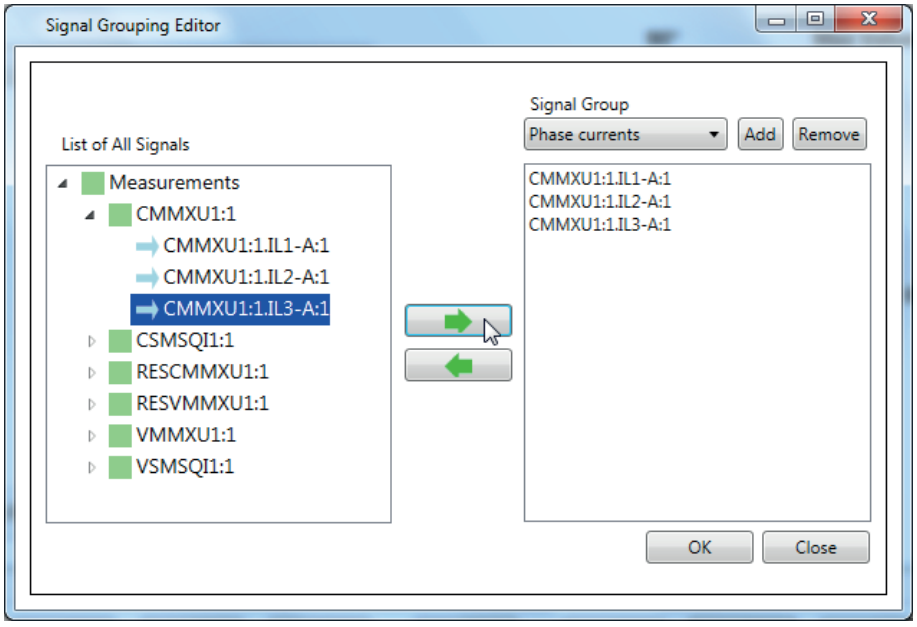



*Figure 87: Adding a signal*

- Remove existing signals.
  1. In **Signal Grouping Editor** dialog, select a group from the **Signal Group** drop-down list.
  2. Select the required signals and click .
  3. Click **OK**.

## 6.1.4 Page Organizer

Page Organizer is used for configuring the main screen of LHMI by creating main pages, linked pages and switchgear HMI pages. Pages can be added, removed or reordered in Page Organizer and, for example, their visibility can be set to "Basic" or "Advanced". These access rights are mapped to user roles with User Management in PCM600 and the pages are filtered based on the mapping. The selection "Basic" or "Advanced" is not applicable to the WHMI. SHMI pages are used on the navigation page of the SHMI.

In the Add Page dialog, some of the pages in the ABB Built-in Pages category are marked with a padlock symbol. They are locked and cannot be modified in Page Editor. If such a page should be modified, it can be enabled by first saving it as a template.

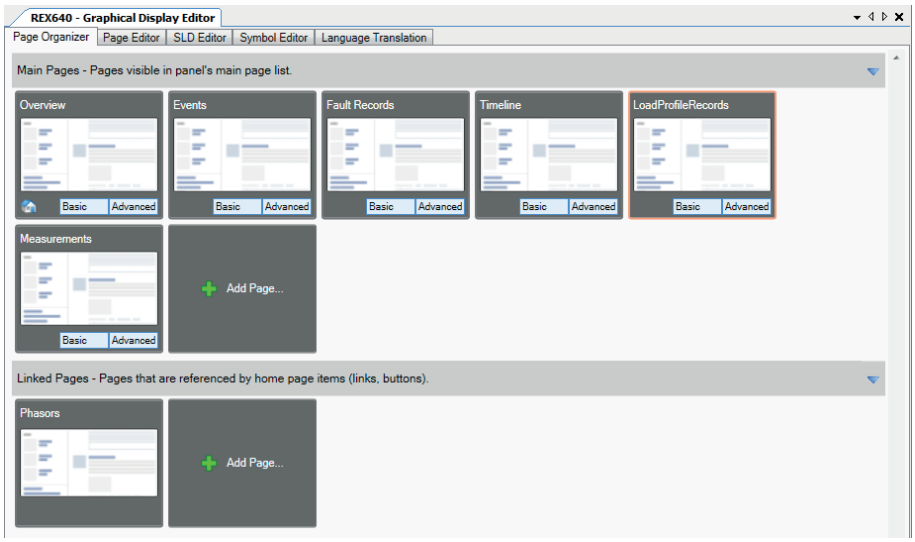



*Figure 88: Page Organizer*

### 6.1.4.1 Main pages and linked pages

Main pages can be navigated using the Home button on the LHMI. The main page visibility is bound to access rights. Linked pages are pages which are linked from other pages; they can be opened from a main page when a button is tapped. Depending on the selected role, linked pages are shown under the main page area.

Both the main pages and the linked pages are defined in Page Organizer.

### 6.1.4.2 Templates

Templates allow replicating the same configuration with less effort. New pages can be created by selecting a template page so that the new page becomes a new instance of the template page. Templates also contain empty pages.

In Page Organizer, the ABB built-in pages are seen as page templates. Both ABB built-in pages and template pages require unique names.

### 6.1.4.3 Creating pages

The relay supports 10 main pages, 20 linked pages and 2 SHMI pages at the maximum.

1. In Page Organizer, create new pages in one of the alternative ways.
   - Under **Main Pages**, click **Add Page** to create a main page.
   - Under **Linked Pages**, click **Add Page** to create a linked page.

Change the page type (main or linked) by dragging the page from one area to the other.

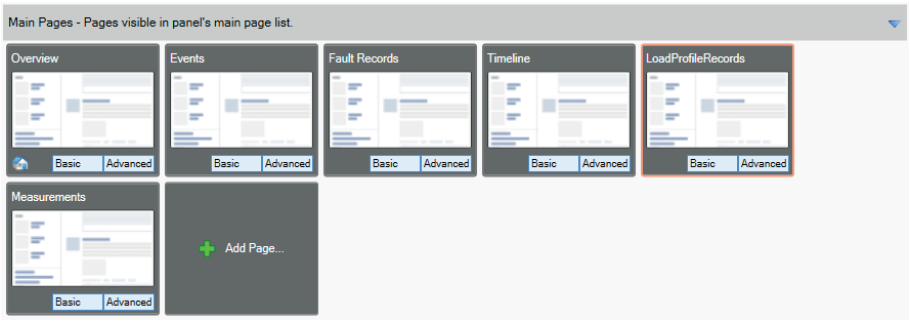



*Figure 89: Adding pages*

2. In the **Add Page** dialog, select a predefined ABB built-in page or a template page and click **Add**.

Define unique names for all main, linked and SHMI pages regardless of their type.

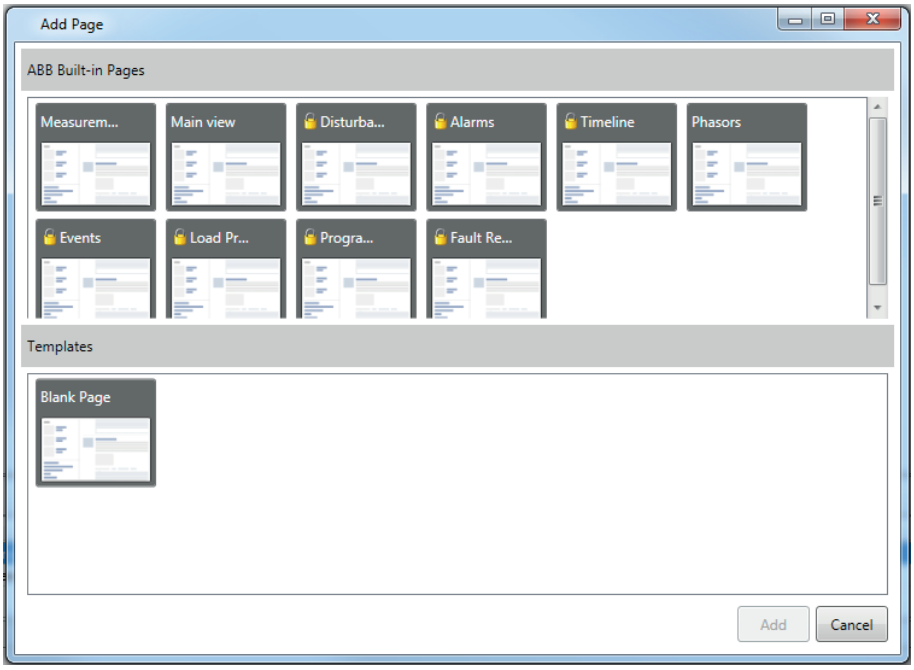



*Figure 90: Using ABB built-in pages or templates*

### 6.1.4.4 Changing page order

- In Page Organizer, change the order of the pages by dragging a page to the required place.
- Pages can also be dragged from **Main Pages** to **Linked Pages** and vice versa.

### 6.1.4.5 Creating templates

When a template is created out of an existing page, it becomes available under the Templates section in the Add Page dialog. Templates allow replicating the same configuration with less effort.

Save pages as templates in one of the alternative ways.

- Click **Options** in the upper-right corner of the page and select **Save as Template** from the shortcut menu.
- Right-click the page and click **Save as Template**.

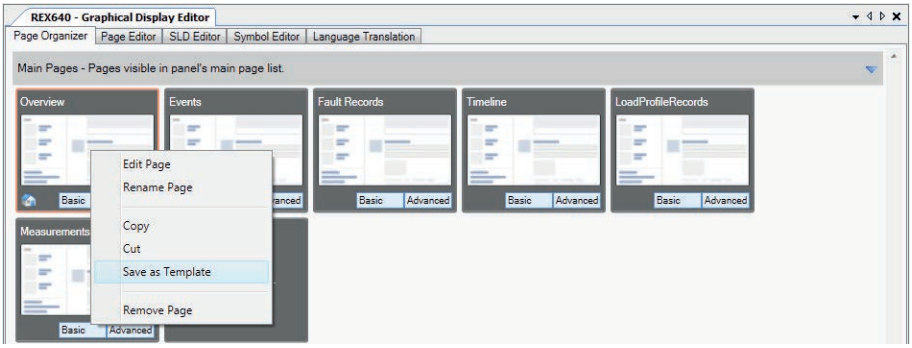



*Figure 91: Saving templates*

## 6.1.5 Switchgear HMI Page Editor

Switchgear HMI Page Editor is used to configure the bay overview shown on the SHMI navigation page. SHMI pages can be configured by adding widgets that are the building blocks for configuring the bay overview. All the supported widgets are populated in the Object Types pane.

Page Browser is shown at the bottom of Switchgear HMI Page Editor. It displays all editable SHMI pages that are available in the Page Organizer. When a page is clicked, it opens in Page Editor. Page templates are not shown in Page Browser.

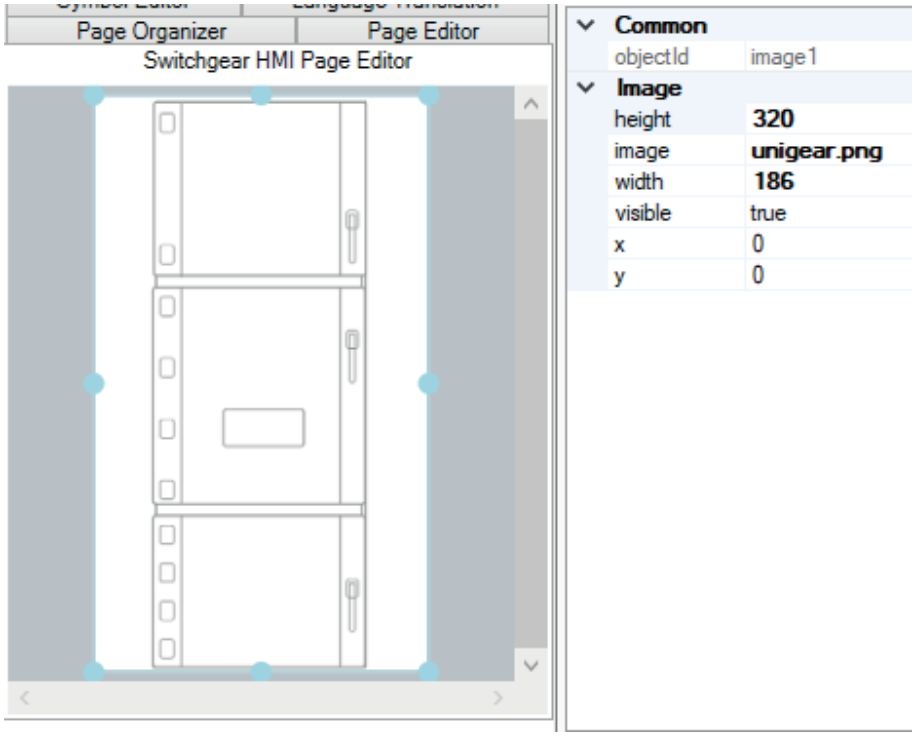



*Figure 92: Page with Image widget*

### 6.1.5.1 Adding widgets

- Add a widget to the page by dragging it from the **Object Types** pane.

- Set the widget properties.

### Adding SLDViewPort

The SLDViewPort widget displays the single-line diagram configured in Switchgear HMI SLD Editor. The single-line diagram is shown on the bay overview area of the SHMI navigation page.

1. Drag the **SLDViewPort** widget from the **Object Types** pane to the page.
2. In **Object Properties**, select the required page from the **page** drop-down list.

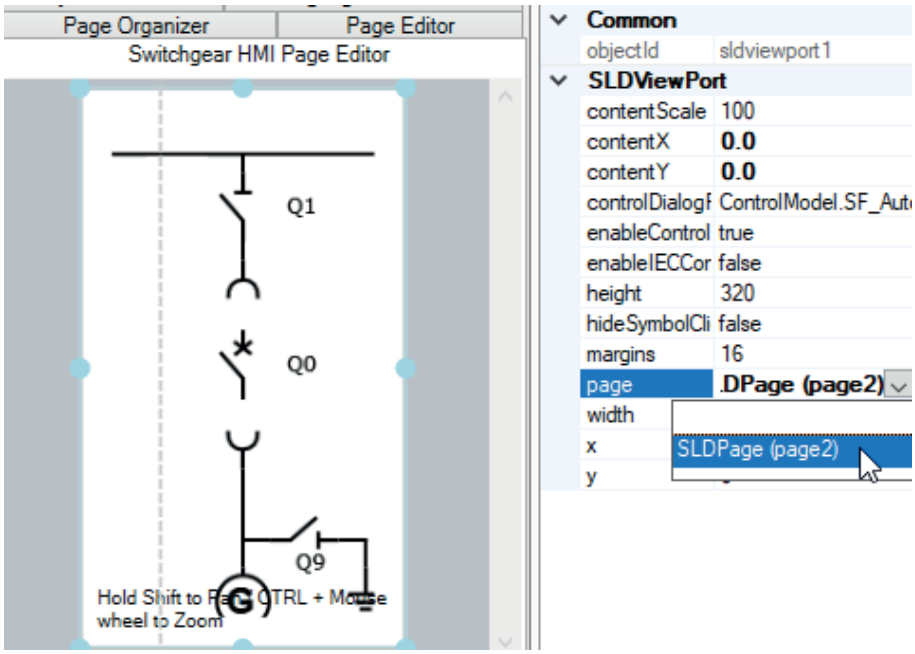



*Figure 93: Configuring the SLDViewPort widget*

### Adding Image

The Image widget displays a custom image on the bay overview area of the SHMI navigation page.

1. Drag the **Image** widget from the **Object Types** pane to the page.
2. In **Object Properties**, select the required image from the file selection dialog.

Slicing of a photo or a static SLD picture for multiple bays should be done in a separate editor application. Maximum size of the picture is 186 × 320 pixels.

## 6.1.6 Page Editor

Page Editor is used for configuring pages. Pages can be configured, for example, by adding widgets that are the building blocks of the LHMI configuration or by creating a single-line diagram.

Any graphical object drawn on the LHMI page is a widget. All the supported widgets are populated in the Object Types pane.

Page Browser is shown at the bottom of Page Editor. It displays all editable pages selected for the Main Pages and Linked Pages categories in Page Organizer. When a page is clicked, it opens in Page Editor. Page templates are not shown in Page Browser.

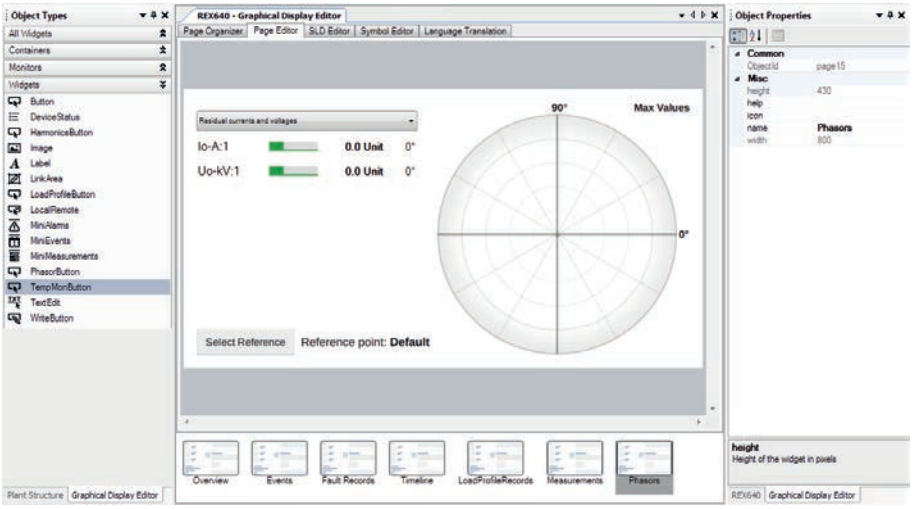



*Figure 94: Page with phasors*

## 6.1.6.1 Adding widgets

- Add a widget to the page by dragging it from the **Object Types** pane.
- Set the widget properties.

### Adding SLDViewPort

The SLDViewPort widget displays the single-line diagram configured in SLD Editor.

1. Drag the **SLDViewPort** widget from the **Object Types** pane to the page.
2. In **Object Properties**, select the required page from the **page** drop-down list.

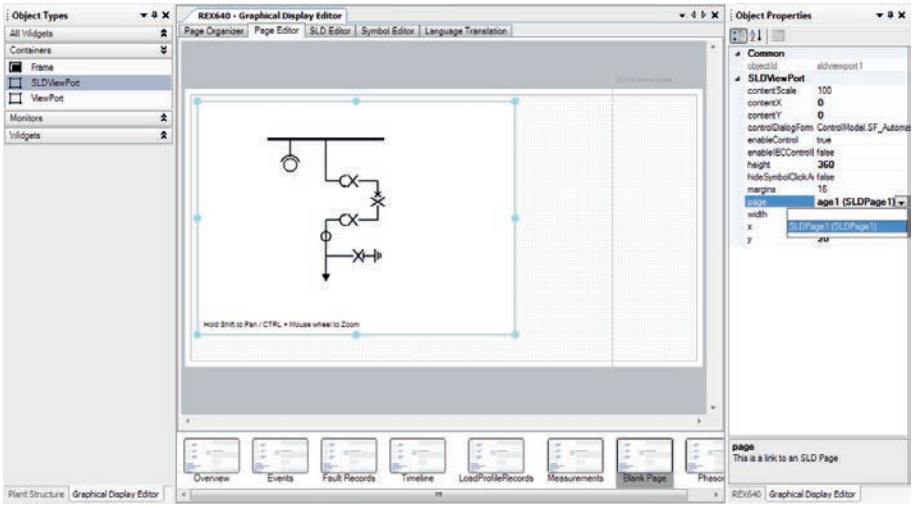



*Figure 95: Configuring the SLDViewPort widget*

### Adding ViewPort

The ViewPort widget displays the contents of a page.

1. Drag the **ViewPort** widget from the **Object Types** pane to the page.
2. In **Object Properties**, select the required page from the **page** drop-down list.

## 6.1.6.2 Configuring pages

- Add new widgets by dragging them from **Object Types** to the page.
- Resize the selected widgets in one of the alternative ways.
  - Click and hold any resize point on the edge or corner of the widget and drag the mouse to resize the widget.
  - Change the width and height properties of the widget in the **Object Properties** pane.
- Set the properties of the selected widget by modifying the values in the **Object properties** pane.

  Once widgets are placed on the HMI page, some of them (Monitors) can be linked to the corresponding function block in the application configuration by using the source property. The values are updated by the protection relay either periodically (measurement) or in case of an event.

  Some of the widget properties can be in an automatic mode. When the property is in the automatic mode, the values are set automatically by the protection relay's LHMI. If a value is specified for an automatic property, the LHMI displays the specified value.

  Some of the widget properties cannot be edited as they are read-only values.

- Group or ungroup multiple widgets regardless of their type.

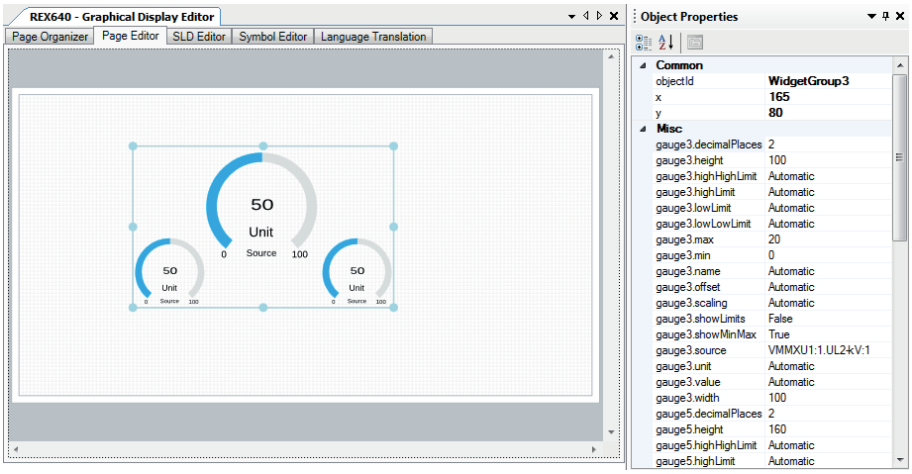



*Figure 96: Grouping widgets*

When a group is created, all the individual widget properties such as the widget name followed by the dot and the property name, are shown in the Object Properties pane. Only properties x and y are common for all the widgets in the group.

The widget group property naming (aliases), visibility and read-only can be modified.

The grouped widgets can be ungrouped by right-clicking the group and selecting **Ungroup**.

- Bind the widget property values to the same or to another widget property values or to signal values from the application configuration function.

  It is possible to specify simple if...else conditions. The property values are then changed based on those conditions.

  For example, the LED color can be changed to red if the signal value is high or to green if button2 is checked. Otherwise the LED color is yellow.

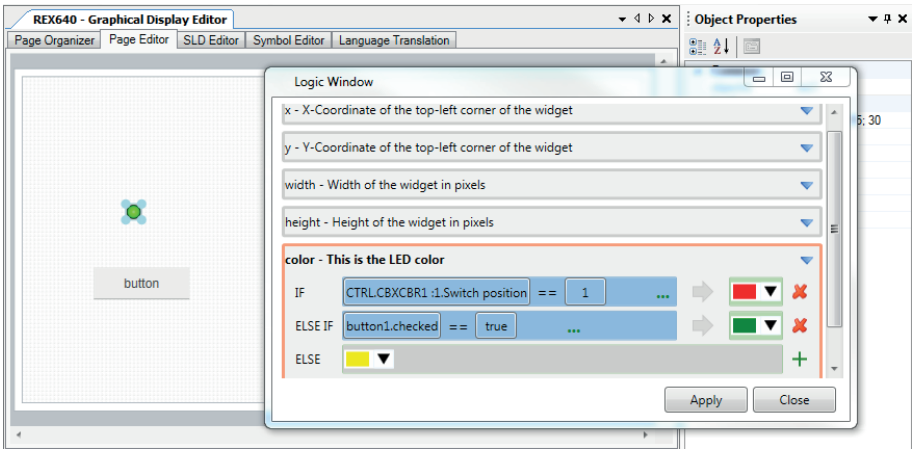



*Figure 97: Binding property data*

## 6.1.7 Symbol Editor

Symbol Editor is used to create symbols for a single-line diagram. It has different drawing tools available such as line, rectangle and ellipse to draw the symbols.

### 6.1.7.1 Symbols

Symbols are used in the single-line diagram. Each symbol has at least one state that represents the graphics of a symbol at different positions.

Symbol Editor supports three types of symbol standards. New symbols can only be created under the custom standard.

- ANSI
- IEC
- Custom

Symbor Editor can be used to create dynamic symbols that have different states corresponding to the different signal values supported by the symbol. For example, the symbol states of a breaker (open, close, intermediate and faulty) can be illustrated in Symbol Editor with the help of drawing tools such as line, rectangle, ellipse, curve or polyline. The symbol State value should match the signal Enum value. On the LHMI the symbols are displayed according to the signal value and the matching symbol state value. One of the states is always the default state. Symbols used in SLD Editor show the default state graphics.

There are several options for the symbol size: 1x1 (normal size), 1x2 (height is doubled), 2x1(width is doubled) and 2x2 (both the height and width are doubled).

Custom symbols can be exported from the Graphical Display Editor and reused in other projects.

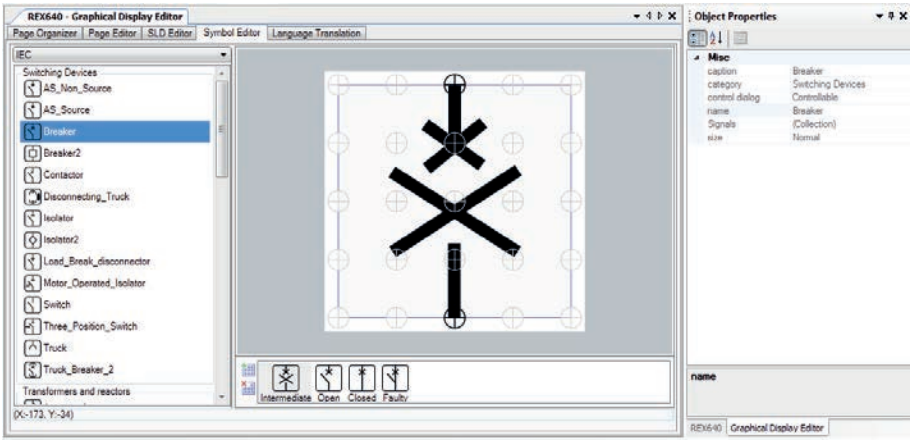



*Figure 98: Symbol Editor*

### 6.1.7.2 Creating custom symbols

New symbols can only be created under the custom standard. The available options are the category, size and states. At least one state should be selected when creating any symbol.

Before creating a new custom symbol, check that the states and category required for the new symbol are available by default. Otherwise, it may be necessary to create new states or categories.

1. Create a new symbol in one of the alternative ways.
   - On the menu bar, point to **Graphical Display Editor**, point to **Symbol Editor** and select **Create Symbol**.
   - Right-click the symbol library and click **Create Symbol**.
   - On the toolbar, click .

2. In the **Create Symbol** dialog, specify a name, category, size and states and click **Create**.

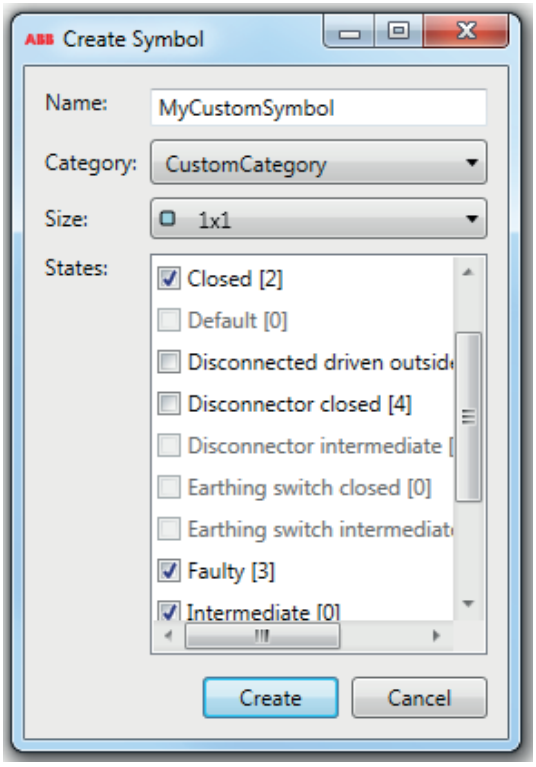



*Figure 99: Creating a new symbol*

The new symbol becomes available in Symbol Editor with the states selected for drawing. Different drawing tools such as line, rectangle and ellipse can be used to draw the graphics for the different states.

3. Select the symbol state to be used as the default and set **is default** to **True** in the **Object Properties** pane.

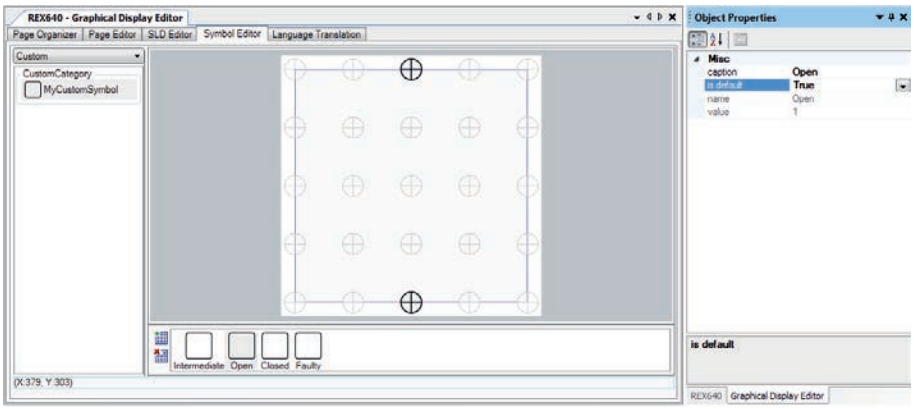



*Figure 100: Setting the default state*

4. Select the signals that should be connectable in SLD Editor via the symbol's Signals property.

a) On the menu bar, point to **Graphical Display Editor**, point to **Symbol Editor**, point to **Symbol** and select **Object Properties**.

b) Select **Signals property** and click **...**.

c) In the **Signals Selection** dialog, use  and  to add or remove signals and click **OK**.

The connectable signal types for symbols are shown on the left side of the Signal Selection dialog. Any signal type can be moved from the left side to the right side and vice versa. These signal types are used to connect to the symbol if the instance is available in the configuration.

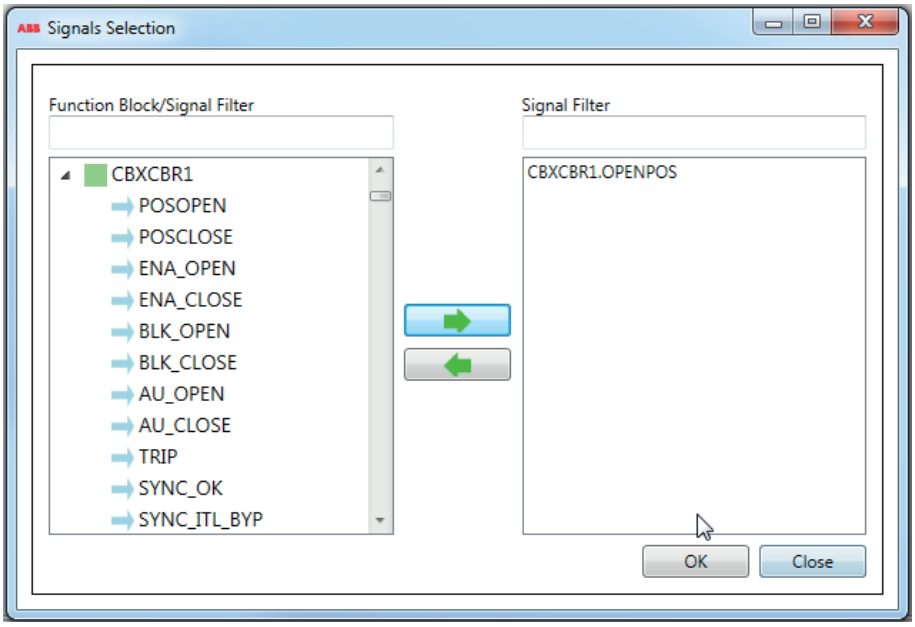



*Figure 101: Selecting the signals for a symbol*

d) If the symbol is of control type, select the correct value in the **control dialog** drop-down list.

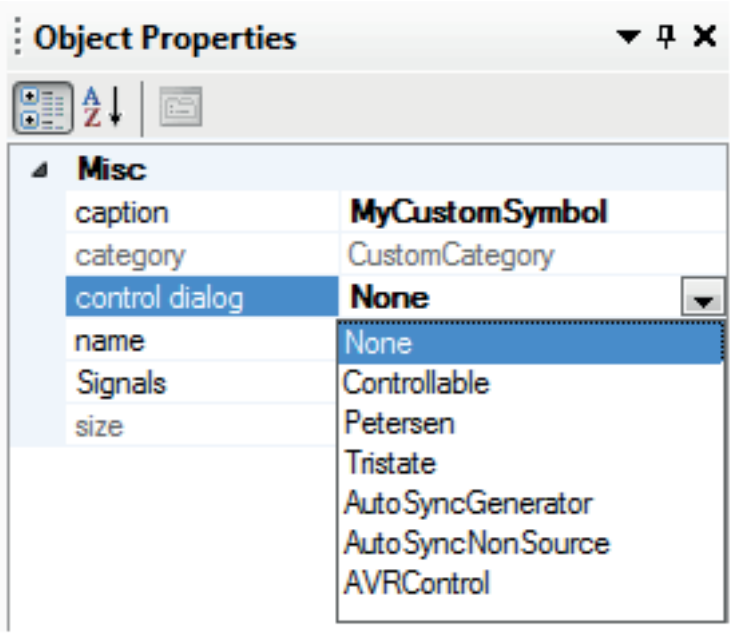



*Figure 102: Selecting the control dialog type*

5. Save the symbol to make it available in SLD Editor.

### 6.1.7.3 Creating categories

1. Create a new category in one of the alternative ways.
   - On the menu bar, point to **Graphical Display Editor**, point to **Symbol Editor** and select **Create Category**.
   - Right-click the symbol library and click **Create Category**.
   - On the toolbar, click .

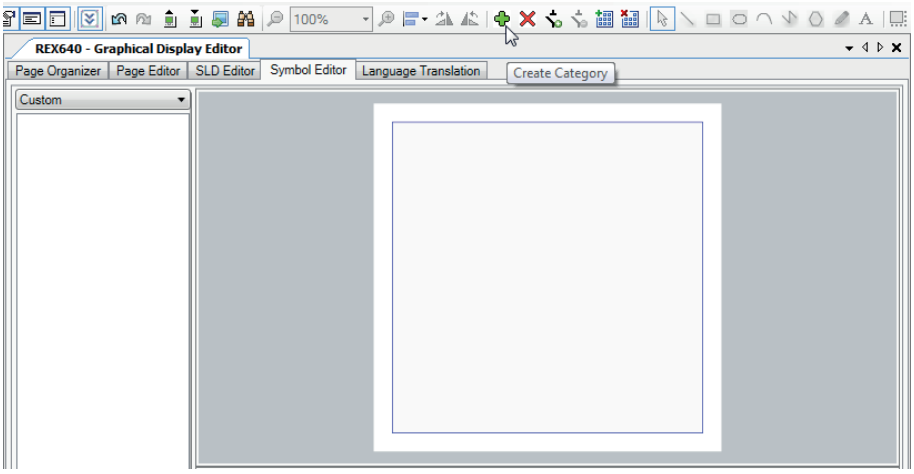



*Figure 103: Creating a category*

2. In the **Create Category** dialog, specify a name and click **Create**.

### 6.1.7.4 Creating states

The symbol can have different states that represent the graphics for the symbol. The symbol graphics are different for each state. The state is selected when creating a new symbol.

1. Create a new state in one of the alternative ways.
   - On the menu bar, point to **Graphical Display Editor**, point to **Symbol Editor** and select **Create State**.
   - On the toolbar, click .
2. In the **Create State** dialog, select **Create new state**.

3. Specify a name and numeric value and click **Create**.

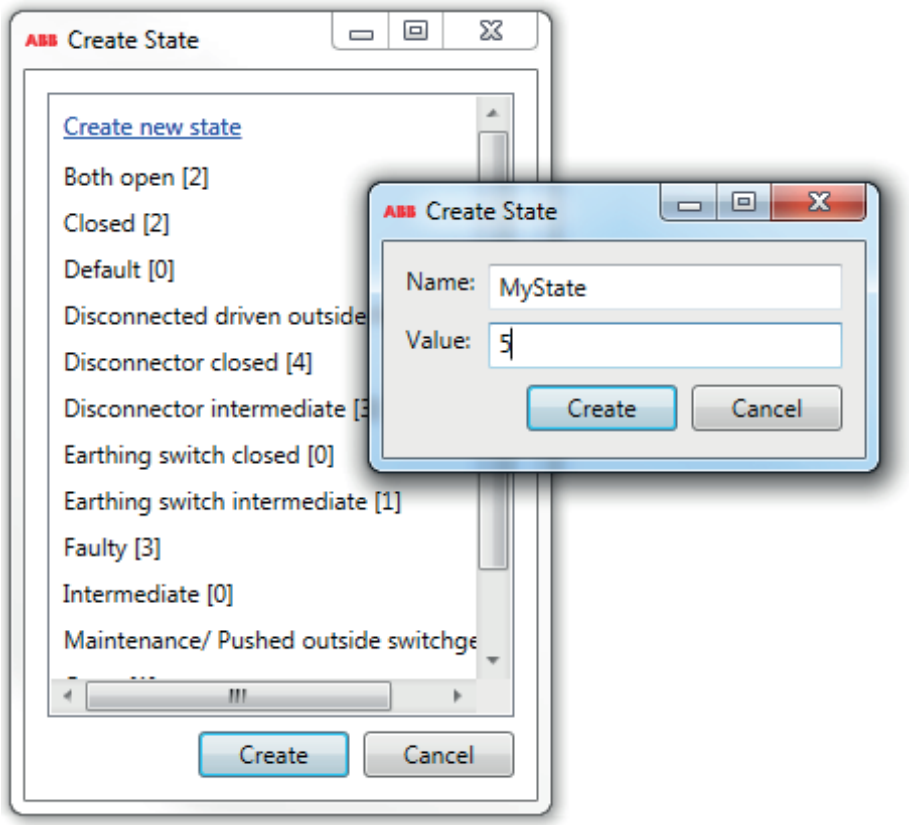



*Figure 104: Creating a state*

## 6.1.8 SLD Editors

SLD editors are used to create single-line diagrams. In SLD editors, bus bars, symbols and text can be added from the object type window and links can be created between symbols. Graphical Display Editor has two separate editors.

- SLD Editor is used to draw single-line diagrams that are used on the normal HMI pages.
- Switchgear HMI SLD Editor is used to draw a single-line diagram that is used on the bay overview area of the SHMI.

Once the symbols are placed on the SLD page, they must be linked in Application Configuration to the corresponding function block that protects or controls the object represented by the symbol. The values are updated by the protection relay either periodically (measurement) or in case of an event.

Single-line diagrams support both ANSI and IEC standards. Single-line diagrams created in ANSI can be changed to IEC and vice versa by changing the symbol standard in PCM600. Custom symbols can be used in both ANSI and IEC standards. In the object type window, symbols are grouped by their category.

The single-line diagram created in SLD Editor can be used on the main pages with a special widget called SLDViewPort. The widget is available under the Container group and its page property populates the list of SLD pages. The single-line

diagram size can be selected from the Object Properties pane. In ViewPort the single-line diagram can be zoomed and paned on the LHMI.

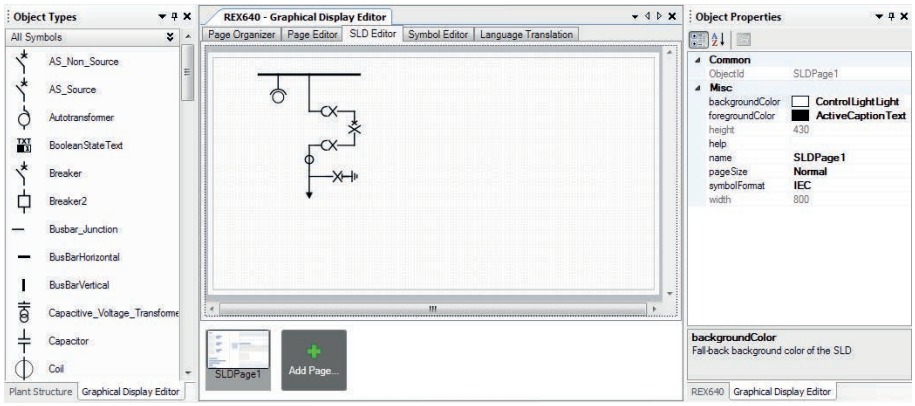



*Figure 105: SLD Editor*

All SLD pages are shown at the bottom of SLD Editor. When a page is clicked, it opens in SLD Editor. New SLD pages can be added by clicking the Add Page button. To remove an SLD page, right-click the SLD page and select the Remove Page option in the context menu.

The relay supports a maximum of 10 SLD pages.

SLD Page Editor is used for various tasks.

- Adding static text
- Adding measurands
- Adding bus bars
- Adding symbols to the display page
- Drawing lines (creating links)

### 6.1.8.1 Adding bus bars

1. In SLD Editor, drag a **BusBarHorizontal** or **BusBarVertical** object from the **Object Types** pane to the page view.

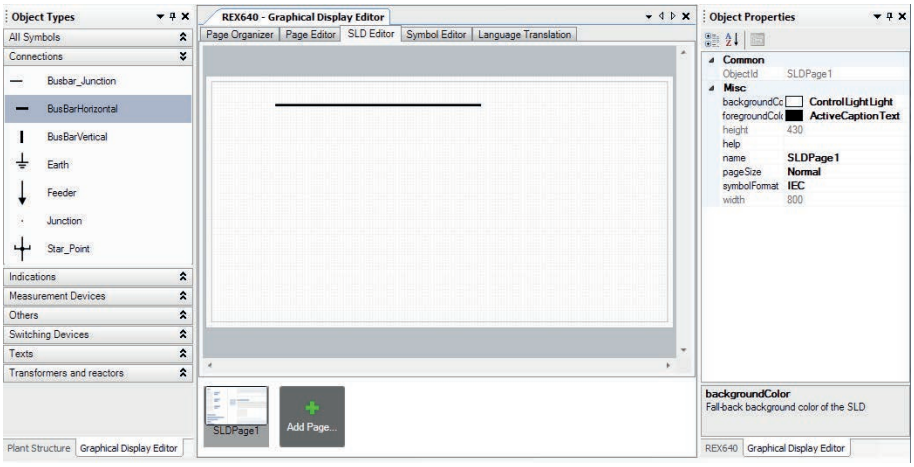



*Figure 106: Adding a bus bar*

2. Select the left or right connection point and drag it to increase the size of the bus bar.

### 6.1.8.2 Managing bus bar coloring

Bus bar coloring is used to assign a color to a bus bar or links. New bus bar color groups can be created and each color group can have one or more logic conditions; each logic condition is associated with one color.

#### Apply the bus bar coloring

1. Right-click anywhere on the page and select **Show Bus Bar Coloring**.
2. In the **SLD Logic Window** dialog, click **+** to add a new color group or **x** to remove an existing color group.
3. Expand any color group and click **+** to add **IF** and **ELSE** conditions and **x** to remove them.
4. Click **...** to add another **And** condition inline. Click **And** to change or remove the condition.
5. To add a value for a condition, click **Value Button**, select any signal value or widget property value and press ENTER.
6. Select any color from the drop-down list.
7. Select **Color Group** and click on any bus bar to apply the coloring.

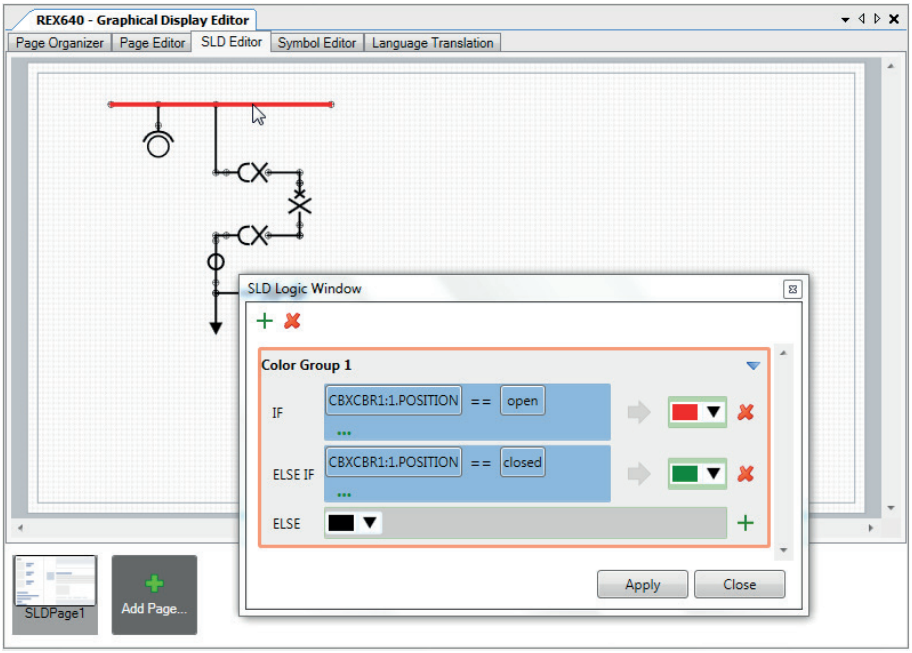



*Figure 107: Managing bus bar coloring*

### Remove the bus bar coloring

1. Right-click anywhere on the page and select **Show Bus Bar Coloring**.
2. Select any color group and click the bus bar to remove the bus bar coloring.

### Bus bar coloring example based on the CBXCBR position value

If the CBXCBR position is open, all the bus bars and links associated with the “Color Group1” group should be displayed in red color. If the CBXCBR position is closed, it should be indicated in green color. Otherwise the color is black.

```
IF CBXCBR1:1. POSITION== open THEN Line Color is Red ELSE
CBXCBR1:1. POSITION== closed THEN Line Color is Green ELSE Line
Color is black.
```

Right-click anywhere on the page and select **Highlight Conditional Bus Bar** to show bus bars that have the coloring applied.

## 6.1.8.3 Adding symbols to an SLD page

1. In SLD Editor, prepare the body of the single-line diagram by placing symbols to the wanted positions on the page view.
2. Drag the apparatus or transformer symbols to the SLD Editor view.
3. Drag the connection symbols.
4. Place the junction points.

5. Connect the symbols where necessary by drawing lines between the symbols' source and destination ports.

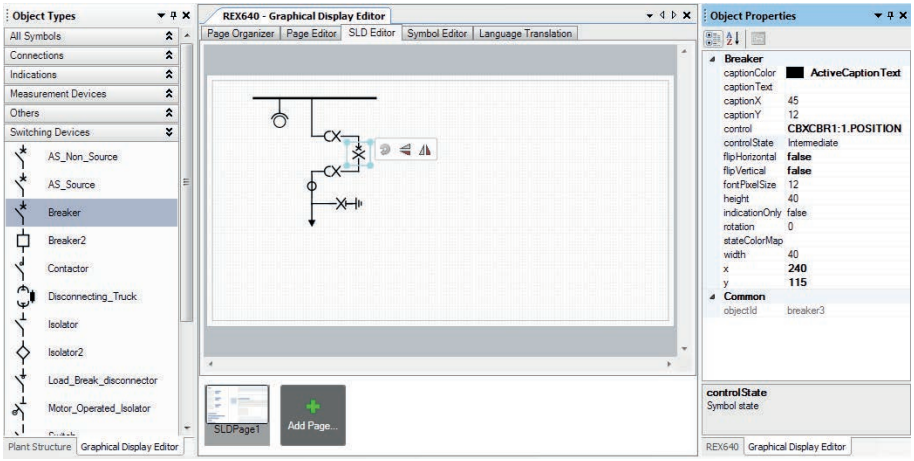



*Figure 108: Adding symbols to an SLD page*

6. In the **Object Properties** pane, set the symbol properties.
   - Use the **x** and **y** coordinates to adjust the placement of symbols in the single-line diagram.
   - Use **controlState** to define the default state of the symbol to be displayed in the view.
   - Use **indicationOnly** to define if the symbol is controllable (true = status only; false = controllable).
   - Use **control** to link the symbol to the function block in the application configuration that protects or controls the object.
   - Use **stateColorMap** to specify colors for the different states of the symbol.

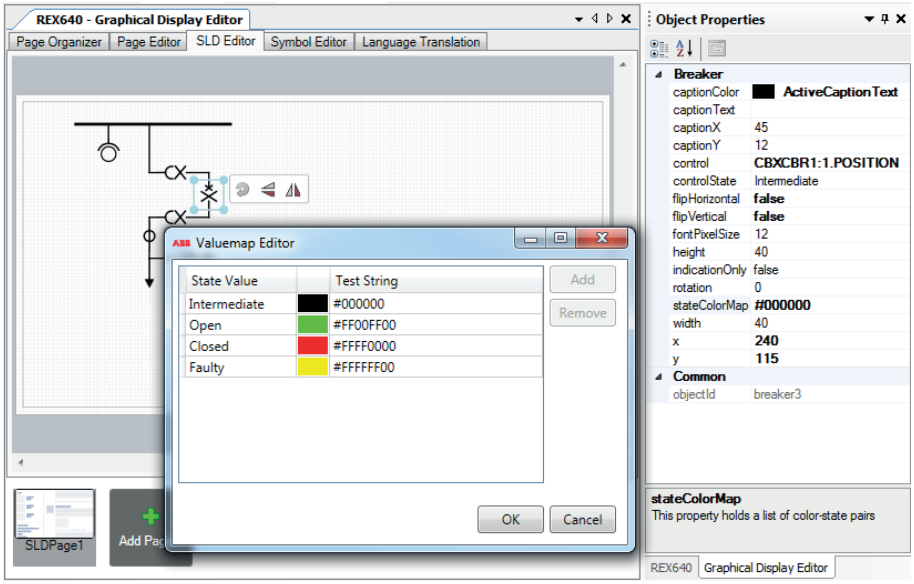



*Figure 109: Setting colors for the different symbol states*

If custom symbols have been used in the SLD configuration and then deleted, the symbol graphics show an error and all the related connections are removed from the configuration.

### 6.1.8.4 Creating SLD pages

1. On the Graphical Display Editor toolbar, select the symbol standard from the drop-down list.
   - IEC
   - ANSI
2. Ensure that the **Snap to grid** and **Show grid** functions are available. These are the default and recommended settings when designing a single-line diagram.
3. Place the primary equipment on the single-line diagram approximately in the wanted position.

   If required, rotate the symbols using the Rotate Left or Rotate Right functions.

4. Consider the necessary symbol connections, that is, links.
   a) Click on the source port and click on the desired position to add a connection point.
   b) Draw a perpendicular line by moving the mouse while pressing SHIFT and clicking on the target port.
5. Connect the symbols where necessary.
   a) Move the mouse pointer over the symbol's connection ports.

      The connection ports of all symbols are activated.
   b) Drag the connection from the source connection port and drop it in the target connection port.

      A connection line between the source and target connection ports is drawn.

      Alternatively, click on the source port and then click once at the target port to create the connection. Move the mouse pointer on the nearest connection port to ensure the target port. A “+” sign appears.
   c) Right-click or press ESC to cancel the connection creation.

   Once a link has been used to connect the symbols, the link follows the symbol when it is moved to a new position or when it is rotated.
6. Move the mouse pointer away from the symbol's port for all the connection ports of the symbols to become deactivated.
7. Select a symbol and modify its properties in the **Object Properties** pane.

   The symbol name can also be changed by double-clicking the symbol.

8. In the **Object Properties** pane, use control to relate dynamic symbols to their source data.

## 6.1.9 Language Translation

Language Translation is used to translate widget properties, page properties and symbol captions into different languages. All the translatable properties, that is, text properties, are displayed on the language translation tab.

With Language Translation the users can add a new language from the list of languages supported by the IED and set the translated text for the language. Once the translations are written to the IED they can be displayed on the LHMI based on the language selected.

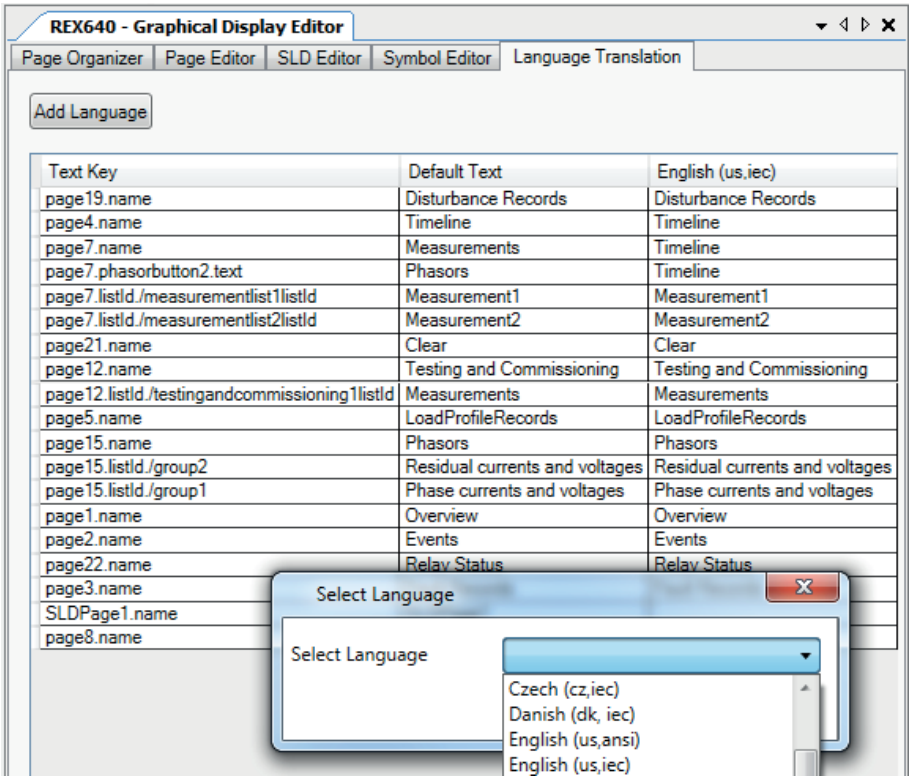



*Figure 110: Language selection*

New languages can be added by clicking the **Add Language** button, selecting any available language and clicking the **OK** button. The options Language 1...10 can be used to specify a custom language.

PCM600 shows all the languages supported by the IED. When adding a new language and writing it to the IED, it must be ensured that the corresponding language binary is loaded in the IED and that the corresponding language pack for the connectivity package is installed in the PC.

A warning message is displayed by the tool if the language binary is not loaded in the IED.

## 6.1.10 Saving, reading and writing configuration to IED

1. Save the LHMI configuration in one of the alternative ways.
   - On the **File** menu, select **Save**.
   - Click the **Save** button on the toolbar.
   - Press CTRL+S.

2. To write the configuration to the IED, click the **Write to IED** button on the toolbar.

   This action must be confirmed before it is carried out, because it overwrites the IED's existing display configuration. The writing operation can take a few seconds or minutes to complete.

3. To read the configuration from the IED, click the **Read from IED** button on the toolbar.

## 6.1.11 Previewing configuration

After the pages have been configured, the configuration can be previewed with a soft LHMI before it is written to the IED. The soft LHMI is a Windows version of the actual LHMI.

To launch the soft LHMI and to preview the configuration, click the **Show Preview** button.

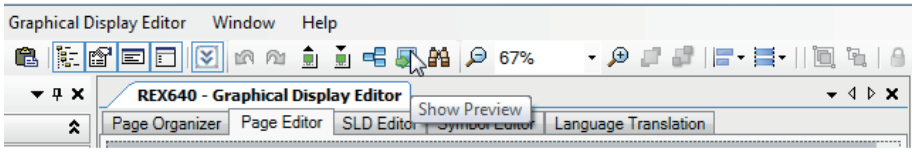



*Figure 111: Launching the LHMI preview*

## 6.1.12 Using HMI Client

REX640 HMI Client can be launched from PCM600. It connects to REX640 via selected Communication Port and shows HMI view that is identical to actual physical HMI.

HMI client can’t be paired with the REX640 and control operations are not possible.

1. Select context menu on the top of REX640 in plant structure using right click.
2. Select **Browse with HMI** > **HMI Client**. When connection is established “No pages configured for the current user” is shown.
3. Click **LOGIN** on and enter credentials.

4. HMI Client is showing the configured HMI pages.

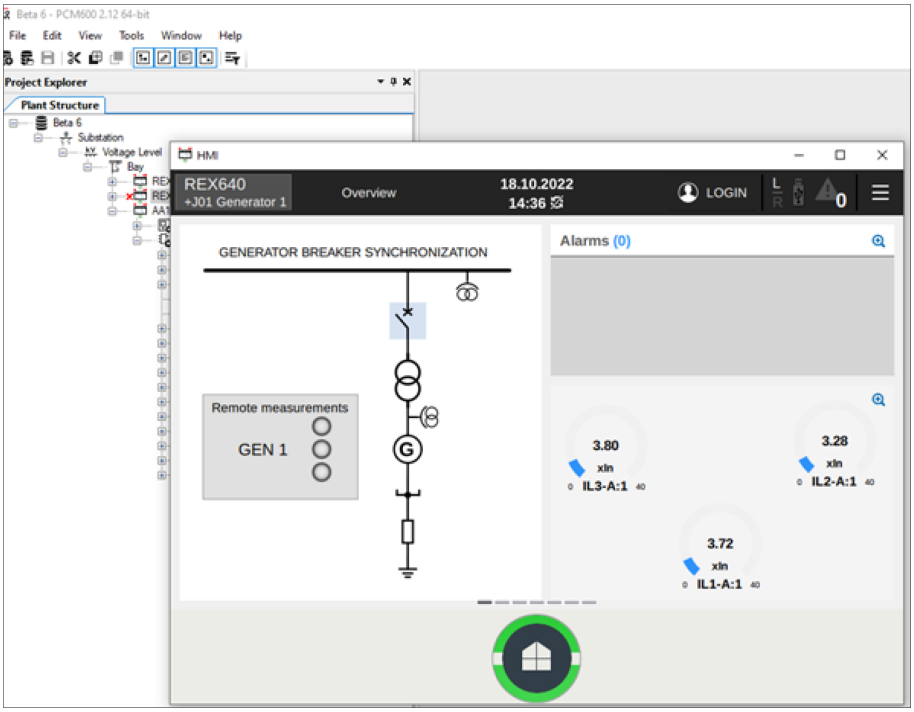



*Figure 112: HMI Client*

## 6.1.13 GDE configuration export and import

The GDE configuration can be exported and then imported to any other IED.

### 6.1.13.1 Exporting GDE configuration

1. On the **File** menu, point to **Display Editor Template** and select **Export**.

2. In the **GDE Export** dialog, select the pages, SLD pages, custom symbols and translations to be exported.

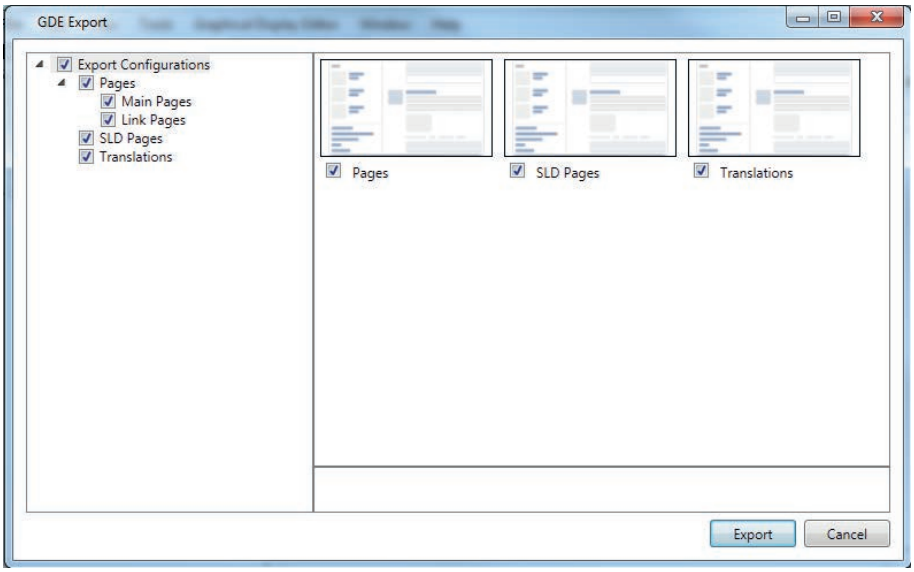



*Figure 113: Selecting objects for export*

3. Click **Export**.

   The selected items are exported in .pgdep format.

   If the configuration contains custom symbols that are not selected, a warning dialog is displayed.
4. Select the location to save the template and click **Save**.

### 6.1.13.2 Importing GDE configuration

1. On the **File** menu, point to **Display Editor Template** and select **Import**.
2. Click **Browse** to select any previously exported template file in .pgdep format and click **Open**.
3. In the **GDE Import** dialog, select the pages, SLD pages, custom symbols and translations to be imported.
   - Items present in the current configuration have a green border.
   - Items present in the current configuration with differences have a red border.
   - Items not present in the current configuration (new items) have a blue border.

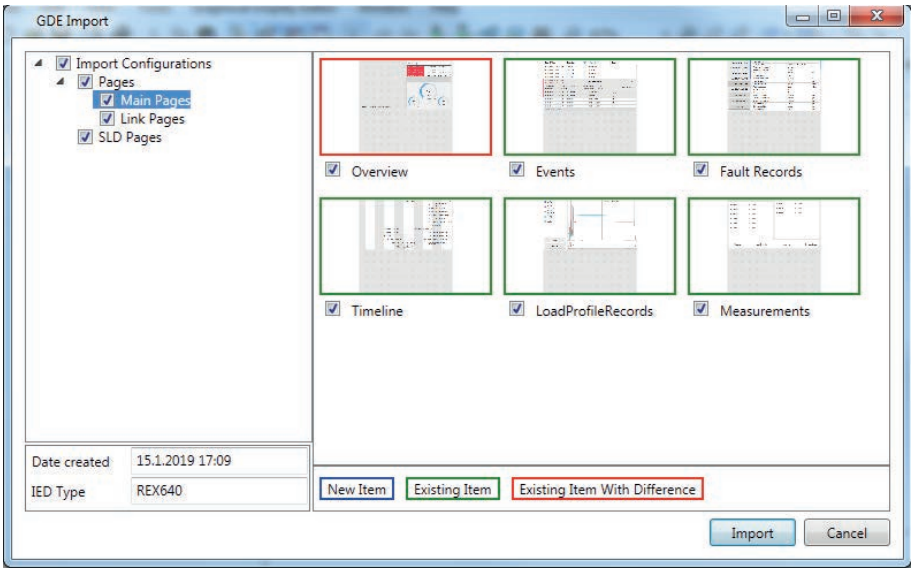



*Figure 114: Selecting objects for import*

4. Click **Import**.

   All page names must be unique. If a page is imported with a name that is used by an existing page, a confirmation dialog is displayed. The options are to overwrite the existing page, to create a new page with a different name or to cancel the import.

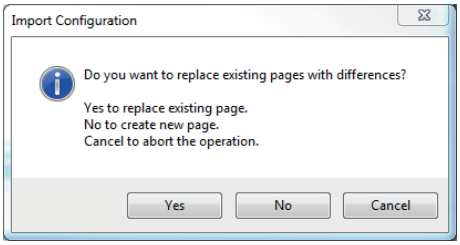



*Figure 115: Confirming action after name conflict*

## 6.2 Switchgear HMI Configuration

Switchgear HMI Configuration is used to configure the SHMI navigation page after the bay overview area has been configured for each relay using Graphical Display Editor.

### 6.2.1 Configuring switchgear HMI navigation page

A maximum of 20 REX640 relays can be connected to one SHMI.

1. In the Plant Structure, right-click a substation, a voltage level or a bay and point to **New**, point to **General** and select **SHMI** to create an SHMI object.

   Each SHMI object represents one SHMI in the installation.
2. Right-click the SHMI object and select **Switchgear HMI Configuration**.
3. Define **Substation Name**, **Voltage Level** and **Switchgear Name** to be shown on the SHMI navigation page.
4. Drag the bay overviews to change their order, to allocate them for the SHMI or to remove them from the SHMI.

   All relays that support the SHMI are visible in the tool, and 20 relays are automatically assigned to the SHMI. The unallocated bay overviews are available to be assigned for other SHMIs in the project.




*Figure 116: Allocating bay overviews to the switchgear HMI*

5. Click **Preview** to test the result on the SHMI.
6. Click **Write** to write the SHMI configuration to all allocated relays.

Ensure that a connection is made to the relays through a station network. All relays should be reachable in the network when the SHMI configuration is written to the relays.

## 6.3 HMI Event Filtering

HMI Event Filtering is a tool that helps in configuring the visibility of the events shown on the IED's LHMI and WHMI. This tool does not modify the actual events on the protocol level.

The event visibility is modified in the event tree view. The events in the tree view are structured in the same way as the functions in the PCM600 plant structure.

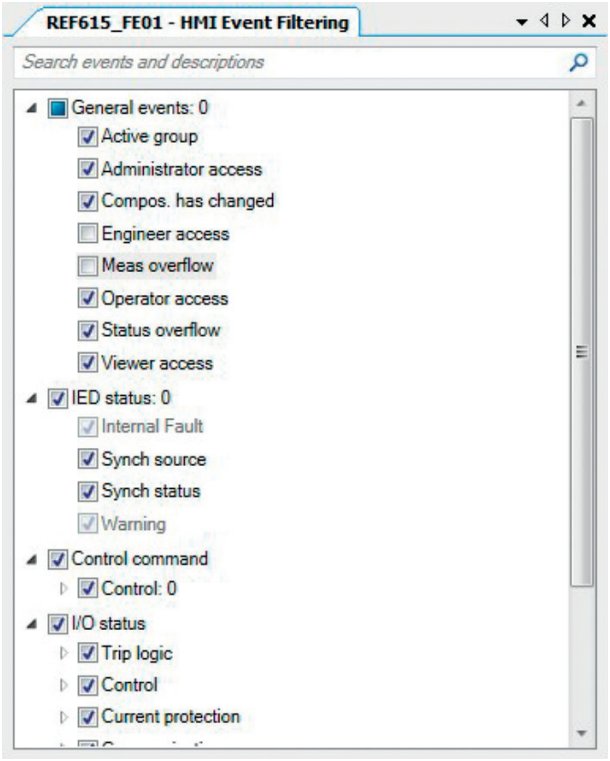



*Figure 117: HMI Event Filtering interface*

## 6.3.1 Starting HMI Event Filtering

Start HMI Event Filtering in one of the alternative ways.

- Right-click an IED and select **HMI Event Filtering**.
- On the **Tools** menu, click **HMI Event Filtering**.

## 6.3.2 Setting visibility of HMI events

The event tree view is used to modify the visibility of the events shown on the LHMI and WHMI. Events in the tree view are structured similarly to the functions in the PCM600 plant structure.

1. Browse the event tree for the event.

   Event nodes in the tree have more detailed description in the tool tip.

2. Select or clear the check box next to the event name to specify its visibility.

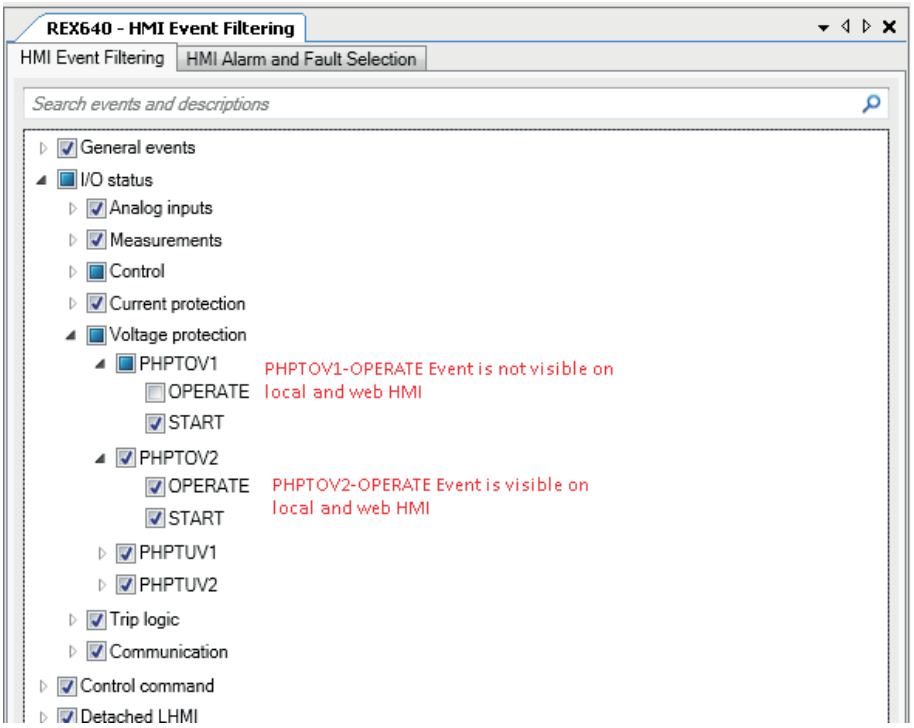



*Figure 118: Setting visibility of the HMI events*

The event is visible on both LHMI and WHMI only when the check box is selected.

Select the check box of the parent node in the event tree view to modify the HMI visibility for multiple events.

Some events in the event tree are read-only and cannot be modified. The read-only events appear dimmed on the user interface.

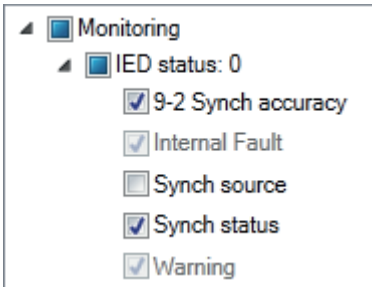



*Figure 119: Read-only events are dimmed*

## 6.3.3 Saving event filter configuration

Save the event filter configuration in one of the alternative ways.

- On the **File** menu, select **Save**.

- Click **Save** on the toolbar.

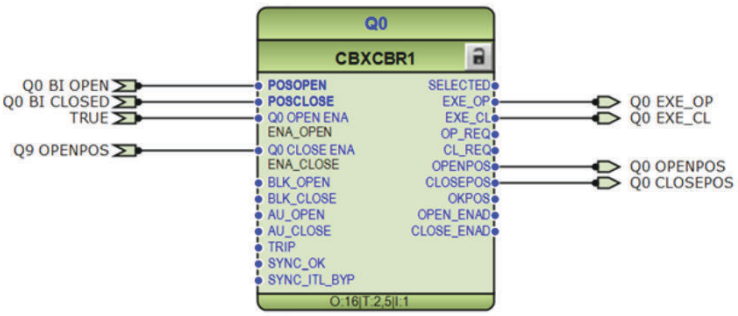
  The **Save** button on the toolbar is activated when the configuration is modified.

## 6.4 User defined names

PCM600 has a feature to set user defined names for signals, function blocks and hardware channels. Functions and signals where setting user defined name is supported are having blue color in application configuration tool. These user defined names are used in different PCM600 tool components and on HMI to ease identification of function or signal usage.

In PCM600 Application Configuration tool user defined name can be set by selecting *Set User Defined Name* from context menu, or by editing *User Defined Name* property in *Object Properties* pane.

User defined names are not shown on REX640 HMI and Web HMI by default. User must enable them by setting parameter **Configuration** > **HMI** > **User defined name**.



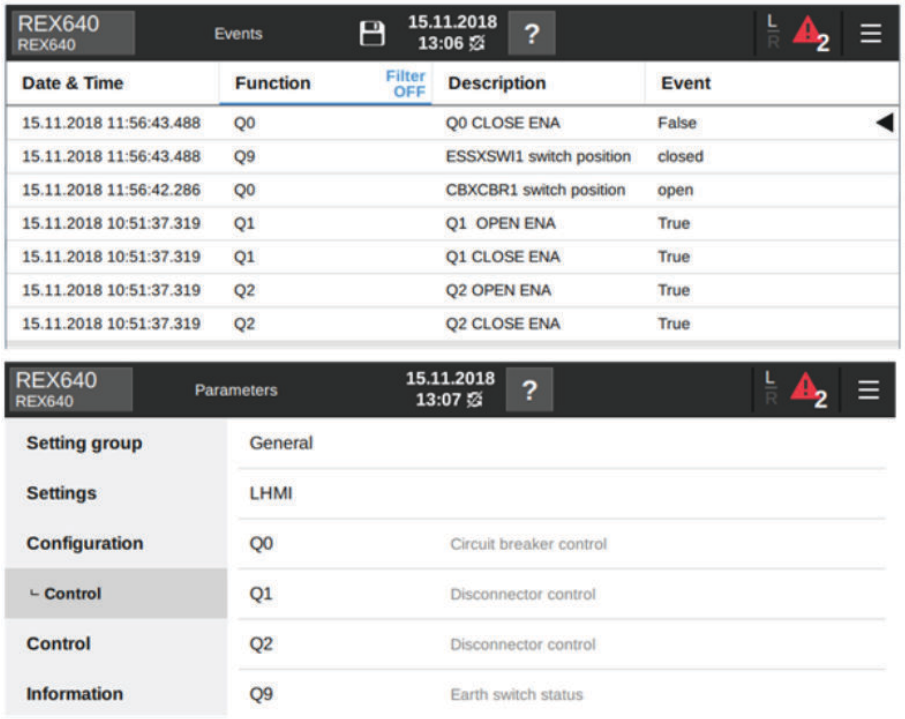



*Figure 120: Example how user defined names are shown in events view and menu structure*

## 6.5 Alarm configuration

The HMI supports two alarm handling approaches.

- Alarm list
- Programmable LEDs

The alarm list approach uses event configuration to elevate an event to an alarm. The programmable LEDs approach is similar to the traditional programmable LEDs where instead of a physical LED, a virtual LED user interface element is used.

Programmable LEDs have three different presentation methods in the user interface.

- Programmable LEDs page
- Virtual Alarm LED widget
- Alarm Annunciator full-page widget

Programmable LEDs page is available in ABB Built-in Pages category in the Page Organizer. Programmable LEDs page automatically shows configured LEDs and alarm texts. Page has buttons for clearing LEDs and resetting trips.

Virtual Alarm LED widget is single programmable LED. It can be added on any operator page on HMI and it shows status and alarm text for configured LED. There are also button widgets available for clearing LEDs and resetting trips.

Alarm annunciator is full page widget where user configures up to 64 alarms. Alarms are presented in groups containing up to 16 alarms each.

## 6.5.1 Alarm list

HMI Event Filtering in PCM600 is used to configure the event visibility on the LHMI and WHMI. Any visible event can be configured as an alarm. See *Chapter 6.3.2 Setting visibility of HMI events*.

### 6.5.1.1 Elevating events to alarms

Alarm configuration is done in the HMI Alarm and Fault Selection view. Any visible events can be elevated to an alarm or priority alarm. An alarm configuration text can also be added to describe the alarm context.

Events can be grouped into a fault (group of selected events) on the LHMI and WHMI event list. Grouping of events as a fault starts when any of the events selected in the Fault column is activated and ends when all the events selected in the Fault column are deactivated.

The group of selected events is shown as a Fault Events row on the event list. Each event is visible by expanding this row.

1. Browse the **HMI Alarm and Fault Selection** view to find the event to be configured as an alarm.

   The event rows in the data grid view have more detailed description in the tool tip.

2. Select or clear the check box in the **Alarm** column to elevate an event to an alarm.

   The event is visible as an alarm on both LHMI and WHMI only when the check box is selected.

3. Select or clear the check box in the **Priority** column to elevate an event to a priority alarm.

   When the check box is selected, the event is visible as a priority alarm on both LHMI and WHMI. The priority alarm is always the topmost in the alarm list. If the check box is cleared, the event is visible as a normal alarm on both LHMI and WHMI if the alarm check box is selected.

4. Select or clear the check box in the **Fault** column to create an event group on the HMI event list.

   When the check box is selected, the event in question (if activated) is included in a fault.

5. In the **Alarm Configuration Text** column, write some text to describe an alarm context.

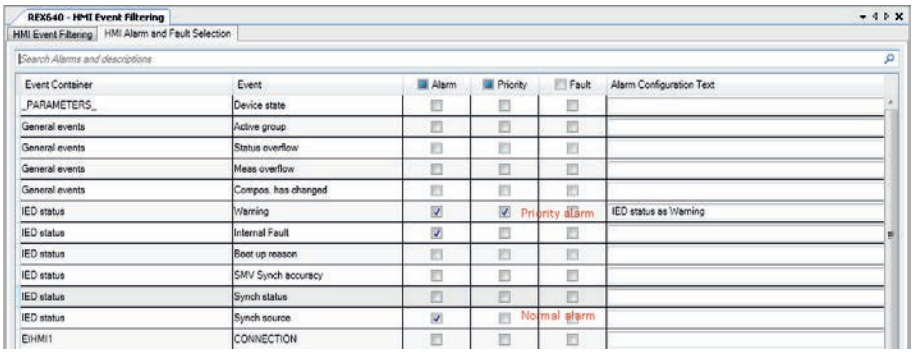



*Figure 121: Elevating events to alarms*

The alarm configuration text can be specified only if an event is elevated to an alarm.

Select the check box in the column header of a column in the data grid view to modify the alarm configuration, priority or fault selection of all events.

### 6.5.1.2 Searching for events and alarms

In HMI Event Filtering, locate an event or alarm in the event filtering or alarm selection views in one of the alternative ways.

- Use the predefined search strings.
- Type a search string manually.

### 6.5.1.3 Saving HMI alarm and fault selection

Save the HMI alarm and fault selection in one of the alternative ways.

- On the **File** menu, select **Save**.
- Click **Save** on the toolbar.

  The **Save** button on the toolbar is activated when the configuration is modified.

## 6.5.2 Virtual programmable LEDs

### 6.5.2.1 Configuring LEDs in application configuration

Three steps must be completed to enable programmable LEDs in the relay's HMI.

1. Instantiate LED functions in application configuration and connect the `OK` and `ALARM` signals in application configuration.

2. Configure LED description texts in **Parameter Setting**. Parameters are in **IED Configuration** > **Configuration** > **Programmable LEDs**.
3. Clear all events elevated as alarms in **HMI Event Filtering** so that the HMI Home button LED can follow the programmable LED state instead of the alarm list.

### 6.5.2.2 Configuring Programmable LEDs page

1. Open **Page Organizer** in Graphical Display Editor.
2. Select **Add Page...** on **Main Pages** section.
3. Select **Programmable LEDs** from **ABB Built-in Pages** section.
4. Select **Add** to insert programmable LED page to operator pages.

### 6.5.2.3 Configuring Virtual Alarm LED widget

1. Open **Page Editor** in Graphical Display Editor.
2. Drag and drop **VirtualAlarmLed** widget on the page.
3. Keep LED widget active and select **LED1...LED66** in Object Properties pane's source property.

### 6.5.2.4 Configuring Alarm Annunciator page

1. Open **Page Organizer** in Graphical Display Editor.
2. Select **Add Page...** on **Main Pages** section.
3. Select **Blank Page** from **Templates** section.
4. Open **Page Editor**, and drag and drop **Alarm Annunciator** widget on the empty page.
5. Select  in the lower-right corner of the alarm annunciator page to open function grouping editor.
6. Select **Add** to create new group.
7. Activate one of the created groups and select **Local HMI/LEDx** in the list of available functions.

8. Select  to add LED to alarm group.

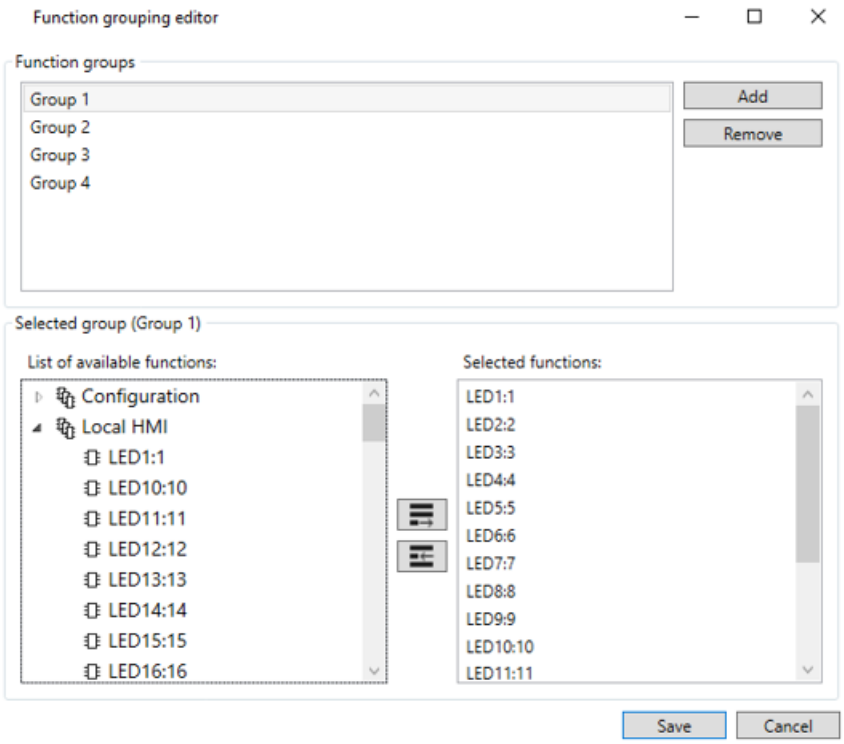



*Figure 122: Function grouping editor and 4 configured groups*

9. Select **Save** to close the editor.
10. Activate **Short description** area for one of the LEDs and type description that is always visible on the annunciator page.

    Description can be split on three lines.

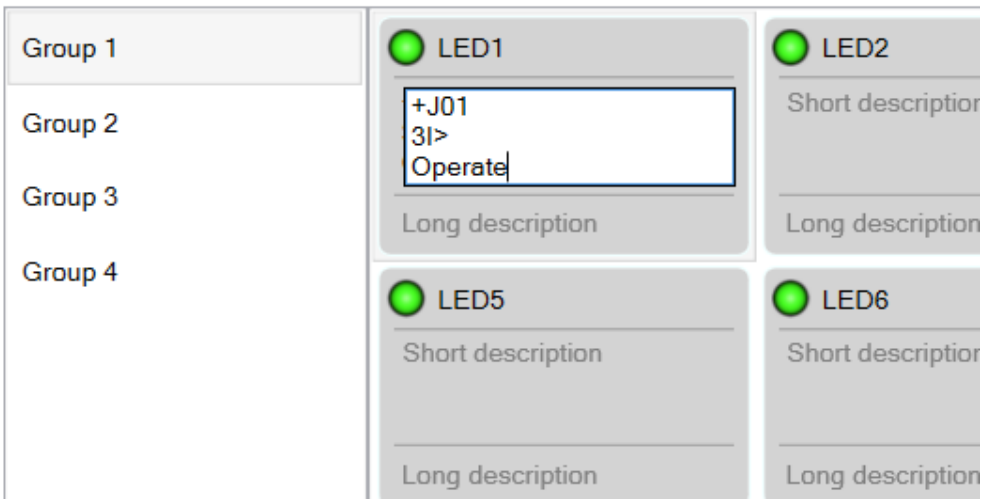



*Figure 123: Editor for short description in the alarm annunciator page*

11. Activate **Long description** for one of the LEDs and type description that becomes visible when alarm is tapped on HMI page.

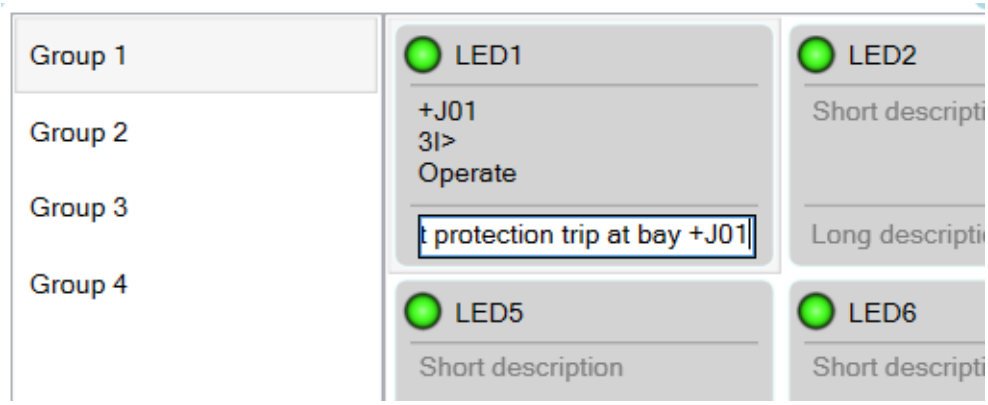



*Figure 124: Editor for long description in the alarm annunciator page*

# 7 IEC 61850 communication engineering

## 7.1 IEC 61850 protocol references and pre-conditions

To engineer the IEC 61850 protocol interface for the protection relay, the following additional manuals or knowledge of their contents is required.

- Knowledge of the IEC 61850 engineering process as described in the IEC 61850 standard
- The technical manual describes the function blocks defined as logical nodes
- IEC 61850 engineering guide
- IEC 61850 conformance documents for the protection relay to be engineered
- IEC 61850 parameter list

## 7.2 IEC 61850 interface



For more information on the implementation of IEC 61850 in protection relays, see IEC 61850 engineering guide and conformance documents.

### 7.2.1 IEC 61850 interface in the protection relay

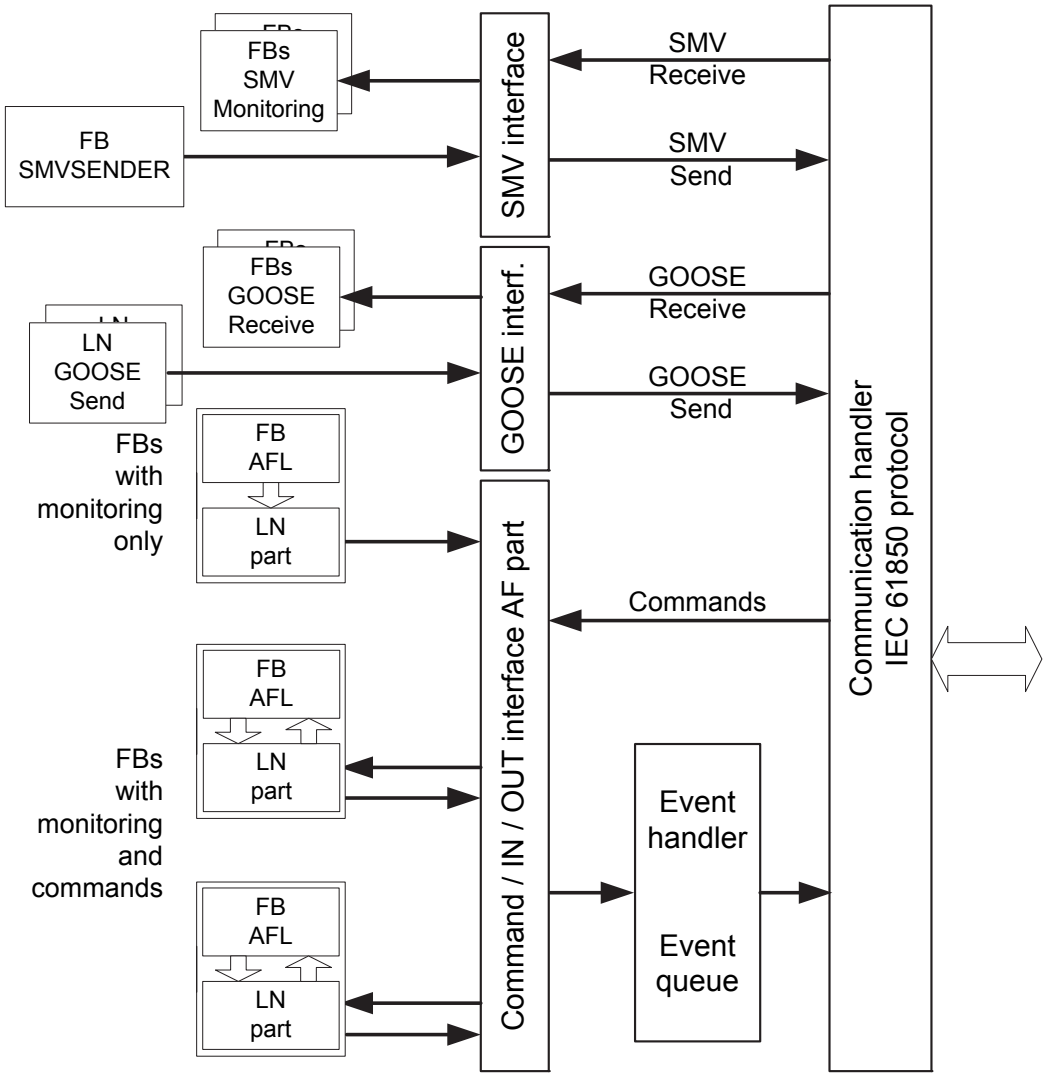



*Figure 125: IEC 61850 communication interface principle*

IEC 61850 provides a method for identifying all signals that belong to a function. These signals are identified through the logical nodes representing the functions. All signal information for relay parameters, settings, control and monitoring are available in logical nodes.

Whenever a function block is instantiated in Application Configuration, PCM600 automatically generates the corresponding logical node data.

#### 7.2.1.1 GOOSE data exchange

The IEC 61850 protocol supports a method to directly exchange data between two or more devices (IEDs). This method is described in the IEC 61850-7-2 clause 15.

The concept is based on sending a multicast over Ethernet. The receiver detects the telegram by its multicast destination address and application identifier, and decodes the telegram for further processing by the application.

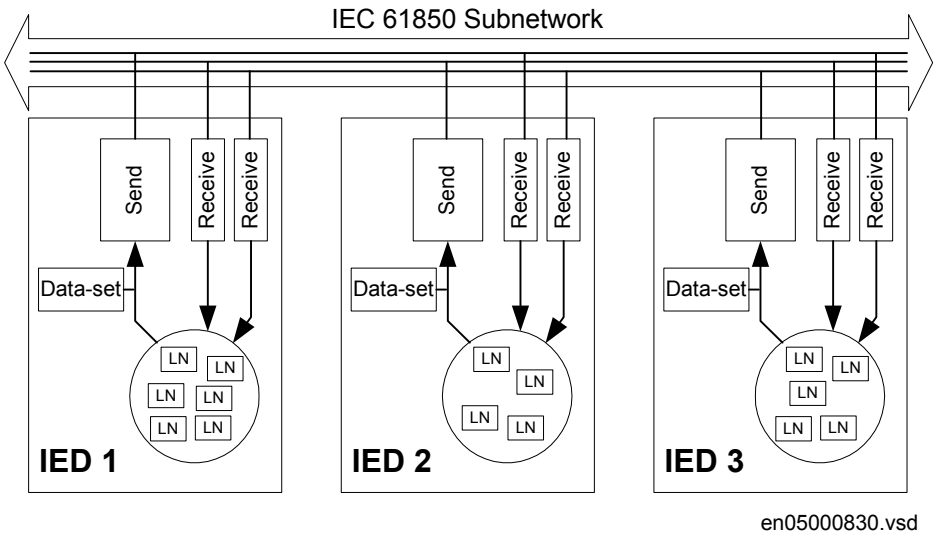



*Figure 126: IEC 61850: Horizontal communication principle, an example of three IEDs where each IED communicates with all others*

When a GOOSE message is to sent, it is defined by configuring the data set with the defined trigger option and GoCB. This engineering process is done in a station configuration tool, for example, IEC 61850 Configuration tool or IET600. The task involves configuring lists with the signal, value and quality (data attributes or data objects) that belong to the GOOSE message data set.

In the opposite direction, the standard only defines the IED as a receiver of a GOOSE message. How the GOOSE input signals are handled must be defined in the device's application configuration. The SCL data generated by the IEC 61850 Configuration tool or IET600 (or any other station configuration tool) contains the GOOSE data sets as input data. The input data must be connected to a GOOSE receive function blocks in the Signal Matrix tool.

In the opposite direction, the standard only defines the IED as a receiver of a GOOSE message. How the GOOSE input signals are handled must be defined in the device's application configuration. The SCL data generated by the IEC 61850 Configuration tool or IET600 (or any other station configuration tool) contains the GOOSE data sets as input data. The input data must be connected to a GOOSE receive function block in Signal Matrix.

## 7.2.2 Function view for IEC 61850 in PCM600

The IED design is directly based on IEC 61850. Thus, the function blocks in PCM600 use IEC 61850 logical node naming for function blocks. This relation is automatically handled by the PCM600 tools.

In the IED, the IEC 61850 data for each function instance is available in the data model, even when the function is not used in the application. This means that it is not necessary to handle any instance information for the functions regarding IEC 61850.

### 7.2.3 Station configuration description file types

The IEC 61850 standard defines SCL file types in the engineering sequence. These files have a different definition, which is explained in IEC 61850-6. Three of the file types are used in the IED's engineering process.

- ICD = IED capability description

  Capability description of the IED in logical nodes and their data. No information about, for example, the communication configuration is included.

  An IED is already extended by default data sets and report control blocks. They are predefined by ABB. Changes or additional data sets, for example, are handled with IEC 61850 Configuration tool or IET600.

- SCD = Station configuration description

  A complete configuration description of all IEDs in a station and the full engineering of the process signals and communication structure is included. This includes all the needed data sets and control blocks.

- CID = Configured IED description

  The CID file contains the information needed for configuring one specific IED. The CID file contains the complete configuration description of the IED: the configured IED name, communication part, data sets and all control blocks.

- IID = Instantiated IED description

  The IID file contains a complete IED configuration, like the CID file. The IID file can include references to other devices which are not present in the file. The IID file is meant for transferring configuration data from the IED configuration tool to a system configuration tool.

## 7.3 IEC 61850 engineering process

The IEC 61850 standard defines how information is communicated in a substation. The information communication can be divided into different parts.

- Description of the substation part, including the used logical nodes
- Description of the IEDs with their logical nodes
- Description of the communication network
- Description of the engineering process

When exporting an SCL file from PCM600, the tool builds a default substation structure and creates default data sets and control blocks for vertical communication between the substation client and IEDs. For more information, see the IEC 61850 standards.

In the following example, it is assumed that PCM600 and IET600 are used as the system configuration tools. Another option is to use IEC 61850 Configuration tool or Application Configuration in PCM600. In that case, the SCL file export and import (steps 1 and 3) are not needed. For more information on the GOOSE engineering

in IEC 61850 Configuration tool and Application Configuration, see the IEC 61850 engineering guide.

1. SCL files are exported from PCM600. In this case, a SCD file. It is also possible to export other SCL file types.
2. Horizontal and vertical communication is configured using the station configuration tool, for example, IEC 61850 Configuration tool or IET600.
3. SCL files are imported to a PCM600 project. In this case, it is the updated SCD file.

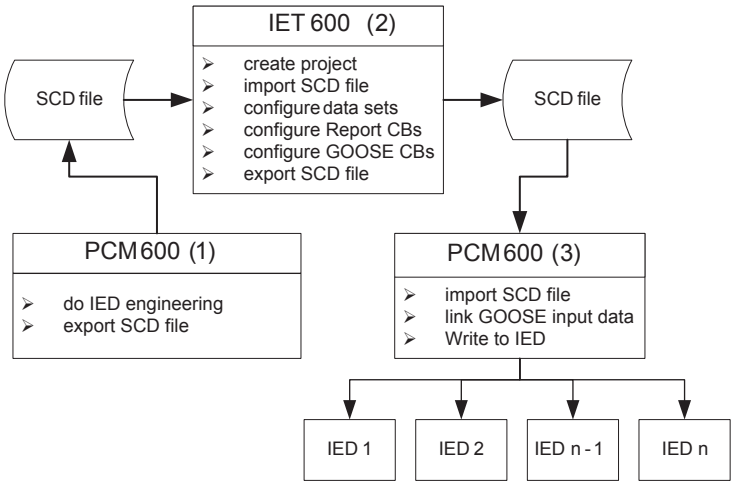



*Figure 127: IEC 61850: signal engineering procedure flow when a complete station is exported as a SCD file*

## 7.3.1 Exporting SCL files from PCM600

A pre-condition for exporting SCL files from PCM600 is that all IEDs in the project must be engineered in PCM600. The IEDs require a unique name and IP addresses and they must be set according to the project definitions. IED configurations must be finalized as far as possible before starting the IEC 61850 configuration part.

### 7.3.1.1 Exporting SCD files

1. In the **Plant Structure** view, right-click the substation and select **Export**.

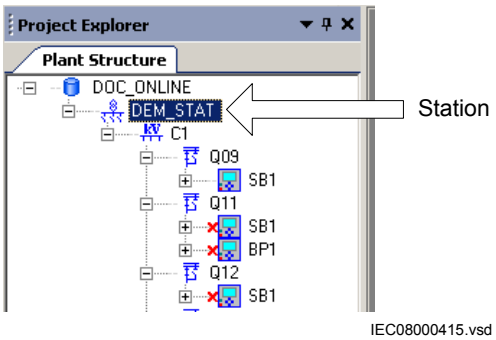



*Figure 128: IEC 61850: selecting the substation*

2. In the **Export** dialog box, select the location to store the file and name it.

3. Click **Save**.
4. In the **SCL Export Options** dialog box, click **Advanced** to change the SCL file version if required by the receiving configuration tool.

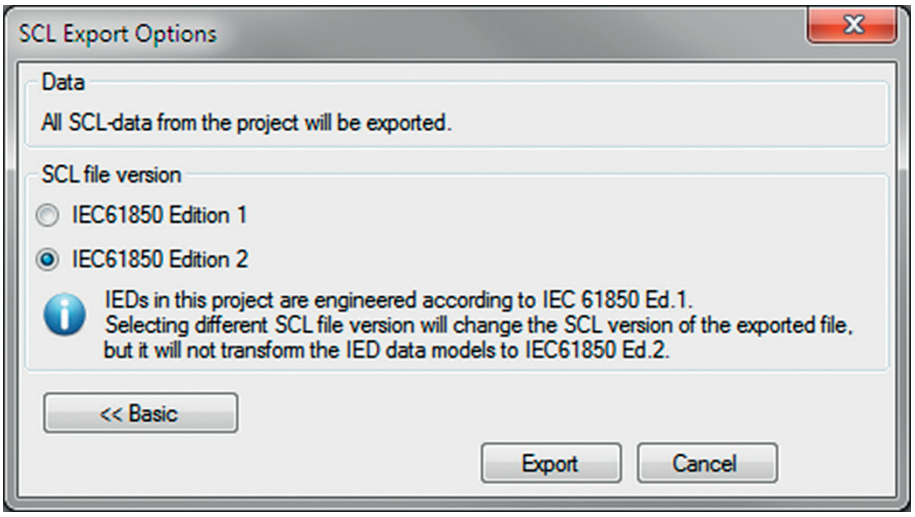



*Figure 129: Selecting the SCL file version*

5. Click **Export** to generate the SCD file.

   A progress window shows the ongoing export of the station.

### 7.3.1.2 Exporting ICD or CID files

1. Select the IED in the **Plant Structure** view.
2. Right-click the IED and select **Export**.
3. In the **Export** dialog box, from the **Save as type** list, select the type of file to export.
   - Configured IED description (.cid) for the IEC 61850 structure as needed for the IED at runtime
   - IED capability description (.icd) for the IEC 61850 structure

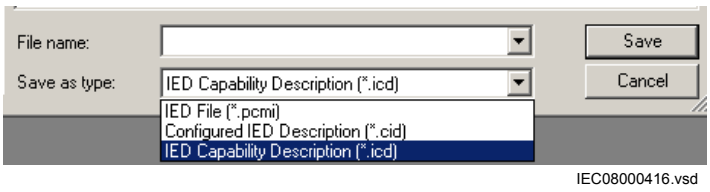



*Figure 130: IEC 61850: Selecting the IED file type for export*

4. Click **Save**.

5. In the **SCL Export Options** dialog box, select the export options.

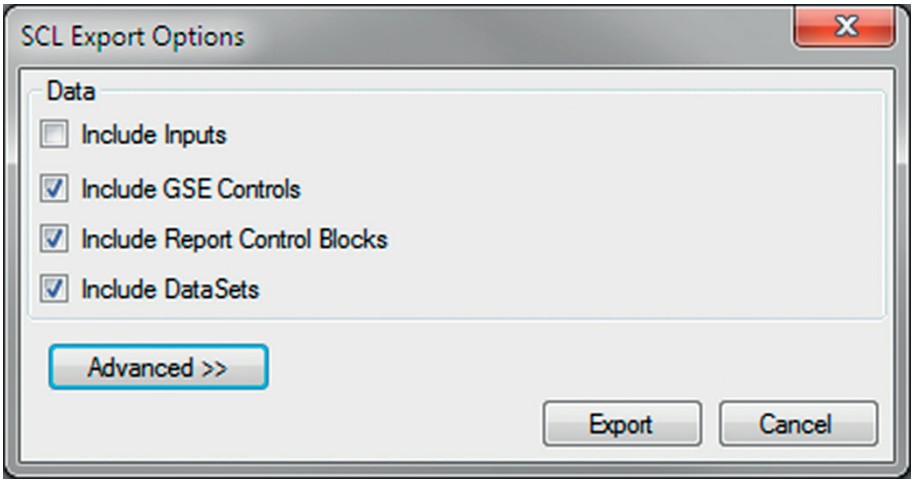



*Figure 131: IEC 61850: Selecting the export options*

6. Click **Advanced** to change the SCL file version if required by the receiving configuration tool.

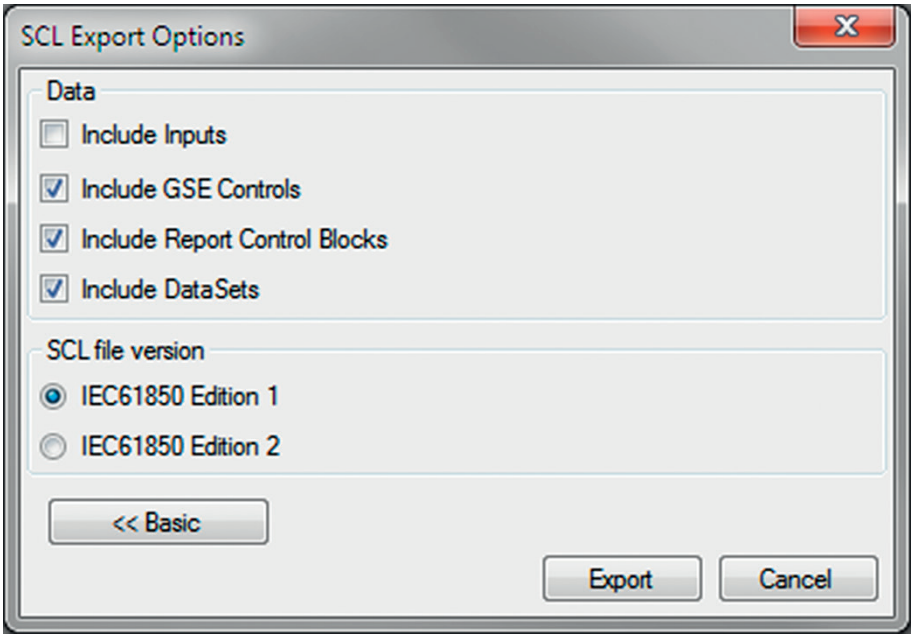



*Figure 132: Selecting the SCL file version*

7. Click **Export**.

## 7.3.2 Engineering vertical and horizontal communication

For IEC 61850 engineering a separate system configuration tool needs to be used with PCM600. The recommended tool for smaller projects is the IEC 61850 Configuration tool. For larger projects it is recommended to use IET600, which is available as a standalone tool.

1. Create a project in IET600. [1]

2. Import the SCD file created by PCM600. [1]
3. Conduct vertical communication engineering (monitoring direction).
   a) Check the default data sets.
   b) Configure the default data sets.

   Data sets meant for vertical reporting can only contain data on the data object level, not on the data attribute level.

   The data set for GOOSE can contain signals on the data attribute or data object level. Data object level GOOSE entries can only be received of the following CDC types: SPS, SPC, ACD, ACT, DPS, DPC, INC, INS, ENC and ENS.

   c) Configure additional **Report Control Blocks** when needed for each data set used for vertical communication.
   d) Link the IED clients to the **Report Control Blocks**.

   Up to five report clients can be configured.

4. Conduct horizontal communication engineering.
   a) Configure GOOSE control blocks for each data set configured for GOOSE messages.

   One data can be included in the GOOSE data set only once.

   b) Define the client IEDs for each GOOSE control block.
   c) Link the IEDs to the GOOSE control block that must receive the GOOSE control block.
5. Export the updated SCD file. [1]

   All data sets, **Report Control Blocks** and GOOSE control blocks must be located in LLN0.

## 7.3.3 Importing SCL files to PCM600

The IED engineering tool must be able to receive an SCD file or an ICD file as an import to receive the engineered communication extensions, for example, for the different IEDs.

To be able to import an SCD file at station level, the option IED 61850 configuration engineering mode enabled has to be cleared in PCM600.

1. On the **Tools** menu, select **Options** and click **IEC 61850 Configuration**.

[1] Applicable when using IET600

2. On the **Engineering** tab, clear the option **IED 61850 configuration engineering mode enabled** and click **OK**.

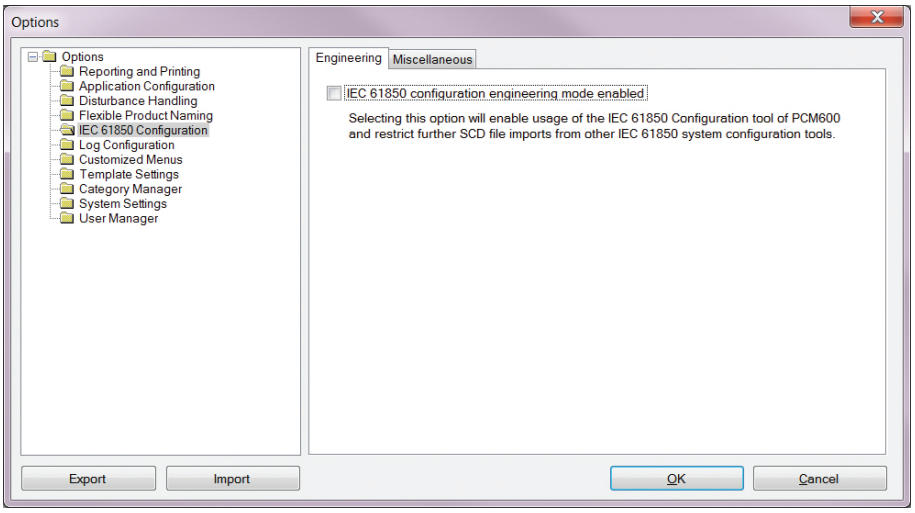



*Figure 133: Enabling SCD file import at station level*

If the IED 61850 configuration engineering mode is enabled, SCD files cannot be imported and an error message is shown.

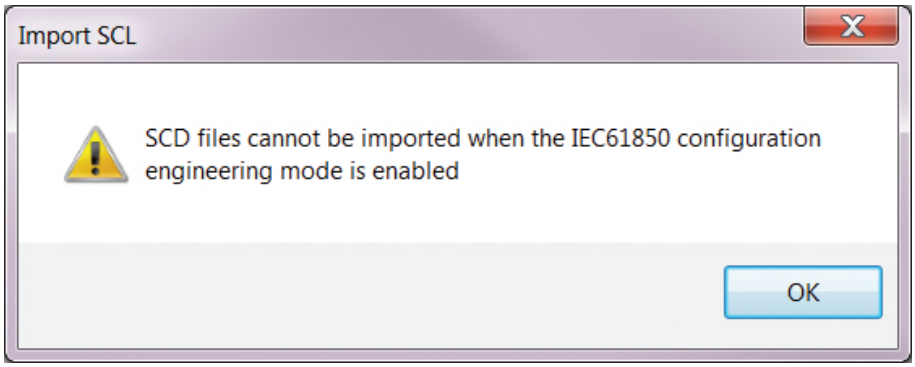



*Figure 134: Error message when SCD files cannot be imported*

### 7.3.3.1 Importing SCD files

To be able to import an SCD file at substation level, the option IED 61850 configuration engineering mode enabled has to be cleared in PCM600.

1. In the **Plant Structure** view, right-click the substation and select **Import**.
2. On the **Import** dialog box, select the file to be imported.
3. In the **SCL Import Options** dialog box, select how to handle the file during the import.

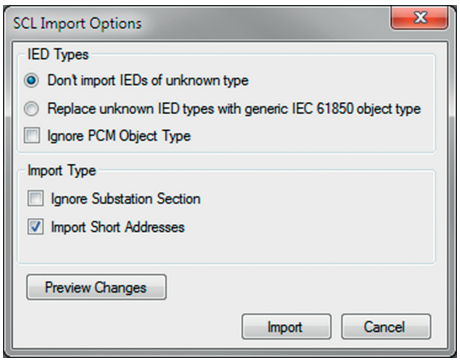



*Figure 135: SCL Import Options*

- Click **Don't import IEDs of unknown type** to protect the existing IEDs in case the SCD file does not match the original configuration in PCM600.
- Click **Replace unknown** if the file includes additional IEDs that are needed. The IED of type “Generic IEC 61850 IED” is used to integrate this kind of IEDs into the plant structure, for example.
- Click **Ignore PCM Object Type** to update the IED object(s) in PCM600 from the IED type(s) in the SCD file, whether or not the IED type(s) in the SCD file matches the IED object(s) in PCM600. This option can be used, for example, when third party IEDs are included in the system and the SCD file sends GOOSE messages to ABB IEDs included in the project.
- Click **Ignore Substation Section** to not import the SSD file part of the SCD file.

4. Click **Import** when the file definition has been completed.
   A progress view displays the importing procedure.
5. Make connections from the sending IEDs to the receiving function blocks with the Signal Matrix.

   Make connections between the signals that the server is send and the function blocks on the receiver's side.

6. Write the configuration to the IED.

   In the **Plant Structure** view, select the IED, right-click and select **Write to IED**.

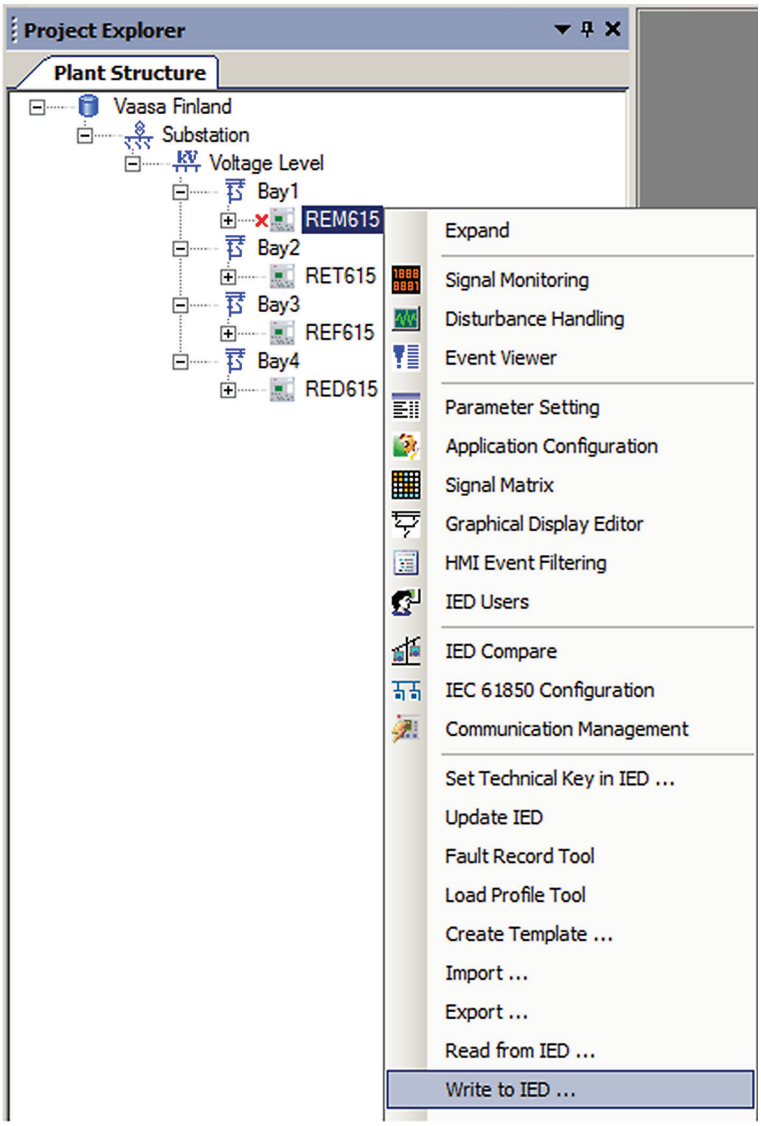



*Figure 136: Write to IED menu*

The engineered data is written to the IED when executing a common *Write to IED operation*.

### 7.3.3.2 Importing ICD or CID files

1. Select an existing IED.
2. From the **Files of type** list, select the IEC 61850 file type to be imported (ICD or CID).
3. In the **SCL Import Option** dialog box, select how the file is to be handled during the import.

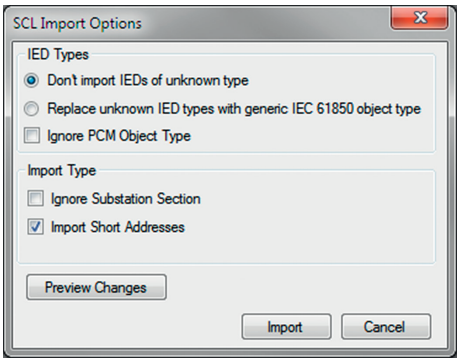



*Figure 137: SCL Import Options*

- **Don't import** protects the existing IEDs if the SCD file does not match the original configuration in PCM600.
- **Replace unknown** can be used when the file includes additional IEDs that are needed. The IED of type “Generic IEC 61850 IED” is used to integrate this kind of IEDs into, for example, the plant structure.
- **Ignore PCM Object Type** updates the IED objects in PCM600 from the IED types in the SCD file, whether or not the IED types in the SCD file match the IED objects in PM600.
- **Ignore Substation Section** does not import the SSD file part of the SCD file.

4. Click **Import** when the definition has been completed.
   A progress view displays the importing procedure.

### 7.3.4 Writing communication configuration to IED

IEC 61850 communication depends on the proper communication configuration in all IEDs that communicate via IEC 61850.

It is possible to make a configuration change in one IED, without affecting the horizontal communication (GOOSE or IEC 61850-9-2 LE) engineering between IEDs. For example, when the Application Configuration tool configuration is changed, but no changes are done to the instantiation or deletion of functions that represent a logical node.

When a changed configuration is written to the IED, the horizontal communication configuration needs to be updated.

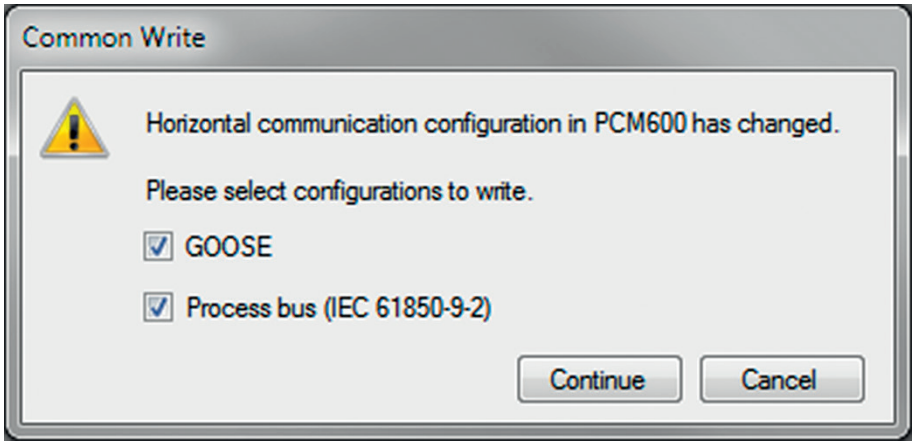



*Figure 138: Updating the communication configuration in the IED with the configuration made in PCM600*

1. Select which configuration part to include in writing.
   - Select **GOOSE** to update the GOOSE configuration part in the IED.
   - Select **Process bus (IEC 61850-9-2)** to update the IEC 61850-9-2 configuration part in the IED.

     The options can be left unselected. In this case, other parts of the configuration are updated.
2. Select whether or not to update the configuration.
   - Click **Continue** to update the selected communication configuration parts in the IED.
   - Click **Cancel** to cancel the writing operation.

# 8 Flexible product naming

## 8.1 IEC 61850 Structure Mapping

IEC 61850 Structure Mapping is used to manage the IED's data model as required. This is done by mapping the data model to the customer-specific data model. IEC 61850 Structure Mapping is available only in FPN projects in PCM600. A PCM600 project can be converted into an FPN project by importing an FPN SCD file into it. FPN is supported for both IEC 61850 Edition 1 and IEC 61850 Edition 2.

FPN allows the use of standardized, predefined and IED vendor independent templates for building and maintaining substations. See the PCM600 documentation for more information about FPN.

### 8.1.1 User interface

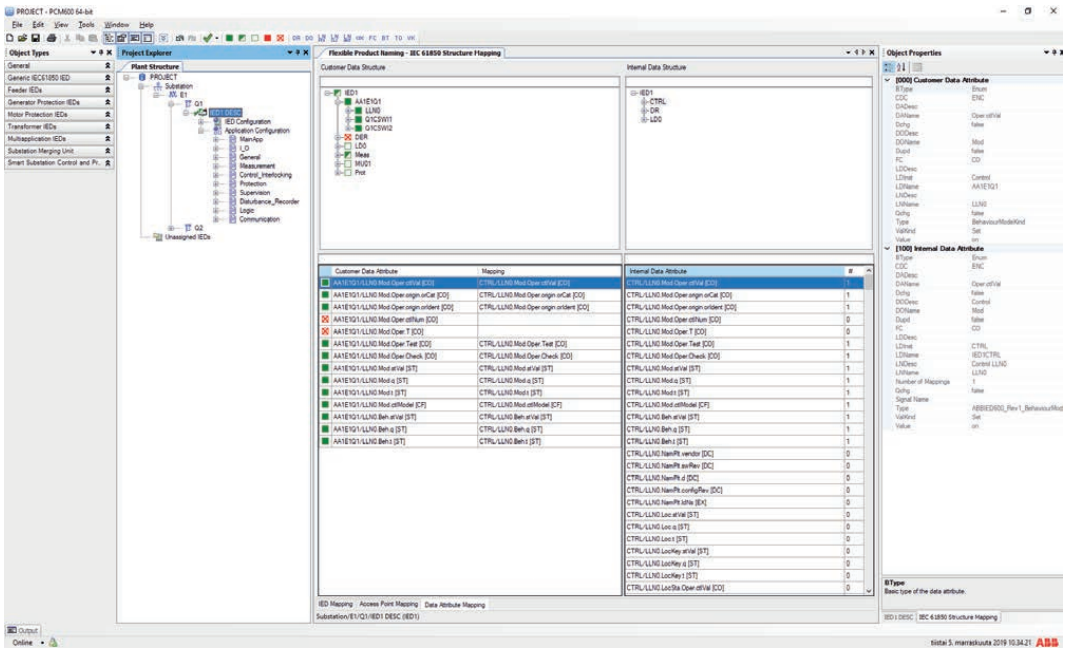


*Figure 139: IEC 61850 Structure Mapping*

#### Plant structure

The data tree displays the FPN IEDs under substation and internal IEDs under unassigned IEDs.

#### IEC 61850 structure mapping

The IEC 61850 structure mapping list displays the FPN objects based on the current selection in the plant structure. The list may display either IEDs or data attributes.

The FPN object's name is displayed in the column on the left and the mapped PCM600 internal object name is displayed in the column on the right. The customer data structure and attributes are on the left, and the internal data structure and attributes are on the right.

**Object properties**

The Object Properties pane displays the properties of the objects selected in the FPN mappings and Internal Data Attribute lists.

## 8.1.2 IED and signal naming convention

The names used for the internal objects can be defined to be either the names used in PCM600 or the names in the internal IEC 61850 model.



To change the naming convention, select the PCM600 naming style in use from **Options**.

## 8.2 Importing substation configuration description file

The SCD file can be imported only at the substation level.

1. On the **Tools** menu, click **Options**.
   a) Select **Flexible Product Naming**. In the **General** tab, select **Import as Flexible Product Naming SCD option enabled**.
   b) Select **IEC 61850 Configuration**. In the **Engineering** tab, clear the **IEC 61850 configuration engineering model enabled** check box.
   c) Click **OK**.

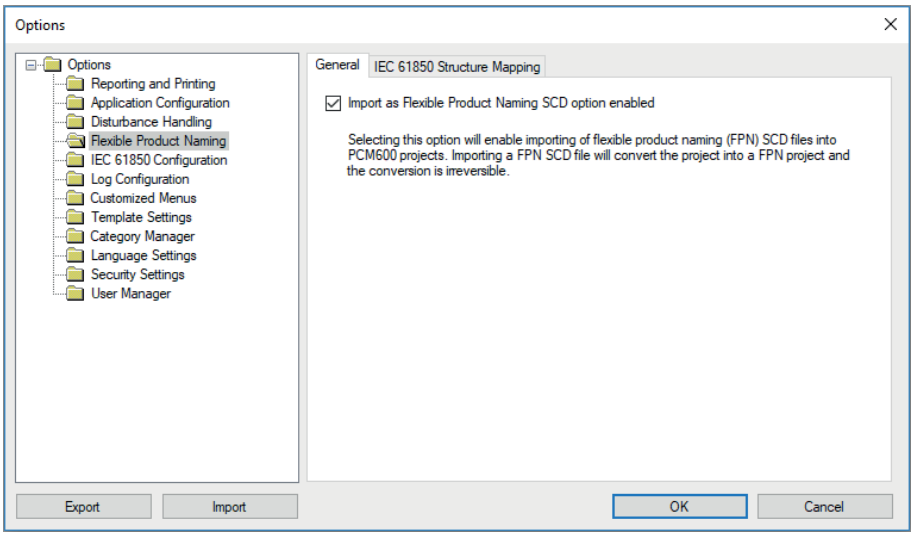



*Figure 140: Enabling the FPN option*

2. Right-click a substation level, and then click **Import**.
3. Browse and select the SCD file.
4. Click **Open** to open the file.

5. Select **Import as Flexible Product Naming SCD**.

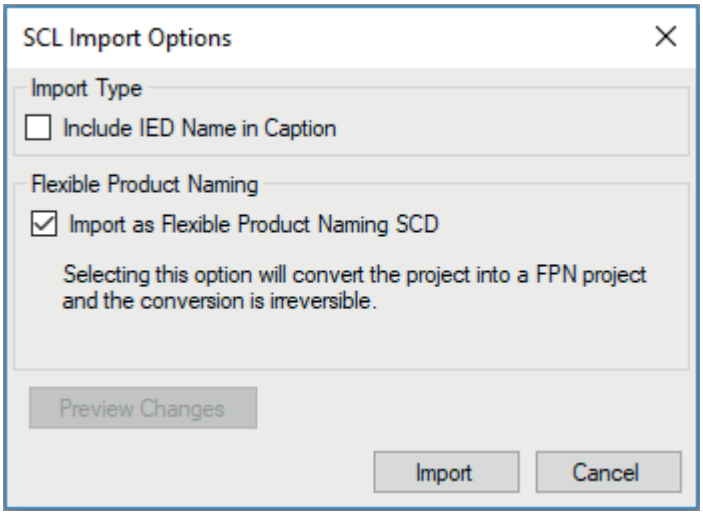



*Figure 141: Importing as Flexible Product Naming SCD*

The imported SCD file changes the substation structure. The internal IED from the original substation structure is replaced and pushed to the unassigned IEDs folder.

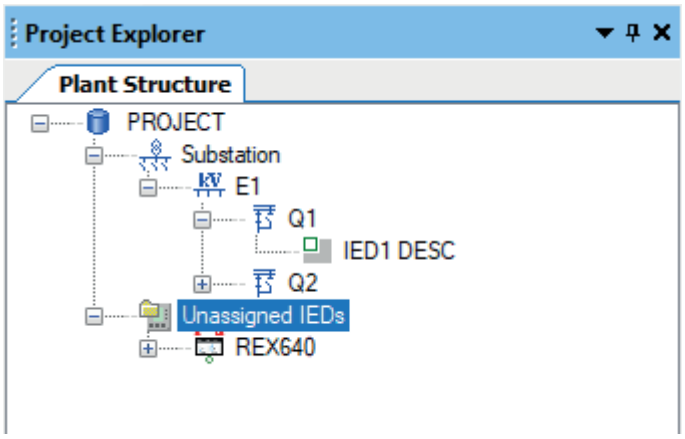



*Figure 142: Unassigned IEDs*

6. Drag the unassigned IED over the internal IED.

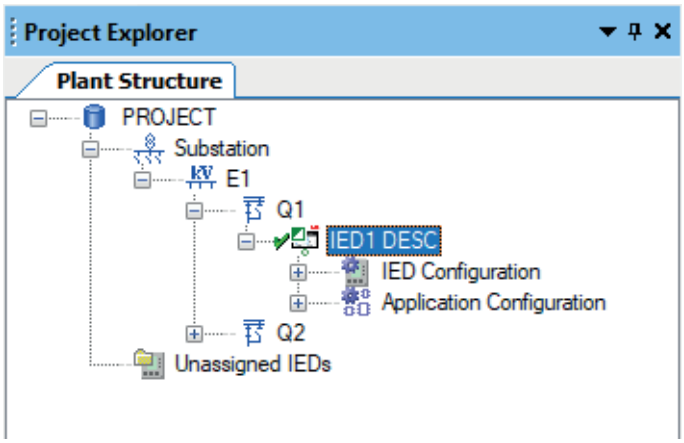



*Figure 143: Assigned IED*

Importing the FPN SCD file converts the project into an FPN project. The conversion is irreversible.

FPN projects do not support configuring GOOSE with Application Configuration.

## 8.3 Starting IEC 61850 Structure Mapping

The tool can be started from any node from the substation to IED level.

1. Right-click one of the IEDs and point to **Flexible Product Naming**.

2. Click **IEC 61850 Structure Mapping**.

   The FPN object's name is displayed in the column on the left and the name of the mapped PCM600 internal object is displayed in the column on the right.

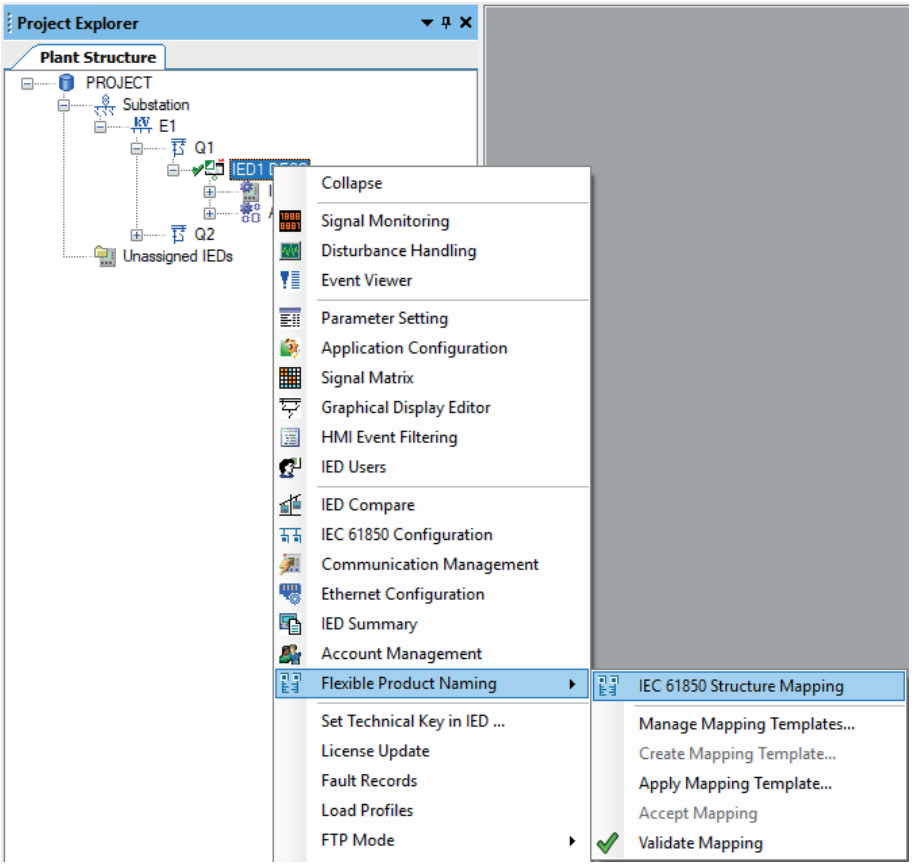



*Figure 144: Flexible product naming tool*

# 8.4 IEC 61850 structure mapping

## 8.4.1 IED mapping

The first step in the IEC 61850 structure mapping is to map the real IEDs to the customer-specific IEDs. IED mapping means that each server IED in the FPN model is mapped with a corresponding IED in the internal PCM600 model, that is, the real device in the substation. A server IED is an IED that has an access point containing a server. IED mapping does not map the data attributes between the IEDs unless the data attribute mapping is complete. IED mapping can be done in the PCM600 plant structure and in IEC 61850 Structure Mapping.

### 8.4.1.1 Mapping IED in PCM600 plant structure

- To map the IED in the plant structure, drag a PCM600 IED from the Unassigned IEDs group onto an FPN IED in the substation.

  IED mapping status is indicated visually in the plant structure.
- To remove an IED mapping from the plant structure, drag a mapped FPN IED onto the Unassigned IEDs group.

  The removed mapping is indicated visually in the plant structure. The PCM600 internal IED, with which the FPN IED was mapped, appears back in the Unassigned IEDs group if it is not mapped with any FPN IEDs.

### 8.4.1.2 IED mapping in IEC 61850 Structure Mapping

#### IED mapping

The tool displays all FPN IEDs and all PCM600 IEDs in separate lists. Mapping is done by dragging the PCM600 IED on the right-hand side to an FPN IED on the lefthand side. The tool indicates the mapping status visually. The mapping needs to be saved to apply it.

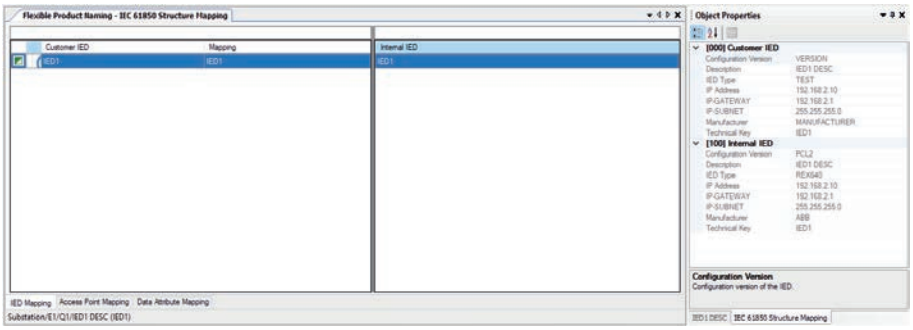


*Figure 145: Mapping of IEDs in IEC 61850 Structure Mapping*

#### Removing IED mapping

Removing IED mapping is done in IEC 61850 Structure Mapping by right-clicking the mapping and selecting the context menu option or pressing the DELETE key. The tool indicates the mapping status visually. The change must be saved.

#### Access point mapping

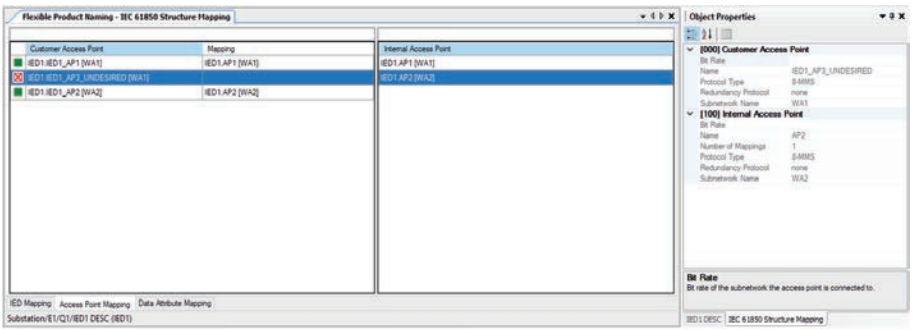


*Figure 146: Access point mapping*

Access point mapping defines the relations between REX640 internal access points and customer access points.

In the above example, REX640 access point AP1 is in subnetwork WA1, while access point AP2 is in subnetwork WA2. The configuration is created using Ethernet configuration.

The network configuration must be correct before the flexible product mapping is started.

REX640 supports one access point for data model. Second access point AP2 is based on the ServerAt concept and has the same data model in different IP addresses.

The REX640 access points are mapped to FPN project's access points IED1_AP1 and IED_AP2. The third access point IED1_AP2_UNDESIRED is excluded from the mapping since it does not have a network interface.

### Data tree view

The data tree view consists of customer data structure in the column on the left and the name of the mapped PCM600 internal data structure in the column on the right.

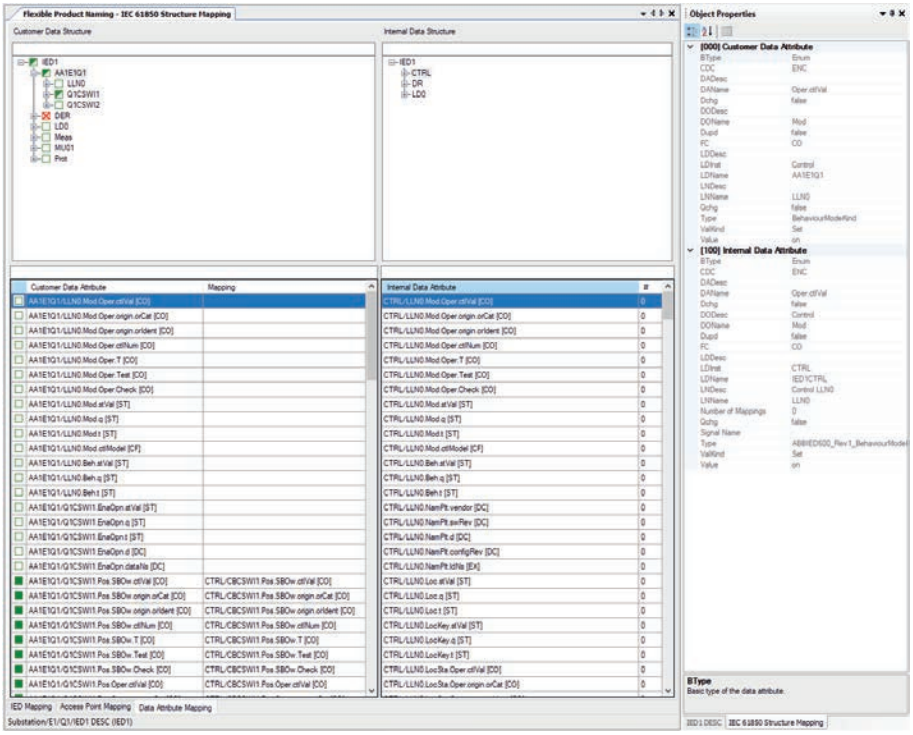


*Figure 147: Data tree view*

### Data attribute list view

The data attribute list view consists of customer data attributes in the column on the left and the PCM600 internal data attributes in the column on the right.

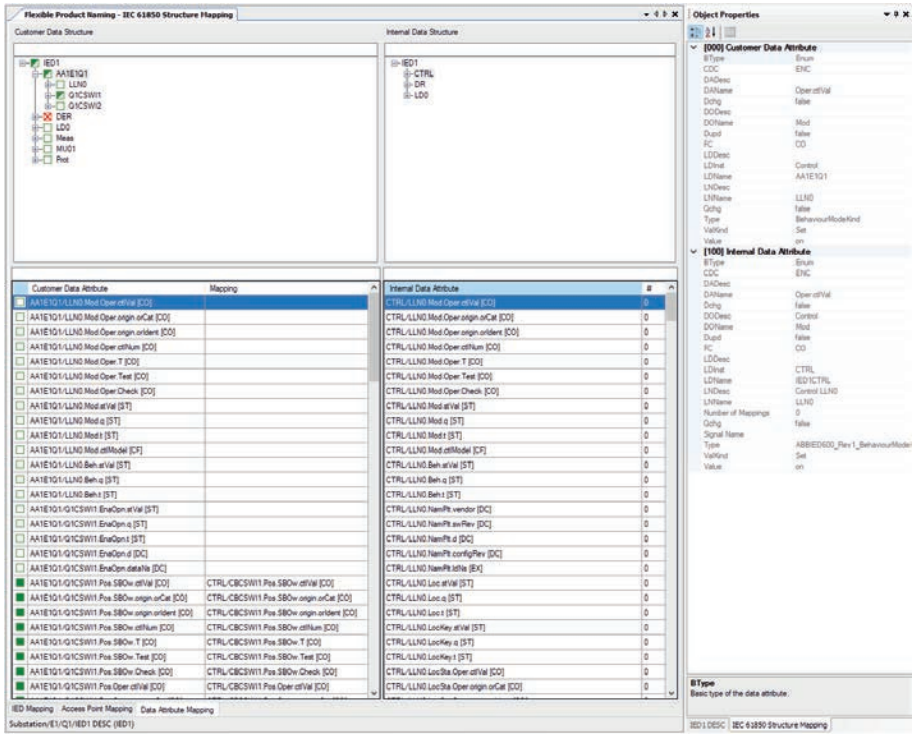


*Figure 148: Data attribute list view*

### Filters

The displayed objects can be filtered using the filtering options on the quick access toolbar.




*Figure 149: Filters*

### Free text filter

The objects are filtered by free text, showing all the objects with a certain name in both Data Structure level and Data Attribute level.

### Show/hide objects by status

The objects are filtered by status, showing only the selected objects in Data Structure level and Data Attribute level.

### Enable and disable type filters

Objects in the FPN can be filtered using additional filtering options available in the quick access menu.

## 8.4.2 Data attribute mapping

Data attribute mapping means that each FPN data attribute in the FPN model is mapped to a corresponding data attribute in the internal PCM600 model, that is, the real device in the substation.

The mapping status is indicated visually. It can be seen what FPN data attribute is mapped to what PCM600 internal data attribute and how many FPN data attributes are mapped to a PCM600 internal data attribute.

Data attribute mapping is complete when all data attributes of the FPN IED, which are not excluded from the mappings, are mapped to a PCM600 internal data attribute. Data attribute mapping must be complete to be able to write to IED.

Data attribute mapping is broken if any of the mapped data attributes - FPN or PCM600 internal - does not exist in the SCL database.

**Table 8: Visual indication of the mapping status**

| Icon | Description |
|---|---|
|  | Completely mapped |
|  | Not mapped |
|  | Broken mapping |
|  | Partially mapped |
|  | Excluded from mappings |



All data attributes in the FPN model must be mapped or excluded, otherwise write to IED fails.

### 8.4.2.1 Mapping data attribute level

IEC 61850 Structure Mapping displays the FPN data attributes and PCM600 internal data attributes in separate lists.

- To map data attributes, drag the FPN data attribute onto a PCM600 internal data attribute.
- Remove a data attribute mapping in one of the alternative ways.
  - Right-click the mapping and select the remove option.
  - Select the mapping and press the DELETE key.

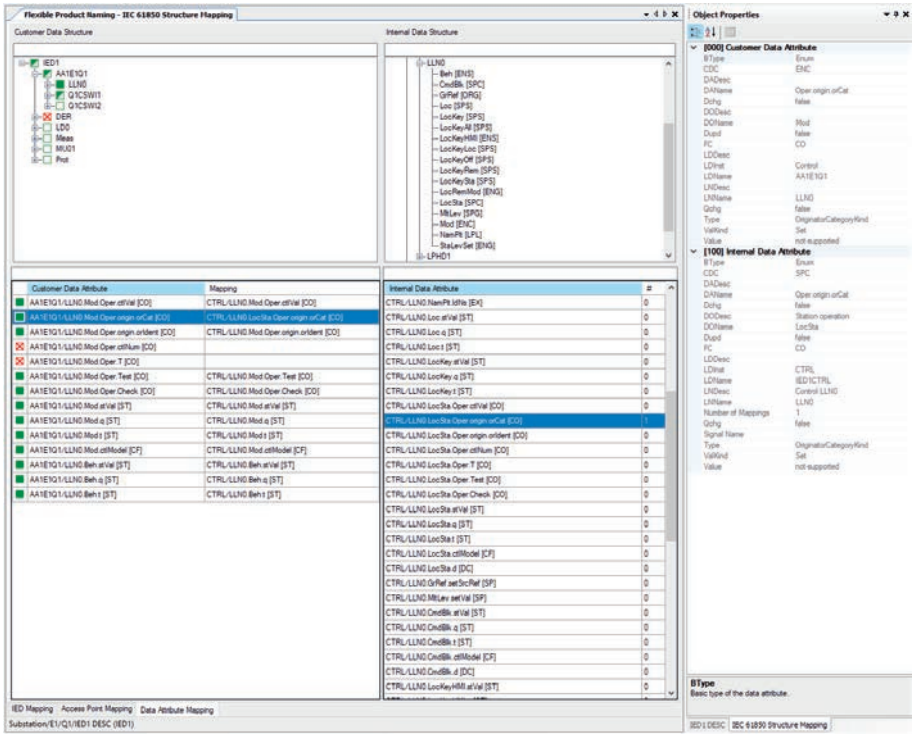


*Figure 150: Data attribute level mapping*

### 8.4.2.2 Mapping data object level

Create data attribute mapping on the data object level in one of the alternative ways.

- Drag a data object from the customer data structure onto a data object in the internal data structure.
- Drag a data object from the internal data structure onto a data object in the customer data structure.

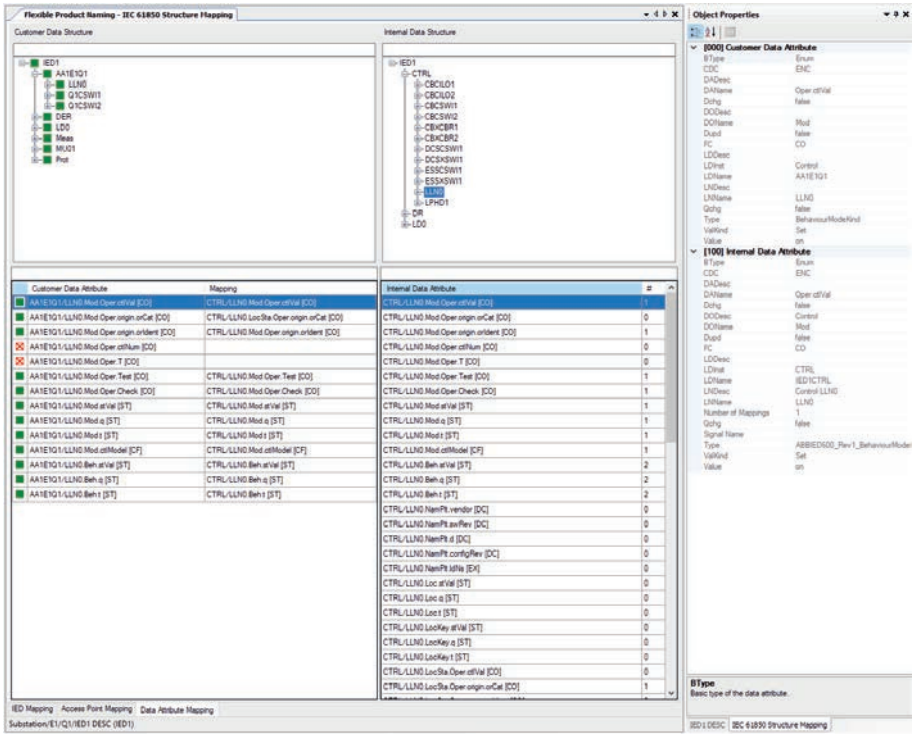


*Figure 151: Completed data object mapping*

### 8.4.2.3 Mapping logical node level

Create data attribute mapping on the logical node level in one of the alternative ways.

- Drag a logical node from the customer data structure onto a logical node in the internal data structure.
- Drag a logical node from the internal data structure onto a logical node in the customer data structure.

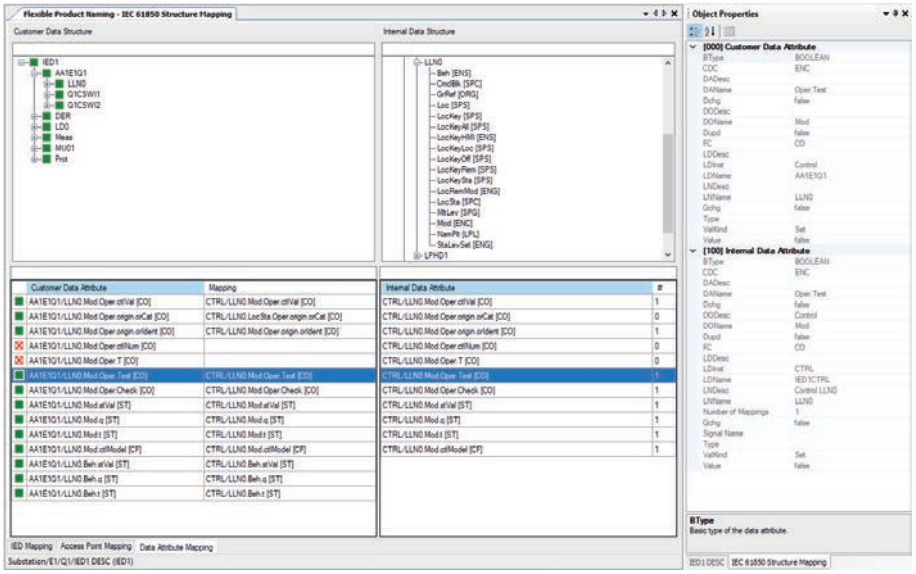


*Figure 152: Logical node level mapping*

### 8.4.2.4 Excluding data attributes from mapping

Exclude the data attributes in one of the alternative ways.

- Select the data attributes to exclude, right-click and select **Exclude Items**.

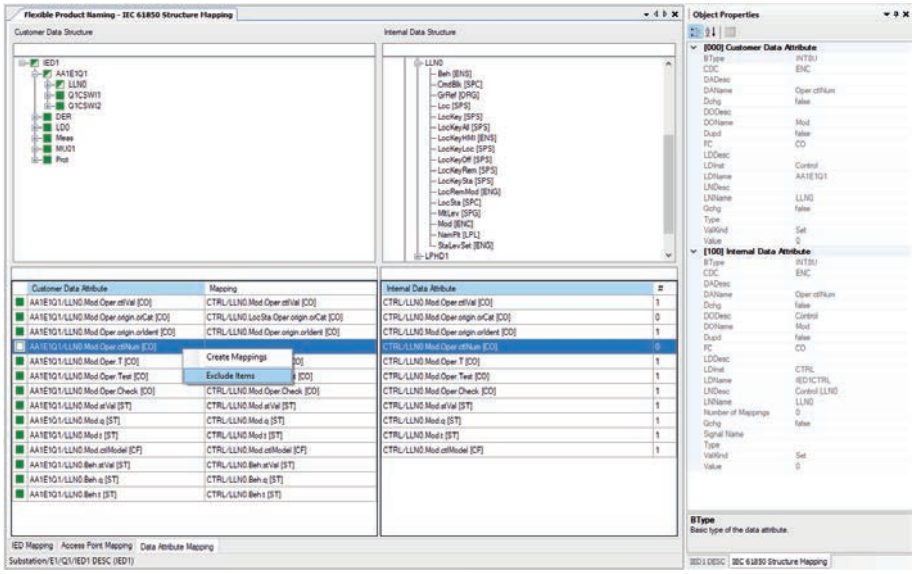



*Figure 153: Excluding data attributes from mapping*

- Exclude all unmapped data attributes from the data object at once by right-clicking the data object and selecting **Exclude Data Attributes**.

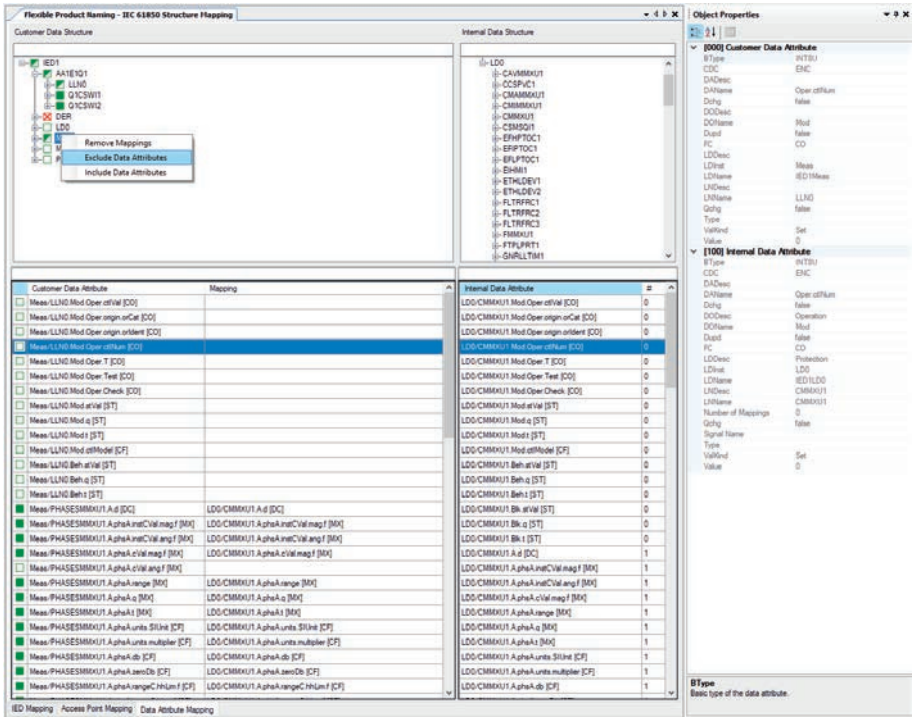


*Figure 154: Excluding data attributes from mapping*

The data attributes that are excluded from the mapping are not excluded from the model. Excluded mappings are ignored when determining if an IED mapping is complete.

It is crucial to set a value to the excluded data attributes before initiating the mapping.

## 8.5 Setting data attribute value

Edit the **Value** field in the **Object Properties** pane.

- For enum type of data attributes, select the value from the list of available values.
- For numeric and string type of data attributes, type the value in the **Value** field.

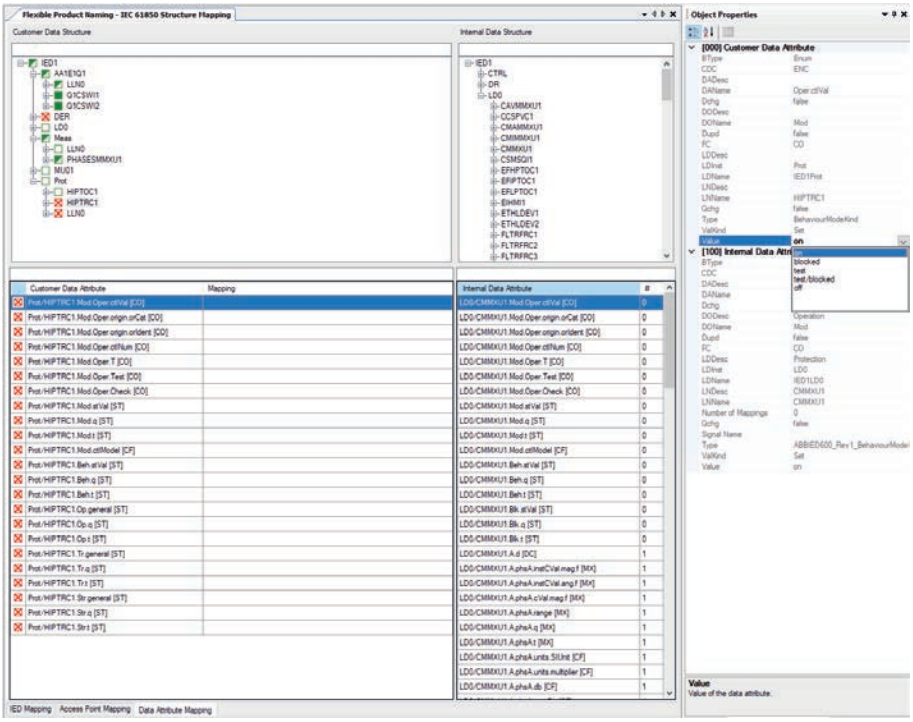


*Figure 155: Setting the data attribute value*

A value cannot be set for all data attributes types. For example, quality and timestamp values cannot be edited.

## 8.6 Validation

Once the FPN mapping is complete, all mapping can be validated in three ways using the validate options available on the toolbar.

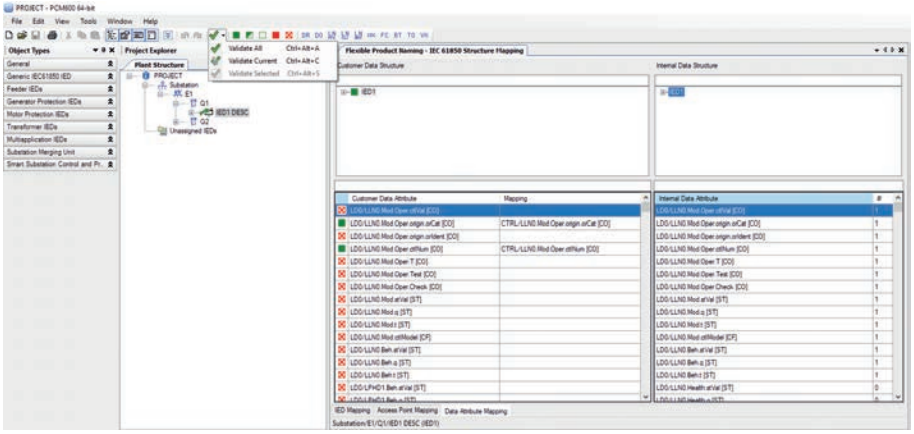


*Figure 156: Validate mapping*

## 8.7 Template creation

It is possible to create a template of an IED's data attribute mapping and store it for reuse. The template contains the description of the data attribute mapping of two IED SCL models.

All mapping templates created in PCM600 are stored in a template library. The template library is not specific to a certain PCM600 project, but it is common for all projects. Templates in the library can be managed in several ways.

- Delete selected templates
- Export templates: One or multiple template files can be exported.
- Import templates: One or multiple template files can be imported. If a template being imported already exists in the library, the user is asked whether to overwrite the existing one.
- Export project's templates: When a PCM600 project is exported, all templates used in the project are automatically included in the exported .pcmp file.
- Import project's templates: When a PCM600 project is imported, all templates included in the imported .pcmp file are automatically imported into the template library. If a template being imported already exists in the library, it overwrites the template in the library.

The mapping templates are also used by IET600 to translate the internal data references in the signal library to the FPN references, because IET600 needs to know what template to use to resolve the internal data references.



Create a template for each IED mapping.

### 8.7.1 Mapping template creation

Data attribute mapping templates can be created from mapped IEDs. If the template is created from an incompletely mapped IED, a dialog box is shown. The user can select an option to not show the dialog box again. The dialog box can be activated afterwards from the PCM600's Options menu.

The template can be created either from IEC 61850 Structure Mapping or from the PCM600 plant structure. The required template information must be filled in before it can be created.

### 8.7.2 Applying of a mapping template to IED

The template can be selected from a list of available templates. The FPN IED must be mapped with a PCM600 internal IED before the template can be applied.

The template can be applied either in IEC 61850 Structure Mapping or in the PCM600 plant structure. In IEC 61850 Structure Mapping, the template can be applied to one or several IEDs at once. In the plant structure, the template can be applied on one IED at a time by right-clicking an IED, or on all IEDs under a bay by right-clicking the bay.

## 8.7.3 Exporting FPN templates

1. Right-click the PCM600 plant structure.
2. Point to **Flexible Product Naming** and select **Manage Mapping Templates**.
3. Select the templates to export and click **Export**.

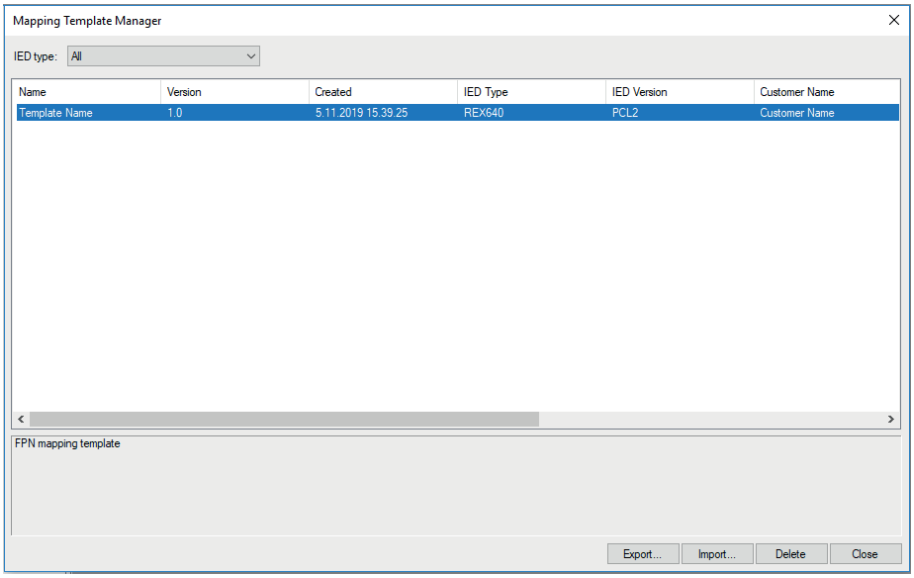



*Figure 157: Exporting FPN templates*

4. Select the folder where to export the templates and click **OK**.

## 8.7.4 Reporting and printing

The report consists of a cross-reference list of the IED and data attribute mappings, that is, a table of all FPN objects together with the PCM600 internal objects they are mapped with.

| Parameter | Customer IED | Internal IED |
|---|---|---|
| Technical Key | IED1 | IED1 |
| Description | IED1 DESC | IED1 DESC |
| IED Type | TEST | TEST |
| Configuration Version | VERSION | VERSION |
| Manufacturer | MANUFACTURER | MANUFACTURER |
| IP Address | 192.168.2.10 | 192.168.2.10 |
| IP-GATEWAY | 192.168.2.1 | 192.168.2.1 |
| IP-SUBNET | 255.255.255.0 | 255.255.255.0 |
| Voltage Level | E1 (E1) | E1 (E1) |
| Bay | Q1 (Q1) | Q1 (Q1) |

*Figure 158: IED mappings*

| Customer Access Point | Internal Access Point |
|---|---|
| IED1.IED1_AP1 [WA1] | IED1.AP1 [WA1] |
| IED1.IED1_AP3_SERVERAT [WA2] | IED1.AP2 [WA2] |

*Figure 159: Access point mappings*

| Customer Data Attribute | Internal Data Attribute | Signal Name |
|---|---|---|
| AA1E1Q1/LLN0.Beh.q [ST] | CTRL/LLN0.Beh.q [ST] | |
| AA1E1Q1/LLN0.Beh.stVal [ST] | CTRL/LLN0.Beh.stVal [ST] | |
| AA1E1Q1/LLN0.Beh.t [ST] | CTRL/LLN0.Beh.t [ST] | |
| AA1E1Q1/LLN0.Mod.ctlModel [CF] | CTRL/LLN0.Mod.ctlModel [CF] | |
| AA1E1Q1/LLN0.Mod.Oper.Check [CO] | CTRL/LLN0.Mod.Oper.Check [CO] | |
| AA1E1Q1/LLN0.Mod.Oper.ctlVal [CO] | CTRL/LLN0.Mod.Oper.ctlVal [CO] | |
| AA1E1Q1/LLN0.Mod.Oper.origin.orCat [CO] | CTRL/LLN0.LocSta.Oper.origin.orCat [CO] | |
| AA1E1Q1/LLN0.Mod.Oper.origin.orIdent [CO] | CTRL/LLN0.Mod.Oper.origin.orIdent [CO] | |
| AA1E1Q1/LLN0.Mod.Oper.Test [CO] | CTRL/LLN0.Mod.Oper.Test [CO] | |
| AA1E1Q1/LLN0.Mod.q [ST] | CTRL/LLN0.Mod.q [ST] | |
| AA1E1Q1/LLN0.Mod.stVal [ST] | CTRL/LLN0.Mod.stVal [ST] | |

*Figure 160: Data attribute mappings*

# 9 Glossary

| | |
|---|---|
| ACT | 1. Application configuration tool in PCM600<br>2. Trip status in IEC 61850 |
| AIM | Analog input module |
| ANSI | American national standards institute |
| ARP | Address resolution protocol |
| CID | Configured IED description |
| CMT | Communication management tool in PCM600 |
| COM600S | Substation management unit. An all-in-one communication gateway, automation platform and user interface solution for utility and industrial distribution substations. |
| COMTRADE | Common format for transient data exchange for power systems. Defined by the IEEE standard. |
| Connectivity package | A collection of software and information related to a specific protection and control IED, providing system products and tools to connect and interact with the IED. |
| DA | Data attribute |
| Data attribute | Defines the name, format, range of possible values and representation of values while being communicated |
| DHCP | Dynamic host configuration protocol |
| DO | Data object |
| EMC | Electromagnetic compatibility |
| Ethernet | A standard for connecting a family of frame-based computer networking technologies into a LAN. |
| FPN | Flexible product naming |
| FTP | File transfer protocol |
| FTPS | FTP Secure |
| GCB | 1. GOOSE control block<br>2. Generator circuit breaker |
| GDE | Graphical display editor in PCM600 |
| GoCB | GOOSE control block |
| GOOSE | Generic object-oriented substation event |
| HMI | Human-machine interface |
| HSR | High-availability seamless redundancy |
| HTTPS | Hypertext transfer protocol secure |
| HW | Hardware |
| I/O | Input/output |
| ICD | IED capability description |

*Table continues on the next page*

| | |
|---|---|
| IEC | International electrotechnical commission |
| IEC 61850 | International standard for substation communication and modeling |
| IEC 61850-9-2 | A communication protocol based on the IEC 61850 standard series |
| IED | Intelligent electronic device |
| IET600 | Integrated engineering toolbox |
| IID | Instantiated IED description |
| Instance | Identical protection function blocks available in a standard configuration. By setting the application-specific parameters of an instance, a protection function stage can be established. |
| IP | Internet protocol |
| IP address | A set of four numbers between 0 and 255, separated by periods. Each server connected to the Internet is assigned a unique IP address that specifies the location for the TCP/IP protocol. |
| LAN | Local area network |
| LED | Light-emitting diode |
| LHMI | Local human-machine interface |
| LN | Logical node |
| MAC | Media access control |
| NCC | Network control center |
| PC | 1. Personal computer<br>2. Polycarbonate |
| PCM600 | Protection and control IED manager |
| PRP | Parallel redundancy protocol |
| PST | Parameter setting tool in PCM600 |
| RTD | Resistance temperature detector |
| SAB600 | Substation automation builder tool |
| SCD | Substation configuration description |
| SCL | XML-based system configuration description language defined by IEC 61850 |
| SLD | Single-line diagram |
| SMT | Signal matrix tool in PCM600 |
| SMV | Sampled measured values |
| Subnet mask | A set of four numbers used to create IP address numbers that are used only within a particular network, subnet |
| VPN | Virtual private network |
| WAN | Wide area network |
| WHMI | Web human-machine interface |
| Widget | Any graphical object drawn on the LHMI page with Page Editor in PCM600 |
| XRIO | eXtended relay interface by OMICRON |

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RELION® PROTECTION AND CONTROL

# REX640

## Product Guide



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**Conformity**

This product complies with following directive and regulations.

Directives of the European parliament and of the council:

- Electromagnetic compatibility (EMC) Directive 2014/30/EU
- Low-voltage Directive 2014/35/EU
- RoHS Directive 2011/65/EU
- RoHS Directive (EU) 2015/863 amending Annex II

UK legislations:

- Electromagnetic Compatibility Regulations 2016
- Electrical Equipment (Safety) Regulations 2016
- The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

These conformities are the result of tests conducted by the third-party testing in accordance with the product standard EN / BS EN 60255-26 for the EMC directive / regulation, and with the product standards EN / BS EN 60255-1 and EN / BS EN 60255-27 for the low voltage directive / safety regulation.

The product is designed in accordance with the international standards of the IEC 60255 series.

## 1. Description

REX640 is a powerful all-in-one protection and control relay for use in advanced power distribution and generation applications with unmatched flexibility available during the complete life cycle of the device – from ordering of the device, through testing and commissioning to upgrading the functionality of the modular software and hardware as application requirements change.

REX640 is available in two different case widths: a narrow case offering five module slots and a standard case offering seven module slots. Software options are identical for both case sizes.

The modular design of both hardware and software elements facilitates the coverage of any comprehensive protection application requirement that may arise during the complete life cycle of the relay and substation.

REX640 makes modification and upgrading easy and pushes the limits of what can be achieved with a single device.

## 2. Application packages

REX640 offers comprehensive base functionality. However, it is possible to further adapt the product to meet special installation needs by including any number of the available optional application packages into a single REX640 relay. For the selected application packages, the functionality can be extended by including the related add-on package. The REX640 connectivity package guides the engineer in optimizing the application configuration and its performance.

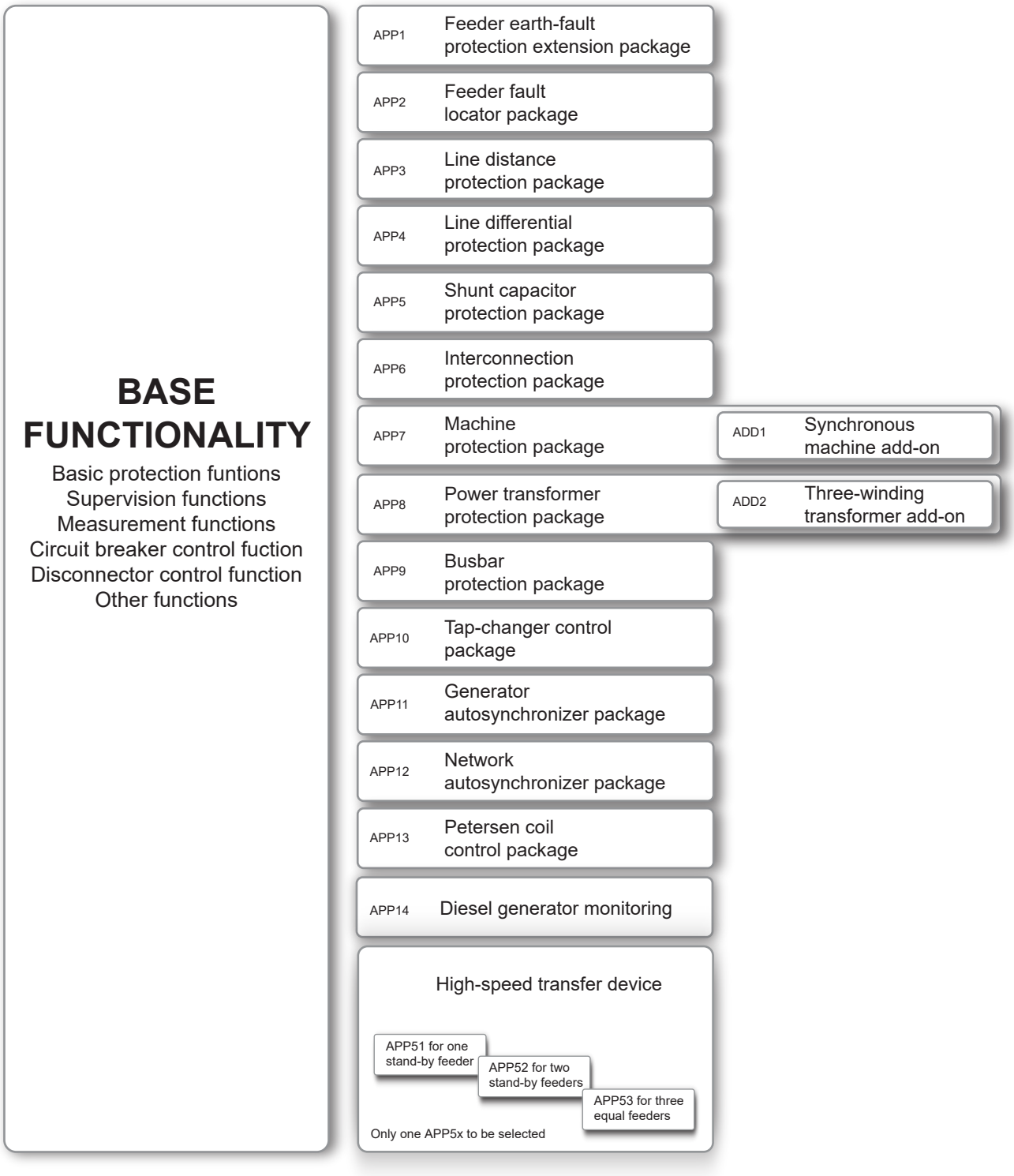



*Figure 1: REX640 base and optional functionality*

## 3. Relay hardware

The relay has mandatory and optional slots. A mandatory slot always contains a module but an optional slot may be empty, depending on the composition variant ordered.

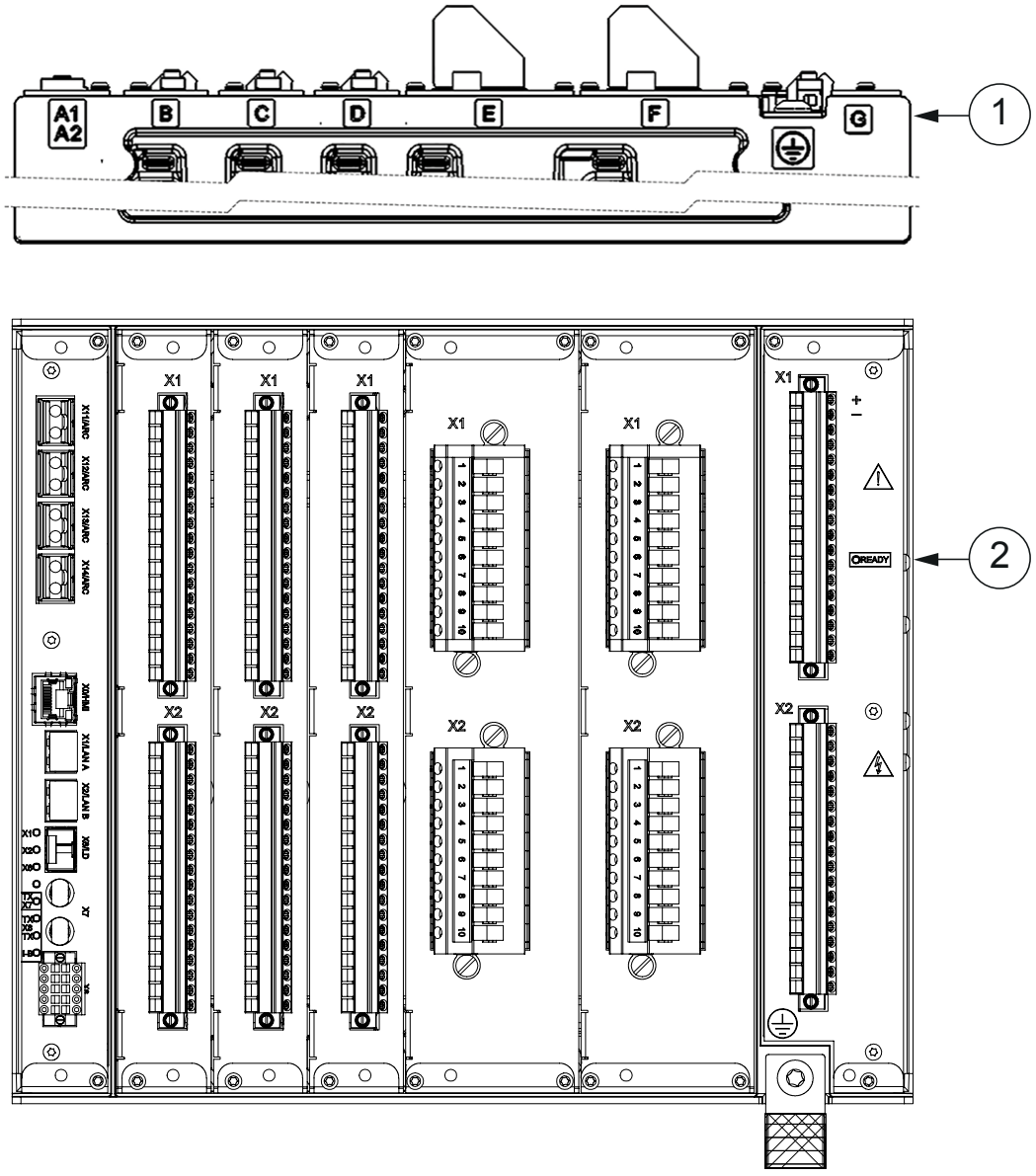
**Table 1: Module slots**

| Module | Standard case | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Slot A1 | Slot A2 | Slot B | Slot C | Slot D | Slot E | Slot F | Slot G |
| | Narrow case | | | | | | | |
| | Slot A1 | Slot A2 | Slot B | Slot C | ------ | ------ | Slot F | Slot G |
| ARC1001 | o | | | | | | | |
| COM1001 | | ● | | | | | | |
| COM1002 | | ● | | | | | | |
| COM1003 | | ● | | | | | | |
| COM1004 | | ● | | | | | | |
| COM1005 | | ● | | | | | | |
| BIO1001 | | | ● | o | o | | | |
| BIO1002 | | | ● | o | o | | | |
| BIO1003 | | | | | | o | | |
| BIO1004 | | | | | | o | | |
| RTD1001 | | | | o | o | | | |
| RTD1002 | | | | o | o | | | |
| AIM1001 | | | | | | o | ● | |
| AIM1002 | | | | | | o | ● | |
| SIM1901 | | | | | | o | ● | |
| SIM1902 | | | | | | o | ● | |
| PSM1001 | | | | | | | | ● |
| PSM1002 | | | | | | | | ● |
| PSM1003 | | | | | | | | ● |

● = Mandatory to have one of the allocated modules in the slot

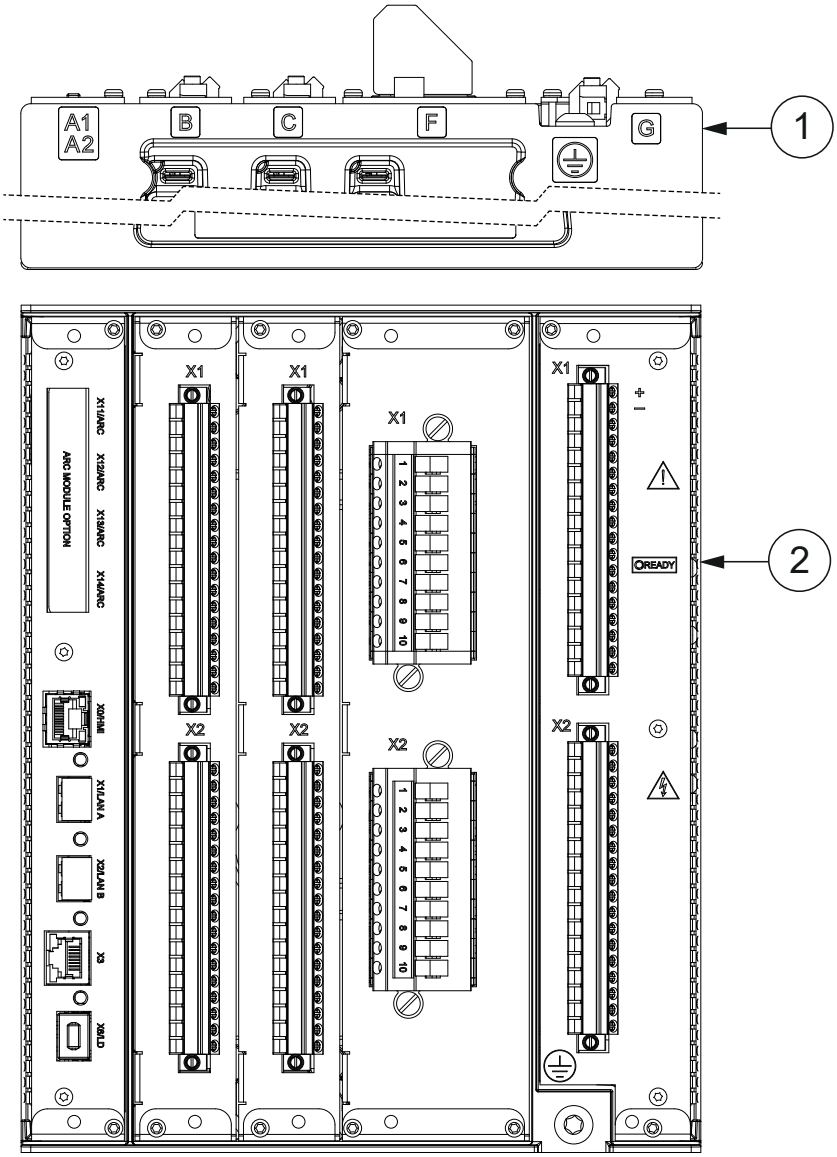
o = Optional to have one of the allocated modules in the slot. The population (order) of the modules in the optional slots depends on the composition variant ordered.

The REX640 relay can also be ordered as a conformal coated variant. Visit ABB Relays-Online *https://relays.protection-control.abb* for more information about the product and assistance in ordering.




1 Slot markings in enclosure (top and bottom) 2 Ready LED

*Figure 2: Hardware module slot overview of standard housing*




1 Slot markings in enclosure (top and bottom) 2 Ready LED

*Figure 3: Hardware module slot overview of narrow housing*

**Table 2: Module description**

| Module | Description |
|---|---|
| ARC1001 | 4 × ARC sensor inputs (lense, loop or mixed) |
| COM1001 | 1 × RJ-45 (LHMI port) + 3 × RJ-45 + 1 × LD-SFP[1] |
| COM1002 | 1 × RJ-45 (LHMI port) + 2 × LC + 1 × RJ-45 + 1 × LD-SFP |

*Table continues on the next page*

[1] Line distance/line differential protection communication + binary signal transfer, optical multi-mode or single-mode LC small form-factor pluggable transceiver (SFP)

| Module | Description |
|---|---|
| COM1003 | 1 × RJ-45 (LHMI port) + 3 × LC + 1 × LD-SFP |
| COM1004 | 1 × RJ-45 (LHMI port) + 2 × RJ-45 + 1 × LD-SFP + 1 × RS-485/IRIG-B + 1 × FO UART |
| COM1005 | 1 × RJ-45 (LHMI port) + 2 × LC + 1 × LD-SFP + 1 × RS-485/IRIG-B + 1 × FO UART |
| BIO1001/ BIO1003 | 14 × BI + 8 × SO |
| BIO1002/ BIO1004 | 6 × SPO + 2 × SPO (TCS) + 9 × BI |
| RTD1001 | 10 × RTD channels + 2 × mA channels (input/output) |
| RTD1002 | 3 x RTD channels + 6 x mA channels (input or output) + 12 x BI |
| AIM1001 | 4 x CT (1/5A) + 1 x CT (0.2/1A for residual current only) + 5 x VT |
| AIM1002 | 6 x CT (1/5A) + 4 x VT |
| SIM1901 | 3 x combi sensor inputs (RJ-45, IEC 60044) + 1 x CT (0.2/1A for residual current only) + 1 x VT |
| SIM1902 | 3 x combi sensor inputs (RJ-45, IEC 61869) + 1 x CT (0.2/1A for residual current only) + 1 x VT |
| PSM1001 | 24...60 VDC, 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO |
| PSM1002 | 48...250 VDC / 100...240 VAC, 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO |
| PSM1003 | 110/125 VDC (77...150 VDC), 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO |

PO = Power Output

SO = Signal Output

SPO = Static Power Output

SSO = Static Signal Output

The relay has a nonvolatile memory which does not need any periodical maintenance. The nonvolatile memory stores all events, recordings and logs to a memory which retains data if the relay loses its auxiliary supply.

## 4. Human-machine interface

REX640 offers different possibilities for creating a humanmachine interface.

- Local HMI (LHMI)
- Switchgear HMI (SHMI)
- Web HMI (WHMI)

The optimum HMI solution can be freely selected. The considerations can cover, for example, the physical installation location, frequency of usage or operators' preference.

LHMI can be connected directly to a dedicated port on the relay's communication module. If a longer distance between the relay and the LHMI is required, the LHMI can be connected into the station Ethernet communication network. In both cases, an LHMI is dedicated to a certain relay and only one LHMI can be connected to one relay.

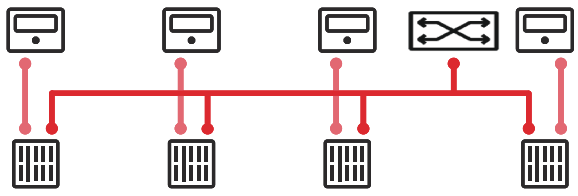


*Figure 4: Local HMIs connected directly to the relays*

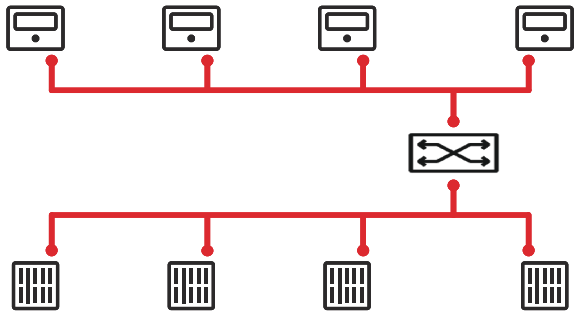


*Figure 5: Local HMIs connected to the relays via a communication network*

SHMI can be connected into a station Ethernet communication network. A single SHMI can serve up to 20 relays. The SHMI provides switchgear level status information as well as an access point to the LHMI level relay information. LHMI and SHMI panels cannot be connected simultaneously to the same relay.

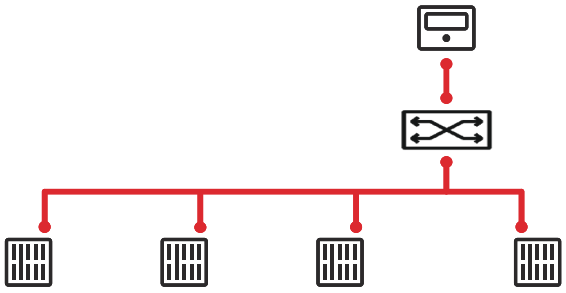


*Figure 6: Switchgear HMI connected to the relays*

The REX640 relays are fully operational even without any connection to a physical HMI. The relays include a Web server enabling access by the WHMI. The Web server is disabled by default and must be enabled by a parameter change. The WHMI can also be used even if the relay is connected to a physical HMI.

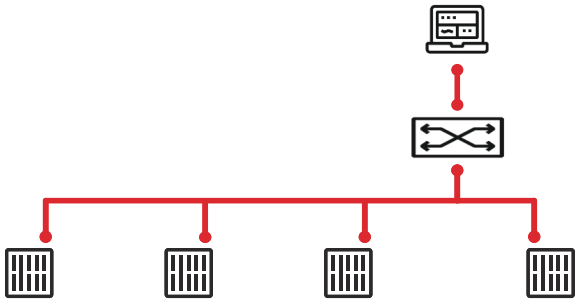


*Figure 7: Web HMI connected to the relays*

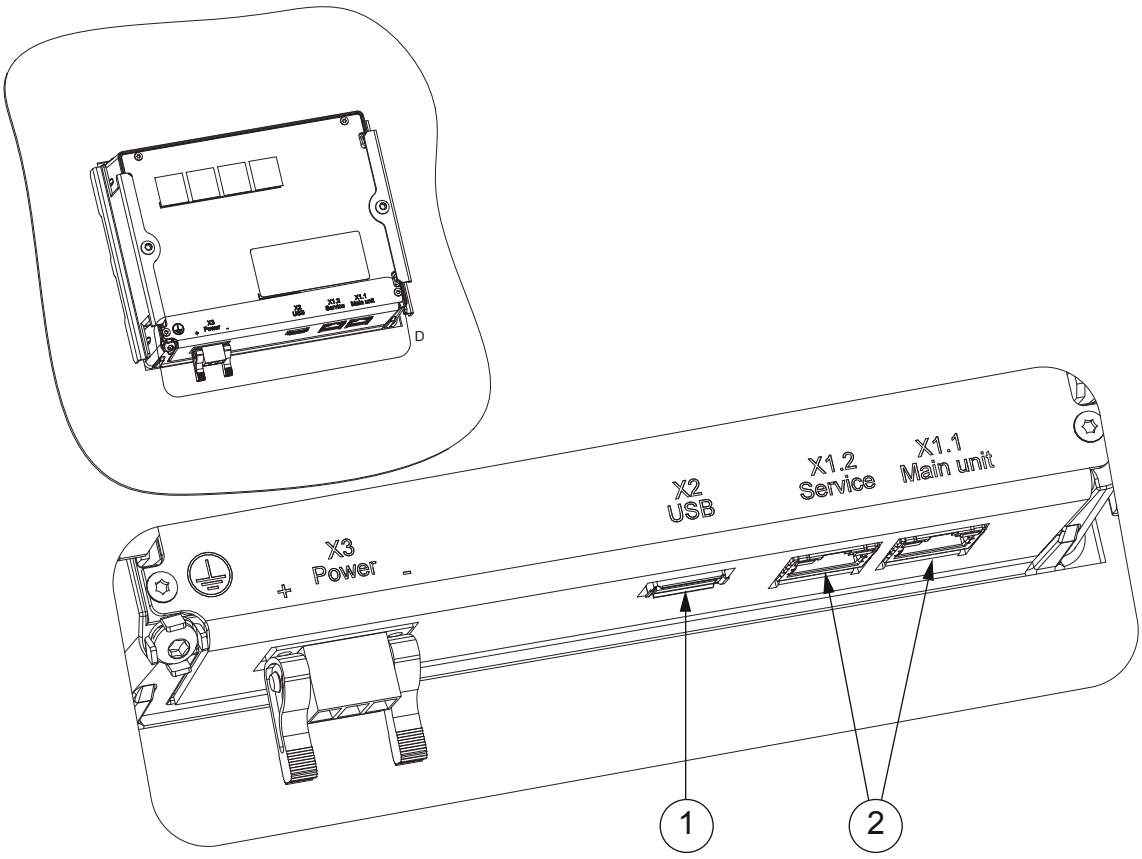



*Figure 8: HMI connectors*

**1** USB port

**2** RJ-45 ports

The main unit port X1.1 is used to connect the LHMI directly to the relay. In case of a remotely installed LHMI or SHMI, the connector X1.1 is used for Ethernet switch connection. The service port X1.2 is used for PCM600 or WHMI connection. The USB port X2 is used for inserting a USB memory stick to enable data retrieval from the relay.

## 5. Local HMI

The LHMI uses rugged 7-inch high resolution color screen with capacitive touch sensing technology. The user interface has been carefully designed to offer the best situational awareness to the user. Visualization of the primary process measurements, events, alarms and switching objects' statuses makes the local interaction with the relay extremely easy and self-evident. The LHMI provides a control point for the selected primary devices via pop-up operator dialogs.

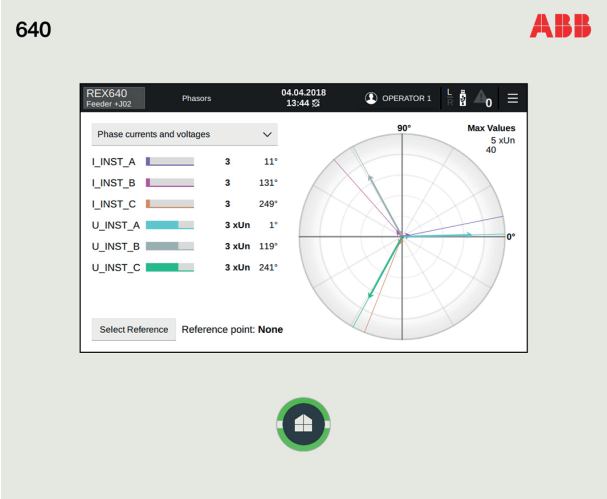



*Figure 9: Phasor presentation of measurements as an example of local HMI pages*

Additionally, the LHMI supports the engineer during the relay's testing, commissioning and troubleshooting activities. The information, traditionally accessible through different paths within the menu structure, is provided in collectively grouped and visualized format.

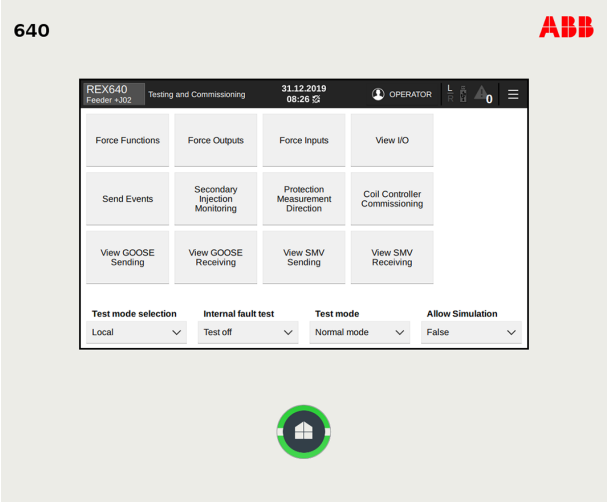



*Figure 10: Test and commissioning support in the local HMI*

The Home button at the bottom of the LHMI indicates the relay's status at a glance. In normal situations, the Home button shows a steady green light. Any other situation that requires the operator's attention is indicated with a flashing light, a red light or a combination of these.

The LHMI presents pages in two categories: the Operator pages and the Engineer pages. The Operator pages include the ones which are typically required as a part of an operator's normal activities, such as a single-line diagram, controls, measurements, events, alarms, and so on. The Engineer's pages include specifically designed pages supporting relay parametrization, troubleshooting, testing and commissioning activities.

The Operator pages can be used as such or customized according to the project's requirements using Graphical Display Editor (GDE) within the PCM600 software tool. The Engineer pages are fixed and cannot be customized.

The Operator pages can be scrolled either by tapping the Home button or by swiping the actual pages. The Engineer pages are accessible by touching the upper horizontal section of the screen.

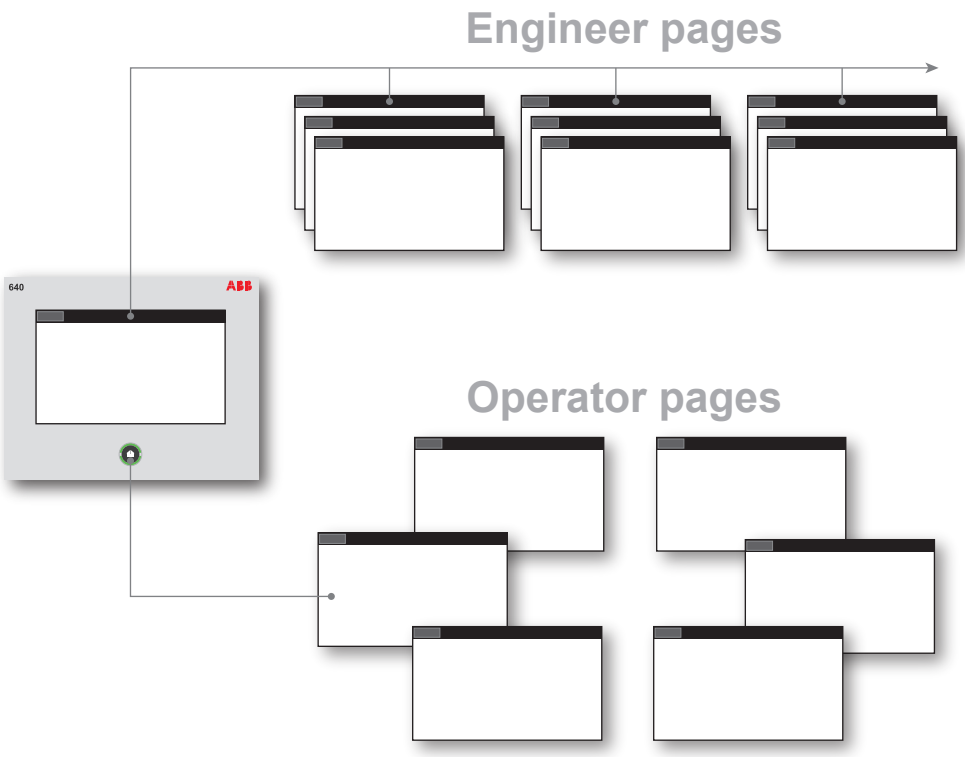



*Figure 11: Local HMI pages*

The LHMI is an accessory for the relay which is fully operational even without the LHMI. The relay communication card has a dedicated port where the LHMI is connected using an RJ-45 connector and a CAT6 S/FTP cable. The LHMI can be connected to the relay also via station communication network if a longer distance is required between the relay and the LHMI.

Additionally, the LHMI contains one Ethernet service port with an RJ-45 connector and one USB port. The service port can be used for the PCM600 connection or for WHMI connection. Data transfer to a USB memory is enabled via the USB port. By default the USB port is disabled and has to be taken into use with a specific parameter.

REX640 can be used as a centralized alarm annunciator. 66pcs of programmable LED functions are available within the graphical application configuration. The LED functions can be controlled by any physical input, GOOSE based or relay's internal binary signal. The Graphical Display Editor (GDE) tool component in PCM600 offers ready made pages for alarm visualization covering 64 alarm channels.

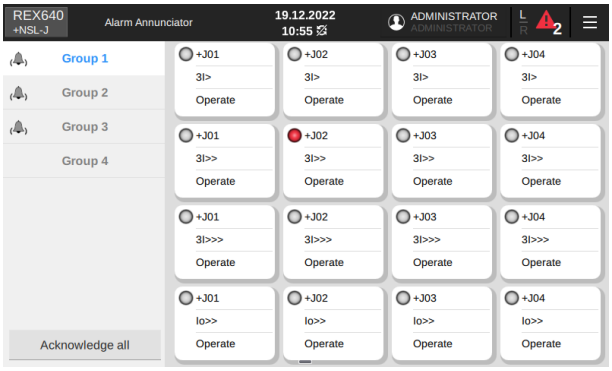



*Figure 12: Alarm annunciator visualization on HMI*

## 6. Switchgear HMI

The SHMI uses the same rugged 7-inch high resolution color screen with capacitive touch sensing technology as the LHMI. The user interface has been carefully designed to offer the best situational awareness to the user. SHMI navigation page provides an overview of the complete switchgear lineup. Four switchgear panels can be shown simultaneously on the navigation page, and the other panels can be

seen by tapping the SHMI panel Home button or by swiping the screen. A single SHMI can support up to 20 relays, and an installation can include several non-overlapping SHMI panels.

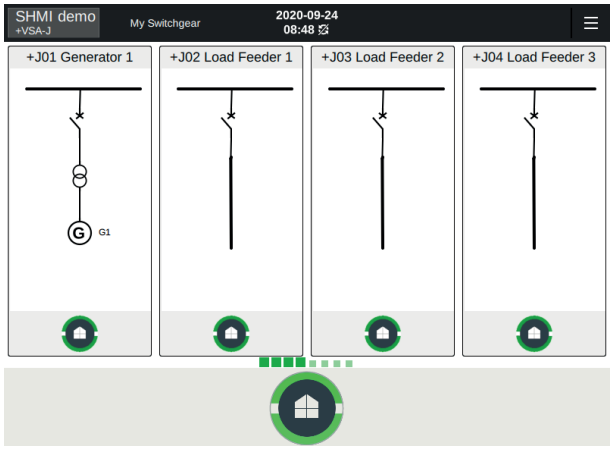



*Figure 13: Switchgear HMI navigation page*

On the navigation page, each switchgear panel can be represented by a dynamic single-line diagram, static figure or even by a photo of the actual panel. The panel-wise representation includes a virtual home button indicating the status of the relay within the panel. The SHMI's physical Home button indicates the common status of the complete switchgear lineup. After tapping on selected switchgear panel on the navigation page, the SHMI connects to the relay. When the connection is established, the SHMI provides all the same features as the LHMI.

If the switchgear lineup on the navigation page is presented by a dynamic single-line diagram, the actual primary switching device's actual positions are shown. To control a primary object, the panel must first be selected from the navigation page. When the SHMI is connected to the selected relay, the control can be carried out in a similar manner as with the LHMI.

SHMI automatically stores backups of the connected relays' configurations. If a relay needs to be replaced with a spare relay that has at least same capabilities as the original one, the relay configuration and parameters can be restored from the SHMI panel.

## 7. Application

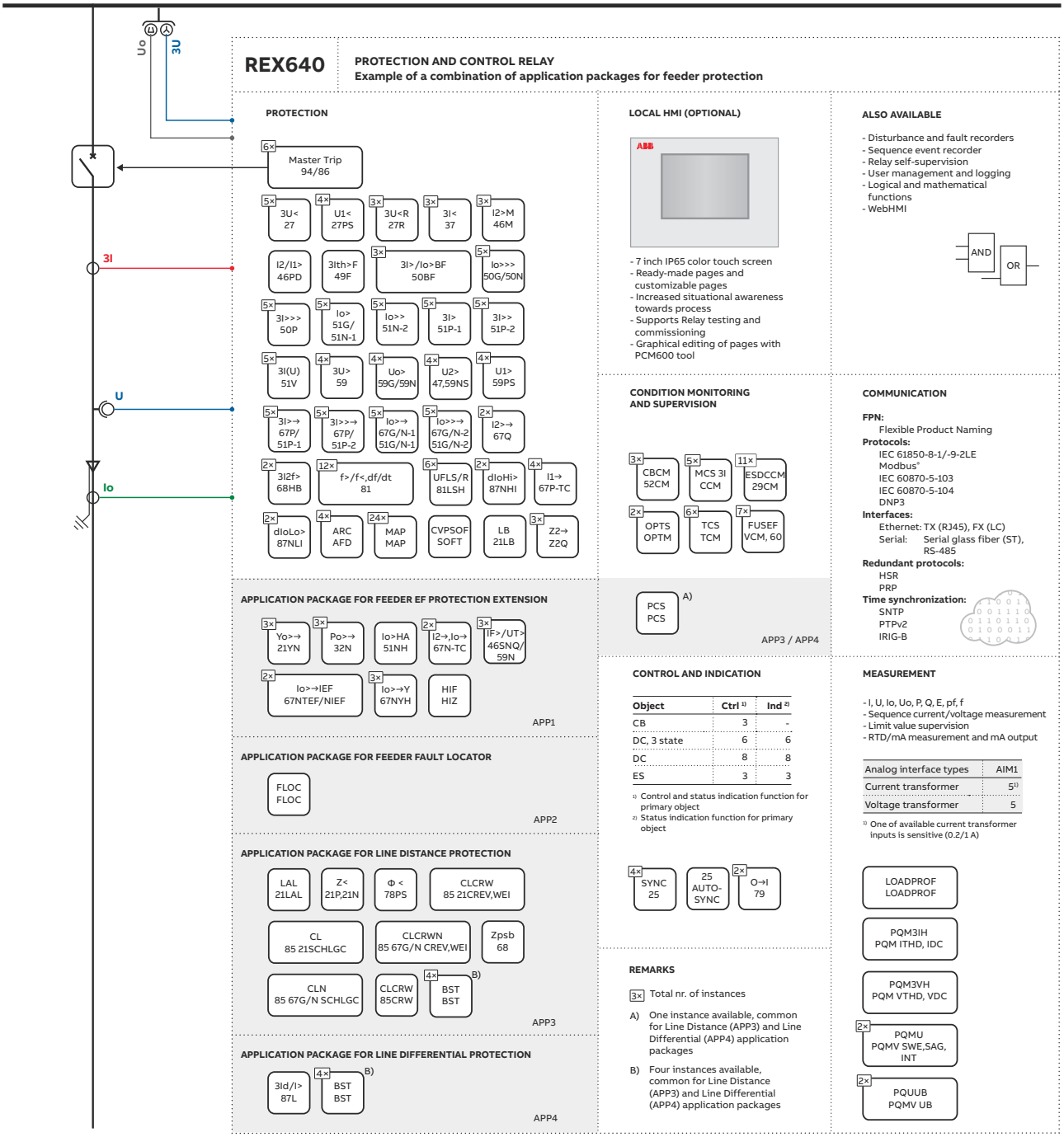



*Figure 14: Feeder application*

*Figure 14* presents REX640 in a feeder application. The base functionality is enhanced with application packages providing both line distance and line differential protections. To provide additional protection against earth faults along the feeder, an additional application package has been selected. Conventional measuring transformers are used in the example case. The AIM1 analog input card provides the best match for them with

five voltage and five current inputs, one being a sensitive input.

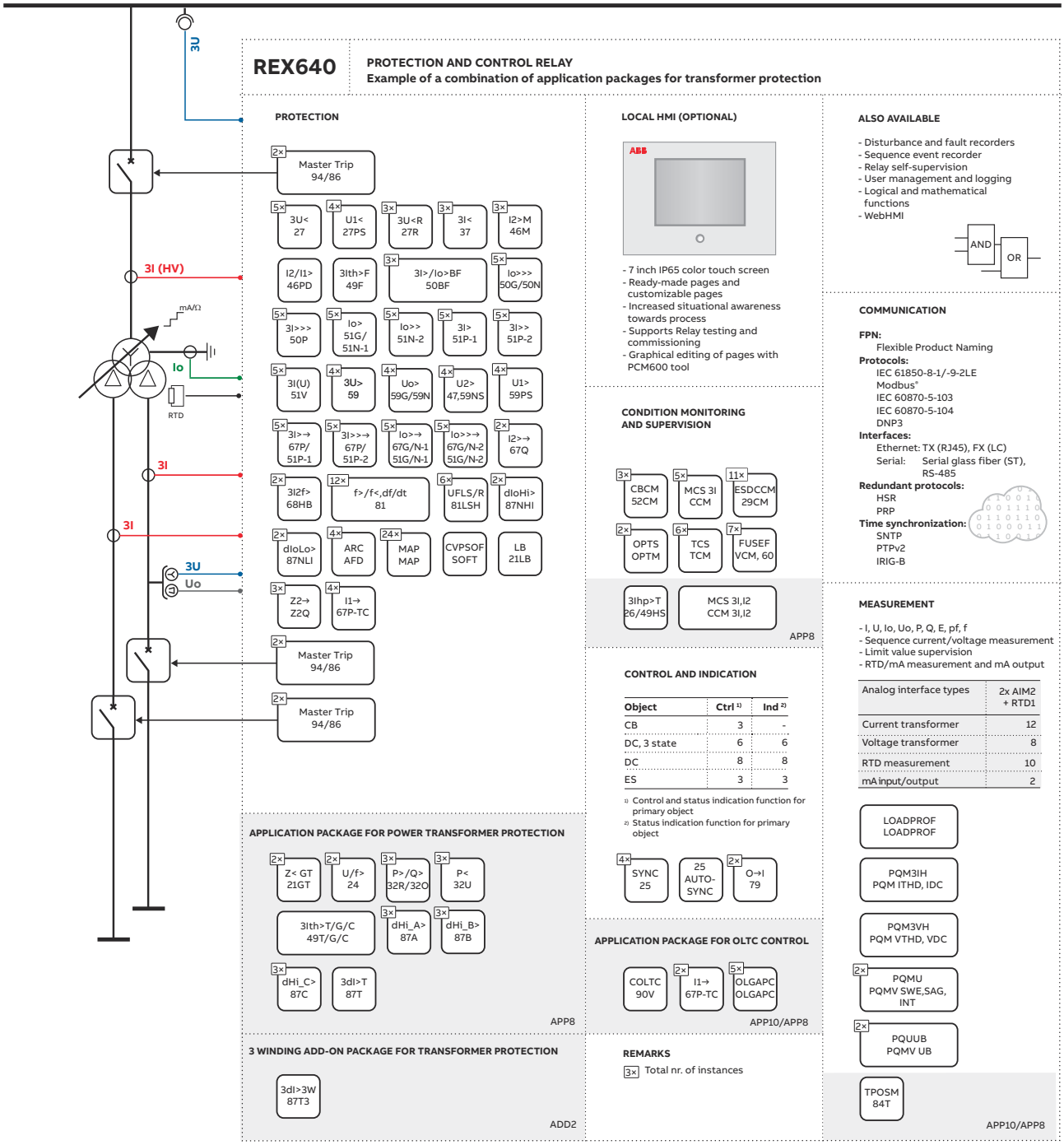



*Figure 15: Transformer application*

*Figure 15* presents REX640 in a three-winding power transformer application. The base functionality is enhanced with a power transformer application package and the related three-winding add-on package. In the example case, REX640 also manages the on-load tap changer's manual and automatic control. For this purpose, the application package for OLTC control has been selected as well. Best match for current and voltage measurement can be managed by selecting two AIM2 cards for the relay. This combination

offers 12 current and 8 voltage channels to be freely allocated for the relay functionalities. The OLTC control function requires information on the tap-changer's actual position. To be able to provide this information, the relay is equipped with an RTD card which can measure the OLTC position either as a resistance value or as an mA signal.

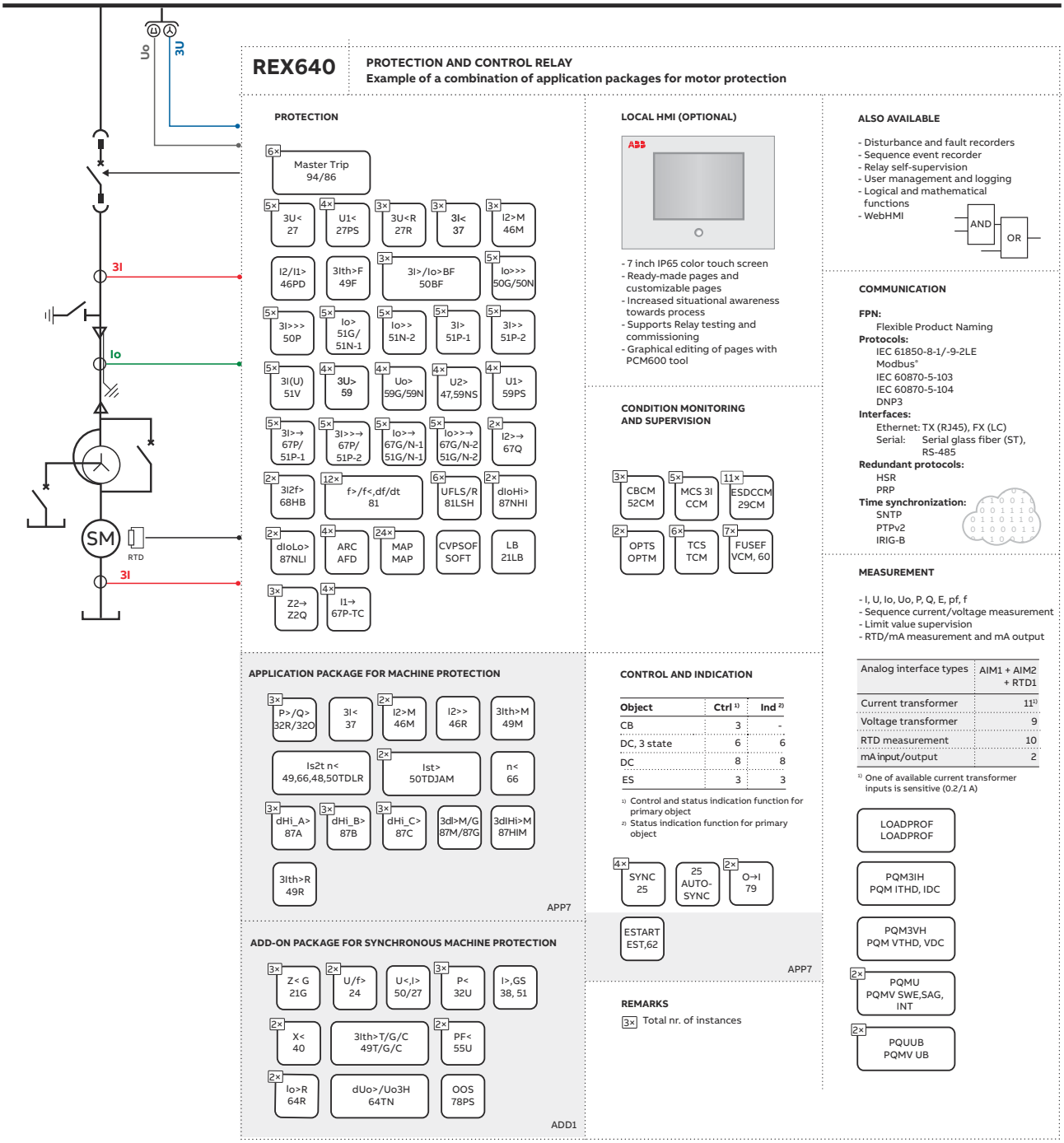



*Figure 16: Motor application*

*Figure 16* presents REX640 in a synchronous motor application. The base functionality is enhanced with a machine protection application package and the related synchronous machine add-on package. Best match for current and voltage measurement can be managed by selecting both AIM1 and AIM2 cards for the relay. This combination offers 11 current and 9 voltage channels to be freely allocated for the relay functionalities. The

stator winding temperatures are monitored via the temperature sensors in the motor. These sensors are connected to the RTD card within the relay.

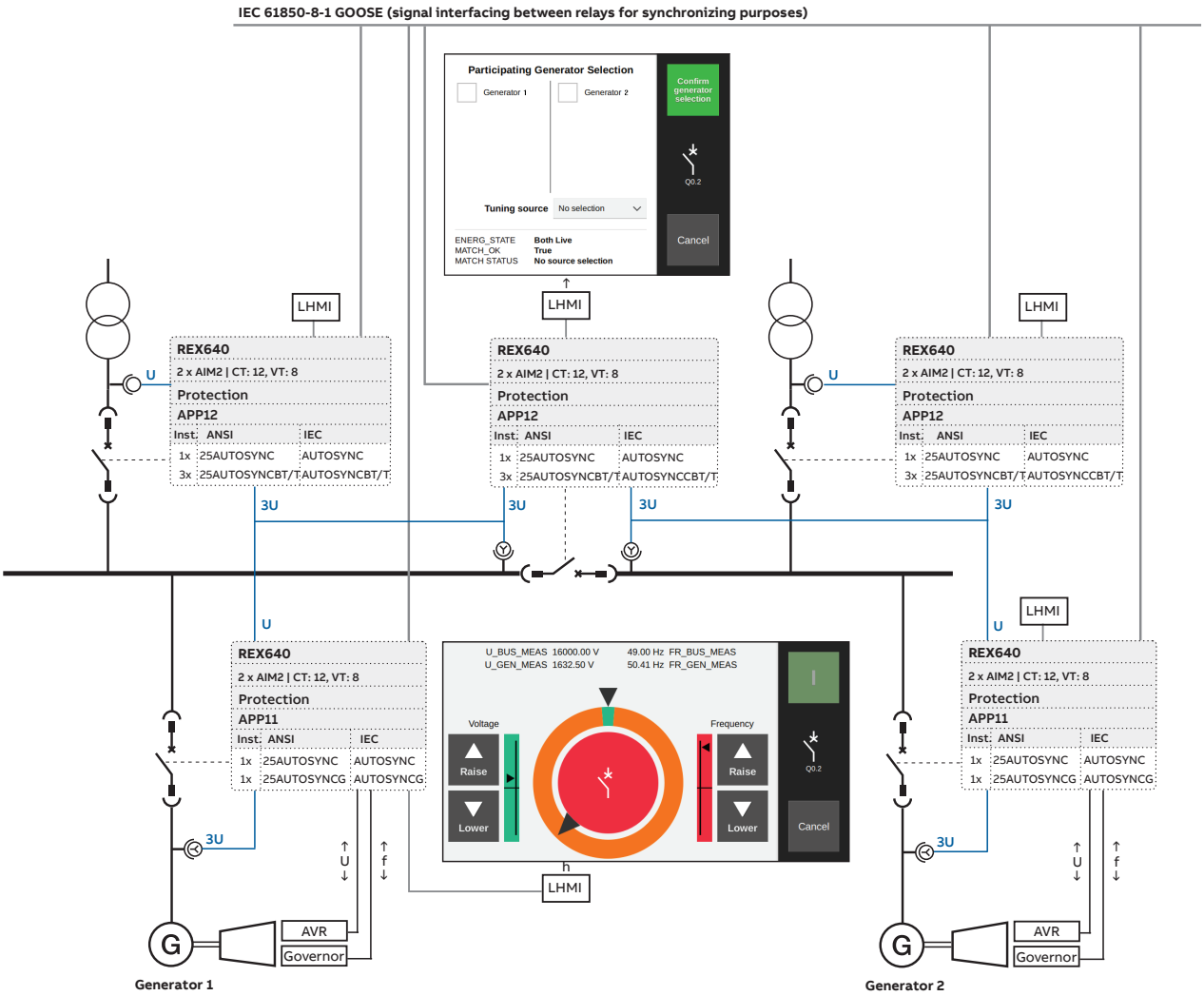



*Figure 17: Autosynchronizer application*

In addition to conventional protection, control, measurement and supervision duties, REX640 can perform both generator (APP11) and non-generator (APP12) circuit breaker synchronizing. Successful synchronization of two alternating power sources can be done by matching their voltage, frequency, phase sequence and phase angle. The circuit breaker (CB) connects the two sources after a period of CB closing time from the instant of a given close command. Hence, all the conditions of synchronization need to be met at the instant of CB close operation for successful synchronization.

Each REX640, being part of the overall synchronizing scheme, contains its own synchronizer function. When a generator CB is to be synchronized, the related REX640 controls the generator's voltage, frequency and angle difference by requesting the generator's AVR and prime mover's governor to change the set-points accordingly. The generator circuit breaker synchronizing does not require information exchange between other REX640 relays within the scheme.

When a non-generator CB is to be synchronized, all the REX640 relays within the scheme exchange information between themselves in order to identify suitable generator(s) for the voltage and frequency matching. Once the generators are identified and selected, the REX640 related to the circuit breaker to be synchronized sends a request to the selected

generator(s) REX640 for the required voltage and frequency corrections. When the voltage, frequency and the angle difference across the CB under synchronization are within the set limits, REX640 closes the circuit breaker. The information exchange between the REX640s takes place using IEC 61850-8-1 binary and analog GOOSE signaling over Ethernet.

The LHMI panels of REX640 can be used as local user interface for circuit breaker synchronization. The upper-level remote control systems like SCADA, DCS or PMS can interact with the synchronizing scheme using MMS or Modbus protocols. The REX640-based synchronizing scheme supports manual, semi-manual and automatic synchronizing modes.

When the synchronizing scheme includes both generator and non-generator CBs, the maximum size of the supported system is eight generator and 17 non-generator CBs.

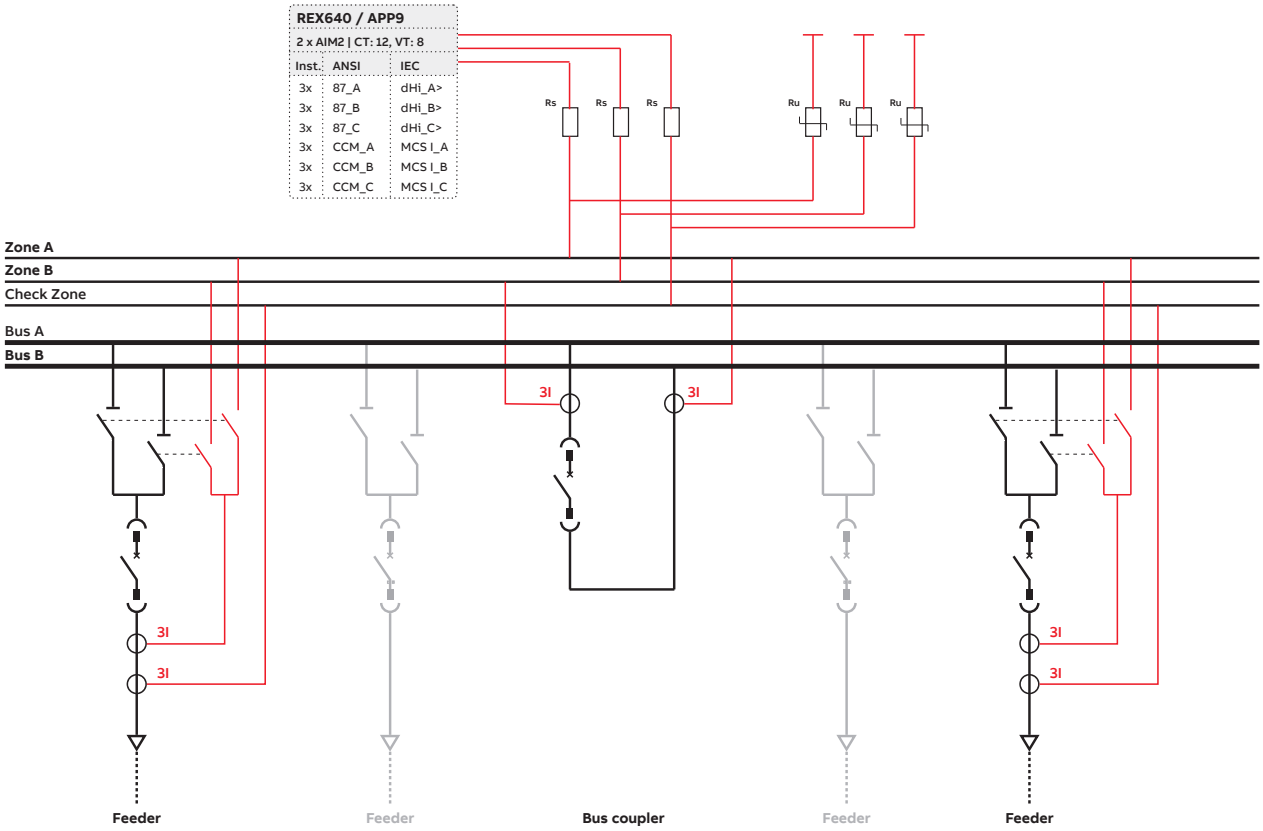



*Figure 18: Busbar protection application*

*Figure 18* presents REX640 in a phase-dedicated highimpedance busbar protection application for a double busbar switchgear. The relay's base functionality is enhanced with the busbar protection application package (APP9). The two AIM2 cards in the relay provide a total of 12 current channels. In the example, 9 out of the 12 current channels are used to create three busbar protection zones. Zones A and B provide selective protection for Bus A and Bus B, respectively. The third zone, called check zone, covers both busbars. The check zone works as the final trip release condition for the selective zones; it provides security against false trip commands initiated by the selective zones, for example, due to a fault within the disconnector's auxiliary switch circuitry. The current transformers' secondary buswires for the three protection zones are supervised by dedicated functions within the relay.

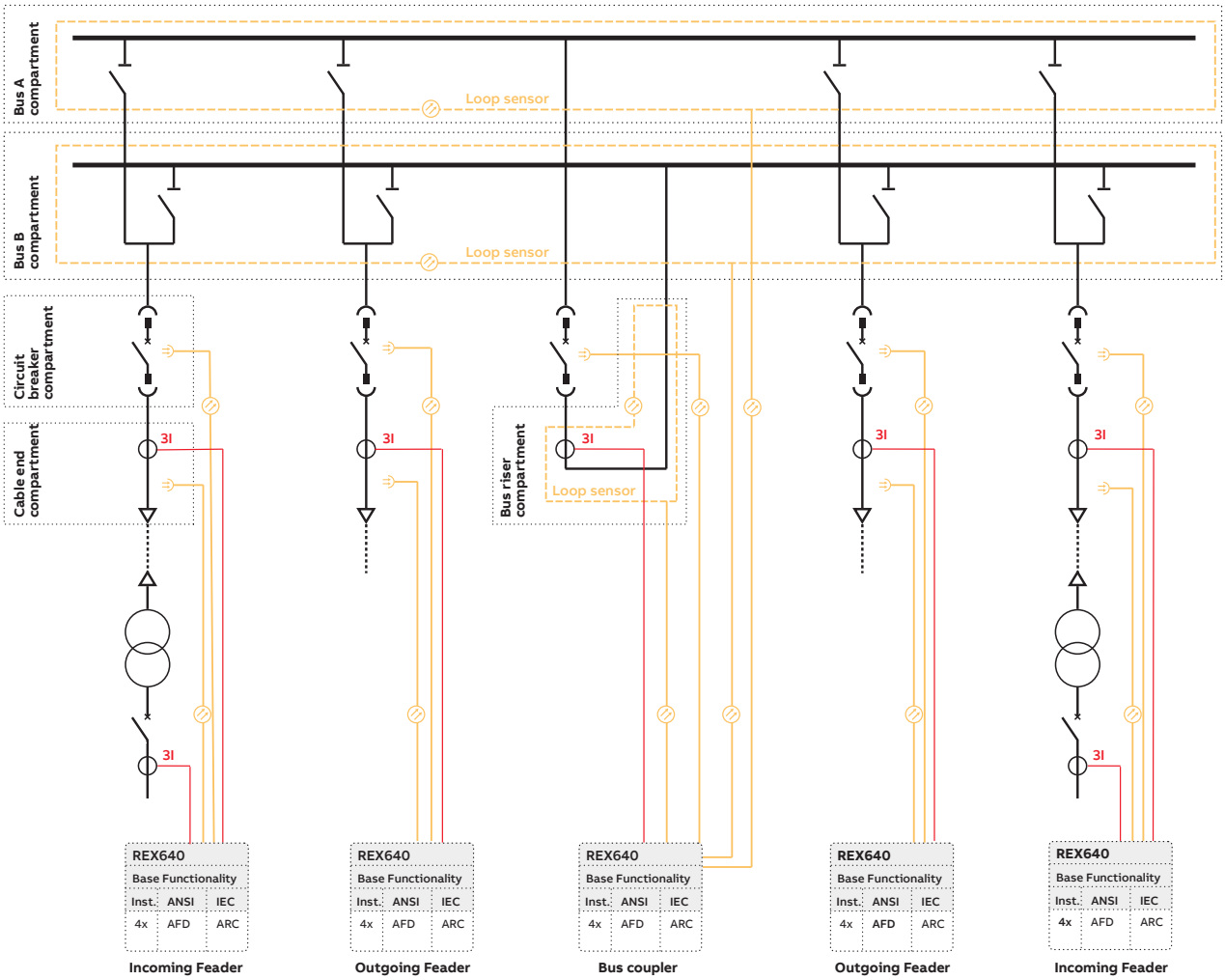



*Figure 19: Arc flash protection application*

*Figure 19* presents an installation-wide arc flash protection scheme for a double busbar switchgear. REX640 protection relays are equipped with arc flash sensor card. The card supports a maximum of four pieces of either loop or lens sensors or a combination thereof. By using suitable sensor combinations for different bays, we can build up a selective arc flash protection scheme for the complete switchgear. The selective operation of the arc flash protection scheme limits the power outage caused by the arc fault to the smallest possible section of the switchgear. The arc flash protection operation is not dependent on light detection only; it is also supervised by arc fault current measurement. Since the arc flash protection operation should be as fast as possible, the use of static power outputs for tripping circuits is highly recommended. The functional condition of the arc flash sensor is continuously supervised and if a problem is detected, an alarm is triggered; this applies to both loop and lens sensors.

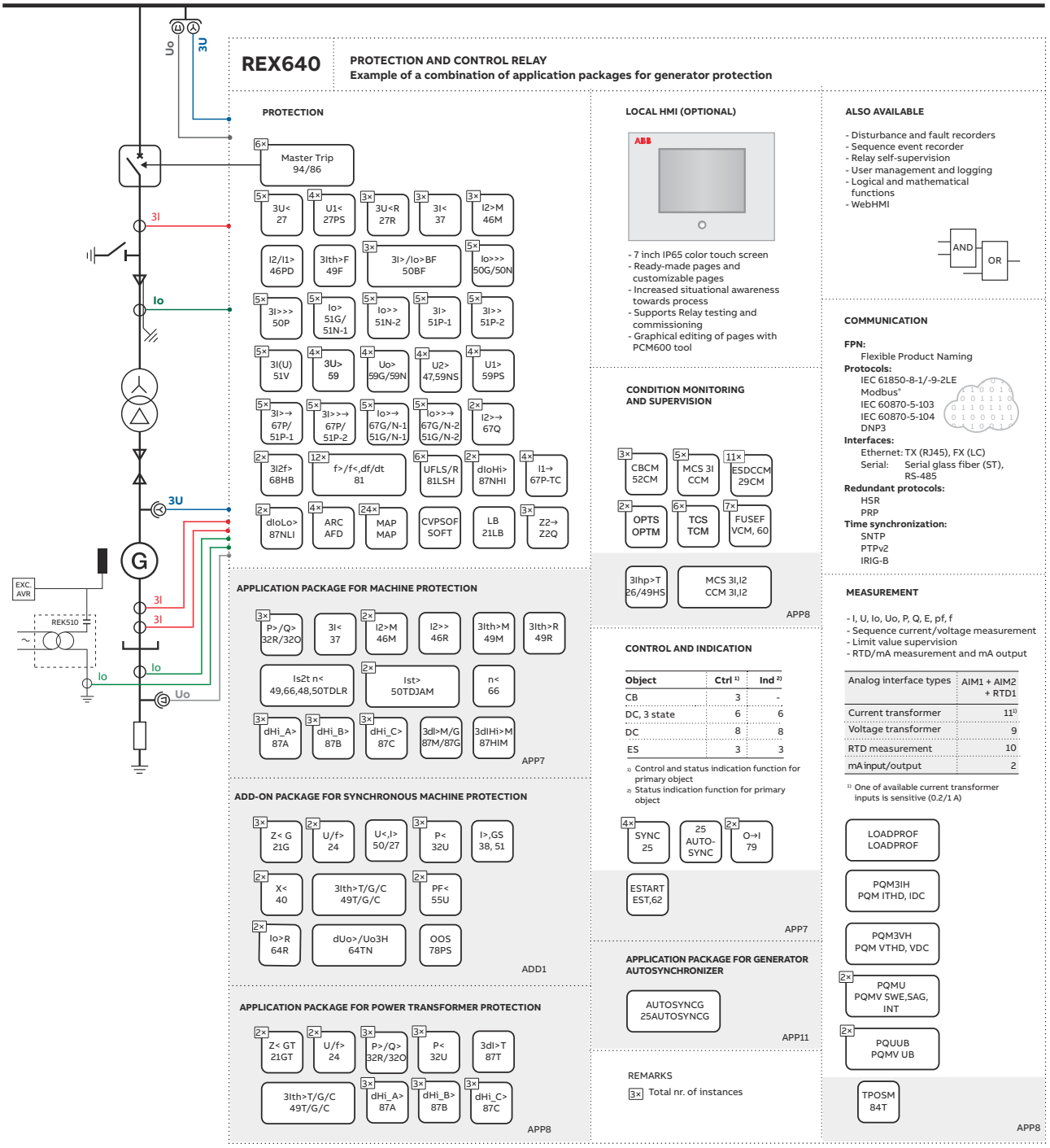



*Figure 20: Generator application*

*Figure 20* presents REX640 in a synchronous generator application including a block transformer. The base functionality is enhanced with the machine protection and transformer protection application packages. The synchronous machine add-on package supports the related protection functions for a synchronous generator. Generator autosynchronizer application packages support the generator's synchronized connection into the busbars, in both manual and auto modes. The relay's LHMI works as the local operator interface for controlling the autosynchronizing sequence. An external injection device (REK 510) enables the generator's excitation circuit supervision against earth faults. Best match for

current and voltage measurement needs can be managed by selecting both AIM1 and AIM2 cards for the relay. This combination offers 11 current and 9 voltage channels to be freely allocated to the functionalities in the relay. The generator's stator winding temperatures are monitored using RTD sensors.

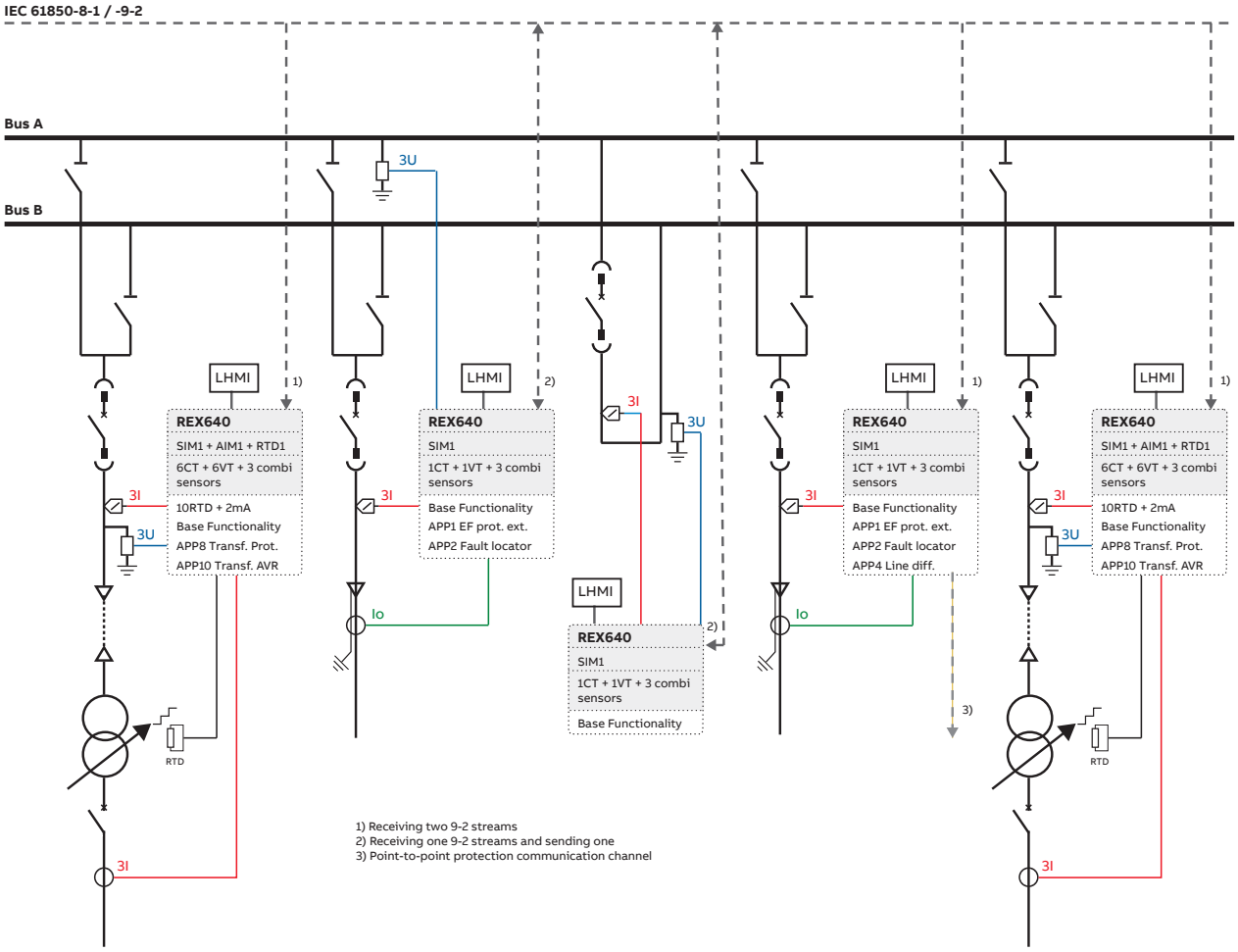



*Figure 21: Digital switchgear application*

REX640 is perfectly aligned with the needs of digital switchgear. Sensors are used for the local phase current and voltage measurements, apart from the high-voltage side current measurement used for power transformer protection, which is carried out by conventional current transformers. For the outgoing cable feeders, the earth-fault protection uses core balance current transformers. The Bus A voltage is measured by the relay in panel +J2, whereas the Bus B voltage is measured by the relay in panel +J3. Both relays send the measured bus voltages to the Ethernet bus as sampled measured values (SMV) according to IEC 61850-9-2 LE. Depending on the type of the feeder, it receives either one or two SMV streams. The feeders receiving two SMV streams automatically switch between the streams based on the position of the busbar disconnectors. All interlocking signals between the panels use binary GOOSE messaging according to IEC 61850-8-1. The incoming power transformer feeders measure also the cable side voltages to enable automatic voltage regulation (tap changer control) and synchronizing check functionality for circuit breaker closing.

## 8. Supported ABB solutions

The REX640 protection relay together with the ABB Ability Electrification Monitoring and Control ZEE600 constitutes a genuine IEC

61850 solution for reliable power distribution in utility and industrial power systems. To facilitate the system engineering, ABB's relays are supplied with connectivity packages. The connectivity packages include a compilation of software and relay-specific information, including single-line diagram templates and a full relay data model. The data model includes event and parameter lists. With the connectivity packages, the relays can be readily configured using PCM600 and integrated with the ZEE600.

REX640 offers native support for IEC 61850 Edition 2.1 including binary and analog horizontal GOOSE messaging. In addition, a process bus enabling sending and receiving of sampled values of analog currents and voltages is supported.

Unlike the traditional hardwired, inter-device signaling, peer-to-peer communication over a switched Ethernet LAN offers an advanced and versatile platform for power system protection. Among the distinctive features of the protection system approach, enabled by the full implementation of the IEC 61850 substation automation standard, are fast communication capability, continuous supervision of the protection and communication system's integrity, and flexible reconfiguration and upgrades. This protection relay series is able to optimally use the interoperability provided by the IEC 61850 Edition 2.1 features.

At substation level, ZEE600 uses the data content of the bay level devices to enhance the substation level functionality.

ZEE600 features a Web browser-based HMI, which provides a customizable graphical display for visualizing single-line mimic diagrams for switchgear bay solutions. Substation devices and processes can also be remotely accessed through the Web HMI, which improves personnel safety.

In addition, ZEE600 can be used as a local data warehouse for the substation's technical documentation and for the network data collected by the devices. The collected network data facilitates extensive reporting and analyzing of network fault situations by using the data historian and event handling features of ZEE600. The historical data can be used for accurate monitoring of process and equipment performance, using calculations based on both real-time and historical values. A better understanding of the process dynamics is achieved by combining time-based process measurements with production and maintenance events.

ZEE600 can also function as a gateway and provide seamless connectivity between the substation devices and network-level control and management systems.

## 9. Control

REX640 integrates functionality for controlling objects such as circuit breakers, disconnectors, earthing switches, on-load tap changers and Petersen coils via the LHMI or by means of remote controls. The relay includes three circuit breaker control blocks. In addition, the relay features 14 disconnector control blocks intended for the motor-operated control of disconnectors or a circuit breaker truck and three control blocks intended for the motor-operated control of the earthing switch. Furthermore, the relay includes eight additional disconnector position indication blocks and three earthing switch position indication blocks that can be used with disconnectors and earthing switches that are only manually controlled.

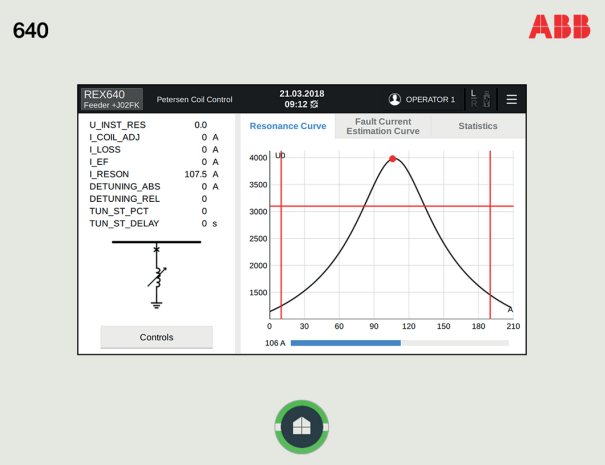



*Figure 22: Petersen Coil control page*

The touch screen LHMI supports a single-line diagram with control points and position indication for the relevant primary devices. Interlocking schemes required by the application are configured using Signal Matrix or Application Configuration in PCM600.

REX640 includes two autoreclosing functions, each with up to five programmable autoreclosing shots of desired type and duration. A load-shedding function performs load shedding based on underfrequency and the rate of change of the frequency.

To validate correct closing conditions for a circuit breaker, REX640 contains a synchrocheck function. For installations including synchronous generators, REX640 introduces a synchronizer that actively controls the generator's voltage and frequency in order to reach a synchronous situation across the circuit breaker. The synchronizer functionality is available for a generator circuit breaker as well as for a nongenerator (network) circuit breaker. A complete installationwide synchronizing system can be built using the REX640 relays. The maximum size of the synchronizing system is eight generator breakers and 17 non-generator breakers.

Synchronization of a generator circuit breaker can be implemented using a single REX640 relay including the ASGCSYN function block. The relay interfaces the external measurement and control circuitry via hardwired binary and analog signals. The excitation and prime mover control signals are based on pulse commands, either with fixed or variable length. The synchronizer function block has three different function modes: manual, semi-automatic and automatic. In each of these modes, the LHMI acts as the local user interface. The LHMI includes the necessary command, indication and measurement features for each of the modes, thus rendering the conventional dedicated synchronizing panel unnecessary.

REX640 also supports systems in which non-generator circuit breakers are synchronized. The prerequisite is that all the feeders within the system are equipped with REX640 relays. The generator relays have to contain the ASGCSYN function block and all the non-generator relays need to contain the ASNSCSYN function block. In addition, all the REX640 relays have to contain the coordinator function block ASCGAPC. The role of ASCGAPC is to model the system primary circuit connection state to involve the correct generators for the synchronization of a non-generator breaker and to interact between the ASGCSYN and ASNSCSYN function blocks. The information exchange between ASCGAPC, ASGCSYN and ASNSCSYN is carried out via binary and analog GOOSE signalling as per IEC 61850-8-1. The LHMI dedicated to the relay (breaker) works as the local user interface for a nongenerator breaker synchronizing. The available synchronizing modes are "automatic" and "semi-automatic". A manual synchronization of the non-generator breaker can be carried out as a back-up solution in situations where the communication system (IEC 61850-8-1) is not available. This requires operator actions from two LHMIs, namely from the LHMI of the concerned non-generator breaker and the LHMI of the manually selected generator relay.

## 10. High-speed transfer device (HSTD)

REX640 can perform automatic high-speed transfer functionality utilizing APP51 or APP52 or APP53 application packages. In the industry the functionality is also referred as high-speed busbar transfer (HSBT), motor bus transfer (MBT), high-speed motor bus transfer (HSMBT) and automatic bus transfer (ABT).

The high-speed transfer is typically required in processes where the electrical supply for the critical system parts must be secured by connecting alternative (stand-by) feeder online. Such processes are typically be found in petrochemical, pharmaceutical, semiconductor manufacturing industries and in electrical power generation plants. Common feature for these examples is that there are motors fed by the switchgear, these motors will back-feed the busbar once the grid connection is lost. The declining busbar voltage and frequency must be considered carefully to determine the correct closing moment for the alternative feeder.

The supported transfer modes are:

- Fast transfer
- Transfer at first phase coincidence
- Residual voltage-based transfer
- Time delay-based transfer

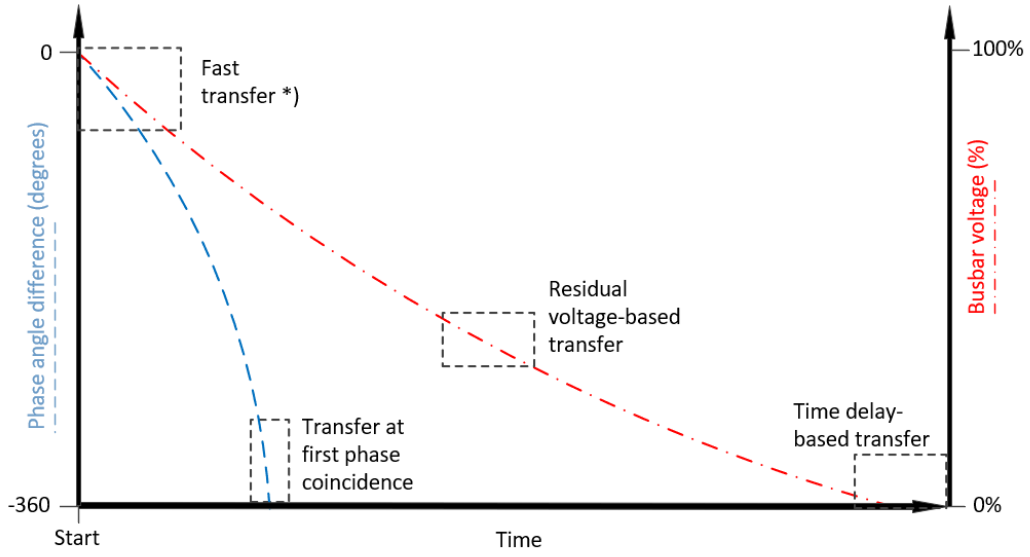
The fast transfer mode can be further divided into simultaneous and sequential circuit breaker control schemes. Selection of the transfer mode takes place dynamically considering the set parameters and the prevailing network conditions. Typically, the fast transfer mode is the preferred one, but in case the network conditions do not allow this mode to be executed, the next one would be

the first phase coincident mode followed by residual and time delayed modes.

The triggering of transfer functionality can happen internally in the REX640 by the HSABTC transfer function, or it can be based on external triggering signal, or it can be manually initiated.

In addition to necessary voltage measurements, the REX640 can be connected to measure main and alternative feeders phase currents. The current measurements are necessary only if the automatic circuit breaker travel time calculation is based on current measurement, instead of circuit breaker position information.

While engineering a REX640 based HSTD scheme, couple of hardware related performance issues must be considered to enable the fast transfer and transfer at first phase coincident operation modes. The static power output module(s) in REX640 must be used for circuit breaker controls within the scheme. The closing delay of the involved circuit breakers must be less than 100 ms.




*) The fast transfer mode offers two circuit breaker control schemes; simultaneous and sequential (break-before-make).

*Figure 23: Conceptual overview of transfer modes*

Each of the APP51, APP52 and APP53 application packages support all the different transfer modes. The difference between the packages is in the number of actual transfer functions (HSABTC) instances, resulting higher scheme flexibility and increase in the number of supported circuit breakers.

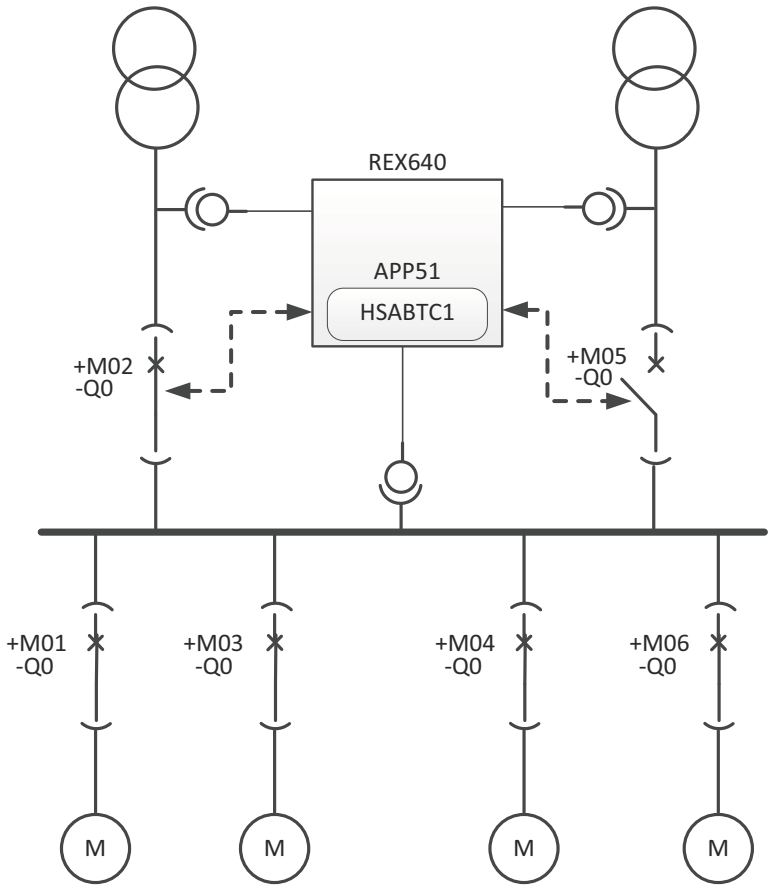



*Figure 24: Example case in using APP51*

In the above example the motor control switchgear is supplied by two incoming feeders +M02 and +M05. Under normal conditions the switchgear is supplied by +M02 feeder only, whereas the feeder +M05 works as the stand-by feeder. In case the HSTD functionality is triggered by supply disturbances in the +M02 feeder, the REX640 will automatically transfer the supply over to +M05 feeder. Once the +M02 feeder is available again, the transfer back to the original configuration can be initiated manually. Cases where the feeder +M05 works as the main feeder and the +M02 as the stand-by feeder, are supported as well.

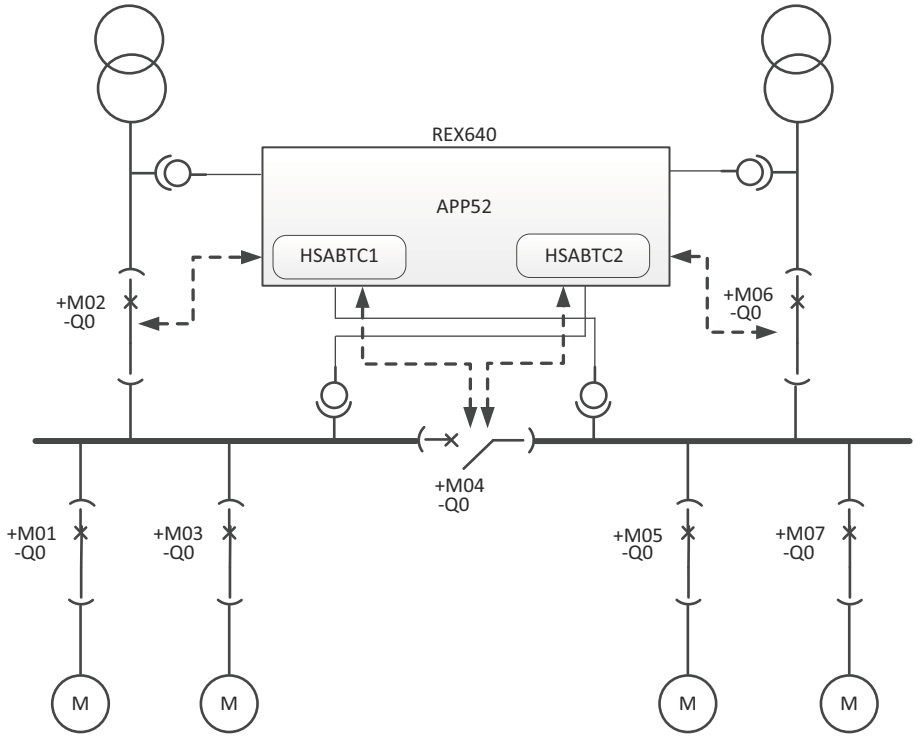



*Figure 25: Example case in using APP52*

In the above example the motor control switchgear is supplied by two incoming feeders +M02 and +M06. Under normal conditions both the incoming feeders are closed, while the bus-sectionalizer +M04 remains open. In case the HSTD functionality is triggered by supply disturbances in either of the incoming feeders, +M02 or +M06, the REX640 will automatically transfer the concerned bus-section supply to the healthy incoming feeder by closing the bus-sectionalizer +M04 circuit breaker. Once the failed incoming feeder is available again, the transfer back to the original configuration can be initiated manually.

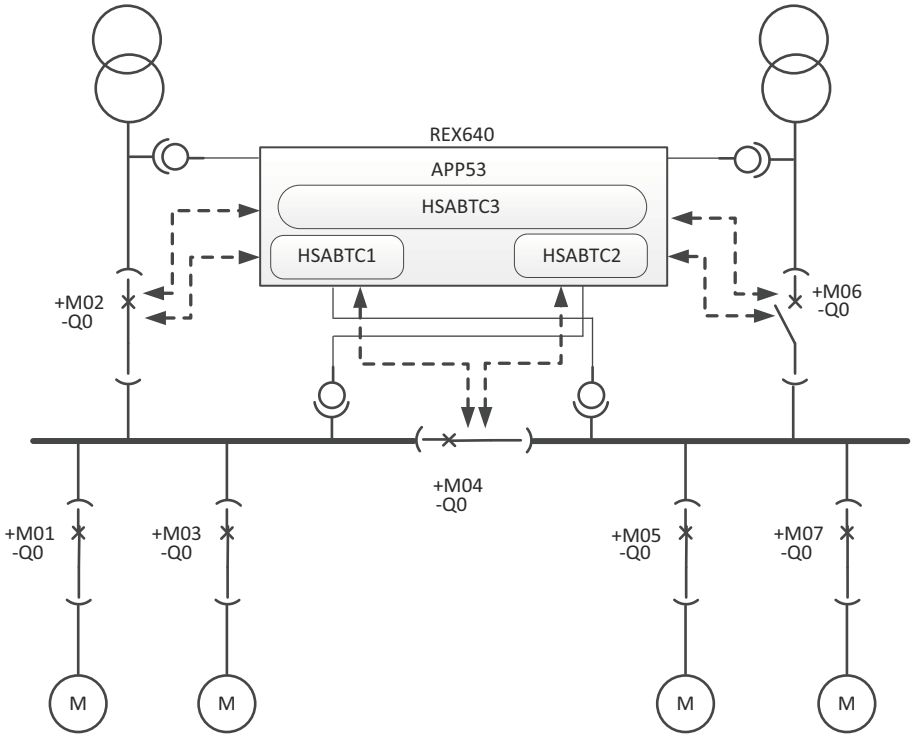



*Figure 26: Example case in using APP53*

The above example of utilizing APP53 application package is very similar to the earlier presented APP52 example case. However, the third instance of HSABTC function enables higher flexibility with the transfer scheme. Let us consider a situation where the switchgear is supplied by one incoming feeder, let's say +M02, and the bus-sectionalizer +M04 is closed. Let us further assume that the other incoming feeder +M06 is available, even though not closed. In case supply disturbances are recognized with the +M02 incoming feeder, the HSTD functionality resulting a transfer from +M02 incoming feeder to +M06 incoming feeder can be initiated. Manually triggered configuration changes between the incoming feeders and the bus-sectionalizer are fully supported.

## 11. Arc flash protection

The arc flash protection is available on the optional hardware module. The module supports connection of up to four sensors. The sensors can be of lens or loop types, or a free mixture. Both sensor types are supervised against sensor failure. Fast tripping increases staff safety and limits material damage, therefore it is recommended to use static power outputs (SPO) instead of normal power outputs (PO). This typically decreases the total operating time with 4..6 ms compared to the normal power outputs.

## 12. Power transformer differential protection

The relay offers low-impedance differential protection for two-winding (two restraints) and three-winding (three restraints) power transformers. The power transformer protection application package includes the protection for a two-winding power transformer. If support for three-winding power transformer is needed, the corresponding

protection add-on package can be selected. Both low-impedance differential functions feature three-phase multi-slope stabilized stages and an instantaneous stage to provide fast and selective protection against short circuits, winding interturn faults and bushing flash-overs. A second harmonic restraint with advanced waveform-based blocking ensures stability at transformer energization. The fifth harmonic based blocking and unblocking limits stabilize the protection performance in moderate overexcitation situations. In case of three-winding differential protection, the connection group phase shift matching can be done with 0.1 degree resolution supporting cycloconverter applications. If the tap-changer position information is available, it is possible to further increase the protection sensitivity by compensating the tap-changer position error within the measured differential current.

The power transformer protection application package also includes high-impedance differential functions for a phasesegregated protection scheme. If this scheme is applied, the related current transformers have to be correctly selected and the necessary secondary circuit components, external to the relay, defined.

## 13. Measurements

The base functionality of the REX640 relay contains a number of basic measurement functions for current, voltage, frequency, symmetrical components of currents and voltages, power, power factor and energy. These measurement functions can be freely connected to the measured secondary quantities available in the relay. The relay can also measure various analog signals via RTD and mA inputs. All these measurements can be used within the relay configuration for additional logics. The measurements are available locally on the HMI and can be accessed remotely via communication. The information is also accessible via WHMI.

The relay is also provided with a load profile recorder. The load profile feature stores the selected load measurement data captured periodically (demand interval). The records can be viewed on the LHMI and are available in COMTRADE format.

## 14. Power quality

In the EN standards, power quality is defined through the characteristics of the supply voltage. Transients, shortduration and long-duration voltage variations and unbalance and waveform distortions are the key characteristics describing power quality. The distortion monitoring functions are used for monitoring the current total demand distortion and the voltage total harmonic distortion.

Power quality monitoring is an essential service that utilities can provide for their industrial and key customers. A monitoring system can provide information about system disturbances and their possible causes. It can also detect problem conditions throughout the system before they cause customer complaints, equipment malfunctions and even equipment damage or failure. Power quality problems are not limited to the utility side of the system. In fact, the majority of power quality problems are localized within customer facilities. Thus, power quality monitoring is not only an effective customer service strategy but also a way to protect a utility's reputation for quality power and service.

The protection relay has the following power quality monitoring functions.

- Voltage variation
- Voltage unbalance
- Current harmonics
- Voltage harmonics

The voltage unbalance and voltage variation functions are used for measuring short-duration voltage variations and monitoring voltage unbalance conditions in power transmission and distribution networks.

The voltage and current harmonics functions provide a method for monitoring the power quality by means of the current waveform distortion and voltage waveform distortion. The functions provide selectable short-term 3- or 60- or 300–second sliding average and a long-term demand for total demand distortion (TDD) and total harmonic distortion (THD). The phase-specific harmonic content is measured for voltages and currents, as well as DC component and fundamental content. The dedicated harmonics measurement page in the LHMI presents the measurements in a userfriendly manner.

## 15. Fault locator

The relay features an optional impedance-measuring fault location function suitable for locating short circuits in radial distribution systems. Earth faults can be located in effectively and low-resistance earthed networks, as well as in compensated networks. When the fault current magnitude is at least of the same order of magnitude or higher than the load current, earth faults can also be located in isolated neutral distribution networks. The fault location function identifies the type of the fault and then calculates the distance to the fault point. The calculations provide information on the fault resistance value and accuracy of the estimated distance to the fault point.

## 16. Disturbance recorder

The relay is provided with a disturbance recorder featuring up to 24 analog and 64 binary signal channels. The analog channels can be set to record either the waveform or the trend of the currents and voltages measured.

The analog channels can be set to trigger the recording function when the measured value falls below or exceeds the set values. The binary signal channels can be set to start a recording either on the rising or the falling edge of the binary signal or on both.

The binary channels can be set to record external or internal relay signals, for example, the start or trip signals of the relay stages, or external blocking or control signals. The recorded information is stored in a nonvolatile memory in COMTRADE format and can be uploaded for subsequent fault analysis.

## 17. Event log

To collect sequence-of-events information, the relay has a nonvolatile memory capable of storing 1024 events with the associated time stamps. The event log facilitates detailed pre- and post-fault analyses of feeder faults and disturbances. The considerable capacity to process and store data and events in the relay supports the growing information demand of future network configurations.

The sequence-of-events information can be accessed either via the LHMI or remotely via the communication interface of the relay. The information can also be accessed locally or remotely using the Web HMI.

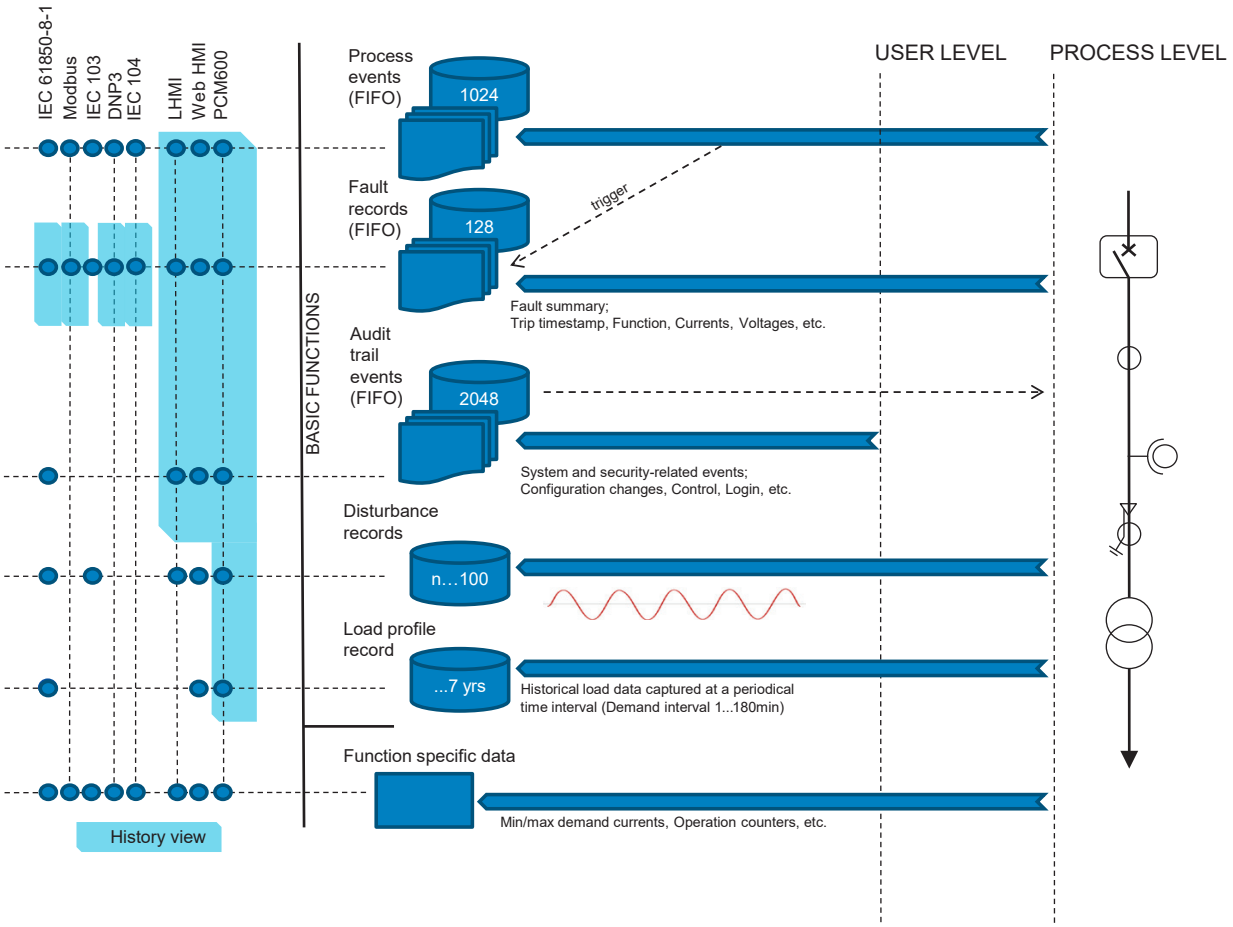



*Figure 27: Event recording*

## 18. Recorded data

The relay can store the records of the latest 128 fault events. The records can be used to analyze the power system events. Each record includes, for example, current, voltage and angle values and a time stamp. The fault recording can be triggered by the start or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. Fault records store relay measurement values when any protection function starts. In addition, the maximum demand current with time stamp is separately recorded. The records are stored in the nonvolatile memory.

## 19. Load profile

The load profile recorder stores the historical load data captured periodically (demand interval). Up to 12 load quantities can be selected for recording and storing in the nonvolatile memory. The recordable quantities include currents, voltages, power and power factor values. The recording time depends on a settable demand interval parameter and the amount of quantities selected. The quantities' type and amount to be recorded are determined in the application configuration. The recorded quantities are stored in the COMTRADE format.

## 20. Trip circuit supervision

The trip circuit supervision continuously monitors the availability and operability of the trip circuit. It provides opencircuit monitoring both when the circuit breaker is in closed and

in open position. It also detects loss of circuit-breaker control voltage.

## 21. Self-supervision

The relay's built-in self-supervision system continuously monitors the state of the relay hardware and the operation of the relay software. Any fault or malfunction detected is used for alerting the operator.

A permanent relay fault blocks the protection functions to prevent incorrect operation.

## 22. Access control and cybersecurity

Cybersecurity measures are implemented to secure safe operation of the protection and control functions. The relay supports these measures with configuration hardening capabilities, encrypted communication, Ethernet filter and rate limiter, security event logging and user access control.

The relay supports role-based user authentication and authorization with individual user accounts as defined in IEC 62351-8. All user activity is logged as security events to an audit trail in a nonvolatile memory and sent as messages to the SysLog server. The nonvolatile memory does not need battery backup or regular component exchange to maintain the memory storage. File transfer and Web HMI use communication encryption protecting the data in transit. Also, the communication link between the relay configuration tool PCM600 and the relay is encrypted. All rear communication ports and optional protocol services can be activated according to the required system setup.

User accounts can be managed by PCM600 or centrally. A central account management is an authentication infrastructure that offers a secure solution for enforcing access control to relays and other systems within a substation. This incorporates management of user accounts, roles and certificates and the distribution of such, a procedure completely transparent to the user. The central server handling user accounts can be, for example, an Active Directory (AD) server such as Windows AD.

The relay supports full Public Key Infrastructure as defined by IEC 62351-9. With this, the user can ensure that the certificates used in secured communication are from a userapproved provider instead of device self-signed certificates.

## 23. Station communication

Operational information and controls are available through a wide range of communication protocols including IEC 61850 Edition 2.1, IEC 61850-9-2 LE, IEC 60870-5-103, IEC 60870-5-104, Modbus® and DNP3. The Profibus DPV1 communication protocol is supported via the protocol converter SPA-ZC 302. Full communication capabilities, forexample, horizontal communication between the relays, are only enabled by IEC 61850.

The relay provides the possibility for a second IP address and a second subnetwork when the communication modules with three Ethernet ports (COM1001...1003) are used. However, only one IP network can be used as the default route. Using two IP addresses, communication networks can be separated based on the dominant user's needs. For example, one IP address can serve the dispatchers and the other one can serve the service engineers' needs.

The IEC 61850 protocol is a core part of the relay as the protection and control application is fully based on standard modelling. The relay supports Edition 2.1 and Edition 1 versions of the standard. With Edition 2.1 support, the relay has the latest functionality modelling for substation applications and the best interoperability for modern substations. The relay supports flexible product naming (FPN) facilitating the mapping of relay's IEC 61850 data model to a customer defined IEC 61850 data model.

The IEC 61850 communication implementation supports monitoring and control functions. Additionally, parameter settings, disturbance recordings and fault records can be accessed using the IEC 61850 protocol. Disturbance recordings are available to any Ethernet-based application in the standard COMTRADE file format. The relay supports simultaneous event reporting to five different clients on the station bus.

The relay can send binary and analog signals to other devices using the IEC 61850-8-1 GOOSE (Generic Object Oriented Substation Event) profile. Binary GOOSE messaging

can, for example, be used for protection and interlocking-based protection schemes. The relay meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard (class P1, <3 ms data exchange between the devices). The relay also supports the sending and receiving of analog values using GOOSE messaging. Analog GOOSE messaging enables easy transfer of analog measurement values over the station bus, thus facilitating, for example, the sending of measurement values between the relays when controlling transformers running in parallel.

The relay also supports IEC 61850 process bus concept by sending and receiving sampled values of currents and voltages. With this functionality the galvanic interpanel wiring can be replaced with Ethernet communication. The analog values are transferred as sampled values using the IEC 61850-9-2 LE protocol. REX640 supports publishing of one and subscribing of four sampled value streams. The intended application for sampled values are current-based differential protection functions or sharing the voltage values with the relays that have voltage-based protection or supervision functions. The relay can receive up to four sampled value streams and totally 16 measurements can be connected into the protection relay application.

Relays with process bus based applications use IEEE 1588 edition 2 for high-accuracy time synchronization.

For redundant Ethernet communication in station bus, the relay offers either two optical or two galvanic Ethernet network interfaces.

An optional third port with optical or galvanic Ethernet network interface is also available. The relay also provides an optional fiber-optic port for dedicated protection communication which can be used for up to 50 km distances depending on the selected fiber transceiver. The intended teleprotection applications for this port are line differential and line distance protection communication or binary signal transfer. The optional third Ethernet interface provides connectivity for any other Ethernet device to an IEC 61850 station bus inside a switchgear bay, for example connection of a remote I/O. Ethernet network redundancy can be achieved using the high-availability seamless redundancy (HSR) protocol or the parallel redundancy protocol (PRP), or with a self-healing ring using RSTP in the managed switches. Ethernet redundancy can be applied to the Ethernet-based IEC 61850, Modbus and DNP3 protocols.

The IEC 61850 standard specifies network redundancy which improves the system availability for the substation communication. The network redundancy is based on two complementary protocols defined in the IEC 62439-3 standard: PRP and HSR protocols. Both protocols are able to overcome a failure of a link or switch with a zero switchover time. In both protocols, each network node has two identical Ethernet ports dedicated for one network connection.

The protocols rely on the duplication of all transmitted information and provide a zero switchover time if the links or switches fail, thus fulfilling all the stringent real-time requirements of substation automation.

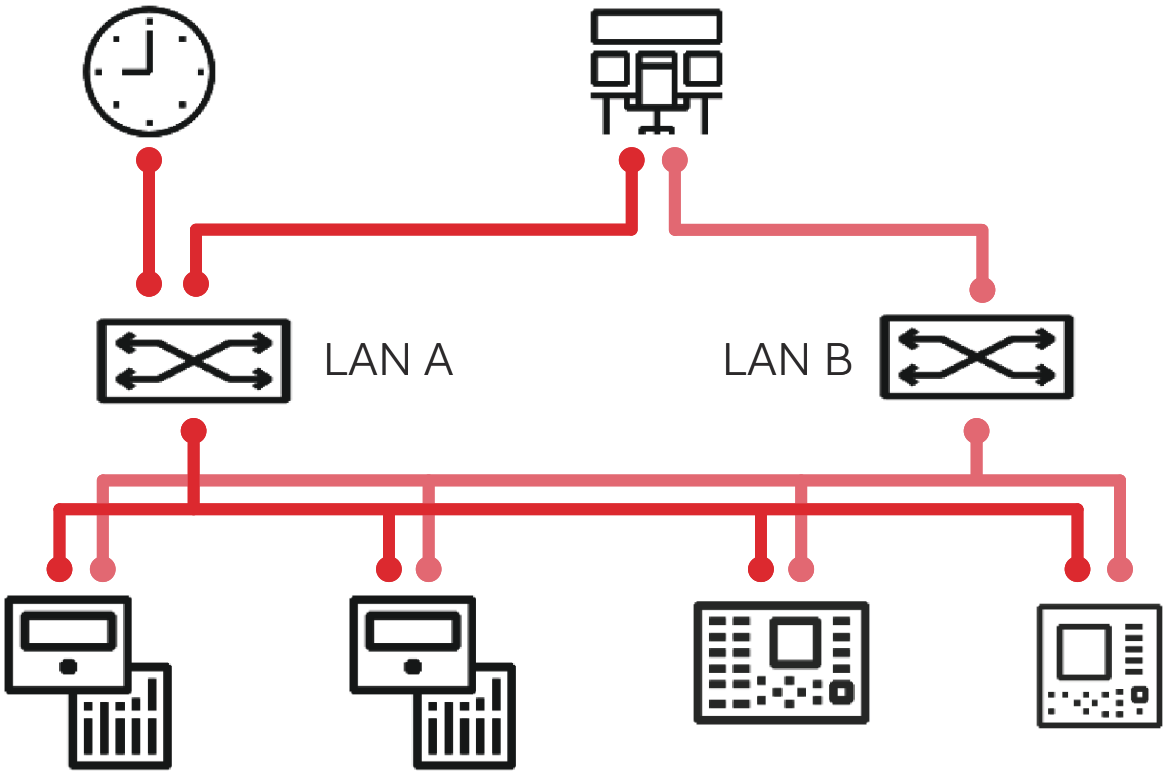



*Figure 28: Parallel redundancy protocol (PRP) solution*

In PRP, each network node is attached to two independent networks operated in parallel. The networks are completely separated to ensure failure independence and can have different topologies. As the networks operate in parallel, they provide zero-time recovery and continuous checking of redundancy to avoid failures.

HSR applies the PRP principle of parallel operation to a single ring. For each message sent, the node sends two frames, one through each port. Both frames circulate in opposite directions over the ring. Every node forwards the frames it receives from one port to another to reach the next node. When the originating sender node receives the frame it sent, the sender node discards the frame to avoid loops. The HSR ring supports the connection of up to 30 relays. If more than 30 relays are to be connected, it is recommended to split the network into several rings to guarantee the performance for real-time applications.

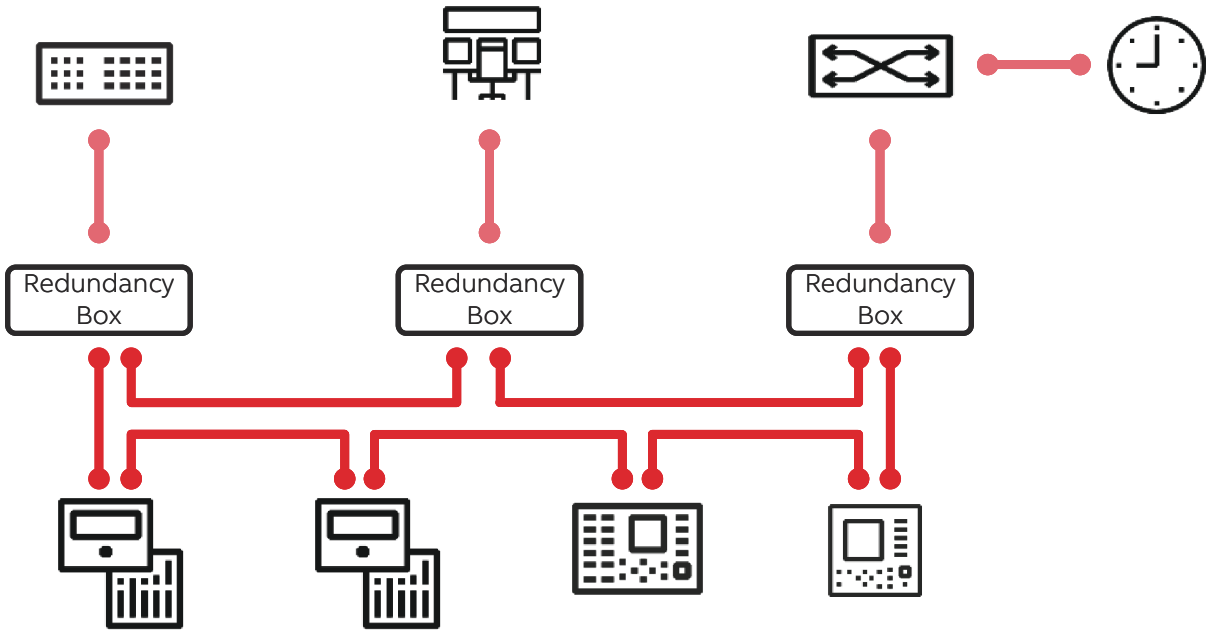



*Figure 29: High-availability seamless redundancy (HSR) solution*

The relay can be connected to Ethernet-based communication systems in a station bus using the RJ-45 connector (100Base-TX) or the multimode fiber optic LC connector (100Base-FX). A dedicated protection communication port uses a pluggable multimode or single mode fiber optic LC connector (100Base-FX). If connection to a serial bus is required, the RS-485 or fiber-optic serial communication ports can be used.

Modbus implementation supports RTU, ASCII and TCP modes. Besides standard Modbus functionality, the relay supports retrieval of time-stamped events, changing the active setting group and uploading of the latest fault records. If a Modbus TCP connection is used, five clients can be connected to the relay simultaneously. Further, Modbus serial and Modbus TCP can be used in parallel, and, if required, both IEC 61850 and Modbus can be run simultaneously.

The IEC 60870-5-103 implementation supports two parallel serial bus connections to two different masters. Besides basic standard functionality, the relay supports changing of the active setting group and uploading of disturbance recordings in IEC 60870-5-103 format. Further, IEC 60870-5-103 can be used at the same time with the IEC 61850 protocol.

**Table 3: Time synchronization methods supported by the relay**

| Methods | Time-stamping resolution |
|---|---|
| SNTP (Simple network time protocol) [2] | 1 ms |
| IRIG-B (Inter-Range Instrumentation Group - Time Code Format B) [3] | 4 µs |
| PTPv2 (IEEE 1588) with Power profile (IEEE Std C37.238-2011) and Utility profile (IEC 61850-9-3) | 4 µs [4] |

[2] Ethernet-based
[3] With special time synchronization wiring
[4] Required especially in process bus applications

DNP3 supports both serial and TCP modes for the connection of up to five masters. Changing the active setting and reading fault records are supported. DNP serial and DNP TCP can be used in parallel. If required, both IEC 61850 and DNP can be run simultaneously.

The relay supports Profibus DPV1 with support of SPA-ZC 302 Profibus adapter. If Profibus is required, the relay must be ordered with Modbus serial options. Modbus implementation includes SPA protocol emulation functionality. This functionality enables connection to SPA-ZC 302.

When the relay uses the RS-485 bus for the serial communication, both two- and four-wire connections are supported. Termination and pull-up/down resistors can be configured with DIP switch on the communication card so that external resistors are not needed.

PTPv2 features:

- PTPv2 Power profile and PTPv2 Utility profile
- Receive (slave): 1-step/2-step
- Transmit (master): 1-step
- Layer 2 mapping
- Peer-to-peer delay calculation and monitoring
- Multicast operation
- Ordinary Clock with Best Master Clock algorithm
- One-step Transparent Clock for Ethernet ring topology
- Slave-only mode

The required accuracy of the grandmaster clock is +/-1 µs to guarantee performance of protection applications. The relay can work as a backup master clock per BMC algorithm if the external primary grandmaster clock is not available for short term.

In addition, the relay supports time synchronization via Modbus, DNP3 and IEC 60870-5-103 serial communication protocols.

**Table 4: Supported station communication interfaces and protocols**

| | Ethernet | | Serial | |
|---|---|---|---|---|
| **Interfaces/Protocols** | **100BASE-TX RJ-45** | **100BASE-FX LC** | **RS-485** | **Fiber optic ST** |
| IEC 61850-8-1 | ● | ● | - | - |
| IEC 61850-9-2 LE | ● | ● | - | - |
| MODBUS RTU/ASCII | - | - | ● | ● |
| MODBUS TCP/IP | ● | ● | - | - |
| DNP3 (serial) | - | - | ● | ● |
| DNP3 TCP/IP | ● | ● | - | - |
| IEC 60870-5-103 | - | - | ● | ● |
| IEC 60870-5-104 | ● | ● | - | - |

● = Supported

## 24. Protection communication and supervision

The protection communication between the relays is enabled by means of a dedicated fiber optic communication channel; 1310 nm multimode or single-mode fibers with LC connectors are used. The communication link transfers analog and binary information between line ends for line differential, line distance and transfer trip functions. No external devices, such as GPS clocks, are needed for the line differential protection communication. Additionally, the link can be used to transfer any freely selectable binary data between line ends. In total, 16 binary signals can be transferred between two REX640 protection relays.

Each REX640 communication card variant contains an SFP rack for dedicated point-to-

point protection communication via an SFP plug-in module. Three variants of SFP plug-in modules can be selected. The variants support optical communication for distances typically up to 2 km (multimode), 20 km (single-mode) and 50 km (single-mode). The SFP plugin unit can be ordered together with the relay or later on when the need to establish the link arises. The line differential protection can be realized between two REX640 relays or between REX640 and RED615 relays. If the line differential protection is to be realized between REX640 and RED615 relays, the SFP plug-in module has to match the RED615 communication card variant. Additionally, the RED615 relay version must be Ver.5.0 FP1 or later and phase current measurements should be realized with conventional current transformers that have 1 A as the nominal secondary current.

The protection communication supervision continuously monitors the protection communication link. The line differential protection function can be blocked if severe interference in the communication link, risking the correct operation of the function, is detected. If the interference persists, an alarm signal is triggered indicating permanent failure in the protection communication.

Communication module COM1003 gives the possibility to assign the third optical Ethernet communication port (interlink port) as an extra dedicated point-to-point protection communication channel. The second channel can transfer up to 16 additional binary signals between two REX640 relays, or alternatively eight additional binary signals between one REX640 and one RED615 relay. Analogue signals, needed for line differential protection, are transferred via the first protection communication channel only. This feature becomes handy in cases where REX640 relays are used in protection and control schemes for ring type RMU installations where a single REX640 must be able transfer binary signals to two different directions within the ring. Both protection communication channels are supervised.

## 25. Technical data

### 25.1 Dimensions of the relay

**Table 5: Dimensions of the relay**

| Description | | Value |
|---|---|---|
| Width (standard case) | | 304.0 mm (11.9685 in) |
| Width (narrow case) | | 212.4 mm (8.3622 in) |
| Height | | 264.8 mm (10.4252 in) |
| Depth | With compression type CT/VT connectors | 242.2 mm (9.5354 in) |
| | With ring lug type CT/VT connectors | 254.1 mm (10.0039 in) |
| | With grounding bar | 274.0 mm (10.7874 in) |
| Weight box (standard case) | | 6.9...8.8 kg (15.2...19.4 lb) |
| Weight box (narrow case) | | 7.0 kg (15.4 lb) |

## 25.2 Dimensions of the HMI

### Table 6: Dimensions of the HMI

| Description | Value |
|---|---|
| Width | 212.5 mm (8.3661 in) |
| Height | 177.5 mm (6.9882 in) |
| Depth | 57.6 mm (2.2677 in) |
| Weight | 1.6 kg (3.5 lb) |
| Display element size | Seven inches |
| Display element resolution | 800 x 480 pixels |

## 25.3 Power supply for the relay

### Table 7: Power supply for the relay

| Description | PSM1001 | PSM1002 | PSM1003 |
|---|---|---|---|
| Nominal auxiliary voltage $U_n$ | 24, 30, 48, 60 V DC | 100, 110, 120, 220, 240 V AC, 50 and 60 Hz | 110, 125 V DC |
| | | 48, 60, 110, 125, 220, 250 V DC | |
| Maximum interruption time in the auxiliary DC voltage without resetting the relay | 50 ms at $U_n$ | | |
| Auxiliary voltage variation | 50...120% of $U_n$ (12...72 V DC) | 55...110% of $U_n$ (55...264 V AC) | 70...120% of $U_n$ (77...150 V DC) |
| | | 80...120% of $U_n$ (38.4...300 V DC) | |
| Start-up threshold | 16 V DC (24 V DC × 67%) | | 77 V DC (110 V DC × 70%) |
| Burden of auxiliary voltage supply under quiescent ($P_q$)/ operating condition | DC <18.0 W (nominal)/<25.0 W (max.) | DC <20.0 W (nominal)/<25.0 W (max.) | DC <17.0 W (nominal)/<25.0 W (max.) |
| | | AC <20.0 W (nominal)/<25.0 W (max.) | |
| Ripple in the DC auxiliary voltage | Max 15% of the DC value (at frequency of 100 Hz) | | |
| Fuse type | T8A/250 V | T4A/250 V | |
| Permissible frequency band | 50/60Hz +-10% | | |

## 25.4 Power supply for the HMI

### Table 8: Power supply for the HMI

| Description | Value |
|---|---|
| Nominal auxiliary voltage $U_n$ | 100, 110, 120, 220, 240 V AC, 50 and 60 Hz |
| | 24, 48, 60, 110, 125, 220, 250 V DC |
| Auxiliary voltage variation | 38...110% of $U_n$ (38...264 V AC) |
| | 80...120% of $U_n$ (19.2...300 V DC) |
| Start-up threshold | 19.2 V DC (24 V DC × 80%) |
| Burden of auxiliary voltage supply under quiescent (Pq)/operating condition | DC <6.0 W (nominal)/<14.0 W (max.)<br>AC <7.0 W (nominal)/<12.0 W (max.) |
| Ripple in the DC auxiliary voltage | Max 15% of the DC value (at frequency of 100 Hz) |
| Fuse type | T3.15A/250V |

## 25.5 Energizing inputs

### Table 9: Energizing inputs

| Description | | Value | |
|---|---|---|---|
| Rated frequency | | 50/60 Hz | |
| Current inputs | Rated current, $I_n$ | 0.2/1 A | 1/5 A [5] |
| | Thermal withstand capability<br>Continuously | 4 A | 20 A |
| | Thermal withstand capability<br>For 1 s | 100 A | 500 A |
| | Dynamic current withstand<br>Half-wave value | 250 A | 1250 A |
| | Input impedance | <100 mΩ | <20 mΩ |
| Voltage inputs | Rated voltage | 57...240 V AC | |
| | Voltage withstand<br>Continuous | 288 V AC | |
| | Voltage withstand<br>For 10 s | 360 V AC | |
| | Burden at rated voltages 100V, 110V and 120V | <0.05VA | |
| | Burden at rated voltage > 120V | <0.20VA | |

[5] Residual current and/or phase current

### 25.6 Energizing inputs (sensors)

**Table 10: Table 9: Energizing Inputs (SIM1901)**

| Description | | Value |
|---|---|---|
| Current sensor input | Rated current voltage | 75 mV ... 9000 mV [6] |
| | Continuous voltage withstand | 125 V |
| | Input impedance at 50/60Hz | 2...3 MΩ [7] |
| Voltage sensor input | Rated secondary voltage | 346 mV…1733 mV [8] |
| | Continuous voltage withstand | 50 V |
| | Input impedance at 50/60Hz | 3 MΩ |

**Table 11: Energizing Inputs (SIM1902)**

| Description | | Value |
|---|---|---|
| Current sensor input | Rated current voltage | 75 mV ... 9000 mV [9] |
| | Continuous voltage withstand | 125 V |
| | Input impedance at 50/60Hz | 2 MΩ |
| Voltage sensor input | Rated secondary voltage | 346 mV…2339 mV [10] |
| | Continuous voltage withstand | 50 V |
| | Input impedance at 50/60Hz | 2 MΩ<br>50 pF |

### 25.7 Binary inputs

**Table 12: Binary inputs**

| Description | Value |
|---|---|
| Operating range | ±20% of the rated voltage |
| Rated voltage | 24...250 V DC |
| Current drain | 1.6...1.9 mA |
| Power consumption | 31.0...570.0 mW |

*Table continues on the next page*

[6] Equals the current range of 40 … 4000 A with 80A, 3mV/Hz Rogowski
[7] Depending on the used nominal current (hardware gain)
[8] Covers 6 kV … 30 kV sensors with division ratio of 10 000:1. Secondary voltages 600mV/√3 … 3 V / √3. Range up to 2 x Rated.
[9] Equals the current range of 40 … 4000 A with 80A, 3mV/Hz Rogowski
[10] Covers 6 kV … 40.5 kV sensors with division ratio of 10 000:1. Secondary voltages 600mV/√3 … 4.05V / √3. Range up to 2 x Rated.

| Description | Value |
|---|---|
| Threshold voltage | 16...176 V DC |
| Ripple in the DC auxiliary voltage | Max 15% of the DC value (at frequency of 100 Hz) |
| Wetting current | 220 mA, impulse period 5ms<br>0...120 mA[11], impulse period 8ms |

## 25.8 RTD/mA inputs and mA outputs

### Table 13: RTD/mA inputs and mA outputs

| Description | | Value | |
|---|---|---|---|
| RTD inputs | Supported RTD sensors | 100 Ω platinum | TCR 0.00385 (DIN 43760) |
| | | 250 Ω platinum | TCR 0.00385 |
| | | 100 Ω nickel | TCR 0.00618 (DIN 43760) |
| | | 120 Ω nickel | TCR 0.00618 |
| | | 250 Ω nickel | TCR 0.00618 |
| | Supported resistance range | 0...4 kΩ | |
| | Maximum lead resistance (three-wire measurement) | 100 Ω per lead | |
| | Isolation | 2 kV (inputs to protective earth) | |
| | Response time | <1 s | |
| | RTD/resistance sensing current | <1 mA rms | |
| | Operation accuracy | Resistance | Temperature |
| | | ± 2.0% or ±1 Ω | ±1°C |
| mA inputs | Supported current range | ±0...20 mA | |
| | Current input impedance | 44 Ω ±0.1% | |
| | Operation accuracy | ±0.5% or ±0.01 mA | |
| mA outputs | Supported current range | ±0...20 mA | |
| | Maximum loop impedance | 700 Ω | |
| | Operation accuracy | ±0.1 mA | |

[11] Adjustable only in RTD1002 module

### 25.9 Signal outputs and IRF output

**Table 14: Signal outputs and IRF output**

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 1250 VA |
| Continuous contact carry | 5 A |
| Make and carry for 3.0 s | 10 A |
| Make and carry 0.5 s | 15 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC | 1 A/0.25 A/0.15 A |
| Minimum contact load | 10 mA at 5 V AC/DC |

### 25.10 Single-pole power output relays

**Table 15: Single-pole power output relays**

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 2000 VA |
| Continuous contact carry | 8 A |
| Make and carry for 3.0 s | 15 A |
| Make and carry for 0.5 s | 30 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC | 5 A/3 A/1 A |
| Minimum contact load | 100 mA at 24 V AC/DC |

### 25.11 Static signal output (SSO) relays

**Table 16: Static signal output (SSO) relays**

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 250 VA |
| Continuous contact carry | 1 A |
| Make and carry for 3.0 s | 5 A |

*Table continues on the next page*

| Description | Value |
|---|---|
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 110 V DC | 0.25 A |
| Minimum load current | 1 mA |
| Maximum operation frequency at 50% duty cycle | 10 Hz |

## 25.12 Double-pole power output relays with TCS function

### Table 17: Double-pole power output relays with TCS function

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 2000 VA |
| Continuous contact carry | 8 A |
| Make and carry for 3.0 s | 15 A |
| Make and carry for 0.5 s | 30 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC (two contacts connected in series) | 5 A/3 A/1 A |
| Minimum contact load | 100 mA at 24 V AC/DC |
| Trip-circuit supervision (TCS)<br>Control voltage range | 20...250 V AC/DC |
| Trip-circuit supervision (TCS)<br>Current drain through the supervision circuit | ~1.5 mA |
| Trip-circuit supervision (TCS)<br>Minimum voltage over the TCS contact | 20 V AC/DC (15...20 V) |

## 25.13 Static power output (SPO) relays

### Table 18: Static power output (SPO) relays

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 2000 VA |
| Continuous contact carry | 5 A, 60 s<br>5 A continuous (one output active at a time per module)<br>1 A continuous (multiple outputs simultaneously active in the same module) |

*Table continues on the next page*

| Description | Value |
|---|---|
| Make and carry for 0.2 s | 30 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC two contacts connected in series | 16 A/6 A/3 A |
| Minimum load current | 1 mA |
| Trip-circuit supervision (TCS) SP06 and SP08<br>Control voltage range | 20...250 V DC |
| Trip-circuit supervision (TCS) SP06 and SP08<br>Current drain through the supervision circuit | ~1.5 mA |
| Trip-circuit supervision (TCS) SP06 and SP08<br>Minimum voltage over the TCS contact | 20 V DC |
| SP05 and SP07<br>Current drain through the circuit | ~3 mA |

## 25.14 Serial interface

### Table 19: Serial interface

| Type | Connector |
|---|---|
| Screw terminal X8 | 10-pin 2-row connector |
| Serial port X7 | Optical ST-connector |

## 25.15 USB interface, HMI

### Table 20: USB interface, HMI

| Type | Description |
|---|---|
| USB | Hi-Speed USB Type A |

### 25.16 Ethernet interfaces (connectors X0, X1, X2 and X3)

**Table 21: Ethernet interfaces (connectors X0, X1, X2 and X3)**

| Connector | Media | Reach [12] | Rate | Wavelength | Permitted path attenuation [13] |
|---|---|---|---|---|---|
| RJ-45 | CAT 6 S/FTP | 100 m | 100 mbits/s | - | – |
| LC | MM 62.5/125 or 50/125 µm glass fiber core | 2 km | 100 mbits/s | 1300 nm | <8 dB |

### 25.17 Protection communication link (connector X6)

**Table 22: Protection communication link (connector X6)**

| Connector | Part number [14] | Fiber type | Reach [15] | Wavelength | Permitted path attenuation [16] |
|---|---|---|---|---|---|
| LC (SFP) | 2RCA045621 | MM 62.5/125 or 50/125 µm | 2 km | 1310 nm | <8 dB |
| LC (SFP) | 2RCA045622 | SM 9/125 µm | 20 km | 1310 nm | <13 dB |
| LC (SFP) | 2RCA045623 | SM 9/125 µm | 50 km | 1310 nm | <26 dB |

### 25.18 IRIG-B (connector X8)

**Table 23: IRIG-B (connector X8)**

| Description | Value |
|---|---|
| IRIG time code format | B004, B005 [17] |
| Isolation | 500V 1 min |
| Modulation | Unmodulated |
| Logic level | 5 V TTL |
| Current consumption | <1.0 mA |
| Power consumption | <0.5 W |

12 Maximum length depends on the cable attenuation and quality, the amount of splices and connectors in the path
13 Maximum allowed attenuation caused by connectors and cable together
14 Only these ABB verified SFP modules are supported in the protection communication link (port X6 in the communication module).
15 Maximum length depends on the cable attenuation and quality, the amount of splices and connectors in the path
16 Maximum allowed attenuation caused by connectors and cable together
17 According to the 200-04 IRIG standard

### 25.19 Lens sensor and optical fiber for arc protection

**Table 24: Lens sensor and optical fiber for arc protection**

| Description | Value |
|---|---|
| Normal service temperature range of the lens | -40...+100°C |
| Maximum service temperature range of the lens, max 1 h | +140°C |
| Minimum permissible bending radius of the connection fiber | 100 mm |
| Arc sensor loop maximum attenuation | 25dB |

### 25.20 Degree of protection of the protection relay

**Table 25: Degree of protection of the protection relay**

| Description | Value |
|---|---|
| Front/connector side | IP 20 (with ring-lug signal connectors IP 00 or IP 10 depending on wiring) |
| Top and bottom | IP 30 |
| Rear | IP 40 |

### 25.21 Degree of protection of the HMI

**Table 26: Degree of protection of the HMI**

| Description | Value |
|---|---|
| Front | IP 54 |
| Other sides | IP 20 |

### 25.22 Environmental conditions

**Table 27: Environmental conditions**

| Description | Value |
|---|---|
| Operating temperature range | -25...+55ºC (continuous) |
| Short-time service temperature range | -40...+85ºC (<16 h) [18, 19] |

*Table continues on the next page*

[18] Degradation in MTBF and HMI performance outside the temperature range of -25...+55 ºC
[19] For relays with an LC communication interface the maximum operating temperature is +70 ºC

| Description | Value |
|---|---|
| Relative humidity | Up to 95%, non-condensing |
| Atmospheric pressure | 86...106 kPa |
| Altitude | Up to 2000 m |
| Transport and storage temperature range | -40...+85ºC |

## 25.23 Electromagnetic compatibility tests

### Table 28: Electromagnetic compatibility tests

| Description | Type test value | Reference |
|---|---|---|
| 1 MHz/100 kHz burst disturbance test<br>Common mode | 2.5 kV | IEC 61000-4-18<br>IEC 60255-26<br>IEEE C37.90.1-2012 |
| 1 MHz/100 kHz burst disturbance test<br>Differential mode | 2.5 kV | |
| 3 MHz, 10 MHz and 30 MHz burst disturbance test<br>Common mode | 2.5 kV | IEC 61000-4-18<br>IEC 60255-26 |
| Electrostatic discharge test<br>Contact discharge | 8 kV | IEC 61000-4-2<br>IEC 60255-26<br>IEEE C37.90.3-2001 |
| Electrostatic discharge test<br>Air discharge | 15 kV | |
| Radio frequency interference test | 10 V (rms)<br>f = 150 kHz...80 MHz<br>10 V/m (rms)<br>f = 80...2700 MHz<br>20 V/m (rms)<br>f = 80...1000 MHz | IEC 61000-4-6<br>IEC 60255-26<br>IEC 61000-4-3<br>IEC 60255-26<br>IEEE C37.90.2-2004 |
| Fast transient disturbance test<br>Communication | 2 kV | IEC 61000-4-4<br>IEC 60255-26<br>IEEE C37.90.1-2012 |
| Fast transient disturbance test<br>Other ports | 4 kV | |
| Surge immunity test<br>Communication | 1 kV, line-to-earth | IEC 61000-4-5<br>IEC 60255-26 |
| Surge immunity test<br>Other ports | 4 kV, line-to-earth<br>2 kV, line-to-line | |

*Table continues on the next page*

| Description | Type test value | Reference |
|---|---|---|
| Power frequency (50 Hz) magnetic field immunity test<br>Continuous | 300 A/m | IEC 61000-4-8<br>IEC 60255-26 |
| Power frequency (50 Hz) magnetic field immunity test<br>1...3 s | 1000 A/m | |
| Pulse magnetic field immunity test | 1000 A/m<br>8/20 µs | IEC 61000-4-9 |
| Damped oscillatory magnetic field immunity test<br>2 s | 100 A/m | IEC 61000-4-10 |
| Damped oscillatory magnetic field immunity test<br>1 MHz | 400 transients/s | |
| Voltage dips and short interruptions | 0%/50 ms Criterion A<br>40%/200 ms Criterion C<br>70%/500 ms Criterion C<br>0%/5000 ms Criterion C | IEC 61000-4-11<br>IEC 61000-4-29<br>IEC 60255-26 |
| Power frequency immunity test<br>Common mode | Binary inputs only<br>300 V rms | IEC 61000-4-16<br>IEC 60255-26, class A |
| Power frequency immunity test<br>Differential mode | Binary inputs only<br>150 V rms | |
| Emission tests<br>Conducted<br>0.15...0.50 MHz | <79 dB (µV) quasi peak<br><66 dB (µV) average | IEC 60255-26<br>CISPR 11<br>CISPR 32 |
| Emission tests<br>Conducted<br>0.5...30 MHz | <73 dB (µV) quasi peak<br><60 dB (µV) average | |
| Emission tests<br>Radiated<br>30...230 MHz | <40 dB (µV/m) quasi peak, measured at 10 m distance | |
| Emission tests<br>Radiated<br>230...1000 MHz | <47 dB (µV/m) quasi peak, measured at 10 m distance | |
| Emission tests<br>Radiated<br>1…3 GHz | <76 dB (µV/m) peak<br><56 dB (µV/m) average, measured at 3 m distance | |
| Emission tests<br>Radiated<br>3…6 GHz | <80 dB (µV/m) peak<br><60 dB (µV/m) average, measured at 3 m distance | |

## 25.24 Safety-related tests

### Table 29: Safety-related tests

| Description | Type test value | Reference |
|---|---|---|
| Overvoltage category | III | IEC 60255-27 |
| Pollution degree | 2 | IEC 60255-27 |
| Insulation class | Class I | IEC 60255-27 |
| Dielectric tests | 500 V, 50 Hz, 1 min, RS-485 and IRIG-B<br>820 V, 50 Hz, 1 min, mA inputs / mA outputs of RTD1002, sensor inputs of SIM1902<br>1 kV, 50 Hz, 1 min, across open contacts<br>1.5 kV, 50 Hz, 1 min, Ethernet RJ-45<br>2 kV, 50 Hz, 1 min, all other isolated circuits | IEC 60255-27 |
| Impulse voltage test | 1 kV, 1.2/50 µs, 0.5 J, RS-485 and IRIG-B<br>1.5 kV, 1.2/50 µs, 0.5 J, mA inputs / mA outputs of RTD1002, sensor inputs of SIM1902<br>2.4 kV, 1.2/50 µs, 0.5 J, Ethernet RJ-45<br>5 kV, 1.2/50 µs, 0.5 J, all other isolated circuits | IEC 60255-27 |
| Insulation resistance measurements | >100 MΩ, 500 V DC | IEC 60255-27 |
| Protective bonding resistance | <0.1 Ω, 4 A, 60 s | IEC 60255-27 |
| Maximum temperature of parts and materials | Tested | IEC 60255-27 |
| Flammability of insulating materials, components and fire enclosures | Evaluated / Tested | IEC 60255-27 |
| Single-fault condition | Tested | IEC 60255-27 |

## 25.25 Mechanical tests

### Table 30: Mechanical tests

| Description | Requirement | Reference |
|---|---|---|
| Vibration tests (sinusoidal) | Class 2 | IEC 60068-2-6 (test Fc)<br>IEC 60255-21-1 |
| Shock and bump test | Class 2 | IEC 60068-2-27 (test Ea shock)<br>IEC 60068-2-29 (test Eb bump)<br>IEC 60255-21-2 |
| Seismic test | Class 2 | IEC 60255-21-3 |

### 25.26 Environmental tests

**Table 31: Environmental tests**

| Description | Type test value | Reference |
|---|---|---|
| Dry heat test | • 96 h at +55°C<br>• 16 h at +85°C [20] | IEC 60068-2-2 |
| Dry cold test | • 96 h at -25°C<br>• 16 h at -40°C | IEC 60068-2-1 |
| Damp heat test | • 6 cycles (12 h + 12 h) at +25…+55°C, humidity >93% | IEC 60068-2-30 |
| Change of temperature test | • 5 cycles (3 h + 3 h) at -25...+55°C | IEC60068-2-14 |
| Storage test | • 96 h at -40°C<br>• 96 h at +85°C | IEC 60068-2-1<br>IEC 60068-2-2 |
| Damp heat steady state | 10 days at +40°C, humidity 93% | IEC 60255-1<br>IEC 60068-2-78 |

### 25.27 Product safety

**Table 32: Product safety**

| Description | Reference |
|---|---|
| LV directive | 2014/35/EU |
| Standard | EN 60255-27 (2014)<br>EN 60255-1 (2009) |
| UL listed (E-file: E225502) | UL508 |

### 25.28 EMC compliance

**Table 33: EMC compliance**

| Description | Reference |
|---|---|
| EMC directive | 2014/30/EU |
| Standard | EN 60255-26 (2013) |

[20] For relays with an LC communication interface the maximum operating temperature is +70°C

## 25.29 RoHS compliance

### Table 34: RoHS compliance

| Description |
|---|
| Complies with RoHS Directive 2011/65/EU |

## 25.30 Protection functions

### 25.30.1 Distance protection (DSTPDIS)

### Table 35: Distance protection (DSTPDIS)

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Impedance:<br>±2.5% of the set value or ±0.05 Ω Phase angle: ±2° |
| Shortest operate time [21] SIR [22]: 0.1...50 | 25 ms |
| Transient overreach SIR = 0.1...50 | <8.5% |
| Reset time | Typically 45 ms |
| Reset ratio | Typically 0.96/1.04 |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

[21] Measured with static power output (SPO)
[22] SIR = Source impedance ratio

### 25.30.2 Distance protection (DSTPDIS) main settings

**Table 36: Distance protection (DSTPDIS) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Phase Sel mode GFC | DSTPDIS | 1 = Overcurrent<br>2 = Vol Dep Overcur<br>3 = Under impedance<br>4 = OC AND Und impedance | - |
| EF detection Mod GFC | DSTPDIS | 1 = Io<br>2 = Io OR Uo<br>3 = Io AND Uo<br>4 = Io AND IoRef | - |
| Operate delay GFC | DSTPDIS | 100...60000 ms | 10 |
| Z Chr Mod Ph Sel GFC | DSTPDIS | 1 = Quadrilateral<br>2 = Mho (circular) | - |
| Directional mode Zn1 | DSTPDIS | 2 = Forward<br>3 = Reverse<br>1 = Non-directional | - |
| R1 zone 1 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X1 zone 1 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X1 reverse zone 1 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| Z1 zone 1 | DSTPDIS | 0.01...3000.00 Ω | 0.01 |
| Z1 angle zone 1 | DSTPDIS | 15.0...90.0° | 0.1 |
| Z1 reverse zone 1 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| PP operate delay Zn1 | DSTPDIS | 20...60000 ms | 1 |
| R0 zone 1 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X0 zone 1 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| Factor K0 zone 1 | DSTPDIS | 0.00…5.00 | 0.01 |
| Factor K0 angle Zn1 | DSTPDIS | -179...180° | 1 |
| Gnd operate Dl Zn1 | DSTPDIS | 20...60000 ms | 1 |
| Directional mode Zn2 | DSTPDIS | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |

*Table continues on the next page*

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| R1 zone 2 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X1 zone 2 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X1 reverse zone 2 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| Z1 zone 2 | DSTPDIS | 0.01...3000.00 Ω | 0.01 |
| Z1 angle zone 2 | DSTPDIS | 15.0...90.0° | 0.1 |
| Z1 reverse zone 2 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| PP Op delay Mod Zn2 | DSTPDIS | 20...60000 ms | 1 |
| R0 zone 2 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X0 zone 2 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| Factor K0 zone 2 | DSTPDIS | 0.00…5.00 | 0.01 |
| Factor K0 angle Zn2 | DSTPDIS | -179...180° | 1 |
| Gnd operate Dl Zn2 | DSTPDIS | 20...60000 ms | 1 |
| Directional mode Zn3 | DSTPDIS | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| R1 zone 3 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X1 zone 3 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X1 reverse zone 3 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| Z1 zone 3 | DSTPDIS | 0.01...3000.00 Ω | 0.01 |
| Z1 angle zone 3 | DSTPDIS | 15.0...90.0° | 0.1 |
| Z1 reverse zone 3 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| PP operate delay Zn3 | DSTPDIS | 20...60000 ms | 1 |
| R0 zone 3 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X0 zone 3 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| Factor K0 zone 3 | DSTPDIS | 0.00…5.00 | 0.01 |
| Factor K0 angle Zn3 | DSTPDIS | -179...180° | 1 |
| Gnd operate Dl Zn3 | DSTPDIS | 20...60000 ms | 1 |

*Table continues on the next page*

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Directional mode Zn4 | DSTPDIS | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| R1 zone 4 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X1 zone 4 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X1 reverse zone 4 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| Z1 zone 4 | DSTPDIS | 0.01...3000.00 Ω | 0.01 |
| Z1 angle zone 4 | DSTPDIS | 15.0...90.0° | 0.1 |
| Z1 reverse zone 4 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| PP operate delay Zn4 | DSTPDIS | 20...60000 ms | 1 |
| R0 zone 4 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X0 zone 4 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| Factor K0 zone 4 | DSTPDIS | 0.00…5.00 | 0.01 |
| Factor K0 angle Zn4 | DSTPDIS | -179...180° | 1 |
| Gnd operate Dl Zn4 | DSTPDIS | 20...60000 ms | 1 |
| Directional mode Zn5 | DSTPDIS | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| R1 zone 5 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X1 zone 5 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X1 reverse zone 5 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| Z1 zone 5 | DSTPDIS | 0.01...3000.00 Ω | 0.01 |
| Z1 angle zone 5 | DSTPDIS | 15.0...90.0° | 0.1 |
| Z1 reverse zone 5 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| PP operate delay Zn5 | DSTPDIS | 20...60000 ms | 1 |
| R0 zone 5 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| X0 zone 5 | DSTPDIS | 0.00...3000.00 Ω | 0.01 |
| Factor K0 zone 5 | DSTPDIS | 0.00…5.00 | 0.01 |
| Factor K0 angle Zn5 | DSTPDIS | -179...180° | 1 |

*Table continues on the next page*

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Gnd operate Dl Zn5 | DSTPDIS | 20...60000 ms | 1 |
| Select active zones | DSTPDIS | 1 = Zone 1<br>2 = Zones 1-2<br>3 = Zones 1-3<br>4 = Zones 1-4<br>5 = All 5 zones | - |

### 25.30.3 Local acceleration logic (DSTPLAL)

**Table 37: Local acceleration logic (DSTPLAL)**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

### 25.30.4 Local acceleration logic (DSTPLAL) main settings

**Table 38: Local acceleration logic (DSTPLAL) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Load current value | DSTPLAL | 0.01...1.00 × $I_n$ | 0.01 |
| Minimum current | DSTPLAL | 0.01...1.00 × $I_n$ | 0.01 |
| Load release off Tm | DSTPLAL | 0...60000 ms | 10 |
| Minimum current time | DSTPLAL | 0...60000 ms | 10 |
| Operation mode | DSTPLAL | 1 = Zone extension<br>2 = Loss of load<br>3 = Both | - |
| Load release on time | DSTPLAL | 0...60000 ms | 10 |

### 25.30.5 Scheme communication logic (DSOCPSCH)

**Table 39: Scheme communication logic (DSOCPSCH)**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

### 25.30.6 Scheme communication logic (DSOCPSCH) main settings

**Table 40: Scheme communication logic (DSOCPSCH) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Scheme type | DSOCPSCH | 1 = None<br>2 = Intertrip<br>3 = Permissive Underreach<br>4 = Permissive Overreach<br>5 = Blocking | - |
| Carrier Min Dur | DSOCPSCH | 0...60000 ms | 1 |
| Coordination Time | DSOCPSCH | 0...60000 ms | 1 |

### 25.30.7 Current reversal and weak-end infeed logic (CRWPSCH)

**Table 41: Current reversal and weak-end infeed logic (CRWPSCH)**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$<br>±1.5% of the set value or ±0.002 × $U_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

### 25.30.8 Current reversal and weak-end infeed logic (CRWPSCH) main settings

**Table 42: Current reversal and weak-end infeed logic (CRWPSCH) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Reversal mode | CRWPSCH | 1 = Off<br>2 = On | - |
| Wei mode | CRWPSCH | 1 = Off<br>3 = Echo<br>4 = Echo and Operate | - |
| PhV level for Wei | CRWPSCH | 0.10...0.90 × $U_n$ | 0.01 |
| PPV level for Wei | CRWPSCH | 0.10...0.90 × $U_n$ | 0.01 |
| Reversal time | CRWPSCH | 0...60000 ms | 10 |
| Reversal reset time | CRWPSCH | 0...60000 ms | 10 |
| Wei Crd time | CRWPSCH | 0...60000 ms | 10 |

### 25.30.9 Communication logic for residual overcurrent (RESCPSCH)

**Table 43: Communication logic for residual overcurrent (RESCPSCH)**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

### 25.30.10 Communication logic for residual overcurrent (RESCPSCH) main settings

**Table 44: Communication logic for residual overcurrent (RESCPSCH) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Scheme type | RESCPSCH | 1 = None<br>2 = Intertrip<br>3 = Permissive Underreach<br>4 = Permissive Overreach<br>5 = Blocking | - |
| Carrier Min Dur | RESCPSCH | 0...60000 ms | 1 |
| Coordination time | RESCPSCH | 0...60000 ms | 1 |

### 25.30.11 Current reversal and weak-end infeed logic for residual overcurrent (RCRWPSCH)

**Table 45: Current reversal and weak-end infeed logic for residual overcurrent (RCRWPSCH)**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$<br>±1.5% of the set value or ±0.002 × $I_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

### 25.30.12 Current reversal and weak-end infeed logic for residual overcurrent (RCRWPSCH) main settings

**Table 46: Current reversal and weak-end infeed logic for residual overcurrent (RCRWPSCH) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Reversal mode | RCRWPSCH | 1 = Off<br>2 = On | - |
| Wei mode | RCRWPSCH | 1 = Off<br>3 = Echo<br>4 = Echo and Operate | - |
| Residual voltage Val | RCRWPSCH | 0.05...0.70 × $U_n$ | 0.01 |

*Table continues on the next page*

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Reversal time | RCRWPSCH | 0...60000 ms | 10 |
| Reversal reset time | RCRWPSCH | 0...60000 ms | 10 |
| Wei Crd time | RCRWPSCH | 0...60000 ms | 10 |

### 25.30.13 Line differential protection with in-zone power transformer (LNPLDF)

**Table 47: Line differential protection with in-zone power transformer (LNPLDF)**

| Characteristics | Value | | |
|---|---|---|---|
| Operation accuracy [23] | Depending on the frequency of the measured current: fn ±2 Hz | | |
| | Low stage | ±2.5% of the set value | |
| | High stage | ±2.5% of the set value | |
| High stage, operate time [24, 25] | Minimum | Typical | Maximum |
| | 20 ms | 23 ms | 27 ms |
| Reset time | Typically 40 ms | | |
| Reset ratio | Typically 0.96 | | |
| Retardation time | <40 ms | | |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | ±5.0% of the set value or ±20 ms [26] | | |
| Suppression of harmonics | RMS: No suppression<br>DFT: -50 dB at f = n × fn, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

### 25.30.14 Line differential protection with in-zone power transformer (LNPLDF) main settings

**Table 48: Line differential protection with in-zone power transformer (LNPLDF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Low operate value | LNPLDF | 10...200 % $I_r$ | 1 |
| High operate value | LNPLDF | 200...4000 % $I_r$ | 1 |
| Start value 2.H | LNPLDF | 10...50% | 1 |
| Time multiplier | LNPLDF | 0.05...15.00 | 0.01 |

*Table continues on the next page*

[23] With the symmetrical communication channel (as when using dedicated fiber optic).
[24] Without additional delay in the communication channel (as when using dedicated fiber optic).
[25] Measured with static power output. When differential current = 2 × *High operate value* and $f_n$ = 50 Hz with galvanic pilot wire link + 5 ms.
[26] *Low operate value* multiples in the range of 1.5...20

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operating curve type | LNPLDF | 1 = ANSI Ext. inv.<br>3 = ANSI Norm. inv.<br>5 = ANSI Def. Time<br>9 = IEC Norm. inv.<br>10 = IEC Very inv.<br>12 = IEC Ext. inv.<br>15 = IEC Def. Time | - |
| Operate delay time | LNPLDF | 45...200000 ms | 1 |
| CT ratio correction | LNPLDF | 0.200...5.000 | 0.001 |

### 25.30.15 Binary signal transfer (BSTGAPC)

**Table 49: Binary signal transfer (BSTGAPC)**

| Characteristic | | Value |
|---|---|---|
| Signalling delay | Fiber optic link | <5 ms |
| | Galvanic pilot wirelink | <10 ms |

### 25.30.16 Switch-onto-fault protection (CVPSOF)

**Table 50: Switch-onto-fault protection (CVPSOF)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2Hz<br>Current: ±1.5% of the set value or ±0.002 × $I_n$<br>Voltage: ±1.5% of the set value or ±0.002 × $U_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,... |

### 25.30.17 Switch-onto-fault protection (CVPSOF) main settings

**Table 51: Switch-onto-fault protection (CVPSOF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| SOTF reset time | CVPSOF | 0...60000 ms | 10 |

### 25.30.18 Three-phase non-directional overcurrent protection (PHxPTOC)

**Table 52: Three-phase non-directional overcurrent protection (PHxPTOC)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | PHLPTOC | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| | PHHPTOC and PHIPTOC | ±1.5% of the set value or ±0.002 × $I_n$ (at currents in the range of 0.1…10 × $I_n$) ±5.0% of the set value (at currents in the range of 10…40 × $I_n$) | | |
| Start time [27] | PHIPTOC [28]: | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2 × set *Start value* | 8 ms | 12 ms | 15 ms |
| | $I_{Fault}t$ = 10 × set *Start value* | 7 ms | 9 ms | 12 ms |
| | PHHPTOC and PHLPTOC [29]: $I_{Fault}$ = 2 × set *Start value* | 23 ms | 26 ms | 29 ms |
| Reset time | | Typically <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms | | |
| Suppression of harmonics | | RMS: No suppression DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression P-to-P+backup: No suppression | | |

### 25.30.19 Three-phase non-directional overcurrent protection (PHxPTOC) main settings

**Table 53: Three-phase non-directional overcurrent protection (PHxPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PHLPTOC | 0.05…10.00 × $I_n$ | 0.01 |
| | PHHPTOC and PHIPTOC | 0.10...40.00 × $I_n$ | 0.01 |
| Time multiplier | PHLPTOC and PHHPTOC | 0.025...15.000 | 0.005 |

*Table continues on the next page*

[27] Set *Operate curve type* = IEC definite time, Measurement mode = default (depends on stage), current before fault = 0.0 × In, fn = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
[28] Measured with static signal output (SSO)
[29] Includes the delay of the signal output contact (SO)

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operate delay time | PHLPTOC and PHHPTOC | 40...300000 ms | 10 |
| | PHIPTOC | 20...300000 ms | 10 |
| Operating curve type [30] | PHLPTOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20 | |
| | PHHPTOC | Definite or inverse time<br>Curve type: 1, 3, 5, 9, 10, 12, 15, 17 | |
| | PHIPTOC | Definite time | |

### 25.30.20 Three-phase directional overcurrent protection (DPHxPDOC)

**Table 54: Three-phase directional overcurrent protection (DPHxPDOC)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | DPHLPDOC | Depending on the frequency of the current/voltage measured: $f_n$ ±2 Hz | | |
| | | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle: ±2° | | |
| | DPHHPDOC | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$)<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle: ±2° | | |
| Start time [31, 32] | $I_{Fault}$ = 2.0 × set *Start value* | Minimum | Typical | Maximum |
| | | 39 ms | 43 ms | 47 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |

*Table continues on the next page*

[30] For further reference, see the Operation characteristics table
[31] *Measurement mode* and PoI quantity = default, current before fault = 0.0 × $I_n$, voltage before fault = 1.0 × $U_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
[32] Includes the delay of the signal output contact

| Characteristic | Value |
|---|---|
| Operate time accuracy in inverse time mode | ±5.0% of the theoretical value or ±20 ms [33] |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

### 25.30.21 Three-phase directional overcurrent protection (DPHxPDOC) main settings

**Table 55: Three-phase directional overcurrent protection (DPHxPDOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | DPHLPDOC | 0.05…10.00 × $I_n$ | 0.01 |
| | DPHHPDOC | 0.10...40.00 × $I_n$ | 0.01 |
| Time multiplier | DPHxPDOC | 0.025...15.000 | 0.005 |
| Operate delay time | DPHxPDOC | 40...300000 ms | 10 |
| Directional mode | DPHxPDOC | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| Characteristic angle | DPHxPDOC | -179...180° | 1 |
| Operating curve type [34] | DPHLPDOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19 | |
| | DPHHPDOC | Definite or inverse time<br>Curve type: 1, 3, 5, 9, 10, 12, 15, 17 | |

### 25.30.22 Non-directional earth-fault protection (EFxPTOC)

**Table 56: Non-directional earth-fault protection (EFxPTOC)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | EFLPTOC | Depending on the frequency of the measured current: fn ±2 Hz<br>±1.5% of the set value or ±0.002 × $I_n$ | | |
| | EFHPTOC<br>and EFIPTOC | ±1.5% of the set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$) | | |
| Start time [35] | EFIPTOC [36]: | Minimum | Typical | Maximum |

*Table continues on the next page*

[33] Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 1.5...20
[34] For further reference, see the Operating characteristics table
[35] *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
[36] Measured with static signal output (SSO)

| Characteristic | | Value | | |
|---|---|---|---|---|
| | $I_{Fault}$ = 2 × set *Start value* | 8 ms | 11 ms | 14 ms |
| | $I_{Fault}$ = 10 × set *Start value* | 8 ms | 9 ms | 11 ms |
| | EFHPTOC and EFLPTOC [37]: | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2 × set *Start value* | 23 ms | 26 ms | 29 ms |
| Reset time | | Typically <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [38] | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

### 25.30.23 Non-directional earth-fault protection (EFxPTOC) main settings

**Table 57: Non-directional earth-fault protection (EFxPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | EFLPTOC | 0.010…10.000 × $I_n$ | 0.005 |
| | EFHPTOC | 0.10...40.00 × $I_n$ | 0.01 |
| | EFIPTOC | 1.00...40.00 × $I_n$ | 0.01 |
| Time multiplier | EFLPTOC and EFHPTOC | 0.025...15.000 | 0.005 |
| Operate delay time | EFLPTOC and EFHPTOC | 40...300000 ms | 10 |
| | EFIPTOC | 20...300000 ms | 10 |
| Operating curve type [39] | EFLPTOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19 | |
| | EFHPTOC | Definite or inverse time<br>Curve type: 1, 3, 5, 9, 10, 12, 15, 17 | |
| | EFIPTOC | Definite time | |

[37] Includes the delay of the signal output contact (SO)
[38] Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in the range of 1.5...20
[39] For further reference, see the Operation characteristics table

### 25.30.24 Directional earth-fault protection (DEFxPDEF)

**Table 58: Directional earth-fault protection (DEFxPDEF)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | DEFLPDEF | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle:<br>±2° | | |
| | DEFHPDEF | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$)<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle:<br>±2° | | |
| Start time [40, 41] | DEFHPDEF | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2 × set *Start value* | 42 ms | 46 ms | 49 ms |
| | DEFLPDEF | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2 × set *Start value* | 58 ms | 62 ms | 66 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [42] | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

[40] Set *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

[41] Includes the delay of the signal output contact

[42] Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 1.5...20

### 25.30.25 Directional earth-fault protection (DEFxPDEF) main settings

**Table 59: Directional earth-fault protection (DEFxPDEF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | DEFLPDEF | 0.010…10.000 × $I_n$ | 0.005 |
| | DEFHPDEF | 0.10...40.00 × $I_n$ | 0.01 |
| Directional mode | DEFxPDEF | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| Time multiplier | DEFxPDEF | 0.025...15.000 | 0.005 |
| Operate delay time | DEFLPDEF | 50...300000 ms | 10 |
| | DEFHPDEF | 40...300000 ms | 10 |
| Operating curve type [43] | DEFLPDEF | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19 | |
| | DEFHPDEF | Definite or inverse time<br>Curve type: 1, 3, 5, 15, 17 | |
| Operation mode | DEFxPDEF | 1 = Phase angle<br>2 = IoSin<br>3 = IoCos<br>4 = Phase angle 80<br>5 = Phase angle 88 | - |

### 25.30.26 Three-phase power directional element (DPSRDIR) main settings

**Table 60: Three-phase power directional element (DPSRDIR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Release delay time | DPSRDIR | 0...1000 ms | 1 |
| Characteristic angle | DPSRDIR | -179...180° | 1 |
| Directional mode | DPSRDIR | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |

[43] For further reference, see the Operating characteristics table

### 25.30.27 Neutral power directional element (DNZSRDIR) main settings

**Table 61: Neutral power directional element (DNZSRDIR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Release delay time | DNZSRDIR | 0...1000 ms | 10 |
| Directional mode | DNZSRDIR | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| Characteristic angle | DNZSRDIR | -179...180° | 1 |
| Pol quantity | DNZSRDIR | 3 = Zero seq. volt.<br>4 = Neg. seq. volt. | - |

### 25.30.28 Load blinder (LBRDOB)

**Table 62: Load blinder (LBRDOB)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the current measured: $f_n$ |
| | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br><br>Impedance accuracy:<br>±3% of the set value<br>(In range load angle<75 deg)<br><br>±4.5% of the set value<br>(In range 75 deg<load angle<83 deg)<br><br>±8% of the set value<br>(In range load angle>83 deg)<br><br>Phase angle: ±2° |
| Reset ratio | Typically 0.96 |
| Operation time [44, 45] | Typically 30 ms |
| Reset time | Typically 25 ms |

[44] $f_n$= 50Hz, results based on statistical distribution of 1000 measurements
[45] Includes the delay of the signal output contact

### 25.30.29 Load blinder (LBRDOB) main settings

**Table 63: Load blinder (LBRDOB) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Resistive reach Fw | LBRDOB | 1.00...6000.00 Ohm | 0.01 |
| Resistive reach Rv | LBRDOB | 1.00...6000.00 Ohm | 0.01 |
| Max impedance angle | LBRDOB | 5...85 Deg | 1 |
| Min impedance angle | LBRDOB | -85...-5 Deg | 1 |
| Directional mode | LBRDOB | 1= Non-directional<br>2= Forward<br>3= Reverse | - |

### 25.30.30 Admittance-based earth-fault protection (EFPADM)

**Table 64: Admittance-based earth-fault protection (EFPADM)**

| Characteristic | Value | | |
|---|---|---|---|
| Operation accuracy [46] | At the frequency f = $f_n$ | | |
| | ±1.0% or ±0.01 mS<br>(In range of 0.5...100 mS) | | |
| Start time [47] | Minimum | Typical | Maximum |
| | 56 ms | 60 ms | 64 ms |
| Reset time | 40 ms | | |
| Operate time accuracy | ±1.0% of the set value of ±20 ms | | |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

[46] Uo = 1.0 × $U_n$

[47] Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

### 25.30.31 Admittance-based earth-fault protection (EFPADM) main settings

**Table 65: Admittance-based earth-fault protection (EFPADM) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Voltage start value | EFPADM | 0.01...2.00 × $U_n$ | 0.01 |
| Directional mode | EFPADM | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| Operation mode | EFPADM | 1 = Yo<br>2 = Go<br>3 = Bo<br>4 = Yo, Go<br>5 = Yo, Bo<br>6 = Go, Bo<br>7 = Yo, Go, Bo | - |
| Operate delay time | EFPADM | 60...300000 ms | 10 |
| Circle radius | EFPADM | 0.05...500.00 mS | 0.01 |
| Circle conductance | EFPADM | -500.00...500.00 mS | 0.01 |
| Circle susceptance | EFPADM | -500.00...500.00 mS | 0.01 |
| Conductance forward | EFPADM | -500.00...500.00 mS | 0.01 |
| Conductance reverse | EFPADM | -500.00...500.00 mS | 0.01 |
| Susceptance forward | EFPADM | -500.00...500.00 mS | 0.01 |
| Susceptance reverse | EFPADM | -500.00...500.00 mS | 0.01 |
| Conductance tilt Ang | EFPADM | -30...30° | 1 |
| Susceptance tilt Ang | EFPADM | -30...30° | 1 |

### 25.30.32 Multifrequency admittance-based earth-fault protection (MFADPSDE)

**Table 66: Multifrequency admittance-based earth-fault protection (MFADPSDE)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $U_n$ |
| Start time [48] | Typically 35 ms |
| Reset time | Typically 40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

[48] Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

### 25.30.33 Multifrequency admittance-based earth-fault protection (MFADPSDE) main settings

**Table 67: Multifrequency admittance-based earth-fault protection (MFADPSDE) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Directional mode | MFADPSDE | 2 = Forward<br>3 = Reverse | - |
| Voltage start value | MFADPSDE | 0.01...1.00 × $U_n$ | 0.01 |
| Operate delay time | MFADPSDE | 60...1200000 ms | 10 |
| Operating quantity | MFADPSDE | 1 = Adaptive<br>2 = Amplitude<br>3 = Resistive | - |
| Min operate current | MFADPSDE | 0.005...5.000 × $I_n$ | 0.001 |
| Operation mode | MFADPSDE | 1 = Intermittent EF<br>2 = Transient EF<br>3 = General EF<br>4 = Alarming EF | - |
| Peak counter limit | MFADPSDE | 2...20 | 1 |

### 25.30.34 Touch voltage based earth-fault current protection IFPTOC (ANSI 46SNQ/59N)

**Table 68: Touch voltage based earth-fault current protection IFPTOC (ANSI 46SNQ/59N)**

| Characteristics | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current $f_n$ ±2 Hz |
| | Earth-fault current and touch voltage:<br>±1% of the set value or ±0.005 × $I_n$ for $I_F^{est}$<br>Accuracy of $U_{EPR}^{est}$ follows $I_F^{est}$ accuracy.<br>Residual voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Residual current:<br>±1.5% of the set value or ±0.002 × $I_n$ (at currents ≤10 x $I_n$, when Uo is nominal)<br>±5.0% of the set value (at currents > 10 x $I_n$) |
| Start time [49] | Typically 30 ms |
| Reset time | <30 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <50 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms (DT)<br>±3% of the theoretical value or ±40 ms (IDMT) |

[49] Measured with static signal output (SSO)

### 25.30.35 Touch voltage based earth-fault current protection IFPTOC (ANSI 46SNQ/59N) main settings

**Table 69: Touch voltage based earth-fault current protection IFPTOC (ANSI 46SNQ/59N) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operation mode | IFPTOC | 1=Alarming EF<br>2=Tripping EF | |
| Voltage start value | IFPTOC | 0.01...1.00 xUn | 0.01 |
| XC stage PP V Val | IFPTOC | 0.01...1.00 xUn | 0.01 |
| XC stage PP Chg Val | IFPTOC | 0.00...1.00 xUn | 0.01 |
| Operating curve type | IFPTOC | 15=Definite time<br>18=Inverse time EN50522<br>19=Inverse time IEEE80 | |
| EF current Str Val | IFPTOC | 0.005...1.000 xIn | 0.001 |
| IEEE multiplier | IFPTOC | 50.0...5000.0 | 0.1 |
| IDMT stage Min Op Tm | IFPTOC | 50...6000 ms | 10 |
| IDMT stage Max Op Tm | IFPTOC | 500...7200000 ms | 10 |
| Touch Vol Str Val | IFPTOC | 10.0...2900.0 V | 0.1 |
| Operation principle | IFPTOC | 1=EF current based<br>2=Touch voltage based | |
| UTp multiplier | IFPTOC | 0.10...5.00 | 0.01 |
| Ena RF compensation | IFPTOC | 0=Disable<br>1=Enable | |
| CB delay Comp | IFPTOC | 0...200 ms | 1 |
| Intr EF counter Lim | IFPTOC | 3...20 | 1 |

### 25.30.36 Wattmetric-based earth-fault protection (WPWDE)

**Table 70: Wattmetric-based earth-fault protection (WPWDE)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current and voltage:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Power:<br>±3% of the set value or ±0.002 × $P_n$ |
| Start time [50, 51] | Typically 63 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in IDMT mode | ±5.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2,3,4,5,… |

### 25.30.37 Wattmetric-based earth-fault protection (WPWDE) main settings

**Table 71: Wattmetric-based earth-fault protection (WPWDE) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Directional mode | WPWDE | 2 = Forward<br>3 = Reverse | - |
| Current start value | WPWDE | 0.010...5.000 × $I_n$ | 0.001 |
| Voltage start value | WPWDE | 0.010...1.000 × $U_n$ | 0.001 |
| Power start value | WPWDE | 0.003...1.000 × $S_n$ | 0.001 |
| Reference power | WPWDE | 0.050...1.000 × $S_n$ | 0.001 |
| Characteristic angle | WPWDE | -179...180° | 1 |
| Time multiplier | WPWDE | 0.025...2.000 | 0.005 |
| Operating curve type [52] | WPWDE | Definite or inverse time Curve type: 5, 15, 20 | |
| Operate delay time | WPWDE | 60...300000 ms | 10 |
| Min operate current | WPWDE | 0.010. 1.000 × $I_n$ | 0.001 |
| Min operate voltage | WPWDE | 0.01. 1.00 × $U_n$ | 0.01 |

[50] Io varied during the test, $U_o$ = 1.0 × $U_n$ = phase to earth voltage during earth fault in compensated or un-earthed network, the residual power value before fault = 0.0 pu, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[51] Includes the delay of the signal output contact
[52] For further reference, see the Operating characteristics table

### 25.30.38 Transient/intermittent earth-fault protection (INTRPTEF)

**Table 72: Transient/intermittent earth-fault protection (INTRPTEF)**

| Characteristic | Value |
|---|---|
| Operation accuracy (Uo criteria with transient protection) | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × Uo |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5 |

### 25.30.39 Transient/intermittent earth-fault protection (INTRPTEF) main settings

**Table 73: Transient/intermittent earth-fault protection (INTRPTEF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Directional mode | INTRPTEF | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| Operate delay time | INTRPTEF | 40...1200000 ms | 10 |
| Voltage start value | INTRPTEF | 0.05...0.50 × $U_n$ | 0.01 |
| Operation mode | INTRPTEF | 1 = Intermittent EF<br>2 = Transient EF | - |
| Peak counter limit | INTRPTEF | 2...20 | 1 |
| Min operate current | INTRPTEF | 0.01. 1.00 × $I_n$ | 0.01 |

### 25.30.40 Harmonics-based earth-fault protection (HAEFPTOC)

**Table 74: Harmonics-based earth-fault protection (HAEFPTOC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±5% of the set value or ±0.004 × $I_n$ |
| Start time [53, 54] | Typically 77 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |

*Table continues on the next page*

[53] Fundamental frequency current = 1.0 × $I_n$, harmonics current before fault = 0.0 × $I_n$, harmonics fault current 2.0 × *Start value* , results based on statistical distribution of 1000 measurements

[54] Includes the delay of the signal output contact

| Characteristic | Value |
|---|---|
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in IDMT mode [55] | ±5.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = $f_n$ |
| | -3 dB at f = 13 × $f_n$ |

### 25.30.41 Harmonics-based earth-fault protection (HAEFPTOC) main settings

**Table 75: Harmonics-based earth-fault protection (HAEFPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | HAEFPTOC | 0.05. 5.00 × $I_n$ | 0.01 |
| Time multiplier | HAEFPTOC | 0.025...15.000 | 0.005 |
| Operate delay time | HAEFPTOC | 100...300000 ms | 10 |
| Operating curve type [56] | HAEFPTOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19 | |
| Minimum operate time | HAEFPTOC | 100...200000 ms | 10 |

### 25.30.42 Negative-sequence overcurrent protection (NSPTOC)

**Table 76: Negative-sequence overcurrent protection (NSPTOC)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [57, 58] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2 × set *Start value* | 23 ms | 26 ms | 28 ms |
| | $I_{Fault}$= 10 × set *Start value* | 15 ms | 18 ms | 20 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |

*Table continues on the next page*

[55] Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 2...20
[56] For further reference, see the Operation characteristics table
[57] Negative sequence current before fault = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[58] Includes the delay of the signal output contact

| Characteristic | Value |
|---|---|
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in inverse time mode | ±5.0% of the theoretical value or ±20 ms [59] |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

### 25.30.43 Negative-sequence overcurrent protection (NSPTOC) main settings

**Table 77: Negative-sequence overcurrent protection (NSPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | NSPTOC | 0.01...5.00 × $I_n$ | 0.01 |
| Time multiplier | NSPTOC | 0.025...15.000 | 0.005 |
| Operate delay time | NSPTOC | 40...200000 ms | 10 |
| Operating curve type [60] | NSPTOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19 | |

### 25.30.44 Phase discontinuity protection (PDNSPTOC)

**Table 78: Phase discontinuity protection (PDNSPTOC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±2% of the set value |
| Start time | <70 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

[59] Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 1.5...20
[60] For further reference, see the Operation characteristics table

### 25.30.45 Phase discontinuity protection (PDNSPTOC) main settings

**Table 79: Phase discontinuity protection (PDNSPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PDNSPTOC | 10...100% | 1 |
| Operate delay time | PDNSPTOC | 100...30000 ms | 1 |
| Min phase current | PDNSPTOC | 0.05...0.30 × $I_n$ | 0.01 |

### 25.30.46 Residual overvoltage protection (ROVPTOV)

**Table 80: Residual overvoltage protection (ROVPTOV)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time [61, 62] | $U_{Fault}$ = 2 × set *Start value* | Minimum | Typical | Maximum |
| | | 48 ms | 51 ms | 54 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

### 25.30.47 Residual overvoltage protection (ROVPTOV) main settings

**Table 81: Residual overvoltage protection (ROVPTOV) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | ROVPTOV | 0.010...1.000 × $U_n$ | 0.001 |
| Operate delay time | ROVPTOV | 40...300000 ms | 1 |

[61] Residual voltage before fault = 0.0 × $U_n$, $f_n$ = 50 Hz, residual voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

[62] Includes the delay of the signal output contact

### 25.30.48 Three-phase undervoltage protection (PHPTUV)

**Table 82: PHPTUV Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 0.85 × set *Start value* [63, 64] | 17 ms | 20 ms | 23 ms |
| | $U_{Fault}$ = 0.85 × set *Start value* [65, 66] | 51 ms | 55 ms | 58 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms[67] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

### 25.30.49 Three-phase undervoltage protection (PHPTUV) main settings

**Table 83: Three-phase undervoltage protection (PHPTUV) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PHPTUV | 0.05...1.20 × $U_n$ | 0.01 |
| Time multiplier | PHPTUV | 0.05...15.00 | 0.01 |
| Operate delay time | PHPTUV | 20...300000 ms | 10 |
| Operating curve type[68] | PHPTUV | Definite or inverse time Curve type: 5, 15, 21, 22, 23 | |

63 *Start value* = 0.97 × $U_n$, voltage level before fault = 1 × $U_n$, $f_n$ = 50 Hz, undervoltage in one phase-to-phase voltage injected from random phase angle, results based on statistical distribution of 1000 measurements, includes the delay (≈0ms) of the static signal output (SSO) contact

64 Start time is accelerated when set *Operate delay time* < 60ms. The shorter the set delay, the shorter the start time. Here measurements done for *Operate delay time* = 20ms

65 *Start value* = 0.97 × $U_n$, voltage level before fault = 1 × $U_n$, $f_n$ = 50 Hz, undervoltage in one phase-to-phase voltage injected from random phase angle, results based on statistical distribution of 1000 measurements, includes the delay (≈0ms) of the static signal output (SSO) contact

66 Valid when set *Operate delay time* ≥ 60ms or inverse time curve selected

67 Minimum *Start value* = 0.50, *Start value* multiples in range of 0.90...0.20

68 For further reference, see the Operation characteristics table

### 25.30.50 Three-phase overvoltage variation protection (PHVPTOV)

**Table 84: Three-phase overvoltage variation protection (PHVPTOV)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage: $f_n$ |
| | ±1.5% of the set value or ±0.002 × $U_n$ |
| Reset ratio | Depends on the set *Relative hysteresis* |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

### 25.30.51 Three-phase overvoltage variation protection (PHVPTOV) main settings

**Table 85: Three-phase overvoltage variation protection (PHVPTOV) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PHVPTOV | 0.05...3.00 × $U_n$ | 0.01 |
| Time interval | PHVPTOV | 1...120 min | 1 |
| Num of start phases | PHVPTOV | 1 = 1 out of 3<br>2 = 2 out of 3<br>3 = 3 out of 3 | - |
| Voltage selection | PHVPTOV | 1 = phase-to-earth<br>2 = phase-to-phase | - |

### 25.30.52 Three-phase overvoltage protection (PHPTOV)

**Table 86: Three-phase overvoltage protection (PHPTOV)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time [69, 70] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 1.1 × set *Start value* | 23 ms | 27 ms | 31 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±7.0% of the theoretical value or ±20 ms [71] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

[69] *Start value* = 1.0 × $U_n$, Voltage before fault = 0.9 × $U_n$, $f_n$ = 50 Hz, overvoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

[70] Includes the delay of the signal output contact

[71] Maximum *Start value* = 1.20 × $U_n$, *Start value* multiples in range of 1.10...2.00

### 25.30.53 Three-phase overvoltage protection (PHPTOV) main settings

**Table 87: Three-phase overvoltage protection (PHPTOV) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PHPTOV | 0.05...1.60 × $U_n$ | 0.01 |
| Time multiplier | PHPTOV | 0.05...15.00 | 0.01 |
| Operate delay time | PHPTOV | 40...300000 ms | 10 |
| Operating curve type [72] | PHPTOV | Definite or inverse time<br>Curve type: 5, 15, 17, 18, 19, 20 | |

### 25.30.54 Positive-sequence overvoltage protection (PSPTOV)

**Table 88: Positive-sequence overvoltage protection (PSPTOV)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time [73, 74] | $U_{Fault}$ = 1.1 × set *Start value* | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 2 × set *Start value* | 29 ms | 32 ms | 34 ms |
| | | 32 ms | 24 ms | 26 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

### 25.30.55 Positive-sequence overvoltage protection (PSPTOV) main settings

**Table 89: Positive-sequence overvoltage protection (PSPTOV) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PSPTOV | 0.400...1.600 × $U_n$ | 0.001 |
| Operate delay time | PSPTOV | 40...120000 ms | 10 |

[72] For further reference, see the Operation characteristics table
[73] Positive-sequence voltage before fault = 0.0 × $U_n$, $f_n$ = 50 Hz, positive-sequence overvoltage of nominal frequency injected from random phase angle
[74] Measured with static signal output (SSO)

### 25.30.56 Positive-sequence undervoltage protection (PSPTUV)

**Table 90: Positive-sequence undervoltage protection (PSPTUV)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time [75, 76] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 0.99 × set *Start value* | 52 ms | 55 ms | 58 ms |
| | $U_{Fault}$ = 0.9 × set *Start value* | 44 ms | 47 ms | 50 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

### 25.30.57 Positive-sequence undervoltage protection (PSPTUV) main settings

**Table 91: Positive-sequence undervoltage protection (PSPTUV) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PSPTUV | 0.010...1.200 × $U_n$ | 0.001 |
| Operate delay time | PSPTUV | 40...120000 ms | 10 |
| Voltage block value | PSPTUV | 0.01...1.00 × $U_n$ | 0.01 |

### 25.30.58 Negative-sequence overvoltage protection (NSPTOV)

**Table 92: Negative-sequence overvoltage protection (NSPTOV)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the voltage measured: $f_n$ | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time [77,78] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 1.1 × set *Start value* | 33 ms | 35 ms | 37 ms |
| | $U_{Fault}$ = 2.0 × set *Start value* | 24 ms | 26 ms | 28 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |

*Table continues on the next page*

75 *Start value* = 1.0 × $U_n$, positive-sequence voltage before fault = 1.1 × $U_n$, $f_n$ = 50 Hz, positive sequence undervoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

76 Includes the delay of the signal output contact

77 Negative-sequence voltage before fault = 0.0 × $U_n$, $f_n$ = 50 Hz, negative-sequence overvoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

78 Includes the delay of the signal output contact

| Characteristic | Value |
|---|---|
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

### 25.30.59 Negative-sequence overvoltage protection (NSPTOV) main settings

**Table 93: Negative-sequence overvoltage protection (NSPTOV) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | NSPTOV | 0.010...1.000 × $U_n$ | 0.001 |
| Operate delay time | NSPTOV | 40...120000 ms | 1 |

### 25.30.60 Frequency protection (FRPFRQ)

**Table 94: Frequency protection (FRPFRQ)**

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | f>/f< | ±5 mHz |
| | df/dt | ±50 mHz/s (in range \|df/dt\| <5 Hz/s)<br>±2.0% of the set value (in range 5 Hz/s < \|df/dt\| < 15 Hz/s) |
| Start time | f>/f< | <80 ms[79] |
| | df/dt | <120 ms |
| Reset time | | <150 ms |
| Operate time accuracy | | ±1.0% of the set value or ±30 ms |

[79] Applies to sudden frequency change of ≤0.2 Hz or to frequency slope of ≤ 5 Hz/s. When frequency change is outside of these limits, start may be delayed by additional 100 ms to prevent false starts when connecting / disconnecting heavy loads.

### 25.30.61 Frequency protection (FRPFRQ) main settings

**Table 95: Frequency protection (FRPFRQ) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operation mode | FRPFRQ | 1 = Freq<<br>2 = Freq><br>3 = df/dt<br>4 = Freq< + df/dt<br>5 = Freq> + df/dt<br>6 = Freq< OR df/dt<br>7 = Freq> OR df/dt | - |
| Start value Freq> | FRPFRQ | 0.9000...1.2000 × $f_n$ | 0.0001 |
| Start value Freq< | FRPFRQ | 0.8000...1.1000 × $f_n$ | 0.0001 |
| Start value df/dt | FRPFRQ | -0.2000...0.2000 × $f_n$/s | 0.0001 |
| Operate Tm Freq | FRPFRQ | 80...5400000 ms | 10 |
| Operate Tm df/dt | FRPFRQ | 120...200000 ms | 10 |

### 25.30.62 Three-phase voltage-dependent overcurrent protection (PHPVOC)

**Table 96: Three-phase voltage-dependent overcurrent protection (PHPVOC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage:<br>$f_n$ ±2 Hz<br><br>Current:<br>±1.5% of the set value or ± 0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$ |
| Start time [80, 81] | Typically 26 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in inverse time mode | ±5.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

80 *Measurement mode* = default, current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

81 Includes the delay of the signal output contact

### 25.30.63 Three-phase voltage-dependent overcurrent protection (PHPVOC) main settings

**Table 97: Three-phase voltage-dependent overcurrent protection (PHPVOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PHPVOC | 0.05...5.00 × $I_n$ | 0.01 |
| Start value low | PHPVOC | 0.05...1.00 × $I_n$ | 0.01 |
| Voltage high limit | PHPVOC | 0.01...1.00 × $U_n$ | 0.01 |
| Voltage low limit | PHPVOC | 0.01...1.00 × $U_n$ | 0.01 |
| Start value Mult | PHPVOC | 0.8...10.0 | 0.1 |
| Time multiplier | PHPVOC | 0.05...15.00 | 0.01 |
| Operating curve type [82] | PHPVOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19 | |
| Operate delay time | PHPVOC | 40...200000 ms | 10 |

### 25.30.64 Accidental energization protection (GAEPVOC)

**Table 98: Accidental energization protection (GAEPVOC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltages: $f_n$ ±2 Hz |
| | Current:<br>±1.5% of the set value or ± 0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$ |
| Start time [83, 84] | Typically 20 ms |
| Reset time | Typically 35 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | Voltage: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, … Current: No suppression |

[82] For further reference, see the Operation characteristics table
[83] Results based on statistical distribution of 1000 measurements
[84] Includes the delay of the signal output contact.

### 25.30.65 Accidental energization protection (GAEPVOC) main settings

**Table 99: Accidental energization protection (GAEPVOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | GAEPVOC | 0.05...9.00 × $I_n$ | 0.01 |
| Arm set voltage | GAEPVOC | 0.05...1.00 × $U_n$ | 0.01 |
| Disarm set voltage | GAEPVOC | 0.50...1.50 × $U_n$ | 0.01 |
| Operate delay time | GAEPVOC | 20...300000 ms | 10 |
| Arm delay time | GAEPVOC | 40...300000 ms | 10 |
| Disarm delay time | GAEPVOC | 40...300000 ms | 10 |
| Operation | GAEPVOC | 1 = on<br>5 = off | |
| Reset delay time | GAEPVOC | 0...60000 ms | 1 |

### 25.30.66 Overexcitation protection (OEPVPH)

**Table 100: Overexcitation protection (OEPVPH)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±3.0% of the set value |
| Start time [85] | Frequency change:<br>Typically 200 ms |
| | Voltage change:<br>Typically 40 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite-time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in inverse-time mode | ±5.0% of the theoretical value or ±50 ms |

[85] Includes the delay of the signal output contact

### 25.30.67 Overexcitation protection (OEPVPH) main settings

**Table 101: Overexcitation protection (OEPVPH) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | OEPVPH | 100...200% | 1 |
| Operating curve type [86] | OEPVPH | Definite or inverse time<br>Curve type: 5, 15, 17, 18, 19, 20 | |
| Time multiplier | OEPVPH | 0.1...100.0 | 0.1 |
| Operate delay time | OEPVPH | 200...200000 ms | 10 |
| Cooling time | OEPVPH | 5...10000 s | 1 |

### 25.30.68 Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR)

**Table 102: Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current measurement: ±1.5% of the set value or ±0.002 × $I_n$ (at currents in the range of 0.01. 4.00 × $I_n$) |
| Operate time accuracy [87] | ±2.0% of the theoretical value or ±0.50 s |

### 25.30.69 Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR) main settings

**Table 103: Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Env temperature Set | T1PTTR | -50...100°C | 1 |
| Current reference | T1PTTR | 0.05...4.00 × $I_n$ | 0.01 |
| Temperature rise | T1PTTR | 0.0...200.0°C | 0.1 |
| Time constant | T1PTTR | 60...60000 s | 1 |
| Maximum temperature | T1PTTR | 22.0...200.0°C | 0.1 |
| Alarm value | T1PTTR | 20.0...150.0°C | 0.1 |
| Reclose temperature | T1PTTR | 20.0...150.0°C | 0.1 |

*Table continues on the next page*

[86] For further reference, see the Operation characteristics table
[87] Overload current > 1.2 × Operate level temperature

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Current multiplier | T1PTTR | 1...5 | 1 |
| Initial temperature | T1PTTR | -50.0. 100.0°C | 0.1 |

### 25.30.70 Three-phase thermal overload protection, two time constants (T2PTTR)

**Table 104: Three-phase thermal overload protection, two time constants (T2PTTR)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current measurement: ±1.5% of the set value or ±0.002 x $I_n$ (at currents in the range of 0.01...4.00 x $I_n$) |
| Operate time accuracy [88] | ±2.0% of the theoretical value or ±0.50 s |

### 25.30.71 Three-phase thermal overload protection, two time constants (T2PTTR) main settings

**Table 105: Three-phase thermal overload protection, two time constants (T2PTTR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Temperature rise | T2PTTR | 0.0...200.0°C | 0.1 |
| Max temperature | T2PTTR | 0.0...200.0°C | 0.1 |
| Operate temperature | T2PTTR | 80.0...120.0% | 0.1 |
| Short time constant | T2PTTR | 6...60000 s | 1 |
| Weighting factor p | T2PTTR | 0.00...1.00 | 0.01 |
| Current reference | T2PTTR | 0.05...4.00 × $I_n$ | 0.01 |
| Operation | T2PTTR | 1 = on<br>5 = off | - |

### 25.30.72 Three-phase overload protection for shunt capacitor banks (COLPTOC)

**Table 106: Three-phase overload protection for shunt capacitor banks (COLPTOC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: fn ±2 Hz, and no harmonics |
| | 5% of the set value or 0.002 × $I_n$ |

*Table continues on the next page*

[88] Overload current > 1.2 x Operate level temperature

| Characteristic | Value |
|---|---|
| Start time for overload stage [89, 90] | Typically 75 ms |
| Start time for under current stage [80, 91] | Typically 26 ms |
| Reset time for overload and alarm stage | Typically 60 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | 1% of the set value or ±20 ms |
| Operate time accuracy in inverse time mode | 10% of the theoretical value or ±20 ms |
| Suppression of harmonics for under current stage | DFT: -50 dB at f = n × $f_n$, where n = 2,3,4,5,.. |

### 25.30.73 Three-phase overload protection for shunt capacitor banks (COLPTOC) main settings

**Table 107: Three-phase overload protection for shunt capacitor banks (COLPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value overload | COLPTOC | 0.30 1.50 × $I_n$ | 0.01 |
| Alarm start value | COLPTOC | 80...120% | 1 |
| Start value Un Cur | COLPTOC | 0.10 0.70 × $I_n$ | 0.01 |
| Time multiplier | COLPTOC | 0.05...2.00 | 0.01 |
| Alarm delay time | COLPTOC | 500...6000000 ms | 100 |
| Un Cur delay time | COLPTOC | 100...120000 ms | 100 |

### 25.30.74 Current unbalance protection for shunt capacitor banks (CUBPTOC)

**Table 108: Current unbalance protection for shunt capacitor banks (CUBPTOC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: fn ±2 Hz |
| Start time [92, 93] | 1.5% of the set value or 0.002 × $I_n$ |
| | Typically 26 ms |
| Reset time | Typically 40 ms |

*Table continues on the next page*

89 Harmonics current before fault = 0.5 × $I_n$, harmonics fault current 1.5 × *Start value*, results based on statistical distribution of 1000 measurements
90 Includes the delay of the signal output contact
91 Harmonics current before fault = 1.2 × $I_n$, harmonics fault current 0.8 × *Start value*, results based on statistical distribution of 1000 measurements
92 Fundamental frequency current = 1.0 × $I_n$, current before fault = 0.0 × $I_n$, fault current = 2.0 × *Start value* , results based on statistical distribution of 1000 measurements
93 Includes the delay of the signal output contact

| Characteristic | Value |
|---|---|
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | 1% of the theoretical value or ±20 ms |
| Operate time accuracy in inverse definite minimum time mode | 5% of the theoretical value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2,3,4,5,.. |

### 25.30.75 Current unbalance protection for shunt capacitor banks (CUBPTOC) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Alarm mode | CUBPTOC | 1 = Normal<br>2 = Element counter | - |
| Start value | CUBPTOC | 0.01...1.00 × $I_n$ | 0.01 |
| Alarm start value | CUBPTOC | 0.01...1.00 × $I_n$ | 0.01 |
| Time multiplier | CUBPTOC | 0.05...15.00 | 0.01 |
| Operating curve type [94] | CUBPTOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19 | |
| Operate delay time | CUBPTOC | 50...200000 ms | 10 |
| Alarm delay time | CUBPTOC | 50...200000 ms | 10 |

### 25.30.76 Three-phase current unbalance protection for shunt capacitor banks (HCUBPTOC)

**Table 109: Three-phase current unbalance protection for shunt capacitor banks (HCUBPTOC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | 1.5% of the set value or 0.002 × $I_n$ |
| Start time [95, 96] | Typically 26 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | 1% of the theoretical value or ±20 ms |
| Operate time accuracy in IDMT mode | 5% of the theoretical value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × fn, where n = 2,3,4,5,.. |

[94] For further reference, see the Operating characteristics table
[95] Fundamental frequency current = 1.0 × $I_n$, current before fault = 0.0 × $I_n$, fault current = 2.0 × *Start value* , results based on statistical distribution of 1000 measurements
[96] Includes the delay of the signal output contact

### 25.30.77 Three-phase current unbalance protection for shunt capacitor banks (HCUBPTOC) main settings

**Table 110: Three-phase current unbalance protection for shunt capacitor banks (HCUBPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | HCUBPTOC | 0.01...1.00 × $I_n$ | 0.01 |
| Alarm start value | HCUBPTOC | 0.01...1.00 × $I_n$ | 0.01 |
| Time multiplier | HCUBPTOC | 0.05...15.00 | 0.01 |
| Operating curve type [97] | HCUBPTOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19 | |
| Operate delay time | HCUBPTOC | 40...200000 ms | 10 |
| Alarm delay time | HCUBPTOC | 40...200000 ms | 10 |

### 25.30.78 Shunt capacitor bank switching resonance protection, current based (SRCPTOC)

**Table 111: Shunt capacitor bank switching resonance protection, current based (SRCPTOC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Operate value accuracy:<br>±3% of the set value or ±0.002 × $I_n$ (for $2^{nd}$ order Harmonics)<br>±1.5% of the set value or ±0.002 × $I_n$ (for $3^{rd}$ order < Harmonics < $10^{th}$ order)<br>±6% of the set value or ±0.004 × $I_n$ (for Harmonics >= $10^{th}$ order) |
| Reset time | Typically 45 ms or maximum 50 ms |
| Retardation time | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = $f_n$ |

[97] For further reference, refer to the Operating characteristics table

### 25.30.79 Shunt capacitor bank switching resonance protection, current based (SRCPTOC) main settings

**Table 112: Shunt capacitor bank switching resonance protection, current based (SRCPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Alarm start value | SRCPTOC | 0.03. 0.50 × $I_n$ | 0.01 |
| Start value | SRCPTOC | 0.03. 0.50 × $I_n$ | 0.01 |
| Tuning harmonic Num | SRCPTOC | 1...11 | 1 |
| Operate delay time | SRCPTOC | 120...360000 ms | 1 |
| Alarm delay time | SRCPTOC | 120...360000 ms | 1 |

### 25.30.80 Compensated neutral unbalance voltage protection (CNUPTOV)

**Table 113: Compensated neutral unbalance voltage protection (CNUPTOV)**

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz |
| | | ±1.5% of the set value or ±0.002 × $U_n$ |
| Start time [98, 99] | $U_{Fault}$ = 1.1 × set Start value | Typically 75 ms |
| Reset time | | Typically 40 ms |
| Reset ratio | | Typically 0.96 |
| Retardation time | | <35 ms |
| Operate time accuracy | | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,... |

### 25.30.81 Compensated neutral unbalance voltage protection (CNUPTOV) main settings

**Table 114: Compensated neutral unbalance voltage protection (CNUPTOV) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | CNUPTOV | 0.01...1.00 × $U_n$ | 0.01 |
| Operate delay time | CNUPTOV | 100...300000 ms | 100 |

98 Start value = 0.1 × $U_n$, Voltage before fault = 0.9 × $U_n$, $f_n$ = 50 Hz, overvoltage in one phase-to-earth with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

99 Measured with static signal output (SSO)

### 25.30.82 Directional negative-sequence overcurrent protection (DNSPDOC)

**Table 115: Directional negative-sequence overcurrent protection (DNSPDOC)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle:<br>±2° | | |
| Start time [100, 101] | $I_{Fault}$ = 2 × set *Start value* | Minimum | Typical | Maximum |
| | | 31 ms | 34 ms | 37 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

### 25.30.83 Directional negative-sequence overcurrent protection (DNSPDOC) main settings

**Table 116: Directional negative-sequence overcurrent protection (DNSPDOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | DNSPDOC | 0.05...5.00 × $I_n$ | 0.01 |
| Directional mode | DNSPDOC | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| Operate delay time | DNSPDOC | 40...300000 ms | 10 |
| Characteristic angle | DNSPDOC | -179...180° | 1 |

100 Measurement mode NPS, NPS current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault NPS current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

101 Measured with static signal output (SSO)

### 25.30.84 Low-voltage ride-through protection (LVRTPTUV)

**Table 117: Low-voltage ride-through protection (LVRTPTUV)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $U_n$ |
| Start time [102, 103] | Typically 40 ms |
| Reset time | Based on maximum value of *Recovery time* setting |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

### 25.30.85 Low-voltage ride-through protection (LVRTPTUV) main settings

**Table 118: Low-voltage ride-through protection (LVRTPTUV) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Voltage start value | LVRTPTUV | 0.05. 1.20 × $U_n$ | 0.01 |
| Num of start phases | LVRTPTUV | 4 = Exactly 1 of 3<br>5 = Exactly 2 of 3<br>6 = Exactly 3 of 3 | - |
| Voltage selection | LVRTPTUV | 1 = Highest Ph-to-E<br>2 = Lowest Ph-to-E<br>3 = Highest Ph-to-Ph<br>4 = Lowest Ph-to-Ph<br>5 = Positive Seq | - |
| Active coordinates | LVRTPTUV | 1...10 | 1 |
| Voltage level 1 | LVRTPTUV | 0.00 1.20 x$U_n$ | 0.01 |
| Voltage level 2 | LVRTPTUV | 0.00 1.20 x$U_n$ | 0.01 |
| Voltage level 3 | LVRTPTUV | 0.00 1.20 x$U_n$ | 0.01 |
| Voltage level 4 | LVRTPTUV | 0.00 1.20 x$U_n$ | 0.01 |
| Voltage level 5 | LVRTPTUV | 0.00 1.20 x$U_n$ | 0.01 |
| Voltage level 6 | LVRTPTUV | 0.00 1.20 x$U_n$ | 0.01 |
| Voltage level 7 | LVRTPTUV | 0.00 1.20 x$U_n$ | 0.01 |
| Voltage level 8 | LVRTPTUV | 0.00 1.20 x$U_n$ | 0.01 |
| Voltage level 9 | LVRTPTUV | 0.00 1.20 x$U_n$ | 0.01 |

*Table continues on the next page*

[102] Tested for *Number of Start phases* = 1 out of 3, results based on statistical distribution of 1000 measurements
[103] Includes the delay of the signal output contact

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Voltage level 10 | LVRTPTUV | 0.00 1.20 x$U_n$ | 0.01 |
| Recovery time 1 | LVRTPTUV | 0...300000 ms | 1 |
| Recovery time 2 | LVRTPTUV | 0...300000 ms | 1 |
| Recovery time 3 | LVRTPTUV | 0...300000 ms | 1 |
| Recovery time 4 | LVRTPTUV | 0...300000 ms | 1 |
| Recovery time 5 | LVRTPTUV | 0...300000 ms | 1 |
| Recovery time 6 | LVRTPTUV | 0...300000 ms | 1 |
| Recovery time 7 | LVRTPTUV | 0...300000 ms | 1 |
| Recovery time 8 | LVRTPTUV | 0...300000 ms | 1 |
| Recovery time 9 | LVRTPTUV | 0...300000 ms | 1 |
| Recovery time 10 | LVRTPTUV | 0...300000 ms | 1 |

### 25.30.86 Voltage vector shift protection (VVSPPAM)

**Table 119: Voltage vector shift protection (VVSPPAM)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n$ ±1 Hz |
| | ±1° |
| Operate time [104, 105] | Typically 53 ms |

### 25.30.87 Voltage vector shift protection (VVSPPAM) main settings

**Table 120: Voltage vector shift protection (VVSPPAM) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | VVSPPAM | 2.0...30.0° | 0.1 |
| Over Volt Blk value | VVSPPAM | 0.40 1.50 × $U_n$ | 0.01 |
| Under Volt Blk value | VVSPPAM | 0.15. 1.00 × $U_n$ | 0.01 |
| Phase supervision | VVSPPAM | 7 = Ph A + B + C<br>8 = Pos sequence | - |

[104] $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[105] Includes the delay of the signal output contact

### 25.30.88 Directional reactive power undervoltage protection (DQPTUV)

**Table 121: Directional reactive power undervoltage protection (DQPTUV)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage:<br>$f_n$ ±2 Hz<br>Reactive power range \|PF\| <0.71 |
| | Power:<br>±3.0% or ±0.002 × $Q_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$ |
| Start time [106, 107] | Typically 46 ms |
| Reset time | <50 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

### 25.30.89 Directional reactive power undervoltage protection (DQPTUV) main settings

**Table 122: Directional reactive power undervoltage protection (DQPTUV) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Voltage start value | DQPTUV | 0.20 1.20 × $U_n$ | 0.01 |
| Operate delay time | DQPTUV | 100...300000 ms | 10 |
| Min reactive power | DQPTUV | 0.01. 0.50 × $S_n$ | 0.01 |
| Min Ps Seq current | DQPTUV | 0.02. 0.20 × $I_n$ | 0.01 |
| Pwr sector reduction | DQPTUV | 0...10° | 1 |

106 *Start value* = 0.05 × $S_n$, reactive power before fault = 0.8 × *Start value*, reactive power overshoot 2 times, results based on statistical distribution of 1000 measurements

107 Includes the delay of the signal output contact

### 25.30.90 Reverse power/directional overpower protection (DOPPDPR)

**Table 123: Reverse power/directional overpower protection (DOPPDPR)**

| Characteristic | Value |
|---|---|
| Operation accuracy [108] | Depending on the frequency of the measured current and voltage:<br>$f = f_n \pm 2$ Hz |
| | Power measurement accuracy ±3% of the set value or ±0.002 × $S_n$<br>Phase angle: ±2° |
| Start time [109, 110] | Typically 45 ms |
| Reset time | Typically 30 ms |
| Reset ratio | Typically 0.94 |
| Operate time accuracy | ±1.0% of the set value of ±20 ms |
| Suppression of harmonics | -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,… |

### 25.30.91 Reverse power/directional overpower protection (DOPPDPR) main settings

**Table 124: Reverse power/directional overpower protection (DOPPDPR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | DOPPDPR | 0.01...2.00 × $S_n$ | 0.01 |
| Operate delay time | DOPPDPR | 40...300000 ms | 10 |
| Directional mode | DOPPDPR | 2 = Forward<br>3 = Reverse | - |
| Power angle | DOPPDPR | -90...90° | 1 |

### 25.30.92 Underpower protection (DUPPDPR)

**Table 125: Underpower protection (DUPPDPR)**

| Characteristic | Value |
|---|---|
| Operation accuracy [111] | Depending on the frequency of the measured current and voltage:<br>$f_n \pm 2$ Hz |
| | Power measurement accuracy ±3% of the set value or ±0.002 × $S_n$<br>Phase angle: ±2° |

*Table continues on the next page*

108 *Measurement mode* = “Pos Seq” (default)
109 U = $U_n$, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
110 Includes the delay of the signal output contact
111 *Measurement mode* = “Pos Seq” (default)

| Characteristic | Value |
|---|---|
| Start time [112, 113] | Typically 45 ms |
| Reset time | Typically 30 ms |
| Reset ratio | Typically 1.04 |
| Operate time accuracy | ±1.0% of the set value of ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

### 25.30.93 Underpower protection (DUPPDPR) main settings

**Table 126: Underpower protection (DUPPDPR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | DUPPDPR | 0.01. 2.00 × $S_n$ | 0.01 |
| Operate delay time | DUPPDPR | 40...300000 ms | 10 |
| Pol reversal | DUPPDPR | 0 = False<br>1 = True | - |
| Disable time | DUPPDPR | 0...60000 ms | 1000 |

### 25.30.94 Three-phase underimpedance protection (UZPDIS)

**Table 127: Three-phase underimpedance protection (UZPDIS)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage: $f_n$ ±2 Hz |
| | ±3.0% of the set value or ±0.2 %Zb |
| Start time [114, 115] | Typically 50 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 1.04 |
| Retardation time | <40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

### 25.30.95 Three-phase underimpedance protection (UZPDIS) main settings

**Table 128: Three-phase underimpedance protection (UZPDIS) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Percentage reach | UZPDIS | 1...6000% $Z_n$ | 1 |
| Operate delay time | UZPDIS | 40...200000 ms | 10 |

[112] U = $U_n$, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[113] Includes the delay of the signal output contact
[114] $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[115] Includes the delay of the signal output contact

### 25.30.96 Three-phase underexcitation protection (UEXPDIS)

**Table 129: Three-phase underexcitation protection (UEXPDIS)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage:<br>$f = f_n \pm 2$ Hz |
| | ±3.0% of the set value or ±0.2% Zb |
| Start time [116, 117] | Typically 45 ms |
| Reset time | Typically 30 ms |
| Reset ratio | Typically 1.04 |
| Retardation time | Total retardation time when the impedance returns from the operating circle <40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,… |

### 25.30.97 Three-phase underexcitation protection (UEXPDIS) main settings

**Table 130: Three-phase underexcitation protection (UEXPDIS) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Diameter | UEXPDIS | 1...6000 %$Z_n$ | 1 |
| Offset | UEXPDIS | -1000...1000 %$Z_n$ | 1 |
| Displacement | UEXPDIS | -1000...1000 %$Z_n$ | 1 |
| Operate delay time | UEXPDIS | 60...200000 ms | 10 |
| External Los Det Ena | UEXPDIS | 0 = Disable<br>1 = Enable | - |

### 25.30.98 Third harmonic-based stator earth-fault protection (H3EFPSEF)

**Table 131: Third harmonic-based stator earth-fault protection (H3EFPSEF)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n \pm 2$ Hz |
| | ±5% of the set value or ±0.004 × $U_n$ |
| Start time [118, 119] | Typically 35 ms |
| Reset time | Typically 35 ms |

*Table continues on the next page*

116 $f_n$= 50Hz, results based on statistical distribution of 1000 measurements
117 Includes the delay of the signal output contact
118 $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
119 Includes the delay of the signal output contact

| Characteristic | Value |
|---|---|
| Reset ratio | Typically 0.96 (differential mode)<br>Typically 1.04 (under voltage mode) |
| Operate time accuracy | ±1.0% of the set value of ±20 ms |

### 25.30.99 Third harmonic-based stator earth-fault protection (H3EFPSEF) main settings

**Table 132: Third harmonic-based stator earth-fault protection (H3EFPSEF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Beta | H3EFPSEF | 0.50...10.00 | 0.01 |
| Voltage N 3.H Lim | H3EFPSEF | 0.005. 0.200 × $U_n$ | 0.001 |
| Operate delay time | H3EFPSEF | 20...300000 ms | 10 |
| Voltage selection | H3EFPSEF | 1 = No voltage<br>2 = Measured Uo<br>3 = Calculated Uo<br>4 = Phase A<br>5 = Phase B<br>6 = Phase C | - |
| CB open factor | H3EFPSEF | 1.00...10.00 | 0.01 |

### 25.30.100 Rotor earth-fault protection, injection method (MREFPTOC)

**Table 133: Rotor earth-fault protection, injection method (MREFPTOC)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the current measured: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [120, 121] | $I_{Fault}$ = 1.2 × set *Start value* | Minimum | Typical | Maximum |
| | | 30 ms | 34 ms | 38 ms |
| Reset time | | <50 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <50 ms | | |
| Operate time accuracy | | ±1.0% of the set value of ±20 ms | | |
| Suppression of harmonics | | -50 dB at f = n × fn, where n = 2, 3, 4, 5,… | | |

120 Current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

121 Includes the delay of the signal output contact

### 25.30.101 Rotor earth-fault protection, injection method (MREFPTOC) main settings

**Table 134: Rotor earth-fault protection, injection method (MREFPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operate start value | MREFPTOC | 0.010...2.000 × $I_n$ | 0.001 |
| Alarm start value | MREFPTOC | 0.010...2.000 × $I_n$ | 0.001 |
| Operate delay time | MREFPTOC | 40...20000 ms | 1 |
| Alarm delay time | MREFPTOC | 40...200000 ms | 1 |

### 25.30.102 High-impedance or flux-balance based differential protection (MHZPDIF)

**Table 135: High-impedance or flux-balance based differential protection (MHZPDIF)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or 0.002 × $I_n$ | | |
| Start time [122, 123] | $I_{Fault}$ = 2.0 × set *Start Value* (one phase fault) | Minimum | Typical | Maximum |
| | | 13 ms | 17 ms | 21 ms |
| | $I_{Fault}$ = 2.0 × set *Start Value* (three phases fault) | 11 ms | 14 ms | 17 ms |
| Reset time | | <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value of ±20 ms | | |

### 25.30.103 High-impedance or flux-balance based differential protection (MHZPDIF) main settings

**Table 136: High-impedance or flux-balance based differential protection (MHZPDIF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operate value | MHZPDIF | 0.5...50.0 %$I_n$ | 0.1 |
| Minimum operate time | MHZPDIF | 20...300000 ms | 10 |

122 Measurement mode = “Peak-to-Peak”, current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

123 Includes the delay of the signal output contact

### 25.30.104 Out-of-step protection with double blinders (OOSRPSB)

**Table 137: Out-of-step protection with double blinders (OOSRPSB)**

| Characteristic | Value |
|---|---|
| Impedance reach | Depending on the frequency of the measured current and voltage: $f_n$<br>±2 Hz |
| | ±3.0% of the reach value or ±0.2% of $U_n/(\sqrt{3} * I_n)$ |
| Reset time | ±1.0% of the set value or ±40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5... |

### 25.30.105 Out-of-step protection (OOSRPSB) main settings

**Table 138: Out-of-step protection (OOSRPSB) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Oos operate mode | OOSRPSB | 1 = Way in 2 = Way out<br>2 = Way out<br>3 = Adaptive | - |
| Forward reach | OOSRPSB | 0.00...6000.00 Ω | 0.01 |
| Reverse reach | OOSRPSB | 0.00...6000.00 Ω | 0.01 |
| Inner blinder R | OOSRPSB | 1.00...6000.00 Ω | 0.01 |
| Outer blinder R | OOSRPSB | 1.01...10000.00 Ω | 0.01 |
| Impedance angle | OOSRPSB | 10.0...90.0° | 0.1 |
| Swing time | OOSRPSB | 20...300000 ms | 10 |
| Zone 1 reach | OOSRPSB | 1...100% | 1 |
| Operate delay time | OOSRPSB | 20...60000 ms | 10 |

### 25.30.106 Negative-sequence overcurrent protection for machines (MNSPTOC)

**Table 139: Negative-sequence overcurrent protection for machines (MNSPTOC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ |
| | ±1.5% of the set value or ±0.002 × $I_n$ |

*Table continues on the next page*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Start time [124, 125] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Start value* | 23 | 25 ms | 28 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [126] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

### 25.30.107 Negative-sequence overcurrent protection for machines (MNSPTOC) main settings

**Table 140: Negative-sequence overcurrent protection for machines (MNSPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | MNSPTOC | 0.01. 0.50 × $I_n$ | 0.01 |
| Operating curve type | MNSPTOC | Definite or inverse time<br>Curve type: 5, 15, 17, 18 | |
| Operate delay time | MNSPTOC | 100...120000 ms | 10 |
| Operation | MNSPTOC | 1 = on<br>5 = off | - |
| Cooling time | MNSPTOC | 5...7200 s | 1 |

### 25.30.108 Loss of phase, undercurrent (PHPTUC)

**Table 141: Loss of phase, undercurrent (PHPTUC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Start time | Typically <55 ms |
| Reset time | <40 ms |
| Reset ratio | Typically 1.04 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | mode ±1.0% of the set value or ±20 ms |

[124] Negative-sequence current before = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[125] Includes the delay of the signal output contact
[126] *Start value* multiples in range of 1.10...5.00

### 25.30.109 Loss of phase, undercurrent (PHPTUC) main settings

**Table 142: Loss of phase, undercurrent (PHPTUC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Current block value | PHPTUC | 0.00...0.50 × $I_n$ | 0.01 |
| Start value | PHPTUC | 0.01...1.00 × $I_n$ | 0.01 |
| Operate delay time | PHPTUC | 50...200000 ms | 10 |

### 25.30.110 Loss of load supervision (LOFLPTUC)

**Table 143: Loss of load supervision (LOFLPTUC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Start time | Typically 300 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 1.04 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

### 25.30.111 Loss of load supervision (LOFLPTUC) main settings

**Table 144: Loss of load supervision (LOFLPTUC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value low | LOFLPTUC | 0.01. 0.50 × I n | 0.01 |
| Start value high | LOFLPTUC | 0.01. 1.00 × I n | 0.01 |
| Operate delay time | LOFLPTUC | 400...600000 ms | 10 |
| Operation | LOFLPTUC | 1 = on<br>5 = off | - |

### 25.30.112 Motor load jam protection (JAMPTOC)

**Table 145: Motor load jam protection (JAMPTOC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

### 25.30.113 Motor load jam protection (JAMPTOC) main settings

**Table 146: Motor load jam protection (JAMPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operation | JAMPTOC | 1 = on<br>5 = off | - |
| Start value | JAMPTOC | 0.10...10.00 × $I_n$ | 0.01 |
| Operate delay time | JAMPTOC | 100...120000 ms | 10 |

### 25.30.114 Motor start-up supervision (STTPMSU)

**Table 147: Motor start-up supervision (STTPMSU)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [127, 128] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 1.1 × set *Start detection A* | 27 ms | 30 ms | 34 ms |
| Operate time accuracy | | ±1.0% of the set value or ±20 ms | | |
| Reset ratio | | Typically 0.90 | | |

### 25.30.115 Motor start-up supervision (STTPMSU) main settings

**Table 148: Motor start-up supervision (STTPMSU) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Motor start-up A | STTPMSU | 1.0 10.0 × $I_n$ | 0.1 |
| Motor start-up time | STTPMSU | 1...80 s | 1 |
| Lock rotor time | STTPMSU | 2...120 s | 1 |
| Operation | STTPMSU | 1 = on<br>5 = off | - |
| Operation mode | STTPMSU | 1 = IIt<br>2 = IIt, CB<br>3 = IIt + stall<br>4 = IIt + stall, CB | - |
| Restart inhibit time | STTPMSU | 0...250 min | 1 |

127 Current before = 0.0 × $I_n$, $f_n$ = 50 Hz, overcurrent in one phase, results based on statistical distribution of 1000 measurements
128 Includes the delay of the signal output contact

### 25.30.116 MSCPMRI Group settings (Basic)

**Table 149: MSCPMRI Group settings (Basic)**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Warm start level | MSCPMRI | 20.0...100.0% | 0.1 |
| Max Num cold start | MSCPMRI | 1...10 | 1 |
| Max Num warm start | MSCPMRI | 1...10 | 1 |

### 25.30.117 Phase reversal protection (PREVPTOC)

**Table 150: Phase reversal protection (PREVPTOC)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [129, 130] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Start value* | 23 ms | 25 ms | 28 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,... | | |

### 25.30.118 Phase reversal protection (PREVPTOC) main settings

**Table 151: Phase reversal protection (PREVPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PREVPTOC | 0.05. 1.00 x $I_n$ | 0.01 |
| Operate delay time | PREVPTOC | 100...60000 ms | 10 |
| Operation | PREVPTOC | 1 = on<br>5 = off | - |

[129] Negative-sequence current before = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements

[130] Includes the delay of the signal output contact

### 25.30.119 Thermal overload protection for motors (MPTTR)

**Table 152: Thermal overload protection for motors (MPTTR)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current measurement: ±1.5% of the set value or ±0.002 × $I_n$ (at currents in the range of 0.01...4.00 × $I_n$) |
| Operate time accuracy [131] | ±2.0% of the theoretical value or ±0.50 s |

### 25.30.120 Thermal overload protection for motors (MPTTR) main settings

**Table 153: Thermal overload protection for motors (MPTTR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Overload factor | MPTTR | 1.00...1.20 | 0.01 |
| Alarm thermal value | MPTTR | 50.0...100.0% | 0.1 |
| Restart thermal Val | MPTTR | 20.0...80.0% | 0.1 |
| Weighting factor p | MPTTR | 20.0...100.0% | 0.1 |
| Time constant normal | MPTTR | 80...4000 s | 1 |
| Time constant start | MPTTR | 80...4000 s | 1 |
| Env temperature mode | MPTTR | 1 = FLC Only<br>2 = Use input<br>3 = Set Amb Temp | - |
| Env temperature Set | MPTTR | -20.0...70.0°C | 0.1 |
| Operation | MPTTR | 1 = on<br>5 = off | - |

### 25.30.121 Thermal overload protection for rotors (RPTTR)

**Table 154: Thermal overload protection for rotors (RPTTR)**

| Characteristics | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current fn ±2 Hz |
| | Current measurement ±1.5% of the set value or ±0.002 x $I_n$ (at currents in the range of ≤4.00 x $I_n$) |
| Operate time accuracy | ±2.0% of the theoretical value or ±0.50 s |

[131] Overload current > 1.2 × Operate level temperature

### 25.30.122 Thermal overload protection for rotors (RPTTR) main settings

**Table 155: Thermal overload protection for rotors (RPTTR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Time constant normal | RPTTR | 80...10000 s | 1 |
| Time constant start | RPTTR | 80...10000 s | 1 |
| Time constant stop | RPTTR | 80...60000 s | 1 |
| Alarm value | RPTTR | 50.0...100.0 % | 0.1 |
| Restart thermal Val | RPTTR | 20.0...80.0 % | 0.1 |
| Weighting factor p | RPTTR | 20.0...100.0 % | 0.1 |
| Overload factor | RPTTR | 1.00...1.20 | 0.01 |
| Env temperature Set | RPTTR | -20.0...70.0 °C | 0.1 |
| Env temperature mode | RPTTR | 1=FLC Only<br>2=Use input<br>3=Set Amb Temp | |
| Motor synchronous speed | RPTTR | 125...3600 | 1 |
| Motor nominal speed | RPTTR | 100...3599 | 1 |

### 25.30.123 Directional negative sequence impedance protection (DNZPDIS)

**Table 156: DNZPDIS Technical data**

| Characteristics | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±3% of the set value or ±0.05 Ω (When $\lvert\angle Z_2 - \angle RCA\rvert$ is outside 80 to 100 degree) |
| Start time [132, 133, 134] | <75 ms |
| Operate time accuracy[135] | ±1.0% of the set value or ±20 ms |
| Reset ratio | 0.96 |
| Reset time | Typically 30 ms |

[132] Results based on statistical distribution of 1000 measurements
[133] Measured with static signal output (SSO)
[134] During fault, $Z_2$= 2.0 × *Ng Seq impedance Rv/Fw*
[135] During fault, $Z_2$= 2.0 × *Ng Seq impedance Rv/Fw*

### 25.30.124 Directional negative sequence impedance protection (DNZPDIS) main settings

**Table 157: Directional negative sequence impedance protection (DNZPDIS) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Direction mode | DNZPDIS | 1=Non-directional<br>2=Forward<br>3=Reverse | |
| Operate delay time | DNZPDIS | 60...300000 ms | 10 |
| Ng Seq impedance Fw | DNZPDIS | 0.01...3000.00 ohm | 0.01 |
| Ng Seq impedance Rv | DNZPDIS | -3000...-0.01 ohm | 0.01 |
| Characteristic angle | DNZPDIS | 1...90 deg | 1 |

### 25.30.125 Power swing detection (DSTRPSB)

**Table 158: Power swing detection (DSTRPSB)**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = fn |
| | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Impedance:<br>±3% of the set value or ±0.05 Ω<br>Phase angle: ±2° |
| Reset ratio | Typically 0.96/1.04 |
| Operate time accuracy[136] | ± 1.0% of the set value or 20 ms |

### 25.30.126 Power swing detection (DSTRPSB) main settings

**Table 159: Power swing detection (DSTRPSB) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Swing time | DSTRPSB | 20...300000 ms | 10 |
| Inner R1 | DSTRPSB | 0.01...5999.99 ohm | 0.01 |
| Inner X1 | DSTRPSB | 0.01...5999.99 ohm | 0.01 |
| Inner X1 reverse | DSTRPSB | 0.01...5999.99 ohm | 0.01 |
| Inner Min Ris Rch | DSTRPSB | 0.01...5999.99 ohm | 0.01 |

*Table continues on the next page*

[136] Measured with static power output (SPO)

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Outer R1 | DSTRPSB | 0.02...6000 ohm | 0.01 |
| Outer X1 | DSTRPSB | 0.02...6000 ohm | 0.01 |
| Outer X1 reverse | DSTRPSB | 0.02...6000 ohm | 0.01 |
| Outer Min Ris Rch | DSTRPSB | 0.02...6000 ohm | 0.01 |
| Max Ng Seq current | DSTRPSB | 0.01...10 xIn | 0.01 |
| Ng Seq current time | DSTRPSB | 20...1000 ms | 10 |
| Slow swing time | DSTRPSB | 80...60000 ms | 10 |
| Pulse time | DSTRPSB | 20...60000 ms | 10 |
| Pe Swg impedance Chr | DSTRPSB | 1=Quadrilateral<br>2=Mho (circular) | |

### 25.30.127 Stabilized and instantaneous differential protection for machines (MPDIF)

**Table 160: Stabilized and instantaneous differential protection for machines (MPDIF)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the current measured: $f_n$ ±2 Hz | | |
| | | ±3% of the set value or ±0.002 x $I_n$ | | |
| Operate time [137, 138] | | Minimum | Typical | Maximum |
| | Low stage | 36 ms | 40 ms | 42 ms |
| | High stage | 18 ms | 22 ms | 27 ms |
| Reset time | | <40 ms | | |
| Reset ratio | | Typically 0.95 | | |
| Retardation time | | <20 ms | | |

### 25.30.128 Stabilized and instantaneous differential protection for machines (MPDIF) main settings

**Table 161: Stabilized and instantaneous differential protection for machines (MPDIF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Low operate value | MPDIF | 5...30 %Ir | 1 |
| High operate value | MPDIF | 100...1000 %Ir | 10 |
| Slope section 2 | MPDIF | 10...50% | 1 |
| End section 1 | MPDIF | 0...100 %Ir | 1 |
| End section 2 | MPDIF | 100...300 %Ir | 1 |
| DC restrain enable | MPDIF | 0 = False 1 = True | - |
| CT connection type | MPDIF | 1 = Type 1 2 = Type 2 | - |

*Table continues on the next page*

[137] $F_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[138] Includes the delay of the power output contact

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| CT ratio Cor Line | MPDIF | 0.40...4.00 | 0.01 |
| CT ratio Cor Neut | MPDIF | 0.40...4.00 | 0.01 |

### 25.30.129 Underpower factor protection (MPUPF)

**Table 162: Underpower factor protection (MPUPF)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Dependent on the frequency of the current measured: fn ±2 Hz |
| | ±0.018 for power factor |
| Operate time accuracy | ±(1.0% or 30 ms) |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, 6, 7 |
| Reset time | <40 ms |

### 25.30.130 Underpower factor protection (MPUPF) main settings

**Table 163: Underpower factor protection (MPUPF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Min operate current | MPUPF | 0.05...0.65 × $I_n$ | 0.01 |
| Min operate voltage | MPUPF | 0.05...0.50 × $U_n$ | 0.01 |
| Disable time | MPUPF | 0...60000 ms | 1 |
| Voltage reversal | MPUPF | 0 = No<br>1 = Yes | - |

### 25.30.131 Stabilized and instantaneous differential protection for two- or three-winding transformers (TR3PTDF)

**Table 164: Stabilized and instantaneous differential protection for two- or three-winding transformers (TR3PTDF)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±3.0% of the set value or ±0.002 × $I_n$ | | |
| Start time [139, 140] | Low stage<br>High stage | Minimum | Typical | Maximum |

*Table continues on the next page*

139 Current before fault = 0.0 × $I_n f_n$ = 50 Hz. Injected differential current = 2.0 × set operation value.
140 Measured with static power output (SPO)

| Characteristic | Value | | |
|---|---|---|---|
| | 30 ms | 35 ms | 40 ms |
| | 17 ms | 18 ms | 20 ms |
| Reset time | Typically 40 ms | | |
| Reset ratio | Typically 0.96 | | |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5... | | |

### 25.30.132 Stabilized and instantaneous differential protection for two- or three-winding transformers (TR3PTDF) main settings

**Table 165: Stabilized and instantaneous differential protection for two- or three-winding transformers (TR3PTDF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| High operate value | TR3PTDF | 500...3000 %Ir | 10 |
| Low operate value | TR3PTDF | 5...50 %Ir | 1 |
| Slope section 2 | TR3PTDF | 10...50% | 1 |
| End section 2 | TR3PTDF | 100...500 %Ir | 1 |
| Restraint mode | TR3PTDF | 5 = Waveform<br>6 = 2.h + waveform<br>8 = 5.h + waveform<br>9 = 2.h + 5.h + wav | - |
| Start value 2.H | TR3PTDF | 7...20% | 1 |
| Start value 5.H | TR3PTDF | 10...50% | 1 |
| Stop value 5.H | TR3PTDF | 10...50% | 1 |
| Slope section 3 | TR3PTDF | 10...100% | 1 |
| Current group 3 type | TR3PTDF | 1 = Not in use 2 = Winding 3<br>3 = Wnd 1 restraint<br>4 = Wnd 2 restraint | - |
| Zro A elimination | TR3PTDF | 1 = Not eliminated<br>2 = Winding 1<br>3 = Winding 2<br>4 = Winding 1 and 2<br>5 = Winding 3<br>6 = Winding 1 and 3<br>7 = Winding 2 and 3<br>8 = Winding 1, 2, 3 | - |
| Phase shift Wnd 1-2 | TR3PTDF | 0.0...359.9° | 0.1 |
| Phase shift Wnd 1-3 | TR3PTDF | 0.0...359.9° | 0.1 |

### 25.30.133 Stabilized and instantaneous differential protection for two-winding transformers (TR2PTDF)

**Table 166: Stabilized and instantaneous differential protection for two-winding transformers (TR2PTDF)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±3.0% of the set value or ±0.002 × $I_n$ | | |
| Operate time [141, 142] | | Minimum | Typical | Maximum |
| | Low stage | 31 ms | 35 ms | 40 ms |
| | High stage | 15 ms | 17 ms | 20 ms |
| Reset time | | <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, … | | |

### 25.30.134 Stabilized and instantaneous differential protection for two-winding transformers (TR2PTDF) main settings

**Table 167: Stabilized and instantaneous differential protection for two-winding transformers (TR2PTDF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| High operate value | TR2PTDF | 500...3000 %Ir | 10 |
| Low operate value | TR2PTDF | 5...50 %Ir | 1 |
| Slope section 2 | TR2PTDF | 10...50% | 1 |
| End section 2 | TR2PTDF | 100...500 %Ir | 1 |
| Restraint mode | TR2PTDF | 5 = Waveform<br>6 = 2.h + waveform<br>8 = 5.h + waveform<br>9 = 2.h + 5.h + wav | - |
| Start value 2.H | TR2PTDF | 7...20% | 1 |
| Start value 5.H | TR2PTDF | 10...50% | 1 |
| Operation | TR2PTDF | 1 = on<br>5 = off | - |

*Table continues on the next page*

141 1) Current before fault = 0.0 × In, fn = 50 Hz. Injected differential current = 2.0 × set operation value

142 1) Measured with static power output. fn = 50 Hz

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Winding 1 type | TR2PTDF | 1 = Y<br>2 = YN<br>3 = D<br>4 = Z<br>5 = ZN | - |
| Winding 2 type | TR2PTDF | 1 = y<br>2 = yn<br>3 = d<br>4 = z<br>5 = zn | - |
| Zro A elimination | TR2PTDF | 1 = Not eliminated<br>2 = Winding 1<br>3 = Winding 2<br>4 = Winding 1 and 2 | - |

### 25.30.135 Numerical stabilized low-impedance restricted earth-fault protection (LREFPNDF)

**Table 168: Numerical stabilized low-impedance restricted earth-fault protection (LREFPNDF)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±2.5% of the set value or ±0.002 x $I_n$ | | |
| Start time [143, 144] | $I_{Fault}$ = 2.0 × set Operate value | Minimum | Typical | Maximum |
| | | 37 ms | 41 ms | 45 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, … | | |

143 Current before fault = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements

144 Includes the delay of the signal output contact

### 25.30.136 Numerical stabilized low-impedance restricted earth-fault protection (LREFPNDF) main settings

**Table 169: Numerical stabilized low-impedance restricted earth-fault protection (LREFPNDF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operate value | LREFPNDF | 5.0. 50.0 %$I_n$ | 1 |
| Minimum operate time | LREFPNDF | 40...300000 ms | 1 |
| Restraint mode | LREFPNDF | 1 = None<br>2 = Harmonic2 | - |
| Start value 2.H | LREFPNDF | 10...50% | 1 |
| Operation | LREFPNDF | 1 = on<br>5 = off | - |

### 25.30.137 High-impedance based restricted earth-fault protection (HREFPDIF)

**Table 170: High-impedance based restricted earth-fault protection (HREFPDIF)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [145, 146] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Operate value* | 16 ms | 21 ms | 23 ms |
| | $I_{Fault}$ = 10 × set *Operate value* | 11 ms | 13 ms | 14 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |

### 25.30.138 High-impedance based restricted earth-fault protection (HREFPDIF) main settings

**Table 171: High-impedance based restricted earth-fault protection (HREFPDIF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operate value | HREFPDIF | 1.0 50.0%$I_n$ | 0.1 |
| Minimum operate time | HREFPDIF | 20...300000 ms | 1 |
| Operation | HREFPDIF | 1 = on<br>5 = off | - |

145 Current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements

146 Includes the delay of the signal output contact

### 25.30.139 High-impedance differential protection (HIxPDIF)

**Table 172: High-impedance differential protection (HIxPDIF)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the current measured: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [147, 148] | $I_{Fault}$ = 2.0 × set *Start value* | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 10 × set *Start value* | 8 ms | 11 ms | 19 ms |
| | | 7 ms | 9 ms | 11 ms |
| Reset time | | Typically <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |

### 25.30.140 High-impedance differential protection (HIxPDIF) main settings

**Table 173: High-impedance differential protection (HIxPDIF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operate value | HIxPDIF | 1.0 200.0 %$I_n$ | 1.0 |
| Minimum operate time | HIxPDIF | 20...300000 ms | 10 |

### 25.30.141 Circuit breaker failure protection (CCBRBRF)

**Table 174: Circuit breaker failure protection (CCBRBRF)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Reset time | <20 ms |
| Retardation time | <20 ms |

147 *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

148 Measured with static signal output (SSO)

### 25.30.142 Circuit breaker failure protection (CCBRBRF) main settings

**Table 175: Circuit breaker failure protection (CCBRBRF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Current value | CCBRBRF | 0.05...2.00 × $I_n$ | 0.01 |
| Current value Res | CCBRBRF | 0.05...2.00 × $I_n$ | 0.01 |
| CB failure trip mode | CCBRBRF | 1 = 2 out of 4<br>2 = 1 out of 3<br>3 = 1 out of 4 | - |
| CB failure mode | CCBRBRF | 1 = Current<br>2 = Breaker status<br>3 = Both (AND)<br>-1 = Both (OR) | - |
| Retrip time | CCBRBRF | 0...60000 ms | 10 |
| CB failure delay | CCBRBRF | 0...60000 ms | 10 |
| CB fault delay | CCBRBRF | 0...60000 ms | 10 |

### 25.30.143 Three-phase inrush detector (INRPHAR)

**Table 176: Three-phase inrush detector (INRPHAR)**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | Current measurement:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Ratio I2f/I1f measurement:<br>±5.0% of the set value |
| Reset time | +35 ms / -0 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy | +35 ms / -0 ms |

### 25.30.144 Three-phase inrush detector (INRPHAR) main settings

**Table 177: Three-phase inrush detector (INRPHAR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | INRPHAR | 5...100% | 1 |
| Operate delay time | INRPHAR | 20...60000 ms | 1 |

### 25.30.145 Arc protection (ARCSARC)

**Table 178: Arc protection (ARCSARC)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | ±3.0% of the set value or ±0.01 × $I_n$ | | |
| Operate time TC | Operation mode = "Light +current" [149] | Minimum | Typical | Maximum |
| | | 9 ms [135] | 10 ms [135] | 13 ms [135] |
| | Operation mode = "Light only" [150] | 3 ms [151] | 5 ms [136] | 6 ms [136] |
| | | 8 ms [135]<br>3 ms [136] | 10 ms [135]<br>5 ms [136] | 13 ms [135]<br>6 ms [136] |
| Reset time | | Typically 50 ms | | |
| Reset ratio | | Typically 0.96 | | |

### 25.30.146 Arc protection (ARCSARC) main settings

**Table 179: Arc protection (ARCSARC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Phase start value | ARCSARC | 0.50...40.00 × $I_n$ | 0.01 |
| Ground start value | ARCSARC | 0.05...8.00 × $I_n$ | 0.01 |
| Operation mode | ARCSARC | 1 = Light+current<br>2 = Light only<br>3 = BI controlled | - |

### 25.30.147 High-impedance fault detection (PHIZ) main settings

**Table 180: High-impedance fault detection (PHIZ) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Security Level | PHIZ | 1...10 | 1 |
| System type | PHIZ | 1 = Grounded<br>2 = Ungrounded | - |

149 *Phase start value* = 1.0 × $I_n$, current before fault = 2.0 × set *Phase start value* , $f_n$ = 50 Hz, fault with nominal frequency, results based on statistical distribution of 200 measurements
150 Includes the delay of the power output (PO) contact
151 Measured with static power output (SPO)

### 25.30.148 Fault locator (SCEFRFLO)

**Table 181: Fault locator (SCEFRFLO)**

| Characteristic | Value |
|---|---|
| Measurement accuracy | At the frequency f = $f_n$ |
| | Impedance:<br>±2.5% or ±0.25 Ω |
| | Distance:<br>±2.5% or ±0.16 km/0.1 mile |
| | XC0F_CALC:<br>±2.5% or ±50 Ω |
| | IFLT_PER_ILD:<br>±5% or ±0.05 |

### 25.30.149 Fault locator (SCEFRFLO) main settings

**Table 182: Fault locator (SCEFRFLO) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Z Max phase load | SCEFRFLO | 1.0...10000.00 Ω | 0.1 |
| Ph leakage Ris | SCEFRFLO | 20...1000000 Ω | 1 |
| Ph capacitive React | SCEFRFLO | 10...1000000 Ω | 1 |
| R1 line section A | SCEFRFLO | 0.000...1000.000 Ω/pu | 0.001 |
| X1 line section A | SCEFRFLO | 0.000...1000.000 Ω/pu | 0.001 |
| R0 line section A | SCEFRFLO | 0.000...1000.000 Ω/pu | 0.001 |
| X0 line section A | SCEFRFLO | 0.000...1000.000 Ω/pu | 0.001 |
| Line Len section A | SCEFRFLO | 0.000...1000.000 pu | 0.001 |

### 25.30.150 Load-shedding and restoration (LSHDPFRQ)

**Table 183: Load-shedding and restoration (LSHDPFRQ)**

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | f< | ±5 mHz |
| | df/dt | ±100 mHz/s (in range \|df/dt\| < 5 Hz/s)<br>± 2.0% of the set value (in range 5 Hz/s < \|df/dt\| < 15 Hz/s) |
| Start time | f< | <80 ms |
| | df/dt | <120 ms |
| Reset time | | <150 ms |
| Operate time accuracy | | ±1.0% of the set value or ±30 ms |

### 25.30.151 Load-shedding and restoration (LSHDPFRQ) main settings

**Table 184: Load-shedding and restoration (LSHDPFRQ) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Load shed mode | LSHDPFRQ | 1 = Freq<<br>6 = Freq< OR df/dt<br>8 = Freq< AND df/dt | - |
| Restore mode | LSHDPFRQ | 1 = Disabled<br>2 = Auto<br>3 = Manual | - |
| Start value Freq | LSHDPFRQ | 0.800 1.200 × $f_n$ | 0.001 |
| Start value df/dt | LSHDPFRQ | -0.200 0.005 × $f_n$/s | 0.005 |
| Operate Tm Freq | LSHDPFRQ | 80...200000 ms | 10 |
| Operate Tm df/dt | LSHDPFRQ | 120...200000 ms | 10 |
| Restore start Val | LSHDPFRQ | 0.800 1.200 × $f_n$ | 0.001 |
| Restore delay time | LSHDPFRQ | 80...200000 ms | 10 |

### 25.30.152 Multipurpose protection (MAPGAPC)

**Table 185: Multipurpose protection (MAPGAPC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.0% of the set value or ±20 ms |

### 25.30.153 Multipurpose protection (MAPGAPC) main settings

**Table 186: Multipurpose protection (MAPGAPC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | MAPGAPC | -10000.0...10000.0 | 0.1 |
| Operate delay time | MAPGAPC | 0...200000 ms | 100 |
| Operation mode | MAPGAPC | 1 = Over<br>2 = Under | - |

### 25.30.154 Generator shaft current leakage protection (GSLPTOC)

**Table 187: GSLPTOC Technical data**

| Characteristics | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.03 × $I_n$ |
| Start time [152, 153] | Typically 30ms |
| Reset time | <30 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <50 ms |
| Operate time accuracy | ±1.0% of the set value of ±20 ms |

### 25.30.155 Generator shaft current leakage protection (GSLPTOC) main settings

**Table 188: Generator shaft current leakage protection (GSLPTOC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Alarm start value | GSLPTOC | 0.10...10.00 A | 0.01 |
| Alarm delay time | GSLPTOC | 40...30000 ms | 10 |
| Sel operate harmonic | GSLPTOC | 1=Fundamental<br>3=Third harmonic<br>5=Fifth harmonic | |
| Operate start value | GSLPTOC | 0.10...10.00 A | 0.01 |
| Operate delay time | GSLPTOC | 40...30000 ms | 10 |

[152] Current before fault = 0.0 x $I_n$, $f_n$ = 50 Hz, nominal frequency fault current 1.1 x set *Start value* is injected, results based on statistical distribution of 1000 measurements

[153] Includes the delay (≈0ms) of the static signal output (SSO)

### 25.30.156 Operation characteristics

**Table 189: Operation characteristics**

| Parameter | Value (Range) |
|---|---|
| Operating curve type | 1 = ANSI Ext. inv.<br>2 = ANSI Very. inv.<br>3 = ANSI Norm. inv.<br>4 = ANSI Mod inv.<br>5 = ANSI Def. Time<br>6 = L.T.E. inv.<br>7 = L.T.V. inv.<br>8 = L.T. inv.<br>9 = IEC Norm. inv.<br>10 = IEC Very inv.<br>11 = IEC inv.<br>12 = IEC Ext. inv.<br>13 = IEC S.T. inv.<br>14 = IEC L.T. inv<br>15 = IEC Def. Time<br>17 = Programmable<br>18 = RI type<br>19 = RD type |
| Operating curve type (voltage protection) | 5 = ANSI Def. Time<br>15 = IEC Def. Time<br>17 = Inv. Curve A<br>18 = Inv. Curve B<br>19 = Inv. Curve C<br>20 = Programmable<br>21 = Inv. Curve A<br>22 = Inv. Curve B<br>23 = Programmable |

## 25.31 Control functions

### 25.31.1 Emergency start-up (ESMGAPC)

**Table 190: Emergency start-up (ESMGAPC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±1.5% of the set value or ±0.002 × $U_n$ |

### 25.31.2 Emergency start-up (ESMGAPC) main settings

**Table 191: Emergency start-up (ESMGAPC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Motor stand still A | ESMGAPC | 0.01...0.20 × $I_n$ | 0.01 |

### 25.31.3 Autoreclosing (DARREC)

**Table 192: Autoreclosing (DARREC)**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

### 25.31.4 Autosynchronizer for generator breaker (ASGCSYN)

**Table 193: Autosynchronizer for generator breaker (ASGCSYN)**

| Characteristic | Value |
|---|---|
| Measurement accuracy | At the frequency f = $f_n$ |
| | Voltage difference:<br>±1.0% or ±0.004 × $U_n$<br>Frequency difference:<br>±10 mHz<br>Phase angle difference:<br>±1° (±2.5° when f = $f_n$±2 Hz ) |
| Operation accuracy | MATCH_OK for voltage:<br>±0.001 × $U_n$<br>MATCH_OK for frequency:<br>±10 mHz |
| Operation time accuracy | Raise/Lower output pulse width:<br>±1.0% of the set value or ±20 ms<br>*Energizing time* for dead-bus closing:<br>±1.0% of the set value or ±35 ms<br>*Minimum Syn time* for SYNC_OK:<br>±1.0% of the set value or ±60 ms |
| Reset time | Typically 20 ms |
| Closing angle accuracy | ±1° |

### 25.31.5 Autosynchronizer for generator breaker (ASGCSYN) main settings

**Table 194: Autosynchronizer for generator breaker (ASGCSYN) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Live dead mode | ASGCSYN | -1 = Off<br>-2 = Command<br>1 = Both Dead<br>4 = Dead B, G Any<br>2 = Live G, Dead B | - |
| Angle Diff positive | ASGCSYN | 5...90° | 1 |
| Angle Diff negative | ASGCSYN | 5...90° | 1 |
| Phase shift | ASGCSYN | -180...180° | 1 |
| Closing time of CB | ASGCSYN | 40...250 ms | 1 |
| Synchronization Dir | ASGCSYN | 1 = Always over synchronous<br>2 = Both direction | - |
| Synchrocheck mode | ASGCSYN | 1 = Off<br>3 = Asynchronous<br>4 = Command | - |
| Dead voltage value | ASGCSYN | 0.10...0.80 × $U_n$ | 0.1 |
| Live voltage value | ASGCSYN | 0.20...1.00 × $U_n$ | 0.1 |
| Voltage match mode | ASGCSYN | 1 = Off<br>2 = Variable Pulse<br>3 = Variable Interval | - |
| Frequency match mode | ASGCSYN | 1 = Off<br>2 = Variable Pulse<br>3 = Variable Interval | - |

### 25.31.6 Autosynchronizer for network breaker (ASNSCSYN)

**Table 195: Autosynchronizer for network breaker (ASNSCSYN)**

| Characteristic | Value |
|---|---|
| Measurement accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz |
| | Voltage difference:<br>±1.0% or ±0.004 × $U_n$<br>Frequency difference:<br>±10 mHz<br>Phase angle difference:<br>±1° |

*Table continues on the next page*

| Characteristic | Value |
|---|---|
| Operation accuracy | MATCH_OK for voltage:<br>±0.001 × $U_n$<br>MATCH_OK for frequency:<br>±10 mHz |
| Operation time accuracy | *Energizing time* for dead-bus closing:<br>±1.0% of the set value or ±35 ms<br>*Minimum Syn time* for SYNC_OK:<br>±1.0% of the set value or ±60 ms |
| Reset time | Typically 20 ms |
| Closing angle accuracy | ±1° |

### 25.31.7 Autosynchronizer for network breaker (ASNSCSYN) main settings

**Table 196: Autosynchronizer for network breaker (ASNSCSYN) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Live dead mode | ASNSCSYN | -2 = Command<br>-1 = Off<br>1 = Both Dead<br>2 = Live B, Dead A<br>3 = Dead B, Live A<br>4 = Dead A, B Any<br>5 = Dead B, A Any<br>6 = One Live, Dead<br>7 = Not Both Live | - |
| Diff voltage | ASNSCSYN | 0.01...0.50 × $U_n$ | 0.01 |
| Diff frequency | ASNSCSYN | 0.001...0.060 × $f_n$ | 0.001 |
| Diff angle | ASNSCSYN | 5...90° | 1 |
| Synchrocheck mode | ASNSCSYN | 1 = Off<br>2 = Synchronous<br>3 = Asynchronous<br>4 = Command | - |
| Dead bus voltage | ASNSCSYN | 0.1...0.8 × $U_n$ | 0.1 |
| Live bus voltage | ASNSCSYN | 0.2...1.0 × $U_n$ | 0.1 |
| Phase shift | ASNSCSYN | -180...180° | 1 |
| Closing time of CB | ASNSCSYN | 40...250 ms | 1 |

### 25.31.8 Synchronism and energizing check (SECRSYN)

**Table 197: Synchronism and energizing check (SECRSYN)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±1 Hz<br>Voltage:<br>±3.0% of the set value or ±0.01 × $U_n$<br>Frequency:<br>±10 mHz<br>Phase angle:<br>±3° |
| Reset time | <50 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

### 25.31.9 Synchronism and energizing check (SECRSYN) main settings

**Table 198: Synchronism and energizing check (SECRSYN) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Live dead mode | SECRSYN | -1 = Off<br>1 = Both Dead<br>2 = Live L, Dead B<br>3 = Dead L, Live B<br>4 = Dead Bus, L Any<br>5 = Dead L, Bus Any<br>6 = One Live, Dead<br>7 = Not Both Live | - |
| Difference voltage | SECRSYN | 0.01...0.50 × $U_n$ | 0.01 |
| Difference frequency | SECRSYN | 0.001...0.100 × $f_n$ | 0.001 |
| Difference angle | SECRSYN | 5...90° | 1 |
| Synchrocheck mode | SECRSYN | 1 = Off<br>2 = Synchronous<br>3 = Asynchronous | - |
| Dead line value | SECRSYN | 0.1...0.8 × $U_n$ | 0.1 |
| Live line value | SECRSYN | 0.2...1.0 × $U_n$ | 0.1 |
| Max energizing V | SECRSYN | 0.50...1.15 × $U_n$ | 0.01 |
| Control mode | SECRSYN | 1 = Continuous<br>2 = Command | - |
| Close pulse | SECRSYN | 200...60000 ms | 10 |
| Phase shift | SECRSYN | -180...180° | 1 |
| Minimum Syn time | SECRSYN | 0...60000 ms | 10 |
| Maximum Syn time | SECRSYN | 100...6000000 ms | 10 |
| Energizing time | SECRSYN | 100...60000 ms | 10 |
| Closing time of CB | SECRSYN | 40...250 ms | 10 |

### 25.31.10 Tap changer control with voltage regulator (OL5ATCC)

**Table 199: Tap changer control with voltage regulator (OL5ATCC)**

| Characteristic | Value |
|---|---|
| Operation accuracy [154] | Depending on the frequency of the measured current: fn ±2 Hz |
| | Differential voltage $U_d$ = ±0.5% of the measured value or ±0.005 × $U_n$ (in measured voltages <2.0 × $U_n$)<br>Operation value = ±1.5% of the $U_d$ for Us = 1.0 × $U_n$ |
| Operate time accuracy in definite time mode [155] | +4.0%/-0% of the set value |
| Operate time accuracy in inverse time mode [138] | +8.5%/-0% of the set value<br>(at theoretical B in range of 1.1…5.0)<br>Also note fixed minimum operate time (IDMT) 1 s |
| Reset ratio for control operation | Typically 0.80 (1.20) |
| Reset ratio for analog based blockings (except run back raise voltage blocking) | Typically 0.96 (1.04) |

### 25.31.11 Tap changer control with voltage regulator (OL5ATCC) main settings

**Table 200: Tap changer control with voltage regulator (OL5ATCC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| LDC enable | OL5ATCC | 0 = False<br>1 = True | - |
| Parallel mode | OL5ATCC | 2 = Master<br>3 = Follower<br>5 = NRP<br>7 = MCC<br>-1 = Input control<br>-2 = Command | - |
| Band center voltage | OL5ATCC | 0.000...2.000 × $U_n$ | 0.001 |
| Line drop V Ris | OL5ATCC | 0.0...25.0% | 0.1 |
| Line drop V React | OL5ATCC | 0.0...25.0% | 0.1 |
| Band reduction | OL5ATCC | 0.00...9.00 %$U_n$ | 0.01 |
| Stability factor | OL5ATCC | 0.0...70.0% | 0.1 |
| Rv Pwr flow allowed | OL5ATCC | 0 = False<br>1 = True | - |

*Table continues on the next page*

[154] Default setting values used
[155] Voltage before deviation = set *Band center voltage*

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operation mode | OL5ATCC | 1 = Manual<br>2 = Auto single<br>3 = Parallel manual<br>4 = Auto parallel<br>5 = Input control<br>6 = Command | - |
| Parallel trafos | OL5ATCC | 0...10 | 1 |
| Delay characteristic | OL5ATCC | 0 = Inverse time<br>1 = Definite time | - |
| Band width voltage | OL5ATCC | 1.20...18.00 %$U_n$ | 0.01 |
| Load current limit | OL5ATCC | 0.10...5.00 × $I_n$ | 0.01 |
| Block lower voltage | OL5ATCC | 0.10...1.20 × $U_n$ | 0.01 |
| LTC pulse time | OL5ATCC | 500...10000 ms | 100 |

### 25.31.12 Petersen coil controller (PASANCR)

**Table 201: PASANCR Technical data**

| Characteristic | Value |
|---|---|
| Measuring accuracy | Resistance:<br>±2% or ±1 Ω |
| Operation accuracy [156] | I_C_NETWORK:<br>Typically ±5% |

### 25.31.13 Petersen coil controller (PASANCR) main settings

**Table 202: Petersen coil controller (PASANCR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Compensation mode | PASANCR | 1 = Absolute<br>2 = Relative | - |
| Detuning level | PASANCR | -100...100 A | 1 |
| Detuning level Rl | PASANCR | -100.0...100.0% | 0.1 |
| Tuning delay | PASANCR | 0...3600 s | 1 |
| V Res variation | PASANCR | 0.1...100.0 %$U_n$ | 0.1 |

*Table continues on the next page*

[156] Network resonance point voltage must be at least 0.005 × $U_n$, where $U_n$ = nominal phase-to-earth voltage

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Tuning mode | PASANCR | 1 = Coil movement<br>2 = Resistor switching | - |
| V Res EF level | PASANCR | 0.00...100.00 %Un | 0.01 |
| EF mode | PASANCR | 1 = Blocked during EF<br>2 = Resonance<br>3 = Tuning during EF | - |
| Resistor healthy St | PASANCR | 0 = Off<br>1 = On | - |
| Resistor repeats | PASANCR | 0...100 | 1 |
| Resistor pause | PASANCR | 0...100000000 ms | 1 |
| Coil V Nom | PASANCR | 0...400000 V | 1 |
| Fix coil V Nom | PASANCR | 0...400000 V | 1 |
| Auxiliary Wnd V Nom | PASANCR | 0...10000 V | 1 |
| Controller mode | PASANCR | 0 = Manual<br>1 = Automatic | - |
| Parallel resistor | PASANCR | 0 = False<br>1 = True | - |
| R0Transformer | PASANCR | 0...100 Ω | 1 |
| X0Transformer | PASANCR | 0...100 Ω | 1 |
| Voltage measurement | PASANCR | 1 = Busbar<br>2 = Coil | - |
| Resistor control | PASANCR | 1 = OFF<br>2 = ON<br>3 = Automatic | - |
| Resistor Nom value | PASANCR | 0.00...100.00 Ω | 0.01 |
| Fix coil value | PASANCR | 0...10000 A | 1 |
| Fix coil type | PASANCR | 1 = OFF<br>2 = ON<br>3 = Automatic | - |

### 25.31.14 High speed bus transfer (HSABTC)

**Table 203: High speed bus transfer (HSABTC)**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | Voltage | ±1.5% of the set value or ±0.002 × Un, frequency range ±10Hz | | |
| | Frequency | ±25mHz of the set value | | |
| Initiation time | | Minimum | Typical | Maximum |
| | Under voltage[157, 158, 159] | 14 ms | 18 ms | 21 ms |
| | Under frequency[160, 161, 162] | 47 ms | 49 ms | 50 ms |
| | External (binary input)[163, 164, 165] | 9 ms | 10 ms | 12 ms |
| Initiation time accuracy | | ±20 ms of the set value | | |
| Operate time accuracy | | ±1.0% of the set value or ±20 ms | | |

### 25.31.15 High speed bus transfer (HSABTC) main settings

**Table 204: High speed bus transfer (HSABTC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Min standby voltage | HSABTC | 0.05...1.20 xUn | 0.01 |
| Min busbar voltage | HSABTC | 0.05...1.20 xUn | 0.01 |
| Residual voltage limit | HSABTC | 0.01...1.00 xUn | 0.01 |
| Start Val frequency | HSABTC | 0.900...1.100 xFn | 0.001 |
| Start Val voltage | HSABTC | 0.50...1.20 xUn | 0.01 |

*Table continues on the next page*

157 *Start val Voltage* = 0.95 × Un, voltage before fault = 1.0 × Un, fault voltage = 0.9 × set *Start val Voltage*, undervoltage in one phase-to-phase voltage with nominal frequency injected from random phase angle
158 Measured with static power output (SPO)
159 Results based on statistical distribution of 1000 measurements
160 Measured with static power output (SPO)
161 Results based on statistical distribution of 1000 measurements
162 Applies to continuous frequency change. If frequency change ≥ 0.5Hz (disturbance in network or due to test setup), then initiation time is increased with 100ms to prevent false reaction.
163 Measured with static power output (SPO)
164 Results based on statistical distribution of 1000 measurements
165 Excluding the delay of the external triggering device

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operation mode | HSABTC | 1=Only ext<br>2=Freq<<br>3=U<<br>4=Both | |
| Max frequency Diff | HSABTC | 0.05...2.50 Hz | 0.01 |
| Maximum phase lead | HSABTC | 5...50 deg | 1 |
| Maximum phase lag | HSABTC | 5...50 deg | 1 |
| Max angle Diff FBBM | HSABTC | 5...90 deg | 1 |
| Maximum DfDt | HSABTC | 5...40 | 1 |
| Transfer delay time | HSABTC | 100...200000 ms | 1 |
| Enable fast transfer | HSABTC | 1=1>2<br>2=2>1<br>3=Both<br>4=Off | |
| Enable FBBM | HSABTC | | |
| Ena 1st Ph transfer | HSABTC | 1=1>2<br>2=2>1<br>3=Both<br>4=Off | |
| Ena Res V transfer | HSABTC | 1=1>2<br>2=2>1<br>3=Both<br>4=Off | |
| Ena Time delay transfer | HSABTC | 1=1>2<br>2=2>1<br>3=Both<br>4=Off | |
| Ena CB open transfer | HSABTC | 1=1>2<br>2=2>1<br>3=Both<br>4=Off | |
| Manual transfer | HSABTC | 1=Off<br>2=On<br>3=Fast MBB | |
| Closing time of CB1 | HSABTC | 0...200 ms | 1 |
| Opening time of CB1 | HSABTC | 0...200 ms | 1 |
| Closing time of CB2 | HSABTC | 0...200 ms | 1 |

*Table continues on the next page*

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Opening time of CB2 | HSABTC | 0...200 ms | 1 |
| Travel time Clc mode | HSABTC | 1=From Cmd to Pos<br>2=From Pos to Pos<br>3=From Cmd to Curr<br>4=From Pos to Curr | |

## 25.32 Condition monitoring and supervision functions

### 25.32.1 Circuit-breaker condition monitoring (SSCBR)

**Table 205: Circuit-breaker condition monitoring (SSCBR)**

| Characteristic | Value |
|---|---|
| Current measuring accuracy | ±1.5% or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0%<br>(at currents in the range of 10…40 × $I_n$) |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Travelling time measurement | +10 ms / -0 ms |

### 25.32.2 Motor controlled earthing switch and disconnector supervision (ESDCSSWI)

**Table 206: Motor controlled earthing switch and disconnector supervision (ESDCSSWI)**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |
| Travelling time measurement | +10 ms / -5 ms |

### 25.32.3 Motor controlled earthing switch and disconnector supervision (ESDCSSWI) main settings

**Table 207: Motor controlled earthing switch and disconnector supervision (ESDCSSWI) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Alarm Op number | ESDCSSWI | 0...99999 | 1 |
| Open alarm time | ESDCSSWI | 40...30000 ms | 10 |
| Close alarm time | ESDCSSWI | 40...30000 ms | 10 |
| Inactive Alm days | ESDCSSWI | 0...9999 | 1 |
| Inactive Alm hours | ESDCSSWI | 0...23 h | 1 |
| Travel time Clc mode | ESDCSSWI | 1=From Cmd to Pos<br>2=From Pos to Pos | |

### 25.32.4 Hot-spot and insulation ageing rate monitoring for transformers (HSARSPTR)

**Table 208: Hot-spot and insulation ageing rate monitoring for transformers (HSARSPTR)**

| Characteristic | Value |
|---|---|
| Warning/alarm time accuracy | ±1.0% of the set value or ±0.50 s |

### 25.32.5 Hot-spot and insulation ageing rate monitoring for transformers (HSARSPTR) main settings

**Table 209: Hot-spot and insulation ageing rate monitoring for transformers (HSARSPTR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Cooling mode | HSARSPTR | 1 = ONAN<br>2 = ONAF<br>3 = OFAF<br>4 = ODAF | - |
| Alarm level | HSARSPTR | 50.0...350.0°C | 0.1 |
| Warning level | HSARSPTR | 50.0...350.0°C | 0.1 |
| Alarm delay time | HSARSPTR | 0...3600000 ms | 10 |
| Warning delay time | HSARSPTR | 0...3600000 ms | 10 |
| Average ambient Tmp | HSARSPTR | -20.00...70.00°C | 0.01 |
| Alarm level Age Rte | HSARSPTR | 0.00...100.00 | 1 |

### 25.32.6 Cable fault detection (RCFD)

**Table 210: Cable fault detection (RCFD)**

| Characteristic | Value | | |
|---|---|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | ±2.5% of the set value or 0.005 x$I_n$ | | |
| Alarm time[166, 167] | Minimum | Typical | Maximum |
| | 10 ms | 15 ms | 20 ms |

166 Results based on statistical distribution of 1000 measurements
167 Measured with static signal output (SSO)

### 25.32.7 Cable fault detection (RCFD) main settings

**Table 211: Cable fault detection (RCFD) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Adaptive Str Val Ena | RCFD | | |
| Maximum fault cycle | RCFD | 1...20 | 1 |
| Minimum load current | RCFD | 0.00...1.00 xIn | 0.10 |
| Residual current limit | RCFD | 0.00...1.00 xIn | 0.10 |
| Phase start value | RCFD | 0.10...40.00 xIn | 0.01 |
| Residual start value | RCFD | 0.10...40.00 xIn | 0.01 |

### 25.32.8 Current circuit supervision (CCSPVC)

**Table 212: Current circuit supervision (CCSPVC)**

| Characteristic | Value |
|---|---|
| Operate time [168] | <30 ms |

### 25.32.9 Current circuit supervision (CCSPVC) main settings

**Table 213: Current circuit supervision (CCSPVC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | CCSPVC | 0.05...0.20 × $I_n$ | 0.01 |
| Max operate current | CCSPVC | 1.00...5.00 × $I_n$ | 0.01 |

### 25.32.10 Advanced current circuit supervision for transformers (CTSRCTF)

**Table 214: Advanced current circuit supervision for transformers (CTSRCTF)**

| Characteristic | Value |
|---|---|
| Operate time [169] | <30 ms |

[168] Including the delay of the output contact
[169] Including the delay of the output contact

### 25.32.11 Current circuit supervision (CTSRCTF) main settings

**Table 215: Current circuit supervision (CTSRCTF) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Min operate current | CTSRCTF | 0.01...0.50 × $I_n$ | 0.01 |
| Max operate current | CTSRCTF | 1.00...5.00 × $I_n$ | 0.01 |
| Max Ng Seq current | CTSRCTF | 0.01...1.00 × $I_n$ | 0.01 |

### 25.32.12 Current transformer supervision for high-impedance protection scheme (HZCCxSPVC)

**Table 216: Current transformer supervision for high-impedance protection scheme (HZCCxSPVC)**

| Characteristic | Value |
|---|---|
| Oeration accuracy | Depending on the frequency of the current measured: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Reset time | <40 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

### 25.32.13 Current transformer supervision for high-impedance protection scheme (HZCCxSPVC) main settings

**Table 217: Current transformer supervision for high-impedance protection scheme (HZCCxSPVC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | HZCCxSPVC | 1.0...100.0 %$I_n$ | 0.1 |
| Alarm delay time | HZCCxSPVC | 100...300000 ms | 10 |
| Alarm output mode | HZCCxSPVC | 1 = Non-latched<br>3 = Lockout | - |

### 25.32.14 Fuse failure supervision (SEQSPVC)

**Table 218: Fuse failure supervision (SEQSPVC)**

| Characteristic | | Value | |
|---|---|---|---|
| Operate time [170] | NPS function | $U_{Fault}$ = 1.1 × set *Neg Seq voltage Lev* | <33 ms |
| | | $U_{Fault}$ = 5.0 × set *Neg Seq voltage Lev* | <18 ms |
| | Delta function | ΔU = 1.1 × set *Voltage change rate* | <30 ms |
| | | ΔU = 2.0 × set *Voltage change rate* | <24 ms |

### 25.32.15 Runtime counter for machines and devices (MDSOPT)

**Table 219: Runtime counter for machines and devices (MDSOPT)**

| Description | Value |
|---|---|
| Motor runtime measurement accuracy[171] | ±0.5% |

### 25.32.16 Runtime counter for machines and devices (MDSOPT) main settings

**Table 220: Runtime counter for machines and devices (MDSOPT) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Warning value | MDSOPT | 0...299999 h | 1 |
| Alarm value | MDSOPT | 0...299999 h | 1 |
| Initial value | MDSOPT | 0...299999 h | 1 |
| Operating time hour | MDSOPT | 0...23 h | 1 |
| Operating time mode | MDSOPT | 1 = Immediate<br>2 = Timed Warn<br>3 = Timed Warn Alm | - |

[170] Includes the delay of the signal output contact, $f_n$ = 50 Hz, fault voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

[171] Of the reading, for a stand-alone relay, without time synchronization

### 25.32.17 Three-phase remanent undervoltage supervision (MSVPR)

**Table 221: Three-phase remanent undervoltage supervision (MSVPR)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>20 Hz < f ≤ 70 Hz:<br>±1.5% of the set value or ±0.002 × $U_n$<br>10 Hz < f ≤ 20 Hz:<br>±4.0% of the set value or ±0.002 × $U_n$ |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 1.04 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

### 25.32.18 Three-phase remanent undervoltage supervision (MSVPR) main settings

**Table 222: Three-phase remanent undervoltage supervision (MSVPR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | MSVPR | 0.05...1.20 × $U_n$ | 0.01 |
| Operate delay time | MSVPR | 100...300000 ms | 100 |
| Voltage selection | MSVPR | 1 = phase-to-earth<br>2 = phase-to-phase | - |
| Num of phases | MSVPR | 1 = 1 out of 3<br>2 = 2 out of 3<br>3 = 3 out of 3 | - |

### 25.32.19 Diesel generator monitoring and protection (DGMGAPC)

**Table 223: Diesel generator monitoring and protection (DGMGAPC)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage and current: $f_n$ ±2 Hz |
| | Voltage:<br>±1.5% of the set value or 0.002 x$U_n$<br>Frequency:<br>±5 mHz<br>Active power:<br>±3% of the set value or 0.002 x$S_n$ |

*Table continues on the next page*

| Characteristic | Value |
|---|---|
| | Reactive power:<br>±3% of the set value or 0.002 x$S_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Reset ratio | Typically 0.96/1.04 |

### 25.32.20 Diesel generator monitoring and protection (DGMGAPC) main settings

**Table 224: Diesel generator monitoring and protection (DGMGAPC) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operate delay time | DGMGAPC | 10...300000 ms | 10 |
| Min Freq limit | DGMGAPC | 0.95...1 xFn | 0.01 |
| Max Freq limit | DGMGAPC | 1...1.05 xFn | 0.01 |
| Min voltage limit | DGMGAPC | 0.5...1.5 xUn | 0.1 |
| Max voltage limit | DGMGAPC | 0.5...1.5 xUn | 0.1 |
| Disable time | DGMGAPC | 10...3600000 ms | 10 |
| Backup delay time | DGMGAPC | 10...300000 ms | 10 |
| Min active power | DGMGAPC | 0.01...1 xSn | 0.01 |
| Max active power | DGMGAPC | 0.1...2 xSn | 0.01 |
| Min reactive power | DGMGAPC | 0.01...1 xSn | 0.01 |
| Max reactive power | DGMGAPC | 0.1...2 xSn | 0.01 |
| F set point no load | DGMGAPC | 0.1...2 xFn | 0.01 |
| Frequency droop | DGMGAPC | 0...100 %Fn | 0.01 |
| U set point no load | DGMGAPC | 0.1...2 xUn | 0.01 |
| Voltage droop | DGMGAPC | 0...100 %Un | 0.01 |
| Total Num of Gn | DGMGAPC | 1...8 | 1 |
| Total Num of tie | DGMGAPC | 1...8 | 1 |

## 25.33 Measurement functions

### 25.33.1 Three-phase current measurement (CMMXU)

**Table 225: Three-phase current measurement (CMMXU)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±0.5% or ±0.002 × $I_n$ |
| | (at currents in the range of 0.01...4.00 × $I_n$) |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |
| | RMS: No suppression |

### 25.33.2 Sequence current measurement (CSMSQI)

**Table 226: Sequence current measurement (CSMSQI)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: f/$f_n$ = ±2 Hz |
| | ±1.0% or ±0.002 × $I_n$ |
| | at currents in the range of 0.01...4.00 × $I_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

### 25.33.3 Residual current measurement (RESCMMXU)

**Table 227: Residual current measurement (RESCMMXU)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the current measured: f/$f_n$ = ±2 Hz |
| | ±0.5% or ±0.002 × $I_n$ |
| | at currents in the range of 0.01...4.00 × $I_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |
| | RMS: No suppression |

### 25.33.4 Three-phase voltage measurement (VMMXU)

**Table 228: Three-phase voltage measurement (VMMXU)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz<br>At voltages in range 0.01…1.15 × $U_n$ |
| | ±0.5% or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

### 25.33.5 Phase voltage measurement (VPHMMXU)

**Table 229: VPHMMXU Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz<br>At voltages in range 0.01…1.15 × $U_n$ |
| | ±0.5 % or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

### 25.33.6 Single-phase voltage measurement (VAMMXU)

**Table 230: Single-phase voltage measurement (VAMMXU)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz<br>At voltages in range 0.01…1.15 × $U_n$ |
| | ±0.5% or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

### 25.33.7 Residual voltage measurement (RESVMMXU)

**Table 231: Residual voltage measurement (RESVMMXU)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage: $f/f_n$ = ±2 Hz |
| | ±0.5% or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |
| | RMS: No suppression |

### 25.33.8 Sequence voltage measurement (VSMSQI)

**Table 232: Sequence voltage measurement (VSMSQI)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz |
| | At voltages in range 0.01…1.15 × $U_n$ |
| | ±1.0% or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

### 25.33.9 Three-phase power and energy measurement (PEMMXU)

**Table 233: Three-phase power and energy measurement (PEMMXU)**

| Characteristic | Value |
|---|---|
| Operation accuracy [172] | At all three currents in range 0.10…1.20 × In At all three voltages in range 0.50…1.15 × $U_n$ At the frequency $f_n$ ±1 Hz |
| | ±1.5% for apparent power S |
| | ±1.5% for active power P and active energy [173] |
| | ±1.5% for reactive power Q and reactive energy [174] |
| | ±0.015 for power factor |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

[172] *Measurement mode* = "Pos Seq" (default)
[173] |PF| >0.5 which equals |cosϕ| >0.5
[174] |PF| <0.86 which equals |sinϕ| >0.5

### 25.33.10 Frequency measurement (FMMXU)

**Table 234: Frequency measurement (FMMXU)**

| Characteristic | Value |
|---|---|
| Operation accuracy | ±5 mHz<br>(in measurement range 35...75 Hz) |

### 25.33.11 Tap changer position indication (TPOSYLTC)

**Table 235: Tap changer position indication (TPOSYLTC)**

| Characteristic | Value |
|---|---|
| Response time for binary inputs | Typically 100 ms |

## 25.34 Power quality functions

### 25.34.1 Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics (CHMHAI)

**Table 236: Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics (CHMHAI)**

| Characteristic | Value |
|---|---|
| Operation accuracy [175] | ±3.0% or ±0.2 |

### 25.34.2 Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics (CHMHAI) main settings

**Table 237: Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics (CHMHAI) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Sliding interval | CHMHAI | 1 = 3 seconds<br>2 = 1 minute<br>3 = 5 minutes | - |
| Reference Cur Sel | CHMHAI | 0 = fundamental<br>2 = absolute | - |
| Demand current | CHMHAI | 0.10...1.00 × $I_n$ | 0.01 |

[175] Nominal frequency 50 Hz. Harmonics in the range 0…0.21 × fundamental amplitude

### 25.34.3 Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics (VHMHAI)

**Table 238: Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics (VHMHAI)**

| Characteristic | Value |
|---|---|
| Operation accuracy [176] | ±3.0% or ±0.2 |

### 25.34.4 Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics (VHMHAI) main settings

**Table 239: Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics (VHMHAI) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Sliding interval | VHMHAI | 1 = 3 seconds<br>2 = 1 minute<br>3 = 5 minutes | - |

### 25.34.5 Voltage variation (PHQVVR)

**Table 240: Voltage variation (PHQVVR)**

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.5% of the set value or ±0.2% of reference voltage |
| Reset ratio | Typically 0.96 (Swell), 1.04 (Dip, Interruption) |

### 25.34.6 Voltage variation (PHQVVR) main settings

**Table 241: Voltage variation (PHQVVR) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Voltage dip set 1 | PHQVVR | 10.0...100.0% | 0.1 |
| Voltage dip set 2 | PHQVVR | 10.0...100.0% | 0.1 |
| Voltage dip set 3 | PHQVVR | 10.0...100.0% | 0.1 |
| Voltage swell set 1 | PHQVVR | 100.0...140.0% | 0.1 |
| Voltage swell set 2 | PHQVVR | 100.0...140.0% | 0.1 |
| Voltage swell set 3 | PHQVVR | 100.0...140.0% | 0.1 |
| Voltage Int set | PHQVVR | 0.0...100.0% | 0.1 |
| VVa Dur Max | PHQVVR | 100...3600000 ms | 100 |

[176] Nominal frequency 50 Hz. Harmonics in the range 0…0.21 × fundamental amplitude

### 25.34.7 Voltage unbalance (VSQVUB)

**Table 242: Voltage unbalance (VSQVUB)**

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.5% of the set value or ±0.002 × $U_n$ |
| Reset ratio | Typically 0.96 |

### 25.34.8 Voltage unbalance (VSQVUB) main settings

**Table 243: Voltage unbalance (VSQVUB) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operation | VSQVUB | 1 = on<br>5 = off | - |
| Unb detection method | VSQVUB | 1 = Neg Seq<br>2 = Zero Seq<br>3 = Neg to Pos Seq<br>4 = Zero to Pos Seq<br>5 = Ph vectors Comp | - |

## 25.35 Logging functions

### 25.35.1 Disturbance recorder, common functionality (RDRE) main settings

**Table 244: Disturbance recorder, common functionality (RDRE) main settings**

| Parameter | function | Value (Range) | Step |
|---|---|---|---|
| Record length | RDRE | 10...500 cycles | 1 |
| Pre-trg length | RDRE | 0...100% | 1 |
| Operation mode | RDRE | 1 = Overwrite<br>2 = Saturation | - |
| Storage rate | RDRE | 32, 16, 8 samples per fundamental cycle | - |

## 25.36 Other functionality

### 25.36.1 Pulse timer, eight channels (PTGAPC)

**Table 245: Pulse timer, eight channels (PTGAPC)**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

### 25.36.2 Time delay off, eight channels (TOFPAGC)

**Table 246: Time delay off, eight channels (TOFPAGC)**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

### 25.36.3 Time delay on, eight channels (TONGAPC)

**Table 247: Time delay on, eight channels (TONGAPC)**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

## 26. Mounting methods

With appropriate mounting accessories, the protection relay can be rack mounted, wall mounted, roof mounted or door mounted. The LHMI can be mounted either on a door or a surface, or in a tilted position (25°) using special accessories. It is also possible to rack mount or door mount the protection relay together with the LHMI.

Mounting options for the relay:

- Rack mounting
- Rack mounting with the LHMI
- Rack mounting with the LHMI including a provision for the RTXP 24 test switch
- Wall mounting
- Roof mounting
- Door mounting
- Door mounting with the LHMI

Mounting options for the HMI:

- Rack mounting
- Door mounting
- Mounting in a 25° tilt

## 27. Selection and ordering data

*Relays-Online* a Next-Generation Order Number Tool, supports order code creation for ABB Distribution Automation IEC products with emphasis on, but not exclusively for the Relion product family. Relays-Online is an easy to use, online tool always containing the latest product information. The complete order code can be created with detailed specification and the result can be printed and mailed. Registration is recommended.

## 28. Modification Sales

Modification Sales is a concept that provides modification support for already delivered relays. Under Modification Sales it is possible to modify both the hardware and software capabilities of the existing relay. The same options are available as when a new relay variant is configured and ordered from the factory: it is possible to add new hardware modules into empty slots, change the type of the existing modules within the slots or add software functions by adding application and, if necessary, add-on packages. If it is needed to use the possibilities provided by the Modification Sales concept, please contact your local ABB unit. The information that is requested by ABB is a) Relay serial number, b) Relay order code and c) The requested modification, separately stated for each relay.

Modification Sales is based on license handling within the relay. Modifying the relay without proper new license from ABB puts the relay in internal relay failure mode.

## 29. Accessories and ordering data

**Table 248: HMI**

| Item | Order number |
|---|---|
| LHMI (including mounting bracket kit) | 2RCA033008A0001 |
| LHMI, conformal coated (including mounting bracket kit) | 2RCA033008A0901 |
| SHMI (including mounting bracket kit) | 2RCA033008A0002 |
| SHMI, conformal coated (including mounting bracket kit) | 2RCA033008A0902 |
| 0.5 m (1.6 ft) connection cable for HMI | 1MRS120549-05 |
| 1.0 m (3.3 ft) connection cable for HMI | 1MRS120549-1 |
| 2.0 m (6.6 ft) connection cable for HMI | 1MRS120549-2 |
| 3.0 m (9.8 ft) connection cable for HMI | 1MRS120549-3 |

*Table continues on the next page*

| Item | Order number |
|---|---|
| 5.0 m (16.4 ft) connection cable for HMI | 1MRS120549-5 |
| RJ-45 coupler for HMI service port | SYJ-ZBE 8A17 |

**Table 249: Communication**

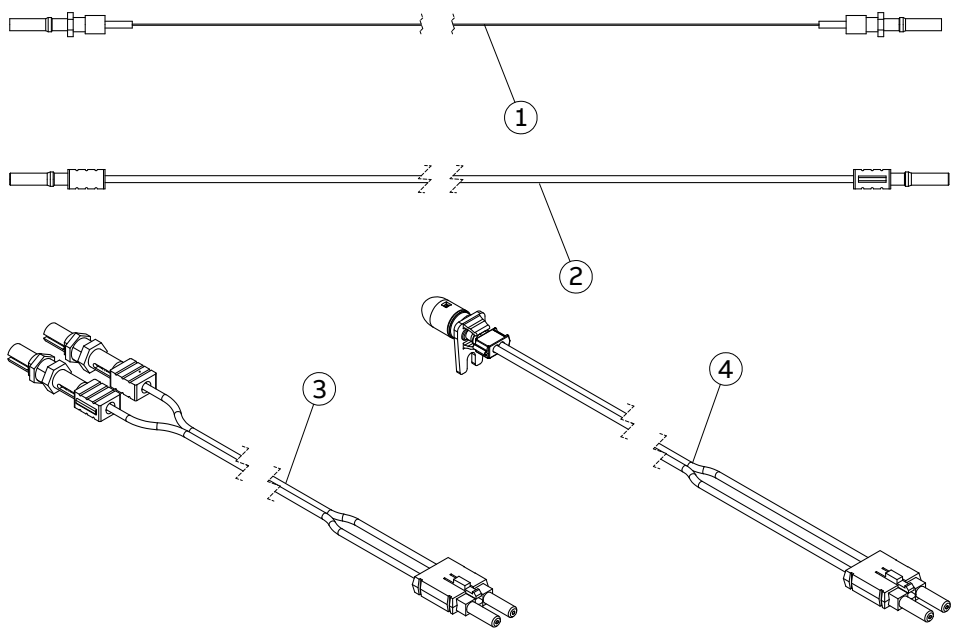
| Item | Order number |
|---|---|
| LC SFP plug-in connector for optical multimode media 100M | 2RCA045621 |
| LC SFP plug-in connector for optical single-mode media 100M, 20.0 km (12.4 mi) | 2RCA045622 |
| LC SFP plug-in connector for optical single-mode media 100M, 50.0 km (31.1 mi) | 2RCA045623 |

**Table 250: Mounting**

| Item | Order number |
|---|---|
| Back wall / side wall mounting kit standard housing | 2RCA040872A0001 |
| Back wall / side wall mounting kit narrow housing | 2RCA058741A0001 |
| Roof mounting kit standard housing | 2RCA040873A0001 |
| Door mounting with LHMI standard housing | 2RCA040882A0001 |
| Door mounting with LHMI narrow housing | 2RCA058742A0001 |
| 19 inch relay rack mounting with HMI standard housing, 7U | 2RCA041125A0001 |
| 19 inch relay rack mounting without HMI standard housing, 7U | 2RCA041127A0001 |
| 19 inch relay rack mounting with HMI one narrow unit, 7U | 2RCA058747A0001 |
| 19 inch relay rack mounting without HMI one narrow unit, 7U | 2RCA058746A0001 |
| 19 inch relay rack mounting with HMI two narrow units, 7U | 2RCA058750A0001 |
| 19 inch relay rack mounting without HMI two narrow units, 7U | 2RCA058749A0001 |
| Surface mounting kit for HMI | 2RCA038783A0001 |
| Tilt mounting kit for HMI | 2RCA038782A0001 |
| Grounding bar kit for RTD module | 2RCA039981A0001 |
| 19 inch relay rack mounting for relay and HMI, including a provision for RTXP 24 test switch, 6U | 2RCA051498A0001 |
| 19 inch relay rack mounting for relay and HMI, including a provision for RTXP 24 test switch, 7U | 2RCA051503A0001 |

**Table 251: Arc sensors**

| Item | Order number |
|---|---|
| ARC lens sensor cable 1.5 m (4.9 ft) | 2RCA040290A0001 |
| ARC lens sensor cable 3.0 m (9.8 ft) | 2RCA040290A0003 |
| ARC lens sensor cable 5.0 m (16.4 ft) | 2RCA040290A0005 |
| ARC lens sensor cable 7.5 m (24.6 ft) | 2RCA040290A0007 |
| ARC lens sensor cable 15.0 m (49.2 ft) | 2RCA040290A0015 |
| ARC loop sensor cable 5.0 m (16.4 ft), plastic fiber | 2RCA051658A0005 |
| ARC loop sensor cable 10.0 m (32.8 ft), plastic fiber | 2RCA051658A0010 |
| ARC loop sensor cable 15.0 m (49.2 ft), plastic fiber | 2RCA051658A0015 |
| ARC loop sensor cable 20.0 m (65.6 ft), plastic fiber | 2RCA051658A0020 |
| ARC loop sensor cable 25.0 m (82.0 ft), plastic fiber | 2RCA051658A0025 |
| ARC loop sensor cable 30.0 m (98.4 ft), plastic fiber | 2RCA051658A0030 |
| ARC loop sensor cable 40.0 m (131.2 ft), glass fiber | 2RCA041050A0040 |
| ARC loop sensor cable 50.0 m (164.0 ft), glass fiber | 2RCA041050A0050 |
| ARC loop sensor cable 60.0 m (196.9 ft), glass fiber | 2RCA041050A0060 |
| Blind extension cable for ARC loop sensors, 2.0 m (6.6 ft), to be used with plastic fiber loops only | 2RCA051662A0001 |
| ARC sensor fiber, 100 m, delivery length | 1MSC 380018.100 |
| ARC sensor fiber, 300 m, delivery length | 1MSC 380018.300 |
| ARC sensor fiber, 500 m, delivery length | 1MSC 380018.500 |
| ARC sensor fiber connector (25 pcs.) | SJG BP05226-02 |
| ARC sensor fiber connector spacer sleeve (25 pcs.) | 2RCA056821 |




1 ARC loop sensor cable, glass fiber
2 ARC loop sensor cable, plastic fiber
3 Blind extension cable for ARC loop sensors
4 ARC lens sensor cable

*Figure 30: Arc sensors and accessories*

**Table 252: Connectors**

| Item | Order number |
|---|---|
| Compression-type signal connectors | SYJ-ZRK 2Z18P1 |
| Ring-lug type signal connectors | SYJ-ZRK 33X18 |
| Push-in type signal connectors | SYJ-ZRK 53P18PM |
| 1 CT-1 VT compression-type connector | 2RCA040474A0004 |
| 5 CT compression-type connector | 2RCA040474A0001 |
| 5 VT compression-type connector | 2RCA040474A0002 |
| 1 CT-4 VT compression-type connector | 2RCA040474A0003 |
| 1 CT-1 VT ring-lug type connector | 2RCA041297A0004 |
| 5 CT ring-lug type connector | 2RCA041297A0001 |
| 5 VT ring-lug type connector | 2RCA041297A0002 |
| 1 CT-4 VT ring-lug type connector | 2RCA041297A0003 |
| RS-485/IRIG-B connector | SYJ-ZRK 44P10 |
| HMI power supply connector | SYJ-ZRK 45X3[177] |

[177] Compatible alternative connector with screw flange fastening Weidmüller 1944340000.

## 30. Tools

The protection relay is delivered with the correct protection and control functionality included but it needs some engineering to fit in the needed application. The default parameter setting values can be changed from the HMI, the Web browser-based user interface (WHMI) or Protection and Control IED Manager PCM600 in combination with the relayspecific connectivity package.

PCM600 offers extensive relay configuration functions. For example, the setting parameters, relay application, graphical display and IEC 61850 communication, including horizontal GOOSE communication, can be modified with PCM600.

The REX640 relay's LHMI pages can be customized and shared between devices with a dedicated Display Editor which offers intuitive graphical drawing tools with editable symbols for single-line diagrams. In addition, it is possible to create personalized views for every supported application. The page access can be customized for every user to enable simple operational usage for all user levels.

When the WHMI is used, the protection relay can be accessed from any of the relay's access points, including the Ethernet connection on the LHMI. For security reasons, the WHMI is disabled by default, but it can be enabled via the LHMI. The WHMI functionality can be limited to read-only access.

**Table 253: Tools**

| Description | Version |
|---|---|
| PCM600 | 2.12 HF3 or later |
| Web browser | Microsoft Edge, Google Chrome and Mozilla Firefox |
| REX640 connectivity package | 1.3.2 or later |

**Table 254: Supported functions**

| Function | Web HMI | PCM600 |
|---|---|---|
| Relay parameter setting | • | • |
| Saving of relay parameter settings in the relay | • | • |
| Signal monitoring | • | • |
| Disturbance recorder handling | • | • |
| Alarm LED viewing | • | • |
| Access control management | • | • |
| Relay signal configuration (Signal Matrix) | - | • |
| Modbus® communication configuration (communication management) | - | • |
| DNP3 communication configuration (communication management) | - | • |
| IEC 60870-5-103 communication configuration (communication management) | - | • |
| Saving of relay parameter settings in the tool | - | • |
| Disturbance record analysis | - | • |
| XRIO parameter export/import | • | • |
| Graphical display configuration | - | • |

*Table continues on the next page*

| Function | Web HMI | PCM600 |
|---|---|---|
| Application configuration | - | ● |
| IEC 61850 communication configuration, GOOSE (communication configuration) | - | ● |
| Phasor diagram viewing | ● | - |
| Event viewing | ● | ● |
| Saving of event data on the user's PC | ● | ● |
| Online monitoring | - | ● |

● = Supported

The relay connectivity package is a collection of software and specific relay information which enables system products and tools to connect and interact with the protection relay. The connectivity packages reduce the risk of errors in system integration, minimizing device configuration and setup times.

Further, the connectivity package for REX640 includes a flexible update tool for adding one additional LHMI language and new functionalities to the protection relay. The flexible modification support of the relay enables adding new protection functionalities whenever the protection and control needs are changing.

## 31. Module diagrams

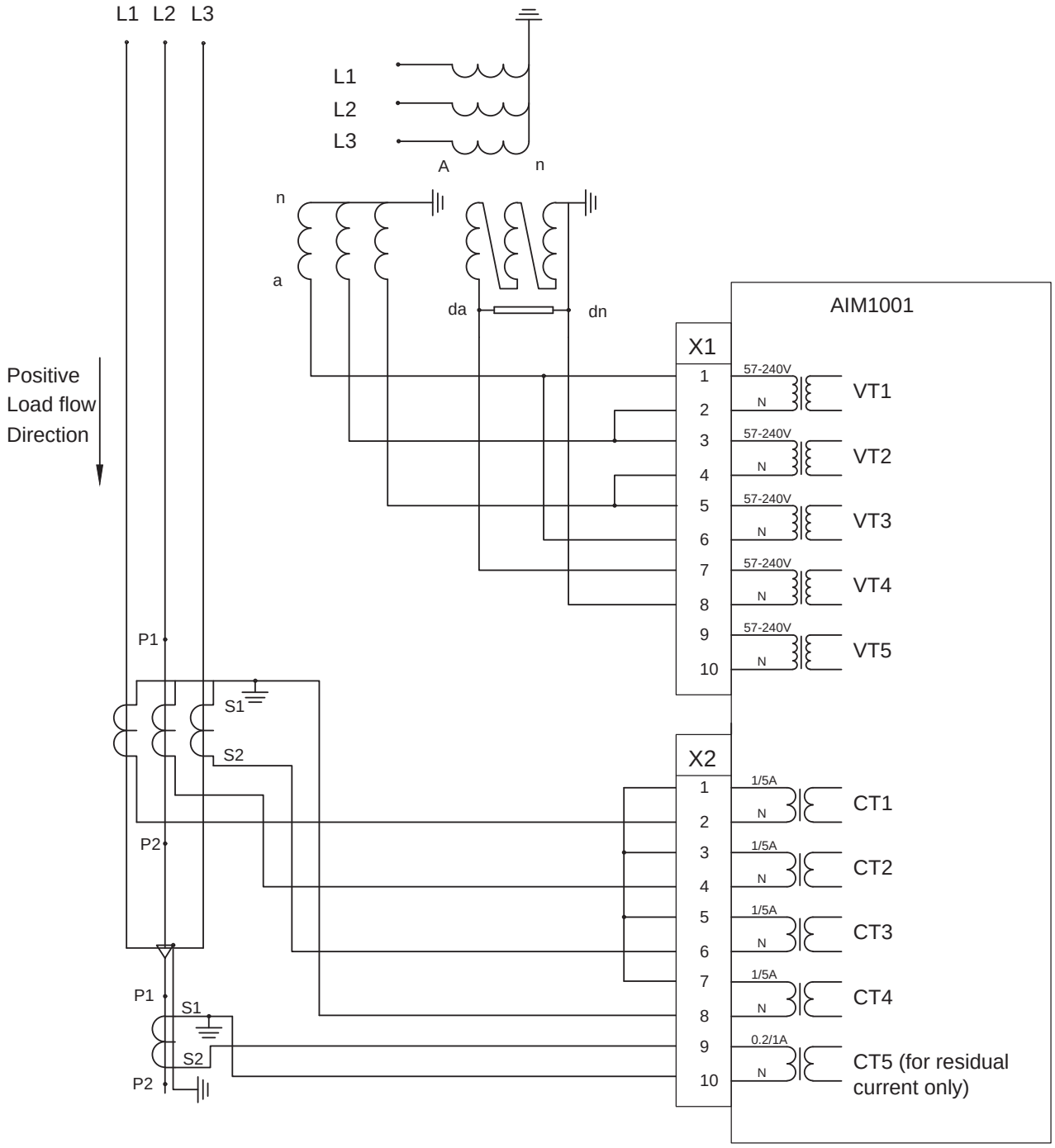



*Figure 31: AIM1001 module*

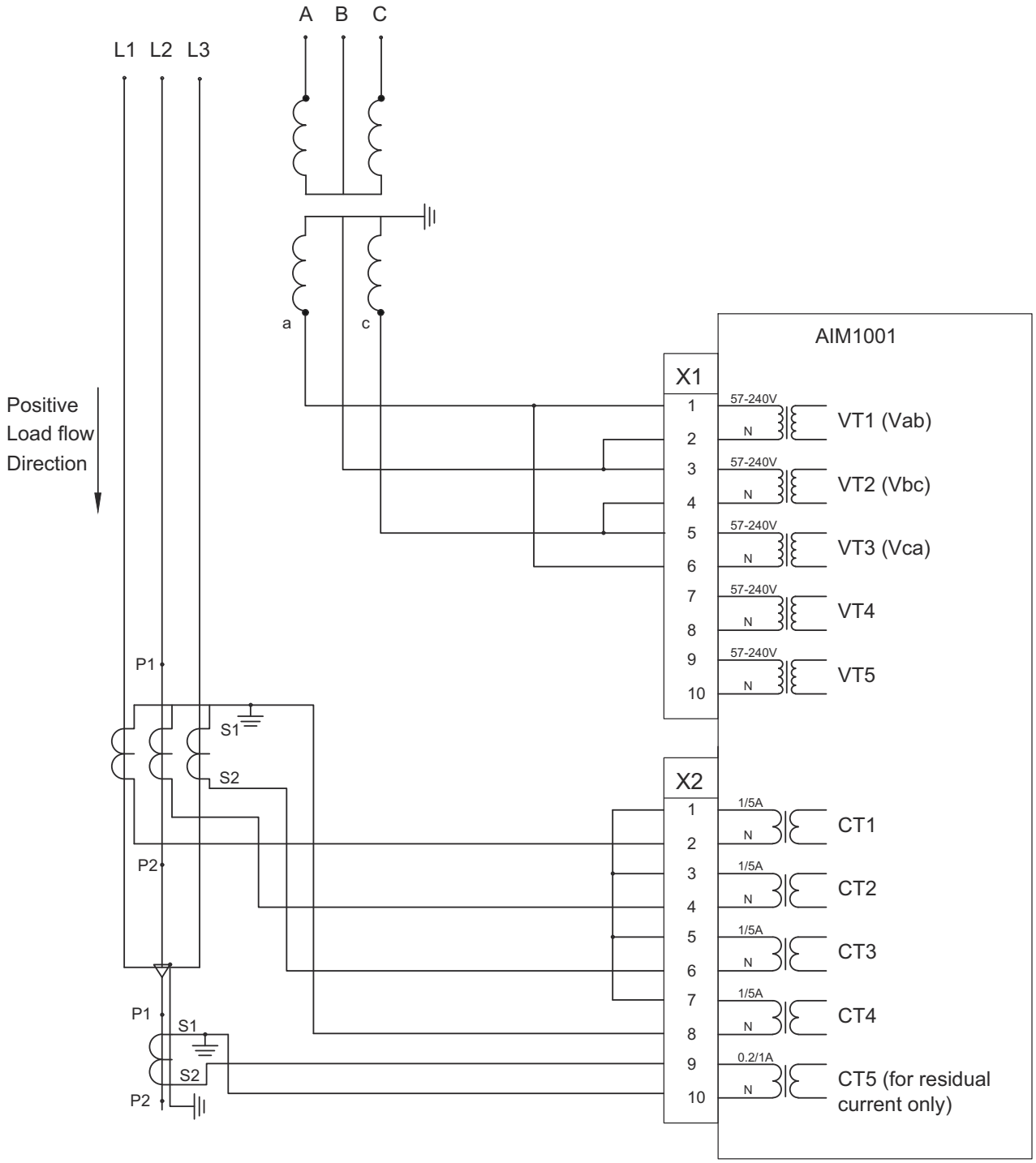



*Figure 32: AIM1001 module (two phase-to-phase VTs)*

The two phase-to-phase VT connection is often referred as “open delta” (ANSI) or as “V” (IEC) connection. The relay measures all three phase-to-phase voltages using only two primary VTs.

The relay will calculate the phase-to-ground voltages internally, with the assumption that the three-phase system is balanced, i.e. residual voltage is zero.

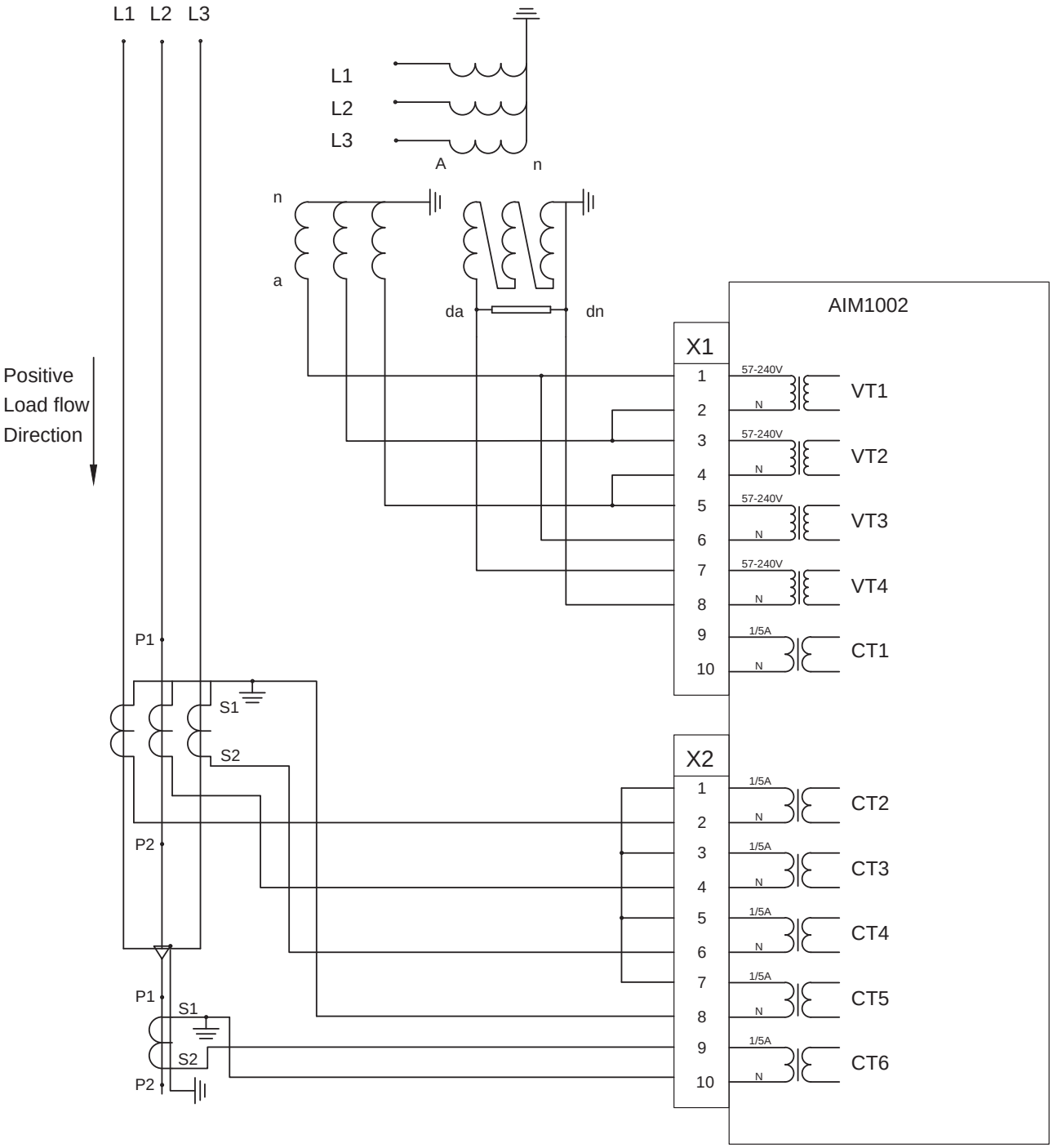



*Figure 33: AIM1002 module*

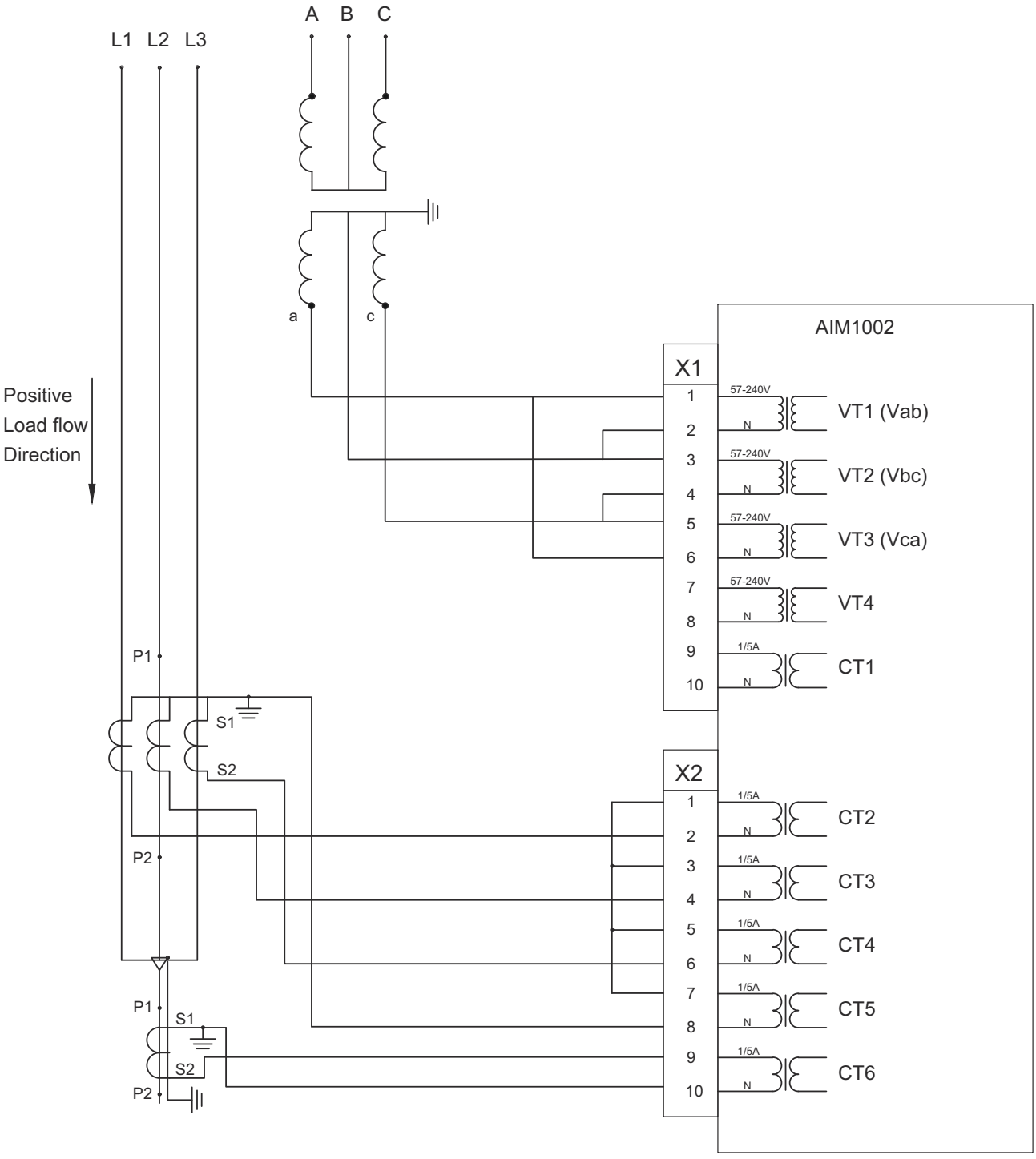



*Figure 34: AIM1002 module (two phase-to-phase VTs)*

The two phase-to-phase VT connection is often referred as “open delta” (ANSI) or as “V” (IEC) connection. The relay measures all three phase-to-phase voltages using only two primary VTs.

The relay will calculate the phase-to-ground voltages internally, with the assumption that the three-phase system is balanced, i.e. residual voltage is zero.

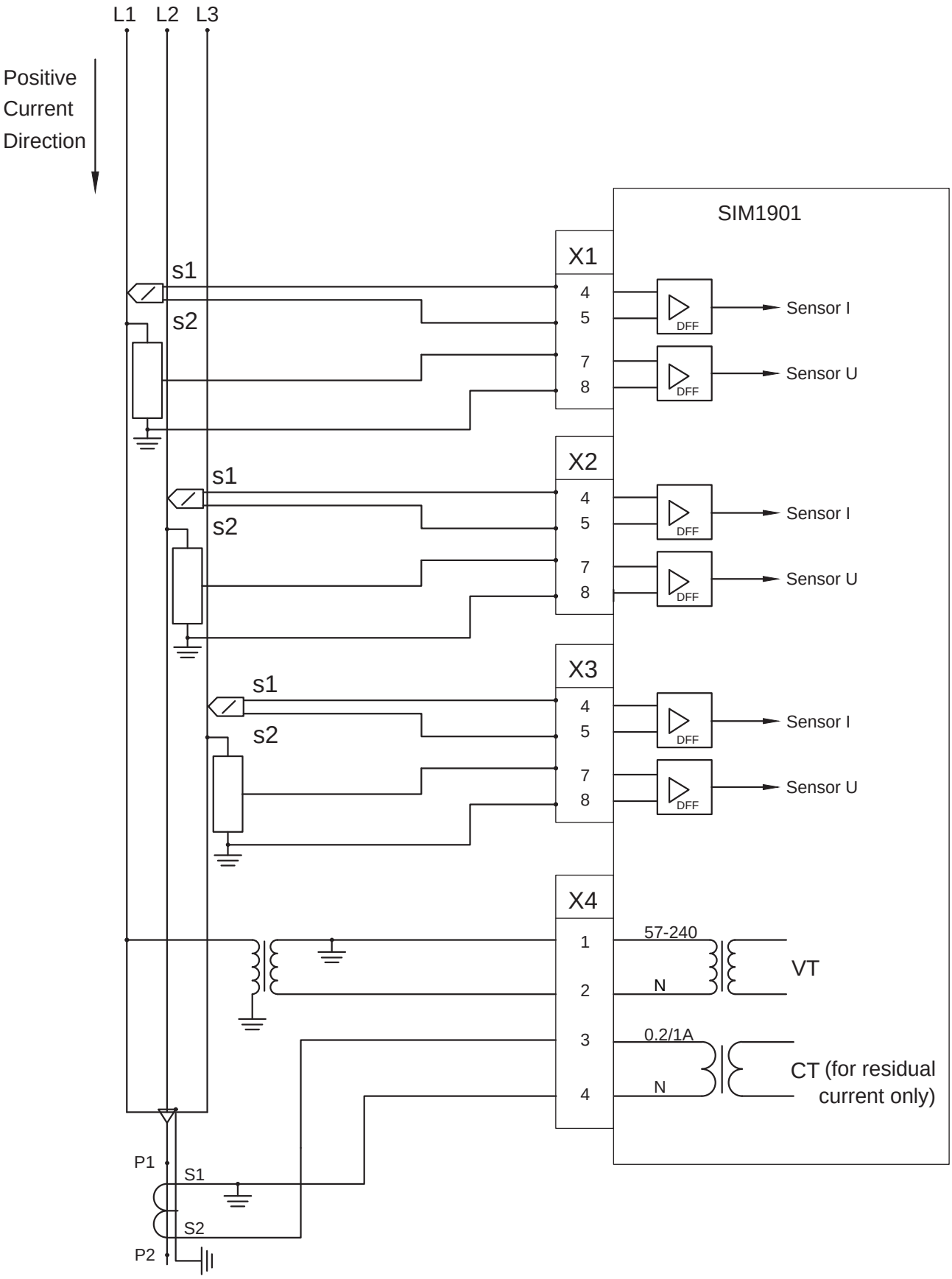



*Figure 35: SIM1901 module (VT primary connection phase-to-earth)*

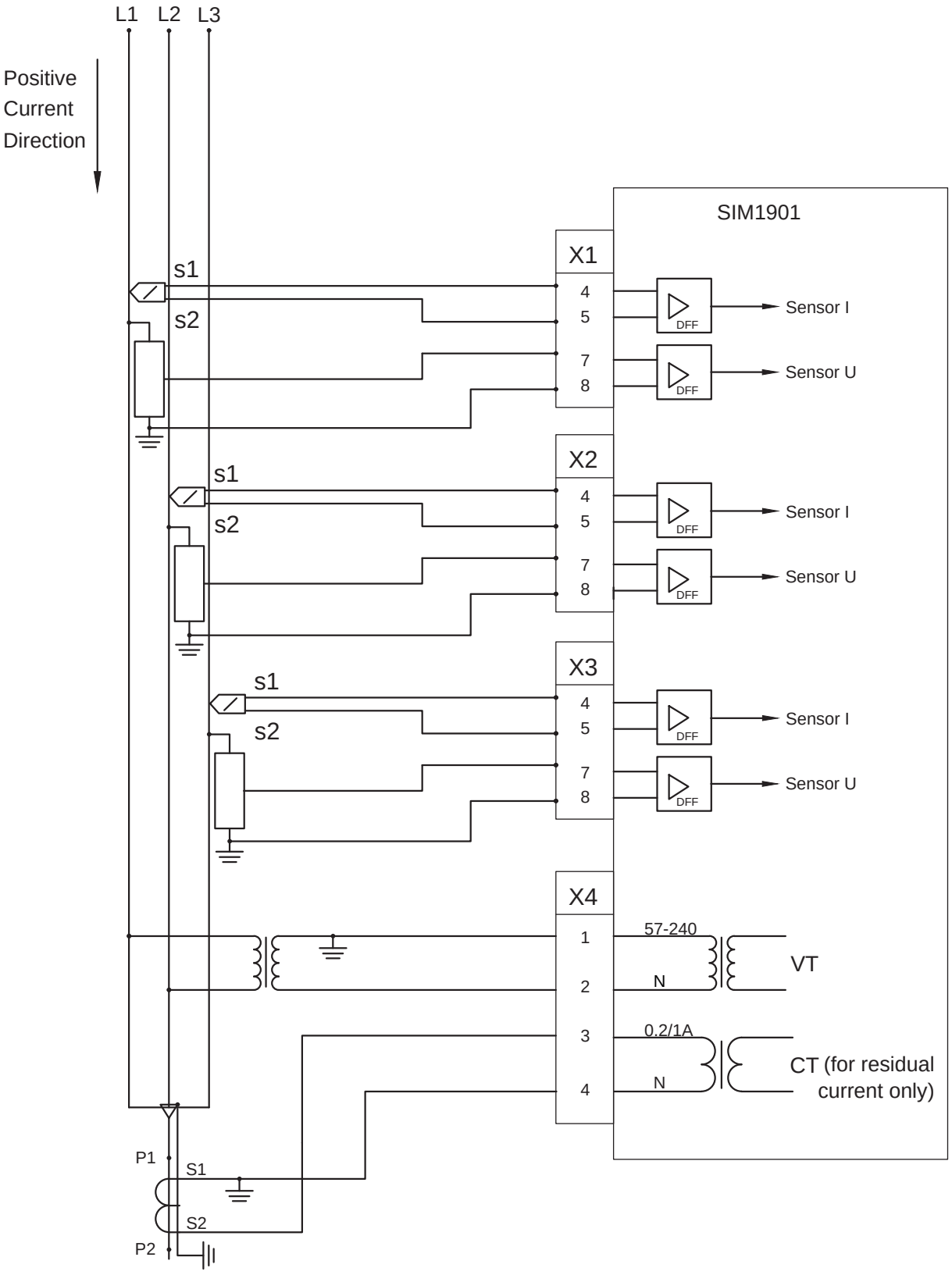



*Figure 36: SIM1901 module (VT primary connection phase-to-phase)*

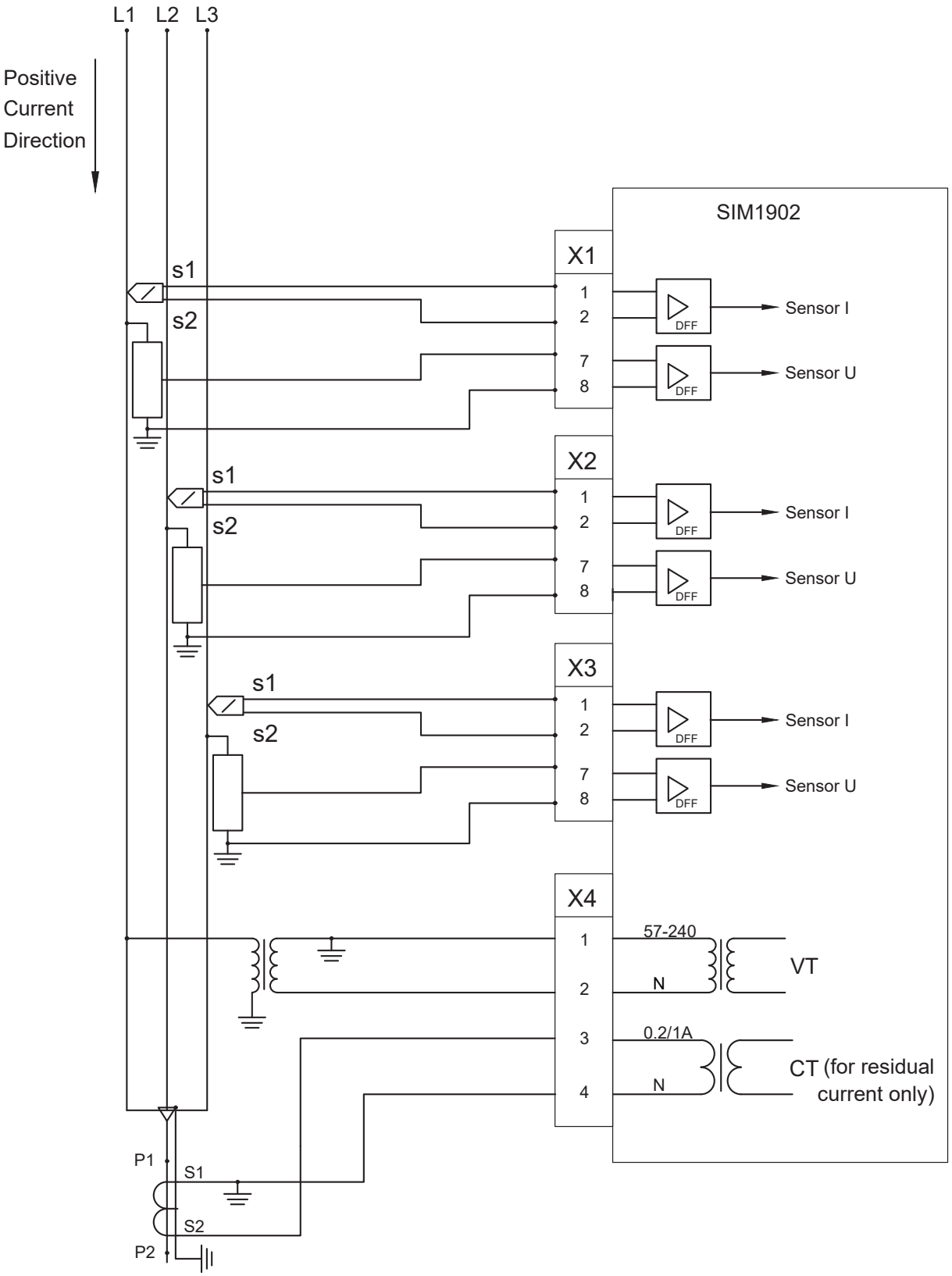



*Figure 37: SIM1902 module (VT primary connection phase-to-earth)*

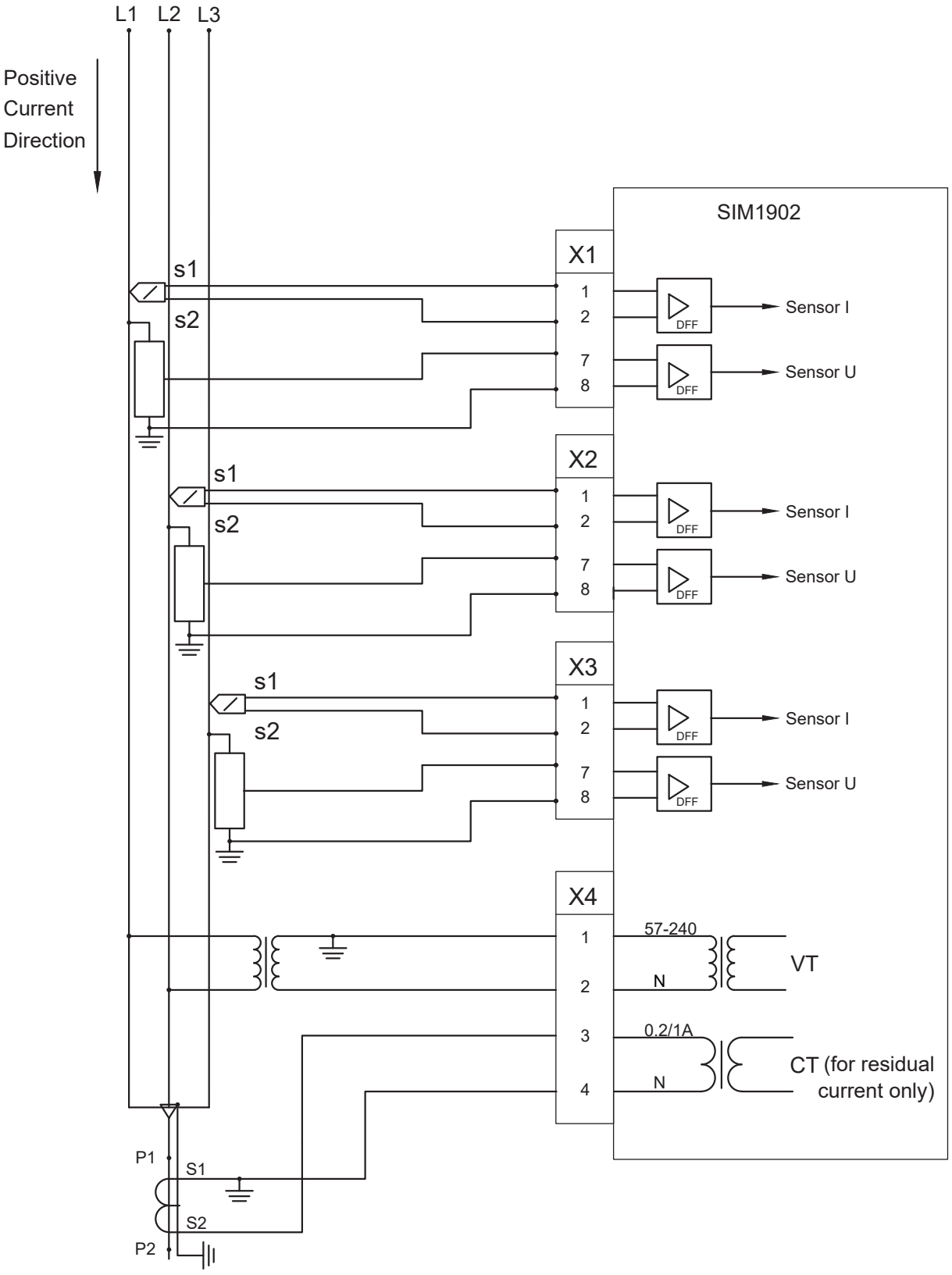



*Figure 38: SIM1902 module (VT primary connection phase-to-phase)*

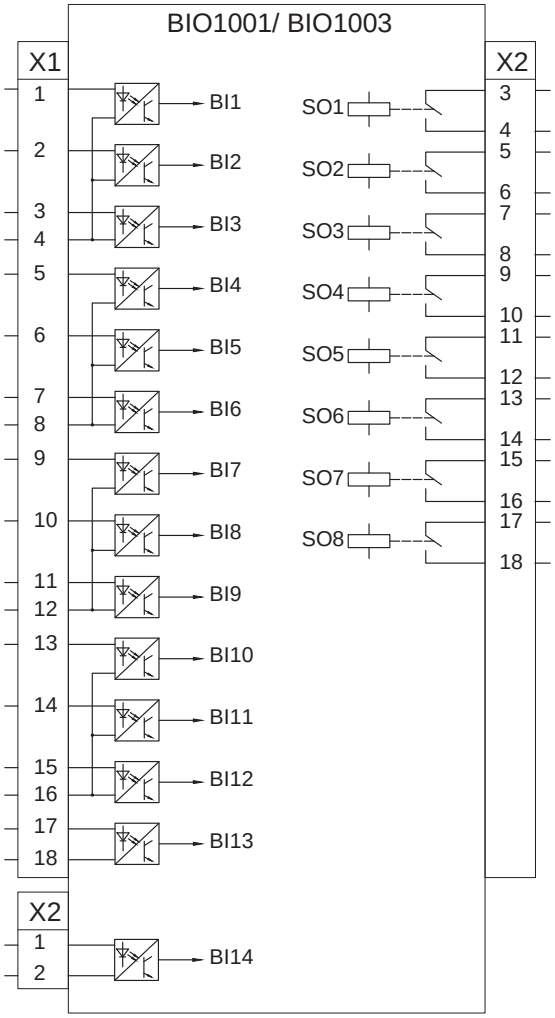



*Figure 39: BIO1001/BIO1003 modules*

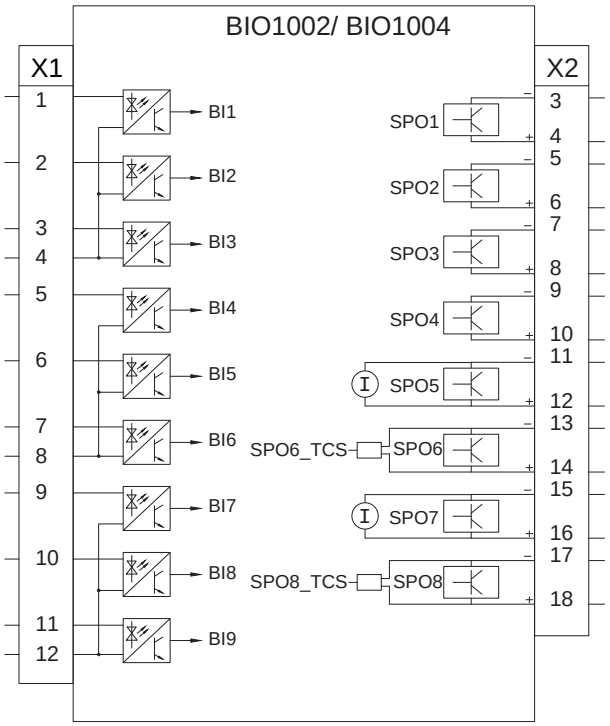



*Figure 40: BIO1002/BIO1004 modules*

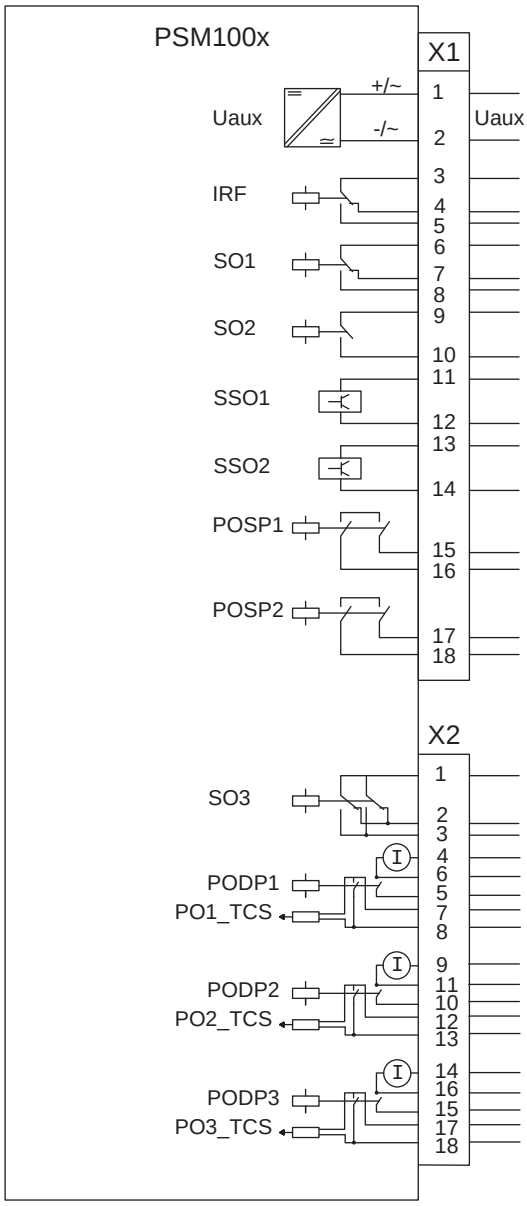



*Figure 41: PSM100x module*

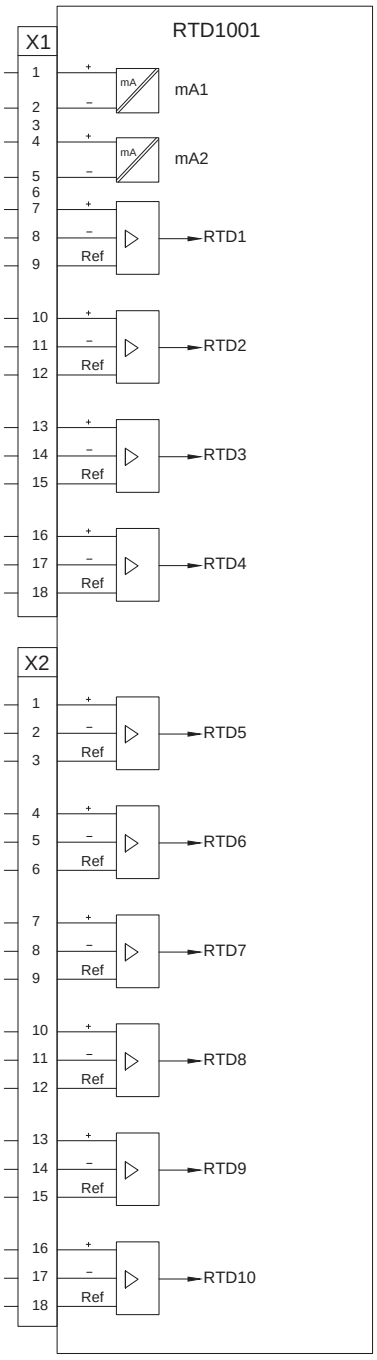



*Figure 42: RTD1001 module*

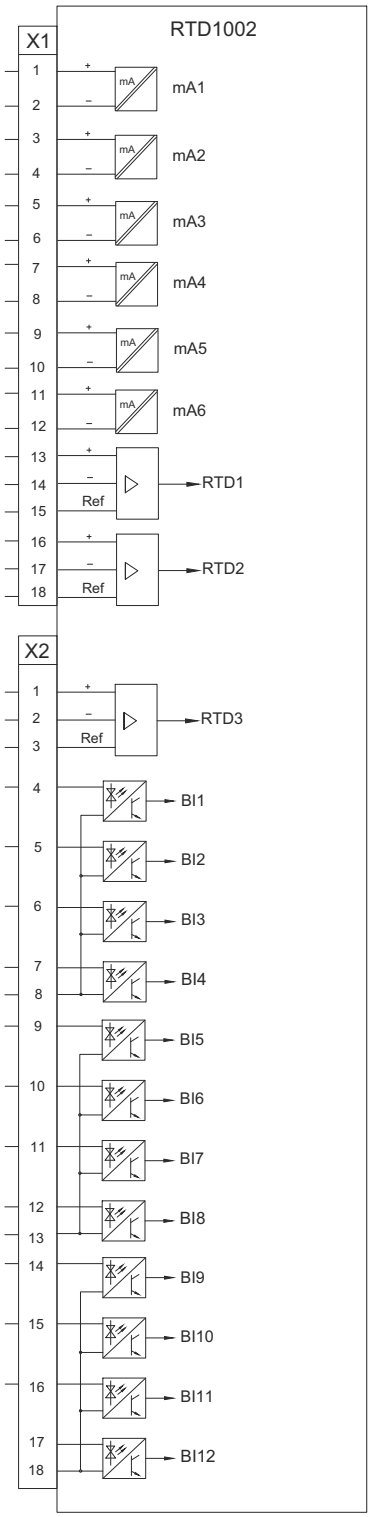



*Figure 43: RTD1002 module*

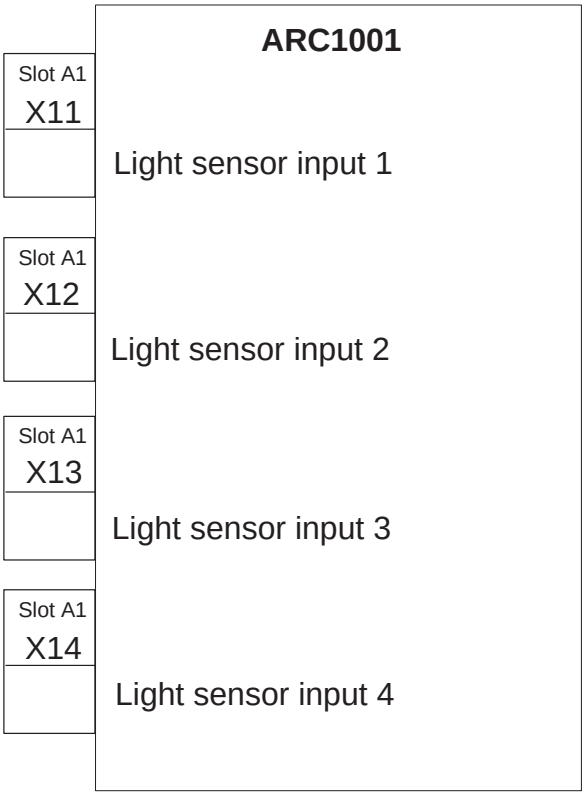



*Figure 44: Arc module*

## 32. Certificates

DNV GL has issued an IEC 61850 Edition 2 with Amendment 1 Certificate Level A1 for REX640 Protection and Control relay. Certificate number: 10358145-DSO 22-3007.

Additional certificates can be found on the *product page*.

## 33. References

The *www.abb.com/substationautomation* portal provides information on the entire range of distribution automation products and services.

The latest relevant information on the REX640 protection and control relay is found on the *product page*. Scroll down the page to find and download the related documentation.

## 34. Functions, codes and symbols

### Table 255: Functions included in the relay

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| **Protection** | | | |
| Distance protection | DSTPDIS | Z< | 21P,21N |
| Local acceleration logic | DSTPLAL | LAL | 21LAL |
| Scheme communication logic | DSOCPSCH | CL | 85 21SCHLGC |
| Current reversal and weak-end infeed logic | CRWPSCH | CLCRW | 85 21CREV,WEI |
| Communication logic for residual overcurrent | RESCPSCH | CLN | 85 67G/N SCHLGC |
| Current reversal and weak-end infeed logic for residual overcurrent | RCRWPSCH | CLCRWN | 85 67G/N CREV,WEI |
| Power swing detection | DSTRPSB | Zpsb | 68 |
| Line differential protection with inzone power transformer | LNPLDF | 3Id/I> | 87L |
| Binary signal transfer | BSTGAPC | BST | BST |
| Switch-onto-fault protection | CVPSOF | CVPSOF | SOTF |
| Three-phase non- directional overcurrent protection, low stage | PHLPTOC | 3I> | 51P-1 |
| Three-phase non- directional overcurrent protection, high stage | PHHPTOC | 3I>> | 51P-2 |
| Three-phase non- directional overcurrent protection, instantaneous stage | PHIPTOC | 3I>>> | 50P |
| Three-phase directional overcurrent protection, low stage | DPHLPDOC | 3I>-> | 67P/51P-1 |
| Three-phase directional overcurrent protection, high stage | DPHHPDOC | 3I>>-> | 67P/51P-2 |
| Non-directional earth-fault protection, low stage | EFLPTOC | Io> | 51G/51N-1 |
| Non-directional earth-fault protection, high stage | EFHPTOC | Io>> | 51N-2 |
| Non-directional earth-fault protection, instantaneous stage | EFIPTOC | Io>>> | 50G/50N |
| Directional earth-fault protection, low stage | DEFLPDEF | Io>-> | 67G/N-1 51G/N-1 |
| Directional earth-fault protection, high stage | DEFHPDEF | Io>>-> | 67G/N-1 51G/N-2 |
| Three-phase power directional element | DPSRDIR | I1 -> | 67P-TC |
| Neutral power directional element | DNZSRDIR | I2->,Io-> | 67N-TC |
| Admittance-based earth-fault protection | EFPADM | Yo>-> | 21YN |
| Multifrequency admittance-based earth-fault protection | MFADPSDE | Io>->Y | 67NYH |
| Wattmetric-based earth-fault protection | WPWDE | Po>-> | 32N |
| Transient/intermittent earth-fault protection | INTRPTEF | Io>->IEF | 67NTEF/NIEF |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Harmonics-based earth-fault protection | HAEFPTOC | Io>HA | 51NH |
| Touch voltage based earth-fault current protection | IFPTOC | IF>/UT> | 46SNQ/59N |
| Negative-sequence overcurrent protection | NSPTOC | I2>M | 46M |
| Phase discontinuity protection | PDNSPTOC | I2/I1> | 46PD |
| Residual overvoltage protection | ROVPTOV | Uo> | 59G/59N |
| Three-phase undervoltage protection | PHPTUV | 3U< | 27 |
| Three-phase overvoltage variation protection | PHVPTOV | 3Urms> | 59.S1 |
| Three-phase overvoltage protection | PHPTOV | 3U> | 59 |
| Positive-sequence overvoltage protection | PSPTOV | U1> | 59PS |
| Positive-sequence undervoltage protection | PSPTUV | U1< | 27PS |
| Negative-sequence overvoltage protection | NSPTOV | U2> | 47,59NS |
| Frequency protection | FRPFRQ | f>/f<,df/dt | 81 |
| Three-phase voltage-dependent overcurrent protection | PHPVOC | 3I(U)> | 51V |
| Overexcitation protection | OEPVPH | U/f> | 24 |
| Three-phase thermal protection for feeders, cables and distribution transformers | T1PTTR | 3Ith>F | 49F |
| Three-phase thermal overload protection, two time constants | T2PTTR | 3Ith>T/G/C | 49T/G/C |
| Three-phase overload protection for shunt capacitor banks | COLPTOC | 3I>3I< | 51,37,86C |
| Current unbalance protection for shunt capacitor banks | CUBPTOC | dI>C | 60N |
| Three-phase current unbalance protection for shunt capacitor banks | HCUBPTOC | 3dI>C | 60P |
| Shunt capacitor bank switching resonance protection, current based | SRCPTOC | TD> | 55ITHD |
| Compensated neutral unbalance voltage protection | CNUPTOV | CNU> | 59NU |
| Directional negative- sequence overcurrent protection | DNSPDOC | I2>-> | 67Q |
| Low-voltage ride- through protection | LVRTPTUV | UU | 27RT |
| Voltage vector shift protection | VVSPPAM | VS | 78VS |
| Directional reactive power undervoltage protection | DQPTUV | Q>-> ,3U< | 32Q,27 |
| Reverse power/ directional overpower protection | DOPPDPR | P>/Q> | 32R/32O |
| Underpower protection | DUPPDPR | P< | 32U |
| Three-phase under impedance protection | UZPDIS | ZZ | 21G |
| Directional negative sequence impedance protection | DNZPDIS | Z2-> | Z2Q |
| Three-phase under excitation protection | UEXPDIS | X< | 40 |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Third harmonic-based stator earth-fault protection | H3EFPSEF | dUo>/Uo3H | 64TN |
| Rotor earth-fault protection (injection method) | MREFPTOC | Io>R | 64R |
| Generator shaft leakage current | GSLPTOC | I>,GS | 38, 51 |
| Thermal overload protection for rotors | RPTTR | 3Ith>R | 49R |
| High-impedance or flux-balance based differential protection | MHZPDIF | 3dIHi>M | 87HIM |
| Out-of-step protection with double blinders | OOSRPSB | OOS | 78PS |
| Negative-sequence overcurrent protection for machines | MNSPTOC | I2>M | 46M |
| Loss of phase, undercurrent | PHPTUC | 3I< | 37 |
| Loss of load supervision | LOFLPTUC | 3I< | 37 |
| Motor load jam protection | JAMPTOC | Ist> | 50TDJAM |
| Motor start-up supervision | STTPMSU | Is2t n< | 49,66,48,50TDLR |
| Motor start counter | MSCPMRI | n< | 66 |
| Phase reversal protection | PREVPTOC | I2>> | 46R |
| Thermal overload protection for motors | MPTTR | 3Ith>M | 49M |
| Stabilized and instantaneous differential protection for machines | MPDIF | 3dI>M/G | 87M/87G |
| Underpower factor protection | MPUPF | PF< | 55U |
| Stabilized and instantaneous differential protection for two- or three- winding transformers | TR3PTDF | 3dI>3W | 87T3 |
| Stabilized and instantaneous differential protection for two-winding transformers | TR2PTDF | 3dI>T | 87T |
| Numerical stabilized low-impedance restricted earth-fault protection | LREFPNDF | dIoLo> | 87NLI |
| High-impedance based restricted earth- fault protection | HREFPDIF | dIoHi> | 87NHI |
| High-impedance differential protection for phase A | HIAPDIF | dHi_A> | 87_A |
| High-impedance differential protection for phase B | HIBPDIF | dHi_B> | 87_B |
| High-impedance differential protection for phase C | HICPDIF | dHi_C> | 87_C |
| Circuit breaker failure protection | CCBRBRF | 3I>/Io>BF | 50BF |
| Three-phase inrush detector | INRPHAR | 3I2f> | 68HB |
| Master trip | TRPPTRC | Master Trip | 94/86 |
| Arc protection | ARCSARC | ARC | AFD |
| High-impedance fault detection | PHIZ | HIF | HIZ |
| Cable Fault Detection | RCFD | CFD | CFD |
| Fault locator | SCEFRFLO | FLOC | FLOC |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Load-shedding and restoration | LSHDPFRQ | UFLS/R | 81LSH |
| Multipurpose protection | MAPGAPC | MAP | MAP |
| Accidental energization protection | GAEPVOC | U<,I> | 50/27 |
| Load blinder | LBRDOB | LB | 21LB |
| **Control** | | | |
| Circuit-breaker control | CBXCBR | I <-> O CB | 52 |
| Three-state disconnector control | P3SXSWI | I<->O P3S | 29DS/GS |
| Disconnector control | DCXSWI | I <-> O DCC | 29DS |
| Earthing switch control | ESXSWI | I <-> O ESC | 29GS |
| Three-state disconnector position indication | P3SSXSWI | I<->O P3SS | 29DS/GS |
| Disconnector position indication | DCSXSWI | I <-> O DC | 29DS |
| Earthing switch position indication | ESSXSWI | I <-> O ES | 29GS |
| Motor controlled earthing switch and disconnector supervision | ESDCSSWI | ESDCCM | 29CM |
| Emergency start-up | ESMGAPC | ESTART | EST,62 |
| Autoreclosing | DARREC | O->I | 79 |
| Autosynchronizer for generator breaker | ASGCSYN | AUTOSYNCG | 25AUTOSYNCG |
| Autosynchronizer for network breaker | ASNSCSYN | AUTOSYNC | 25AUTOSYNCBT/T |
| Autosynchronizer co-ordinator | ASCGAPC | AUTOSYNC | 25AUTOSYNC |
| Synchronism and energizing check | SECRSYN | SYNC | 25 |
| Tap changer control with voltage regulator | OL5ATCC | COLTC | 90V |
| Transformer data combiner | OLGAPC | OLGAPC | OLGAPC |
| Petersen coil controller | PASANCR | ANCR | 90 |
| High speed bus transfer | HSABTC | I<->O BT | HSBT |
| **Condition monitoring and supervision** | | | |
| Circuit-breaker condition monitoring | SSCBR | CBCM | 52CM |
| Hot-spot and insulation ageing rate monitoring for transformers | HSARSPTR | 3Ihp>T | 26/49HS |
| Trip circuit supervision | TCSSCBR | TCS | TCM |
| Current circuit supervision | CCSPVC | MCS 3I | CCM |
| Current circuit supervision for transformers | CTSRCTF | MCS 3I,I2 | CCM 3I,I2 |
| Current transformer supervision for high- impedance protection scheme for phase A | HZCCASPVC | MCS I_A | CCM_A |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Current transformer supervision for high- impedance protection scheme for phase B | HZCCBSPVC | MCS I_B | CCM_B |
| Current transformer supervision for high- impedance protection scheme for phase C | HZCCCSPVC | MCS I_C | CCM_C |
| Fuse failure supervision | SEQSPVC | FUSEF | VCM, 60 |
| Protection communication supervision | PCSITPC | PCS | PCS |
| Runtime counter for machines and devices | MDSOPT | OPTS | OPTM |
| Three-phase remanent undervoltage supervision | MSVPR | 3U<R | 27R |
| Diesel Generator Monitoring | DGMGAPC | P><,U/f >< | 32/40G |
| **Measurement** | | | |
| Three-phase current measurement | CMMXU | 3I | IA, IB, IC |
| Sequence current measurement | CSMSQI | I1, I2, I0 | I1, I2, I0 |
| Residual current measurement | RESCMMXU | Io | IG |
| Three-phase voltage measurement | VMMXU | 3U | VA, VB, VC |
| Single-phase voltage measurement | VAMMXU | U_A | V_A |
| Phase voltage measurement | VPHMMXU | 3UL | VL |
| Residual voltage measurement | RESVMMXU | Uo | VG/VN |
| Sequence voltage measurement | VSMSQI | U1, U2, U0 | V1, V2, V0 |
| Three-phase power and energy measurement | PEMMXU | P, E | P, E |
| Load profile recorder | LDPRLRC | LOADPROF | LOADPROF |
| Frequency measurement | FMMXU | f | f |
| Tap changer position indication | TPOSYLTC | TPOSM | 84T |
| **Power quality** | | | |
| Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics | CHMHAI | PQM3IH | PQM ITHD,IDC |
| Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics | VHMHAI | PQM3VH | PQM VTHD,VDC |
| Voltage variation | PHQVVR | PQMU | PQMV SWE,SAG,INT |
| Voltage unbalance | VSQVUB | PQUUB | PQMV UB |
| **Traditional LED indication** | | | |
| LED indication control | LEDPTRC | LEDPTRC | LEDPTRC |
| Individual virtual LED control | LED | LED | LED |
| **Logging functions** | | | |
| Disturbance recorder (common functionality) | RDRE | DR | RDRE |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Disturbance recorder, analog channels 1...12 | A1RADR | A1RADR | A1RADR |
| Disturbance recorder, analog channels 13...24 | A2RADR | A2RADR | A2RADR |
| Disturbance recorder, binary channels 1...32 | B1RBDR | B1RBDR | B1RBDR |
| Disturbance recorder, binary channels 33...64 | B2RBDR | B2RBDR | B2RBDR |
| Fault recorder | FLTRFRC | FAULTREC | FR |
| **Other functionality** | | | |
| Parameter setting groups | PROTECTION | PROTECTION | PROTECTION |
| Time master supervision | GNRLLTMS | TSYNC | TSYNC |
| Serial port supervision | SERLCCH | SERLCCH | SERLCCH |
| IEC 61850-1 MMS | MMSLPRT | MMS | MMS |
| IEC 61850-1 GOOSE | GSELPRT | GSE | GSE |
| IEC 60870-5-103 protocol | I3CLPRT | I3C | I3C |
| IEC 60870-5-104 protocol | I5CLPRT | I5C | I5C |
| DNP3 protocol | DNPLPRT | DNP 3.0 | DNP 3.0 |
| Modbus protocol | MBSLPRT | MBS | MBS |
| OR gate with two inputs | OR | OR | OR |
| OR gate with six inputs | OR6 | OR6 | OR6 |
| OR gate with twenty inputs | OR20 | OR20 | OR20 |
| AND gate with two inputs | AND | AND | AND |
| AND gate with six inputs | AND6 | AND6 | AND6 |
| AND gate with twenty inputs | AND20 | AND20 | AND20 |
| XOR gate with two inputs | XOR | XOR | XOR |
| NOT gate | NOT | NOT | NOT |
| Real maximum value selector | MAX3R | MAX3R | MAX3R |
| Real minimum value selector | MIN3R | MIN3R | MIN3R |
| Rising edge detector | R_TRIG | R_TRIG | R_TRIG |
| Falling edge detector | F_TRIG | F_TRIG | F_TRIG |
| Real switch selector | SWITCHR | SWITCHR | SWITCHR |
| Integer 32-bit switch selector | SWITCHI32 | SWITCHI32 | SWITCHI32 |
| SR flip-flop, volatile | SR | SR | SR |
| RS flip-flop, volatile | RS | RS | RS |
| Minimum pulse timer, two channels | TPGAPC | TP | 62TP |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Minimum pulse timer second resolution, two channels | TPSGAPC | TPS | 62TPS |
| Minimum pulse timer minutes resolution, two channels | TPMGAPC | TPM | 62TPM |
| Pulse counter for energy measurement | PCGAPC | PCGAPC | PCGAPC |
| Pulse timer, eight channels | PTGAPC | PT | 62PT |
| Time delay off, eight channels | TOFGAPC | TOF | 62TOF |
| Time delay on, eight channels | TONGAPC | TON | 62TON |
| Daily timer | DTMGAPC | DTM | DTM |
| Calendar function | CALGAPC | CAL | CAL |
| SR flip-flop, eight channels, nonvolatile | SRGAPC | SR | SR |
| Boolean value event creation | MVGAPC | MV | MV |
| Integer value event creation | MVI4GAPC | MVI4 | MVI4 |
| Analog value event creation with scaling | SCA4GAPC | SCA4 | SCA4 |
| Generic control points | SPCGAPC | SPC | SPCG |
| Generic up-down counter | UDFCNT | UDCNT | UDCNT |
| Local/Remote control | CONTROL | CONTROL | CONTROL |
| External HMI wake-up | EIHMI | EIHMI | EIHMI |
| Real addition | ADDR | ADDR | ADDR |
| Real subtraction | SUBR | SUBR | SUBR |
| Real multiplication | MULR | MULR | MULR |
| Real division | DIVR | DIVR | DIVR |
| Real equal comparator | EQR | EQR | EQR |
| Real not equal comparator | NER | NER | NER |
| Real greater than or equal comparator | GER | GER | GER |
| Real less than or equal comparator | LER | LER | LER |
| Voltage switch | VMSWI | VSWI | VSWI |
| Current sum | CMSUM | CSUM | CSUM |
| Current switch | CMSWI | CMSWI | CMSWI |
| Phase current preprocessing | ILTCTR | ILTCTR | ILTCTR |
| Residual current preprocessing | RESTCTR | RESTCTR | RESTCTR |
| Phase and residual voltage preprocessing | UTVTR | UTVTR | UTVTR |
| Residual current preprocessing, current measured as voltage | RESUTCTR | Io(U) | Io(U) |
| SMV stream receiver (IEC 61850-9-2LE) | SMVRCV | SMVRCV | SMVRCV |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| SMV stream sender (IEC 61850-9-2LE) | SMVSENDER | SMVSENDER | SMVSENDER |
| Redundant Ethernet channel supervison | RCHLCCH | RCHLCCH | RCHLCCH |
| Ethernet channel supervision | SCHLCCH | SCHLCCH | SCHLCCH |
| HMI Ethernet channel supervision | HMILCCH | HMILCCH | HMILCCH |
| Received GOOSE binary information | GOOSERCV_BIN | GOOSERCV_BIN | GOOSERCV_BIN |
| Received GOOSE double binary information | GOOSERCV_DP | GOOSERCV_DP | GOOSERCV_DP |
| Received GOOSE measured value information | GOOSERCV_MV | GOOSERCV_MV | GOOSERCV_MV |
| Received GOOSE 8- bit integer value information | GOOSERCV_INT8 | GOOSERCV_INT8 | GOOSERCV_INT8 |
| Received GOOSE 32- bit integer value information | GOOSERCV_INT32 | GOOSERCV_INT32 | GOOSERCV_INT32 |
| Received GOOSE interlocking information | GOOSERCV_INTL | GOOSERCV_INTL | GOOSERCV_INTL |
| Received GOOSE measured value (phasor) information | GOOSERCV_CMV | GOOSERCV_CMV | GOOSERCV_CMV |
| Received GOOSE enumerator value information | GOOSERCV_ENUM | GOOSERCV_ENUM | GOOSERCV_ENUM |
| Bad signal quality | QTY_BAD | QTY_BAD | QTY_BAD |
| Good signal quality | QTY_GOOD | QTY_GOOD | QTY_GOOD |
| Received GOOSE Test mode | QTY_GOOSE_TEST | QTY_GOOSE_TEST | QTY_GOOSE_TEST |
| GOOSE communication quality | QTY_GOOSE_COMM | QTY_GOOSE_COMM | QTY_GOOSE_COMM |
| GOOSE data health | T_HEALTH | T_HEALTH | T_HEALTH |
| Fault direction evaluation | T_DIR | T_DIR | T_DIR |
| Enumerator to boolean conversion | T_TCMD | T_TCMD | T_TCMD |
| 32-bit integer to binary command conversion | T_TCMD_BIN | T_TCMD_BIN | T_TCMD_BIN |
| Binary command to 32-bit integer conversion | T_BIN_TCMD | T_BIN_TCMD | T_BIN_TCMD |
| Switching device status decoder - CLOSE position | T_POS_CL | T_POS_CL | T_POS_CL |
| Switching device status decoder - OPEN position | T_POS_OP | T_POS_OP | T_POS_OP |
| Switching device status decoder - OK status | T_POS_OK | T_POS_OK | T_POS_OK |
| Controllable gate, 8 Channels | GATEGAPC | GATEGAPC | GATEGAPC |
| Security application | GSAL | GSAL | GSAL |
| Hotline tag | HLTGAPC | HLTGAPC | HLTGAPC |
| 16 settable 32-bit integer values | SETI32GAPC | SETI32GAPC | SETI32GAPC |
| 16 settable real values | SETRGAPC | SETRGAPC | SETRGAPC |
| Boolean to integer 32- bit conversion | T_B16_TO_I32 | T_B16_TO_I32 | T_B16_TO_I32 |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Integer 32-bit to boolean conversion | T_I32_TO_B16 | T_I32_TO_B16 | T_I32_TO_B16 |
| Integer 32-bit to real conversion | T_I32_TO_R | T_I32_TO_R | T_I32_TO_R |
| Real to integer 8-bit conversion | T_R_TO_I8 | T_R_TO_I8 | T_R_TO_I8 |
| Real to integer 32-bit conversion | T_R_TO_I32 | T_R_TO_I32 | T_R_TO_I32 |
| Constant FALSE | FALSE | FALSE | FALSE |
| Constant TRUE | TRUE | TRUE | TRUE |

## 35. Contents of application packages

REX640 offers comprehensive base functionality. However, it is possible to further adapt the product to meet special installation needs by including any number of the available optional application packages into a single REX640 relay. For the selected application packages, the functionality can be extended by including the related add-on package. The REX640 connectivity package guides the engineer in optimizing the application configuration and its performance.

**Table 256: Application packages**

| Description | ID |
|---|---|
| Feeder earth-fault protection extension package | APP1 |
| Feeder fault locator package | APP2 |
| Line distance protection package | APP3 |
| Line differential protection package | APP4 |
| Shunt capacitor protection package | APP5 |
| Interconnection protection package | APP6 |
| Machine protection package | APP7 |
| Power transformer protection package | APP8 |
| Busbar protection package | APP9 |
| OLTC control package | APP10 |
| Generator autosynchronizer package | APP11 |
| Network autosynchronizer package | APP12 |
| Petersen coil control package | APP13 |
| DG-set monitoring package | APP14 |
| HSTD for one stand-by feeder | APP51 |
| HSTD for two stand-by feeders | APP52 |
| HSTD for three equal feeders | APP53 |
| Synchronous machine add-on | ADD1 |
| 3-winding transformer add-on | ADD2 |

**Table 257: Base and optional functionality**

| IEC 61850 | Pcs | Base | APP 1 | APP 2 | APP 3 | APP 4 | APP 5 | APP 6 | APP 7 | APP 8 | APP 9 | APP 10 | APP 11 | APP 12 | APP 13 | APP 14 | APP 51 | APP 52 | APP 53 | ADD 1 | ADD 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Protection** | | | | | | | | | | | | | | | | | | | | | |
| DSTPDIS | 1 | | | | • | | | | | | | | | | | | | | | | |
| DSTPLAL | 1 | | | | • | | | | | | | | | | | | | | | | |
| DSOCPSCH | 1 | | | | • | | | | | | | | | | | | | | | | |
| CRWPSCH | 1 | | | | • | | | | | | | | | | | | | | | | |
| RESCPSCH | 1 | | | | • | | | | | | | | | | | | | | | | |
| RCRWPSCH | 1 | | | | • | | | | | | | | | | | | | | | | |
| DSTRPSB | 1 | | | | • | | | | | | | | | | | | | | | | |
| LNPLDF | 1 | | | | | • | | | | | | | | | | | | | | | |
| BSTGAPC | 4 | | | | • | • | | | | | | | | | | | | | | | |
| CVPSOF | 1 | • | | | | | | | | | | | | | | | | | | | |
| PHLPTOC | 5 | • | | | | | | | | | | | | | | | | | | | |
| PHHPTOC | 5 | • | | | | | | | | | | | | | | | | | | | |
| PHIPTOC | 5 | • | | | | | | | | | | | | | | | | | | | |
| DPHLPDOC | 5 | • | | | | | | | | | | | | | | | | | | | |
| DPHHPDOC | 5 | • | | | | | | | | | | | | | | | | | | | |
| EFLPTOC | 5 | • | | | | | | | | | | | | | | | | | | | |
| EFHPTOC | 5 | • | | | | | | | | | | | | | | | | | | | |
| EFIPTOC | 5 | • | | | | | | | | | | | | | | | | | | | |
| DEFLPDEF | 5 | • | | | | | | | | | | | | | | | | | | | |
| DEFHPDEF | 5 | • | | | | | | | | | | | | | | | | | | | |
| DPSRDIR | 4 | | | | | | | • | | | | • | | | | | | | | | |
| DNZSRDIR | 2 | | • | | | | | | | | | | | | | | | | | | |
| EFPADM | 3 | | • | | | | | | | | | | | | | | | | | | |
| MFADPSDE | 3 | | • | | | | | | | | | | | | | | | | | | |
| WPWDE | 3 | | • | | | | | | | | | | | | | | | | | | |
| INTRPTEF | 2 | | • | | | | | | | | | | | | | | | | | | |
| HAEFPTOC | 1 | | • | | | | | | | | | | | | | | | | | | |
| IFPTOC | 3 | | • | | | | | | | | | | | | | | | | | | |
| NSPTOC | 3 | • | | | | | | | | | | | | | | | | | | | |
| PDNSPTOC | 1 | • | | | | | | | | | | | | | | | | | | | |
| ROVPTOV | 4 | • | | | | | | | | | | | | | | | | | | | |
| PHPTUV | 5 | • | | | | | | | | | | | | | | | | | | | |
| PHVPTOV | 2 | | | | | | | • | | | | | | | | | | | | | |
| PHPTOV | 4 | • | | | | | | | | | | | | | | | | | | | |
| PSPTOV | 4 | • | | | | | | | | | | | | | | | | | | | |
| PSPTUV | 4 | • | | | | | | | | | | | | | | | | | | | |
| NSPTOV | 4 | • | | | | | | | | | | | | | | | | | | | |
| FRPFRQ | 12 | • | | | | | | | | | | | | | | | | | | | |
| PHPVOC | 5 | • | | | | | | | | | | | | | | | | | | | |
| OEPVPH | 2 | | | | | | | | | • | | | | | | | | | | • | |
| T1PTTR | 1 | • | | | | | | | | | | | | | | | | | | | |

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| IEC 61850 | Pcs | Base | APP 1 | APP 2 | APP 3 | APP 4 | APP 5 | APP 6 | APP 7 | APP 8 | APP 9 | APP 10 | APP 11 | APP 12 | APP 13 | APP 14 | APP 51 | APP 52 | APP 53 | ADD 1 | ADD 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T2PTTR | 1 | | | | | | | | | • | | | | | | | | | | • | |
| COLPTOC | 1 | | | | | | • | | | | | | | | | | | | | | |
| CUBPTOC | 3 | | | | | | • | | | | | | | | | | | | | | |
| HCUBPTOC | 2 | | | | | | • | | | | | | | | | | | | | | |
| SRCPTOC | 1 | | | | | | • | | | | | | | | | | | | | | |
| CNUPTOV | 2 | | | | | | • | | | | | | | | | | | | | | |
| DNSPDOC | 2 | • | | | | | | | | | | | | | | | | | | | |
| LVRTPTUV | 3 | | | | | | | • | | | | | | | | | | | | | |
| VVSPPAM | 3 | | | | | | | • | | | | | | | | | | | | | |
| DQPTUV | 2 | | | | | | | • | | | | | | | | | | | | | |
| DOPPDPR | 3 | | | | | | | • | • | • | | | | | | | | | | | |
| DUPPDPR | 3 | | | | | | | | | • | | | | | | | | | | • | |
| UZPDIS | 3 | | | | | | | | | • | | | | | | | | | | • | |
| DNZPDIS | 3 | • | | | | | | | | | | | | | | | | | | | |
| UEXPDIS | 2 | | | | | | | | | | | | | | | | | | | • | |
| H3EFPSEF | 1 | | | | | | | | | | | | | | | | | | | • | |
| MREFPTOC | 2 | | | | | | | | | | | | | | | | | | | • | |
| GSLPTOC | 1 | | | | | | | | | | | | | | | | | | | • | |
| RPTTR | 1 | | | | | | | | • | | | | | | | | | | | | |
| MHZPDIF | 1 | | | | | | | | • | | | | | | | | | | | | |
| OOSRPSB | 1 | | | | • | | | | | | | | | | | | | | | • | |
| MNSPTOC | 2 | | | | | | | | • | | | | | | | | | | | | |
| PHPTUC | 3 | • | | | | | | | | | | | | | | | | | | | |
| LOFLPTUC | 1 | | | | | | | | • | | | | | | | | | | | | |
| JAMPTOC | 2 | | | | | | | | • | | | | | | | | | | | | |
| STTPMSU | 1 | | | | | | | | • | | | | | | | | | | | | |
| MSCPMRI | 1 | | | | | | | | • | | | | | | | | | | | | |
| PREVPTOC | 1 | | | | | | | | • | | | | | | | | | | | | |
| MPTTR | 1 | | | | | | | | • | | | | | | | | | | | | |
| MPDIF | 1 | | | | | | | | • | | | | | | | | | | | | |
| MPUPF | 2 | | | | | | | • | | | | | | | | | | | | • | |
| TR3PTDF | 1 | | | | | | | | | | | | | | | | | | | | • |
| TR2PTDF | 1 | | | | | | | | | • | | | | | | | | | | | |
| LREFPNDF | 2 | • | | | | | | | | | | | | | | | | | | | |
| HREFPDIF | 2 | • | | | | | | | | | | | | | | | | | | | |
| HIAPDIF | 3 | | | | | | | | • | • | • | | | | | | | | | | |
| HIBPDIF | 3 | | | | | | | | • | • | • | | | | | | | | | | |
| HICPDIF | 3 | | | | | | | | • | • | • | | | | | | | | | | |
| CCBRBRF | 3 | • | | | | | | | | | | | | | | | | | | | |
| INRPHAR | 2 | • | | | | | | | | | | | | | | | | | | | |
| TRPPTRC | 6 | • | | | | | | | | | | | | | | | | | | | |
| ARCSARC | 4 | • | | | | | | | | | | | | | | | | | | | |
| PHIZ | 1 | | • | | | | | | | | | | | | | | | | | | |
| SCEFRFLO | 1 | | | • | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LSHDPFRQ | 6 | • | | | | | | | | | | | | | | | | | | | |
| MAPGAPC | 24 | • | | | | | | | | | | | | | | | | | | | |
| GAEPVOC | 1 | | | | | | | | | | | | | | | | | | | • | |
| LBRDOB | 1 | • | | | | | | | | | | | | | | | | | | | |
| **Control** | | | | | | | | | | | | | | | | | | | | | |
| CBXCBR | 3 | • | | | | | | | | | | | | | | | | | | | |
| CBXCBR | 2 | | | | | | | | | | | | | | | | • | • | • | | |
| P3SXSWI | 6 | • | | | | | | | | | | | | | | | | | | | |
| DCXSWI | 8 | • | | | | | | | | | | | | | | | | | | | |
| ESXSWI | 3 | • | | | | | | | | | | | | | | | | | | | |
| P3SSXSWI | 6 | • | | | | | | | | | | | | | | | | | | | |
| DCSXSWI | 8 | • | | | | | | | | | | | | | | | | | | | |
| ESSXSWI | 3 | • | | | | | | | | | | | | | | | | | | | |
| ESMGAPC | 1 | | | | | | | | • | | | | | | | | | | | | |
| DARREC | 2 | • | | | | | | | | | | | | | | | | | | | |
| ASGCSYN | 1 | | | | | | | | | | | | • | | | | | | | | |
| ASNSCSYN | 3 | | | | | | | | | | | | | • | | | | | | | |
| ASCGAPC | 1 | • | | | | | | | | | | | | | | | | | | | |
| SECRSYN | 4 | • | | | | | | | | | | | | | | | | | | | |
| OL5ATCC | 1 | | | | | | | | | | | • | | | | | | | | | |
| OLGAPC | 5 | | | | | | | | | | | • | | | | | | | | | |
| PASANCR | 1 | | | | | | | | | | | | | | • | | | | | | |
| HSABTC | 1 | | | | | | | | | | | | | | | | • | | | | |
| HSABTC | 2 | | | | | | | | | | | | | | | | | • | | | |
| HSABTC | 3 | | | | | | | | | | | | | | | | | | • | | |
| **Condition monitoring and supervision** | | | | | | | | | | | | | | | | | | | | | |
| SSCBR | 3 | • | | | | | | | | | | | | | | | | | | | |
| ESDCSSWI | 11 | • | | | | | | | | | | | | | | | | | | | |
| HSARSPTR | 1 | | | | | | | | | • | | | | | | | | | | | |
| RCFD | 3 | • | | | | | | | | | | | | | | | | | | | |
| TCSSCBR | 6 | • | | | | | | | | | | | | | | | | | | | |
| CCSPVC | 5 | • | | | | | | | | | | | | | | | | | | | |
| CTSRCTF | 1 | | | | | | | | | • | | | | | | | | | | | |
| HZCCASPVC | 3 | | | | | | | | | | • | | | | | | | | | | |
| HZCCBSPVC | 3 | | | | | | | | | | • | | | | | | | | | | |
| HZCCCSPVC | 3 | | | | | | | | | | • | | | | | | | | | | |
| SEQSPVC | 7 | • | | | | | | | | | | | | | | | | | | | |
| PCSITPC | 2 | | | | • | • | | | | | | | | | | | | | | | |
| MDSOPT | 2 | • | | | | | | | | | | | | | | | | | | | |
| MSVPR | 3 | • | | | | | | | | | | | | | | | | | | | |
| DGMGAPC | 1 | | | | | | | | | | | | | | | • | | | | | |
| **Measure-ment** | | | | | | | | | | | | | | | | | | | | | |
| CMMXU | 8 | • | | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CSMSQI | 8 | ● | | | | | | | | | | | | | | | | | | | |
| RESCMMXU | 8 | ● | | | | | | | | | | | | | | | | | | | |
| VMMXU | 8 | ● | | | | | | | | | | | | | | | | | | | |
| VAMMXU | 4 | ● | | | | | | | | | | | | | | | | | | | |
| VPHMMXU | 2 | ● | | | | | | | | | | | | | | | | | | | |
| RESVMMXU | 8 | ● | | | | | | | | | | | | | | | | | | | |
| VSMSQI | 8 | ● | | | | | | | | | | | | | | | | | | | |
| PEMMXU | 3 | ● | | | | | | | | | | | | | | | | | | | |
| LDPRLRC | 1 | ● | | | | | | | | | | | | | | | | | | | |
| FMMXU | 5 | ● | | | | | | | | | | | | | | | | | | | |
| TPOSYLTC | 1 | | | | | | | | | ● | | ● | | | | | | | | | |
| **Power quality** | | | | | | | | | | | | | | | | | | | | | |
| CHMHAI | 2 | ● | | | | | | | | | | | | | | | | | | | |
| VHMHAI | 2 | ● | | | | | | | | | | | | | | | | | | | |
| PHQVVR | 2 | ● | | | | | | | | | | | | | | | | | | | |
| VSQVUB | 2 | ● | | | | | | | | | | | | | | | | | | | |
| **Traditional LED indication** | | | | | | | | | | | | | | | | | | | | | |
| LEDPTRC | 1 | ● | | | | | | | | | | | | | | | | | | | |
| LED | 66 | ● | | | | | | | | | | | | | | | | | | | |
| **Logging functions** | | | | | | | | | | | | | | | | | | | | | |
| RDRE | 1 | ● | | | | | | | | | | | | | | | | | | | |
| A1RADR | 1 | ● | | | | | | | | | | | | | | | | | | | |
| A2RADR | 1 | ● | | | | | | | | | | | | | | | | | | | |
| B1RBDR | 1 | ● | | | | | | | | | | | | | | | | | | | |
| B2RBDR | 1 | ● | | | | | | | | | | | | | | | | | | | |
| FLTRFRC | 1 | ● | | | | | | | | | | | | | | | | | | | |
| **Other functionality** | | | | | | | | | | | | | | | | | | | | | |
| PROTECTION | 1 | ● | | | | | | | | | | | | | | | | | | | |
| GNRLLTMS | 1 | ● | | | | | | | | | | | | | | | | | | | |
| SERLCCH | 2 | ● | | | | | | | | | | | | | | | | | | | |
| MMSLPRT | 1 | ● | | | | | | | | | | | | | | | | | | | |
| GSELPRT | 1 | ● | | | | | | | | | | | | | | | | | | | |
| I3CLPRT | 2 | ● | | | | | | | | | | | | | | | | | | | |
| I5CLPRT | 5 | ● | | | | | | | | | | | | | | | | | | | |
| DNPLPRT | 5 | ● | | | | | | | | | | | | | | | | | | | |
| MBSLPRT | 5 | ● | | | | | | | | | | | | | | | | | | | |
| OR | 400 | ● | | | | | | | | | | | | | | | | | | | |
| OR6 | 400 | ● | | | | | | | | | | | | | | | | | | | |
| OR20 | 20 | ● | | | | | | | | | | | | | | | | | | | |
| AND | 400 | ● | | | | | | | | | | | | | | | | | | | |
| AND6 | 400 | ● | | | | | | | | | | | | | | | | | | | |
| AND20 | 20 | ● | | | | | | | | | | | | | | | | | | | |
| XOR | 400 | ● | | | | | | | | | | | | | | | | | | | |
| NOT | 400 | ● | | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX3R | 20 | ● | | | | | | | | | | | | | | | | | | | |
| MIN3R | 20 | ● | | | | | | | | | | | | | | | | | | | |
| R_TRIG | 10 | ● | | | | | | | | | | | | | | | | | | | |
| F_TRIG | 10 | ● | | | | | | | | | | | | | | | | | | | |
| SWITCHR | 30 | ● | | | | | | | | | | | | | | | | | | | |
| SWITCHI32 | 30 | ● | | | | | | | | | | | | | | | | | | | |
| SR | 30 | ● | | | | | | | | | | | | | | | | | | | |
| RS | 30 | ● | | | | | | | | | | | | | | | | | | | |
| TPGAPC | 4 | ● | | | | | | | | | | | | | | | | | | | |
| TPSGAPC | 2 | ● | | | | | | | | | | | | | | | | | | | |
| TPMGAPC | 2 | ● | | | | | | | | | | | | | | | | | | | |
| PCGAPC | 4 | ● | | | | | | | | | | | | | | | | | | | |
| PTGAPC | 10 | ● | | | | | | | | | | | | | | | | | | | |
| TOFGAPC | 10 | ● | | | | | | | | | | | | | | | | | | | |
| TONGAPC | 10 | ● | | | | | | | | | | | | | | | | | | | |
| DTMGAPC | 4 | ● | | | | | | | | | | | | | | | | | | | |
| CALGAPC | 4 | ● | | | | | | | | | | | | | | | | | | | |
| SRGAPC | 4 | ● | | | | | | | | | | | | | | | | | | | |
| MVGAPC | 16 | ● | | | | | | | | | | | | | | | | | | | |
| MVI4GAPC | 4 | ● | | | | | | | | | | | | | | | | | | | |
| SCA4GAPC | 24 | ● | | | | | | | | | | | | | | | | | | | |
| SPCGAPC | 6 | ● | | | | | | | | | | | | | | | | | | | |
| UDFCNT | 12 | ● | | | | | | | | | | | | | | | | | | | |
| CONTROL | 1 | ● | | | | | | | | | | | | | | | | | | | |
| EIHMI | 1 | ● | | | | | | | | | | | | | | | | | | | |
| ADDR | 10 | ● | | | | | | | | | | | | | | | | | | | |
| SUBR | 10 | ● | | | | | | | | | | | | | | | | | | | |
| MULR | 10 | ● | | | | | | | | | | | | | | | | | | | |
| DIVR | 10 | ● | | | | | | | | | | | | | | | | | | | |
| EQR | 10 | ● | | | | | | | | | | | | | | | | | | | |
| NER | 10 | ● | | | | | | | | | | | | | | | | | | | |
| GER | 10 | ● | | | | | | | | | | | | | | | | | | | |
| LER | 10 | ● | | | | | | | | | | | | | | | | | | | |
| VMSWI | 3 | ● | | | | | | | | | | | | | | | | | | | |
| CMSUM | 1 | ● | | | | | | | | | | | | | | | | | | | |
| CMSWI | 3 | ● | | | | | | | | | | | | | | | | | | | |
| ILTCTR | 8 | ● | | | | | | | | | | | | | | | | | | | |
| RESTCTR | 8 | ● | | | | | | | | | | | | | | | | | | | |
| UTVTR | 8 | ● | | | | | | | | | | | | | | | | | | | |
| RESUTCTR | 1 | ● | | | | | | | | | | | | | | | | | | | |
| SMVRCV | 4 | ● | | | | | | | | | | | | | | | | | | | |
| SMVSENDER | 1 | ● | | | | | | | | | | | | | | | | | | | |
| RCHLCCH | 1 | ● | | | | | | | | | | | | | | | | | | | |
| SCHLCCH | 5 | ● | | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HMILCCH | 1 | ● | | | | | | | | | | | | | | | | | | | |
| GOOSERCV_BIN | 200 | ● | | | | | | | | | | | | | | | | | | | |
| GOOSERCV_DP | 100 | ● | | | | | | | | | | | | | | | | | | | |
| GOOSERCV_MV | 50 | ● | | | | | | | | | | | | | | | | | | | |
| GOOSERCV_INT8 | 50 | ● | | | | | | | | | | | | | | | | | | | |
| GOOSERCV_INT32 | 50 | ● | | | | | | | | | | | | | | | | | | | |
| GOOSERCV_INTL | 100 | ● | | | | | | | | | | | | | | | | | | | |
| GOOSERCV_CMV | 9 | ● | | | | | | | | | | | | | | | | | | | |
| GOOSERCV_ENUM | 100 | ● | | | | | | | | | | | | | | | | | | | |
| QTY_BAD | 20 | ● | | | | | | | | | | | | | | | | | | | |
| QTY_GOOD | 20 | ● | | | | | | | | | | | | | | | | | | | |
| QTY_GOOSE_COMM | 100 | ● | | | | | | | | | | | | | | | | | | | |
| T_HEALTH | 100 | ● | | | | | | | | | | | | | | | | | | | |
| T_DIR | 50 | ● | | | | | | | | | | | | | | | | | | | |
| T_TCMD | 100 | ● | | | | | | | | | | | | | | | | | | | |
| T_TCMD_BIN | 100 | ● | | | | | | | | | | | | | | | | | | | |
| T_BIN_TCMD | 100 | ● | | | | | | | | | | | | | | | | | | | |
| T_POS_CL | 150 | ● | | | | | | | | | | | | | | | | | | | |
| T_POS_OP | 150 | ● | | | | | | | | | | | | | | | | | | | |
| T_POS_OK | 150 | ● | | | | | | | | | | | | | | | | | | | |
| GATEGAPC | 1 | ● | | | | | | | | | | | | | | | | | | | |
| GSAL | 1 | ● | | | | | | | | | | | | | | | | | | | |
| HLTGAPC | 1 | ● | | | | | | | | | | | | | | | | | | | |
| SETI32GAPC | 2 | ● | | | | | | | | | | | | | | | | | | | |
| SETRGAPC | 2 | ● | | | | | | | | | | | | | | | | | | | |
| T_B16_TO_I32 | 10 | ● | | | | | | | | | | | | | | | | | | | |
| T_I32_TO_B16 | 10 | ● | | | | | | | | | | | | | | | | | | | |
| T_I32_TO_R | 10 | ● | | | | | | | | | | | | | | | | | | | |
| T_R_TO_I8 | 10 | ● | | | | | | | | | | | | | | | | | | | |
| T_R_TO_I32 | 10 | ● | | | | | | | | | | | | | | | | | | | |
| FALSE | 10 | ● | | | | | | | | | | | | | | | | | | | |
| TRUE | 10 | ● | | | | | | | | | | | | | | | | | | | |

## 36. Document revision history

| Document revision/date | Product connectivity level | History |
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| B/2019-03-27 | PCL1 | Content updated |
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1MRS759144 J

RELION® PROTECTION AND CONTROL

# REX640

## Technical Manual







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## Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2014/35/EU). This conformity is the result of tests conducted by the third party testing laboratory Intertek in accordance with the product standard EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The product is designed in accordance with the international standards of the IEC 60255 series.

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# 1 Introduction

## 1.1 This manual

The technical manual contains application and functionality descriptions and lists function blocks, logic diagrams, input and output signals, setting parameters and technical data sorted per function. The manual can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

## 1.2 Intended audience

This manual addresses system engineers and installation and commissioning personnel, who use technical data during engineering, installation and commissioning, and in normal service.

The system engineer must have a thorough knowledge of protection systems, protection equipment, protection functions and the configured functional logic in the protection relays. The installation and commissioning personnel must have a basic knowledge in handling electronic equipment.

# 1.3 Product documentation

## 1.3.1 Product documentation set

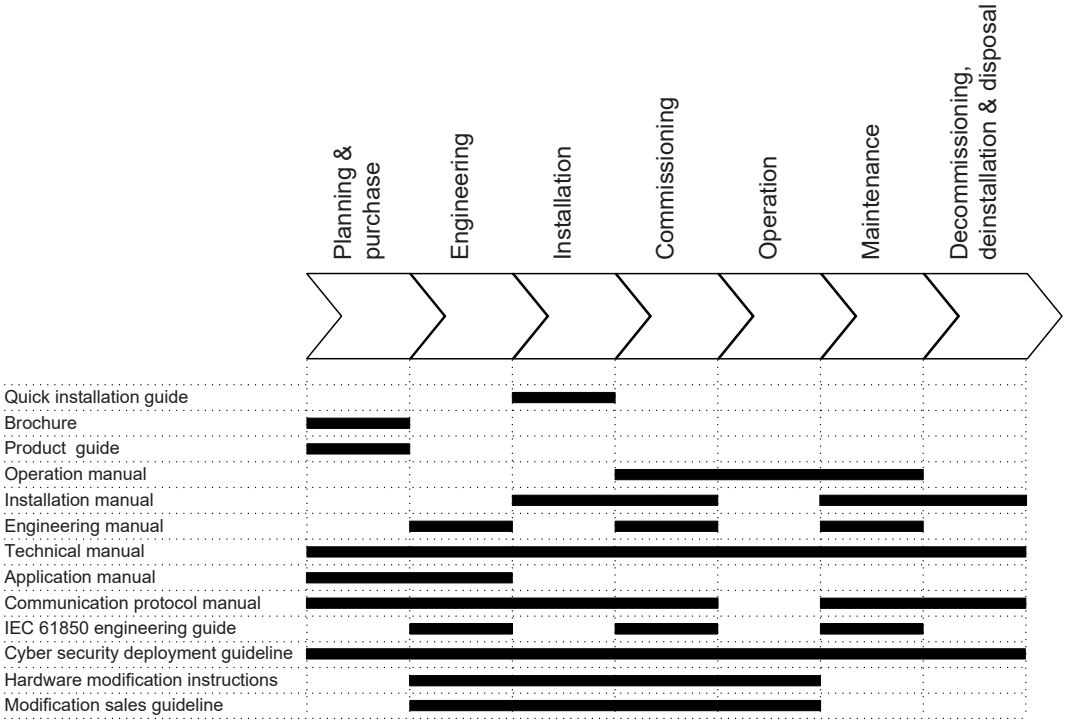



*Figure 1: The intended use of documents during the product life cycle*

## 1.3.2 Document revision history

| Document revision/ date | Product connectivity level | History |
|---|---|---|
| A/2018-12-14 | PCL1 | First release |
| B/2019-03-27 | PCL1 | Content updated |
| C/2019-08-15 | PCL1 | Content updated |
| D/2020-02-13 | PCL2 | Content updated to correspond to the product connectivity level |
| E/2020-12-09 | PCL3 | Content updated to correspond to the product connectivity level |
| F/2023-02-07 | PCL4 | Content updated to correspond to the product connectivity level |

### 1.3.3 Related documentation

| Name of the document | Document ID |
|---|---|
| TISSUES Implementation Conformance Statement (TICS) for the IEC 61850 interface in REX640 | 1MRS759027 |
| Protocol Implementation extra Information for Testing (PIX-IT) for the IEC 61850 interface in REX640 | 1MRS759030 |
| Protocol Implementation extra Information for Testing (PIX-IT) for the IEC 61850 9–2LE interface in REX640 | 1MRS759037 |
| Protocol Implementation Conformance Statement (PICS) for the IEC 61850 interface in REX640 | 1MRS759029 |
| IEC 61850 Ed2 Model Implementation Conformance Statement (MICS) for REX640 | 1MRS759028 |

Download the latest documents from the ABB Web site *www.abb.com/mediumvoltage*.

## 1.4 Symbols and conventions

### 1.4.1 Symbols



The electrical warning icon indicates the presence of a hazard which could result in electrical shock.



The warning icon indicates the presence of a hazard which could result in personal injury.



The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.



The information icon alerts the reader of important facts and conditions.



The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

### 1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms are spelled out in the glossary. The glossary also contains definitions of important terms.
- Menu paths are presented in bold.

  Select **Main menu** > **Settings**.
- Parameter names are shown in italics.

  The function can be enabled and disabled with the *Operation* setting
- Parameter values are indicated with quotation marks.

  The corresponding parameter values are "On" and "Off".
- Input/output messages and monitored data names are shown in Courier font.

  When the function starts, the `START` output is set to TRUE.
- Values of quantities are expressed with a number and an SI unit. The corresponding imperial units may be given in parentheses.
- This document assumes that the parameter setting visibility is "Advanced".
- Protective earthing is indicated in figures with the symbol ⏚.

## 1.4.3 Functions, codes and symbols

**Table 1: Functions included in the relay**

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| **Protection** | | | |
| Distance protection | DSTPDIS | Z< | 21P,21N |
| Local acceleration logic | DSTPLAL | LAL | 21LAL |
| Scheme communication logic | DSOCPSCH | CL | 85 21SCHLGC |
| Current reversal and weak-end infeed logic | CRWPSCH | CLCRW | 85 21CREV,WEI |
| Communication logic for residual overcurrent | RESCPSCH | CLN | 85 67G/N SCHLGC |
| Current reversal and weak-end infeed logic for residual overcurrent | RCRWPSCH | CLCRWN | 85 67G/N CREV,WEI |
| Power swing detection | DSTRPSB | Zpsb | 68 |
| Line differential protection with inzone power transformer | LNPLDF | 3Id/I> | 87L |
| Binary signal transfer | BSTGAPC | BST | BST |
| Switch-onto-fault protection | CVPSOF | CVPSOF | SOTF |
| Three-phase non- directional overcurrent protection, low stage | PHLPTOC | 3I> | 51P-1 |
| Three-phase non- directional overcurrent protection, high stage | PHHPTOC | 3I>> | 51P-2 |
| Three-phase non- directional overcurrent protection, instantaneous stage | PHIPTOC | 3I>>> | 50P |
| Three-phase directional overcurrent protection, low stage | DPHLPDOC | 3I>-> | 67P/51P-1 |
| Three-phase directional overcurrent protection, high stage | DPHHPDOC | 3I>>-> | 67P/51P-2 |
| Non-directional earth-fault protection, low stage | EFLPTOC | Io> | 51G/51N-1 |
| Non-directional earth-fault protection, high stage | EFHPTOC | Io>> | 51N-2 |
| Non-directional earth-fault protection, instantaneous stage | EFIPTOC | Io>>> | 50G/50N |
| Directional earth-fault protection, low stage | DEFLPDEF | Io>-> | 67G/N-1 51G/N-1 |
| Directional earth-fault protection, high stage | DEFHPDEF | Io>>-> | 67G/N-1 51G/N-2 |
| Three-phase power directional element | DPSRDIR | I1 -> | 67P-TC |
| Neutral power directional element | DNZSRDIR | I2->,Io-> | 67N-TC |
| Admittance-based earth-fault protection | EFPADM | Yo>-> | 21YN |
| Multifrequency admittance-based earth-fault protection | MFADPSDE | Io>->Y | 67NYH |
| Wattmetric-based earth-fault protection | WPWDE | Po>-> | 32N |
| Transient/intermittent earth-fault protection | INTRPTEF | Io>->IEF | 67NTEF/NIEF |
| Harmonics-based earth-fault protection | HAEFPTOC | Io>HA | 51NH |
| Touch voltage based earth-fault current protection | IFPTOC | IF>/UT> | 46SNQ/59N |
| Negative-sequence overcurrent protection | NSPTOC | I2>M | 46M |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Phase discontinuity protection | PDNSPTOC | I2/I1> | 46PD |
| Residual overvoltage protection | ROVPTOV | Uo> | 59G/59N |
| Three-phase undervoltage protection | PHPTUV | 3U< | 27 |
| Three-phase overvoltage variation protection | PHVPTOV | 3Urms> | 59.S1 |
| Three-phase overvoltage protection | PHPTOV | 3U> | 59 |
| Positive-sequence overvoltage protection | PSPTOV | U1> | 59PS |
| Positive-sequence undervoltage protection | PSPTUV | U1< | 27PS |
| Negative-sequence overvoltage protection | NSPTOV | U2> | 47,59NS |
| Frequency protection | FRPFRQ | f>/f<,df/dt | 81 |
| Three-phase voltage-dependent overcurrent protection | PHPVOC | 3I(U)> | 51V |
| Overexcitation protection | OEPVPH | U/f> | 24 |
| Three-phase thermal protection for feeders, cables and distribution transformers | T1PTTR | 3Ith>F | 49F |
| Three-phase thermal overload protection, two time constants | T2PTTR | 3Ith>T/G/C | 49T/G/C |
| Three-phase overload protection for shunt capacitor banks | COLPTOC | 3I>3I< | 51,37,86C |
| Current unbalance protection for shunt capacitor banks | CUBPTOC | dI>C | 60N |
| Three-phase current unbalance protection for shunt capacitor banks | HCUBPTOC | 3dI>C | 60P |
| Shunt capacitor bank switching resonance protection, current based | SRCPTOC | TD> | 55ITHD |
| Compensated neutral unbalance voltage protection | CNUPTOV | CNU> | 59NU |
| Directional negative- sequence overcurrent protection | DNSPDOC | I2>-> | 67Q |
| Low-voltage ride- through protection | LVRTPTUV | UU | 27RT |
| Voltage vector shift protection | VVSPPAM | VS | 78VS |
| Directional reactive power undervoltage protection | DQPTUV | Q>-> ,3U< | 32Q,27 |
| Reverse power/ directional overpower protection | DOPPDPR | P>/Q> | 32R/32O |
| Underpower protection | DUPPDPR | P< | 32U |
| Three-phase under impedance protection | UZPDIS | ZZ | 21G |
| Directional negative sequence impedance protection | DNZPDIS | Z2-> | Z2Q |
| Three-phase under excitation protection | UEXPDIS | X< | 40 |
| Third harmonic-based stator earth-fault protection | H3EFPSEF | dUo>/Uo3H | 64TN |
| Rotor earth-fault protection (injection method) | MREFPTOC | Io>R | 64R |
| Generator shaft leakage current | GSLPTOC | I>,GS | 38, 51 |
| Thermal overload protection for rotors | RPTTR | 3Ith>R | 49R |
| High-impedance or flux-balance based differential protection | MHZPDIF | 3dIHi>M | 87HIM |
| Out-of-step protection with double blinders | OOSRPSB | OOS | 78PS |
| Negative-sequence overcurrent protection for machines | MNSPTOC | I2>M | 46M |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Loss of phase, undercurrent | PHPTUC | 3I< | 37 |
| Loss of load supervision | LOFLPTUC | 3I< | 37 |
| Motor load jam protection | JAMPTOC | Ist> | 50TDJAM |
| Motor start-up supervision | STTPMSU | Is2t n< | 49,66,48,50TDLR |
| Motor start counter | MSCPMRI | n< | 66 |
| Phase reversal protection | PREVPTOC | I2>> | 46R |
| Thermal overload protection for motors | MPTTR | 3Ith>M | 49M |
| Stabilized and instantaneous differential protection for machines | MPDIF | 3dI>M/G | 87M/87G |
| Underpower factor protection | MPUPF | PF< | 55U |
| Stabilized and instantaneous differential protection for two- or three- winding transformers | TR3PTDF | 3dI>3W | 87T3 |
| Stabilized and instantaneous differential protection for two-winding transformers | TR2PTDF | 3dI>T | 87T |
| Numerical stabilized low-impedance restricted earth-fault protection | LREFPNDF | dIoLo> | 87NLI |
| High-impedance based restricted earth- fault protection | HREFPDIF | dIoHi> | 87NHI |
| High-impedance differential protection for phase A | HIAPDIF | dHi_A> | 87_A |
| High-impedance differential protection for phase B | HIBPDIF | dHi_B> | 87_B |
| High-impedance differential protection for phase C | HICPDIF | dHi_C> | 87_C |
| Circuit breaker failure protection | CCBRBRF | 3I>/Io>BF | 50BF |
| Three-phase inrush detector | INRPHAR | 3I2f> | 68HB |
| Master trip | TRPPTRC | Master Trip | 94/86 |
| Arc protection | ARCSARC | ARC | AFD |
| High-impedance fault detection | PHIZ | HIF | HIZ |
| Cable Fault Detection | RCFD | CFD | CFD |
| Fault locator | SCEFRFLO | FLOC | FLOC |
| Load-shedding and restoration | LSHDPFRQ | UFLS/R | 81LSH |
| Multipurpose protection | MAPGAPC | MAP | MAP |
| Accidental energization protection | GAEPVOC | U<,I> | 50/27 |
| Load blinder | LBRDOB | LB | 21LB |
| **Control** | | | |
| Circuit-breaker control | CBXCBR | I <-> O CB | 52 |
| Three-state disconnector control | P3SXSWI | I<->O P3S | 29DS/GS |
| Disconnector control | DCXSWI | I <-> O DCC | 29DS |
| Earthing switch control | ESXSWI | I <-> O ESC | 29GS |
| Three-state disconnector position indication | P3SSXSWI | I<->O P3SS | 29DS/GS |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Disconnector position indication | DCSXSWI | I <-> O DC | 29DS |
| Earthing switch position indication | ESSXSWI | I <-> O ES | 29GS |
| Motor controlled earthing switch and disconnector supervision | ESDCSSWI | ESDCCM | 29CM |
| Emergency start-up | ESMGAPC | ESTART | EST,62 |
| Autoreclosing | DARREC | O->I | 79 |
| Autosynchronizer for generator breaker | ASGCSYN | AUTOSYNCG | 25AUTOSYNCG |
| Autosynchronizer for network breaker | ASNSCSYN | AUTOSYNC | 25AUTOSYNCBT/T |
| Autosynchronizer co-ordinator | ASCGAPC | AUTOSYNC | 25AUTOSYNC |
| Synchronism and energizing check | SECRSYN | SYNC | 25 |
| Tap changer control with voltage regulator | OL5ATCC | COLTC | 90V |
| Transformer data combiner | OLGAPC | OLGAPC | OLGAPC |
| Petersen coil controller | PASANCR | ANCR | 90 |
| High speed bus transfer | HSABTC | I<->O BT | HSBT |
| **Condition monitoring and supervision** | | | |
| Circuit-breaker condition monitoring | SSCBR | CBCM | 52CM |
| Hot-spot and insulation ageing rate monitoring for transformers | HSARSPTR | 3Ihp>T | 26/49HS |
| Trip circuit supervision | TCSSCBR | TCS | TCM |
| Current circuit supervision | CCSPVC | MCS 3I | CCM |
| Current circuit supervision for transformers | CTSRCTF | MCS 3I,I2 | CCM 3I,I2 |
| Current transformer supervision for high- impedance protection scheme for phase A | HZCCASPVC | MCS I_A | CCM_A |
| Current transformer supervision for high- impedance protection scheme for phase B | HZCCBSPVC | MCS I_B | CCM_B |
| Current transformer supervision for high- impedance protection scheme for phase C | HZCCCSPVC | MCS I_C | CCM_C |
| Fuse failure supervision | SEQSPVC | FUSEF | VCM, 60 |
| Protection communication supervision | PCSITPC | PCS | PCS |
| Runtime counter for machines and devices | MDSOPT | OPTS | OPTM |
| Three-phase remanent undervoltage supervision | MSVPR | 3U<R | 27R |
| Diesel Generator Monitoring | DGMGAPC | P><,U/f >< | 32/40G |
| **Measurement** | | | |
| Three-phase current measurement | CMMXU | 3I | IA, IB, IC |
| Sequence current measurement | CSMSQI | I1, I2, I0 | I1, I2, I0 |
| Residual current measurement | RESCMMXU | Io | IG |
| Three-phase voltage measurement | VMMXU | 3U | VA, VB, VC |
| Single-phase voltage measurement | VAMMXU | U_A | V_A |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Phase voltage measurement | VPHMMXU | 3UL | VL |
| Residual voltage measurement | RESVMMXU | Uo | VG/VN |
| Sequence voltage measurement | VSMSQI | U1, U2, U0 | V1, V2, V0 |
| Three-phase power and energy measurement | PEMMXU | P, E | P, E |
| Load profile recorder | LDPRLRC | LOADPROF | LOADPROF |
| Frequency measurement | FMMXU | f | f |
| Tap changer position indication | TPOSYLTC | TPOSM | 84T |
| **Power quality** | | | |
| Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics | CHMHAI | PQM3IH | PQM ITHD,IDC |
| Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics | VHMHAI | PQM3VH | PQM VTHD,VDC |
| Voltage variation | PHQVVR | PQMU | PQMV SWE,SAG,INT |
| Voltage unbalance | VSQVUB | PQUUB | PQMV UB |
| **Traditional LED indication** | | | |
| LED indication control | LEDPTRC | LEDPTRC | LEDPTRC |
| Individual virtual LED control | LED | LED | LED |
| **Logging functions** | | | |
| Disturbance recorder (common functionality) | RDRE | DR | RDRE |
| Disturbance recorder, analog channels 1...12 | A1RADR | A1RADR | A1RADR |
| Disturbance recorder, analog channels 13...24 | A2RADR | A2RADR | A2RADR |
| Disturbance recorder, binary channels 1...32 | B1RBDR | B1RBDR | B1RBDR |
| Disturbance recorder, binary channels 33...64 | B2RBDR | B2RBDR | B2RBDR |
| Fault recorder | FLTRFRC | FAULTREC | FR |
| **Other functionality** | | | |
| Parameter setting groups | PROTECTION | PROTECTION | PROTECTION |
| Time master supervision | GNRLLTMS | TSYNC | TSYNC |
| Serial port supervision | SERLCCH | SERLCCH | SERLCCH |
| IEC 61850-1 MMS | MMSLPRT | MMS | MMS |
| IEC 61850-1 GOOSE | GSELPRT | GSE | GSE |
| IEC 60870-5-103 protocol | I3CLPRT | I3C | I3C |
| IEC 60870-5-104 protocol | I5CLPRT | I5C | I5C |
| DNP3 protocol | DNPLPRT | DNP 3.0 | DNP 3.0 |
| Modbus protocol | MBSLPRT | MBS | MBS |
| OR gate with two inputs | OR | OR | OR |
| OR gate with six inputs | OR6 | OR6 | OR6 |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| OR gate with twenty inputs | OR20 | OR20 | OR20 |
| AND gate with two inputs | AND | AND | AND |
| AND gate with six inputs | AND6 | AND6 | AND6 |
| AND gate with twenty inputs | AND20 | AND20 | AND20 |
| XOR gate with two inputs | XOR | XOR | XOR |
| NOT gate | NOT | NOT | NOT |
| Real maximum value selector | MAX3R | MAX3R | MAX3R |
| Real minimum value selector | MIN3R | MIN3R | MIN3R |
| Rising edge detector | R_TRIG | R_TRIG | R_TRIG |
| Falling edge detector | F_TRIG | F_TRIG | F_TRIG |
| Real switch selector | SWITCHR | SWITCHR | SWITCHR |
| Integer 32-bit switch selector | SWITCHI32 | SWITCHI32 | SWITCHI32 |
| SR flip-flop, volatile | SR | SR | SR |
| RS flip-flop, volatile | RS | RS | RS |
| Minimum pulse timer, two channels | TPGAPC | TP | 62TP |
| Minimum pulse timer second resolution, two channels | TPSGAPC | TPS | 62TPS |
| Minimum pulse timer minutes resolution, two channels | TPMGAPC | TPM | 62TPM |
| Pulse counter for energy measurement | PCGAPC | PCGAPC | PCGAPC |
| Pulse timer, eight channels | PTGAPC | PT | 62PT |
| Time delay off, eight channels | TOFGAPC | TOF | 62TOF |
| Time delay on, eight channels | TONGAPC | TON | 62TON |
| Daily timer | DTMGAPC | DTM | DTM |
| Calendar function | CALGAPC | CAL | CAL |
| SR flip-flop, eight channels, nonvolatile | SRGAPC | SR | SR |
| Boolean value event creation | MVGAPC | MV | MV |
| Integer value event creation | MVI4GAPC | MVI4 | MVI4 |
| Analog value event creation with scaling | SCA4GAPC | SCA4 | SCA4 |
| Generic control points | SPCGAPC | SPC | SPCG |
| Generic up-down counter | UDFCNT | UDCNT | UDCNT |
| Local/Remote control | CONTROL | CONTROL | CONTROL |
| External HMI wake-up | EIHMI | EIHMI | EIHMI |
| Real addition | ADDR | ADDR | ADDR |
| Real subtraction | SUBR | SUBR | SUBR |
| Real multiplication | MULR | MULR | MULR |
| Real division | DIVR | DIVR | DIVR |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Real equal comparator | EQR | EQR | EQR |
| Real not equal comparator | NER | NER | NER |
| Real greater than or equal comparator | GER | GER | GER |
| Real less than or equal comparator | LER | LER | LER |
| Voltage switch | VMSWI | VSWI | VSWI |
| Current sum | CMSUM | CSUM | CSUM |
| Current switch | CMSWI | CMSWI | CMSWI |
| Phase current preprocessing | ILTCTR | ILTCTR | ILTCTR |
| Residual current preprocessing | RESTCTR | RESTCTR | RESTCTR |
| Phase and residual voltage preprocessing | UTVTR | UTVTR | UTVTR |
| Residual current preprocessing, current measured as voltage | RESUTCTR | Io(U) | Io(U) |
| SMV stream receiver (IEC 61850-9-2LE) | SMVRCV | SMVRCV | SMVRCV |
| SMV stream sender (IEC 61850-9-2LE) | SMVSENDER | SMVSENDER | SMVSENDER |
| Redundant Ethernet channel supervison | RCHLCCH | RCHLCCH | RCHLCCH |
| Ethernet channel supervision | SCHLCCH | SCHLCCH | SCHLCCH |
| HMI Ethernet channel supervision | HMILCCH | HMILCCH | HMILCCH |
| Received GOOSE binary information | GOOSERCV_BIN | GOOSERCV_BIN | GOOSERCV_BIN |
| Received GOOSE double binary information | GOOSERCV_DP | GOOSERCV_DP | GOOSERCV_DP |
| Received GOOSE measured value information | GOOSERCV_MV | GOOSERCV_MV | GOOSERCV_MV |
| Received GOOSE 8- bit integer value information | GOOSERCV_INT8 | GOOSERCV_INT8 | GOOSERCV_INT8 |
| Received GOOSE 32- bit integer value information | GOOSERCV_INT32 | GOOSERCV_INT32 | GOOSERCV_INT32 |
| Received GOOSE interlocking information | GOOSERCV_INTL | GOOSERCV_INTL | GOOSERCV_INTL |
| Received GOOSE measured value (phasor) information | GOOSERCV_CMV | GOOSERCV_CMV | GOOSERCV_CMV |
| Received GOOSE enumerator value information | GOOSERCV_ENUM | GOOSERCV_ENUM | GOOSERCV_ENUM |
| Bad signal quality | QTY_BAD | QTY_BAD | QTY_BAD |
| Good signal quality | QTY_GOOD | QTY_GOOD | QTY_GOOD |
| Received GOOSE Test mode | QTY_GOOSE_TEST | QTY_GOOSE_TEST | QTY_GOOSE_TEST |
| GOOSE communication quality | QTY_GOOSE_COMM | QTY_GOOSE_COMM | QTY_GOOSE_COMM |
| GOOSE data health | T_HEALTH | T_HEALTH | T_HEALTH |
| Fault direction evaluation | T_DIR | T_DIR | T_DIR |
| Enumerator to boolean conversion | T_TCMD | T_TCMD | T_TCMD |
| 32-bit integer to binary command conversion | T_TCMD_BIN | T_TCMD_BIN | T_TCMD_BIN |
| Binary command to 32-bit integer conversion | T_BIN_TCMD | T_BIN_TCMD | T_BIN_TCMD |
| Switching device status decoder - CLOSE position | T_POS_CL | T_POS_CL | T_POS_CL |

*Table continues on the next page*

| Function | IEC 61850 | IEC 60617 | ANSI |
|---|---|---|---|
| Switching device status decoder - OPEN position | T_POS_OP | T_POS_OP | T_POS_OP |
| Switching device status decoder - OK status | T_POS_OK | T_POS_OK | T_POS_OK |
| Controllable gate, 8 Channels | GATEGAPC | GATEGAPC | GATEGAPC |
| Security application | GSAL | GSAL | GSAL |
| Hotline tag | HLTGAPC | HLTGAPC | HLTGAPC |
| 16 settable 32-bit integer values | SETI32GAPC | SETI32GAPC | SETI32GAPC |
| 16 settable real values | SETRGAPC | SETRGAPC | SETRGAPC |
| Boolean to integer 32- bit conversion | T_B16_TO_I32 | T_B16_TO_I32 | T_B16_TO_I32 |
| Integer 32-bit to boolean conversion | T_I32_TO_B16 | T_I32_TO_B16 | T_I32_TO_B16 |
| Integer 32-bit to real conversion | T_I32_TO_R | T_I32_TO_R | T_I32_TO_R |
| Real to integer 8-bit conversion | T_R_TO_I8 | T_R_TO_I8 | T_R_TO_I8 |
| Real to integer 32-bit conversion | T_R_TO_I32 | T_R_TO_I32 | T_R_TO_I32 |
| Constant FALSE | FALSE | FALSE | FALSE |
| Constant TRUE | TRUE | TRUE | TRUE |

# 2 REX640 overview

## 2.1 Overview

REX640 is a powerful all-in-one protection and control relay for use in advanced power distribution and generation applications with unmatched flexibility available during the complete life cycle of the device – from ordering of the device, through testing and commissioning to upgrading the functionality of the modular software and hardware as application requirements change.

The modular design of both hardware and software elements facilitates the coverage of any comprehensive protection application requirement that may arise during the complete life cycle of the relay and substation.

REX640 makes modification and upgrading easy and pushes the limits of what can be achieved with a single device.

### 2.1.1 PCM600 and relay connectivity package version

- Protection and Control IED Manager PCM600 Ver. 2.12 or later
- REX640 Connectivity Package Ver. 1.3.0 or later

Download connectivity packages from the ABB Web site *www.abb.com/mediumvoltage* or directly with Update Manager in PCM600.

## 2.2 Relay hardware

The relay includes a Ready LED on the power supply module that indicates the relay's status. In normal situations, the Ready LED has a steady green light. Any other situation that requires the operator’s attention is indicated with a flashing light.

The relay has mandatory and optional slots. A mandatory slot always contains a module but an optional slot may be empty, depending on the composition variant ordered.

**Table 2: Module slots**

| Module | Slot A1 | Slot A2 | Slot B | Slot C | Slot D | Slot E | Slot F | Slot G |
|---|---|---|---|---|---|---|---|---|
| ARC1001 | o | | | | | | | |
| COM1001 | | • | | | | | | |
| COM1002 | | • | | | | | | |
| COM1003 | | • | | | | | | |

*Table continues on the next page*

| Module | Slot A1 | Slot A2 | Slot B | Slot C | Slot D | Slot E | Slot F | Slot G |
|---|---|---|---|---|---|---|---|---|
| COM1004 | | ● | | | | | | |
| COM1005 | | ● | | | | | | |
| BIO1001 | | | ● | o | o | | | |
| BIO1002 | | | ● | o | o | | | |
| BIO1003 | | | | | | o | | |
| BIO1004 | | | | | | o | | |
| RTD1001 | | | | o | o | | | |
| RTD1002 | | | | o | o | | | |
| AIM1001 | | | | | | o | ● | |
| AIM1002 | | | | | | o | ● | |
| SIM1901 | | | | | | o | ● | |
| SIM1902 | | | | | | o | ● | |
| PSM1001 | | | | | | | | ● |
| PSM1002 | | | | | | | | ● |
| PSM1003 | | | | | | | | ● |

● = Mandatory to have one of the allocated modules in the slot

o = Optional to have one of the allocated modules in the slot. The population (order) of the modules in the optional slots depends on the composition variant ordered.

In case the relay and the HMI will be exposed to harsh environmental conditions; like high humidity, chemicals or other corrosive agents, we recommend using the conformal coated versions of both. Contact the nearest ABB sales representative for more information regarding the ordering data.

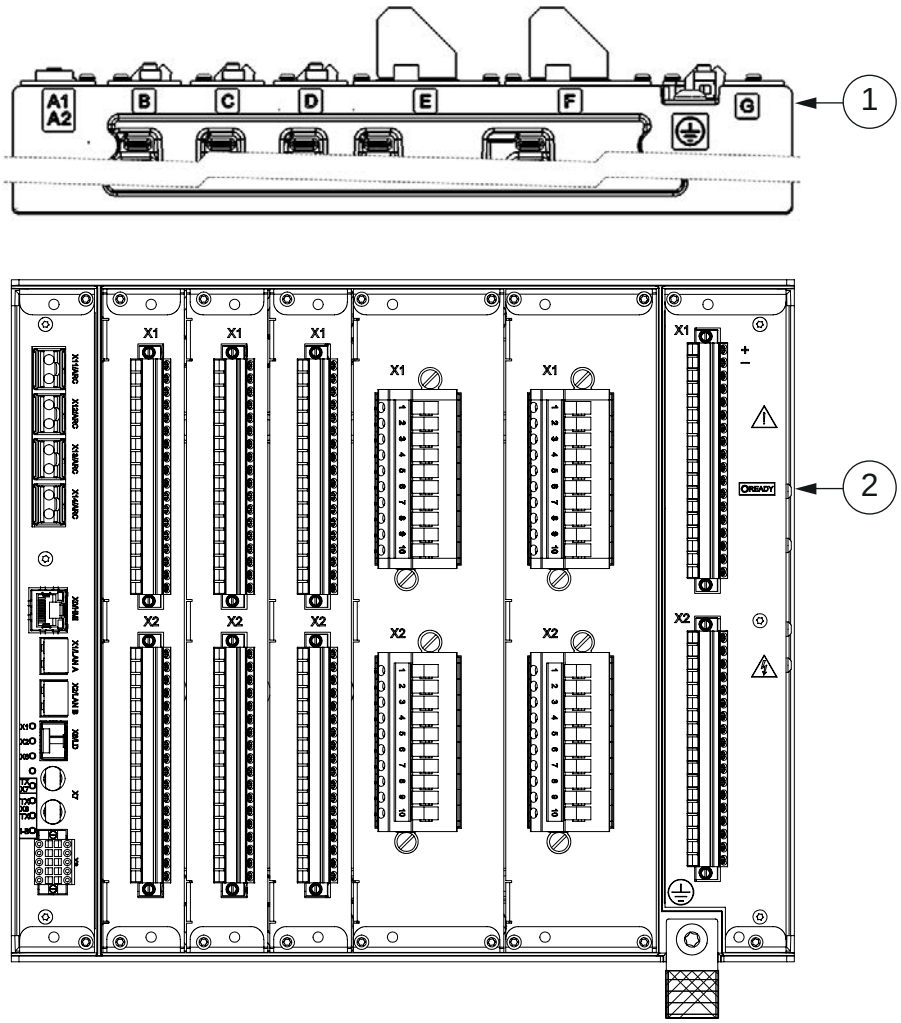



*Figure 2: Hardware module slot overview of the REX640 relay*

**1** Slot markings in enclosure (top and bottom)

**2** Ready LED

**Table 3: Module description**

| Module | Description |
|---|---|
| ARC1001 | 4 × ARC sensor inputs (lense, loop or mixed) |
| COM1001 | 1 × RJ-45 (LHMI port) + 3 × RJ-45 + 1 × LD-SFP [1] |
| COM1002 | 1 × RJ-45 (LHMI port) + 2 × LC + 1 × RJ-45 + 1 × LD-SFP |
| COM1003 | 1 × RJ-45 (LHMI port) + 3 × LC + 1 × LD-SFP |
| COM1004 | 1 × RJ-45 (LHMI port) + 2 × RJ-45 + 1 × LD-SFP + 1 × RS-485/IRIG-B + 1 × FO UART |

*Table continues on the next page*

[1] Line distance/line differential protection communication + binary signal transfer, optical multi-mode or single-mode LC small form-factor pluggable transceiver (SFP)

| Module | Description |
|---|---|
| COM1005 | 1 × RJ-45 (LHMI port) + 2 × LC + 1 × LD-SFP + 1 × RS-485/IRIG-B + 1 × FO UART |
| BIO1001/ BIO1003 | 14 × BI + 8 × SO |
| BIO1002/ BIO1004 | 6 × SPO + 2 × SPO (TCS) + 9 × BI |
| RTD1001 | 10 × RTD channels + 2 × mA channels (input/output) |
| RTD1002 | 3 × RTD channels + 6 × mA channels (input/output) + 12 x BI |
| AIM1001 | 4 × CT + 1 × CT (sensitive, for residual current only) + 5 × VT |
| AIM1002 | 6 × CT + 4 × VT |
| SIM1901 | 3 × combi sensor inputs (RJ-45) + 1 × CT (sensitive, for residual current only) + 1 × VT |
| SIM1902 | 3 × combi sensor inputs (RJ-45) + 1 × CT (sensitive, for residual current only) + 1 × VT |
| PSM1001 | 24...60 VDC, 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO |
| PSM1002 | 48...250 VDC / 100...240 VAC, 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO |
| PSM1003 | 110/125 VDC (77...150 VDC), 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO |

PO = Power Output
SO = Signal Output
SPO = Static Power Output
SSO = Static Signal Output

The relay has a nonvolatile memory which does not need any periodical maintenance. The nonvolatile memory stores all events, recordings and logs to a memory which retains data if the relay loses its auxiliary supply.

## 2.3 Local HMI

The LHMI is used for setting, monitoring and controlling the protection relay and the related process. It comprises a 7-inch color screen with capacitive touch sensing and a Home button at the bottom of the LHMI.



The LHMI must be paired with the protection relay to enable all the functionalities in it. See the operation manual for the pairing procedure.



The LHMI is an accessory for the relay which is fully operational even without the LHMI.

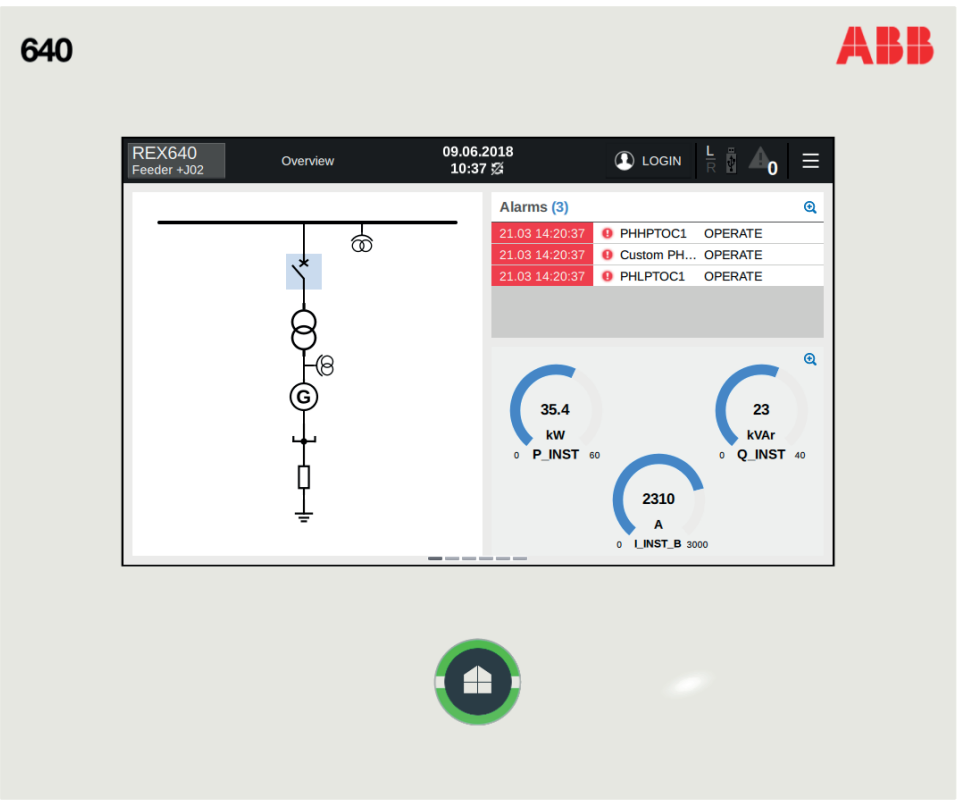



*Figure 3: Example of a local HMI page*

The LHMI presents pages in two categories.

- Operator pages are typically required as a part of an operator's normal activities, such as a single-line diagram, controls, measurements, events or alarms
- Engineer pages are specifically designed pages supporting relay parametrization, troubleshooting, testing and commissioning activities

The Operator pages can be scrolled either by pressing the Home button or by swiping the actual pages. The Engineer pages are accessible by tapping the menu button in the menu bar on the top of the LHMI display.

The Home button indicates the relay's status at a glance. In normal situations, the Home button shows a steady green light. Any other situation that requires the operator's attention is indicated with a flashing light, a red light or a combination of these.

**Table 4: Power supply module Ready LED and local HMI Home button LED**

| State | Power supply module Ready LED | LHMI Home button | Alarm acknowledged |
|---|---|---|---|
| Relay under normal operation and LHMI connected | Steady green | Steady green | N/A |
| Relay's IRF activated, but communicates with LHMI | High frequency blinking green [1] | High frequency blinking red [1] | N/A |

*Table continues on the next page*

[1] High frequency = 3 Hz

| State | Power supply module Ready LED | LHMI Home button | Alarm acknowledged |
|---|---|---|---|
| Communication lost between Relay and LHMI, but no IRF | Steady green | High frequency blinking green [1] | N/A |
| LHMI not running normally or in start-up initialization phase | Steady green | High frequency blinking green [1] | N/A |
| Process related alarm active | Steady green | Low frequency blinking red [2] | No |
| Process related alarm active | Steady green | Steady red | Yes |
| Process related alarm has been active earlier, but is not any more active. | Steady green | Low frequency blinking red [2] | No |
| Process related alarm has been active earlier, but is not any more active. | Steady green | Steady green | Yes |
| Relay set to Test Mode | Low frequency blinking green [2] | High frequency blinking green [2] | No |

The Operator pages can be used as such or customized according to the project's requirements using Graphical Display Editor in PCM600. The Engineer pages are fixed and cannot be customized.

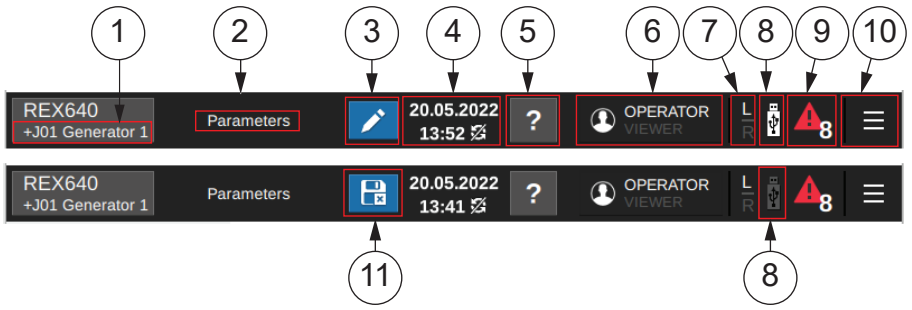



*Figure 4: Menu bar elements*

**1** Bay name for the relay

**2** Page name

**3** Edit mode active (parameter editing)

**4** Date, time and time synchronization status

**5** Page help (visible if help is available for the page)

**6** Login button/logged in user indication

**7** Local/remote indication

**8** USB memory not connected/connected (visible only if USB port is enabled)

**9** Number of active alarms

**10** Menu button for Engineer pages

**11** Store or reject changed parameters indication

[2] Low frequency = 1 Hz

**Table 5: Local HMI default pages**

| Page category | Pages | Subpages |
|---|---|---|
| Operator pages | Overview | Alarms |
| | Events | |
| | Fault Records | |
| | Timeline | |
| | Measurements | Phasors |
| | | Load Profile Records |
| Engineer pages | Parameters | |
| | Testing and Commissioning | Force Functions |
| | | Force Outputs |
| | | Simulate Inputs |
| | | View I/O |
| | | Send Events |
| | | Secondary Injection Monitoring |
| | | Protection Measurement Direction |
| | | Coil Controller Commissioning [3] |
| | | View GOOSE sending |
| | | View GOOSE receiving |
| | | View SMV sending |
| | | View SMV receiving |
| | Relay Status | Monitoring |
| | Clear | |
| | Disturbance Records | |
| | Alarms | |
| | Device Information | |
| | USB Actions | |

[3] Available with the Petersen coil control application package

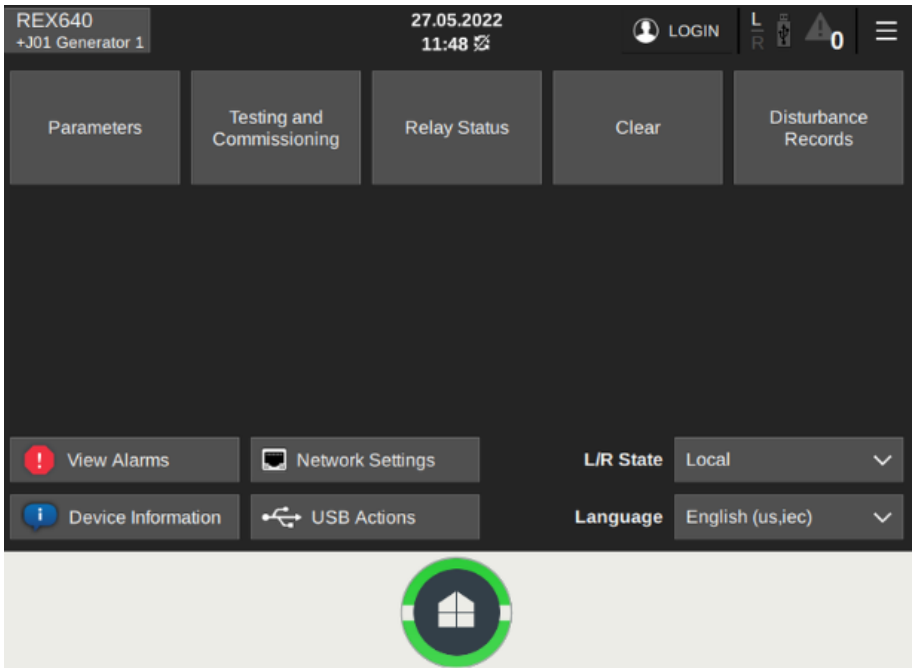



*Figure 5: Engineer pages menu*

## 2.4 Switchgear HMI

The SHMI is used for setting, monitoring and controlling up to 20 REX640 protection relays and the related processes. It comprises a 7-inch color screen with capacitive touch sensing and a Home button at the bottom of the SHMI. All features of standard HMI are also available in the SHMI.

The SHMI is an accessory for the relay which is fully operational even without the SHMI.

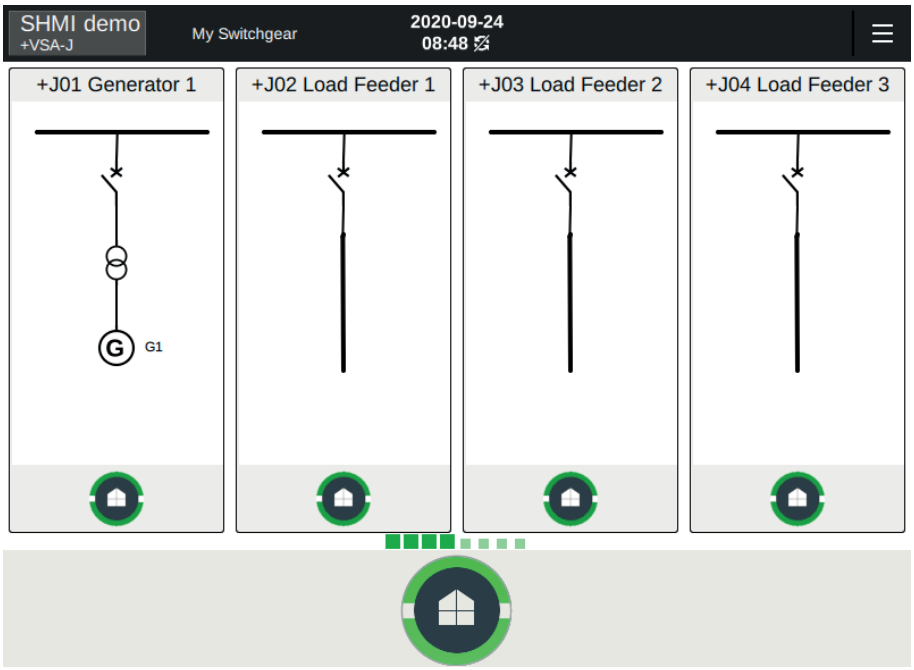



*Figure 6: Example of a switchgear HMI navigation page*

The SHMI has a navigation page which presents the physical switchgear lineup installation and indicates the status of each REX640 within the system. The area presenting a single switchgear bay has a small user-configurable bay overview section and a virtual Home button showing the status of the connected relay. By tapping the selected bay overview area, the SHMI connects with the related REX640 and works as normal LHMI for that relay.

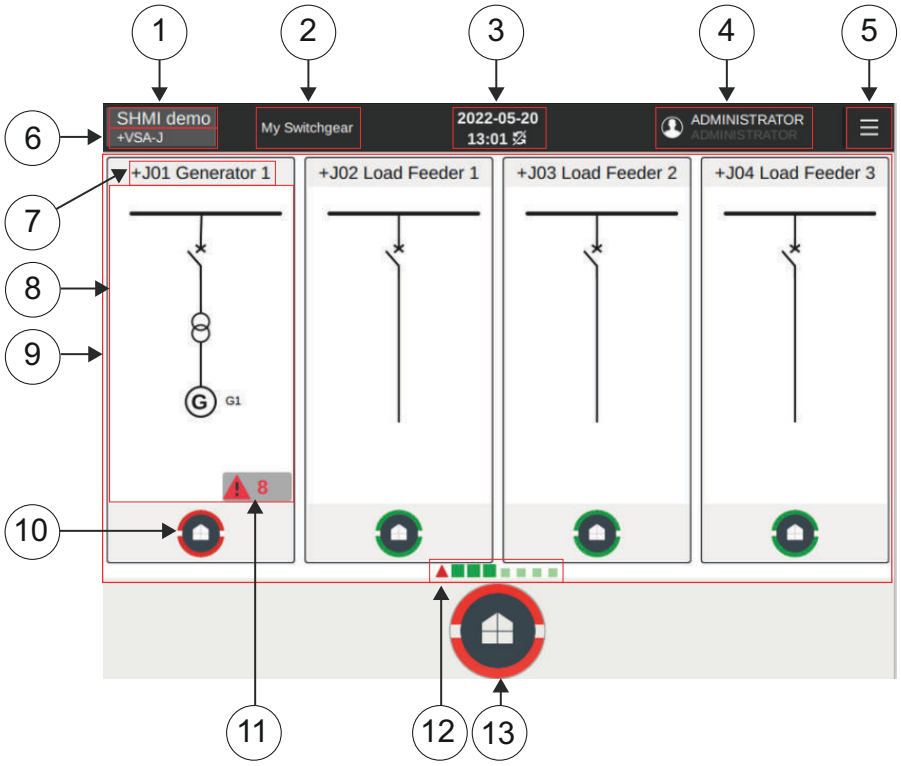



*Figure 7: Navigation page elements*

**1** User-defined substation name

**2** User-defined name for the switchgear or sub-part of switchgear lineup controlled by the SHMI

**3** Date, time and time synchronization status

**4** Logout button and authentication status

**5** Menu button

**6** User-defined voltage level name

**7** User defined bay name and voltage level extension

**8** Bay overview area showing static or dynamic information for a bay and functioning as a navigation point to launch the HMI view for the respective relay, user-defined content

**9** SHMI navigation page

**10** Virtual Home button representing the status of the respective relay's physical Home button

**11** Number of active alarms

**12** Panel lineup overview showing the current status of all connected relays and the current position of navigation page

**13** SHMI's physical Home button

### 2.4.1 Bay overview area

Bay overview area consists either of a static picture or a dynamic SLD. They are configured with Graphical Display Editor in PCM600. One relay can have two overview pages.

Static picture may be, for example, a drawing or a photo of switchgear lineup. Maximum size of the picture is 186 × 320 px.

SLD does not support control operations. The following features are available.

- Static symbols such as connections, measurement devices, transformers and reactors
- Dynamic status for switching devices, but no control operations
- Dynamic and static text objects
  - Boolean state text
  - Integer state text
  - Label (translation not supported)
  - Numeric value
  - String value
- Custom symbols
- Busbar coloring

### 2.4.2 Physical and virtual Home buttons

On the SHMI navigation page, the virtual Home button shows the status of each relay as it would be shown with the physical Home button on a normal LHMI panel. In normal situations, the virtual Home button shows a steady green light. All other situations in which the relay requires operator's attention are indicated with a flashing light, a red light or a combination of these.

SHMI's physical Home button has two operation modes.

- On the SHMI navigation page, the Home button indicates the combined status of all connected relays. If multiple relays have different statuses, the Home button shows the indication with the highest priority.
- On the HMI view, the Home button indicates the status of the respective relay as described in *Figure 3*.

### 2.4.3 Navigation

Navigation page is the default view for the SHMI. The navigation page shows bay overviews areas which are lined up to represent the actual panel installations. The navigation page can be scrolled by swiping the screen horizontally or by pressing the physical Home button to move the page from left to right one bay overview at a time.

Bay overview area is the configured view for one relay. It may show static or dynamic information but all control operations are disabled. The whole bay overview area works as a navigation point to the relay's HMI view. Tapping this area opens the HMI view of the respective relay.

Panel lineup overview shows the position of the navigation page by highlighting the visible bay overviews. It also shows the status of all connected relays and helps in

identifying which relay requires operator's attention when the bay overview is not visible on the navigation page.

When the HMI view is opened for a relay, the SHMI works exactly like a normal HMI. All the same features are available, and the Home button switches between the configured home pages and indicates the alarm status for the respective relay.

Navigation area on the top left corner of the HMI view is used to navigate back to the SHMI's navigation page. The navigation area shows the bay name on the button to identify which relay's HMI is open.

## 2.5 Physical ports

The relay communication module has a dedicated port where the LHMI is connected using an RJ-45 connector and a CAT 6 S/FTP galvanic cable. The HMI can be connected to the relay also via station communication network if a longer distance is required between the relay and the HMI. For more information, see the installation manual.

Additionally, the HMI contains one Ethernet service port with an RJ-45 connector and one USB port. The service port can be used for the PCM600 connection or for WHMI connection. Data transfer to a USB stick is enabled via the USB port. By default the USB port is disabled and has to be taken into use with a specific parameter.

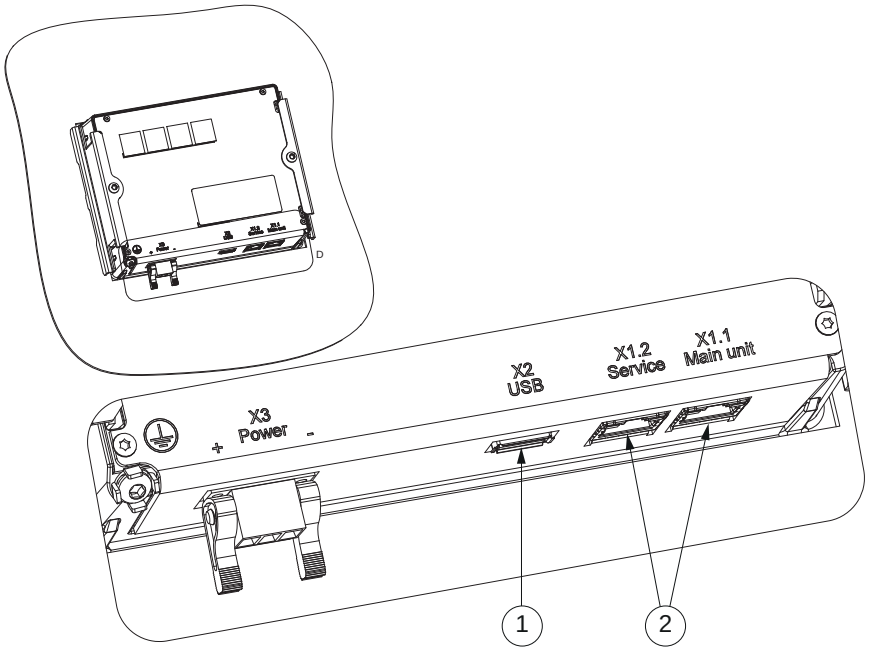



*Figure 8: Local HMI connectors*

**1** USB port

**2** RJ-45 ports

## 2.6 Web HMI

The WHMI allows secure access to the protection relay via a Web browser. The WHMI is verified with Google Chrome, Mozilla Firefox and Microsoft Edge.

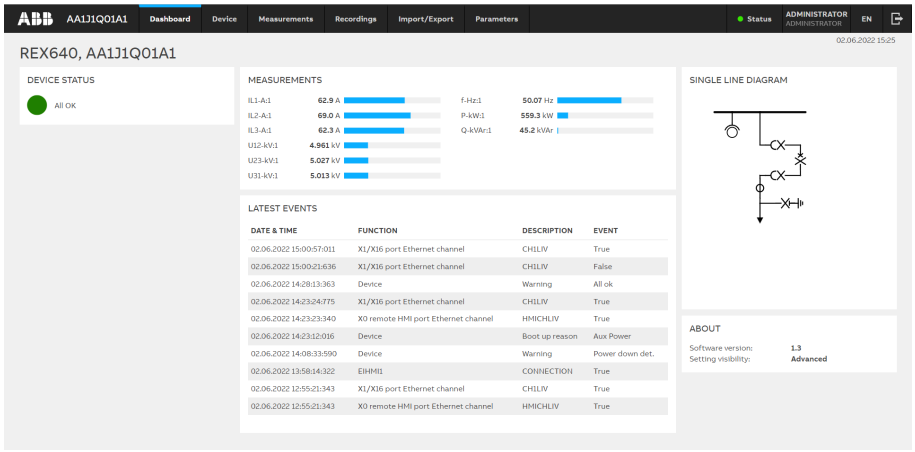



*Figure 9: Example view of the Web HMI*

WHMI offers several functions. The menu tree structure on the WHMI is almost identical to the one on the LHMI.

**Table 6: Web HMI main groups and submenus**

| Main groups | Submenus | Description |
|---|---|---|
| Dashboard | | Used to see an overview of the protection relay including status, measurements, single-line diagram and latest events |
| Device | Monitoring<br>Information<br>Self-supervision<br>Single Line Diagram<br>Clear<br>Change Password<br>About | Used to navigate to monitoring, information, self-supervision, single-line diagram or clear pages |
| Measurements | Measurements<br>Phasor Diagrams | Used to navigate to the measurements or phasor diagrams |
| Recordings | Events<br>Disturbance records<br>Fault records<br>Load Profile Record<br>Alarm List | Used to view the events, disturbance records, fault records, load profile records and alarms |
| Import/Export | Report Summary<br>Import/Export Set-tings<br>Parameter List | Used to export a parameter list or a report summary, and to import and export settings |

*Table continues on the next page*

| Main groups | Submenus | Description |
|---|---|---|
| Parameters | | Used to view the menu tree structure for the protection relay's setting parameters |
| Language selection | | Used to change the language |
| Logout | | Used to end the session |

The WHMI can be accessed locally and remotely.

- Locally by connecting the laptop to the protection relay
- Remotely over LAN/WAN

## 2.7 User authorization

The user management for the protection relay can be handled in two possible ways. Only one user management way can be enabled in the protection relay at a time.

For more information, see the cyber security deployment guideline.

### 2.7.1 Local user account management

Four factory default user accounts (VIEWER, OPERATOR, ENGINEER and ADMINISTRATOR) have been predefined for the LHMI and the WHMI, each with different rights and default passwords. The roles for these user accounts are the same as the username. Additional user accounts can be added for the protection relay.

IED Users in PCM600 is used to manage the user accounts. Each protection relay supports eight fixed roles and 50 user accounts belonging to any one of these roles. Each user account can be mapped to a maximum of eight roles.

The factory default passwords can be changed with Administrator user rights or by the users themselves. Relay user passwords can be changed using the LHMI, IED Users in PCM600 or the WHMI. Only Administrator can create user accounts and update the roles-to-rights mapping. Administrator can also reset the passwords of the users.

User authorization is disabled by default for the LHMI and can be enabled with the *Local override* parameter via the menu path **Configuration** > **Authorization** > **Passwords**. WHMI always requires authentication. Changes in user management settings do not cause the protection relay to reboot. The changes are taken into use immediately after committing the changed settings.

### 2.7.2 Central account management

The user accounts and roles can be created and authenticated centrally in a CAM server. CAM needs to be activated in the protection relay from Account Management in PCM600.

A CAM server can be an Active Directory (AD) server such as Windows AD. There can also be a secondary or redundant CAM server configured which can act as a backup CAM server if the primary CAM server is not accessible.

The protection relay is the CAM client and can maintain its own replica database of the user accounts and roles configured in the CAM server. This CAM replica database acts as a backup authentication mechanism if primary and secondary CAM servers are not accessible from the protection relay.

Each protection relay supports eight roles and 50 user accounts in the CAM replica database. Each user account can be mapped to a maximum of eight roles.

For more information on user management and security logging, see the cyber security deployment guideline.

For user authorization for PCM600, see the PCM600 documentation.

## 2.8 Station communication

Operational information and controls are available through a wide range of communication protocols including IEC 61850 Edition 2, IEC 61850-9-2 LE, IEC 60870-5-103, IEC 60870-5-104, Modbus® and DNP3. Full communication capabilities, for example, horizontal communication between the relays, are only enabled by IEC 61850.

The relay provides the possibility for a second IP address and a second subnetwork when the communication modules with three Ethernet ports (COM1001...1003) are used. However, only one IP network can be used as the default route. Using two IP addresses, communication networks can be separated based on the dominant user's needs. For example, one IP address can serve the dispatchers and the other one can serve the service engineers' needs.

The IEC 61850 protocol is a core part of the relay as the protection and control application is fully based on standard modelling. The relay supports Edition 2 and Edition 1 versions of the standard. With Edition 2 support, the relay has the latest functionality modelling for substation applications and the best interoperability for modern substations. The relay supports flexible product naming (FPN) facilitating the mapping of relay's IEC 61850 data model to a customer defined IEC 61850 data model.

## 2.9 Modification Sales

Modification Sales is a concept that provides modification support for already delivered relays. Under Modification Sales it is possible to modify both the hardware and software capabilities of the existing relay. The same options are available as when a new relay variant is configured and ordered from the factory: it is possible to add new hardware modules into empty slots, change the type of the existing modules within the slots or add software functions by adding application and, if necessary, add-on packages. If it is needed to use the possibilities provided by the Modification Sales concept, please contact your local ABB unit.

# 3 Basic functions

## 3.1 General parameters

### 3.1.1 Authorization settings

**Table 7: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Remote Update | 0=Disable<br>1=Enable | | | 0=Disable | Remote update |
| Thumbprint | | | | 0 | ClientThumb Print |
| Remote override | 0=False<br>1=True | | | 1=True | Disable authority |
| Local override | 0=False<br>1=True | | | 1=True | Disable authority |
| Clear AD userlist | 0=False<br>1=True | | | 0=False | Clear Active Directory user list |
| FTP write access | 0=Off<br>1=On | | | 1=On | FTP write access |
| MMS write access | 0=Off<br>1=On | | | 1=On | MMS write access |
| HTTPS write access | 0=Off<br>1=On | | | 1=On | HTTPS write access |
| FTP write access | 0=Off<br>1=On | | | 1=On | FTP write access |
| MMS write access | 0=Off<br>1=On | | | 1=On | MMS write access |
| HTTPS write access | 0=Off<br>1=On | | | 1=On | HTTPS write access |
| FTP write access | 0=Off<br>1=On | | | 1=On | FTP write access |
| MMS write access | 0=Off<br>1=On | | | 1=On | MMS write access |

## 3.1.2 Binary input settings

**Table 8: Binary input settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Slot specific threshold | 0=False<br>1=True | | | 0=False | Use slot specific binary input voltage threshold |
| Slot specific hysteresis | 0=False<br>1=True | | | 0=False | Use slot specific binary input voltage hysteresis |
| Input threshold voltage | 16...176 | Vdc | 2 | 16 | Global binary input threshold for all slots |
| Input threshold hysteresis | 10...50 | % | 2 | 10 | Global binary input hysteresis for all slots |
| Input osc. level | 2...50 | events/s | 1 | 30 | Binary input oscillation suppression threshold |
| Input osc. hyst | 2...50 | events/s | 1 | 10 | Binary input oscillation suppression hysteresis |

## 3.1.3 Network1 address settings

**Table 9: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| IP address | | | | 192.168.2.10 | IP address for Network1 |
| Subnet mask | | | | 255.255.255.0 | Subnet mask for Network1 |
| Default gateway | | | | 192.168.2.1 | Default gateway for Network1 |
| Mac address | | | | XX-XX-XX-XX-XX-XX | Mac address for Network1 |

## 3.1.4 Network2 address settings

**Table 10: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Enable | 0=False<br>1=True | | | 0=False | Enable Network2 IP address |
| IP address | | | | 192.168.3.10 | IP address for Network2 |
| Subnet mask | | | | 255.255.255.0 | Subnet mask for Network2 |
| Default gateway | | | | 0.0.0.0 | Default gateway for Network2 (only in-use if NW1 GW = 0.0.0.0) |
| Mac address | | | | XX-XX-XX-XX-XX-XX | Mac address for Network2 |

## 3.1.5 HMI port address settings

**Table 11: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| IP address | | | | 192.168.0.254 | IP address for front port (fixed) |
| Mac address | | | | XX-XX-XX-XX-XX-XX | Mac address for front port |

## 3.1.6 System settings

**Table 12: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Rated frequency | 1=50Hz<br>2=60Hz | | | 1=50Hz | Rated frequency of the network |
| Phase rotation | 1=ABC<br>2=ACB | | | 1=ABC | Phase rotation order |
| Blocking mode | 1=Freeze timer<br>2=Block all<br>3=Block OPERATE output | | | 1=Freeze timer | Behaviour for function BLOCK inputs |
| Bay name | | | | REX640 | Bay name in system |
| IDMT Sat point | 10...50 | I/I> | 1 | 50 | Overcurrent IDMT saturation point |
| Frequency adaptivity | 0=Disable<br>1=Enable | | | 0=Disable | Enabling frequency adaptivity |
| SMV Max Delay | 0=2/2 ms<br>1=3/3 ms<br>2=5/4 ms<br>3=6/5 ms<br>4=7/6 ms | | | 1=3/3 ms | SMV Maximum allowed delay |
| Test mode selection | 1=Local<br>2=Local+Remote, maintenance<br>3=Local+Remote, all levels<br>4=Binary input | | | 1=Local | Authority for remote activation of test mode |

## 3.1.7 HMI Settings

**Table 13: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| FB naming convention | 1=IEC61850<br>2=IEC60617<br>3=ANSI | | | 1=IEC61850 | FB naming convention used in IED |
| Backlight timeout[1] | 1...60 | min | 1 | 3 | LHMI backlight timeout |
| Web HMI mode | 0=Off<br>1=On | | | 0=Off | Web HMI functionality |
| HMI timeout | 1...60 | min | 1 | 3 | HMI login timeout |
| SLD symbol format | 1=IEC<br>2=ANSI | | | 1=IEC | Single Line Diagram symbol format |
| Setting visibility | 1=Basic<br>2=Advanced | | | 2=Advanced | Setting visibility for HMI |
| User defined name | 0=Disabled<br>1=Enabled | | | false | Configuration of User defined name |

## 3.1.8 HMI control settings

### Confirmation dialog

If the parameter *Breaker operation* in **Configuration** > **Control** > **HMI** is set to "After confirmation", a confirmation dialog box opens after tapping the control button. The confirmation dialog box has a progress bar indicating the *Select timeout* set for the controllable object. If the *Control mode* setting of a control function is set to "sbo-with-enhanced-security", the confirmation dialog box always opens regardless of the *Breaker operation* setting value.

### Delayed close

If the parameter *Close delay* mode in **Configuration** > **Control** > **LHMI** is set to "In use", a timer is started after tapping the close button and accepting the possible confirmation dialog. Close operation is performed only after the timer reaches zero. Remaining time is displayed on top of close button, user can cancel the operation during countdown by tapping the Cancel button. The delay can be configured by *Close delay* in **Configuration** > **Control** > **LHMI**.

**Table 14: HMI control settings**

| Parameter | Values | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Close delay mode | 1=In use<br>2=Not in use | | | 2=Not in use | Delayed operation when closing circuit breakers, disconnec- |

*Table continues on the next page*

[1] SHMI has separate backlight timeout setting that is used while in switchgear view. The SHMI setting can be accessed from SHMI settings page, that is available while in SHMI's switchgear page.

| Parameter | Values | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | | | | | tors and earthing switches from HMI |
| Close delay | 5…900 | s | 1 | 60 | Operation delay for *Close delay* mode |
| Breaker operation | 0=After confirmation<br>1=Without confirmation | | | 0=After confirmation | Enable or disable confirmation dialog before operating circuit breakers, disconnectors and earthing switches from HMI |

## 3.1.9 IEC 103 Settings

**Table 15: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 5=off | Selects if this protocol instance is enabled or disabled |
| Serial port | 1=COM 1<br>2=COM 2 | | | 1=COM 1 | COM port |
| Address | 1...255 | | 1 | 1 | Unit address |
| Start delay | 0...20 | char | 1 | 4 | Start frame delay in chars |
| End delay | 0...20 | char | 1 | 4 | End frame delay in chars |
| DevFunType | 0...255 | | 1 | 9 | Device Function Type |
| UsrFunType | 0...255 | | 1 | 10 | Function type for User Class 2 Frame |
| UsrInfNo | 0...255 | | 1 | 230 | Information Number for User Class2 Frame |
| Class1Priority | 0=Ev High<br>1=Ev/DR Equal<br>2=DR High | | | 0=Ev High | Class 1 data sending priority relationship between Events and Disturbance Recorder data. |
| Class2Interval | 0...86400 | s | 1 | 0 | Interval in seconds to send class 2 response |
| Frame1InUse | -1=Not in use<br>0=User frame<br>1=Standard frame 1<br>2=Standard frame 2<br>3=Standard frame 3<br>4=Standard frame 4<br>5=Standard frame 5<br>6=Private frame 6<br>7=Private frame 7 | | | 6=Private frame 6 | Active Class2 Frame 1 |
| Frame2InUse | -1=Not in use | | | -1=Not in use | Active Class2 Frame 2 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 0=User frame<br>1=Standard frame 1<br>2=Standard frame 2<br>3=Standard frame 3<br>4=Standard frame 4<br>5=Standard frame 5<br>6=Private frame 6<br>7=Private frame 7 | | | | |
| Frame3InUse | -1=Not in use<br>0=User frame<br>1=Standard frame 1<br>2=Standard frame 2<br>3=Standard frame 3<br>4=Standard frame 4<br>5=Standard frame 5<br>6=Private frame 6<br>7=Private frame 7 | | | -1=Not in use | Active Class2 Frame 3 |
| Frame4InUse | -1=Not in use<br>0=User frame<br>1=Standard frame 1<br>2=Standard frame 2<br>3=Standard frame 3<br>4=Standard frame 4<br>5=Standard frame 5<br>6=Private frame 6<br>7=Private frame 7 | | | -1=Not in use | Active Class2 Frame 4 |
| Class1OvInd | 0=No indication<br>1=Both edges<br>2=Rising edge | | | 2=Rising edge | Overflow Indication |
| Class1OvFType | 0...255 | | 1 | 10 | Function Type for Class 1 overflow indication |
| Class1OvInfNo | 0...255 | | 1 | 255 | Information Number for Class 1 overflow indication |
| Class1OvBackOff | 0...500 | | 1 | 500 | Backoff Range for Class1 buffer |
| GI Optimize | 0=Standard behaviour<br>1=Skip spontaneous<br>2=Only overflown<br>3=Combined | | | 0=Standard behaviour | Optimize GI traffic |
| DR Notification | 0=False<br>1=True | | | 0=False | Disturbance Recorder spontaneous indications enabled/disabled |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Block Monitoring | 0=Not in use<br>1=Discard events<br>2=Keep events | | | 0=Not in use | Blocking of Monitoring Direction |
| EC_FRZ | 0=False<br>1=True | | | 0=False | Control point for freezing energy counters |
| Prtl Customization | 0...2147483647 | | 1 | 0 | Customization parameter. Please, refer to the protocol manual. |

## 3.1.10 IEC 103 Monitored data

**Table 16: Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Customization Mode | Enum | 0=Off/Normal<br>1=By Parameter<br>2=By File | | Protocol Customization Mode |
| Reset counters | BOOLEAN | 0=False<br>1=True | | Reset counters |
| Received frames | INT32 | -1...2147483646 | | Received frames |
| Checksum errors | INT32 | -1...2147483646 | | Checksum errors |
| Transmitted frames | INT32 | -1...2147483646 | | Transmitted frames |

## 3.1.11 IEC 101-104 General settings

**Table 17: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 5=off | Selects if this protocol instance is enabled or disabled |
| Port | 3=IEC104 - Ethernet | | | 3=IEC104 - Ethernet | Port selection |
| Mapping select | 1...2 | | 1 | 1 | Mapping select |
| ClientIP | | | | 0.0.0.0 | IP address of the client |
| TCP Port | 0...65535 | | 1 | 2404 | Server TCP port |
| Device Address | 1...65535 | | 1 | 1 | Device address |
| ASDU Address | 1...65535 | | 1 | 1 | Common address of ASDU |
| Link Mode | 0=Balanced<br>1=Unbalanced | | | 0=Balanced | Link mode setting |
| COT Length | 1...2 | | 1 | 1 | Cause of transmission length |
| IOA Length | 1...3 | | 1 | 2 | Information Object Address length |
| Link Address Length | 1...2 | | 1 | 1 | Link Address Length |
| ASDU Address Length | 1...2 | | 1 | 1 | ASDU Address Length |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Single Char Resp | 0=False<br>1=True | | | 0=False | Single character response enabled/disabled |
| Show Bad Time | 0=False<br>1=True | | | 1=True | Enable/disable bad time quality indication in events |
| Time Format | 1=Full 56bit | | | 1=Full 56bit | Time stamp format 3 or 7 octet |
| Time Zone | 0=Local<br>1=UTC | | | 1=UTC | Selects between UTC/Local time |
| Overflow Mode | 0=Oldest+indication<br>1=Keep newest | | | 0=Oldest+indication | Event buffer overflow handling mechanism |
| OvInd IOA | 0...16777215 | | 1 | 60000 | Overflow indication address for interrogated data |
| OvInd NoGI IOA | 0...16777215 | | 1 | 60000 | Overflow indication address for non-interrogated data |
| Selection Timeout | 1...65 | s | 1 | 30 | Selection timeout for control SBO operations |
| Counter Reporting | 0=Read by master<br>1=Spontaneous | | | 0=Read by master | Counter reporting after freeze |
| Freeze mode | 0=Not in use<br>1=Freeze only<br>2=Freeze and Reset | | | 0=Not in use | Freezing mode for externally triggered integrated totals |
| TX window (k) | 1...20 | | 1 | 12 | IEC60870-5-104 transmit window (k) |
| RX window (w) | 1...20 | | 1 | 8 | IEC60870-5-104 receive window (w) |
| TX timeout (t1) | 1...2147483647 | ms | 1 | 30000 | IEC60870-5-104 transmit timeout (t1) |
| RX timeout (t2) | 1...2147483647 | ms | 1 | 10000 | IEC60870-5-104 receive timeout (t1) |
| Test interval (t3) | 0...2147483647 | ms | 1 | 20000 | IEC60870-5-104 link test interval (t3) - 0: Disables the transmission of test frames |
| Cyclical Period | 1...604800 | s | 1 | 10 | Cyclical period in seconds |
| IT_FRZ | 0=False<br>1=True | | | 0=False | Control point for freezing integrated totals |
| Command delay | 0...65535 | ms | 1 | 5000 | Maximum delay for timestamped commands in milliseconds. |
| Prtl Customization | 0...2147483647 | | 1 | 0 | Customization parameter. Please, refer to the protocol manual. |

## 3.1.12 IEC 101-104 Secure settings

**Table 18: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Protocol Security Mode | 1=App. authentication<br>2=TLS and appl. auth.<br>0=Off | | | 0=Off | Protocol Security Mode - 0: Off; 1: Aplication authentication; 2: TLS and Aplication authentication |
| Reply timeout | 100...120000 | ms | 1 | 2000 | Reply timeout |
| Exp Sesn key Chg Intv | 0...14400 | s | 1 | 1800 | Expected Session key change interval - Value zero will indicate that interval is not used |
| Exp Sesn key Chg Cnt | 2...10000000 | | 1 | 4000 | Expected session key change count |
| Max Sesn key Stat Cnt | 1...255 | | 1 | 5 | Maximum session key status count |
| Sec Stat Cnt Grp | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4 | | | 4=Group 4 | Secure statistics counter group |
| Sec Stat Cnt IOA | 1...65535 | | 1 | 61000 | Information object address for secure statistics counters |

## 3.1.13 IEC 101-104 Secure statistics thresholds settings

**Table 19: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Unexpected Msgs | 1...65535 | | 1 | 3 | Security statistics threshold for unexpected messages |
| Auth failures | 1...65535 | | 1 | 5 | Security statistics threshold for authorization failures |
| Authn failures | 1...65535 | | 1 | 5 | Security statistics threshold for authentication failures |
| Reply timeouts | 1...65535 | | 1 | 3 | Security statistics threshold for reply timeouts |
| Rekeys Authn failure | 1...65535 | | 1 | 3 | Security statistics threshold for rekeys due to authentication failure |
| Total Msgs Tx | 1...65535 | | 1 | 100 | Security statistics threshold for total messages sent |
| Total Msgs Rx | 1...65535 | | 1 | 100 | Security statistics threshold for total messages received |
| Total Crit Msgs Rx | 1...65535 | | 1 | 100 | Security statistics threshold for total critical messages received |
| Discarded Msgs | 1...65535 | | 1 | 10 | Security statistics threshold discarded messages |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Error Msgs Tx | 1...65535 | | 1 | 10 | Security statistics threshold error messages sent |
| Error Msgs Rx | 1...65535 | | 1 | 10 | Security statistics threshold error messages received |
| Successful Authn | 1...65535 | | 1 | 100 | Security statistics threshold for successful authentications |
| Sesn key Chg | 1...65535 | | 1 | 10 | Security statistics threshold for session key changes |
| Failed Sesn key Chgs | 1...65535 | | 1 | 5 | Security statistics threshold for failed session key changes |
| Upd key Chgs | 1...65535 | | 1 | 1 | Security statistics threshold for update key changes |
| Failed Upd key Chgs | 1...65535 | | 1 | 1 | Security statistics threshold for failed update key changes |

## 3.1.14 IEC 101-104 Monitored data

**Table 20: Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Customization Mode | Enum | 0=Off/Normal<br>1=By Parameter<br>2=By File | | Protocol Customization Mode |
| Reset counters | BOOLEAN | 0=False<br>1=True | | Reset counters |
| Received frames | INT32 | -1...2147483646 | | Received frames |
| Transmitted frames | INT32 | -1...2147483646 | | Transmitted frames |
| Physical errors | INT32 | -1...2147483646 | | Physical layer errors |
| Link errors | INT32 | -1...2147483646 | | Link layer errors |
| Transport errors | INT32 | -1...2147483646 | | Transport layer errors |
| CnReject no sockets | INT32 | -1...2147483646 | | Number of rejected connections due to no sockets available |
| CnReject unregistered | INT32 | -1...2147483646 | | Connection rejected due to unregistered client |

## 3.1.15 IEC 101-104 Secure monitored data

**Table 21: Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Unexp Msgs Cnt | INT32 | 0...2147483646 | | Security statistics counter for unexpected messages |
| Auth Fail Cnt | INT32 | 0...2147483646 | | Security statistics counter for authorization failures |
| Authn Fail Cnt | INT32 | 0...2147483646 | | Security statistics counter for authentication failures |
| Reply timeouts Cnt | INT32 | 0...2147483646 | | Security statistics counter for reply timeouts |
| Rekey Authn Fail Cnt | INT32 | 0...2147483646 | | Security statistics counter for rekeys due to authentication failure |
| Total Msgs Tx | INT32 | 0...2147483646 | | Security statistics counter for total messages sent |
| Total Msgs Rx | INT32 | 0...2147483646 | | Security statistics counter for total messages received |
| Critical Msgs Rx Cnt | INT32 | 0...2147483646 | | Security statistics counter for critical messages received |
| Discarded Msgs Cnt | INT32 | 0...2147483646 | | Security statistics counter for discarded messages |
| Err Msgs Tx Cnt | INT32 | 0...2147483646 | | Security statistics counter error messages sent |
| Err Msgs Rx Cnt | INT32 | 0...2147483646 | | Security statistics counter error messages received |
| Successful Authn Cnt | INT32 | 0...2147483646 | | Security statistics counter for successful authentications |
| Session Key Chg Cnt | INT32 | 0...2147483646 | | Security statistics counter for session key changes |
| Fail Ses Key Chg Cnt | INT32 | 0...2147483646 | | Security statistics counter for failed session key changes |
| Upd Key Chgs Cnt | INT32 | 0...2147483646 | | Security statistics counter update key changes |
| Fail Upd Key Chgs Cnt | INT32 | 0...2147483646 | | Security statistics counter for failed update key changes |

## 3.1.16 IEC 61850-8-1 MMS settings

**Table 22: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Unit mode | 1=Primary<br>0=Nominal<br>2=Primary-Nominal | | | 0=Nominal | IEC 61850-8-1 unit mode |
| MMS | 0=Off<br>1=On | | | 1=On | MMS communication mode |
| MMS | 0=Off | | | 1=On | MMS communication mode |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 1=On | | | | |
| MMS | 0=Off<br>1=On | | | 1=On | MMS communication mode |

## 3.1.17 MODBUS Settings

**Table 23: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 5=off | Enable or disable this protocol instance |
| Port | 1=COM 1<br>2=COM 2<br>3=Ethernet - TCP 1 | | | 3=Ethernet - TCP 1 | Port selection for this protocol instance. Select between serial and Ethernet based communication. |
| Mapping selection | 1...2 | | 1 | 1 | Chooses which mapping scheme will be used for this protocol instance. |
| Address | 1...254 | | 1 | 1 | Unit address |
| Link mode | 1=RTU<br>2=ASCII | | | 1=RTU | Selects between ASCII and RTU mode. For TCP, this should always be RTU. |
| TCP port | 1...65535 | | 1 | 502 | Defines the listening port for the Modbus TCP server. Default = 502. |
| Parity | 0=none<br>1=odd<br>2=even | | | 2=even | Parity for the serial connection. |
| Start delay | 0...20 | | 1 | 4 | Start delay in character times for serial connection |
| End delay | 0...20 | | 1 | 4 | End delay in character times for serial connections |
| CRC order | 0=Hi-Lo<br>1=Lo-Hi | | | 0=Hi-Lo | Selects between normal or swapped byte order for checksum for serial connection. Default: Hi-Lo. |
| Client IP | | | | 0.0.0.0 | Sets the IP address of the client. If set to zero, connection from any client is accepted. |
| Write authority | 0=Read only<br>1=Disable 0x write<br>2=Full access | | | 2=Full access | Selects the control authority scheme |
| Time format | 0=UTC<br>1=Local | | | 1=Local | Selects between UTC and local time for events and timestamps. |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Event ID selection | 0=Address<br>1=UID | | | 0=Address | Selects whether the events are reported using the MB address or the UID number. |
| Event buffering | 0=Keep oldest<br>1=Keep newest | | | 0=Keep oldest | Selects whether the oldest or newest events are kept in the case of event buffer overflow. |
| Event backoff | 1...500 | | 1 | 200 | Defines how many events have to be read after event buffer overflow to allow new events to be buffered. Applicable in "Keep oldest" mode only. |
| ControlStructPWd 1 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 2 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 3 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 4 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 5 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 6 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 7 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| ControlStructPWd 8 | | | | **** | Password for control operations using Control Struct mechanism, which is available on 4x memory area. |
| Prtl Customization | 0...2147483647 | | 1 | 0 | Customization parameter. Please, refer to the protocol manual. |

## 3.1.18 MODBUS Monitored data

**Table 24: Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Customization Mode | Enum | 0=Off/Normal<br>1=By Parameter<br>2=By File | | Protocol Customization Mode |
| Reset counters | BOOLEAN | 0=False<br>1=True | | Reset counters |
| Received frames | INT32 | -1...2147483646 | | Number of received frames |
| Transmitted frames | INT32 | -1...2147483646 | | Number of transmitted frames |
| Transmitted exc A | INT32 | -1...2147483646 | | Number of transmitted exception responses 01 and 02 |
| Transmitted exc B | INT32 | -1...2147483646 | | Number of transmitted exception responses 03 |
| Checksum errors | INT32 | -1...2147483646 | | Number of checksum errors |
| CnReject no sockets | INT32 | -1...2147483646 | | Number of rejected connections due to no sockets available |
| CnReject unregistered | INT32 | -1...2147483646 | | Connection rejected due to unregistered client |

## 3.1.19 DNP 3.0 Settings

**Table 25: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 5=off | Operation Off / On |
| Port | 1=COM 1<br>2=COM 2<br>3=Ethernet - TCP 1<br>4=Ethernet TCP+UDP 1<br>5=Ethernet - UDP 1 | | | 3=Ethernet - TCP 1 | Communication interface selection |
| Unit address | 0...65519 | | 1 | 1 | DNP unit address |
| Master address | 0...65519 | | 1 | 3 | DNP master and UR address |
| Mapping select | 1...2 | | 1 | 1 | Mapping select |
| ClientIP | | | | 0.0.0.0 | IP address of client |
| TCP port | 20000...65535 | | 1 | 20000 | TCP Port used on ethernet communication |
| UDP Rx Port | 1...65535 | | 1 | 20000 | UDP Port for accepting data from client/master |
| UDP Tx Port Ini | 1...65535 | | 1 | 20000 | UDP Port for initial NULL response to client/master |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| UDP Tx Port | 0...65535 | | 1 | 0 | UDP Destination Port for client/master |
| Client control authority | 0=No clients<br>1=Reg. clients<br>2=All clients | | | 2=All clients | 0=no client controls allowed; 1=Controls allowed by registered clients; 2=Controls allowed by all clients |
| Link keep-alive | 0...1000000 | s | 1 | 0 | Link keep-alive interval for DNP |
| Validate master addr | 1=Disable<br>2=Enable | | | 1=Disable | Validate master address on receive |
| Self address | 1=Disable<br>2=Enable | | | 2=Enable | Support self address query function |
| Need time interval | 0...65535 | min | 1 | 30 | Period to set IIN need time bit |
| Time format | 0=UTC<br>1=Local | | | 1=Local | UTC or local. Coordinate with master. |
| CROB select timeout | 1...65535 | s | 1 | 10 | Control Relay Output Block select timeout |
| Data link confirm | 0=Never<br>1=Only Multiframe<br>2=Always | | | 0=Never | Data link confirm mode |
| Data link confirm TO | 100...65535 | ms | 1 | 3000 | Data link confirm timeout |
| Data link retries | 0...65535 | | 1 | 3 | Data link retries count |
| Data link Rx to Tx delay | 0...255 | ms | 1 | 0 | Turnaround transmission delay |
| Data link inter char delay | 0...20 | char | 1 | 4 | Inter character delay for incoming messages |
| App layer confirm | 1=Disable<br>2=Enable | | | 1=Disable | Application layer confirm mode |
| App/UR confirm TO | 100...65535 | ms | 1 | 5000 | Application layer confirm and UR timeout |
| App layer fragment | 256...2048 | bytes | 1 | 2048 | Application layer fragment size |
| UR mode | 1=Disable<br>2=Enable | | | 1=Disable | Unsolicited responses mode |
| UR retries | 0...65535 | | 1 | 3 | Unsolicited retries before switching to UR offline mode |
| UR retry delay | 0...65535 | ms | 1 | 5000 | Additional delay kept after App/UR confirm TO before sending new unsolicited retry |
| UR offline interval | 0...65535 | min | 1 | 15 | Unsolicited offline interval |
| UR Class 1 Min events | 0...999 | | 1 | 2 | Min number of class 1 events to generate UR |
| UR Class 1 TO | 0...65535 | ms | 1 | 50 | Max holding time for class 1 events to generate UR |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| UR Class 2 Min events | 0...999 | | 1 | 2 | Min number of class 2 events to generate UR |
| UR Class 2 TO | 0...65535 | ms | 1 | 50 | Max holding time for class 2 events to generate UR |
| UR Class 3 Min events | 0...999 | | 1 | 2 | Min number of class 3 events to generate UR |
| UR Class 3 TO | 0...65535 | ms | 1 | 50 | Max holding time for class 3 events to generate UR |
| Legacy master UR | 1=Disable<br>2=Enable | | | 1=Disable | Legacy DNP master unsolicited mode support. When enabled relay does not send initial unsolicited message. |
| Legacy master SBO | 1=Disable<br>2=Enable | | | 1=Disable | Legacy DNP Master SBO sequence number relax enable |
| Default Var Obj 01 | 1=1:BI<br>2=2:BI&status | | | 1=1:BI | 1=BI; 2=BI with status. |
| Default Var Obj 02 | 1=1:BI event<br>2=2:BI event&time | | | 2=2:BI event&time | 1=BI event; 2=BI event with time. |
| Default Var Obj 03 | 1=1:DBI<br>2=2:DBI&status | | | 1=1:DBI | 1=DBI; 2=DBI with status. |
| Default Var Obj 04 | 1=1:DBI event<br>2=2:DBI event&time | | | 2=2:DBI event&time | 1=DBI event; 2=DBI event with time. |
| Default Var Obj 20 | 1=1:32bit Cnt<br>2=2:16bit Cnt<br>5=5:32bit Cnt no-flag<br>6=6:16bit Cnt no-flag | | | 2=2:16bit Cnt | 1=32 bit counter; 2=16 bit counter; 5=32 bit counter without flag; 6=16 bit counter without flag. |
| Default Var Obj 21 | 1=1:32bit FrzCnt<br>2=2:16bit FrzCnt<br>5=5:32bit FrzCnt&time<br>6=6:16bit FrzCnt&time<br>9=9:32bit FrzCnt noflag<br>10=10:16bit FrzCnt noflag | | | 6=6:16bit FrzCnt&time | 1=32 bit frz counter; 2=16 bit frz counter; 5=32 bit frz counter with time; 6=16 bit frz counter with time; 9=32 bit frz counter without flag;10=16 bit frz counter without flag. |
| Default Var Obj 22 | 1=1:32bit Cnt evt<br>2=2:16bit Cnt evt<br>5=5:32bit Cnt evt&time<br>6=6:16bit Cnt evt&time | | | 6=6:16bit Cnt evt&time | 1=32 bit counter event; 2=16 bit counter event; 5=32 bit counter event with time; 6=16 bit counter event with time. |
| Default Var Obj 23 | 1=1:32bit FrzCnt evt<br>2=2:16bit FrzCnt evt<br>5=5:32bit FrzCnt evt&time | | | 6=6:16bit FrzCnt evt&time | 1=32 bit frz counter event; 2=16 bit frz counter event; 5=32 bit frz counter event with time; |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 6=6:16bit FrzCnt evt&time | | | | 6=16 bit frz counter event with time. |
| Default Var Obj 30 | 1=1:32bit AI<br>2=2:16bit AI<br>3=3:32bit AI noflag<br>4=4:16bit AI noflag<br>5=5:AI float<br>6=6:AI double | | | 5=5:AI float | 1=32 bit AI; 2=16 bit AI; 3=32 bit AI without flag; 4=16 bit AI without flag; 5=AI float; 6=AI double. |
| Default Var Obj 32 | 1=1:32bit AI evt<br>2=2:16bit AI evt<br>3=3:32bit AI evt&time<br>4=4:16bit AI evt&time<br>5=5: float AI evt<br>6=6:double AI evt<br>7=7:float AI evt&time<br>8=8:double AI evt&time | | | 7=7:float AI evt&time | 1=32 bit AI event; 2=16 bit AI event; 3=32 bit AI event with time; 4=16 bit AI event with time; 5=float AI event; 6=double AI event; 7=float AI event with time; 8=double AI event with time. |
| Default Var Obj 40 | 1=1:32bit AO<br>2=2:16bit AO<br>3=3:AO float<br>4=4:AO double | | | 2=2:16bit AO | 1=32 bit AO; 2=16 bit AO; 3=AO float; 4=AO double. |
| Default Var Obj 42 | 1=1:32bit AO evt<br>2=2:16bit AO evt<br>3=3:32bit AO evt&time<br>4=4:16bit AO evt&time<br>5=5:float AO evt<br>6=6:double AO evt<br>7=7:float AO evt&time<br>8=8:double AO evt&time | | | 4=4:16bit AO evt&time | 1=32 bit AO event; 2=16 bit AO event; 3=32 bit AO event with time; 4=16 bit AO event with time; 5=float AO event; 6=double AO event; 7=float AO event with time; 8=double AO event with time. |
| An In Evt Mod | 0=0:SOE<br>1=1:Most Recent | | | 0=0:SOE | Analog Input Event Mode - 0: Sequence of Events, 1: Most Recent |
| Prtl Customization | 0...2147483647 | | 1 | 0 | Customization parameter. Please, refer to the protocol manual. |

## 3.1.20 DNP 3.0 Secure settings

**Table 26: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Protocol Security Mode | 1=App. authentication | | | 0=Off | Protocol Security Mode - 0: Off; 1: Aplication authentication; 2: TLS and |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=TLS and appl. auth.<br>0=Off | | | | Aplication authentication |
| Aggressive mode enable | 1=Disable<br>2=Enable | | | 1=Disable | Aggressove mode - 1: disable; 2: enable |
| Reply timeout | 100...120000 | ms | 1 | 2000 | Reply timeout |
| Exp Sesn key Chg Intv | 0...14400 | s | 1 | 1800 | Expected Session key change interval - Value zero will indicate that interval is not used |
| Exp Sesn key Chg Cnt | 2...10000000 | | 1 | 4000 | Expected session key change count |
| Max Sesn key Stat Cnt | 1...255 | | 1 | 5 | Maximum session key status count |
| Max Authn Fail Thres | 1...65535 | | 1 | 5 | Maximum authentication failures threshold |
| Max Reply Tm Thres | 1...65535 | | 1 | 3 | Maximum reply timeouts threshold |
| Max Authn Rekey Thres | 1...65535 | | 1 | 3 | Maximum authentication rekeys threshold |
| Max Err Msg Tx Thres | 1...65335 | | 1 | 10 | Maximum error messages sent threshold |
| Event Class Obj 122 | 1=1<br>2=2<br>3=3<br>4=1&2<br>5=1&3<br>6=2&3<br>7=1&2&3 | | | 1=1 | Event Class for Obj 122 |
| Default Var Obj 122 | 1=32bit SecStat evt<br>2=32bit SecStat evt&time | | | 1=32bit SecStat evt | 1=32bit Secure Statistics event; 2=32bit Secure Statistics event with time |
| Clear User List | 0=False<br>1=True | | | 0=False | Clear DNP Secure authentication User List |

## 3.1.21 DNP 3.0 Secure statistics thresholds settings

**Table 27: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Unexpected Msgs | 1...65535 | | 1 | 3 | Security statistics threshold for unexpected messages |
| Auth failures | 1...65535 | | 1 | 5 | Security statistics threshold for authorization failures |
| Authn failures | 1...65535 | | 1 | 5 | Security statistics threshold for authentication failures |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reply timeouts | 1...65535 | | 1 | 3 | Security statistics threshold for reply timeouts |
| Rekeys Authn failure | 1...65535 | | 1 | 3 | Security statistics threshold for rekeys due to authentication failure |
| Total Msgs Tx | 1...65535 | | 1 | 100 | Security statistics threshold for total messages sent |
| Total Msgs Rx | 1...65535 | | 1 | 100 | Security statistics threshold for total messages received |
| Total Crit Msgs Rx | 1...65535 | | 1 | 100 | Security statistics threshold for total critical messages received |
| Discarded Msgs | 1...65535 | | 1 | 10 | Security statistics threshold discarded messages |
| Error Msgs Tx | 1...65535 | | 1 | 10 | Security statistics threshold error messages sent |
| Error Msgs Rx | 1...65535 | | 1 | 10 | Security statistics threshold error messages received |
| Successful Authn | 1...65535 | | 1 | 100 | Security statistics threshold for successful authentications |
| Sesn key Chg | 1...65535 | | 1 | 10 | Security statistics threshold for session key changes |
| Failed Sesn key Chgs | 1...65535 | | 1 | 5 | Security statistics threshold for failed session key changes |
| Upd key Chgs | 1...65535 | | 1 | 1 | Security statistics threshold for update key changes |
| Failed Upd key Chgs | 1...65535 | | 1 | 1 | Security statistics threshold for failed update key changes |

## 3.1.22 DNP 3.0 Monitored data

**Table 28: Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Customization Mode | Enum | 0=Off/Normal<br>1=By Parameter<br>2=By File | | Protocol Customization Mode |
| Reset counters | BOOLEAN | 0=False<br>1=True | | Reset counters |
| Received frames | INT32 | -1...2147483646 | | Received frames |
| Transmitted frames | INT32 | -1...2147483646 | | Transmitted frames |
| Physical errors | INT32 | -1...2147483646 | | Physical layer errors |
| Link errors | INT32 | -1...2147483646 | | Link layer errors |
| Transport errors | INT32 | -1...2147483646 | | Transport layer errors |
| Mapping errors | INT32 | -1...2147483646 | | Mapping errors |

## 3.1.23 DNP 3.0 Secure monitored data

**Table 29: Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Unexp Msgs Cnt | INT32 | 0...2147483646 | | Security statistics counter for unexpected messages |
| Auth Fail Cnt | INT32 | 0...2147483646 | | Security statistics counter for authorization failures |
| Authn Fail Cnt | INT32 | 0...2147483646 | | Security statistics counter for authentication failures |
| Reply timeouts Cnt | INT32 | 0...2147483646 | | Security statistics counter for reply timeouts |
| Rekey Authn Fail Cnt | INT32 | 0...2147483646 | | Security statistics counter for rekeys due to authentication failure |
| Total Msgs Tx | INT32 | 0...2147483646 | | Security statistics counter for total messages sent |
| Total Msgs Rx | INT32 | 0...2147483646 | | Security statistics counter for total messages received |
| Critical Msgs Rx Cnt | INT32 | 0...2147483646 | | Security statistics counter for critical messages received |
| Discarded Msgs Cnt | INT32 | 0...2147483646 | | Security statistics counter for discarded messages |
| Err Msgs Tx Cnt | INT32 | 0...2147483646 | | Security statistics counter error messages sent |
| Err Msgs Rx Cnt | INT32 | 0...2147483646 | | Security statistics counter error messages received |
| Successful Authn Cnt | INT32 | 0...2147483646 | | Security statistics counter for successful authentications |
| Session Key Chg Cnt | INT32 | 0...2147483646 | | Security statistics counter for session key changes |
| Fail Ses Key Chg Cnt | INT32 | 0...2147483646 | | Security statistics counter for failed session key changes |
| Upd Key Chgs Cnt | INT32 | 0...2147483646 | | Security statistics counter update key changes |
| Fail Upd Key Chgs Cnt | INT32 | 0...2147483646 | | Security statistics counter for failed update key changes |

## 3.1.24 COM1 Settings

**Table 30: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Serial mode | 1=RS485 2Wire<br>2=RS485 4Wire<br>3=RS232 no handshake | | | 1=RS485 2Wire | Serial mode |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 4=RS232 with hand-shake | | | | |
| Baudrate | 1=300<br>2=600<br>3=1200<br>4=2400<br>5=4800<br>6=9600<br>7=19200<br>8=38400<br>9=57600<br>10=115200 | | | 6=9600 | Baudrate |

## 3.1.25 COM1 Monitored data

**Table 31: Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Characters received | INT32 | -1...2147483646 | | Characters received |
| Frames received | INT32 | -1...2147483646 | | Number of successfully received frames |
| Frames discarded | INT32 | -1...2147483646 | | Number of discarded frames |
| Frames transmitted | INT32 | -1...2147483646 | | Number of transmitted frames |
| CD lost | INT32 | -1...2147483646 | | CD lost |
| Collision | INT32 | -1...2147483646 | | Collision |
| CTS Timeout | INT32 | -1...2147483646 | | CTS Timeout |
| Transmission timeout | INT32 | -1...2147483646 | | Transmission timeout |
| Parity errors | INT32 | -1...2147483646 | | Number of parity errors |
| Overrun errors | INT32 | -1...2147483646 | | Number of overrun errors |
| Framing errors | INT32 | -1...2147483646 | | Number of framing errors |
| Reset counters | BOOLEAN | 0=False<br>1=True | | Resets counters |

## 3.1.26 COM2 Settings

**Table 32: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Serial mode | 1=RS485 2Wire<br>2=RS485 4Wire<br>3=RS232 no hand-shake<br>4=RS232 with hand-shake | | | 1=RS485 2Wire | Serial mode |
| Fiber mode | 0=No fiber | | | 0=No fiber | Fiber mode (light ON/OFF = idle) |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 1=Fiber light ON loop<br>2=Fiber light OFF loop<br>3=Fiber light ON star<br>4=Fiber light OFF star | | | | |
| Baudrate | 1=300<br>2=600<br>3=1200<br>4=2400<br>5=4800<br>6=9600<br>7=19200<br>8=38400<br>9=57600<br>10=115200 | | | 6=9600 | Baudrate |

## 3.1.27 COM2 Monitored data

**Table 33: Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Characters received | INT32 | -1...2147483646 | | Characters received |
| Frames received | INT32 | -1...2147483646 | | Number of successfully received frames |
| Frames discarded | INT32 | -1...2147483646 | | Number of discarded frames |
| Frames transmitted | INT32 | -1...2147483646 | | Number of transmitted frames |
| CD lost | INT32 | -1...2147483646 | | CD lost |
| Collision | INT32 | -1...2147483646 | | Collision |
| CTS Timeout | INT32 | -1...2147483646 | | CTS Timeout |
| Transmission timeout | INT32 | -1...2147483646 | | Transmission timeout |
| Parity errors | INT32 | -1...2147483646 | | Number of parity errors |
| Overrun errors | INT32 | -1...2147483646 | | Number of overrun errors |
| Framing errors | INT32 | -1...2147483646 | | Number of framing errors |
| Reset counters | BOOLEAN | 0=False<br>1=True | | Resets counters |

## 3.1.28 IO modules settings

**Table 34: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Slot specific threshold | 0=False | | | 0=False | Use slot specific binary input voltage threshold |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 1=True | | | | |
| Slot specific hysteresis | 0=False<br>1=True | | | 0=False | Use slot specific binary input voltage hysteresis |
| Input threshold voltage | 16...176 | Vdc | 2 | 16 | Global binary input threshold for all slots |
| Input threshold hysteresis | 10...50 | % | 2 | 10 | Global binary input hysteresis for all slots |
| Input osc. level | 2...50 | events/s | 1 | 30 | Binary input oscillation suppression threshold |
| Input osc. hyst | 2...50 | events/s | 1 | 10 | Binary input oscillation suppression hysteresis |

## 3.2 Communication

The protection relay supports a range of communication protocols including IEC 61850, IEC 61850-9-2 LE, IEC 60870-5-103, IEC 60870-5-104, Modbus® and DNP3. Profibus DPV1 communication protocol is supported by using the protocol converter SPA-ZC 302. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the protection relays, is only enabled by the IEC 61850 communication protocol.

One full IEC 61850-9-2 LE stream containing both voltages and currents can be sent. Receiving of up to four SMV streams is supported with a total of maximum 16 channels. The channels are freely configurable with the possibility to engineer SMV stream redundancy using the voltage and current switch functions with either another SMV stream or local measurements. The SMV stream quality along with other Application Configuration logic can be used for switching between measurement sources.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter settings, disturbance recordings and fault records can be accessed using the IEC 61850 protocol. Disturbance recordings are available to any Ethernet-based application in the IEC 60255-24 standard COMTRADE file format. The protection relay can send and receive binary signals from other devices (so-called horizontal communication) using the IEC 61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported. Furthermore, the protection relay supports sending and receiving of analog values using GOOSE messaging. The protection relay meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard.

The protection relay can support five simultaneous clients. If PCM600 reserves one client connection, only four client connections are left, for example, for IEC 61850 and Modbus.

All communication connectors are placed on integrated optional communication modules. The protection relay can be connected to Ethernet-based communication systems via the RJ-45 connector (100Base-TX) or the fiber-optic LC connector (100Base-FX).

The LHMI has two RJ-45 connectors. One is for connecting the LHMI to the protection relay main unit and the second is a service port which is used for connecting the LHMI and a computer. This computer can be, for example, a laptop with the PCM600 engineering tool or a browser for WHMI.

An optional serial interface is available for RS-485 communication.

### 3.2.1 Ethernet addresses for HMI

There is a DHCP server available at X0 port that can provide an IP address and a netmask for one client. The service port on the LHMI has a DHCP server that can also serve one client. To use WHMI or PCM600, a PC can be connected either directly to X0 port or to the LHMI's service port. In both cases, the PC can use the DHCP client to receive the IP address automatically.

If the LHMI is connected to the relay through the station network, the service port still offers the DHCP server even if the LHMI's main unit port uses a static address. The LHMI device functions as a router between the PC and the protection relay.

Main unit's X0 port IP address can also be changed to avoid conflicts with other network addresses. Parameter is located under Configuration/Communication/Ethernet/HMI address. Subnet mask for X0 IP address is always 255.255.255.0 and cannot be changed.

### 3.2.2 Self-healing Ethernet ring

The protection relay supports a self-healing ring solution for small installations. For the correct operation of self-healing ring topology, the network topology must be a ring. It is essential that the external switches in the network support the RSTP protocol and that it is enabled in the switches. Otherwise, connecting the ring topology can cause problems to the network.

The protection relay itself does not support link-down detection or RSTP. The ring recovery process is based on the aging of the MAC addresses and the link-up/linkdown events can cause temporary breaks in communication. For a better performance of the self-healing ring, it is recommended that the external switch furthest from the protection relay loop is assigned as the root switch (bridge priority = 0) and the bridge priority increases towards the protection relay ring. The end links of the protection relay loop can be attached to the same external switch or to two adjacent external switches. If two adjacent external switches are connected to the relay loop, the point-to-point Ethernet link connecting these two switches should be prioritized by setting higher RSTP priority (lower setting value for port priority). This ensures that most of the network traffic that is not meant for the relays flows between the Ethernet switches.



The self-healing ring solution supports the connection of up to 30 protection relays. However, the HSR or PRP network is recommended to ensure redundant and proper functionality.



Self-healing is not recommended for time-critical applications using IEC 61850-9-2 and PTP due to longer recovery time. Instead, HSR/PRP is recommended to ensure reliable performance.

## 3.2.3 Ethernet redundancy

IEC 61850 specifies a network redundancy scheme that improves the system availability for substation communication. It is based on two complementary protocols defined in the IEC 62439-3:2012 standard: parallel redundancy protocol PRP and high-availability seamless redundancy HSR protocol. Both protocols rely on the duplication of all transmitted information via two Ethernet ports for one logical network connection. Therefore, both are able to overcome the failure of a link or switch with a zero-switchover time, thus fulfilling the most demanding real-time application requirements for the substation automation.

Ethernet network redundancy can be achieved using HSR or PRP and it is applied to all services using the Ethernet/TCP network.

PRP specifies that each device is connected in parallel to two local area networks. HSR applies the PRP principle to rings and to the rings of rings to achieve cost-effective redundancy. Thus, each device incorporates a switch element that forwards frames from port to port.



IEC 62439-3:2012 cancels and replaces the first edition published in 2010. These standard versions are also referred to as IEC 62439-3 Edition 1 and IEC 62439-3 Edition 2. The protection relay supports IEC 62439-3:2016 (Edition 3) and IEC 62439-3:2012 and it is not compatible with IEC 62439-3:2010.

**PRP**

Each PRP node, called a double attached node with PRP (DAN), is attached to two independent LANs operated in parallel. These parallel networks in PRP are called LAN A and LAN B. The networks are completely separated to ensure failure independence, and they can have different topologies. Both networks operate in parallel, thus providing zero-time recovery and continuous checking of redundancy to avoid communication failures. Non-PRP nodes, called single attached nodes (SANs), are either attached to one network only (and can therefore communicate only with DANs and SANs attached to the same network), or are attached through a redundancy box, a device that behaves like a DAN.

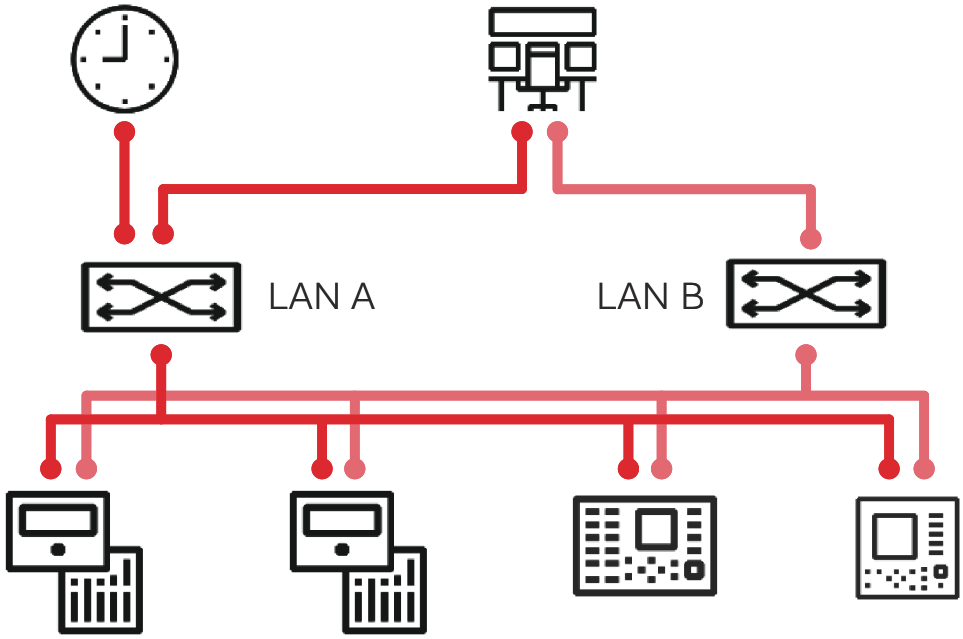



*Figure 10: Parallel redundancy protocol solution*

In case a laptop or a PC workstation is connected as a non-PRP node to one of the PRP networks, LAN A or LAN B, it is recommended to use a redundancy box device or an Ethernet switch with similar functionality between the PRP network and SAN to remove additional PRP information from the Ethernet frames. In some cases, default PC workstation adapters are not able to handle the maximum-length Ethernet frames with the PRP trailer.

There are different alternative ways to connect a laptop or a workstation as SAN to a PRP network.

- Via an external redundancy box (RedBox) or a switch capable of connecting to PRP and normal networks
- By connecting the node directly to LAN A or LAN B as SAN
- By connecting the node to the protection relay's interlink port

**HSR**

HSR applies the PRP principle of parallel operation to a single ring, treating the two directions as two virtual LANs. For each frame sent, a node, DAN, sends two frames, one over each port. Both frames circulate in opposite directions over the ring and each node forwards the frames it receives, from one port to the other. When the originating node receives a frame sent to itself, it discards that to avoid loops; therefore, no ring protocol is needed. Individually attached nodes, SANs, such as laptops and printers, must be attached through a “redundancy box” that acts as a ring element. For example, a REX640 protection relay with HSR support can be used as a redundancy box.

Each protection relay has a 50-µs store-and-forward delay. To fulfil the performance requirements for fast horizontal communication for protection applications using GOOSE and SMV, the ring size is limited to 30 protection relays.

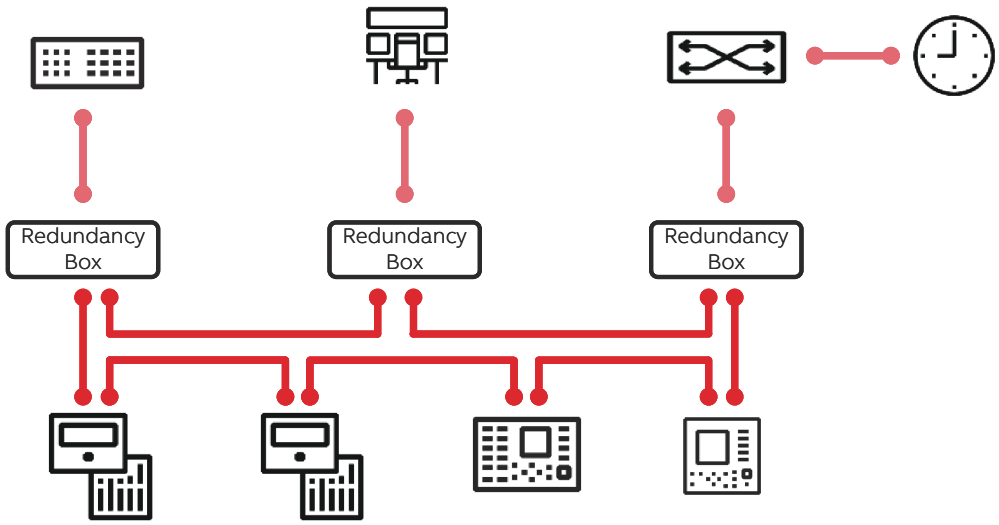



*Figure 11: High-availability seamless redundancy solution*

### 3.2.3.1 Interlink port

In the relay redundant COM module, the port without LAN-A/LAN-B tag is so called interlink-port. This port can be used to connect a device directly to the relay. Mainly this port should be used to connect a single point-to-point device, such as RIO600. Although it is possible, it not recommended to connect big amount of devices behind the interlink port, thus making the relay act as a hub between two network segments. The relay should preferrably act as a network end-device, and not as a hub for network traffic.

## 3.2.4 Process bus

Process bus IEC 61850-9-2 defines the transmission of Sampled Measured Values within the substation automation system. International Users Group created a guideline IEC 61850-9-2 LE that defines an application profile of IEC 61850-9-2 to facilitate implementation and enable interoperability. Process bus is used for distributing process data from the primary circuit to all process bus compatible devices in the local network in a real-time manner. The data can then be processed by any protection relay to perform different protection, automation and control functions.

Redundant SMV streams are also supported by using the voltage (VMSWI) and current (CMSWI) function blocks. Automatic switching to the backup SMV stream can be configured in Application Configuration using SMV quality and/or other logic.

UniGear Digital switchgear concept relies on the process bus together with current and voltage sensors. The process bus enables several advantages for the UniGear Digital like simplicity with reduced wiring, flexibility with data availability to all devices, improved diagnostics and longer maintenance cycles.

With process bus the galvanic interpanel wiring for sharing busbar voltage value can be replaced with Ethernet communication. Transmitting measurement samples

over process bus brings also higher error detection because the signal transmission is automatically supervised. Additional contribution to the higher availability is the possibility to use redundant Ethernet network for transmitting SMV signals.

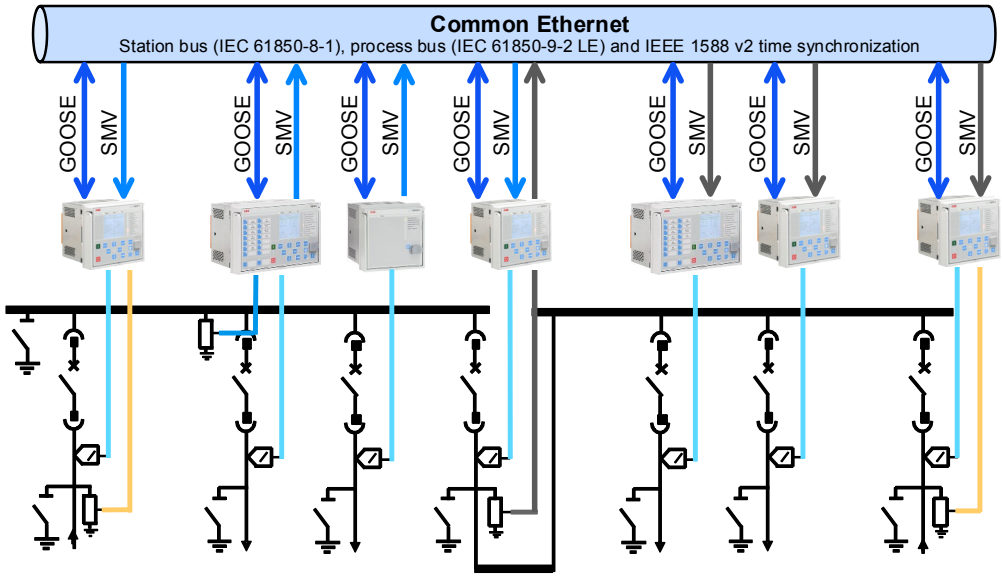



*Figure 12: Process bus application of voltage sharing and synchrocheck*

REX640 supports IEC 61850 process bus with sampled values of analog currents and voltages. The measured values are transferred as sampled values using the IEC 61850-9-2 LE protocol which uses the same physical Ethernet network as the IEC 61850-8-1 station bus. One example application is sharing the measured busbar voltage from one or several REX640 relays with the other REX640 relays. This can be done even for a double busbar switchgear installation using automatic 9-2 stream selection based on the bus disconnectors' physical position.

REX640 protection relays with process bus based applications use IEEE 1588 v2 Precision Time Protocol (PTP) according to IEEE C37.238-2011 or IEC 61850-9-3 profiles for high accuracy time synchronization. With IEEE 1588 v2, the cabling infrastructure requirement is reduced by allowing time synchronization information to be transported over the same Ethernet network as the data communications.

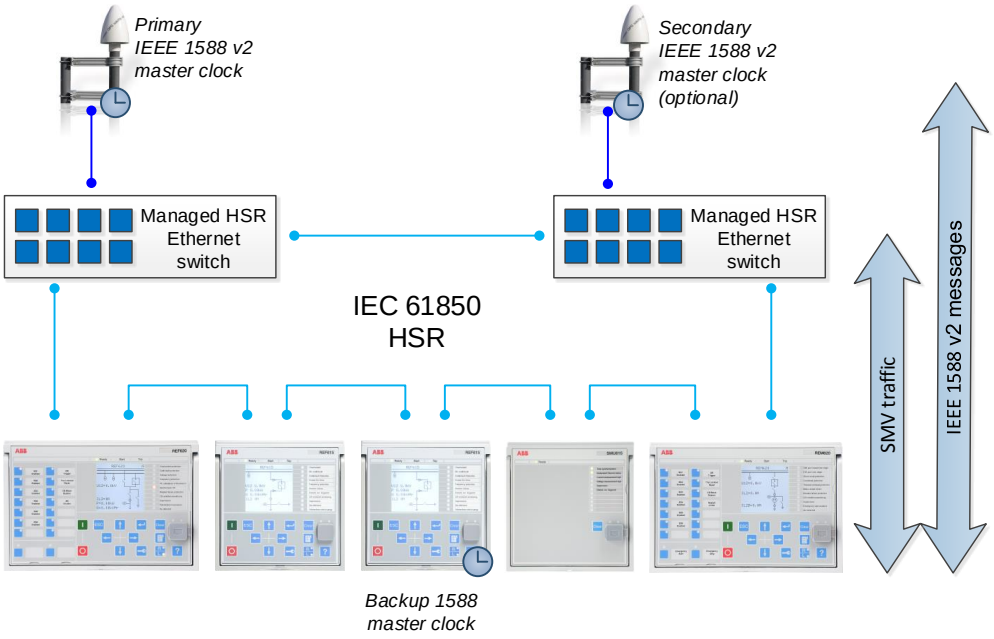



*Figure 13: Example network topology with process bus, redundancy and IEEE 1588 v2 time synchronization*

## 3.2.5 Secure communication

The protection relay supports secure communication for WHMI and file transfer protocol using Transport Layer Security protocol. The WHMI must be connected from a Web browser using the HTTPS protocol. File transfer client must use explicit FTPS.

## 3.2.6 Communication services control

### 3.2.6.1 Ethernet ports

The protection relay allows the use of a secondary IP address for the station ports on the communication modules COM1001...COM1003. This secondary IP network is assigned to a single Ethernet port and can be used to make separate networks for different communication protocols or, for example, a separate service network for configuration purposes. Multicast station/bus communication, such as IEC 61850-9-2 LE sampled values and GOOSE, is only supported on the Network 1 interface. The parameters for setting the secondary IP network are located under **Configuration** > **Communication** > **Ethernet** > **Network 2 address**.

**Table 35: Secondary IP address parameters**

| Parameter | Options | Description |
|---|---|---|
| Configuration/Communication/Ethernet/Network 2 address/ Enable | False (default) | Network 2 disabled |
| | TRUE | Network 2 enabled |
| Configuration/Communication/Ethernet/Network 2 address/IP address | 0.0.0.0 | IP address for Network 2 |
| Configuration/Communication/Ethernet/Network 2 address/IP address | 0.0.0.0 | Subnet address for Network 2 |
| Configuration/Communication/Ethernet/Network 2 address/MAC address | xx-xx-xx-xx-xx-xx | MAC address for Network 2 |

The IP address for Network 2 is disabled by default settings, and all Ethernet ports are assigned to the same IP address used in the Network 1 address menu **Configuration** > **Communication** > **Ethernet** > **Network 1**. If Network 2 is taken into use by the setting Enable="True" (requires reboot), the interlink port X3 of the COM module is assigned to this second network, using the IP address and subnet parameters in the Network 2 address menu **Configuration** > **Communication** > **Ethernet** > **Network 2 address**.

If the Network 2 interface is enabled, PTP time synchronization and SMV/GOOSE multicast are disabled for that port.

The secondary IP setting must not collide with the primary Network 1 IP address or LHMI IP address, otherwise the secondary IP address is not taken into use.

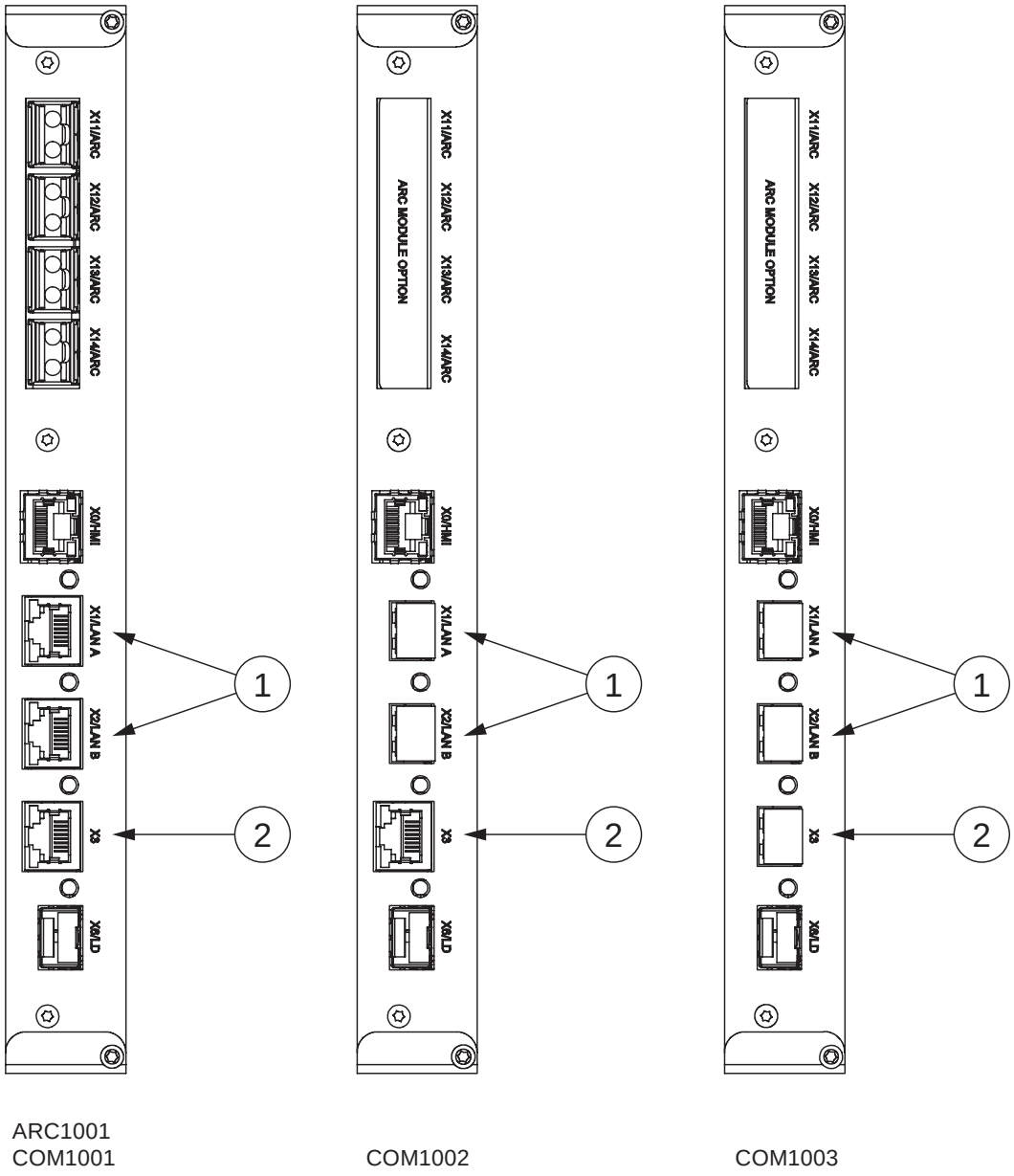



*Figure 14: Ethernet modes with Network 1 and Network 2*

**1** Network 1

**2** Network 1 / Network 2

### 3.2.6.2 Protocol control

It is possible to allow or block different protocols for different network interfaces in the protection relay using the parameters in **Configuration** > **Communication** > **Protocols** > **Network1**, **Configuration** > **Communication** > **Protocols** > **Network2** and **Configuration** > **Communication** > **Protocols** > **HMI Port**.

All protocols are allowed for each network by default, and can be separately disabled.

**Table 36: Protocol control in the protection relay**

| Parameter | Options | Description |
|---|---|---|
| Configuration/Communication/Protocols/Network1/FTP | Off | Denies FTP and FTPS |
| | On | Allows FTP and FTPS |
| | Secure (Default) | Allows FTPS only |
| Configuration/Communication/Protocols/Network2/FTP | Off | Denies FTP and FTPS |
| | On | Allows FTP and FTPS |
| | Secure (Default) | Allows FTPS only |
| Configuration/Communication/Protocols/HMI Port/FTP | Off | Denies FTP and FTPS |
| | On | Allows FTP and FTPS |
| | Secure (Default) | Allows FTPS only |
| Configuration/Communication/Protocols/Network1/HTTPS | Off | Denies HTTPS |
| | On (Default) | Allows HTTPS |
| Configuration/Communication/Protocols/Network2/HTTPS | Off | Denies HTTPS |
| | On (Default) | Allows HTTPS |
| Configuration/Communication/Protocols/Network1/MMS | Off | Denies IEC 61850 MMS |
| | On (Default) | Allows IEC 61850 MMS |
| Configuration/Communication/Protocols/Network2/MMS | Off | Denies IEC 61850 MMS |
| | On (Default) | Allows IEC 61850 MMS |
| Configuration/Communication/Protocols/HMI Port/MMS | Off | Denies IEC 61850 MMS |
| | On (Default) | Allows IEC 61850 MMS |
| Configuration/Communication/Protocols/Network1/DNP | Off | Denies DNP3 |
| | On (Default) | Allows DNP3 |
| Configuration/Communication/Protocols/Network2/DNP | Off | Denies DNP3 |
| | On (Default) | Allows DNP3 |
| Configuration/Communication/Protocols/Network1/Modbus | Off | Denies Modbus |
| | On (Default) | Allows Modbus |
| Configuration/Communication/Protocols/Network2/Modbus | Off | Denies Modbus |
| | On (Default) | Allows Modbus |
| Configuration/Communication/Protocols/Network1/ IEC-60870-5-104 | Off | Denies IEC 60870-5-104 |
| | On (Default) | Allows IEC 60870-5-104 |
| Configuration/Communication/Protocols/Network2/ IEC-60870-5-104 | Off | Denies IEC 60870-5-104 |
| | On (Default) | Allows IEC 60870-5-104 |

### 3.2.6.3 Protocol write access rights

Write access rights are configurable for FTP, MMS, and HTTPS protocols in **Configuration** > **Authorization**. The write access parameters are used to narrow down services that allow setting changes on different network interfaces. Disabling the FTP and IEC 61850 MMS write access on Network 1 and 2 prevents the user from updating the configuration to the protection relay from PCM600. Disabling the HTTPS write access prevents the user from writing setting changes from WHMI.

**Table 37: Protocol write access in the protection relay**

| Parameter | Options | Description |
|---|---|---|
| Configuration/Authorization/Network1/FTP write access | Off | FTP write access denied for Network 1 |
| | On (Default) | FTP write access allowed for Network 1 |
| Configuration/Authorization/Network1/MMS write access | Off | IEC 61850 MMS write access denied for Network 1 |
| | On (Default) | IEC 61850 MMS write access allowed for Network 1 |
| Configuration/Authorization/Network1/HTTPS write access | Off | HTTPS write access denied for Network 1 |
| | On (Default) | HTTPS write access allowed for Network 1 |
| Configuration/Authorization/Network2/FTP write access | Off | FTP write access denied for Network 2 |
| | On (Default) | FTP write access allowed for Network 2 |
| Configuration/Authorization/Network2/MMS write access | Off | IEC 61850 MMS write access denied for Network 2 |
| | On (Default) | IEC 61850 MMS write access allowed for Network 2 |
| Configuration/Authorization/Network2/HTTPS write access | Off | HTTPS write access denied for Network 2 |
| | On (Default) | HTTPS write access allowed for Network 2 |
| Configuration/Authorization/HMI/FTP write access | Off | FTP write access denied for the HMI port |
| | On (Default) | FTP write access allowed for the HMI port |
| Configuration/Authorization/HMI/MMS write access | Off | IEC 61850 MMS write access denied for the HMI port |
| | On (Default) | IEC 61850 MMS write access allowed for the HMI port |

PCM600 is using FTP or FTPS protocol to communicate with the protection relay. If the FTP write access is disabled for a network PCM600 functionality is limited to support read operations only from Disturbance handling, Event viewer and Parameter Setting.

Enabling Network 2 IP address requires additional configuration in PCM600 to define IEC 61580 subnetworks. This configuration is done via Ethernet Configuration and IEC 61850 Configuration in PCM600.

## 3.2.7 Serial port supervision SERLCCH

### 3.2.7.1 Function block

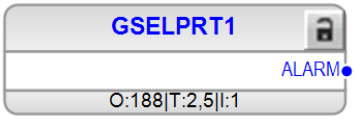



*Figure 15: Function block*

### 3.2.7.2 Functionality

The function block represents the IEC61850 GOOSE communication monitoring and diagnostics in the relay. Function block includes the GOOSE diagnostic counters that can be accessed via HMI, and ALARM output.

ALARM output indicates if overall GOOSE communication status is good or not. If ALARM output status is “False”, all GOOSE inputs are receiving data within the timeout limits. If the output is “True”, there is an issue (e.g. timeout or decoding), with one or more of GOOSE inputs in the relay.

For more information on the GOOSE configuration and monitoring refer to the IEC61850 engineering manual.

## 3.2.8 Serial port supervision SERLCCH

### 3.2.8.1 Function block




*Figure 16: Function block*

### 3.2.8.2 Functionality

The serial port supervision function SERLCCH represents one serial communication port driver. Depending on the hardware configuration, the protection relay can be equipped with two UART-based serial communication ports. The communication ports can be both galvanic (RS-485) or one port could be fiber-optic. The protection relay uses the ports for serial communication protocol links.

Serial communication drivers are identified in the device configuration as COM1 and COM2, which correspond to function blocks SERLCCH1 and SERLCCH2, respectively. Each COM port driver has its own setting parameters on the HMI under **Configuration** > **Communication** > **COMn (n=1,2)**.

Output LNKxLIV is active (TRUE) whenever characters are received on the serial interface. Output CHxLIV is active (TRUE) while complete link frames are received. Both outputs go to FALSE state after 15 seconds of inactivity on the port.

## 3.2.9 Assigning of a serial communication protocol to a COM serial port

The settings of the serial communication protocol instance include a setting parameter, called either *Port* or *Serial port*, which is used to select the COM1 or COM2 setting.

Since not all serial protocol standards allow changes in link parameters, all link setting parameters are not found in the COMn settings. Additional link setting parameters are found in the setting parameter list of the used serial protocol.

## 3.2.10 Physical locations of the serial channels

The physical location of the COM1 and COM2 drivers depends on the link mode used which, in turn, depends on the used communication hardware option. Serial channels can be found on communication boards COM1004...COM1005.

- X7 is the fiber-optic interface. Only driver COM2 can be configured into fiber-optic mode.
- X8 is the RS-485/IRIG-B interface. Both drivers COM1 and COM2 can be configured to this interface: COM1 and COM2 can act as two RS-485 2-wire links or, alternatively, COM1 can act as one single RS-485 4-wire link. Both ports are galvanically isolated serial communication ports.

**Table 38: Connector X8 signals**

| Pin No | Pin name | Description | Alternative |
|---|---|---|---|
| 1 | GND | EARTH | |
| 2 | GNDC | GND connected to earth via 1nF capacitor | |
| 3 | NC | | |
| 4 | IRIG-B - | ISOL2_GND | |
| 5 | IRIG-B + | | |
| 6 | ISOL_GND | RS485 GND | |
| 7 | RS485 B1/- | 2-wire - , COM1 | 4-wire TX pair, COM1 |
| 8 | RS485 A1/+ | 2-wire + , COM1 | 4-wire TX pair, COM1 |
| 9 | RS485 B2/- | 2-wire - , COM2 | 4-wire RX pair, COM1 |
| 10 | RS485 A2/+ | 2-wire + , COM2 | 4-wire RX pair, COM1 |

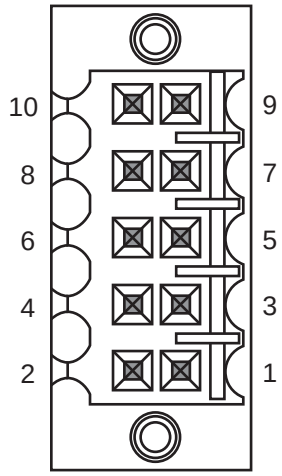



*Figure 17: X8 connector pinout for socket on communication board*

**Table 39: LED configuration (COM1004...COM1005)**

| LED | Description |
|---|---|
| X1 | X1 LANA |
| X2 | X2 LANB |
| X6 | X6 LD |
| X7 TX | FO-UART |
| X8 TX | RS-485/COM2 |
| X8 TX | RS-485/COM1 |
| IRIG-B | IRIG-B |

## 3.2.11 RS-485 bias and termination settings

A 6 x DIP switch is located on the COM1004...COM1005 cards. The COM card needs to be pulled out from the relay case to access the switch. See *Figure 18* for the location of the switch. RS-485 biasing and termination settings are possible through this switch. If the switch is in “OFF” position, bias and termination are disabled and in “ON” position, they are enabled.

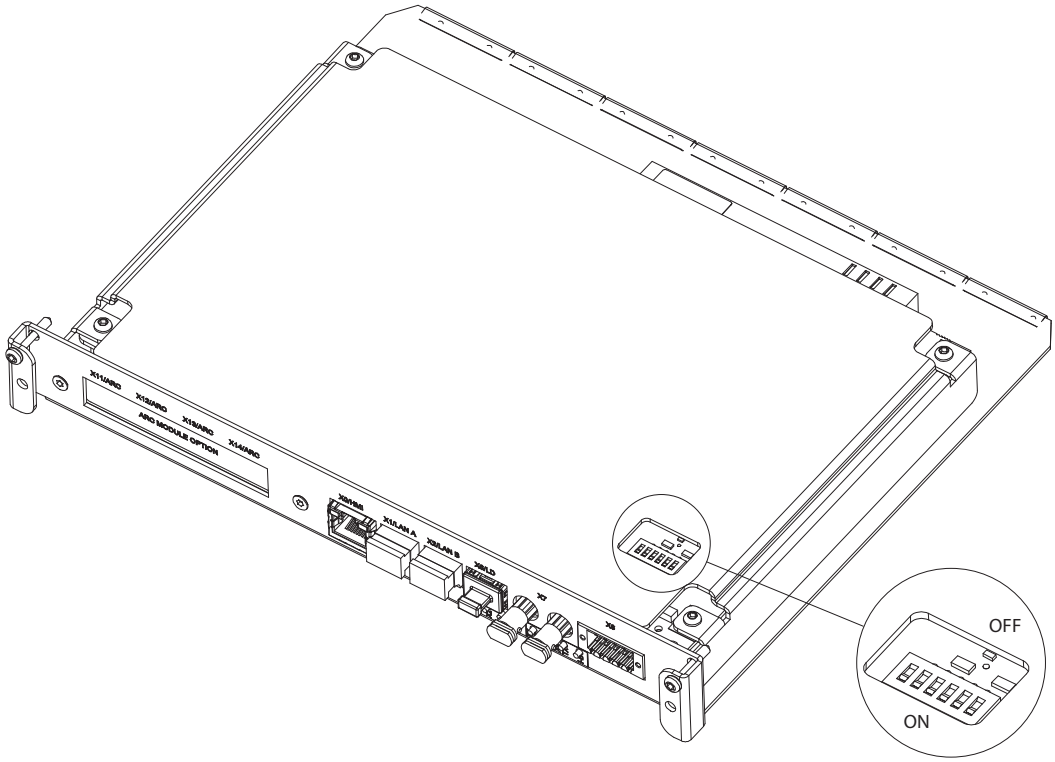



*Figure 18: DIP switches on the COM1004...COM1005 cards*

**Table 40: Bias and termination DIP switch**

| Switch | Signal | X8 pin | Type |
|---|---|---|---|
| 1 | RS485_A1/+ | 8 | Bias |
| 2 | RS485_A1/+<br>RS485_B1/- | | Bus termination |
| 3 | RS485_B1/- | 7 | Bias |
| 4 | RS485_A2/+ | 10 | Bias |
| 5 | RS485_A2/+<br>RS485_B2/- | | Bus termination |
| 6 | RS485_B2/- | 9 | Bias |

## 3.2.12 Serial link diagnostics and monitoring

Serial communication diagnostics and monitoring is divided between the serial link driver and the serial communication protocol. The lower-level physical and protocol-independent aspects of the UART-based serial communication are monitored in the serial link driver. Diagnostic counters and monitoring values are located on the HMI under **Monitoring** > **Communication** > **COMn** (n= 1,2,...).

Depending on the communication protocol, the serial driver software receives single characters or complete protocol frames, based on the frame start/stop characters or on link frame timing.

**Table 41: Setting parameters**

| Parameter | Description |
|---|---|
| Fiber mode | Defines the fiber-optic mode used. Setting "No fiber" is the same as galvanic mode. |
| Serial mode | Used for galvanic RS-485 modes 2- or 4-wire. This setting is relevant only if Fiber mode is set to "No fiber". |
| Baudrate | Communication speed used. |

**Table 42: Diagnostic counters and indications**

| Counters | Description |
|---|---|
| Characters received | Counts all incoming non-erroneous characters. This counter operates regardless of whether the serial driver is set to detect a whole protocol link frame or just separate characters. |
| Frames received | Counts all protocol-specific non-erroneous frames received. Protocol-specific frames can be based on timing (for example, Modbus RTU) or on special start and stop characters (for example, Modbus ASCII). |
| Frames discarded | Counts all protocol-specific erroneous frames received. If the driver detects an error while receiving a frame, the whole frame is automatically discarded. This also means that the protocol in question never receives a faulty link frame from the driver. When this counter is incremented, one of the detailed error counters (Parity, Overrun, Framing) can also be incremented. |
| Frames transmitted | Counts all protocol-specific frames transmitted from the COM channel. |
| Collisions | Counts the number of transmission collisions that have occurred. Used in RS-485 mode by some protocols where transmissions could collide with reception. For example, DNP3 unsolicited reporting mode. |
| Parity errors | Counts the number of parity errors detected in characters received. |
| Overrun errors | Counts the number of overrun errors detected in characters received. |
| Framing errors | Counts the number of framing errors detected in characters received. |
| Link status | In write direction: By writing value 1 to this parameter, all the diagnostic counters are reset to 0. |
| Link status | In monitoring direction: If the driver instance is in use by any communication protocol, the monitoring value shows value 1. Otherwise, the value is 0. |

## 3.2.13 Modbus protocol MBSLPRT

### 3.2.13.1 Function block




*Figure 19: Function block*

### 3.2.13.2 Functionality

The function block represents a Modbus server protocol instance in the protection relay. Function block settings include communication interface assignment for the instance, that is, Ethernet/TCP or serial.

A Modbus server protocol instance is activated if the function block instance is added to the application configuration. The setting *Operation* should be "On" and setting *Port* should have the communication interface assignment.

The STATUS output of the function block is active if Modbus client requests have been received on the communication interface within 15 seconds.

By default no Modbus data is mapped to the protocol interface. Protocol data has to be created using Communication Management in PCM600. There are two mapping sets, “Mapping 1” and “Mapping 2”, and either can be used. Setting parameter *Mapping selection* points to the mapping set used. Several Modbus protocol instances can point to the same mapping set.

For more information on the Modbus server protocol, see the Modbus communication protocol manual.

## 3.2.14 DNP3 protocol DNPLPRT

### 3.2.14.1 Function block




*Figure 20: Function block*

### 3.2.14.2 Functionality

The function block represents one DNP3 server protocol instance in the protection relay. Function block settings include communication interface assignment for the instance, that is, Ethernet/TCP(+UDP) or serial.

Over Ethernet/TCP, the protocol optionally supports secure authentication with symmetric keys. The implementation follows the IEC 62351-5 security standard specification as well as the descriptions in DNP3 standard part 7, IP-networking chapter "Secure authentication".

A DNP3 server protocol instance is activated if the function block instance is added to the application configuration. The setting *Operation* should be "On" and setting *Port* should have the communication interface assignment.

The STATUS output of the function block is active if DNP3 client requests or DNP3 supervision messages have been received on the communication interface within an interval defined by the link keep-alive parameter.

By default no DNP3 data is mapped to the protocol interface. Protocol data has to be created using Communication Management in PCM600. There are two mapping sets, “Mapping 1” and “Mapping 2”, and either can be used. Setting parameter *Mapping selection* points to the mapping set used. Several DNP3 protocol instances can point to the same mapping set.

For more information on the DNP3 server protocol, see the DNP3 communication protocol manual.

## 3.2.15 IEC 60870-5-103 protocol I3CLPRT

### 3.2.15.1 Function block




*Figure 21: Function block*

### 3.2.15.2 Functionality

The function block represents one IEC 60870-5-103 server protocol instance in the protection relay. Function block settings include communication interface assignment for the instance, that is, serial communication port 1 or 2.

An IEC 60870-5-103 server protocol instance is activated if the function block instance is added to the application configuration. The setting *Operation* should be "On" and setting *Serial port* should have the communication interface assignment.

The STATUS output of the function block is active if IEC 60870-5-103 client requests have been received on the communication interface within 15 seconds.

The function block input EC_FRZ relates to possible ASDU 205 (mostly energy) counters defined in the protection relay. Activation of the EC_FRZ input freezes and captures the current ASDU 205 counter values and sends them to the IEC 60870-5-103 client. Several options for the activation exist.

1. EC_FRZ object exists as a control object in the IEC 60870-5-103 data model, and can be written from the client.
2. EC_FRZ physical input can be activated from an internal or external timer application signal.

By default most IEC 60870-5-103 data is pre-mapped to the protocol interface. However, protocol data can be deleted, added and modified using Communication Management in PCM600.

For more information on the IEC 60870-5-103 server protocol, see the IEC 60870-5-103 communication protocol manual.

## 3.2.16 IEC 60870-5-104 protocol I5CLPRT

### 3.2.16.1 Function block




*Figure 22: Function block*

### 3.2.16.2 Functionality

The function block represents one IEC 60870-5-104 TCP/IP server protocol instance in the protection relay.

An IEC 60870-5-104 server protocol instance is activated if the function block instance is added to the application configuration. The setting *Operation* should be "On".

The protocol optionally supports secure authentication version with symmetric keys. The implementation follows the IEC 62351-5 security standard specification and the descriptions in the pro-tocol standard part IEC 60870-5-7 “Transmission procedures, extension for secure communica-tion”. **Functionality is limited to single user mode only**.

The `STATUS` output of the function block is active if IEC 60870-5-104 client activity is noticed on the communication interface within 15 seconds.

The function block input `IT_FRZ` relates to the IEC 610870-5-104 integration totals counter objects defined in the protection relay. The `IT_FRZ` input can be configured for external counter freezing.

By default no IEC 60870-5-104 data objects are mapped to the protocol instance. Protocol data can be added and modified using Communication Management in PCM600.

For more information on the IEC 60870-5-104 server protocol, see the IEC 60870-5-104 communication protocol manual.

# 3.3 Self-supervision

The protection relay's extensive self-supervision system continuously supervises the relay’s software, hardware and certain external circuits. It handles the run-time fault situation and informs the user about a fault via the LHMI, the relay's main unit power module Ready LED and through the communication channels. The target of the self-supervision is to safeguard the relay’s reliability by increasing both dependability and security. The dependability can be described as the relay’s ability to operate when required. The security can be described as the relay scheme’s ability to refrain from operating when not required. The dependability is increased by letting the system operators know about the problem, giving them a chance to take the necessary actions as soon as possible. The security is increased by

preventing the relay from making false decisions, such as issuing false control commands.

There are two types of fault indications.

- Internal faults
- Warnings

Warnings are indications of less severe situations which can also be caused by external reasons, for example, in case the RTD sensor measurement circuit is not complete.

On the LHMI, the self-supervision status is available as an advanced page under Relay Status page. The self-supervision status is indicated with Internal Fault, Warning and All OK LEDs. In normal operation, All OK LED is lit. The selfsupervision also controls the status of IRF output relay. The IRF output relay is energized under normal conditions and de-energized under internal fault conditions.

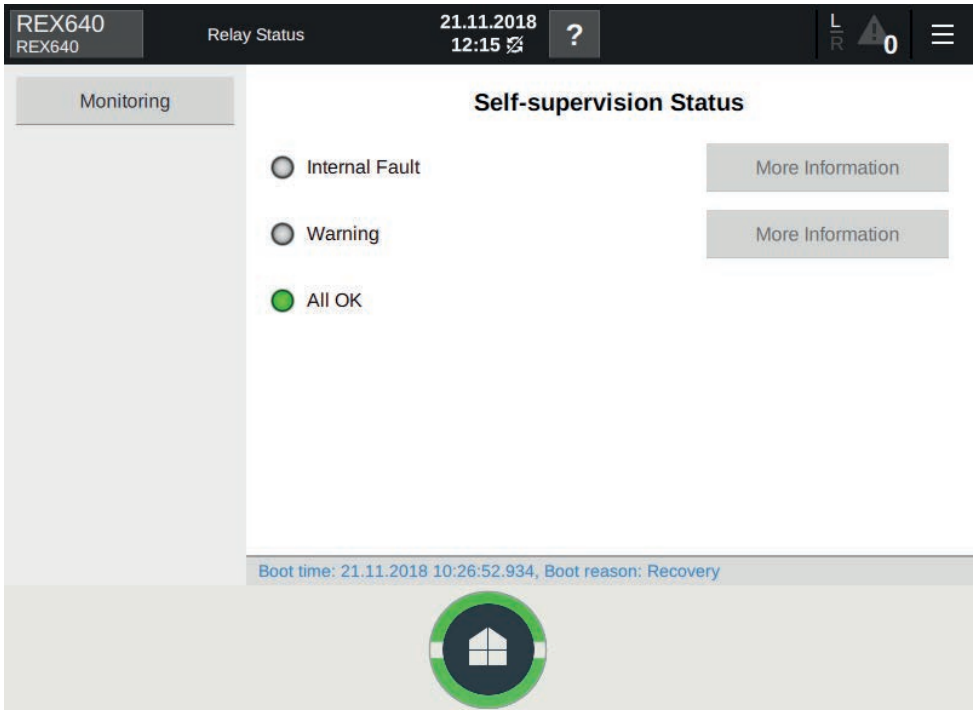



*Figure 23: Relay self-supervision status on local HMI*

On the WHMI, the self-supervision status is available under Device menu. The top right LED indicates the relay status.

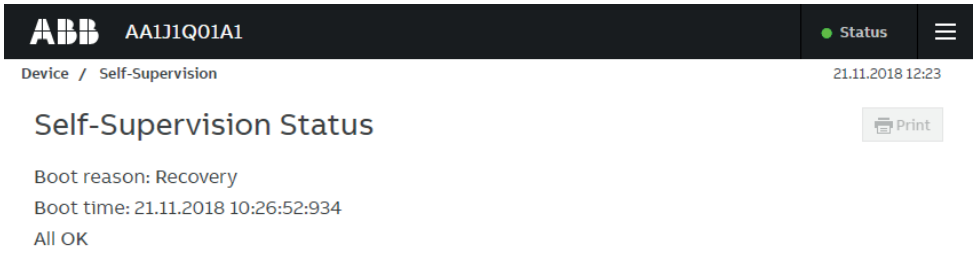



*Figure 24: Relay self-supervision status on Web HMI*

In addition, the last boot reason and time are shown on both LHMI and WHMI.

## 3.3.1 Internal faults

When an internal relay fault is detected, the relay protection operation is disabled, the self-supervision output relay is de-energized, and the change-over contact is released. In the main unit, the main indication of an internal fault is a flashing green Ready LED behind the power module, and on the HMI, a rapidly flashing red Home button.

Different actions are taken depending on the severity of the internal fault. In case of a temporary fault, the protection relay tries to recover from the situation by restarting. The restart procedure includes two stages; when the relay detects a fault, it restarts itself in a few seconds after the fault occurrence. If the relay did not recover after the first restart, or the fault reoccurs during the next 60 minutes, the second restart is delayed for 10 minutes. In case of a permanent fault, the protection relay stays in the internal fault mode. All output relays are de-energized and contacts are released for the internal fault. The protection relay continues to perform internal tests during the fault situation. If the internal fault disappears, the fault indication LEDs stop flashing and the protection relay returns to the normal service state.

One possible cause for an internal fault situation is a so-called soft error. The soft error is a probabilistic phenomenon which is rare in a single device, statistically not happening more often than once in a relay's lifetime. No hardware failures are expected and a full recovery from the soft error is possible by a self-supervision controlled restart of the relay.

The self-supervision signal output operates on the closed-circuit principle. Under normal conditions, the IRF output relay is energized and the contact gap 3-5 is closed. If the auxiliary power supply fails or an internal fault is detected, the IRF output relay is de-energized and the contact gap 3-5 opens.

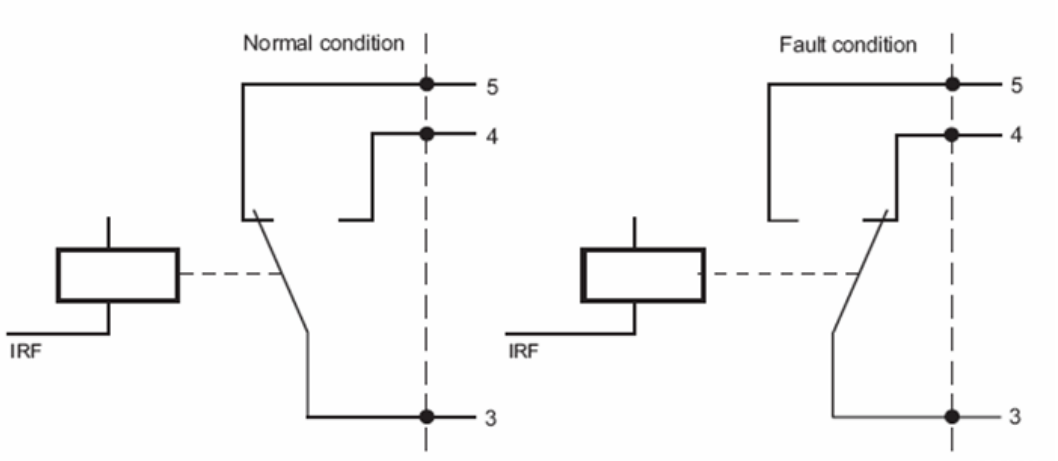



*Figure 25: Output contact*

The internal fault code indicates the type of internal relay fault. When a fault appears, the code must be recorded so that it can be reported to ABB customer service.

More details about the active internal fault are found on the Relay Status page. On the LHMI, the internal fault state is indicated with a red LED. More information about the fault and recovery options can be accessed by tapping More Information.

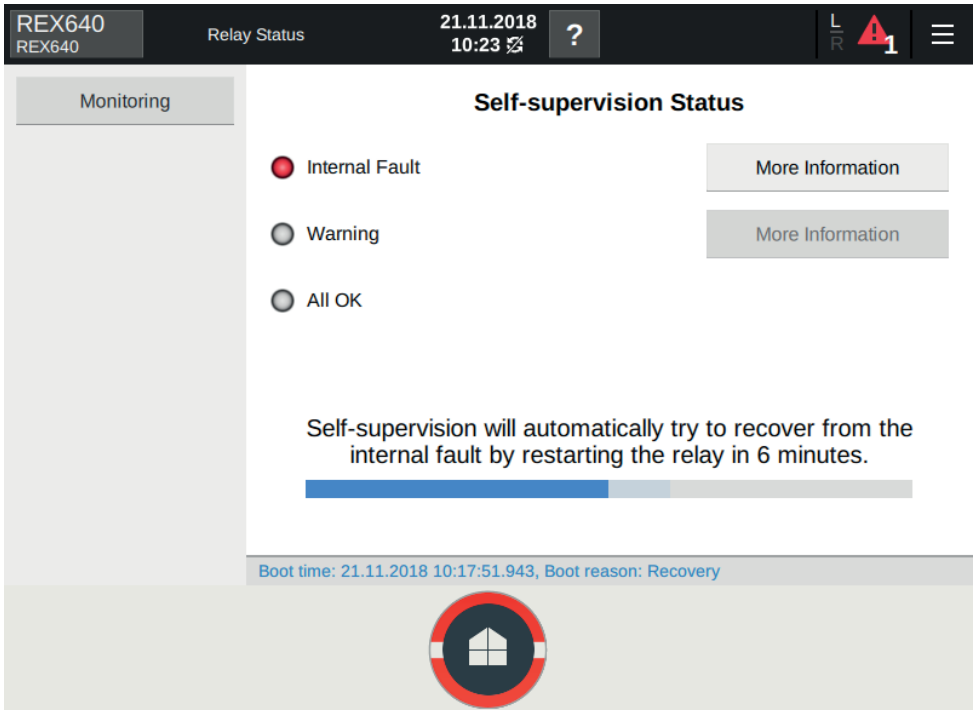



*Figure 26: Internal fault state indicated with red LED*

More Information shows all active faults and the corresponding fault codes. In addition, a recovery procedure is described.

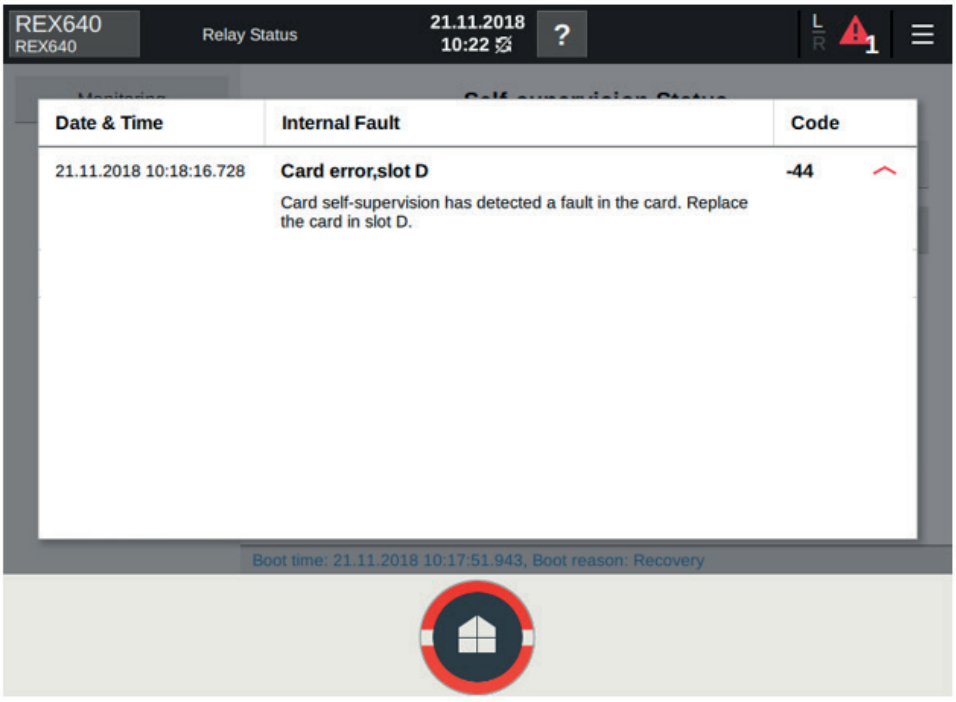



*Figure 27: More information about the fault*

On the WHMI, internal fault information is shown under Self-Supervision Status.

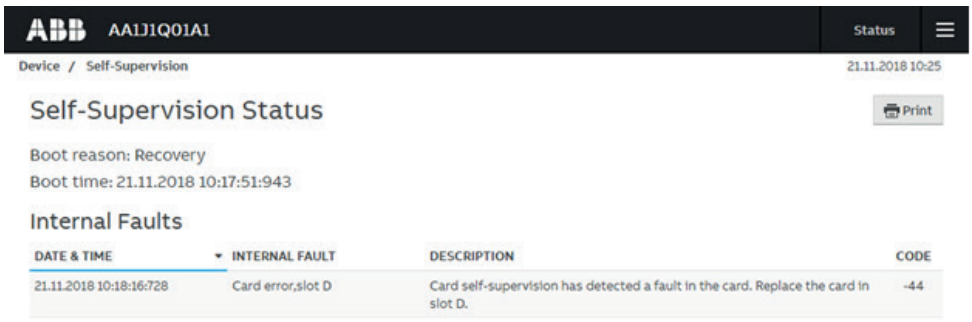



*Figure 28: Internal fault information on Web HMI*

**Table 43: Internal fault indications and codes**

| Fault indication | Fault code | Additional information | Fast self-recovery attempt | Slow 10min self-recovery (# of attempts) | Immediate IRF-mode | Action in permanent fault state |
|---|---|---|---|---|---|---|
| Internal Fault System error | 2 | Start up error: HW/SW mismatch | No | No | Yes | If relay SW has just been updated, redo it. If not recovered, contact your nearest ABB representative to check the next possible corrective action. |
| Internal Fault System error | 2 | Start up or runtime error: Data bus error, CPU module | Yes | Yes (3) | No | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module. |
| Internal Fault System error | 2 | Start up error: SCL file missing | No | No | Yes | Do factory restore or rewrite configuration using PCM600. |
| Internal Fault System error | 2 | Start up error: Missing order number | No | No | Yes | Do factory restore. If not recovered, contact your nearest ABB representative to check the next possible corrective action. |
| Internal Fault System error | 2 | Start up error: FPGA HW error, CPU module | Yes | Yes (3) | No | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module. |
| Internal Fault System error | 2 | Start up error: FPGA image corrupted, CPU module | Yes | Yes (3) | No | Restart the relay or if relay SW has just been updated, redo it. If recovered by restarting, continue relay normal operation. If not recovered by restarting or redoing SW update, replace the relay, most probably hardware failure in CPU module. |
| Internal Fault System error | 2 | Runtime error: CPU internal fault | Yes | Yes (3) | No | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restart- |

*Table continues on the next page*

| Fault indication | Fault code | Additional information | Fast self-recovery attempt | Slow 10min self-recovery (# of attempts) | Immediate IRF-mode | Action in permanent fault state |
|---|---|---|---|---|---|---|
| | | | | | | ing, replace the relay, most probably hardware failure in CPU module. |
| Internal Fault System error | 2 | Start up error: Card init fault | Yes | Yes (3) | No | Restart the relay. If recovered by restarting, continue relay normal operation. If not recovered by restarting, check for example relay's Information menu to see which card(s) are not shown correctly and replace it (them). |
| Internal Fault File system error | 7 | Start up error or runtime error: file system error | Yes | No | Yes | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module. |
| Internal Fault Test | 8 | Internal fault test activated manually by the user. | No | No | - | Just check the "Internal fault test" -setting parameter position, if relay is in test mode |
| Internal Fault SW watchdog error | 10 | Start up error: Watchdog reset has occurred too many times within an hour. Note! This is different indication than Warning code 10: Watchdog reset | No | No | Yes | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay. |
| Internal Fault LHMI module | 79 | Start up error: EEPROM error in LHMI module. The fault indication may not be seen on the LHMI during the fault. | No | No | Yes | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, check LHMI connection cable and connection to be proberly fixed. If then not recovered by restarting, exchange the LHMI module. |
| Internal Fault LHMI module | 79 | Runtime error: LHMI LCD error. The fault indication may not be seen on the LHMI during the fault. | Yes | Yes (3) | No | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, check LHMI connection cable and connection to be proberly fixed. If then not recovered by restarting, exchange the LHMI module. |
| Internal Fault RAM error | 80 | Runtime error: Error in the RAM memory on the CPU module. | No | Yes (3) | No | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module. |
| Internal Fault ROM error | 81 | Runtime error: Error in the ROM memory on the CPU module. | Yes | No | Yes | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module. |

*Table continues on the next page*

| Fault indication | Fault code | Additional information | Fast self-recovery attempt | Slow 10min self-recovery (# of attempts) | Immediate IRF-mode | Action in permanent fault state |
|---|---|---|---|---|---|---|
| Internal Fault EEPROM error | 82 | Start up error: Error in the EEPROM memory on the CPU module. | No | No | Yes | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module. |
| Internal Fault EEPROM error | 82 | Start up error: CRC check failure in the EEPROM memory on boot-up on the CPU module. | Yes | Yes (3) | No | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module. |
| Internal Fault FPGA error | 83 | Runtime error: Error in the FPGA on the CPU module. | Yes | Yes (3) | No | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module. |
| Internal Fault RTC error | 84 | Start up error: Error in the RTC on the CPU module. | Yes | No | Yes | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module. |
| Internal Fault COM card error | 116 | Runtime error: Error in the COM card. | Yes | Yes (3) | No | Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the communication module in slot X000. |
| Internal Fault SO-relay(s), Slot C | -10 | Runtime error: Faulty Signal Output relay(s) in card located in slot C. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot C. |
| Internal Fault SO-relay(s), Slot E | -11 | Runtime error: Faulty Signal Output relay(s) in card located in slot E. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot E. |
| Internal Fault SO-relay(s), Slot A2 | -12 | Runtime error: Faulty Signal Output relay(s) in card located in slot A2. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot A2. |
| Internal Fault SO-relay(s), Slot B | -13 | Runtime error: Faulty Signal Output relay(s) in card located in slot B. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot B. |

*Table continues on the next page*

| Fault indication | Fault code | Additional information | Fast self-recovery attempt | Slow 10min self-recovery (# of attempts) | Immediate IRF-mode | Action in permanent fault state |
|---|---|---|---|---|---|---|
| Internal Fault SO-relay(s), Slot D | -14 | Runtime error: Faulty Signal Output relay(s) in card located in slot D. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot D. |
| Internal Fault SO-relay(s), Slot F | -15 | Runtime error: Faulty Signal Output relay(s) in card located in slot F. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot F. |
| Internal Fault SO-relay(s), Slot G | -16 | Runtime error: Faulty Signal Output relay(s) in card located in slot G. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot G. |
| Internal Fault SO-relay(s), Slot A1 | -17 | Runtime error: Faulty Signal Output relay(s) in card located in slot A1. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot A1. |
| Internal Fault PO-relay(s), Slot C | -20 | Runtime error: Faulty Power Output relay(s) in card located in slot C. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot C. |
| Internal Fault PO-relay(s), Slot E | -21 | Runtime error: Faulty Power Output relay(s) in card located in slot E. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot E. |
| Internal Fault PO-relay(s), Slot A2 | -22 | Runtime error: Faulty Power Output relay(s) in card located in slot A2. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot A2. |
| Internal Fault PO-relay(s), Slot B | -23 | Runtime error: Faulty Power Output relay(s) in card located in slot B | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot B. |
| Internal Fault PO-relay(s), Slot D | -24 | Runtime error: Faulty Power Output relay(s) in card located in slot D. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot D. |

*Table continues on the next page*

| Fault indication | Fault code | Additional information | Fast self-recovery attempt | Slow 10min self-recovery (# of attempts) | Immediate IRF-mode | Action in permanent fault state |
|---|---|---|---|---|---|---|
| Internal Fault PO-relay(s), Slot F | -25 | Runtime error: Faulty Power Output relay(s) in card located in slot F. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot F. |
| Internal Fault PO-relay(s), Slot G | -26 | Runtime error: Faulty Power Output relay(s) in card located in slot G. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot G. |
| Internal Fault PO-relay(s), Slot A1 | -27 | Runtime error: Faulty Power Output relay(s) in card located in slot A1. | Yes | Yes (3) | No | Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot A1. |
| Internal Fault Conf. error, Slot C | -30 | Start up error: Card in slot C is wrong type, is missing, does not belong to original configuration or card firmware is faulty. | No | No | Yes | Check that the card in slot C is proper type and properly installed. Then restart the relay. If does not then recover by restarting, it is hardware module failure most likely in question. Exchange the hardware module in slot C. |
| Internal Fault Conf. error, Slot E | -31 | Start up error: Card in slot E is wrong type, is missing, does not belong to original configuration or card firmware is faulty. | No | No | Yes | Check that the card in slot E is proper type and properly installed. Then restart the relay. If does not then recover by restarting, it is hardware module failure most likely in question. Exchange the hardware module in slot E. |
| Internal Fault Conf. error, Slot A2 | -32 | Start up error: Card in slot A2 is wrong type, is missing, does not belong to original configuration or card firmware is faulty. | No | No | Yes | Check that the communication card in slot A2 is proper type and properly installed. Then restart the relay. If does not then recover by restarting, it is hardware module failure most likely in question. Exchange the communication module in slot A2. |
| Internal Fault Conf. error, Slot B | -33 | Start up error: Card in slot B is wrong type, is missing, does not belong to original configuration or card firmware is faulty. | No | No | Yes | Check that the card in slot B is proper type and properly installed. Then restart the relay. If does not then recover by restarting, it is hardware module failure most likely in question. Exchange the hardware module in slot B. |
| Internal Fault Conf. error, Slot D | -34 | Start up error: Card in slot D is wrong type, is missing, does not belong to original configuration or card firmware is faulty. | No | No | Yes | Check that the card in slot D is proper type and properly installed. Then restart the relay. If does not then recover by restarting, it is hardware module failure most likely in question. Ex- |

*Table continues on the next page*

| Fault indication | Fault code | Additional information | Fast self-recovery attempt | Slow 10min self-recovery (# of attempts) | Immediate IRF-mode | Action in permanent fault state |
|---|---|---|---|---|---|---|
| | | | | | | change the hardware module in slot D. |
| Internal Fault Conf. error, Slot F | -35 | Start up error: Card in slot F is wrong type, is missing, does not belong to original configuration or card firmware is faulty. | No | No | Yes | Check that the card in slot F is proper type and properly installed. Then restart the relay. If does not then recover by restarting, it is hardware module failure most likely in question. Exchange the hardware module in slot F. |
| Internal Fault Conf. error, Slot G | -36 | Start up error: Card in slot G is wrong type, is missing, does not belong to original configuration or card firmware is faulty. | No | No | Yes | Check that the card in slot G is proper type and properly installed. Then restart the relay. If does not then recover by restarting, it is hardware module failure most likely in question. Exchange the hardware module in slot G. |
| Internal Fault Conf. error, Slot A1 | -37 | Start up error: Card in slot A1 is wrong type, is missing, does not belong to original configuration or card firmware is faulty. | No | No | Yes | Check that the card in slot A1 is proper type and properly installed. Then restart the relay. If does not then recover by restarting, it is hardware module failure most likely in question. Exchange the hardware module in slot A1. |
| Internal Fault Card error, Slot C | -40 | Card in slot C is faulty. | Yes | No | Yes | Exchange the hardware module in slot C. |
| Internal Fault Card error, Slot E | -41 | Card in slot E is faulty. | Yes | No | Yes | Exchange the hardware module in slot E. |
| Internal Fault Card error, Slot A2 | -42 | Card in slot A2 is faulty. | Yes | No | Yes | Exchange the communication module in slot A2. |
| Internal Fault Card error, Slot B | -43 | Card in slot B is faulty. | Yes | No | Yes | Exchange the hardware module in slot B. |
| Internal Fault Card error, Slot D | -44 | Card in slot D is faulty. | Yes | No | Yes | Exchange the hardware module in slot D. |
| Internal Fault Card error, Slot F | -45 | Card in slot F is faulty. | Yes | No | Yes | Exchange the hardware module in slot F. |
| Internal Fault Card error, Slot G | -46 | Card in slot G is faulty. | Yes | No | Yes | Exchange the hardware module in slot G. |
| Internal Fault Card error, Slot A1 | -47 | Card in slot A1 is faulty. | Yes | No | Yes | Exchange the hardware module in slot A1. |
| Internal Fault 640-Prod. License error | -62 | Runtime error: Product license error, license file is not found or is wrong | No | No | Yes | If SW update under Modification Sales has been carried out, redo the update. If not recovered, contact your nearest ABB representative to check the next possible corrective action. |

## 3.3.2 Warnings

In case of a warning, the protection relay continues to operate except for those protection functions affected by the fault. The main unit status LED remains lit as during normal operation. If the device warning event is configured as alarms, the LHMI Home button flashes red.

If a warning appears, record the name and code so that it can be provided to ABB customer service. See the operation manual for more information on reading internal log files from the relay.

On the LHMI, an active warning is indicated with a yellow LED. More information about the warning and recovery options can be accessed by tapping More Information.

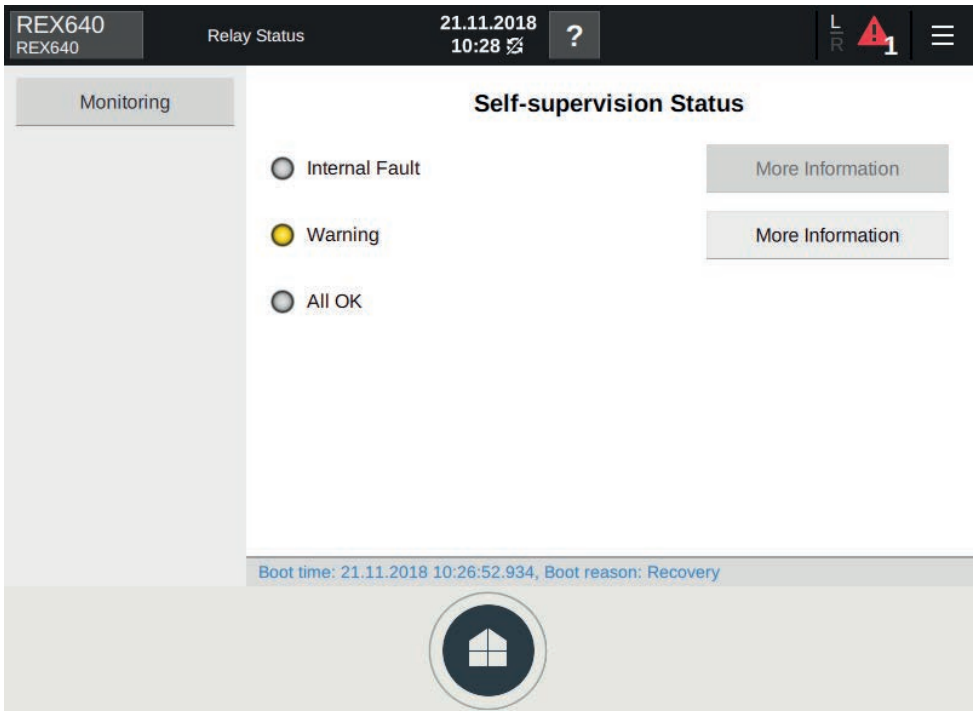



*Figure 29: Active warning on local HMI*

More information shows all active warnings and corresponding fault codes. In addition, a recovery procedure is described.

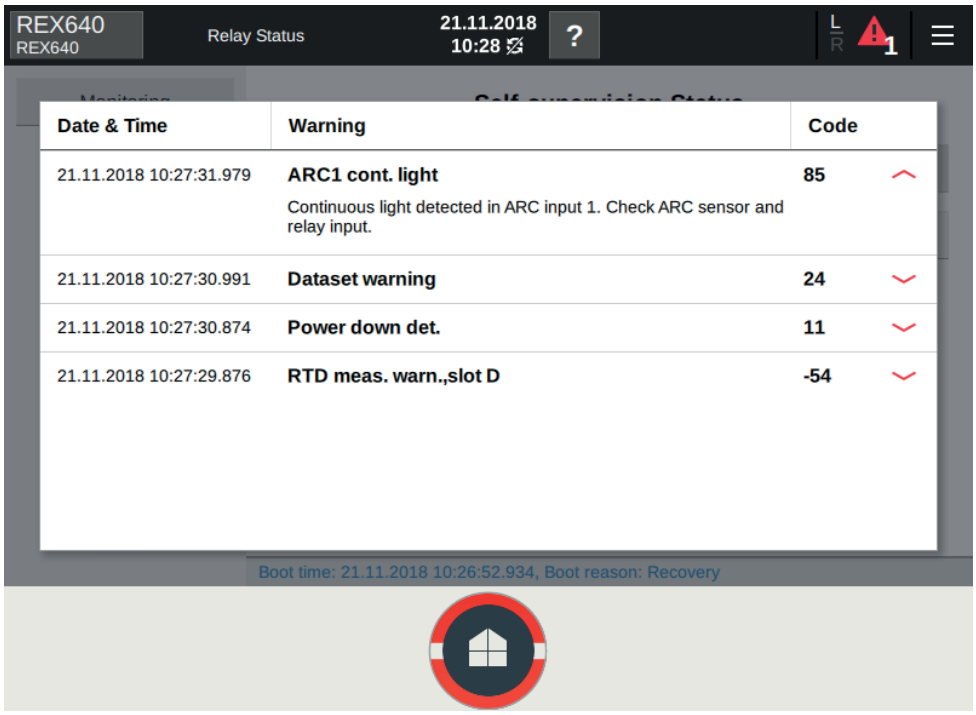



*Figure 30: More information about the warning*

The warning alarm is only displayed when configured in PCM600 event filtering.

**Table 44: Warning indications and codes**

| Warning indication | Warning code | Additional information |
|---|---|---|
| Watchdog reset | 10 | A watchdog reset has occurred. |
| Power down det. | 11 | The auxiliary supply voltage has dropped too low. |
| DNP3 warning | 22 | Error in the DNP3 communication. |
| Dataset warning | 24 | Error in the Data set(s). |
| Report cont. warning | 25 | Error in the Report control block(s). |
| GOOSE contr. warning | 26 | Error in the GOOSE control block(s). |
| SCL config warning | 27 | Error in the SCL configuration file or the file is missing. |
| Logic warning | 28 | |
| SMT logic warning | 29 | |
| GOOSE input warning | 30 | |
| ACT warning | 31 | Analog channel configuration warning. |
| GOOSE rec. warning | 32 | |
| AFL warning | 33 | |
| SMV warning | 34 | Error in the SMV configuration. |

*Table continues on the next page*

| Warning indication | Warning code | Additional information |
|---|---|---|
| Comm. channel down | 35 | Redundant Ethernet (HSR/ PRP) communication interrupted. |
| Settings mismatch | 36 | Mismatch between parameter settings and application configuration. |
| Protection comm. | 50 | Error in protection communication. |
| ARC1 cont. light | 85 | A continuous light has been detected on the ARC light input 1. |
| ARC2 cont. light | 86 | A continuous light has been detected on the ARC light input 2. |
| ARC3 cont. light | 87 | A continuous light has been detected on the ARC light input 3. |
| ARC4 cont. light | 88 | A continuous light has been detected on the ARC light input 4. |
| RTD meas. warn.,slot D | –54 | Abnormal signal from sensor(s) received in slot D. |
| RTD meas. warn.,slot C | –50 | Abnormal signal from sensor(s) received in slot C. |
| mA output warn.,slot D | –24 | Temporary error occurred in RTD module located in slot D. |
| mA output warn.,slot C | –20 | Temporary error occurred in RTD module located in slot C. |

## 3.3.3 Power supply module Ready LED and HMI Home button LED

Both power supply module Ready LED and LHMI Home button LED visualize the self-supervision state of the relay. *Table 45* shows how these states are indicated.

**Table 45: Power supply module Ready LED and local HMI Home button LED**

| State | Power supply module Ready LED | LHMI Home button | Alarm acknowledged |
|---|---|---|---|
| Relay under normal operation and LHMI connected | Steady green | Steady green | N/A |
| Relay's IRF activated, but communicates with LHMI | HF blinking green | HF blinking red | N/A |
| Communication lost between Relay and LHMI, but no IRF | Steady green | HF blinking green | N/A |
| LHMI not running normally or in start-up initialization phase | Steady green | HF blinking green | N/A |
| Process related alarm active | Steady green | LF blinking red | No |
| Process related alarm active | Steady green | Steady red | Yes |
| Process related alarm has been active earlier, but is not any more active | Steady green | LF blinking red | No |

*Table continues on the next page*

| State | Power supply module Ready LED | LHMI Home button | Alarm acknowledged |
|---|---|---|---|
| Process related alarm has been active earlier, but is not any more active | Steady green | Steady green | Yes |
| Relay set to Test Mode | LF blinking green | LF blinking green | No |

The physical SHMI Home button has two operation modes.

- On the SHMI's navigation page, the Home button indicates the combined status of all connected relays. If multiple relays have different statuses, the Home button shows the indication with the highest priority.
- On the HMI view, the Home button indicates the status of the respective relay as described in *Table 45*.

## 3.3.4 Fail-safe principle for relay protection

The relay behavior during an internal fault situation has to be considered when engineering trip circuits under the fail-safe principle. The considerations discussed and examples given are mainly based on the need of protection scheme reliability.

The reliability need can be divided into two subparts: dependability and security. The dependability can be described as the protection scheme's ability to operate when required. The security can be described as the protection scheme's ability to refrain from operating when not required. The protection scheme fail-safe principle is typically related to satisfying these two performance criteria. Depending on the requirements set to the electricity distribution process, one of the criteria may get more attention than the other. However, in some industrial electricity distribution networks, the main (productization) process is so dependent on reliable electricity supply that both criteria are addressed equally.

The examples presented focus on the relay's protection role in the fail-safe circuitry using traditional hardwiring. If communication between the relays, or to an upper level system, is a part of the fail-safe functionality, it must be also be a part of the circuitry.

### 3.3.4.1 Motor feeder

The target is to prevent the motor from running uncontrollably and to secure the emergency stop circuit functionality.

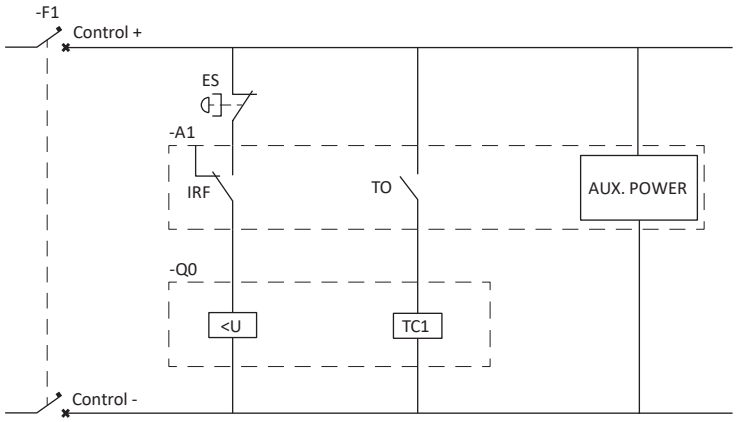



*Figure 31: Motor feeder fail-safe trip circuit principle, example 1*

| | |
|---|---|
| A1 | Protection relay |
| ES | Emergency stop |
| Q0 | Circuit breaker (CB) |
| TO | Protection relay trip output |
| IRF | Internal relay fault indication |
| <U | CB undervoltage trip coil |
| TC1 | CB trip coil 1 |
| DCS | Distributed process control system |
| F1 | Miniature circuit breaker |

In example 1, the fail-safe approach aims at securing motor shutdown via an emergency switch and in case the control voltage disappears. In case of a temporary internal relay fault, the circuit breaker is immediately tripped before the relay recovers from the situation. In case the IRF output relay is directly connected to the undervoltage trip coil circuit, the output's performance figures (make and break values) must be checked.

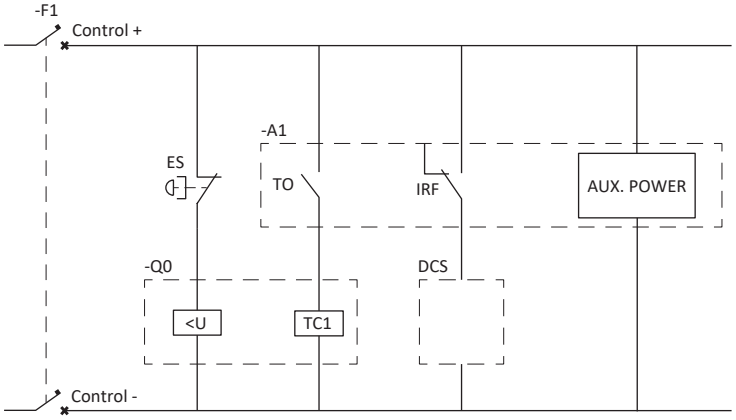



*Figure 32: Motor feeder fail-safe trip circuit principle, example 2*

| | |
|---|---|
| A1 | Protection relay |
| ES | Emergency stop |
| Q0 | Circuit breaker (CB) |

*Table continues on the next page*

| | |
|---|---|
| TO | Protection relay trip output |
| IRF | Internal relay fault indication |
| <U | CB undervoltage trip coil |
| TC1 | CB trip coil 1 |
| DCS | Distributed process control system |
| F1 | Miniature circuit breaker |

In example 2, the fail-safe approach aims at securing motor shutdown via an emergency switch and in case the control voltage disappears. In case of internal relay fault, the necessary actions must be initiated by the process operators or by the control system.

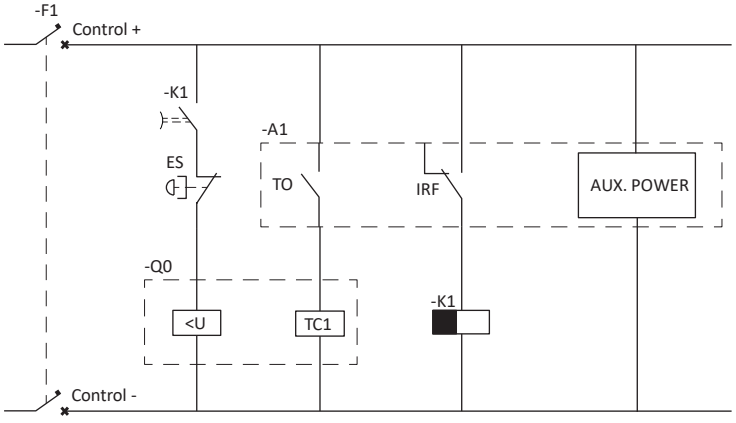



*Figure 33: Motor feeder fail-safe trip circuit principle, example 3*

| | |
|---|---|
| A1 | Protection relay |
| ES | Emergency stop |
| Q0 | Circuit breaker (CB) |
| TO | Protection relay trip output |
| IRF | Internal relay fault indication |
| <U | CB undervoltage trip coil |
| TC1 | CB trip coil 1 |
| K1 | OFF delay time relay |
| F1 | Miniature circuit breaker |

In example 3, the fail-safe approach aims at securing motor shutdown via an emergency switch and in case the control voltage disappears. In case of internal relay fault, the circuit breaker is tripped via an undervoltage coil after a preset time delay. The additional time delay allows the relay to recover from the internal fault situation without tripping the circuit breaker.

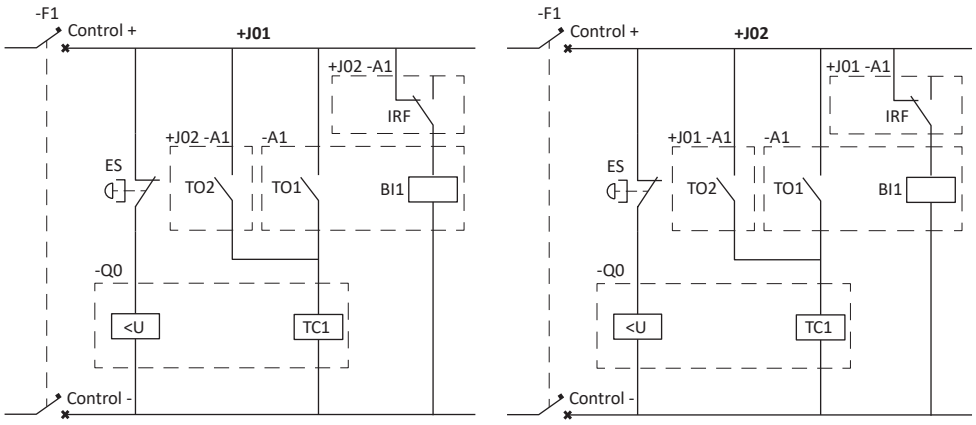



*Figure 34: Motor feeder fail-safe trip circuit principle, example 4*

| | |
|---|---|
| J01 | Feeder #1 panel |
| J02 | Feeder #2 panel |
| ES | Emergency stop |
| Q0 | Circuit breaker |
| TO1 | Relay trip output #1 |
| TO2 | Relay trip output #2 |
| IRF | Relay internal fault indication |
| BI1 | Relay binary input #1 |
| <U | CB undervoltage trip coil |
| TC1 | CB trip coil 1 |
| F1 | Miniature circuit breaker |

In example 4, the fail-safe approach aims at securing motor shutdown via an emergency switch and in case the control voltage disappears. The adjacent panels provide backup for each other in internal relay fault situations. In case of an internal relay fault, the situation is noticed by the relay in the adjacent panel and the circuit breaker in the panel with the faulty relay is tripped after a preset time delay. The additional time delay allows the relay to recover from the internal fault situation without tripping the circuit breaker.

### 3.3.4.2 Other critical feeders

The examples given for motor feeders can be applied for other types of feeders as well. The following examples are for critical feeders in which the protection system dependability, security or both are the drivers.

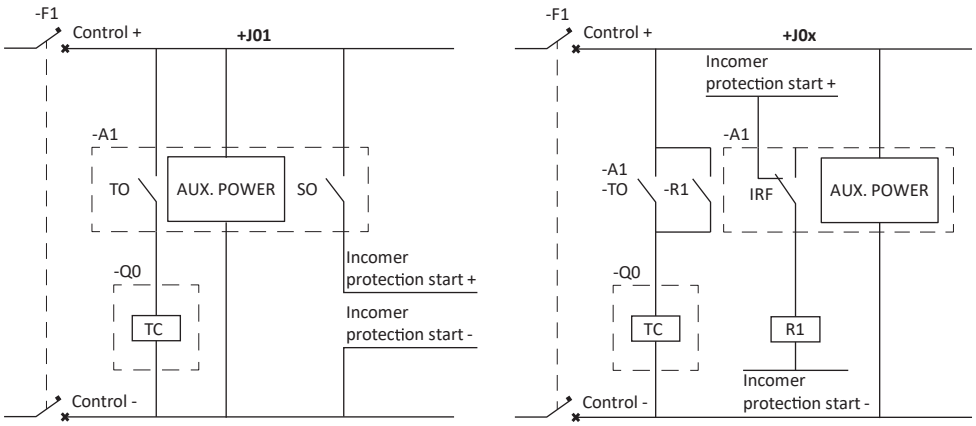



*Figure 35: Redundant protection fail-safe principle, example 1*

| | |
|---|---|
| J01 | Incomer feeder panel |
| J0x | Load feeder panels |
| Q0 | Circuit breaker (CB) |
| TO | Relay trip output |
| SO | Relay start output |
| A1 | Protection relay |
| R1 | Auxiliary relay |
| TC | CB trip coil |
| F1 | Miniature circuit breaker |

In example 1, the fail-safe approach aims at securing circuit breaker tripping even if a relay fails. The incomer panel relay indicates the start of selected protection functions. This start signal is distributed to all load feeder panels. If a relay in the load feeder panel indicates an IRF status, the start signal of the incomer panel relay results in circuit breaker tripping. This approach offers basic protection for a load feeder while the actual protection relay performs a self-supervision controlled restart sequence.

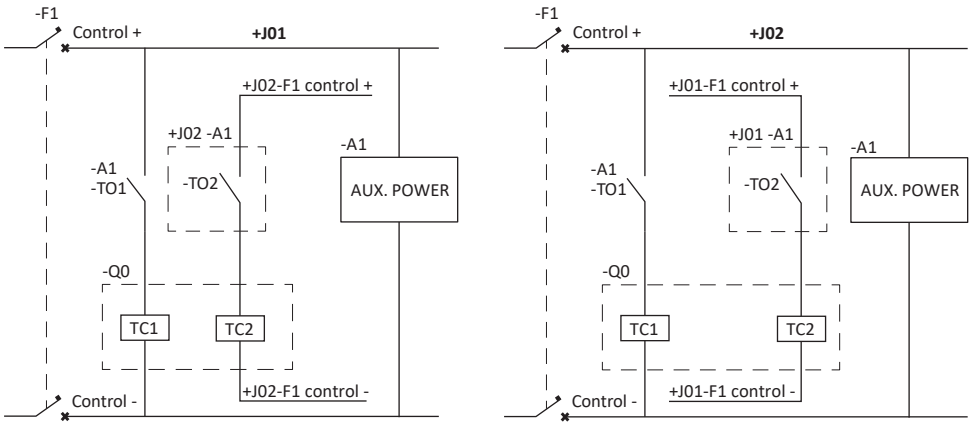



*Figure 36: Redundant protection fail-safe principle, example 2*

| | |
|---|---|
| J01 | Feeder #1 panel |
| J02 | Feeder #2 panel |
| Q0 | Circuit breaker (CB) |
| TO1 | Relay trip output #1 |
| TO2 | Relay trip output #2 |
| A1 | Protection relay |
| TC1 | CB trip coil 1 |
| TC2 | CB trip coil 2 |
| F1 | Miniature circuit breaker |

In example 2, the fail-safe approach aims at securing circuit breaker tripping even if a relay fails. A relay in a panel measures also the adjacent panel's currents (and voltages) and receives the necessary primary device's position information. In other words, the relay in a panel functions as a backup relay for the adjacent panel. This approach allows service continuation while the failed relay is waiting for spare parts or a complete replacement. The backup protection features provided by the adjacent panel's relay do not necessarily fully match the features available in the main relay.

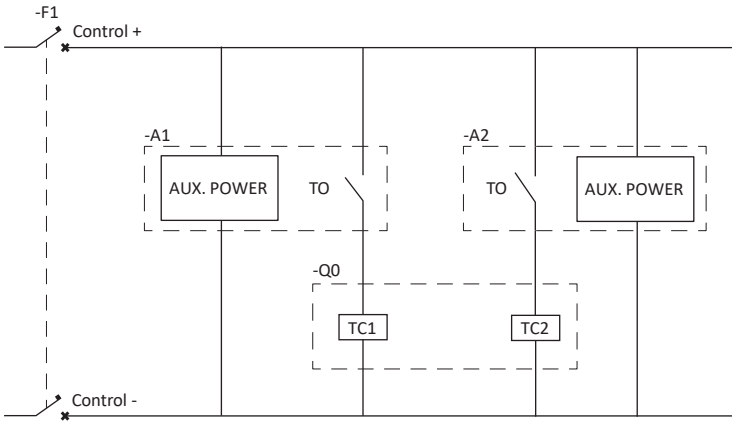



*Figure 37: Redundant protection fail-safe principle, example 3*

| | |
|---|---|
| Q0 | Circuit breaker (CB) |
| A1 | Protection relay #1 |
| A2 | Protection relay #2 |
| TO | Protection relay trip output |
| TC1 | CB trip coil 1 |
| TC2 | CB trip coil 2 |
| F1 | Miniature circuit breaker |

In example 3, the fail-safe approach aims at securing circuit breaker tripping even if one of the redundant relays fails. The scheme is often referred to as the 1-outof- 2 approach. This approach allows service continuation while the failed relay is waiting for spare parts or a complete replacement. The redundancy in this example covers relays and circuit breaker tripping coils but it can be expanded to auxiliary power supplies (two station batteries and isolated distribution), cabling, circuit breaker failure protection, and so on. Another variant of this approach is to have a main relay and a backup relay instead of two fully redundant relays. The backup relay does not

have all the features of the main relay, mainly containing a minimum acceptable set of protection functions.

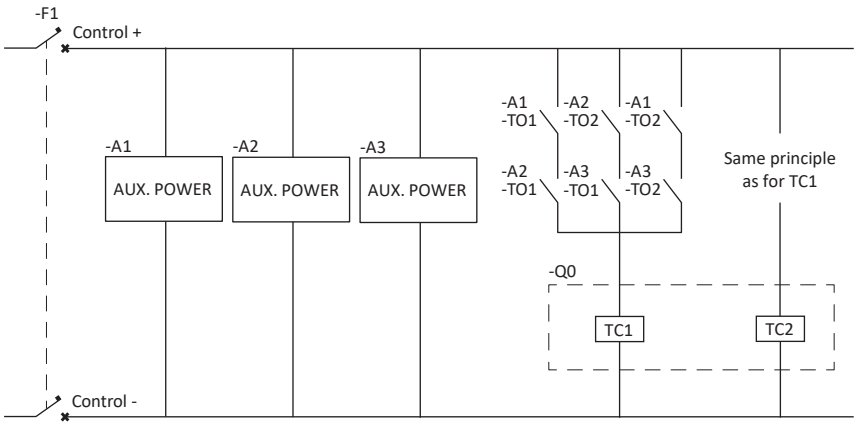



*Figure 38: Redundant protection fail-safe principle, example 4*

| | |
|---|---|
| Q0 | Circuit breaker (CB) |
| A1 | Protection relay #1 |
| A2 | Protection relay #2 |
| A3 | Protection relay #3 |
| TO# | Protection relay trip output |
| TC1 | CB trip coil 1 |
| TC2 | CB trip coil 2 |
| F1 | Miniature circuit breaker |

In example 4, the fail-safe approach aims at securing circuit breaker tripping even if one of the redundant relays fails and, in addition, no single relay alone can cause the circuit breaker tripping. The scheme is often referred to as the 2-out-of-3 approach. This approach allows service continuation while the failed relay is waiting for spare parts or a complete replacement. The redundancy in this example covers relays and circuit breaker tripping coils but it can be expanded to auxiliary power supplies (two station batteries and isolated distribution), cabling, circuit breaker failure protection, and so on. All three relays are similar with the same protection functions. This principle is used in cases where the primary process requires absolute dependability and security from the supplying feeder protection.

## 3.4 LED indication control LEDPTRC

### 3.4.1 Function block

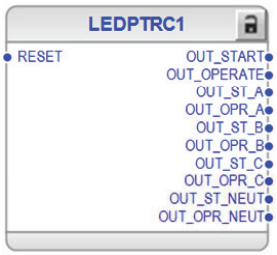



*Figure 39: Function block*

### 3.4.2 Functionality

The protection relay includes a global conditioning function LEDPTRC that is used to control the virtual Start and Trip indication LEDs.

LED indication control should never be used for tripping purposes. There is a separate trip logic function TRPPTRC available in the relay configuration.

LED indication control is preconfigured in a such way that all the protection function general start and operate signals are combined with this function (available as output signals `OUT_START` and `OUT_OPERATE`). These signals are internally connected to Device Status on WHMI Dashboard and the Device Status widget on the LHMI if the widget has been instantiated in the LHMI engineering phase. LEDPTRC collects and combines phase information from different protection functions (available as output signals `OUT_ST_A /_B /_C` and `OUT_OPR_A /_B /_C`). There is also combined earth fault information collected from all the earth-fault functions available in the relay configuration (available as output signals `OUT_ST_NEUT` and `OUT_OPR_NEUT`).

## 3.5 Individual virtual LED control LED

### 3.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE identification |
|---|---|---|---|
| Individual virtual LED control | LED | LED | LED |

## 3.5.2 Function block

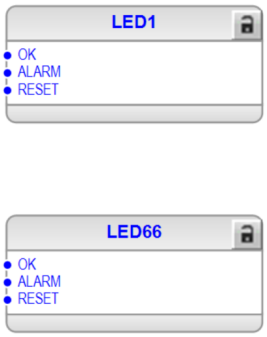



*Figure 40: Function block*

## 3.5.3 Functionality

The virtual, programmable LEDs are visible on the Programmable LEDs page in LHMI and on the WHMI dashboard.

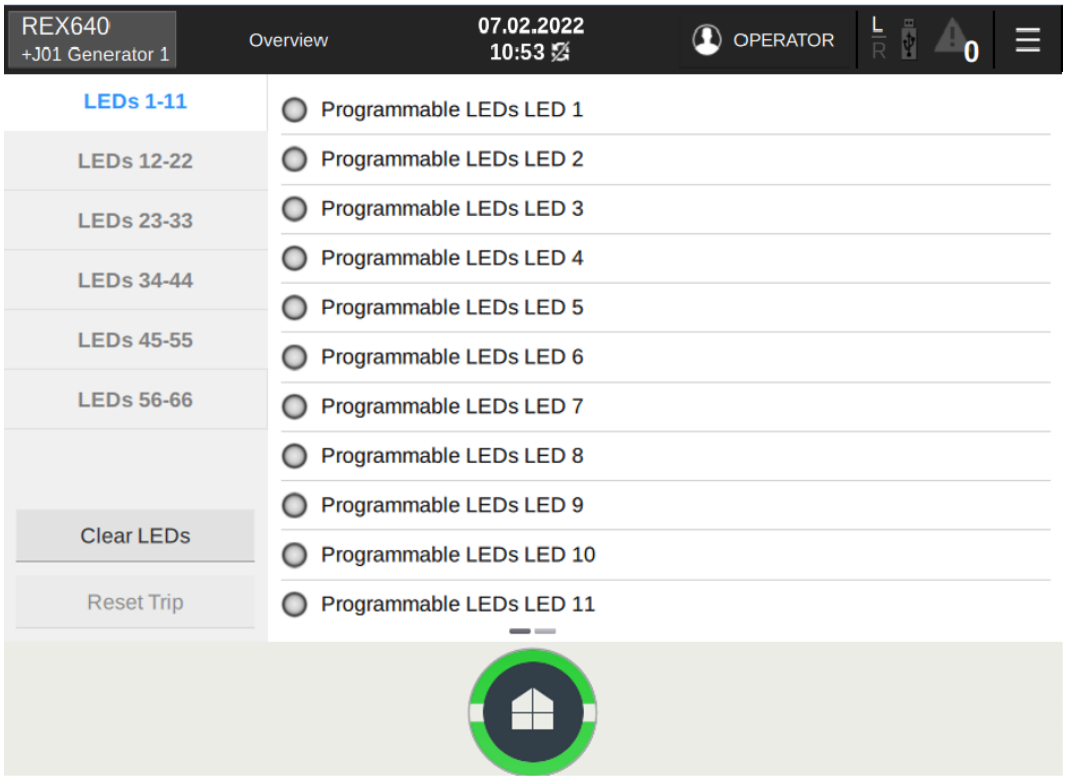



*Figure 41: Programmable LEDs page in LHMI*

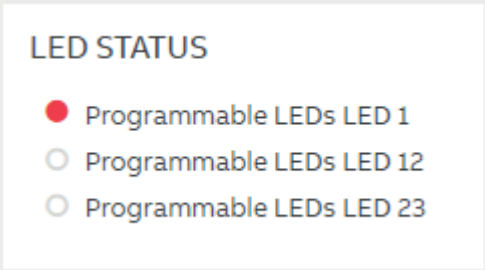



*Figure 42: Programmable LEDs status in WHMI*

Programmable LEDs are available only when at least one LED has been instantiated and the OK or ALARM signal is connected in Application Configuration in PCM600.

All the programmable LEDs on the protection relay's HMI have two colors, green and red. For each LED, the different colors are individually controllable.

Each LED has two control inputs, ALARM and OK. The color setting is common for all the LEDs. It is controlled with the *Alarm colour* setting, the default value being "Red". The OK input corresponds to the color that is available, with the default value being "Green".

Changing the *Alarm colour* setting to "Green" changes the color behavior of the OK inputs to red.

The ALARM input has a higher priority than the OK input. When a LED is in the alarming state, a bell symbol is shown on the LHMI next to the title of the Programmable LEDs page.

Each LED is seen in Application Configuration as an individual function block. Each LED has a user-editable description text for event description. The state ("None", "OK", "Alarm") of each LED can also be read under a common monitored data view for programmable LEDs.

The LED status also provides a means for resetting the individual LED via communication. The LED can also be reset from configuration with the RESET input.

The resetting and clearing function for all LEDs is available at the left side of the Programmable LEDs page and under the **Clear** menu.

The menu structure for the programmable LEDs is presented in *Figure 43*. The common color selection setting *Alarm colour* for all ALARM inputs is in the **General** menu, while the LED-specific settings are under the LED-specific menu nodes.

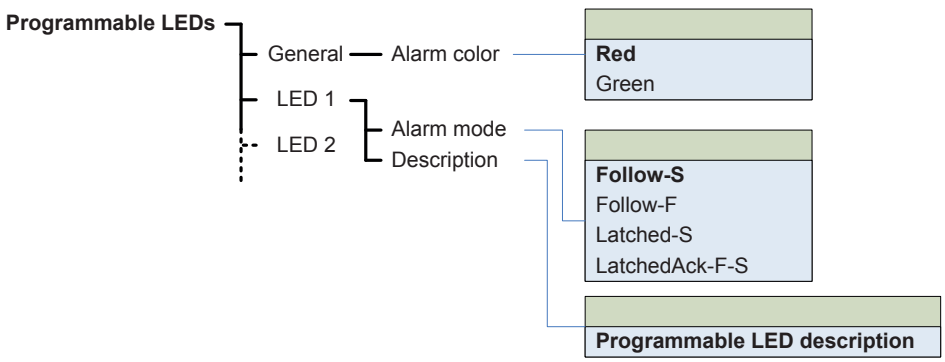



*Figure 43: Menu structure*

**Alarm mode alternatives**

The ALARM input behavior can be selected with the alarm mode settings from the alternatives "Follow-S", "Follow-F", "Latched-S" and "LatchedAck-F-S". The OK input behavior is always according to "Follow-S". The alarm input latched modes can be cleared with the reset input in the application logic.

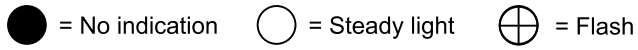



*Figure 44: Symbols used in the sequence diagrams*

**"Follow-S": Follow Signal, ON**

In this mode ALARM follows the input signal value, Non-latched.

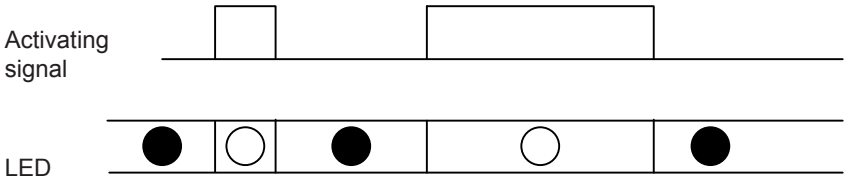



*Figure 45: Operating sequence "Follow-S"*

**"Follow-F": Follow Signal, Flashing**

Similar to "Follow-S", but instead the LED is flashing when the input is active, Non-latched.

**"Latched-S": Latched, ON**

This mode is a latched function. At the activation of the input signal, the alarm shows a steady light. After acknowledgement by the local operator pressing any key on the keypad, the alarm disappears.

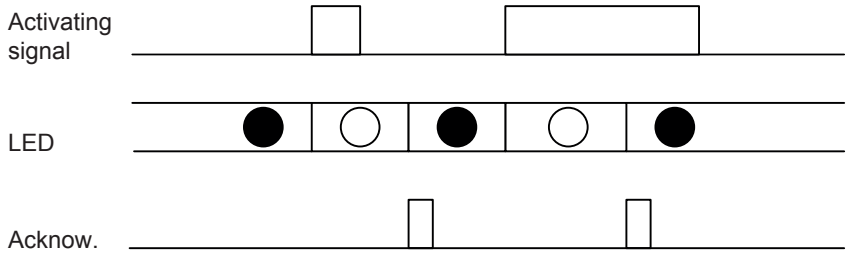



*Figure 46: Operating sequence "Latched-S"*

**"LatchedAck-F-S": Latched, Flashing-ON**

This mode is a latched function. At the activation of the input signal, the alarm starts flashing. After acknowledgement, the alarm disappears if the signal is not present and gives a steady light if the signal is present.

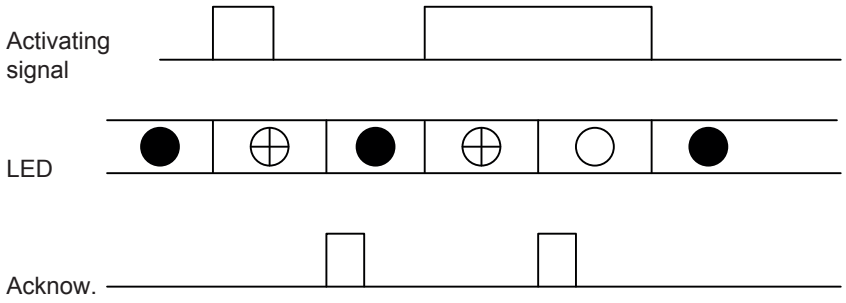



*Figure 47: Operating sequence "LatchedAck-F-S"*

## 3.5.4 Signals

**Table 46: Input signals for LEDs 1...66**

| Name | Type | Default | Description |
|---|---|---|---|
| OK | BOOLEAN | 0=False | Ok input for the LED |
| ALARM | BOOLEAN | 0=False | Alarm input for the LED |
| RESET | BOOLEAN | 0=False | Reset input for the LED |

## 3.5.5 Settings

**Table 47: Settings for LEDs 1...66**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Alarm colour | 1=Green<br>2=Red | | | 2=Red | Colour for the alarm state of the LED |
| Alarm mode | 0=Follow-S<br>1=Follow-F<br>2=Latched-S<br>3=LatchedAck-F-S | | | 0=Follow-S | Alarm mode for the programmable LED |

## 3.5.6 Monitored data

**Table 48: Monitored data for LEDs 1...66**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Programmable LED n [1] | Enum | 0=None<br>1=Ok<br>3=Alarm | | Status of the programmable LED |

[1] n = 1...66

**Table 49: IEC 61850 mapping**

| LED instance in Application Configuration | Mapping in IEC 61850 data model (ALARM and OK signals) |
|---|---|
| LED1...LED11 | LEDGGIO1.Alm1...LEDGGIO1.Alm11 |
| | LEDGGIO1.Ind1...LEDGGIO1.Ind11 |
| LED12...LED22 | LEDGGIO2.Alm1...LEDGGIO2.Alm11 |
| | LEDGGIO2.Ind1...LEDGGIO2.Ind11 |
| LED23....LED33 | LEDGGIO3.Alm1...LEDGGIO3.Alm11 |
| | LEDGGIO3.Ind1...LEDGGIO3.Ind11 |
| LED34...LED44 | LEDGGIO4.Alm1...LEDGGIO4.Alm11 |
| | LEDGGIO4.Ind1...LEDGGIO4.Ind11 |
| LED45...LED55 | LEDGGIO5.Alm1...LEDGGIO5.Alm11 |
| | LEDGGIO5.Ind1...LEDGGIO5.Ind11 |
| LED56....LED66 | LEDGGIO6.Alm1...LEDGGIO6.Alm11 |
| | LEDGGIO6.Ind1...LEDGGIO6.Ind11 |

# 3.6 Time synchronization

## 3.6.1 Time master supervision GNRLLTMS

### 3.6.1.1 Function block




*Figure 48: Function block*

### 3.6.1.2 Functionality

The protection relay has a disciplined RTC in hardware with a resolution of one nanosecond. The clock can be either free-running or synchronized to an external source. The RTC is used to time-stamp events, recorded data, disturbance recordings, sampled measured values and various other system services.

The protection relay supports SNTP, IRIG-B, IEEE 1588 v2, DNP3, Modbus, IEC 60870-5-101/104, IEC 60870-5-103 and line differential communication to synchronize the RTC. IEEE 1588 v2 with a GNSS grandmaster clock and IRIG-B provide the accuracy of ±1 µs. The accuracy is ±1 ms with SNTP.

### Real-time clock at power off

During power off, the system time is kept in a separate capacitor-backed RTC. This RTC provides a millisecond resolution and digital temperature compensation for the crystal oscillator. Typical accuracy is 5 ppm which means the time may drift maximum 0.5 seconds per day. This RTC runs on a stored charge in a supercapacitor at least for 48 hours. After the capacitor has been discharged, the time is lost.

### Real-time clock at power-up

At startup, the initial system time is recovered from the capacitor-backed RTC or set to 01-01-2010 if the RTC time was lost. The clock is free-running until the selected synchronization source becomes available. The first synchronization message sets the time to an accurate value and later synchronization messages additionally discipline the clock so that the time drift between synchronization messages is minimized. If the synchronization source is lost, the drift can be 0.25 ppm if the external clock source was a high-quality clock and the surrounding temperature is constant.

The setting *Synch source* determines the method for synchronizing the RTC. If it is set to "None", the clock is free-running and the settings *Date* and *Time* can be used to set the time manually. In this mode the typical accuracy is 5 ppm and the time may drift maximum 0.5 seconds per day.

Other setting values activate a communication protocol that provides the time synchronization. Only one synchronization method can be active at a time. Both IEEE 1588 v2 and SNTP provide time master backup functionality.



Connect at least one measurement channel in Application Configuration in PCM600 either from the hardware (AIM or SIM) or from SMVRCV to ensure that the time system works correctly.

### Line differential communication

When using line differential communication between the protection relays, the time synchronization messages can be received from the other line end protection relay within the protection telegrams. The protection relay begins to synchronize its RTC with the remote end protection relay's time if the "Line differential" time synchronization source is selected. This does not affect the protection synchronization used in the line differential protection or the selection of the remote end protection relay's time synchronization method. It is expected that the remote end protection relay has another time synchronization source activated and therefore operates as a time gateway. Line differential time synchronization is available only for X6 port.

GNRLLTMS supervision functionality depends on the synchronization source. This means that the GNRLLTMS supervision signal values and their combinations have different meanings depending on the used synchronization source.

### SNTP

The relay can use one of two SNTP servers, the primary or the secondary server. The primary server is mainly in use, whereas the secondary server is used if the primary server cannot be reached or a KoD response is received. While using the secondary SNTP server, the relay tries to switch back to the primary server on every third SNTP request attempt. If both SNTP servers are offline, event time stamps have the time invalid status.

If one SNTP server is used, it is recommended to set *IP SNTP secondary* as "0.0.0.0". This disables the server redundancy scheme and prevents the IED from attempting to access a non-existing secondary server.

The time is requested from the SNTP server every 60 seconds. Supported SNTP versions are 3 and 4. SNTP requires a high-performance server to meet the performance expectations.

**IEEE 1588v2**

The protection relay's 1588 precision time protocol synchronization complies with the IEEE C37.238-2011 and IEC 61850-9-3 profiles, which are interoperable with IEEE 1588 v2. The protection relay is an ordinary clock which can operate either in slave-only and slave or master mode. According to the supported profiles, the frame format used is IEEE 802.3 Ethernet frames with 0x88F7 Ethertype as the communication service and the delay mechanism is P2P. For both profiles, the TLVs required are included in the announce frame (IEEE C37.238-2011: Organization extension and Alternate time offset indicator TLVs, IEC 61850-9-3: Alternate time offset indicator TLV).

Time synchronization with IEEE 1588 v2 creates many possible scenarios since it is a dynamic synchronization method whereby the current master is determined with the BMC algorithm. GNRLLTMS outputs reflect this status. When IEEE 1588 v2 is used as a time synchronization source, the device stores the grandmasters in priority order according to the BMC algorithm. When the grandmaster clock is lost, an alarm and a warning are activated based on the stored grandmasters' list. The alarm is activated when there are no clocks with capabilities equivalent to primary or secondary grandmaster clocks. The warning is activated when a primary grandmaster clock is not available. The grandmaster list can be Section 3 1MRS759142 E Basic functions 132 REX640 Technical Manual cleared using the *Clear clock* list setting, for example, if the grandmaster clocks need to be replaced. The setting af-fects only the alarm and warning states.

If the current master is not within the 1 µs accuracy, `ALARM` is set to TRUE. If the current master is not the saved primary master, `WARNING` is set to TRUE. The `EXTCLKMSTR` output indicates if the ordinary clock is a slave to an external master.

Since the list is updated via the current primary master in the network, it is possible to lower the current grandmaster's priority to a point where another clock takes the role and the priority value in the list for the original master is no longer updated. This means that there is a discrepancy between the list and the device. Consequently, the GNRLLTMS warning status becomes TRUE as the saved primary master is no longer considered connected. The list logic can be reset to clear the clock list.



When IEEE 1588 v2 time synchronization is used, the recommended maximum num-ber of network hops from the grandmaster is 15 to ensure that the total inaccuracy stays within 1 µs. The grandmaster and each switch on the path must comply with the performance requirements set by the selected profile.



The protection relay is an ordinary clock which can operate either in slave-only and slave or master mode.

#### IRIG-B

IRIG-B time synchronization requires IRIG-B format B00x and IRIG-B time code extensions according to IEEE Std C37.118.1TM-2011. The extensions are defined by Annex D.

The synchronization time in IRIG-B can be either UTC time or local time. As no reboot is necessary, the time synchronization starts immediately after the IRIG-B synchronization source is selected and the IRIG-B signal source is connected. GNRLLTMS signals reflect the signal status from the IRIG-B master.

IRIG-B time synchronization requires a COM module with an `IRIG-B` input.

#### DNP3, Modbus, IEC 60870-5-101/104 and IEC 60870-5-103

For legacy protocols as synchronization source, a timeout can be set by *Time Syn Src Tmm* (minutes). This setting defines the maximum interval required by the protocol master sending the time synchronization commands. If a time synchronization command has not been received from the protocol master during this period, bad synchronization status is raised for the protection relay.

Legacy protocols as time synchronization sources do not offer the best accuracy. For better accuracy PTP, SNTP or IRIG-B time synchronization is recommended.

### 3.6.1.3 Signals

**Table 50: GNRLLTMS Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm status for clock synchronization Always FALSE with *Synch source* set to "None". |
| WARNING | BOOLEAN | Warning status for clock synchronization Always FALSE with *Synch source* set to "None". |
| EXTCLKMSTR | BOOLEAN | Status of the protection relay's clock synchronization Always FALSE with *Synch source* set to "None". |

**Table 51: SNTP Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm status for clock synchronization TRUE if the connection to both primary and secondary SNTP servers has been lost. FALSE if the connection to the secondary SNTP server is detected. |
| WARNING | BOOLEAN | Warning status for clock synchronization TRUE if the connection to SNTP primary server has been lost. Otherwise FALSE. |
| EXTCLKMSTR | BOOLEAN | Status of the protection relay's clock synchronization.<br>TRUE if the protection relay has been synchronized by an SNTP server. |

| Name | Type | Description |
|---|---|---|
| | | FALSE if the clock has not been synchronized by an SNTP server. |

**Table 52: IEEE 1588v2 Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm status for clock synchronization.<br>TRUE if the current master's accuracy is not within 1µs or priority1 is bigger than that of first secondary's. Also TRUE if the external master was lost and the protection relay itself acts as a master. Otherwise FALSE. |
| WARNING | BOOLEAN | Warning status for clock synchronization.<br>TRUE if a previously connected and stored primary master has been lost. Otherwise FALSE. |
| EXTCLKMSTR | BOOLEAN | Status of the protection relay's clock synchronization.<br>TRUE if the protection relay has been synchronized by an external master.<br>FALSE if the clock has not been synchronized by an external master. |

**Table 53: IRIG-B Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm status for clock synchronization.<br>TRUE if the signal has been lost for a minute. Otherwise FALSE. |
| WARNING | BOOLEAN | Warning status for clock synchronization.<br>TRUE if the signal connection is lost.<br>FALSE if the relay is synchronized to an IRIG-B master. |
| EXTCLKMSTR | BOOLEAN | Status of the protection relay's clock synchronization.<br>TRUE if the protection relay has been synchronized to an IRIG-B master. Otherwise FALSE. |

**Table 54: DNP3, Modbus, IEC 60870-5-101/104 and IEC 60870-5-103 Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm status for clock synchronization.<br>TRUE if the clock has not been synchronized by the master. |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| | | FALSE if the clock has been synchronized by the master. |
| WARNING | BOOLEAN | Warning status for clock synchronization.<br>TRUE if the clock has not been synchronized by the master.<br>FALSE if the clock has been synchronized by the master. |
| EXTCLKMSTR | BOOLEAN | Status of the protection relay's clock synchronization.<br>TRUE if the protection relay has been synchronized by an external master.<br>FALSE if the clock has not been synchronized by an external master. |

**Table 55: Line differential Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm status for clock synchronization.<br>TRUE if the LD connection has been lost. |
| WARNING | BOOLEAN | Warning status for clock synchronization.<br>TRUE if the LD connection has been lost. |
| EXTCLKMSTR | BOOLEAN | Status of the protection relay's clock synchronization.<br>TRUE if the clock has been synchronized to the LD partner. |

## 3.6.1.4 Settings

### Time format settings

**Table 56: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Time format | 1=24H:MM:SS:MS<br>2=12H:MM:SS:MS | | | 1=24H:MM:SS:MS | Time format |
| Date format | 1=DD.MM.YYYY<br>2=DD/MM/YYYY<br>3=DD-MM-YYYY<br>4=MM.DD.YYYY<br>5=MM/DD/YYYY<br>6=YYYY-MM-DD<br>7=YYYY-DD-MM<br>8=YYYY/DD/MM | | | 1=DD.MM.YYYY | Date format |

### Time settings

**Table 57: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Synch source | 0=None<br>1=SNTP<br>2=Modbus<br>3=IEEE 1588<br>5=IRIG-B<br>9=DNP<br>17=IEC60870-5-103 | | | 1=SNTP | Time synchronization source |
| PTP Profile | 1=IEEE C37.238-2011<br>2=IEC 61850-9-3 | | | 1=IEEE C37.238-2011 | Profile Selection for the Precision Time Protocol |
| PTP domain ID | 0...255 | | 1 | 0 | The domain is identified by an integer, the domainNumber, in the range of 0 to 255. |
| PTP priority 1 | 0...255 | | 1 | 128 | PTP priority 1, in the range of 0 to 255. |
| PTP priority 2 | 0...255 | | 1 | 128 | PTP priority 2, in the range of 0 to 255. |
| PTP Slave-only | 0=False<br>1=True | | | 0=False | If true, the IED cannot become a clock master |
| Time master mode | 1=Master with finite holdover<br>2=Master with infinite holdover | | | 1=Master with finite holdover | Device Time Master Mode |
| Clear clock list | 0=False<br>1=True | | | 0=False | Clears the stored master clock list |
| Time Syn Src Tmm | 1...65535 | min | 1 | 3 | Time synchronization timeout for legacy protocols as clock source (Modbus, IEC103, IEC101, IEC104 and DNP) |

**Table 58: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Date | | | | 0 | Date |
| Time | | | | 0 | Time |
| Local time offset | -840...840 | min | 1 | 0 | Local time offset in minutes |

**Table 59: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| IP SNTP primary | | | | 192.168.2.166 | IP address for SNTP primary server |
| IP SNTP secondary | | | | 192.168.2.165 | IP address for SNTP secondary server |

**Table 60: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| DST in use | 0=False<br>1=True | | | 1=True | DST in use setting |
| DST on time (hours) | 0...23 | h | | 2 | Daylight saving time on, time (hh) |
| DST on time (minutes) | 0...59 | min | | 0 | Daylight saving time on, time (mm) |
| DST on date (day) | 1...31 | | | 1 | Daylight saving time on, date (dd:mm) |
| DST on date (month) | 1=January<br>2=February<br>3=March<br>4=April<br>5=May<br>6=June<br>7=July<br>8=August<br>9=September<br>10=October<br>11=November<br>12=December | | | 5=May | Daylight saving time on, date (dd:mm) |
| DST on day (weekday) | 0=reserved<br>1=Monday<br>2=Tuesday<br>3=Wednesday<br>4=Thursday<br>5=Friday<br>6=Saturday<br>7=Sunday | | | 0=reserved | Daylight saving time on, day of week |
| DST off time (hours) | 0...23 | h | | 2 | Daylight saving time off, time (hh) |
| DST off time (minutes) | 0...59 | min | | 0 | Daylight saving time off, time (mm) |
| DST off date (day) | 1...31 | | | 25 | Daylight saving time off, date (dd:mm) |
| DST off date (month) | 1=January<br>2=February<br>3=March<br>4=April<br>5=May<br>6=June<br>7=July<br>8=August<br>9=September<br>10=October<br>11=November<br>12=December | | | 9=September | Daylight saving time off, date (dd:mm) |
| DST off day (weekday) | 0=reserved<br>1=Monday | | | 0=reserved | Daylight saving time off, day of week |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=Tuesday<br>3=Wednesday<br>4=Thursday<br>5=Friday<br>6=Saturday<br>7=Sunday | | | | |
| DST offset | -720...720 | min | 1 | 60 | Daylight saving time offset |

### 3.6.1.5 Monitored data

**Table 61: Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Synch source | Enum | 0=Not defined<br>1=SNTP primary<br>2=SNTP secondary<br>4=IEEE 1588 master<br>5=IEEE 1588 slave<br>7=IRIG-B 8=DNP 3.0<br>9=Modbus<br>17=IEC 60870-5-103<br>21=Line differential<br>99=Free running | | Time synchronization source |
| Synch status | Bool | 0=Down<br>1=Up | | Time synchronization status |
| Synch accuracy | Int | 0...128 | | Time synchronization accuracy. Number of the significant bits in fraction of second. |
| PTP gm identity | String | | | PTP grand master clock identity according PTP standard |
| PTP gm time Src | Enum | 1=Atomic clock<br>2=GPS<br>3=Terrestrial radio<br>4=PTP<br>5=NTP<br>6=Hand set<br>7=Other<br>8=Internal oscil. | | PTP grand master clock source type |
| PTP gm accuracy | Enum | 1=25 ns<br>2=100 ns<br>3=250 ns<br>4=1 us<br>5=2.5 us<br>6=10 us<br>7=25 us<br>8=100 us<br>9=250 us<br>10=1 ms | | PTP grand master accuracy according PTP standard |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 11=2.5 ms<br>12=10 ms<br>13=25 ms<br>14=100 ms<br>15=250 ms<br>16=1 s<br>17=10 s<br>18=more than 10 s | | |

# 3.7 Generic protection control PROTECTION

## 3.7.1 Function block

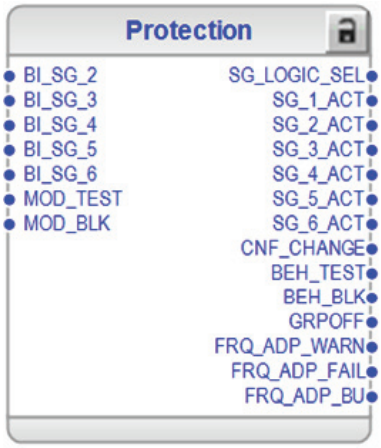



*Figure 49: Function block*

## 3.7.2 Functionality

### 3.7.2.1 Setting group control

The protection relay supports six setting groups. Each setting group contains parameters categorized as group settings inside application functions. The customer can change the active setting group at run time.

The active setting group can be changed by a parameter or via binary inputs depending on the mode selected with the **Configuration** > **Setting Group** > **SG operation mode** setting.

The default value of all inputs is FALSE, which makes it possible to use only the required number of inputs and leave the rest disconnected. The setting group selection is not dependent on the `SG_x_ACT` outputs.

**Table 62: Optional operation modes for setting group selection**

| SG operation mode | Description |
|---|---|
| Operator (Default) | Setting group can be changed with the setting Settings/Setting group/Active group. Value of the SG_LOGIC_SEL output is FALSE. |
| Logic mode 1 | Setting group can be changed with binary inputs (BI_SG_2...BI_SG_6). The highest TRUE binary input defines the active setting group. Value of the SG_LOGIC_SEL output is TRUE. |
| Logic mode 2 | Setting group can be changed with binary inputs where BI_SG_4 is used for selecting setting groups 1–3 or 4–6.<br>When binary input BI_SG_4 is FALSE, setting groups 1–3 are selected with binary inputs BI_SG_2 and BI_SG_3. When binary input BI_SG_4 is TRUE, setting groups 4–6 are selected with binary inputs BI_SG_5 and BI_SG_6. Value of the SG_LOGIC_SEL output is TRUE. |

For example, six setting groups can be controlled with three binary inputs. *SG operation mode* is set to "Logic mode 2" and inputs BI_SG_2 and BI_SG_5 are connected together the same way as inputs BI_SG_3 and BI_SG_6.

**Table 63: SG operation mode = "Logic mode 1"**

| Input | | | | | |
|---|---|---|---|---|---|
| **BI_SG_2** | **BI_SG_3** | **BI_SG_4** | **BI_SG_5** | **BI_SG_6** | **Active group** |
| FALSE | FALSE | FALSE | FALSE | FALSE | 1 |
| TRUE | FALSE | FALSE | FALSE | FALSE | 2 |
| any | TRUE | FALSE | FALSE | FALSE | 3 |
| any | any | TRUE | FALSE | FALSE | 4 |
| any | any | any | TRUE | FALSE | 5 |
| any | any | any | any | TRUE | 6 |

**Table 64: SG operation mode = "Logic mode 2"**

| Input | | | | | |
|---|---|---|---|---|---|
| **BI_SG_2** | **BI_SG_3** | **BI_SG_4** | **BI_SG_5** | **BI_SG_6** | **Active group** |
| FALSE | FALSE | FALSE | any | any | 1 |
| TRUE | FALSE | FALSE | any | any | 2 |
| any | TRUE | FALSE | any | any | 3 |
| any | any | TRUE | FALSE | FALSE | 4 |
| any | any | TRUE | TRUE | FALSE | 5 |
| any | any | TRUE | any | TRUE | 6 |

Setting group 1 can be copied to any other or all groups from HMI (Copy group 1).

### 3.7.2.2 Test mode

The function has two outputs, BEH_TST and BEH_BLK, which are activated in test mode according to *Table 65*.

**Table 65: Test mode**

| Test mode | Description | Protection BEH_BLK | Protection BEH_TST |
|---|---|---|---|
| Normal mode | Normal operation | FALSE | FALSE |
| IED blocked | Protection works as in “Normal mode” but the ACT configuration can be used to block physical outputs to process. Control function commands are blocked. | TRUE | FALSE |
| IED test | Protection works as in “Normal mode” but protection functions work in parallel with test parameters. | FALSE | TRUE |
| IED test and blocked | Protection works as in “Normal mode” but protection functions work in parallel with the test parameter. The ACT configuration can be used to block physical outputs to process. Control function command is blocked. | TRUE | TRUE |

For more information, see the Test mode section in this manual.

### 3.7.2.3 Frequency adaptivity

The FRQ_ADP_WARN output is active when full adaptation to the actual frequency is not reached or guaranteed. The FRQ_ADP_FAIL output is active when no frequency source has sufficient amplitude and the nominal frequency window size is used in measurements. The FRQ_ADP_BU output is active when the backup adaptivity frequency source is active.

When switching from the main frequency source to the backup frequency source, there is an interval of 200 ms where the last known frequency is used to determine the measurement window size. During this period, FRQ_ADP_WARN is activated. This also happens when no frequency source has sufficient amplitude and the last frequency is held for 3 s before activating output FRQ_ADP_FAIL.

### 3.7.2.4 Special function block outputs

The function block has a few outputs dedicated for special purposes.

**Table 66: Special function block outputs**

| Output | Description |
|---|---|
| CNF_CHANGE | Any setting change in the protection relay activates this output for a short period of time (100...200 ms). |
| GRPOFF | Some application function blocks do now allow unconnected analog inputs. In such a case, `GRPOFF` must be connected to such an input. |
| DEV_WARN | A protection relay's internal warning activates this output. For more information, see Warnings under the Self-supervision section. |

## 3.7.3 Signals

**Table 67: PROTECTION Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BI_SG2 | BOOLEAN | 0 | Setting group 2 is active |
| BI_SG3 | BOOLEAN | 0 | Setting group 3 is active |
| BI_SG4 | BOOLEAN | 0 | Setting group 4 is active |
| BI_SG5 | BOOLEAN | 0 | Setting group 5 is active |
| BI_SG6 | BOOLEAN | 0 | Setting group 6 is active |
| MOD_TEST | BOOLEAN | 0 | Activation of test mode |
| MOD_BLK | BOOLEAN | 0 | Block test mode |

**Table 68: PROTECTION Output signals**

| Name | Type | Description |
|---|---|---|
| SG_LOGIC_SEL | BOOLEAN | Logic selection for setting group |
| SG_1_ACT | BOOLEAN | Setting group 1 is active |
| SG_2_ACT | BOOLEAN | Setting group 2 is active |
| SG_3_ACT | BOOLEAN | Setting group 3 is active |
| SG_4_ACT | BOOLEAN | Setting group 4 is active |
| SG_5_ACT | BOOLEAN | Setting group 5 is active |
| SG_6_ACT | BOOLEAN | Setting group 6 is active |
| CNF_CHANGE | BOOLEAN | Active after any setting change |
| BEH_TEST | BOOLEAN | Logical device LD0 test status |
| BEH_BLK | BOOLEAN | Logical device LD0 block status |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| GRPOFF | Group signal | Group off signal for function blocks |
| DEV_WARN | BOOLEAN | Protection relay internal warning |
| FRQ_ADP_WARN | BOOLEAN | Frequency adaptivity warning |
| FRQ_ADP_FAIL | BOOLEAN | Frequency adaptivity status fail |
| FRQ_ADP_BU | BOOLEAN | Main frequency adaptivity source |

### 3.7.4 Settings

**Table 69: PROTECTION Settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| SG operation mode | 1=Operator<br>2=Logic mode 1<br>3=Logic mode 2 | | | 1=Operator | Operation mode for setting group change |

## 3.8 Local/Remote control CONTROL

### 3.8.1 Function block

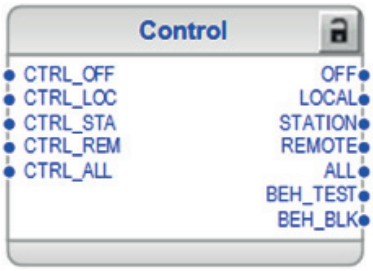



*Figure 50: Function block*

### 3.8.2 Functionality

Local/Remote control is by default realized through the R/L button on the front panel. The control via binary input can be enabled by setting the value of the *LR control* setting to "Binary input". The binary input control requires that the CONTROL function is instantiated in the product configuration.

Local/Remote control supports multilevel access for control operations in substations according to the IEC 61850 standard. Multilevel control access with separate station control access level is not supported by other protocols than IEC 61850.

The actual Local/Remote control state is evaluated by the priority scheme on the function block inputs. If more than one input is active, the input with the highest priority is selected. The priority order is “off”, “local”, “station”, “remote”, “all”.

The actual state is reflected on the CONTROL function outputs. Only one output is active at a time.

**Table 70: Truth table for CONTROL**

| Input | | | | | Output |
|---|---|---|---|---|---|
| **CTRL_OFF** | **CTRL_LOC** | **CTRL_STA** | **CTRL_REM** | **CTRL_ALL** | |
| TRUE | N/A | N/A | N/A | N/A | OFF = TRUE |
| FALSE | TRUE | N/A | N/A | N/A | LOCAL = TRUE |
| FALSE | FALSE | TRUE | N/A | N/A | STATION = TRUE |
| FALSE | FALSE | FALSE | TRUE | TRUE | REMOTE = TRUE |
| FALSE | FALSE | FALSE | FALSE | TRUE | ALL = TRUE |
| FALSE | FALSE | FALSE | FALSE | FALSE | OFF = TRUE |

## 3.8.3 L/R control access

Four different Local/Remote control access scenarios are possible depending on the selected station authority level: “L,R”, “L,R,L+R”, “L,S,R” and “L, S, S+R, L+S, L+S+R”. If control commands need to be allowed from multiple levels, multilevel access can be used. Multilevel access is possible only by using the station authority levels “L,R,L+R” and “L, S, S+R, L+S, L+S+R”. Multilevel access status is available from IEC 61850 data object CTRL.LLN0.MltLev.

Control access selection is made with R/L button or CONTROL function block and IEC 61850 data object CTRL.LLN0.LocSta. When writing CTRL.LLN0.LocSta IEC 61850 data object, IEC 61850 command originator category station must be used by the client, and remote IEC 61850 control access must be allowed by the relay station authority. CTRL.LLN0.LocSta data object value is retained in the nonvolatile memory. The present control status can be monitored in the HMI or PCM600 via **Monitoring** > **Control command** with the *LR state* parameter or from the IEC 61850 data object CTRL.LLN0. LocKeyHMI.

IEC 61850 command originator category is always set by the IEC 61850 client. The relay supports station and remote IEC 61850 command originator categories, depending on the selected station authority level.

## 3.8.4 Station authority level “L,R"

Relay default station authority level is “L,R”. In this scenario only local or remote control access is allowed. Control access with IEC61850 command originator category station is interpreted as remote access. There is no multilevel access

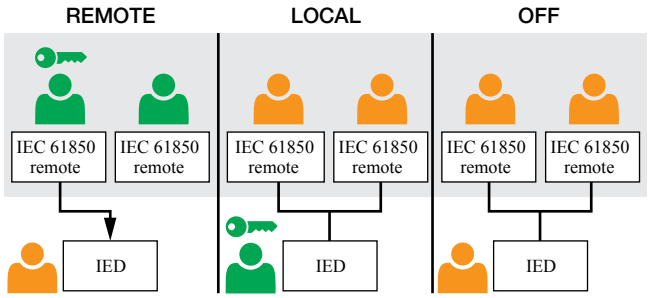



*Figure 51: Station authority is "L,R"*

When station authority level "L,R" is used, control access can be selected using R/L button or CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block inputs `CTRL_STA` and `CTRL_ALL` are not applicable for this station authority level.

**Table 71: Station authority level "L,R" using R/L button**

| L/R control | | L/R control status | | Control access | |
|---|---|---|---|---|---|
| **R/L button** | **CTRL.LLN0.LocSta** | **CTRL.LLN0.MltLev** | **L/R state CTRL.LLN0.LocKey HMI** | **Local user** | **IEC 61850 client [1]** |
| Local | N/A | FALSE | 1 | x | |
| Remote | N/A | FALSE | 2 | | x |
| Off | N/A | FALSE | 0 | | |

**Table 72: Station authority "L,R" using CONTROL function block**

| L/R control | | L/R control status | | Control access | |
|---|---|---|---|---|---|
| **Control FB input** | **CTRL.LLN0.LocSta** | **CTRL.LLN0.MltLev** | **L/R state CTRL.LLN0.LocKey HMI** | **Local user** | **IEC 61850 client [2]** |
| CTRL_OFF | N/A | FALSE | 0 | | |
| CTRL_LOC | N/A | FALSE | 1 | x | |
| CTRL_STA | N/A | FALSE | 0 | | |
| CTRL_REM | N/A | FALSE | 2 | | x |
| CTRL_ALL | N/A | FALSE | 0 | | |

[1] Client IEC 61850 command originator category check is not performed.
[2] Client IEC 61850 command originator category check is not performed.

## 3.8.5 Station authority level "L,R,L+R"

Station authority level "L,R, L+R" adds multilevel access support. Control access can also be simultaneously permitted from local or remote location. Simultaneous local or remote control operation is not allowed as one client and location at time can access controllable objects and they remain reserved until the previously started control operation is first completed by the client. Control access with IEC61850 originator category station is interpreted as remote access.

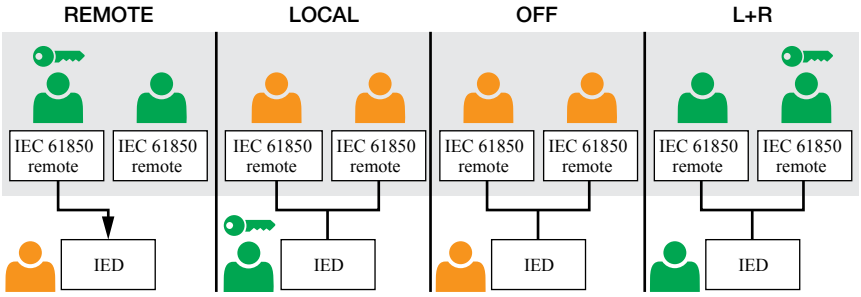



*Figure 52: Station authority is "L,R,L+R"*

When station authority level "L,R, L+R" is used, the control access can be selected using R/L button or CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block input `CTRL_STA` are not applicable for this station authority level.

**Table 73: Station authority level "L,R,L+R" using R/L button**

| L/R Control | | L/R Control status | | Control access | |
|---|---|---|---|---|---|
| **R/L button** | **CTRL.LLN0.LocSta** | **CTRL.LLN0.MltLev** | **L/R state CTRL.LLN0.LocKey HMI** | **Local user** | **IEC 61850 client[1]** |
| Local | N/A | FALSE | 1 | x | |
| Remote | N/A | FALSE | 2 | | x |
| Local + Remote | N/A | TRUE | 4 | x | x |
| Off | N/A | FALSE | 0 | | |

**Table 74: Station authority "L,R,L+R" using CONTROL function block**

| L/R Control | | L/R Control status | | Control access | |
|---|---|---|---|---|---|
| **Control FB input** | **CTRL.LLN0.LocSta** | **CTRL.LLN0.MltLev** | **L/R state CTRL.LLN0.LocKey HMI** | **Local user** | **IEC 61850 client[2]** |
| CTRL_OFF | N/A | FALSE | 0 | | |
| CTRL_LOC | N/A | FALSE | 1 | x | |
| CTRL_STA | N/A | FALSE | 0 | | |
| CTRL_REM | N/A | FALSE | 2 | | x |
| CTRL_ALL | N/A | TRUE | 4 | x | x |

[1] Client IEC 61850 command originator category check is not performed.
[2] Client IEC 61850 command originator category check is not performed.

## 3.8.6 Station authority level "L,S,R"

Station authority level "L,S,R" adds station control access. In this level IEC 61850 command originator category validation is performed to distinguish control commands with IEC 61850 command originator category set to “Remote” or “Station”. There is no multilevel access.

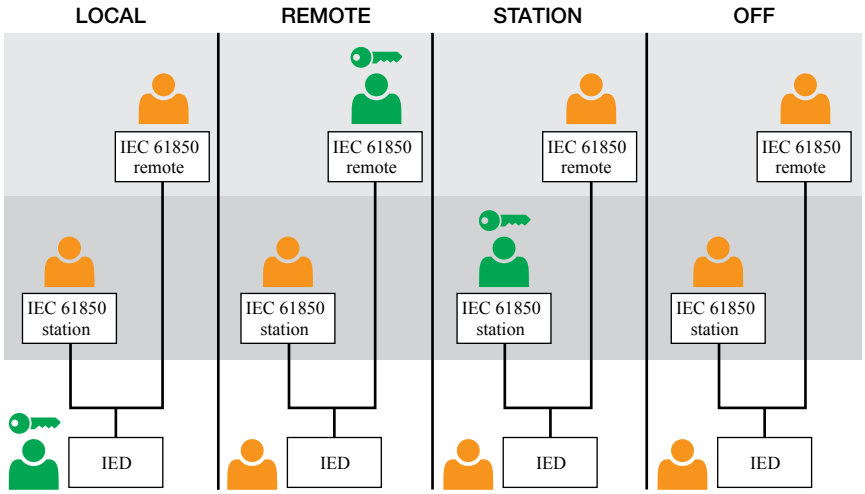



*Figure 53: Station authority is “"L,S,R"*

When the station authority level “L,S,R” is used, the control access can be selected using R/L button or CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block input `CTRL_STA` are applicable for this station authority level.

Station control access can be reserved by using R/L button or CONTROL function block together with IEC 61850 data object CTRL.LLN0.LocSta

**Table 75: Station authority level “L,S,R” using R/L button**

| L/R Control | | L/R Control status | | Control access | | |
|---|---|---|---|---|---|---|
| **R/L button** | **CTRL.LLN0.LocSta**[1] | **CTRL.LLN0.MltLev** | **L/R state CTRL.LLN0.LocKeyHMI** | **Local user** | **IEC 61850 client**[2] | **IEC 61850 client**[3] |
| Local | FALSE | FALSE | 1 | x | | |
| Remote | FALSE | FALSE | 2 | | x | |
| Remote | TRUE | FALSE | 3 | | | x |
| Off | FALSE | FALSE | 0 | | | |

[1] Station client reserves the control operating by writing controllable point LocSta.
[2] Client IEC 61850 command originator category is remote.
[3] Client IEC 61850 command originator category is station.

**Table 76: Station authority level “L,S,R” using CONTROL function block**

| L/R Control | | L/R Control status | | Control access | | |
|---|---|---|---|---|---|---|
| R/L button | CTRL.LLN0.LocSta[4] | CTRL.LLN0.MltLev | L/R state CTRL.LLN0.LocKeyHMI | Local user | IEC 61850 client[5] | IEC 61850 client[6] |
| CTRL_OFF | FALSE | FALSE | 0 | | | |
| CTRL_LOC | FALSE | FALSE | 1 | x | | |
| CTRL_STA | TRUE | FALSE | 3 | | | |
| CTRL_REM[7] | TRUE | FALSE | 3 | | | x |
| CTRL_REM | FALSE | FALSE | 2 | | x | |
| CTRL_ALL | FALSE | FALSE | 0 | | | |

## 3.8.7 Station authority level “L,S,S+R,L+S,L+S+R”

Station authority level "L,S,S+R,L+S,L+S+R" adds station control access together with several different multilevel access scenarios. Control access can also be simultaneously permitted from local, station or remote location. Simultaneous local, station or remote control operation is not allowed as one client and location at time can access controllable objects and they remain reserved until the previously started control operation is first completed by the client.

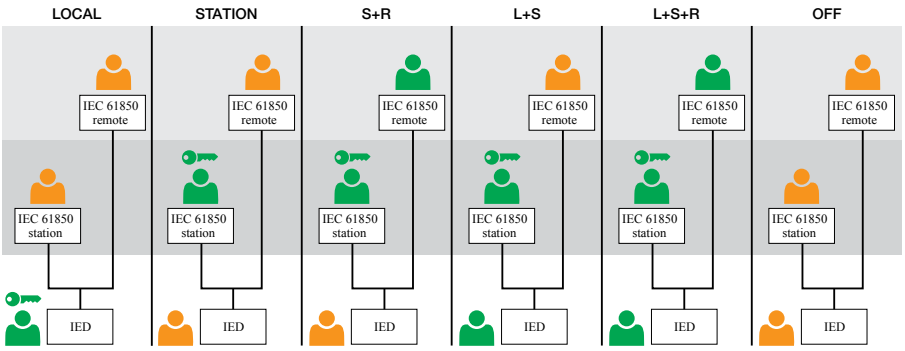



*Figure 54: Station authority is “L,S,S+R,L+S,L+S+R”*

When station authority level “L,S,S+R,L+S,L+S+R” is used, control access can be selected using R/L button or CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block input `CTRL_STA` are applicable for this station authority level.

“Station” and “Local + Station” control access can be reserved by using R/L button or CONTROL function block in combination with IEC 61850 data object CTRL.LLN0.LocSta.

4 Station client reserves the control operating by writing controllable point LocSta.
5 Client IEC 61850 command originator category is remote.
6 Client IEC 61850 command originator category is station.
7 CTRL_STA unconnected in application configuration. Station client reserves the control operating by writing controllable point LocSta.

**Table 77: Station authority level “L,S,S+R,L+S,L+S+R” using R/L button**

| L/R Control | | L/R Control status | | Control access | | |
|---|---|---|---|---|---|---|
| R/L button | CTRL.LLN0.LocSta[1] | CTRL.LLN0.MltLev | L/R state CTRL.LLN0.LocKeyHMI | Local user | IEC 61850 client[2] | IEC 61850 client[3] |
| Local | FALSE | FALSE | 1 | x | | |
| Remote | FALSE | TRUE | 7 | | x | x |
| Remote | TRUE | FALSE | 3 | | | x |
| Local + Remote | FALSE | TRUE | 6 | x | x | x |
| Local + Remote | TRUE | TRUE | 5 | x | | x |
| Off | FALSE | FALSE | 0 | | | |

**Table 78: Station authority level “L,S,S+R,L+S,L+S+R” using CONTROL function block**

| L/R Control | | L/R Control status | | Control access | | |
|---|---|---|---|---|---|---|
| R/L button | CTRL.LLN0.LocSta[4] | CTRL.LLN0.MltLev | L/R state CTRL.LLN0.LocKeyHMI | Local user | IEC 61850 client[5] | IEC 61850 client[6] |
| CTRL_OFF | FALSE | FALSE | 0 | | | |
| CTRL_LOC | FALSE | FALSE | 1 | x | | |
| CTRL_STA | FALSE | FALSE | 3 | | | x |
| CTRL_REM [7] | TRUE | TRUE | 3 | | | x |
| CTRL_REM | FALSE | TRUE | 7 | | x | x |
| CTRL_ALL | FALSE | TRUE | 6 | x | x | x |
| CTRL_ALL [7] | TRUE | TRUE | 5 | x | | x |

## 3.8.8 Control mode

The function has two outputs BEH_TST and BEH_BLK which are activated in test mode according to *Table 79*.

**Table 79: Control mode**

| Control mode | Description | Control BEH_BLK |
|---|---|---|
| On | Normal operation | FALSE |
| Blocked | Control function commands blocked | TRUE |
| Off | Control functions disabled | FALSE |

For more information, see the Test mode chapter in this manual.

1 Station client reserves the control operating by writing controllable point LocSta.
2 Client IEC 61850 command originator category is remote.
3 Client IEC 61850 command originator category is station.
4 Station client reserves the control operating by writing controllable point LocSta.
5 Client IEC 61850 command originator category is remote.
6 Client IEC 61850 command originator category is station.
7 CTRL_STA unconnected in application configuration. Station client reserves the control operating by writing controllable point LocSta.

## 3.8.9 Signals

**Table 80: CONTROL Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| CTRL_OFF | BOOLEAN | 0 | Control input OFF |
| CTRL_LOC | BOOLEAN | 0 | Control input Local |
| CTRL_STA | BOOLEAN | 0 | Control input Station |
| CTRL_REM | BOOLEAN | 0 | Control input Remote |
| CTRL_ALL | BOOLEAN | 0 | Control input All |

**Table 81: CONTROL Output signals**

| Name | Type | Description |
|---|---|---|
| OFF | BOOLEAN | Control output OFF |
| LOCAL | BOOLEAN | Control output Local |
| STATION | BOOLEAN | Control output Station |
| REMOTE | BOOLEAN | Control output Remote |
| ALL | BOOLEAN | Control output All |
| BEH_BLK | BOOLEAN | Logical device CTRL block status |
| BEH_TST | BOOLEAN | Logical device CTRL test status |

## 3.8.10 Settings

**Table 82: Non group settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| LR control | 1=LR key<br>2=Binary input | | | 1=LR key | LR control through LR key or binary input |
| Station authority | 1=L,R<br>2=L,S,R<br>3=L,R,L+R<br>4=L,S,S+R,L+S,L +S+R | | | 1=L,R | Control command originator category usage |
| Control mode | 1=On<br>2=Blocked<br>5=Off | | | 1=On | Enabling and disabling control |

## 3.8.11 Monitored data

**Table 83: Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Command response | Enum | 0=No commands<br>1=Select open<br>2=Select close<br>3=Operate open<br>4=Operate close<br>5=Direct open<br>6=Direct close<br>7=Cancel<br>8=Position reached<br>9=Position timeout<br>10=Object status only<br>11=Object direct<br>12=Object select<br>13=RL local allowed<br>14=RL remote allowed<br>15=RL off<br>16=Function off<br>17=Function blocked<br>8=Command progress<br>19=Select timeout<br>20=Missing authority<br>21=Close not enabled<br>22=Open not enabled<br>23=Internal fault<br>24=Already close<br>25=Wrong client<br>26=RL station allowed<br>27=RL change<br>28=Abortion by trip<br>29=Reed not closed<br>30=Motor blocked<br>31=Motor wrong direction | | Latest command response |
| LR state | Enum | 0=Off<br>1=Local<br>2=Remote<br>3=Station<br>4=L+R<br>5=L+S<br>6=L+S+R<br>7=S+R | | LR state monitoring |

# 3.9 Fault recorder FLTRFRC (ANSI FR)

## 3.9.1 Function block




*Figure 55: Function block*

## 3.9.2 Functionality

The protection relay has the capacity to store the records of the latest 128 fault events. Fault records include fundamental or RMS current values. The records enable the user to analyze recent power system events. Each fault record (FLTRFRC) is marked with an up-counting fault number and a time stamp that is taken from the beginning of the fault.

The fault recording period begins from the start event of any protection function connected to the START input and ends if any protection function connected to the OPERATE input trips or the start is restored before the operate event. If a start is restored without an operate event, the start duration shows the protection function that has started first. The TRIG input can be used to start the fault recording period with, for example, binary input.

If *Start duration* has the value "100%", it indicates that a protection function has operated during the fault; if none of the protection functions has operated, *Start duration* always shows values less than 100%.

The fault recorded data *Protection* (rec. set 1 or rec. set 2) and *Start duration* are from the same protection function. The fault recorded data operate time shows the time of the actual fault period. This value is the time difference between the activation of the internal start and operate signals. The actual operate time also includes the starting time and the delay of the output relay. The fault recorded data Breaker clear time is the time difference between the internal operate signal and the activation of the CB_CLRD input.

If some functions in the relay application are sensitive to start frequently, it might be advisable to set the setting parameter Trig mode to "From operate". Then only faults that cause an operate event trigger a new fault recording.

The fault-related current, voltage, frequency, angle values, shot pointer and the active setting group number are taken from the moment of the operate event, or from the beginning of the fault if only a start event occurs during the fault. The maximum current value collects the maximum fault currents during the fault. If frequency cannot be measured, nominal frequency is used for frequency and zero for frequency gradient and validity is set accordingly.

The measuring mode for phase current and residual current values can be selected with the *A measurement mode* setting parameter.

For a detailed description of the measurement modes, see *Chapter 11.6 Measurement modes* in this manual.

## 3.9.3 Analog channel configuration

FLTRFRC has twelve analog group inputs which must be properly configured. All inputs can be connected to GRPOFF.

**Table 84: Analog inputs**

| Input | Description |
|---|---|
| I3P1 [1] | Three-phase currents |
| I3P2 [1] | Three-phase currents |
| I3P3 [1] | Three-phase currents |
| IRES1 [1] | Residual current (measured or calculated) |
| IRES2 [1] | Residual current (measured or calculated) |
| IRES3 [1] | Residual current (measured or calculated) |
| U3P1 [1] | Three-phase voltages |
| U3P2 [1] | Three-phase voltages |
| U3P3 [1] | Three-phase voltages |
| URES1 [1] | Residual voltage (measured or calculated) |
| URES2 [1] | Residual voltage (measured or calculated) |
| URES3 [1] | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

[1] Can be connected to GRPOFF

**Table 85: Special conditions**

| Condition | Description |
|---|---|
| *URES1* connected to the calculated residual voltage | The function requires that all three voltage channels are connected to UTVTR. Setting *VT connection* must be "Wye" in that particular UTVTR. |
| *URES2* connected to the calculated residual voltage | The function requires that all three voltage channels are connected to UTVTR. Setting *VT connection* must be "Wye" in that particular UTVTR. |
| *URES3* connected to the calculated residual voltage | The function requires that all three voltage channels are connected to UTVTR. Setting *VT connection* must be "Wye" in that particular UTVTR. |

## 3.9.4 Signals

### 3.9.4.1 FLTRFRC Input signals

**Table 86: FLTRFRC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| I3P3 | SIGNAL | - | Three-phase currents 3 |
| IRES1 | SIGNAL | - | Residual current 1 |
| IRES2 | SIGNAL | - | Residual current 2 |
| IRES3 | SIGNAL | - | Residual current 3 |
| U3P1 | SIGNAL | - | Three-phase voltages 1 |
| U3P2 | SIGNAL | - | Three-phase voltages 2 |
| U3P3 | SIGNAL | - | Three-phase voltages 3 |
| URES1 | SIGNAL | - | Residual voltage 1 |
| URES2 | SIGNAL | - | Residual voltage 2 |
| URES3 | SIGNAL | - | Residual voltage 3 |

## 3.9.5 Settings

### 3.9.5.1 FLTRFRC Settings

**Table 87: FLTRFRC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Trig mode | 0=From all faults<br>1=From operate<br>2=From only start | | | 0=From all faults | Triggering mode |

**Table 88: FLTRFRC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| A measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode phase currents and residual current |

## 3.9.6 Monitored data

### 3.9.6.1 FLTRFRC Monitored data

**Table 89: FLTRFRC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Fault number | INT32 | 0...999999 | | Fault record number |
| Time and date | Timestamp | | | Fault record time stamp |
| Protection (rec. set 1) | Enum | 0=None<br>1=PHLPTOC1<br>2=PHLPTOC2<br>6=PHHPTOC1<br>7=PHHPTOC2<br>8=PHHPTOC3<br>9=PHHPTOC4<br>12=PHIPTOC1<br>13=PHIPTOC2<br>17=EFLPTOC1<br>18=EFLPTOC2<br>19=EFLPTOC3<br>22=EFHPTOC1<br>23=EFHPTOC2<br>24=EFHPTOC3<br>25=EFHPTOC4<br>30=EFIPTOC1<br>31=EFIPTOC2<br>32=EFIPTOC3<br>35=NSPTOC1<br>36=NSPTOC2<br>-7=INTRPTEF1<br>-5=STTPMSU1<br>-3=JAMPTOC1 | | Protection function (rec. set1) |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 41=PDNSPTOC1<br>44=T1PTTR1<br>46=T2PTTR1<br>48=MPTTR1<br>50=DEFLPDEF1<br>51=DEFLPDEF2<br>53=DEFHPDEF1<br>56=EFPADM1<br>57=EFPADM2<br>58=EFPADM3<br>59=FRPFRQ1<br>60=FRPFRQ2<br>61=FRPFRQ3<br>62=FRPFRQ4<br>63=FRPFRQ5<br>64=FRPFRQ6<br>65=LSHDPFRQ1<br>66=LSHDPFRQ2<br>67=LSHDPFRQ3<br>68=LSHDPFRQ4<br>69=LSHDPFRQ5<br>71=DPHLPDOC1<br>72=DPHLPDOC2<br>74=DPHHPDOC1<br>77=MAPGAPC1<br>78=MAPGAPC2<br>79=MAPGAPC3<br>85=MNSPTOC1<br>86=MNSPTOC2<br>88=LOFLPTUC1<br>90=TR2PTDF1<br>91=LNPLDF1<br>92=LREFPNDF1<br>94=MPDIF1<br>96=HREFPDIF1<br>100=ROVPTOV1<br>101=ROVPTOV2<br>102=ROVPTOV3<br>104=PHPTOV1<br>105=PHPTOV2<br>106=PHPTOV3<br>108=PHPTUV1<br>109=PHPTUV2<br>110=PHPTUV3<br>112=NSPTOV1<br>113=NSPTOV2<br>116=PSPTUV1<br>118=ARCSARC1<br>119=ARCSARC2<br>120=ARCSARC3 | | |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | -96=SPHIPTOC1<br>-93=SPHLPTOC2<br>-92=SPHLPTOC1<br>-89=SPHHPTOC2<br>-88=SPHHPTOC1<br>-87=SPHPTUV4<br>-86=SPHPTUV3<br>-85=SPHPTUV2<br>-84=SPHPTUV1<br>-83=SPHPTOV4<br>-82=SPHPTOV3<br>-81=SPHPTOV2<br>-80=SPHPTOV1<br>-25=OEPVPH4<br>-24=OEPVPH3<br>-23=OEPVPH2<br>-22=OEPVPH1<br>-19=PSPTOV2<br>-18=PSPTOV1<br>-15=PREVPTOC1<br>-12=PHPTUC2<br>-11=PHPTUC1<br>-9=PHIZ1<br>5=PHLTPTOC1<br>20=EFLPTOC4<br>26=EFHPTOC5<br>27=EFHPTOC6<br>37=NSPTOC3<br>38=NSPTOC4<br>45=T1PTTR2<br>54=DEFHPDEF2<br>75=DPHHPDOC2<br>89=LOFLPTUC2<br>103=ROVPTOV4<br>117=PSPTUV2<br>-13=PHPTUC3<br>3=PHLPTOC3<br>10=PHHPTOC5<br>11=PHHPTOC6<br>28=EFHPTOC7<br>29=EFHPTOC8<br>107=PHPTOV4<br>111=PHPTUV4<br>114=NSPTOV3<br>115=NSPTOV4<br>-30=PHDSTPDIS1<br>-29=TR3PTDF1<br>-28=HICPDIF1<br>-27=HIBPDIF1<br>-26=HIAPDIF1 | | |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | -32=LSHDPFRQ8<br>-31=LSHDPFRQ7<br>70=LSHDPFRQ6<br>80=MAPGAPC4<br>81=MAPGAPC5<br>82=MAPGAPC6<br>83=MAPGAPC7<br>-102=MAPGAPC12<br>-101=MAPGAPC11<br>-100=MAPGAPC10<br>-99=MAPGAPC9<br>-98=RESCPSCH1<br>-57=FDEFLPDEF2<br>-56=FDEFLPDEF1<br>-54=FEFLPTOC1<br>-53=FDPHLPDOC2<br>-52=FDPHLPDOC1<br>-50=FPHLPTOC1<br>-47=FRPFRQ8<br>-46=FRPFRQ7<br>-45=MAPGAPC24<br>-44=MAPGAPC23<br>-43=MAPGAPC22<br>-42=MAPGAPC21<br>-41=MAPGAPC20<br>-40=MAPGAPC19<br>-37=HAEFPTOC1<br>-35=WPWDE3<br>-34=WPWDE2<br>-33=WPWDE1<br>52=DEFLPDEF3<br>84=MAPGAPC8<br>93=LREFPNDF2<br>97=HREFPDIF2<br>-117=XDEFLPDEF2<br>-116=XDEFLPDEF1<br>-115=SDPHLPDOC2<br>-114=SDPHLPDOC1<br>-113=XNSPTOC2<br>-112=XNSPTOC1<br>-111=XEFIPTOC2<br>-110=XEFHPTOC4<br>-109=XEFHPTOC3<br>-108=XEFLPTOC3<br>-107=XEFLPTOC2<br>-66=DQPTUV1<br>-65=VVSPPAM1<br>-64=PHPVOC1<br>-63=H3EFPSEF1<br>-60=HCUBPTOC1 | | |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | -59=CUBPTOC1<br>-72=DOPPDPR1<br>-69=DUPPDPR1<br>-61=COLPTOC1<br>-106=MAPGAPC16<br>-105=MAPGAPC15<br>-104=MAPGAPC14<br>-103=MAPGAPC13<br>-76=MAPGAPC18<br>-75=MAPGAPC17<br>-62=SRCPTOC1<br>-74=DOPPDPR3<br>-73=DOPPDPR2<br>-70=DUPPDPR2<br>-58=UZPDIS1<br>-36=UEXPDIS1<br>14=MFADPSDE1<br>-10=LVRTPTUV1<br>-8=LVRTPTUV2<br>-6=LVRTPTUV3<br>-122=DPH3LPDOC1<br>-121=DPH3HPDOC2<br>-120=DPH3HPDOC1<br>-119=PH3LPTOC2<br>-118=PH3LPTOC1<br>-79=PH3HPTOC2<br>-78=PH3HPTOC1<br>-77=PH3IPTOC1<br>-127=PHAPTUV1<br>-124=PHAPTOV1<br>-123=DPH3LPDOC2<br>-68=PHPVOC2<br>-67=DQPTUV2<br>-39=UEXPDIS2<br>98=MHZPDIF1<br>-4=MREFPTOC1<br>-16=MPUPF1<br>-14=OOSRPSB1<br>121=PSPTUV3<br>122=PSPTOV3<br>123=PHVPTOV1<br>39=DNSPDOC1<br>40=DNSPDOC2<br>-126=PHCPTOV1<br>-125=PHBPTOV1<br>-97=HIAPDIF3<br>-95=HICPDIF3<br>-94=HICPDIF2<br>-91=HIBPDIF3<br>-90=HIBPDIF2 | | |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | -71=HIAPDIF2<br>-55=FRPFRQ12<br>-51=FRPFRQ11<br>-49=FRPFRQ10<br>-48=FRPFRQ9<br>-38=DSTPDIS1<br>-21=CUBPTOC3<br>-20=CUBPTOC2<br>-17=MPUPF2<br>-2=PHCPTUV1<br>-1=PHBPTUV1<br>4=PHIPTOC3<br>15=MFADPSDE2<br>16=MFADPSDE3<br>73=DPHLPDOC3<br>76=DPHHPDOC3<br>95=HCUBPTOC2<br>99=MREFPTOC2<br>124=PSPTUV4<br>125=PSPTOV4<br>127=JAMPTOC2<br>21=DEFHPDEF4<br>33=DPHHPDOC4<br>34=DPHLPDOC4<br>47=DEFLPDEF4<br>55=DEFHPDEF3 | | |
| Protection (rec. set 2) | Enum | 0=None<br>1=External<br>2=IFPTOC1<br>3=IFPTOC2<br>4=IFPTOC3 | | Protection function (rec. set 2) |
| Start duration | FLOAT32 | 0.00...100.00 | % | Maximum start duration of all stages during the fault |
| Operate time | FLOAT32 | 0.000...999999.999 | s | Operate time |
| Breaker clear time | FLOAT32 | 0.000...3.000 | s | Breaker clear time |
| Fault distance | FLOAT32 | 0.00...3000.00 | pu | Distance to fault measured in pu |
| Fault resistance | FLOAT32 | 0.00...3000.00 | ohm | Fault resistance |
| Fault reactance | FLOAT32 | 0.00...3000.00 | ohm | Fault reactance |
| Active group | INT32 | 1...6 | | Active setting group |
| Shot pointer | INT32 | 1...7 | | Autoreclosing shot pointer value |
| Max diff current IL1:1 | FLOAT32 | 0.000...80.000 | pu | Maximum phase A differential current (1) |
| Max diff current IL2:1 | FLOAT32 | 0.000...80.000 | pu | Maximum phase B differential current (1) |
| Max diff current IL3:1 | FLOAT32 | 0.000...80.000 | pu | Maximum phase C differential current (1) |
| Diff current IL1:1 | FLOAT32 | 0.000...80.000 | pu | Differential current phase A (1) |
| Diff current IL2:1 | FLOAT32 | 0.000...80.000 | pu | Differential current phase B (1) |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Diff current IL3:1 | FLOAT32 | 0.000...80.000 | pu | Differential current phase C (1) |
| Max bias current IL1:1 | FLOAT32 | 0.000...50.000 | pu | Maximum phase A bias current: (1) |
| Max bias current IL2:1 | FLOAT32 | 0.000...50.000 | pu | Maximum phase B bias current (1) |
| Max bias current IL3:1 | FLOAT32 | 0.000...50.000 | pu | Maximum phase C bias current (1) |
| Bias current IL1:1 | FLOAT32 | 0.000...50.000 | pu | Bias current phase A (1) |
| Bias current IL2:1 | FLOAT32 | 0.000...50.000 | pu | Bias current phase B (1) |
| Bias current IL3:1 | FLOAT32 | 0.000...50.000 | pu | Bias current phase C (1) |
| Diff current Io:1 | FLOAT32 | 0.000...80.000 | pu | Differential current residual (1) |
| Bias current Io:1 | FLOAT32 | 0.000...50.000 | pu | Bias current residual (1) |
| Max current IL1:1 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase A current (1) |
| Max current IL2:1 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase B current (1) |
| Max current IL3:1 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase C current (1) |
| Max current Io:1 | FLOAT32 | 0.000...50.000 | xIn | Maximum residual current (1) |
| Current IL1:1 | FLOAT32 | 0.000...50.000 | xIn | Phase A current (1) |
| Current IL2:1 | FLOAT32 | 0.000...50.000 | xIn | Phase B current (1) |
| Current IL3:1 | FLOAT32 | 0.000...50.000 | xIn | Phase C current (1) |
| Current Io:1 | FLOAT32 | 0.000...50.000 | xIn | Residual current (1) |
| Current Io-Calc:1 | FLOAT32 | 0.000...50.000 | xIn | Calculated residual current (1) |
| Current Ps-Seq:1 | FLOAT32 | 0.000...50.000 | xIn | Positive sequence current (1) |
| Current Ng-Seq:1 | FLOAT32 | 0.000...50.000 | xIn | Negative sequence current (1) |
| Max current IL1:2 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase A current (2) |
| Max current IL2:2 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase B current (2) |
| Max current IL3:2 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase C current (2) |
| Max current Io:2 | FLOAT32 | 0.000...50.000 | xIn | Maximum residual current (2) |
| Current IL1:2 | FLOAT32 | 0.000...50.000 | xIn | Phase A current (2) |
| Current IL2:2 | FLOAT32 | 0.000...50.000 | xIn | Phase B current (2) |
| Current IL3:2 | FLOAT32 | 0.000...50.000 | xIn | Phase C current (2) |
| Current Io:2 | FLOAT32 | 0.000...50.000 | xIn | Residual current (2) |
| Current Io-Calc:2 | FLOAT32 | 0.000...50.000 | xIn | Calculated residual current (2) |
| Current Ps-Seq:2 | FLOAT32 | 0.000...50.000 | xIn | Positive sequence current (2) |
| Current Ng-Seq:2 | FLOAT32 | 0.000...50.000 | xIn | Negative sequence current (2) |
| Max current IL1:3 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase A current (3) |
| Max current IL2:3 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase B current (3) |
| Max current IL3:3 | FLOAT32 | 0.000...50.000 | xIn | Maximum phase C current (3) |
| Max current Io:3 | FLOAT32 | 0.000...50.000 | xIn | Maximum residual current (3) |
| Current IL1:3 | FLOAT32 | 0.000...50.000 | xIn | Phase A current (3) |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Current IL2:3 | FLOAT32 | 0.000...50.000 | xIn | Phase B current (3) |
| Current IL3:3 | FLOAT32 | 0.000...50.000 | xIn | Phase C current (3) |
| Current Io:3 | FLOAT32 | 0.000...50.000 | xIn | Residual current (3) |
| Current Io-Calc:3 | FLOAT32 | 0.000...50.000 | xIn | Calculated residual current (3) |
| Current Ps-Seq:3 | FLOAT32 | 0.000...50.000 | xIn | Positive sequence current (3) |
| Current Ng-Seq:3 | FLOAT32 | 0.000...50.000 | xIn | Negative sequence current (3) |
| Voltage UL1:1 | FLOAT32 | 0.000...4.000 | xUn | Phase A voltage |
| Voltage UL2:1 | FLOAT32 | 0.000...4.000 | xUn | Phase B voltage |
| Voltage UL3:1 | FLOAT32 | 0.000...4.000 | xUn | Phase C voltage |
| Voltage U12:1 | FLOAT32 | 0.000...4.000 | xUn | Phase A to phase B voltage |
| Voltage U23:1 | FLOAT32 | 0.000...4.000 | xUn | Phase B to phase C voltage |
| Voltage U31:1 | FLOAT32 | 0.000...4.000 | xUn | Phase C to phase A voltage |
| Voltage Uo:1 | FLOAT32 | 0.000...4.000 | xUn | Residual voltage |
| Voltage Zro-Seq:1 | FLOAT32 | 0.000...4.000 | xUn | Zero sequence voltage |
| Voltage Ps-Seq:1 | FLOAT32 | 0.000...4.000 | xUn | Positive sequence voltage |
| Voltage Ng-Seq:1 | FLOAT32 | 0.000...4.000 | xUn | Negative sequence voltage |
| Voltage UL1:2 | FLOAT32 | 0.000...4.000 | xUn | Phase A voltage (2) |
| Voltage UL2:2 | FLOAT32 | 0.000...4.000 | xUn | Phase B voltage (2) |
| Voltage UL3:2 | FLOAT32 | 0.000...4.000 | xUn | Phase B voltage (2) |
| Voltage U12:2 | FLOAT32 | 0.000...4.000 | xUn | Phase A to phase B voltage (2) |
| Voltage U23:2 | FLOAT32 | 0.000...4.000 | xUn | Phase B to phase C voltage (2) |
| Voltage U31:2 | FLOAT32 | 0.000...4.000 | xUn | Phase C to phase A voltage (2) |
| Voltage Uo:2 | FLOAT32 | 0.000...4.000 | xUn | Residual voltage (2) |
| Voltage Zro-Seq:2 | FLOAT32 | 0.000...4.000 | xUn | Zero sequence voltage (2) |
| Voltage Ps-Seq:2 | FLOAT32 | 0.000...4.000 | xUn | Positive sequence voltage (2) |
| Voltage Ng-Seq:2 | FLOAT32 | 0.000...4.000 | xUn | Negative sequence voltage (2) |
| Voltage UL1:3 | FLOAT32 | 0.000...4.000 | xUn | Phase A voltage (3) |
| Voltage UL2:3 | FLOAT32 | 0.000...4.000 | xUn | Phase B voltage (3) |
| Voltage UL3:3 | FLOAT32 | 0.000...4.000 | xUn | Phase C voltage (3) |
| Voltage UL12:3 | FLOAT32 | 0.000...4.000 | xUn | Phase A to phase B voltage (3) |
| Voltage UL23:3 | FLOAT32 | 0.000...4.000 | xUn | Phase B to phase C voltage (3) |
| Voltage UL31:3 | FLOAT32 | 0.000...4.000 | xUn | Phase C to phase A voltage (3) |
| Voltage Uo:3 | FLOAT32 | 0.000...4.000 | xUn | Residual voltage (3) |
| Voltage Zro-Seq:3 | FLOAT32 | 0.000...4.000 | xUn | Zero sequence voltage (3) |
| Voltage Ps-Seq:3 | FLOAT32 | 0.000...4.000 | xUn | Positive sequence voltage (3) |
| Voltage Ng-Seq:3 | FLOAT32 | 0.000...4.000 | xUn | Negative sequence voltage (3) |
| PTTR thermal level | FLOAT32 | 0.00...99.99 | | PTTR calculated temperature of the protec- |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | | | ted object relative to the operate level |
| PDNSPTOC1 rat. I2/I1 | FLOAT32 | 0.00...999.99 | % | PDNSPTOC1 ratio I2/I1 |
| Frequency:1 | FLOAT32 | 0.00...80.00 | Hz | Frequency (1) |
| Frequency gradient:1 | FLOAT32 | -10.00...10.00 | Hz/s | Frequency gradient (1) |
| Frequency:2 | FLOAT32 | 0.00...80.00 | Hz | Frequency (2) |
| Frequency gradient:2 | FLOAT32 | -10.00...10.00 | Hz/s | Frequency gradient (2) |
| Frequency:3 | FLOAT32 | 0.00...80.00 | Hz | Frequency (3) |
| Frequency gradient:3 | FLOAT32 | -10.00...10.00 | Hz/s | Frequency gradient (3) |
| Conductance Yo | FLOAT32 | -1000.00...1000.00 | mS | Conductance Yo |
| Susceptance Yo | FLOAT32 | -1000.00...1000.00 | mS | Susceptance Yo |
| Angle Uo:1 - Io:1 | FLOAT32 | -180.00...180.00 | deg | Angle residual voltage (1) - residual current (1) |
| Angle U23:1- IL1:1 | FLOAT32 | -180.00...180.00 | deg | Angle phase B to phase C voltage (1) - phase A current (1) |
| Angle U31:1 - IL2:1 | FLOAT32 | -180.00...180.00 | deg | Angle phase C to phase A voltage (1) - phase B current (1) |
| Angle U12:1 - IL3:1 | FLOAT32 | -180.00...180.00 | deg | Angle phase A to phase B voltage (1) - phase C current (1) |
| Angle Uo:2 - Io:2 | FLOAT32 | -180.00...180.00 | deg | Angle residual voltage (2) - residual current (2) |
| Angle U23:2 - IL1:2 | FLOAT32 | -180.00...180.00 | deg | Angle phase B to phase C voltage (2) - phase A current (2) |
| Angle U31:2 - IL2:2 | FLOAT32 | -180.00...180.00 | deg | Angle phase C to phase A voltage (2) - phase B current (2) |
| Angle U12:2 - IL3:2 | FLOAT32 | -180.00...180.00 | deg | Angle phase A to phase B voltage (2) - phase C current (2) |
| Angle Uo:3 - Io:3 | FLOAT32 | -180.00...180.00 | deg | Angle residual voltage (3) - residual current (3) |
| Angle U23:3 - IL1:3 | FLOAT32 | -180.00...180.00 | deg | Angle phase B to phase C voltage (3) - phase A current (3) |
| Angle U31:3 - IL2:3 | FLOAT32 | -180.00...180.00 | deg | Angle phase C to phase A voltage (3) - phase B current (3) |
| Angle U12:3 - IL3:3 | FLOAT32 | -180.00...180.00 | deg | Angle phase A to phase B voltage (3) - phase C current (3) |

The recorded differential and bias currents as well as the maximum differential and bias currents are provided by LNPLDF1, MPDIF1, TR2PTDF1 or TR3PTDF1. If the configuration contains more than one of these functions, only the currents from the function first found on the list are recorded.

## 3.10 Nonvolatile memory

The relay does not include any battery backup power. If the auxiliary power is lost, critical information such as relay configuration and settings, events, disturbance recordings and other critical data are saved to the relay's nonvolatile memory. The relay's real-time clock keeps running via a 48-hour capacitor backup.

- Up to 1024 events are stored. The stored events are visible in HMI and Event viewer tool in PCM600.
- Recorded data
  - Fault records (up to 128)
  - Maximum demands
- Circuit breaker condition monitoring
- Latched alarm and trip LEDs' statuses
- Trip circuit lockout
- Counter values

## 3.11 Analog measurement channels

The maximum number of physical analog measurement channels is 20. This can be achieved with two analog input modules. The protection relay also supports up to 16 SMV channels in four separate 9-2 streams. In addition to the local or 9-2 channels, a certain number of numerical channels is always calculated from physical measurements. This number also depends on the connection type of the TVTR function block.

**Table 90: TVTR/TCTR connection types and numerical channels**

| Connection type | Function block | Physical channels | Numerical channels |
|---|---|---|---|
| ULx × 1 | ULxTVTR | 1 | 0 |
| URES | ULxTVTR | 1 | 0 |
| ULx × 2 (Wye/Delta) | ULxTVTR | 2 | 4 |
| ULx × 2 + URES (Wye/Delta) | ULxTVTR | 3 | 4 |
| ULx × 3 (Delta) | ULxTVTR | 3 | 3 |
| ULx × 3 (Wye) | ULxTVTR | 3 | 4 |
| ILx × 3 | ILxTCTR | 3 | 1 |
| IRES | RESxTCTR | 1 | 0 |
| ILx × 6 | CMSUM | 6 | 4 |

The maximum number of measurement channels is 64. This can be calculated by adding physical and numerical channels together.

In REX640 relays, the UTVTR functions automatically calculate missing signals if enough information is available. If measured Uo is needed for calculations but it is not provided, it is assumed to be zero. *Table 91* shows possible voltage connections and outcome of the UTVTR function. A three-phase current connection in the ILTCTR function always provides a calculated Io channel.

**Table 91: Calculated voltages for different connection types**

| Voltage connection | Phase-to-phase voltages (Ph-Ph) | Phase-to-neutral voltages (Ph-n) | Residual voltage Uo |
|---|---|---|---|
| 3 × ph-n | yes, calculated | yes | yes, calculated |
| 3 × ph-n + Uo | yes, calculated | yes | yes |
| 2 × ph-n | yes, calculated [1] | yes, missing ph-n calculated [1] | no |
| 2 × ph-n + Uo | yes, calculated | yes, missing ph-n calculated | yes |
| 3 × ph-ph | yes | yes, calculated [1] | no |
| 3 × ph-ph + Uo | yes | yes, calculated | yes |
| 2 × ph-ph | yes, missing ph-ph calculated | yes, calculated [1] | no |
| 2 × ph-ph + Uo | yes, missing ph-ph calculated | yes, calculated | yes |

## 3.12 Sensor inputs for currents and voltages

This chapter gives short examples on how to define the correct parameters for sensor measurement interfaces.

Sensors can have correction factors, measured and verified by the sensor manufacturer, to increase the measurement accuracy. Correction factors are recommended to be set to the relay. Two types of correction factors are available for voltage and current (Rogowski) sensors. The Amplitude correction factor is named *Amplitude corr. A(B/C)* and Angle correction factor is named *Angle corr A(B/C)*. These correction factors can be found on the Sensor's rating plate and/or sensor routine test protocol. If the correction factors are not available, contact the sensor manufacturer for more information.

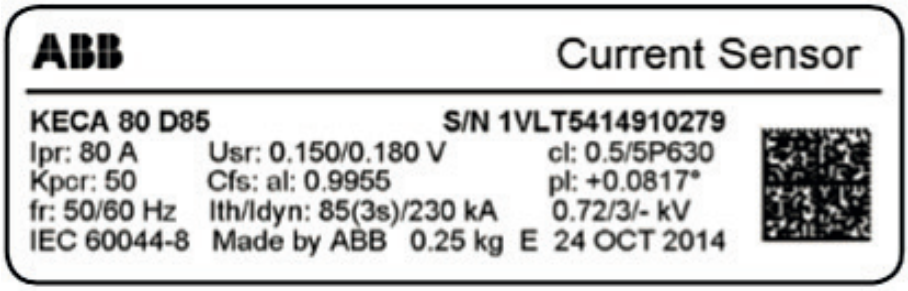



*Figure 56: Example of ABB Rogowski current sensor KECA 80 D85 rating plate*

### Current (Rogowski) sensor setting example

In this example, an 80 A/0.150 V at 50 Hz (0.180 V at 60 Hz) sensor, such as the example shown in *Figure 56*, is used in a 50 Hz electrical network. The application has a 150 A nominal current (In) corresponding to the protected object's nominal current. The application nominal current is set to Rogowski

[1] Uo assumed zero.

sensor setting *Primary current*. Taken from the sensor's technical data, this example sensor can be used with up to 4000 A application nominal current. As the Rogowski sensor is linear and does not saturate, the 80 A/0.150 V at 50 Hz sensor also works as a 150 A/0.28125 V at 50 Hz sensor. When defining another primary value for the sensor, also the nominal voltage has to be redefined to maintain the same transformation ratio. However, the setting in the protection relay (*Rated Secondary Value*) is not in V but in mV/Hz, which makes the same setting *Rated Secondary Value* valid for both 50 and 60 Hz nominal frequency.

$$RSV = \frac{\frac{I_n}{I_{pr}} \times K_r}{f_n}$$

(Equation 1)

| | |
|---|---|
| RSV | *Rated Secondary Value* in mV/Hz |
| $I_n$ | Application nominal current |
| $I_{pr}$ | Sensor-rated primary current |
| $f_n$ | Network nominal frequency |
| $K_r$ | Sensor-rated voltage at the rated current in mV |

In this example, the value is as calculated using the equation.

$$\frac{\frac{150A}{80A} \times 150mV}{50Hz} = 5.625\frac{mV}{Hz}$$

(Equation 2)

With this information, the protection relay's current (Rogowski) sensor settings can be set.

**Table 92: Example setting values for current (Rogowski) sensor**

| Setting | Value |
|---|---|
| Primary current | 150 A |
| Rated secondary value | 5.625 mV/Hz |

When considering setting values for current sensor interfaces and for protection functions utilizing these measurements, it should be noted that the sensor measurement inputs in the relay have limits for linear behavior. When this limit is exceeded, the input starts to saturate. The saturation is reflected to the protection functions connected to the sensor inputs. To ensure that the related protection functions operate correctly, the start value setting for protection functions utilizing either instantaneous or definite minimum time characteristics must not exceed the linear measurement range. Furthermore, the effect on protection functions utilizing inverse time characteristics should be considered. The upper limit of the linear measurement range depends on the selected application nominal current and the type of the current sensor used. *Table 93* shows the limits for an 80A/150mV 50Hz sensor.

**Table 93: Application nominal current relation to the upper limit of linear measurement range**

| Application nominal current ($I_n$) | Rated secondary value with 80A / 0.150 V at 50 Hz (0.180 V at 60 Hz) | Upper limit of linear measurement range |
|---|---|---|
| 40...800 A | 1.500...30.000 mV/Hz | 60 × $I_n$ |
| 800...1250 A | 30.000...46.875 mV/Hz | 60...40 × $I_n$ |
| 1250...2500 A | 46.875...93.750 mV/Hz | 40...20 × $I_n$ |
| 2500...4000 A | 93.750...150.000 mV/Hz | 20...12.5 × $I_n$ |

*Table 93* shows the upper limits of the linear measurement range based on a certain range in application nominal current. The linear measurement limit for a given application nominal current can be derived from the values stated in the table with a simple proportion equation. For example, the upper limit for linear measurement for 3000 A application nominal current would be 17.5 xIn.

It can also be calculated from *Table 93* that with the stated sensor the relay input can linearly measure up to 50 kA (RMS) short circuit currents.

### Rogowski sensor and overcurrent protection setting evaluation example

A 20 kV utility substation with a single busbar switchgear rated up to 40 kA shortcircuit currents has one incomer and 20 outgoing feeder relays using 80 A/0.150 V at 50 Hz Rogowski current sensors with rating plate values similar to *Figure 56*. For the incomer panel, electrical system designer has evaluated the application nominal current to be 1250 A. Customer specification for these protection relays defines normal instantaneous and time-delayed overcurrent and earth-fault protection functions. Overcurrent protection requires functions to be settable up to 20 xIn.

The sensor setting *Primary current* is set to be the same as the evaluated application nominal current 1250 A. According to the sensor's technical data, the application nominal current matches the sensor's capability which is up to 4000 A.

The setting *Rated secondary value* is calculated by using *Equation 1*.

$$\frac{\frac{1250A}{80A} \cdot 150mV}{50Hz} = 46.875 \frac{mV}{Hz}$$

(Equation 3)

From *Table 93* it is seen that with the 1250 A application nominal current value, the maximum setting for overcurrent protection is 40 xIn. This covers the customer specification requirements for overcurrent settings of up to 20 xIn.

### Voltage sensor setting example

The voltage sensor is based on the resistive divider or capacitive divider principle. Therefore, the voltage is linear throughout the whole measuring range. The output signal is a voltage, directly proportional to the primary

voltage. For the voltage sensor, all parameters are readable directly from its rating plate and/or sensor routine test protocol, and conversions are not needed.

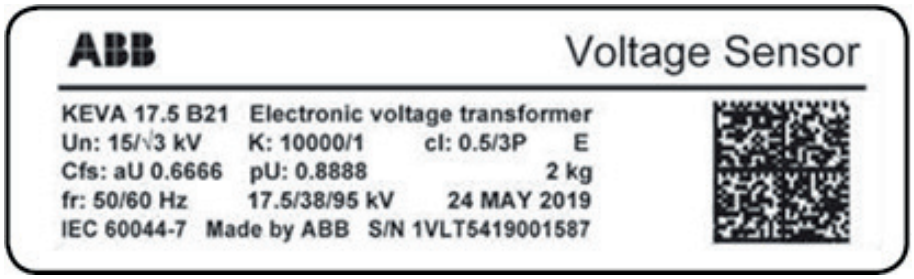



*Figure 57: Example of ABB voltage sensor KEVA 17.5 B21 rating plate*

In this example the system phase-to-phase voltage rating is 10 kV. Thus, the *Primary voltage* parameter is set to 10 kV. For protection relays with sensor measurement support, the *Voltage input type* is set to "Voltage sensor". The VT connection parameter is set to the "WYE" type. The division ratio for ABB voltage sensors is most often 10000:1. Thus, the *Division ratio* parameter is usually set to "10000". The primary voltage is proportionally divided by this division ratio.

**Table 94: Example setting values for voltage sensor**

| Setting | Value |
|---|---|
| Primary voltage | 10 kV |
| VT connection | Wye |
| Voltage input type | 3=Voltage sensor |
| Division ratio | 10000 |

## 3.13 Binary inputs

The binary inputs are mainly assembled in groups of three inputs that have one common connection. The binary inputs are bipolar so the common connection can be tied to ground or to supply voltage. Input groups are isolated from each other and from the secondary side. In addition, there can be groups with only one input. For more information, see *Chapter 13.1 Module diagrams* in this manual.

In harsh industrial environments binary inputs are exposed to contamination. This causes a thin film of insulating sulfidation, oxidation, or contaminates on the surface of the contacts. Film must be removed to establish circuit continuity. Binary inputs have an oxide-burn feature to create a high wetting current impulse to burn off oxidation layer when the threshold is reached. Input wetting current is reduced to a steady-state current when oxide-burn is completed.

In BIO1001 and BIO1003 modules oxide-burn feature can be disabled only on binary input 14 to use it as pulse counter input. The pulse counter input is enabled by setting the parameter *Input 14 counter-mode* in **Configuration** > **I/O modules** > **Slot #** > **Input filtering**. When enabled, the pulse counter input has dedicated *Input*

*counter threshold voltage* and *Input counter threshold hysteresis* settings. Oxide-burn feature cannot be disabled in BIO1002 & BIO1004.

In RTD1002 module wetting current can be adjusted by setting the parameter *Input oxide burn A* in **Configuration** > **I/O modules** > **Slot #** > **Input filtering**. This parameter is common for all binary inputs in the module.

### 3.13.1 Binary input threshold voltage

The parameter *Input threshold voltage* is used to set the threshold level of the binary inputs. *Input threshold voltage* determines the voltage level for the activation of the inputs. The threshold can be set for every module or slot specifically depending on the *Slot specific threshold* setting.

**Table 95: Input threshold voltage parameters**

| Parameter | Values | Default |
|---|---|---|
| Slot specific threshold | 0=False<br>1=True | 0=False |
| Input threshold voltage | 16…176 V | 16 V |

### 3.13.2 Threshold hysteresis

Threshold hysteresis is used to determine the deactivation threshold for the binary inputs in case of voltage drops in the auxiliary voltage supply. Threshold hysteresis value determines how low the deactivation voltage is compared to the activation voltage as a percentage. Hysteresis can be set for every module or slot specifically depending on the *Slot specific hysteresis* setting.

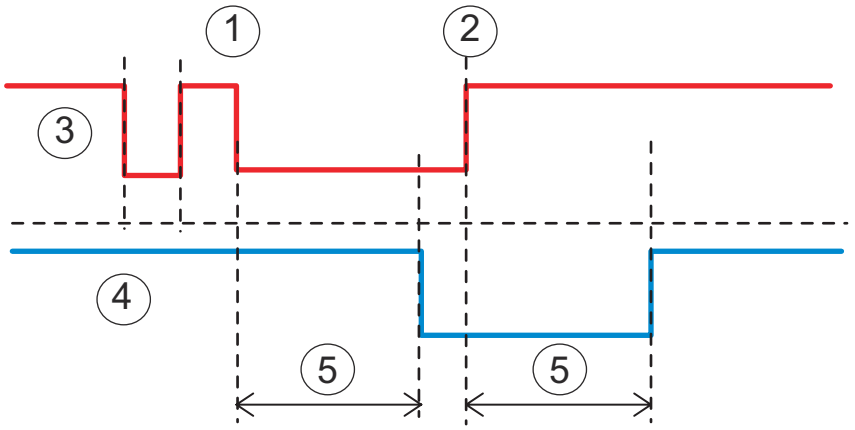
Binary inputs always deactivate when the voltage level drops below 14 V.

**Table 96: Threshold hysteresis parameters**

| Parameter | Values | Default |
|---|---|---|
| Slot specific hysteresis | 0=False<br>1=True | 0=False |
| Input threshold hysteresis | 10…50 % | 10 % |

### 3.13.3 Binary input filter time

The filter time eliminates debounces and short disturbances on a binary input. The filter time is set for each binary input of the protection relay.




1 $t_0$
2 $t_1$
3 Input signal
4 Filtered input signal
5 Filter time

*Figure 58: Binary input filtering*

At the beginning, the input signal is at the high state, the short low state is filtered and no input state change is detected. The low state starting from the time $t_0$ exceeds the filter time, which means that the change in the input state is detected and the time tag attached to the input change is $t_0$. The high state starting from $t_1$ is detected and the time tag $t_1$ is attached.

Each binary input has a filter time parameter *"Input # filter"*, where # is the number of the binary input of the module in question (for example *"Input 1 filter"*).

**Table 97: Input filter parameter values**

| Parameter | Values | Default |
|---|---|---|
| Input # filter time | 5...1000 ms | 5 ms |

## 3.13.4 Binary input inversion

The parameter *Input # invert* is used to invert a binary input.

**Table 98: Binary input states**

| Control voltage | Input # invert | State of binary input |
|---|---|---|
| No | 0 | FALSE (0) |
| Yes | 0 | TRUE (1) |
| No | 1 | TRUE (1) |
| Yes | 1 | FALSE (0) |

When a binary input is inverted, the state of the input is TRUE (1) when no control voltage is applied to its terminals. Accordingly, the input state is FALSE (0) when a control voltage is applied to the terminals of the binary input.

### 3.13.5 Oscillation suppression

Oscillation suppression is used to reduce the load from the system when a binary input starts oscillating. A binary input is regarded as oscillating if the number of valid state changes (= number of events after filtering) during one second is equal to or greater than the set oscillation level value. During oscillation, the binary input is blocked (the status is invalid) and an event is generated. The state of the input will not change when it is blocked, that is, its state depends on the condition before blocking.

The binary input is regarded as non-oscillating if the number of valid state changes during one second is less than the set oscillation level value minus the set oscillation hysteresis value. Note that the oscillation hysteresis must be set lower than the oscillation level to enable the input to be restored from oscillation. When the input returns to a non-oscillating state, the binary input is deblocked (the status is valid) and an event is generated.

**Table 99: Oscillation parameters**

| Parameter | Value | Default |
|---|---|---|
| Input osc. level | 2...50 events/s | 30 events/s |
| Input osc. hyst | 2...50 events/s | 10 events/s |

## 3.14 Binary outputs

The protection relay provides a number of binary outputs used for tripping, executing local or remote control actions of a breaker or a disconnector, and for connecting the protection relay to external annunciation equipment for indicating, signalling and recording.

Power output contacts are used when the current rating requirements of the contacts are high, for example, for controlling a breaker, such as energizing the breaker trip and closing coils.

The contacts used for external signalling, recording and indicating, the signal outputs, need to adjust to smaller currents, but they can require a minimum current (burden) to ensure a guaranteed operation.

The protection relay provides both power output and signal output contacts. To guarantee proper operation, the type of the contacts used are chosen based on the operating and reset time, continuous current rating, make and carry for short time, breaking rate and minimum connected burden. A combination of series or parallel contacts can also be used for special applications. When appropriate, a signal output can also be used to energize an external trip relay, which in turn can be confiugred to energize the breaker trip or close coils.



Using an external trip relay can require an external trip circuit supervision relay. It can also require wiring a separate trip relay contact back to the protection relay for breaker failure protection function.

All contacts are freely programmable, except the internal fault output IRF.

## 3.14.1 Power output contacts

Power output contacts are normally used for energizing the breaker closing coil and trip coil, external high burden lockout or trip relays.

### 3.14.1.1 Dual single-pole power outputs POSP1 and POSP2

Dual (series-connected) single-pole (normally open/form A) power output contacts POSP1 and POSP2 are rated for continuous current of 8 A. The contacts are normally used for closing circuit breakers and energizing high burden trip relays. They can be arranged to trip the circuit breakers when the trip circuit supervision is not available or when external trip circuit supervision relay is provided.

The power outputs are included in the power supply module in slot G.

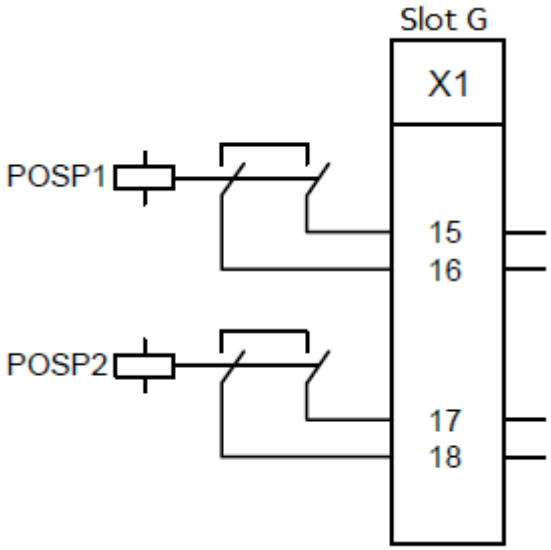



*Figure 59: Dual single-pole power outputs in power supply module*

### 3.14.1.2 Double-pole power outputs PODP1, PODP2 and PODP3 with trip circuit supervision

The power outputs PODP1, PODP2 and PODP3 are double-pole normally open/ form A power outputs with trip circuit supervision. The trip circuit supervision hardware includes constant current generator to provide trip circuit supervision (TCS) current and TCS input that can be connected to the TCS function with Application Configuration in PCM600. See Trip circuit supervision TCSSCBR function for TCS connections.

When the two poles of the contacts are connected in series, they have the same technical specification as POSP1/POSP2 for breaking duty. Contacts PODP1, PODP2 and PODP3 are usually used for energizing the breaker trip coils.

The power outputs are included in the power supply module in slot G.

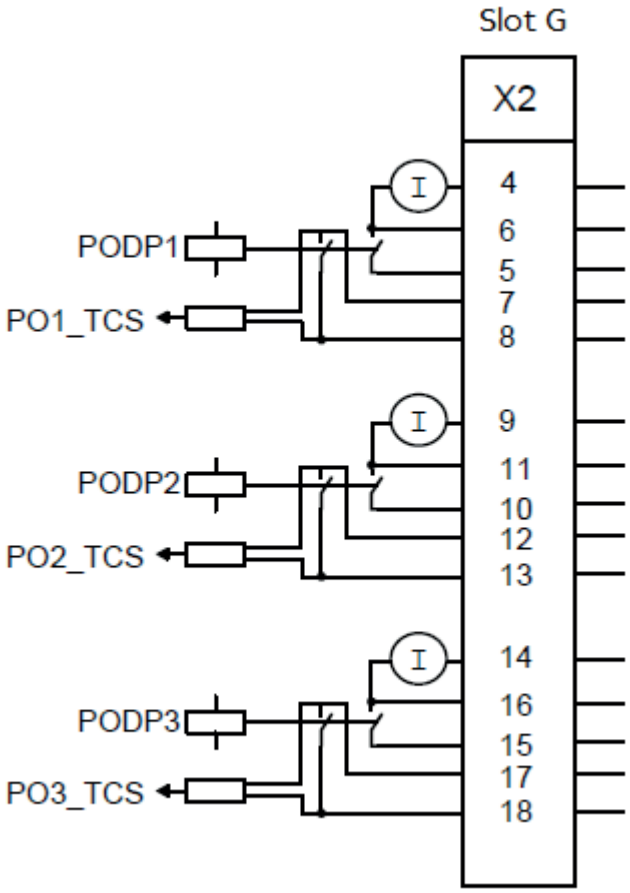



*Figure 60: Double-pole power outputs with trip circuit supervision in power supply module*

### 3.14.1.3 Static power outputs SPO1...SPO8

The outputs are normally used in applications that require fast relay output contact activation time to achieve fast opening of a breaker, such as, arc-protection or breaker failure protection, where fast operation is required either to minimize fault effects to the equipment or to avoid a fault to expand to a larger area. With the static power outputs, the total time from the application to the relay output contact activation is 4...6 ms shorter than when using output contacts with conventional mechanical output relays.

SPO5 and SPO7 are equipped with constant current generator to provide trip circuit supervision (TCS) current. SPO6 and SPO8 are equipped with TCS input that can be connected to the TCS function with Application Configuration in PCM600. See Trip circuit supervision TCSSCBR function for TCS connections.

The static power outputs are included in BIO1002 and BIO1004 modules.

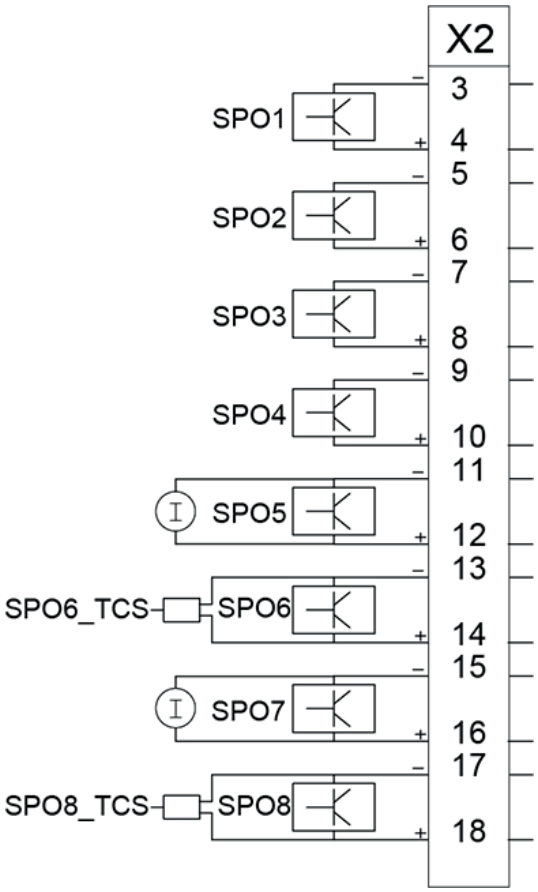



*Figure 61: Static power outputs SPO1...SPO8*

## 3.14.2 Signal output contacts

Signal output contacts are single-pole, single (normally open/form A or change-over/form C) signal output contacts (SO1, SO2,...) or parallel connected dual contacts.

The signal output contacts are used for energizing, for example, external low burden trip relays, auxiliary relays, annunciators and LEDs.

A single signal contact is rated for a continuous current of 5 A. It has a make and carry for 0.5 seconds at 15 A.

When two contacts are connected in parallel, the relay is of a different design. It has the make and carry rating of 30 A for 0.5 seconds. This can be applied for energizing breaker close coil and tripping coil. Due to the limited breaking capacity, a breaker auxiliary contact can be required to break the circuit.

Static signal outputs (SSO1, SSO2) are light-duty fast binary signal outputs and can also be used as pulse outputs.




*Figure 62: Signal outputs in power supply module*

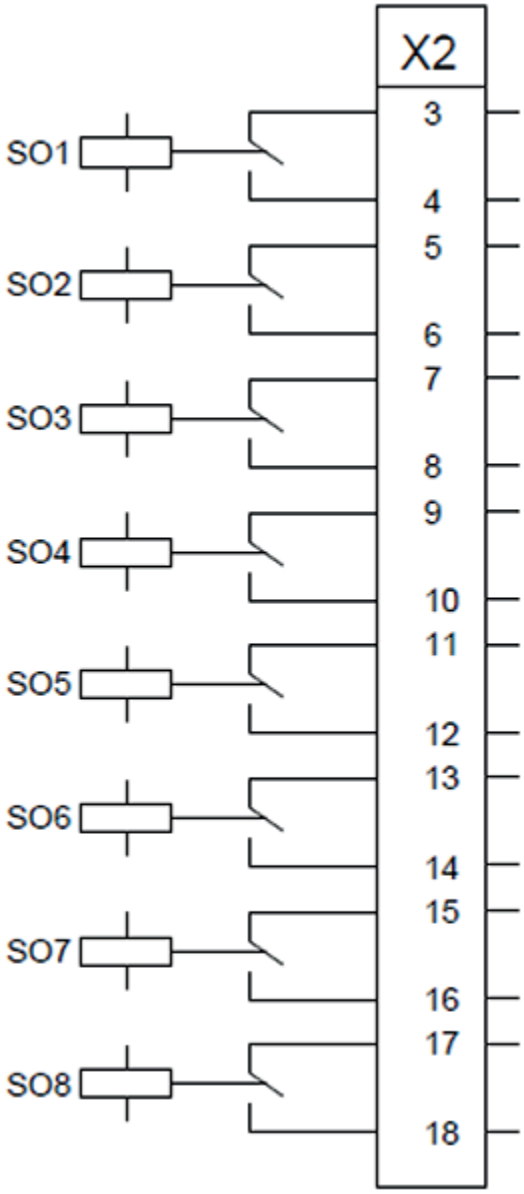



*Figure 63: Signal outputs in BIO1001 and BIO1003 modules*

### 3.14.2.1 Internal fault signal output IRF

The internal fault signal output (change-over/form C) IRF is a single contact included in the power supply module of the protection relay in slot G.

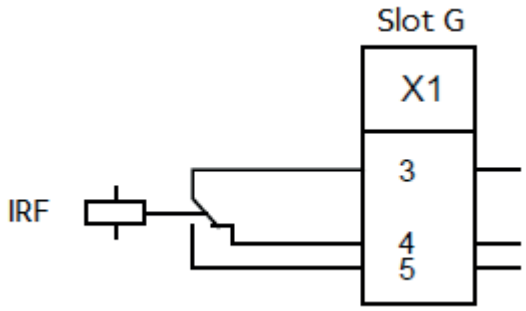



*Figure 64: Internal fault signal output IRF*

# 3.15 RTD/mA inputs/mA outputs

## 3.15.1 Function blocks

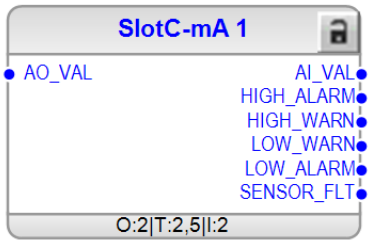



*Figure 65: Function block for mA channel*

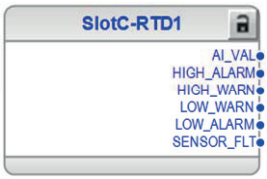



*Figure 66: Function block for RTD channel*

## 3.15.2 Functionality

The Slot#-mA#/RTD# function is an interface function between the relay's mA/RTD hardware channels. The function is split into separate function blocks for each hardware channel.

The mA function block works as an interface for the mA current channel. The channel can be defined either as a measuring input or a controllable output.

The RTD function block works as an interface for the RTD measuring channel that supports various types of RTD sensors.

Both function blocks have limit supervision alarm outputs and an output for sensor fault.

## 3.15.3 Operation principle

The operation of Slot#-mA#/RTD# can be described with a module diagram that illustrates a single input-output combination of the actual function block. All the modules in the diagram are explained in the next sections.

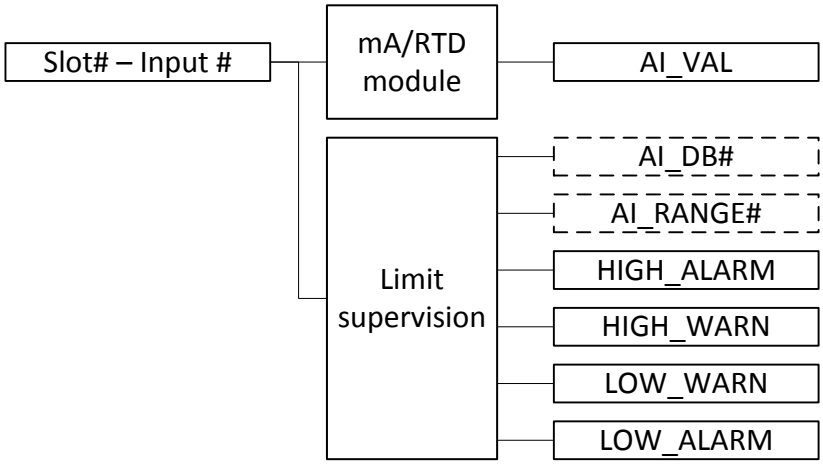



*Figure 67: Functional module diagram for input mode*

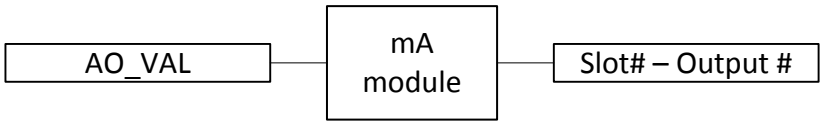



*Figure 68: Functional module diagram for output mode*

**mA modules**

mA current channels are used for input current measurement or output current control in the range of -20…20 mA (DC current). The channels are configured for particular input or output signal types by using channel-specific settings. When Input 1 is activated with setting "-20…20mA", the Output 1 mode is blocked. If Output 2 mode is activated with setting "-20…20mA", the Input 2 mode is blocked. When a channel is configured as an output, the alarm outputs are deactivated.

**RTD modules**

RTD channels are used for resistance measurements and they are only input channels. The inputs are configured for a particular input signal type by using the channel-specific *Input mode* setting. The default mode for each channel is "Not in use" which means that the channel is not sampled and the output value quality is set accordingly.

All the channels are independent mA/RTD channels with separated protection, filtering, reference, A/D-conversion and isolation. Thus, the RTD group is isolated from mA channels.

The RTD inputs measure resistance in the range of 0...4000 Ω. All inputs are calibrated and the calibration factors are stored on the module in nonvolatile memory. The calibration circuitry monitors the RTD channels continuously and reports the circuitry break of any channel.

The RTD inputs have separate setting values for value update interval. The settings are: "No delay", "10 ms delay", "50 ms delay" and "100 ms delay". Between the update intervals the RTD input constantly returns the last valid value before updating to the new value after the interval time expires.

### 3.15.3.1 Input mode

**Table 100: Analog input modes for the mA inputs**

| Input mode | Description |
|---|---|
| Not in use | Default selection when the corresponding input is not used. |
| –20...20 mA | The analog input covers the range of –20...20 mA. The input can be used in a narrower range by setting *Input minimum* and *Input maximum*. Settings *Value minimum* and *Value maximum* are used to scale the output within the appropriate range. The output unit is selected with the set *Value unit*. |

**Table 101: Analog input modes for the RTD inputs**

| Input mode | Description |
|---|---|
| Not in use | Default selection when the corresponding input is not used. |
| Resistance | Freely settable resistance input. *Input minimum* and *Input maximum* define the resistive input range. The corresponding output can be scaled based on *Value minimum* and *Value maximum*. The output unit is selected with the set *Value unit*. |
| Pt 100 | The input is expected to be the selected temperature sensor. The set *Value unit* should be set to degrees Celsius. The expected input range is –40...200°C. However, the output can be scaled to a narrower output range by setting *Value minimum* and *Value maximum*. |
| Pt 250 | |
| Ni 100 | |
| Ni 120 | |
| Ni 250 | |

**Selection of value unit format**

Each input has an independent *Value unit* setting that is used to select the unit for the channel value representation. The default value for the *Value unit* setting is "Dimensionless". The *Input minimum*, *Input maximum*, *Value maximum* and *Value minimum* settings have to be adjusted according to the input channel and if *Value unit* is changed.

When the RTD channel input is used for the temperature sensor type, the *Value unit* setting needs to be changed to "Degrees Celsius". When *Value unit* is set to "Degrees Celsius", linear scaling is not applied but the default range (–40…200°C) can be decreased with the *Value maximum* and *Value minimum* settings.

When the DC milliampere signal is connected to the mA channel and the application requires a linear scaling of the input range, the *Value unit* setting value has to be set to "Dimensionless" so that the input range can be linearly scaled with the settings Input minimum and Input maximum to *Value minimum* and *Value maximum*. When milliampere is used as a value unit, *Value unit* has to be "Ampere". When *Value unit* is set to "Ampere", the default range (–20…20 mA) can be decreased with the *Value maximum* and *Value minimum* settings.

When a resistance type signal is connected to the RTD channel and the application requires a linear scaling of the input range, the *Value unit* setting value has to be set to "Dimensionless" so that the input range can be linearly scaled with the settings *Input minimum* and *Input maximum* to *Value minimum* and *Value maximum*. When resistance is used as a value unit, *Value unit* has to be "Ohm". When *Value unit* is set to "Ohm", the default range (0...4000 Ω) can be decreased with the *Value maximum* and *Value minimum* settings.

### RTD temperature vs. resistance

The resistance values of temperature sensors at specified temperatures are given in *Table 102*.

**Table 102: Temperature vs. resistance**

| Temp °C | Platinum TCR 0.00385 | | Nickel TCR 0.00618 | | |
|---|---|---|---|---|---|
| | Pt 100 | Pt 250 | Ni 100 | Ni 120 | Ni 250 |
| –40 | 84.28 | 210.70 | 79.13 | 94.96 | 197.83 |
| –30 | 88.22 | 220.56 | 84.15 | 100.97 | 210.36 |
| –20 | 92.16 | 230.40 | 89.30 | 107.16 | 223.24 |
| –10 | 96.09 | 240.21 | 94.58 | 113.50 | 236.45 |
| 0 | 100.00 | 250.00 | 100.00 | 120.00 | 250.00 |
| 10 | 103.90 | 259.76 | 105.55 | 126.66 | 263.88 |
| 20 | 107.79 | 269.48 | 111.24 | 133.48 | 278.09 |
| 30 | 111.67 | 279.18 | 117.06 | 140.47 | 292.64 |
| 40 | 115.54 | 288.85 | 123.01 | 147.61 | 307.53 |
| 50 | 119.40 | 298.49 | 129.11 | 154.93 | 322.76 |
| 60 | 123.24 | 308.10 | 135.34 | 162.41 | 338.35 |
| 70 | 127.08 | 317.69 | 141.72 | 170.06 | 354.30 |
| 80 | 130.90 | 327.24 | 148.25 | 177.90 | 370.63 |
| 90 | 134.71 | 336.77 | 154.93 | 185.92 | 387.34 |
| 100 | 138.51 | 346.26 | 161.78 | 194.13 | 404.45 |
| 110 | 142.29 | 355.73 | 168.79 | 202.55 | 421.97 |
| 120 | 146.07 | 365.17 | 175.97 | 211.17 | 439.93 |
| 130 | 149.83 | 374.58 | 183.33 | 220.00 | 458.34 |
| 140 | 153.58 | 383.96 | 190.89 | 229.06 | 477.22 |
| 150 | 157.33 | 393.31 | 198.63 | 238.36 | 496.59 |
| 160 | 161.05 | 402.64 | 206.59 | 247.91 | 516.47 |
| 170 | 164.77 | 411.93 | 214.76 | 257.71 | 536.89 |
| 180 | 168.48 | 421.20 | 223.15 | 267.78 | 557.88 |
| 190 | 172.17 | 430.43 | 231.78 | 278.14 | 579.46 |
| 200 | 175.86 | 439.64 | 240.66 | 288.79 | 601.65 |

#### Self-supervision

Each input contains functionality to monitor the input measurement chain. The circuitry monitors the RTD channels continuously and reports a circuitry break of any enabled input channel. If the measured input value is outside the limits, the minimum/maximum value is shown in the corresponding output. The quality of the corresponding output is set accordingly, and the fault is reported at SENSOR_FLT to indicate misbehavior in the mA/RTD input.

**Table 103: Limits for the mA/RTD inputs**

| mA/RTD input | Limit value |
|---|---|
| RTD temperature, high | > 200°C |
| RTD temperature, low | < –40°C |
| mA current, high | > 24 mA |
| mA current, low | < –24 mA |
| Resistance, high | > 4000 Ω |
| Resistance, low | Not defined [1] |

When necessary, the valid measuring range may be narrower than the default of the selected measuring range. A narrower range can be defined with the *Value minimum* and *Value maximum* settings.

#### RTD input supervision

RTD sensor currents are measured continuously at a fixed rate. The delay between the RTD current/connectivity checks is about 10s at a maximum (if all 10 RTD channels are active). If the RTD current is not within ±5% of the expected current, the measurement is considered to be invalid, and the channel is discarded until a valid current is obtained.

The expected currents are 1 mA for RTD sensors and 0.21 mA for pure resistance. While the quality of the invalid input is set accordingly, a warning is also provided on the **Relay Status** page of LHMI/WHMI. The invalid signal is deactivated as soon as the corresponding input signal is within the valid range.

Delay for SENSOR_FLT activation depends on the connected sensor type, amount of connected channels and RTD module type. The maximum delay is 10 seconds.

#### mA input supervision

The current limit for mA input supervision is defined by parameter *Sensor fault level*. Value must be below *Input minimum* parameter. SENSOR_FLT is activated, and measurement quality is set bad when measured current is below set limit. The supervision is disabled if *Sensor fault level* is set to 0 mA.

### 3.15.3.2 Output mode

A measurement value from another function, mA input or RTD input can be represented by the mA output. The mA output scaling principle is otherwise similar

[1] Low limit is not defined for the resistance input. In practice the low limit is 0 because the resistance cannot be negative.

to the input scaling but there is also a possibility to use up to four different knee points. To be able to cover a wide range of input units, the input settings used for scaling are dimensionless. The output range of the mA output is selected with parameters *Value maximum* and *Value minimum* and the selected number of knee points with parameter *Num of knee points*. Depending on the amount of *Num of knee points*, the knee point settings *Input knee point 1-4* and *Value knee point 1-4* are visible.

**Table 104: Analog output modes for the mA outputs**

| Output mode | Description |
|---|---|
| Not in use | Default selection when the corresponding output is not used. |
| –20...20 mA | Analog output can operate in the range of –20...20 mA.<br>The output can be used in a narrower range by setting *Value minimum* and *Value maximum*. |

## 3.15.4 Application

The general function block can be used in REX640 relays that are equipped with an RTD/analog module.

The function can be applied to various applications, for example, to measure temperature, pressure or flow.

### 3.15.4.1 Input scaling

Each mA/RTD input can be scaled linearly by constructing a separate scaling curve for each input. The curve consists of two points where the x-axis of the curve illustrates a range selected for the input and the y-axis is the scaled absolute value of the input. The input scaling is enabled only when mA or resistance input is used.

When the scaling is enabled, the settings *Value maximum* and *Value minimum* affect the scaled range. The range of the scaled input is defined with the settings *Input minimum* and *Input maximum*.

#### Scaling example 1

The function is used with a Pt100 temperature sensor. Predefined scaling can be selected when *Input mode* is set to "Pt100".

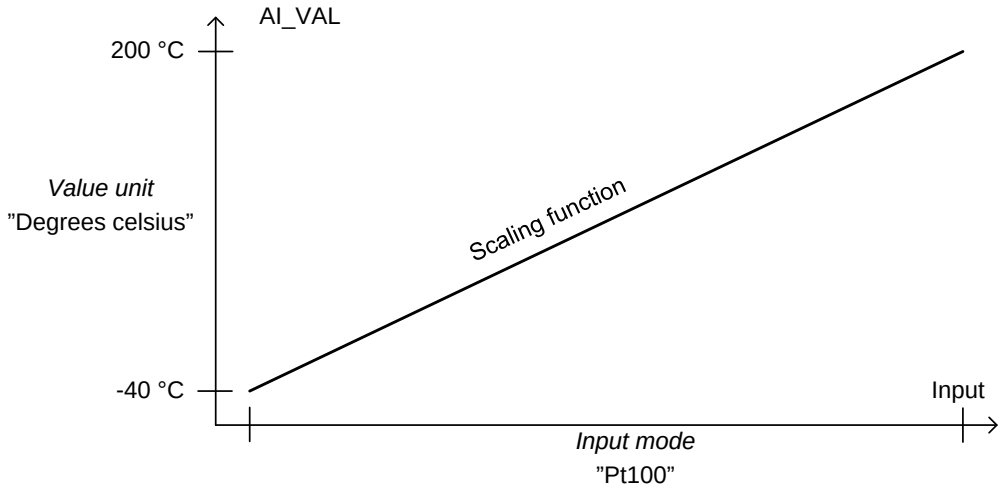



*Figure 69: Pt100 scaling function*

**Scaling example 2**

*Input mode* is set to –20...20 mA that is used for tap position information fed from the tap changer. The tap positions are between –36...36. Thus, the scaling setting *Value minimum* is set to "–36" and *Value maximum* is set to "36". These settings apply the input scaling to the output. In the tap position case, the *Value unit* should be set to "Dimensionless".

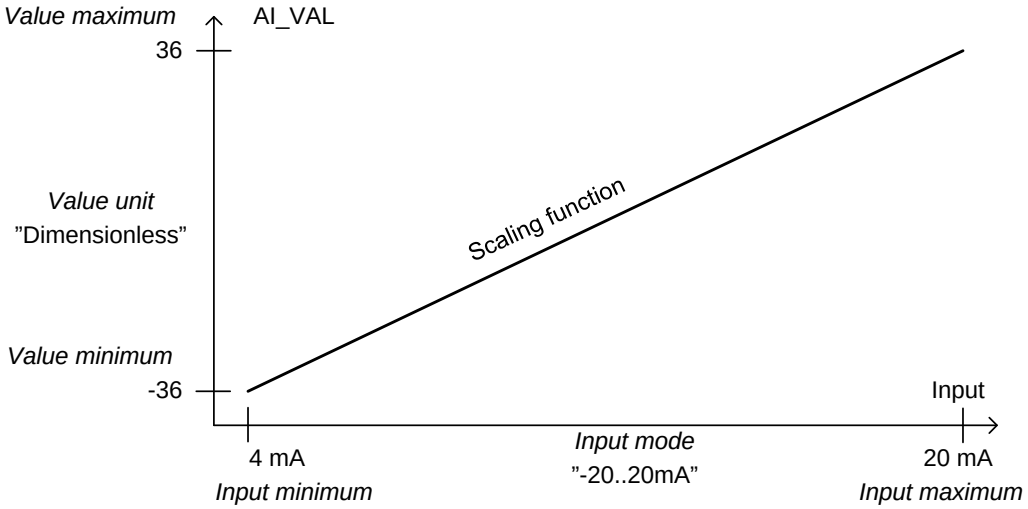



*Figure 70: Tap changer position from mA input*

**Scaling example 3**

When *Input mode* is set to "Resistance", the output can be scaled as desired. For example, the desired function output is a ratio in a function of resistance. If the input resistance varies between 100...1600 ohms, *Input minimum* is set to "100" and *Input maximum* is set to "1600". As the wanted output should be in percents, the setting *Value unit* is set to "Dimensionless". When *Input mode* is set to "Resistance", output scaling is enabled. Thus, *Value minimum* is set to "0" and *Value maximum* is set to "100". These settings allow the input values to be scaled as a ratio of the resistance range.

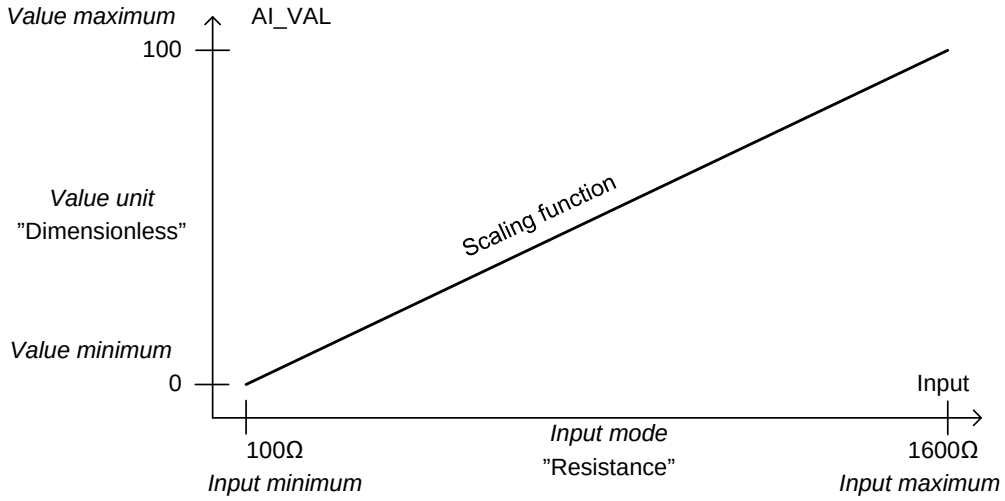



*Figure 71: Output as a ratio of the resistance range*

The output scaling function:

$$k = \frac{Input\ maximum - Input\ minimum}{Value\ maximum - Value\ minimum}$$

(Equation 4)

$$f = -k \cdot Value\ minimum + Input\ minimum$$

(Equation 5)

$$AI_VAL = \frac{Input - f}{k}$$

(Equation 6)

### 3.15.4.2 Limit value supervision

All the measurement inputs have individual limit supervision modules that operate similarly as in the measurement functions. The measured values are compared against their set value limits. The limit supervision outputs are `HIGH_ALARM`, `HIGH_WARN`, `LOW_WARN` and `LOW_ALARM`.

When an output is scaled, *Value maximum* and *Value minimum* are the range limits to which the output value is limited or scaled. Hysteresis is added to the range limit values so that the output value is allowed to slightly exceed or go below the limit value before being treated as out of range.

The pre-defined hysteresis values are set based on the set *Value unit*.

**Table 105: Pre-defined hysteresis values based on Value unit**

| Value unit | Hysteresis |
|---|---|
| Dimensionless | Based on the scaling function [1] |
| Ampere | 0.1 mA |

*Table continues on the next page*

| Value unit | Hysteresis |
|---|---|
| Degrees Celsius | 0.5°C |
| Ohm | 2 Ω |

$$Hysteresis \cdot \left| \frac{Value\ maximum - Value\ minimum}{Input\ maximum - Input\ minimum} \right|$$

(Equation 7)

**Example**

Ampere input –20…20 mA is scaled to tap position information 0...36. The actual hysteresis for limit supervision is 0.18.

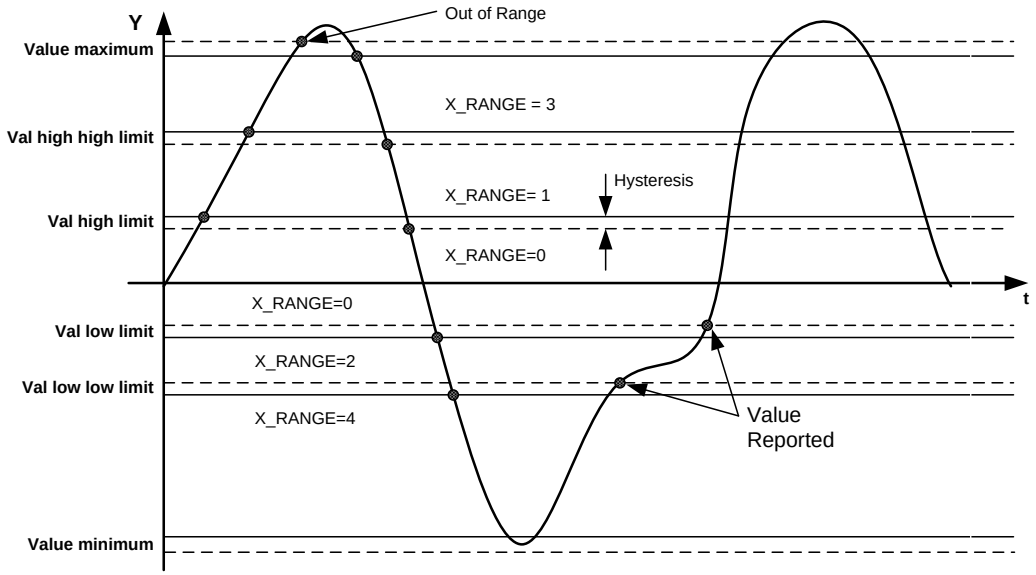



*Figure 72: Limit value supervision*

### 3.15.4.3 Deadband supervision

This is the same functionality as in measurement functions.

### 3.15.4.4 Output scaling

The mA outputs are scaled linearly by constructing linear scaling curves for each output.

*Value maximum* and *Value minimum* affect the scaled output range. The range of the scaled input is defined with the settings *Input minimum* and *Input maximum*. Depending on setting *Num of knee points*, the output can be scaled with up to five

[1] When the input is scaled to the "Dimensionless" output, the additional hysteresis is added the initial table value.

linear curves. The knee points are defined by parameters *Input knee point 1-4* and *Value knee point 1-4*.

**Example 1: VMMXU1 to mA output**

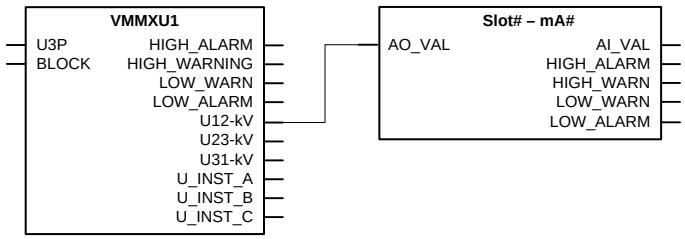



*Figure 73: Application example for VMMXU1 to mA output*

The measured phase-to-phase voltage from VMMXU is connected to AO_VAL. *Input maximum* value is set to "24" (kV) and *Input minimum* value is set to "18" (kV). The input unit is not significant as long as the value range is in the same scale. *Value maximum* is set to "20" mA and *Value minimum* to "4" mA. *Num of knee points* is set to "0".

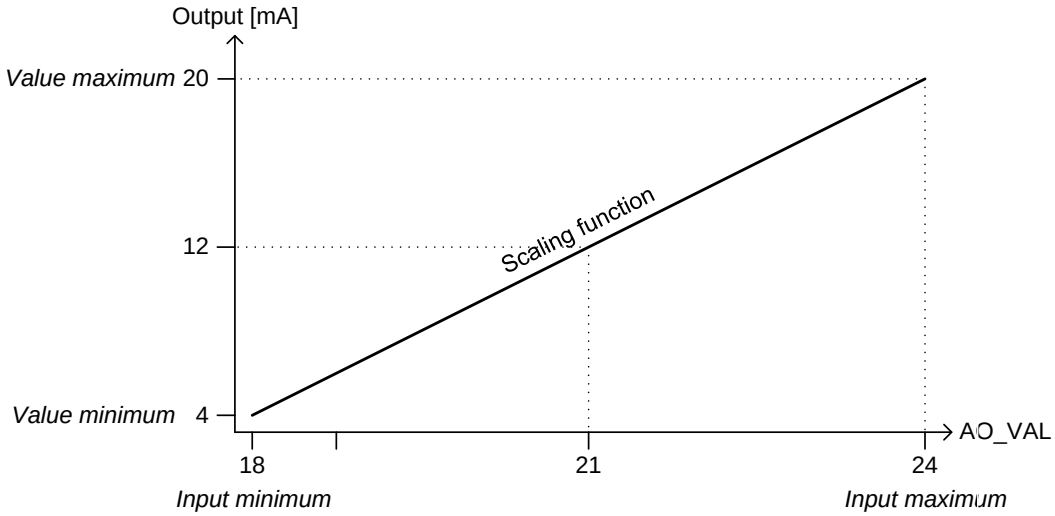



*Figure 74: Scaling of AO_VAL to mA output*

**Example 2: mA input to mA output**

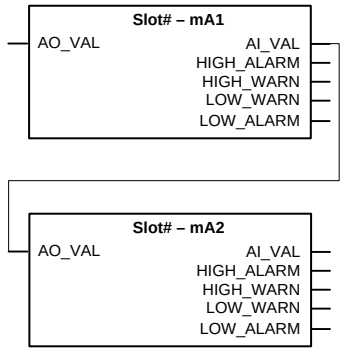



*Figure 75: Application example for mA input to mA output*

mA current is measured at channel 1. AI_VAL from measuring channel 1 is connected to AO_VAL of output channel 2. *Input maximum* is set to "20" (mA) and *Input minimum* to "–20" (mA). *Value maximum* is set to "20" mA and *Value minimum* is set to "0" mA. *Num of knee points* is set to "2".

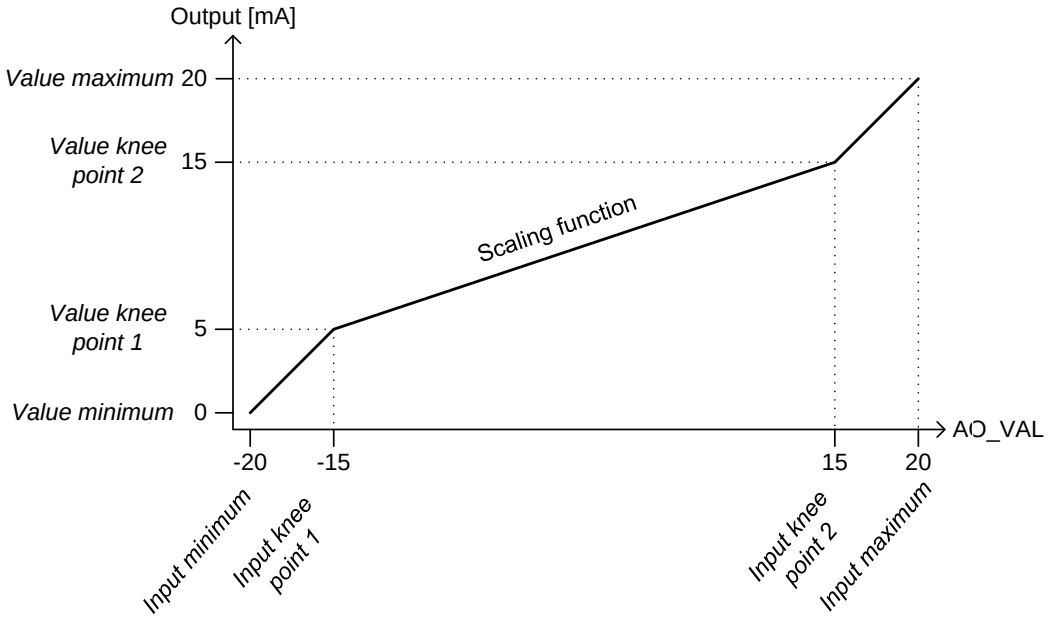



*Figure 76: Scaling of AO_VAL to mA output with two knee points*

**Example 3: RTD input to mA output**

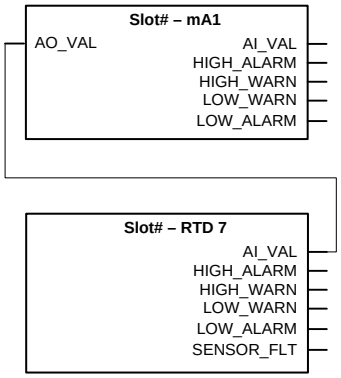



*Figure 77: Application example for RTD input to mA output*

Tap position is measured by the RTD channel 7. AI_VAL from channel 7 is connected to AO_VAL of channel 1. *Input maximum* is set to "160" (ohm) and *Input minimum* to "10" (ohm). *Value maximum* is set to "20" mA and *Value minimum* is set to "4" mA. *Num of knee points* is set to "4".

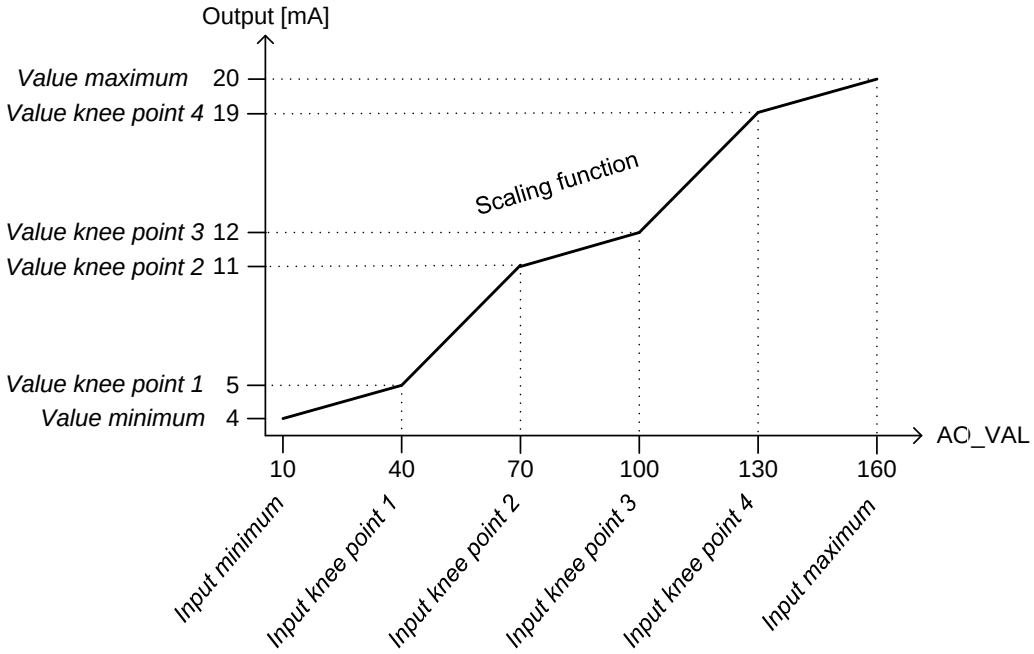



*Figure 78: Scaling of AO_VAL to mA output with four knee points*

Incorrect knee point values against the minimum and maximum values and a too narrow interval between the knee point values can cause inaccuracy to the output scaling function. Use increasing linearity and a value interval >1.0 for most accurate results.

## 3.15.5 RTD/mA input/mA output connection

RTD inputs can be used with a 2-wire or 3-wire connection with common ground. When using the 3-wire connection, it is important that all three wires connecting the sensor are symmetrical, that is, the wires are of the same type and length. Thus the wire resistance is automatically compensated.

### RTD/mA card variants

The available variants of RTD cards are 10RTD/2mA and 3RTD/6mA. The features are similar in both cards.

10RTD/2mA card

This card accepts two milliampere inputs and ten inputs from the RTD sensors. The inputs 1 and 2 are used for current measurement, whereas inputs from 3 to 12 are used for resistance type of measurements.

3RTD/6mA card

This card accepts six milliampere inputs and three inputs from the RTD sensors. The inputs from 1 to 6 are used for current measurement, whereas inputs from 7 to 9 are used for resistance type of measurements.

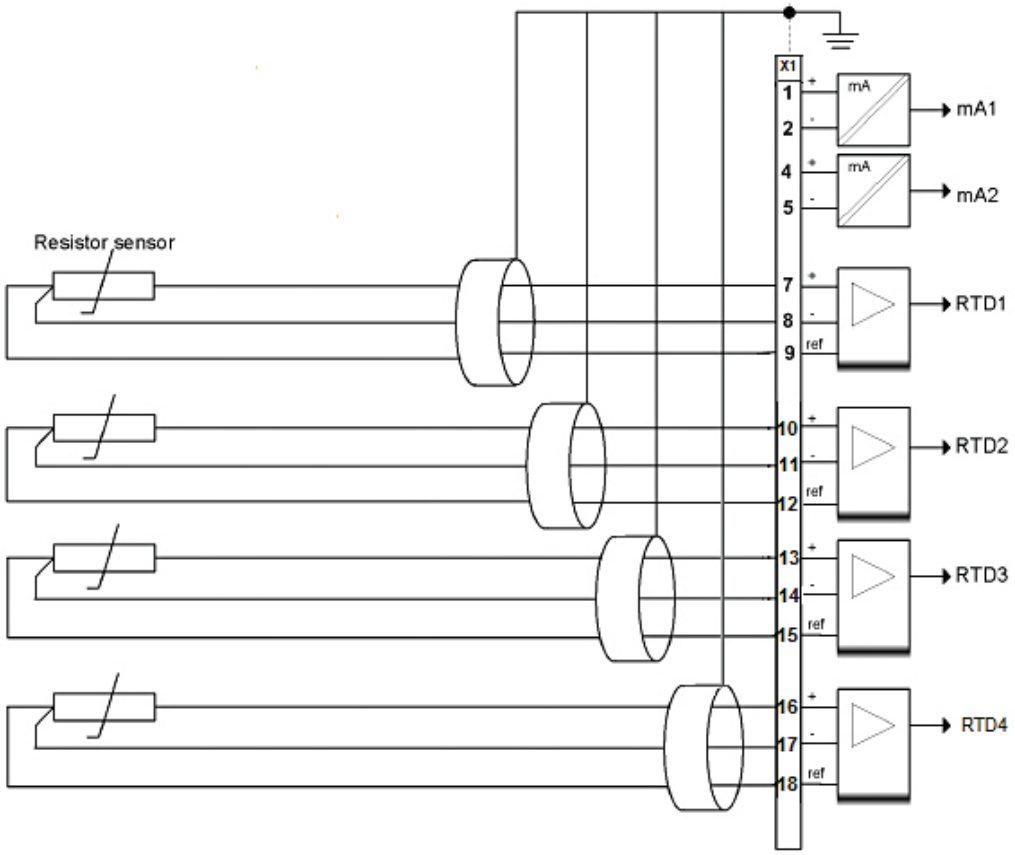



*Figure 79: Four RTD/resistance sensors connected according to the 3-wire connection for 10RTD/2mA card*

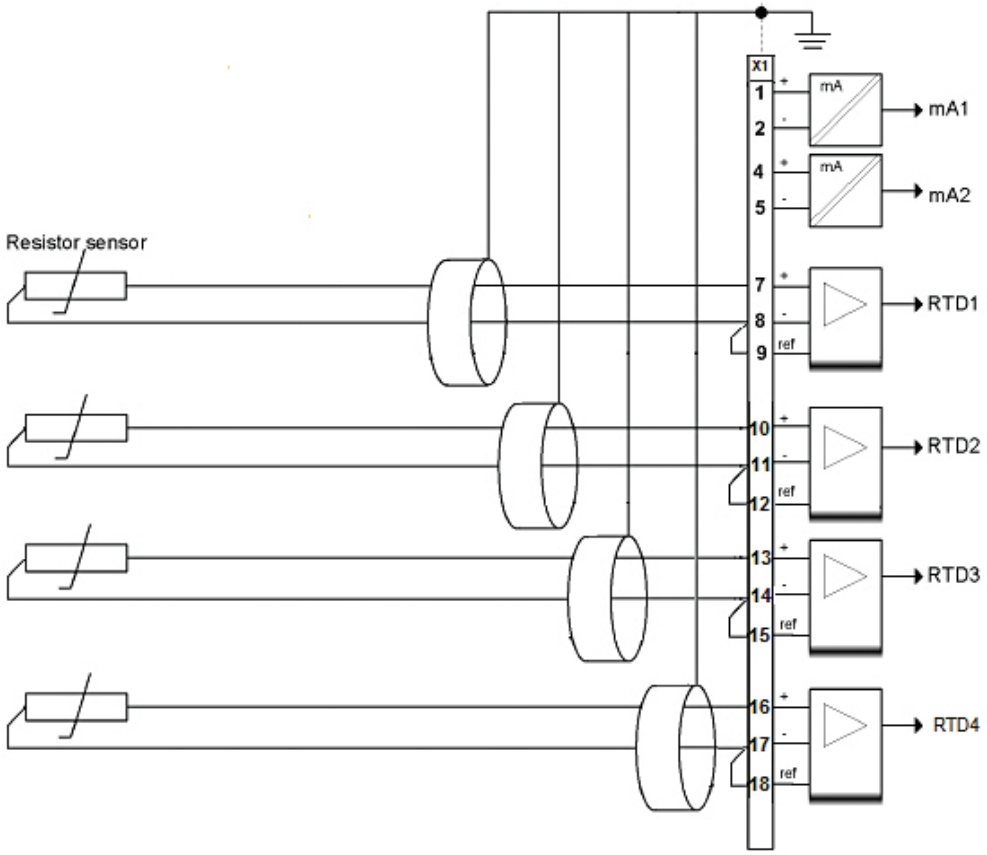



*Figure 80: Four RTD/resistance sensors connected according to the 2-wire connection for 10RTD/2mA card*

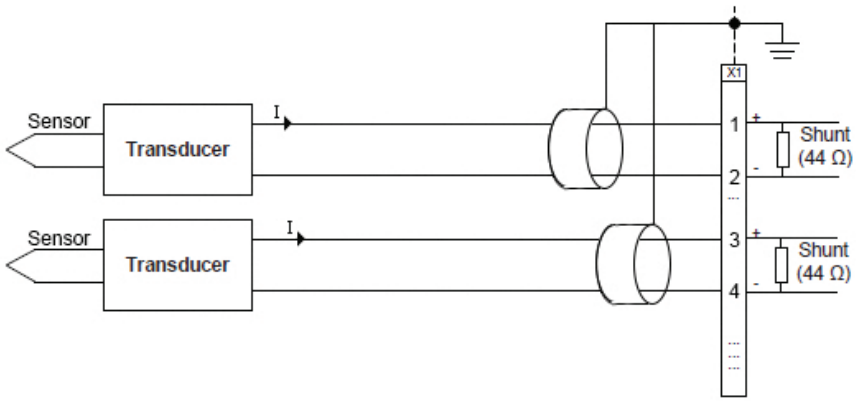



*Figure 81: mA channels working as mA inputs*

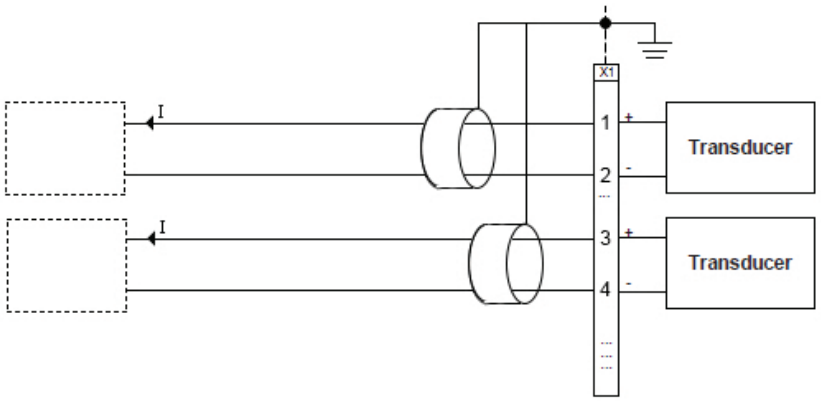



*Figure 82: mA channels working as mA outputs*

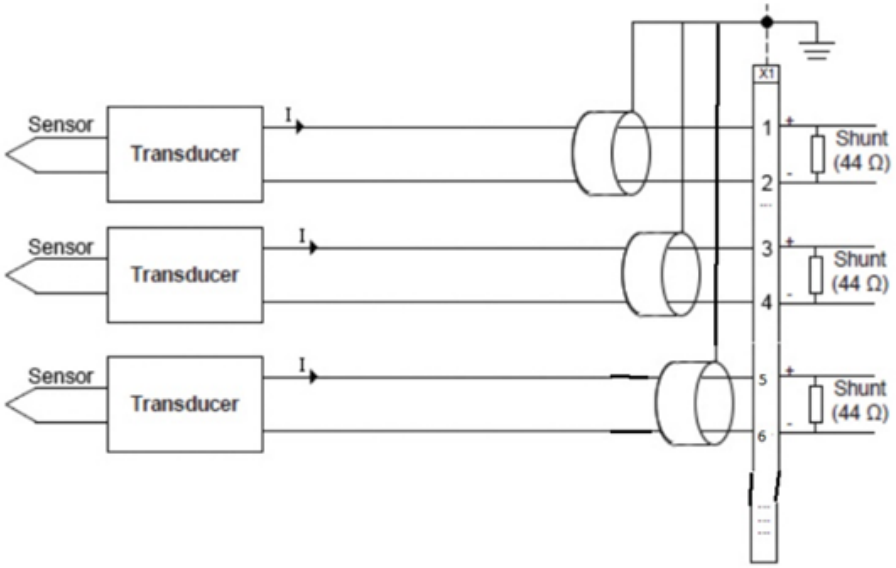



*Figure 83: mA channels working as mA inputs*

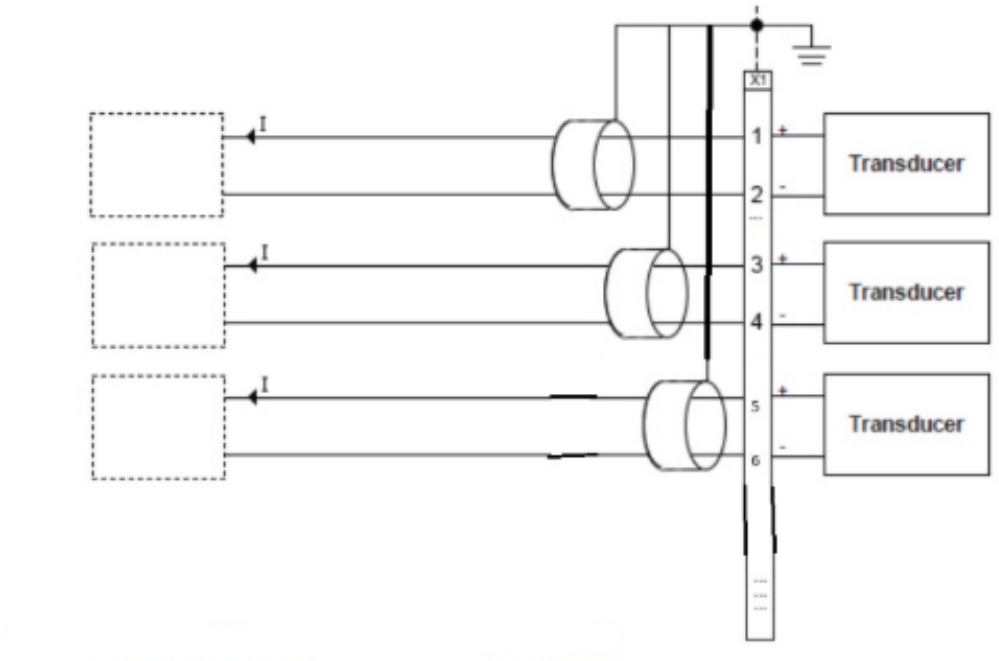



*Figure 84: mA channels working as mA outputs*

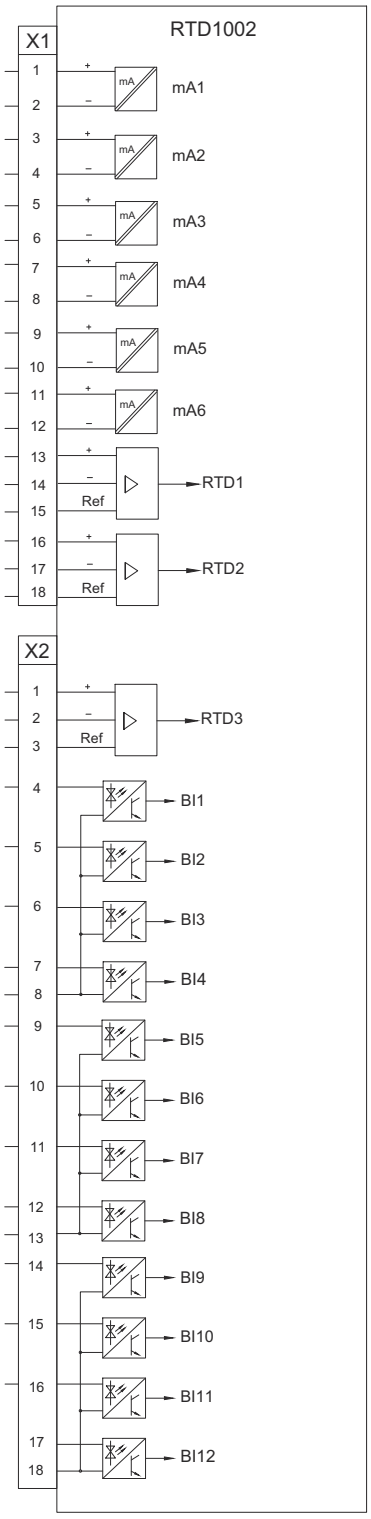



*Figure 85: RTD1002 module*

## 3.15.6 Signals

**Table 106: mA Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| AO_VAL | FLOAT32 | 0 | mA output, instantaneous value |

**Table 107: mA Output signals**

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | mA input, instantaneous value |

**Table 108: RTD Output signals**

| Name | Type | Description |
|---|---|---|
| AI_VAL | FLOAT32 | RTD input, instantaneous value |
| SENSOR_FLT | BOOLEAN | Sensor fault |

**Table 109: Common outputs for each function block**

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | General high alarm |
| HIGH_WARN | BOOLEAN | General high warning |
| LOW_WARN | BOOLEAN | General low warning |
| LOW_ALARM | BOOLEAN | General low alarm |

## 3.15.7 Settings

**Table 110: Input-specific settings for mA**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Input mode | 1=Not in use<br>5=0..20mA | | | 1=Not in use | Analogue input mode |
| Input maximum | –20...20 | mA | | | Maximum analogue input value for mA or resistance scaling |
| Input minimum | –20...20 | mA | | | Minimum analogue input value for mA or resistance scaling |
| Value unit | 1=Dimensionless<br>5=Ampere<br>23=Degrees celsius<br>30=Ohm | | | 1=Dimensionless | Selected unit for output value format |
| Value maximum | –10000.0...10000.0 | | | 10000 | Maximum output value for scaling and supervision |
| Value minimum | –10000.0...10000.0 | | | –10000 | Minimum output value for scaling and supervision |
| Val high high limit | –10000.0...10000.0 | | | 10000 | Output value high alarm limit for supervision |
| Value high limit | –10000.0...10000.0 | | | 10000 | Output value high warning limit for supervision |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Value low limit | –10000.0...10000.0 | | | –10000 | Output value low warning limit for supervision |
| Value low low limit | –10000.0...10000.0 | | | –10000 | Output value low alarm limit for supervision |
| Value deadband | 100...100000 | | | 1000 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |
| Sensor fault level | 0…3 | mA | | 0 | Below this current level sensor fault is activated |

**Table 111: Input-specific settings for RTD**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Input mode | 1=Not in use<br>2=Resistance<br>10=Pt100<br>11=Pt250<br>20=Ni100<br>21=Ni120<br>22=Ni250<br>30=Cu10 | | | 1=Not in use | Analogue input mode |
| Input maximum | 0...4000 | Ω | | | Maximum analogue input value for mA or resistance scaling |
| Input minimum | 0...4000 | Ω | | | Minimum analogue input value for mA or resistance scaling |
| Value unit | 1=Dimensionless<br>5=Ampere<br>23=Degrees celsius<br>30=Ohm | | | 1=Dimensionless | Selected unit for output value format |
| Value maximum | –10000.0...10000.0 | | | 10000 | Maximum output value for scaling and supervision |
| Value minimum | –10000.0...10000.0 | | | –10000 | Minimum output value for scaling and supervision |
| Val high high limit | –10000.0...10000.0 | | | 10000 | Output value high alarm limit for supervision |
| Value high limit | –10000.0...10000.0 | | | 10000 | Output value high warning limit for supervision |
| Value low limit | –10000.0...10000.0 | | | –10000 | Output value low warning limit for supervision |
| Value low low limit | –10000.0...10000.0 | | | –10000 | Output value low alarm limit for supervision |
| Value deadband | 100...100000 | | | 1000 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |
| Update interval | 0=No delay<br>1=10 ms<br>2=50 ms<br>3=100 ms | | | 0 | Value update interval |

**Table 112: Output-specific settings for mA**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Output mode | 1=Not in use | | | 1=Not in use | Analog output mode |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 6=0...20mA | | | | |
| Num of knee points | 0...4 | | | 0 | Number of knee points in scaling |
| Input maximum | –10000.0...10000.0 | | | 10000.0 | Maximum analog input value for mA scaling |
| Input knee point 4 | –10000.0...10000.0 | | | 0.0 | Input knee point value 4 for scaling |
| Input knee point 3 | –10000.0...10000.0 | | | 0.0 | Input knee point value 3 for scaling |
| Input knee point 2 | –10000.0...10000.0 | | | 0.0 | Input knee point value 2 for scaling |
| Input knee point 1 | –10000.0...10000.0 | | | 0.0 | Input knee point value 1 for scaling |
| Input minimum | –10000.0...10000.0 | | | –10000.0 | Minimum analog input value for mA scaling |
| Value maximum | –20.0...20.0 | mA | | 20 | Maximum analog output value for mA output |
| Value knee point 4 | –20.0...20.0 | mA | | 0 | Knee point value 4 for output scaling |
| Value knee point 3 | –20.0...20.0 | mA | | 0 | Knee point value 3 for output scaling |
| Value knee point 2 | –20.0...20.0 | mA | | 0 | Knee point value 2 for output scaling |
| Value knee point 1 | –20.0...20.0 | mA | | 0 | Knee point value 1 for output scaling |
| Value minimum | –20.0...20.0 | mA | | –20 | Minimum analog output value for mA output |

### 3.15.8 Monitored data

**Table 113: mA Monitored data**

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | mA input, range |
| AI_DB | FLOAT32 | | | mA input, reported value |

**Table 114: RTD Monitored data**

| IEC name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| AI_RANGE | Enum | | | RTD input, range |
| AI_DB | FLOAT32 | | | RTD input, reported value |

## 3.16 SMV function blocks

SMV function blocks are used in the process bus applications with the IEC 61850-9-2 LE protocol. Function blocks represent the sending of the sampled measured values of analog currents and voltages and the receiving of the sampled values of analog currents and voltages.

## 3.16.1 SMV stream sender (IEC 61850-9-2LE) SMVSENDER

### 3.16.1.1 Function block

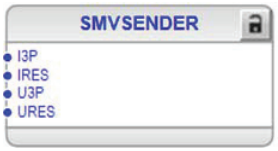



*Figure 86: Function block*

### 3.16.1.2 Functionality

The SMV stream sender (IEC 61850-9-2LE) function SMVSENDER is used for activating the SMV sending functionality. It adds/removes the sampled value control block and the related data set into/from the sending device's configuration. It has only input signals.

SMVSENDER can be disabled with the *Operation* setting value “off”. Toggling SMVSENDER “on” or “off” can be done from the LHMI. When disabled, the sending of the sample values is disabled.

### 3.16.1.3 Settings

**Table 115: SMVSENDER Settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation |

## 3.16.2 SMV stream receiver (IEC 61850-9-2LE) SMVRCV

### 3.16.2.1 Function block

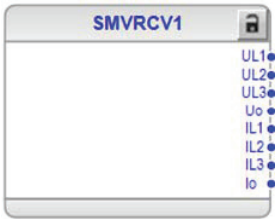



*Figure 87: Function block*

### 3.16.2.2 Functionality

The SMV stream receiver (IEC 61850-9-2LE) function SMVRCV is used for connecting SMV channels to the application.

### 3.16.2.3 Signals

**Table 116: SMVRCV Output signals**

| Name | Type | Description |
|---|---|---|
| UL1 | INT32-UL1 | IEC61850-9-2 phase 1 voltage |
| UL2 | INT32-UL2 | IEC61850-9-2 phase 2 voltage |
| UL3 | INT32-UL3 | IEC61850-9-2 phase 3 voltage |
| U0 | INT32-Uo | IEC61850-9-2 residual voltage |
| IL1 | INT32-IL1 | IEC61850-9-2 phase 1 current |
| IL2 | INT32-IL2 | IEC61850-9-2 phase 2 current |
| IL3 | INT32-IL3 | IEC61850-9-2 phase 3 current |
| I0 | INT32-I0 | IEC61850-9-2 residual current |

# 3.17 Preprocessing blocks

## 3.17.1 Phase current preprocessing ILTCTR

### 3.17.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Phase current preprocessing | ILTCTR | ILTCTR | ILTCTR |

### 3.17.1.2 Function block

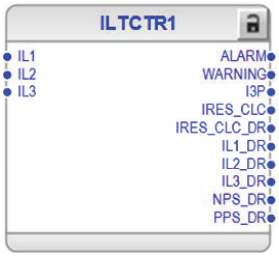



*Figure 88: Function block*

### 3.17.1.3 Functionality

The phase current preprocessing function ILTCTR is used for setting up the three phase current measurement channels. The input channels for ILTCTR are either physical hardware or IEC 61850-9-2 sampled value channels. The output `I3P` channel of ILTCTR can be connected to different applications which require 3 phase current and positive- and negative-sequence current. The output `IRES_CLC` can be connected to functions using the calculated residual current.

The current transducer selection can be made by setting *Current input type* to "Current trafo" for conventional CT or to "Current sensor" for current sensor type.

The sensor's or the CT's primary rated current can be set using *Primary current* setting. The setting *Secondary current* defines the nominal current of the CT's secondary winding. This is used as a reference to scale the measurements accordingly. These settings also affect the scaling of the calculated residual current.

Current magnitude correction of an external CT can be made using settings *Amplitude Corr A*, *Amplitude Corr B* and *Amplitude Corr C*.

Current angle correction of an external CT can be made using settings *Angle Corr A*, *Angle Corr B* and *Angle Corr C*.

*Rated secondary Val* setting defines the ratio for sensor use. This value multiplied by the *Rated frequency* setting (under **Configuration** > **System**) gives the sensor's nominal voltage corresponding to the sensors' primary rated current.

*Reverse polarity* setting is used to reverse the polarity of phase CTs.

The WARNING output in the receiver is activated if the synchronization accuracy of the sender or the receiver is worse than 4 µs. The output remains on for 10 seconds after the synchronization accuracy returns within limits.

The ALARM in the receiver is activated if the synchronization accuracy of the sender or the receiver is not within tolerances. The output is held on for 10 seconds after the synchronization accuracy returns within limits. If the effect on protection is negligible, the WARNING or ALARM output is not activated.

The *SMV Max Delay* setting defines how long the receiver waits for the SMV frames before activating the ALARM output. This setting can be accessed via **Configuration** > **System**. Waiting for the SMV frames delays the local measurements of the receiver to keep them correctly time aligned. The *SMV Max Delay* values include sampling, processing and network delay.

Frequency adaptive measurements for a three-phase current can be activated with the setting *Frequency adaptivity*. Three selections are provided.

**Table 117: Frequency adaptivity setting for three-phase current measurement**

| Setting value | Description |
|---|---|
| Disable | Frequency adaptive measurements are disabled for this ILTCTR. Measurements are fixed to nominal frequency defined with **Configuration** > **System** > **Rated frequency**. |
| Enable | Frequency adaptive measurements are enabled. In this case, the estimated network frequency is defined by another preprocessing block. |
| Backup frequency source | Frequency adaptive measurements are enabled. If the main frequency source cannot determine the network frequency, the currents of the preprocessing block determine the network frequency. |

All three phases must be always connected.

ILTCTR setting *Frequency adaptivity* is visible only if the system setting **Configuration** > **System** > **Frequency adaptivity** is set to "Enable".

### 3.17.1.4 Signals

#### ILTCTR Input signals

**Table 118: ILTCTR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IL1 | SIGNAL | - | Analog input |
| IL2 | SIGNAL | - | Analog input |
| IL3 | SIGNAL | - | Analog input |

**ILTCTR Output signals**

**Table 119: ILTCTR Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm |
| WARNING | BOOLEAN | Warning |
| I3P | SIGNAL | Three-phase currents |
| IRES_CLC | SIGNAL | Residual current, calculated |
| IRES_CLC_DR | SIGNAL | Residual current, calculated, for disturbance recorder |
| IL1_DR | SIGNAL | Phase current IL1 for disturbance recorder |
| IL2_DR | SIGNAL | Phase current IL2 for disturbance recorder |
| IL3_DR | SIGNAL | Phase current IL3 for disturbance recorder |
| NPS_DR | SIGNAL | Negative sequence current for disturbance recorder |
| PPS_DR | SIGNAL | Positive sequence current for disturbance recorder |

## 3.17.1.5 Settings

**ILTCTR Settings**

**Table 120: ILTCTR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current input type | 2=Current trafo<br>4=Current sensor | | | 2=Current trafo | Type of the current input |
| Primary current | 1.0...15000.0 | A | 0.1 | 100.0 | Rated primary current |
| Secondary current | 2=1A<br>3=5A | | | 2=1A | Rated secondary current |
| Rated secondary Val | 1.000...150.000 | mV/Hz | 0.001 | 3.000 | Rated Secondary Value (RSV) ratio |
| Amplitude Corr A | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase A amplitude correction factor |
| Amplitude Corr B | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase B amplitude correction factor |
| Amplitude Corr C | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase C amplitude correction factor |
| Angle Corr A | -8.0000...8.0000 | deg | 0.0001 | 0.0000 | Phase A angle correction factor |
| Angle Corr B | -8.0000...8.0000 | deg | 0.0001 | 0.0000 | Phase B angle correction factor |
| Angle Corr C | -8.0000...8.0000 | deg | 0.0001 | 0.0000 | Phase C angle correction factor |

**Table 121: ILTCTR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reverse polarity | 0=False<br>1=True | | | 0=False | Reverse the polarity of the phase CTs |
| Frequency adaptivity | 0=Disable<br>1=Enable<br>3=Backup frequency source | | | 0=Disable | Frequency adaptivity selection |

#### 3.17.1.6 Monitored data

Monitored data is available in three locations.

- **Monitoring** > **I/O status** > **Analog inputs**
- **Monitoring** > **IED status** > **SMV traffic**
- **Monitoring** > **IED status** > **SMV accuracy**

## 3.17.2 Residual current preprocessing RESTCTR

### 3.17.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Residual current preprocessing | RESTCTR | RESTCTR | RESTCTR |

### 3.17.2.2 Function block




*Figure 89: Function block*

### 3.17.2.3 Functionality

The residual current preprocessing function RESTCTR is used for setting up the residual current measurement channels. Input channels for RESTCTR are either physical hardware or IEC 61850-9-2 sampled value channels. The output `IRES_MEAS` channel of RESTCTR can be connected to different applications which require measured residual current.

The current transducer selection can be made by setting *Current input type* to "Current trafo" for conventional CT or to "Current sensor" for current sensor type.

The residual CTs' primary rated current can be set using *Primary current* setting. The setting *Secondary current* defines the nominal current of the CT's secondary winding. This is used as a reference to scale measurements accordingly.

Residual current magnitude correction of an external CT can be made using the *Amplitude Corr* setting.

Residual current angle correction of an external CT can be made using the *Angle correction setting*.

*Rated secondary Val* (RSV) setting in combination with *Primary current* setting defines the ratio for sensor use. See *Chapter 3.12 Sensor inputs for currents and voltages* in this manual for further details.

*Rated secondary Val* should be set to same value in all RESTCTR instances which are configured to sensor measurement.

The *Reverse polarity* setting is used to reverse the polarity of the residual CT.

The WARNING output in the receiver is activated if the synchronization accuracy of the sender or the receiver is worse than 4 µs. The output is held on for 10 seconds after the synchronization accuracy returns within limits.

The ALARM in the receiver is activated if the synchronization accuracy of the sender or the receiver is not within tolerances. The output is held on for 10 seconds after the synchronization accuracy returns within limits. If the effect on protection is negligible, the WARNING or ALARM outputs are not activated.

The *SMV Max Delay* setting defines how long the receiver waits for the SMV frames before activating the ALARM output. This setting can be accessed via **Configuration** > **System**. Waiting for the SMV frames also delays the local measurements of the receiver to keep them correctly time aligned. The *SMV Max Delay* values include sampling, processing and network delay.

Frequency adaptive measurements for residual current can be activated with the setting *Frequency adaptivity*. Two selections are provided.

**Table 122: Frequency adaptivity setting for residual current measurement**

| Setting value | Description |
|---|---|
| Disable | Frequency adaptive measurements are disabled for this RESTCTR. Measurements are fixed to nominal frequency defined with **Configuration** > **System** > **Rated frequency**. |
| Enable | Frequency adaptive measurements are enabled. In this case, the estimated network frequency is defined by another preprocessing block. |

RESTCTR setting *Frequency adaptivity* is visible only if system setting **Configuration** > **System** > **Frequency adaptivity** is set to "Enable".

### 3.17.2.4 Signals

#### RESTCTR Input signals

**Table 123: RESTCTR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |

**RESTCTR Output signals**

**Table 124: RESTCTR Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm |
| WARNING | BOOLEAN | Warning |
| IRES_MEAS | SIGNAL | Residual current, measured |
| IRES_MEAS_DR | SIGNAL | Residual current, measured, for disturbance recorder |

### 3.17.2.5 Settings

**RESTCTR Settings**

**Table 125: RESTCTR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current input type | 2=Current trafo<br>4=Current sensor | | | 2=Current trafo | Type of the current input |
| Primary current | 1.0...15000.0 | A | 0.1 | 100.0 | Primary current |
| Secondary current | 1=0.2A<br>2=1A<br>3=5A | | | 2=1A | Secondary current |
| Rated secondary Val | 1.000...150.000 | mV/Hz | 0.001 | 3.000 | Rated Secondary Value (RSV) ratio |
| Amplitude Corr | 0.9000...1.1000 | | 0.0001 | 1.0000 | Amplitude correction |
| Angle correction | -8.0000...8.0000 | deg | 0.0001 | 0.0000 | Angle correction factor |

**Table 126: RESTCTR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reverse polarity | 0=False<br>1=True | | | 0=False | Reverse the polarity of the residual CT |
| Frequency adaptivity | 0=Disable<br>1=Enable | | | 0=Disable | Frequency adaptivity selection |

### 3.17.2.6 Monitored data

Monitored data is available in three locations.

- **Monitoring** > **I/O status** > **Analog inputs**
- **Monitoring** > **IED status** > **SMV traffic**
- **Monitoring** > **IED status** > **SMV accuracy**

## 3.17.3 Phase and residual voltage preprocessing UTVTR

### 3.17.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Phase and residual voltage preprocessing | UTVTR | UTVTR | UTVTR |

### 3.17.3.2 Function block

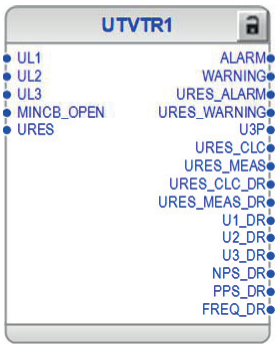



*Figure 90: Function block*

### 3.17.3.3 Functionality

The phase and residual voltage preprocessing function UTVTR is used for setting up the three phase voltage measurement channels and residual voltage measurement. The input channels for UTVTR are either physical hardware or IEC 61850-9-2 sampled value channels.

The output channel U3P of UTVTR can be connected to different applications which require phase voltage, positive and negative sequence.

Outputs URES_MEAS and URES_CLC can be connected to different applications which require measured residual voltage or calculated residual voltage (from phase voltages), respectively.

If only two phase-to-earth/phase-to-phase voltages are available, then the third phase-to-earth/phase-to-phase voltage can be calculated without URES input connected (assumed to be zero in that case). Positive- and negative-sequence components are also calculated using these voltages. The accuracy of the calculated phase-to-earth values is affected if the actual residual voltage is not zero.

If an application function requires only the frequency value, output U3P of UTVTR still needs to be connected since the frequency is calculated from the voltage.

The voltage transducer selection can be made by setting *Voltage input type* to "Voltage trafo" for conventional VT or to "Voltage sensor" for voltage sensor type.

The sensor's or the VTs' primary rated voltage can be set using *Primary voltage* setting. The setting *Secondary voltage* defines the nominal voltage of the VT's secondary winding. This is used as a reference to scale the measurements accordingly.

*Division ratio* setting defines the ratio for sensor use.

The division ratio for ABB voltage sensors is typically 10000:1. Thus, the Division ratio setting is usually set to "10000". For more information on Division ratio, see *Chapter 3.12 Sensor inputs for currents and voltages*.

The Voltage (Uo) residual voltage settings are also used for scaling the calculated residual voltage in comparison to the measured residual voltage.

The Voltage (Uo) settings must be set for output URES_MEAS and URES_CLC scaling. If the residual voltage is not connected to UTVTR, Voltage (Uo) settings must be set only for the calculated residual voltage URES_CLC scaling.

If the residual voltage is not connected to UTVTR, the **Voltage (Uo)** > **Primary voltage** cannot be set smaller than 1/√3 times **Voltage (3U)** > **Primary voltage**.

Voltage magnitude correction can be made using settings *Amplitude Corr A*, *Amplitude Corr B* and *Amplitude Corr C* for an external three-phase VT and *Amplitude Corr* setting for an external residual VT.

Voltage angle correction can be made using settings *Angle Corr A*, *Angle Corr B* and *Angle Corr C* for an external three-phase VT and *Angle correction* setting for an external residual VT.

The VT connection can be set using *VT connection*. For three phase-to-earth voltage measurements, *VT connection* can be set to "Wye", and for three phase-to-phase voltage measurements, *VT connection* can be set to "Delta".

The MINCB_OPEN input signal is connected through a relay binary input to the NC auxiliary contact of the MCB protecting the VT secondary circuit. The MINCB_OPEN signal receives information about the MCB open state. When MINCB_OPEN is active, the outputs ALARM and WARNING are activated.

The MCB open state does not affect IEC 61850-9-2 sampled value quality information.

The WARNING and URES_WARNING outputs in the receiver are activated if the synchronization accuracy of the sender or the receiver is worse than 4 µs. The outputs remain on for 10 seconds after the synchronization accuracy returns within limits.

ALARM and URES_ALARM in the receiver are activated if the synchronization accuracy of the sender or the receiver is not within tolerances. The outputs remain on for 10 seconds after the synchronization accuracy returns within limits. If the effect on protection is negligible, the WARNING, URES_WARNING, ALARM or URES_ALARM outputs are not activated.

The *SMV Max Delay* setting defines how long the receiver waits for the SMV frames before activating the ALARM and URES_ALARM outputs. This setting can be accessed via **Configuration** > **System**. Waiting for the SMV frames delays the local measurements of the receiver to keep them correctly time aligned. The *SMV Max Delay* values include sampling, processing and network delay.

Outputs WARNING and URES_WARNING are always internally active whenever outputs ALARM and URES_ALARM, respectively, are active.

The receiver activates the WARNING, URES_WARNING, ALARM and URES_ALARM outputs if any of the quality bits, except for the derived bit, is activated. When the receiver is in the test mode, it accepts SMV frames with test bit without activating the WARNING, URES_WARNING, ALARM and URES_ALARM outputs.

Frequency adaptive measurements for three-phase voltages can be activated with the setting *Frequency adaptivity*. Four selections are provided.

**Table 127: Frequency adaptivity setting for three-phase voltage measurement**

| Setting value | Description |
|---|---|
| Disable | Frequency adaptive measurements are disabled for this UTVTR. Measurements are fixed to nominal frequency defined with **Configuration** > **System** > **Rated frequency**. |
| Enable | Frequency adaptive measurements are enabled. In this case, the estimated network frequency is defined by another preprocessing block. |
| Main frequency source | Frequency adaptive measurements are enabled and other preprocessing blocks follow the network frequency defined by this preprocessing block. |
| Backup frequency source | Frequency adaptive measurements are enabled. If the main frequency source cannot determine the network frequency, the voltages of this preprocessing block determine the network frequency. |

All three phases must to be connected if the main or backup frequency source is selected.

Frequency adaptive measurements for residual voltage can be activated with the setting *Frequency adaptivity*. Two selections are provided.

**Table 128: Frequency adaptivity setting for residual voltage measurement**

| Setting value | Description |
|---|---|
| Disable | Frequency adaptive measurements are disabled for this UTVTR. Measurements are fixed to nominal frequency defined with **Configuration** > **System** > **Rated frequency**. |
| Enable | Frequency adaptive measurements are enabled. In this case, the estimated network frequency is defined by another preprocessing block. |

UTVTR setting *Frequency adaptivity* is visible only if system setting **Configuration** > **System** > **Frequency adaptivity** is set to "Enable".

### 3.17.3.4 Residual voltage scaling

Calculated $U_0$ is scaled to the same level as measured $U_0$. The scaling is determined by the ratio of ULTVTR primary voltage and RESTVTR primary voltage within one UTVTR instance. The assumption is open-delta $U_0$ measurement type.

Typical markings of an open-delta $U_0$ transformer in a 20 kV network can be: **20kV/sqrt(3) :100V/sqrt(3) :100V/3**. In case of a solid earth fault, this transformer gives 100 V output which corresponds to 11.547 kV. If ULTVTR primary voltage is set to 20 kV and RESTVTR primary voltage is set to 11.547 kV when this transformer is used, URES_CLC and URES_MEAS output equal amplitude.

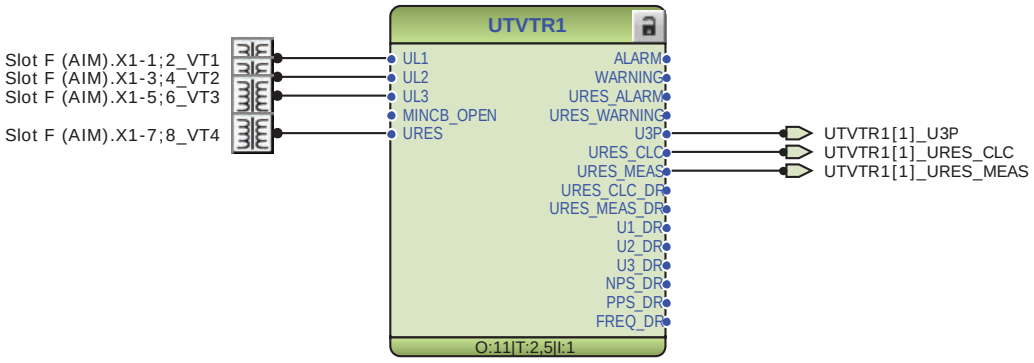



*Figure 91: UTVTR1 configured with both measured and calculated U0*

The VT connection mode must be "WYE".

In this case, ROVPTOV1 and ROVPTOV2 in *Figure 92* can both use the same $U_0$ reference level in their settings. URES_CLC and URES_MEAS in *Figure 91* are scaled to the same level.

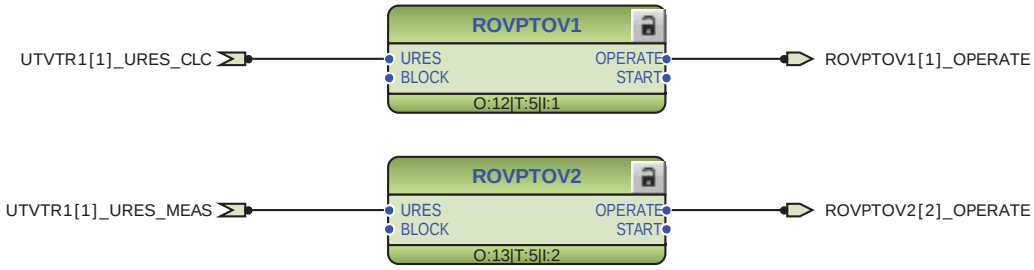



*Figure 92: Two ROVPTOV instances, one using calculated U0 and the other measured U0*

## 3.17.3.5 Signals

### UTVTR Input signals

**Table 129: UTVTR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| UL1 | SIGNAL | - | Analog input |
| UL2 | SIGNAL | - | Analog input |
| UL3 | SIGNAL | - | Analog input |
| URES | SIGNAL | - | Residual voltage |
| MINCB_OPEN | BOOLEAN | 0=False | Active when external MCB opens protected voltage circuit |

**UTVTR Output signals**

**Table 130: UTVTR Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm |
| WARNING | BOOLEAN | Warning |
| URES_ALARM | BOOLEAN | Alarm |
| URES_WARNING | BOOLEAN | Warning |
| U3P | SIGNAL | Three-phase voltages |
| URES_CLC | SIGNAL | Residual voltage, calculated |
| URES_MEAS | SIGNAL | Residual voltage, measured |
| URES_CLC_DR | SIGNAL | Residual voltage, calculated, for disturbance recorder |
| URES_MEAS_DR | SIGNAL | Residual voltage, measured, for disturbance recorder |
| U1_DR | SIGNAL | Phase voltage U1 for disturbance recorder |
| U2_DR | SIGNAL | Phase voltage U2 for disturbance recorder |
| U3_DR | SIGNAL | Phase voltage U3 for disturbance recorder |
| NPS_DR | SIGNAL | Negative sequence current for disturbance recorder |
| PPS_DR | SIGNAL | Positive sequence current for disturbance recorder |
| FREQ_DR | SIGNAL | Measured frequency for disturbance recorder |

## 3.17.3.6 UTVTR Settings

**Table 131: UTVTR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage input type | 1=Voltage trafo<br>3=Voltage sensor | | | 1=Voltage trafo | Type of the voltage input |
| Primary voltage | 0.100...800.000 | kV | 0.001 | 20.000 | Primary rated phase-to-phase voltage |
| Secondary voltage | 57...416 | V | 1 | 100 | Secondary rated phase-to-phase voltage |
| Division ratio | 1000...20000 | | 1 | 10000 | Voltage sensor division ratio |
| VT connection | 1=Wye<br>2=Delta | | | 2=Delta | Voltage transducer measurement connection |
| Amplitude Corr A | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase A Voltage phasor magnitude |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | | | | | correction of an external voltage transformer |
| Amplitude Corr B | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase B Voltage phasor magnitude correction of an external voltage transformer |
| Amplitude Corr C | 0.9000...1.1000 | | 0.0001 | 1.0000 | Phase C Voltage phasor magnitude correction of an external voltage transformer |
| Angle Corr A | -8.0000...8.0000 | deg | 0.0001 | 0.0000 | Phase A Voltage phasor angle correction of an external voltage transformer |
| Angle Corr B | -8.0000...8.0000 | deg | 0.0001 | 0.0000 | Phase B Voltage phasor angle correction of an external voltage transformer |
| Angle Corr C | -8.0000...8.0000 | deg | 0.0001 | 0.0000 | Phase C Voltage phasor angle correction of an external voltage transformer |

**Table 132: UTVTR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Frequency adaptivity | 0=Disable<br>1=Enable<br>2=Main frequency source<br>3=Backup frequency source | | | 0=Disable | Frequency adaptivity selection |

**Table 133: UTVTR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Primary voltage | 0.100...800.000 | kV | 0.001 | 11.547 | Primary voltage |
| Secondary voltage | 57...240 | V | 1 | 100 | Secondary voltage |
| Amplitude Corr | 0.9000...1.1000 | | 0.0001 | 1.0000 | Amplitude correction |
| Angle correction | -8.0000...8.0000 | deg | 0.0001 | 0.0000 | Angle correction factor |

**Table 134: UTVTR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Frequency adaptivity | 0=Disable<br>1=Enable | | | 0=Disable | Frequency adaptivity selection |

## 3.17.4 Residual current preprocessing, current measured as voltage RESUTCTR

### 3.17.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE identification |
|---|---|---|---|
| Residual current preprocessing, current measured as voltage | RESUTCTR | Io(U) | Io(U) |

### 3.17.4.2 Function block

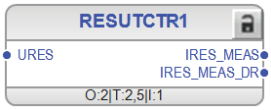



*Figure 93: Function block*

### 3.17.4.3 Functionality

The preprocessing block RESUTCTR is used for setting up the residual current measurement when the current is measured as voltage and the measured signal is wired via VT channel.

Input channel for RESUTCTR can be physical hardware voltage channel only.

The output *IRES_MEAS* channel of the RESUTCTR can be connected to only GSLPTOC which optionally can use this special way of current measurement.

The residual primary rated current can be set using *Primary current* setting. The setting *Secondary voltage* defines the nominal voltage of the measuring arrangement. This is used as a reference to scale the measurements accordingly.

Residual current magnitude correction of an external measuring arrangement can be made using *Amplitude Corr* setting.

Residual current angle correction of an external measuring arrangement can be made using *Angle Correction* setting.

*Reverse polarity* setting is used to reverse the polarity of residual CT.

Purpose of the outputs `IRES_MEAS` and `IRES_MEAS_DR` are described in the Outputs table.

Frequency adaptivity functionality is enabled by first enabling the main *Frequency adaptivity* setting under System parameter settings (**Configuration** > **System** > **Frequency adaptivity**), then by setting RESUTCTR *Frequency adaptivity* mode to “Enable”.

### 3.17.4.4 Signals

#### RESUTCTR Input signals

**Table 135: RESUTCTR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| URES | SIGNAL | - | Residual voltage |

#### RESUTCTR Output signals

**Table 136: RESUTCTR Output signals**

| Name | Type | Description |
|---|---|---|
| IRES_MEAS | SIGNAL | Residual current, measured |
| IRES_MEAS_DR | SIGNAL | Residual current, measured, for disturbance recorder |

### 3.17.4.5 RESUTCTR Settings

**Table 137: RESUTCTR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Primary current | 1.0...15000.0 | A | 0.1 | 100.0 | Primary current |
| Secondary voltage | 4...240 | | 1 | 10 | Secondary voltage |
| Amplitude Corr | 0.9000...1.1000 | | 0.0001 | 1.0000 | Amplitude correction |
| Angle correction | -8.0000...8.0000 | deg | 0.0001 | 0.0000 | Angle correction factor |

**Table 138: RESUTCTR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reverse polarity | 0=False<br>1=True | | | 0=False | Reverse the polarity of the residual measurement |
| Frequency adaptivity | 0=Disable<br>1=Enable | | | 0=Disable | Frequency adaptivity selection |

## 3.18 GOOSE function blocks

GOOSE function blocks are used for connecting incoming GOOSE data to application. They support BOOLEAN, Dbpos, Enum, FLOAT32, INT8 and INT32 data types.

#### Common signals

The VALID output indicates the validity of received GOOSE data, which means in case of valid, that the GOOSE communication is working and received data quality bits (if configured) indicate good process data. Invalid status is caused either by

bad data quality bits or GOOSE communication failure. See IEC 61850 engineering guide for details.

The OUT output passes the received GOOSE value for the application. Default value (0) is used if VALID output indicates invalid status. The IN input is defined in the GOOSE configuration and can always be seen in SMT sheet.

**Settings**

The GOOSE function blocks do not have any parameters available in LHMI or PCM600.

## 3.18.1 Received GOOSE binary information GOOSERCV_BIN

### 3.18.1.1 Function block




*Figure 94: Function block*

### 3.18.1.2 Functionality

The received GOOSE binary information function GOOSERCV_BIN is used to connect the GOOSE binary inputs to the application.

### 3.18.1.3 Signals

**Table 139: GOOSERCV_BIN Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | BOOLEAN | 0 | Input signal |

**Table 140: GOOSERCV_BIN Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.2 Received GOOSE double binary information GOOSERCV_DP

### 3.18.2.1 Function block

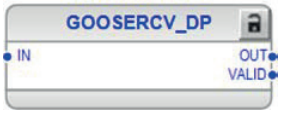



*Figure 95: Function block*

### 3.18.2.2 Functionality

The received GOOSE double binary information function GOOSERCV_DP is used to connect the GOOSE double binary inputs to the application.

### 3.18.2.3 Signals

**Table 141: GOOSERCV_DP Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Dbpos | 00 | Input signal |

**Table 142: GOOSERCV_DP Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | Dbpos | Output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.3 Received GOOSE measured value information GOOSERCV_MV

### 3.18.3.1 Function block




*Figure 96: Function block*

### 3.18.3.2 Functionality

The received GOOSE measured value information function GOOSERCV_MV is used to connect the GOOSE measured value inputs to the application.

### 3.18.3.3 Signals

**Table 143: GOOSERCV_MV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | FLOAT32 | 0 | Input signal |

**Table 144: GOOSERCV_MV Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | FLOAT32 | Output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.4 Received GOOSE 8-bit integer value information GOOSERCV_INT8

### 3.18.4.1 Function block




*Figure 97: Function block*

### 3.18.4.2 Functionality

The received GOOSE 8-bit integer value information function GOOSERCV_INT8 is used to connect the GOOSE 8-bit integer inputs to the application.

### 3.18.4.3 Signals

**Table 145: GOOSERCV_INT8 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | INT8 | 0 | Input signal |

**Table 146: GOOSERCV_INT8 Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | INT8 | Output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.5 Received GOOSE 32-bit integer value information GOOSERCV_INT32

### 3.18.5.1 Function block

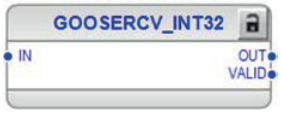



*Figure 98: Function block*

### 3.18.5.2 Functionality

The received GOOSE 32-bit integer value information function GOOSERCV_INT32 is used to connect GOOSE 32-bit integer inputs to the application.

### 3.18.5.3 Signals

**Table 147: GOOSERCV_INT32 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | INT32 | 0 | Input signal |

**Table 148: GOOSERCV_INT32 Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | INT32 | Output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.6 Received GOOSE interlocking information GOOSERCV_INTL

### 3.18.6.1 Function block




*Figure 99: Function block*

### 3.18.6.2 Functionality

The received GOOSE interlocking information function GOOSERCV_INTL is used to connect the GOOSE double binary input to the application and extracting single binary position signals from the double binary position signal.

The `OP` output signal indicates that the position is open. Default value (0) is used if `VALID` output indicates invalid status.

The `CL` output signal indicates that the position is closed. Default value (0) is used if `VALID` output indicates invalid status.

The `OK` output signal indicates that the position is neither in faulty or intermediate state. The default value (0) is used if `VALID` output indicates invalid status.

### 3.18.6.3 Signals

**Table 149: GOOSERCV_INTL Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Dbpos | 0 | Input signal |

**Table 150: GOOSERCV_INTL Output signals**

| Name | Type | Description |
|---|---|---|
| OP | BOOLEAN | Position open output signal |
| CL | BOOLEAN | Position closed output signal |
| OK | BOOLEAN | Position OK output signal |
| VALID | BOOLEAN | Output signal |

## 3.18.7 Received GOOSE measured value (phasor) information GOOSERCV_CMV

### 3.18.7.1 Function block

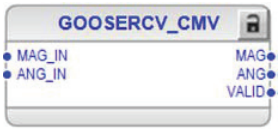



*Figure 100: Function block*

### 3.18.7.2 Functionality

The received GOOSE measured value (phasor) information function GOOSERCV_CMV is used to connect GOOSE measured value inputs to the application. The MAG_IN(amplitude) and ANG_IN (angle) inputs are defined in the GOOSE configuration (PCM600).

The MAG output passes the received GOOSE amplitude and ANG the received angle value for the application.

### 3.18.7.3 Signals

**Table 151: GOOSERCV_CMV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| MAG_IN | FLOAT32 | 0 | Input signal (amplitude) |
| ANG_IN | FLOAT32 | 0 | Input signal (angle) |

**Table 152: GOOSERCV_CMV Output signals**

| Name | Type | Description |
|---|---|---|
| MAG | FLOAT32 | Output signal (amplitude) |
| ANG | FLOAT32 | Output signal (angle) |
| VALID | BOOLEAN | Output signal |

## 3.18.8 Received GOOSE enumerator value information GOOSERCV_ENUM

### 3.18.8.1 Function block




*Figure 101: Function block*

### 3.18.8.2 Functionality

The received GOOSE enumerator value information function GOOSERCV_ENUM is used to connect GOOSE enumerator inputs to the application.

### 3.18.8.3 Signals

**Table 153: GOOSERCV_ENUM Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Enum | 0 | Input signal |

**Table 154: GOOSERCV_ENUM Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | Enum | Output signal |
| VALID | BOOLEAN | Output signal |

# 3.19 Type conversion function blocks

## 3.19.1 Good signal quality QTY_GOOD

### 3.19.1.1 Function block




*Figure 102: Function block*

### 3.19.1.2 Functionality

The good signal quality function QTY_GOOD evaluates the quality bits of the input signal and passes it as a Boolean signal for the application.

The IN input can be connected to any logic application signal (except preprocessing block). Due to application logic quality bit propagation, each (simple and even combined) signal has quality which can be evaluated.

The OUT output indicates quality good of the input signal. Input signals that have no quality bits set or only test bit is set, will indicate quality good status.

### 3.19.1.3 Signals

**Table 155: QTY_GOOD Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Any | 0 | Input signal |

**Table 156: QTY_GOOD Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output signal |

## 3.19.2 Bad signal quality QTY_BAD

### 3.19.2.1 Function block




*Figure 103: Function block*

### 3.19.2.2 Functionality

The bad signal quality function QTY_BAD evaluates the quality bits of the input signal and passes it as a Boolean signal for the application.

The IN input can be connected to any logic application signal (except preprocessing block). Due to application logic quality bit propagation, each (simple and even combined) signal has quality which can be evaluated.

The OUT output indicates quality bad of the input signal. Input signals that have any other than test bit set, will indicate quality bad status.

### 3.19.2.3 Signals

**Table 157: QTY_BAD Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Any | 0 | Input signal |

**Table 158: QTY_BAD Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output signal |

## 3.19.3 Received GOOSE test mode QTY_GOOSE_TEST

### 3.19.3.1 Function block

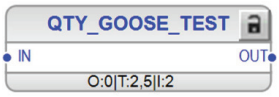



*Figure 104: Function block*

### 3.19.3.2 Functionality

The GOOSE test mode function QTY_GOOSE_TEST determines whether test mode is used between two relays communicating over GOOSE. The conditions needed for enabling the test mode differ in both editions 1 and 2 of the IEC 61850 standard. For more information, see the IEC 61850 engineering guide.

The IN input can be connected to any GOOSE application logic output signal, for example, GOOSERCV_BIN.

The OUT output indicates the test mode status of the GOOSE function block. When the output is in the true (1) state, the GOOSE test mode is active. The value false (0) indicates that the test mode is not in use.

### 3.19.3.3 Signals

**Table 159: QTY_GOOSE_TEST Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Any | 0 | Input signal |

**Table 160: QTY_GOOSE_TEST Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output signal |

## 3.19.4 GOOSE communication quality QTY_GOOSE_COMM

### 3.19.4.1 Function block




*Figure 105: Function block*

### 3.19.4.2 Functionality

The GOOSE communication quality function QTY_GOOSE_COMM evaluates the peer device communication status from the quality bits of the input signal and passes it as a Boolean signal to the application.

The IN input can be connected to any GOOSE application logic output signal, for example, GOOSERCV_BIN.

The COMMVALID output indicates the communication status of the GOOSE function block. When the output is in the true (1) state, the GOOSE communication is active. The value false (0) indicates communication timeout.

### 3.19.4.3 Signals

**Table 161: QTY_GOOSE_COMM Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Any | 0 | Input signal |

**Table 162: QTY_GOOSE_COMM Output signals**

| Name | Type | Description |
|---|---|---|
| COMMVALID | BOOLEAN | Output signal |

## 3.19.5 GOOSE data health T_HEALTH

### 3.19.5.1 Function block




*Figure 106: Function block*

### 3.19.5.2 Functionality

The GOOSE data health function T_HEALTH evaluates enumerated data of “Health” data attribute. This function block can only be used with GOOSE.

The IN input can be connected to GOOSERCV_ENUM function block, which is receiving the LD0.LLN0.Health.stVal data attribute sent by another device.

The outputs OK, WARNING and ALARM are extracted from the enumerated input value. Only one of the outputs can be active at a time. In case the GOOSERCV_ENUM function block does not receive the value from the sending device or it is invalid, the default value (0) is used and the ALARM is activated in the T_HEALTH function block.

### 3.19.5.3 Signals

**Table 163: T_HEALTH Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | Any | 0 | Input signal |

**Table 164: T_HEALTH Output signals**

| Name | Type | Description |
|---|---|---|
| OK | BOOLEAN | Output signal |
| WARNING | BOOLEAN | Output signal |
| ALARM | BOOLEAN | Output signal |

## 3.19.6 Fault direction evaluation T_DIR

### 3.19.6.1 Function block




*Figure 107: Function block*

### 3.19.6.2 Functionality

The fault direction evaluation function T_DIR evaluates enumerated data of the FAULT_DIR and DIRECTION data attributes of the directional functions.

The outputs `FWD` and `REV` are extracted from the enumerated input value.

### 3.19.6.3 Signals

**Table 165: T_DIR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| DIR | Enum | 0 | Input signal |

**Table 166: T_DIR Output signals**

| Name | Type | Description |
|---|---|---|
| FWD | BOOLEAN | Direction forward |
| REV | BOOLEAN | Direction backward |

## 3.19.7 Fault direction evaluation T_DIR_FWD

### 3.19.7.1 Function block

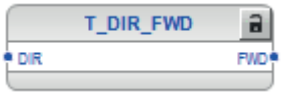



*Figure 108: Function block*

### 3.19.7.2 Functionality

The fault direction evaluation function T_DIR_FWD evaluates enumerated data of the FAULT_DIR and DIRECTION data attributes of the directional functions.

The output `FWD` is extracted from the enumerated input value.

### 3.19.7.3 Signals

**Table 167: T_DIR_FWD Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| DIR | Enum | 0 | Input signal |

**Table 168: T_DIR_FWD Output signals**

| Name | Type | Description |
|---|---|---|
| FWD | BOOLEAN | Direction forward |

## 3.19.8 Fault direction evaluation T_DIR_REV

### 3.19.8.1 Function block




*Figure 109: Function block*

### 3.19.8.2 Functionality

The fault direction evaluation function T_DIR_REV evaluates enumerated data of the FAULT_DIR and DIRECTION data attributes of the directional functions.

The output `REV` is extracted from the enumerated input value.

### 3.19.8.3 Signals

**Table 169: T_DIR_REV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| DIR | Enum | 0 | Input signal |

**Table 170: T_DIR_REV Output signals**

| Name | Type | Description |
|---|---|---|
| REV | BOOLEAN | Direction backward |

## 3.19.9 Enumerator to boolean conversion T_TCMD

### 3.19.9.1 Function block

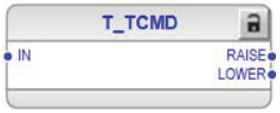



*Figure 110: Function block*

### 3.19.9.2 Functionality

The enumerator to boolean conversion function T_TCMD is used to convert enumerated input signals to boolean output signals.

**Table 171: Conversion from enumerated to Boolean**

| IN | RAISE | LOWER |
|---|---|---|
| 0 | FALSE | FALSE |
| 1 | FALSE | TRUE |
| 2 | TRUE | FALSE |
| x | FALSE | FALSE |

### 3.19.9.3 Signals

**Table 172: T_TCMD input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | Enum | 0 | Input signal |

**Table 173: T_TCMD output signals**

| Name | Type | Description |
|---|---|---|
| RAISE | BOOLEAN | Raise command |
| LOWER | BOOLEAN | Lower command |

## 3.19.10 32-bit integer to binary command conversion T_TCMD_BIN

### 3.19.10.1 Function block




*Figure 111: Function block*

### 3.19.10.2 Functionality

The 32-bit integer to binary command conversion function T_TCMD_BIN is used to convert 32 bit integer input signal to boolean output signals.

**Table 174: Conversion from integer to Boolean**

| IN | RAISE | LOWER |
|---|---|---|
| 0 | FALSE | FALSE |
| 1 | FALSE | TRUE |
| 2 | TRUE | FALSE |
| x | FALSE | FALSE |

### 3.19.10.3 Signals

**Table 175: T_TCMD_BIN input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN | INT32 | 0 | Input signal |

**Table 176: T_TCMD_BIN output signals**

| Name | Type | Description |
|---|---|---|
| RAISE | BOOLEAN | Raise command |
| LOWER | BOOLEAN | Lower command |

## 3.19.11 Binary command to 32-bit integer conversion T_BIN_TCMD

### 3.19.11.1 Function block

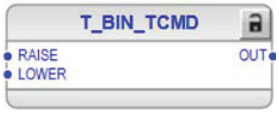



*Figure 112: Function block*

### 3.19.11.2 Functionality

The binary command to 32-bit integer conversion function T_BIN_TCMD is used to convert boolean input signals to 32 bit integer output signals.

**Table 177: Conversion from Boolean to integer**

| RAISE | LOWER | OUT |
|---|---|---|
| FALSE | FALSE | 0 |
| FALSE | TRUE | 1 |
| TRUE | FALSE | 2 |

### 3.19.11.3 Signals

**Table 178: T_BIN_TCMD input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| RAISE | BOOLEAN | 0 | Raise command |
| LOWER | BOOLEAN | 0 | Lower command |

**Table 179: T_BIN_TCMD output signals**

| Name | Type | Description |
|---|---|---|
| OUT | INT32 | Output signal |

## 3.19.12 Integer 32-bit to real conversion T_I32_TO_R

### 3.19.12.1 Function block




*Figure 113: Function block*

### 3.19.12.2 Functionality

The integer 32-bit to real conversion function T_I32_TO_R converts a 32-bit integer to a real value. The output quality follows the input quality information.

If the integer value is greater than 2097151, then the real value is set to 2097151 and the output quality is set as bad. If the integer value is less than –2097152, then the real value is set to -2097152 and the output quality is set as bad.

### 3.19.12.3 Signals

**Table 180: T_I32_TO_R Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| INT32_IN | INT32 | 0 | Integer input value |

**Table 181: T_I32_TO_R Output signals**

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output value |

## 3.19.13 Real to integer 8-bit conversion T_R_TO_I8

### 3.19.13.1 Function block




*Figure 114: Function block*

### 3.19.13.2 Functionality

The real to integer 8-bit conversion function T_R_TO_I8 converts a real to an integer 8-bit value. The real value is floored to integer value. The output quality follows the input quality information.

If the real value is 10.6, 10.5, 10.4, –10.6, –10.5, –10.4, the integer value is converted to 10, 10, 10, –11, –11, –11, respectively.

### 3.19.13.3 Signals

**Table 182: T_R_TO_I8 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN | FLOAT32 | 0 | Real input value |

**Table 183: T_R_TO_I8 Output signals**

| Name | Type | Description |
|---|---|---|
| INT8_OUT | INT8 | Integer output value |

## 3.19.14 Real to integer 32-bit conversion T_R_TO_I32

### 3.19.14.1 Function block




*Figure 115: Function block*

### 3.19.14.2 Functionality

The real to integer 32-bit conversion function T_R_TO_I32 converts a real to an integer 32-bit value. The real value is floored to integer value. The output quality follows the input quality information.

If the real value is 10.6, 10.5, 10.4, –10.6, –10.5, –10.4, the integer value is converted to 10, 10, 10, –11, –11, –11, respectively.

### 3.19.14.3 Signals

**Table 184: T_R_TO_I32 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN | FLOAT32 | 0 | Real input value |

**Table 185: T_R_TO_I32 Output signals**

| Name | Type | Description |
|---|---|---|
| INT32_OUT | INT32 | Integer output value |

## 3.19.15 Integer 32-bit switch selector SWITCHI32

### 3.19.15.1 Function block




*Figure 116: Function block*

### 3.19.15.2 Functionality

The integer 32-bit switch selector function SWITCHI32 is operated by the `CTL_SW` input, which selects the output value `INT32_OUT` between the `INT32_IN1` and `INT32_IN2` inputs.

**Table 186: SWITCHI32**

| CTL_SW value | INT_OUT value |
|---|---|
| FALSE (0) | INT32_IN1 |
| TRUE (1) | INT32_IN2 |

### 3.19.15.3 Signals

**Table 187: SWITCHI32 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| CTL_SW | BOOLEAN | 0 | Control Switch |
| INT_IN1 | INT32 | 0 | Integer input value 1 |
| INT_IN2 | INT32 | 0 | Integer input value 2 |

**Table 188: SWITCHI32 Output signals**

| Name | Type | Description |
|---|---|---|
| INT_OUT | INT32 | Integer switch output |

## 3.19.16 Integer 32-bit to boolean conversion T_I32_TO_B16

### 3.19.16.1 Function block

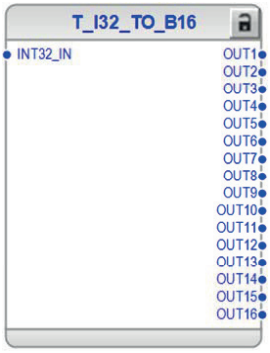



*Figure 117: Function block*

### 3.19.16.2 Functionality

The integer 32-bit to boolean conversion function T_I32_TO_B16 is used to transform an integer input `INT32_IN` into a set of 16 binary (logical) signals `OUT1`...`OUT16`. T_I32_TO_B16 is designed for receiving the integer input locally.

Conversion is done for the lowest 16 bits only. If `INT32_IN` is higher than 65535 ($2^{16}$–1), the higher bits are ignored in conversion.

### 3.19.16.3 Signals

**Table 189: T_I32_TO_B16 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| INT32_IN | INT32 | 0 | Integer input value |

**Table 190: T_I32_TO_B16 Output signals**

| Name | Type | Description |
|---|---|---|
| OUT1 | BOOLEAN | Boolean output value 1 |
| OUT2 | BOOLEAN | Boolean output value 2 |
| OUT3 | BOOLEAN | Boolean output value 3 |
| OUT4 | BOOLEAN | Boolean output value 4 |
| OUT5 | BOOLEAN | Boolean output value 5 |
| OUT6 | BOOLEAN | Boolean output value 6 |
| OUT7 | BOOLEAN | Boolean output value 7 |
| OUT8 | BOOLEAN | Boolean output value 8 |
| OUT9 | BOOLEAN | Boolean output value 9 |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| OUT10 | BOOLEAN | Boolean output value 10 |
| OUT11 | BOOLEAN | Boolean output value 11 |
| OUT12 | BOOLEAN | Boolean output value 12 |
| OUT13 | BOOLEAN | Boolean output value 13 |
| OUT14 | BOOLEAN | Boolean output value 14 |
| OUT15 | BOOLEAN | Boolean output value 15 |
| OUT16 | BOOLEAN | Boolean output value 16 |

## 3.19.17 Boolean to integer 32-bit conversion T_B16_TO_I32

### 3.19.17.1 Function block




*Figure 118: Function block*

### 3.19.17.2 Functionality

The boolean to integer 32-bit conversion function T_B16_TO_I32 is used to transform a set of 16 binary (logical) signals `IN1...IN16` into an integer 32-bit output `INT32_OUT` value.

### 3.19.17.3 Signals

**Table 191: T_B16_TO_I32 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0 (FALSE) | Boolean input value 1 |
| IN2 | BOOLEAN | 0 (FALSE) | Boolean input value 2 |
| IN3 | BOOLEAN | 0 (FALSE) | Boolean input value 3 |
| IN4 | BOOLEAN | 0 (FALSE) | Boolean input value 4 |
| IN5 | BOOLEAN | 0 (FALSE) | Boolean input value 5 |
| IN6 | BOOLEAN | 0 (FALSE) | Boolean input value 6 |
| IN7 | BOOLEAN | 0 (FALSE) | Boolean input value 7 |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| IN8 | BOOLEAN | 0 (FALSE) | Boolean input value 8 |
| IN9 | BOOLEAN | 0 (FALSE) | Boolean input value 9 |
| IN10 | BOOLEAN | 0 (FALSE) | Boolean input value 10 |
| IN11 | BOOLEAN | 0 (FALSE) | Boolean input value 11 |
| IN12 | BOOLEAN | 0 (FALSE) | Boolean input value 12 |
| IN13 | BOOLEAN | 0 (FALSE) | Boolean input value 13 |
| IN14 | BOOLEAN | 0 (FALSE) | Boolean input value 14 |
| IN15 | BOOLEAN | 0 (FALSE) | Boolean input value 15 |
| IN16 | BOOLEAN | 0 (FALSE) | Boolean input value 16 |

**Table 192: T_B16_TO_I32 Output signals**

| Name | Type | Description |
|---|---|---|
| INT32_OUT | INT32 | Integer output value |

## 3.19.18 Integer 8-bit to integer 32-bit conversion T_I8_TO_I32

### 3.19.18.1 Function block




*Figure 119: Function block*

### 3.19.18.2 Functionality

The integer 8-bit to integer 32-bit conversion function T_I8_TO_I32 converts a 8-bit integer value to a 32-bit integer value. The output quality follows the input quality information.

### 3.19.18.3 Signals

**Table 193: T_I8_TO_I32 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| INT8_IN | INT8 | 0 | Integer input value |

**Table 194: T_I8_TO_I32 Output signals**

| Name | Type | Description |
|---|---|---|
| INT32_OUT | INT32 | Integer output value |

# 3.20 Configurable logic blocks

## 3.20.1 Minimum pulse timer

### 3.20.1.1 Minimum pulse timer, two channels TPGAPC (ANSI 62TP)

**Identification**

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Minimum pulse timer, two channels | TPGAPC | TP | 62TP |

**Function block**




*Figure 120: Function block*

**Functionality**

The minimum pulse timer, two channels, function TPGAPC contains two independent timers. The function has a settable pulse length (in milliseconds). The timers are used for setting the minimum pulse length for example, the signal outputs. Once the input is activated, the output is set for a specific duration using the *Pulse time* setting. Both timers use the same setting parameter.

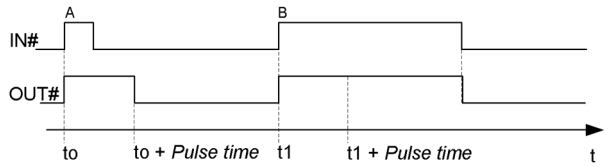



*Figure 121: A = Trip pulse is shorter than Pulse time setting, B = Trip pulse is longer than Pulse time setting*

### Signals

**Table 195: TPGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 |
| IN2 | BOOLEAN | 0=False | Input 2 |

**Table 196: TPGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| OUT1 | BOOLEAN | Output 1 status |
| OUT2 | BOOLEAN | Output 2 status |

### Settings

**Table 197: TPGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pulse time | 0...60000 | ms | 1 | 0 | Minimum pulse time |

## 3.20.1.2 Minimum pulse timer second resolution, two channels TPSGAPC (ANSI 62TPS)

### Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Minimum pulse timer second resolution, two channels | TPSGAPC | TPS | 62TPS |

### Function block

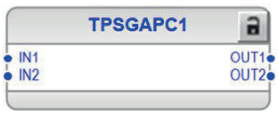



*Figure 122: Function block*

### Functionality

The minimum pulse timer second resolution, two channels, function TPSGAPC contains two independent timers. The function has a settable pulse length (in seconds). The timers are used for setting the minimum pulse length for example, the signal outputs. Once the input is activated, the output is set for a specific duration using the *Pulse time* setting. Both timers use the same setting parameter.

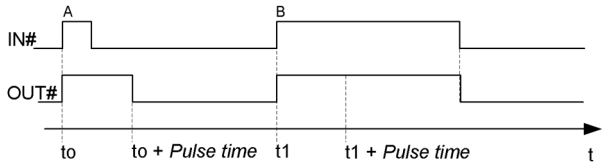



*Figure 123: A = Trip pulse is shorter than Pulse time setting, B = Trip pulse is longer than Pulse time setting*

### Signals

**Table 198: TPSGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 |
| IN2 | BOOLEAN | 0=False | Input 2 |

**Table 199: TPSGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| OUT1 | BOOLEAN | Output 1 status |
| OUT2 | BOOLEAN | Output 2 status |

### Settings

**Table 200: TPSGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pulse time | 0...300 | s | 1 | 0 | Minimum pulse time |

### 3.20.1.3 Minimum pulse timer minutes resolution, two channels TPMGAPC (ANSI 62TPM)

#### Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Minimum pulse timer minutes resolution, two channels | TPMGAPC | TPM | 62TPM |

#### Function block

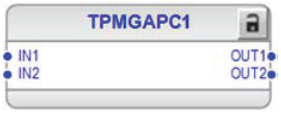



*Figure 124: Function block*

#### Functionality

The minimum pulse timer minutes resolution, two channels, function TPMGAPC contains two independent timers. The function has a settable pulse length (in minutes). The timers are used for setting the minimum pulse length for example, the signal outputs. Once the input is activated, the output is set for a specific duration using the *Pulse time* setting. Both timers use the same setting parameter.

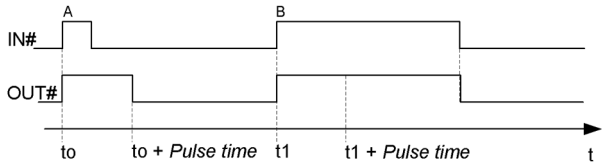



*Figure 125: A = Trip pulse is shorter than Pulse time setting, B = Trip pulse is longer than Pulse time setting*

#### Signals

**Table 201: TPMGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 |
| IN2 | BOOLEAN | 0=False | Input 2 |

**Table 202: TPMGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| OUT1 | BOOLEAN | Output 1 status |
| OUT2 | BOOLEAN | Output 2 status |

**Settings**

**Table 203: TPMGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pulse time | 0...2880 | min | 1 | 0 | Minimum pulse time |

**Technical revision history**

**Table 204: TPMGAPC Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL2 | E | Changed the maximum pulse time from 5 h to 48 h |

## 3.20.2 Pulse timer, eight channels PTGAPC (ANSI 62PT)

### 3.20.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Pulse timer, eight channels | PTGAPC | PT | 62PT |

### 3.20.2.2 Function block

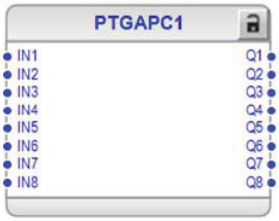



*Figure 126: Function block*

### 3.20.2.3 Functionality

The pulse timer function PTGAPC contains eight independent timers. The function has a settable pulse length. Once the input is activated, the output is set for a specific duration using the *Pulse delay time* setting.

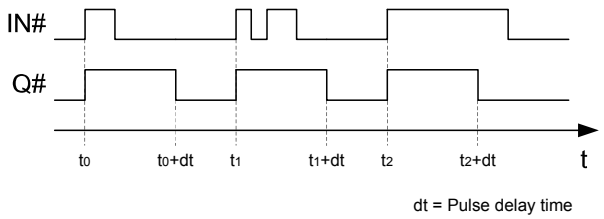



*Figure 127: Timer operation*

### 3.20.2.4 Signals

**Table 205: PTGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 status |
| IN2 | BOOLEAN | 0=False | Input 2 status |
| IN3 | BOOLEAN | 0=False | Input 3 status |
| IN4 | BOOLEAN | 0=False | Input 4 status |
| IN5 | BOOLEAN | 0=False | Input 5 status |
| IN6 | BOOLEAN | 0=False | Input 6 status |
| IN7 | BOOLEAN | 0=False | Input 7 status |
| IN8 | BOOLEAN | 0=False | Input 8 status |

**Table 206: PTGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Output 1 status |
| Q2 | BOOLEAN | Output 2 status |
| Q3 | BOOLEAN | Output 3 status |
| Q4 | BOOLEAN | Output 4 status |
| Q5 | BOOLEAN | Output 5 status |
| Q6 | BOOLEAN | Output 6 status |
| Q7 | BOOLEAN | Output 7 status |
| Q8 | BOOLEAN | Output 8 status |

### 3.20.2.5 Settings

**Table 207: PTGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pulse time 1 | 0...3600000 | ms | 1 | 0 | Pulse time |
| Pulse time 2 | 0...3600000 | ms | 1 | 0 | Pulse time |
| Pulse time 3 | 0...3600000 | ms | 1 | 0 | Pulse time |
| Pulse time 4 | 0...3600000 | ms | 1 | 0 | Pulse time |
| Pulse time 5 | 0...3600000 | ms | 1 | 0 | Pulse time |
| Pulse time 6 | 0...3600000 | ms | 1 | 0 | Pulse time |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pulse time 7 | 0...3600000 | ms | 1 | 0 | Pulse time |
| Pulse time 8 | 0...3600000 | ms | 1 | 0 | Pulse time |

### 3.20.2.6 Monitored data

**Table 208: PTGAPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| T_LEFT1 | FLOAT32 | 0...3600 | s | Time left 1 |
| T_LEFT2 | FLOAT32 | 0...3600 | s | Time left 2 |
| T_LEFT3 | FLOAT32 | 0...3600 | s | Time left 3 |
| T_LEFT4 | FLOAT32 | 0...3600 | s | Time left 4 |
| T_LEFT5 | FLOAT32 | 0...3600 | s | Time left 5 |
| T_LEFT6 | FLOAT32 | 0...3600 | s | Time left 6 |
| T_LEFT7 | FLOAT32 | 0...3600 | s | Time left 7 |
| T_LEFT8 | FLOAT32 | 0...3600 | s | Time left 8 |

### 3.20.2.7 Technical data

**Table 209: PTGAPC Technical data**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

### 3.20.2.8 Technical revision history

**Table 210: PTGAPC Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL2 | E | Changed the *Pulse time* step to 1 ms |

## 3.20.3 Daily timer DTMGAPC (ANSI DTM)

### 3.20.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Daily timer | DTMGAPC | DTM | DTM |

### 3.20.3.2 Function block




*Figure 128: Function block*

### 3.20.3.3 Functionality

The daily timer function DTMGAPC is used to activate or deactivate its output at the set time of the day. It is possible to set a different activation or deactivation time separately for each day of the week.

### 3.20.3.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DTMGAPC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

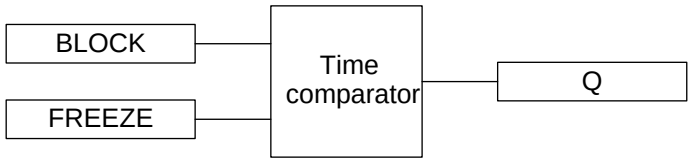



*Figure 129: Functional module diagram*

#### Time comparator

This module compares the current day and time with the activation hour and minute defined with the settings *xxx Act hour* and *xxx Act Mn*, respectively. When the time of the day reaches the set activation time, output Q is activated and remains active for the duration defined by the setting *xxx off delay*.

The output remains active until the next day if the value for *xxx off delay* is set so that it results into rollover of the day.

Different activation and deactivation times can be set for all days of the week. The activation and deactivation can also be disabled for a specific day. For example, if the activation or deactivation is not needed on Sundays, the setting *Sunday Act enable* can be set as "False".

Activation of the BLOCK input deactivates the function output whereas the activation of the FREEZE input freezes the output. The BLOCK input always has a higher priority than the FREEZE input.

### 3.20.3.5 Application

DTMGAPC is useful in applications that require signal activation and deactivation at a specific time of the day. Different activation times and duration can be set for

different days of the week. For example, if the signal should be active on Mondays between 7:15 and 16:00, the *Monday Act enable* setting should be "True", *Monday Act hour* should be "7", *Monday Act Mn* should be "15", and *Monday off delay* should be "525" minutes. The behavior of output Q is illustrated in *Figure 130*.

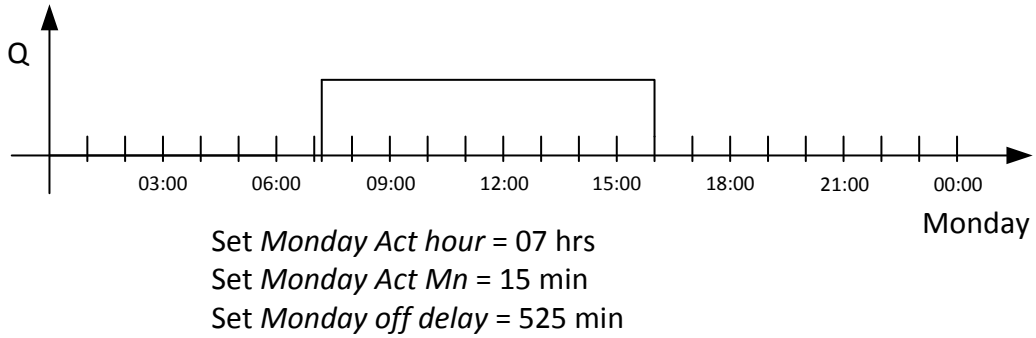



*Figure 130: Example setting values for output Q activation*

### 3.20.3.6 Signals

#### DTMGAPC Input signals

**Table 211: DTMGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for binary output |
| FREEZE | BOOLEAN | 0=False | Freeze signal for binary output |

#### DTMGAPC Output signals

**Table 212: DTMGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Output status |

### 3.20.3.7 DTMGAPC Settings

**Table 213: DTMGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Monday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Monday |
| Monday Act hour | 0...23 | h | | 8 | Activation hour time for Monday |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Monday Act Mn | 0...59 | min | | 0 | Activation minute time for Monday |
| Monday off delay | 1...1440 | min | 1 | 60 | Activation duration for Monday |
| Tuesday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Tuesday |
| Tuesday Act hour | 0...23 | h | | 8 | Activation hour time for Tuesday |
| Tuesday Act Mn | 0...59 | min | | 0 | Activation minute time for Tuesday |
| Tuesday off delay | 1...1440 | min | 1 | 60 | Activation duration for Tuesday |
| Wednesday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Wednesday |
| Wednesday Act hour | 0...23 | h | | 8 | Activation hour time for Wednesday |
| Wednesday Act Mn | 0...59 | min | | 0 | Activation minute time for Wednesday |
| Wednesday off delay | 1...1440 | min | 1 | 60 | Activation duration for Wednesday |
| Thursday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Thursday |
| Thursday Act hour | 0...23 | h | | 8 | Activation hour time for Thursday |
| Thursday Act Mn | 0...59 | min | | 0 | Activation minute time for Thursday |
| Thursday off delay | 1...1440 | min | 1 | 60 | Activation duration for Thursday |
| Friday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Friday |
| Friday Act hour | 0...23 | h | | 8 | Activation hour time for Friday |
| Friday Act Mn | 0...59 | min | | 0 | Activation minute time for Friday |
| Friday off delay | 1...1440 | min | 1 | 60 | Activation duration for Friday |
| Saturday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Saturday |
| Saturday Act hour | 0...23 | h | | 8 | Activation hour time for Saturday |
| Saturday Act Mn | 0...59 | min | | 0 | Activation minute time for Saturday |
| Saturday off delay | 1...1440 | min | 1 | 60 | Activation duration for Saturday |
| Sunday Act enable | 0=False<br>1=True | | | false | Activation / deactivation need on Sunday |
| Sunday Act hour | 0...23 | h | | 8 | Activation hour time for Sunday |
| Sunday Act Mn | 0...59 | min | | 0 | Activation minute time for Sunday |
| Sunday off delay | 1...1440 | min | 1 | 60 | Activation duration for Sunday |

### 3.20.3.8 DTMGAPC Monitored data

**Table 214: DTMGAPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| DTMGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 3.20.4 Calendar function CALGAPC (ANSI CAL)

### 3.20.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Calendar function | CALGAPC | CAL | CAL |

### 3.20.4.2 Function block

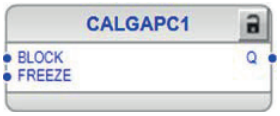



*Figure 131: Function block*

### 3.20.4.3 Functionality

The calendar function CALGAPC is used to activate a function output at a set activation date of the calendar year. The output remains activated till the set deactivation date of the calendar year.

### 3.20.4.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of CALGAPC can be described with a module diagram.

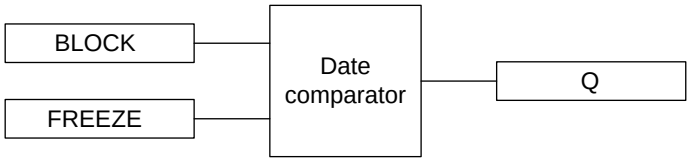



*Figure 132: Functional module diagram*

**Date comparator**

This module compares the current date (excluding the calendar year) with the set activation and deactivation date and month settings. If the system date and month

are the same or greater than *Activation day* and *Activation month* settings, output Q is activated and remains active till the date reaches the set *Deactivation day* and *Deactivation month* settings.

Activation of the BLOCK input deactivates the function output whereas the activation of the FREEZE input freezes the output. The BLOCK input always has a higher priority than the FREEZE input.

The module automatically handles the leap day and different month lengths.

- The function output remains active during the leap day if the leap day falls within the set activation period.
- If the set *Activation day* is not a valid date (for example, 31st April), then the output does not activate.
- If the set *Deactivation day* is not a valid date (for example, 31st April), then the last date of the month is considered.

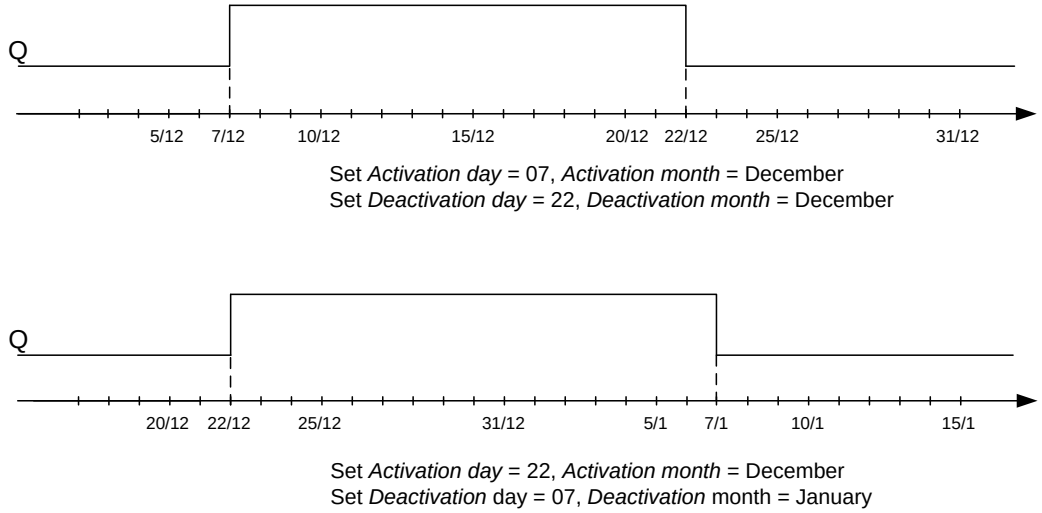



*Figure 133: Examples of how output Q is activated for different settings*

### 3.20.4.5 Application

The function activates an output for a specific set duration of the calendar year.

Consider an application where the output of the daily timer function DTMGAPC needs to be activated only for specific days of the calendar year. The output of CALGAPC can be connected to the BLOCK input of DTMGAPC (using NOT gate) so that DTMGAPC activates only for the duration defined by CALGAPC.




*Figure 134: Example of Calendar function usage*

### 3.20.4.6 Signals

**CALGAPC Input signals**

**Table 215: CALGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for binary output |
| FREEZE | BOOLEAN | 0=False | Freeze signal for binary output |

**CALGAPC Output signals**

**Table 216: CALGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Output status |

### 3.20.4.7 CALGAPC Settings

**Table 217: CALGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Activation day | 1...31 | | | 1 | Activation day |
| Activation month | 1=January<br>2=February<br>3=March<br>4=April<br>5=May<br>6=June<br>7=July<br>8=August<br>9=September<br>10=October<br>11=November<br>12=December | | | 1=January | Activation month |
| Deactivation day | 1...31 | | | 31 | Deactivation day |
| Deactivation month | 1=January<br>2=February<br>3=March<br>4=April<br>5=May<br>6=June<br>7=July<br>8=August<br>9=September<br>10=October<br>11=November | | | 1=January | Deactivation month |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 12=December | | | | |

### 3.20.4.8 CALGAPC Monitored data

**Table 218: CALGAPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| CALGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 3.20.5 Time delay off, eight channels TOFGAPC (ANSI 62TOF)

### 3.20.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Time delay off, eight channels | TOFGAPC | TOF | 62TOF |

### 3.20.5.2 Function block

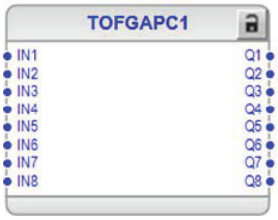



*Figure 135: Function block*

### 3.20.5.3 Functionality

The time delay off, eight channels, function TOFGAPC can be used, for example, for a drop-off-delayed output related to the input signal. The function contains eight independent timers. There is a settable delay in the timer. Once the input is activated, the output is set immediately. When the input is cleared, the output stays on until the time set with the *Off delay time* setting has elapsed.

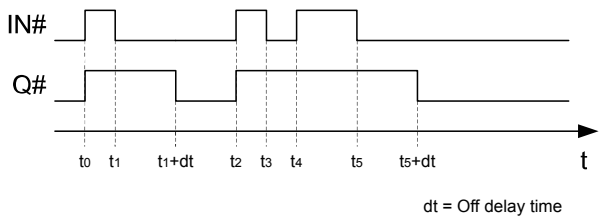



*Figure 136: Timer operation*

### 3.20.5.4 Signals

**Table 219: TOFGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 status |
| IN2 | BOOLEAN | 0=False | Input 2 status |
| IN3 | BOOLEAN | 0=False | Input 3 status |
| IN4 | BOOLEAN | 0=False | Input 4 status |
| IN5 | BOOLEAN | 0=False | Input 5 status |
| IN6 | BOOLEAN | 0=False | Input 6 status |
| IN7 | BOOLEAN | 0=False | Input 7 status |
| IN8 | BOOLEAN | 0=False | Input 8 status |

**Table 220: TOFGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Output 1 status |
| Q2 | BOOLEAN | Output 2 status |
| Q3 | BOOLEAN | Output 3 status |
| Q4 | BOOLEAN | Output 4 status |
| Q5 | BOOLEAN | Output 5 status |
| Q6 | BOOLEAN | Output 6 status |
| Q7 | BOOLEAN | Output 7 status |
| Q8 | BOOLEAN | Output 8 status |

### 3.20.5.5 Settings

**Table 221: TOFGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Off delay time 1 | 0...3600000 | ms | 1 | 0 | Off delay time |
| Off delay time 2 | 0...3600000 | ms | 1 | 0 | Off delay time |
| Off delay time 3 | 0...3600000 | ms | 1 | 0 | Off delay time |
| Off delay time 4 | 0...3600000 | ms | 1 | 0 | Off delay time |
| Off delay time 5 | 0...3600000 | ms | 1 | 0 | Off delay time |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Off delay time 6 | 0...3600000 | ms | 1 | 0 | Off delay time |
| Off delay time 7 | 0...3600000 | ms | 1 | 0 | Off delay time |
| Off delay time 8 | 0...3600000 | ms | 1 | 0 | Off delay time |

### 3.20.5.6 Monitored data

**Table 222: TOFGAPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| T_LEFT1 | FLOAT32 | 0...3600 | s | Time left 1 |
| T_LEFT2 | FLOAT32 | 0...3600 | s | Time left 2 |
| T_LEFT3 | FLOAT32 | 0...3600 | s | Time left 3 |
| T_LEFT4 | FLOAT32 | 0...3600 | s | Time left 4 |
| T_LEFT5 | FLOAT32 | 0...3600 | s | Time left 5 |
| T_LEFT6 | FLOAT32 | 0...3600 | s | Time left 6 |
| T_LEFT7 | FLOAT32 | 0...3600 | s | Time left 7 |
| T_LEFT8 | FLOAT32 | 0...3600 | s | Time left 8 |

### 3.20.5.7 Technical data

**Table 223: TOFGAPC Technical data**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

### 3.20.5.8 Technical revision history

**Table 224: TOFGAPC Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL2 | D | Changed the *Off delay time* step to 1 ms |

## 3.20.6 Time delay on, eight channels TONGAPC (ANSI 62TON)

### 3.20.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Time delay on, eight channels | TONGAPC | TON | 62TON |

### 3.20.6.2 Function block

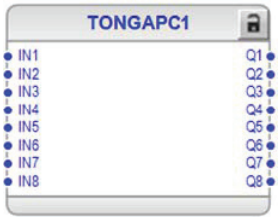



*Figure 137: Function block*

### 3.20.6.3 Functionality

The time delay on, eight channels, function TONGAPC can be used, for example, for time-delaying the output related to the input signal. TONGAPC contains eight independent timers. The timer has a settable time delay. Once the input is activated, the output is set after the time set by the *On delay time* setting has elapsed.

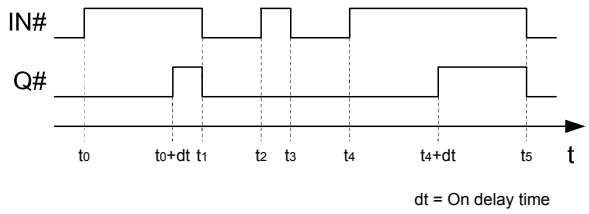



*Figure 138: Timer operation*

### 3.20.6.4 Signals

**Table 225: TONGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | Input 1 |
| IN2 | BOOLEAN | 0=False | Input 2 |
| IN3 | BOOLEAN | 0=False | Input 3 |
| IN4 | BOOLEAN | 0=False | Input 4 |
| IN5 | BOOLEAN | 0=False | Input 5 |
| IN6 | BOOLEAN | 0=False | Input 6 |
| IN7 | BOOLEAN | 0=False | Input 7 |
| IN8 | BOOLEAN | 0=False | Input 8 |

**Table 226: TONGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Output 1 |
| Q2 | BOOLEAN | Output 2 |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| Q3 | BOOLEAN | Output 3 |
| Q4 | BOOLEAN | Output 4 |
| Q5 | BOOLEAN | Output 5 |
| Q6 | BOOLEAN | Output 6 |
| Q7 | BOOLEAN | Output 7 |
| Q8 | BOOLEAN | Output 8 |

### 3.20.6.5 Settings

**Table 227: TONGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| On delay time 1 | 0...3600000 | ms | 1 | 0 | On delay time |
| On delay time 2 | 0...3600000 | ms | 1 | 0 | On delay time |
| On delay time 3 | 0...3600000 | ms | 1 | 0 | On delay time |
| On delay time 4 | 0...3600000 | ms | 1 | 0 | On delay time |
| On delay time 5 | 0...3600000 | ms | 1 | 0 | On delay time |
| On delay time 6 | 0...3600000 | ms | 1 | 0 | On delay time |
| On delay time 7 | 0...3600000 | ms | 1 | 0 | On delay time |
| On delay time 8 | 0...3600000 | ms | 1 | 0 | On delay time |

### 3.20.6.6 Monitored data

**Table 228: TONGAPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| T_LEFT1 | FLOAT32 | 0...3600 | s | Time left 1 |
| T_LEFT2 | FLOAT32 | 0...3600 | s | Time left 2 |
| T_LEFT3 | FLOAT32 | 0...3600 | s | Time left 3 |
| T_LEFT4 | FLOAT32 | 0...3600 | s | Time left 4 |
| T_LEFT5 | FLOAT32 | 0...3600 | s | Time left 5 |
| T_LEFT6 | FLOAT32 | 0...3600 | s | Time left 6 |
| T_LEFT7 | FLOAT32 | 0...3600 | s | Time left 7 |
| T_LEFT8 | FLOAT32 | 0...3600 | s | Time left 8 |

### 3.20.6.7 Technical data

**Table 229: TONGAPC Technical data**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

#### 3.20.6.8 Technical revision history

**Table 230: TONGAPC Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL2 | D | Changed the *On delay time* step to 1 ms |

## 3.20.7 SR flip-flop, eight channels, nonvolatile SRGAPC (ANSI SR)

### 3.20.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| SR flip-flop, eight channels, nonvolatile | SRGAPC | SR | SR |

### 3.20.7.2 Function block

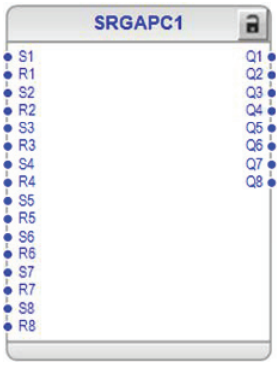



*Figure 139: Function block*

### 3.20.7.3 Functionality

The SR flip-flop, eight channels, nonvolatile function SRGAPC is a simple SR flip-flop with a memory that can be set or that can reset an output from the S# or R# inputs, respectively. The function contains eight independent set-reset flip-flop latches where the SET input has the higher priority over the RESET input. The status of each Q# output is retained in the nonvolatile memory. The individual reset for each Q# output is available on the LHMI or through tool via communication.

**Table 231: Truth table for SRGAPC**

| S# | R# | Q# |
|---|---|---|
| 0 | 0 | 0[1] |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

### 3.20.7.4 Signals

**Table 232: SRGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| S1 | BOOLEAN | 0=False | Set Q1 output when set |
| R1 | BOOLEAN | 0=False | Resets Q1 output when set |
| S2 | BOOLEAN | 0=False | Set Q2 output when set |
| R2 | BOOLEAN | 0=False | Resets Q2 output when set |
| S3 | BOOLEAN | 0=False | Set Q3 output when set |
| R3 | BOOLEAN | 0=False | Resets Q3 output when set |
| S4 | BOOLEAN | 0=False | Set Q4 output when set |
| R4 | BOOLEAN | 0=False | Resets Q4 output when set |
| S5 | BOOLEAN | 0=False | Set Q5 output when set |
| R5 | BOOLEAN | 0=False | Resets Q5 output when set |
| S6 | BOOLEAN | 0=False | Set Q6 output when set |
| R6 | BOOLEAN | 0=False | Resets Q6 output when set |
| S7 | BOOLEAN | 0=False | Set Q7 output when set |
| R7 | BOOLEAN | 0=False | Resets Q7 output when set |
| S8 | BOOLEAN | 0=False | Set Q8 output when set |
| R8 | BOOLEAN | 0=False | Resets Q8 output when set |

[1] Keep state/no change

**Table 233: SRGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Q1 status |
| Q2 | BOOLEAN | Q2 status |
| Q3 | BOOLEAN | Q3 status |
| Q4 | BOOLEAN | Q4 status |
| Q5 | BOOLEAN | Q5 status |
| Q6 | BOOLEAN | Q6 status |
| Q7 | BOOLEAN | Q7 status |
| Q8 | BOOLEAN | Q8 status |

### 3.20.7.5 Settings

**Table 234: SRGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset Q1 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q1 output when set |
| Reset Q2 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q2 output when set |
| Reset Q3 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q3 output when set |
| Reset Q4 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q4 output when set |
| Reset Q5 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q5 output when set |
| Reset Q6 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q6 output when set |
| Reset Q7 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q7 output when set |
| Reset Q8 | 0=Cancel<br>1=Reset | | | 0=Cancel | Resets Q8 output when set |

## 3.20.8 Boolean value event creation MVGAPC (ANSI MV)

### 3.20.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Boolean value event creation | MVGAPC | MV | MV |

### 3.20.8.2 Function block

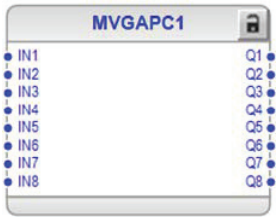



*Figure 140: Function block*

### 3.20.8.3 Functionality

The boolean value event creation function MVGAPC is used for user logic bits. Each input state is directly copied to the output state. This allows the creating of events from advanced logic combinations.

### 3.20.8.4 Signals

**Table 235: MVGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0=False | IN1 status |
| IN2 | BOOLEAN | 0=False | IN2 status |
| IN3 | BOOLEAN | 0=False | IN3 status |
| IN4 | BOOLEAN | 0=False | IN4 status |
| IN5 | BOOLEAN | 0=False | IN5 status |
| IN6 | BOOLEAN | 0=False | IN6 status |
| IN7 | BOOLEAN | 0=False | IN7 status |
| IN8 | BOOLEAN | 0=False | IN8 status |

**Table 236: MVGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Q1 status |
| Q2 | BOOLEAN | Q2 status |
| Q3 | BOOLEAN | Q3 status |
| Q4 | BOOLEAN | Q4 status |
| Q5 | BOOLEAN | Q5 status |
| Q6 | BOOLEAN | Q6 status |
| Q7 | BOOLEAN | Q7 status |
| Q8 | BOOLEAN | Q8 status |

### 3.20.8.5 Settings

**Table 237: MVGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Description | | | | MVGAPC1 Q1 | Output description |
| Description | | | | MVGAPC1 Q2 | Output description |
| Description | | | | MVGAPC1 Q3 | Output description |
| Description | | | | MVGAPC1 Q4 | Output description |
| Description | | | | MVGAPC1 Q5 | Output description |
| Description | | | | MVGAPC1 Q6 | Output description |
| Description | | | | MVGAPC1 Q7 | Output description |
| Description | | | | MVGAPC1 Q8 | Output description |

## 3.20.9 Integer value event creation MVI4GAPC (ANSI MVI4)

### 3.20.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Integer value event creation | MVI4GAPC | MVI4 | MVI4 |

### 3.20.9.2 Function block

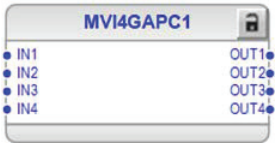



*Figure 141: Function block*

### 3.20.9.3 Functionality

The integer value event creation function MVI4GAPC is used for creation of the events from the integer values. The integer input value is received via `IN1...4` input. The integer output value is available on `OUT1...4` output.

The integer input range is from –2147483648 to 2147483647.

### 3.20.9.4 Signals

**Table 238: MVI4GAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | INT32 | 0 | Integer input value 1 |
| IN2 | INT32 | 0 | Integer input value 2 |
| IN3 | INT32 | 0 | Integer input value 3 |
| IN4 | INT32 | 0 | Integer input value 4 |

**Table 239: MVI4GAPC Output signals**

| Name | Type | Description |
|---|---|---|
| OUT1 | INT32 | Integer output value 1 |
| OUT2 | INT32 | Integer output value 2 |
| OUT3 | INT32 | Integer output value 3 |
| OUT4 | INT32 | Integer output value 4 |

## 3.20.10 Analog value event creation with scaling SCA4GAPC (ANSI SCA4)

### 3.20.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Analog value event creation with scaling | SCA4GAPC | SCA4 | SCA4 |

### 3.20.10.2 Function block

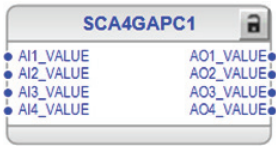



*Figure 142: Function block*

### 3.20.10.3 Functionality

The analog value event creation with scaling function SCA4GAPC is used for scaling the analog value. It allows creating events from analog values.

The analog value received via the AIn_VALUE input is scaled with the *Scale ratio n* setting. The scaled value is available on the AOn_VALUE output.

Analog input range is from –10000.0 to 10000.0.

Analog output range is from –2000000.0 to 2000000.0.

If the value of the AIn_VALUE input exceeds the analog input range, AOn_VALUE is set to 0.0.

If the result of AIn_VALUE multiplied by the Scale ratio n setting exceeds the analog output range, AOn_VALUE shows the minimum or maximum value, according to analog value range.

### 3.20.10.4 Signals

**Table 240: SCA4GAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| AI1_VALUE | FLOAT32 | 0.0 | Analog input value of channel 1 |
| AI2_VALUE | FLOAT32 | 0.0 | Analog input value of channel 2 |
| AI3_VALUE | FLOAT32 | 0.0 | Analog input value of channel 3 |
| AI4_VALUE | FLOAT32 | 0.0 | Analog input value of channel 4 |

**Table 241: SCA4GAPC Output signals**

| Name | Type | Description |
|---|---|---|
| AO1_VALUE | FLOAT32 | Analog value 1 after scaling |
| AO2_VALUE | FLOAT32 | Analog value 2 after scaling |
| AO3_VALUE | FLOAT32 | Analog value 3 after scaling |
| AO4_VALUE | FLOAT32 | Analog value 4 after scaling |

### 3.20.10.5 Settings

**Table 242: SCA4GAPC settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Scale ratio 1 | 0.001...1000.000 | | 0.001 | 1.000 | Scale ratio for analog value 1 |
| Scale ratio 2 | 0.001...1000.000 | | 0.001 | 1.000 | Scale ratio for analog value 2 |
| Scale ratio 3 | 0.001...1000.000 | | 0.001 | 1.000 | Scale ratio for analog value 3 |
| Scale ratio 4 | 0.001...1000.000 | | 0.001 | 1.000 | Scale ratio for analog value 4 |

## 3.20.11 16 settable real values SETRGAPC

### 3.20.11.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| 16 settable real values | SETRGAPC | SETRGAPC | SETRGAPC |

### 3.20.11.2 Function block




*Figure 143: Function block*

### 3.20.11.3 Functionality

The value of function outputs AO1_VALUE...AO16_VALUE can be set with settings *Set value 1...Set value 16*.

### 3.20.11.4 Signals

**Table 243: SETRGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| AO1_VALUE | FLOAT32 | Analog value 1 |
| AO2_VALUE | FLOAT32 | Analog value 2 |
| AO3_VALUE | FLOAT32 | Analog value 3 |
| AO4_VALUE | FLOAT32 | Analog value 4 |
| AO5_VALUE | FLOAT32 | Analog value 5 |
| AO6_VALUE | FLOAT32 | Analog value 6 |
| AO7_VALUE | FLOAT32 | Analog value 7 |
| AO8_VALUE | FLOAT32 | Analog value 8 |
| AO9_VALUE | FLOAT32 | Analog value 9 |
| AO10_VALUE | FLOAT32 | Analog value 10 |
| AO11_VALUE | FLOAT32 | Analog value 11 |
| AO12_VALUE | FLOAT32 | Analog value 12 |
| AO13_VALUE | FLOAT32 | Analog value 13 |
| AO14_VALUE | FLOAT32 | Analog value 14 |
| AO15_VALUE | FLOAT32 | Analog value 15 |
| AO16_VALUE | FLOAT32 | Analog value 16 |

### 3.20.11.5 Settings

**Table 244: SETRGAPC Non-group settings (Basic)**

| IEC name | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Set value 1 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 1 |
| Set value 2 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 2 |
| Set value 3 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 3 |
| Set value 4 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 4 |
| Set value 5 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 5 |
| Set value 6 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 6 |
| Set value 7 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 7 |
| Set value 8 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 8 |
| Set value 9 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 9 |
| Set value 10 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 10 |
| Set value 11 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 11 |
| Set value 12 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 12 |
| Set value 13 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 13 |
| Set value 14 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 14 |
| Set value 15 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 15 |
| Set value 16 | –2000000.000...2000000.000 | | 0.001 | 0 | Set value for analog value 16 |

## 3.20.12 16 settable 32-bit integer values SETI32GAPC

### 3.20.12.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| 16 settable 32-bit integer values | SETI32GAPC | SETI32GAPC | SETI32GAPC |

### 3.20.12.2 Function block




*Figure 144: Function block*

### 3.20.12.3 Functionality

The value of function outputs `IO1_VALUE...IO16_VALUE` can be set with settings *Set value 1...Set value 16*.

### 3.20.12.4 Signals

**Table 245: SETI32GAPC Output signals**

| Name | Type | Description |
|---|---|---|
| IO1_VALUE | INT32 | Integer value 1 |
| IO2_VALUE | INT32 | Integer value 2 |
| IO3_VALUE | INT32 | Integer value 3 |
| IO4_VALUE | INT32 | Integer value 4 |
| IO5_VALUE | INT32 | Integer value 5 |
| IO6_VALUE | INT32 | Integer value 6 |
| IO7_VALUE | INT32 | Integer value 7 |
| IO8_VALUE | INT32 | Integer value 8 |
| IO9_VALUE | INT32 | Integer value 9 |
| IO10_VALUE | INT32 | Integer value 10 |
| IO11_VALUE | INT32 | Integer value 11 |
| IO12_VALUE | INT32 | Integer value 12 |
| IO13_VALUE | INT32 | Integer value 13 |
| IO14_VALUE | INT32 | Integer value 14 |
| IO15_VALU | INT32 | Integer value 15 |
| IO16_VALUE | INT32 | Integer value 16 |

### 3.20.12.5 Settings

**Table 246: SETI32GAPC Non-group settings (Basic)**

| IEC name | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Set value 1 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 1 |
| Set value 2 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 2 |
| Set value 3 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 3 |
| Set value 4 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 4 |
| Set value 5 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 5 |
| Set value 6 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 6 |
| Set value 7 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 7 |
| Set value 8 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 8 |
| Set value 9 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 9 |
| Set value 10 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 10 |
| Set value 11 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 11 |
| Set value 12 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 12 |
| Set value 13 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 13 |
| Set value 14 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 14 |
| Set value 15 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 15 |
| Set value 16 | –2147483648...2147 483647 | | 1 | 0 | Set value for integer value 16 |

## 3.20.13 Generic control points SPCGAPC (ANSI SPCG)

### 3.20.13.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Generic control points | SPCGAPC | SPC | SPCG |

### 3.20.13.2 Function block

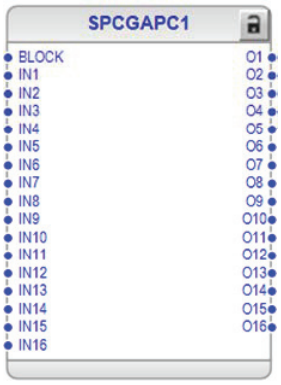



*Figure 145: Function block*

### 3.20.13.3 Functionality

The generic control points function SPCGAPC contains 16 independent control points. SPCGAPC offers the capability to activate its outputs through a local or remote control. The local control request can be issued through the buttons in the single-line diagram or via inputs and the remote control request through communication. The rising edge of the input signal is interpreted as a control request, and the output operation is triggered. When remote control requests are used the control points behaves as persistent.

The *Loc Rem restriction* setting is used for enabling or disabling the restriction for SPCGAPC to follow the R/L button state. If *Loc Rem restriction* is "True", as it is by default, the local or remote control operations are accepted according to the R/L button state.

Each of the 16 generic control point outputs has the *Operation mode*, *Pulse length* and *Description* setting. If *Operation mode* is "Toggle", the output state is toggled for every control request received. If Operation mode is "Pulsed", the output pulse of a preset duration (the *Pulse length* setting) is generated for every control request received. The *Description* setting can be used for storing information on the actual use of the control point in application, for instance.

For example, if the *Operation mode* is "Toggle", the output O# is initially “False”. The rising edge in IN# sets O# to “True”. The falling edge of IN# has no effect. Next rising edge of IN# sets O# to “False”.

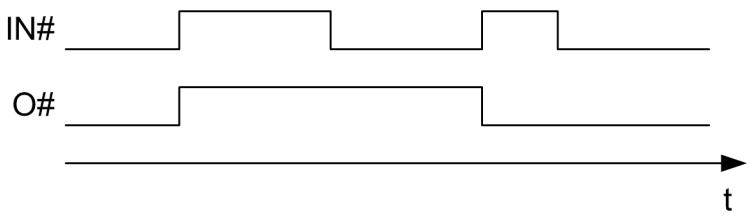



*Figure 146: Operation in "Toggle" mode*

The BLOCK input can be used for blocking the functionality of the outputs. The operation of the BLOCK input depends on the Operation mode setting. If Operation mode is "Toggle", the output state freezes and cannot be changed while the BLOCK

input is active. If *Operation mode* is "Pulsed", the activation of the BLOCK input resets the outputs to the "False" state and further control requests are ignored while the BLOCK input is active.

From the remote communication point of view SPCGAPC toggled operation mode is always working as persistent mode. The output O# follows the value written to the input IN#.

### 3.20.13.4 Signals

**Table 247: SPCGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| IN1 | BOOLEAN | 0=False | Input of control point 1 |
| IN2 | BOOLEAN | 0=False | Input of control point 2 |
| IN3 | BOOLEAN | 0=False | Input of control point 3 |
| IN4 | BOOLEAN | 0=False | Input of control point 4 |
| IN5 | BOOLEAN | 0=False | Input of control point 5 |
| IN6 | BOOLEAN | 0=False | Input of control point 6 |
| IN7 | BOOLEAN | 0=False | Input of control point 7 |
| IN8 | BOOLEAN | 0=False | Input of control point 8 |
| IN9 | BOOLEAN | 0=False | Input of control point 9 |
| IN10 | BOOLEAN | 0=False | Input of control point 10 |
| IN11 | BOOLEAN | 0=False | Input of control point 11 |
| IN12 | BOOLEAN | 0=False | Input of control point 12 |
| IN13 | BOOLEAN | 0=False | Input of control point 13 |
| IN14 | BOOLEAN | 0=False | Input of control point 14 |
| IN15 | BOOLEAN | 0=False | Input of control point 15 |
| IN16 | BOOLEAN | 0=False | Input of control point 16 |

**Table 248: SPCGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| O1 | BOOLEAN | Output 1 status |
| O2 | BOOLEAN | Output 2 status |
| O3 | BOOLEAN | Output 3 status |
| O4 | BOOLEAN | Output 4 status |
| O5 | BOOLEAN | Output 5 status |
| O6 | BOOLEAN | Output 6 status |
| O7 | BOOLEAN | Output 7 status |
| O8 | BOOLEAN | Output 8 status |
| O9 | BOOLEAN | Output 9 status |
| O10 | BOOLEAN | Output 10 status |
| O11 | BOOLEAN | Output 11 status |
| O12 | BOOLEAN | Output 12 status |
| O13 | BOOLEAN | Output 13 status |
| O14 | BOOLEAN | Output 14 status |
| O15 | BOOLEAN | Output 15 status |
| O16 | BOOLEAN | Output 16 status |

### 3.20.13.5 Settings

**Table 249: SPCGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Loc Rem restriction | 0=False<br>1=True | | | 1=True | Local remote switch restriction |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 1 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 2 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 3 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 4 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 5 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 6 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 7 | Generic control point description |
| Operation mode | 0=Pulsed | | | -1=Off | Operation mode for generic control point |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 1=Toggle/Persistent<br>-1=Off | | | | |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 8 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 9 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 10 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 11 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 12 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 13 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 14 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 15 | Generic control point description |
| Operation mode | 0=Pulsed<br>1=Toggle/Persistent<br>-1=Off | | | -1=Off | Operation mode for generic control point |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pulse length | 10...3600000 | ms | 10 | 1000 | Pulse length for pulsed operation mode |
| Description | | | | SPCGAPC1 Output 16 | Generic control point description |

## 3.20.14 Pulse counter for energy measurement PCGAPC

### 3.20.14.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Pulse counter for energy measurement | PCGAPC | PCGAPC | PCGAPC |

### 3.20.14.2 Function block

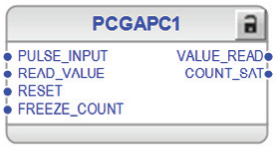



*Figure 147: Function block*

### 3.20.14.3 Functionality

The pulse counter for energy measurement function PCGAPC counts externally generated binary pulses, for example, pulses coming from an external energy meter, for the calculation of energy consumption values. The pulses are captured by the binary input module and read by PCGAPC. The number of pulses in the counter is then reported via the station bus to the automation system or read via the station monitoring system as a service value. The scaled value is also available over IEC 61850 communication.

The pulses are captured by the binary input module and read by PCGAPC with a frequency of up to 40 Hz. PCGAPC can also be used as a general-purpose counter.

### 3.20.14.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of PCGAPC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

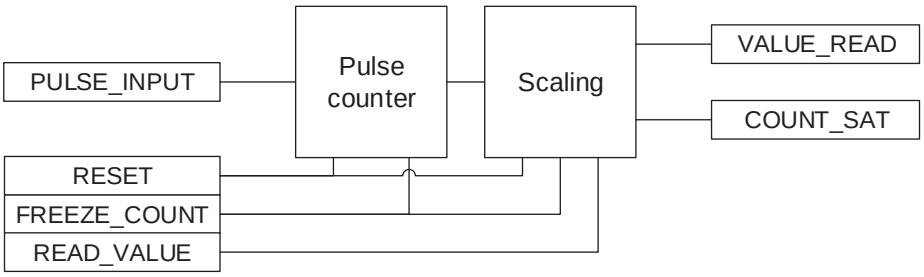



*Figure 148: Functional module diagram*

### Pulse counter

This module counts the number of pulses available at PULSE_INPUT. The count value is incremented depending upon *Count criteria* setting.

**Table 250: Relation between setting Count criteria and count value behavior**

| *Count criteria* values | PULSE_INPUT count value |
|---|---|
| Rising edge | Count value is incremented on the rising edge of PULSE_INPUT. |
| Falling edge | Count value is incremented on the falling edge of PULSE_INPUT. |
| On change | Count value is incremented each time a rising edge or falling edge is available at PULSE_INPUT. |
| Freeze | Counting is frozen. |

The count value is available at COUNT_VALUE in the Monitored data view and is stored in a nonvolatile memory. This output is updated cyclically and sent to the station HMI over various communication protocols, depending on the Reporting interval setting. The start of *Reporting interval* corresponds to the start of the function operation in the protection relay.

Binary output `VALUE_READ` activates for a fixed 200 ms each time the reporting timer completes its cycle. It is also possible to update COUNT_VALUE before completion of *Reporting interval* and make it available for communication by providing a minimum 1-second-long pulse at `READ_VALUE` input. Besides COUNT_VALUE activation, `READ_VALUE` also activates output `VALUE_READ` for 200 ms.

The activation of RESET resets COUNT_VALUE to zero. Activation of FREEZE_COUNT freezes further counting.

Changing *Count criteria* does not reset COUNT_VALUE.

### Scaling

This module scales the count value available at COUNT_VALUE. The scaling depends on the *Unit selection* setting. When the function is used for general-purpose counting, *Unit selection* is set as "Count" and the count value is multiplied by the *Pulse quantity* setting to calculate the scaled value.

When using this function for energy measurement, *Unit selection* is set accordingly, that is, real, active or apparent energy and the count value is divided by *Impulse ratio* to calculate the scaled value. The prefix for unit of *Impulse ratio* is defined by setting *Impulse ratio prefix*.

The energy meter defines the impulse ratio (also known as meter constant), that is, it indicates the number of pulses the meter generated per kWh (or MWh). *Impulse ratio* must be set based on the energy meter used.

For example, if the impulse ratio is 100 impulses / MWh, set *Impulse ratio* as 100 and *Impulse ratio prefix* as Mega.

If the impulse ratio is 800 impulses / KWh, set *Impulse ratio* as 800 and *Impulse ratio prefix* as Kilo.

The scaled value is available at SCALED_VALUE in the Monitored data view. This output is updated cyclically and sent to the station HMI over various communication protocols depending on *Reporting interval* setting. The start of *Reporting interval* corresponds to the start of the function operation in the protection relay.

The activation of RESET resets SCALED_VALUE to zero.

If *Pulse quantity*, *Impulse ratio* or *Impulse ratio prefix* is changed in between, SCALED_VALUE is updated immediately based on the new setting.

Binary output VALUE_READ activates for a fixed 200 ms each time the reporting timer completes its cycle.

It is also possible to update SCALED_VALUE before completion of *Reporting interval* and make it available for communication by providing a pulse at READ_VALUE input. The pulse width should be greater than 1 s. Besides updating SCALED_VALUE, the READ_VALUE activation also activates output VALUE_READ for 200 ms.

Activation of FREEZE_COUNT input immediately updates SCALED_VALUE output with a pulse at VALUE_READ output.

Output COUNT_SAT activates when either SCALED_VALUE or COUNT_VALUE exceeds the count range and it is not possible to count further.

*Figure 149* and *Figure 150* explain PCGAPC operation.

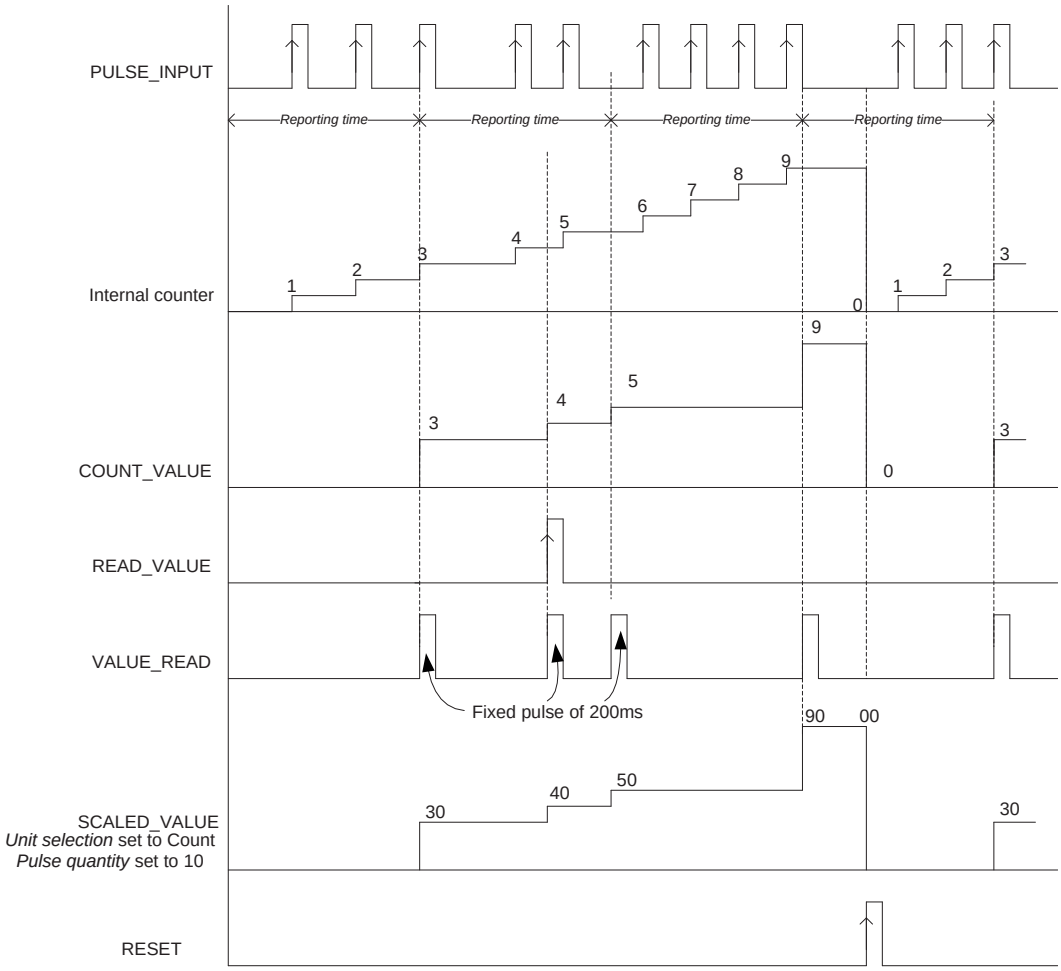



*Figure 149: PCGAPC operation*

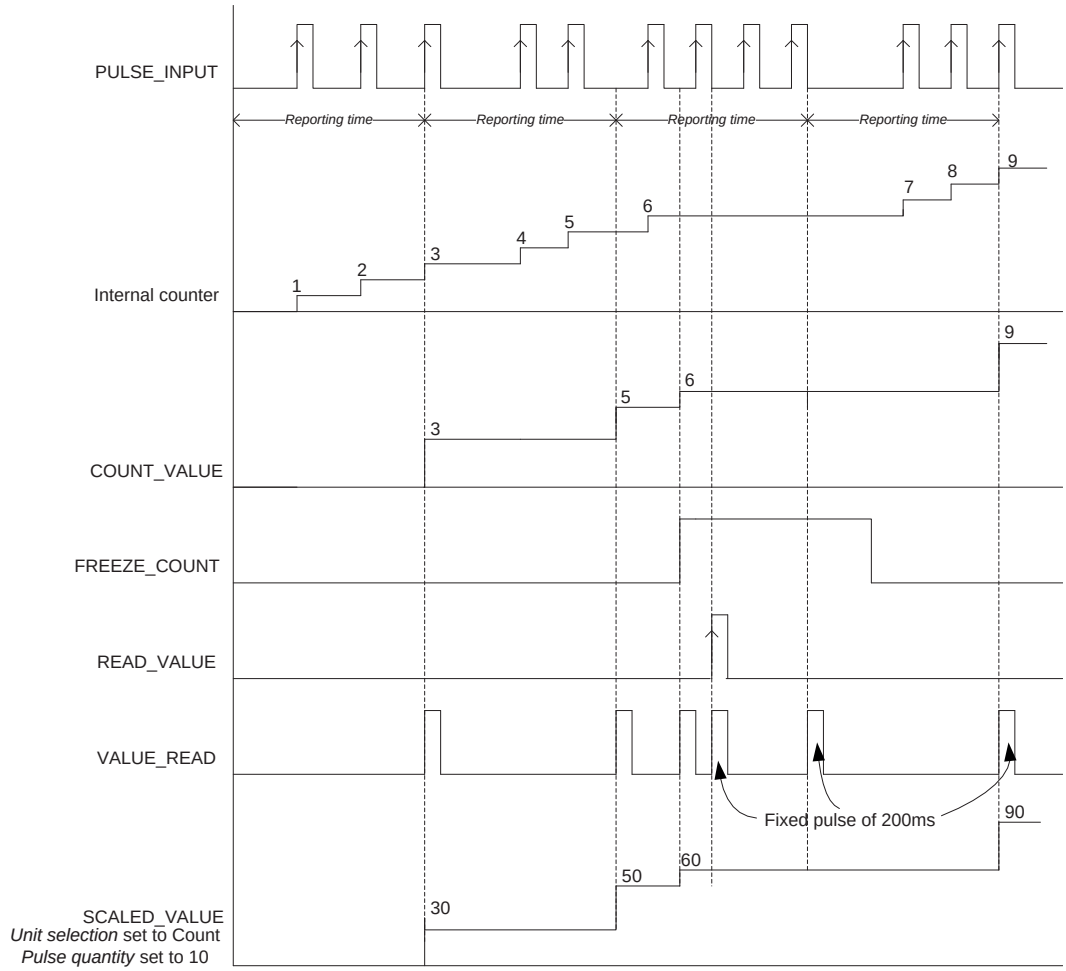



*Figure 150: Behavior of FREEZE_COUNT input*

### 3.20.14.5 Application

PCGAPC counts externally generated binary pulses, for example, pulses coming from an external energy meter, for the calculation of energy consumption values. The pulses are captured by the binary input module and read by PCGAPC with a frequency of up to 40 Hz. The number of pulses in the counter is then reported via the station bus to the substation automation system or read via the station monitoring system as a service value. When using IEC 61850, a scaled service value is available over the station bus.

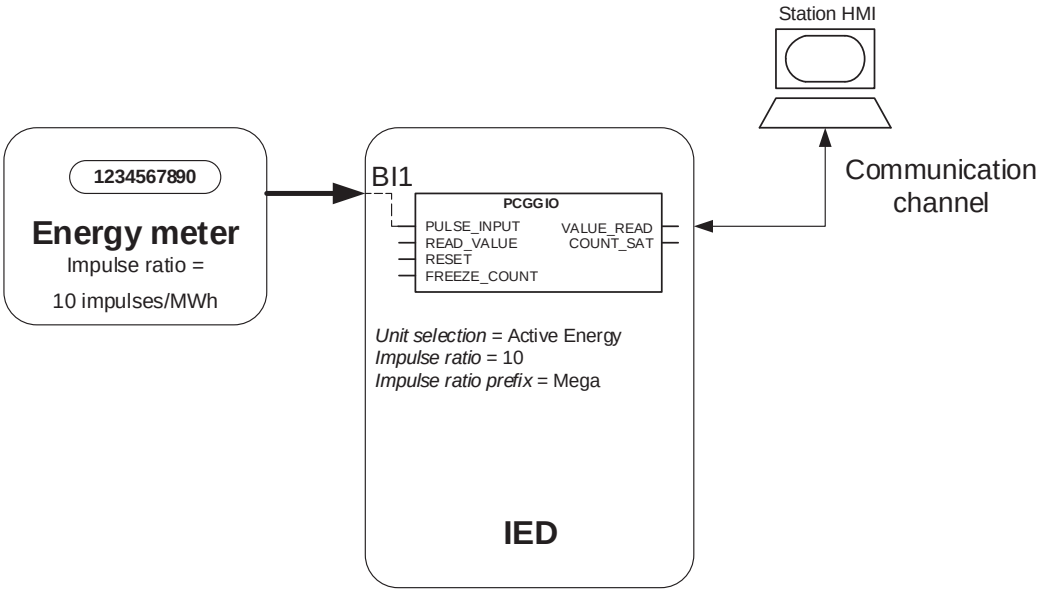



*Figure 151: Typical application of PCGAPC*

PCGAPC can also be used as a general-purpose counter.

## 3.20.14.6 Signals

### PCGAPC Input signals

**Table 251: PCGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| PULSE_INPUT | BOOLEAN | 0=False | Connect binary input channel for counting |
| READ_VALUE | BOOLEAN | 0=False | Initiates an additional pulse counter reading |
| RESET | BOOLEAN | 0=False | Resets pulse counter value |
| FREEZE_COUNT | BOOLEAN | 0=False | Freeze counting of pulse available at input |

### PCGAPC Output signals

**Table 252: PCGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| VALUE_READ | BOOLEAN | Scaled value is updated |
| COUNT_SAT | BOOLEAN | Counter reaches saturation limit and cannot count further |

### 3.20.14.7 PCGAPC Settings

**Table 253: PCGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Count criteria | 1=Freeze<br>2=Rising edge<br>3=Falling edge<br>4=On change | | | 2=Rising edge | Pulse counter criteria |
| Unit selection | 1=Count<br>71=Apparent energy<br>72=Active energy<br>73=Reactive energy | | | 1=Count | Measured quantity for SCALED_VALUE output |
| Impulse ratio | 1...9999 | | 1 | 1 | Energy meter constant |
| Impulse ratio prefix | 0=No prefix<br>3=k<br>6=M | | | 0=No prefix | Prefix for unit of impulse ratio |
| Pulse quantity | 0.0001...90000.0000 | | 0.0001 | 1.0000 | Factor to be multiplied with COUNT_VALUE |
| Reporting interval | 0=1 minute<br>1=5 minutes<br>2=10 minutes<br>3=15 minutes<br>4=30 minutes<br>5=60 minutes<br>6=180 minutes | | | 0=1 minute | Reporting interval for counter value |

### 3.20.14.8 PCGAPC Monitored data

**Table 254: PCGAPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| COUNT_VALUE | INT64 | 0...2147483647 | da | Actual pulse counter value |
| SCALED_VALUE | FLOAT32 | 0.0000...1000.0000 | | Scaled value derived from COUNT_VALUE |

## 3.20.15 Hotline tag HLTGAPC

### 3.20.15.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Hotline tag | HLTGAPC | HLTGAPC | HLTGAPC |

### 3.20.15.2 Function block




*Figure 152: Function block*

### 3.20.15.3 Functionality

The hotline tag function HLTGAPC is used to block all reclosing of the breaker, from both local and remote sources, when activated. When the function is activated locally, it can only be reset locally. If activated remotely, it can be reset depending on the *Remote tag mode* setting.

### 3.20.15.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off". When the *Operation* setting is changed from "off" to "on", the monitored variable TAG_SOURCE is set to “None” and saved to a nonvolatile memory.

When the *Operation* setting is "on" and a reboot occurs, the TAG_SOURCE variable is read from the nonvolatile memory.

The operation of HLTGAPC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

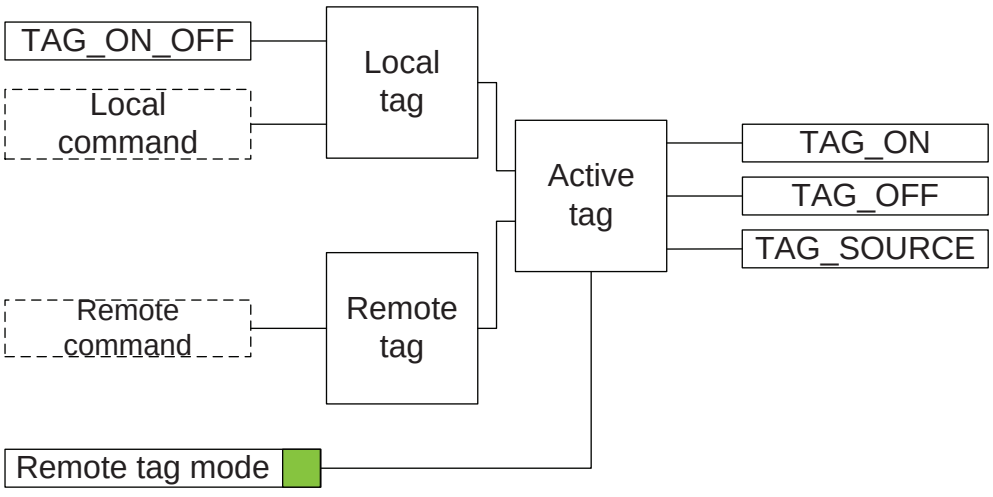



*Figure 153: Functional module diagram*

#### Local tag

Local tag is activated or deactivated on rising edge detection of `TAG_ON_OFF` input or with a local command from the LHMI when the protection relay is in local mode.

If a rising edge tag is detected locally, and the status of the nonvolatile variable TAG_SOURCE is “None”, the tag is locally activated. TAG_SOURCE changes to “Local” while TAG_ON is set to TRUE and TAG_OFF to FALSE.

If a rising edge tag is detected locally, and the status of TAG_SOURCE is “Local”, the tag is locally deactivated. TAG_SOURCE changes to “None” while TAG_ON is set to FALSE and TAG_OFF to TRUE.

When TAG_SOURCE is “Remote” and the *Remote tag mode* setting is "Untag Rem only", all local commands are prohibited. However, when the *Remote tag mode* setting is "Untag Loc or Rem", deactivation can be done locally.

**Remote tag**

Remote tag is activated or deactivated on rising edge detection through a communication channel in remote mode.

If a rising edge tag is detected remotely, and the status of the nonvolatile variable TAG_SOURCE is “None”, the tag is remotely activated. TAG_SOURCE changes to “Remote” while TAG_ON is set to TRUE and TAG_OFF to FALSE.

If a rising edge tag is detected remotely, and the status of TAG_SOURCE is “Remote”, the tag is remotely deactivated. TAG_SOURCE changes to “None” while TAG_ON is set to FALSE and TAG_OFF to TRUE.

If TAG_SOURCE is “Local”, remote commands are always prohibited.

### 3.20.15.5 Application

HLTGAPC is used to prevent the protection relay from reclosing and re-energizing a feeder where maintenance is performed. While HLTGAPC is active, no reclosing is allowed regardless of whether it is initiated through a protection trip, requested locally through the LHMI, or remotely through a communications command.

In order to operate correctly, HLTGAPC must be properly configured with Application Configuration. The TAG_ON and TAG_OFF outputs are connected where they can block or enable any reclosing that is configured. Typically, TAG_ON can be used on a recloser function block to inhibit reclosing and TAG_OFF can be used on a circuit breaker function block to enable closing.

A LED or a button on the LHMI can be used to indicate that the HLTGAPC condition is active. HLTGAPC can be activated, and the panel tagged, from the LHMI or from a remote communications command. The protection relay retains the original source (local or remote) of HLTGAPC and allows HLTGAPC to be deactivated only from the same source. That is, a locally initiated HLTGAPC can only be deactivated locally and a remotely initiated HLTGAPC can only be deactivated remotely. An exception to this rule allowing remotely initiated HLTGAPC commands to be deactivated locally can be made by changing the *Remote tag mode* setting from the default "Untag Rem only" to "Untag Loc or Rem". It is not possible to allow locally initiated HLTGAPC to be deactivated remotely.

As an alternative to using a button to activate HLTGAPC locally, the function can be activated from the Control menu of the LHMI.

The HLTGAPC status and the original source of the function are retained if power is removed and restored or through any other re-initialization of the protection relay. The HLTGAPC condition prior to the protection relay's reboot is automatically restored after the protection relay re-initializes.

The tag activation, deactivation and status information can be configured through the Graphical Display Editor (GDE).

### 3.20.15.6 Signals

#### HLTGAPC Input signals

**Table 255: HLTGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| TAG_ON_OFF | BOOLEAN | 0=False | Toggles the local tag on/off with each rising edge |

#### HLTGAPC Output signals

**Table 256: HLTGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| TAG_ON | BOOLEAN | Hotline tag active |
| TAG_OFF | BOOLEAN | Hotline tag is not active |

### 3.20.15.7 HLTGAPC Settings

**Table 257: HLTGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Remote tag mode | 1=Untag Rem only<br>2=Untag Loc or Rem | | | 1=Untag Rem only | Deactivation mode for remotely set hotline tag |

### 3.20.15.8 HLTGAPC Monitored data

**Table 258: HLTGAPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TAG_SOURCE | Enum | 0=None<br>1=Local<br>2=Remote | | Source of active hotline tag |
| HLTGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 3.20.16 Voltage switch VMSWI (ANSI VSWI)

### 3.20.16.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Voltage switch | VMSWI | VSWI | VSWI |

### 3.20.16.2 Function block

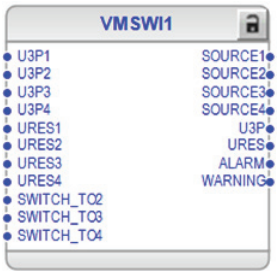



*Figure 154: Function block*

### 3.20.16.3 Functionality

The voltage switch function VMSWI performs the switching function between up to four voltage groups (Bus1, Bus 2, Bus 3 and Bus 4).

Residual voltage input can be optional and depends of the application configuration. The switching operation can also be associated with the residual voltage if available.

The calculated components U+, U- and $U_0$ and the calculated P2P / P2E (depending of the wye/delta mode) are switch-controlled as well.

### 3.20.16.4 Analog channel configuration

VMSWI has eight analog group inputs which must be properly configured. All inputs can be connected to GRPOFF.

**Table 259: Analog inputs**

| Input | Description |
|---|---|
| U3P1 [1] | Three-phase voltages |
| U3P2 [1] | Three-phase voltages |
| U3P3 [1] | Three-phase voltages |
| U3P4 [1] | Three-phase voltages |
| URES1 [1] | Residual voltage (measured or calculated) |
| URES2 [1] | Residual voltage (measured or calculated) |

*Table continues on the next page*

[1] Can be connected to GRPOFF

| Input | Description |
|---|---|
| URES3 [1] | Residual voltage (measured or calculated) |
| URES4 [1] | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

**Table 260: Special conditions**

| Condition | Description |
|---|---|
| U3P1/U3P2/U3P3/U3P4 connected to real measurements | The function requires that at least one voltage channel is connected. The function requires that all the U3Px that are connected to real source must be capable of providing (at least) the same data that the default source U3P1 is capable of. E.g. if the source UTVTR conneted to U3P1 has two inputs (e.g. UL1, UL2) connected then others need to also have at least two inputs connected (e.g. UL1, UL2 or UL2, UL3 or UL3, UL1). |
| URES1/URES2/URES3/URES4 calculated | The function requires that all three voltage channels are connected to calculate the residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

### 3.20.16.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

For this function, the setting is hidden and fixed to "on".

The switch logic depends on inputs SWITCH_TO2, SWITCH_TO3 and SWITCH_TO4. Source 1 is selected as default and switching is done on increased priority.

GRPOFF signal must be connected to unused voltage inputs. GRPOFF signal is available as output from the Protection function block.

**Table 261: Switching operation**

| Control input signals | | | Outputs | | | | | |
|---|---|---|---|---|---|---|---|---|
| SWITCH_TO2 | SWITCH_TO3 | SWITCH_TO4 | SOURCE1 | SOURCE2 | SOURCE3 | SOURCE4 | Source for U3P | Source for URES |
| FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | U3P1 | URES1 |
| TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | U3P2 | URES2 |
| x [1] | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | U3P3 | URES3 |
| x [1] | x [1] | TRUE | FALSE | FALSE | FALSE | TRUE | U3P4 | URES4 |

[1] No difference

If the numbers of channels connected to U3P1...U3P4 and URES1...URES4 does not match with the number of connected SWITCH_TOx inputs, the configuration of the function fails.

Outputs ALARM and URES_ALARM indicate bad quality data of system measurements for selected U3P and URES, respectively.

Outputs WARNING and URES_WARNING indicate questionable quality data of system measurements for selected U3P and URES, respectively.

Depending on the connected U3P channels to the voltage switch, the *Primary voltage* settings between the source U3P must match. Respectively, depending on the connected URES channels, the *Primary voltage* settings between the source URES must match. Setting validation for the primary voltages fails unless they are all stored simultaneously to the protection relay.

### 3.20.16.6 Signals

**Table 262: VMSWI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P1 | SIGNAL | - | Three-phase voltages 1 |
| U3P2 | SIGNAL | - | Three-phase voltages 2 |
| U3P3 | SIGNAL | - | Three-phase voltages 3 |
| U3P4 | SIGNAL | - | Three-phase voltages 4 |
| URES1 | SIGNAL | - | Residual voltage 1 |
| URES2 | SIGNAL | - | Residual voltage 2 |
| URES3 | SIGNAL | - | Residual voltage 3 |
| URES4 | SIGNAL | - | Residual voltage 4 |
| SWITCH_TO2 | BOOLEAN | 0=False | Switch to source 2 |
| SWITCH_TO3 | BOOLEAN | 0=False | Switch to source 3 |
| SWITCH_TO4 | BOOLEAN | 0=False | Switch to source 4 |

**Table 263: VMSWI Output signals**

| Name | Type | Description |
|---|---|---|
| SOURCE1 | BOOLEAN | Selected voltage source is source 1 |
| SOURCE2 | BOOLEAN | Selected voltage source is source 2 |
| SOURCE3 | BOOLEAN | Selected voltage source is source 3 |
| SOURCE4 | BOOLEAN | Selected voltage source is source 4 |
| U3P | SIGNAL | Three-phase voltages |
| URES | SIGNAL | Residual voltage |
| ALARM | BOOLEAN | Alarm |
| WARNING | BOOLEAN | Warning |

### 3.20.16.7 VMSWI Monitored data

**Table 264: VMSWI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SWITCH_POS | Enum | 1=Source 1<br>2=Source 2<br>3=Source 3<br>4=Source 4 | | Switch position |

## 3.20.17 Current switch CMSWI

### 3.20.17.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current switch | CMSWI | CMSWI | CMSWI |

### 3.20.17.2 Function block

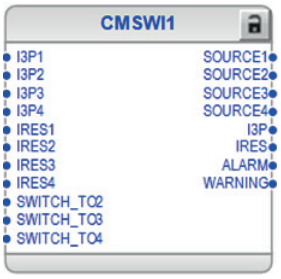



*Figure 155: Function block*

### 3.20.17.3 Functionality

The current switch function CMSWI performs the switching function between up to four current groups (Bus1, Bus 2, Bus 3 and Bus 4). The residual current input is optional and depends of the application configuration. Switching operation can also be associated with the residual current if this is available.

### 3.20.17.4 Analog channel configuration

CMSWI has eight analog group inputs which must be properly configured. All inputs can be connected to `GRPOFF`.

**Table 265: Analog inputs**

| Input | Description |
|---|---|
| I3P1 [1] | Three-phase currents |
| I3P2 [1] | Three-phase currents |
| I3P3 [1] | Three-phase currents |
| I3P4 [1] | Three-phase currents |
| IRES1 [1] | Residual current (measured or calculated) |
| IRES2 [1] | Residual current (measured or calculated) |
| IRES3 [1] | Residual current (measured or calculated) |
| IRES4 [1] | Residual current (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

### 3.20.17.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

For this function, the setting is hidden and fixed to "on".

The switch logic depends on inputs SWITCH_TO2, SWITCH_TO3 and SWITCH_TO4. Source 1 is selected as default and switching is done on increased priority.

GRPOFF signal must be connected to unused current inputs. GRPOFF signal is available as output from the Protection function block.

**Table 266: Switching operation**

| Control input signals | | | Outputs | | | | | |
|---|---|---|---|---|---|---|---|---|
| SWITCH_TO 2 | SWITCH_TO 3 | SWITCH_TO 4 | SOURCE1 | SOURCE2 | SOURCE3 | SOURCE4 | Source for I3P | Source for IRES |
| FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | I3P1 | IRES1 |
| TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | I3P2 | IRES2 |
| x [1] | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | I3P3 | IRES3 |
| x [1] | x [1] | TRUE | FALSE | FALSE | FALSE | TRUE | I3P4 | IRES4 |

If the numbers of channels connected to I3P1...I3P4 and IRES1...IRES4 does not match with the number of connected SWITCH_TOx inputs, the configuration of the function fails.

Outputs ALARM and IRES_ALARM indicate bad quality data of system measurements for selected I3P and IRES, respectively.

Outputs WARNING and IRES_WARNING indicate questionable quality data of system measurements for selected I3P and IRES, respectively.

[1] Can be connected to GRPOFF
[1] No difference

Depending on the connected I3P channels to the current switch, the *Primary current* settings between the source `I3P` must match. Depending on the connected IRES channels, the *Primary current* settings between the source `IRES` must match. Setting validation for the primary current fails unless they are all stored simultaneously to the protection relay.

### 3.20.17.6 Signals

**Table 267: CMSWI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| I3P3 | SIGNAL | - | Three-phase currents 3 |
| I3P4 | SIGNAL | - | Three-phase currents 4 |
| IRES1 | SIGNAL | - | Residual current 1 |
| IRES2 | SIGNAL | - | Residual current 2 |
| IRES3 | SIGNAL | - | Residual current 3 |
| IRES4 | SIGNAL | - | Residual current 4 |
| SWITCH_TO2 | BOOLEAN | 0=False | Switch to source 2 |
| SWITCH_TO3 | BOOLEAN | 0=False | Switch to source 3 |
| SWITCH_TO4 | BOOLEAN | 0=False | Switch to source 4 |

**Table 268: CMSWI Output signals**

| Name | Type | Description |
|---|---|---|
| SOURCE1 | BOOLEAN | Selected current source is source 1 |
| SOURCE2 | BOOLEAN | Selected current source is source 2 |
| SOURCE3 | BOOLEAN | Selected current source is source 3 |
| SOURCE4 | BOOLEAN | Selected current source is source 4 |
| I3P | SIGNAL | Three-phase currents |
| IRES | SIGNAL | Residual current |
| ALARM | BOOLEAN | Alarm |
| WARNING | BOOLEAN | Warning |

### 3.20.17.7 CMSWI Monitored data

**Table 269: CMSWI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SWITCH_POS | Enum | 1=Source 1<br>2=Source 2 | | Switch position |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 3=Source 3<br>4=Source 4 | | |

## 3.20.18 Generic up-down counter UDFCNT

### 3.20.18.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Generic up-down counter | UDFCNT | UDCNT | UDCNT |

### 3.20.18.2 Function block

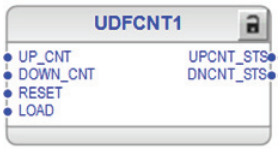



*Figure 156: Function block*

### 3.20.18.3 Functionality

The Generic up-down counter function UDFCNT counts up or down for each positive edge of the corresponding inputs. The counter value output can be reset to zero or preset to some other value if required.

The function provides up-count and down-count status outputs, which specify the relation of the counter value to a loaded preset value and to zero respectively.

### 3.20.18.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of UDFCNT can be described with a module diagram. All the modules in the diagram are explained in the next sections.

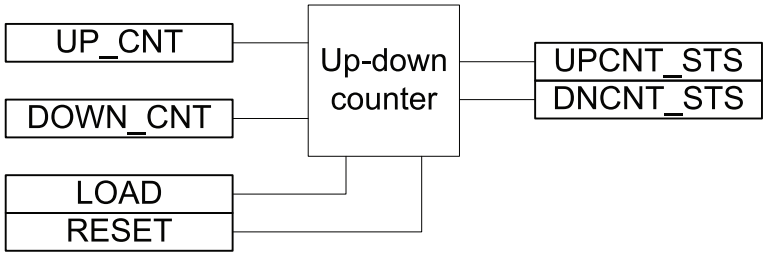



*Figure 157: Functional module diagram*

**Up-down counter**

Each rising edge of the UP_CNT input increments the counter value CNT_VAL by one and each rising edge of the DOWN_CNT input decrements the CNT_VAL by one. If there is a rising edge at both the inputs UP_CNT and DOWN_CNT, the counter value CNT_VAL is unchanged. The CNT_VAL is available in the monitored data view.

The counter value CNT_VAL is stored in a nonvolatile memory. The range of the counter is 0...+2147483647. The count of CNT_VAL saturates at the final value of 2147483647, that is, no further increment is possible.

The value of the setting *Counter load value* is loaded into counter value CNT_VAL either when the LOAD input is set to "True" or when the *Load Counter* is set to "Load" in the LHMI. Until the LOAD input is "True", it prevents all further counting.

The function also provides status outputs UPCNT_STS and DNCNT_STS. The UPCNT_STS is set to "True" when the CNT_VAL is greater than or equal to the setting Counter load value. DNCNT_STS is set to "True" when the CNT_VAL is zero.

The RESET input is used for resetting the function. When this input is set to "True" or when *Reset counter* is set to "reset", the CNT_VAL is forced to zero.

### 3.20.18.5 Signals

**Table 270: UDFCNT Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| UP_CNT | BOOLEAN | 0=False | Input for up counting |
| DOWN_CNT | BOOLEAN | 0=False | Input for down counting |
| RESET | BOOLEAN | 0=False | Reset input for counter |
| LOAD | BOOLEAN | 0=False | Load input for counter |

**Table 271: UDFCNT Output signals**

| Name | Type | Description |
|---|---|---|
| UPCNT_STS | BOOLEAN | Status of the up counting |
| DNCNT_STS | BOOLEAN | Status of the down counting |

### 3.20.18.6 Settings

**Table 272: UDFCNT Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Counter load value | 0...2147483647 | | 1 | 10000 | Preset counter value |
| Reset counter | 0=Cancel | | | 0=Cancel | Resets counter value |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 1=Reset | | | | |
| Load counter | 0=Cancel<br>1=Load | | | 0=Cancel | Loads the counter to preset value |

### 3.20.18.7 Monitored data

**Table 273: UDFCNT Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| CNT_VAL | INT64 | 0...2147483647 | | Output counter value |

## 3.20.19 Current sum CMSUM (ANSI CSUM)

### 3.20.19.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current sum | CMSUM | CSUM | CSUM |

### 3.20.19.2 Function block




*Figure 158: Function block*

### 3.20.19.3 Functionality

The current sum function CMSUM is a phase-by-phase specific summing function for two current triplets. Output `I3P` can be used as normal current input for the application functions using current. Different measurement modes (DFT, RMS, Peak-to-peak) are supported. Also, positive, negative and zero-sequence components are calculated for the summed currents. Output `IRES` provides the calculated residual current based on the summed currents.

Example configuration:

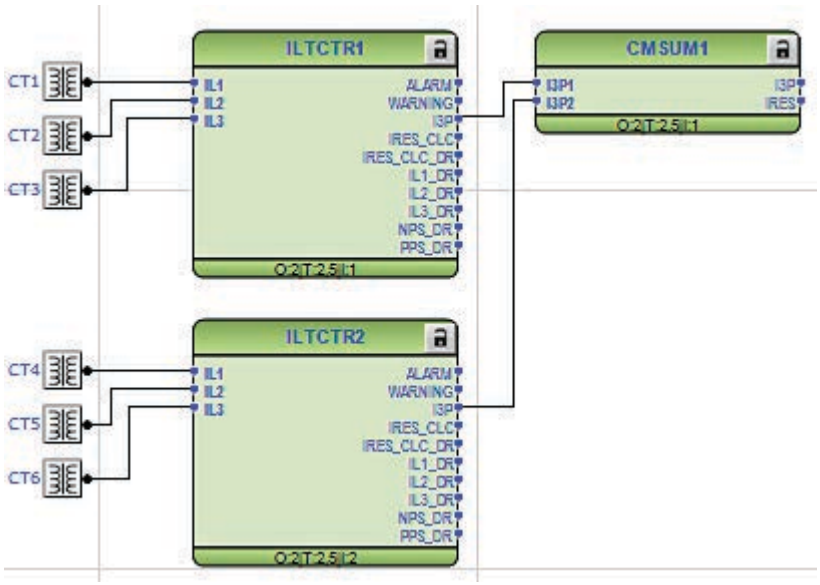



*Figure 159: Current summing configuration*

### 3.20.19.4 Analog channel configuration

CMSUM has two analog group inputs which must be properly configured, that is, both of the ILTCTR function blocks connected to these inputs must have the same primary current setting value.

**Table 274: Analog inputs**

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

### 3.20.19.5 Signals

**Table 275: CMSUM Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |

**Table 276: CMSUM Output signals**

| Name | Type | Description |
|---|---|---|
| I3P | SIGNAL | Summed three-phase currents |
| IRES | SIGNAL | Calculated residual current of summed three-phase currents |

## 3.20.20 Transformer data combiner OLGAPC

### 3.20.20.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Transformer data combiner | OLGAPC | OLGAPC | OLGAPC |

### 3.20.20.2 Function block

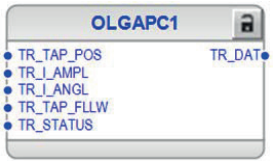



*Figure 160: Function block*

### 3.20.20.3 Functionality

The transformer data combiner function OLGAPC is intended for the voltage regulator function OL5ATCC.

### 3.20.20.4 Operation principle

The function of OLGAPC is to collect data from a parallel transformer via GOOSE communication. The `TR_DAT` output, which contains the combined input data, is connected to the OL5ATCC function block.

### 3.20.20.5 Application

See the application example in *Figure 161*.

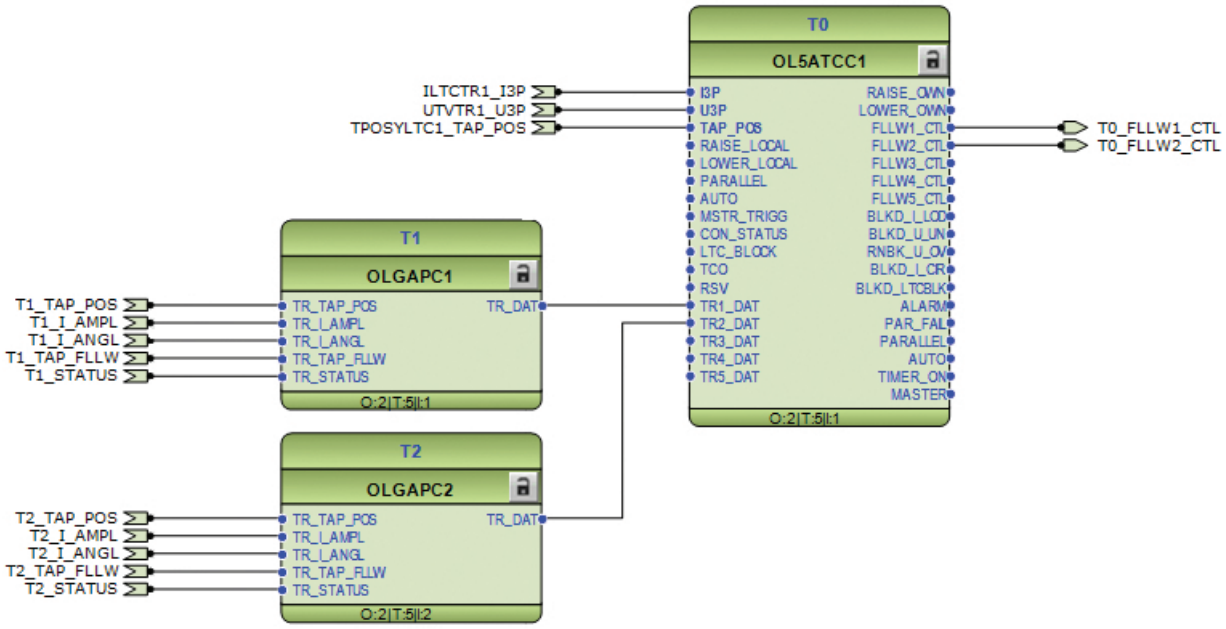



*Figure 161: Application example*

## 3.20.20.6 Signals

### OLGAPC Input signals

**Table 277: OLGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| TR_TAP_POS | INT32 | 0 | Integer value representing tap changer position of transformer |
| TR_I_AMPL | FLOAT32 | 0.00 | Received current magnitude from transformer |
| TR_I_ANGL | FLOAT32 | 0.00 | Received current angle from transformer |
| TR_STATUS | Enum | 0=Independent | Transformer status information |

### OLGAPC Output signals

**Table 278: OLGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| TR_DAT | INT8_TRDAT | Analog output |

## 3.20.21 Controllable gate, 8 channels GATEGAPC

### 3.20.21.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Controllable gate, 8 channels | GATEGAPC | GATEGAPC | GATEGAPC |

### 3.20.21.2 Function block

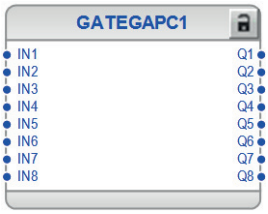



*Figure 162: Function block*

### 3.20.21.3 Functionality

Controllable gate function GATEGAPC can pass each input IN1...IN8 to output Q1...Q8 depending on the related setting *Connect INx to Qx*. Additionally, each output Qx can be named with *Description* setting.

### 3.20.21.4 Signals

**Table 279: GATEGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IN1 | BOOLEAN | 0 | IN1 status |
| IN2 | BOOLEAN | 0 | IN2 status |
| IN3 | BOOLEAN | 0 | IN3 status |
| IN4 | BOOLEAN | 0 | IN4 status |
| IN5 | BOOLEAN | 0 | IN5 status |
| IN6 | BOOLEAN | 0 | IN6 status |
| IN7 | BOOLEAN | 0 | IN7 status |
| IN8 | BOOLEAN | 0 | IN8 status |

**Table 280: GATEGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| Q1 | BOOLEAN | Q1 status |
| Q2 | BOOLEAN | Q2 status |
| Q3 | BOOLEAN | Q3 status |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| Q4 | BOOLEAN | Q4 status |
| Q5 | BOOLEAN | Q5 status |
| Q6 | BOOLEAN | Q6 status |
| Q7 | BOOLEAN | Q7 status |
| Q8 | BOOLEAN | Q8 status |

### 3.20.21.5 Settings

**Table 281: GATEGAPC settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Connect IN1 to Q1 | 1=On<br>0=Off | | | 0=Off | IN1 to Q1 connection |
| Description | GATEGAPC1 Q1 | | | | Output description |
| Connect IN2 to Q2 | 1=On<br>0=Off | | | 0=Off | IN2 to Q2 connection |
| Description | GATEGAPC1 Q2 | | | | Output description |
| Connect IN3 to Q3 | 1=On<br>0=Off | | | 0=Off | IN3 to Q3 connection |
| Description | GATEGAPC1 Q3 | | | | Output description |
| Connect IN4 to Q4 | 1=On<br>0=Off | | | 0=Off | IN4 to Q4 connection |
| Description | GATEGAPC1 Q4 | | | | Output description |
| Connect IN5 to Q5 | 1=On<br>0=Off | | | 0=Off | IN5 to Q5 connection |
| Description | GATEGAPC1 Q5 | | | | Output description |
| Connect IN6 to Q6 | 1=On<br>0=Off | | | 0=Off | IN6 to Q6 connection |
| Description | GATEGAPC1 Q6 | | | | Output description |
| Connect IN7 to Q7 | 1=On<br>0=Off | | | 0=Off | IN7 to Q7 connection |
| Description | GATEGAPC1 Q7 | | | | Output description |
| Connect IN8 to Q8 | 1=On<br>0=Off | | | 0=Off | IN8 to Q8 connection |
| Description | GATEGAPC1 Q8 | | | | Output description |

# 3.21 Standard logic operators

## 3.21.1 OR gate with two inputs OR, six inputs OR6 and twenty inputs OR20

### 3.21.1.1 Function block

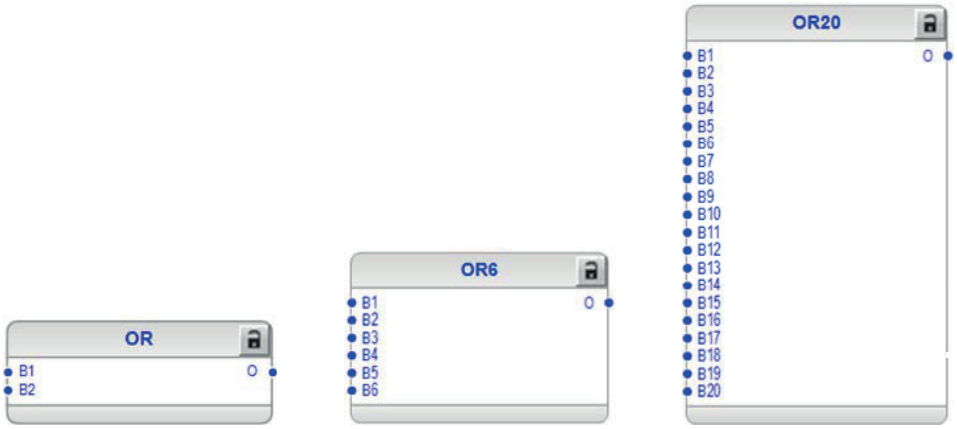



*Figure 163: Function block*

### 3.21.1.2 Functionality

OR, OR6 and OR20 are used to form general combinatory expressions with boolean variables.

The O output is activated when at least one input has the value TRUE. The default value of all inputs is FALSE, which makes it possible to use only the required number of inputs and leave the rest disconnected.

OR has two inputs, OR6 six and OR20 twenty inputs.

### 3.21.1.3 Signals

**Table 282: OR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 0 | Input signal 1 |
| B2 | BOOLEAN | 0 | Input signal 2 |

**Table 283: OR6 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 0 | Input signal 1 |
| B2 | BOOLEAN | 0 | Input signal 2 |
| B3 | BOOLEAN | 0 | Input signal 3 |
| B4 | BOOLEAN | 0 | Input signal 4 |
| B5 | BOOLEAN | 0 | Input signal 5 |
| B6 | BOOLEAN | 0 | Input signal 6 |

**Table 284: OR20 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 0 | Input signal 1 |
| B2 | BOOLEAN | 0 | Input signal 2 |
| B3 | BOOLEAN | 0 | Input signal 3 |
| B4 | BOOLEAN | 0 | Input signal 4 |
| B5 | BOOLEAN | 0 | Input signal 5 |
| B6 | BOOLEAN | 0 | Input signal 6 |
| B7 | BOOLEAN | 0 | Input signal 7 |
| B8 | BOOLEAN | 0 | Input signal 8 |
| B9 | BOOLEAN | 0 | Input signal 9 |
| B10 | BOOLEAN | 0 | Input signal 10 |
| B11 | BOOLEAN | 0 | Input signal 11 |
| B12 | BOOLEAN | 0 | Input signal 12 |
| B13 | BOOLEAN | 0 | Input signal 13 |
| B14 | BOOLEAN | 0 | Input signal 14 |
| B15 | BOOLEAN | 0 | Input signal 15 |
| B16 | BOOLEAN | 0 | Input signal 16 |
| B17 | BOOLEAN | 0 | Input signal 17 |
| B18 | BOOLEAN | 0 | Input signal 18 |
| B19 | BOOLEAN | 0 | Input signal 19 |
| B20 | BOOLEAN | 0 | Input signal 20 |

**Table 285: OR Output signals**

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

**Table 286: OR6 Output signals**

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

**Table 287: OR20 Output signals**

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

### 3.21.1.4 Settings

The function does not have any parameters available in LHMI or PCM600.

## 3.21.2 AND gate with two inputs AND, six inputs AND6 and twenty inputs AND20

### 3.21.2.1 Function block

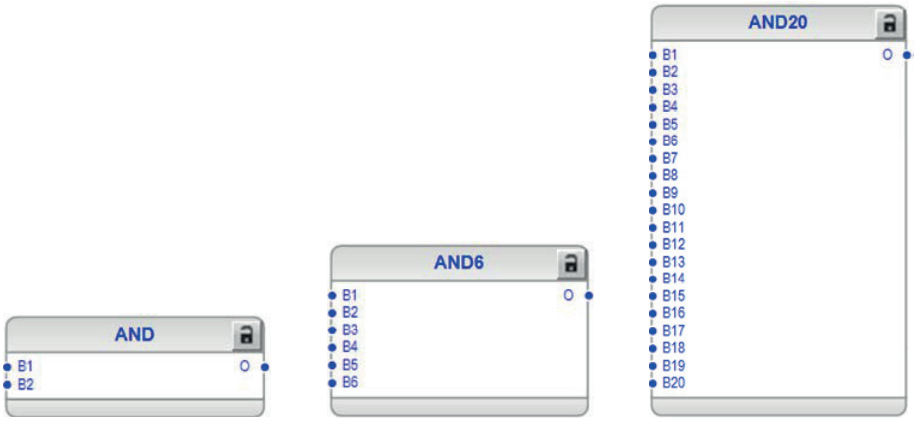



*Figure 164: Function blocks*

### 3.21.2.2 Functionality

AND, AND6 and AND20 are used to form general combinatory expressions with boolean variables.

The default value in all inputs is logical TRUE, which makes it possible to use only the required number of inputs and leave the rest disconnected.

AND has two inputs, AND6 six inputs and AND20 twenty inputs.

### 3.21.2.3 Signals

**Table 288: AND Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 1 | Input signal 1 |
| B2 | BOOLEAN | 1 | Input signal 2 |

**Table 289: AND6 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 1 | Input signal 1 |
| B2 | BOOLEAN | 1 | Input signal 2 |
| B3 | BOOLEAN | 1 | Input signal 3 |
| B4 | BOOLEAN | 1 | Input signal 4 |
| B5 | BOOLEAN | 1 | Input signal 5 |
| B6 | BOOLEAN | 1 | Input signal 6 |

**Table 290: AND20 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 0 | Input signal 1 |
| B2 | BOOLEAN | 0 | Input signal 2 |
| B3 | BOOLEAN | 0 | Input signal 3 |
| B4 | BOOLEAN | 0 | Input signal 4 |
| B5 | BOOLEAN | 0 | Input signal 5 |
| B6 | BOOLEAN | 0 | Input signal 6 |
| B7 | BOOLEAN | 0 | Input signal 7 |
| B8 | BOOLEAN | 0 | Input signal 8 |
| B9 | BOOLEAN | 0 | Input signal 9 |
| B10 | BOOLEAN | 0 | Input signal 10 |
| B11 | BOOLEAN | 0 | Input signal 11 |
| B12 | BOOLEAN | 0 | Input signal 12 |
| B13 | BOOLEAN | 0 | Input signal 13 |
| B14 | BOOLEAN | 0 | Input signal 14 |
| B15 | BOOLEAN | 0 | Input signal 15 |
| B16 | BOOLEAN | 0 | Input signal 16 |
| B17 | BOOLEAN | 0 | Input signal 17 |
| B18 | BOOLEAN | 0 | Input signal 18 |
| B19 | BOOLEAN | 0 | Input signal 19 |
| B20 | BOOLEAN | 0 | Input signal 20 |

**Table 291: AND Output signals**

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

**Table 292: AND6 Output signals**

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

**Table 293: AND20 Output signals**

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

### 3.21.2.4 Settings

The function does not have any parameters available in LHMI or PCM600.

## 3.21.3 XOR gate with two inputs XOR

### 3.21.3.1 Function block




*Figure 165: Function block*

### 3.21.3.2 Functionality

The exclusive OR function XOR is used to generate combinatory expressions with boolean variables.

The output signal is TRUE if the input signals are different and FALSE if they are equal.

### 3.21.3.3 Signals

**Table 294: XOR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| B1 | BOOLEAN | 0 | Input signal 1 |
| B2 | BOOLEAN | 0 | Input signal 2 |

**Table 295: XOR Output signals**

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

### 3.21.3.4 Settings

The function does not have any parameters available in LHMI or PCM600.

## 3.21.4 NOT gate NOT

### 3.21.4.1 Function block




*Figure 166: Function block*

### 3.21.4.2 Functionality

NOT is used to generate combinatory expressions with boolean variables.

NOT inverts the input signal.

### 3.21.4.3 Signals

**Table 296: NOT Input signal**

| Name | Type | Default | Description |
|---|---|---|---|
| 1 | BOOLEAN | 0 | Input signal |

**Table 297: NOT Output signal**

| Name | Type | Description |
|---|---|---|
| O | BOOLEAN | Output signal |

### 3.21.4.4 Settings

The function does not have any parameters available in LHMI or PCM600.

## 3.21.5 Rising edge detector R_TRIG

### 3.21.5.1 Function block




*Figure 167: Function block*

### 3.21.5.2 Functionality

R_TRIG is used as a rising edge detector.

R_TRIG detects the transition from FALSE to TRUE at the `CLK` input. When the rising edge is detected, the element assigns the output to TRUE. At the next execution round, the output is returned to FALSE despite the state of the input.

### 3.21.5.3 Signals

**Table 298: R_TRIG Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| CLK | BOOLEAN | 0 | Input signal |

**Table 299: R_TRIG Output signals**

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Output signal |

### 3.21.5.4 Settings

The function does not have any parameters available in LHMI or PCM600.

## 3.21.6 Falling edge detector F_TRIG

### 3.21.6.1 Function block




*Figure 168: Function block*

### 3.21.6.2 Functionality

F_TRIG is used as a falling edge detector.

The function detects the transition from TRUE to FALSE at the `CLK` input. When the falling edge is detected, the element assigns the `Q` output to TRUE. At the next execution round, the output is returned to FALSE despite the state of the input.

### 3.21.6.3 Signals

**Table 300: F_TRIG Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| CLK | BOOLEAN | 0 | Input signal |

**Table 301: F_TRIG Output signals**

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Output signal |

### 3.21.6.4 Settings

The function does not have any parameters available in LHMI or PCM600.

## 3.21.7 Switching device status decoder CLOSE position T_POS_CL, OPEN position T_POS_OP and OK status T_POS_OK

### 3.21.7.1 Function block




*Figure 169: Function blocks*

### 3.21.7.2 Functionality

The circuit breaker position information can be communicated with the IEC 61850 GOOSE messages. The position information is a double binary data type which is fed to the POS input.

T_POS_CL and T_POS_OP are used for extracting the circuit breaker status information. Respectively, T_POS_OK is used to validate the intermediate or faulty breaker position.

**Table 302: Cross reference between circuit breaker position and function block output**

| Circuit breaker position | Output of the function block | | |
|---|---|---|---|
| | T_POS_CL | T_POS_OP | T_POS_OK |
| Intermediate '00' | FALSE | FALSE | FALSE |
| Close '01' | TRUE | FALSE | TRUE |
| Open '10' | FALSE | TRUE | TRUE |
| Faulty '11' | TRUE | TRUE | FALSE |

### 3.21.7.3 Signals

**Table 303: T_POS_CL Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| POS | Double binary | 0 | Input signal |

**Table 304: T_POS_OP Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| POS | Double binary | 0 | Input signal |

**Table 305: T_POS_OK Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| POS | Double binary | 0 | Input signal |

**Table 306: T_POS_CL Output signals**

| Name | Type | Description |
|---|---|---|
| CLOSE | BOOLEAN | Output signal |

**Table 307: T_POS_OP Output signals**

| Name | Type | Description |
|---|---|---|
| CLOSE | BOOLEAN | Output signal |

**Table 308: T_POS_OK Output signals**

| Name | Type | Description |
|---|---|---|
| CLOSE | BOOLEAN | Output signal |

#### 3.21.7.4 Settings

The function does not have any parameters available in LHMI or PCM600.

## 3.21.8 SR flip-flop, volatile SR

### 3.21.8.1 Function block




*Figure 170: Function block*

### 3.21.8.2 Functionality

The SR flip-flop output `Q` can be set or reset from the `S` or `R` inputs. `S` input has a higher priority over the `R` input. Output `NOTQ` is the negation of output `Q`.

The statuses of outputs `Q` and `NOTQ` are not retained in the nonvolatile memory.

**Table 309: Truth table for SR flip-flop**

| S | R | Q |
|---|---|---|
| 0 | 0 | 0 [1] |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

### 3.21.8.3 Signals

**Table 310: SR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| S | BOOLEAN | 0=False | Set Q output when set |
| R | BOOLEAN | 0=False | Resets Q output when set |

**Table 311: SR Output signals**

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Q status |
| NOTQ | BOOLEAN | NOTQ status |

## 3.21.9 RS flip-flop, volatile RS

### 3.21.9.1 Function block




*Figure 171: Function block*

### 3.21.9.2 Functionality

The RS flip-flop output Q can be set or reset from the S or R inputs. R input has a higher priority over the S input. Output NOTQ is the negation of output Q.

The statuses of outputs Q and NOTQ are not retained in the nonvolatile memory.

[1] Keep state/no change

**Table 312: Truth table for RS flip-flop**

| S | R | Q |
|---|---|---|
| 0 | 0 | 0 [1] |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

### 3.21.9.3 Signals

**Table 313: RS Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| S | BOOLEAN | 0=False | Set Q output when set |
| R | BOOLEAN | 0=False | Resets Q output when set |

**Table 314: RS Output signals**

| Name | Type | Description |
|---|---|---|
| Q | BOOLEAN | Q status |
| NOTQ | BOOLEAN | NOTQ status |

# 3.22 Mathematical operators

## 3.22.1 Real addition ADDR

### 3.22.1.1 Function block

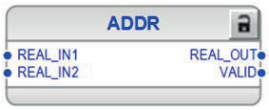



*Figure 172: Function block*

### 3.22.1.2 Functionality

The real addition function ADDR adds the inputs `REAL_IN1` and `REAL_IN2` together. ADDR executes the equation

`REAL_OUT = REAL_IN1 + REAL_IN2`

[1] Keep state/no change

If the value of the sum is outside the range, then the output quality is set as bad and VALID is set to FALSE. The minimum negative sum value is restricted to –2097152.000 and the maximum positive sum value is restricted to 2097152.000.

### 3.22.1.3 Signals

**Table 315: ADDR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |

**Table 316: ADDR Output signals**

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output 1 |
| VALID | BOOLEAN | Output validity |

## 3.22.2 Real division DIVR

### 3.22.2.1 Function block




*Figure 173: Function block*

### 3.22.2.2 Functionality

The real division function DIVR divides the REAL_IN1 input by REAL_IN2. DIVR executes the equation

$$REAL_OUT = \frac{REAL_IN1}{REAL_IN2}$$

(Equation 8)

If the denominator value is less than ≈ 0.001, the resultant quotient is considered out of range.

If the value of the quotient is outside the range, then the output quality is set as bad and VALID is set to FALSE. The minimum negative quotient value is restricted to –2097152.000 and the maximum positive quotient value is restricted to 2097152.000.

### 3.22.2.3 Signals

**Table 317: DIVR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |

**Table 318: DIVR Output signals**

| Name | Type | Description |
|---|---|---|
| REAL_OUT | IN1 | Real output |
| VALID | BOOLEAN | Output validity |

## 3.22.3 Real multiplication MULR

### 3.22.3.1 Function block




*Figure 174: Function block*

### 3.22.3.2 Functionality

The real multiplication function MULR multiplies the real input REAL_IN1 by the real input REAL_IN2 together. MULR executes the equation

REAL_OUT = REAL_IN1 x REAL_IN2

If the value of the product is outside the range, then the output quality is set as bad and VALID is set to FALSE. The minimum negative product value is restricted to -2097152.000 and the maximum positive product value is restricted to 2097152.000.

### 3.22.3.3 Signals

**Table 319: MULR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |

**Table 320: MULR Output signals**

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output |
| VALID | BOOLEAN | Output validity |

## 3.22.4 Real subtraction SUBR

### 3.22.4.1 Function block




*Figure 175: Function block*

### 3.22.4.2 Functionality

The real subtraction function SUBR subtracts input REAL_IN2 from REAL_IN1. SUBR executes the equation

REAL_OUT = REAL_IN1 – REAL_IN2

If the value of the difference is outside the range, then the output quality is set as bad and VALID is set to FALSE. The minimum negative difference value is restricted to –2097152.000 and the maximum positive difference value is restricted to 2097152.000.

### 3.22.4.3 Signals

**Table 321: SUBR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |

**Table 322: SUBR Output signals**

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output |
| VALID | BOOLEAN | Output validity |

## 3.22.5 Real equal comparator EQR

### 3.22.5.1 Function block




*Figure 176: Function block*

### 3.22.5.2 Functionality

The real equal comparator function EQR compares the real input REAL_IN1 with the real input REAL_IN2 and activates the binary output OUT if REAL_IN1 is within the region of REAL_IN2 + TOLR and REAL_IN2 –TOLR, that is, if REAL_IN1 ≥ (REAL_IN2 – TOLR) and REAL_IN1 ≤ (REAL_IN2 + TOLR), OUT = 1, else OUT = 0.

If inputs REAL_IN1 or REAL_IN2 are outside the range, then OUT is set to 0.




*Figure 177: Region of EQR comparison*

EQR requires a positive value for TOLR, otherwise it may not function properly. The TOLR value can be set using SETRGAPC.

EQR function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have closely varying values.

### 3.22.5.3 Signals

**Table 323: EQR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |
| TOLR | FLOAT32 | 0 | Tolerance for comparison |

**Table 324: EQR Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output value |

## 3.22.6 Real not equal comparator NER

### 3.22.6.1 Function block




*Figure 178: Function block*

### 3.22.6.2 Functionality

The real not equal comparator function NER compares the real input REAL_IN1 with the real input REAL_IN2 and activates the binary output OUT if REAL_IN1 is outside the region of REAL_INT2 + TOLR and REAL_IN2 - TOLR. That is, if REAL_IN1 < (REAL_IN2 - TOLR) or REAL_IN1 > (REAL_IN2 + TOLR), OUT= 1, else OUT = 0.

If inputs REAL_IN1 or REAL_IN2 are outside the range, then OUT is set to 0.

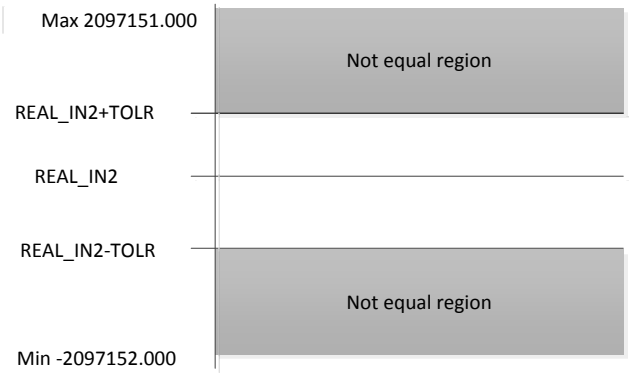



*Figure 179: Region of NER comparison*

NER requires a positive value for TOLR, otherwise it may not function properly. The TOLR value can be set using SETRGAPC.

NER function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have closely varying values.

### 3.22.6.3 Signals

**Table 325: NER Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |
| TOLR | FLOAT32 | 0 | Tolerance for comparison |

**Table 326: NER Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output value |

## 3.22.7 Real greater than or equal comparator GER

### 3.22.7.1 Function block




*Figure 180: Function block*

### 3.22.7.2 Functionality

The real greater than or equal comparator function GER compares the real input REAL_IN1 with the real input REAL_IN2 and activates the binary output OUT if REAL_IN1 is equal to or greater than REAL_IN2 - TOLR or greater than input REAL_IN2. That is, if REAL_IN1≥ (REAL_IN2 - TOLR) or REAL_IN1 > (REAL_IN2), OUT = 1, else OUT = 0.

If inputs REAL_IN1 or REAL_IN2 are outside the range, then OUT is set to 0.




*Figure 181: Region of GER comparison*

GER function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have closely varying values.

### 3.22.7.3 Signals

**Table 327: GER Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |
| TOLR | FLOAT32 | 0 | Tolerance for comparison |

**Table 328: GER Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output value |

## 3.22.8 Real less than or equal comparator LER

### 3.22.8.1 Function block




*Figure 182: Function block*

### 3.22.8.2 Functionality

The real less than or equal comparator function LER compares real input REAL_IN1 with the real input REAL_IN2 and activates the binary output OUT if REAL_IN1 is equal to or less than REAL_IN2 + TOLR or less than REAL_IN2 input. That is, if REAL_IN1 ≤ (REAL_IN2 + TOLR) or REAL_IN1 < (REAL_IN2), OUT = 1, else OUT = 0.

LER function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have closely varying values.




*Figure 183: Region of LER comparison*

### 3.22.8.3 Signals

**Table 329: LER Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input 2 |
| TOLR | FLOAT32 | 0 | Tolerance for comparison |

**Table 330: LER Output signals**

| Name | Type | Description |
|---|---|---|
| OUT | BOOLEAN | Output value |

## 3.22.9 Real maximum value selector MAX3R

### 3.22.9.1 Function block

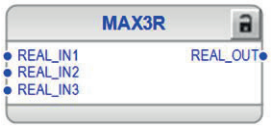



*Figure 184: Function block*

### 3.22.9.2 Functionality

The real maximum value selector function MAX3R selects the maximum value from three analog values. Disconnected inputs and inputs whose quality is bad are ignored. If all inputs are disconnected or the quality is bad, MAX3R output value is set to $-2^{21}$.

### 3.22.9.3 Signals

**Table 331: MAX3R Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input value 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input value 2 |
| REAL_IN3 | FLOAT32 | 0 | Real input value 3 |

**Table 332: MAX3R Output signals**

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output value |

## 3.22.10 Real minimum value selector MIN3R

### 3.22.10.1 Function block

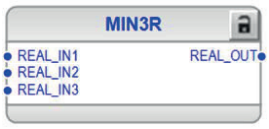



*Figure 185: Function block*

### 3.22.10.2 Functionality

The real minimum value selector function MIN3R selects the minimum value from three analog values. Disconnected inputs and inputs whose quality is bad are ignored. If all inputs are disconnected or the quality is bad, MIN3R output value is set to $2^{21}$.

### 3.22.10.3 Signals

**Table 333: MIN3R Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| REAL_IN1 | FLOAT32 | 0 | Real input value 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input value 2 |
| REAL_IN3 | FLOAT32 | 0 | Real input value 3 |

**Table 334: MIN3R Output signals**

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real output value |

## 3.22.11 Real switch selector SWITCHR

### 3.22.11.1 Function block




*Figure 186: Function block*

### 3.22.11.2 Functionality

The real switch selector function SWITCHR is operated by the `CTL_SW` input and selects the output value `REAL_OUT` between the `REAL_IN1` and `REAL_IN2` inputs.

**Table 335: SWITCHR**

| CTL_SW value | REAL_OUT value |
|---|---|
| TRUE (1) | REAL_IN1 |
| FALSE (0) | REAL_IN2 |

### 3.22.11.3 Signals

**Table 336: SWITCHR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| CTL_SW | BOOLEAN | 0 | Control Switch |
| REAL_IN1 | FLOAT32 | 0 | Real input value 1 |
| REAL_IN2 | FLOAT32 | 0 | Real input value 2 |

**Table 337: SWITCHR Output signals**

| Name | Type | Description |
|---|---|---|
| REAL_OUT | FLOAT32 | Real switch output |

## 3.22.12 Integer 32-bit switch selector SWITCHI32

### 3.22.12.1 Function block




*Figure 187: Function block*

### 3.22.12.2 Functionality

The integer 32-bit switch selector function SWITCHI32 is operated by the `CTL_SW` input, which selects the output value `INT32_OUT` between the `INT32_IN1` and `INT32_IN2` inputs.

**Table 338: SWITCHI32**

| CTL_SW value | INT_OUT value |
|---|---|
| FALSE (0) | INT32_IN1 |
| TRUE (1) | INT32_IN2 |

### 3.22.12.3 Signals

**Table 339: SWITCHI32 Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| CTL_SW | BOOLEAN | 0 | Control Switch |
| INT_IN1 | INT32 | 0 | Integer input value 1 |
| INT_IN2 | INT32 | 0 | Integer input value 2 |

**Table 340: SWITCHI32 Output signals**

| Name | Type | Description |
|---|---|---|
| INT_OUT | INT32 | Integer switch output |

# 3.23 Factory settings restoration

In case of configuration data loss or any other file system error that prevents the protection relay from working properly, the whole file system can be restored to the original factory state. All default settings and configuration files stored in the factory are restored. For further information on restoring factory settings, see the operation manual.

# 3.24 Load profile LDPRLRC (ANSI LOADPROF)

## 3.24.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Load profile recorder | LDPRLRC | LOADPROF | LOADPROF |

## 3.24.2 Function block

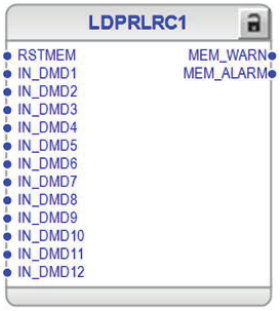



*Figure 188: Function block*

## 3.24.3 Functionality

The protection relay is provided with a load profile recorder. The load profile feature stores the historical load data captured at a periodical time interval (demand interval). Up to 12 load quantities can be selected for recording and storing in a nonvolatile memory. The value range for the recorded load quantities is about eight times the nominal value, and values higher than that saturate. The recording time depends on a settable demand interval parameter and the amount of quantities selected. The record output is in the COMTRADE format.

### 3.24.3.1 Quantities

**Table 341: Signals supported by the load profile recorder**

| Function | Signal | Description |
|---|---|---|
| CMMXU | I_DMD_A | Demand value of IL1 current |
| | I_DMD_B | Demand value of IL2 current |
| | I_DMD_C | Demand value of IL3 current |

*Table continues on the next page*

| Function | Signal | Description |
|---|---|---|
| PEMMXU | S_DMD | Demand value of apparent power |
| | P_DMD | Demand value of active power |
| | Q_DMD | Demand value of reactive power |
| | PF_DMD | Demand value of power factor |
| RESCMMXU | I_DMD_RES | Demand value of residual current |
| VMMXU | U_DMD_AB | Demand value of U12 voltage |
| | U_DMD_BC | Demand value of U23 voltage |
| | U_DMD_CA | Demand value of U31 voltage |
| | U_DMD_A | Demand value of UL1 voltage |
| | U_DMD_B | Demand value of UL2 voltage |
| | U_DMD_C | Demand value of UL3 voltage |
| RESVMMXU | U_DMD_RES | Demand value of residual voltage |
| VAMMXU | U_DMD | Demand value of phase voltage |

If the data source for the selected quantity is removed, for example, with Application Configuration in PCM600, the load profile recorder stops recording it and the previously collected data are cleared.

### 3.24.3.2 Length of record

The recording capability is about 7.4 years when one quantity is recorded and the demand interval is set to 180 minutes. The recording time scales down proportionally when a shorter demand time is selected or more quantities are recorded. The recording lengths in days with different settings used are presented in *Table 342*. When the recording buffer is fully occupied, the oldest data are overwritten by the newest data.

**Table 342: Recording capability in days with different settings**

| | Demand interval | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 minute | 5 minutes | 10 minutes | 15 minutes | 30 minutes | 60 minutes | 180 minutes |
| **Amount of quantities** | **Recording capability in days** | | | | | | |
| 1 | 15.2 | 75.8 | 151.6 | 227.4 | 454.9 | 909.7 | 2729.2 |
| 2 | 11.4 | 56.9 | 113.7 | 170.6 | 341.1 | 682.3 | 2046.9 |

*Table continues on the next page*

| | Demand interval | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | 9.1 | 45.5 | 91.0 | 136.5 | 272.9 | 545.8 | 1637.5 |
| 4 | 7.6 | 37.9 | 75.8 | 113.7 | 227.4 | 454.9 | 1364.6 |
| 5 | 6.5 | 32.5 | 65.0 | 97.5 | 194.9 | 389.9 | 1169.6 |
| 6 | 5.7 | 28.4 | 56.9 | 85.3 | 170.6 | 341.1 | 1023.4 |
| 7 | 5.1 | 25.3 | 50.5 | 75.8 | 151.6 | 303.2 | 909.7 |
| 8 | 4.5 | 22.7 | 45.5 | 68.2 | 136.5 | 272.9 | 818.8 |
| 9 | 4.1 | 20.7 | 41.4 | 62.0 | 124.1 | 248.1 | 744.3 |
| 10 | 3.8 | 19.0 | 37.9 | 56.9 | 113.7 | 227.4 | 682.3 |
| 11 | 3.5 | 17.5 | 35.0 | 52.5 | 105.0 | 209.9 | 629.8 |
| 12 | 3.2 | 16.2 | 32.5 | 48.7 | 97.5 | 194.9 | 584.8 |

### 3.24.3.3 Uploading of record

The protection relay stores the load profile COMTRADE files to the C:\LDP\COMTRADE folder. The files can be uploaded with the PCM600 tool or any appropriate computer software that can access the C:\LDP\COMTRADE folder.

The load profile record consists of two COMTRADE file types: the configuration file (.CFG) and the data file (.DAT). The file name is same for both file types.

To ensure that both the uploaded file types are generated from the same data content, the files need to be uploaded successively. Once either of the files is uploaded, the recording buffer is halted to give time to upload the other file.

Data content of the load profile record is sequentially updated. Therefore, the size attribute for both COMTRADE files is "0".

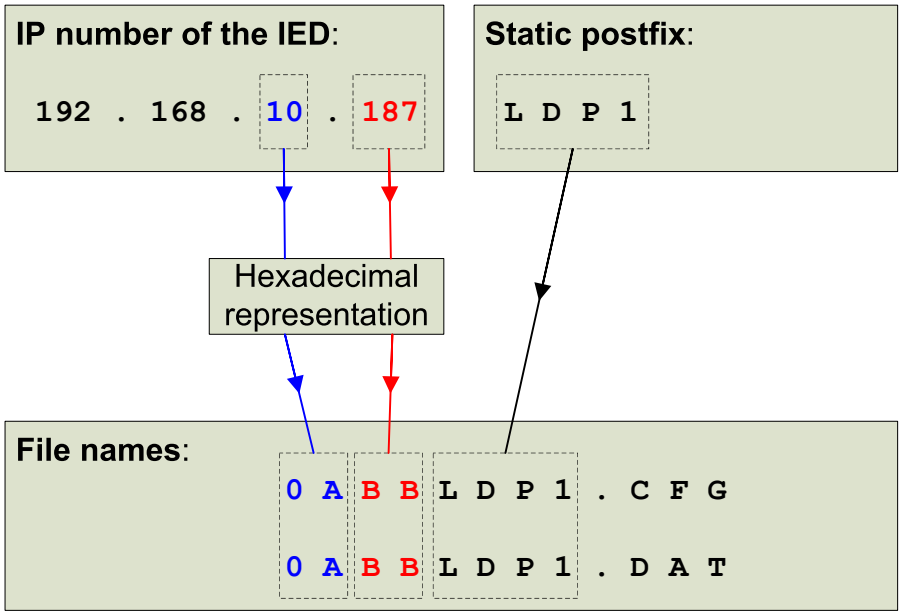



*Figure 189: Load profile record file naming*

### 3.24.3.4 Clearing of record

The load profile record can be cleared with *Reset load profile rec* via HMI, communication or the ACT input in PCM600. Clearing of the record is allowed only on the engineer and administrator authorization levels.

The load profile record is automatically cleared if the quantity selection parameters are changed or any other parameter which affects the content of the COMTRADE configuration file is changed. Also, if data source for selected quantity is removed, for example, with ACT, the load profile recorder stops recording and previously collected data are cleared.

## 3.24.4 Configuration

The load profile record can be configured with the PCM600 or any tool supporting the IEC 61850 standard.

The load profile record can be enabled or disabled with the *Operation* setting under the **Configuration/Load Profile Record** menu.

Any demand output can be connected to any of the quantity channels of the load profile record. The mapping is done in Application Configuration in PCM600.

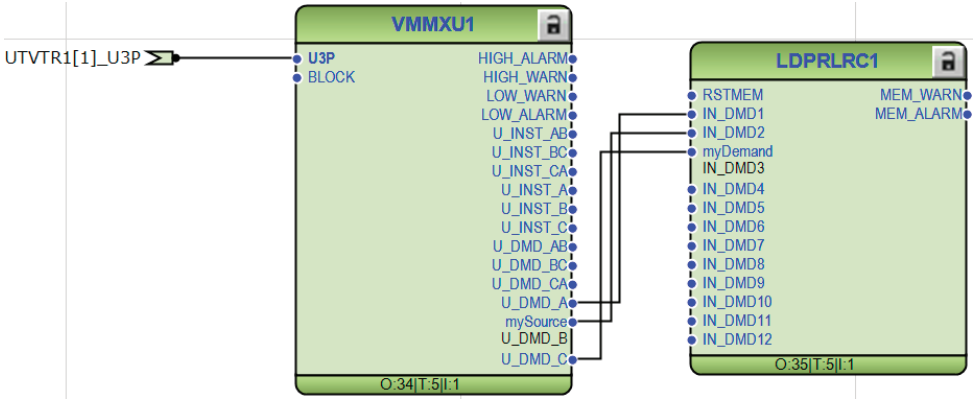



*Figure 190: Example of a load profile record ACT configuration*

The memory consumption of load profile record is supervised, and indicated with two signals `MEM_WARN` and `MEM_ALARM`, which could be used to notify the customer that recording should be backlogged by reading the recorded data from the protection relay. The levels for MEM_WARN and MEM_ALARM are set by two parameters *Mem.warn level* and *Mem. Alarm level*.

The IP number of the protection relay and the content of the Bay name setting are both included in the COMTRADE configuration file for identification purposes.

## 3.24.5 Signals

#### 3.24.5.1 LDPRLRC Output signals

**Table 343: LDPRLRC Output signals**

| Name | Type | Description |
|---|---|---|
| MEM_WARN | BOOLEAN | Recording memory warning status |
| MEM_ALARM | BOOLEAN | Recording memory alarm status |

### 3.24.6 LDPRLRC Settings

**Table 344: LDPRLRC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Mem. warning level | 0...100 | % | 1 | 0 | Set memory warning level |
| Mem. alarm level | 0...100 | % | 1 | 0 | Set memory alarm level |

### 3.24.7 LDPRLRC Monitored data

**Table 345: LDPRLRC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Rec. memory used | INT32 | 0...100 | % | How much recording memory is currently used |

## 3.25 Ethernet channel supervision functions

The protection relay offers a bandwidth rate limiting functionality to limit the Ethernet/TCP network traffic. The main purpose of this feature is the possibility to divide network segments for different multicast frame types and also to limit the network congestion and traffic towards the protection relay processing during network attacks (such as a Denial of Service attack) or in case of network configuration issues.

See the cyber security deployment guideline for the Ethernet filter and rate limiter functionality.

### 3.25.1 Redundant Ethernet channel supervision RCHLCCH

### 3.25.1.1 Function block




*Figure 191: Function block*

### 3.25.1.2 Functionality

Redundant Ethernet channel supervision RCHLCCH represents LAN A and LAN B redundant Ethernet channels.

### 3.25.1.3 Signals

**Table 346: RCHLCCH Output signals**

| Name | Values (Range) | Description |
|---|---|---|
| CHLIV | BOOLEAN | Status of redundant Ethernet channel LAN A When *Redundant mode* is set to "HSR" or "PRP", value is TRUE if the protection relay is receiving redundancy supervision frames. Otherwise the value is FALSE. |
| REDCHLIV | BOOLEAN | Status of redundant Ethernet channel LAN B When *Redundant mode* is set to "HSR" or "PRP", value is TRUE if the protection relay is receiving redundancy supervision frames. Otherwise the value is FALSE. |
| LNKLIV | BOOLEAN | Link status of redundant port LAN A Valid only when *Redundant mode* is set to "HSR" or "PRP". Value is "Up" or "Down". |
| REDLNKLIV | BOOLEAN | Link status of redundant port LAN B Valid only when *Redundant mode* is set to "HSR" or "PRP". Value is "Up" or "Down". |

### 3.25.1.4 Settings

**Table 347: RCHLCCH Settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Redundant mode | Off<br>PRP<br>HSR | | | | Mode selection for Ethernet switch on redundant communication modules. The "None" mode is used with normal and Self-healing Ethernet topologies. |
| Filter Mode A_B | Off<br>SMV<br>GOOSE<br>GOOSE & SMV | | | Off | Filtering selection for message types |
| Goose rate limiter A_B | 0.512...90.000 | | | 10.000 | Goose rate limit (Mbps) |
| SMV rate limit A_B | 0.512...90.000 | | | 70.000 | Sampled measured values rate limit (Mbps) |
| Def. rate limit A_B | 0.512...90.000 | | | 8.000 | Default rate limit (Mbps) |

### 3.25.1.5 Monitored data

Monitored data is available in four locations.

- **Monitoring** > **Communication** > **Ethernet** > **Activity** > **CHLIV_A**
- **Monitoring** > **Communication/** > **Ethernet** > **Activity** > **REDCHLIV_B**
- **Monitoring** > **Communication** > **Ethernet** > **Link statuses** > **LNKLIV_A**
- **Monitoring** > **Communication** > **Ethernet** > **Link statuses** > **REDLNKLIV_B**

### 3.25.1.6 Diagnostics

Diagnostics data is available in **Monitoring** > **Communication** > **Ethernet** > **Diagnostics** > **A_B**.

**Table 348: Diagnostic parameters for the redundant Ethernet channels LAN A and LAN B**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset counters | FALSE / TRUE | | | FALSE | Reset counters command |
| GOOSE limit count | 0...1000000 | | | 0 | Goose rate limit exceed count |
| SMV limit count | 0...1000000 | | | 0 | Sampled measured values limit exceed count |
| Ucast limit count | 0...1000000 | | | 0 | Unicast rate limit exceed count |
| Def. limit count | 0...1000000 | | | 0 | Default rate limit exceed count |
| GOOSE limit alarm | FALSE / TRUE | | | FALSE | Goose rate limit exceed alarm |
| SMV limit alarm | FALSE / TRUE | | | FALSE | Sampled measured values limit alarm |
| Ucast limit alarm | FALSE / TRUE | | | FALSE | Unicast rate limit exceed alarm |
| Def. limit alarm | FALSE / TRUE | | | FALSE | Default rate limit exceed alarm |

## 3.25.2 Ethernet channel supervision SCHLCCH

### 3.25.2.1 Function block




*Figure 192: Function block*

### 3.25.2.2 Functionality

Ethernet channel supervision SCHLCCH represents X1/LAN, X2/LAN and X3/LAN Ethernet channels.

An unused Ethernet port can be set "Off" with the setting **Configuration** > **Communication** > **Ethernet** > **Rear port(s)** > **Port x Mode**. This setting closes the port from software, disabling the Ethernet communication in that port. Closing an unused Ethernet port enhances the cyber security of the relay.

### 3.25.2.3 Signals

**Table 349: SCHLCCH1 Output signals**

| Name | Type | Description |
|---|---|---|
| CH1LIV | BOOLEAN | Status of Ethernet channel X1/LAN When *Redundant mode* is set to "None" or port is not one of the redundant ports (LAN A or LAN B), value is TRUE if the port is receiving Ethernet frames. Otherwise the value is FALSE. |
| LNK1LIV | BOOLEAN | Link status of Ethernet port X1/LAN Value is "Up" or "Down". |

**Table 350: SCHLCCH2 Output signals**

| Name | Type | Description |
|---|---|---|
| CH2LIV | BOOLEAN | Status of Ethernet channel X2/LAN When *Redundant mode* is set to "None" or port is not one of the redundant ports (LAN A or LAN B), value is TRUE if the port is receiving Ethernet frames. Otherwise the value is FALSE. |
| LNK2LIV | BOOLEAN | Link status of Ethernet port X2/LAN Value is "Up" or "Down". |

**Table 351: SCHLCCH3 Output signals**

| Name | Type | Description |
|---|---|---|
| CH3LIV | BOOLEAN | Status of Ethernet channel X3/LAN When *Redundant mode* is set to "None" or port is not one of the redundant ports (LAN A or LAN B), value is TRUE if the port is receiving Ethernet frames. Otherwise the value is FALSE. |
| LNK3LIV | BOOLEAN | Link status of Ethernet port X3/LAN Value is "Up" or "Down". |

### 3.25.2.4 Settings

**Table 352: SCHLCCH Settings**

| Parameter [1] | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Port n Mode | Off<br>On<br>Dedicated channel [2] | | | On | Mode selection for rear port(s). If port is not used, it can be set to "Off". Port cannot be set to "Off" when *Redundant mode* is "HSR" or "PRP" and port is one of the redundant ports (LAN A or LAN B). |
| Filter Mode Xn | Off<br>SMV<br>GOOSE<br>GOOSE & SMV | | | Off | Selection for message filtering |
| Goose rate limiter Xn | 0.512...90.000 | | | 10.000 | Goose rate limit (Mbps) |
| SMV rate limit Xn | 0.512...90.000 | | | 70.000 | Sampled measured values rate limit (Mbps) |
| Def. rate limit Xn | 0.512...90.000 | | | 8.000 | Default rate limit (Mbps) |

### 3.25.2.5 Monitored data

Monitored data is available in six locations.

- **Monitoring** > **Communication** > **Ethernet** > **Activity** > **CH1LIV**
- **Monitoring** > **Communication** > **Ethernet** > **Activity** > **CH2LIV**
- **Monitoring/** > **Communication** > **Ethernet** > **Activity** > **CH3LIV**
- **Monitoring/** > **Communication** > **Ethernet** > **Link statuses** > **LNK1LIV**
- **Monitoring** > **Communication** > **Ethernet** > **Link statuses** > **LNK2LIV**
- **Monitoring** > **Communication** > **Ethernet** > **Link statuses** > **LNK3LIV**

### 3.25.2.6 Diagnostics

Diagnostics data is available in **Monitoring** > **Communication** > **Ethernet** > **Diagnostics** > **Xn** (n = 1...3).

**Table 353: Diagnostic parameters for X1/LAN, X2/LAN and X3/LAN**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset counters | FALSE / TRUE | | | FALSE | Reset counters command |
| GOOSE limit count | 0...1000000 | | | 0 | Goose rate limit exceed count |
| SMV limit count | 0...1000000 | | | 0 | Sampled measured values limit exceed count |
| Ucast limit count | 0...1000000 | | | 0 | Unicast rate limit exceed count |
| Def. limit count | 0...1000000 | | | 0 | Default rate limit exceed count |
| GOOSE limit alarm | FALSE / TRUE | | | FALSE | Goose rate limit exceed alarm |
| SMV limit alarm | FALSE / TRUE | | | FALSE | Sampled measured values limit alarm |
| Ucast limit alarm | FALSE / TRUE | | | FALSE | Unicast rate limit exceed alarm |
| Def. limit alarm | FALSE / TRUE | | | FALSE | Default rate limit exceed alarm |

[1] n = 1...3
[2] Only available for port X3

# 3.26 External HMI wake-up EIHMI

## 3.26.1 Function block

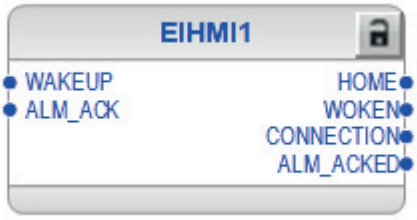



*Figure 193: Function block*

## 3.26.2 Functionality

The external HMI wake-up function EIHMI is a control block that is used to control certain parts of the HMI with Application Configuration in PCM600.

Some data can be bound to control options to enable the required features: remote HMI wake-up, remote acknowledgment of alarms, information when the device has been woken up, indication when the Home button on the HMI is activated and indication when alarms are being acknowledged either remotely or from the HMI.

All functionalities described here are applicable only to paired HMI devices.

## 3.26.3 Operation principle

The input signal WAKEUP is used to wake the HMI from a low-power state and restore the display's backlight if it has been dimmed or turned off. The display’s backlight can be controlled with parameter *Backlight timeout* under **Configuration** > **HMI**. The HMI remains in normal operation mode as long as there is user input from the HMI or a wake-up signal before the time set with *Backlight timeout* elapses.

The signal used to wake up the HMI is boolean rising edge. The wake-up can be triggered only after the connected signal has been in FALSE state for longer than a single function cycle.

The input signal ALM_ACK is used to acknowledge all active and fleeting alarms. These alarms are displayed on the HMI's alarms page and mini-alarms widget.

The signal used to acknowledge the alarms is boolean rising edge. Acknowledge alarms can be triggered only after the connected signal has been in the FALSE state for longer than a single function cycle. The actual acknowledgement takes effect only after the ALM_ACKED output has been in the FALSE state for longer than 100 ms.

The output signal HOME is activated when the capacitive Home button is activated on the HMI unit. This generates a boolean TRUE value pulse that persists for a

second until the output is reset to FALSE. The output remains in this state until the Home button is pressed again.

The output signal WOKEN is activated whenever the HMI device is woken from a low-power state. This generates a one-second boolean TRUE value pulse. After one second, the output is reset to FALSE. A new output can be triggered once the HMI has entered the low-power state.

The output CONNECTION is activated whenever the paired HMI is connected to the protection relay. If the communication between the protection relay and the HMI is severed, this output resets itself to FALSE until communication has been restored.

When an SHMI is connected and paired with the protection relay, the CONNECTION output is activated when the user navigates from the SHMI navigation page to the HMI view. The CONNECTION output is deactivated when the user returns to the navigation view or the connection between the relay and the SHMI is lost. The output can be used to visually indicate that the SHMI is connected to the relay in the panel, and it works as an LHMI for the relay.

The output ALM_ACKED is activated when any alarms are acknowledged either by the boolean rising edge on the ALM_ACK input or by acknowledging alarms from the HMI. This generates a one-second boolean TRUE value pulse. After one second, the output is reset to FALSE until some alarms are acknowledged. There is at least a 100 ms FALSE state between each pulse. If alarms are acknowledged from the HMI during the TRUE state or within 100 ms after resetting to FALSE, additional pulses are not be produced.

#### PCM600 parameters

EIHMI contains three paths to populate parameters visible in Parameter Setting in PCM600.

- **Configuration** > **HMI**
- **Monitoring** > **Detached LHMI**
- **Information** > **HW modules** > **EIHMI1**

## 3.26.4 Application

#### Substation HMI wake-up (door sensor)

In this example, substation HMI devices need to be woken up when a person enters the substation to see that everything works as expected.

A switch signal is directly connected to the binary input, which activates the paired HMI.

Depending on the hardware solution, this hardware signal can be distributed to all affected protection relays on the substation. Optionally, the processed signal can be routed in horizontal communication through process bus communications, that is, GOOSE, to other protection relays.

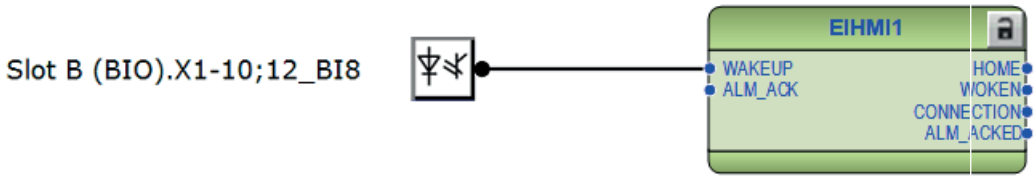



*Figure 194: Binary input connection*

Do not keep the HMI backlight always on as it may cause premature and unnecessary wear of the display panel.

## 3.26.5 Signals

**Table 354: EIHMI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| WAKEUP | BOOLEAN | 0=False | HMI wake-up command |
| ALM_ACK | BOOLEAN | 0=False | Acknowledge alarms command |

**Table 355: EIHMI Output signals**

| Name | Type | Description |
|---|---|---|
| HOME | BOOLEAN | HMI home button indicator |
| WOKEN | BOOLEAN | HMI woken indicator |
| CONNECTION | BOOLEAN | HMI connection status indicator |
| ALM_ACKED | BOOLEAN | Alarms acknowledged indicator |

## 3.26.6 Settings

**Table 356: HMI configuration parameters**

| Parameter | Description |
|---|---|
| Backlight brightness | Controls the HMI maximum backlight brightness. Actual brightness can be lower due to thermal compensation. |
| Enable USB access | Enables or disables HMI connector X2. |
| Enable HMI service port | Enables or disables HMI service port X1.2. |

### 3.26.7 Monitored data

**Table 357: HMI monitoring parameters**

| Parameter | Description |
|---|---|
| CONNECTION | Status of connection between the protection relay and HMI. The parameter is set TRUE when the paired HMI is connected to the protection relay. |
| Service port IP address | IP address of service port connector X1.2. Changes to this setting are available only on the HMI. |
| Main unit port IP address | IP address assigned to the main unit port connector X1.1. Changes to this setting are available only on the HMI. |

## 3.27 HMI Ethernet channel supervision HMILCCH

### 3.27.1 Function block

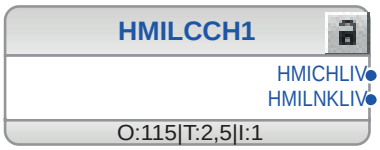



*Figure 195: Function block*

### 3.27.2 Functionality

Ethernet channel supervision HMILCCH represents the X0/HMI Ethernet channel.

### 3.27.3 Signals

**Table 358: HMILCCH Output signals**

| Name | Type | Description |
|---|---|---|
| HMICHLIV | BOOLEAN | Status of the Ethernet channel X0/LAN Value is TRUE if the port is receiving Ethernet frames. Otherwise the value is FALSE. |
| HMILNKLIV | BOOLEAN | Link status of Ethernet port X0/LAN Value is "Up" or "Down". |

### 3.27.4 Settings

**Table 359: HMILCCH Settings**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| IP Address | | | | 192.168.2.254 | IP address for the HMI. |
| MAC Address | | | | XX-XX-XX-XX-XXXX | MAC address for the HMI. This parameter is read-only. |

### 3.27.5 Monitored data

Monitored data is available in two locations.

- **Monitoring** > **Communication** > **Ethernet** > **Activity** > **HMICHLIV**
- **Monitoring** > **Communication** > **Ethernet** > **Link statuses** > **HMICHLIV**

## 3.28 Line differential communication port supervision SCHLCCH6

### 3.28.1 Function block

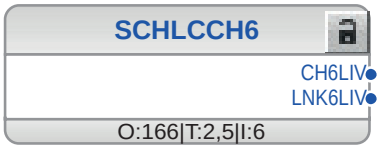



*Figure 196: Function block*

### 3.28.2 Functionality

Line differential channel supervision function SCHLCCH6 represents the X6/LD line differential channel.

### 3.28.3 Signals

**Table 360: SCHLCCH6 Output signals**

| Name | Type | Description |
|---|---|---|
| CH6LIV | BOOLEAN | Status of the line differential port X5/LD Value is TRUE if the port is receiving Ethernet frames. Otherwise the value is FALSE. |
| LNK6LIV | BOOLEAN | Link status of the line differential port X6/LD Value is "Up" or "Down". |

## 3.28.4 Monitored data

Monitored data is available in two locations.

- **Monitoring** > **Communication** > **Ethernet** > **Activity** > **CH6LIV**
- **Monitoring** > **Communication** > **Ethernet** > **Link statuses** > **LNK6LIV**

## 3.28.5 Diagnostics

Diagnostics data is available in **Monitoring** > **Communication** > **Ethernet** > **Diagnostics** > **X&**.

**Table 361: Parameters read from the SFP module connected in the X6/LD line differential channel**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Temperature | –128.0...128.0 | C | | 0 | Measured SFP transceiver temperature |
| Voltage | 0.000...6.550 | V | | 0 | Measured SFP transceiver voltage |
| Bias current | 0.0...131.0 | mA | | 0 | Measured SFP transceiver bias current |
| Tx power | 0.000...6.550 | MW | | 0 | Measured SFP transceiver's transmitter power |
| Rx power | 0.000...6.550 | mW | | 0 | Measured SFP transceiver's receiver power |
| XCVR detected | FALSE / TRUE | | | FALSE | SFP Transceiver detection state |
| Rx Power alarm | FALSE / TRUE | | | FALSE | SFP Receiver power alarm |
| Tx Power alarm | FALSE / TRUE | | | FALSE | SFP Transmitter power alarm |
| Voltage alarm | FALSE / TRUE | | | FALSE | SFP transceiver voltage alarm |
| Temperature alarm | FALSE / TRUE | | | FALSE | SFP temperature alarm |
| Part name | SFP not inserted<br>SFP not supported<br>2RCA045621 (MM 2 km)<br>2RCA045622 (SM 20 km)<br>2RCA045623 (SM 50 km) | | | SFP not inserted | Name, type and operational distance for the SFP module |

# 4 Protection functions

## 4.1 Three-phase current protection

### 4.1.1 Three-phase non-directional overcurrent protection PHxPTOC (ANSI 51P-1, 51P-2, 50P)

#### 4.1.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase non-directional overcurrent protection, low stage | PHLPTOC | 3I> | 51P-1 |
| Three-phase non-directional overcurrent protection, high stage | PHHPTOC | 3I>> | 51P-2 |
| Three-phase non-directional overcurrent protection, instantaneous stage | PHIPTOC | 3I>>> | 50P |

#### 4.1.1.2 Function block




*Figure 197: Function block*

#### 4.1.1.3 Functionality

The three-phase non-directional overcurrent protection function PHxPTOC is used as one-phase, two-phase or three-phase non-directional overcurrent and short-circuit protection.

The function starts when the current exceeds the set limit. The operate time characteristics for low stage PHLPTOC and high stage PHHPTOC can be selected to be either definite time ( DT) or inverse definite minimum time ( IDMT). The instantaneous stage PHIPTOC always operates with the DT characteristic.

In the DT mode, the function operates after a predefined operate time and resets when the fault current disappears. The IDMT mode provides current-dependent timer characteristics.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.1.1.4 Analog input configuration

PHxPTOC has one analog group input which must be properly configured.

**Table 362: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PHxPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

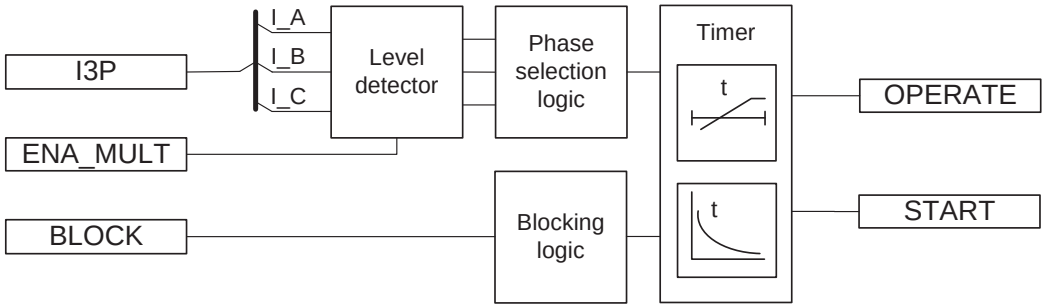



*Figure 198: Functional module diagram*

#### Level detector

The measured phase currents are compared phasewise to the set *Start value*. If the measured value exceeds the set *Start value*, the level detector reports the exceeding of the value to the phase selection logic. If the `ENA_MULT` input is active, the *Start value* setting is multiplied by the *Start value Mult* setting.

The protection relay does not accept the *Start value* or *Start value Mult* setting if the product of these settings exceeds the *Start value* setting range.

The start value multiplication is normally done when the inrush detection function (INRPHAR) is connected to the ENA_MULT input.

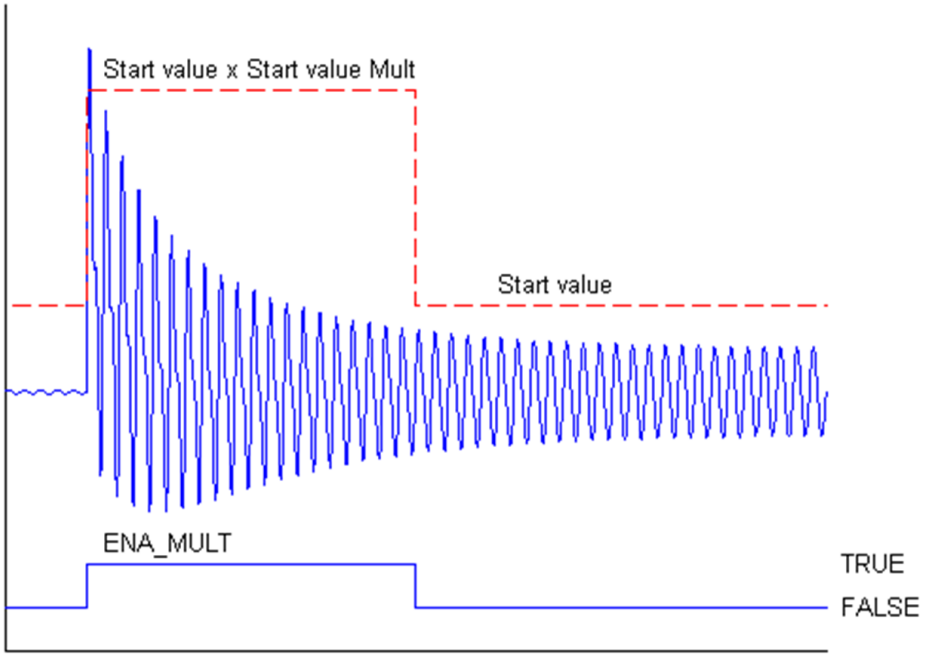



*Figure 199: Start value behavior with ENA_MULT input activated*

**Phase selection logic**

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the measured current exceeds the setting. If the phase information matches the *Num of start phases* setting, the phase selection logic activates the timer module.

**Timer**

Once activated, the timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The functionality of the timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate"

causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation and the value of START_DUR. The START output is deactivated when the reset timer has elapsed.

The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operate and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see *Chapter 11.2.1 IDMT curves for overcurrent protection* in this manual.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

#### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.1.1.6 Measurement modes

The function operates on four alternative measurement modes: "RMS", "DFT", "Peak-to-Peak" and "P-to-P + backup". Additionally, there is “Wide P-to-P” measurement mode in some products variants. The measurement mode is selected with the setting *Measurement mode*.

**Table 363: Measurement modes supported by PHxPTOC stages**

| Measurement mode | PHLPTOC | PHHPTOC | PHIPTOC |
|---|---|---|---|
| RMS | x | x | |
| DFT | x | x | |
| Peak-to-Peak | x | x | |
| P-to-P + backup | | | x |
| Wide P-to-P | x [2] | | |

For a detailed description of the measurement modes, see *Chapter 11.6 Measurement modes* in this manual.

### 4.1.1.7 Timer characteristics

PHxPTOC supports both DT and IDMT characteristics. The user can select the timer characteristics with the *Operating curve type* and *Type of reset curve* settings. When the DT characteristic is selected, it is only affected by the *Operate delay time* and *Reset delay time* settings.

The protection relay provides 16 IDMT characteristics curves, of which seven comply with the IEEE C37.112 and six with the IEC 60255-3 standard. Two curves follow the special characteristics of ABB praxis and are referred to as RI and RD. One curve is for rectifier bridge protection. In addition to this, a user programmable curve can be used if none of the standard curves are applicable. The DT characteristics can be chosen by selecting the *Operating curve type* values "ANSI Def. Time" or "IEC Def. Time". The functionality is identical in both cases.

The timer characteristics supported by different stages comply with the list in the IEC 61850-7-4 specification, indicate the characteristics supported by different stages:

**Table 364: Timer characteristics supported by different stages**

| Operating curve type | PHLPTOC | PHHPTOC |
|---|---|---|
| (1) ANSI Extremely Inverse | x | x |
| (2) ANSI Very Inverse | x | |
| (3) ANSI Normal Inverse | x | x |
| (4) ANSI Moderately Inverse | x | |
| (5) ANSI Definite Time | x | x |
| (6) Long Time Extremely Inverse | x | |
| (7) Long Time Very Inverse | x | |
| (8) Long Time Inverse | x | |
| (9) IEC Normal Inverse | x | x |
| (10) IEC Very Inverse | x | x |
| (11) IEC Inverse | x | |
| (12) IEC Extremely Inverse | x | x |
| (13) IEC Short Time Inverse | x | |
| (14) IEC Long Time Inverse | x | |
| (15) IEC Definite Time | x | x |
| (17) User programmable | x | x |
| (18) RI type | x | |
| (19) RD type | x | |
| (20) UK rectifier | x | |

[2] Available only in REG615 standard configurations C and D

PHIPTOC supports only definite time characteristic.

For a detailed description of timers, see *Chapter 11 General function block features* in this manual.

**Table 365: Reset time characteristics supported by different stages**

| Reset curve type | PHLPTOC | PHHPTOC | Note |
|---|---|---|---|
| (1) Immediate | x | x | Available for all operate time curves |
| (2) Def time reset | x | x | Available for all operate time curves |
| (3) Inverse reset | x | x | Available only for ANSI and user programmable curves |

The *Type of reset curve* setting does not apply to PHIPTOC or when the DT operation is selected. The reset is purely defined by the *Reset delay time* setting.

### 4.1.1.8 Application

PHxPTOC is used in several applications in the power system. The applications include but are not limited to:

- Selective overcurrent and short-circuit protection of feeders in distribution and subtransmission systems
- Backup overcurrent and short-circuit protection of power transformers and generators
- Overcurrent and short-circuit protection of various devices connected to the power system, for example shunt capacitor banks, shunt reactors and motors
- General backup protection

PHxPTOC is used for single-phase, two-phase and three-phase non-directional overcurrent and short-circuit protection. Typically, overcurrent protection is used for clearing two and three-phase short circuits. Therefore, the user can choose how many phases, at minimum, must have currents above the start level for the function to operate. When the number of start-phase settings is set to "1 out of 3", the operation of PHxPTOC is enabled with the presence of high current in one-phase.

When the setting is "2 out of 3" or "3 out of 3", single-phase faults are not detected. The setting "3 out of 3" requires the fault to be present in all three phases.

Many applications require several steps using different current start levels and time delays. PHxPTOC consists of three protection stages.

- Low PHLPTOC
- High PHHPTOC
- Instantaneous PHIPTOC

PHLPTOC is used for overcurrent protection. The function contains several types of time-delay characteristics. PHHPTOC and PHIPTOC are used for fast clearance of very high overcurrent situations.

### Transformer overcurrent protection

The purpose of transformer overcurrent protection is to operate as main protection, when differential protection is not used. It can also be used as coarse back-up protection for differential protection in faults inside the zone of protection, that is, faults occurring in incoming or outgoing feeders, in the region of transformer terminals and tank cover. This means that the magnitude range of the fault current can be very wide. The range varies from 6x$I_n$ to several hundred times $I_n$, depending on the impedance of the transformer and the source impedance of the feeding network. From this point of view, it is clear that the operation must be both very fast and selective, which is usually achieved by using coarse current settings.

The purpose is also to protect the transformer from short circuits occurring outside the protection zone, that is through-faults. Transformer overcurrent protection also provides protection for the LV-side busbars. In this case the magnitude of the fault current is typically lower than 12x$I_n$ depending on the fault location and transformer impedance. Consequently, the protection must operate as fast as possible taking into account the selectivity requirements, switching-in currents, and the thermal and mechanical withstand of the transformer and outgoing feeders.

Traditionally, overcurrent protection of the transformer has been arranged as shown in *Figure 200*. The low-set stage PHLPTOC operates time-selectively both in transformer and LV-side busbar faults. The high-set stage PHHPTOC operates instantaneously making use of current selectivity only in transformer HV-side faults. If there is a possibility, that the fault current can also be fed from the LV-side up to the HV-side, the transformer must also be equipped with LV-side overcurrent protection. Inrush current detectors are used in start-up situations to multiply the current start value setting in each particular protection relay where the inrush current can occur. The overcurrent and contact based circuit breaker failure protection CCBRBRF is used to confirm the protection scheme in case of circuit breaker malfunction.

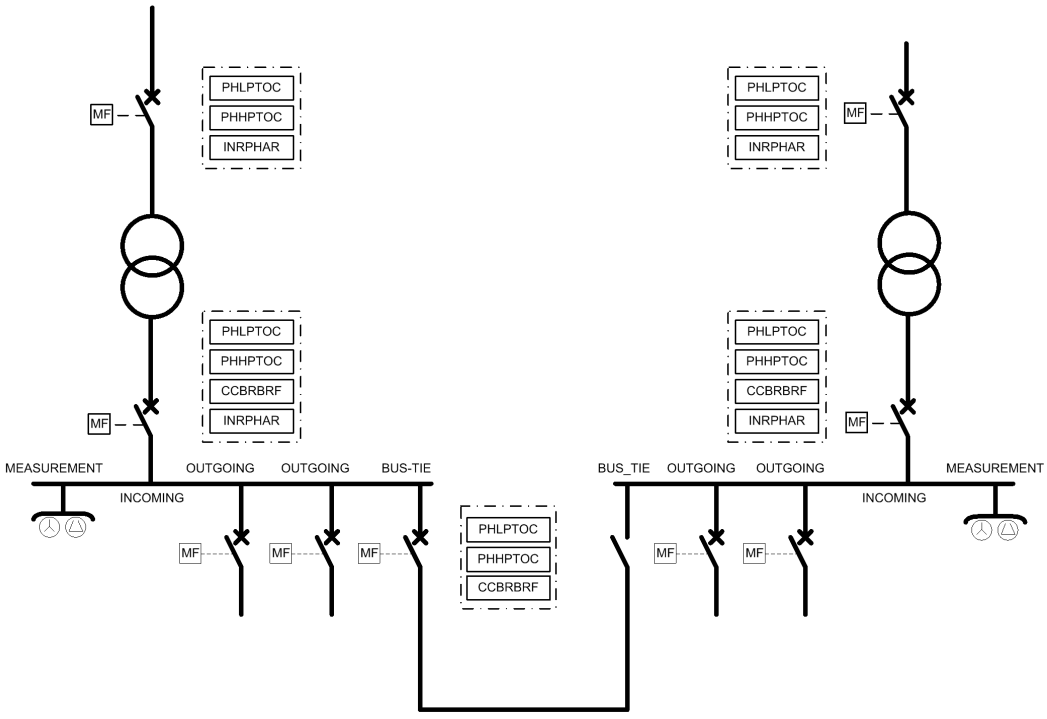



*Figure 200: Example of traditional time selective transformer overcurrent protection*

The operating times of the main and backup overcurrent protection of the above scheme become quite long, this applies especially in the busbar faults and also in the transformer LV-terminal faults. In order to improve the performance of the above scheme, a multiple-stage overcurrent protection with reverse blocking is proposed. *Figure 202* shows this arrangement.

**Overcurrent protection with line differential protection**

The line differential protection relay has also four separate overcurrent functions which can be used as the backup protection of line differential function for lines and cables. There are three stages available with definite or inverse time characteristics and an instantaneous stage.

The differential protection is available only if the communication between the units is working properly and no CT failure situation is detected. If a communication failure exists, the protect area or unit is left out from the primary protection scheme. Therefore it is practical to use overcurrent protection as a local backup functionality.

In the standard configuration of the protection relay, the backup overcurrent protection is implemented with four overcurrent stages so that under normal conditions, that is, when the line differential communication is healthy, only two lowest stages are available for the remote backup protection. In case a line differential communication failure exists, two more stages are released for rapid local backup overcurrent and short circuit protection. These stages are blocked in normal situation and automatically unblocked when the communication failure is detected. The setting of the overcurrent stages for local backup protection has to be considered carefully in order to achieve the best possible protection performance under abnormal conditions.

Two situations, case A and B, are shown in *Figure 201*. In case A, the communication media is valid and therefore the line differential protection is in operation. In this case, the two lowest stages of overcurrent protection are in operation simultaneously. In case B, a communication failure causes a situation where the line differential function is not able to work properly. Unblocking of the two highest overcurrent protection stages releases these functions to protect the line against overcurrents and short-circuits.

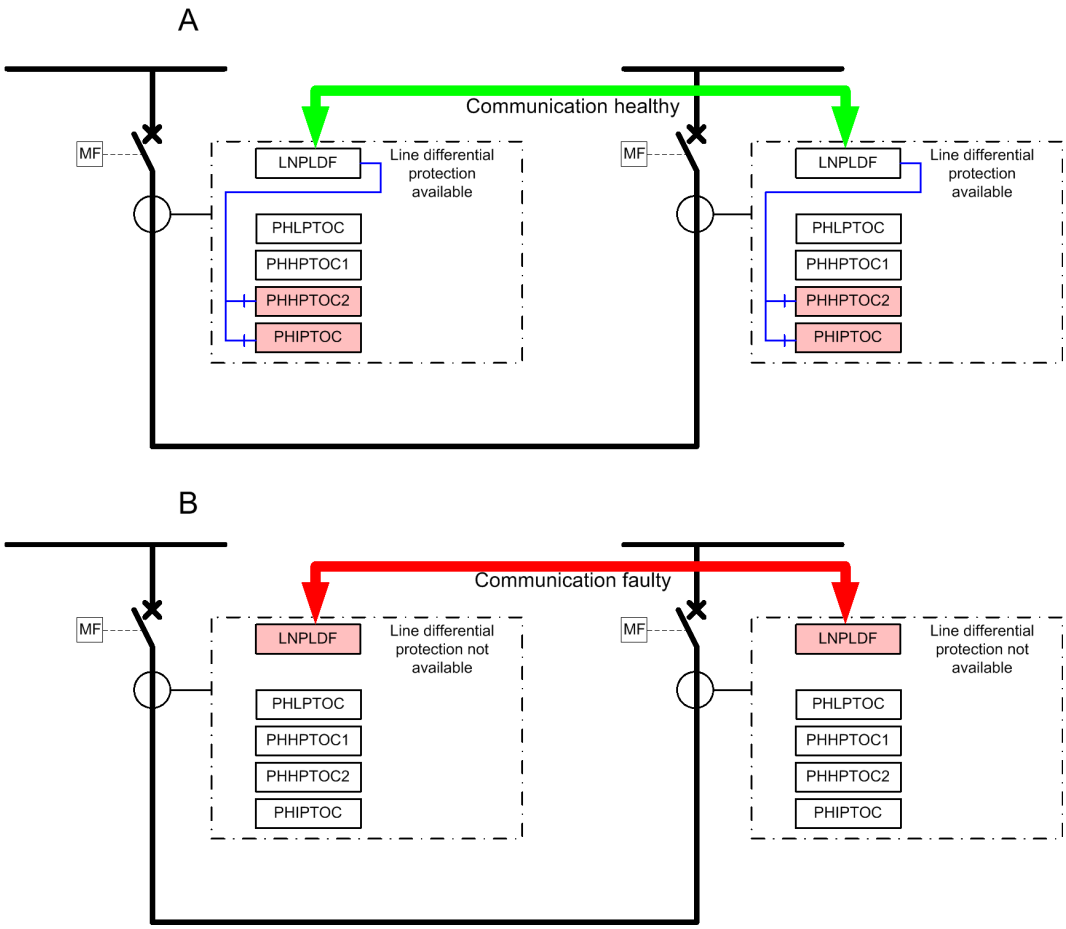



*Figure 201: Backup overcurrent protection for line differential applications*

**Transformer and busbar overcurrent protection with reverse blocking principle**

By implementing a full set of overcurrent protection stages and blocking channels between the protection stages of the incoming feeders, bus-tie and outgoing feeders, it is possible to speed up the operation of overcurrent protection in the busbar and transformer LV-side faults without impairing the selectivity. Also, the security degree of busbar protection is increased, because there is now a dedicated, selective and fast busbar protection functionality which is based on the blockable overcurrent protection principle. The additional time selective stages on the transformer HV and LV-sides provide increased security degree of backup protection for the transformer, busbar and also for the outgoing feeders.

Depending on the overcurrent stage in question, the selectivity of the scheme in *Figure 202* is based on the operating current, operating time or blockings between successive overcurrent stages. With blocking channels, the operating time of the protection can be drastically shortened if compared to the simple time selective protection. In addition to the busbar protection, this blocking principle is applicable for the protection of transformer LV terminals and short lines. The functionality and performance of the proposed overcurrent protections can be summarized as seen in the table.

**Table 366: Proposed functionality of numerical transformer and busbar overcurrent protection. DT = definite time, IDMT = inverse definite minimum time**

| O/C-stage | Operating char. | Selectivity mode | Operation speed | Sensitivity |
|---|---|---|---|---|
| HV/3I> | DT/IDMT | time selective | low | very high |
| HV/3I>> | DT | blockable/time selective | high/low | high |
| HV/3I>>> | DT | current selective | very high | low |
| LV/3I> | DT/IDMT | time selective | low | very high |
| LV/3I>> | DT | time selective | low | high |
| LV/3I>>> | DT | blockable | high | high |

In case the bus-tie breaker is open, the operating time of the blockable overcurrent protection is approximately 100 ms (relaying time). When the bus-tie breaker is closed, that is, the fault current flows to the faulted section of the busbar from two directions, the operation time becomes as follows: first the bus-tie relay unit trips the tie breaker in the above 100 ms, which reduces the fault current to a half. After this the incoming feeder relay unit of the faulted bus section trips the breaker in approximately 250 ms (relaying time), which becomes the total fault clearing time in this case.

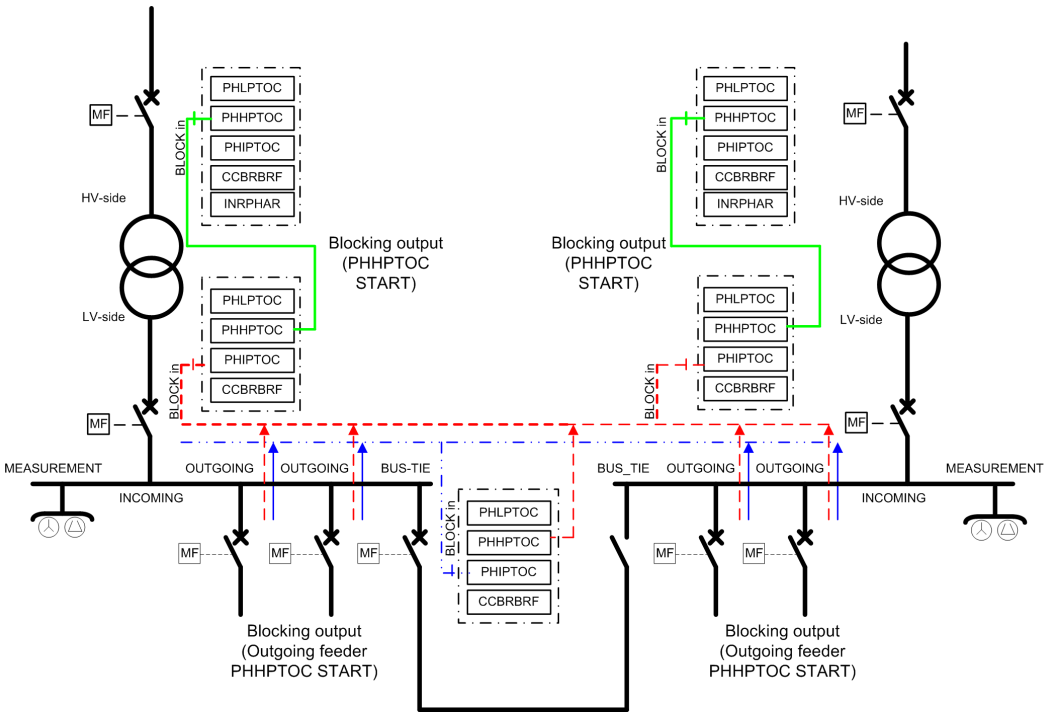



*Figure 202: Numerical overcurrent protection functionality for a typical sub-transmission/distribution substation (feeder protection not shown). Blocking output = digital output signal from the start of a protection stage, Blocking in = digital input signal to block the operation of a protection stage*

The operating times of the time selective stages are very short, because the grading margins between successive protection stages can be kept short. This is mainly due to the advanced measuring principle allowing a certain degree of CT saturation, good operating accuracy and short retardation times of the numerical units. So, for

example, a grading margin of 150 ms in the DT mode of operation can be used, provided that the circuit breaker interrupting time is shorter than 60 ms.

The sensitivity and speed of the current-selective stages become as good as possible due to the fact that the transient overreach is very low. Also, the effects of switching inrush currents on the setting values can be reduced by using the protection relay's logic, which recognizes the transformer energizing inrush current and blocks the operation or multiplies the current start value setting of the selected overcurrent stage with a predefined multiplier setting.

Finally, a dependable trip of the overcurrent protection is secured by both a proper selection of the settings and an adequate ability of the measuring transformers to reproduce the fault current. This is important in order to maintain selectivity and also for the protection to operate without additional time delays. For additional information about available measuring modes and current transformer requirements, see *Chapter 11.6 Measurement modes* in this manual.

**Radial outgoing feeder overcurrent protection**

The basic requirements for feeder overcurrent protection are adequate sensitivity and operation speed taking into account the minimum and maximum fault current levels along the protected line, selectivity requirements, inrush currents and the thermal and mechanical withstand of the lines to be protected.

In many cases the above requirements can be best fulfilled by using multiple-stage overcurrent units. *Figure 203* shows an example of this. A brief coordination study has been carried out between the incoming and outgoing feeders.

The protection scheme is implemented with three-stage numerical overcurrent protection, where the low-set stage PHLPTOC operates in IDMT-mode and the two higher stages PHHPTOC and PHIPTOC in DT-mode. Also the thermal withstand of the line types along the feeder and maximum expected inrush currents of the feeders are shown. Faults occurring near the station where the fault current levels are the highest are cleared rapidly by the instantaneous stage in order to minimize the effects of severe short circuit faults. The influence of the inrush current is taken into consideration by connecting the inrush current detector to the start value multiplying input of the instantaneous stage. By this way the start value is multiplied with a predefined setting during the inrush situation and nuisance tripping can be avoided.

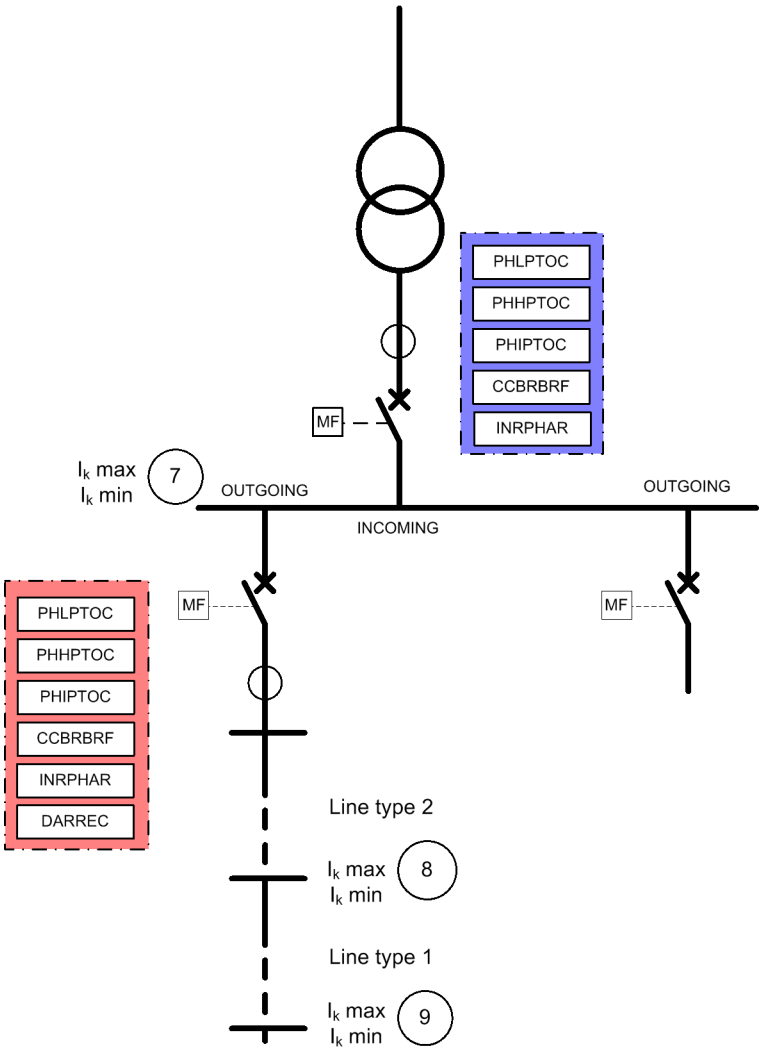



*Figure 203: Functionality of numerical multiple-stage overcurrent protection*

The coordination plan is an effective tool to study the operation of time selective operation characteristics. All the points mentioned earlier, required to define the overcurrent protection parameters, can be expressed simultaneously in a coordination plan. In *Figure 204*, the coordination plan shows an example of operation characteristics in the LV-side incoming feeder and radial outgoing feeder.

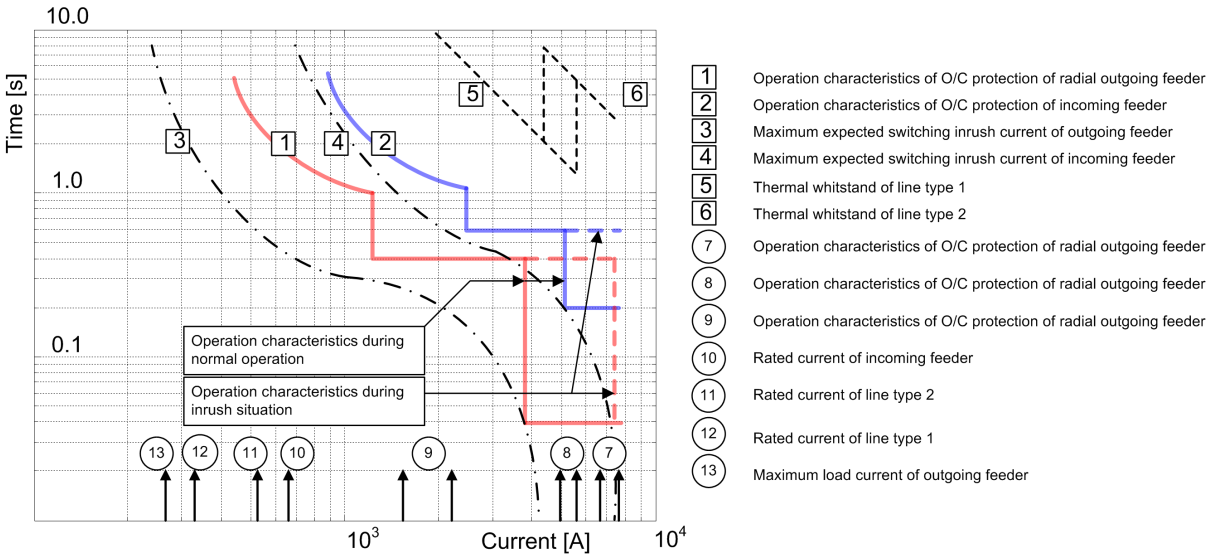



*Figure 204: Example coordination of numerical multiple-stage overcurrent protection*

## 4.1.1.9 Signals

### PHLPTOC Input signals

**Table 367: PHLPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

### PHHPTOC Input signals

**Table 368: PHHPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

#### PHIPTOC Input signals

**Table 369: PHIPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

#### PHLPTOC Output signals

**Table 370: PHLPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

#### PHHPTOC Output signals

**Table 371: PHHPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

#### PHIPTOC Output signals

**Table 372: PHIPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

## 4.1.1.10 Settings

#### PHLPTOC Settings

**Table 373: PHLPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...10.00 | xIn | 0.01 | 0.05 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type<br>20=UK rectifier | | | 15=IEC Def. Time | Selection of time delay curve type |

**Table 374: PHLPTOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

**Table 375: PHLPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.0086...50000.0000 | | 0.0001 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 0.0001 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...6.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 0.01 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 376: PHLPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak<br>5=Wide P-to-P | | | 2=DFT | Selects used measurement mode |

### PHHPTOC Settings

**Table 377: PHHPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.10...40.00 | xIn | 0.01 | 0.10 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>3=ANSI Norm. inv.<br>5=ANSI Def. Time<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>12=IEC Ext. inv.<br>15=IEC Def. Time<br>17=Programmable | | | 15=IEC Def. Time | Selection of time delay curve type |

**Table 378: PHHPTOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

**Table 379: PHHPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.0086...120.0000 | | 0.0001 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 0.0001 | 0.1217 | Parameter B for customer programmable curve |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 0.01 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 380: PHHPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

### PHIPTOC Settings

**Table 381: PHIPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.10...40.00 | xIn | 0.01 | 1.00 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Operate delay time | 20...300000 | ms | 10 | 20 | Operate delay time |

**Table 382: PHIPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |

**Table 383: PHIPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

## 4.1.1.11 Monitored data

### PHLPTOC Monitored data

**Table 384: PHLPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHLPTOC | Enum | 1=on | | Status |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 2=blocked<br>3=test<br>4=test/blocked<br>5=off | | |

**PHHPTOC Monitored data**

**Table 385: PHHPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHHPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

**PHIPTOC Monitored data**

**Table 386: PHIPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHIPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 4.1.1.12 Technical data

**Table 387: PHxPTOC Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | PHLPTOC | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| | PHHPTOC<br>and<br>PHIPTOC | ±1.5% of set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$) | | |
| Start time [1] | | Minimum | Typical | Maximum |
| | PHIPTOC: [2] | 8 ms | 12 ms | 15 ms |

*Table continues on the next page*

| Characteristic | | Value | | |
|---|---|---|---|---|
| | $I_{Fault}$ = 2 × set *Start value*<br>$I_{Fault}$ = 10 × set *Start value* | 7 ms | 9 ms | 12 ms |
| | PHHPTOC and PHLPTOC: [3]<br>$I_{Fault}$ = 2 × set *Start value* | 23 ms | 26 ms | 29 ms |
| Reset time | | Typically <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [4] | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression<br>P-to-P+backup: No suppression | | |

#### 4.1.1.13 Technical revision history

**Table 388: PHLPTOC Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | G | Setting *Start value* maximum value extended to 10.00xIn. |

## 4.1.2 Three-phase directional overcurrent protection DPHxPDOC (ANSI 67P/51P-1, 67P/51P-2)

[1] *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements.
[2] Measured with static signal output (SSO).
[3] Includes the delay of the signal output contact (SO).
[4] *Maximum Start value* = 2.5 × $I_n$, *Start value* multiples in the range of 1.5...20.

### 4.1.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase directional overcurrent protection, low stage | DPHLPDOC | 3I> -> | 67P/51P-1 |
| Three-phase directional overcurrent protection, high stage | DPHHPDOC | 3I>> -> | 67P/51P-2 |

### 4.1.2.2 Function block

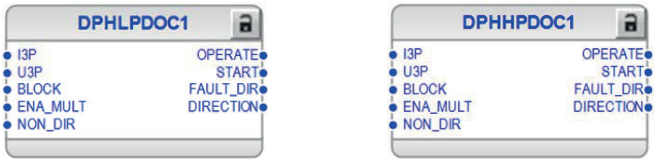



*Figure 205: Function block*

### 4.1.2.3 Functionality

The three-phase directional overcurrent protection function DPHxPDOC is used as one-phase, two-phase or three-phase directional overcurrent and short-circuit protection for feeders.

DPHxPDOC starts up when the value of the current exceeds the set limit and directional criterion is fulfilled. The operate time characteristics for low stage DPHLPDOC and high stage DPHHPDOC can be selected to be either definite time (DT) or inverse definite minimum time (IDMT).

In the DT mode, the function operates after a predefined operate time and resets when the fault current disappears. The IDMT mode provides current-dependent timer characteristics.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.1.2.4 Analog channel configuration

DPHxPDOC has two analog group inputs which must be properly configured.

**Table 389: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 390: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of DPHxPDOC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

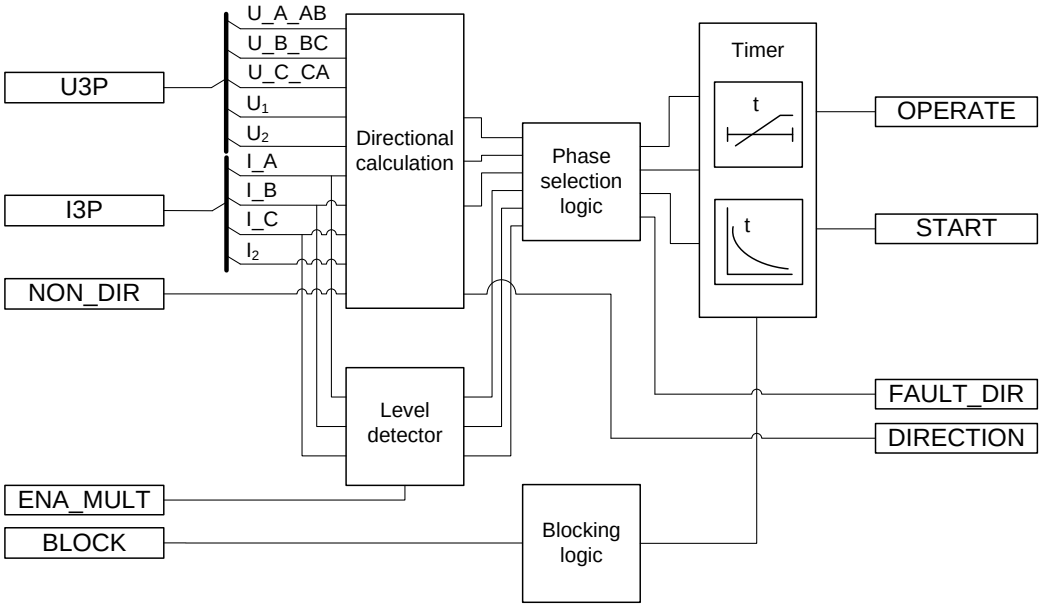



*Figure 206: Functional module diagram*

#### Directional calculation

The directional calculation compares the current phasors to the polarizing phasor. A suitable polarization quantity can be selected from the different polarization quantities, which are the positive sequence voltage, negative sequence voltage, self-polarizing (faulted) voltage and cross-polarizing voltages (healthy voltages). The polarizing method is defined with the *Pol quantity* setting.

**Table 391: Polarizing quantities**

| Polarizing quantity | Description |
|---|---|
| Pos. seq. volt | Positive sequence voltage |
| Neg. seq. volt | Negative sequence voltage |
| Self pol | Self polarization |
| Cross pol | Cross polarization |

The directional operation can be selected with the *Directional mode* setting. The user can select either "Non-directional", "Forward" or "Reverse" operation. By setting the value of *Allow Non Dir* to "True", the non-directional operation is allowed when the directional information is invalid.

The *Characteristic angle* setting is used to turn the directional characteristic. The value of *Characteristic angle* should be chosen in such a way that all the faults in the operating direction are seen in the operating zone and all the faults in the opposite direction are seen in the non-operating zone. The value of *Characteristic angle* depends on the network configuration.

Reliable operation requires both the operating and polarizing quantities to exceed certain minimum amplitude levels. The minimum amplitude level for the operating quantity (current) is set with the *Min operate current* setting. The minimum amplitude level for the polarizing quantity (voltage) is set with the *Min operate voltage* setting. If the amplitude level of the operating quantity or polarizing quantity is below the set level, the direction information of the corresponding phase is set to "Unknown".

The polarizing quantity validity can remain valid even if the amplitude of the polarizing quantity falls below the value of the *Min operate voltage* setting. In this case, the directional information is provided by a special memory function for a time defined with the *Voltage Mem time* setting.

DPHxPDOC is provided with a memory function to secure a reliable and correct directional protection relay operation in case of a close short circuit or an earth fault characterized by an extremely low voltage. At sudden loss of the polarization quantity, the angle difference is calculated on the basis of a fictive voltage. The fictive voltage is calculated using the positive phase sequence voltage measured before the fault occurred, assuming that the voltage is not affected by the fault. The memory function enables the function to operate up to a maximum of three seconds after a total loss of voltage. This time can be set with the *Voltage Mem time* setting. The voltage memory cannot be used for the "Negative sequence voltage" polarization because it is not possible to substitute the positive sequence voltage for negative sequence voltage without knowing the network unsymmetry level. This is the reason why the fictive voltage angle and corresponding direction information are frozen immediately for this polarization mode when the need for a voltage memory arises and these are kept frozen until the time set with *Voltage Mem time* elapses.



The value for the *Min operate voltage* setting should be carefully selected since the accuracy in low signal levels is strongly affected by the measuring device accuracy.

When the voltage falls below *Min operate voltage* at a close fault, the fictive voltage is used to determine the phase angle. The measured voltage is applied again as soon as the voltage rises above *Min operate voltage* and hysteresis. The fictive voltage is also discarded if the measured voltage stays below *Min operate voltage* and hysteresis for longer than *Voltage Mem time* or if the fault current disappears

while the fictive voltage is in use. When the voltage is below *Min operate voltage* and hysteresis and the fictive voltage is unusable, the fault direction cannot be determined. The fictive voltage can be unusable for two reasons:

- The fictive voltage is discarded after *Voltage Mem time*
- The phase angle cannot be reliably measured before the fault situation.

DPHxPDOC can be forced to the non-directional operation with the NON_DIR input. When the NON_DIR input is active, DPHxPDOC operates as a non-directional overcurrent protection, regardless of the *Directional mode* setting.

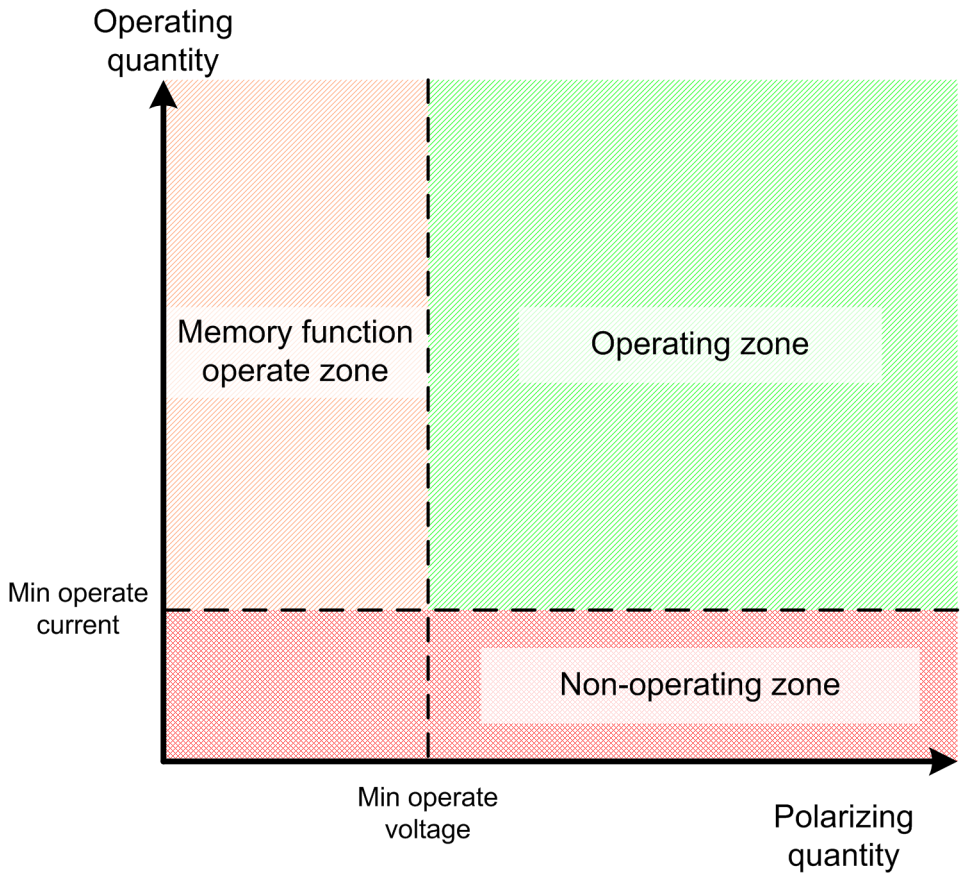



*Figure 207: Operating zones at minimum magnitude levels*

The DIRECTION output indicates on which operating sector the current is measured. The value combines phase-specific directions which are available in monitored data as DIR_A, DIR_B and DIR_C.

### Level detector

The measured phase currents are compared phasewise to the set *Start value*. If the measured value exceeds the set *Start value*, the level detector reports the exceeding of the value to the phase selection logic. If the ENA_MULT input is active, the *Start value* setting is multiplied by the *Start value Mult* setting.

The protection relay does not accept the *Start value* or *Start value Mult* setting if the product of these settings exceeds the *Start value* setting range.

The start value multiplication is normally done when the inrush detection function (INRPHAR) is connected to the ENA_MULT input.

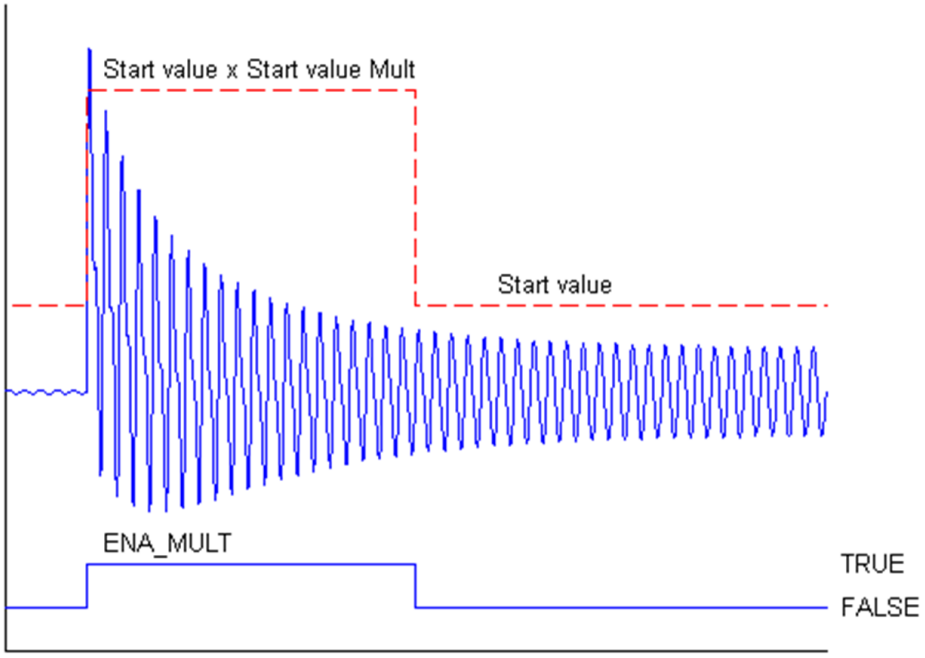



*Figure 208: Start value behavior with ENA_MULT input activated*

**Phase selection logic**

If the fault criteria are fulfilled in the level detector and the directional calculation, the phase selection logic detects the phase or phases in which the measured current exceeds the setting. If the phase information matches the *Num of start phases* setting, the phase selection logic activates the timer module.

FAULT_DIR gives the detected direction of the fault during fault situations, that is, when the START output is active.

**Timer**

Once activated, the timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and Curve parameter E.

If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The functionality of the timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic

is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation and the value of START_DUR. The START output is deactivated when the reset timer has elapsed.

The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operate and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see *Chapter 11.2.1 IDMT curves for overcurrent protection* in this manual.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

#### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.1.2.6 Measurement modes

The function operates on three alternative measurement modes: “RMS”, “DFT” and “Peak-to-Peak” . The measurement mode is selected with the *Measurement mode* setting.

**Table 392: Measurement modes supported by DPHxPDOC stages**

| Measurement mode | DPHLPDOC | DPHHPDOC |
|---|---|---|
| RMS | x | x |
| DFT | x | x |
| Peak-to-Peak | x | x |

### 4.1.2.7 Directional overcurrent characteristics

The forward and reverse sectors are defined separately. The forward operation area is limited with the *Min forward angle* and *Max forward angle* settings. The reverse operation area is limited with the *Min reverse angle* and *Max reverse angle* settings.

The sector limits are always given as positive degree values.

In the forward operation area, the *Max forward angle* setting gives the counterclockwise sector and the *Min forward angle* setting gives the corresponding clockwise sector, measured from the *Characteristic angle* setting.

In the backward operation area, the *Max reverse angle* setting gives the counterclockwise sector and the *Min reverse angle* setting gives the corresponding clockwise sector, a measurement from the *Characteristic angle* setting that has been rotated 180 degrees.

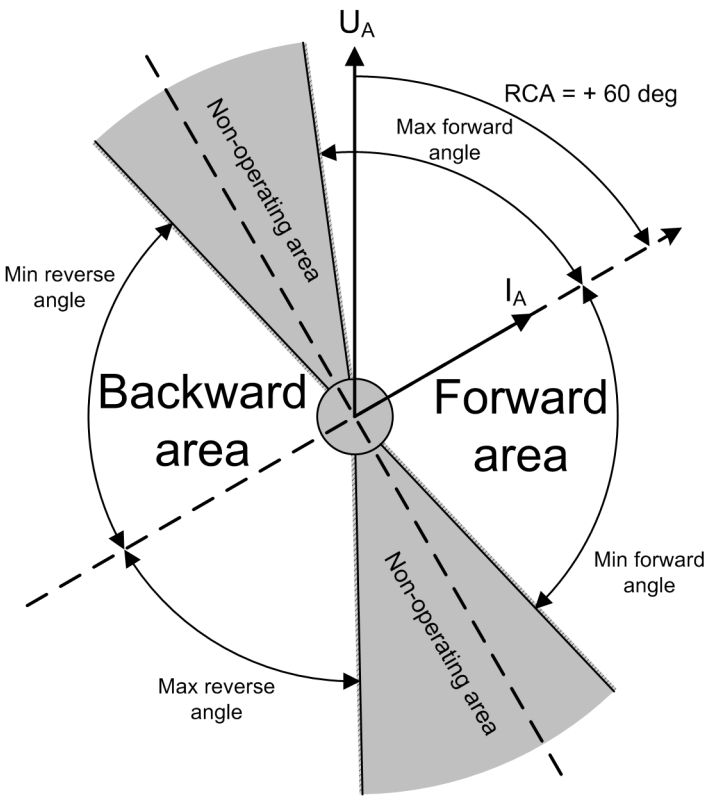



*Figure 209: Configurable operating sectors*

**Table 393: Momentary per phase direction value for monitored data view**

| Criterion for per phase direction information | The value for DIR_A/_B/_C |
|---|---|
| The ANGLE_X is not in any of the defined sectors, or the direction cannot be defined due too low amplitude | 0 = unknown |
| The ANGLE_X is in the forward sector | 1 = forward |

*Table continues on the next page*

| Criterion for per phase direction information | The value for DIR_A/_B/_C |
|---|---|
| The ANGLE_X is in the reverse sector | 2 = backward |
| (The ANGLE_X is in both forward and reverse sectors, that is, when the sectors are overlapping) | 3 = both |

**Table 394: Momentary phase combined direction value for monitored data view**

| Criterion for phase combined direction information | The value for DIRECTION |
|---|---|
| The direction information (DIR_X) for all phases is unknown | 0 = unknown |
| The direction information (DIR_X) for at least one phase is forward, none being in reverse | 1 = forward |
| The direction information (DIR_X) for at least one phase is reverse, none being in forward | 2 = backward |
| The direction information (DIR_X) for some phase is forward and for some phase is reverse | 3 = both |

FAULT_DIR gives the detected direction of the fault during fault situations, that is, when the START output is active.

### Self-polarizing as polarizing method

**Table 395: Equations for calculating angle difference for self-polarizing method**

| Faulted phases | Used fault current | Used polarizing voltage | Angle difference |
|---|---|---|---|
| A | $\underline{I}_A$ | $\underline{U}_A$ | $ANGLE_A = \varphi(\underline{U}_A) - \varphi(\underline{I}_A) - \varphi_{RCA}$ (Equation 9) |
| B | $\underline{I}_B$ | $\underline{U}_B$ | $ANGLE_B = \varphi(\underline{U}_B) - \varphi(\underline{I}_B) - \varphi_{RCA}$ (Equation 10) |
| C | $\underline{I}_C$ | $\underline{U}_C$ | $ANGLE_C = \varphi(\underline{U}_C) - \varphi(\underline{I}_C) - \varphi_{RCA}$ (Equation 11) |
| A - B | $\underline{I}_A$-$\underline{I}_B$ | $\underline{U}_{AB}$ | $ANGLE_A = \varphi(\underline{U}_{AB}) - \varphi(\underline{I}_A - \underline{I}_B) - \varphi_{RCA}$ (Equation 12) |
| B - C | $\underline{I}_B$-$\underline{I}_C$ | $\underline{U}_{BC}$ | $ANGLE_B = \varphi(\underline{U}_{BC}) - \varphi(\underline{I}_B - \underline{I}_C) - \varphi_{RCA}$ (Equation 13) |
| C - A | $\underline{I}_C$-$\underline{I}_A$ | $\underline{U}_{CA}$ | $ANGLE_C = \varphi(\underline{U}_{CA}) - \varphi(\underline{I}_C - \underline{I}_A) - \varphi_{RCA}$ (Equation 14) |

In an example case of the phasors in a single-phase earth fault where the faulted phase is phase A, the angle difference between the polarizing quantity $U_A$ and operating quantity $I_A$ is marked as ϕ. In the self-polarization method, there is no need to rotate the polarizing quantity.

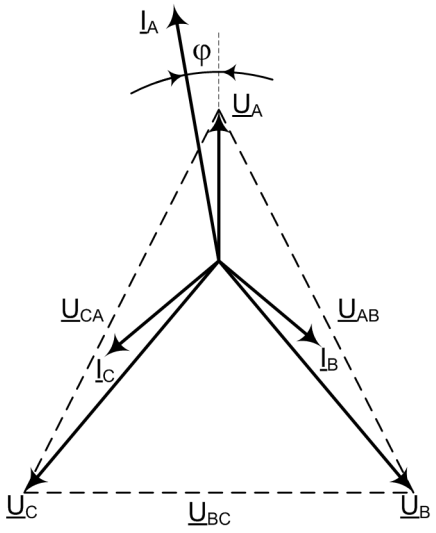



*Figure 210: Single-phase earth fault, phase A*

In an example case of a two-phase short-circuit failure where the fault is between phases B and C, the angle difference is measured between the polarizing quantity $U_{BC}$ and operating quantity $I_B - I_C$ in the self-polarizing method.

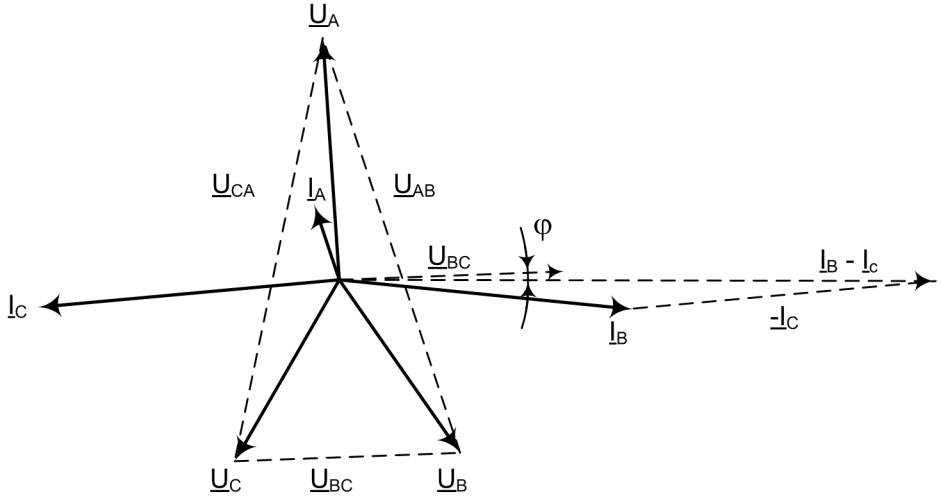



*Figure 211: Two-phase short circuit, short circuit is between phases B and C*

**Cross-polarizing as polarizing quantity**

**Table 396: Equations for calculating angle difference for cross-polarizing method**

| Faulted phases | Used fault current | Used polarizing voltage | Angle difference |
|---|---|---|---|
| A | $\underline{I}_A$ | $\underline{U}_{BC}$ | $ANGLE_A = \varphi(\underline{U}_{BC}) - \varphi(\underline{I}_A) - \varphi_{RCA} + 90^o$ (Equation 15) |
| B | $\underline{I}_B$ | $\underline{U}_{CA}$ | $ANGLE_B = \varphi(\underline{U}_{CA}) - \varphi(\underline{I}_B) - \varphi_{RCA} + 90^o$ (Equation 16) |
| C | $\underline{I}_C$ | $\underline{U}_{AB}$ | $ANGLE_C = \varphi(\underline{U}_{AB}) - \varphi(\underline{I}_C) - \varphi_{RCA} + 90^o$ (Equation 17) |
| A - B | $\underline{I}_A$-$\underline{I}_B$ | $\underline{U}_{BC}$-$\underline{U}_{CA}$ | $ANGLE_A = \varphi(\underline{U}_{BC} - \underline{U}_{CA}) - \varphi(\underline{I}_A - \underline{I}_B) - \varphi_{RCA} + 90^o$ (Equation 18) |
| B - C | $\underline{I}_B$-$\underline{I}_C$ | $\underline{U}_{CA}$-$\underline{U}_{AB}$ | $ANGLE_B = \varphi(\underline{U}_{CA} - \underline{U}_{AB}) - \varphi(\underline{I}_B - \underline{I}_C) - \varphi_{RCA} + 90^o$ (Equation 19) |
| C - A | $\underline{I}_C$-$\underline{I}_A$ | $\underline{U}_{AB}$-$\underline{U}_{BC}$ | $ANGLE_C = \varphi(\underline{U}_{AB} - \underline{U}_{BC}) - \varphi(\underline{I}_C - \underline{I}_A) - \varphi_{RCA} + 90^o$ (Equation 20) |

The angle difference between the polarizing quantity $U_{BC}$ and operating quantity $I_A$ is marked as ϕ in an example of the phasors in a single-phase earth fault where the faulted phase is phase A. The polarizing quantity is rotated with 90 degrees. The characteristic angle is assumed to be ~ 0 degrees.

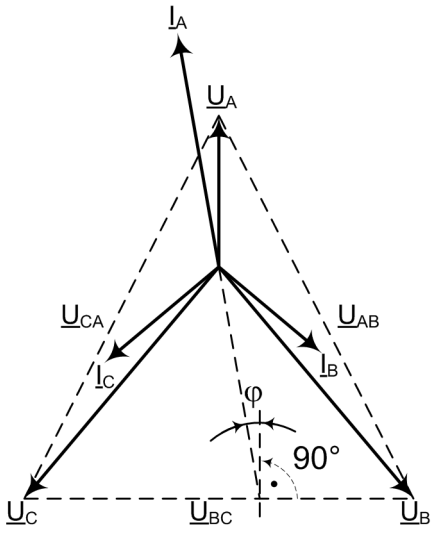



*Figure 212: Single-phase earth fault, phase A*

In an example of the phasors in a two-phase short-circuit failure where the fault is between the phases B and C, the angle difference is measured between the polarizing quantity $\underline{U}_{AB}$ and operating quantity $\underline{I}_B$ - $\underline{I}_C$ marked as ϕ.

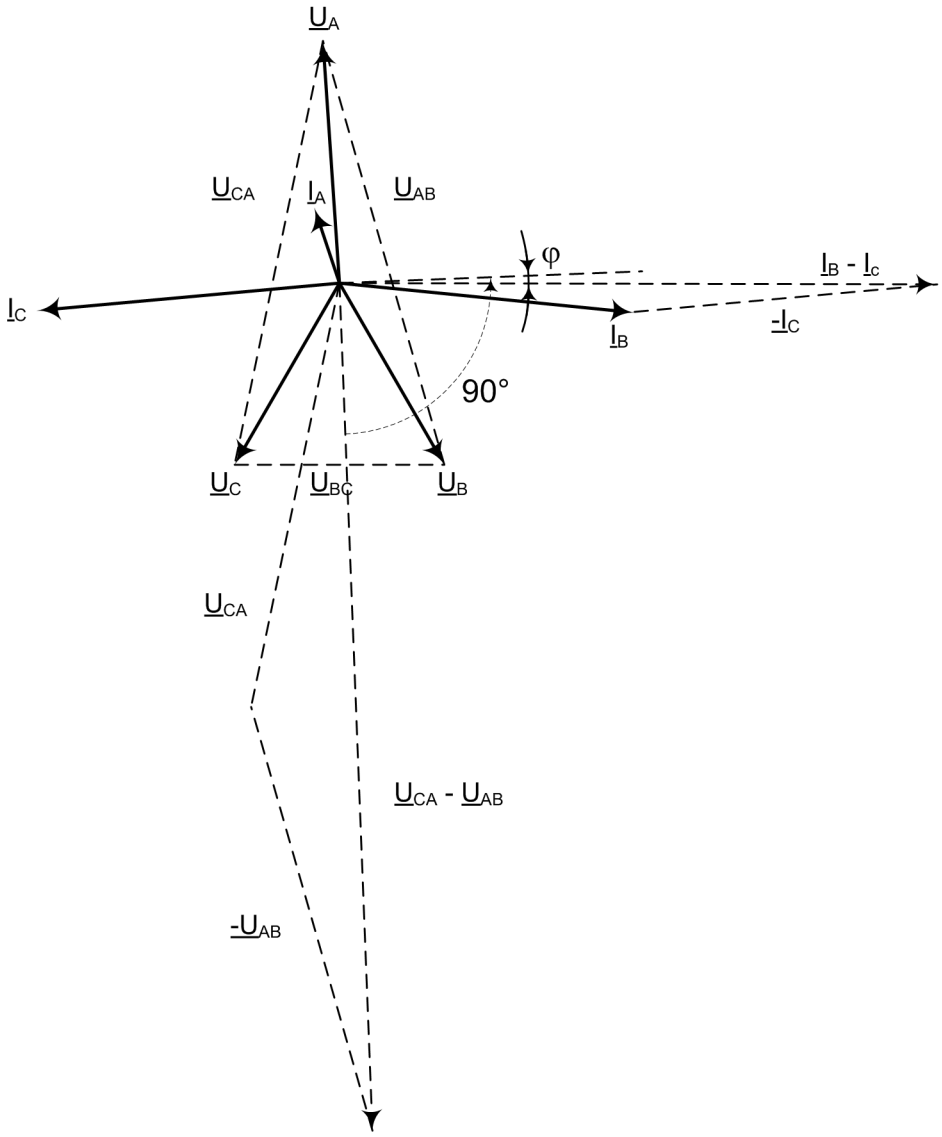



*Figure 213: Two-phase short circuit, short circuit is between phases B and C*

The equations are valid when network rotating direction is counter-clockwise, that is, ABC. If the network rotating direction is reversed, 180 degrees is added to the calculated angle difference. This is done automatically with a system parameter *Phase rotation*.

**Negative sequence voltage as polarizing quantity**

When the negative voltage is used as the polarizing quantity, the angle difference between the operating and polarizing quantity is calculated with the same formula for all fault types:

$$ANGLE_X = \varphi(-\underline{U}_2) - \varphi(\underline{I}_2) - \varphi_{RCA}$$

(Equation 21)

This means that the actuating polarizing quantity is - $\underline{U}_2$.

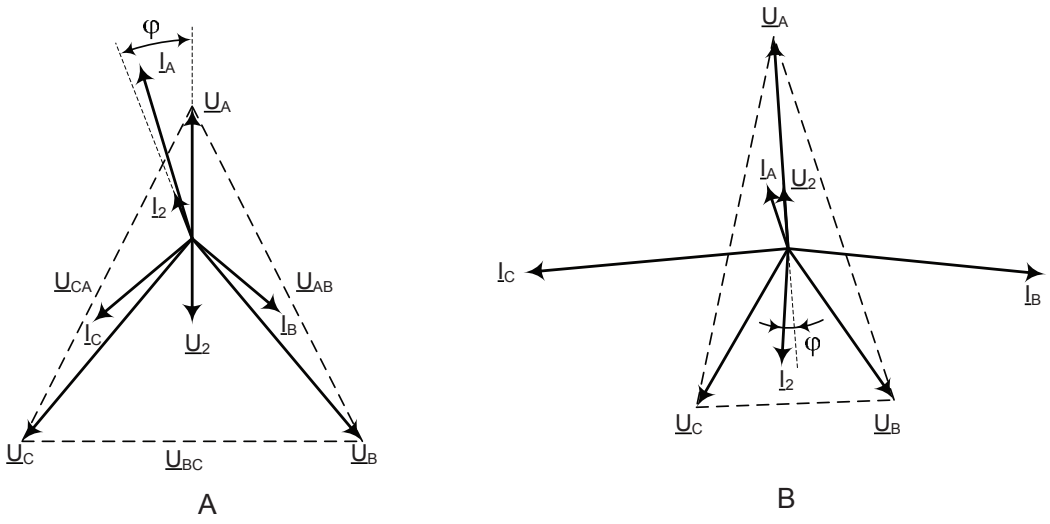



*Figure 214: Phasors in a single-phase earth fault, phases A-N, and two-phase short circuit, phases B and C, when the actuating polarizing quantity is the negative-sequence voltage -U2*

**Positive sequence voltage as polarizing quantity**

**Table 397: Equations for calculating angle difference for positive-sequence quantity polarizing method**

| Faulted phases | Used fault current | Used polarizing voltage | Angle difference |
|---|---|---|---|
| A | $\underline{I}_A$ | $\underline{U}_1$ | $ANGLE_A = \varphi(\underline{U}_1) - \varphi(\underline{I}_A) - \varphi_{RCA}$ (Equation 22) |
| B | $\underline{I}_B$ | $\underline{U}_1$ | $ANGLE_B = \varphi(\underline{U}_1) - \varphi(\underline{I}_B) - \varphi_{RCA} - 120^\circ$ (Equation 23) |
| C | $\underline{I}_C$ | $\underline{U}_1$ | $ANGLE_C = \varphi(\underline{U}_1) - \varphi(\underline{I}_C) - \varphi_{RCA} + 120^\circ$ (Equation 24) |
| A - B | $\underline{I}_A$-$\underline{I}_B$ | $\underline{U}_1$ | $ANGLE_A = \varphi(\underline{U}_1) - \varphi(\underline{I}_A - \underline{I}_B) - \varphi_{RCA} + 30^\circ$ (Equation 25) |

*Table continues on the next page*

| Faulted phases | Used fault current | Used polarizing voltage | Angle difference |
|---|---|---|---|
| B - C | $\underline{I}_B$-$\underline{I}_C$ | $\underline{U}_1$ | $ANGLE_B = \varphi(\underline{U}_1) - \varphi(\underline{I}_B - \underline{I}_C) - \varphi_{RCA} - 90^\circ$ (Equation 26) |
| C - A | $\underline{I}_C$-$\underline{I}_A$ | $\underline{U}_1$ | $ANGLE_C = \varphi(\underline{U}_1) - \varphi(\underline{I}_C - \underline{I}_A) - \varphi_{RCA} + 150^\circ$ (Equation 27) |

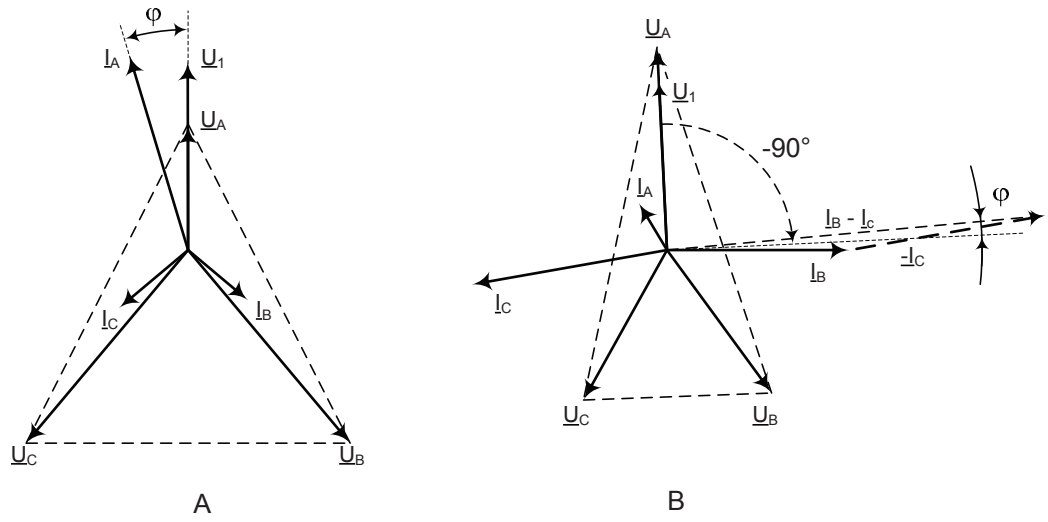



*Figure 215: Phasors in a single-phase earth fault, phase A to ground, and a two-phase short circuit, phases B-C, are short-circuited when the polarizing quantity is the positive-sequence voltage U 1*

### Network rotation direction

Typically, the network rotating direction is counter-clockwise and defined as "ABC". If the network rotating direction is reversed, meaning clockwise, that is, "ACB", the equations for calculating the angle difference needs to be changed. The network rotating direction is defined with a system parameter *Phase rotation*. The change in the network rotating direction affects the phase-to-phase voltages polarization method where the calculated angle difference needs to be rotated 180 degrees. Also, when the sequence components are used, which are, the positive sequence voltage or negative sequence voltage components, the calculation of the components are affected but the angle difference calculation remains the same. When the phase-to-ground voltages are used as the polarizing method, the network rotating direction change has no effect on the direction calculation.

The network rotating direction is set in the protection relay using the parameter in the HMI menu **Configuration** > **System** > **Phase rotation**. The default parameter value is "ABC".

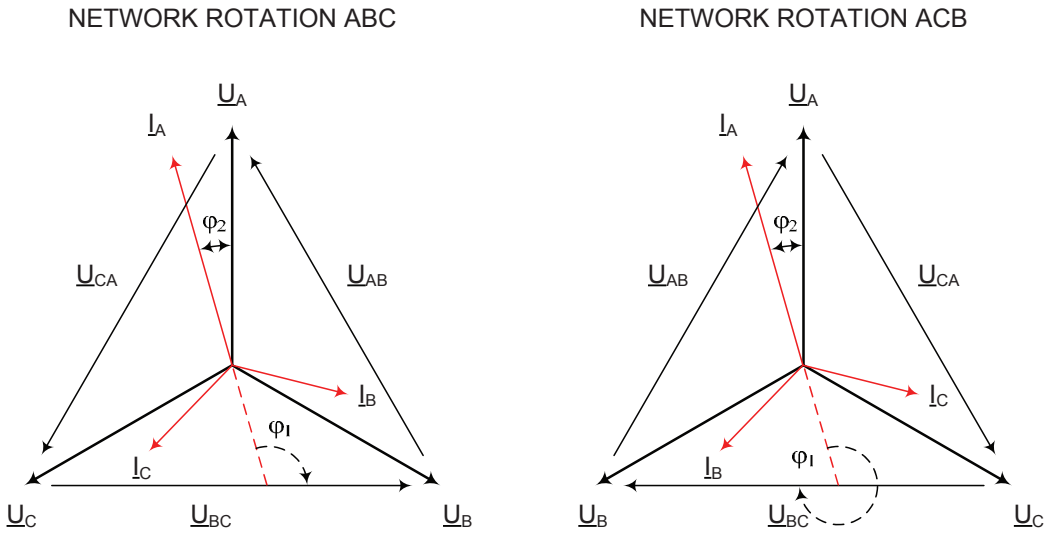



*Figure 216: Examples of network rotating direction*

## 4.1.2.8 Application

DPHxPDOC is used as short-circuit protection in three-phase distribution or sub transmission networks operating at 50 or 60 Hz.

In radial networks, phase overcurrent protection relays are often sufficient for the short circuit protection of lines, transformers and other equipment. The current-time characteristic should be chosen according to the common practice in the network. It is recommended to use the same current-time characteristic for all overcurrent protection relays in the network. This includes the overcurrent protection of transformers and other equipment.

The phase overcurrent protection can also be used in closed ring systems as short circuit protection. Because the setting of a phase overcurrent protection system in closed ring networks can be complicated, a large number of fault current calculations are needed. There are situations with no possibility to have the selectivity with a protection system based on overcurrent protection relays in a closed ring system.

In some applications, the possibility of obtaining the selectivity can be improved significantly if DPHxPDOC is used. This can also be done in the closed ring networks and radial networks with the generation connected to the remote in the system thus giving fault current infeed in reverse direction. Directional overcurrent protection relays are also used to have a selective protection scheme, for example in case of parallel distribution lines or power transformers fed by the same single source. In ring connected supply feeders between substations or feeders with two feeding sources, DPHxPDOC is also used.

### Parallel lines or transformers

When the lines are connected in parallel and if a fault occurs in one of the lines, it is practical to have DPHxPDOC to detect the direction of the fault. Otherwise, there is a risk that the fault situation in one part of the feeding system can de-energize the whole system connected to the LV side.

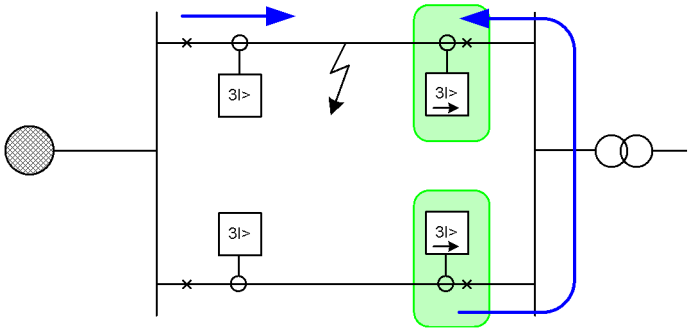



*Figure 217: Overcurrent protection of parallel lines using directional protection relays*

DPHxPDOC can be used for parallel operating transformer applications. In these applications, there is a possibility that the fault current can also be fed from the LV-side up to the HV-side. Therefore, the transformer is also equipped with directional overcurrent protection.

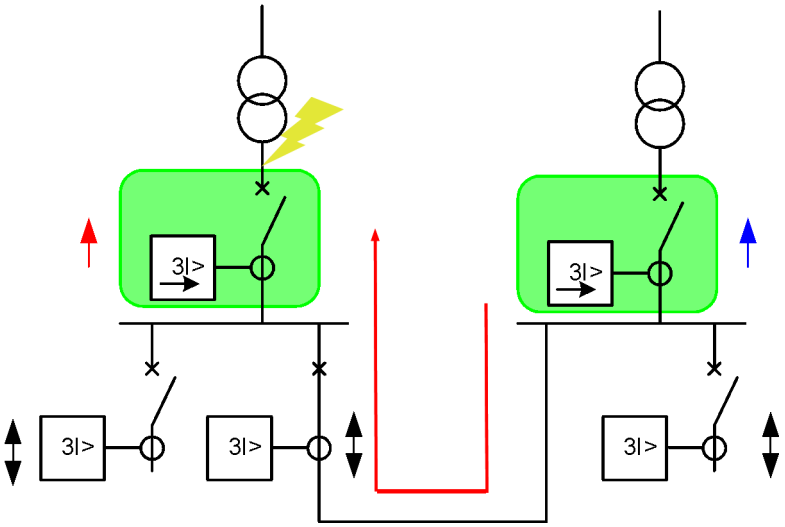



*Figure 218: Overcurrent protection of parallel operating transformers*

**Closed ring network topology**

The closed ring network topology is used in applications where electricity distribution for the consumers is secured during network fault situations. The power is fed at least from two directions which means that the current direction can be varied. The time grading between the network level stages is challenging without unnecessary delays in the time settings. In this case, it is practical to use the directional overcurrent protection relays to achieve a selective protection scheme. Directional overcurrent functions can be used in closed ring applications. The arrows define the operating direction of the directional functionality. The double arrows define the non-directional functionality where faults can be detected in both directions.

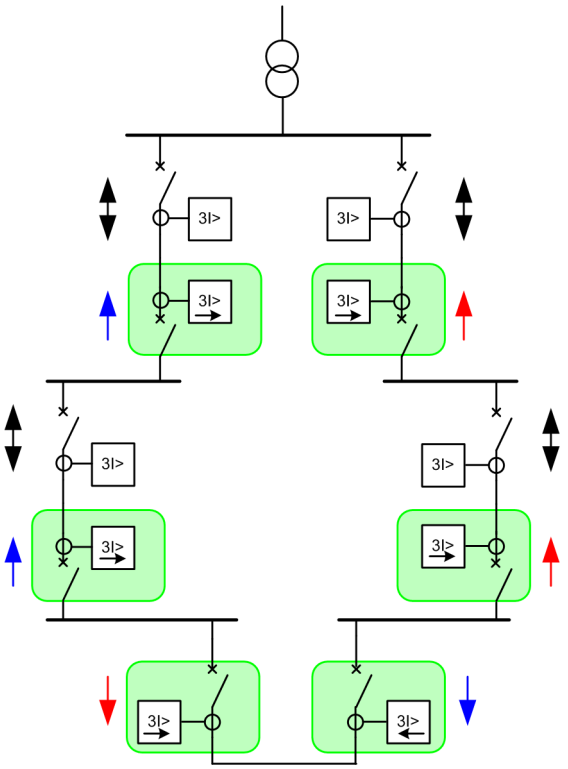



*Figure 219: Closed ring network topology where feeding lines are protected with directional overcurrent protection relays*

### 4.1.2.9 Signals

#### DPHLPDOC Input signals

**Table 398: DPHLPDOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |
| NON_DIR | BOOLEAN | 0=False | Forces protection to non-directional |

### DPHHPDOC Input signals

**Table 399: DPHHPDOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |
| NON_DIR | BOOLEAN | 0=False | Forces protection to non-directional |

### DPHLPDOC Output signals

**Table 400: DPHLPDOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| FAULT_DIR | Enum | Detected fault direction |
| DIRECTION | Enum | Direction information |

### DPHHPDOC Output signals

**Table 401: DPHHPDOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| FAULT_DIR | Enum | Detected fault direction |
| DIRECTION | Enum | Direction information |

## 4.1.2.10 Settings

### DPHLPDOC Settings

**Table 402: DPHLPDOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...10.00 | xIn | 0.01 | 0.05 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Characteristic angle | -179...180 | deg | 1 | 60 | Characteristic angle |
| Max forward angle | 0...90 | deg | 1 | 80 | Maximum phase angle in forward direction |
| Max reverse angle | 0...90 | deg | 1 | 80 | Maximum phase angle in reverse direction |
| Min forward angle | 0...90 | deg | 1 | 80 | Minimum phase angle in forward direction |
| Min reverse angle | 0...90 | deg | 1 | 80 | Minimum phase angle in reverse direction |

**Table 403: DPHLPDOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |
| Voltage Mem time | 0...3000 | ms | 1 | 40 | Voltage memory time |
| Pol quantity | 1=Self pol<br>4=Neg. seq. volt.<br>5=Cross pol<br>7=Pos. seq. volt. | | | 5=Cross pol | Reference quantity used to determine fault direction |

**Table 404: DPHLPDOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.0086...120.0000 | | 0.0001 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 0.0001 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 0.01 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 405: DPHLPDOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |
| Allow Non Dir | 0=False<br>1=True | | | 0=False | Allows prot activation as non-dir when dir info is invalid |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.01 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.01 | Minimum operating voltage |

### DPHHPDOC Settings

**Table 406: DPHHPDOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.10...40.00 | xIn | 0.01 | 0.10 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operating curve type | 1=ANSI Ext. inv. | | | 15=IEC Def. Time | Selection of time delay curve type |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 3=ANSI Norm. inv.<br>5=ANSI Def. Time<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>12=IEC Ext. inv.<br>15=IEC Def. Time<br>17=Programmable | | | | |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Characteristic angle | -179...180 | deg | 1 | 60 | Characteristic angle |
| Max forward angle | 0...90 | deg | 1 | 80 | Maximum phase angle in forward direction |
| Max reverse angle | 0...90 | deg | 1 | 80 | Maximum phase angle in reverse direction |
| Min forward angle | 0...90 | deg | 1 | 80 | Minimum phase angle in forward direction |
| Min reverse angle | 0...90 | deg | 1 | 80 | Minimum phase angle in reverse direction |

**Table 407: DPHHPDOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |
| Voltage Mem time | 0...3000 | ms | 1 | 40 | Voltage memory time |
| Pol quantity | 1=Self pol<br>4=Neg. seq. volt.<br>5=Cross pol<br>7=Pos. seq. volt. | | | 5=Cross pol | Reference quantity used to determine fault direction |

**Table 408: DPHHPDOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 0.0001 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 0.0001 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 0.01 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 3=3 out of 3 | | | | |

**Table 409: DPHHPDOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Allow Non Dir | 0=False<br>1=True | | | 0=False | Allows prot activation as non-dir when dir info is invalid |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.01 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.01 | Minimum operating voltage |

## 4.1.2.11 Monitored data

### DPHLPDOC Monitored data

**Table 410: DPHLPDOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| DIR_A | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase A |
| DIR_B | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase B |
| DIR_C | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase C |
| ANGLE_A | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase A |
| ANGLE_B | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase B |
| ANGLE_C | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase C |
| VMEM_USED | BOOLEAN | 0=False<br>1=True | | Voltage memory in use status |
| DPHLPDOC | Enum | 1=on<br>2=blocked<br>3=test | | Status |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 4=test/blocked<br>5=off | | |

### DPHHPDOC Monitored data

**Table 411: DPHHPDOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| DIR_A | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase A |
| DIR_B | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase B |
| DIR_C | Enum | 0=unknown<br>1=forward<br>2=backward<br>-1=both | | Direction phase C |
| ANGLE_A | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase A |
| ANGLE_B | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase B |
| ANGLE_C | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference, Phase C |
| VMEM_USED | BOOLEAN | 0=False<br>1=True | | Voltage memory in use status |
| DPHHPDOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 4.1.2.12 Technical data

**Table 412: DPHxPDOC Technical data**

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | DPHLPDOC | Depending on the frequency of the current/voltage measured: $f_n$ ±2 Hz |
| | | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$ |

*Table continues on the next page*

| Characteristic | | Value | | |
|---|---|---|---|---|
| | | Phase angle: ±2° | | |
| | DPHHPDOC | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$)<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle: ±2° | | |
| Start time [1, 2] | $I_{Fault}$= 2.0 x set *Start value* | Minimum | Typical | Maximum |
| | | 39 ms | 43 ms | 47 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [3] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

### 4.1.2.13 Technical revision history

**Table 413: DPHLPDOC Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | G | Setting *Start value* maximum value extended to 10.00xIn. |

[1] *Measurement mode* and *Pol quantity* = default, current before fault = 0.0 × $I_n$, voltage before fault = 1.0 × $U_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
[2] Includes the delay of the signal output contact
[3] Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 1.5...20

## 4.1.3 Three-phase voltage-dependent overcurrent protection PHPVOC (ANSI 51V)

### 4.1.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase voltage-dependent overcurrent protection | PHPVOC | 3I(U)> | 51V |

### 4.1.3.2 Function block

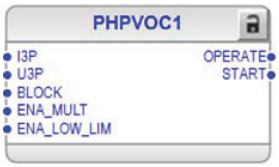



*Figure 220: Function block*

### 4.1.3.3 Functionality

The three-phase voltage-dependent overcurrent protection function PHPVOC is used for single-phase, two-phase or three-phase voltage-dependent time overcurrent protection of generators against overcurrent and short circuit conditions.

PHPVOC starts when the input phase current exceeds a limit which is dynamically calculated based on the measured terminal voltages. The operating characteristics can be selected to be either inverse definite minimum time IDMT or definite time DT.

PHPVOC contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.1.3.4 Analog channel configuration

PHPVOC has two analog group inputs which all must be properly configured.

**Table 414: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 415: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PHPVOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

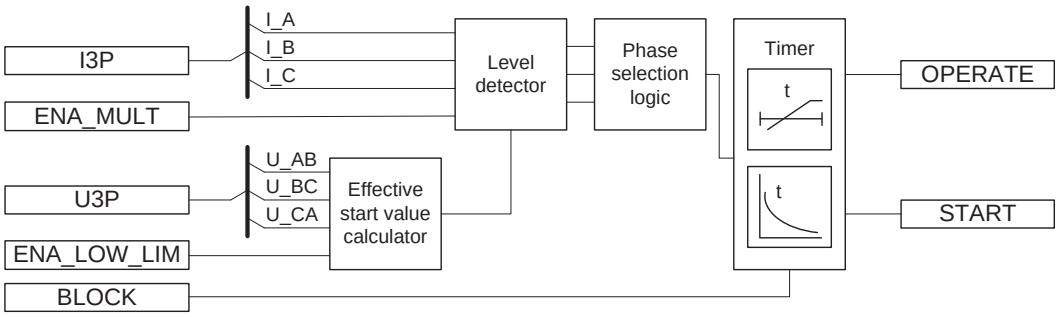



*Figure 221: Functional module diagram*

#### Effective start value calculator

The normal starting current above which the overcurrent protection starts is set through the *Start value* setting. The Effective start value of the current may need to be changed during certain conditions like magnetizing inrush or when the terminal voltages drop due to a fault. Hence, the effective start value calculator module dynamically calculates the effective start value above which the overcurrent protection starts.

Four methods of calculating the effective start value are provided in PHPVOC. These can be chosen with the *Control mode* setting to be either "Voltage control", "Input control", "Volt & Input Ctrl" or "No Volt dependency".

The calculated effective start value per phase, `EFF_ST_VAL_A`, `EFF_ST_VAL_B`, `EFF_ST_VAL_C`, is available in the Monitored data view and is used by the Level detector module.

All three phase-to-phase voltages should be available for the function to operate properly.

**Voltage control mode**

In the Voltage control mode, the Effective start value is calculated based on the magnitude of input voltages U_AB, U_BC and U_CA. The voltage dependency is phase sensitive, which means that the magnitude of one input voltage controls the start value of only the corresponding phase, that is, the magnitude of voltage inputs U_AB, U_BC and U_CA independently control the current start values of phases A, B and C.

Two voltage control characteristics, voltage step and voltage slope, can be achieved with the *Voltage high limit* and *Voltage low limit* settings.

The voltage step characteristic is achieved when the *Voltage high limit* setting is equal to the *Voltage low limit* setting. The effective start value is calculated based on the equations.

| Voltage level | Effective start value (I> effective) |
|---|---|
| U < *Voltage high limit* | *Start value low* |
| U ≥ *Voltage high limit* | *Start value* |

In this example, U represents the measured input voltage. This voltage step characteristic is graphically represented in *Figure 222*.

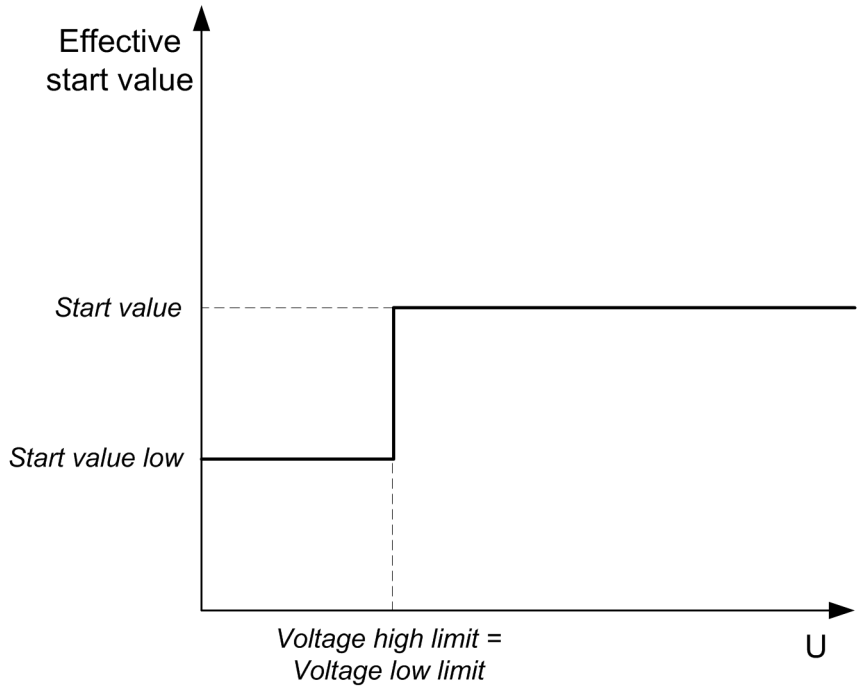



*Figure 222: Effective start value for voltage step characteristic*

The voltage slope characteristic is achieved by assigning different values to *Voltage high limit* and *Voltage low limit*. The effective start value calculation is based on the equations.

| Voltage level | Effective start value (I> effective) |
|---|---|
| U < *Voltage low limit* | *Start value low* |
| U ≥ *Voltage high limit* | *Start value* |

If *Voltage low limit* ≤ U < *Voltage high limit*,

I>(*effective*) = I> - [ ((I> - A) / (C – D)) * (C – U) ]

(Equation 28)

| | |
|---|---|
| A | set *Start value low* |
| I> | set *Start value* |
| C | set *Voltage high limit* |
| D | set *Voltage low limit* |

Here U represents the measured input voltage. The voltage slope characteristic is graphically represented.

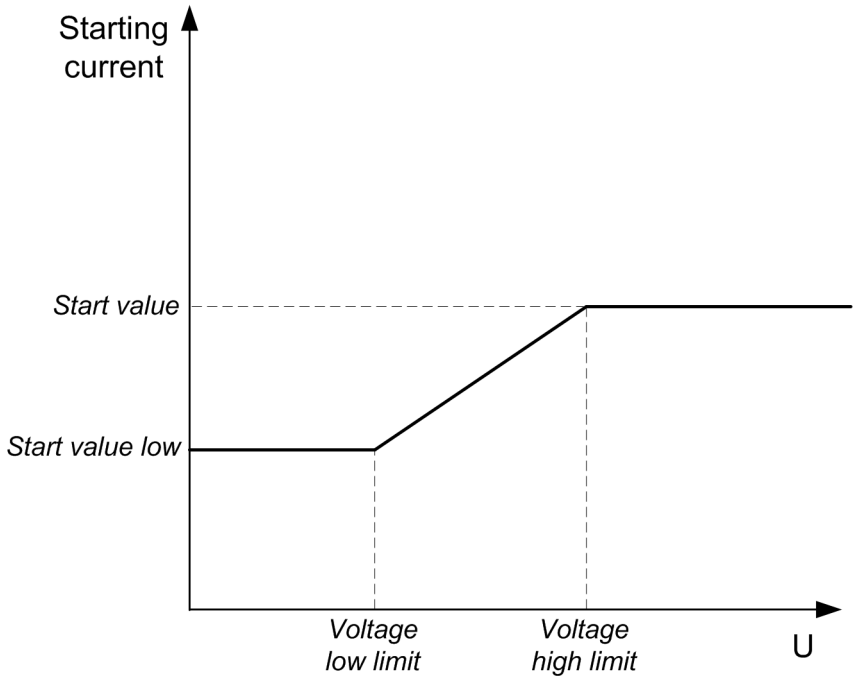



*Figure 223: Effective start value or voltage slope characteristic*

To achieve the voltage slope characteristics, *Voltage high limit* must always be set to a value greater than *Voltage low limit*.

If *Voltage high limit* is lower than *Voltage low limit*, the voltage step characteristic is active with *Voltage low limit* being the cutoff value.

The value of the setting *Start value* should always be greater than the setting *Start value low*. Otherwise, *Start value low* is used as the effective start value.

**External input control mode**

The External input control mode is used to enable voltage control from an external application. If *Control mode* is set to the "Input Control" mode, the effective start value for all phases is influenced by the status of the binary input `ENA_U_MULT`.

*If ENA_U_MULT is TRUE :*
*Effective start value = Start value low*

(Equation 29)

*If ENA_U_MULT is FALSE :*
*Effective start value = Start value*

(Equation 30)

**Voltage and input control mode**

If *Control mode* is set to "Voltage and input Ctrl", both the "Voltage control" and "Input control" modes are used. However, the “Input control” functionality is dominant over the “Voltage control” mode when ENA_LOW_LIM is active.

**No voltage dependency mode**

When *Control mode* is set to "No Volt dependency", the effective start value has no voltage dependency and the function acts as a normal time overcurrent function with effective start value being equal to the *Start value* setting.

**Level detector**

The measured phase currents are compared phasewise to the calculated effective start value. If the measured value exceeds the calculated effective start value, the Level detector reports the exceeding value to the phase selection logic. If the ENA_MULT input is active, the effective start value is multiplied by the *Start value Mult* setting.

Do not set the multiplier *Start value Mult* setting higher than necessary. If the value is too high, the function may not operate at all during an inrush followed by a fault, no matter how severe the fault is.

The start value multiplication is normally done when the inrush detection function INRPHAR is connected to the ENA_MULT input.

**Phase selection logic**

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the measured current exceeds the setting. If the phase information matches the *Num of start phases* setting, the phase selection logic activates the Timer module.

**Timer**

Once activated, the Timer module activates the START output.

Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user programmable IDMT curve is selected, the operation time characteristics are defined by the settings *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

In a drop-off situation, that is, when a fault suddenly disappears before the operating delay is exceeded, the timer reset state is activated. The functionality of the Timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation and the value of START_DUR. The START output is deactivated when the reset timer has elapsed.



The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The *Time multiplier* is used for scaling the IDMT operate and reset times.

The *Minimum operate time* setting defines the minimum desired operating time for IDMT operation. The setting is applicable only when the IDMT curves are used.



Though the *Time multiplier* and *Minimum operate time* settings are common for different IDMT curves, the operating time essentially depends upon the type of IDMT curve chosen.

The Timer calculates the start duration value START_DUR which indicates the percentage ratio of the start situation and the set operating time. This output is available in the Monitored data view.

#### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.1.3.6 Application

The three-phase voltage-dependent overcurrent protection is used as a backup protection for the generators and system from damage due to the phase faults which are not cleared by primary protection and associated breakers.

In case of a short circuit, the sustained fault current of the generator, determined by the machine synchronous reactance, could be below the full-load current. If the generator excitation power is fed from the generator terminals, a voltage drop caused by a short circuit also leads to low fault current. The primary protection, like normal overcurrent protection, might not detect this kind of fault situation. In some cases, the automatic voltage regulator AVR can help to maintain high fault

currents by controlling the generator excitation system. If the AVR is out of service or if there is an internal fault in the operation of AVR, the low fault currents can go unnoticed and therefore a voltage-depended overcurrent protection should be used for backup.

Two voltage control characteristics, voltage step and voltage slope, are available in PHPVOC. The choice is made based on the system conditions and the level of protection to be provided.

Voltage step characteristic is applied to generators used in industrial systems. Under close-up fault conditions when the generator terminal voltages drop below the settable threshold value, a new start value of the current, well below the normal load current, is selected. The control voltage setting should ensure that PHPVOC does not trip under the highest loading conditions to which the system can be subjected. Choosing too high a value for the control voltage may allow an undesired operation of the function during wide-area disturbances. When the terminal voltage of the generator is above the control voltage value, the normal start value is used. This ensures that PHPVOC does not operate during normal overloads when the generator terminal voltages are maintained near the normal levels.

Voltage slope characteristic is often used as an alternative to impedance protection on small to medium (5...150 MVA) size generators to provide backup to the differential protection. Other applications of the voltage slope characteristic protection exist in networks to provide better coordination and fault detection than plain overcurrent protection. The voltage slope method provides an improved sensitivity of overcurrent operation by making the overcurrent start value proportional to the terminal voltage. The current start value varies correspondingly with the generator terminal voltages between the set voltage high limit and voltage low limit, ensuring the operation of PHPVOC despite the drop in fault current value.

The operation of PHPVOC should be time-graded with respect to the main protection scheme to ensure that PHPVOC does not operate before the main protection.

### 4.1.3.7 Signals

#### PHPVOC Input signals

**Table 416: PHPVOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |
| ENA_LOW_LIM | BOOLEAN | 0=False | Enable signal for voltage dependent lower start value |

**PHPVOC Output signals**

**Table 417: PHPVOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.1.3.8 PHPVOC Settings

**Table 418: PHPVOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...5.00 | xIn | 0.01 | 0.05 | Start value |
| Start value low | 0.05...1.00 | xIn | 0.01 | 0.05 | Lower start value based on voltage control |
| Voltage high limit | 0.01...1.00 | xUn | 0.01 | 1.00 | Voltage high limit for voltage control |
| Voltage low limit | 0.01...1.00 | xUn | 0.01 | 1.00 | Voltage low limit for voltage control |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.05...15.00 | | 0.01 | 1.00 | Time multiplier in IEC/ANSI IDMT curves |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 40...200000 | ms | 10 | 40 | Operate delay time |

**Table 419: PHPVOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

**Table 420: PHPVOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.0086...120.0000 | | 0.0001 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 0.0001 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 0.01 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 421: PHPVOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |
| Control mode | 1=Voltage control<br>2=Input control<br>3=Voltage and input Ctl<br>4=No Volt dependency | | | 1=Voltage control | Type of control |
| Minimum operate time | 40...60000 | ms | 1 | 40 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

## 4.1.3.9 PHPVOC Monitored data

**Table 422: PHPVOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| EFF_ST_VAL_A | FLOAT32 | 0.00...50.00 | xIn | Effective start value for phase A |
| EFF_ST_VAL_B | FLOAT32 | 0.00...50.00 | xIn | Effective start value for phase B |
| EFF_ST_VAL_C | FLOAT32 | 0.00...50.00 | xIn | Effective start value for phase C |
| PHPVOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked | | Status |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 5=off | | |

### 4.1.3.10 Technical data

**Table 423: PHPVOC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage:<br>$f_n$ ±2 Hz |
| | Current:<br>±1.5% of the set value or ± 0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$ |
| Start time , [2] | Typically 26 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in inverse time mode | ±5.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 4.1.4 Accidental energization protection GAEPVOC (ANSI 27/50)

### 4.1.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Accidental energization protection | GAEPVOC | U<,I> | 27/50 |

### 4.1.4.2 Function block

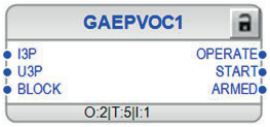



*Figure 224: Function block*

[1] *Measurement mode* = default, current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

[2] Includes the delay of the signal output contact

### 4.1.4.3 Functionality

The accidental energization protection function GAEPVOC for the synchronous generator is an overcurrent protection function which is enabled only when the generator is at a standstill or in turning gear. The function is used to protect the generator rotor from damage due to rapid heating.

A number of field conditions, such as generator operating errors, breaker head flashovers, control circuit malfunctions, false actuation of breaker, or a combination of these can cause accidental energization of the generators. The generator under this condition suddenly causes a relatively heavy load to the surrounding network, which might lead to power balance instability.

Since the generator starts behaving as an asynchronous motor, this three-phase current develops higher current in the rotor, which may thermally damage the generator in a few seconds. A very high thermal stress in both the stator winding and the rotor has been produced by this situation.

The prime mover can also suffer from mechanical damage in moving parts like turbine blades or gearing teeth. Lack of oil may damage the bearings as lube pumps are not in operation when the generator is at a standstill. The turning gear oil pumps are not in operation either and the accidental energization may significantly damage the turning gear.

### 4.1.4.4 Analog channel configuration

GAEPVOC has two analog group inputs which must be properly configured.

**Table 424: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |



See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 425: Special conditions**

| Condition | Description |
|---|---|
| U3P connected real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.4.5 Operation principle

The function can be enabled and disabled with the *Operation setting*. The corresponding parameter values are "on" and "off".

The operation of GAEPVOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

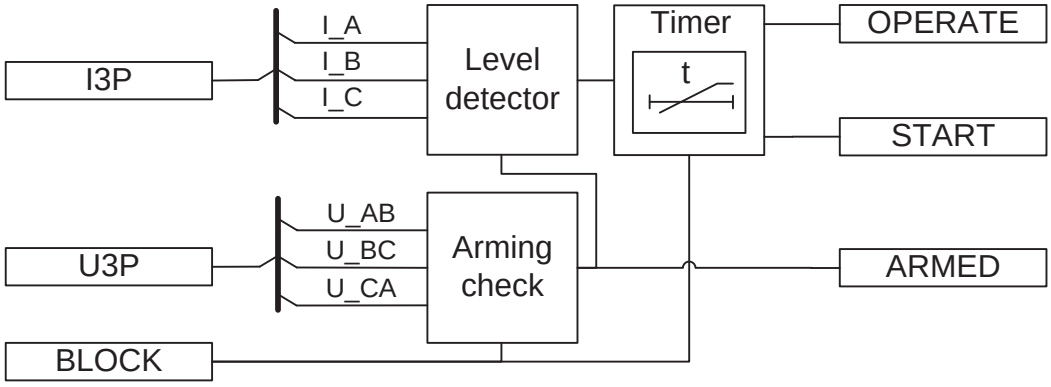



*Figure 225: Functional module diagram*

#### Arming check

The fundamental frequency component of the three measured phase-to-phase generator side voltages are compared with setting *Arm set voltage*. If all measured voltages are below the set *Arm set voltage* for longer than *Arm delay time*, the ARMED signal is set to TRUE and simultaneously Level detector is enabled.

The value of *Arm set voltage* must be set lower than any emergency low voltage condition that can occur when the system is under extreme stress conditions. When the generator returns to service and the voltage exceeds the *Disarm set voltage* setting, the scheme is automatically removed from service (Level detector disabled) after a time delay (*Disarm delay time setting*) and the ARMED output is set to FALSE. GAEPVOC must only be activated when the generator is out-of-service and disabled when the generator is online.

The setting value of *Arm set voltage* should be less than the setting value of *Disarm set voltage*.

Activation of BLOCK input resets the ARMED output to FALSE state.

#### Level detector

The measured peak-to-peak values of three phase currents are compared with the set *Start value*. If the measured values exceed *Start value*, an enable signal is sent to Timer.

#### Timer

Once activated, Timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If a drop-off situation occurs, the Timer reset state is activated. If the reset timer reaches the value set by *Reset delay time*, Timer resets.

The activation of the BLOCK input resets Timer and blocks the START and OPERATE outputs.

Timer calculates the start duration value START_DUR which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

### 4.1.4.6 Application

Accidental energization protection or dead machine protection is necessary as part of the generator protection application. In case of operating error, breaker head flashovers, control circuit malfunctions or a combination of these, the generator may be accidentally energized while offline. High currents might cause mechanical and thermal stress to the generator and cables, and other related power station equipment.

### 4.1.4.7 Signals

#### GAEPVOC Input signals

**Table 426: GAEPVOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

#### GAEPVOC Output signals

**Table 427: GAEPVOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ARMED | BOOLEAN | Current limit active (Armed) |

### 4.1.4.8 GAEPVOC Settings

**Table 428: GAEPVOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...9.00 | xIn | 0.01 | 1.20 | Start value |
| Arm set voltage | 0.05...1.00 | xUn | 0.01 | 0.30 | Voltage level to arm the protection (Phase-to-phase value of voltage) |
| Disarm set voltage | 0.50...1.50 | xUn | 0.01 | 0.80 | Voltage level to disarm the pro- |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | | | | | tection (Phase-to-phase value of voltage) |
| Operate delay time | 20...300000 | ms | 10 | 40 | Operate delay time |
| Arm delay time | 40...300000 | ms | 10 | 5000 | Time delay to arm the function |
| Disarm delay time | 40...300000 | ms | 10 | 500 | Time delay to disarm the function |

**Table 429: GAEPVOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 430: GAEPVOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.1.4.9 GAEPVOC Monitored data

**Table 431: GAEPVOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| GAEPVOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.1.4.10 Technical data

**Table 432: GAEPVOC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltages: $f_n$ ±2 Hz |
| | Current: ±1.5% of the set value or ± 0.002 × $I_n$<br>Voltage: ±1.5% of the set value or ±0.002 × $U_n$ |
| Start time [1,2] | Typically 20 ms |
| Reset time | Typically 35 ms |
| Reset ratio | Typically 0.96 |

*Table continues on the next page*

[1] Results based on statistical distribution of 1000 measurements.
[2] Measured with static signal output (SSO).

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | Voltage: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, …<br>Current: No suppression |

## 4.1.5 Three-phase thermal protection for feeders, cables and distribution transformers T1PTTR (ANSI 49F)

### 4.1.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase thermal protection for feeders, cables and distribution transformers | T1PTTR | 3Ith>F | 49F |

### 4.1.5.2 Function block

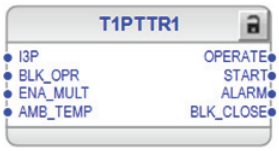



*Figure 226: Function block*

### 4.1.5.3 Functionality

The increased utilization of power systems closer to the thermal limits has generated a need for a thermal overload function also for power lines.

A thermal overload is in some cases not detected by other protection functions, and the introduction of the three-phase thermal protection for feeders, cables and distribution transformers function T1PTTR allows the protected circuit to operate closer to the thermal limits.

An alarm level gives an early warning to allow operators to take action before the line trips. The early warning is based on the three-phase current measuring function using a thermal model with first order thermal loss with the settable time constant. If the temperature rise continues the function will operate based on the thermal model of the line.

Re-energizing of the line after the thermal overload operation can be inhibited during the time the cooling of the line is in progress. The cooling of the line is estimated by the thermal model.

### 4.1.5.4 Analog channel configuration

T1PTTR has one analog group input which must be properly configured.

**Table 433: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of T1PTTR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

The function uses ambient temperature which can be measured locally or remotely. Local measurement is done by the protection relay. Remote measurement uses analog GOOSE to connect `AMB_TEMP` input.

If the quality of remotely measured temperature is invalid or communication channel fails the function uses ambient temperature set in *Env temperature Set*.

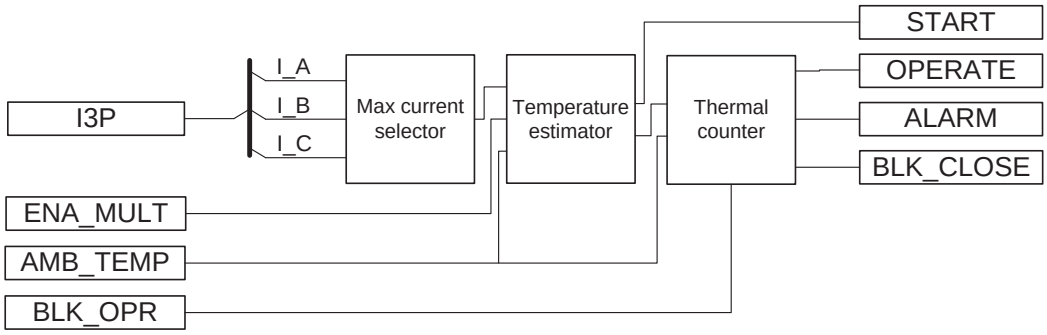



*Figure 227: Functional module diagram*

#### Max current selector

The max current selector of the function continuously checks the highest measured TRMS phase current value. The selector reports the highest value to the temperature estimator.

#### Temperature estimator

The final temperature rise is calculated from the highest of the three-phase currents according to the expression:

$$\Theta_{final} = \left( \frac{I}{I_{ref}} \right)^2 \cdot T_{ref}$$

(Equation 31)

| | |
|---|---|
| I | the highest phase current |
| $I_{ref}$ | set *Current reference* |
| $T_{ref}$ | set *Temperature rise* |

The ambient temperature is added to the calculated final temperature rise estimation, and the ambient temperature value used in the calculation is also available in the monitored data as TEMP_AMB in degrees. If the final temperature estimation is higher than the set *Maximum temperature*, the START output is activated.

*Current reference* and *Temperature rise* setting values are used in the final temperature estimation together with the ambient temperature. It is suggested to set these values to the maximum steady state current allowed for the line or cable under emergency operation for a few hours per years. Current values with the corresponding conductor temperatures are given in cable manuals. These values are given for conditions such as ground temperatures, ambient air temperature, the way of cable laying and ground thermal resistivity.

**Thermal counter**

The actual temperature at the actual execution cycle is calculated as:

$$\Theta_n = \Theta_{n-1} + \left( \Theta_{final} - \Theta_{n-1} \right) \cdot \left( 1 - e^{-\frac{\Delta t}{\tau}} \right)$$

(Equation 32)

| | |
|---|---|
| $\Theta_n$ | calculated present temperature |
| $\Theta_{n-1}$ | calculated temperature at previous time step |
| $\Theta_{final}$ | calculated final temperature with actual current |
| Δt | time step between calculation of actual temperature |
| t | thermal time constant for the protected device (line or cable), set *Time constant* |

The actual temperature of the protected component (line or cable) is calculated by adding the ambient temperature to the calculated temperature, as shown above. The ambient temperature can be given a constant value or it can be measured. The calculated component temperature can be monitored as it is exported from the function as a real figure.

When the component temperature reaches the set alarm level *Alarm value*, the output signal ALARM is set. When the component temperature reaches the set trip level *Maximum temperature*, the OPERATE output is activated. The OPERATE signal pulse length is fixed to 100 ms.

There is also a calculation of the present time to operation with the present current. This calculation is only performed if the final temperature is calculated to be above the operation temperature:

$$t_{operate} = -\tau \cdot \ln\left(\frac{\Theta_{final} - \Theta_{operate}}{\Theta_{final} - \Theta_{n}}\right)$$

(Equation 33)

Caused by the thermal overload protection function, there can be a lockout to reconnect the tripped circuit after operating. The lockout output BLK_CLOSE is activated at the same time when the OPERATE output is activated and is not reset until the device temperature has cooled down below the set value of the *Reclose temperature* setting. The *Maximum temperature* value must be set at least two degrees above the set value of *Reclose temperature*.

The time to lockout release is calculated, that is, the calculation of the cooling time to a set value. The calculated temperature can be reset to its initial value (the *Initial temperature* setting) via a control parameter that is located under the clear menu. This is useful during testing when secondary injected current has given a calculated false temperature level.

$$t_{lockout_release} = -\tau \cdot \ln\left(\frac{\Theta_{final} - \Theta_{lockout_release}}{\Theta_{final} - \Theta_{n}}\right)$$

(Equation 34)

Here the final temperature is equal to the set or measured ambient temperature.

In some applications, the measured current can involve a number of parallel lines. This is often used for cable lines where one bay connects several parallel cables. By setting the *Current multiplier* parameter to the number of parallel lines (cables), the actual current on one line is used in the protection algorithm. To activate this option, the ENA_MULT input must be activated.

The ambient temperature can be measured with the RTD measurement. The measured temperature value is then connected, for example, from the AI_VAL3 output of the X130 RTD function to the AMB_TEMP input of T1PTTR.

The *Env temperature Set* setting is used to define the ambient temperature if the ambient temperature measurement value is not connected to the AMB_TEMP input. The *Env temperature Set* setting is also used when the ambient temperature measurement connected to T1PTTR is set to “Not in use” in the X130 RTD function.

The temperature calculation is initiated from the value defined with the *Initial temperature* setting parameter. This is done in case the protection relay is powered up, the function is turned "Off" and back "On" or reset through the Clear menu. The temperature is also stored in the nonvolatile memory and restored in case the protection relay is restarted.

The thermal time constant of the protected circuit is given in seconds with the *Time constant* setting. Please see cable manufacturers manuals for further details.

T1PTTR thermal model complies with the IEC 60255-149 standard.

### 4.1.5.6 Application

The lines and cables in the power system are constructed for a certain maximum load current level. If the current exceeds this level, the losses will be higher than expected. As a consequence, the temperature of the conductors will increase. If the temperature of the lines and cables reaches too high values, it can cause a risk of damages by, for example, the following ways:

- The sag of overhead lines can reach an unacceptable value.
- If the temperature of conductors, for example aluminium conductors, becomes too high, the material will be destroyed.
- In cables the insulation can be damaged as a consequence of overtemperature, and therefore phase-to-phase or phase-to-earth faults can occur.

In stressed situations in the power system, the lines and cables may be required to be overloaded for a limited time. This should be done without any risk for the above-mentioned risks.

The thermal overload protection provides information that makes temporary overloading of cables and lines possible. The thermal overload protection estimates the conductor temperature continuously. This estimation is made by using a thermal model of the line/cable that is based on the current measurement.

If the temperature of the protected object reaches a set warning level, a signal is given to the operator. This enables actions in the power system to be done before dangerous temperatures are reached. If the temperature continues to increase to the maximum allowed temperature value, the protection initiates a trip of the protected line.

### 4.1.5.7 Signals

**T1PTTR Input signals**

**Table 434: T1PTTR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLK_OPR | BOOLEAN | 0=False | Block signal for operate outputs |
| ENA_MULT | BOOLEAN | 0=False | Enable Current multiplier |
| AMB_TEMP | FLOAT32 | 0 | The ambient temperature used in the calculation |

**T1PTTR Output signals**

**Table 435: T1PTTR Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Thermal Alarm |
| BLK_CLOSE | BOOLEAN | Thermal overload indicator. To inhibite reclose. |

### 4.1.5.8 T1PTTR Settings

**Table 436: T1PTTR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Env temperature Set | -50...100 | °C | 1 | 40 | Ambient temperature used when no external temperature measurement available |
| Current reference | 0.05...4.00 | xIn | 0.01 | 1.00 | The load current leading to Temperature raise temperature |
| Temperature rise | 0.0...200.0 | °C | 0.1 | 75.0 | End temperature rise above ambient |
| Time constant | 60...60000 | s | 1 | 2700 | Time constant of the line in seconds. |
| Maximum temperature | 22.0...200.0 | °C | 0.1 | 90.0 | Temperature level for operate |
| Alarm value | 20.0...150.0 | °C | 0.1 | 80.0 | Temperature level for start (alarm) |
| Reclose temperature | 20.0...150.0 | °C | 0.1 | 70.0 | Temperature for reset of block reclose after operate |

**Table 437: T1PTTR Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current multiplier | 1...5 | | 1 | 1 | Current multiplier when function is used for parallel lines |

**Table 438: T1PTTR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 439: T1PTTR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Initial temperature | -50.0...100.0 | °C | 0.1 | 0.0 | Temperature raise above ambient temperature at startup |

### 4.1.5.9 T1PTTR Monitored data

**Table 440: T1PTTR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TEMP | FLOAT32 | -100.0...9999.9 | °C | The calculated temperature of the protected object |
| TEMP_RL | FLOAT32 | 0.00...99.99 | | The calculated temperature of the protected object relative to the operate level |
| T_OPERATE | INT32 | 0...60000 | s | Estimated time to operate |
| T_ENA_CLOSE | INT32 | 0...60000 | s | Estimated time to deactivate BLK_CLOSE |
| TEMP_AMB | FLOAT32 | -99...999 | °C | The ambient temperature used in the calculation |
| T1PTTR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.1.5.10 Technical data

**Table 441: T1PTTR Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current measurement: ±1.5% of the set value or ±0.002 × $I_n$ (at currents in the range of 0.01...4.00 × $I_n$) |
| Operate time accuracy [1] | ±2.0% of the theoretical value or ±0.50 s |

## 4.1.6 Three-phase thermal overload protection, two time constants T2PTTR (ANSI 49T/G/C)

### 4.1.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase thermal overload protection, two time constants | T2PTTR | 3Ith>T/G/C | 49T/G/C |

[1] Overload current > 1.2 × Operate level temperature

### 4.1.6.2 Function block




*Figure 228: Function block*

### 4.1.6.3 Functionality

The three-phase thermal overload protection, two time constants, protection function T2PTTR protects the transformer mainly from short-time overloads. The transformer is protected from long-time overloads with the oil temperature detector included in its equipment.

The alarm signal gives an early warning to allow the operators to take action before the transformer trips. The early warning is based on the three-phase current measuring function using a thermal model with two settable time constants. If the temperature rise continues, T2PTTR operates based on the thermal model of the transformer.

After a thermal overload operation, the re-energizing of the transformer is inhibited during the transformer cooling time. The transformer cooling is estimated with a thermal model.

### 4.1.6.4 Analog channel configuration

T2PTTR has one analog group input which must be properly configured.

**Table 442: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of T2PTTR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

The function uses ambient temperature which can be measured locally or remotely. Local measurement is done by the protection relay. Remote measurement uses analog GOOSE to connect AMB_TEMP input.

If the quality of remotely measured temperature is invalid or communication channel fails the function uses ambient temperature set in *Env temperature Set*.

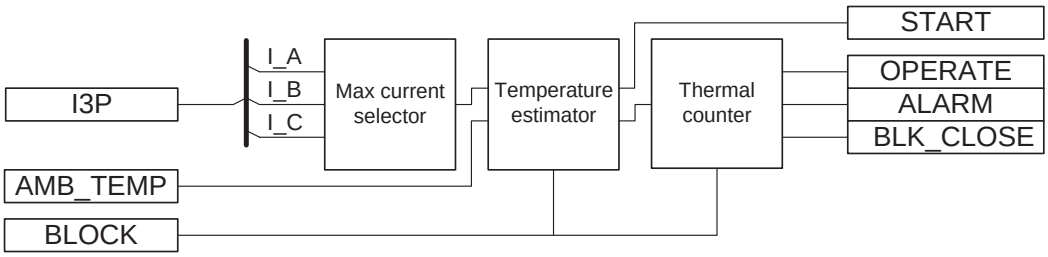



*Figure 229: Functional module diagram*

### Max current selector

The max current selector of the function continuously checks the highest measured TRMS phase current value. The selector reports the highest value to the thermal counter.

### Temperature estimator

The final temperature rise is calculated from the highest of the three-phase currents according to the expression:

$$\Theta_{final} = \left( \frac{I}{I_{ref}} \right)^2 \cdot T_{ref}$$

(Equation 35)

| | |
|---|---|
| I | highest measured phase current |
| $I_{ref}$ | the set value of the *Current reference* setting |
| $T_{ref}$ | the set value of the *Temperature rise* setting (temperature rise (°C) with the steady-state current $I_{ref}$ |

The ambient temperature value is added to the calculated final temperature rise estimation. If the total value of temperature is higher than the set operate temperature level, the START output is activated.

The *Current reference* setting is a steady-state current that gives the steady-state end temperature value *Temperature rise*. It gives a setting value corresponding to the rated power of the transformer.

The *Temperature rise* setting is used when the value of the reference temperature rise corresponds to the *Current reference* value. The temperature values with the corresponding transformer load currents are usually given by transformer manufacturers.

**Thermal counter**

T2PTTR applies the thermal model of two time constants for temperature measurement. The temperature rise in degrees Celsius (°C) is calculated from the highest of the three-phase currents according to the expression:

$$\Delta\Theta = \left[ p * \left( \frac{I}{I_{ref}} \right)^2 * T_{ref} \right] \cdot \left( 1 - e^{-\frac{\Delta t}{\tau 1}} \right) + \left[ (1-p) \cdot \left( \frac{I}{I_{ref}} \right)^2 \cdot T_{ref} \right] \cdot \left( 1 - e^{-\frac{\Delta t}{\tau 2}} \right)$$

(Equation 36)

| | |
|---|---|
| ΔΘ | calculated temperature rise (°C) in transformer |
| I | measured phase current with the highest TRMS value |
| $I_{ref}$ | the set value of the *Current reference* setting (rated current of the protected object) |
| $T_{ref}$ | the set value of the *Temperature rise* setting (temperature rise setting (°C) with the steady-state current $I_{ref}$) |
| p | the set value of the *Weighting factor p* setting (weighting factor for the short time constant) |
| Δt | time step between the calculation of the actual temperature |
| $t_1$ | the set value of the *Short time constant* setting (the short heating / cooling time constant) |
| $t_2$ | the set value of the *Long time constant* setting (the long heating / cooling time constant) |

The warming and cooling following the two time-constant thermal curve is a characteristic of transformers. The thermal time constants of the protected transformer are given in seconds with the *Short time constant* and *Long time constant* settings. The *Short time constant* setting describes the warming of the transformer with respect to windings. The *Long time constant* setting describes the warming of the transformer with respect to the oil. Using the two time-constant model, the protection relay is able to follow both fast and slow changes in the temperature of the protected object.

The *Weighting factor p* setting is the weighting factor between *Short time constant* $\tau_1$ and *Long time constant* $\tau_2$. The higher the value of the *Weighting factor p* setting, the larger is the share of the steep part of the heating curve. When *Weighting factor p* =1, only *Short-time constant* is used. When *Weighting factor p* = 0, only *Long time constant* is used.

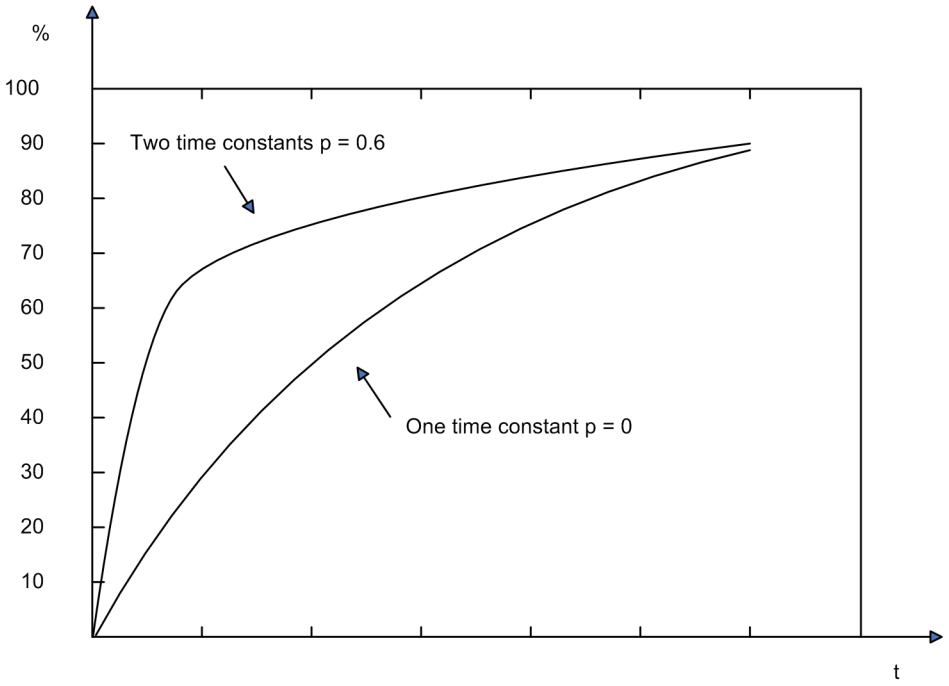



*Figure 230: Effect of the Weighting factor p factor and the difference between the two time constants and one time constant models*

The actual temperature of the transformer is calculated by adding the ambient temperature to the calculated temperature.

$$\Theta = \Delta\Theta + \Theta_{amb}$$

(Equation 37)

| | |
|---|---|
| $\Theta$ | temperature in transformer (°C) |
| $\Delta\Theta$ | calculated temperature rise (°C) in transformer |
| $\Theta_{amb}$ | set value of the *Env temperature Set* setting or measured ambient temperature |

The ambient temperature can be measured with RTD measurement. The measured temperature value is connected, for example, from the AI_VAL3 output of the X130 RTD function to the AMB_TEMP input of T2PTTR.

The *Env temperature Set* setting is used to define the ambient temperature if the ambient temperature measurement value is not connected to the AMB_TEMP input. The *Env temperature Set* setting is also used when the ambient temperature measurement connected to T2PTTR is set to “Not in use” in the X130 RTD function.

The temperature calculation is initiated from the value defined with the *Initial temperature* and *Max temperature* setting parameters. The initial value is a percentage of *Max temperature* defined by *Initial temperature*. This is done when the protection relay is powered up or the function is turned off and back on or reset through the Clear menu. The temperature is stored in a nonvolatile memory and restored if the protection relay is restarted.

The *Max temperature* setting defines the maximum temperature of the transformer in degrees Celsius (°C). The value of the *Max temperature* setting is usually given by

transformer manufacturers. The actual alarm, operating and lockout temperatures for T2PTTR are given as a percentage value of the *Max temperature* setting.

When the transformer temperature reaches the alarm level defined with the *Alarm temperature* setting, the ALARM output signal is set. When the transformer temperature reaches the trip level value defined with the *Operate temperature* setting, the OPERATE output is activated. The OPERATE output is deactivated when the value of the measured current falls below 10 percent of the *Current Reference* value or the calculated temperature value falls below *Operate temperature*.

There is also a calculation of the present time to operation with the present current. T_OPERATE is only calculated if the final temperature is calculated to be above the operation temperature. The value is available in the monitored data view.

After operating, there can be a lockout to reconnect the tripped circuit due to the thermal overload protection function. The BLK_CLOSE lockout output is activated when the device temperature is above the *Reclose temperature* lockout release temperature setting value. The time to lockout release T_ENA_CLOSE is also calculated. The value is available in the monitored data view.

### 4.1.6.6 Application

The transformers in a power system are constructed for a certain maximum load current level. If the current exceeds this level, the losses are higher than expected. This results in a rise in transformer temperature. If the temperature rise is too high, the equipment is damaged:

- Insulation within the transformer ages faster, which in turn increases the risk of internal phase-to-phase or phase-to-earth faults.
- Possible hotspots forming within the transformer degrade the quality of the transformer oil.

During stressed situations in power systems, it is required to overload the transformers for a limited time without any risks. The thermal overload protection provides information and makes temporary overloading of transformers possible.

The permissible load level of a power transformer is highly dependent on the transformer cooling system. The two main principles are:

- ONAN: The air is naturally circulated to the coolers without fans, and the oil is naturally circulated without pumps.
- OFAF: The coolers have fans to force air for cooling, and pumps to force the circulation of the transformer oil.

The protection has several parameter sets located in the setting groups, for example one for a non-forced cooling and one for a forced cooling situation. Both the permissive steady-state loading level as well as the thermal time constant are influenced by the transformer cooling system. The active setting group can be changed by a parameter, or through a binary input if the binary input is enabled for it. This feature can be used for transformers where forced cooling is taken out of operation or extra cooling is switched on. The parameters can also be changed when a fan or pump fails to operate.

The thermal overload protection continuously estimates the internal heat content, that is, the temperature of the transformer. This estimation is made by using a thermal model of the transformer which is based on the current measurement.

If the heat content of the protected transformer reaches the set alarm level, a signal is given to the operator. This enables the action that needs to be taken in the

power systems before the temperature reaches a high value. If the temperature continues to rise to the trip value, the protection initiates the trip of the protected transformer.

After the trip, the transformer needs to cool down to a temperature level where the transformer can be taken into service again. T2PTTR continues to estimate the heat content of the transformer during this cooling period using a set cooling time constant. The energizing of the transformer is blocked until the heat content is reduced to the set level.

The thermal curve of two time constants is typical for a transformer. The thermal time constants of the protected transformer are given in seconds with the *Short time constant* and *Long time constant* settings. If the manufacturer does not state any other value, the *Long time constant* can be set to 4920 s (82 minutes) for a distribution transformer and 7260 s (121 minutes) for a supply transformer. The corresponding *Short time constants* are 306 s (5.1 minutes) and 456 s (7.6 minutes).

If the manufacturer of the power transformer has stated only one, that is, a single time constant, it can be converted to two time constants. The single time constant is also used by itself if the p-factor *Weighting factor p* setting is set to zero and the time constant value is set to the value of the *Long time constant* setting. The thermal image corresponds to the one time constant model in that case.

**Table 443: Conversion table between one and two time constants**

| Single time constant (min) | *Short time constant* (min) | *Long time constant* (min) | *Weighting factor p* |
|---|---|---|---|
| 10 | 1.1 | 17 | 0.4 |
| 15 | 1.6 | 25 | 0.4 |
| 20 | 2.1 | 33 | 0.4 |
| 25 | 2.6 | 41 | 0.4 |
| 30 | 3.1 | 49 | 0.4 |
| 35 | 3.6 | 58 | 0.4 |
| 40 | 4.1 | 60 | 0.4 |
| 45 | 4.8 | 75 | 0.4 |
| 50 | 5.1 | 82 | 0.4 |
| 55 | 5.6 | 90 | 0.4 |
| 60 | 6.1 | 98 | 0.4 |
| 65 | 6.7 | 107 | 0.4 |
| 70 | 7.2 | 115 | 0.4 |
| 75 | 7.8 | 124 | 0.4 |

The default *Max temperature* setting is 105°C. This value is chosen since even though the IEC 60076-7 standard recommends 98°C as the maximum allowable temperature in long-time loading, the standard also states that a transformer can withstand the emergency loading for weeks or even months, which may produce the winding temperature of 140°C. Therefore, 105°C is a safe maximum temperature value for a transformer if the *Max temperature* setting value is not given by the transformer manufacturer.

### 4.1.6.7 Signals

**T2PTTR Input signals**

**Table 444: T2PTTR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| AMB_TEMP | FLOAT32 | 0 | The ambient temperature used in the calculation |

**T2PTTR Output signals**

**Table 445: T2PTTR Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Thermal Alarm |
| BLK_CLOSE | BOOLEAN | Thermal overload indicator. To inhibite reclose. |

### 4.1.6.8 T2PTTR Settings

**Table 446: T2PTTR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Env temperature Set | -50...100 | °C | 1 | 40 | Ambient temperature used when no external temperature measurement available |
| Temperature rise | 0.0...200.0 | °C | 0.1 | 78.0 | End temperature rise above ambient |
| Max temperature | 22.0...200.0 | °C | 0.1 | 105.0 | Maximum temperature allowed for the transformer |
| Operate temperature | 80.0...120.0 | % | 0.1 | 100.0 | Operate temperature, percent value |
| Alarm temperature | 40.0...100.0 | % | 0.1 | 90.0 | Alarm temperature, percent value |
| Reclose temperature | 40.0...100.0 | % | 0.1 | 60.0 | Temperature for reset of block reclose after operate |
| Short time constant | 6...60000 | s | 1 | 450 | Short time constant in seconds |
| Long time constant | 60...60000 | s | 1 | 7200 | Long time constant in seconds |
| Weighting factor p | 0.00...1.00 | | 0.01 | 0.40 | Weighting factor of the short time constant |

**Table 447: T2PTTR Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current reference | 0.05...4.00 | xIn | 0.01 | 1.00 | The load current leading to Temperature raise temperature |

**Table 448: T2PTTR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 449: T2PTTR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Initial temperature | 0.0...100.0 | % | 0.1 | 80.0 | Initial temperature, percent value |

### 4.1.6.9 T2PTTR Monitored data

**Table 450: T2PTTR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TEMP | FLOAT32 | -100.0...9999.9 | °C | The calculated temperature of the protected object |
| TEMP_RL | FLOAT32 | 0.00...99.99 | | The calculated temperature of the protected object relative to the operate level |
| T_OPERATE | INT32 | 0...60000 | s | Estimated time to operate |
| T_ENA_CLOSE | INT32 | 0...60000 | s | Estimated time to deactivate BLK_CLOSE in seconds |
| TEMP_AMB | FLOAT32 | -99...999 | °C | The ambient temperature used in the calculation |
| T2PTTR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.1.6.10 Technical data

**Table 451: T2PTTR Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current measurement: ±1.5% of the set value or ±0.002 x $I_n$ (at currents in the range of 0.01...4.00 x $I_n$) |
| Operate time accuracy[1] | ±2.0% of the theoretical value or ±0.50 s |

## 4.1.7 Motor load jam protection JAMPTOC (ANSI 50TDJAM)

### 4.1.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Motor load jam protection | JAMPTOC | Ist> | 50TDJAM |

### 4.1.7.2 Function block




*Figure 231: Function block*

### 4.1.7.3 Functionality

The motor load jam protection function JAMPTOC is used for protecting the motor in stall or mechanical jam situations during the running state.

When the motor is started, a separate function is used for the startup protection, and JAMPTOC is normally blocked during the startup period. When the motor has passed the starting phase, JAMPTOC monitors the magnitude of phase currents. The function starts when the measured current exceeds the breakdown torque level, that is, above the set limit. The operation characteristic is definite time.

The function contains a blocking functionality. It is possible to block the function outputs.

### 4.1.7.4 Analog channel configuration

JAMPTOC has one analog group input which must be properly configured.

[1] Overload current > 1.2 x Operate level temperature

**Table 452: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.7.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of JAMPTOC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

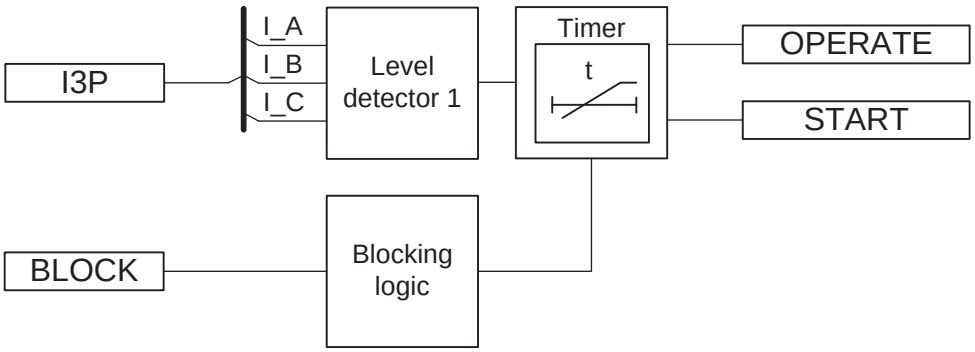



*Figure 232: Functional module diagram*

#### Level detector

The measured phase currents are compared to the set *Start value*. The TRMS values of the phase currents are considered for the level detection. The timer module is enabled if at least two of the measured phase currents exceed the set *Start value*.

#### Timer

Once activated, the internal `START` signal is activated. The value is available only through the Monitored data view. The time characteristic is according to DT. When the operation timer has reached the *Operate delay time* value, the `OPERATE` output is activated.

When the timer has elapsed but the motor stall condition still exists, the `OPERATE` output remains active until the phase currents values drop below the *Start value*, that is, until the stall condition persists. If the drop-off situation occurs while the operating time is still counting, the reset timer is activated. If the drop-off time exceeds the set *Reset delay time*, the operating timer is reset.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.1.7.6 Application

The motor protection during stall is primarily needed to protect the motor from excessive temperature rise, as the motor draws high currents during the stall phase. This condition causes a temperature rise in the stator windings. Due to reduced speed, the temperature also rises in the rotor. The rotor temperature rise is more critical when the motor stops.

The physical and dielectric insulations of the system deteriorate with age and the deterioration is accelerated by the temperature increase. Insulation life is related to the time interval during which the insulation is maintained at a given temperature.

An induction motor stalls when the load torque value exceeds the breakdown torque value, causing the speed to decrease to zero or to some stable operating point well below the rated speed. This occurs, for example, when the applied shaft load is suddenly increased and is greater than the producing motor torque due to the bearing failures. This condition develops a motor current almost equal to the value of the locked-rotor current.

JAMPTOC is designed to protect the motor in stall or mechanical jam situations during the running state. To provide a good and reliable protection for motors in a stall situation, the temperature effects on the motor have to be kept within the allowed limits.

### 4.1.7.7 Signals

**JAMPTOC Input signals**

**Table 453: JAMPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**JAMPTOC Output signals**

**Table 454: JAMPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |

## 4.1.7.8 JAMPTOC Settings

**Table 455: JAMPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Start value | 0.10...10.00 | xIn | 0.01 | 2.50 | Start value |
| Operate delay time | 100...120000 | ms | 10 | 2000 | Operate delay time |

**Table 456: JAMPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 100 | Reset delay time |

## 4.1.7.9 JAMPTOC Monitored data

**Table 457: JAMPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START | BOOLEAN | 0=False<br>1=True | | Start |
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| JAMPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 4.1.7.10 Technical data

**Table 458: JAMPTOC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |

*Table continues on the next page*

| Characteristic | Value |
|---|---|
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

## 4.1.8 Loss of load supervision LOFLPTUC (ANSI 37)

### 4.1.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Loss of load supervision | LOFLPTUC | 3I< | 37 |

### 4.1.8.2 Function block




*Figure 233: Function block*

### 4.1.8.3 Functionality

The loss of load supervision function LOFLPTUC is used to detect a sudden load loss which is considered as a fault condition.

LOFLPTUC starts when the current is less than the set limit. It operates with the definite time (DT) characteristics, which means that the function operates after a predefined operate time and resets when the fault current disappears.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.1.8.4 Analog channel configuration

LOFLPTUC has one analog group input which must be properly configured.

**Table 459: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing

blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.8.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of LOFLPTUC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

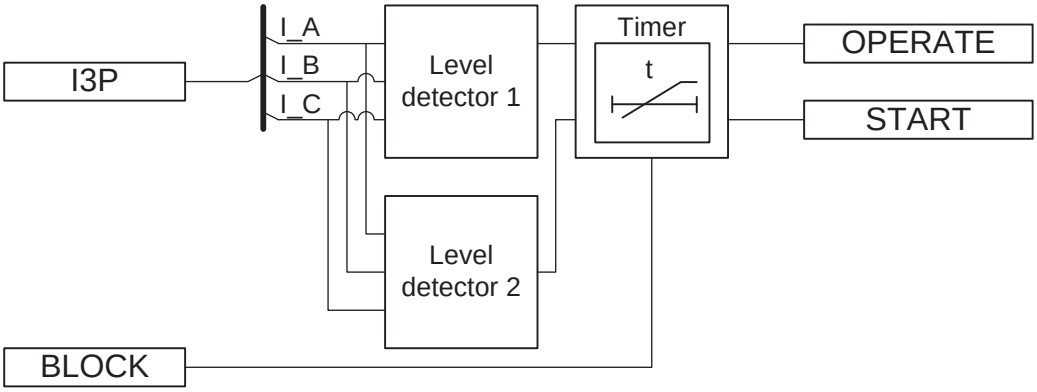



*Figure 234: Functional module diagram*

#### Level detector 1

This module compares the phase currents (RMS value) to the set *Start value high* setting. If all the phase current values are less than the set *Start value high* value, the loss of load condition is detected and an enable signal is sent to the timer. This signal is disabled after one or several phase currents have exceeded the set *Start value high* value of the element.

#### Level detector 2

This is a low-current detection module, which monitors the de-energized condition of the motor. It compares the phase currents (RMS value) to the set *Start value low* setting. If any of the phase current values is less than the set *Start value low*, a signal is sent to block the operation of the timer.

#### Timer

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

The BLOCK signal blocks the operation of the function and resets the timer.

### 4.1.8.6 Application

When a motor runs with a load connected, it draws a current equal to a value between the no-load value and the rated current of the motor. The minimum load current can be determined by studying the characteristics of the connected load. When the current drawn by the motor is less than the minimum load current drawn, it can be inferred that the motor is either disconnected from the load or the coupling mechanism is faulty. If the motor is allowed to run in this condition, it may aggravate the fault in the coupling mechanism or harm the personnel handling the machine. Therefore, the motor has to be disconnected from the power supply as soon as the above condition is detected.

LOFLPTUC detects the condition by monitoring the current values and helps disconnect the motor from the power supply instantaneously or after a delay according to the requirement.

When the motor is at standstill, the current will be zero and it is not recommended to activate the trip during this time. The minimum current drawn by the motor when it is connected to the power supply is the no load current, that is, the higher start value current. If the current drawn is below the lower start value current, the motor is disconnected from the power supply. LOFLPTUC detects this condition and interprets that the motor is de-energized and disables the function to prevent unnecessary trip events.

### 4.1.8.7 Signals

#### LOFLPTUC Input signals

**Table 460: LOFLPTUC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block all binary outputs by resetting timers |

#### LOFLPTUC Output signals

**Table 461: LOFLPTUC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.1.8.8 LOFLPTUC Settings

**Table 462: LOFLPTUC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value low | 0.01...0.50 | xIn | 0.01 | 0.10 | Current setting/Start value low |
| Start value high | 0.01...1.00 | xIn | 0.01 | 0.50 | Current setting/Start value high |
| Operate delay time | 400...600000 | ms | 10 | 2000 | Operate delay time |

**Table 463: LOFLPTUC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 464: LOFLPTUC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.1.8.9 LOFLPTUC Monitored data

**Table 465: LOFLPTUC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| LOFLPTUC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.1.8.10 Technical data

**Table 466: LOFLPTUC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Start time | Typically 300 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 1.04 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

## 4.1.9 Loss of phase, undercurrent PHPTUC (ANSI 37)

### 4.1.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Loss of phase, undercurrent | PHPTUC1 | 3I< | 37 |

### 4.1.9.2 Function block

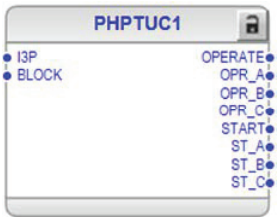



*Figure 235: Function block*

### 4.1.9.3 Functionality

The phase undercurrent protection function PHPTUC is used to detect an undercurrent that is considered as a fault condition.

PHPTUC starts when the current is less than the set limit. Operation time characteristics are according to definite time (DT).

The function contains a blocking functionality. It is possible to block function outputs and reset the definite timer.

### 4.1.9.4 Analog input configuration

PHPTUC has one analog group input which must be properly configured.

**Table 467: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.9.5 Operation principle

The function can be enabled and disabled with the *Operation setting*. The corresponding parameter values are "On" and "Off".

The operation of PHPTUC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

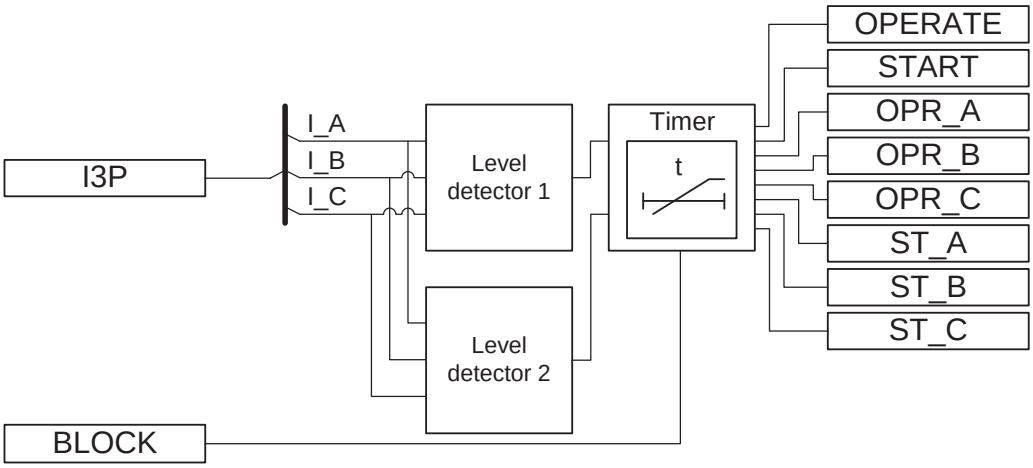



*Figure 236: Functional module diagram*

#### Level detector 1

This module compares the phase currents (RMS value) to the *Start value* setting. The *Operation mode* setting can be used to select the "3-phase" or "1-phase" mode.

If in the "3-phase" mode all the phase current values are less than the value of the *Start value* setting, the condition is detected and an enable signal is sent to the timer. This signal is disabled after one or several phase currents have exceeded the set *Start value* value of the element.

If in the "1-phase" mode any of the phase current values are less than the value of the *Start value* setting, the condition is detected and an enable signal is sent to the timer. This signal is disabled after all the phase currents have exceeded the set *Start value* value of the element.

The protection relay does not accept the *Start value* to be smaller than *Current block value*.

#### Level detector 2

This is a low-current detection module that monitors the de-energized condition of the protected object. The module compares the phase currents (RMS value) to the *Current block value* setting. If all the phase current values are less than the *Current block value* setting, a signal is sent to block the operation of the timer.

#### Timer

Once activated, the timer activates the START output and the phase-specific ST_X output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output and the phase specific OPR_X output are activated. If the fault disappears before the module

operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available through the monitored data view.

The BLOCK signal blocks the operation of the function and resets the timer.

### 4.1.9.6 Application

In some cases, smaller distribution power transformers are used where the high-side protection involves only power fuses. When one of the high-side fuses blows in a single-phase condition, knowledge of it on the secondary side is lacking. The resulting negative-sequence current leads to a premature failure due to excessive heating and breakdown of the transformer insulation. Knowledge of this condition when it occurs allows for a quick fuse replacement and saves the asset.

The *Current block value* setting can be set to zero to not block PHPTUC with a low three-phase current. However, this results in an unnecessary event sending when the transformer or protected object is disconnected.

Phase-specific start and operate can give a better picture about the evolving faults when one phase has started first and another follows.

PHPTUC is meant to be a general protection function, so that it could be used in other cases too.

In case of undercurrent-based motor protection, see the Loss of load protection.

### 4.1.9.7 Signals

**Table 468: PHPTUC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | – | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block all binary outputs by resetting timers |

**Table 469: PHPTUC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| OPR_A | BOOLEAN | Operate phase A |
| OPR_B | BOOLEAN | Operate phase B |
| OPR_C | BOOLEAN | Operate phase C |
| START | BOOLEAN | Start |
| ST_A | BOOLEAN | Start phase A |
| ST_B | BOOLEAN | Start phase B |
| ST_C | BOOLEAN | Start phase C |

### 4.1.9.8 Settings

**Table 470: PHPTUC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current block value | 0.00...0.50 | xIn | 0.01 | 0.10 | Low current setting to block internally |
| Start value | 0.01...1.00 | xIn | 0.01 | 0.50 | Current setting to start |
| Operate delay time | 50...200000 | ms | 10 | 2000 | Operate delay time |

**Table 471: PHPTUC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=Three Phase<br>2=Single Phase | | | 1=Three Phase | Number of phases needed to start |

**Table 472: PHPTUC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.1.9.9 Monitored data

**Table 473: PHPTUC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHPTUC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.1.9.10 Technical data

**Table 474: PHPTUC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the current measured: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ± 0.002 × $I_n$ |

*Table continues on the next page*

| Characteristic | Value |
|---|---|
| Start time | Typically <55 ms |
| Reset time | <40 ms |
| Reset ratio | Typically 1.04 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | mode ±1.0% of the set value or ±20 ms |

## 4.1.10 Thermal overload protection for motors MPTTR (ANSI 49M)

### 4.1.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Thermal overload protection for motors | MPTTR | 3Ith>M | 49M |

### 4.1.10.2 Function block

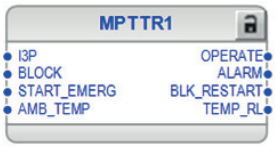



*Figure 237: Function block*

### 4.1.10.3 Functionality

The thermal overload protection for motors function MPTTR protects the electric motors from overheating. MPTTR models the thermal behavior of motor on the basis of the measured load current and disconnects the motor when the thermal content reaches 100 percent. The thermal overload conditions are the most often encountered abnormal conditions in industrial motor applications. The thermal overload conditions are typically the result of an abnormal rise in the motor running current, which produces an increase in the thermal dissipation of the motor and temperature or reduces cooling. MPTTR prevents an electric motor from drawing excessive current and overheating, which causes the premature insulation failures of the windings and, in worst cases, burning out of the motors.

### 4.1.10.4 Analog channel configuration

MPTTR has one analog group input which must be properly configured.

**Table 475: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.1.10.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of MPTTR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

The function uses ambient temperature which can be measured locally or remotely. Local measurement is done by the protection relay. Remote measurement uses analog GOOSE to connect `AMB_TEMP` input.

If the quality of remotely measured temperature is invalid or communication channel fails the function uses ambient temperature set in *Env temperature Set*.

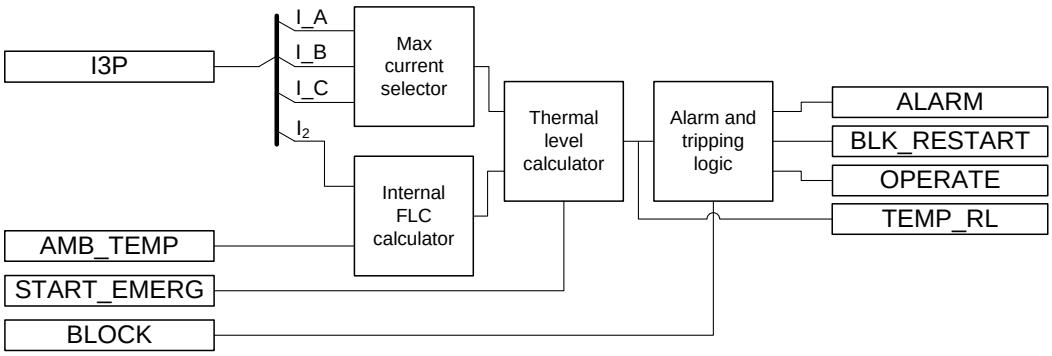



*Figure 238: Functional module diagram*

#### Max current selector

Max current selector selects the highest measured TRMS phase current and reports it to Thermal level calculator.

#### Internal FLC calculator

Full load current ( FLC) of the motor is defined by the manufacturer at an ambient temperature of 40°C. Special considerations are required with an application where the ambient temperature of a motor exceeds or remains below 40°C. A motor operating at a higher temperature, even if at or below rated load, can subject the motor windings to excessive temperature similar to that resulting from overload operation at normal ambient temperature. The motor rating has to be appropriately reduced for operation in such high ambient temperatures. Similarly, when the ambient temperature is considerably lower than the nominal 40°C, the motor can be slightly overloaded. For calculating thermal level it is better that the FLC values

are scaled for different temperatures. The scaled currents are known as internal FLC. An internal FLC is calculated based on the ambient temperature shown in the table. The *Env temperature mode* setting defines whether the thermal level calculations are based on FLC or internal FLC.

When the value of the *Env temperature mode* setting is set to the "FLC Only" mode, no internal FLC is calculated. Instead, the FLC given in the data sheet of the manufacturer is used. When the value of the *Env temperature mode* setting is set to "Set Amb Temp" mode, the internal FLC is calculated based on the ambient temperature taken as an input through the *Env temperature Set* setting. When the *Env temperature mode* setting is on "Use input" mode, the internal FLC is calculated from temperature data available through resistance temperature detectors ( RTDs) using the AMB_TEMP input.

**Table 476: Modification of internal FLC**

| Ambient Temperature $T_{amb}$ | Internal FLC |
|---|---|
| <20°C | FLC x 1.09 |
| 20 to <40°C | FLC x (1.18 - $T_{amb}$ x 0.09/20) |
| 40°C | FLC |
| >40 to 65°C | FLC x (1 –[($T_{amb}$ -40)/100]) |
| >65°C | FLC x 0.75 |

The ambient temperature is used for calculating thermal level and it is available in the monitored data view from the TEMP_AMB output. The activation of the BLOCK input does not affect the TEMP_AMB output.

The *Env temperature Set* setting is used:

- If the ambient temperature measurement value is not connected to the AMB_TEMP input in ACT.
- When the ambient temperature measurement connected to 49M is set to "Not in use" in the RTD function.
- In case of any errors or malfunctioning in the RTD output.

**Thermal level calculator**

The module calculates the thermal load considering the TRMS and negative-sequence currents. The heating up of the motor is determined by the square value of the load current.

However, in case of unbalanced phase currents, the negative-sequence current also causes additional heating. By deploying a protection based on both current components, abnormal heating of the motor is avoided.

The thermal load is calculated based on different situations or operations and it also depends on the phase current level. The equations used for the heating calculations are:

$$\theta_B = \left[ \left( \frac{I}{k \times I_r} \right)^2 + K_2 \times \left( \frac{I_2}{k \times I_r} \right)^2 \right] \times \left( 1 - e^{-t/\tau} \right) \times p\%$$

(Equation 38)

$$\theta_A = \left[ \left( \frac{I}{k \times I_r} \right)^2 + K_2 \times \left( \frac{I_2}{k \times I_r} \right)^2 \right] \times \left( 1 - e^{-t/\tau} \right) \times 100\%$$

(Equation 39)

| | |
|---|---|
| I | TRMS value of the measured max of phase currents |
| $I_r$ | set *Current reference*, FLC or internal FLC |
| $I_2$ | measured negative sequence current |
| k | set value of *Overload factor* |
| $K_2$ | set value of *Negative Seq factor* |
| p | set value of *Weighting factor* |
| t | time constant |

The equation $\theta_B$ is used when the values of all the phase currents are below the overload limit, that is, k x $I_r$. The equation $\theta_A$ is used when the value of any one of the phase currents exceeds the overload limit.

During overload condition, the thermal level calculator calculates the value of $\theta_B$ in background, and when the overload ends the thermal level is brought linearly from $\theta_A$ to $\theta_B$ with a speed of 1.66 percent per second. For the motor at standstill, that is, when the current is below the value of 0.12 x $I_r$, the cooling is expressed as:

$$\theta = \theta_{02} \times e^{\frac{-t}{\tau}}$$

(Equation 40)

| | |
|---|---|
| $\theta_{02}$ | initial thermal level when cooling begins |

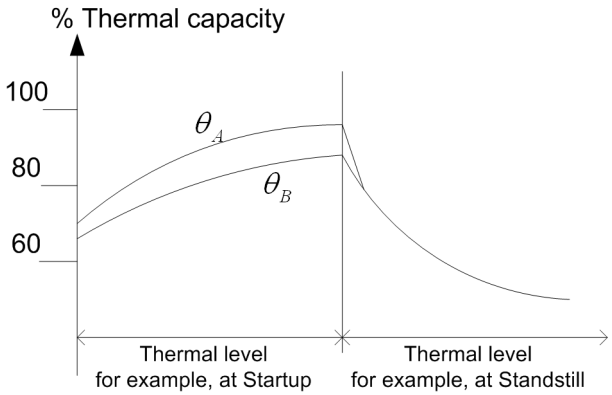



*Figure 239: Thermal behavior*

The required overload factor and negative sequence current heating effect factor are set by the values of the *Overload factor* and *Negative Seq factor* settings.

In order to accurately calculate the motor thermal condition, different time constants are used in the above equations. These time constants are employed based on different motor running conditions, for example starting, normal or stop, and are set through the *Time constant start*, *Time constant normal* and *Time constant stop* settings. Only one time constant is valid at a time.

**Table 477: Time constant and the respective phase current values**

| Time constant (tau) in use | Phase current |
|---|---|
| Time constant start | Any current whose value is over 2.5 x $I_r$ |
| Time constant normal | Any current whose value is over 0.12 x $I_r$ and all currents are below 2.5 x $I_r$ |
| Time constant stop | All the currents whose values are below 0.12 x $I_r$ |

The *Weighting factor p* setting determines the ratio of the thermal increase of the two curves $\theta_A$ and $\theta_B$.

The thermal level at the power-up of the protection relay is defined by the *Initial thermal Val* setting.

The temperature calculation is initiated from the value defined in the *Initial thermal Val* setting. This is done if the protection relay is powered up or the function is turned off and back on or reset through the Clear menu.

The calculated temperature of the protected object relative to the operate level, the TEMP_RL output, is available through the monitored data view. The activation of the BLOCK input does not affect the calculated temperature.

The calculated temperature of the protected object relative to the operate level, the TEMP_RL output, is available through the monitored data view or through the output signal TEMP_RL. The activation of the BLOCK input does not affect the calculated temperature.

The thermal level at the beginning of the start-up condition of a motor and at the end of the start-up condition is available in the monitored data view at the THERMLEV_ST and THERMLEV_END outputs respectively. The activation of the BLOCK input does not have any effect on these outputs.

**Alarm and tripping logic**

The module generates alarm, restart inhibit and tripping signals.

When the thermal level exceeds the set value of the *Alarm thermal value* setting, the ALARM output is activated. Sometimes a condition arises when it becomes necessary to inhibit the restarting of a motor, for example in case of some extreme starting condition like long starting time. If the thermal content exceeds the set value of the *Restart thermal val* setting, the BLK_RESTART output is activated. The time for the next possible motor start-up is available through the monitored data view from the T_ENARESTART output. The T_ENARESTART output estimates the time for the BLK_RESTART deactivation considering as if the motor is stopped.

When the emergency start signal START_EMERG is set high, the thermal level is set to a value below the thermal restart inhibit level. This allows at least one motor start-up, even though the thermal level has exceeded the restart inhibit level.

When the thermal content reaches 100 percent, the OPERATE output is activated. The OPERATE output is deactivated when the value of the measured current falls below 12 percent of *Current reference* or the thermal content drops below 100 percent.

The activation of the BLOCK input blocks the ALARM, BLK_RESTART and OPERATE outputs.

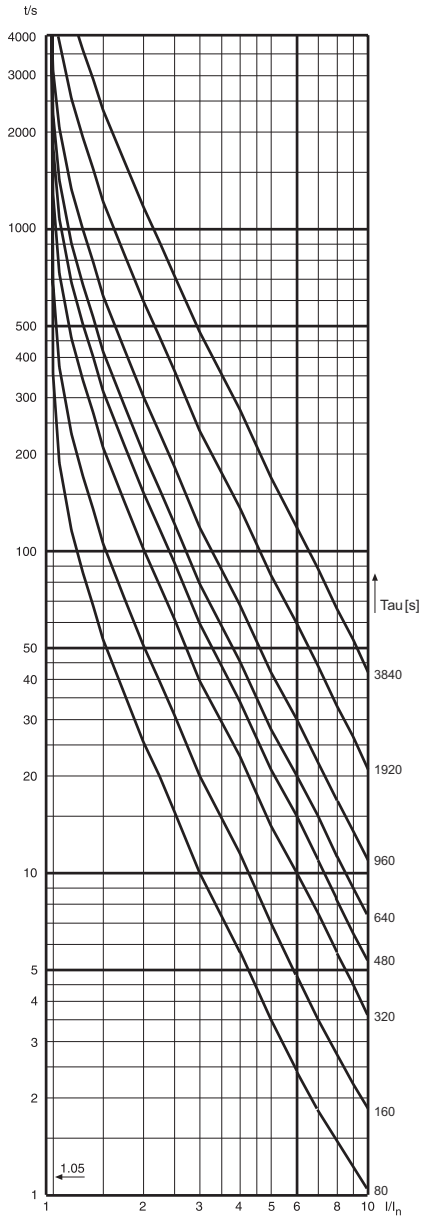



*Figure 240: Trip curves when no prior load and p=20...100 %. Overload factor = 1.05.*

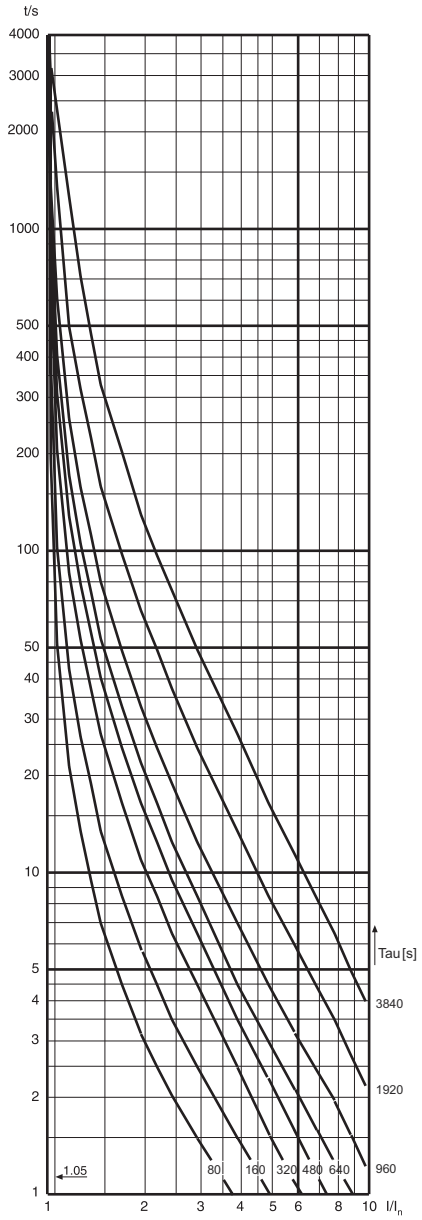



*Figure 241: Trip curves at prior load 1 x FLC and p=100 %, Overload factor = 1.05.*

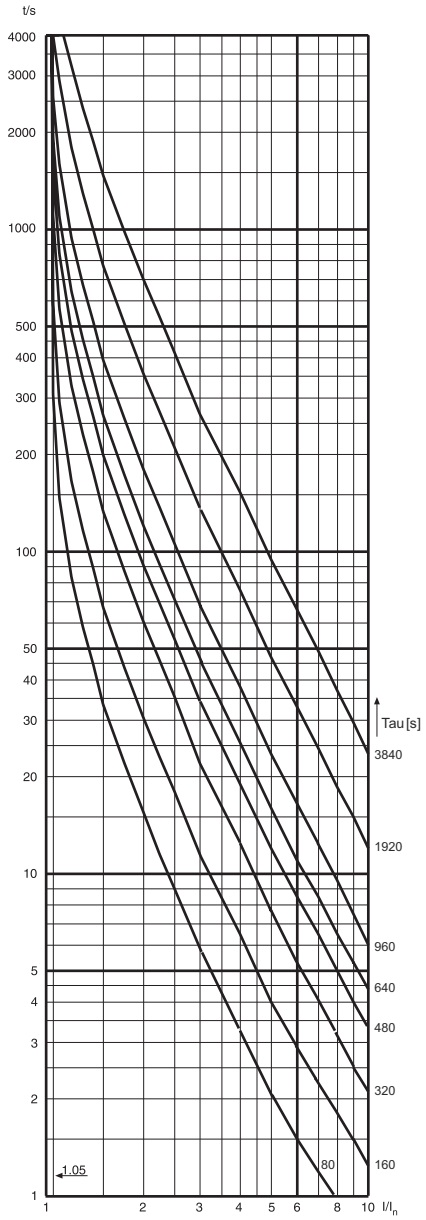



*Figure 242: Trip curves at prior load 1 x FLC and p=50 %. Overload factor = 1.05.*

### 4.1.10.6 Application

MPTTR is intended to limit the motor thermal level to predetermined values during the abnormal motor operating conditions. This prevents a premature motor insulation failure.

The abnormal conditions result in overheating and include overload, stalling, failure to start, high ambient temperature, restricted motor ventilation, reduced speed operation, frequent starting or jogging, high or low line voltage or frequency, mechanical failure of the driven load, improper installation and unbalanced line voltage or single phasing. The protection of insulation failure by the implementation of current sensing cannot detect some of these conditions, such as restricted ventilation. Similarly, the protection by sensing temperature alone can be inadequate in cases like frequent starting or jogging. The thermal overload

protection addresses these deficiencies to a larger extent by deploying a motor thermal model based on load current.

The thermal load is calculated using the true RMS phase value and negative sequence value of the current. The heating up of the motor is determined by the square value of the load current. However, while calculating the thermal level, the rated current should be re-rated or de-rated depending on the value of the ambient temperature. Apart from current, the rate at which motor heats up or cools is governed by the time constant of the motor.

**Setting the weighting factor**

There are two thermal curves: one which characterizes the short-time loads and long-time overloads and which is also used for tripping and another which is used for monitoring the thermal condition of the motor. The value of the *Weighting factor p* setting determines the ratio of the thermal increase of the two curves.

When the *Weighting factor p* setting is 100 percent, a pure single time constant thermal unit is produced which is used for application with the cables. As presented in *Figure 243*, the hot curve with the value of *Weighting factor p* being 100 percent only allows an operate time which is about 10 percent of that with no prior load. For example, when the set time constant is 640 seconds, the operate time with the prior load 1 x FLC (full Load Current) and overload factor 1.05 is only 2 seconds, even if the motor could withstand at least 5 to 6 seconds. To allow the use of the full capacity of the motor, a lower value of *Weighting factor p* should be used.

Normally, an approximate value of half of the thermal capacity is used when the motor is running at full load. Thus by setting *Weighting factor p* to 50 percent, the protection relay notifies a 45 to 50 percent thermal capacity use at full load.

For direct-on-line started motors with hot spot tendencies, the value of *Weighting factor p* is typically set to 50 percent, which will properly distinguish between short-time thermal stress and long-time thermal history. After a short period of thermal stress, for example a motor start-up, the thermal level starts to decrease quite sharply, simulating the leveling out of the hot spots. Consequently, the probability of successive allowed start-ups increases.

When protecting the objects without hot spot tendencies, for example motors started with soft starters, and cables, the value of *Weighting factor p* is set to 100 percent. With the value of *Weighting factor p* set to 100 percent, the thermal level decreases slowly after a heavy load condition. This makes the protection suitable for applications where no hot spots are expected. Only in special cases where the thermal overload protection is required to follow the characteristics of the object to be protected more closely and the thermal capacity of the object is very well known, a value between 50 and 100 percent is required.

For motor applications where, for example, two hot starts are allowed instead of three cold starts, the value of the setting *Weighting factor p* being 40 percent has proven to be useful. Setting the value of *Weighting factor p* significantly below 50 percent should be handled carefully as there is a possibility to overload the protected object as a thermal unit might allow too many hot starts or the thermal history of the motor has not been taken into account sufficiently.

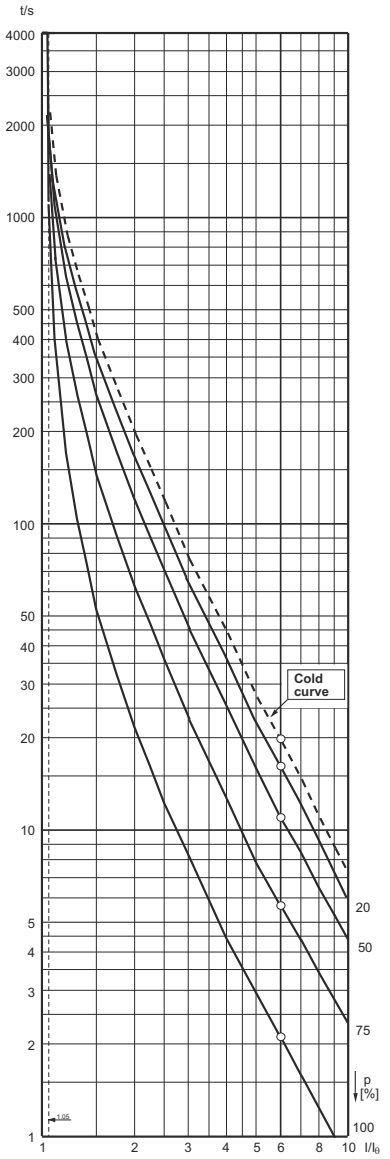



*Figure 243: The influence of Weighting factor p at prior load 1xFLC, timeconstant = 640 s, and Overload factor = 1.05*

### Setting the overload factor

The value of *Overload factor* defines the highest permissible continuous load. The recommended value is 1.05.

### Setting the negative sequence factor

During the unbalance condition, the symmetry of the stator currents is disturbed and a counter-rotating negative sequence component current is set up. An increased stator current causes additional heating in the stator and the negative sequence component current excessive heating in the rotor. Also mechanical problems like rotor vibration can occur.

The most common cause of unbalance for three-phase motors is the loss of phase resulting in an open fuse, connector or conductor. Often mechanical problems

can be more severe than the heating effects and therefore a separate unbalance protection is used.

Unbalances in other connected loads in the same busbar can also affect the motor. A voltage unbalance typically produces 5 to 7 times higher current unbalance. Because the thermal overload protection is based on the highest TRMS value of the phase current, the additional heating in stator winding is automatically taken into account. For more accurate thermal modeling, the *Negative Seq factor* setting is used for taking account of the rotor heating effect.

$$Negative\,Seq\ factor = \frac{R_{R2}}{R_{R1}}$$

(Equation 41)

$R_{R2}$ Rotor negative sequence resistance

$R_{R1}$ Rotor positive sequence resistance

A conservative estimate for the setting can be calculated:

$$Negative\,Seq\ factor = \frac{175}{I_{LR}^2}$$

(Equation 42)

$I_{LR}$ Locked rotor current (multiple of set *Rated current*). The same as the start-up current at the beginning of the motor start-up.

For example, if the rated current of a motor is 230 A, start-up current is 5.7 x $I_r$,

$$Negative\,Seq\ factor = \frac{175}{5.7^2} = 5.4$$

(Equation 43)

**Setting the thermal restart level**

The restart disable level can be calculated as follows:

$$\theta_i = 100\% - \left( \frac{startup\,time\,of\,the\,motor}{operate\,time\,when\,no\,prior\,load} \times 100\% + margin \right)$$

(Equation 44)

For example, the motor start-up time is 11 seconds, start-up current 6 x rated and *Time constant start* is set for 800 seconds. Using the trip curve with no prior load, the operation time at 6 x rated current is 25 seconds, one motor start-up uses 11/25 ≈ 45 percent of the thermal capacity of the motor. Therefore, the restart disable level must be set to below 100 percent - 45 percent = 55 percent, for example to 50 percent (100 percent - (45 percent + margin), where margin is 5 percent).

**Setting the thermal alarm level**

Tripping due to high overload is avoided by reducing the load of the motor on a prior alarm.

The value of *Alarm thermal value* is set to a level which allows the use of the full thermal capacity of the motor without causing a trip due to a long overload time. Generally, the prior alarm level is set to a value of 80 to 90 percent of the trip level.

### 4.1.10.7 Signals

#### MPTTR Input signals

**Table 478: MPTTR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| START_EMERG | BOOLEAN | 0=False | Signal for indicating the need for emergency start |
| AMB_TEMP | FLOAT32 | 0 | The ambient temperature used in the calculation |

#### MPTTR Output signals

**Table 479: MPTTR Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| ALARM | BOOLEAN | Thermal Alarm |
| BLK_RESTART | BOOLEAN | Thermal overload indicator, to inhibit restart |
| TEMP_RL | FLOAT32 | The calculated temperature of the protected object relative to the operate level |

### 4.1.10.8 MPTTR Settings

**Table 480: MPTTR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Overload factor | 1.00...1.20 | | 0.01 | 1.05 | Overload factor (k) |
| Alarm thermal value | 50.0...100.0 | % | 0.1 | 95.0 | Thermal level above which function gives an alarm |
| Restart thermal Val | 20.0...80.0 | % | 0.1 | 40.0 | Thermal level above which function inhibits motor restarting |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Negative Seq factor | 0.0...10.0 | | 0.1 | 0.0 | Heating effect factor for negative sequence current |
| Weighting factor p | 20.0...100.0 | % | 0.1 | 50.0 | Weighting factor (p) |
| Time constant normal | 80...4000 | s | 1 | 320 | Motor time constant during the normal operation of motor |
| Time constant start | 80...4000 | s | 1 | 320 | Motor time constant during the start of motor |
| Time constant stop | 80...60000 | s | 1 | 500 | Motor time constant during the standstill condition of motor |
| Env temperature mode | 1=FLC Only<br>2=Use input<br>3=Set Amb Temp | | | 1=FLC Only | Mode of measuring ambient temperature |
| Env temperature Set | -20.0...70.0 | °C | 0.1 | 40.0 | Ambient temperature used when no external temperature measurement available |

**Table 481: MPTTR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 482: MPTTR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current reference | 0.30...2.00 | xIn | 0.01 | 1.00 | Rated current (FLC) of the motor |
| Initial thermal Val | 0.0...100.0 | % | 0.1 | 74.0 | Initial thermal level of the motor |

### 4.1.10.9 MPTTR Monitored data

**Table 483: MPTTR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TEMP_AMB | FLOAT32 | -99...999 | °C | The ambient temperature used in the calculation |
| THERMLEV_ST | FLOAT32 | 0.00...9.99 | | Thermal level at beginning of motor startup |
| THERMLEV_END | FLOAT32 | 0.00...9.99 | | Thermal level at the end of motor startup situation |
| T_ENARESTART | INT32 | 0...99999 | s | Estimated time to reset of block restart |
| MPTTR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked | | Status |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 5=off | | |
| Therm-Lev:1 | FLOAT32 | 0.00...9.99 | | Thermal level of protected object (1.00 is the operate level) |

#### 4.1.10.10 Technical data

**Table 484: MPTTR Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current measurement: ±1.5% of the set value or ±0.002 × $I_n$ (at currents in the range of 0.01...4.00 × $I_n$) |
| Operate time accuracy [1] | ±2.0% of the theoretical value or ±0.50 s |

## 4.1.11 Thermal overload protection for rotors RPTTR (ANSI 49R)

### 4.1.11.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Thermal overload protection for rotors | RPTTR | 3Ith>R | 49R |

### 4.1.11.2 Function block

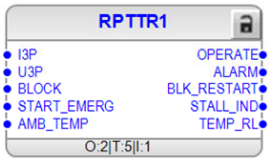



*Figure 244: Function block*

### 4.1.11.3 Functionality

The thermal overload protection for rotors RPTTR protects the rotor of the induction motor from overheating. RPTTR models the rotor thermal behavior on the basis of the measured load current and voltage and disconnects the motor when the thermal content reaches 100 percent. The rotor thermal overload conditions are

[1] Overload current > 1.2 × Operate level temperature

often encountered during the motor start-up and with abnormal conditions such as locked rotor or unbalance, which both produce excess heat due to the skin effect. The skin effect causes the current to distribute in a smaller surface in the rotor bars, increasing the resistance, and therefore also the heating effect.

The function also provides locked rotor protection. The locked rotor condition can be identified from the slip estimate that the function calculates.

### 4.1.11.4 Analog channel configuration

RPTTR has two analog group inputs which must be properly configured.

**Table 485: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

### 4.1.11.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of RPTTR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

The function uses ambient temperature which can be measured locally or remotely. Local measurement is done by the protection relay. Remote measurement uses analog IEC 61850-8-1 GOOSE to connect `AMB_TEMP` input.

If the quality of remotely measured temperature is invalid or communication channel fails the function uses ambient temperature set in *Env temperature Set*.

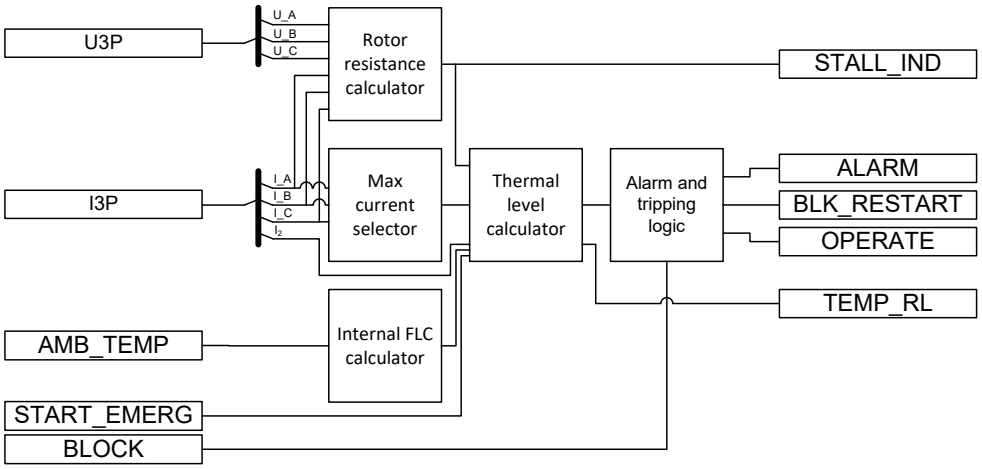



*Figure 245: RPTTR module diagram*

**Alarm and tripping logic**

The modules generate alarm, restart inhibit and tripping signal.

When the thermal level exceeds the set value of the *Alarm thermal value* setting, the ALARM output is activated. Sometimes a condition arises when it becomes necessary to inhibit the restarting of a motor, for example in case of some extreme starting condition like long starting time. If the thermal content exceeds the set value of the *Restart thermal Val* setting, the BLK_RESTART output is activated. The time for the next possible motor start-up is available through the monitored data view from T_ENARESTART. The T_ENARESTART estimates the time for the BLK_RESTART deactivation considering as if the motor is stopped.

When the emergency start signal START_EMERG is set high, the thermal level is set to a value below the *Restart thermal Val*. This allows at least one motor start-up, even though the thermal level has exceeded the *Restart thermal Val*.

When the thermal content reaches 100 percent, the OPERATE output is activated. The OPERATE output is deactivated when the value of the measured current falls below 12 percent of *Current reference* or the thermal content drops below 100 percent.

The activation of the BLOCK input blocks the ALARM, BLK_RESTART and OPERATE outputs.

**Thermal level calculator**

The module calculates the thermal load based on the rotor resistances factors, true RMS and negative sequence current. The rotor heating is determined by the squared value of the load current.

However, in case of unbalanced phase currents, the negative-sequence current also causes additional heating. By deploying a protection based on both current components, abnormal heating of rotor is avoided.

The equations used for the thermal level calculations are:

$$\theta_A = \left(R_{r+} \cdot \left(\frac{I}{k \cdot I_{IFLC}}\right)^2 + R_{r-} \cdot \left(\frac{I_2}{k \cdot I_{IFLC}}\right)^2\right) \cdot \left(1 - e^{-\frac{t}{\tau}}\right) \cdot 100\%$$

(Equation 45)

$$\theta_B = \left(R_{r+} \cdot \left(\frac{I}{k \cdot I_{IFLC}}\right)^2 + R_{r-} \cdot \left(\frac{I_2}{k \cdot I_{IFLC}}\right)^2\right) \cdot \left(1 - e^{-\frac{t}{\tau}}\right) \cdot p\%$$

(Equation 46)

| | |
|---|---|
| θA | is the thermal level during overload, |
| θB | is the thermal level during nominal conditions, |
| $R_{r+}$ | is the rotor positive sequence resistance factor, |
| $R_{r-}$ | is the rotor negative sequence resistance factor, |
| $I$ | is the True RMS value of the measured max of phase currents, |
| $I_{IFLC}$ | is the calculated internal FLC, |
| $I_2$ | is the measured negative sequence current, |

*Table continues on the next page*

| | |
|---|---|
| *k* | is the set value of *Overload factor*, |
| ρ | is the set value of *Weighting factor* and |
| t | is the time constant. |

The equation θB is used whenever all phase current is below overload limit i.e. 2.5 · $I_{IFLC}$, whereas equation θA is used when any of the phase current exceeds overload limit.

During overload condition, the function calculated the θB in background, when overload ends the thermal level is brought linearly from θA to θB, with speed of 1.66% per second. For the motor at standstill i.e. when the current is below the value 0.12 · $I_{IFLC}$, the cooling can be expressed as:

$$\theta = \theta_{02} \cdot e^{-\frac{t}{\tau}}$$

(Equation 47)

$\theta_{02}$ = initial thermal level when cooling begins

The thermal behavior can be understood from *Figure 246*.

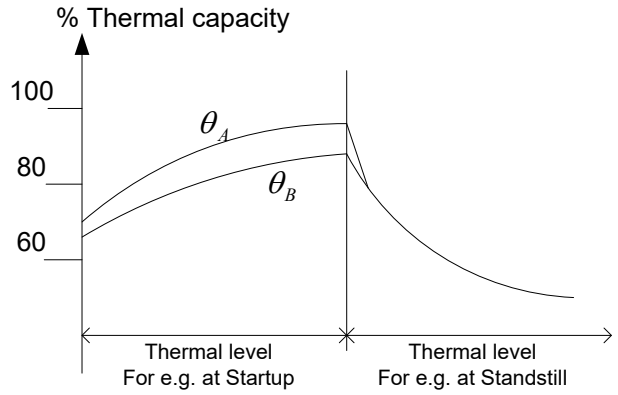



*Figure 246: Thermal behavior*

The required *Overload factor* is used to define the highest permissible continuous load. The recommended value is at minimum 1.05.

In order to accurately calculate the rotor thermal condition, different time constants are used in the above equations. These time constants are employed based on different motor running conditions, for example starting, normal or stop, and are set through the *Time constant start*, *Time constant normal*, and *Time constant stop* settings. Only one time constant is valid at a time. Different running conditions are defined by the comparison of the $I_{IFLC}$ and the phase currents, which can be seen in *Table 486*.

**Table 486: Time constant and the respective phase current values**

| Time constant in use | Phase current |
|---|---|
| tStart | Any current is over 2.5 · $I_{IFLC}$ |
| tNormal | Any current is over 0.12 · $I_{IFLC}$ and all currents are below 2.5 · $I_{IFLC}$ |
| tStop | All currents are below 0.12 · $I_{IFLC}$ |

Setting *Weighting factor p* determines the ratio of the thermal increase of the two curves θA and θB.

The thermal level of the rotor at power up of the protection relay is defined by the setting *Initial thermal Val*.

The temperature calculation is initiated from the value defined in the *Initial thermal Val* setting. This is done if the protection relay is powered up or the function is turned off and back on or reset through the Clear menu.

Calculated thermal level TEMP_RL is available in monitored data view.

Thermal levels at the beginning and the end of the latest startup are available through the monitored data view at THERMLEV_ST and THERMLEV_END respectively.

**Internal FLC calculator**

Full load current (FLC) of the motor is defined by the manufacturer at an ambient temperature of 40°C. The FLC of the motor is set by *Current reference* setting. Special considerations are required with an application where the ambient temperature of a motor exceeds or remains below 40°C. A motor operating in a higher ambient temperature, even at or below rated load, can subject the motor windings to excessive temperature. The motor rating has to be appropriately reduced for operation in such high ambient temperatures. Similarly, when the ambient temperature is considerably lower than the nominal 40°C, the motor can be slightly overloaded. For calculating thermal level, it is better that the FLC values are scaled for different temperatures. The scaled currents are known as internal FLC ($I_{IFLC}$). An $I_{IFLC}$ is calculated based on the ambient temperature shown in the table. The *Env temperature mode* setting defines whether the thermal level calculations are based on FLC or $I_{IFLC}$.

When the value of the *Env temperature mode* setting is set to the "FLC Only" mode, no $I_{IFLC}$ is calculated. Instead, the FLC given in the data sheet of the manufacturer is used. When the value of the *Env temperature mode* setting is set to "Set Amb Temp" mode, the $I_{IFLC}$ is calculated based on the ambient temperature taken as an input through the Env temperature Set setting. When the *Env temperature mode* setting is on "Use input" mode, the $I_{IFLC}$ is calculated from temperature data available through resistance temperature detectors (RTDs) using the `AMB_TEMP` input.

**Table 487: Temperature dependency of $I_{IFLC}$**

| Ambient Temperature ($T_{amb}$) | $I_{IFLC}$ |
|---|---|
| <20°C | FLC x 1.09 |
| 20 to <40°C | FLC x (1.18 - $T_{amb}$ x 0.09/20) |
| 40°C | FLC |
| >40 to 65°C | FLC x (1 –[($T_{amb}$ -40)/100]) |
| >65°C | FLC x 0.75 |

The ambient temperature TEMP_AMB is available in the monitored data view.

The *Env temperature Set* setting is used:

- If the ambient temperature measurement value is not connected to the AMB_TEMP input in ACT.
- When the ambient temperature measurement connected to RPTTR is set to "Not in use" in the RTD function.
- In case of any errors or malfunctioning in the RTD input.

**Max current selector**

Max current selector selects the highest measured True RMS phase current and reports it to Thermal level calculator.

**Rotor resistance calculator**

The module calculates rotor resistances as a function of estimated slip. Slip estimate is based on the measured phase currents and line voltages.

Necessary initial values for slip estimation are rotor resistance at locked rotor and rotor resistance at nominal speed, calculated with following equations. Settings mentioned in equations can be found from the motor datasheet information.

$$R_N = 1 - \frac{RPM_N}{RPM_S}$$

(Equation 48)

| | |
|---|---|
| $R_N$ | is the rotor resistance at nominal speed, |
| $RPM_N$ | is the setting *Nominal speed* and |
| $RPM_S$ | is the setting *Synchronous* speed. |

$$R_L = \frac{T_L}{I_L^2}$$

(Equation 49)

| | |
|---|---|
| $R_L$ | is the rotor resistance at locked rotor, |
| $T_L$ | is the setting *Relative starting torque* and |
| $I_L$ | is the setting *Relative starting current* . |

In addition to $R_N$ and $R_L$, the slip estimate calculation uses line voltages and phase currents to calculate the apparent total resistance and the initial stator resistance.

$$S = \frac{R_N}{1.2 \cdot (R - R_{SI}) - (R_L - R_N)}$$

(Equation 50)

| | |
|---|---|
| S | is the motor slip, |
| R | is the apparent total resistance calculated from line voltages and phase currents, |

*Table continues on the next page*

| | |
|---|---|
| $R_{SI}$ | is the initial stator resistance calculated from line voltages and phase currents, |
| $R_N$ | is the rotor resistance at nominal speed and |
| $R_L$ | is the rotor resistance at locked rotor. |

The rotor positive and negative sequence resistance vary depending on the motor slip. The slip estimate values are used to calculate the rotor positive and negative sequence resistance factors:

$$R_{r+} = \frac{(R_L - R_N)\cdot S + R_N}{R_N}$$

(Equation 51)

$$R_{r-} = \frac{(R_L - R_N)\cdot (2 - S) + R_N}{R_N}$$

(Equation 52)

| | |
|---|---|
| $R_{r+}$ | is the rotor positive sequence resistance factor, |
| $R_{r-}$ | is the rotor negative sequence resistance factor, |
| $R_L$ | is the rotor resistance at locked rotor, |
| $R_N$ | is the rotor resistance at nominal speed and |
| S | is the motor slip. |

These resistance factors are then used in the thermal calculations to depict the thermal behavior that the skin effect causes.

The skin effect describes the situation where the rotor bars are induced with high amplitude and high frequency current which make the current flow in the rotor bars to be distributed close to the rotor bar surface, increasing the resistance of the rotor bar.

The rotor resistances depend on the relation of the rotating magnetic fluxes and the rotor speed, i.e. slip. The faster the fluxes cut the rotor bars the higher amplitude and higher frequency currents are induced to the rotor bars.

The rotor positive sequence resistance factor $R_{r+}$ is at its highest at motor standstill (S=1), and smallest when the slip is at nominal value (S≈0). The rotor negative sequence resistance factor $R_{r-}$, however, grows larger as the rotor starts to revolve in the intended direction since the magnetic flux that the unbalance creates rotates in the opposite direction compared to the rotor, making the skin effect stronger.

STALL_IND output is provided for monitoring purposes or external logic. A TRUE value indicates that the rotor is stalling. The output is functional only when the motor is energized.

The rotational speed of the rotor is provided in monitored data at SPEED_RPM. The monitored data is also only functional when the motor is energized.

### 4.1.11.6 Application

Rotor thermal overload protection function is intended to prevent the rotor from overheating especially during motor starting and abnormal operating conditions

which cause the heating to be rapid. This prevents premature degeneration of the rotor unit. Additionally, the function provides an estimate of the motor slip, which allows identify locked rotor. This function is applicable for direct-on-line started induction motors with the motor line voltages available.

The rotor thermal overload protection function should be used in parallel with the motor thermal overload protection function MPTTR. This way both, the more rapid heating of the rotor, and the stable heating of the entire motor are taken into account.

Abnormal conditions that can result in overheating the rotor include overload, stalling, failure to start, high ambient temperature, restricted motor ventilation, reduced speed operation, frequent starting or jogging, high or low line voltage or frequency, mechanical failure of the driven load, improper installation, and unbalanced line voltage or single phasing. Protecting from insulation failure by implementation of current sensing alone cannot detect all of these conditions, such as restricted ventilation. Similarly, protection by sensing temperature alone may be inadequate, in cases like frequent starting or jogging. Thermal overload protection addresses these deficiencies to a large extent by deploying a rotor thermal model based on load current and the load voltage.

Rotor thermal level is calculated based on the rotor resistance factors, True RMS phase currents and negative sequence current. The rotor resistance factor is based on the estimated slip, that is calculated based on the measured line voltage and measured load current.

In addition, motor ambient temperature is taken into account in the thermal level calculation. Apart from current and the rotor resistance factor, the rate at which rotor heats up or cools is governed by time constant of the rotor.

**Selecting of weighing factor**

Motor manufacturers usually define two thermal limit curves one for warm and one for cold starts. The demands that these curves set are answered with the corresponding relay curves *Figure 247*.

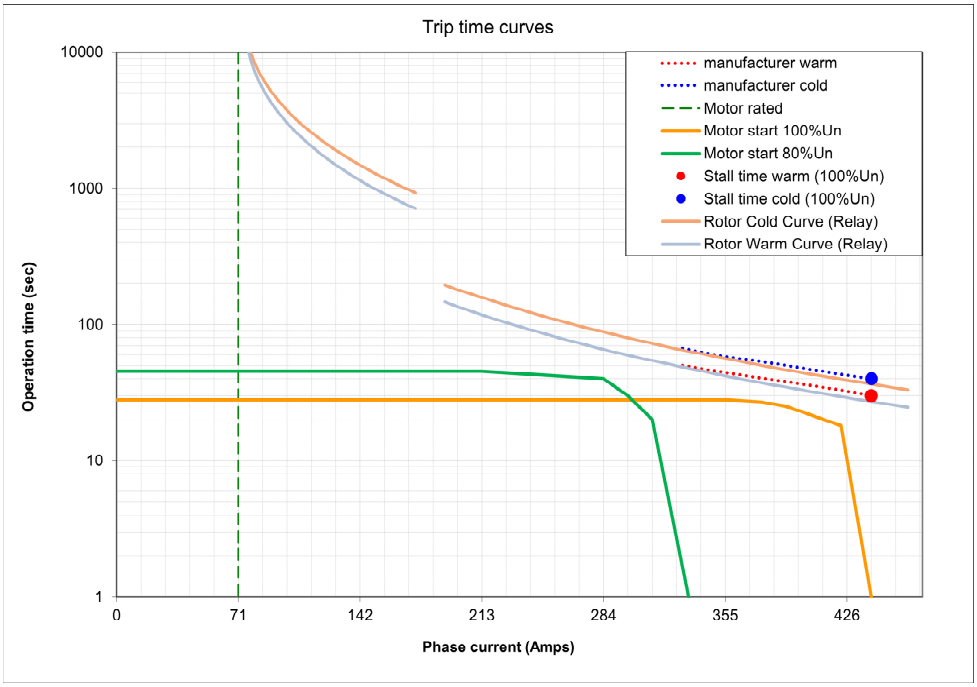



*Figure 247: Trip time curves*

In order to account for the difference between the warm and cold curves the *Weighting factor p* is used. This defines the difference, which is based on the warm and cold locked rotor times defined by the motor manufacturer. *Weighting factor p* can be calculated by the following equation:

$$Weighting\ factor\ p = k^2 \cdot \left(1 - \frac{LRT_{warm}}{LRT_{cold}}\right) \cdot 100\%$$

(Equation 53)

| | |
|---|---|
| $k$ | is the *Overload factor*, |
| $LRT_{warm}$ | is the locked rotor time for warm start and |
| $LRT_{cold}$ | is the locked rotor time for warm start. |

The *Weighting factor p* for the rotor is usually lower than for the stator, since the temperature limit for the rotor is often higher. Therefore, the used thermal capacity, when running at full load, can be quite low. For example, with warm and cold locked rotor times being 5 and 6 seconds and *Overload factor* being 1.05, the *Weighting factor p* could be set to 18.4%.

$$Weighting\ factor\ p = 1.05^2 \cdot \left(1 - \frac{5}{6}\right) \cdot 100\% = 18.4\%$$

(Equation 54)

In addition, the *Weighting factor p* is used in the cumulative thermal level calculation. It is used to properly distinguish between short-time thermal stress

and long-time thermal history, allowing more critical situations like motor start-ups to be taken into consideration more carefully.

**Setting of thermal restart level**

The *Restart thermal Val* can be calculated as follows:

$$\theta_i = 100\% - \left(\frac{start-up\ time\ of\ the\ motor}{operate\ time\ when\ no\ prior\ load}\right) \cdot 100\% + margin$$

(Equation 55)

For instance, if the start-up time of the motor is 4 seconds, and the calculated operate time of the thermal protection stage for cold motor is 6 seconds, one motor start-up will use 4/6 = 66.6% of the thermal capacity of the motor. Therefore, the *Restart thermal Val* must be set to below 100% - 66.6% = 33.3% say to 28.3% (100% - (66.6% + margin), where margin is 5%).

**Setting of thermal alarm level**

Tripping due to high overload can be avoided by reducing the load of the motor when the thermal level reaches a set alarm level.

The *Alarm thermal value* can be set to a level, which will allow the use of the motor's full thermal capacity without causing a trip due to long time overload. Generally, the *Alarm thermal value* is set to 80....90% of the trip level.

### 4.1.11.7 Signals

**RPTTR Input signals**

**Table 488: RPTTR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| START_EMERG | BOOLEAN | 0=False | Signal for indicating the need for emergency start |
| AMB_TEMP | FLOAT32 | 0 | The ambient temperature used in the calculation |

**RPTTR Output signals**

**Table 489: RPTTR Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| ALARM | BOOLEAN | Thermal Alarm |
| BLK_RESTART | BOOLEAN | Thermal overload indicator, to inhibit restart |
| STALL_IND | BOOLEAN | Indicates that the rotor is stalling |
| TEMP_RL | FLOAT32 | The calculated temperature of the protected object relative to the operate level |

## 4.1.11.8 RPTTR Settings

**Table 490: RPTTR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Env temperature mode | 1=FLC Only<br>2=Use input<br>3=Set Amb Temp | | | 1=FLC Only | Mode of measuring ambient temperature |
| Env temperature Set | -20.0...70.0 | °C | 0.1 | 40.0 | Ambient temperature used when no external temperature measurement available |
| Overload factor | 1.00...1.20 | | 0.01 | 1.05 | Overload factor (k) |
| Alarm value | 50.0...100.0 | % | 0.1 | 95.0 | Temperature level for start (alarm) |
| Restart thermal Val | 20.0...80.0 | % | 0.1 | 40.0 | Thermal level above which function inhibits motor restarting |
| Weighting factor p | 20.0...100.0 | % | 0.1 | 50.0 | Weighting factor (p) |
| Time constant normal | 80...10000 | s | 1 | 320 | Rotor time constant during the normal operation of motor |
| Time constant start | 80...10000 | s | 1 | 320 | Rotor time constant during the start of motor |
| Time constant stop | 80...60000 | s | 1 | 500 | Rotor time constant during the standstill condition of motor |

**Table 491: RPTTR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Relative starting torque | 0.10...3.00 | | 0.01 | 0.70 | Relative starting torque i.e. locked rotor torque |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Relative starting current | 100.0...2000.0 | %Ir | 0.1 | 600.0 | Relative starting current i.e. locked rotor current |
| Motor synchronous speed | 125...3600 | | 1 | 1500 | Motor synchronous speed in rpm |
| Motor nominal speed | 100...3599 | | 1 | 1485 | Motor speed at nominal load in rpm |

**Table 492: RPTTR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current reference | 0.30...2.00 | xIn | 0.01 | 1.00 | Rated current (FLC) of the motor |
| Initial thermal Val | 0.0...100.0 | % | 0.1 | 74.0 | Initial thermal level of the rotor |
| Slip Clc delay | 10...2000 | ms | 1 | 200 | Delay before slip estimate calculation starts |

### 4.1.11.9 RPTTR Monitored data

**Table 493: RPTTR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TEMP_AMB | FLOAT32 | -99...999 | °C | The ambient temperature used in the calculation |
| THERMLEV_ST | FLOAT32 | 0.00...9.99 | | Thermal level at beginning of motor startup |
| THERMLEV_END | FLOAT32 | 0.00...9.99 | | Thermal level at the end of motor startup situation |
| T_ENARESTART | INT32 | 0...99999 | s | Estimated time to reset of block restart |
| I_REF_CLC | FLOAT32 | 0.1...3.0 | | Adjusted Rated current (FLC) of the motor |
| RPTTR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| Therm-Lev:1 | FLOAT32 | 0.00...9.99 | | Thermal level of protected object (1.00 is the operate level) |

### 4.1.11.10 Technical data

**Table 494: RPTTR Technical data**

| Characteristics | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current fn ±2 Hz |
| | Current measurement ±1.5% of the set value or ±0.002 x $I_n$ (at currents in the range of ≤4.00 x $I_n$) |
| Operate time accuracy | ±2.0% of the theoretical value or ±0.50 s |

## 4.1.12 Generator shaft current leakage protection GSLPTOC ( ANSI 38,51)

### 4.1.12.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Generator shaft current leakage protection | GSLPTOC | I>,GS | 38, 51 |

### 4.1.12.2 Function block

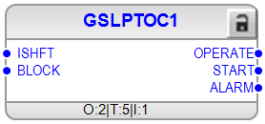



*Figure 248: Function block*

### 4.1.12.3 Functionality

Generator shaft current leakage protection function GSLPTOC protects the generator rotor bearings from damage caused by the shaft leakage current.

The function compares measured shaft current to the set alarm and operate levels. Operate time characteristics are according to definite time (DT).

### 4.1.12.4 Analog channel configuration

GSLPTOC has one analog input which must be properly configured.

**Table 495: Analog inputs**

| Input | Description |
|---|---|
| ISHFT | Measured shaft current |

### 4.1.12.5 Operation principle

The *Operation* setting is used to enable or disable the function. When selected "On" the function is enabled and respectively "Off" means function is disabled.

The operation of *Generator shaft current leakage protection* can be described by using a module diagram (see figure below). All the modules in the diagram are explained in the next sections.

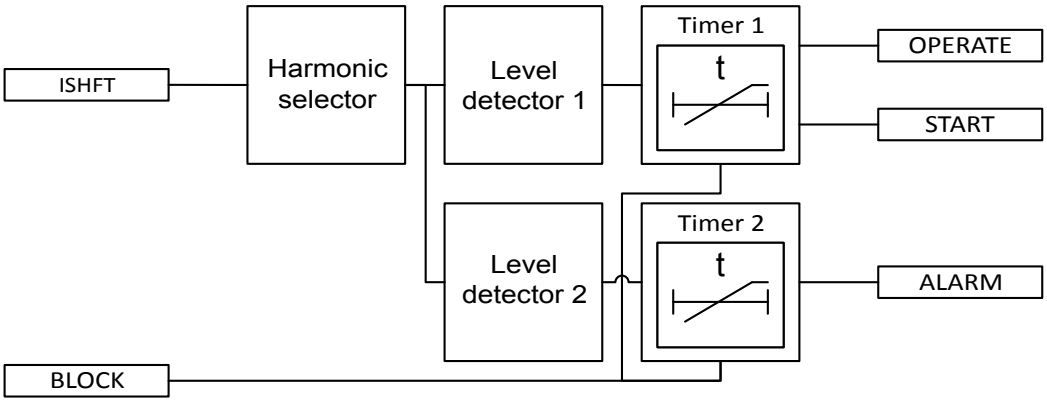



*Figure 249: Functional module diagram*

**Harmonic selector**

This module receives the shaft current measurement signal ISHAFT from the measurement arrangement. The recommended measurement arrangements (axial shaft CT with resistor or Rogowski coil with integrator) provide a voltage signal which is amplified for the relay input. The voltage signal is converted to current inside the function. Alternatively shaft current can be directly measured by relay current input when CT is used alone.

The operating harmonic component is selected according to the *Select harmonic* setting which is obtained from the commissioning test.

The selected harmonic component from the shaft current measurement is available in monitored data under `I_SHAFT`. Additionally, each of the available harmonics are available in monitored data under `I_SHAFT_H1`, `I_SHAFT_H3` and `I_SHAFT_H5`.

**Level detector 1**

The module compares the measured shaft current to the setting *Operate start value*, which is set in primary amps. If the level exceeds the set value, a enable signal is sent to Timer 1 module.

**Level detector 2**

The module compares the measured shaft current to the setting *Alarm start value*, which is set in primary amps. If the level exceeds the set value, a enable signal is sent to Timer 2 module.

**Timer 1**

Once activated, the Timer 1 activates the `START` output. The time characteristics are according to DT. When the operate timer reaches the value set by *Operate delay time*, the `OPERATE` output is activated. If the fault disappears before the module generates an `OPERATE` signal, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets.

The activation of the `BLOCK` signal resets the Timer 1 and deactivates the `OPERATE` and `START` outputs.

The module calculates the start duration value *START_DUR*, which indicates the percentage ratio of the start time and the set operating time. The value is available in the monitored data view.

**Timer 2**

Once activated, the alarm timer is activated. The time characteristics are according to DT. When the alarm timer reaches the value set by *Alarm delay time*, the ALARM output is activated. If the fault disappears before the module generates an ALARM signal, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the alarm timer resets. The activation of the BLOCK signal resets the Timer 2 and deactivates the ALARM output.

### 4.1.12.6 Application

In order to prevent the generator shaft from getting electrically charged the shaft is grounded. Different types of generators have different ways for shaft grounding. With hydro-generators, the water acts as a grounding point, and with turbogenerators the shaft can be grounded with a slip ring. However, the leakage current can still occur if the bearing pedestal, which is isolated from the ground, becomes grounded. This imposes shaft voltage on the oil-film of the bearing. The current can break the insulation that the oil-film provides and thus it can cause pitting and abrasion on the bearing face.

The measured shaft current is fed to the protection relay. The function compares the current signal to the set alarm and operate levels. Operate time characteristics are according to definite time.

**Measurement device options**

There are two different applicable shaft current measurement devices, the Rogowski coil and the current transformer (CT). Both devices are installed around the generator shaft. For both devices it is necessary to amplify the voltage signal. The recommended measurement principles are depicted in *Figure 250* and *Figure 251*.

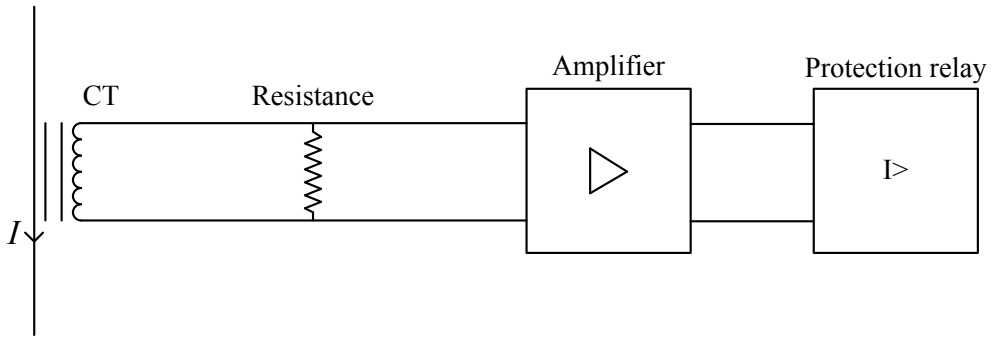



*Figure 250: Current transformer measurement arrangement*

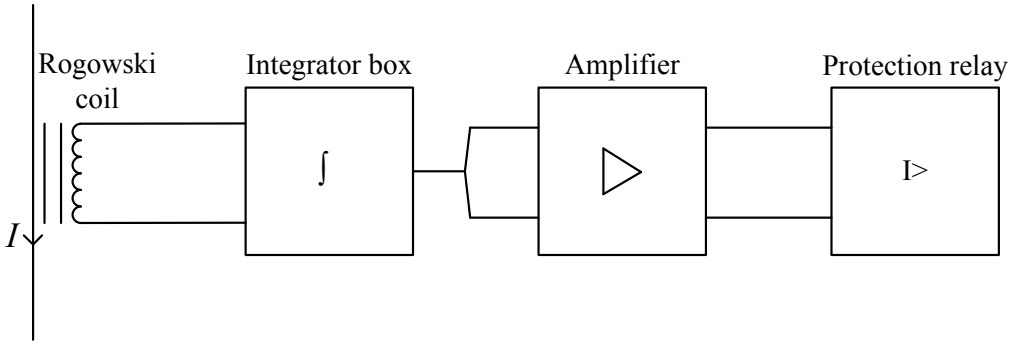



*Figure 251: Rogowski coil measurement arrangement*

It is also possible to feed shaft current, measured with CT, directly to the relay current input. Proper signal levels need to be ensured for reaching acceptable operation accuracy.

**Setting *Alarm start value* and *Operate start value***

The current level that causes damage to bearings depends on the contact surface of the bearings. Current densities over 0.1 A/mm$^2$ start to damage the bearings. This can be generalized so, that currents over 1 A can be considered harmful. Therefore, the recommended setting for *Operate start value* is 0.5 A and for *Alarm start value* 0.25 A. Both values are set in primary amperes.

### 4.1.12.7 Signals

**GSLPTOC Input signals**

**Table 496: GSLPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| ISHFT | SIGNAL | - | Analog input |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

**GSLPTOC Output signals**

**Table 497: GSLPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Alarm |

### 4.1.12.8 GSLPTOC Settings

**Table 498: GSLPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Sel operate harmonic | 1=Fundamental<br>3=Third harmonic<br>5=Fifth harmonic | | | 1=Fundamental | Select operating harmonic |
| Alarm start value | 0.10...10.00 | A | 0.01 | 0.25 | Alarm start value |
| Operate start value | 0.10...10.00 | A | 0.01 | 0.50 | Operate start value |
| Alarm delay time | 40...30000 | ms | 10 | 3000 | Alarm delay time |
| Operate delay time | 40...30000 | ms | 10 | 3000 | Operate delay time |

**Table 499: GSLPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Reset delay time | 0...10000 | ms | 1 | 1000 | Reset delay time |

### 4.1.12.9 GSLPTOC Monitored data

**Table 500: GSLPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_SHAFT | FLOAT32 | 0.00...10.00 | A | Amplitude of the measured shaft current |
| I_SHAFT_H1 | FLOAT32 | 0.00...10.00 | A | Amplitude of the fundamental component of the measured shaft current |
| I_SHAFT_H3 | FLOAT32 | 0.00...10.00 | A | Amplitude of the third harmonic component of the measured shaft current |
| I_SHAFT_H5 | FLOAT32 | 0.00...10.00 | A | Amplitude of the fifth harmonic component of the measured shaft current |
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| GSLPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.1.12.10 Technical data

**Table 501: GSLPTOC Technical data**

| Characteristics | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.03 × $I_n$ |
| Start time [1, 2] | Typically 30ms |
| Reset time | <30 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <50 ms |
| Operate time accuracy | ±1.0% of the set value of ±20 ms |

## 4.2 Earth-fault protection

### 4.2.1 Non-directional earth-fault protection EFxPTOC (ANSI 51G/51N-1, 51G/51N-2, 50G/50N)

#### 4.2.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Non-directional earth-fault protection, low stage | EFLPTOC | Io> | 51G/51N-1 |
| Non-directional earth-fault protection, high stage | EFHPTOC | Io>> | 51G/51N-2 |
| Non-directional earth-fault protection, instantaneous stage | EFIPTOC | Io>>> | 50G/50N |

#### 4.2.1.2 Function block




*Figure 252: Function block*

[1] Current before fault = 0.0 x $I_n$, $f_n$ = 50 Hz, nominal frequency fault current 1.1 x set *Start value* is injected, results based on statistical distribution of 1000 measurements

[2] Includes the delay (≈0ms) of the static signal output (SSO)

### 4.2.1.3 Functionality

The non-directional earth-fault protection function EFxPTOC is used as non-directional earth-fault protection for feeders.

The function starts and operates when the residual current exceeds the set limit. The operate time characteristic for low stage EFLPTOC and high stage EFHPTOC can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). The instantaneous stage EFIPTOC always operates with the DT characteristic.

In the DT mode, the function operates after a predefined operate time and resets when the fault current disappears. The IDMT mode provides current-dependent timer characteristics.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.1.4 Analog channel configuration

EFxPTOC has one analog group input which must be properly configured.

**Table 502: Analog inputs**

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |



See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of EFxPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

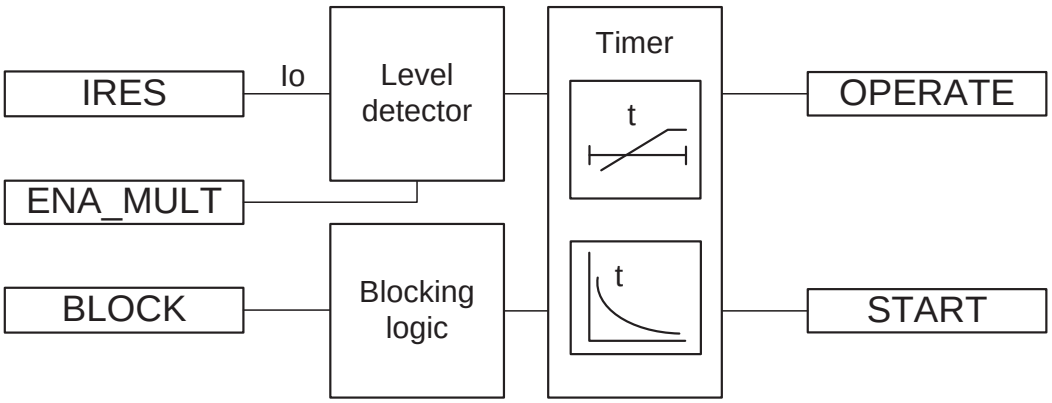



*Figure 253: Functional module diagram*

### Level detector

The measured residual current is compared to the set *Start value*. If the measured value exceeds the set *Start value*, the level detector sends an enable-signal to the timer module. If the ENA_MULT input is active, the *Start value* setting is multiplied by the *Start value Mult* setting.

The protection relay does not accept the *Start value* or *Start value Mult* setting if the product of these settings exceeds the *Start value* setting range.

The start value multiplication is normally done when the inrush detection function (INRPHAR) is connected to the ENA_MULT input.

### Timer

Once activated, the timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The functionality of the timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation and the value of START_DUR. The START output is deactivated when the reset timer has elapsed.

The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operate and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see *Chapter 11.2.1 IDMT curves for overcurrent protection* in this manual.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

#### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.2.1.6 Measurement modes

The function operates on three alternative measurement modes: "RMS", "DFT" and "Peak-to-Peak". The measurement mode is selected with the *Measurement mode* setting.

**Table 503: Measurement modes supported by EFxPTOC stages**

| Measurement mode | EFLPTOC | EFHPTOC | EFIPTOC |
|---|---|---|---|
| RMS | x | x | |
| DFT | x | x | |
| Peak-to-Peak | x | x | x |

For a detailed description of the measurement modes, see *Chapter 11.6 Measurement modes* in this manual.

### 4.2.1.7 Timer characteristics

EFxPTOC supports both DT and IDMT characteristics. The user can select the timer characteristics with the *Operating curve type* and *Type of reset curve* settings.

When the DT characteristic is selected, it is only affected by the *Operate delay time* and *Reset delay time* settings.

The protection relay provides 16 IDMT characteristics curves, of which seven comply with the IEEE C37.112 and six with the IEC 60255-3 standard. Two curves follow the special characteristics of ABB praxis and are referred to as RI and RD. In addition to this, a user programmable curve can be used if none of the standard curves are applicable. The user can choose the DT characteristic by selecting the *Operating curve type* values "ANSI Def. Time" or "IEC Def. Time". The functionality is identical in both cases.

The following characteristics, which comply with the list in the IEC 61850-7-4 specification, indicate the characteristics supported by different stages.

**Table 504: Timer characteristics supported by different stages**

| Operating curve type | EFLPTOC | EFHPTOC |
|---|---|---|
| (1) ANSI Extremely Inverse | x | x |
| (2) ANSI Very Inverse | x | |
| (3) ANSI Normal Inverse | x | x |
| (4) ANSI Moderately Inverse | x | |
| (5) ANSI Definite Time | x | x |
| (6) Long Time Extremely Inverse | x | |
| (7) Long Time Very Inverse | x | |
| (8) Long Time Inverse | x | |
| (9) IEC Normal Inverse | x | x |
| (10) IEC Very Inverse | x | x |
| (11) IEC Inverse | x | |
| (12) IEC Extremely Inverse | x | x |
| (13) IEC Short Time Inverse | x | |
| (14) IEC Long Time Inverse | x | |
| (15) IEC Definite Time | x | x |
| (17) User programmable curve | x | x |
| (18) RI type | x | |
| (19) RD type | x | |

EFIPTOC supports only definite time characteristics.

For a detailed description of timers, see *Chapter 11 General function block features* in this manual.

**Table 505: Reset time characteristics supported by different stages**

| Reset curve type | EFLPTOC | EFHPTOC | Note |
|---|---|---|---|
| (1) Immediate | x | x | Available for all operate time curves |
| (2) Def time reset | x | x | Available for all operate time curves |
| (3) Inverse reset | x | x | Available only for ANSI and user programmable curves |

The *Type of reset curve* setting does not apply to EFIPTOC or when the DT operation is selected. The reset is purely defined by the *Reset delay time* setting.

### 4.2.1.8 Application

EFxPTOC is designed for protection and clearance of earth faults in distribution and sub-transmission networks where the neutral point is isolated or earthed via a resonance coil or through low resistance. It also applies to solidly earthed networks and earth-fault protection of different equipment connected to the power systems, such as shunt capacitor bank or shunt reactors and for backup earth-fault protection of power transformers.

Many applications require several steps using different current start levels and time delays. EFxPTOC consists of three different protection stages.

- Low EFLPTOC
- High EFHPTOC
- Instantaneous EFIPTOC

EFLPTOC contains several types of time-delay characteristics. EFHPTOC and EFIPTOC are used for fast clearance of serious earth faults.

### 4.2.1.9 Signals

#### EFLPTOC Input signals

**Table 506: EFLPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

### EFHPTOC Input signals

**Table 507: EFHPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

### EFIPTOC Input signals

**Table 508: EFIPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

### EFLPTOC Output signals

**Table 509: EFLPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### EFHPTOC Output signals

**Table 510: EFHPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### EFIPTOC Output signals

**Table 511: EFIPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

## 4.2.1.10 Settings

### EFLPTOC Settings

**Table 512: EFLPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.010...10.000 | xIn | 0.005 | 0.010 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |

**Table 513: EFLPTOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

**Table 514: EFLPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 0.0001 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 0.0001 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Curve parameter D | 0.46...30.00 | | 0.01 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 515: EFLPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

### EFHPTOC Settings

**Table 516: EFHPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.10...40.00 | xIn | 0.01 | 0.10 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>3=ANSI Norm. inv.<br>5=ANSI Def. Time<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>12=IEC Ext. inv.<br>15=IEC Def. Time<br>17=Programmable | | | 15=IEC Def. Time | Selection of time delay curve type |

**Table 517: EFHPTOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

**Table 518: EFHPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 0.0001 | 28.2000 | Parameter A for customer programmable curve |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Curve parameter B | 0.0000...0.7120 | | 0.0001 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 0.01 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 519: EFHPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

#### EFIPTOC Settings

**Table 520: EFIPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 1.00...40.00 | xIn | 0.01 | 1.00 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Operate delay time | 20...300000 | ms | 10 | 20 | Operate delay time |

**Table 521: EFIPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 522: EFIPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

## 4.2.1.11 Monitored data

#### EFLPTOC Monitored data

**Table 523: EFLPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| EFLPTOC | Enum | 1=on<br>2=blocked<br>3=test | | Status |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 4=test/blocked<br>5=off | | |

### EFHPTOC Monitored data

**Table 524: EFHPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| EFHPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### EFIPTOC Monitored data

**Table 525: EFIPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| EFIPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 4.2.1.12 Technical data

**Table 526: EFxPTOC Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | EFLPTOC | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| | EFHPTOC<br>and<br>EFIPTOC | ±1.5% of set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$) | | |
| Start time [1] | | Minimum | Typical | Maximum |
| | EFIPTOC [2]: | | | |

*Table continues on the next page*

[1] *Measurement mode* = fault current in one phase with nominal frequency injected from random phase angle, results based onstatistical distribution of 1000 meas urements

| Characteristic | | Value | | |
|---|---|---|---|---|
| | $I_{Fault}$ = 2 × set *Start value*<br>$I_{Fault}$ = 10 × set *Start value* | 8 ms<br>8 ms | 11 ms<br>9 ms | 14 ms<br>11 ms |
| | EFHPTOC and EFLPTOC [3]:<br>$I_{Fault}$ = 2 × set *Start value* | 23 ms | 26 ms | 29 ms |
| Reset time | | Typically <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode [5] | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [4] | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

### 4.2.1.13 Technical revision history

**Table 527: EFLPTOC Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | I | Setting *Start value* maximum value extended to 10.000xIn. |

## 4.2.2 Directional earth-fault protection DEFxPDEF (ANSI 67G/N-1 51G/N-1, 67G/N-1 51G/N-2)

### 4.2.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Directional earth-fault protection, low stage | DEFLPDEF | Io> -> | 67G/N-1 |

*Table continues on the next page*

[2] Measured with static signal output (SSO).
[3] Includes the delay of the signal output contact (SO).
[5] Start time of the function also included.
[4] Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 1.5...20.

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| | | | 51G/N-1 |
| Directional earth-fault protection, high stage | DEFHPDEF | Io>> -> | 67G/N-1<br>51G/N-2 |

### 4.2.2.2 Function block

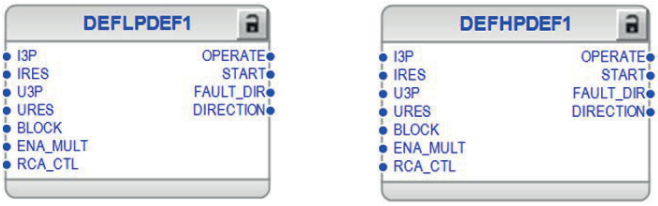



*Figure 254: Function block*

### 4.2.2.3 Functionality

The directional earth-fault protection function DEFxPDEF is used as directional earth-fault protection for feeders.

The function starts and operates when the operating quantity (current) and polarizing quantity (voltage) exceed the set limits and the angle between them is inside the set operating sector. The operate time characteristic for low stage (DEFLPDEF) and high stage (DEFHPDEF) can be selected to be either definite time (DT) or inverse definite minimum time (IDMT).

In the DT mode, the function operates after a predefined operate time and resets when the fault current disappears. The IDMT mode provides current-dependent timer characteristics.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.2.4 Analog channel configuration

DEFxPDEF has four analog group inputs which must be properly configured.

**Table 528: Analog inputs**

| Input | Description |
|---|---|
| I3P [1] | Three-phase currents, necessary when *Pol quantity* is set to "Neg. seq. volt." |
| IRES | Residual current (measured or calculated) |

*Table continues on the next page*

[1] Can be connected to GRPOFF if *Pol quantity* is set to "Zero seq. volt" or *Directional mode* is set to "Nondirectional".

| Input | Description |
|---|---|
| U3P [1] | Three-phase voltages, necessary when *Pol quantity* is set to "Neg. seq. volt." |
| URES [2] | Residual voltage (measured or calculated), necessary when *Pol quantity* is set to "Zero seq. volt." |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

**Table 529: Special conditions**

| Condition | Description |
|---|---|
| U3P connected real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |
| URES calculated | Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of DEFxPDEF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

[2] Can be connected to GRPOFF if *Pol quantity* is set to "Neg. seq. volt" or *Directional mode* is set to "Nondirectional".

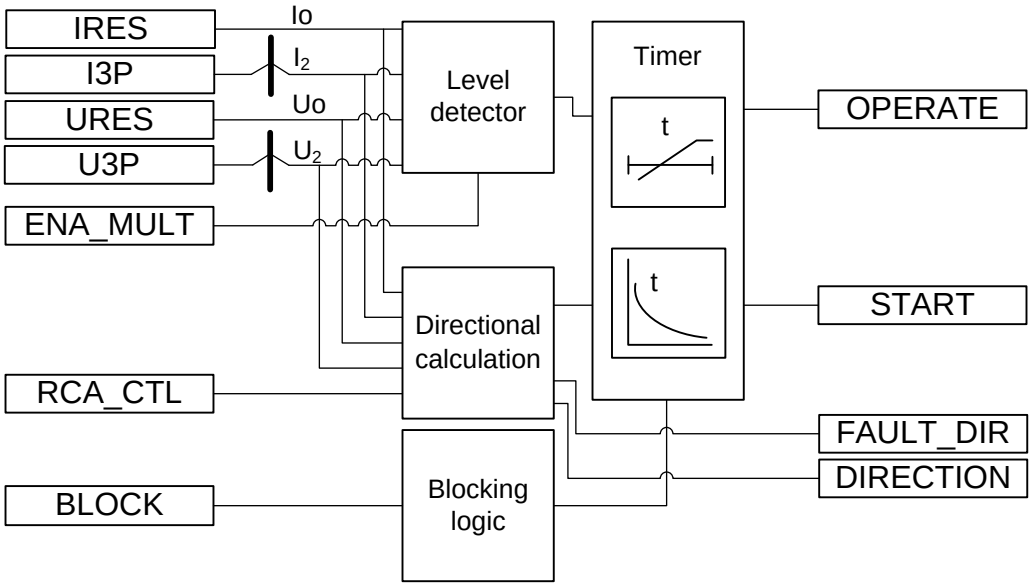



*Figure 255: Functional module diagram*

### Level detector

The magnitude of the operating quantity is compared to the set *Start value* and the magnitude of the polarizing quantity is compared to the set *Voltage start value*. If both the limits are exceeded, the level detector sends an enabling signal to the timer module. When the *Enable voltage limit* setting is set to "False", *Voltage start value* has no effect and the level detection is purely based on the operating quantity. If the ENA_MULT input is active, the *Start value* setting is multiplied by the *Start value Mult* setting.

If the *Enable voltage limit* setting is set to "True", the magnitude of the polarizing quantity is checked even if the *Directional mode* was set to "Non-directional" or *Allow Non Dir* to "True". The protection relay does not accept the *Start value* or *Start value Mult* setting if the product of these settings exceeds the *Start value* setting range.

Typically, the ENA_MULT input is connected to the inrush detection function INRHPAR. In case of inrush, INRPHAR activates the ENA_MULT input, which multiplies *Start value* by the *Start value Mult* setting.

### Directional calculation

The directional calculation module monitors the angle between the polarizing quantity and operating quantity. Depending on the *Pol quantity* setting, the polarizing quantity can be the residual voltage (measured or calculated) or the negative sequence voltage. When the angle is in the operation sector, the module sends the enabling signal to the timer module.

The minimum signal level which allows the directional operation can be set with the *Min operate current* and *Min operate voltage* settings.

If *Pol quantity* is set to "Zero. seq. volt", the residual current and residual voltage are used for directional calculation.

If *Pol quantity* is set to "Neg. seq. volt", the negative sequence current and negative sequence voltage are used for directional calculation.

In the phasor diagrams representing the operation of DEFxPDEF, the polarity of the polarizing quantity (Uo or U2) is reversed, that is, the polarizing quantity in the phasor diagrams is either -Uo or -U2. Reversing is done by switching the polarity of the residual current measuring channel (see the connection in the Protection relay's physical connections section). Similarly the polarity of the calculated Io and $I_2$ is also switched.

For defining the operation sector, there are five modes available through the *Operation mode* setting.

**Table 530: Operation modes**

| Operation mode | Description |
|---|---|
| Phase angle | The operating sectors for forward and reverse are defined with the settings *Min forward angle*, *Max forward angle*, *Min reverse angle* and *Max reverse angle*. |
| IoSin | The operating sectors are defined as "forward" when \|Io\| x sin (ANGLE) has a positive value and "reverse" when the value is negative. ANGLE is the angle difference between -Uo and Io. |
| IoCos | As "IoSin" mode. Only cosine is used for calculating the operation current. |
| Phase angle 80 | The sector maximum values are frozen to 80 degrees respectively. Only *Min forward angle* and *Min reverse angle* are settable. |
| Phase angle 88 | The sector maximum values are frozen to 88 degrees. Otherwise as "Phase angle 80" mode. |

Polarizing quantity selection "Neg. seq. volt." is available only in the "Phase angle" operation mode.

The directional operation can be selected with the *Directional mode* setting. The alternatives are "Non-directional", "Forward" and "Reverse" operation. The operation criterion is selected with the *Operation mode* setting. By setting *Allow Non Dir* to "True", non-directional operation is allowed when the directional information is invalid, that is, when the magnitude of the polarizing quantity is less than the value of the *Min operate voltage* setting.

Typically, the network rotating direction is counter-clockwise and defined as "ABC". If the network rotating direction is reversed, meaning clockwise, that is, "ACB", the equation for calculating the negative sequence voltage component need to be changed. The network rotating direction is defined with a system parameter *Phase rotation*. The calculation of the component is affected but the angle difference calculation remains the same. When the residual voltage is used as the polarizing method, the network rotating direction change has no effect on the direction calculation.

The network rotating direction is set in the protection relay using the parameter in the HMI menu: **Configuration** > **System** > **Phase rotation**.

The default parameter value is "ABC".

If the *Enable voltage limit* setting is set to "True", the magnitude of the polarizing quantity is checked even if *Directional mode* is set to "Non-directional" or *Allow Non Dir* to "True".

The *Characteristic angle* setting is used in the "Phase angle" mode to adjust the operation according to the method of neutral point earthing so that in an isolated network the *Characteristic angle* ($\phi_{RCA}$) = -90° and in a compensated network $\phi_{RCA}$ = 0°. In addition, the characteristic angle can be changed via the control signal RCA_CTL. RCA_CTL affects the *Characteristic angle* setting.

The *Correction angle* setting can be used to improve selectivity due the inaccuracies in the measurement transformers. The setting decreases the operation sector. The correction can only be used with the "IoCos" or "IoSin" modes.

The polarity of the polarizing quantity can be reversed by setting the *Pol reversal* to "True", which turns the polarizing quantity by 180 degrees.



For definitions of different directional earth-fault characteristics, see *Chapter 4.2.2.9 Directional earth-fault characteristics* in this manual.

The DIRECTION output indicates on which operating sector the operating quantity is measured. The FAULT_DIR output indicates in which operation sector the fault current is measured. The output is operational once the function is started.

The directional calculation module calculates several values which are presented in the monitored data.

**Table 531: Monitored data values**

| Monitored data values | Description |
|---|---|
| ANGLE | Also called operating angle, shows the angle difference between the polarizing quantity (Uo, $U_2$) and operating quantity (Io, $I_2$). |
| ANGLE_RCA | The angle difference between the operating angle and Characteristic angle, that is, ANGLE_RCA = ANGLE – Characteristic angle. |
| I_OPER | The current that is used for fault detection. If the Operation mode setting is "Phase angle", "Phase angle 80" or "Phase angle 88", I_OPER is the measured or calculated residual current. If the Operation mode setting is "IoSin", I_OPER is calculated as follows I_OPER = Io x sin(ANGLE). If the Operation mode setting is "IoCos", I_OPER is calculated as follows I_OPER = Io x cos(ANGLE). |

### Timer

Once activated, the timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The functionality of the timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT

curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation and the value of START_DUR. The START output is deactivated when the reset timer has elapsed.

The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operate and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see *Chapter 11.2.1 IDMT curves for overcurrent protection* in this manual.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

#### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.2.2.6 Directional earth-fault principles

In many cases it is difficult to achieve selective earth-fault protection based on the magnitude of residual current only. To obtain a selective earth-fault protection scheme, it is necessary to take the phase angle of Io into account. This is done by comparing the phase angle of the operating and polarizing quantity.

#### Relay characteristic angle

The *Characteristic angle* setting, also known as Relay Characteristic Angle (RCA), Relay Base Angle or Maximum Torque Angle (MTA), is used in the "Phase angle" mode to turn the directional characteristic if the expected fault current angle does not coincide with the polarizing quantity to produce the maximum torque. That is, RCA is the angle between the maximum torque line and polarizing quantity. If the polarizing quantity is in phase with the maximum torque line, RCA is 0 degrees. The

angle is positive if the operating current lags the polarizing quantity and negative if it leads the polarizing quantity.

**Example 1**

The "Phase angle" mode is selected, compensated network (ϕRCA = 0 deg)

=> *Characteristic angle* = 0 deg

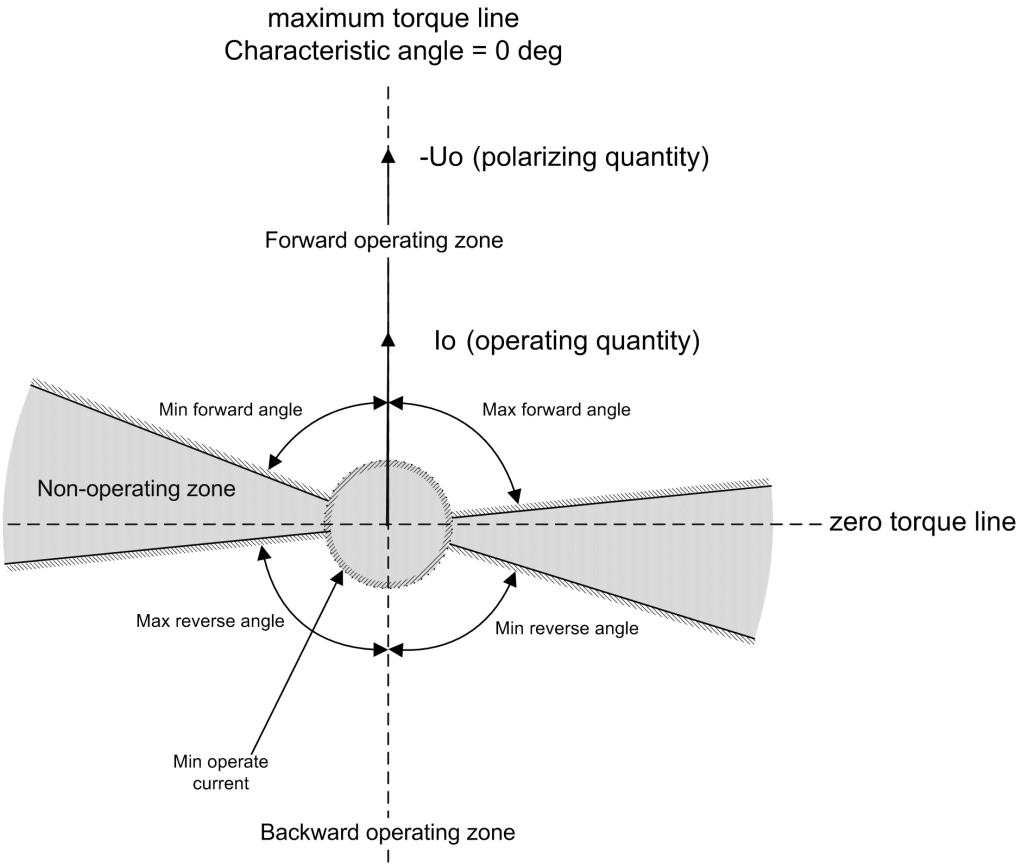



*Figure 256: Definition of the relay characteristic angle, RCA=0 degrees in a compensated network*

**Example 2**

The "Phase angle" mode is selected, solidly earthed network (ϕRCA = +60 deg)

=> *Characteristic angle* = +60 deg

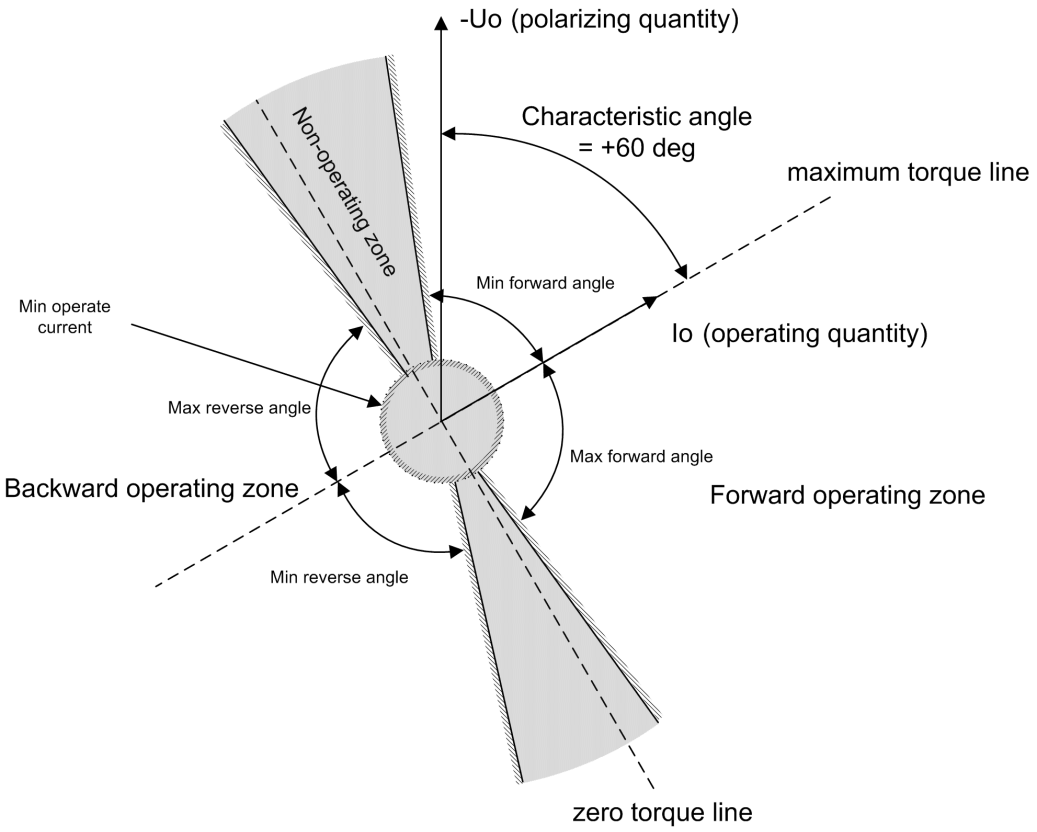



*Figure 257: Definition of the relay characteristic angle, RCA=+60 degrees in a solidly earthed network*

**Example 3**

The "Phase angle" mode is selected, isolated network (ϕRCA = -90 deg)

=> *Characteristic angle* = -90 deg

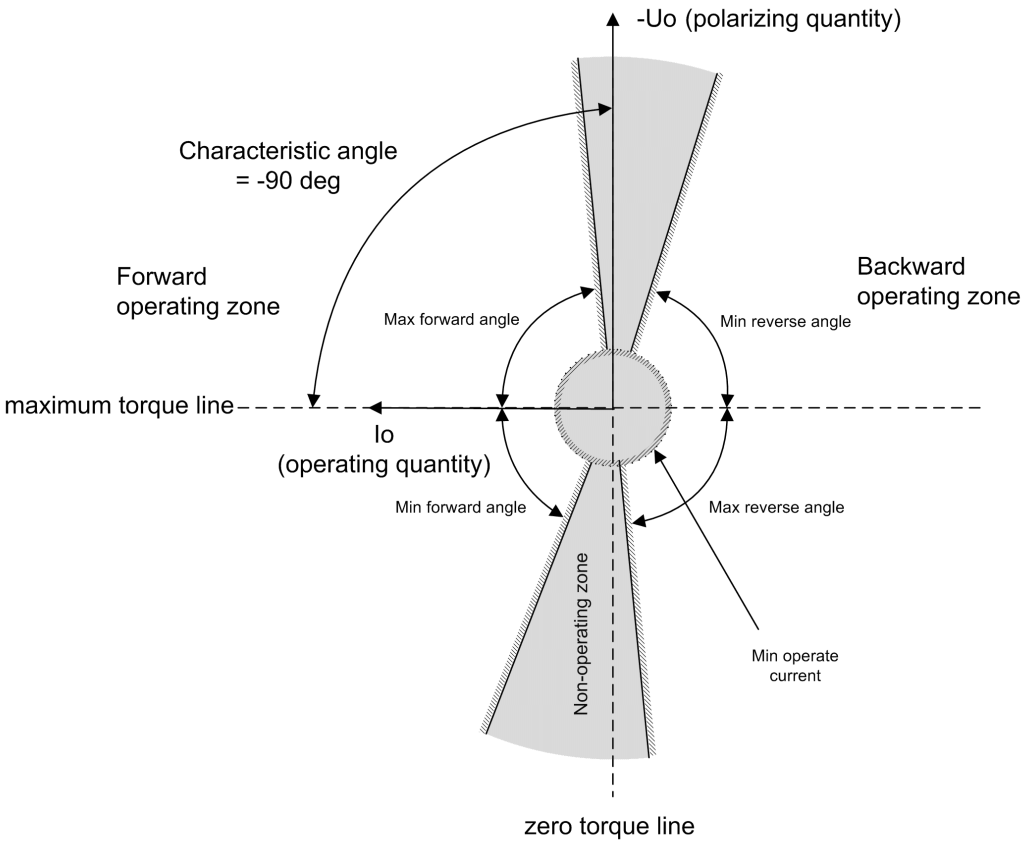



*Figure 258: Definition of the relay characteristic angle, RCA=–90 degrees in an isolated network*

**Directional earth-fault protection in an isolated neutral network**

In isolated networks, there is no intentional connection between the system neutral point and earth. The only connection is through the phase-to-earth capacitances ($C_0$) of phases and leakage resistances ($R_0$). This means that the residual current is mainly capacitive and has a phase shift of -90 degrees compared to the polarizing voltage. Consequently, the relay characteristic angle (RCA) should be set to -90 degrees and the operation criteria to "IoSin" or "Phase angle". The width of the operating sector in the phase angle criteria can be selected with the settings *Min forward angle*, *Max forward angle*, *Min reverse angle* or *Max reverse angle*. *Figure 259* illustrates a simplified equivalent circuit for an unearthed network with an earth fault in phase C.

For definitions of different directional earth-fault characteristics, see *Chapter 4.2.2.9 Directional earth-fault characteristics* .

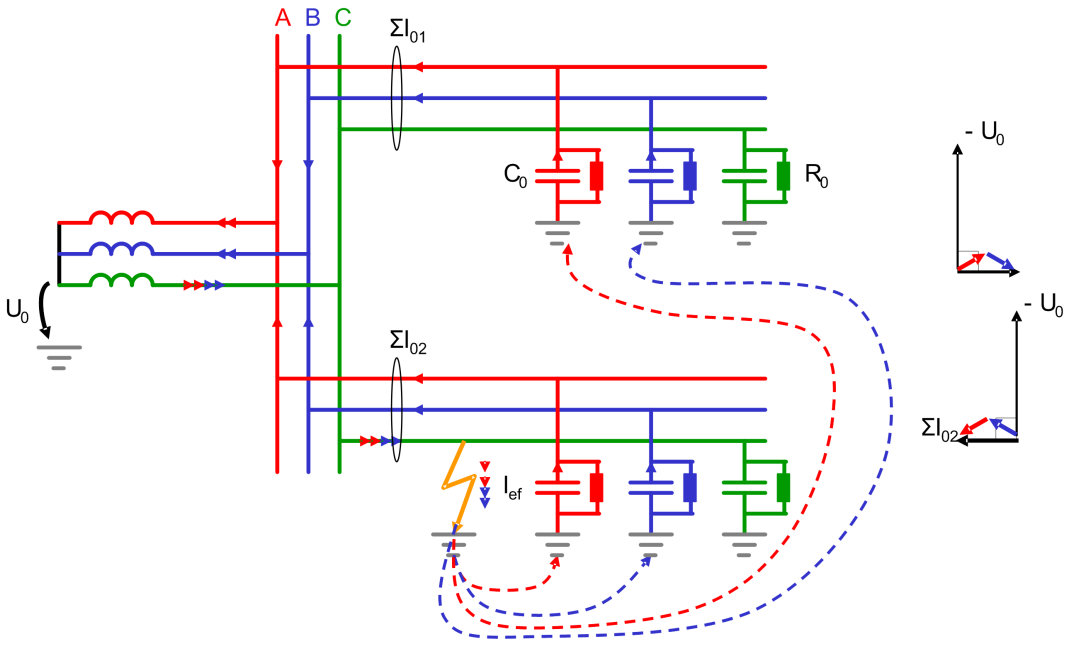



*Figure 259: Earth-fault situation in an isolated network*

**Directional earth-fault protection in a compensated network**

In compensated networks, the capacitive fault current and the inductive resonance coil current compensate each other. The protection cannot be based on the reactive current measurement, since the current of the compensation coil would disturb the operation of the protection relays. In this case, the selectivity is based on the measurement of the active current component. The magnitude of this component is often small and must be increased by means of a parallel resistor in the compensation equipment. When measuring the resistive part of the residual current, the *Operation mode* should be set to "Phase angle" and the relay characteristic angle (RCA) should be set to 0 degrees. Alternatively, the *Operation mode* can be set to "IoCos". *Figure 259* illustrates a simplified equivalent circuit for a compensated network with an earth fault in phase C.

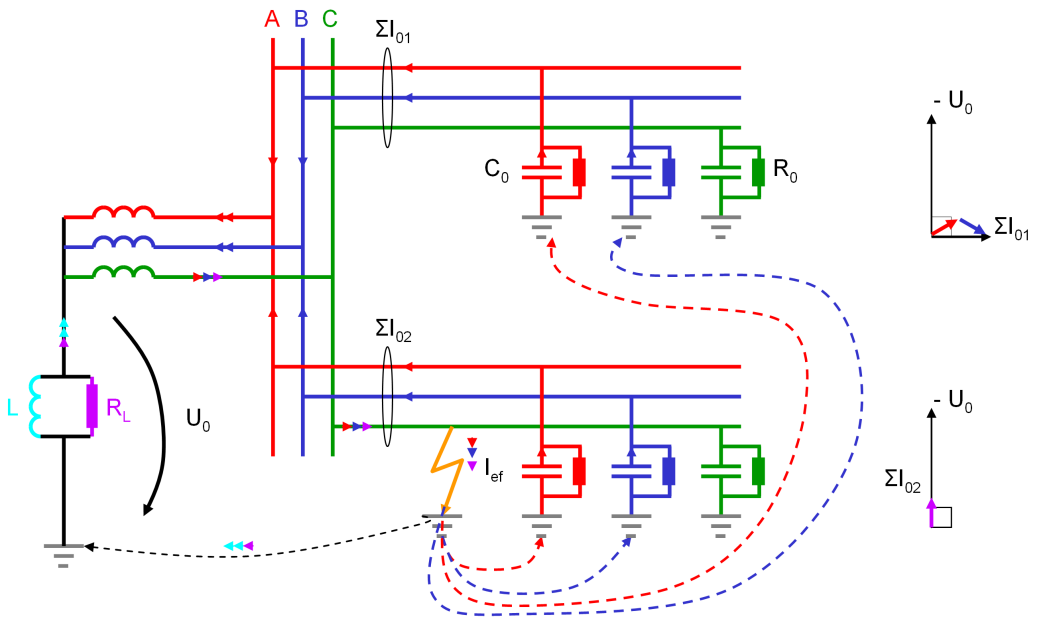



*Figure 260: Earth-fault situation in a compensated network*

The Petersen coil or the earthing resistor may be temporarily out of operation. To keep the protection scheme selective, it is necessary to update the *Characteristic angle* setting accordingly. This can be done with an auxiliary input in the protection relay which receives a signal from an auxiliary switch of the disconnector of the Petersen coil in compensated networks. As a result the characteristic angle is set automatically to suit the earthing method used. The RCA_CTL input can be used to change the operation criteria as described in *Table 532* and *Table 533*.

**Table 532: Relay characteristic angle control in Iosin(ϕ) and Iocos(ϕ) operation criteria**

| ***Operation mode* setting:** | **RCA_CTL = FALSE** | **RCA_CTL = TRUE** |
|---|---|---|
| Iosin | Actual operation mode: Iosin | Actual operation mode: Iocos |
| Iocos | Actual operation mode: Iocos | Actual operation mode: Iosin |

**Table 533: *Characteristic angle* control in phase angle operation mode**

| ***Characteristic angle* setting** | **RCA_CTL = FALSE** | **RCA_CTL = TRUE** |
|---|---|---|
| -90° | $\phi_{RCA}$ = -90° | $\phi_{RCA}$ = 0° |
| 0° | $\phi_{RCA}$ = 0° | $\phi_{RCA}$ = -90° |

### Use of the extended phase angle characteristic

The traditional method of adapting the directional earth-fault protection function to the prevailing neutral earthing conditions is done with the *Characteristic angle* setting. In an unearthed network, *Characteristic angle* is set to -90 degrees and in a compensated network *Characteristic angle* is set to 0 degrees. In case the earthing method of the network is temporarily changed from compensated to unearthed due to the disconnection of the arc suppression coil, the *Characteristic angle* setting should be modified correspondingly. This can be done using the setting

groups or the RCA_CTL input. Alternatively, the operating sector of the directional earth-fault protection function can be extended to cover the operating sectors of both neutral earthing principles. Such characteristic is valid for both unearthed and compensated network and does not require any modification in case the neutral earthing changes temporarily from the unearthed to compensated network or vice versa.

The extended phase angle characteristic is created by entering a value of over 90 degrees for the *Min forward angle* setting; a typical value is 170 degrees ( *Min reverse angle* in case *Directional mode* is set to "Reverse"). The *Max forward angle* setting should be set to cover the possible measurement inaccuracies of current and voltage transformers; a typical value is 80 degrees ( *Max reverse angle* in case *Directional mode* is set to "Reverse").

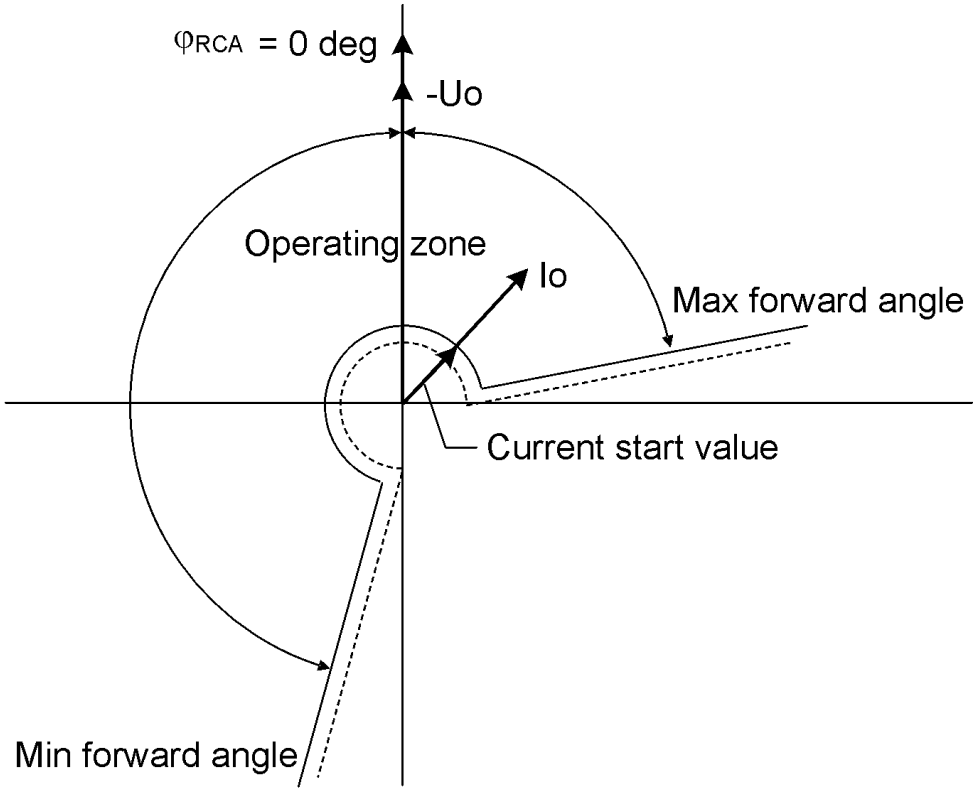



*Figure 261: Extended operation area in directional earth-fault protection*

### 4.2.2.7 Measurement modes

The function operates on three alternative measurement modes: "RMS", "DFT" and "Peak-to-Peak". The measurement mode is selected with the *Measurement mode* setting.

**Table 534: Measurement modes supported by DEFxPDEF stages**

| Measurement mode | DEFLPDEF | DEFHPDEF |
|---|---|---|
| RMS | x | x |
| DFT | x | x |
| Peak-to-Peak | x | x |

For a detailed description of the measurement modes, see *Chapter 11.6 Measurement modes* in this manual.

### 4.2.2.8 Timer characteristics

DEFxPDEF supports both DT and IDMT characteristics. The user can select the timer characteristics with the *Operating curve type* setting.

The protection relay provides 16 IDMT characteristics curves, of which seven comply with the IEEE C37.112 and six with the IEC 60255-3 standard. Two curves follow the special characteristics of ABB praxis and are referred to as RI and RD. In addition to this, a user programmable curve can be used if none of the standard curves are applicable. The user can choose the DT characteristic by selecting the *Operating curve type* values "ANSI Def. Time" or "IEC Def. Time". The functionality is identical in both cases.

The following characteristics, which comply with the list in the IEC 61850-7-4 specification, indicate the characteristics supported by different stages.

**Table 535: Timer characteristics supported by different stages**

| Operating curve type | DEFLPDEF | DEFHPDEF |
|---|---|---|
| (1) ANSI Extremely Inverse | x | x |
| (2) ANSI Very Inverse | x | |
| (3) ANSI Normal Inverse | x | x |
| (4) ANSI Moderately Inverse | x | |
| (5) ANSI Definite Time | x | x |
| (6) Long Time Extremely Inverse | x | |
| (7) Long Time Very Inverse | x | |
| (8) Long Time Inverse | x | |
| (9) IEC Normal Inverse | x | |
| (10) IEC Very Inverse | x | |
| (11) IEC Inverse | x | |
| (12) IEC Extremely Inverse | x | |
| (13) IEC Short Time Inverse | x | |
| (14) IEC Long Time Inverse | x | |
| (15) IEC Definite Time | x | x |
| (17) User programmable curve | x | x |
| (18) RI type | x | |
| (19) RD type | x | |

For a detailed description of the timers, see *Chapter 11 General function block features* in this manual.

**Table 536: Reset time characteristics supported by different stages**

| Reset curve type | DEFLPDEF | DEFHPDEF | Note |
|---|---|---|---|
| (1) Immediate | x | x | Available for all operate time curves |
| (2) Def time reset | x | x | Available for all operate time curves |
| (3) Inverse reset | x | x | Available only for ANSI and user programmable curves |

### 4.2.2.9 Directional earth-fault characteristics

#### Phase angle characteristic

The operation criterion phase angle is selected with the *Operation mode* setting using the value "Phase angle".

When the phase angle criterion is used, the DIRECTION output indicates on which operating sector the operating quantity is measured. The FAULT_DIR output indicates in which operation sector the fault current is measured. The output is operational once the function is started.

The forward and reverse sectors are defined separately. The forward operation area is limited with the *Min forward angle* and *Max forward angle* settings. The reverse operation area is limited with the *Min reverse angle* and *Max reverse angle* settings.



The sector limits are always given as positive degree values.

In the forward operation area, the *Max forward angle* setting gives the clockwise sector and the *Min forward angle* setting correspondingly the counterclockwise sector, measured from the *Characteristic angle* setting.

In the reverse operation area, the *Max reverse angle* setting gives the clockwise sector and the *Min reverse angle* setting correspondingly the counterclockwise sector, measured from the complement of the *Characteristic angle* setting (180 degrees phase shift) .

The relay characteristic angle (RCA) is set to positive if the operating current lags the polarizing quantity. It is set to negative if it leads the polarizing quantity.

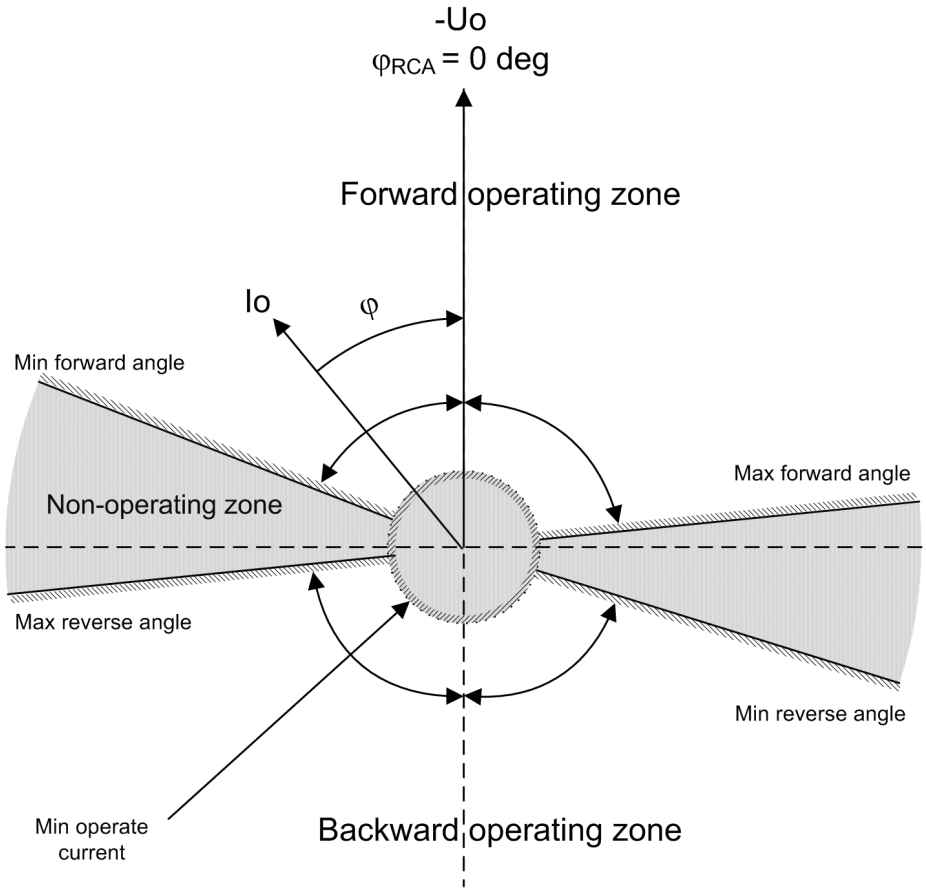



*Figure 262: Configurable operating sectors in phase angle characteristic*

**Table 537: Momentary operating direction**

| Fault direction | The value for DIRECTION |
|---|---|
| Angle between the polarizing and operating quantity is not in any of the defined sectors. | 0 = unknown |
| Angle between the polarizing and operating quantity is in the forward sector. | 1= forward |
| Angle between the polarizing and operating quantity is in the reverse sector. | 2 = backward |
| Angle between the polarizing and operating quantity is in both the forward and the reverse sectors, that is, the sectors are overlapping. | 3 = both |

If the *Allow Non Dir* setting is "False", the directional operation (forward, reverse) is not allowed when the measured polarizing or operating quantities are invalid, that is, their magnitude is below the set minimum values. The minimum values can be defined with the settings *Min operate current* and *Min operate voltage*. In case of low magnitudes, the FAULT_DIR and DIRECTION outputs are set to 0 = unknown, except when the *Allow non dir* setting is "True". In that case, the function is allowed to operate in the directional mode as non-directional, since the directional information is invalid.

### Iosin(ϕ) and Iocos(ϕ) criteria

A more modern approach to directional protection is the active or reactive current measurement. The operating characteristic of the directional operation depends on the earthing principle of the network. The Iosin(ϕ) characteristics is used in an isolated network, measuring the reactive component of the fault current caused by the earth capacitance. The Iocos(ϕ) characteristics is used in a compensated network, measuring the active component of the fault current.

The operation criteria Iosin(ϕ) and Iocos(ϕ) are selected with the *Operation mode* setting using the values "IoSin" or "IoCos" respectively.

The angle correction setting can be used to improve selectivity. The setting decreases the operation sector. The correction can only be used with the Iosin(ϕ) or Iocos(ϕ) criterion. The RCA_CTL input is used to change the Io characteristic:

**Table 538: Relay characteristic angle control in the IoSin and IoCos operation criteria**

| Operation mode: | RCA_CTL = "False" | RCA_CTL = "True" |
|---|---|---|
| IoSin | Actual operation criterion: Io-sin(ϕ) | Actual operation criterion: Io-cos(ϕ) |
| IoCos | Actual operation criterion: Io-cos(ϕ) | Actual operation criterion: Io-sin(ϕ) |

When the Iosin(ϕ) or Iocos(ϕ) criterion is used, the component indicates a forward- or reverse-type fault through the FAULT_DIR and DIRECTION outputs, in which 1 equals a forward fault and 2 equals a reverse fault. Directional operation is not allowed (the *Allow non dir* setting is "False") when the measured polarizing or operating quantities are not valid, that is, when their magnitude is below the set minimum values. The minimum values can be defined with the *Min operate current* and *Min operate voltage* settings. In case of low magnitude, the FAULT_DIR and DIRECTION outputs are set to 0 = unknown, except when the *Allow non dir* setting is "True". In that case, the function is allowed to operate in the directional mode as non-directional, since the directional information is invalid.

The calculated Iosin(ϕ) or Iocos(ϕ) current used in direction determination can be read through the I_OPER monitored data. The value can be passed directly to a decisive element, which provides the final start and operate signals.

The I_OPER monitored data gives an absolute value of the calculated current.

The following examples show the characteristics of the different operation criteria:

**Example 1.**

Iosin(ϕ) criterion selected, forward-type fault

```
=> FAULT_DIR = 1
```

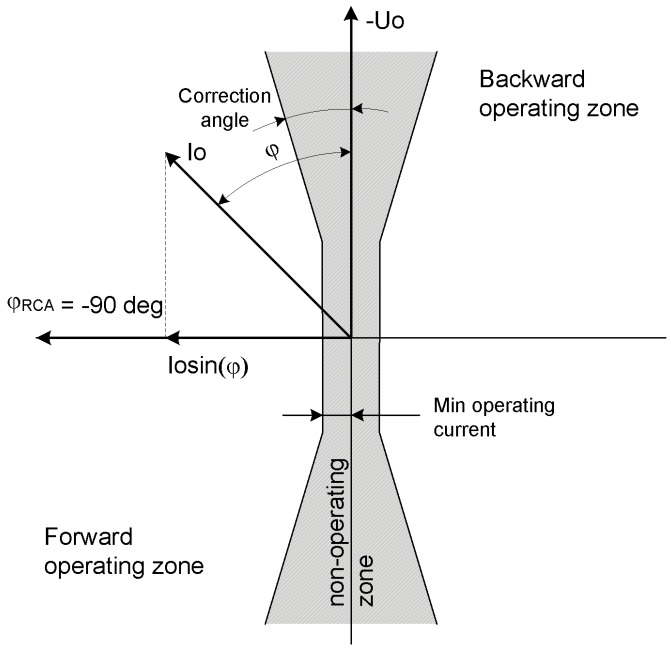



*Figure 263: Operating characteristic Iosin(ϕ) in forward fault*

The operating sector is limited by angle correction, that is, the operating sector is 180 degrees - 2*(angle correction).

**Example 2.**

Iosin(ϕ) criterion selected, reverse-type fault

```
=> FAULT_DIR = 2
```

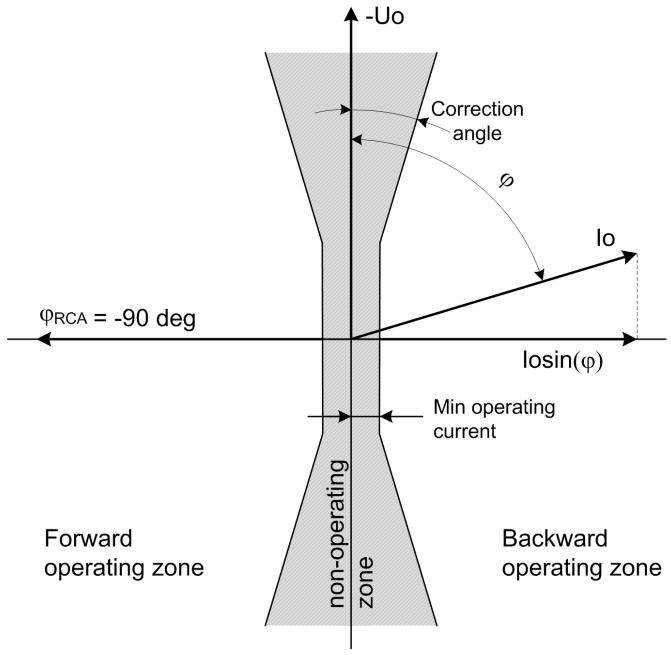



*Figure 264: Operating characteristic Iosin(ϕ) in reverse fault*

**Example 3.**

Iocos(ϕ) criterion selected, forward-type fault

```
=> FAULT_DIR = 1
```

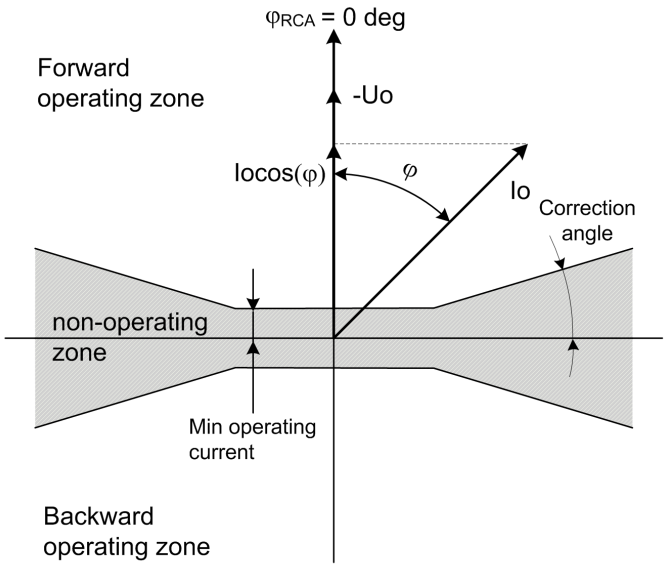



*Figure 265: Operating characteristic Iocos(ϕ) in forward fault*

**Example 4.**

Iocos(ϕ) criterion selected, reverse-type fault

```
=> FAULT_DIR = 2
```

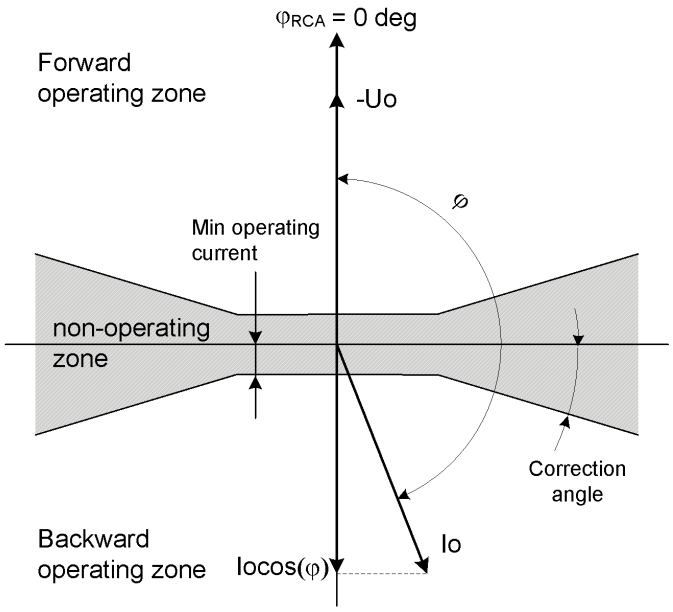



*Figure 266: Operating characteristic Iocos(ϕ) in reverse fault*

### Phase angle 80

The operation criterion phase angle 80 is selected with the *Operation mode* setting by using the value "Phase angle 80".

Phase angle 80 implements the same functionality as the phase angle but with the following differences:

- The *Max forward angle* and *Max reverse angle* settings cannot be set but they have a fixed value of 80 degrees
- The sector limits of the fixed sectors are rounded.

The sector rounding is used for cancelling the CT measurement errors at low current amplitudes. When the current amplitude falls below three percent of the nominal current, the sector is reduced to 70 degrees at the fixed sector side. This makes the protection more selective, which means that the phase angle measurement errors do not cause faulty operation.

There is no sector rounding on the other side of the sector.

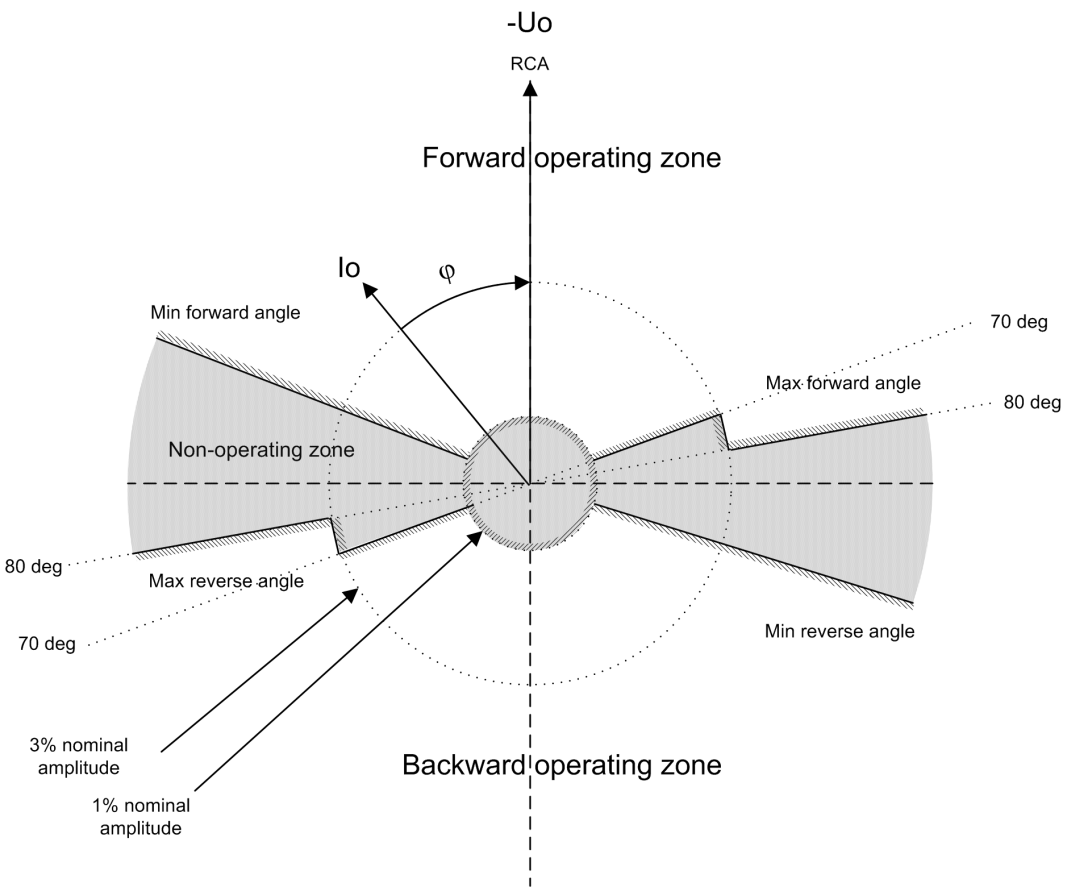



*Figure 267: Operating characteristic for phase angle 80*

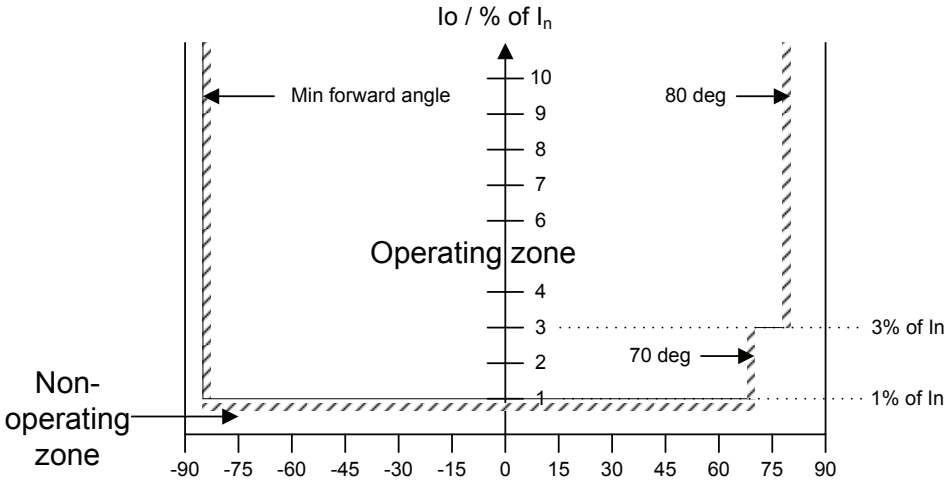



*Figure 268: Phase angle 80 amplitude ( Directional mode = Forward)*

**Phase angle 88**

The operation criterion phase angle 88 is selected with the *Operation mode* setting using the value "Phase angle 88".

Phase angle 88 implements the same functionality as the phase angle but with the following differences:

- The *Max forward angle* and *Max reverse angle* settings cannot be set but they have a fixed value of 88 degrees
- The sector limits of the fixed sectors are rounded.

Sector rounding in the phase angle 88 consists of three parts.

- If the current amplitude is between 1...20 percent of the nominal current, the sector limit increases linearly from 73 degrees to 85 degrees
- If the current amplitude is between 20...100 percent of the nominal current, the sector limit increases linearly from 85 degrees to 88 degrees
- If the current amplitude is more than 100 percent of the nominal current, the sector limit is 88 degrees.

There is no sector rounding on the other side of the sector.

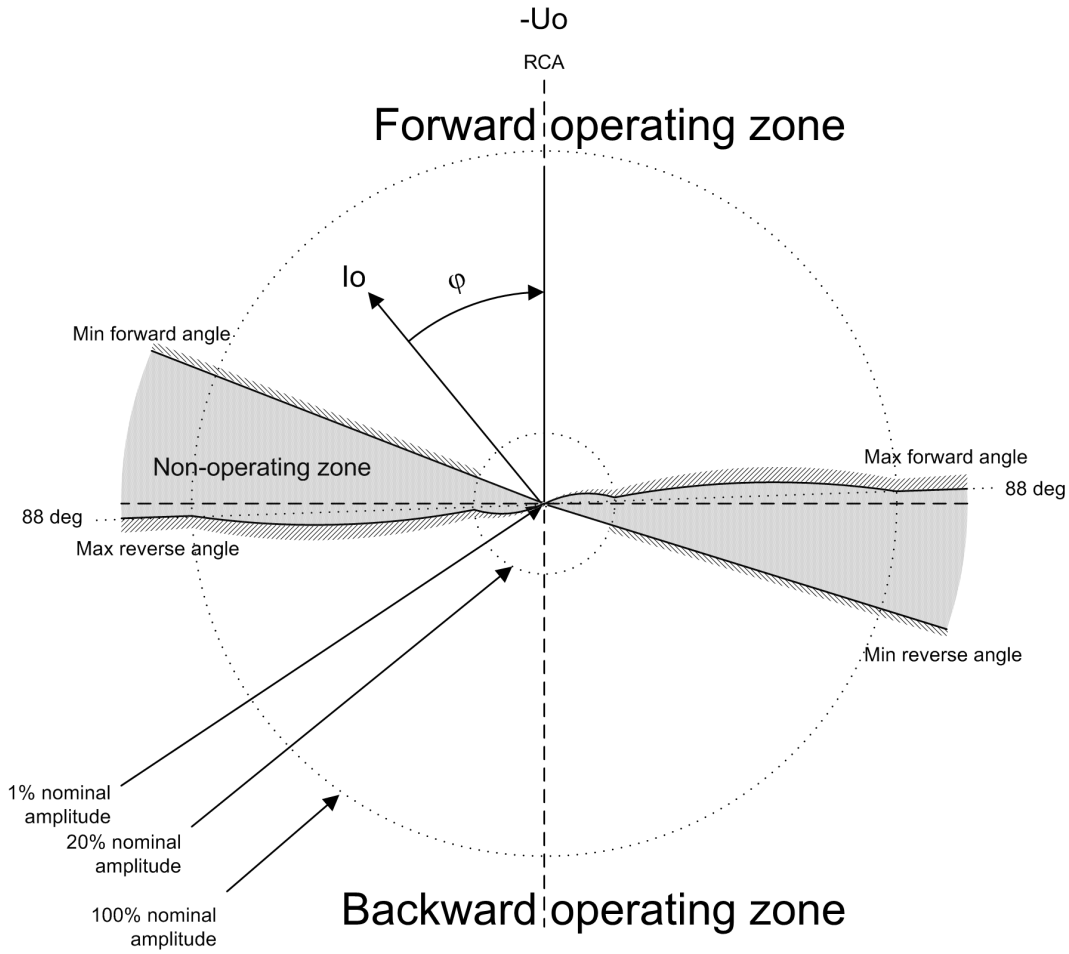



*Figure 269: Operating characteristic for phase angle 88*

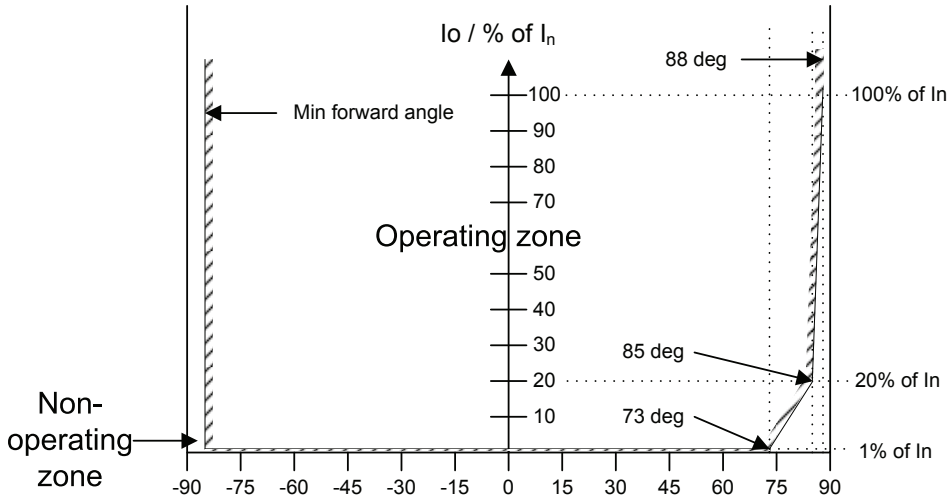



*Figure 270: Phase angle 88 amplitude ( Directional mode = Forward)*

### 4.2.2.10 Application

The directional earth-fault protection DEFxPDEF is designed for protection and clearance of earth faults and for earth-fault protection of different equipment connected to the power systems, such as shunt capacitor banks or shunt reactors, and for backup earth-fault protection of power transformers.

Many applications require several steps using different current start levels and time delays. DEFxPDEF consists of two different stages.

- Low DEFLPDEF
- High DEFHPDEF

DEFLPDEF contains several types of time delay characteristics. DEFHPDEF is used for fast clearance of serious earth faults.

The protection can be based on the phase angle criterion with extended operating sector. It can also be based on measuring either the reactive part Iosin(ϕ) or the active part Iocos(ϕ) of the residual current. In isolated networks or in networks with high impedance earthing, the phase-to-earth fault current is significantly smaller than the short-circuit currents. In addition, the magnitude of the fault current is almost independent of the fault location in the network.

The function uses the residual current components Iocos(ϕ) or Iosin(ϕ) according to the earthing method, where ϕ is the angle between the residual current and the reference residual voltage (-Uo). In compensated networks, the phase angle criterion with extended operating sector can also be used. When the relay characteristic angle RCA is 0 degrees, the negative quadrant of the operation sector can be extended with the *Min forward angle* setting. The operation sector can be set between 0 and -180 degrees, so that the total operation sector is from +90 to -180 degrees. In other words, the sector can be up to 270 degrees wide. This allows the protection settings to stay the same when the resonance coil is disconnected from between the neutral point and earth.

System neutral earthing is meant to protect personnel and equipment and to reduce interference for example in telecommunication systems. The neutral earthing sets challenges for protection systems, especially for earth-fault protection.

In isolated networks, there is no intentional connection between the system neutral point and earth. The only connection is through the line-to-earth capacitances ($C_0$) of phases and leakage resistances ($R_0$). This means that the residual current is mainly capacitive and has -90 degrees phase shift compared to the residual voltage (-Uo). The characteristic angle is -90 degrees.

In resonance-earthed networks, the capacitive fault current and the inductive resonance coil current compensate each other. The protection cannot be based on the reactive current measurement, since the current of the compensation coil would disturb the operation of the relays. In this case, the selectivity is based on the measurement of the active current component. This means that the residual current is mainly resistive and has zero phase shift compared to the residual voltage (-Uo) and the characteristic angle is 0 degrees. Often the magnitude of this component is small, and must be increased by means of a parallel resistor in the compensation equipment.

In networks where the neutral point is earthed through low resistance, the characteristic angle is also 0 degrees (for phase angle). Alternatively, Iocos(ϕ) operation can be used.

In solidly earthed networks, the *Characteristic angle* is typically set to +60 degrees for the phase angle. Alternatively, Iosin(ϕ) operation can be used with a reversal polarizing quantity. The polarizing quantity can be rotated 180 degrees by setting

the *Pol reversal* parameter to "True" or by switching the polarity of the residual voltage measurement wires. Although the Iosin(ϕ) operation can be used in solidly earthed networks, the phase angle is recommended.

**Connection of measuring transformers in directional earth fault applications**

The residual current Io can be measured with a core balance current transformer or the residual connection of the phase current signals. If the neutral of the network is either isolated or earthed with high impedance, a core balance current transformer is recommended to be used in earth-fault protection. To ensure sufficient accuracy of residual current measurements and consequently the selectivity of the scheme, the core balance current transformers should have a transformation ratio of at least 70:1. Lower transformation ratios such as 50:1 or 50:5 are not recommended.

Attention should be paid to make sure the measuring transformers are connected correctly so that DEFxPDEF is able to detect the fault current direction without failure. As directional earth fault uses residual current and residual voltage (-Uo), the poles of the measuring transformers must match each other and also the fault current direction. Also the earthing of the cable sheath must be taken into notice when using core balance current transformers. The following figure describes how measuring transformers can be connected to the protection relay.

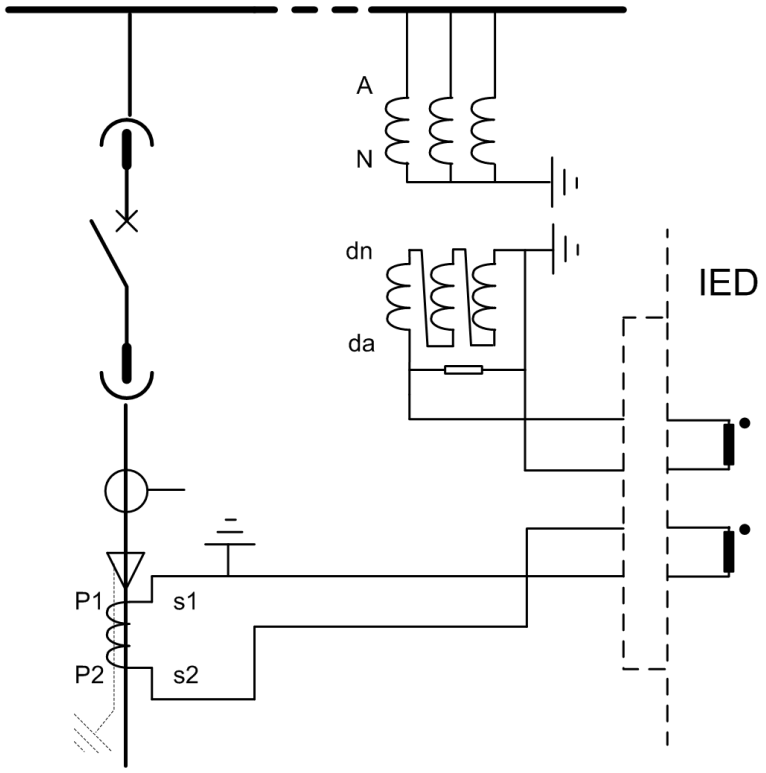



*Figure 271: Connection of measuring transformers*

## 4.2.2.11 Signals

### DEFLPDEF Input signals

**Table 539: DEFLPDEF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |
| RCA_CTL | BOOLEAN | 0=False | Relay characteristic angle control |

### DEFHPDEF Input signals

**Table 540: DEFHPDEF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |
| RCA_CTL | BOOLEAN | 0=False | Relay characteristic angle control |

### DEFLPDEF Output signals

**Table 541: DEFLPDEF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| FAULT_DIR | Enum | Detected fault direction |
| DIRECTION | Enum | Direction information |

### DEFHPDEF Output signals

**Table 542: DEFHPDEF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| FAULT_DIR | Enum | Detected fault direction |
| DIRECTION | Enum | Direction information |

## 4.2.2.12 Settings

### DEFLPDEF Settings

**Table 543: DEFLPDEF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.010...10.000 | xIn | 0.005 | 0.010 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 50...300000 | ms | 10 | 50 | Operate delay time |
| Characteristic angle | -179...180 | deg | 1 | -90 | Characteristic angle |
| Max forward angle | 0...180 | deg | 1 | 80 | Maximum phase angle in forward direction |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max reverse angle | 0...180 | deg | 1 | 80 | Maximum phase angle in reverse direction |
| Min forward angle | 0...180 | deg | 1 | 80 | Minimum phase angle in forward direction |
| Min reverse angle | 0...180 | deg | 1 | 80 | Minimum phase angle in reverse direction |
| Voltage start value | 0.010...1.000 | xUn | 0.001 | 0.010 | Voltage start value |

**Table 544: DEFLPDEF Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |
| Operation mode | 1=Phase angle<br>2=IoSin<br>3=IoCos<br>4=Phase angle 80<br>5=Phase angle 88 | | | 1=Phase angle | Operation criteria |
| Enable voltage limit | 0=False<br>1=True | | | 1=True | Enable voltage limit |

**Table 545: DEFLPDEF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 0.0001 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 0.0001 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 0.01 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 546: DEFLPDEF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Minimum operate time | 50...60000 | ms | 1 | 50 | Minimum operate time for IDMT curves |
| Allow Non Dir | 0=False<br>1=True | | | 0=False | Allows prot activation as non-dir when dir info is invalid |
| Measurement mode | 1=RMS | | | 2=DFT | Selects used measurement mode |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=DFT<br>3=Peak-to-Peak | | | | |
| Min operate current | 0.5...100.0 | %In | 0.1 | 0.5 | Minimum operating current |
| Min operate voltage | 1.0...100.0 | %Un | 0.1 | 1.0 | Minimum operating voltage |
| Correction angle | 0.0...10.0 | deg | 0.1 | 0.0 | Characteristic correction angle in IoCos and IoSin mode |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |
| Pol quantity | 3=Zero seq. volt.<br>4=Neg. seq. volt. | | | 3=Zero seq. volt. | Reference quantity used to determine fault direction |

### DEFHPDEF Settings

**Table 547: DEFHPDEF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.10...40.00 | xIn | 0.01 | 0.10 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operating curve type | 1=ANSI Ext. inv.<br>3=ANSI Norm. inv.<br>5=ANSI Def. Time<br>15=IEC Def. Time<br>17=Programmable | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Characteristic angle | -179...180 | deg | 1 | -90 | Characteristic angle |
| Max forward angle | 0...180 | deg | 1 | 80 | Maximum phase angle in forward direction |
| Max reverse angle | 0...180 | deg | 1 | 80 | Maximum phase angle in reverse direction |
| Min forward angle | 0...180 | deg | 1 | 80 | Minimum phase angle in forward direction |
| Min reverse angle | 0...180 | deg | 1 | 80 | Minimum phase angle in reverse direction |
| Voltage start value | 0.010...1.000 | xUn | 0.001 | 0.010 | Voltage start value |

**Table 548: DEFHPDEF Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate | | | 1=Immediate | Selection of reset curve type |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=Def time reset<br>3=Inverse reset | | | | |
| Operation mode | 1=Phase angle<br>2=IoSin<br>3=IoCos<br>4=Phase angle 80<br>5=Phase angle 88 | | | 1=Phase angle | Operation criteria |
| Enable voltage limit | 0=False<br>1=True | | | 1=True | Enable voltage limit |

**Table 549: DEFHPDEF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 0.0001 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 0.0001 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 0.01 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 550: DEFHPDEF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Minimum operate time | 40...60000 | ms | 1 | 40 | Minimum operate time for IDMT curves |
| Allow Non Dir | 0=False<br>1=True | | | 0=False | Allows prot activation as non-dir when dir info is invalid |
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |
| Min operate current | 0.5...100.0 | %In | 0.1 | 0.5 | Minimum operating current |
| Min operate voltage | 1.00...100.00 | %Un | 1.00 | 1.00 | Minimum operating voltage |
| Correction angle | 0.0...10.0 | deg | 0.1 | 0.0 | Characteristic correction angle in IoCos and IoSin mode |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |
| Pol quantity | 3=Zero seq. volt.<br>4=Neg. seq. volt. | | | 3=Zero seq. volt. | Reference quantity used to determine fault direction |

### 4.2.2.13 Monitored data

#### DEFLPDEF Monitored data

**Table 551: DEFLPDEF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| ANGLE_RCA | FLOAT32 | -180.00...180.00 | deg | Angle between operating angle and characteristic angle |
| ANGLE | FLOAT32 | -180.00...180.00 | deg | Angle between polarizing and operating quantity |
| I_OPER | FLOAT32 | 0.00...40.00 | xIn | Calculated operating current |
| DEFLPDEF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### DEFHPDEF Monitored data

**Table 552: DEFHPDEF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| ANGLE_RCA | FLOAT32 | -180.00...180.00 | deg | Angle between operating angle and characteristic angle |
| ANGLE | FLOAT32 | -180.00...180.00 | deg | Angle between polarizing and operating quantity |
| I_OPER | FLOAT32 | 0.00...40.00 | xIn | Calculated operating current |
| DEFHPDEF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.2.14 Technical data

**Table 553: DEFxPDEF Technical data**

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | DEFLPDEF | Current:<br>±1.5% of the set value or ±0.002 × $I_n$ |

*Table continues on the next page*

| Characteristic | | Value | | |
|---|---|---|---|---|
| | | Voltage<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle:<br>±2° | | |
| | DEFHPDEF | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$)<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle:<br>±2° | | |
| Start time [1, 2] | | Minimum | Typical | Maximum |
| | DEFHPDEF<br>$I_{Fault}$ = 2 × set *Start value* | 42 ms | 46 ms | 49 ms |
| | DEFLPDEF<br>$I_{Fault}$ = 2 × set *Start value* | 58 ms | 62 ms | 66 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode [4] | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [3] | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

[1] *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements.
[2] Includes the delay of the signal output contact.
[4] Start time of the function also included.
[3] Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 1.5...20.

#### 4.2.2.15 Technical revision history

**Table 554: DEFLPDEF Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | H | Setting *Start value* maximum value extended to 10.000xIn. |

## 4.2.3 Transient-intermittent earth-fault protection INTRPTEF (ANSI 67NTEF/NIEF)

### 4.2.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Transient/intermittent earth-fault protection | INTRPTEF | Io> -> IEF | 67NTEF/NIEF |

### 4.2.3.2 Function block

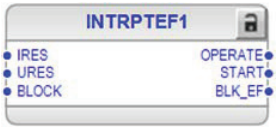



*Figure 272: Function block*

### 4.2.3.3 Functionality

The transient/intermittent earth-fault protection function INTRPTEF is a function designed for the protection and clearance of permanent and intermittent earth faults in distribution and sub-transmission networks. Fault detection is done from the residual current and residual voltage signals by monitoring the transients.

The operating time characteristics are according to definite time (DT).

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.3.4 Analog channel configuration

INTRPTEF has two analog group inputs which must be properly configured.

**Table 555: Analog inputs**

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |
| URES | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 556: Special conditions**

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected for calculating the residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of INTRPTEF can be described with a module diagram. All the modules in the diagram are explained in the next sections.

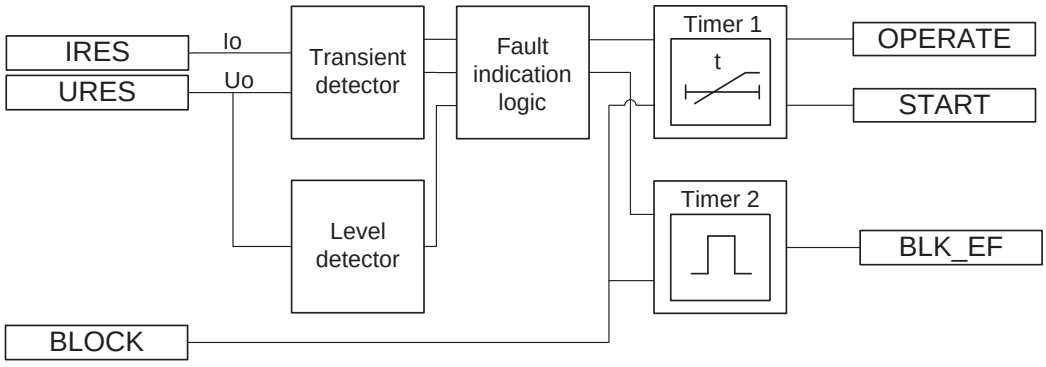



*Figure 273: Functional module diagram*

#### Level detector

The Level detector module is used only when selected *Operation mode* is "Transient EF". The module compares the measured residual voltage to the set *Voltage start* value. If the measured value exceeds the set *Voltage start* value, the module reports the exceeding of the value to the Fault indication logic.

#### Transient detector

The Transient detector module is used for detecting transients in the residual current and residual voltage signals.

The transient detection is supervised with a settable current threshold. With a special filtering technique, the setting *Min operate current* is based on the

fundamental frequency current. This setting should be set based on the value of the parallel resistor of the coil, with security margin. For example, if the resistive current of the parallel resistor is 10 A, then a value of 0.7×10 A = 7 A could be used. The same setting is also applicable in case the coil is disconnected and the network becomes unearthed. Generally, a smaller value should be used and it must never exceed the value of the parallel resistor in order to allow operation of the faulted feeder.

**Fault indication logic**

Depending on the set *Operation mode*, INTRPTEF has two independent modes for detecting earth faults. The "Transient EF" mode is intended to detect all kinds of earth faults. The "Intermittent EF" mode is dedicated for detecting intermittent earth faults in cable networks.



To satisfy the sensitivity requirements, basic earth-fault protection (based on fundamental frequency phasors) should always be used in parallel with the INTRPTEF function.

The Fault indication logic module determines the direction of the fault. The fault direction determination is secured by multi-frequency neutral admittance measurement and special filtering techniques. This enables fault direction determination which is not sensitive to disturbances in measured Io and Uo signals, for example, switching transients.

When *Directional mode* setting "Forward" is used, the protection operates when the fault is in the protected feeder. When *Directional mode* setting "Reverse" is used, the protection operates when the fault is outside the protected feeder (in the background network). If the direction has no importance, the value "Non-directional" can be selected. The detected fault direction (FAULT_DIR) is available in the monitored data view.

In the "Transient EF" mode, when the start transient of the fault is detected and the Uo level exceeds the set *"Voltage start value"*, Timer 1 is activated. Timer 1 is kept activated until the Uo level exceeds the set value or in case of a drop-off, the drop-off duration is shorter than the set *Reset delay time*.

In the "Intermittent EF" mode, when the start transient of the fault is detected and the Uo level exceeds the set *Voltage start value*, the Timer 1 is activated. When a required number of intermittent earth-fault transients set with the *Peak counter limit* setting are detected without the function being reset (depends on the drop-off time set with the *Reset delay time* setting), the START output is activated. The Timer 1 is kept activated as long as transients are occurring during the drop-off time defined by setting *Reset delay time*.

**Timer 1**

The time characteristic is according to DT.

In the "Transient EF" mode, the OPERATE output is activated after *Operate delay time* if the residual voltage exceeds the set *"Voltage start value"*. The *Reset delay time* starts to elapse when residual voltage falls below *Voltage start value*. If there is no OPERATE activation, for example, the fault disappears momentarily, START stays activated until the the *Reset delay time* elapses. After OPERATE activation, START and OPERATE signals are reset as soon as Uo falls below *Voltage start value*.

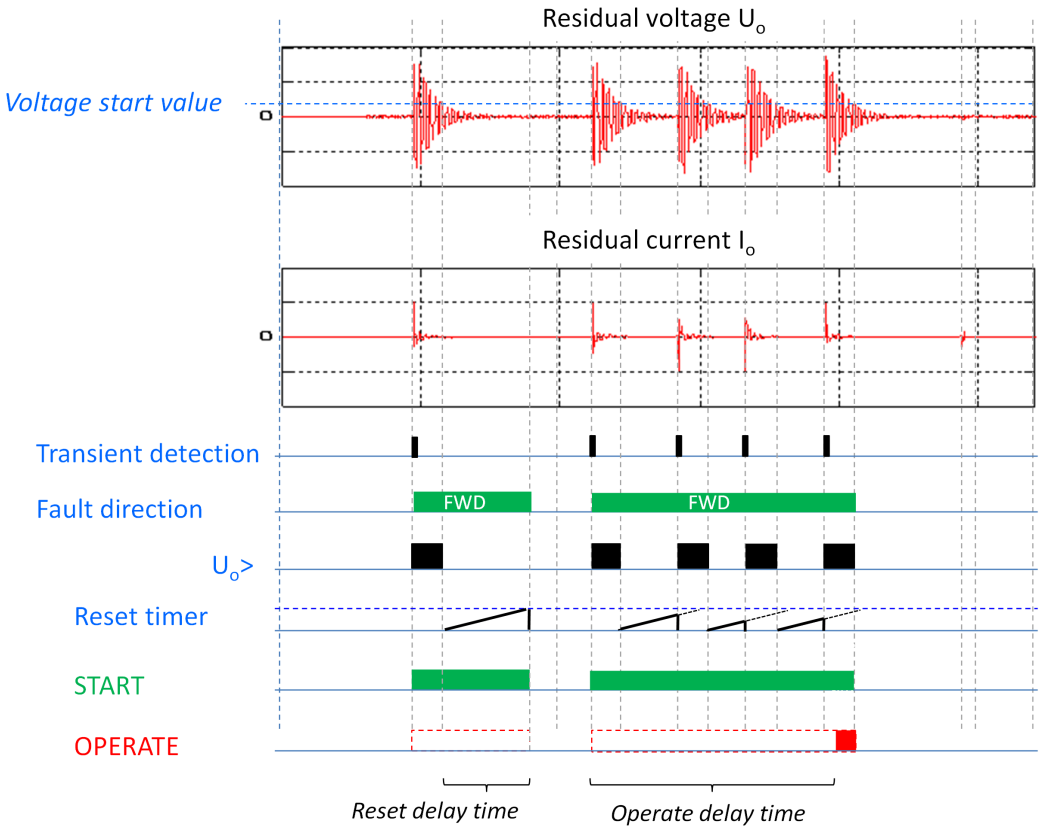



*Figure 274: Example of INTRPTEF operation in "Transient EF" mode in the faulty feeder*

In the "Intermittent EF" mode the OPERATE output is activated when the following conditions are fulfilled:

- the number of transients that have been detected exceeds the *Peak counter limit* setting
- the timer has reached the time set with the *Operate delay time*
- and one additional transient is detected during the drop-off cycle

The *Reset delay time* starts to elapse from each detected transient (peak). In case there is no OPERATE activation, for example, the fault disappears momentarily START stays activated until the *Reset delay time* elapses, that is, reset takes place if time between transients is more than *Reset delay time*. After OPERATE activation, a fixed pulse length of 100 ms for OPERATE is given, whereas START is reset after *Reset delay time* elapses

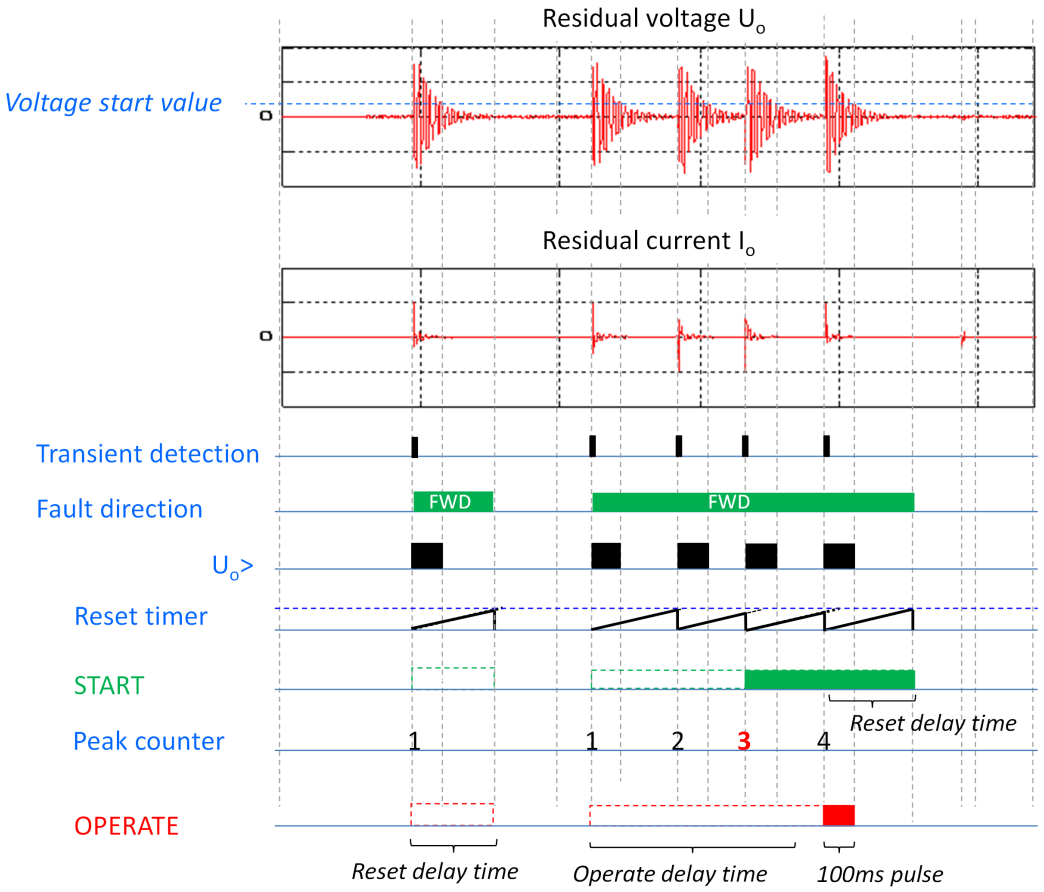



*Figure 275: Example of INTRPTEF operation in "Intermittent EF" mode in the faulty feeder, Peak counter limit=3*

The timer calculates the start duration value START_DUR which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

### Timer 2

If the function is used in the directional mode and an opposite direction transient is detected, the BLK_EF output is activated for the fixed delay time of 25 ms. If the START output is activated when the BLK_EF output is active, the BLK_EF output is deactivated.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE

output" mode, the function operates normally but the OPERATE output is not activated.

### 4.2.3.6 Application

INTRPTEF is an earth-fault function dedicated to operate in intermittent and permanent earth faults occurring in distribution and sub-transmission networks. Fault detection is done from the residual current and residual voltage signals by monitoring the transients with predefined criteria. As the function has a dedicated purpose for the fault types, fast detection and clearance of the faults can be achieved.

#### Intermittent earth fault

Intermittent earth fault is a special type of fault that is encountered especially in compensated networks with underground cables. A typical reason for this type of fault is the deterioration of cable insulation either due to mechanical stress or due to insulation material aging process where water or moisture gradually penetrates the cable insulation. This eventually reduces the voltage withstand of the insulation, leading to a series of cable insulation breakdowns. The fault is initiated as the phase-to-earth voltage exceeds the reduced insulation level of the fault point and mostly extinguishes itself as the fault current drops to zero for the first time, as shown in *Figure 276*. As a result, very short transients, that is, rapid changes in the form of spikes in residual current (Io) and in residual voltage (Uo), can be repeatedly measured. Typically, the fault resistance in case of an intermittent earth fault is only a few ohms.

***Residual current Io and residual voltage Uo***

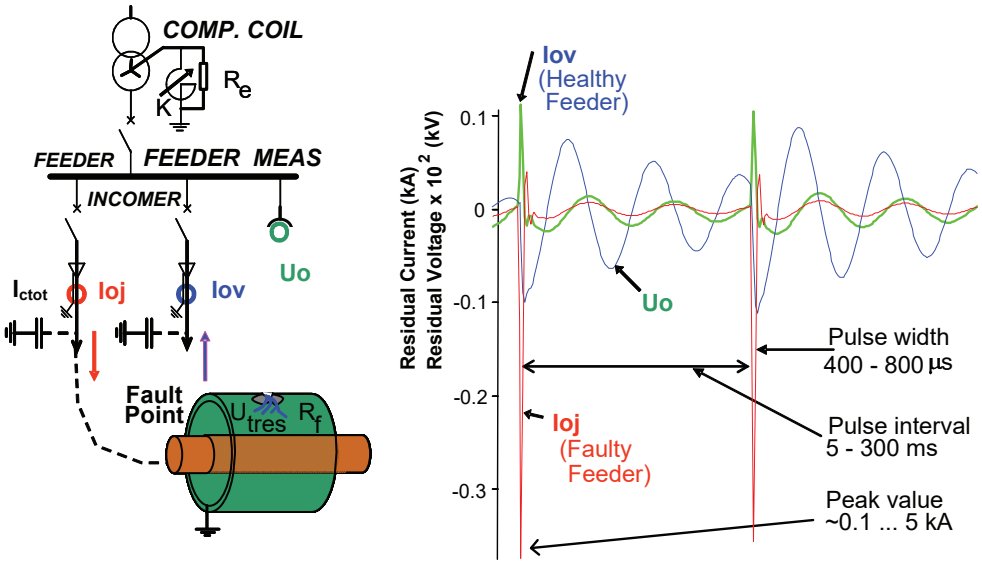



*Figure 276: Typical intermittent earth-fault characteristics*

#### Earth-fault transients

In general, earth faults generate transients in currents and voltages. There are several factors that affect the magnitude and frequency of these transients, such as the fault moment on the voltage wave, fault location, fault resistance and the parameters of the feeders and the supplying transformers. In the fault initiation,

the voltage of the faulty phase decreases and the corresponding capacitance is discharged to earth (→ discharge transients). At the same time, the voltages of the healthy phases increase and the related capacitances are charged (→ charge transient).

If the fault is permanent (non-transient) in nature, only the initial fault transient in current and voltage can be measured, whereas the intermittent fault creates repetitive transients.

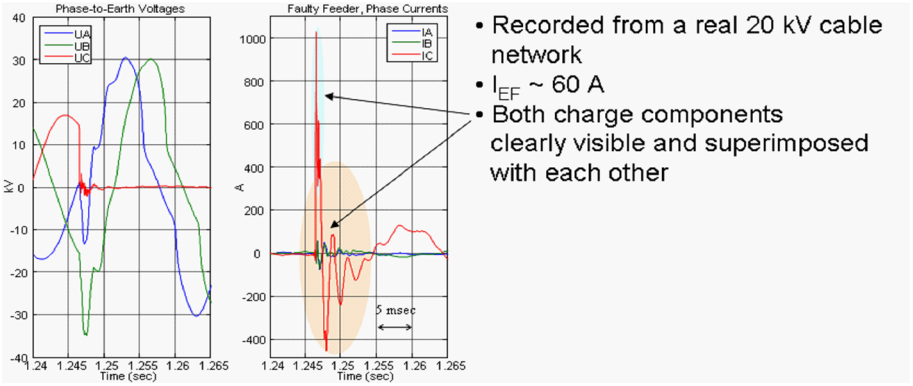



*Figure 277: Example of earth-fault transients, including discharge and charge transient components, when a permanent fault occurs in a 20 kV network in phase C*

## 4.2.3.7 Signals

### INTRPTEF Input signals

**Table 557: INTRPTEF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### INTRPTEF Output signals

**Table 558: INTRPTEF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| BLK_EF | BOOLEAN | Block signal for EF to indicate opposite direction peaks |

### 4.2.3.8 INTRPTEF Settings

**Table 559: INTRPTEF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Operate delay time | 40...1200000 | ms | 10 | 500 | Operate delay time |
| Voltage start value | 0.05...0.50 | xUn | 0.01 | 0.20 | Voltage start value |

**Table 560: INTRPTEF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=Intermittent EF<br>2=Transient EF | | | 1=Intermittent EF | Operation criteria |

**Table 561: INTRPTEF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 40...60000 | ms | 1 | 500 | Reset delay time |
| Peak counter limit | 2...20 | | 1 | 2 | Min requirement for peak counter before start in IEF mode |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.01 | Minimum operating current for transient detector |

### 4.2.3.9 INTRPTEF Monitored data

**Table 562: INTRPTEF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| FAULT_DIR | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Detected fault direction |
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| INTRPTEF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.2.3.10 Technical data

**Table 563: INTRPTEF Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy (Uo criteria with transient protection) | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $U_o$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5 |

## 4.2.4 Admittance-based earth-fault protection EFPADM (ANSI 21NY)

### 4.2.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Admittance-based earth-fault protection | EFPADM | Yo> -> | 21NY |

### 4.2.4.2 Function block

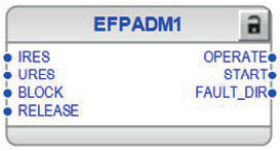



*Figure 278: Function block*

### 4.2.4.3 Functionality

The admittance-based earth-fault protection function EFPADM provides a selective earth-fault protection function for high-resistance earthed, unearthed and compensated networks. It can be applied for the protection of overhead lines as well as with underground cables. It can be used as an alternative solution to traditional residual current-based earth-fault protection functions, such as the IoCos mode in DEFxPDEF. Main advantages of EFPADM include a versatile applicability, good sensitivity and easy setting principles.

EFPADM is based on evaluating the neutral admittance of the network, that is, the quotient:

$$\underline{Yo} = \underline{Io} / -\underline{Uo}$$

(Equation 56)

The measured admittance is compared to the admittance characteristic boundaries in the admittance plane. The supported characteristics include overadmittance, oversusceptance, overconductance or any combination of the three. The

directionality of the oversusceptance and overconductance criteria can be defined as forward, reverse or non-directional, and the boundary lines can be tilted if required by the application. This allows the optimization of the shape of the admittance characteristics for any given application.

EFPADM supports two calculation algorithms for admittance. The admittance calculation can be set to include or exclude the prefault zero-sequence values of Io and Uo. Furthermore, the calculated admittance is recorded at the time of the trip and it can be monitored for post-fault analysis purposes.

To ensure the security of the protection, the admittance calculation is supervised by a residual overvoltage condition which releases the admittance protection during a fault condition. Alternatively, the release signal can be provided by an external binary signal.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.4.4 Analog channel configuration

EFPADM has two analog group inputs which must be properly configured.

**Table 564: Analog inputs**

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |
| URES | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 565: Special conditions**

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected. Setting *VT connection* must be "Wye" in that particular UTVTR.. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of EFPADM can be described using a module diagram. All the modules in the diagram are explained in the next sections.

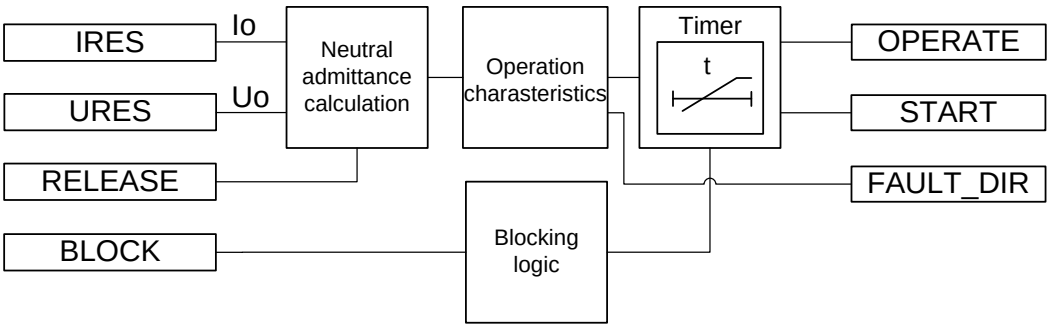



*Figure 279: Functional module diagram*

**Neutral admittance calculation**

When the residual voltage exceeds the set threshold *Voltage start value*, an earth fault is detected and the neutral admittance calculation is released.

To ensure a sufficient accuracy for the Io and Uo measurements, it is required that the residual voltage exceeds the value set by *Min operate voltage*. If the admittance calculation mode is "Delta", the minimum change in the residual voltage due to a fault must be 0.01 × Un to enable the operation. Similarly, the residual current must exceed the value set by *Min operate current*.

The polarity of the polarizing quantity Uo can be changed, that is, rotated by 180 degrees, by setting the *Pol reversal* parameter to "True" or by switching the polarity of the residual voltage measurement wires.

As an alternative for the internal residual overvoltage-based start condition, the neutral admittance protection can also be externally released by utilizing the RELEASE input.

When *Admittance Clc mode* is set to "Delta", the external logic used must be able to give RELEASE in less than 0.1 s from fault initiation. Otherwise the collected pre-fault values are overwritten with fault time values. If it is slower, *Admittance Clc mode* must be set to “Normal”.

Neutral admittance is calculated as the quotient between the residual current and residual voltage (polarity reversed) fundamental frequency phasors. The *Admittance Clc mode* setting defines the calculation mode.

*Admittance Clc mode* = "Normal"

$$\underline{Yo} = \frac{\underline{Io}_{fault}}{-\underline{Uo}_{fault}}$$

(Equation 57)

*Admittance Clc mode* = "Delta"

$$\underline{Yo} = \frac{\underline{Io}_{fault} - \underline{Io}_{prefault}}{-(\underline{Uo}_{fault} - \underline{Uo}_{prefault})} = \frac{\Delta \underline{Io}}{-\Delta \underline{Uo}}$$

(Equation 58)

| | |
|---|---|
| $\underline{Yo}$ | Calculated neutral admittance [Siemens] |
| $\underline{Io}_{fault}$ | Residual current during the fault [Amperes] |
| $\underline{Uo}_{fault}$ | Residual voltage during the fault [Volts] |
| $\underline{Io}_{prefault}$ | Prefault residual current [Amperes] |
| $\underline{Uo}_{prefault}$ | Prefault residual voltage [Volts] |
| $\Delta \underline{Io}$ | Change in the residual current due to fault [Amperes] |
| $\Delta \underline{Uo}$ | Change in the residual voltage due to fault [Volts] |

Traditionally, admittance calculation is done with the calculation mode "Normal", that is, with the current and voltage values directly measured during the fault. As an alternative, by selecting the calculation mode "Delta", the prefault zero-sequence asymmetry of the network can be removed from the admittance calculation. Theoretically, this makes the admittance calculation totally immune to fault resistance, that is, the estimated admittance value is not affected by fault resistance. Utilization of the change in Uo and Io due to a fault in the admittance calculation also mitigates the effects of the VT and CT measurement errors, thus improving the measuring accuracy, the sensitivity and the selectivity of the protection.

Calculation mode "Delta" is recommended in case a high sensitivity of the protection is required, if the network has a high degree of asymmetry during the healthy state or if the residual current measurement is based on sum connection, that is, the Holmgren connection.

Neutral admittance calculation produces certain values during forward and reverse faults.

Fault in reverse direction, that is, outside the protected feeder.

$$\underline{Yo} = -\underline{Y}_{Fdtot}$$

(Equation 59)

$$\approx -j \cdot \frac{I_{eFd}}{U_{ph}}$$

(Equation 60)

| | |
|---|---|
| $\underline{Y}_{Fdtot}$ | Sum of the phase-to-earth admittances ( $\underline{Y}_{FdA}$, $\underline{Y}_{FdB}$, $\underline{Y}_{FdC}$) of the protected feeder |
| $I_{eFd}$ | Magnitude of the earth-fault current of the protected feeder when the fault resistance is zero ohm |
| $U_{ph}$ | Magnitude of the nominal phase-to-earth voltage of the system |

*Equation 59* shows that in case of outside faults, the measured admittance equals the admittance of the protected feeder with a negative sign. The measured admittance is dominantly reactive; the small resistive part of the measured admittance is due to the leakage losses of the feeder. Theoretically, the measured admittance is located in the third quadrant in the admittance plane close to the im( $\underline{Yo}$) axis, see *Figure 280*.

The result of *Equation 59* is valid regardless of the neutral earthing method. In compensated networks the compensation degree does not affect the result. This enables a straightforward setting principle for the

neutral admittance protection: admittance characteristic is set to cover the value $\underline{Y}o = -\underline{Y}_{Fdtot}$ with a suitable margin.

Due to inaccuracies in voltage and current measurement, the small real part of the calculated neutral admittance may appear as positive, which brings the measured admittance in the fourth quadrant in the admittance plane. This should be considered when setting the admittance characteristic.

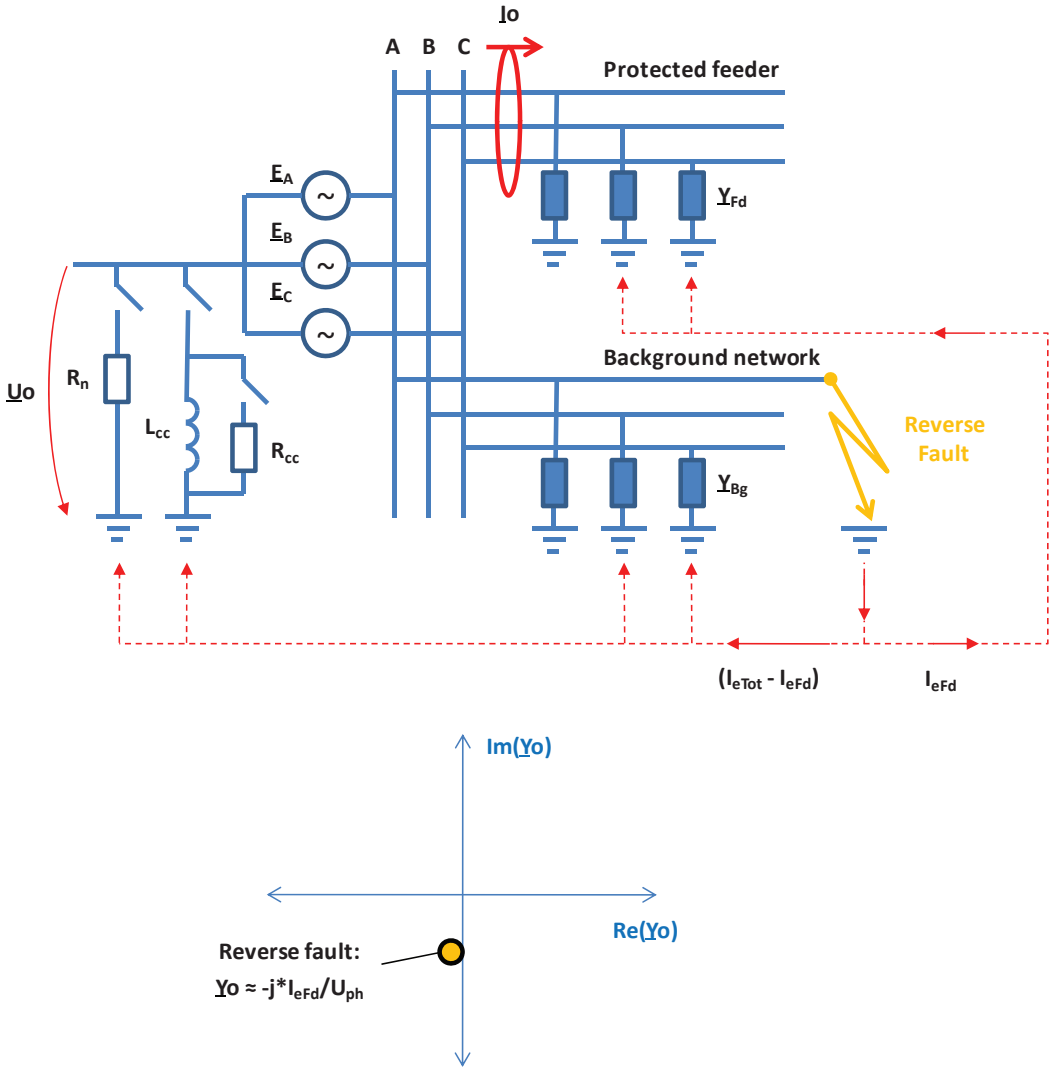



*Figure 280: Admittance calculation during a reverse fault*

| | |
|---|---|
| $R_{CC}$ | Resistance of the parallel resistor |
| $L_{CC}$ | Inductance of the compensation coil |
| $R_n$ | Resistance of the neutral earthing resistor |
| $\underline{Y}_{Fd}$ | Phase-to-earth admittance of the protected feeder |
| $\underline{Y}_{Bg}$ | Phase-to-earth admittance of the background network |

For example, in a 15 kV compensated network with the magnitude of the earth-fault current in the protected feeder being 10 A (Rf = 0 Ω), the theoretical value for the measured admittance during an earth fault in the reverse direction, that is, outside the protected feeder, can be calculated.

$$\underline{Yo} \approx -j \cdot \frac{I_{eFd}}{U_{ph}} = -j \cdot \frac{10A}{15/\sqrt{3}kV} = -j \cdot 1.15 \text{ milliSiemens}$$

(Equation 61)

The result is valid regardless of the neutral earthing method.

In this case, the resistive part of the measured admittance is due to leakage losses of the protected feeder. As they are typically very small, the resistive part is close to zero. Due to inaccuracies in the voltage and current measurement, the small real part of the apparent neutral admittance may appear positive. This should be considered in the setting of the admittance characteristic.

Fault in the forward direction, that is, inside the protected feeder.

Unearthed network:

$$\underline{Yo} = \underline{Y}_{Bgtot}$$

(Equation 62)

$$\approx j \cdot \left( \frac{I_{eTot} - I_{eFd}}{U_{ph}} \right)$$

(Equation 63)

Compensated network:

$$\underline{Yo} = \underline{Y}_{Bgtot} + \underline{Y}_{CC}$$

(Equation 64)

$$\approx \frac{I_{Rcc} + j \cdot \left( I_{eTot} \cdot (1-K) - I_{eFd} \right)}{U_{ph}}$$

(Equation 65)

High-resistance earthed network:

$$\underline{Yo} = \underline{Y}_{Bgtot} + \underline{Y}_{Rn}$$

(Equation 66)

$$\approx \frac{I_{Rn} + j \cdot \left( I_{eTot} - I_{eFd} \right)}{U_{ph}}$$

(Equation 67)

| | |
|---|---|
| $\underline{Y}_{Bgtot}$ | Sum of the phase-to-earth admittances ( $\underline{Y}_{BgA}$, $\underline{Y}_{BgB}$, $\underline{Y}_{BgC}$) of the background network |
| $\underline{Y}_{CC}$ | Admittance of the earthing arrangement (compensation coil and parallel resistor) |
| $I_{Rcc}$ | Rated current of the parallel resistor |

*Table continues on the next page*

| | |
|---|---|
| $I_{eFd}$ | Magnitude of the earth-fault current of the protected feeder when the fault resistance is zero ohm |
| $I_{eTot}$ | Magnitude of the uncompensated earth-fault current of the network when Rf is zero ohm |
| K | Compensation degree, K = 1 full resonance, K<1 undercompensated, K>1 overcompensated |
| $I_{Rn}$ | Rated current of the neutral earthing resistor |

*Equation 62* shows that in case of a fault inside the protected feeder in unearthed networks, the measured admittance equals the admittance of the background network. The admittance is dominantly reactive; the small resistive part of the measured admittance is due to the leakage losses of the background network. Theoretically, the measured admittance is located in the first quadrant in the admittance plane, close to the im(Yo) axis, see *Figure 281*.

*Equation 64* shows that in case of a fault inside the protected feeder in compensated networks, the measured admittance equals the admittance of the background network and the coil including the parallel resistor. Basically, the compensation degree determines the imaginary part of the measured admittance and the resistive part is due to the parallel resistor of the coil and the leakage losses of the background network and the losses of the coil. Theoretically, the measured admittance is located in the first or fourth quadrant in the admittance plane, depending on the compensation degree, see *Figure 281*.



Before the parallel resistor is connected, the resistive part of the measured admittance is due to the leakage losses of the background network and the losses of the coil. As they are typically small, the resistive part may not be sufficiently large to secure the discrimination of the fault and its direction based on the measured conductance. This and the rating and the operation logic of the parallel resistor should be considered when setting the admittance characteristic in compensated networks.

*Equation 66* shows that in case of a fault inside the protected feeder in high-resistance earthed systems, the measured admittance equals the admittance of the background network and the neutral earthing resistor. Basically, the imaginary part of the measured admittance is due to the phase-to-earth capacitances of the background network, and the resistive part is due to the neutral earthing resistor and the leakage losses of the background network. Theoretically, the measured admittance is located in the first quadrant in the admittance plane, see *Figure 281*.

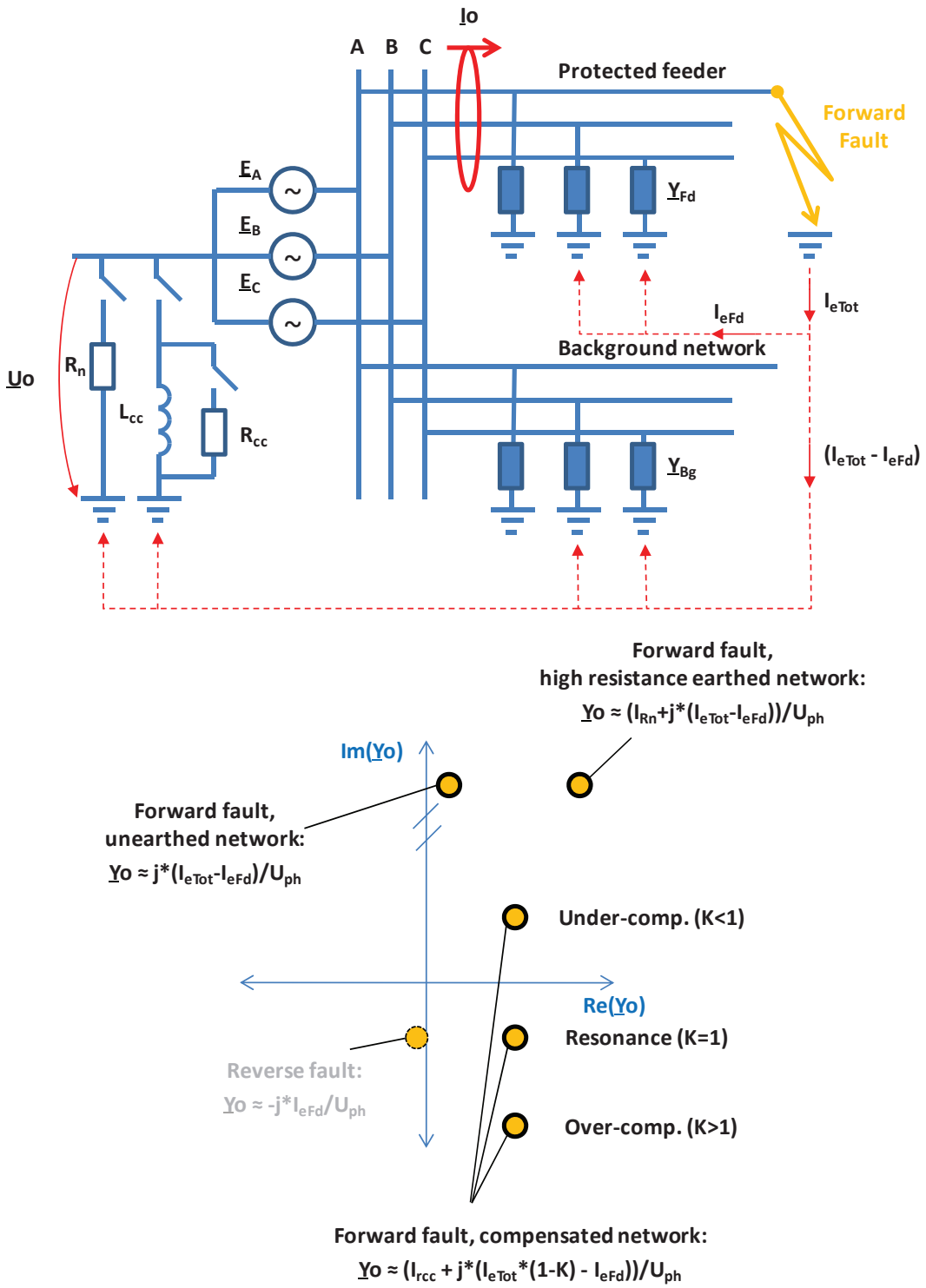



*Figure 281: Admittance calculation during a forward fault*

When the network is fully compensated in compensated networks, theoretically during a forward fault, the imaginary part of the measured admittance equals the susceptance of the protected feeder with a negative sign. The discrimination between a forward and reverse fault

must therefore be based on the real part of the measured admittance, that is, conductance. Thus, the best selectivity is achieved when the compensated network is operated either in the undercompensated or overcompensated mode.

For example, in a 15 kV compensated network, the magnitude of the earth-fault current of the protected feeder is 10 A (Rf = 0 Ω) and the magnitude of the network is 100 A (Rf = 0 Ω). During an earth fault, a 15 A resistor is connected in parallel to the coil after a 1.0 second delay. Compensation degree is overcompensated, K = 1.1.

During an earth fault in the forward direction, that is, inside the protected feeder, the theoretical value for the measured admittance after the connection of the parallel resistor can be calculated.

$$\underline{Y_O} \approx \frac{I_{Rcc} + j \cdot \left( I_{eTot} \cdot (1 - K) - I_{eFd} \right)}{U_{ph}}$$

$$= \frac{15A + j \cdot \left( 100A \cdot (1 - 1.1) - 10A \right)}{15kV / \sqrt{3}} \approx (1.73 - j \cdot 2.31) \text{ milliSiemens}$$

(Equation 68)

Before the parallel resistor is connected, the resistive part of the measured admittance is due to the leakage losses of the background network and the losses of the coil. As they are typically small, the resistive part may not be sufficiently large to secure the discrimination of the fault and its direction based on the measured conductance. This and the rating and the operation logic of the parallel resistor should be considered when setting the admittance characteristic.

When a high sensitivity of the protection is required, the residual current should be measured with a cable/ring core CT, that is, the Ferranti CT. Also the use of the sensitive Io input should be considered. The residual voltage measurement should be done with an open delta connection of the three single pole-insulated voltage transformers.

The sign of the admittance characteristic settings should be considered based on the location of characteristic boundary in the admittance plane. All forward-settings are given with positive sign and reverse-settings with negative sign.

**Operation characteristic**

After the admittance calculation is released, the calculated neutral admittance is compared to the admittance characteristic boundaries in the admittance plane. If the calculated neutral admittance Yo moves outside the characteristic, the enabling signal is sent to the timer.

EFPADM supports a wide range of different characteristics to achieve the maximum flexibility and sensitivity in different applications. The basic characteristic shape is selected with the *Operation mode* and *Directional mode* settings. *Operation mode* defines which operation criterion or criteria are enabled and *Directional mode* defines if the forward, reverse or non-directional boundary lines for that particular operation mode are activated. The FAULT_DIR output indicates which operation sector the fault is measured. The output is operational once the function is started.

**Table 566: Operation criteria**

| Operation mode | Description |
|---|---|
| Yo | Admittance criterion |
| Bo | Susceptance criterion |
| Go | Conductance criterion |
| Yo, Go | Admittance criterion combined with the conductance criterion |
| Yo, Bo | Admittance criterion combined with the susceptance criterion |
| Go, Bo | Conductance criterion combined with the susceptance criterion |
| Yo, Go, Bo | Admittance criterion combined with the conductance and susceptance criterion |

The options for the *Directional mode* setting are "Non-directional", "Forward" and "Reverse".

*Figure 282*, *Figure 283* and *Figure 284* illustrate the admittance characteristics supported by EFPADM and the settings relevant to that particular characteristic. The most typical characteristics are highlighted and explained in details in *Chapter 4.2.4.6 Neutral admittance characteristics*. Operation is achieved when the calculated neutral admittance Yo moves outside the characteristic (the operation area is marked with gray).

The settings defining the admittance characteristics are given in primary milliSiemens (mS). The conversion equation for the admittance from secondary to primary is:

$$Y_{pri} = Y_{sec} \cdot \frac{ni_{CT}}{nu_{VT}}$$

(Equation 69)

| | |
|---|---|
| ni $_{CT}$ | CT ratio for the residual current Io |
| nu $_{VT}$ | VT ratio for the residual voltage Uo |

Example: Admittance setting in the secondary is 5.00 milliSiemens. The CT ratio is 100/1 A and the VT ratio is 11547/100 V. The admittance setting in the primary can be calculated.

$$Y_{pri} = 5.00\ mS \cdot \frac{\frac{100}{1}A}{\frac{11547}{100}V} = 4.33\ mS$$

(Equation 70)

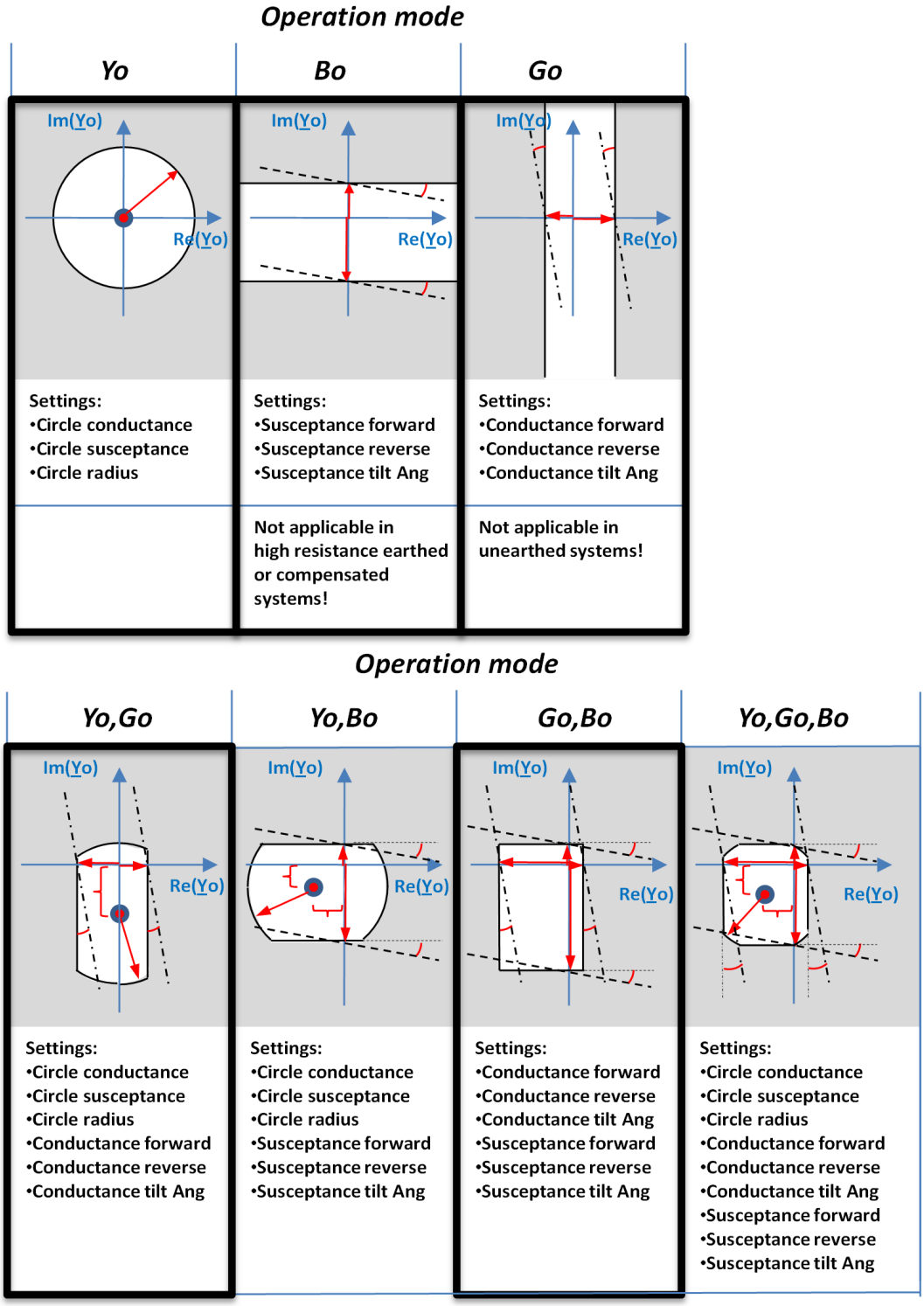



*Figure 282: Admittance characteristic with different operation modes when Directional mode = "Non-directional"*

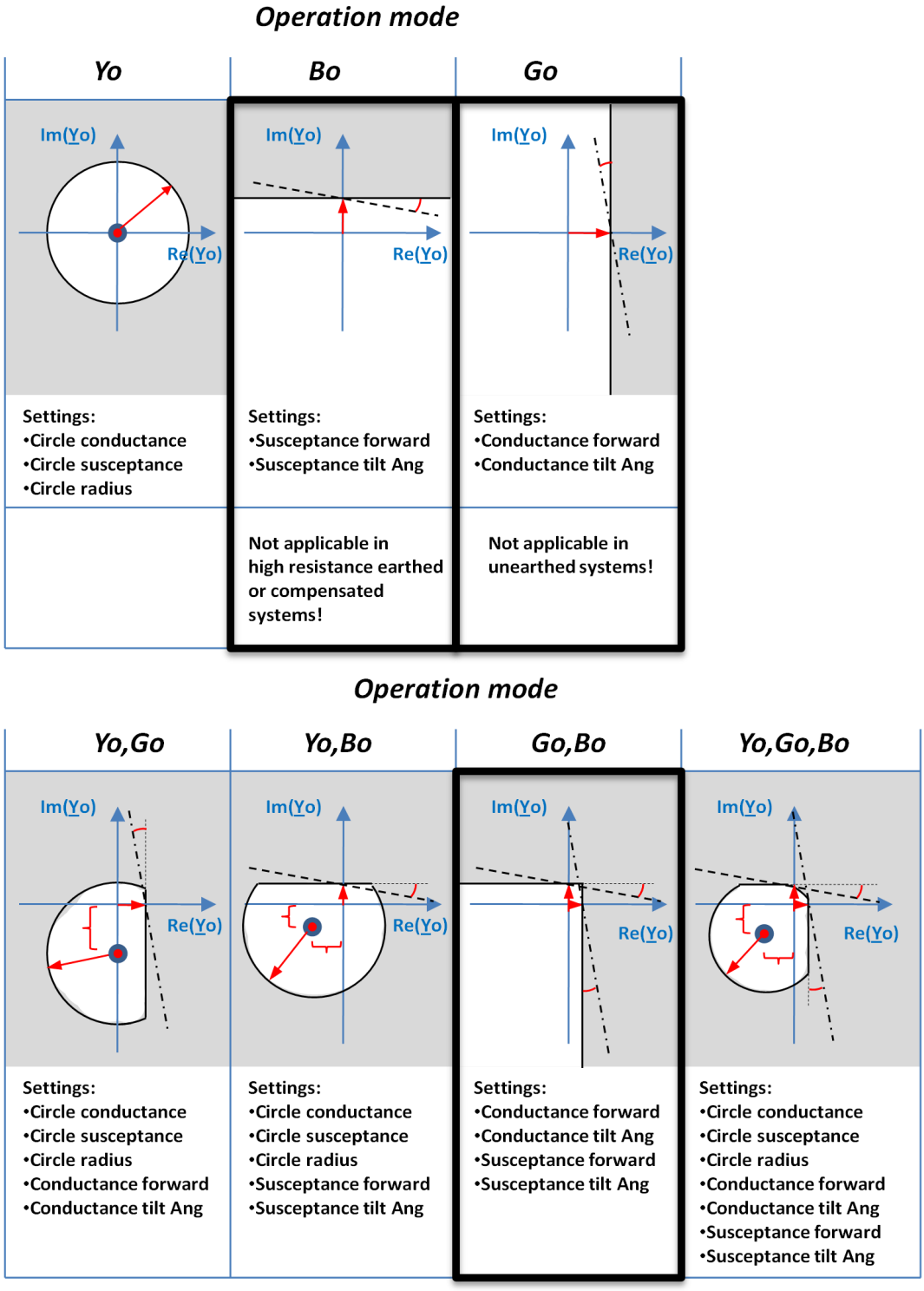



*Figure 283: Admittance characteristic with different operation modes when Directional mode = "Forward"*

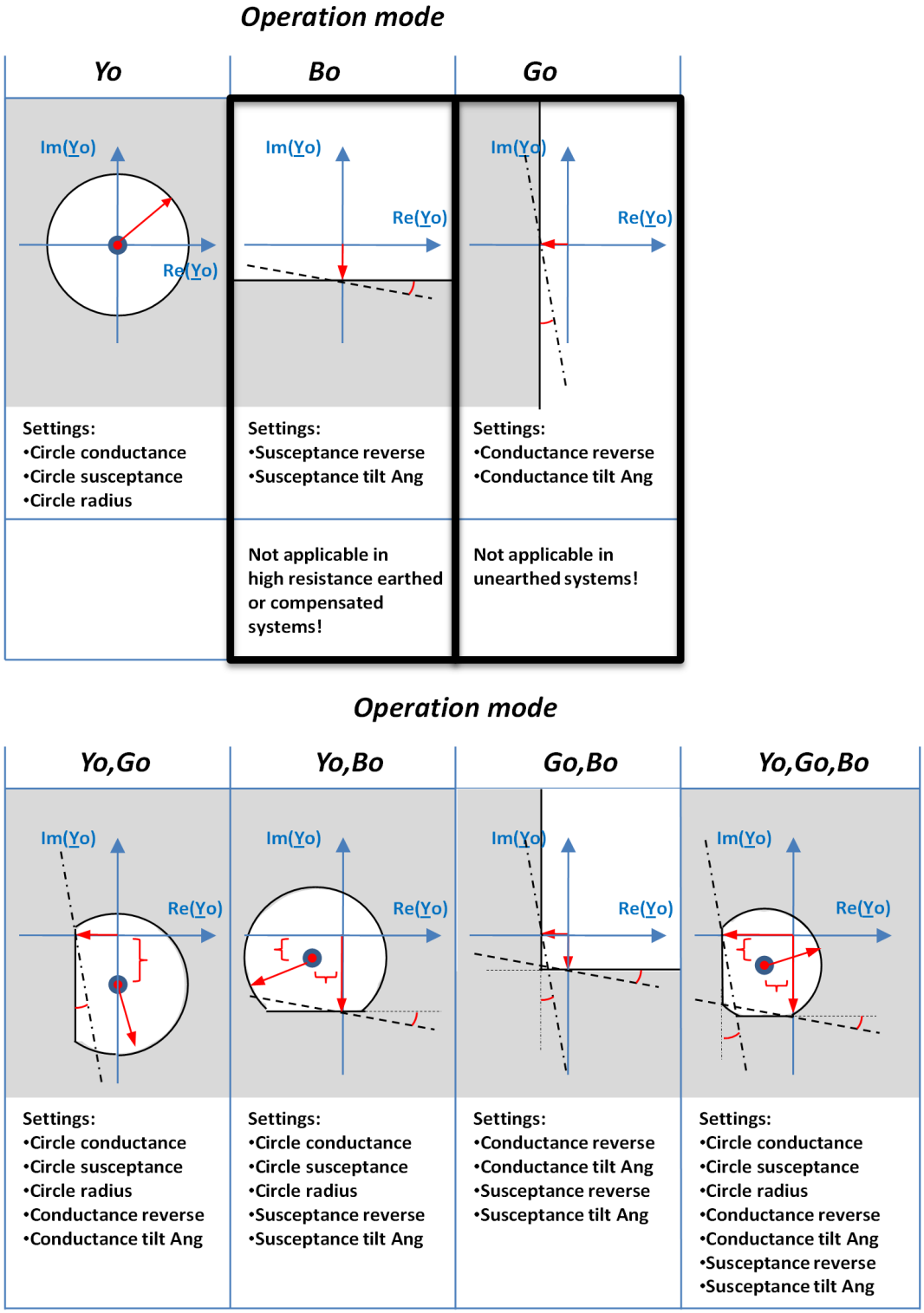



*Figure 284: Admittance characteristic with different operation modes when Directional mode = "Reverse"*

#### Timer

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set with the *Operate delay time* setting, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set with the *Reset delay time* setting, the operation timer resets and the START output is deactivated. The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

#### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.2.4.6 Neutral admittance characteristics

The applied characteristic should always be set to cover the total admittance of the protected feeder with a suitable margin. However, more detailed setting value selection principles depend on the characteristic in question.



The settings defining the admittance characteristics are given in primary milliSiemens.

The forward and reverse boundary settings should be set so that the forward setting is always higher than the reverse setting and that there is space between them.

#### Overadmittance characteristic

The overadmittance criterion is enabled with the setting *Operation mode* set to "Yo". The characteristic is a circle with the radius defined with the *Circle radius* setting. For the sake of application flexibility, the midpoint of the circle can be moved away from the origin with the *Circle conductance* and *Circle susceptance* settings. Default values for *Circle conductance* and *Circle susceptance* are 0.0 mS, that is, the characteristic is an origin-centered circle.

Operation is achieved when the measured admittance moves outside the circle.

The overadmittance criterion is typically applied in unearthed networks, but it can also be used in compensated networks, especially if the circle is set off from the origin.

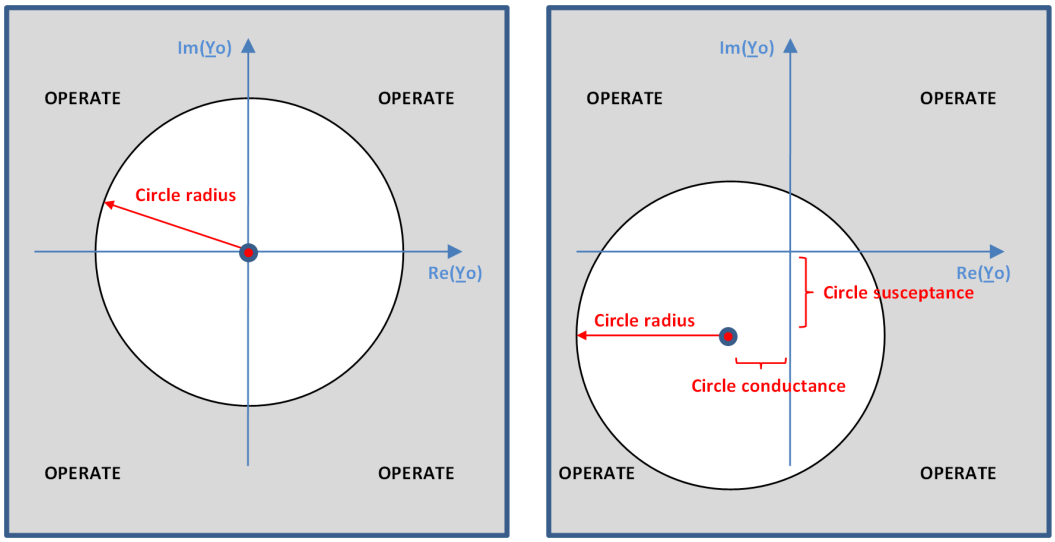



*Figure 285: Overadmittance characteristic. Left figure: classical origin-centered admittance circle. Right figure: admittance circle is set off from the origin.*

### Non-directional overconductance characteristic

The non-directional overconductance criterion is enabled with the *Operation mode* setting set to "Go" and *Directional mode* to "Non-directional". The characteristic is defined with two overconductance boundary lines with the *Conductance forward* and *Conductance reverse* settings. For the sake of application flexibility, the boundary lines can be tilted by the angle defined with the *Conductance tilt Ang* setting. By default, the tilt angle is zero degrees, that is, the boundary line is a vertical line in the admittance plane. A positive tilt value rotates the boundary line counterclockwise from the vertical axis.

In case of non-directional conductance criterion, the *Conductance reverse* setting must be set to a smaller value than *Conductance forward*.

Operation is achieved when the measured admittance moves over either of the boundary lines.

The non-directional overconductance criterion is applicable in high-resistance earthed and compensated networks. It must not be applied in unearthed networks.

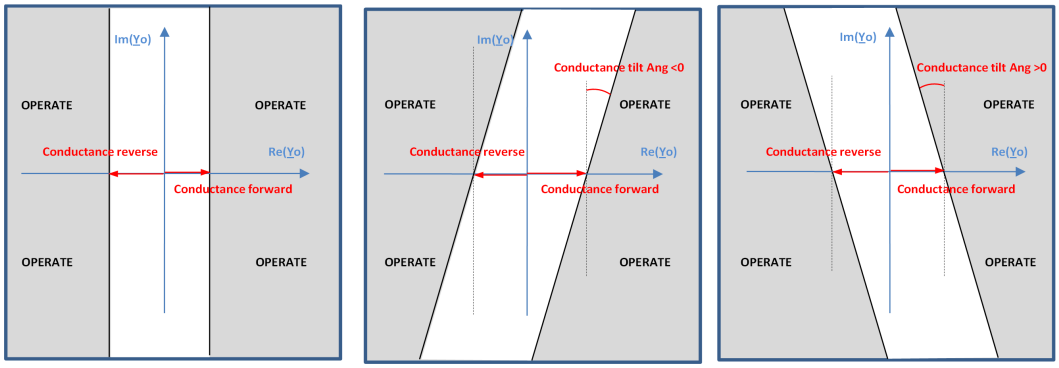



*Figure 286: Non-directional overconductance characteristic. Left figure: classical non-directional overconductance criterion. Middle figure: characteristic is tilted with negative tilt angle. Right figure: characteristic is tilted with positive tilt angle.*

### Forward directional overconductance characteristic

The forward directional overconductance criterion is enabled with the *Operation mode* setting set to "Go" and *Directional mode* set to "Forward". The characteristic is defined by one overconductance boundary line with the *Conductance forward* setting. For the sake of application flexibility, the boundary line can be tilted with the angle defined with the *Conductance tilt Ang* setting. By default, the tilt angle is zero degrees, that is, the boundary line is a vertical line in the admittance plane. A positive tilt value rotates the boundary line counterclockwise from the vertical axis.

Operation is achieved when the measured admittance moves over the boundary line.

The forward directional overconductance criterion is applicable in high-resistance earthed and compensated networks. It must not be applied in unearthed networks.

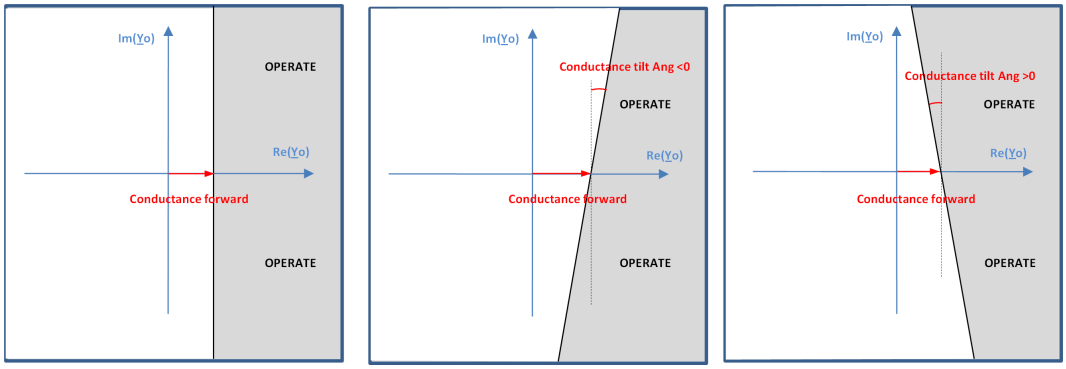



*Figure 287: Forward directional overconductance characteristic. Left figure: classical forward directional overconductance criterion. Middle figure: characteristic is tilted with negative tilt angle. Right figure: characteristic is tilted with positive tilt angle.*

### Forward directional oversusceptance characteristic

The forward directional oversusceptance criterion is enabled with the *Operation mode* setting set to "Bo" and *Directional mode* to "Forward". The characteristic is defined by one oversusceptance boundary line with the *Susceptance forward* setting. For the sake of application flexibility, the boundary line can be tilted by the angle defined with the *Susceptance tilt Ang* setting. By default, the tilt angle is zero degrees, that is, the boundary line is a horizontal line in the admittance plane. A positive tilt value rotates the boundary line counterclockwise from the horizontal axis.

Operation is achieved when the measured admittance moves over the boundary line.

The forward directional oversusceptance criterion is applicable in unearthed networks. It must not be applied to compensated networks.

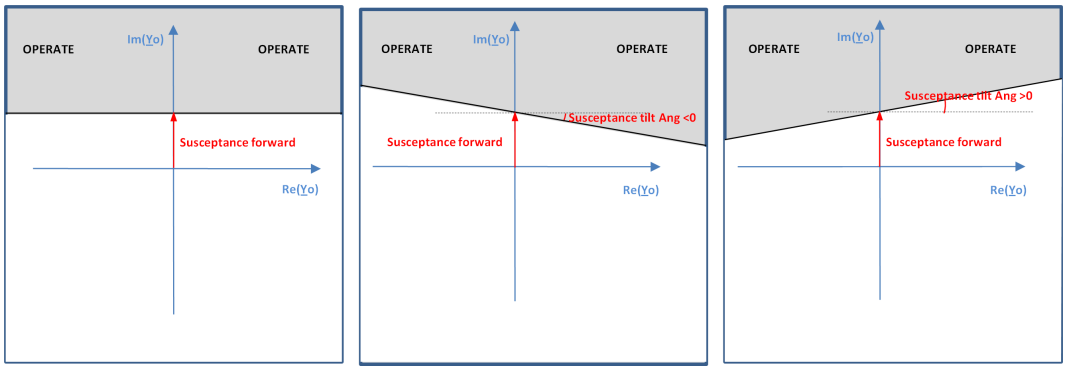



*Figure 288: Forward directional oversusceptance characteristic. Left figure: classical forward directional oversusceptance criterion. Middle figure: characteristic is tilted with negative tilt angle. Right figure: characteristic is tilted with positive tilt angle.*

**Combined overadmittance and overconductance characteristic**

The combined overadmittance and overconductance criterion is enabled with the *Operation mode* setting set to "Yo, Go" and *Directional mode* to "Non-directional". The characteristic is a combination of a circle with the radius defined with the *Circle radius* setting and two overconductance boundary lines with the settings *Conductance forward* and *Conductance reverse*. For the sake of application flexibility, the midpoint of the circle can be moved from the origin with the *Circle conductance* and *Circle susceptance* settings. Also the boundary lines can be tilted by the angle defined with the *Conductance tilt Ang* setting. By default, the *Circle conductance* and *Circle susceptance* are 0.0 mS and *Conductance tilt Ang* equals zero degrees, that is, the characteristic is a combination of an origin-centered circle with two vertical overconductance boundary lines. A positive tilt value for the *Conductance tilt Ang* setting rotates boundary lines counterclockwise from the vertical axis.

In case of the non-directional conductance criterion, the *Conductance reverse* setting must be set to a smaller value than *Conductance forward*.

Operation is achieved when the measured admittance moves outside the characteristic.

The combined overadmittance and overconductance criterion is applicable in unearthed, high-resistance earthed and compensated networks or in systems where the system earthing may temporarily change during normal operation from compensated network to unearthed system.

Compared to the overadmittance criterion, the combined characteristic improves sensitivity in high-resistance earthed and compensated networks. Compared to the non-directional overconductance criterion, the combined characteristic enables the protection to be applied also in unearthed systems.

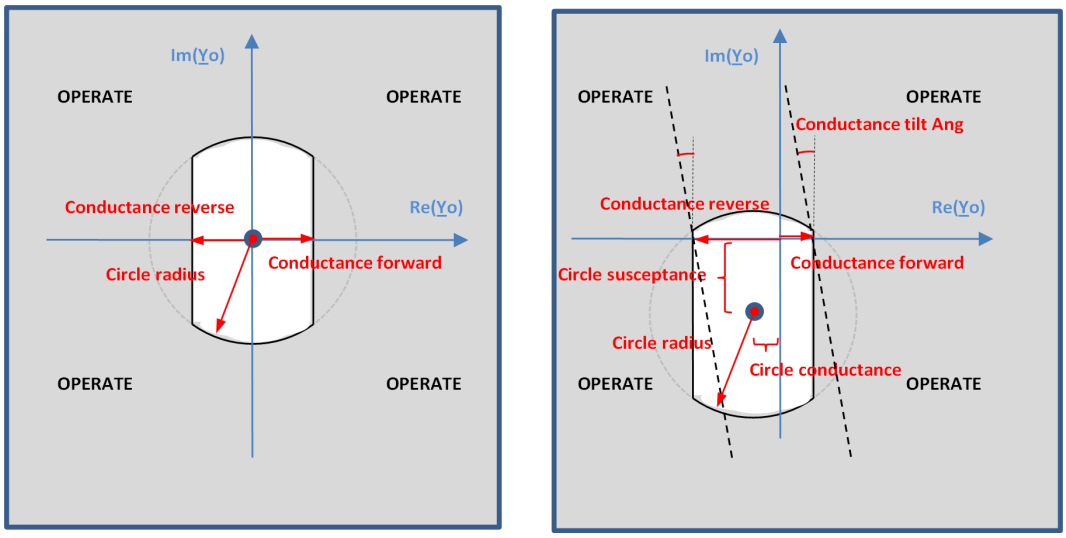



*Figure 289: Combined overadmittance and overconductance characteristic. Left figure: classical origin-centered admittance circle combined with two overconductance boundary lines. Right figure: admittance circle is set off from the origin.*

### Combined overconductance and oversusceptance characteristic

The combined overconductance and oversusceptance criterion is enabled with the *Operation mode* setting set to "Go, Bo".

By setting *Directional mode* to "Forward", the characteristic is a combination of two boundary lines with the settings *Conductance forward* and *Susceptance forward*. See *Figure 290*.

By setting *Directional mode* to "Non-directional", the characteristic is a combination of four boundary lines with the settings *Conductance forward*, *Conductance reverse*, *Susceptance forward* and *Susceptance reverse*. See *Figure 291*.

For the sake of application flexibility, the boundary lines can be tilted by the angle defined with the *Conductance tilt Ang* and *Susceptance tilt Ang* settings. By default, the tilt angles are zero degrees, that is, the boundary lines are straight lines in the admittance plane. A positive *Conductance tilt Ang* value rotates the overconductance boundary line counterclockwise from the vertical axis. A positive *Susceptance tilt Ang* value rotates the oversusceptance boundary line counterclockwise from the horizontal axis.

In case of the non-directional conductance and susceptance criteria, the *Conductance reverse* setting must be set to a smaller value than *Conductance forward* and the *Susceptance reverse* setting must be set to a smaller value than *Susceptance forward*.

Operation is achieved when the measured admittance moves outside the characteristic.

The combined overconductance and oversusceptance criterion is applicable in high-resistance earthed, unearthed and compensated networks or in the systems where the system earthing may temporarily change during normal operation from compensated to unearthed system.

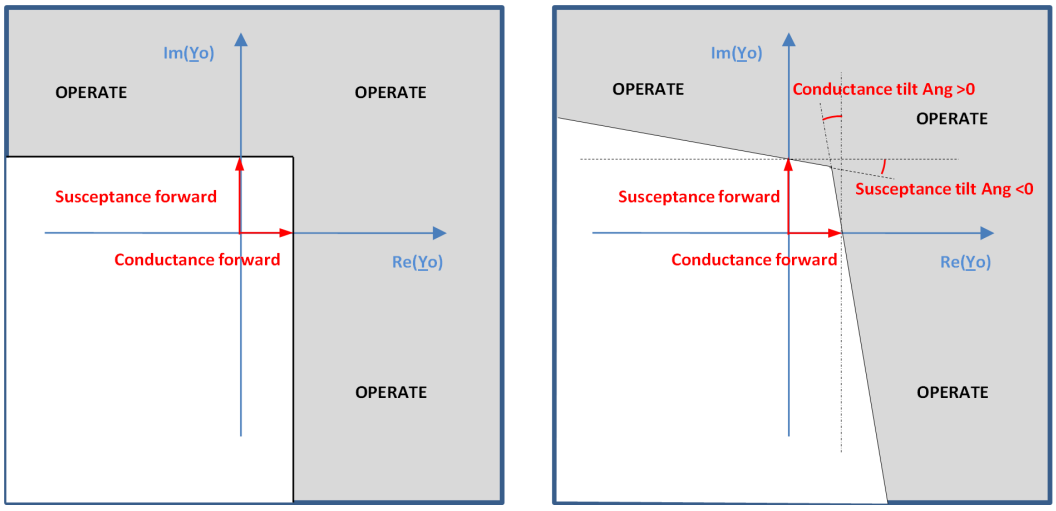



*Figure 290: Combined forward directional overconductance and forward directional oversusceptance characteristic. Left figure: the Conductance tilt Ang and Susceptance tilt Ang settings equal zero degrees. Right figure: the setting Conductance tilt Ang > 0 degrees and the setting Susceptance tilt Ang < 0 degrees.*

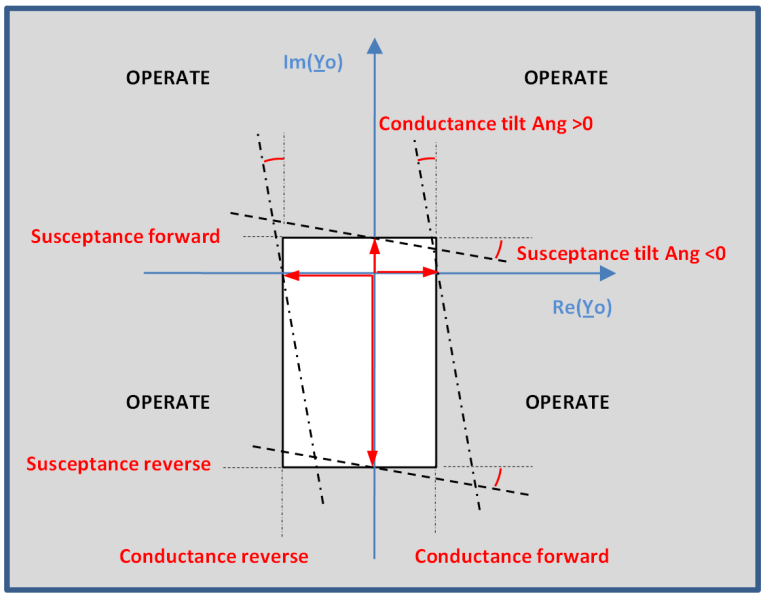



*Figure 291: Combined non-directional overconductance and non-directional oversusceptance characteristic*

The non-directional overconductance and non-directional oversusceptance characteristic provides a good sensitivity and selectivity when the characteristic is set to cover the total admittance of the protected feeder with a proper margin.

The sign of the admittance characteristic settings should be considered based on the location of characteristic boundary in the admittance plane. All forward-settings are given with positive sign and reverse-settings with negative sign.

### 4.2.4.7 Application

Admittance-based earth-fault protection provides a selective earth-fault protection for high-resistance earthed, unearthed and compensated networks. It can be applied for the protection of overhead lines as well as with underground cables. It can be used as an alternative solution to traditional residual current-based earth-fault protection functions, for example the IoCos mode in DEFxPDEF. Main advantages of EFPADM include versatile applicability, good sensitivity and easy setting principles.

Residual overvoltage condition is used as a start condition for the admittance-based earth-fault protection. When the residual voltage exceeds the set threshold *Voltage start value*, an earth fault is detected and the neutral admittance calculation is released. In order to guarantee a high security of protection, that is, avoid false starts, the *Voltage start value* setting must be set above the highest possible value of Uo during normal operation with a proper margin. It should consider all possible operation conditions and configuration changes in the network. In unearthed systems, the healthy-state Uo is typically less than 1%×Uph (Uph = nominal phase-to-earth voltage). In compensated networks, the healthy-state Uo may reach values even up to 30%×Uph if the network includes large parts of overheadlines without a phase transposition. Generally, the highest Uo is achieved when the compensation coil is tuned to the full resonance and when the parallel resistor of the coil is not connected.

The residual overvoltage-based start condition for the admittance protection enables a multistage protection principle. For example, one instance of EFPADM could be used for alarming to detect faults with a high fault resistance using a relatively low value for the *Voltage start value* setting. Another instance of EFPADM could then be set to trip with a lower sensitivity by selecting a higher value of the *Voltage start value* setting than in the alarming instance (stage).

To apply the admittance-based earth-fault protection, at least the following network data are required:

- System earthing method
- Maximum value for Uo during the healthy state
- Maximum earth-fault current of the protected feeder when the fault resistance Rf is zero ohm
- Maximum uncompensated earth-fault current of the system (Rf = 0 Ω)
- Rated current of the parallel resistor of the coil (active current forcing scheme) in the case of a compensated neutral network
- Rated current of the neutral earthing resistor in the case of a high-resistance earthed system
- Knowledge of the magnitude of Uo as a function of the fault resistance to verify the sensitivity of the protection in terms of fault resistance

*Figure 292* shows the influence of fault resistance on the residual voltage magnitude in unearthed and compensated networks. Such information should be available to verify the correct *Voltage start value* setting, which helps fulfill the requirements for the sensitivity of the protection in terms of fault resistance.

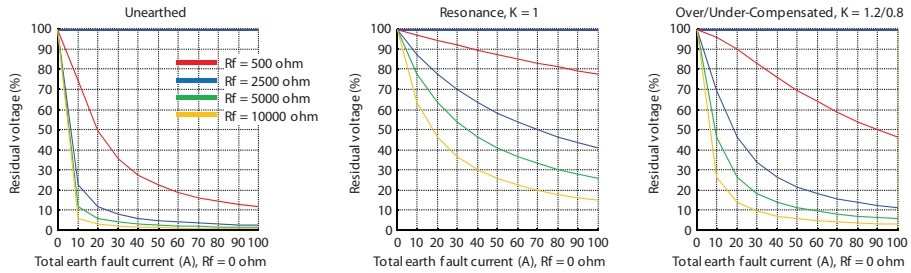



*Figure 292: Influence of fault resistance on the residual voltage magnitude in 10 kV unearthed and compensated networks. The leakage resistance is assumed to be 30 times higher than the absolute value of the capacitive reactance of the network. Parallel resistor of the compensation coil is assumed to be disconnected.*

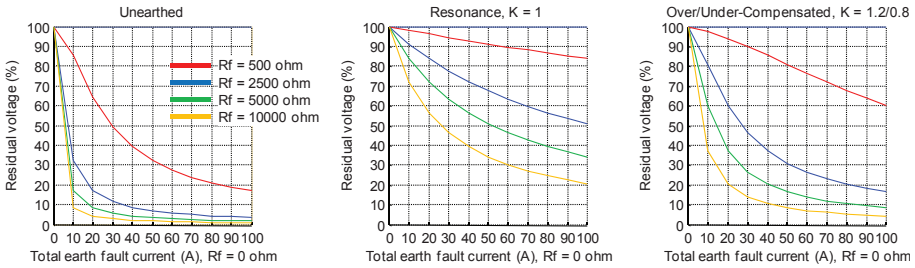



*Figure 293: Influence of fault resistance on the residual voltage magnitude in 15 kV unearthed and compensated networks. The leakage resistance is assumed to be 30 times higher than the absolute value of the capacitive reactance of the network. Parallel resistor of the compensation coil is assumed to be disconnected.*

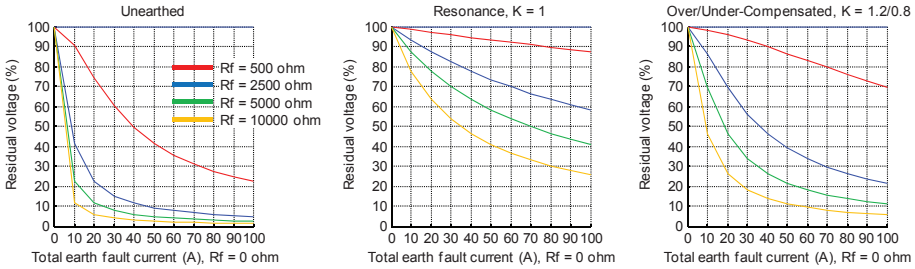



*Figure 294: Influence of fault resistance on the residual voltage magnitude in 20 kV unearthed and compensated networks. The leakage resistance is assumed to be 30 times higher than the absolute value of the capacitive reactance of the network. Parallel resistor of the compensation coil is assumed to be disconnected.*

**Example**

In a 15 kV, 50 Hz compensated network, the maximum value for Uo during the healthy state is 10%×Uph. Maximum earth-fault current of the system is 100 A. The maximum earth-fault current of the protected feeder is 10 A (Rf = 0 Ω). The applied active current forcing scheme uses a 15 A resistor (at 15 kV), which is connected in parallel to the coil during the fault after a 1.0 second delay.

Solution: As a start condition for the admittance-based earth-fault protection, the internal residual overvoltage condition of EFPADM is used. The *Voltage start value* setting must be set above the maximum healthy-state Uo of 10%×Uph with a suitable margin.

*Voltage start value* = 0.15 × Un

According to *Figure 293*, this selection ensures at least a sensitivity corresponding to a 2000 ohm fault resistance when the compensation degree varies between 80% and 120%. The greatest sensitivity is achieved when the compensation degree is close to full resonance.

An earth-fault current of 10 A can be converted into admittance.

$$\underline{Y}_{Fdtot} = \frac{10A}{15kV/\sqrt{3}} \approx j \cdot 1.15 \text{ mS}$$

(Equation 71)

A parallel resistor current of 15 A can be converted into admittance.

$$G_{cc} = \frac{15A}{15kV/\sqrt{3}} \approx 1.73 \text{ mS}$$

(Equation 72)

According to *Equation 59*, during an outside fault EFPADM measures the following admittance:

$$\underline{Yo} = -\underline{Y}_{Fdtot} \approx -j \cdot 1.15 \text{ mS}$$

(Equation 73)

According to *Equation 62*, during an inside fault EFPADM measures the admittance after the connection of the parallel resistor:

$$\underline{Yo} = \underline{Y}_{Bgtot} + \underline{Y}_{CC} \approx \left(1.73 + j \cdot B\right) \text{ mS}$$

(Equation 74)

Where the imaginary part of the admittance, B, depends on the tuning of the coil (compensation degree).

The admittance characteristic is selected to be the combined overconductance and oversusceptance characteristic ("Box"-characteristics) with four boundary lines:

*Operation mode* = "Go, Bo"

*Directional mode* = "Non-directional"

The admittance characteristic is set to cover the total admittance of the protected feeder with a proper margin, see *Figure 295*. Different setting groups can be used to allow adaptation of protection settings to different feeder and network configurations.

**Conductance forward**

This setting should be set based on the parallel resistor value of the coil. It must be set to a lower value than the conductance of the parallel resistor, in order to enable dependable operation. The selected value should move the boundary line

from origin to include some margin for the admittance operation point due to CT/VT-errors, when fault is located outside the feeder.

*Conductance forward*: 15 A/(15 kV/sqrt(3)) * 0.2 = +0.35 mS corresponding to 3.0 A (at 15 kV). The selected value provides margin considering also the effect of CT/VT-errors in case of outside faults.

In case of a lower rated value of the parallel resistor, for example, 5 A (at 15 kV), the recommended security margin should be higher, for example 0.7, so that sufficient margin for CT/VT-errors can be achieved.

**Susceptance forward**

By default, this setting should be based on the minimum operate current of 1 A.

*Susceptance forward*: 1 A/(15 kV/sqrt(3)) = +0.1 mS

**Susceptance reverse**

This setting should be set based on the value of the maximum earth-fault current produced by the feeder (considering possible feeder topology changes) with a security margin. This ensures that the admittance operating point stays inside the "Box"-characteristics during outside fault. The recommended security margin should not be lower than 1.5.

*Susceptance reverse*: - (10 A * 1.5)/ (15 kV/sqrt(3)) = -1.73 mS

**Conductance reverse**

This setting is used to complete the non-directional characteristics by closing the "Box"-characteristic. In order to keep the shape of the characteristic reasonable and to allow sufficient margin for the admittance operating point during outside fault, it is recommended to use the same value as for setting Susceptance reverse.

*Conductance reverse* = -1.73 mS

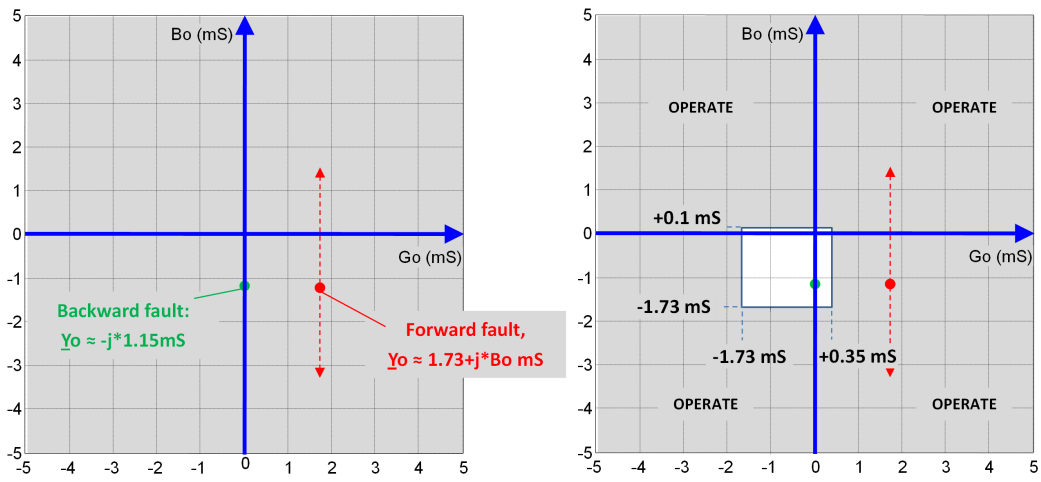



*Figure 295: Admittances of the example*

## 4.2.4.8 Signals

**EFPADM Input signals**

**Table 567: EFPADM Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RELEASE | BOOLEAN | 0=False | External trigger to release neutral admittance protection |

**EFPADM Output signals**

**Table 568: EFPADM Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| FAULT_DIR | Enum | Detected fault direction |

## 4.2.4.9 EFPADM Settings

**Table 569: EFPADM Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage start value | 0.01...2.00 | xUn | 0.01 | 0.15 | Voltage start value |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Operation mode | 1=Yo<br>2=Go<br>3=Bo<br>4=Yo, Go<br>5=Yo, Bo<br>6=Go, Bo<br>7=Yo, Go, Bo | | | 1=Yo | Operation criteria |
| Operate delay time | 60...300000 | ms | 10 | 60 | Operate delay time |
| Circle radius | 0.05...500.00 | mS | 0.01 | 1.00 | Admittance circle radius |
| Circle conductance | -500.00...500.00 | mS | 0.01 | 0.00 | Admittance circle midpoint, conductance |
| Circle susceptance | -500.00...500.00 | mS | 0.01 | 0.00 | Admittance circle midpoint, susceptance |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Conductance forward | -500.00...500.00 | mS | 0.01 | 1.00 | Conductance threshold in forward direction |
| Conductance reverse | -500.00...500.00 | mS | 0.01 | -1.00 | Conductance threshold in reverse direction |
| Susceptance forward | -500.00...500.00 | mS | 0.01 | 1.00 | Susceptance threshold in forward direction |
| Susceptance reverse | -500.00...500.00 | mS | 0.01 | -1.00 | Susceptance threshold in reverse direction |

**Table 570: EFPADM Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Conductance tilt Ang | -30...30 | deg | 1 | 0 | Tilt angle of conductance boundary line |
| Susceptance tilt Ang | -30...30 | deg | 1 | 0 | Tilt angle of susceptance boundary line |

**Table 571: EFPADM Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 572: EFPADM Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Admittance Clc mode | 1=Normal<br>2=Delta | | | 1=Normal | Admittance calculation mode |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.01 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.01 | Minimum operating voltage |

## 4.2.4.10 EFPADM Monitored data

**Table 573: EFPADM Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| COND_RES | FLOAT32 | -1000.00...1000.00 | mS | Real part of calculated neutral admittance |
| SUS_RES | FLOAT32 | -1000.00...1000.00 | mS | Imaginary part of calculated neutral admittance |
| EFPADM | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked | | Status |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 5=off | | |

### 4.2.4.11 Technical data

**Table 574: EFPADM Technical data**

| Characteristic | Value | | |
|---|---|---|---|
| Operation accuracy [1] | At the frequency f = $f_n$ | | |
| | ±1.0% or ±0.01 mS<br>(In range of 0.5...100 mS) | | |
| Start time [2] | Minimum | Typical | Maximum |
| | 56 ms | 60 ms | 64 ms |
| Reset time | 40 ms | | |
| Operate time accuracy | ±1.0% of the set value of ±20 ms | | |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,... | | |

## 4.2.5 Rotor earth-fault protection, injection method MREFPTOC (ANSI 64R)

### 4.2.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Rotor earth-fault protection, injection method | MREFPTOC | Io>R | 64R |

### 4.2.5.2 Function block

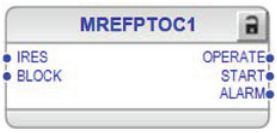



*Figure 296: Function block*

### 4.2.5.3 Functionality

The rotor earth-fault protection, injection method, function MREFPTOC is used to detect an earth fault in the rotor circuit of synchronous machines. MREFPTOC is used with the injection device REK510, which requires a secured 58, 100 or 230 V AC

[1] $U_o = 1.0 \times U_n$.
[2] Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements.

50/60 Hz input source and injects a 100 V AC voltage via its coupling capacitors to the rotor circuit towards earth.

MREFPTOC consists of independent alarm and operating stages. The operating time characteristic is according to definite time (DT) for both stages.

MREFPTOC contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.5.4 Analog channel configuration

MREFPTOC has one analog group input which must be properly configured.

**Table 575: Analog signals**

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of MREFPTOC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

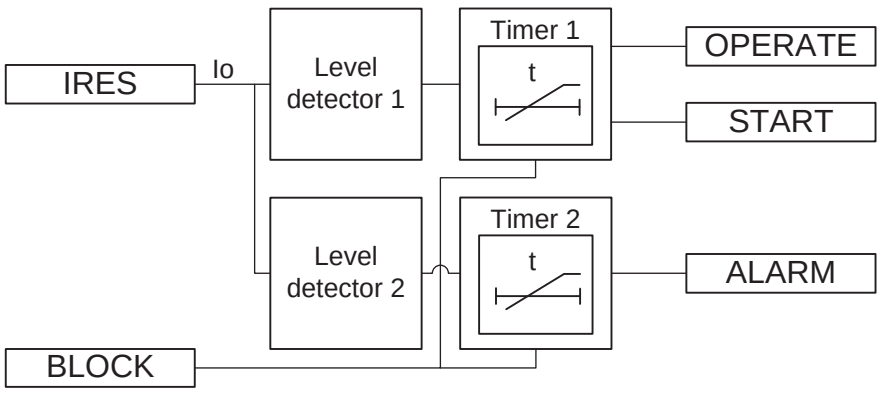



*Figure 297: Functional module diagram*

**Level detector 1**

The measured rotor earth-fault current (DFT value) is compared to the *Operate start value* setting. If the measured value exceeds that of the *Operate start value* setting, Level detector 1 sends a signal to start the Timer 1 module.

**Level detector 2**

The measured rotor earth-fault current (DFT value) is compared to the set *Alarm start value*. If the measured value exceeds that of the *Alarm start value* setting, Level detector 2 sends a signal to start the Timer 2 module.

For MREFPTOC, the earth-fault current is the current that flows due to the voltage injected by the injection device in the rotor circuit when an earth fault arises.

A considerable amount of harmonics, mainly 3rd and 6th, can occur in the excitation current under normal no-fault conditions, especially with the thyristor excitation and rotating diode rectifier systems. MREFPTOC uses DFT value calculation to filter DC and harmonic components which could otherwise give out false alarms or trips.

**Timer 1**

Once activated, the Timer activates the START output. The timer characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time* in the DT mode, the OPERATE output is activated. If a drop-off situation occurs, that is, a fault suddenly disappears before the operating delay is exceeded, the timer reset state is activated. The reset time depends on the *Reset delay time* setting.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all outputs and resets the internal timers.

**Timer 2**

Once activated, the Timer activates the alarm timer. The timer characteristic is according to DT. When the alarm timer has reached the value set by *Alarm delay time* in the DT mode, the ALARM output is activated. If a drop-off situation occurs, that is, a fault suddenly disappears before the alarm delay is exceeded, the timer reset state is activated. The reset time depends on the *Alm reset delay time* setting.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all outputs and resets the internal timers.

### 4.2.5.6 Application

The rotor circuit of synchronous machines is normally isolated from the earth. The rotor circuit can be exposed to an abnormal mechanical or thermal stress due to, for example, vibrations, overcurrent and choked cooling medium flow. This can result in the breakdown of the insulation between the field winding and the rotor iron at the point exposed to excessive stress. If the isolation resistance is decreased significantly, this can be seen as an earth fault. For generators with slip rings, the rotor insulation resistance is sometimes reduced due to the accumulated carbon dust layer produced by the carbon brushes. As the circuit has a high impedance to earth, a single earth fault does not lead to any immediate damage because the fault current is small due to a low voltage. There is, however, a risk that a second earth

fault appears, creating a rotor winding interturn fault and causing severe magnetic imbalance and heavy rotor vibrations that soon lead to a severe damage.

Therefore, it is essential that any occurrence of an insulation failure is detected and that the machine is disconnected as soon as possible. Normally, the device is tripped after a short time delay.

A 50/60 Hz voltage is injected via the injection device REK 510 to the rotor field winding circuit of the synchronous machine as shown in *Figure 298*. The injected voltage is 100 V AC via the coupling capacitors. A coupling capacitor prevents a DC current leakage through the injection device.

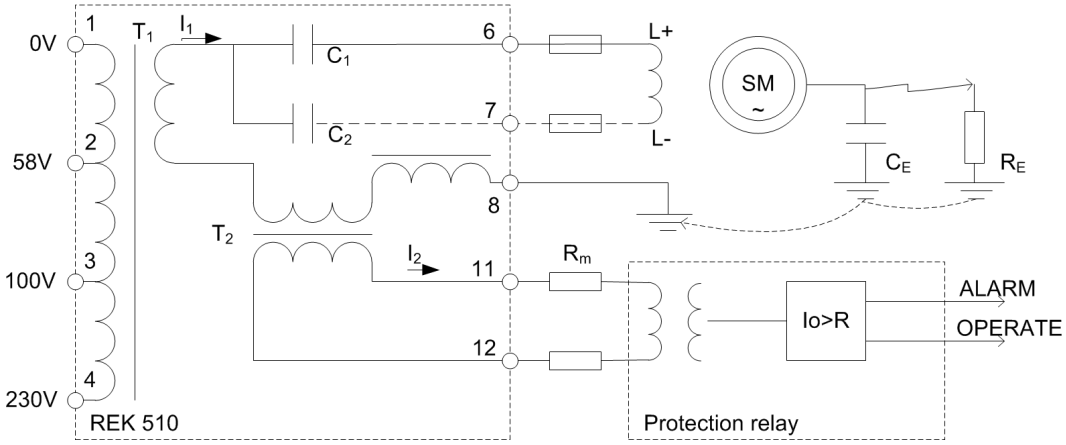



*Figure 298: Principle of the rotor earth-fault protection with the current injection device*

The auxiliary AC voltage forms a small charging current $I_1$ to flow via the coupling capacitors, resistances of the brushes and the leakage capacitance between the field circuit and earth. The field-to-earth capacitance $C_E$ affects the level of the resulting current to an extent which is a few milliamperes during normal no-fault operating conditions.

If an earth fault arises in the rotor field circuit, this current increases and can reach a level of 130 mA at a fully developed earth fault (fault resistance $R_E$ = 0, one coupling capacitor $C_1$ = 2µF is used). The integrated current transformer of the injection device REK 510 then amplifies this current with the ratio of 1:10 to a measurable level. MREFPTOC is used to measure this current.

An example of the measured curves with various field-to-earth leakage capacitance values is given in *Figure 299*.

It is recommended that the alarm and operation stages of MREFPTOC are both used. The alarm stage for giving an indication for weakly developed earth faults with a start value setting corresponds to a 10 kΩ fault resistance with a 10-second delay. The operation stage for a protection against fully developed earth faults with a start value setting corresponds to a 1...2 kΩ fault resistance with a 0.5-second delay.

The current setting values corresponding to the required operating fault resistances can be tested by connecting an adjustable fault simulating resistor between the excitation winding poles and the earth. Whether only one of the coupling capacitors or both should be used in a parallel connection should be determined on a case-by-case basis, taking into consideration the consequences of a possibly excessive current at a direct earth fault.

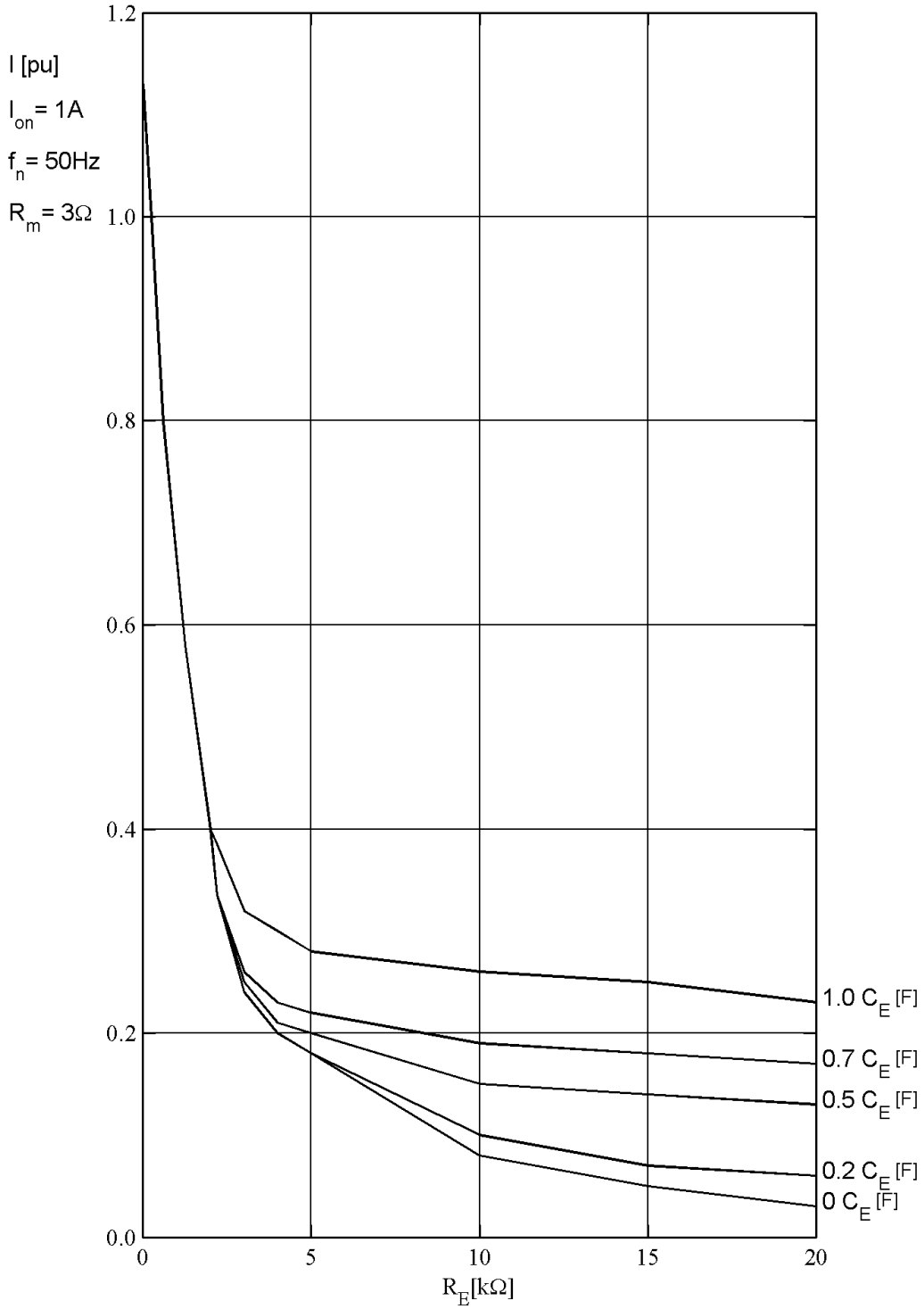



*Figure 299: Measured current as a function of the rotor earth-fault resistance with various field-to-earth capacitance values with the measuring circuit resistance Rm = 3.0 Ω, fn = 50 Hz. Only one coupling capacitor is used.*

### 4.2.5.7 Signals

**MREFPTOC Input signals**

**Table 576: MREFPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**MREFPTOC Output signals**

**Table 577: MREFPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Alarm |

## 4.2.5.8 MREFPTOC Settings

**Table 578: MREFPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate start value | 0.010...2.000 | xIn | 0.001 | 0.010 | Operate start value |
| Alarm start value | 0.010...2.000 | xIn | 0.001 | 0.010 | Alarm start value |
| Operate delay time | 40...20000 | ms | 1 | 500 | Operate delay time |
| Alarm delay time | 40...200000 | ms | 1 | 10000 | Alarm delay time |

**Table 579: MREFPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 580: MREFPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Alm reset delay time | 0...60000 | ms | 1 | 20 | Alarm reset delay time |

## 4.2.5.9 MREFPTOC Monitored data

**Table 581: MREFPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| MREFPTOC | Enum | 1=on<br>2=blocked | | Status |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 3=test<br>4=test/blocked<br>5=off | | |

### 4.2.5.10 Technical data

**Table 582: MREFPTOC Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the current measured: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [1, 2] | $I_{Fault}$ = 1.2 × set *Start value* | Minimum | Typical | Maximum |
| | | 30 ms | 34 ms | 38 ms |
| Reset time | | <50 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <50 ms | | |
| Operate time accuracy | | ±1.0% of the set value of ±20 ms | | |
| Suppression of harmonics | | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

## 4.2.6 Harmonics-based earth-fault protection HAEFPTOC (ANSI 51NH)

### 4.2.6.1 Identification

| Description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Harmonics-based earth-fault protection | HAEFPTOC | Io>HA | 51NH |

### 4.2.6.2 Function block

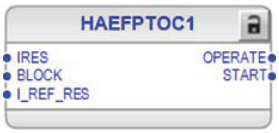



*Figure 300: Function block*

### 4.2.6.3 Functionality

The harmonics-based earth-fault protection function HAEFPTOC is used instead of a traditional earth-fault protection in networks where a fundamental frequency component of the earth-fault current is low due to compensation.

[1] Current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements.
[2] Includes the delay of the signal output contact.

By default, HAEFPTOC is used as a standalone mode. Substation-wide application can be achieved using horizontal communication where the detection of a faulty feeder is done by comparing the harmonics earth-fault current measurements.

The function starts when the harmonics content of the earth-fault current exceeds the set limit. The operation time characteristic is either definite time (DT) or inverse definite minimum time (IDMT). If the horizontal communication is used for the exchange of current values between the protection relays, the function operates according to the DT characteristic.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

### 4.2.6.4 Analog channel configuration

HAEFPTOC has one analog group input which must be properly configured.

**Table 583: Analog signals**

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |



See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of HAEFPTOC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

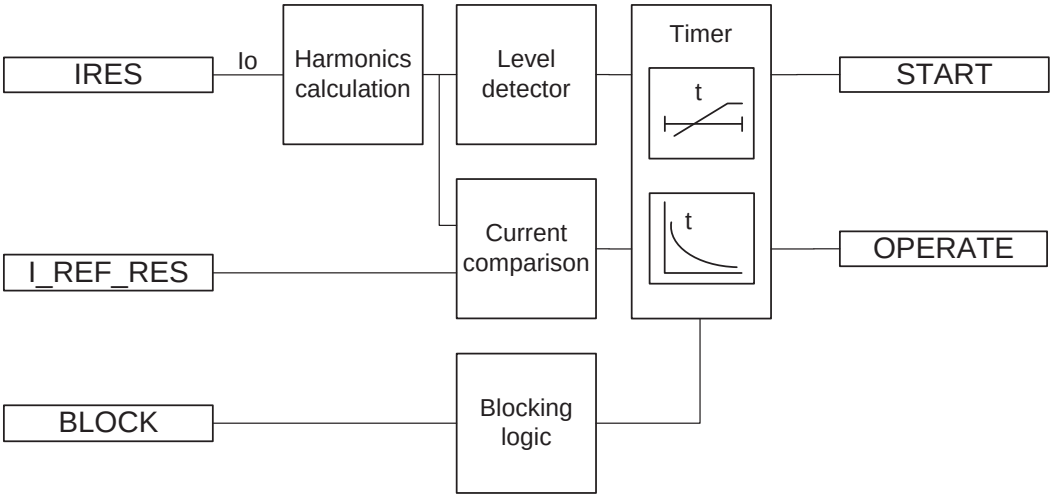



*Figure 301: Functional module diagram*

**Harmonics calculation**

This module feeds the measured residual current to the high-pass filter, where the frequency range is limited to start from two times the fundamental frequency of the network (for example, in a 50 Hz network the cutoff frequency is 100 Hz), that is, summing the harmonic components of the network from the second harmonic. The output of the filter, later referred to as the harmonics current, is fed to the Level detector and Current comparison modules.

The harmonics current I_HARM_RES is available in the monitored data view. The value is also sent over horizontal communication to the other protection relays on the parallel feeders configured in the protection scheme.

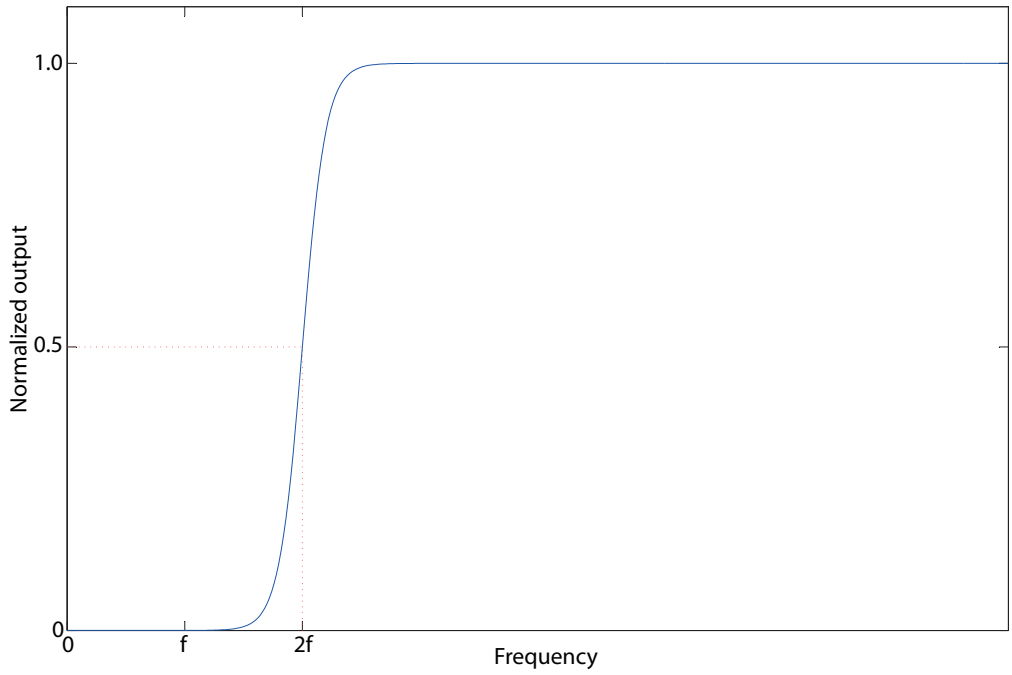



*Figure 302: High-pass filter*

**Level detector**

The harmonics current is compared to the *Start value* setting. If the value exceeds the value of the *Start value* setting, Level detector sends an enabling signal to the Timer module.

**Current comparison**

The maximum of the harmonics currents reported by other parallel feeders in the substation, that is, in the same busbar, is fed to the function through the I_REF_RES input. If the locally measured harmonics current is higher than I_REF_RES, the enabling signal is sent to Timer.

If the locally measured harmonics current is lower than I_REF_RES, the fault is not in that feeder. The detected situation blocks Timer internally, and simultaneously also the BLKD_I_REF output is activated.

The module also supervises the communication channel validity which is reported to the Timer.

**Timer**

The START output is activated when Level detector sends the enabling signal. Functionality and the time characteristics depend on the selected value of the *Enable reference use* setting.

**Table 584: Values of the Enable reference use setting**

| *Enable reference use* | | Functionality |
|---|---|---|
| Standalone | | In the standalone mode, depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of the *Operate delay time* setting in the DT mode or the value defined by the inverse time curve, the OPERATE output is activated. |
| Reference use | Communication valid | When using the horizontal communication, the function is forced to use the DT characteristics. When the operation timer has reached the value of the *Minimum operate time* setting and simultaneously the enabling signal from the Current comparison module is active, the OPERATE signal is activated. |
| | Communication invalid | Function operates as in the standalone mode. |

The *Enable reference use* setting forces the function to use the DT characteristics where the operating time is set with the *Minimum operate time* setting.

If the communication for some reason fails, the function switches to use the *Operation curve type* setting, and if DT is selected, *Operate delay time* is used. If the IDMT curve is selected, the time characteristics are according to the selected curve and the *Minimum operate time* setting is used for restricting too fast an operation time.

In case of a communication failure, the start duration may change substantially depending on the user settings.

When the programmable IDMT curve is selected, the operation time characteristics are defined with the *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E* parameters.

If a drop-off situation happens, that is, a fault suddenly disappears before the operation delay is exceeded, the Timer reset state is activated. The functionality of Timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the value of the *Reset delay time* setting is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation and the value of START_DUR. If the drop-off situation continues, the reset timer is reset and the START output is deactivated.

The "Inverse reset" selection is only supported with ANSI or the programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operation and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operation time for IDMT. The setting is applicable only when the IDMT curves are used

The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve but always at least the value of the *Minimum operate time* setting. More information can be found in *Chapter 11.2.1 IDMT curves for overcurrent protection*.

Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation, and the set operating time, which can be either according to DT or IDMT. The value is available in the monitored data view.

More information can be found in *Chapter 11 General function block features*.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the *Block OPERATE output* mode, the function operates normally but the OPERATE output is not activated.

### 4.2.6.6 Application

During an earth fault, HAEFPTOC calculates the maximum current for the current feeder. The value is sent over an analog GOOSE to other protection relays of the busbar in the substation. At the configuration level, all the values received over the analog GOOSE are compared through the MAX function to find the maximum value. The maximum value is sent back to HAEFPTOC as the I_REF_RES input. The operation of HAEFPTOC is allowed in case I_REF_RES is lower than the locally measured harmonics current. If I_REF_RES exceeds the locally measured harmonics current, the operation of HAEFPTOC is blocked.

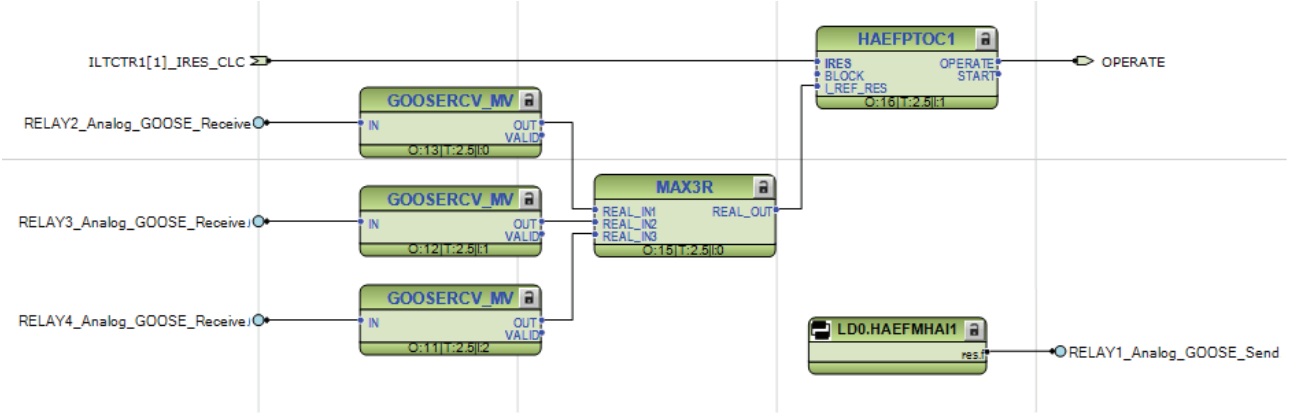



*Figure 303: Protection scheme based on the analog GOOSE communication with three analog GOOSE receivers*

### 4.2.6.7 Signals

#### HAEFPTOC Input signals

**Table 585: HAEFPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| I_REF_RES | FLOAT32 | 0.0 | Reference current |

#### HAEFPTOC Output signals

**Table 586: HAEFPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.2.6.8 HAEFPTOC Settings

**Table 587: HAEFPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...5.00 | xIn | 0.01 | 0.10 | Start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 100...300000 | ms | 10 | 600 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |

**Table 588: HAEFPTOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 100...200000 | ms | 10 | 500 | Minimum operate time for IDMT curves |
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |
| Enable reference use | 0=False<br>1=True | | | 0=False | Enable using current reference from other IEDs instead of stand-alone |

**Table 589: HAEFPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 0.0001 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 0.0001 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 0.01 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 590: HAEFPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |

## 4.2.6.9 HAEFPTOC Monitored data

**Table 591: HAEFPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| I_HARM_RES | FLOAT32 | 0.0...30000.0 | A | Calculated harmonics current |
| BLKD_I_REF | BOOLEAN | 0=False<br>1=True | | Current comparison status indicator |
| HAEFPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.2.6.10 Technical data

**Table 592: HAEFPTOC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±5% of the set value or ±0.004 × $I_n$ |
| Start time , | Typically 77 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode [3] | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in IDMT mode | ±5.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = $f_n$ |
| | -3 dB at f = 13 × $f_n$ |

## 4.2.7 Wattmetric-based earth-fault protection WPWDE (ANSI 32N)

### 4.2.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Wattmetric-based earth-fault protection | WPWDE | Po> -> | 32N |

### 4.2.7.2 Function block




*Figure 304: Function block*

### 4.2.7.3 Functionality

The wattmetric-based earth-fault protection function WPWDE can be used to detect earth faults in unearthed networks, compensated networks (Petersen coil-earthed networks) or networks with a high-impedance earthing. It can be used as an alternative solution to the traditional residual current-based earth-fault protection functions, for example, the IoCos mode in the directional earth-fault protection function DEFxPDEF.

[1] Fundamental frequency current = 1.0 × $I_n$, harmonics current before fault = 0.0 × $I_n$, harmonics fault current 2.0 × *Start value*, results based on statistical distribution of 1000 measurements.
[2] Includes the delay of the signal output contact.
[3] Start time of the function also included.
[4] Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 2...20.

WPWDE measures the earth-fault power 3UoIoCosϕ and gives an operating signal when the residual current Io, residual voltage Uo and the earth-fault power exceed the set limits and the angle (ϕ) between the residual current and the residual voltage is inside the set operating sector, that is, forward or backward sector. The operating time characteristic can be selected to be either definite time (DT) or a special wattmetric-type inverse definite minimum type (wattmetric type IDMT).

The wattmetric-based earth-fault protection is very sensitive to current transformer errors and it is recommended that a core balance CT is used for measuring the residual current.

WPWDE contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.2.7.4 Analog channel configuration

WPWDE has two analog group inputs which must be properly configured.

**Table 593: Analog inputs**

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |
| URES | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 594: Special conditions**

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected for calculating the residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.7.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

For WPWDE, certain notations and definitions are used.

Residual voltage Uo = (UA+UB+UC)/3 = $U_0$, where $U_0$ = zero-sequence voltage

Residual current Io = -(IA+IB+IC) = 3×- $I_0$, where $I_0$ = zero-sequence current

The minus sign (-) is needed to match the polarity of calculated and measured residual currents.

The operation of WPWDE can be described with a module diagram. All the modules in the diagram are explained in the next sections.

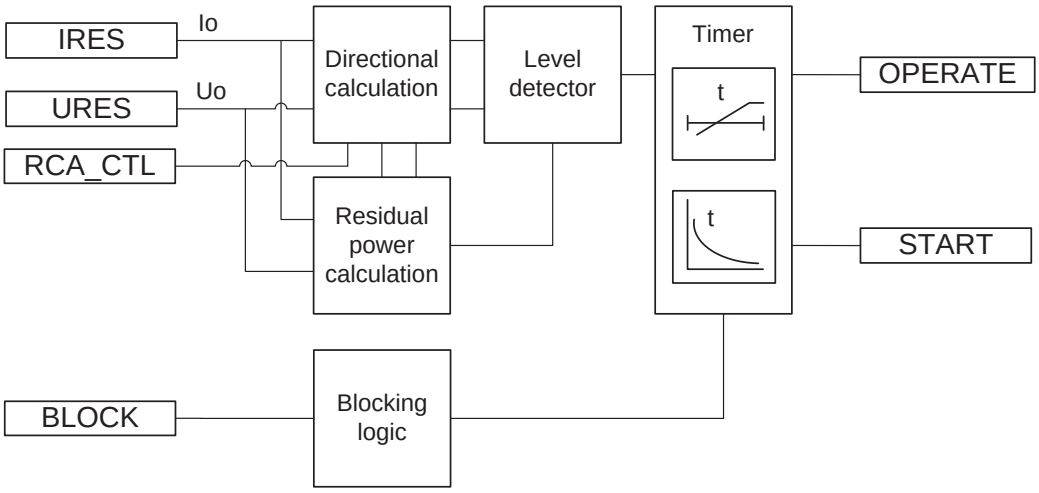



*Figure 305: Function module diagram*

**Directional calculation**

The Directional calculation module monitors the angle between the operating quantity (residual current Io) and polarizing quantity (residual voltage Uo). The operating quantity can be selected with the setting *Io signal Sel*. The selectable options are “Measured Io” and “Calculated Io”. The polarizing quantity can be selected with the setting *Pol signal Sel*. The selectable options are “Measured Uo” and “Calculated Uo”. When the angle between operating quantity and polarizing quantity after considering the *Characteristic angle* setting is in the operation sector, the module sends an enabling signal to Level detector. The directional operation is selected with the *Directional mode* setting. Either the “Forward” or “Reverse” operation mode can be selected. The direction of fault is calculated based on the phase angle difference between the operating quantity Io and polarizing quantity Uo, and the value (ANGLE) is available in the monitored data view.

In the phasor diagrams representing the operation of WPWDE, the polarity of the polarizing quantity (residual voltage Uo) is reversed. Reversing is done by switching the polarity of the residual current measuring channel (see the connection in the Protection relay's physical connections section).

If the angle difference lies between -90° to 0° or 0° to +90°, a forward-direction fault is considered. If the phase angle difference lies within -90° to -180° or +90° to +180°, a reverse-direction fault is detected. Thus, the normal width of a sector is 180°.

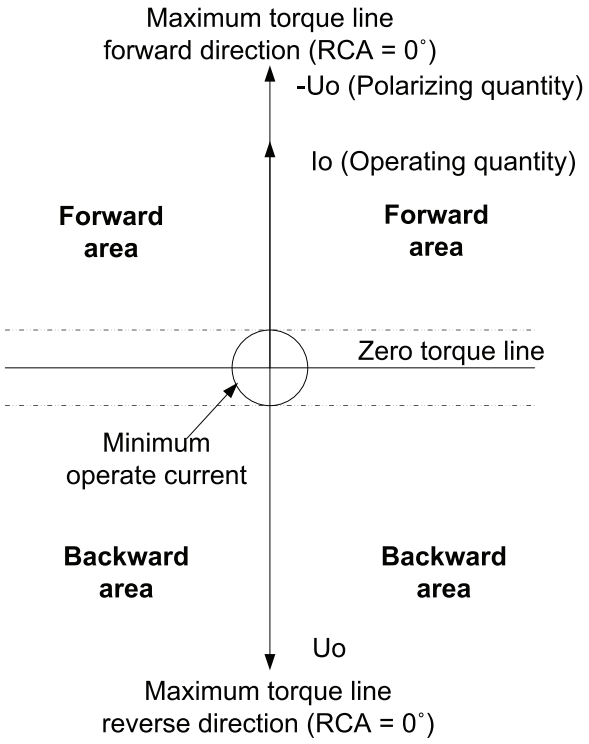



*Figure 306: Definition of the relay characteristic angle*

The phase angle difference is calculated based on the *Characteristic angle* setting (also known as Relay Characteristic Angle (RCA) or Relay Base Angle or Maximum Torque Angle (MTA)). The *Characteristic angle* setting is done based on the method of earthing employed in the network. For example, in case of an unearthed network, the *Characteristic angle* setting is set to -90°, and in case of a compensated network, the *Characteristic angle* setting is set to 0°. In general, *Characteristic angle* is selected so that it is close to the expected fault angle value, which results in maximum sensitivity. *Characteristic angle* can be set anywhere between -179° to +180°. Thus, the effective phase angle (ϕ) for calculating the residual power considering characteristic angle is according to the equation.

$$\phi = \left( \angle(-Uo) - \angle Io - Characteristic\ angle \right)$$

(Equation 75)

In addition, the characteristic angle can be changed via the control signal RCA_CTL. The RCA_CTL input is used in the compensated networks where the compensation coil sometimes is temporarily disconnected. When the coil is disconnected, the compensated network becomes isolated and the *Characteristic angle* setting must be changed. This can be done automatically with the RCA_CTL input, which results in the addition of -90° in the *Characteristic angle* setting.

The value (ANGLE_RCA) is available in the monitored data view.

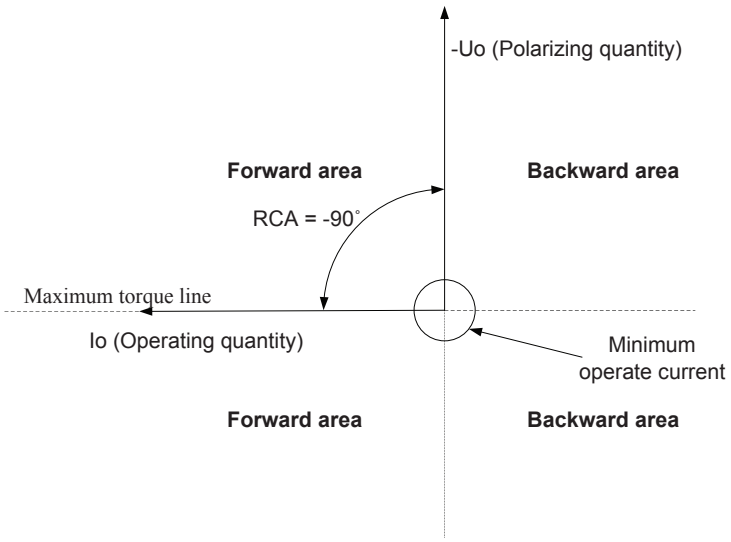



*Figure 307: Definition of relay characteristic angle, RCA = -90° in an isolated network*

*Characteristic angle* should be set to a positive value if the operating signal lags the polarizing signal and to a negative value if the operating signal leads the polarizing signal.

| Type of network | Recommended characteristic angle |
|---|---|
| Compensated network | 0° |
| Unearthed network | -90° |

In unearthed networks, when the characteristic angle is -90°, the measured residual power is reactive (varmetric power).

The fault direction is also indicated `FAULT_DIR` (available in the monitored data view), which indicates 0 if a fault is not detected, 1 for faults in the forward direction and 2 for faults in the backward direction.

The direction of the fault is detected only when the correct angle calculation can be made. If the magnitude of the operating quantity or polarizing quantity is not high enough, the direction calculation is not reliable. Hence, the magnitude of the operating quantity is compared to the *Min operate current* setting and the magnitude of the polarizing quantity is compared to *Min operate voltage*, and if both the operating quantity and polarizing quantity are higher than their respective limit, a valid angle is calculated and the residual power calculation module is enabled.

The *Correction angle* setting can be used to improve the selectivity when there are inaccuracies due to the measurement transformer. The setting decreases the operation sector. The *Correction angle* setting should be done carefully as the phase angle error of the measurement transformer varies with the connected burden as well as with the magnitude of the actual primary current that is being measured. An example of how *Correction angle* alters the operating region is as shown:

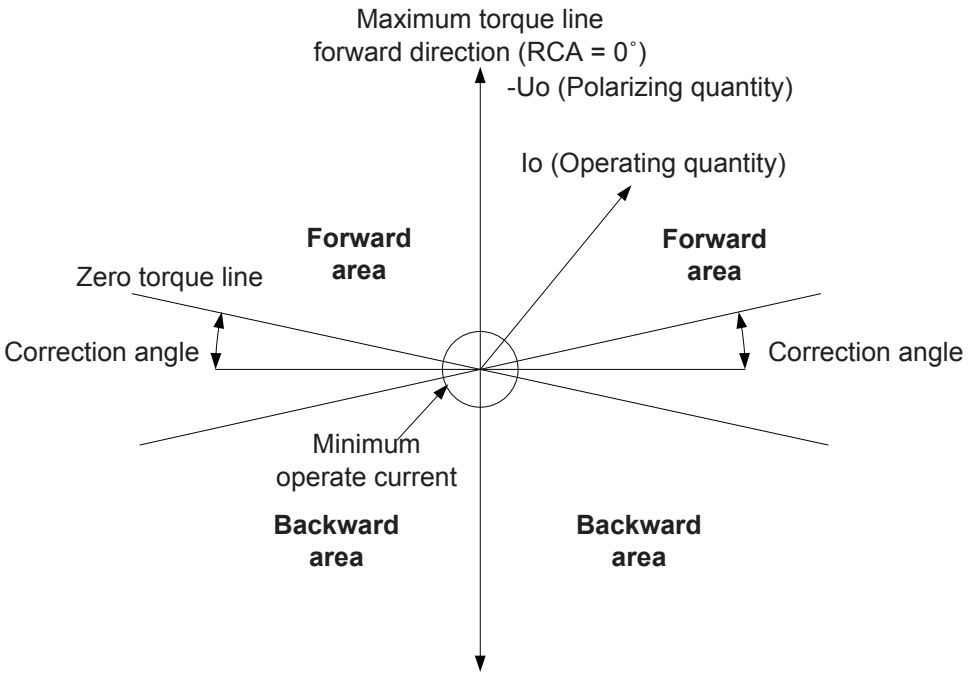



*Figure 308: Definition of correction angle*

The polarity of the polarizing quantity can be changed (rotated by 180°) by setting *Pol reversal* to "True" or by switching the polarity of the residual voltage measurement wires.

**Residual power calculation**

The Residual power calculation module calculates the magnitude of residual power 3UoIoCosϕ. Angle ϕ is the angle between the operating quantity and polarizing quantity, compensated with a characteristic angle. The angle value is received from the Directional calculation module. The Directional calculation module enables the residual power calculation only if the minimum signal levels for both operating quantity and polarizing quantity are exceeded. However, if the angle calculation is not valid, the calculated residual power is zero. Residual power (RES_POWER) is calculated continuously and it is available in the monitored data view. The power is given in relation to nominal power calculated as Pn = Un × In, where Un and In are obtained from the entered voltage transformer and current transformer ratios entered.

**Level detector**

Level detector compares the magnitudes of the measured operating quantity (residual current Io), polarizing quantity (residual voltage Uo) and calculated residual power to the set *Current start value* (×In), *Voltage start value* (×Un) and *Power start value* (×Pn) respectively. When all three quantities exceed the limits, Level detector enables the Timer module.

As nominal power is the result of the multiplication of the nominal current and the nominal voltage Pn = Un × In, the calculation of the setting value for *Power start value* (×Pn) depends on whether Io and Uo are measured or calculated from the phase quantities.

**Timer**

Once activated, Timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or wattmetric IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated. If a drop-off situation happens, that is, a fault suddenly disappears before the operating delay is exceeded, the timer reset state is activated. The reset time is identical for both DT or wattmeter IDMT. The reset time depends on the *Reset delay time* setting.

Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the *Block OPERATE output* mode, the function operates normally but the OPERATE output is not activated.

### 4.2.7.6 Timer characteristics

In the wattmetric IDMT mode, the OPERATE output is activated based on the timer characteristics:

$$t[s] = \frac{k * P_{ref}}{P_{cal}}$$

(Equation 76)

| | |
|---|---|
| t[s] | operation time in seconds |
| k | set value of *Time multiplier* |
| $P_{ref}$ | set value of *Reference power* |
| $P_{cal}$ | calculated residual power |

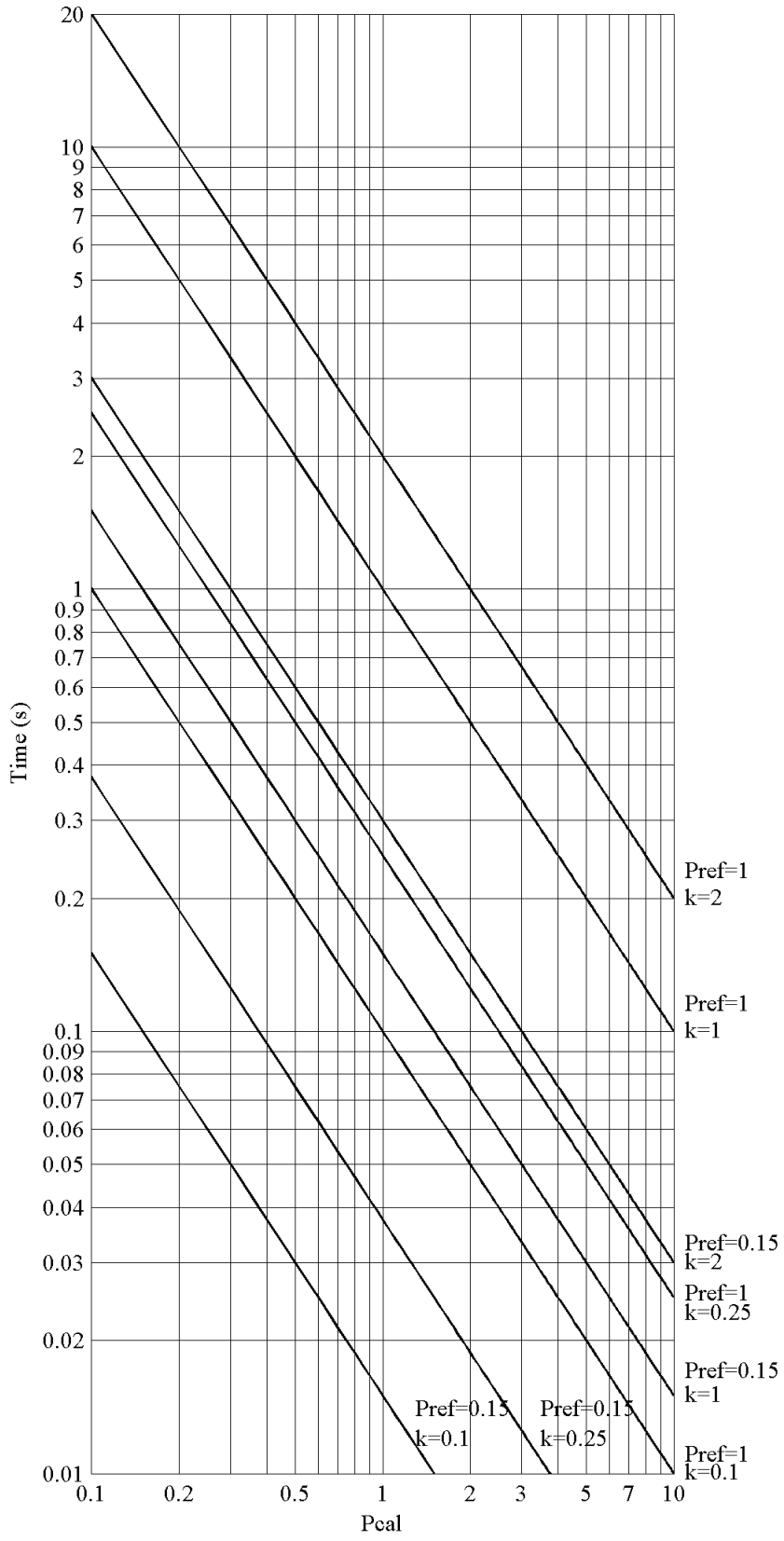



*Figure 309: Operation time curves for wattmetric IDMT for S ref set at 0.15 xPn*

### 4.2.7.7 Measurement modes

The function operates on three alternative measurement modes: "RMS", "DFT" and "Peak-to-Peak". The measurement mode is selected with the *Measurement mode* setting.

### 4.2.7.8 Application

The wattmetric method is one of the commonly used directional methods for detecting the earth faults especially in compensated networks. The protection uses the residual power component 3UoIoCosϕ (ϕ is the angle between the polarizing quantity and operating quantity compensated with a relay characteristic angle).

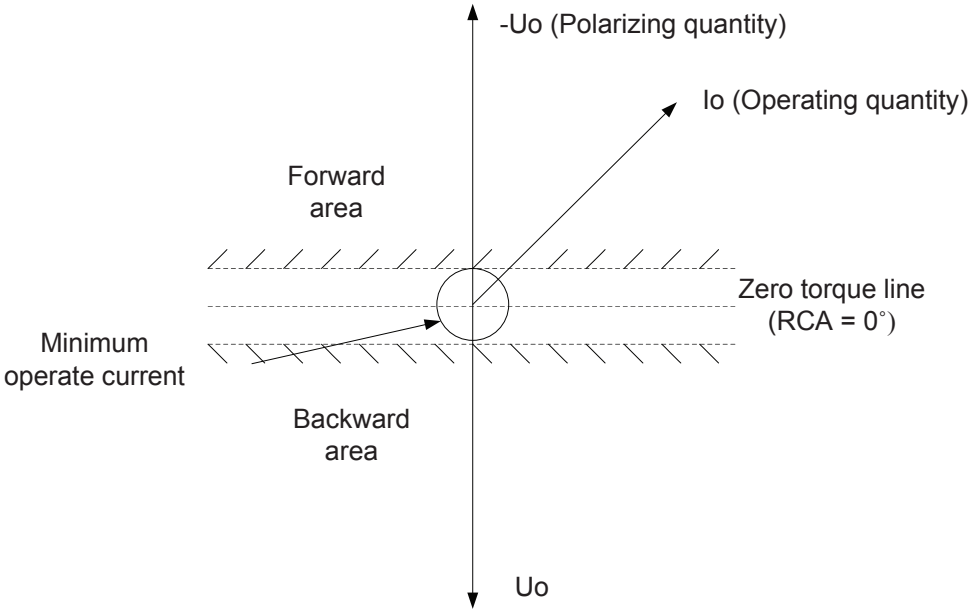



*Figure 310: Characteristics of wattmetric protection*

In a fully compensated radial network with two outgoing feeders, the earth-fault currents depend mostly on the system earth capacitances ($C_0$) of the lines and the compensation coil (L). If the coil is tuned exactly to the system capacitance, the fault current has only a resistive component. This is due to the resistances of the coil and distribution lines together with the system leakage resistances ($R_0$). Often a resistor ($R_L$) in parallel with the coil is used for increasing the fault current.

When a single phase-to-earth fault occurs, the capacitance of the faulty phase is bypassed and the system becomes unsymmetrical. The fault current is composed of the currents flowing through the earth capacitances of two healthy phases. The protection relay in the healthy feeder tracks only the capacitive current flowing through its earth capacitances. The capacitive current of the complete network (sum of all feeders) is compensated with the coil.

A typical network with the wattmetric protection is an undercompensated network where the coil current $I_L = I_{Ctot} - I_{Cfd}$ ($I_{Ctot}$ is the total earth-fault current of the network and $I_{Cfd}$ is the earth-fault current of the healthy feeder).

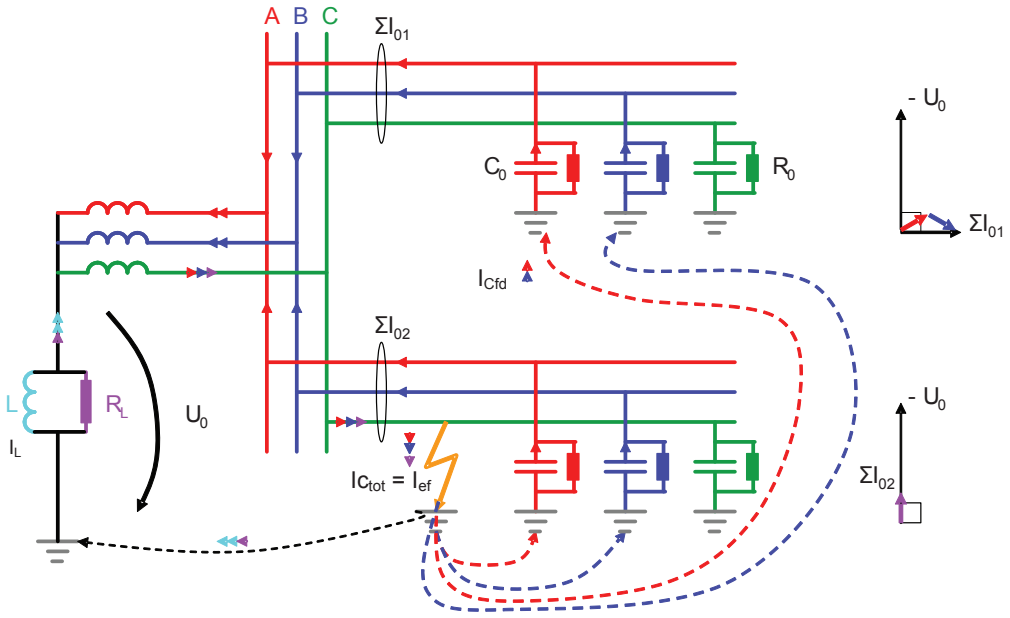



*Figure 311: Typical radial compensated network employed with wattmetric protection*

The wattmetric function is activated when the residual active power component exceeds the set limit. However, to ensure a selective operation, it is also required that the residual current and residual voltage also exceed the set limit.

It is highly recommended that core balance current transformers are used for measuring Io when using the wattmetric method. When a low transformation ratio is used, the current transformer can suffer accuracy problems and even a distorted secondary current waveform with some core balance current transformers. Therefore, to ensure a sufficient accuracy of the residual current measurement and consequently a better selectivity of the scheme, the core balance current transformer should preferably have a transformation ratio of at least 70:1. Lower transformation ratios such as 50:1 or 50:5 are not recommended, unless the phase displacement errors and current transformer amplitude are checked first.

It is not recommended to use the directional wattmetric protection in case of a ring or meshed system as the wattmetric requires a radial power flow to operate.

The relay characteristic angle needs to be set based on the system earthing. In an unearthed network, that is, when the network is only coupled to earth via the capacitances between the phase conductors and earth, the characteristic angle is chosen as -90°.

In compensated networks, the capacitive fault current and inductive resonance coil current compensate each other, meaning that the fault current is mainly resistive and has zero phase shift compared to the residual voltage. In such networks, the characteristic angle is chosen as 0°. Often the magnitude of an active component is small and must be increased by means of a parallel resistor in a compensation coil. In networks where the neutral point is earthed through a low resistance, the characteristic angle is always 0°.

As the amplitude of the residual current is independent of the fault location, the selectivity of the earth-fault protection is achieved with time coordination.

The use of wattmetric protection gives a possibility to use the dedicated inverse definite minimum time characteristics. This is applicable in large high-impedance earthed networks with a large capacitive earth-fault current.

In a network employing a low-impedance earthed system, a medium-size neutral point resistor is used. Such a resistor gives a resistive earth-fault current component of about 200...400 A for an excessive earth fault. In such a system, the directional residual power protection gives better possibilities for selectivity enabled by the inverse time power characteristics.

### 4.2.7.9 Signals

#### WPWDE Input signals

**Table 595: WPWDE Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RCA_CTL | BOOLEAN | 0=False | Relay characteristic angle control |

#### WPWDE Output signals

**Table 596: WPWDE Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.2.7.10 WPWDE Settings

**Table 597: WPWDE Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Directional mode | 2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Current start value | 0.010...5.000 | xIn | 0.001 | 0.010 | Minimum operate residual current for deciding fault direction |
| Voltage start value | 0.010...1.000 | xUn | 0.001 | 0.010 | Start value for residual voltage |
| Power start value | 0.003...1.000 | xSn | 0.001 | 0.003 | Start value for residual active power |
| Reference power | 0.050...1.000 | xSn | 0.001 | 0.150 | Reference value of residual power for Wattmetric IDMT curves |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Characteristic angle | -179...180 | deg | 1 | -90 | Characteristic angle |
| Time multiplier | 0.025...2.000 | | 0.005 | 1.000 | Time multiplier for Wattmetric IDMT curves |
| Operating curve type | 5=ANSI Def. Time<br>15=IEC Def. Time<br>20=Wattmetric IDMT | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 60...300000 | ms | 10 | 60 | Operate delay time for definite time |

**Table 598: WPWDE Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 599: WPWDE Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used current measurement mode |
| Correction angle | 0.0...10.0 | deg | 0.1 | 2.0 | Angle correction |
| Min operate current | 0.010...1.000 | xIn | 0.001 | 0.010 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.01 | Minimum operating voltage |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |

### 4.2.7.11 WPWDE Monitored data

**Table 600: WPWDE Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| FAULT_DIR | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Detected fault direction |
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| DIRECTION | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction information |
| ANGLE | FLOAT32 | -180.00...180.00 | deg | Angle between polarizing and operating quantity |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ANGLE_RCA | FLOAT32 | -180.00...180.00 | deg | Angle between operating angle and characteristic angle |
| RES_POWER | FLOAT32 | -160.000...160.000 | xPn | Calculated residual active power |
| WPWDE | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.2.7.12 Technical data

**Table 601: WPWDE Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current and voltage:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Power:<br>±3% of the set value or ±0.002 × $P_n$ |
| Start time [1, 2] | Typically 63 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode [3] | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in IDMT mode | ±5.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2,3,4,5,… |

## 4.2.8 Third harmonic based stator earth-fault protection H3EFPSEF (ANSI 64TN)

### 4.2.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Third harmonic-based stator earth-fault protection | H3EFPSEF | dUo>/Uo3H | 64TN |

[1] Io varied during the test, $U_o$ = 1.0 × $U_n$ = phase-to-earth voltage during earth fault in compensated or unearthed network, the residual power value before fault = 0.0 pu, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements.
[2] Includes the delay of the signal output contact.
[3] Start time of the function also included.

### 4.2.8.2 Function block




*Figure 312: Function block*

### 4.2.8.3 Functionality

The third harmonic-based stator earth-fault protection H3EFPSEF is used to detect stator earth fault at the neutral point and at least up to 15...20% from the neutral point along the stator winding. H3EFPSEF compares the third harmonic voltages produced by the generator itself at both neutral and terminal side of the generator for detecting earth fault.

H3EFPSEF provides two alternative protection methods:

- Differential of the third harmonic component measured both at generator neutral and terminal side
- Neutral side third harmonic undervoltage

H3EFPSEF operates with the definite time DT characteristics.

H3EFPSEF contains a blocking functionality. Blocking deactivates all outputs and reset timers.

### 4.2.8.4 Analog channel configuration

H3EFPSEF has three analog group inputs which must be properly configured.

**Table 602: Analog inputs**

| Input | Description |
|---|---|
| U3P [1] | Three-phase voltages Necessary when *Voltage selection* is set to "Uo", "Phase A", "Phase B" or "Phase C" |
| URES [2] | Residual voltage (measured or calculated) Necessary when *Voltage selection* is set to "Uo" |
| UNEUT | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

[1] Can be connected to GRPOFF if *Voltage selection* is set to "No voltage" or "Uo".
[2] Can be connected to GRPOFF if *Voltage selection* is other than "Uo".

**Table 603: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with at least one voltage channel connected. |
| URES calculated | The function requires that all three voltage channels from the terminal side are connected to calculate residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |
| UNEUT calculated | The function requires that all three voltage channels from the neutral side are connected to calculate residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.8.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”.

The operation of the third harmonic-based stator earth-fault protection function can be described using a module diagram. All the modules in the diagram are explained in the next sections.

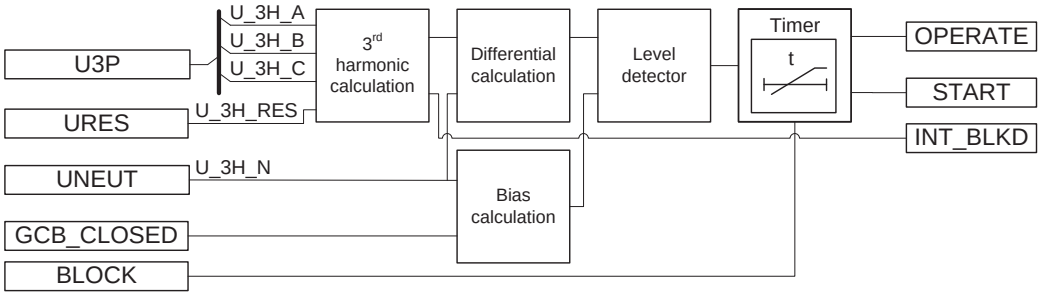



*Figure 313: Functional module diagram*

#### 3rd harmonic calculation (terminal side)

3rd harmonic calculation calculates the magnitude and phase angle of the third harmonic voltage at the generator terminal $\bar{U}_{3H_T}$. Calculation of the third harmonic voltage depends on the availability of terminal side voltage and is specified by the *Voltage selection* setting.

- *Voltage selection* setting is set to "No voltage" if phase-to-earth voltages are not available at the terminal side. Even in a situation where only phase-to-phase voltages are available, *Voltage selection* is set to "No Voltage" because phase-to-phase voltages do not contain a third harmonic component. With *Voltage*

*selection* set to "No Voltage", third harmonic-based earth-fault protection is based on third harmonic neutral side undervoltage protection.

- *Voltage selection* setting is set to "Measured Uo" if the third harmonic voltage is measured directly from an open-delta voltage connection of the voltage transformer or the third harmonic voltage is calculated using all three phase-to-earth voltages. If the terminal side voltage is fed from an open-delta voltage connection of the voltage transformer, the terminal side third harmonic voltage Û3H_T is the same as the measured open-delta voltage Û3H_RES.

$$\overline{U}_{3H_T} = \overline{U}_{3H_RES}$$

(Equation 77)

If all three phase-to-earth voltages are available, the terminal side third harmonic voltage is calculated as a vector average of the third harmonic voltages of all three phases.

$$\overline{U}_{3H_T} = \frac{1}{3} \times (\overline{U}_{3H_A} + \overline{U}_{3H_B} + \overline{U}_{3H_C})$$

(Equation 78)

- If only one phase-to-earth voltage is available, the *Voltage selection* setting is set to the respective phase, that is, "Phase A" or "Phase B" or "Phase C" based on the available phase. In this case, the magnitude of the terminal side third harmonic voltage is assumed to be equal to the third harmonic voltage of the phase available.

$$\overline{U}_{3H_T} = \overline{U}_{3H_A} \text{ or } \overline{U}_{3H_B} \text{ or } \overline{U}_{3H_C}$$

(Equation 79)

The function is internally blocked if the magnitude of calculated $\bar{U}_{3H_T}$ is lower than the set *Voltage block value*. This also activates the `INT_BLKD` output.

**Differential calculation**

The amplitude of the third harmonic differential voltage can be calculated using the following equation.

$$UD_{3H} = \left| \overline{U}_{3H_T} + \overline{U}_{3H_N} \right|$$

(Equation 80)

| | |
|---|---|
| $UD_{3H}$ | Magnitude of the third harmonic differential voltage |
| $\bar{U}_{3H_T}$ | Terminal side third harmonic voltage phasor |
| $\bar{U}_{3H_N}$ | Neutral side third harmonic voltage phasor |

The magnitude of the third harmonic differential voltage `UD_3H` and the phase angle difference between the terminal side and neutral side third harmonic voltage `U_3HANGL_T_N` are available in the Monitored data view.

**Bias calculation**

The amplitude of the third harmonic bias voltage can be calculated using the following equation.

$$UB_{3H} = Beta \times \left| \bar{U}_{3H_N} \right|$$

(Equation 81)

| | |
|---|---|
| $UB_{3H}$ | Magnitude of the third harmonic bias voltage |
| *Beta* | Setting to achieve the required degree of security under healthy conditions |
| $\bar{U}_{3H_N}$ | Neutral side third harmonic voltage phasor |

The third harmonic bias voltage calculation shown in *Equation 81* is valid under all operating conditions if there is no generator circuit breaker between generator and transformer. But if the generator circuit breaker is used, it is needed to reduce the sensitivity of the protection when it is open. The use of the generator circuit breaker is defined by *Generator CB used* setting set to "Yes" and the open position is sensed when the binary input GCB_CLOSED available is FALSE.

With the generator breaker in the open position, function desensitizes the protection by multiplying the value of the *Beta* setting with the set constant *CB open factor* setting.

$$UB_{3H} = CB\ open\ factor \times Beta \times \left| \bar{U}_{3H_N} \right|$$

(Equation 82)

Neutral side third harmonic voltage is measured via a voltage transformer between the generator neutral point and the earth. The magnitude of the third harmonic biased voltage UB_3H is available in the Monitored data view.

**Level detector**

In the third harmonic differential method, Level detector compares the third harmonic differential voltage with the third harmonic bias voltage. If the differential voltage exceeds the biased voltage, the module sends an enabling signal to start the timer.

If the terminal voltage is not available, that is, *Voltage selection* is set to "No voltage" the module compares the neutral side third harmonic voltage U_3H_N to the set *Voltage N 3.H Lim*.

**Timer**

Once activated, Timer activates the START output. The Timer characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

Timer calculates the start duration START_DUR value, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all outputs and resets internal timers.

### 4.2.8.6 Application

Mechanical and thermal stress deteriorates stator winding insulation, which can eventually cause an earth fault between the winding and stator core.

The fault current magnitude in case of stator earth fault depends on the grounding type. Common practice in most countries is to earth the generator neutral side through a resistor. The resistor is selected such as to limit the maximum earth-fault current in the range of 5...10 A. The same can be done by connecting a single phase voltage transformer between the neutral side and earth, and with an equivalent resistor on the secondary side of the transformer.

In a normal operating condition, that is, when there is no earth fault, the residual voltage is close to zero with no zero-sequence current flowing in the generator. When a phase-to-earth fault occurs, the residual voltage increases and the current flows through the neutral. The simplest way to protect the stator winding against an earth fault is by providing residual overvoltage protection (or residual/neutral overcurrent protection). However, at best these simple schemes can protect only 95% of the stator winding, leaving 5% of the neutral end unprotected. This is because the voltage generated in the faulted winding decreases as the fault point becomes closer to the neutral point and it is not enough to drive the protection. Under certain unfavorable conditions, the blind zone may extend up to 20% from the neutral point.

An earth fault close to the neutral point is not dangerous, but an undetected fault may develop into an interturn fault or phase-to-phase fault. Also an undetected earth fault near the neutral point is bypassing the high-impedance grounding, and then another earth fault at the terminal results in a catastrophic situation.

Therefore, it is important to extend the protection to full 100%. The third harmonic voltage-based protection is one such protection which provides effective protection during an earth fault at the neutral point, and at least in the range up to 15...20% from the neutral point along the stator winding.

To achieve a complete stator earth-fault protection, two protection functions should always run in parallel.

- Fundamental frequency-based residual overvoltage protection ROVPTOV
- Third harmonic-based stator earth-fault protection H3EFPSEF

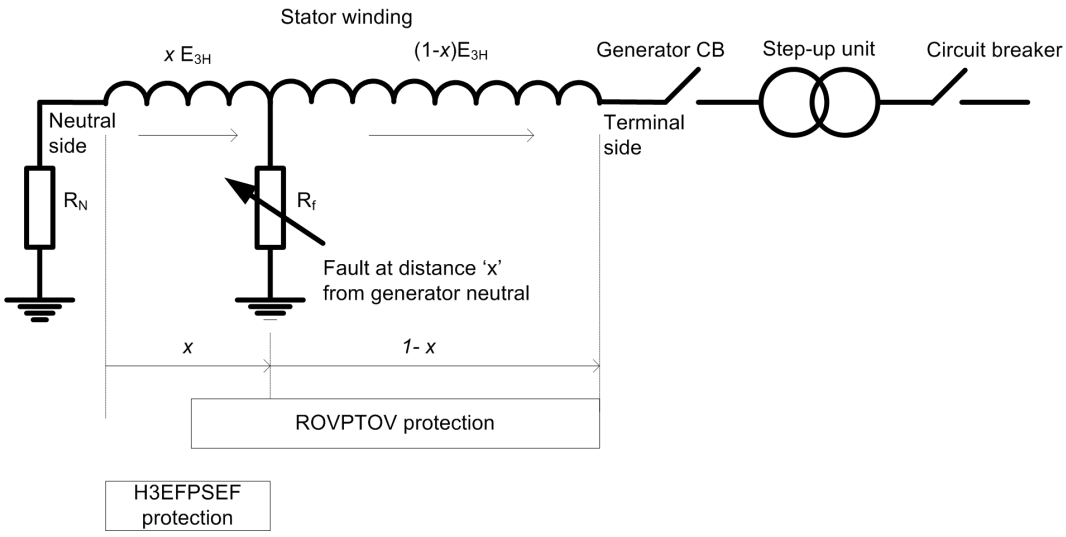



*Figure 314: Complete stator earth-fault protection*

**Third harmonic voltage-based differential protection**

The voltage generated by a generator is not a perfect sinusoidal wave but contains triplen harmonics voltages. These triplen harmonics appear in each phase with the same magnitude and angle, due to which they do not sum to zero and thus also appear in the neutral side of the generator as a zero-sequence quantity. Among all the triplen harmonics voltages generated, the third harmonic voltage has the highest magnitude with the magnitude varying between 1% and 10% of the terminal voltage, depending on the generator design philosophy. However, for a particular generator the magnitude of third harmonics on the neutral side and terminal side depends also on the active power generated.

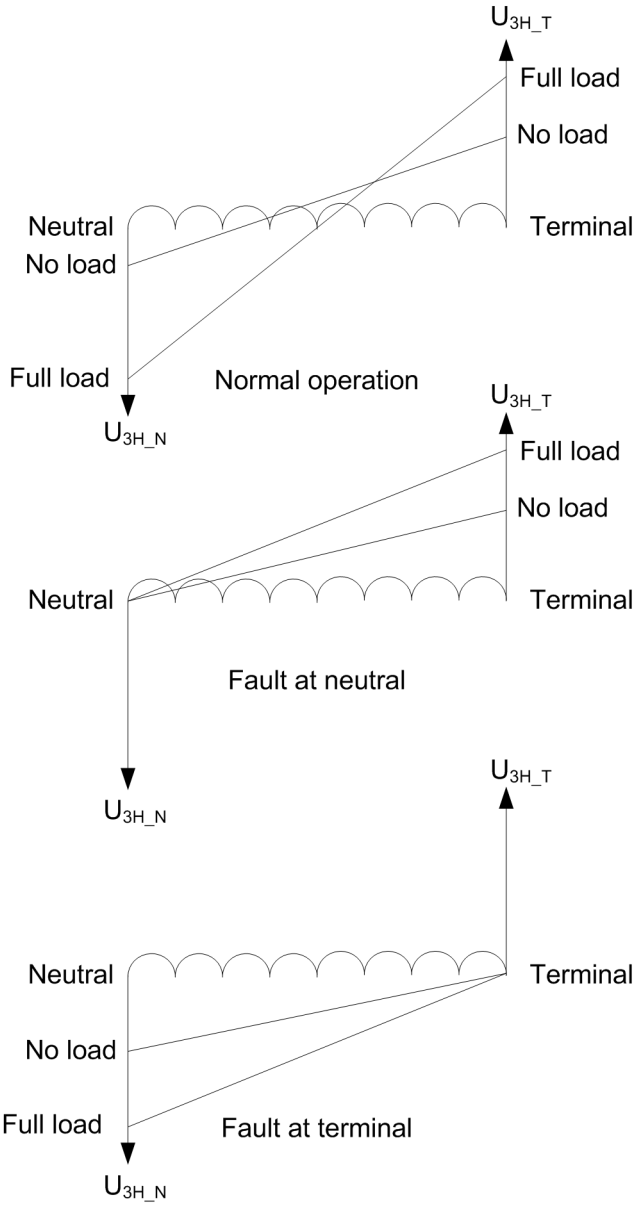



*Figure 315: Typical example of the third-harmonic voltage measured at the generator neutral and terminals under different conditions*

The operating equation of the protection is described in the following equation.

$$\left|\bar{U}_{3H_T} + \bar{U}_{3H_N}\right| - Beta \times \left|\bar{U}_{3H_N}\right| = 0$$

(Equation 83)

The third harmonic voltages $\bar{U}_{3H_T}$ and $\bar{U}_{3H_N}$ are the phasor with its real and imaginary parts. $\bar{U}_{3H_T}$ is approximately in the opposite direction to that of the $\bar{U}_{3H_N}$, however the actual no-fault angle between those two phasors depends on the type of generator earthing. For example, the angle is about 145 degrees for a high-resistance-earthed unit generator.

The equation defines the "operate" and "restrain" regions of the protection. The third harmonic differential protection operates according to the following equation.

$$\left|\bar{U}_{3H_T} + \bar{U}_{3H_N}\right| \geq Beta \times \left|\bar{U}_{3H_N}\right|$$

(Equation 84)

| | |
|---|---|
| $\bar{U}_{3H_N}$ | Neutral side third harmonic voltage phasor |
| $\bar{U}_{3H_T}$ | Terminal side third harmonic voltage phasor |
| *Beta* | Setting to achieve a required degree of security under healthy conditions |
| $\lvert\bar{U}_{3H_T}+\bar{U}_{3H_N}\rvert$ | Magnitude of the third harmonic differential voltage |
| $Beta \cdot \lvert\bar{U}_{3H_N}\rvert$ | Magnitude of the third harmonic bias (restrain) voltage |

Factor *Beta*, which is a setting, can be determined from the condition.

$$\frac{Beta \times \left|\bar{U}_{3H_N}\right|}{\left|\bar{U}_{3H_T} + \bar{U}_{3H_N}\right|} = K$$

(Equation 85)

K is the security factor, for example K = 1.5. *Equation 85* must be satisfied in the normal, healthy condition of the protected generator, with a high enough value for K, so that no unwanted operation of the protection should be expected, regardless the load on the generator.

To assure a reliable functioning of the protection, it is necessary that the generator produces third harmonic voltage which is at least 1% of the generator rated voltage.

As phase-to-phase voltages do not contain a third harmonic component, in situations where the VTs on the terminal side are connected between phase-to-phase, the differential protection in *Equation 85* cannot work. In such case, the *Voltage selection* setting is set to "No Voltage" and H3EFPSEF operates as a simple neutral side third harmonic undervoltage protection.

When H3EFPSEF is reduced to function as only a third harmonic neutral point undervoltage protection, it is necessary to block the function during start-up and shutdown of generator and also when there is no sufficient voltage.

### Calculating Beta value

The setting *Beta* gives the proportion of the third harmonic voltage in the neutral point of the generator to be used as bias quantity. *Beta* must be set so that there

is no risk of trip during the normal, non-faulted operation of the generator. If *Beta* is set high, this limits the portion of the stator winding covered by the protection. In most cases, the default setting “3.00” gives an acceptable sensitivity for an earth fault near the neutral point of the stator winding. However, to assure the best performance, measurements during the normal operation of the generator are to be made during commissioning.

1. The value of the *Beta* setting must be set to “1.00”.
2. Loading of the generator is done at 5 to 10 different load points and the third harmonic differential and bias voltage are measured. Both quantities can be obtained from the Monitored data view of the function.
3. A graph indicating differential and bias voltages as a functions of the load on the generator must be plotted.
4. Based on the graph, such value of the *Beta* setting must be selected that the bias voltage, even in the worst condition, is at least 30% to 50% higher than the differential voltage.

The angle between the third harmonic voltage phasors $\bar{U}_{3H_T}$ and $\bar{U}_{3H_N}$ is 150°, and with the *Beta* setting value "1.0", protection guarantees a stability margin of 25%. This requires the value of *Beta* to be increased so as to increase the stability of protection. The recommended value of the *Beta* setting is at least “1.2”.

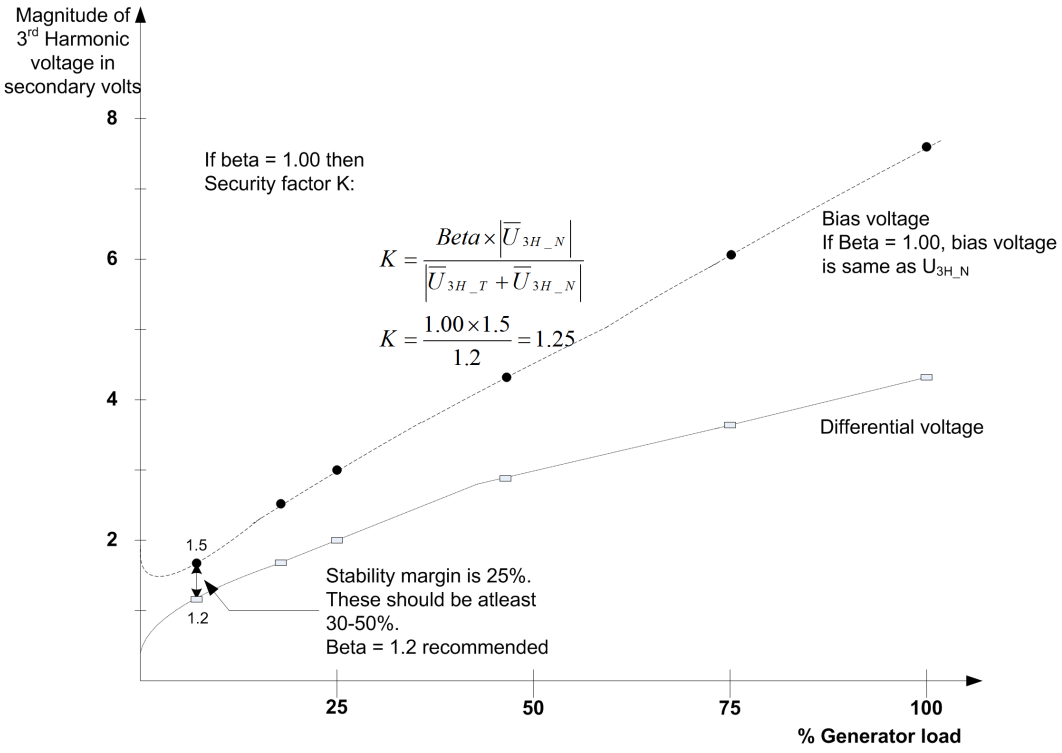



*Figure 316: Typical example of variation of the bias voltage and differential voltage with a change in the active generated load (the angle between the third harmonic terminal and neutral voltage is 150°)*

### Calculating CB Open factor

One of the factors, though not major, governing the magnitude of the generated third harmonic voltage is the generator terminal capacitance. If there is no generator breaker, the capacitive coupling to earth is the same under all operating

conditions. However, the generator breaker normally exists between the protected generator and its power transformer.

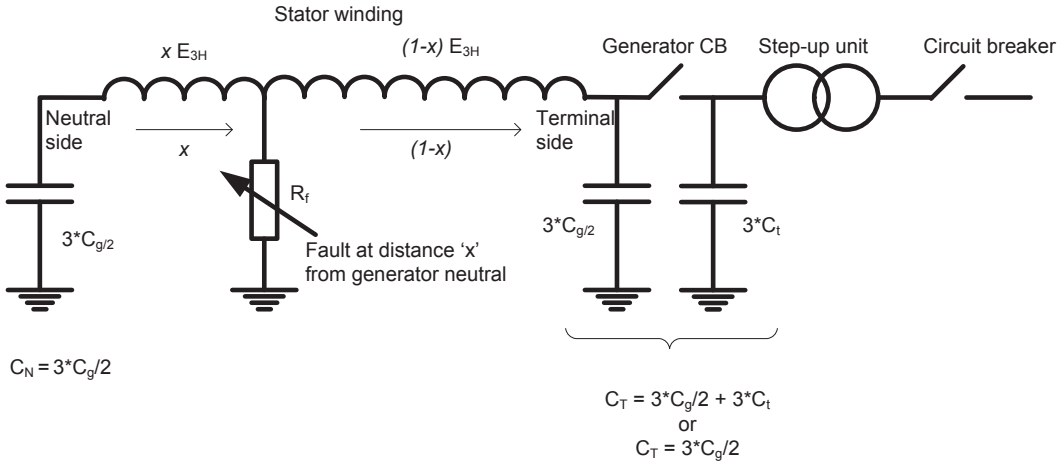



*Figure 317: Capacitance seen at generator terminal and neutral side*

| | |
|---|---|
| $C_g$ | Phase capacitance of generator stator winding |
| $C_t$ | Total external phase capacitance of the system as seen from the generator |
| $C_N$ | Phase-to-ground lumped capacitance of the generator stator winding, between the earth-fault location and the generator neutral |
| $C_T$ | Phase-to-ground lumped capacitance of the generator stator winding, between the generator terminal and earth-fault location |

When there is a generator breaker, the capacitive coupling to earth differs between the operating conditions when the generator is running with the generator breaker open (before synchronization) and with the circuit breaker closed.

With the generator breaker open, the total capacitance is smaller compared to normal operating conditions. This means that the neutral side third harmonic voltage is reduced compared to the normal operating condition. Therefore, there is a need to reduce the sensitivity of the protection. When generator breaker is open, H3EFPSEF desensitizes the protection by multiplying the *Beta* setting with a set constant *CB open factor* setting.

$$\left|\overline{U}_{3H_T} + \overline{U}_{3H_N}\right| \geq \text{CB open factor} \times \text{Beta} \times \left|\overline{U}_{3H_N}\right|$$

(Equation 86)

The *CB Open factor* setting is obtained during commissioning.

1. For a particular value of *Beta* the third harmonic neutral voltage is measured with the generator in the no-load condition and the circuit breaker in the closed position.
2. With the same condition, the third harmonic neutral voltage with the circuit breaker in the open position is measured.
3. *CB Open factor* should be set equal to the ratio of the third harmonic neutral voltage measured with the circuit breaker in the closed position to that in the open.

### 4.2.8.7 Signals

#### H3EFPSEF Input signals

**Table 604: H3EFPSEF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| UNEUT | SIGNAL | - | Analog input |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| GCB_CLOSED | BOOLEAN | 0=False | Generator CB in closed position |

#### H3EFPSEF Output signals

**Table 605: H3EFPSEF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| INT_BLKD | BOOLEAN | Protection internally blocked |

### 4.2.8.8 H3EFPSEF Settings

**Table 606: H3EFPSEF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Beta | 0.50...10.00 | | 0.01 | 3.00 | Portion of neutral side 3rd harmonic used as bias |
| Voltage N 3.H Lim | 0.005...0.200 | xUn | 0.001 | 0.010 | Start value for 3rd harmonic residual undervoltage protection |
| Operate delay time | 20...300000 | ms | 10 | 20 | Operate delay time |

**Table 607: H3EFPSEF Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage selection | 1=No voltage<br>2=Uo<br>4=Phase A<br>5=Phase B<br>6=Phase C | | | 2=Uo | Type of voltage connection available at generator terminal |
| CB open factor | 1.00...10.00 | | 0.01 | 1.00 | Multiplication factor for beta when CB is in open condition |

**Table 608: H3EFPSEF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 609: H3EFPSEF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage block value | 0.010...0.100 | xUn | 0.001 | 0.010 | Low level blocking for 3rd harmonic differential protection |
| Generator CB used | 0=No<br>1=Yes | | | 0=No | Defines if generator circuit breaker exists |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

## 4.2.8.9 H3EFPSEF Monitored data

**Table 610: H3EFPSEF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| UD_3H | FLOAT32 | 0.00...40.00 | xUn | 3rd harmonic differential voltage amplitude |
| UB_3H | FLOAT32 | 0.00...40.00 | xUn | 3rd harmonic bias voltage amplitude |
| U_3H_T | FLOAT32 | 0.00...40.00 | xUn | Terminal side 3rd harmonic voltage amplitude |
| U_3H_N | FLOAT32 | 0.00...40.00 | xUn | Neutral side 3rd harmonic voltage amplitude |
| U_3H_N | FLOAT32 | 0.00...40.00 | xUn | Neutral side 3rd harmonic voltage amplitude |
| U_3HANGL_T_N | FLOAT32 | -180.00...180.00 | deg | Phase angle between 3rd harmonic terminal and neutral voltage |
| H3EFPSEF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.8.10 Technical data

**Table 611: H3EFPSEF Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n$ ±2 Hz |
| | ±5% of the set value or ±0.004 × $U_n$ |
| Start time [1, 2] | Typically 35 ms |
| Reset time | Typically 35 ms |
| Reset ratio | Typically 0.96 (differential mode)<br>Typically 1.04 (under voltage mode) |
| Operate time accuracy | ±1.0% of the set value of ±20 ms |

## 4.2.9 Multifrequency admittance-based earth-fault protection MFADPSDE (ANSI 67NYH)

### 4.2.9.1 Identification

| Description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Multifrequency admittance-based earth-fault protection | MFADPSDE | Io> ->Y | 67NYH |

### 4.2.9.2 Function block

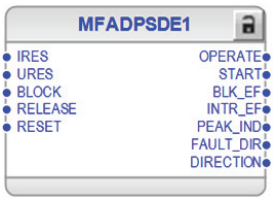



*Figure 318: Function block*

### 4.2.9.3 Functionality

The multifrequency admittance-based earth-fault protection function MFADPSDE provides selective directional earth-fault protection for high-impedance earthed networks, that is, for compensated, unearthed and high-resistance earthed systems. It can be applied for the earth-fault protection of overhead lines and underground cables, regardless of the earth-fault type (continuous, transient or

[1] $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[2] Includes the delay of the signal output contact

intermittent) or the fault resistance value (low or high ohmic). MFADPSDE replaces traditional sensitive directional earth-fault protection (such as Iocos) and transient earth-fault protection (such as Wischer principle) combining the same functionality into a single function block (see *Table 612*).

**Table 612: Comparison of the MFADPSDE functionality with traditional methods in resonant earthed networks**

| | Earth-fault type | | | | |
|---|---|---|---|---|---|
| | **Transient** | **Continuous** | **Restriking/ Intermittent** | **Low-ohmic** | **High-ohmic** |
| Traditional Iocos | | x | | x | x |
| Traditional Wischer | x | | x | x | |
| MFADPSDE | x | x | x | x | x |

As shown by numerous practical field tests, MFADPSDE provides better sensitivity and selectivity compared with traditional methods with less complexity in settings and configuration. MFADPSDE provides enhanced earth-fault protection performance, especially in networks with cable feeders where distributed compensation coils are applied and the earth-fault type is typically intermittent. It is applicable in feeders with distributed compensation regardless of the size or localization of distributed coils. Selective protection can be achieved also in case of overcompensated feeders.

The neutral point in compensated networks is earthed via a controllable centralized arc suppression coil located typically in the primary substation. Additionally, (fixed) distributed compensation coils can be used, which are installed in relevant locations along the protected feeders.

In unearthed networks, the neutral point in the primary substation is not connected to earth. However, in unearthed networks (fixed) distributed compensation coils can also be used to compensate a part of the total capacitive earth-fault current. Typically, the resulting compensation degree is less than 50 percent. Thus, unearthed networks with or without distributed compensation coils are generally referred to as unearthed networks in this manual.

MFADPSDE operation is based on multifrequency neutral admittance measurement using the cumulative phasor summing technique. This concept provides extremely secure, dependable and selective earth-fault protection also when the residual quantities are highly distorted and contain non-fundamental frequency components.

The sensitivity that can be achieved is comparable with traditional fundamental frequency based methods such as IoCos/IoSin (DEFxPTOC), Watt/Varmetric (WPWDE) and neutral admittance (EFPADM).

MFADPSDE can detect faults with dominantly fundamental frequency content as well as transient, intermittent and restriking earth faults. The function can be used as an alternative solution to transient or intermittent function INTRPTEF.

MFADPSDE supports fault direction indication both in operate and in non-operate direction, which can be used during fault location process. The in-built transient detector can be used to identify restriking or intermittent earth faults, and discriminate them from permanent or continuous earth faults.

The operation characteristic is defined by a tilted operation sector, which is universally valid for unearthed and compensated networks.

The operating time characteristic is according to the definite time (DT).

MFADPSDE contains a blocking functionality to block function outputs, timers or the function itself.

### 4.2.9.4 Analog channel configuration

MFADPSDE has two analog group inputs which must be properly configured.

**Table 613: Analog inputs**

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |
| URES | Residual voltage (measured or calculated) |



See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 614: Special conditions**

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected for calculating the residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.9.5 Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "on" and "off".

The operation of MFADPSDE can be described using a module diagram. All the modules in the diagram are explained in the following sections.

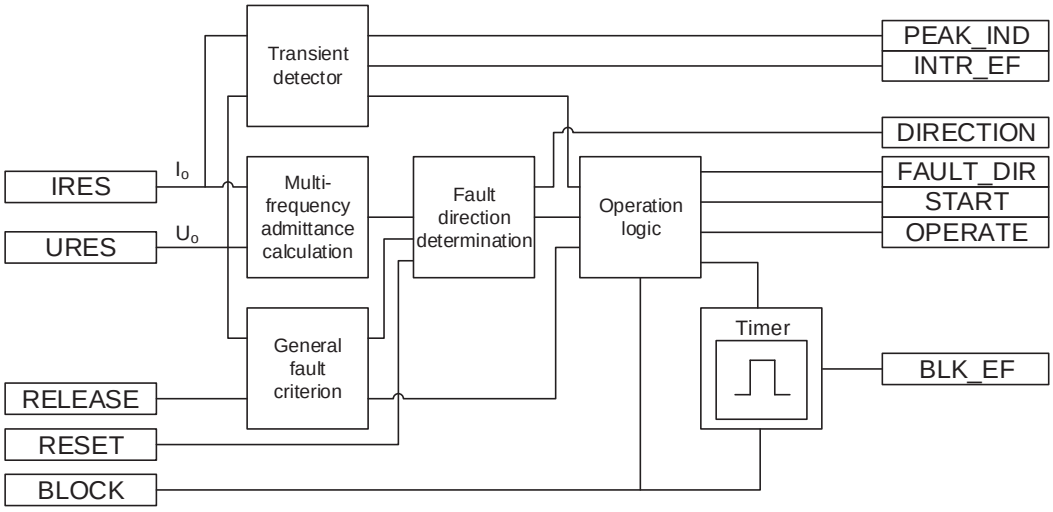



*Figure 319: Functional module diagram*

**General fault criterion**

The General fault criterion ( GFC) module monitors the presence of earth faults in the network and it is based on the value of the fundamental frequency zero-sequence voltage defined as the vector sum of fundamental frequency phase voltage phasors divided by three.

$$\overline{U_0^1} = \frac{\left(\overline{U_A^1} + \overline{U_B^1} + \overline{U_C^1}\right)}{3}$$

(Equation 87)

MFADPSDE supports zero-sequence voltage monitoring based on measurement (from open-delta winding) or calculated (derived from phase-to-earth voltages).

When the magnitude of $\overline{U_o^1}$ exceeds setting *Voltage start value*, an earth fault is detected. The GFC module reports the exceeded value to the Fault direction determination module and Operation logic. The reporting is referenced as General Fault Criterion release.

The setting *Voltage start value* defines the basic sensitivity of MFADPSDE. To avoid unselective start or operation, *Voltage start value* must always be set above the maximum healthy-state zero-sequence voltage value, considering network topology changes, compensation coil and parallel resistor switching status and compensation degree variations. The setting *Voltage start value* can be easily selected based on the resonance curve calculated by the coil controller in corresponding network conditions (see *Figure 320*).

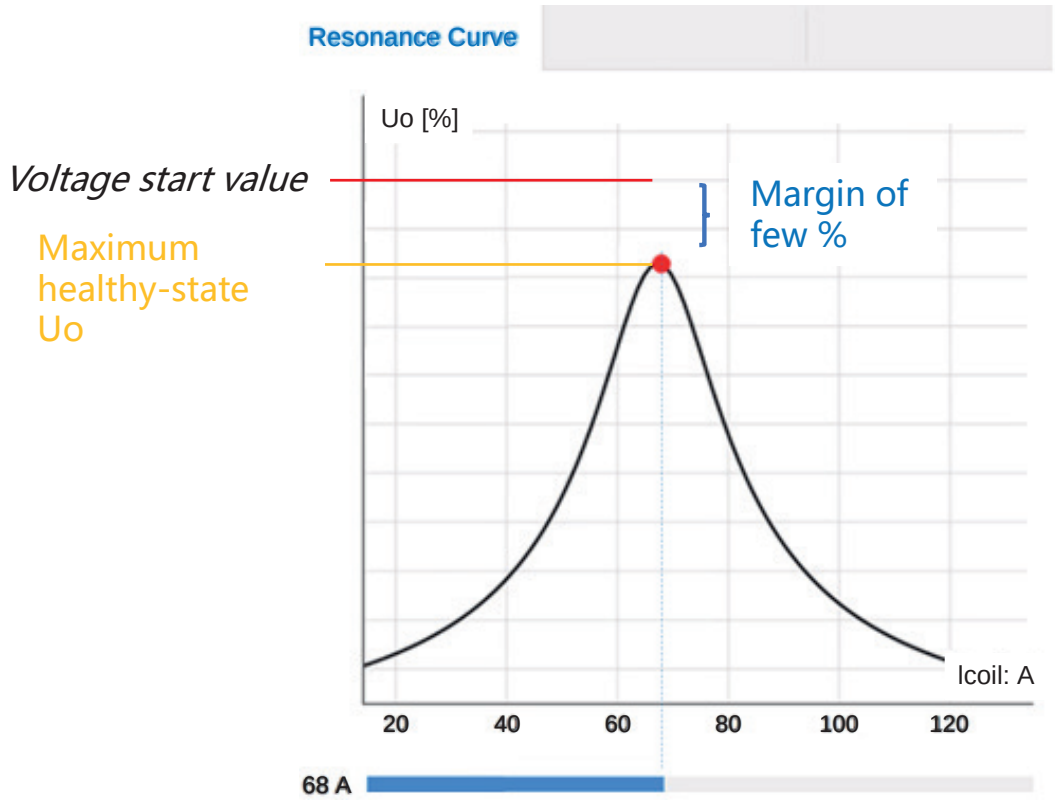



*Figure 320: Example of selection of setting Voltage start value to maximize the earth-fault detection sensitivity based on the resonance curve calculated by the coil controller*

There are three MFADPSDE instances (stages) available. The sensitivity of different stages should be selected differently. For example, stage 1 could have the highest *Voltage start value* and the shortest *Operate delay time*. Thus it would fulfill the requirements for protection operation speed by providing fast operation for low-ohmic earth faults. Stage 2 should have lower *Voltage start value* and longer *Operate delay time* compared with stage 1. This stage would fulfill the requirements for protection sensitivity (in terms of fault resistance value). Stage 3 could be used to detect high-ohmic earth faults and generate alarms for them. To maximize the earth-fault detection sensitivity of stage 3, *Voltage start value* should be selected based on the network's resonance curve (see *Figure 320*).

Such coordination of different protection stages enables:

- Indication (but no tripping) of transient, self-extinguishing earth faults, where the zero-sequence voltage may temporarily rise to a high value and then decay slowly away. This can be achieved by monitoring the START outputs. Delayed operation times of stages 1 and 2 avoid unnecessary breaker operations during self-extinguishing earth faults.
- Fast tripping of low-ohmic permanent earth faults regardless of their type (continuous or intermittent), stage 1
- Delayed tripping of higher-ohmic permanent earth faults regardless of their type (continuous or intermittent), stage 2

- Alarms (but no tripping) about high-ohmic earth faults in order to monitor the insulation status of the network and provide early indication of evolving faults before they cause tripping (by stages 1 or 2), stage 3.

Besides the internal start condition based on residual zero-sequence overvoltage, MFADPSDE can also be externally released by using the RELEASE input. In this case, the external release signal overrides the *Voltage start value* setting and sets the internal limit to the minimum value.

**Multi-frequency admittance calculation**

The Multi-frequency admittance calculation module calculates neutral admittances using fundamental frequency and the 2nd, 3rd, 5th, 7th and 9th harmonic components of residual current and zero-sequence voltage. The fundamental frequency admittance (conductance and susceptance) is calculated if the magnitude of a harmonic in residual current and zero-sequence voltage is measurable by the relay.

$$\overline{Y_0^1} = \frac{3 \cdot \overline{I_0^1}}{-\overline{U_0^1}} = G_o^1 + j \cdot B_o^1$$

(Equation 88)

$\overline{Y_0^1}$ Fundamental frequency neutral admittance phasor

$\overline{I_0^1}$ Fundamental frequency zero-sequence current phasor $(= \frac{(\overline{I_A^1} + \overline{I_B^1} + \overline{I_C^1})}{3})$

$\overline{U_0^1}$ Fundamental frequency zero-sequence voltage phasor $(= \frac{(\overline{U_A^1} + \overline{U_B^1} + \overline{U_C^1})}{3})$

$G_o^1$ Fundamental frequency conductance, $\mathrm{Re}\left(\overline{Y_0^1}\right)$

$B_o^1$ Fundamental frequency susceptance, $\mathrm{Im}\left(\overline{Y_0^1}\right)$

$$\mathrm{Im}\left[\overline{Y_0^n}\right] = \mathrm{Im}\left[\frac{3 \cdot \overline{I_0^n}}{-\overline{U_0^n}}\right] = j \cdot B_o^n$$

(Equation 89)

where n = 2, 3, 5, 7 and 9

$\overline{Y_0^n}$ nth harmonic frequency neutral admittance phasor

$\overline{I_0^n}$ nth harmonic frequency zero-sequence current phasor

*Table continues on the next page*

$\overline{U_0^n}$ nth harmonic frequency zero-sequence voltage phasor

$B_o^n$ nth harmonic frequency susceptance, $\mathrm{Im}\left(\overline{Y_0^n}\right)$

For fault direction determination, the fundamental frequency admittance and harmonic susceptances are summed together in phasor format. The result is the sum admittance phasor defined as

$$\overline{Y}_{osum} = \mathrm{Re}\left[\overline{Y_0^1}\right] + j \cdot \mathrm{Im}\left[\overline{Y_0^1} + \sum_{n=2}^{9} \overline{Y_0^n}\right] = G_o^1 + j \cdot B_{osum}$$

(Equation 90)

The polarity of the polarizing quantity (residual voltage) can be changed (rotated by 180 degrees) by setting the *Pol reversal* parameter to "True" or by switching the polarity of the residual voltage measurement wires.

**Fault direction determination**

If an earth fault is detected by the GFC module, the fault direction is evaluated based on the calculated sum admittance phasor $\overline{Y}_{osum}$ obtained from the Multi-frequency admittance calculation module. To obtain dependable and secure fault direction determination regardless of the fault type (transient, intermittent, restriking, permanent, high or low ohmic), the fault direction is calculated using a special filtering algorithm, Cumulative Phasor Summing (CPS) technique. This filtering method is advantageous during transient, intermittent and restriking earth faults with dominantly non-sinusoidal or transient content. It is equally valid during continuous (stable) earth faults.

The concept of CPS is illustrated in *Figure 321*. It is the result of adding the values of the measured sum admittance phasors together in phasor format in chronological order during the fault. Using the discrete sum admittance phasors $\overline{Y}_{osum}$ in different time instants ($t_1$...$t_5$), the corresponding accumulated sum admittance phasor $\overline{Y}_{osum_CPS}$ is calculated. This phasor is used as directional phasor in determining the direction of the fault.

$$\overline{Y}_{osum_CPS}(t_1) = \overline{Y}_{osum}(t_1)$$

(Equation 91)

$$\overline{Y}_{osum_CPS}(t_2) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2)$$

(Equation 92)

$$\overline{Y}_{osum_CPS}(t_3) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2) + \overline{Y}_{osum}(t_3)$$

(Equation 93)

$$\overline{Y}_{osum_CPS}(t_4) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2) + \overline{Y}_{osum}(t_3) + \overline{Y}_{osum}(t_4)$$

(Equation 94)

$$\overline{Y}_{osum_CPS}(t_5) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2) + \overline{Y}_{osum}(t_3) + \overline{Y}_{osum}(t_4) + \overline{Y}_{osum}(t_5)$$

(Equation 95)

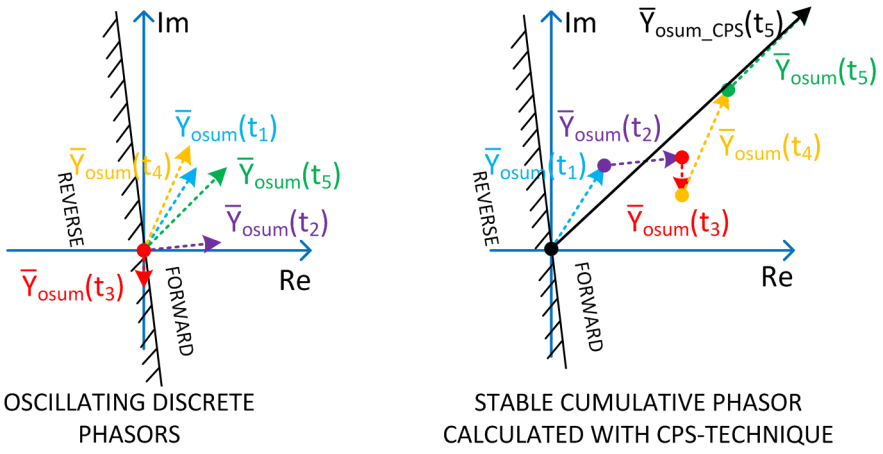



*Figure 321: Principle of Cumulative Phasor Summing (CPS)*

The CPS technique provides a stable directional phasor quantity despite individual phasors varying in magnitude and phase angle in time due to an unstable fault type such as a restriking or intermittent earth fault. This is also true for harmonic components included in the sum admittance phasor. Harmonics typically have a highly fluctuating character.

Harmonic components provide a more distinctive directional determination in compensated networks than the fundamental frequency component. With higher frequencies, the compensation coil appears as very high impedance and the harmonics are not affected by compensation coil and degree of compensation. When harmonics are present, they cause the sum admittance phasor to behave as in case of an unearthed network, where directional phasors point in opposite directions in the faulty and healthy feeder.

The direction of MFADPSDE is defined with setting *Directional mode* as "Forward" or "Reverse". The operation characteristic is defined by a tilted operation sector as illustrated in *Figure 322*. The characteristic provides universal applicability, that is, it is valid in both compensated and unearthed networks even if the compensation coil is temporarily switched off. The tilt of the operation sector is defined with setting *Tilt angle* to compensate the measurement errors of residual current and voltage transformers. The typical setting value of 5 degrees is recommended, but it should always reflect the maximum expected measurement errors.

In case of unearthed network operation, adequate tilt angle must be allowed to ensure dependable operation of MFADPSDE.

In *Figure 322*, phasors 1...4 demonstrate the behavior of the directional phasor in different network fault conditions.

- Phasor 1 depicts the direction of the accumulated sum admittance phasor in case of earth fault outside the protected feeder (assuming that the admittance of the protected feeder is dominantly capacitive). The result is valid regardless of the fault type (low ohmic, high(er) ohmic, permanent, intermittent or restriking). If harmonic components are present in the fault quantities, they turn the phasor alignment to the negative Im(Yo) axis.
- Phasor 2 depicts the direction of accumulated sum admittance phasor in case of earth fault inside the protected feeder when the network is unearthed. The result is also valid in compensated networks when there are harmonic components in the fault quantities (typically low-ohmic permanent, intermittent or restriking fault). In this case, the result is valid regardless of network's actual compensation degree. Harmonics would turn the phasor align to the positive Im(Yo) axis.
- Phasors 3 and 4 depict the direction of accumulated sum admittance phasor in case of higher-ohmic earth fault in the protected feeder without harmonics in the fault quantities when the network is compensated. As no harmonic components are present, the phase angle of the accumulated phasor is determined by the compensation degree of the network. With a high degree of overcompensation, the phasor turns towards the negative Im(Yo) axis (as phasor 4).

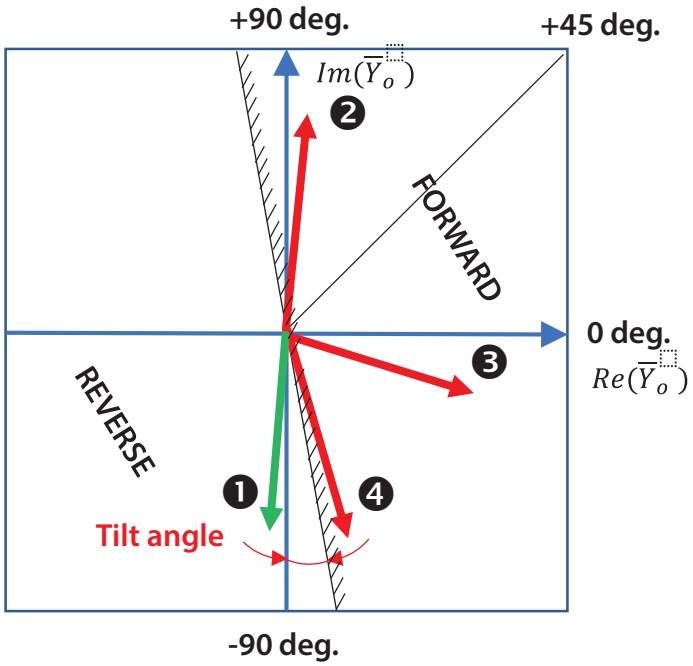



*Figure 322: Directional characteristic of MFADPSDE*

The residual current should be measured with accurate Core Balance Current Transformer (CBCT) to minimize the measurement errors, especially phase displacement. This is especially important when high sensitivity of protection is targeted.

The characteristic *Tilt angle* should reflect the measurement errors, that is, the larger the measurement errors, the higher the *Tilt angle* setting should be. A typical setting value of 5 degrees is recommended.

The maximum value for characteristic *Tilt angle* depends on the ratio of the resistive and reactive component in the measured residual current Io. The operation point moves away from the operation sector mid-point; the lower is the ratio of the resistive and reactive component in the

measured residual current Io. The phase angle of operation point in the faulted feeder can be approximated with equation

$$\varphi = atan\left(\frac{I_{EFFd} + I_{detuning}}{I_{damping}}\right)$$

(Equation 96)

| | |
|---|---|
| $I_{EFFd}$ | Earth-fault current produced by the protected feeder [A] |
| $I_{detuning}$ | Detuning of the arc suppression coil [A] |
| $I_{damping}$ | System damping [A] |

**Example 1:**

$I_{EFFd}$ = 30 A, $I_{detuning}$ = +10 A and $I_{damping}$ = 10 A. From *Equation 96*, j = 76 deg. Thus *Tilt angle* should not exceed ~10 deg.

**Example 2:**

$I_{EFFd}$ = 50 A, $I_{detuning}$ = +10 A and $I_{damping}$ = 5 A. From *Equation 96*, j = 85 deg. Thus *Tilt angle* should not exceed ~3 deg. However, such a low Tilt angle setting may endanger the security of protection due to measurement errors of the CBCTs. In this case, the phase angle of operation point should be increased by considering:

1. System damping increase by increasing the current value of the parallel resistor of the coil.
2. Reduction of the earth-fault current produced by the protected feeder by, for example, installation of distributed compensation coils or by change of the feeder topology.
3. Reduction of overcompensation of the network. The recommendation is to use the undercompensation mode.

The DIRECTION output indicates on which operating sector the current is measured. The FAULT_DIR output indicates in which operation sector the fault current is measured. The output is operational once the function is started.

To adapt the fault direction determination to possible fault direction change during the fault, for example, during manual fault location process, a cyclic accumulation of sum admittance phasors is conducted. The duration of this directional evaluation cycle is 1.2 · *Reset delay time* (minimum of 600 ms). If the fault direction based on the cyclic phasor accumulation is opposite to the function direction output for *Reset delay time* or 500 ms (minimum of 500 ms), the function is reset and fault direction calculation of MFADPSDE is restarted.

If the earth-fault protection generates alarms, MFADPSDE also includes a RESET input which can be used to externally re-trigger the fault direction determination if reevaluation of fault direction during a persistent earth fault is required.

It is also recommended to connect the start signal of non-directional earth fault protection (EFxPTOC), set to operate in case of a cross-country fault, to RESET input or BLOCK input of MFADPSDE to reset phasor accumulation during a cross-country fault. MFADPSDE can then adapt to a fault direction change more rapidly if a singlephase earth fault persists in the system after the other faulty feeder has been tripped (the cross-country fault has been transformed into a single-phase earth fault).

The direction of MFADPSDE is supervised by a settable current magnitude threshold, setting *Min operate current*. The operate current used in the magnitude supervision is measured with a special filtering method, which provides a stable

residual current estimate regardless of the fault type. This estimate is the result of the fundamental frequency admittance calculation using the CPS technique. The stabilized current value is obtained (after conversion) from the corresponding admittance value by multiplying it by the system nominal phase-to-earth voltage value. The equations for calculating the stabilized values of the fundamental frequency admittance and the corresponding current are given below.

$$\overline{Y^1_{o\ stab}} = \frac{3 \cdot \overline{I^1_{0\,CPS}}}{-\overline{U^1_{0\,CPS}}} = \mathrm{Re}\left[\overline{Y^1_{o\ stab}}\right] + j \cdot \mathrm{Im}\left[\overline{Y^1_{o\ stab}}\right] = G^1_{ostab} + j \cdot B^1_{ostab}$$

(Equation 97)

$\overline{Y^1_{o\ stab}}$ Stabilized fundamental frequency admittance estimate, which is result from fundamental frequency admittance calculation utilizing the Cumulative Phasor Summing (CPS) technique.

$\overline{I^1_{0\,CPS}}$ Fundamental frequency zero-sequence current phasor calculated utilizing the Cumulative Phasor Summing (CPS) technique.

$\overline{U^1_{0\,CPS}}$ Fundamental frequency zero-sequence voltage phasor calculated utilizing the Cumulative Phasor Summing (CPS) technique.

$G^1_{ostab}$ Real-part of stabilized fundamental frequency conductance estimate.

$B^1_{ostab}$ Imaginary part of stabilized fundamental frequency susceptance estimate.

$$\overline{I^1_{o\ stab}} = (G^1_{ostab} + j \cdot B^1_{ostab}) \cdot U_{baseres} = I^1_{oCosstab} + j \cdot I^1_{oSinstab}$$

(Equation 98)

$\overline{I^1_{o\ stab}}$ Stabilized fundamental frequency residual current estimate, which is obtained (after conversion) from the corresponding admittance value by multiplying it with the system nominal phase-to-earth voltage value.

$\overline{I^1_{o\ Cosstab}}$ Real-part of stabilized fundamental frequency residual current estimate.

$\overline{I^1_{o\ Sinstab}}$ Imaginary part of stabilized fundamental frequency residual current estimate.

$U_{baseres}$ System nominal phase-to-earth voltage value.

The main advantage of the filtering method is that due to the admittance calculation, the resulting current value does not depend on the fault resistance value, that is, the estimated current magnitude equals the value that is measured during a solid earth fault (Rf = 0 Ω). Another advantage of the method is that it can estimate correct current magnitude also during intermittent or restriking faults.

The setting *Min operate current* defines the minimum operate current which must be exceeded for the function to start or operate.

Setting *Operating quantity* defines whether the current magnitude supervision is based on the “Adaptive”, “Amplitude” or “Resistive” methods.

**Table 615: Comparison of Operating quantity of MFADPSDE with traditional methods**

| Traditional method | Setting Operating quantity of MFADPSDE | | |
|---|---|---|---|
| | Adaptive | Amplitude | Resistive |
| Iosin | | x | |
| Iocos | | | x |
| Iosin/Iocos | x | | |

When Operating quantity is set to "Adaptive", the method adapts the principle of current magnitude supervision to the system earthing condition. This is done by monitoring the phase angle of accumulated sum admittance phasor, (see *Figure 323*).

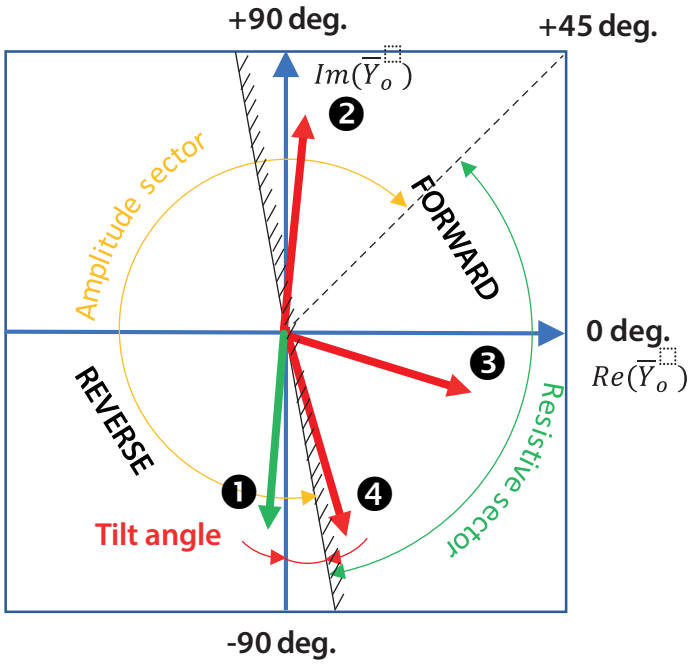



*Figure 323: Automatic adaptation of current magnitude supervision condition (setting Min operate current) to either resistive part or amplitude of I1 ostab based on the phase angle of accumulated sum admittance phasor, when setting Operating quantity = "Adaptive". Directional mode = "Forward"*

If the phase angle of accumulated sum admittance phasor is greater than 45 degrees, current magnitude supervision is based on the amplitude of $\overline{I^1_{o\,stab}}$, which must exceed the set minimum operate current threshold. If the phase angle of accumulated sum admittance phasor is below 45 degrees, current magnitude supervision is based on the resistive part of $\overline{I^1_{o\,stab}}$, which must exceed the set minimum operate current threshold. This automatic adaptation of the magnitude supervision condition enables secure and dependable directional determination in compensated networks, and it is also valid when the network is unearthed (compensation coil is switched off).

If operation direction is set to reverse, the resistive and amplitude sectors are mirrored in the operation characteristics.

Setting *Operating quantity* should be set to "Adaptive" in resonant earthed systems, except when protected feeders are overcompensated by distributed coils. In such a case, *Operating quantity* should be set to "Resistive".

Setting *Operating quantity* to "Adaptive" enables secure and dependable directional determination in compensated networks, which is also valid when the compensation coil is switched off and the network becomes unearthed. In case of an unearthed network, *Min operate current* is automatically compared to the amplitude of $\overline{I^1_{o\ stab}}$. In case of restriking earth-faults, harmonics created by the fault type make the accumulated sum admittance phasor behave as in case of an unearthed network. Therefore, operation can be achieved without the need for resistive part of $\overline{I^1_{o\ stab}}$. This also means that in compensated networks during earth faults with rich harmonic content in residual quantities, operation can be achieved without the parallel resistor of the centralized compensation coil.

When *Operating quantity* is set to "Resistive", the set minimum operate current threshold (setting Min operate current) is compared to the resistive component of $\overline{I^1_{o\ stab}}$ in the whole defined operate sector (see *Figure 324*).

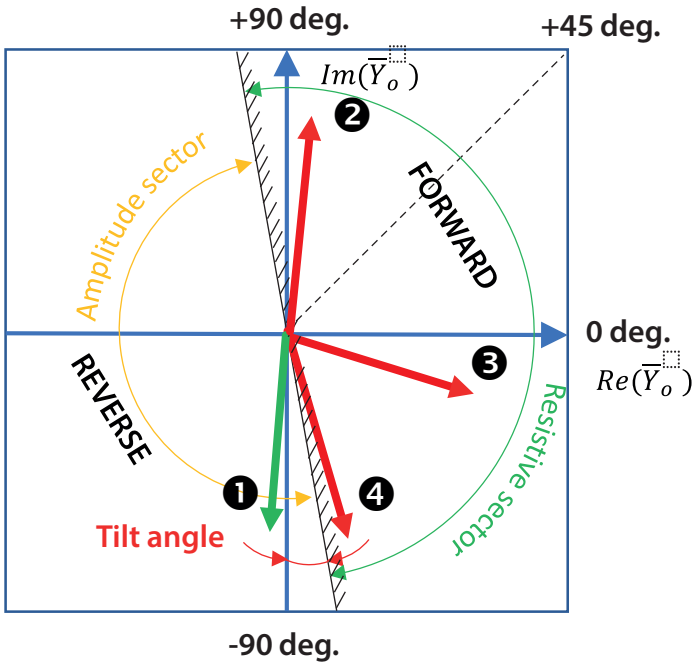



*Figure 324: Operating quantity = "Resistive" and Directional mode = "Forward"*

The resistive mode is valid for resonant earthed networks and high-resistance earthed systems, but not in case of unearthed networks. The resistive mode must be selected when there is a risk of local overcompensation of a protected feeder, that is, when the earth-fault current is compensated with distributed compensation coils and their inductive current exceeds the amount of capacitive current produced by the phase-to-earth capacitances of the feeder.

In compensated networks, where distributed compensation coils are also used to compensate earth-fault current, setting *Operating quantity* should be set to "Resistive". This enables secure and dependable directional determination also in case of local overcompensation where the earth-fault current produced by the healthy feeder can become inductive.

When *Operating quantity* is set to "Amplitude", the set minimum operate current threshold (setting *Min operate current*) is compared to the amplitude of $\overline{I}^{1}_{o\,stab}$ in the whole defined operate sector (see *Figure 325*). This selection can be used in unearthed networks.

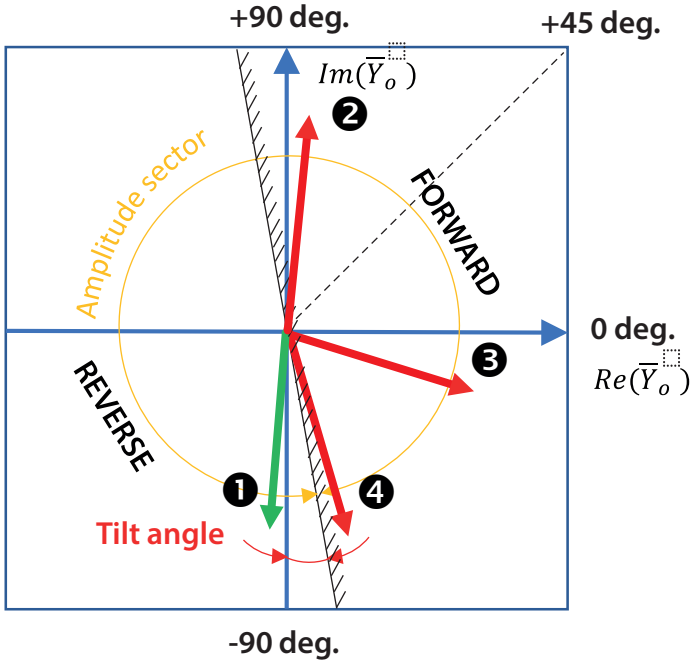



*Figure 325: Operating quantity = "Amplitude" and Directional mode = "Forward"*

If the “Adaptive” or “Resistive” operating quantity is selected, the setting *Min operate current* should be set to value:

$$[pu] < p \cdot IRtot$$

(Equation 99)

| | |
|---|---|
| [pu] | Min operate current |
| IRtot | Total resistive earth-fault current of the network corresponding to the resistive current of the parallel resistor of the coil and the natural losses of the system (typically in order of 1...5 % of the total capacitive earth-fault current of the network). |
| p | security factor = 0.5…0.7 |

It must be set to a value which is lower than the total resistive earth-fault current in order to enable dependable operation.

Estimation of the total resistive earth-fault current of the network including the parallel resistor of the coil and the network losses can be obtained from the

network calculation results of the coil controller in resonant earthed networks. In Petersen coil controller, this value is denoted as 'I_DAMPING' [A]. When evaluating this numerical value, the connection status of the parallel resistor of the coil must be considered. See the example in *Figure 326*. In this case, the parallel resistor of the coil has value 8.6 A and it is permanently connected. The total system damping is calculated as 11.29 A. Thus the natural network losses including the losses of the coil are 11.29 A - 8.6 A = 2.69 A.

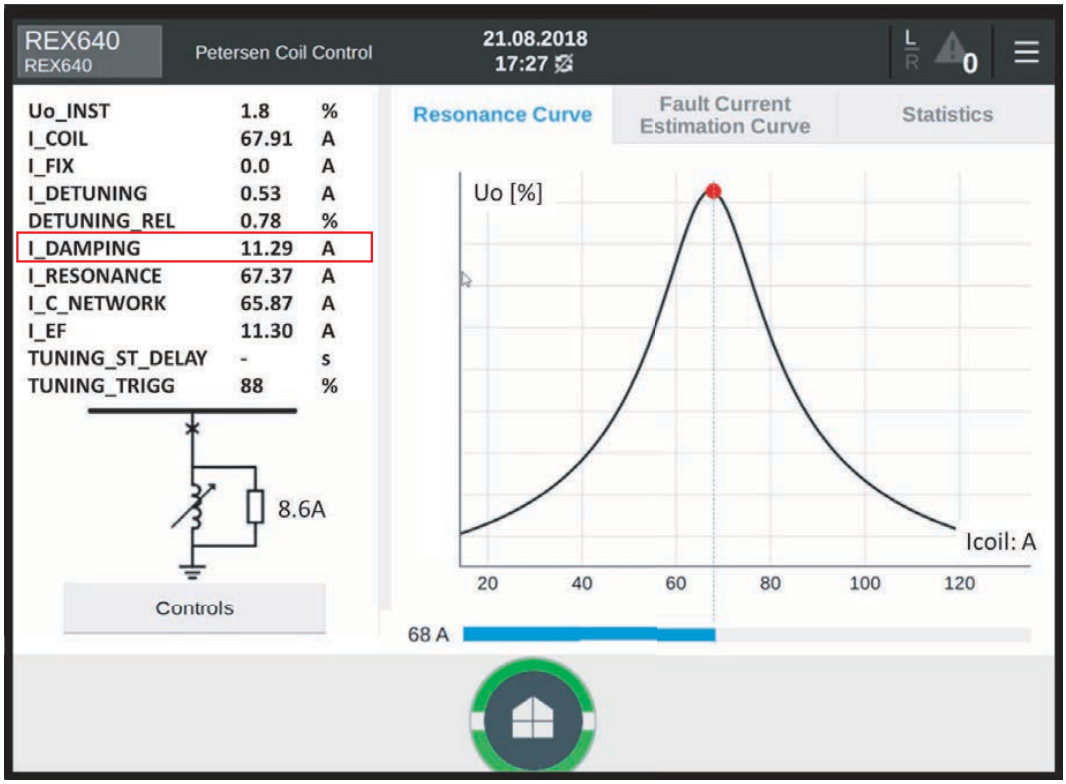



*Figure 326: Example of interpretation of network damping value, I_DAMPING, calculated by the coil controller*

For example, if the resistive current of the parallel resistor is 10 A (at primary voltage level), then a value of 0.5 · 10 A = 5 A could be used for setting *Min operate current*.

The network damping value, I_DAMPING, calculated by the coil controller can be used as a base for setting *Min operate current*.

If *Operating quantity* is set to "Adaptive", the setting value *Min operate current* is also applicable if the coil is disconnected and the network becomes unearthed. In this case, the current magnitude supervision is automatically based on the amplitude of $\overline{I^1_{o\,stab}}$). The selected setting value must never exceed the ampere value of the parallel resistor in order to allow operation in the faulty feeder. In case of smaller ampere value of the parallel resistor, for example 5 A, the recommended security factor should be higher, for example 0.7, so that sufficient margin for CT and VT errors can be achieved.

If *Operating quantity* is set to "Amplitude", the *Min operate current* setting should be selected based on the capacitive earth-fault current values produced by the background network in case of a solid earth fault with a security margin.

The main task of the current magnitude supervision module is to secure the correct directional determination of an earth fault so that only the faulty feeder is disconnected or generates alarms. Therefore, the threshold value *Min operate current* should be selected carefully and should not be set too high as this can inhibit the disconnection of the faulty feeder.

The residual current should be measured with an accurate CBCT to minimize the measurement errors, especially phase displacement.

The parallel resistor should be kept connected during the healthy state so that in case of a fault, earth-fault protection can immediately see sufficient value of resistive component for operation. If the parallel resistor is kept disconnected during the healthy state, it should be immediately connected when the earth fault is detected. This enables the earth-fault protection to operate without delay.

**Transient detector**

The Transient detector module is used for detecting transients in the residual current and zero-sequence voltage signals. Whenever transient is detected, this is indicated with the `PEAK_IND` output. When the number of detected transients equals or exceeds the *Peak counter limit* setting (without the function being reset, depending on the drop-off time set with the *Reset delay time* setting), `INTR_EF` output is activated. This indicates detection of restriking or intermittent earth fault in the network.

Transient detector affects the operation of MFADPSDE ( `START` and `OPERATE` outputs) when operation mode is “Intermittent EF”. For other operation modes, (“General EF”, “Alarming EF”), `PEAK_IND` and `INTR_EF` outputs can be used for monitoring purposes. The operation of the Transient detector is illustrated in *Figure 327*.

Several factors affect the magnitude and frequency of fault transients, such as the fault inception angle on the voltage wave, fault location, fault resistance and the parameters of the feeders and the supplying transformers. If the fault is permanent (non-transient), the initial fault transient in current and voltage can be measured, whereas the intermittent fault creates repetitive transients. The practical sensitivity of transient detection is limited to approximately a few hundreds of ohms of fault resistance. Therefore the application of transient detection is limited to low-ohmic earth faults.

Transient detector is a non-directional function. Thus, if detection of restriking or intermittent earth faults is wanted only in the faulted feeder, the `START` and `INTR_EF` outputs must be ANDed in the configuration.

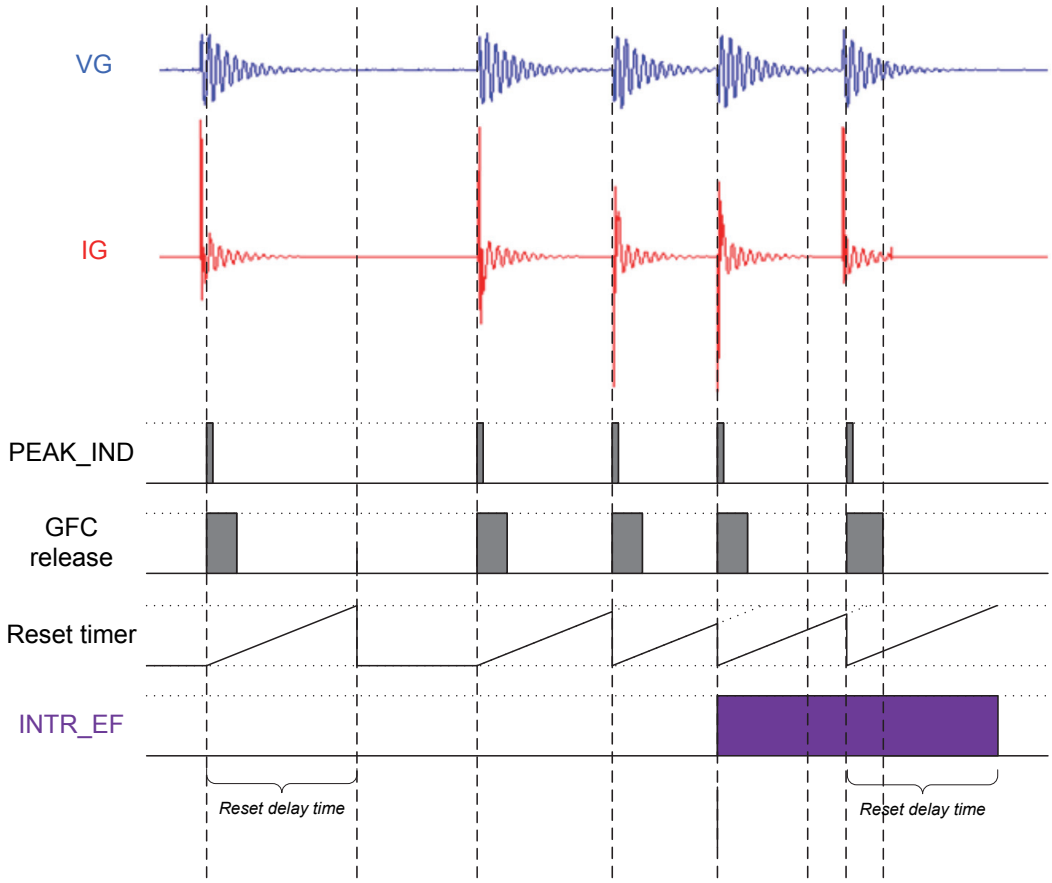



*Figure 327: Example of operation of Transient detector: indication of detected transient by PEAK_IND output and detection of restriking or intermittent earth fault by INTR_EF output (setting Peak counter limit = 3)*

### Operation logic

MFADPSDE supports four operation modes selected with setting Operation mode: "General EF", "Alarming EF", "Intermittent EF" and "Transient EF".

### General EF

Operation mode “General EF” is applicable to various earth faults in high-impedance earthed networks, that is, in compensated, unearthed and high-resistance earthed networks. It detects earth faults regardless of their type (transient, intermittent or restriking, permanent, high or low ohmic) and provides definite operate time for protection regardless of the fault type.

In “General EF” mode, the operate timer is started in the following conditions.

- Earth fault is detected by the GFC
- Fault direction equals *Directional mode* setting
- Estimated stabilized fundamental frequency residual current $\overline{I^{1}_{o\,stab}}$ exceeds the set *Min operate current* level which is applied in current magnitude threshold supervision, and which is further defined with setting *Operating quantity* (available options are "Adaptive", "Amplitude" and "Resistive").

The START output is activated once *Start delay time* has elapsed. OPERATE output is activated once *Operate delay time* has elapsed and the above three conditions are valid. Reset timer is started if any of the above three conditions is not valid. If the fault is transient and self-extinguishes, START output stays activated until the elapse of reset timer (setting Reset delay time). After OPERATE output activation, START and OPERATE outputs are reset immediately, if any of the above three conditions is not valid. The start duration value START_DUR, available in the Monitored data view, indicates the percentage ratio of the start situation and the set operating time.

If detection of temporary earth faults is not desired, the activation of START output can be delayed with setting *Start delay time*. The same setting can also be used to avoid restarting of the function during long lasting post-fault oscillations, if time constant of post-fault oscillations is very long (network losses and damping is low).

To keep the operate timer activated between current spikes during intermittent or restriking earth fault, the *Reset delay time* should be set to a value exceeding the maximum expected time interval between fault spikes (obtained at full resonance condition). Recommended value is at least 300 ms.

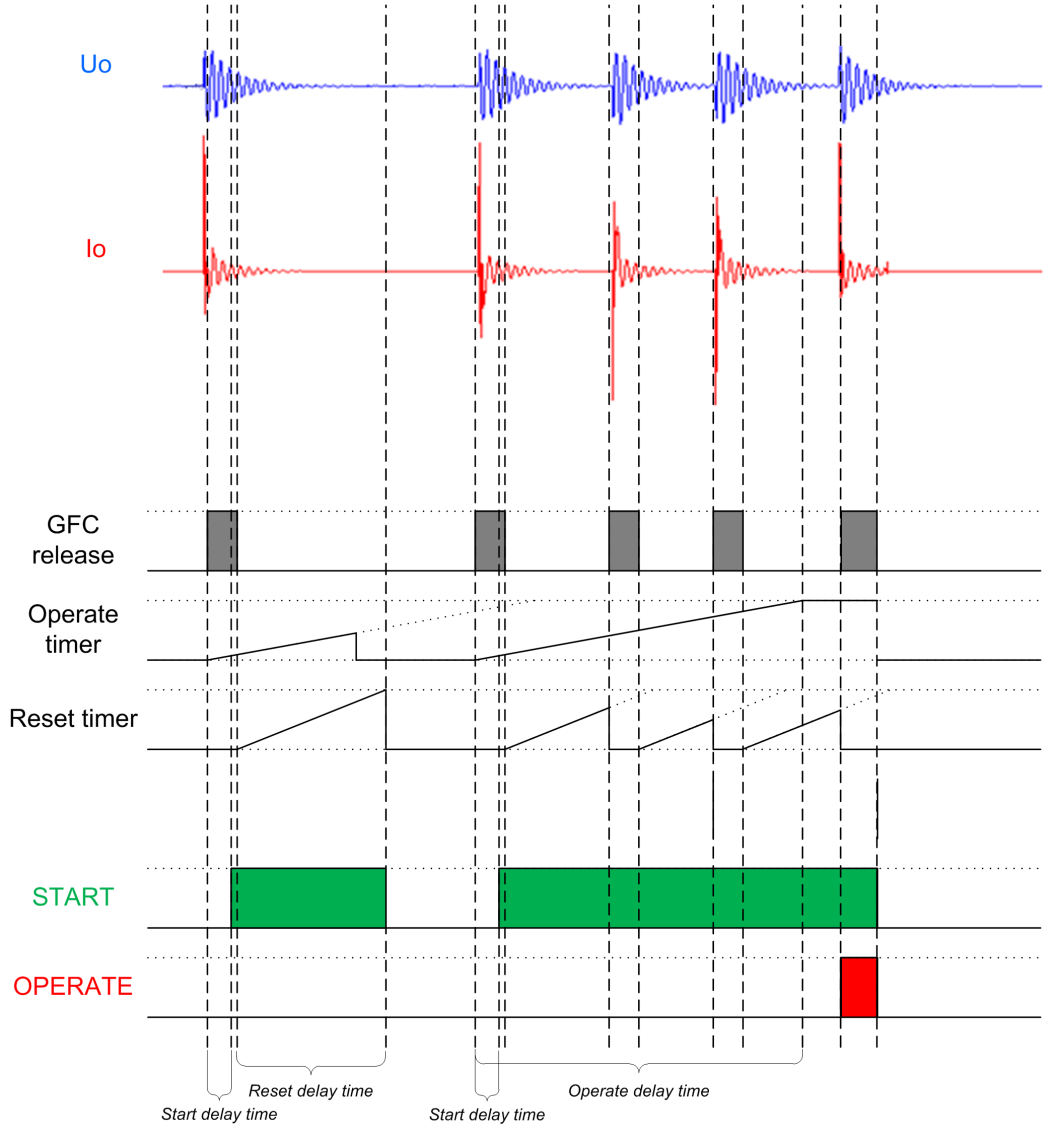



*Figure 328: Operation in "General EF" mode*

**Alarming EF**

Operation mode "Alarming EF" is applicable in all kinds of earth faults in high-impedance earthed networks, that is, in compensated, unearthed and high resistance earthed networks, where fault detection is only alarming. It is intended to detect earth faults regardless of their type (transient, intermittent or restriking, permanent, high or low ohmic).

In "Alarming EF" mode, the operate timer is started during the following conditions.

- Earth fault is detected by the GFC
- Fault direction equals *Directional mode* setting
- Estimated stabilized fundamental frequency residual current $\overline{I^{1}_{o\,stab}}$ exceeds the set *Min operate current* level, which is applied in current magnitude threshold supervision, and which is further defined with setting *Operating quantity* (available options are "Adaptive", "Amplitude" and "Resistive").

The START output is activated once *Start delay time* has elapsed. OPERATE output is not valid in the “Alarming EF” mode. Reset timer is started if any of the above three conditions are not valid. In case the fault is transient and self-extinguishes, START output stays activated until the elapse of reset timer (setting *Reset delay time*).

If detection of temporary earth faults is not desired, the activation of START output can be delayed with setting *Start delay time*.

To keep the operate timer activated between current spikes during intermittent or restriking earth fault, the *Reset delay time* should be set above the maximum expected time interval between fault spikes (obtained at full resonance condition). The recommended value is at least 300 ms.

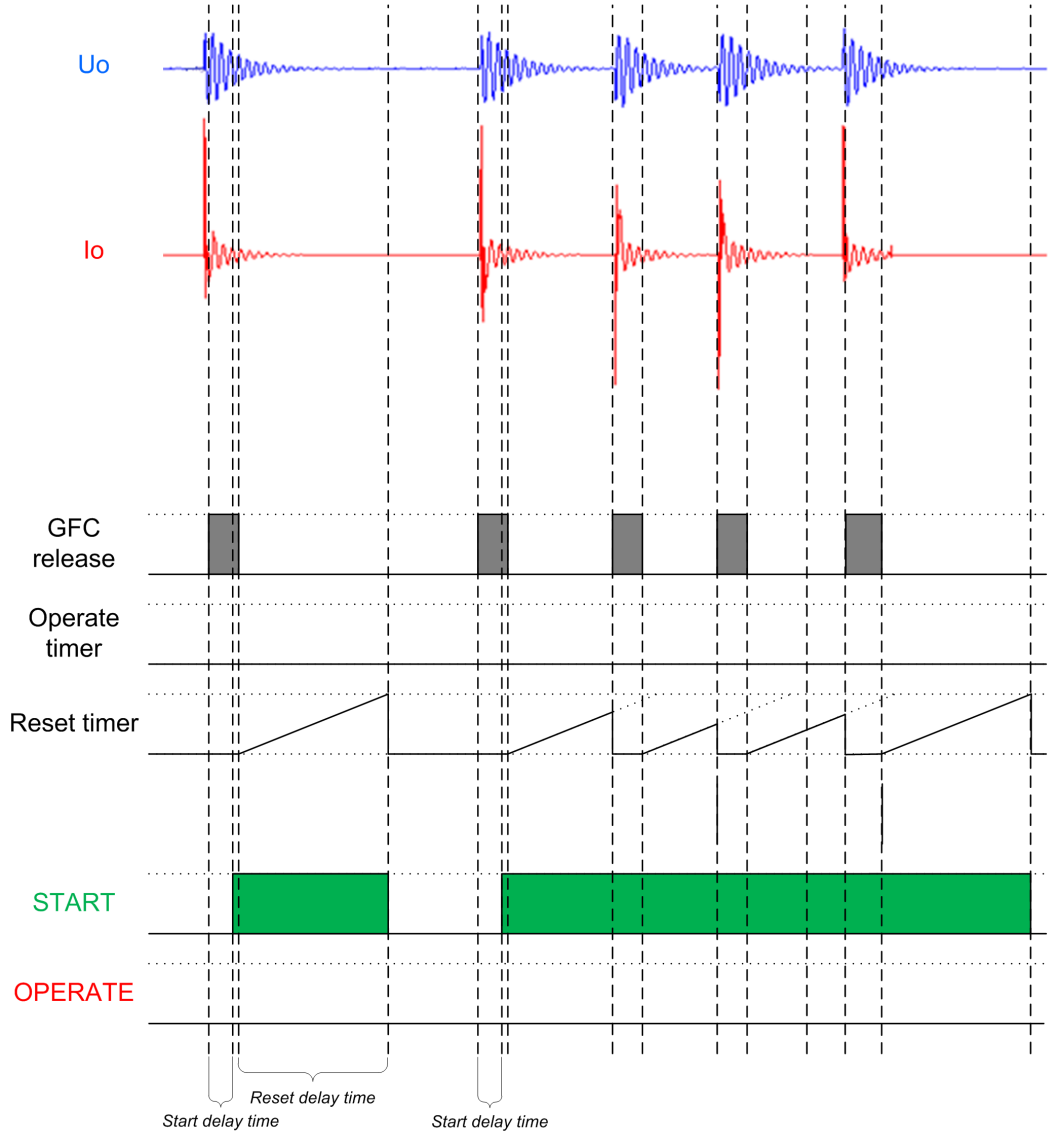



*Figure 329: Operation in “Alarming EF” mode*

**Intermittent EF**

Operation mode “Intermittent EF” is used to detect restriking or intermittent earth faults. A required number of intermittent earth fault transients set with the *Peak counter limit* setting must be detected for operation. Therefore, transient faults or permanent faults with only initial fault ignition transient are not detected in this mode. The application of “Intermittent EF” mode is limited to low ohmic intermittent or restriking earth faults.

In the “Intermittent EF” mode, the operate timer is started when the following conditions are met.

- Transient is detected by the Transient detector (indicated with PEAK_IND output)
- Earth fault is detected by the GFC at time of transient
- Fault direction equals *Directional mode* setting
- Estimated stabilized fundamental frequency residual current $\overline{I^{1}_{o\,stab}}$ exceeds the set *Min operate current* level, which is applied in current magnitude threshold supervision, and which is further defined with setting *Operating quantity* (available options are "Adaptive", "Amplitude" and "Resistive").

When a required number of intermittent earth-fault transients set with the *Peak counter limit* setting are detected without the function being reset (depends on the drop-off time set with the *Reset delay time* setting), the START output is activated. The INTR_EF output is activated to indicate the fault type is intermittent or restriking earth fault. The operate timer is kept activated as long as transients occur during the drop-off time defined by setting *Reset delay time*.

The OPERATE output is activated when *Operate delay time* has elapsed, required number of transients has been detected, earth fault is detected by the GFC, fault direction matches the *Directional mode* setting and estimated stabilized fundamental frequency residual current exceeds set *Minimum operate current* setting.

*Reset delay time* starts to elapse from each detected transient. Function is reset if time between current peaks is more that *Reset delay time* or if the General Fault Criterion release is reset. After OPERATE output activation, START and OPERATE outputs are reset immediately at the falling edge of General Fault Criterion release, that is, when zero-sequence voltage falls below *Voltage start value*. This should be considered if “Intermittent EF" mode is applied in case earth faults are only alarmed to avoid repetitive start and operate events.

*Peak counter limit* setting should not be set below 3 in order to provide secure indication of intermittent/restriking earth faults. This is due to the fact that sometimes the fault ignition transient is characterized by highly distorted waveform, which may result in multiple transient detection at time of fault ignition. By increasing the value of *Peak counter limit* setting, the security of correct fault type identification is increased.

To keep the operate timer activated between current spikes during intermittent or restriking earth faults, *Reset delay time* should be set above the maximum expected time interval between fault spikes (obtained at full resonance condition). The recommended value is at least 300 ms.

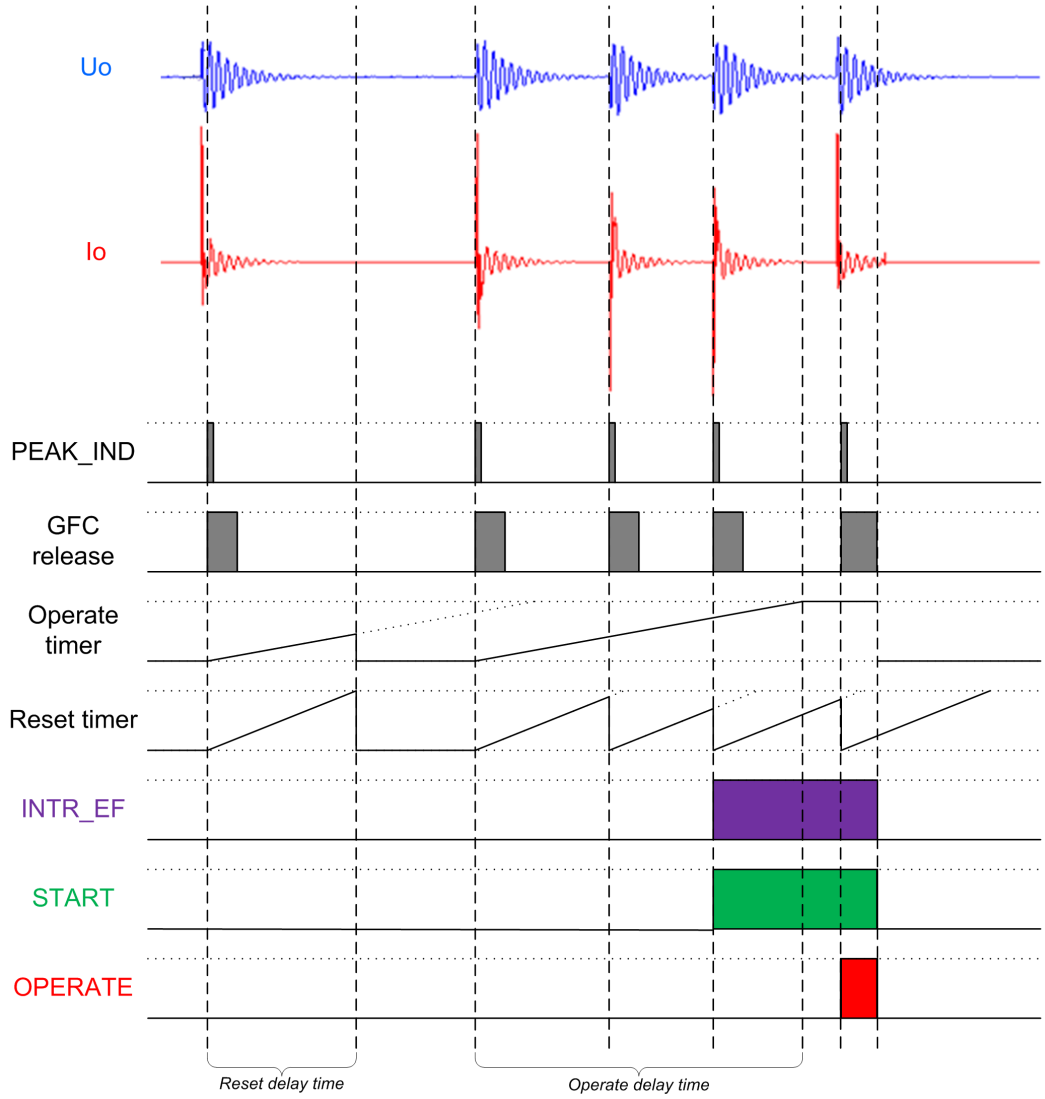



*Figure 330: Operation in "Intermittent EF" mode, Peak counter limit = 3*

**Transient EF**

Operation mode "Transient EF" is dedicated for detecting fast transient faults where the fault current stays on only for a very short time. It is recommended method in networks, where network damping has very small value or when parallel resistor of the coil is not used, for example in sub-transmission networks.

In the "Transient EF" mode, the fault direction is determined from the beginning of the fault and is held until earth-fault is detected by GFC.

In the "Transient EF" mode, the operate timer is started when the following conditions are met.

- Earth fault is detected by the GFC
- Fault direction equals Directional mode setting and fault direction detection is done only at the beginning of the fault

- Estimated stabilized fundamental frequency residual current $\overline{I^1_{o\,stab}}$ exceeds the set Min operate current level, which is applied in current magnitude threshold supervision, and which is further defined with setting Operating quantity (available options are "Adaptive", "Amplitude" and "Resistive").

In the “Transient EF” mode, the START output is activated immediately when start conditions are met.

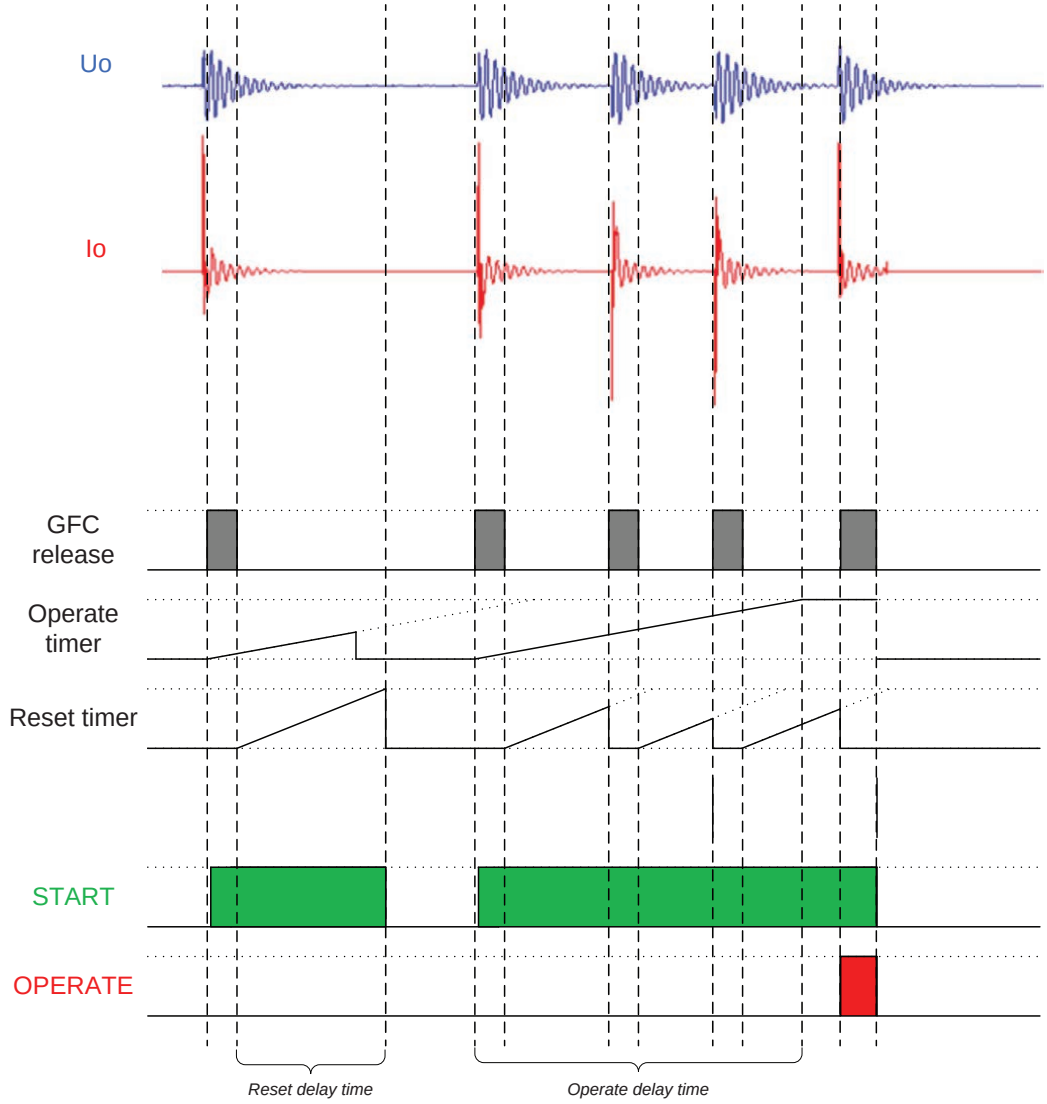



*Figure 331: Operation in “Transient EF” mode*

When operation mode “Transient EF” is selected, *Operating quantity* should be set to "Resistive" and *Min operate current* to the minimum value. *Tilt angle* should be 10 degrees especially if the residual current is measured with Holmgreen (sum) connection of phase current CTs.

### Blocking logic

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be

controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

If the BLOCK input of MFADPSDE is used in the configuration, then "Block all" mode is recommended.

Recommended uses of the BLOCK input of MFADPSDE are:

1. Connecting the start signal of non-directional earth fault protection (EFxPTOC), set to operate in case of a cross-country fault, to BLOCK input of MFADPSDE to reset phasor accumulation during a cross-country fault. MFADPSDE can then adapt to a fault direction change more rapidly if a single-phase earth fault persists in the system after the other faulty feeder has been tripped (the cross-country fault has been transformed into a single-phase earth fault).
2. Connecting the 'Auto-Reclose in progress' output (INPRO) from DARREC to BLOCK input of MFADPSDE to allow faster reset of MFADPSDE during high-speed auto-reclosing cycle HSAR when setting *Reset delay time* equals or is higher than the dead time of high-speed auto-reclosing cycle HSAR.
3. In case of a network with distributed coils but no centralized arc suppression coil at the primary substation (unearthed network), it is recommended to add an additional logic to protection configuration, which blocks MFADPSDE if the frequency of measured Uo and Io becomes lower than nominal. Such condition is valid in network when earth fault becomes disconnected and a phenomenon called 'post-fault oscillation' is initiated.
4. If the parallel resistor of the coil has long connection delay, it is recommended to add an additional logic to protection configuration to enable the release of MFADPSDE at the time of the parallel resistor switching.

The logic to release MFADPSDE at time of resistor (re)connection is illustrated in *Figure 332*.

- Detection of earth fault from residual overvoltage, ROVPTOV
- Delay of release MFADPSDE using TONGAPC connected to the BLOCK input of MFA (inversed)
- Delay of release (TONGAPC: On delay time (ms)) based on known time delays in resistor connection
- Protection operate delay time to be set smaller than the resistor connection duration.

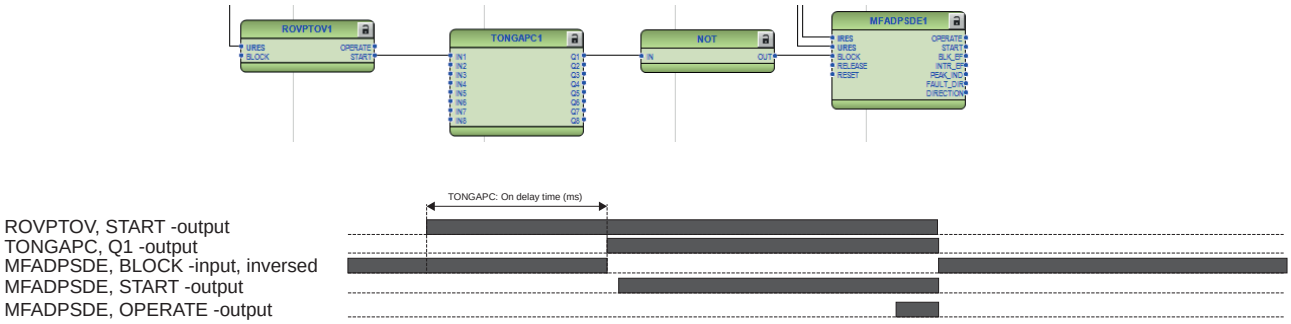



*Figure 332: Logic to release MFADPSDE at the time of resistor (re)connection*

The logic enables exact operate time of MFADPSDE elapsed from time of resistor (re)connection.

In the configuration, equal *Reset delay time* and *Voltage start value* must be used for ROVPTOV and MFADPSDE.

The release delay should be based on known delays in resistor (re)connection:

- Logic OFF-ON-OFF: *Switch on delay* of the parallel resistor.
- Logic ON-OFF-ON: *Switch off delay* + *Time off* time of the parallel resistor.

The resulting total protection operate time is defined as follows:

- Logic OFF-ON-OFF: *Switch on delay* of the parallel resistor + set *Operate delay time* of MFADPSDE.
- Logic ON-OFF-ON: *Switch off delay* + *Time off* time of the parallel resistor + set *Operate delay time* of MFADPSDE.
- Set *Operate delay time* of MFADPSDE smaller than the connection duration time of the resistor.

If earth faults are only alarmed, the external logic is not needed.

When the proposed logic is used and indication of transient earth faults is needed, the START output from INTRPTEF can be used.

### Timer

If the detected fault direction is opposite to the set directional mode and GFC release is active, BLK_EF output is activated once *Start delay time* has elapsed. Reset timer is activated at the falling edge of GFC release, that is, when zero-sequence voltage falls below *Voltage start value*. BLK_EF is reset once the reset delay time elapses. Activation of the BLOCK input deactivates the BLK_EF output and resets Timer.

BLK_EF output is activated when the following conditions are met:

- Earth fault is detected by the GFC
- Fault direction is opposite to *Directional mode* setting

The estimated stabilized fundamental frequency residual current $\overline{I^{1}_{o\,stab}}$ exceeds the internally fixed threshold, which is 1% of In. This current magnitude threshold supervision is based on the “Amplitude” method.

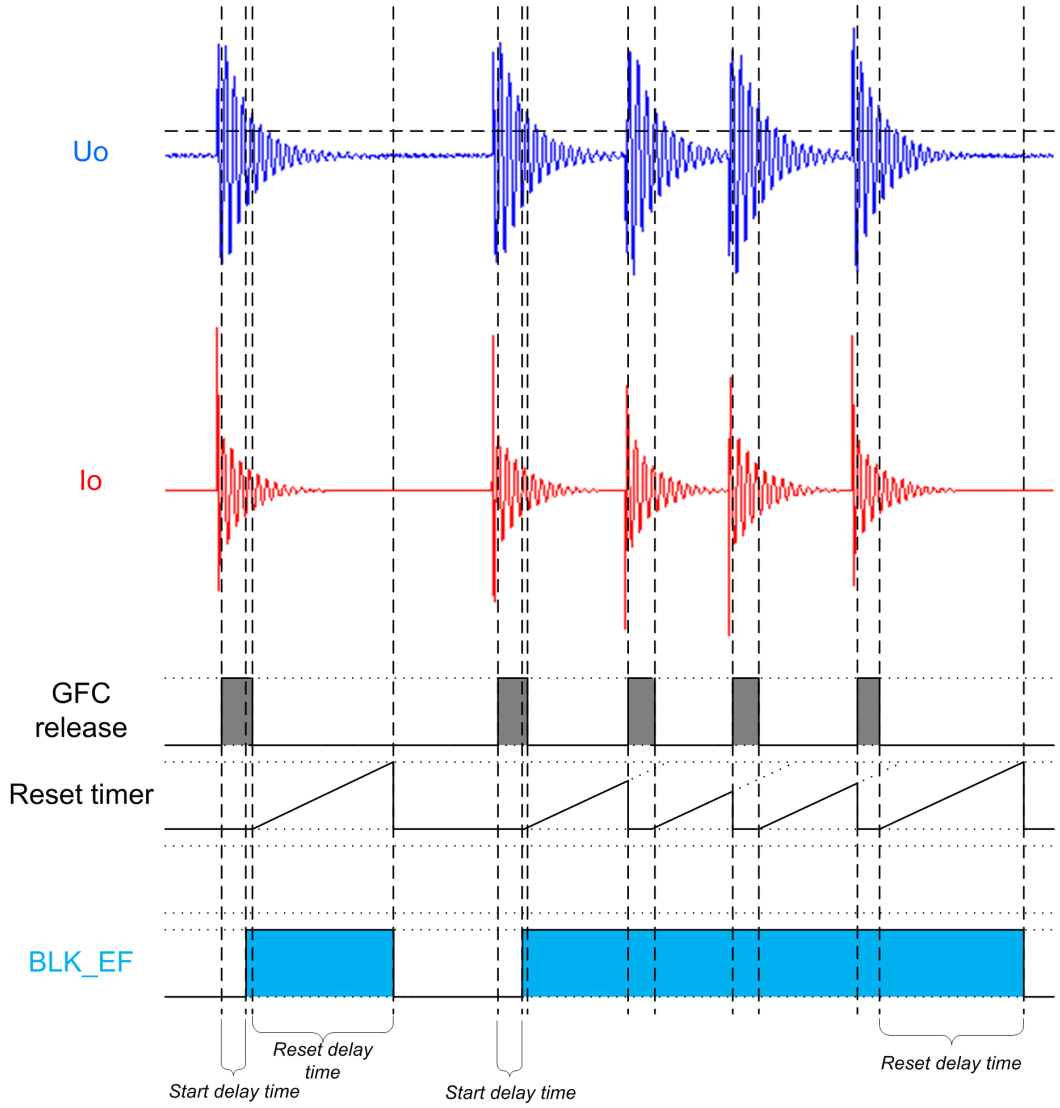



*Figure 333: Activation of BLK_EF output (indication that fault is located opposite to the set operate direction)*

### 4.2.9.6 Application

MFADPSDE provides selective directional earth-fault protection for high-impedance earthed networks, that is, for compensated, unearthed and high-resistance earthed systems. It can be applied for the earth-fault protection of overhead lines and underground cables, regardless of the earth-fault type (continuous, transient or intermittent) or the fault resistance value (low or high ohmic). MFADPSDE replaces traditional sensitive directional earth-fault protection (such as Iocos) and transient earth-fault protection (such as Wischer principle) combining the same functionality into a single function block (see *Table 616*).

**Table 616: Comparison of the MFADPSDE functionality with traditional methods in resonant earthed networks**

| | Earth-fault type | | | | |
|---|---|---|---|---|---|
| | Transient | Continuous | Restriking / Intermittent | Low-ohmic | High-ohmic |
| Traditional Iocos | | x | | x | x |
| Traditional Wischer | x | | x | x | |
| New MFADPSDE | x | x | x | x | x |

As shown by numerous practical field tests, MFADPSDE provides better sensitivity and selectivity compared with traditional methods with less complexity in settings and configuration. MFADPSDE provides enhanced earth-fault protection performance, especially in networks with cable feeders where distributed compensation coils are applied and earth-fault type is typically intermittent. It is applicable in feeders with distributed compensation regardless of the size or localization of distributed coils. Selective protection can be achieved also in case of overcompensated feeders.

MFADPSDE operation is based on multifrequency neutral admittance measurement using the cumulative phasor summing technique. This concept provides extremely secure, dependable and selective earth-fault protection also when the residual quantities are highly distorted and contain non-fundamental frequency components. MFADPSDE is well-suited for compensated networks where measurement signals may have such characteristics, for example, during intermittent earth faults.

MFADPSDE can operate with both low-ohmic and higher-ohmic earth faults, where the sensitivity limit is defined with the residual overvoltage condition. This allows earth faults with several kilohms of fault resistance to be detected in a symmetrical system. The achieved sensitivity is comparable with traditional fundamental frequency based methods such as the IoCos/IoSin (DEFxPTOC), Watt/Varmetric (WPWDE) and neutral admittance (EFPADM).

MFADPSDE can detect faults with dominantly fundamental frequency content as well as transient, intermittent or restriking earth faults. MFADPSDE can be used as an alternative solution to transient or intermittent function INTRPTEF.

MFADPSDE supports fault direction indication in operate and non-operate directions which can be used during fault location process. The in-built transient detector can be used to identify restriking or intermittent earth faults, and discriminate them from permanent or continuous earth faults.

The direction of MFADPSDE can be set as forward or reverse. The operation characteristic is defined by a tilted operation sector, which is universally valid both in unearthed and compensated networks. The tilt of the operation sector should be selected based on the measurement errors of the applied residual current and voltage measurement transformers.

The operating time characteristic is according to the definite time (DT).

The function contains a blocking functionality to block function outputs, timers or the function itself.

MFADPSDE supports both tripping and alarming operation modes. For the alarming earth-fault protection application, the function contains a dedicated operation mode. MFADPSDE provides reliability and sensitivity of protection with a single function. This enables a protection scheme implementation that is simpler than

separate fault type dedicated earth-fault functions which need to be coordinated. Other advantages of MFADPSDE include versatile applicability, good selectivity, good sensitivity and easy setting principles.

Three instances (stages) of MFADPSDE are available.

### 4.2.9.7 Signals

#### MFADPSDE Input signals

**Table 617: MFADPSDE Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RELEASE | BOOLEAN | 0=False | External trigger to release neutral admittance protection |
| RESET | BOOLEAN | 0=False | External trigger to reset direction calculatio |

#### MFADPSDE Output signals

**Table 618: MFADPSDE Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| BLK_EF | BOOLEAN | Block signal for EF to indicate opposite direction peaks |
| INTR_EF | BOOLEAN | Intermittent earth-fault indication |
| PEAK_IND | BOOLEAN | Current transient detection indication |
| FAULT_DIR | Enum | Detected fault direction |
| DIRECTION | Enum | Direction information |

### 4.2.9.8 MFADPSDE Settings

**Table 619: MFADPSDE Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Directional mode | 2=Forward | | | 2=Forward | Directional mode |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 3=Reverse | | | | |
| Voltage start value | 0.01...1.00 | xUn | 0.01 | 0.10 | Voltage start value |
| Operate delay time | 60...1200000 | ms | 10 | 500 | Operate delay time |

**Table 620: MFADPSDE Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operating quantity | 1=Adaptive<br>2=Amplitude<br>3=Resistive | | | 1=Adaptive | Operating quantity selection |
| Min operate current | 0.005...5.000 | xIn | 0.001 | 0.010 | Minimum operate current |
| Tilt angle | 2.0...20.0 | deg | 0.1 | 5.0 | Characteristic tilt angle |

**Table 621: MFADPSDE Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=Intermittent EF<br>2=Transient EF<br>3=General EF<br>4=Alarming EF | | | 3=General EF | Operation criteria |

**Table 622: MFADPSDE Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Peak counter limit | 2...20 | | 1 | 2 | Peak counter limit for restriking EF |
| Start delay time | 30...60000 | ms | 1 | 30 | Start delay time |
| Reset delay time | 0...60000 | ms | 1 | 500 | Reset delay time |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |

## 4.2.9.9 MFADPSDE Monitored data

**Table 623: MFADPSDE Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| ANGLE | FLOAT32 | -180.00...180.00 | deg | Angle between polarizing and operating quantity |
| I_OPER | FLOAT32 | 0.000...40.000 | xIn | Calculated operating current |
| MFADPSDE | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.2.9.10 Technical data

**Table 624: MFADPSDE Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $U_n$ |
| Start time [1] | Typically 35 ms |
| Reset time | Typically 40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

## 4.2.10 Touch voltage based earth-fault current protection IFPTOC (ANSI 46SNQ/59N)

### 4.2.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Touch voltage based earth-fault current protection | IFPTOC | IFPTOC | 46SNQ/59N |

### 4.2.10.2 Function block

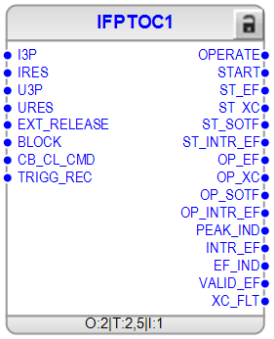



*Figure 334: Function block*

### 4.2.10.3 Functionality

The touch voltage-based earth-fault current protection function IFPTOC provides selective earth-fault protection for single-phase earth faults in high-impedance earthed networks, that is, in compensated, unearthed and high resistance earthed

[1] Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements.

systems. It can be applied for the earth-fault protection of overhead lines and underground cables, regardless of actual earth-fault type (continuous or intermittent) or fault resistance value (low or high ohmic). Operation time of IFPTOC can either be definite time or inverse time. In case of inverse time operation, operation time becomes automatically adapted to estimated single-phase earth-fault current or touch-voltage magnitude.

Traditional directional, sensitive earth-fault protection functions applied in high-impedance earthed networks are typically based on residual quantities ($U_o$, $I_o$). In high-impedance earthed networks residual current does not accurately match the fault current flowing at fault location. This is since the capacitive current contribution of the faulted feeder itself is not measurable using residual current. The higher is the capacitive current contribution of the faulted feeder, the greater is the mismatch of true fault current and residual current ($I_o$). This is the root reason, why operate time cannot be based on measured magnitude of current ($I_o$). Therefore, in traditional directional sensitive earth-fault protection functions operate time must be pre-defined and it is thus based on *assumed* magnitude of fault current. *Actual* fault current magnitude depends on e.g. the prevailing detuning degree of the network during an earth fault, which depends on the actual values of network shunt capacitance and coil inductance. In modern networks with increased degree of cabling, switching operations may result into large variations of network capacitance. On the other hand, typical practical arrangement for adjustment of coil inductance involves mechanical movement of air gap in the iron core, which is a time-consuming process. In case there is great mismatch between the assumed and true fault current magnitude, the fulfillment of electrical safety regulations is questionable. It should be noted that the time constant of coil tuning is much longer than requirements for protection operate time. In modern networks, high temporary detuning conditions are possible due to increase of use of underground cables, which increase feeder total phase-to-earth capacitance enormously.

However, operation of IFPTOC is not based on traditional residual quantities ($U_o$, $I_o$), but on accurate estimation of earth-fault (EF) current flowing at the fault location. Estimation of earth-fault current is done in real-time utilizing changes in phase currents measured at the beginning of the feeder due to a single-phase earth fault.

Thanks to its novel operation principle, the method has several advantages over the traditional state-of-art earth-fault protection methods such as the wattmetric method:

- The method enables automatic, real-time adaptation of protection operation speed according to the prevailing (estimated) single-phase earth-fault current magnitude. The estimated earth-fault current magnitude can be converted into corresponding touch voltage or earth potential rise (EPR) value, which enables direct compliance of protection operation speed according to standard EN50522. As another option, IFPTOC enables protection operation speed according to standard IEEE80. This operation mode can also be used when maximum allowed earth potential rise vs. operation speed follows a relationship such as 750V/ $\sqrt{t}$[*sec*].
- The harmonic content of fault current can be included into fault current magnitude estimate, which further enhances the accuracy and practicality of the novel protection method.
- IFPTOC enables significant improvement on safety and overall dependability of the protection schemes used today in compensated networks. IFPTOC provides unique advantages, for example during the following practical network conditions:
  - On feeders with high capacitive earth-fault current contribution (e.g. long cable feeders), where traditional earth-fault protection is challenged by the

fact that the phase angle difference between $U_o$ and $I_o$ increases as the capacitive earth-fault current contribution increases. Phase angle difference may become so high that correct operation of traditional protection functions is endangered. This is not the case for IFPTOC, as fault current estimate is not affected by the capacitive earth-fault current contribution of the protected feeder itself.
  - In case earth fault occurs during abnormal network topologies, or when fault current compensation is temporarily not effective or when network is operated heavily over- or under-compensated.
- Magnitude of true fault current is estimated without need on any pre-defined information on the network topology.
- Also, the effect of fault resistance can be considered and compensated in the estimated earth-fault current magnitude applying dedicated fault resistance compensation method. This functionality allows acceleration of protection operation speed during high(er) ohmic earth fault when actual fault current magnitude is low.

IFPTOC includes also dedicated protection functionality for important practical earth-fault scenarios such as switch onto fault (SOTF) condition, for intermittent earth faults and for high current cross-country earth-faults. Each of such fault condition can be tripped with individually defined operation criteria enabling high application flexibility and reliability.

### 4.2.10.4 Analog channel configuration

IFPTOC has four analog group inputs which must be properly configured.

**Table 625: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three phase currents |
| IRES | Residual current (measured or calculated) |
| U3P | Three phase voltages |
| URES | Measured or calculated residual voltage |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 626: Special conditions**

| Condition | Description |
|---|---|
| U3P connected real measurements | Recommendation to connect all three phase-to-earth voltage channels. Alternative is at least two phase-to-earth / phaseto-phase voltages and measured residual voltage (URES). |
| URES calculated | Three phase-to-earth voltages must be connected for calculating the residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. check the contents of this chapter and also the preprocessing blocks in this

document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.2.10.5 Operation principle

The *Operation* setting is used to enable or disable the function. When selected “on” the function is enabled and respectively “off” means function is disabled.

The operation of *Touch voltage-based earth-fault current protection IFPTOC* can be described by using a module diagram (see figure below). All the modules in the diagram are explained in the next sections.

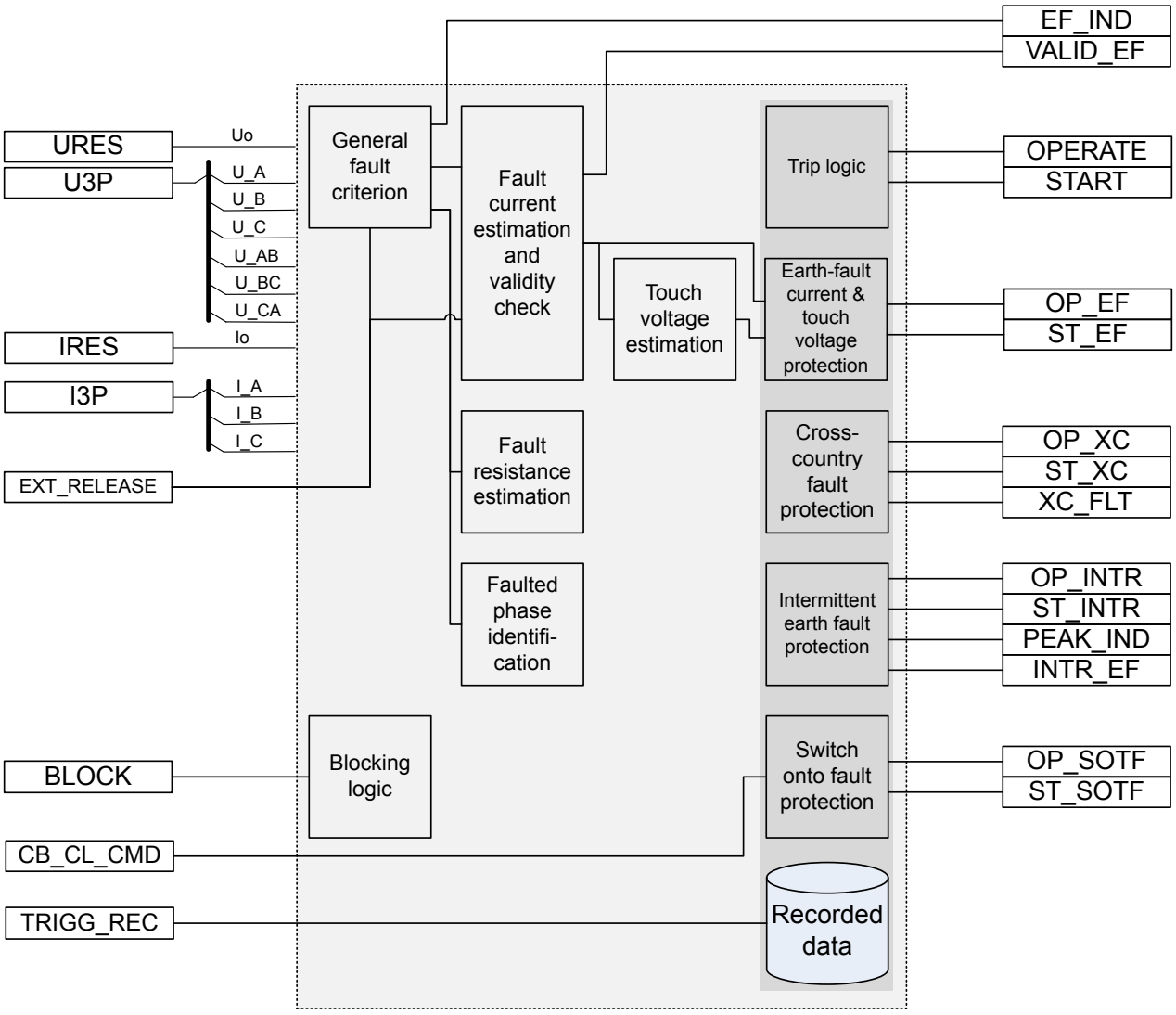



*Figure 335: Functional module diagram*

#### General fault criterion

The General fault criterion (GFC) module monitors the presence of earth fault in the network. It is based on the value of the fundamental frequency residual voltage $\overline{U}_o$

defined as the vector sum of fundamental frequency phase voltage phasors divided by three.

$$\underline{U_o} = (\underline{U_A} + \underline{U_B} + \underline{U_C})/3$$

(Equation 100)

When the magnitude of $U_o$ exceeds setting *Voltage start value*, an earth fault is detected and EF_IND output is set to TRUE. Setting value *Voltage start value* is given in per unit format with system nominal phase-to-earth value ($U_{n_PE}$) as reference.

IFPTOC supports fundamental frequency residual voltage monitoring based on measured $U_o$ from open-delta winding or internally calculated $U_o$ derived from connected phase-to-earth voltages.

Input EXT_RELEASE is alternative method for internal GFC and validity check modules to indicate the presence of earth fault in the protected feeder and to release the calculation of IFPTOC function. Activation of EXT_RELEASE will also override earth-fault validity check criterion i.e. earth-fault current estimate is considered as valid when EXT_RELEASE is activated. It is therefore mandatory that EXT_RELEASE is based on start of directional earth-fault detection function, such as MFADPSDE or DEFxPDEF.

The setting *Voltage start value* defines the basic sensitivity of the IFPTOC function in terms of fault resistance. Fault detection sensitivity in terms of fault resistance can be estimated using the equation below:

$$R_F[ohm] \leq \frac{U_{PE}\cdot\left(\sqrt{I_d^2+I_v^2-I_v^2\cdot U_{o_pu}^2}-I_d\cdot U_{o_pu}\right)}{(I_d^2+I_v^2)\cdot U_{o_pu}}$$

(Equation 101)

where $U_{PE}$ is the system phase-to-earth voltage [V], $I_d$ is the total system damping [A], $I_v$ is the network detuning value [A] and $U_{o_pu}$ is setting *Voltage start value* in per unit.

In compensated networks the minimum value for the setting *Voltage start value* can be easily selected based on the resonance curve calculated by the coil controller considering different network topologies and conditions, refer to *Figure 336*.

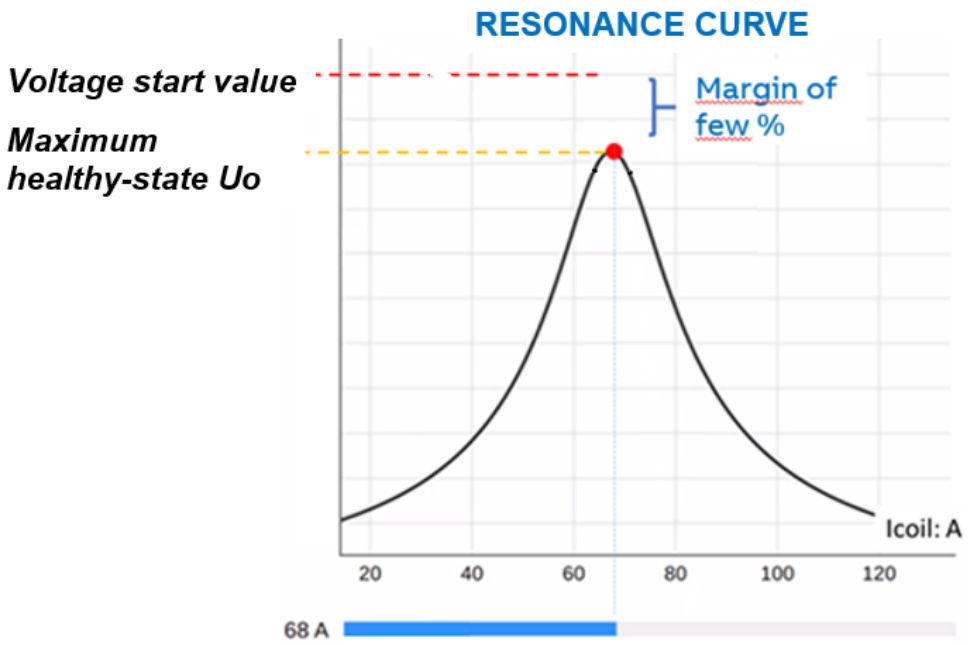



*Figure 336: Example of selection of setting Voltage start value in order to maximize the earth-fault detection sensitivity of IFPTOC based on the resonance curve calculated by the coil controller*

To avoid unselective start or operation of IFPTOC, *Voltage start value* must always be set to a value which exceeds the maximum healthy-state residual voltage value, taking into consideration of possible network topology changes (variation in unbalance), compensation coil and parallel resistor switching status (variation in damping) and compensation degree variations (variation in detuning).

Activation of `EF_IND` output is determined to be the time instant when the earth fault is detected. This information is needed as the IFPTOC utilizes “delta” calculation i.e. changes in phase currents due to earth fault. For example, the change of phase A current phasor due to earth fault can be written as:

$$\Delta \underline{I}_A = \underline{I}_A(t_{FLT}) - \underline{I}_A(t_{PRE_FLT})$$

(Equation 102)

Where:

$t_{FLT}$ is the time during the detected earth fault

$t_{PRE_FLT}$ is the time prior to detected earth fault occurrence and it represents time during pre-fault or healthy-state conditions. This pre-fault operation point is determined based on user setting *Revert time* as follows:

$$t_{PRE_FLT} = t_{FLT}(1) - Revert\ time$$

(Equation 103)

where $t_{FLT}(1)$ equals the first time instant, when earth fault is detected by the GFC-module. Pre-fault time moment is at least *Revert time* before earth fault occurrence moment.

*Revert time* setting should be set high enough (default value is 300 ms), because during a high(er) ohmic fault the increase speed (gradient) of the magnitude of $U_o$ may be slow, refer to example in *Figure 337*, where earth-fault occurs at time 0 ms. Earth fault is detected by GFC module slightly after that, at time instant $t_{FLT}(1)$ marked with red dot, when magnitude of $U_o$ exceeds setting *Voltage start value*. As an indication of detected earth-fault output `EF_IND` is activated.

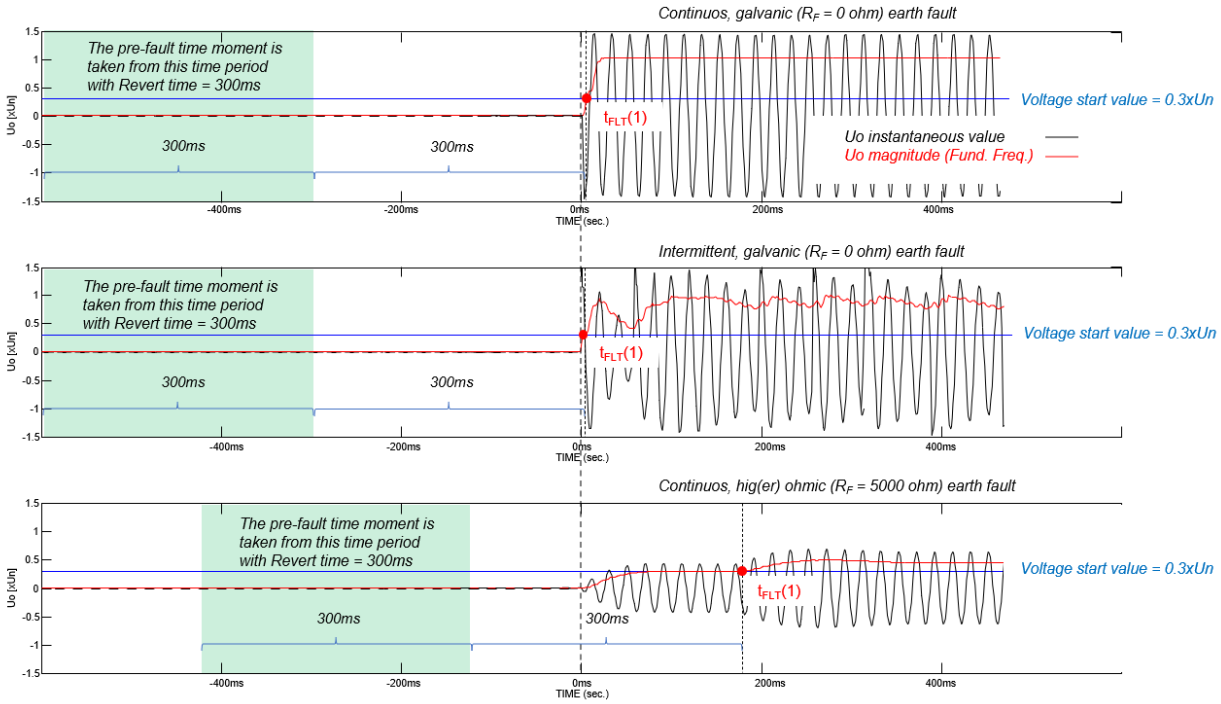



*Figure 337: Illustration of operation of General Fault Criterion (GFC) module and the meaning of setting Revert time*

In case of secondary testing of IFPTOC function, the pre-fault time in the test file must be longer than *2xRevert time*. For example, if *Revert time* = 300 ms, then pre-fault time in the test file must be longer than 600 ms.

Indication of detected earth fault is available in Recorded data: *EF indication*.

**Fault current estimation and validity check**

Operation of IFPTOC is based on estimating the magnitude of earth-fault current flowing in the fault spot, or on touch voltage magnitude derived from the earth-fault current estimate.

In compensated network, the magnitude of fundamental frequency earth-fault current depends on the network damping ($I_d$), detuning ($I_v$), voltage ($U_{PE}$) and fault resistance ($R_F$) and can be written as:

$$I_F^1 = \sqrt{\frac{(I_d^2+I_v^2)\cdot U_{PE}^2}{(I_d^2+I_v^2)\cdot R_F^2+2\cdot I_d\cdot R_F\cdot U_{PE}+U_{PE}^2}}$$

(Equation 104)

Maximum fault current value is obtained when fault resistance ($R_F$) is zero, in case of *Equation 104* can be written as:

$$\max(I_F^1) = \sqrt{I_d^2 + I_v^2}$$

(Equation 105)

Interpretation of *Equation 105* is that fault current has resistive part due to network damping and imaginary part due to network detuning. Fault current magnitude increases when damping or detuning increases.

The effect of fault resistance to fault current magnitude can be written as:

$$I_F^1 = \max(I_F^1) \cdot U_{o_{pu}} = \sqrt{I_d^2 + I_v^2} \cdot U_{o_{pu}}$$

(Equation 106)

where

$$U_{o_{pu}} = \left| \frac{U_{PE}}{R_F\cdot(I_d - j\cdot I_v)+U_{PE}} \right|$$

(Equation 107)

Interpretation of *Equation 106* is that effect of fault resistance to fault current magnitude is proportional to scaling the fault current magnitude at zero fault resistance with the per unit value of residual voltage ($U_{o_{pu}}$) due to fault resistance.

Minimum fault current magnitude is always obtained at resonance, when detuning ($I_v$) is zero, in case *Equation 104* can be written as:

$$\min(I_F^1) = \sqrt{\frac{I_d^2\cdot U_{PE}^2}{(I_d\cdot R_F + U_{PE})^2}}$$

(Equation 108)

At resonance, fault current is only due to system resistive shunt losses i.e. due to network damping ($I_d$) and possible harmonic components.

In case of unearthed network, detuning value ($I_v$) equals the uncompensated earth-fault current due to total network phase-to-earth capacitance value. In case of high resistance earthed network detuning value ($I_v$) equals the uncompensated earth-

fault current due to total network phase-to-earth capacitance value and the network damping ($I_d$) value includes losses due to the neutral point resistor.

Estimation of earth-fault current and methods for ensuring its validity are explained next.

**Fault current estimation**

In IFPTOC the estimation of earth-fault current flowing at the fault location is done utilizing changes in phase currents measured due to an earth fault.

To estimate the earth-fault current magnitude, change in threefold negative-sequence component due to earth fault is calculated (phase A as reference, phase rotation: ABC):

$$\underline{I}_F^{est} = 3 \cdot \underline{I}_2 = \underline{I}_A + \underline{a}^2 \cdot \underline{I}_B + \underline{a} \cdot \underline{I}_C$$

(Equation 109)

$$\underline{I}_F^{est} = 3 \cdot \Delta\underline{I}_2 = \Delta\underline{I}_A + \underline{a}^2 \cdot \Delta\underline{I}_B + \underline{a} \cdot \Delta\underline{I}_C$$

(Equation 110)

$$I_F^{est} = abs(\underline{I}_F^{est})$$

(Equation 111)

Where

$\underline{I}_F^{est}$ = Earth-fault current estimate (phasor)

$I_F^{est}$ = Earth-fault current estimate (magnitude)

$\Delta\underline{I}_A = \underline{I}_A(t_{FLT}) - \underline{I}_A(t_{PRE_FLT})$ = change of phase A current phasor due to earth fault

$\Delta\underline{I}_B = \underline{I}_B(t_{FLT}) - \underline{I}_B(t_{PRE_FLT})$ = change of phase B current phasor due to earth fault

$\Delta\underline{I}_C = \underline{I}_C(t_{FLT}) - \underline{I}_C(t_{PRE_FLT})$ = change of phase C current phasor due to earth fault

$\Delta\underline{I}_2 = \underline{I}_2(t_{FLT}) - \underline{I}_2(t_{PRE_FLT})$ = change of negative sequence-current phasor due to earth fault

$\underline{a}$ = Phase rotation operator = cos(120°) + j·sin(120°)

Applying the “delta” calculation i.e. change in phase currents due to earth fault removes the healthy-state negative-sequence component from earth-fault current estimate, which may exist due to the practical unbalances in load currents and capacitive charging currents. Pre-fault negative-sequence current value is typically rather low in magnitude and constant in time domain, which enables good estimation accuracy regardless of load current level variations, or in case of uncertainty in the exactness of the pre-fault value (e.g. during auto-reclosing cycle).

The validity of memorized pre-fault negative-sequence component value that is utilized in delta calculation becomes poorer in time. There is thus a maximum time defined by the user that delta calculation is valid. This is given with setting

*Max Dur delta Calc* (maximum duration for delta calculation). After this time is elapsed from initial fault detection moment, then the validity of delta-calculation is not considered to be valid anymore and thus fault current estimation is done without delta calculation i.e. based on real time measurement of threefold negative-sequence component ( *Equation 109*). The memorized pre-fault negative-sequence component values are reset when function is reset.

In practical compensated networks, earth-fault current may include a large share of harmonic components, especially during low ohmic faults. In IFPTOC the estimation of earth-fault (EF) current can be done with or without harmonic components. Refer to Figure 5 for illustrating the effect of harmonics on earth-fault current estimate. Measurement of harmonic components can be enabled with setting *Enable harmonics* = “Enable”, “Disable”.

Fundamental frequency component is always included into fault current magnitude estimation, even when setting *Enable harmonics* = “Disable”.

When setting *Enable harmonics* = “Enable”, the included harmonics are (if their magnitudes are sufficient for an accurate measurement): 2nd, 3rd, 5th, 7th and 9th.

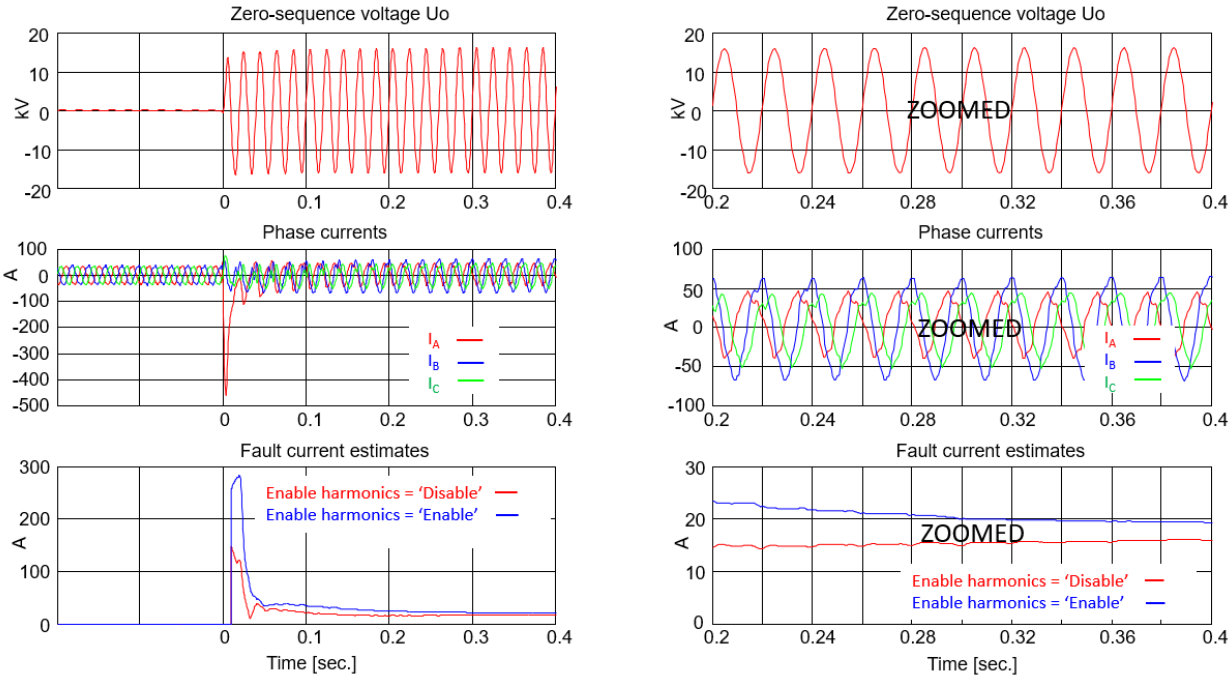



*Figure 338: Illustration of earth-fault current estimate with and without harmonics calculation enabled (zoomed view on right hand column)*

The harmonic components are only included in the earth-fault current estimate if their magnitudes are sufficient for an accurate measurement i.e. their values exceed minimum predefined value (0.3% from $I_n$). Also, the effect of harmonics is only taken into account, if the magnitude of fundamental frequency fault current estimate or touch voltage exceeds set start thresholds.

For the earth-fault current estimate magnitude, $I_F^{est}$, can be written:

When setting *Enable harmonics* = “Disable”:

$$I_F^{est} = \Delta 3I_2^1$$

(Equation 112)

When setting *Enable harmonics* = “Enable”:

$$I_F^{est} = \sqrt{(\Delta 3I_2^1)^2 + (\Delta 3I_2^2)^2 + (\Delta 3I_2^3)^2 + (\Delta 3I_2^5)^2 + (\Delta 3I_2^7)^2 + (\Delta 3I_2^9)^2}$$

(Equation 113)

Where $I_2^n$ is the magnitude of the n$^{th}$ harmonic negative-sequence current component (n = 1, 2, 3, 5, 7 and 9).

In case of frequency adaptive system measurements, only 2$^{nd}$, 3$^{rd}$ and 5$^{th}$ harmonics are calculated.

In case there is fault resistance included in the fault current path, the effect of fault resistance is to decrease the value of earth-fault current as shown by *Equation 106*.

The downscaling of fault current magnitude can be estimated to be proportional to the magnitude of per unit value of residual voltage, refer to *Equation 106*. With setting *Ena RF Compensation* = “Enable”, user can compensate the effect of fault resistance and then earth-fault current estimate becomes independent of actual fault resistance value. This is done by dividing the fault current estimate with per unit value of residual voltage (< 1pu):

Estimate for “fault resistance compensated” earth-fault current, $I_F^{est_Rfcomp}$:

$$I_F^{est_Rfcomp} = I_F^{est}[A]/Uo[pu]$$

(Equation 114)

This means that with setting *Ena RF Compensation* = “Enable”, regardless of actual fault resistance magnitude, the earth-fault current estimate matches the value that would be valid if the fault would be a galvanic one (fault resistance equals zero). Thanks to this feature the fault is always seen and treated as a galvanic fault regardless of possible fault resistance. This functionality allows acceleration of protection operation speed during high(er) ohmic earth fault when fault current magnitude is low.

In case IFPTOC is used to detect high(er) ohmic earth faults, all start thresholds (*Voltage start value*, *EF current Str Val* or *Touch Vol Str Val*) must be set according to sensitivity requirements. Otherwise *Ena RF Compensation* may not be effective during actual high(er) ohmic earth fault.

In case of setting *Ena RF Compensation* = “Enable”, the effect of harmonics are not taken into account i.e. fault current estimation is based only on fundamental frequency component.

*Figure 339* illustrates this concept: In the left-hand column is shown residual voltage, phase currents and fault current estimate during a galvanic earth fault ($R_F$ = 0 ohm). During a galvanic fault $U_o$ equals system nominal phase-to-earth voltage

and has thus value of 1. 0pu (x$U_{n_PE}$, $U_{n_PE}$ = Nominal phase-to-earth voltage). In the middle column is shown residual voltage, phase currents and fault current estimate during a higher ohmic earth fault ($R_F$ = 3000 ohm). During a higher ohmic earth fault $U_o$ reduces and thus also the magnitude of fault current is reduced. But the magnitude of fault current is reduced proportionally to residual voltage. In the right-hand column the effect of fault resistance is compensated by scaling the fault current estimate by dividing it with the per unit value of residual voltage. With fault resistance compensation, the operation speed of IFPTOC can be accelerated during high(er) ohmic earth faults.

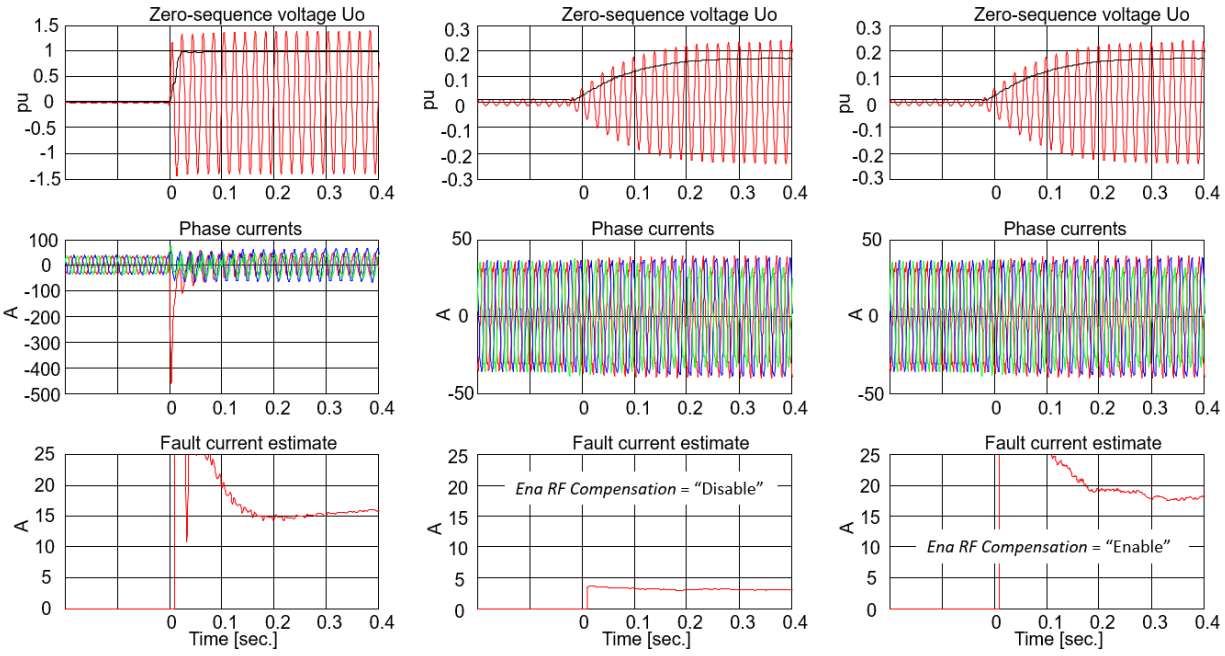



*Figure 339: Illustration of fault resistance compensation functionality in IFPTOC. Left-hand column: galvanic earth fault ($R_F$ = 0 ohm). Middle column: a higher ohmic earth fault ($R_F$ = 3000 ohm) with setting Ena $R_F$ Compensation = "Disable". Right-hand column: a higher ohmic earth fault ($R_F$ = 3000 ohm) with setting Ena $R_F$ Compensation = "Enable".*

Note that it is the "effective" earth-fault current estimate which determines operation of IFPTOC. "Effective" earth-fault current includes the effect of user setting *Reduction factor*.

Effective earth-fault current estimate, $I_F^{est_eff}$ :

$$I_F^{est_eff} = I_F^{est} \cdot Reduction\ factor$$

(Equation 115)

Setting *Reduction factor* is a user defined reduction factor, which can be used to scale down the estimated earth-fault current magnitude. Setting *Reduction factor* allows e.g. consideration that not all the earth-fault current ($I_F$) will flow back through "remote" earth. See illustration in Figure 7. A portion of the earth-fault current ($I_{SCR}$) may have alternative return paths, e.g. through cable sheaths/screens. Only current which flows through earth ($I_E$) will introduce rise of earth potential (earth potential rise, EPR, also called as ground potential rise GPR), which must

be considered from electrical safety perspective. Setting *Reduction factor* = 1.00 means that 100% of earth-fault current flows back through “remote” earth and thus 100% of earth-fault current will introduce rise of earth potential.

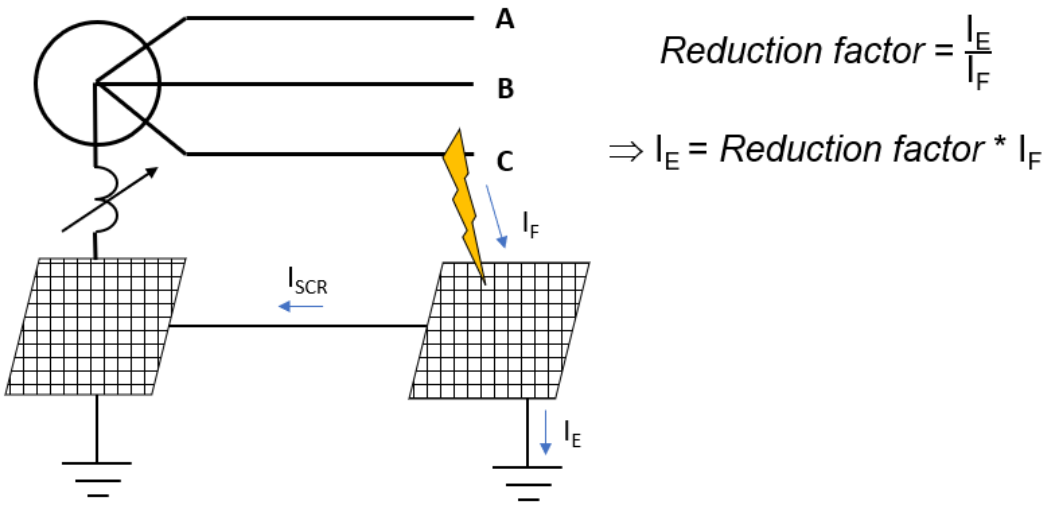



*Figure 340: Simplified illustration and explanation of setting Reduction factor. Only fault current which flows through earth ($I_E$) will introduce rise of earth potential (earth potential rise, EPR, also called as ground potential rise, GPR).*

Magnitude of the estimated effective earth-fault current is given in Recorded data:

- *Fault current* (fundamental frequency magnitude)
- *Fault current rms* (rms-value).

In Monitored data the magnitude of estimated effective earth-fault current is given in as:

- *FLT_CURRENT* (fundamental frequency magnitude)
- *FLT_CURR_RMS* (rms-value).

In case of setting *Ena RF Compensation* = “Enable”, actual earth-fault current value affected by fault resistance is then not available in Monitored/Recorded data, but the monitored/recorded current value is fault resistance compensated.

**Validity check**

Validity of earth-fault current estimate is defined with settings *EF validity Op mode* and *EF validity Min Curr*. *EF validity Op mode* has three options “Resistive”, “Resistive, Reactive” and “No Validity”.

Validity of earth-fault current estimate is based on evaluating the polarity of the measured admittance ($\underline{Y}_o = \underline{I}_o/\underline{U}_o$) at fault ignation. The accuracy of $\underline{I}_o$ and $\underline{U}_o$ should be therefore as good as possible. Especially the measurement of $\underline{I}_o$ should be based on accurate Core Balance CT (CBCT).

The validity of earth-fault current estimate is based on evaluating the polarity of the measured admittance ($\underline{Y}_o = \underline{I}_o/\underline{U}_o$) during the fault ignition moment (during the transient phase of fault). Admittance is calculated utilizing cumulative phasor summing technique (CPS). The measured “transient admittance” is converted into equivalent current value by multiplying it with nominal phase-to-earth voltage value

and then compared with setting *EF validity Min Curr*. The current values used in validity check are called as transient resistive and reactive components and noted as *Transient Ris Comp* and *Transient React Comp* in Recorded data and TR_RIS_COMP and TR_REACT_COMP in Monitored Data.

Validity of earth-fault current estimate is indicated by VALID_EF = TRUE.

In case *EF validity Op mode* = 'Resistive', then validity of earth-fault current estimate is confirmed by evaluating the polarity of the resistive part of measured admittance (real($\underline{Y}_o$) = real($\underline{I}_o/\underline{U}_o$)) during the fault ignition moment (during the transient phase of fault). The measured "transient admittance" is converted into equivalent current value by multiplying it with nominal phase-to-earth voltage value and then compared with setting *EF validity Min Curr*. *EF validity Op mode* = 'Resistive' is valid in compensated systems regardless of compensation degree and also in high resistance earthed systems. Note that situation, when the compensation coil becomes unintentionally disconnected, may result to condition where measured resistive component is not sufficient for validity confirmation. In such case *EF validity Op mode* should be selected as 'Resistive, Reactive'.

In case *EF validity Op mode* = 'Resistive, Reactive', then validity of earth-fault current estimate is confirmed by evaluating the polarity of the resistive (real($\underline{Y}_o$) = real($\underline{I}_o/\underline{U}_o$)) and reactive (imaginary) part (imag($\underline{Y}_o$) = imag($\underline{I}_o/\underline{U}_o$)) of measured admittance during the fault ignition moment (during the transient phase of fault). The measured "transient admittance" is converted into equivalent current value by multiplying it with nominal phase-to-earth voltage value and then compared with setting *EF validity Min Curr*. Either one, resistive or reactive part of measured admittance is used to confirm validity of earth-fault current estimate. *EF validity Op mode* = 'Resistive, Reactive' is valid in compensated, unearthed and in high resistance earthed systems. In compensated systems this criterion is applicable unless the protected feeder is over-compensated i.e. earth-fault current produced by protected feeder is inductive. In such case *EF validity Op mode* must be set to 'Resistive'.

In case *EF validity Op mode* = 'No validity", then validity of earth-fault current estimate is not confirmed and protection operates based on estimated earth-fault current or touch voltage magnitude. *EF validity Op mode* = 'No validity' can be applied e.g. when current measurement is at incomer and when compensation coil with parallel resistor is located at dedicated earthing transformer bay. In this case, during an earth fault in the network, residual current at incomer is zero and thus validity evaluation based on resistive or reactive component is not possible. Thus in order to apply IFPTOC at the incomer, *EF validity Op mode* = 'No validity', must be selected.

Setting *EF validity Min Curr* is given in per unit format with residual current channel primary current as base value. The value should be selected based on following principles:

- In compensated networks *EF validity Min Curr* should be selected based on the known system damping value, in practice e.g. based on the ampere value of the parallel resistor of the coil. For example, if parallel resistor of the coil has rating of 10A, then *EF validity Min Curr* should be smaller than this value with margin, for example 5A. Based on practical experience, value of 3A is found to be suitable for most applications. The value of *EF validity Min Curr* should also be set higher than the transient resistive component generated by the protected feeder during post-fault oscillation to avoid false activations of validity check module in healthy feeders during an earth fault.

  Transient resistive component can be approximated with following equation:

$$real(\underline{Y}_o^{Tr}) = real\left(\frac{I_o}{-\underline{U}_o}\right) = G_{oTot} \cdot \frac{|B_{oFdTot}|}{|B_{oTot}|} - G_{oFdTot}$$

(Equation 116)

where

$G_{oTot}$ = Conductance representing the total system shunt losses, i.e. losses of the coil(s), the parallel resistor and the total network shunt losses.

$|B_{oFdTot}|$ = The sum of absolute values of capacitive and inductive susceptances of the protected feeder. This term represents the energy stored in the LC-branches of the feeder. For example, if the capacitive susceptance of the feeder equals $20A^{cap}$ and the inductive susceptance of the distributed coils at the feeder equal $20A^{ind}$, then the sum of absolute values of susceptances of the feeder equal 40A.

$|B_{oTot}|$ = The sum of absolute values of capacitive and inductive susceptances of the network. This term represents the energy stored in the LC-branches of the total network. For example if capacitive susceptance of the network equal $100A^{cap}$ and the inductive susceptance of the central and distributed coils equal $100A^{ind}$, then the sum of absolute values of susceptances of the network equal 200A.

$G_{oFdTot}$ = Conductance representing the total shunt losses of protected feeder i.e. losses of the coil(s) located at the feeder and natural shunt losses of the feeder.

- In unearthed networks *EF validity Min Curr* should be selected based on the earth-fault current of connected feeders. Value must be smaller than the capacitive earth-fault current due to parallel feeders. Based on practical experience, value of 3A is found to be suitable for most applications.
- In resistance earthed networks *EF validity Min Curr* should be selected based on the value of earthing resistor. Value must be smaller than the ampere value of earthing resistor.

To adapt the earth-fault current validity determination to a possible fault direction change during the fault, for example during manual fault location process, a cyclic accumulation of admittance phasor can be enabled with setting *Ena cyclic reset* = “Enable”. The duration of this evaluation cycle is only few fundamental cycles so that function can rapidly adapt to changes in fault direction. Evaluation is based on monitoring the sign of the accumulation of admittance phasor compared with sign of transient admittance stored at fault ignation. In case change of polarity is detected, and duration of polarity change exceeds setting *Intr EF reset time* and a cyclic accumulation of admittance (real- or imaginary part converted into equivalent current value) exceeds *EF validity Min Curr*, the validity evaluation of earth-fault current estimate is reset and restarted. As default, setting *Ena cyclic reset* = “Enable”.

Information about the validity of earth-fault current estimate is also available in *Recorded data: Valid EF detection*.

Magnitude of transient resistive or reactive current component used in evaluation of earth-fault current validity is given in recorded data as *Transient Ris Comp* and *Transient React Comp* (fundamental frequency magnitude) and in Monitored data as `TR_RIS_COMP` and `TR_REACT_COMP`

(fundamental frequency magnitude). Positive value means that fault is seen inside the protected feeder, negative value means that fault is seen outside the protected feeder.

**Touch voltage estimation**

After estimate for earth-fault current is calculated and its validity confirmed, then conversion of fault current estimate $I_F^{est}$ into earth potential rise estimate $U_{EPR}^{est}$ is derived using equations below:

Effective earth potential rise estimate:

$$U_{EPR}^{est} = Maximum\ earthing\ Ris \cdot Reduction\ factor \cdot I_F^{est}$$

(Equation 117)

with *Equation 115*, *Equation 117* can also be written as:

$$U_{EPR}^{est} = Maximum\ earthing\ Ris \cdot I_F^{est_eff}$$

(Equation 118)

Where

Setting *Maximum earthing Ris* is a user defined maximum earthing resistance value encountered in the earthings located at the protected feeder. Higher earthing resistance results in higher earth potential rise and touch voltage during the fault.

For estimating the hazardous touch voltage at fault location, $U_{TF}^{est}$, the estimate of the effective earth potential rise is used:

$$U_{TF}^{est} = U_{EPR}^{est}$$

(Equation 119)

Setting *Reduction factor* enables down scaling of the estimated earth potential rise, which determines operation speed of IFPTOC:

- In case *Reduction factor* = 1, it is assumed that touch voltage equals 100% of earth potential rise.
- In case *Reduction factor* < 1, then it is assumed that touch voltage equals only part of earth potential rise. In this case the value of setting *Reduction factor* depends e.g. on actual reduction effect in the return path of earth-fault current and properties of earthing systems in the protected feeder.

Magnitude of estimated touch voltage is given in Recorded data:

- *Touch voltage* (fundamental frequency magnitude)
- *Touch voltage rms* (rms-value).

In Monitored data the magnitude of estimated touch voltage is given in as:

- `TCH_VOLTAGE` (fundamental frequency magnitude)
- `TCH_VOLT_RMS` (rms-value).

**Earth-fault current and touch voltage protection**

Based on the practical experience from real earth faults, some faults have re-striking/intermittent characteristics, where the voltage and current waveforms generated by earth fault are rich with harmonics and non-sinusoidal content. In such fault type the operation of IFPTOC can alternatively be based on the counted number of transients instead of estimated fault current or touch voltage. Dedicated functionality to allow this type of operation is described in *Chapter 4.2.10.5.6 Intermittent earth-fault protection*.

*Principle based on earth fault current estimate*

The operation of IFPTOC based on earth-fault current estimate is described next. In case *Operation principle* = “EF current based”, then operation is based on the estimated effective earth-fault current magnitude taking account the effect of *Reduction factor*. The harmonic content of fault current can be included into estimate with setting *Enable harmonics* = “Enable”.

Operation time can be either definite time or inverse time, selected with setting *Operating curve type* = “Definite time”, “Inverse time EN50522” or “Inverse time IEEE80”.

**When *Operating curve type* = “Definite time” is selected, then**

- Operate time is according to definite time (DT) operation
- START and ST_EF outputs are activated when estimated earth-fault current magnitude (considering the effect of settings *Reduction factor* and *Enable harmonics*) exceeds setting *EF current Str Val* and earth fault is detected, and earth-fault current estimate is validated. Note that *Ena RF Compensation* = “Enable” does not affect this start condition. It is important to set setting *EF current Str Val* according to required protection sensitivity.
- OPERATE and OP_EF outputs are activated after operation timer has elapsed, defined with setting *DT stage Op time*.
- Reset timer is started if any of the above conditions for START is not anymore valid. START and ST_EF outputs stay activated until the reset timer expires (setting *Reset delay time*). After OPERATE output activation, START, ST_EF, OPERATE and OP_EF outputs are reset immediately i.e. reset delay time is no longer valid.
- During re-striking/intermittent earth faults, in case operation should be based preferably on counted number of transients, then setting *Reset delay time* should be set to low value, say 20-40 ms, thus definite time operation is ineffective during re-striking/intermittent earth faults as DT-timer becomes reset between re-strikes. Dedicated intermittent earth-fault protection functionality based on counted number of transients is described in *Chapter 4.2.10.5.6 Intermittent earth-fault protection*.
- Applicable settings are: *Reduction factor, EF current Str Val, DT stage Op time* and *Reset delay time*.
- Note that setting *CB Delay Comp* (circuit breaker delay compensation) is not applicable in definite time operation, but it must be taken into account in setting *DT stage Op time*.



Minimum practical value for setting *EF current Str Val* is 0.5% from CT primary current. For example, in case CT primary current is 200 A, then minimum practical value for setting *EF current Str Val* is 0.5%*200A = 1 A. For CT with 400 A primary current, then minimum practical value for setting *EF current Str Val* is 0.5%*400A = 2 A. The lower setting *EF current Str Val* is used, the higher sensitivity in terms of fault resistance

can be obtained. Sensitivity in terms of fault resistance depends also on the network parameters (nominal voltage, damping and detuning) as described by equation below:

$$R_F[ohm] \leq \frac{U_{PE}\cdot\left(\sqrt{I_d^4+2I_d^2\cdot I_v^2-I_F^2\cdot I_v^2+I_v^4}-I_d\cdot I_F\right)}{(I_d^2+I_v^2)\cdot I_F}$$

(Equation 120)

where $U_{PE}$ is the nominal phase-to-earth voltage [V], $I_d$ is the total system damping [A], $I_v$ is the detuning [A], $I_F$ is setting *EF current Str Val* in primary amperes.

Consider next the following example:

**Example 1.** Definite time operation of IFPTOC, when Operation principle = “EF current based”, *Operating curve type* = “Definite time” is illustrated in *Figure 341*. In the example, setting *EF current Str Val* = 0.04*In (4 A with primary 100 A) and *DT stage Op time* = 400 ms. *Reduction factor* =1.0. IFPTOC starts when estimated fault current exceeds 4 A and operates after 400 ms, if start conditions are met. For illustrating possible operating speed requirements of protection, limits of touch voltage and earth potential rise durations defined in standard EN50522 scaled into corresponding earth-fault current requirements using the maximum earthing resistance $R_{Emax}$ (setting *Maximum earthing Ris*) encountered in protected feeder are shown for reference.

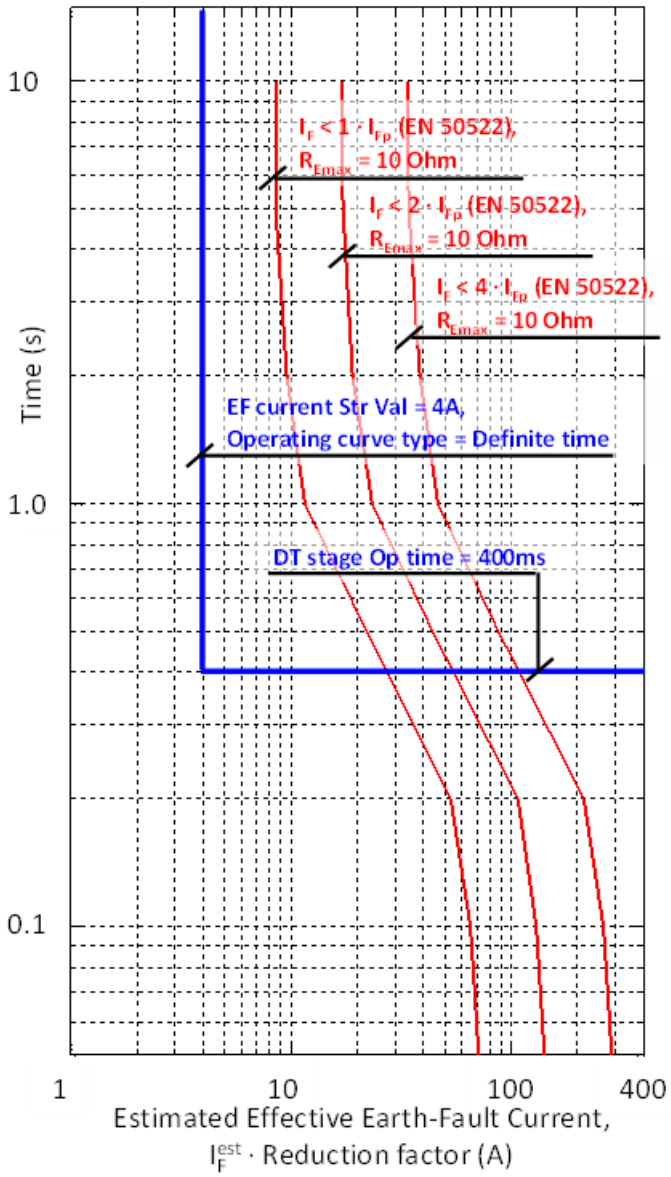



*Figure 341: Example of definite time operation of IFPTOC, when Operation principle = "EF current based", Operating curve type = "Definite time". Settings EF current Str Val = 0.04*In (4A) and DT stage Op time = 400ms. Reduction factor = 1.0. Maximum earthing Ris = 10ohm.*

**When *Operating curve type* = "Inverse time EN50522" is selected, then**

- Operate time is inverse time according to standard EN50522:

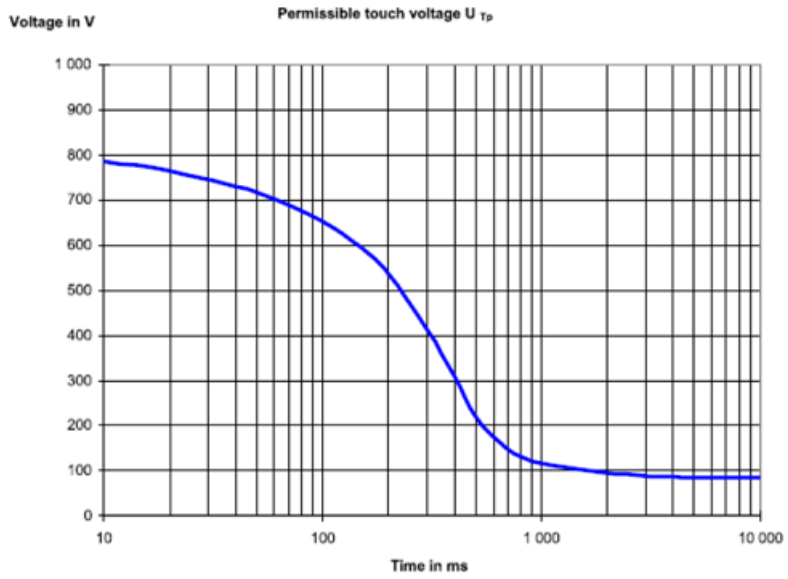



*Figure 342: Permissible time-touch voltage characteristics given in standard EN 50522*

- Time margin for practical circuit-breaker operate time can be applied with setting *CB delay Comp*. Default time margin is 0 ms.
- START and ST_EF outputs are activated when estimated effective earth-fault current magnitude (considering the effect of settings *Reduction factor* and *Enable harmonics*) exceeds setting *EF current Str Val* and earth fault is detected, and earth-fault current estimate is validated. Note that *Ena RF Compensation* = “Enable” does not affect this start condition.
- OPERATE and OP_EF outputs are activated according to the operate time - touch voltage and earth potential rise requirements defined in standard EN 50522. i.e. operate time is inversely proportional to the estimated fault current.
- Reset timer is started if any of the above conditions for START is not anymore valid. START and ST_EF outputs stay activated until the reset timer expires (setting *Reset delay time*). After OPERATE output activation, START, ST_EF, OPERATE and OP_EF outputs are reset immediately i.e. reset delay time is no longer valid. During re-striking/intermittent earth faults, the very high current transient may result to very fast operation times. In case longer operation time during re-striking/intermittent earth faults is preferred and operation should be based preferably on counted number of transients, then setting *Reset delay time* should be set to low value, say 20-40 ms. Dedicated intermittent earth-fault protection functionality based on counted number of transients is described in *Chapter 4.2.10.5.6 Intermittent earth-fault protection*.
- Applicable settings are: *Reduction factor, EF current Str Val, CB delay Comp, UTp multiplier, Maximum earthing Ris, IDMT stage Min Op Tm, IDMT stage Max Op Tm, Reset delay time*.

It is important to note, that:

1. Setting *Maximum earthing Ris* is used to scale the touch voltage and earth potential rise requirements defined in standard EN 50522 into corresponding earth-fault current requirements.
2. Setting *UTp multiplier* enables operation based on permissible earth potential rise $U_E$, by scaling of the permissible time-touch voltage characteristics given in standard EN 50522 with Setting *UTp multiplier*, see table below.

**Table 627: Permissible touch voltages $U_{Tp}$ and earth potential rise $U_E$ values given in standard EN50522 converted into equivalent permissible earth-fault current $I_{Fp}$ values as a function of the fault duration $t_f$. Conversion is made with parameter $R_{Emax}$, which is the setting *Maximum earthing Ris* in primary ohms i.e. the maximum earthing resistance encountered in protected feeder.**

| Fault duration $t_f$ [sec.] | Permissible touch voltage, $U_{Tp}$ converted into corresponding permissible fault current, $I_{Fp}$, $U_{Tp}$ multiplier = 1.0 [A] | Permissible earth potential rise, $U_E$ converted into corresponding permissible fault current, $I_{Fp}$, $U_{Tp}$ multiplier = 2.0 [A] | Permissible earth potential rise, $U_E$ converted into corresponding permissible fault current, $I_{Fp}$, $U_{Tp}$ multiplier = 4.0 [A] |
|---|---|---|---|
| 0.05 | 716 V/$R_{Emax}$ | 1432 V/$R_{Emax}$ | 2864 V/$R_{Emax}$ |
| 0.10 | 654 V/$R_{Emax}$ | 1308 V/$R_{Emax}$ | 2616 V/$R_{Emax}$ |
| 0.20 | 537 V/$R_{Emax}$ | 1074 V/$R_{Emax}$ | 2148 V/$R_{Emax}$ |
| 0.50 | 220 V/$R_{Emax}$ | 440 V/$R_{Emax}$ | 880 V/$R_{Emax}$ |
| 1.00 | 117 V/$R_{Emax}$ | 234 V/$R_{Emax}$ | 468 V/$R_{Emax}$ |
| 2.00 | 96 V/$R_{Emax}$ | 192 V/$R_{Emax}$ | 384 V/$R_{Emax}$ |
| 5.00 | 86 V/$R_{Emax}$ | 172 V $R_{Emax}$ | 344 V/$R_{Emax}$ |
| 10.00 | 85 V/$R_{Emax}$ | 170 V/$R_{Emax}$ | 340 V/$R_{Emax}$ |

3. Minimum effective earth-fault current magnitude (considering the effect of setting *Reduction factor*), which must be exceeded for the function to start, is defined with setting *EF current Str Val*. It is important to set this value according to required protection sensitivity.
4. With *IDMT stage Min Op Tm* setting user can define minimum allowed operate time for IFPTOC i.e. this is the minimum allowed operate time of IFPTOC.
5. With *IDMT stage Max Op Tm* setting user can define maximum allowed operate time for IFPTOC i.e. this is the maximum allowed operate time of IFPTOC although IDMT timer would define slower operate time.

Parameter defining maximum earthing resistance, setting *Maximum earthing Ris* must be always set in case *Operation principle* = “EF current based” and *Operating curve type* = “Inverse time EN50522” is selected. Setting *Maximum earthing Ris* is needed to scale the touch voltage and earth potential rise requirements defined in standard EN 50522 into corresponding earth-fault current requirements.

Setting *Reduction factor* considers the fact that only part of the earth-fault current ($I_F$) will flow back through “remote” earth and introduces earth potential rise and touch voltages.

Minimum practical value for setting *EF current Str Val* is 0.5% from CT primary current. For example, in case CT primary current is 200A, then minimum practical value for setting *EF current Str Val* is 0.5%*200 A = 1 A. For CT with 400 A primary current, then minimum practical value

for setting *EF current Str Val* is 0.5%*400 A = 2 A. The lower setting *EF current Str Val* is used, the higher sensitivity in terms of fault resistance can be obtained. Sensitivity in terms of fault resistance depends also on the network parameters (nominal voltage, damping and detuning) as described by *Equation 120*.

When *Operating curve type* = “Inverse time EN50522” is selected, then the protection operate time as a function of estimated effective earth-fault current $I_F^{est}$ (taking into account the effect of settings *Reduction factor* and *Enable harmonics*) is according to equation below:

$$t = 0.29 \times e^{ln\left(-\frac{722.8-\left(\frac{I_F^{est} \times Reduction\ factor \times Maximum\ earthing\ Ris}{UTp\ multiplier}\right)}{85.3-\left(\frac{I_F^{est} \times Reduction\ factor \times Maximum\ earthing\ Ris}{UTp\ multiplier}\right)}\right)/2.39} - CB\ delay\ Comp\ [s]$$

(Equation 121)

In IFPTOC function, the preferred presentation of operation timer characteristics is by plotting the protection operate time as a function of permissible/estimated earth-fault current as illustrated in figures from *Figure 343*, *Figure 344* and *Figure 345*.

Consider next three examples with *Operating curve type* = “Inverse time EN50522”:

**Table 628: Comparison of operation times given in EN50522 with IFPTOC. The theoretical operate time of IFPTOC has been calculated assuming CB delay Comp = 0 s**

| EN50522, $U_{tp}$ [V] | EN50522, $t_f$ [sec] | IFPTOC, $t_f$ Theoretical [sec] |
|---|---|---|
| 716 | 0.05 | 0.04 |
| 654 | 0.1 | 0.12 |
| 537 | 0.2 | 0.20 |
| 220 | 0.5 | 0.50 |
| 117 | 1 | 1.00 |
| 96 | 2 | 1.59 |
| 86 | 5 | 5.02 |
| 85 | 10 | 8.48 |

**Example 2a.** Inverse time operation of IFPTOC, when *Operation principle* = “EF-current based” and *Operating curve type* = “Inverse time EN50522” is illustrated in *Figure 343*. Start value for operation is set to be 0.02*In (2 A if primary 100 A). IFPTOC is set to have minimum operate time 100 ms and maximum operate time of 5000 ms. Setting *UTp multiplier* is 1.0 and setting *Maximum earthing Ris* is 10 ohms. Reduction factor = 1.0. For illustrating the operating speed requirement of protection, limits of touch voltage durations defined in standard EN50522 scaled the into corresponding earth-fault current requirements using the maximum earthing resistance $R_{Emax}$ (setting *Maximum earthing Ris*) encountered in protected feeder are shown for reference.

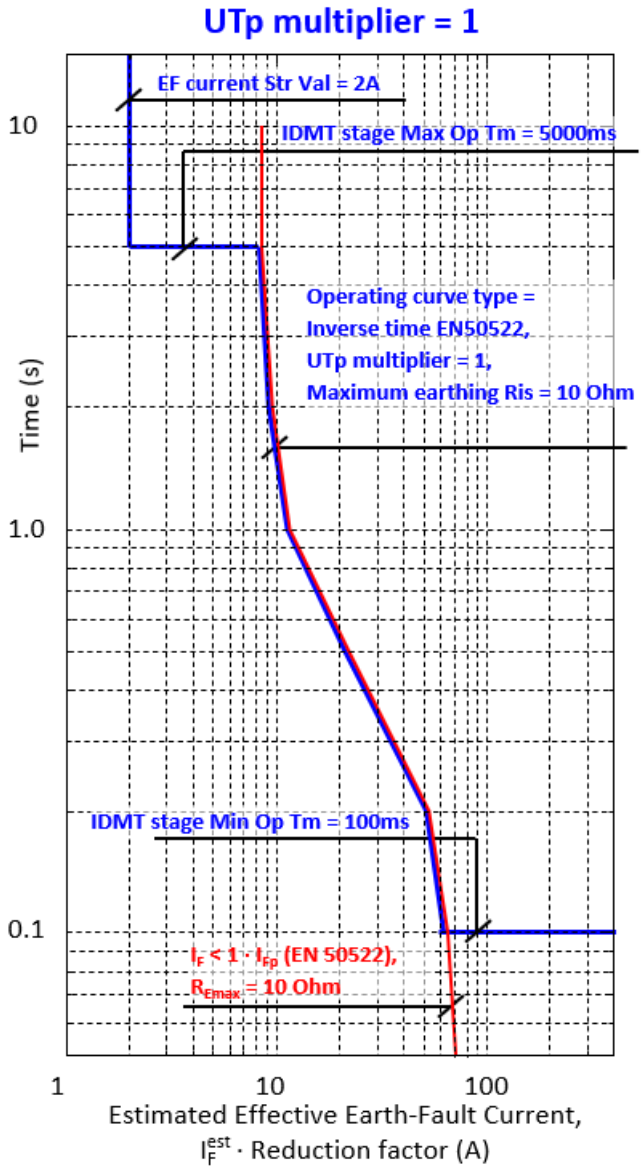



*Figure 343: Operation timer characteristic of IFPTOC function when Operation principle = "EF-current based" and Operating curve type = "Inverse time EN50522". Setting UTp multiplier is 1.0, Maximum earthing Ris = 10ohms, EF current Str Val = 0.02*In (2A), IDMT stage Min Op Tm = 100 ms and IDMT stage Max Op Tm = 5000 ms. Reduction factor = 1.0. Characteristics are according to standard EN50522.*

**Example 2b.** Inverse time operation of IFPTOC, when *Operation principle* = "EF-current based" and *Operating curve type* = "Inverse time EN50522" is illustrated in *Figure 344*. Start value for operation is set to be 0.04*In (4 A). IFPTOC is set to have minimum operate time 100 ms and maximum operate time of 5000 ms. Setting *UTp multiplier* is 2.0 and setting *Maximum earthing Ris* is 10 ohms. Reduction factor = 1.0. For illustrating the operating speed requirement of protection, limits of earth potential rise durations defined in standard EN50522 scaled into corresponding earth-fault current requirements using the maximum earthing resistance $R_{Emax}$ (setting *Maximum earthing Ris*) encountered in protected feeder are shown for reference.

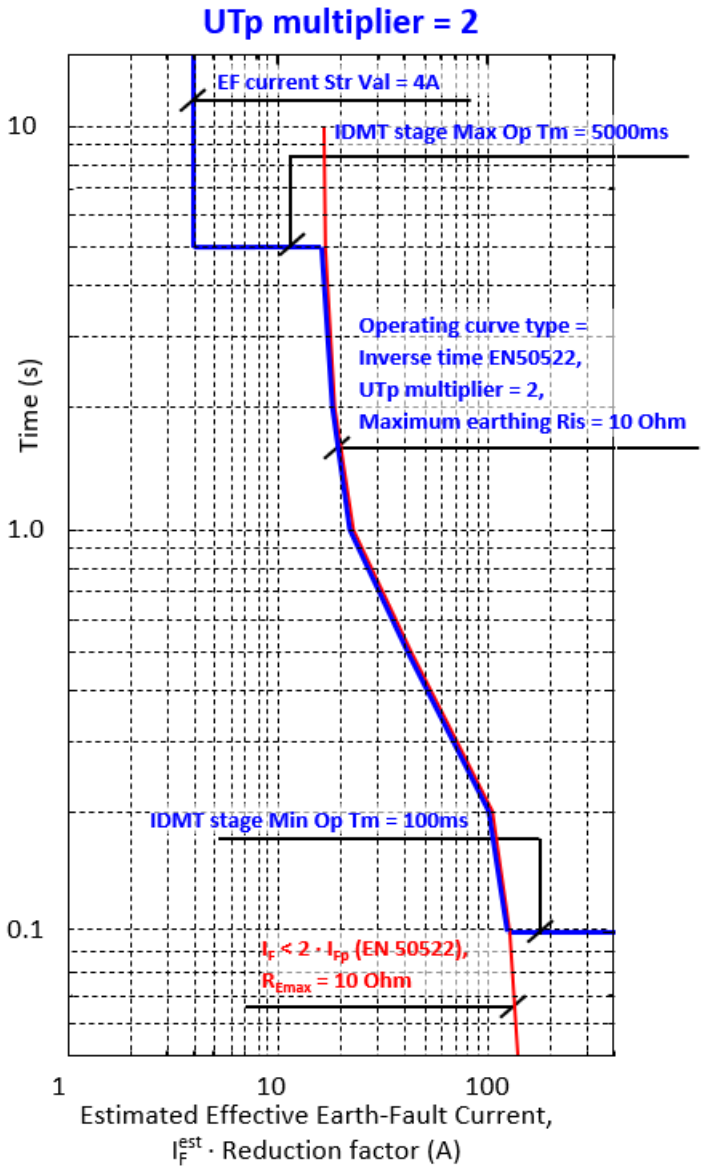



*Figure 344: Operation timer characteristic of IFPTOC function when Operation principle = "EF-current based" and Operating curve type = "Inverse time EN50522". Setting UTp multiplier is 2.0, Maximum earthing Ris = 10 ohms, EF current Str Val = 0.02*In (4 A), IDMT stage Min Op Tm = 100 ms and IDMT stage Max Op Tm = 5000 ms. Reduction factor = 1.0. Characteristics are according to standard EN50522.*

**Example 2c.** Inverse time operation of IFPTOC, when *Operation principle* = "EF-current based" and *Operating curve type* = "Inverse time EN50522" is illustrated in *Figure 345*. Start value for operation is set to be 0.06*In (6 A). IFPTOC is set to have minimum operate time 100 ms and maximum operate time of 5000 ms. Setting *UTp multiplier* is 4.0 and setting *Maximum earthing Ris* is 10 ohms. Reduction factor = 1.0. For illustrating the operating speed requirement of protection, limits of earth potential rise durations defined in standard EN50522 scaled into corresponding earth-fault current requirements using the maximum earthing resistance $R_{Emax}$ (setting *Maximum earthing Ris*) encountered in protected feeder are shown for reference.

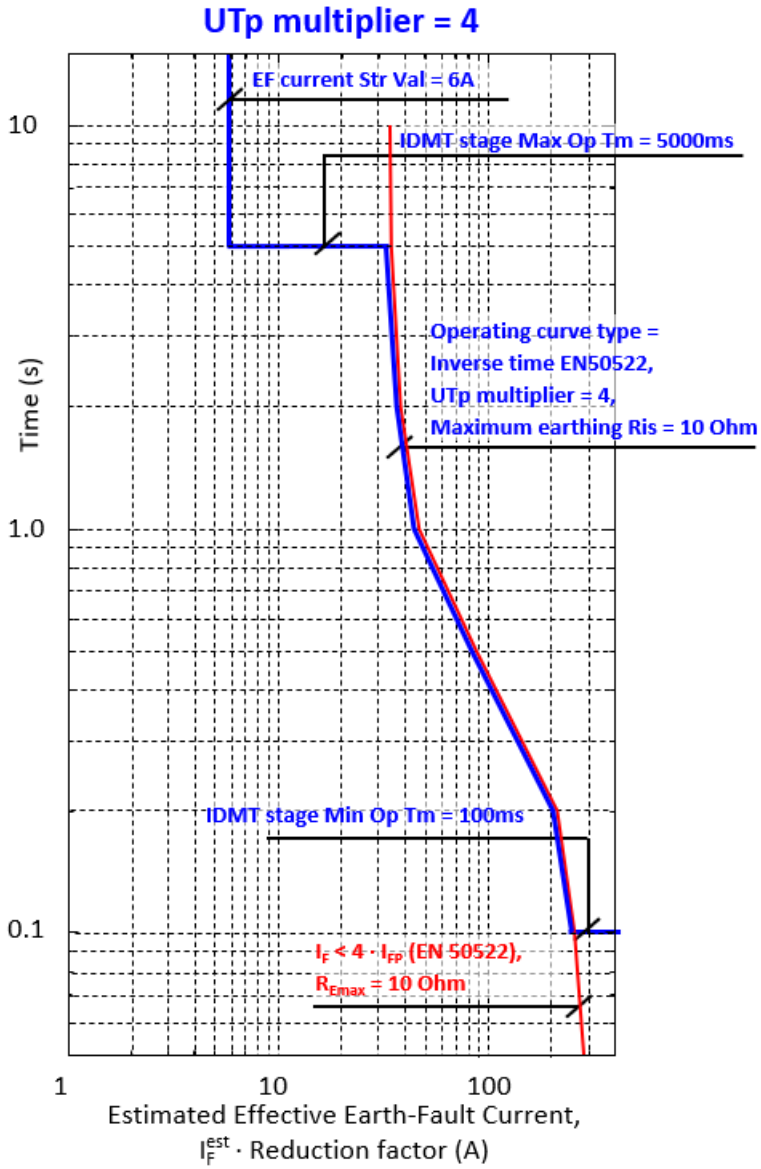



*Figure 345: Operation timer characteristic of IFPTOC function when Operation principle = "EF-current based" and Operating curve type = "Inverse time EN50522". Setting UTp multiplier is 4.0, Maximum earthing Ris = 10 ohms, EF current Str Val = 0.06*In (6 A), IDMT stage Min Op Tm = 100 ms and IDMT stage Max Op Tm = 5000 ms. Reduction factor = 1.0. Characteristics are according to standard EN50522.*

**When Operating curve type = "Inverse time IEEE80" is selected, then**

- Operate time is inverse time according to standard IEEE80:

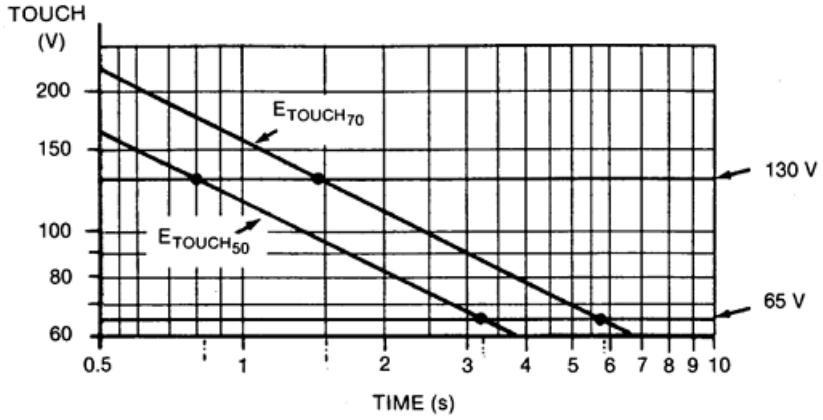



*Figure 346: Permissible time-touch voltage characteristics given in standard IEEE80 (metal-to-metal contact)*

- This operation mode can be also used when maximum allowed earth potential rise vs. operation speed follows a relationship such as 750 V/√*t*[*sec*].
- Time margin for practical circuit-breaker operate time can be applied with setting *CB delay Comp*. Default setting is 0 ms.
- START and ST_EF outputs are activated when estimated effective earth-fault current magnitude (considering the effect of settings *Reduction factor* and *Enable harmonics*) exceeds setting *EF current Str Val* and earth fault is detected, and earth-fault current estimate is validated. Note that *Ena RF Compensation* = "Enable" does not affect this start condition. It is important to set setting *EF current Str Val* according to required protection sensitivity.
- OPERATE and OP_EF-outputs are activated so that the operate time is according to the touch voltage requirements defined in standard IEEE80. i.e. operate time is inversely proportional to the estimated fault current.
- Reset timer is started if any of the above conditions for START is not anymore valid. START and ST_EF outputs stay activated until the reset timer expires (setting *Reset delay time*). After OPERATE output activation, START, ST_EF, OPERATE and OP_EF outputs are reset immediately i.e. reset delay time is no longer valid.
- During re-striking/intermittent earth faults, the very high current transient may result to very fast operation times. In case longer operation during re-striking/ intermittent earth faults is preferred and operation should be based preferably on counted number of transients, then setting *Reset delay time* should be set to low value, say 20-40 ms. Dedicated intermittent earth-fault protection functionality based on counted number of transients is described in *Chapter 4.2.10.5.6 Intermittent earth-fault protection*.
- Applicable settings are: *Reduction factor, EF current Str Val, CB delay Comp, IEEE multiplier, Maximum earthing Ris, IDMT stage Min Op Tm, IDMT stage Max Op Tm, Reset delay time*.

According to the standard IEEE80, the values of the permissible touch voltage $U_{Tp}$ as a function of the fault duration $t_f$ are defined as follows:

For body weight of 50kg:

$$U_{Tp} = (1000 + 1.5 \cdot C_s \cdot \rho_s) \cdot \frac{0.116}{\sqrt{t_s}}$$

(Equation 122)

For body weight of 70kg:

$$U_{Tp} = (1000 + 1.5 \cdot C_s \cdot \rho_s) \cdot \frac{0.157}{\sqrt{t_s}}$$

(Equation 123)

where

$C_s$ is the surface layer derating factor

$\rho_s$ is the surface material resistivity in Ω·m

$\rho$ is the resistivity of the earth beneath the surface material in Ω·m

If no protective surface layer is used, then $C_s$ =1 and $\rho_s = \rho$.

The equations of IEEE Std 80-2013 are in IFPTOC-function modelled with following simplified equation, with only one setting *IEEE multiplier*:

$$U_{TF}^{est} = IEEE\ multiplier \cdot \frac{1}{\sqrt{t_s}}$$

(Equation 124)

With setting *IEEE multiplier* the operate time as a function of estimated touch voltage magnitude can be adjusted. For body weight of 70kg, $C_s$ =1, $\rho_s = \rho$ = 0 Ω·m, then *IEEE multiplier* equals 157.0.

In case *Operation principle* = “EF current based”, setting *Maximum earthing Ris* is used to scale the touch voltage and earth potential rise requirements defined in standard IEEE80 into corresponding earth-fault current requirements. When *Operating curve type* = “Inverse time IEEE80” is selected, then the protection operate time as a function of estimated effective earth-fault current $I_F^{est}$ (taking into account the effect of settings *Reduction factor* and *Enable harmonics*) is according to equation below:

$$t = \left( \frac{IEEE\ multiplier}{Maximum\ earthing\ Ris * Reduction\ factor * I_F^{est}} \right)^2 - CB\ delay\ comp\ [s]$$

(Equation 125)

Example numerical values of the permissible touch voltage $U_{Tp}$ converted into corresponding earth-fault current requirements as a function of the fault duration $t_f$ according to standard IEEE80 are shown in table below.

**Table 629: Numerical example of the values of the permissible touch voltages $U_{Tp}$ as a function of the fault duration $t_f$ according to standard IEEE80 converted into corresponding permissible earth-fault current values. The numerical values assume body weight of 70 kg, $C_s$ =1, $\rho_s = \rho$ = 0 Ω·m, then IEEE multiplier equals 157. Conversion is made with parameter $R_{Emax}$, which is the setting *Maximum***

***earthing Ris*** **in primary ohms i.e. the maximum earthing resistance encountered in protected feeder.**

| Fault duration $t_f$ [sec.] | Permissible touch voltage, $U_{Tp}$ converted into corresponding permissible fault current, $I_{Fp}$ [A] |
|---|---|
| 0.05 | 702 V/$R_{Emax}$ |
| 0.10 | 496 V/$R_{Emax}$ |
| 0.20 | 351 V/$R_{Emax}$ |
| 0.50 | 222 V/$R_{Emax}$ |
| 1.00 | 157 V/$R_{Emax}$ |
| 2.00 | 111 V/$R_{Emax}$ |
| 5.00 | 70 V/$R_{Emax}$ |
| 10.00 | 50 V/$R_{Emax}$ |

In some countries, safety during an earth fault is defined in terms of highest allowed earth potential rise (EPR) as a function of fault duration. As an example, in Finnish national Electrical Safety Regulations 89 define highest allowed earth potential rise as a function of fault duration as shown in table below.

**Table 630: Highest allowed EPR values based on Electrical Safety**

| Group | Highest allowed EPR [V], when earth fault is automatically disconnected within time *t* [sec] |
|---|---|
| a | 750V/√*t* |
| b | 2000V/√*t* |
| c | 3000V/√*t* |
| d | 500V/√*t* |
| e1 | 750V/√*t* |
| e2 | 1000V/√*t* |

The regulations of *Table 630* are implemented into IFPTOC. In case *Operation principle* = “EF current based”, setting *Maximum earthing Ris* is used to convert the highest allowed earth potential risevalues into corresponding earth-fault current values. Setting *IEEE multiplier* is set to equal the highest allowed voltage value, for example for group d, *IEEE multiplier* = 500. Conversion of the highest allowed earth potential rise value to the highest allowed earth-fault current magnitude with setting *Maximum earthing Ris* is shown in *Table 631*.

Setting *Maximum earthing Ris* in primary ohms is selected based on the maximum earthing resistance encountered in protected feeder.

**Table 631: Conversion of the highest allowed earth potential rise value into corresponding earth-fault current values according to the Electrical Safety Regulations**

**89 with setting *Maximum earthing Ris* in primary ohms i.e. the maximum earthing resistance encountered in protected feeder.**

| Group | Highest allowed EPR values [V] converted into corresponding permissible fault current, $I_{Fp}$ [A],when earth fault is automatically disconnected within time t [sec] |
|---|---|
| a | (750 V/ *Maximum earthing Ris*)/√t |
| b | (2000 V/ *Maximum earthing Ris*)/√t |
| c | (3000 V/ *Maximum earthing Ris*)/√t |
| d | (500 V/ *Maximum earthing Ris*)/√t |
| e1 | (750 V/ *Maximum earthing Ris*)/√t |
| e2 | (1000 V/ *Maximum earthing Ris*)/√t |

It is important to note, that:

1. Minimum effective earth-fault current magnitude (considering the effect of *Reduction factor*), which must be exceeded for the function to start, is defined with setting *EF current Str Val*. It is important to set this value according to required protection sensitivity.
2. With *IDMT stage Min Op Tm* setting user can define minimum allowed operate time for IFPTOC i.e. this is the minimum allowed operate time of IFPTOC.
3. With *IDMT stage Max Op Tm* setting user can define maximum allowed operate time for IFPTOC i.e. this is the maximum allowed operate time of IFPTOC although IDMT timer would define slower operate time.

Parameter defining maximum earthing resistance, setting *Maximum earthing Ris* must be always set in case *Operation principle* = “EF current based” and *Operating curve type* = “Inverse time IEEE80” is selected. Setting *Maximum earthing Ris* is needed to scale the touch voltage and earth potential rise requirements defined in standard IEEE80 into corresponding earth-fault current requirements.

Setting *Reduction factor* considers the fact that only part of the earth-fault current ($I_F$) will flow back through “remote” earth and introduces earthing and touch voltages.

When *Operating curve type* = “Inverse time IEEE80” is selected, then setting *UTp multiplier* is not effective.

Consider next the following example with *Operating curve type* = “Inverse time IEEE80”:

**Example 3.** Inverse time operation of IFPTOC, when *Operation principle* = “EF-current based” and *Operating curve type* = “Inverse time IEEE80” is illustrated in *Figure 347*. Start value for operation is set to be 0.02*In (2 A). IFPTOC is set to have minimum operate time 100 ms and maximum operate time of 5000 ms. Setting *IEEE multiplier* is 500 and setting *Maximum earthing Ris* is 10 ohms. *Reduction factor* = 1.0. For illustrating the operating speed requirement of protection, limits of earth potential rise durations defined in Finnish national Electrical Safety Regulations 89 scaled the into corresponding earth-fault current requirements using the maximum earthing resistance $R_{Emax}$ (setting *Maximum earthing Ris*) encountered in protected feeder are shown for reference.

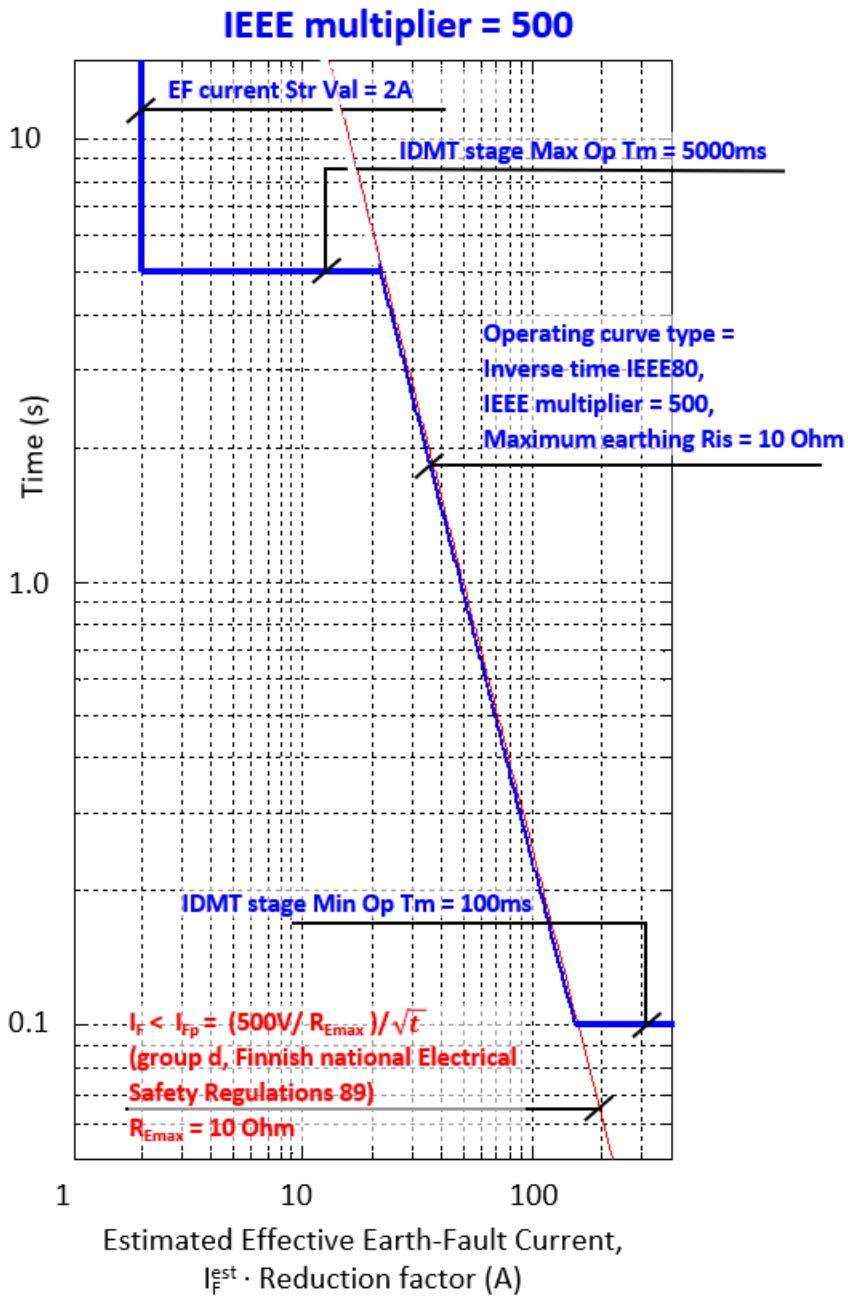



*Figure 347: Operation timer characteristic of IFPTOC-function when Operation principle = "EF-current based" and Operating curve type = "Inverse time IEEE80". Setting IEEE multiplier is 500,Maximum earthing Ris is 10 ohms, EF current Str Val = 0.02*In (2 A), IDMT stage Min Op Tm = 100 ms and IDMT stage Max Op Tm = 5000 ms. Reduction factor = 1.0. Characteristics are according to standard IEEE80.*

*Principle based on touch voltage estimate*

The operation of IFPTOC based on touch voltage estimate is described next. In case *Operation principle* = "Touch voltage based", then operation is based on the estimated touch voltage magnitude according to *Equation 119*. The harmonic content of touch voltage can be included into estimate with setting *Enable harmonics* = "Enable".

Operation time can be either definite time or inverse time, selected with setting *Operating curve type* = “Definite time”, “Inverse time EN50522” or “Inverse time IEEE80”.

**When *Operating curve type* = “Definite time” is selected, then**

- Operate time is according to definite time (DT) operation.
- START and ST_EF outputs are activated when estimated touch voltage (considering the effect of settings *Reduction factor* and *Enable harmonics*) exceeds setting *Touch Vol Str Val* and earth fault is detected and earth-fault current estimate is validated. Note that *Ena RF Compensation* = “Enable” does not affect this start condition. It is important to set setting *Touch Vol Str Val* according to required protection sensitivity.
- OPERATE and OP_EF outputs are activated after *Operation timer* has elapsed, defined with setting *DT stage Op time*.
- Reset timer is started if any of the above conditions for START is not anymore valid. START and ST_EF outputs stay activated until the reset timer expires (setting Reset delay time). After OPERATE output activation, START, ST_EF, OPERATE and OP_EF outputs are reset immediately i.e. reset delay time is no longer valid.
- During re-striking/intermittent earth faults, in case operation should be based preferably on counted number of transients, then setting *Reset delay time* should be set to low value, say 20-40 ms, thus definite operation is ineffective during re-striking/intermittent earth faults. Dedicated intermittent earth-fault protection functionality based on counted number of transients is described in *Chapter 4.2.10.5.6 Intermittent earth-fault protection*.
- Applicable settings are: *Reduction factor, Maximum earthing Ris, Touch Vol Str Val, DT stage Op time, Reset delay time*.
- Note that setting *CB Delay Comp* (circuit breaker delay compensation) is not applicable in definite time operation.

Consider next the following example:

**Example 4.** Setting *Touch Vol Str Val* = 40 V and *DT stage Op time* = 400 ms. IFPTOC starts when estimated touch voltage exceeds 40 V and operates after 400 ms, if start conditions are met. Maximum earthing resistance value encountered in the protected feeder is set to be 10 ohms (setting *Maximum earthing Ris*) and *Reduction factor* = 1. For illustrating possible operating speed requirements of protection, limits of touch and earth potential rise durations defined in standard EN50522 are shown for reference.

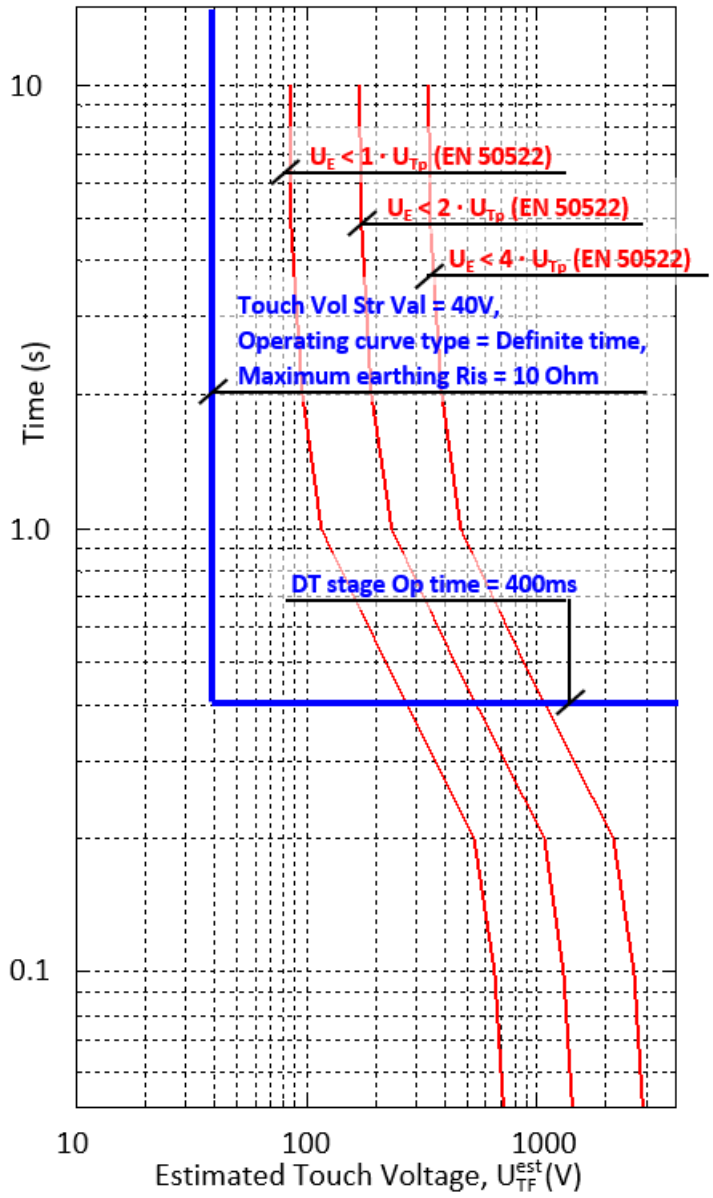



*Figure 348: Example of definite time operation of IFPTOC, when Operation principle = "Touch voltage based", Operating curve type = "Definite time". Setting Touch Vol Str Val = 40 V and DT stage Op time = 400 ms. Maximum earthing Ris = 10 ohm*

Parameter defining maximum earthing resistance, setting *Maximum earthing Ris* must be always set in case *Operation principle* = "Touch voltage based" and *Operating curve type* = "Definite time" is selected. Setting *Maximum earthing Ris* is needed to scale the estimated earth-fault current value into corresponding touch voltage or earth potential rise value.

**When *Operating curve type* = "Inverse time EN50522" is selected, then**

- Operate time is inverse time according to standard EN50522:

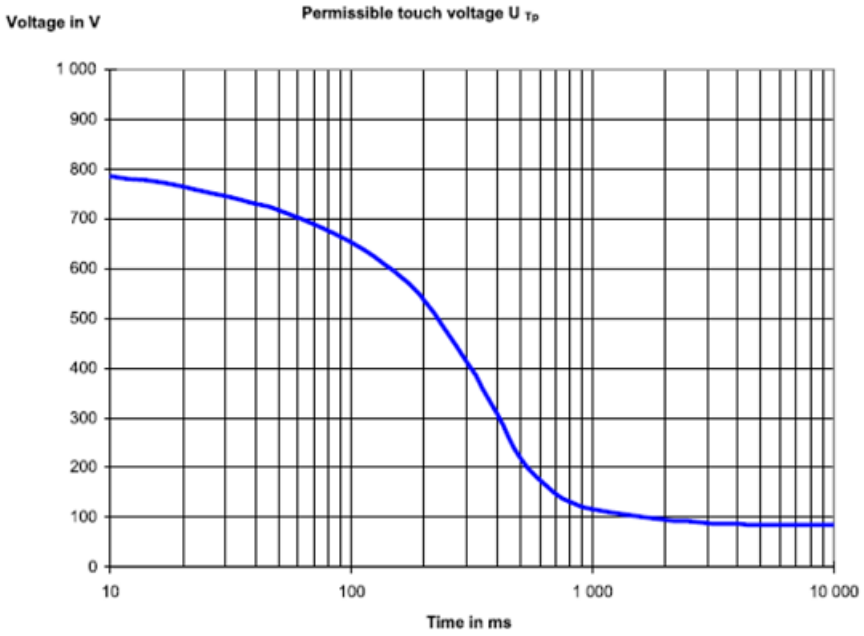



*Figure 349: Permissible time-touch voltage characteristics given in standard EN 50522*

- Time margin for practical circuit-breaker operate time can be applied with setting *CB delay Comp*. Default setting is 0 ms.
- START and ST_EF outputs are activated when estimated touch voltage (considering the effect of settings *Reduction factor* and *Enable harmonics*) exceeds setting *Touch Vol Str Val* and earth fault is detected and earth-fault current estimate is validated. Note that *Ena RF Compensation* = “Enable” does not affect this start condition.
- OPERATE and OP_EF outputs are activated according to time-touch voltage characteristics given in standard EN 50522 i.e. operate time is inversely proportional to the estimated touch voltage.
- Reset timer is started if any of the above conditions for START is not anymore valid. START and ST_EF outputs stay activated until the reset timer expires (setting Reset delay time). After OPERATE output activation, START, ST_EF, OPERATE and OP_EF outputs are reset immediately i.e. reset delay time is no longer valid.
- During re-striking/intermittent earth faults, the very high current transient may result to very fast operation times. In case longer operation during re-striking/ intermittent earth faults is preferred and operation should be based preferably on counted number of transients, then setting *Reset delay time* should be set to low value, say 20-40 ms. Dedicated intermittent earth-fault protection functionality based on counted number of transients is described in *Chapter 4.2.10.5.6 Intermittent earth-fault protection*.
- Applicable settings are: *Reduction factor, Maximum earthing Ris, Touch Vol Str Val, CB delay Comp, UTp multiplier, IDMT stage Min Op Tm, IDMT stage Max Op Tm, Reset delay time*.

It is important to note, that:

1. Settings *Reduction factor* and *Maximum earthing Ris* are used to scale the estimated effective earth-fault current value into corresponding touch voltage or earth-potential rise estimate.
2. Setting *UTp multiplier* enables operation based on permissible earth potential rise $U_E$, by scaling of the permissible time-touch voltage characteristics given in standard EN 50522 with Setting *UTp multiplier*, see table below.

**Table 632: Permissible touch voltages $U_{Tp}$ and earth potential rise $U_E$ values as a function of the fault duration $t_f$ according to standard EN50522 with $U_{Tp}$ multiplier as a parameter**

| Fault duration $t_f$ [sec.] | Permissible touch voltage, $U_{Tp}$, $U_{Tp}$ multiplier = 1.0 [V] | Permissible earth potential rise, $U_E$, $U_{Tp}$ multiplier = 2.0 [V] | Permissible earth potential rise, $U_E$, $U_{Tp}$ multiplier = 4.0 [V] |
|---|---|---|---|
| 0.05 | 716 | 1432 | 2864 |
| 0.10 | 654 | 1308 | 2616 |
| 0.20 | 537 | 1074 | 2148 |
| 0.50 | 220 | 440 | 880 |
| 1.00 | 117 | 234 | 468 |
| 2.00 | 96 | 192 | 384 |
| 5.00 | 86 | 172 | 344 |
| 10.00 | 85 | 170 | 340 |

3. Minimum touch voltage or earth potential rise magnitude (considering the effect of *Reduction factor*), which must be exceeded for the function to start, is defined with setting *Touch Vol Str Val*. It is important to set setting *Touch Vol Str Val* according to required protection sensitivity.
4. With *IDMT stage Min Op Tm* setting user can define minimum allowed operate time for IFPTOC i.e. this is the minimum allowed operate time of IFPTOC.
5. With *IDMT stage Max Op Tm* setting user can define maximum allowed operate time for IFPTOC i.e. this is the maximum allowed operate time of IFPTOC although IDMT timer would define slower operate time.

Parameter defining maximum earthing resistance, setting *Maximum earthing Ris* must be always set in case *Operation principle* = “Touch voltage based” and *Operating curve type* = “Inverse time EN50522” is selected. Setting *Maximum earthing Ris* is needed to scale the estimated effective earth-fault current value to corresponding touch voltage or earth potential rise value.

Setting *Reduction factor* considers the fact that only part of the earth-fault current ($I_F$) will flow back through “remote” earth and introduces earthing and touch voltages.

Minimum practical value for setting *Touch Vol Str Val* is 0.5% of CT primary current multiplied by setting *Maximum earthing Ris*. For example, in case CT primary current is 200 A, and *Maximum earthing Ris* = 10 ohm, then minimum practical value for setting *Touch Vol Str Val* is 0.5%*200 A*10 ohm = 10 V. For CT with 400 A primary current, then minimum practical value for setting *Touch Vol Str Val* is 0.5%*400 A*10 ohm = 20 V. The lower setting *Touch Vol Str Val* is used, the higher sensitivity in terms of fault resistance can be obtained. Sensitivity

in terms of fault resistance depends also on the network parameters (nominal voltage, damping and detuning) as described by *Equation 126*.

$$R_F[ohm] \leq \frac{U_{PE}\cdot\left(\sqrt{I_d^4+2I_d^2\cdot I_v^2-(U_F/R_E)^2\cdot I_v^2+I_v^4}-I_d\cdot(U_F/R_E)\right)}{(I_d^2+I_v^2)\cdot(U_F/R_E)}$$

(Equation 126)

where $U_{PE}$ is the nominal phase-to-earth voltage [V], $I_d$ is the total system damping [A], $I_v$ is the detuning [A], $U_F$ is setting *Touch Vol Str Val* in primary volts and $R_E$ is setting *Maximum earthing Ris* in primary ohms.

When *Operating curve type* = “Inverse time EN50522” is selected, then the protection operate time as a function of estimated touch voltage $U_{TF}^{est}$ (taking account the effect of *Reduction factor*) is according to *Equation 127*:

$$t = 0.29 \times e^{ln\left(-\frac{722.8-\left(\frac{U_{TF}^{est}}{UTp\ multiplier}\right)}{85.3-\left(\frac{U_{TF}^{est}}{UTp\ multiplier}\right)}\right)/2.39} - CB\ delay\ comp\ [s]$$

(Equation 127)

In IFPTOC function, the preferred presentation of operation timer characteristics is by plotting the protection operate time as a function of permissible/estimated touch voltage as illustrated in *Figure 350*, *Figure 351* and *Figure 352*.

Consider next three examples with *Operating curve type* = “Inverse time EN50522”:

**Example 5a.** Inverse time operation of IFPTOC, when *Operation principle* = “Touch voltage based”, *Operating curve type* = “Inverse time EN50522” and setting *UTp multiplier* = 1.0 is illustrated in *Figure 350*. Start value for operation is set to be 20 V (setting *Touch Vol Str Val*). IFPTOC is set to have minimum operate time 100 ms and maximum operate time of 5000 ms (settings *IDMT stage Min Op Tm, IDMT stage Max Op Tm*). Maximum earthing resistance value encountered in the protected feeder is set to be 10 ohms (setting *Maximum earthing Ris*) and Reduction factor = 1. For illustrating the operating speed requirement of protection, limits of touch voltage durations defined in standard EN50522 are shown for reference.

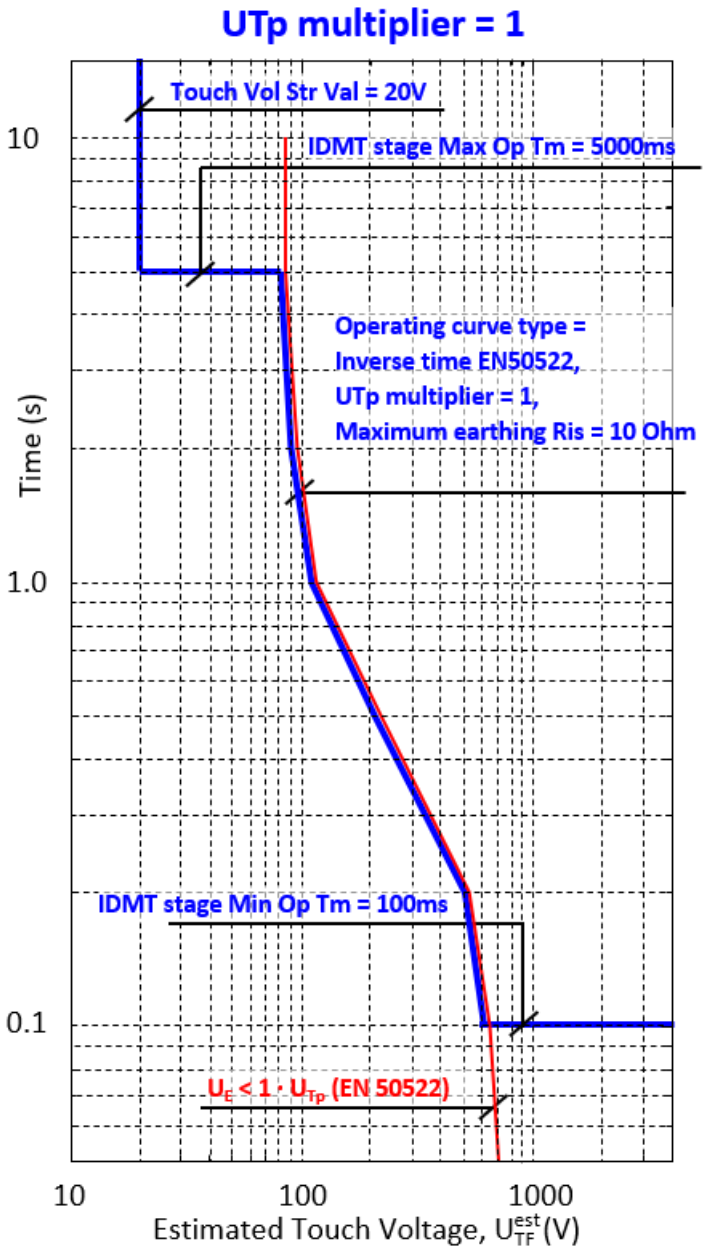



*Figure 350: Operation timer characteristic of IFPTOC function when Operation principle = "Touch voltage based", Operating curve type = "Inverse time EN50522" and Operating curve type = 1.0. Characteristics are according to standard EN50522. Maximum earthing Ris = 10 ohm.*

**Example 5b.** Inverse time operation of IFPTOC, when *Operation principle* = "Touch voltage based", *Operating curve type* = "Inverse time EN50522" and setting *UTp multiplier* = 2.0 is illustrated in *Figure 351*. Start value for operation is set to be 40 V (setting *Touch Vol Str Val*). IFPTOC is set to have minimum operate time 100 ms and maximum operate time of 5000 ms (settings *IDMT stage Min Op Tm, IDMT stage Max Op Tm*). Maximum earthing resistance value encountered in the protected feeder is set to be 10 ohms (setting *Maximum earthing Ris*) and *Reduction factor* = 1. For illustrating the operating speed requirement of protection, limits of earth potential rise durations defined in standard EN50522 are shown for reference.

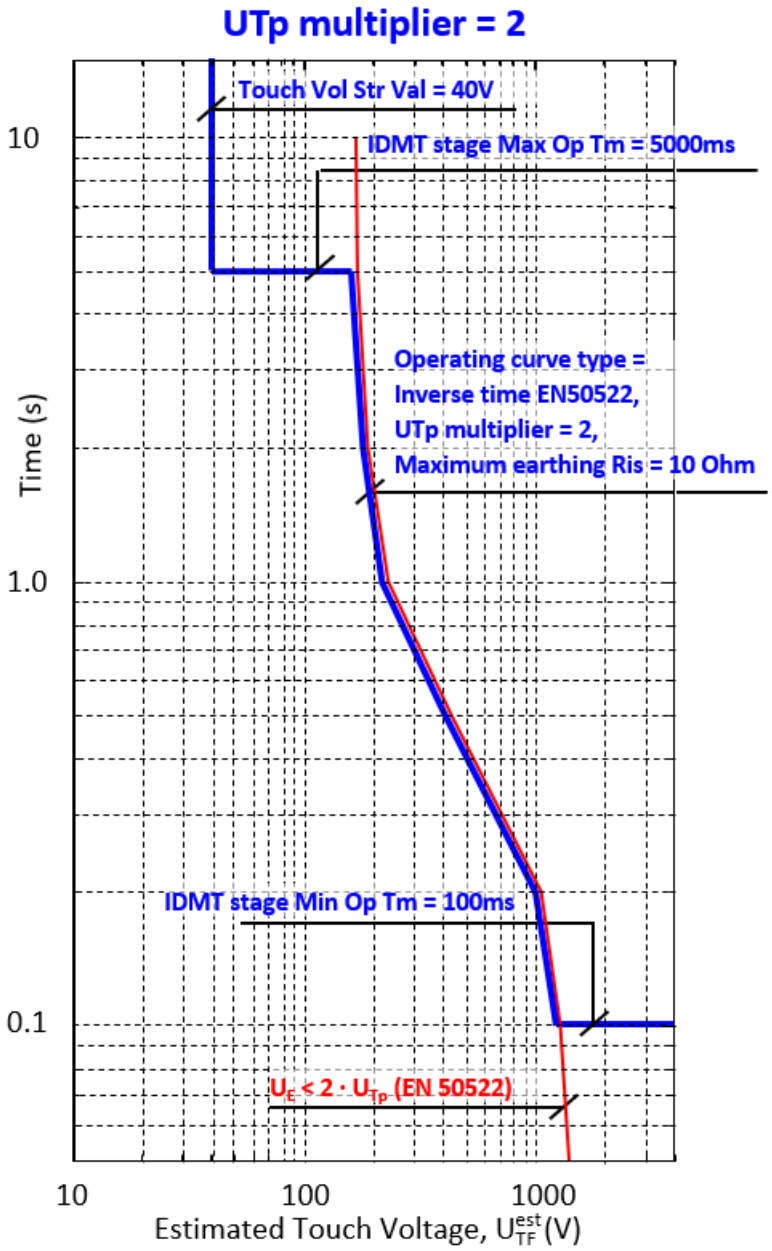



*Figure 351: Operation timer characteristic of IFPTOC function when Operation principle = "Touch voltage based", Operating curve type = "Inverse time EN50522" and UTp multiplier = 2.0. Characteristics are according to standard EN50522. Maximum earthing Ris = 10 ohm.*

**Example 5c.** Inverse time operation of IFPTOC, when *Operation principle* = "Touch voltage based", *Operating curve type* = "Inverse time EN50522" and setting *UTp multiplier* = 4.0 is illustrated in *Figure 352*. Start value for operation is set to be 60 V (setting *Touch Vol Str Val*). IFPTOC is set to have minimum operate time 100 ms and maximum operate time of 5000 ms (settings *IDMT stage Min Op Tm, IDMT stage Max Op Tm*). Maximum earthing resistance value encountered in the protected feeder is set to be 10 ohms (setting *Maximum earthing Ris*) and *Reduction factor* = 1. For illustrating the operating speed requirement of protection, limits of earth potential rise durations defined in standard EN50522 are shown for reference.

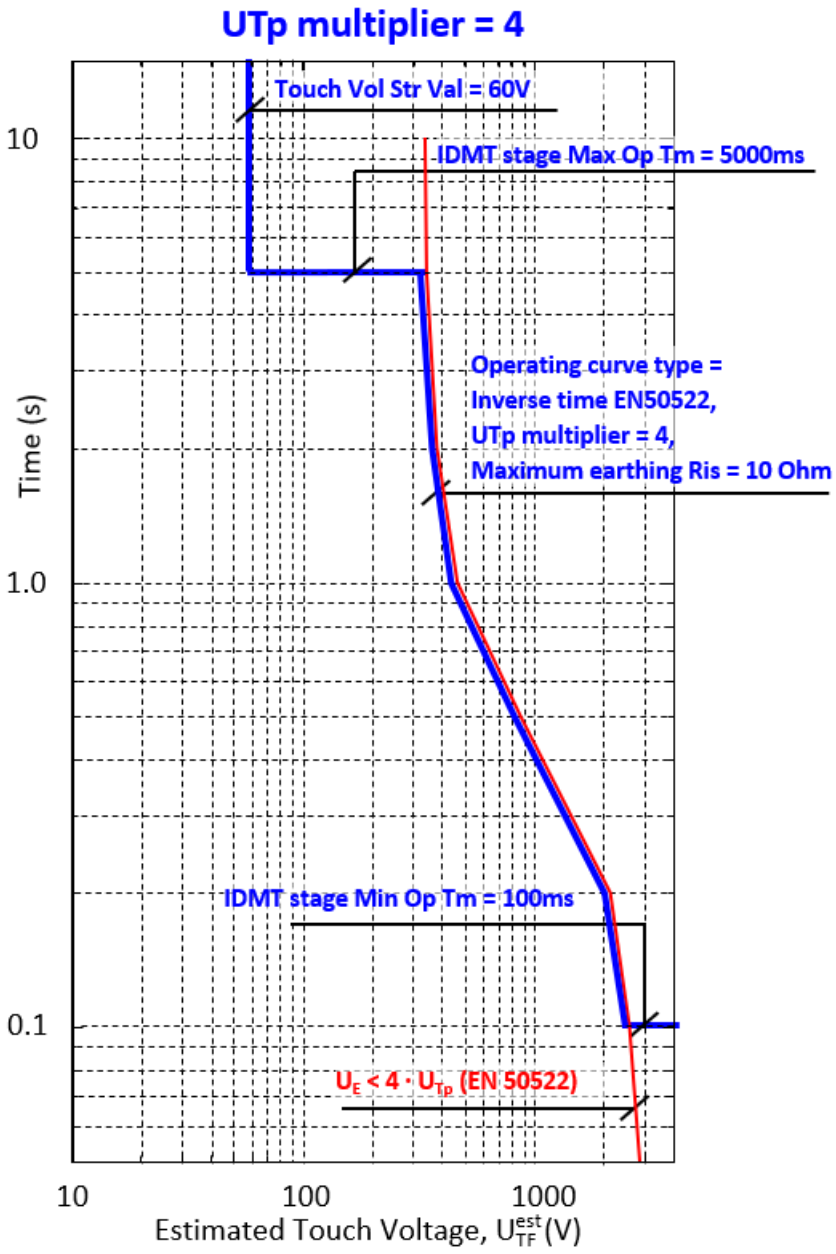



*Figure 352: Operation timer characteristic of IFPTOC function when Operation principle = "Touch voltage based", Operating curve type = "Inverse time EN50522" and UTp multiplier = 4.0. Characteristics are according to standard EN50522. Maximum earthing Ris = 10 ohm.*

**When *Operating curve type* = "Inverse time IEEE80" is selected, then**

- Operate time is inverse time according to standard IEEE80:

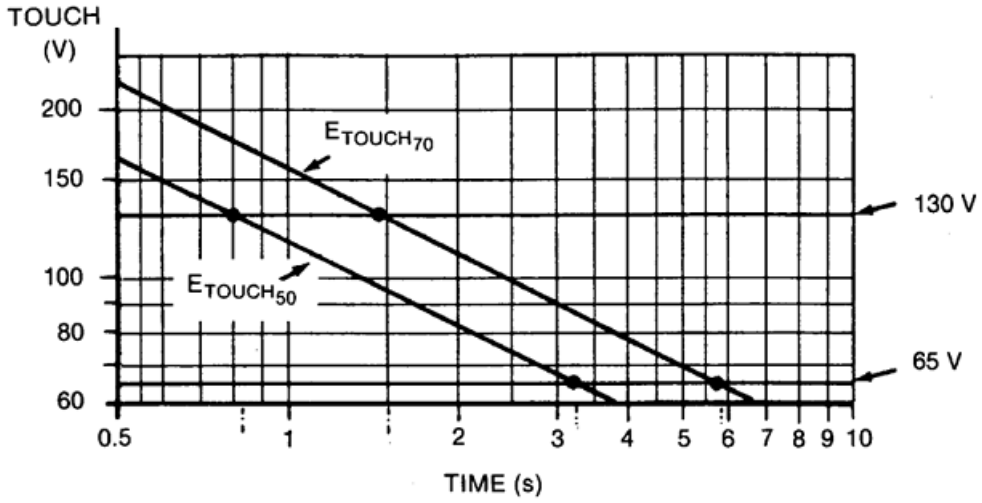



*Figure 353: Permissible time-touch voltage characteristics given in standard IEEE80 (metal-to-metal contact).*

- This operation mode can be also used when maximum allowed earthing voltage, i.e. earth potential rise, vs. operation speed follows a relationship such as 750V/√*t*[*sec*].
- Time margin for practical circuit-breaker operate time can be applied with setting *CB delay Comp*. Default setting is 0 ms.
- START and ST_EF outputs are activated when estimated touch voltage (considering the effect of settings *Reduction factor* and *Enable harmonics*) exceeds setting *Touch Vol Str Val* and earth fault is detected and earth-fault current estimate is validated. Note that *Ena RF Compensation* = “Enable” does not affect this start condition.
- OPERATE and OP_EF outputs are activated according to time-touch voltage characteristics given in standard IEEE80 i.e. operate time is inversely proportional to the estimated touch voltage.
- Reset timer is started if any of the above conditions for START is not anymore valid. START and ST_EF outputs stay activated until the reset timer expires (setting *Reset delay time*). After OPERATE output activation, START, ST_EF, OPERATE and OP_EF outputs are reset immediately i.e. reset delay time is no longer valid.
- During re-striking/intermittent earth faults, the very high current transient may result to very fast operation times. In case longer operation during re-striking/ intermittent earth faults is preferred and operation should be based preferably on counted number of transients, then setting *Reset delay time* should be set to low value, say 20-40 ms. Dedicated intermittent earth-fault protection functionality based on counted number of transients is described in *Chapter 4.2.10.5.6 Intermittent earth-fault protection*.
- Applicable settings are: *Reduction factor, Maximum earthing Ris, Touch Vol Str Val, CB delay Comp, IEEE multiplier, IDMT stage Min Op Tm, IDMT stage Max Op Tm, Reset delay time*.

According to the standard IEEE80, the values of the permissible touch voltage $U_{Tp}$ as a function of the fault duration $t_f$ are defined as follows:

For body weight of 50 kg:

$$U_{Tp} = (1000 + 1.5 \cdot C_s \cdot \rho_s) \cdot \frac{0.116}{\sqrt{t_s}}$$

(Equation 128)

For body weight of 70 kg:

$$U_{Tp} = (1000 + 1.5 \cdot C_s \cdot \rho_s) \cdot \frac{0.157}{\sqrt{t_s}}$$

(Equation 129)

where

$C_s$ is the surface layer derating factor

$\rho_s$ is the surface material resistivity in Ω·m

$\rho$ is the resistivity of the earth beneath the surface material in Ω·m

If no protective surface layer is used, then $C_s$ =1 and $\rho_s$ = $\rho$.

The equations of IEEE Std 80-2013 are in IFPTOC function modelled with following simplified equation, with only one parameter *IEEE multiplier*:

$$U_{TF}^{est} = IEEE\ multiplier \cdot \frac{1}{\sqrt{t_s}}$$

(Equation 130)

With setting *IEEE multiplier* operate time as a function of estimated touch voltage magnitude can be adjusted. For body weight of 70 kg, $C_s$ =1, $\rho_s$ = $\rho$ = 0 Ω·m, then *IEEE multiplier* equals 157.0.

In IFPTOC, the protection operate time $t$ as a function of estimated touch voltage $U_{TF}^{est}$ according to standard IEEE80 follows equation below:

$$t = \left(\frac{IEEE\ multiplier}{U_{TF}^{est}}\right)^2 - CB\ delay\ comp\ [s]$$

(Equation 131)

Example numerical values of the permissible touch voltage $U_{Tp}$ as a function of the fault duration $t_f$ according to standard IEEE80 are shown in *Table 633*. Values in *Table 633* assume body weight of 70 kg, $C_s$ =1, $\rho_s$ = $\rho$ = 0 Ω·m, then IEEE multiplier equals 157.0.

**Table 633: Numerical example of the values of the permissible touch voltages $U_{Tp}$ as a function of the fault duration $t_f$ according to standard IEEE80 programmed**

**into IFPTOC. The numerical values assume body weight of 70 kg, $C_s$ =1, $\rho_s$ = $\rho$ = 0 Ω·m, then *IEEE multiplier* equals 157.**

| Fault duration $t_f$ [sec.] | Permissible touch voltage, $U_{Tp}$ [V] |
|---|---|
| 0.05 | 702 |
| 0.10 | 496 |
| 0.20 | 351 |
| 0.50 | 222 |
| 1.00 | 157 |
| 2.00 | 111 |
| 5.00 | 70 |
| 10.00 | 50 |

In some countries, safety during an earth fault is defined in terms of highest allowed earth potential rise (EPR) as a function of fault duration. As an example, in Finnish national Electrical Safety Regulations 89 define highest allowed earth potential rise (EPR) as a function of fault duration as shown in table below.

**Table 634: Highest allowed EPR value based on Electrical Safety Regulations 89**

| Group | Highest allowed EPR [V], when earth-fault is automatically disconnected within time *t* [sec] |
|---|---|
| a | 750V/√*t* |
| b | 2000V/√*t* |
| c | 3000V/√*t* |
| d | 500V/√*t* |
| e1 | 750V/√*t* |
| e2 | 1000V/√*t* |

The regulations of *Table 634* are implemented into IFPTOC. Setting *IEEE multiplier* is set to equal the highest allowed voltage value, for example for group d, *IEEE multiplier* = 500.

It is important to note, that:

1. Minimum effective touch-voltage magnitude (considering the effect of *Reduction factor*), which must be exceeded for the function to start, is defined with setting *Touch Vol Str Val*. It is important to set setting *Touch Vol Str Val* according to required protection sensitivity.
2. With *IDMT stage Min Op Tm* setting user can define minimum allowed operate time for IFPTOC i.e. this is the minimum allowed operate time of IFPTOC.
3. With *IDMT stage Max Op Tm* setting user can define maximum allowed operate time for IFPTOC i.e. this is the maximum allowed operate time of IFPTOC although IDMT timer would define slower operate time.



Parameter defining maximum earthing resistance, setting *Maximum earthing Ris* must be always set in case *Operation principle* = “Touch voltage based” and *Operating curve type* = “Inverse time IEEE80” is selected. Setting *Maximum earthing Ris* is needed to scale the estimated earth-fault current value into corresponding touch voltage or earth potential rise value.

Setting *Reduction factor* considers the fact that only part of the earth-fault current ($I_F$) will flow back through “remote” earth and introduces earth potential rise and touch voltages.

When *Operating curve type* = “Inverse time IEEE80” is selected, then setting *UTp multiplier* is not effective.

Consider next the following example with Operating curve type = “Inverse time IEEE80”:

**Example 6.** Inverse time operation of IFPTOC, when *Operation principle* = “Touch voltage based”, *Operating curve type* = “Inverse time IEEE80” and setting *IEEE multiplier* = 500 is illustrated in *Figure 354*. Start value for operation is set to be 20 V (setting *Touch Vol Str Val*). IFPTOC is set to have minimum operate time 100 ms and maximum operate time of 5000 ms (settings *IDMT stage Min Op Tm, IDMT stage Max Op Tm*). Maximum earthing resistance value encountered in the protected feeder is set to be 10 ohms (setting *Maximum earthing Ris*) and *Reduction factor* = 1. For illustrating the operating speed requirement of protection, limits of earth potential rise durations defined in Finnish national Electrical Safety Regulations 89 are shown for reference.

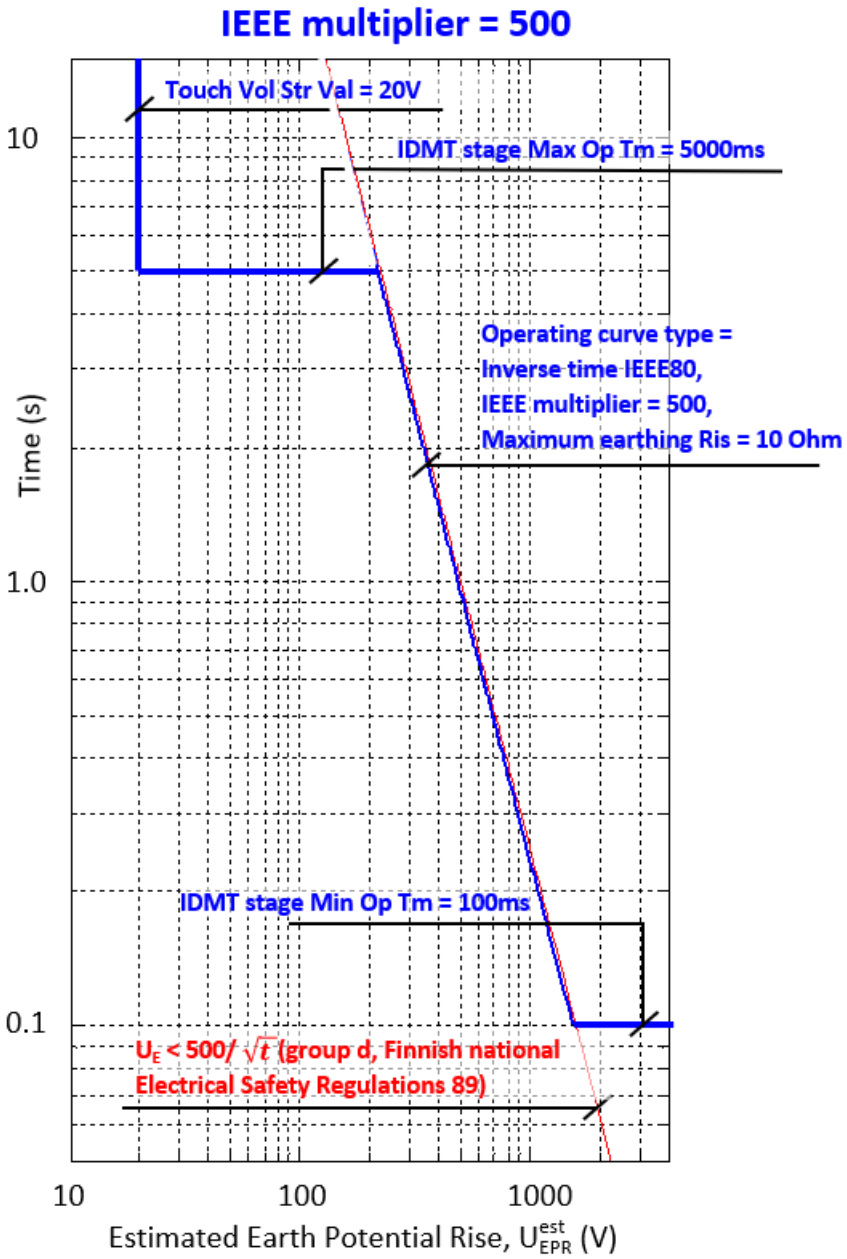



*Figure 354: Operation timer characteristic of IFPTOC function when Operation principle = "Touch voltage based", Operating curve type = "Inverse time IEEE80" and IEEE multiplier = 500. Characteristics are according to standard IEEE80. Maximum earthing Ris = 10ohm.*

### Cross-country fault protection

In high impedance earthed networks, single phase earth fault introduces over-voltages in the healthy phases. Such over-voltages may initiate another single-phase earth fault in another phase and location in a galvanically connected network. Such fault condition is commonly known as cross-country fault, which is a two phase short-circuit through earth with high earth fault current. Cross-country fault must be therefore quickly disconnected in order to limit risk to health and damages to equipment.

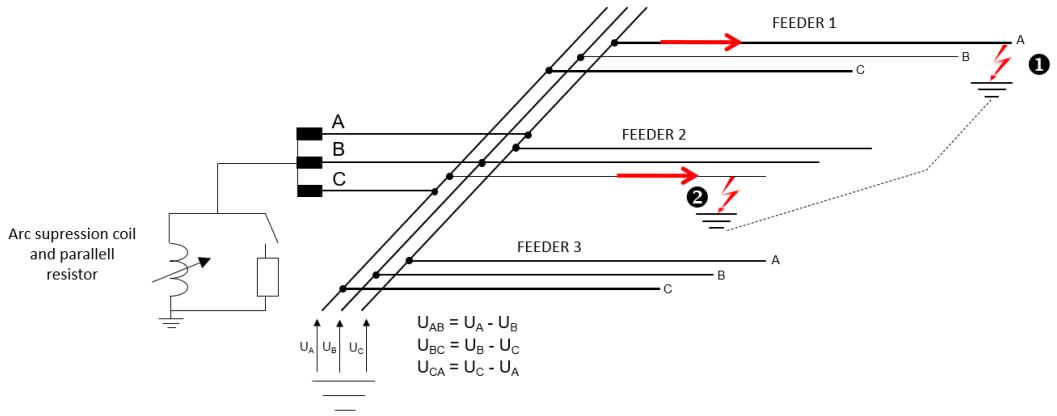



*Figure 355: Simplified illustration of a cross-country fault between phases A and C, where two simultaneous single-phase earth faults occur in two different locations and two different phases in the network*

IFPTOC has an in-build dedicated functionality for cross-county fault detection and tripping. Detection of cross-country fault is always enabled, but tripping may be enabled or disabled with setting *Enable XC Op mode* = “on” or “off”. In case multiple instances of IFPTOC are applied in the protection configuration, only single instance of IFPTOC requires cross-country fault tripping functionality to be enabled; in other instances, cross-country fault tripping functionality may be disabled. As default *Enable XC Op mode* = “on” i.e. tripping is enabled during cross-country faults.

There are two independent criteria for cross-country fault detection: The 1st criterion requires that residual current exceeds a value which is higher than maximum single-phase earth-fault current of the network, and the 2nd criterion monitors voltage dip in any of the phase-to-phase voltages.

**Residual over-current criterion**

Monitoring of the magnitude of calculated residual current ($I_o$) and comparing it to setting *XC stage A Str Val* during a detected earth fault:

$$EF_IND = TRUE, \ AND$$
$$I_o \ (calculated) > XC \ stage \ A \ Str \ Val$$

(Equation 132)

Calculated $I_o$ is used to avoid problems in case of possible CBCT saturation during high current cross-country fault.

It should be noted, that setting value *XC stage A Str Val* is given in unit [xIn], where In is phase current nominal value. Typical value for *XC stage A Str Val* in primary amperes is few hundreds of amperes. The setting *XC stage A Str Val* should not be higher than the estimated minimum cross-country fault current ($I_{F_XCmin}$), and on the other hand it must be checked against the uncompensated earth-fault current of the network ($I_{eNet}$) and setting of the low-set overcurrent stage (*3I>*):

*XC stage A Str Val* < $I_{F_XCmin}$ AND
*XC stage A Str Val* > max(2·$I_{eNet}$, *3I>*)

(Equation 133)

where

$I_{eNet}$ = Uncompensated earth-fault current of the network taking into account the decentralized compensation.

*3I>* = Setting of the low-set overcurrent stage of the protected feeder

The magnitude of the minimum expected cross-country fault current can be coarsely estimated based on the knowledge of the maximum earthing resistance values, *Maximum earthing Ris*, of all the feeders in the substation, and using the following equation:

$$I_{F_XCmin} \approx \sqrt{\frac{3 \cdot {U_{PE}}^2 \cdot {Y_{F1}}^2 \cdot {Y_{F2}}^2}{{Y_{F1}}^2 + {Y_{F2}}^2 + 2 \cdot Y_{F1} \cdot Y_{F2} + 4 \cdot {X_k}^2 \cdot {Y_{F1}}^2 \cdot {Y_{F2}}^2 + 4 \cdot {R_k}^2 \cdot {Y_{F1}}^2 \cdot {Y_{F2}}^2 + 4 \cdot R_k \cdot ({Y_{F1}}^2 \cdot Y_{F2} + {Y_{F2}}^2 \cdot Y_{F1})}}$$

(Equation 134)

where

$I_{F_XCmin}$ = Minimum expected cross-country fault current

$U_{n_PE}$ = Nominal phase-to-earth voltage

$Y_{F1}$ = 1 / *Maximum earthing Ris* = Admittance corresponding to the set maximum earthing resistance value of the protected feeder

$Y_{F2}$ = 1 / max(*Maximum earthing Ris_i*) = Admittance corresponding to the maximum of the set earthing resistance values of other feeders in the substation

$X_k$ = Sum of short-circuit reactances of the incoming HV-network and main transformer referred to MV-side

$R_k$ = Sum of short-circuit resistances of the incoming HV-network and main transformer referred to MV-side

**Example 1:**

- $U_{n_PE}$ = 11.547 kV
- *Maximum earthing Ris* = 15 ohm
- *Maximum earthing Ris_i* = 10 ohm
- $X_k$ = 2.2 ohm
- $R_k$ = 0.2 ohm
- *3I>* = 200 A
- $I_{eNet}$ = 320 A

Using the above parameters $I_{F_XCmin}$ equals 0.8 kA in order of magnitude, which is also higher than the uncompensated earth-fault current of the network and the setting of the low-set overcurrent stage of the protected feeder. So, setting *XC stage A Str Val* can be selected between $I_{eNet}$ = 320 A and $I_{F_XCmin}$ = 800 A.

Assuming phase CT-ratio 400/1 A, the setting *XC stage A Str Val* is selected to be 700 A (1.75*In).

**Phase-to-phase under-voltage criterion**

Monitoring of the magnitude of any phase-to-phase voltage ($U_{AB}$, $U_{BC}$ or $U_{CA}$) and comparing it to setting *XC stage PP V Val* during a detected earth fault:

$$EF_IND = TRUE, \ \ AND$$

$$U_{ph-ph} < XC\ stage\ PP\ V\ Val$$

(Equation 135)

During a single-phase earth fault phase-to-phase voltages are not affected, but during a cross-country fault the phase-to-phase voltages are affected, refer to *Figure 356*. Default setting for *XC stage PP V Val* is 0.9x$U_{n_PP}$, where $U_{n_PP}$ is the nominal phase-to-phase voltage.

In case all three phase-to-phase voltages ($U_{AB}$, $U_{BC}$ and $U_{CA}$) are under setting for *XC stage PP V Val*, such condition is considered as permanent three phase under-voltage condition, not a cross-country fault.

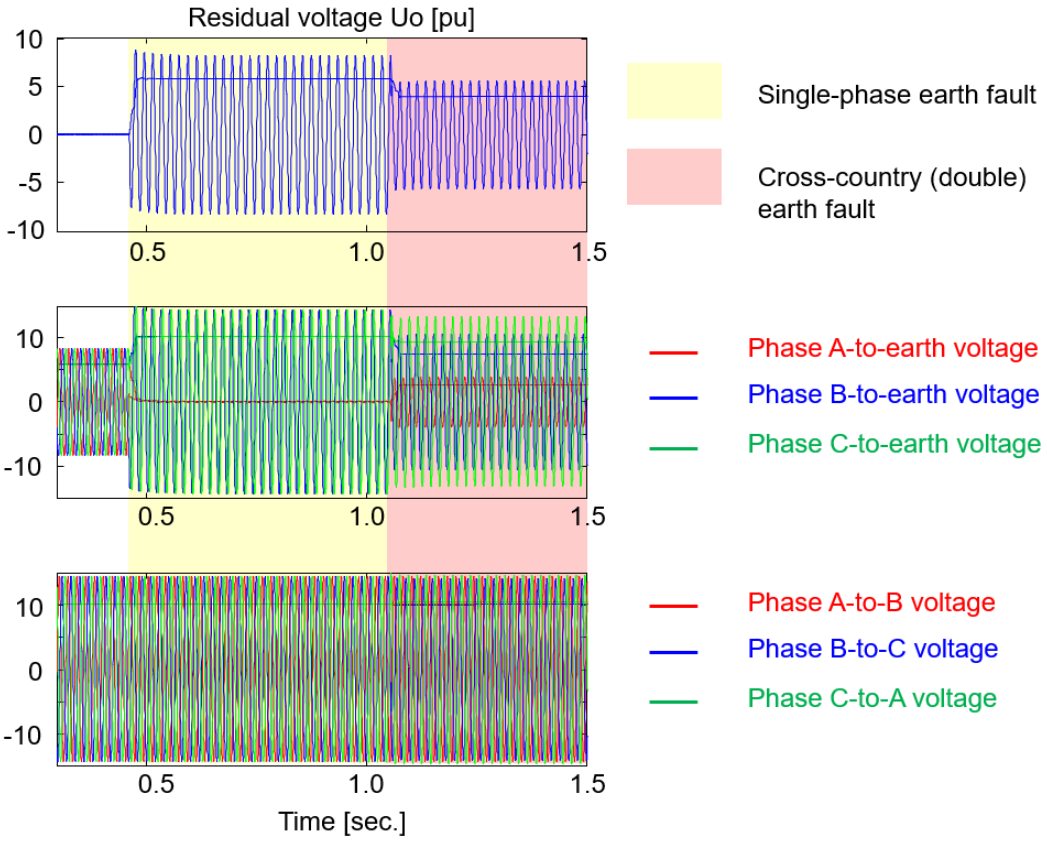



*Figure 356: Illustration of behavior of residual, phase-to-earth and phase-to-phase voltages during an evolvement of single-phase earth fault into cross-country fault in a 10 kV compensated network*

The magnitude of phase-to-phase voltage between faulted phases during a cross-country fault can be estimated using the following equation:

$$U_{PP_XC} \approx \sqrt{\frac{3 \cdot (Y_{F1}{}^2 + Y_{F2}{}^2 + 2 \cdot Y_{F1} \cdot Y_{F2}) \cdot U_{PE}{}^2}{Y_{F1}{}^2 + Y_{F2}{}^2 + 2 \cdot Y_{F1} \cdot Y_{F2} + 4 \cdot X_k{}^2 \cdot Y_{F1}{}^2 \cdot Y_{F2}{}^2 + 4 \cdot R_k{}^2 \cdot Y_{F1}{}^2 \cdot Y_{F2}{}^2 + 4 \cdot R_k \cdot (Y_{F1}{}^2 \cdot Y_{F2} + Y_{F2}{}^2 \cdot Y_{F1})}}$$

(Equation 136)

where

$U_{PP_XC}$ = Estimate of the highest phase-to-phase voltage during cross-country fault with minimum expected cross-country fault current according to *Equation 136*.

**Example 2:**

- $U_{n_PP}$ = 20 kV
- *Maximum earthing Ris* = 15 ohm
- *Maximum earthing Ris_i* = 10 ohm
- $X_k$ = 2.2 ohm
- $R_k$ = 0.2 ohm

Using the above parameters $U_{PP_XC}$ equals 19.3 kV in order of magnitude (19.3 kV/20 kV=~0.97x$U_{n_PP}$). However, taking additionally into account normal variations in supply voltage, the setting *XC stage PP V Val* can be selected 0.9x$U_{n_PP}$ (18.0 kV). In this way unnecessary activations of phase-to-phase undervoltage condition can be prevented.

*Figure 357* illustrates fault current magnitude according to *Equation 134* and phase-to-phase voltage magnitude according to *Equation 136*, during a cross-country fault as a function of fault resistance. Note that fault resistance is due to earthing resistances of the fault locations only, and its value equals the average of fault resistances $R_{F1}$ and $R_{F2}$ in both fault locations. $U_{n_PP}$ = 20 kV, $X_k$ = 2.2 ohm, $R_k$ = 0.2 ohm.

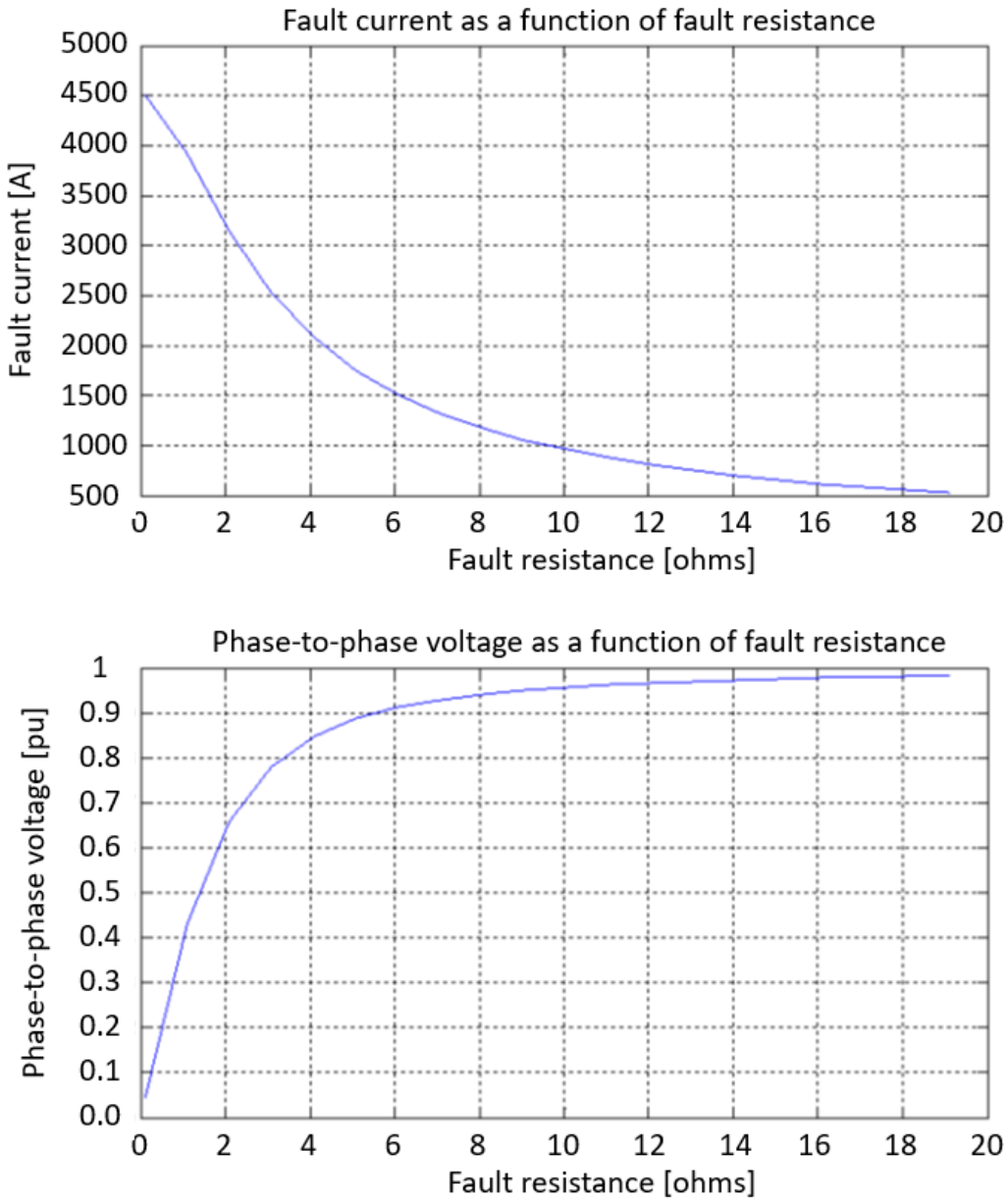



*Figure 357: Illustration of fault current magnitude and phase-to-phase voltage magnitude during a cross-country fault as a function of fault resistance. Note that fault resistance equals the average of fault resistances $R_{F1}$ and $R_{F2}$. $U_{n_PP}$ = 20 kV, $X_k$ = 2.2 ohm, $R_k$ = 0.2 ohm.*

Setting value *XC stage PP V Val* is given in per unit format with system nominal phase-to-phase value as reference.

Fulfilment of either *Equation 132* or *Equation 135* declares cross-county fault detection condition in the network. The cross-country fault is indicated by activating the XC_FLT output.

During detected cross-country fault, the “EF current based” or “Touch voltage based” operation of IFPTOC is blocked.

In case tripping of cross-country fault is enabled (setting *Enable XC Op mode* = “on”), then operation of IFPTOC requires that simultaneously both the magnitude of calculated residual current ($I_o$) and estimated earth-fault current ($I_F^{est}$) exceeds setting *XC stage A Str Val* during a detected earth fault:

$$EF_IND = TRUE, \ \ AND$$
$$I_o\ (calculated) > XC\ stage\ A\ Str\ Val, \ \ AND$$
$$I_F^{est} > XC\ stage\ A\ Str\ Val$$

(Equation 137)

Operate time for cross-country fault operation is given with setting *XC stage Op time*. Typical operate time is 60-100 ms.

The cross-country stage earth fault module always evaluates the true fault current magnitude (considering the effect of setting *Enable harmonics*) i.e. it is not affected by settings *Ena RF Compensation* and *Reduction factor*.

The cross-country fault indication is given in Recorded data as *XC fault detection* or in Output data as XC_FLT.

When start and operate conditions of cross-country earth fault module are fulfilled, this is indicated by activation of START and OPERATE outputs and ST_XC and OP_XC outputs.

In case tripping of cross-country fault is enabled, operate time is given with setting *XC stage Op time*. Reset time is defined with setting *Reset delay time*. Note that setting *CB Delay comp* (circuit breaker delay compensation) is not applicable in definite time operation, but it must be taken into account in setting *XC stage Op time*.

Applicable settings for cross-country earth fault module are: *Enable XC Op mode, XC stage A Str Val, XC stage PP V Val, XC stage Op time and Reset delay time*.

**Intermittent earth-fault protection**

Operation time requirement of earth-fault protection in safety standards assumes continuous flow of fault current. In case of resonant earthed network, earth faults are often re-striking i.e. fault arc is not continuous, but intermittent. During re-striking/intermittent earth faults, the very high but narrow current transient may result to very fast operation times, if operation time is based on IDMT-operation i.e. *Operation curve type* = Inverse time EN50522 or Inverse time IEEE80. Requirement for operation with IDMT-timer is that timer is not reset between successive current transients i.e. *Reset delay time* should be set long enough. However, in case operation during re-striking/intermittent earth faults is preferably based on number of counted transients, then setting *Reset delay time* should be set to low value, say 20-40 ms, and dedicated intermittent earth-fault protection functionality must be enabled.

Intermittent earth-fault module is enabled with setting *Ena Intermit EF mode* = “on”. Module is enabled by default. In case multiple instances of IFPTOC are applied in the protection configuration, and operation during re-striking/intermittent earth faults is preferably based on number of counted transients, only single instance of IFPTOC requires Intermittent earth-fault module functionality to be enabled; in other instances, Intermittent earth-fault module functionality may be disabled.

The IFPTOC has inbuild directional transient detector module for detecting earth-fault transients. Transient detector module is used to count the number of transients during an earth fault to discriminate intermittent earth fault from continuous earth fault.

Transient detector module counts the number of transients during an earth fault both in faulty and healthy feeders. Detection of transients is indicated with PEAK_IND output.

Internal start of intermittent earth-fault module is obtained when the presence of earth fault is indicated (EF_IND), it's validity is confirmed (VALID_EF) and at least one transient is detected in the protected feeder. Whenever a fault transient is detected, this is indicated with the PEAK_IND output.

When the number of detected transients reaches the *Intr EF counter Lim* setting, INTR_EF output is activated. Activation of INTR_EF output indicates detection of a restriking or intermittent earth fault in the protected feeder.

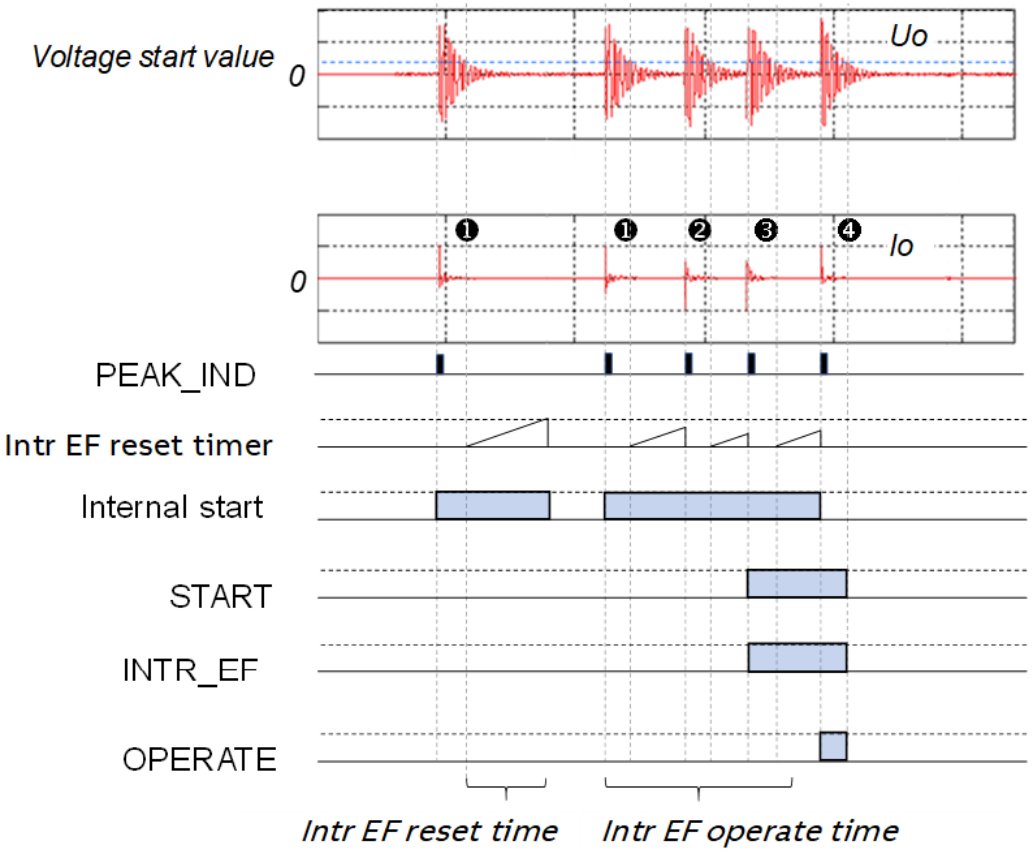



*Figure 358: Illustration of operation of intermittent earth-fault module. Setting Intr EF counter Lim = 3*

When a required number of intermittent earth-fault transients set with the *Intr EF counter Lim* setting are detected without the function being reset (depends on the drop-off time set with the setting *Intr EF reset time*) and the presence of single-phase earth fault in the protected feeder is confirmed (activation of EF_IND and VALID_EF outputs), the START and ST_INTR_EF outputs are activated. The OPERATE and OP_INTR_EF outputs are activated when operate delay time *Intr EF operate time* has elapsed (from fault beginning), required number of transients exceeds setting *Intr EF counter Lim* (so actually for operation there must be *Intr*

*EF counter Lim* +1 detected transients). OPERATE output activation occurs always at time of detected transient. OPERATE output signal has fixed length of 100 ms, but OP_INTR_EF signal is activated for only one cycle time i.e. 2. 5m.

Several factors affect the magnitude and frequency of fault transients, such as the fault inception angle on the voltage wave, fault location, fault resistance and the parameters of the feeders and the supplying transformers. If the fault is permanent (non-transient), the initial fault transient in current and voltage can be measured, whereas the intermittent fault creates repetitive transients. The practical sensitivity of transient detection is limited to approximately a few hundreds of ohms of fault resistance. Therefore, the application of transient detection is limited to low-ohmic earth faults.

Setting *Intr EF counter Lim* minimum value is 3 in order to provide secure indication of intermittent/re-striking earth fault. This is due to the fact that sometimes the fault ignition transient is characterized by highly distorted waveform, which may result into multiple transients to be detected at time of fault ignition. By increasing the value of *Intr EF counter Lim* setting, one increases the security of correct fault type identification.

Information about detected intermittent earth fault is also available in *Recorded data* as *Intermittent EF Det* or in Output data as INTR_EF.

During re-striking/intermittent earth faults, the very high current transient may result to very fast operation times in case operation principle is based on earth fault current or touch voltage estimate. In case longer and more deterministic operation during re-striking/ intermittent earth faults is preferred, the operation can be based on counted number of transients instead of IDMT operation. In transient counter-based operation the setting *Reset delay time* should be set to low value, say 20-40 ms. For the Intermittent earth-fault module reset delay time is defined with setting *Intr EF reset time*. During intermittent earth faults, typically longer reset time is needed to prevent unwanted function reset between the current spikes. Recommended setting value for *Intr EF reset time* is between 300-500 ms.

Actual operation time of intermittent earth-fault module cannot pre-determined exactly as the timing of successive transients is not constant.

At time OPERATE output is activated from intermittent earth-fault protection, also output OP_INTR_EF is activated OPERATE output signal has fixed length of 100 ms, but OP_INTR_EF signal is activated for only one cycle time i.e. 2.5 m. If OP_INTR_EF is to be used in e.g. protection logics, it should be prolonged with TOF-function in protection configuration.

Applicable settings for Intermittent earth-fault module are: *Ena Intermit EF mode, Intr EF counter Lim, Intr EF operate time and Intr EF reset time*.

Note that setting *CB Delay Comp* (circuit breaker delay compensation) is not applicable in definite time operation, but it must be taken into account in setting *Intr EF operate time*.

**Switch onto fault protection**

During switch onto fault condition i.e. when breaker is closed into existing fault, earth-fault current estimate may be disturbed by the inrush currents of energized transformers. Therefore, IFPTOC includes a dedicated switch onto fault (SOTF) logic module. SOTF-functionality provides dedicated fault detection and tripping in case feeder breaker is closed into earth fault.

Switch onto fault protection module is enabled with setting *Enable SOTF mode* = “on”. Module is enabled by default.

In case multiple instances of IFPTOC are applied in the protection configuration, ALL instances of IFPTOC requires SOTF module functionality to be enabled to provide selective operation during an SOTF condition.

SOTF condition is declared, if an earth fault is detected (`EF_IND = TRUE`) within set *SOTF Cond duration* milliseconds from breaker close command (input `CB_CL_CMD` is activated).

Indication of detected SOTF condition is declared by activation of `ST_SOTF` and `START` outputs.

Operate time during switch onto fault condition is given with setting SOTF operate time. `OPERATE` and `OP_SOTF` outputs are activated after operation timer has elapsed.

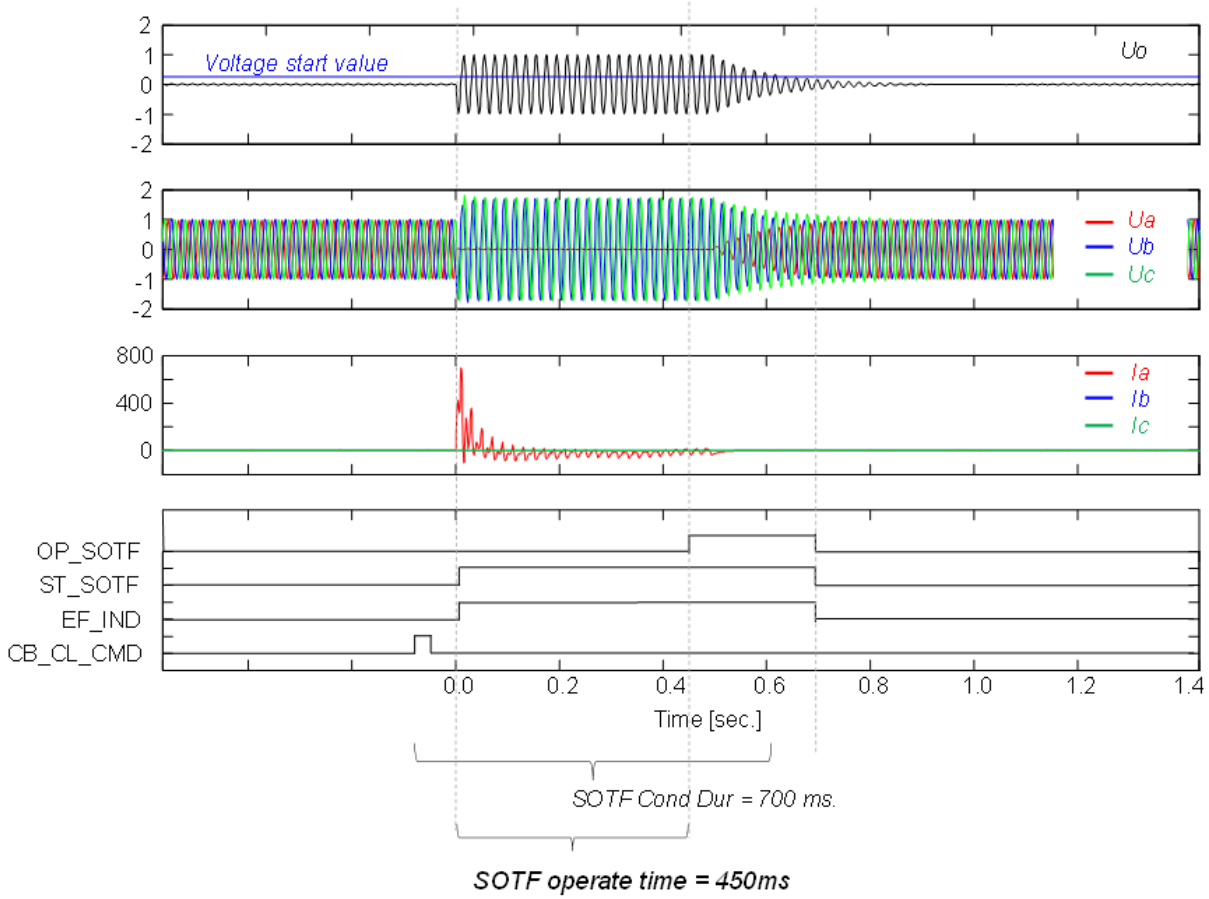



*Figure 359: Illustration of switch onto fault condition and operation of SOTF logic in IFPTOC*

Switch-onto-fault (SOTF) logic module enabling requires connection of breaker close command into input CB_CL_CMD. Switch-onto-fault (SOTF) logic module can be disabled by not connecting the breaker close command signal to IFPTOC.

In case SOTF condition is detected, then all other functionality of IFPTOC function is blocked.

Setting *SOTF Cond duration* must be set higher than *SOTF operate time* + *SOTF reset time*. SOTF functionality is reset after *SOTF Cond duration* expires or at least when earth-fault detection signal deactivates (EF_IND).

SOTF logic is not activated in case earth fault is detected (EF_IND = TRUE) before breaker close command (input CB_CL_CMD is activated).

For the SOTF module typically longer reset time is needed to prevent unwanted function reset between the current spikes during intermittent earth fault, setting SOTF reset time. Recommended setting value is between 300-500 ms.

Applicable settings for the SOTF-module are: *Enable SOTF mode, SOTF Cond duration, SOTF operate time and SOTF reset time*.

Note that setting *CB Delay comp* (circuit breaker delay compensation) is not applicable in definite time operation, but it must be taken into account in setting *SOTF operate time*.

**Faulted phase identification**

The faulted phase selection module provides information about the faulted phase (A, B or C) during a single-phase earth fault.

The faulted phase is identified by monitoring the “phase-wise” fault current estimators as follows:

$$I^1_{EF_A} = abs(\Delta\underline{I}^1_A - (\Delta\underline{I}^1_B + \Delta\underline{I}^1_C)/2)$$

(Equation 138)

$$I^1_{EF_B} = abs(\Delta\underline{I}^1_B - (\Delta\underline{I}^1_C + \Delta\underline{I}^1_A)/2)$$

(Equation 139)

$$I^1_{EF_C} = abs(\Delta\underline{I}^1_C - (\Delta\underline{I}^1_A + \Delta\underline{I}^1_B)/2)$$

(Equation 140)

Maximum value indicates the faulted phase. Actual implementation utilizes Cumulative Phasor Summing (CPS) together with admittance calculation.

Faulted phase is available in Recorded data as *Faulted phase*. In Monitored data faulted phase is given in FAULT_PHASE.

Faulted phase information is not given in case of cross-country fault (XC_FLT = TRUE).

**Fault resistance estimation**

Protection function IFPTOC includes fault resistance ($R_F$) magnitude estimation based on information on the faulted phase, the faulted phase voltage and estimated earth fault current magnitude (fundamental frequency). Fault resistance magnitude can be estimated with equation:

$$R_F = \frac{U_{ph_faulted}}{I_F^{est1}}$$

(Equation 141)

Where

$U_{ph_faulted}$ = Faulted phase voltage magnitude, fundamental frequency [V]

$I_F^{est1}$ = Estimated earth-fault current magnitude, fundamental frequency [A]

Actual implementation utilizes Cumulative Phasor Summing (CPS).

Magnitude of estimated fault resistance in primary ohms is available in Recorded data: *Fault resistance*. In monitored data this information is given: RF.

Fault resistance estimation is not done in case of cross-country fault (XC_FLT = TRUE).

In case of intermittent earth fault, fault resistance estimation is not accurate.

**Trip logic**

Protection function IFPTOC supports both tripping and alarming earth-fault handling defined with setting *Operation mode* = “Alarming EF” or “Tripping EF”. With *Operation mode* = “Alarming EF”, OPERATE and corresponding OP_EF/OP_XC/OP_SOTF/OP_INTR outputs are not activated. *Operation mode* = “Alarming EF” is applicable in networks, where due to low touch voltages tripping of earth-fault is not required (requires existence of Global Earthing System, GES). Monitoring of prevailing earth-fault current and/or touch voltage magnitude can be done via Monitored data.

When start conditions of touch voltage protection, earth-fault current protection, cross-country fault protection, intermittent earth-fault protection or switch onto fault protection are fulfilled, this is indicated by activation of START and corresponding ST_EF/ST_XC/ST_SOTF/ST_INTR outputs. When operate conditions are fulfilled and setting *Operation mode* = “Tripping EF”, this is indicated by activation of OPERATE and corresponding OP_EF/OP_XC/OP_SOTF/OP_INTR outputs.

The timer calculates the start duration value, which indicates the percentage elapse of operate timer, 100% means that operate time is completely elapsed and OPERATE output is activated. The value is available in the Recorded data as *Start duration* and in Monitored data as START_DUR.

Estimate for time left to operate is available in in Monitored data as TIME_TO_OPER in real time based on fault current or touch voltage magnitude. In the Recorded data estimate for time left to operate is available as *Time left to operate* with assumption that fault current or touch voltage at the triggering moment (recorded data is triggered with TRIGG_REC input rising edge) will remain the same until the OPERATE and corresponding OP_EF/OP_XC/OP_SOTF/OP_INTR outputs would become activated. Furthermore, if OPERATE and corresponding OP_EF/OP_XC/OP_SOTF/OP_INTR outputs have been activated, the actual operate time of protection is available in the Recorded data as *Operate time* and in Monitored data as OPERATE_TIME.

Information about started and operated timers are available in Recorded data: *Started timers, Operated timers*. This data is binary coded number as illustrated in *Table 635*.

**Table 635: Binary to decimal conversion of the *Started timers* and *Operated timers* in Recorded data**

| Timer notation | Timer1 | Timer2 | Timer3 | Timer4 |
|---|---|---|---|---|
| Timer description | Touch voltage/fault current estimation module | Cross-country earth-fault module | Switch onto fault (SOTF) module | Intermittent earth fault module |
| Binary (0 or 1)<br>0=not started/not operated,<br>1=started/operated | 0 or 1 | 0 or 1 | 0 or 1 | 0 or 1 |

*Started/Operated timers* (integer): Timer1·$2^0$+ Timer2·$2^1$+ Timer3·$2^2$+ Timer4·$2^3$

**Numerical example.** If both Touch voltage/fault current estimation module timer (+1) and intermittent timer (+8) have been started but only Touch voltage estimation module timer have operated, then: *Started timers* 1+8 = 9 and *Operated timers* = 1.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal in protection configuration. The influence of the BLOCK input signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timer” mode, the operation timer is frozen to the prevailing value, but the operate outputs are not deactivated when blocking is activated. In the “Block all” mode, the whole function is blocked, and the timers and pre-fault phasor buffers are reset. In the “Block OPERATE output” mode, only the operate outputs are blocked.

### Recorded data

The required information for later fault analysis is recorded when the recording function of IFPTOC function is triggered by activating TRIGG_REC input or writing to the corresponding DO “LD0.IF1RFRC1.RcdTrg.Oper.ctlVal”.

Activation of OPERATE output results to automatic triggering of fault recording.

The recording function of IFPTOC includes recorded data 1 data objects as shown in *Table 636*.

**Table 636: Recorded data 1 data objects of the IFPTOC function**

| Parameter name | Parameter description | Recorded Data DO |
|---|---|---|
| *Triggering time* | Triggering time | (Timestamp) IF1RFRCx.TchV.t. |
| *Residual voltage* | Residual voltage magnitude [xUn] | (MX) IF1RFRCx.VRes.mag.f |
| *Residual current* | Residual current magnitude [xIn] | (MX) IF1RFRCx.ARes.mag.f |
| *Touch voltage* | Touch voltage magnitude [V] | (MX) IF1RFRCx.TchV.mag.f |
| *Touch voltage rms* | Touch voltage magnitude incl harmonics [V] | (MX) IF1RFRCxTchVRms.mag.f |
| *Fault current* | Fault current magnitude (incl. reduction) [A] | (MX)) IF1RFRCx.FltA.res.cVal.mag.f |
| *Fault current rms* | Fault current magnitude incl harmonics (and reduction) [A] | (MX) IF1RFRCx.FltARms.mag.f |
| *Start duration* | Start duration [%] | (MX) IF1RFRCx.StrDur.mag.f |
| *Faulted phase* | Faulted phase | (ST) IF1RFRCx.FltLoop.stVal |
| *Fault resistance* | Fault point resistance [in primary ohm] | (MX) IF1RFRCx.FltPtRis.mag.f |
| *Transient Ris Comp* | Transient resistive component [A] | (MX) IF1RFRCx.AResReal.mag.f |
| *Transient React Comp* | Transient reactive component [A] | (MX) IF1RFRCx.AResImag.mag.f |
| *Non qualified Harmon* | Non qualified harmonics | (ST) IF1RFRCx.NonQualH.stVal |
| *EF indication* | Non-directional earth fault detection | (ST) IF1RFRCx.EFDet.stVal |
| *Valid EF detection* | Valid EF detection in protected feeder | (ST) IF1RFRCx.EFDetVald.stVal |
| *XC fault detection* | Cross-country fault detection | (ST) IF1RFRCx.XcnDet.stVal |
| *Time left to operate* | Time left to operate [sec.] | (MX) IF1RFRCx.TmOpEst.mag.f |
| *Intermittent EF Det* | Restriking (intermittent) earth fault detection | (ST) IF1RFRCx.ItmEFInd.stVal |
| *Started timers* | Started timers | (ST) IF1RFRCx.ActStrSt.stVal |
| *Operated timers* | Operated timers | (ST) IF1RFRCx.ActOpSt.stVal |
| *Operate time* | Actual operate time [sec] | (MX) IF1RFRCx.StrOpTm.mag.f |

A total of two sets of recorded data are saved in data banks *Recorded data 1* and *Recorded data 2*. Data bank *Recorded data 1* holds the most recent recorded data and the older data is moved into the data bank *Recorded data 2* when triggering occurs. When all two banks have data and a new triggering occurs, the latest data is placed into bank *Recorded data 1* and the data in bank *Recorded data 2* is overwritten by the data from bank *Recorded data 1*.

It is possible to reset corresponding recorded data by either:

- activating LHMI parameter Clear/Clear/IFPTOCx reset = 1 (“Clear”) or
- writing directly by MMS LD0.IFPTRCx.RcdRs.Oper.ctlVal = 1 (“Clear”)”

## 4.2.10.6 Signals

### IFPTOC Input signals

**Table 637: IFPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| EXT_RELEASE | BOOLEAN | 0=False | External GFC start signal, alternative for internal GFC module. |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| CB_CL_CMD | BOOLEAN | 0=False | Defines breaker close command. This signal is used in the switch on to fault (SOTF) logic. |
| TRIGG_REC | BOOLEAN | 0=False | External recorded data triggering. There are two recorded data banks available. |

### IFPTOC Output signals

**Table 638: IFPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ST_EF | BOOLEAN | Start signal according to estimated fault current or touch voltage according to the standards |
| ST_XC | BOOLEAN | Start signal according to cross-country stage earth-fault module |
| ST_SOTF | BOOLEAN | Start signal according to SOTF-module |
| ST_INTR_EF | BOOLEAN | Start signal according to intermittent earth-fault module |
| OP_EF | BOOLEAN | Operate signal according to estimated fault current or |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| | | touch voltage according to the standards |
| OP_XC | BOOLEAN | Operate signal according to cross-country stage earth-fault module |
| OP_SOTF | BOOLEAN | Operate signal according to SOTF-module |
| OP_INTR_EF | BOOLEAN | Operate signal according to intermittent earth-fault module |
| PEAK_IND | BOOLEAN | Current transient detection indication (both in the faulty and healthy feeder) |
| INTR_EF | BOOLEAN | Intermittent earth fault indication in the faulty feeder |
| EF_IND | BOOLEAN | Non-directional indication of earth-fault in the network |
| VALID_EF | BOOLEAN | Validity of earth-fault current estimate is confirmed |
| XC_FLT | BOOLEAN | Indication of cross-country fault in the network |

### 4.2.10.7 IFPTOC Settings

**Table 639: IFPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage start value | 0.01...1.00 | xUn | 0.01 | 0.20 | Start value for neutral point voltage Uo. Note that Un means phase to earth nominal voltage. |
| EF current Str Val | 0.005...1.000 | xIn | 0.001 | 0.010 | Earth-fault current threshold for DT stage or IDMT stage. Note that In means phase nominal current. |
| Touch Vol Str Val | 10.0...2900.0 | V | 0.1 | 80.0 | Touch voltage start threshold for DT stage or IDMT stage in primary volts |
| Operating curve type | 15=Definite time<br>18=Inverse time EN50522<br>19=Inverse time IEEE80 | | | 18=Inverse time EN50522 | Selection of time delay curve type in touch voltage/fault current estimation module |
| Ena RF compensation | 0=Disable<br>1=Enable | | | 0=Disable | Enable compensation of fault resistance in the estimated earth-fault current |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| DT stage Op time | 100...60000 | ms | 10 | 500 | Operate delay time for Touch voltage/fault current estimation module, DT timer |
| IDMT stage Min Op Tm | 50...6000 | ms | 10 | 100 | Minimum operate delay for touch voltage/fault current estimation module IDMT timer according to standard EN50522/IEEE80 |
| IDMT stage Max Op Tm | 500...7200000 | ms | 10 | 10000 | Maximum operate delay for touch voltage/fault current estimation module IDMT timer according to standard EN50522/IEEE80 |
| UTp multiplier | 0.10...5.00 | | 0.01 | 1.00 | UTp multiplier for IDMT curve according to standard EN50522 |
| Reduction factor | 0.10...1.00 | | 0.01 | 1.00 | Reduction factor in the touch voltage/fault current estimation module according to standard EN50522/IEEE80 |
| Maximum earthing Ris | 0.5...1000.0 | ohm | 0.1 | 10.0 | Maximum earthing resistance encountered in the protected feeder in primary ohms according to standard EN50522/IEEE80 |
| IEEE multiplier | 50.0...5000.0 | | 0.1 | 157.0 | Multiplier according to standard IEEE80 |
| XC stage A Str Val | 0.10...5.00 | xIn | 0.01 | 1.00 | Current threshold for cross-country fault module. Note that In means phase nominal current |
| XC stage PP V Val | 0.01...1.00 | xUn | 0.01 | 0.90 | Phase-to-phase voltage threshold for cross-country fault detection module. Note that Un means phase to phase nominal voltage. |
| XC stage Op time | 60...60000 | ms | 10 | 200 | Operate delay time for cross-country fault detection stage |
| Intr EF operate time | 100...10000 | ms | 10 | 1000 | Operate delay time during intermittent earth fault |

**Table 640: IFPTOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| EF validity Op mode | 1=Resistive<br>2=Resistive, Reactive | | | 2=Resistive, Reactive | EF validity operation mode |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 3=No validity | | | | |
| EF validity Min Curr | 0.005...0.200 | *In | 0.001 | 0.010 | Minimum current for EF validity evaluation. Note that In means residual nominal current. |
| Ena cyclic reset | 0=Disable<br>1=Enable | | | 1=Enable | Enable adaptation of fault direction determination to a fault direction change during the fault |
| Intr EF reset time | 40...60000 | ms | 10 | 500 | Reset delay time used in intermittent earth fault module |

**Table 641: IFPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation principle | 1=EF current based<br>2=Touch voltage based | | | 2=Touch voltage based | Operation principle |
| Enable harmonics | 0=Disable<br>1=Enable | | | 0=Disable | Enable harmonics for fault current calculation |
| Operation mode | 1=Alarming EF<br>2=Tripping EF | | | 2=Tripping EF | Operation criteria |
| Enable XC Op mode | 1=on<br>5=off | | | 1=on | Enable cross-country fault tripping functionality |
| Reset delay time | 0...6000 | ms | 10 | 20 | Reset delay time |
| Ena Intermit EF mode | 1=on<br>5=off | | | 1=on | Enable intermittent earth fault module |
| Enable SOTF mode | 1=on<br>5=off | | | 1=on | Enable Switch-On-To-Fault logic module |
| SOTF Cond duration | 100...16000 | ms | 10 | 2000 | Switch-On-To-Fault module duration |
| SOTF operate time | 40...6000 | ms | 10 | 60 | Switch-On-To-Fault module operate delay time |

**Table 642: IFPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| SOTF reset time | 100...10000 | ms | 10 | 500 | Reset delay time for Switch-OnTo-Fault (SOTF) module |
| Revert time | 200...10000 | ms | 10 | 300 | Revert time for delta-calculation |
| Max Dur delta Calc | 300...10000 | ms | 10 | 2000 | Maximum duration for delta calculation |
| Intr EF counter Lim | 3...20 | | 1 | 3 | Peak counter limit for discrimination of intermittent earth fault from |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | | | | | continuous earth fault. |
| CB delay Comp | 0...200 | ms | 1 | 0 | Delay compensation for circuit-breaker operate time |

### 4.2.10.8 IFPTOC Monitored data

**Table 643: IFPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| FLT_CURRENT | FLOAT32 | 0.00...6000.00 | A | Magnitude of estimated earth-fault current [primary amperes] (fundamental freq.) |
| FLT_CURR_RMS | FLOAT32 | 0.00...6000.00 | A | Magnitude of estimated earth-fault current [primary amperes], rms (incl. harmonics) |
| TCH_VOLTAGE | FLOAT32 | 0.00...440000.00 | V | Magnitude of estimated touch voltage (fundamental freq.) [primary volts] |
| TCH_VOLT_RMS | FLOAT32 | 0.00...440000.00 | V | Magnitude of estimated touch voltage [primary volts], rms (incl. harmonics) |
| RF | FLOAT32 | 0.0...20000.0 | ohm | Fault point resistance in primary ohms |
| FAULT_PHASE | Enum | -5=No fault<br>-4=ABCG Fault<br>-3=CAG Fault<br>-2=BCG Fault<br>-1=ABG Fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault | | Faulted phase |
| TR_RIS_COMP | FLOAT32 | -6000.0...6000.0 | A | Magnitude of transient real part of residual current, in primary amperes (fundamental freq.) |
| TR_REACT_COMP | FLOAT32 | -6000.0...6000.0 | A | Magnitude of transient imaginary part of residual current, in primary amperes (fundamental freq.) |
| NON_Q_HARMON | INT32 | 0...127 | | Non qualified harmonics in binary coded format |
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| OPERATE_TIME | FLOAT32 | 0.000...7200.000 | s | Actual operate time |
| TIME_TO_OPER | FLOAT32 | 0.000...7200.000 | s | Time left to operate |

#### 4.2.10.9 Technical data

**Table 644: IFPTOC Technical data**

| Characteristics | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current $f_n$ ±2 Hz |
| | Earth-fault current and touch voltage:<br>±1% of the set value or ±0.005 × $I_n$ for $I_F^{est}$<br>Accuracy of $U_{EPR}^{est}$ follows $I_F^{est}$ accuracy.<br>Residual voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Residual current:<br>±1.5% of the set value or ±0.002 × $I_n$ (at currents ≤10 x $I_n$, when Uo is nominal)<br>±5.0% of the set value (at currents > 10 x $I_n$) |
| Start time [1] | Typically 30 ms |
| Reset time | <30 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <50 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms (DT)<br>±3% of the theoretical value or ±40 ms (IDMT) |

# 4.3 Differential protection

## 4.3.1 Line differential protection with in-zone power transformer LNPLDF (ANSI 87L)

### 4.3.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Line differential protection with in-zone power transformer | LNPLDF | 3Id/I> | 87L |

[1] Measured with static signal output (SSO)

### 4.3.1.2 Function block

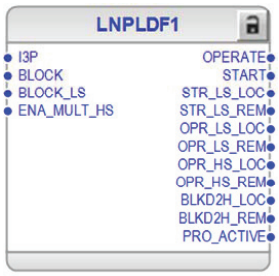



*Figure 360: Function block*

### 4.3.1.3 Functionality

The line differential protection with in-zone power transformer LNPLDF is used as feeder differential protection for the distribution network lines and cables. LNPLDF includes low, stabilized and high, non-stabilized stages. The line differential protection can also be used when there is an in-zone transformer in the protected feeder section.

The stabilized low stage provides a fast clearance of faults while remaining stable with high currents passing through the protected zone increasing errors on current measuring. Second harmonic restraint insures that the low stage does not operate due to energizing of a tapped or in-zone transformer. The high stage provides a very fast clearance of severe faults with a high differential current regardless of their harmonics.

The operating time characteristic for the low stage can be selected to be either definite time (DT) or inverse definite time (IDMT). The direct inter-trip ensures both ends are always operated, even without local criteria.

### 4.3.1.4 Analog channel configuration

LNPLDF has one analog group input which must be properly configured.

**Table 645: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”.

The function can also be set into test mode by setting the *Operation* setting to “test/blocked”.

The operation of the line differential protection and related measurements, stabilized and instantaneous stages can be described using a module diagram.

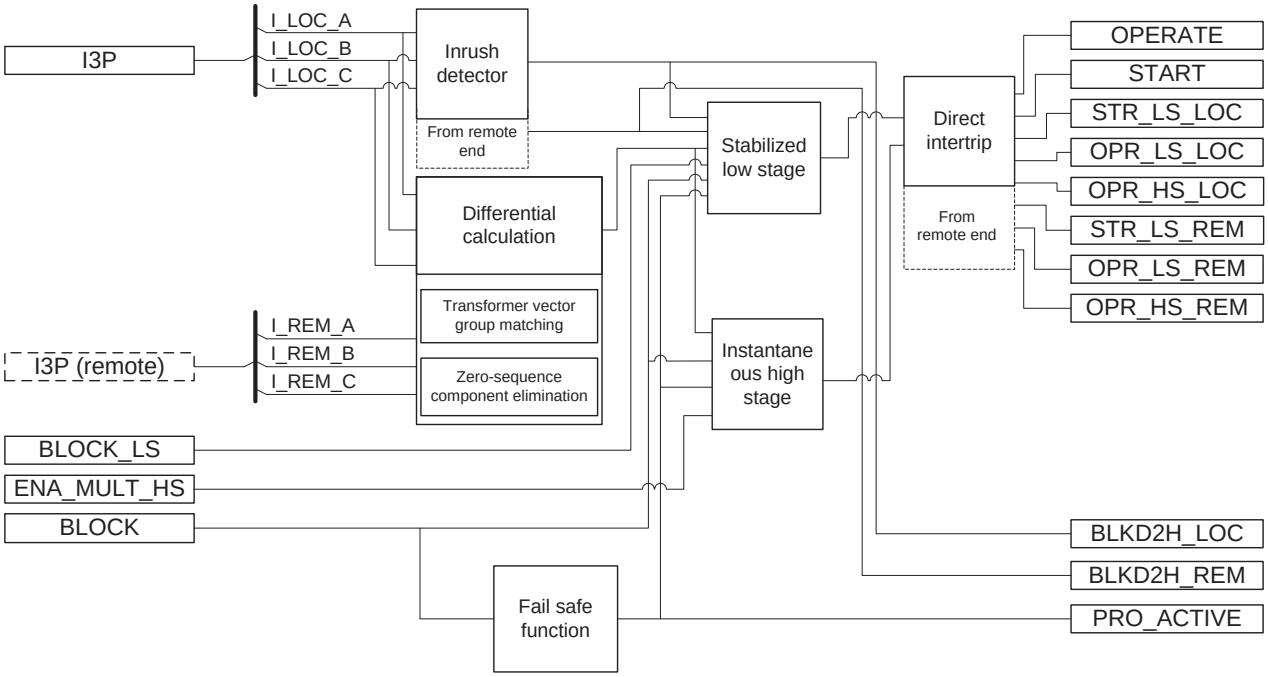



*Figure 361: Functional module diagram. I_LOC_x stands for current of the local end and I_REM_x for phase currents of the remote ends.*

**Stabilized low stage**

In the stabilized low stage, the higher the load current is, the higher the differential current required for tripping is. This happens on normal operation or during external faults. When an internal fault occurs, the currents on both sides of the protected object flow towards the fault and cause the stabilizing current to be considerably lower. This makes the operation more sensitive during internal faults. The low stage includes a timer delay functionality.

The characteristic of the low stage taking the apparent differential current into account is influenced by various factors:

- Small tapped loads within the protection zone
- Current transformer errors
- Current transformer saturation
- Small asymmetry of the communication channel go and return paths
- Small steady state line charging current
- In-zone transformer no load current
- Impact of tap changer positions

The timer is activated according to the calculated differential, stabilizing current and the set differential characteristic.

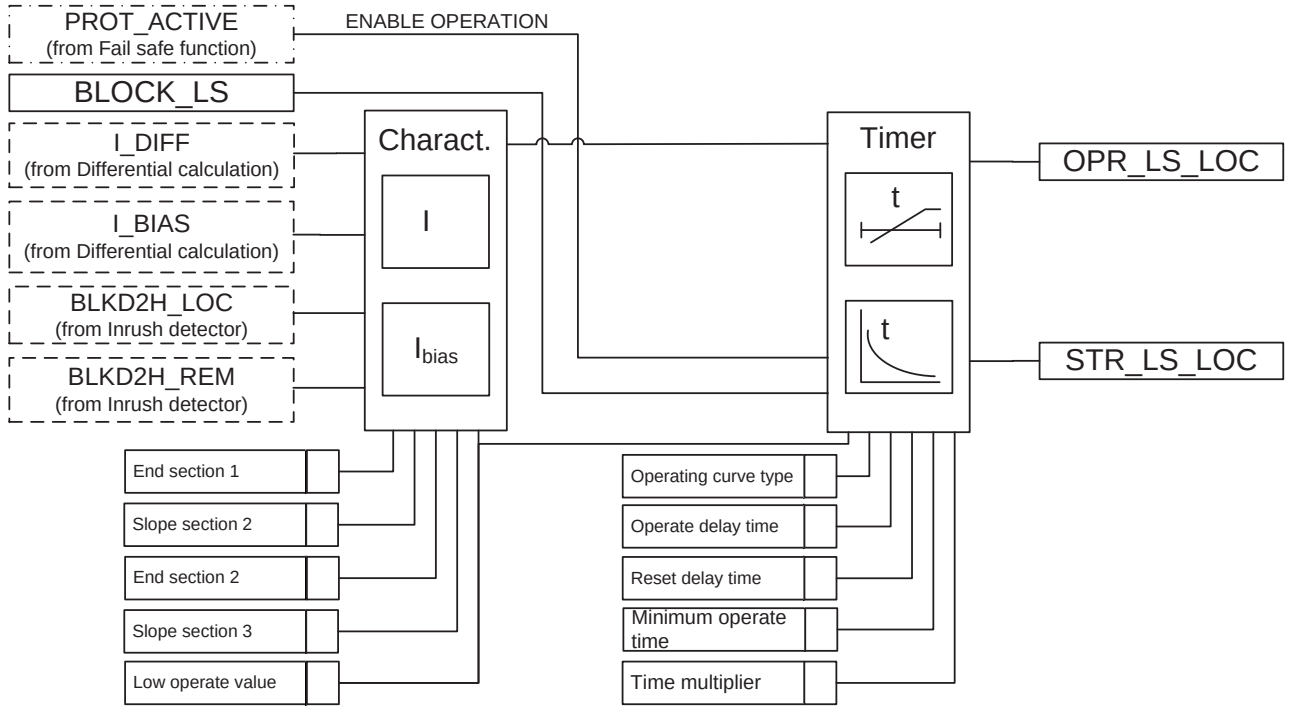



*Figure 362: Operation logic of the stabilized low stage*

The stabilization affects the operation of the function.

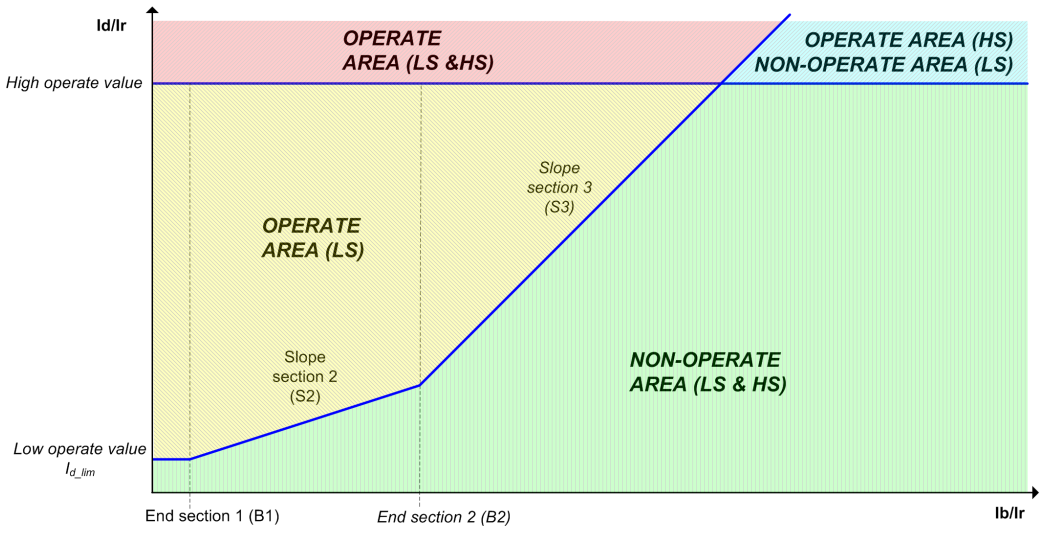



*Figure 363: Operating characteristics of the protection. (LS) stands for the low stage and (HS) for the high stage.*

The slope of the operating characteristic curve of the differential function varies in the different sections of the range:

- Section 1 where 0.0 < $I_b/I_r$ < *End section 1*. The differential current required for tripping is constant. The value of the differential current is the same as the basic setting ( *Low operate value*) selected for the function. The basic setting allows the appearance of the no-load current of the line, the load current of the tapped load and minor inaccuracies of the current transformers. It can also be used to influence the overall level of the operating characteristic.
- Section 2 where *End section 1* < $I_b/I_r$ < *End Section 2*. This is called the influence area of the starting ratio. In this section, the variations in the starting ratio affect the slope of the characteristic, meaning the required change for tripping in the differential current in comparison with the change in the load current. CT errors should be considered in the starting ratio.
- Section 3 where *End section 2* < $I_b/I_r$. By setting the slope in this section, attention can be paid to prevent unnecessary operation of the protection when there is an external fault, and the differential current is mainly produced by saturated current transformers.

The operation of the differential protection is based on the fundamental frequency components. The operation is accurate and stable and the DC component and the harmonics of the current do not cause unwanted operations.

**Inrush detector**

The transformer inrush currents cause high degrees of second harmonic to the measured phase currents. The inrush detector detects inrush situations in transformers. The second harmonic based local blocking is selected into use with the *Restraint mode* parameter. The blocking for the low stage on the local end is issued when the second harmonic blocking is selected and the inrush is detected.

The inrush detector calculates the ratio of the second harmonic current `I_2H_LOC_A` and the fundamental frequency current `I_1H_LOC_A`. If the line differential protection is used in normal mode (*Winding selection* is “Not in use”), the calculated value is compared with the parameter value of the *Start value 2.H* setting. If the calculated value exceeds the set value and the fundamental frequency current `I_1H_LOC_A` is more than seven percent of the nominal current, the output signal `BLK2H_A` is activated. The inrush detector handles the other phases the same way.

If the line differential protection is used in the in-zone transformer mode (*Winding selection* is “Winding 1” or “Winding 2”), the weighted average is calculated for the 2 $^{nd}$ harmonic ratios in different phases and the weighted ratio is then compared with the value of the *Start value 2.H* setting. If the calculated weighted ratio value exceeds the set value and the fundamental frequency current `I_1H_LOC_A` is more than seven percent of the nominal current, output signal `BLK2H_A` is activated.

The locally detected transformer inrush is also transferred to the remote end as a binary indication signal independently of the local *Restraint mode* setting parameter value. When the internal blocking of the stabilized low stage is activated, the `RSTD2H_LOC` and `RSTD2H_REM` outputs will also be activated at the same time depending on whether the inrush has been detected on local or remote end or on both ends.

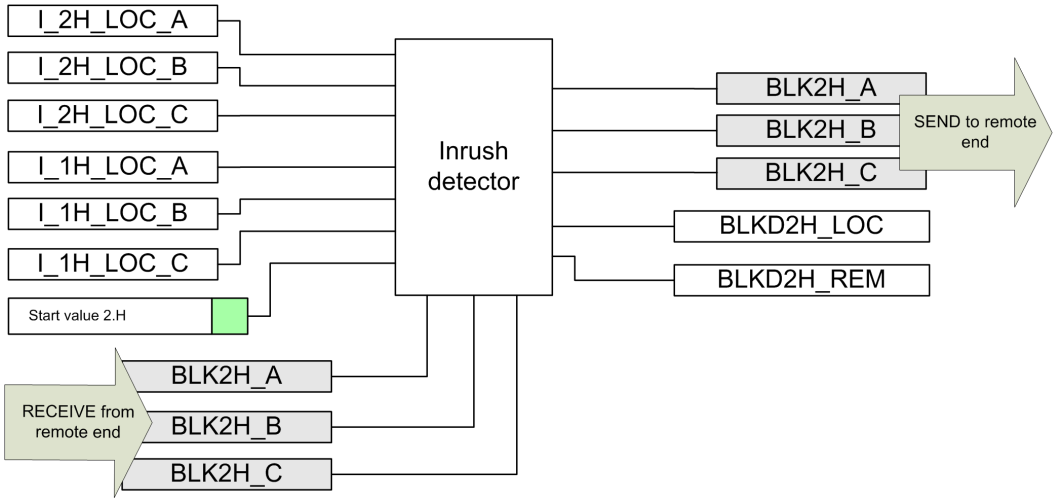



*Figure 364: Inrush current detection logic*

### Differential calculation

The operating principle is to calculate on both ends differential current from currents entering and leaving the protection zone by utilizing the digital communication channels for data exchange. The differential currents are almost zero on normal operation. The differential protection is phase segregated and the differential currents are calculated separately on both ends.

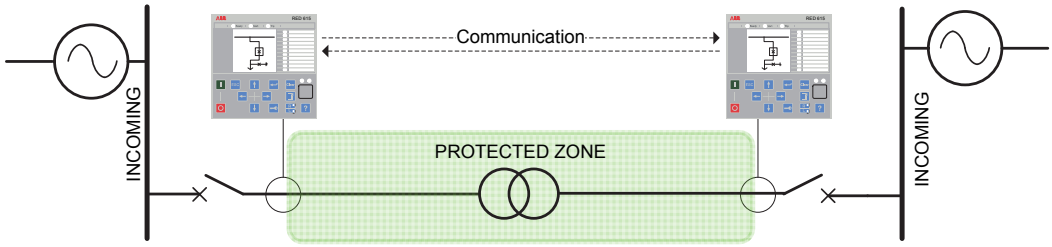



*Figure 365: Basic protection principle*

The differential current IΔ ($I_d$) of the protection relay is obtained on both ends with the formula:

$$I_d = \left| \bar{I}_{LOC} + \bar{I}_{REM} \right|$$

(Equation 142)

The stabilizing current $I_{bias}$ ($I_b$) of the protection relay is obtained on both ends with the formula:

$$I_b = \frac{\left| \bar{I}_{LOC} - \bar{I}_{REM} \right|}{2}$$

(Equation 143)

Depending on the location of the star points of the current transformers, the polarity of the local end remote currents may be different causing malfunction of the calculation algorithms. The CT transformation ratio may be different and this

needs to be compensated to provide a correct differential current calculation result on both ends.

The operation characteristics related settings are given in units as percentage of the current transformer secondary nominal current on each line end protection relay. For the actual primary setting, the corresponding CT ratio on each line end has to be considered. An example of how the *CT ratio correction* parameter values should be selected on both line ends in the example case to compensate the difference in the nominal levels can be presented.

Another example for differential application without in-zone transformer where line rated current is 400 A. The ratio of CTs are 800/1 and 400/1.

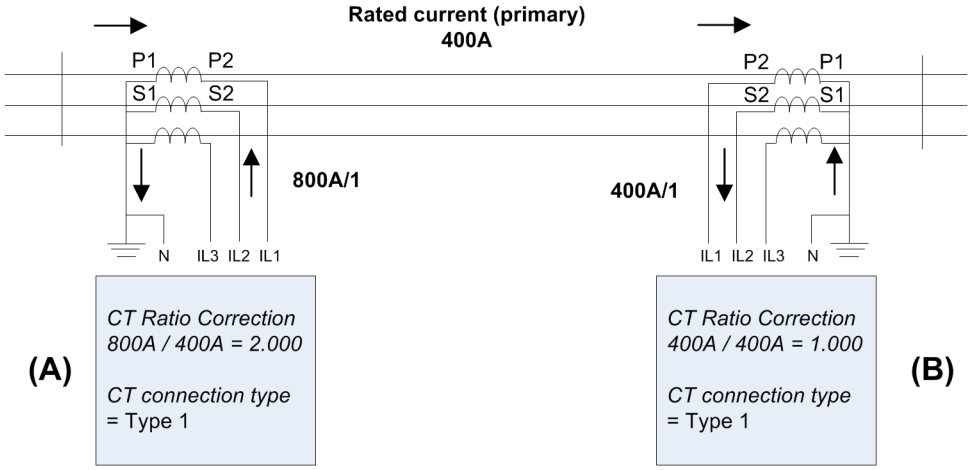



*Figure 366: Example of CT ratio correction setting calculation in line differential application*

The settings for *CT ratio Corrections* for protection relay A and protection relay (B) are:

CT ratio Correction (A) = 800 A / 400 A = 2.000

CT ratio Correction (B) = 400 A / 400 A = 1.000

The CT secondary current often differs from the rated current at the rated load of the power transformer. The CT transforming ratio can be corrected on both sides of the power transformer with the *CT ratio Correction* setting.

First, the rated load of the power transformer is calculated on both sides when the apparent power and phase-to-phase voltage are known.

$$I_{nT} = \frac{S_n}{\sqrt{3} \times U_n}$$

(Equation 144)

| | |
|---|---|
| $I_{nT}$ | Rated load of the power transformer |
| $S_n$ | Rated power of the power transformer |
| $U_n$ | Rated phase-to-phase voltage |

Next, the settings for the CT ratio correction can be calculated with the formula:

$$CT\ ratio\ correction = \frac{I_n}{I_{nT}}$$

(Equation 145)

$I_n$ Nominal primary current of the CT

After the CT ratio correction, the measured currents and corresponding setting values of LNPLDF are expressed in multiples of the rated power transformer current Ir (×Ir) or percentage value of Ir (%Ir).

An example shows how the CT ratio correction settings are calculated; when the rated power of the transformer is 5 MVA, the ratio of CTs on the 20 kV side is 200/1 and that on the 10.5 kV side is 300/1.

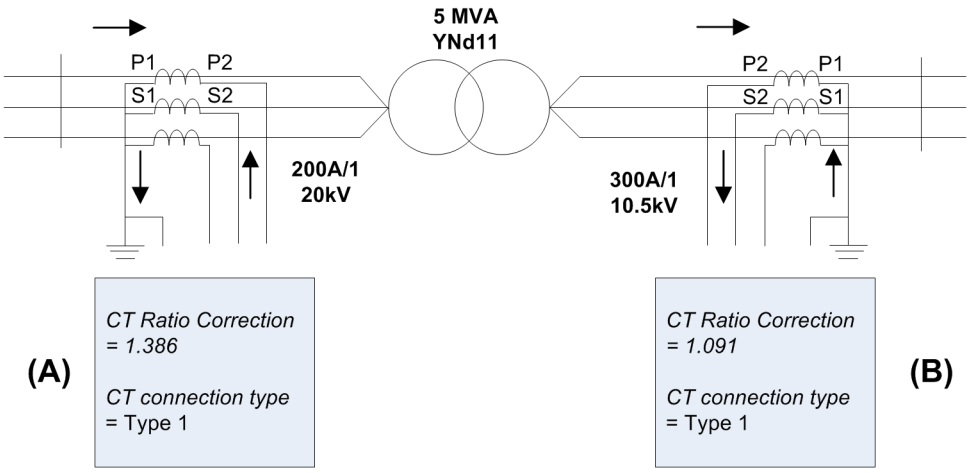



*Figure 367: Example of CT ratio correction setting calculation with in-zone transformer*

The rated load of the transformer is:

HV side (A): $I_{nT_A}$= 5 MVA / (1.732 × 20 kV) = 144.3 A

LV side (A): $I_{nT_B}$= 5 MVA / (1.732 × 10.5 kV) = 274.9 A

So the settings for *CT ratio corrections* at HV (A) and LV (B) side are:

CT ratio correction (A) = 200 A / 144.3 A = 1.386

CT ratio correction (B) = 300 A / 274.9 A = 1.091

**CT connections**

The connections of the primary current transformers are designated as “Type 1” and “Type 2”.

- If the positive directions of the winding 1 and winding 2 protection relay currents are opposite, the *CT connection type* setting parameter is “Type 1”. The connection examples of “Type 1” are as shown in the *Figure 368* and *Figure 369*.
- If the positive directions of the winding 1 and winding 2 protection relay currents equate, the *CT connection type* setting parameter is “Type 2”. The connection examples of “Type 2” are as shown in the *Figure 370* and *Figure 371*.
- The default value of the *CT connection type* setting is “Type 1”.

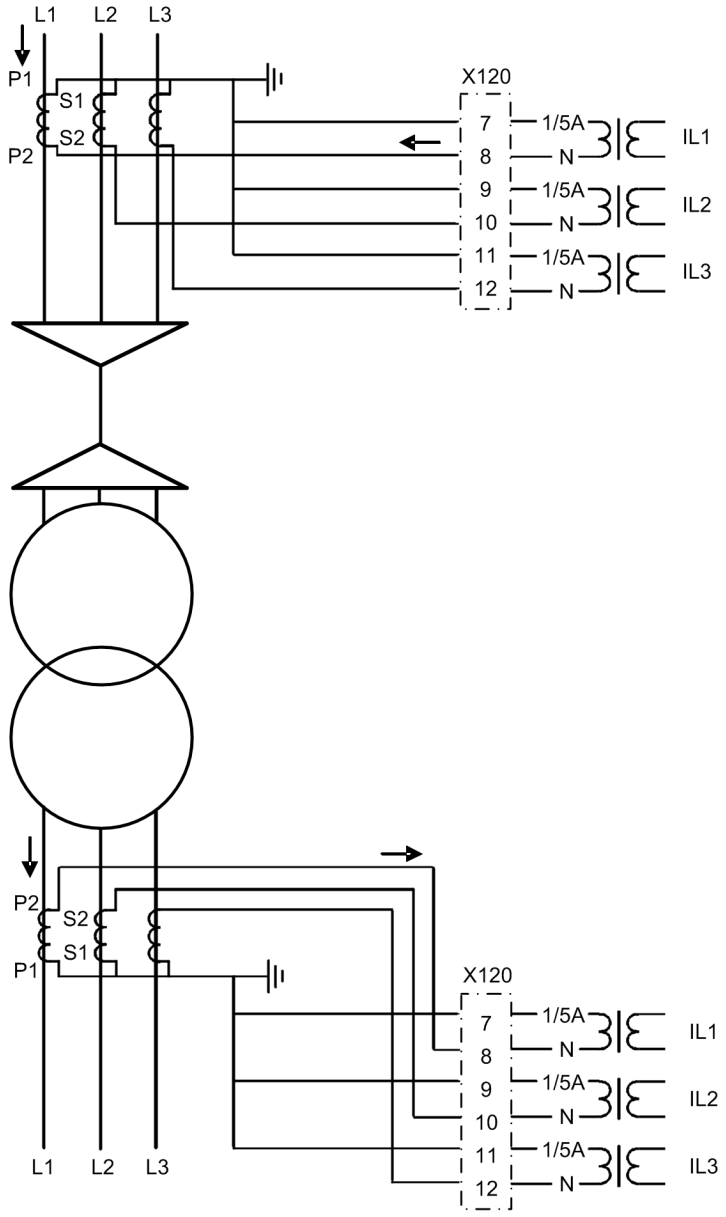



*Figure 368: Connection example of current transformers of Type 1*

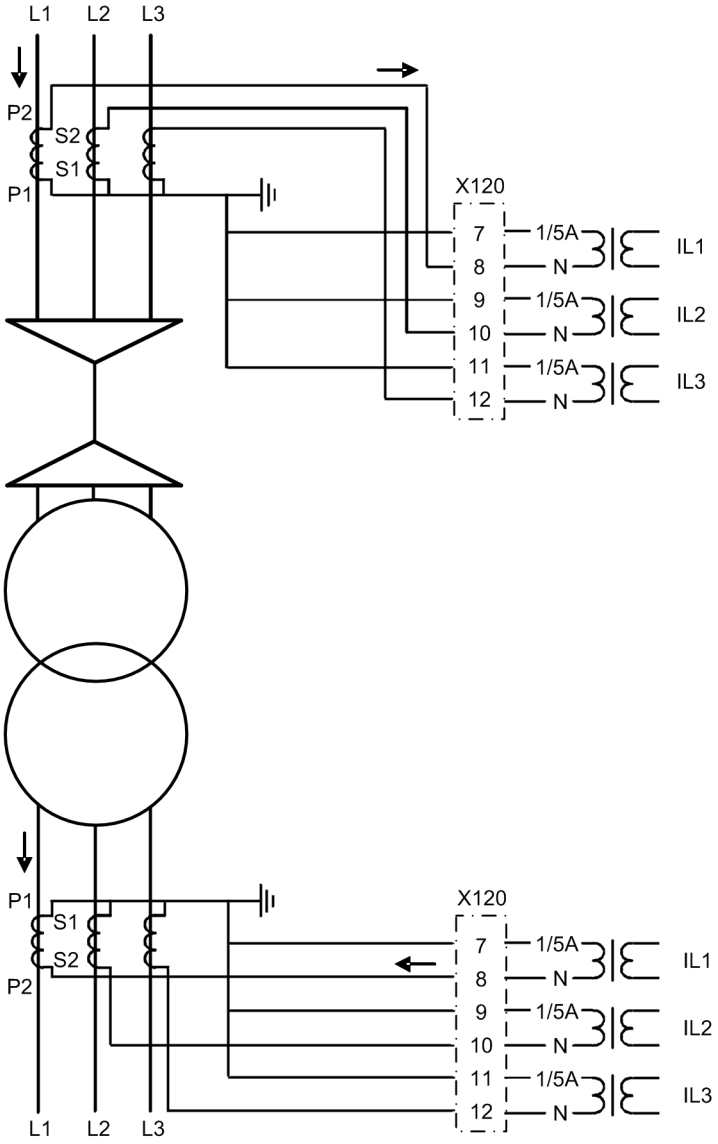



*Figure 369: Connection example of current transformers of Type 1*

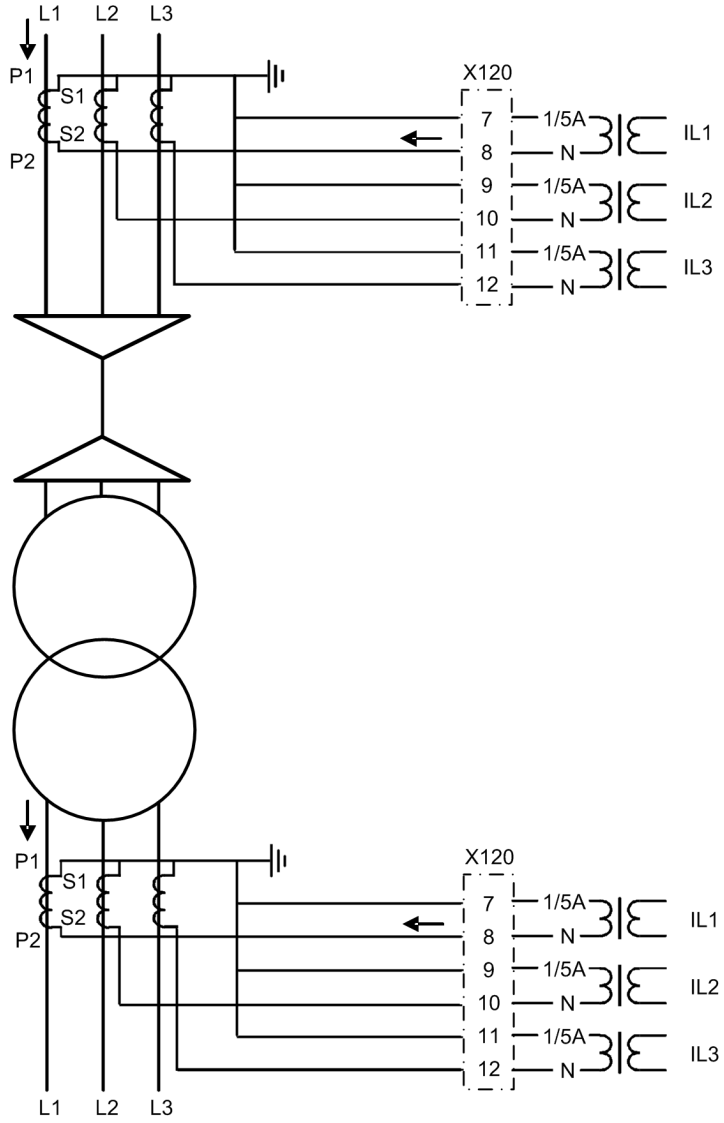



*Figure 370: Connection example of current transformers of Type 2*

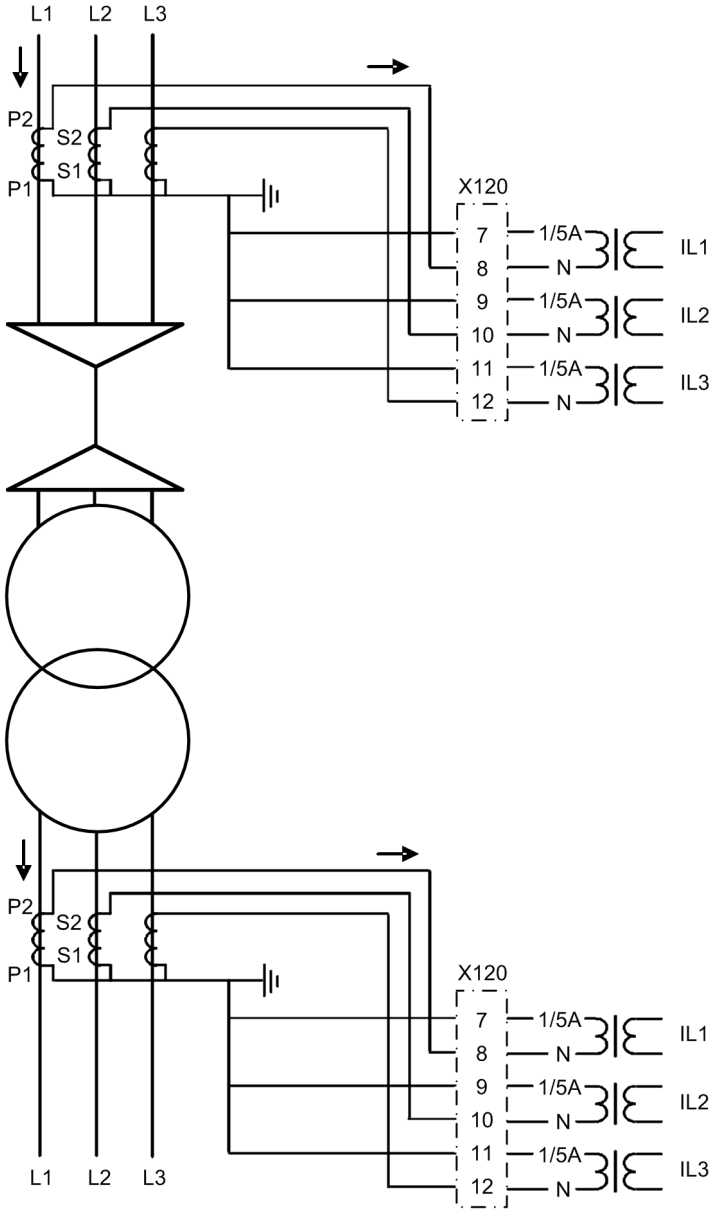



*Figure 371: Connection example of current transformers of Type 2*

**Transformer vector group matching**

Before differential and bias currents can be calculated, the phase difference of the currents must be vector group matched based on the transformer connection type. The vector group of the power transformer is numerically matched on the high voltage and low voltage sides by means of the *Winding selection*, *Winding 1 type*, *Winding 2 type* and *Clock number* settings. Thus no interposing CTs are needed if there is only a power transformer inside the protected zone. The matching is based on phase shifting and a numerical delta connection in the protection relay. If the neutral of a star-connected power transformer is earthed, any earth-fault in the network is perceived by the protection relay as a differential current. The elimination of the zero-sequence component can be selected for that winding by setting the Zro A elimination parameter.

*Winding selection* setting defines the protection relay location respect to the transformer. If the protection relay is situated at the HV side of the transformer, then protection relay location setting is set to “Winding 1” and respectively to “Winding 2” if protection relay is situated at the LV side. If the differential protection relays are used to protect a line without in-zone transformer, then the setting is set to “Not in use”. In this case vector group matching is ignored.

The matching of the phase difference is based on the phase shifting and the numerical delta connection inside the protection relay. The *Winding 1 type* parameter determines the connection on winding 1 (“Y”, “YN”, “D”, “Z”, “ZN”). The vector group matching can be implemented either on both, winding 1 and winding 2, or only on winding 1 or winding 2, at intervals of 30° with the *Clock number* setting. Similarly, the *Winding 2 type* parameter determines the connections of the phase windings on the low voltage side (“y”, “yn”, “d”, “z”, “zn”).

When the vector group matching is Yy0 and the *CT connection type* is according to “Type 2”, the phase angle of the phase currents connected to the protection relay does not change. When the vector group matching is Yy6, the phase currents are on one side turned 180° in the protection relay.

Example 1, vector group matching of an YNd11-connected power transformer on winding 1, *CT connection type* according to type 1. The *Winding 1 type* setting is “YN”, *Winding 2 type* is “d” and *Clock number* is “Clk Num 11”. This is compensated internally by giving winding 1 internal compensation value +30° and winding 2 internal compensation value 0°:

$$\bar{I}_{L1mHV} = \frac{\bar{I}_{L1} - \bar{I}_{L2}}{\sqrt{3}}$$

(Equation 146)

$$\bar{I}_{L2mHV} = \frac{\bar{I}_{L2} - \bar{I}_{L3}}{\sqrt{3}}$$

(Equation 147)

$$\bar{I}_{L3mHV} = \frac{\bar{I}_{L3} - \bar{I}_{L1}}{\sqrt{3}}$$

(Equation 148)

Example 2, if vector group is Yd11 and *CT connection type* is according to type 1, the compensation is a little different. The *Winding 1 type* setting is “Y”, *Winding 2 type* is “d” and *Clock number* is “Clk Num 11”. This is compensated internally by giving winding 1 internal compensation value 0° and winding 2 internal compensation value -30°:

$$\bar{I}_{L1mLV} = \frac{\bar{I}_{L1} - \bar{I}_{L3}}{\sqrt{3}}$$

(Equation 149)

$$\bar{I}_{L2mLV} = \frac{\bar{I}_{L2} - \bar{I}_{L1}}{\sqrt{3}}$$

(Equation 150)

$$\bar{I}_{L3mLV} = \frac{\bar{I}_{L3} - \bar{I}_{L2}}{\sqrt{3}}$$

(Equation 151)

The “Y” side currents stay untouched, while the “d” side currents are compensated to match the currents actually flowing in the windings.

In this example there is no neutral current on either side of the transformer (assuming there are no earthing transformers installed). In the previous example, the matching is done differently to have the winding 1 neutral current compensated at the same time.

**Table 646: LNPLDF vector group matching**

| Vector group of the transformer | Winding 1 type | Winding 2 type | Phase shift | Zero sequence current elimination |
|---|---|---|---|---|
| Yy0 | Y | y | 0 | Not needed |
| YNy0 | YN | y | 0 | HV side |
| YNyn0 | YN | yn | 0 | HV & LV side |
| Yyn0 | Y | yn | 0 | LV side |
| Yy2 | Y | y | 2 | Not needed |
| YNy2 | YN | y | 2 | (Automatic) |
| YNyn2 | YN | yn | 2 | (Automatic) |
| Yyn2 | Y | yn | 2 | (Automatic) |
| Yy4 | Y | y | 4 | Not needed |
| YNy4 | YN | y | 4 | (Automatic) |
| YNyn4 | YN | yn | 4 | (Automatic) |
| Yyn4 | Y | yn | 4 | (Automatic) |
| Yy6 | Y | y | 6 | Not needed |
| YNy6 | YN | y | 6 | HV side |
| YNyn6 | YN | yn | 6 | HV & LV side |
| Yyn6 | Y | yn | 6 | LV side |
| Yy8 | Y | y | 8 | Not needed |
| YNy8 | YN | y | 8 | (Automatic) |
| YNyn8 | YN | yn | 8 | (Automatic) |
| Yyn8 | Y | yn | 8 | (Automatic) |
| Yy10 | Y | y | 10 | Not needed |

*Table continues on the next page*

| Vector group of the transformer | Winding 1 type | Winding 2 type | Phase shift | Zero sequence current elimination |
|---|---|---|---|---|
| YNy10 | YN | y | 10 | (Automatic) |
| YNyn10 | YN | yn | 10 | (Automatic) |
| Yyn10 | Y | yn | 10 | (Automatic) |
| Yd1 | Y | d | 1 | Not needed |
| YNd1 | YN | d | 1 | (Automatic) |
| Yd5 | Y | d | 5 | Not needed |
| YNd5 | YN | d | 5 | (Automatic) |
| Yd7 | Y | d | 7 | Not needed |
| YNd7 | YN | d | 7 | (Automatic) |
| Yd11 | Y | d | 11 | Not needed |
| YNd11 | YN | d | 11 | (Automatic |
| Dd0 | D | d | 0 | Not needed |
| Dd2 | D | d | 2 | Not needed |
| Dd4 | D | d | 4 | Not needed |
| Dd6 | D | d | 6 | Not needed |
| Dd8 | D | d | 8 | Not needed |
| Dd10 | D | d | 10 | Not needed |
| Dy1 | D | y | 1 | Not needed |
| Dyn1 | D | yn | 1 | (Automatic) |
| Dy5 | D | y | 5 | Not needed |
| Dyn5 | D | yn | 5 | (Automatic) |
| Dy7 | D | y | 7 | Not needed |
| Dyn7 | D | yn | 7 | (Automatic) |
| Dy11 | D | y | 11 | Not needed |
| Dyn11 | D | yn | 11 | (Automatic) |
| Yz1 | Y | z | 1 | Not needed |
| YNz1 | YN | z | 1 | (Automatic) |
| YNzn1 | YN | zn | 1 | LV side |
| Yzn1 | Y | zn | 1 | (Automatic) |
| Yz5 | Y | z | 5 | Not needed |
| YNz5 | YN | z | 5 | (Automatic) |
| YNzn5 | YN | zn | 5 | LV side |
| Yzn5 | Y | zn | 5 | (Automatic) |
| Yz7 | Y | z | 7 | Not needed |
| YNz7 | YN | z | 7 | (Automatic) |
| YNzn7 | YN | zn | 7 | LV side |
| Yzn7 | Y | zn | 7 | (Automatic) |

*Table continues on the next page*

| Vector group of the transformer | Winding 1 type | Winding 2 type | Phase shift | Zero sequence current elimination |
|---|---|---|---|---|
| Yz11 | Y | z | 11 | Not needed |
| YNz11 | YN | z | 11 | (Automatic) |
| YNzn11 | YN | zn | 11 | LV side |
| Yzn11 | Y | zn | 11 | (Automatic) |
| Zy1 | Z | y | 1 | Not needed |
| Zyn1 | Z | yn | 1 | (Automatic) |
| ZNyn1 | ZN | yn | 1 | HV side |
| ZNy1 | ZN | y | 1 | (Automatic) |
| Zy5 | Z | y | 5 | Not needed |
| Zyn5 | Z | yn | 5 | (Automatic) |
| ZNyn5 | ZN | yn | 5 | HV side |
| ZNy5 | ZN | y | 5 | (Automatic) |
| Zy7 | Z | y | 7 | Not needed |
| Zyn7 | Z | yn | 7 | (Automatic) |
| ZNyn7 | ZN | yn | 7 | HV side |
| ZNy7 | ZN | y | 7 | (Automatic) |
| Zy11 | Z | y | 11 | Not needed |
| Zyn11 | Z | yn | 11 | (Automatic) |
| ZNyn11 | ZN | yn | 11 | HV side |
| ZNy11 | ZN | y | 11 | (Automatic) |
| Dz0 | D | z | 0 | Not needed |
| Dzn0 | D | zn | 0 | LV side |
| Dz2 | D | z | 2 | Not needed |
| Dzn2 | D | zn | 2 | (Automatic) |
| Dz4 | D | z | 4 | Not needed |
| Dzn4 | D | zn | 4 | (Automatic) |
| Dz6 | D | z | 6 | Not needed |
| Dzn6 | D | zn | 6 | LV side |
| Dz8 | D | z | 8 | Not needed |
| Dzn8 | D | zn | 8 | (Automatic) |
| Dz10 | D | z | 10 | Not needed |
| Dzn10 | D | zn | 10 | (Automatic) |
| Zd0 | Z | d | 0 | Not needed |
| ZNd0 | ZN | d | 0 | HV side |
| Zd2 | Z | d | 2 | Not needed |
| ZNd2 | ZN | d | 2 | (Automatic) |
| Zd4 | Z | d | 4 | Not needed |

*Table continues on the next page*

| Vector group of the transformer | Winding 1 type | Winding 2 type | Phase shift | Zero sequence current elimination |
|---|---|---|---|---|
| ZNd4 | ZN | d | 4 | (Automatic) |
| Zd6 | Z | d | 6 | Not needed |
| ZNd6 | ZN | d | 6 | HV side |
| Zd8 | Z | d | 8 | Not needed |
| ZNd8 | ZN | d | 8 | (Automatic) |
| Zd10 | Z | d | 10 | Not needed |
| ZNd10 | ZN | d | 10 | (Automatic) |
| Zz0 | Z | z | 0 | Not needed |
| ZNz0 | ZN | z | 0 | HV side |
| ZNzn0 | ZN | zn | 0 | HV & LV side |
| Zzn0 | Z | zn | 0 | LV side |
| Zz2 | Z | z | 2 | Not needed |
| ZNz2 | ZN | z | 2 | (Automatic) |
| ZNzn2 | ZN | zn | 2 | (Automatic) |
| Zzn2 | Z | zn | 2 | (Automatic) |
| Zz4 | Z | z | 4 | Not needed |
| ZNz4 | ZN | z | 4 | (Automatic) |
| ZNzn4 | ZN | zn | 4 | (Automatic) |
| Zzn4 | Z | zn | 4 | (Automatic) |
| Zz6 | Z | z | 6 | Not needed |
| ZNz6 | ZN | z | 6 | HV side |
| ZNzn6 | ZN | zn | 6 | HV & LV side |
| Zzn6 | Z | zn | 6 | LV side |
| Zz8 | Z | z | 8 | Not needed |
| ZNz8 | ZN | z | 8 | (Automatic) |
| ZNzn8 | ZN | zn | 8 | (Automatic) |
| Zzn8 | Z | zn | 8 | (Automatic) |
| Zz10 | Z | z | 10 | Not needed |
| ZNz10 | ZN | z | 10 | (Automatic) |
| ZNzn10 | ZN | zn | 10 | (Automatic) |
| Zzn10 | Z | zn | 10 | (Automatic) |

**Zero-sequence component elimination**

If *Clock number* is “Clk Num 2“, “Clk Num 4”, “Clk Num 8” or “Clk Num 10”, the vector group matching is always done on both, winding 1 and winding 2. The combination results in the correct compensation. In this case the zero-sequence component is always removed from both sides automatically. The *Zro A elimination* parameter cannot change this.

If *Clock number* is “Clk Num 1”, “Clk Num 5”, “Clk Num 7” or “Clk Num 11”, the vector group matching is done on one side only. A possible zero-sequence component of the phase currents at earth faults occurring outside the protection area is automatically eliminated in the numerically implemented delta connection before the differential current and the biasing current are calculated. This is why the vector group matching is almost always made on the star connected side of the “Ynd” and “Dyn” connected transformers.

If *Clock number* is “Clk Num 0” or “Clk Num 6”, the zero-sequence component of the phase currents is not eliminated automatically on either side. Therefore, the zero-sequence component on the star connected side that is earthed at its star point has to be eliminated by using the Zro A elimination parameter.

The same parameter has to be used to eliminate the zero-sequence component if there is, for example, an earthing transformer on the delta-connected side of the “Ynd” power transformer in the area to be protected. In this case, the vector group matching is normally made on the side of the star connection. On the side of the delta connection, the elimination of the zero-sequence component has to be eliminated by using the Zro A elimination parameter.

By using the Zro A elimination parameter, the zero-sequence component of the local phase currents is calculated and reduced for each phase current:

$$\bar{I}_{LOC_A} = \bar{I}_{LOC_A} - \frac{1}{3} \times \left( \bar{I}_{LOC_A} + \bar{I}_{LOC_B} + \bar{I}_{LOC_C} \right)$$

(Equation 152)

$$\bar{I}_{LOC_B} = \bar{I}_{LOC_B} - \frac{1}{3} \times \left( \bar{I}_{LOC_A} + \bar{I}_{LOC_B} + \bar{I}_{LOC_C} \right)$$

(Equation 153)

$$\bar{I}_{LOC_C} = \bar{I}_{LOC_C} - \frac{1}{3} \times \left( \bar{I}_{LOC_A} + \bar{I}_{LOC_B} + \bar{I}_{LOC_C} \right)$$

**Fail safe function**

To prevent malfunction during communication interference, the operation of LNPLDF is blocked when the protection communication supervision detects severe interference in the communication channel. The timer reset stage is activated in case the stabilized stage is started during a communication interruption. The protection communication supervison is connected internally from PCSITPC to LNPLDF (dotted OK line).

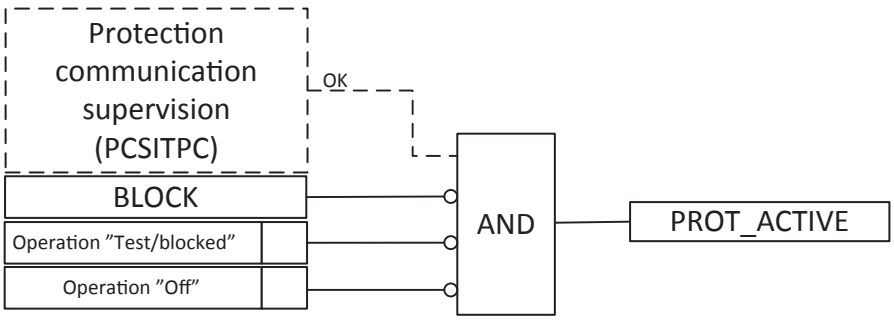



*Figure 372: Operation logic of the fail safe function*

The function can also be set into “test/blocked” state with the *Operation* setting. This can also be utilized during the commissioning.

The BLOCK input is provided for blocking the function with the logic. When the function is blocked, the monitored data and measured values are still available but the binary outputs are blocked. When the function is blocked, the direct inter-trip is also blocked.

The PRO_ACTIVE output is always active when the protection function is capable of operating. PRO_ACTIVE can be used as a blocking signal for backup protection functions.

**Timer**

Once activated, the timer activates the STR_LS_LOC output. Depending on the value of the set *Operating curve type*, the timer characteristics are according to DT or IDMT. When the operation timer has reached the value set with the *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPR_LS_LOC output is activated. When the operation mode is according to IDMT, *Low operate value* is used as reference value (Start value) in the IDMT equations presented in the Standard inverse-time characteristics section.

A timer reset state is activated when a drop-off situation happens. The reset is done according to the DT characteristics.

For a detailed description of the timer characteristics, see the *Chapter 11 General function block features* section in this manual.

**Instantaneous high stage**

In addition to the stabilized low stage, LNPLDF has an instantaneous high stage. The stabilizing is not done with the instantaneous high stage. The instantaneous high stage operates immediately when the differential current amplitude is higher than the set value of the *High operate value* setting. If the ENA_MULT_HS input is active, the *High operate value* setting is internally multiplied by the *High Op value Mult* setting.

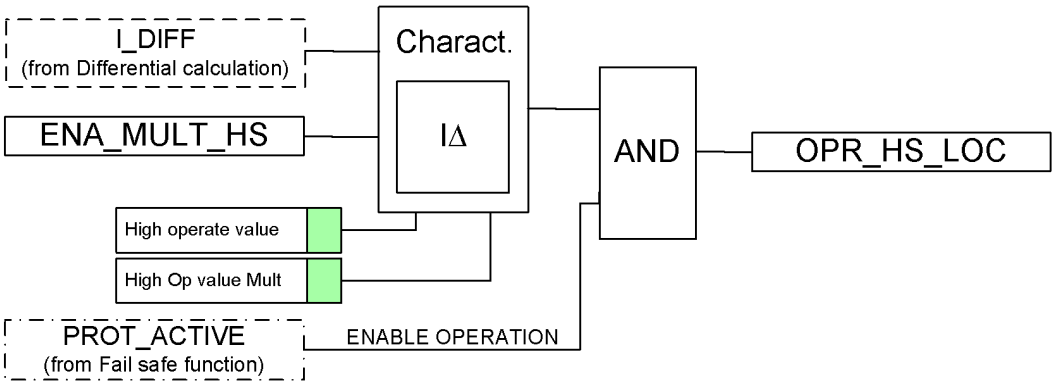



*Figure 373: Operation logic of instantaneous high stage*

**Direct inter-trip**

Direct inter-trip is used to ensure the simultaneous opening of the circuit breakers at both ends of the protected line when a fault is detected. Both start and operate signals are sent to the remote end via communication. The direct-intertripping of the line differential protection is included into LNPLDF. The `OPERATE` output combines the operate signals from both stages, local and remote, so that it can be used for the direct inter-trip signal locally.

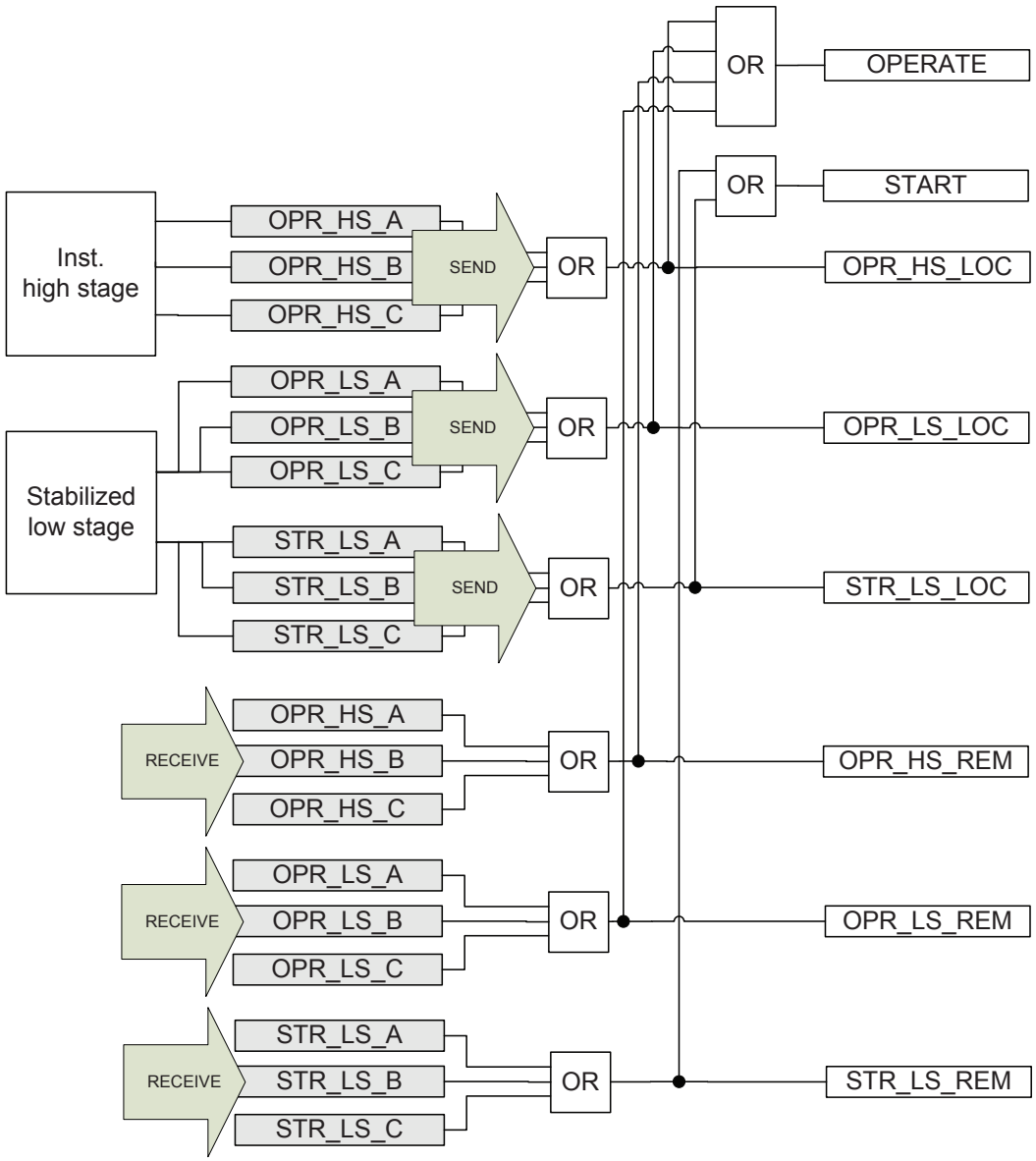



*Figure 374: Operation logic of the direct intertrip function*

The start and operate signals are provided separately for the low and high stages, and in the local and remote.

**Blocking functionality**

There are two independent inputs that can be used for blocking the function: `BLOCK` and `BLOCK_LS`. The difference between these inputs is that `BLOCK_LS` (when TRUE) blocks only the stabilized low stage leaving the instantaneous high stage operative. `BLOCK` (when TRUE) blocks both stages and also the `PRO_ACTIVE` output is updated according to the `BLOCK` input status, as described in the Fail safe function chapter.

The `BLOCK` and `BLOCK_LS` input statuses affect only the behavior of the local protection instance. When a line differential protection stage (stabilized low or instantaneous high) is blocked, also the received remote signals related to the corresponding stage are ignored (received direct inter-trip signals from the remote end). The binary signal transfer functionality should therefore be used for

transferring the possible additional blocking information between the local and remote terminals whenever the blocking logic behavior needs to be the same on both line ends.

### Test mode

The line differential function in one protection relay can be set to test mode, that is, the *Operation* setting is set to “test/blocked”. This blocks the line differential protection outputs in the protection relay and sets the remote protection relay to a remote test mode, such that the injected currents are echoed back with the shifted phase. It is also possible that both protection relays are simultaneously in the test mode. When the line differential protection function is in the test mode:

- The remote end protection relay echoes locally injected current samples back with the shifted phase. The current samples that are sent to the remote protection relay are scaled with the CT ratio correction setting.
- The operation of both stages (stabilized low or instantaneous high) are blocked, and also the direct inter-trip functionality is blocked (both receive and send) in the protection relay where the test mode is active.
- The remote end line differential protection function that is in the normal mode (On) is not affected by the local end being in the test mode. This means that the remote end function is operative but, at the same time, it ignores the received current samples from the other end protection relay which is in the test mode.
- The PRO_ACTIVE output is false only in the protection relay that is currently in the test mode.

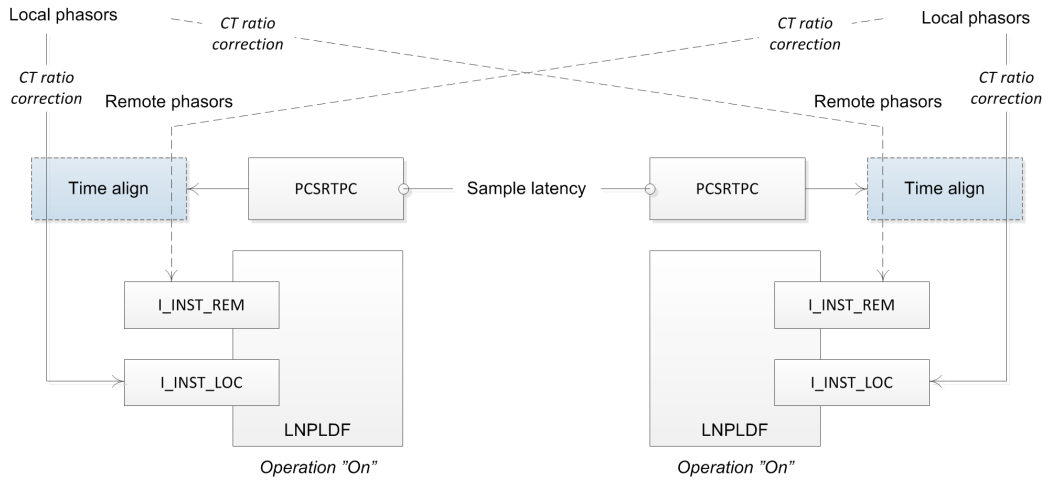



*Figure 375: Operation during the normal operation of the line differential protection*

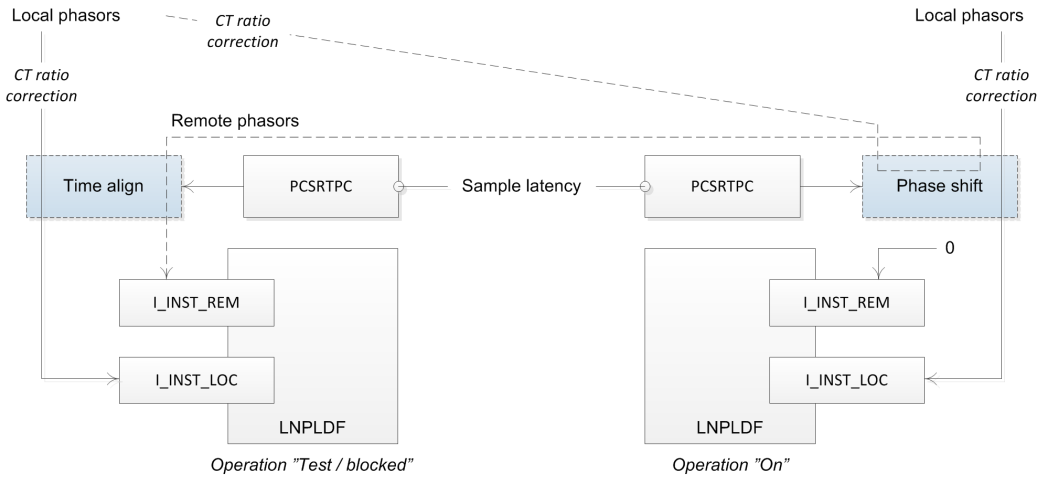



*Figure 376: Operation during test operation of the line differential protection*

## 4.3.1.6 Commissioning

The commissioning of the line differential protection scheme would be difficult without any support features in the functionality because of the relatively long distance between the protection relays. This has been taken into consideration in the design of the line differential protection. The communication channel can be used for echoing the locally fed current phasors from the remote end. By using this mode, it is possible to verify that differential calculation is done correctly in each phase. Also, the protection communication operation is taken into account with the differential current calculation when this test mode is used.

**Required material for testing the protection relay**

- Calculated settings
- Terminal diagram
- Circuit diagrams
- Technical and application manuals of the protection relay
- Single of three-phase secondary current source
- Single of three-phase primary current source
- Timer with start and stop interfaces
- Auxiliary voltage source for the protection relays
- PC with related software, a Web browser for WHMI

The setting and configuration of the protection relay must be completed before testing.

The terminal diagram, available in the technical manual, is a general diagram of the protection relay.

The same diagram is not always applicable to each specific delivery, especially for the configuration of all the binary inputs and outputs. Therefore, before testing, check that the available terminal diagram corresponds to the protection relay.

The circuit diagrams of the application are recommended to be available. These are required for checking the terminal block numbers of the current, trip, alarm and possibly other auxiliary circuits.

The technical and application manuals contain application and functionality summaries, function blocks, logic diagrams, input and output signals, setting parameters and technical data sorted per function.

The minimum requirement for a secondary current injection test device is the ability to work as a one phase current source.

The protection relay should be prepared for the test before testing a particular function. The logic diagram of the tested protection function must be considered while performing the test. All included functions in the protection relay are tested according to the corresponding test instructions in this chapter. The functions can be tested in any order according to user preferences. Therefore, the test instructions are presented in alphabetical order. Only the functions that are in use ( *Operation* is set to "On") should be tested.

The response from the test can be viewed in different ways.

- Binary output signals
- Monitored data values in the LHMI (logical signals)
- A PC with a Web browser for WHMI use (logical signals and phasors)

All used setting groups should be tested.

**Checking the external optical and electrical connections**

The user must check the installation to verify that the protection relay is connected to the other required parts of the protection system. The protection relay and all the connected circuits are to be de-energized during the check-up.

*Checking of CT circuits*

Check that the wiring is in strict accordance with the supplied connection diagram.

The CTs must be connected in accordance with the terminal diagram provided with the protection relay, both with regards to phases and polarity. The following tests are recommended for every primary CT or CT core connected to the protection relay.

- Primary injection test to verify the current ratio of the CT, the correct wiring up to the protection relay and correct phase sequence connection (that is L1, L2, L3.)
- Polarity check to prove that the predicted direction of the secondary current flow is correct for a given direction of the primary current flow. This is an essential test for the proper operation of the directional function, protection or measurement in the protection relay.
- CT secondary loop resistance measurement to confirm that the current transformer secondary loop DC resistance is within specification and that there are no high resistance joints in the CT winding or wiring.
- CT excitation test to ensure that the correct core in the CT is connected to the protection relay. Normally only a few points along the excitation curve are checked to ensure that there are no wiring errors in the system, for example, due to a mistake in connecting the CT's measurement core to the protection relay.
- CT excitation test to ensure that the CT is of the correct accuracy rating and that there are no short circuited turns in the CT windings. Manufacturer's design curves should be available for the CT to compare the actual results.

- Earthing check of the individual CT secondary circuits to verify that each three-phase set of main CTs is properly connected to the station earth and only at one electrical point.
- Insulation resistance check.
- Phase identification of CT shall be made.



CT and VT connectors are pre-coded, and the CT and VT connector markings are different. For more information, see the installation manual.



De-energize the CT primary side and disconnect the CT secondary circuits from the protection relay while carrying out the CT core excitation curve plotting.



If the CT secondary circuit is opened or its earth connection is missing or removed without the CT primary being de-energized first, dangerous voltages may be produced. This can be lethal and cause damage to the insulation. The re-energizing of the CT primary should be prohibited as long as the CT secondary is open or unearthed.

*Checking of the power supply*

Check that the auxiliary supply voltage remains within the permissible input voltage range under all operating conditions. Check that the polarity is correct before powering the protection relay.

*Checking binary I/O circuits*

Always check the binary input circuits from the equipment to the protection relay interface to make sure that all signals are connected correctly. If there is no need to test a particular input, the corresponding wiring can be disconnected from the terminal of the protection relay during testing. Check all the connected signals so that both input voltage level and polarity are in accordance with the protection relay specifications. However, attention must be paid to the electrical safety instructions.

Always check the binary output circuits from the protection relay to the equipment interface to make sure that all signals are connected correctly. If a particular output needs to be tested, the corresponding wiring can be disconnected from the terminal of the protection relay during testing. Check all the connected signals so that both load and polarity are in accordance with the protection relay specifications. However, attention must be paid to the electrical safety instructions.

*Checking of optical connections*

Check that the Tx and Rx optical connections are correct.



A relay equipped with optical connections requires a minimum depth of 180 mm (7.0866 in) for plastic fiber cables and 275 mm (10.8268 in) for glass fiber cables. Check the allowed minimum bending radius from the optical cable manufacturer.

**Applying of required settings for the protection relay**

Download all calculated settings and measurement transformer parameters in the protection relay.

### Connecting of test equipment to the protection relay

Before testing, connect the test equipment according to the protection relay specific connection diagram.

Pay attention to the correct connection of the input and output current terminals. Check that the input and output logical signals in the logic diagram for the function under test are connected to the corresponding binary inputs and outputs of the protection relay. Select the correct auxiliary voltage source according to the power supply module of the protection relay. Select the correct auxiliary voltage source according to the power supply module of the protection relay.

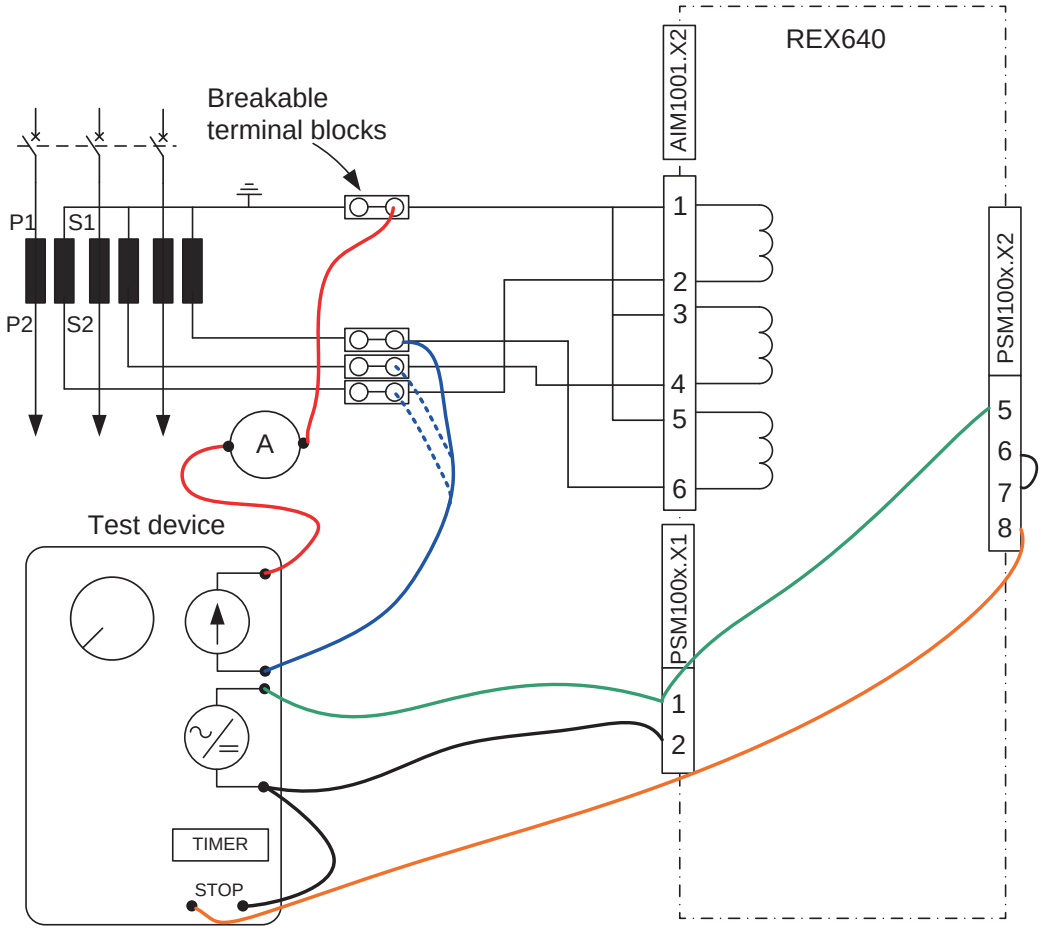



*Figure 377: Example of connections to test the line differential protection relay*

### Secondary current injection

There are two alternative modes to check the operation of a line differential protection relay. These are not exclusive methods for each other and can be used for various test on the protection relay.

*Normal mode*

In normal mode, that is, the mode when the function is on normal operation, the local end protection relay sends phasors to the remote end protection relay and receives phasors measured by the remote end protection relay. This mode can be

used in testing the operating level and time of the low and high stages of the local end protection relay. This is due to a test situation when the remote end does not measure any current and therefore, all the current fed to the local end current circuit is seen as differential current at both ends.

Testing of the line differential protection is done with both protection relays separated geographically from each other. It is important to note that local actions in one protection relay cause operation also in the remotely located protection relay. When testing the line differential function, actions have to be done in both protection relays.

Before the test, the trip signal to the circuit breaker shall be blocked, for example by breaking the trip circuit by opening the terminal block or by using some other suitable method.

When injecting current to one phase in the local end protection relay, the current is seen as a differential current at both ends. If a current $I_{injected}$ is injected, L1 in phase L1, the differential and stabilizing currents for phase L1 are:

$$ID_A = I_{injected}$$

(Equation 154)

$$IB_A = \frac{I_{injected}}{2}$$

(Equation 155)

The operation is equal for phases L2 and L3.

*Verifying the settings*

1. Block the unwanted trip signals from the protection relay units involved.
2. Inject a current in phase L1 and increase the current until the function operates for phase L1.

   The injected operate current corresponds to the set *Low operate value*. The monitored values for ID_A should be equal to the injected current.

3. Repeat point 2 by current injection in phases L2 and L3.
4. Measure the operating time by injecting the single-phase current in phase L1.

   The injected current should be four times the operating current. The time measurement is stopped by the trip output from the protection relay unit.

5. Disconnect the test equipment and reconnect the current transformers and all other circuits including the trip circuit.

*Phasor echoing method*

The line differential function in one protection relay can be set to special test mode, that is, the *Operation* setting is set to “test/blocked”. When this mode is in use, the remote end protection relay echoes locally injected current phasors back with the shifted phase and settable amplitude. Therefore, the local end line differential function is also automatically blocked and the remote end line differential function discards the phasors it receives from the protection relay in the test mode.

When the test mode is active, the *CT connection type* is still used by the line differential protection function as in the normal operation mode. The setting can be used for shifting the phase (0 or 180 degrees).

Parameter Settings - LNPLDF1

Edit | Refresh Values | Setting Group 1*

| PARAMETER NAME | RELAY VALUE | UNIT | MIN. | MAX. | STEP |
|---|---|---|---|---|---|
| Operation | test/blocked | | | | |
| Winding selection | Not in use | | | | |
| CT ratio correction | 1.000 | | 0.2 | 5 | 0.001 |
| CT connection type | Type 2 | | | | |
| Restraint mode | None | | | | |
| Reset delay time | 0 | ms | 0 | 60000 | 1 |
| **Setting Group 1** | | | | | |
| Low operate value | 10 | %Ir | 10 | 200 | 1 |
| High operate value | 200 | %Ir | 200 | 4000 | 1 |
| High Op value Mult | 1.0 | | 0.5 | 1 | 0.1 |
| End section 1 | 100 | %Ir | 0 | 200 | 1 |
| Slope section 2 | 50 | % | 10 | 50 | 1 |
| End section 2 | 200 | %Ir | 200 | 2000 | 1 |
| Slope section 3 | 150 | % | 10 | 200 | 1 |
| Operating curve type | IEC Def. Time | | | | |
| Operate delay time | 45 | ms | 45 | 200000 | 1 |

*Figure 378: An example of a test mode situation where three-phase currents are injected to the local end protection relay*

## 4.3.1.7 Application

LNPLDF is designed for the differential protection of overhead line and cable feeders in a distribution network. LNPLDF provides absolute selectivity and fast operating times as unit protection also in short lines where distance protection cannot be applied.

LNPLDF provides selective protection for radial, looped and meshed network topologies and can be used in isolated neutral networks, resistance earthed networks, compensated (impedance earthed) networks and solidly earthed networks. In a typical network configuration where the line differential protection scheme is applied, the protected zone, that is, the line or cable, is fed from two directions.

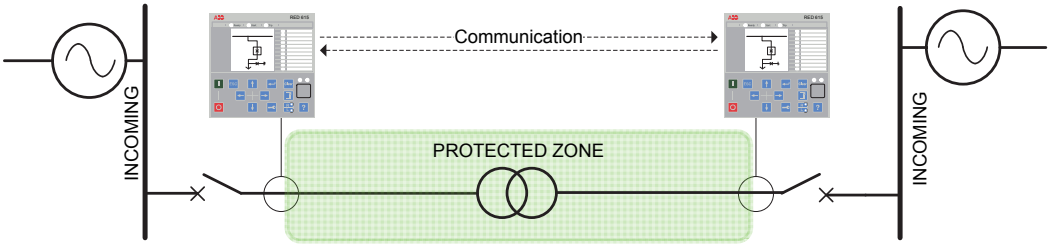



*Figure 379: Line protection with phase segregated line differential with in-zone transformer*

LNPLDF can be utilized for various types of network configurations or topologies. Case A shows the protection of a ring-type distribution network. The network is also used in the closed ring mode. LNPLDF is used as the main protection for different sections of the feeder. In case B, the interconnection of two substations is done with parallel lines and each line is protected with the line differential protection. In case C, the connection line to mid scale power generation (typical size

around 10...50 MVA) is protected with the line differential function. The protection includes the transformer from the protection field. In case D, the connection between two substations and a small distribution transformer is located at the tapped load. The usage of LNPLDF is not limited to these applications.

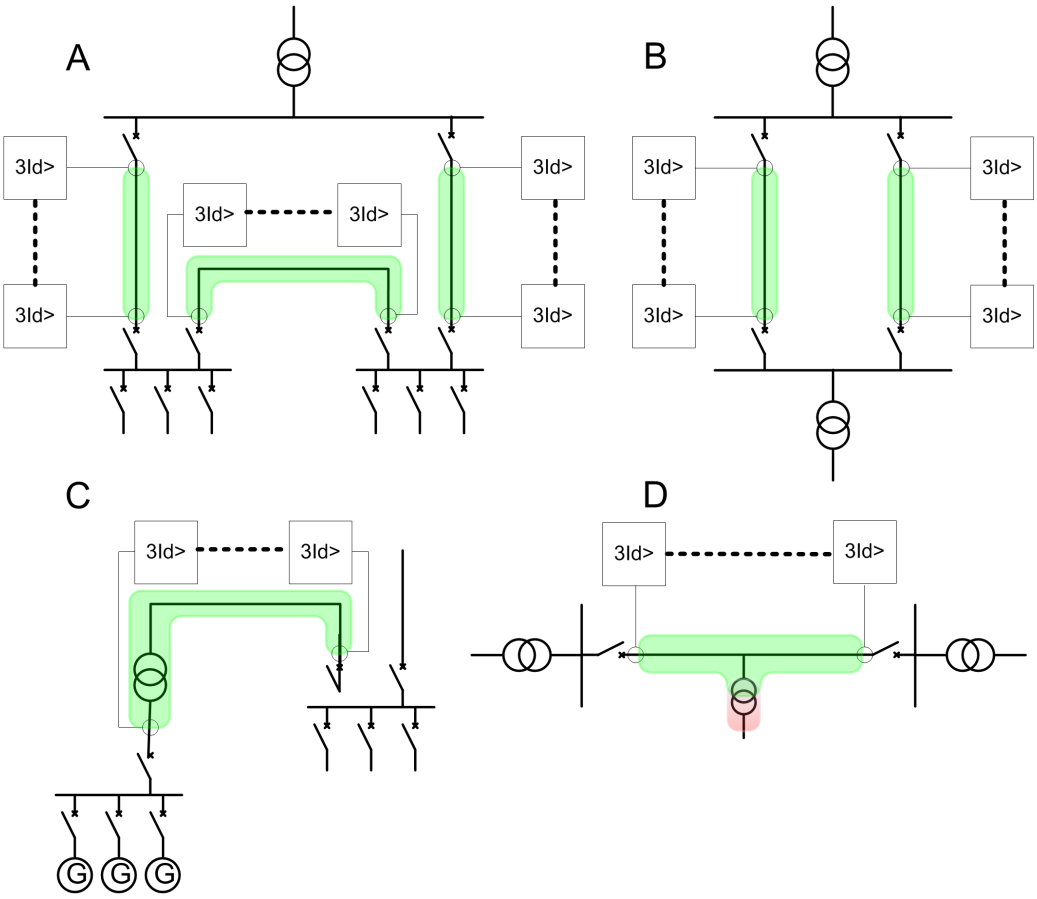



*Figure 380: Line differential applications*

### Communication supervision

A typical line differential protection application includes LNPLDF as the main protection. Backup over current functions is needed if a protection communication failure occurs. When the communication supervision function detects a failure in the communication between the protective units, the safe operation of the line is still guaranteed by blocking the line differential protection and unblocking the over current functions.

When a communication failure is detected, the protection communication supervision function issues block for the LNPLDF line differential protection and unblock for the instantaneous and high stages (instance 2) of the over current protection. These are used to give backup protection for the remote end feeder protection relay. In situations where the selectivity is weaker than usually, the protection should still be available for the system.

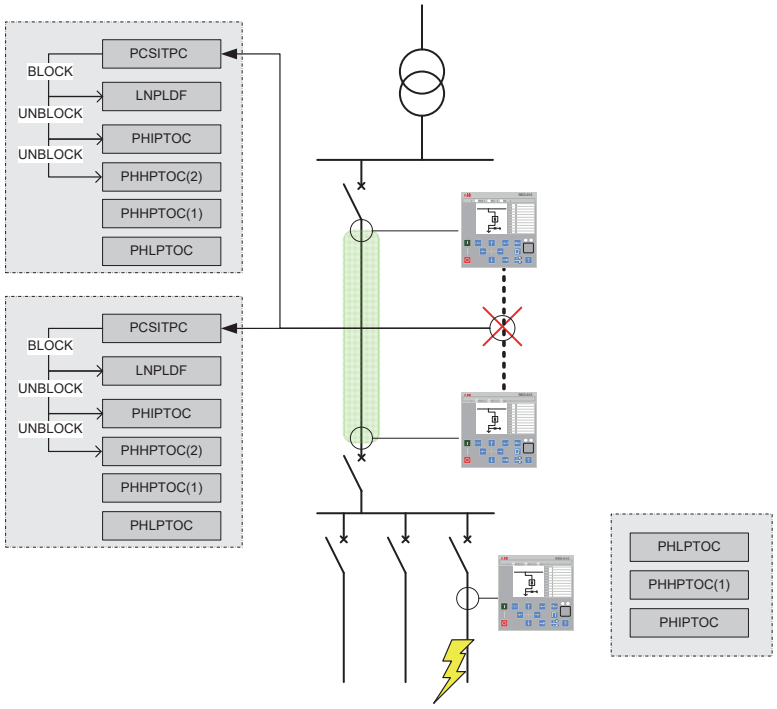



*Figure 381: Protection communication supervision detects failures on communication*

**In-zone transformer**

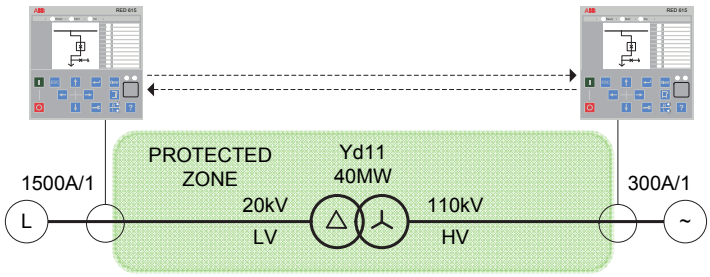



*Figure 382: In-zone transformer example about CT ratio correction calculation*

The CT ratio correction calculation starts with the rated load current calculation for HV and LV sides. The rated load current is defined as the rated power of the transformer divided by the square root of three times the nominal phase-to-phase voltage at the HV or LV side.

$$I_{nT} = \frac{S_n}{\sqrt{3} \times U_n}$$

(Equation 156)

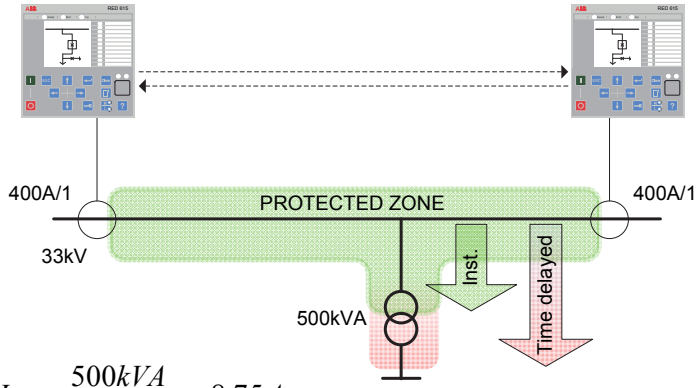
The rated load current of the transformer on the HV side is 209.9 A (40 MW / (√3 × 110 kV)) and the rated load current of the transformer on the LV side is 1154.7 A (40 MW / (√3 × 20 kV)). This means that the CT ratio corrections for the HV and LV sides are:

CT ratio correction (HV) = 1.429 (300 A / 209.9 A)

CT ratio correction (LV) = 1.299 (1500 A / 1154.7 A)

**Small power transformers in a tap**

With a relatively small power transformer in a line tap, the line differential protection can be applied without the need of current measurement from the tap. In such cases, the line differential function is time delayed for low differential currents below the high set limit and LNPLDF coordinates with the downstream protection relays in the relevant tap. For differential currents above the set limit, the operation is instantaneous. As a consequence, when the load current of the tap is negligible, the low resistive line faults are cleared instantaneously at the same time as maximum sensitivity for the high resistive faults are maintained but with a time delayed operation. The maximum sensitivity for high resistive faults is maintained at the same time, but with a time delayed operation.

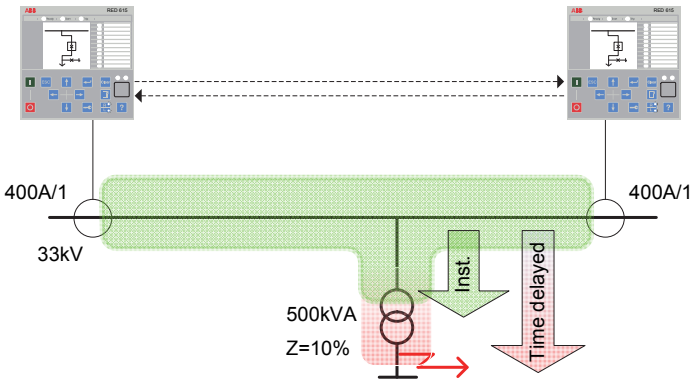



$$I_L = \frac{500kVA}{\sqrt{3} \cdot 33kV} \cong 8.75A$$

$$I_\Delta > \left[\frac{8.75A}{400\ A}\right] * 1A = 0.02A = 2\%$$

*Figure 383: Influence of the tapped transformer load current to the stabilized low stage setting*

The stabilized stage provides both DT and IDMT characteristics that are used for time selective protection against faults which are not covered by the instantaneous stage. The impedance of the line is typically an order of magnitude lower than the transformer impedance providing significantly higher fault currents when the fault is located on the line.




$$I_F = \frac{1.1 \cdot 500kVA}{\sqrt{3} \cdot 33kV \cdot 0.10} \cong 96.23A$$

$$I_\Delta < \left[\frac{96.23A}{400\ A}\right] * 1A = 0.24A = 24\%$$

*Figure 384: Influence of the short circuit current at LV side of the tapped transformer to the differential current*

### Detection of the inrush current during transformer start-up

When the line is energized, the transformer magnetization inrush current is seen as differential current by the line differential protection and may cause malfunction of the protection if not taken into account. The inrush situation may only be detected on one end but the differential current is always seen on both ends. The inrush

current includes high order harmonic components which can be detected and used as the blocking criteria for the stabilized stage. The inrush detection information is changed between two ends so that fast and safe blocking of the stabilized stage can be issued on both ends.

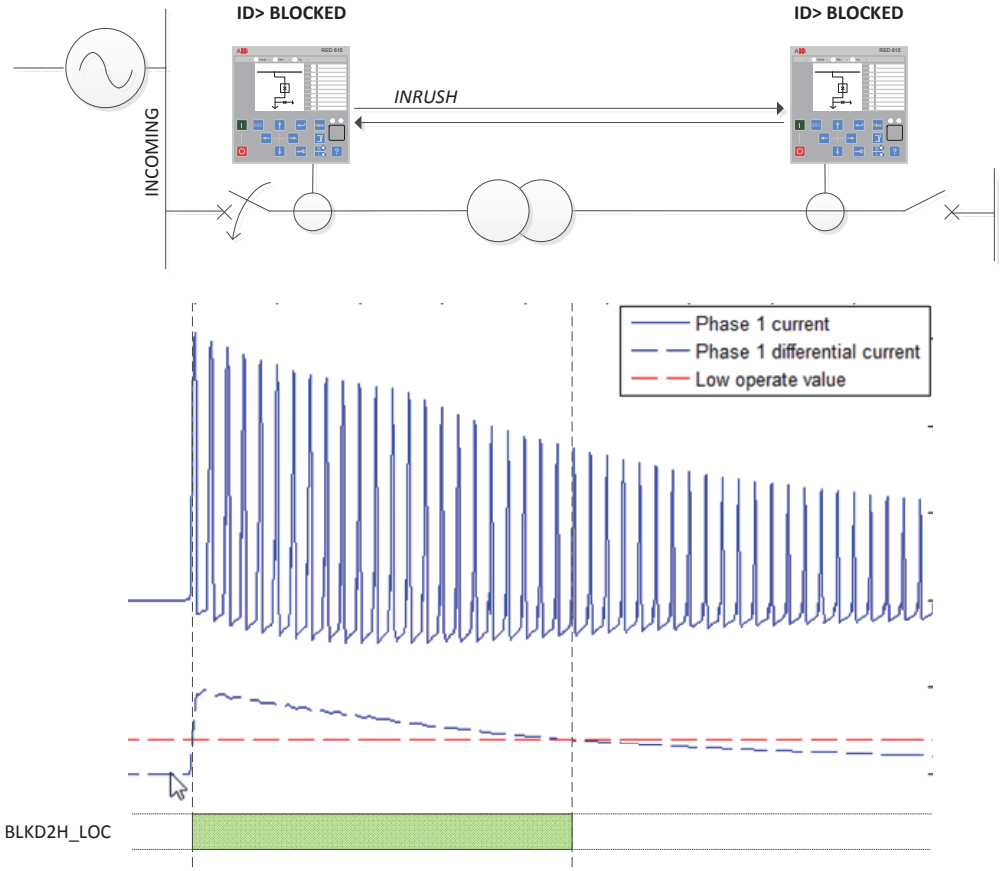



*Figure 385: Blocking of line differential functions during detected transformer start-up current*

If the protection stage is allowed to start during the inrush situation, the time delay can be selected so that the stabilized stage does not operate in the inrush situation.

## 4.3.1.8 Signals

### LNPLDF Input signals

**Table 647: LNPLDF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Signal for blocking the function |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK_LS | BOOLEAN | 0=False | Signal for blocking the stab. stage |
| ENA_MULT_HS | BOOLEAN | 0=False | Enables the high stage multiplier |

**LNPLDF Output signals**

**Table 648: LNPLDF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate, local or remote, stabilized or instantaneous stage |
| START | BOOLEAN | Start, local or remote |
| STR_LS_LOC | BOOLEAN | Start stabilized stage local |
| STR_LS_REM | BOOLEAN | Start stabilized stage remote |
| OPR_LS_LOC | BOOLEAN | Operate stabilized stage local |
| OPR_LS_REM | BOOLEAN | Operate stabilized stage remote |
| OPR_HS_LOC | BOOLEAN | Operate instantaneous stage local |
| OPR_HS_REM | BOOLEAN | Operate instantaneous stage remote |
| BLKD2H_LOC | BOOLEAN | Restraint due 2nd harmonics detected local |
| BLKD2H_REM | BOOLEAN | Restraint due 2nd harmonics detected remote |
| PRO_ACTIVE | BOOLEAN | Status of the protection, true when function is operative |

## 4.3.1.9 LNPLDF Settings

**Table 649: LNPLDF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Low operate value | 10...200 | %Ir | 1 | 10 | Basic setting for the stabilized stage start |
| High operate value | 200...4000 | %Ir | 1 | 2000 | Instantaneous stage operate value |
| Start value 2.H | 10...50 | % | 1 | 20 | The ratio of the 2. harmonic component to fundamental component required for blocking |
| High Op value Mult | 0.5...1.0 | | 0.1 | 1.0 | Multiplier for scaling the high stage operate value |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Time multiplier | 0.05...15.00 | | 0.01 | 1.00 | Time multiplier in IDMT curves |
| End section 1 | 0...200 | %Ir | 1 | 100 | Turn-point between the first and the second line of the operating characteristics |
| Slope section 2 | 10...50 | % | 1 | 50 | Slope of the second line of the operating characteristics |
| End section 2 | 200...2000 | %Ir | 1 | 500 | Turn-point between the second and the third line of the operating characteristics |
| Slope section 3 | 10...200 | % | 1 | 150 | Slope of the third line of the operating characteristics |
| Operating curve type | 1=ANSI Ext. inv.<br>3=ANSI Norm. inv.<br>5=ANSI Def. Time<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>12=IEC Ext. inv.<br>15=IEC Def. Time | | | 15=IEC Def. Time | Selection of time delay curve for stabilized stage |
| Operate delay time | 45...200000 | ms | 1 | 45 | Operate delay time for stabilized stage |

**Table 650: LNPLDF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>4=test/blocked<br>5=off | | | 1=on | Operation mode of the function |
| Winding selection | 1=Not in use<br>2=Winding 1<br>3=Winding 2 | | | 1=Not in use | IED location respect to transformer, HV (Winding 1) side or LV (Winding 2) side |
| Winding 1 type | 1=Y<br>2=YN<br>3=D<br>4=Z<br>5=ZN | | | 1=Y | Connection of the HV side windings |
| Winding 2 type | 1=y<br>2=yn<br>3=d<br>4=z<br>5=zn | | | 1=y | Connection of the LV side windings |
| Clock number | 0=Clk Num 0<br>1=Clk Num 1<br>2=Clk Num 2<br>4=Clk Num 4<br>5=Clk Num 5<br>6=Clk Num 6<br>7=Clk Num 7 | | | 0=Clk Num 0 | Setting the phase shift between HV and LV with clock number for connection group compensation (e.g. Dyn11 -> 11) |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 8=Clk Num 8<br>10=Clk Num 10<br>11=Clk Num 11 | | | | |
| CT ratio correction | 0.200...5.000 | | 0.001 | 1.000 | Local phase current transformer ratio correction |
| CT connection type | 1=Type 1<br>2=Type 2 | | | 1=Type 1 | CT connection type. Determined by the directions of the connected current transformers. |
| Zro A elimination | 1=Not eliminated<br>2=Winding 1<br>3=Winding 2<br>4=Winding 1 and 2 | | | 1=Not eliminated | Elimination of the zero-sequence current |
| Restraint mode | 1=None<br>2=Harmonic2 | | | 1=None | Selects what restraint modes are in use |

**Table 651: LNPLDF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 0 | Reset delay time for stabilized stage |
| Minimum operate time | 45...60000 | ms | 1 | 45 | Minimum operate time for stabilized stage IDMT curves |

### 4.3.1.10 LNPLDF Monitored data

**Table 652: LNPLDF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| I_AMPL_LOC_A | FLOAT32 | 0.00...40.00 | xIr | Local phase A amplitude after correction |
| I_AMPL_LOC_B | FLOAT32 | 0.00...40.00 | xIr | Local phase B amplitude after correction |
| I_AMPL_LOC_C | FLOAT32 | 0.00...40.00 | xIr | Local phase C amplitude after correction |
| I_AMPL_REM_A | FLOAT32 | 0.00...40.00 | xIr | Remote phase A amplitude after correction |
| I_AMPL_REM_B | FLOAT32 | 0.00...40.00 | xIr | Remote phase B amplitude after correction |
| I_AMPL_REM_C | FLOAT32 | 0.00...40.00 | xIr | Remote phase C amplitude after correction |
| ID_A | FLOAT32 | 0.00...80.00 | xIr | Differential current phase A |
| ID_B | FLOAT32 | 0.00...80.00 | xIr | Differential current phase B |
| ID_C | FLOAT32 | 0.00...80.00 | xIr | Differential current phase C |
| IB_A | FLOAT32 | 0.00...80.00 | xIr | Stabilization current phase A |
| IB_B | FLOAT32 | 0.00...80.00 | xIr | Stabilization current phase B |
| IB_C | FLOAT32 | 0.00...80.00 | xIr | Stabilization current phase C |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_ANGL_DIFF_A | FLOAT32 | -180.00...180.00 | deg | Current phase angle differential between local and remote, phase A |
| I_ANGL_DIFF_B | FLOAT32 | -180.00...180.00 | deg | Current phase angle differential between local and remote, phase B |
| I_ANGL_DIFF_C | FLOAT32 | -180.00...180.00 | deg | Current phase angle differential between local and remote, phase C |
| LNPLDF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| IL1-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL1 |
| IL2-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL2 |
| IL3-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL3 |
| IL1-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL1 |
| IL2-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL2 |
| IL3-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL3 |

### 4.3.1.11 Technical data

**Table 653: LNPLDF Technical data**

| Characteristics | Value | | |
|---|---|---|---|
| Operation accuracy [1] | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | Low stage | ±2.5% of the set value | |
| | High stage | ±2.5% of the set value | |
| High stage, operate time [2, 3] | Minimum | Typical | Maximum |
| | 20 ms | 23 ms | 27 ms |
| Reset time | Typically 40 ms | | |
| Reset ratio | Typically 0.96 | | |
| Retardation time | <40 ms | | |

*Table continues on the next page*

[1] With the symmetrical communication channel (as when using dedicated fiber optic).
[2] Without additional delay in the communication channel (as when using dedicated fiber optic).
[3] Measured with static power output. When differential current = 2 × *High operate value* and $f_n$ = 50 Hz with galvanic pilot wire link + 5 ms.

| Characteristics | Value |
|---|---|
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in inverse time mode | ±5.0% of the set value or ±20 ms [4] |
| Suppression of harmonics | RMS: No suppression<br>DFT: -50 dB at f = n × fn, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression |

## 4.3.2 Stabilized and instantaneous differential protection for two-winding transformers TR2PTDF (ANSI 87T)

### 4.3.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Stabilized and instantaneous differential protection for two-winding transformers | TR2PTDF | 3dI>T | 87T |

### 4.3.2.2 Function block

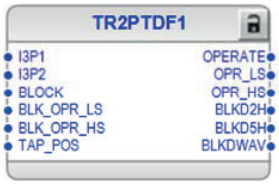



*Figure 386: Function block*

### 4.3.2.3 Functionality

The stabilized and instantaneous differential protection for two-winding transformers function TR2PTDF is designed to protect two-winding transformers and generator-transformer blocks. TR2PTDF includes low biased and high instantaneous stages.

The biased low stage provides a fast clearance of faults while remaining stable with high currents passing through the protected zone increasing errors on current measuring. The second harmonic restraint, together with the waveform based algorithms, ensures that the low stage does not operate due to the transformer inrush currents. The fifth harmonic restraint ensures that the low stage does not operate on apparent differential current caused by a harmless transformer over-excitation.

[4] *Low operate value* multiples in the range of 1.5...20

The instantaneous high stage provides a very fast clearance of severe faults with a high differential current regardless of their harmonics.

The setting characteristic can be set more sensitive with the aid of tap changer position compensation. The correction of transformation ratio due to the changes in tap position is done automatically based on the tap changer status information.

### 4.3.2.4 Analog channel configuration

TR2PTDF has two analog group inputs which must be properly configured.

**Table 654: Analog inputs**

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase currents |



See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of TR2PTDF can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

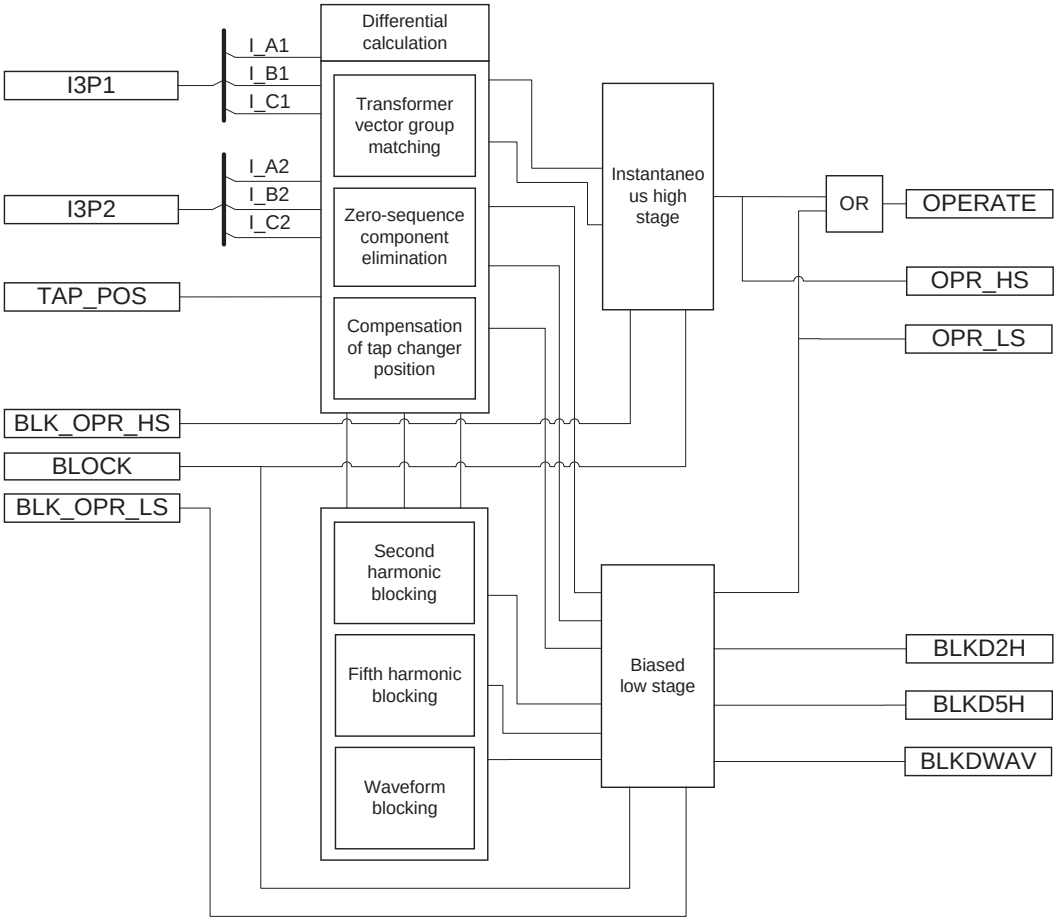



*Figure 387: Functional module diagram*

**Differential calculation**

TR2PTDF operates phase-wise on a difference of incoming and outgoing currents. The positive direction of the currents is towards the protected object.

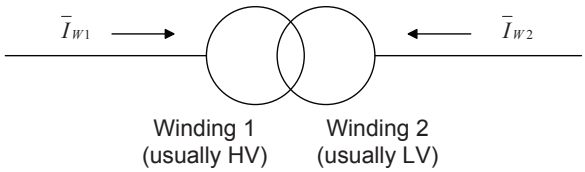



*Figure 388: Positive direction of the currents*

$$I_d = \left| \bar{I}_{W1} + \bar{I}_{W2} \right|$$

(Equation 157)

In a normal situation, no fault occurs in the area protected by TR2PTDF. Then the currents $\bar{I}_{W1}$ and $\bar{I}_{W2}$ are equal and the differential current $I_d$ is zero. In practice, however, the differential current deviates from zero in normal situations. In the power transformer protection, the differential current is caused by CT

inaccuracies, variations in tap changer position (if not compensated), transformer no-load current and instantaneous transformer inrush currents. An increase in the load current causes the differential current, caused by the CT inaccuracies and the tap changer position, to grow at the same percentage rate.

In a biased differential protection relay in normal operation or during external faults, the higher the load current is the higher is the differential current required for tripping. When an internal fault occurs, the currents on both sides of the protected object are flowing into it. This causes the biasing current to be considerably smaller, which makes the operation more sensitive during internal faults.

$$I_b = \frac{\left|\bar{I}_{W1} - \bar{I}_{W2}\right|}{2}$$

(Equation 158)

If the biasing current is small compared to the differential current or if the phase angle between the winding 1 and winding 2 phase currents is close to zero (in a normal situation, the phase difference is 180 degrees), a fault has most certainly occurred in the area protected by the differential protection relay. Then the operation value set for the instantaneous stage is automatically halved and the internal blocking signals of the biased stage are inhibited.

**Transformer vector group matching**

The phase difference of the winding 1 and winding 2 currents that is caused by the vector group of the power transformer is numerically compensated. The matching of the phase difference is based on the phase shifting and the numerical delta connection inside the protection relay. The *Winding 1 type* parameter determines the connection on winding 1 (”Y”, ”YN”, ”D”, ”Z”, ”ZN”). The *Winding 2 type* parameter determines the connections of the phase windings on the low voltage side (“y”, ”yn”, ”d”, ”z”, ”zn”).

The vector group matching can be implemented either on both, winding 1 and winding 2, or only on winding 1 or winding 2, at intervals of 30° with the *Clock number* setting.

When the vector group matching is Yy0 and the *CT connection type* is according to "Type 2", the phase angle of the phase currents connected to the protection relay does not change. When the vector group matching is Yy6, the phase currents are turned 180° in the protection relay.

**Example 1**

Vector group matching of a Ynd11-connected power transformer on winding 1, *CT connection type* according to type 1. The *Winding 1 type* setting is ”YN”, *Winding 2 type* is “d” and *Clock number* is “Clk Num 11”. This is compensated internally by giving winding 1 internal compensation value +30° and winding 2 internal compensation value 0°:

$$\bar{I}_{L1mHV} = \frac{\bar{I}_{L1} - \bar{I}_{L2}}{\sqrt{3}}$$
$$\bar{I}_{L2mHV} = \frac{\bar{I}_{L2} - \bar{I}_{L3}}{\sqrt{3}}$$
$$\bar{I}_{L3mHV} = \frac{\bar{I}_{L3} - \bar{I}_{L1}}{\sqrt{3}}$$

(Equation 159)

**Example 2**

But if vector group is Yd11 and *CT connection type* is according to type 1, the compensation is a little different. The *Winding 1 type* setting is ”Y”, *Winding 2 type* is “d” and *Clock number* is “Clk Num 11”. This is compensated internally by giving winding 1 internal compensation value 0° and winding 2 internal compensation value -30°;

$$\bar{I}_{L1mLV} = \frac{\bar{I}_{L1} - \bar{I}_{L3}}{\sqrt{3}}$$
$$\bar{I}_{L2mLV} = \frac{\bar{I}_{L2} - \bar{I}_{L1}}{\sqrt{3}}$$
$$\bar{I}_{L3mLV} = \frac{\bar{I}_{L3} - \bar{I}_{L2}}{\sqrt{3}}$$

(Equation 160)

The "Y" side currents stay untouched, while the "d" side currents are compensated to match the currents actually flowing in the windings.

In this example there is no neutral current on either side of the transformer (assuming there are no earthing transformers installed). In the previous example, however, the matching is done differently to have the winding 1 neutral current compensated at the same time.

**Zero-sequence component elimination**

If *Clock number* is "Clk Num 2", "Clk Num 4", "Clk Num 8" or "Clk Num 10", the vector group matching is always done on both, winding 1 and winding 2. The combination results in the correct compensation. In this case the zero-sequence component is always removed from both sides automatically. The *Zro A elimination* parameter cannot change this.

If *Clock number* is "Clk Num 1", "Clk Num 5", "Clk Num 7" or "Clk Num 11", the vector group matching is done on one side only. A possible zero-sequence component of the phase currents at earth faults occurring outside the protection area is eliminated in the numerically implemented delta connection before the differential current and the biasing current are calculated. This is why the vector group matching is almost always made on the star connected side of the "Ynd" and "Dyn" connected transformers.

If *Clock number* is "Clk Num 0" or "Clk Num 6", the zero-sequence component of the phase currents is not eliminated automatically on either side. Therefore, the

zero-sequence component on the star connected side that is earthed at its star point has to be eliminated by using the *Zro A elimination* parameter.

The same parameter has to be used to eliminate the zero-sequence component if there is, for example, an earthing transformer on the delta-connected side of the "Ynd" power transformer in the area to be protected. In this case, the vector group matching is normally made on the side of the star connection. On the side of the delta connection, the elimination of the zero-sequence component has to be separately selected.

By using the *Zro A elimination* parameter, the zero-sequence component of the phase currents is calculated and reduced for each phase current:

$$\bar{I}_{L1m} = \bar{I}_{L1} - \frac{1}{3} x \left( \bar{I}_{L1} + \bar{I}_{L2} + \bar{I}_{L3} \right)$$

$$\bar{I}_{L2m} = \bar{I}_{L2} - \frac{1}{3} x \left( \bar{I}_{L1} + \bar{I}_{L2} + \bar{I}_{L3} \right)$$

$$\bar{I}_{L3m} = \bar{I}_{L3} - \frac{1}{3} x \left( \bar{I}_{L1} + \bar{I}_{L2} + \bar{I}_{L3} \right)$$

(Equation 161)

In many cases with the earthed neutral of a "wye" winding, it is possible to make the compensation so that a zero-sequence component of the phase currents is automatically eliminated. For example, in a case of a "Ynd" transformer, the compensation is made on the winding 1 side to automatically eliminate the zero-sequence component of the phase currents on that side (and the "d" side does not have them). In those cases, explicit elimination is not needed.

**Compensation of tap changer position**

The position of the tap changer used for voltage control can be compensated and the position information is provided for the protection function through the tap position indication function TPOSYLTC.

Typically, the tap changer is located within the high voltage winding, that is, winding 1, of the power transformer. The *Tapped winding* parameter specifies whether the tap changer is connected to the high voltage side winding or the low voltage side winding. This parameter is also used to enable and disable the automatic adaptation to the tap changer position. The possible values are "Not in use", "Winding 1" or "Winding 2".

The *Tap nominal* parameter tells the number of the tap, which results in the nominal voltage (and current). When the current tap position deviates from this value, the input current values on the side where the tap changer resides are scaled to match the currents on the other side.

A correct scaling is determined by the number of steps and the direction of the deviation from the nominal tap and the percentage change in voltage resulting from a deviation of one tap step. The percentage value is set using the *Step of tap* parameter.

The operating range of the tap changer is defined by the *Min winding tap* and *Max winding tap* parameters. The *Min winding tap* parameter tells the tap position number resulting in the minimum effective number of winding turns on the side of the transformer where the tap changer is connected. Correspondingly, the *Max*

*winding tap* parameter tells the tap position number resulting in the maximum effective number of winding turns.

The *Min winding tap* and *Max winding tap* parameters help the tap position compensation algorithm know in which direction the compensation is being made. This ensures also that if the current tap position information is corrupted for some reason, the automatic tap changer position adaptation does not try to adapt to any unrealistic position values.

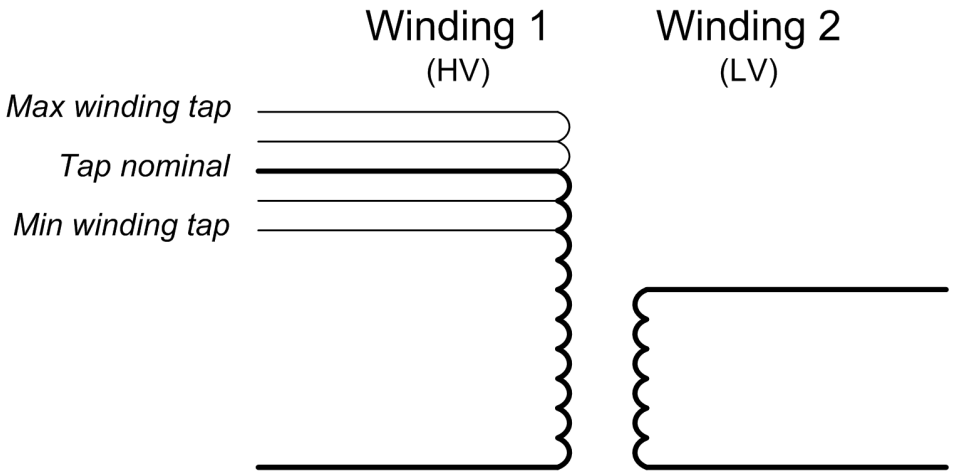



*Figure 389: Simplified presentation of the high voltage and medium voltage windings with demonstration of the Max winding tap, Min winding tap and Tap nominal parameters*

The position value is available through the Monitored data view on LHMI or through other communication tools in the tap position indication function. When the quality of the TAP_POS value is not good, the position information in TAP_POS is not used but the last value with the good quality information is used instead. In addition, the minimum sensitivity of the biased stage, set by the *Low operate value* setting, is automatically desensitized with the total range of the tap position correction. The new acting low operate value is

$$Desensitized\ Low\ operate\ value = Low operate value + ABS(Max Winding tap - Min winding tap) \times Step of tap$$

(Equation 162)

**Second harmonic blocking**

The transformer magnetizing inrush currents occur when energizing the transformer after a period of de-energization. The inrush current can be many times the rated current and the halving time can be up to several seconds. To the differential protection, the inrush current represents a differential current, which would cause the differential protection to operate almost always when the transformer is connected to the network. Typically, the inrush current contains a large amount of second harmonics.

Blocking the operation of the TR2PTDF biased low stage at a magnetizing inrush current is based on the ratio of the amplitudes of the second harmonic digitally filtered from the differential current and the fundamental frequency (Id2f /Id1f).

The blocking also prevents unwanted operation at the recovery and sympathetic magnetizing inrushes. At the recovery inrush, the magnetizing current of the transformer to be protected increases momentarily when the voltage returns to

normal after the clearance of a fault outside the protected area. The sympathetic inrush is caused by the energization of another transformer running in parallel with the protected transformer already connected to the network.

The ratio of the second harmonic to a fundamental component can vary considerably between the phases. Especially when the delta compensation is done for a Ynd1 connected transformer and the two phases of the inrush currents are otherwise equal but opposite in phase angle, the subtraction of the phases in a delta compensation results in a very small second harmonic component.

Some measures have to be taken in order to avoid the false tripping of a phase having too low a ratio of the second harmonic to the fundamental component. One way could be to always block all the phases when the second harmonic blocking conditions are fulfilled in at least one phase. The other way is to calculate the weighted ratios of the second harmonic to the fundamental component for each phase using the original ratios of the phases. The latter option is used here. The second harmonic ratios I_2H_RAT_x are given in Monitored data.

The ratio to be used for second harmonic blocking is, therefore, calculated as a weighted average on the basis of the ratios calculated from the differential currents of the three phases. The ratio of the concerned phase is of most weight compared to the ratios of the other two phases. In this protection relay, if the weighting factors are four, one and one, four is the factor of the phase concerned. The operation of the biased stage on the concerned phase is blocked if the weighted ratio of that phase is above the set blocking limit *Start value 2.H* and if blocking is enabled through the *Restraint mode* parameter.

Using separate blocking for the individual phases and weighted averages calculated for the separate phases provides a blocking scheme that is stable at the connection inrush currents.

If the peak value of the differential current is very high, that is $I_r$>12×In, the limit for the second harmonic blocking is desensitized (in the phase in question) by increasing it proportionally to the peak value of the differential current.

The connection of the power transformer against a fault inside the protected area does not delay the operation of the tripping, because in such a situation the blocking based on the second harmonic of the differential current is prevented by a separate algorithm based on a different waveform and a different rate of change of the normal inrush current and the inrush current containing the fault current. The algorithm does not eliminate the blocking at inrush currents, unless there is a fault in the protected area.

The feature can also be enabled and disabled with the *Harmonic deblock 2.H* parameter.

**Fifth harmonic blocking**

The inhibition of TR2PTDF operation in the situations of overexcitation is based on the ratio of the fifth harmonic and the fundamental component of the differential current (Id5f/Id1f) . The ratio is calculated separately for each phase without weighting . If the ratio exceeds the setting value of *Start value 5.H* and if blocking is enabled through the *Restraint mode* parameter, the operation of the biased stage of TR2PTDF in the concerned phase is blocked. The fifth harmonic ratios I_5H_RAT_x are given in Monitored data.

At dangerous levels of overvoltage, which can cause damage to the transformer, the blocking can be automatically eliminated. If the ratio of the fifth harmonic and the fundamental component of the differential current exceeds the *Stop value*

*5.H* parameter, the blocking removal is enabled. The enabling and disabling of deblocking feature is also done through the *Harmonic deblock 5.H* parameter.

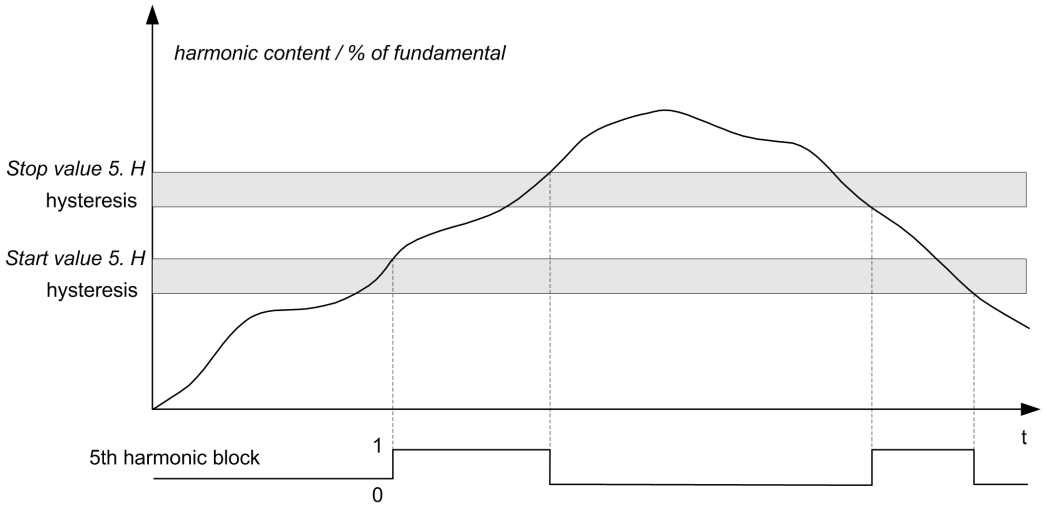



*Figure 390: The limits and operation of the fifth harmonic blocking when both blocking and deblocking features are enabled using the Harmonic deblock 5.H control parameter.*

The fifth harmonic blocking has a hysteresis to avoid rapid fluctuation between "TRUE" and "FALSE". The blocking also has a counter, which counts the required consecutive fulfillments of the condition. When the condition is not fulfilled, the counter is decreased (if >0).

Also the fifth harmonic deblocking has a hysteresis and a counter which counts the required consecutive fulfillments of the condition. When the condition is not fulfilled, the counter is decreased (if >0).

**Waveform blocking**

The biased low stage can always be blocked with waveform blocking. The stage can not be disabled with the *Restraint mode* parameter. This algorithm has two parts. The first part is intended for external faults while the second is intended for inrush situations. The algorithm has criteria for a low current period during inrush where also the differential current (not derivative) is checked.

**Biased low stage**

The current differential protection needs to be biased because the possible appearance of a differential current can be due to something else than an actual fault in the transformer (or generator).

In the case of transformer protection, a false differential current can be caused by:

- CT errors
- Varying tap changer positions (if not automatically compensated)
- Transformer no-load current
- Transformer inrush currents
- Transformer overexcitation in overvoltage
- Underfrequency situations
- CT saturation at high currents passing through the transformer

The differential current caused by CT errors or tap changer positions increases at the same percent ratio as the load current.

In the protection of generators, the false differential current can be caused by various factors.

- CT errors
- CT saturation at high currents passing through the generator

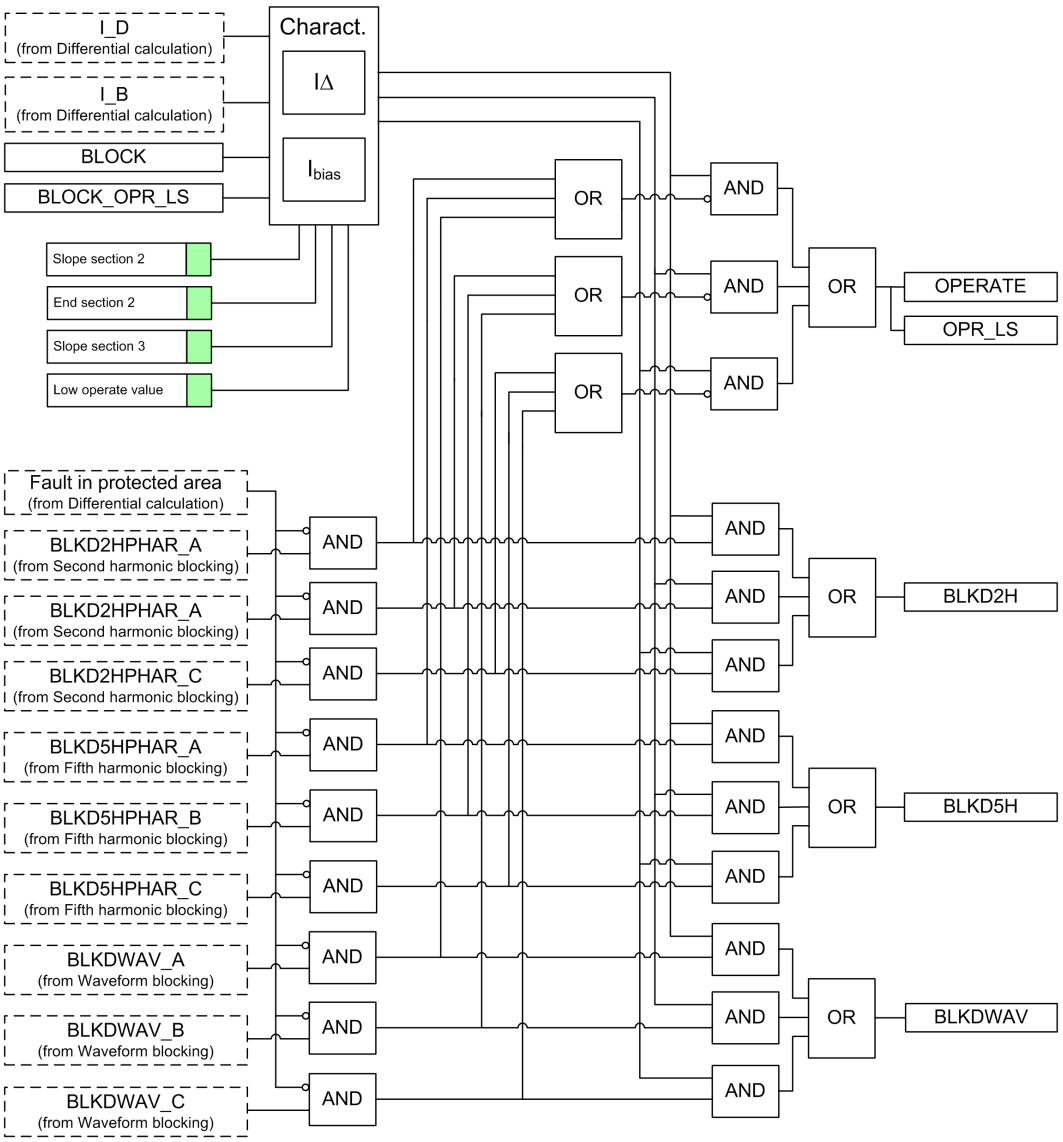



*Figure 391: Operation logic of the biased low stage*

The high currents passing through a protected object can be caused by the short circuits outside the protected area, the high currents fed by the transformer in motor start-up or the transformer inrush situations. Therefore, the operation of the differential protection is biased in respect to the load current. In biased differential protection, the higher the differential current required for the protection to operate, the higher the load current.

The operating characteristic of the biased low stage is determined by *Low operate value*, *Slope section 2* and the setting of the second turning point of the operating characteristic curve, *End section 2* (the first turning point is fixed). The settings are

the same for all the phases. When the differential current exceeds the operating value determined by the operating characteristic, the differential function awakes. If the differential current stays above the operating value continuously for a suitable period, which is 1.1 times the fundamental cycle, the OPR_LS output is activated. The OPERATE output is always activated when the OPR_LS output is activated .

The stage can be blocked internally by the second or fifth harmonic restraint, or by special algorithms detecting inrush and current transformer saturation at external faults. When the operation of the biased low stage is blocked by the second harmonic blocking functionality, the BLKD2H output is activated.

When operation of the biased low stage is blocked by the fifth harmonic blocking functionality, the BLKD5H output is activated. Correspondingly, when the operation of the biased low stage is blocked by the waveform blocking functionality, the BLKDWAV output is activated according to the phase information.

When required, the operate outputs of the biased low stage can be blocked by the BLK_OPR_LS or BLOCK external control signals.

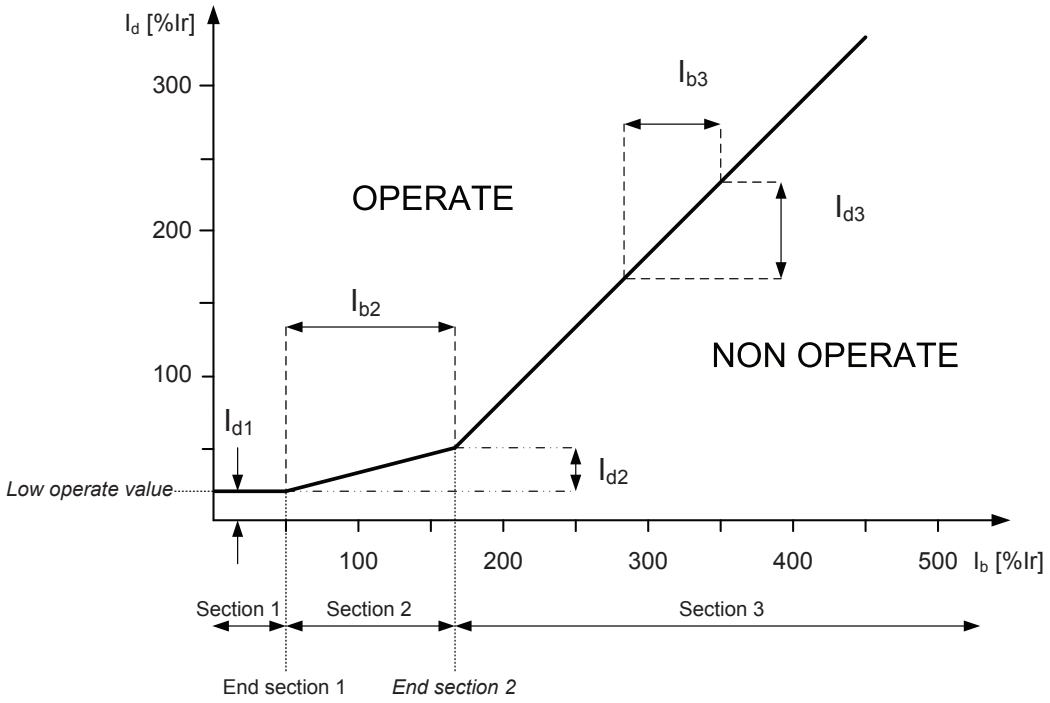



*Figure 392: Operation characteristic for biased operation of TR2PTDF*

The *Low operate value* of the biased stage of the differential function is determined according to the operation characteristic:

*Low operate value* = Id1

*Slope section 2* and *Slope section 3* are determined correspondingly:

$$Slope\ \ section\,2 = \frac{I_{d2}}{I_{b2}} \cdot 100\%$$

(Equation 163)

$$Slope\ \ section3 = \frac{I_{d3}}{I_{b3}} \cdot 100\%$$

(Equation 164)

The second turning point *End section 2* can be set in the range of 100 percent to 500 percent.

The slope of the differential function's operating characteristic curve varies in the different sections of the range.

- In section 1, where 0 percent Ir < Ib < End section 1, End section 1 being fixed to 50 percent Ir, the differential current required for tripping is constant. The value of the differential current is the same as the *Low operate value* selected for the function. *Low operate value* basically allows the no-load current of the power transformer and small inaccuracies of the current transformers, but it can also be used to influence the overall level of the operating characteristic. At the rated current, the no-load losses of the power transformer are about 0.2 percent. If the supply voltage of the power transformer suddenly increases due to operational disturbances, the magnetizing current of the transformer increases as well. In general the magnetic flux density of the transformer is rather high at rated voltage and a rise in voltage by a few percent causes the magnetizing current to increase by tens of percent. This should be considered in *Low operate value*
- In section 2, where End section 1 < Ib/In < *End section 2*, is called the influence area of *Slope section 2*. In this section, variations in the starting ratio affect the slope of the characteristic, that is, how big a change in the differential current is required for tripping in comparison with the change in the load current. The starting ratio should consider CT errors and variations in the transformer tap changer position (if not compensated). Too high a starting ratio should be avoided, because the sensitivity of the protection for detecting inter-turn faults depends basically on the starting ratio.
- In section 3, where Ib/In > *End section 2*, the slope of the characteristic can be set by *Slope section 3* that defines the increase in the differential current to the corresponding increase in the biasing current.

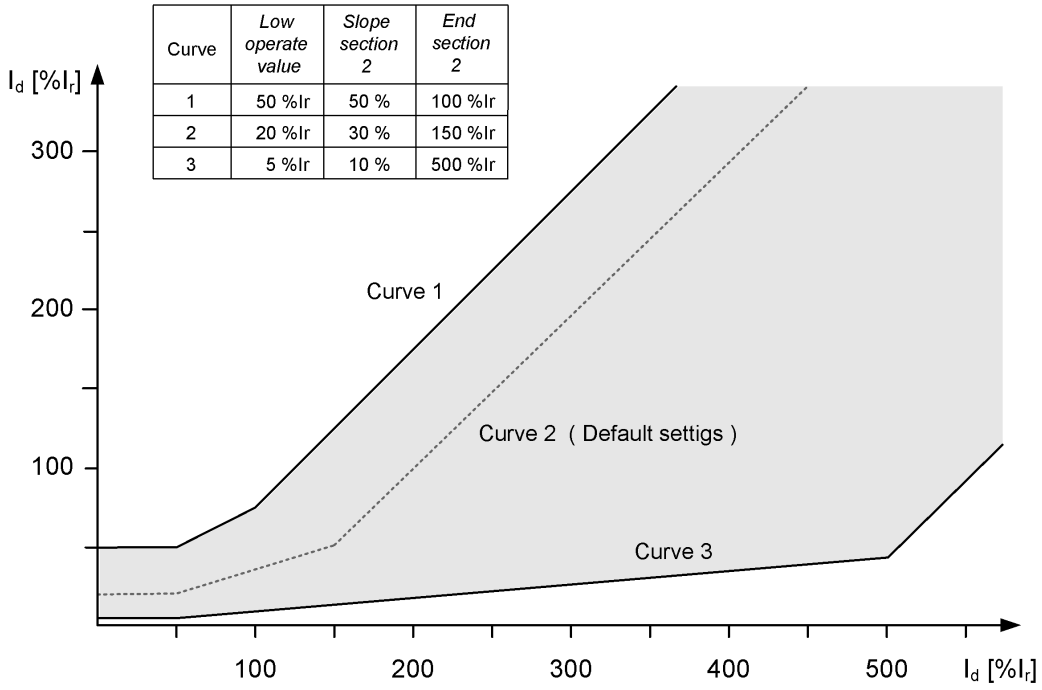



*Figure 393: Setting range for biased low stage*

If the biasing current is small compared to the differential current of the phase angle between the winding 1 and winding 2 phase currents is close to zero (in a normal situation, the phase difference is 180 degrees), a fault has most likely occurred in the area protected by TR2PTDF. Then the internal blocking signals of the biased stage are inhibited.

**Instantaneous high stage**

The instantaneous high stage operation can be enabled and disabled with the *Enable high set* setting. The corresponding parameter values are "TRUE" and "FALSE."

The operation of the instantaneous high stage is not biased. The instantaneous stage operates and the output `OPR_HS` is activated when the amplitude of the fundamental frequency component of the differential current exceeds the set *High operate value* or when the instantaneous value of the differential current exceeds 2.5 times the value of *High operate value*. The factor 2.5 (=1.8 × √2) is due to the maximum asymmetric short circuit current.

If the biasing current is small compared to the differential current or the phase angle between the winding 1 and winding 2 phase currents is close to zero (in a normal situation, the phase difference is 180 degrees), a fault has occurred in the area protected by TR2PTDF. Then the operation value set for the instantaneous stage is automatically halved and the internal blocking signals of the biased stage are inhibited.

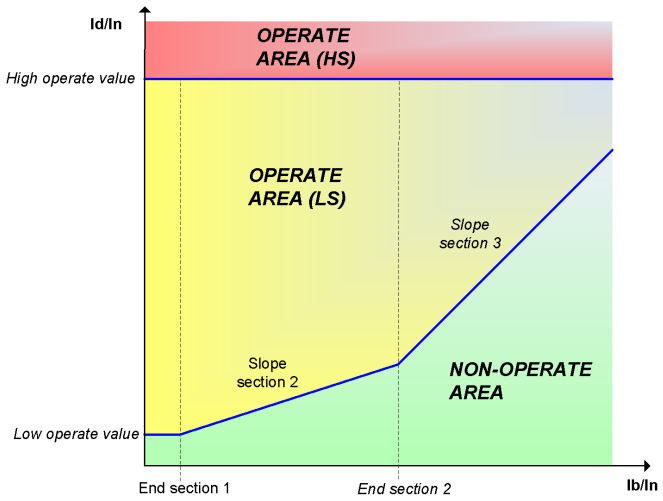



*Figure 394: Operating characteristics of the protection. (LS) stands for the biased low stage and (HS) for the instantaneous high stage*

The OPERATE output is activated always when the OPR_HS output activates .

The internal blocking signals of the differential function do not prevent the operate signal of the instantaneous differential current stage. When required, the operate outputs of the instantaneous high stage can be blocked by the BLK_OPR_HS and BLOCK external control signals.

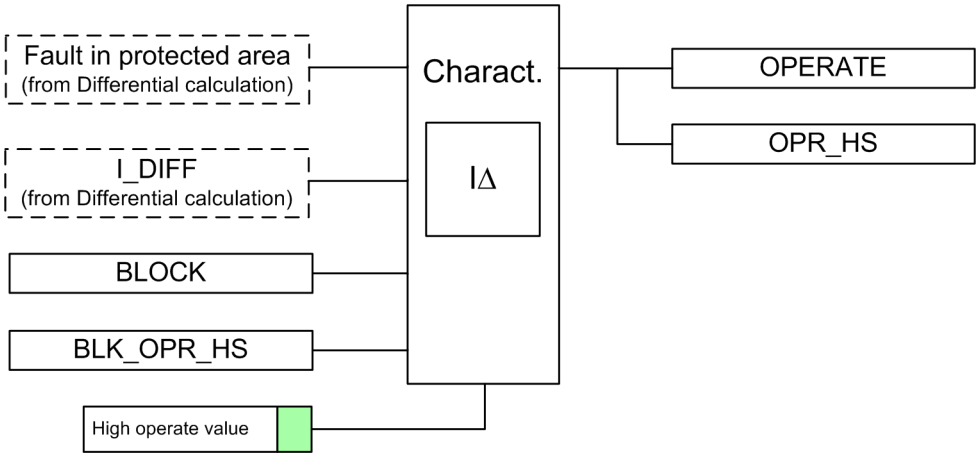



*Figure 395: Operation logic of instantaneous high stage*

**Reset of the blocking signals (de-block)**

All three blocking signals, that is, waveform and second and fifth harmonic, have a counter, which holds the blocking on for a certain time after the blocking conditions have ceased to be fulfilled. The deblocking takes place when those counters have elapsed. This is a normal case of deblocking.

The blocking signals can be reset immediately if a very high differential current is measured or if the phase difference of the compared currents (the angle between the compared currents) is close to zero after the automatic vector group matching has been made (in a normal situation, the phase difference is 180 degrees). This

does not, however, reset the counters holding the blockings, so the blocking signals may return when these conditions are not valid anymore.

**External blocking functionality**

TR2PTDF has three inputs for blocking.

- When the BLOCK input is active ("TRUE"), the operation of the function is blocked but measurement output signals are still updated.
- When the BLK_OPR_LS input is active ("TRUE"), TR2PTDF operates normally except that the OPR_LS output is not active or activated in any circumstance. Additionally, the OPERATE output can be activated only by the instantaneous high stage (if not blocked as well).
- When the BLK_OPR_HS input is active ("TRUE"), TR2PTDF operates normally except that the OPR_HS output is not active or activated in any circumstance. Additionally, the OPERATE output can be activated only by the biased low stage (if not blocked as well).

### 4.3.2.6 Application

TR2PTDF is a unit protection function serving as the main protection for transformers in case of winding failure. The protective zone of a differential protection includes the transformer, the bus-work or the cables between the current transformer and the power transformer. When bushing current transformers are used for the differential protection relay, the protective zone does not include the bus work or cables between the circuit breaker and the power transformer.

In some substations, there is a current differential protection for the busbar. The busbar protection includes bus work or cables between the circuit breaker and the power transformer. Internal electrical faults are very serious and cause immediate damage. Short circuits and earth faults in windings and terminals are normally detected by the differential protection. If enough turns are short-circuited, the interturn faults, which are flashovers between the conductors within the same physical winding, are also detected. The interturn faults are the most difficult transformer-winding faults to detect with electrical protections. A small interturn fault including a few turns results in an undetectable amount of current until the fault develops into an earth fault. Therefore, it is important that the differential protection has a high level of sensitivity and that it is possible to use a sensitive setting without causing unwanted operations for external faults.

It is important that the faulty transformer is disconnected as fast as possible. As TR2PTDF is a unit protection function, it can be designed for fast tripping, thus providing a selective disconnection of the faulty transformer. TR2PTDF should never operate to faults outside the protective zone.

TR2PTDF compares the current flowing into the transformer to the current leaving the transformer. A correct analysis of fault conditions by TR2PTDF must consider the changes to voltages, currents and phase angles. The traditional transformer differential protection functions required auxiliary transformers for the correction of the phase shift and turns ratio. The numerical microprocessor based differential algorithm implemented in TR2PTDF compensates for both the turns ratio and the phase shift internally in the software.

The differential current should theoretically be zero during normal load or external faults if the turns ratio and the phase shift are correctly compensated. However, there are several different phenomena other than internal faults that cause

unwanted and false differential currents. The main reasons for unwanted differential currents are:

- Mismatch due to varying tap changer positions
- Different characteristics, loads and operating conditions of the current transformers
- Zero sequence currents that only flow on one side of the power transformer
- Normal magnetizing currents
- Magnetizing inrush currents
- Overexcitation magnetizing currents.

TR2PTDF is designed mainly for the protection of two-winding transformers. TR2PTDF can also be utilized for the protection of generator-transformer blocks as well as short cables and overhead lines. If the distance between the measuring points is relatively long in line protection, interposing CTs can be required to reduce the burden of the CTs.

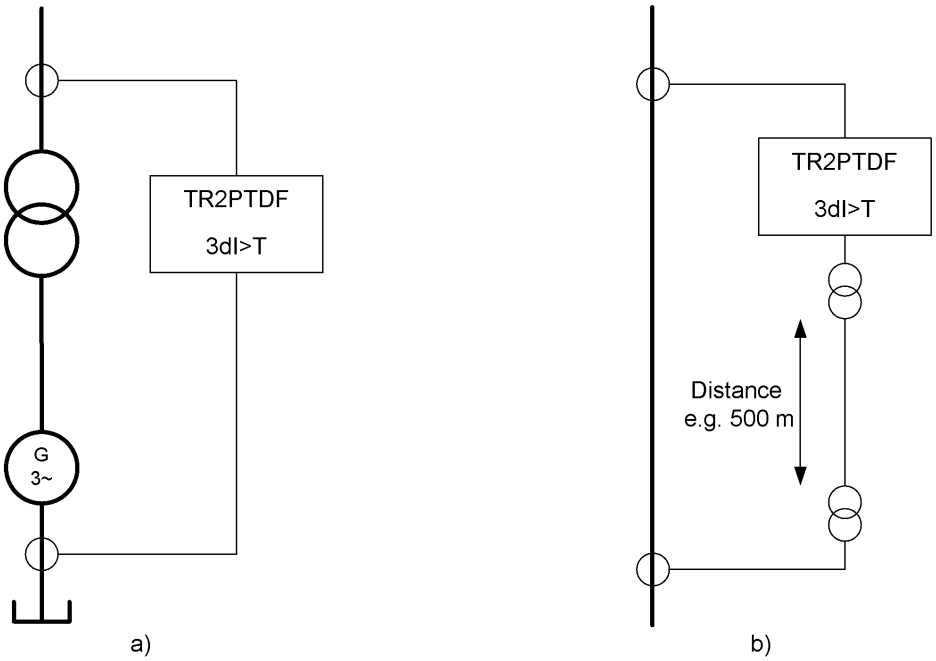



*Figure 396: Differential protection of a generator-transformer block and short cable/line*

TR2PTDF can also be used in three-winding transformer applications or two-winding transformer applications with two output feeders.

On the double-feeder side of the power transformer, the current of the two CTs per phase must be summed by connecting the two CTs of each phase in parallel. Generally this requires the interposing CTs to handle the vector group and/or ratio mismatch between the two windings/feeders.

The accuracy limit factor for the interposing CT must fulfill the same requirements as the main CTs. Please note that the interposing CT imposes an additional burden to the main CTs.

The most important rule in these applications is that at least 75 percent of the short-circuit power has to be fed on the side of the power transformer with only one connection to the protection relay.

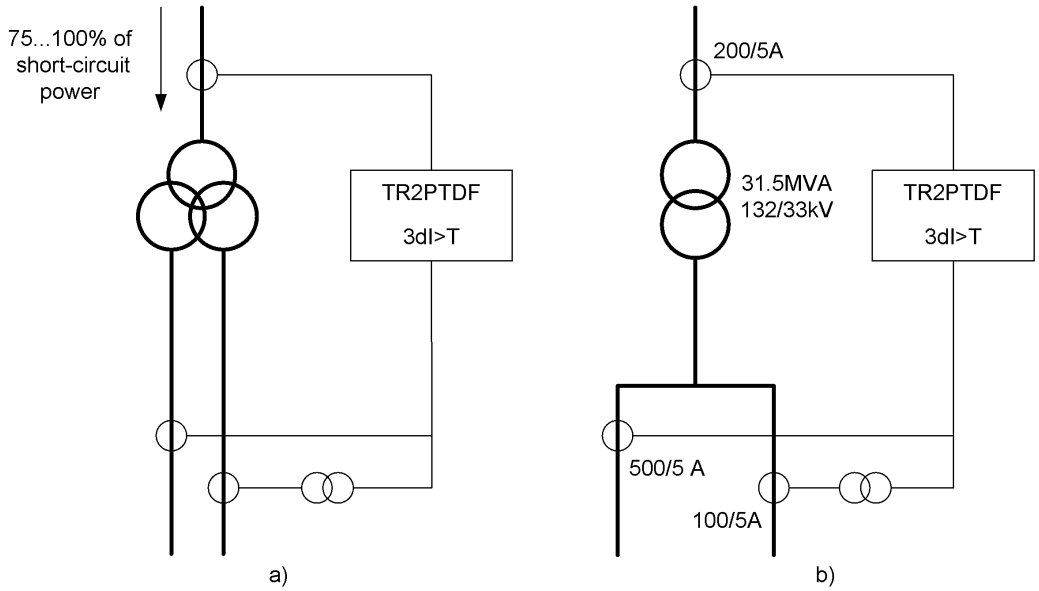



*Figure 397: Differential protection of a three-winding transformer and a transformer with two output feeders*

TR2PTDF can also be used for the protection of the power transformer feeding the frequency converter. An interposing CT is required for matching the three-winding transformer currents to a two-winding protection relay.

The fundamental frequency component is numerically filtered with a Fourier filter, DFT. The filter suppresses frequencies other than the set fundamental frequency, and therefore the protection relay is not adapted for measuring the output of the frequency converter, that is, TR2PTDF is not suited for protecting of a power transformer or motor fed by a frequency converter

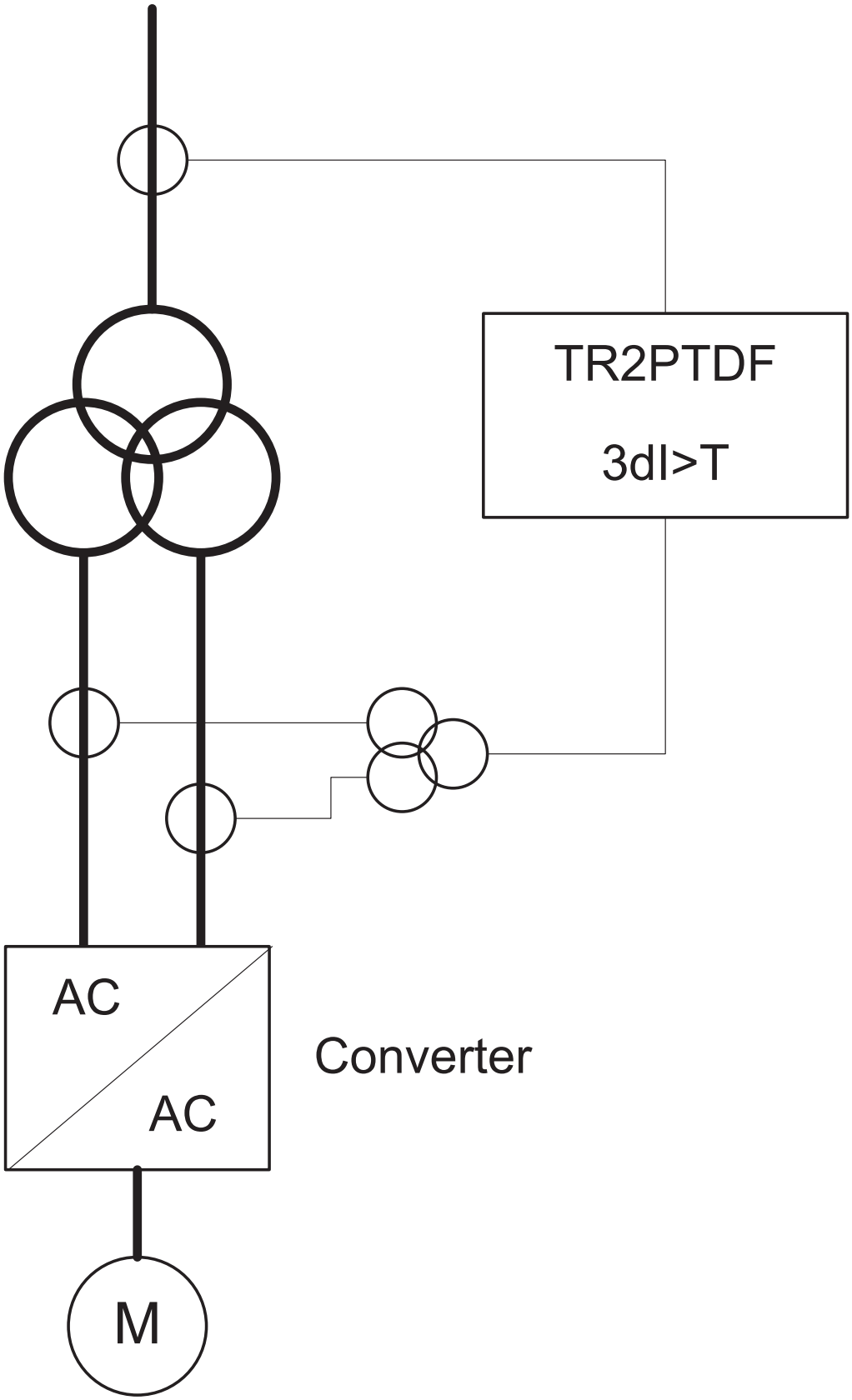



*Figure 398: Protection of the power transformer feeding the frequency converter*

**Transforming ratio correction of CTs**

The CT secondary currents often differ from the rated current at the rated load of the power transformer. The CT transforming ratios can be corrected on both sides of the power transformer with the *CT ratio Cor Wnd 1* and *CT ration Cor Wnd 2* settings.

First, the rated load of the power transformer must be calculated on both sides when the apparent power and phase-to-phase voltage are known.

$$I_{nT} = \frac{S_n}{\sqrt{3} \times U_n}$$

(Equation 165)

| | |
|---|---|
| $I_{nT}$ | rated load of the power transformer |
| $S_n$ | rated power of the power transformer |
| $U_n$ | rated phase-to-phase voltage |

Next, the settings for the CT ratio correction can be calculated.

$$CT\ ratio\ correction = \frac{I_{1n}}{I_{nT}}$$

(Equation 166)

| | |
|---|---|
| $I_{1n}$ | nominal primary current of the CT |

After the CT ratio correction, the measured currents and corresponding setting values of TR2PTDF are expressed in multiples of the rated power transformer current $I_r$ ($xI_r$) or percentage value of $I_r$ ($\%I_r$).

The rated input current (1A or 5A) of the relay does not have to be same for the HV and the LV side. For example, the rated secondary current of 5 A can be used on the HV side, while 1A is used on the LV side or vice versa.

**Example**

The rated power of the transformer is 25 MVA, the ratio of the CTs on the 110 kV side is 300/1 and that on the 21 kV side is 1000/1

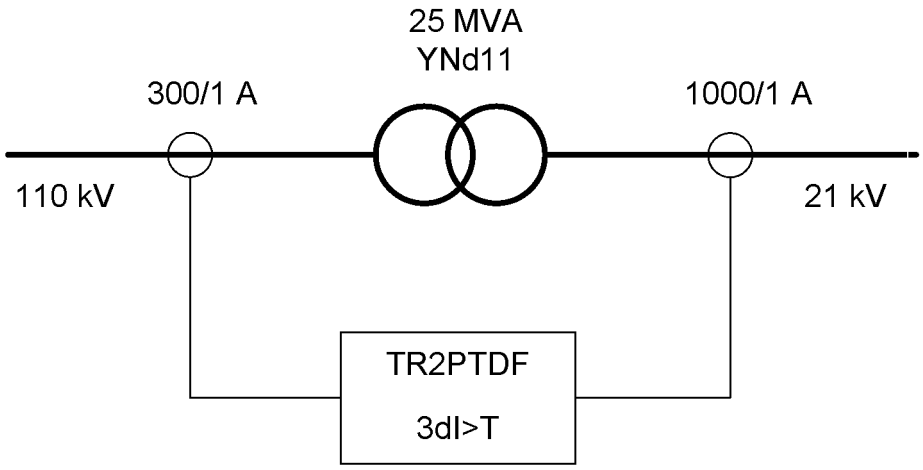



*Figure 399: Example of two-winding power transformer differential protection*

The rated load of the transformer is calculated:

HV side: $I_{nT_Wnd1}$ = 25 MVA / (1.732 x 110 kV) = 131.2 A

LV side: $I_{nT_Wnd2}$ = 25 MVA / (1.732 x 21 kV) = 687.3 A

**Settings:**

*CT ratio Cor Wnd 1*= 300 A / 131.2 A = “2.29”

*CT ratio Cor Wnd 2*= 1000 A / 687.3 A = “1.45”

**Vector group matching and elimination of the zero-sequence component**

The vector group of the power transformer is numerically matched on the high voltage and low voltage sides by means of the *Winding 1 type*, *Winding 2 type* and *Clock number* settings. Thus no interposing CTs are needed if there is only a power transformer inside the protected zone. The matching is based on phase shifting and a numerical delta connection in the protection relay. If the neutral of a star-connected power transformer is earthed, any earth fault in the network is perceived by the protection relay as a differential current. The elimination of the zero-sequence component can be selected for that winding by setting the *Zro A elimination* parameter.

**Table 655: TR2PTDF settings corresponding to the power transformer vector groups and zero-sequence elimination**

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| Yy0 | Y | y | Clk Num 0 | Not needed |
| YNy0 | YN | y | Clk Num 0 | HV side |
| YNyn0 | YN | yn | Clk Num 0 | HV & LV side |
| Yyn0 | Y | yn | Clk Num 0 | LV side |
| Yy2 | Y | y | Clk Num 2 | Not needed |
| YNy2 | YN | y | Clk Num 2 | Not needed |

*Table continues on the next page*

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| YNyn2 | YN | yn | Clk Num 2 | Not needed |
| Yyn2 | Y | yn | Clk Num 2 | Not needed |
| Yy4 | Y | y | Clk Num 4 | Not needed |
| YNy4 | YN | y | Clk Num 4 | Not needed |
| YNyn4 | YN | yn | Clk Num 4 | Not needed |
| Yyn4 | Y | yn | Clk Num 4 | Not needed |
| Yy6 | Y | y | Clk Num 6 | Not needed |
| YNy6 | YN | y | Clk Num 6 | HV side |
| YNyn6 | YN | yn | Clk Num 6 | HV & LV side |
| Yyn6 | Y | yn | Clk Num 6 | LV side |
| Yy8 | Y | y | Clk Num 8 | Not needed |
| YNy8 | YN | y | Clk Num 8 | Not needed |
| YNyn8 | YN | yn | Clk Num 8 | Not needed |
| Yyn8 | Y | yn | Clk Num 8 | Not needed |
| Yy10 | Y | y | Clk Num 10 | Not needed |
| YNy10 | YN | y | Clk Num 10 | Not needed |
| YNyn10 | YN | yn | Clk Num 10 | Not needed |
| Yyn10 | Y | yn | Clk Num 10 | Not needed |
| Yd1 | Y | d | Clk Num 1 | Not needed |
| YNd1 | YN | d | Clk Num 1 | Not needed |
| Yd5 | Y | d | Clk Num 5 | Not needed |
| YNd5 | YN | d | Clk Num 5 | Not needed |
| Yd7 | Y | d | Clk Num 7 | Not needed |
| YNd7 | YN | d | Clk Num 7 | Not needed |
| Yd11 | Y | d | Clk Num 11 | Not needed |
| YNd11 | YN | d | Clk Num 11 | Not needed |
| Dd0 | D | d | Clk Num 0 | Not needed |
| Dd2 | D | d | Clk Num 2 | Not needed |
| Dd4 | D | d | Clk Num 4 | Not needed |
| Dd6 | D | d | Clk Num 6 | Not needed |
| Dd8 | D | d | Clk Num 8 | Not needed |
| Dd10 | D | d | Clk Num 10 | Not needed |
| Dy1 | D | y | Clk Num 1 | Not needed |
| Dyn1 | D | yn | Clk Num 1 | Not needed |
| Dy5 | D | y | Clk Num 5 | Not needed |
| Dyn5 | D | yn | Clk Num 5 | Not needed |
| Dy7 | D | y | Clk Num 7 | Not needed |

*Table continues on the next page*

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| Dyn7 | D | yn | Clk Num 7 | Not needed |
| Dy11 | D | y | Clk Num 11 | Not needed |
| Dyn11 | D | yn | Clk Num 11 | Not needed |
| Yz1 | Y | z | Clk Num 1 | Not needed |
| YNz1 | YN | z | Clk Num 1 | Not needed |
| YNzn1 | YN | zn | Clk Num 1 | LV side |
| Yzn1 | Y | zn | Clk Num 1 | Not needed |
| Yz5 | Y | z | Clk Num 5 | Not needed |
| YNz5 | YN | z | Clk Num 5 | Not needed |
| YNzn5 | YN | zn | Clk Num 5 | LV side |
| Yzn5 | Y | zn | Clk Num 5 | Not needed |
| Yz7 | Y | z | Clk Num 7 | Not needed |
| YNz7 | YN | z | Clk Num 7 | Not needed |
| YNzn7 | YN | zn | Clk Num 7 | LV side |
| Yzn7 | Y | zn | Clk Num 7 | Not needed |
| Yz11 | Y | z | Clk Num 11 | Not needed |
| YNz11 | YN | z | Clk Num 11 | Not needed |
| YNzn11 | YN | zn | Clk Num 11 | LV side |
| Yzn11 | Y | zn | Clk Num 11 | Not needed |
| Zy1 | Z | y | Clk Num 1 | Not needed |
| Zyn1 | Z | yn | Clk Num 1 | Not needed |
| ZNyn1 | ZN | yn | Clk Num 1 | HV side |
| ZNy1 | ZN | y | Clk Num 1 | Not needed |
| Zy5 | Z | y | Clk Num 5 | Not needed |
| Zyn5 | Z | yn | Clk Num 5 | Not needed |
| ZNyn5 | ZN | yn | Clk Num 5 | HV side |
| ZNy5 | ZN | y | Clk Num 5 | Not needed |
| Zy7 | Z | y | Clk Num 7 | Not needed |
| Zyn7 | Z | yn | Clk Num 7 | Not needed |
| ZNyn7 | ZN | yn | Clk Num 7 | HV side |
| ZNy7 | ZN | y | Clk Num 7 | Not needed |
| Zy11 | Z | y | Clk Num 11 | Not needed |
| Zyn11 | Z | yn | Clk Num 11 | Not needed |
| ZNyn11 | ZN | yn | Clk Num 11 | HV side |
| ZNy11 | ZN | y | Clk Num 11 | Not needed |
| Dz0 | D | z | Clk Num 0 | Not needed |
| Dzn0 | D | zn | Clk Num 0 | LV side |

*Table continues on the next page*

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| Dz2 | D | z | Clk Num 2 | Not needed |
| Dzn2 | D | zn | Clk Num 2 | Not needed |
| Dz4 | D | z | Clk Num 4 | Not needed |
| Dzn4 | D | zn | Clk Num 4 | Not needed |
| Dz6 | D | z | Clk Num 6 | Not needed |
| Dzn6 | D | zn | Clk Num 6 | LV side |
| Dz8 | D | z | Clk Num 8 | Not needed |
| Dzn8 | D | zn | Clk Num 8 | Not needed |
| Dz10 | D | z | Clk Num 10 | Not needed |
| Dzn10 | D | zn | Clk Num 10 | Not needed |
| Zd0 | Z | d | Clk Num 0 | Not needed |
| ZNd0 | ZN | d | Clk Num 0 | HV side |
| Zd2 | Z | d | Clk Num 2 | Not needed |
| ZNd2 | ZN | d | Clk Num 2 | Not needed |
| Zd4 | Z | d | Clk Num 4 | Not needed |
| ZNd4 | ZN | d | Clk Num 4 | Not needed |
| Zd6 | Z | d | Clk Num 6 | Not needed |
| ZNd6 | ZN | d | Clk Num 6 | HV side |
| Zd8 | Z | d | Clk Num 8 | Not needed |
| ZNd8 | ZN | d | Clk Num 8 | Not needed |
| Zd10 | Z | d | Clk Num 10 | Not needed |
| ZNd10 | ZN | d | Clk Num 10 | Not needed |
| Zz0 | Z | z | Clk Num 0 | Not needed |
| ZNz0 | ZN | z | Clk Num 0 | HV side |
| ZNzn0 | ZN | zn | Clk Num 0 | HV & LV side |
| Zzn0 | Z | zn | Clk Num 0 | LV side |
| Zz2 | Z | z | Clk Num 2 | Not needed |
| ZNz2 | ZN | z | Clk Num 2 | Not needed |
| ZNzn2 | ZN | zn | Clk Num 2 | Not needed |
| Zzn2 | Z | zn | Clk Num 2 | Not needed |
| Zz4 | Z | z | Clk Num 4 | Not needed |
| ZNz4 | ZN | z | Clk Num 4 | Not needed |
| ZNzn4 | ZN | zn | Clk Num 4 | Not needed |
| Zzn4 | Z | zn | Clk Num 4 | Not needed |
| Zz6 | Z | z | Clk Num 6 | Not needed |
| ZNz6 | ZN | z | Clk Num 6 | HV side |
| ZNzn6 | ZN | zn | Clk Num 6 | HV & LV side |

*Table continues on the next page*

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| Zzn6 | Z | zn | Clk Num 6 | LV side |
| Zz8 | Z | z | Clk Num 8 | Not needed |
| ZNz8 | ZN | z | Clk Num 8 | Not needed |
| ZNzn8 | ZN | zn | Clk Num 8 | Not needed |
| Zzn8 | Z | zn | Clk Num 8 | Not needed |
| Zz10 | Z | z | Clk Num 10 | Not needed |
| ZNz10 | ZN | z | Clk Num 10 | Not needed |
| ZNzn10 | ZN | zn | Clk Num 10 | Not needed |
| Zzn10 | Z | zn | Clk Num 10 | Not needed |
| Yy0 | Y | y | Clk Num 0 | Not needed |
| YNy0 | YN | y | Clk Num 0 | HV side |
| YNyn0 | YN | yn | Clk Num 0 | HV & LV side |
| Yyn0 | Y | yn | Clk Num 0 | LV side |
| Yy2 | Y | y | Clk Num 2 | Not needed |
| YNy2 | YN | y | Clk Num 2 | Not needed |
| YNyn2 | YN | yn | Clk Num 2 | Not needed |
| Yyn2 | Y | yn | Clk Num 2 | Not needed |
| Yy4 | Y | y | Clk Num 4 | Not needed |
| YNy4 | YN | y | Clk Num 4 | Not needed |
| YNyn4 | YN | yn | Clk Num 4 | Not needed |
| Yyn4 | Y | yn | Clk Num 4 | Not needed |
| Yy6 | Y | y | Clk Num 6 | Not needed |
| YNy6 | YN | y | Clk Num 6 | HV side |
| YNyn6 | YN | yn | Clk Num 6 | HV & LV side |
| Yyn6 | Y | yn | Clk Num 6 | LV side |
| Yy8 | Y | y | Clk Num 8 | Not needed |
| YNy8 | YN | y | Clk Num 8 | Not needed |
| YNyn8 | YN | yn | Clk Num 8 | Not needed |
| Yyn8 | Y | yn | Clk Num 8 | Not needed |
| Yy10 | Y | y | Clk Num 10 | Not needed |
| YNy10 | YN | y | Clk Num 10 | Not needed |
| YNyn10 | YN | yn | Clk Num 10 | Not needed |
| Yyn10 | Y | yn | Clk Num 10 | Not needed |
| Yd1 | Y | d | Clk Num 1 | Not needed |
| YNd1 | YN | d | Clk Num 1 | Not needed |
| Yd5 | Y | d | Clk Num 5 | Not needed |
| YNd5 | YN | d | Clk Num 5 | Not needed |

*Table continues on the next page*

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| Yd7 | Y | d | Clk Num 7 | Not needed |
| YNd7 | YN | d | Clk Num 7 | Not needed |
| Yd11 | Y | d | Clk Num 11 | Not needed |
| YNd11 | YN | d | Clk Num 11 | Not needed |
| Dd0 | D | d | Clk Num 0 | Not needed |
| Dd2 | D | d | Clk Num 2 | Not needed |
| Dd4 | D | d | Clk Num 4 | Not needed |
| Dd6 | D | d | Clk Num 6 | Not needed |
| Dd8 | D | d | Clk Num 8 | Not needed |
| Dd10 | D | d | Clk Num 10 | Not needed |
| Dy1 | D | y | Clk Num 1 | Not needed |
| Dyn1 | D | yn | Clk Num 1 | Not needed |
| Dy5 | D | y | Clk Num 5 | Not needed |
| Dyn5 | D | yn | Clk Num 5 | Not needed |
| Dy7 | D | y | Clk Num 7 | Not needed |
| Dyn7 | D | yn | Clk Num 7 | Not needed |
| Dy11 | D | y | Clk Num 11 | Not needed |
| Dyn11 | D | yn | Clk Num 11 | Not needed |
| Yz1 | Y | z | Clk Num 1 | Not needed |
| YNz1 | YN | z | Clk Num 1 | Not needed |
| YNzn1 | YN | zn | Clk Num 1 | LV side |
| Yzn1 | Y | zn | Clk Num 1 | Not needed |
| Yz5 | Y | z | Clk Num 5 | Not needed |
| YNz5 | YN | z | Clk Num 5 | Not needed |
| YNzn5 | YN | zn | Clk Num 5 | LV side |
| Yzn5 | Y | zn | Clk Num 5 | Not needed |
| Yz7 | Y | z | Clk Num 7 | Not needed |
| YNz7 | YN | z | Clk Num 7 | Not needed |
| YNzn7 | YN | zn | Clk Num 7 | LV side |
| Yzn7 | Y | zn | Clk Num 7 | Not needed |
| Yz11 | Y | z | Clk Num 11 | Not needed |
| YNz11 | YN | z | Clk Num 11 | Not needed |
| YNzn11 | YN | zn | Clk Num 11 | LV side |
| Yzn11 | Y | zn | Clk Num 11 | Not needed |
| Zy1 | Z | y | Clk Num 1 | Not needed |
| Zyn1 | Z | yn | Clk Num 1 | Not needed |
| ZNyn1 | ZN | yn | Clk Num 1 | HV side |

*Table continues on the next page*

| Vector group of the transformer | Winding 1 type | Winding 2 type | Clock number | Zro A Elimination |
|---|---|---|---|---|
| ZNy1 | ZN | y | Clk Num 1 | Not needed |
| Zy5 | Z | y | Clk Num 5 | Not needed |
| Zyn5 | Z | yn | Clk Num 5 | Not needed |
| ZNyn5 | ZN | yn | Clk Num 5 | HV side |
| ZNy5 | ZN | y | Clk Num 5 | Not needed |
| Zy7 | Z | y | Clk Num 7 | Not needed |
| Zyn7 | Z | yn | Clk Num 7 | Not needed |
| ZNyn7 | ZN | yn | Clk Num 7 | HV side |
| ZNy7 | ZN | y | Clk Num 7 | Not needed |
| Yy0 | Y | y | Clk Num 0 | Not needed |

**Commissioning**

The correct settings, which are *CT connection type*, *Winding 1 type*, *Winding 2 type* and *Clock number*, for the connection group compensation can be verified by monitoring the angle values `I_ANGL_A1_B1`, `I_ANGL_B1_C1`, `I_ANGL_C1_A1`, `I_ANGL_A2_B2`, `I_ANGL_B2_C2`, `I_ANGL_C2_A2`, `I_ANGL_A1_A2`, `I_ANGL_B1_B2` and `I_ANGL_C1_C2` while injecting the current into the transformer. These angle values are calculated from the compensated currents. See signal description from Monitored data table.

When a station service transformer is available, it can be used to provide current to the high voltage side windings while the low voltage side windings are short-circuited. This way the current can flow in both the high voltage and low voltage windings. The commissioning signals can be provided by other means as well. The minimum current to allow for phase current and angle monitoring is 0.015 $I_r$.

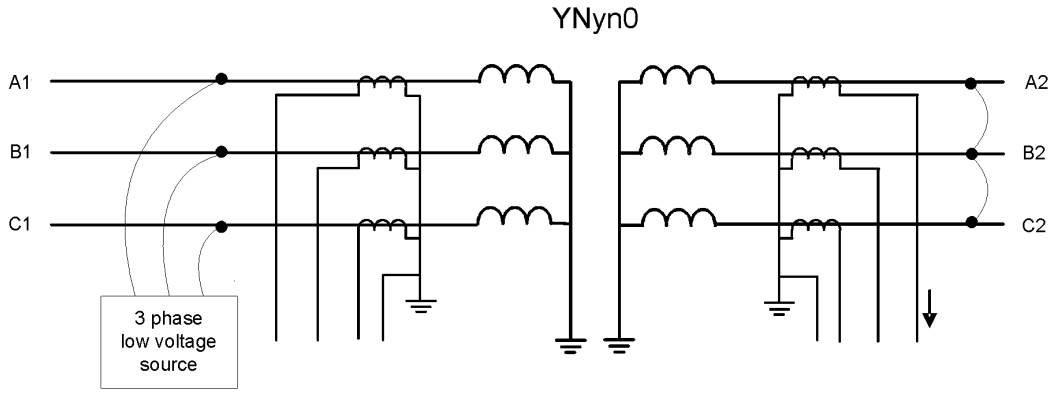



*Figure 400: Low voltage test arrangement. The three-phase low voltage source can be the station service transformer.*

The *Tapped winding* control setting parameter has to be set to “Not in use” to make sure that the monitored current values are not scaled by the automatic adaptation to the tap changer position. When only the angle values are required, the setting of *Tapped winding* is not needed since angle values are not affected by the tap changer position adaptation.

When injecting the currents in the high voltage winding, the angle values I_ANGL_A1_B1, I_ANGL_B1_C1, I_ANGL_C1_A1, I_ANGL_A2_B2, I_ANGL_B2_C2 and I_ANGL_C2_A2 have to show +120 deg. Otherwise the phase order can be wrong or the polarity of a current transformer differs from the polarities of the other current transformers on the same side.

If the angle values I_ANGL_A1_B1, I_ANGL_B1_C1 and I_ANGL_C1_A1 show -120 deg, the phase order is wrong on the high voltage side. If the angle values I_ANGL_A2_B2, I_ANGL_B2_C2 and I_ANGL_C2_A2 show -120 deg, the phase order is wrong on the low voltage side. If the angle values I_ANGL_A1_B1, I_ANGL_B1_C1 and I_ANGL_C1_A1 do not show the same value of +120, the polarity of one current transformer can be wrong. For instance, if the polarity of the current transformer measuring IL2 is wrong, I_ANGL_A1_B1 shows -60 deg, I_ANGL_B1_C1 shows -60 deg and I_ANGL_C1_A1 shows +120 deg.

When the phase order and the angle values are correct, the angle values I_ANGL_A1_A2, I_ANGL_B1_B2 and I_ANGL_C1_C2 usually show ±180 deg. There can be several reasons if the angle values are not ±180 deg. If the values are 0 deg, the value given for *CT connection type* is probably wrong. If the angle values are something else, the value for *Clock number* can be wrong. Another reason is that the combination of *Winding 1 type* and *Winding 2 type* does not match *Clock number*. This means that the resulting connection group is not supported.

**Example**

If *Winding 1 type* is set to "Y", *Winding 2 type* is set to "y" and *Clock number* is set to "Clk num 1", the resulting connection group "Yy1" is not a supported combination. Similarly if *Winding 1 type* is set to "Y", *Winding 2 type* is set to "d" and *Clock number* is set to "Clk num 0", the resulting connection group "Yd0" is not a supported combination. All the non-supported combinations of *Winding 1 type*, *Winding 2 type* and *Clock number* settings result in the default connection group compensation that is "Yy0".

### 4.3.2.7 CT connections and transformation ratio correction

The connections of the primary current transformers are designated as "Type 1" and "Type 2".

- If the positive directions of the winding 1 and winding 2 protection relay currents are opposite, the *CT connection type* setting parameter is "Type 1". The connection examples of "Type 1" are as shown in *Figure 401* and *Figure 402*.
- If the positive directions of the winding 1 and winding 2 protection relay currents equate, the *CT connection type* setting parameter is "Type 2". The connection examples of "Type 2" are as shown in *Figure 403* and *Figure 404*.
- The default value of the *CT connection type* setting is "Type 1".

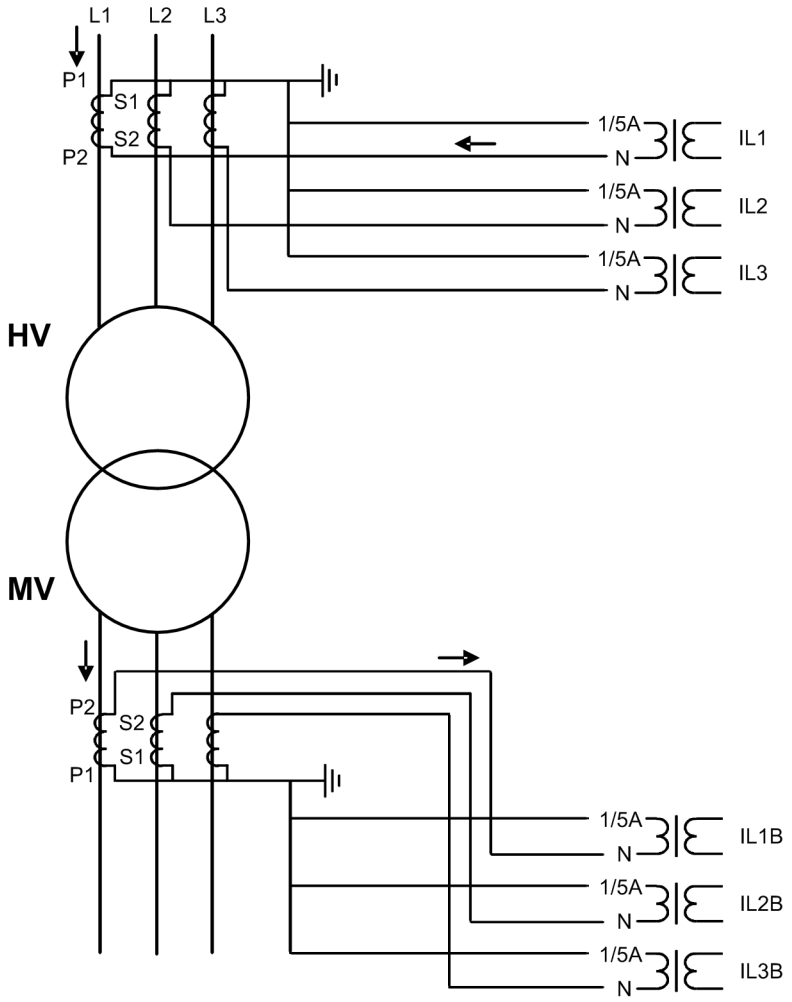



*Figure 401: Connection example of current transformers of Type 1*

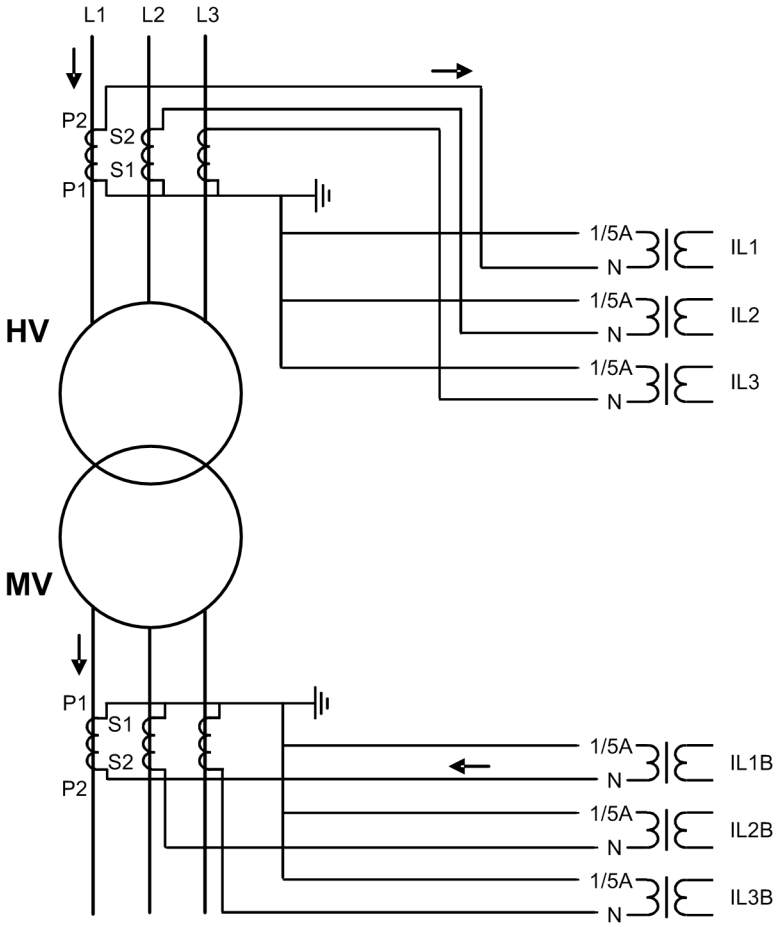



*Figure 402: Alternative connection example of current transformers of Type 1*

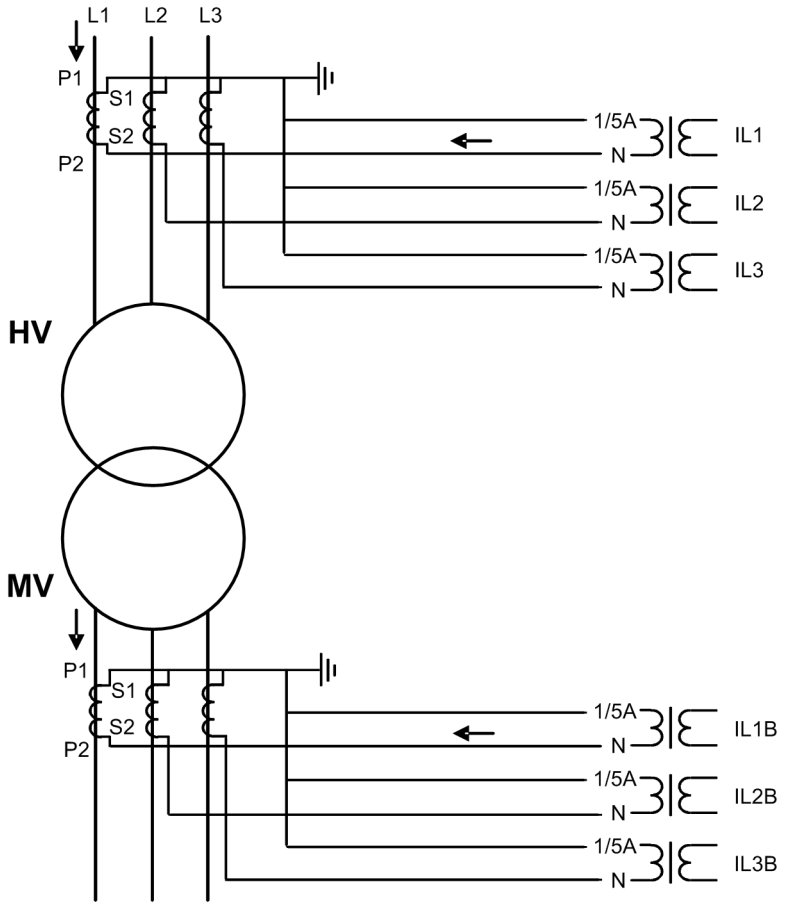



*Figure 403: Connection of current transformers of Type 2 and example of the currents during an external fault*

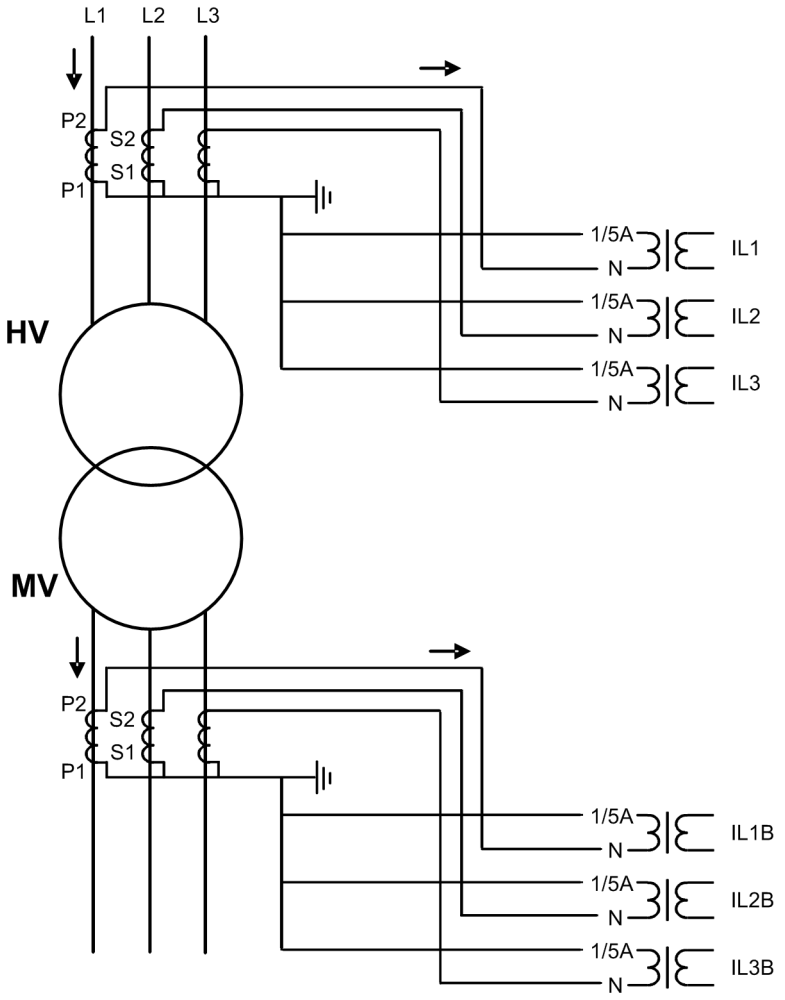



*Figure 404: Alternative connection example of current transformers of Type 2*

The CT secondary currents often differ from the rated current at the rated load of the power transformer. The CT transforming ratios can be corrected on both sides of the power transformer with the *CT ratio Cor Wnd 1* and *CT ratio Cor Wnd 2* settings.

## 4.3.2.8 Signals

### TR2PTDF Input signals

**Table 656: TR2PTDF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| BLOCK | BOOLEAN | 0=False | Block |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| BLK_OPR_LS | BOOLEAN | 0=False | Blocks operate outputs from biased stage |
| BLK_OPR_HS | BOOLEAN | 0=False | Blocks operate outputs from instantaneous stage |

**TR2PTDF Output signals**

**Table 657: TR2PTDF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate combined |
| OPR_LS | BOOLEAN | Operate from low set |
| OPR_HS | BOOLEAN | Operate from high set |
| BLKD2H | BOOLEAN | 2nd harmonic restraint block status |
| BLKD5H | BOOLEAN | 5th harmonic restraint block status |
| BLKDWAV | BOOLEAN | Waveform blocking status |

### 4.3.2.9 TR2PTDF Settings

**Table 658: TR2PTDF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| High operate value | 500...3000 | %Ir | 10 | 1000 | Instantaneous stage setting |
| Low operate value | 5...50 | %Ir | 1 | 20 | Basic setting for biased operation |
| Slope section 2 | 10...50 | % | 1 | 30 | Slope of the second line of the operating characteristics |
| End section 2 | 100...500 | %Ir | 1 | 150 | Turn-point between the second and the third line of the operating characteristics |
| Restraint mode | 5=Waveform<br>6=2.h + waveform<br>8=5.h + waveform<br>9=2.h + 5.h + wav | | | 9=2.h + 5.h + wav | Restraint mode |
| Start value 2.H | 7...20 | % | 1 | 15 | 2. harmonic blocking ratio |
| Start value 5.H | 10...50 | % | 1 | 35 | 5. harmonic blocking ratio |

**Table 659: TR2PTDF Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Enable high set | 0=False<br>1=True | | | 1=True | Enable high set stage |
| Slope section 3 | 10...100 | % | 1 | 100 | Slope of the third line of the operating characteristics |
| Harmonic deblock 2. | 0=False<br>1=True | | | 1=True | 2. harmonic deblocking in case of switch on to fault |
| Stop value 5.H | 10...50 | % | 1 | 35 | 5. harmonic deblocking ratio |
| Harmonic deblock 5. | 0=False<br>1=True | | | 0=False | 5. harmonic deblocking in case of severe overvoltage |

**Table 660: TR2PTDF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off/On |
| CT connection type | 1=Type 1<br>2=Type 2 | | | 1=Type 1 | CT connection type. Determined by the directions of the connected current transformers |
| Winding 1 type | 1=Y<br>2=YN<br>3=D<br>4=Z<br>5=ZN | | | 1=Y | Connection of the HV side windings |
| Winding 2 type | 1=y<br>2=yn<br>3=d<br>4=z<br>5=zn | | | 1=y | Connection of the LV side windings |
| Clock number | 0=Clk Num 0<br>1=Clk Num 1<br>2=Clk Num 2<br>4=Clk Num 4<br>5=Clk Num 5<br>6=Clk Num 6<br>7=Clk Num 7<br>8=Clk Num 8<br>10=Clk Num 10<br>11=Clk Num 11 | | | 0=Clk Num 0 | Setting the phase shift between HV and LV with clock number for connection group compensation (e.g. Dyn11 -> 11) |
| Zro A elimination | 1=Not eliminated<br>2=Winding 1<br>3=Winding 2<br>4=Winding 1 and 2 | | | 1=Not eliminated | Elimination of the zero-sequence current |
| CT ratio Cor Wnd 1 | 0.40...4.00 | | 0.01 | 1.00 | CT ratio correction, winding 1 |
| CT ratio Cor Wnd 2 | 0.40...4.00 | | 0.01 | 1.00 | CT ratio correction, winding 2 |

**Table 661: TR2PTDF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min winding tap | -36...36 | | 1 | 17 | The tap position number resulting the minimum number of effective winding turns on the side of the transformer where the tap changer is. |
| Max winding tap | -36...36 | | 1 | 0 | The tap position number resulting the maximum number of effective winding turns on the side of the transformer where the tap changer is. |
| Tap nominal | -36...36 | | 1 | 8 | The nominal position of the tap changer resulting the default transformation ratio of the transformer (as if there was no tap changer) |
| Tapped winding | 1=Not in use<br>2=Winding 1<br>3=Winding 2 | | | 1=Not in use | The winding where the tap changer is connected to |
| Step of tap | 0.60...9.00 | % | 0.01 | 1.50 | The percentage change in voltage corresponding one step of the tap changer |

## 4.3.2.10 TR2PTDF Monitored data

**Table 662: TR2PTDF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| OPR_A | BOOLEAN | 0=False<br>1=True | | Operate phase A |
| OPR_B | BOOLEAN | 0=False<br>1=True | | Operate phase B |
| OPR_C | BOOLEAN | 0=False<br>1=True | | Operate phase C |
| BLKD2H_A | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase A status |
| BLKD2H_B | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase B status |
| BLKD2H_C | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase C status |
| BLKD5H_A | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase A status |
| BLKD5H_B | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase B status |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| BLKD5H_C | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase C status |
| BLKDWAV_A | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase A status |
| BLKDWAV_B | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase B status |
| BLKDWAV_C | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase C status |
| BLKD2HPHAR | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, combined |
| BLKD2HPHAR_A | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase A |
| BLKD2HPHAR_B | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase B |
| BLKD2HPHAR_C | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase C |
| BLKD5HPHAR | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, combined |
| BLKD5HPHAR_A | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase A |
| BLKD5HPHAR_B | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase B |
| BLKD5HPHAR_C | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase C |
| I_AMPL_A1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase A |
| I_AMPL_B1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase B |
| I_AMPL_C1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase C |
| I_AMPL_A2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase A |
| I_AMPL_B2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase B |
| I_AMPL_C2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase C |
| ID_A | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase A |
| ID_B | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase B |
| ID_C | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase C |
| IB_A | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase A |
| IB_B | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase B |
| IB_C | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase C |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_2H_RAT_A | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase A |
| I_2H_RAT_B | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase B |
| I_2H_RAT_C | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase C |
| I_ANGL_A1_B1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, winding 1 |
| I_ANGL_B1_C1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, winding 1 |
| I_ANGL_C1_A1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, winding 1 |
| I_ANGL_A2_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, winding 2 |
| I_ANGL_B2_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, winding 2 |
| I_ANGL_C2_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, winding 2 |
| I_ANGL_A1_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase A |
| I_ANGL_B1_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase B |
| I_ANGL_C1_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase C |
| I_5H_RAT_A | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase A |
| I_5H_RAT_B | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase B |
| I_5H_RAT_C | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase C |
| TR2PTDF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| IL1-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL1 |
| IL2-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL2 |
| IL3-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL3 |
| IL1-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL1 |
| IL2-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL2 |
| IL3-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL3 |

#### 4.3.2.11 Technical data

**Table 663: TR2PTDF Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±3.0% of the set value or ±0.002 × $I_n$ | | |
| Start time [1, 2] | | Minimum | Typical | Maximum |
| | Low stage | 31 ms | 35 ms | 40 ms |
| | High stage | 15 ms | 17 ms | 20 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, … | | |

## 4.3.3 Stabilized and instantaneous differential protection for two- or three-winding transformers TR3PTDF (ANSI 87T3)

### 4.3.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Stabilized and instantaneous differential protection for two- or three-winding transformers | TR3PTDF | 3dI>3W | 87T3 |

### 4.3.3.2 Function block

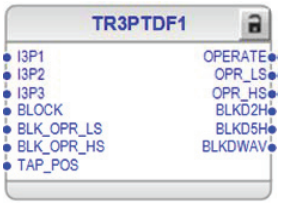



*Figure 405: Function block*

### 4.3.3.3 Functionality

The stabilized and instantaneous differential protection for two- or three-winding transformers function TR3PTDF provides up to three three-phase current sets or restraints designed for the protection of two-winding or three-winding transformers and generator-transformer blocks. It is possible to have two three-

[1] Current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz. Injected differential current = 2.0 × set operation value
[2] Measured with static power output $f_n$ = 50 Hz.

phase current sets either on the winding 1 or winding 2 side in case of two-winding transformer protection. The function includes a biased low stage and an instantaneous high stage.

The biased low stage provides fast fault clearing while remaining stable with the high currents passing through the protected zone, which increase the errors in current measuring. The second harmonic restraint, together with waveform-based algorithms, ensures that the low stage does not operate due to the transformer inrush currents. The fifth harmonic restraint ensures that the low stage does not operate on apparent differential current caused by a harmless transformer overexcitation.

The instantaneous high stage provides very fast clearing of severe faults with a high differential current regardless of their harmonics.

The setting characteristic can be set more sensitive with tap changer position compensation. The correction of the transformation ratio due to changes in tap position is done automatically based on the tap changer status information provided to the function through input.

### 4.3.3.4 Analog channel configuration

TR3PTDF has three analog group inputs which must be properly configured.

**Table 664: Analog inputs**

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase currents |
| I3P3 [1] | Three-phase currents Necessary when *Current group 3 type* is other than "Not in use" |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of TR3PTDF can be described with a module diagram. All the modules in the diagram are explained in the next sections.

[1] Can be connected to GRPOFF if *Current group 3 type* is set to "Not in use"

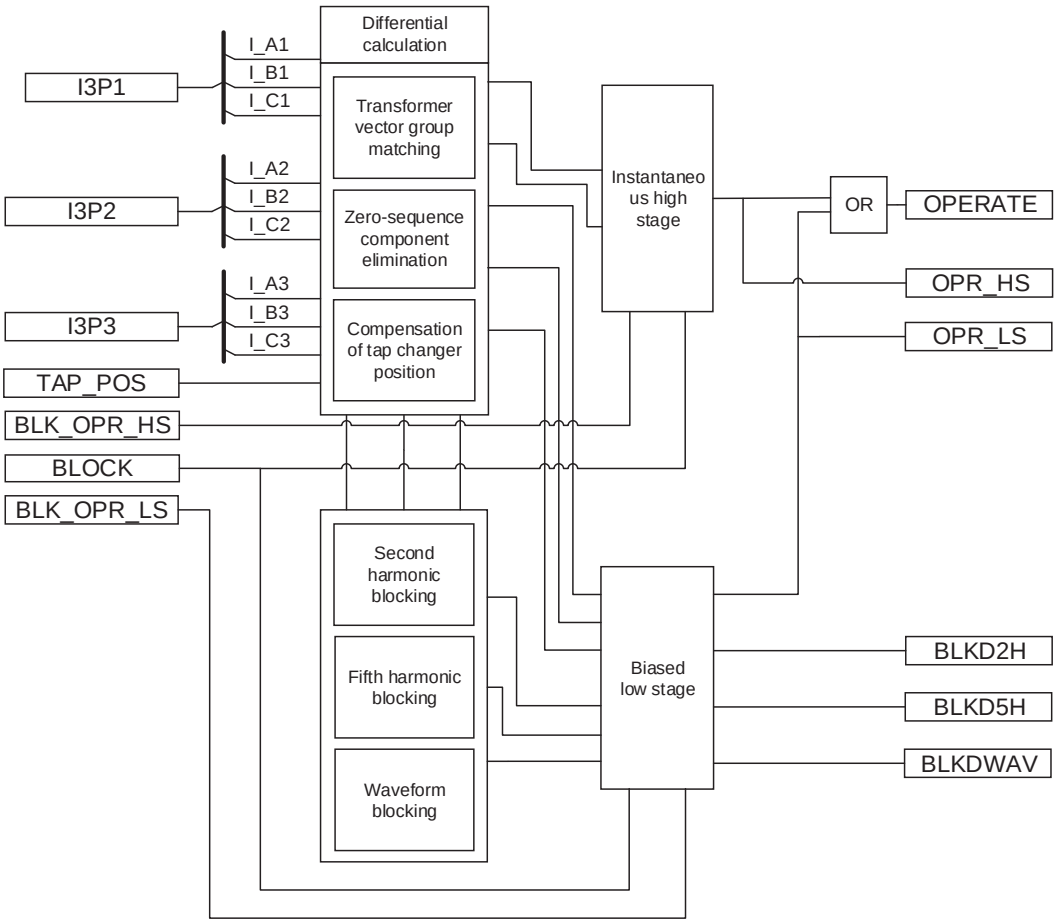



*Figure 406: Functional module diagram*

**Differential calculation**

TR3PTDF operates phasewise on the difference of incoming and outgoing currents. The positive direction of the currents is towards the protected object.

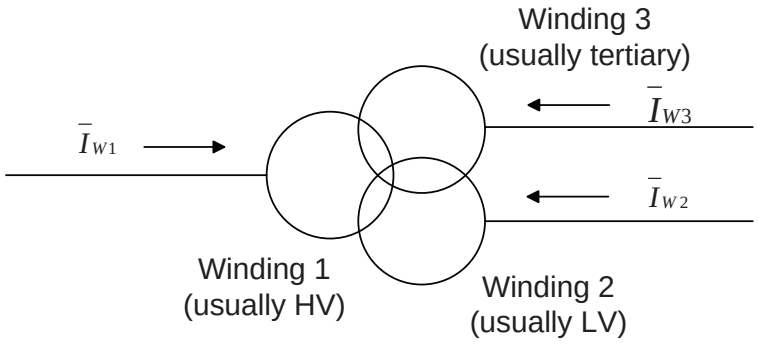



*Figure 407: Single-line diagram of the positive direction of the currents in a threewinding transformer*

The normalized amplitude of the differential current per phase Id is obtained using the equation:

$$I_d = \left|\bar{I}_{W1} + \bar{I}_{W2} + \bar{I}_{W3}\right|$$

(Equation 167)

In a normal situation, no fault occurs in the area protected by TR3PTDF. Then the currents $I_{W1}$, $I_{W2}$ and $I_{W3}$ cancel each other and the differential current $I_d$ is zero. In practice, however, the differential current deviates from zero in normal situations. In the power transformer protection, the differential current is caused by CT inaccuracies, variations in tap changer position (if not compensated), transformer no-load current and instantaneous transformer inrush currents. An increase in the load current makes the differential current, caused by the CT inaccuracies and the tap changer position, grow at the same percentage rate.

In a biased differential protection relay in normal operation or during external faults, the higher the load current is, the higher the differential current required for tripping. When an internal fault occurs, the currents on both sides of the protected object are flowing into it. This causes the bias current to be considerably smaller, which makes the operation more sensitive during internal faults.

$$I_b = \frac{\left|\bar{I}_X - \bar{I}_Y - \bar{I}_Z\right|}{2}$$

(Equation 168)

| | |
|---|---|
| $I_X$ | One of the normalized currents $I_{W1}$, $I_{W2}$ and $I_{W3}$ determined by the angle differences between the currents and their amplitudes |
| $I_Y$ and $I_Z$ | Remaining two currents |

$I_X$ is selected based on one of the criteria below.

- The angle between $I_X$ and $I_Y$ and also between $I_X$ and $I_Z$ is over 120 degrees while the amplitude of $I_X$ is not less than

  $0.9 \cdot MAX(|I_X|, |I_Y|, |I_Z|)$
- The one with the highest amplitude ($I_X = MAX(|I_X|, |I_Y|, |I_Z|)$ )

In case of a two-winding transformer having additional restraint (additional three-phase current set) either on the winding 1 or winding 2 side, currents are connected to the third winding current inputs. This ensures that if the currents of the opposite direction are measured in the restraints (through current), meaning the current is passing through the protected zone, this current affects the bias current of the differential protection.

If the bias current is small compared to the differential current or if the phase angle between the currents of two windings with the highest phase current (in case of three-winding transformer) or the phase angle between the compared phase currents (in case of two-winding transformer) is close to zero, a fault has most certainly occurred in the area protected by the differential protection relay. The operating value set for the instantaneous stage is automatically halved and the internal blocking signals of the biased stage are inhibited.

### Transformer vector group matching

The phase differences of the winding 1 and winding 2 currents (winding 1 and winding 3 in case of a three-winding transformer) that are caused by the vector groups of the power transformer are numerically compensated in the function.

Phase difference matching is based on the ABB-patented generalized transform method. Settings *Phase shift Wnd 1-2* and *Phase shift Wnd 1-3* determine the current phase angle difference between windings 1 and 2 and between 1 and 3, respectively.

Normally, the transformer vector group designation includes the winding configurations and the phase angle difference between given with a clock number. For example, YNd1 has clock number 1. Settings *Phase shift Wnd 1-2* and *Phase shift Wnd 1-3* are calculated as clock number · 30 deg.

**Table 665: Examples of Phase shift Wnd 1-2 (and Phase shift Wnd 1-3) settings for some common vector groups**

| Vector group between windings 1 and 2 (or windings 1 and 3) | Phase angle |
|---|---|
| YNd1, Yd1, Dyn1, Dy1 | 30° |
| YNd5, Yd5, Dyn5, Dy5 | 150° |
| YNd7, Yd7, Dyn7, Dy7 | 210° |
| YNd11, Yd11, Dyn11, Dy11 | 330° |

The vector group matching can be set in the resolution of 0.1 degrees, which allows for cycloconverter applications with a phase angle difference of, for example, 7.5 degrees between windings.

The *Phase Ref winding* setting is used to define which of the windings is the reference. The phase reference can be selected from *Phase Ref winding* as "Winding 1", "Winding 2" or "Winding 3". The currents in the winding selected as the phase reference are not modified (except the removal of the zero-sequence current if set active) when the currents in other windings are matched with the reference winding (if the set phase shift between the windings is not zero).



The *Phase Ref winding* setting does not affect settings *Phase shift Wnd 1-2* and *Phase shift Wnd 1-3*.

### Zero-sequence component elimination

If a wye-connected power transformer neutral is earthed, or if there is a separate earthing transformer inside the differential protection zone, any out-of-zone earth fault in the network is seen as differential current unless the zero-sequence component is correctly eliminated.

The zero-sequence elimination is done with the *Zro A elimination* setting. The recommended rules for this setting are:

- For power transformer wye-connected windings with earthed neutral point, *Zro A elimination* must be activated.
- For power transformer wye-connected windings with isolated neutral, and for delta-connected windings, *Zro A elimination* is not activated unless there is a separate earthing transformer inside the protected zone (that is, between the power transformer winding and CTs).
- It does no harm to activate *Zro A elimination* even if it is not needed.

### Compensation of tap changer position

The position of the tap changer used for voltage control can be compensated according to the actual tap changer position. The position information is provided

to the protection function through the tap changer position indication function TPOSYLTC.

Typically, the tap changer is located within the HV winding, that is, winding 1 of the power transformer. The *Tapped winding* setting parameter specifies whether the tap changer is connected to winding 1, winding 2 or winding 3. The *Tapped winding* setting parameter is also used to enable or disable the automatic adaptation to the tap changer position. The possible values are "Not in use", "Winding 1", "Winding 2", "Winding 3".

There can be only one tap changer in the transformer, that is, the function can take into account and compensate only for one tap changer.

The *Tap nominal* setting parameter provides the number of the tap which results in the nominal voltage and current. When the current tap position deviates from this value, the input current values where the tap changer resides are scaled to match the currents on the other side.

A correct scaling is determined by the number of steps, the direction of the deviation from the nominal tap and the percentage change in the voltage resulting from a deviation of one tap step. The percentage value is set via the *Step of tap* setting.

The operating range of the tap changer is defined by the *Min winding tap* and *Max winding tap* settings. The *Min winding tap* setting gives the tap position number resulting from the minimum effective number of winding turns on the side of the transformer where the tap changer is connected. Correspondingly, the *Max winding tap* setting gives the tap position number resulting from the maximum effective number of winding turns.

The *Min winding tap* and *Max winding tap* settings help the tap position compensation algorithm find the direction of the compensation. This also ensures that if the current tap position information is corrupted, the automatic tap changer position adaptation does not try to adapt to any unrealistic position values.

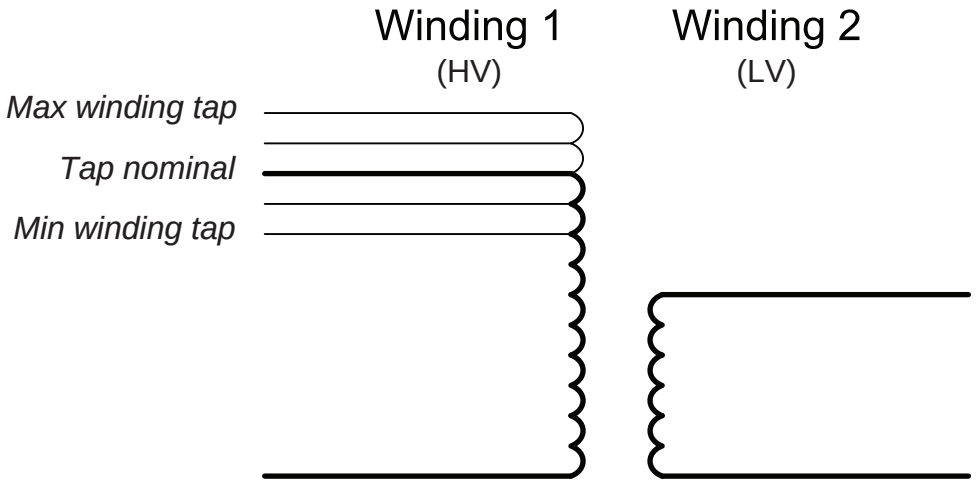



*Figure 408: Simplified presentation of the HV and LV windings of a two-winding transformer with demonstration of the settings Max winding tap, Min winding tap and Tap nominal*

The position value is available in the Monitored data view on LHMI or through other communication tools in TPOSYLTC. When the quality of the TAP_POS input value is not good, the position information in the TAP_POS input is not used, and

the last value with the good quality information is used instead. In addition, the minimum sensitivity of the biased stage, set by the *Low operate value* setting, is automatically desensitized with the total range of the tap position correction. The new acting low operate value can be calculated.

$$Desensitized\ Low\ operate\ value = Low\ operate\ value + ABS(Max\ winding\ tap - Min\ winding\ tap) \cdot Step\ of\ tap$$

(Equation 169)

**Second harmonic blocking**

Transformer-magnetizing inrush currents occur when the transformer is energized after a period of de-energization. The inrush current may be many times the rated current, and the half-life can be up to several seconds. To the differential protection relay, the inrush current represents a differential current that causes the protection relay to operate almost always when the transformer is connected to the network. Typically, the inrush current contains a large amount of second harmonics.

The blocking of the biased low stage of the protection relay at magnetizing inrush current is based on the ratio of the amplitudes of the second harmonic to the fundamental frequency component of the differential current (Id2f / Id1f).

The blocking also prevents an unwanted operation at recovery and a sympathetic magnetizing inrush. At recovery inrush, the magnetizing current of the transformer to be protected increases momentarily when the voltage returns to normal after the clearance of a fault outside the protected area. The sympathetic inrush is caused by the energization of another transformer running in parallel with the protected transformer already connected to the network.

The ratio of the second harmonic to the fundamental component can vary considerably between the phases. Especially when the delta compensation is done for a Ynd1-connected transformer and the two phases of the inrush currents are otherwise equal but opposite in phase angle, their subtraction in a delta compensation results in a very small second harmonic component.

Because of the small second harmonic component, some action must be taken to avoid false tripping of the phase having a too low ratio of the second harmonic to the fundamental component. One way could be to block all phases when the second harmonic blocking conditions are fulfilled at least in one phase. The other way is to calculate weighted ratios of the second harmonic to the fundamental for each phase using the original ratios of the phases. The latter option is used here.

The ratio used for the second harmonic blocking is calculated as a weighted average on the basis of the ratios calculated from the differential currents of the three phases. The ratio of the phase has the most weight compared to the ratios of the other two phases (the weighting factors are 4, 1 and 1, where 4 is the factor of the phase). The operation of the biased stage on the phase is blocked if the weighted ratio of that phase is above the set *Start value 2.H* blocking limit and if the blocking is enabled through the *Restraint mode* setting.

Using separate blocking for the individual phases and weighted averages calculated for the separate phases provides a stable blocking scheme at connection inrush currents.

The switching of the power transformer onto fault inside the protected area does not delay the operation of the tripping, because in such a situation the blocking based on the second harmonic of the differential current is prevented by a separate algorithm based on the different waveform and the different rate of change of the normal inrush current and the inrush current containing the fault current. The

algorithm does not eliminate the blocking at inrush currents unless there is a fault in the protected area.

The feature can be enabled and disabled through the *Harmonic deblock 2.* setting.

**Fifth harmonic blocking**

The inhibition of the protection relay operation in situations of overexcitation is based on the ratio of the fifth harmonic to the fundamental component of the differential current (Id5f / Id1f). The ratio is calculated separately for each phase without weighting factors. If the ratio exceeds the set value of *Start value 5.H* and blocking is enabled through the *Restraint mode* setting, the operation of the biased stage of the protection relay in the phase is blocked.

At dangerous levels of overvoltage which may cause damage to the transformer, the blocking can be automatically eliminated. The blocking is removed if the ratio of the fifth harmonic to the fundamental component of the differential current exceeds the set value of the *Stop value 5.H* setting, and the blocking removal is enabled. The deblocking feature can be enabled or disabled with the *Harmonic deblock 5.* setting.

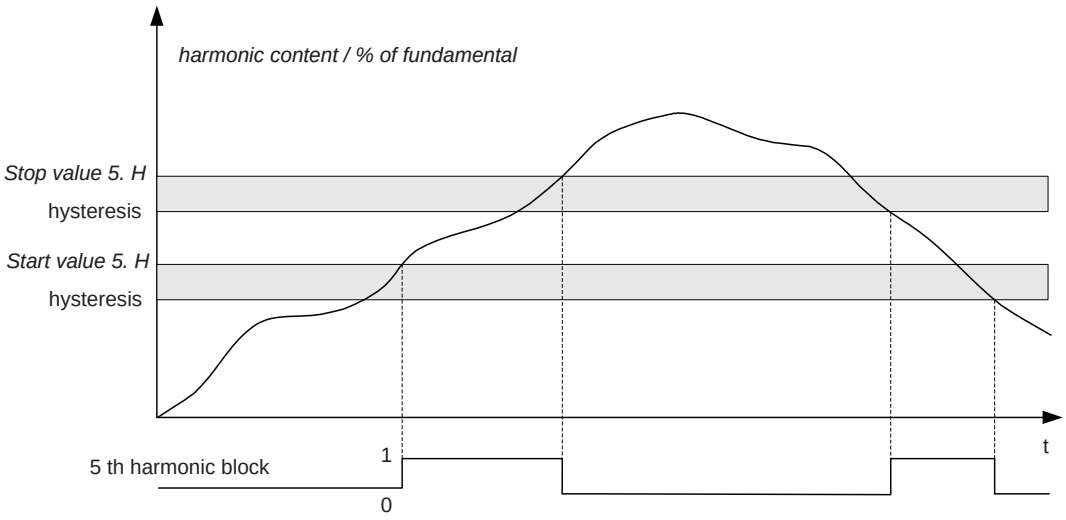



*Figure 409: The fifth harmonic blocking limits and the operation when both blocking and deblocking features are enabled through the Harmonic deblock 5. setting*

Fifth harmonic blocking has a hysteresis to avoid rapid fluctuation between TRUE and FALSE. The required consecutive fulfillments of the condition can be counted using the blocking counter. When the condition is not fulfilled, the counter is decreased (if >0).

Also fifth harmonic deblocking (based on the higher limit, *Stop value 5.H*, if enabled with *Harmonic deblock 5.*) has a hysteresis and a counter which counts the required consecutive fulfillments of the condition. When the condition is not fulfilled, the counter is decreased (if >0).

**Waveform blocking**

The biased low stage can always be blocked with waveform blocking; it cannot be disabled with *Restraint mode*. This algorithm has two parts. The first part is intended for external faults while the second is intended for inrush situations. The algorithm has criteria for the low-current periods of differential current during the inrush and external fault.

**Blocking reset**

All three blocking signals, that is, waveform and the second and fifth harmonic, have a counter or time limit which holds the blocking on for a certain time after the blocking conditions have ceased to be fulfilled. The deblocking takes place when the counters or time have elapsed. This is a normal case of deblocking.

The blocking signals can be reset immediately if a very high differential current is measured or if the phase difference (angle) between the compared currents is close to zero (in normal situations, the phase difference is 180 degrees).

**Biased low stage**

Biasing of the current differential protection is needed since a possible appearance of a differential current can also be due to something else than an actual fault in the transformer (or generator).

In the case of transformer protection, there can be several reasons for the false differential current.

- CT errors
- Varying tap changer positions (if not automatically compensated)
- Transformer no-load current
- Transformer inrush currents
- Transformer overexcitation during overvoltage situations
- Transformer overexcitation during underfrequency situations
- CT saturation at high currents passing through the transformer

The differential current caused by CT errors and tap changer position increases at the same percentage ratio as the load current.

In the protection of generators, the false differential current can be caused by several reasons.

- CT errors
- CT saturation at high currents flowing through the generator

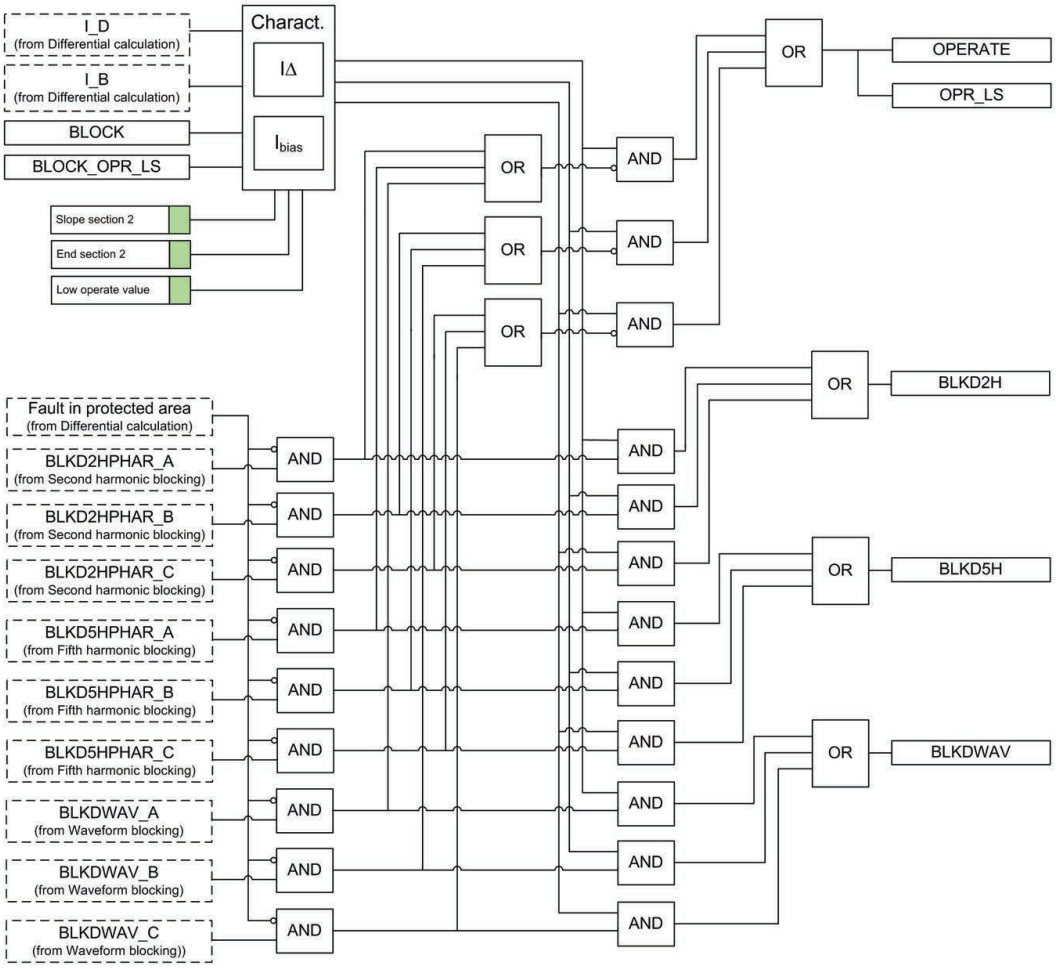



*Figure 410: Operation logic of the biased low stage*

The high currents passing through a protected object can be caused by the short circuits outside the protected area, the high currents fed by the transformer in a motor startup or transformer inrush situations. Therefore, the operation of the differential protection is biased with respect to the load current. In biased differential protection, the higher the differential current required for the protection to trip, the higher the load current.

The operation characteristic of the biased low stage is determined by *Low operate value*, *Slope section 2* and the second turning point setting of the operating characteristic curve, *End section 2* (the first turning point and the slope of the last part of the characteristic are fixed). The settings are the same for each phase. When the differential current exceeds the operating value determined by the operating characteristic, the differential function is activated. If the differential current stays above the operating value continuously for a suitable period, the `OPR_LS` output is activated. The activation of the `OPR_LS` output activates the **OPERATE** output.

The stage can be blocked internally by the second or the fifth harmonic restraint, or by special algorithms detecting the inrush and current transformer saturation at external faults. When the operation of the biased low stage is blocked by the second harmonic blocking functionality, the `BLKD2H` output is activated.

The `BLKD5H` output is activated when the biased low stage is blocked by the fifth harmonic blocking functionality. Correspondingly, when the operation of the biased

low stage is blocked by the waveform blocking functionality, the BLKDWAV output is activated according to the phase information.

When required, the operating outputs of the biased low stage can be blocked by the external control signals BLK_OPR_LS and BLOCK.

The operation of the protection relay is affected by biasing as shown in *Figure 411*.

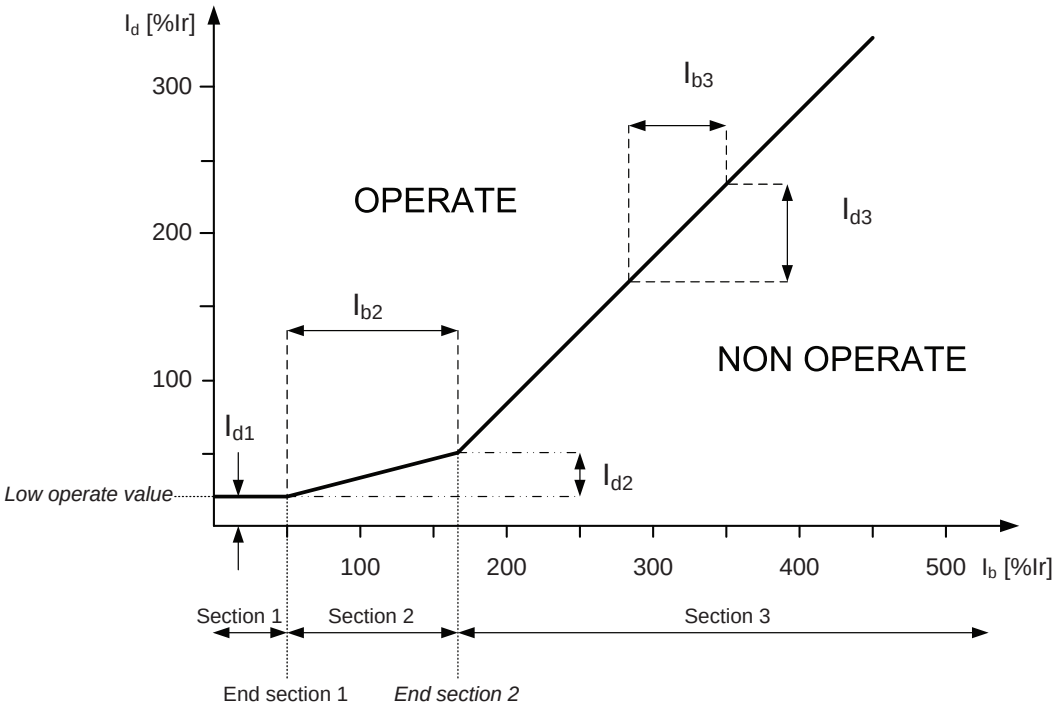



*Figure 411: Operation characteristic for biased operation of TR3PTDF*

The *Low operate value* setting of the biased stage of the differential function is determined according to the operating characteristics curve:

$$Low\,operate\,value = Id1$$

(Equation 170)

The *Slope section 2* setting is determined correspondingly:

$$Slope\ section\ 2 = \frac{Id2}{Ib2} \cdot 100\,\%$$

(Equation 171)

The second turning point *End section 2* can be set in the range 100...500 %.

The slope of the operating characteristic curve of the differential function varies in three different sections of the range.

**Table 666: Different sections of the range and their operation**

| Sections | Operation |
|---|---|
| Section 1 | In section 1, where 0 percent Ir < Ib < End section 1, with End section 1 being fixed to 50 percent of Ir, the differential current required for tripping is constant. The value of the differential current is the same as the *Low operate value* selected for the function. The *Low operate value* setting allows for the no-load current of the power transformer and small inaccuracies of the current transformers, but it can also be used to influence the overall level of the operation characteristic. At the rated current, the no-load losses of the power transformer are about 0.2 percent. If the supply voltage of the power transformer suddenly increases due to operational disturbances, the magnetizing current of the transformer increases as well. In general, the magnetic flux density of the transformer is rather high at the rated voltage and the rise in voltage by a few percent causes the magnetizing current to increase by tens percent. This should be considered in *Low operate value*. |
| Section 2 | Section 2, where End section 1 < Ib < *End section 2*, is called the influence area of *Slope section 2*. In this section, the variations in the starting ratio affect the slope of the characteristic, that is, how big a change in the differential current is required for tripping compared to the change in the load current. The starting ratio should consider CT errors and variations in the transformer tap changer position (if not compensated). Too high a starting ratio should be avoided, because the sensitivity of the protection for detecting interturn faults depends on the starting ratio. |
| Section 3 | In section 3, where Ib > *End section 2*, the slope of the characteristic is constant. The slope is 100 percent, which means that the increase in the differential current is equal to the corresponding increase in the biasing current. |

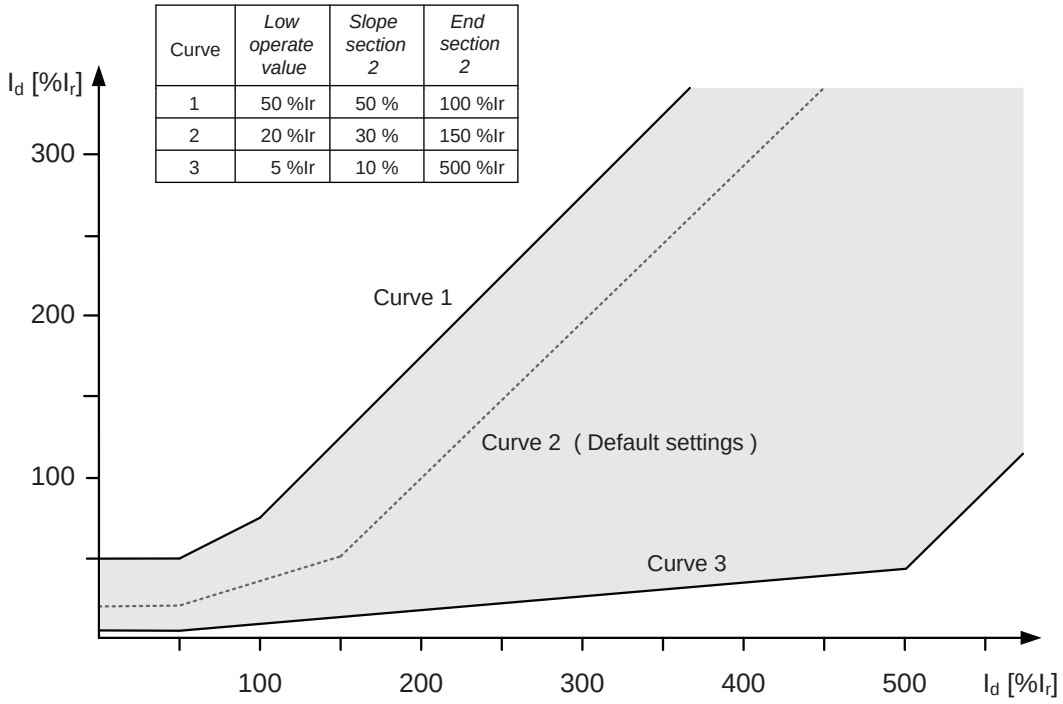



*Figure 412: Setting range for biased low stage*

If the biasing current is small compared to the differential current or if the phase angle between the currents of two windings with the highest phase current is close to zero (normally, the phase difference is 180 degrees) or the phase angle between the compared phase currents (in case of two-winding transformer) is close to zero, a fault has most certainly occurred in the area protected by the differential protection relay. The internal blocking signals of the biased stage are inhibited.

The operation of the differential protection is based on the fundamental frequency components. The operation is accurate and stable: the DC component and harmonics of the current do not cause unwanted operations.

**Instantaneous high stage**

Instantaneous high stage can be enabled or disabled with the *Enable high set* setting. The corresponding parameter values are "True" and "False".

The operation of Instantaneous high stage is not biased. The instantaneous stage operates and the `OPR_HS` output is activated when the amplitude of the fundamental frequency component of the differential current exceeds the set operation value *High operate value* or when the instantaneous value of the differential current exceeds 2.5 · *High operate value*. The value 2.5 (=1.8 · √2) is due to the maximum asymmetric short circuit current.

If the biasing current is small compared to the differential current, or if the phase angle between the currents of the two windings with the highest phase current is close to zero (normally, the phase difference is 180 degrees) or the phase angle between the compared phase currents (in case of a two-winding transformer) is close to zero, a fault has occurred in the area protected by the differential protection. The operating value set for the instantaneous stage is automatically halved and the internal blocking signals of the biased stage are inhibited.

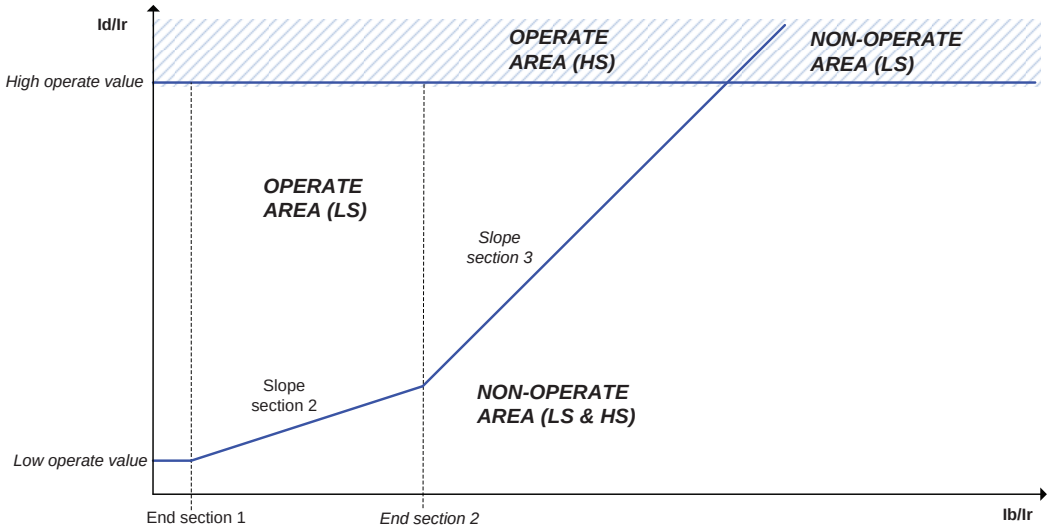



*Figure 413: Operating characteristics of the protection. LS stands for the biased low stage and HS for the instantaneous high stage*

The OPERATE output is always activated with the OPR_HS output. The internal blocking signals of the differential function do not prevent the trip signal of the instantaneous differential current stage from being activated. When required, the operating outputs of Instantaneous high stage can be blocked by the external control signals BLK_OPR_HS or BLOCK.

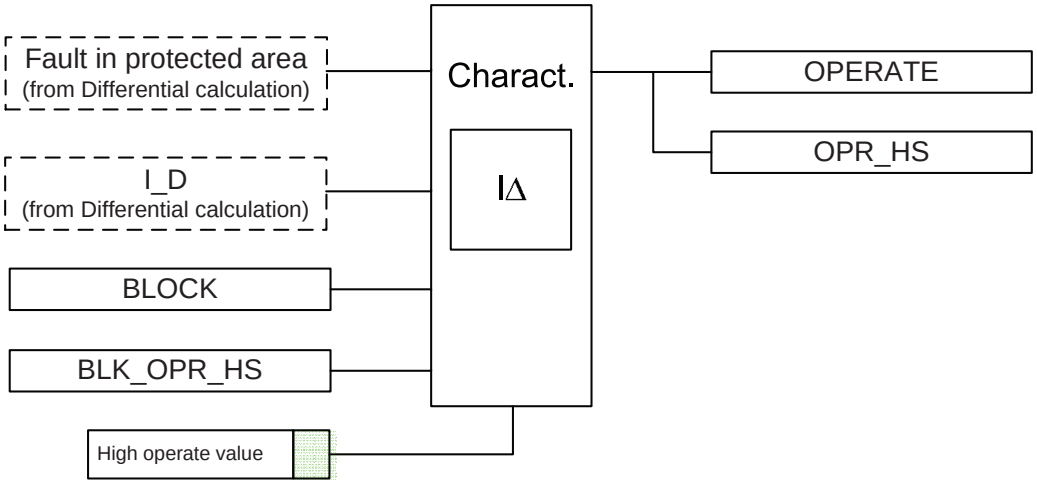



*Figure 414: Operation logic of Instantaneous high stage*

**External blocking functionality**

TR3PTDF has three inputs for blocking.

| Blocking inputs | Description |
|---|---|
| BLOCK | When active (TRUE), the operation of the function is blocked; only measurement value outputs are updated. |
| BLK_OPR_LS | When active (TRUE), TR3PTDF acts normally except that the OPR_LS output is not active or activated in any circumstances. Additionally, the OPERATE output can be activated only by the instantaneous high stage (if not blocked). |
| BLK_OPR_HS | When active (TRUE), TR3PTDF acts normally except that the OPR_HS output is not active or activated in any circumstances. Additionally, the OPERATE output can be activated only by the biased low stage (if not blocked). |

### 4.3.3.6 Current transformer connections and transformation ratio correction

The combinations of the connections of the primary current transformers are designated as "Type 1" and "Type 2". The type needs to be selected separately for the combination of CT connections on the winding 1 and 2 sides as well as for the combination of CT connections on the winding 1 and 3 sides in case of three-winding transformer.

- If the positive directions of the winding 1 and winding 2 relay currents are opposite, the setting parameter *CT connection 1-2* is "Type 1", as shown in *Figure 415*.
- If the positive directions of the winding 1 and winding 2 relay currents are equal, the setting parameter *CT connection 1-2* is "Type 2", as shown in *Figure 416*.
- 'The default value of the *CT connection 1-2* settings is "Type 1".
- The same applies for the *CT connection 1-3* settings.

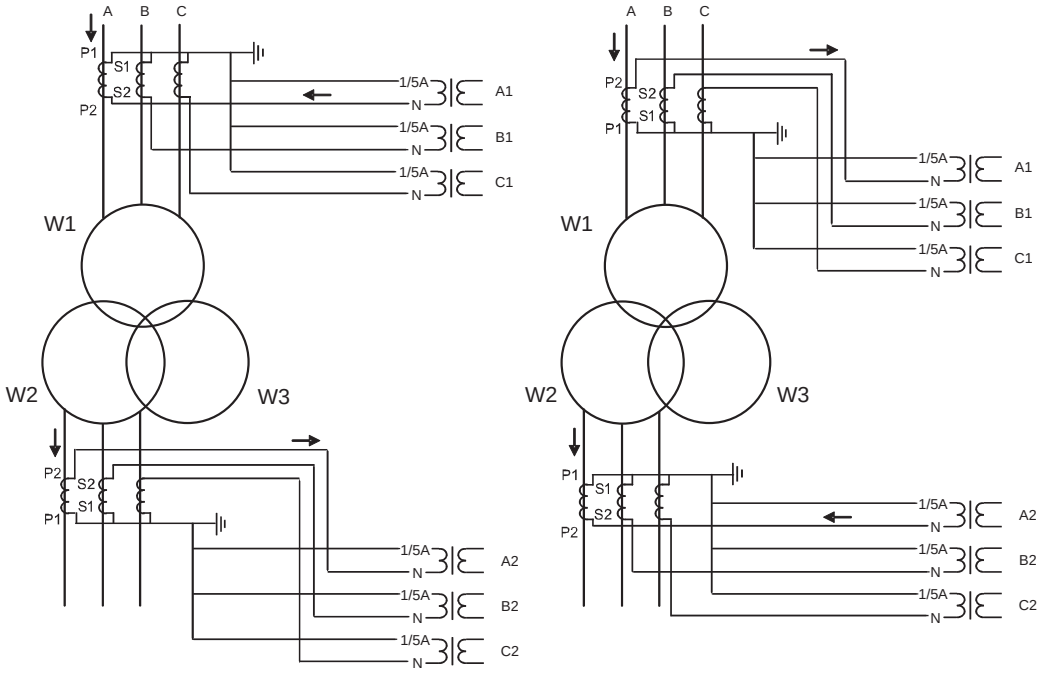



*Figure 415: Connection of current transformers of Type 1 and example of currents during an external fault*

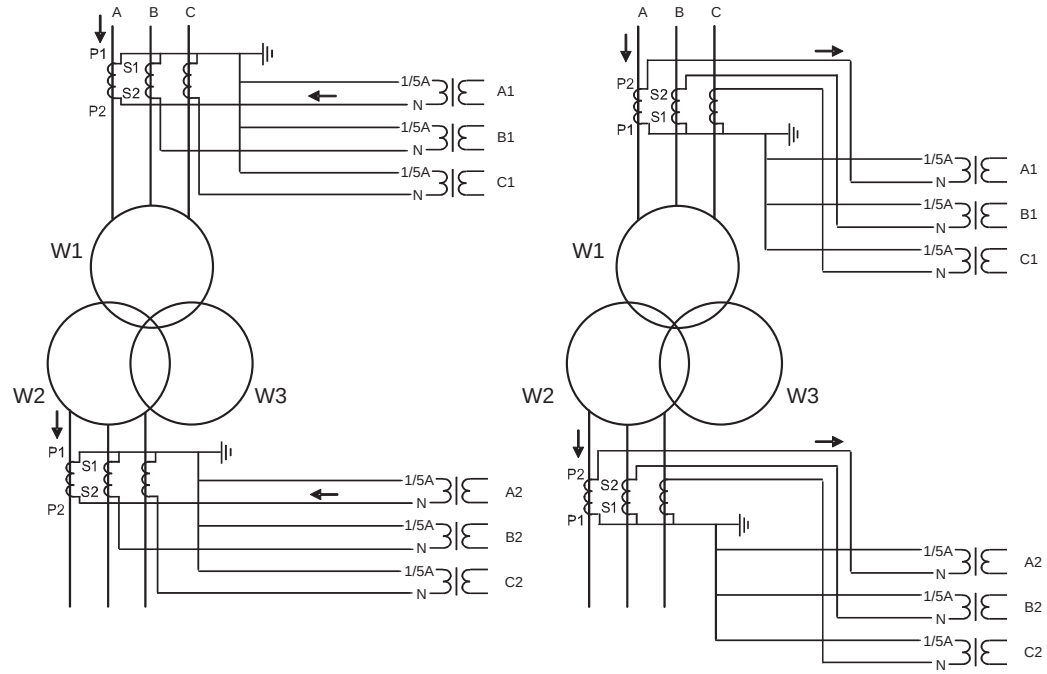



*Figure 416: Connection of current transformers of Type 2 and example of currents during an external fault*

Similar connections are done for a three-winding transformer.

If the rated primary current of the current transformers is not equal to the rated current of the power transformer on a side of the transformer, setting parameters *CT ratio Cor Wnd 1*, *CT ratio Cor Wnd 2* and *CT ratio Cor 3* must be used to correct

the transformation ratios. *CT ratio Cor Wnd 1* and *CT ratio Cor Wnd 2* are used to correct the ratios on winding 1 and 2 while the use of *CT ratio Cor 3* depends on the setting *Current group 3 type*. If *Current group 3 type* is "Winding 3", the *CT ratio Cor 3* setting is used to correct the ratios on winding 3. If *Current group 3* type is "Wnd 2 restraint", the ratio correction is made to the ratios of the second restraint on winding 2. If *Current group 3 type* is "Wnd 1 restraint", the ratio correction is made to the ratios of the second restraint on winding 1.

### 4.3.3.7 Application

TR3PTDF is a unit protection. It acts as the main protection of transformers in case of winding failure. The protective zone of a differential protection includes the transformer itself and the bus work or cables between the current transformer and the power transformer. When bushing current transformers are used for the differential protection relay, the protective zone does not include the bus work or cables between the circuit breaker and the power transformer.

In some substations, there is a current differential protection for the busbar. Such a busbar protection includes the bus work or cables between the circuit breaker and the power transformer. The internal electrical faults are serious and cause immediate damage. The short circuits and earth faults in the windings and terminals are normally detected by the differential protection. Inter-turn faults, which are flashovers between conductors within the same physical winding, can also be detected if a large enough number of turns are short-circuited. Inter-turn faults are the most difficult transformer winding faults to detect with electrical protections. A small inter-turn fault including just a few turns results in an undetectable amount of current until it develops into an earth fault. Therefore the differential protection must have a high level of sensitivity and it must be possible to use a sensitive setting without causing unwanted operations for external faults.

The faulty transformer must be disconnected as fast as possible. As the differential protection is a unit protection, it can be designed for fast tripping, thus providing a selective disconnection of the faulty transformer. The differential protection should not operate because of faults outside the protective zone.

A transformer differential protection compares the current flowing into the transformer to the current leaving the transformer. A correct analysis of fault conditions by the differential protection must consider changes to voltages, currents and phase angles. The traditional transformer differential protection functions required auxiliary transformers for the correction of the phase shift and ratio. The numerical microprocessor-based differential algorithm implemented in TR3PTDF compensates for both the turns ratio and the phase shift internally in the software.

The differential current should theoretically be zero during a normal load or external faults if the turns ratio and phase shift are correctly compensated. However, there are several different phenomena other than internal faults that cause unwanted and false differential currents. There can be several main reasons for unwanted differential currents.

- Mismatch due to varying tap changer positions.
- Different characteristics, loads and operating conditions of the CTs.
- Zero-sequence currents that flow only on one side of the power transformer.
- Normal magnetizing currents.
- Magnetizing inrush currents.
- Overexcitation of magnetizing currents.

TR3PTDF is designed mainly for protection of two-winding or three-winding transformers. TR3PTDF can also be used for the protection of generator-transformer blocks as well as short cables and overhead lines. If the distance between the measuring points is relatively long in line protection, interposing CTs might be needed to reduce the burden of the CTs. For the interposing CT, the accuracy limit factor must fulfill the same requirements as for the main CTs. The interposing CT imposes an additional burden to the main CTs.

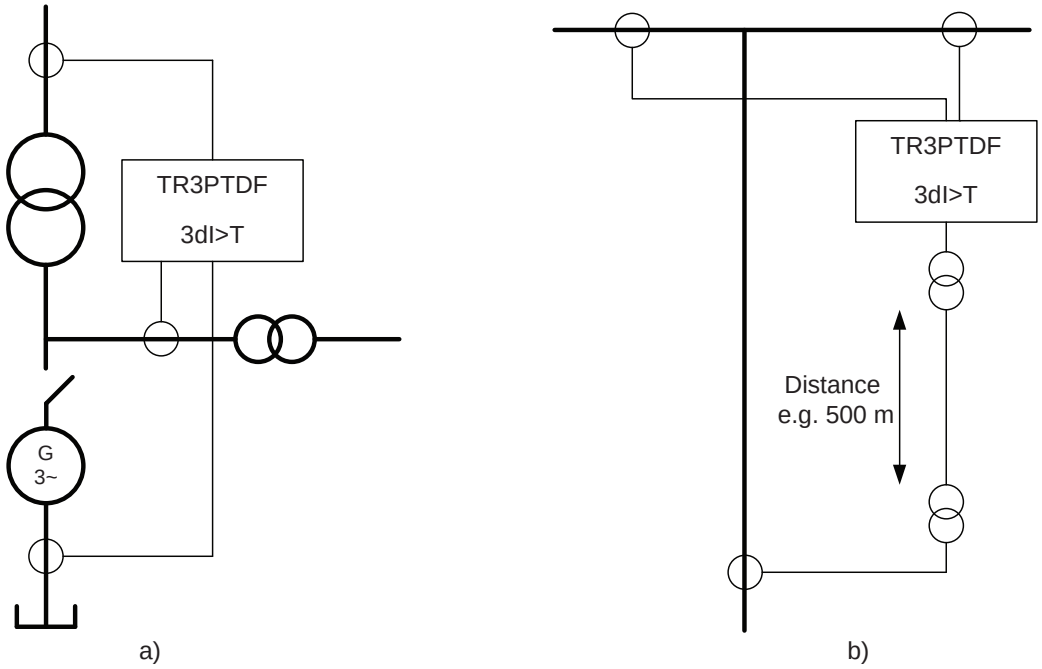



*Figure 417: Differential protection of a generator-transformer block and short cable or line*

TR3PTDF can be used in three-winding transformer applications or two-winding transformer applications with two output feeders.

On the double-feeder side of the two-winding power transformer, the currents from the other feeder are connected to the third three-phase current set of the protection relay (*Current group 3 type* to be set as "Wnd 2 restraint").

If the double-feeder side is on the input side of the transformer, *Current group 3 type* must be set as "Wnd 1 restraint".

In three-winding transformer applications, currents from winding 3 are always connected to the third three-phase current input set of the protection relay (*Current group 3 type* to be set as "Winding 3").

In the normal two-winding transformer application with one set of three-phase currents on both sides of the transformer, the *Current group 3 type* setting must be set as "Not in use".

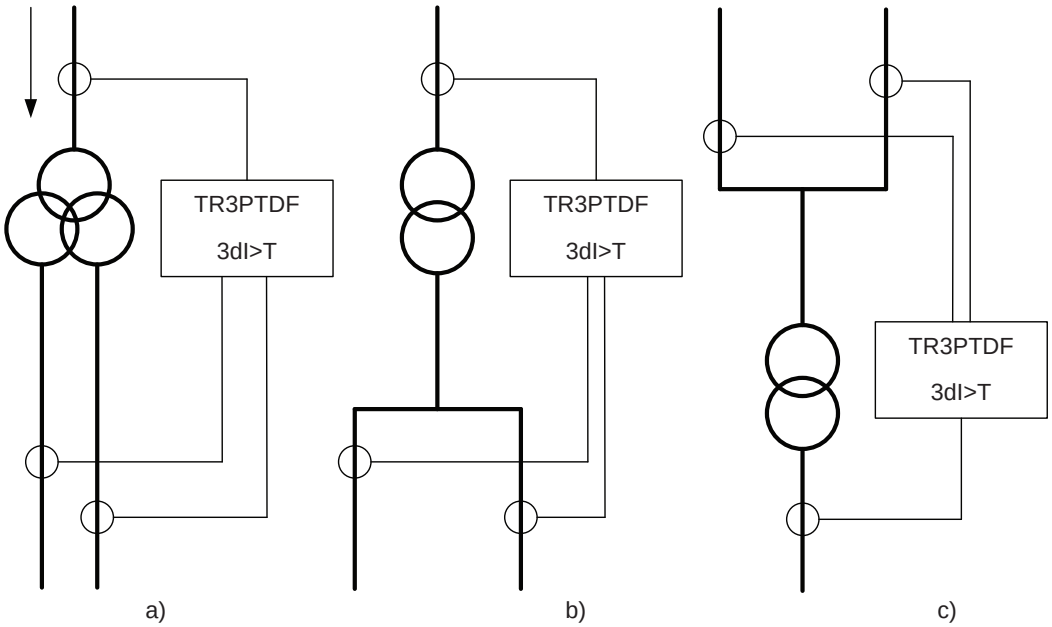



*Figure 418: Differential protection of a three-winding transformer, transformer with two output feeders and transformer with two input feeders*

**Transforming ratio correction of CTs**

The CT secondary currents often differ from the rated current at the rated load of the power transformer. The CT transforming ratios can be corrected on all sides of the power transformer with the CT ratio correction settings.

$$I_{nT} = \frac{S_n}{\sqrt{3} \cdot U_n}$$

(Equation 172)

| | |
|---|---|
| $I_{nT}$ | Rated load of the power transformer |
| $S_n$ | Rated power of the power transformer |
| $U_n$ | Rated phase-to-phase voltage |

**Three-winding transformer with one set of currents on each side of the transformer**

100 MVA YNyn0d1 power transformer 154 kV/14.4 kV/4.37 kV. The corresponding rated currents are 375 A, 3007 A and 3303 A. At the HV side, the CT is 400 A, and on the MV sides both are 4000 A.

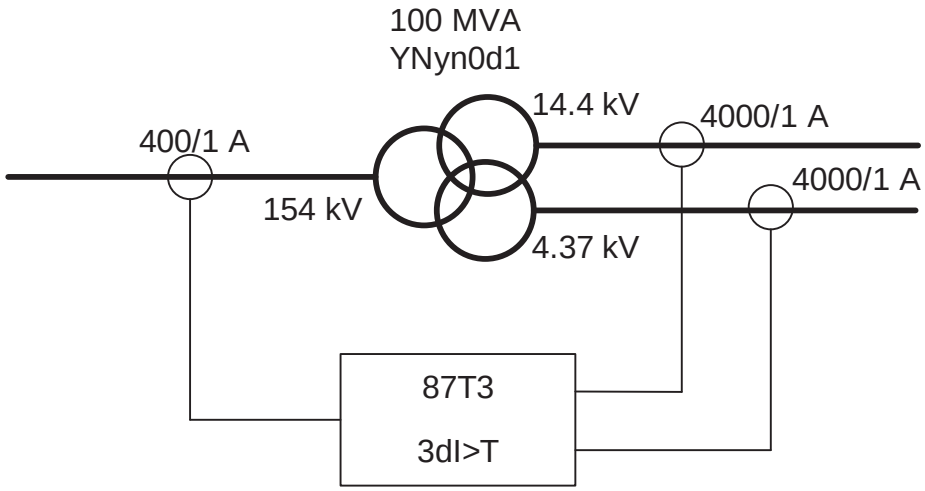



*Figure 419: Example of three-winding power transformer differential protection*

154 kV side: CT ratio correction factor = 400 A / 375 A = 1.07

The rated current 375 A corresponds to a 100 MVA power but on the MV sides 1.732 · 14.4 kV · 3007 A = 75 MVA and 1.732 · 4.37 kV · 3303 A = 25 MVA. Thus, the MV side rated currents cannot be used for calculations.

14.4kV side: CT ratio correction factor = 4000 A / (375 A · 154 kV / 14.4 kV) = 1.00

4.37kV side: CT ratio correction factor = 4000 A / (375 A · 154 kV / 4.37 kV) = 0.30

Assume for example a 50 MVA load on the 14.4 kV side and zero on the 4.37 kV side.

- 154 kV side current = 50 MVA / (1.732 · 154 kV) = 187.45 A

  TR3PTDF sees this as 185.45 A / 400 A · 1.07 = 0.50 xIr
- 14.4 kV side current = 50 MVA / (1.732 · 14.4 kV) = 2004.7 A

  TR3PDF seez this as 2004.7 A / 4000 A · 1.00 = 0.50 xIr

Assume for example a 20 MVA load on the 4.37 kV side and zero on the 14.4 kV side.

- 154kV side current = 20 MVA / (1.732 · 154 kV) = 75.0 A

  TR3PTDF sees this as 75 A / 400 A · 1.07 = 0.20 xIr
- 4.37kV side current = 20 MVA / (1.732 · 4.37 kV) = 2642.3 A

  TR3PTDF sees this as 2642.3 A / 4000 A · 0.30 = 0.20 xIr

**Vector group matching and elimination of the zero-sequence component**

The vector group of the power transformer is numerically matched on the windings on different sides of the transformer by the *Phase shift Wnd 1-2* and *Phase shift Wnd 1-3* settings. Thus no interposing CTs are needed if there is only a power transformer inside the protected zone. The matching is based on phase shifting and a numerical delta connection in the function.

If the neutral of a star-connected power transformer is earthed, any earth fault in the network is perceived by the protection as differential current. The elimination of the zero-sequence component can be selected to be on or off for that winding by the *Zro A elimination* setting. By default, the elimination is done for every winding.

**Commissioning**

The settings for the connection group compensation (*CT connection 1-2*, *Phase shift Wnd 1-2* and, in case of a three-winding transformer, also *CT connection 1-3* and *Phase shift Wnd 1-3* settings) can be verified by monitoring the angle values (I_ANGL_A1_B1, I_ANGL_B1_C1, I_ANGL_C1_A1, I_ANGL_A2_B2, I_ANGL_B2_C2, I_ANGL_C2_A2, I_ANGL_A1_A2, I_ANGL_B1_B2 and I_ANGL_C1_C2 and in case of three-winding transformer also I_ANGL_A3_B3, I_ANGL_B3_C3, I_ANGL_C3_A3, I_ANGL_A1_A3, I_ANGL_B1_B3 and I_ANGL_C1_C3) when injecting the current into the transformer. These angle values are calculated from the compensated currents.

When a station service transformer is available, it can be used to provide current into the winding 1 side, for example, HV windings, while the winding 2 side, for example, LV windings are short-circuited, as shown in *Figure 420* (in case of a three-winding transformer, the tertiary winding side is short-circuited). This way the current can flow both in high-voltage and low-voltage windings (and in winding 3 in case of three-winding transformer). The commissioning signals can also be provided through other means. The currents need to be at least 0.015 pu to allow the phase current and angle monitoring.

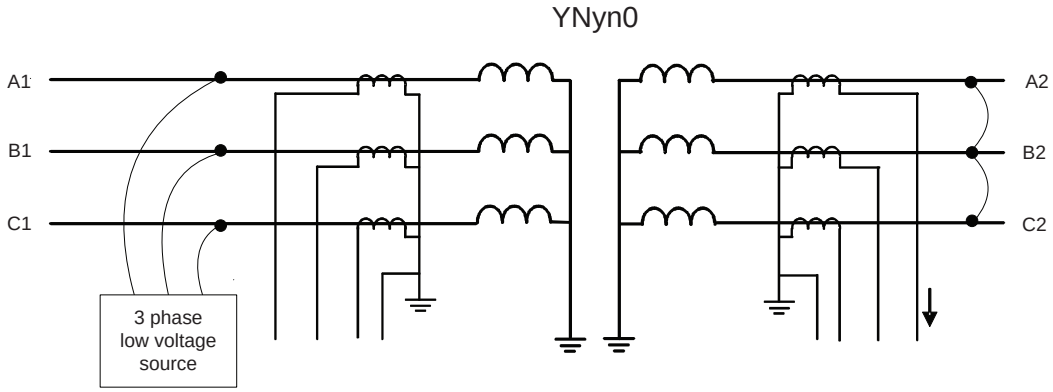



*Figure 420: Low-voltage test arrangement. The three-phase low-voltage source can be the station service transformer, for example*

The control setting *Tapped winding* should be set to value "Not in use" to ensure that the monitored current values are not scaled by the automatic adaptation to the tap changer position. When only the angle values are taken, this is not needed since the angle values are not affected by the tap changer position.

When injecting the currents into the HV winding, the angle values I_ANGL_A1_B1, I_ANGL_B1_C1, I_ANGL_C1_A1, I_ANGL_A2_B2, I_ANGL_B2_C2 and I_ANGL_C2_A2, and in case of three winding transformer, I_ANGL_A3_B3, I_ANGL_B3_C3 and I_ANGL_C3_A3, should be +120.

Otherwise, the phase order may be wrong or the polarity of one current transformer differs from the polarities of the other current transformers on the same side. If the angle values I_ANGL_A1_B1, I_ANGL_B1_C1 and I_ANGL_C1_A1 show -120°, the phase order is wrong on winding 1, for example, the high-voltage side. If the angle values I_ANGL_A2_B2, I_ANGL_B2_C2 and I_ANGL_C2_A2 show -120°, the phase order is wrong on winding 2, for example, the low-voltage side. If the angle values

I_ANGL_A3_B3, I_ANGL_B3_C3 and I_ANGL_C3_A3 show -120°, the phase order is wrong on winding 3, for example, the tertiary side. If the angle values I_ANGL_A1_B1, I_ANGL_B1_C1 and I_ANGL_C1_A1 do not show the same value (+120°), the polarity of one current transformer may be wrong. For example, if the polarity of the current transformer measuring IL2 is wrong, I_ANGL_A1_B1 shows -60°, I_ANGL_B1_C1 shows -60° and I_ANGL_C1_A1 shows +120°.

When the phase order and the angle values are correct, the angle values I_ANGL_A1_A2, I_ANGL_B1_B2 and I_ANGL_C1_C2 should show ±180° and in case of a three-winding transformer, also the angle values I_ANGL_A1_A3, I_ANGL_B1_B3 and I_ANGL_C1_C3 should show ±180°. There can be several reasons if this is not the case. If the angle values are 0, most probably the value given for *CT connection 1-2* (or *CT connection 1-3*) is wrong. If the angle values are something else, the value for *Phase shift Wnd 1-2* or *Phase shift Wnd 1-3* may be wrong.

**Table 667: Angle outputs when settings CT connection 1-2 and CT connection 1-3 match the actual CT connections on windings 1, 2 and 3**

| Angle output name | Angle value | Possible reason if not OK |
|---|---|---|
| I_ANGL_A1_B1 | 120 | OK |
| I_ANGL_B1_C1 | 120 | OK |
| I_ANGL_C1_A1 | 120 | OK |
| I_ANGL_A2_B2 | 120 | OK |
| I_ANGL_B2_C2 | 120 | OK |
| I_ANGL_C2_A2 | 120 | OK |
| I_ANGL_A3_B3 | 120 | OK |
| I_ANGL_B3_C3 | 120 | OK |
| I_ANGL_C3_A3 | 120 | OK |
| I_ANGL_A1_A2 | ±180 | OK |
| I_ANGL_B1_B2 | ±180 | OK |
| I_ANGL_C1_C2 | ±180 | OK |
| I_ANGL_A1_A3 | ±180 | OK |
| I_ANGL_B1_B3 | ±180 | OK |
| I_ANGL_C1_C3 | ±180 | OK |

**Table 668: Angle outputs when settings CT connection 1-2 and CT connection 1-3 match the actual CT connections on windings 1, 2 and 3 but the phase order is wrong on winding 1**

| Angle output name | Angle value | Possible reason if not OK |
|---|---|---|
| I_ANGL_A1_B1 | –120 | Wrong phase order |
| I_ANGL_B1_C1 | –120 | Wrong phase order |
| I_ANGL_C1_A1 | –120 | Wrong phase order |
| I_ANGL_A2_B2 | +120 | OK |
| I_ANGL_B2_C2 | +120 | OK |
| I_ANGL_C2_A2 | +120 | OK |
| I_ANGL_A3_B3 | +120 | OK |
| I_ANGL_B3_C3 | +120 | OK |
| I_ANGL_C3_A3 | +120 | OK |
| I_ANGL_A1_A2 | +60 | Winding 1 phase B connected as phase A |
| I_ANGL_B1_B2 | –60 | Winding 1 phase A connected as phase B |
| I_ANGL_C1_C2 | ±180 | OK |
| I_ANGL_A1_A3 | +60 | Winding 1 phase B connected as phase A |
| I_ANGL_B1_B3 | –60 | Winding 1 phase A connected as phase B |
| I_ANGL_C1_C3 | ±180 | OK |

**Table 669: Angle outputs when settings CT connection 1-2 and CT connection 1-3 match the actual CT connections on windings 1, 2 and 3 but the phase order is wrong on winding 2**

| Angle output name | Angle value | Possible reason if not OK |
|---|---|---|
| I_ANGL_A1_B1 | +120 | OK |
| I_ANGL_B1_C1 | +120 | OK |
| I_ANGL_C1_A1 | +120 | OK |
| I_ANGL_A2_B2 | –120 | Wrong phase order |
| I_ANGL_B2_C2 | –120 | Wrong phase order |
| I_ANGL_C2_A2 | –120 | Wrong phase order |
| I_ANGL_A3_B3 | +120 | OK |
| I_ANGL_B3_C3 | +120 | OK |
| I_ANGL_C3_A3 | +120 | OK |
| I_ANGL_A1_A2 | –60 | Winding 2 phase B connected as phase A |
| I_ANGL_B1_B2 | +60 | Winding 2 phase A connected as phase B |

*Table continues on the next page*

| Angle output name | Angle value | Possible reason if not OK |
|---|---|---|
| I_ANGL_C1_C2 | ±180 | OK |
| I_ANGL_A1_A3 | ±180 | OK |
| I_ANGL_B1_B3 | ±180 | OK |
| I_ANGL_C1_C3 | ±180 | OK |

**Table 670: Angle outputs when settings CT connection 1-2 and CT connection 1-3 match the actual CT connections on windings 1, 2 and 3 but the phase B polarity is wrong compared to other phases on winding 2**

| Angle output name | Angle value | Possible reason if not OK |
|---|---|---|
| I_ANGL_A1_B1 | +120 | OK |
| I_ANGL_B1_C1 | +120 | OK |
| I_ANGL_C1_A1 | +120 | OK |
| I_ANGL_A2_B2 | –60 | Wrong polarity phase B |
| I_ANGL_B2_C2 | –60 | Wrong polarity phase B |
| I_ANGL_C2_A2 | +120 | OK |
| I_ANGL_A3_B3 | +120 | OK |
| I_ANGL_B3_C3 | +120 | OK |
| I_ANGL_C3_A3 | +120 | OK |
| I_ANGL_A1_A2 | ±180 | OK |
| I_ANGL_B1_B2 | 0 | Winding 2, wrong polarity phase B |
| I_ANGL_C1_C2 | ±180 | OK |
| I_ANGL_A1_A3 | ±180 | OK |
| I_ANGL_B1_B3 | ±180 | OK |
| I_ANGL_C1_C3 | ±180 | OK |

### 4.3.3.8 Recommendations for current transformers

The more important the object to be protected, the more attention should be paid to the CTs. Normally, it is not possible to dimension the CTs so that they repeat currents with high DC components without saturating when the residual flux of the current transformer is high. TR3PTDF operates reliably even though the CTs are partially saturated. The purpose of the following current transformer recommendations is to secure the stability of the relay at high through-currents and the quick and sensitive operation of the relay at faults occurring in the protected area where the fault currents can be high.

The accuracy class recommended for CTs to be used with TR3PTDF is 5P, where the limit of the current error at the rated primary current is 1 percent and the limit of the phase displacement is 60 minutes. The limit of the composite error at the rated accuracy limit primary current is 5 percent.

The approximate value of the accuracy limit factor $F_a$ corresponding to the actual CT burden can be calculated on the basis of the rated accuracy limit factor $F_n$ (ALF)

at the rated burden, the rated burden $S_n$, the internal burden $S_{in}$ and the actual burden $S_a$ of the CT.

$$F_a = F_n \cdot \frac{S_{in} + S_n}{S_{in} + S_a}$$

(Equation 173)

**Example 1**

In the example, the rated burden $S_n$ of the CTs 5P20 is 10 VA, the secondary rated current 5A, the internal resistance $R_{in}$ = 0.07 Ω and the accuracy limit factor $F_n$(ALF) corresponding to the rated burden is 20 (5P20). The internal burden of the current transformer is $S_{in}$ = (5 A)$^2$ · 0.07 Ω = 1.75 VA. The input impedance of the relay at a rated current of 5 A is < 20 mΩ. If the measurement conductors have a resistance of 0.113 Ω, the actual burden of the current transformer is $S_a$ =(5 A)2 · (0.113 + 0.020) Ω = 3.33 VA. Thus the accuracy limit factor $F_a$ corresponding to the actual burden is 46.

The CT burden can grow considerably at the rated current of 5 A. At the rated current of 1 A, the actual burden of the current transformer decreases, while the repeatability simultaneously improves.

At faults occurring in the protected area, the fault currents can be very high compared to the rated currents of the CTs. Due to the instantaneous stage of the differential function block, it is enough that during the first cycle, the CTs can repeat the current required for instantaneous tripping.

The CTs should be able to reproduce the asymmetric fault current without saturating within the next 10 ms after the occurrence of the fault, to secure that the operating times of the protection relay comply with the times stated in *Chapter 4.3.3.12 Technical data* .

The accuracy limit factors corresponding to the actual burden of the phase current transformer to be used in differential protection fulfill the requirement of the equation.

$$Fa > K_r \; I_{kmax} \cdot (T_{dc} \cdot \omega \cdot (1 - e^{-\frac{Tm}{Tdc}}) + 1)$$

(Equation 174)

| | |
|---|---|
| $I_{kmax}$ | Maximum through-going fault current (in pu) at which the protection is not allowed to operate |
| $T_{dc}$ | Primary DC time constant related to $I_{kmax}$ |
| ω | Angular frequency, that is, 2 · π · 50 Hz |
| $T_m$ | Time to saturate, that is, the duration of the saturation-free transformation |
| $K_r$ | Remanence factor, 1/(1-r) |

The parameter *r* gives the maximum remanence flux density in the CT core. The value of the parameter *r* depends on the magnetic material used and on the construction of the CT. For example, the value *r* = "0.4" means that the remanence flux density may be 40 percent of the saturation flux density. The manufacturer of the CT should be contacted when an accurate value for the parameter *r* is needed. The value *r* = "0.4" is recommended to be used when an accurate value is not available.

The minimum time to saturate ($T_m$) in TR3PTDF is 10 ms.

Two typical cases considered for the determination of the sufficient accuracy limit factor ($F_a$) are a fault occurring at the substation bus and re-energizing against a fault occurring further down in the network.

**A fault occurring at the substation bus**

The protection must be stable when a fault occurs during a normal operating situation. Re-energizing the transformer against a bus fault leads to very high fault currents and thermal stress. Therefore, re-energizing is not preferred in this case.

With this assumption, the remanence can be neglected.

The maximum through-going fault current $I_{kmax}$ is typically 10 pu for a substation's main transformer. At a short circuit fault close to the supply transformer, the DC time constant ($T_{dc}$) of the fault current is almost the same as that of the transformer, the typical value being 100 ms.

$$F_a > K_r \cdot I_{kmax} \cdot (T_{dc} \cdot \omega \cdot (1 - e^{-\frac{Tm}{Tdc}}) + 1) \approx 40$$

(Equation 175)

| | |
|---|---|
| $I_{kmax}$ | 10 (pu) |
| $T_{dc}$ | 100 (ms) |
| ω | 100π (Hz) |
| $T_m$ | 10 (ms) |
| $K_r$ | 1 |

**Re-energizing against a fault occurring further down in the network**

The protection must be stable during the re-energization against a fault on the line. In this case, the existence of remanence is very probable. In this example, it is 40 percent.

The fault current is now smaller and since the ratio of the resistance to the reactance is greater in this location, having a full DC offset is not possible. Furthermore, the DC time constant ($T_{dc}$) of the fault current is now smaller, here 50 ms.

Assuming a maximum fault current is 30 percent lower than in the bus fault and a DC offset 90 percent of the maximum.

$$F_a > K_r \cdot I_{kmax} \cdot 0.9 \cdot (T_{dc} \cdot \omega \cdot (1 - e^{-\frac{Tm}{Tdc}}) + 1) \approx 40$$

(Equation 176)

| | |
|---|---|
| $I_{kmax}$ | 0.7 · 10 = 7 (pu) |
| $T_{dc}$ | 50 (ms) |
| ω | 100π (Hz) |
| $T_m$ | 10 (ms) |
| $K_r$ | 1/(1-0.4) = 1.6667 |

If the actual burden of the current transformer ($S_a$) in *Equation 173* cannot be reduced enough to provide a sufficient value for $F_a$, there are two alternatives.

- A current transformer with a higher rated burden $S_n$ can be chosen (which also means a higher rated accuracy limit $F_n$) or
- A current transformer with a higher nominal primary current $I1_n$ (but the same rated burden) can be chosen.

**Example 2**

Assuming that the actions according to the current transformer with a higher nominal primary current $I1_n$ (but the same rated burden) are taken to improve the actual accuracy limit factor ($F_a$):

| | |
|---|---|
| $I_{rTR}$ = 1000 A | Rated secondary current of the transformer |
| $I_{rCT}$ = 1500 A | Rated primary current of the CT on the transformer secondary side |
| $F_n$ = 30 | Rated accuracy limit factor of the CT |
| $F_a = (I_{rCT} / I_{rTR}) \cdot F_n$ | Actual accuracy limit factor due to oversizing the CT |

$F_a = (1500/1000) \cdot 30 = 45$

In differential protection it is important that the accuracy limit factors ($F_a$) at both sides of the phase CTs correspond with each other, that is, the burdens of the CTs on both sides should be as equal as possible. If high inrush or start currents with high DC components flow through the protected object when it is connected to the network, special attention should be paid to the performance and the burdens of the CTs and to the settings of the function block.

## 4.3.3.9 Signals

### TR3PTDF Input signals

**Table 671: TR3PTDF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| I3P3 | SIGNAL | - | Three-phase currents 3 |
| BLOCK | BOOLEAN | 0=False | Block |
| BLK_OPR_LS | BOOLEAN | 0=False | Blocks operate outputs from biased stage |
| BLK_OPR_HS | BOOLEAN | 0=False | Blocks operate outputs from instantaneous stage |

**TR3PTDF Output signals**

**Table 672: TR3PTDF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate combined |
| OPR_LS | BOOLEAN | Operate from low set |
| OPR_HS | BOOLEAN | Operate from high set |
| BLKD2H | BOOLEAN | 2nd harmonic restraint block status |
| BLKD5H | BOOLEAN | 5th harmonic restraint block status |
| BLKDWAV | BOOLEAN | Waveform blocking status |

## 4.3.3.10 TR3PTDF Settings

**Table 673: TR3PTDF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| High operate value | 500...3000 | %Ir | 10 | 1000 | Instantaneous stage setting |
| Enable high set | 0=False<br>1=True | | | 1=True | Enable high set stage |
| Low operate value | 5...50 | %Ir | 1 | 20 | Basic setting for biased operation |
| Slope section 2 | 10...50 | % | 1 | 30 | Slope of the second line of the operating characteristics |
| End section 2 | 100...500 | %Ir | 1 | 150 | Turn-point between the second and the third line of the operating characteristics |
| Restraint mode | 5=Waveform<br>6=2.h + waveform<br>8=5.h + waveform<br>9=2.h + 5.h + wav | | | 9=2.h + 5.h + wav | Restraint mode |
| Start value 2.H | 7...20 | % | 1 | 15 | 2. harmonic blocking ratio |
| Start value 5.H | 10...50 | % | 1 | 35 | 5. harmonic blocking ratio |
| Stop value 5.H | 10...50 | % | 1 | 35 | 5. harmonic deblocking ratio |
| Harmonic deblock 2. | 0=False<br>1=True | | | 1=True | 2. harmonic deblocking in case of switch on to fault |
| Harmonic deblock 5. | 0=False<br>1=True | | | 0=False | 5. harmonic deblocking in case of severe overvoltage |

**Table 674: TR3PTDF Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Slope section 3 | 10...100 | % | 1 | 100 | Slope of the third line of the operating characteristics |

**Table 675: TR3PTDF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off/On |
| Current group 3 type | 1=Not in use<br>2=Winding 3<br>3=Wnd 1 restraint<br>4=Wnd 2 restraint | | | 2=Winding 3 | Type of the third set/group of current inputs |
| CT connection 1-2 | 1=Type 1<br>2=Type 2 | | | 1=Type 1 | CT connection type consideration between current groups 1 and 2 |
| CT connection 1-3 | 1=Type 1<br>2=Type 2 | | | 1=Type 1 | CT connection type consideration between current groups 1 and 3 |
| Phase Ref winding | 2=Winding 1<br>3=Winding 2<br>4=Winding 3 | | | 2=Winding 1 | Reference winding for vector group matching |
| Zro A elimination | 1=Not eliminated<br>2=Winding 1<br>3=Winding 2<br>4=Winding 1 and 2<br>5=Winding 3<br>6=Winding 1 and 3<br>7=Winding 2 and 3<br>8=Winding 1, 2, 3 | | | 1=Not eliminated | Elimination of the zero-sequence current |
| Phase shift Wnd 1-2 | 0.0...359.9 | deg | 0.1 | 0.0 | Setting the phase shift between winding 1 and 2 in degrees |
| Phase shift Wnd 1-3 | 0.0...359.9 | deg | 0.1 | 0.0 | Setting the phase shift between winding 1 and 3 in degrees |
| Min winding tap | -36...36 | | 1 | 17 | The tap position number resulting the minimum number of effective winding turns on the side of the transformer where the tap changer is. |
| Max winding tap | -36...36 | | 1 | 0 | The tap position number resulting the maximum number of effective winding turns on the side of the transformer where the tap changer is. |
| Tap nominal | -36...36 | | 1 | 8 | The nominal position of the tap changer resulting the default transformation ratio of the transformer (as if there was no tap changer) |
| Tapped winding | 1=Not in use<br>2=Winding 1 | | | 1=Not in use | The winding where the tap changer is connected to |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 3=Winding 2<br>4=Winding 3 | | | | |
| Step of tap | 0.60...9.00 | % | 0.01 | 1.50 | The percentage change in voltage corresponding one step of the tap changer |
| CT ratio Cor Wnd 1 | 0.20...5.00 | | 0.01 | 1.00 | CT ratio correction, winding 1 |
| CT ratio Cor Wnd 2 | 0.20...5.00 | | 0.01 | 1.00 | CT ratio correction, winding 2 |
| CT ratio Cor 3 | 0.20...5.00 | | 0.01 | 1.00 | CT ratio correction, current group 3 |

### 4.3.3.11 TR3PTDF Monitored data

**Table 676: TR3PTDF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| OPR_A | BOOLEAN | 0=False<br>1=True | | Operate phase A |
| OPR_B | BOOLEAN | 0=False<br>1=True | | Operate phase B |
| OPR_C | BOOLEAN | 0=False<br>1=True | | Operate phase C |
| BLKD2H_A | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase A status |
| BLKD2H_B | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase B status |
| BLKD2H_C | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint block phase C status |
| BLKD5H_A | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase A status |
| BLKD5H_B | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase B status |
| BLKD5H_C | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint block phase C status |
| BLKDWAV_A | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase A status |
| BLKDWAV_B | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase B status |
| BLKDWAV_C | BOOLEAN | 0=False<br>1=True | | Waveform blocking phase C status |
| BLKD2HPHAR | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, combined |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| BLKD2HPHAR_A | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase A |
| BLKD2HPHAR_B | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase B |
| BLKD2HPHAR_C | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint blocking for PHAR LN, phase C |
| BLKD5HPHAR | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, combined |
| BLKD5HPHAR_A | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase A |
| BLKD5HPHAR_B | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase B |
| BLKD5HPHAR_C | BOOLEAN | 0=False<br>1=True | | 5th harmonic restraint blocking for PHAR LN, phase C |
| I_AMPL_A1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase A |
| I_AMPL_B1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase B |
| I_AMPL_C1 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated primary current phase C |
| I_AMPL_A2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase A |
| I_AMPL_B2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase B |
| I_AMPL_C2 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated secondary current phase C |
| I_AMPL_A3 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated tertiary current phase A |
| I_AMPL_B3 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated tertiary current phase B |
| I_AMPL_C3 | FLOAT32 | 0.00...40.00 | xIr | Connection group compensated tertiary current phase C |
| ID_A | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase A |
| ID_B | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase B |
| ID_C | FLOAT32 | 0.00...80.00 | xIr | Differential Current phase C |
| IB_A | FLOAT32 | 0.00...80.00 | xIr | Restraint current phase A |
| IB_B | FLOAT32 | 0.00...80.00 | xIr | Restraint current phase B |
| IB_C | FLOAT32 | 0.00...80.00 | xIr | Restraint current phase C |
| I_2H_RAT_A | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase A |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_2H_RAT_B | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase B |
| I_2H_RAT_C | FLOAT32 | 0.00...1.00 | | Differential current second harmonic ratio, phase C |
| I_5H_RAT_A | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase A |
| I_5H_RAT_B | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase B |
| I_5H_RAT_C | FLOAT32 | 0.00...1.00 | | Differential current fifth harmonic ratio, phase C |
| I_ANGL_A1_B1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, winding 1 |
| I_ANGL_B1_C1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, winding 1 |
| I_ANGL_C1_A1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, winding 1 |
| I_ANGL_A2_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, winding 2 |
| I_ANGL_B2_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, winding 2 |
| I_ANGL_C2_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, winding 2 |
| I_ANGL_A3_B3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, winding 3 |
| I_ANGL_B3_C3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, winding 3 |
| I_ANGL_C3_A3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, winding 3 |
| I_ANGL_A1_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase A |
| I_ANGL_B1_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase B |
| I_ANGL_C1_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 2, phase C |
| I_ANGL_A1_A3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 3, phase A |
| I_ANGL_B1_B3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 3, phase B |
| I_ANGL_C1_C3 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between winding 1 and 3, phase C |
| TR3PTDF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| IL1-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL1 |
| IL2-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL2 |
| IL3-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL3 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| IL1-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL1 |
| IL2-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL2 |
| IL3-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL3 |

#### 4.3.3.12 Technical data

**Table 677: TR3PTDF Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±3.0% of the set value or ±0.002 × $I_n$ | | |
| Start time [1, 2] | | Minimum | Typical | Maximum |
| | Low stage | 30 ms | 35 ms | 40 ms |
| | High stage | 17 ms | 18 ms | 20 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, … | | |

### 4.3.4 Numerically stabilized low-impedance restricted earth-fault protection LREFPNDF (ANSI 87NLI)

#### 4.3.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Numerically stabilized low-impedance restricted earth-fault protection | LREFPNDF | dIoLo> | 87NLI |

#### 4.3.4.2 Function block




*Figure 421: Function block*

[1] Current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz. Injected differential current = 2.0 × set operation value.
[2] Measured with static power output (SPO)

### 4.3.4.3 Functionality

The numerical stabilized low-impedance restricted earth-fault protection function LREFPNDF for a two-winding transformer is based on the numerically stabilized differential current principle. No external stabilizing resistor or non-linear resistor are required.

The fundamental components of the currents are used for calculating the residual current of the phase currents, the neutral current, differential currents and stabilizing currents. The operating characteristics are according to the definite time.

LREFPNDF contains a blocking functionality. The neutral current second harmonic is used for blocking during the transformer inrush situation. It is also possible to block function outputs, timers or the function itself.

### 4.3.4.4 Analog channel configuration

LREFPDIF has two analog group inputs which must be properly configured.

**Table 678: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| IRES | Residual current (measured) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 679: Special conditions**

| Condition | Description |
|---|---|
| IRES measured | The function requires that the current measured from the neutral side is connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of LREFPNDF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

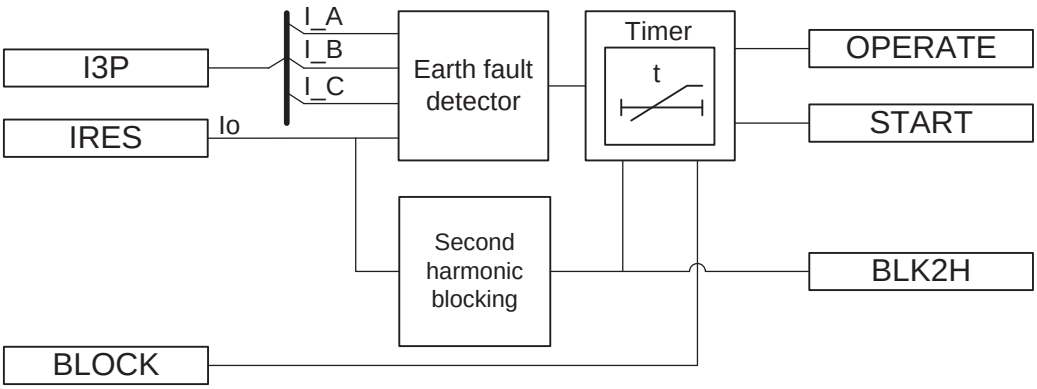



*Figure 422: Functional module diagram*

**Earth-fault detector**

The operation is based on comparing the amplitude and the phase difference between the sum of the fundamental frequency component of the phase currents (ΣI, residual current) and the fundamental frequency component of the neutral current (Io) flowing in the conductor between the transformer or generator's neutral point and earth. The differential current is calculated as the absolute value of the difference between the residual current, that is, the sum of the fundamental frequency components of the phase currents I_A, I_B and I_C, and the neutral current. The directional differential current ID_COSPHI is the product of the differential current and cosϕ. The value is available in the monitored data view.

$$ID_COSPHI = (\left|\overline{\Sigma I} - \overline{Io}\right|) \times \cos\varphi$$

(Equation 177)

$\overline{\Sigma I}$ Residual current

φ Phase difference between the residual and neutral currents

$\overline{Io}$ Neutral current

An earth fault occurring in the protected area, that is, between the phase CTs and the neutral connection CT, causes a differential current. The directions, that is, the phase difference of the residual current and the neutral current, are considered in the operation criteria to maintain selectivity. A correct value for *CT connection type* is determined by the connection polarities of the current transformer.

The current transformer ratio mismatch between the phase current transformer and neutral current transformer (residual current in the analog input settings) is taken into account by the function with the properly set analog input setting values.

During an earth fault in the protected area, the currents ΣI and Io are directed towards the protected area. The factor cosϕ is 1 when the phase difference of the residual current and the neutral current is 180 degrees, that is, when the currents are in opposite direction at the earth faults within the protected area. Similarly, ID_COSPHI is specified to be 0 when the phase difference between the residual current and the neutral current is less than 90 degrees in situations where there is

no earth fault in the protected area. Thus tripping is possible only when the phase difference between the residual current and the neutral current is above 90 degrees.

The stabilizing current IB used by the stabilizing current principle is calculated as an average of the phase currents in the windings to be protected. The value is available in the monitored data view.

$$IB = \frac{\left|\overline{I_A}\right| + \left|\overline{I_B}\right| + \left|\overline{I_C}\right|}{3}$$

(Equation 178)

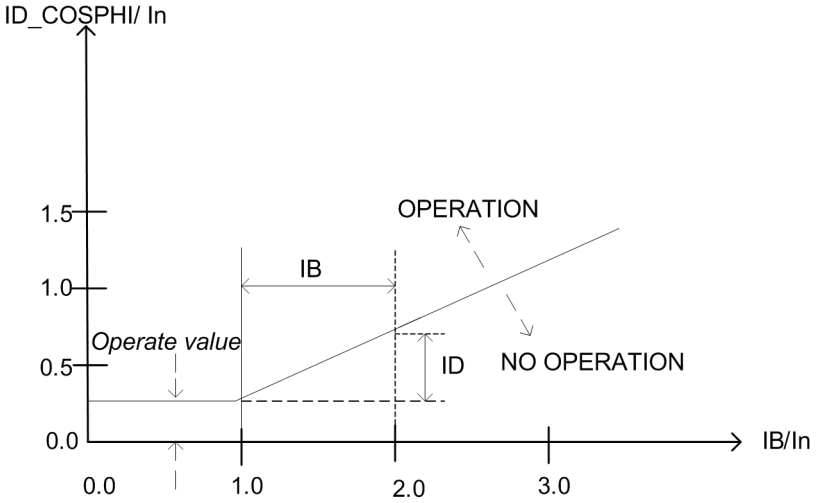



*Figure 423: Operating characteristics of the stabilized earth-fault protection function*

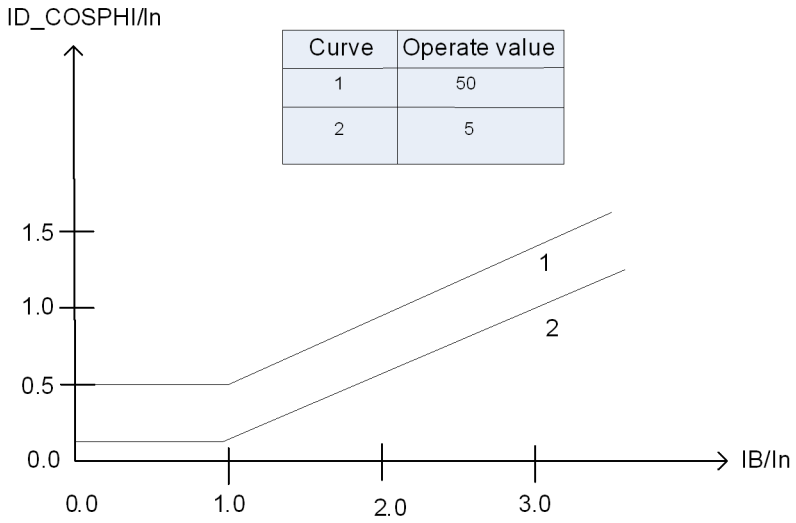



*Figure 424: Setting range of the operating characteristics for the stabilized differential current principle of the earth-fault protection function*

The *Operate value* setting is used for defining the characteristics of the function. The differential current value required for tripping is constant at the stabilizing current values 0.0 < IB/In < 1.0, where In is the nominal current, and the In in this context refers to the nominal of the phase current inputs. When the stabilizing

current is higher than 1.0, the slope of the operation characteristic (ID/IB) is constant at 50 percent. Different operating characteristics are possible based on the *Operate value* setting.

For the protection of the trip, the measured neutral current has to be above 4 percent. When the condition has been fulfilled, the measured neutral current must stay above 2 percent, otherwise reset time is started.

To calculate the directional differential current ID_COSPHI, the fundamental frequency amplitude of both the residual and neutral currents has to be above 4 percent of In. If neither or only one condition is fulfilled at a time, the cosϕ term is forced to 1. After the conditions are fulfilled, both currents must stay above 2 percent of In to allow the continuous calculation of the cosϕ term.

**Second harmonic blocking**

This module compares the ratio of the current second harmonic ($I_0$_2H) and fundamental component of $I_0$ to the set value *Start value 2.H*. If the ratio ($I_0$_2H / $I_0$) value exceeds the set value, the BLK2H output is activated.

The blocking also prevents unwanted operation at the recovery and sympathetic magnetizing inrushes. At the recovery inrush, the magnetizing current of the transformer to be protected increases momentarily when the voltage returns to normal after the clearance of a fault outside the protected area. The sympathetic inrush is caused by the energization of a transformer running in parallel with the protected transformer connected to the network.

The second harmonic blocking is disabled when *Restraint mode* is set to "None" and enabled when set to "Harmonic2".

**Timer**

Once activated, the Timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Minimum operate time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the reset timer resets and the START output is deactivated.

The Timer calculates the start duration value START_DUR which indicates the percentage ratio of the start situation and the set operate time. The value is available through the Monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated. The activation of the output of the second harmonic blocking signal BLK2H deactivates the OPERATE output.

### 4.3.4.6 Application

An earth-fault protection using an overcurrent element does not adequately protect the transformer winding in general and the star-connected winding in particular.

The restricted earth-fault protection is mainly used as a unit protection for the transformer windings. LREFPNDF is a sensitive protection applied to protect the star-connected winding of a transformer. This protection system remains stable for all the faults outside the protected zone.

LREFPNDF provides higher sensitivity for the detection of earth faults than the overall transformer differential protection. This is a high-speed unit protection scheme applied to the star-connected winding of the transformer. LREFPNDF is normally applied when the transformer is earthed solidly or through low-impedance resistor (NER). LREFPNDF can be also applied on the delta side of the transformer if an earthing transformer (zig-zag transformer) is used there. In LREFPNDF, the difference of the fundamental component of all three phase currents and the neutral current is provided to the differential element to detect the earth fault in the transformer winding based on the numerical stabilized differential current principle.

#### Connection of current transformers

The connections of the primary current transformers are designated as "Type 1" and "Type 2".

- If the positive directions of the winding 1 and winding 2 protection relay currents are opposite, the *CT connection type* setting parameter is "Type 1". The connection examples of "Type 1" are as shown in figures *Figure 425* and *Figure 426*.
- If the positive directions of the winding 1 and winding 2 protection relay currents equate, the *CT connection type* setting parameter is "Type 2". The connection examples of "Type 2" are as shown in figures *Figure 427* and *Figure 428*.
- The default value of the *CT connection type* setting is "Type 1".

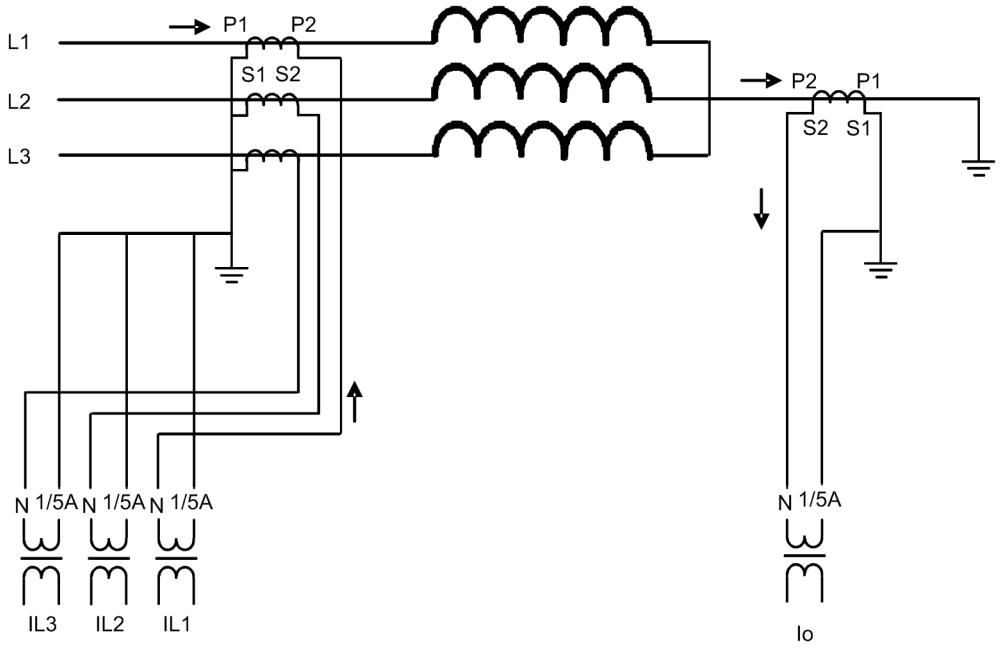



*Figure 425: Connection of the current transformers of Type 1. The connected phase currents and the neutral current have opposite directions at an external earth-fault situation.*

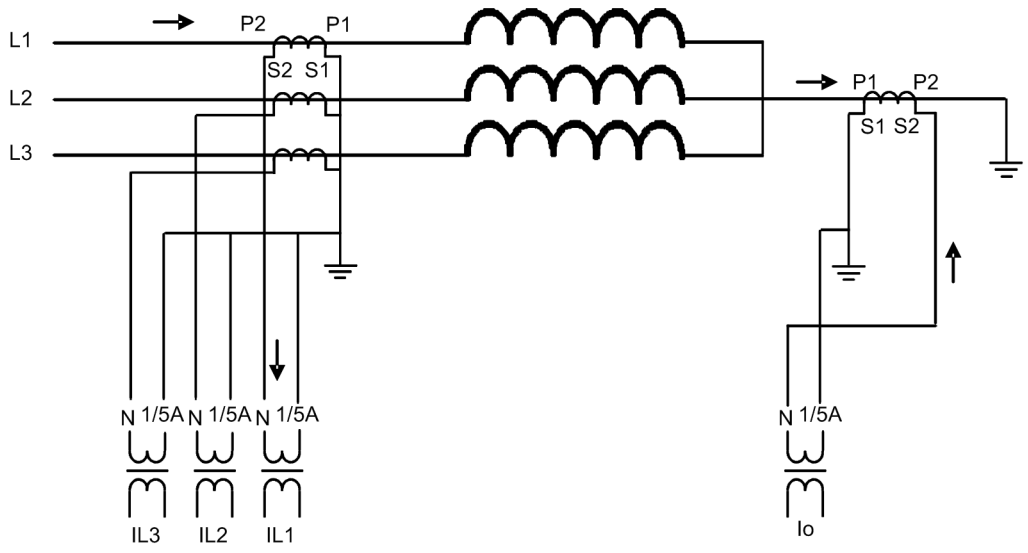



*Figure 426: Connection of the current transformers of Type 1. The connected phase currents and the neutral current have opposite directions at an external earth-fault situation.*

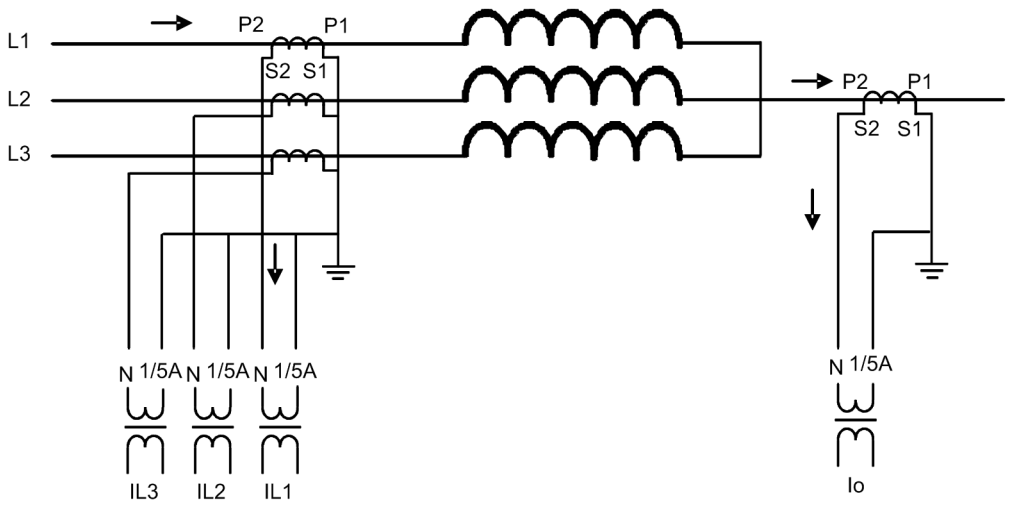



*Figure 427: Connection of the current transformers of Type 2. The phase currents and the neutral current have equal directions at an external earth-fault situation.*

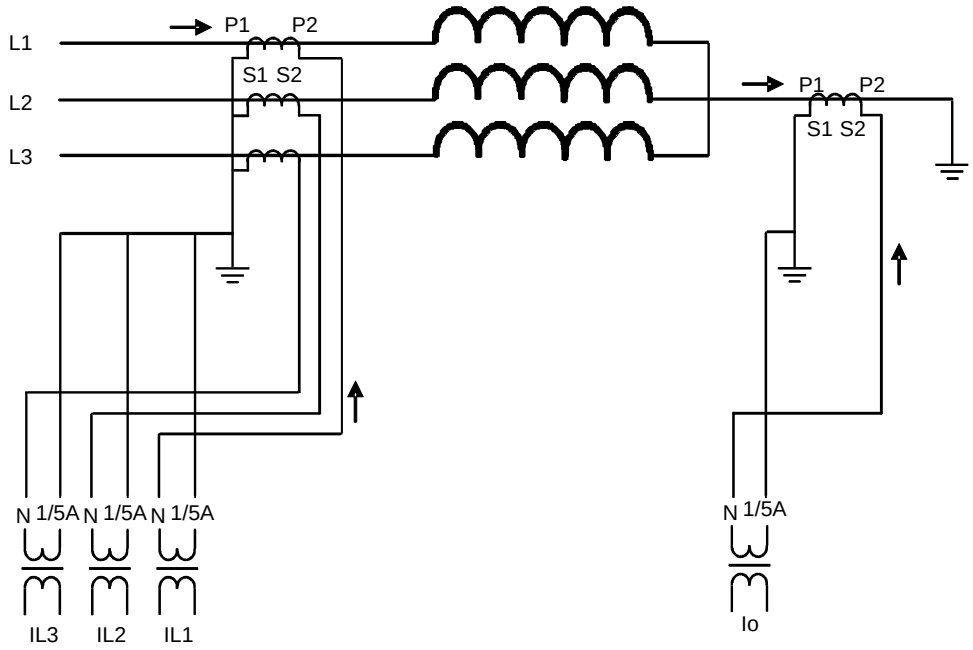



*Figure 428: Connection of the current transformers of Type 2. The phase currents and the neutral current have equal directions at an external earth-fault situation.*

### Internal and external faults

LREFPNDF does not respond to any faults outside the protected zone. An external fault is detected by checking the phase angle difference of the neutral current and the sum of the phase currents. When the difference is less than 90 degrees, the operation is internally restrained or blocked. Hence the protection is not sensitive to an external fault. *Figure 429* and *Figure 430* are valid for CT connection type 1.

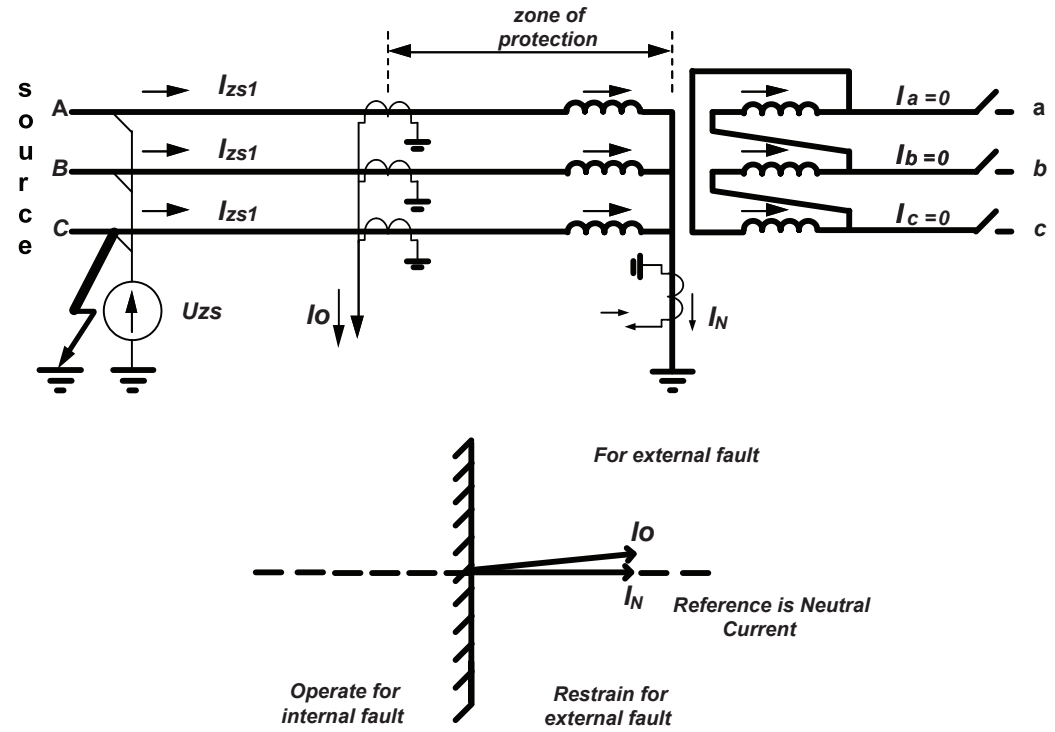



*Figure 429: Current flow in all the CTs for an external fault*

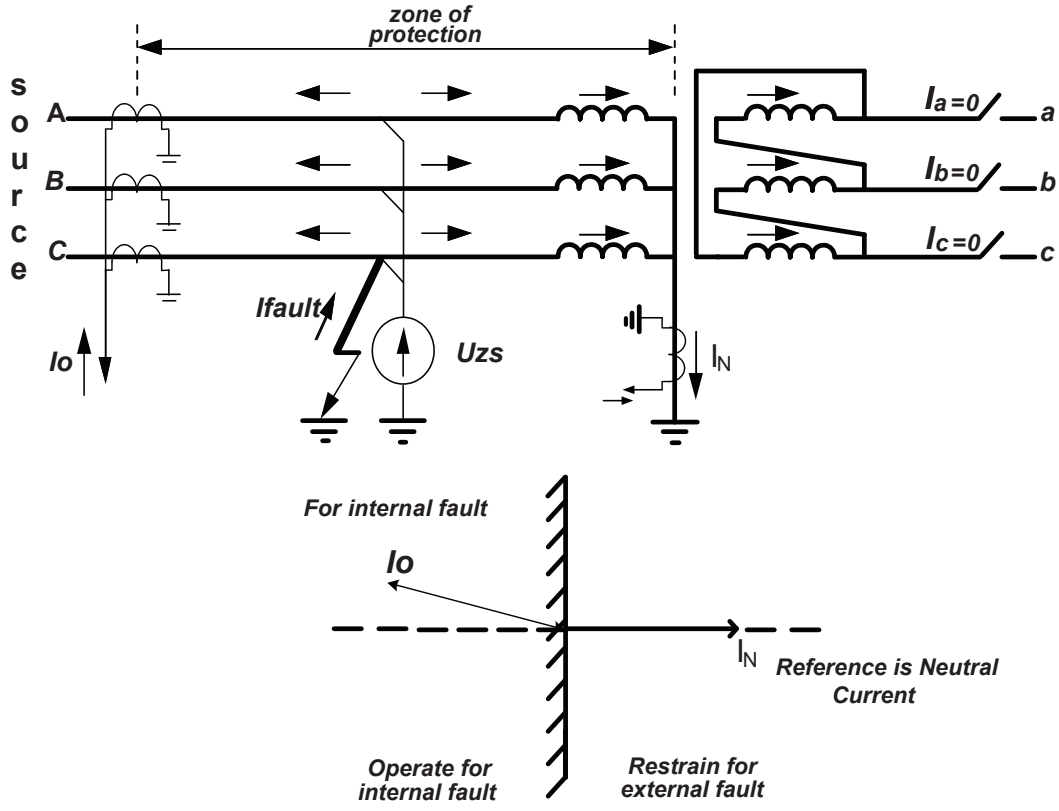



*Figure 430: Current flow in all the CTs for an internal fault*

LREFPNDF does not respond to phase-to-phase faults either, as in this case the fault current flows between the two line CTs and so the neutral CT does not experience this fault current.

**Blocking based on the second harmonic of the neutral current**

The transformer magnetizing inrush currents occur when the transformer is energized after a period of de-energization. The inrush current can be many times the rated current, and the halving time can be up to several seconds. For the differential protection relay, the inrush current represents the differential current, which causes the protection relay to operate almost always when the transformer is connected to the network. Typically, the inrush current contains a large amount of second harmonics.

The blocking also prevents unwanted operation at the recovery and sympathetic magnetizing inrushes. At the recovery inrush, the magnetizing current of the transformer to be protected increases momentarily when the voltage returns to normal after the clearance of a fault outside the protected area. The sympathetic inrush is caused by the energization of a transformer running in parallel with the protected transformer already connected to the network.

Blocking the starting of the restricted earth-fault protection at the magnetizing inrush is based on the ratio of the second harmonic and the fundamental frequency amplitudes of the neutral current Io_2H / Io. Typically, the second harmonic content of the neutral current at the magnetizing inrush is higher than that of the phase currents.

### 4.3.4.7 Signals

**LREFPNDF Input signals**

**Table 680: LREFPNDF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**LREFPNDF Output signals**

**Table 681: LREFPNDF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| BLKD2H | BOOLEAN | 2nd harmonic block |

### 4.3.4.8 LREFPNDF Settings

**Table 682: LREFPNDF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 5.0...50.0 | %In | 1.0 | 5.0 | Operate value |

**Table 683: LREFPNDF Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 40...300000 | ms | 1 | 40 | Minimum operate time |
| Restraint mode | 1=None<br>2=Harmonic2 | | | 1=None | Restraint mode |
| Start value 2.H | 10...50 | % | 1 | 50 | The ratio of the 2. harmonic to fundamental component required for blocking |

**Table 684: LREFPNDF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| CT connection type | 1=Type 1<br>2=Type 2 | | | 2=Type 2 | CT connection type |

**Table 685: LREFPNDF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.3.4.9 LREFPNDF Monitored data

**Table 686: LREFPNDF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| RES2H | BOOLEAN | 0=False<br>1=True | | 2nd harmonic restraint |
| ID_COSPHI | FLOAT32 | 0.00...80.00 | xIn | Directional differential current Id cosphi |
| IB | FLOAT32 | 0.00...80.00 | xIn | Bias current |
| LREFPNDF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.3.4.10 Technical data

**Table 687: LREFPNDF Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±2.5% of the set value or ±0.002 x $I_n$ | | |
| Start time [1, 2] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Operate value* | 37 ms | 41 ms | 45 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, … | | |

## 4.3.5 High-impedance based restricted earth-fault protection HREFPDIF (ANSI 87NHI)

### 4.3.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| High-impedance based restricted earth-fault protection | HREFPDIF | dIoHi> | 87NHI |

### 4.3.5.2 Function block




*Figure 431: Function block*

### 4.3.5.3 Functionality

The high-impedance based restricted earth-fault protection function HREFPDIF is used for the restricted earth-fault protection of generators and power transformers.

The function starts when the differential neutral current exceeds the set limit. HREFPDIF operates with the DT characteristic.

[1] Current before fault = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements

[2] Includes the delay of the signal output contact

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.3.5.4 Analog channel configuration

HREFPDIF has one analog group input which must be properly configured.

**Table 688: Analog inputs**

| Input | Description |
|---|---|
| IRES | Residual current (measured) |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of HREFPDIF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

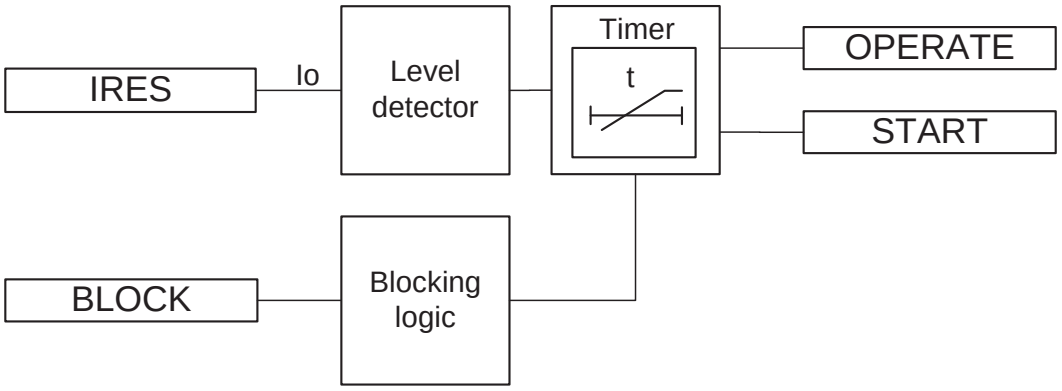



*Figure 432: Functional module diagram*

#### Level detector

The level detector compares the differential neutral current IDo to the set value of the *Operate value* setting. If the differential neutral current exceeds the *Operate value* setting, the level detector sends an enable signal to the timer module to start the definite timer.

**Timer**

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Minimum operate time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the ratio of the start situation and the set operation time. The value is available in the monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration/System/ Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.3.5.6 Application

In solidly earthed systems, the restricted earth-fault protection is always deployed as a complement to the normal transformer differential protection. The advantage of the restricted earth-fault protection is its high sensitivity. Sensitivities of close to 1.0 percent can be achieved, whereas normal differential protection relays have their minimum sensitivity in the range of 5 to 10 percent. The level for HREFPDIF is dependent on the current transformers' magnetizing currents. The restricted earth-fault protection is also very fast due to the simple measuring principle as it is a unit type of protection.

The differences in measuring principle limit the biased differential protection relay's possibility to detect the earth faults. Such faults are then only detected by the restricted earth-fault function.

The restricted earth-fault protection relay is connected across each directly or to low-ohmic earthed transformer winding. If the same CTs are connected to other protection relays,, separate cores are to be used.

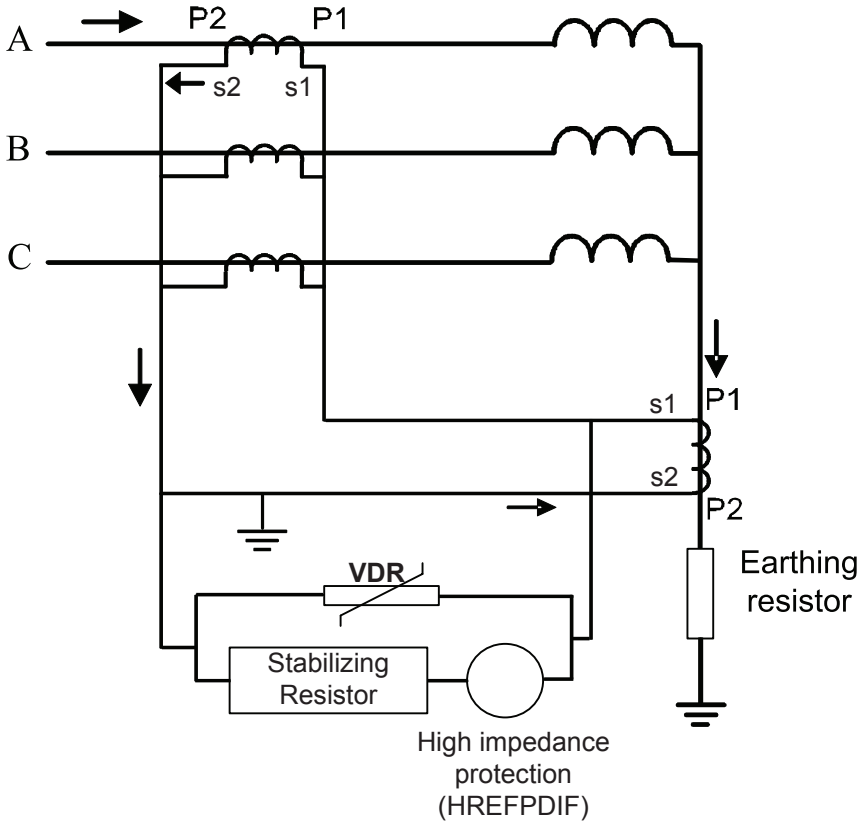



*Figure 433: Connection scheme for the restricted earth-fault protection according to the high-impedance principle*

**High-impedance principle**

High-impedance principle is stable for all types of faults outside the zone of protection. The stabilization is obtained by a stabilizing resistor in the differential circuit. This method requires that all the CTs used have a similar magnetizing characteristic, same ratio and relatively high knee point voltage. CTs on each sides are connected in parallel along with a relay-measuring branch as shown in *Figure 434*. The measuring branch is a series connection of stabilizing resistor and protection relay.

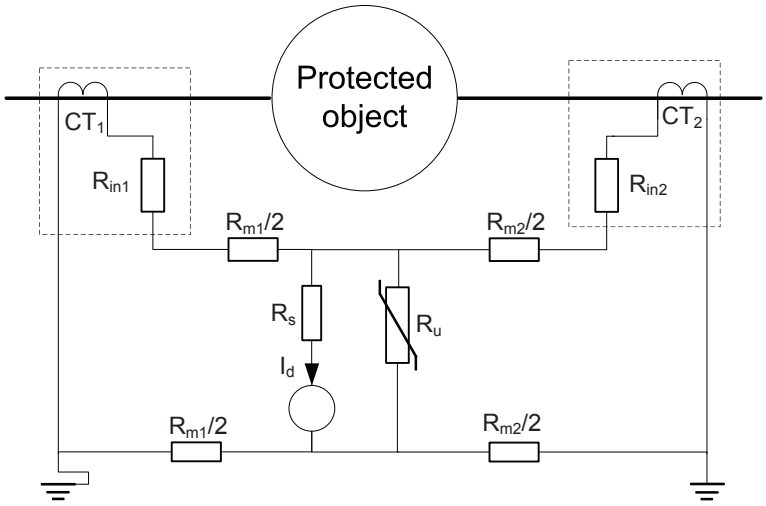



*Figure 434: High-impedance principle*

The stability of the protection is based on the use of the stabilizing resistor (Rs) and the fact that the impedance of the CT secondary quickly decreases as the CT saturates. The magnetization reactance of a fully saturated CT goes to zero and the impedance is formed only by the resistance of the winding ($R_{in}$) and lead resistance ($R_m$).

The CT saturation causes a differential current which now has two paths to flow: through the saturated CT because of the near-zero magnetizing reactance and through the measuring branch. The stabilizing resistor is selected as such that the current in the measuring branch is below the relay operating current during out-of-zone faults. As a result, the operation is stable during the saturation and can still be sensitive at the non-saturated parts of the current waveform as shown in *Figure 435*.

In case of an internal fault, the fault current cannot circulate through the CTs but it flows through the measuring branch and the protection operates. Partial CT saturation can occur in case of an internal fault, but the non-saturated part of the current waveform causes the protection to operate.

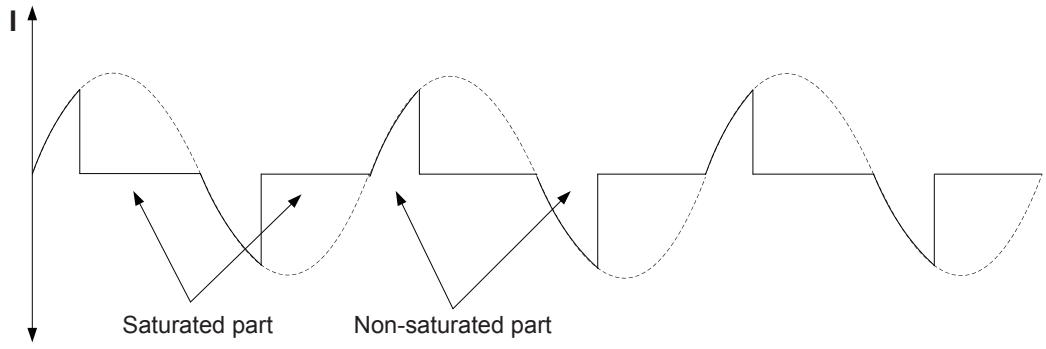



*Figure 435: Secondary waveform of a saturated CT*

At internal fault, the secondary circuit voltage can easily exceed the isolation voltage of the CTs, connection wires and IED. To limit this voltage, a voltage-dependent resistor VDR is used as shown in *Figure 434*.

The whole scheme, that is, the stabilizing resistor, voltage-dependent resistor and wiring, must be adequately maintained (operation- and insulation-tested regularly) to be able to withstand the high-voltage pulses which appear during an internal fault throughout the lifetime of the equipment. Otherwise, during a fault within the zone of protection, any flashover in the CT secondary circuits or in any other part of the scheme may prevent a correct operation of the high-impedance differential function.

### 4.3.5.7 The measuring configuration

The external measuring configuration is composed of four current transformers measuring the currents and a stabilizing resistor. A varistor is needed if high overvoltages are expected.

The value of the stabilizing resistor is calculated with the formula:

$$R_s = \frac{U_s}{I_{rs}}$$

(Equation 179)

| | |
|---|---|
| $R_s$ | the resistance of the stabilizing resistor |
| $U_s$ | the stabilizing voltage of the IED |
| $I_{rs}$ | the value of the *Low operate value* setting |

The stabilizing voltage is calculated with the formula:

$$U_s = \frac{I_{k\max}}{n}(R_{in} + R_m)$$

(Equation 180)

| | |
|---|---|
| $I_{kmax}$ | the highest through-fault current |
| n | the turns ratio of the CT |
| $R_{in}$ | the secondary internal resistance of the CT |
| $R_m$ | the resistance of the longest loop of secondary circuit |

Additionally, it is required that the current transformers' knee-point voltages $U_k$ are at least twice the stabilizing voltage value $U_s$.

### 4.3.5.8 Recommendations for current transformers

The sensitivity and reliability of the protection depends a lot on the characteristics of the current transformers. The CTs must have an identical transformation ratio. It is recommended that all current transformers have an equal burden and characteristics and are of same type, preferably from the same manufacturing batch, that is, an identical construction should be used. If the CT characteristics and burden values are not equal, calculation for each branch in the scheme should be done separately and the worst-case result is then used.

First, the stabilizing voltage, that is, the voltage appearing across the measuring branch during the out-of-zone fault, is calculated assuming that one of the parallel connected CT is fully saturated. The stabilizing voltage can be calculated with the formula

$$U_s = \frac{I_{k\max}}{n}(R_{in} + R_m)$$

(Equation 181)

| | |
|---|---|
| $I_{kmax}$ | the highest through-fault current in primary amps. The highest earth-fault or short circuit current during the out-of-zone fault. |
| n | the turns ratio of the CT |
| $R_{in}$ | the secondary internal resistance of the CT in ohms |
| $R_m$ | the resistance (maximum of $R_{in}$ + $R_m$) of the CT secondary circuit in ohms |

The current transformers must be able to force enough current to operate the protection relay through the differential circuit during a fault condition inside the zone of protection. To ensure this, the knee point voltage $U_{kn}$ should be at least two times higher than the stabilizing voltage $U_s$.

The required knee point voltage $U_{kn}$ of the current transformer is calculated using the formula

$$U_{kn} \geq 2 \times U_s$$

(Equation 182)

| | |
|---|---|
| $U_{kn}$ | the knee point voltage |
| $U_s$ | the stabilizing voltage |

The factor two is used when no delay in the operating time of the protection in any situation is acceptable. To prevent the knee point voltage from growing too high, it is advisable to use current transformers, the secondary winding resistance of which is of the same size as the resistance of the measuring loop.

As the impedance of the protection relay alone is low, a stabilizing resistor is needed. The value of the stabilizing resistor is calculated with the formula

$$R_s = \frac{U_s}{I_{rs}}$$

(Equation 183)

| | |
|---|---|
| $R_s$ | the resistance of the stabilizing resistor |
| $U_s$ | the stabilizing voltage of the protection relay |
| $I_{rs}$ | the value of the *Operate value* setting in secondary amps. |

The stabilizing resistor should be capable to dissipate high energy within a very short time; therefore, the wire wound-type resistor should be used. Because of the possible CT inaccuracy, which might cause some current through the stabilizing resistor in a normal load situation, the rated power should be 25 W minimum.

If $U_{kn}$ is high or the stabilizing voltage is low, a resistor with a higher power rating is needed. Often resistor manufacturers allow 10 times rated power for 5 seconds. Thus the power of the resistor can be calculated with the equation

$$\frac{U_{kn}^2}{R_s \times 10}$$

(Equation 184)

The actual sensitivity of the protection is affected by the protection relay setting, the magnetizing currents of the parallel connected CTs and the shunting effect of the voltage-dependent resistor ( VDR). The value of the primary current $I_{prim}$ at which the protection relay operates at a certain setting can be calculated with the formula

$$I_{prim} = n \times (I_{rs} + I_u + m \times I_m)$$

(Equation 185)

| | |
|---|---|
| $I_{prim}$ | the primary current at which the protection is to start |
| n | the turn ratio of the current transformer |
| $I_{rs}$ | the value of the *Operate value* setting |
| $I_u$ | the leakage current flowing through the VDR at the $U_s$ voltage |
| m | the number of current transformers included in the protection per phase (=4) |
| $I_m$ | the magnetizing current per current transformer at the $U_s$ voltage |

The $I_e$ value given in many catalogs is the excitation current at the knee point voltage. Assuming $U_{kn} \approx 2 \times U_s$, the value of $I_m \approx \frac{I_e}{2}$ gives an approximate value for *Equation 185*.

The selection of current transformers can be divided into procedures:

1. In principle, the highest through-fault should be known. However, when the necessary data are not available, approximates can be used:
   - Small power transformers: $I_{kmax} = 16 \times I_n$ (corresponds to $z_k = 6\%$ and infinite grid)
   - Large power transformers: $I_{kmax} = 12 \times I_n$ (corresponds to $z_k = 8\%$ and infinite grid)
   - Generators and motors: $I_{kmax} = 6 \times I_n$

   Where $I_n$ = rated current and $z_k$ = short circuit impedance of the protected object
2. The rated primary current $I_{1n}$ of the CT has to be higher than the rated current of the machine.

   The choice of the CT also specifies $R_{in}$.
3. The required $U_{kn}$ is calculated with *Equation 182*. If the $U_{kn}$ of the CT is not high enough, another CT has to be chosen. The value of the $U_{kn}$ is given by the manufacturer in the case of Class X current transformers or it can be estimated with *Equation 186*.
4. The sensitivity $I_{prim}$ is calculated with *Equation 185*. If the achieved sensitivity is sufficient, the present CT is chosen. If a better sensitivity is needed, a CT with a bigger core is chosen.

If other than Class X CTs are used, an estimate for $U_{kn}$ is calculated with the equation

$$U_{kn} = 0.8 \times F_n \times I_{2n} \times \left( R_{in} + \frac{S_n}{I_{2n}^2} \right)$$

(Equation 186)

| | |
|---|---|
| $F_n$ | the rated accuracy limit factor corresponding to the rated burden $S_n$ |
| $I_{2n}$ | the rated secondary current of the CT |
| $R_{in}$ | the secondary internal resistance of the CT |
| $S_n$ | the volt-amp rating of the CT |

The formulas are based on choosing the CTs according to *Equation 182*, which results an absolutely stable scheme. In some cases, it is possible to achieve stability with knee point voltages lower than stated in the formulas. The conditions in the network, however, have to be known well enough to ensure the stability.

1. If $U_k \geq 2 \times U_s$, fast protection relay operation is secure.
2. If $U_k \geq 1.5 \times U_s$ and $< 2 \times U_s$, protection relay operation can be slightly prolonged and should be studied case by case.

   If $U_k < 1.5 \times U_s$, the protection relay operation is jeopardized. Another CT has to be chosen.

The need for the VDR depends on certain conditions.

First, voltage $U_{max}$, ignoring the CT saturation during the fault, is calculated with the equation

$$U_{max} = \frac{I_{k\,max\,in}}{n} \times \left( R_{in} + R_m + R_s \right) \approx \frac{I_{k\,max\,in}}{n} \times R_s$$

(Equation 187)

| | |
|---|---|
| $I_{kmaxin}$ | the maximum fault current inside the zone, in primary amps |
| n | the turns ration of the CT |
| $R_{in}$ | the internal resistance of the CT in ohms |
| $R_m$ | the resistance of the longest loop of the CT secondary circuit, in ohms |
| $R_s$ | the resistance of the stabilized resistor, in ohms |

Next, the peak voltage û, which includes the CT saturation, is estimated with the formula (given by P.Mathews, 1955)

$$\hat{u} = 2\sqrt{2U_{kn}\left(U_{max} - U_{kn}\right)}$$

(Equation 188)

| | |
|---|---|
| $U_{kn}$ | the knee point voltage of the CT |

The VDR is recommended when the peak voltage û ≥ 2kV, which is the insulation level for which the protection relay is tested.

If $R_s$ was smaller, the VDR could be avoided. However, the value of $R_s$ depends on the protection relay operation current and stabilizing voltage. Thus, either a higher setting must be used in the protection relay or the stabilizing voltage must be lowered.

### 4.3.5.9 Setting examples

**Example 1**

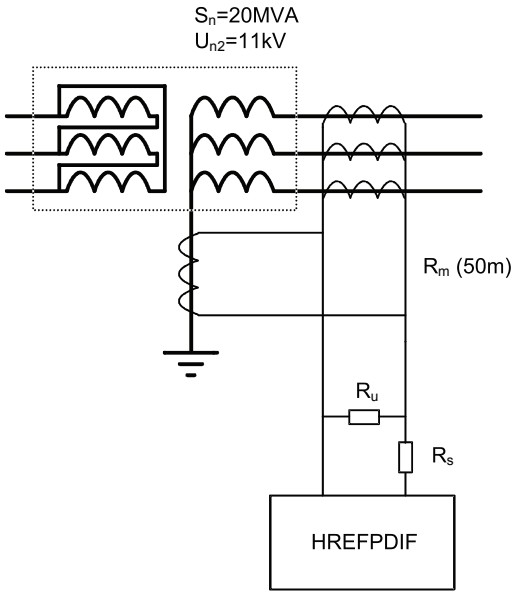



*Figure 436: Restricted earth-fault protection of a transformer*

The data for the protected power transformer are:

$S_n$ = 20 MVA

$U_{2n}$ = 11 kV

The longest distance of the secondary circuit is 50 m (the whole loop is 100 m) and the area of the cross section is 10 $mm^2$.

$I_n = S_n / (\sqrt{3} \cdot U_n)$ = 1050 A

$I_{kmax} = 12 \cdot I_n$= 12600 A

In this example, the CT type is IHBF 12, the core size is 35 percent, the primary current is 1200 A and the secondary current is 5 A.

$R_{in}$ = 0.26 Ω (value given by the manufacturer).

$U_k$ = 40 V (value given by the manufacturer).

$I_e$ = 0.055 A (value given by the manufacturer).

$R_m$ = 1.81 Ω/km · 2 · 0.05 km = 0.181 Ω ≈ 0.18 Ω

$$U_s = \frac{12600 \times (0.26 + 0.18)}{240} V \approx 23V$$

According to the criterion, the value of $U_k$ should be $2 \cdot U_s = 2 \cdot 23$ V = 46 V. It depends on if the stability of the scheme is achieved with $U_k$ = 40 V. Otherwise, it is possible to choose a bigger core of 65 percent with:

$R_{in}$ = 0.47 Ω (value given by the manufacturer).

$U_k$ = 81 V (value given by the manufacturer).

$R_m$ = 0.18 Ω

$$U_s = \frac{12600 \times (0.47 + 0.18)}{240} V \approx 34 V$$

$U_k = 2 \cdot U_s = 68$ V (required value).

As mentioned earlier, $I_m = 0.5 \cdot I_e$ gives a realistic value for $I_{prim}$ in *Equation 185*. If $I_u = 0$ and $I_{rs} = m \cdot 0.5 \cdot I_o$, the value for the sensitivity is:

$I_{prim} = n \cdot m \cdot I_e = 240 \cdot 4 \cdot 0.055$ A ≈ 53 A

$I_{rs} = 4 \cdot 0.5 \cdot 0.055$ A = 0.11 A

The setting value can be calculated with:

$$Operate\ value = \left( \frac{I_{rs}}{I_{CT_n2}} \right) = \left( \frac{0.11 A}{5 A} \right) \approx 2.2\%$$

The resistance of the stabilizing resistor can be calculated:

$R_s = U_s / I_{rs} = 34$ V / 0.11 A ≈ 309 Ω

However, the sensitivity can be calculated more accurately when the actual values of $I_u$ and $I_{rs}$ are known. The stabilizing resistor of the relay is chosen freely in the above example and it is assumed that the resistor value is not fixed.

**Example 2a**

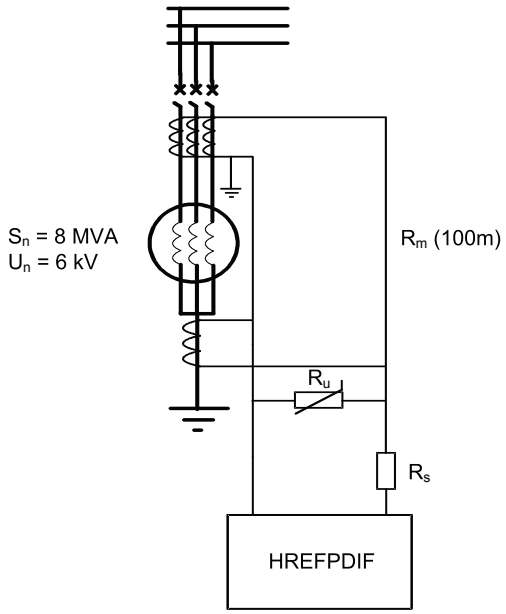



*Figure 437: Restricted earth-fault protection of a generator*

In the protected generator:

$S_n = 8$ MVA

$U_n = 6$ kV.

$I_n$ = 770 A

$I_{kmax} = 6 \cdot I_n = 6 \cdot 770$ A = 4620 A

In this example, the CT type is KOFD 12 A 21 with:

$I_{CT_1n}$ = 1000 A (value given by the manufacturer).

$I_{CT_2n}$ = 1 A (value given by the manufacturer).

$U_k$ = 323 V (value given by the manufacturer).

$R_{in}$ = 15.3 Ω (value given by the manufacturer).

$I_e$ = 0.012 A (value given by the manufacturer).

If the length of the secondary circuit is 100 m (the whole loop is 200 m) and the area of the cross section is 2.5 $mm^2$:

$R_m = 7.28\ \Omega/km \cdot 2 \cdot 0.1\ km \approx 1.46\ \Omega$

The required knee-point voltage can be calculated using equation

$U_k = 2 \cdot ( 4620\ A / 1000 ) \cdot ( 15.3 + 1.46 ) \approx 155$ V.

The value 155 V is lower than the value 323 V, which means that the value of $U_k$ is high enough.

As mentioned earlier, $I_m = 0.5 \cdot I_e$ gives a realistic value for $I_{prim}$ in *Equation 185*. If $I_u = 0$ and $I_{rs} = m \cdot 0.5 \cdot I_e$, the value for the sensitivity is:

$I_{prim} = n \cdot m \cdot I_e = 1000 \cdot 4 \cdot 0.012$ A = 48 A ( ≈ 6 % x $I_n$).

$I_{rs} = 4 \cdot 0.5 \cdot 0.012$ A = 0.024 A.

The setting value can be calculated with:

$$Operate\ value = \left( \frac{I_{rs}}{I_{CT_2n}} \right) = \left( \frac{0.024\ A}{1A} \right) \approx 2.4\%$$

The resistance of the stabilizing resistor can now be calculated:

$R_s = U_s / I_{rs} = 78\ V / (2 \cdot I_e) = 78\ V / (2 \cdot 0.012\ A) = 3250\ \Omega$.

**Example 2b**

In this example, $I_{rs} = 4 \times 12$ mA = 48 mA and $I_u$ = 30 mA. This results in the sensitivity:

$I_{prim} = n \cdot ( I_{rs} + I_u + m \cdot I_m) = 1000 \cdot (48 + 30 + 24)$ mA = 102 A

The setting value can be calculated with:

$$Operate\ value = \left( \frac{I_{rs}}{I_{CT_2n}} \right) = \left( \frac{0.048\ A}{1A} \right) \approx 4.8\%$$

The resistance of the stabilizing resistor is now:

$R_s = U_s / I_{rs} = 78\ V / 48\ mA \approx 1630\ \Omega$

In this example, the relay is of such a type that the stabilizing resistor can be chosen freely.

## 4.3.5.10 Signals

### HREFPDIF Input signals

**Table 689: HREFPDIF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### HREFPDIF Output signals

**Table 690: HREFPDIF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

## 4.3.5.11 Settings

### HREFPDIF Settings

**Table 691: HREFPDIF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 1.0...50.0 | %In | 0.1 | 5.0 | Low operate value, percentage of the nominal current |
| Minimum operate time | 20...300000 | ms | 1 | 20 | Minimum operate time |

**Table 692: HREFPDIF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 693: HREFPDIF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

## 4.3.5.12 Monitored data

**HREFPDIF Monitored data**

**Table 694: HREFPDIF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| HREFPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.3.5.13 Technical data

**Table 695: HREFPDIF Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [1, 2] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Operate value*<br>$I_{Fault}$ = 10.0 × set *Operate value* | 16 ms<br>11 ms | 21 ms<br>13 ms | 23 ms<br>14 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |

## 4.3.6 High-impedance differential protection HIxPDIF (ANSI 87_A, 87_B, 87_C)

[1] Current before fault = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements.
[2] Includes the delay of the signal output contact.

### 4.3.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| High-impedance differential protection for phase A | HIAPDIF | dHi_A> | 87_A |
| High-impedance differential protection for phase B | HIBPDIF | dHi_B> | 87_B |
| High-impedance differential protection for phase C | HICPDIF | dHi_C> | 87_C |

### 4.3.6.2 Function block

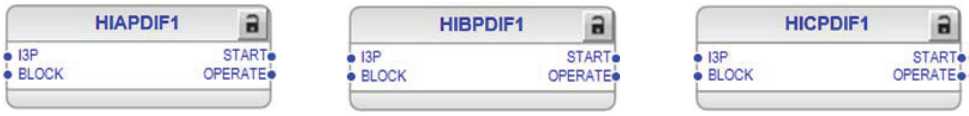



*Figure 438: Function block*

### 4.3.6.3 Functionality

The high-impedance differential protection function HIxPDIF is a general differential protection. It provides a phase-segregated short circuit protection for the busbar. However, the function can also be used for providing generator, motor, transformer and reactor protection.

The function starts and operates when the differential current exceeds the set limit. The operate time characteristics are according to definite time (DT).

The function contains a blocking functionality. It is possible to block the function outputs, timer or the whole function.

### 4.3.6.4 Analog channel configuration

HIxPDIF has one analog group input which must be properly configured.

**Table 696: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of HIxPDIF can be described with a module diagram. All the modules in the diagram are explained in the next sections.

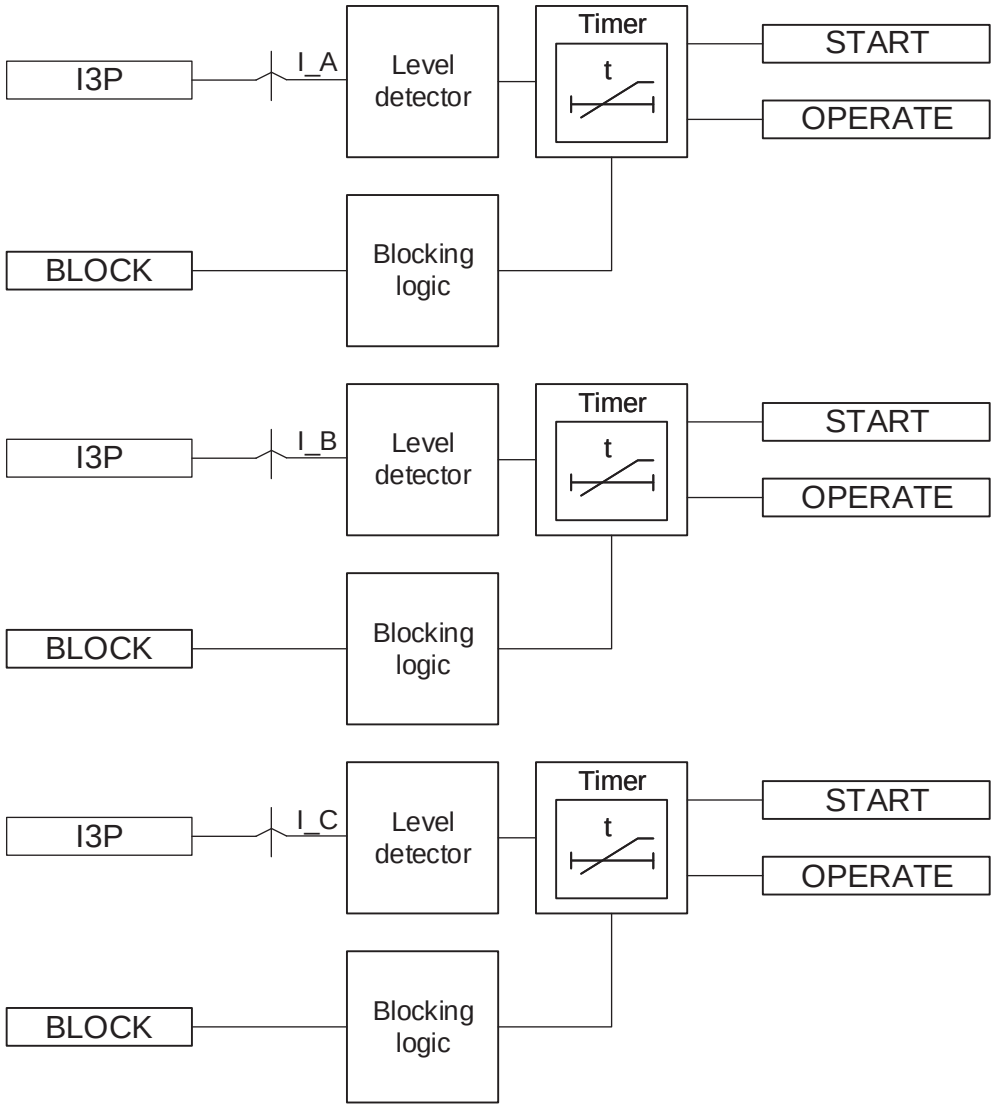



*Figure 439: Functional module diagram*

The module diagram illustrates all the phases of the function. Functionality for phases A, B and C is identical.

All three phases have independent settings.

#### Level detector

The module compares differential currents I_A calculated by the peak-to-peak measurement mode to the set *Operate value*. The Timer module is activated if the differential current exceeds the value of the *Operate value* setting.

#### Timer

Once activated, Timer activates the START output. The time characteristic is according to DT. When the operation timer reaches the value set by *Minimum operate time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

Timer calculates the start duration START_DUR value, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the Monitored data view.

The activation of the BLOCK input resets Timer and deactivates the START and OPERATE outputs.

#### Blocking logic

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.3.6.6 Application

HIxPDIF provides a secure and dependable protection scheme against all types of faults. The high-impedance principle is used for differential protection due to its capability to manage the through-faults also with the heavy current transformer (CT) saturation.

For current transformer recommendations, see the Requirements for measurement transformers section in this manual.

#### High-impedance principle

The phase currents are measured from both the incoming and the outgoing feeder sides of the busbar. The secondary of the current transformer in each phase is connected in parallel with a protection relay measuring branch. Hence, the relay measures only the difference of the currents. In an ideal situation, there is a differential current to operate the relay only if there is a fault between the CTs, that is, inside the protected zone.

If there is a fault outside the zone, a high current, known as the through-fault current, can go through the protected object. This can cause partial saturation in the CTs. The relay operation is avoided with a stabilizing resistor ($R_s$) in the protection relay measuring branch. $R_s$ increases the impedance of the protection relay; hence the name high-impedance differential scheme.

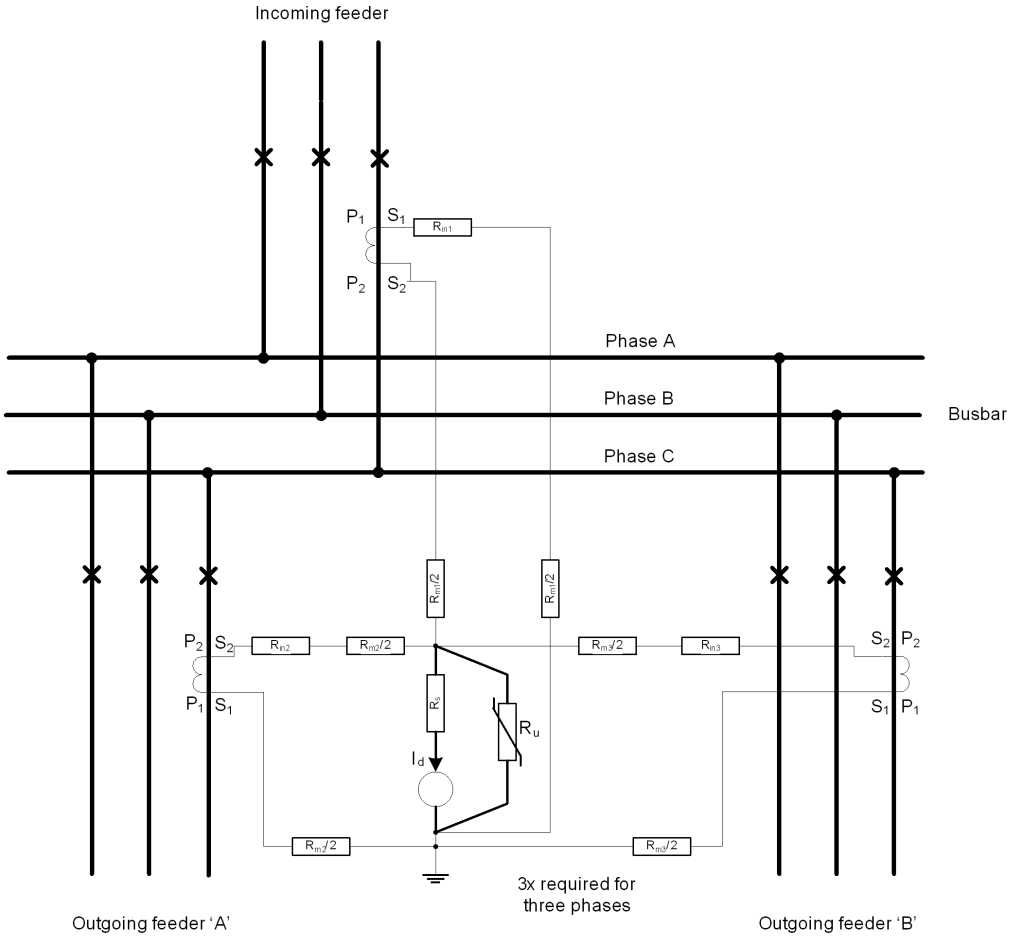



*Figure 440: Phase-segregated bus differential protection based on high-impedance principle*

CT secondary winding resistances ($R_{in}$) and connection wire resistances ($R_m/2$) are also shown in *Figure 441*.

*Figure 441* demonstrates a simplified circuit consisting only of one incoming and outgoing feeder. To keep it simple, the voltage-dependent resistor ($R_u$) is not included. The wiring resistances are presented as total wiring resistances $R_{m1}$ and $R_{m2}$.

$R_{m1}$ is the maximum wiring resistance concerning all incoming feeder sets, whereas $R_{m2}$ is the maximum wiring resistance concerning all outgoing feeder sets.

The lower part of *Figure 441* shows the voltage balance when there is no fault in the system and no CT saturation.

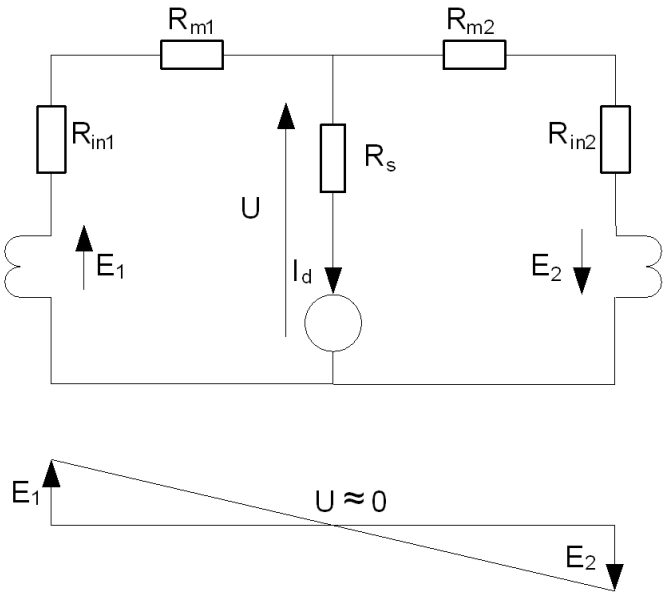



*Figure 441: Equivalent circuit when there is no fault or CT saturation*

When there is no fault, the CT secondary currents and their emf voltages, $E_1$ and $E_2$, are opposite and the protection relay measuring branch has no voltage or current. If an in-zone fault occurs, the secondary currents have the same direction. The relay measures the sum of the currents as a differential and trips the circuit breaker. If the fault current goes through only one CT, its secondary emf magnetizes the opposite CT, that is, $E_1 \approx E_2$.

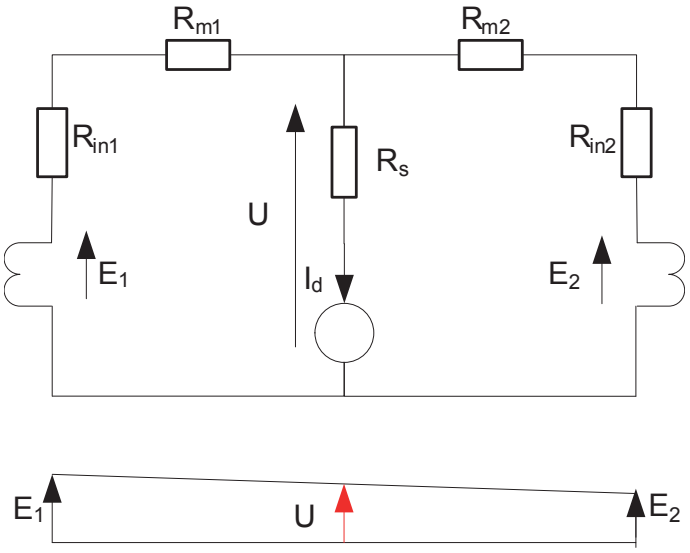



*Figure 442: Equivalent circuit in case of in-zone fault*

*Figure 443* shows CT saturation at a through-fault, that is, out-of-zone, situation. The magnetization impedance of a saturated CT is almost zero. The saturated CT winding can be presented as a short circuit. When one CT is saturated, the current of the non-saturated CT follows two paths, one through the protection relay measuring branch ($R_s$ + relay) and the other through the saturated CT ($R_m + R_{in2}$).

The protection relay must not operate during the saturation. This is achieved by increasing the relay impedance by using the stabilizing resistor ($R_s$) which forces the majority of the differential current to flow through the saturated CT. As a result, the relay operation is avoided, that is, the relay operation is stabilized against the CT saturation at through-fault current. The stabilizing voltage $U_s$ is the basis of all calculations.

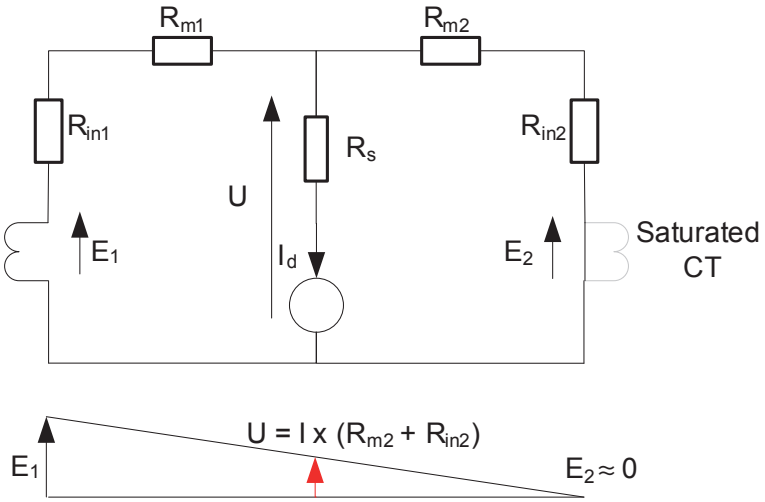



*Figure 443: Equivalent circuit in case of the CT saturation at through-fault*

The CT saturation happens most likely in the case of an in-zone fault. This is not a problem, because although the operation remains stable (non-operative) during the saturated parts of the CT secondary current waveform, the non-saturated part of the current waveform causes the protection to operate.

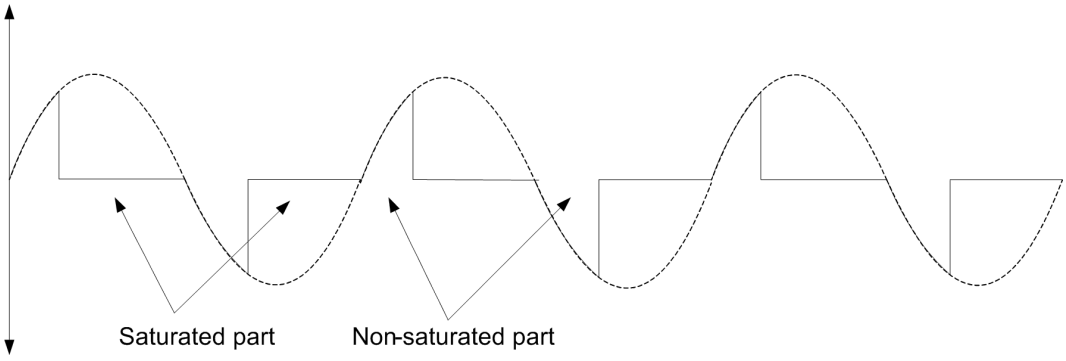



*Figure 444: Secondary waveform of a saturated CT*

The secondary circuit voltage can easily exceed the isolation voltage of the CTs, connection wires and the protection relay because of the stabilizing resistance and CT saturation. A voltage dependent resistor (VDR, $R_u$) is used to limit the voltage as shown in *Figure 440*.

**Busbar protection scheme**

The basic concept for any bus differential protection relay is a direct use of Kirchoff's first law that the sum of all currents connected to one differential protection zone is zero. If the sum is not zero, an internal fault has occurred. In other words, as seen by the busbar differential protection, the sum of all currents that

flow into the protection zone, that is, currents with positive value, must be equal to currents that flow out of the protection zone, that is, currents with negative value, at any instant of time.

*Figure 445* shows an example of a phase segregated single busbar protection employing high-impedance differential protection. The example system consists of a single incoming busbar feeder and two outgoing busbar feeders. The CTs from both the outgoing busbar feeders and the incoming busbar feeders are connected in parallel with the polarity. During normal load conditions, the total instantaneous incoming current is equal to the total instantaneous outgoing current and the difference current is negligible. A fault in the busbar results in an imbalance between the incoming and the outgoing current. The difference current flows through the protection relay, which generates a trip signal.

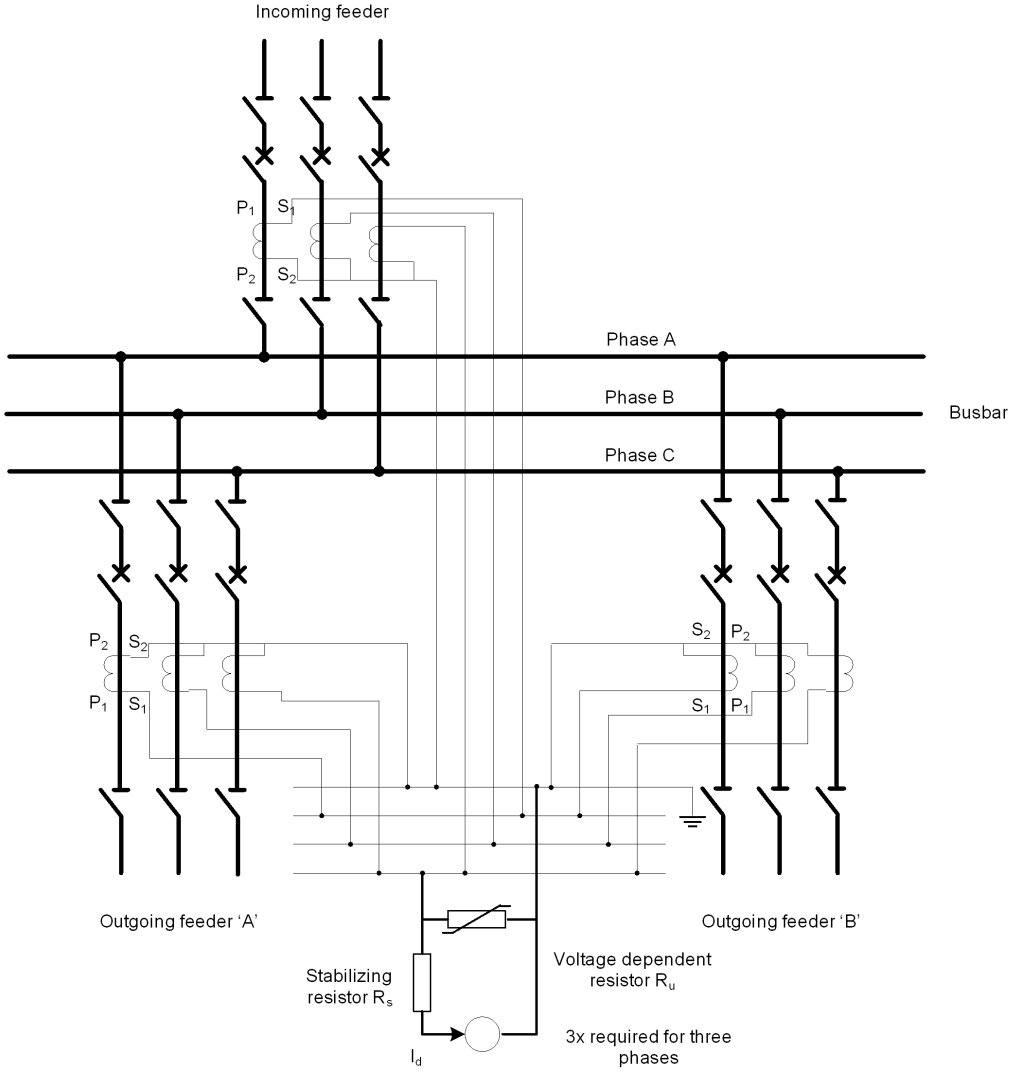



*Figure 445: Phase-segregated single busbar protection employing high-impedance differential protection*

*Figure 446* shows an example for a system consisting of two busbar section coupled with a bus coupler. Each busbar section consists of two feeders and both sections are provided with a separate differential protection to form different zones. The formed zones overlap at the bus coupler.

When the bus coupler is in the open position, each section of the busbar handles the current flow independently, that is, the instantaneous incoming current is equal to the total instantaneous outgoing current and the difference current is negligible. The difference current is no longer zero with a fault in the busbar and the protection operates.

With the bus coupler in the closed position, the current also flows from one busbar section to another busbar section. Thus, the current flowing through the bus coupler needs to be considered in calculating differential current. During normal condition, the summation of the current on each bus section is zero. However, if there is a fault in any busbar section, the difference current is no longer zero and the protection operates.

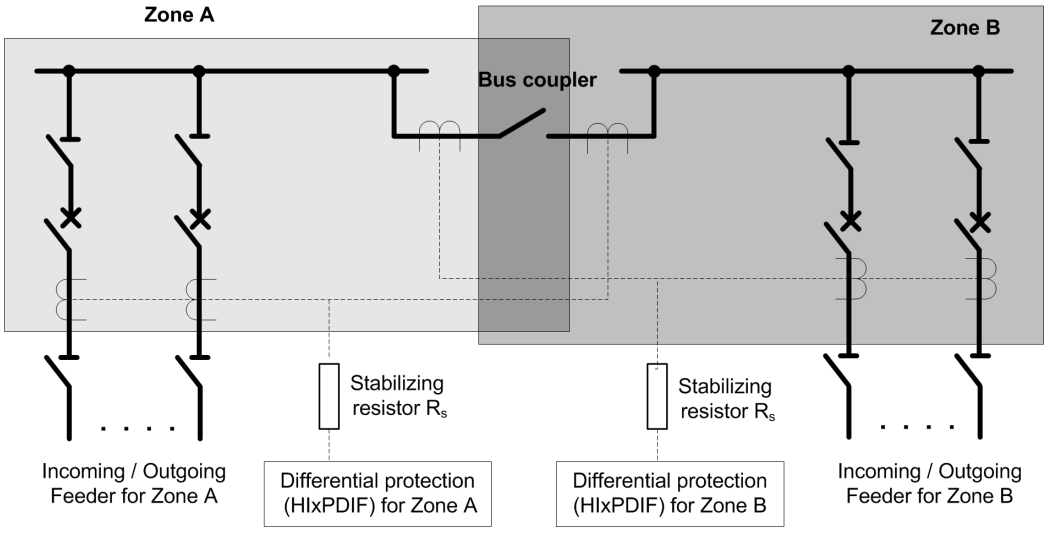



*Figure 446: Differential protection on busbar with bus coupler (Single-phase representation)*

### 4.3.6.7 Example calculations for busbar high-impedance differential protection

The protected object in the example for busbar differential protection is a single-bus system with two zones of protection.

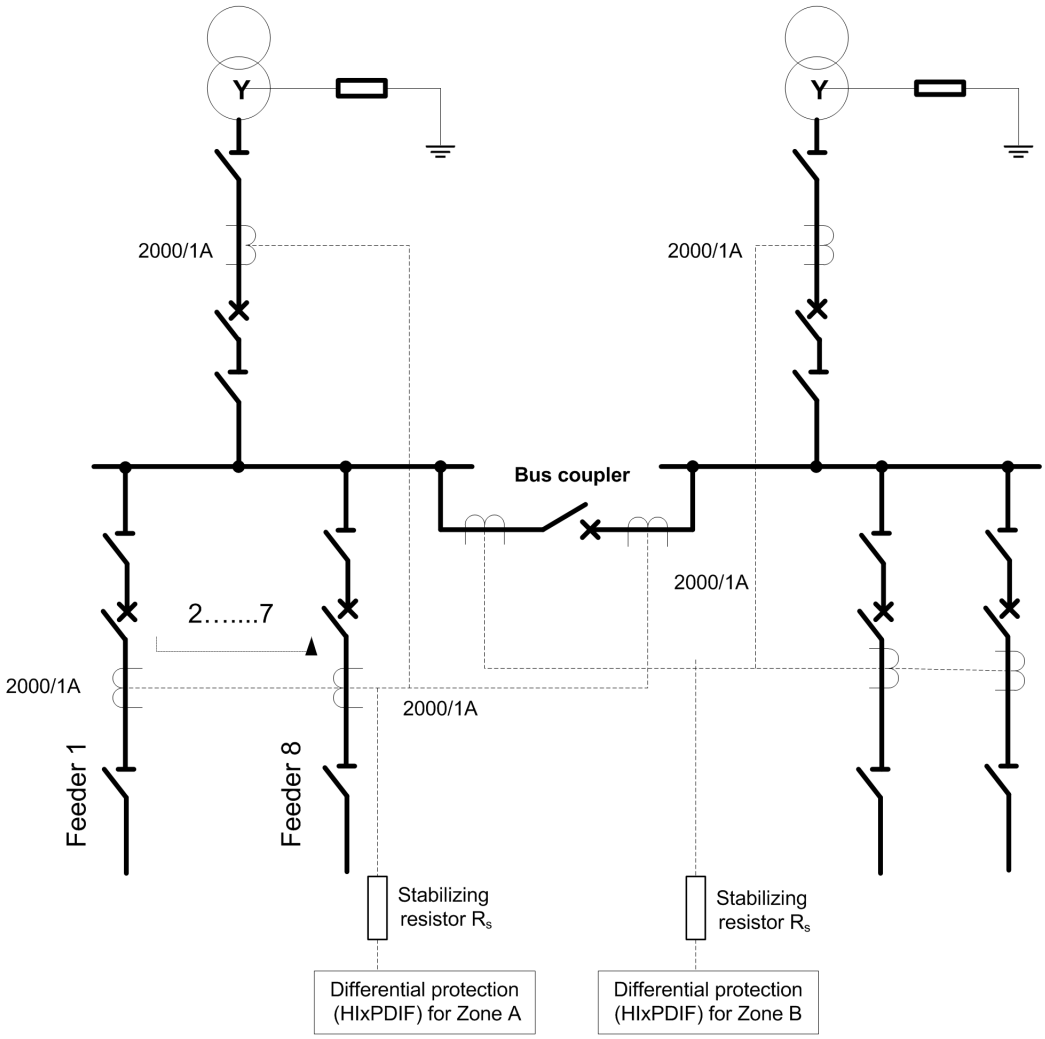



*Figure 447: Example for busbar differential protection*

Bus data:

| | |
|---|---|
| $U_n$ | 20 kV |
| $I_n$ | 2000 A |
| $I_{kmax}$ | 25 kA |

10 feeders per protected zone including bus coupler and incomer.

CT data is assumed to be:

| | |
|---|---|
| CT | 2000/1 A |
| $R_{in}$ | 15.75 Ω |
| $U_{kn}$ | 436 V |
| $I_e$ | <7 mA (at $U_{kn}$) |
| $R_m$ | 1Ω |

The stabilizing voltage is calculated using the formula:

$$U_s = \frac{25000A}{2000}(15.75\Omega + 1.\Omega) \approx 209.37\ V$$

(Equation 189)

In this case, the requirement for the current transformer knee point voltage is fulfilled because $U_{kn} > 2U_s$.

The magnetizing curve of the CT is assumed to be linear. The magnetizing current at the stabilizing voltage can be estimated as:

$$I_m = \frac{U_s}{U_{kn}} \cdot I_e$$

(Equation 190)

$$I_m = \frac{209.37V}{436V} \cdot 7mA \approx 3.4mA$$

(Equation 191)

To obtain adequate protection stability, the setting current $I_{rs}$ must be at the minimum of the sum of magnetizing currents of all connected CTs.

$$I_{rs} = 10 \cdot 3.4mA \approx 34\,mA$$

(Equation 192)

The resistance of the stabilizing resistor is calculated based on *Equation 193*.

$$R_S = \frac{209.37\ V}{0.034A} \approx 6160\,\Omega$$

(Equation 193)

The calculated value is the maximum value for the stabilizing resistor. If the value is not available, the next available value below should be selected and the protection relay setting current is tuned according to the selected resistor. For example, in this case, the resistance value 5900 Ω is used.

$$I_{rs} = \frac{209.37V}{5900\,\Omega} \approx 35\,mA$$

(Equation 194)

The sensitivity of the protection is obtained as per *Equation 195*, assuming $I_u = 0$.

$$I_{prim} = 2000 \cdot (0.035\,A + 10 \cdot 0.0034\,A + 0\,A) \approx 140A$$

(Equation 195)

The power of the stabilizing resistor is calculated:

$$P \geq \frac{(436V)^2}{5900\Omega} \approx 32W$$

(Equation 196)

Based on *Equation 197* and *Equation 198*, the need for voltage-dependent resistor is checked.

$$U_{max} = \frac{25000A}{2000}(5900\Omega + 15.75\Omega + 1.00\Omega) \approx 74.0kV$$

(Equation 197)

$$\breve{u} = 2 \cdot \sqrt{2 \cdot 436V \cdot (74000V - 436V)} \approx 16.0kV$$

(Equation 198)

The voltage-dependent resistor (one for each phase) is needed in this case as the voltage during the fault is higher than 2 kV.

The leakage current through the VDR at the stabilizing voltage can be available from the VDR manual, assuming that to be approximately 2 mA at stabilizing voltage $Iu \approx 0.002\,A$

(Equation 199)

The sensitivity of the protection can be recalculated taking into account the leakage current through the VDR as per *Equation 200*.

$$I_{prim} = 2000 \cdot (0.035\,A + 10 \cdot 0.0034\,A + 0.002\,A) \approx 142A$$

(Equation 200)

### 4.3.6.8 Signals

#### HIAPDIF Input signals

**Table 697: HIAPDIF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### HIBPDIF Input signals

**Table 698: HIBPDIF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### HICPDIF Input signals

**Table 699: HICPDIF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### HIAPDIF Output signals

**Table 700: HIAPDIF Output signals**

| Name | Type | Description |
|---|---|---|
| START | BOOLEAN | Start |
| OPERATE | BOOLEAN | Operate |

### HIBPDIF Output signals

**Table 701: HIBPDIF Output signals**

| Name | Type | Description |
|---|---|---|
| START | BOOLEAN | Start |
| OPERATE | BOOLEAN | Operate |

### HICPDIF Output signals

**Table 702: HICPDIF Output signals**

| Name | Type | Description |
|---|---|---|
| START | BOOLEAN | Start |
| OPERATE | BOOLEAN | Operate |

## 4.3.6.9 Settings

### HIAPDIF Settings

**Table 703: HIAPDIF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 1.0...200.0 | %In | 1.0 | 5.0 | Operate value, percentage of the nominal current |
| Minimum operate time | 20...300000 | ms | 10 | 20 | Minimum operate time |

**Table 704: HIAPDIF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 705: HIAPDIF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |

### HIBPDIF Settings

**Table 706: HIBPDIF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 1.0...200.0 | %In | 1.0 | 5.0 | Operate value, percentage of the nominal current |
| Minimum operate time | 20...300000 | ms | 10 | 20 | Minimum operate time |

**Table 707: HIBPDIF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 708: HIBPDIF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |

### HICPDIF Settings

**Table 709: HICPDIF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 1.0...200.0 | %In | 1.0 | 5.0 | Operate value, percentage of the nominal current |
| Minimum operate time | 20...300000 | ms | 10 | 20 | Minimum operate time |

**Table 710: HICPDIF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on | | | 1=on | Operation Off / On |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 5=off | | | | |

**Table 711: HICPDIF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |

## 4.3.6.10 Monitored data

### HIAPDIF Monitored data

**Table 712: HIAPDIF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| HIAPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### HIBPDIF Monitored data

**Table 713: HIBPDIF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| HIBPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### HICPDIF Monitored data

**Table 714: HICPDIF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| HICPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.3.6.11 Technical data

**Table 715: HIxPDIF Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the current measured: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [1, 2] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Start value* | 8 ms | 11 ms | 19 ms |
| | $I_{Fault}$ = 10 × set *Start value* | 7 ms | 9 ms | 11 ms |
| Reset time | | Typically <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |

[1] *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements.
[2] Measured with static signal output (SSO).

## 4.3.7 Stabilized and instantaneous differential protection for machines MPDIF (ANSI 87M/87G)

### 4.3.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Stabilized and instantaneous differential protection for machines | MPDIF | 3dI>G/M | 87M/87G |

### 4.3.7.2 Function block

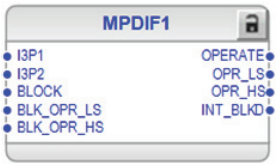



*Figure 448: Function block*

### 4.3.7.3 Functionality

The stabilized and instantaneous differential protection for machines function MPDIF is a unit protection function. The possibility of internal failures of the machine is relatively low. However, the consequences in terms of cost and production loss are often serious, which makes the differential protection an important protection function.

The stability of the differential protection is enhanced by a DC restraint feature. This feature decreases the sensitivity of the differential protection optionally for a temporary time period to avoid an unnecessary disconnection of the machine during the external faults that have a fault current with high DC currents. MPDIF also includes a CT saturation-based blocking which prevents unnecessary tripping in case of the detection of the magnetizing inrush currents which can be present at the switching operations, overvoltages or external faults.

### 4.3.7.4 Analog channel configuration

MPDIF has two analog group inputs which must be properly configured.

**Table 716: Analog inputs**

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.7.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of MPDIF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

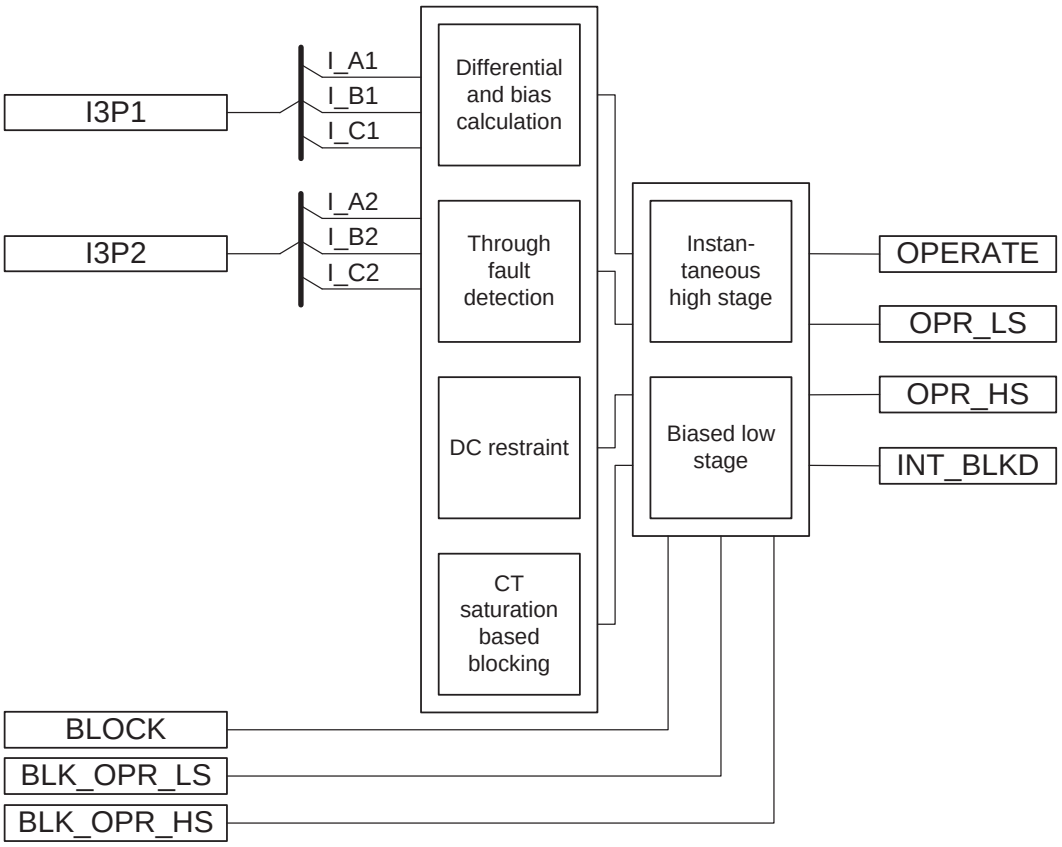



*Figure 449: Functional module diagram*

#### Differential and bias calculation

Differential calculation module calculates the differential current. The differential current is the difference in current between the phase and neutral sides of the machine.

The phase currents $\bar{I}_1$ and $\bar{I}_2$ denote the fundamental frequency components on the phase and neutral sides of the current. The amplitude of the differential current $I_d$ is obtained using the equation (assuming that the positive direction of the current is towards the machine):

$$I_d = \left| \bar{I}_1 + \bar{I}_2 \right|$$

(Equation 201)

During normal conditions, there is no fault in the area protected by the function block, so the currents $\bar{I}_1$ and $\bar{I}_2$ are equal and the differential current $I_d = 0$. However, in practice some differential current exists due to inaccuracies in the current transformer on the phase and neutral sides, but it is very small during normal conditions.

The module calculates the differential current for all three phases.

The low-stage differential protection is stabilized with a bias current. The bias current is also known as the stabilizing current. Stabilization means that the differential current required for tripping increases according to the bias current and the operation characteristics. When an internal fault occurs, the currents on both sides of the protected object are flowing into it. This causes the biasing current to be considerably smaller, which makes the operation more sensitive during internal faults.

The traditional way for calculating the stabilized current is:

$$I_b = \left| \frac{\bar{I}_1 - \bar{I}_2}{2} \right|$$

(Equation 202)

The module calculates the bias current for all three phases.

**Through-fault detection**

Through-fault (TF) detection module is for detecting whether the fault is external, that is, going through, or internal. This information is essential for ensuring the correct operation of the protection in case of the CT saturation.

- In a through-fault situation, CTs can saturate because of a high fault current magnitude. Such AC saturation does not happen immediately when the fault begins. Thus, the TF module sees the fault as external because the bias current is high but the differential current remains low. If the AC saturation then occurs, a CT saturation-based blocking is allowed to work to prevent tripping.
- Normally, the phase angle between the machine neutral and line side CTs is 180 degrees. If an internal fault occurs during a through fault, an angle less than 50 degrees clearly indicates an internal fault and the TF module overrules, that is, deblocks the presence of any blocking due to CT saturation.

**CT saturation-based blocking**

Higher currents during the motor startup or abnormally high magnetizing currents at an overvoltage (transformer-fed motor) or an external fault may saturate the current transformers. The uneven saturation of the star and line side CTs (for example, due to burden differences) may lead to a differential current which can cause a differential protection to operate. This module blocks the operation of MPDIF biased low stage internally in case of the CT saturation. Once the blocking is activated, it is held for a certain time after the blocking conditions have ceased to be fulfilled.

**DC restraint**

On detection of a DC component, the function temporarily desensitizes the differential protection. The functioning of this module depends on the *DC restrain Enable* setting. The DC components are continuously extracted from the three instantaneous differential currents. The highest DC component of all three is taken as a kind of DC restraint in a sense that the highest effective, temporary sensitivity of the protection is temporarily decreased as a function of this highest DC offset. The calculated DC restraint current is not allowed to decay (from its highest ever measured value) faster than with a time constant of one second. The value of the temporarily effective sensitivity limit is limited upwards to the rated current of the machine or 3.3 times that of *Low operate value*, whichever is smaller. The temporary extra limit decays exponentially from its maximum value with a time constant of one second.

This feature should be used in case of networks where very long time constants are expected. The temporary sensitivity limit is higher to the set operating characteristics. In other words, the temporary limit has superposed the unchanged operating characteristics and temporarily determines the highest sensitivity of the protection. The temporary sensitivity is less than the sensitivity in section 1 of the operating characteristic and is supposed to prevent an unwanted trip during the external faults with lower currents.

**Biased low stage**

The current differential protection needs to be biased because of the possible appearance of a differential current which can be due to something else than an actual fault in the machine. In case of differential protection, a false differential current can be caused by:

- CT errors
- CT saturation at high currents passing through the machine

The differential current caused by CT errors increases at the same percent ratio as the load current.

The high currents passing through the protected object can be caused by the through fault. Therefore, the operation of the differential protection is biased with respect to the load current. In the biased differential protection, the higher the differential current required for the protection of operation, the higher the load current.

Based on the conditions checked from the through-fault module, the DC (component) detection module and the CT saturation-based blocking modules, the biased low-stage module decides whether the differential current is due to the internal faults or some false reason. In case of detection of the TF, DC or CT saturation, the internal differential blocking signal is generated, which in turn blocks the operating signal. In case of internal faults, the operation of the differential protection is affected by the bias current.

The *Low operate value* setting for the stabilized stage of the function block is determined with the equation:

$$Low\,operate\,value = I_{d1}$$

(Equation 203)

The *Slope section 2* and *Slope section 3* settings are determined correspondingly:

$$Slope\ section\ 2 = \frac{I_{d2}}{I_{b2}} \cdot 100\%$$

(Equation 204)

$$Slope\ section\ 3 = \frac{I_{d3}}{I_{b3}} \cdot 100\%$$

(Equation 205)

The end of the first section *End section 1* can be set at a desired point within the range of 0 to 100 percent (or % $I_r$). Accordingly, the end of the second section *End section 2* can be set within the range of 100 percent to 300 percent (or % $I_r$).

The slope of the operating characteristic for the function block varies in different parts of the range.

In section 1, where 0.0 < $I_b/I_n$ < *End section 1*, the differential current required for tripping is constant. The value of the differential current is the same as the *Low operate value* setting selected for the function block. The *Low operate value* setting allows for small inaccuracies of the current transformers but it can also be used to influence the overall level of the operating characteristic.

Section 2, where *End section 1* < $I_b/I_n$ < *End section 2*, is called the influence area of the setting *Slope section 2*. In this section, variations in *End section 2* affect the slope of the characteristic, that is, how big the change in the differential current required for tripping is in comparison to the change in the load current. The *End section 2* setting allows for CT errors.

In section 3, where $I_b/I_n$ > *End section 2*, the slope of the characteristic can be set by *Slope section 3* that defines the increase in the differential current to the corresponding increase in the biasing current.

The required differential current for tripping at a certain stabilizing current level can be calculated using the formulae:

For a stabilizing current lower than *End section 1*

$$I_{doperate}[\%I_r] = Set\ Low operate\ value$$

(Equation 206)

For a stabilizing current higher than *End section 1* but lower than *End section 2*

$$I_{doperate}[\%I_r] = Low operate\ value + (I_b[\%Ir] - End\ section\ 1) \cdot Slope\ section\ 2$$

(Equation 207)

For higher stabilizing current values exceeding *End section 2*

$$I_{d\,operate}[\%I_r] = Low operate\ value + (End\ section\ 2 - End\ section\ 1) \cdot Slope\ section\ 2 + (I_b[\%I_r] - End\ section\ 2) \cdot Slope\ section\ 3$$

(Equation 208)

When the differential current exceeds the operating value determined by the operating characteristics, the OPR_LS output is activated. The OPERATE output is always activated when the OPR_LS output activates.

The operate signal due to the biased stage can be blocked by the activation of the BLK_OPR_LS or BLOCK input. Also, when the operation of the biased low stage is

blocked by the waveform blocking functionality, the INT_BLKD output is activated according to the phase information.

The phase angle difference between the two currents I_A1 and I_A2 is theoretically 180 electrical degrees for the external fault and 0 electrical degrees for the internal fault conditions. If the phase angle difference is less than 50 electrical degrees or if the biasing current drops below 30 percent of the differential current, a fault has most likely occurred in the area protected by MPDIF. Then the internal blocking signals (CT saturation and DC blocking) of the biased stage are inhibited.

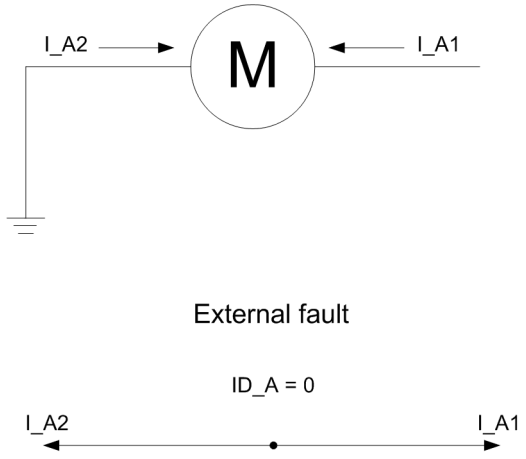



*Figure 450: Positive direction of current*

**Instantaneous high stage**

The differential protection includes an unbiased instantaneous high stage. The instantaneous stage operates and the OPR_HS output is activated when the amplitude of the fundamental frequency component of the differential current exceeds the set *High operate value* or when the instantaneous peak values of the differential current exceed 2.5 · *High operate value*. The factor 2.5 (= 1.8 · √2) is due to the maximum asymmetric short circuit current.

The OPERATE output is always activated when the OPR_HS output activates.

The internal blocking signals of the function block do not prevent the operation of the instantaneous stage. When required, the operate signal due to instantaneous operation can be blocked by the binary inputs BLK_OPR_HS or BLOCK.

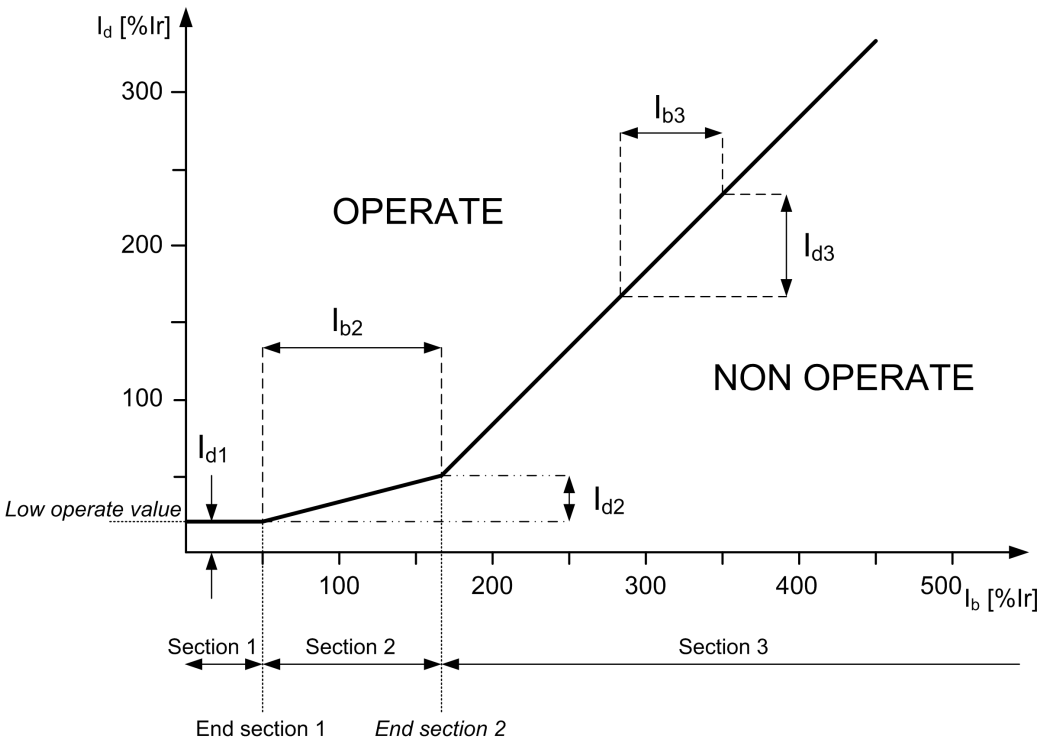



*Figure 451: Operating characteristic for the stabilized stage of the generator differential protection function*

### 4.3.7.6 Application

The differential protection works on the principle of calculating the differential current at the two ends of the winding, that is, the current entering the winding is compared to the current exiting the winding. In case of any internal fault, the currents entering and exiting the winding are different, which results in a differential current, which is then used as a base for generating the operating signal. Due to this principle, the differential protection does not trip during external faults. However, it should be noted that interturn faults in the same phase are usually not detected unless they developed into some other kind of fault.

The short circuit between the phases of the stator windings normally causes high fault currents. The short circuit creates a risk of damages to the insulation, windings and stator core. The high short circuit currents cause strong current forces which can damage other components in the machine. The short circuit can also initiate explosion and fire. When a short circuit occurs in a machine, there is a damage that has to be repaired. The severity and the repair time depend on the degree of damage, which is highly dependent on the fault time. The fast fault clearance of this fault type is of greatest importance to limit the damages and the economic loss.

To limit the damages in connection to the stator winding short circuits, the fault clearance time must be as short as possible (instantaneous). The fault current contributions from both the external power system (via the machine or the block circuit breaker) and from the machine itself must be disconnected as fast as possible.

The DC restraint feature should be used in case of an application with a long DC time constant in the fault currents is present. This fault current may be of a lesser magnitude (less than rated current) but is unpleasant and tends to saturate the CT and operate the differential protection for external faults. This feature is effective at moderate through-currents and ineffective at higher through-currents.

Although the short circuit fault current is normally very high, that is, significantly higher than the rated current of the machine, it is possible that a short circuit can occur between phases close to the neutral point of the machine, causing a relatively small fault current. The fault current fed from the synchronous machine can also be limited due to a low excitation of the synchronous generator. This is normally the case at the run-up of the synchronous machine, before synchronization to the network. Therefore, it is desired that the detection of the machine phase-to-phase short circuits shall be relatively sensitive, thus detecting the small fault currents.

It is also important that the machine short circuit protection does not trip for external faults when a high fault current is fed from the machine. To combine fast fault clearance, sensitivity and selectivity, the machine current differential protection is normally the best alternative for the phase-to-phase short circuits.

The risk of an unwanted differential protection operation caused by the current transformer saturation is a universal differential protection problem. If a big synchronous machine is tripped in connection to an external short circuit, it gives an increased risk of a power system collapse. Besides, there is a production loss for every unwanted trip of the machine. Therefore, preventing the unwanted disconnection of machines has a great economical value.

**Recommendations for current transformers**

The more important the object to be protected is, the more attention is paid to the current transformers. It is not normally possible to dimension the current transformers so that they repeat the currents with high DC components without saturating when the residual flux of the current transformer is high. The differential protection function block operates reliably even though the current transformers are partially saturated.

The accuracy class recommended for current transformers to be used with the differential function block is 5P, in which the limit of the current error at the rated primary current is 1 percent and the limit of the phase displacement is 60 minutes. The limit of the composite error at the rated accuracy limit primary current is 5 percent.

The approximate value of the actual accuracy limit factor $F_a$ corresponding to the actual CT burden can be calculated on the basis of the rated accuracy limit factor $F_n$ (ALF) at the rated burden, the rated burden $S_n$, the internal burden $S_{in}$ and the actual burden $S_a$ of the current transformer.

$$F_a = F_n \times \frac{S_{in} + S_n}{S_{in} + S_a}$$

(Equation 209)

**Example 1**

The rated burden $S_n$ of the current transformer 5P20 is 10 VA, the secondary rated current 5A, the internal resistance $R_{in}$ = 0.07 Ω and the rated accuracy limit factor $F_n$ corresponding to the rated burden is 20 (5P20). The internal burden of the current transformer is $S_{in} = (5A)^2 \times 0.07\ \Omega = 1.75$ VA. The input impedance of the protection relay at a rated current of 5A is < 20 mΩ. If the

measurement conductors have a resistance of 0.113 Ω, the actual burden of the current transformer is $S_a = (5A)^2 \times (0.113 + 0.020)\ \Omega = 3.33$ VA. Thus, the accuracy limit factor $F_a$ corresponding to the actual burden is about 46.

The CT burden can grow considerably at the rated current 5A. The actual burden of the current transformer decreases at the rated current of 1 A while the repeatability simultaneously improves.

At faults occurring in the protected area, the fault currents can be very high compared to the rated currents of the current transformers. Due to the instantaneous stage of the differential function block, it is sufficient that the current transformers are capable of repeating the current required for an instantaneous tripping during the first cycle.

Thus the current transformers usually are able to reproduce the asymmetric fault current without saturating within the next 10 ms after the occurrence of the fault to secure the operating times of the protection relay comply with the retardation time.

The accuracy limit factors corresponding to the actual burden of the phase current transformer to be used in differential protection must fulfill the requirement:

$$F_a > K_r \times Ik_{\max} \times (T_{dc} \times \omega \times (1 - e^{\frac{-T_m}{T_{dc}}}) + 1)$$

(Equation 210)

| | |
|---|---|
| $Ik_{max}$ | The maximum through-going fault current (in $I_R$) at which the protection is not allowed to operate |
| $T_{dc}$ | The primary DC time constant related to $Ik_{max}$ |
| ω | The angular frequency, that is, $2 \times \pi \times f_n$ |
| $T_m$ | The time to saturate, that is, the duration of the saturation-free transformation |
| $K_r$ | The remanence factor 1/(1-r), where r is the maximum remanence flux in pu from the saturation flux |

The parameter r is the maximum remanence flux density in the CT core in pu from the saturation flux density. The value of the parameter r depends on the magnetic material used and also on the construction of the CT. For instance, if the value r = 0.4, the remanence flux density can be 40 percent of the saturation flux density. The manufacturer of the CT has to be contacted when an accurate value for the parameter r is needed. The value r = 0.4 is recommended to be used when an accurate value is not available.

The required minimum time-to-saturate $T_m$ in MPDIF is half-fundamental cycle period (10 ms when $f_n$ = 50 Hz).

Two typical cases are considered for the determination of the sufficient actual accuracy limit factor $F_a$:

1. A fault occurring at the substation bus.

   The protection must be stable at a fault arising during a normal operating situation. The reenergizing of the transformer against a bus fault leads to very high fault currents and thermal stress. Therefore, reenergizing is not preferred in this case. The remanence can be neglected.

   The maximum through-going fault current $Ik_{max}$ is typically 6 $I_R$ for a motor. At a short circuit fault close to the supply transformer, the DC time constant $T_{dc}$ of the fault current is almost the same as that of the transformer, the typical value being 100 ms.

   | | |
   |---|---|
   | $Ik_{max}$ | = 6 $I_R$ |
   | $T_{dc}$ | = 100 ms |
   | ω | = 100π Hz |
   | $T_m$ | = 10 ms |
   | $K_r$ | = 1 |

   *Equation 210* with these values gives the result:

   $$F_a > K_r \times Ik_{\max} \times (T_{dc} \times \omega \times (1 - e^{\frac{-T_m}{T_{dc}}}) + 1) \approx 24$$

2. Reenergizing against a fault occurring further down in the network.

   The protection must be stable also during reenergization against a fault on the line. In this case, the existence of remanence is very probable. It is assumed to be 40 percent here.

   On the other hand, the fault current is now smaller and since the ratio of the resistance and reactance is greater in this location, having a full DC offset is not possible. Furthermore, the DC time constant ($T_{dc}$) of the fault current is now smaller, assumed to be 50 ms here.

   Assuming the maximum fault current is 30 percent lower than in the bus fault and a DC offset 90 percent of the maximum.

   | | |
   |---|---|
   | $Ik_{max}$ | = 0.7 × 6 = 4.2 ($I_R$) |
   | $T_{dc}$ | = 50 ms |
   | ω | = 100π Hz |
   | $T_m$ | = 10 ms |
   | $K_r$ | = 1/(1-0.4) = 1.6667 |

   *Equation 210* with these values gives the result:

   $$F_a > K_r \times Ik_{\max} \times 0.9 \times (T_{dc} \times \omega \times (1 - e^{\frac{-T_m}{T_{dc}}}) + 1) \approx 24$$

If the actual burden of the current transformer $S_a$ in the accuracy limit factor equation cannot be reduced low enough to provide a sufficient value for $F_a$, there are two alternatives to deal with the situation.

1. A current transformer with a higher rated burden $S_n$ can be chosen (which also means a higher rated accurate limit $F_n$).
2. A current transformer with a higher nominal primary current $I_{1n}$ (but the same rated burden) can be chosen.

Alternative 2 is more cost-effective and therefore often better, although the sensitivity of the scheme is slightly reduced.

**Example 2**

Here the actions according to alternative 2 are taken to improve the actual accuracy limit factor.

$$F_a = \left( \frac{I_R CT}{I_R Motor} \right) \times F_n$$

(Equation 211)

| | |
|---|---|
| $I_R$CT | rated primary current of the CT, for example, 1500A |
| $I_R$Motor | rated current of the motor under protection, for example, 1000A |
| $F_n$ | rated accuracy limit factor of the CT, for example, 30 |
| $F_a$ | actual accuracy limit factor due to oversizing the CT, substituting the values in the equation, $F_a$ = 45 |

In differential protection it is important that the accuracy limit factors $F_a$ of the phase current transformers at both sides correspond with each other, that is, the burdens of the current transformers on both sides are to be as close to each other as possible. If high inrush or start currents with high DC components pass through the protected object when it is connected to the network, special attention is required for the performance and the burdens of the current transformers and the settings of the function block.

**Connection of current transformers**

The connections of the primary current transformers are designated as Type 1 and Type 2.

- If the positive directions of the winding 1 and winding 2 protection relay currents are opposite, the *CT connection type* is of "Type 1". The connection examples of "Type 1" are as shown in figures *Figure 452* and *Figure 453*.
- If the positive directions of the winding 1 and winding 2 protection relay currents equate, the *CT connection type* setting parameter is "Type 2". The connection examples of "Type 2" are as shown in figures *Figure 454* and *Figure 455*.
- The default value of the *CT connection type* setting is "Type 1".

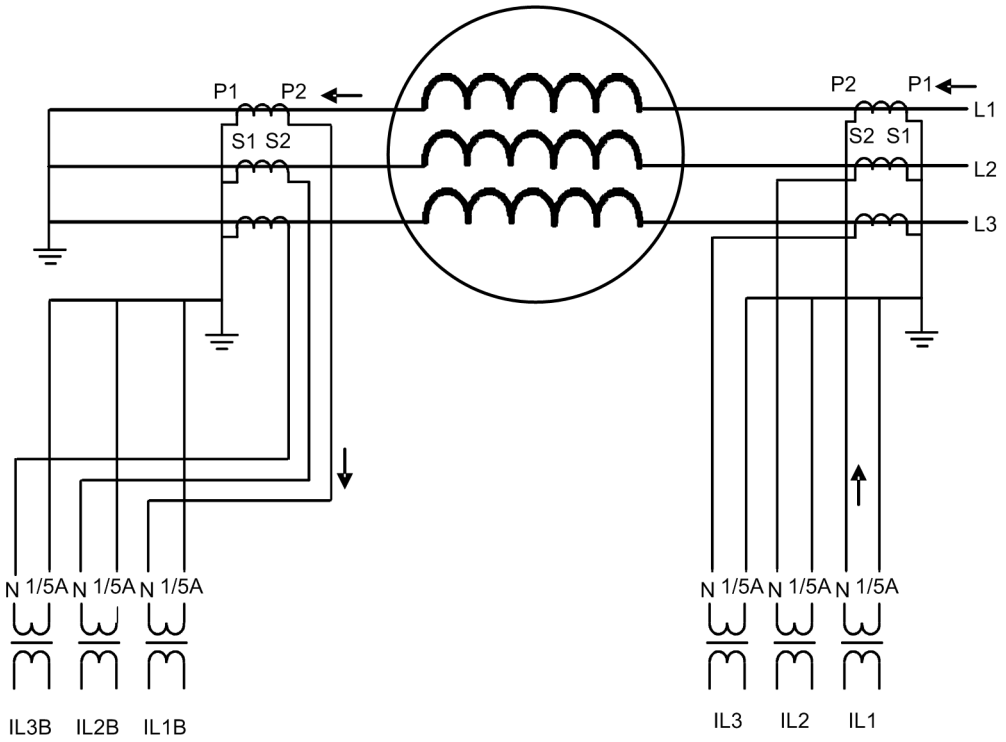



*Figure 452: Connection of current transformer of Type 1, example 1*

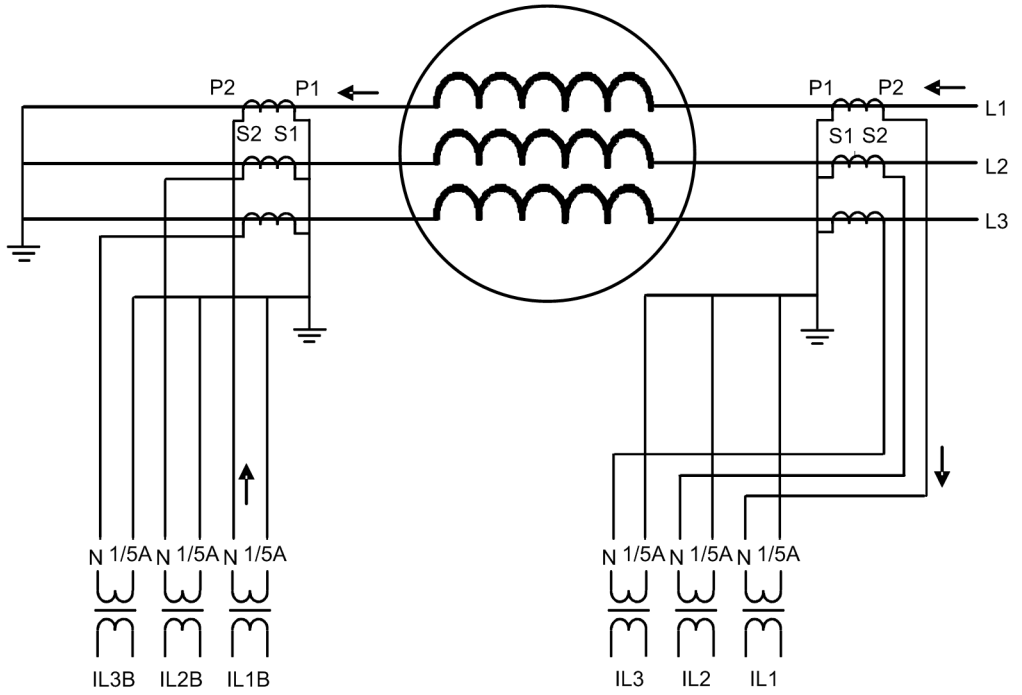



*Figure 453: Connection of current transformer of Type 1, example 2*

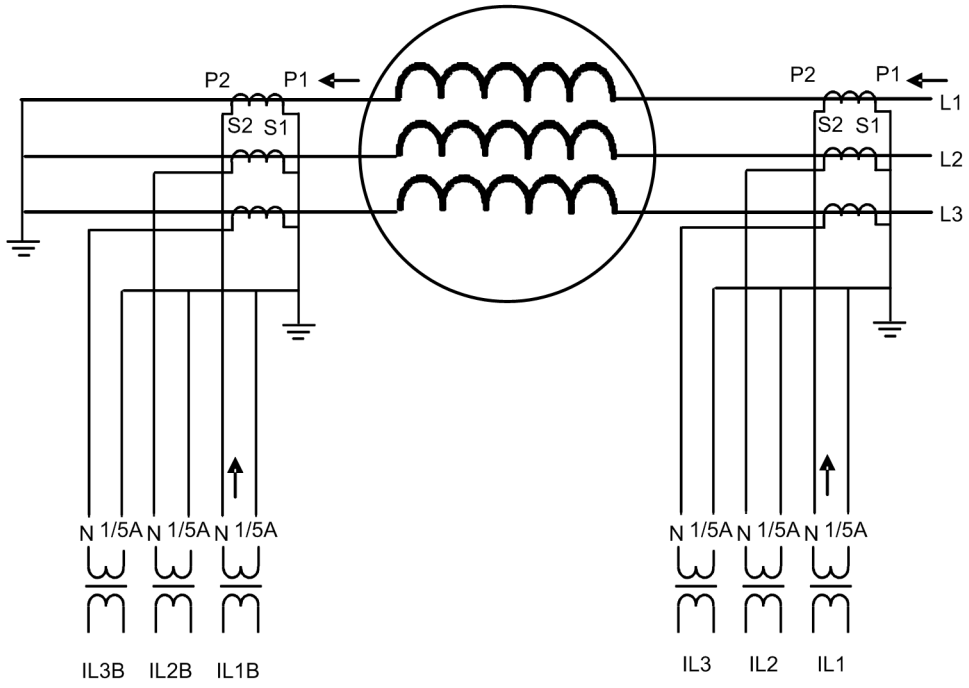



*Figure 454: Connection of current transformer of Type 2, example 1*

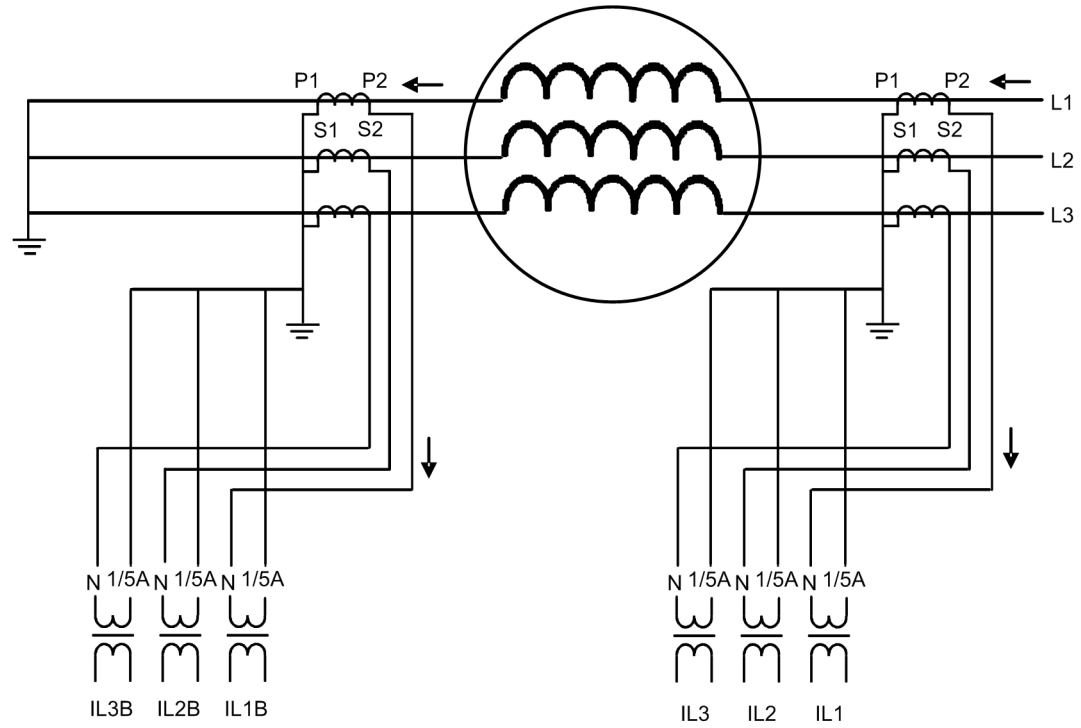



*Figure 455: Connection of current transformer of Type 2, example 2*

**Saturation of current transformers**

There are basically two types of saturation phenomena that have to be detected: the AC saturation and the DC saturation. The AC saturation is caused by a high fault current where the CT magnetic flux exceeds its maximum value. As a result, the secondary current is distorted as shown in *Figure 456*. A DC component in the current also causes the flux to increase until the CT saturates. This is known as DC saturation.

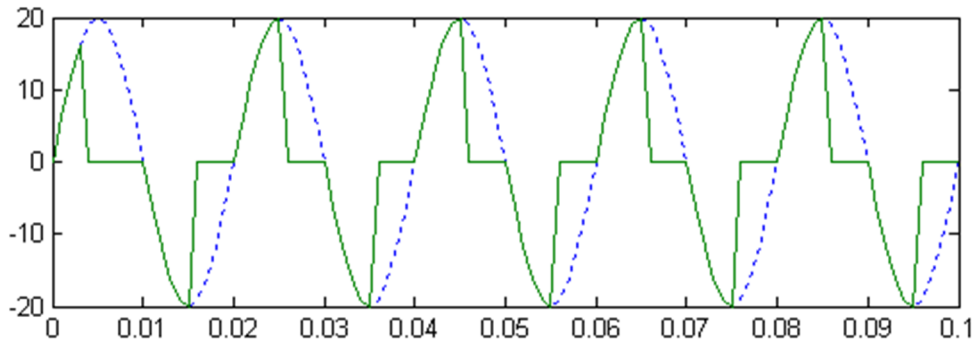



*Figure 456: AC saturation*

When having a short circuit in a power line, the short circuit current contains a DC component. The magnitude of the DC component depends on the phase angle when the short circuit occurs. *Figure 457* shows the secondary current of the CT in the fault situation. Because of the DC component, the flux reaches its maximum value at 0.07 seconds, causing saturation. As the DC component decays, the CT recovers gradually from the saturation.

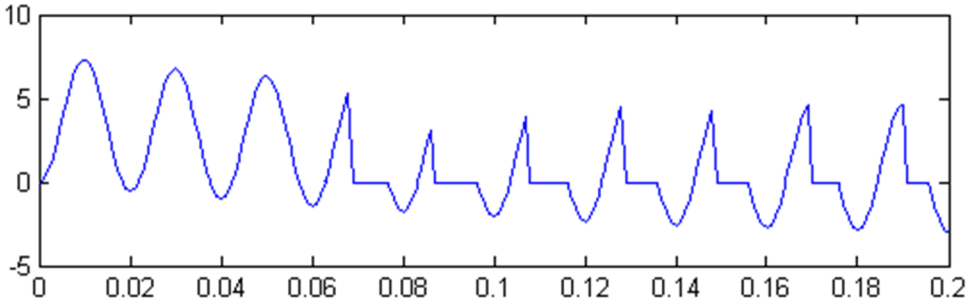



*Figure 457: DC saturation*

## 4.3.7.7 Signals

**MPDIF Input signals**

**Table 717: MPDIF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_OPR_LS | BOOLEAN | 0=False | Blocks operate outputs from biased stage |
| BLK_OPR_HS | BOOLEAN | 0=False | Blocks operate outputs from instantaneous stage |

**MPDIF Output signals**

**Table 718: MPDIF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| OPR_LS | BOOLEAN | Operate from low set |
| OPR_HS | BOOLEAN | Operate from high set |
| INT_BLKD | BOOLEAN | Internal block status |

## 4.3.7.8 MPDIF Settings

**Table 719: MPDIF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Low operate value | 5...30 | %Ir | 1 | 5 | Basic setting for the stabilized stage start |
| High operate value | 100...1000 | %Ir | 10 | 500 | Instantaneous stage operate value |
| Slope section 2 | 10...50 | % | 1 | 30 | Slope of the second line of the operating characteristics |
| End section 1 | 0...100 | %Ir | 1 | 50 | Turn-point between the first and the second line of the operating characteristics |
| End section 2 | 100...300 | %Ir | 1 | 150 | Turn-point between the second and the third line of the operating characteristics |

**Table 720: MPDIF Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Slope section 3 | 10...100 | % | 1 | 100 | Slope of the third line of the operating characteristics |
| DC restrain enable | 0=False<br>1=True | | | 0=False | Setting for enabling DC restrain feature |

**Table 721: MPDIF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| CT connection type | 1=Type 1<br>2=Type 2 | | | 1=Type 1 | CT connection type. Determined by the directions of the connected current transformers |
| CT ratio Cor Line | 0.40...4.00 | | 0.01 | 1.00 | CT ratio correction, line side |
| CT ratio Cor Neut | 0.40...4.00 | | 0.01 | 1.00 | CT ratio correction, neutral side |

## 4.3.7.9 MPDIF Monitored data

**Table 722: MPDIF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| OPR_A | BOOLEAN | 0=False<br>1=True | | Operate phase A |
| OPR_B | BOOLEAN | 0=False<br>1=True | | Operate phase B |
| OPR_C | BOOLEAN | 0=False<br>1=True | | Operate phase C |
| INT_BLKD_A | BOOLEAN | 0=False<br>1=True | | Internal block status phase A |
| INT_BLKD_B | BOOLEAN | 0=False<br>1=True | | Internal block status phase B |
| INT_BLKD_C | BOOLEAN | 0=False<br>1=True | | Internal block status phase C |
| ID_A | FLOAT32 | 0.00...80.00 | xIr | Differential current phase A |
| ID_B | FLOAT32 | 0.00...80.00 | xIr | Differential current phase B |
| ID_C | FLOAT32 | 0.00...80.00 | xIr | Differential current phase C |
| IB_A | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase A |
| IB_B | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase B |
| IB_C | FLOAT32 | 0.00...80.00 | xIr | Biasing current phase C |
| I_ANGL_A1_B1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, line side |
| I_ANGL_B1_C1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, line side |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_ANGL_C1_A1 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, line side |
| I_ANGL_A2_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase A to B, neutral side |
| I_ANGL_B2_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase B to C, neutral side |
| I_ANGL_C2_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle phase C to A, neutral side |
| I_ANGL_A1_A2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between line and neutral side, Phase A |
| I_ANGL_B1_B2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between line and neutral side, Phase B |
| I_ANGL_C1_C2 | FLOAT32 | -180.00...180.00 | deg | Current phase angle diff between line and neutral side, Phase C |
| MPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| IL1-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL1 |
| IL2-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL2 |
| IL3-diff:1 | FLOAT32 | 0.00...80.00 | | Measured differential current amplitude phase IL3 |
| IL1-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL1 |
| IL2-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL2 |
| IL3-bias:1 | FLOAT32 | 0.00...80.00 | | Measured bias current amplitude phase IL3 |

## 4.3.7.10 Technical data

**Table 723: MPDIF Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz<br>±3.0% of the set value or ±0.002 x $I_n$ | | |
| Operate time [1, 2] | Low stage | Minimum | Typical | Maximum |
| | | 32 ms | 35 ms | 37 ms |

*Table continues on the next page*

[1] $F_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[2] Measured with static power output (SPO)

| Characteristic | | Value | | |
|---|---|---|---|---|
| | High stage | 9 ms | 13 ms | 19 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.95 | | |
| Retardation time | | <20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5... | | |

## 4.3.8 High-impedance or flux-balance based differential protection MHZPDIF (ANSI 87HIM)

### 4.3.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| High-impedance or flux-balance based differential protection | MHZPDIF | 3dIHi>M | 87HIM |

### 4.3.8.2 Function block




*Figure 458: Function block*

### 4.3.8.3 Functionality

The high-impedance/flux-balance based differential protection for motors function MHZPDIF provides winding short circuit protection for motors.

MHZPDIF starts and operates when any of the three-phase differential currents, ID_A, ID_B or ID_C, exceeds the set limit. The operation timer characteristic is according to the definite time (DT).

This function contains a blocking functionality. It is possible to block the function outputs, timers or the function itself.

### 4.3.8.4 Analog channel configuration

MHZPDIF has one analog group input which must be properly configured.

**Table 724: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.3.8.5 Operation principle

The function can be enabled and disabled with the *Operation setting*. The corresponding parameter values are "On" and "Off".

The operation of MHZPDIF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

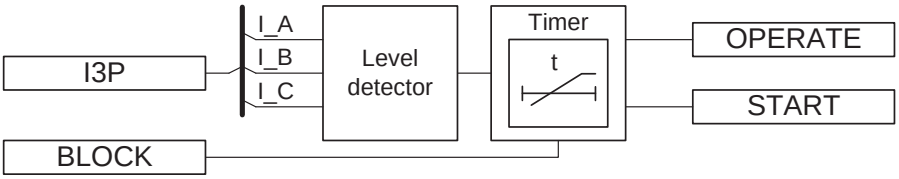



*Figure 459: Functional module diagram*

#### Level detector

This module compares the three-phase differential currents to the set *Operate value*. If any of the differential currents ID_A, ID_B or ID_C exceeds the set *Operate value*, the Level detector module sends an enable signal to the Timer module to start the definite timer (DT).

#### Timer

Once activated, the Timer activates the START output. The Timer characteristic is according to DT. When the operation timer has reached the value set by *Minimum operate time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

The Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

The activation of the BLOCK signal resets the Timer and deactivates the START and OPERATE outputs.

### 4.3.8.6 Application

MHZPDIF provides the winding short circuit and earth-fault protection for motors. The high-impedance or flux-balance principle has been used through many years for differential protection due to the capability to manage through-faults with a heavy current transformer (CT) saturation.

#### High-impedance principle

The high-impedance principle is stable for all types of faults outside the protection zone. The stabilization is obtained by a stabilizing resistor in the differential circuit. This method requires all the CTs to have a similar magnetizing characteristic, same ratio and a relatively high knee point voltage. The CTs in each phase are connected in parallel with a relay measuring branch. The measuring branch is a series connection of the stabilizing resistor and the protection relay.

The stability of the protection is based on the use of the stabilizing resistor ($R_s$) and the fact that the impedance of the CT secondary quickly decreases as the CT

saturates. The magnetization reactance of a fully saturated CT drops to zero and the impedance is formed only by the resistance of the winding ($R_{in}$) and lead resistance ($R_m$).

The CT saturation causes a differential current which can flow through the saturated CT, because of the near-zero magnetizing reactance, or through the measuring branch. The stabilizing resistor is selected so that the current in the measuring branch is below the protection relay's operating current during out-of-zone faults. As a result, the operation is stable during the saturation and can still be sensitive at the undistorted parts of the current waveform.

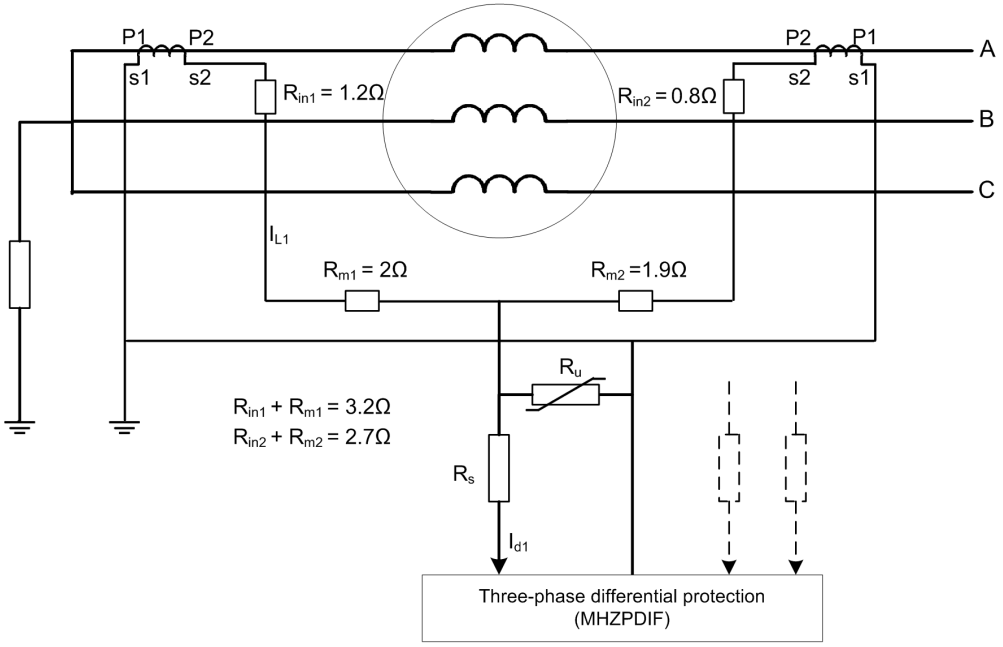



*Figure 460: Three-phase differential protection for motors based on highimpedance principle*

In case of an internal fault, the fault current cannot circulate through the CTs. It flows through the measuring branch, and the protection operates. A partial CT saturation can occur in case of an internal fault, but the undistorted part of the current waveform causes the protection to operate.

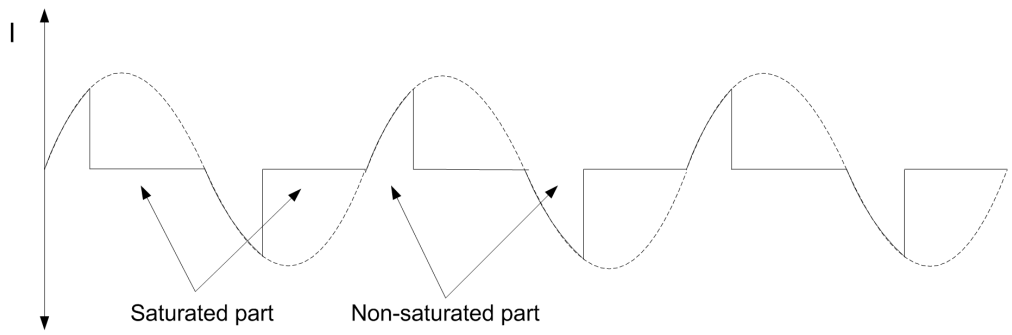



*Figure 461: Secondary waveform of a saturated CT*

At an internal fault, the secondary circuit voltage can easily exceed the isolation voltage of the CTs, connection wires and the protection relay. To limit this voltage, a voltage-dependent resistor (VDR) is used.

The whole scheme, that is, the stabilizing resistor, voltage-dependent resistor and wiring, must be adequately maintained (operation and insulation tested regularly) to be able to withstand the high-voltage pulses that appear during an internal fault throughout the lifetime of the equipment. Otherwise, during a fault within the zone of protection, any flashover in the CT secondary circuits or any other part of the scheme can prevent the correct operation of MHZPDIF.

**Flux-balancing principle**

In a measuring configuration for the three-phase differential currents according to the flux-balancing principle, no stabilizing resistors are needed. The configuration, however, requires the use of core balance current transformers. The compared currents, the one at the line end and the other at the neutral end, are both measured by the same core balance current transformer.

In this scheme, the currents flowing through one core balance transformer cancel each other out when there is no fault within the protected zone. When a fault occurs within the protected zone, the currents flowing through the core balance transformer amplify each other and the differential protection operates.

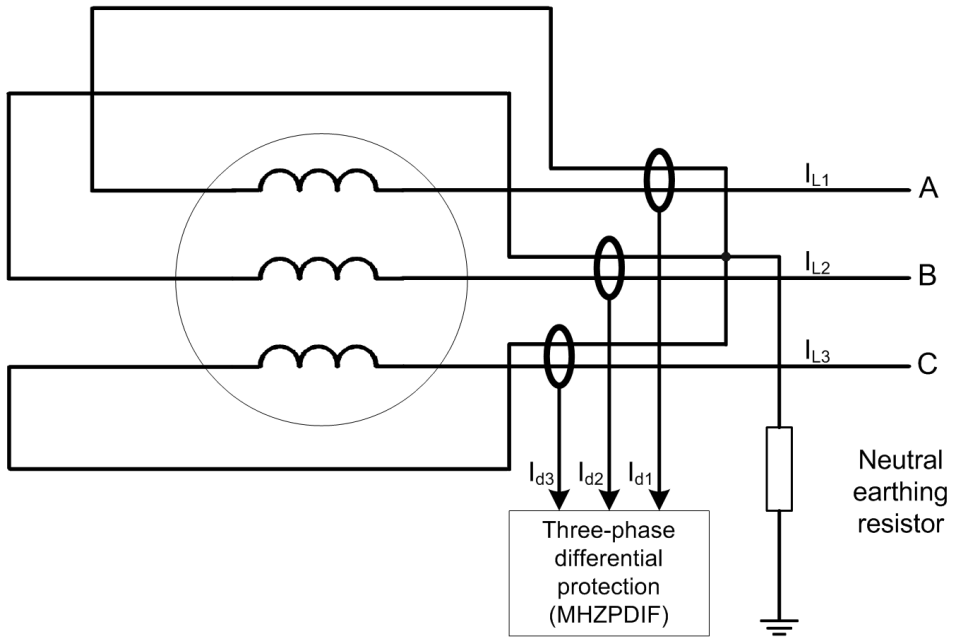



*Figure 462: Three-phase differential protection for motors based on fluxbalancing principle*

The advantage of this scheme is that the CT rated primary current can be selected smaller than the rated current of the machine.

If six current transformers are used, the flux-balancing principle, that is, summing two CTs in each phase, cannot be used. Instead, the high-

impedance principle or stabilized three-phase differential protection must be used.

### 4.3.8.7 Recommendations for current transformers

**High-impedance principle**

The sensitivity and reliability of the protection depend on the characteristics of the current transformers. The CTs must have an identical transformation ratio. It is recommended that all current transformers have an equal burden and characteristics and that they are of the same type. This means that they should be preferably from the same manufacturing batch, that is, an identical construction is used. If the CT characteristics and the burden values are not equal, the calculation for each branch in the scheme should be done separately and the worst-case result is used. If the CT winding resistance and the burden of the branches are not equal, the maximum burden equal to 3.2 Ω should be used for calculating the stabilized voltage.

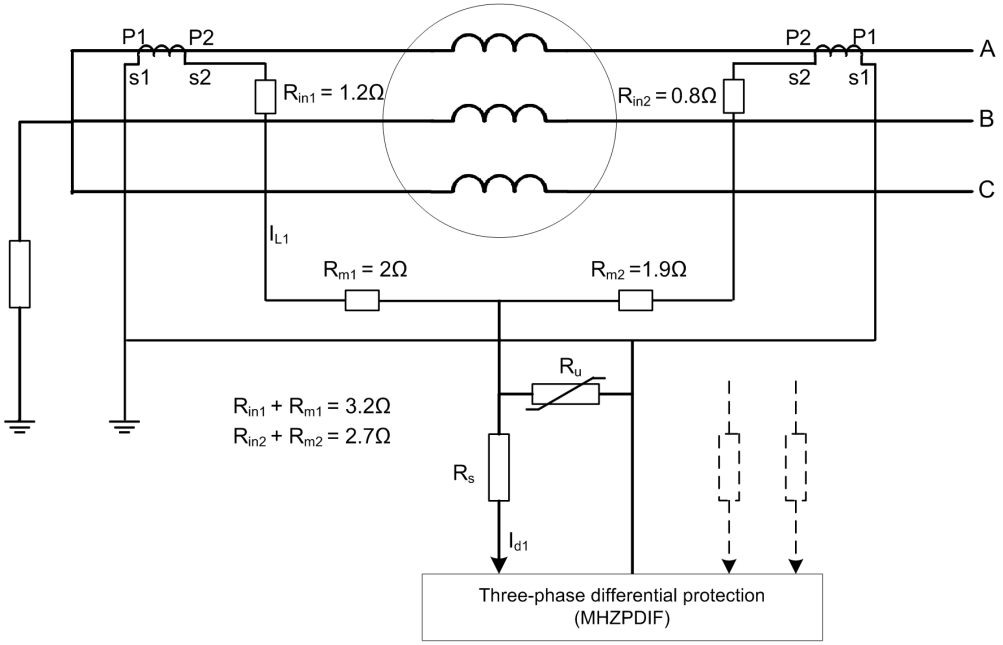



*Figure 463: High-impedance differential protection with different CT burden value on each branch*

The stabilizing voltage, that is the voltage appearing across the measuring branch during an out-of-zone fault, is calculated assuming that one of the CTs connected in parallel is fully saturated. The stabilizing voltage can be calculated using the formula

$$U_s = \frac{I_{k\max}}{n}(R_{in} + R_m)$$

(Equation 212)

| | |
|---|---|
| $I_{kmax}$ | The highest through-fault current in primary amps. The highest earth-fault or short circuit current during the out-of-zone fault. |
| n | The turns ratio of the CT |
| $R_{in}$ | The secondary internal resistance of the CT in ohms |
| $R_m$ | The resistance (maximum of $R_{in} + R_m$) of the CT secondary circuit in ohms |

The current transformers must be able to force enough current to operate the IED through the differential circuit during a fault condition inside the zone of protection. To ensure this, the knee point voltage $U_{kn}$ should be at least two times higher than the stabilizing voltage $U_s$.

The required knee point voltage $U_{kn}$ of the current transformer is calculated using the formula

$$U_{kn} \geq 2 \times U_s$$

(Equation 213)

| | |
|---|---|
| $U_{kn}$ | The knee point voltage |
| $U_s$ | The stabilizing voltage |

The factor two is used when no delay in the operating time of the protection in any situation is acceptable. To prevent the knee point voltage from growing too high, it is advisable to use current transformers, the secondary winding resistance of which is of the same size as the resistance of the measuring loop.

As the impedance of the IED alone is low, a stabilizing resistor is needed. The value of the stabilizing resistor is calculated with the formula

$$R_s = \frac{U_s}{I_{rs}}$$

(Equation 214)

| | |
|---|---|
| $R_s$ | The resistance of the stabilizing resistor |
| $U_s$ | The stabilizing voltage of the protection relay |
| $I_{rs}$ | The value of the *Operate value* setting in secondary amps. |

The stabilizing resistor should be capable to dissipate high energy within a very short time; therefore, the wire wound-type resistor should be used. Because of the possible CT inaccuracy, which might cause some current through the stabilizing resistor in a normal load situation, the rated power should be 25 W minimum.

If $U_{kn}$ is high or the stabilizing voltage is low, a resistor with a higher power rating is needed. Often resistor manufacturers allow 10 times rated power for 5 seconds. Thus the power of the resistor can be calculated with the equation

$$\frac{U_{kn}^2}{R_s \times 10}$$

(Equation 215)

The actual sensitivity of the protection is affected by the protection relay setting, the magnetizing currents of the parallel connected CTs and the shunting effect of the voltage-dependent resistor ( VDR). The value of the primary current $I_{prim}$ at which the protection relay operates at a certain setting can be calculated with the formula

$$I_{prim} = n \cdot \left( I_{rs} + I_u + m \cdot I_m \right)$$

(Equation 216)

| | |
|---|---|
| $I_m$ | The magnetizing current per current transformer at the $U_s$ voltage |
| $I_{prim}$ | The primary current at which the protection is to start |
| $I_{rs}$ | The value of the *Operate value* setting |
| $I_u$ | The leakage current flowing through the VDR at the $U_s$ voltage |
| n | The turn ratio of the current transforme |
| m | The number of current transformers included in the protection per phase (=2) |

The $I_e$ value given in many catalogs is the excitation current at the knee point voltage.

Assuming $U_{kn} \approx 2 \times U_s$, the value of $I_m \approx \frac{I_e}{2}$ gives an approximate value for *Equation 216*.

The selection of current transformers can be divided into the following steps.

1. The rated current In of the protected machine should be known. The value of In also affects the magnitude of $I_{kmax}$. Normally the $I_{kmax}$ value for motors is $6 \cdot I_n$.
2. The rated primary current $I_{1n}$ of the CT has to be higher than the rated current of the machine.

   The choice of the CT also specifies $R_{in}$.
3. The required $U_{kn}$ is calculated with *Equation 213*. If the $U_{kn}$ of the CT is not high enough, another CT has to be chosen. The value of the $U_{kn}$ is given by the manufacturer in the case of Class X current transformers or it can be estimated with *Equation 217*.
4. The sensitivity $I_{prim}$ is calculated with *Equation 216*. If the achieved sensitivity is sufficient, the present CT is chosen. A CT with a bigger core is chosen if a better sensitivity is needed.

If a Class X CT is not used, an estimate for Ukn is calculated using *Equation 216*.

$$U_{kn} = 0.8 \times F_n \times I_{2n} \times \left( R_{in} + \frac{S_n}{I_{2n}^2} \right)$$

(Equation 217)

| | |
|---|---|
| $F_n$ | The rated accuracy limit factor corresponding to the rated burden $S_n$ |
| $I_{2n}$ | The rated secondary current of the CT |
| $R_{in}$ | The secondary internal resistance of the CT |
| $S_n$ | The volt-amp rating of the CT |

The formulas are based on choosing the CTs according to *Equation 213*, which results an absolutely stable scheme. In some cases, it is possible to achieve stability with knee point voltages lower than stated in the formulas. However, the network conditions have to be known well enough to ensure the stability.

- If $U_k \geq 2 \times U_s$, fast relay operation is secure.
- If $U_k \geq 1.5 \times U_s$ and $< 2 \times U_s$, relay operation can be slightly prolonged and should be studied case by case.
- If $U_k < 1.5 \times U_s$, the relay operation is jeopardized. Another CT has to be chosen.

The need for voltage dependent resistor (VDR) depends on the insulation level for which the protection relays are tested.

Voltage Umax, ignoring the CT saturation during the fault is calculated using

First, voltage $U_{max}$, ignoring the CT saturation during the fault, is calculated with the equation *Equation 218*.

$$U_{max} = \frac{I_{k\,max\,in}}{n} \times \left( R_{in} + R_m + R_s \right) \approx \frac{I_{k\,max\,in}}{n} \times R_s$$

(Equation 218)

| | |
|---|---|
| $I_{kmaxin}$ | Maximum fault current inside the zone, in primary amps |
| n | Turns ration of the CT |
| $R_{in}$ | Internal resistance of the CT in ohms |
| $R_m$ | Resistance of the longest loop of the CT secondary circuit, in ohms |
| $R_s$ | Resistance of the stabilized resistor, in ohms |

The peak voltage û, which includes the CT saturation, is estimated by using *Equation 219* (given by P. Mathews 1955).

$$\hat{u} = 2\sqrt{2U_{kn}\left(U_{max} - U_{kn}\right)}$$

(Equation 219)

| | |
|---|---|
| $U_{kn}$ | Knee point voltage of the CT |

The VDR is recommended when the peak voltage û ≥ 2kV, which is the insulation level for which the IED is tested.

For example, the maximum fault current in case of a fault inside the zone is 12.6 kA in primary, CT is of 1250/5 A, that is, ratio n = 240, and knee point voltage is 81 V. The stabilizing resistor is 330 Ohms.

$$U_{max} = \frac{12600\,A}{240} \cdot 330\,\Omega = 17325\,V$$

(Equation 220)

$$\check{u} = 2\sqrt{2 \cdot 81 \cdot (17325 - 81)} \approx 3.34\,kV$$

(Equation 221)

As the peak voltage û = 3.2 kV, VDR must be used. In some cases, VDR can be avoided if $R_s$ is smaller. The value of $R_s$ depends on the protection relay operation current and stabilizing voltage. Thus, a higher setting in the protection relay must be used or the stabilizing voltage lowered.

### Flux-balancing principle

When the function block is used with the flux-balancing principle, there are no extra requirements for the measuring devices. The core-balance transformers used in an ordinary overcurrent protection are adequate here as well.

### 4.3.8.8 Example calculations for high-impedance differential protection

The example shows the calculations for the *Operate value* setting, stabilizing resistor value ($R_s$) and required knee point voltage ($U_{kn}$) of the CTs.

**Table 725: Protected generator values**

| Quantity | Value |
|---|---|
| $S_n$ | 8 MVA |
| $U_n$ | 6 kV |
| $I_n$ | 770 A |
| $I_{kmax}$ | 4620 A (6 × $I_n$) out-of-zone fault |
| $I_{kmaxin}$ | 9.24 kA (12 × $I_n$) in-zone fault |

**Table 726: Assumed CT data**

| Quantity | Value |
|---|---|
| CT | 1000/1 A |
| $R_{in}$ | 15.3 Ω |
| $U_{kn}$ | 323 V |
| $I_e$ | 35 mA (at $U_{kn}$) |

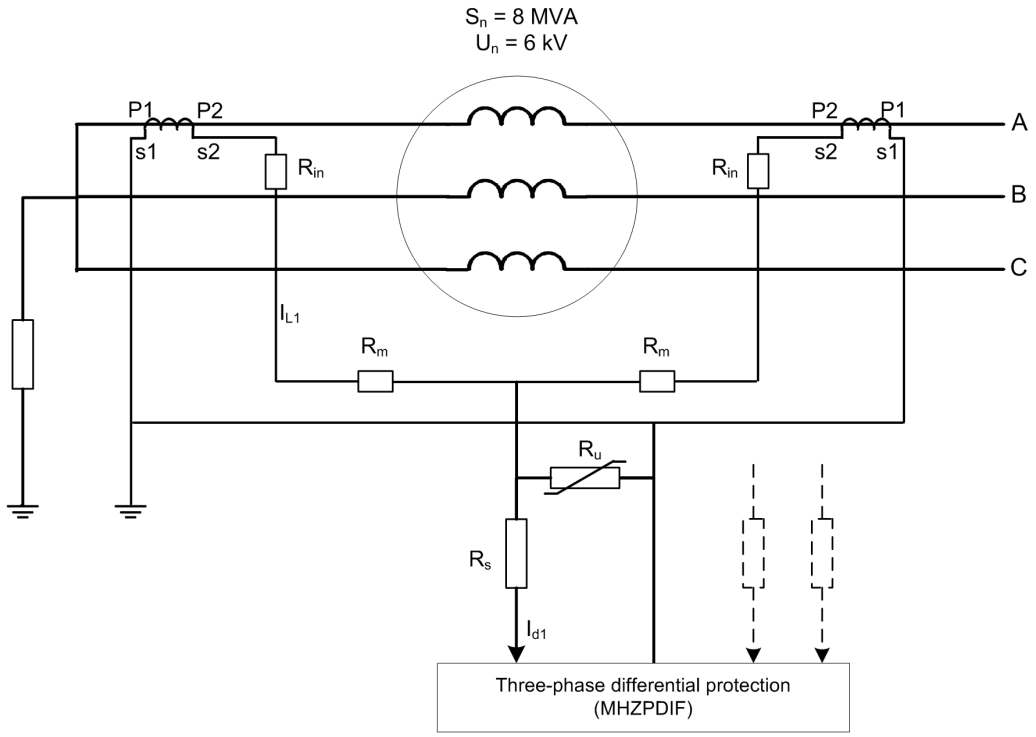



*Figure 464: Example calculation for high-impedance differential protection (only one phase is presented in detail)*

The length of the secondary circuit loop is 200 m and the area of the cross-section is 2.5 $mm^2$. Resistance at 75°C is 0.00865 Ω/m.

$$R_m = 0.00865 \frac{\Omega}{m} \cdot 200m \approx 1.73\Omega$$

(Equation 222)

First the stabilizing voltage is calculated based on equation

$$U_s = \frac{6 \cdot 770\,A}{1000} \cdot (15.3\Omega + 1.73\Omega) \approx 78.7V$$

(Equation 223)

In this case the requirement for the current transformer knee point voltage is fulfilled because $U_{kn} > 2U_s$.

The magnetising curve of the CT is assumed to be linear. The magnetizing current at the stabilizing voltage can be estimated.

$$I_m = \frac{U_s}{U_{kn}} \cdot I_e$$

(Equation 224)

$$I_m = \frac{78.7V}{323V} \cdot 35mA \approx 8.5mA$$

(Equation 225)

The setting current $I_{rs}$ should be at the minimum of the sum of the magnetizing currents of all connected CTs to obtain adequate protection stability.

$$I_{rs} = 2 \cdot 8.5\,mA \approx 17\,mA$$

(Equation 226)

The resistance of the stabilizing resistor is calculated based on equation

$$R_s = \frac{78.7V}{0.017A} \approx 4629\,\Omega$$

(Equation 227)

The calculated value 4629 Ω is the maximum value for the stabilizing resistor. If this value is not available, the next available value downwards should be chosen and the protection relay setting current is to be tuned according to the selected resistor. For example in this case the resistance value 3900 Ω is used.

$$I_{rs} = \frac{78.7V}{3900V} \approx 20\,mA$$

(Equation 228)

The sensitivity of the protection is obtained as per equation (assuming $I_u$ to be zero)

$$I_{prim} = 1000 \cdot (0.020\,A + 2 \cdot 0.0085\,A + 0\,A) \approx 37\,A$$

(Equation 229)

The power of the stabilizing resistor is calculated as follows.

$$P \geq \frac{(323\,V)^2}{3900\,\Omega} \approx 27\,W$$

(Equation 230)

The need for voltage dependent resistor is checked with equations

$$U_{max} = \frac{12 \cdot 770\,A}{1000} \cdot (3900\,\Omega + 15.3\,\Omega + 1.73\,\Omega + 0.10\,\Omega) \approx 36.2\,kV$$

(Equation 231)

$$\check{u} = 2\sqrt{2 \cdot 323\,V \cdot (36200\,V - 323\,V)} \approx 9.6\,kV$$

(Equation 232)

The voltage dependent resistor, one for each phase, is needed in this case because the voltage during the fault is much higher than 2 kV.

The leakage current through the varistor at the stabilizing voltage can be available from the varistor manual, assuming that to be approximately 2 mA at stabilizing voltage.

$$Iu \approx 0.002\,A$$

(Equation 233)

The sensitivity of the protection can be re-calculated taking into account the leakage current through the varistor as per equation

$$I_{prim} = 1000 \cdot (0.020\,A + 2 \cdot 0.0085\,A + 0.002\,A) \approx 39\,A$$

(Equation 234)

### 4.3.8.9 Signals

#### MHZPDIF Input signals

**Table 727: MHZPDIF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**MHZPDIF Output signals**

**Table 728: MHZPDIF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

## 4.3.8.10 MHZPDIF Settings

**Table 729: MHZPDIF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operate value | 0.5...50.0 | %In | 0.1 | 0.5 | Operate value, percentage of the nominal current |
| Minimum operate time | 20...300000 | ms | 10 | 20 | Minimum operate time |

**Table 730: MHZPDIF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 731: MHZPDIF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 0 | Reset delay time |

## 4.3.8.11 MHZPDIF Monitored data

**Table 732: MHZPDIF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| ID_A | FLOAT32 | 0.00...80.00 | xIn | Differential current phase A |
| ID_B | FLOAT32 | 0.00...80.00 | xIn | Differential current phase B |
| ID_C | FLOAT32 | 0.00...80.00 | xIn | Differential current phase C |
| MHZPDIF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.3.8.12 Technical data

**Table 733: MHZPDIF Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz<br>±1.5% of the set value or 0.002 × $I_n$ | | |
| Start time [1, 2] | $I_{Fault}$ = 2.0 × set *Start Value* (one phase fault) | Minimum | Typical | Maximum |
| | | 13 ms | 17 ms | 21 ms |
| | $I_{Fault}$ = 2.0 × set *Start Value* (three phases fault) | 11 ms | 14 ms | 17 ms |
| Reset time | | <40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value of ±20 ms | | |

# 4.4 Unbalance protection

## 4.4.1 Negative-sequence overcurrent protection NSPTOC (ANSI 46M)

### 4.4.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Negative-sequence overcurrent protection | NSPTOC | I2>M | 46M |

[1] *Measurement mode* = “Peak-to-Peak”, current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

[2] Includes the delay of the signal output contact

### 4.4.1.2 Function block




*Figure 465: Function block*

### 4.4.1.3 Functionality

The negative-sequence overcurrent protection function NSPTOC is used for increasing sensitivity to detect single-phase and phase-to-phase faults or unbalanced loads due to, for example, broken conductors or unsymmetrical feeder voltages.

NSPTOC can also be used for detecting broken conductors.

The function is based on the measurement of the negative sequence current. In a fault situation, the function starts when the negative sequence current exceeds the set limit. The operate time characteristics can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). In the DT mode, the function operates after a predefined operate time and resets when the fault current disappears. The IDMT mode provides current-dependent timer characteristics.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.4.1.4 Analog channel configuration

NSPTOC has one analog group input which must be properly configured.

**Table 734: Analog signals**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.4.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of NSPTOC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

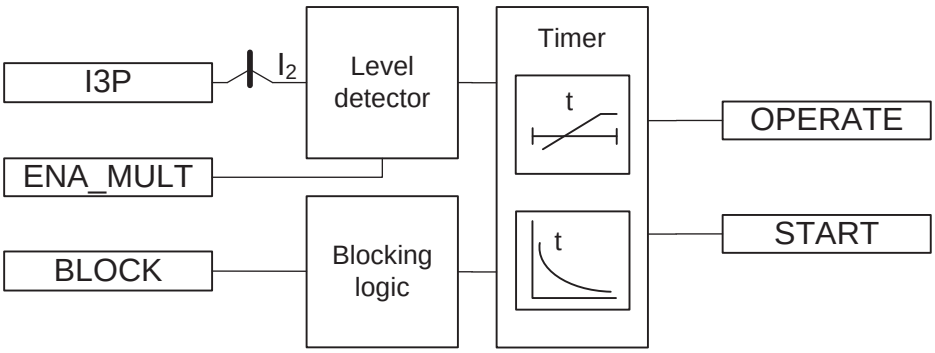



*Figure 466: Functional module diagram*

**Level detector**

The measured negative-sequence current is compared to the set *Start value* . If the measured value exceeds the set *Start value* , Level detector activates the Timer module. If the ENA_MULT input is active, the set *Start value* is multiplied by the set *Start value Mult*.

The protection relay does not accept the *Start value* or *Start value Mult* setting if the product of the settings exceeds the *Start value* setting range.

**Timer**

Once activated, Timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of Operate delay time in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The functionality of the timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the *Type of reset curve* setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation. The START output is deactivated when the reset timer has elapsed.

If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The functionality of the timer in the reset state depends on the combination of the *Operating curve type*, *Type of reset curve* and *Reset delay time* settings. When the DT characteristic

is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, the Type of reset curve setting can be set to "Immediate", "Def time reset" or "Inverse reset". The reset curve type "Immediate" causes an immediate reset. With the reset curve type "Def time reset", the reset time depends on the *Reset delay time* setting. With the reset curve type "Inverse reset", the reset time depends on the current during the drop-off situation and the value of START_DUR. The START output is deactivated when the reset timer has elapsed.



The "Inverse reset" selection is only supported with ANSI or user programmable types of the IDMT operating curves. If another operating curve type is selected, an immediate reset occurs during the drop-off situation.

The setting *Time multiplier* is used for scaling the IDMT operate and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.



The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see *Chapter 11.2.1 IDMT curves for overcurrent protection* in this manual.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

#### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.4.1.6 Application

Since the negative sequence current quantities are not present during normal, balanced load conditions, the negative sequence overcurrent protection elements can be set for faster and more sensitive operation than the normal phase-overcurrent protection for fault conditions occurring between two phases. The negative sequence overcurrent protection also provides a back-up protection functionality for the feeder earth-fault protection in solid and low resistance earthed networks.

The negative sequence overcurrent protection provides the back-up earth-fault protection on the high voltage side of a delta-wye connected power transformer for earth faults taking place on the wye-connected low voltage side. If an earth fault

occurs on the wye-connected side of the power transformer, negative sequence current quantities appear on the delta-connected side of the power transformer.

The most common application for the negative sequence overcurrent protection is probably rotating machines, where negative sequence current quantities indicate unbalanced loading conditions (unsymmetrical voltages). Unbalanced loading normally causes extensive heating of the machine and can result in severe damages even over a relatively short time period.

Multiple time curves and time multiplier settings are also available for coordinating with other devices in the system.

### 4.4.1.7 Signals

#### NSPTOC Input signals

**Table 735: NSPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_MULT | BOOLEAN | 0=False | Enable signal for current multiplier |

#### NSPTOC Output signals

**Table 736: NSPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.4.1.8 NSPTOC Settings

**Table 737: NSPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...5.00 | xIn | 0.01 | 0.30 | Start value |
| Start value Mult | 0.8...10.0 | | 0.1 | 1.0 | Multiplier for scaling the start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...200000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv. | | | 15=IEC Def. Time | Selection of time delay curve type |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | | |

**Table 738: NSPTOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset<br>3=Inverse reset | | | 1=Immediate | Selection of reset curve type |

**Table 739: NSPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.0086...120.0000 | | 0.0001 | 28.2000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.0000...0.7120 | | 0.0001 | 0.1217 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter D | 0.46...30.00 | | 0.01 | 29.10 | Parameter D for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 740: NSPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

#### 4.4.1.9 NSPTOC Monitored data

**Table 741: NSPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| NSPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.4.1.10 Technical data

**Table 742: NSPTOC Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [1, 2] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2 × set *Start value*<br>$I_{Fault}$ = 10 × set *Start value* | 23 ms<br>15 ms | 26 ms<br>18 ms | 28 ms<br>20 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [3] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

## 4.4.2 Directional negative-sequence overcurrent protection DNSPDOC (ANSI 67Q)

#### 4.4.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Directional negative-sequence overcurrent protection | DNSPDOC | I2> -> | 67Q |

[1] Negative sequence current before fault = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements.
[2] Includes the delay of the signal output contact.
[3] Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 1.5...20.

### 4.4.2.2 Function block

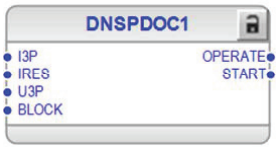



*Figure 467: Function block*

### 4.4.2.3 Functionality

The directional negative-sequence overcurrent protection function DNSPDOC is used as directional overcurrent and short-circuit protection.

DNSPDOC starts up when the fundamental value of the operating quantity (negative-sequence or residual current) exceeds the set limit and the directional criterion is fulfilled. The operate time characteristic is according to definite time (DT).

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.4.2.4 Analog channel configuration

DNSPDOC has three analog group inputs which must be properly configured.

**Table 743: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| IRES [3] | Residual current (measured or calculated) Necessary when *Operating quantity* is "Residual" or "Residual (calc)" |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

**Table 744: Special conditions**

| Condition | Description |
|---|---|
| U3P connected real measurements | The function requires that at least two voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing

[3] Can be connected to GRPOFF if *Operating quantity* is set to "Negative seq"

blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.4.2.5 Operation principle

The function can be enabled and disabled with the *Operation setting*. The corresponding parameter values are "on" and "off".

The operation of DNSPDOC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

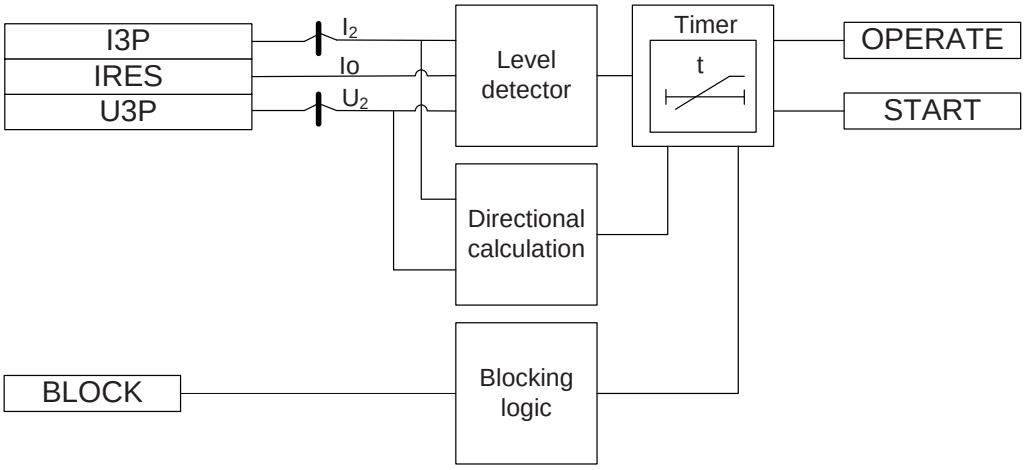



*Figure 468: Functional module diagram*

#### Level detector

The operating signal is compared to the set *Start value*. If the operating signal exceeds the set *Start value*, Level detector sends an enabling signal to the Timer module. Timer starts when it is enabled and the directional criterion is fulfilled. A suitable operating quantity can be selected with the *Operating quantity* setting. The options are "Negative seq" or "Residual". The value of operating quantity I_OPER is also available in the Monitored data view.

Irrespective of the operating quantity selected, directional calculation is always determined using the negative-sequence current.

#### Directional calculation

Directional calculation compares the negative-sequence current phasor with the negative-sequence voltage phasor, that is, the polarizing quantity. The directional operation can be selected with the *Directional mode* setting. The options are "Nondirectional", "Forward" or "Reverse" operation. By setting the value of *Allow Non Dir* to "True", the non-directional operation is allowed when the directional information is invalid.

The *Characteristic angle* setting is used to turn the directional characteristics. The value of *Characteristic angle* should be chosen so that all the faults in the operating direction are seen in the operating zone and all the faults in the opposite direction are seen in the non-operating zone. The value of *Characteristic angle* depends on the network configuration.

Reliable directional calculation requires that both negative-sequence current and negative-sequence voltage quantities exceed certain minimum amplitude levels. The minimum amplitude level for the negative-sequence current is set with the *Min operate current* setting. The minimum amplitude level for the polarizing quantity, that is, the negative-sequence voltage, is set with the *Min operate voltage* setting. If the amplitude level of the operating quantity or polarizing quantity is below the set level, the direction information of the corresponding phase is set to “unknown”. If the negative-sequence voltage before the fault situation is below *Min operate voltage*, the voltage direction cannot be determined.

The value for the *Min operate voltage* setting should be carefully selected since the accuracy in low signal levels is strongly affected by the measuring device accuracy.

**Timer**

Once activated, Timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated if the operating signal persists.

In a drop-off situation, that is, if a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated. The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, the function operates normally but the OPERATE output is not activated.

### 4.4.2.6 Directional overcurrent characteristics

The forward and reverse sectors are defined separately. The forward operation area is limited with the *Min forward angle* and *Max forward angle* settings. The reverse operation area is limited with the *Min reverse angle* and *Max reverse angle* settings.

The sector limits are always given as positive degree values.

In the forward operation area, the *Max forward angle* setting gives the counterclockwise sector and the *Min forward angle* setting gives the corresponding clockwise sector, measured from the *Characteristic angle* setting.

In the backward operation area, the *Max reverse angle* setting gives the counterclockwise sector and the *Min reverse angle* setting gives the corresponding

clockwise sector, a measurement from the *Characteristic angle* setting that has been rotated 180 degrees.

Relay characteristic angle (RCA) is set positive if the operating current lags the polarizing quantity and negative if the operating current leads the polarizing quantity.

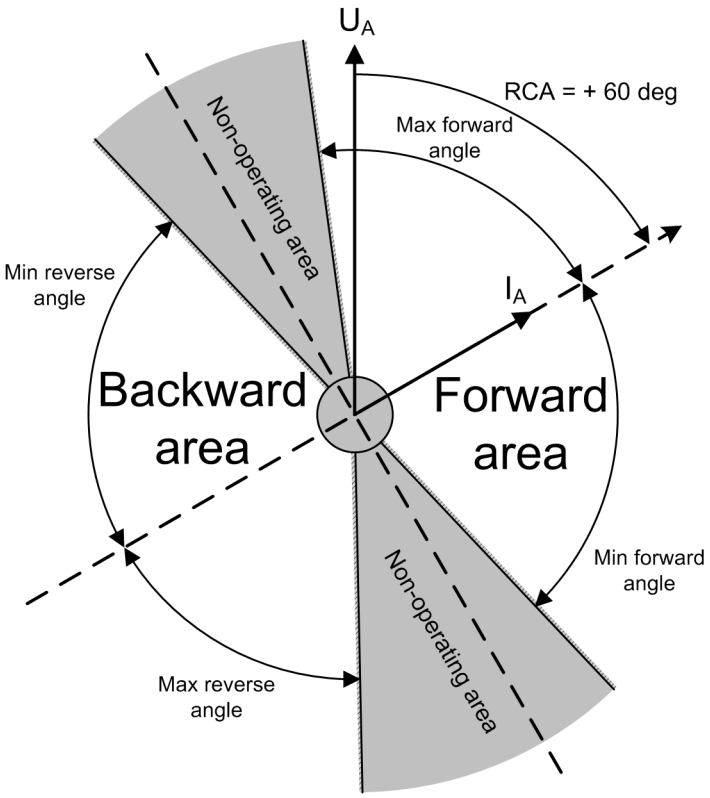



*Figure 469: Configurable operating sectors*

The angle difference ANGLE between the negative-sequence current and the polarizing quantity is calculated as shown below and is available in the Monitored data view.

$$ANGLE = \phi(-U_2) - \phi(I_2) - \phi_{RCA}$$

(Equation 235)

Based on the ANGLE value, the direction information DIRECTION is evaluated and is made available in the Monitored data view.

**Table 745: Momentary direction value for monitored data view**

| Criterion for direction information | Value for DIRECTION |
|---|---|
| ANGLE_X is not in any of the defined sectors, or the direction cannot be defined due too low amplitude | 0 = unknown |
| ANGLE_X is in the forward sector | 1 = forward |
| ANGLE_X is in the reverse sector | 2 = backward |

FAULT_DIR gives the detected direction of the fault during fault situations, that is, when the START output is active.

### 4.4.2.7 Application

The ability of a protection relay to provide direction information for faults is referred to as its directional security. It is extremely important for the directional protection function to identify the direction of the fault relative to the location of the protection relay. The fault direction can be either downstream (forward fault) or upstream of the protection relay (backward fault).

Different directional elements are used to determine the fault direction. One such element is the negative-sequence voltage. As directional element, the negative-sequence voltage can identify the direction of all unbalance faults. One of the advantages of using negative-sequence elements is that the negative-sequence component is insensitive to zero-sequence mutual coupling. The negative sequence is also used where the source is not strong enough because with such a source the value of the negative sequence near the protection relay has higher magnitude.

### 4.4.2.8 Signals

#### DNSPDOC Input signals

**Table 746: DNSPDOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

#### DNSPDOC Output signals

**Table 747: DNSPDOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.4.2.9 DNSPDOC Settings

**Table 748: DNSPDOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...5.00 | xIn | 0.01 | 0.05 | Start value |
| Directional mode | 1=Non-directional | | | 2=Forward | Directional mode |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=Forward<br>3=Reverse | | | | |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Characteristic angle | -179...180 | deg | 1 | 60 | Characteristic angle |
| Max forward angle | 0...90 | deg | 1 | 80 | Maximum phase angle in forward direction |
| Max reverse angle | 0...90 | deg | 1 | 80 | Maximum phase angle in reverse direction |
| Min forward angle | 0...90 | deg | 1 | 80 | Minimum phase angle in forward direction |
| Min reverse angle | 0...90 | deg | 1 | 80 | Minimum phase angle in reverse direction |

**Table 749: DNSPDOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operating quantity | 1=Negative seq<br>2=Residual | | | 1=Negative seq | Operating quantity |

**Table 750: DNSPDOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 751: DNSPDOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Allow Non Dir | 0=False<br>1=True | | | 0=False | Allows prot activation as non-dir when dir info is invalid |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.01 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.01 | Minimum operating voltage |

## 4.4.2.10 DNSPDOC Monitored data

**Table 752: DNSPDOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| FAULT_DIR | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Detected fault direction |
| DIRECTION | Enum | 0=unknown<br>1=forward | | Direction information |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 2=backward<br>3=both | | |
| ANGLE | FLOAT32 | -180.00...180.00 | deg | Calculated angle difference |
| I_OPER | FLOAT32 | 0.00...40.00 | xIn | Calculated operating current |
| DNSPDOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.4.2.11 Technical data

**Table 753: DNSPDOC Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the current measured: $f_n$ ±2 Hz | | |
| | | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle:<br>±2° | | |
| Start time [1, 2] | $I_{Fault}$ = 2 × set *Start value* | Minimum | Typical | Maximum |
| | | 31 ms | 34 ms | 37 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy | | ±1.0% of the set value of ±20 ms | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

## 4.4.3 Phase discontinuity protection PDNSPTOC (ANSI 46PD)

### 4.4.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Phase discontinuity protection | PDNSPTOC | I2/I1> | 46PD |

[1] Measurement mode NPS, NPS current before fault = 0.0 × $I_n$, $f_n$ = 50 Hz, fault NPS current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements.
[2] Measured with static signal output (SSO).

### 4.4.3.2 Function block




*Figure 470: Function block*

### 4.4.3.3 Functionality

The phase discontinuity protection function PDNSPTOC is used for detecting unbalance situations caused by broken conductors.

The function starts and operates when the unbalance current $I_2/I_1$ exceeds the set limit. To prevent faulty operation at least one phase current needs to be above the minimum level. PDNSPTOC operates with DT characteristic.

The function contains a blocking functionality. It is possible to block the function output, timer or the function itself.

### 4.4.3.4 Analog channel configuration

PDNSPTOC has one analog group input which must be properly configured.

**Table 754: Analog signals**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.4.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PDNSPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

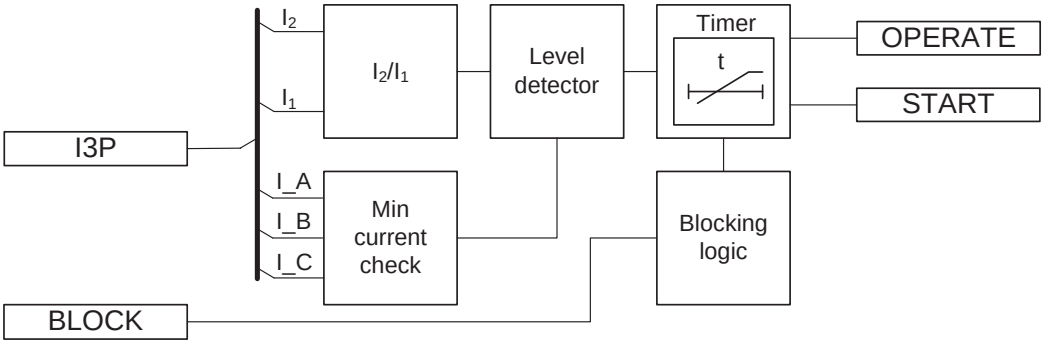



*Figure 471: Functional module diagram*

### $I_2/I_1$

The $I_2/I_1$ module calculates the ratio of the negative and positive sequence current. It reports the calculated value to the level detector.

### Level detector

The level detector compares the calculated ratio of the negative and positive-sequence currents to the set *Start value*. If the calculated value exceeds the set *Start value* and the min current check module has exceeded the value of *Min phase current*, the level detector reports the exceeding of the value to the timer.

### Min current check

The min current check module checks whether the measured phase currents are above the set *Min phase current*. At least one of the phase currents needs to be above the set limit to enable the level detector module.

### Timer

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole

function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.4.3.6 Application

In three-phase distribution and subtransmission network applications the phase discontinuity in one phase can cause an increase of zero-sequence voltage and short overvoltage peaks and also oscillation in the corresponding phase.

PDNSPTOC is a three-phase protection with DT characteristic, designed for detecting broken conductors in distribution and subtransmission networks. The function is applicable for both overhead lines and underground cables.

The operation of PDNSPTOC is based on the ratio of the positive-sequence and negative-sequence currents. This gives a better sensitivity and stability compared to plain negative-sequence current protection since the calculated ratio of positive-sequence and negative-sequence currents is relatively constant during load variations.

The unbalance of the network is detected by monitoring the negative-sequence and positive-sequence current ratio, where the negative-sequence current value is $I_2$ and $I_1$ is the positive-sequence current value. The unbalance is calculated with the equation.

$$Iratio = \frac{I_2}{I_1}$$

(Equation 236)

Broken conductor fault situation can occur in phase A in a feeder.

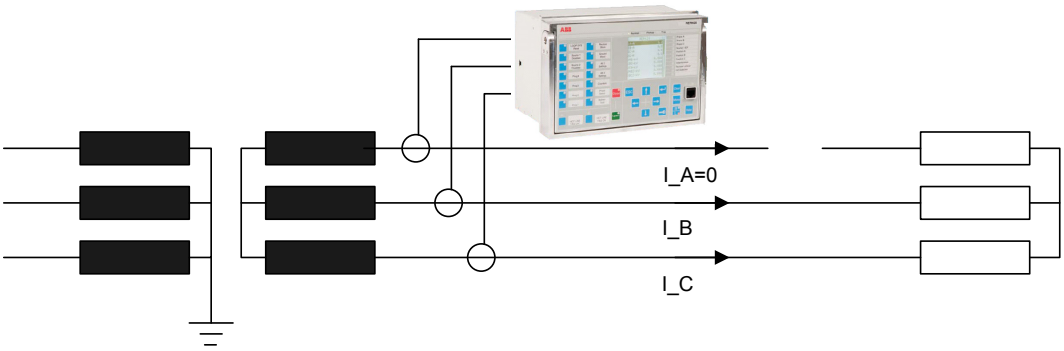



*Figure 472: Broken conductor fault situation in phase A in a distribution or subtransmission feeder*

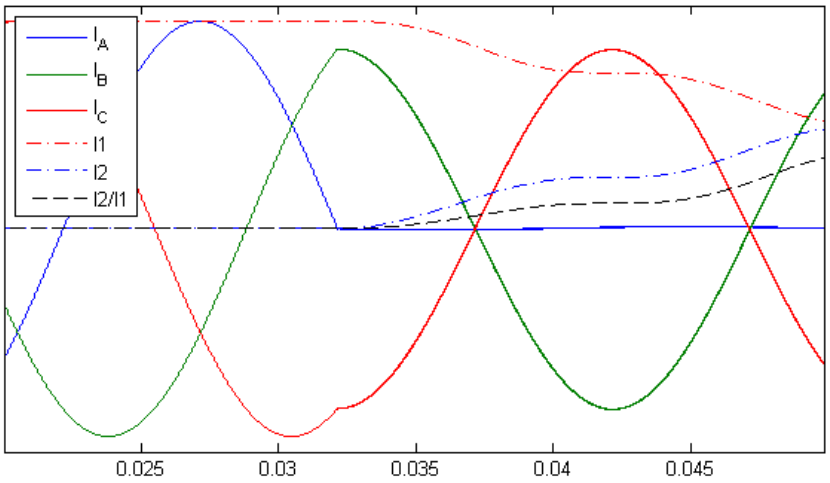



*Figure 473: Three-phase current quantities during the broken conductor fault in phase A with the ratio of negative-sequence and positive-sequence currents*

## 4.4.3.7 Signals

### PDNSPTOC Input signals

**Table 755: PDNSPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### PDNSPTOC Output signals

**Table 756: PDNSPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

## 4.4.3.8 PDNSPTOC Settings

**Table 757: PDNSPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 10...100 | % | 1 | 10 | Start value |
| Operate delay time | 100...30000 | ms | 1 | 100 | Operate delay time |

**Table 758: PDNSPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 759: PDNSPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Min phase current | 0.05...0.30 | xIn | 0.01 | 0.10 | Minimum phase current |

### 4.4.3.9 PDNSPTOC Monitored data

**Table 760: PDNSPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| RATIO_I2_I1 | FLOAT32 | 0.00...999.99 | % | Measured current ratio I2 / I1 |
| PDNSPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.4.3.10 Technical data

**Table 761: PDNSPTOC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±2% of the set value |
| Start time | <70 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 4.4.4 Phase reversal protection PREVPTOC (ANSI 46R)

### 4.4.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Phase reversal protection | PREVPTOC | I2>> | 46R |

### 4.4.4.2 Function block

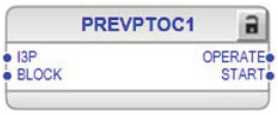



*Figure 474: Function block*

### 4.4.4.3 Functionality

The phase reversal protection function PREVPTOC is used to detect the reversed connection of the phases to a three-phase motor by monitoring the negative phase sequence current $I_2$ of the motor.

PREVPTOC starts and operates when $I_2$ exceeds the set limit. PREVPTOC operates on definite time ( DT) characteristics. PREVPTOC is based on the calculated $I_2$, and the function detects too high $I_2$ values during the motor start-up. The excessive $I_2$ values are caused by incorrectly connected phases, which in turn makes the motor rotate in the opposite direction.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

### 4.4.4.4 Analog input configuration

PREVPTOC has one analog group input which must be properly configured.

**Table 762: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.4.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PREVPTOC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

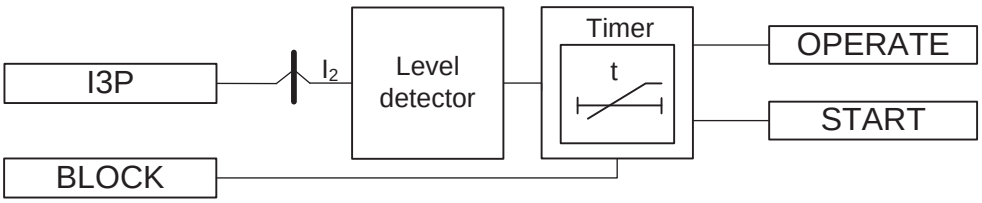



*Figure 475: Functional module diagram*

**Level detector**

The level detector compares the negative-sequence current to the set *Start value*. If the $I_2$ value exceeds the set *Start value*, the level detector sends an enabling signal to the timer module.

**Timer**

Once activated, the timer activates the START output. When the operation timer has reached the set *Operate delay time* value, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value of 200 ms, the operation timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

### 4.4.4.6 Application

The rotation of a motor in the reverse direction is not a desirable operating condition. When the motor drives fans and pumps, for example, and the rotation direction is reversed due to a wrong phase sequence, the driven process can be disturbed and the flow of the cooling air of the motor can become reversed too. With a motor designed only for a particular rotation direction, the reversed rotation direction can lead to an inefficient cooling of the motor due to the fan design.

In a motor, the value of the negative-sequence component of the phase currents is very negligible when compared to the positive-sequence component of the current during a healthy operating condition of the motor. But when the motor is started with the phase connections in the reverse order, the magnitude of $I_2$ is very high. So whenever the value of $I_2$ exceeds the start value, the function detects the reverse rotation direction and provides an operating signal that disconnects the motor from the supply.

### 4.4.4.7 Signals

**PREVPTOC Input signals**

**Table 763: PREVPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**PREVPTOC Output signals**

**Table 764: PREVPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.4.4.8 PREVPTOC Settings

**Table 765: PREVPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...1.00 | xIn | 0.01 | 0.75 | Start value |
| Operate delay time | 100...60000 | ms | 10 | 100 | Operate delay time |

**Table 766: PREVPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

### 4.4.4.9 PREVPTOC Monitored data

**Table 767: PREVPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PREVPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.4.4.10 Technical data

**Table 768: PREVPTOC Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [1, 2] | $I_{Fault}$ = 2.0 × set *Start value* | Minimum | Typical | Maximum |
| | | 23 ms | 25 ms | 28 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

## 4.4.5 Negative-sequence overcurrent protection for machines MNSPTOC (ANSI 46M)

### 4.4.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Negative-sequence overcurrent protection for machines | MNSPTOC | I2>M | 46M |

### 4.4.5.2 Function block




*Figure 476: Function block*

### 4.4.5.3 Functionality

The negative-sequence overcurrent protection for machines function MNSPTOC protects electric motors from phase unbalance. A small voltage unbalance can produce a large negative-sequence current flow in the motor. For example, a 5 percent voltage unbalance produces a stator negative-sequence current of 30 percent of the full load current, which can severely heat the motor. MNSPTOC detects the large negative-sequence current and disconnects the motor.

The function contains a blocking functionality. It is possible to block the function outputs, timers or the function itself.

[1] Negative-sequence current before = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements.
[2] Includes the delay of the signal output contact.

### 4.4.5.4 Analog channel configuration

MNSPTOC has one analog group input which must be properly configured.

**Table 769: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.4.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of MNSPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

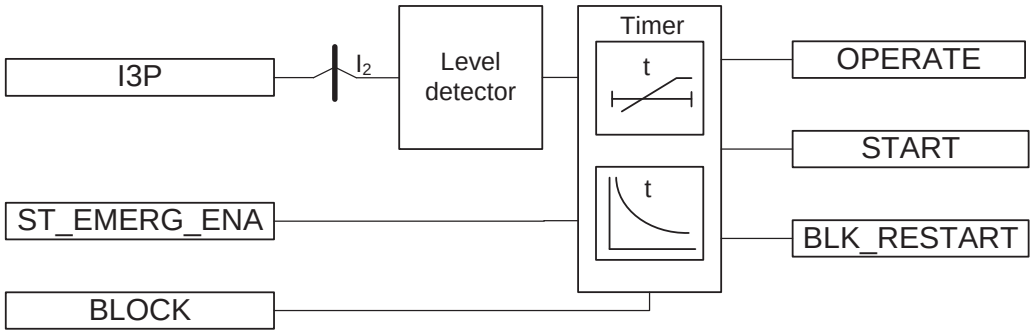



*Figure 477: Functional module diagram*

#### Level detector

The calculated negative-sequence current is compared to the *Start value* setting. If the measured value exceeds the *Start value* setting, the function activates the timer module.

#### Timer

Once activated, the timer activates the START output. Depending on the value of the set *Operating curve type*, the time characteristics are according to DT or IDMT. When the operation timer has reached the value set by *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated.

In a drop-off situation, that is, when the value of the negative-sequence current drops below the *Start value* setting, the reset timer is activated and the START output resets after the time delay of *Reset delay time* for the DT characteristics. For IDMT, the reset time depends on the curve type selected.

For the IDMT curves, it is possible to define minimum and maximum operate times with the *Minimum operate time* and *Maximum operate time* settings. The *Machine time Mult* setting parameter corresponds to the machine constant, equal to the $I_2^2t$ constant of the machine, as stated by the machine manufacturer. In case there is a mismatch between the used CT and the protected motor's nominal current values, it is possible to fit the IDMT curves for the protected motor using the *Current reference* setting.

The activation of the OPERATE output activates the BLK_RESTART output. The deactivation of the OPERATE output activates the cooling timer. The timer is set to the value entered in the *Cooling time* setting. The BLK_RESTART output is kept active until the cooling timer is exceeded. If the negative-sequence current increases above the set value during this period, the OPERATE output is activated immediately.

T_ENARESTART indicates the duration for which the BLK_RESTART output remains active, that is, it indicates the remaining time of the cooling timer. The value is available in the monitored data view.

When the ST_EMERG_ENA emergency start is set high, the value of the T_ENARESTART is immediately set to "False". This disables BLK_RESTART and in turn makes the restart of the motor possible.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

The T_ENARESTART output indicates the duration for which the BLK_RESTART output remains active, that is, it indicates the remaining time of the cooling timer. The value is available in the monitored data view.

When the ST_EMERG_ENA emergency start is set high, the value of the T_ENARESTART is immediately set to "False". This disables BLK_RESTART and in turn makes the restart of the motor possible.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

### 4.4.5.6 Timer characteristics

MNSPTOC supports both DT and IDMT characteristics. The DT timer characteristics can be selected with "ANSI Def. Time" or "IEC Def. Time" in the *Operating curve type* setting. The functionality is identical in both cases. When the DT characteristics are selected, the functionality is only affected by the *Operate delay time* and *Reset delay time* settings.

The protection relay provides two user-programmable IDMT characteristics curves, "Inv. curve A" and "Inv. curve B".

#### Current-based inverse definite minimum time curve (IDMT)

In inverse-time modes, the operate time depends on the momentary value of the current: the higher the current, the shorter the operate time. The operate time

calculation or integration starts immediately when the current exceeds the set *Start value* and the START output is activated.

The OPERATE output of the component is activated when the cumulative sum of the integrator calculating the overcurrent situation exceeds the value set by the inverse time mode. The set value depends on the selected curve type and the setting values used.

The *Minimum operate time* and *Maximum operate time* settings define the minimum operate time and maximum operate time possible for the IDMT mode. For setting these parameters, a careful study of the particular IDMT curves is recommended.

***Inv. curve A***

The inverse time equation for curve type A is:

$$t[s] = \frac{k}{\left(\frac{I_2}{I_r}\right)^2}$$

(Equation 237)

| | |
|---|---|
| t[s] | Operate time in seconds |
| k | Set *Machine time Mult* |
| $I_2$ | Negative-sequence current |
| $I_r$ | Set *Rated current* |

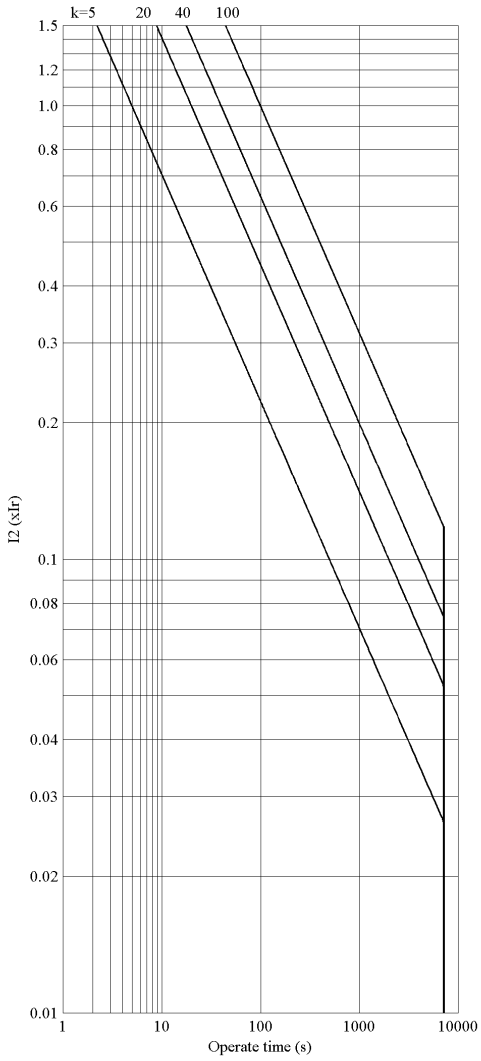



*Figure 478: MNSPTOC Inverse Curve A*

If the negative sequence current drops below the *Start value* setting, the reset time is defined as:

$$t[s] = a \times \left( \frac{b}{100} \right)$$

(Equation 238)

| | |
|---|---|
| t[s] | Reset time in seconds |
| a | set *Cooling time* |
| b | percentage of start time elapse ( START_DUR) |

When the reset period is initiated, the time for which START has been active is saved. If the fault reoccurs, that is, the negative-sequence current rises above the

set value during the reset period, the operate calculations are continued using the saved values. If the reset period elapses without a fault being detected, the operate timer is reset and the saved values of start time and integration are cleared.

***Inv. curve B***

The inverse time equation for curve type B is:

$$t[s] = \frac{k}{\left(\frac{I_2}{I_r}\right)^2 - \left(\frac{I_S}{I_r}\right)^2}$$

(Equation 239)

| | |
|---|---|
| t[s] | Operate time in seconds |
| k | *Machine time Mult* |
| $I_2$ | Negative-sequence current |
| $I_S$ | Set *Start value* |
| $I_r$ | Set *Rated current* |

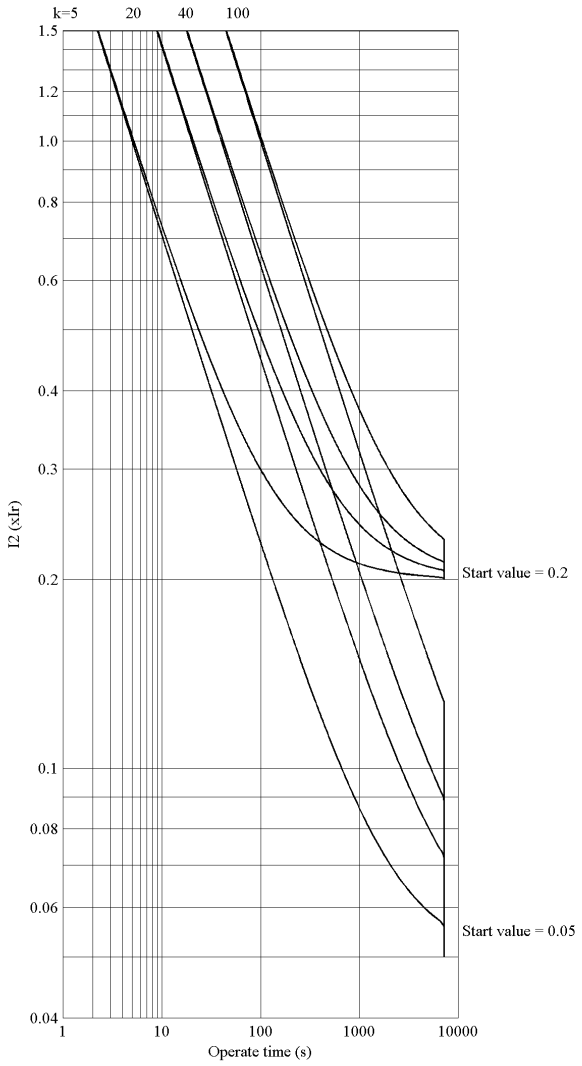



*Figure 479: MNSPTOC Inverse Curve B*

If the fault disappears, the negative-sequence current drops below the *Start value* setting and the START output is deactivated. The function does not reset instantaneously. Resetting depends on the equation or the *Cooling time* setting.

The timer is reset in three ways:

- When the negative sequence current drops below start value the subtraction in the denominator becomes negative and the cumulative sum starts to decrease. The decrease in the sum indicates the cooling of the machine and the cooling speed depends on the value of the negative-sequence current. If the sum reaches zero without a fault being detected, the accumulation stops and the timer is reset.
- If the reset time set through the *Cooling time* setting elapses without a fault being detected, the timer is reset.
- If ST_EMERG_ENA is activated, the timer is reset.

The reset period thus continues for a time equal to the *Cooling time* setting or until the operate time decreases to zero, whichever is less.

### 4.4.5.7 Application

In a three-phase motor, the conditions that can lead to unbalance are single phasing, voltage unbalance from the supply and single-phase fault. The negative sequence current damages the motor during the unbalanced voltage condition, and therefore the negative sequence current is monitored to check the unbalance condition.

When the voltages supplied to an operating motor become unbalanced, the positive-sequence current remains substantially unchanged, but the negative-sequence current flows due to the unbalance. For example, if the unbalance is caused by an open circuit in any phase, a negative-sequence current flows and it is equal and opposite to the previous load current in a healthy phase. The combination of positive and negative-sequence currents produces phase currents approximately 1.7 times the previous load in each healthy phase and zero current in the open phase.

The negative-sequence currents flow through the stator windings inducing negative-sequence voltage in the rotor windings. This can result in a high rotor current that damages the rotor winding. The frequency of the induced current is approximately twice the supply frequency. Due to skin effect, the induced current with a frequency double the supply frequency encounters high rotor resistance which leads to excessive heating even with phase currents with value less than the rated current of the motor.

The negative-sequence impedance of induction or a synchronous motor is approximately equal to the locked rotor impedance, which is approximately one-sixth of the normal motor impedance, considering that the motor has a locked-rotor current of six times the rated current. Therefore, even a three percent voltage unbalance can lead to 18 percent stator negative sequence current in windings. The severity of this is indicated by a 30-40 percent increase in the motor temperature due to the extra current.

### 4.4.5.8 Signals

#### MNSPTOC Input signals

**Table 770: MNSPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ST_EMERG_ENA | BOOLEAN | 0=False | Enable emergency start to disable lock of start of motor |

**MNSPTOC Output signals**

**Table 771: MNSPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| BLK_RESTART | BOOLEAN | Overheated machine reconnection blocking |

## 4.4.5.9 MNSPTOC Settings

**Table 772: MNSPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...0.50 | xIn | 0.01 | 0.20 | Start value |
| Operating curve type | 5=ANSI Def. Time<br>15=IEC Def. Time<br>17=Inv. Curve A<br>18=Inv. Curve B | | | 15=IEC Def. Time | Selection of time delay curve type |
| Machine time Mult | 5.0...100.0 | | 0.1 | 5.0 | Machine related time constant |
| Operate delay time | 100...120000 | ms | 10 | 1000 | Operate delay time |

**Table 773: MNSPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Maximum operate time | 500000...7200000 | ms | 1000 | 1000000 | Max operate time regardless of the inverse characteristic |
| Minimum operate time | 100...120000 | ms | 1 | 100 | Minimum operate time for IDMT curves |
| Cooling time | 5...7200 | s | 1 | 50 | Time required to cool the machine |

**Table 774: MNSPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current reference | 0.30...2.00 | xIn | 0.01 | 1.00 | Rated current (Ir) of the machine (used only in the IDMT) |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.4.5.10 MNSPTOC Monitored data

**Table 775: MNSPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| T_ENARESTART | INT32 | 0...10000 | s | Estimated time to reset of block restart |
| MNSPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.4.5.11 Technical data

**Table 776: MNSPTOC Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time [1, 2] | $I_{Fault}$ = 2.0 × set *Start value* | Minimum | Typical | Maximum |
| | | 23 | 25 ms | 28 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [3] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,... | | |

### 4.4.5.12 Technical revision history

**Table 777: MNSPTOC Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL2 | E | Added new input ST_EMERG_ENA which allows motor energization in an emergency case |

## 4.5 Voltage protection

[1] Negative-sequence current before = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements.
[2] Includes the delay of the signal output contact.
[3] *Start value* multiples in range of 1.10...5.00.

## 4.5.1 Three-phase overvoltage protection PHPTOV (ANSI 59)

### 4.5.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase overvoltage protection | PHPTOV | 3U> | 59 |

### 4.5.1.2 Function block

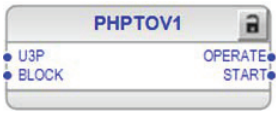



*Figure 480: Function block*

### 4.5.1.3 Functionality

The three-phase overvoltage protection function PHPTOV is applied on power system elements, such as generators, transformers, motors and power lines, to protect the system from excessive voltages that could damage the insulation and cause insulation breakdown. The three-phase overvoltage function includes a settable value for the detection of overvoltage either in a single phase, two phases or three phases.

PHPTOV includes both definite time ( DT) and inverse definite minimum time ( IDMT) characteristics for the delay of the trip.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

### 4.5.1.4 Analog channel configuration

PHPTOV has one analog group input which must be properly configured.

**Table 778: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 779: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected if *Num of start phases* is set to "1 out of 3". Otherwise, at least two vol- |

| Condition | Description |
|---|---|
| | tages must be connected (third one will be derived). |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PHPTOV can be described using a module diagram. All the modules in the diagram are explained in the next sections.

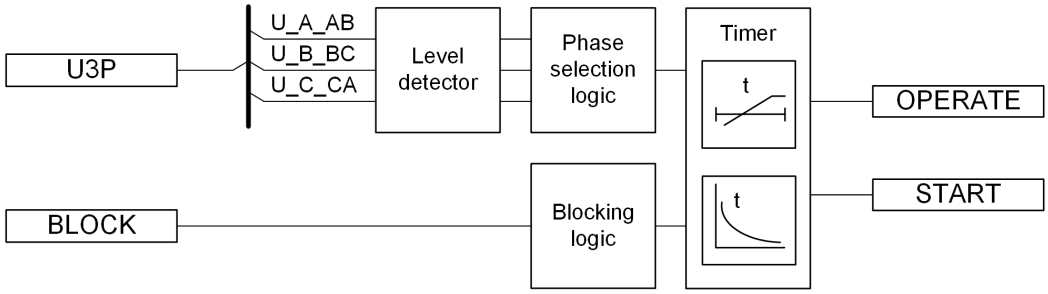



*Figure 481: Functional module diagram*

#### Level detector

The fundamental frequency component of the measured three-phase voltages are compared phase-wise to the set value of the *Start value* setting. If the measured value is higher than the set value of the *Start value* setting, the level detector enables the phase selection logic module. The *Relative hysteresis* setting can be used for preventing unnecessary oscillations if the input signal slightly differs from the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return to the hysteresis area.

The *Voltage selection* setting is used for selecting phase-to-earth or phase-to-phase voltages for protection.

For the voltage IDMT operation mode, the used IDMT curve equations contain discontinuity characteristics. The *Curve Sat Relative* setting is used for preventing undesired operation.

For a more detailed description of the IDMT curves and the use of the *Curve Sat Relative* setting, see *Chapter 11.3.1.3 IDMT curve saturation of overvoltage protection* in this manual.

#### Phase selection logic

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the fault level is detected. If the number of faulty

phases match with the set *Num of start phases*, the phase selection logic activates the Timer.

**Timer**

Once activated, the Timer activates the START output. Depending on the value of the set *Operating curve type*, the time characteristics are selected according to DT or IDMT.



For a detailed description of the voltage IDMT curves, see *Chapter 11.2.1 IDMT curves for overcurrent protection* in this manual.

When the operation timer has reached the value set by *Operate delay time* in the DT mode or the maximum value defined by the IDMT, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operate time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation occurs, that is, a fault suddenly disappears before the operate delay is exceeded, the reset state is activated. The behavior in the drop-off situation depends on the selected operate time characteristics. If the DT characteristics are selected, the reset timer runs until the set *Reset delay time* value is exceeded. If the drop-off situation exceeds the set *Reset delay time*, the Timer is reset and the START output is deactivated.

When the IDMT operate time curve is selected, the functionality of the Timer in the drop-off state depends on the combination of the *Type of reset curve*, *Type of time reset* and *Reset delay time* settings.

**Table 780: Reset time functionality when IDMT operation time curve selected**

| Reset functionality | | Setting Type of reset curve | Setting Type of time reset | Setting Reset delay time |
|---|---|---|---|---|
| Instantaneous reset | Operation timer is “Reset instantaneously” when drop-off occurs | “Immediate” | Setting has no effect | Setting has no effect |
| Frozen timer | Operation timer is frozen during drop-off | “Def time reset” | “Freeze Op timer” | Operate timer is reset after the set *Reset delay time* has elapsed |
| Linear decrease | Operation timer value linearly decreases during the drop-off situation | “Def time reset” | “Decrease Op timer” | Operate timer is reset after the set *Reset delay time* has elapsed |

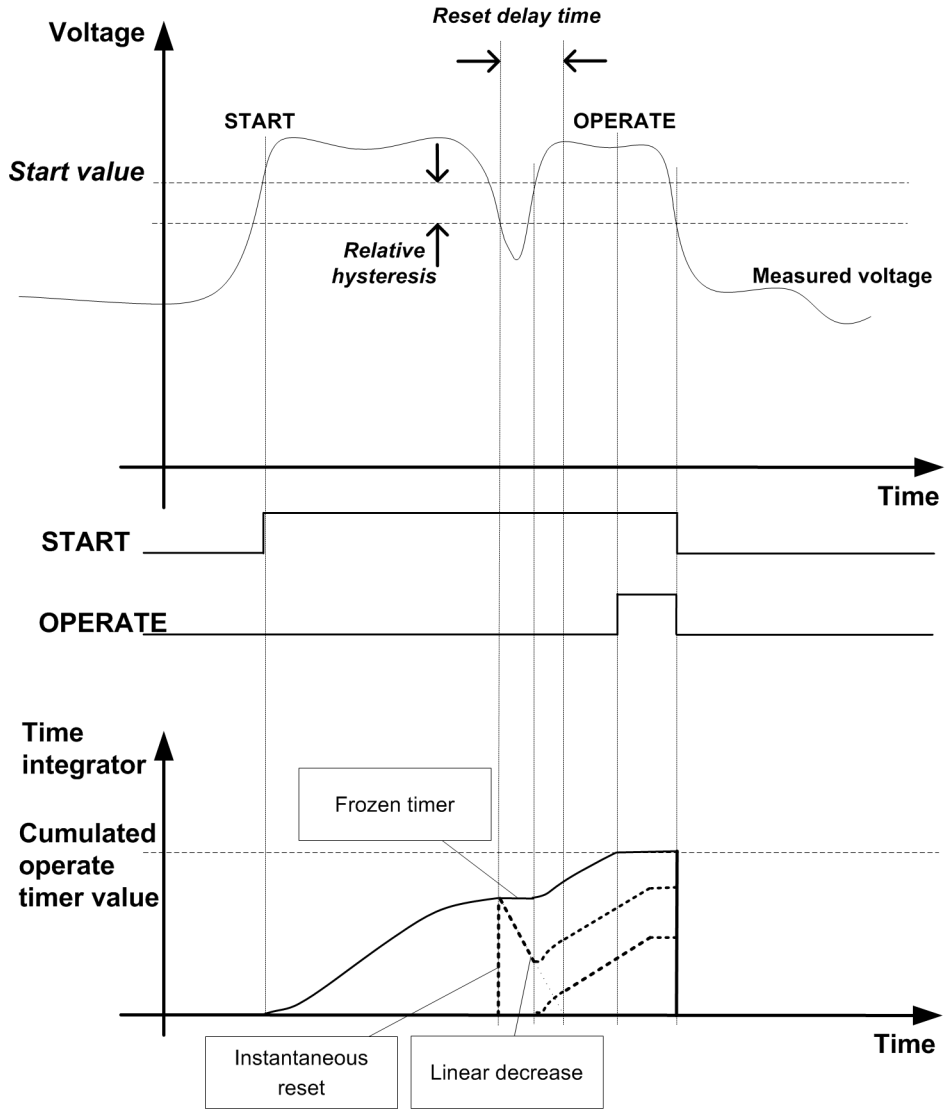



*Figure 482: Behavior of different IDMT reset modes. Operate signal is based on settings Type of reset curve = "Def time reset" and Type of time reset= "Freeze Op timer". The effect of other reset modes is also presented*

The *Time multiplier* setting is used for scaling the IDMT operate times.

The *Minimum operate time* setting parameter defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see *Chapter 11.3.1 IDMT curves for overvoltage protection* in this manual.

The Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK input signal activation is preselected with the global *Blocking mode* setting.

The *Blocking mode* setting has three blocking methods. In the "Freeze timer" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the Timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

The “Freeze timers” mode of blocking has no effect during the inverse reset mode.

### 4.5.1.6 Timer characteristics

The operating curve types supported by PHPTOV are:

**Table 781: Timer characteristics supported by IDMT operate curve types**

| Operating curve type |
|---|
| (5) ANSI Def. Time |
| (15) IEC Def. Time |
| (17) Inv. Curve A |
| (18) Inv. Curve B |
| (19) Inv. Curve C |
| (20) Programmable |

### 4.5.1.7 Application

Overvoltage in a network occurs either due to the transient surges on the network or due to prolonged power frequency overvoltages. Surge arresters are used to protect the network against the transient overvoltages, but the relay's protection function is used to protect against power frequency overvoltages.

The power frequency overvoltage may occur in the network due to contingencies such as:

- The defective operation of the automatic voltage regulator when the generator is in isolated operation.
- Operation under manual control with the voltage regulator out of service. A sudden variation of load, in particular the reactive power component, gives rise to a substantial change in voltage because of the inherent large voltage regulation of a typical alternator.
- Sudden loss of load due to the tripping of outgoing feeders, leaving the generator isolated or feeding a very small load. This causes a sudden rise in the terminal voltage due to the trapped field flux and overspeed.

If a load sensitive to overvoltage remains connected, it leads to equipment damage.

It is essential to provide power frequency overvoltage protection, in the form of time delayed element, either IDMT or DT to prevent equipment damage.

### 4.5.1.8 Signals

#### PHPTOV Input signals

**Table 782: PHPTOV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

#### PHPTOV Output signals

**Table 783: PHPTOV Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.1.9 PHPTOV Settings

**Table 784: PHPTOV Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...1.60 | xUn | 0.01 | 1.10 | Start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Operating curve type | 5=ANSI Def. Time<br>15=IEC Def. Time<br>17=Inv. Curve A<br>18=Inv. Curve B<br>19=Inv. Curve C<br>20=Programmable | | | 15=IEC Def. Time | Selection of time delay curve type |

**Table 785: PHPTOV Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset | | | 1=Immediate | Selection of reset curve type |
| Type of time reset | 1=Freeze Op timer<br>2=Decrease Op timer | | | 1=Freeze Op timer | Selection of time reset |

**Table 786: PHPTOV Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.005...200.000 | | 0.001 | 1.000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.50...100.00 | | 0.01 | 1.00 | Parameter B for customer programmable curve |
| Curve parameter C | 0.0...1.0 | | 0.1 | 0.0 | Parameter C for customer programmable curve |
| Curve parameter D | 0.000...60.000 | | 0.001 | 0.000 | Parameter D for customer programmable curve |
| Curve parameter E | 0.000...3.000 | | 0.001 | 1.000 | Parameter E for customer programmable curve |
| Voltage selection | 1=phase-to-earth<br>2=phase-to-phase | | | 2=phase-to-phase | Parameter to select phase or phase-to-phase voltages |

**Table 787: PHPTOV Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 40...60000 | ms | 1 | 40 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Curve Sat Relative | 0.0...10.0 | | 0.1 | 0.0 | Tuning parameter to avoid curve discontinuities |
| Relative hysteresis | 1.0...5.0 | % | 0.1 | 4.0 | Relative hysteresis for operation |

## 4.5.1.10 PHPTOV Monitored data

**Table 788: PHPTOV Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.5.1.11 Technical data

**Table 789: PHPTOV Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1, 2] | $U_{Fault}$ = 1.1 × set *Start value* | Minimum | Typical | Maximum |
| | | 23 ms | 27 ms | 31 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms[3] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

## 4.5.2 Three-phase undervoltage protection PHPTUV (ANSI 27)

### 4.5.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase undervoltage protection | PHPTUV | 3U< | 27 |

### 4.5.2.2 Function block

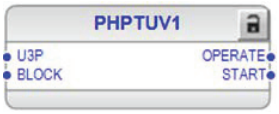



*Figure 483: Function block*

### 4.5.2.3 Functionality

The three-phase undervoltage protection function PHPTUV is used to disconnect from the network devices, for example electric motors, which are damaged when subjected to service under low voltage conditions. PHPTUV includes a settable value

[1] *Start value* = 1.0 × $U_n$, Voltage before fault = 0.9 × $U_n$, $f_n$ = 50 Hz, overvoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
[2] Includes the delay of the signal output contact
[3] Maximum *Start value* = 1.20 × $U_n$, *Start value* multiples in range of 1.10...2.00

for the detection of undervoltage either in a single phase, two phases or three phases.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

### 4.5.2.4 Analog channel configuration

PHPTUV has one analog group input which must be properly configured.

**Table 790: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 791: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected if *Num of start phases* is set to "1 out of 3" but the other two channels must be fed with high values (considerably above *Start value*). For other values of *Num of start phases*, all three voltage channels must be connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PHPTUV can be described using a module diagram. All the modules in the diagram are explained in the next sections.

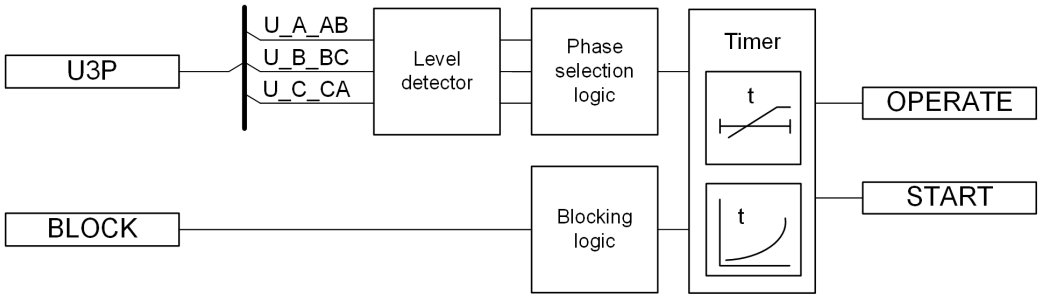



*Figure 484: Functional module diagram*

### Level detector

The fundamental frequency component of the measured three phase voltages are compared phase-wise to the set *Start value*. If the measured value is lower than the set value of the *Start value* setting, the level detector enables the phase selection logic module. The *Relative hysteresis* setting can be used for preventing unnecessary oscillations if the input signal slightly varies above or below the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return back to the hysteresis area.

The *Voltage selection* setting is used for selecting the phase-to-earth or phase-to-phase voltages for protection.

For the voltage IDMT mode of operation, the used IDMT curve equations contain discontinuity characteristics. The *Curve Sat relative* setting is used for preventing unwanted operation.

For more detailed description on IDMT curves and usage of *Curve Sat Relative* setting, see *Chapter 11.3.2 IDMT curves for undervoltage protection* in this manual.

The level detector contains a low-level blocking functionality for cases where one of the measured voltages is below the desired level. This feature is useful when unnecessary starts and operates are wanted to avoid during, for example, an autoreclose sequence. The low-level blocking is activated by default ( *Enable block value* is set to "True") and the blocking level can be set with the *Voltage block value* setting.

### Phase selection logic

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the fault level is detected. If the number of faulty phases match with the set *Num of start phases*, the phase selection logic activates the Timer.

### Timer

Once activated, the Timer activates the `START` output. Depending on the value of the set *Operating curve type*, the time characteristics are selected according to DT or IDMT.

For a detailed description of the voltage IDMT curves, see *Chapter 11.3.2 IDMT curves for undervoltage protection* in this manual.

When the operation timer has reached the value set by *Operate delay time* in the DT mode or the maximum value defined by the IDMT, the OPERATE output is activated.

When the user-programmable IDMT curve is selected, the operate time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D* and *Curve parameter E*.

If a drop-off situation occurs, that is, a fault suddenly disappears before the operate delay is exceeded, the reset state is activated. The behavior in the drop-off situation depends on the selected operate time characteristics. If the DT characteristics are selected, the reset timer runs until the set *Reset delay time* value is exceeded. If the drop-off situation exceeds the set *Reset delay time*, the Timer is reset and the START output is deactivated.

When the IDMT operate time curve is selected, the functionality of the Timer in the drop-off state depends on the combination of the *Type of reset curve*, *Type of time reset* and *Reset delay time* settings.

**Table 792: Reset time functionality when IDMT operation time curve selected**

| Reset functionality | | Setting Type of reset curve | Setting Type of time reset | Setting Reset delay time |
|---|---|---|---|---|
| Instantaneous reset | Operation timer is “Reset instantaneously” when drop-off occurs | “Immediate” | Setting has no effect | Setting has no effect |
| Frozen timer | Operation timer is frozen during drop-off | “Def time reset” | “Freeze Op timer” | Operate timer is reset after the set *Reset delay time* has elapsed |
| Linear decrease | Operation timer value linearly decreases during the drop-off situation | “Def time reset” | “Decrease Op timer” | Operate timer is reset after the set *Reset delay time* has elapsed |

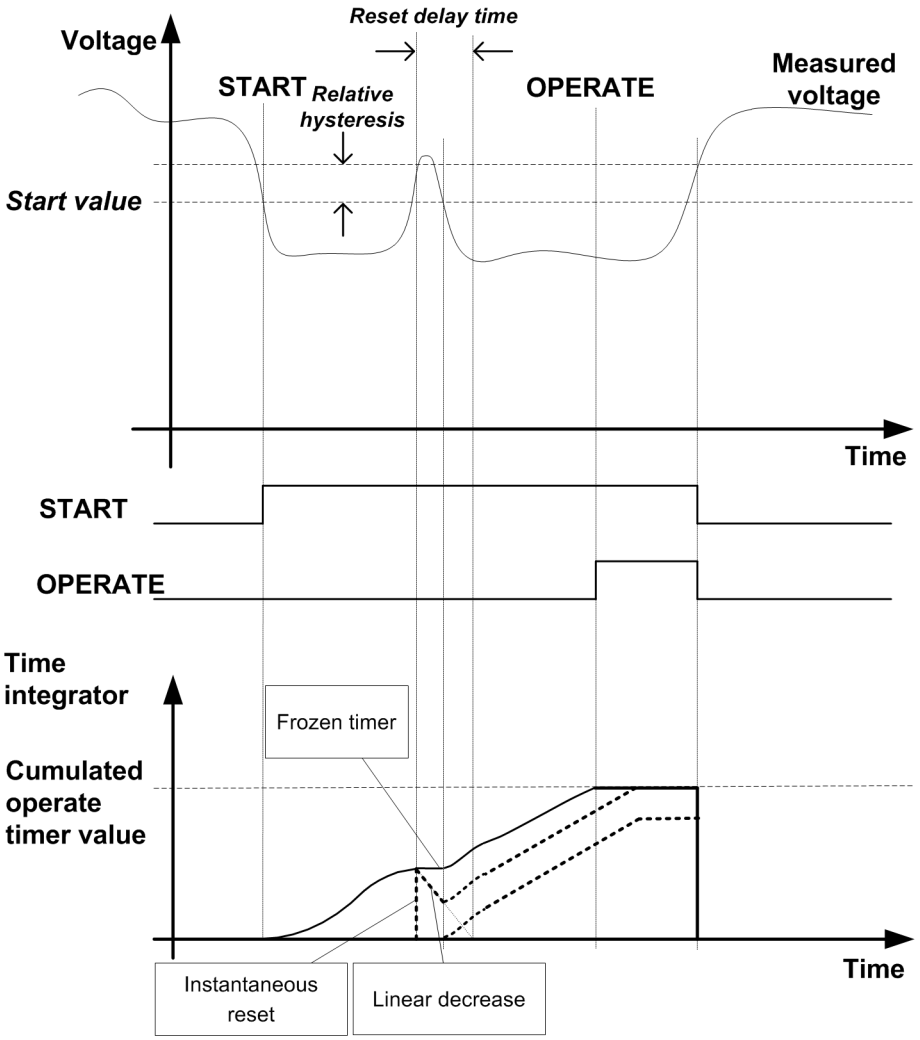



*Figure 485: Behavior of different IDMT reset modes. Operate signal is based on settings Type of reset curve = "Def time reset" and Type of time reset= "Freeze Op timer". The effect of other reset modes is also presented*

The *Time multiplier* setting is used for scaling the IDMT operate times.

The *Minimum operate time* setting parameter defines the minimum desired operate time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting. For more information, see *Chapter 11.3.2 IDMT curves for undervoltage protection* in this manual.

The Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled

by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK input signal activation is preselected with the global *Blocking mode* setting.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the Timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

The “Freeze timers” mode of blocking has no effect during the “Inverse reset” mode.

### 4.5.2.6 Timer characteristics

The operating curve types supported by PHPTUV are:

**Table 793: Supported IDMT operate curve types**

| Operating curve type |
|---|
| (5) ANSI Def. Time |
| (15) IEC Def. Time |
| (21) Inv. Curve A |
| (22) Inv. Curve B |
| (23) Programmable |

### 4.5.2.7 Application

PHPTUV is applied to power system elements, such as generators, transformers, motors and power lines, to detect low voltage conditions. Low voltage conditions are caused by abnormal operation or a fault in the power system. PHPTUV can be used in combination with overcurrent protections. Other applications are the detection of a no-voltage condition, for example before the energization of a high voltage line, or an automatic breaker trip in case of a blackout. PHPTUV is also used to initiate voltage correction measures, such as insertion of shunt capacitor banks, to compensate for a reactive load and thereby to increase the voltage.

PHPTUV can be used to disconnect from the network devices, such as electric motors, which are damaged when subjected to service under low voltage conditions. PHPTUV deals with low voltage conditions at power system frequency. Low voltage conditions can be caused by:

- Malfunctioning of a voltage regulator or incorrect settings under manual control (symmetrical voltage decrease)
- Overload (symmetrical voltage decrease)
- Short circuits, often as phase-to-earth faults (unsymmetrical voltage increase).

PHPTUV prevents sensitive equipment from running under conditions that could cause overheating and thus shorten their life time expectancy. In many cases, PHPTUV is a useful function in circuits for local or remote automation processes in the power system.

### 4.5.2.8 Signals

#### PHPTUV Input signals

**Table 794: PHPTUV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

#### PHPTUV Output signals

**Table 795: PHPTUV Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.2.9 PHPTUV Settings

**Table 796: PHPTUV Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...1.20 | xUn | 0.01 | 0.90 | Start value |
| Time multiplier | 0.025...15.000 | | 0.005 | 1.000 | Time multiplier in IEC/ANSI IDMT curves |
| Operate delay time | 20...300000 | ms | 10 | 60 | Operate delay time |
| Operating curve type | 5=ANSI Def. Time<br>15=IEC Def. Time<br>21=Inv. Curve A<br>22=Inv. Curve B<br>23=Programmable | | | 15=IEC Def. Time | Selection of time delay curve type |

**Table 797: PHPTUV Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Type of reset curve | 1=Immediate<br>2=Def time reset | | | 1=Immediate | Selection of reset curve type |
| Type of time reset | 1=Freeze Op timer<br>2=Decrease Op timer | | | 1=Freeze Op timer | Selection of time reset |

**Table 798: PHPTUV Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on | | | 1=on | Operation Off / On |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 5=off | | | | |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Curve parameter A | 0.005...200.000 | | 0.001 | 1.000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.50...100.00 | | 0.01 | 1.00 | Parameter B for customer programmable curve |
| Curve parameter C | 0.0...1.0 | | 0.1 | 0.0 | Parameter C for customer programmable curve |
| Curve parameter D | 0.000...60.000 | | 0.001 | 0.000 | Parameter D for customer programmable curve |
| Curve parameter E | 0.000...3.000 | | 0.001 | 1.000 | Parameter E for customer programmable curve |
| Voltage selection | 1=phase-to-earth<br>2=phase-to-phase | | | 2=phase-to-phase | Parameter to select phase or phase-to-phase voltages |

**Table 799: PHPTUV Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum operate time | 20...60000 | ms | 1 | 60 | Minimum operate time for IDMT curves |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Curve Sat Relative | 0.0...10.0 | | 0.1 | 0.0 | Tuning parameter to avoid curve discontinuities |
| Voltage block value | 0.05...1.00 | xUn | 0.01 | 0.20 | Low level blocking for undervoltage mode |
| Enable block value | 0=False<br>1=True | | | 1=True | Enable internal blocking |
| Relative hysteresis | 1.0...5.0 | % | 0.1 | 4.0 | Relative hysteresis for operation |

## 4.5.2.10 PHPTUV Monitored data

**Table 800: PHPTUV Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PHPTUV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.5.2.11 Technical data

**Table 801: PHPTUV Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 0.85 × set *Start value*[1, 2] | 17 ms | 20 ms | 23 ms |
| | $U_{Fault}$ = 0.85 × set *Start value*[1, 3] | 51 ms | 55 ms | 58 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms[4] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

#### 4.5.2.12 Technical revision history

**Table 802: PHPTUV Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | F | New minimum value 20 ms for *Operate delay time* and *Minimum operate time* settings |

### 4.5.3 Residual overvoltage protection ROVPTOV (ANSI 59G/59N)

#### 4.5.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Residual overvoltage protection | ROVPTOV | Uo> | 59G/59N |

[1] *Start value* = 0.97 × $U_n$, voltage level before fault = 1 × $U_n$, $f_n$ = 50 Hz, undervoltage in one phase-to-phase voltage injected from random phase angle, results based on statistical distribution of 1000 measurements, includes the delay (≈0ms) of the static signal output (SSO) contact
[2] Start time is accelerated when set *Operate delay time* < 60ms. The shorter the set delay, the shorter the start time. Here measurements done for *Operate delay time* = 20ms
[3] Valid when set *Operate delay time* ≥ 60ms or inverse time curve selected
[4] Minimum *Start value* = 0.50, *Start value* multiples in range of 0.90...0.20

### 4.5.3.2 Function block

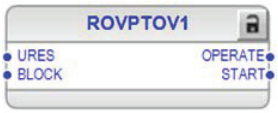



*Figure 486: Function block*

### 4.5.3.3 Functionality

The residual overvoltage protection function ROVPTOV is used in distribution networks where the residual overvoltage can reach non-acceptable levels in, for example, high impedance earthing.

The function starts when the residual voltage exceeds the set limit. ROVPTOV operates with the definite time (DT) characteristic.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.5.3.4 Analog channel configuration

ROVPTOV has one analog group input which must be properly configured.

**Table 803: Analog inputs**

| Input | Description |
|---|---|
| URES | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 804: Special conditions**

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected to calculate residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of ROVPTOV can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

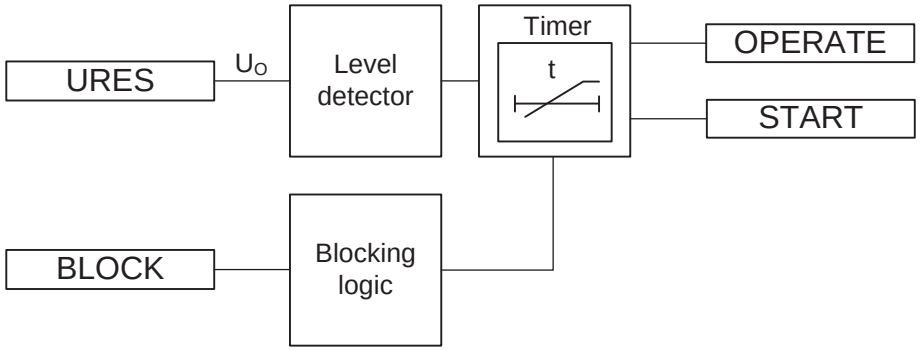



*Figure 487: Functional module diagram*

#### Level detector

The residual voltage is compared to the set *Start value*. If the value exceeds the set *Start value*, the level detector sends an enable signal to the timer.

#### Timer

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

#### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.5.3.6 Application

ROVPTOV is designed to be used for earth-fault protection in isolated neutral, resistance earthed or reactance earthed systems. In compensated networks, starting of the function can be used to control the switching device of the neutral resistor. The function can also be used for the back-up protection of feeders for busbar protection when a more dedicated busbar protection would not be justified.

In compensated and isolated neutral systems, the system neutral voltage, that is, the residual voltage, increases in case of any fault connected to earth. Depending on the type of the fault and the fault resistance, the residual voltage reaches different values. The highest residual voltage, equal to the phase-to-earth voltage, is achieved for a single-phase earth fault. The residual voltage increases approximately the same amount in the whole system and does not provide any guidance in finding the faulty component. Therefore, this function is often used as a backup protection or as a release signal for the feeder earth-fault protection.

The protection can also be used for the earth-fault protection of generators and motors and for the unbalance protection of capacitor banks.

The residual voltage can be calculated internally based on the measurement of the three-phase voltage. This voltage can also be measured by a single-phase voltage transformer, located between a transformer star point and earth, or by using an open-delta connection of three single-phase voltage transformers.

### 4.5.3.7 Signals

#### ROVPTOV Input signals

**Table 805: ROVPTOV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

#### ROVPTOV Output signals

**Table 806: ROVPTOV Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.3.8 ROVPTOV Settings

**Table 807: ROVPTOV Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.010...1.000 | xUn | 0.001 | 0.030 | Residual overvoltage start value |
| Operate delay time | 40...300000 | ms | 1 | 40 | Operate delay time |

**Table 808: ROVPTOV Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 809: ROVPTOV Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.5.3.9 ROVPTOV Monitored data

**Table 810: ROVPTOV Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| ROVPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.3.10 Technical data

**Table 811: ROVPTOV Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1, 2] | $U_{Fault}$ = 2 × set *Start value* | Minimum | Typical | Maximum |
| | | 48 ms | 51 ms | 54 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

[1] Residual voltage before fault = 0.0 × $U_n$, $f_n$ = 50 Hz, residual voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

[2] Includes the delay of the signal output contact

## 4.5.4 Positive-sequence overvoltage protection PSPTOV (ANSI 59PS)

### 4.5.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Positive-sequence overvoltage protection | PSPTOV | U1> | 59PS |

### 4.5.4.2 Function block

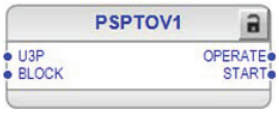



*Figure 488: Function block*

### 4.5.4.3 Functionality

The positive-sequence overvoltage protection function PSPTOV is used as an alternative to the ordinary three-phase overvoltage protection. PSPTOV is used for supervision and for detection of abnormal conditions, and, together with the other protection functions, increases the security of the protection system.

The function starts when the positive-sequence voltage exceeds the set limit. PSPTOV operates on definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.5.4.4 Analog channel configuration

PSPTOV has one analog group input which must be properly configured.

**Table 812: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 813: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PSPTOV can be described with a module diagram. All the modules in the diagram are explained in the next sections.

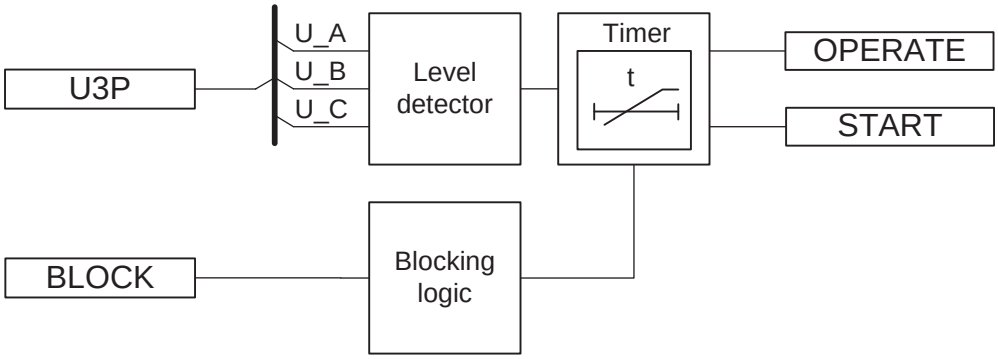



*Figure 489: Functional module diagram*

#### Level detector

The calculated positive-sequence voltage is compared to the set *Start value* setting. If the value exceeds the set *Start value*, the level detector enables the timer. The *Relative hysteresis* setting can be used for preventing unnecessary oscillations if the input signal slightly varies from the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return to the hysteresis area.

#### Timer

Once activated, Timer activates the `START` output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the `OPERATE` output is activated if the overvoltage condition persists. If the positive-sequence voltage normalizes before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the `START` output is deactivated.

Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

**Blocking logic**

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all outputs and resets internal timers.

### 4.5.4.6 Application

A sudden power loss, tap changer regulating failures and open line ends on long lines are abnormal conditions which cause overvoltage in a power system. PSPTOV is applied to power system elements, such as generators, transformers, motors and power lines, to detect overvoltage conditions.

PSPTOV can be used in combination with low-current signals or a directional reactive overpower function to identify the distribution line with an open remote end. PSPTOV can also be used to initiate voltage correction measures, such as insertion of shunt reactors or switching out capacitor banks, to control the voltage.

Overvoltage faced by the power transformer can lead to an overexcitation problem. Overexcitation normally occurs when the voltage-to-frequency ratio increases much above the design value resulting into transformer operation under a nonlinear region. A transformer can be in such an overvoltage situation during a sudden loss of load due to underfrequency load shedding. Overexcitation results in an increase of the exciting current which leads to core heating and thus to transformer damage. PSPTOV along with the underfrequency protection can be used for the protection of the transformer during overexcitation.

Some common reasons leading to positive-sequence overvoltages are:

- Broken conductor falling to a crossing overhead line, transformer flash overfault from high-voltage winding to low-voltage winding
- Malfunctioning of a voltage regulator or wrong settings under manual control (symmetrical voltage increase)
- Low load compared to the reactive power generation (symmetrical voltage increase)

PSPTOV prevents sensitive equipment from running under overvoltage conditions which cause equipment overheating or stress on insulation material.

### 4.5.4.7 Signals

**PSPTOV Input signals**

**Table 814: PSPTOV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**PSPTOV Output signals**

**Table 815: PSPTOV Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.4.8 PSPTOV Settings

**Table 816: PSPTOV Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.400...1.600 | xUn | 0.001 | 0.650 | Start value |
| Operate delay time | 40...120000 | ms | 10 | 40 | Operate delay time |

**Table 817: PSPTOV Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 818: PSPTOV Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Relative hysteresis | 1.0...5.0 | % | 0.1 | 4.0 | Relative hysteresis for operation |

### 4.5.4.9 PSPTOV Monitored data

**Table 819: PSPTOV Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PSPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.4.10 Technical data

**Table 820: PSPTOV Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ |
| | ±1.5% of the set value or ±0.002 × $U_n$ |

*Table continues on the next page*

| Characteristic | | Value | | |
|---|---|---|---|---|
| Start time [1, 2] | $U_{Fault}$ = 1.1 × set *Start value*<br>$U_{Fault}$ = 2.0 × set *Start value* | Minimum<br>29 ms<br>32 ms | Typical<br>32 ms<br>24 ms | Maximum<br>34 ms<br>26 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,... | | |

## 4.5.5 Negative-sequence overvoltage protection NSPTOV (ANSI 59NS)

### 4.5.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Negative-sequence overvoltage protection | NSPTOV | U2> | 59NS |

### 4.5.5.2 Function block

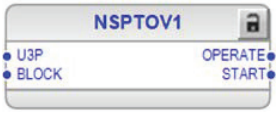



*Figure 490: Function block*

### 4.5.5.3 Functionality

The negative-sequence overvoltage protection function NSPTOV is used to detect negative sequence overvoltage conditions. NSPTOV is used for the protection of machines.

The function starts when the negative sequence voltage exceeds the set limit. NSPTOV operates with the definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

[1] Positive-sequence voltage before fault = 0.0 × $U_n$, $f_n$ = 50 Hz, positive-sequence overvoltage of nominal frequency injected from random phase angle
[2] Measured with static signal output (SSO)

### 4.5.5.4 Analog channel configuration

NSPTOV has one analog group input which must be properly configured.

**Table 821: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 822: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that any two voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of NSPTOV can be described using a module diagram. All the modules in the diagram are explained in the next sections.

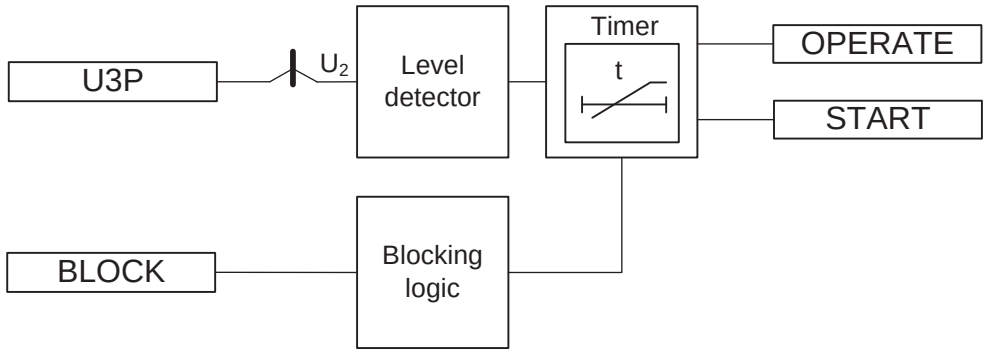



*Figure 491: Functional module diagram*

#### Level detector

The calculated negative-sequence voltage is compared to the set *Start value* setting. If the value exceeds the set *Start value*, the level detector enables the timer.

**Timer**

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated if the overvoltage condition persists. If the negative-sequence voltage normalizes before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.5.5.6 Application

A continuous or temporary voltage unbalance can appear in the network for various reasons. The voltage unbalance mainly occurs due to broken conductors or asymmetrical loads and is characterized by the appearance of a negative-sequence component of the voltage. In rotating machines, the voltage unbalance results in a current unbalance, which heats the rotors of the machines. The rotating machines, therefore, do not tolerate a continuous negative-sequence voltage higher than typically 1-2 percent x $U_n$.

The negative-sequence component current $I_2$, drawn by an asynchronous or a synchronous machine, is linearly proportional to the negative-sequence component voltage $U_2$. When $U_2$ is P% of $U_n$, $I_2$ is typically about 5 x P% x $I_n$.

The negative-sequence overcurrent NSPTOC blocks are used to accomplish a selective protection against the voltage and current unbalance for each machine separately. Alternatively, the protection can be implemented with the NSPTOV function, monitoring the voltage unbalance of the busbar.

If the machines have an unbalance protection of their own, the NSPTOV operation can be applied as a backup protection or it can be used as an alarm. The latter can be applied when it is not required to trip loads tolerating voltage unbalance better than the rotating machines.

If there is a considerable degree of voltage unbalance in the network, the rotating machines should not be connected to the network at all. This logic can be implemented by inhibiting the closure of the circuit breaker if the NSPTOV operation has started. This scheme also prevents connecting the machine to the network if the phase sequence of the network is not correct.

An appropriate value for the setting parameter *Voltage start value* is approximately 3 percent of $U_n$. A suitable value for the setting parameter *Operate delay time* depends on the application. If the NSPTOV operation is used as backup protection, the operate time should be set in accordance with the operate time of NSPTOC used as main protection. If the NSPTOV operation is used as main protection, the operate time should be approximately one second.

### 4.5.5.7 Signals

#### NSPTOV Input signals

**Table 823: NSPTOV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

#### NSPTOV Output signals

**Table 824: NSPTOV Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.5.8 NSPTOV Settings

**Table 825: NSPTOV Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.010...1.000 | xUn | 0.001 | 0.030 | Start value |
| Operate delay time | 40...120000 | ms | 1 | 40 | Operate delay time |

**Table 826: NSPTOV Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 827: NSPTOV Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.5.5.9 NSPTOV Monitored data

**Table 828: NSPTOV Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| NSPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.5.10 Technical data

**Table 829: NSPTOV Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the voltage measured: $f_n$ | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1, 2] | $U_{Fault}$ = 1.1 × set *Start value*<br>$U_{Fault}$ = 2.0 × set *Start value* | Minimum | Typical | Maximum |
| | | 33 ms<br>24 ms | 35 ms<br>26 ms | 37 ms<br>28 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

## 4.5.6 Positive-sequence undervoltage protection PSPTUV (ANSI 27PS)

### 4.5.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Positive-sequence undervoltage protection | PSPTUV | U1< | 27PS |

[1] Negative-sequence voltage before fault = 0.0 × $U_n$, $f_n$ = 50 Hz, negative-sequence overvoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

[2] Includes the delay of the signal output contact

### 4.5.6.2 Function block

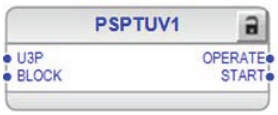



*Figure 492: Function block*

### 4.5.6.3 Functionality

The positive-sequence undervoltage protection function PSPTUV is used to detect positive-sequence undervoltage conditions. PSPTUV is used for the protection of small power generation plants. The function helps in isolating an embedded plant from a fault line when the fault current fed by the plant is too low to start an overcurrent function but high enough to maintain the arc. Fast isolation of all the fault current sources is necessary for a successful autoreclosure from the network-end circuit breaker.

The function starts when the positive-sequence voltage drops below the set limit. PSPTUV operates with the definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.5.6.4 Analog channel configuration

PSPTUV has one analog group input which must be properly configured.

**Table 830: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 831: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PSPTUV can be described using a module diagram. All the modules in the diagram are explained in the next sections.

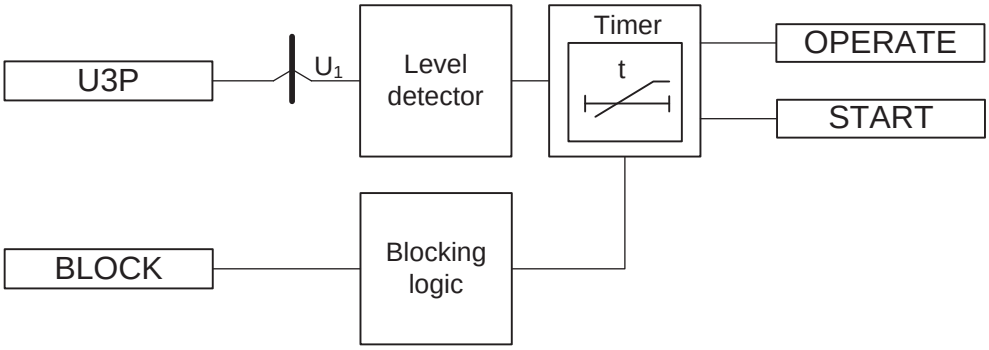



*Figure 493: Functional module diagram. U1 is used for representing positive phase sequence voltage.*

#### Level detector

The calculated positive-sequence voltage is compared to the set *Start value* setting. If the value drops below the set *Start value*, the level detector enables the timer. The *Relative hysteresis* setting can be used for preventing unnecessary oscillations if the input signal slightly varies from the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return to the hysteresis area.

The level detector contains a low-level blocking functionality for cases where the positive-sequence voltage is below the desired level. This feature is useful when unnecessary starts and operates are wanted to avoid during, for example, an autoreclose sequence. The low-level blocking is activated by default (*Enable block value* is set to “Enabled”) and the blocking level can be set with the *Voltage block value* setting.

#### Timer

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated if the undervoltage condition persists. If the positive-sequence voltage normalizes before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

#### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can

be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.5.6.6 Application

PSPTUV can be applied for protecting a power station used for embedded generation when network faults like short circuits or phase-to-earth faults in a transmission or a distribution line cause a potentially dangerous situations for the power station. A network fault can be dangerous for the power station for various reasons. The operation of the protection can cause an islanding condition, also called a loss-of-mains condition, in which a part of the network, that is, an island fed by the power station, is isolated from the rest of the network. There is then a risk of an autoreclosure taking place when the voltages of different parts of the network do not synchronize, which is a straining incident for the power station. Another risk is that the generator can lose synchronism during the network fault. A sufficiently fast trip of the utility circuit breaker of the power station can avoid these risks.

The lower the three-phase symmetrical voltage of the network is, the higher is the probability that the generator loses the synchronism. The positive-sequence voltage is also available during asymmetrical faults. It is a more appropriate criterion for detecting the risk of loss of synchronism than, for example, the lowest phase-to-phase voltage.

Analyzing the loss of synchronism of a generator is rather complicated and requires a model of the generator with its prime mover and controllers. The generator can be able to operate synchronously even if the voltage drops by a few tens of percent for some hundreds of milliseconds. The setting of PSPTUV is thus determined by the need to protect the power station from the risks of the islanding conditions since that requires a higher setting value.

The loss of synchronism of a generator means that the generator is unable to operate as a generator with the network frequency but enters into an unstable condition in which it operates by turns as a generator and a motor. Such a condition stresses the generator thermally and mechanically. This kind of loss of synchronism should not be mixed with the one between an island and the utility network. In the islanding situation, the condition of the generator itself is normal but the phase angle and the frequency of the phase-to-phase voltage can be different from the corresponding voltage in the rest of the network. The island can have a frequency of its own relatively fast when fed by a small power station with a low inertia.

PSPTUV complements other loss-of-grid protection principles based on the frequency and voltage operation.

Motor stalling and failure to start can lead to a continuous undervoltage. The positive-sequence undervoltage is used as a backup protection against the motor stall condition.

### 4.5.6.7 Signals

**PSPTUV Input signals**

**Table 832: PSPTUV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**PSPTUV Output signals**

**Table 833: PSPTUV Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

## 4.5.6.8 PSPTUV Settings

**Table 834: PSPTUV Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.010...1.200 | xUn | 0.001 | 0.500 | Start value |
| Operate delay time | 40...120000 | ms | 10 | 40 | Operate delay time |

**Table 835: PSPTUV Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage block value | 0.01...1.00 | xUn | 0.01 | 0.20 | Internal blocking level |
| Enable block value | 0=False<br>1=True | | | 1=True | Enable Internal Blocking |

**Table 836: PSPTUV Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 837: PSPTUV Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Relative hysteresis | 1.0...5.0 | % | 0.1 | 4.0 | Relative hysteresis for operation |

### 4.5.6.9 PSPTUV Monitored data

**Table 838: PSPTUV Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PSPTUV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.6.10 Technical data

**Table 839: PSPTUV Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time [1, 2] | $U_{Fault}$ = 0.99 × set *Start value*<br>$U_{Fault}$ = 0.9 × set *Start value* | Minimum<br>52 ms<br>44 ms | Typical<br>55 ms<br>47 ms | Maximum<br>58 ms<br>50 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

## 4.5.7 Overexcitation protection OEPVPH (ANSI 24)

### 4.5.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Overexcitation protection | OEPVPH | U/f> | 24 |

[1] *Start value* = 1.0 × $U_n$, positive-sequence voltage before fault = 1.1 × $U_n$, $f_n$ = 50 Hz, positive sequence undervoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

[2] Includes the delay of the signal output contact

### 4.5.7.2 Function block




*Figure 494: Function block*

### 4.5.7.3 Functionality

The overexcitation protection function OEPVPH is used to protect generators and power transformers against an excessive flux density and saturation of the magnetic core.

The function calculates the U/f ratio (volts/hertz) proportional to the excitation level of the generator or transformer and compares this value to the setting limit. The function starts when the excitation level exceeds the set limit and operates when the set operating time has elapsed. The operating time characteristic can be selected to be either definite time (DT) or overexcitation inverse definite minimum time (overexcitation type IDMT).

This function contains a blocking functionality. It is possible to block the function outputs, reset timer or the function itself.

### 4.5.7.4 Analog channel configuration

OEPVPH has two analog group inputs which must be properly configured.

**Table 840: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 841: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with at least one voltage channel connected (A, B or C according to *Phase selection* “1”, “2” or “3”) if *Voltage selection* is set to "phase-to-earth". |
| | The function can work with any two voltage channels connected (AB, BC or CA according |

*Table continues on the next page*

| Condition | Description |
|---|---|
| | to *Phase selection* “1”, “2” or “3”) if *Voltage selection* is set to "phase-to-phase". |
| | The function requires that all three voltage channels are connected if *Voltage selection* is set to "pos sequence". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.7.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of OEPVPH can be described using a module diagram. All the modules in the diagram are explained in the next sections.

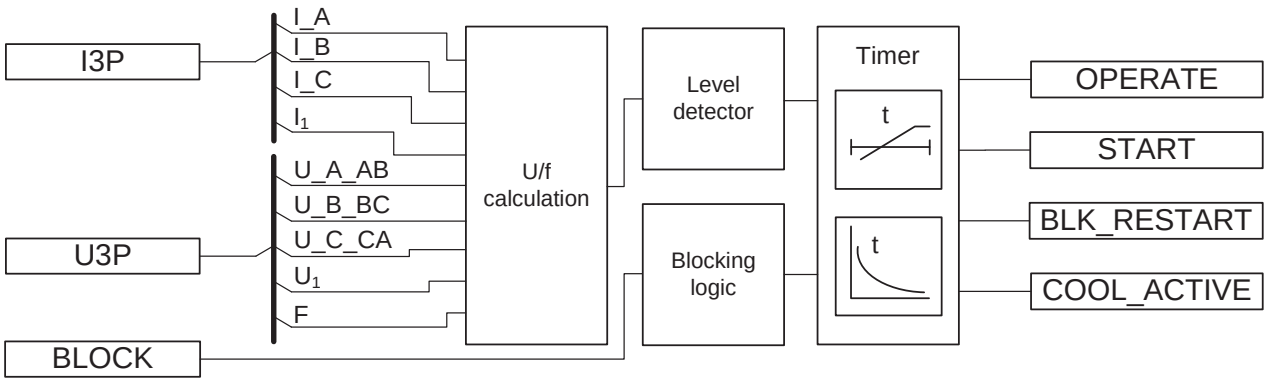



*Figure 495: Functional module diagram*

#### U/f calculation

This module calculates the U/f ratio, that is, the excitation level from the internal induced voltage (E) and frequency. The actual measured voltage ($U_m$) deviates from the internal induced voltage (E), a value the equipment has to withstand. This voltage compensation is based on the load current ($I_L$) and the leakage reactance ($X_{leak}$) of the equipment. The leakage reactance of the transformer or generator is set through the *Leakage React* setting in percentage of the Z base.

The internal induced voltage (E) is calculated from the measured voltage. The settings *Voltage selection* and *Phase supervision* determine which voltages and currents are to be used. If the *Voltage selection* setting is set to "phase-to-earth" or "phase-to-phase", the *Phase supervision* setting is used for determining which phases or phase-to-phase voltages ("A or AB", "B or BC" and "C or CA") and currents are to be used for the calculation of the induced voltage.

**Table 842: Voltages and currents used for induced voltage (emf) E calculation**

| Voltage selection setting | Phase supervision setting | Calculation of internal induced voltage (emf) E [1] |
|---|---|---|
| phase-to-earth | A or AB | $\overline{E} = \sqrt{3} \cdot \left( \overline{U_A} + \overline{I_A} \cdot (j \cdot X_{leak}) \right)$ (Equation 240) |
| phase-to-earth | B or BC | $\overline{E} = \sqrt{3} \cdot \left( \overline{U_B} + \overline{I_B} \cdot (j \cdot X_{leak}) \right)$ (Equation 241) |
| phase-to-earth | C or CA | $\overline{E} = \sqrt{3} \cdot \left( \overline{U_C} + \overline{I_C} \cdot (j \cdot X_{leak}) \right)$ (Equation 242) |
| phase-to-phase | A or AB | $\overline{E} = \overline{U_{AB}} + \left( (\overline{I_A} - \overline{I_B}) \cdot (j \cdot X_{leak}) \right)$ (Equation 243) |
| phase-to-phase | B or BC | $\overline{E} = \overline{U_{BC}} + \left( (\overline{I_B} - \overline{I_C}) \cdot (j \cdot X_{leak}) \right)$ (Equation 244) |
| phase-to-phase | C or CA | $\overline{E} = \overline{U_{CA}} + \left( (\overline{I_C} - \overline{I_A}) \cdot (j \cdot X_{leak}) \right)$ (Equation 245) |
| Pos sequence | N/A | $\overline{E} = \sqrt{3} \cdot \left( \overline{U_1} + \overline{I_1} \cdot (j \cdot X_{leak}) \right)$ (Equation 246) |

If all three phase or phase-to-phase voltages and phase currents are fed to the protection relay, the positive-sequence alternative is recommended.

If the leakage reactance of the protected equipment is unknown or if the measured voltage ($U_m$) is to be used in the excitation level calculation, then by setting the leakage reactance value to zero the calculated induced voltage (E) is equal to the measured voltage.

The calculated U/f ratio is scaled to a value based on the nominal $U_n/f_n$ ratio. However, the highest allowed continuous voltage (in % $U_n$) can be defined by setting the parameter *Voltage Max Cont* to change the basis of the voltage. The measured voltage is compared to the new base value to obtain the excitation level.

[1] Voltages, currents and the leakage reactance $X_{leak}$ in the calculations are given in volts, amps and ohms.

The excitation level (M) can be calculated:

$$M = \frac{\frac{E}{f_m}}{\frac{U_n}{f_n} \cdot \frac{Volt\ Max\ continuous}{100}}$$

(Equation 247)

| | |
|---|---|
| M | excitation level (U/f ratio or volts/hertz) in pu |
| E | internal induced voltage (emf) |
| $f_m$ | measured frequency |
| $U_n$ | nominal phase-to-phase voltage |
| $f_n$ | nominal frequency |

If the input frequency ($f_m$) is less than 20 percent of the nominal frequency ($f_n$), the calculation of the excitation level is disabled and forced to zero value. This means that the function is blocked from starting and operating during a low-frequency condition.

The calculated excitation level (U/f ratio or volts/hertz) VOLTPERHZ is available in the Monitored data view.

**Level detector**

Level detector compares the calculated excitation level to the *Start value* setting. If the excitation level exceeds the set limit, the module sends an enabling signal to start Timer.

**Timer**

Once activated, Timer activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value set by *Operate delay time* in the DT mode or the value defined by the inverse time curve, the OPERATE output is activated.

In a drop-off situation, that is, when the excitation level drops below *Start value* before the function operates, the reset timer is activated and the START output resets after the time delay of *Reset delay time* for the DT characteristics. For the IDMT curves, the reset operation is as described in *Chapter 4.5.7.6 Timer characteristics* .

For the IDMT curves, it is possible to define the maximum and minimum operating times via the *Minimum operate time* and *Maximum operate time* settings. The *Maximum operate time* setting is used to prevent infinite start situations at low degrees of overexcitation. The *Time multiplier* setting is used for scaling the IDMT operate times.

The activation of the OPERATE output activates the BLK_RESTART output.

For the DT characteristics, the deactivation of the OPERATE output activates the cooling timer. The timer is set to the value entered in the *Cooling time* setting. The BLK_RESTART and COOL_ACTIVE outputs are kept active until the cooling timer is reset. If the excitation increases above the set value during this period, the OPERATE output is activated immediately. For IDMT, the deactivation of BLK_RESTART and COOL_ACTIVE depends on the curve type selected.

The T_ENARESTART output indicates in seconds the duration for which the BLK_RESTART output still remains active. The value is available in the Monitored data view.

Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the Monitored data view.

#### Blocking logic

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.5.7.6 Timer characteristics

OEPVPH supports both DT and IDMT characteristics. The DT timer characteristics can be selected as "ANSI Def. Time" or "IEC Def. Time" in the *Operating curve type* setting. The functionality is identical in both cases. When the DT characteristics are selected, the functionality is only affected by the *Operate delay time* and *Reset delay time* settings.

OEPVPH also supports four overexcitation IDMT characteristic curves: "OvExt IDMT Crv1", "OvExt IDMT Crv2", "OvExt IDMT Crv3" and "OvExt IDMT Crv4".

#### Overexcitation inverse definite minimum time curve (IDMT)

In the inverse time modes, the operate time depends on the momentary value of the excitation: the higher the excitation level, the shorter the operate time. The operate time calculation or integration starts immediately when the excitation level exceeds the set *Start value* and the START output is activated.

The OPERATE output is activated when the cumulative sum of the integrator calculating the overexcitation situation exceeds the value set by the inverse time mode. The set value depends on the selected curve type and the setting values used.

The *Minimum operate time* and *Maximum operate time* settings define the minimum operate time and maximum operate time possible for the IDMT mode. For setting these parameters, a careful study of the particular IDMT curves is recommended.



The operation time of the function block can vary much between different operating curve types even if other setting parameters for the curves were not changed.

Once activated, the Timer activates the START output for the IDMT curves. If the excitation level drops below the *Start value* setting before the function operates, the reset timer is activated and the START output resets immediately. If START

reoccurs during the reset time, the operation calculation is made based on the effects of the period when START was previously active. This is intended to allow an operating condition to occur in less time to account for the heating effects from the previous active start period.

When START becomes active, the reset time is based on the following equation.

$$reset\ time = \left( \frac{START_DUR}{100} \right) \cdot Cooling\ time$$

(Equation 248)

For the IDMT curves, when START is deactivated, the integral value calculated during START is continuously decremented by a constant that causes its value to become zero when the reset time elapses during the reset period. If a fault reoccurs, the integration continues from the current integral value and the start time is adjusted, as shown in *Figure 496*. The start time becomes the value at the time when the fault dropped off minus the amount of reset time that occurred. If the reset period elapses without a fault being detected, the saved values of the start time and integration are cleared.

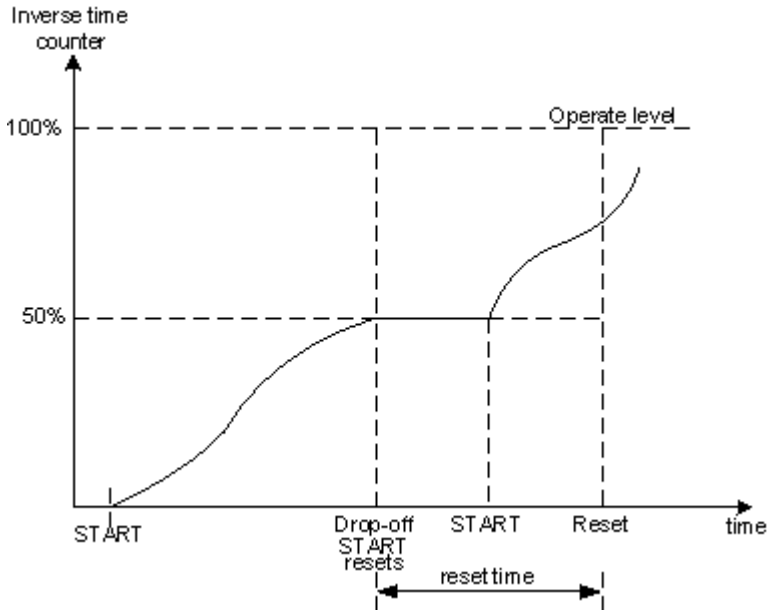



*Figure 496: An example of a delayed reset in the inverse time characteristics. When the start becomes active during the reset period, the operate time counter continues from the level corresponding to the drop-off (reset time = 0.50 · Cooling time)*

### Overexcitation IDMT curves 1, 2 and 3

The base equation for the IDMT curves "OvExt IDMT Crv1", "OvExt IDMT Crv2" and "OvExt IDMT Crv3" is:

$$t(s) = 60 \cdot e^{\left( \frac{ak+b-100M}{c} \right)}$$

(Equation 249)

| | |
|---|---|
| t(s) | Operate time in seconds |
| M | Excitation level (U/f ratio or volts/hertz) in pu |
| k | *Time multiplier* setting |

The constant "60" in *Equation 249* converts time from minutes to seconds.

**Table 843: Parameters a, b and c for different IDMT curves**

| ***Operating curve type* setting** | **a** | **b** | **c** |
|---|---|---|---|
| OvExt IDMT Crv1 | 2.5 | 115.00 | 4.886 |
| OvExt IDMT Crv2 | 2.5 | 113.50 | 3.040 |
| OvExt IDMT Crv3 | 2.5 | 108.75 | 2.443 |

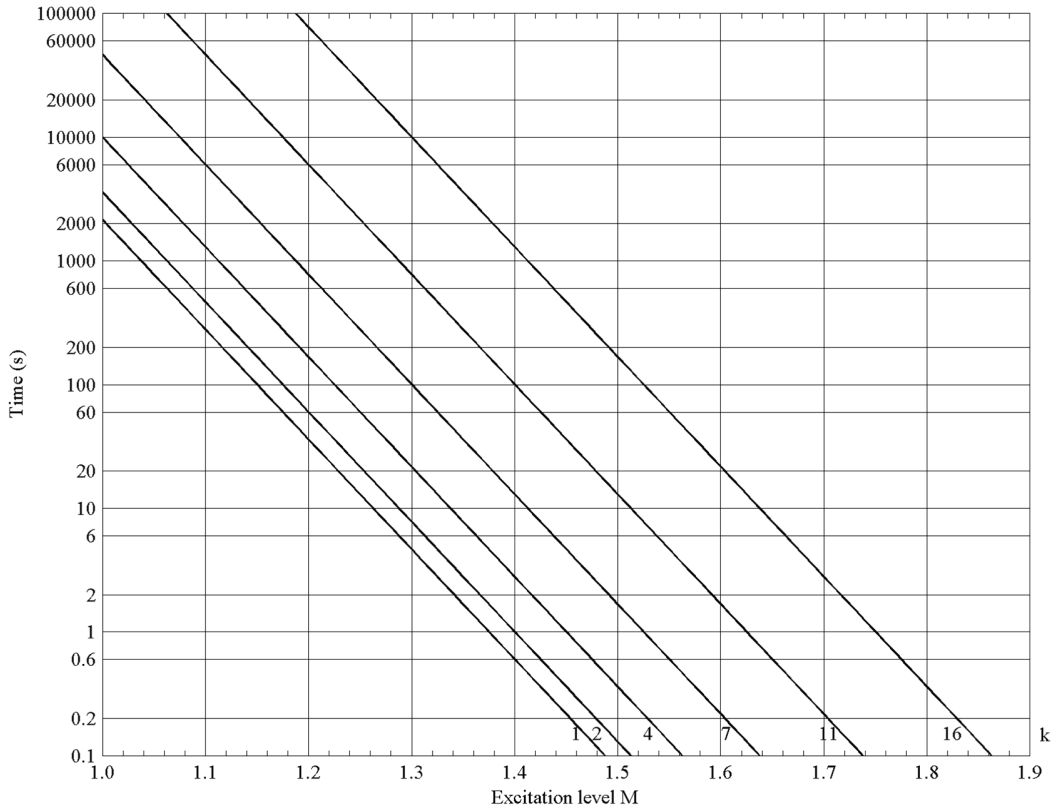



*Figure 497: Operating time curves for the overexcitation IDMT curve ("OvExt IDMT Crv1") for parameters a = 2.5, b = 115.0 and c = 4.886*

### Overexcitation IDMT curve 4

The base equation for the IDMT curve "OvExt IDMT Crv4" is:

$$t(s) = d + \frac{0.18k}{(M-1)^2}$$

(Equation 250)

| | |
|---|---|
| t(s) | Operate time in seconds |
| d | *Constant delay* setting in milliseconds |
| M | Excitation value (U/f ratio or volts/hertz) in pu |
| k | *Time multiplier* setting |

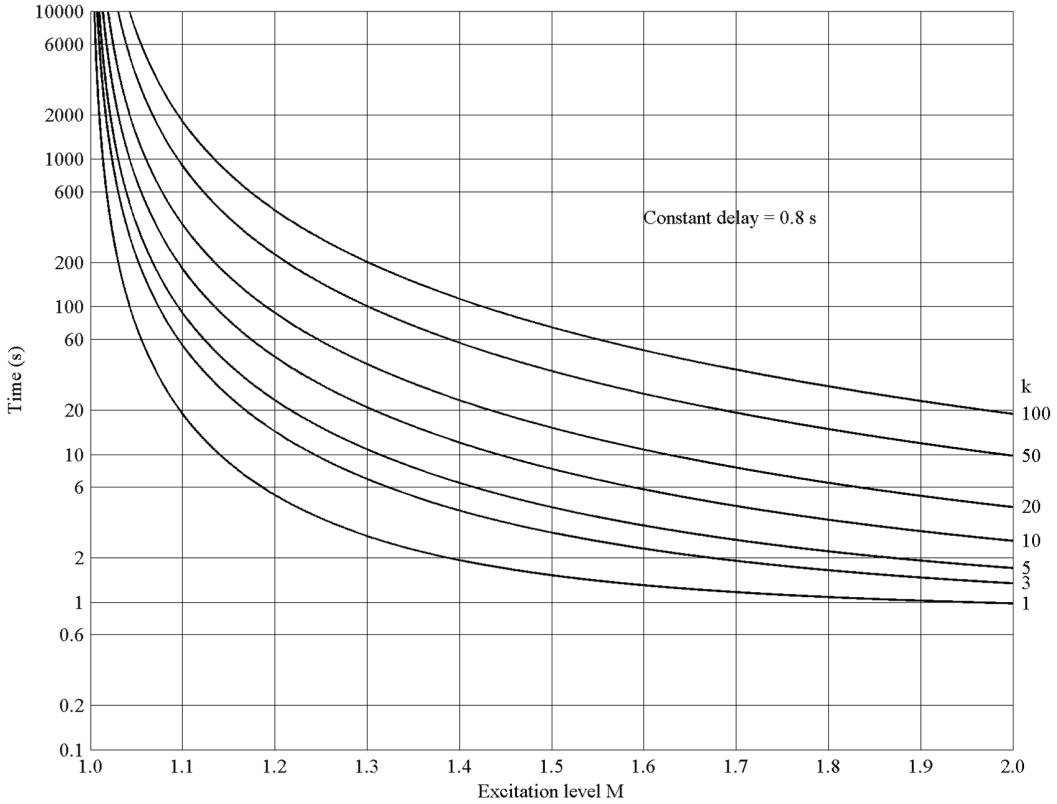



*Figure 498: Operating time curves for the overexcitation IDMT curve 4 ("OvExt IDMT Crv4") for different values of the Time multiplier setting when the Constant delay is 800 milliseconds*

The activation of the OPERATE output activates the BLK_RESTART output.

If the excitation level increases above the set value when BLK_RESTART is active, the OPERATE output is activated immediately.

If the excitation level increases above the set value when BLK_RESTART is not active but COOL_ACTIVE is active, the OPERATE output is not activated instantly. In this case, the remaining part of the cooling timer affects the calculation of the operate timer as shown in *Figure 499*. This compensates for the heating effect and makes the overall operate time shorter.

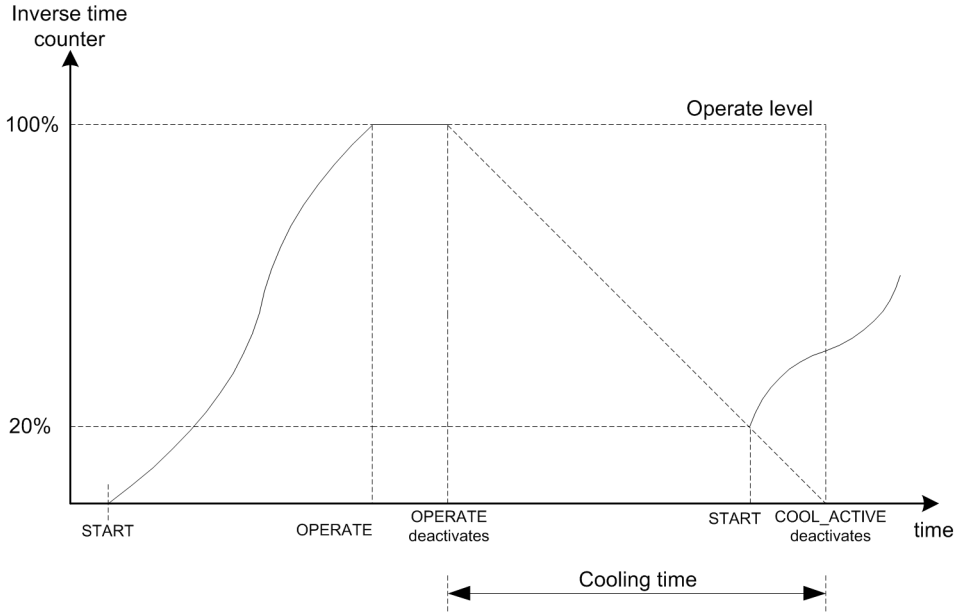



*Figure 499: Example of an inverse time counter operation if START occurs when BLK_RESTART is inactive while COOL_ACTIVE is active.*

### 4.5.7.7 Application

If the laminated core of a power transformer or generator is subjected to a magnetic flux density beyond its designed limits, the leakage flux increases. This results in a heavy hysteresis and eddy current losses in the non-laminated parts. These losses can cause excessive heating and severe damage to the insulation and adjacent parts in a relatively short time.

Overvoltage, underfrequency or a combination of the two, results in an excessive flux density level. Since the flux density is directly proportional to the voltage and inversely proportional to the frequency, the overexcitation protection calculates the relative V/Hz ratio instead of measuring the flux density directly. The nominal level (nominal voltage at nominal frequency) is usually considered as the 100 percent level, which can be exceeded slightly based on the design.

The greatest risk for overexcitation exists in a thermal power station when the generator-transformer unit is disconnected from the rest of the network or in the network islands where high voltages or low frequencies can occur.

Overexcitation can occur during the start-up and shutdown of the generator if the field current is not properly adjusted. The loss-of-load or load shedding can also result in overexcitation if the voltage control and frequency governor do not function properly. The low frequency in a system isolated from the main network can result in overexcitation if the voltage-regulating system maintains a normal voltage.

Overexcitation protection for the transformer is generally provided by the generator overexcitation protection, which uses the VTs connected to the generator terminals. The curves that define the generator and transformer V/Hz limits must be coordinated properly to protect both equipment.

If the generator can be operated with a leading power factor, the high-side voltage of the transformer can have a higher pu V/Hz than the generator V/Hz. This needs

to be considered in a proper overexcitation protection of the transformer. Also, measurement for the voltage must not be taken from any winding where OLTC is located.

It is assumed that overexcitation is a symmetrical phenomenon caused by events such as loss-of-load. A high phase-to-earth voltage does not mean overexcitation. For example, in an unearthed power system, a single phase-to-earth fault means high voltages of the healthy two phases to earth but no overexcitation on any winding. The phase-to-phase voltages remain essentially unchanged. An important voltage to be considered for the overexcitation is the voltage between the two ends of each winding.

**Example calculations for overexcitation protection**

**Example 1**

Nominal values of the machine

| | |
|---|---|
| Nominal phase-to-phase voltage ($U_n$) | 11000 V |
| Nominal phase current ($I_n$) | 7455 A |
| Nominal frequency ($f_n$) | 50 Hz |
| Leakage reactance ($X_{leak}$) | 20% or 0.2 pu |

Measured voltage and load currents of the machine

| | |
|---|---|
| Phase A-to-phase B voltage ($U_{AB}$) | 11500∠0° V |
| Phase A current ($I_A$) | 5600∠-63.57° A |
| Phase B current ($I_B$) | 5600∠176.42° A |
| Measured frequency ($f_m$) | 49.98 Hz |
| The setting *Voltage Max Cont* | 100% |
| The setting *Voltage selection* | phase-to-phase |
| The setting *Phase supervision* | A or AB |

The pu leakage reactance $X_{leakPU}$ is converted to ohms.

$$X_{leak\Omega} = X_{leakPU} \cdot \frac{U_n}{I_n \cdot \sqrt{3}} = 0.2 \cdot \frac{11000}{7455 \cdot \sqrt{3}} = 0.170378\ Ohms$$

(Equation 251)

The internal induced voltage E of the machine is calculated.

$$\overline{E} = \overline{U_{AB}} + (\overline{I_A} - \overline{I_B}) \cdot (jX_{leak})$$

(Equation 252)

E = 11500∠0°+ (5600∠-63.57°- 5600∠176.42°) · (0.170378∠90°) = 12490 V

The excitation level M of the machine is calculated.

$$Excitation\ level\ M = \frac{\frac{12490}{49.98}}{\frac{11000}{50} \cdot 1.00} = 1.1359$$

(Equation 253)

**Example 2**

The situation and the data are according to Example 1. In this case, the manufacturer of the machine allows the continuous operation at 105 percent of the nominal voltage at the rated load and this value to be used as the base for overexcitation.

Usually, the U/f characteristics are specified so that the ratio is 1.00 at the nominal voltage and nominal frequency. Therefore, the value 100 percent for the setting *Voltage Max Cont* is recommended.

If the *Voltage Max Cont* setting is 105 percent, the excitation level M of the machine is calculated with the equation.

$$Excitation\ level\ M = \frac{\frac{12490}{49.98}}{\frac{11000}{50} \cdot 1.05} = 1.0818$$

(Equation 254)

**Example 3**

In this case, the function operation is according to IDMT. The *Operating curve type* setting is selected as "OvExt IDMT Crv2". The corresponding example settings for the IDMT curve operation are given as: *Start value* = 110%, *Voltage Max Cont* = 100%, *Time multiplier* = 4, *Maximum operate time* = 1000 s, *Minimum operate time* = 1 s and *Cooling time* = 200 s.

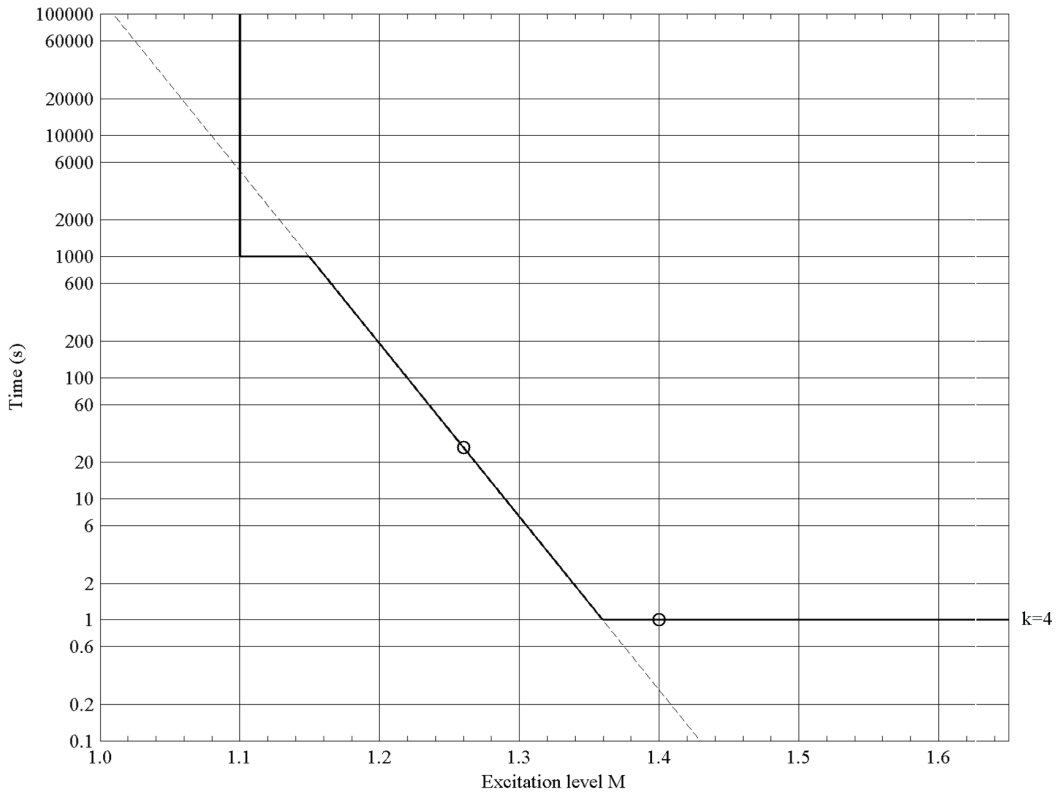



*Figure 500: Operating curve of "OvExt IDMT Crv2" based on the settings specified in example 3. The two dots marked on the curve are referred to in the text.*

If the excitation level stays at 1.26, the operation occurs after 26.364 s as per the marked dot in *Figure 500*. For the excitation level of 1.4, the second dot in *Figure 500*, the curve "OvExt IDMT Crv2" gives 0.2636 s as per *Equation 249*, but the *Minimum operate time* setting limits the operate time to 1.0 s.

The *Maximum operate time* setting limits the operate time to 1000 s if the excitation level stays between 1.1 and 1.16.

In general, however, the excitation level seldom remains constant. Therefore, the exact operate times in any inverse time mode are difficult to predict.

**Example 4**

In this case, the function operation is according to IDMT. The *Operating curve type* setting is selected as "OvExt IDMT Crv4". The corresponding example settings for the IDMT curve operation are given as: *Start value* = 110%, *Voltage Max Cont* = 100%, *Time multiplier* = 5, *Maximum operate time* = 3600 s, *Constant delay* = 0.8 s and *Cooling time* = 100 s.

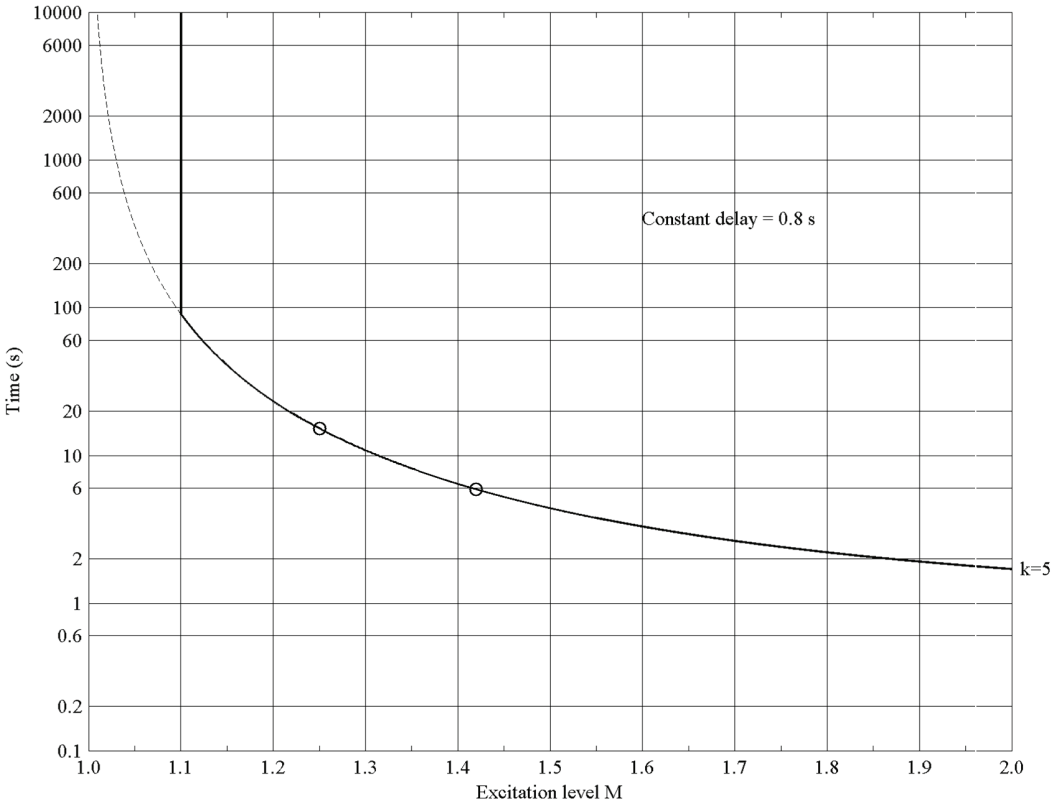



*Figure 501: Operating curve of "OvExt IDMT Crv4" based on the specified settings. The two dots marked on the curve are referred to in the text.*

If the excitation level stays at 1.25, the operation occurs after 15.20 s. At the excitation level of 1.42, the time to operation would be 5.90 s as per the two dots in *Figure 501*. In this case, the setting *Maximum operate time* 3600 s does not limit the maximum operate time because the operate time at *Start value* = 110% (1.1 pu) is approximately 75 s.

## 4.5.7.8 Signals

### OEPVPH Input signals

**Table 844: OEPVPH Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal |

**OEPVPH Output signals**

**Table 845: OEPVPH Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operated |
| START | BOOLEAN | Started |
| BLK_RESTART | BOOLEAN | Signal for blocking reconnection of an overheated machine |
| COOL_ACTIVE | BOOLEAN | Signal to indicate machine is in cooling process |

## 4.5.7.9 OEPVPH Settings

**Table 846: OEPVPH Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 100...200 | % | 1 | 100 | Over excitation start value |
| Operating curve type | 5=ANSI Def. Time<br>15=IEC Def. Time<br>17=OvExt IDMT Crv1<br>18=OvExt IDMT Crv2<br>19=OvExt IDMT Crv3<br>20=OvExt IDMT Crv4 | | | 15=IEC Def. Time | Selection of time delay curve type |
| Time multiplier | 0.1...100.0 | | 0.1 | 3.0 | Time multiplier for Overexcitation IDMT curves |
| Operate delay time | 200...200000 | ms | 10 | 500 | Operate delay time in definite- time mode |

**Table 847: OEPVPH Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Mode Off / On |
| Cooling time | 5...10000 | s | 1 | 600 | Time required to cool the machine |
| Constant delay | 100...120000 | ms | 10 | 800 | Parameter constant delay |
| Maximum operate time | 500000...10000000 | ms | 10 | 1000000 | Maximum operate time for IDMT curves |
| Voltage selection | 1=phase-to-earth<br>2=phase-to-phase<br>3=pos sequence | | | 3=pos sequence | Selection of phase / phase-to-phase / pos sequence voltages |
| Phase selection | 1=A or AB<br>2=B or BC<br>3=C or CA | | | 1=A or AB | Parameter for phase selection |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Leakage React | 0.0...50.0 | % | 0.1 | 0.0 | Leakage reactance of the machine |
| Voltage Max Cont | 80...160 | % | 1 | 110 | Maximum allowed continuous operating voltage ratio |

**Table 848: OEPVPH Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 100 | Resetting time of the operate time counter in DT mode |
| Minimum operate time | 200...60000 | ms | 10 | 200 | Minimum operate time for IDMT curves |

### 4.5.7.10 OEPVPH Monitored data

**Table 849: OEPVPH Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time (in %) |
| T_ENARESTART | INT32 | 0...10000 | s | Estimated time to reset of block restart |
| VOLTPERHZ | FLOAT32 | 0.00...10.00 | pu | Excitation level, i.e U/f ratio or Volts/Hertz |
| OEPVPH | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.7.11 Technical data

**Table 850: OEPVPH Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±3.0% of the set value |
| Start time [1] | Frequency change:<br>Typically 200 ms |
| | Voltage change:<br>Typically 40 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <35 ms |

*Table continues on the next page*

[1] Includes the delay of the signal output contact

| Characteristic | Value |
|---|---|
| Operate time accuracy in definite-time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in inverse-time mode | ±5.0% of the theoretical value or ±50 ms |

## 4.5.8 Low-voltage ride-through protection LVRTPTUV (ANSI 27RT)

### 4.5.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Low-voltage ride-through protection | LVRTPTUV | U<RT | 27RT |

### 4.5.8.2 Function block

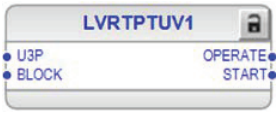



*Figure 502: Function block*

### 4.5.8.3 Functionality

The low-voltage ride-through protection function LVRTPTUV is principally a three-phase undervoltage protection. It differs from the traditional three-phase undervoltage protection PHPTUV by allowing the grid operators to define its own Low-Voltage Ride-Through ( LVRT) curve for generators, as defined by local or national grid codes. The LVRT curve can be defined accurately according to the requirements by setting the appropriate time-voltage coordinates.

This function contains a blocking functionality. LVRTPTUV can be blocked with the `BLOCK` input. Blocking resets timers and outputs.

### 4.5.8.4 Analog channel configuration

LVRTPTUV has one analog group input which must be properly configured.

**Table 851: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 852: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that at least two voltage channels are connected as the the third channel can then be derived. However, it is recommended that all three voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.8.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of LVRTPTUV is described using a module diagram. All modules in the diagram are explained in the next sections.

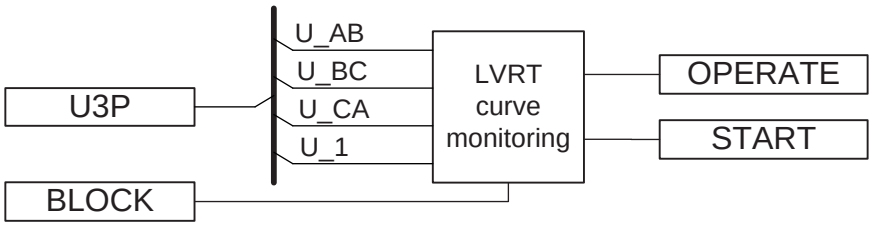



*Figure 503: Functional module diagram*

#### LVRT curve monitoring

LVRT curve monitoring starts with detection of undervoltage. Undervoltage detection depends on *Voltage selection* setting. All selectable options are based on fundamental frequency components.

Function uses phase-to-earth voltages when *Voltage selection* is set to “Highest Ph-to-E” or “Lowest Ph-to-E” and phase-to-phase voltages when *Voltage selection* is set to “Highest Ph-to-Ph” or “Lowest Ph-to-Ph”.

When the *Voltage selection* setting is set to “Highest Ph-to-E”, “Lowest Ph-to-E”, “Highest Ph-to-Ph” or “Lowest Ph-to-Ph”, the measured three-phase voltages are compared phase-wise to the set *Voltage start value*. If the measured value is lower than the set *Voltage start value* setting in number of phases equal to that set *Num of start phases*, the `START` output is activated.

The setting options available for *Num of start phases* are “Exactly 1 of 3”, "Exactly 2 of 3", and “Exactly 3 of 3”, which are different from conventional setting options available in other functions. For example, *Num of start phases* is set to "Exactly 2 of 3", any two voltages should drop below *Voltage start value* within one cycle network for the `START` output to activate. Even if more than two voltages drop below *Voltage start value*, `START` output is not activated.

When the *Voltage selection* setting is “Positive Seq”, the positive-sequence component is compared with the set *Voltage start value*. If it is lower than the set *Voltage start value*, the START output is activated.

Once START is activated, the function monitors the behavior of the voltage defined by *Voltage selection setting* with the defined LVRT curve. When defined voltage enters the operating area, the OPERATE output is activated instantaneously. The pulse length of OPERATE is fixed to 100 ms. START also deactivates along with OPERATE.

If a drop-off situation occurs, that is, voltage restores above *Voltage start value*, before OPERATE is activated, the function does not reset until maximum recovery time under consideration has elapsed, that is, START output remains active.

LVRT curve is defined using time-voltage settings coordinates. The settings available are *Recovery time 1*... *Recovery time 10* and *Voltage level 1*... *Voltage level 10*. The number of coordinates required to define a LVRT curve is set by *Active coordinate* settings.

When *Recovery time 1* is set to non-zero value, it results into horizontal characteristics from point of fault till *Recovery time 1.*

Two examples of LVRT curve are defined in *Figure 504* and *Figure 505* with corresponding settings in *Table 853*.

It is necessary to set the coordinate points correctly in order to avoid maloperation. For example, setting for *Recovery time 2* should be greater than *Recovery time 1*. *Recovery time 1*... *Recovery time 10* are the respective time setting from the point of fault.

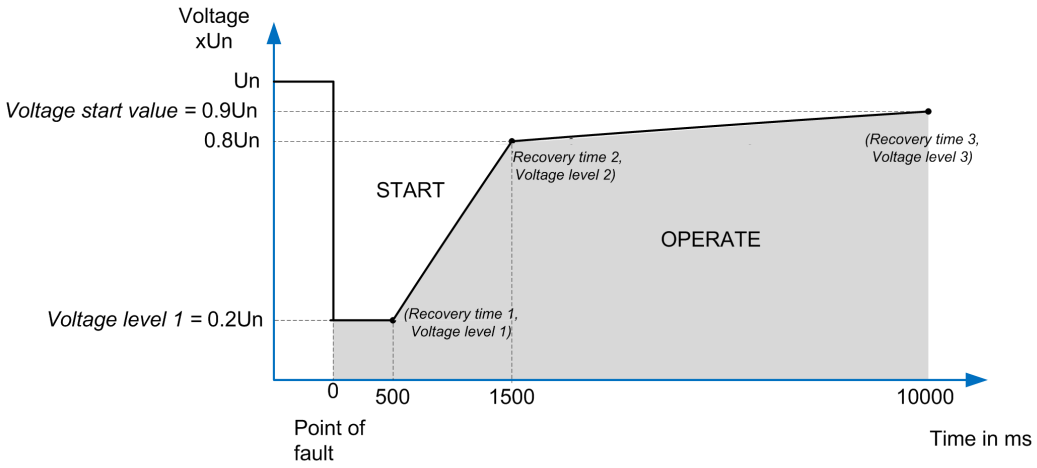



*Figure 504: Low voltage ride through example curve A*

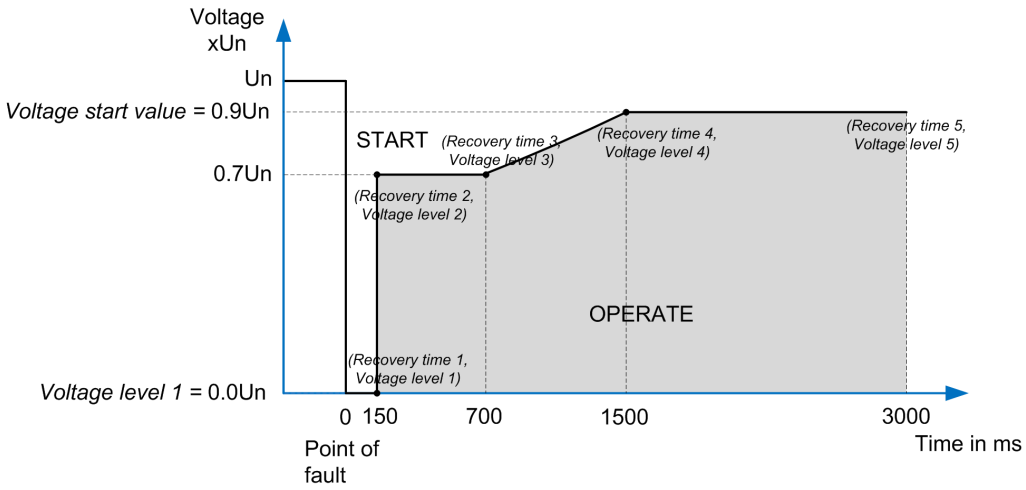



*Figure 505: Low voltage ride through example curve B*

**Table 853: Settings for example A and B**

| Settings | Curve A | Curve B |
|---|---|---|
| Voltage start value | 0.9 · Un | 0.9 · Un |
| Active coordinates | 3 | 5 |
| Voltage level 1 | 0.2 · Un | 0 · Un |
| Recovery time 1 | 500 ms | 150 ms |
| Voltage level 2 | 0.8 · Un | 0.7 · Un |
| Recovery time 2 | 1500 ms | 150 ms |
| Voltage level 3 | 0.9 · Un | 0.7 · Un |
| Recovery time 3 | 10000 ms | 700 ms |
| Voltage level 4 | - | 0.9 · Un |
| Recovery time 4 | - | 1500 ms |
| Voltage level 5 | - | 0.9 · Un |
| Recovery time 5 | - | 3000 ms |

It is necessary that the last active *Voltage level X* setting is set greater than or equal to *Voltage start value*. Settings are not accepted if the last active *Voltage level X* setting is not set greater than or equal to *Voltage start value*.

*Figure 506* describes an example of operation of LVRTPTUV protection function set to operate with *Num of start phases* set to “Exactly 2 of 3” and *Voltage selection* as “Lowest Ph-to-Ph” voltage.

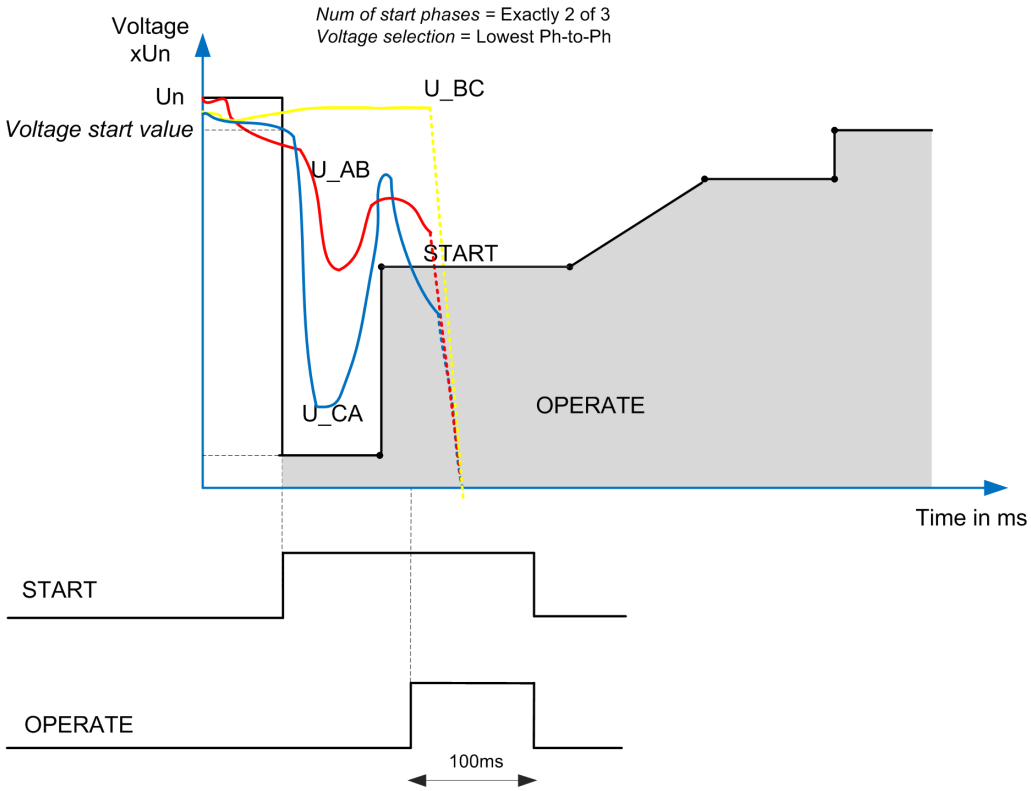



*Figure 506: Typical example of operation of LVRTPTUV function*

Activation of the BLOCK input resets the timers and deactivates the function outputs.

### 4.5.8.6 Application

Distributed generation, mainly wind and solar farms, are rapidly increasing due to liberalized markets (deregulation) and the global trend to use more renewable sources of energy. These farms are directly connected to grids, and due to their large size may influence the behavior of the grid. These farms are now required to comply with stringent grid connection requirement, which was previously mandatory only for high capacity power plants. These requirements include helping grid in maintaining system stability, reactive power support, transient recovery and voltage-frequency regulation. These requirements make it necessary for the wind and solar farms to remain in operation in the event of network disturbances.

Many grid codes now demand that the distributed generation connected to HV grids must withstand voltage dips to a certain percentage of nominal voltage (down to 0% in some cases) and for a specific duration. Such requirements are known as Low-Voltage Ride-Through (LVRT) or Fault-Ride-Through (FRT) and are described by a voltage versus time characteristics.

Typical LVRT behavior of a distributed generation can be divided into three areas according to the variation in voltage over time.

- At the time of system faults, the magnitude of the voltage may dip to *Voltage level 1* for time defined by *Recovery time 1*. The generating unit has to remain connected to the network during such condition. This boundary defines area A.

- Area B defines the linear growth recovery voltage level from *Voltage level 1* to *Voltage level 2* in a time period from *Recovery time 1* to *Recovery time 2*.
- Area C is the zone where voltage stabilizes. *Voltage level 3* is defined to same value as *Voltage level 2*. The system should remain above this voltage in a time period from *Recovery time 2* to *Recovery time 3*.

The system restores to a normal state and function resets when the voltage is equal or greater than *Voltage level 4* after *Recovery time 4* time period.

When the voltage at the point of common coupling is above the LVRT curve, the generation unit must remain connected, and must be disconnected only if the voltage takes values below the curve.

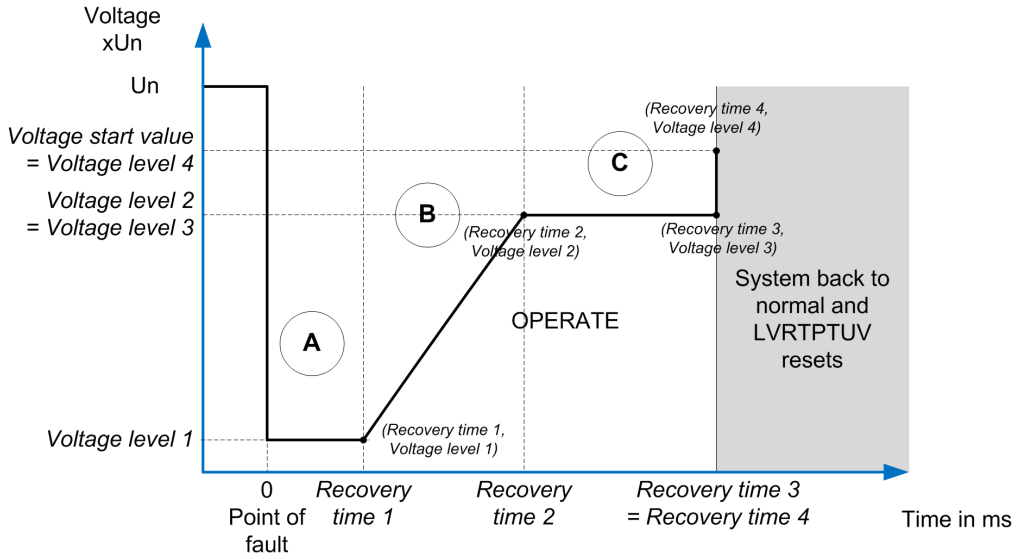



*Figure 507: A typical required ride-through voltage capability of generating unit*

The LVRT requirement depends on the power system characteristics and the protection employed, varying significantly from each other. The requirement also differs from country to country. LVRTPTUV function incorporates four types of LVRT curves which satisfy most of the power system needs. Grid operators can fine-tune the LVRT curve by setting the parameters as per their requirement, making the use simpler in comparison with different conventional undervoltage protection with different operate time setting and logics.

## 4.5.8.7 Signals

### LVRTPTUV Input signals

**Table 854: LVRTPTUV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**LVRTPTUV Output signals**

**Table 855: LVRTPTUV Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

## 4.5.8.8 LVRTPTUV Settings

**Table 856: LVRTPTUV Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage start value | 0.05...1.20 | xUn | 0.01 | 0.90 | Voltage value below which function starts |

**Table 857: LVRTPTUV Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 4=Exactly 1 of 3<br>5=Exactly 2 of 3<br>6=Exactly 3 of 3 | | | 4=Exactly 1 of 3 | Number of faulty phases |
| Voltage selection | 1=Highest Ph-to-E<br>2=Lowest Ph-to-E<br>3=Highest Ph-to-Ph<br>4=Lowest Ph-to-Ph<br>5=Positive Seq | | | 4=Lowest Ph-to-Ph | Parameter to select voltage for curve monitoring |
| Active coordinates | 1...10 | | 1 | 3 | Coordinates used for defining LVRT curve |
| Voltage level 1 | 0.00...1.20 | xUn | 0.01 | 0.20 | 1st voltage coordinate for defining LVRT curve |
| Voltage level 2 | 0.00...1.20 | xUn | 0.01 | 0.80 | 2nd voltage coordinate for defining LVRT curve |
| Voltage level 3 | 0.00...1.20 | xUn | 0.01 | 0.90 | 3rd voltage coordinate for defining LVRT curve |
| Voltage level 4 | 0.00...1.20 | xUn | 0.01 | 0.90 | 4th voltage coordinate for defining LVRT curve |
| Voltage level 5 | 0.00...1.20 | xUn | 0.01 | 0.90 | 5th voltage coordinate for defining LVRT curve |
| Voltage level 6 | 0.00...1.20 | xUn | 0.01 | 0.90 | 6th voltage coordinate for defining LVRT curve |
| Voltage level 7 | 0.00...1.20 | xUn | 0.01 | 0.90 | 7th voltage coordinate for defining LVRT curve |
| Voltage level 8 | 0.00...1.20 | xUn | 0.01 | 0.90 | 8th voltage coordinate for defining LVRT curve |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage level 9 | 0.00...1.20 | xUn | 0.01 | 0.90 | 9th voltage coordinate for defining LVRT curve |
| Voltage level 10 | 0.00...1.20 | xUn | 0.01 | 0.90 | 10th voltage coordinate for defining LVRT curve |
| Recovery time 1 | 0...300000 | ms | 1 | 500 | 1st time coordinate for defining LVRT curve |
| Recovery time 2 | 0...300000 | ms | 1 | 1000 | 2nd time coordinate for defining LVRT curve |
| Recovery time 3 | 0...300000 | ms | 1 | 10000 | 3rd time coordinate for defining LVRT curve |
| Recovery time 4 | 0...300000 | ms | 1 | 10000 | 4th time coordinate for defining LVRT curve |
| Recovery time 5 | 0...300000 | ms | 1 | 10000 | 5th time coordinate for defining LVRT curve |
| Recovery time 6 | 0...300000 | ms | 1 | 10000 | 6th time coordinate for defining LVRT curve |
| Recovery time 7 | 0...300000 | ms | 1 | 10000 | 7th time coordinate for defining LVRT curve |
| Recovery time 8 | 0...300000 | ms | 1 | 10000 | 8th time coordinate for defining LVRT curve |
| Recovery time 9 | 0...300000 | ms | 1 | 10000 | 9th time coordinate for defining LVRT curve |
| Recovery time 10 | 0...300000 | ms | 1 | 10000 | 10th time coordinate for defining LVRT curve |

### 4.5.8.9 LVRTPTUV Monitored data

**Table 858: LVRTPTUV Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LVRTPTUV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.8.10 Technical data

**Table 859: LVRTPTUV Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $U_n$ |

*Table continues on the next page*

| Characteristic | Value |
|---|---|
| Start time [1, 2] | Typically 40 ms |
| Reset time | Based on maximum value of *Recovery time* setting |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 4.5.9 Voltage vector shift protection VVSPPAM (ANSI 78VS)

### 4.5.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Voltage vector shift protection | VVSPPAM | VS | 78VS |

### 4.5.9.2 Function block




*Figure 508: Function block*

### 4.5.9.3 Functionality

The voltage vector shift protection function VVSPPAM, also known as vector surge or delta phi function, measures continuously the duration of a voltage cycle. At the instance of islanding, the duration of measured voltage cycle becomes shorter or longer than the previous one, that is, the measured voltage cycle shifts with time. This shifting of voltage is measured in terms of phase angle. VVSPPAM issues an instantaneous trip when the shift in voltage vector exceeds the set value.

VVSPPAM can be blocked with `BLOCK` input. Blocking resets timers and outputs.

### 4.5.9.4 Analog channel configuration

VVSPPAM has one analog group input which must be properly configured.

**Table 860: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

[1] Tested for *Number of Start phases* = 1 out of 3, results based on statistical distribution of 1000 measurements
[2] Includes the delay of the signal output contact

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 861: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.9.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”.

The operation of VVSPPAM can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

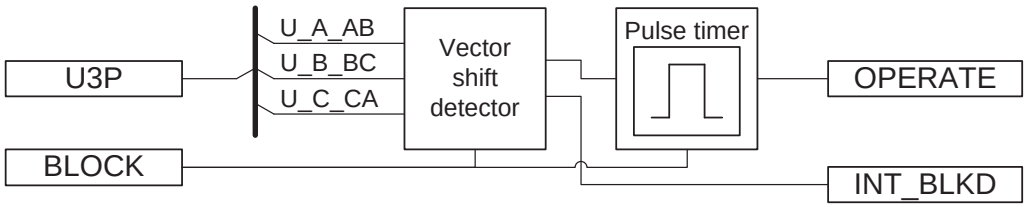



*Figure 509: Functional module diagram*

#### Vector shift detector

This module measures the duration of each cycle of the voltage signal phase. The duration of the present cycle is compared to the previous cycle, considered as reference. When the mains is lost, a sudden change is seen in the cycle length, if loading of the generator changes suddenly and power mismatch or unbalance (generation vs. load) in the islanded part of the network is large enough. The cycle shifts with time, that is, the frequency may not change but a vector shift is seen in phase as shown in *Figure 510*.

This step is measured in degrees for each voltage signal defined by the *Phase supervision* setting. The *Phase supervision* setting determines which voltage is used for detecting vector shift. The available *Phase supervision* options are “All” and “Pos sequence”. If the calculated value of Δδ exceeds the set *Start value* setting for all the defined phases, the module sends an enabling signal to start the Pulse timer.

The *Voltage selection* setting is used to select whether the available voltage signal is phase-to-earth or phase-to-phase voltage.

The recommended and the default value for *Phase supervision* is “Pos sequence”.

If the magnitude of the voltage level of any of the monitored voltage signal, defined by the *Phase supervision* setting, drops below *Under Volt Blk value* or exceeds *Over Volt Blk value*, the calculation of vector shift is disabled and the INT_BLKD output is activated.

The function is blocked and LOWAMPL_BLKD is activated, if the measured frequency deviates ±5% from the nominal value.

The magnitude of calculated vector shift for three phase-to-earth or phase-to-phase voltages, USHIFT_A_AB, USHIFT_B_BC and USHIFT_C_CA or positive sequence voltage U1SHIFT, which resulted in the activation of last OPERATE output, are available in the Monitored data view.

The activation of BLOCK input deactivates the INT_BLKD output.

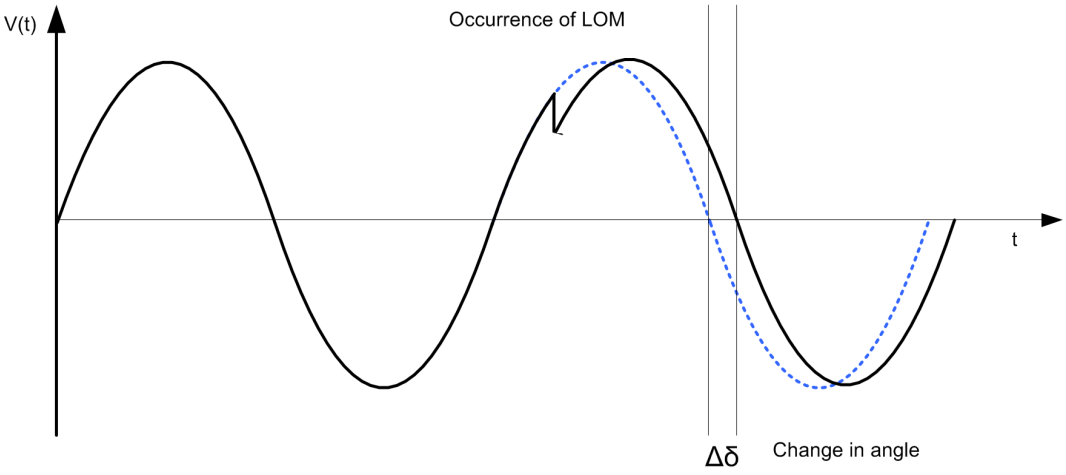



*Figure 510: Vector shift during Loss of Mains*

**Pulse timer**

Once the Pulse timer is activated, it activates the OPERATE output. The pulse length of OPERATE is fixed to 100 ms.

The activation of the BLOCK input deactivates the OPERATE binary output and resets the timer.

## 4.5.9.6 Application

Use of distributed generation ( DG) units is increasing due to liberalized markets (deregulation) and the global trend to use more renewable sources of energy. They generate power in the range of 10 kW...10 MW and most of them are interconnected to the distribution network. They can supply power into the network as well as to the local loads. It is not common to connect generators directly to the distribution networks and thus the distributed generation can cause some challenges for the protection of distribution networks. From the protection point of view, one of the most challenging issue is islanding.

Islanding is defined as a condition in which a distributed generation unit continues to supply power to a certain part of the distribution network when power from the

larger utility main grid is no longer available after the opening of a circuit-breaker. Islanding is also referred as Loss of Mains ( LOM) or Loss of Grid ( LOG). When LOM occurs, neither the voltage or the frequency is controlled by the utility supply. These distributed generators are not equipped with voltage and frequency control; therefore, the voltage magnitude of an islanded network may not be kept within the desired limits which causes undefined voltage magnitudes during islanding situations and frequency instability. Uncontrolled frequency represents a high risk for drives and other machines. Islanding can occur as a consequence of a fault in the network, due to circuit breaker maloperation or due to circuit breaker opening during maintenance. If the distributed generator continues its operation after the utility supply is disconnected, faults do not clear under certain conditions as the arc is charged by the distributed generators. Moreover, the distributed generators are incompatible with the current reclosing practices. During the reclosing sequence dead time, the generators in the network tend to drift out of synchronism with the grid and reconnecting them without synchronizing may damage the generators introducing high currents and voltages in the neighboring network.

To avoid these technical challenges, protection is needed to disconnect the distributed generation once it is electrically isolated from the main grid supply. Various techniques are used for detecting Loss of Mains. However, the present function focuses on voltage vector shift.

The vector shift detection guarantees fast and reliable detection of mains failure in almost all operational conditions when a distributed generation unit is running in parallel with the mains supply, but in certain cases this may fail.

If the active and reactive power generated by the distributed generation units is nearly balanced (for example, if the power mismatch or unbalance is less than 5...10%) with the active and reactive power consumed by loads, a large enough voltage phase shift may not occur which can be detected by the vector shift algorithm. This means that the vector shift algorithm has a small non-detection-zone (NDZ) which is also dependent on the type of generators, loads, network and start or operate value of the vector shift algorithm. Other network events like capacitor switching, switching of very heavy loads in weak networks or connection of parallel transformer at HV/MV substation, in which the voltage magnitude is not changed considerably (unlike in faults) can potentially cause maloperation of vector shift algorithm, if very sensitive settings are used.

The vector shift detection also protects synchronous generators from damaging due to islanding or loss-of-mains. To detect loss-of-mains with vector shift function, the generator should aim to export or import at least 5...10% of the generated power to the grid, in order to guarantee detectable change in loading after islanding or loss-of-mains.

**Multicriteria Loss of Mains**

Apart from vector shift, there are other passive techniques which are used for detecting Loss of Mains. Some of these passive techniques are over/under voltage, over/under frequency, rate of change of frequency, voltage unbalance, rate of change of power and so on. These passive methods use voltage and frequency to identify Loss of Mains. The performance of these methods depends on the power mismatch between local generation and load. The advantage of all these methods is that, they are simple and cost effective, but each method has a non detectable zone. To overcome this problem, it is recommended to combine different criteria for detecting Loss of Mains.

Two or more protection functions run in parallel to detect Loss of Mains. When all criteria are fulfilled to indicate Loss of Mains, an alarm or a trip can be generated.

Vector shift and rate of change of frequency are two parallel criteria typically used for detection of Loss of Mains.

Chosen protection criteria can be included in the Application Configuration tool to create multicriteria loss of mains alarm or trip.

### 4.5.9.7 Signals

#### VVSPPAM Input signals

**Table 862: VVSPPAM Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

#### VVSPPAM Output signals

**Table 863: VVSPPAM Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| INT_BLKD | BOOLEAN | Protection function internally blocked |

### 4.5.9.8 VVSPPAM Settings

**Table 864: VVSPPAM Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 2.0...30.0 | deg | 0.1 | 6.0 | Start value for vector shift |

**Table 865: VVSPPAM Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Over Volt Blk value | 0.40...1.50 | xUn | 0.01 | 1.20 | Voltage above which function will be internally blocked |
| Under Volt Blk value | 0.15...1.00 | xUn | 0.01 | 0.80 | Voltage below which function will be internally blocked |

**Table 866: VVSPPAM Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 867: VVSPPAM Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase supervision | 7=Ph A + B + C<br>8=Pos sequence | | | 8=Pos sequence | Monitored voltage phase |

### 4.5.9.9 VVSPPAM Monitored data

**Table 868: VVSPPAM Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| VEC_SHT_A_AB | FLOAT32 | -180.00...180.00 | deg | Vector shift for phase to earth voltage A or phase to phase voltage AB |
| VEC_SHT_B_BC | FLOAT32 | -180.00...180.00 | deg | Vector shift for phase to earth voltage B or phase to phase voltage BC |
| VEC_SHT_C_CA | FLOAT32 | -180.00...180.00 | deg | Vector shift for phase to earth voltage C or phase to phase voltage CA |
| VEC_SHT_U1 | FLOAT32 | -180.00...180.00 | deg | Vector shift for positive sequence voltage |
| VVSPPAM | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.5.9.10 Technical data

**Table 869: VVSPPAM Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n$ ±1 Hz |
| | ±1° |
| Operate time [1, 2] | Typically 53 ms |

## 4.5.10 Three-phase overvoltage variation protection PHVPTOV (ANSI 59.S1)

[1] $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[2] Includes the delay of the signal output contact

### 4.5.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase overvoltage variation protection | PHVPTOV | 3Urms> | 59.S1 |

### 4.5.10.2 Function block




*Figure 511: Function block*

### 4.5.10.3 Functionality

The three-phase overvoltage variation protection function PHVPTOV monitors the quality of the voltages. The function evaluates the power quality in the voltage by calculating the average RMS value of the voltage over a set period. The function includes a settable limit for the detection of overvoltage in a single phase, two phases or three phases.

The function starts when the average RMS value of the voltage exceeds the set limit. PHVPTOV operates with the definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.5.10.4 Analog channel configuration

PHVPTOV has one analog group input which must be properly configured.

**Table 870: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 871: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected if *Num of start phases* is set to "1 out of 3". Otherwise, all three voltage channels must be connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.5.10.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PHVPTOV can be described with a module diagram. All the modules in the diagram are explained in the next sections.

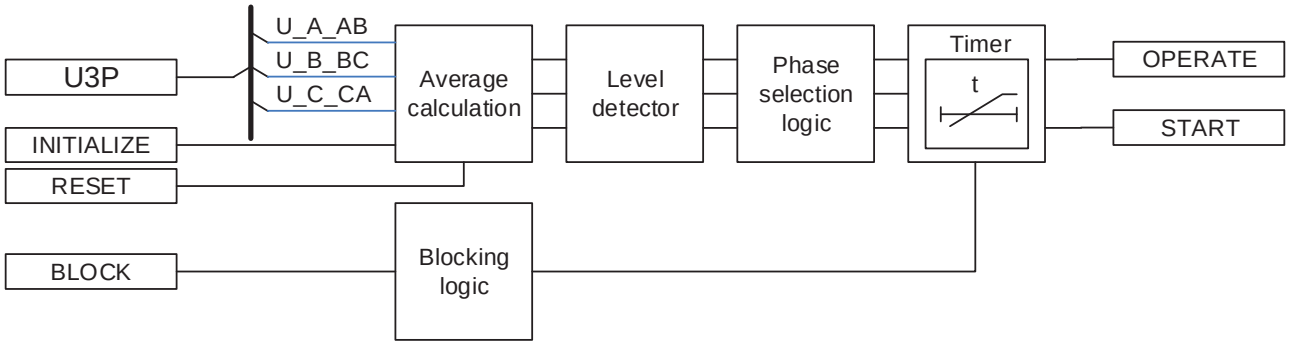



*Figure 512: Functional module diagram*

**Average calculation**

The module calculates the average voltage magnitude variation for each of the three input phase voltages. The calculation is done in three successive aggregations.

- 10/12-cycle voltage input samples are aggregated to calculate the 10/12-cycle RMS voltage.
- 10/12-cycle RMS voltages are aggregated over a time period of $T_{refresh}$ to get the refresh value.
- Refresh values are aggregated over a time period $T_{average}$ to get the average RMS voltage magnitude.

The *Voltage selection* setting is used for selecting phase-to-earth or phase-to-phase voltages for protection.

**Calculation of 10/12-cycle RMS voltage**

The 10/12-cycle RMS voltage is calculated for each of the three input voltages by applying the standard RMS formula using the voltage samples over a range of 0.2 s. Depending on the *Voltage selection* setting, voltage samples are either phase-to-earth or phase-to-phase voltage samples.

**Calculation of RMS refresh voltage**

The RMS refresh voltage is calculated by aggregating the $U_{10cycles}$ / $U_{12cycles}$ RMS voltage over a time period of $T_{refresh}$. The time period $T_{refresh}$ depends on the setting *Time interval*.

$$T_{refresh} = Roundup\left(\frac{Time\ interval\ in\ seconds}{200}\right)$$

(Equation 255)

The function Roundup rounds up the result to the next higher time multiple of 0.2 s because the result of the division is not a multiple of 0.2 s in case of an odd *Time interval* setting (1, 3, 5…120 mins).

$$U_{Refresh} = \sqrt{\frac{1}{N}\sum_{i=1}^{N} U_{10/12cycles}^{2}(i)}$$

(Equation 256)

N Number of values to be aggregated as defined by *Equation 257*

$$N = \left(\frac{T_{refresh}}{0.2}\right)$$

(Equation 257)

**Calculation of RMS average voltage**

The RMS average voltage is calculated by aggregating the RMS $U_{refresh}$ voltage over a time period equal to the *Time interval*.

$$U_{Average} = \sqrt{\frac{1}{M}\sum_{i=1}^{M} U_{Refresh}^{2}(i)}$$

(Equation 258)

M Number of values to be aggregated as defined by *Equation 259*

$$M = Round\left(\frac{Time\ interval\ in\ seconds}{T_{Refresh}}\right)$$

(Equation 259)

At the initialization of the function, the average voltage is calculated considering initial values as zero. On the IEC 61850 mapped data, the quality of the calculated average voltage value is indicated as “Questionable” until the first complete time interval passes. The calculated average voltage measurement for the set *Time interval* for all three phase-to-earth and phase-to-phase voltages U_MEAN_A, U_MEAN_B, U_MEAN_C, U_MEAN_AB, U_MEAN_BC and U_MEAN_CA is available in the Monitored data view.

The calculated average voltage can be reset by the RESET binary input. The calculated average voltage can also be reset using PHVPTOV1 Reset mean on the Clear menu.

When the INITIALIZE input is activated, the average voltage measurement value is initialized with the 10/12-cycle RMS voltage. The average voltage measurement value can also be initialized using PHVPTOV1 Ini mean on the Clear menu.

### Level detector

The calculated average voltage for all three voltages is compared phase-wise to the set *Start value* setting. If the calculated voltage value is higher than the set value of the *Start value* setting, Level detector enables the Phase selection logic module. The *Relative hysteresis* setting can be used for preventing unnecessary oscillations if the input signal slightly differs from the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return to the hysteresis area.

### Phase selection logic

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the fault level is detected. If the number of faulty phases matches with the set *Num of start phases*, the phase selection logic activates the Timer module.

### Timer

Once activated, the timer activates the START output. The operate delay time is not settable directly but it depends on the *Operate delay Mult* setting and refresh timer $T_{refresh}$. The operate delay time is calculated as:

$$Operate\ delay\ time\ in\ s = Operate\ delay\ Mult \cdot T_{refresh}$$

(Equation 260)

When the operation timer has reached the value equal to *Operate delay time*, the OPERATE output is activated if the overvoltage condition persists. If the average voltage value normalizes before the module operates, the reset timer is activated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the monitored data view.

When the relay has tripped due to variation overvoltage protection, check that operation is safe before closing the breaker. Clear the average voltage value by using *PHVPTOV1 Reset mean* on the **Clear** menu to prevent immediate retripping of breaker by PHVPTOV.

Considering the slow dynamic of the measurement, the protection may remain in the START status for a long time. If the measured voltage returns to a value lower than *Start value*, the function does not immediately reset. The function resets when the calculated average RMS value drops below *Start value*.

### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the “Block all” mode, the whole

function is blocked and the timers are reset. In the “Block OPERATE output” mode, the function operates normally but the OPERATE output is not activated.

### 4.5.10.6 Application

Overvoltage in a network occurs either due to the transient surges on the network or due to power frequency overvoltages. Surge arresters are used to protect the network against the transient overvoltages; power frequency overvoltage of magnitude greater than 15...20% of nominal voltage is normally handled by traditional overvoltage protection. However, slow voltage variations are usually quantified by calculating the RMS value of the voltage. To assess the RMS voltage, measurements are taken over a relatively long period of time to avoid any instantaneous effect caused by switching transients or faults.

It is important to monitor such slow voltage variation which can cause sub-optimal operation of the equipment. EN 50160 quantifies slow voltage variation using 10 min mean RMS value. CEI EN 50160 standard indicates that the RMS value of the voltage calculated over a period of 10 min should not exceed 110% of the nominal voltage; if the voltage exceeds this level, the generator must be disconnected from the network within 3 s. PHVPTOV provides overvoltage protection by calculating the RMS value over a period of 10 min.

A sudden change in the magnitude of the supply voltage is not immediately detected by the RMS calculation; hence this is mainly used as an indication of voltage quality supplied by the utility.

### 4.5.10.7 Signals

#### PHVPTOV Input signals

**Table 872: PHVPTOV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| INITIALIZE | BOOLEAN | 0=False | Initialize the voltage average measurement |
| RESET | BOOLEAN | 0=False | Reset the voltage average measurement values |

#### PHVPTOV Output signals

**Table 873: PHVPTOV Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.5.10.8 PHVPTOV Settings

**Table 874: PHVPTOV Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.05...3.00 | xUn | 0.01 | 1.10 | Start value |
| Time interval | 1...120 | min | 1 | 10 | Time interval for average voltage calculation |
| Operate delay Mult | 0...100 | | 1 | 1 | Trip delay expressed as a multiple of refresh time |

**Table 875: PHVPTOV Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Voltage selection | 1=phase-to-earth<br>2=phase-to-phase | | | 1=phase-to-earth | Parameter to select phase or phase-to-phase voltages |

**Table 876: PHVPTOV Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Relative hysteresis | 1.0...5.0 | % | 0.1 | 4.0 | Relative hysteresis for operation |

### 4.5.10.9 PHVPTOV Monitored data

**Table 877: PHVPTOV Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| U_MEAN_A | FLOAT32 | 0.00...5.00 | xUn | Mean value of phase to earth voltage A |
| U_MEAN_B | FLOAT32 | 0.00...5.00 | xUn | Mean value of phase to earth voltage B |
| U_MEAN_C | FLOAT32 | 0.00...5.00 | xUn | Mean value of phase to earth voltage C |
| U_MEAN_AB | FLOAT32 | 0.00...5.00 | xUn | Mean value of Phase to phase voltage AB |
| U_MEAN_BC | FLOAT32 | 0.00...5.00 | xUn | Mean value of Phase to phase voltage BC |
| U_MEAN_CA | FLOAT32 | 0.00...5.00 | xUn | Mean value of Phase to phase voltage CA |
| PHVPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.5.10.10 Technical data

**Table 878: PHVPTOV Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage: $f_n$ |
| | ±1.5 % of the set value or ±0.002 × $U_n$ |
| Reset ratio | Depends on the set *Relative hysteresis* |
| Operate time accuracy in definite time mode | ±1.0 % of the set value or ±20 ms |

# 4.6 Frequency protection

## 4.6.1 Frequency protection FRPFRQ (ANSI 81)

### 4.6.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Frequency protection | FRPFRQ | f>/f<,df/dt | 81 |

### 4.6.1.2 Function block

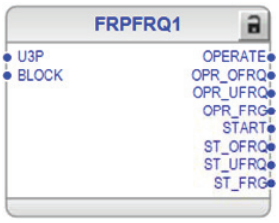



*Figure 513: Function block*

### 4.6.1.3 Functionality

The frequency protection function FRPFRQ is used to protect network components against abnormal frequency conditions.

The function provides basic overfrequency, underfrequency and frequency rate-of-change protection. Additionally, it is possible to use combined criteria to achieve even more sophisticated protection schemes for the system.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

### 4.6.1.4 Analog channel configuration

FRPFRQ has one analog group input which must be properly configured.

**Table 879: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 880: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that at least one phase or phase-to-phase voltage channel is connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.6.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of FRPFRQ can be described using a module diagram. All the modules in the diagram are explained in the next sections.

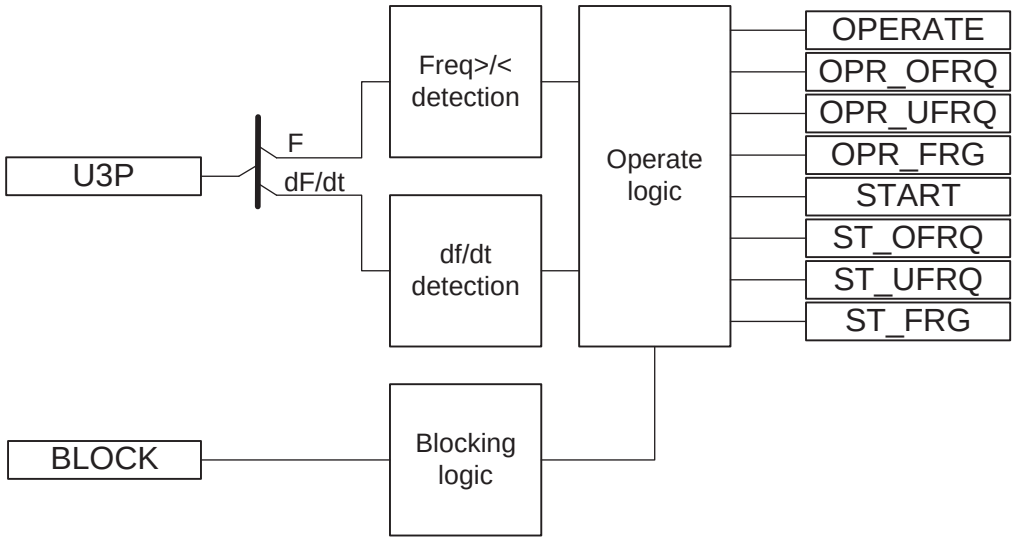



*Figure 514: Functional module diagram*

### Freq>/< detection

The frequency detection module includes an overfrequency or underfrequency detection based on the *Operation mode* setting.

In the “Freq>” mode, the measured frequency is compared to the set *Start value Freq>*. If the measured value exceeds the set value of the *Start value Freq>* setting, the module reports the exceeding of the value to the operate logic module.

In the “Freq<” mode, the measured frequency is compared to the set *Start value Freq<*. If the measured value is lower than the set value of the *Start value Freq<* setting, the module reports the value to the operate logic module.

### df/dt detection

The frequency gradient detection module includes a detection for a positive or negative rate-of-change (gradient) of frequency based on the set *Start value df/dt* value. The negative rate-of-change protection is selected when the set value is negative. The positive rate-of-change protection is selected when the set value is positive. When the frequency gradient protection is selected and the gradient exceeds the set *Start value df/dt* value, the module reports the exceeding of the value to the operate logic module.

The protection relay does not accept a value between -0.002...+0.002 for the *Start value df/dt* setting.

### Operate logic

This module is used for combining different protection criteria based on the frequency and the frequency gradient measurement to achieve a more sophisticated behavior of the function. The criteria are selected with the *Operation mode* setting.

**Table 881: Operation modes for operation logic**

| *Operation mode* | Description |
|---|---|
| Freq< | The function operates independently as the underfrequency ("Freq<") protection function. When the measured frequency is below the set value of the *Start value Freq<* setting, the module activates the START and STR_UFRQ outputs. The time characteristic is according to DT. When the operation timer has reached the value set by the *Operate Tm Freq* setting, the OPERATE and OPR_UFRQ outputs are activated. If the frequency restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm Freq* setting, the operate timer resets and the START and STR_UFRQ outputs are deactivated. |
| Freq> | The function operates independently as the overfrequency ("Freq>") protection function. When the measured frequency exceeds the set value of the *Start value Freq>* setting, the module activates the START and STR_OFRQ outputs. The time characteristic is according to DT. When the operation timer has reached the value set by the *Operate Tm Freq* setting, the OPERATE and OPR_OFRQ outputs are activated. |

*Table continues on the next page*

| *Operation mode* | **Description** |
|---|---|
| | If the frequency restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm Freq* setting, the operate timer resets and the START and STR_OFRQ outputs are deactivated. |
| df/dt | The function operates independently as the frequency gradient ("df/dt"), rate-of-change, protection function. When the frequency gradient exceeds the set value of the *Start value df/dt* setting, the module activates the START and STR_FRG outputs. The time characteristic is according to DT. When the operation timer has reached the value set by the *Operate Tm df/dt* setting, the OPERATE and OPR_FRG outputs are activated. If the frequency gradient restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm df/dt* setting, the operate timer resets and the START and STR_FRG outputs are deactivated. |
| Freq< + df/dt | A consecutive operation is enabled between the protection methods. When the measured frequency is below the set value of the *Start value Freq<* setting, the frequency gradient protection is enabled. After the frequency has dropped below the set value, the frequency gradient is compared to the set value of the *Start value df/dt* setting. When the frequency gradient exceeds the set value, the module activates the START and STR_FRG outputs. The time characteristic is according to DT. When the operation timer has reached the value set by the *Operate Tm df/dt* setting, the OPERATE and OPR_FRG outputs are activated. If the frequency gradient restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm df/dt* setting, the operate timer resets and the START and STR_FRG outputs are deactivated. The OPR_UFRQ output is not active when this operation mode is used. |
| Freq> + df/dt | A consecutive operation is enabled between the protection methods. When the measured frequency exceeds the set value of the *Start value Freq>* setting, the frequency gradient protection is enabled. After the frequency exceeds the set value, the frequency gradient is compared to the set value of the *Start value df/dt* setting. When the frequency gradient exceeds the set value, the module activates the START and STR_FRG outputs. The time characteristic is according to DT. When the operation timer has reached the value set by the *Operate Tm df/dt* setting, the OPERATE and OPR_FRG outputs are activated. If the frequency gradient restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm df/dt* setting, the operate timer resets and the START and STR_FRG outputs are deactivated. The OPR_OFRQ output is not active when this operation mode is used. |

*Table continues on the next page*

| *Operation mode* | Description |
|---|---|
| Freq< OR df/dt | A parallel operation between the protection methods is enabled. The START output is activated when either of the measured values of the protection module exceeds its set value. Detailed information about the active module is available at the STR_UFRQ and STR_FRG outputs. The shortest operate delay time from the set *Operate Tm Freq* or *Operate Tm df/dt* is dominant regarding the OPERATE output. The time characteristic is according to DT. The characteristic that activates the OPERATE output can be seen from the OPR_UFRQ or OPR_FRG output. If the frequency gradient restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm df/dt* setting, the operate timer resets and the STR_FRG output is deactivated. If the frequency restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm Freq* setting, the operate timer resets and the STR_UFRQ output is deactivated. |
| Freq> OR df/dt | A parallel operation between the protection methods is enabled. The START output is activated when either of the measured values of the protection module exceeds its set value. A detailed information from the active module is available at the STR_OFRQ and STR_FRG outputs. The shortest operate delay time from the set *Operate Tm Freq* or *Operate Tm df/dt* is dominant regarding the OPERATE output. The time characteristic is according to DT. The characteristic that activates the OPERATE output can be seen from the OPR_OFRQ or OPR_FRG output. If the frequency gradient restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm df/dt* setting, the operate timer resets and the STR_FRG output is deactivated. If the frequency restores before the module operates, the reset timer is activated. If the timer reaches the value set by the *Reset delay Tm Freq* setting, the operate timer resets and the STR_UFRQ output is deactivated. |

The module calculates the start duration value which indicates the percentage ratio of the start situation and set operate time (DT). The start duration is available according to the selected value of the *Operation mode* setting.

**Table 882: Start duration value**

| Operation mode in use | Available start duration value |
|---|---|
| Freq< | ST_DUR_UFRQ |
| Freq> | ST_DUR_OFRQ |
| df/dt | ST_DUR_FRG |

The combined start duration START_DUR indicates the maximum percentage ratio of the active protection modes. The values are available via the Monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.6.1.6 Application

The frequency protection function uses the positive phase-sequence voltage to measure the frequency reliably and accurately.

The system frequency stability is one of the main principles in the distribution and transmission network maintenance. To protect all frequency-sensitive electrical apparatus in the network, the departure from the allowed band for a safe operation should be inhibited.

The overfrequency protection is applicable in all situations where high levels of the fundamental frequency of a power system voltage must be reliably detected. The high fundamental frequency in a power system indicates an unbalance between production and consumption. In this case, the available generation is too large compared to the power demanded by the load connected to the power grid. This can occur due to a sudden loss of a significant amount of load or due to failures in the turbine governor system. If the situation continues and escalates, the power system loses its stability.

The underfrequency is applicable in all situations where a reliable detection of a low fundamental power system voltage frequency is needed. The low fundamental frequency in a power system indicates that the generated power is too low to meet the demands of the load connected to the power grid.

The underfrequency can occur as a result of the overload of generators operating in an isolated system. It can also occur as a result of a serious fault in the power system due to the deficit of generation when compared to the load. This can happen due to a fault in the grid system on the transmission lines that link two parts of the system. As a result, the system splits into two with one part having the excess load and the other part the corresponding deficit.

The frequency gradient is applicable in all the situations where the change of the fundamental power system voltage frequency should be detected reliably. The frequency gradient can be used for both increasing and decreasing the frequencies. This function provides an output signal suitable for load shedding, generator shedding, generator boosting, set point change in sub-transmission DC systems and gas turbine startup. The frequency gradient is often used in combination with a low frequency signal, especially in smaller power systems where the loss of a large generator requires quick remedial actions to secure the power system integrity. In such situations, the load shedding actions are required at a rather high frequency level. However, in combination with a large negative frequency gradient, the underfrequency protection can be used at a high setting.

### 4.6.1.7 Signals

#### FRPFRQ Input signals

**Table 883: FRPFRQ Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

#### FRPFRQ Output signals

**Table 884: FRPFRQ Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| OPR_OFRQ | BOOLEAN | Operate signal for overfrequency |
| OPR_UFRQ | BOOLEAN | Operate signal for underfrequency |
| OPR_FRG | BOOLEAN | Operate signal for frequency gradient |
| START | BOOLEAN | Start |
| ST_OFRQ | BOOLEAN | Start signal for overfrequency |
| ST_UFRQ | BOOLEAN | Start signal for underfrequency |
| ST_FRG | BOOLEAN | Start signal for frequency gradient |

### 4.6.1.8 FRPFRQ Settings

**Table 885: FRPFRQ Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation mode | 1=Freq<<br>2=Freq><br>3=df/dt<br>4=Freq< + df/dt<br>5=Freq> + df/dt<br>6=Freq< OR df/dt<br>7=Freq> OR df/dt | | | 1=Freq< | Frequency protection operation mode selection |
| Start value Freq> | 0.9000...1.2000 | xFn | 0.0001 | 1.0500 | Frequency start value overfrequency |
| Start value Freq< | 0.8000...1.1000 | xFn | 0.0001 | 0.9500 | Frequency start value underfrequency |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value df/dt | -0.2000...0.2000 | xFn/s | 0.0001 | 0.0100 | Frequency start value rate of change |
| Operate Tm Freq | 80...5400000 | ms | 10 | 200 | Operate delay time for frequency |
| Operate Tm df/dt | 120...200000 | ms | 10 | 400 | Operate delay time for frequency rate of change |

**Table 886: FRPFRQ Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 887: FRPFRQ Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay Tm Freq | 0...60000 | ms | 1 | 0 | Reset delay time for frequency |
| Reset delay Tm df/dt | 0...60000 | ms | 1 | 0 | Reset delay time for rate of change |

### 4.6.1.9 FRPFRQ Monitored data

**Table 888: FRPFRQ Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Start duration |
| ST_DUR_OFRQ | FLOAT32 | 0.00...100.00 | % | Start duration |
| ST_DUR_UFRQ | FLOAT32 | 0.00...100.00 | % | Start duration |
| ST_DUR_FRG | FLOAT32 | 0.00...100.00 | % | Start duration |
| FRPFRQ | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.6.1.10 Technical data

**Table 889: FRPFRQ Technical data**

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | f>/f< | ±5 mHz |
| | df/dt | ±50 mHz/s (in range \|df/dt\| <5 Hz/s)<br>±2.0% of the set value (in range 5 Hz/s <<br>\|df/dt\| < 15 Hz/s) |
| Start time | f>/f< | <80 ms[1] |

*Table continues on the next page*

| Characteristic | | Value |
|---|---|---|
| | df/dt | <120 ms |
| Reset time | | <150 ms |
| Operate time accuracy | | ±1.0% of the set value or ±30 ms |

#### 4.6.1.11 Technical revision history

**Table 890: FRPRFQ Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | F | Setting *Operate Tm Freq* maximum value extended to 5400000 ms (90 mins). |

### 4.6.2 Load-shedding and restoration LSHDPFRQ (ANSI 81LSH)

#### 4.6.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Load-shedding and restoration | LSHDPFRQ | UFLS/R | 81LSH |

#### 4.6.2.2 Function block




*Figure 515: Function block*

#### 4.6.2.3 Functionality

The load-shedding and restoration function LSHDPFRQ is capable of performing load-shedding based on underfrequency and the rate of change of the frequency. The load that is shed during the frequency disturbance can be restored once the frequency has stabilized to the normal level.

[1] Applies to sudden frequency change of ≤0.2 Hz or to frequency slope of ≤ 5 Hz/s. When frequency change is outside of these limits, start may be delayed by additional 100 ms to prevent false starts when connecting / disconnecting heavy loads.

The measured system frequency is compared to the set value to detect the underfrequency condition. The measured rate of change of frequency (df/dt) is compared to the set value to detect a high frequency reduction rate. The combination of the detected underfrequency and the high df/dt is used for the activation of the load-shedding. There is a definite time delay between the detection of the underfrequency and high df/dt and the activation of LSHDPFRQ. This time delay can be set and it is used to prevent unwanted load-shedding actions when the system frequency recovers to the normal level.

Throughout this document, “high df/dt” is used to mean “a high rate of change of the frequency in negative direction.”

Once the frequency has stabilized, LSHDPFRQ can restore the load that is shed during the frequency disturbance. The restoration is possible manually or automatically.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.6.2.4 Analog channel configuration

LSHDPFRQ has one analog group input which must be properly configured.

**Table 891: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 892: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that at least one phase or phase-to-phase voltage channel is connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.6.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of LSHDPFRQ can be described using a module diagram. All the modules are explained in the next sections.

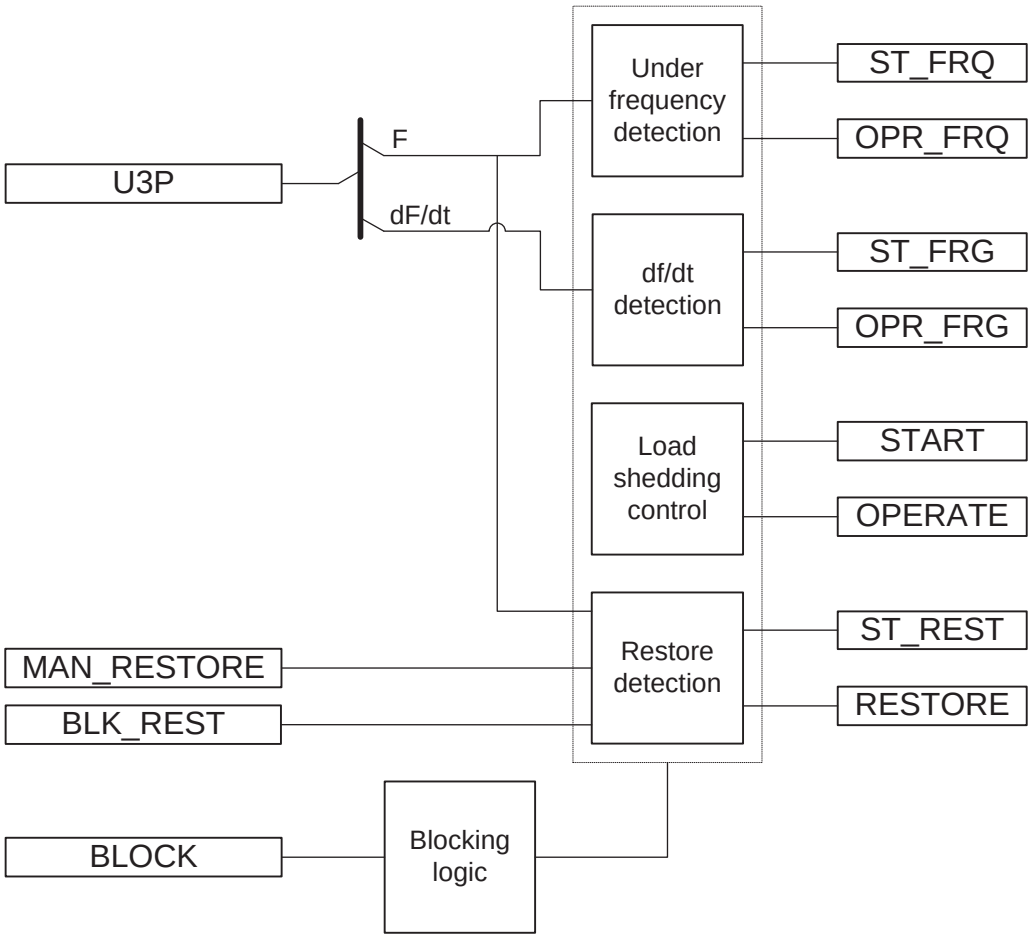



*Figure 516: Functional module diagram*

**Underfrequency detection**

The underfrequency detection measures the input frequency calculated from the voltage signal. An underfrequency is detected when the measured frequency drops below the set value of the *Start value Freq* setting.

The underfrequency detection module includes a timer with the definite time (DT) characteristics. Upon detection of underfrequency, operation timer activates the `ST_FRQ` output. When the underfrequency timer has reached the value set by *Operate Tm Freq*, the `OPR_FRQ` output is activated if the underfrequency condition still persists. If the frequency becomes normal before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the timer resets and the `ST_FRQ` output is deactivated.

**df/dt detection**

The df/dt detection measures the input frequency calculated from the voltage signal and calculates its gradient. A high df/dt condition is detected by comparing the gradient to the *Start value df/dt* setting. The df/dt detection is activated when the frequency gradient decreases at a faster rate than the set value of *Start value df/dt*.

The df/dt detection module includes a timer with the DT characteristics. Upon detection of df/dt, operation timer activates the ST_FRG output. When the timer has reached the value set by *Operate Tm df/dt*, the OPR_FRG output is activated if the df/dt condition still persists. If df/dt becomes normal before the module operates, the reset timer is activated. If the reset timer reaches the value of the *Reset delay time* setting, the timer resets and the ST_FRG output is deactivated.

**Load-shedding control**

The way of load-shedding, that is, whether to operate based on underfrequency or high df/dt or both, is defined with the *Load shed mode* user setting. The valid operation modes for the *Load shed mode* settings are "Freq<", "Freq< AND df/dt" and "Freq< OR df/dt".

Once the selected operation mode conditions are satisfied, the START and OPERATE output signals are activated.

When the START output is active, the percentage of the elapsed delay time can be monitored through START_DUR which is available as monitored data.

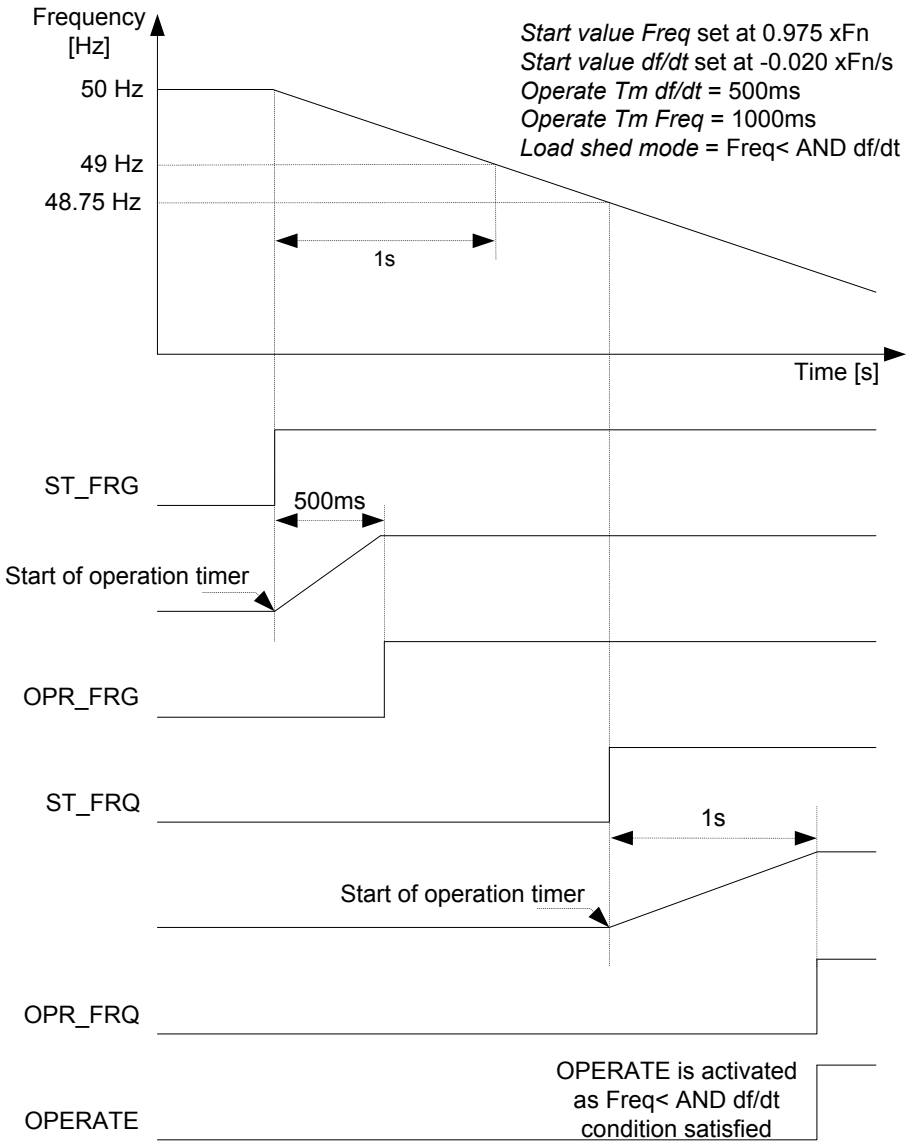



*Figure 517: Load-shedding operation in the "Freq< AND df/dt>" mode when both Freq< and df/dt conditions are satisfied ( Rated frequency=50 Hz)*

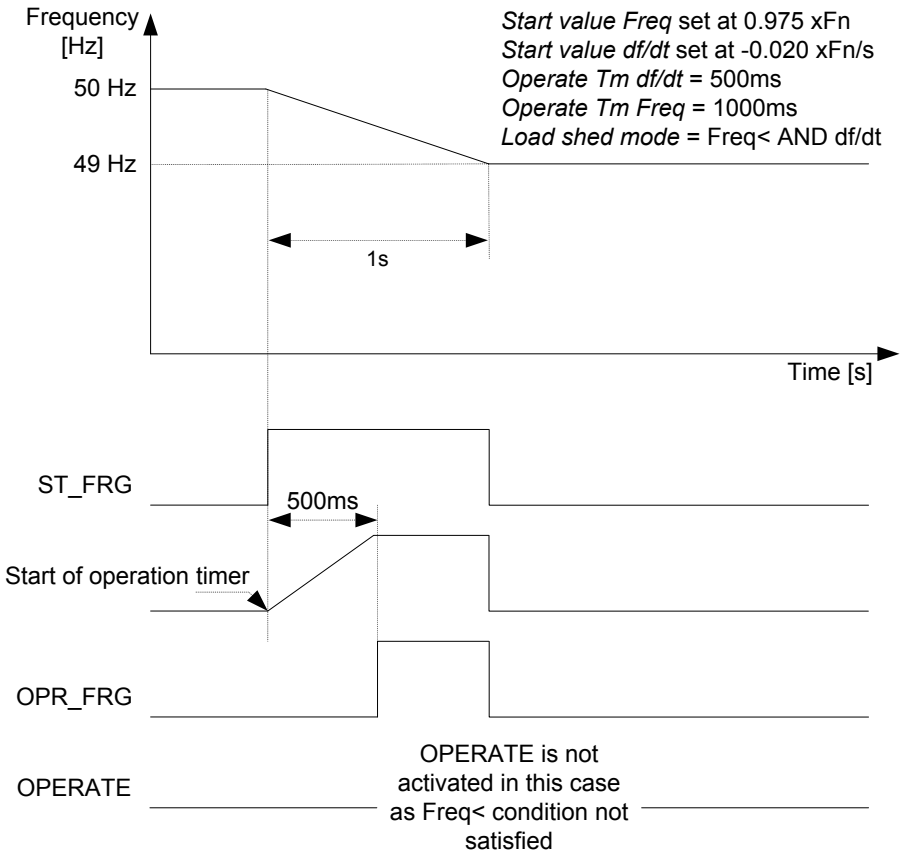



*Figure 518: Load-shedding operation in the "Freq< AND df/dt>" mode when only the df/dt condition is satisfied ( Rated frequency=50 Hz)*

**Restore detection**

If after the activation of the OPERATE output the frequency recovers to a level above the *Restore start Val* setting, the RESTORE signal output is activated. The RESTORE output remains active for 100 ms. The *Restore mode* setting is used to select the restoring mode to be "Disabled", "Auto" or "Manual".

| Restoring mode | Description |
|---|---|
| Disabled | Load restoration is disabled. |
| Auto | In the "Auto" mode, input frequency is continuously compared to the *Restore start Val* setting. The restore detection module includes a timer with the DT characteristics. Upon detection of restoring, the operation timer activates the ST_REST output. When the timer has reached the value of the *Restore delay time* setting, the RESTORE output is activated if the restoring condition still persists. If the frequency drops below the *Restore start Val* before the RESTORE output is activated, the reset timer is activated. If the reset timer reaches the value of the *Reset delay time* setting, the timer resets and the ST_REST start output is deactivated. |
| Manual | In the "Manual" mode, a manual restoration is possible through the MAN_RESTORE input or via communication. The ST_REST output is activated if the MAN_RESTORE command is available and the frequen- |

| Restoring mode | Description |
|---|---|
| | cy has exceeded the *Restore start Val* setting. The manual restoration includes a timer with the DT characteristics. When the timer has reached the set value of the *Restore delay time* setting, the RESTORE output is activated if the restoring condition still persists. If the frequency drops below the *Restore start Val* setting before the RESTORE output is activated, the reset timer is activated. If the reset timer reaches the value of the *Reset delay time* setting, the timer resets and the ST_REST start output is deactivated. |

A condition can arise where the restoring operation needs to be canceled. Activating the BLK_REST input for the "Auto" or "Manual" modes cancels the restoring operation. In the "Manual" restoring mode, the cancellation happens even if MAN_RESTORE is present.

Once the RESTORE output command is cancelled, the reactivation of RESTORE is possible only after the reactivation of the OPERATE output, that is, when the next load-shedding operation is detected.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** that selects the blocking mode. The BLOCK input can be controlled with a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK input signal activation is preselected with the *Blocking mode* global setting.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE, OPR_FRQ and OPR_FRG outputs are not activated.

### 4.6.2.6 Application

An AC power system operates at a defined rated frequency. The nominal frequency in most systems in the world is 50 Hz or 60 Hz. The system operation is such that the operating frequency remains approximately at the nominal frequency value by a small margin. The safe margin of operation is usually less than ±0.5 Hz. The system frequency stability is one of the main concerns in the transmission and distribution network operation and control. To protect the frequency-sensitive electrical equipment in the network, departure from the allowed band for safe operation should be inhibited.

Any increase in the connected load requires an increase in the real power generation to maintain the system frequency. Frequency variations form whenever there are system conditions that result in an unbalance between the generation and load. The rate of change of the frequency represents the magnitude of the difference between the load and generation. A reduction in frequency and a negative rate of change of the frequency are observed when the load is greater than the generation, and an increase in the frequency along with a positive rate of change of the frequency are observed if the generation is greater than the load. The rate of change of the frequency is used for a faster decision of load-shedding. In an

underfrequency situation, the load-shedding trips out the unimportant loads to stabilize the network. Thus, loads are normally prioritized so that the less important loads are shed before the important loads.

During the operation of some of the protective schemes or other system emergencies, the power system is divided into small islands. There is always a load - generation imbalance in such islands that leads to a deviation in the operating frequency from the nominal frequency. This off-nominal frequency operation is harmful to power system components like turbines and motors. Therefore, such situation must be prevented from continuing. The frequency-based load-shedding scheme should be applied to restore the operation of the system to normal frequency. This is achieved by quickly creating the load - generation balance by disconnecting the load.

As the formation of the system islands is not always predefined, several load-shedding relays are required to be deployed at various places near the load centers. A quick shedding of a large amount of load from one place can cause a significant disturbance in the system. The load-shedding scheme can be made most effective if the shedding of load feeders is distributed and discrete, that is, the loads are shed at various locations and in distinct steps until the system frequency reaches the acceptable limits.

Due to the action of load-shedding schemes, the system recovers from the disturbance and the operating frequency value recovers towards the nominal frequency. The load that was shed during the disturbance can be restored. The load-restoring operation should be done stepwise in such a way that it does not lead the system back to the emergency condition. This is done through an operator intervention or in case of remote location through an automatic load restoration function. The load restoration function also detects the system frequency and restores the load if the system frequency remains above the value of the set restoration frequency for a predefined duration.

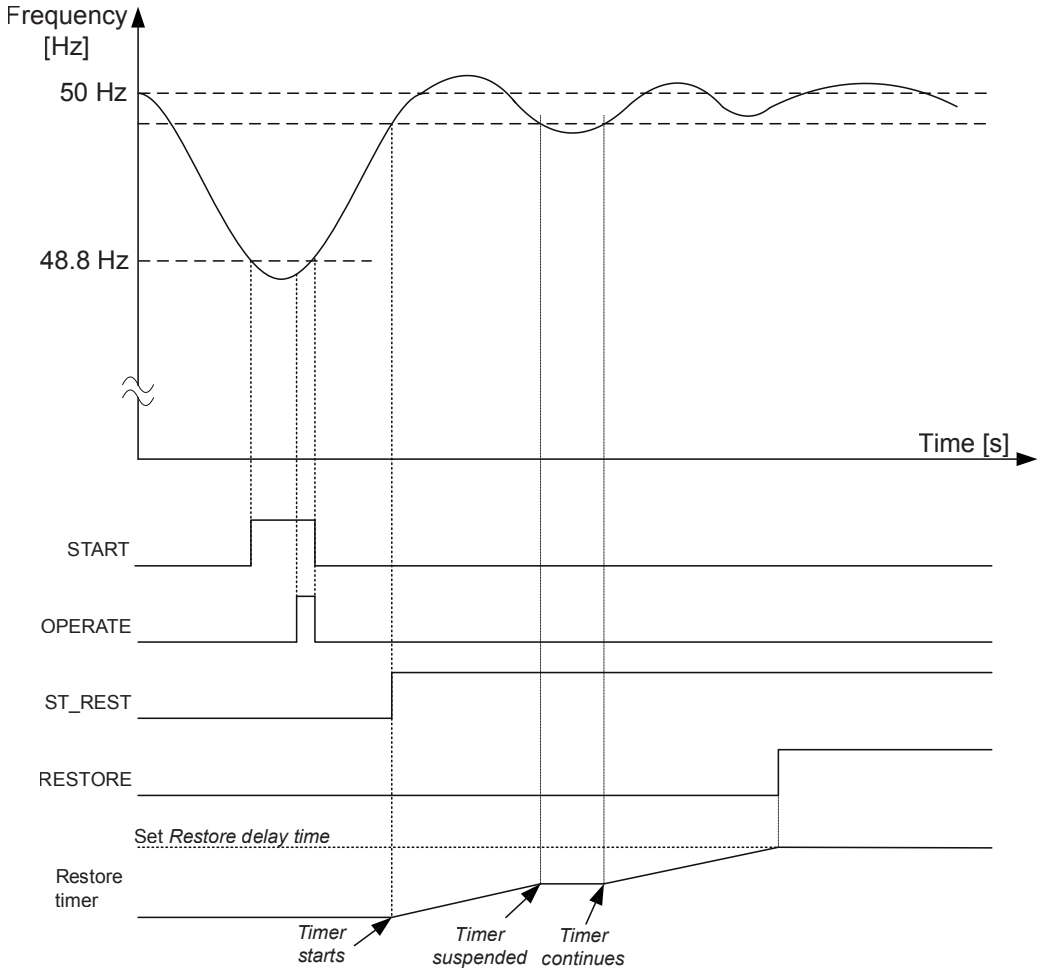



*Figure 519: Operation of the load-shedding function*

**Power system protection by load-shedding**

The decision on the amount of load that is required to be shed is taken through the measurement of frequency and the rate of change of frequency (df/dt). At a single location, many steps of load-shedding can be defined based on different criteria of the frequency and df/dt. Typically, the load-shedding is performed in six or four steps with each shedding increasing the portion of load from five to twenty-five percent of full load within a few seconds. After every shedding, the system frequency is read back and further shedding actions are taken only if necessary. In order to take the effect of any transient, a sufficient time delay should be set.

The value of the setting has to be well below the lowest occurring normal frequency and well above the lowest acceptable frequency of the system. The setting level, the number of steps and the distance between two steps (in time or in frequency) depend on the characteristics of the power system under consideration. The size of the largest loss of generation compared to the size of the power system is a critical parameter. In large systems, the load-shedding can be set at a high frequency level and the time delay is normally not critical. In small systems, the frequency start level has to be set at a low value and the time delay must be short.

If a moderate system operates at 50 Hz, an underfrequency should be set for different steps from 49.2 Hz to 47.5 Hz in steps of 0.3 – 0.4 Hz. The operating time

for the underfrequency can be set from a few seconds to a few fractions of a second stepwise from a higher frequency value to a lower frequency value.

**Table 893: Setting for a five-step underfrequency operation**

| Load-shedding steps | Start value Freq setting | Operate Tm Freq setting |
|---|---|---|
| 1 | 0.984 · Fn (49.2 Hz) | 45000 ms |
| 2 | 0.978 · Fn (48.9 Hz) | 30000 ms |
| 3 | 0.968 · Fn (48.4 Hz) | 15000 ms |
| 4 | 0.958 · Fn (47.9 Hz) | 5000ms |
| 5 | 0.950 · Fn (47.5 Hz) | 500 ms |

The rate of change of frequency function is not instantaneous since the function needs time to supply a stable value. It is recommended to have a time delay long enough to take care of the signal noise.

Small industrial systems can experience the rate of change of frequency as high as 5 Hz/s due to a single event. Even large power systems can form small islands with a large imbalance between the load and generation when severe faults or combinations of faults are cleared. Up to 3 Hz/s has been experienced when a small island becomes isolated from a large system. For normal severe disturbances in large power systems, the rate of change of the frequency is much less, often just a fraction of 1.0 Hz/s.

Similarly, the setting for df/dt can be from 0.1 Hz/s to 1.2 Hz/s in steps of 0.1 Hz/s to 0.3 Hz/s for large distributed power networks, with the operating time varying from a few seconds to a few fractions of a second. Here, the operating time should be kept in minimum for the higher df/dt setting.

**Table 894: Setting for a five-step df/dt< operation**

| Load-shedding steps | Start value df/dt setting | Operate Tm df/dt setting |
|---|---|---|
| 1 | -0.005 · Fn /s (-0.25 Hz/s) | 8000 ms |
| 2 | -0.010 · Fn /s (-0.50 Hz/s) | 2000 ms |
| 3 | -0.015 · Fn /s (-0.75 Hz/s) | 1000 ms |
| 4 | -0.020 · Fn /s (-1.00 Hz/s) | 500 ms |
| 5 | -0.025 · Fn /s (-1.25 Hz/s) | 250 ms |

Once the frequency has stabilized, the shed load can be restored. The restoring operation should be done stepwise, taking care that it does not lead the system back to the emergency condition.

**Table 895: Setting for a five-step restoring operation**

| Load-shedding steps | Restore start Val setting | Restore delay time setting |
|---|---|---|
| 1 | 0.990 · Fn (49.5 Hz) | 200000 ms |
| 2 | 0.990 · Fn (49.5 Hz) | 160000 ms |
| 3 | 0.990 · Fn (49.5 Hz) | 100000 ms |

*Table continues on the next page*

| Load-shedding steps | Restore start Val setting | Restore delay time setting |
|---|---|---|
| 4 | 0.990 · Fn (49.5 Hz) | 50000 ms |
| 5 | 0.990 · Fn (49.5 Hz) | 10000 ms |

### 4.6.2.7 Signals

#### LSHDPFRQ Input signals

**Table 896: LSHDPFRQ Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_REST | BOOLEAN | 0=False | Block restore |
| MAN_RESTORE | BOOLEAN | 0=False | Manual restore signal |

#### LSHDPFRQ Output signals

**Table 897: LSHDPFRQ Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operation of load shedding |
| OPR_FRQ | BOOLEAN | Operate signal for under frequency |
| OPR_FRG | BOOLEAN | Operate signal for high df/dt |
| START | BOOLEAN | Start |
| ST_FRQ | BOOLEAN | Pick-Up signal for under frequency detection |
| ST_FRG | BOOLEAN | Pick-Up signal for high df/dt detection |
| RESTORE | BOOLEAN | Restore signal for load restoring purposes |
| ST_REST | BOOLEAN | Restore frequency attained and restore timer started |

### 4.6.2.8 LSHDPFRQ Settings

**Table 898: LSHDPFRQ Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Load shed mode | 1=Freq<<br>6=Freq< OR df/dt | | | 1=Freq< | Set the operation mode for load shedding function |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 8=Freq< AND df/dt | | | | |
| Restore mode | 1=Disabled<br>2=Auto<br>3=Manual | | | 1=Disabled | Mode of operation of restore functionality |
| Start value Freq | 0.8000...1.2000 | xFn | 0.0001 | 0.9750 | Frequency setting/start value |
| Start value df/dt | -0.2000...-0.0050 | xFn/s | 0.0001 | -0.0100 | Setting of frequency gradient for df/dt detection |
| Operate Tm Freq | 80...200000 | ms | 10 | 200 | Time delay to operate for under frequency stage |
| Operate Tm df/dt | 120...200000 | ms | 10 | 200 | Time delay to operate for df/dt stage |
| Restore start Val | 0.8000...1.2000 | xFn | 0.0001 | 0.9980 | Restore frequency setting value |
| Restore delay time | 80...200000 | ms | 10 | 300 | Time delay to restore |

**Table 899: LSHDPFRQ Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 900: LSHDPFRQ Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 50 | Time delay after which the definite timers will reset |

### 4.6.2.9 LSHDPFRQ Monitored data

**Table 901: LSHDPFRQ Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Start duration |
| LSHDPFRQ | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.6.2.10 Technical data

**Table 902: LSHDPFRQ Technical data**

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | f< | ±5 mHz |
| | df/dt | ±100 mHz/s (in range \|df/dt\| < 5 Hz/s) |

*Table continues on the next page*

| Characteristic | | Value |
|---|---|---|
| | | ± 2.0% of the set value (in range 5 Hz/s < \|df/dt\| < 15 Hz/s) |
| Start time | f< | <80 ms |
| | df/dt | <120 ms |
| Reset time | | <150 ms |
| Operate time accuracy | | ±1.0% of the set value or ±30 ms |

#### 4.6.2.11 Technical revision history

**Table 903: LSHDPFRQ Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL2 | E | Changed the *Start value Freq* and *Restore start Val* steps to 0.0001 xFn |

# 4.7 Impedance protection

## 4.7.1 Distance protection DSTPDIS (ANSI 21P, 21N)

### 4.7.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Distance protection | DSTPDIS | Z< | 21P, 21N |

### 4.7.1.2 Function block

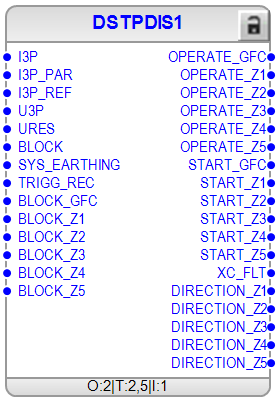



*Figure 520: Function block*

### 4.7.1.3 Functionality

The distance protection function DSTPDIS provides a full-scheme distance protection function for distribution networks where three-phase tripping is allowed for all kinds of faults.

DSTPDIS has five flexible, configurable impedance zones for protection (Z1...Z5).

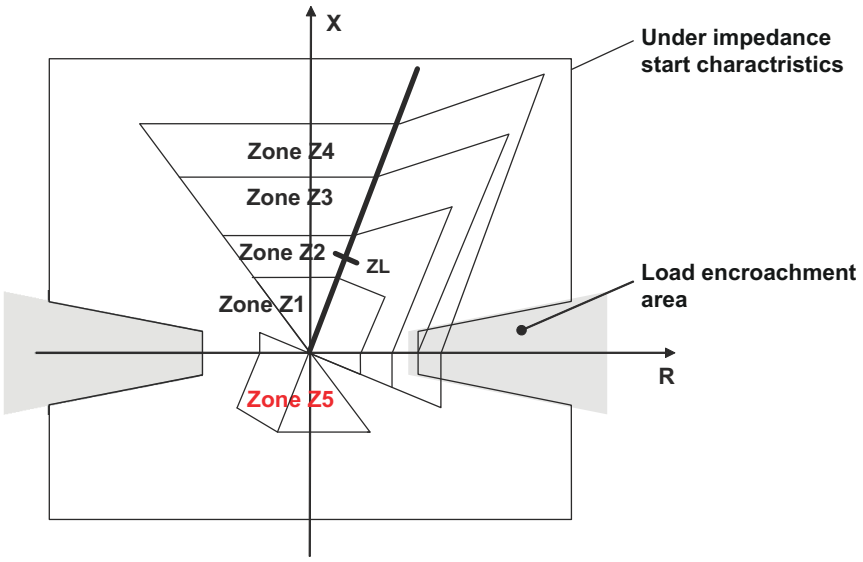



*Figure 521: Zones of DSTPDIS function (example 1)*

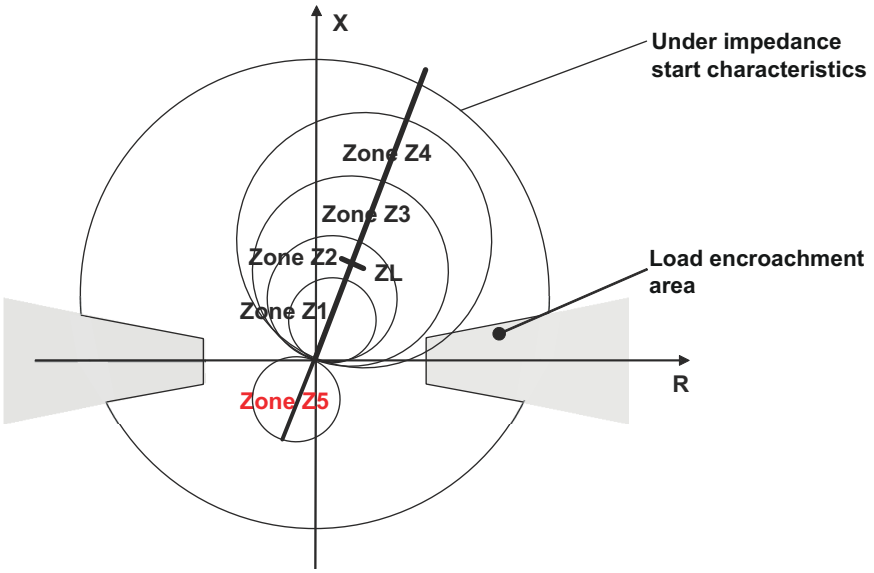



*Figure 522: Zones of DSTPDIS function (example 2)*

The supported zone characteristic shapes are quadrilateral, mho (circular) or bullet (quadrilateral and mho characteristics combined). Mho can be combined with directional lines to secure directionality and to enable increased fault resistance coverage with an offset mho circle.

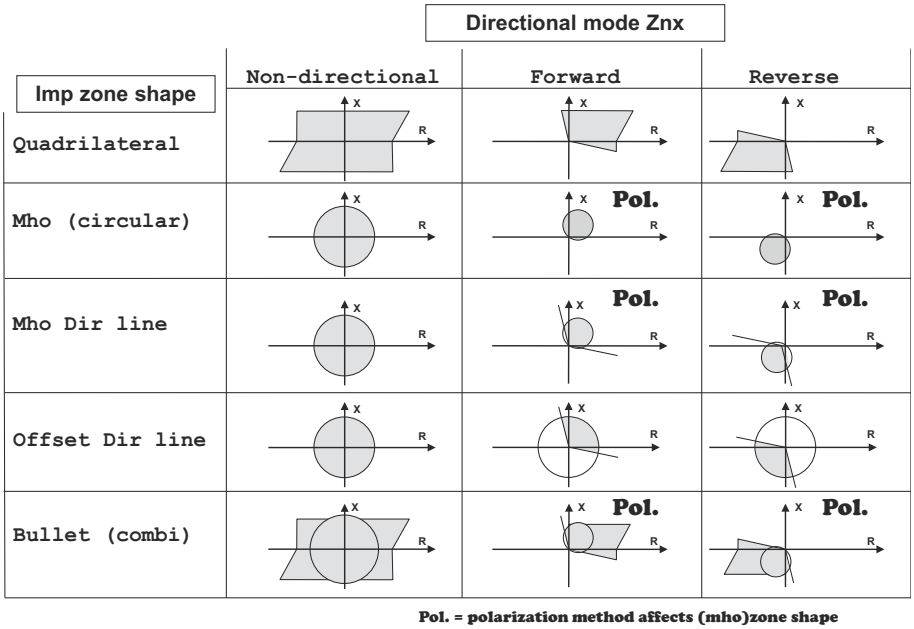



*Figure 523: Possible combinations of Directional mode Znx and Zone characteristics settings. Pol. here means that the shape of the characteristic is affected by the selected polarization method of mho circle (Pol quantity zone = "Cross pol", "Pos. seq. volt.", "Self pol")*

The directional lines are polarized with the set polarizing quantity of all impedance measuring elements. In addition, the memory voltage that is based on positive-sequence voltage substitute for the measured voltage with any impedance measurement element polarization if the corresponding voltage drops too low.

DSTPDIS has separate and independent measurement elements for each fault loop in the distance protection zone. In addition to the full scheme design, the separate measuring elements are used for general fault detection and faulted phase selection.

DSTPDIS supports both fault detection dependent control of zone timers and zone-dedicated phasewise timer control for maximum application flexibility.

The impedance measurement is always done the same way regardless of the zone shape. The operation is based on the impedance mapping approach where the fault loop impedance is first calculated and then compared to the zone boundaries. If impedance is recognized within the operation zone, the corresponding operate output is activated after the operate time has elapsed.

The impedance measurement is based on full-cycle DFT filtered current and voltage phasors.

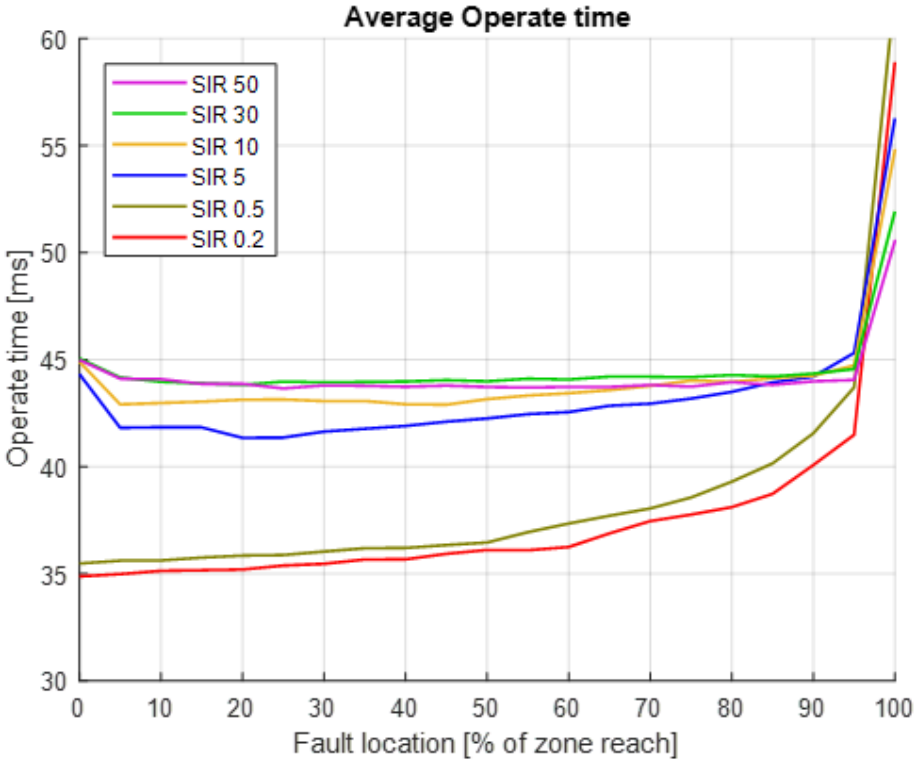



*Figure 524: Average operate time of DSTPDIS according to IEC 60255-121 network models Short line and Long line (50 Hz)*

SIR curves are plotted from the data which includes variation of fault location (0…100% of zone reach, 5% step), fault type (LN, LL, LLN, LLL) and fault inception angle (0, 30, 60, 90 degrees). Each combination has been repeated ten times giving the total number of 26880 shots. The operate times include the delay of relay output contacts. The SIR curves presented in *Figure 524* were obtained using the static power outputs (SPOs) and with *Zone timer mode* = "common".

### 4.7.1.4 Analog channel configuration

DSTPDIS has five analog group inputs which must be properly configured.

**Table 904: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| I3P_PAR [1] | Three-phase currents<br>Necessary when *Par line Comp zone x* is set to True |
| I3P_REF [2] | Three-phase currents |

*Table continues on the next page*

[1] Can be connected to GRPOFF if *Par line Comp zone x* is set to False.
[2] Can be connected to GRPOFF if *EF detection Mod GFC* is not set to "Io AND IoRef"

| Input | Description |
|---|---|
| | Necessary when *EF detection Mod GFC* is set to "Io AND IoRef" |
| U3P | Three-phase voltages |
| URES [3] | Residual voltage (measured)<br>Necessary when *EF detection Mod GFC* is set to "Io OR Uo" or "Io AND Uo". Necessary also if only main voltages are available but *Phase voltage Meas* is set to "Accurate". |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

**Table 905: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.7.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The function consists of sub-functions which are described in the next sections.

[3] Can be connected to GRPOFF if *EF detection Mod GFC* is set to "Io" or "Io AND IoRef" or *Phase voltage Meas* is set to "Ph-to-ph without Uo"

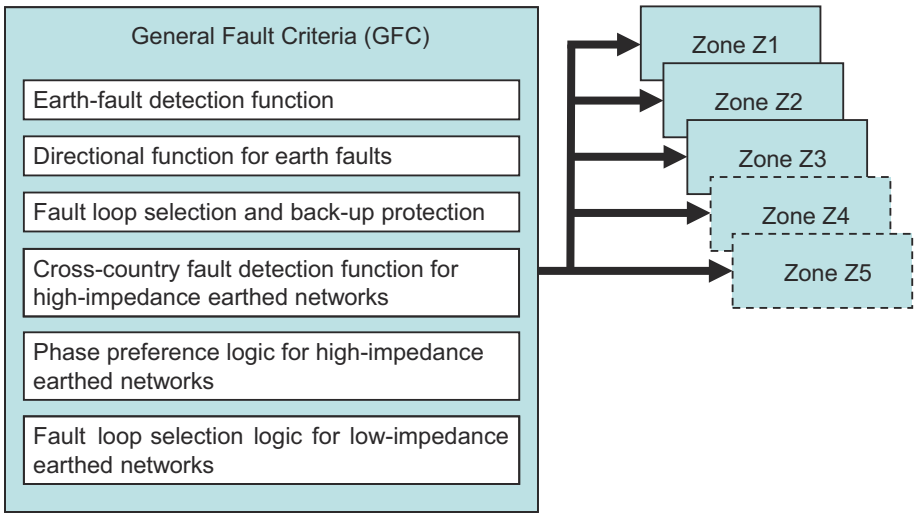



*Figure 525: Main functionality of DSTPDIS*

All outputs and the operation of all sub-functions can be blocked with the BLOCK binary input signal. In addition, it resets the timers.

### Blocking

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE_Z1...5 output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE_Z1...5 output is not activated.

In addition, the function has zone-specific blocking signals BLOCK_Z1...5. The signal resets zone timers disabling the corresponding start and operate output activation.

BLOCK_GFC deactivates START_GFC and OPERATE_GFC. It also resets GFC operate time (set by *Operate delay GFC*). Blocking does not prevent GFC operation.

### Earth-fault detection function

The recognition of an earth fault is an important part in identifying the correct fault type. This information is used in faulted loop (phase) selection to release the correct impedance-measuring elements. The earth-fault recognition is always required to release the phase-to-earth impedance-measuring elements.

The earth-fault detection is indicated with the EARTH_FLT monitored data. The earth-fault detection criterion can be defined with the *EF detection Mod GFC* setting. The fundamental criterion is based on the residual current. The residual voltage and reference neutral current, measured from the transformer neutral point, can be used for the earth-fault detection criteria.

**Table 906: Selection of earth-fault detection criteria**

| Setting | Enumerator name |
|---|---|
| EF detection Mod GFC | • Io<br>• Io OR Uo<br>• Io AND Uo<br>• Io AND IoRef |

If the residual current Io is derived from the phase currents either by the summation connection of CTs, that is, the Holmgreen connection, or by internally summing the phase currents, there is a risk of a false earth-fault detection due to apparent residual current from the current transformer errors. This risk can be eliminated using a stabilized residual current measurement. The stabilization is enabled by setting the *EF Cur stabilization* setting to "True". The stabilization increases the residual current *Gnd Op current GFC* threshold setting when the maximum phase current exceeds the nominal current. The increase is defined with the *Stab slope 1 GFC* setting. The apparent residual current may exist during short circuits and in inrush current situations if the CTs saturate partially. The earth-fault detection function takes the CT saturation into account with additional stabilization settings *Gnd Op current 2 GFC, A Ph Stab value GFC* and *Stab slope 2 GFC*.

Setting *EF Cur stabilization* to "False" disables the stabilization of the residual current measurement and should be used only when the residual current is measured with a cable current transformer. The residual current threshold setting for earth-fault detection is *Gnd Op current GFC*. If the residual current is measured from a transformer neural point, *Gnd Op A Ref GFC* is used. This is valid when the setting *EF detection Mod GFC* is "Io AND IoRef".

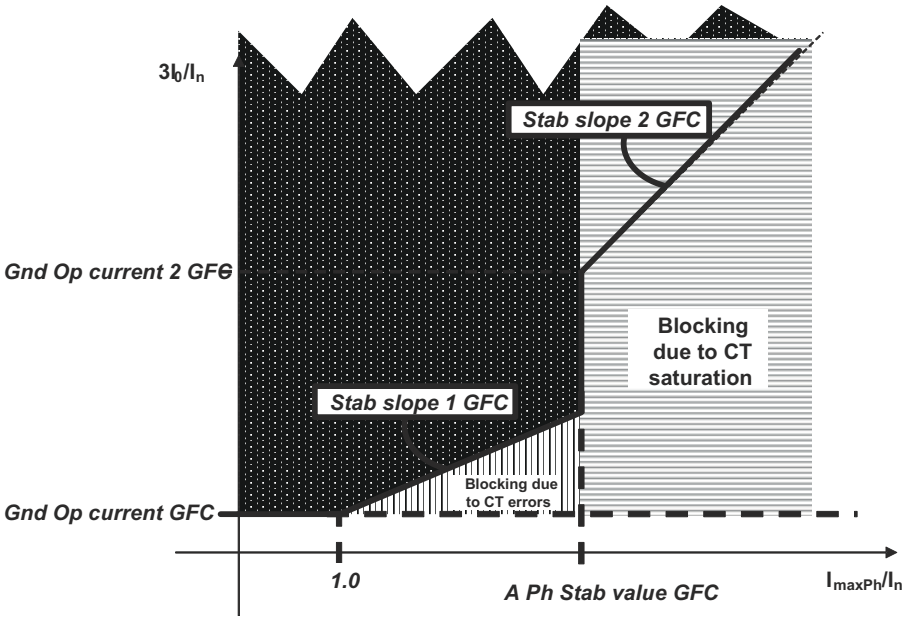



*Figure 526: Stabilized residual current measurement for earth-fault detection*

The residual voltage can also be used as a complementary criterion for earth-fault detection. This is valid when the setting *EF detection Mod GFC* is "Io OR Uo" or *EF detection Mod GFC* is "Io AND Uo". The threshold setting for the residual voltage is *Gnd Str voltage GFC*.

**Directional function for earth faults**

In low-impedance earthed networks, when the *System grounding GFC* setting is set to "Low impedance", the earth-fault detection function can be optionally supervised by a directional function which can be enabled with the *Dir mode EF GFC* setting. If *Dir mode EF GFC* is set to "Forward" or "Reverse", the earth-fault direction is also detected. The calculated direction for the earth fault is indicated in the DIR_E_FLT monitored data ("unknown", "forward", "backward" (reverse), "both"). Direction criteria do not directly affect earth-fault detection, but the earth-fault direction information is used for zone starting, when only those directional zones that are set to the indicated earth-fault direction can be started.

The operation characteristic of the directional function is defined by three settings: *Chr angle GFC*, *Min phase angle GFC* and *Max phase angle GFC*.

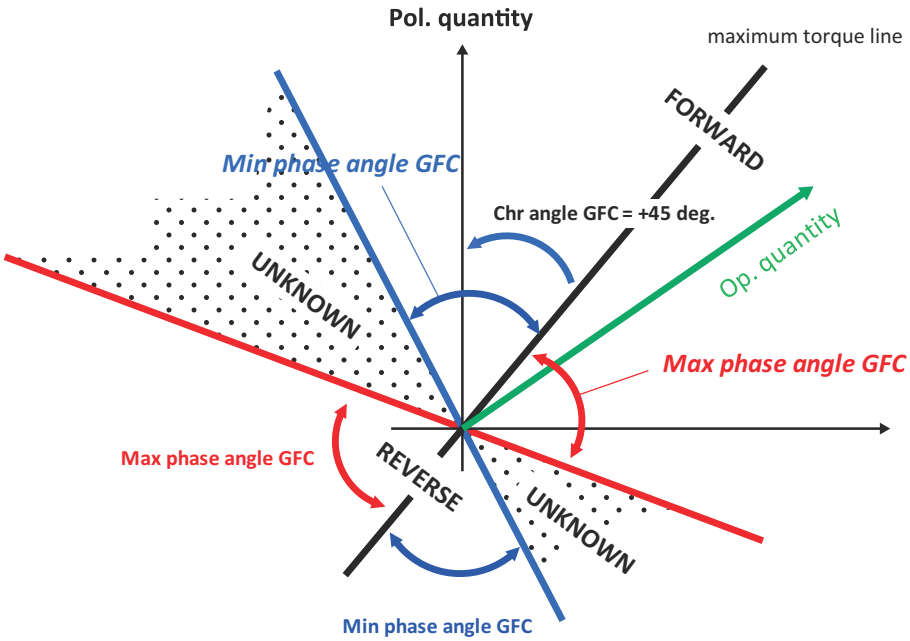



*Figure 527: Characteristic of the directional function for earth faults*

The *Chr angle GFC* setting, also known as relay characteristic angle or basic angle, is used to turn the directional characteristic. It has a positive value when the operating quantity lags the polarizing quantity and a negative value when the operating quantity leads the polarizing quantity. For low-impedance earthed networks, *Chr angle GFC* equals the angle of the fault loop impedance and is typically positive.

The *Min phase angle GFC* and *Max phase angle GFC* settings define the width of the operating sector. These settings are mirror-symmetric to the origin for reverse (backward).

The directional function for earth faults must operate at fault current values below the magnitude of the load currents. The use of sequence quantities is preferred for polarizing quantity as phase quantities are affected by the load currents. Four possibilities are available and defined by the *Pol quantity GFC* setting.

**Table 907: Polarizing quantities for optional directional function for earth faults in low-impedance earthed networks**

| Pol quantity GFC | Polarizing quantity | Operating quantity | Description |
|---|---|---|---|
| Zero seq. volt. | $-U_0$ | $I_0$ | Zero-sequence voltage polarization |
| Neg. seq. volt. | $-U_2$ | $I_2$ | Negative-sequence voltage polarization |
| Zero seq. cur. | $I_{oref}$ | $I_0$ | Zero-sequence current polarization |
| Zro vol. OR cur. | $-U_0$ OR $I_{0ref}$ | $I_0$ | Dual polarization |

The polarizing quantity is $-U_0$ and the operating quantity is $I_0$ in case of zero-sequence voltage polarization.

The polarizing quantity is $-U_2$ and the operating quantity is $I_2$ in case of negative-sequence polarization.

In case of zero-sequence current polarization "Zero seq. cur.", the zero-sequence current $I_0$ of the protected line is the operating quantity while another reference zero-sequence current $I_{0ref}$ is the polarizing quantity. $I_{0ref}$, for example, could be the current from the neutral of a power transformer. In case of zero-sequence current polarization, the relay characteristic angle *Chr angle GFC* is internally fixed and is equal to zero degrees. The zero-sequence current direction must remain unchanged during all network configurations and faults. Therefore, all transformer configurations or constructions are not suitable for polarization.

In case of dual polarization "Zro vol. OR cur.", the zero-sequence voltage polarization and zero-sequence current polarization elements are logically OR:ed. Typically, when $I_0$ is high, $U_0$ is low, and when $I_0$ is low, $U_0$ is high. Hence the protection can benefit from both elements as the two polarization methods complement each other. If the zero-sequence current polarization source is switched off for service, the flexibility is increased as the zero-sequence voltage polarization can be used.

### Faulted loop phase selection

A reliable identification of a fault and faulted phases is needed to guarantee a selective operation of the distance protection. This information is used to release correct measuring elements of the protection zones.

In DSTPDIS, the faulted phase selection can be done in various ways and defined with the *Phase Sel mode GFC* setting.

**Table 908: Supported methods for phase selection**

| Setting | Enumerator value |
|---|---|
| Phase Sel mode GFC | • Overcurrent<br>• Vol Dep Overcur<br>• Under impedance<br>• OC AND Und impedance |

- The “Overcurrent” method is the basic method for identifying the faulted phases. It can be used in applications where the fault current magnitude exceeds the load current despite the changes in the network configuration and fault type.

- The “Vol Dep Overcur” method combines overcurrent and undervoltage conditions. An undervoltage condition allows lower current threshold settings and increases the sensitivity of the fault detection.
- The “Under impedance” method uses fault loop impedance for identifying the faulted phases. The underimpedance characteristic can be either quadrilateral or circular in shape. The sensitivity of the fault detection is defined by an independent setting in resistive and reactive reaches. The underimpedance method is supervised by a load encroachment logic which ensures that the load impedance does not interfere with the faulted phase selection.

The ”OC AND Und impedance” method combines “Overcurrent” and “Under impedance” methods so that both criteria have to be fulfilled.

All phase selection methods require that all three phase currents are measured and all three phase-to-earth voltages are available. If only phase-to-phase voltages are available (*Phase voltage Meas* = “Ph-to-ph without Uo”), only phase-to-phase measuring loops can be released for measurement. The release of phase-to-earth fault measuring elements is then blocked, RELEASE_PE = “No fault”.

The operation of the faulted phase selection function is highly dependent on the earth-fault detection function. The phase preference or faulted loop selection logic can be set to filter the faulted phases to be released for measurement in the protection zones.

The general indication of a fault is given in the binary output START_GFC. The faulted phase information can be found from the integer monitored data signal STARTS_GFC.

**Table 909: Enumeration values for integer monitored data signal STARTS_GFC**

| Enumeration name | Value |
|---|---|
| No fault | -5 |
| AG Fault | 1 |
| BG Fault | 2 |
| CG Fault | 3 |
| AB Fault | 4 |
| BC Fault | 5 |
| CA Fault | 6 |
| ABC Fault | 7 |

The fault loops released for measurement are indicated with the integer monitored data signals RELEASE_PE and RELEASE_PP. These signals may be filtered by the phase preference of the faulted loop selection logic.

**Table 910: Enumeration values for integer monitored data signal RELEASE_PE**

| Enumeration name | Value |
|---|---|
| No fault | -5 |
| AG Fault | 1 |
| BG Fault | 2 |
| CG Fault | 3 |
| AB Fault | 4 |

*Table continues on the next page*

| Enumeration name | Value |
|---|---|
| BC Fault | 5 |
| CA Fault | 6 |
| ABC Fault | 7 |

**Table 911: Enumeration values for integer monitored data signal RELEASE_PP**

| Enumeration name | Value |
|---|---|
| No fault | -5 |
| AB Fault | 4 |
| BC Fault | 5 |
| CA Fault | 6 |
| ABC Fault | 7 |

The phase selection function can be set to issue an operate signal as the faulted phase selection uses independent measuring elements from the distance protection zones. This can be applied as a back-up protection for the measurement zones. The time delay of the operate signals is defined with the *Operate delay GFC* setting. The operate signal is the binary output `OPERATE_GFC`.

*Faulted loop phase selection by the overcurrent method*

The "Overcurrent" method is the basic method used for identifying the faulted phases. It can be used in applications where the fault current magnitude exceeds the load current despite the possible changes in the network configuration and fault type.

In the overcurrent-based faulted phase selection method, the amplitude of each phase current is compared to the *Str A Ph Sel GFC* threshold setting. If the phase current magnitude exceeds the value of *Str A Ph Sel GFC*, that particular phase is faulty.

Earth-fault recognition is always required to release a phase-to-earth impedance-measuring element.

**Table 912: Conversion from element start to monitored data signals**

| Start of element | START_GFC | STARTS_GFC | RELEASE_PE | RELEASE_PP |
|---|---|---|---|---|
| $I_A$> & `EARTH_FLT` | TRUE | AG Fault | AG Fault | No fault |
| $I_B$> & `EARTH_FLT` | TRUE | BG Fault | BG Fault | No fault |
| $I_C$> & `EARTH_FLT` | TRUE | CG Fault | CG Fault | No fault |
| $I_A$> & $I_B$> | TRUE | AB Fault | No fault | AB Fault |

*Table continues on the next page*

| Start of element | START_GFC | STARTS_GFC | RELEASE_PE | RELEASE_PP |
|---|---|---|---|---|
| $I_B$> & $I_C$> | TRUE | BC Fault | No fault | BC Fault |
| $I_C$> & $I_A$> | TRUE | CA Fault | No fault | CA Fault |
| $I_A$> & $I_B$> & EARTH_FLT | TRUE | AB Fault | AB Fault | AB Fault |
| $I_B$> & $I_C$> & EARTH_FLT | TRUE | BC Fault | BC Fault | BC Fault |
| $I_C$> & $I_A$> & EARTH_FLT | TRUE | CA Fault | CA Fault | CA Fault |
| $I_A$> & $I_B$> & $I_C$[4] | TRUE | ABC Fault | No fault | ABC Fault |
| $I_A$> & $I_B$> & $I_C$> & EARTH_FLT [5] | TRUE | ABC Fault | ABC Fault | ABC Fault |

In case of a high-impedance earthed network, a phase preference logic can be added to complement the phase selection in case of a cross-country fault. This can affect the RELEASE_PE signals.

In case of a low-impedance earthed network, a faulted loop selection logic can be added to complement the phase selection in case of a two-phase-to-earth fault. This can affect the RELEASE_PE and RELEASE_PP signals.

*Faulted phase selection, the voltage-dependent overcurrent method*

The "Voltdep overcur" method combines the overcurrent and undervoltage conditions. The phase current amplitude is compared to the *Str A Ph Sel GFC* threshold setting but a lower current *Lo A Ph Sel GFC* threshold is valid during an undervoltage condition. This increases the sensitivity of the fault detection. The amplitude of phase-to-earth and phase-to-phase voltages is compared to the *Ph V Ph Sel GFC* and *PP V Ph Sel GFC* settings. In case of a three-phase fault, the phase-to-phase voltages are monitored and compared to the *PP V Ph Sel GFC* setting.

Earth-fault recognition is always required to release a phase-to-earth impedance-measuring element.

[4] This applies to near three-phase faults. If voltages are still relatively high, all PP releases are given.

[5] This applies to near three-phase faults with EF indication. If voltages are still relatively high, all PE and PP releases (except ABC Fault) are given.

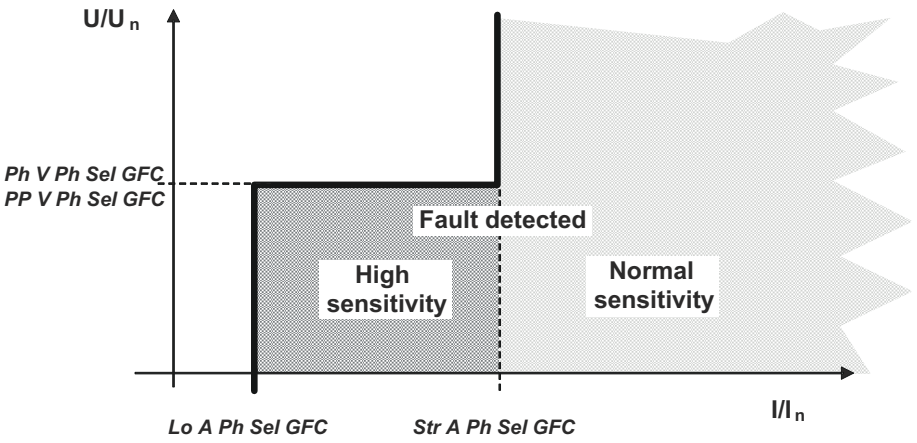



*Figure 528: Overcurrent/undervoltage characteristics*

**Table 913: Conversion from element start to monitored data signals**

| Start of element | START_GFC | STARTS_GFC | RELEASE_PE | RELEASE_PP |
|---|---|---|---|---|
| $I_A$> & $U_A$< & EARTH_FLT \| $I_A$>> & EARTH_FLT | TRUE | AG Fault | AG Fault | No fault |
| $I_B$> & $U_B$< & EARTH_FLT \| $I_B$>> & EARTH_FLT | TRUE | BG Fault | BG Fault | No fault |
| $I_C$> & $U_C$< & EARTH_FLT \| $I_C$>>& EARTH_FLT | TRUE | CG Fault | CG Fault | No fault |
| $I_A$> & $I_B$> & $U_{AB}$< \| $I_A$>> & $I_B$>> | TRUE | AB Fault | No fault | AB Fault |
| $I_B$> & $I_C$> & $U_{BC}$< \| $I_B$>> & $I_C$>> | TRUE | BC Fault | No fault | BC Fault |
| $I_C$> & $I_A$> & $U_{CA}$< \| $I_C$>> & $I_A$>> | TRUE | CA Fault | No fault | CA Fault |
| $I_A$> & $I_B$> & $U_{AB}$< & EARTH_FLT \| $I_A$>> & $I_B$>> & EARTH_FLT | TRUE | AB Fault | AB Fault | AB Fault |
| $I_B$> & $I_C$> & $U_{BC}$< & EARTH_FLT \| | TRUE | BC Fault | BC Fault | BC Fault |

*Table continues on the next page*

| Start of element | START_GFC | STARTS_GFC | RELEASE_PE | RELEASE_PP |
|---|---|---|---|---|
| $I_B$>> & $I_C$>> & EARTH_FLT | | | | |
| $I_C$> & $I_A$> & $U_{CA}$< & EARTH_FLT \| $I_C$>> & $I_A$>> & EARTH_FLT | TRUE | CA Fault | CA Fault | CA Fault |
| $I_A$> & $I_B$> & $I_C$ & $U_{AB}$< & $U_{BC}$< $U_{CA}$< \| $I_A$>> , $I_B$>> & $I_C$ >> [6] | TRUE | ABC Fault | No fault | ABC Fault |
| $I_A$> & $I_B$> & $I_C$& $U_{AB}$< & $U_{BC}$< $U_{CA}$ < & EARTH_FLT \| $I_A$>>, $I_B$>> & $I_C$ >> & EARTH_FLT [7] | TRUE | ABC Fault | No fault | ABC Fault |

| | |
|---|---|
| $I_x$> | Phase current exceeds the *Lo A Ph Sel GFC* setting |
| $I_x$>> | Phase current exceeds the *Str A Ph Sel GFC* setting |
| $U_x$< | Phase voltage undershoots the *Ph V Ph Sel GFC* setting |
| $U_{xy}$< | Phase-to-phase voltage undershoots the *PP V Ph Sel GFC* setting |

*Faulted phase selection, the underimpedance method*

The "Under impedance" and "OC AND Und impedance" methods use fault loop impedance for identifying the faulted phases. The advantage of the underimpedance criterion is that the sensitivity of the fault detection is independent of the source impedance. The underimpedance function has six impedance measuring elements. The phase-to-earth measuring elements are calculated:

$$\underline{Z}_A = \frac{\underline{U}_A}{\underline{I}_A}$$

(Equation 261)

[6] This applies to near three-phase faults. If voltages are still relatively high, all PP releases are given.

[7] This applies to near three-phase faults with EF indication. If voltages are still relatively high, all PE and PP releases (except ABC Fault) are given.

$$\underline{Z}_B = \frac{\underline{U}_B}{\underline{I}_B}$$

(Equation 262)

$$\underline{Z}_C = \frac{\underline{U}_C}{\underline{I}_C}$$

(Equation 263)

The phase-to-phase measuring elements are based on the formula:

$$\underline{Z}_{AB} = \frac{\underline{U}_{AB}}{\underline{I}_{AB}}$$

(Equation 264)

$$\underline{Z}_{BC} = \frac{\underline{U}_{BC}}{\underline{I}_{BC}}$$

(Equation 265)

$$\underline{Z}_{CA} = \frac{\underline{U}_{CA}}{\underline{I}_{CA}}$$

(Equation 266)

The faulted phase identification is done by comparing the measured impedance to the operating characteristics in the impedance domain. If a measured fault loop impedance is inside the characteristics, the corresponding phases are identified as faulty.

The shape of the characteristic is selected with the *Z Chr Mod Ph Sel GFC* setting. Two shapes are available.

- "Mho (circular)", Non-directional mho
- "Quadrilateral", Non-directional quadrilateral

The two shapes can be flexibly configured. It is possible to set the reactive reaches independently in forward and in reverse direction and for phase-to-earth (Gnd) and phase-to-phase (PP) measurement elements, for example, the *X Gnd Fwd reach GFC*, *X Gnd Rv reach GFC*, *X PP Fwd reach GFC* and *X PP Rv reach GFC* settings. Also, the resistive reach in case of quadrilateral characteristic can be set both forward and reverse independently of reactive reaches, for example, the *Ris Gnd Fwd Rch GFC, Ris Gnd Rv Rch GFC, Ris PP Fwd Rch GFC* and *Ris PP Rv Rch GFC* settings. The characteristic is always mirror-symmetric around the reactance axis.

The impedance settings are in primary ohms.

In case of heavy loaded feeders, the optional load encroachment logic can be enabled with the *Load Dsr mode GFC* setting. The logic reserves an area for load

impedance defined by the *Ris Fwd Rch Lod GFC, Ris Rv Rch Lod GFC* and *Angle load area GFC* settings.

The underimpedance characteristics in case of phase-to-earth measuring elements are illustrated in *Figure 529* and *Figure 530*. Similar characteristics apply also to phase-to-phase measuring elements with independent settings.

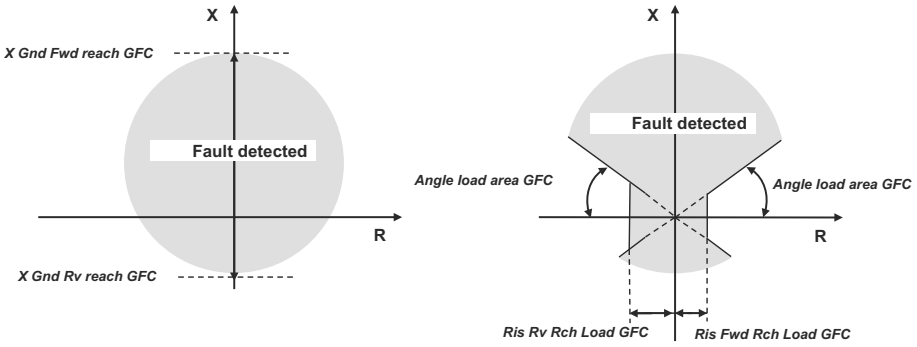



*Figure 529: Circular mho underimpedance characteristics*

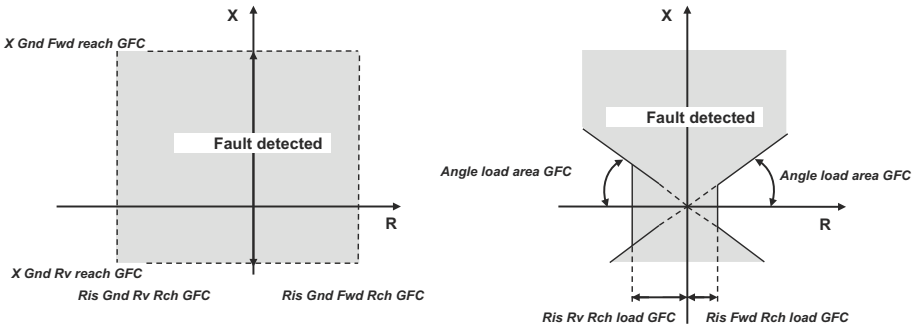



*Figure 530: Quadrilateral underimpedance characteristics*

**Table 914: Conversion from element start to monitored data signals**

| Start of element | START_GFC | STARTS_GFC | RELEASE_PE | RELEASE_PP |
|---|---|---|---|---|
| $Z_A$< & EARTH_FLT | TRUE | AG Fault | AG Fault | No fault |
| $Z_B$< & EARTH_FLT | TRUE | BG Fault | BG Fault | No fault |
| $Z_C$< & EARTH_FLT | TRUE | CG Fault | CG Fault | No fault |
| $Z_{AB}$< | TRUE | AB Fault | No fault | AB Fault |
| $Z_{BC}$< | TRUE | BC Fault | No fault | BC Fault |
| $Z_{CA}$< | TRUE | CA Fault | No fault | CA Fault |

*Table continues on the next page*

| Start of element | START_GFC | STARTS_GFC | RELEASE_PE | RELEASE_PP |
|---|---|---|---|---|
| $Z_{AB}$< & EARTH_FLT | TRUE | AB Fault | AB Fault | AB Fault |
| $Z_{BC}$< & EARTH_FLT | TRUE | BC Fault | BC Fault | BC Fault |
| $Z_{CA}$< & EARTH_FLT | TRUE | CA Fault | CA Fault | CA Fault |
| $Z_{AB}$< & $Z_{BC}$< & $Z_{CA}$<[8] | TRUE | ABC Fault | No fault | ABC Fault |
| $Z_{AB}$< & $Z_{BC}$< & $Z_{CA}$<& EARTH_FLT [9] | TRUE | ABC Fault | No fault | ABC Fault |

In case of a high-impedance earthed network, a phase preference logic can be added to complement the phase selection in case of a cross-country fault. This can affect the RELEASE_PE signals.

In case of a low-impedance earthed network, a faulted loop selection logic can be added to complement the phase selection in case of a two-phase-to-earth fault. This can affect the RELEASE_PE and RELEASE_PP monitored data signals.

**Cross-country fault detection function for high-impedance earthed networks**

In isolated and high-impedance earthed networks, the overvoltages produced by a single-phase earth fault may lead to a cross-country fault, where two simultaneous single-phase earth faults are present in the system but in different locations and phases. The cross-country fault is hazardous because the magnitude of the fault current through earth can be as high as in the case of a two-phase short circuit fault. The protection must therefore remove the cross-country fault quickly without sacrificing the selectivity. This can be done with a phase preference logic which is activated by the cross-country fault detection function. The phase preference logic transforms the fault into an ordinary single-phase earth fault by selectively tripping one of the faulted feeders.

The cross-country detecting function can become active only if the network is either isolated or high-impedance earthed (*System grounding GFC* = "High impedance" or selection "From input" and binary input SYS_EARTHING is active).

The fault detection is based on monitoring two quantities.

- Residual current
- Phase-to-phase voltages

A cross-country fault is detected if:

- An earth fault is detected, EARTH_FLT = TRUE.

AND

[8] This applies to near three-phase faults. If voltages are still relatively high, all PP releases are given, depending on the impedances seen inside the GFC zone.

[9] This applies to near three-phase faults with EF indication. If voltages are still relatively high, all or some PE and PP releases (except ABC Fault) are given, depending on the impedances seen inside the GFC zone.

- The calculated residual current exceeds the value of *Gnd Op A XC GFC* setting. This setting value should exceed the highest expected single-phase earth-fault current (calculated from phase currents). The condition is needed because the cable current transformer saturates easily due to the high fault current.

AND

- The residual overcurrent condition must be valid at least for the duration defined by the *Cross-country DI GFC* setting. This shows that the detection is not misled by the high-magnitude initial transients of a single-phase earth fault.

OR

- Any phase-to-phase voltage drops below the value of the *PP voltage XC GFC* setting. The undervoltage condition is based on the fact that during a single-phase earth fault, the phase-to-phase voltages are unaffected in isolated and high-impedance earthed networks. The fulfilment of this criterion in combination with the residual overcurrent condition avoids the need for any delays.

The detection of a cross-country fault is indicated by the `XC_FLT` output signal.

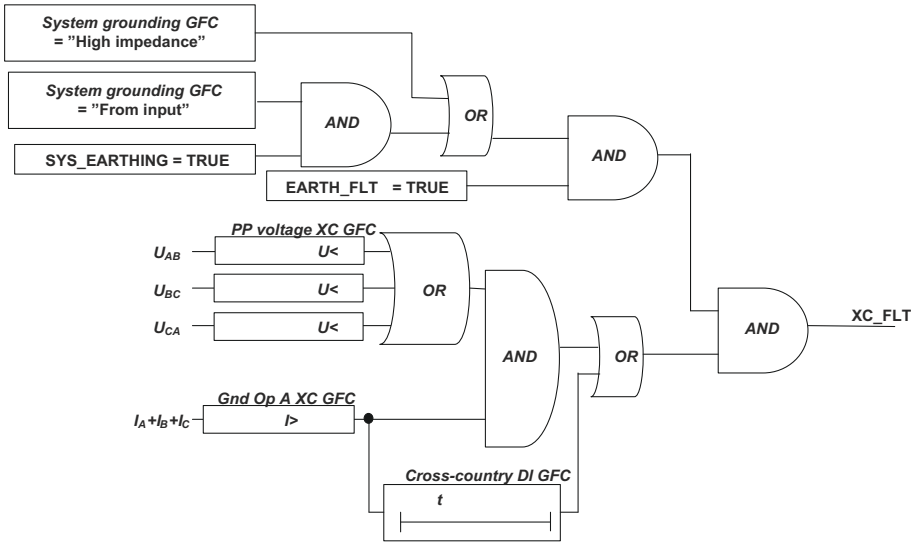



*Figure 531: Cross-country fault detection logic for high-impedance earthed networks*

**Phase preference logic for high-impedance earthed networks**

The phase preference logic is applicable only in isolated and high-impedance earthed networks. The phase preference logic for high-impedance earthed networks is a supplement to the faulted phase identification function. It provides selective filtering of phase-to-earth measurement elements in case of a cross-country fault or double earth-fault in isolated and high-impedance earthed networks.

The logic releases the preferred phase-to-earth loop for measurement when a cross-country fault with two faulted phase-to-earth loops is detected. If only one faulted phase-to-earth loop is detected by phase selection logic (GFC), the other faulted phase-to-earth loop is determined by analysing voltages. The phase preference scheme must be set in the same way for the entire system so that all distance relays measure the same preferred phase-to-earth loop. As a result, the cross-country fault is changed into an ordinary single-phase earth-fault by selectively tripping one of the faulted feeders.

The phase preference logic influences only the selection of the phase-earth loops and has no effect on the selection of the phase-to-phase loops. The influence is seen in the RELEASE_PE monitored data. The logic does not affect the RELEASE_PP monitored data or START_GFC/STARTS_GFC outputs.

All schemes, except "No filter", require a cross-country fault detection XC_FLT = TRUE; otherwise all the phase-to-earth measuring elements are blocked resulting in RELEASE_PE value "No fault". This guarantees that tripping at a single-phase earth fault in the high-impedance earthed network is blocked.

If a cross-country fault is detected, XC_FLT = TRUE and only a single fault loop can be identified as faulty by the faulted phase selection function, then that loop is directly selected for measurement. In such a case, simultaneous tripping of both faulted feeders during a cross-country fault is expected.

**Example**

Consider a cross-country fault where phases A and B become faulted simultaneously. All relays, R1, R2, R3 and R4, are equipped with an "Acyc C-A-B" phase preference scheme.

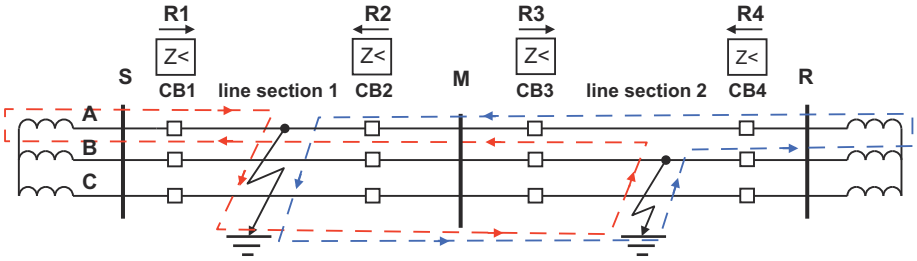



*Figure 532: Cross-country fault (or double earth fault) in a high-impedance earthed system*

The expected operations of the relays are:

- R1: The cross-country fault cannot be detected as the residual current does not flow through relay R1. The phase-to-phase loop AB is measured in the forward direction but the estimated impedance represents an average impedance between two fault locations and therefore is not seen in zone Z1.
- R2: The cross-country fault is detected as a high residual current flows through relay R2. Phase A earth fault is seen in forward direction and phase B earth fault in reverse direction. Based on "Acyc C-A-B" phase preference scheme, phase A is selected for measurement. Relay R2 operates without delay and opens the CB2 circuit breaker.
- R3: The cross-country fault is detected when a high residual current flows through relay R3. The phase A earth fault is seen in reverse direction and phase B earth fault in forward direction. Based on the "Acyc C-A-B" phase preference scheme, phase A is selected for measurement. As the fault direction does not coincide with the zone direction, relay R3 does not operate.
- R4: Same as relay R1

As a result of the circuit breaker CB2 operation, the cross-country fault is transformed into an ordinary single-phase earth fault.

*Table 915*, *Table 916* and *Table 917* summarize the available phase preference logic schemes and their operation in different fault scenarios. The logic is selected with the *Ph Prf mode Hi Z GFC* setting. In case the logic is not required, then the "No filter" option should be selected.



"No filter" option does not block the single-phase earth-faults, therefore this option should be used with caution.

**Table 915: Supported phase preference logic schemes for high-impedance earthed networks and their operation in case of single phase start with and without cross-country fault detection**

| Ph Prf mode Hi Z GFC | | Faulted loops | | | | | |
|---|---|---|---|---|---|---|---|
| | | A & EARTH_FLT | B & EARTH_FLT | C & EARTH_FLT | A & XC_FLT | B & XC_FLT | C & XC_FLT |
| | | RELEASE_PE | | | RELEASE_PP | | |
| 1 | No filter | AG Fault | BG Fault | CG Fault | AG Fault | BG Fault | CG Fault |
| 2 | No preference | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 3 | Cyc A-B-C-A | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 4 | Cyc A-C-B-A | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 5 | Acyc A-B-C | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 6 | Acyc A-C-B | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 7 | Acyc B-A-C | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 8 | Acyc B-C-A | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 9 | Acyc C-A-B | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |
| 10 | Acyc C-B-A | No fault | No fault | No fault | AG Fault | BG Fault | CG Fault |

**Table 916: Supported phase preference logic schemes for high-impedance earthed networks and their operation in case of two phase starts without cross-country fault detection**

| Ph Prf mode Hi Z GFC | | Faulted loops | | | | | |
|---|---|---|---|---|---|---|---|
| | | A & B EARTH_FLT | B & C EARTH_FLT | C & A EARTH_FLT | A & B EARTH_FLT | B & C EARTH_FLT | C & A EARTH_FLT |
| | | RELEASE_PE | | | RELEASE_PP | | |
| 1 | No filter | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 2 | No preference | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 3 | Cyc A-B-C-A | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 4 | Cyc A-C-B-A | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 5 | Acyc A-B-C | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 6 | Acyc A-C-B | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 7 | Acyc B-A-C | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 8 | Acyc B-C-A | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 9 | Acyc C-A-B | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |
| 10 | Acyc C-B-A | No fault | No fault | No fault | AB Fault | BC Fault | CA Fault |

**Table 917: Supported phase preference logic schemes for high-impedance earthed networks and their operation in case of two phase starts with cross-country fault detection**

| Ph Pref logic Hi Imp | | Faulted loops | | | | | |
|---|---|---|---|---|---|---|---|
| | | A & B XC_FLT | B & C XC_FLT | C & A XC_FLT | A & B XC_FLT | B & C XC_FLT | C & A XC_FLT |
| | | RELEASE_PE | | | RELEASE_PP | | |
| 1 | No filter | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 2 | No preference | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 3 | Cyc A-B-C-A | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 4 | Cyc A-C-B-A | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 5 | Acyc A-B-C | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 6 | Acyc A-C-B | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 7 | Acyc B-A-C | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |

*Table continues on the next page*

| Ph Pref logic Hi Imp | | Faulted loops | | | | | |
|---|---|---|---|---|---|---|---|
| | | A & B XC_FLT | B & C XC_FLT | C & A XC_FLT | A & B XC_FLT | B & C XC_FLT | C & A XC_FLT |
| | | RELEASE_PE | | | RELEASE_PP | | |
| 8 | Acyc B-C-A | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 9 | Acyc C-A-B | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |
| 10 | Acyc C-B-A | AB Fault | BC Fault | CA Fault | AB Fault | BC Fault | CA Fault |

### Faulted loop phase selection for low-impedance earthed networks

The faulted loop selection logic for low-impedance earthed networks serves as a supplement to the faulted phase identification function and it provides a selective filtering of measurement elements in case of a two-phase-to-earth fault in low-impedance earthed networks. The earth faults can be located close to each other.

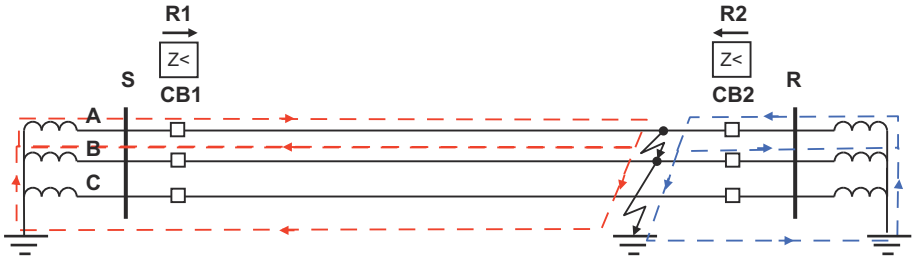



*Figure 533: Two-phase-to-earth fault in low-impedance earthed system*

Impedance can be measured during a two-phase-to-earth fault when the earth faults are located in the same direction and they are in close proximity to each other. Generally, too large an impedance is measured for the lagging phase-to-earth loop, for example phase B in an AB-E fault. Similarly, low impedance is measured for the leading phase-to-earth loop, for example phase A in an AB-E fault. The corresponding phase-to-phase loop is measured correctly, for example phase-to-phase loop AB in an AB-E fault.

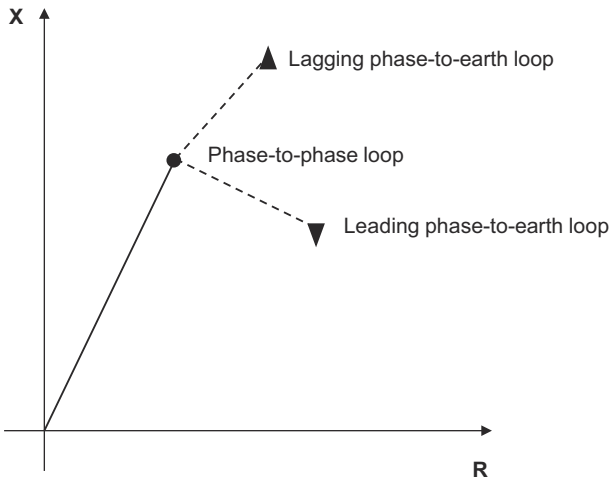



*Figure 534: Impedance measured during a two-phase-to-earth fault*

The available faulted loop selection logic schemes allow blocking the phase-earth loop of the leading phase to prevent overreaching *Ph Prf mode Lo Z GFC* = "BLK leading PE".

It is also possible to block the lagging phase-earth loop, *Ph Prf mode Lo Z GFC* = "BLK lagging PE". If only the phase-to-phase loop or phase-to-earth loops must be measured, settings *Ph Prf mode Lo Z GFC* = "PP only" or *Ph Prf mode Lo Z GFC* = "PE only" should be used, and if the logic is not required, "All loops" option should be selected.

The tables summarize the available faulted loop selection logic schemes and their operations. The logic is selected with the *Ph Prf mode Lo Z GFC* setting.

**Table 918: Supported faulted loop phase selection schemes for low-impedance earthed networks and their influence on the RELEASE_PE monitored data**

| | Ph Prf mode Lo Z GFC | | | | |
|---|---|---|---|---|---|
| **Element start** | **All loops** | **PE only** | **PP only** | **BLK leading PE** | **BLK lagging PE** |
| **RELEASE_PE** | | | | | |
| A & B & EARTH_FLT | AB Fault | AB Fault | No fault | BG Fault | AG Fault |
| B & C & EARTH_FLT | BC Fault | BC Fault | No fault | CG Fault | BG Fault |
| C & A & EARTH_FLT | CA Fault | CA Fault | No fault | AG Fault | CG Fault |

**Table 919: Supported faulted loop phase selection schemes for low-impedance earthed networks and their influence on the RELEASE_PP monitored data**

| | Ph Prf mode Lo Z GFC | | | | |
|---|---|---|---|---|---|
| **Element start** | **All loops** | **PE only** | **PP only** | **BLK leading PE** | **BLK lagging PE** |
| **RELEASE_PP** | | | | | |
| A & B & EARTH_FLT | AB Fault | No fault | AB Fault | AB Fault | AB Fault |
| B & C & EARTH_FLT | BC Fault | No fault | BC Fault | BC Fault | BC Fault |
| C & A & EARTH_FLT | CA Fault | No fault | CA Fault | CA Fault | CA Fault |

**Impedance protection zones**

DSTPDIS has five flexible and configurable impedance zones Z1..Z5. The number of active zones has to be selected by setting *Select active zones*. For example, all five zones can be set active by selection "All 5 zones" and only zone 1 is activated by "Zone 1". The purpose of this setting is effectively dimming non-active zone settings in PCM600 or the protection relay's HMI.

**Example**

If only zones 1 and 3 should be activated, "Zones 1-3" should be selected and then zone 2 timers can be disabled or `BLOCK_Z2` can be activated to hide zone 2 operations.

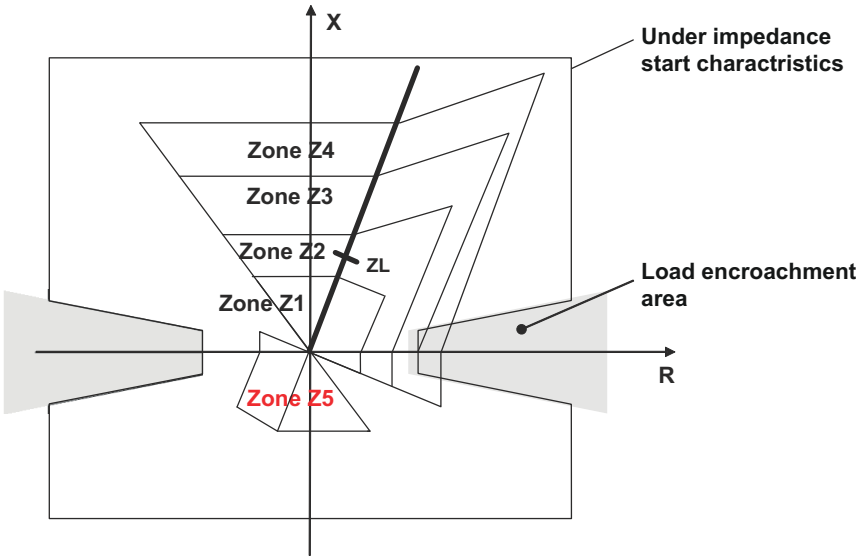



*Figure 535: Zones of DSTPDIS function (example 1)*

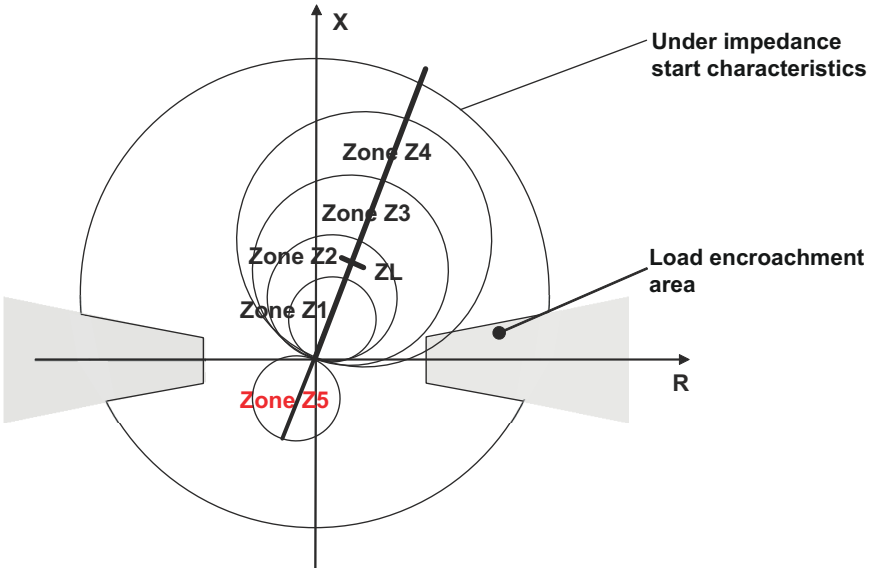



*Figure 536: Zones of DSTPDIS function (example 2)*

Each zone in DSTPDIS provides three independent phase-to-earth and three phase-to-phase measuring elements. A three-phase fault is measured with a dedicated measuring element. Each measuring element is controlled by the faulted loop phase selection function. Based on the recognized fault type, the release signals are given for the corresponding measuring elements.

DSTPDIS supports both fault detection dependent control of zone timers and zone-dedicated timer control for maximum application flexibility. Zone-dedicated timer control is enabled when configuration parameter *Zone timer mode* is set to "Independent" (change requires relay reboot). In this case, operate delay timers of protection zones are independent of each other and start when a fault is seen in their protection zone. Fault detection dependent control of zone timers is enabled when *Zone timer mode* is set to "Common". In this case, operate delay timers of all protection zones start simultaneously as soon as the fault is seen by the GFC.

The operation of a particular zone is given after the set operate delay time for the particular zone has elapsed (considering the fault type). The actual operate time is the value calculated from the initial fault detection and it is not affected, for example, in case the fault moves between zones.

The general indication of fault for each zone is given in the START_Zx (x = 1...5) binary output. The faulted phase information can be found from the STARTS_Zx (x = 1... 5) integer type output signal. This signal indicates (bitwise) the started measuring elements for the corresponding phase. Value 0 does not exist but due to the IEC 61850 standard requirement, it is shown by value “-5” as “No fault”. Value range is thus -5, 1..63. The three-phase fault is here indicated by “AB Fault, BC Fault, CA Fault”. However, three-phase fault indication for GFC depends also on the additional condition for voltage (see *Table 913*).

**Table 920: STARTS_Zx information**

| Value | Value information |
|---|---|
| -5 | No zone starts |
| 1 | AG Fault |
| 2 | BG Fault |
| 3 | AG Fault, BG Fault |
| 4 | CG Fault |
| 5 | AG Fault, CG Fault |
| 6 | BG Fault, CG Fault |
| 7 | AG Fault, BG Fault, CG Fault |
| 8 | AB Fault |
| 9 | AG Fault, AB Fault |
| 10 | BG Fault, AB Fault |
| 11 | AG Fault, BG Fault, AB Fault |
| 12 | CG Fault, AB Fault |
| 13 | AG Fault, CG Fault, AB Fault |
| 14 | BG Fault, CG Fault, AB Fault |
| 15 | AG Fault, BG Fault, CG Fault, AB Fault |
| 16 | BC Fault |
| 17 | AG Fault, BC Fault |
| 18 | BG Fault, BC Fault |
| 19 | AG Fault, BG Fault, BC Fault |
| 20 | CG Fault, BC Fault |
| 21 | AG Fault, CG Fault, BC Fault |
| 22 | BG Fault, CG Fault, BC Fault |
| 23 | AG Fault, BG Fault, CG Fault, BC Fault |
| 24 | AB Fault, BC Fault |
| 25 | AG Fault, AB Fault, BC Fault |
| 26 | BG Fault, AB Fault, BC Fault |
| 27 | AG Fault, BG Fault, AB Fault, BC Fault |
| 28 | CG Fault, AB Fault, BC Fault |

*Table continues on the next page*

| Value | Value information |
|---|---|
| 29 | AG Fault, CG Fault, AB Fault, BC Fault |
| 30 | BG Fault, CG Fault, AB Fault, BC Fault |
| 31 | AG Fault, BG Fault, CG Fault, AB Fault, BC Fault |
| 32 | CA Fault |
| 33 | AG Fault, CA Fault |
| 34 | BG Fault, CA Fault |
| 35 | AG Fault, BG Fault, CA Fault |
| 36 | CG Fault, CA Fault |
| 37 | AG Fault, CG Fault, CA Fault |
| 38 | BG Fault, CG Fault, CA Fault |
| 39 | AG Fault, BG Fault, CG Fault, CA Fault |
| 40 | AB Fault, CA Fault |
| 41 | AG Fault, AB Fault, CA Fault |
| 42 | BG Fault, AB Fault, CA Fault |
| 43 | AG Fault, BG Fault, AB Fault, CA Fault |
| 44 | CG Fault, AB Fault, CA Fault |
| 45 | AG Fault, CG Fault, AB Fault, CA Fault |
| 46 | BG Fault, CG Fault, AB Fault, CA Fault |
| 47 | AG Fault, BG Fault, CG Fault, AB Fault, CA Fault |
| 48 | BC Fault, CA Fault |
| 49 | AG Fault, BC Fault, CA Fault |
| 50 | BG Fault, BC Fault, CA Fault |
| 51 | AG Fault, BG Fault, BC Fault, CA Fault |
| 52 | CG Fault, BC Fault, CA Fault |
| 53 | AG Fault, CG Fault, BC Fault, CA Fault |
| 54 | BG Fault, CG Fault, BC Fault, CA Fault |
| 55 | AG Fault, BG Fault, CG Fault, BC Fault, CA Fault |
| 56 | AB Fault, BC Fault, CA Fault |
| 57 | AG Fault, AB Fault, BC Fault, CA Fault |
| 58 | BG Fault, AB Fault, BC Fault, CA Fault |
| 59 | AG Fault, BG Fault, AB Fault, BC Fault, CA Fault |
| 60 | CG Fault, AB Fault, BC Fault, CA Fault |
| 61 | AG Fault, CG Fault, AB Fault, BC Fault, CA Fault |
| 62 | BG Fault, CG Fault, AB Fault, BC Fault, CA Fault |
| 63 | AG Fault, BG Fault, CG Fault, AB Fault, BC Fault, CA Fault |

The operate signal from each zone is the OPERATE_Zx (x = 1...5) binary output signal.

The output from each zone can be blocked and the timers are also reset with the BLOCK_Zx (x = 1...5) binary input signal.

The TLT_ANG_CONFLICT monitored data is an assisting integer output which supervises the validity of a tilt angle of quadrilateral characteristics so that the characteristics always produce a closed boundary.

*Impedance measurement*

DSTPDIS provides three independent phase-to-earth and phase-to-phase measuring elements per zone. The three-phase fault is measured with a dedicated measurement element.

The impedance measurement is done similarly regardless of the zone shape. The operation is based on impedance mapping where the fault loop impedance is first calculated and then compared with the zone boundaries. If impedance is recognized inside the operation zone, the corresponding operate output is activated after the operate time has elapsed.

*Phase-to-earth impedance measuring elements*

The phase-to-earth impedance measuring elements provide the basic earth-fault protection in direct or low-impedance earthed networks. The earth-fault protection is enabled with the setting *Op Mod Gnd loops Znx* (x = 1...5) = "True". The enabling requires that all three phase-to-earth voltages are measured. Otherwise, the release of the earth-fault measuring elements is automatically blocked.

The reach of phase-to-earth measuring elements is based on loop impedance

$$\underline{Z}_1 + \underline{Z}_N + RF = \left( R_1 + \frac{R_0 - R_1}{3} \right) + j \cdot \left( X_1 + \frac{X_0 - X_1}{3} \right) + RF$$

(Equation 267)

The earth return path impedance is included in the calculated fault loop impedance of the phase-to-earth measuring element.

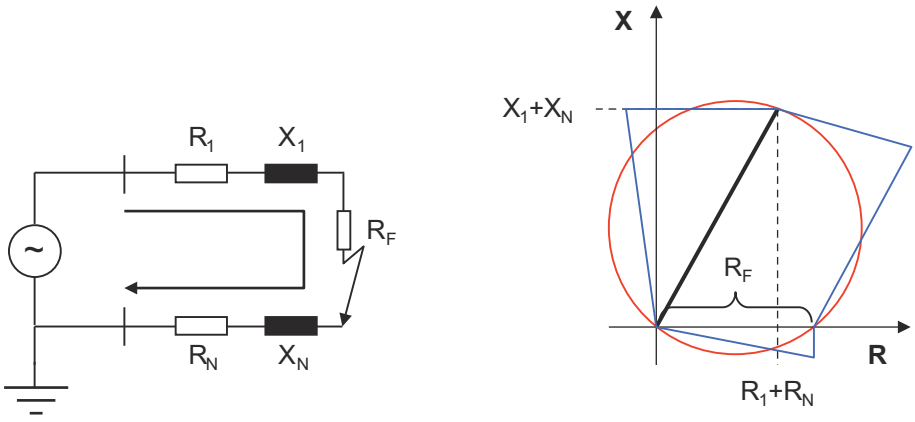



*Figure 537: The fault loop impedance model for phase-to-earth impedance measuring elements*

| | |
|---|---|
| $R_1$ | Positive-sequence resistance from measuring point to fault location |
| $X_1$ | Positive-sequence reactance from measuring point to fault location |

*Table continues on the next page*

$R_N$ Earth return path resistance = (R0 - R1)/3 from measuring point to fault location

$X_N$ Earth return path reactance = (X0 - X1)/3 from measuring point to fault location

$R_0$ Zero-sequence resistance from measuring point to fault location

$X_0$ Zero-sequence reactance from measuring point to fault location

$R_F$ Physical fault resistance between phase and earth (includes arc and earthing resistances)

Considering the load in case of a single line-to-earth fault, conventional distance protection might overreach at the exporting end and underreach at the importing end. DSTPDIS has a load compensation functionality which increases the security in such applications. Load compensation is enabled with the setting *Load Comp zone x* (x = 1...5) = "True".

Load compensation is used only with single phase-to-earth faults. Load compensation is not used if multiple phases are included in the fault (more than one single earth fault release).

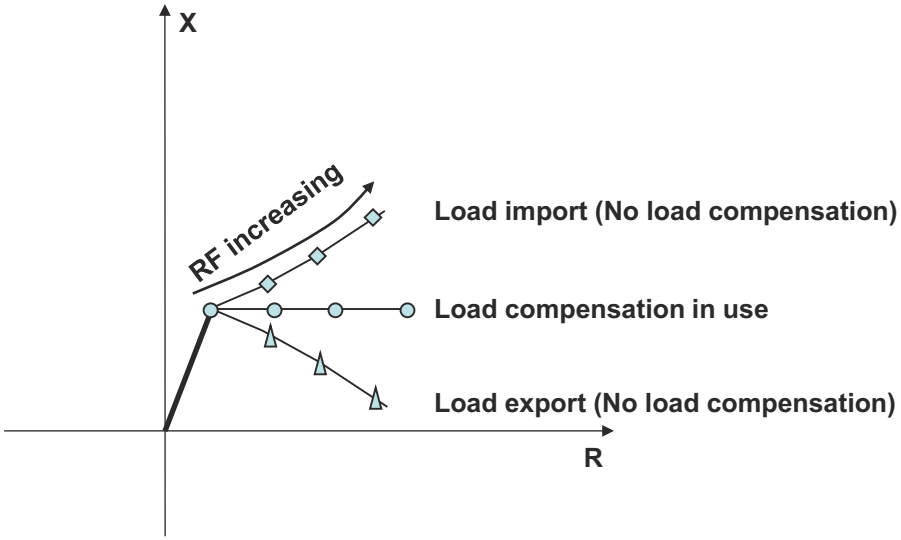



*Figure 538: Operation principle of load compensation functionality*

When three-phase feeders are placed close to each other, a mutual inductive zero-sequence coupling of the current path exists. This has an impact during earth faults. If no measures are taken, this leads to errors in the impedance calculation. The residual current of the parallel line induces a voltage in the protection line and changes the measured voltage at the relay location. The influence depends on the system configuration, that is, the magnitude and polarity of the residual current in a parallel line.

The phase-to-earth impedance measuring elements in DSTPDIS take the zero-sequence mutual coupling into account in impedance calculation. The compensation is enabled and set with settings *Par line Comp zone x* ("True"), *Mutual R0 zone x* and *Mutual X0 zone x* (x = 1...5). The residual current of the parallel line must be available and connected to the `I3P_PAR` input. The earth-current balance logic is implemented to prevent malfunctioning of the protection relay on the healthy parallel line. This means that the parallel compensation functionality is internally

blocked when the ratio between residual current of the parallel line and protected lines exceeds the *Fact EF current Bal* configuration setting.

The parallel line compensation functionality is only used with single phase-to-earth faults. Parallel line compensation is not used if multiple phases are included into fault (more than one single earth fault releases).

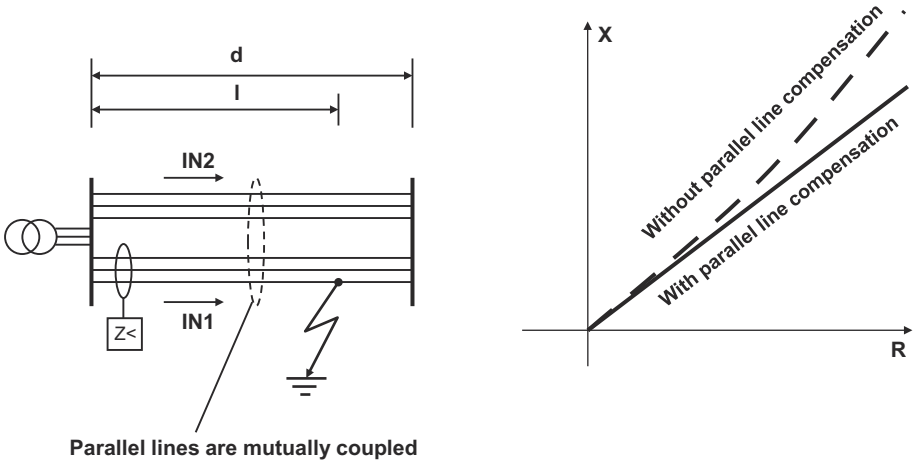



*Figure 539: Operation principle of parallel line compensation functionality*

The operation time delay is defined with the *Gnd operate Dl Znx* (x = 1...5) setting. The timer can be disabled with the *Gnd Op Dl mode Znx* = "False" setting. This blocks the `OPERATE_Zx` (x = 1...5) output of the phase-to-earth measuring elements.

*Phase-to-phase impedance measuring elements*

The phase-to-phase distance protection is suitable as a basic protection function against two-phase short circuit faults in various networks, regardless of the treatment of the neutral point. The short circuit fault protection is enabled with the *Op Mod PP loops Znx* (x = 1...5) = "True" setting.

The reach of the phase-to-phase measuring elements is based on the loop impedance

$$\underline{Z}_1 + \frac{R_F}{2} = R_1 + j \cdot X_1 + \frac{R_F}{2}$$

(Equation 268)

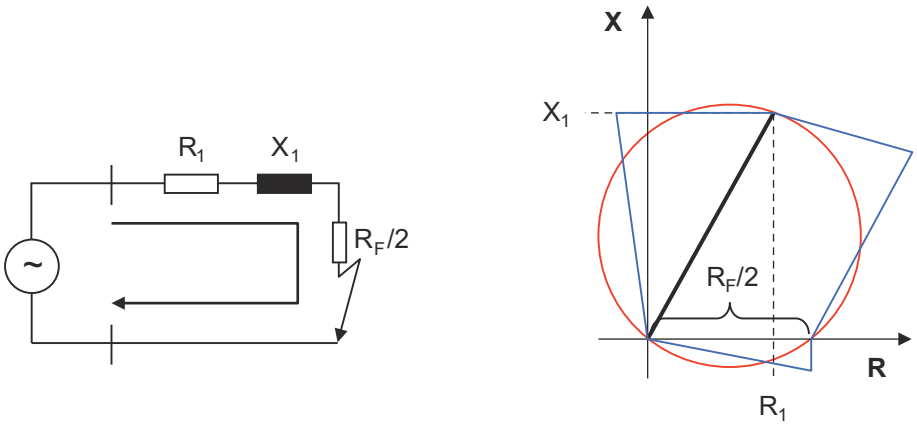



*Figure 540: The fault loop impedance model for phase-to-phase impedance measuring elements*

$R_1$ Positive-sequence resistance from measuring point to fault location.

$X_1$ Positive-sequence reactance from measuring point to fault location.

$R_F$ Physical fault resistance between phases, for example, arc resistance.

The phase-to-phase impedance measuring elements measure only half of the physical fault resistance between phases. This must be taken into account when the resistive reach of the phase-to-phase elements is set (that is, setting the value of 5 Ω corresponds 5+5=10 Ω of physical arc resistance between phases).

The resistive reach setting is common for phase-to-phase and three-phase impedance measuring elements.

The operation time delay is defined with the setting *PP operate delay Znx* (x = 1... 5). The timer can be disabled with the setting *PP Op delay Mod Znx* = "False". This blocks the `OPERATE_Zx` (x = 1... 5) output of the phase-to-phase measuring elements.

*Three-phase impedance measuring element*

DSTPDIS has a dedicated measuring element for a three-phase short circuit fault for each zone. The three-phase measuring element uses the positive-sequence quantities for a fault loop impedance estimation which increases the accuracy by reducing the influence of line parameter asymmetry. This is advantageous especially in case of non-transposed, asymmetrical lines. The three-phase impedance measuring element is enabled together with the phase-to-phase impedance elements by the setting *Op Mod PP loops Znx* (x = 1... 5) = "True".

The reach of the three-phase measuring element is based on the loop impedance

$$\text{Three-phase measuring element reach} = Z_1 + R_F = R_1 + j X_1 + R_F$$

(Equation 269)

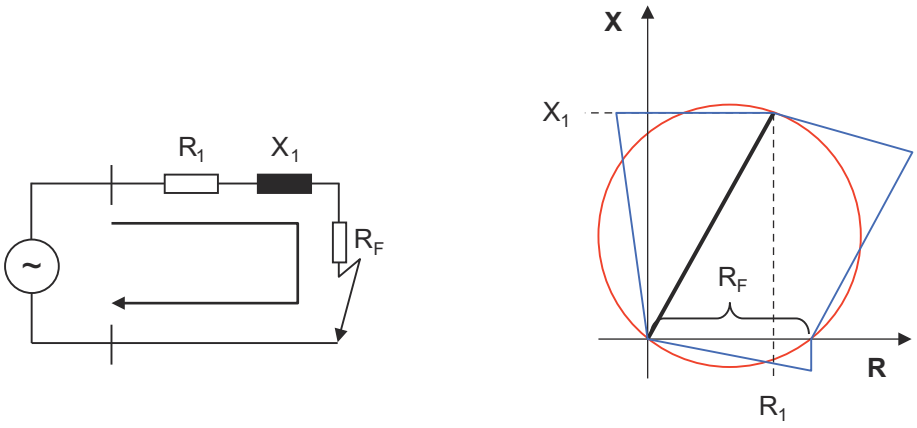



*Figure 541: The fault loop impedance model for three-phase impedance measuring element*

| | |
|---|---|
| $R_1$ | Positive-sequence resistance from measuring point to fault location |
| $X_1$ | Positive-sequence reactance from measuring point to fault location. |
| $R_F$ | Physical fault resistance per phase, for example, arc resistance. |

The three-phase impedance measuring element measures the physical fault resistance per phase. The resistive reach setting is common for three-phase and phase-to-phase impedance measuring elements.

The time delay of operation is defined with the *PP operate delay Znx* (x = 1... 5) setting. The timer can be disabled with the setting *PP Op delay Mod Znx* = "False". This blocks the `OPERATE_Zx` (x = 1... 5) output of the three-phase measuring elements.

*Entering the line reach*

The line reach is entered in primary ohms. The impedance format is selected with *Impedance mode Zn* = "Rectangular" for the vectors R, X and "Polar" for the magnitude and angle.

**Impedance mode Zn = Rectangular**

In case of phase-to-phase or three-phase impedance measuring elements, the line reach is defined with:

- Resistive reach: *R1 zone x* (x = 1...5)
- Reactive reach: *X1 zone x* (x = 1...5)

In case of non-directional characteristics, the reactive reach in reverse direction is defined with the *X1 reverse zone x* (x = 1...5) setting. The characteristic line angle, denoted as α, is the same for both forward and reverse direction.

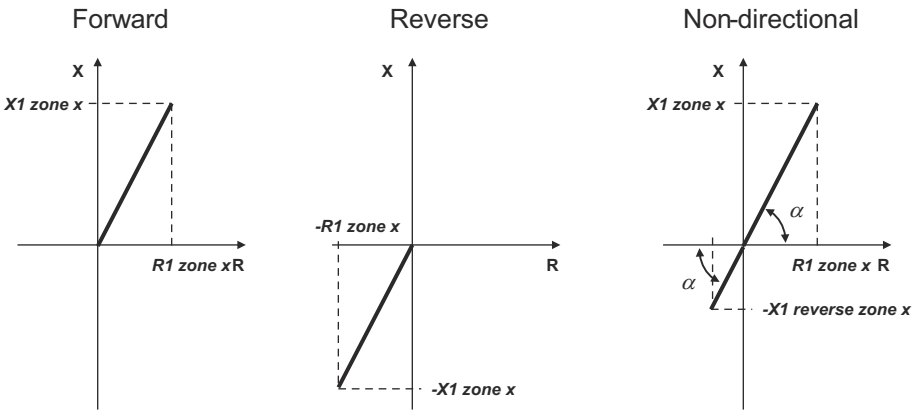



*Figure 542: Settings which define the line reach for phase-to-phase or three-phase impedance measuring elements if Impedance mode Zn = "Rectangular"*

In case of phase-to-earth impedance measuring elements, the line reach is defined with:

- Resistive reach : (2·*R1 zone x* + *R0 zone x*)/3, (x = 1...5)
- Reactive reach : (2·*X1 zone x* + *X0 zone x*)/3, (x = 1...5)

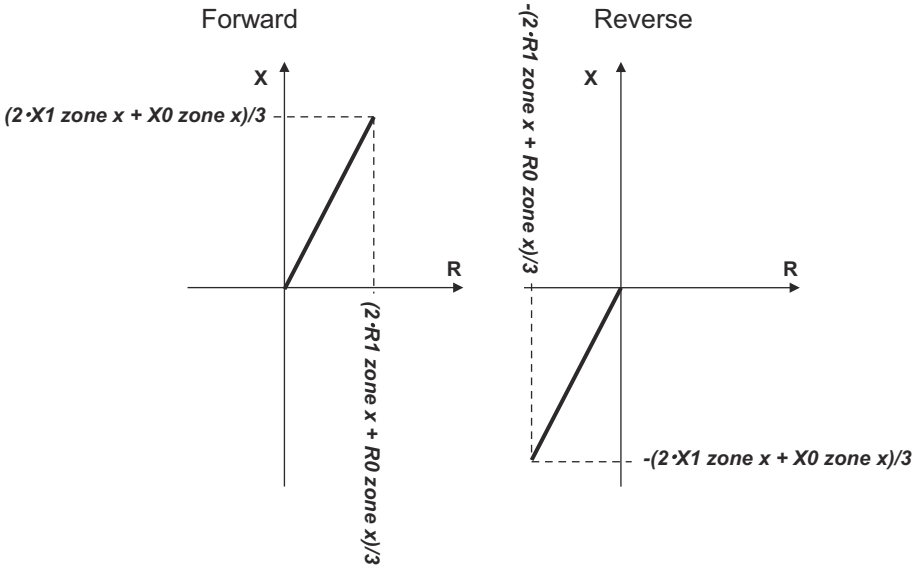



*Figure 543: Settings which define the line reach for phase-to-earth impedance measuring elements if Impedance mode Zn = "Rectangular", forward or reverse directionality*

In case of non-directional characteristics, the reactive reach in reverse direction is defined with the *X1 reverse zone x* (x = 1...5) setting. The total reactive reach in reverse direction includes a part which is common to both forward and reverse direction. This part is automatically calculated based on the values of the settings *R1 zone x, R0 zone 0, X1 zone x* and *X0 zone x*. The characteristic line angle, denoted as α, is the same for forward and reverse direction.

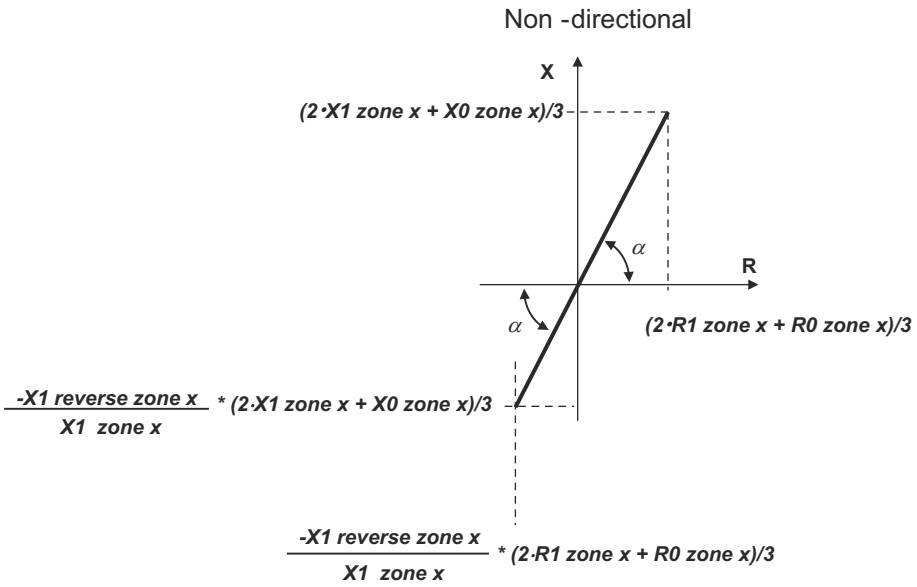



*Figure 544: Settings which define the line reach for phase-to-earth impedance measuring elements if Impedance mode Zn = "Rectangular", non-directional directionality*

**Impedance mode Zn = Polar**

In case of phase-to-phase or three-phase impedance measuring elements, the line reach is defined with:

- *Z1 zone x* (x = 1...5)
- *Z1 angle zone x* (x = 1...5)

In case of non-directional characteristics, the reactive reach magnitude in reverse direction is defined with the *Z1 reverse zone x* (x = 1...5) setting. The characteristic line angle, *Z1 angle zone x,* is the same for forward and reverse direction.

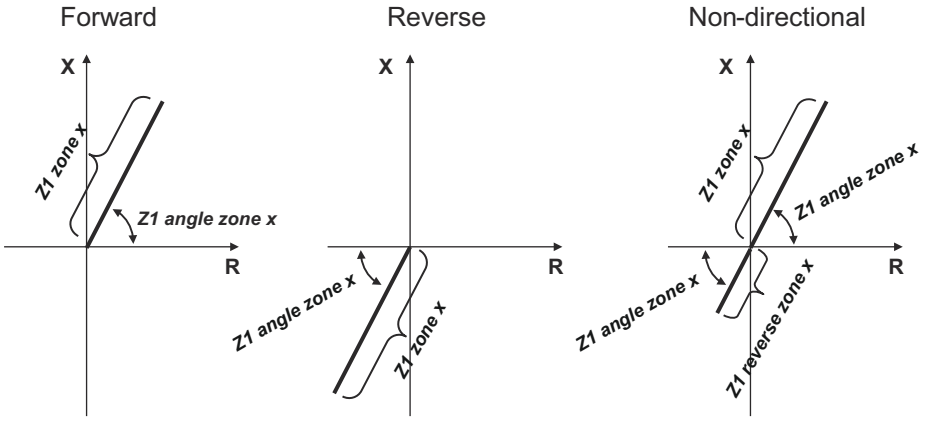



*Figure 545: Settings which define the line reach for phase-to-phase or three-phase impedance measuring elements if Impedance mode Zn = "Polar"*

In case of phase-to-earth impedance measuring elements, the line reach is defined with:

- *Z1 zone x* (x = 1...5)

- *Z1 angle zone x* (x = 1...5)
- *Factor K0 zone x* (x = 1...5)
- *Factor K0 angle Zn x* (x = 1...5)

The reach magnitude and angle are:

$$Magnitude = abs(\underline{Z}1 + \underline{Z}1 \times \underline{K}_N)$$

(Equation 270)

$$Angle = angle(\underline{Z}1 + \underline{Z}1\underline{K}_N)$$

(Equation 271)

$$\underline{Z}_1 = Z1\ zone\ x(\cos(Z1 angle\ zone\ x) + j\sin(Z1 angle\ zone\ x))$$

$$\underline{K}_N = Factor\ K0\ zone\ x(\cos(Factor\ K0 angle\ znx) + j\sin(Factor\ K0 angle\ znx))$$

In case of non-directional characteristics, the reactive reach in reverse direction is defined with the *Z1 reverse zone x* (x = 1...5) setting.

$$\underline{Z}1R = Z1\ reverse\ zone\ x(\cos(Z1 angle\ zone\ x) + j\sin(Z1 angle\ zone\ x))$$

(Equation 272)

The total reactive reach in reverse direction includes a part which is defined by the residual compensation factor $\underline{K}_N$. The characteristic line angle, denoted as α, is the same for forward and reverse direction.

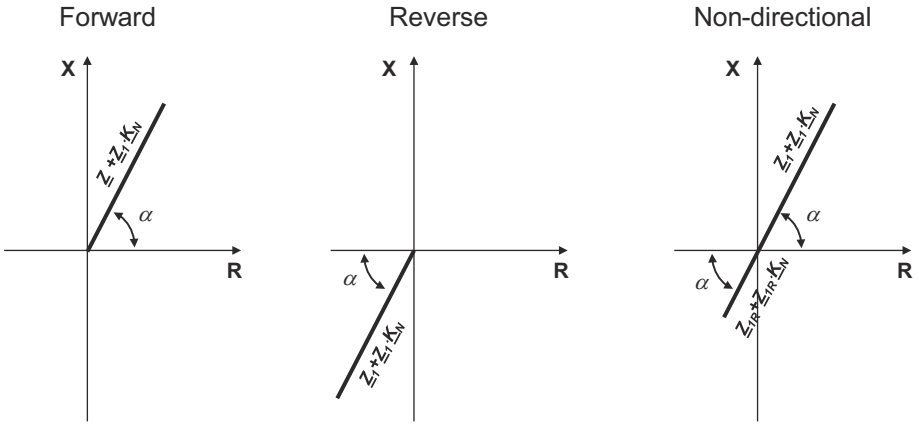



*Figure 546: Settings which define the line reach for phase-to-earth impedance measuring elements if Impedance mode Zn = "Polar"*

*Protection zone characteristics*

DSTPDIS has both “Quadrilateral” and “Mho (circular)” characteristics available for the protection zones and they can be combined also with the bullet characteristic. The shape of a tripping characteristic can be set independently for phase-to-earth, phase-to-phase or three-phase impedance elements. The zone shape is defined with the *Impedance Chr Gnd Zn* setting for phase-to-earth impedance elements, and with the *Impedance Chr PP Zn* setting for phase-to-phase or three-phase impedance elements. The alternatives are "Quadrilateral", "Mho (circular)", "Mho Dir line", "Offset Dir line" and "Bullet (combi)".

All impedance values defining the zone shape are entered in primary ohms. Angles are given in degrees.

*Quadrilateral characteristic*

If the zone has the "Quadrilateral" shape, DSTPDIS has a polygonal tripping characteristic.

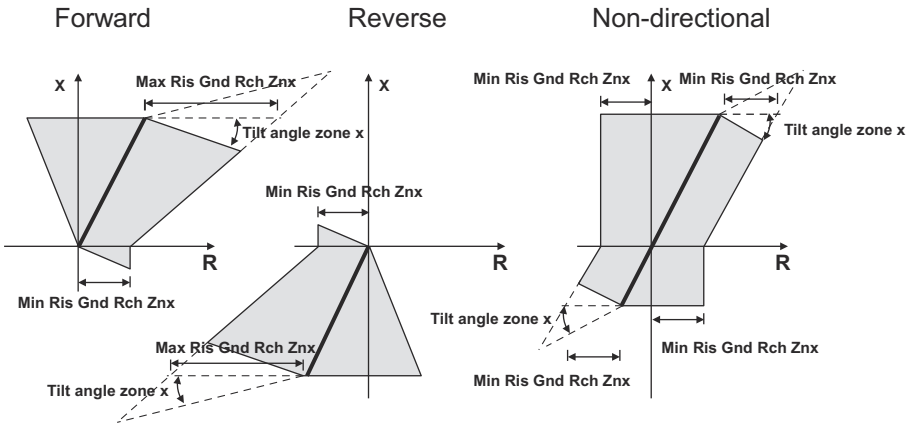



*Figure 547: Tripping characteristic for phase-to-earth impedance elements if the zone shape is quadrilateral. The tilt angle is set to compensate for possible under- or overreaching.*

The reach in the reactive direction is defined by the line reach independently for phase-to-earth and for phase-to-phase/three-phase elements. The resistive reach is defined at the minimum and maximum resistive reach with settings *Min Ris Gnd Rch Znx, Max Ris Gnd Rch Znx, Min Ris PP Rch Znx, Max Ris PP Rch Znx* (x = 1...5). In case of a non-directional zone, only settings *Min Ris Gnd Rch Znx and Min Ris PP Rch Znx* (x = 1...5) are valid. The resistive reach can be set independently for phase-to-earth and for phase-to-phase or three-phase elements.

In case of phase-to-earth impedance elements, the resistive reach value corresponds to the physical fault resistance between phase and earth including arc and earthing resistance.

The reactive reach can be adjusted by tilting the top reactance boundary line by an angle defined with *Tilt angle zone x* (x = 1...5). The negative value decreases the tripping zone area while the positive value increases the tripping area. The negative value is used in case of underreaching zones to compensate a possible overreaching. The positive value is used in case of overreaching zones to compensate a possible underreaching.

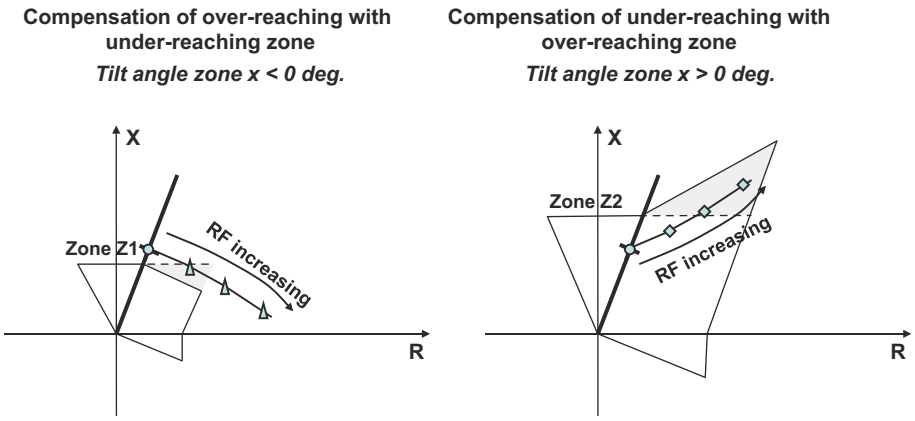



*Figure 548: Operation principle of top reactance line tilting*

The tilt angle must be carefully set. If the tilt angle has been set to a value where polygon boundaries do not form a close loop for an element, an internal mechanism modifies the tilt angle for that element so that the polygon boundary is always closed. If the set tilt angle is suitable for another element, the tilt angle of that element is not internally modified. Tilt angle conflicts are monitored by TLT_ANG_CONFLICT value. This integer value is a ten-bit value indicating tilt angle modifications per zone and fault type.

**Table 921: TLT_ANG_CONFLICT description**

| TLT_ANG_CONFLICT bit field | Description |
|---|---|
| (MSB) xx xx xx xx YZ (LSB) | Y active = Zone 1 earth-fault impedance element tilt angle modified<br>Z active = Zone 1 short circuit impedance element tilt angle modified |
| (MSB) xx xx xx YZ zz (LSB) | Y active = Zone 2 earth-fault impedance element tilt angle modified<br>Z active = Zone 2 short circuit impedance element tilt angle modified |
| (MSB) xx xx YZ xx xx (LSB) | Y active = Zone 3 earth-fault impedance element tilt angle modified<br>Z active = Zone 3 short circuit impedance element tilt angle modified |
| (MSB) xx YZ xx xx xx (LSB) | Y active = Zone 4 earth-fault impedance element tilt angle modified<br>Z active = Zone 4 short circuit impedance element tilt angle modified |
| (MSB) YZ xx xx xx xx (LSB) | Y active = Zone 5 earth-fault impedance element tilt angle modified<br>Z active = Zone 5 short circuit impedance element tilt angle modified |

For example, TLT_ANG_CONFLICT value “36” = “00 00 10 01 00” indicates that the tilt angles of the zone 2 earth-fault impedance element and zone 3 short circuit or

three-phase impedance element have been modified. These zone settings should be checked to see whether a non-zero TLT_ANG_CONFLICT value has been found although, internally, the polygon boundary has been closed for existing settings.

*Directional lines*

The direction of a zone is defined with setting *Directional mode Znx* = "Nondirectional", "Forward" or "Reverse". The directionality of each zone can be set independently of other zones. For example, zones Z1 and Z2 can be set in the "Forward" direction and Z3 in the "Reverse" direction. Furthermore, the optionally supervised earth-fault directional criteria (in low-impedance earthed networks) given for GFC are checked here together with zone direction criteria fulfilment.

The directionality of a quadrilateral zone is defined with two independent directional lines. The directional lines can be included into the mho characteristics to secure the directionality or to transform the non-directional mho characteristic into a directional one.

The directional lines are adjusted with the *Min phase angle zone* and *Max phase angle zone* settings, which are common for all the zones. The angles are given in degrees. The directional lines are polarized with the *Pol quantity zone* method. By default, the polarization method is positive-sequence voltage ("Pos. seq. volt.").

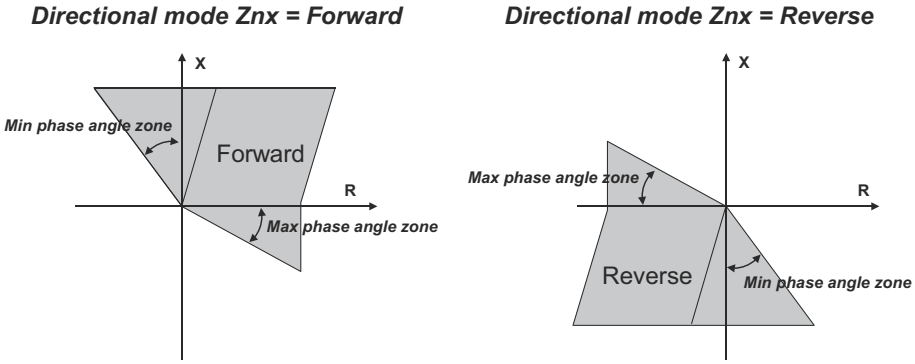



*Figure 549: Settings that adjust directional lines in case of quadrilateral characteristics*

The calculated direction of the fault or load (if there is no fault present) current is indicated for each zone with outputs DIRECTION_Z1 - Z5 which may have values "unknown", "forward", "backward" or "both". It is important to check setting *X1 reverse zone x* (or *Z1 reverse zone x* reactance part) for quadrilateral directional characteristics (see *Figure 541* and the corresponding phase-to-earth impedance given in *Figure 543*) so that it does not restrict the negative-reactance reach defined by settings *Min Ris Gnd/PP Rch Znx* and *Max phase angle zone.*

*Memory voltage*

The memory voltage is based on the healthy positive-sequence voltage stored during the network healthy state. This fictive voltage is substituted for the measured voltage with any impedance measurement element polarization if the corresponding voltage drops too low (limit is 5% Un). Fictive voltage use is indicated by the active monitored data output VMEM_USED. The polarized impedance direction for a corresponding impedance element is frozen after a fixed 100 ms of fictive voltage use, but the memory function enables impedance polarization to operate up to a maximum of 300 s. This time can be set with the

*Voltage Mem time* setting. After set *Voltage Mem time* elapses, fictive voltage (and frozen impedance direction) can no more be used without memory refreshment by a healthy positive-sequence voltage and also the frozen impedance direction is reset.

Switch onto fault function (CVPSOF) should be used together with distance protection. CVPSOF accelerates and secures the operation of the protection if a close-in three-phase fault is detected immediately after circuit breaker closing.

*Mho circular characteristic*

When the zone characteristic is "Mho (circular)", the distance protection has a circular tripping characteristic. The zone reach is defined independently by the line reach for phase-to-earth and phase-to-phase or three-phase elements. The resistive reach of the tripping characteristic depends on the selected polarization method defined with setting *Pol quantity zone* = "Cross pol", "Pos. seq. volt." or "Self pol". The non-directional mho characteristic is an exception as it is independent of the selected polarization method. It is always explicitly defined by the reach settings and thus fixed in the impedance plane.

**Table 922: Polarization methods and corresponding polarization voltages**

| Fault loop | Self pol | Cross pol | Pos. seq. volt. |
|---|---|---|---|
| $Z_A$ | $U_{L1}$ | $j \cdot U_{L23}/\sqrt{3}$ | $U_1$ |
| $Z_B$ | $U_{L2}$ | $j \cdot U_{L31}/\sqrt{3}$ | $U_1 \cdot 1\angle -120°$ |
| $Z_C$ | $U_{L3}$ | $j \cdot U_{L23}/\sqrt{3}$ | $U_1 \cdot 1\angle 120°$ |
| $Z_{AB}$ | $U_{L12}$ | $j \cdot (U_{L23}-U_{L31})/\sqrt{3}$ | $U_1 \cdot \sqrt{3} \cdot 1\angle 30°$ |
| $Z_{BC}$ | $U_{L23}$ | $j \cdot (U_{L31}-U_{L12})/\sqrt{3}$ | $U_1 \cdot \sqrt{3} \cdot 1\angle -90°$ |
| $Z_{CA}$ | $U_{L31}$ | $j \cdot (U_{L12}-U_{L23})/\sqrt{3}$ | $U_1 \cdot \sqrt{3} \cdot 1\angle 150°$ |
| $Z_{ABC}$ | $U_1$ | | |

In case of cross-polarization "Cross pol", the polarization voltages are theoretically quadrature to the fault loop voltage. The phase angle of the polarization voltage is rotated 90° to match the original fault loop voltage. The cross-polarization expands the tripping characteristic according to the prevailing system conditions. In case of short circuit faults, the circle expands as a function of the source impedance magnitude $Z_{1source}$. In case of an earth fault, the circle expands as a function of the source impedance $Z_{1source}$, $Z_{0source}$ and earthing impedance magnitudes $Z_E$ as $(2 \cdot Z_{1source} + Z_{0source})/3 + Z_E$.

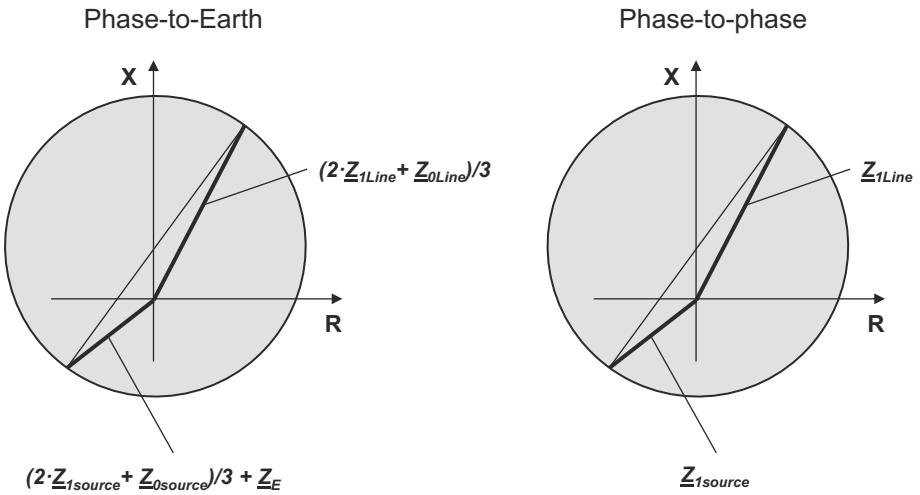



*Figure 550: Tripping characteristic in case the zone characteristic is "Mho (circular)" and Pol quantity zone is "Cross pol"*

In case of positive-sequence polarization "Pos. seq. volt.", the polarization voltage is the positive-sequence voltage. The voltage phase angle is rotated to match the original fault loop voltage. The positive-sequence polarization expands the tripping characteristic according to the prevailing system conditions. In case of short circuit faults, the circle expands as a function of the source impedance magnitude $\underline{Z}_{1source}/2$. In case of an earth fault, the circle expands as a function of source impedance and earthing impedance magnitudes: $(Z_{1source} + Z_{0source})/3 + Z_E$.

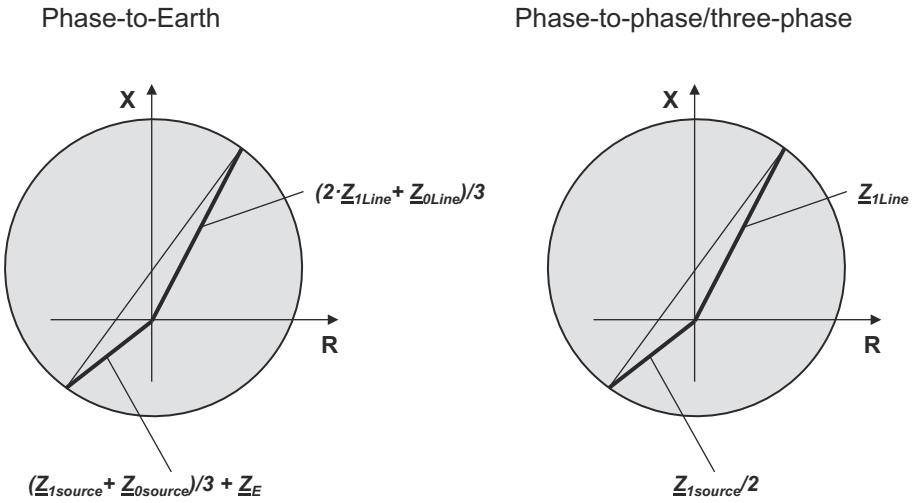



*Figure 551: Tripping characteristic in case the zone characteristic is "Mho (circular)" and Pol quantity zone is "Pos. seq. volt."*

One alternative for polarization is also "Self pol" despite the drawbacks when using it as a polarization method. The mho circle does not expand when using this polarization method.

In case of cross and positive-sequence polarization, the expansion of the mho circle is a positive feature as the fault resistance coverage is increased. The reach of the zone is not affected by the expansion. The greatest expansion is obtained with cross-polarization.

The directional offset mho is explicitly defined by the reach settings and is thus fixed in the impedance plane. The polarization method does not expand this circle even for directional mode. However, directional lines criteria are defined using polarized signals.

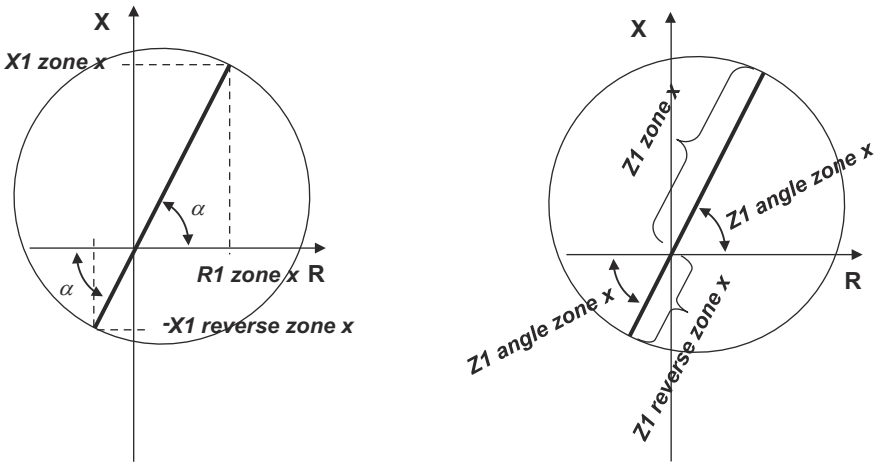



*Figure 552: Tripping characteristic for phase-to-phase or three-phase impedance measuring elements if Impedance Chr PP Zn is "Mho (circular)" and Directional mode Znx is "Non-directional". On the left, Impedance mode Zn is "Rectangular". On the right, Impedance mode Zn is "Polar".*

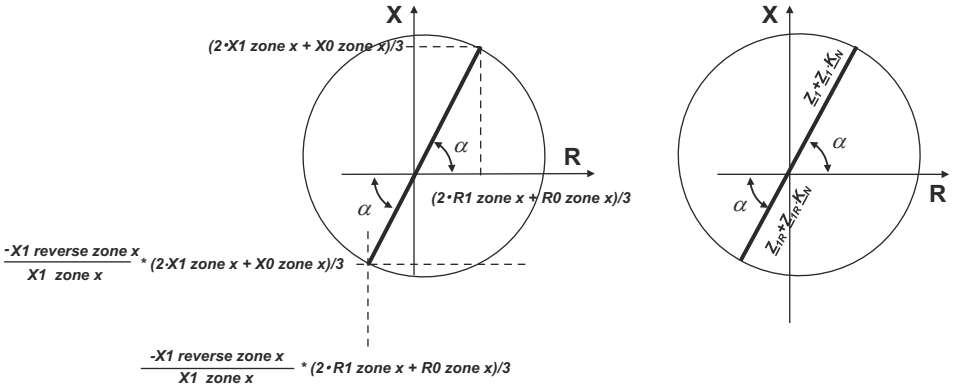



*Figure 553: Tripping characteristic for phase-to-earth impedance measuring elements if Impedance Chr GND Zn is "Mho (circular)" and Directional mode Znx is "Non-directional". On the left, Impedance mode Zn is "Rectangular". On the right, Impedance mode Zn is "Polar".*

*Adding of directional lines into circular mho characteristic*

Directional lines which are always included in the directional quadrilateral characteristic can also be included in the mho characteristics to secure the directionality or to transform the non-directional mho characteristics into a directional one.

Directional lines with mho are available only when the zone is set to directional, that is, *Directional mode Znx* is "Forward" or "Reverse".

The directionality of the directional mho characteristic is secured with directional lines by setting *Impedance Chr Gnd Zn and Impedance Chr PP Zn* to "Mho Dir line". The directional mho characteristic can also be created by adding directional lines in

the offset mho characteristic. This is done by selecting *Impedance Chr Gnd Zn* and *Impedance Chr PP Zn* as "Offset Dir line".

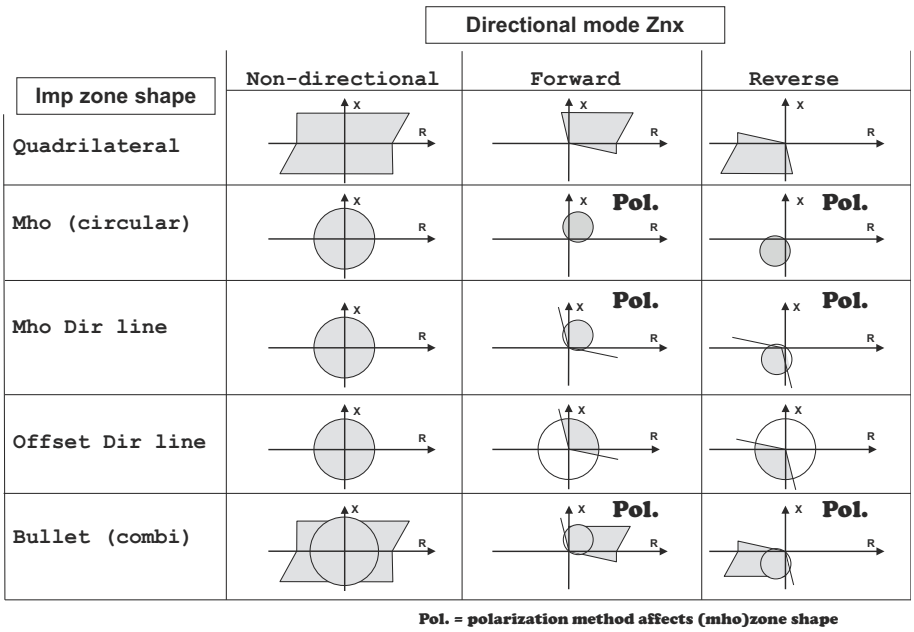



*Figure 554: Possible combinations of Directional mode Znx and zone characteristics settings. Pol. in the figure means that the shape of the characteristic is affected by the selected polarization method of the mho circle, Pol quantity zone = "Cross pol", "Pos. seq. volt.", "Self pol").*

*Bullet combi characteristic*

If the impedance zone shape equals "Bullet (combi)", the distance protection has a tripping characteristic which is a combination of the quadrilateral and mho. All settings relevant to the quadrilateral and mho are applicable. The shape of the "Bullet (combi)" characteristic is affected by the selected polarization method of the mho circle (*Pol quantity zone* = "Cross pol", "Pos. seq. volt.", "Self pol").

The directionality of the "Bullet (combi)" characteristic is defined by the directional lines when *Directional mode Znx* is "Forward" or "Reverse". For directional "Bullet (combi)" characteristic, the quadrilateral resistance does not reach negative (positive) values for “Forward” (“Reverse”) direction (see *Figure 555*).

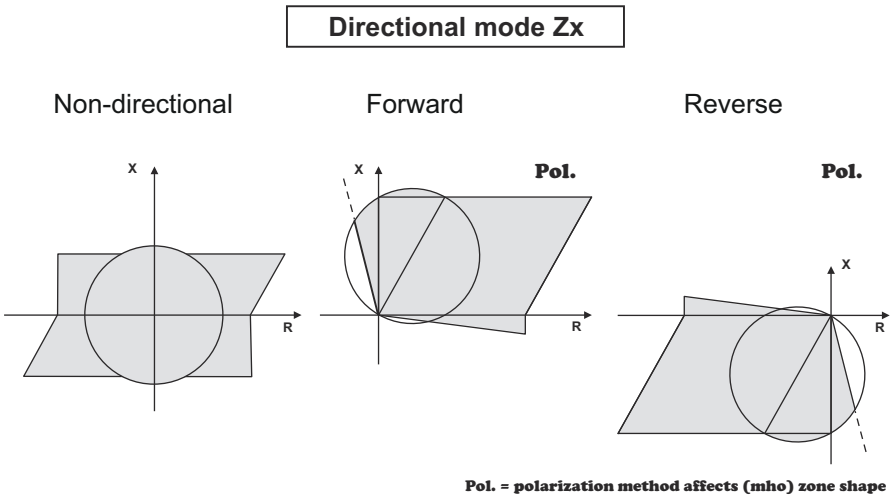



*Figure 555: Bullet combi tripping characteristic. Pol. in the figure means the shape of the characteristic is affected by the selected polarization method, Pol quantity zone = "Cross pol", "Pos. seq. volt.", "Self pol"*

### 4.7.1.6 Recorded data

The required information for later fault analysis is recorded when the recording function of DSTPDIS is triggered by activating TRIGG_REC input or writing to the corresponding DO “LD0.GFCPDIS1.RcdTrg.Oper.ctlVal”. During external triggering (input signal TRIGG_REC), the recorded data of all zones and the phase selection function are recorded.

A total of three sets of recorded data are saved in data banks Fault 1, 2 and 3. Data bank Fault 1 holds the most recent recorded data and the older data is moved into the following banks (1->2 and 2->3) when triggering occurs. When all three banks have data and a new triggering occurs, the latest data is placed into bank 1 and the data in bank 3 is overwritten by the data from bank 2.

**Table 923: Recorded data for the phase selection function**

| Parameter name | Description |
|---|---|
| Time | Recorded data time stamp |
| Release PE-loop | Release signals for PE loops, GFC |
| Release PP-loop | Release signals for PP/3P loops, GFC |
| Earth fault detected | Indication of a single-phase earth fault, GFC |
| Cross country fault | Indication of a cross-country fault (high imp. earthed), GFC |
| Earth fault direction | Earth-fault direction (low imp. earthed), GFC |
| Operate of all zones | Operate signals of all zones (this is zone information but it is taken here because it represents all zone information combined) |

The values of parameter Operate of all zones indicate by a number (0...31) which zones have been operated.

**Table 924: Enumerator values for parameter Operate of all zones**

| Enumerator value | Description |
|---|---|
| 0 | No zone operates |
| 1 | Zone 1 |
| 2 | Zone 2 |
| 3 | Zones 1 and 2 |
| 4 | Zone 3 |
| 5 | Zones 1 and 3 |
| 6 | Zones 2 and 3 |
| 7 | Zones 1,2 and 3 |
| 8 | Zone 4 |
| 9 | Zones 1 and 4 |
| 10 | Zones 2 and 4 |
| 11 | Zones 1,2 and 4 |
| 12 | Zones 3 and 4 |
| 13 | Zones 1,3 and 4 |
| 14 | Zones 2,3 and 4 |
| 15 | Zones 1,2,3 and 4 |
| 16 | Zone 5 |
| 17 | Zones 1 and 5 |
| 18 | Zones 2 and 5 |
| 19 | Zones 1,2 and 5 |
| 20 | Zones 3 and 5 |
| 21 | Zones 1,3 and 5 |
| 22 | Zones 2,3 and 5 |
| 23 | Zones 1,2,3 and 5 |
| 24 | Zones 4 and 5 |
| 25 | Zones 1,4 and 5 |

*Table continues on the next page*

| Enumerator value | Description |
|---|---|
| 26 | Zones 2,4 and 5 |
| 27 | Zones 1,2,4 and 5 |
| 28 | Zones 3,4 and 5 |
| 29 | Zones 1,3,4 and 5 |
| 30 | Zones 2,3,4 and 5 |
| 31 | Zones 1,2,3,4 and 5 |

**Table 925: Recorded data parameters regarding specific zones**

| Parameter | Description |
|---|---|
| Fault/load Dir Znx | Direction of fault or load zone Zx |
| Dir resistance Znx | Direction resistance, zone Zx |
| Dir reactance Znx | Direction reactance, zone Zx |
| Flt loop 1st Ris Znx | First PE-Loop resistance, zone Zx |
| Flt loop 1st Rea Znx | First PE-Loop reactance, zone Zx |
| Flt loop 2nd Ris Znx | Second PE-Loop resistance, zone Zx |
| Flt loop 2nd Rea Znx | Second PE-Loop reactance, zone Zx |
| Flt PP-loop Ris Znx | PP-Loop resistance, zone Zx |
| Flt PP-loop Rea Znx | PP-Loop reactance, zone Zx |
| Phase reactance Znx | Phase reactance Znx |

In case of a no-fault condition, the direction of the load current seen by a three-phase fault measuring element (based on positive-sequence signal data) is indicated. DIR_LOOP_R and DIR_LOOP_X are the loop resistance and reactance from the impedance calculation used in directional discrimination for zone 1. Depending on the released fault loops, the calculated fault loop impedance can be read from the parameters FLTLOOP_RFST, FLTLOOP_XFST, FLTLOOP_RPP and FLTLOOP_XPP. If two phase-to-earth loops are released simultaneously for measurement, the second phase-to-earth impedance can be found from the parameters FLTLOOP_RSND and FLTLOOP_XSND. The corresponding positive-sequence phase-to-earth fault reactance can be found from parameter FLTPH_X.



The impedances are shown in primary ohms.

### 4.7.1.7 Application

DSTPDIS provides a fast and reliable protection for overhead lines and power cables. The function is applied in distribution and sub-transmission networks where three-phase tripping is allowed for all kinds of faults.

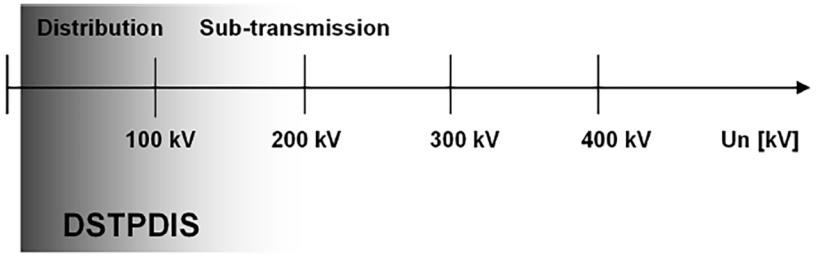



*Figure 556: Application scope of DSTPDIS*

Typically these networks are operated in ring or meshed type configurations. The switching state of these networks is changed frequently due to daily operation and load flow considerations. The networks also include varying capacities of distributed generation which makes it impossible to apply simple overcurrent-based schemes. In these networks, DSTPDIS is used to provide a fast and selective protection for overhead lines and power cables. It can also be applied for radial feeders to increase the sensitivity of the protection, especially if the short circuit power of the source is low or it changes due to network operation.

From the selectivity point of view, it is advantageous that in the protection chain all functions in different positions operate according to the same measuring principle. Therefore, DSTPDIS can also be applied for the backup protection of main transformers and buses. This way, selectivity in the distance protection of the outgoing lines is easier to achieve.

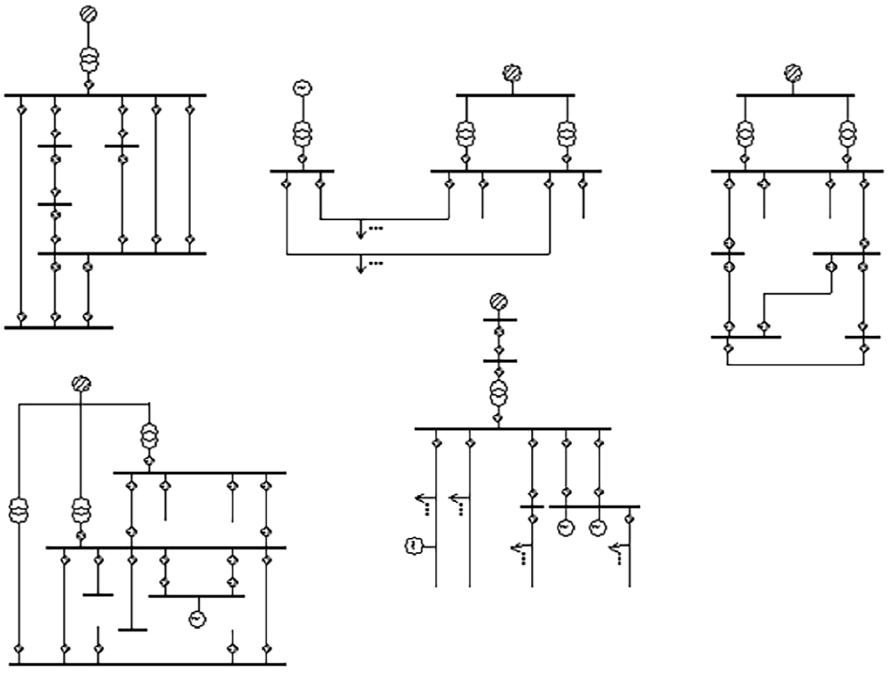


*Figure 557: Typical network configurations for DSTPDIS application*

DSTPDIS has five flexible configurable impedance zones for protection (Z1...Z5).

Phase-to-earth distance protection is a basic earth-fault protection in solidly or low-impedance earthed networks. Together with the phase preference logic, it also serves as a selective protection function at cross-country faults in isolated or Petersen coil compensated networks. In certain applications, system earthing is changed during operation from high-impedance to low-impedance earthed system due to fault location procedures. DSTPDIS can be used in such applications by setting System grounding GFC to "From input" and by providing information about the type of earthing through binary input SYS_EARTHING. Low (inactive) SYS_EARTHING input indicates low-impedance earthing system.

DSTPDIS is suitable as a basic protection function against two- and three-phase faults in various networks, regardless of the treatment of the neutral point. The independent setting of the reach in the reactive and the resistive directions makes it possible to create a fast and selective short circuit protection in many applications.

### 4.7.1.8 Signals

#### DSTPDIS Input signals

**Table 926: DSTPDIS Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| I3P_PAR | SIGNAL | - | Three-phase currents |
| I3P_REF | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| SYS_EARTHING | BOOLEAN | 0=False | Network earthing method |
| TRIGG_REC | BOOLEAN | 0=False | External triggering for all recorded data |
| BLOCK_GFC | BOOLEAN | 0=False | Block GFC operate |
| BLOCK_Z1 | BOOLEAN | 0=False | Block zone 1 |
| BLOCK_Z2 | BOOLEAN | 0=False | Block zone 2 |
| BLOCK_Z3 | BOOLEAN | 0=False | Block zone 3 |
| BLOCK_Z4 | BOOLEAN | 0=False | Block zone 4 |
| BLOCK_Z5 | BOOLEAN | 0=False | Block zone 5 |

**DSTPDIS Output signals**

**Table 927: DSTPDIS Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE_GFC | BOOLEAN | Time delayed operate signal, GFC |
| OPERATE_Z1 | BOOLEAN | Time delayed operate signal, zone 1 |
| OPERATE_Z2 | BOOLEAN | Time delayed operate signal, zone 2 |
| OPERATE_Z3 | BOOLEAN | Time delayed operate signal, zone 3 |
| OPERATE_Z4 | BOOLEAN | Time delayed operate signal, zone 4 |
| OPERATE_Z5 | BOOLEAN | Time delayed operate signal, zone 5 |
| START_GFC | BOOLEAN | Start, GFC |
| START_Z1 | BOOLEAN | General start signal, zone 1 |
| START_Z2 | BOOLEAN | General start signal, zone 2 |
| START_Z3 | BOOLEAN | General start signal, zone 3 |
| START_Z4 | BOOLEAN | General start signal, zone 4 |
| START_Z5 | BOOLEAN | General start signal, zone 5 |
| XC_FLT | BOOLEAN | Indication of a cross-country-fault (high imp. earthed), GFC |
| DIRECTION_Z1 | Enum | Direction of fault or load zone 1 |
| DIRECTION_Z2 | Enum | Direction of fault or load zone 2 |
| DIRECTION_Z3 | Enum | Direction of fault or load zone 3 |
| DIRECTION_Z4 | Enum | Direction of fault or load zone 4 |
| DIRECTION_Z5 | Enum | Direction of fault or load zone 5 |

### 4.7.1.9 DSTPDIS Settings

**Table 928: DSTPDIS Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase Sel mode GFC | 1=Overcurrent<br>2=Vol Dep Overcur<br>3=Under impe-dance | | | 1=Overcurrent | Phase selection method |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 4=OC AND Und impedance | | | | |
| EF detection Mod GFC | 1=Io<br>2=Io OR Uo<br>3=Io AND Uo<br>4=Io AND IoRef | | | 1=Io | Earth-fault (EF) detection method |
| Operate delay GFC | 100...60000 | ms | 10 | 3000 | Time delay to operate, GFC |
| Str A Ph Sel GFC | 0.10...10.00 | xIn | 0.01 | 2.00 | Phase current start value, PSL |
| Lo A Ph Sel GFC | 0.10...10.00 | xIn | 0.01 | 0.80 | Phase current start value, voltage dep. over current, PSL |
| Ph V Ph Sel GFC | 0.05...1.00 | xUn | 0.01 | 0.46 | PE-voltage start value, voltage dep. over current, PSL |
| PP V Ph Sel GFC | 0.10...1.00 | xUn | 0.01 | 0.80 | PP-voltage start value, voltage dep. over current, PSL |
| Z Chr Mod Ph Sel GFC | 1=Quadrilateral<br>2=Mho (circular) | | | 1=Quadrilateral | Impedance characteristic, underimpedance, PSL |
| Load Dsr mode GFC | 0=False<br>1=True | | | 0=False | Enable load discrimination, underimpedance, PSL |
| X Gnd Fwd reach GFC | 0.00...3000.00 | ohm | 0.01 | 40.00 | Reactive forward reach for PE-loops, underimpedance, PSL |
| X Gnd Rv reach GFC | 0.00...3000.00 | ohm | 0.01 | 40.00 | Reactive reverse reach for PE-loops, underimpedance, PSL |
| Ris Gnd Fwd Rch GFC | 0.00...500.00 | ohm | 0.01 | 100.00 | Resistive forward reach for PE-loops, underimpedance, PSL |
| Ris Gnd Rv Rch GFC | 0.00...500.00 | ohm | 0.01 | 100.00 | Resistive reverse reach for PE-loops, underimpedance, PSL |
| X PP Fwd reach GFC | 0.00...3000.00 | ohm | 0.01 | 40.00 | Reactive forward reach for PP-loops, underimpedance, PSL |
| X PP Rv reach GFC | 0.00...3000.00 | ohm | 0.01 | 40.00 | Reactive reverse reach for PP-loops, underimpedance, PSL |
| Ris PP Fwd Rch GFC | 0.00...100.00 | ohm | 0.01 | 30.00 | Resistive forward reach for PP-loops, underimpedance, PSL |
| Ris PP Rv Rch GFC | 0.00...100.00 | ohm | 0.01 | 30.00 | Resistive reverse reach for PP-loops, underimpedance, PSL |
| Ris Fwd Rch Lod GFC | 0.00...3000.00 | ohm | 0.01 | 80.00 | Resistive forward reach for load discrimination, undrerimpedance, PSL |
| Ris Rv Rch Lod GFC | 0.00...3000.00 | ohm | 0.01 | 80.00 | Resistive reverse reach for load discrimination, un- |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | | | | | drerimpedance, PSL |
| Angle load area GFC | 5.0...45.0 | deg | 0.1 | 25.0 | Load discrimination angle, PSL |
| Gnd Op current GFC | 0.00...10.00 | xIn | 0.01 | 0.10 | Basic start value for residual curr., EF-detection function |
| Gnd Op A Ref GFC | 0.01...10.00 | xIn | 0.01 | 0.10 | Transformer neutral curr. start val., EF-detection function |
| Gnd Str voltage GFC | 0.02...1.00 | xUn | 0.01 | 0.15 | Residual voltage start value, EF-detection function |
| Gnd Op A XC GFC | 0.10...10.00 | xIn | 0.01 | 0.20 | Residual current start value, XC-fault detection function |
| PP voltage XC GFC | 0.10...1.00 | xUn | 0.01 | 0.80 | PP-voltage start value, XC-fault detection function |
| Directional mode Zn1 | 2=Forward<br>3=Reverse<br>1=Non-directional | | | 2=Forward | Directional mode, zone 1 |
| Op Mod PP loops Zn1 | 0=False<br>1=True | | | 0=False | Enable PP/3P-loop measurement, zone 1 |
| PP Op delay Mod Zn1 | 0=False<br>1=True | | | 1=True | Enable operate timer for PP/3P-loops, zone 1 |
| R1 zone 1 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence resistive reach, zone 1 |
| X1 zone 1 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive reach, zone 1 |
| X1 reverse zone 1 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Pos. seq. reactive reach in rev. dir., non-dir. zone 1 |
| Z1 zone 1 | 0.01...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach, zone 1 |
| Z1 angle zone 1 | 15.0...90.0 | deg | 0.1 | 45.0 | Positive sequence line angle, zone 1 |
| Z1 reverse zone 1 | 0.00...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach in rev. dir., non-dir. zone 1 |
| Min Ris PP Rch Zn1 | 0.00...100.00 | ohm | 0.01 | 30.00 | Minimum resistive reach of PP/3P-loops, zone 1 |
| Max Ris PP Rch Zn1 | 0.00...100.00 | ohm | 0.01 | 30.00 | Maximum resistive reach of PP/3P-loops, zone 1 |
| PP operate delay Zn1 | 20...60000 | ms | 1 | 20 | Time delay to operate of PP/3P-loops, zone 1 |
| Op Mod Gnd loops Zn1 | 0=False<br>1=True | | | 0=False | Enable PE-loop measurement, zone 1 |
| Gnd Op Dl mode Zn1 | 0=False<br>1=True | | | 1=True | Enable operate timer for PE-loops, zone 1 |
| Load Comp zone 1 | 0=False<br>1=True | | | 1=True | Enable load compensation for PE-loops, zone 1 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| R0 zone 1 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence resistive reach, zone 1 |
| X0 zone 1 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence reactive reach, zone 1 |
| Factor K0 zone 1 | 0.00...5.00 | | 0.01 | 1.00 | Residual compensation factor magnitude, zone 1 |
| Factor K0 angle Zn1 | -179...180 | deg | 1 | 0 | Residual compensation factor angle, zone 1 |
| Min Ris Gnd Rch Zn1 | 0.00...500.00 | ohm | 0.01 | 100.00 | Minimum resistive reach of PE-loops, zone 1 |
| Max Ris Gnd Rch Zn1 | 0.00...500.00 | ohm | 0.01 | 100.00 | Maximum resistive reach of PE-loops, zone 1 |
| Gnd operate Dl Zn1 | 20...60000 | ms | 1 | 20 | Time delay to operate of PE-loops, zone 1 |
| Directional mode Zn2 | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode, zone 2 |
| Op Mod PP loops Zn2 | 0=False<br>1=True | | | 0=False | Enable PP/3P-loop measurement, zone 2 |
| PP Op delay Mod Zn2 | 0=False<br>1=True | | | 1=True | Enable operate timer for PP/3P-loops, zone 2 |
| R1 zone 2 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence resistive reach, zone 2 |
| X1 zone 2 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive reach, zone 2 |
| X1 reverse zone 2 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Pos. seq. reactive reach in rev. dir., non-dir. zone 2 |
| Z1 zone 2 | 0.01...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach, zone 2 |
| Z1 angle zone 2 | 15.0...90.0 | deg | 0.1 | 45.0 | Positive sequence line angle, zone 2 |
| Z1 reverse zone 2 | 0.00...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach in rev. dir., non-dir. zone 2 |
| Min Ris PP Rch Zn2 | 0.00...100.00 | ohm | 0.01 | 30.00 | Minimum resistive reach of PP/3P-loops, zone 2 |
| Max Ris PP Rch Zn2 | 0.00...100.00 | ohm | 0.01 | 30.00 | Maximum resistive reach of PP/3P-loops, zone 2 |
| PP operate delay Zn2 | 20...60000 | ms | 1 | 20 | Time delay to operate of PP/3P-loops, zone 2 |
| Op Mod Gnd loops Zn2 | 0=False<br>1=True | | | 0=False | Enable PE-loop measurement, zone 2 |
| Gnd Op Dl mode Zn2 | 0=False<br>1=True | | | 1=True | Enable operate timer for PE-loops, zone 2 |
| Load Comp zone 2 | 0=False<br>1=True | | | 1=True | Enable load compensation for PE-loops, zone 2 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| R0 zone 2 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence resistive reach, zone 2 |
| X0 zone 2 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence reactive reach, zone 2 |
| Factor K0 zone 2 | 0.00...5.00 | | 0.01 | 1.00 | Residual compensation factor magnitude, zone 2 |
| Factor K0 angle Zn2 | -179...180 | deg | 1 | 0 | Residual compensation factor angle, zone 2 |
| Min Ris Gnd Rch Zn2 | 0.00...500.00 | ohm | 0.01 | 100.00 | Minimum resistive reach of PE-loops, zone 2 |
| Max Ris Gnd Rch Zn2 | 0.00...500.00 | ohm | 0.01 | 100.00 | Maximum resistive reach of PE-loops, zone 2 |
| Gnd operate Dl Zn2 | 20...60000 | ms | 1 | 20 | Time delay to operate of PE-loops, zone 2 |
| Directional mode Zn3 | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode, zone 3 |
| Op Mod PP loops Zn3 | 0=False<br>1=True | | | 0=False | Enable PP/3P-loop measurement, zone 3 |
| PP Op delay Mod Zn3 | 0=False<br>1=True | | | 1=True | Enable operate timer for PP/3P-loops, zone 3 |
| R1 zone 3 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence resistive reach, zone 3 |
| X1 zone 3 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive reach, zone 3 |
| X1 reverse zone 3 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Pos. seq. reactive reach in rev. dir., non-dir. zone 3 |
| Z1 zone 3 | 0.01...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach, zone 3 |
| Z1 angle zone 3 | 15.0...90.0 | deg | 0.1 | 45.0 | Positive sequence line angle, zone 3 |
| Z1 reverse zone 3 | 0.00...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach in rev. dir., non-dir. zone 3 |
| Min Ris PP Rch Zn3 | 0.00...100.00 | ohm | 0.01 | 30.00 | Minimum resistive reach of PP/3P-loops, zone 3 |
| Max Ris PP Rch Zn3 | 0.00...100.00 | ohm | 0.01 | 30.00 | Maximum resistive reach of PP/3P-loops, zone 3 |
| PP operate delay Zn3 | 20...60000 | ms | 1 | 20 | Time delay to operate of PP/3P-loops, zone 3 |
| Op Mod Gnd loops Zn3 | 0=False<br>1=True | | | 0=False | Enable PE-loop measurement, zone 3 |
| Gnd Op Dl mode Zn3 | 0=False<br>1=True | | | 1=True | Enable operate timer for PE-loops, zone 3 |
| Load Comp zone 3 | 0=False<br>1=True | | | 1=True | Enable load compensation for PE-loops, zone 3 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| R0 zone 3 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence resistive reach, zone 3 |
| X0 zone 3 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence reactive reach, zone 3 |
| Factor K0 zone 3 | 0.00...5.00 | | 0.01 | 1.00 | Residual compensation factor magnitude, zone 3 |
| Factor K0 angle Zn3 | -179...180 | deg | 1 | 0 | Residual compensation factor angle, zone 3 |
| Min Ris Gnd Rch Zn3 | 0.00...500.00 | ohm | 0.01 | 100.00 | Minimum resistive reach of PE-loops, zone 3 |
| Max Ris Gnd Rch Zn3 | 0.00...500.00 | ohm | 0.01 | 100.00 | Maximum resistive reach of PE-loops, zone 3 |
| Gnd operate Dl Zn3 | 20...60000 | ms | 1 | 20 | Time delay to operate of PE-loops, zone 3 |
| Directional mode Zn4 | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode, zone 4 |
| Op Mod PP loops Zn4 | 0=False<br>1=True | | | 0=False | Enable PP/3P-loop measurement, zone 4 |
| PP Op delay Mod Zn4 | 0=False<br>1=True | | | 1=True | Enable operate timer for PP/3P-loops, zone 4 |
| R1 zone 4 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence resistive reach, zone 4 |
| X1 zone 4 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive reach, zone 4 |
| X1 reverse zone 4 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Pos. seq. reactive reach in rev. dir., non-dir. zone 4 |
| Z1 zone 4 | 0.01...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach, zone 4 |
| Z1 angle zone 4 | 15.0...90.0 | deg | 0.1 | 45.0 | Positive sequence line angle, zone 4 |
| Z1 reverse zone 4 | 0.00...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach in rev. dir., non-dir. zone 4 |
| Min Ris PP Rch Zn4 | 0.00...100.00 | ohm | 0.01 | 30.00 | Minimum resistive reach of PP/3P-loops, zone 4 |
| Max Ris PP Rch Zn4 | 0.00...100.00 | ohm | 0.01 | 30.00 | Maximum resistive reach of PP/3P-loops, zone 4 |
| PP operate delay Zn4 | 20...60000 | ms | 1 | 20 | Time delay to operate of PP/3P-loops, zone 4 |
| Op Mod Gnd loops Zn4 | 0=False<br>1=True | | | 0=False | Enable PE-loop measurement, zone 4 |
| Gnd Op Dl mode Zn4 | 0=False<br>1=True | | | 1=True | Enable operate timer for PE-loops, zone 4 |
| Load Comp zone 4 | 0=False<br>1=True | | | 1=True | Enable load compensation for PE-loops, zone 4 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| R0 zone 4 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence resistive reach, zone 4 |
| X0 zone 4 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence reactive reach, zone 4 |
| Factor K0 zone 4 | 0.00...5.00 | | 0.01 | 1.00 | Residual compensation factor magnitude, zone 4 |
| Factor K0 angle Zn4 | -179...180 | deg | 1 | 0 | Residual compensation factor angle, zone 4 |
| Min Ris Gnd Rch Zn4 | 0.00...500.00 | ohm | 0.01 | 100.00 | Minimum resistive reach of PE-loops, zone 4 |
| Max Ris Gnd Rch Zn4 | 0.00...500.00 | ohm | 0.01 | 100.00 | Maximum resistive reach of PE-loops, zone 4 |
| Gnd operate Dl Zn4 | 20...60000 | ms | 1 | 20 | Time delay to operate of PE-loops, zone 4 |
| Directional mode Zn5 | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode, zone 5 |
| Op Mod PP loops Zn5 | 0=False<br>1=True | | | 0=False | Enable PP/3P-loop measurement, zone 5 |
| PP Op delay Mod Zn5 | 0=False<br>1=True | | | 1=True | Enable operate timer for PP/3P-loops, zone 5 |
| R1 zone 5 | 0.00...3000.00 | ohm | 0.01 | 40.00 | ositive sequence resistive reach, zone 5 |
| X1 zone 5 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive reach, zone 5 |
| X1 reverse zone 5 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Pos. seq. reactive reach in rev. dir., non-dir. zone 5 |
| Z1 zone 5 | 0.01...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach, zone 5 |
| Z1 angle zone 5 | 15.0...90.0 | deg | 0.1 | 45.0 | Positive sequence line angle, zone 5 |
| Z1 reverse zone 5 | 0.00...3000.00 | ohm | 0.01 | 56.57 | Positive sequence reach in rev. dir., non-dir. zone 5 |
| Min Ris PP Rch Zn5 | 0.00...100.00 | ohm | 0.01 | 30.00 | Minimum resistive reach of PP/3P-loops, zone 5 |
| Max Ris PP Rch Zn5 | 0.00...100.00 | ohm | 0.01 | 30.00 | Maximum resistive reach of PP/3P-loops, zone 5 |
| PP operate delay Zn5 | 20...60000 | ms | 1 | 20 | Time delay to operate of PP/3P-loops, zone 5 |
| Op Mod Gnd loops Zn5 | 0=False<br>1=True | | | 0=False | Enable PE-loop measurement, zone 5 |
| Gnd Op Dl mode Zn5 | 0=False<br>1=True | | | 1=True | Enable operate timer for PE-loops, zone 5 |
| Load Comp zone 5 | 0=False<br>1=True | | | 1=True | Enable load compensation for PE-loops, zone 5 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| R0 zone 5 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence resistive reach, zone 5 |
| X0 zone 5 | 0.00...3000.00 | ohm | 0.01 | 160.00 | Zero sequence reactive reach, zone 5 |
| Factor K0 zone 5 | 0.00...5.00 | | 0.01 | 1.00 | Residual compensation factor magnitude, zone 5 |
| Factor K0 angle Zn5 | -179...180 | deg | 1 | 0 | Residual compensation factor angle, zone 5 |
| Min Ris Gnd Rch Zn5 | 0.00...500.00 | ohm | 0.01 | 100.00 | Minimum resistive reach of PE-loops, zone 5 |
| Max Ris Gnd Rch Zn5 | 0.00...500.00 | ohm | 0.01 | 100.00 | Maximum resistive reach of PE-loops, zone 5 |
| Gnd operate Dl Zn5 | 20...60000 | ms | 1 | 20 | Time delay to operate of PE-loops, zone 5 |

**Table 929: DSTPDIS Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Gnd Op current 2 GFC | 0.10...10.00 | xIn | 0.01 | 1.00 | Res. curr. start value for slope 2, EF-detection function |
| Stab slope 1 GFC | 0.00...0.30 | | 0.01 | 0.10 | Slope 1 for res. curr. stabilization, EF-detection function |
| Stab slope 2 GFC | 0.00...1.00 | | 0.01 | 1.00 | Slope 2 for res. current stabilization, EF-detection function |
| A Ph Stab value GFC | 1.00...10.00 | xIn | 0.01 | 2.00 | Phase current start value for slope 2, EF-detection function |
| Dir mode EF GFC | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 1=Non-directional | Directional mode, earth-fault directional function |
| Pol quantity GFC | -1=Zro vol.OR cur.<br>2=Zero seq. cur.<br>3=Zero seq. volt.<br>4=Neg. seq. volt. | | | 3=Zero seq. volt. | Polarization method, earth-fault directional function |
| Chr angle GFC | -179...180 | deg | 1 | 75 | Characteristic angle, earth-fault directional function |
| Max phase angle GFC | 0...90 | deg | 1 | 80 | Right hand side angle, earth-fault directional function |
| Min phase angle GFC | 0...90 | deg | 1 | 80 | Left hand side angle, earth-fault directional function |
| Cross-country Dl GFC | 0...10000 | ms | 10 | 100 | Time delay for residual current, XC-fault detection function |
| Tilt angle zone 1 | -45...45 | deg | 1 | 0 | Tilt angle (positive value increases zone area), zone 1 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Par line Comp zone 1 | 0=False<br>1=True | | | 0=False | Enable parallel line compensation for PE-loops, zone 1 |
| Mutual R0 zone 1 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual resistance, zone 1 |
| Mutual X0 zone 1 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual reactance, zone 1 |
| Tilt angle zone 2 | -45...45 | deg | 1 | 0 | Tilt angle (positive value increases zone area), zone 2 |
| Par line Comp zone 2 | 0=False<br>1=True | | | 0=False | Enable parallel line compensation for PE-loops, zone 2 |
| Mutual R0 zone 2 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual resistance, zone 2 |
| Mutual X0 zone 2 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual reactance, zone 2 |
| Tilt angle zone 3 | -45...45 | deg | 1 | 0 | Tilt angle (positive value increases zone area), zone 3 |
| Par line Comp zone 3 | 0=False<br>1=True | | | 0=False | Enable parallel line compensation for PE-loops, zone 3 |
| Mutual R0 zone 3 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual resistance, zone 3 |
| Mutual X0 zone 3 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual reactance, zone 3 |
| Tilt angle zone 4 | -45...45 | deg | 1 | 0 | Tilt angle (positive value increases zone area), zone 4 |
| Par line Comp zone 4 | 0=False<br>1=True | | | 0=False | Enable parallel line compensation for PE-loops, zone 4 |
| Mutual R0 zone 4 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual resistance, zone 4 |
| Mutual X0 zone 4 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual reactance, zone 4 |
| Tilt angle zone 5 | -45...45 | deg | 1 | 0 | Tilt angle (positive value increases zone area), zone 5 |
| Par line Comp zone 5 | 0=False<br>1=True | | | 0=False | Enable parallel line compensation for PE-loops, zone 5 |
| Mutual R0 zone 5 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual resistance, zone 5 |
| Mutual X0 zone 5 | 0.00...3000.00 | ohm | 0.01 | 40.00 | Parallel line zero sequence mutual reactance, zone 5 |

**Table 930: DSTPDIS Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on | | | 1=on | Operation Off / On |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 5=off | | | | |
| Phase voltage Meas | 1=Accurate<br>2=Ph-to-ph without Uo | | | 1=Accurate | Phase voltage measurement principle |
| Select active zones | 1=Zone 1<br>2=Zones 1-2<br>3=Zones 1-3<br>4=Zones 1-4<br>5=All 5 zones | | | 1=Zone 1 | Active zones selection |
| System grounding GFC | 1=High impedance<br>2=Low impedance<br>3=From input | | | 2=Low impedance | Network neutral earthing method |
| Ph Prf mode Lo Z GFC | 1=All loops<br>2=PE only<br>3=PP only<br>4=BLK leading PE<br>5=BLK lagging PE | | | 1=All loops | Loop selection mode for low impedance earthed network |
| Ph Prf mode Hi Z GFC | 1=No filter<br>2=No preference<br>3=Cyc A-B-C-A<br>4=Cyc A-C-B-A<br>5=Acyc A-B-C<br>6=Acyc A-C-B<br>7=Acyc B-A-C<br>8=Acyc B-C-A<br>9=Acyc C-A-B<br>10=Acyc C-B-A | | | 1=No filter | Phase preference mode for high impedance earthed network |
| Impedance mode Zn | 1=Rectangular<br>2=Polar | | | 1=Rectangular | Impedance characteristic, underimpedance, PSL |
| Impedance Chr Gnd Zn | 1=Quadrilateral<br>2=Mho (circular)<br>3=Mho Dir line<br>4=Offset Dir line<br>5=Bullet (combi) | | | 1=Quadrilateral | Impedance characteristic for PE-loops, zones |
| Impedance Chr PP Zn | 1=Quadrilateral<br>2=Mho (circular)<br>3=Mho Dir line<br>4=Offset Dir line<br>5=Bullet (combi) | | | 1=Quadrilateral | Impedance characteristic for PP/3P-loops, zones |
| Pol quantity zone | 5=Cross pol<br>7=Pos. seq. volt.<br>1=Self pol | | | 7=Pos. seq. volt. | Mho polarization method for zones |
| Max phase angle zone | 0...60 | deg | 1 | 15 | Angle from R-axis to right hand side directional line |
| Min phase angle zone | 90...150 | deg | 1 | 115 | Angle from R-axis to left hand side directional line |

**Table 931: DSTPDIS Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| EF Cur stabilization | 0=False<br>1=True | | | 0=False | EF current stabilization enabled |
| Fact EF current Bal | 1.000...2.000 | | 0.001 | 1.200 | Residual current ratio for parallel line compensation |
| Zone timer mode | 1=Independent<br>2=Common | | | 1=Independent | Operate timer start mode, zones |
| Voltage Mem time | 0...300000 | ms | 10 | 40 | Voltage memory time |

## 4.7.1.10 DSTPDIS Monitored data

**Table 932: DSTPDIS Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| STARTS_GFC | Enum | 4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault<br>-5=No fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault | | Start signals for phases A, B and C, GFC |
| RELEASE_PE | Enum | -5=No fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault | | Release signals for PE-loops, GFC |
| RELEASE_PP | Enum | 5=BC Fault<br>6=CA Fault<br>7=ABC Fault<br>4=AB Fault<br>-5=No fault | | Release signals for PP/3P loops, GFC |
| EARTH_FLT | BOOLEAN | 0=False<br>1=True | | Indication of a single phase earth-fault, GFC |
| DIR_E_FLT | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Earth-fault direction (low imp. earthed), GFC |
| STARTS_Z1 | INT32 | -5...63 | | Start signals for phases A, B and C, zone 1 |
| STARTS_Z2 | INT32 | -5...63 | | Start signals for phases A, B and C, zone 2 |
| STARTS_Z3 | INT32 | -5...63 | | Start signals for phases A, B and C, zone 3 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| STARTS_Z4 | INT32 | -5...63 | | Start signals for phases A, B and C, zone 4 |
| STARTS_Z5 | INT32 | -5...63 | | Start signals for phases A, B and C, zone 5 |
| DIR_LOOP_R | FLOAT32 | -3000.00...3000.00 | ohm | Resistance used in dir. evaluation, zone 1 |
| DIR_LOOP_X | FLOAT32 | -3000.00...3000.00 | ohm | Reactance used in dir. eval., zone 1 |
| FLTLOOP_RFST | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 1 |
| FLTLOOP_XFST | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 1 |
| FLTLOOP_RSND | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 1 |
| FLTLOOP_XSND | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 1 |
| FLTLOOP_RPP | FLOAT32 | -3000.00...3000.00 | ohm | PP/3P-loop resistance, zone 1 |
| FLTLOOP_XPP | FLOAT32 | -3000.00...3000.00 | ohm | PP/3P-loop reactance, zone 1 |
| FLTPH_X | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 1 |
| VMEM_USED | BOOLEAN | 0=False<br>1=True | | Voltage memory in use status |
| TLT_ANG_CONFLICT | INT32 | 0...1023 | | Tilt angle conflict |
| DSTPDIS | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| Time | Timestamp | | | Time |
| Release PE-loop | Enum | -5=No fault<br>-4=ABCG Fault<br>-3=CAG Fault<br>-2=BCG Fault<br>-1=ABG Fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault | | Release signals for PE-loops, GFC |
| Release PP-loop | Enum | -5=No fault<br>-4=ABCG Fault<br>-3=CAG Fault<br>-2=BCG Fault<br>-1=ABG Fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault | | Release signals for PP/3P loops. GFC |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 5=BC Fault<br>6=CA Fault<br>7=ABC Fault | | |
| Cross country fault | BOOLEAN | 0=False<br>1=True | | Indication of a cross-country-fault (high imp. earthed), GFC |
| Earth fault detected | BOOLEAN | 0=False<br>1=True | | Indication of a single phase earth-fault, GFC |
| Earth-fault direction | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Earth-fault direction (low impedance earthed), GFC |
| Operate of all zones | INT32 | 0...31 | | Operate signal of all zones |
| Fault/load Dir Zn1 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 1 |
| Dir resistance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 1 |
| Dir reactance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 1 |
| Flt loop 1st Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 1 |
| Flt loop 1st Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 1 |
| Flt loop 2nd Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 1 |
| Flt loop 2nd Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 1 |
| Flt PP-loop Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 1 |
| Flt PP-loop Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 1 |
| Phase reactance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 1 |
| Fault/load Dir Zn2 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 2 |
| Dir resistance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 2 |
| Dir reactance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 2 |
| Flt loop 1st Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 2 |
| Flt loop 1st Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 2 |
| Flt loop 2nd Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 2 |
| Flt loop 2nd Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 2 |
| Flt PP-loop Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 2 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Flt PP-loop Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 2 |
| Phase reactance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 2 |
| Fault/load Dir Zn3 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 3 |
| Dir resistance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 3 |
| Dir reactance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 3 |
| Flt loop 1st Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 3 |
| Flt loop 1st Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 3 |
| Flt loop 2nd Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 3 |
| Flt loop 2nd Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 3 |
| Flt PP-loop Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 3 |
| Flt PP-loop Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 3 |
| Phase reactance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 3 |
| Fault/load Dir Zn4 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 4 |
| Dir resistance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 4 |
| Dir reactance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 4 |
| Flt loop 1st Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 4 |
| Flt loop 1st Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 4 |
| Flt loop 2nd Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 4 |
| Flt loop 2nd Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 4 |
| Flt PP-loop Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 4 |
| Flt PP-loop Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 4 |
| Phase reactance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 4 |
| Fault/load Dir Zn5 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 5 |
| Dir resistance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 5 |
| Dir reactance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 5 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Flt loop 1st Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 5 |
| Flt loop 1st Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 5 |
| Flt loop 2nd Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 5 |
| Flt loop 2nd Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 5 |
| Flt PP-loop Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 5 |
| Flt PP-loop Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 5 |
| Phase reactance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 5 |
| Time | Timestamp | | | Time |
| Release PE-loop | Enum | -5=No fault<br>-4=ABCG Fault<br>-3=CAG Fault<br>-2=BCG Fault<br>-1=ABG Fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault | | Release signals for PE-loops, GFC |
| Release PP-loop | Enum | -5=No fault<br>-4=ABCG Fault<br>-3=CAG Fault<br>-2=BCG Fault<br>-1=ABG Fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault | | Release signals for PP/3P loops. GFC |
| Cross country fault | BOOLEAN | 0=False<br>1=True | | Indication of a cross-country-fault (high imp. earthed), GFC |
| Earth fault detected | BOOLEAN | 0=False<br>1=True | | Indication of a single phase earth-fault, GFC |
| Earth-fault direction | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Earth-fault direction (low impedance earthed), GFC |
| Operate of all zones | INT32 | 0...31 | | Operate signal of all zones |
| Fault/load Dir Zn1 | Enum | 0=unknown | | Direction of fault or load zone 1 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 1=forward<br>2=backward<br>3=both | | |
| Dir resistance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 1 |
| Dir reactance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 1 |
| Flt loop 1st Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 1 |
| Flt loop 1st Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 1 |
| Flt loop 2nd Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 1 |
| Flt loop 2nd Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 1 |
| Flt PP-loop Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 1 |
| Flt PP-loop Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 1 |
| Phase reactance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 1 |
| Fault/load Dir Zn2 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 2 |
| Dir resistance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 2 |
| Dir reactance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 2 |
| Flt loop 1st Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 2 |
| Flt loop 1st Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 2 |
| Flt loop 2nd Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 2 |
| Flt loop 2nd Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 2 |
| Flt PP-loop Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 2 |
| Flt PP-loop Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 2 |
| Phase reactance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 2 |
| Fault/load Dir Zn3 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 3 |
| Dir resistance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 3 |
| Dir reactance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 3 |
| Flt loop 1st Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 3 |
| Flt loop 1st Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 3 |
| Flt loop 2nd Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 3 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Flt loop 2nd Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 3 |
| Flt PP-loop Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 3 |
| Flt PP-loop Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 3 |
| Phase reactance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 3 |
| Fault/load Dir Zn4 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 4 |
| Dir resistance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 4 |
| Dir reactance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 4 |
| Flt loop 1st Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 4 |
| Flt loop 1st Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 4 |
| Flt loop 2nd Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 4 |
| Flt loop 2nd Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 4 |
| Flt PP-loop Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 4 |
| Flt PP-loop Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 4 |
| Phase reactance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 4 |
| Fault/load Dir Zn5 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 5 |
| Dir resistance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 5 |
| Dir reactance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 5 |
| Flt loop 1st Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 5 |
| Flt loop 1st Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 5 |
| Flt loop 2nd Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 5 |
| Flt loop 2nd Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 5 |
| Flt PP-loop Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 5 |
| Flt PP-loop Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 5 |
| Phase reactance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 5 |
| Time | Timestamp | | | Time |
| Release PE-loop | Enum | -5=No fault<br>-4=ABCG Fault<br>-3=CAG Fault | | Release signals for PE-loops, GFC |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | -2=BCG Fault<br>-1=ABG Fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault | | |
| Release PP-loop | Enum | -5=No fault<br>-4=ABCG Fault<br>-3=CAG Fault<br>-2=BCG Fault<br>-1=ABG Fault<br>1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault | | Release signals for PP/3P loops. GFC |
| Cross country fault | BOOLEAN | 0=False<br>1=True | | Indication of a cross-country-fault (high imp. earthed), GFC |
| Earth fault detected | BOOLEAN | 0=False<br>1=True | | Indication of a single phase earth-fault, GFC |
| Earth-fault direction | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Earth-fault direction (low impedance earthed), GFC |
| Operate of all zones | INT32 | 0...31 | | Operate signal of all zones |
| Fault/load Dir Zn1 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 1 |
| Dir resistance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 1 |
| Dir reactance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 1 |
| Flt loop 1st Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 1 |
| Flt loop 1st Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 1 |
| Flt loop 2nd Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 1 |
| Flt loop 2nd Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 1 |
| Flt PP-loop Ris Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 1 |
| Flt PP-loop Rea Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 1 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Phase reactance Zn1 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 1 |
| Fault/load Dir Zn2 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 2 |
| Dir resistance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 2 |
| Dir reactance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 2 |
| Flt loop 1st Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 2 |
| Flt loop 1st Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 2 |
| Flt loop 2nd Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 2 |
| Flt loop 2nd Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 2 |
| Flt PP-loop Ris Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 2 |
| Flt PP-loop Rea Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 2 |
| Phase reactance Zn2 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 2 |
| Fault/load Dir Zn3 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 3 |
| Dir resistance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 3 |
| Dir reactance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 3 |
| Flt loop 1st Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 3 |
| Flt loop 1st Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 3 |
| Flt loop 2nd Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 3 |
| Flt loop 2nd Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 3 |
| Flt PP-loop Ris Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 3 |
| Flt PP-loop Rea Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 3 |
| Phase reactance Zn3 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 3 |
| Fault/load Dir Zn4 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 4 |
| Dir resistance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 4 |
| Dir reactance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 4 |
| Flt loop 1st Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 4 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Flt loop 1st Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 4 |
| Flt loop 2nd Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 4 |
| Flt loop 2nd Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 4 |
| Flt PP-loop Ris Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 4 |
| Flt PP-loop Rea Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 4 |
| Phase reactance Zn4 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 4 |
| Fault/load Dir Zn5 | Enum | 0=unknown<br>1=forward<br>2=backward<br>3=both | | Direction of fault or load zone 5 |
| Dir resistance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Direction resistance, zone 5 |
| Dir reactance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Direction reactance, zone 5 |
| Flt loop 1st Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop resistance, zone 5 |
| Flt loop 1st Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | First PE-loop reactance, zone 5 |
| Flt loop 2nd Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop resistance, zone 5 |
| Flt loop 2nd Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Second PE-loop reactance, zone 5 |
| Flt PP-loop Ris Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop resistance, zone 5 |
| Flt PP-loop Rea Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | PP-loop reactance, zone 5 |
| Phase reactance Zn5 | FLOAT32 | -3000.00...3000.00 | ohm | Phase to earth reactance in phase domain, zone 5 |

### 4.7.1.11 Technical data

**Table 933: DSTPDIS Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$<br>Current:<br>±1.5% of the set value or ±0.002 × $I_n$ Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Impedance:<br>±2.5% of the set value or ±0.05 Ω Phase angle: ±2° |
| Shortest operate time [1] SIR [2]: 0.1...50 | 25 ms |

*Table continues on the next page*

[1] Measured with static power output (SPO)

| Characteristic | Value |
|---|---|
| Transient overreach SIR = 0.1...50 | <8.5% |
| Reset time | Typically 45 ms |
| Reset ratio | Typically 0.96/1.04 |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

#### 4.7.1.12 Technical revision history

**Table 934: DSTPDIS Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | B | New outputs added: DIRECTION_Z1...Z5. Setting *Factor K0 zone 1...5* range extended to 0.00...5.00. Setting *Factor K0 angle Zn1...5* range extended to -180...180. Setting *Min phase angle zone* range extended to 90....150. Setting *Max phase angle zone* range extended to 0...60 |

### 4.7.2 Out of step OOSRPSB (ANSI 78PS)

#### 4.7.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Out-of-step protection with double blinders | OOSRPSB | OOS | 78PS |

#### 4.7.2.2 Function block

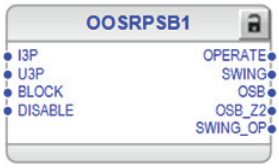



*Figure 558: Function block*

#### 4.7.2.3 Functionality

The Out-of-step protection with double blinders function OOSRPSB detects out of step conditions by monitoring impedance.

[2] SIR = Source impedance ratio

The protection uses two impedance measurement elements known as inner and outer blinders on mho characteristics with a timer. The function calculates the impedance. If the measured impedance stays between inner and outer blinder for a predetermined time and moves farther inside the inner blinder, then an out of step condition is indicated. Operate is generated if out of step is indicated and impedance moves out of mho characteristics. The mho characteristic can be divided into two zones so separate trips can be generated based on the zone. Operating can also be selected to occur when the impedance is on the way into the zone or for when the impedance is on the way out of the zone.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.7.2.4 Analog channel configuration

OOSRPSB has two analog group inputs which must be properly configured.

**Table 935: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 936: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.7.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of OOSRPSB can be described using a module diagram. All the modules in the diagram are explained in the next sections.

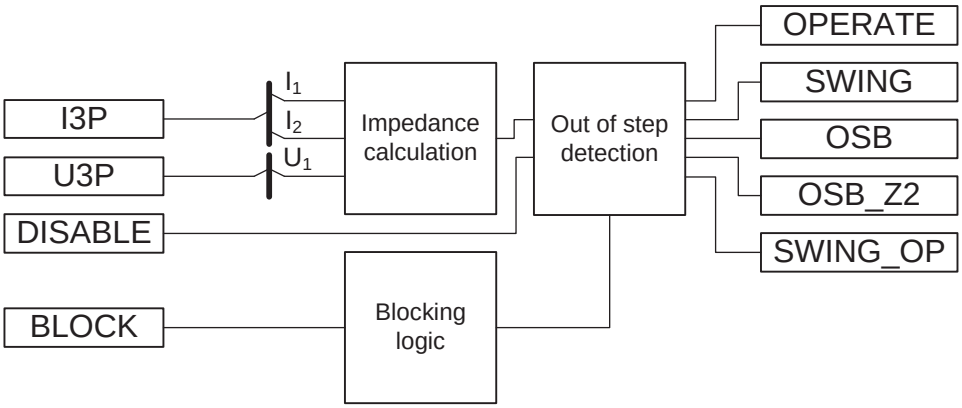



*Figure 559: Functional module diagram*

### Impedance calculation

This module calculates the positive-sequence impedance (Z1) using positive-sequence voltage and current. For the module to calculate impedance it is required that the positive-sequence current is above *Min Ps Seq current* setting and the negative-sequence current is below the *Max Ng Seq current* setting.

The calculated positive-sequence impedance amplitude Z1_AMPL and angle Z1_ANGLE are available in ohms and degrees, respectively, in the Monitored data view.

The calculated impedance is converted to ohms as the operating characteristics are defined with the ohm settings.

### Out of step detection

The operating characteristic is a circular offset mho on the impedance plane with two pair of blinders. The mho characteristic is defined with the *Forward reach*, *Reverse reach*, and *Impedance angle* settings. *Forward reach* defines the impedance from the origin to the edge of circle on the top side. *Reverse reach* defines the impedance from the origin to the edge of the circle on the bottom side. The diameter of the mho characteristics is the sum of *Forward reach* and *Reverse reach* settings. Two sets of blinders are defined by *Inner blinder R* and *Outer blinder R* intercepting at R-axis. The blinders are at the same angle as the *Impedance angle*. The second blinder of each outer and inner pair is automatically made symmetrical with the origin of the R-X plane.

For a correct operation, it is required that the setting for *Inner blinder R* is less than the setting for *Outer blinder R*.

The circular mho characteristic can be further divided into two zones by setting *Zone 2 enable* to “Yes”. The boundary between zones is set using the setting *Zone 1 reach*. The lower portion of the circle, Zone 1, is separated from the upper portion, Zone 2, by a line, perpendicular to the blinders, located at a set percentage of the *Forward reach* setting from the origin.

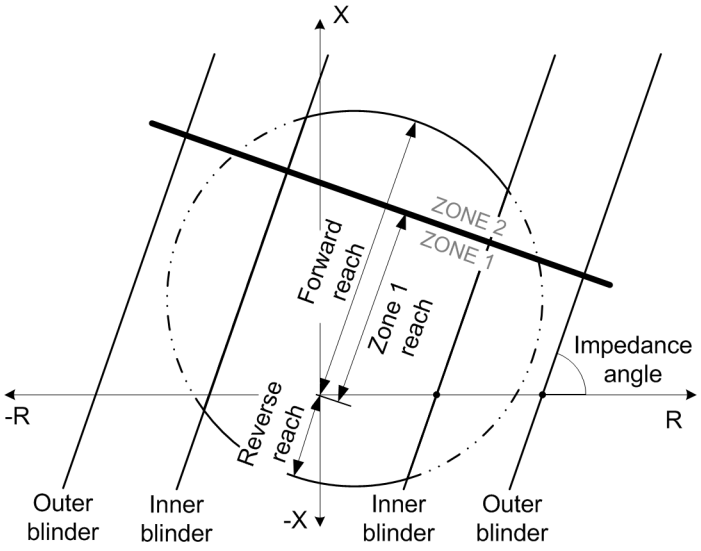



*Figure 560: Operating region for out of step with double blinder*

An impedance is only considered to be within the mho circle if it is also between the inner blinders.

A third zone, Zone 3, can be enabled by setting *Zone 3 enable* to “Yes”. Zone 3 is defined to include the area outside of the circular mho characteristic but inside the area that is bound with the magnitude of the minimum positive-sequence current defined by setting *Min Ps Seq*. *Figure 561* shows the three zones. Settings that determine the shape of the zones should be coordinated with the settings for any distance protection functions. The zones and their respective slip counters are applicable only for Way out operations when the *Oos operation mode* setting option is “Way out” or “Adaptive”.

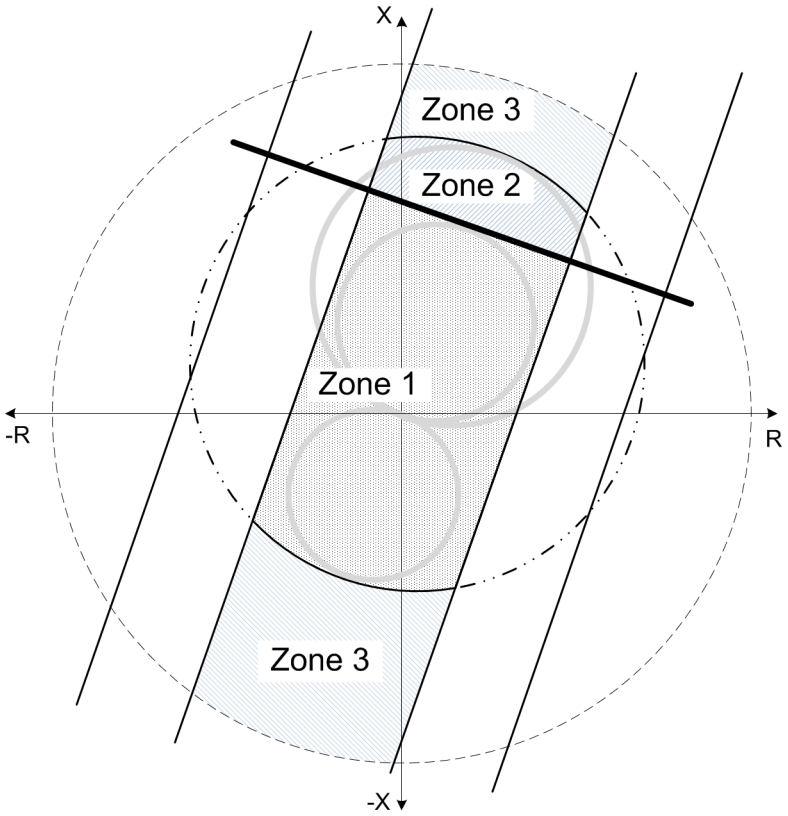



*Figure 561: Defined zones*

The impedance is continuously monitored for detecting an out of step condition. When the impedance enters inside from the outer blinder, the out of step detection timer is triggered. If impedance remains between outer and inner blinder for the duration of the *Swing time* setting, output SWING is activated. If the impedance enters the mho circle in zone 1, out of step blocking ( OSB) for zone 1 is detected and output OSB is activated, or if the impedance enters the mho circle in zone 2, OSB for zone 2 is detected and output OSB_Z2 is activated if setting *Zone 2 enable* is set to “Yes”. Both OSB and OSB_Z2 can be activated if the impedance passes through zone 1 and zone 2 while inside the mho circle. The OSB or OSB_Z2 output deactivates when impedance exits and remains outside the mho circle and the inner blinder for a duration of five cycles.

Activation of the OPERATE output depends on the *Oos operate mode* selected. The available options are “Way in”, “Way out”, and “Adaptive”. If the “Way in” option is selected, the function triggers the delay timer after detecting an OSB condition. When the set *Operate delay time* has elapsed, the OPERATE output is activated. When using the “Way in” option, the zone-related settings and zone slip counters are not applicable.

If the “Way out” option is selected, after detecting an OSB condition, the function further checks if impedance exits the outer blinder. On exiting the outer blinder, Way out timer defined by *Operate delay time* setting is triggered and the respective zone slip counter is incremented after the set *Operate delay time* has elapsed. If the slip counter value is equal to the set number of slips in the respective enabled zone, the OPERATE output is activated. If the swing impedance passes through both zone 1 and zone 2, only the zone 1 slip counter is incremented. The zone 2 slip counter is incremented if the impedance passes through the Mho circle but only through the zone 2 portion. The zone 3 slip counter is incremented if the impedance misses the

Mho circle entirely and the setting *Zone 3 enable* is also set to “Yes”. Increment of the slip counter triggers also the Reset timer. All of the zone slip counters reset after the set *Reset time* has elapsed and the impedance does not cross into the outer blinder again, or on activation of the OPERATE output.

When the “Way out” or "Adaptive" option is selected, the breaker open time, if known, can be incorporated to optimize breaker trip time when a way out trip command is issued. The ideal time for the breaker to interrupt current is when the swing angle approaches zero. If the swing angle is $\delta_0$ when the impedance exits the outer blinder, the dynamic Trip delay, $T_{od}$, can be set as shown in *Equation 273*.

$$T_{od} = \frac{1 - 2 \cdot f_{slip} \cdot (T_{co} + BrkropenTm)}{2 \cdot f_{slip}}$$

(Equation 273)

| | |
|---|---|
| $T_{od}$ | Dynamic Trip delay |
| $T_{co}$ | The time for the impedance to travel from the center impedance line (where the swing angle is π radians) to the outer blinder on the opposite side from which it entered. |
| BrkopenTm | Set *Breaker open time* |
| $f_{slip}$ | Slip frequency |

The *Breaker open time* setting should include the time from when the relay issues a trip command to the time when the breaker receives the command. The function uses the *Breaker open time* setting to determine the trip delay time if it is not set to “0”. If the *Breaker open time* is set to “0”, the function does not dynamically calculate a trip delay but uses the fixed *Operate delay time* before activating the OPERATE output.

The slip frequency is calculated using *Equation 274*.

$$f_{slip} = \frac{\delta_i - \delta_0}{2 \cdot \pi \cdot T_{oi}}$$

(Equation 274)

| | |
|---|---|
| $f_{slip}$ | Slip frequency |
| $T_{oi}$ | The time for the impedance to pass from the outer to the inner blinder. |
| $\delta_0$ | Swing angle at the outer blinder |
| $\delta_I$ | Swing angle at the inner blinder |

The swing angles, $\delta_0$ and $\delta_I$, are estimated from the measured impedance when crossing the blinders. It is the difference in these quantities that is important for determining the slip frequency.

If the “Adaptive” option is selected, after detecting an OSB condition, the function further examines the slip frequency $f_{slip}$, *V dip time* setting, and swing angle at the outer blinder ($\delta_0$) to determine if the operate is asserted on the way in or on the way out. OPERATE is activated on the way in, entering the mho circle from an inner blinder, if the relationship in *Equation 275* is true.

$$f_{slip} \le \frac{(\pi - \delta_0)}{\pi \cdot VoltagedipTm}$$

(Equation 275)

| | |
|---|---|
| $f_{slip}$ | Slip frequency |
| $\delta_0$ | Swing angle at the outer blinder |
| VoltagedipTm | Set *V dip time* |

Otherwise, OPERATE is activated on the way out, when the impedance exits an outer blinder and the swing repeats for the set *Max number slips* count in the respective enabled zone that the swing has passed through.

If the *Swing time* has elapsed but the impedance exits the inner blinder and continues through the opposite blinders without passing through the mho circle, the SWING output is activated. The SWING output remains activated for a time determined by the *Reset time* setting unless another swing occurs before the reset time expires causing the output to remain active for another *Reset time* interval. If this swing is repeated for the set *Max Num slips Zn3* count and the *Zone 3 enable* setting is “Yes”, the SWING_OP output is activated. The SWING_OP output remains activated for a time determined by the *Operate dropout time* setting.

If the “Adaptive” option is selected and an OSB condition is not detected, but the impedance enters the mho circle after remaining between the inner and outer blinders for greater than 1.5 cycles, the function assumes a severe swing and assert the OPERATE output.

The drop out delay for OPERATE output can be set by *Operate dropout time* setting.

If the polarity of the voltage signal is opposite to the normal polarity, the correction can be done by setting *Voltage reversal* to “Yes”, which rotates the impedance vector by 180 degrees.

The DISABLE input can be used to coordinate the correct operation during the start-up situation. The function is blocked by activating the DISABLE signal. Once the DISABLE signal is deactivated, the function remains blocked (outputs disabled) for additional time duration as set through the setting *Disable time*.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, the function operates normally but the OPERATE output is not activated.

### 4.7.2.6 Application

Out of step protection functions detect stable power swings and out of step conditions based on the fact that the voltage/current variation during a power swing is slow compared to the step change during a fault. Both faults and power swings may cause the measured impedance to enter into the operating characteristic of a distance relay element. The apparent impedance moves from the pre-fault value to a fault value in a very short time, a few milliseconds, during a fault condition. However, the rate of change of the impedance is much slower during a power swing or out of step condition than during a fault depending on the slip frequency of the out of step. The impedance measurement should not be used by itself to distinguish between a fault condition and an out of step condition from a phase fault. The fundamental method for discriminating between faults and power swings is to track the rate of change of the measured impedance.

The function measures the rate of change of the impedance using two impedance measurement elements known as blinders together with a timing device. If the measured impedance stays between the blinders for a predetermined time, the function declares a power swing condition and asserts an output that can be used to block the distance protection. However, if the impedance passes the inner blinder and exits on the other side of the mho characteristics (that is, the resistive component of impedance has opposite sign as at the time of point of entry) an out of step operate is issued by the function. *Figure 562* gives an example of out of step detection.

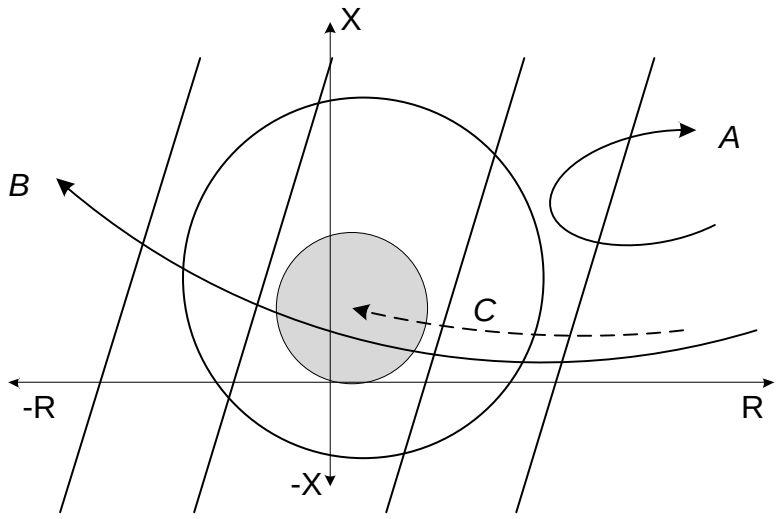



*Figure 562: Example of out of step detection*

The shaded region indicates a fault zone in a distance protection function. For curve A, the impedance moves into the out of step zone and leaves slowly, indicating the occurrence of a swing that quickly stabilizes. For curve B, the impedance moves slowly into the out of step zone and exits the zone indicating that the network is becoming unstable. For curve C, impedance rapidly moves into, and remains in, the fault zone indicating an actual fault and not an out of step condition.

### 4.7.2.7 Signals

**OOSRPSB Input signals**

**Table 937: OOSRPSB Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| DISABLE | BOOLEAN | 0=False | Disable input |

**OOSRPSB Output signals**

**Table 938: OOSRPSB Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Out of step operate on zone 1 or zone 2 |
| SWING | BOOLEAN | Swing condition detected |
| OSB | BOOLEAN | Out of step block for zone 1 |
| OSB_Z2 | BOOLEAN | Out of step block for zone 2 |
| SWING_OP | BOOLEAN | Out of step operate on zone 3 |

## 4.7.2.8 OOSRPSB Settings

**Table 939: OOSRPSB Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Oos operate mode | 1=Way in<br>2=Way out<br>3=Adaptive | | | 2=Way out | Operate mode for tripping when out of step condition is detected |
| Forward reach | 0.00...6000.00 | ohm | 0.01 | 1000.00 | Forward reach of mho circle |
| Reverse reach | 0.00...6000.00 | ohm | 0.01 | 100.00 | Reverse reach of mho circle |
| Inner blinder R | 1.00...6000.00 | ohm | 0.01 | 150.00 | Resistance value if inner blinder at R axis |
| Outer blinder R | 1.01...10000.00 | ohm | 0.01 | 400.00 | Resistance value of outer blinder at R axis |
| Impedance angle | 10.0...90.0 | deg | 0.1 | 90.0 | Angle of mho circle and blinders with respect to R axis |
| Swing time | 20...300000 | ms | 10 | 500 | Time between blinders for swing to be detected |

**Table 940: OOSRPSB Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Zone 1 reach | 1...100 | % | 1 | 70 | Percent of Mho forward reach indicating the end of zone 1 and the beginning of zone 2 |
| Max number slips | 1...10 | | 1 | 1 | Number of pole slips before operating zone 1 |
| Max Num slips Zn2 | 1...20 | | 1 | 1 | Number of pole slips before operating zone 2 |
| Max Num slips Zn3 | 1...20 | | 1 | 1 | Number of pole slips before operating zone 3 |
| Operate delay time | 20...60000 | ms | 10 | 300 | Delay after OOS operate detected |
| Operate dropout time | 20...60000 | ms | 10 | 100 | Time operate output remains active |
| V dip time | 500...5000 | ms | 10 | 2000 | Maximum allowable time for voltage to dip |
| Zone 2 enable | 1=Yes<br>0=No | | | 0=No | Enable zone 2 feature |
| Zone 3 enable | 1=Yes<br>0=No | | | 0=No | Enable zone 3 feature |

**Table 941: OOSRPSB Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 942: OOSRPSB Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min Ps Seq current | 0.01...10.00 | xIn | 0.01 | 0.10 | Minimum positive sequence current for operation |
| Max Ng Seq current | 0.01...10.00 | xIn | 0.01 | 0.20 | Maximum negative sequence current for operation |
| Breaker open time | 0...300 | ms | 1 | 30 | Opening time of the breaker |
| Disable time | 20...60000 | ms | 10 | 5000 | Additional time function is disabled after removal of DISABLE input |
| Reset time | 20...60000 | ms | 10 | 5000 | Time to reset OOS condition and counters |
| Voltage reversal | 0=No<br>1=Yes | | | 0=No | Rotate voltage signals by 180 degrees |

#### 4.7.2.9 OOSRPSB Monitored data

**Table 943: OOSRPSB Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Z1_AMPL | FLOAT32 | 0.00...99999.00 | ohm | Positive sequence impedance amplitude |
| Z1_ANGLE | FLOAT32 | -180...180 | deg | Positive sequence impedance phase angle |
| SLIP_CNT_Z1 | INT32 | 0...9999 | | Zone 1 slip counter |
| SLIP_CNT_Z2 | INT32 | 0...9999 | | Zone 2 slip counter |
| SLIP_CNT_Z3 | INT32 | 0...9999 | | Zone 3 slip counter |
| OOSRPSB | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.7.2.10 Technical data

**Table 944: OOSRPSB Technical data**

| Characteristic | Value |
|---|---|
| Impedance reach | Depending on the frequency of the measured current and voltage: $f_n$ ±2 Hz |
| | ±3.0% of the reach value or ±0.2% of $U_n/(\sqrt{3} \times I_n)$ |
| Reset time | ±1.0% of the set value or ±40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5... |

### 4.7.3 Three-phase underexcitation protection UEXPDIS (ANSI 40)

#### 4.7.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase underexcitation protection | UEXPDIS | X< | 40 |

### 4.7.3.2 Function block




*Figure 563: Function block*

### 4.7.3.3 Functionality

The three-phase underexcitation protection function UEXPDIS is used to protect the synchronous machine against the underexcitation or loss of excitation condition.

The protection is based on the offset-mho circular characteristics on the impedance plane. The function calculates the apparent impedance from the machine terminal voltages and currents. If the impedance vector enters the offset-mho circle, the function gives the operating signal after a set definite time. The operating time characteristics are according to definite time (DT).

This function contains a blocking functionality. It is possible to block the function outputs, timer or the function itself.

### 4.7.3.4 Analog channel configuration

UEXPDIS has two analog group inputs which all must be properly configured.

**Table 945: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 946: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected (*Phase Sel for Z Clc* set to "A or AB", "B or BC" or "C or CA"), if the setting *Impedance Meas mode* is set to "1Phase-to-earth" or "1Phaseto- phase". |
| | The function requires that at least two (the third voltage will be derived) or all three voltage channels are connected if *Impedance Meas mode* is set to "3Phase-to-earth", "3Phase-to-phase" or "Pos sequence". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.7.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of UEXPDIS can be described using a module diagram. All the modules in the diagram are explained in the next sections.

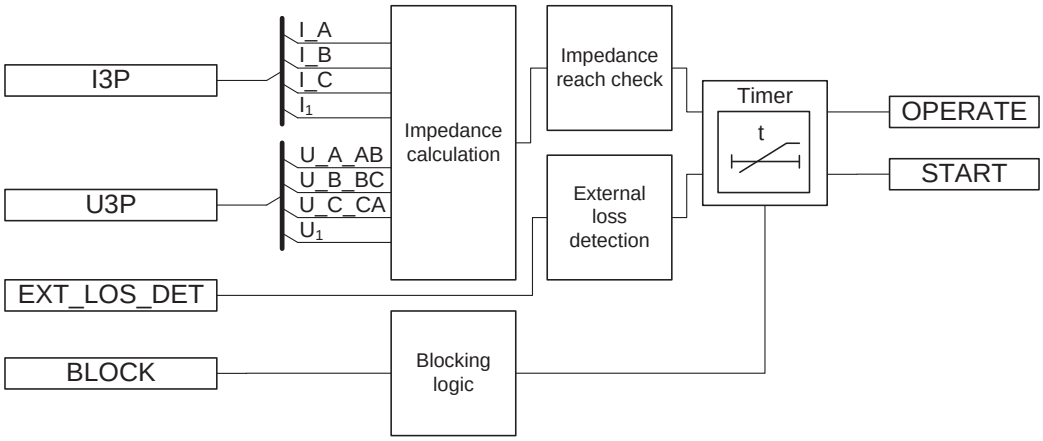



*Figure 564: Functional module diagram*

#### Impedance calculation

This module calculates the apparent impedance based on the selected voltages and currents. The *Measurement mode* and *Phase Sel for Z Clc* settings determine which voltages and currents are to be used. If the *Measurement mode* is set to "1Phase-earth" or "1Phase-phase", the *Phase Sel for Z Clc* setting is needed for determining which phase or phase-phase voltages ("A or AB", "B or BC" and "C or CA") and currents should be used for calculating the impedance.

**Table 947: Voltages and currents used in impedance calculation**

| Measurement mode | Phase Sel for Z Clc | Voltages and currents |
|---|---|---|
| 1Phase-earth | A or AB | U_A, I_A |
| 1Phase-earth | B or BC | U_B, I_B |
| 1Phase-earth | C or CA | U_C, I_C |
| 1Phase-phase | A or AB | U_AB, I_A, I_B |
| 1Phase-phase | B or BC | U_BC, I_B, I_C |
| 1Phase-phase | C or CA | U_CA, I_C, I_A |
| 3Phase-earth | N/A | U_A, U_B, U_C, I_A, I_B, I_C |

*Table continues on the next page*

| Measurement mode | Phase Sel for Z Clc | Voltages and currents |
|---|---|---|
| 3Phase-phase | N/A | U_AB, U_BC, U_CA, I_A, I_B, I_C |
| Pos seqn | N/A | { U_A,U_B,U_C } or { U_AB,U_BC,U_CA } and I_A, I_B, I_C |

If all three phase voltages and phase currents are fed to the protection relay, the positive-sequence alternative is recommended.

If the polarity of the voltage signals is opposite to the normal polarity, the correction can be done by setting *Voltage reversal* to "Yes", which rotates the impedance vector by 180 degrees.

If the magnitude of the voltage is less than 0.05 · $U_N$, the calculated impedance is not reliable and the impedance calculation is disabled. $U_N$ is the rated phase-to-phase voltage.

The calculated impedance magnitudes and angles are available in the Monitored data view. The impedance angles are provided between -180...180 degrees.

The calculated apparent impedance is converted to pu impedance as the operating characteristics are defined with the pu settings.

**Impedance reach check**

The operating characteristic is a circular offset mho on the impedance plane. The operating characteristics are defined with the *Offset*, *Diameter* and *Displacement* settings. If the calculated impedance value enters the circle in the impedance plane, the module sends an enabling signal to start the Timer.

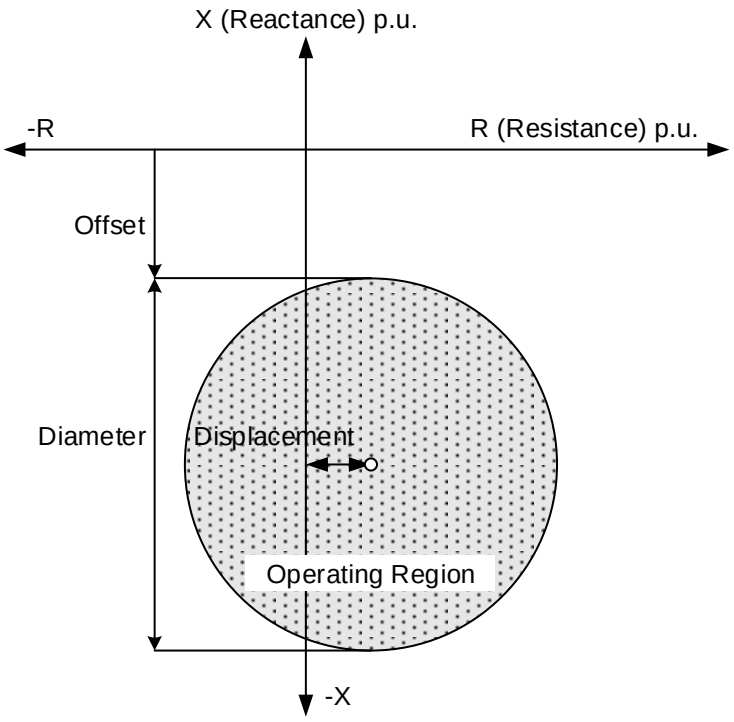



*Figure 565: Operating region of the impedance mho circle*

It is possible to add a restraint with the help of settings *Restraint enable*, *Rst offset X* and *Rst offset X angle*, as shown in the Figure *Figure 566*.

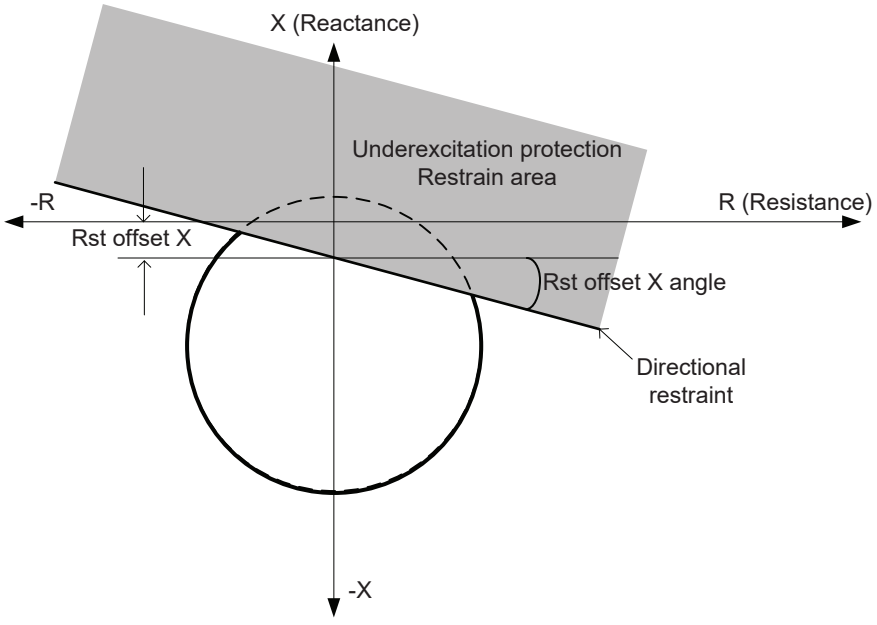



*Figure 566: Settings Restraint enable, Rst offset X and Rst offset X angle*

The directional restraint shown in *Figure 566* is obtained when both *Rst offset X* and *Rst offset X angle* are set with negative signs.

A fault in Automatic Voltage Regulator ( AVR) or in the excitation system may cause a total loss of excitation. A short circuit on the slip rings reduces the excitation voltage to zero. This causes a gradual reduction of the excitation current and eventually a loss of excitation. An open circuit in the field circuit also causes a loss of excitation. These are typical examples which cause underexcitation in synchronous machines. This module detects the underexcitation condition for the above cases when the calculated impedance enters the operating characteristics.

#### External loss detection

The module checks the status information of the excitation system. It is activated when the *External Los Det Ena* setting is set to "Enable". The total loss of excitation current or a failure in the excitation system is indicated by connecting the external binary signal to the EXT_LOS_DET input. The Timer is enabled immediately when the EXT_LOS_DET input is activated.

#### Timer

Once activated, the Timer activates the START output. The time characteristic is according to DT. When the duration of the underexcitation exceeds the set definite *Operate delay time*, the OPERATE output is activated. If the impedance locus moves out of the offset-mho operating characteristics before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operating timer resets and the START output is deactivated.

The Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time (DT). The value isavailable in the Monitored data view.

#### Blocking logic

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.7.3.6 Application

There are limits for the underexcitation of a synchronous machine. A reduction of the excitation current weakens the coupling between the rotor and the external power system. The machine may lose the synchronism and start to operate like an induction machine, which increases the consumption of the reactive power. Even if the machine does not lose synchronism, it is not recommended to operate in this state. The underexcitation causes excessive heating in the end region of the stator winding. This can damage the insulation of the stator winding and even the iron core.

The underexcitation also causes the generator to operate in the asynchronous mode. This increases the rotor speed, which causes heating in the rotor iron and damps the windings. A high intake of the reactive power from the network during underexcitation causes problems in the network, for example voltage dip, stability and power swings. Power swings stress the prime mover, causing for example turbine blade cavitation and mechanical stress in the gearbox.

The capability curve of a synchronous generator describes the underexcitation capability of the machine. An excessive capacitive load on the synchronous machine causes it to drop out-of-step. The reason is the steady-state stability limit as defined by the load angle being 90°, which can only be reached when the unit is underexcited.

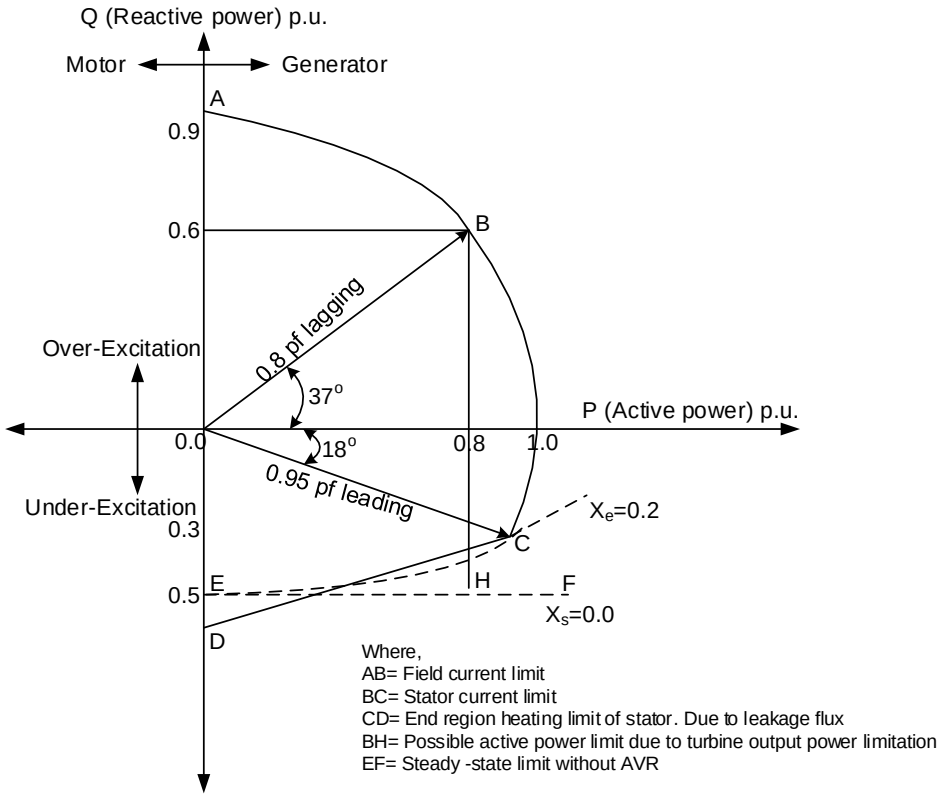



*Figure 567: Capability curve of a synchronous generator*

UEXPDIS protects the synchronous machines against an unstable operation due to loss of excitation. A partial or total loss of excitation causes a reactive power intake from the network to the machine, and the reactance of the system viewed from the machine terminals turns negative. This kind of drop-of-reactance condition can be detected by measuring the impedance of the system.

The operating characteristic is an offset-mho circle in the impedance plane, and the circle is parameterized with the *Offset*, *Diameter* and *Displacement* setting values. To avoid unwanted operation of the UEXPDIS function, a restrain area can be defined which is enabled with *Restraint enable* and parameterized with *Rst offset X* and *Rst offset X angle* setting values.

**Table 948: Parameters of the circle**

| Setting values | Description |
|---|---|
| Offset | Distance of the top of the circle from the R-axis. This is usually set equal to - $x_d'/2$, where $x_d'$ is the transient reactance of the machine. The sign of the setting value determines the top of the circle regarding the R-axis. If the sign is negative, the circle lies below the R-axis. |
| Diameter | Normally set equal to the machine's synchronous reactance $x_d$, which determines the size of the impedance circle. |
| Displacement | Displacement of the center of the circle from the reactance axis or the R-coordinate of the center. The setting can be used to adjust the sensitivity of the underexcitation protection. If the sign of the setting is positive, the circle is shifted to the right, that is, closer to the normal operating point. Respectively, if the sign is negative, the circle is shifted to the left and thus moves away from the normal operating point. |
| Rst offset X | Displacement from origin to a point on reactance axis (X-axis) through which the directional restraint line passes. The setting can be used to adjust the restrain area of the underexcitation protection along with *Rst offset X angle*. If the sign of the *Rst offset X* setting is positive, the restraint line passes through a point on X-axis which is above the R-axis and if it is negative, it passes through a point on X-axis which is below the R-axis. |
| Rst offset X angle | Angle between the R-axis (or *Rst offset X* line) and the directional restraint line. If the sign of the *OffsetXAng* setting is positive, the angle is taken in anti-clockwise direction from the R-axis (or *Rst offset X* line). Respectively, if the sign is negative, the angle is taken in clockwise direction from R-axis (or *Rst offset X* line). |

The setting parameters of the off-set mho circle are to be given in pu values. The base impedance ($Z_N$) in ohms is:

$$Z_N = \left| \frac{U_N^2}{S_N} \right|$$

(Equation 276)

| | |
|---|---|
| $U_N$ | rated (phase-to-phase) voltage in kV |
| $S_N$ | rated power of the protected machine in MVA |

The corresponding calculation to convert ohms to pu values is:

$$X_{pu} = \frac{X_{ohm}}{Z_N}$$

(Equation 277)

| | |
|---|---|
| $X_{pu}$ | pu value |
| $X_{ohm}$ | reactance in ohms |
| $Z_N$ | base impedance |

**Example of impedance locus in underexcitation**

In an example of a typical impedance locus, once the impedance locus enters the relay operation characteristics, the relay operates after a settable definite time.

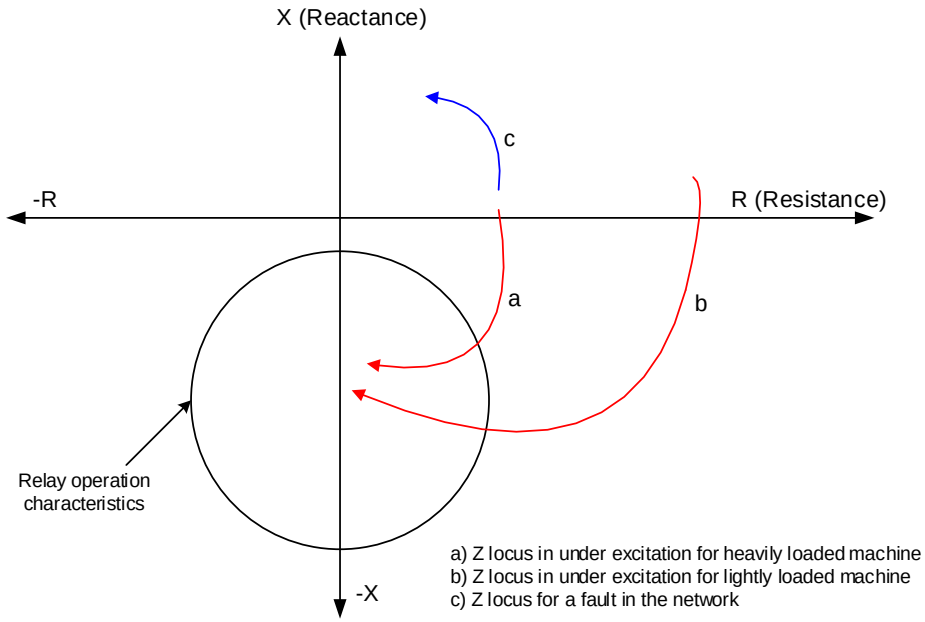



*Figure 568: Typical impedance locus in underexcitation: a) heavy load b) light load c) fault in the network*

### 4.7.3.7 Signals

#### UEXPDIS Input signals

**Table 949: UEXPDIS Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| EXT_LOS_DET | BOOLEAN | 0=False | External signal for excitation loss detection |

#### UEXPDIS Output signals

**Table 950: UEXPDIS Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.7.3.8 UEXPDIS Settings

**Table 951: UEXPDIS Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Diameter | 1...6000 | %Zn | 1 | 200 | Diameter of the Mho diagram |
| Offset | -1000...1000 | %Zn | 1 | -10 | Offset of top of the impedance circle from the R-axis |
| Displacement | -1000...1000 | %Zn | 1 | 0 | Displacement of impedance circle centre from the X-axis |
| Operate delay time | 60...200000 | ms | 10 | 5000 | Operate delay time |

**Table 952: UEXPDIS Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Restraint enable | 0=Disable<br>1=Enable | | | 0=Disable | Enable restrain area |
| Rst offset X | -1000...1000 | %Zn | 1 | 0 | Offset of directional line from origin along X-axis |
| Rst offset X angle | -180.0...180.0 | deg | 0.1 | -13.0 | Angle between R-axis and directional line |

**Table 953: UEXPDIS Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| External Los Det Ena | 0=Disable<br>1=Enable | | | 1=Enable | Enable external excitation loss detection |
| Voltage reversal | 0=No<br>1=Yes | | | 0=No | Rotate voltage signals by 180 degrees |
| Impedance Meas mode | 1=1Phase-to-earth<br>2=1Phase-to-phase<br>3=3Phase-to-earth<br>4=3Phase-to-phase<br>5=Pos sequence | | | 5=Pos sequence | Select voltage and currents for impedance calculation |
| Phase Sel for Z Clc | 1=A or AB<br>2=B or BC<br>3=C or CA | | | 1=A or AB | Voltage phase selection |

**Table 954: UEXPDIS Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 3000 | Reset delay time |

### 4.7.3.9 UEXPDIS Monitored data

**Table 955: UEXPDIS Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time (in %) |
| Z_AMPL_A | FLOAT32 | 0.00...200.00 | xZn | Impedance amplitude phase A |
| Z_ANGLE_A | FLOAT32 | -180.00...180.00 | deg | Impedance angle phase A |
| Z_AMPL_B | FLOAT32 | 0.00...200.00 | xZn | Impedance amplitude phase B |
| Z_ANGLE_B | FLOAT32 | -180.00...180.00 | deg | Impedance angle phase B |
| Z_AMPL_C | FLOAT32 | 0.00...200.00 | xZn | Impedance amplitude phase C |
| Z_ANGLE_C | FLOAT32 | -180.00...180.00 | deg | Impedance angle phase C |
| Z_AMPL_AB | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase A-B impedance amplitude |
| Z_ANGLE_AB | FLOAT32 | -180.00...180.00 | deg | Phase-to-phase A-B impedance phase angle |
| Z_AMPL_BC | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase B-C impedance amplitude |
| Z_ANGLE_BC | FLOAT32 | -180.00...180.00 | deg | Phase-to-phase B-C impedance phase angle |
| Z_AMPL_CA | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase C-A impedance amplitude |
| Z_ANGLE_CA | FLOAT32 | -180.00...180.00 | deg | Phase-to-phase C-A impedance phase angle |
| Z1_AMPL | FLOAT32 | 0.00...200.00 | xZn | Positive sequence impedance amplitude |
| Z1_ANGLE | FLOAT32 | -180.00...180.00 | deg | Positive sequence impedance phase angle |
| UEXPDIS | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.7.3.10 Technical data

**Table 956: UEXPDIS Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage:<br>$f = f_n \pm 2$ Hz |
| | ±3.0% of the set value or ±0.2% Zb |
| Start time [1, 2] | Typically 45 ms |
| Reset time | Typically 30 ms |

*Table continues on the next page*

[1] $f_n$= 50Hz, results based on statistical distribution of 1000 measurements
[2] Includes the delay of the signal output contact

| Characteristic | Value |
|---|---|
| Reset ratio | Typically 1.04 |
| Retardation time | Total retardation time when the impedance returns from the operating circle <40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

#### 4.7.3.11 Technical revision history

**Table 957: UEXPDIS Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | C | Added support for settable blinder in offset mho characteristic. |

### 4.7.4 Three-phase underimpedance protection UZPDIS (ANSI 21G)

#### 4.7.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase underimpedance protection | UZPDIS | Z<G | 21G |

#### 4.7.4.2 Function block

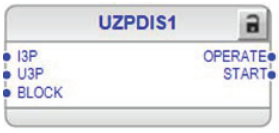



*Figure 569: Function block*

#### 4.7.4.3 Functionality

The three-phase underimpedance protection UZPDIS is generally applied as a backup protection for generators and transformers against short circuit faults.

The protection is based on the origin-centric circular characteristics on the impedance plane. The function calculates the impedance value from the voltage and current phasors. If the impedance vector enters the origin-centric circle, the function produces the operating signal after a set delay. The operating time characteristics are according to definite time (DT).

However, it is also possible to enable separate zones of offset-mho based protection with multiple instances of the function.

This function contains a blocking functionality. It is possible to block the function outputs, reset timer or the function itself.

### 4.7.4.4 Analog channel configuration

UZPDIS has two analog group inputs which all must be properly configured.

**Table 958: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 959: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected (*Phase Sel for Z Clc set* to "AB", "BC" or "CA"), if the setting *Impedance Meas* mode is set to "1Phase-to-phase". |
| | The function requires that at least two (the third voltage will be derived) or all three voltage channels are connected if *Impedance Meas mode* is set to "3Phase-to-phase". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.7.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of UZPDIS can be described with a module diagram. All the modules in the diagram are explained in the next sections.

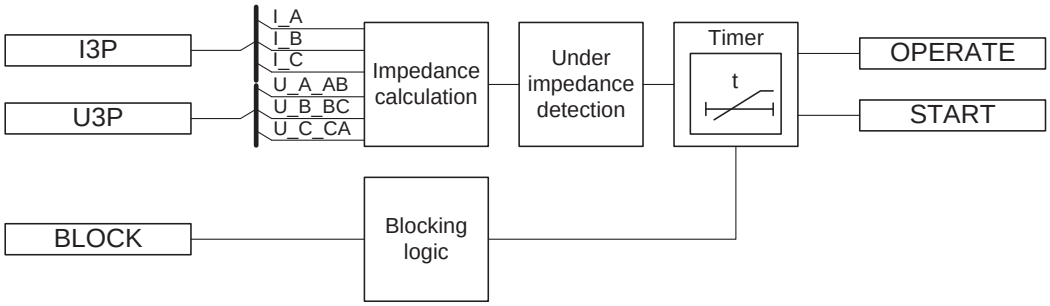



*Figure 570: Functional module diagram*

### Impedance calculation

This module calculates the impedance based on the selected voltages and currents. The *Impedance Meas mode* and *Phase Sel for Z Clc* settings determine which voltages and currents are to be used. If *Impedance Meas mode* is set to "1Phase-phase", the *Phase Sel for Z Clc* setting is needed for determining which phase-phase voltages ("AB", "BC" and "CA") and currents should be used for calculating the impedance.

**Table 960: Voltages and currents used in impedance calculation**

| Impedance Meas mode | Phase Sel for Z Clc | Voltages and currents used in impedance calculation [1] |
|---|---|---|
| 1Phase-phase | AB | $\overline{ZAB} = \frac{U_AB}{I_A - I_B}$ |
| 1Phase-phase | BC | $\overline{ZBC} = \frac{U_BC}{I_B - I_C}$ |
| 1Phase-phase | CA | $\overline{ZCA} = \frac{U_CA}{I_C - I_A}$ |
| 3Phase-phase | N/A | $\overline{ZAB} = \frac{U_AB}{I_A - I_B}$<br>$\overline{ZBC} = \frac{U_BC}{I_B - I_C}$<br>$\overline{ZCA} = \frac{U_CA}{I_C - I_A}$ |

If all three phase or phase-phase voltages and phase currents are fed to the protection relay, the "3Phase-phase" mode is recommended.

[1] Voltages and currents in the calculations are given in volts and amps.

The current measurement of the function is based on two alternative measurement modes, "DFT" and "Peak-To-Peak". The measurement mode is selected using the *Measurement mode* setting.

If the current magnitude is below 0.02 · $I_N$, where $I_N$ is the nominal phase current, the impedance value is not evaluated and the maximum impedance value (99.999 pu) is shown in the Monitored data view.

The calculated impedances are converted to a pu impedance as the operating characteristics are defined using the *Polar reach* setting in %Zb.

The calculated phase-phase impedance amplitudes Z_AMPL_AB, Z_AMPL_BC and Z_AMPL_CA are available as pu values in the Monitored data view.

**Underimpedance detection**

The operating characteristic is an origin-centric circle on the impedance plane. The origin-centric circular characteristic is defined using the *Polar reach* setting. If the calculated impedance value enters the circle in the impedance plane, the module sends an enabling signal to start the Timer.

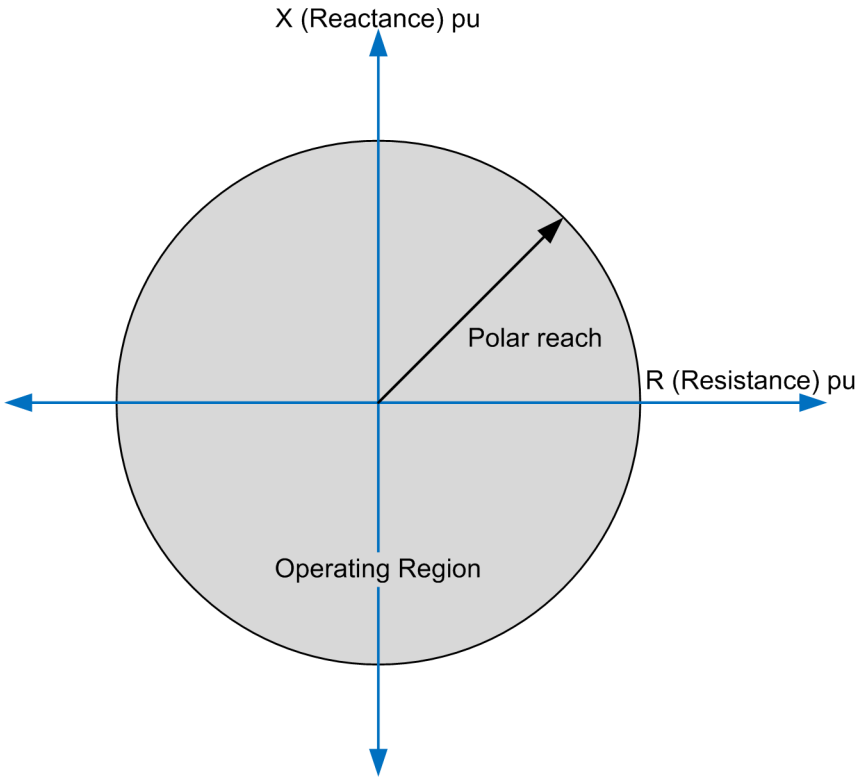



*Figure 571: Origin-centric circular operating characteristics*

Separate zones with an offset-mho characteristic can be designed using multiple instances of the UZPDIS function with *Offset enable* setting and parameterized with *Offset* and *Displacement* setting values as shown in Figure *Figure 572*. *Offset* is the distance of the top of the circle from R-axis. If the sign of the *Offset* is positive, the top of the circle is above the R-axis and if it is negative, the top of the circle will be below the R-axis. *Displacement* is the distance by which the center of the circle is displaced from the X-axis. If the sign of the *Displacement* setting is positive,

the circle is shifted to the right of the X-axis and if the sign is negative, the circle is shifted to the left of the X-axis. For an origin-centric mho characteristic, *Offset enable* is kept disabled.

When using the mho-characteristics, the *Offset* and *Displacement* settings are as given in the UEXPDIS function, but *Polar reach* is half of UEXPDIS *Diameter* setting.

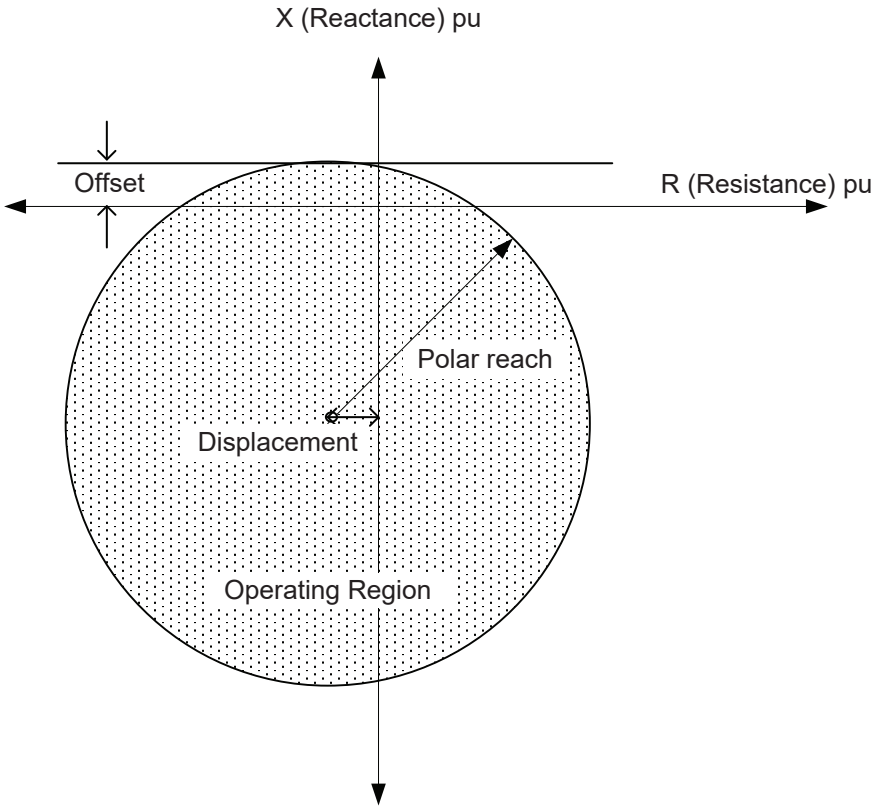



*Figure 572: Designing zones with Offset and Displacement*

The offset-mho characteristic shown in Figure *Figure 572* is designed with a positive value for *Offset* and a negative value for *Displacement*.

More than one impedance value is available when *Impedance Meas mode* is set to "3Phase-phase", and the function considers the lowest impedance value for starting and operating.

**Timer**

Once activated, the Timer activates START output. The time characteristic is according to DT. When the duration of the underimpedance condition exceeds the set definite *Operate delay time*, the OPERATE output is activated. If the impedance locus moves out of circular operating characteristics before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operating timer resets and the START output is deactivated.

The Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time (DT). The value is available in the Monitored data view.

#### Blocking logic

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.7.4.6 Application

The three-phase underimpedance protection is used as a backup protection against short circuit faults at the generator terminals or on the high-voltage side of a step-up transformer. This function can be used either instead of the definite time voltage-dependent overcurrent protection or to obtain a limited protection zone and the optimum operating time instead of the non-directional overcurrent protection.

#### Comparison between overcurrent and underimpedance protection

Phase current for three-phase short circuit is shown in *Figure 573*. In this case, with an ordinary over current relay having the current setting as $1.2 \cdot I_n$, the time setting should be less than 0.2 seconds, since with a higher value the short-circuit current decays below the set value and the relay drops off. The current setting can also be reduced to $1.1 \cdot I_n$, although this provides no substantial rise in the time setting. In some situations, either of the above current settings is appropriate, but if longer tripping times are required to maintain the time selectivity, the underimpedance protection is needed.

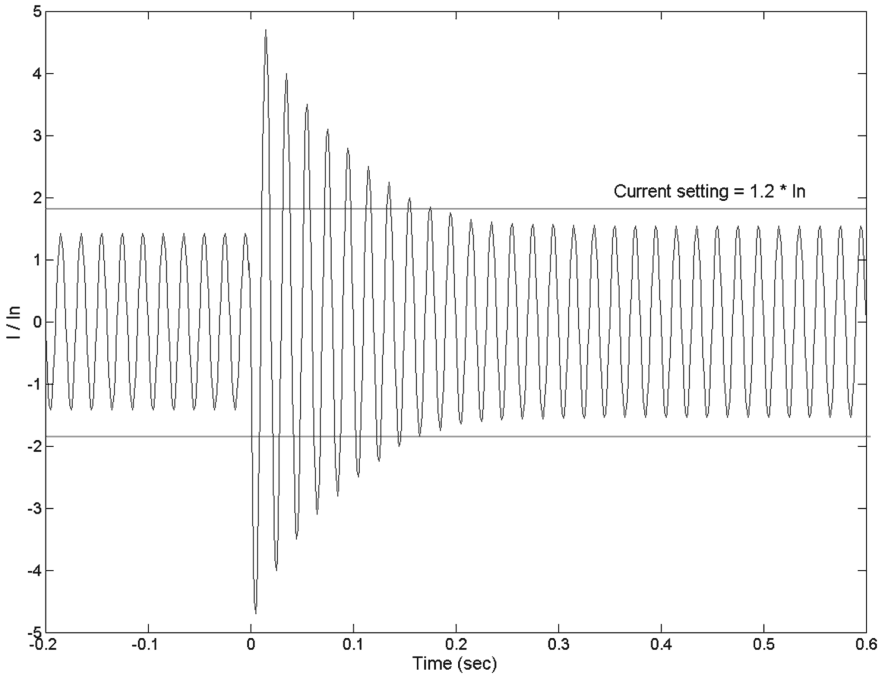



*Figure 573: Short circuit current waveform, fault occurs at time 0 seconds (Current setting limit is multiplied by the square root of 2)*

The phase voltage in a three-phase short circuit when a fault occurs at time = 0 s is shown in *Figure 574*. The voltage drop caused by a three-phase fault provides more time for determining the fault by means of an underimpedance protection.

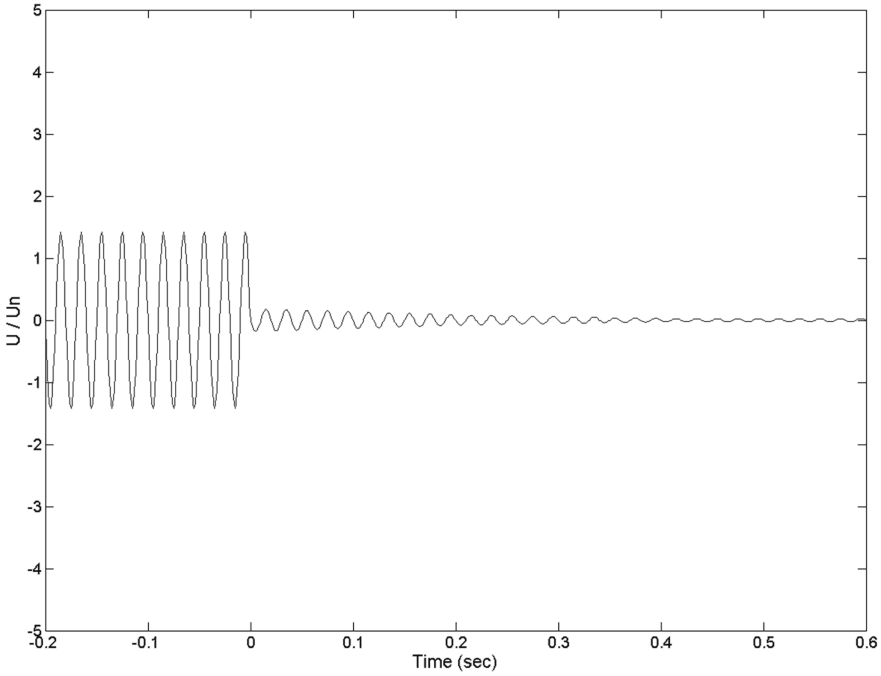



*Figure 574: Short-circuit voltage waveform, fault occurs at time 0 seconds*

In a typical impedance trajectory during a short circuit, the fault impedance remains inside the impedance circle for a longer time, in which case the underimpedance protection provides longer tripping delay times to maintain the time selectivity.

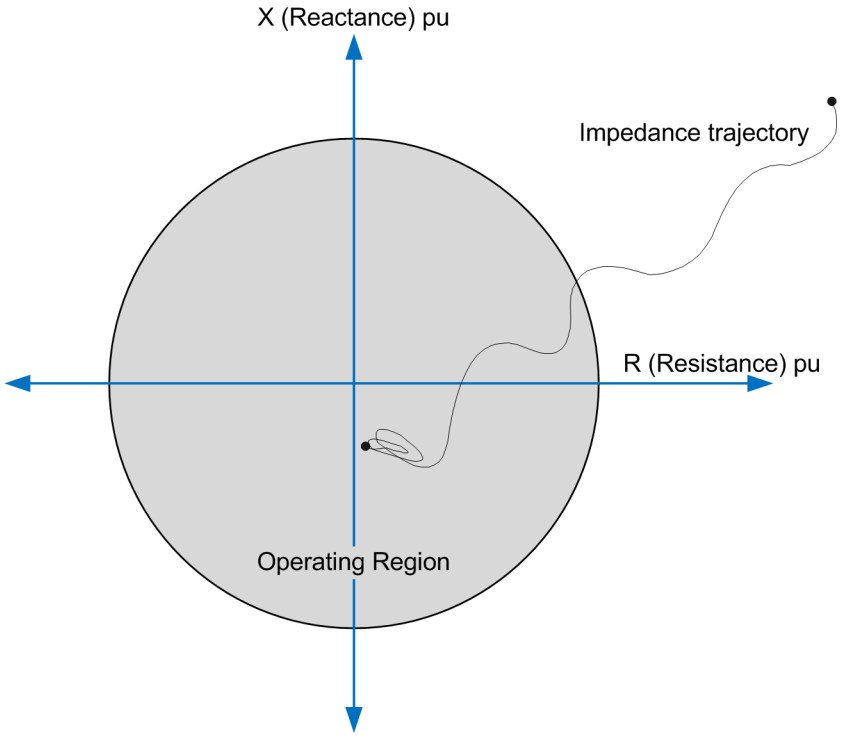



*Figure 575: Typical impedance trajectory during a short circuit*

**Underimpedance protection for transformers**

The underimpedance function is used as a short circuit protection instead of the overcurrent protection. It is also used as a backup to the differential protection of transformers.

The voltage and current phasors are measured with the VTs and CTs connected on the HV side of the transformer.

The phase and current shifts due to transformer D/Y connections and other factors complicate the settings for the faults in the secondary winding (as seen from the protection relay), and detailed calculations are necessary for a good coverage.

The *Polar reach* setting is set to a value equal to 150 percent of the transformer short circuit impedance. The setting also provides a backup protection for the busbar and feeder faults on the HV side.

**Underimpedance protection for generators**

The underimpedance protection is set to protect the zone between the generator windings and the generator side windings of the step-up transformer. The function mainly protects the generator bus, the low-voltage part of the step-up transformer and a part of the stator winding against any short circuits.

The voltages should be measured from the generator terminals and the phase currents from the neutral point of the generator.

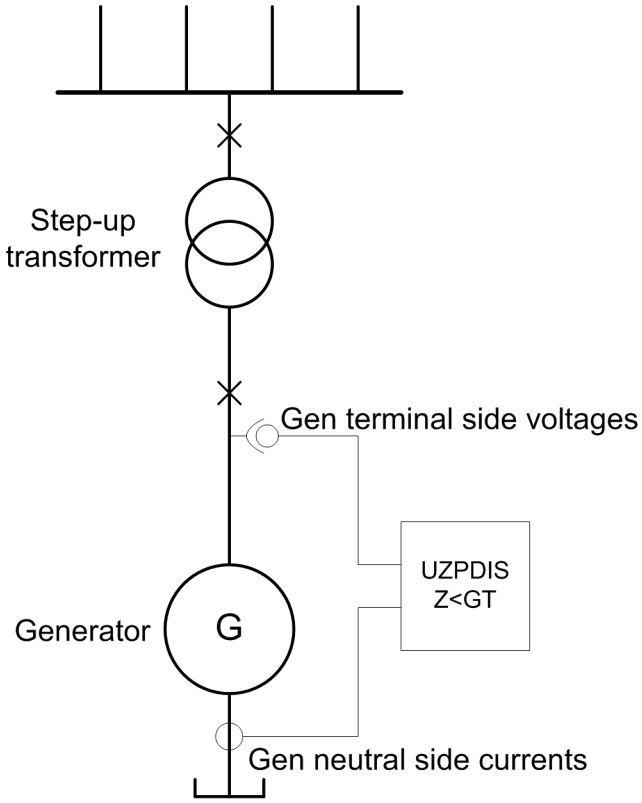



*Figure 576: Current and voltage signals for underimpedance protection*

To prevent malfunctioning of the underimpedance protection in case of nearby faults, the *Polar reach* setting is set to a value equal to 70 percent of the step-up transformer short circuit impedance.

In directly connected machines where the impedance towards the network is limited only by the lines or bus bars, it must be secured that the function does not cause any selectivity problems. In such cases, it is recommended to use the voltage-dependent overcurrent protection instead of the underimpedance protection.

**Function blocking guidelines**

The operation of the underimpedance protection must be restrained if the voltage in one or more phases suddenly drops close to zero without any significant change in the current observed at the same time. This situation is considered as a fuse failure or a miniature circuit breaker operation in the voltage transformer secondary circuit. The voltage drop could cause an unwanted operation of the function block since the calculated impedance could fall below the set operating limit even if there is no actual fault in the primary system.

The blocking operation is provided by an external function block, the fuse failure supervision SEQSPVC, whose output is connected to the `BLOCK` input of UZPDIS.

### 4.7.4.7 Signals

**UZPDIS Input signals**

**Table 961: UZPDIS Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**UZPDIS Output signals**

**Table 962: UZPDIS Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.7.4.8 UZPDIS Settings

**Table 963: UZPDIS Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Polar reach | 1...6000 | %Zn | 1 | 7 | Impedance start value, i.e. radius of impedance circle |
| Operate delay time | 40...200000 | ms | 10 | 200 | Operate delay time |

**Table 964: UZPDIS Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Offset enable | 0=Disable<br>1=Enable | | | false | Enable offset-mho characteristic |
| Offset | -1000...1000 | %Zn | 1 | -10 | Offset of top of the impedance circle from the R-axis |
| Displacement | -1000...1000 | %Zn | 1 | 0 | Displacement of impedance circle centre from the X-axis |

**Table 965: UZPDIS Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Measurement mode | 2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |
| Impedance Meas mode | 2=1Phase-to-phase | | | 4=3Phase-to-phase | Select voltage and current signals for |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 4=3Phase-to-phase | | | | impedance calculation |
| Phase Sel for Z Clc | 1=AB<br>2=BC<br>3=CA | | | 1=AB | Select phase/ phase-phase voltages and currents for Z calculation. |

**Table 966: UZPDIS Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |

### 4.7.4.9 UZPDIS Monitored data

**Table 967: UZPDIS Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time (in %) |
| Z_AMPL_AB | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase A-B impedance amplitude |
| Z_AMPL_BC | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase B-C impedance amplitude |
| Z_AMPL_CA | FLOAT32 | 0.00...200.00 | xZn | Phase-to-phase C-A impedance amplitude |
| UZPDIS | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.7.4.10 Technical data

**Table 968: UZPDIS Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage: $f_n$ ±2 Hz |
| | ±3.0% of the set value or ±0.2 %Zb |
| Start time [1, 2] | Typically 50 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 1.04 |
| Retardation time | <40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

[1] $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[2] Includes the delay of the signal output contact

#### 4.7.4.11 Technical revision history

**Table 969: UZPDIS Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | C | Support for separate zones with an offset mho characteristic. |

## 4.7.5 Directional negative sequence impedance protection DNZPDIS (ANSI Z2Q)

### 4.7.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Directional negative sequence impedance protection | DNZPDIS | Z2 -> | Z2Q |

### 4.7.5.2 Function block

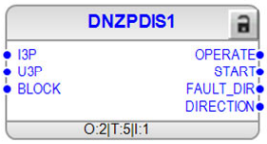



*Figure 577: Function block*

### 4.7.5.3 Functionality

Directional negative sequence impedance protection function (DNZPDIS) is used to detect the unsymmetrical fault such as the phase to phase fault, phase-ground fault and double phase to ground fault on power system network.

Operating principle is based on negative sequence impedance. Function compares the negative sequence impedance value against given setting values. Directional operation is based on following theory, impedance value is positive for forward faults and negative for reverse faults. Operate time is according to definite time characteristics.

### 4.7.5.4 Analog channel configuration

DNZPDIS has two analog group inputs which must be properly configured.

**Table 970: Analog Inputs**

| Input | Description |
|---|---|
| I3P | Three phase currents |
| U3P | Three phase voltages |

**Table 971: Special conditions**

| Condition | Description |
|---|---|
| U3P connected real measurements | The function requires that at least two voltage channels are connected |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings.

### 4.7.5.5 Operation principle

The *Operation* setting is used to enable or disable the function. When selected "On" the function is enabled and respectively "Off" means function is disabled.

The operation of DNZPDIS can be described by using a module diagram ( see *Figure 578* below). All the modules in the diagram are explained in the next sections.

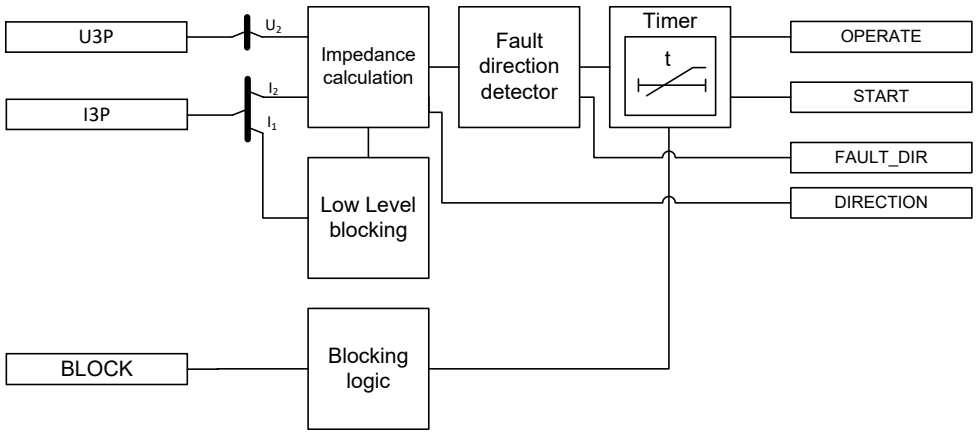



*Figure 578: Functional module diagram*

#### Low level blocking

This module receives positive sequence current ($I_1$) and negative sequence current ($I_2$). Both are calculated from fundamental frequency three phase currents.

Low level blocking is used to block the Impedance calculation if negative sequence current does not satisfy minimum level criteria. If negative sequence current exceeds setting *Min Ng Seq current Fw* value, impedance calculation is allowed in forward direction. Alternatively, if negative sequence current is exceeds setting *Min Ng Seq current Rv* value, impedance calculation is allowed in reverse direction.

The negative sequence current to positive sequence current ratio ($I_2/I_1$) should also exceed the setting *Restrain factor* to enable impedance calculation.

### Impedance calculation

This module receives positive sequence voltage ($U_1$) and negative sequence voltage ($U_2$) which are calculated from fundamental frequency three phase voltages. Also positive sequence current ($I_1$) and negative sequence current ($I_2$) which are respectively calculated from fundamental frequency three phase currents.

Once activated the negative sequence impedance ($Z_2$) is calculated from the negative sequence current, the negative sequence voltage and Relay characteristic angle (RCA) using the below equation.

$$Z_2 = \left|\frac{U_2}{I_2}\right| * \cos\left(\angle U_2 + 180 - \angle I_2 - \angle RCA\right)$$

(Equation 278)

The RCA in the above equation can be obtained from *Characteristic angle* setting.

The $Z_2$ value in primary ohms is available as Z2_VALUE in monitored data.

**Table 972: Direction value for monitored data view**

| Criterion for direction information | The value for DIRECTION |
|---|---|
| Default (low level blocking active) | 0 = unknown |
| $Z_2 > 0$ | 1 = forward |
| $Z_2 < 0$ | 2 = backward |

### Fault direction detector

This module checks if the value of $Z_2$ meets the operation criteria. Detection to only forward direction can be achieved by setting the *Direction mode* to “Forward”. Thus, forward fault is detected if the value of $Z_2$ is higher than the *Ng Seq impedance Fw* setting. Respectively operation to only reverse direction can be activated by setting *Direction mode* is set to “Reverse”. Reverse fault is detected if the value of $Z_2$ is below the setting *Ng Seq impedance Rv* setting. In case *Direction mode* is set to “Non-directional”, operation is allowed if condition for forward or reverse direction is fulfilled.

The *Ng Seq impedance Fw* setting and *Ng Seq impedance Rv* settings are set in primary ohms.

FAULT_DIR gives the direction information during fault, if operation criteria is satisfied. that is, when the START output is active. The fault direction (FAULT_DIR) is available in monitored data and as function block output. FAULT_DIR values are the same as for DIRECTION output given in the *Table 972*. The FAULT_DIR is set to value 0 = unknown after the START output is deactivated.

*Figure 579* illustrates the directional operating characteristics on negative sequence impedance level as shown in the vertical line.

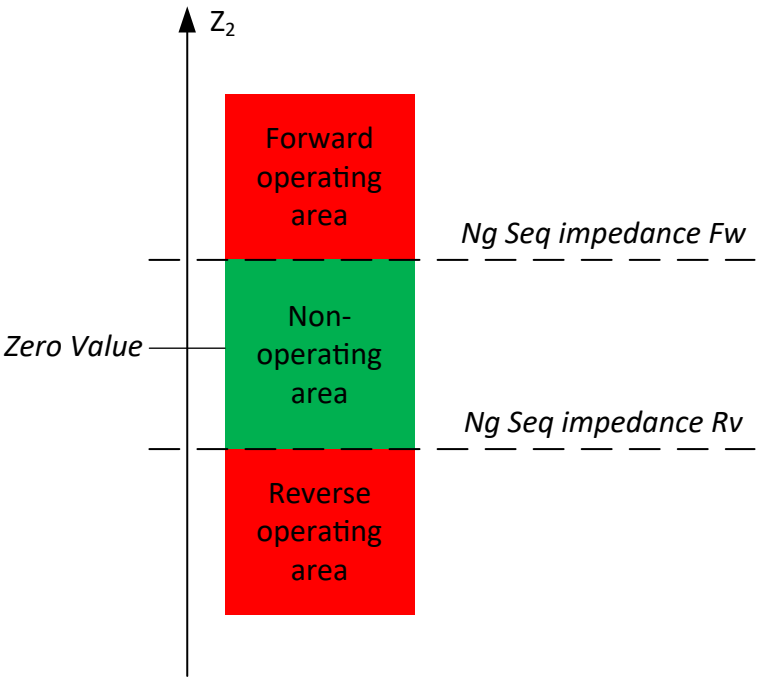



*Figure 579: Fault direction estimation on negative sequence impedance level*

**Timer**

Once activated, the Timer activates the START output. The timer characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated if the operating conditions persists.

If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated. The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the relay program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timer" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.7.5.6 Application

The directional negative sequence impedance function is normally used on incoming line or feeder connected to the busbar, which is made to operate in the specified direction for secured operation. The fault direction can be either referred as forward or reverse of the relay.

There are different directional elements used to determine the direction of faults, one such element is negative sequence impedance. The calculated negative sequence impedance is sensitive enough to identify fault in power system networks with strong source where less negative-sequence voltage and current will be present during faults.

By using suitable restraint factor, it is also possible to avoid false tripping with systems having un-transposed lines where some default negative sequence current will be present during normal operation.

#### Application example

Relay setting calculation for the DNZPDIS function is shown with below application example of parallel lines with two end sources of power system network.

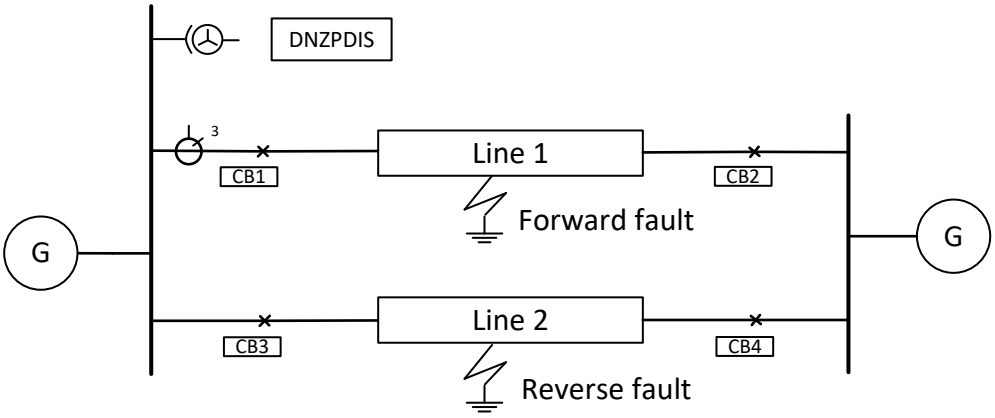



*Figure 580: Power system network with parallel line and two sources*

#### Setting value calculation

Line parameters:

Resistance = 0.126 ohm/km

Reactance = 0.600 ohm/km

Line length = 100 km

Total impedance ($Z_1$tot) of line1 or line2 is calculated below

$$Z_1\text{tot} = (0.126 + j0.60 \text{ ohm/km}) * 100 \text{ km}$$
$$= 12.6 + j60.1 \text{ in ohm}$$

(Equation 279)

Magnitude of positive sequence impedance ($Z_1$tot) = 60.4 ohm. The following settings are obtained to set the relay located at circuit breaker 1(CB1).

- *Ng Seq impedance Fw* can be set to 50% of the $Z_1$tot magnitude of the line 1 which equals in primary ohms 60.4/2 = 30.2.
- *Ng Seq impedance Rv* can be set to 50% of the $Z_1$tot magnitude of the line 2. Setting is for reverse fault in parallel line and therefore magnitude is negative. Thus setting value is in primary ohms -60.4/2 = -30.2.
- If *Characteristic angle* mode is set to “Fixed”, then the value for *Characteristic angle* setting can be calculated as below.

$$\begin{aligned}\text{Characteristic angle} &= \arctan(X/R)\\ &= \arctan(60.1/12.6)\\ &= 78.3 \text{ deg}\end{aligned}$$

(Equation 280)

The setting *Restrain factor* is set based on the minimum unbalance loading allowed in the power system network. In this case 10% unbalance is allowed in the given example system, hence the *Restrain factor* is set to 0.1.

**Fault simulation**

The phase to ground faults are simulated in the given example shown in *Figure 580*, the relay is located at the sending end of the line1 and the output is captured for forward and reverse direction fault.

The phase A to ground fault is applied on the line1 in the forward direction, the $Z_2$ value is positive as well as exceeds the *Ng seq impedance Fw* setting threshold, hence the START output issued, FAULT_DIR indicates the fault in the forward direction and the OPERATE output will be issued after the *Operate delay time* setting has passed as shown in below *Figure 581*.

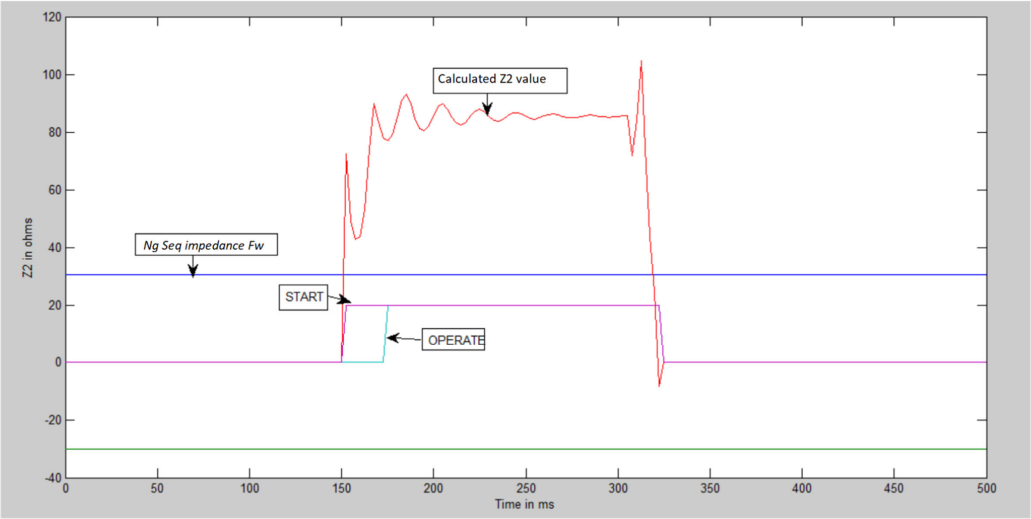



*Figure 581: Phase A to ground fault on forward direction*

The phase A to ground fault is applied on the line2 in the reverse direction, the calculated $Z_2$ value is negative as well as lower the *Ng seq impedance Rv* setting threshold, hence the START output issued, FAULT_DIR indicates the fault in the reverse direction and the OPERATE output will be issued after the *Operate delay time* setting has passed as shown in below *Figure 582*.

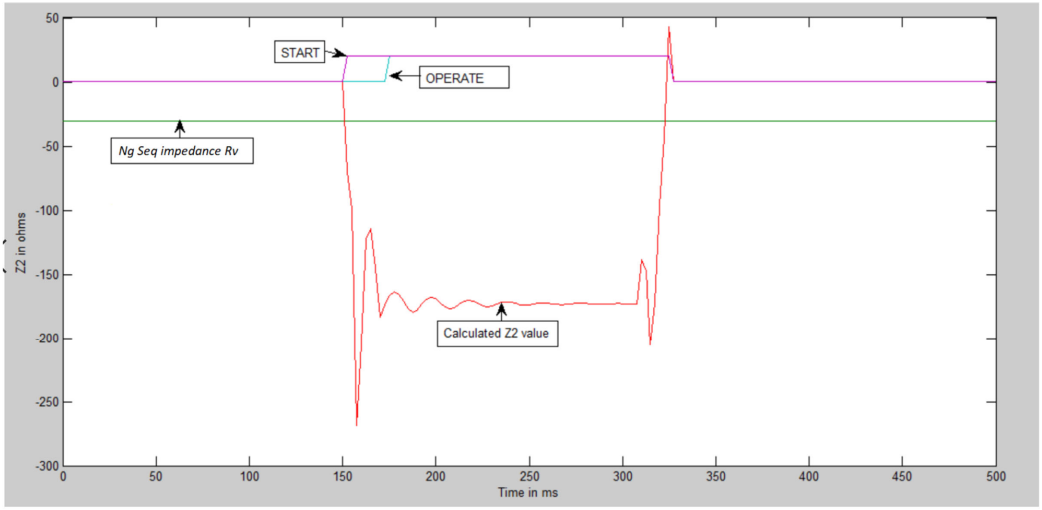



*Figure 582: Phase A to ground fault on reverse direction*

## 4.7.5.7 Signals

### DNZPDIS Input signals

**Table 973: DNZPDIS Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### DNZPDIS Output signals

**Table 974: DNZPDIS Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| FAULT_DIR | Enum | Detected fault direction |
| DIRECTION | Enum | Direction information |

## 4.7.5.8 Settings

#### DNZPDIS Settings

**Table 975: DNZPDIS Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Direction mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Direction mode |
| Restrain factor | 0.02...0.50 | | 0.01 | 0.20 | The restrain factor |
| Operate delay time | 60...300000 | ms | 10 | 60 | Operate delay time |
| Ng Seq impedance Fw | 0.01...3000.00 | ohm | 0.01 | 40.00 | Forward negative sequence impedance primary threshold in ohm |
| Ng Seq impedance Rv | -3000.00...-0.01 | ohm | 0.01 | -40.00 | Reverse negative sequence impedance primary threshold in ohm |
| Min Ng Seq current Fw | 0.05...1.00 | xIn | 0.01 | 0.05 | Minimum forward negative sequence current threshold |
| Min Ng Seq current Rv | 0.05...1.00 | xIn | 0.01 | 0.05 | Minimum reverse negative sequence current threshold |
| Characteristic angle | 1...90 | deg | 1 | 67 | Characteristic angle |

**Table 976: DNZPDIS Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 977: DNZPDIS Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

## 4.7.5.9 Monitored data

#### DNZPDIS Monitored data

**Table 978: DNZPDIS Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time (in %) |
| Z2_VALUE | FLOAT32 | -99999.00...99999.00 | ohm | Calculated negative sequence impedance value |
| DNZPDIS | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.7.5.10 Technical data

**Table 979: DNZPDIS Technical data**

| Characteristics | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±3% of the set value or ±0.05 Ω (When \|∠$Z_2$ - ∠RCA\| is outside 80 to 100 degree) |
| Start time [1, 2, 3] | <75 ms |
| Operate time accuracy [3] | ±1.0% of the set value or ±20 ms |
| Reset ratio | 0.96 |
| Reset time | Typically 30 ms |

## 4.7.6 Power swing detection DSTRPSB (ANSI 68)

### 4.7.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Power swing detection | DSTRPSB | Zpsb | 68 |

### 4.7.6.2 Function block

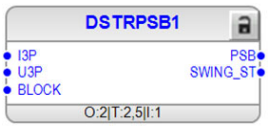



*Figure 583: Function block*

### 4.7.6.3 Functionality

The power swing detection function DSTRPSB detects power swing condition and can be used for blocking the distance protection function. The power swing detection function comprises an inner and an outer impedance characteristic. The supported zone characteristic shapes for inner and outer characteristic are quadrilateral and mho (circular). The power swing detection function is supervised by a load encroachment logic which ensures that the load impedance does not enter the characteristic of the power swing detection function during normal power system operation.

[1] Results based on statistical distribution of 1000 measurements
[2] Measured with static signal output (SSO)
[3] During fault, $Z_2$= 2.0 × *Ng Seq impedance Rv/Fw*

The function calculates the positive sequence impedance. Calculation is based on fundamental frequency components of positive sequence current and voltage. If the measured impedance stays between inner and outer characteristic longer than predetermined time and moves farther inside the inner characteristic, then a power swing condition is indicated.

### 4.7.6.4 Analog channel configuration

DSTRPSB has two analog group inputs which must be properly configured.

**Table 980: Analog Inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

There are a few special conditions which must be noted with the configuration.

**Table 981: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

### 4.7.6.5 Operation principle

The *Operation* setting is used to enable or disable the function. When selected "On" the function is enabled and respectively "Off" means function is disabled.

The operation of DSTRPSB can be described by using a module diagram (see figure below). All the modules in the diagram are explained in the next sections.

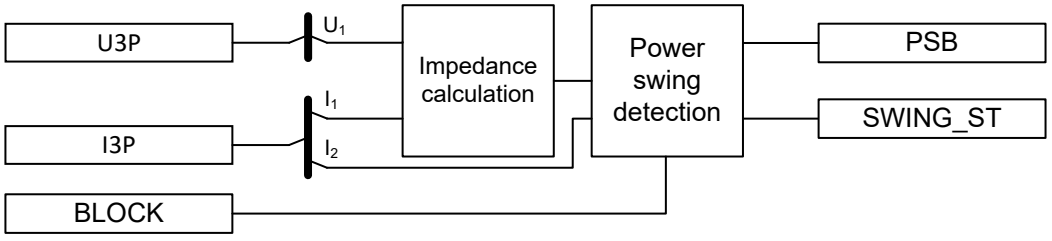



*Figure 584: Function module diagram*

**Impedance calculation**

This module receives positive sequence voltage which is calculated from fundamental frequency three phase voltages and positive sequence current calculated respectively from fundamental frequency three phase currents. For the module to calculate impedance it is required that the positive-sequence current is above 0.1xIn.

Operation is based on positive sequence impedance ($Z_1$) which is calculated using positive sequence voltage and current as follows:

$$\underline{Z}_1 = \frac{\underline{U}_1}{\underline{I}_1}$$

(Equation 281)

The calculated positive-sequence impedance amplitude Z1_AMPL and angle Z1_ANGLE are available in primary ohms and degrees, respectively, in the Monitored data view.

The calculated impedance is converted to ohms as the operating characteristics are defined with the ohm settings.

**Power swing detection**

Power swing detection function comprises an inner and outer quadrilateral /circular measurement characteristic. The positive sequence impedance is continuously monitored for detecting a power swing condition. During normal power system operation, the impedance is outside of outer characteristic. When the impedance enters outer characteristic, output `SWING_ST` is activated, and the power swing detection timer is triggered. The `SWING_ST` output will be deactivated if the impedance leaves the zone between inner and outer characteristic. If the impedance remains between the inner and outer characteristics longer than the time defined by the setting *Swing time* , and the impedance enters inner characteristic, output `PSB` is activated. The `PSB` output will be deactivated after the impedance leaves outer characteristic for the time defined by *Pulse time* setting.

When an unbalanced fault occurs during power swing, the `PSB` output should be deactivated to allow tripping. For the purpose module is monitoring negative sequence current which is calculated from fundamental frequency three phase currents. Negative sequence current level can be monitored if *Ng Seq current Spvn* is set to "Enable". When the negative sequence current is above the *Max Ng Seq current* setting longer than the time delay defined by the setting *Neg Seq current time*, the Power swing detection module is disabled. The module is disabled until negative sequence current drops below the setting value. The *Max Ng Seq current* setting should be set above the maximum negative sequence current which may appear during power swing.

Slow power swing can be used as criterion for disabling power swing detection. Monitoring is activated by setting *Slow swing Spvn* to "Enable". If the positive sequence impedance enters and remains inside outer characteristic longer than the time delay defined by the setting *Slow swing time*, the Power swing detection module is disabled. The module is disabled until the positive sequence impedance moves outside outer characteristics. The setting *Slow swing time* should be coordinated with network or cable current rating characteristics. Too long lasting large current may need to be cleared even if situation is classified as power swing.

In case of heavily loaded lines, the optional load encroachment logic can be enabled with the *Load discrimination* setting. The logic reserves an area for load impedance defined by the *Outer Fw Ld Ris Rch, Outer Rv Ld Ris Rch, Inner Fw Ld Ris Rch, Inner Rv Ld Ris Rch, Load angle1* and *Load angle2* settings.

**Quadrilateral characteristic**

If the *Pe Swg impedance Chr* is ‘Quadrilateral’, DSTRPSB has a double-polygon characteristic.

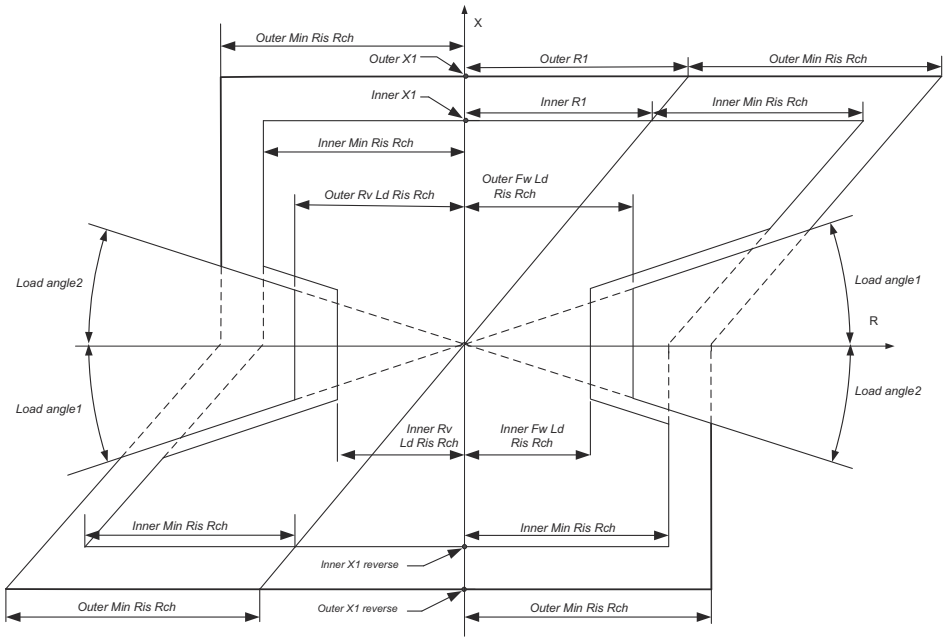



*Figure 585: Quadrilateral operation characteristics*

The reach of inner polygon in the reactive direction is defined by the line reach independently with the settings *Inner R1, Inner X1, Inner X1 reverse*. The resistive reach of inner polygon is defined at the minimum resistive reach with settings *Inner Min Ris Rch*. The reach of outer polygon in the reactive direction is defined by the line reach independently with the settings *Outer R1, Outer X1, Outer X1 reverse*. The resistive reach of outer polygon is defined at the minimum resistive reach with settings *Outer Min Ris Rch*.

**Mho circular characteristics**

When the *Pe Swg impedance Chr* is "Mho (circular)", the DSTRPSB has a double circular characteristic.

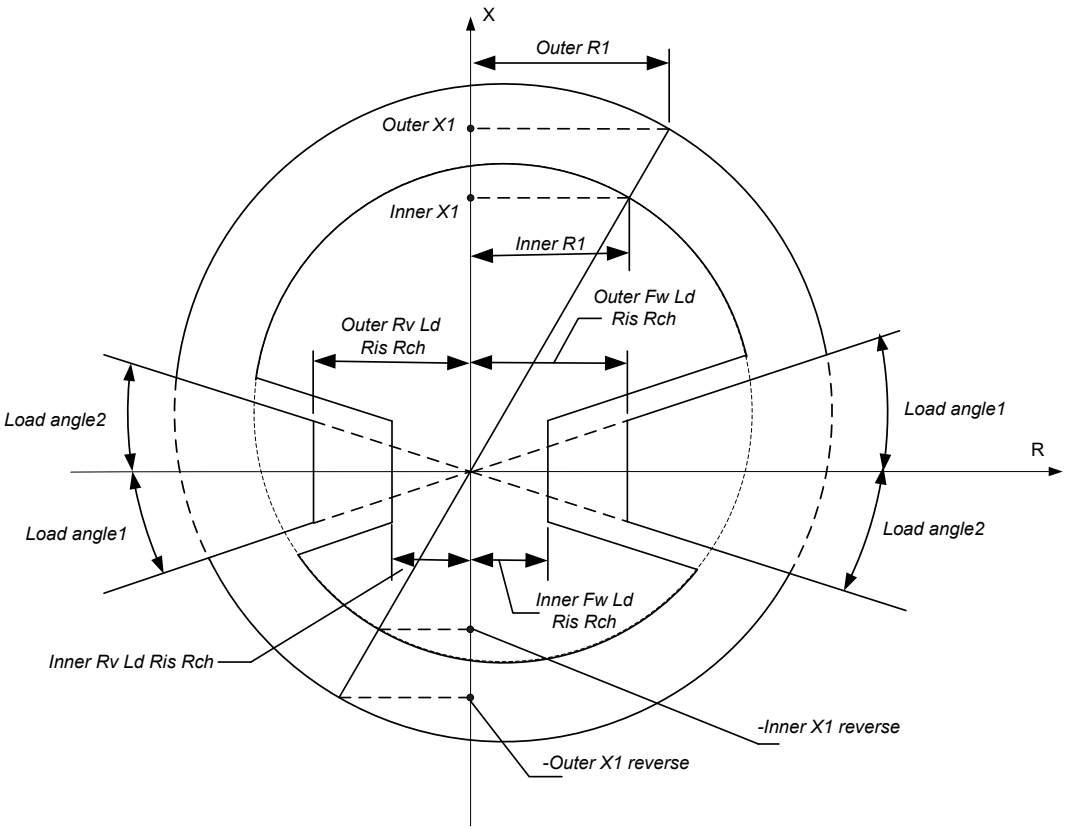



*Figure 586: Mho operation characteristics*

The reach of inner circle is defined by the settings *Inner R1, Inner X1, Inner X1 reverse*. Angle defined by settings *Inner R1* and *Inner X1* defines also reverse zone angle. The reach of outer circle is defined by the settings *Outer R1, Outer X1, Outer X1 reverse*. Angle defined by settings *Outer R1* and *Outer X1* defines also reserve zone angle.

The PSB and SWING_ST outputs can be blocked by activating BLOCK input. Blocking also resets internal timers and impedance calculation.

### 4.7.6.6 Application

Describe different application possibilities of the function. The application information answers one or more of the following questions:

- The problem of the application
- The purpose of the function
- Solution for the problem in general level
- Where can the function be used?
- When can the function be used?
- The application information shall NOT describe what the user should consider or should calculate, plan, dimension etc. to make the function work in the applications.

Power swing detection functions detect power swing conditions by using the fact that the voltage/current variation during a power swing is slow compared to the step change during a fault. Both faults and power swings may cause the positive sequence impedance to enter into the operating characteristic of a distance relay

element. The apparent impedance moves from the pre-fault value to a fault value in a very short time, a few milliseconds, during a fault condition. However, the rate of change of the positive sequence impedance is much slower during a power swing condition than during a fault. It should be noted that the impedance measurement should not be used by itself to distinguish between a power swing condition from a phase fault. The fundamental method for discriminating between faults and power swings is to track the rate of change of the measured impedance.

The function measuring the rate of change of the positive sequence impedance comprises an inner and an outer impedance characteristic with a timer. If the positive sequence impedance remains between the inner and outer characteristics for a predetermined time and enters the inner characteristic, the function declares a power swing condition and asserts an output that can be used to block the distance protection. Figure below gives an example of power swing detection.

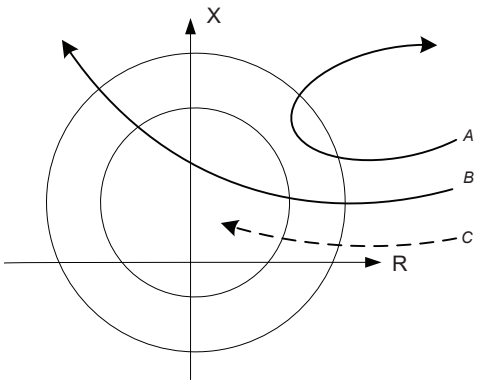



*Figure 587: Example of power swing detection*

In the above figure, the power swing detection characteristics and three typical positive sequence impedance trajectories are plotted. For trajectory A, the impedance moves into the power swing detection zone and leaves slowly, indicating the occurrence of a swing that quickly stabilizes. For trajectory C, impedance rapidly moves into, and remains in, the inner characteristic indicating an actual fault and not a power swing condition. For trajectory B, the impedance moves slowly into the power swing detection zone and exits the zone indicating that the network is becoming unstable. Only in this case power swing blocking functionality should be activated in order to avoid unwanted/unselective operation of distance protection.

The settings of outer impedance measurement characteristic of DSTRPSB should be set so that load impedance does not enter the outer characteristic during normal operation of the power system and covers the inner characteristic entirely. The settings of inner impedance measurement characteristic should be set to make the inner characteristic cover the distance protection zone entirely which will be blocked during power swing.

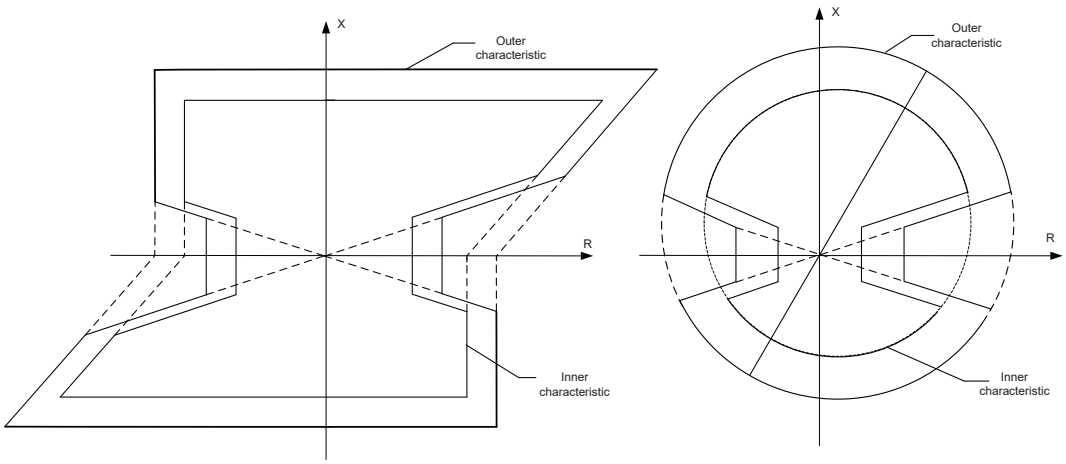



*Figure 588: Relationship between inner and outer characteristic*

## 4.7.6.7 Signals

### DSTRPSB Input signals

**Table 982: DSTRPSB Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### DSTRPSB Output signals

**Table 983: DSTRPSB Output signals**

| Name | Type | Description |
|---|---|---|
| PSB | BOOLEAN | Power swing detected |
| SWING_ST | BOOLEAN | Impedance between inner and outer characteristic |

## 4.7.6.8 Settings

### DSTRPSB Settings

**Table 984: DSTRPSB Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Inner R1 | 0.01...5999.99 | ohm | 0.01 | 30.00 | Positive sequence resistive zone reach, inner border |
| Inner X1 | 0.01...5999.99 | ohm | 0.01 | 30.00 | Positive sequence reactive zone reach, inner border |
| Inner X1 reverse | 0.01...5999.99 | ohm | 0.01 | 30.00 | Positive sequence reactive zone reach in reverse direction, inner border |
| Inner Min Ris Rch | 0.01...5999.99 | ohm | 0.01 | 30.00 | Minimum resistive reach, inner border |
| Outer R1 | 0.02...6000.00 | ohm | 0.01 | 40.00 | Positive sequence resistive zone reach, outer border |
| Outer X1 | 0.02...6000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive zone reach, outer border |
| Outer X1 reverse | 0.02...6000.00 | ohm | 0.01 | 40.00 | Positive sequence reactive zone reach in reverse direction, outer border |
| Outer Min Ris Rch | 0.02...6000.00 | ohm | 0.01 | 40.00 | Minimum resistive reach, outer border |
| Swing time | 20...300000 | ms | 10 | 40 | Power swing detection timer for impedance stays between the inner characteristic and outer characteristic |
| Load discrimination | 0=False<br>1=True | | | 0=False | Enable load discrimination |
| Inner Fw Ld Ris Rch | 0.01...6000.00 | ohm | 0.01 | 15.00 | Resistive forward reach of inner characteristic for load discrimination |
| Inner Rv Ld Ris Rch | 0.01...6000.00 | ohm | 0.01 | 15.00 | Resistive reverse reach of inner characteristic for load discrimination |
| Outer Fw Ld Ris Rch | 0.01...6000.00 | ohm | 0.01 | 25.00 | Resistive forward reach of outer characteristic for load discrimination |
| Outer Rv Ld Ris Rch | 0.01...6000.00 | ohm | 0.01 | 25.00 | Resistive reverse reach of outer characteristic for load discrimination |
| Max impedance angle | 5...85 | deg | 1 | 25 | Maximum impedance angle, load discrimination |
| Min impedance angle | -85...-5 | deg | 1 | -25 | Minimum impedance angle, load discrimination |

**Table 985: DSTRPSB Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Pe Swg impedance Chr | 1=Quadrilateral | | | 1=Quadrilateral | Impedance characteristic |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=Mho (circular) | | | | |

**Table 986: DSTRPSB Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Ng Seq current Spvn | 0=False<br>1=True | | | 0=False | Negative sequence current supervision enabled |
| Max Ng Seq current | 0.01...10.00 | xIn | 0.01 | 0.20 | Maximum allowed negative sequence current for power swing detection |
| Ng Seq current time | 20...1000 | ms | 10 | 20 | Time for negative sequence current supervision blocking the function |
| Slow swing Spvn | 0=False<br>1=True | | | 0=False | Slow swing supervision enabled |
| Slow swing time | 80...60000 | ms | 10 | 2000 | Time for slow swing supervision blocking the function |
| Pulse time | 20...60000 | ms | 10 | 500 | Time for holding output PSB |

## 4.7.6.9 Monitored data

### DSTRPSB Monitored data

**Table 987: DSTRPSB Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Z1_AMPL | FLOAT32 | 0.00...99999.00 | ohm | Positive sequence impedance amplitude |
| Z1_ANGLE | FLOAT32 | -180.00...180.00 | deg | Positive sequence impedance phase angle |
| DSTRPSB | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 4.7.6.10 Technical data

**Table 988: DSTRPSB Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = fn |
| | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Impedance: |

*Table continues on the next page*

| Characteristic | Value |
|---|---|
| | ±3% of the set value or ±0.05 Ω<br>Phase angle: ±2° |
| Reset ratio | Typically 0.96/1.04 |
| Operate time accuracy[1] | ±1.0% of the set value or 20 ms |

# 4.8 Power protection

## 4.8.1 Underpower protection DUPPDPR (ANSI 32U)

### 4.8.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Underpower protection | DUPPDPR | P< | 32U |

### 4.8.1.2 Function block




*Figure 589: Function block*

### 4.8.1.3 Functionality

The underpower protection function DUPPDPR is used for protecting generators and prime movers against the effects of very low power outputs or reverse power condition.

The function operates when the measured active power falls below the set value. The operating characteristics are according to definite time DT.

This function contains a blocking functionality. It is possible to block the function outputs, timer or the function itself.

### 4.8.1.4 Analog channel configuration

DUPPDPR has two analog group inputs which must be properly configured.

[1] Measured with static power output (SPO)

**Table 989: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 990: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with the corresponding one voltage channel connected if the measurement mode is set to "PhsAB", "PhsBC", "PhsCA", "PhsA", "PhsB" or "PhsC". |
| | The function requires that at least two (the third voltage will be derived) or all three voltage channels are connected for the other measurement modes. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.8.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”.

The operation of DUPPDPR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

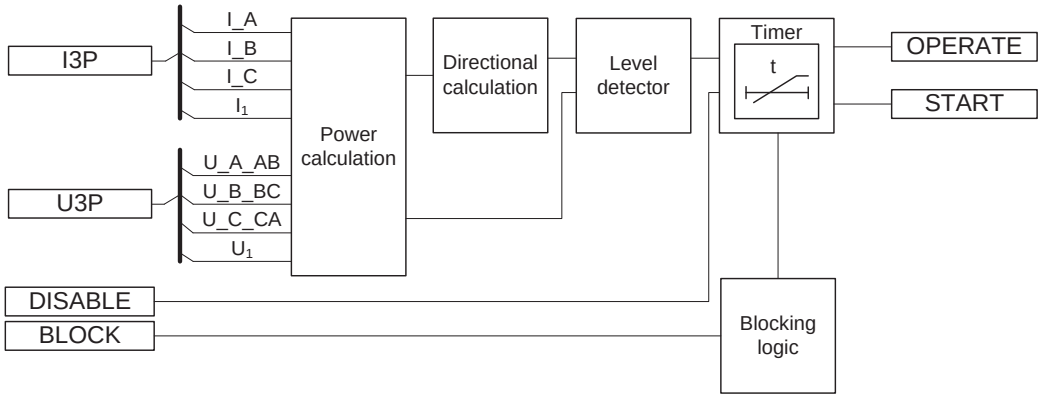



*Figure 590: Functional module diagram*

### Power calculation

This module calculates the apparent power based on the selected voltage and current measurements as described in *Table 991*. The *Measurement mode* setting determines which voltage and current measurements are to be used.

It is also possible to use positive-sequence components for calculating apparent power, which makes the determination of power insensitive to the possible asymmetry in currents or voltages and corresponds to the real load of the prime mover of the generator. S¯ ¯¯s¯

**Table 991: Power calculation**

| Measurement mode setting | Power calculation |
|---|---|
| PhsA, PhsB, PhsC | $\bar{S} = \bar{U}_a \cdot \bar{I}_a^* + \bar{U}_b \cdot \bar{I}_b^* + \bar{U}_c \cdot \bar{I}_c^*$<br>$P = Re(\bar{S})$ |
| Arone | $\bar{S} = \bar{U}_{ab} \cdot \bar{I}_a^* - \bar{U}_{bc} \cdot \bar{I}_c^*$<br>$P = Re(\bar{S})$ |
| Pos Seq | $\bar{S} = 3 \cdot \bar{U}_1 \cdot \bar{I}_1^*$<br>$P = Re(\bar{S})$ |
| PhsAB | $\bar{S} = \sqrt{3} \cdot \bar{U}_{ab} \cdot (\bar{I}_a^* - \bar{I}_b^*)$<br>$P = Re(\bar{S})$ |
| PhsBC | $\bar{S} = \sqrt{3} \cdot \bar{U}_{bc} \cdot (\bar{I}_b^* - \bar{I}_c^*)$<br>$P = Re(\bar{S})$ |
| PhsCA | $\bar{S} = \sqrt{3} \cdot \bar{U}_{ca} \cdot (\bar{I}_c^* - \bar{I}_a^*)$<br>$P = Re(\bar{S})$ |
| PhsA | $\bar{S} = 3 \cdot \bar{U}_a \cdot \bar{I}_a^*$<br>$P = Re(\bar{S})$ |
| PhsB | $\bar{S} = 3 \cdot \bar{U}_b \cdot \bar{I}_b^*$ |

*Table continues on the next page*

| Measurement mode setting | Power calculation |
|---|---|
| | $P = Re(\bar{S})$ |
| PhsC | $\bar{S} = 3 \cdot \bar{U}_c \cdot \bar{I}_c^*$<br>$P = Re(\bar{S})$ |

If all three phase voltages and phase currents are fed to the protection relay, the positive-sequence alternative is recommended (default).

Depending on the set *Measurement mode*, the power calculation calculates active power, reactive power and apparent power values from the available set of measurements. The calculated powers S, P, Q and the power factor angle, PF_ANGL, are available in the Monitored data.

### Directional calculation

Directional calculation determines the direction of the measured power. The measured power is considered to be in the forward direction if the active power is positive, else it is considered to be in the reverse direction.

A typical error is, for example, that the VT or CT poles are wrongly connected. This is seen as a power flow opposite to that of the intended direction. The *Pol Reversal* setting can be used to correct the situation. By setting the value to "True", the measured apparent power is turned 180 degrees.

### Level detector

Level detector compares the calculated value of the active power with a set *Start value*. If the calculated value of the active power falls below *Start value* in the forward direction or if the measured power is in the reverse direction, Level detector enables the Timer module.

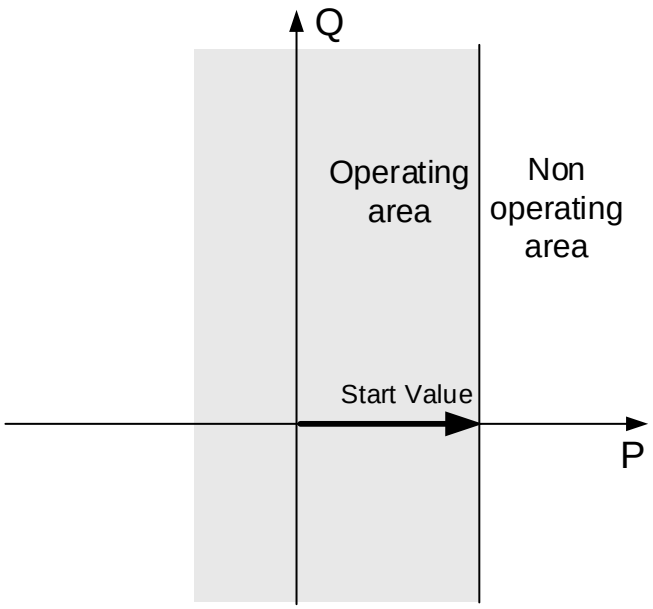



*Figure 591: Operating characteristics of DUPPDPR with setting Start value*

**Timer**

Once activated, the Timer activates the START output. The time characteristics are according to DT. When the operation timer has reached the value of *Operate delay time*, the OPERATE output is activated. In a drop-off situation, that is, if the underpower condition disappears before the operation delay is exceeded, the timer reset state is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

The Timer calculates the START_DUR value which indicates the percentage of the time elapsed since the activation of the START output with respect to *Operate delay time*. The value is available in the Monitored data.

The DISABLE input can be used to coordinate the correct operation during the generator start-up situation. By activating the DISABLE signal, both the START and OPERATE outputs are blocked. Once the DISABLE signal is deactivated, the Timer remains blocked for an additional time duration as set through the setting *Disable time*.

**Blocking logic**

There are three operation modes in the blocking functionality. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode,

the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.8.1.6 Application

The task of a generator in a power plant is to convert mechanical energy into electrical energy. Sometimes the mechanical power from the prime mover may decrease so much that it does not cover the internal losses. The task of an underpower protection is to protect the generator from very low power output conditions.

Steam turbines become easily overheated if the steam flow becomes too low or if the steam ceases to flow through the turbine. Hydro turbine of the Kaplan type may be damaged due to the fact that the turbine blade surfs on the water and sets up axial pressure on the bearing. Diesel engines may be damaged due to insufficient lubrication.

If the generator size is very large, it is uneconomical to continue running it with low generated power. In the reverse power condition, large generators draw a considerable amount of power from the rest of the system to feed their internal losses. Hence, it is desirable to disconnect the generator in such situations.

In case of the parallel-connected generators, for example, the load of one generator may be so low that it is better to disconnect it and let the remaining generators feed the network.

Where a low value of power setting is required, for example less than 2%, the correction parameters should be used to compensate for the measuring errors. The manufacturer of the measuring devices is to be contacted for information on the measuring errors.

If the measuring errors are not compensated for, the underpower setting should not be lower than the sum of the current-measuring and voltage-measuring errors.

For example, if the error of the current-measuring device is 2% and that of the voltage-measuring device is 1%, the minimum setting is (2 + 1)% = 3%.

### 4.8.1.7 Signals

#### DUPPDPR Input signals

**Table 992: DUPPDPR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| DISABLE | BOOLEAN | 0=False | Signal to block the function during generator startup |

**DUPPDPR Output signals**

**Table 993: DUPPDPR Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.8.1.8 DUPPDPR Settings

**Table 994: DUPPDPR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...2.00 | xSn | 0.01 | 0.10 | Start value |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |

**Table 995: DUPPDPR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation On/Off |

**Table 996: DUPPDPR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=PhsA, PhsB, PhsC<br>2=Arone<br>3=Pos Seq<br>4=PhsAB<br>5=PhsBC<br>6=PhsCA<br>7=PhsA<br>8=PhsB<br>9=PhsC | | | 3=Pos Seq | Selection of power calculation method |
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |
| Pol reversal | 0=False<br>1=True | | | 0=False | Reverse the definition of the power direction |
| Disable time | 0...60000 | ms | 1000 | 0 | Additional wait time after CB closing |

### 4.8.1.9 DUPPDPR Monitored data

**Table 997: DUPPDPR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| P | FLOAT32 | -160.000...160.000 | xSn | Active power |
| Q | FLOAT32 | -160.000...160.000 | xSn | Reactive power |
| S | FLOAT32 | 0.000...160.000 | xSn | Apparent power |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| PF_ANGLE | FLOAT32 | -180.00...180.00 | deg | Power factor angle |
| DUPPDPR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.8.1.10 Technical data

**Table 998: DUPPDPR Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy [1] | Depending on the frequency of the measured current and voltage:<br>$f_n$ ±2 Hz |
| | Power measurement accuracy ±3% of the set value or ±0.002 × $S_n$<br>Phase angle: ±2° |
| Start time [2, 3] | Typically 45 ms |
| Reset time | Typically 30 ms |
| Reset ratio | Typically 1.04 |
| Operate time accuracy | ±1.0% of the set value of ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,... |

### 4.8.2 Reverse power-directional overpower protection DOPPDPR (ANSI 32R/32O)

#### 4.8.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Reverse power/directional overpower protection | DOPPDPR | P>/Q> | 32R/32O |

[1] *Measurement mode* = “Pos Seq” (default)
[2] U = $U_n$, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[3] Includes the delay of the signal output contact

### 4.8.2.2 Function block




*Figure 592: Function block*

### 4.8.2.3 Functionality

The reverse power/directional overpower protection function DOPPDPR can be used for generator protection against delivering an excessive power beyond the generator's capacity to the grid, against the generator running like a motor, and against the motor running like a generator and for protecting a motor which consumes more reactive power due to loss of field. It can also be used in feeder protection for indicating overload on the distribution system, to indicate that a customer is supplying power into the grid and for protecting the transformer from delivering an excessive load.

The function starts and operates when the measured power exceeds the set limit and in a specified direction. The operate time characteristics are according to definite time (DT).

This function contains a blocking functionality. It is possible to block the function outputs, timer or the function itself.

### 4.8.2.4 Analog channel configuration

DOPPDPR has two analog group inputs which must be properly configured.

**Table 999: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1000: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with the corresponding one voltage channel connected if the *Measurement mode* is set to "PhsAB", "PhsBC", "PhsCA", "PhsA", "PhsB" or "PhsC". |
| | The function requires that at least two (the third voltage will be derived) or all three voltage channels are connected for the other measurement modes. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.8.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of DOPPDPR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

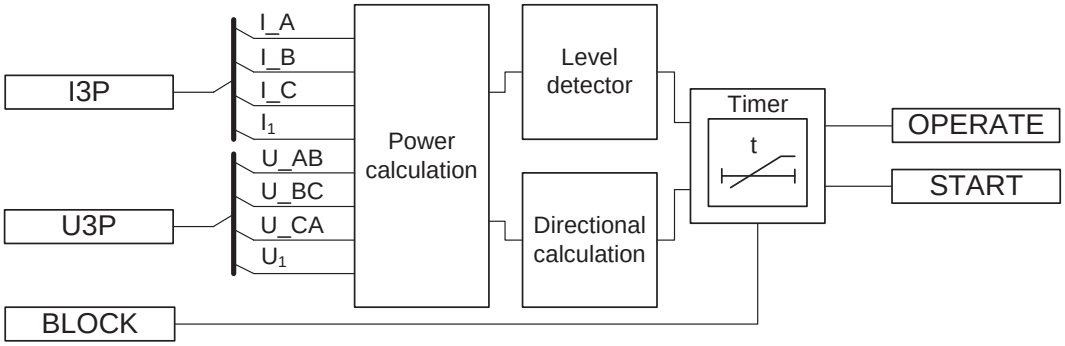



*Figure 593: Functional module diagram*

#### Power calculation

This module calculates the apparent power based on the selected voltages and currents. The *Measurement mode* setting determines which voltages and currents are used. It is also possible to use positive-sequence components for calculating the apparent power which makes the determination of power insensitive to a possible asymmetry in currents or voltages and corresponds to the real load on the prime mover of the generator.

**Table 1001: Power calculation**

| Measurement mode setting | Power calculation |
|---|---|
| PhsA, PhsB, PhsC | $\bar{S} = \bar{U}_a \cdot \bar{I}_a^* + \bar{U}_b \cdot \bar{I}_b^* + \bar{U}_c \cdot \bar{I}_c^*$<br>$P = Re(\bar{S})$ |
| Arone | $\bar{S} = \bar{U}_{ab} \cdot \bar{I}_a^* - \bar{U}_{bc} \cdot \bar{I}_c^*$<br>$P = Re(\bar{S})$ |

*Table continues on the next page*

| Measurement mode setting | Power calculation |
|---|---|
| Pos Seq | $\bar{S} = 3 \cdot \bar{U}_1 \cdot \bar{I}_1^*$<br>$P = Re(\bar{S})$ |
| PhsAB | $\bar{S} = \sqrt{3} \cdot \bar{U}_{ab} \cdot (\bar{I}_a^* - \bar{I}_b^*)$<br>$P = Re(\bar{S})$ |
| PhsBC | $\bar{S} = \sqrt{3} \cdot \bar{U}_{bc} \cdot (\bar{I}_b^* - \bar{I}_c^*)$<br>$P = Re(\bar{S})$ |
| PhsCA | $\bar{S} = \sqrt{3} \cdot \bar{U}_{ca} \cdot (\bar{I}_c^* - \bar{I}_a^*)$<br>$P = Re(\bar{S})$ |
| PhsA | $\bar{S} = 3 \cdot \bar{U}_a \cdot \bar{I}_a^*$<br>$P = Re(\bar{S})$ |
| PhsB | $\bar{S} = 3 \cdot \bar{U}_b \cdot \bar{I}_b^*$<br>$P = Re(\bar{S})$ |
| PhsC | $\bar{S} = 3 \cdot \bar{U}_c \cdot \bar{I}_c^*$<br>$P = Re(\bar{S})$ |

If all three phase voltages and phase currents are fed to the protection relay, the positive-sequence alternative is recommended.

The calculated powers S, P, Q and the power factor angle PF_ANGL are available in the Monitored data view.

### Level detector

The Level detector compares the magnitude of the measured apparent power to the set *Start value*. If the measured value exceeds the set *Start value*, the Level detector sends an enabling signal to the Timer module.

### Directional calculation

The Directional calculation module monitors the direction of the apparent power. When the apparent power flow is in the operating area, the module sends the enabling signal to the Timer module. The directional operation can be selected with

the combination of the settings *Directional mode* and *Power angle*. The selectable options for the *Directional mode* setting are "Forward" and "Reverse". The *Power angle* setting can be used to set the power direction between the reactive and active power.

A typical error is, for example, that the VT or CT poles are wrongly connected. This is seen as a power flow opposite to that of the intended direction. The *Pol Reversal* setting can be used to correct the situation. By setting the value to "True", the measured apparent power is turned 180 degrees.

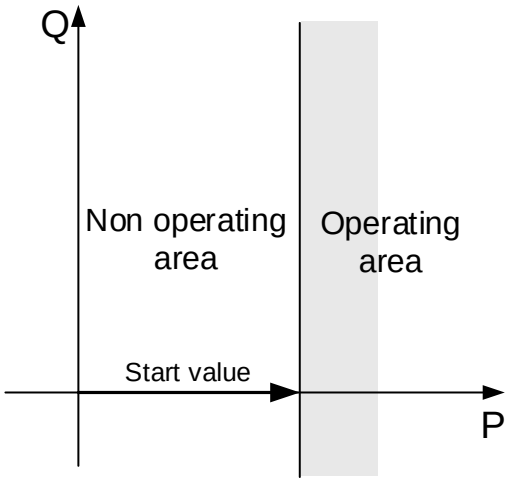



*Figure 594: Operating characteristics with the Start Value setting, the Power angle setting being 0 and Directional mode "Forward"*

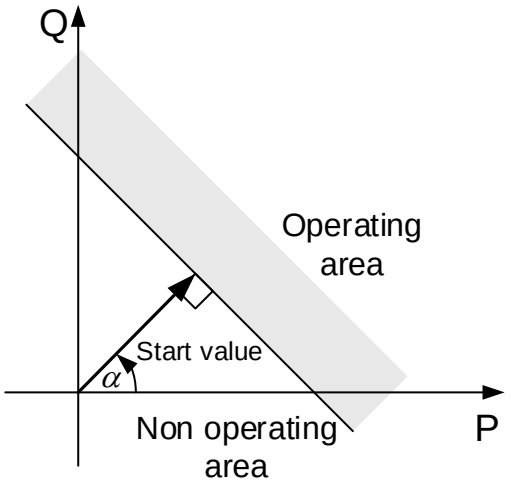



*Figure 595: Operating characteristics with the Start Value setting, Power angle (α) being +45 and Directional mode "Forward"*

**Timer**

Once activated, the Timer activates the START output. The time characteristics are according to DT. When the operation timer has reached the value of *Operate delay time*, the OPERATE output is activated. If a drop-off situation happens, that is, the value of power drops below *Start value* before the operate delay is exceeded, the timer reset state is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the START output is deactivated.

The Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time (DT). The value is available in the Monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode**, which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operate timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.8.2.6 Application

DOPPDPR is used to provide protection against an excessive power flow in the set operating direction. The main application is the protection of generators and

turbines. It can also be used in feeder protection applications, for example, the ring network.

DOPPDPR in the forward direction can be used to protect the generators or motors from delivering or consuming excess power. For example, the generator overpower protection can be used to shed a noncritical feeder load or to start parallel generators. A synchronous motor may start consuming more reactive power in case of loss of excitation, in which case the forward overpower protection is used to detect such condition.

The DOPPDPR function has many applications when used as reverse power protection. A generator in a power plant converts mechanical energy to electrical energy. Sometimes the mechanical power from a prime mover may decrease to a limit that it does not cover the internal losses. The synchronous generator becomes a synchronous motor and starts importing power from the system. The effect of a generator acting as a motor implies no risk to the machine but can cause damage to the prime mover. The extent of the damage depends on the type of the prime mover.

Steam turbines become overheated easily if the steam flow drops too low or if the steam ceases to flow through the turbine. The break of a main steam pipe, damage to one or more blades in the steam turbine or an inadvertent closing of the main stop valves are typical causes for the low steam flow. The steam turbines of turbo generators can be protected during a low steam flow with the overpower protection operating in reverse direction. Hydroturbines tolerate reverse power much better than steam turbines do. There is a risk that the turbine runner moves axially and touches stationary parts. They are not always strong enough to withstand the associated stresses.

A hydroturbine that rotates in water with the closed wicket gates draws about 10 % of the rated power from the rest of the power system if the intake is blocked due to ice, snow, branches or leaves. A complete blockage of the intake may cause cavitations. If there is only air in the hydroturbine, the power demand drops to about 3 %. The risk of damages to the hydroturbines can justify the reverse operation of the overpower protection in unattended plants.



Whenever a low value of the reverse power setting is required, an underpower protection should also be used in conjunction with DOPPDPR. The limit depends on the CT and VT accuracy.

Diesel engines should have overpower protection in reverse direction. The generator takes about 15 % or more of its rated power from the system. A stiff engine may require 25 % of the rated power to motor it. A well run engine may need no more than 5 %. It is necessary to obtain information from the engine manufacturer and to measure the reverse power during commissioning.

Reverse overpower can also act as an alternative for an under excitation protection in case of small generators. If the field excitation is reduced, the generator may start importing the reactive power, making the generator run as an asynchronous generator. A synchronous generator is not designed to work asynchronously and may become damaged due to heating in the damper windings or heating in the rotor due to slip frequency current.

When operated in reverse power direction, DOPPDPR can be used as an alarm if the power flowing from the industry is feeding the grid, which may not be desired as per the rules and regulations of the utility owning the grid.

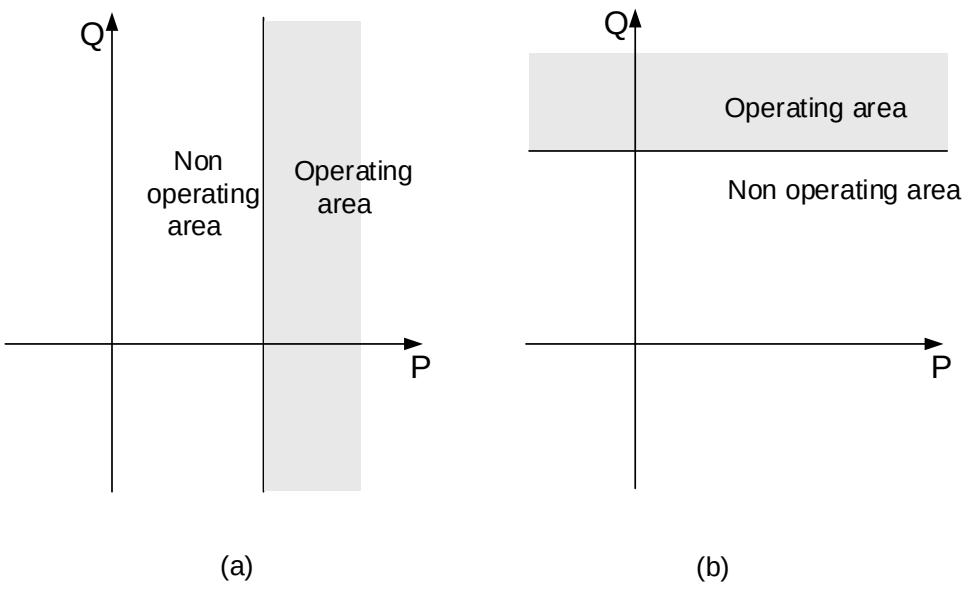



*Figure 596: Forward active overpower characteristics (a) and forward reactive overpower characteristics (b)*

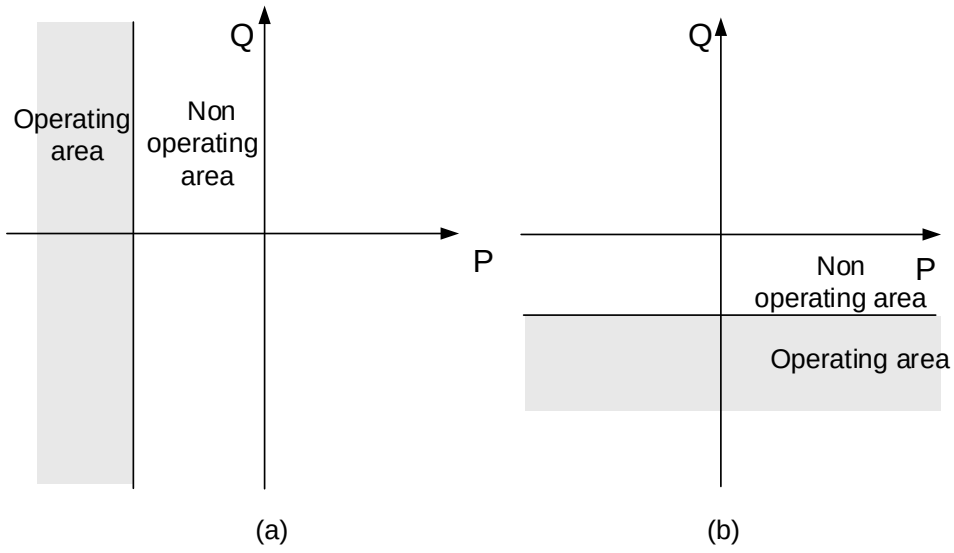



*Figure 597: Reverse active overpower characteristics (a) and reverse reactive overpower characteristics (b)*

### 4.8.2.7 Signals

**DOPPDPR Input signals**

**Table 1002: DOPPDPR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**DOPPDPR Output signals**

**Table 1003: DOPPDPR Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.8.2.8 DOPPDPR Settings

**Table 1004: DOPPDPR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...2.00 | xSn | 0.01 | 1.00 | Start value |
| Operate delay time | 40...300000 | ms | 10 | 40 | Operate delay time |
| Directional mode | 2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Power angle | -90...90 | deg | 1 | 0 | Adjustable angle for power |

**Table 1005: DOPPDPR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation On/Off |
| Measurement mode | 1=PhsA, PhsB, PhsC<br>2=Arone<br>3=Pos Seq<br>4=PhsAB<br>5=PhsBC<br>6=PhsCA<br>7=PhsA<br>8=PhsB<br>9=PhsC | | | 3=Pos Seq | Selection of power calculation method |

**Table 1006: DOPPDPR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |
| Pol reversal | 0=False<br>1=True | | | 0=False | Reverse the definition of the power direction |

### 4.8.2.9 DOPPDPR Monitored data

**Table 1007: DOPPDPR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| P | FLOAT32 | -160.000...160.000 | xSn | Active power |
| Q | FLOAT32 | -160.000...160.000 | xSn | Reactive power |
| S | FLOAT32 | 0.000...160.000 | xSn | Apparent power |
| PF_ANGLE | FLOAT32 | -180.00...180.00 | deg | Power factor angle |
| DOPPDPR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.8.2.10 Technical data

**Table 1008: DOPPDPR Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy [1] | Depending on the frequency of the measured current and voltage:<br>f = $f_n$ ±2 Hz |
| | Power measurement accuracy ±3% of the set value or ±0.002 × $S_n$<br>Phase angle: ±2° |
| Start time [2, 3] | Typically 45 ms |
| Reset time | Typically 30 ms |
| Reset ratio | Typically 0.94 |
| Operate time accuracy | ±1.0 % of the set value of ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

[1] *Measurement mode* = “Pos Seq” (default)
[2] U = $U_n$, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
[3] Includes the delay of the signal output contact

## 4.8.3 Directional reactive power undervoltage protection DQPTUV (ANSI 32Q,27)

### 4.8.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Directional reactive power under-voltage protection | DQPTUV | Q> ->,3U< | 32Q,27 |

### 4.8.3.2 Function block




*Figure 598: Function block*

### 4.8.3.3 Functionality

The directional reactive power undervoltage protection function DQPTUV is used at the grid connection point of distributed power generating units as stipulated by various grid codes to prevent voltage collapse of the grid due to network faults. DQPTUV measures phase voltages and current at the grid connection point. The generating facility is disconnected from the network with a specific time delay if all phase voltages decrease and remain at or below the specified limit and if reactive power is simultaneously consumed (that is, under-excitation operation).

DQPTUV contains a blocking functionality to block function outputs, timer or the function itself.

### 4.8.3.4 Analog channel configuration

DQPTUV has two analog group inputs which must be properly configured.

**Table 1009: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1010: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.8.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of DQPTUV can be described using a module diagram. All the modules in the diagram are explained in the next sections.

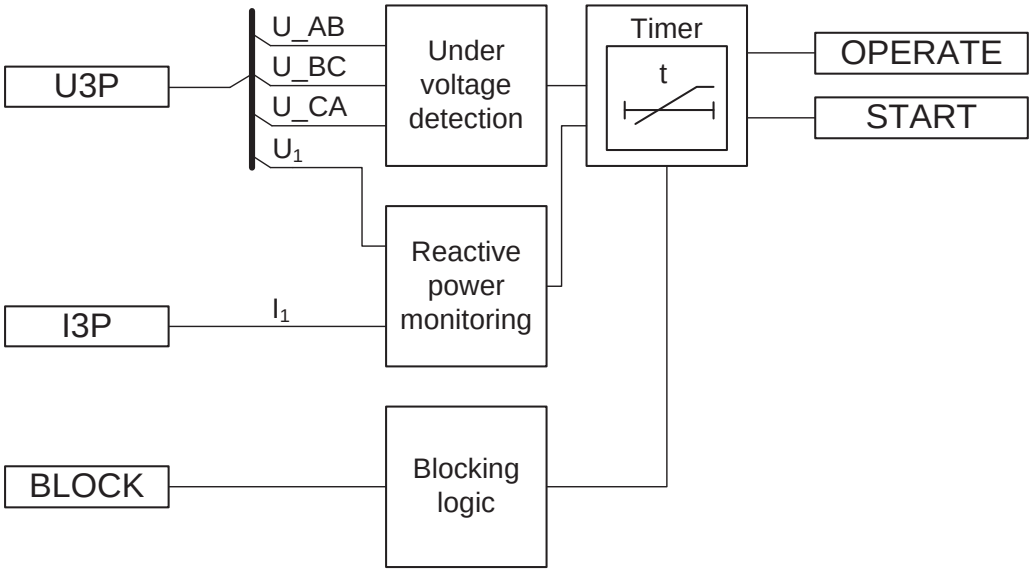



*Figure 599: Functional module diagram*

#### Under voltage detection

Under voltage detection compares the fundamental frequency component of all three phase-to-phase voltages with the set *Voltage start value*. When all three phase-to-phase voltages are lower than the set *Voltage start value*, the Under voltage detection module sends an enable signal to the Timer indicating an undervoltage condition at the grid connection point.

#### Reactive power monitoring

This module calculates and monitors the reactive power based on positive sequence current and voltage. The use of a positive sequence component makes the determination of power insensitive to a possible asymmetry in current and voltages.

When the reactive power exceeds *Min reactive power* and flows in the operating area, the module sends an enable signal to the Timer indicating that the reactive power is being consumed at the grid connection point. A slight tilt in the curve can be obtained by the setting *Pwr sector reduction*.

To avoid false tripping, reactive power calculation is blocked if the magnitude of positive sequence current is less than the set *Min Ps Seq current*.

The magnitude of calculated reactive power Q is available in the Monitored data view.

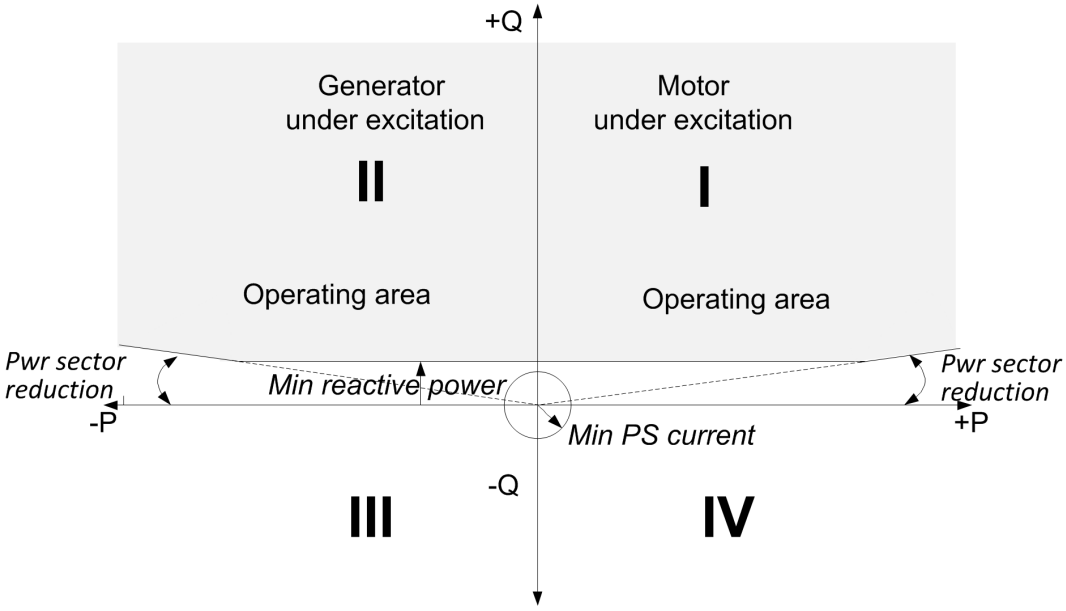



*Figure 600: Operating area of DQPTUV function*

| | |
|---|---|
| Quadrant II | Generator produces active power, but draws reactive power (under-excited) |
| Quadrant III | Generator produces both active and reactive power |

The power direction can be reversed by setting *Pol reversal* to “True”.

**Timer**

Once activated by both Under voltage detection and Reactive power monitoring module, the Timer activates the START output. The Timer characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If the fault disappears before the module operates, the Timer is reset instantaneously.

The Timer calculates the start duration value "START_DUR" which indicates the percentage ratio of the start situation and the set operating time. The value is available through the Monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled

by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode setting* has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.8.3.6 Application

Use of distributed power generating units ( PGU) is rapidly increasing due to liberalized markets (deregulation) and the global trend to use more renewable sources of energy. As the capacity of these generating units increase, they are connected directly to medium voltage networks. Until recent years it had been a practice by grid operators to disconnect the distributed power generator from the network in case of fault in the network.

If there is a considerable loss in the power generation, it may affect the system’s ability to recover. To ensure power system stability, various grid codes have revised their requirements and therefore require that the distributed PGUs have to make a contribution to network support. In case of network faults, the distributed power generator should not be immediately disconnected from the network. Instead, as a matter of principle, generating plants connected to the medium-voltage network must be capable of participating in steady-state voltage control and dynamic network support. However, if the generators stay connected, it must be ensured that they do not take reactive power from the network because this may lead to collapse of the grid. DQPTUV is used for detecting such situations, that is, simultaneous undervoltage and reactive power (under excited generators) and trip the generators.

The protection function DQPTUV is developed considering various grid codes. For example, in the BDEW Technical Guideline “Generating Plants Connected to the Medium-Voltage Network” (June 2008 issue, Germany), it is stated that if all three phase-to-phase voltages at the grid connection point decrease and remain at and below a value of 85% of the rated and if reactive power is simultaneously consumed at the grid connection point (under-excited operation), the generating facility must be disconnected from the network with a time delay of 0.5 s.

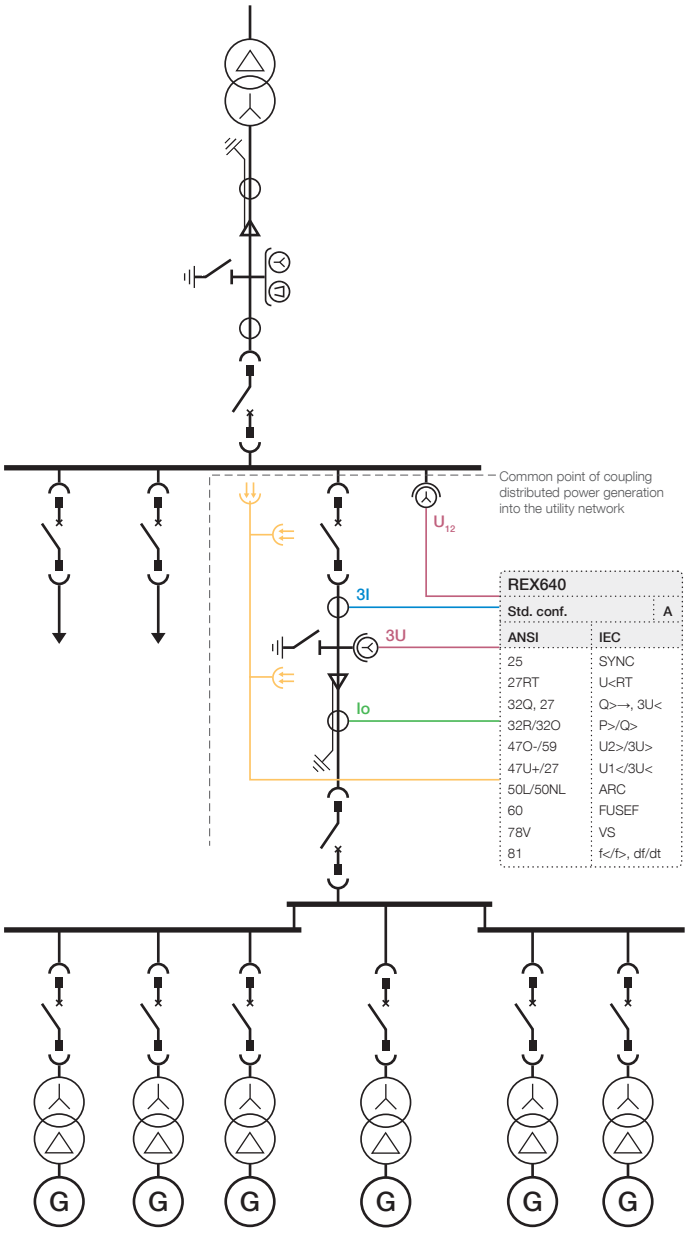



*Figure 601: Application example of wind power plant as distributed power generation coupled into the utility network*

### 4.8.3.7 Signals

**DQPTUV Input signals**

**Table 1011: DQPTUV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**DQPTUV Output signals**

**Table 1012: DQPTUV Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.8.3.8 DQPTUV Settings

**Table 1013: DQPTUV Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage start value | 0.20...1.20 | xUn | 0.01 | 0.85 | Start value for under voltage detection |
| Operate delay time | 100...300000 | ms | 10 | 500 | Operate delay time |

**Table 1014: DQPTUV Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation On/Off |

**Table 1015: DQPTUV Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min reactive power | 0.01...0.50 | xSn | 0.01 | 0.05 | Minimum reactive power needed for function to operate |
| Min Ps Seq current | 0.02...0.20 | xIn | 0.01 | 0.05 | Minimum positive sequence current |
| Pwr sector reduction | 0...10 | deg | 1 | 3 | Power sector reduction |
| Pol reversal | 0=False<br>1=True | | | 0=False | Reverse the definition of the positive reactive power direction |

### 4.8.3.9 DQPTUV Monitored data

**Table 1016: DQPTUV Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| Q | FLOAT32 | -160.000...160.000 | xSn | Reactive power |
| DQPTUV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.8.3.10 Technical data

**Table 1017: DQPTUV Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current and voltage:<br>$f_n$ ±2 Hz<br>Reactive power range \|PF\| <0.71 |
| | Power:<br>±3.0 % or ±0.002 × $Q_n$<br>Voltage:<br>±1.5 % of the set value or ±0.002 × $U_n$ |
| Start time [1, 2] | Typically 46 ms |
| Reset time | <50 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 4.8.4 Underpower factor protection MPUPF (ANSI 55U)

### 4.8.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Underpower factor protection | MPUPF | PF< | 55U |

[1] *Start value* = 0.05 × $S_n$, reactive power before fault = 0.8 × *Start value*, reactive power overshoot 2 times, results based on statistical distribution of 1000 measurements
[2] Includes the delay of the signal output contact

### 4.8.4.2 Function block

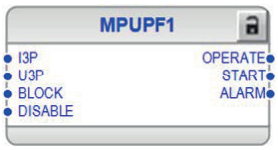



*Figure 602: Function block*

### 4.8.4.3 Functionality

The under power factor function MPUPF is used to provide out-of-step and loss of, or under excitation protection for small synchronous motors and generators. The function calculates the power factor and uses a threshold of under power factor as an indication of an out-of-step and/or loss of excitation condition.

In addition, the function can be applied as a power factor controller.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.8.4.4 Analog channel configuration

MPUPF has two analog group inputs which must be properly configured.

**Table 1018: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1019: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that any two voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.8.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of MPUPF can be described using a module diagram. All the modules in the diagram are explained in the next sections.

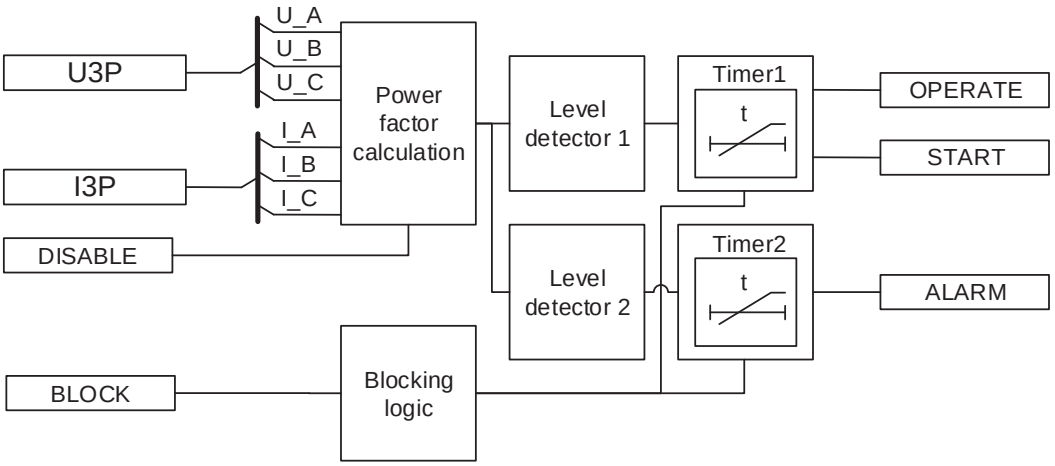



*Figure 603: Functional module diagram*

**Power factor calculation**

This module calculates three phase power factor using phase currents and voltages.

The three-phase power is calculated from the fundamental frequency components (DFT) of the phase-to-earth voltages and phase-to-earth currents.

$$\overline{S} = \overline{U}_A \cdot \overline{I}_A^* + \overline{U}_B \cdot \overline{I}_B^* + \overline{U}_C \cdot \overline{I}_C^*$$

*Figure 604: Equation*

$$P = \mathrm{Re}(\overline{S})$$

*Figure 605: Equation*

$$PF = \frac{P}{|\overline{S}|}$$

*Figure 606: Equation*

*Figure 607* shows the resulting sign of the power factor. This should be consistent with the settings in the power and energy metering function of the relay.

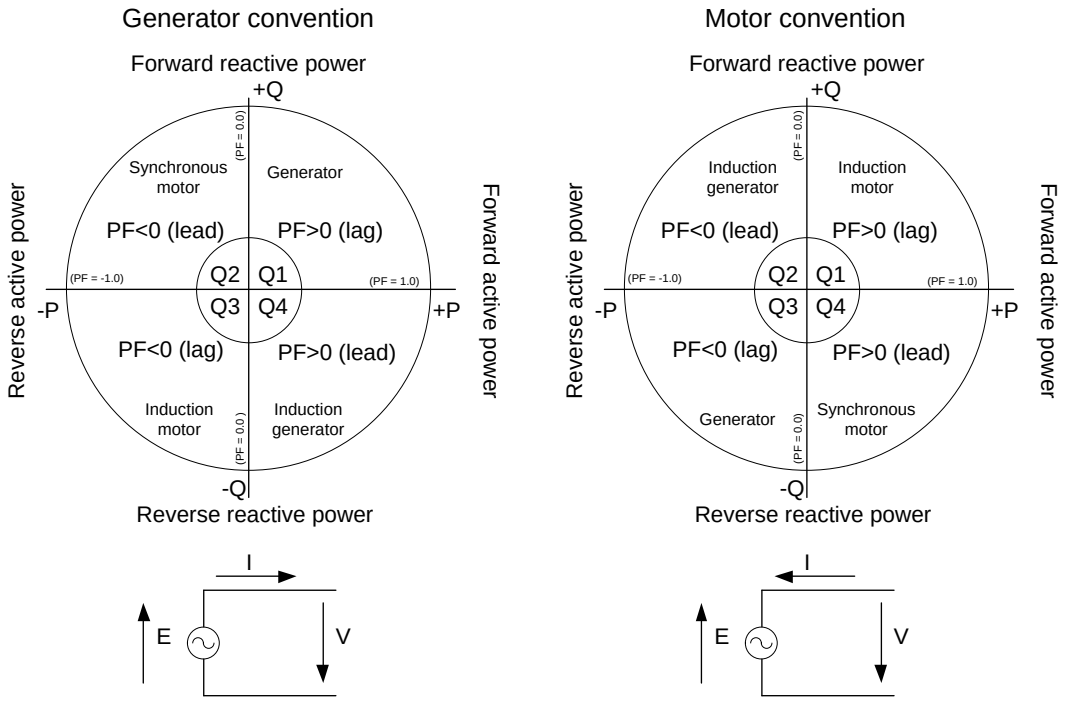



*Figure 607: Power factor quadrant*

If the polarity of the voltage signal is opposite to the normal polarity, the correction can be done by setting *Voltage reversal* to “Yes”, which rotates the power factor vector by 180 degrees.

If the magnitude of all three phase currents or voltages are respectively less than *Current block value* and *Voltage block value* settings, the power factor is set as unity that is 1.00 and the function is disabled internally.

The DISABLE input can be used to coordinate the correct operation during the startup situation. By activating the DISABLE signal, the power factor calculation is blocked. Once the DISABLE signal is deactivated, the function remains blocked for additional time duration as set through the setting *Disable time*.

**Level detector 1**

The Level detector 1 compares the calculated power factor to the set *Start value*. If the power factor value goes below the set *Start value* in the direction as defined by *Dir start value*, the Level detector sends an enabling signal to the Timer 1 module.

**Level detector 2**

The Level detector 2 compares the calculated power factor to the set *Alarm value*. If the power factor value goes below the set *Alarm value* in the direction as defined by *Dir alarm value*, the Level detector sends an enabling signal to the Timer 2 module.

**Timer 1**

Once activated, the Timer 1 activates the START output. The timer characteristic is according to DT. When the operate timer has reached the value set by *Start delay time* in the DT mode, the OPERATE output is activated. If a drop-off situation occurs, that is, a power factor improves and exceeds the *Start reset value* in the direction as defined by *Dir start reset value* before the operate delay is exceeded or either

magnitude of all three phase current or voltages goes below *Current block value* and *Voltage block value* respectively, the timer reset state is activated. The reset timer depends on the *Reset delay time* setting.

The Timer 1 calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operating time. The value is available in the Monitored data view.

**Timer 2**

Once activated, the Timer 2 activates the alarm timer. The timer characteristic is according to DT. When the alarm timer has reached the value set by *Alarm delay time* in the DT mode, the ALARM output is activated. If a drop-off situation occurs, that is, a power factor improves and exceeds the *Alarm reset value* in the direction as defined by *Dir alarm reset value* before the alarm delay is exceeded or either magnitude of all three phase current or voltages goes below *Current block value* and *Voltage block value* respectively, the timer reset state is activated. The reset timer depends on the *Reset delay time* setting.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

### 4.8.4.6 Application

The MPUPF function can be used to detect loss of excitation or for power factor correction. Synchronous motors are mostly operated at leading power factor and its operation as lagging power for extended period can be used an indication of an out-of-step condition possibly caused by under or loss of excitation. To detect such a situation, the relay is typically set to operate when the current into a motor lags more than 30 degrees, that is, a power factor goes below +0.87 lagging.

The function provides alarm facility which can be used as an early indication that the power factor is moving outside the allowable range; therefore the *Alarm value* setting should be set higher than the *Start value*. The delay time for alarm should also be set as low as possible, only long enough to prevent spurious activation of the output.

In a power factor correction application, the ALARM and START outputs can be used as controls to switch in capacitive loads when the *Alarm value* and *Start value* settings, respectively, are exceeded. The ALARM output is set for a higher value to add the first corrective load and the START output set for a second stage of corrective load, if needed. The *Start reset value* and *Alarm reset value* settings allow their respective outputs to remain activated to maintain the correction after power factor rises as a result, but to drop out after it reaches a level where corrective capacitive loading is no longer needed.

There are two general applications which can best utilize under power factor protection; power-factor control and loss of excitation.

When applying the function for power-factor control, both the start value and the start reset value should be the same sign (positive/negative) as well as the same direction (leading/lagging). Additionally, the absolute value of the start reset value should be greater than or equal to the absolute value of the start value. This allows the function to properly control any power factor controls within the system.

When applying the function for loss of excitation, both the start value and the start reset value should be the same sign (positive/negative), but the directions should be different (leading/lagging). This application is well-suited to protect against back-spinning. In this case the start reset value will only come into play once the system provides power in the opposite quadrant of the start value, for example, lagging PF turns to leading PF.

### 4.8.4.7 Signals

#### MPUPF Input signals

**Table 1020: MPUPF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| DISABLE | BOOLEAN | 0=False | Signal to block the function during machine startup |

#### MPUPF Output signals

**Table 1021: MPUPF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Alarm |

### 4.8.4.8 MPUPF Settings

**Table 1022: MPUPF Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value Dir | 1=Lagging | | | 1=Lagging | PF direction for start value |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=Leading | | | | |
| Start reset Val Dir | 1=Lagging<br>2=Leading | | | 1=Lagging | PF direction for start reset value |
| Alarm value Dir | 1=Lagging<br>2=Leading | | | 1=Lagging | PF direction for alarm value |
| Alarm reset Val Dir | 1=Lagging<br>2=Leading | | | 1=Lagging | PF direction for alarm reset value |
| Start value | -0.99...0.99 | | 0.01 | 0.80 | Start value |
| Start reset value | -0.99...0.99 | | 0.01 | 0.85 | Value at which start resets, drops out |
| Alarm value | -0.99...0.99 | | 0.01 | 0.85 | Alarm start value |
| Alarm reset value | -0.99...0.99 | | 0.01 | 0.90 | Value at which alarm resets, drops out |
| Operate delay time | 100...300000 | ms | 1 | 500 | Time delay for operation |
| Alarm delay time | 100...300000 | ms | 1 | 500 | Time delay for alarm |

**Table 1023: MPUPF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Min operate current | 0.05...0.65 | xIn | 0.01 | 0.10 | Minimum operating current |
| Min operate voltage | 0.05...0.50 | xUn | 0.01 | 0.10 | Minimum operating voltage |
| Disable time | 0...60000 | ms | 1 | 5000 | Additional wait time after CB closing |
| Voltage reversal | 0=No<br>1=Yes | | | 0=No | Rotates the PF by 180 degrees |

**Table 1024: MPUPF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

## 4.8.4.9 MPUPF Monitored data

**Table 1025: MPUPF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| PF | FLOAT32 | -1.00...1.00 | | Calculated value of the 3-phase power factor |
| MPUPF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

#### 4.8.4.10 Technical data

**Table 1026: MPUPF Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Dependent on the frequency of the current measured: $f_n$ ±2 Hz |
| | ±0.018 for power factor |
| Operate time accuracy | ±(1.0 % or 30 ms) |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5, 6, 7 |
| Reset time | <40 ms |

## 4.9 Arc protection ARCSARC (ANSI AFD)

### 4.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Arc protection | ARCSARC | ARC | AFD |

### 4.9.2 Function block

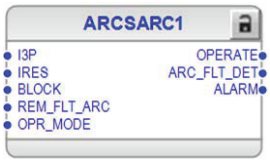



*Figure 608: Function block*

### 4.9.3 Functionality

The arc protection function ARCSARC detects arc situations in air-insulated metal-clad switchgears caused by, for example, human errors during maintenance or insulation breakdown during operation.

The function detects light from an arc either locally or via a remote light signal. The function also monitors phase and residual currents to be able to make accurate decisions on ongoing arcing situations.

The function contains a blocking functionality. Blocking deactivates all outputs and resets timers.

## 4.9.4 Analog channel configuration

ARCSARC has two analog group inputs which must be properly configured.

**Table 1027: Analog inputs**

| Input | Description |
|---|---|
| I3P [1] | Three-phase currents, necessary when the operation mode "Light +current" is used |
| IRES [1] | Residual current (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 4.9.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of ARCSARC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

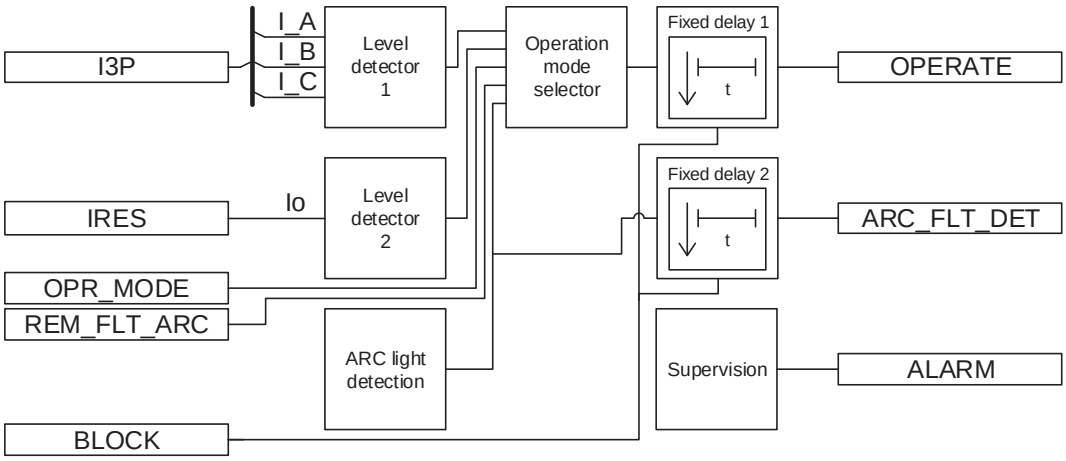



*Figure 609: Functional module diagram*

### Level detector 1

The measured phase currents are compared phasewise to the set *Phase start value*. If the measured value exceeds the set *Phase start value*, the level detector reports the exceeding of the value to the operation mode selector.

[1] Can be connected to GRPOFF if "Light only" or "BI controlled" operation modes are used

**Level detector 2**

The measured residual currents are compared to the set *Ground start value*. If the measured value exceeds the set *Ground start value*, the level detector reports the exceeding of the value to the Operation mode selector.

**ARC light detection**

ARC detection information is received directly from the relay hardware input. The detected ARC fault is directly signalled to the Operation mode selector and Fixed delay 2 modules. There are four ARC detection inputs in the protection relay. Each input is connected to a dedicated ARCSARC function.

**Table 1028: ARC detection inputs connected to ARCSARC**

| ARC input | ARC protection function |
|---|---|
| X11/ARC | ARCSARC1 |
| X12/ARC | ARCSARC2 |
| X13/ARC | ARCSARC3 |
| X14/ARC | ARCSARC4 |

**Operation mode selector**

Depending on the *Operation mode* setting, Operation mode selector makes sure that all required criteria are fulfilled for a reliable decision of an arc fault situation. The operation is based on both current and light information in “Light+current” mode, on light information only in “Light only” mode or on remotely controlled information in “BI controlled” mode. When the "BI controlled" mode is in use and the OPR_MODE input is activated, the operation of the function is based on light information only. When the OPR_MODE input is deactivated, the operation of the function is based on both light and current information. When the required criteria are met, Fixed delay 1 timer is activated.

**Fixed delay 1**

Once this timer is activated, the OPERATE signal output is activated immediately. The output is kept active for minimum 25 ms or as long as the input is activated. The BLOCK signal can be used to block the OPERATE signal.

**Fixed delay 2**

Once this timer is activated, the ARC_FLT_DET output is activated immediately. The output is kept active for minimum 25 ms or as long as the input is activated. The BLOCK signal can be used to block the ARC light signal output ARC_FLT_DET.

**Supervision**

If a faulty arc sensor is internally detected or if the connection to the arc sensor is lost, ALARM output is activated if *Sensor supervision* is set to "on".

When *Sensor supervision* is set to "off", ALARM output stays false even though the arc sensor is faulty or unconnected.

## 4.9.6 Application

The arc protection can be realized as a stand-alone function in a single relay or as a station-wide arc protection, including several protection relays. If realized as a station-wide arc protection, different tripping schemes can be selected for the operation of the circuit breakers of the incoming and outgoing feeders. Consequently, the relays in the station can, for example, be set to trip the circuit breaker of either the incoming or the outgoing feeder, depending on the fault location in the switchgear. For maximum safety, the relays can be set to always trip both the circuit breaker of the incoming feeder and that of the outgoing feeder.

The arc protection consists of:

- Optional arc light detection hardware with automatic backlight compensation for lens type sensors
- Light signal output ARC_FLT_DET for routing indication of locally detected light signal to another relay
- Protection stage with phase- and earth-fault current measurement.

The function detects light from an arc either locally or via a remote light signal. Locally, the light is captured either by lens type point sensors or transparent fiber loop sensors connected to the light sensor input of the relay. This captured light is guided via optical fiber to the sensor input of the relay, where it is converted to electrical signal by means of a photo diode. The optical light sensors can be placed in the various compartments of the switchgear, for example, in the busbar compartment, the circuit breaker compartments, the bus riser and the outgoing feeder cable end compartments.

The light detected by the lens sensor inputs is compared to an automatically adjusted reference level. Each light sensor input has its own reference level. When the light exceeds the reference level of one of the inputs, the light is detected locally. When the light has been detected locally or remotely and, depending on the operation mode, if one or several phase currents exceed the set *Phase start value* limit, or the earth-fault current the set *Ground start value* limit, the arc protection stage generates an operation signal. The stage is reset in 30 ms, after all three-phase currents and the earth-fault current have fallen below the set current limits.

The light signal output from an arc protection stage ARC_FLT_DET is activated immediately in the detection of light in all situations. A station-wide arc protection is realized by routing the light signal output to an output contact connected to a binary input of another relay, or by routing the light signal output through the communication to an input of another relay.

It is possible to block the tripping and the light signal output of the arc protection stage with a binary input or a signal from another function block.

**Arc protection with one protection relay**

In installations, with limited possibilities to realize signaling between protection relays protecting incoming and outgoing feeders, or if only the protection relay for the incoming feeder is to be exchanged, an arc protection with a less selective level can be achieved with one protection relay. In arc detection, the arc protection stage trips the circuit breaker of the incoming feeder. The maximum recommended installation distance between the two lens sensors in the busbar area is six meters and the maximum distance from a lens sensor to the end of the busbar is three meters.

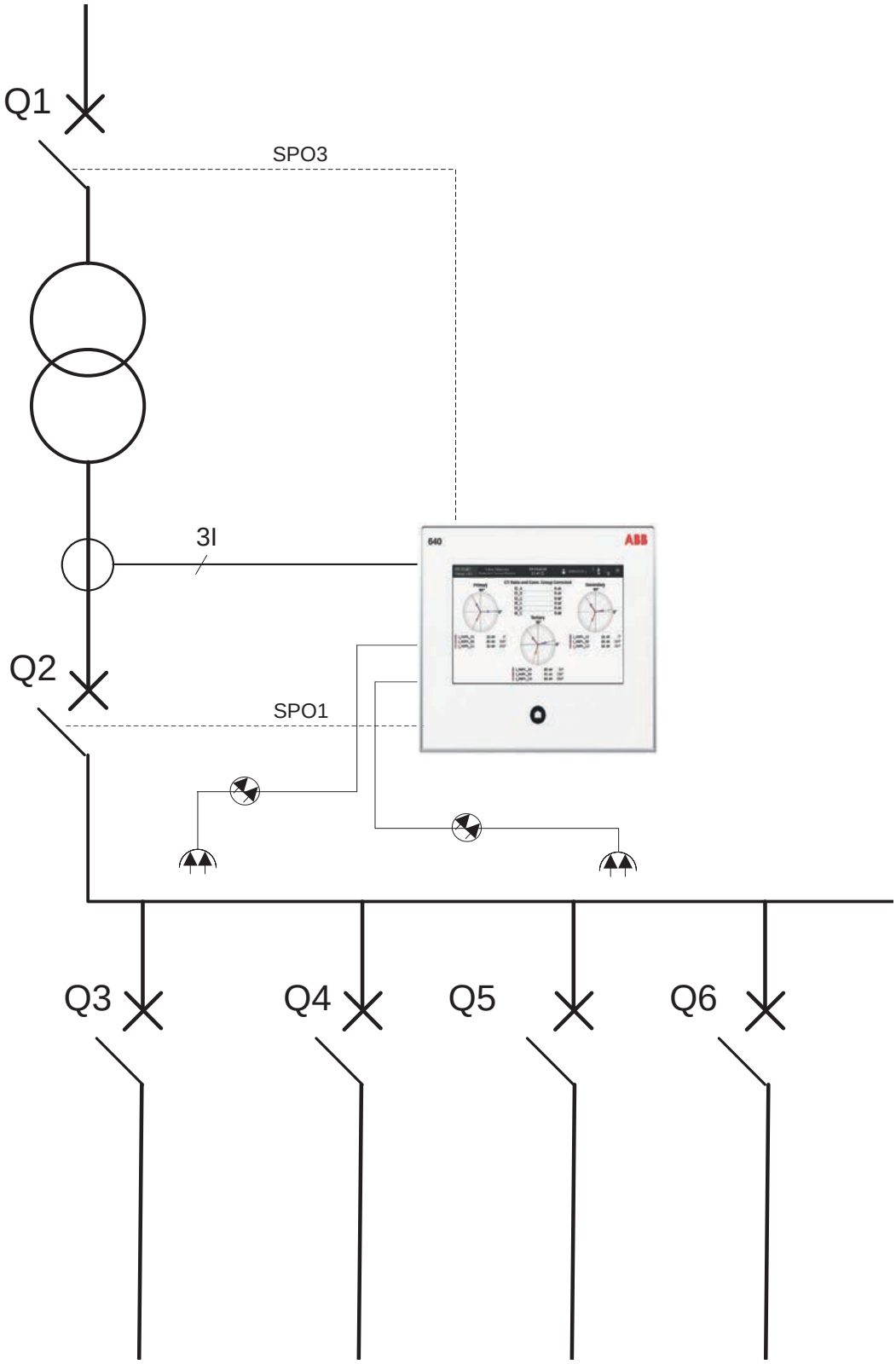



*Figure 610: Arc protection with one protection relay*

### Arc protection with several protection relays

When using several protection relays, the protection relay protecting the outgoing feeder trips the circuit breaker of the outgoing feeder when detecting an arc at the cable terminations. If the protection relay protecting the outgoing feeder detects an arc on the busbar or in the breaker compartment via one of the other lens sensors, it generates a signal to the protection relay protecting the incoming feeder. When detecting the signal, the protection relay protecting the incoming feeder trips the circuit breaker of the incoming feeder and generates an external trip signal to all protection relays protecting the outgoing feeders, which in turn results in tripping of all circuit breakers of the outgoing feeders. For maximum safety, the protection relays can be configured to trip all the circuit breakers regardless of where the arc is detected.

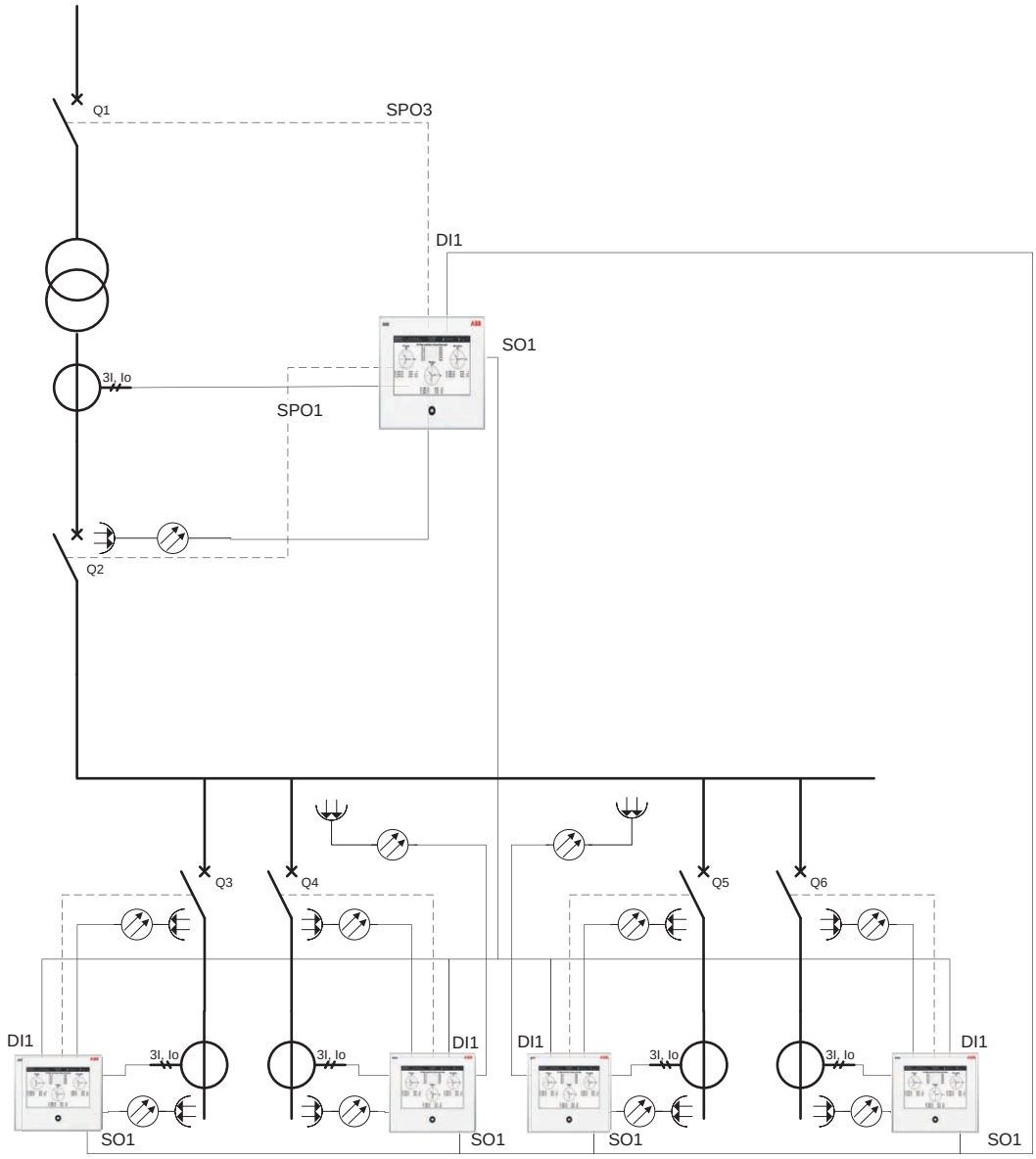



*Figure 611: Arc protection with several protection relays and normal outputs*

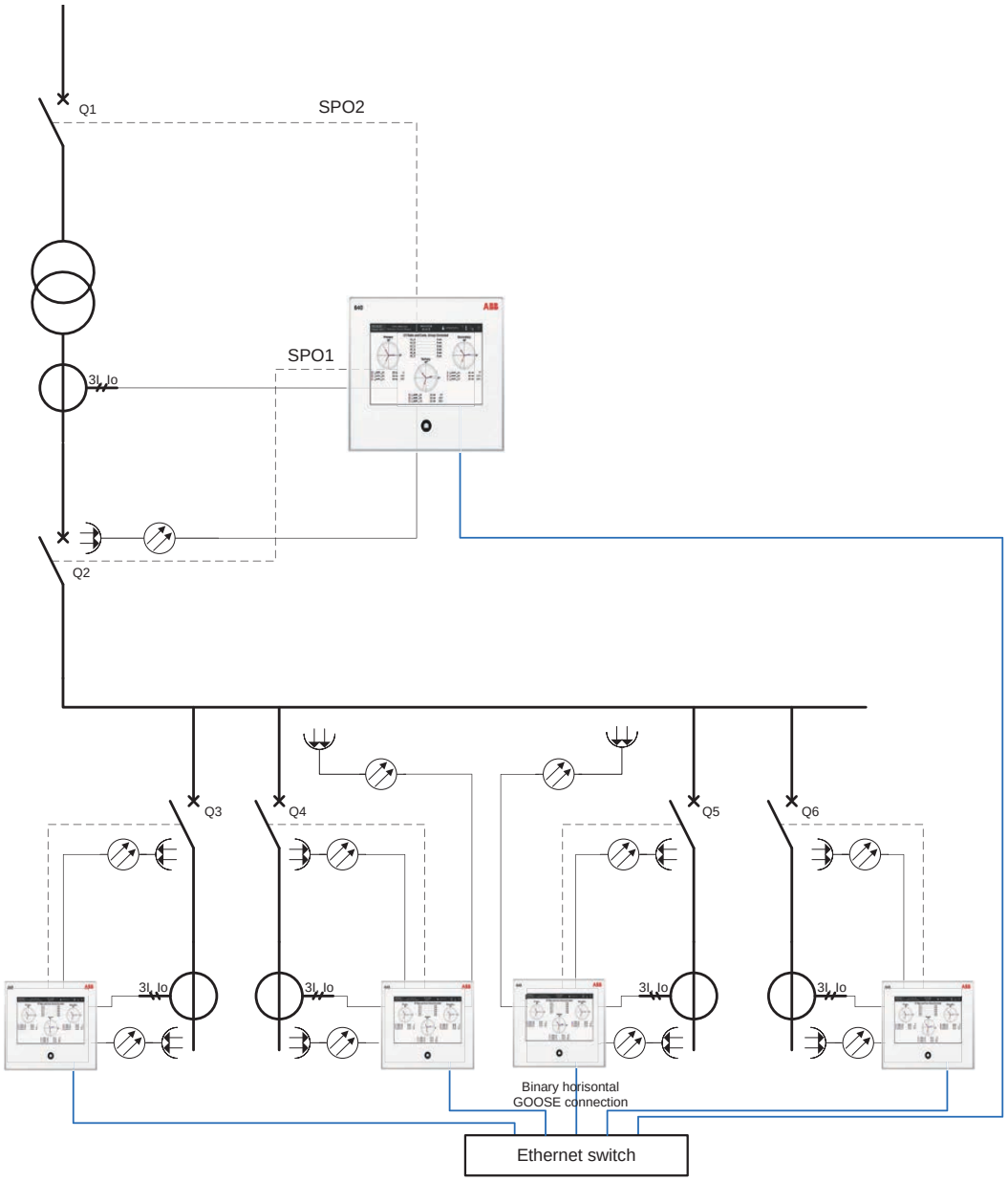



*Figure 612: Arc protection with several protection relays and high-speed outputs and GOOSE*

## 4.9.7 Signals

### 4.9.7.1 ARCSARC Input signals

**Table 1029: ARCSARC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |
| REM_FLT_ARC | BOOLEAN | 0=False | Remote Fault arc detected |
| OPR_MODE | BOOLEAN | 0=False | Operation mode input |

### 4.9.7.2 ARCSARC Output signals

**Table 1030: ARCSARC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| ARC_FLT_DET | BOOLEAN | Fault arc detected=light signal output |
| ALARM | BOOLEAN | Self supervision alarm |

## 4.9.8 ARCSARC Settings

**Table 1031: ARCSARC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase start value | 0.50...40.00 | xIn | 0.01 | 2.50 | Operating phase current |
| Ground start value | 0.05...8.00 | xIn | 0.01 | 0.20 | Operating residual current |
| Operation mode | 1=Light+current<br>2=Light only<br>3=BI controlled | | | 1=Light+current | Operation mode |

**Table 1032: ARCSARC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Sensor supervision | 0=off<br>1=on | | | 1=on | Sensor supervision selection |

### 4.9.9 ARCSARC Monitored data

**Table 1033: ARCSARC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ARCSARC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.9.10 Technical data

**Table 1034: ARCSARC Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | ±3.0 % of the set value or ±0.01 × $I_n$ | | |
| Operate time | | Minimum | Typical | Maximum |
| | *Operation mode* = "Light+current" [1, 2] | 9 ms [2]<br>3 ms [3] | 10 ms [2]<br>5 ms [3] | 13 ms [2]<br>6 ms [3] |
| | *Operation mode* = "Light only" [2] | 8 ms [2]<br>3 ms [3] | 10 ms [2]<br>5 ms [3] | 13 ms [2]<br>6 ms [3] |
| Reset time | | Typically 50 ms | | |
| Reset ratio | | Typically 0.96 | | |

## 4.10 Motor start-up supervision STTPMSU (ANSI 49,66,48,50TDLR)

### 4.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Motor start-up supervision | STTPMSU | Is2t n< | 49,66,48,50TDLR |

[1] *Phase start value* = 1.0 × $I_n$, current before fault = 2.0 × set *Phase start value*, $f_n$ = 50 Hz, fault with nominal frequency, results based on statistical distribution of 200 measurements
[2] Includes the delay of the power output (PO) contact
[3] Measured with static power output (SPO)

## 4.10.2 Function block

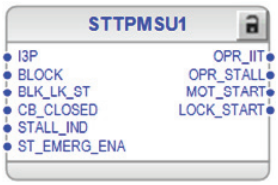



*Figure 613: Function block*

## 4.10.3 Functionality

The motor start-up supervision function STTPMSU is designed for protection against excessive starting time and locked rotor conditions of the motor during starting. For a good and reliable operation of the motor, the thermal stress during the motor starting is maintained within the allowed limits.

The starting of the motor is supervised by monitoring the TRMS magnitude of all the phase currents or by monitoring the status of the circuit breaker connected to the motor.

During the start-up period of the motor, STTPMSU calculates the integral of the $I^2t$ value. If the calculated value exceeds the set value, the operate signal is activated.

STTPMSU has the provision to check the locked rotor condition of the motor using the speed switch, which means checking if the rotor is able to rotate or not. This feature operates after a predefined operating time.

STTPMSU also protects the motor from an excessive number of start-ups. Upon exceeding the specified number of start-ups within certain duration, STTPMSU blocks further starts. The restart of the motor is also inhibited after each start and continues to be inhibited for a set duration. When the lock of start of motor is enabled, STTPMSU gives the time remaining until the restart of the motor.

STTPMSU contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

## 4.10.4 Analog input configuration

STTPMSU has one analog group input which must be properly configured.

**Table 1035: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing

blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 4.10.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of STTPMSU can be described with a module diagram. All the modules in the diagram are explained in the next sections.

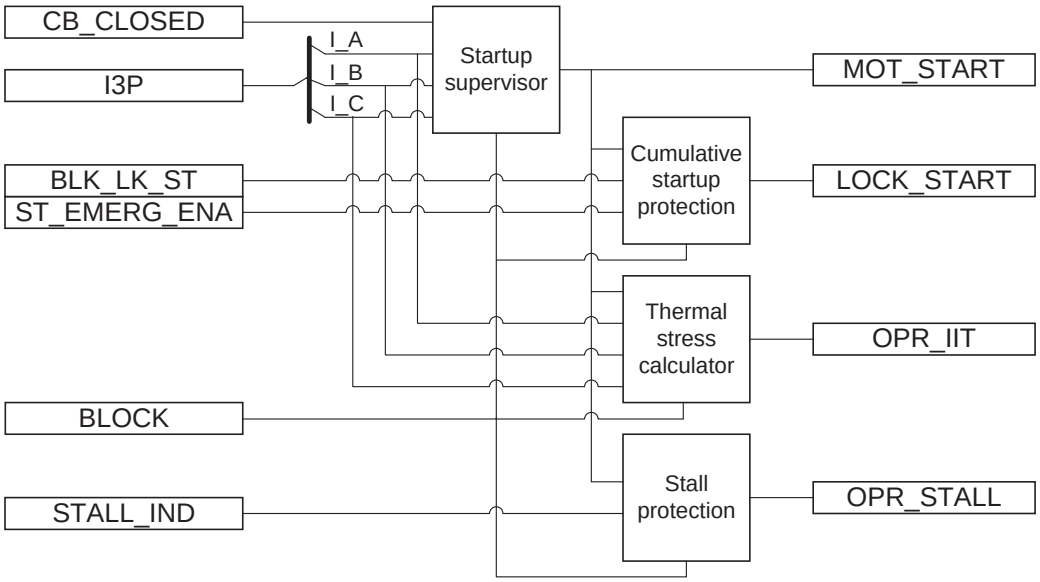



*Figure 614: Functional module diagram*

**Startup supervisor**

This module detects the starting of the motor. The starting and stalling motor conditions are detected in four different modes of operation. This is done through the *Operation mode* setting.

When the *Operation mode* setting is operated in the "IIt" mode, the function calculates the value of the thermal stress of the motor during the start-up condition. In this mode, the start-up condition is detected by monitoring the TRMS currents.

The *Operation mode* setting in the "IIt, CB" mode enables the function to calculate the value of the thermal stress when a start-up is monitored in addition to the `CB_CLOSED` input.

In the "IIt & stall" mode, the function calculates the thermal stress of the motor during the start-up condition. The start-up condition is detected by monitoring the TRMS currents.

In the "IIt & stall, CB" mode, the function calculates the thermal stress of the motor during the start-up condition but the start-up condition is detected by monitoring the TRMS current as well as the circuit breaker status.

In both the "IIt & stall" and "IIt & stall, CB" mode, the function also checks for motor stalling by monitoring the speed switch.

When the measured current value is used for start-up supervision in the "IIt" and "IIt & stall" modes, the module initially recognizes the de-energized condition of the motor when the values of all three phase currents are less than *Motor standstill A* for longer than 100 milliseconds. If any of the phase currents of the de-energized condition rises to a value equal to or greater than *Start detection A*, the MOT_START output signal is activated indicating that the motor start-up is in progress. The MOT_START output remains active until the values of all three phase currents drop below 90 percent of the set value of *Start detection A* and remain below that level for a time of *Str over delay time*, that is, until the start-up situation is over.

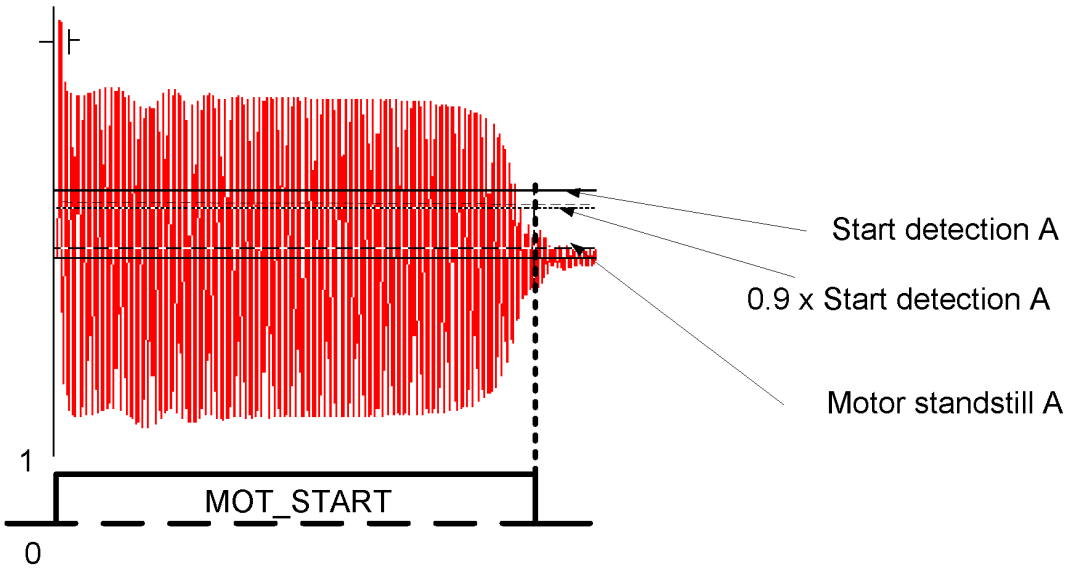



*Figure 615: Functionality of start-up supervision in the "IIt and IIt&stall" mode*

In case of the "IIt, CB" or "IIt & stall, CB" modes, the function initially recognizes the de-energized condition of the motor when the value of all three phase currents is below the value of the *Motor standstill A* setting for 100 milliseconds. The beginning of the motor start-up is recognized when CB is closed, that is, when the CB_CLOSED input is activated and at least one phase current value exceeds the *Motor standstill A* setting.

These two events do not take place at the same instant, that is, the CB main contact is closed first, in which case the phase current value rises above 0.1 pu and after some delay the CB auxiliary contact gives the information of the CB_CLOSED input. In some cases, the CB_CLOSED input can be active but the value of current may not be greater than the value of the *Motor standstill A* setting. To allow both possibilities, a time slot of 200 milliseconds is provided for current and the CB_CLOSED input. If both events occur during this time, the motor start-up is recognized.

The motor start-up ends either within the value of the *Str over delay time* setting from the beginning of the start-up or the opening of CB or when the CB_CLOSED input is deactivated. The operation of the MOT_START output signal in this operation mode is as illustrated in *Figure 616*.

This CB mode can be used in soft-started or slip ring motors for protection against a high starting current, that is, a problem in starting and so on.

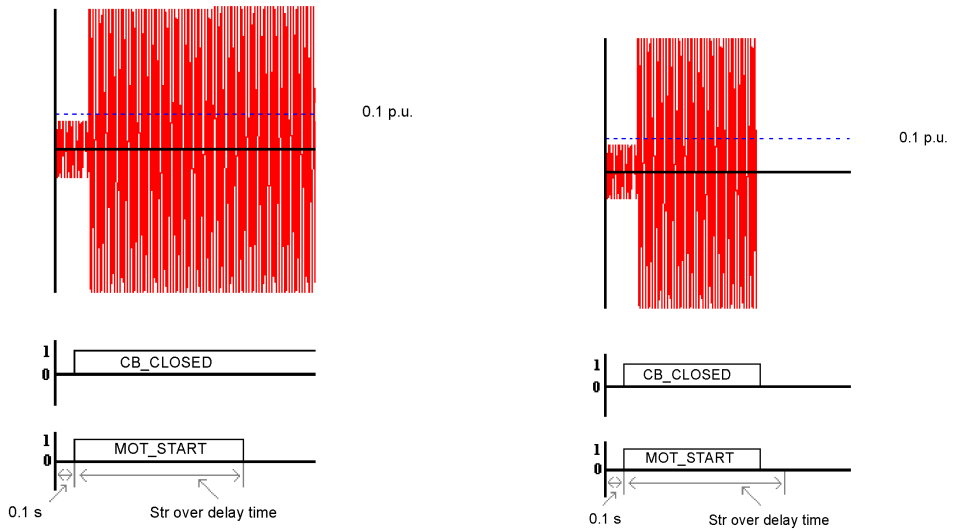



*Figure 616: Functionality of start-up supervision in the "IIt, CB" mode and the "IIt and stall, CB" mode*

The *Str over delay time* setting has different purposes in different modes of operation.

- In the “IIt” or “IIt & stall” modes, the aim of this setting is to check for the completion of the motor start-up period. The purpose of this time delay setting is to allow for short interruptions in the current without changing the state of the MOT_START output. In this mode of operation, the value of the setting is in the range of around 100 milliseconds.
- In the “IIt, CB” or “IIt & stall, CB” modes, the purpose of this setting is to check for the life of the protection scheme after the CB_CLOSED input has been activated. Based on the values of the phase currents, the completion of the start-up period cannot be judged. So in this mode of operation, the value of the time delay setting can even be as high as within the range of seconds, for example around 30 seconds.

The activation of the BLOCK input signal deactivates the MOT_START output.

### Thermal stress calculator

Because of the high current surges during the start-up period, a thermal stress is imposed on the rotor. With less air circulation in the ventilation of the rotor before it reaches its full speed, the situation becomes even worse. Consequently, a long start-up causes a rapid heating of the rotor.

This module calculates the thermal stress developed in the motor during start-up. The heat developed during the starting can be calculated with the equation.

$$W = R_s \int_0^t i_s^2(t)\,dt$$

(Equation 282)

| | |
|---|---|
| $R_s$ | combined rotor and stator resistance |
| $i_s$ | starting current of the motor |
| t | starting time of the motor |

This equation is normally represented as the integral of $I^2t$. It is a commonly used method in protective protection relays to protect the motor from thermal stress during starting. The advantage of this method over the traditional definite time overcurrent protection is that when the motor is started with a reduced voltage as in the star-delta starting method, the starting current is lower. This allows more starting time for the motor since the module is monitoring the integral of $I^2t$.

The module calculates the accumulated heat continuously and compares it to the limiting value obtained from the product of the square of the values of the *Motor start-up A* and *Motor start-up time* settings. When the calculated value of the thermal stress exceeds this limit, the OPR_IIT output is activated.

The module also measures the time START_TIME required by the motor to attain the rated speed and the relative thermal stress IIT_RL. The values are available in the Monitored data view.

The activation of the BLOCK input signal resets the thermal stress calculator and deactivates the OPR_IIT output.

**Stall protection**

This module is activated only when the selected *Operation mode* setting value is "IIt & stall" or "IIt & stall, CB".

The start-up current is specific to each motor and depends on the start-up method used, such as direct online, autotransformer and rotor resistance insertion. The start-up time is dependent on the load connected to the motor.

Based on the motor characteristics supplied by the manufacturer, this module is required if the stalling time is shorter than or too close to the starting time. In such cases, a speed switch must be used to indicate whether a motor is accelerating during start-up or not.

At motor standstill, the STALL_IND input is active. It indicates that the rotor is not rotating. When the motor is started, at certain revolution the deactivation of the STALL_IND by the speed switch indicates that the rotor is rotating. If the input is not deactivated within *Lock rotor time*, the OPR_STALL output is activated.

The module calculates the duration of the motor in stalling condition, the STALL_RL output indicating the percent ratio of the start situation and the set value of *Lock rotor time*. The value is available in the Monitored data view.

The activation of the BLOCK input signal resets the operation time and deactivates the OPR_STALL output.

**Cumulative start-up protection**

This module protects the motor from an excessive number of start-ups.

Whenever the motor is started, the latest value of START_TIME is added to the existing value of T_ST_CNT and the updated cumulative start-up time is available at T_ST_CNT. If the value of T_ST_CNT is greater than the value of *Cumulative time Lim*, the LOCK_START output is activated and lockout condition for the restart of motor is enabled during the time the output is active. The LOCK_START output remains high until the T_ST_CNT value reduces to a value less than the value of

*Cumulative time Lim*. The start time counter reduces at the rate of the value of *Counter Red rate*.

The LOCK_START output becomes activated at the start of MOT_START. The output remains active for a period of *Restart inhibit time*.

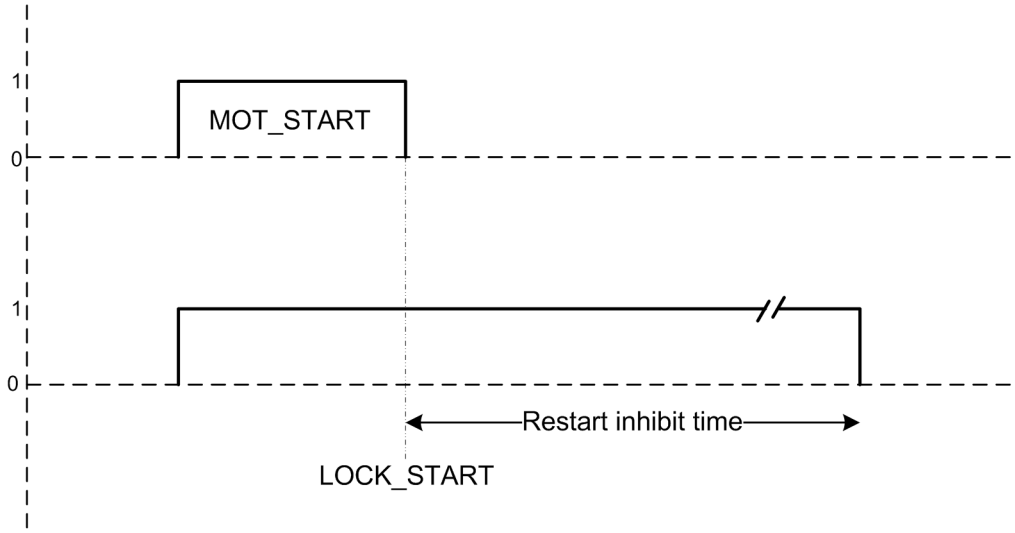



*Figure 617: Time delay for cumulative start*

This module also protects the motor from consecutive start-ups. When the LOCK_START output is active, T_RST_ENA shows the possible time for next restart. The value of T_RST_ENA is calculated by the difference of *Restart inhibit time* and the elapsed time from the instant LOCK_START is enabled.

When the ST_EMERG_ENA emergency start is set high, the value of the cumulative start-up time counter is set to *Cumulative time Lim* - 60s · *Emg start Red rate*. This disables LOCK_START and in turn makes the restart of the motor possible.

This module also calculates the total number of start-ups occurred, START_CNT. The value can be reset from the Clear menu.

The old *Number of motor start-ups occurred* counter value ( START_CNT) can be taken into use by writing the value to the *Ini start up counter* parameter and resetting the value via the Clear menu from WHMI or LHMI.

The calculated values of T_RST_ENA, T_ST_CNT and START_CNT are available in the Monitored data view.

The activation of the BLK_LK_ST input signal deactivates the LOCK_START output. The activation of the BLOCK input signal resets the cumulative start-up counter module.

## 4.10.6 Application

When a motor is started, it draws a current well in excess of the motor's full-load rating throughout the period it takes for the motor to run up to the rated speed. The motor starting current decreases as the motor speed increases and the value of current remains close to the rotor-locked value for most of the acceleration period.

The full-voltage starting or the direct-on-line starting method is used out of the many methods used for starting the induction motor. If there is either an electrical

or mechanical constraint, this starting method is not suitable. The full-voltage starting produces the highest starting torque. A high starting torque is generally required to start a high-inertia load to limit the acceleration time. In this method, full voltage is applied to the motor when the switch is in the "On" position. This method of starting results in a great initial current surge, which is typically four to eight times that of the full-load current drawn by the motor. If a star-delta starter is used, the value of the line current will only be about one-third of the direct-on-line starting current.

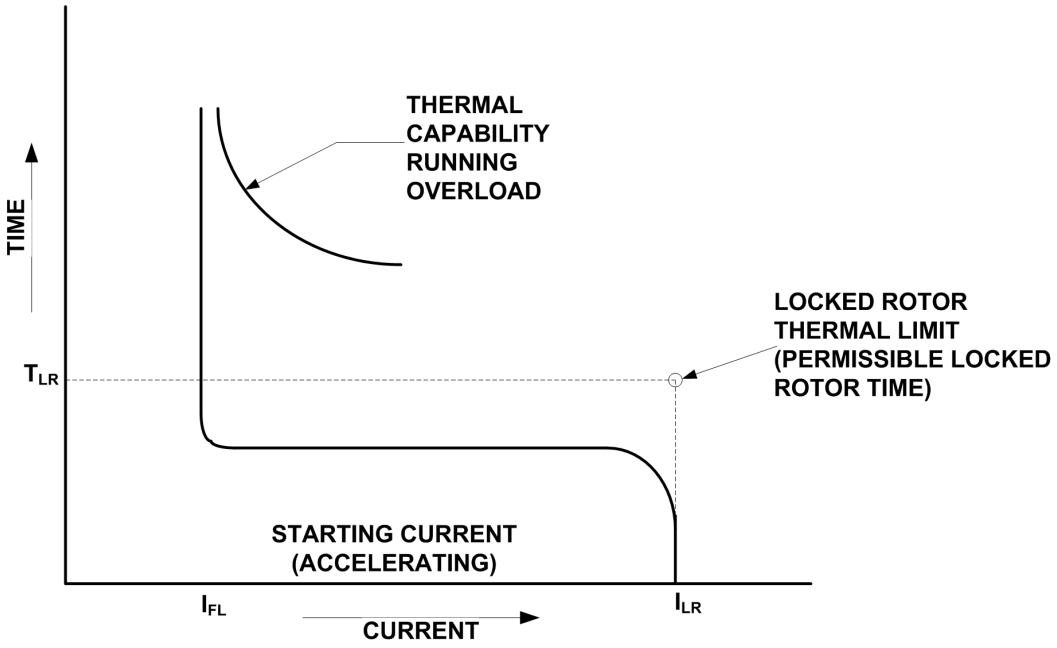



*Figure 618: Typical motor starting and capability curves*

The start-up supervision of a motor is an important function because of the higher thermal stress developed during starting. During the start-up, the current surge imposes a thermal strain on the rotor. This is exaggerated as the air flow for cooling is less because the fans do not rotate in their full speed. Moreover, the difference of speed between the rotating magnetic field and the rotor during the start-up time induces a high magnitude of slip current in the rotor at frequencies higher than when the motor is at full speed. The skin effect is stronger at higher frequencies and all these factors increase the losses and the generated heat. This is worse when the rotor is locked.

The starting current for slip-ring motors is less than the full load current and therefore it is advisable to use the circuit breaker in the closed position to indicate the starting for such type of motors.

The starting times vary depending on motor design and load torque characteristics. The time taken may vary from less than two seconds to more than 60 seconds. The starting time is determined for each application.

When the permissible stall time is less than the starting time of the motor, the stalling protection is used and the value of the time delay setting should be set slightly less than the permissible stall time. The speed switch on the motor shaft must be used for detecting whether the motor begins to accelerate or not. However, if the safe stall time is longer than the start-up time of the motor, the speed switch is not required.

The failure of a motor to accelerate or to reach its full nominal speed in an acceptable time when the stator is energized is caused by several types of abnormal conditions, including a mechanical failure of the motor or load bearings, low supply voltage, open circuit in one phase of a three-phase voltage supply or too high starting voltage. All these abnormal conditions result in overheating.

Repeated starts increase the temperature to a high value in the stator or rotor windings, or both, unless enough time is allowed for the heat to dissipate. To ensure a safe operation it is necessary to provide a fixed-time interval between starts or limit the number of starts within a period of time. This is why the motor manufacturers have restrictions on how many starts are allowed in a defined time interval. This function does not allow starting of the motor if the number of starts exceeds the set level in the register that calculates them. This insures that the thermal effects on the motor for consecutive starts stay within permissible levels.

For example, the motor manufacturer may state that three starts at the maximum are allowed within 4 hours and the start-up situation time is 60 seconds. By initiating three successive starts we reach the situation as illustrated. As a result, the value of the register adds up to a total of 180 seconds. Right after the third start has been initiated, the output lock of start of motor is activated and the fourth start will not be allowed, provided the time limit has been set to 121 seconds.

Furthermore, a maximum of three starts in 4 hours means that the value of the register should reach the set start time counter limit within 4 hours to allow a new start. Accordingly, the start time counter reduction should be 60 seconds in 4 hours and should thus be set to 60 s / 4 h = 15 s / h.

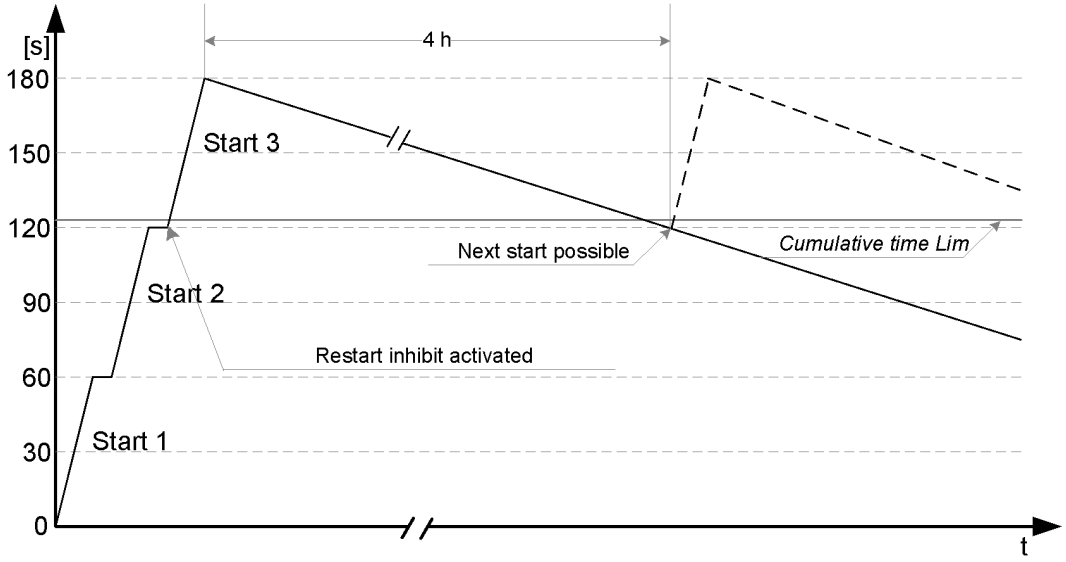



*Figure 619: Typical motor-starting and capability curves*

**Setting of *Cumulative time Lim***

*Cumulative time Lim* is calculated by

$$\sum t_{si} = (n-1) \times t + margin$$

(Equation 283)

| | |
|---|---|
| n | specified maximum allowed number of motor start-ups |
| t | start-up time of the motor (in seconds) |
| margin | safety margin (~10...20 percent) |

**Setting of *Counter Red rate***

*Counter Red rate* is calculated by

$$\Delta\sum t_s = \frac{t}{t_{reset}}$$

(Equation 284)

| | |
|---|---|
| t | specified start time of the motor in seconds |
| $t_{reset}$ | duration during which the maximum number of motor start-ups stated by the manufacturer can be made; time in hours |

## 4.10.7 Signals

### 4.10.7.1 STTPMSU Input signals

**Table 1036: STTPMSU Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block of function |
| BLK_LK_ST | BOOLEAN | 0=False | Blocks lock out condition for restart of motor |
| CB_CLOSED | BOOLEAN | 0=False | Input showing the status of motor circuit breaker |
| STALL_IND | BOOLEAN | 0=False | Input signal for showing the motor is not stalling |
| ST_EMERG_ENA | BOOLEAN | 0=False | Enable emergency start to disable lock of start of motor |

### 4.10.7.2 STTPMSU Output signals

**Table 1037: STTPMSU Output signals**

| Name | Type | Description |
|---|---|---|
| OPR_IIT | BOOLEAN | Operate/trip signal for thermal stress. |
| OPR_STALL | BOOLEAN | Operate/trip signal for stalling protection. |
| MOT_START | BOOLEAN | Signal to show that motor startup is in progress |
| LOCK_START | BOOLEAN | Lock out condition for restart of motor. |

## 4.10.8 STTPMSU Settings

**Table 1038: STTPMSU Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Motor start-up A | 1.0...10.0 | xIn | 0.1 | 2.0 | Motor starting current |
| Motor start-up time | 1...80 | s | 1 | 5 | Motor starting time |
| Lock rotor time | 2...120 | s | 1 | 10 | Permitted stalling time |
| Str over delay time | 0...60000 | ms | 1 | 100 | Time delay to check for completion of motor startup period |

**Table 1039: STTPMSU Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start detection A | 0.1...10.0 | xIn | 0.1 | 1.5 | Current value for detecting starting of motor. |

**Table 1040: STTPMSU Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=IIt<br>2=IIt, CB<br>3=IIt + stall<br>4=IIt + stall, CB | | | 1=IIt | Motor start-up operation mode |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Counter Red rate | 2.0...250.0 | s/h | 0.1 | 60.0 | Start time counter reduction rate |
| Cumulative time Lim | 1...500 | s | 1 | 10 | Cumulative time based restart inhibit limit |
| Emg start Red rate | 0.00...100.00 | % | 0.01 | 20.00 | Start time reduction factor when emergency start is On |
| Restart inhibit time | 0...250 | min | 1 | 30 | Time delay between consecutive startups |
| Ini start up counter | 0...999999 | | 1 | 0 | Initial value for the START_CNT |

**Table 1041: STTPMSU Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Motor standstill A | 0.01...0.20 | xIn | 0.01 | 0.12 | Current limit to check for motor standstill condition |

## 4.10.9 STTPMSU Monitored data

**Table 1042: STTPMSU Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_CNT | INT32 | 0...999999 | | Number of motor start-ups occurred |
| START_TIME | FLOAT32 | 0.0...999.9 | s | Measured motor latest startup time in sec |
| T_ST_CNT | FLOAT32 | 0.0...99999.9 | s | Cumulated start-up time in sec |
| T_RST_ENA | INT32 | 0...999 | min | Time left for restart when lockstart is enabled in minutes |
| IIT_RL | FLOAT32 | 0.00...100.00 | % | Thermal stress relative to set maximum thermal stress |
| STALL_RL | FLOAT32 | 0.00...100.00 | % | Start time relative to the operate time for stall condition |
| STTPMSU | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.10.10 Technical data

**Table 1043: STTPMSU Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | | ±1.5 % of the set value or ±0.002 × $I_n$ | | |
| Start time [1, 2] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 1.1 × set *Start detection A* | 27 ms | 30 ms | 34 ms |
| Operate time accuracy | | ±1.0 % of the set value or ±20 ms | | |
| Reset ratio | | Typically 0.90 | | |

### 4.10.11 Technical revision history

**Table 1044: STTPMSU Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | E | Setting *Motor standstill A* minimum value changed from 0.05xIn to 0.01xIn. |

## 4.11 Multipurpose protection MAPGAPC (ANSI MAP)

### 4.11.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Multipurpose protection | MAPGAPC | MAP | MAP |

[1] Current before = 0.0 × $I_n$, $f_n$ = 50 Hz, overcurrent in one phase, results based on statistical distribution of 1000 measurements
[2] Includes the delay of the signal output contact

## 4.11.2 Function block

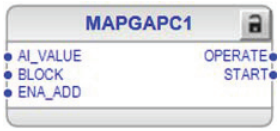



*Figure 620: Function block*

## 4.11.3 Functionality

The multipurpose protection function MAPGAPC is used as a general protection with many possible application areas as it has flexible measuring and setting facilities. The function can be used as an under- or overprotection with a settable absolute hysteresis limit. The function operates with the definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

## 4.11.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of MAPGAPC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

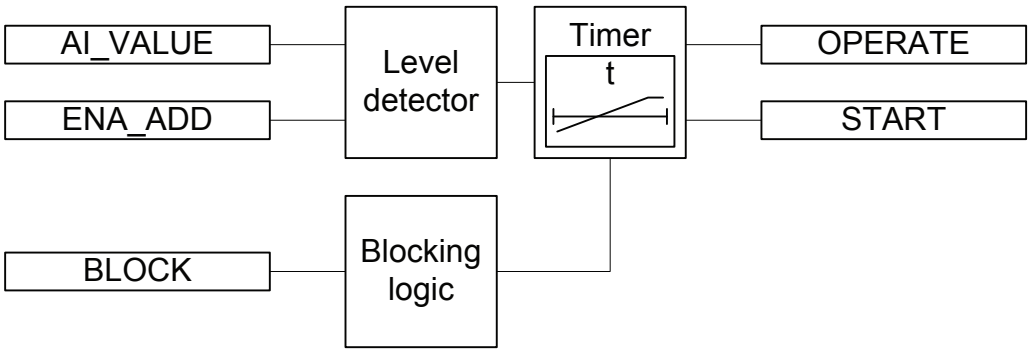



*Figure 621: Functional module diagram*

### Level detector

The level detector compares `AI_VALUE` to the *Start value* setting. The *Operation mode* setting defines the direction of the level detector.

**Table 1045: *Operation mode* types**

| Operation Mode | Description |
|---|---|
| "Under" | If the input signal AI_VALUE is lower than the set value of the "Start value" setting, the level detector enables the timer module. |
| "Over" | If the input signal AI_VALUE exceeds the set value of the *Start value* setting, the level detector enables the timer module. |

The *Absolute hysteresis* setting can be used for preventing unnecessary oscillations if the input signal is slightly above or below the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return to the hysteresis area. If the ENA_ADD input is activated, the threshold value of the internal comparator is the sum of the *Start value Add* and *Start value* settings. The resulting threshold value for the comparator can be increased or decreased depending on the sign and value of the *Start value Add* setting.

**Timer**

Once activated, the timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated. If the starting condition disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

The timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, the function operates normally but the OPERATE output is not activated.

## 4.11.5 Application

The function block can be used for any general analog signal protection, either underprotection or overprotection. The setting range is wide, allowing various protection schemes for the function. Thus, the absolute hysteresis can be set to a value that suits the application.

The temperature protection using the RTD sensors can be done using the function block. The measured temperature can be fed from the RTD sensor to the function input that detects too high temperatures in the motor bearings or windings, for example. When the ENA_ADD input is enabled, the threshold value of the internal comparator is the sum of the *Start value Add* and *Start value* settings. This allows a temporal increase or decrease of the level detector depending on the sign and value of the *Start value Add* setting, for example, when the emergency start is activated. If, for example, *Start value* is 100, *Start value Add* is 20 and the ENA_ADD input is active, the input signal needs to rise above 120 before MAPGAPC operates.

## 4.11.6 Signals

### 4.11.6.1 MAPGAPC Input signals

**Table 1046: MAPGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| AI_VALUE | FLOAT32 | 0.0 | Analogue input value |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ENA_ADD | BOOLEAN | 0=False | Enable start added |

### 4.11.6.2 MAPGAPC Output signals

**Table 1047: MAPGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

## 4.11.7 MAPGAPC Settings

**Table 1048: MAPGAPC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | -10000.0...10000.0 | | 0.1 | 0.0 | Start value |
| Start value Add | -100.0...100.0 | | 0.1 | 0.0 | Start value Add |
| Operate delay time | 0...200000 | ms | 100 | 0 | Operate delay time |

**Table 1049: MAPGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=Over<br>2=Under | | | 1=Over | Operation mode |

**Table 1050: MAPGAPC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 100 | 0 | Reset delay time |
| Absolute hysteresis | 0.01...100.00 | | 0.01 | 0.10 | Absolute hysteresis for operation |

### 4.11.8 MAPGAPC Monitored data

**Table 1051: MAPGAPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| MAPGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.11.9 Technical data

**Table 1052: MAPGAPC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.0 % of the set value or ±20 ms |

## 4.12 Capacitor bank protection

### 4.12.1 Three-phase overload protection for shunt capacitor banks COLPTOC (ANSI 51,37,86C)

#### 4.12.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase overload protection for shunt capacitor banks | COLPTOC | 3I> 3I< | 51,37,86C |

### 4.12.1.2 Function block

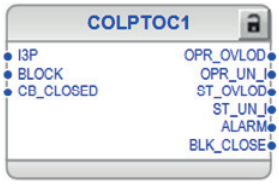



*Figure 622: Function block symbol*

### 4.12.1.3 Functionality

The three-phase overload protection for shunt capacitor banks function COLPTOC provides single-phase, two-phase and three-phase protection against overloads caused by harmonic currents and overvoltages in shunt capacitor banks. The operation of overload and alarm is based on the peak value of the integrated current which is proportional to the voltage across the capacitor.

The overload function operates with IDMT characteristic and an alarm function operates with DT characteristic.

COLPTOC provides undercurrent protection to detect disconnection of the capacitor. COLPTOC has breaker reclosing inhibit feature to enable complete capacitor discharging before breaker reclosing after it has operated.

COLPTOC contains blocking functionality. It is possible to block the function outputs, timers or the function itself.

### 4.12.1.4 Analog channel configuration

COLPTOC has one analog group input which must be properly configured.

**Table 1053: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.12.1.5 Operation principle

The function can be enabled and disabled with the Operation setting. The corresponding parameter values are “On” and “Off”.

The operation of COLPTOC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

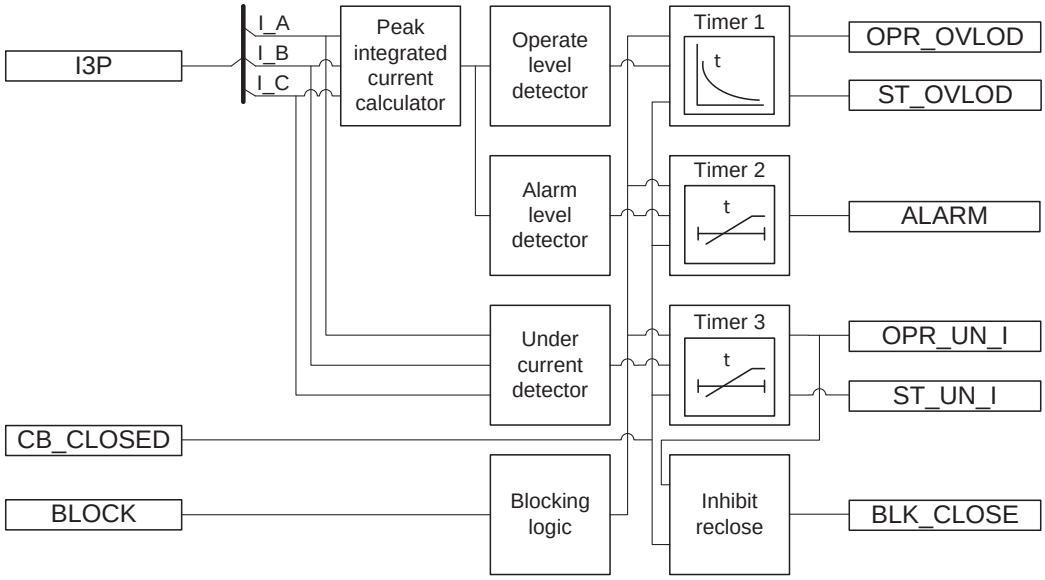



*Figure 623: Functional module diagram*

### Peak integrated current calculator

The peak integrated current calculator calculates peak value of integrated current (`I_PEAK_INT_A`, `I_PEAK_INT_B` and `I_PEAK_INT_C`) which is proportional to the voltage over capacitor. The `I_PEAK_INT_A`, `I_PEAK_INT_B` and `I_PEAK_INT_C` values are available in monitored data view. The frequency response of the peak integrated current calculator can be seen in *Figure 624*.

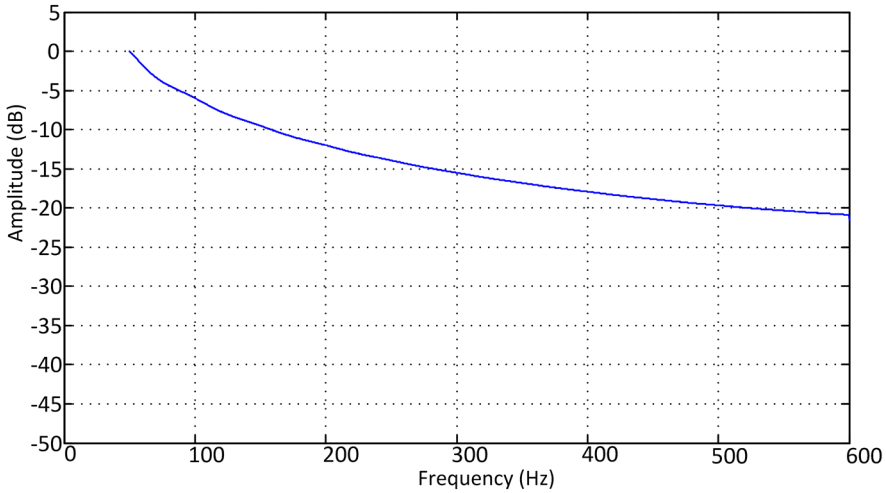



*Figure 624: Frequency response of the peak integrated current calculator*

### Operate level detector

The Operate level detector compares `I_PEAK_INT_x` value to *Start value overload*. If the phase or phases in which `I_PEAK_INT_x` exceeds the setting matches the *Num of start phases* setting, the Operate level detector module activates the Timer 1 module.

**Timer 1**

Once activated, the Timer 1 module activates the ST_OVLOD output. The operation time depends on the overload level and *Time multiplier*. The operation time under standard characteristics is based on ANSI/IEEE 37.99 and IEC 60871-1 recommendations.

**Table 1054: Standard Curve characteristics for IDMT Curve**

| Overload value | IED operate time(s) with k = 1 | Standard |
|---|---|---|
| 1.10 | 43200 | IEC60871-1 |
| 1.15 | 1800 | IEC60871-1 |
| 1.20 | 300 | IEC60871-1 |
| 1.30 | 60 | ANSI/IEEE37.99,IEC60871-1 |
| 1.40 | 15 | ANSI/IEEE37.99 |
| 1.70 | 1 | ANSI/IEEE37.99 |
| 2.20 | 0.120 | ANSI/IEEE37.99 |

Operate time is based on maximum value of I_PEAK_INT_A, I_PEAK_INT_B and I_PEAK_INT_C. From maximum value calculated , operate time between any two consecutive points in the standard table is based on logarithmic interpolation.

The operate time can be scaled using the *Time multiplier* setting. The OPR_OVLOD output is activated if the overload situation lasts long enough to exceed the operation time.

The operate time for the operation overload stage is limited between 0.1 s to 43200 s (12 hours) if *Time multiplier* is used.

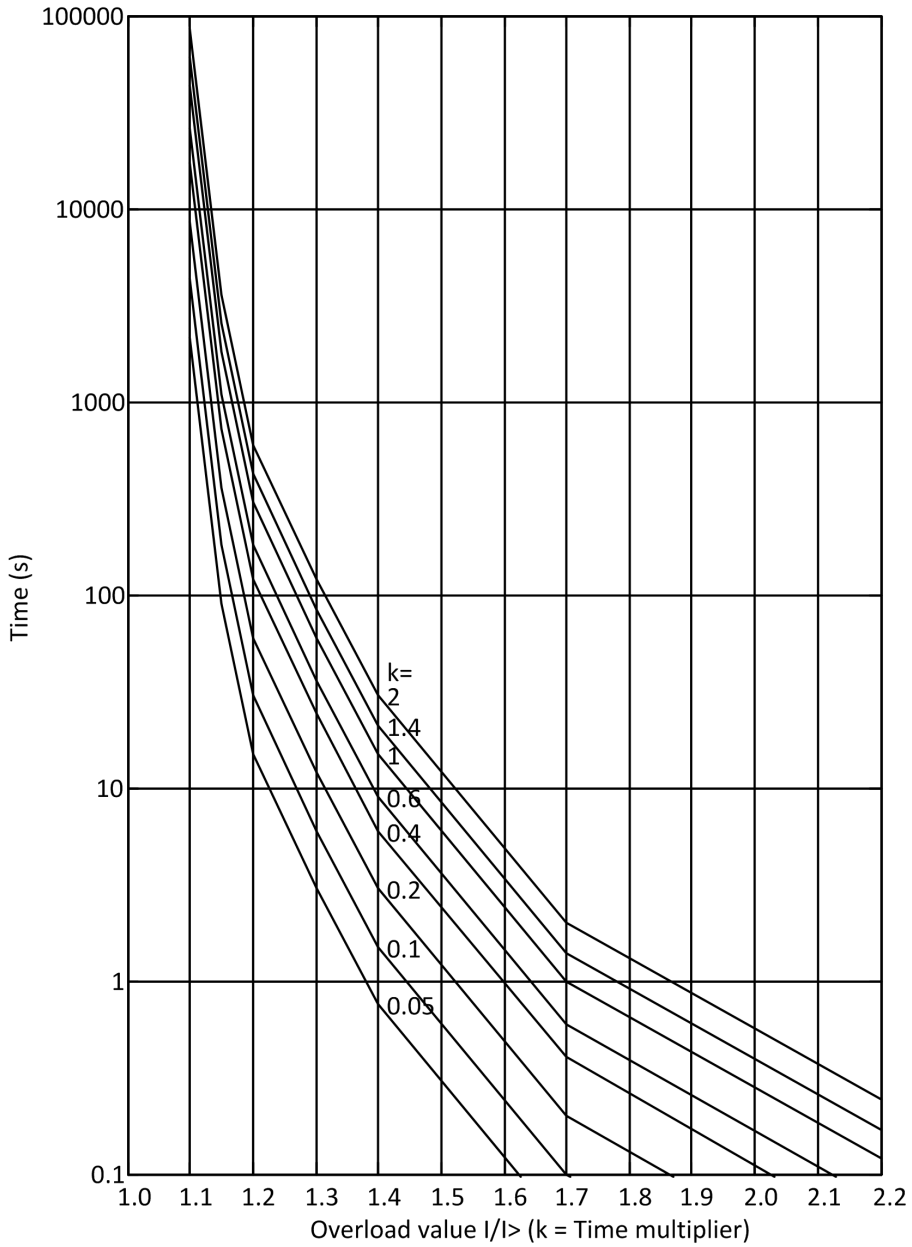



*Figure 625: Inverse-time characteristic curves for overload stage*

If the integrated current exceeds 1.1 times the setting *Start value overload* for a short period but does not operate as the current decreases within *Start value overload*, the output ST_OVLOD is kept active but the operation timer is frozen. However, if the integrated current exceeds 1.1 times the *Start value overload* setting value again, the operation timer continue from the freezing point. Thus, the operation timer is cumulative. If the integrated current exceeds 1.1 times the setting *Start value overload* only once and remains within the *Start value overload* area for 24 hours, the operation timer and the output ST_OVLOD are reset.

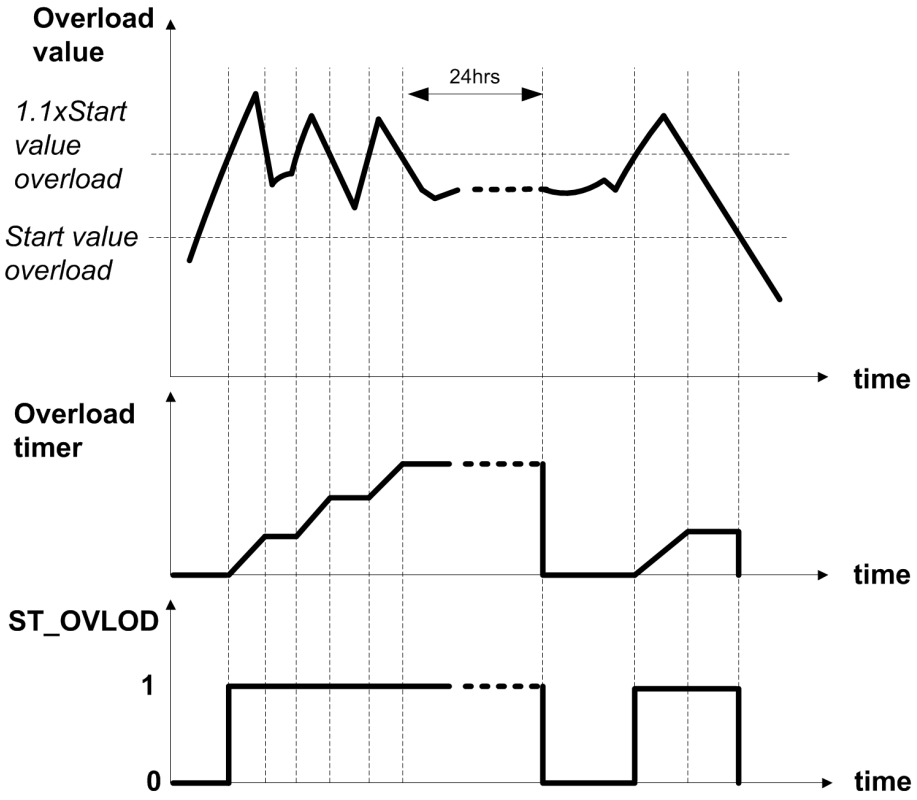



*Figure 626: The behavior of the IDMT timer and the output ST_OVLOD*

The ST_DUR_OVLOD output indicates the percentage ratio of the start situation and the operation time in the Timer 1 module and is available in the monitored data view.

The Timer 1 module is internally blocked for one second after the capacitor bank is connected by detecting the rising edge of the CB_CLOSED signal. The CB_CLOSED signal is True when the CB position is closed.

### Alarm level detector

The Alarm level detector compares I_PEAK_INT_x value to *Alarm start value*. If the phase or phases in which I_PEAK_INT_x exceeds the setting matches the *Num of start phases* setting, the Alarm level detector module activates the Timer 2 module.

The *Num of start phases* setting is a common setting for both Operate level detector and Alarm level detector.

### Timer 2

The Timer 2 characteristics are according to Definite Time (DT) .When the operation timer has reached the value of *Alarm delay time*, the ALARM output is activated.

If a drop-off situation happens, the timer is reset.

The Timer 2 module is internally blocked for one second after the capacitor bank is connected by detecting the rising edge of the

CB_CLOSED signal. The CB_CLOSED signal is True when the CB position is closed.

**Under current detector**

The Under current detector module can be enabled by setting *Enable under current* to “Enable” and disabled by setting it to “Disable”. The Under current detector module is also disabled when CB_CLOSED is FALSE, that is, when circuit breaker is open.

The fundamental frequency component of phase currents is compared to the setting *Start value Un Cur*. If all the three-phase currents are below the setting *Start value Un Cur*, the Under current detector module enables the Timer 3 module.

**Timer 3**

Once activated, the Timer 3 module activates the ST_UN_I output. The operation is based on DT characteristics. When the operation timer has reached the value of *Un Cur delay time*, the OPR_UN_I output is activated.

If the undercurrent situation disappears, the operation timer is reset. The ST_DUR_UN_I output indicates the percentage ratio of the undercurrent start situation and the set operation time in the Timer 3 module and is available in the monitored data view.

The OPR_UN_I output is of pulse type and remains TRUE for 150 ms. After that, ST_DUR_UN_I and OPR_UN_I are deactivated and ST_DUR_UN_I is reset.

If the circuit breaker closed status signal is not detected, the constant value TRUE has to be connected to CB_CLOSED input to enable the undercurrent detector.

If the circuit breaker status signal is not connected to CB_CLOSED input, the OPR_UN_I output is activated even if the circuit breaker is open and undercurrent is detected.

**Inhibit reclose**

When the output OPR_UN_I becomes active or when the CB_CLOSED state changes from TRUE to FALSE, that is, when circuit breaker opens, the reclosing inhibition module activates output BLK_CLOSE.

If *Enable under current* is set to “Disable”, the reclosing inhibition operation is based purely on the CB_CLOSED input.

When the relay powers up after a reboot or software reset, or if the Operation of COLPTOC function is switched from off to on, the BLK_CLOSE output is activated defined by the *Reclose inhibit time*, regardless the *Reclose inhibit mode*.

The behavior of the BLK_CLOSE output depends on *Reclose inhibit mode*. If *Reclose inhibit mode* is set to “Lockout”, the BLK_CLOSE output needs to be reset manually from the clearing menu parameter *COLPTOC inhibit recl*. If *Reclose inhibit mode* is set to “Non-latched”, the BLK_CLOSE output resets after the set *Reclose inhibit time* has elapsed.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** >

**Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, COLPTOC is executed normally but the OPR_OVLOD and OPR_UN_I outputs are not allowed to activate.



The BLOCK input does not block the BLK_CLOSE signal.

### 4.12.1.6 Application

The application area for three-phase overload protection function of shunt capacitor bank is the protection of power capacitor banks intended for reactive power compensation and filtering of the harmonics. Shunt capacitor banks provide a low-impedance path to harmonic currents and hence attract harmonic currents flowing in the system. Increased harmonic currents result in excessive voltage stress across the capacitor bank. According to the standards, a high-voltage capacitor shall be able to withstand 10% overload. Loading beyond that can cause damage to the capacitor bank and in turn to the system. Hence, COLPTOC is specially designed for the protection against overloads produced by harmonic currents and overvoltage.

Undercurrent protection is used to disconnect the capacitor bank from the rest of the power system when the voltage at the capacitor bank terminals is too low for too long a period of time. To avoid an undercurrent trip operation when the capacitor bank is disconnected from the power system, the undercurrent functionality is blocked by using the capacitor bank circuit breaker status signal.

Furthermore, the reclosing inhibition feature provides protection against the reconnection of a charged capacitor to a live network. Whenever the capacitor bank circuit breaker is opened, the reclosing is inhibited for the duration of the discharge time of the capacitor. The reclosing inhibition functionality can be disabled manually or automatically. In the manual mode, the inhibition reclosing has to be manually reset and in automatic mode, the reclosing inhibitionl resets automatically after the set time.

### 4.12.1.7 Signals

**COLPTOC Input signals**

**Table 1055: COLPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| CB_CLOSED | BOOLEAN | 0=False | Input showing the status of capacitor circuit breaker |

**COLPTOC Output signals**

**Table 1056: COLPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPR_OVLOD | BOOLEAN | Overload operated |
| OPR_UN_I | BOOLEAN | Operate under current |
| ST_OVLOD | BOOLEAN | Overload started |
| ST_UN_I | BOOLEAN | Under current started |
| ALARM | BOOLEAN | Alarm |
| BLK_CLOSE | BOOLEAN | Inhibit re-close of capacitor bank |

### 4.12.1.8 COLPTOC Settings

**Table 1057: COLPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value overload | 0.30...1.50 | xIn | 0.01 | 1.00 | Start value for overload stage |
| Alarm start value | 80...120 | % | 1 | 105 | Alarm start value (% of Start value overload) |
| Start value Un Cur | 0.10...0.70 | xIn | 0.01 | 0.50 | Start value for under current operation |
| Time multiplier | 0.05...2.00 | | 0.01 | 1.00 | Time multiplier for Capacitor Bank protection curves |
| Alarm delay time | 500...6000000 | ms | 100 | 300000 | Alarm delay time |
| Un Cur delay time | 100...120000 | ms | 100 | 1000 | Delay time for under current operation |

**Table 1058: COLPTOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reclose inhibit time | 1...6000 | s | 1 | 1 | Reclose inhibit time |

**Table 1059: COLPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Reclose inhibit mode | 1=Non-latched<br>3=Lockout | | | 1=Non-latched | Reclose inhibit mode |
| Num of start phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |

**Table 1060: COLPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Enable under current | 0=Disable<br>1=Enable | | | 1=Enable | Enable under current functionality |

### 4.12.1.9 COLPTOC Monitored data

**Table 1061: COLPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ST_DUR_OVLOD | FLOAT32 | 0.00...100.00 | % | Start duration for overload stage |
| ST_DUR_UN_I | FLOAT32 | 0.00...100.00 | % | Start duration for under current operation |
| I_PEAK_INT_A | FLOAT32 | 0.00...40.00 | | Phase A peak value of the integrated current of the capacitor |
| I_PEAK_INT_B | FLOAT32 | 0.00...40.00 | | Phase B peak value of the integrated current of the capacitor |
| I_PEAK_INT_C | FLOAT32 | 0.00...40.00 | | Phase C peak value of the integrated current of the capacitor |
| COLPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.12.1.10 Technical data

**Table 1062: COLPTOC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz, and no harmonics |
| | 5 % of the set value or 0.002 × $I_n$ |
| Start time for overload stage [1, 2] | Typically 75 ms |

*Table continues on the next page*

| Characteristic | Value |
|---|---|
| Start time for under current stage [2, 3] | Typically 26 ms |
| Reset time for overload and alarm stage | Typically 60 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | 1 % of the set value or ±20 ms |
| Operate time accuracy in inverse time mode | 10 % of the theoretical value or ±20 ms |
| Suppression of harmonics for under current stage | DFT: -50 dB at f = n × fn, where n = 2,3,4,5,.. |

## 4.12.2 Current unbalance protection for capacitor banks CUBPTOC (ANSI 60N)

### 4.12.2.1 Identification

**Table 1063: Function identification**

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current unbalance protection for shunt capacitor banks | CUBPTOC | dI>C | 60N |

### 4.12.2.2 Function block

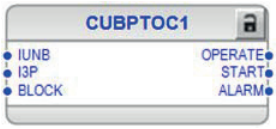



*Figure 627: Function block symbol*

### 4.12.2.3 Functionality

The current unbalance protection for shunt capacitor banks function CUBPTOC is used to protect the double-Y-connected capacitor banks from internal faults. CUBPTOC is suitable for the protection of internally fused, externally fused and fuseless applications.

CUBPTOC has two stages of operation, that is, operation stage and alarm stage. In the operating stage, CUBPTOC starts when the measured unbalance current

[1] Harmonics current before fault = 0.5 × $I_n$, harmonics fault current 1.5 × *Start value*, results based on statistical distribution of 1000 measurements
[2] Includes the delay of the signal output contact
[3] Harmonics current before fault = 1.2 × $I_n$, harmonics fault current 0.8 × *Start value*, results based on statistical distribution of 1000 measurements

exceeds the set limit. The operation time characteristics can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). The operation under alarm stage is either based on the DT characteristics or the faulty element counter of a capacitor bank.

CUBPTOC has a blocking functionality. It is possible to block the function outputs, timers or the function itself.

### 4.12.2.4 Analog channel configuration

CUBPTOC has two analog group inputs which must be properly configured.

**Table 1064: Analog inputs**

| Input | Description |
|---|---|
| IUNB | Unbalance current (measured) |
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1065: Special conditions**

| Condition | Description |
|---|---|
| IUNB measurement | The function requires that the unbalance current measurement is connected via the RESTCTR function block. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.12.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”. The current unbalance protection for shunt capacitor banks operates on the DFT measurement mode.

The operation of CUBPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

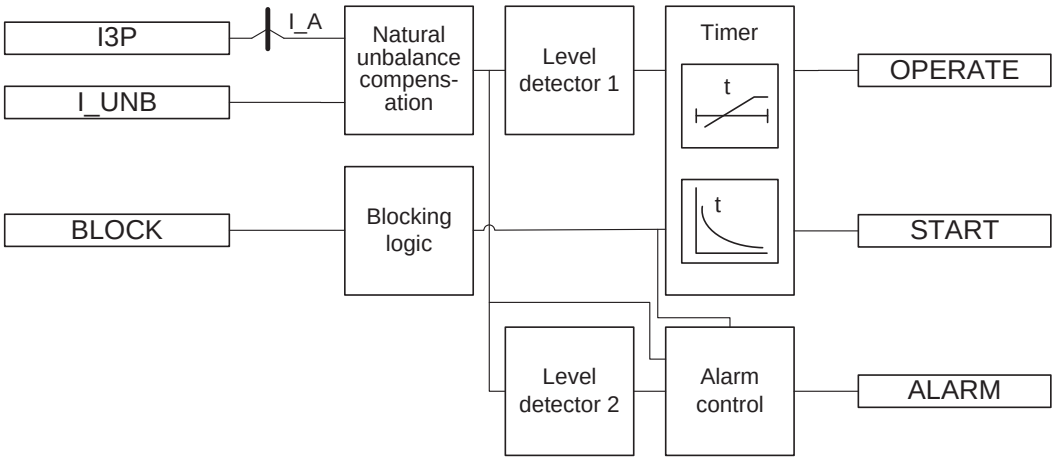



*Figure 628: Functional module diagram*

**Natural unbalance Compensation**

A standard double-Y-connected shunt capacitor bank configuration is shown in *Figure 629*. The fundamental frequency component of an unbalance current is measured on the common neutral connecting the two balanced parts of a shunt capacitor bank, that is, between star point 1 and star point 2.

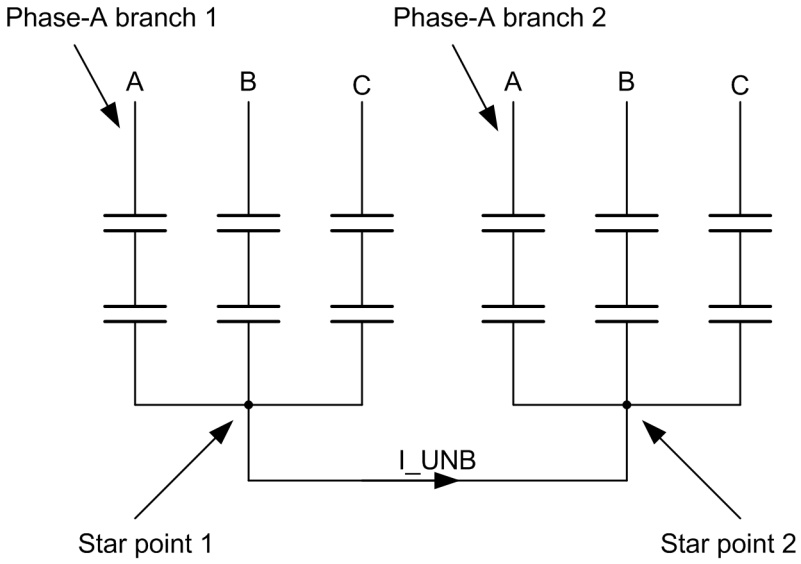



*Figure 629: Double-Y-connected capacitor bank*

The phase angle of the measured fundamental frequency component of the unbalance current I_UNB is synchronized by using the phase current I_A as a reference.

$$\angle\overline{I_{unb}} = \angle\overline{I_UNB} - \angle\overline{I_A}$$

(Equation 285)

In a three-phase star-connected capacitor bank circuit, there may be some amount of natural unbalance current flowing through the neutral, which is primarily due

to capacitor manufacturing tolerances. The natural unbalance current must be compensated for before using the measured unbalance current for the function operation. The natural unbalance current needs to be recorded when there is no fault in the capacitor banks, and it is initiated through the command *Record unbalance*, available under menu path **Control** > **CUBPTOC**. By selecting *Record unbalance* with value “Record”, the measured unbalance current $\bar{I}_{Unb}$ is considered as the natural unbalance current $\bar{I}_{NatUnb}$ and is stored as a reference. The amplitude and angle of the recorded natural unbalance current I_AMPL_NAT and I_ANGL_NAT are available in the monitored data view.

Once the natural unbalance current is recorded during further executions of the function, the natural unbalance current is subtracted from the measured unbalance current $\bar{I}_{Unb}$ to obtain the compensated unbalance current $\bar{I}_{CompUnb}$ as shown in *Figure 630*.

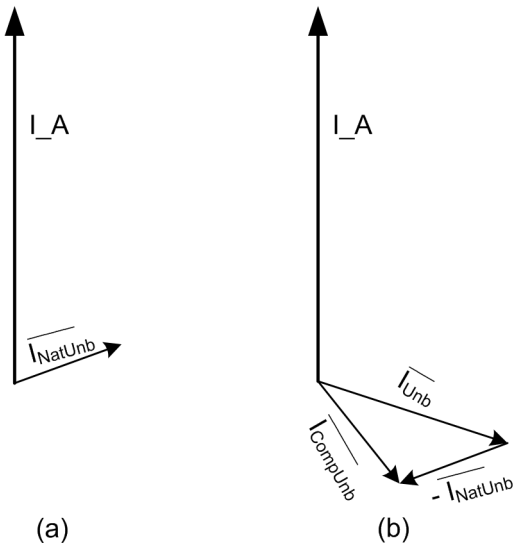



*Figure 630: Natural unbalance compensation. (a) Healthy condition when the natural unbalance is recorded (b) Unbalance compensation during faulty conditions*

The natural unbalance current compensation is enabled using the setting *Natural Comp Enable*. If *Natural Comp Enable* is set to “FALSE”, the unbalance current is not compensated. If *Natural Comp Enable* is set to “TRUE”, the compensated unbalance current is calculated based on the equation.

$$\bar{I}_{CompUnb} = \bar{I}_{Unb} - \bar{I}_{NatUnb}$$

(Equation 286)

The amplitude I_AMPL_COMP and the angle I_ANGL_COMP of the compensated unbalance current $\bar{I}_{CompUnb}$ are available in the monitored data view.

**Level detector 1**

The calculated compensated unbalance current I_AMPL_COMP is compared to the set "Start value". If I_AMPL_COMP exceeds the set "Start value", the Level detector 1 sends an enabling signal to the Timer 1 module.

**Timer 1**

Once activated, the Timer 1 module activates the START output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the OPERATE output is activated. When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C* and *Curve parameter E*.

In a drop-off situation, that is when a fault suddenly disappears before the operate delay is exceeded, the Timer 1 reset state is activated. The functionality of the Timer 1 in the reset state depends on the combination of the Operating curve type and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves are selected, an immediate reset occurs. The START output is deactivated when the reset timer has elapsed.

The setting *Time multiplier* is used for scaling the IDMT operation and reset times.

The setting parameter *Minimum operate time* defines the minimum desired operation time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve but always at least the value of the *Minimum operate time* setting.

The Timer 1 module calculates the start duration value START_DUR, which indicates the percentile ratio of the start situation and the set operation time. The value is available in the monitored data view.

In a typical double-Y-connected configuration ( *Figure 629*), there are two branches in every phase and hence six individual counters COUNT_BR1_A, COUNT_BR2_A, COUNT_BR1_B, COUNT_BR2_B, COUNT_BR1_C and COUNT_BR2_C are maintained. Based on the phase angle of the compensated unbalance current I_ANGL_COMP, the phase and the branch of the element failure location is detected. However, the element failure location also depends on the type of capacitor banks, that is, whether internal or external fuses are used. The setting *Fuse location* is used to set the capacitor bank type as “External” or “Internal”.

For an external fuse capacitor bank, the element failure location and corresponding counters to be incremented are determined based on the phase angle of the compensated unbalance current.

**Table 1066: Element failure location and counters to be incremented for external fuse case**

| Phase angle of the compensated unbalance current (degrees) | Phase and branch of the element failure | Counters to be incremented |
|---|---|---|
| -15...+15 | Phase-A branch 1 | COUNT_BR1_A |
| -15...-45 | Phase-A branch 1<br>Phase-C branch 2 | COUNT_BR1_A<br>COUNT_BR2_C |
| -45...-75 | Phase-C branch 2 | COUNT_BR2_C |
| -75...-105 | Phase-B branch 1<br>Phase-C branch 2 | COUNT_BR1_B<br>COUNT_BR2_C |
| -105...-135 | Phase-B branch 1 | COUNT_BR1_B |
| -135...-165 | Phase-B branch 1<br>Phase-A branch 2 | COUNT_BR1_B<br>COUNT_BR2_A |
| -165...-180 | Phase-A branch 2 | COUNT_BR2_A |
| +165...+180 | Phase-A branch2 | COUNT_BR2_A |
| +135...+165 | Phase-C branch 1<br>Phase-A branch 2 | COUNT_BR1_C<br>COUNT_BR2_A |
| +105...+135 | Phase-C branch 1 | COUNT_BR1_C |
| +75...+105 | Phase-C branch1<br>Phase-B branch2 | COUNT_BR1_C<br>COUNT_BR2_B |
| +45...+75 | Phase-B branch2 | COUNT_BR2_B |
| +15...+45 | Phase-A branch1<br>Phase-B branch2 | COUNT_BR1_A<br>COUNT_BR2_B |

If the capacitor bank is fuseless, then the setting *Fuse location* should be set to “External” and *Table 1066* can be used to determine the element failure location.

If the compensated unbalance current I_AMPL_COMP is greater than three times the set *Alarm value*, it is considered to be a case of blown external fuse. For the internal fuse and blown fuse cases, the element failure location and corresponding counters to be incremented are determined based on the phase angle of the compensated unbalance current.

**Table 1067: Element failure location and counters to be incremented for internal fuse and blown fuse case**

| Phase angle of the compensated unbalance current (degrees) | Phase and branch of the element failure | Counters to be incremented |
|---|---|---|
| -15...+15 | Phase-A branch 2 | COUNT_BR2_A |
| -15... -45 | Phase-A branch 2 | COUNT_BR2_A |

*Table continues on the next page*

| Phase angle of the compensated unbalance current (degrees) | Phase and branch of the element failure | Counters to be incremented |
|---|---|---|
| | Phase-C branch 1 | COUNT_BR1_C |
| -45...-75 | Phase-C branch 1 | COUNT_BR1_C |
| -75...-105 | Phase-B branch 2<br>Phase-C branch 1 | COUNT_BR2_B<br>COUNT_BR1_C |
| -105...-135 | Phase-B branch 2 | COUNT_BR2_B |
| -135...-165 | Phase-B branch 2<br>Phase-A branch 1 | COUNT_BR2_B<br>COUNT_BR1_A |
| -165...-180 | Phase-A branch 1 | COUNT_BR1_A |
| +165...+180 | Phase-A branch 1 | COUNT_BR1_A |
| +135...+165 | Phase-C branch 2<br>Phase-A branch 1 | COUNT_BR2_C<br>COUNT_BR1_A |
| +105...+135 | Phase-C branch 2 | COUNT_BR2_C |
| +75...+105 | Phase-C branch 2<br>Phase-B branch 1 | COUNT_BR2_C<br>COUNT_BR1_B |
| +45...+75 | Phase-B branch 1 | COUNT_BR1_B |
| +15...+45 | Phase-A branch 2<br>Phase-B branch 1 | COUNT_BR2_A<br>COUNT_BR1_B |

After *Alarm delay time* has elapsed, the corresponding counter value is incremented based on the magnitude of the unbalance current. If I_AMPL_COMP is less than 1.5 times the set *Alarm value*, the counter is incremented by one. Furthermore, if I_AMPL_COMP is between 1.5 and 2.5 times the set *Alarm value*, the counter is incremented by two and so on.



Normally, the setting *Alarm value* is about 0.1 percent lower than the value of the unbalance current which is caused by one faulty element. This setting value has to be chosen carefully because a slightly lower value may lead to a situation where the counters show more failures than the actual. Too high setting leads to a situation where a fault is not detected.

The counter values COUNT_BR1_A, COUNT_BR2_A, COUNT_BR1_B, COUNT_BR2_B, COUNT_BR1_C and COUNT_BR2_C are available in the monitoring data view. The total number of element failures in double-Y-connected capacitor banks, FAIL_COUNT, is available in the monitored data view.

The ALARM output is activated, when the value of FAIL_COUNT exceeds the setting *Element failure limit*.

The counter values can be reset via *CUBPTOC counters* which is located under the Clear menu.

**Level detector 2**

The calculated compensated unbalance current I_AMPL_COMP is compared to the set *Alarm start value*. If the I_AMPL_COMP exceeds the set *Alarm value* the Level detector *2* sends enabling signal to the Alarm control module.

**Alarm control**

Depending on the *Alarm mode* setting, the alarm stage operation is according to “Normal mode” or “Element counter mode”.

In the “Normal mode” the time characteristic is according to DT. When the alarm timer has reached the value set by *Alarm delay time*, the ALARM output is activated. If the fault disappears before the alarm activates, the alarm timer is reset immediately.

The “Element counter mode” is used to detect faulty elements of the capacitor bank and count the number of element failures in each branch and line. On activation, this module increments the corresponding element failure counters after the set *Alarm delay time* has elapsed.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode**, which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the IED program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the "Freeze timers" mode, the operation timer is frozen to the prevailing value. In the "Block all" mode, the whole function is blocked and the timers are reset. In the "Block OPERATE output" mode, CUBPTOC operates normally but the OPERATE output is not activated.

### 4.12.2.6 Application

CUBPTOC is designed for the protection against internal faults in double-Y-connected capacitor banks. This unbalance protection detects an asymmetry in the capacitor bank caused by blown fuses or short circuits across bushings or between capacitor units and the racks in which they are mounted.

Normally, the capacitor units are designed to withstand 110 percent of the nominal voltage continuously. When an element inside a capacitor bank fails, the remaining healthier elements experience an increase in voltage across them. If the voltage exceeds the 110 percent value of the nominal voltage, it can lead to a failure of the healthier elements of the bank and in turn fail the entire capacitor bank. Since the capacitor unbalance current is directly proportional to the element failures, unbalance protection is an effective way of detecting capacitor element failures. The current unbalance protection function is usually used with the three-phase capacitor bank overload protection function to increase the sensitivity of protection for capacitor banks.

Due to the two-stage (operation and alarm stage) unbalance protection and the natural unbalance compensation facility, the protection of capacitor banks with internal fuses can be implemented with a very high degree of sensitivity.

Furthermore, CUBPTOC provides a sophisticated method of detecting the number of faulty elements in each phase by calculating the differential unbalance current.

The unbalance protection function can be used for internally fused, externally fused and fuseless shunt capacitor banks. Since a fuseless capacitor bank lacks the individual capacitor unit fuses, current unbalance protection becomes even more critical for fuseless applications.

When an individual element fails, it causes unbalance current. With an increasing number of element failures, the unbalance current increases and CUBPTOC gives an alarm. The alarm level is normally set to 50 percent of the maximum permitted level. The capacitor bank needs to be taken out of service to replace the faulty units. If this is not done, the capacitor bank is tripped when the maximum allowed unbalance current level is exceeded.

If two simultaneous faults occur in the same phase but in different branches, there is no change in the unbalance current and CUBPTOC does not detect this type of faults.

If two simultaneous faults occur in the same branch but in different phases, it may cause a phase angle equal to a situation where there is only one fault in the branch. Therefore, the element failure counters show only one fault instead of two.

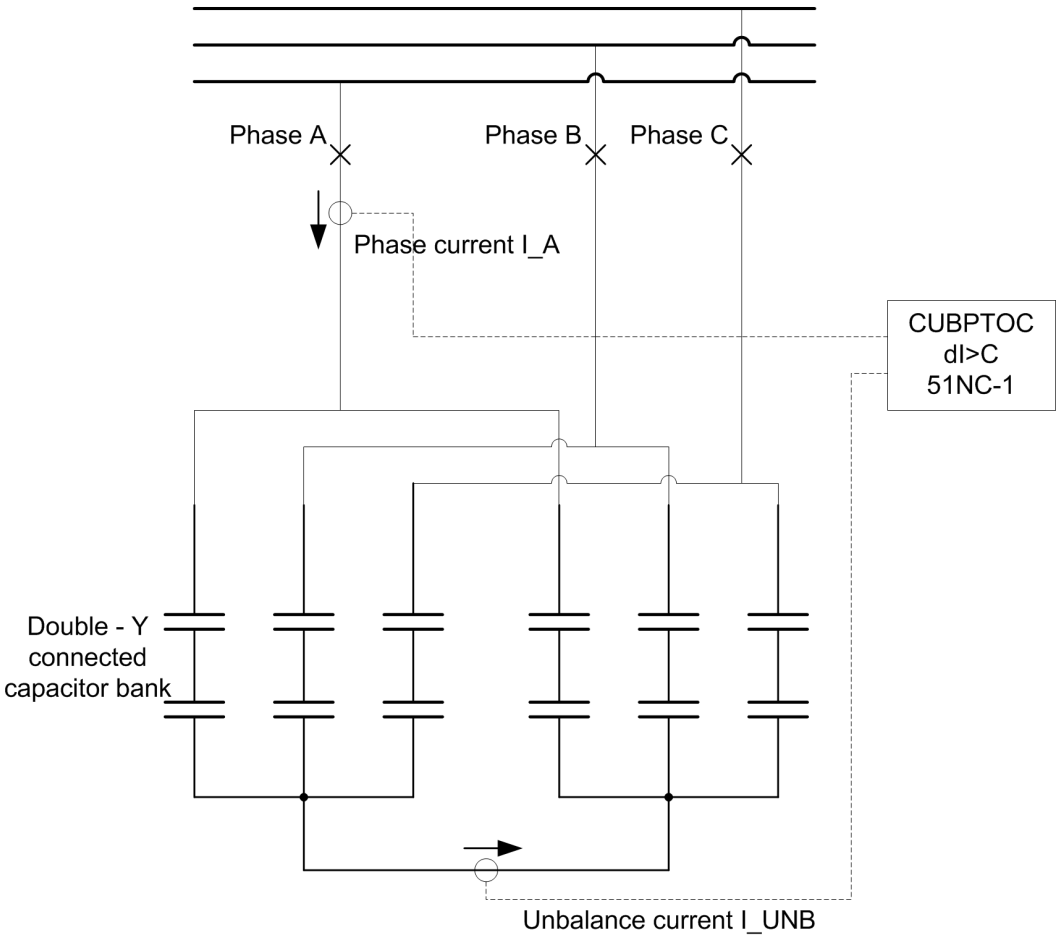



*Figure 631: Example of double-Y-connected shunt capacitor bank unbalance protection*

Connect the phase current analog input I_A and unbalance current I_UNB to the protection relay for the CUBPTOC function to start working.

**Steps to measure natural unbalance current**

1. The setting *Natural Comp Enable* must be set to “TRUE”.
2. The capacitor bank must be energized.
3. The capacitor bank compensated unbalance current I_COM_AMPL is observed from Monitored data.
4. The command *Record unbalance* must be activated by selecting the value “Record” which stores the unbalance reference for future unbalance calculations.
5. The compensated unbalance current ( I_COM_AMPL) is re-checked to be approximately zero.

The natural unbalance recording should be made only during the steady-state condition and when all the capacitor bank elements are assumed to be in service.

### 4.12.2.7 Signals

#### CUBPTOC Input signals

**Table 1068: CUBPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IUNB | SIGNAL | - | Analog input |
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

#### CUBPTOC Output signals

**Table 1069: CUBPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Alarm |

### 4.12.2.8 CUBPTOC Settings

**Table 1070: CUBPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Alarm mode | 1=Normal | | | 1=Normal | Mode of operation for Alarm stage |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=Element counter | | | | |
| Start value | 0.01...1.00 | xIn | 0.01 | 0.10 | Start value |
| Alarm start value | 0.01...1.00 | xIn | 0.01 | 0.05 | Alarm start value |
| Time multiplier | 0.05...15.00 | | 0.01 | 1.00 | Time multiplier in IEC/ANSI IDMT curves |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type<br>19=RD type | | | 15=IEC Def. Time | Selection of time delay curve type |
| Operate delay time | 50...200000 | ms | 10 | 5000 | Operate delay time |
| Alarm delay time | 50...200000 | ms | 10 | 200000 | Alarm delay time |

**Table 1071: CUBPTOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Fuse location | 1=Internal<br>2=External | | | 1=Internal | Location of capacitor fuse |
| Element fail limit | 1...100 | | 1 | 3 | Element failure limit above which alarm is active |
| Natural Comp enable | 0=False<br>1=True | | | 0=False | Enable natural unbalance compensation |

**Table 1072: CUBPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.00860...120.00000 | | 0.00001 | 28.20000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.00000...0.71200 | | 0.00001 | 0.12170 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 1073: CUBPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |

### 4.12.2.9 CUBPTOC Monitored data

**Table 1074: CUBPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| I_NAT_AMPL | FLOAT32 | 0.00...5.00 | xIn | Recorded natural unbalance current amplitude |
| I_NAT_ANGL | FLOAT32 | -179.00...179.00 | deg | Recorded natural unbalance current angle |
| I_COM_AMPL | FLOAT32 | 0.00...5.00 | xIn | Compensated unbalance current amplitude |
| I_COM_ANGL | FLOAT32 | -179.00...179.00 | deg | Compensated unbalance current angle |
| COUNT_BR1_A | INT32 | 0...2147483647 | | Number of element failures in branch1 phase-A |
| COUNT_BR2_A | INT32 | 0...2147483647 | | Number of element failures in branch2 phase-A |
| COUNT_BR1_B | INT32 | 0...2147483647 | | Number of element failures in branch1 phase-B |
| COUNT_BR2_B | INT32 | 0...2147483647 | | Number of element failures in branch2 phase-B |
| COUNT_BR1_C | INT32 | 0...2147483647 | | Number of element failures in branch1 phase-C |
| COUNT_BR2_C | INT32 | 0...2147483647 | | Number of element failures in branch2 phase-C |
| FAIL_COUNT | INT32 | 0...2147483647 | | Total number of element failures |
| CUBPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| I-unb-xIn:1 | FLOAT32 | 0.00...5.00 | xIn | Measured neutral unbalance current amplitude |

### 4.12.2.10 Technical data

**Table 1075: CUBPTOC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | 1.5 % of the set value or 0.002 × $I_n$ |
| Start time [1, 2] | Typically 26 ms |

*Table continues on the next page*

| Characteristic | Value |
|---|---|
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | 1 % of the theoretical value or ±20 ms |
| Operate time accuracy in inverse definite minimum time mode | 5 % of the theoretical value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2,3,4,5,.. |

## 4.12.3 Three-phase current unbalance protection for shunt capacitor banks HCUBPTOC (ANSI 60P)

### 4.12.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase current unbalance protection for shunt capacitor banks | HCUBPTOC | 3dI>C | 60P |

### 4.12.3.2 Function block

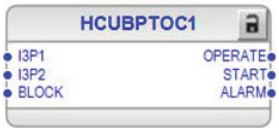



*Figure 632: Function block symbol*

### 4.12.3.3 Functionality

The three-phase current unbalance protection function for shunt capacitor banks HCUBPTOC is used to protect the H-bridge capacitor banks against internal faults. HCUBPTOC is suitable for protection of internally fused, externally fused and fuseless capacitor bank applications.

HCUBPTOC has two stages of operation, the operation stage and alarm stage. In the operation stage, HCUBPTOC starts when the measured unbalance current exceeds the set limit. The operating time characteristics can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). In the alarm stage, the alarm starts when the measured unbalance current exceeds the set alarm limit. The alarm time characteristics are based on DT.

HCUBPTOC contains blocking functionality. It is possible to block the function outputs, timers or the function itself.

[1] Fundamental frequency current = 1.0 × $I_n$, current before fault = 0.0 × $I_n$, fault current = 2.0 × *Start value*, results based on statistical distribution of 1000 measurements

[2] Includes the delay of the signal output contact

### 4.12.3.4 Analog channel configuration

HCUBPTOC has two analog group inputs which must be properly configured.

**Table 1076: Analog inputs**

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase unbalance currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.12.3.5 Operation principle

The function can be enabled and disabled with the Operation setting. The corresponding parameter values are “On” and “Off”.

The three-phase current unbalance protection for shunt capacitor banks operates on the DFT measurement mode. The operation of HCUBPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

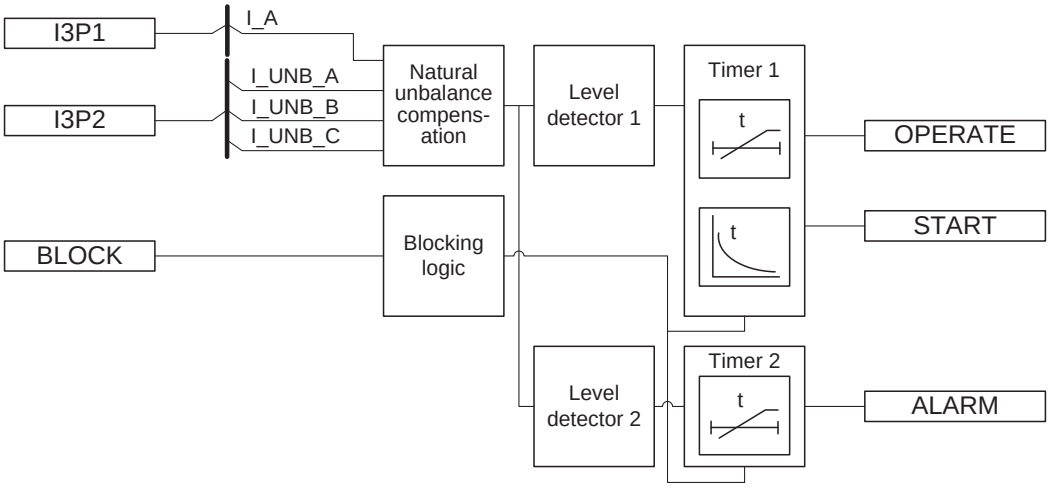



*Figure 633: Function module diagram*

#### Natural unbalance compensation

In the three-phase H-bridge-connected shunt capacitor bank configuration, the unbalance currents `I_UNB_A`, `I_UNB_B` and `I_UNB_C` are measured at the common points of the H-bridge.

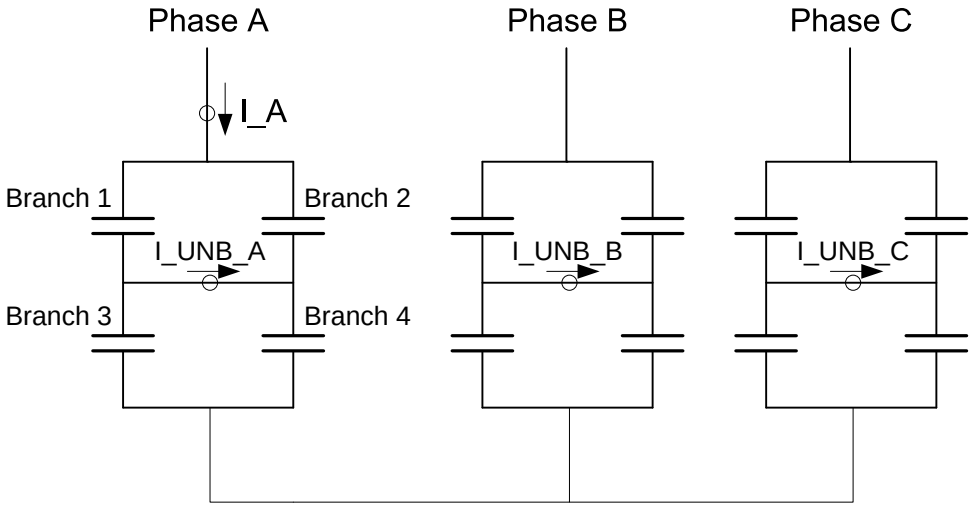



*Figure 634: H-Bridge-connected capacitor bank*

The phase angles of three-phase measured unbalance currents are synchronized using the phase current I_A as reference. The phase-A unbalance current phase angle can be calculated with the equation.

$$\angle\overline{I_{Unb_A}} = \angle\overline{I_UNB_A} - \angle\overline{I_A}$$

(Equation 287)

A three-phase H-bridge-connected capacitor bank circuit may have some amount of natural unbalance current flowing through the common points of H-bridge, which may primarily be due to capacitor manufacturing tolerances. Therefore, the natural unbalance current must be compensated for before using the measured unbalance current for function operation.

The natural unbalance current needs to be recorded when there is no fault in the capacitor banks, and it is initiated through the command *Record unbalance* available under menu path **Control** > **HCUBPTOC**. The natural unbalance currents are recorded for all the phases at the same time by setting command *Record unbalance* to “Record all phases” or each natural unbalance current can be recorded separately for individual phases by setting command *Record unbalance* to “Record phase A” or “Record phase B” or “Record phase C”. By selecting *Record unbalance* with value “Record”, the measured three-phase unbalance currents ( $\overline{I_{Unb_A}}, \overline{I_{Unb_B}}, \overline{I_{Unb_C}}$, ) are considered the natural unbalance currents for each phase respectively and stored as a reference. The amplitude and angle of the phasewise-recorded natural unbalance currents `I_NAT_AMPL_A`, `I_NAT_ANGL_A`, `I_NAT_AMPL_B`, `I_NAT_ANGL_B`, `I_NAT_AMPL_C` and `I_NAT_ANGL_C` are available in the monitored data view.

Once a natural unbalance current is recorded, the phasewise natural unbalance current is subtracted from the corresponding phase-measured unbalance current ( $\overline{I_{Unb}}$ ) during further executions of the function to obtain the compensated unbalance current ( $\overline{I_{CompUnb}}$ ) .

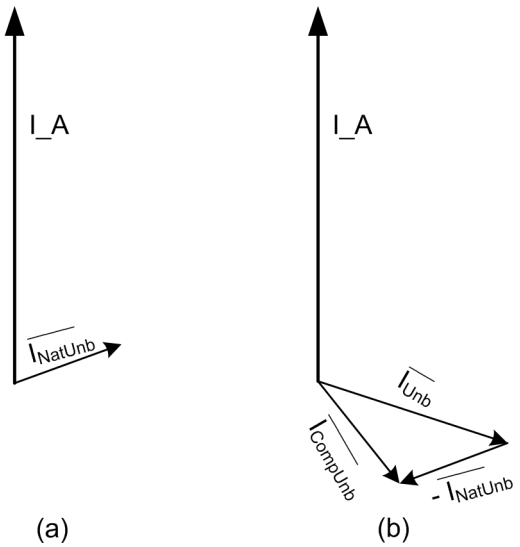



*Figure 635: Natural unbalance compensation. (a) Healthy condition when the natural unbalance is recorded (b) Unbalance compensation during faulty conditions*

The natural unbalance compensation for each phase is enabled based on the settings *Natural Comp Ena PhA*, *Natural Comp Ena PhB* and *Natural Comp Ena PhC* respectively. For example, if *Natural Comp Ena PhA* is set to “FALSE”, the unbalance current is not compensated. If *Natural Comp Ena PhA* is set to “TRUE”, the compensated unbalance current for phase A is calculated based on the equation.

$$\overline{I_{CompUnb_A}} = \overline{I_{Unb_A}} - \overline{I_{NatUnb_A}}$$

(Equation 288)

| | |
|---|---|
| $I_{CompUnb_A}$ | Phase A-compensated unbalance current |
| $I_{Urb_A}$ | Phase A-measured unbalance current |
| $I_{NatUnb_A}$ | Phase A-recorded natural unbalance current |

The phasewise-compensated unbalance current amplitudes and angles `I_COM_AMPL_A`, `I_COM_ANGL_A`, `I_COM_AMPL_B`, `I_COM_ANGL_B`, `I_COM_AMPL_C` and `I_COM_ANGL_C` are available in the monitored data view.

The phase angles of the unbalance currents indicate the branch of a faulty element in a capacitor bank. For an internal fuse capacitor bank, the element failure branch location is determined based on the phase angle of the compensated unbalance current.

**Table 1077: Detection of element failure location for internal fuse capacitor bank**

| Name of the phase angle | Phase angle of unbalance current | Element failure branch location *Figure 634* |
|---|---|---|
| I_COM_ANGL_A | ~+180° | Phase A - Branch 1 or Phase A - Branch 4 |
| I_COM_ANGL_A | ~0° | Phase A - Branch 2 or Phase A - Branch 3 |

*Table continues on the next page*

| | | |
|---|---|---|
| I_COM_ANGL_B | ~+60° | Phase B - Branch 1 or Phase B - Branch 4 |
| I_COM_ANGL_B | ~–120° | Phase B - Branch 2 or Phase B - Branch 3 |
| I_COM_ANGL_C | ~–60° | Phase C - Branch 1 or Phase C - Branch 4 |
| I_COM_ANGL_C | ~+120° | Phase C - Branch 2 or Phase C - Branch 3 |

If external fuses are used, the direction of an unbalance current is opposite to that of the bank where internal fuses are in use.

**Table 1078: Detection of element failure location for external fuse capacitor bank**

| Name of the phase angle | Phase angle of unbalance current | Element failure branch location *Figure 634* |
|---|---|---|
| I_COM_ANGL_A | ~0° | Phase A - Branch 1 or Phase A - Branch 4 |
| I_COM_ANGL_A | ~+180° | Phase A - Branch 2 or Phase A - Branch 3 |
| I_COM_ANGL_B | ~–120° | Phase B - Branch 1 or Phase B - Branch 4 |
| I_COM_ANGL_B | ~+60° | Phase B - Branch 2 or Phase B - Branch 3 |
| I_COM_ANGL_C | ~+120° | Phase C - Branch 1 or Phase C - Branch 4 |
| I_COM_ANGL_C | ~–60° | Phase C - Branch 2 or Phase C - Branch 3 |

**Level detector 1**

The phasewise-compensated unbalance currents `I_COM_AMPL_A`, `I_COM_AMPL_B` and `I_COM_AMPL_C` are compared to the set *Start value*. If the compensated unbalance current in one or more phases exceeds the set *Start value*, the Level detector 1 module sends the enabling signal to the Timer 1 module.

**Timer 1**

Once activated, the Timer 1 module activates the `START` output. Depending on the value of the *Operating curve type* setting, the time characteristics are according to DT or IDMT. When the operation timer has reached the value of *Operate delay time* in the DT mode or the maximum value defined by the inverse time curve, the `OPERATE` output is activated.

When the user-programmable IDMT curve is selected, the operation time characteristics are defined by the parameters *Curve parameter A*, *Curve parameter B*, *Curve parameter C* and *Curve parameter E*.

In a drop-off situation, that is, when a fault suddenly disappears before the operation delay is exceeded, the Timer 1 reset state is activated. The functionality of Timer 1 in the reset state depends on the combination of the *Operating curve type* and *Reset delay time* settings. When the DT characteristic is selected, the reset timer runs until the set *Reset delay time* value is exceeded. When the IDMT curves

are selected, an immediate reset occurs. The START output is deactivated when the reset timer has elapsed.

The setting *Time multiplier* is used for scaling the IDMT operation times.

The setting parameter *Minimum operate time* defines the minimum desired operation time for IDMT. The setting is applicable only when the IDMT curves are used.

The *Minimum operate time* setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the *Minimum operate time* setting.

Timer 1 calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the monitored data view.

#### Level detector 2

The phasewise-compensated unbalance currents I_COM_AMPL_A, I_COM_AMPL_B and I_COM_AMPL_C are compared to the set *Alarm start value*. If the compensated unbalance current in one or more phases exceeds the set *Alarm start value*, the Level detector 2 module sends the enabling signal to the Timer 2 module.

#### Timer 2

Once activated, the timer activates the alarm timer. The timer characteristic is according to DT. When the alarm timer has reached the value set by *Alarm delay time*, the ALARM output is activated.

If the fault disappears before the alarm activates, the alarm timer is reset immediately.

#### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, HCUBPTOC operates normally but the OPERATE output is not activated.

### 4.12.3.6 Application

Shunt capacitor banks (SCBs) are widely used in transmission and distribution networks to produce reactive power support. Located in relevant places such as in the vicinity of load centers, SCBs have beneficial effects on power system performance: increased power factor, reduced losses, improved system capacity and better voltage level at load points.

The capacitor bank terminology ‘Bank’, ‘Unit’ and ‘Element’ is shown in *Figure 636*.

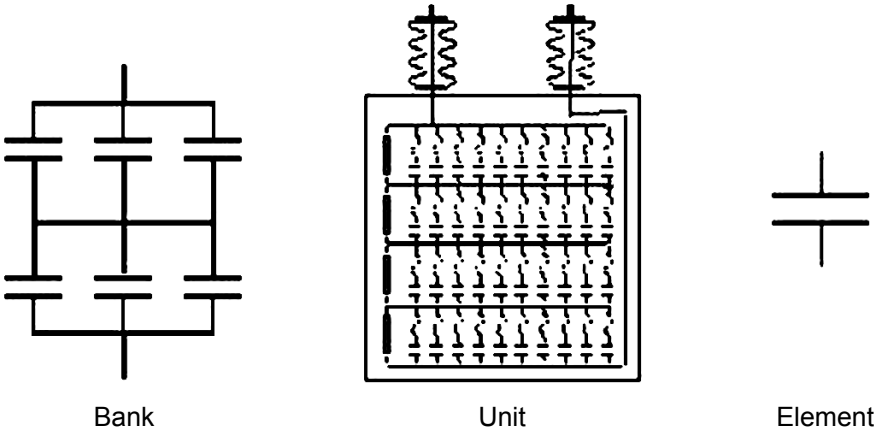



*Figure 636: Bank, unit and element of a capacitor bank*

HCUBPTOC is designed for the protection against internal faults in H-bridge-connected capacitor banks. This unbalance protection detects an asymmetry in the capacitor bank, caused by blown fuses or short-circuits across bushings, or between capacitor units and the racks in which they are mounted.

Normally, the capacitor units are designed to withstand 110% of the nominal voltage continuously. When an element inside a capacitor bank fails, the remaining healthy elements experience an increase in voltage across them. If the voltage exceeds 110% of the nominal voltage, it can lead to a failure of the healthy elements of the bank and in turn fail the entire capacitor bank. Since the capacitor unbalance current is directly proportional to element failures, unbalance protection is an effective way of detecting capacitor element failures. The current unbalance protection function is usually used along with the three-phase capacitor bank overload protection function to increase the sensitivity of protection for capacitor banks.

Due to the two-stage (operation and alarm stage) unbalance protection and the natural unbalance compensation facility, the protection of capacitor banks with internal fuses can be implemented with a very high degree of sensitivity.

The unbalance protection function can be used for internally fused, externally fused and fuseless shunt capacitor banks. Since a fuseless capacitor bank lacks the individual capacitor unit fuses, current unbalance protection becomes even more critical for fuseless applications.

When an individual element fails, it creates current unbalance. With an increasing number of element failures, the unbalance current increases and HCUBPTOC gives an alarm. The alarm level is normally set to 50% of the maximum permitted level. The capacitor bank then should be taken out of service to replace the faulty units. If not, the capacitor bank is tripped when the maximum allowed unbalance current level is exceeded.

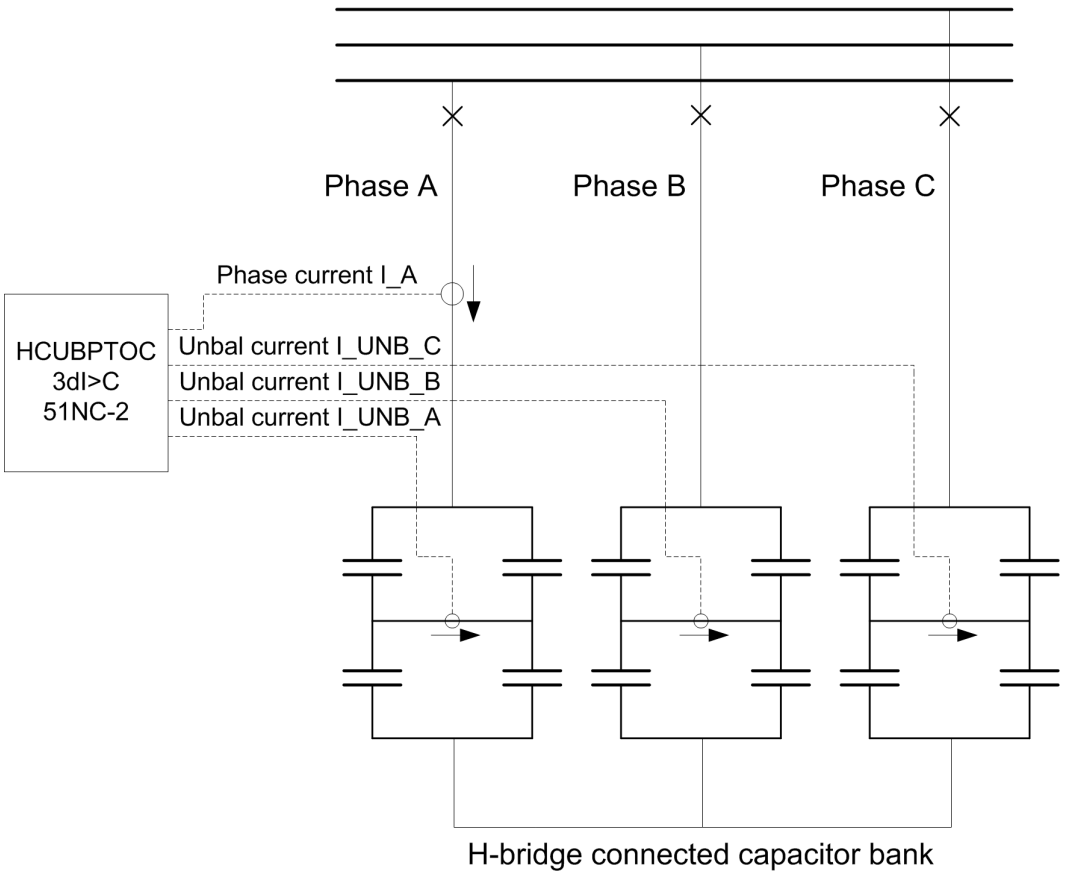



*Figure 637: Application example of capacitor bank unbalance protection*

The phase current analog input I_A and at least one unbalance current must be connected to the protection relay for the HCUBPTOC function to start working.

**Steps to measure natural unbalance current**

1. The setting *Natural Comp Enable* must be set to “TRUE”.
2. The capacitor bank must be energized.
3. The capacitor bank compensated unbalance current `I_COM_AMPL` is observed from Monitored data.
4. The command *Record unbalance* must be activated by selecting the value “Record” which stores the unbalance reference for future unbalance calculations.
5. The compensated unbalance current ( `I_COM_AMPL`) is re-checked to be approximately zero.

The natural unbalance recording should be made only during the steady-state condition and when all the capacitor bank elements are assumed to be in service.

### 4.12.3.7 Signals

**HCUBPTOC Input signals**

**Table 1079: HCUBPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**HCUBPTOC Output signals**

**Table 1080: HCUBPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |
| ALARM | BOOLEAN | Alarm |

### 4.12.3.8 HCUBPTOC Settings

**Table 1081: HCUBPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...1.00 | xIn | 0.01 | 0.10 | Start value |
| Alarm start value | 0.01...1.00 | xIn | 0.01 | 0.05 | Alarm start value |
| Time multiplier | 0.05...15.00 | | 0.01 | 1.00 | Time multiplier in IEC/ANSI IDMT curves |
| Operating curve type | 1=ANSI Ext. inv.<br>2=ANSI Very inv.<br>3=ANSI Norm. inv.<br>4=ANSI Mod. inv.<br>5=ANSI Def. Time<br>6=L.T.E. inv.<br>7=L.T.V. inv.<br>8=L.T. inv.<br>9=IEC Norm. inv.<br>10=IEC Very inv.<br>11=IEC inv.<br>12=IEC Ext. inv.<br>13=IEC S.T. inv.<br>14=IEC L.T. inv.<br>15=IEC Def. Time<br>17=Programmable<br>18=RI type | | | 15=IEC Def. Time | Selection of time delay curve type |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 19=RD type | | | | |
| Operate delay time | 40...200000 | ms | 10 | 5000 | Operate delay time |
| Alarm delay time | 40...200000 | ms | 10 | 200000 | Alarm delay time |

**Table 1082: HCUBPTOC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Natural Comp Ena PhA | 0=False<br>1=True | | | 0=False | Enable natural unbalance compensation PhA |
| Natural Comp Ena PhB | 0=False<br>1=True | | | 0=False | Enable natural unbalance compensation PhB |
| Natural Comp Ena PhC | 0=False<br>1=True | | | 0=False | Enable natural unbalance compensation PhC |

**Table 1083: HCUBPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Curve parameter A | 0.00860...120.00000 | | 0.00001 | 28.20000 | Parameter A for customer programmable curve |
| Curve parameter B | 0.00000...0.71200 | | 0.00001 | 0.12170 | Parameter B for customer programmable curve |
| Curve parameter C | 0.02...2.00 | | 0.01 | 2.00 | Parameter C for customer programmable curve |
| Curve parameter E | 0.0...1.0 | | 0.1 | 1.0 | Parameter E for customer programmable curve |

**Table 1084: HCUBPTOC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Minimum operate time | 20...60000 | ms | 1 | 20 | Minimum operate time for IDMT curves |

### 4.12.3.9 HCUBPTOC Monitored data

**Table 1085: HCUBPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| I_NAT_AMPL_A | FLOAT32 | 0.00...5.00 | xIn | Recorded natural unbalance current amplitude phase A |
| I_NAT_ANGL_A | FLOAT32 | -179.00...179.00 | deg | Recorded natural unbalance current angle phase A |
| I_NAT_AMPL_B | FLOAT32 | 0.00...5.00 | xIn | Recorded natural unbalance current amplitude phase B |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_NAT_ANGL_B | FLOAT32 | -179.00...179.00 | deg | Recorded natural unbalance current angle phase B |
| I_NAT_AMPL_C | FLOAT32 | 0.00...5.00 | xIn | Recorded natural unbalance current amplitude phase C |
| I_NAT_ANGL_C | FLOAT32 | -179.00...179.00 | deg | Recorded natural unbalance current angle phase C |
| I_COM_AMPL_A | FLOAT32 | 0.00...5.00 | xIn | Compensated unbalance current amplitude phase A |
| I_COM_ANGL_A | FLOAT32 | -179.00...179.00 | deg | Compensated unbalance current angle phase A |
| I_COM_AMPL_B | FLOAT32 | 0.00...5.00 | xIn | Compensated unbalance current amplitude phase B |
| I_COM_ANGL_B | FLOAT32 | -179.00...179.00 | deg | Compensated unbalance current angle phase B |
| I_COM_AMPL_C | FLOAT32 | 0.00...5.00 | xIn | Compensated unbalance current amplitude phase C |
| I_COM_ANGL_C | FLOAT32 | -179.00...179.00 | deg | Compensated unbalance current angle phase C |
| HCUBPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| IL1-unb:1 | FLOAT32 | 0.00...5.00 | xIn | Measured unbalance current amplitude phase A |
| IL2-unb:1 | FLOAT32 | 0.00...5.00 | xIn | Measured unbalance current amplitude phase B |
| IL3-unb:1 | FLOAT32 | 0.00...5.00 | xIn | Measured unbalance current amplitude phase C |

### 4.12.3.10 Technical data

**Table 1086: HCUBPTOC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | 1.5 % of the set value or 0.002 × $I_n$ |
| Start time [1, 2] | Typically 26 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |

*Table continues on the next page*

[1] Fundamental frequency current = 1.0 × $I_n$, current before fault = 0.0 × $I_n$, fault current = 2.0 × *Start value*, results based on statistical distribution of 1000 measurements

[2] Includes the delay of the signal output contact

| Characteristic | Value |
|---|---|
| Operate time accuracy in definite time mode | 1 % of the theoretical value or ±20 ms |
| Operate time accuracy in IDMT mode | 5 % of the theoretical value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2,3,4,5,.. |

## 4.12.4 Shunt capacitor bank switching resonance protection, current based, SRCPTOC (ANSI 55ITHD)

### 4.12.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Shunt capacitor bank switching resonance protection, current based | SRCPTOC | TD> | 55ITHD |

### 4.12.4.2 Function block




*Figure 638: Function block symbol*

### 4.12.4.3 Functionality

The shunt capacitor bank switching resonance protection, current based, function SRCPTOC is used for detecting three-phase resonance caused by capacitor switching or topology changes in the network. The operating characteristic is a definite time (DT).

SRCPTOC contains a blocking functionality. It is possible to block function outputs, timers or the function itself.

### 4.12.4.4 Analog input configuration

SRCPTOC has one analog group input which must be properly configured.

**Table 1087: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.12.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”.

The operation of SRCPTOC can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

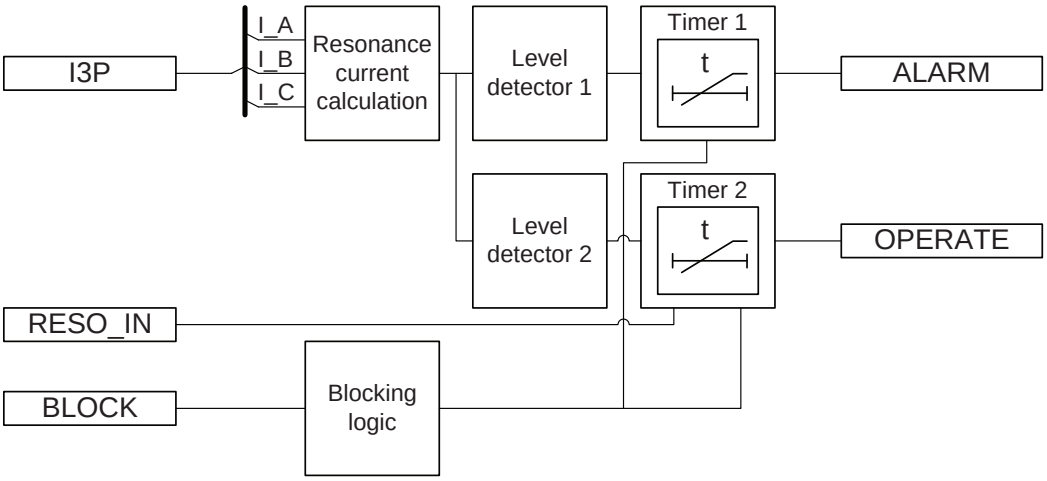



*Figure 639: Functional module diagram*

#### Resonance current calculation

This module calculates the resonance current per phase set as per setting *Tuning harmonic Num*. The resonance current for phase A is calculated with the equation.

$$I_RESO_A = \sqrt{I^2_{RMS_A} - I^2_{1_A} - I^2_{DC_A} - I^2_{K_A}}$$

(Equation 289)

| | |
|---|---|
| $I_{RMS_A}$ | RMS value of current in phase A (contains up to 11 $^{th}$ harmonic) |
| $I_{DC_A}$ | DC-component in phase A current |
| $I_{1_A}$ | Fundamental component in phase A current |
| $I_{K_A}$ | K $^{th}$ harmonic component in phase A current, K is defined by setting *Tuning harmonic Num* |
| I_RESO_A | Calculated resonance current for phase A |

The resonance current is calculated through the filter implementation. The DC and fundamental components are removed by passing the total RMS current through the High pass filter. The K $^{th}$ harmonic component is removed by passing the High pass filter output through the K $^{th}$ harmonic Band stop filter. The magnitude

response of the High pass filter and all the harmonic Band stop filters are shown in *Figure 640*.

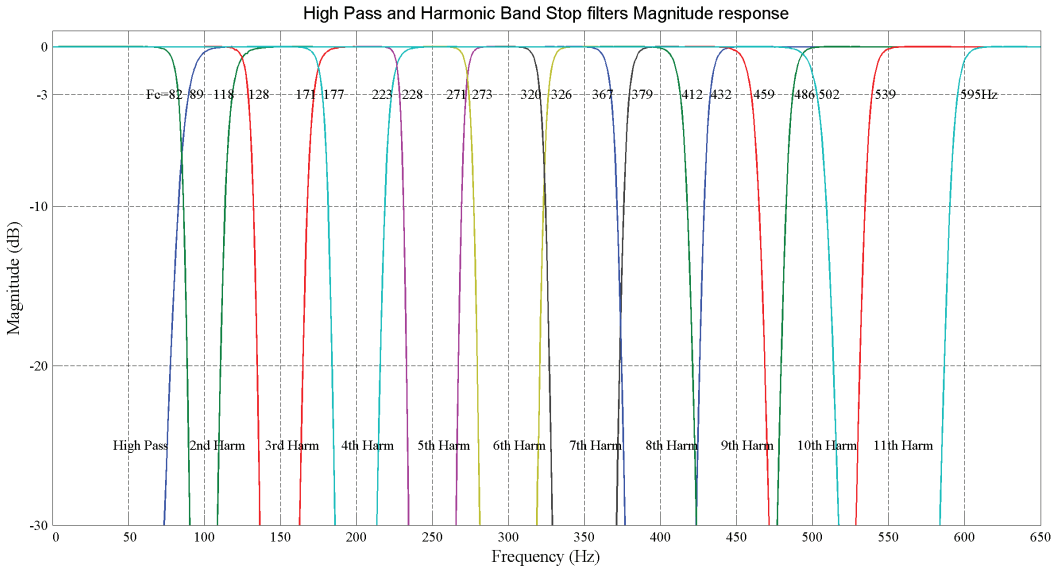



*Figure 640: Magnitude response of High pass and all the harmonic Band stop filters*

Similarly resonance current is calculated in the same way for phase B and phase C. Resonance currents `I_RESO_A`, `I_RESO_B` and `I_RESO_C` are available in the monitored data view.

The maximum of the three calculated resonance currents is further considered for calculation.

$$I_RESONANCE = Max(I_RESO_A, I_RESO_B, I_RESO_C)$$

(Equation 290)

If a capacitor bank is used only for reactive power compensation and there is no series reactor in a filter branch, the resonance protection is very important. In this case, the setting *Tuning harmonic Num* should be set to 1 because the capacitor branch is not tuned for a special frequency as in tuned filter applications. Even though *Tuning harmonic Num* is set to 1, the fundamental component is subtracted only once from $I_{RMS}$.

### Level detector 1

The maximum calculated resonance current is compared to the set *Alarm start value*. If the calculated `I_RESONANCE` exceeds the set *Alarm start value*, the module sends the enabling signal to the Timer 1 module.

### Level detector 2

The maximum calculated resonance current is compared to the set *Start value*. If the calculated `I_RESONANCE` exceeds the set *Start value*, this module sends the enabling signal to the Timer 2 module.

**Timer 1**

Once activated, the timer activates the alarm timer. The timer characteristic is according to DT. When the alarm timer has reached the value set by *Alarm delay time*, the ALARM output is activated.

If the fault disappears before the alarm activates, the alarm timer is reset immediately.

**Timer 2**

Once activated, the timer activates the operation timer. The timer characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the OPERATE output is activated.

If the fault disappears before the operate activates, the operation timer is reset immediately.

If the input RESO_IN becomes active, the OPERATE output is activated immediately. If the resonance protection at a higher-order filter branch has already operated, the function in lower-order filter branches can be tripped immediately using this feature.

**Blocking logic**

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the IED program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, SRCPTOC operates normally but the OPERATE output is not activated.

### 4.12.4.6 Application

Switched shunt capacitor banks are widely used by utilities and customers in industrial distribution systems to provide voltage support and to improve the power factor of a load. Capacitor steps may be switched in and out of circuits routinely as the demand for capacitive VAR compensation of a load fluctuates. Normally, automatic power factor controllers are employed which automatically switch on or off the capacitors of the capacitor bank, depending upon the prevalent reactive power requirement in the system.

One potential problem for the application of automatic power factor controllers is that it may cause harmonic resonance under certain system conditions. Capacitor switching changes the parameters of the system, which may cause the resonance frequency of the circuit to be equal to one of the frequencies of the harmonic sources prevalent in the system. Harmonic resonance, when it occurs, may result in severe voltage and current distortions, which increases losses and causes overheating of other equipment in the circuit.

A traditional way of solving the problem is to conduct a detailed system study for each individual installation and use the results to properly size the capacitors and determine the right operating range of capacitors to avoid harmonic resonance

with other system components. However, this method is not economical but more time-consuming.

The capacitor switching-resonance protection function can be used as a solution to the above mentioned problem. The basis for the harmonic resonance protection is the detection of a current harmonic resonance condition caused by capacitor switching. A prolonged increase of the harmonic distortion level after a switching operation is a clear indication of such condition. When a resonant condition caused by capacitor switching occurs in a circuit, SRCPTOC detunes the circuit by taking the reverse action, that is, switching the capacitor bank off if switching it on causes resonance. If the resonance situation has been detected and SRCPTOC has switched off a capacitor bank, power factor controller should not try to switch on the capacitor bank until the switching resonance function reset.

The capacitor switching-resonance protection function can also be used to protect harmonic filters. In harmonic filter bank applications, the SRCPTOC function can be tuned to harmonic frequency for which the harmonic filter is designed to ensure that the function does not include thr tuned harmonic frequency current into the calculation of the resonance current. If there is more than one harmonic filter bank involved, each SRCPTOC tunes to the harmonic frequency of its corresponding filter bank. The interlinking between the functions can be done in such a way that if resonance occurs in a higher harmonic frequency filter bank, all the lower harmonic frequency filter banks can be tripped immediately by activating the function input `RESO_IN`.

The settings *Alarm start value* and *Start value* determine the portion of the total harmonic current (excluding the harmonic defined by the setting *Tuning harmonic Num*) in relation to the CT nominal value required for SRCPTOC to give alarm and operate respectively.

For power factor correction application

- *Tuning harmonic Num* must be set to 1.
- *Alarm start value* and *Start value* must be set according to the standard IEEE519 -1992.

For harmonic filter application

- *Tuning harmonic Num* must be set to the filter design tuning frequency.
- *Alarm start value* and *Start value* must be set according to the standard IEEE519 -1992.



Settings *Alarm start value* and *Start value* should be selected as such that in normal operation SRCPTOC should not operate.

### 4.12.4.7 Signals

**SRCPTOC Input signals**

**Table 1088: SRCPTOC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RESO_IN | BOOLEAN | 0=False | Input signal from higher frequency resonance branch |

**SRCPTOC Output signals**

**Table 1089: SRCPTOC Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm |
| OPERATE | BOOLEAN | Operate signal |

### 4.12.4.8 SRCPTOC Settings

**Table 1090: SRCPTOC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Alarm start value | 0.03...0.50 | xIn | 0.01 | 0.03 | Alarm limit for filtered harmonic currents |
| Start value | 0.03...0.50 | xIn | 0.01 | 0.03 | Tripping limit for filtered harmonic currents indicating resonance condition |
| Tuning harmonic Num | 1...11 | | 1 | 11 | Tuning frequency harmonic number of the filter branch |
| Operate delay time | 120...360000 | ms | 1 | 200 | Operate delay time for resonance |
| Alarm delay time | 120...360000 | ms | 1 | 200 | Alarm delay time for resonance alarm |

**Table 1091: SRCPTOC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

### 4.12.4.9 SRCPTOC Monitored data

**Table 1092: SRCPTOC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_RESO_A | FLOAT32 | 0.00...40.00 | xIn | Resonance current for phase A |
| I_RESO_B | FLOAT32 | 0.00...40.00 | xIn | Resonance current for phase B |
| I_RESO_C | FLOAT32 | 0.00...40.00 | xIn | Resonance current for phase C |
| SRCPTOC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.12.4.10 Technical data

**Table 1093: SRCPTOC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Operate value accuracy:<br>±3 % of the set value or ±0.002 × $I_n$ (for 2nd order Harmonics)<br>±1.5 % of the set value or ±0.002 × $I_n$ (for 3rd order < Harmonics < 10th order)<br>±6 % of the set value or ±0.004 × $I_n$ (for Harmonics >= 10th order) |
| Reset time | Typically 45 ms or maximum 50 ms |
| Retardation time | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0 % of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = $f_n$ |

## 4.12.5 Compensated neutral unbalance voltage protection CNUPTOV (ANSI 59NU)

### 4.12.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Compensated neutral unbalance voltage protection | CNUPTOV | CNU> | 59NU |

### 4.12.5.2 Function block

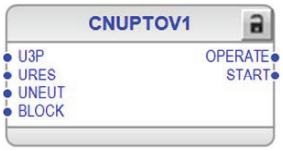



*Figure 641: Function block*

### 4.12.5.3 Functionality

The compensated neutral unbalance voltage protection function CNUPTOV detects overvoltage at the neutral point of the shunt capacitor. A blown fuse or a shortcircuited capacitor element results in unbalance in the shunt capacitor bank causing increase in neutral point voltage. With CNUPTOV, an inherent capacitor bank unbalance which results in non-zero neutral point voltage can be compensated automatically on a continuous basis.

The function starts when the fundamental (DFT) component of the compensated neutral unbalance voltage exceeds the set limit. CNUPTOV operates with the definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself.

### 4.12.5.4 Analog channel configuration

CNUPTOV has three analog group inputs which must be properly configured.

**Table 1094: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three phase voltages |
| URES | Residual voltage (measured or calculated) |
| UNEUT | Measured neutral voltage |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1095: Special conditions**

| Condition | Description |
|---|---|
| U3P connected real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |
| URES calculated | The function requires that all three voltage channels from terminal side are connected to calculate residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. Check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 4.12.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of CNUPTOV can be described with a module diagram. All the modules in the diagram are explained in the next sections.

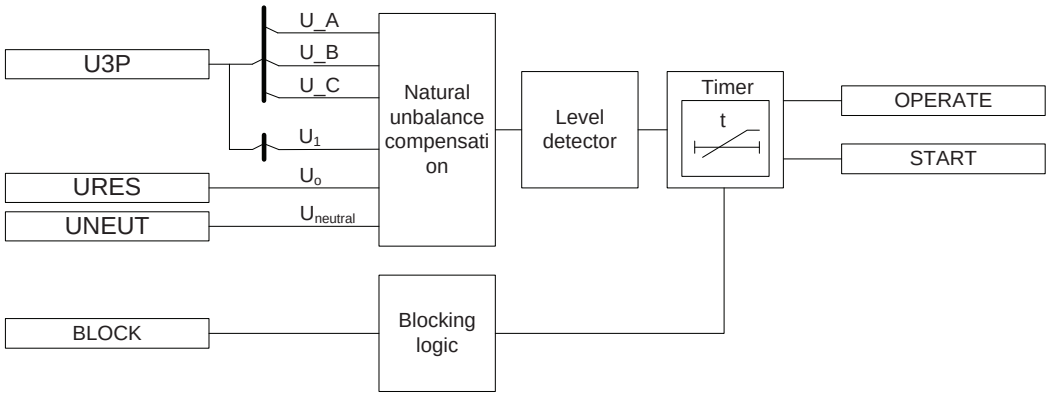



*Figure 642: Functional module diagram*

#### Natural unbalance compensation

This module calculates the natural unbalance compensation. Calculation for compensation is initiated through the command Record unbalance, available under the menu path **Control** > **CNUPTOV**. The function equates the operating signal to zero and calculates $\overline{U_{unb}}$ from the available known quantities. $\overline{U_{unb}}$ is memorized as $\overline{U_{unb}}(m)$. This memorized value is then used when calculating the operating quantity. For more information, see the *Chapter 4.12.5.6 Operating quantity* section in this manual.

If the positive-sequence voltage is available at the time of memorizing the $\overline{U_{unb}}(m)$ value, the positive-sequence voltage is also memorized as $\overline{U_1}(m)$. The function then applies the revised compensation voltage to account for change in bus voltages between the moment of memorizing the compensation voltage and the time of applying it.

$$\overline{U_{unb}} = \overline{U_{unb}}(m) \cdot \frac{\overline{U_1}}{\overline{U_1}(m)}$$

*Figure 643: Equation*

#### Level detect

The operating signal is compared to the set *Start value*. If the operating signal exceeds the set *Start value*, Level detector sends an enabling signal to the Timer module.

#### Timer

Once activated, Timer activates the START output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay* time, the OPERATE output is activated if the operating signal persists. If a drop-off situation happens, that is, the fault disappears before the operate delay is exceeded, the timer reset state is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the START output is deactivated.

Timer calculates the start duration value START_DUR, which indicates the percentage ratio of the start situation and the set operation time. The value is available in the Monitored data view.

#### Blocking logic

There are three operation modes in the blocking function. The operation modes are controlled by the BLOCK input and the global setting in **Configuration** > **System** > **Blocking mode** which selects the blocking mode. The BLOCK input can be controlled by a binary input, a horizontal communication input or an internal signal of the protection relay's program. The influence of the BLOCK signal activation is preselected with the global setting *Blocking mode*.

The *Blocking mode* setting has three blocking methods. In the “Freeze timers” mode, the operation timer is frozen to the prevailing value, but the OPERATE output is not deactivated when blocking is activated. In the “Block all” mode, the whole function is blocked and the timers are reset. In the “Block OPERATE output” mode, the function operates normally but the OPERATE output is not activated.

### 4.12.5.6 Operating quantity

#### Operating quantity in ungrounded SCB

Consider a case of a standard ungrounded shunt capacitor bank as shown in *Figure 644*.

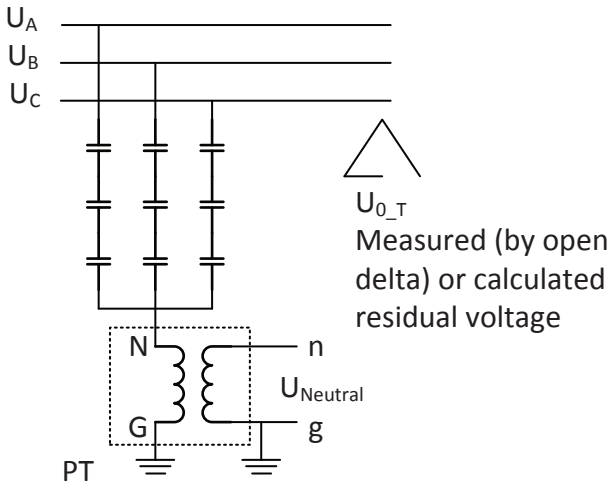



*Figure 644: Ungrounded SCB*

The operating signal for the compensated neutral voltage unbalance in per unit with reference to the neutral side of an ungrounded SCB is as indicated in *Figure 645*.

$$Operating\ signal = \left| \frac{\overline{U}_{Neutral}}{U_{N_sr}} - \frac{n_{Uo}}{U_{N_pr}} \cdot \overline{U}_o - \overline{U}_{unb} \right|$$

*Figure 645: Equation*

| | |
|---|---|
| $U_{Neutral}$ | Measured shunt capacitor neutral voltage |
| $U_o$ | Measured open delta voltage |
| $U_{unb}$ | Natural unbalance compensation component |
| $n_{Uo}$ | Voltage ratio of open delta VT |
| $U_{N_sr}$ | Rated secondary voltage of neutral connected VT |
| $U_{N_pr}$ | Rated primary voltage of neutral connected VT |

The rated *Primary voltage* and *Secondary voltage* for the neutral voltage channel $U_{Neutral}$, and for $U_{N_pr}$ and $U_{N_sr}$ are set in the global setting under **Configuration** > **Analog inputs** > **Voltage (Uo,VT)**.

The operating signal setting is given as multiple of the neutral VT rated voltage.

In monitored data, xUn refers to neutral VT rated voltage.

### 4.12.5.7 Application

Shunt capacitor banks are provided with an unbalance protection function which is mainly used to detect problems within capacitor units using the presumed symmetry in the impedances of the protected bank. The unbalance protection responds to unbalances in the measured signals caused by changes in the impedance of the capacitor bank.

In compensating unbalance protection, the operating signal compensates both the inherent capacitor bank unbalance and the system unbalance. The method involves measuring the residual voltage at the capacitor terminal side and at the neutral

side. The terminal side's residual voltage component is obtained directly by VTs connected in open delta or by deriving open delta voltage using all three terminal side phase voltages. The neutral side's residual voltage is measured directly by connecting a VT between the neutral point and earth. It is advisable to block the function with the fuse failure function.

**Example 1, ungrounded SCB**

*Figure 646* illustrates how much the neutral voltage changes in case of failure of some phase elements of the ungrounded SCB.

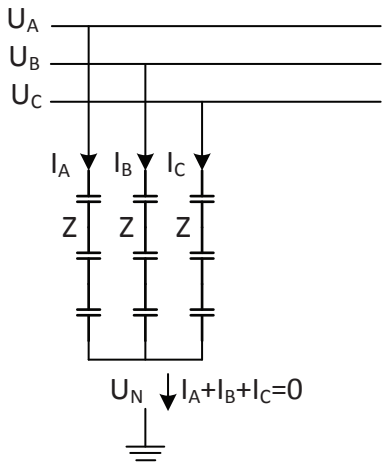



*Figure 646: Ungrounded SCB*

In a healthy ungrounded capacitor bank, the sum of the phase currents is

$$\bar{I}_A + \bar{I}_B + \bar{I}_C = 0$$

*Figure 647: Equation*

If the capacitor bank is symmetrical, that is, there is equal impedance in each phase, the equation can be

$$\left(\frac{\bar{U}_A - \bar{U}_N}{Z}\right) + \left(\frac{\bar{U}_B - \bar{U}_N}{Z}\right) + \left(\frac{\bar{U}_C - \bar{U}_N}{Z}\right) = 0$$

*Figure 648: Equation*

If the fault in the capacitor bank changes the phase A impedance to kZ

$$\left(\frac{\bar{U}_A - \bar{U}_N}{kZ}\right) + \left(\frac{\bar{U}_B - \bar{U}_N}{Z}\right) + \left(\frac{\bar{U}_C - \bar{U}_N}{Z}\right) = 0$$

*Figure 649: Equation*

$$\frac{\bar{U}_A}{kZ} + \frac{\bar{U}_B}{Z} + \frac{\bar{U}_C}{Z} = \bar{U}_N \cdot \left(\frac{1}{kZ} + \frac{2}{Z}\right)$$

*Figure 650: Equation*

$$\overline{U}_A + k \cdot \left(\overline{U}_B + \overline{U}_C\right) = \overline{U}_N \cdot \left(1 + 2 \cdot k\right)$$

*Figure 651: Equation*

If the system is symmetrical, that is, the system is healthy without any fault

$$\overline{U}_A + \overline{U}_B + \overline{U}_C = 0$$

*Figure 652: Equation*

Combining *Figure 651* and *Figure 652* results in

$$\overline{U}_A + k \cdot \left(-\overline{U}_A\right) = \overline{U}_N \cdot \left(1 + 2 \cdot k\right)$$

*Figure 653: Equation*

$$\overline{U}_N = \overline{U}_A \cdot \frac{\left(1 - k\right)}{\left(1 + 2 \cdot k\right)}$$

*Figure 654: Equation*

Considering the neutral VT ratio, per unit voltage referred to the neutral side is given by

$$\overline{U}_N = \frac{\overline{U}_A \cdot \frac{\left(1 - k\right)}{\left(1 + 2 \cdot k\right)}}{U_{N_pr}}$$

*Figure 655: Equation*

For example, if the impedance of the 20 kV system ($U_A$ = 11.547 kV) capacitance drops by 5 percent, that is, k = 0.95, the neutral voltage is around 200 V according to *Figure 654*. If the voltage rating of a neutral VT is 20 kV/100 V, then in per unit terms refer to neutral side, the neutral voltage is around 0.01 · Un, that is, *Start value* should be set around 0.01.

In addition, assume that residual voltage (terminal side) is measured directly using an open-delta VT having ratio of $\frac{20kV}{\sqrt{3}} / \frac{100V}{\sqrt{3}} / \frac{100V}{3}$. Also, the *Primary voltage* and *Secondary voltage* settings under **Configuration** > **Analog inputs** > **Voltage (UoB,VT)** in a grounded system are set as 11.547 kV and 100 V, respectively. Similarly, if the VT connected at the neutral point has a ratio of $\frac{20kV}{\sqrt{3}} / \frac{100V}{\sqrt{3}}$, the *Primary voltage* and *Secondary voltage* settings under **Configuration** > **Analog inputs** > **Voltage (UoB,VT)** must be set as 20 kV and 100 V, respectively.

### 4.12.5.8 Signals

**CNUPTOV Input signals**

**Table 1096: CNUPTOV Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| UNEUT | SIGNAL | - | Analog input |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

**CNUPTOV Output signals**

**Table 1097: CNUPTOV Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| START | BOOLEAN | Start |

### 4.12.5.9 CNUPTOV Settings

**Table 1098: CNUPTOV Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 0.01...1.00 | xUn | 0.01 | 0.01 | Start value |
| Operate delay time | 100...300000 | ms | 100 | 100 | Operate delay time |

**Table 1099: CNUPTOV Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 1100: CNUPTOV Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

### 4.12.5.10 CNUPTOV Monitored data

**Table 1101: CNUPTOV Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| START_DUR | FLOAT32 | 0.00...100.00 | % | Ratio of start time / operate time |
| U_AMPL_RES | FLOAT32 | 0.00...5.00 | xUn | Magnitude of capacitor terminal open delta voltage (either calculated or derived) |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U_ANGL_RES | FLOAT32 | -180.00...180.00 | deg | Angle of capacitor terminal open delta voltage (either calculated or derived) |
| U_AMPL_N | FLOAT32 | 0.00...5.00 | xUn | Magnitude of capacitor neutral zero sequence voltage |
| U_ANGL_N | FLOAT32 | -180.00...180.00 | deg | Angle of capacitor neutral zero sequence voltage |
| U_UNB_AMPL | FLOAT32 | 0.00...5.00 | xUn | Magnitude of recorded natural unbalance compensation component voltage |
| U_UNB_ANGL | FLOAT32 | -180.00...180.00 | deg | Angle of recorded natural unbalance compensation component voltage |
| U_OPR | FLOAT32 | 0.00...5.00 | xUn | Calculated operating voltage |
| CNUPTOV | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 4.12.5.11 Technical data

**Table 1102: CNUPTOV Technical data**

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz |
| | | ±1.5 % of the set value or ±0.002 × $U_n$ |
| Start time [1, 2] | $U_{Fault}$ = 1.1 × set *Start value* | Typically 75 ms |
| Reset time | | Typically 40 ms |
| Reset ratio | | Typically 0.96 |
| Retardation time | | <35 ms |
| Operate time accuracy | | ±1.0 % of the set value or ±20 ms |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

[1] *Start value* = 0.1 × $U_n$, Voltage before fault = 0.9 × $U_n$, $f_n$ = 50 Hz, overvoltage in one phase-to-earth with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

[2] Measured with static signal output (SSO)

# 5 Protection related functions

## 5.1 Three-phase inrush detector INRPHAR (ANSI 68HB)

### 5.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase inrush detector | INRPHAR | 3I2f> | 68HB |

### 5.1.2 Function block




*Figure 656: Function block*

### 5.1.3 Functionality

The three-phase inrush detector function INRPHAR is used to detect transformer inrush situations in distribution networks.

Transformer inrush detection is based on the following principle: the output signal BLK2H is activated once the numerically derived ratio of second harmonic current I_2H and the fundamental frequency current I_1H exceeds the set value.

The operate time characteristic for the function is of definite time (DT) type.

The function contains a blocking functionality. Blocking deactivates all outputs and resets timers.

### 5.1.4 Analog channel configuration

INRPHAR has one analog group input which must be properly configured.

**Table 1103: Analog signals**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of INRPHAR can be described using a module diagram. All the modules in the diagram are explained in the next sections.

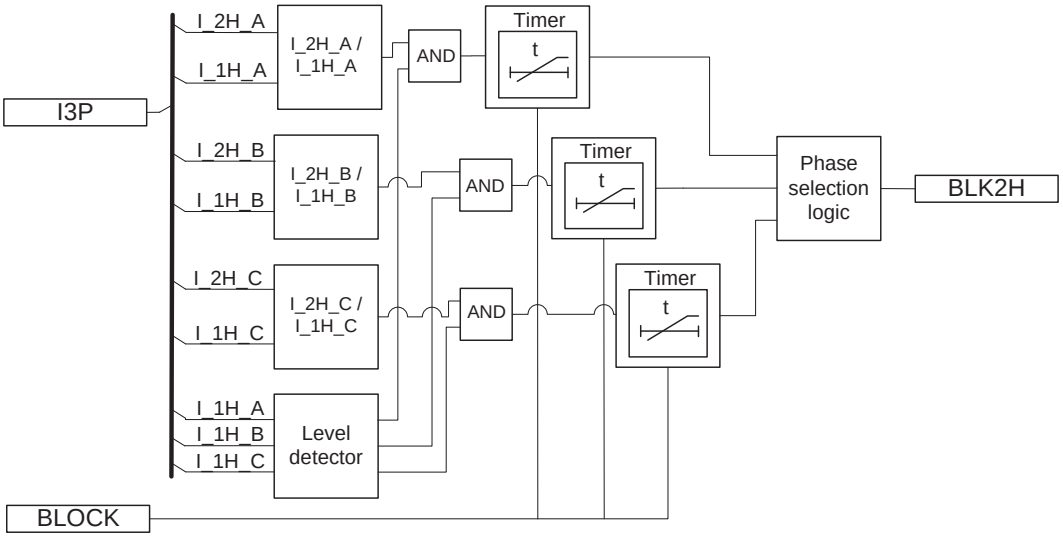



*Figure 657: Functional module diagram*

### I_2H/I_1H

These modules calculate the ratio of the second harmonic (I_2H) and fundamental frequency (I_1H) of the phase currents. The calculated value is compared to the set *Start value*. If the calculated value exceeds the set *Start value*, the module output is activated.

### Level detector

The output of the phase-specific level detector is activated when the fundamental frequency current I_1H exceeds the set *Min operate current* of the nominal current.

### Timer

Once activated, Timer runs until the set *Operate delay time* value is exceeded. The time characteristics is according to DT. When the operation timer has reached the *Operate delay time* value, the Timer module output is activated. If the timer has

elapsed and the inrush situation still exists, the Timer module output remains active until the I_2H/I_1H ratio drops below the set *Start value* , that is, until the inrush situation is over. If the drop-off situation occurs within the operate time up counting, the reset timer is activated. If the drop-off time exceeds *Reset delay time* , the operate timer is reset.

The BLOCK input can be controlled with a binary input, a horizontal communication input or an internal signal of the relay program. The activation of the BLOCK input prevents the BLK2H output from being activated.

**Phase selection logic**

This module determines the number of phases used for activating the BLK2H output. If Num of start phases = "1 out of 3", an inrush on any of the phases activates output BLK2H. If the set value equals "2 out of 3", an inrush or at least two phases are required to activate output BLK2H.

## 5.1.6 Application

Transformer protections require high stability to avoid tripping during magnetizing inrush conditions. A typical example of an inrush detector application is doubling the start value of an overcurrent protection during inrush detection.

The inrush detection function can be used to selectively block overcurrent and earth-fault function stages when the ratio of the second harmonic component to the fundamental component exceeds the set value.

Other applications of this function include the detection of inrush in lines connected to a transformer.

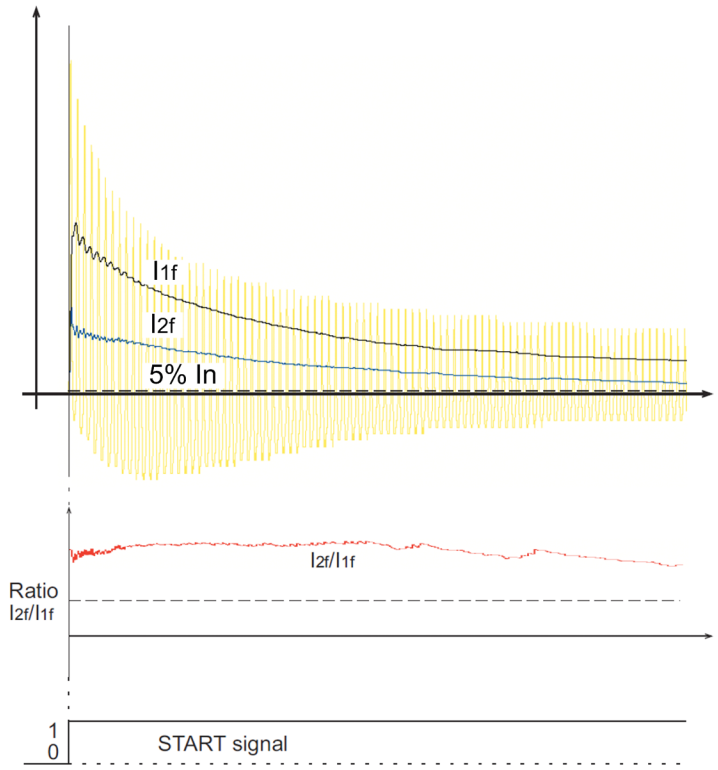



*Figure 658: Inrush current in transformer*

It is recommended to use the second harmonic and the waveform based inrush blocking from the transformer differential protection function TR2PTDF, if available.

## 5.1.7 Signals

### 5.1.7.1 INRPHAR Input signals

**Table 1104: INRPHAR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block input status |

### 5.1.7.2 INRPHAR Output signals

**Table 1105: INRPHAR Output signals**

| Name | Type | Description |
|---|---|---|
| BLK2H | BOOLEAN | Second harmonic based block |

## 5.1.8 INRPHAR Settings

**Table 1106: INRPHAR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start value | 5...100 | % | 1 | 20 | Ratio of the 2. to the 1. harmonic leading to restraint |
| Operate delay time | 20...60000 | ms | 1 | 20 | Operate delay time |

**Table 1107: INRPHAR Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min operate current | 5...500 | %In | 1 | 5 | Minimum fundamental component of phase current for activation |

**Table 1108: INRPHAR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 1109: INRPHAR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Num of start phases | 1=1 out of 3<br>2=2 out of 3 | | | 1=1 out of 3 | Number of phases required for operate activation |
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

## 5.1.9 INRPHAR Monitored data

**Table 1110: INRPHAR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| INRPHAR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.1.10 Technical data

**Table 1111: INRPHAR Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | Current measurement: |

*Table continues on the next page*

| Characteristic | Value |
|---|---|
| | ±1.5 % of the set value or ±0.002 × $I_n$<br>Ratio I2f/I1f measurement:<br>±5.0 % of the set value |
| Reset time | +35 ms / -0 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy | +35 ms / -0 ms |

# 5.2 Circuit breaker failure protection CCBRBRF (ANSI 50BF)

## 5.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Circuit breaker failure protection | CCBRBRF | 3I>/Io>BF | 50BF |

## 5.2.2 Function block

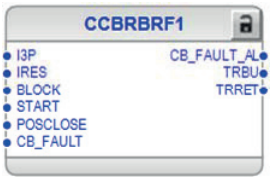



*Figure 659: Function block*

## 5.2.3 Functionality

The circuit breaker failure protection function CCBRBRF is activated by trip commands from the protection functions. The commands are either internal commands to the terminal or external commands through binary inputs. The start command is always a default for three-phase operation. CCBRBRF includes a three-phase conditional or unconditional retrip function, and also a three-phase conditional back-up trip function.

CCBRBRF uses the same levels of current detection for both retrip and back-up trip. The operating values of the current measuring elements can be set within a predefined setting range. The function has two independent timers for trip purposes: a retrip timer for the repeated tripping of its own breaker and a back-up timer for the trip logic operation for upstream breakers. A minimum trip pulse length can be set independently for the trip output.

The function contains a blocking functionality which can be used to block the function outputs.

## 5.2.4 Analog channel configuration

CCBRBRF has two analog group inputs which must be properly configured.

**Table 1112: Analog inputs**

| Input | Description |
|---|---|
| I3P [1] | Three-phase currents, necessary when *CB failure mode* is set other than "Breaker status" |
| IRES [1] | Residual current (measured or calculated), necessary when *CB failure mode* is set other than "Breaker status" |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of CCBRBRF can be described using a module diagram. All the modules in the diagram are explained in the next sections. Also further information on the retrip and backup trip logics is given in sub-module diagrams.

[1] Can be connected to GRPOFF if *CB failure mode* is set to "Breaker status" and *CB fail retrip mode* is not set to "Current check".

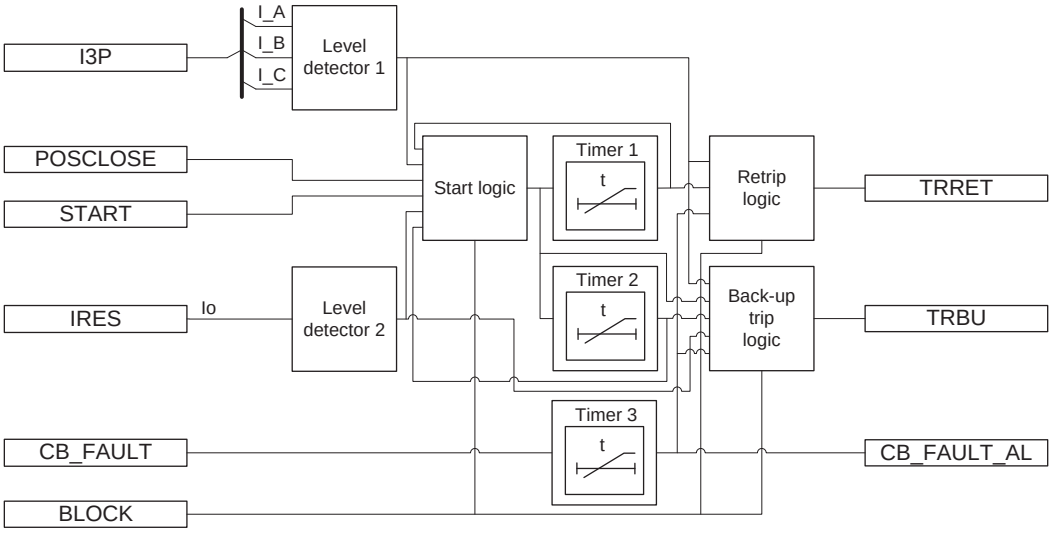



*Figure 660: Functional module diagram*

### Level detector 1

The measured phase currents are compared phasewise to the set *Current value*. If the measured value exceeds the set *Current value*, the level detector reports the exceeding of the value to the start, retrip and backup trip logics. The parameter should be set low enough so that breaker failure situations with small fault current or high load current can be detected. The setting can be chosen in accordance with the most sensitive protection function to start the breaker failure protection.

### Level detector 2

The measured residual current is compared to the set *Current value Res*. If the measured value exceeds the set *Current value Res*, the level detector reports the exceeding of the value to the start and backup trip logics. In high-impedance earthed systems, the residual current at phase-to-earth faults is normally much smaller than the short circuit currents. To detect a breaker failure at single-phase earth faults in these systems, it is necessary to measure the residual current separately. In effectively earthed systems, also the setting of the earth-fault current protection can be chosen at a relatively low current level. The current setting should be chosen in accordance with the setting of the sensitive earth-fault protection.

### Start logic

Start logic is used to manage the starting of Timer 1 and Timer 2. It also resets the function after the circuit breaker failure is handled. On the rising edge of the `START` input, the enabling signal is sent to Timer 1 and Timer 2. Typically, the `START` input is activated when any protection function operates and trips the circuit breaker.

The Start logic module is reset depending on the settings *CB failure mode* and *CB failure trip mode* as shown in *Table 1113*. In all cases in *Table 1113*, however, the resetting is possible only after 150 ms from the activation of Start logic. This time is for ensuring correct operation in case of oscillation in the starting signal.

**Table 1113: Start logic operation**

| Value of setting CB failure mode | Value of setting CB failure trip mode | Start logic reset condition |
|---|---|---|
| Current | 1 out of 3 | All phase currents drop below *Current value* setting. |
| | 1 out of 4 | All phase currents drop below *Current value* setting and the residual current drops below *Current value Res* setting. |
| | 2 out of 4 | Either of the following is true:<br>• All phase currents drop below *Current value* setting.<br>• The residual current drops below *Current value Res* setting and (at least) two phases are below *Current value* setting. |
| Breaker status | 1 out of 3<br>1 out of 4<br>2 out of 4 | CB is in open position. |
| Both(AND) | 1 out of 3 | Either of the following is true:<br>• CB is in open position.<br>• All phase currents drop below *Current value* setting. |
| | 1 out of 4 | Either of the following is true:<br>• CB is in open position.<br>• All phase currents drop below *Current value* setting and the residual current drops below *Current value Res* setting. |
| | 2 out of 4 | One of the following is true:<br>• CB is in open position.<br>• All phase currents drop below *Current value* setting.<br>• The residual current drops below *Current value Res* setting and (at least) two phases are below *Current value* setting. |
| Both(OR) | 1 out of 3 | CB is in open position and all phase currents drop below *Current value* setting. |
| | 1 out of 4 | CB is in open position and all phase currents drop below *Current value* setting and the residual current drops below *Current value Res* setting. |
| | 2 out of 4 | CB is in open position and either of the following is true:<br>• All phase currents drop below *Current value* setting. |

| Value of setting CB failure mode | Value of setting CB failure trip mode | Start logic reset condition |
|---|---|---|
| | | • The residual current drops below *Current value Res* setting and (at least) two phases are below *Current value* setting. |

In addition, the function is immediately reset if:

- *Start latching mode* is set to "Level sensitive", and the START signal is deactivated. The recommended setting value is "Rising edge".
- The BLOCK input is activated.

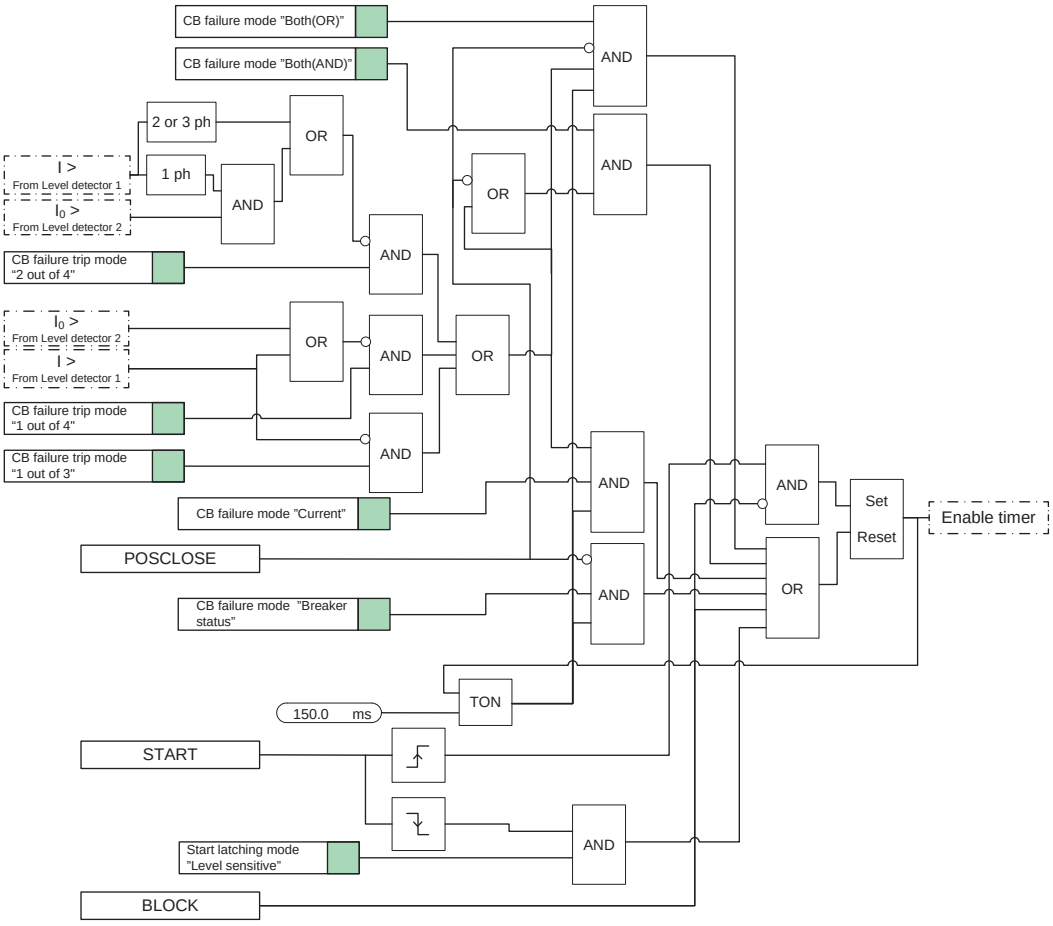



*Figure 661: Start logic*

### Timer 1

Once activated, the timer runs until the set *Retrip time* value has elapsed. The time characteristic is according to DT. When the operation timer has reached the value set with *Retrip time*, the retrip logic is activated. A typical setting is 0...50 ms.

### Timer 2

Once activated, the timer runs until the set *CB failure delay* value has elapsed. The time characteristic is according to DT. When the operation timer has reached the set maximum time value *CB failure delay*, the backup trip logic is activated. The value of

this setting is made as low as possible at the same time as any unwanted operation is avoided. A typical setting is 90 - 150 ms, which is also dependent on the retrip timer.

The minimum time delay for the CB failure delay can be estimated as:

$$CBfailuredelay \geq Retriptime + t_{cbopen} + t_{BFP_reset} + t_{margin}$$

(Equation 291)

| | |
|---|---|
| $t_{cbopen}$ | Maximum opening time for the circuit breaker |
| $t_{BFP_reset}$ | Maximum time for the breaker failure protection to detect the correct breaker function (the current criteria reset) |
| $t_{margin}$ | Safety margin |

It is often required that the total fault clearance time is less than the given critical time. This time often depends on the ability to maintain transient stability in case of a fault close to a power plant.

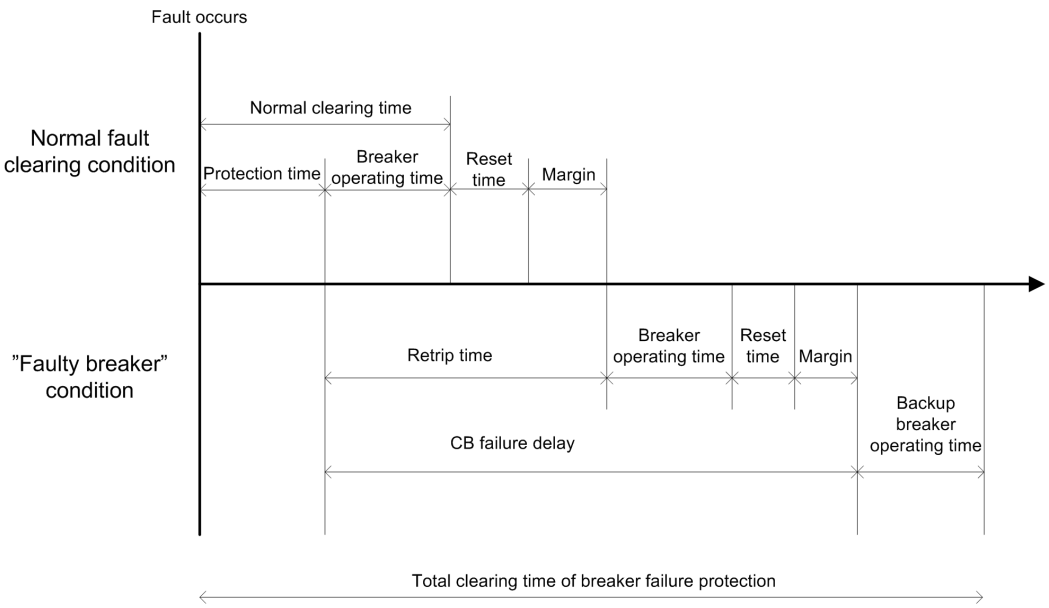



*Figure 662: Timeline of the breaker failure protection*

### Timer 3

This module is activated by the CB_FAULT signal. Once activated, the timer runs until the set *CB fault delay* value has elapsed. The time characteristic is according to DT. When the operation timer has reached the maximum time value *CB fault delay*, the CB_FAULT_AL output is activated. After the set time, an alarm is given so that the circuit breaker can be repaired. A typical value is 5 s.

### Retrip logic

Timer 1 activates Retrip logic, which can be used to give a retrip signal TRRET for the main circuit breaker. The operation of Retrip logic depends on the settings *CB failure mode* and *CB fail retrip mode* as shown in *Table 1114*.

**Table 1114: Retrip logic operation**

| Value of setting CB fail retrip mode | Value of setting CB failure mode | Retrip functionality |
|---|---|---|
| Off | Current<br>Breaker status<br>Both(AND)<br>Both(OR | Retrip functionality switched off. TRRET is not activated. |
| Without Check | Current<br>Breaker status<br>Both(AND)<br>Both(OR | TRRET is activated after Timer 1 elapses. |
| Current check | Current | TRRET is activated after Timer 1 elapses and any phase current exceeds *Current value* setting. |
| | Breaker status | TRRET is activated after Timer 1 elapses and CB is in closed position. |
| | Both(AND) | TRRET is activated after Timer 1 elapses and CB is in closed position and any phase current exceeds *Current value* setting. |
| | Both(OR) | TRRET is activated after Timer 1 elapses and either of the following is true:<br>• CB is in closed position.<br>• Any phase current exceeds *Current value* setting. |

TRRET activation is blocked if either CB_FAULT_AL output (from Timer 3) is active or the BLOCK input is activated.

Once activated, TRRET remains active for the set *Trip pulse time* or until the reasons for activation are reset. TRRET is also reset if CB_FAULT_AL or BLOCK is activated.

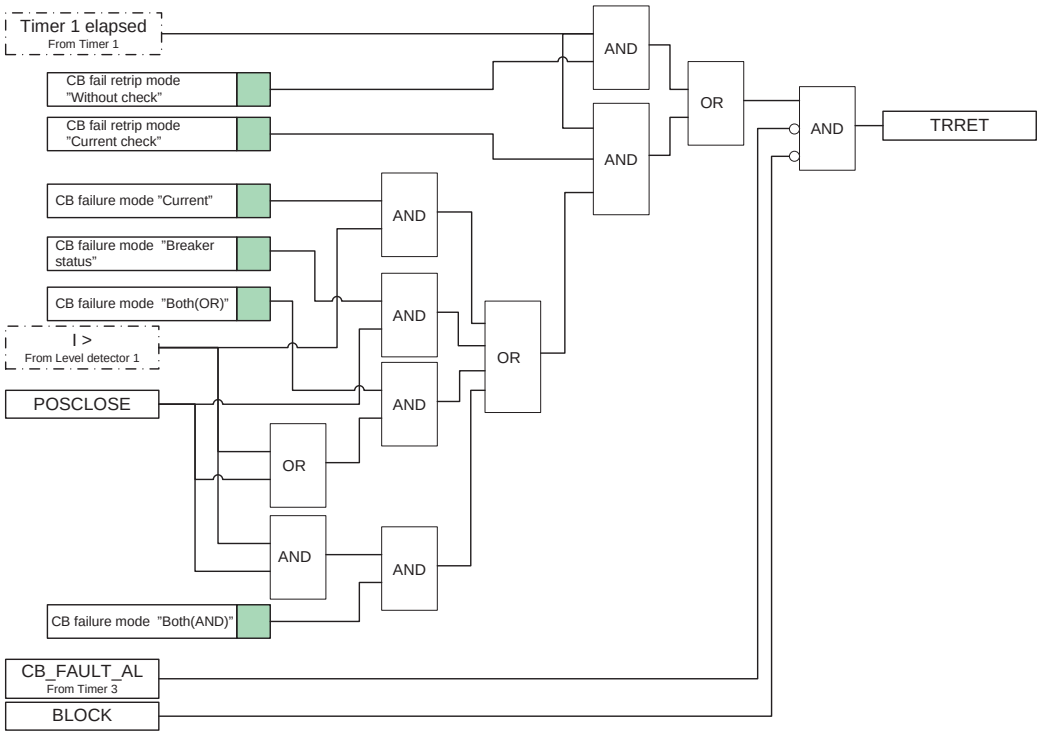



*Figure 663: Retrip logic*

### Backup trip logic

Timer 2 activates Backup trip logic, which gives a backup trip TRBU for the upstream circuit breaker if the main circuit breaker fails to clear the fault. Backup trip logic is also activated if the timer-enabling signal from the Start logic module (rising edge of the START input detected) and CB_FAULT_AL are both active.

The operation of Backup trip logic depends on the settings *CB failure mode* and *CB failure trip* mode as shown in *Table 1115*.

**Table 1115: Backup trip logic operation**

| Value of setting CB failure mode | Value of setting CB failure trip mode | Conditions for activating Backup trip logic |
|---|---|---|
| Current | 1 out of 3 | Any phase current exceeds *Current value* setting. |
| | 1 out of 4 | Either of the following is true:<br>• Any phase current exceeds *Current value* setting.<br>• The residual current exceeds *Current value Res* setting. |
| | 2 out of 4 | Either of the following is true:<br>• Any phase current exceeds *Current value* setting and the residual current exceeds *Current value Res* setting. |

*Table continues on the next page*

| Value of setting CB failure mode | Value of setting CB failure trip mode | Conditions for activating Backup trip logic |
|---|---|---|
| | | • Two or three phase currents exceed *Current value* setting. |
| Breaker status | 1 out of 3<br>1 out of 4<br>2 out of 4 | CB is in closed position. |
| Both(AND) | 1 out of 3 | CB is in closed position and any phase current exceeds *Current value* setting. |
| | 1 out of 4 | CB is in closed position and either of the following is true:<br>• Any phase current exceeds *Current value* setting.<br>• The residual current exceeds *Current value Res* setting. |
| | 2 out of 4 | CB is in closed position and either of the following is true:<br>• Any phase current exceeds *Current value* setting and the residual current exceeds *Current value Res* setting.<br>• Two or three phase currents exceed *Current value* setting. |
| Both(OR) | 1 out of 3 | Either of the following is true:<br>• CB is in closed position.<br>• Any phase current exceeds *Current value* setting. |
| | 1 out of 4 | One of the following is true:<br>• CB is in closed position.<br>• Any phase current exceeds *Current value* setting.<br>• The residual current exceeds *Current value Res* setting. |
| | 2 out of 4 | One of the following is true:<br>• CB is in closed position.<br>• Any phase current exceeds *Current value* setting and the residual current exceeds *Current value Res* setting.<br>• Two or three phase currents exceed *Current value* setting. |

Once activated, TRBU remains active until the set *Trip pulse time* or until the reasons for activation are reset. TRRET is also reset if BLOCK is activated.



In most applications, "1 out of 3" is sufficient.

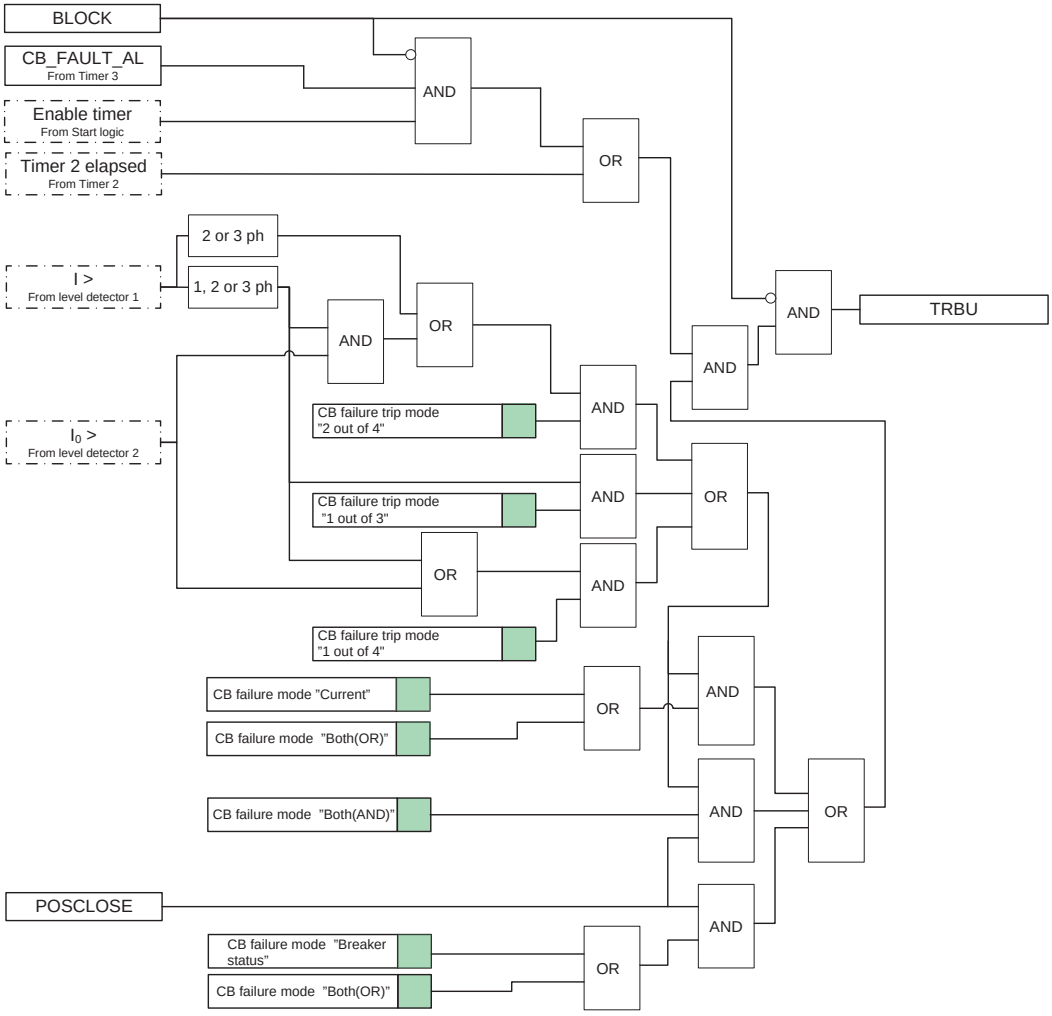



*Figure 664: Backup trip logic*

## 5.2.6 Application

The n-1 criterion is often used in the design of a fault clearance system. This means that the fault is cleared even if some component in the fault clearance system is faulty. A circuit breaker is a necessary component in the fault clearance system. For practical and economical reasons, it is not feasible to duplicate the circuit breaker for the protected component, but breaker failure protection is used instead.

The breaker failure function issues a backup trip command to up-stream circuit breakers in case the original circuit breaker fails to trip for the protected component. The detection of a failure to break the current through the breaker is made by measuring the current or by detecting the remaining trip signal (unconditional).

CCBRBRF can also retrip. This means that a second trip signal is sent to the protected circuit breaker. The retrip function is used to increase the operational reliability of the breaker. The function can also be used to avoid backup tripping of several breakers in case mistakes occur during protection relay maintenance and tests.

CCBRBRF is initiated by operating different protection functions or digital logics inside the protection relay. It is also possible to initiate the function externally through a binary input.

CCBRBRF can be blocked by using an internally assigned signal or an external signal from a binary input. This signal blocks the function of the breaker failure protection even when the timers have started or the timers are reset.

The retrip timer is initiated after the start input is set to true. When the pre-defined time setting is exceeded, CCBRBRF issues the retrip and sends a trip command, for example, to the circuit breaker's second trip coil. Both a retrip with current check and an unconditional retrip are available. When a retrip with current check is chosen, the retrip is performed only if there is a current flow through the circuit breaker.

The backup trip timer is also initiated at the same time as the retrip timer. If CCBRBRF detects a failure in tripping the fault within the set backup delay time, which is longer than the retrip time, it sends a backup trip signal to the chosen backup breakers. The circuit breakers are normally upstream breakers which feed fault current to a faulty feeder.

The backup trip always includes a current check criterion. This means that the criterion for a breaker failure is that there is a current flow through the circuit breaker after the set backup delay time.

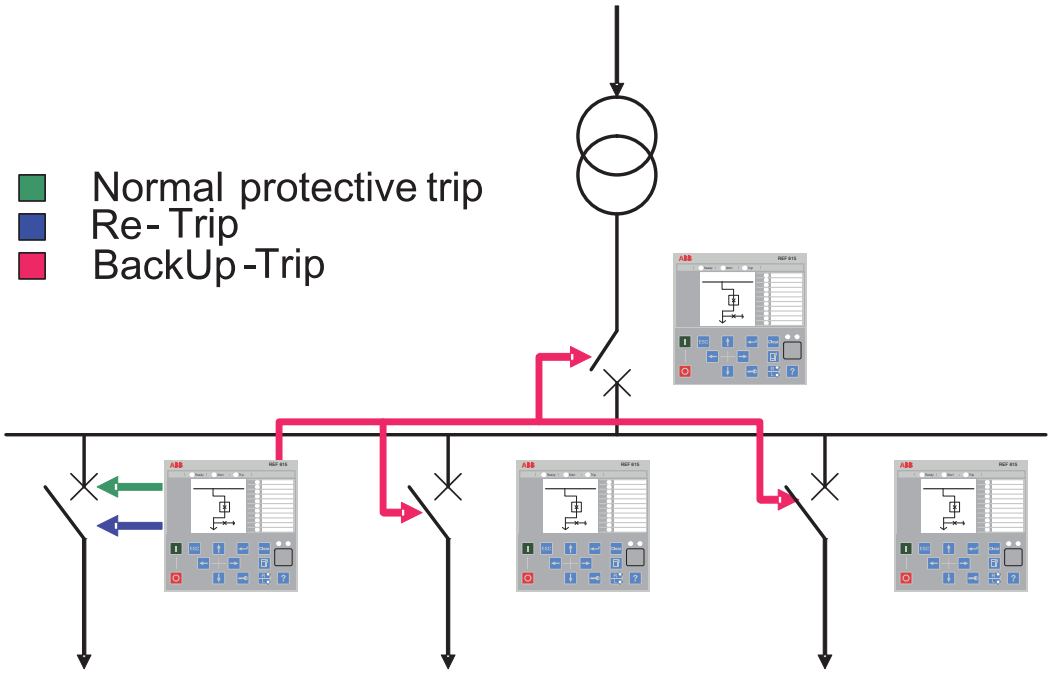



*Figure 665: Typical breaker failure protection scheme in distribution substations*

## 5.2.7 Signals

### 5.2.7.1 CCBRBRF Input signals

**Table 1116: CCBRBRF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block CBFP operation |
| START | BOOLEAN | 0=False | CBFP start command |
| POSCLOSE | BOOLEAN | 0=False | CB in closed position |
| CB_FAULT | BOOLEAN | 0=False | CB faulty and unable to trip |

### 5.2.7.2 CCBRBRF Output signals

**Table 1117: CCBRBRF Output signals**

| Name | Type | Description |
|---|---|---|
| CB_FAULT_AL | BOOLEAN | Delayed CB failure alarm |
| TRBU | BOOLEAN | Backup trip |
| TRRET | BOOLEAN | Retrip |

## 5.2.8 CCBRBRF Settings

**Table 1118: CCBRBRF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Current value | 0.05...2.00 | xIn | 0.01 | 0.30 | Operating phase current |
| Current value Res | 0.05...2.00 | xIn | 0.01 | 0.30 | Operating residual current |
| CB failure trip mode | 1=2 out of 4<br>2=1 out of 3<br>3=1 out of 4 | | | 2=1 out of 3 | Backup trip current check mode |
| CB failure mode | 1=Current<br>2=Breaker status<br>3=Both (AND)<br>-1=Both (OR) | | | 1=Current | Operating mode of function |
| CB fail retrip mode | 1=Off<br>2=Without Check<br>3=Current check | | | 1=Off | Operating mode of retrip logic |
| Retrip time | 0...60000 | ms | 10 | 120 | Delay timer for retrip |
| CB failure delay | 0...60000 | ms | 10 | 240 | Delay timer for backup trip |

**Table 1119: CCBRBRF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| CB fault delay | 0...60000 | ms | 10 | 5000 | Circuit breaker faulty delay |
| Measurement mode | 2=DFT<br>3=Peak-to-Peak | | | 3=Peak-to-Peak | Phase current measurement mode of function |
| Trip pulse time | 0...60000 | ms | 10 | 200 | Pulse length of retrip and backup trip outputs |
| Start latching mode | 1=Rising edge<br>2=Level sensitive | | | 1=Rising edge | Start reset delayed or immediately |

## 5.2.9 CCBRBRF Monitored data

**Table 1120: CCBRBRF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| CCBRBRF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.2.10 Technical data

**Table 1121: CCBRBRF Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5 % of the set value or ±0.002 × $I_n$ |
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |
| Reset time | <20 ms |
| Retardation time | <20 ms |

## 5.2.11 Technical revision history

**Table 1122: CCBRBRF Technical revision history**

| Technical revision | Change |
|---|---|
| B | Default trip pulse time changed to 150 ms |
| C | Added new setting parameter *Start latching mode*. Maximum value changed to 2.00 xIn for the *Current value* setting. |

*Table continues on the next page*

| Technical revision | Change |
|---|---|
| D | Internal improvement. |
| E | Maximum value for *Current value* and *Current value Res* changed from “1.00 x In” to “2.00 x In”. |

# 5.3 Master trip TRPPTRC (ANSI 94/86)

## 5.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Master trip | TRPPTRC | Master Trip | 94/86 |

## 5.3.2 Function block




*Figure 666: Function block*

## 5.3.3 Functionality

The master trip function TRPPTRC is used as a trip command collector and handler after the protection functions. The features of this function influence the trip signal behavior of the circuit breaker. The minimum trip pulse length can be set when the non-latched mode is selected. It is also possible to select the latched or lockout mode for the trip signal.

## 5.3.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

When the TRPPTRC function is disabled, all trip outputs intended to go through the function to the circuit breaker trip coil are blocked.

The operation of TRPPTRC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

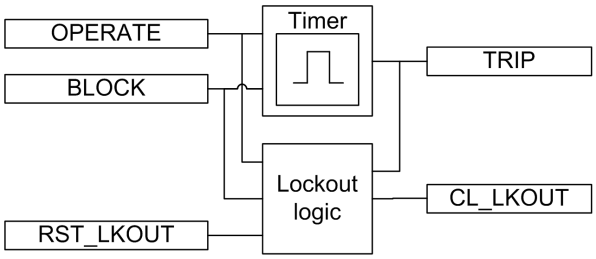



*Figure 667: Functional module diagram*

### Timer

The duration of the TRIP output signal from TRPPTRC can be adjusted with the *Trip pulse time* setting when the "Non-latched" operation mode is used. The pulse length should be long enough to secure the opening of the breaker. For three-pole tripping, TRPPTRC has a single input OPERATE, through which all trip output signals are routed from the protection functions within the protection relay, or from external protection functions via one or more of the protection relay's binary inputs. The function has a single trip output TRIP for connecting the function to one or more of the protection relay's binary outputs, and also to other functions within the protection relay requiring this signal.

The BLOCK input blocks the TRIP output and resets the timer.

### Lockout logic

TRPPTRC is provided with possibilities to activate a lockout. When activated, the lockout can be manually reset after checking the primary fault by activating the RST_LKOUT input or from the LHMI clear menu parameter. When using the "Latched" mode, the resetting of the TRIP output can be done similarly as when using the "Lockout" mode. It is also possible to reset the "Latched" mode remotely through a separate communication parameter.

The minimum pulse trip function is not active when using the "Lockout" or "Latched" modes but only when the "Non-latched" mode is selected.

The CL_LKOUT and TRIP outputs can be blocked with the BLOCK input.

**Table 1123: Operation modes for the TRPPTRC trip output**

| Mode | Operation |
|---|---|
| Non-latched | The *Trip pulse length* parameter gives the minimum pulse length for TRIP |
| Latched | TRIP is latched ; both local and remote clearing is possible. |
| Lockout | TRIP is locked and can be cleared only locally via menu or the RST_LKOUT input. |

## 5.3.5 Application

All trip signals from different protection functions are routed through the trip logic. The most simplified application of the logic function is linking the trip signal and ensuring that the signal is long enough.

The tripping logic in the protection relay is intended to be used in the three-phase tripping for all fault types (3ph operating). To prevent the closing of a circuit breaker after a trip, TRPPTRC can block the CBXCBR closing.

TRPPTRC is intended to be connected to one trip coil of the corresponding circuit breaker. If tripping is needed for another trip coil or another circuit breaker which needs, for example, different trip pulse time, another trip logic function can be used. The two instances of the PTRC function are identical, only the names of the functions, TRPPTRC1 and TRPPTRC2, are different. Therefore, even if all references are made only to TRPPTRC1, they also apply to TRPPTRC2.

The inputs from the protection functions are connected to the `OPERATE` input. Usually, a logic block OR is required to combine the different function outputs to this input. The `TRIP` output is connected to the binary outputs on the IO board. This signal can also be used for other purposes within the protection relay, for example when starting the breaker failure protection.

TRPPTRC is used for simple three-phase tripping applications.

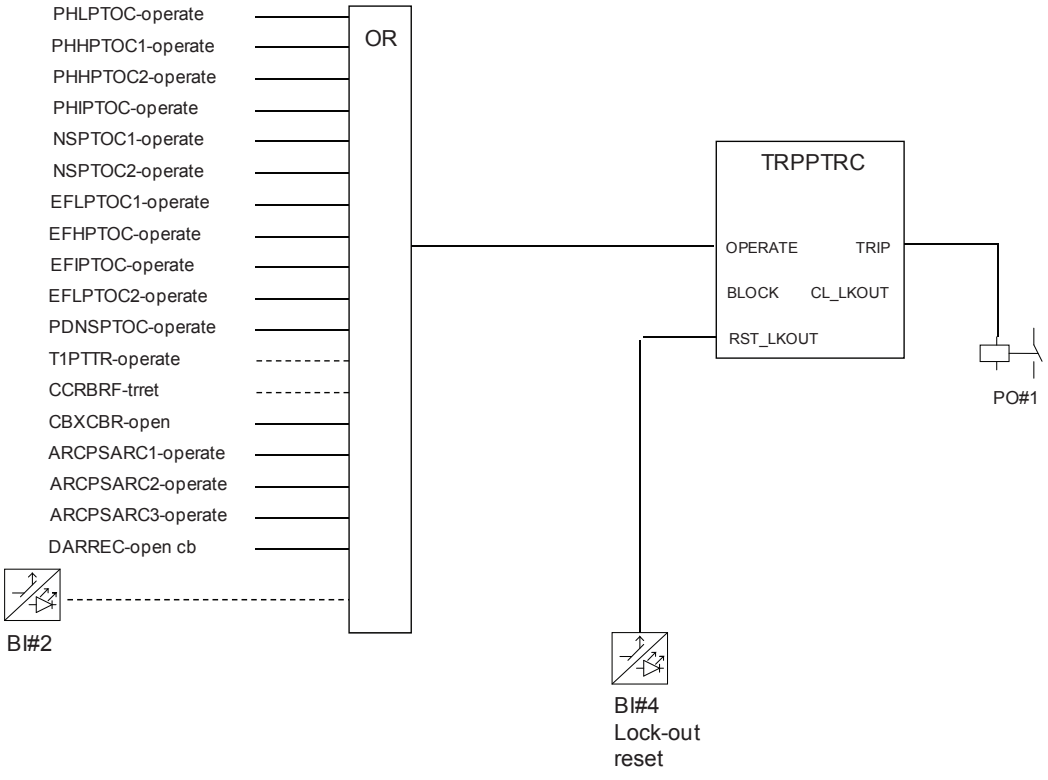



*Figure 668: Typical TRPPTRC connection*

## 5.3.6 Signals

### 5.3.6.1 TRPPTRC Input signals

**Table 1124: TRPPTRC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block of function |
| OPERATE | BOOLEAN | 0=False | Operate |
| RST_LKOUT | BOOLEAN | 0=False | Input for resetting the circuit breaker lockout function |

### 5.3.6.2 TRPPTRC Output signals

**Table 1125: TRPPTRC Output signals**

| Name | Type | Description |
|---|---|---|
| TRIP | BOOLEAN | General trip output signal |
| CL_LKOUT | BOOLEAN | Circuit breaker lockout output (set until reset) |

## 5.3.7 TRPPTRC Settings

**Table 1126: TRPPTRC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Trip pulse time | 20...60000 | ms | 1 | 250 | Minimum duration of trip output signal |
| Trip output mode | 1=Non-latched<br>2=Latched<br>3=Lockout | | | 1=Non-latched | Select the operation mode for trip output |

## 5.3.8 TRPPTRC Monitored data

**Table 1127: TRPPTRC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TRPPTRC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

# 5.4 High-impedance fault detection PHIZ (ANSI HIZ)

## 5.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| High-impedance fault detection | PHIZ | HIF | HIZ |

## 5.4.2 Function block

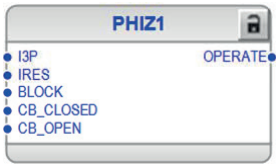



*Figure 669: Function block*

## 5.4.3 Functionality

A small percentage of earth faults have a very large impedance. They are comparable to load impedance and consequently have very little fault current. These high-impedance faults do not pose imminent danger to power system equipment. However, they are a substantial threat to humans and properties; people can touch or get close to conductors carrying large amounts of energy.

ABB has developed a patented technology (US Patent 7,069,116 B2 June 27, 2006, US Patent 7,085,659 B2 August 1, 2006) to detect a high-impedance fault.

The high-impedance fault detection function PHIZ also contains a blocking functionality. It is possible to block function outputs, if desired.

## 5.4.4 Analog channel configuration

PHIZ has two analog group inputs which must be properly configured.

**Table 1128: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| IRES | Residual current (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

PHIZ uses a multi-algorithm approach. Each algorithm uses various features of earth currents to detect a high-impedance fault.

Although the PHIZ algorithm is very sophisticated, the setting required to operate the function is simple. The *Security Level* setting, with the setting range of 1 to 10, is set to strike a balance between the extremes of security and dependability which together constitute the reliability of any system. The setting value “10” is more secure than “1”.

The higher the *Security Level* setting, the lower the probability of false detection, but the system might miss out some genuine fault. On the other hand, a lower setting would make the system operate more dependably for high-impedance faults in the line, but the operation is more likely for other transients in the system. There are events in electrical networks which can cause similar current waveforms like high-impedance faults. These events could then be detected by the PHIZ algorithm causing unnecessary detections. Normally, electrical network operator does not know the existence of these events well and those can also be happening very randomly. The effect is also always dependent on event location compared to protection relay measurement location. All these facts make the PHIZ algorithm operation in certain electrical networks quite hard to measure and forecast beforehand. There is not any direct formula which can calculate the exact right setting based on known electrical network parameters.

It is hence recommended to set the value midway to “5” initially. Based on experience and confidence gained in a particular application, the setting can be moved either side. In many cases, it would be a good practice to use PHIZ as an indicative function during a piloting phase, until enough experience has been gathered and a suitable setting found.

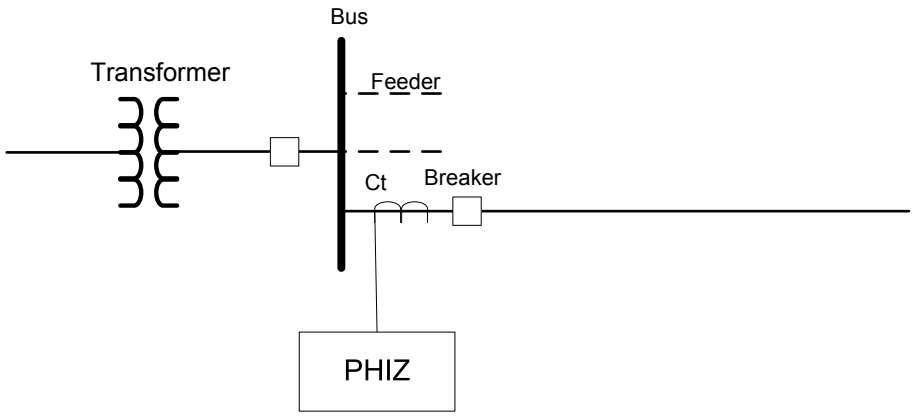



*Figure 670: Electrical power system equipped with PHIZ*

Power system signals are acquired, filtered and then processed by individual high-impedance fault detection algorithm. The results of these individual algorithms are further processed by a decision logic to provide the detection decision. The decision logic can be modified depending on the application requirement.

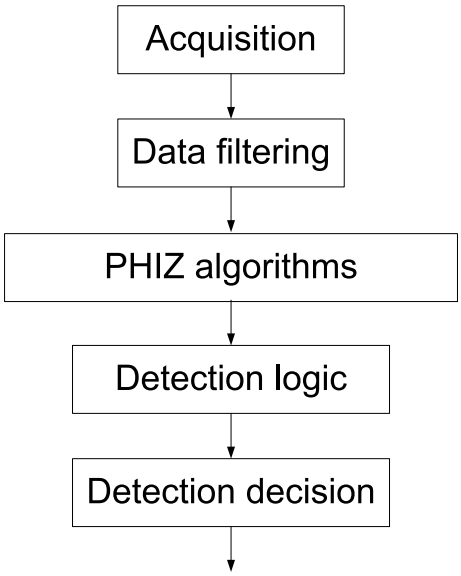



*Figure 671: Block diagram of PHIZ*

PHIZ is based on algorithms that use earth current signatures which are considered non-stationary, temporally volatile and of various burst duration. All harmonic and non-harmonic components within the available data window can play a vital role in the high-impedance fault detection. A major challenge is to develop a data model that acknowledges that high-impedance faults could take place at any time within the observation window of the signal and could be delayed randomly and attenuated substantially. The model is motivated by extensive research, actual experimental observations in the laboratory, field testing and what traditionally represents an accurate depiction of a non-stationary signal with a time-dependent spectrum.



*Figure 672: Validation of PHIZ on gravel*



*Figure 673: Validation of PHIZ on concrete*



*Figure 674: Validation of PHIZ on sand*



*Figure 675: Validation of PHIZ on grass*

## 5.4.6 Application

PHIZ is used to detect a downed conductor dropping to a very resistive ground, causing an earth fault which is very difficult to detect by a conventional protection relay functionality. PHIZ is then targeted to be used with overhead lines. PHIZ must be used in electrical networks with efficiently grounded or isolated neutral.

Electric power lines experience faults for many reasons. In most cases, electrical faults manifest in mechanical damage, which must be repaired before returning the line to service.

Most of the electrical network faults are earth faults. Conventional protection systems based on overcurrent, impedance or other principles are suitable for detecting relatively low-impedance faults which have a relatively high fault current.

However, a small percentage of the earth faults have a very large impedance. They are comparable to load impedance and consequently have very little fault current. These high-impedance faults do not pose imminent danger to power system equipment. However, they are a considerable threat to people and property. The IEEE Power System Relay Committee working group on High Impedance Fault Detection Technology defines High Impedance Faults as those that 'do not produce enough fault current to be detectable by conventional overcurrent relays or fuses.

PHIZ always needs sensitive Io measurement.

High-impedance fault (PHIZ) detection requires a different approach than that for conventional low-impedance faults. Reliable detection of PHIZ provides safety to humans and animals. ABB has developed innovative technology for highimpedance fault detection with over ten years of research resulting in many successful field tests.

## 5.4.7 Signals

### 5.4.7.1 PHIZ Input signals

**Table 1129: PHIZ Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| CB_CLOSED | BOOLEAN | 0=False | Circuit Breaker Closed input |
| CB_OPEN | BOOLEAN | 0=False | Circuit Breaker Open input |

### 5.4.7.2 PHIZ Output signals

**Table 1130: PHIZ Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |

## 5.4.8 PHIZ Settings

**Table 1131: PHIZ Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Security Level | 1...10 | | 1 | 5 | Security Level |

**Table 1132: PHIZ Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| System type | 1=Grounded<br>2=Ungrounded | | | 1=Grounded | System Type |

## 5.4.9 PHIZ Monitored data

**Table 1133: PHIZ Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Position | Dbpos | 0=intermediate | | Position |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 1=open<br>2=closed<br>3=faulty | | |
| PHIZ | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

# 5.5 Binary signal transfer BSTGAPC (ANSI BST)

## 5.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Binary signal transfer | BSTGAPC | BST | BST |

## 5.5.2 Function block

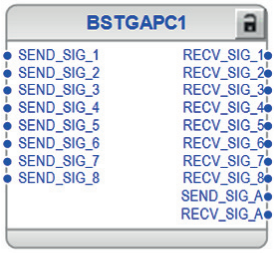



*Figure 676: Function block*

## 5.5.3 Functionality

The binary signal transfer function BSTGAPC is used for transferring binary signals between the local and remote end line differential protection relays. The function includes eight binary signals that are transferred in the protection communication telegram and can be freely configured and used for any purpose in the line differential application.

BSTGAPC transfers binary data continuously over the protection communication channel between the terminals. Each of the eight signals are bidirectional and the binary data sent locally is available remotely as a received signal.

BSTGAPC includes a minimum pulse time functionality for the received binary signals. Each received signal has its own minimum pulse time setting parameter.

BSTGAPC includes two alarm output signals. The SEND_SIG_A output signal is updated according to the status of the sent binary signals. The RECV_SIG_A output signal is updated according to the status of the received binary signals. Each signal can be separately included or excluded from the alarm logic with a setting parameter.

## 5.5.4 Operation principle

The *Signal 1...8 mode* setting can be used for changing the operation of the bidirectional signal channel. The signal channel can be disabled by setting the corresponding parameter value to “Not in use”. When the signal channel is disabled locally or remotely, the corresponding RECV_SIG_1...8 signal status is always false on both ends.

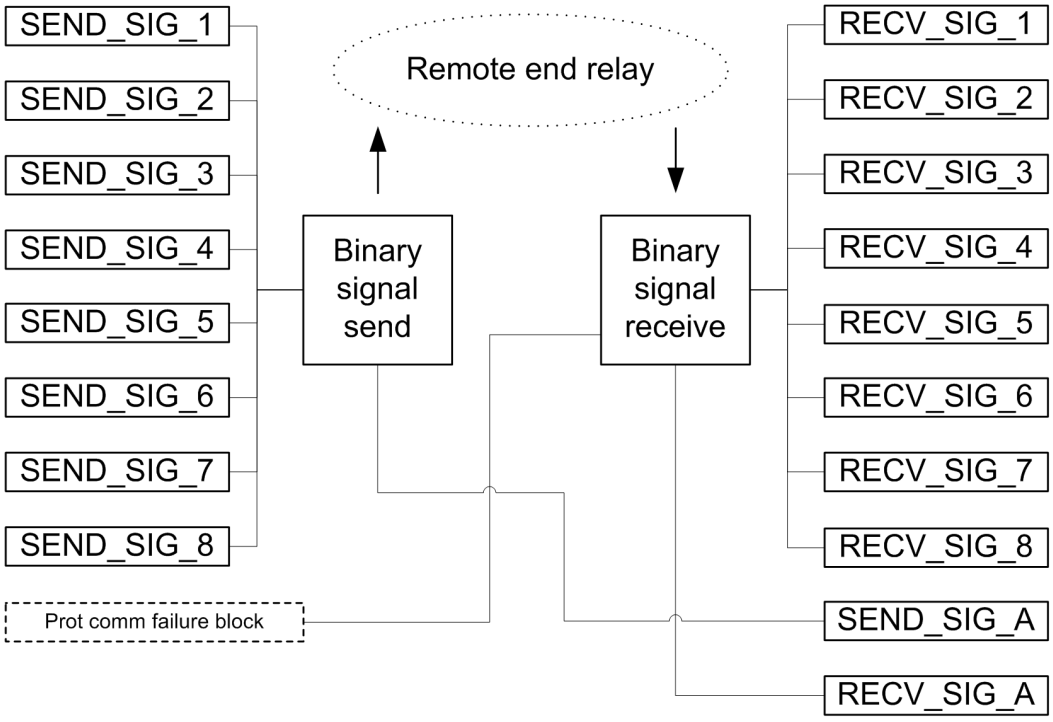



*Figure 677: Functional module diagram*

**Binary signal send**

The status of the inputs is continuously sent in the line differential protection telegrams. SEND_SIG_A can be used for alarming based on the status of SEND_SIG_1...8. By selecting the signal mode as "In use, alarm sel.", the sending status of the corresponding signal affects also the activation criteria of SEND_SIG_A. Further, in case more than one signal channels are selected into the alarm logic, the activation criteria can be defined according to "Any of selected" (OR) or "All of selected" (AND).

**Binary signal receive**

The function receives continuous binary data within the protection telegrams from the remote end protection relay. This received binary data status is then available as the RECV_SIG_1...8 outputs on the local end protection relay. RECV_SIG_A

can be used for alarming based on the status of RECV_SIG_1...8. By selecting the signal mode as "In use, alarm sel.", the received status of the corresponding signal affects the activation criteria of RECV_SIG_A. Further, in case more than one signal channels are selected into the alarm logic, the activation criteria can be defined according to "Any of selected" (OR) or "All of selected" (AND). Each signal has also the *Pulse time 1...8* setting that defines the minimum pulse length for RECV_SIG_1...8. Also, in case the protection communication supervision detects a failure in the communication, the RECV_SIG_1...8 outputs are not set to false sooner than the minimum pulse length defined is first ensured for each signal.

## 5.5.5 Application

Among with the analog data, the binary data can also be exchanged with the line differential protection relays. The usage of the binary data is application specific and can vary in each separate case. The demands for the speed of the binary signals vary depending on the usage of the data. When the binary data is used as blocking signals for the line differential protection, the transfer response is extremely high. Binary signal interchange can be used in applications such as:

- Remote position indications
- Inter-tripping of the circuit breakers on both line ends
- Blocking of the line differential protection during transformer inrush or current circuit supervision failure
- Protection schemes; blocking or permissive
- Remote alarming

The figure shows the overall chain to transfer binary data in an example application. The position indication of the local circuit breaker is connected to the protection relay's input interface and is then available for the relay configuration. The circuit breaker position indication is connected to the first input of BSTGAPC which is used to send information to the remote end via communication. In the remote end, this information is handled as a remote circuit breaker open position and it is available from the first output of BSTGAPC. This way the information can be exchanged.

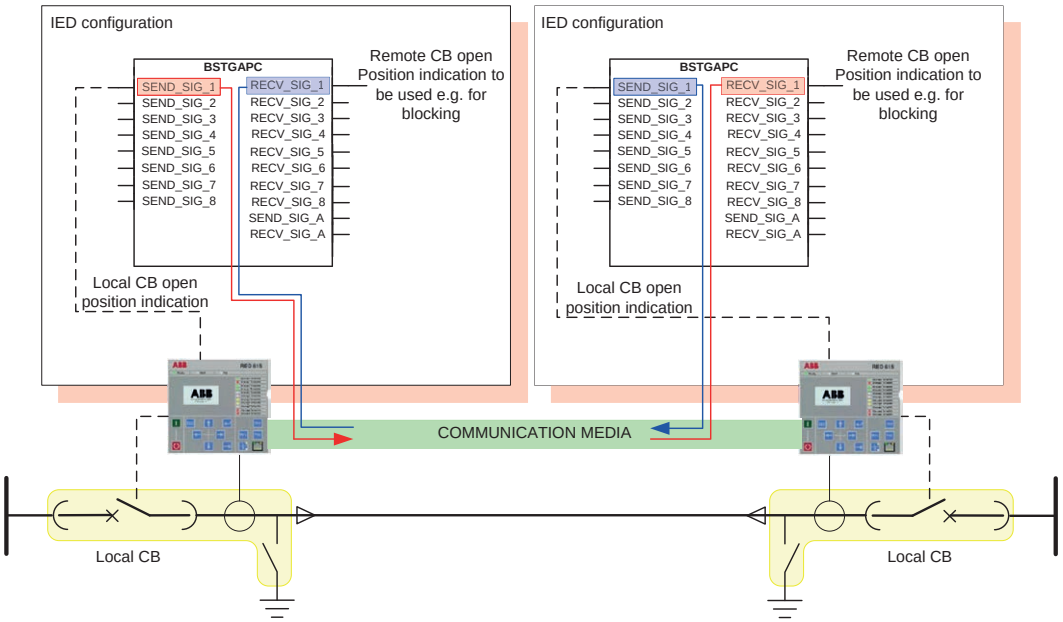



*Figure 678: Example of usage of binary signal transfer for position indication change*

Additional dedicated channel can be used to transfer binary signal infor-mation quickly without the need to configure GOOSE. This minimizes the configuration effort since configuration templates can be directly used when signal transfer is required only for point to point instead of multipoint.

In addition to X6 Ethernet port which is tied to PCSITPC1 and BSTGAPC1-2, X3 Ethernet port can be configured to dedicated channel mode. It also requires PCSITPC2 block for supervision and one of the BSTGAPC3-4 for signal connections. Analog signals are not available for this channel.

| Dedicated channel | Functions | Description |
|---|---|---|
| Ethernet Port X6 | BSTGAPC1-2, PCSITPC1, LNPLDF1 | Includes analog data and can be used for line differential application as well as for binary signal transfer. |
| Ethernet Port X3 | BSTGAPC3-4, PCSITPC2 | Analog data cannot be either send or received. Only used for binary signal transfer. Ethernet port must be set to dedicated channel mode. |

Relay pairs exchanging only binary signals can be connected to either port. However, one must verify that connector types match especially when X3 is connected to X6 (SFP module).

## 5.5.6 Signals

**Table 1134: BSTGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| SEND_SIG_1 | BOOLEAN | 0=False | Send signal 1 state |
| SEND_SIG_2 | BOOLEAN | 0=False | Send signal 2 state |
| SEND_SIG_3 | BOOLEAN | 0=False | Send signal 3 state |
| SEND_SIG_4 | BOOLEAN | 0=False | Send signal 4 state |
| SEND_SIG_5 | BOOLEAN | 0=False | Send signal 5 state |
| SEND_SIG_6 | BOOLEAN | 0=False | Send signal 6 state |
| SEND_SIG_7 | BOOLEAN | 0=False | Send signal 7 state |
| SEND_SIG_8 | BOOLEAN | 0=False | Send signal 8 state |

**Table 1135: BSTGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| RECV_SIG_1 | BOOLEAN | Receive signal 1 state |
| RECV_SIG_2 | BOOLEAN | Receive signal 2 state |
| RECV_SIG_3 | BOOLEAN | Receive signal 3 state |
| RECV_SIG_4 | BOOLEAN | Receive signal 4 state |
| RECV_SIG_5 | BOOLEAN | Receive signal 5 state |
| RECV_SIG_6 | BOOLEAN | Receive signal 6 state |
| RECV_SIG_7 | BOOLEAN | Receive signal 7 state |
| RECV_SIG_8 | BOOLEAN | Receive signal 8 state |
| SEND_SIG_A | BOOLEAN | Binary signal transfer sending alarm state |
| RECV_SIG_A | BOOLEAN | Binary signal transfer receive alarm state |

## 5.5.7 Settings

**Table 1136: BSTGAPC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Signal 1 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 2=In use, alarm sel. | Operation mode for signal 1 |
| Signal 2 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 2=In use, alarm sel. | Operation mode for signal 2 |
| Signal 3 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 1=In use | Operation mode for signal 3 |
| Signal 4 mode | 1=In use<br>2=In use, alarm sel. | | | 1=In use | Operation mode for signal 4 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 3=Not in use | | | | |
| Signal 5 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 1=In use | Operation mode for signal 5 |
| Signal 6 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 1=In use | Operation mode for signal 6 |
| Signal 7 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 1=In use | Operation mode for signal 7 |
| Signal 8 mode | 1=In use<br>2=In use, alarm sel.<br>3=Not in use | | | 1=In use | Operation mode for signal 8 |
| Pulse time 1 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 1 |
| Pulse time 2 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 2 |
| Pulse time 3 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 3 |
| Pulse time 4 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 4 |
| Pulse time 5 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 6 |
| Pulse time 6 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 6 |
| Pulse time 7 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 7 |
| Pulse time 8 | 0...60000 | ms | 1 | 0 | Minimum pulse time for received signal 8 |

**Table 1137: BSTGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Alarm mode | 1=Any of selected<br>2=All of selected | | | 1=Any of selected | Selects the used alarm logic mode for activating SEND_SIG_A and RECV_SIG_A |

## 5.5.8 Technical data

**Table 1138: BSTGAPC Technical data**

| Characteristic | | Value |
|---|---|---|
| Signalling delay | Fiber optic link | <5 ms |
| | Galvanic pilot wire link | <10 ms |

# 5.6 Emergency start-up ESMGAPC (ANSI EST,62)

## 5.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Emergency start-up | ESMGAPC | ESTART | EST,62 |

## 5.6.2 Function block




*Figure 679: Function block*

## 5.6.3 Functionality

An emergency condition can arise in cases where the motor needs to be started despite knowing that this can increase the temperature above limits or cause a thermal overload that can damage the motor. The emergency start-up function ESMGAPC allows motor start-ups during such emergency conditions. ESMGAPC is only to force the protection relay to allow the restarting of the motor. After the emergency start input is activated, the motor can be started normally. ESMGAPC itself does not actually restart the motor.

The function contains a blocking functionality. It is possible to block function outputs, timer or the function itself.

## 5.6.4 Analog channel configuration

ESMGAPC has one analog group input which must be properly configured.

**Table 1139: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing

blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of ESMGAPC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

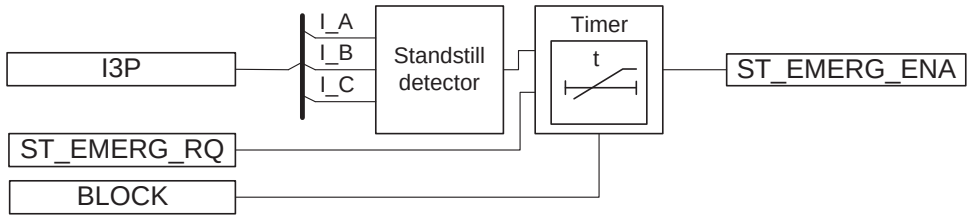



*Figure 680: Functional module diagram*

**Standstill detector**

The module detects if the motor is in a standstill condition. The standstill condition can be detected based on the phase current values. If all three phase currents are below the set value of *Motor standstill A*, the motor is considered to be in a standstill condition.

**Timer**

The timer is a fixed 10-minute timer that is activated when the ST_EMERG_RQ input is activated and motor standstill condition is fulfilled. Thus, the activation of the ST_EMERG_RQ input activates the ST_EMERG_ENA output, provided that the motor is in a standstill condition. The ST_EMERG_ENA output remains active for 10 minutes or as long as the ST_EMERG_RQ input is high, whichever takes longer.

The activation of the BLOCK input blocks and also resets the timer.

The function also provides the ST_EMERG_ENA output change date and time, T_ST_EMERG. The information is available in the monitored data view.

## 5.6.6 Application

If the motor needs to be started in an emergency condition at the risk of damaging the motor, all the external restart inhibits are ignored, allowing the motor to be restarted. Furthermore, if the calculated thermal level is higher than the restart inhibit level at an emergency start condition, the calculated thermal level is set slightly below the restart inhibit level. Also, if the register value of the cumulative start-up time counter exceeds the restart inhibit level, the value is set slightly below the restart disable value to allow at least one motor start-up.

The activation of the ST_EMERG_RQ digital input allows to perform emergency start. The protection relay is forced to a state which allows the restart of motor, and the operator can now restart the motor. A new emergency start cannot be made

until the 10 minute time-out has passed or until the emergency start is released, whichever takes longer.

The last change of the emergency start output signal is recorded.

## 5.6.7 Signals

### 5.6.7.1 ESMGAPC Input signals

**Table 1140: ESMGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| ST_EMERG_RQ | BOOLEAN | 0=False | Emergency start input |

### 5.6.7.2 ESMGAPC Output signals

**Table 1141: ESMGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| ST_EMERG_ENA | BOOLEAN | Emergency start |

## 5.6.8 ESMGAPC Settings

**Table 1142: ESMGAPC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Motor standstill A | 0.01...0.20 | xIn | 0.01 | 0.12 | Current limit to check for motor standstill condition |

**Table 1143: ESMGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

## 5.6.9 ESMGAPC Monitored data

**Table 1144: ESMGAPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| T_ST_EMERG | Timestamp | | | Emergency start activation timestamp |
| ESMGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.6.10 Technical data

**Table 1145: ESMGAPC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±1.5 % of the set value or ±0.002 × $U_n$ |

## 5.6.11 Technical revision history

**Table 1146: ESMGAPC Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | E | Setting *Motor standstill A* minimum value changed from 0.05xIn to 0.01xIn. |

# 5.7 Fault locator SCEFRFLO (ANSI FLOC)

## 5.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Fault locator | SCEFRFLO | FLOC | FLOC |

## 5.7.2 Function block

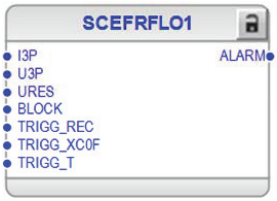



*Figure 681: Function block*

## 5.7.3 Functionality

The fault locator function SCEFRFLO provides impedance-based fault location. It is designed for radially operated distribution systems, and it can locate short circuits in all kinds of distribution networks. Earth faults can be located in effectively earthed and in low-resistance or low-reactance earthed networks. With certain limitations, SCEFRFLO can also be used for locating an earth fault in unearthed distribution networks. Moreover, SCEFRFLO can be applied to compensated (resonant earthed) networks where an earth-fault current raising resistor is connected in parallel with the arc suppression coil. The location of the continuous low-ohmic earth fault can be determined by using the switching of the parallel resistor of the coil during an earth fault.

The fault distance calculation is based on the locally measured fundamental frequency current and voltage phasors. The full operation of SCEFRFLO requires all phase currents and phase-to-earth voltages to be measured.

The fault distance estimate is obtained when SCEFRFLO is externally or internally triggered.

## 5.7.4 Analog channel configuration

SCEFRFLO has three analog group inputs which must be properly configured.

**Table 1147: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |
| URES [1] | Residual voltage (measured), necessary when the phase-to-phase voltages are measured and Phase voltage Meas is set to "Accurate" |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

[1] Can be connected to GRPOFF if *Phase voltage Meas* is set to "Ph-to-ph without Uo"

**Table 1148: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.7.5 Operation principle

The function can be enabled or disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of SCEFRFLO can be described with a module diagram. All the modules in the diagram are explained in the next sections.

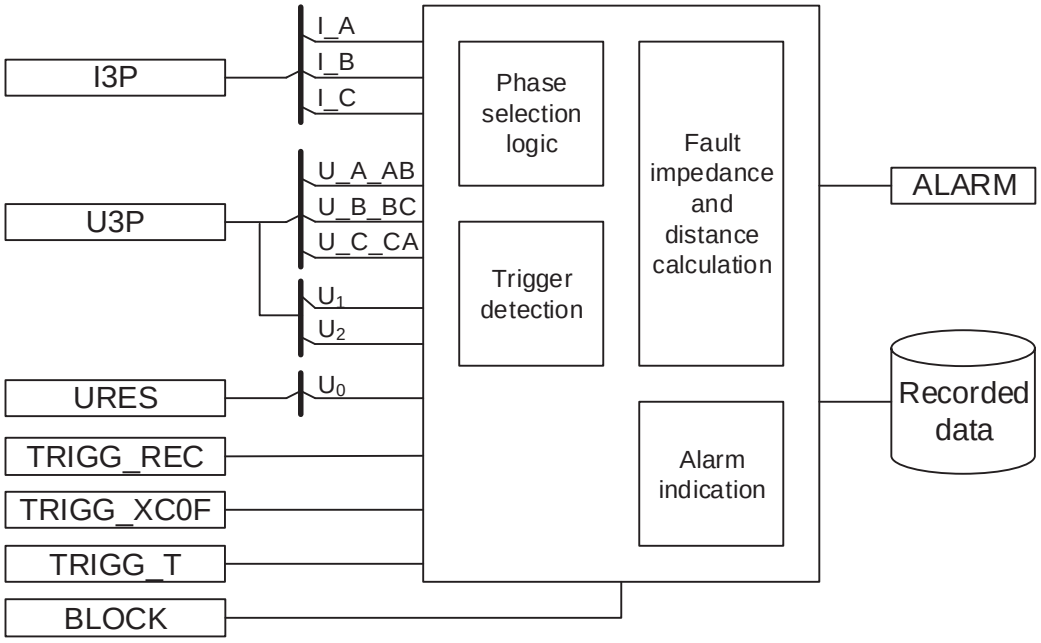



*Figure 682: Functional module diagram*

The fault distance calculation is done in two steps. First, the fault type is determined with the in-built Phase selection logic (PSL). Second, based on the selected impedance measuring element (fault loop) the fault distance from the measuring point to the fault location is calculated.

The phase current magnitude's minimum threshold value is 1 % xIn.

### 5.7.5.1 Phase selection logic

Phase selection logic identifies the faulty phases based on a combined impedance and current criterion. Phase selection logic is virtually setting-free and has only one parameter, *Z Max phase load*, for discriminating a heavy symmetrical load from a three-phase fault. The setting *Z Max phase load* can be calculated using the equation

$$Z\,Max\ phase\,load = 0.8 \cdot \frac{U_{xy}^2}{S_{max}}$$

(Equation 292)

| | |
|---|---|
| $U_{xy}$ | Nominal phase-to-phase voltage |
| $S_{max}$ | Maximum three-phase load |

For example, if $U_{xy}$ = 20 kV and $S_{max}$ = 1 MVA, then *Z Max phase load* = 320.0 Ω.

The identification of the faulty phases is compulsory for the correct operation of SCEFRFLO. This is because only one of the impedance-measuring elements (fault loops) provides the correct result for a specific fault type. A three-phase fault is an exception and theoretically it can be calculated with any of the fault loops. The fault loop used in the fault distance calculation is indicated in the recorded data Flt loop as specified in *Table 1149*.

**Table 1149: Fault types and corresponding fault loops**

| Fault type | Description | Flt loop |
|---|---|---|
| - | No fault | No fault |
| A-E | Phase A-to-earth fault | AG Fault |
| B-E | Phase B-to-earth fault | BG Fault |
| C-E | Phase C-to-earth fault | CG Fault |
| A-B | Phase A-to-B short circuit fault | AB Fault |
| B-C | Phase B-to-C short circuit fault | BC Fault |
| C-A | Phase C-to-A short circuit fault | AC Fault |
| A-B-C-(E) | Three-phase short circuit | ABC Fault |

In case of two-phase-to-earth-faults (A-B-E, B-C-E or C-A-E), the selected fault loop depends on the location of the earth faults. When the faults are located at the same feeder, the corresponding phase-to-phase loop (“AB Fault”, “BC Fault” or “CA Fault”) is used for calculation. When the faults are located at different feeders, the phase-to-earth loop (“AG Fault”, “BG Fault” or “CG Fault”) corresponding to the faulty phase at the protected feeder is used for calculation.

### 5.7.5.2 Fault impedance and distance calculation

As soon as a fault condition is recognized by Phase selection logic, the fault distance calculation is started with one of the seven impedance-measuring elements, that is, the fault loops. SCEFRFLO uses independent algorithms for each fault type to achieve optimal performance.

The inherent result from the fault distance calculation is the ohmic fault loop impedance value.

**Table 1150: The calculated impedance values available in the recorded data**

| Impedance valule | Description |
|---|---|
| Flt phase reactance | Estimated positive sequence reactance from the substation to the fault location in primary ohms. |
| Flt point resistance | Fault resistance value in the fault spot in primary ohms. The composition of this term depends on the fault loop as described in the following subsections. |
| Flt loop resistance | The total fault loop resistance from the substation to the fault location in primary ohms. Fault point resistance is included in this value. The composition of this term is different for short-circuit and earth-fault loops as described in the following subsections. |
| Flt loop reactance | The total fault loop reactance from the substation to the fault location in primary ohms. The composition of this term is different for short-circuit and earth-faults loops as described in the following subsections. |

These impedance values can be used as such or they can be further processed in system-level fault location applications, such as distribution management system (DMS).

### 5.7.5.3 Fault loops “AG Fault” or “BG Fault” or “CG Fault”

Fault loops “AG Fault”, “BG Fault” and “CG Fault” are used for single-phase-toearth faults. When the earth faults are located at different feeders, they are also applied in the case of two-phase-to-earth faults. In this case, the phase-to-earth loop (“AG Fault”, “BG Fault” or “CG Fault”) corresponding to the faulty phase at the protected feeder is used for calculation. *Figure 683* shows the phase-to-earth fault loop model. The following impedances are measured and stored in the recorded data of SCEFRFLO.

$$Flt\ point\ resistance = R_{fault}$$

(Equation 293)

$$Flt\ loop\ resistance = R_1 + R_N + R_{fault}$$

(Equation 294)

$$Flt\ loop\ reactance = X_1 + X_N$$

(Equation 295)

$$Flt\ phase\ reactance = X_1$$

(Equation 296)

| | |
|---|---|
| $R_1$ | Estimated positive-sequence resistance from the substation to the fault location |
| $X_1$ | Estimated positive-sequence reactance from the substation to the fault location |
| $R_0$ | Estimated zero-sequence resistance from the substation to the fault location |
| $X_0$ | Estimated zero-sequence reactance from the substation to the fault location |
| $R_N$ | Estimated the earth return path resistance (= (R0 – R1)/3) from the substation to the fault location |
| $X_N$ | Estimated is the earth return path reactance (= (X0 – X1)/3) from the substation to the fault |
| $R_{fault}$ | Estimated fault resistance at the fault location |

The recorded data Flt phase reactance provides the estimated positive-sequence reactance from the substation to the fault location.

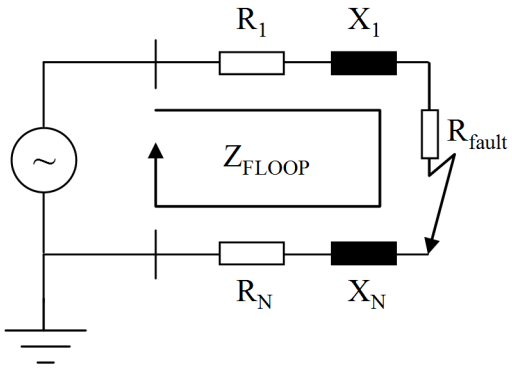



*Figure 683: Fault loop impedance for phase-to-earth fault loops “AG Fault”, “BG Fault” or “CG Fault”*

Setting *Flt Loc Det mode* is used for selecting between different algorithms for the calculation of the earth-fault distance. In case of compensated (resonant earthed) networks where an earth-fault current raising resistor is used, setting *Flt Loc Det mode* = "Comp, switched R" should be selected. In all other cases of system neutral point earthing (effectively earthed, low-resistance, low-reactance or unearthed networks), setting "Non-comp" should be selected.

**Earth-fault distance calculation in case of non-compensated networks**

In case of non-compensated networks (effectively earthed, low-resistance, lowreactance or unearthed networks), the setting *Flt Loc Det mode* is equal to "Noncomp". Furthermore, the earth-fault distance calculation algorithm is selected with setting *EF algorithm Sel*. Options for the selection are "Load compensation" and "Load modelling". For the correct operation of both algorithms, there should not be any zero-sequence current sources, for example, earthing transformers, in front of the protection relay.

The “Load compensation” algorithm uses symmetrical components to compensate for the effect of load on the measured voltages and currents. In case of radial feeders, this algorithm should be selected with low-impedance/effectively earthed systems where the fault current is fed from one side only and there are no in-feeds along the protected line.

The “Load modelling” algorithm takes into account the effect of the load in the measured currents and voltages by considering it in the fault loop model. In case

of radial feeders, this algorithm can be applied with low-impedance/effectively earthed systems where the fault current is fed from one side only. The “Load modelling” algorithm has been especially designed for unearthed systems.

The “Load modelling” algorithm requires the *Equivalent load Dis* setting, that is, an equivalent load distance, as an additional parameter. The derivation and meaning of this parameter is illustrated in *Figure 684*, where the load is assumed to be evenly distributed along the feeder, resulting in the actual voltage drop curve as seen in the middle part of *Figure 684*.

In case of evenly distributed load, *Equivalent load Dis* ~ 0.5. When the load is tapped at the end of the feeder, *Equivalent load Dis* = 1.0. If the load distribution is unknown, a default value of 0.5 can be used for *Equivalent load Dis*.

The maximum value of the voltage drop, denoted as $U_{drop}$(real), appears at the end of the feeder. The *Equivalent load Dis* setting is the distance at which a single load tap corresponding to the total load of the feeder results in a voltage drop equal to $U_{drop}$(real). The dashed curve shows the voltage drop profile in this case.

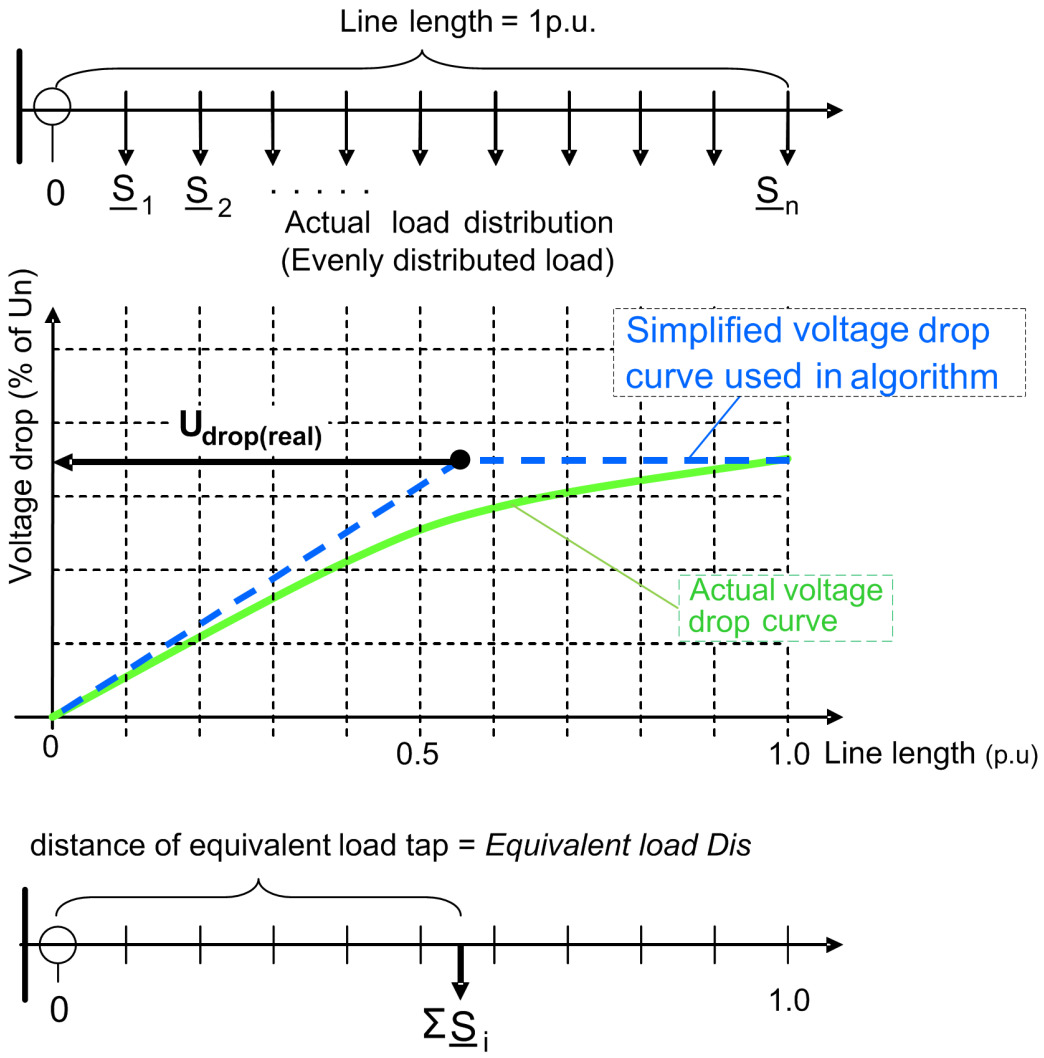



*Figure 684: Description of the equivalent load distance*

The exact value for *Equivalent load Dis* can be calculated based on the load flow and voltage drop calculations using data from DMS-system and the following equation.

$$Equivalent\ load\ Dis = \frac{U_{d(real)}}{U_{d(tap,d=1)}}$$

(Equation 297)

| | |
|---|---|
| $U_{d(real)}$ | The actual maximum voltage drop of the feeder |
| $U_{d(tap,d=1)}$ | The fictional voltage drop, if the entire load would be tapped at the end (d=1) of the feeder (not drawn in *Figure 684*). The calculation of this value requires data from the DMS system. |

Alternatively, the setting *Equivalent load Dis* can be determined by conducting a single-phase earth-fault test ($R_{fault}$ = 0 Ω) at that point of the feeder where the maximum actual voltage drop takes place. This point is typically located at the end of the main line. As a result, the calculated value is stored in the recorded data Equivalent load Dis.

In addition, when the setting *EF algorithm Sel* is equal to "Load modelling", the *EF algorithm Cur Sel* setting determines whether the used algorithm is based on zero-sequence "Io based" or negative-sequence "I2 based" current. The difference between "Io based" and "I2 based" methods is that "I2 based" does not require the *Ph capacitive React* and *Ph leakage Ris* settings. In case of "Io based", these settings are needed to compensate for the influence of the line-charging capacitances of the protected feeder. This improves the accuracy of the fault location estimate when fault resistance is involved in the fault.

With certain restrictions, the “Load modelling” algorithm can also be applied to unearthed networks. In this case the *EF algorithm Cur Sel* setting should be set to “Io based” and thus *Ph capacitive React* and *Ph leakage Ris* settings must be determined.

The prerequisite for the operation of SCEFRFLO in earth faults in unearthed networks is that the earth-fault current of the network corresponding to a solid fault exceeds the pre-fault load current; that is the *Equation 298* is valid.

$$Flt\ to\ Lod\ Cur\ ratio = \frac{\left|I_{ef(Rfault=0)}\right|}{\left|I_{Load}\right|} \geq 1$$

(Equation 298)

This ratio is estimated by SCEFRFLO and stored in the recorded data Flt to Lod Cur ratio together with the fault distance estimate.

In case of an unearthed network, sufficient fault current magnitude resulting in Flt to Lod Cur ratio >1 can be achieved, for example, with proper switching operations in the background network, if possible, which increase the fault current. If the faulty feeder is re-energized after the switching operation, a new estimate for the fault distance can be obtained. Fault resistance decreases the fault location accuracy so the resistance should not be higher than a few hundred ohms. Also, a low value of Flt to Lod Cur ratio causes inaccuracy and affects the quality of the fault distance estimate. The inaccuracies affecting the calculated fault distance estimate are reported in the recorded result quality indicator value Flt Dist quality in *Table 93*.

**Earth-fault distance calculation in case of compensated (resonant earthed) networks where an earth-fault current raising resistor is used**

In case of compensated (resonant earthed) networks where an earth-fault current raising resistor is used, the setting *Flt Loc Det mode* is equal to "Comp, switched R". The algorithm for calculation of earth-fault distance requires a measurable change in the measured phase currents and phase-to-earth voltages during an earth fault. Such a change can be accomplished by switching on the resistor of the PAW winding (Power Auxiliary Winding) of the compensation coil during the fault.

The algorithm requires three independent time instances, which are assumed to be known by the algorithm:

- $t_0$ = time instance before the fault
- $t_1$ = time instance before the change during the earth fault
- $t_2$ = time instance after the change during the earth fault

The effect of loads is considered by applying “Load modelling” algorithm.

The required settings of the algorithm are:

- R1 = Positive-sequence resistance of the protected feeder [ohm, prim]
- X1 = Positive-sequence reactance of the protected feeder [ohm, prim]
- R0 = Zero-sequence resistance of the protected feeder [ohm, prim]
- X0 = Zero-sequence reactance of the protected feeder [ohm, prim]
- s = Equivalent load distance [pu]

**Determining timings of changes: determination of earth fault occurrence and time instance t0**

Timing $t_0$ is needed to store the current and voltage phasors right before the occurrence of the earth fault. Timing $t_0$ is common to both triggering types (*Calculation Trg mode* either “Internal” or “External”). Pre-fault (indicating healthy network) phasors are continuously updated and stored at intervals of 300 ms until the earth fault is indicated. When the earth fault is detected (internal detection), the pre-fault phasor is stored at least 300 ms before the detection of the earth fault. This time instance before the earth fault is noted as $t_0$ (see *Figure 685*).

**Determining timings of changes: determination of changes during an earth fault due to parallel resistor switching, time instances t1 and t2**

- Time instance $t_1$ equals the time during earth fault, right before the switching of the parallel resistor of the coil (see *Figure 685*)
- Time instance $t_2$ equals the time during earth fault, just after the switching of the parallel resistor of the coil (see *Figure 685*)

In case of external triggering, time instances $t_1$ and $t_2$ are determined using input `TRIGG_T` and delay setting *Time delay*. `TRIGG_T` input should be activated when the parallel resistor is switched ON. Time instance $t_1$ is taken at least one fundamental cycle before `TRIGG_T` rising edge. Time instance $t_2$ is taken according to the set *Time delay* after the rising edge of `TRIGG_T` signal. Setting *Time delay* should be few hundreds of ms and it is needed due to oscillations in currents and voltages after the switching of the parallel resistor.



`TRIGG_T` activation must be given after the initial earth-fault ignition transients. Only one activation of `TRIGG_T` is allowed during an earth fault. However, further activations are internally disabled.

Activation of input TRIGG_REC is required in case of external triggering to record the calculated estimates for fault distance. TRIGG_REC should be activated during the earth fault after the switching of the parallel resistor.

In case of internal triggering, time instances $t_1$ and $t_2$ are determined by monitoring the change of the resistive component of Io current using admittance calculation during the earth fault and comparing the magnitude of change to setting *Zero Ris Curr change*. Time instance $t_1$ is taken at least one fundamental cycle before and $t_2$ at least one fundamental cycle after the change in the resistive component of Io exceeding the start value (setting *Zero Ris Curr change*). The value for setting Zero Ris Curr change should be chosen based on the rated current value of the parallel resistor with proper margin:

*Zero Ris Curr change* < Ipar_rated [A] · q

where q = 0.5–0.7

For example, if the rated current value of the parallel resistor is 10A@20kV and In = 100 A for Io channel, then

*Zero Ris Curr change* < 0.05–0.07xIn

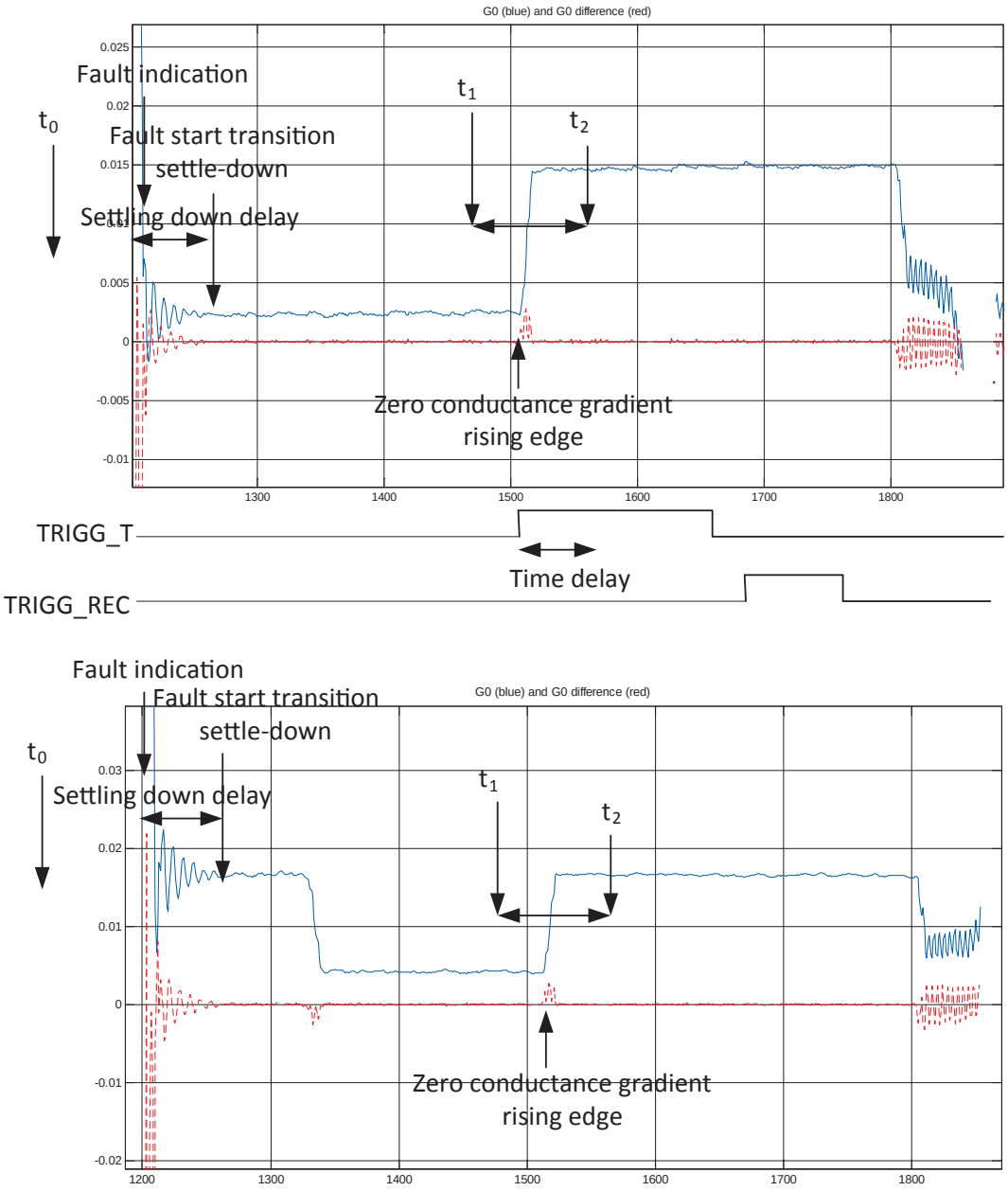



*Figure 685: Fault distance estimate triggering moment definitions*

**Fault loops “AB Fault”, “BC Fault” or “CA Fault”**

Fault loops “AB Fault”, “BC Fault” or “CA Fault” are used for phase-to-phase short circuit faults as well as in the case of a two-phase-to-earth fault if the individual earth faults are located at the same feeder. *Figure 686* shows the phase-to-phase fault loop model. The following impedances are measured and stored in the recorded data of SCEFRFLO.

$$Flt\ point\ resistance = \frac{R_{fault}}{2}$$

(Equation 299)

$$Flt\ loop\ resistance = R_1 + \frac{R_{fault}}{2}$$

(Equation 300)

$$Flt\ loop\ reactance = Flt\ phase\ reactance = X_1$$

(Equation 301)

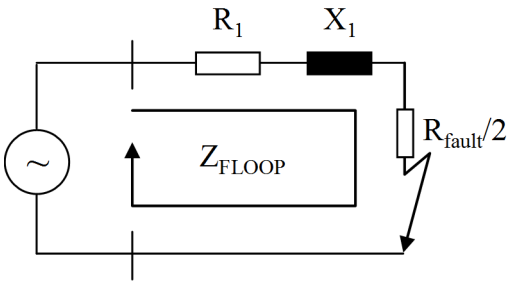



*Figure 686: Fault loop impedance for phase-to-phase fault loops (either "AB Fault", "BC Fault" or "CA Fault")*

The fault distance calculation algorithm for the phase-to-phase fault loops is defined by using settings *Load Com PP loops* and *Enable simple model*. Options for the selection are "Disabled" or "Enabled".

Load compensation can be enabled or disabled with setting *Load Com PP loops*. Load compensation should be disabled only if the ratio between the fault current and load current is high or when the value of the fault distance estimate for the short circuit fault is required from each shot of an autoreclosing sequence.

The fault distance calculation is most accurate when calculated with the fault loop model. This model requires positive-sequence impedances of the protected feeder to be given as settings. If these settings are not available, valid impedance values can be calculated also without the fault loop model with setting *Enable simple model* = "Enabled". However, a valid distance estimate, that is, the conversion of measured impedance ("electrical fault distance") into a physical fault distance requires accurate positive-sequence impedance settings.

**Fault loop "ABC Fault"**

Fault loop "ABC Fault" is used exclusively for the three-phase short circuit fault. *Figure 687* shows the three-phase fault loop model. The following impedances are measured and stored in the recorded data of SCEFRFLO.

$$Flt\ point\ resistance = R_{fault}$$

(Equation 302)

$$Flt\ loop\ resistance = R_1 + R_{fault}$$

(Equation 303)

$$Flt\ loop\ reactance = Flt\ phase\ reactance = X_1$$

(Equation 304)

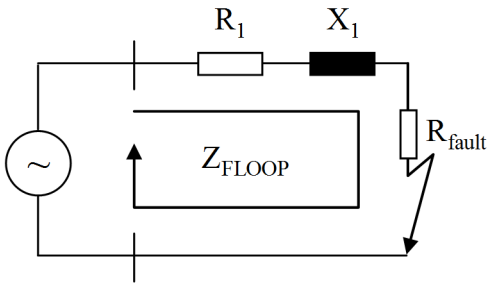



*Figure 687: Fault loop impedance for a three-phase fault loop (“ABC Fault”)*

The three-phase fault distance is calculated with a special measuring element using positive-sequence quantities. This is advantageous especially in case of non-transposed (asymmetric) lines, as the influence of line parameter asymmetry is reduced. If the line is non-transposed, all the phase-to-phase loops have different fault loop reactances. The use of positive-sequence quantities results in the average value of phase-to-phase loop reactances, that is, the most representative estimate in case of three-phase faults.

The fault distance calculation algorithm for the three-phase fault loop is defined with settings *Load Com PP loops* and *Enable simple model*. Options for the selection are "Disabled" or "Enabled".

Load compensation can be enabled or disabled with setting *Load Com PP loops*. The load compensation should be disabled only if the ratio between the fault current and load current is high or when the value of the fault distance estimate for the short circuit fault is required from each shot of an autoreclosing sequence.

The fault distance calculation is most accurate when the calculation is made with the fault loop model. This model requires positive sequence impedances of the protected feeder to be given as settings. If these settings are not available, valid impedance values can be calculated also without the fault loop model with setting *Enable simple model* = "Enabled". However, a valid distance estimate, that is, the conversion of measured impedance (“electrical fault distance”) into a physical fault distance requires accurate positive-sequence impedance settings.

**Estimation of fault resistance in different fault loops**

The fault point resistance value provided by the impedance calculation is available in recorded data Flt point resistance and it depends on the applied fault loop as shown in *Figure 688*. In case of earth faults, the estimated fault point resistance includes the total fault point resistance between the faulty phase and earth, for example, the arc and earthing resistances. In case of phase-to-phase faults, the estimated fault point resistance is half of the total fault point resistance between the phases. In case of a three-phase fault, the estimated fault point resistance equals the total fault point resistance per phase, for example, the arc resistance per phase.

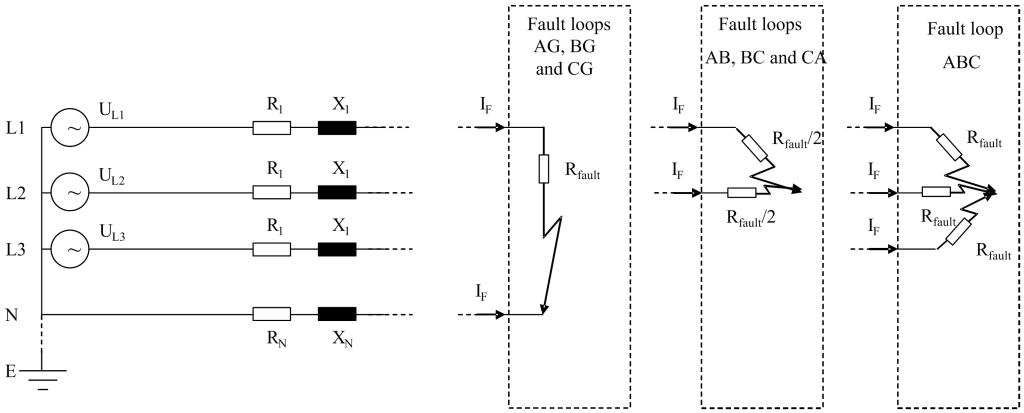



*Figure 688: Definition of a physical fault point resistance in different fault loops*

**Steady-state asymmetry and load compensation**

Power systems are never perfectly symmetrical. The asymmetry produces steady-state quantities in the form of zero-sequence and negative-sequence voltages and currents. If not compensated, these are error sources for fault distance calculation especially in case of earth faults. All earth-fault distance calculation algorithms of SCEFRFLO use the delta quantities which mitigate the effects of the steady-state asymmetry.

The load current is another error source for fault distance calculation. Its influence increases with higher fault resistance values. SCEFRFLO employs independent load compensation methods for each fault type to achieve optimal performance. The purpose of load compensation is to improve the accuracy of the fault distance calculation models by estimating the actual fault current in the fault location. Delta-quantities are used for this to mitigate the effect of load current on fault distance estimation.

For earth faults, the load compensation is done automatically inside the fault distance calculation algorithm. For short circuit faults, load compensation is enabled with setting *Load Com PP loops*. The default value is "Enabled". The parameter should be set to "Disabled" only if the ratio between the expected fault current and load current is high or when the fault distance estimate for the short circuit fault is required for each shot of an autoreclosing sequence.

The delta quantity describes the change in measured signal due to the fault.

$$\Delta x = x_{fault} + x_{pre\text{-}fault}$$

(Equation 305)

| | |
|---|---|
| $x_{fault}$ | Signal value during fault |
| $x_{pre\text{-}fault}$ | Signal value during healthy state just before fault |

**Result quality indicator**

The quality of the estimated fault distance is judged and reported in recorded data as the Flt Dist quality together with the fault distance estimate. The Flt Dist quality is a bit vector indicating detected sources of inaccuracy in the fault distance estimate. If Flt Dist quality equals 1, the result is not affected by error sources. This results in good quality for the fault distance estimate. If factors affecting negatively

the fault distance estimation are detected, the Flt Dist quality is according to *Table 93*. In this case, the estimated fault distance (Flt distance) value is given on the HMI in parentheses.

**Table 1151: Fault distance quality indicator Flt Dist quality**

| Value | Corresponding inaccuracy description |
|---|---|
| 2 | Estimation stability criterion has not been reached |
| 4 | Fault point resistance exceeds 500 Ω |
| 8 | Fault point resistance exceeds 5 × $X_{loop}$ |
| 16 | Fault point resistance exceeds 20 × $X_{loop}$[1] |
| 32 | Flt to Lod Cur ratio is below 1.00 |
| 64 | Fault distance estimate outside tolerances (<-0.1 pu or >1.1 pu) |
| 128 | Distance estimate calculation is not done due to too low magnitudes of I or U |
| 256 | Distance estimate calculation cannot be performed (for example avoiding internal division by zero) |

For example, if fault point resistance exceeds 500 Ω and Flt to Lod Cur ratio is below 1.0, Flt Dist quality is “36”. As another example, if no error sources are found, but stability criterion is not met, the value of Flt Dist quality is “2”.

### Impedance settings

The fault distance calculation in SCEFRFLO is based on the fault loop impedance modeling. The fault loop is parametrized with the impedance settings and these can be set at maximum for three line sections (A, B and C). Each section is enabled by entering a section length, which ranges from zero to settings *Line Len section A*, *Line Len section B* or *Line Len section C* in the order section A-> section B-> section C.

The earth-fault loops require both positive-sequence and zero-sequence impedances, for example, *R1 line section A* and *X1 line section A*, *R0 line section A* and *X0 line section A*. For the short circuit loops, only positive-sequence impedances are needed, but they can be omitted if the setting *Enable simple model* equals "Enabled".

If the impedance settings are in use, it is important that the settings closely match the impedances of used conductor types. The impedance settings are given in primary ohms [ohm/pu] and the line section lengths in per unit [pu]. Thus, impedances can be either given in ohm/km and section length in km, or ohm/mile and section length in miles. The resulting Flt distance matches the units entered for the line section lengths.

### Positive-sequence impedance values

Fault location requires accurate setting values for line impedances. Positive-sequence impedances are required both for location of short circuits and earth faults. As data sheet impedance per unit values are generally valid only for a certain tower configuration, the values should be adjusted according to the

[1] Xloop is the total loop reactance according to settings

actual installation configuration. This minimizes the fault location errors caused by inaccurate settings.

The positive-sequence reactance per unit and per phase can be calculated with a following approximation equation which applies to symmetrically transposed three-phase aluminium overhead lines without ground wires.

$$X_1 \approx \omega_n \cdot 10^{-4} \left( 2 \cdot \ln \frac{a_{en}}{r} + 0.5 \right) [\Omega / km]$$

(Equation 306)

$\omega_n$ $2 \times \pi \times f_n$, where $f_n$ = fundamental frequency [Hz]

$a_{en}$ $\sqrt[3]{(a_{12} \cdot a_{23} \cdot a_{31})}$

the geometric average of phase distances [m]

$a_{xy}$ distance [m] between phases x and y

r radius [m] for single conductor

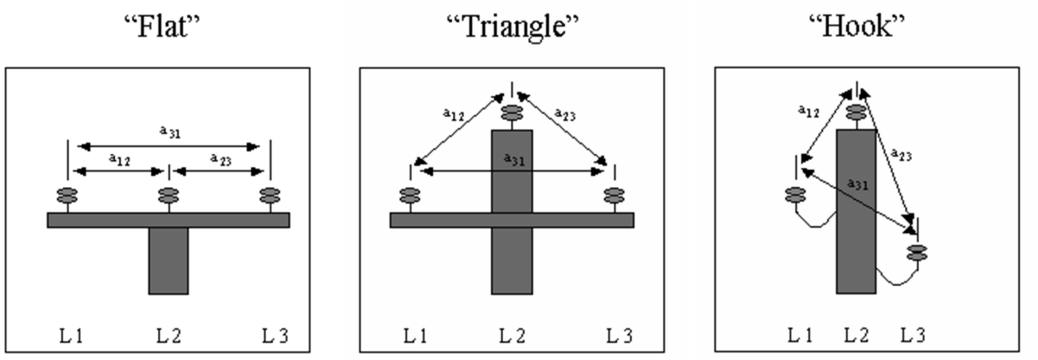



*Figure 689: Typical distribution line tower configurations*

Example values of positive-sequence impedances for typical medium voltage overhead-lines are given in the following tables.

**Table 1152: Positive-sequence impedance values for typical 11 kV conductors, "Flat" tower configuration**

| Name | R1 [Ω/km] | X1 [Ω/km] |
|---|---|---|
| ACSR 50 SQ.mm | 0.532 | 0.373 |
| ACSR 500 SQ.mm | 0.0725 | 0.270 |

**Table 1153: Positive-sequence impedance values for typical 10/20 kV conductors, "Flat" tower configuration**

| Name | R1 [Ω/km] | X1 [Ω/km] |
|---|---|---|
| Al/Fe 36/6 Sparrow | 0.915 | 0.383 |
| Al/Fe 54/9 Raven | 0.578 | 0.368 |
| Al/Fe 85/14 Pigeon | 0.364 | 0.354 |

*Table continues on the next page*

| Name | R1 [Ω/km] | X1 [Ω/km] |
|---|---|---|
| Al/Fe 93/39 Imatra | 0.335 | 0.344 |
| Al/Fe 108/23 Vaasa | 0.287 | 0.344 |
| Al/Fe 305/39 Duck | 0.103 | 0.314 |

**Table 1154: Positive-sequence impedance values for typical 33 kV conductors, "Flat" tower configuration**

| Name | R1 [Ω/km] | X1 [Ω/km] |
|---|---|---|
| ACSR 50 sq.mm | 0.529 | 0.444 |
| ACSR 100 sq.mm | 0.394 | 0.434 |
| ACSR 500 sq.mm | 0.0548 | 0.346 |

**Zero-sequence impedance values**

Location of earth faults requires both positive-sequence and zero-sequence impedances. For short circuit faults, zero-sequence impedances are not required.

The positive-sequence impedance per unit values for the lines are typically known or can easily be obtained from data sheets. The zero-sequence values are generally not as easy to obtain as they depend on the actual installation conditions and configurations. Sufficient accuracy can, however, be obtained with rather simple calculations using the following equations, which apply per phase for symmetrically transposed three-phase aluminium overhead lines without ground wires.

$$R_0\,[50Hz] \approx R1 + 0.14804\,[\Omega / km]$$

(Equation 307)

$$R_0\,[60Hz] \approx R1 + 0.17765\,[\Omega / km]$$

(Equation 308)

$$X_0 \approx 2 \cdot \omega_n \cdot 10^{-4} \left( 3 \cdot \ln \frac{w}{r_{en}} + 0.25 \right) [\Omega / km]$$

(Equation 309)

$R_1$ conductor AC resistance [Ω/km]

W $658\sqrt{\frac{\rho_{earth}}{f_n}}$

the equivalent depth [m] of the earth return path

$\rho_{earth}$ earth resistivity [Ωm]

*Table continues on the next page*

$r_{en}$ $\sqrt[3]{r \cdot \sqrt[3]{a_{12}^2 \cdot a_{23}^2 \cdot a_{31}^2}}$

the equivalent radius [m] for conductor bundle

r radius [m] for single conductor

$a_{xy}$ distance [m] between phases x and y

### *Ph leakage Ris* and *Ph capacitive React* settings

The *Ph leakage Ris* and *Ph capacitive React* settings are used for improving fault distance estimation accuracy for earth faults. They are critical for an accurate fault location in unearthed networks. In other types of networks they are less critical. The *Ph leakage Ris* setting represents the leakage losses of the protected feeder in terms of resistance per phase. The *Ph capacitive React* setting represents the total phase-to-earth capacitive reactance of the protected feeder per phase. Based on experience, a proper estimate for *Ph leakage Ris* should be about 20...40 × *Ph capacitive React*.

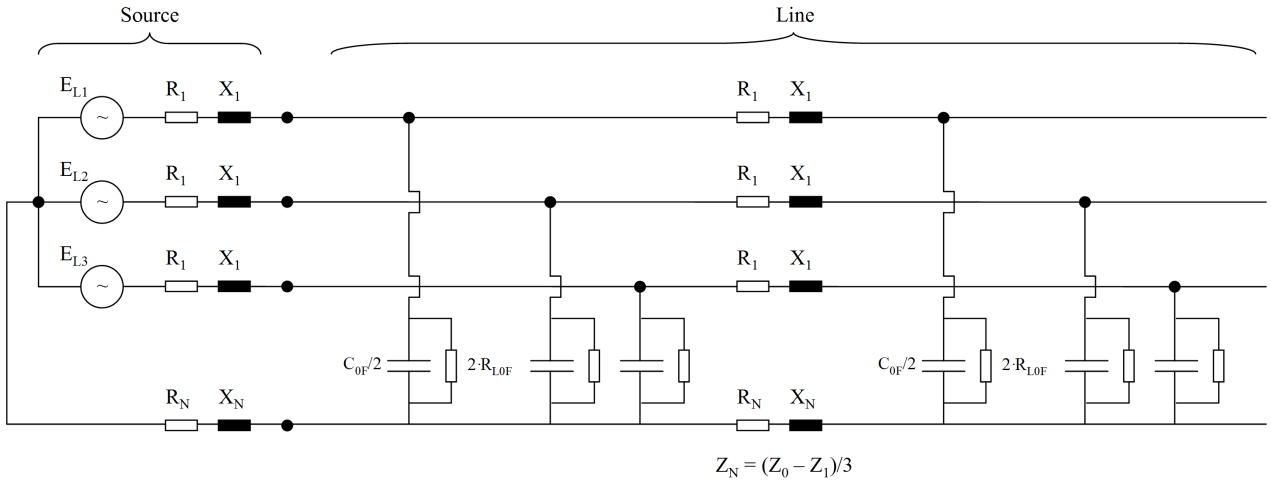



*Figure 690: Equivalent diagram of the protected feeder. R L0F = Ph leakage Ris.*

The determination of the *Ph capacitive React* setting can be based either on network data or measurement.

If the total phase-to-earth capacitance (including all branches) per phase $C_{0F}$ of the protected feeder is known, the setting value can be calculated.

$$Ph\ capacitive\ React = \frac{1}{\left(\omega_n \cdot C_{0F}\right)}$$

(Equation 310)

In case of unearthed network, if the earth-fault current produced by the protected feeder $I_{ef}$ is known, the setting value can be calculated.

$$Ph\ capacitive\ React = \frac{\sqrt{3} \cdot U_{xy}}{I_{ef}}$$

(Equation 311)

$U_{xy}$ Phase-to-earth voltage

SCEFRFLO can also determine the value for the *Ph capacitive React* setting by measurements. The calculation of *Ph capacitive React* is triggered by the binary signal connected to the TRIGG_XC0F input when an earth-fault test is conducted outside the protected feeder during commissioning, for example, at the substation busbar. The *Calculation Trg mode* has to be “External”. After the activation of the TRIGG_XC0F triggering input, the calculated value for setting *Ph capacitive React* is obtained from recorded data as parameter *XC0F Calc*. This value has to be manually entered for the *Ph capacitive React* setting. The calculated value matches the current switching state of the feeder so if the switching state of the protected feeder changes, the value should be updated.

*Figure 691* shows an example configuration, which enables the measurement of setting *Ph capacitive React*.

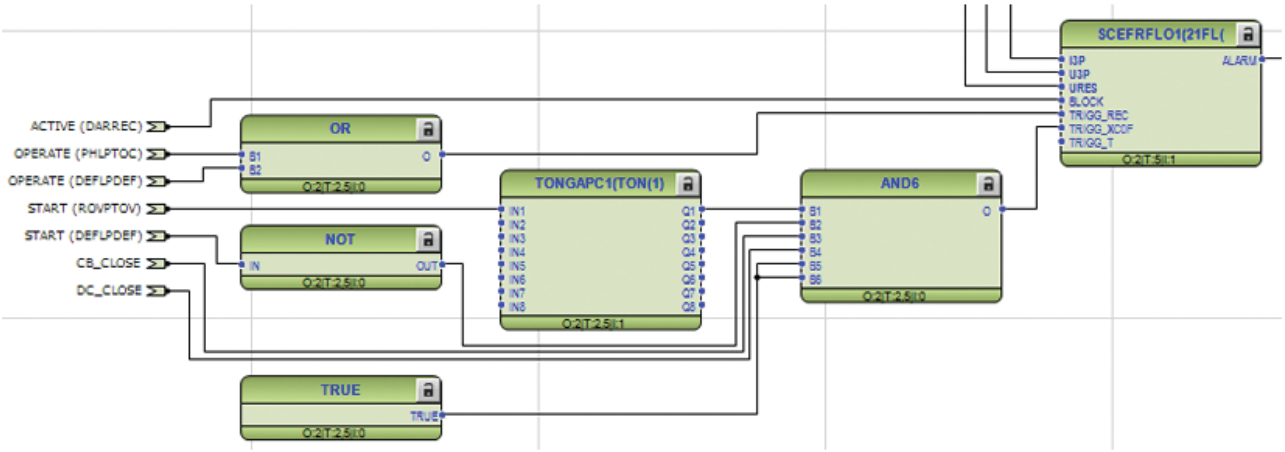



*Figure 691: An example configuration, which enables the measurement of setting Ph capacitive React*

If the earth fault is detected by the residual overvoltage function ( START of ROVPTOV), but not seen by the forward-looking earth-fault protection function ( START of DEFLPDEF), the fault is located outside the protected feeder. This is mandatory for valid measurement of setting *Ph capacitive React*. After a set delay (TONGAPC), the input TRIGG_XC0F is activated and the parameter *XC0F Calc* in the recorded data is updated. The delay (TONGAPC) must be set longer than the start delay of the directional earth-fault function DEFLPDEF, but shorter than the minimum operating time of the directional earth-fault functions in any of the feeders. For example, if the start delay is 100 ms and the shortest operating time 300 ms, a value of 300 ms can be used. Circuit breaker and disconnector status is used to verify that the entire feeder is measured.

**Modeling a non-homogeneous line**

A typical distribution feeder is built with several different types of overhead lines and cables. This means that the feeder is electrically non-homogeneous. SCEFRFLO allows the modeling of the line impedance variation in protection relay with three line sections with independent impedance settings. This improves the accuracy of

physical fault distance conversion done in the protection relay, especially in cases where the line impedance non-homogeneity is severe. Each section is enabled by entering a section length, which differs from zero, to settings *Line Len section A*, *Line Len section B* or *Line Len section C* in the order section A-> section B-> section C.

The impedance model with one line section is enabled by setting *Line Len section A* to differ from zero. In this case the impedance settings *R1 line section A*, *X1 line section A*, *R0 line section A* and *X0 line section A* are used for the fault distance calculation and for conversion from reactance to physical fault distance. This option should be used only in the case of a homogeneous line, that is, when the protected feeder consists of only one conductor type.

The impedance model with two line sections is enabled by setting both *Line Len section A* and *Line Len section B* to differ from zero. In this case the impedance settings *R1 line section A*, *X1 line section A*, *R0 line section A*, *X0 line section A*, *R1 line section B*, *X1 line section B*, *R0 line section B* and *X0 line section B* are used for the fault distance calculation and for conversion from reactance to physical fault distance. This option should be used in the case of a non-homogeneous line when the protected feeder consists of two types of conductors.

The impedance model with three line sections is enabled by setting *Line Len section A*, *Line Len section B* and *Line Len section C* to differ from zero. In this case, the impedance settings *R1 line section A*, *X1 line section A*, *R0 line section A*, *X0 line section A*, R1 line section B, *X1 line section B*, *R0 line section B*, *X0 line section B*, *R1 line section C*, *X1 line section C*, *R0 line section C* and *X0 line section C* are used for the fault distance calculation and for conversion from reactance to physical fault distance. This option should be used in the case of a non-homogeneous line when the protected feeder consists of more than two types of conductors.

The effect of line impedance non-homogeneity on the conversion of fault loop reactance into physical fault distance is demonstrated in the example shown in *Figure 692* with a 10-km-long feeder with three line types. The total line impedance for the 10 km line is R1 = 6.602 Ω (0.660 Ω/km) and X1 = 3.405 Ω (0.341 Ω/km), consisting of the following sections and impedance values.

- 4 km of PAS 150 (R1 = 0.236 Ω/km, X1 = 0.276 Ω/km)
- 3 km of Al/Fe 54/9 Raven (R1 = 0.536 Ω/km, X1 = 0.369 Ω/km)
- 3 km of Al/Fe 21/4 Swan (R1 = 1.350 Ω/km, X1 = 0.398 Ω/km)

The non-homogeneity of feeder impedance can be illustrated by drawing the protected feeder in RX-diagram (in the impedance plane), as shown in *Figure 692*.

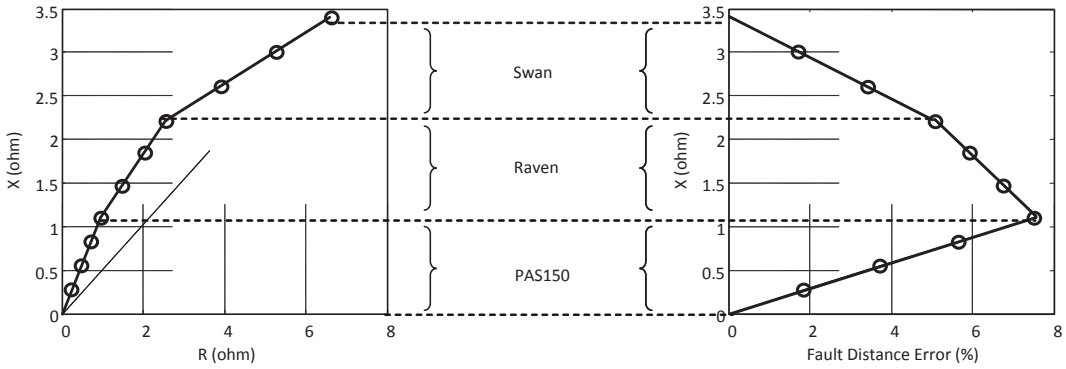



*Figure 692: Example impedance diagram of an electrically non-homogeneous feeder (left), and the resulting error in fault distance if the measured fault loop reactance is converted into physical fault distance by using only one line section parameters (right).*

In *Figure 692* the feeder is modelled either with one or three line sections with parameters given in *Table 1155*.

**Table 1155: Impedance settings**

| Parameter | Impedance model with one section | Impedance model with three sections |
|---|---|---|
| R1 line section A | 0.660 Ω/pu | 0.236 Ω/pu |
| X1 line section A | 0.341 Ω/pu | 0.276 Ω/pu |
| Line Len section A | 10.000 pu | 4.000 pu |
| R1 line section B | N/A | 0.536 Ω/pu |
| X1 line section B | N/A | 0.369 Ω/pu |
| Line Len section B | 0.000 pu | 3.000 pu |
| R1 line section C | N/A | 1.350 Ω/pu |
| X1 line section C | N/A | 0.398 Ω/pu |
| Line Len section C | 0.000 pu | 3.000 pu |

*Figure 692* illustrates the error when converting the measured fault loop reactance into physical fault distance. The fault location is varied from 1 km to 10 km in 1 km steps (marked with circles). An error of nearly eight per cent at maximum is created by the conversion procedure when modeling a non-homogenous line with only one section. By using impedance model with three line sections, there is no error in the conversion.

The previous example assumed a short circuit fault and thus, only positive-sequence impedance settings were used. The results, however, also apply for earth faults.

**Taps or spurs in the feeder**

If the protected feeder consists of taps or spurs, the measured fault impedance corresponds to several physical fault locations (For example, A or B in *Figure 693*). The actual fault location must be identified using additional information, for example, short circuit current indicators placed on tapping points.

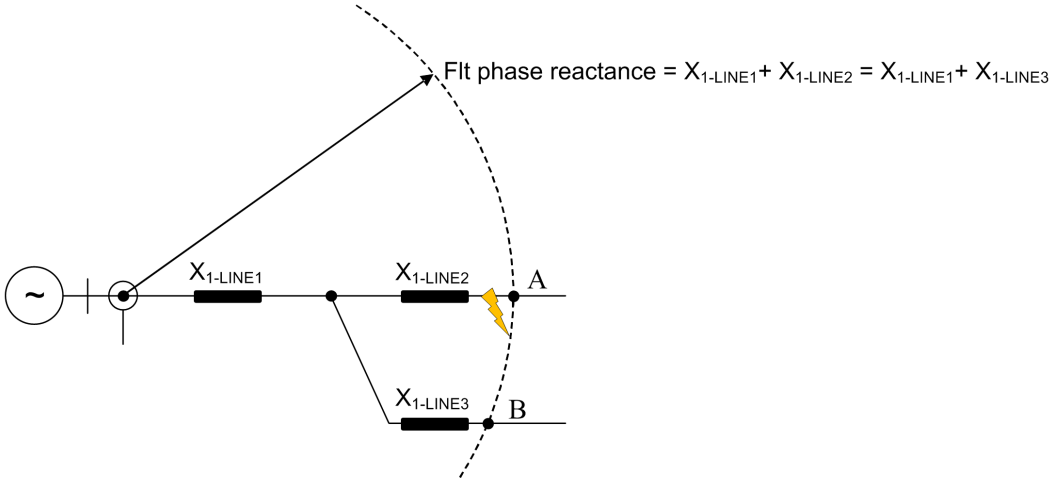



*Figure 693: Fault on a distribution line with spurs*

## 5.7.5.4 Trigger detection

The fault distance estimate is obtained when SCEFRFLO is triggered. The triggering method is defined with setting *Calculation Trg mode*. The options for selection are "External" or "Internal", where the default value is "External". The TRIGG_OUT event indicates the fault distance value recording moment. The fault distance estimate, Flt distance, together with the time stamp of actual triggering are saved in the recorded data of SCEFRFLO.

- In case of external triggering, an external trigger signal should be connected to the `TRIGG_REC` input. The triggering signal is typically a trip signal from a protective function. At triggering moment the fault distance is stored into recorded data. It is important that triggering be timed suitably to provide sufficient time for the distance estimation calculation before tripping of the feeder circuit breaker.
- In case of internal triggering, the `TRIGG_REC` input is not used for triggering. Instead, the trigger signal is created internally so that the estimation is started when Phase selection logic detects a fault and the estimate is triggered when its value has stabilized sufficiently. This is judged by maximum variation in fault distance estimate and defined with setting *Distance estimate Va* (in the same unit as the fault distance estimate). When successive estimates during one fundamental cycle are within “final value ± *Distance estimate Va*”, the fault distance estimate (mean of successive estimates) is recorded. If the stabilization criterion has not been fulfilled, the fault distance estimate is given right before the fault ends. Phase selection logic is a non-directional function so internal triggering should not be used when directionality is required.

Generally, SCEFRFLO requires a minimum of two fundamental cycles of measuring time after the fault occurrence. *Figure 694* illustrates typical behavior of fault distance estimate of SCEFRFLO as a function of time.

- Immediately after the fault occurrence, the estimate is affected by initial fault transients in voltages and currents.
- Approximately one fundamental cycle after the fault occurrence, the fault distance estimate starts to approach the final value.
- Approximately two fundamental cycles after the fault occurrence, the stability criterion for fault distance estimate is fulfilled and the TRIGG_OUT event is sent. The recorded data values are stored at this moment.

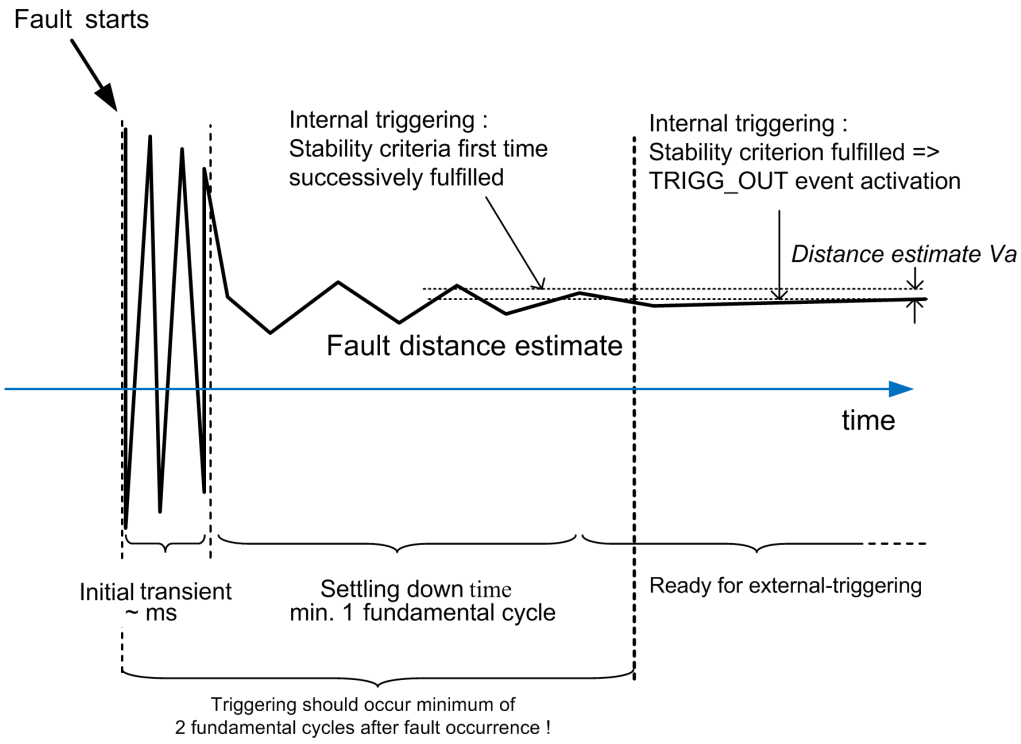



*Figure 694: The behavior of fault distance estimate in time*

### 5.7.5.5 Alarm indication

SCEFRFLO contains an alarm output for the calculated fault distance. If the calculated fault distance FLT_DISTANCE is between the settings *Low alarm Dis limit* and *High alarm Dis limit*, the ALARM output is activated. If setting *High alarm Dis limit* has been set below *Low alarm Dis limit*, the ALARM operation is inverted: the ALARM output is activated if *High alarm Dis limit* is undershot or *Low alarm Dis limit* is exceeded. The default value for both is zero so that no distance estimate activates ALARM.

The ALARM output can be utilized, for example, in regions with waterways or other places where knowledge of certain fault locations is of high importance.

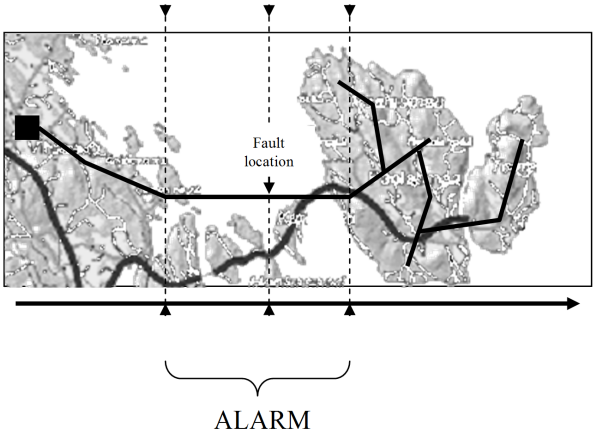



*Figure 695: An example of the ALARM output use*

### 5.7.5.6 Recorded data

All the information required for a later fault analysis is recorded to SCEFRFLO recorded data. In the protection relay, recorded data is found in **Monitoring** > **Recorded data** > **Other protection** > **SCEFRFLO**.

SCEFRFLO has also monitored data values which are used for the read-out of continuous calculation values. *Table 1156* shows which of the recorded data values are available as continuous monitoring values during a fault.

**Table 1156: Cross reference table for recorded and monitored data values**

| Recorded data | Monitored data |
|---|---|
| Flt loop | FAULT_LOOP |
| Flt distance | FLT_DISTANCE |
| Flt Dist quality | FLT_DIST_Q |
| Flt loop resistance | RFLOOP |
| Flt loop reactance | XFLOOP |
| Flt phase reactance | XFPHASE |
| Flt point resistance | RF |
| Flt to Lod Cur ratio | IFLT_PER_ILD |
| Equivalent load Dis | S_CALC |
| XC0F Calc | XC0F_CALC |

## 5.7.6 Measurement modes

The full operation of SCEFRFLO requires that all three phase-to-earth voltages are measured. The voltages can be measured with conventional voltage transformers or voltage dividers connected between the phase and earth ( *VT connection* is set to “Wye”). Another alternative is to measure phase-to-phase voltages ( *VT connection* is set to “Delta”) and residual voltage (Uo). Both alternatives are covered by setting the configuration parameter *Phase voltage Meas* to "Accurate".

The function can operate correctly with only two phase-to-earth voltages if the residual voltage is also measured and connected to the source UTVTR which provides the phase-to-earth voltages to the function. In this case, the missing phase-to-earth voltage is correctly calculated internally in the relay. If the measured residual voltage is connected to SCEFRFLO input URES, *Phase voltage Meas* can be set to "Accurate".

When the *Phase voltage Meas* setting is set to "Ph-to-ph without Uo" and only phase-to-phase voltages are available (but not Uo), only short-circuit measuring loops (fault loops “AB Fault”, “BC Fault”, “CA Fault” or “ABC Fault”) can be measured accurately. In this case, the earth-fault loops (fault loops “AG Fault”, “BG Fault” or “CG Fault”) cannot provide correct fault distance estimates and the triggering of the function in case of an earth fault is automatically disabled. The situation is similar if only two phase-to-earth voltages are measured and the measured residual voltage is not connected to SCEFRFLO.

## 5.7.7 Application

The main objective of the feeder terminals is a fast, selective and reliable operation in faults inside the protected feeder. In addition, information on the distance to the fault point is very important for those involved in operation and maintenance. Reliable information on the fault location greatly decreases the downtime of the protected feeders and increases the total availability of a power system.

SCEFRFLO provides impedance-based fault location. It is designed for radially operated distribution systems and is applicable for locating short circuits in all kinds of distribution networks. Earth faults can be located in effectively earthed and low-resistance/low-reactance earthed networks. With certain limitations, SCEFRFLO can also be used for locating an earth fault in unearthed distribution networks.

### Configuration example

A typical configuration example for SCEFRFLO triggering is illustrated in *Figure 691* where external triggering is applied, that is, *Calculation Trg mode* is set to “External”. The OPERATE signal from non-directional overcurrent function PHLPTOC is used to provide an indication of a short circuit fault. The OPERATE signal from the directional earth-fault function DEFLPDEF is used to provide an indication of an earth fault at the protected feeder.

### SCEFRFLO with the autoreclosing function

When SCEFRFLO is used with the autoreclosing sequence, the distance estimate from the first trip is typically the most accurate one. The fault distance estimates from successive trips are possible but accuracy can be decreased due to inaccurate load compensation. During the dead time of an autoreclosing sequence, the load condition of the feeder is uncertain.

The triggering of SCEFRFLO can also be inhibited during the autoreclosing sequence. This is achieved by connecting the signal ACTIVE from the autoreclosing function DARREC, which indicates that the autoreclosing sequence is in progress, to the BLOCK input of SCEFRFLO. Blocking of the SCEFRFLO triggering is indicated during the autoreclosing sequence when the load compensation or steady-state asymmetry elimination is based on the delta quantities. This applies to the short circuit faults when *Load Com PP loops* is set to "Enabled" or, to earth faults, when *EF algorithm Sel* is set to "Load compensation" or "Load modelling".

## 5.7.8 Signals

### 5.7.8.1 SCEFRFLO Input signals

**Table 1157: SCEFRFLO Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Signal for blocking the triggering |
| TRIGG_REC | BOOLEAN | 0=False | Distance calculation triggering signal |
| TRIGG_XC0F | BOOLEAN | 0=False | XC0F calculation triggering signal |
| TRIGG_T | BOOLEAN | 0=False | Start calculation sequence for compensation network |

### 5.7.8.2 SCEFRFLO Output signals

**Table 1158: SCEFRFLO Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Fault location alarm signal |

## 5.7.9 SCEFRFLO Settings

**Table 1159: SCEFRFLO Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Flt Loc Det mode | 2=Non-comp<br>1=Comp, switched R | | | 2=Non-comp | Fault location detection mode |
| Z Max phase load | 1.0...10000.0 | ohm | 0.1 | 80.0 | Impedance per phase of max. load, overcurr./under-imp., PSL |
| Ph leakage Ris | 20...1000000 | ohm | 1 | 210000 | Line PhE leakage resistance in primary ohms |
| Ph capacitive React | 10...1000000 | ohm | 1 | 7000 | Line PhE capacitive reactance in primary ohms |
| R1 line section A | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line resistance, line section A |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| X1 line section A | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line reactance, line section A |
| R0 line section A | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line resistance, line section A |
| X0 line section A | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line reactance, line section A |
| Line Len section A | 0.000...1000.000 | pu | 0.001 | 0.000 | Line length, section A |

**Table 1160: SCEFRFLO Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| High alarm Dis limit | 0.000...1.000 | pu | 0.001 | 0.000 | High alarm limit for calculated distance |
| Low alarm Dis limit | 0.000...1.000 | pu | 0.001 | 0.000 | Low alarm limit for calculated distance |
| Equivalent load Dis | 0.00...1.00 | | 0.01 | 0.50 | Equivalent load distance when EF algorithm equals to load modelling |
| R1 line section B | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line resistance, line section B |
| X1 line section B | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line reactance, line section B |
| R0 line section B | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line resistance, line section B |
| X0 line section B | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line reactance, line section B |
| Line Len section B | 0.000...1000.000 | pu | 0.001 | 0.000 | Line length, section B |
| R1 line section C | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line resistance, line section C |
| X1 line section C | 0.000...1000.000 | ohm / pu | 0.001 | 1.000 | Positive sequence line reactance, line section C |
| R0 line section C | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line resistance, line section C |
| X0 line section C | 0.000...1000.000 | ohm / pu | 0.001 | 4.000 | Zero sequence line reactance, line section C |
| Line Len section C | 0.000...1000.000 | pu | 0.001 | 0.000 | Line length, section C |

**Table 1161: SCEFRFLO Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Phase voltage Meas | 1=Accurate<br>2=Ph-to-ph without Uo | | | 1=Accurate | Phase voltage measurement principle |
| Calculation Trg mode | 1=Internal<br>2=External | | | 2=External | Trigger mode for distance calculation |

**Table 1162: SCEFRFLO Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| EF algorithm Sel | 1=Load compensation<br>2=Load modelling | | | 1=Load compensation | Selection for PhE-loop calculation algorithm |
| EF algorithm Cur Sel | 1=Io based<br>2=I2 based | | | 1=Io based | Selection for earth-fault current model |
| Load Com PP loops | 0=Disabled<br>1=Enabled | | | 1=Enabled | Enable load compensation for PP/3P-loops |
| Enable simple model | 0=Disabled<br>1=Enabled | | | 0=Disabled | Enable calc. without impedance settings for PP/3P-loops |
| Time delay | 0...3000 | ms | 10 | 100 | Time delay to start calculation in compensated networks |
| Zero Ris Curr change | 0.005...1.000 | xIn | 0.001 | 0.010 | Change in measured resistive component current due to fault |
| Distance estimate Va | 0.001...0.300 | | 0.001 | 0.015 | Allowed variation of short circuit distance estimate |

## 5.7.10 SCEFRFLO Monitored data

**Table 1163: SCEFRFLO Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| RF | FLOAT32 | 0.00...3000.00 | ohm | Fault point resistance in primary ohms |
| FAULT_LOOP | Enum | 1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault<br>-5=No fault | | Fault impedance loop |
| FLT_DISTANCE | FLOAT32 | 0.00...3000.00 | pu | Fault distance in units selected by the user |
| FLT_DIST_Q | INT32 | 0...511 | | Fault distance quality |
| RFLOOP | FLOAT32 | 0.00...3000.00 | ohm | Fault loop resistance in primary ohms |
| XFLOOP | FLOAT32 | 0.00...3000.00 | ohm | Fault loop reactance in primary ohms |
| XFPHASE | FLOAT32 | 0.00...3000.00 | ohm | Positive sequence fault reactance in primary ohms |
| IFLT_PER_ILD | FLOAT32 | 0.00...60000.00 | | Fault to load current ratio |
| S_CALC | FLOAT32 | 0.00...1.00 | | Estimated equivalent load distance |
| XC0F_CALC | FLOAT32 | 0.00...3000.00 | ohm | Estimated PhE capacitive reactance of line |
| SCEFRFLO | Enum | 1=on | | Status |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 2=blocked<br>3=test<br>4=test/blocked<br>5=off | | |
| Triggering time | Timestamp | | | Estimate triggering time |
| Flt loop | Enum | 1=AG Fault<br>2=BG Fault<br>3=CG Fault<br>4=AB Fault<br>5=BC Fault<br>6=CA Fault<br>7=ABC Fault<br>-5=No fault | | Fault loop |
| Flt distance | FLOAT32 | 0.00...3000.00 | pu | Fault distance |
| Flt Dist quality | INT32 | 0...511 | | Fault distance quality |
| Flt loop resistance | FLOAT32 | 0.00...3000.00 | ohm | Fault loop resistance |
| Flt loop reactance | FLOAT32 | 0.00...3000.00 | ohm | Fault loop reactance |
| Flt phase reactance | FLOAT32 | 0.00...3000.00 | ohm | Fault phase reactance |
| Flt point resistance | FLOAT32 | 0.00...3000.00 | ohm | Fault resistance |
| Flt to Lod Cur ratio | FLOAT32 | 0.00...60000.00 | | Fault to load current ratio |
| Equivalent load Dis | FLOAT32 | 0.00...1.00 | | Estimated equivalent load distance |
| XC0F Calc | FLOAT32 | 0.00...3000.00 | ohm | Estimated PhE capacitive reactance of the line |
| Pre fault time | Timestamp | | | Pre-fault time |
| A Pre Flt Phs A Magn | FLOAT32 | 0.00...40.00 | xIn | Pre-fault current phase A, magnitude |
| A Pre Flt Phs A Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault current phase A, angle |
| A Pre Flt Phs B Magn | FLOAT32 | 0.00...40.00 | xIn | Pre-fault current phase B, magnitude |
| A Pre Flt Phs B Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault current phase B, angle |
| A Pre Flt Phs C Magn | FLOAT32 | 0.00...40.00 | xIn | Pre-fault current phase C, magnitude |
| A Pre Flt Phs C Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault current phase C, angle |
| V Pre Flt Phs A Magn | FLOAT32 | 0.00...40.00 | xUn | Pre-fault voltage phase A, magnitude |
| V Pre Flt Phs A Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault voltage phase A, angle |
| V Pre Flt Phs B Magn | FLOAT32 | 0.00...40.00 | xUn | Pre-fault voltage phase B, magnitude |
| V Pre Flt Phs B Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault voltage phase B, angle |
| V Pre Flt Phs C Magn | FLOAT32 | 0.00...40.00 | xUn | Pre-fault voltage phase C, magnitude |
| V Pre Flt Phs C Angl | FLOAT32 | -180.00...180.00 | deg | Pre-fault voltage phase C, angle |
| A Flt Phs A Magn | FLOAT32 | 0.00...40.00 | xIn | Fault current phase A, magnitude |
| A Flt Phs A angle | FLOAT32 | -180.00...180.00 | deg | Fault current phase A, angle |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| A Flt Phs B Magn | FLOAT32 | 0.00...40.00 | xIn | Fault current phase B, magnitude |
| A Flt Phs B angle | FLOAT32 | -180.00...180.00 | deg | Fault current phase B, angle |
| A Flt Phs C Magn | FLOAT32 | 0.00...40.00 | xIn | Fault current phase C, magnitude |
| A Flt Phs C angle | FLOAT32 | -180.00...180.00 | deg | Fault current phase C, angle |
| V Flt Phs A Magn | FLOAT32 | 0.00...40.00 | xUn | Fault voltage phase A, magnitude |
| V Flt Phs A angle | FLOAT32 | -180.00...180.00 | deg | Fault voltage phase A, angle |
| V Flt Phs B Magn | FLOAT32 | 0.00...40.00 | xUn | Fault voltage phase B, magnitude |
| V Flt Phs B angle | FLOAT32 | -180.00...180.00 | deg | Fault voltage phase B, angle |
| V Flt Phs C Magn | FLOAT32 | 0.00...40.00 | xUn | Fault voltage phase C, magnitude |
| V Flt Phs C angle | FLOAT32 | -180.00...180.00 | deg | Fault voltage phase C, angle |

### 5.7.11 Technical data

**Table 1164: SCEFRFLO Technical data**

| Characteristic | Value |
|---|---|
| Measurement accuracy | At the frequency f = $f_n$<br>Impedance:<br>±2.5 % or ±0.25 Ω<br>Distance:<br>±2.5 % or ±0.16 km/0.1 mile<br>XC0F_CALC:<br>±2.5 % or ±50 Ω<br>IFLT_PER_ILD:<br>±5 % or ±0.05 |

## 5.8 Switch-onto-fault protection CVPSOF (ANSI SOTF)

### 5.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Switch-onto-fault protection | CVPSOF | CVPSOF | SOTF |

## 5.8.2 Function block




*Figure 696: Function block*

## 5.8.3 Functionality

The switch-onto-fault function CVPSOF is a complementary function, especially to the distance protection function (DSTPDIS), but it can also be used to complement the non-directional or directional overcurrent protection functions (PHxPTOC, DPHxPDOC).

CVPSOF accelerates the operation of the protection ensuring a fast trip when the breaker is closed onto faulted feeder or bus. Without CVPSOF the measured voltages may be too small for the impedance zones or the directional overcurrent stages to operate reliably. This condition exists when the voltage transformers are located in the feeder or the bus side to be energized and therefore the voltage memory required for a correct directional measurement is not available.

## 5.8.4 Analog channel configuration

CVPSOF has two analog group inputs which must be properly configured.

**Table 1165: Analog inputs**

| Input | Description |
|---|---|
| I3P [1] | Three-phase currents, necessary when Operation mode is other than "Start" |
| U3P [2] | Three-phase voltages, necessary when Operation mode is other than "Start |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

[1] Can be connected to GRPOFF if *Operation mode* is set to "Start" and *Automatic SOTF Ini* is set to "DLD disabled" or "Voltage"

[2] Can be connected to GRPOFF if *Operation mode* is set to "Start" and *Automatic SOTF Ini* is set to "DLD disabled" or "Current"

**Table 1166: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.8.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of CVPSOF can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

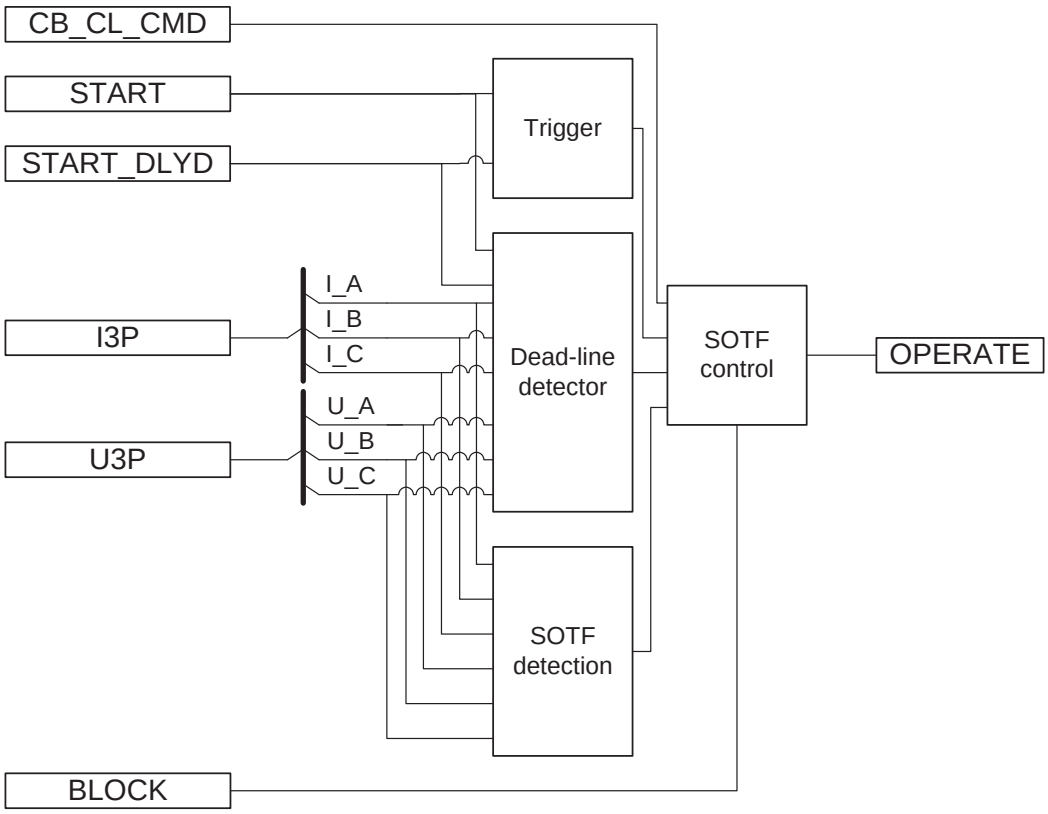



*Figure 697: Functional module diagram*

**Trigger**

This module is used for detecting a possible fault immediately after circuit breaker closing. The use of external protection function, typically the start signal from a

non-directional distance zone or overcurrent stage, is required for fault indication. The START and START_DLYD inputs are available for the purpose.

- The START input has no delay. Thus, a switch-onto-fault situation is immediately signalled to SOTF control.
- START_DLYD is used when an additional delay is required to start the signal. The switch-onto-fault situation is signalled to the SOTF control after the set *Operate delay time*.

### Dead-line detector

The dead line detection should be used only when the voltage transformers are located on the line side of the circuit breaker.

The *Automatic SOTF Ini* setting is used to configure the internal dead line detection function.

**Table 1167: Options for dead line detection**

| Automatic SOTF Ini | Description |
|---|---|
| DLD disabled | The dead line detection function is disabled. This operation mode must be applied when voltage transformers are located on the bus side of the circuit breaker. |
| Voltage | The dead line detection function is enabled and based solely on the undervoltage condition. A dead line condition is declared, if all the phase voltages are below the *Voltage dead Lin Val* setting. The dead line is detected if the dead line condition is declared and simultaneously no fault is detected by the START and START_DLYD inputs . The dead line condition is signalled to the SOTF control after the delay defined with the *Dead line time* setting. |
| Current | The dead line detection function is enabled and based solely on the undercurrent condition. A dead line condition is declared, if all the phase currents are below the *Current dead Lin Val* setting. The dead line is detected if the dead line condition is declared and simultaneously no fault is detected by the START and START_DLYD inputs. The dead line condition is signalled to the SOTF control after delay defined with the *Dead line time* setting. |
| Current & Voltage | The dead line detection function is enabled and based on undercurrent and undervoltage condition. A dead line condition is declared, if all the phase currents are below the *Current dead Lin Val* setting and simultaneously all phase voltages are below the *Voltage dead Lin Val* setting. The dead line is detected if the dead line condition is declared and simultaneously no fault is detected by the START and START_DLYD inputs. The dead line condition is signalled to the SOTF control after delay defined with the *Dead line time* setting. |

### SOTF detection

The purpose of this module is to detect the switch onto fault situation based on the current and voltage measurements. If the voltage, in any of the phases, is below the *Voltage dead Lin Val* setting and simultaneously the current in the same phase

exceeds the *Current dead Lin Val* setting, the SOTF situation is signalled to SOTF control module after the set *Cur voltage Det time*.

**SOTF control**

The SOTF control module needs to be activated before the operation is possible in the switch-onto-fault situation. There are two ways to activate the SOTF control module.

- By CB_CL_CMD (circuit breaker closing command).
- By the dead line condition received from the dead line detection module.

Dead line detection should be used only when the voltage transformers are located on the line side of the circuit breaker.

When the CB_CL_CMD input is activated or the dead line condition is detected, the SOTF control module becomes active. The reset timer is started when CB_CL_CMD is inactivated or the dead line condition disappears. Thus, the module becomes inactive after the set *SOTF reset time* is exceeded.

When the SOTF control module is active, the *Operation mode* setting defines the operation criteria for the detection of a switch-onto-fault condition. The detection can be based on the external start signals from the distance or overcurrent functions, on the measured internal voltage and current levels, or on both.

**Table 1168: Options for SOTF detection**

| Operation mode | Description |
|---|---|
| Start | The OPERATE output is activated immediately after a signal from the trigger module. This indicates that the breaker is closed onto fault. |
| Current & Voltage | The OPERATE output is activated immediately after a signal from the SOTF detection module. This indicates that the breaker is closed onto fault. This operation mode can be used, for example, if the non-directional distance zone is not available. |
| Both | The OPERATE output is activated immediately after a signal from the trigger or SOTF detection modules. This indicates that the breaker is closed onto fault. |

The OPERATE output can be blocked by activating the BLOCK input.

## 5.8.6 Application

The operation of CVPSOF is generally based on the non-directional distance zone or the non-directional overcurrent stage. When the feeder-side voltage transformers are used for providing the polarization quantity for the distance or directional overcurrent protection, the use of non-directional impedance or current based protection for starting CVPSOF secures a fast switch-onto-fault tripping in the close-in three-phase short circuits. The non-directional protection provides a fast fault clearance when the protection is used for energizing a bus from the feeder with a short circuit fault in it. Other protection functions, like time delayed zero-sequence overcurrent functions, can be connected to CVPSOF to increase the dependability of the scheme. The other main advantage of using CVPSOF is that it

typically accelerates the tripping in case of energizing a feeder onto a fault. Without CVPSOF, this tripping is normally performed by the normal time-graded protection or alternatively by the time-delayed local backup protection, for which operating times are considerably longer than with CVPSOF tripping.

An internal dead line detection check is provided to activate the function when the voltage transformers are located on the feeder side. An initiation by the dead line detection is highly recommended for the busbar configurations where more than one circuit breaker at one feeder end can energize the protected feeder or the feeder can also be energized from the other end.

**Setting guidelines**

Input `START`: If a distance zone is used for starting the switch-onto-fault function, the zone has to be set to cover the entire protected feeder with a safety margin of minimum 20 percent. If the non-directional zone is not available, the internal *Current & Voltage* criterion or the start signal from the GFC function can be used instead. If a non-directional overcurrent is used for starting, the current setting must not be higher than what is required for the non-delayed and dependable tripping for a close-in three-phase fault during minimum source conditions. If the short-circuit current along the feeder is considerably higher than the maximum load currents, it is possible that the whole feeder length is covered by CVPSOF tripping. If it is required to delay the tripping, for example, due to high inrush currents, the starting signal can be connected to the `START_DLYD` input instead.

The *Current dead Lin Val* setting parameter is set to 20 percent of the base current by default. The parameter must be set with a sufficient margin of 15...20 percent under the minimum expected load current. The setting must still exceed the maximum charging current of a feeder.

The *Voltage dead Lin Val* setting parameter is set to 70 percent of the base voltage by default. This is a suitable setting in most cases, but it is recommended to check the suitability in the actual application.

The *Cur voltage Det time* setting parameter is set to 0.02 seconds by default. This is suitable in most applications. This delay can be coordinated, for example, with the dead time settings of the AR shots to prevent the release of CVPSOF by the dead line detection function when the high-speed autoreclosing is in progress.

The *Dead line time* setting parameter is set to 0.2 seconds by default. This is suitable in most applications. The delay must not be set too short to avoid unwanted activations during the transients in the system.

The *SOTF reset time* setting parameter is set to 1 second by default. This is suitable for most applications.

## 5.8.7 Signals

### 5.8.7.1 CVPSOF Input signals

**Table 1169: CVPSOF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| CB_CL_CMD | BOOLEAN | 0=False | External enabling of SOTF by CB close command |
| START | BOOLEAN | 0=False | Start from function to be accelerated by SOTF |
| START_DLYD | BOOLEAN | 0=False | Start from function to be accelerated with delay by SOTF |

### 5.8.7.2 CVPSOF Output signals

**Table 1170: CVPSOF Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |

## 5.8.8 CVPSOF Settings

**Table 1171: CVPSOF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 1172: CVPSOF Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation mode | 1=Start<br>2=Current&voltage<br>3=Both | | | 3=Both | Mode of operation of SOTF Function |
| SOTF initialization | 1=SwitchCommand<br>-2=Voltage or SwitchCmd<br>-3=Current or SwitchCmd<br>-4=Cur&Vol or SwitchCmd | | | -2=Voltage or SwitchCmd | Switch onto fault initialization |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Current dead Lin Val | 0.01...1.00 | xIn | 0.01 | 0.20 | Dead line value, current. Used also in auto activation logic |
| Voltage dead Lin Val | 0.01...0.58 | xUn | 0.01 | 0.40 | Dead line value, voltage. Used also in auto activation logic |
| Cur voltage Det time | 0...60000 | ms | 10 | 20 | Time delay for voltage and current based detection |
| Operate time delay | 0...120000 | ms | 10 | 20 | Delay for the delayed start input |
| SOTF reset time | 0...60000 | ms | 10 | 1000 | SOTF detection period after initialization |
| Dead line time | 0...60000 | ms | 10 | 200 | Delay time for activation of dead line detection |

## 5.8.9 CVPSOF Monitored data

**Table 1173: CVPSOF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| CVPSOF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 5.8.10 Technical data

**Table 1174: CVPSOF Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2Hz |
| | Current: ±1.5 % of the set value or ±0.002 × $I_n$<br>Voltage: ±1.5 % of the set value or ±0.002 × $U_n$ |
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 5.9 Local acceleration logic DSTPLAL (ANSI 21LAL)

### 5.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Local acceleration logic | DSTPLAL | LAL | 21LAL |

### 5.9.2 Function block

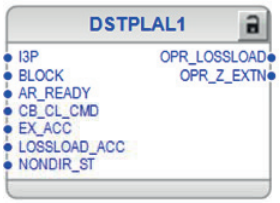



*Figure 698: Function block*

### 5.9.3 Functionality

The local acceleration logic function DSTPLAL is a complementary function to the distance protection function DSTPDIS. DSTPLAL is not intended for a stand-alone use.

The main purpose of DSTPLAL is to achieve a fast fault clearing which is independent of the fault location on the protected feeder when no communication channel is available between the local and remote terminals. DSTPLAL enables a fast fault clearing during certain conditions, but the function cannot completely replace the communication scheme logic.

DSTPLAL can be controlled either by the autorecloser (zone extension logic) or by monitoring the loss of load currents (the loss of load logic). Both operation modes are enabled independently.

## 5.9.4 Analog channel configuration

DSTPLAL has one analog group input which must be properly configured.

**Table 1175: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.9.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DSTPLAL can be described with a module diagram. All the modules in the diagram are explained in the next sections.

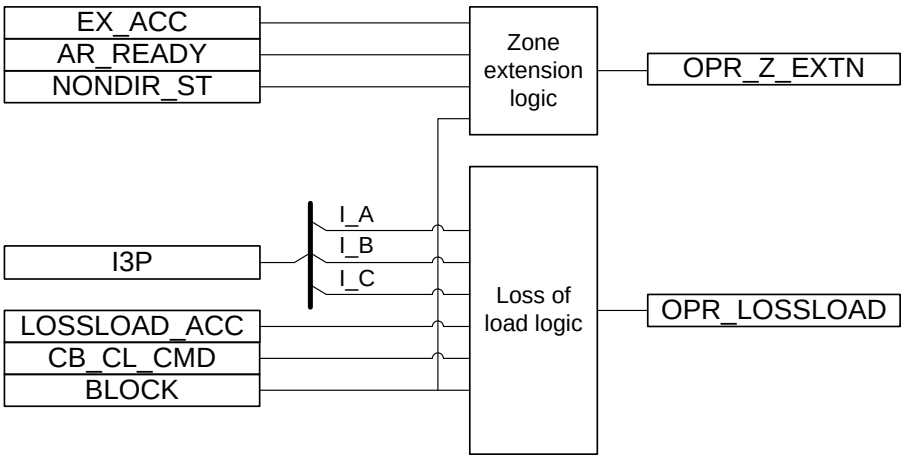



*Figure 699: Functional module diagram*

### Zone extension logic

Zone extension logic is enabled with *Operation mode* = "Zone extension".

When the zone extension operation mode is enabled, the autoreclosing function DARREC enables a fast fault clearance that covers the entire length of the protected

feeder. This is achieved by allowing a time-delayed overreaching zone to trip instantaneously when a fault occurs. For this purpose, one of the DSTPDIS zones can be configured with an independently set reach.

After the overreaching zone instantaneously trips, the autoreclosing sequence starts. If the fault is transient, the system may get restored in the first shot of AR. However, in case of a persistent fault only the first trip of the AR sequence is accelerated by Zone extension logic. During the rest of the sequence, Zone extension logic is blocked and AR initiation is performed selectively by the time-graded distance zones.

If the fault is located on the adjacent feeder or bus within the reach of the overreaching zone, tripping and AR initiation take place in an external fault.

Zone extension logic can be described using a module diagram.

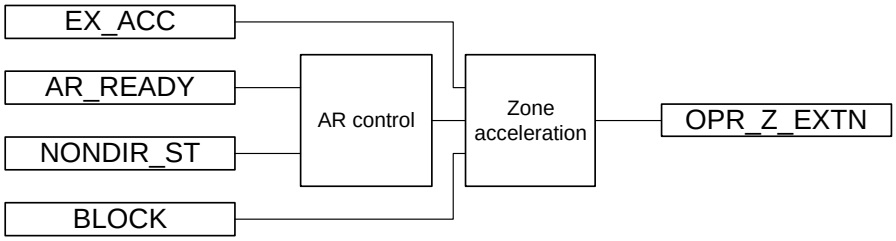



*Figure 700: Functional module diagram of Zone extension logic*

### AR control

The AR control module supervises the zone acceleration by monitoring the status of the AR_READY and NONDIR_ST input signals. The READY output signal from the autorecloser (AR) function, which indicates the status of the autoreclosing, is connected to the AR_READY input. The start signal from the non-directional zone is connected to the NONDIR_ST input. If the non-directional zone is not available for this, then the start output from the overreaching zone with the biggest reach or GFC can be used instead.

The permission for zone acceleration is given if AR_READY = TRUE, that is, the AR function is ready to start a new AR sequence. If the set reclaim time of the AR function expires before the fault is cleared, the NONDIR_ST input signal is used to block the activation of the zone acceleration. This ensures that the accelerated trip followed by the AR initiation is not repeated for the same fault regardless of the reclaim time setting and the reach of the overreaching zone connected to the EX_ACC input. Otherwise, this could lead to pumping of the circuit breaker, that is, the repetition of the first shot without being able to complete the desired AR sequence.

The AR control module blocks the Zone acceleration module after the initiation of the first shot until the AR sequence has been completed, that is, until the AR_READY input signal changes its state back from FALSE to TRUE.

### Zone acceleration

The start signal from the overreaching zone whose operation is to be accelerated is connected to the EX_ACC input. When the EX_ACC input is activated and, simultaneously, the AR control module gives permission for acceleration, the

operate signal from Zone extension logic is obtained from the OPR_Z_EXTN output, which is used to trip the circuit breaker and initiate the autoreclosing (the AR shot).

The activation of the BLOCK input blocks the OPR_Z_EXTN output.

### Loss of load logic

Loss of load logic is enabled with *Operation mode* = "Loss of load".

When the loss of load operation mode is enabled, a time-delayed overreaching zone is allowed to trip instantaneously if the loss of load current condition is detected.

The loss of load function does not operate in case of a three-phase fault as all the phases are faulty. Therefore, none of the current values drops below the *Minimum current* setting, meaning that the loss of load current condition cannot be detected.

Loss of load logic can be described using a module diagram.

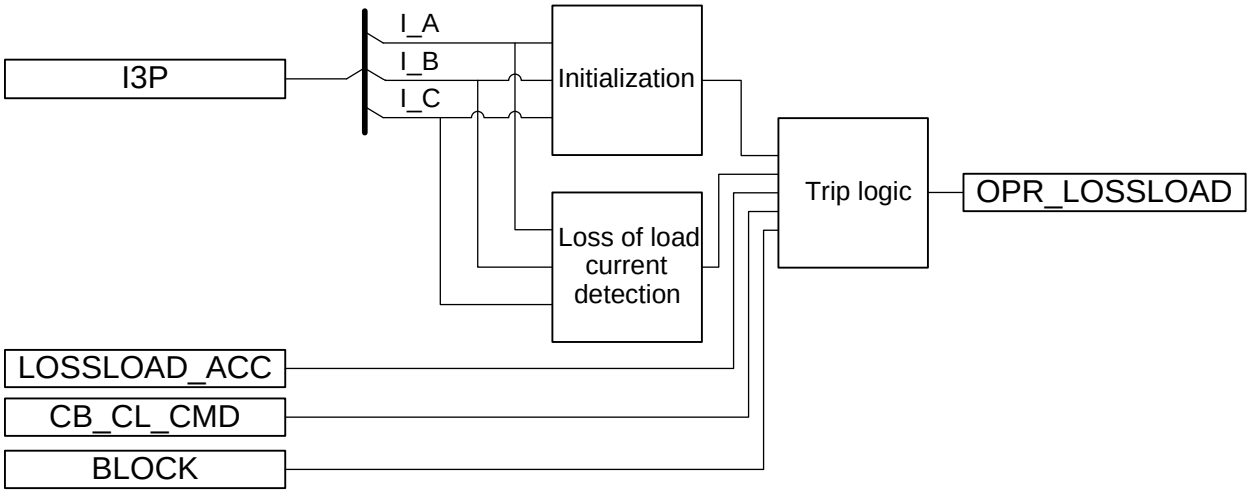



*Figure 701: Functional module diagram of Loss of load logic*

### Initialization

The Initialization module gives an enabling signal to the Trip logic module when the values of all three phase currents are above the set value of *Load current value* for more than the time set with *Load release on time*. The enabling signal has a drop-off delay defined with the *Load release off Tm* setting.

### Loss of load current detection

The Loss of load current detection module gives an enabling signal to the Trip logic module if any of the phase current values drops below the *Minimum current* setting due to a remote end breaker opening and, simultaneously, the value of at least one phase current exceeds the value of the *Load current value* setting due to a fault. Such a condition has to be valid for longer than the *Minimum current time* setting.

### Trip logic

The operate signal is obtained from the OPR_LOSSLOAD output if the enable signal is received from both Initialization and Loss of load current detection modules and, simultaneously, a fault is seen by the overreaching zone connected to the LOSSLOAD_ACC input.

The activation of the BLOCK input blocks the OPR_LOSSLOAD output. Temporary blocking is achieved using the circuit breaker's close command pulse connected to the CB_CL_CMD input. It is used to prevent an unwanted operation due to initial transients after the breaker is closed, for example, in case of inrush currents.

## 5.9.6 Application

DSTPLAL is used in those applications where the conventional communication scheme logic cannot be applied (when no communication channel is available), but the user still requires a fast clearance for the faults on the entire feeder.

DSTPLAL enables a fast fault clearing during certain conditions, but it is unable to replace the communication scheme logic due to a possible lack of selectivity during the first trip and AR initiation and also as the loss of load logic cannot operate for three-phase faults. DSTPLAL is controlled either by the autoreclosing (Zone extension logic) or by monitoring the loss of load current (Loss of load logic).

### Zone extension logic

The zone extension operation mode can be applied when the autoreclosing function DARREC is in operation. When the zone extension is enabled, DARREC is used to enable the fast fault clearance independent of the fault location on the protected feeder. This is achieved by allowing a time-delayed overreaching zone to trip instantly when a fault occurs. Also, if there are tapped loads on the protected feeder, it is required to set a dedicated zone to initiate one or two shots as fast as possible before the protection devices of these taps clear. If the fault is still present after these shots, further tripping is delayed in accordance with the other zones so that the operation becomes slower than the protection of the load taps, enabling it to clear. The final tripping that ends the sequence is always performed selectively according to the time grading of the zones.



If the fault is located on the adjacent feeder or bus within the reach of the overreaching zone, the tripping and the AR initiation take place during an external fault.

### Setting guidelines

The *Load current value* setting must be set below the minimum three-phase load current during the healthy state. A security factor of 0.5 is used:

*Load current value* = $0.5 \cdot I_{minload}$

$I_{minload}$ minimum load current during normal operation conditions

The loss of load function is released after *Load release on time* is elapsed and the load current in all three phases is above the *Load current value* setting. If the current values drop below the *Load current value* setting, the release condition stays activated until the drop-out delay time has expired (the *Load release off Tm* setting). The value of *Load release off Tm* is by default set to "0.3 s". The *Load release on time* setting is used to increase the security of the loss of load function, for example, in the case of transient inrush currents during the energizing of a power transformer. When there is no need for delaying the release, the *Load release on time* is set to zero in applications.

The *Minimum current* setting is used to detect the loss of load condition in healthy phases during the fault. The *Minimum current* setting is set to a value higher than the maximum current flowing in the healthy phases during the fault when

the breaker at the remote end has been opened and the load flowing through has therefore been disconnected. This current can be, for example, due to the charging current of the phases or the load current of the tapped loads. The *Minimum current* setting value is set below the *Load current value* setting. By default, the *Minimum current* setting value is set to "0.05 pu".

The *Minimum current time* setting is used to provide the start delay for the loss of load current detection to avoid an unwanted release of the function. The value of *Minimum current time* is by default set to "0.2 s".

## 5.9.7 Signals

### 5.9.7.1 DSTPLAL Input signals

**Table 1176: DSTPLAL Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| AR_READY | BOOLEAN | 0=False | Autoreclosure ready, releases function used for fast trip |
| CB_CL_CMD | BOOLEAN | 0=False | CB close command |
| EX_ACC | BOOLEAN | 0=False | Connected to function used for tripping at zone extension |
| LOSSLOAD_ACC | BOOLEAN | 0=False | Connected to function used for tripping at loss of load |
| NONDIR_ST | BOOLEAN | 0=False | Non directional criteria used to prevent instantaneous trip |

### 5.9.7.2 DSTPLAL Output signals

**Table 1177: DSTPLAL Output signals**

| Name | Type | Description |
|---|---|---|
| OPR_LOSSLOAD | BOOLEAN | Operate by loss of load |
| OPR_Z_EXTN | BOOLEAN | Operate by zone extension |

## 5.9.8 DSTPLAL Settings

**Table 1178: DSTPLAL Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Load current value | 0.01...1.00 | xIn | 0.01 | 0.10 | Load current before disturbance |
| Minimum current | 0.01...1.00 | xIn | 0.01 | 0.05 | Level taken as current loss due to remote CB trip |
| Load release off Tm | 0...60000 | ms | 10 | 300 | Time delay on drop off for load current release |
| Minimum current time | 0...60000 | ms | 10 | 200 | Time delay on pick-up for Minimum current value |
| Operation mode | 1=Zone extension<br>2=Loss of load<br>3=Both | | | 3=Both | Operation mode |
| Load release on time | 0...60000 | ms | 10 | 0 | Time delay on pick-up for load current release |

## 5.9.9 DSTPLAL Monitored data

**Table 1179: DSTPLAL Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| DSTPLAL | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.9.10 Technical data

**Table 1180: DSTPLAL Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±1.5 % of the set value or ±0.002 × $I_n$ |
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

# 5.10 Scheme communication logic DSOCPSCH (ANSI 85 21SCHLGC)

## 5.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Scheme communication logic | DSOCPSCH | CL | 85 21SCHLGC |

## 5.10.2 Function block

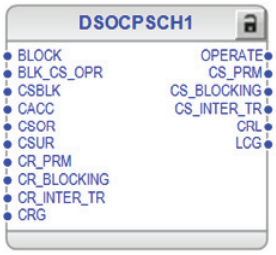



*Figure 702: Function block*

## 5.10.3 Functionality

The scheme communication logic function DSOCPSCH is used to achieve instantaneous fault clearing independent of the fault location on the protected feeder. Several communication scheme types are available.

- Direct underreaching transfer trip DUTT
- Permissive underreaching transfer trip PUTT
- Permissive overreaching transfer trip POTT
- Directional comparison blocking scheme DCB

The directional comparison unblocking scheme DCUB can also be implemented by complementing the permissive schemes with an additional logic called the unblocking function, which is also included in DSOCPSCH.

If the permissive overreach scheme is used, some of the power system conditions require additional special logic circuits, such as the current reversal and weak-end infeed logic function CRWPSCH.

## 5.10.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DSOCPSCH can be described with a module diagram. All the modules in the diagram are explained in the next sections.

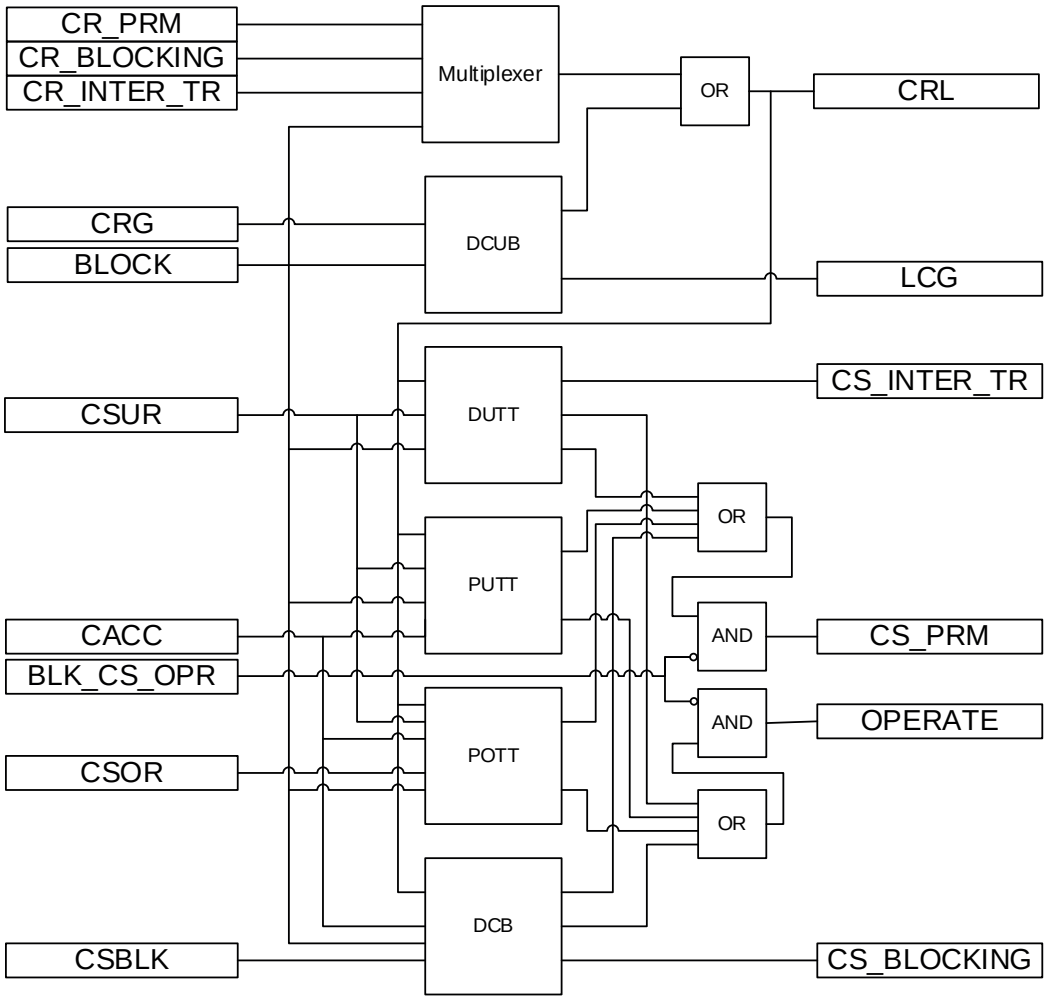



*Figure 703: Functional module diagram*

The applied communication scheme logic in DSOCPSCH is selected with the *Scheme type* setting.

**Table 1181: Communication scheme based on the Scheme type value**

| ***Scheme type* value** | **Communication scheme** |
|---|---|
| "Intertrip" | DUTT |
| "Permissive Underreach" | PUTT |
| "Permissive Overreach" | POTT |
| "Blocking" | DCB |

The unblocking scheme (DCUB) is enabled with the *Unblock Mode* setting.

### Multiplexer

The multiplexer connects an input signal to an output based on the value of the *Scheme type* setting.

**Table 1182: Connected inputs based on the Scheme type value**

| *Scheme type* value | Inputs connected to an output |
|---|---|
| "Intertrip" | CR_INTER_TR |
| "Permissive Underreach" or "Permissive Overreach" | CR_PRM |
| "Blocking" | CR_BLOCKING |

### Direct underreaching transfer trip scheme DUTT

The direct intertrip scheme is enabled with *Scheme type* = "Intertrip".

In the direct intertrip scheme, the start signal from the underreaching zone Z1 is connected to the CSUR input to create a carrier send CS_INTER_TR signal. The duration of the CSUR input signal is prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration for the CS_INTER_TR signal.

The local circuit breaker is directly tripped (activation of the OPERATE output) with the carrier received CS_INTER_TR signal after a settable pick-up delay *Coordination Time* has elapsed without further local criteria.

The unblocking function (*Unblock Mode* = "Permanent" and *Unblock Mode* = "Time window") must not be enabled with the DUTT scheme, as the lost guard signal results in an immediate trip of the local circuit breaker.

The activation of the BLOCK input totally blocks the direct intertrip scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

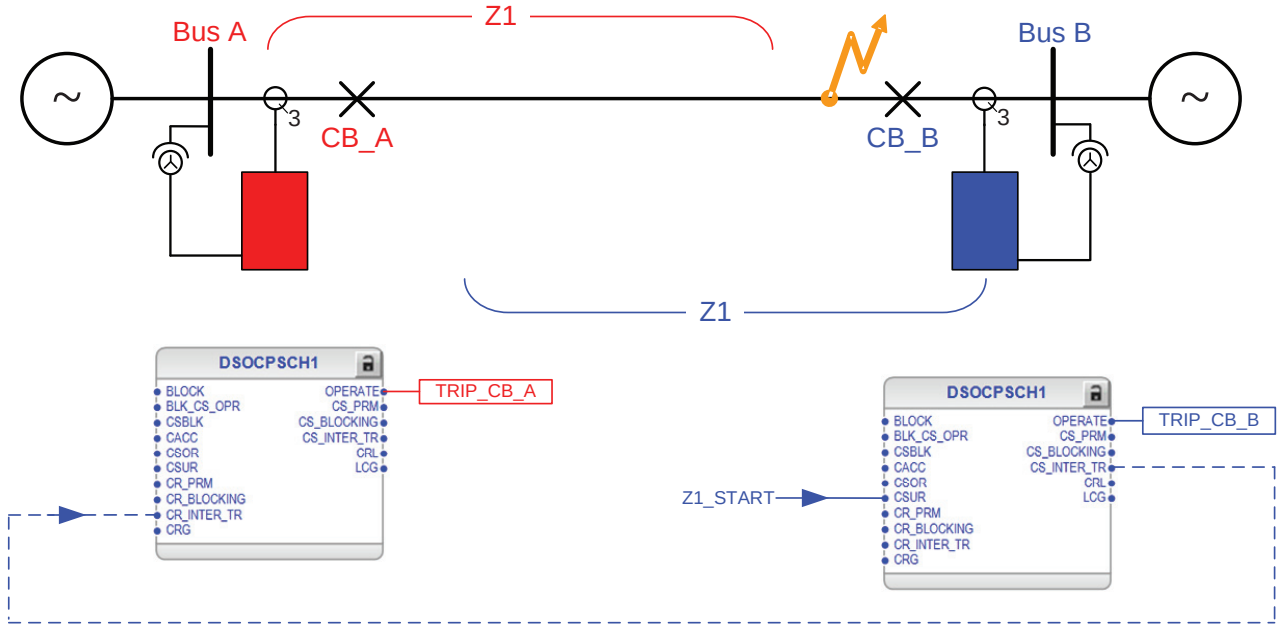



*Figure 704: Simplified functional diagram of the direct intertrip scheme*

### Permissive underreaching transfer trip scheme PUTT

The permissive underreach scheme is enabled with *Scheme type* = "Permissive Underreach".

In the permissive underreach scheme, the start signal from the underreaching zone Z1 is connected to the CSUR input to create a CS_PRM signal. The duration of the CSUR input signal can be prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_PRM signal.

In the permissive underreach scheme, the CS_PRM signal, or the CRL signal if the unblocking function is enabled, is used to allow the overreaching zone Z2 to trip (activation of the OPERATE output) after the pick-up delay *Coordination Time*. The start signal from the overreaching zone Z2 is connected to the CACC input.

Activating the BLOCK input totally blocks the permissive underreach scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

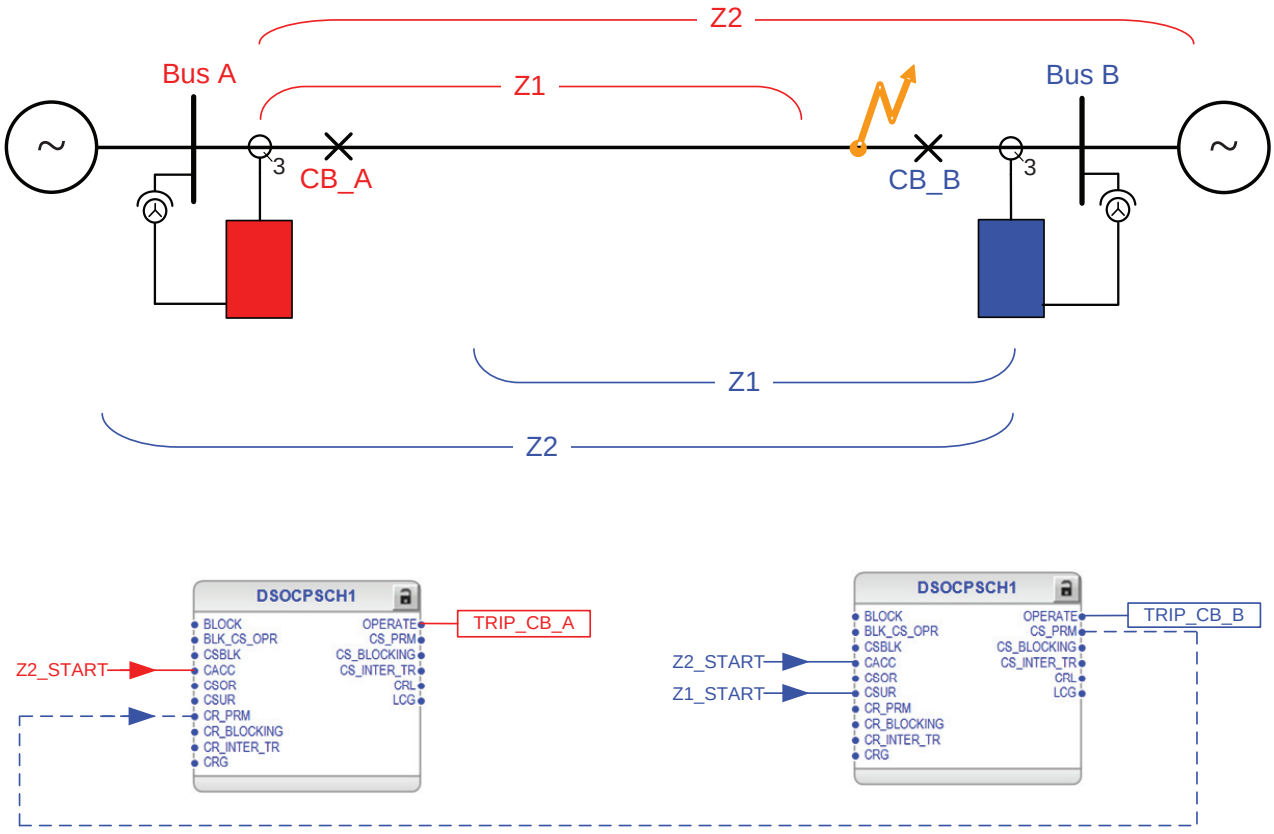



*Figure 705: Simplified functional diagram of the permissive underreach scheme*

**Permissive overrreaching transfer trip scheme POTT**

The permissive overreach scheme is enabled with *Scheme type* = "Permissive Overreach".

In this scheme, the start signal from the overreaching zone Z2 is connected to the CSOR input to create a CS_PRM signal. The CS_PRM signal can also be issued simultaneously from the underreaching zone Z1. In this case, the start signal from the underreaching zone Z1 is connected to the CSUR input. The duration of the CSUR input signal is prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_PRM signal.

In case of parallel feeders, and when the external current reversal logic (CRWPSCH) is enabled, the CS_PRM signal is not prolonged and the value of *Carrier Min Dur* is set to zero to secure correct operation.

In the permissive overreach scheme, the received signal CR_PRM, or CRL if the unblocking function is enabled, is used to allow the overreaching zone Z2 to trip (activation of the OPERATE output) after the settable pick-up delay *Coordination Time*. The start signal from the overreaching zone is connected to the CACC input.

Activating the BLOCK input totally blocks the permissive overreach scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

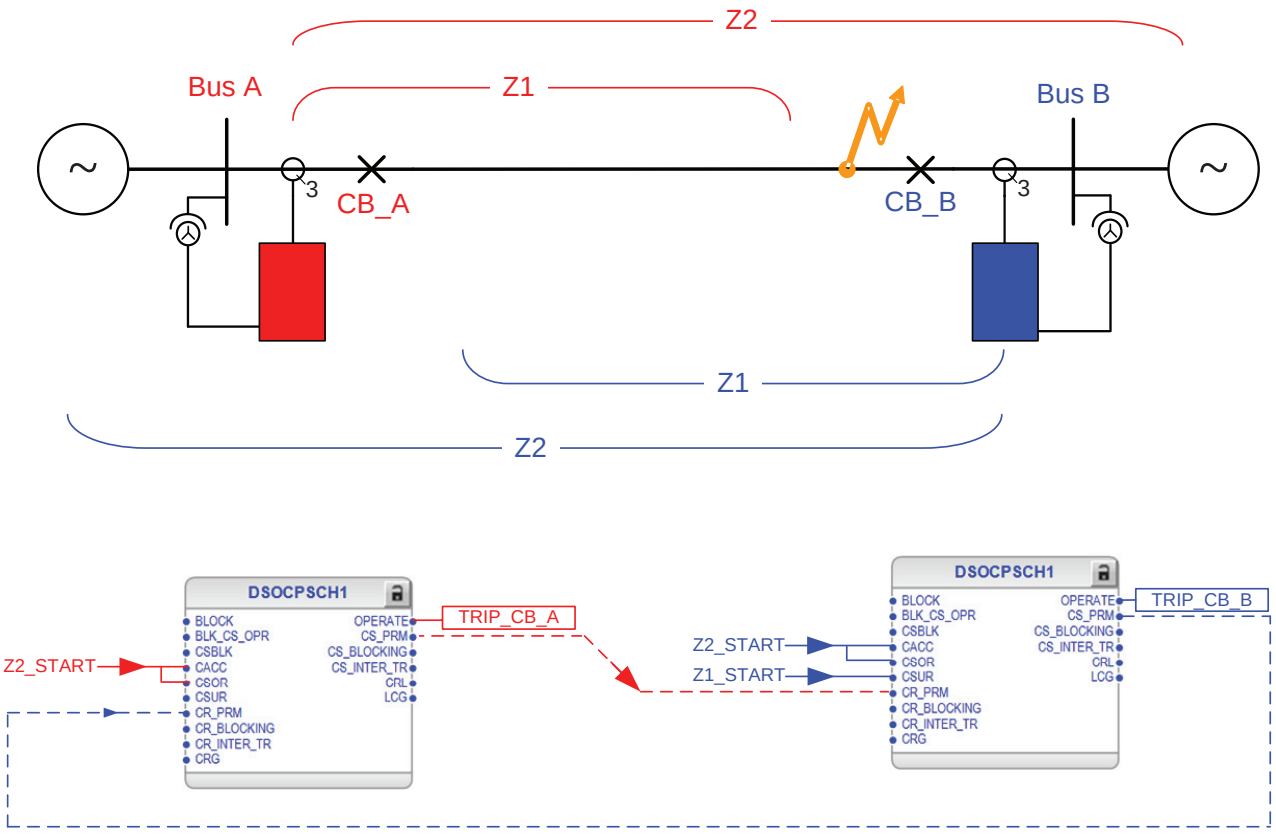



*Figure 706: Simplified functional diagram of the permissive overreach scheme*

**Directional comparison blocking scheme DCB**

The directional comparison blocking scheme is enabled with *Scheme type* = "Blocking".

In the blocking scheme, the start signal from the reverse-looking zone Z3 is connected to the CSBLK input to create a CS_BLOCKING signal. The starting of the reverselooking zone indicates that the fault is located outside the protected feeder. The duration of the CSBLK input signal can be prolonged with the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_BLOCKING signal.

The blocking scheme is mainly used to allow the overreaching zone Z2 to trip (activation of the OPERATE output) after the settable *Coordination Time* has elapsed, and if no blocking signal is received from the remote terminal. To prevent a false trip in case of an external fault, the block signal CR_BLOCKING must be received before the *Coordination Time* has elapsed. The start signal from the overreaching zone Z2 is connected to the CACC input.

The *Coordination Time* setting in the blocking scheme depends, for example, on the communication system delay and on the terminal's

response times in transmitting the CS_BLOCKING signal to the other feeder end. The *Coordination Time* setting must not be zero.

Activating the BLOCK input totally blocks the directional comparison blocking scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

In *Figure 707*, in case of internal faults, the CS_BLOCKING signal is not sent because the fault is not sent as it is not seen by the reverse-looking zones (Z3).

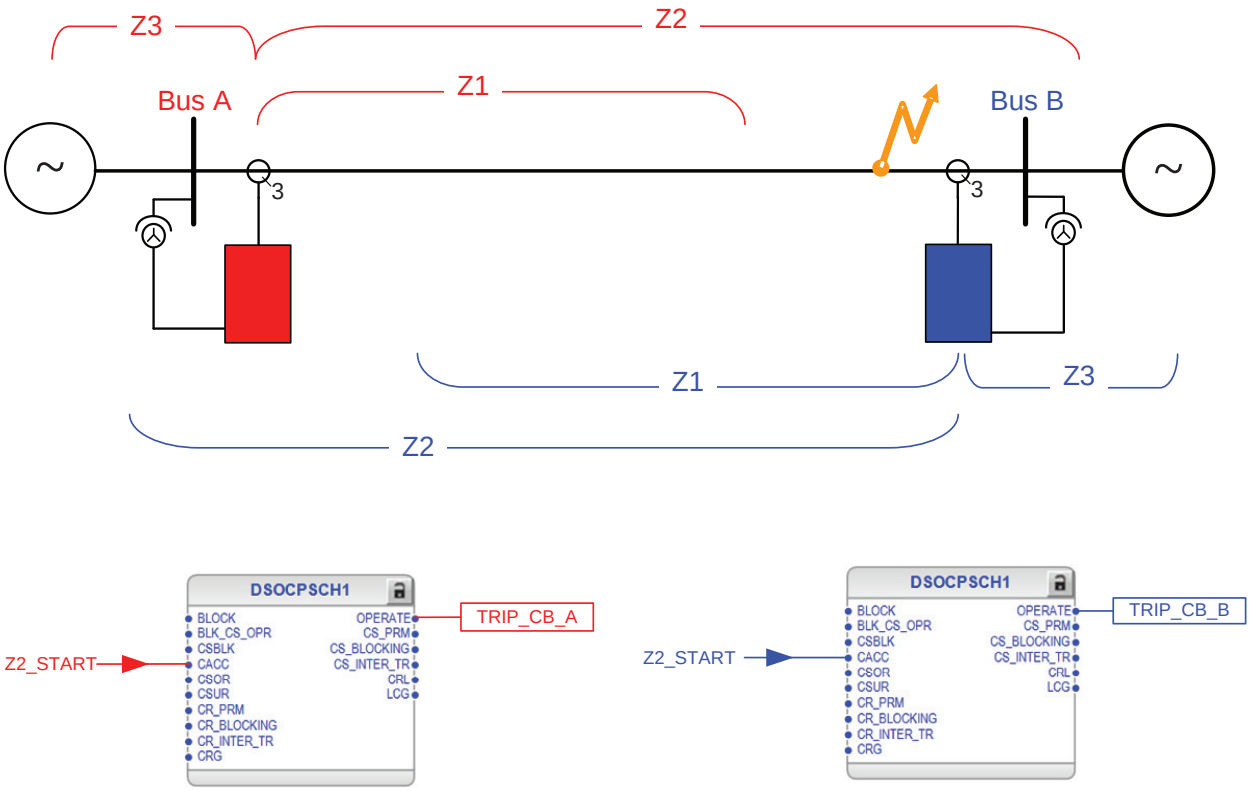



*Figure 707: Simplified functional diagram of the blocking scheme, internal fault*

In *Figure 708*, in case of external faults, the protection relay at bus B sees the fault in the reverse direction and sends a blocking signal CS_BLOCKING to the protection relay at bus A. There is no CB operation at either end.

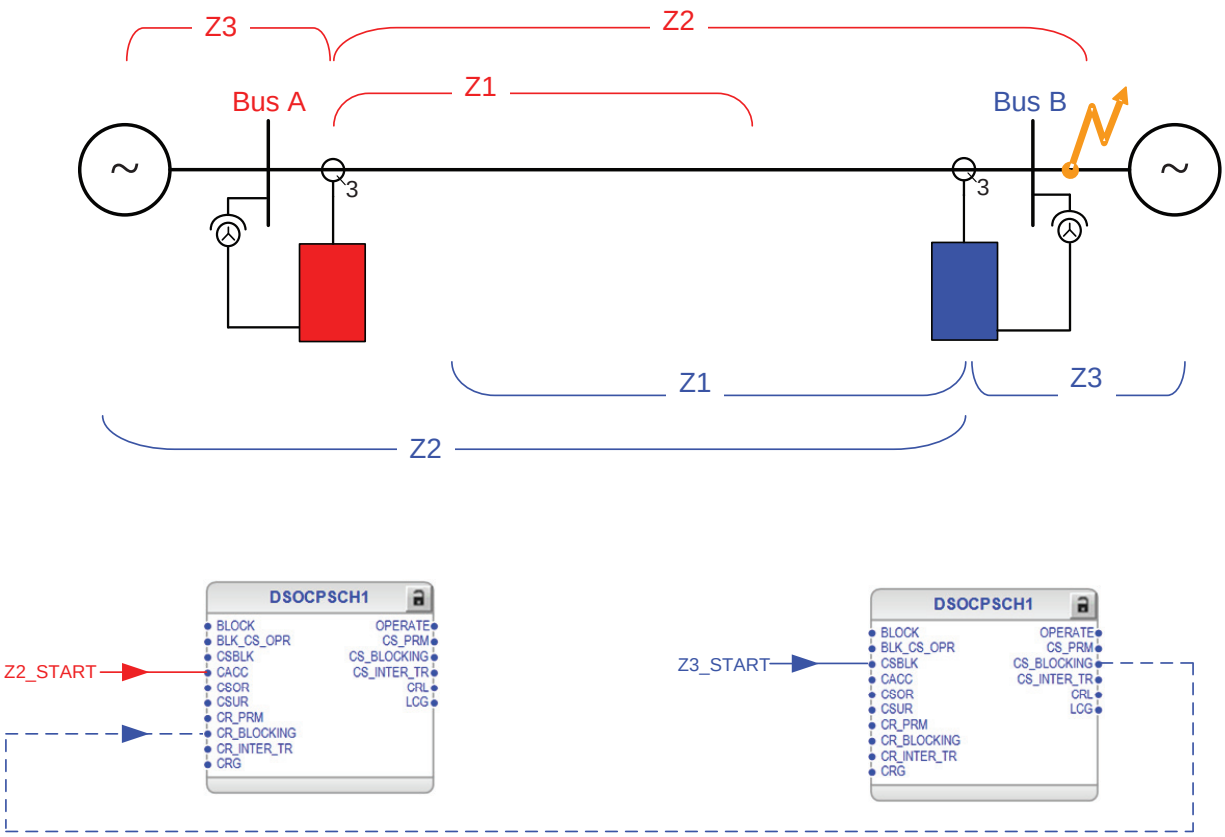



*Figure 708: Simplified functional diagram of the blocking scheme, external fault*

The unblocking function used with the blocking function provides a possibility to supervise the communication channel. In this case, the CRL output signal is used as a local blocking signal.

The operation mode *Unblock Mode* = "Time window" is not recommended as the blocking is activated only for 150 ms after the guard signal disappears. This results in an unwanted operation of the protection.

**Directional comparison unblocking scheme DCUB**

The unblocking function is a complementary logic which can be used together with the permissive communication schemes. In the unblocking scheme, the dependability of the permissive schemes is improved by using the loss of guard signal from the communication equipment to create a CRL output signal locally. This enables the permissive scheme to operate even if the communication channel is interrupted or lost.

The unblocking function uses a carrier guard signal which must always be present. The absence of the CRG signal for a time longer than the value of the *Loss of carrier time* setting generates a logical CRL signal. A communication failure shorter than the value of the *Loss of carrier time* setting is always ignored.

The unblocking function is configured with the *Unblock Mode* setting.

- *Unblock Mode* = "Off": The unblocking function is disabled.
- *Unblock Mode* = "Permanent": If the CRG signal disappears for a longer time than defined in the *Loss of carrier time* setting, the logical CRL signal is

generated. The CRL output signal remains active until the CRG signal reappears. The communication failure is not signaled by the LCG output.

- *Unblock Mode* = "Time window": If the CRG signal disappears for a longer time than defined in the *Loss of carrier time* setting, the CRL output signal is generated. The CRL output signal remains active for 150 ms, after which a communication failure is signaled by the LCG output. The LCG output is reset 200 ms after the CRG signal reappears. The purpose of this mode is to ensure tripping during a fixed delay of 150 ms after the loss of communication due to possible consequences of an internal fault. After this time, the accelerated tripping is allowed only if the CR_PRM signal is received again.

With operation modes *Unblock Mode* = "Permanent" and *Unblock Mode* = "Time window", the created CRL output signal is internally ORed with the CR_PRM input to allow the permissive scheme to operate even when the communication channel has been interrupted or lost. The CRL and LCG output signals are also available as outputs for monitoring purposes. Activating the BLOCK input blocks the CRL and LCG outputs.

## 5.10.5 Application

To achieve fast fault clearing on the part of the protected feeder not covered by the instantaneous zone Z1, the stepped distance protection function can be used with DSOCPSCH.

Applying DSOCPSCH requires a communication channel capable of transmitting an "On" or "Off" signal in each direction. To enable fast tripping, the most important requirement for the communication channel is the communication speed.

The performance of DSOCPSCH is directly related to the communication channel speed, and to the security against false or lost signals. Therefore, dedicated communication channels are recommended. With short distances of up to a few kilometers, a typical communication media is a simple pilot wire based on auxiliary power. With distances of up to 50 km with the integrated communication interface or up to 150 km with external equipment, fibre-optic cables using digital data transmission can be used. To avoid false signals causing unwanted operation, the security of the communication channel should be emphasized. Also, the dependability of the communication channel should be considered to ensure that the signals are reliably transmitted during the power system faults.

DSOCPSCH supports five communication schemes.

- Direct underreaching transfer trip DUTT
- Permissive underreaching transfer trip PUTT
- Permissive overreaching transfer trip POTT
- Directional comparison blocking scheme DCB
- Directional comparison unblocking scheme DCUB

Depending on whether the communication channel is used for sending a block or a trip signal, the communication schemes can be divided into blocking schemes and permissive schemes.

In permissive schemes, the trip signals of the distance zones are interchanged between the terminals to receive a permission to trip during an internal fault. The tripping of the local terminal depends on both the starting of its own forward-looking zone and on the received signal from the opposite terminal. In the underreaching scheme, no signals are sent during an external fault. During an external fault, a trip signal is also sent to the opposite terminal if the fault is seen

in the forward direction and the overreaching scheme is used. However, in case of external faults, tripping is always blocked because either no signal is received as the opposite terminal sees a reverse fault or because the signal is received but the fault is seen in the reverse direction. In either case, the blocking is not dependent on the received signal so a lost communication channel does not result in false operation.

In the blocking scheme, a blocking signal is sent to the opposite terminal if the fault is locally seen in the reverse direction, that is, during an external fault. Thus, the blocking is dependent on the received signal, and there is typically a need to delay the tripping of the terminal receiving the blocking signal. This delay depends, for example, on the response times of the communication channel and terminals. During an internal fault, there is no signal transmission between the terminals, so the tripping does not depend on the received signal from the opposite terminal.

In conclusion, compared to the blocking schemes, the permissive schemes are inherently faster and have better security [1] against false tripping, since tripping in an external fault is not possible in case of a channel interruption. In a blocking scheme, a lost communication channel and a simultaneous external fault may lead to a false operation of the protection if the communication channel is not supervised. On the other hand, as the fast trip of the permissive scheme depends on the received signal, its dependability [2] is lower than that of the blocking scheme.

The unblocking scheme enhances the dependability of the permissive scheme. If the communication channel is interrupted and, simultaneously, a fault occurs in the forward direction, tripping is still possible either during a fixed time interval, counting from the beginning of the interruption, or for as long as the communication channel is lost. This is achieved by connecting the supervision output of the implemented communication functionality to the dedicated carrier guard signal input of DSOCPSCH. In general, the unblocking scheme provides better security than the blocking scheme because tripping in external faults is only possible if the fault occurs within the fixed time interval after the beginning of the channel interruption.

The direct transfer trip scheme uses the underreaching zone to trip the local breaker and to transfer the trip signal to a remote terminal. The remote terminal operates immediately based on the received transfer trip signal, without any additional conditions. This scheme is very simple, but the security is low as a spurious signal results in false operation of the protection.

**Direct underreaching transfer trip DUTT**

In some applications, there is a need to trip the remote-end breaker immediately because of fault detection by the local measurements. This applies, for example, when the transformers or reactors are connected to the system without circuit breakers, or for remote tripping after the operation of the local breaker failure protection (CBFP).

In the direct intertrip scheme (DUTT), the carrier send signal `CS_INTER_TR` is initiated by an underreaching zone, or by the tripping signal from an external protection relay, such as transformer or reactor protection. At the remote end, the received signal initiates a breaker trip immediately without any further local protection criteria. To limit the risk of an unwanted trip due to spurious sending of signals, the trip can be delayed by the *Coordination Time* setting, which should be set to 10...30 ms, depending on the type of the communication channel. The

[1] The ability to block operation in case of an external fault.
[2] The ability to operate in case of an internal fault.

communication channel operating in direct intertripping applications should be secure and dependable.

**Setting guidelines for the intertrip scheme DUTT**

- *Scheme type* = "Intertrip"
- *Coordination Time* = "0.050" s (10 ms + maximal transmission time)
- *Carrier Min Dur* = "0.1" s

**Permissive underreaching transfer trip PUTT**

In the permissive underreach scheme, the permission to trip is obtained locally from the underreaching zone and sent to the remote end. The received signal is combined with the local fault indication from the overreaching zone resulting in a trip command after a settable pick-up delay *Coordination Time*.

The protection relay of either feeder end sends a permissive signal to trip the other end. The communication channel must be able to receive and transmit at the same time. In permissive schemes, the communication channel must be fast and secure, but also dependable. Inadequate security causes unwanted tripping for the external faults. Inadequate speed or dependability causes delayed tripping for internal faults.

The CS_PRM signal is issued based on the underreaching zone Z1.

The underreach scheme is not applicable on short feeder lengths because the impedance measurement cannot easily distinguish between the internal and external faults in such cases.

The underreaching zones Z1 at the local and remote ends must overlap to prevent a gap between the protection zones, where the faults are not detected. If the underreaching zone does not meet the required sensitivity, for example, the fault infeed from a remote end, the blocking or permissive overreach scheme is considered.

To achieve an instantaneous trip, the carrier received signal CR_PRM must be received when the overreaching zone Z2 is still starting. In some cases, due to a fault in current distribution, the overreaching zone can operate only after the fault has been cleared by the remote terminal. In this case, there is a risk that if the remote terminal is tripped directly by, for example, zone Z1, the CR_PRM signal issued by the zone resets before the overreaching zone of the local end terminal has operated. To assure a sufficient duration of the CR_PRM signal, the CR_PRM signal can be prolonged by the time *Carrier Min Dur*. The recommended value of the *Carrier Min Dur* setting is "0.1" s.

The received communication signal is combined with the output from the local overreaching zone. Therefore, there is less concern about a false signal causing an incorrect trip, and therefore the timer *Coordination Time* is set to "0". A communication channel failure does not affect the selectivity, but delays the tripping at the other end for certain fault locations.

**Setting guidelines for the permissive underreach scheme PUTT**

- *Scheme type* = "Permissive Underreach"
- *Coordination Time* = "0" s
- *Carrier Min Dur* = "0.1" s

**Permissive overreaching transfer trip POTT**

In the permissive overreach scheme, the permission to trip is obtained locally from an overreaching zone and sent to the remote end. The received signal is then combined with the local fault indication from the overreaching zone, resulting in a trip command after a settable pick-up delay *Coordination Time*.

The protection relay at either end of the feeder sends a permissive signal to trip the other end. Therefore the communication channel must be able to receive and transmit at the same time. The communication on permissive schemes should be fast and secure.

The CS_PRM signal is issued based on the overreaching zone Z2.

The permissive overreach scheme can be used for all feeder types and lengths.

In the permissive overreach scheme, the communication channel plays an essential role in obtaining a fast tripping at both ends. Typically, a lost communication channel does not cause false tripping. However, it delays the operation of the protection for the faults anywhere on the feeder.

The communication channel for a permissive overreach scheme must be fast and secure, but also dependable. Inadequate security can cause unwanted tripping for external faults. Inadequate speed or dependability can cause delayed tripping for internal faults.

In the permissive overreaching scheme, the CS_PRM signal can be issued in parallel both from the overreaching and underreaching zones. The CS_PRM signal from the overreaching zone must not be prolonged, while the CS_PRM signal from the underreaching zone must typically be prolonged. In parallel feeder applications, the scheme typically needs to be complemented by the current reversal logic. To ensure the correct operation in this case, the CS_PRM signal must not be prolonged (*Carrier Min Dur* = "0" s). There is no need to delay the tripping while receiving the carrier signal, so the timer *Coordination Time* is set to "0".

**Setting guidelines for the permissive overreaching transfer trip scheme POTT**

- *Scheme type* = "Permissive Overreach"
- *Coordination Time* = "0" s
- *Carrier Min Dur* = "0.1" s
- *Carrier Min Dur* = "0" s (in case of parallel lines and current reversal logic)

**Directional comparison blocking scheme DCB**

In the blocking scheme, the reverse-looking zone Z3 is used for sending a block signal to the remote end to block the overreaching zone.

The blocking scheme is very dependable because it operates on faults anywhere on the protected feeder, even if the communication channel is out of service. Conversely, it is less secure than a permissive scheme because it trips for the external faults within the reach of the overreaching local zone if the communication channel is out of service and no block signal is received.

Inadequate speed or low dependability of the communication channel can cause spurious tripping for external faults.

To secure that the blocking signal arrives before the local overreaching zone trips, the trip is delayed by the *Coordination Time* setting. This setting must be set longer than the sum of the maximal transmission time of the channel and the start and response times of the protection relays sending and receiving the CS_BLOCKING

signal. A security margin of at least 10 ms should be considered. The time delay *Carrier Min Dur* for prolonging the CS_BLOCKING signal is set to "0".

**Setting guidelines for the blocking scheme DCB**

- *Scheme type* = "Blocking"
- *Coordination Time* = "0.1" s (10 ms + maximal transmission time)
- *Carrier Min Dur* = "0" s

**Directional comparison unblocking scheme DCUB**

Metallic communication paths unfavorably affected by fault-generated noise or by other electrical phenomena, such as lightning, are not suitable for conventional permissive schemes that rely on the signal transmitted during a fault in the protected feeder. Principally, the communication media must be properly shielded or otherwise designed to provide an adequate performance during such conditions.

The unblocking scheme can be used to overcome the lower dependability of permissive schemes. The function is used in older, less reliable communication, where the signal has to be sent through the primary fault. The unblocking function uses a carrier guard signal CRG which must always be present, even when no CR_PRM signal is received. Due to the absence of the CRG signal during the security time, the *Loss of carrier time* setting is used as a CR_PRM signal. This also enables a permissive scheme to operate when the communication channel is temporarily lost during an internal fault.

**Setting guidelines for the unblocking scheme DCUB**

The unblocking function is configured with the *Unblock Mode* setting.

- *Unblock Mode* = "Off": The unblocking function is disabled.
- *Unblock Mode* = "Permanent": If the CRG signal disappears for a longer time than defined in the *Loss of carrier time* setting, a logical carrier received signal CRL is generated. The CRL signal remains active until the CRG signal is present. The communication failure is not signalled by the LCG output. The *Loss of carrier time* setting is set to "35" ms.
- *Unblock Mode* = "Time window": If the CRG signal disappears for a longer time period than the *Loss of carrier time* setting, a CRL signal is generated. The CRL signal remains active for 150 ms, after which a communication failure is signalled by the LCG output. The value of the LCG output is reset 200 ms after the CRG signal reappears. The *Loss of carrier time* setting is set to "35" ms.

## 5.10.6 Signals

### 5.10.6.1 DSOCPSCH Input signals

**Table 1183: DSOCPSCH Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_CS_OPR | BOOLEAN | 0=False | Signal for blocking CS and Operate in all schemes |
| CSBLK | BOOLEAN | 0=False | Reverse directed distance protection zone signal for requesting activation of TxBlk |
| CACC | BOOLEAN | 0=False | Permissive distance protection zone signal |
| CSOR | BOOLEAN | 0=False | Overreaching distance protection zone signal |
| CSUR | BOOLEAN | 0=False | Underreaching distance protection zone signal |
| CR_PRM | BOOLEAN | 0=False | Received teleprotection permissive from the other side |
| CR_BLOCKING | BOOLEAN | 0=False | Received teleprotection blocking from the other side |
| CR_INTER_TR | BOOLEAN | 0=False | Received direct trip from the other side |
| CRG | BOOLEAN | 0=False | Carrier guard signal received |

### 5.10.6.2 DSOCPSCH Output signals

**Table 1184: DSOCPSCH Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| CS_PRM | BOOLEAN | Permissive transmitted to the other side |
| CS_BLOCKING | BOOLEAN | Blocking transmitted to the other side |
| CS_INTER_TR | BOOLEAN | Direct trip transmitted to the other side |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| CRL | BOOLEAN | Carrier received after unblock logic |
| LCG | BOOLEAN | Loss of guard |

## 5.10.7 DSOCPSCH Settings

**Table 1185: DSOCPSCH Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Scheme type | 1=None<br>2=Intertrip<br>3=Permissive Underreach<br>4=Permissive Overreach<br>5=Blocking | | | 3=Permissive Underreach | Scheme type, mode of operation |
| Carrier Min Dur | 0...60000 | ms | 1 | 100 | Minimum duration of a carrier send signal |
| Coordination Time | 0...60000 | ms | 1 | 35 | Co-ordination timer for blocking scheme |

**Table 1186: DSOCPSCH Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Unblock Mode | 1=Off<br>2=Permanent<br>3=Time window | | | 1=Off | Operation mode of unblocking logic |
| Loss of carrier time | 0...60000 | ms | 1 | 35 | Pickup security timer on loss of carrier guard signal |

## 5.10.8 DSOCPSCH Monitored data

**Table 1187: DSOCPSCH Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| DSOCPSCH | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 5.10.9 Technical data

**Table 1188: DSOCPSCH Technical data**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |

## 5.11 Communication logic for residual overcurrent RESCPSCH (ANSI 85 67G/N SCHLGC)

### 5.11.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Communication logic for residual overcurrent | RESCPSCH | CLN | 85 67G/N SCHLGC |

### 5.11.2 Function block

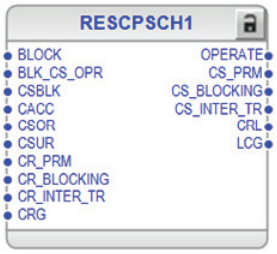



*Figure 709: Function block*

### 5.11.3 Functionality

The communication logic for residual overcurrent function RESCPSCH is used to achieve instantaneous fault clearing independent of the fault location on the protected feeder. There are four available communication scheme types.

- Direct underreaching transfer trip DUTT
- Permissive underreaching transfer trip PUTT
- Permissive overreaching transfer trip POTT
- Directional comparison blocking scheme DCB

The directional comparison unblocking scheme DCUB can also be provided by complementing the permissive schemes with an additional logic called the unblocking function, which is also included in RESCPSCH.

If the permissive overreaching scheme is used, some of the power system conditions require additional special logic circuits, such as the current reversal and weak-end infeed logic for residual overcurrent function RCRWPSCH.

## 5.11.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of RESCPSCH can be described with a module diagram. All the modules in the diagram are explained in the next sections.

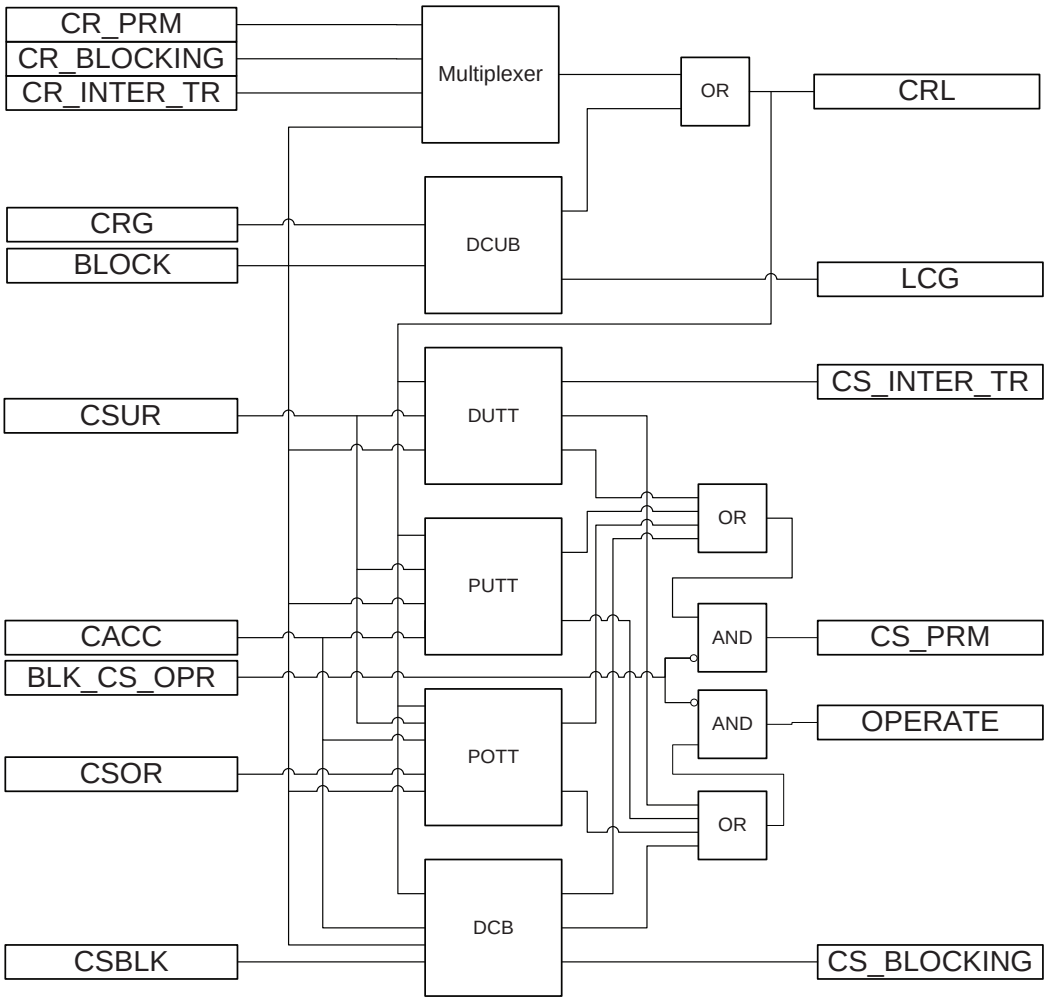



*Figure 710: Functional module diagram*

The applied communication scheme logic in RESCPSCH is selected with the *Scheme type* setting.

**Table 1189: Communication scheme based on the Scheme type value**

| ***Scheme type* value** | **Communication scheme** |
|---|---|
| "Intertrip" | DUTT |
| "Permissive Underreach" | PUTT |
| "Permissive Overreach" | POTT |
| "Blocking" | DCB |

The unblocking scheme (DCUB) is enabled with the *Unblock mode* setting.

### Multiplexer

The multiplexer connects an input signal to an output based on the value of the *Scheme type* setting.

**Table 1190: Connected inputs based on the Scheme type value**

| *Scheme type* value | Inputs connected to an output |
|---|---|
| "Intertrip" | CR_INTER_TR |
| "Permissive Underreach" or "Permissive Overreach" | CR_PRM |
| "Blocking" | CR_BLOCKING |

### Direct underreaching transfer trip scheme DUTT

The direct intertrip scheme is enabled with *Scheme type* = "Intertrip".

In the direct intertrip scheme, the start signal from the underreaching (instantaneous) residual overcurrent function DEFHPDEF is connected to the CSUR input to create a carrier send CS_INTER_TR signal. The duration of the CSUR input signal can be prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration for the CS_INTER_TR signal.

The local circuit breaker is directly tripped (activation of the OPERATE output) with the carrier received CS_INTER_TR signal after a settable pick-up delay *Coordination time* has elapsed without further local criteria.

The unblocking function (*Unblock mode* = "Permanent" and *Unblock mode* = "Time window") must not be enabled with the DUTT scheme, as the lost guard signal results in an immediate trip of the local circuit breaker.

The activation of the BLOCK input totally blocks the direct intertrip scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

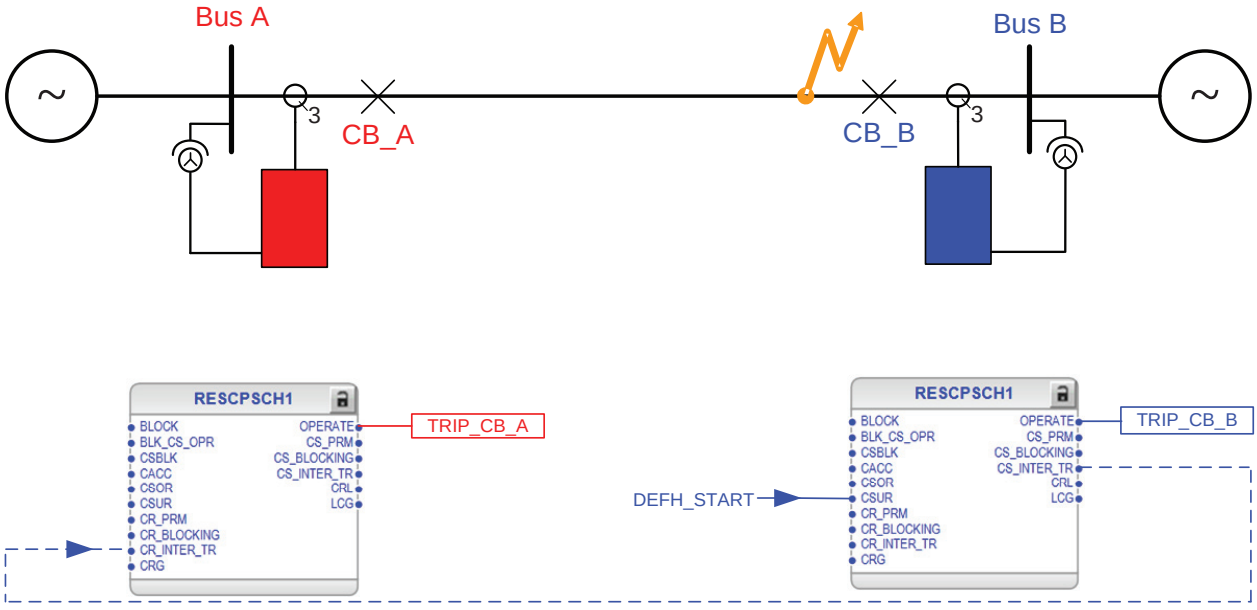



*Figure 711: Simplified functional diagram of the direct intertrip scheme*

**Permissive underreaching transfer trip scheme PUTT**

The permissive underreach scheme is enabled with *Scheme type* = "Permissive Underreach".

In the permissive underreach scheme, the start signal from the underreaching (instantaneous) residual overcurrent function DEFHPDEF is connected to the CSUR input to create a CS_PRM signal. The duration of the CSUR input signal can be prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_PRM signal.

In the permissive underreach scheme, the CR_PRM signal or CRL signal, if the unblocking function is enabled, is used to allow the overreaching residual overcurrent function DEFLPDEF to trip (activation of the OPERATE output) after the pick-up delay *Coordination time*. The start signal from the overreaching function is connected to the CACC input. A general start signal in the forward direction can also be connected to the CACC input.

The CS_PRM signal is also generated if the CR_PRM signal is received and the local carrier acceleration signal CACC is active.

Activating the BLOCK input totally blocks the permissive underreach scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

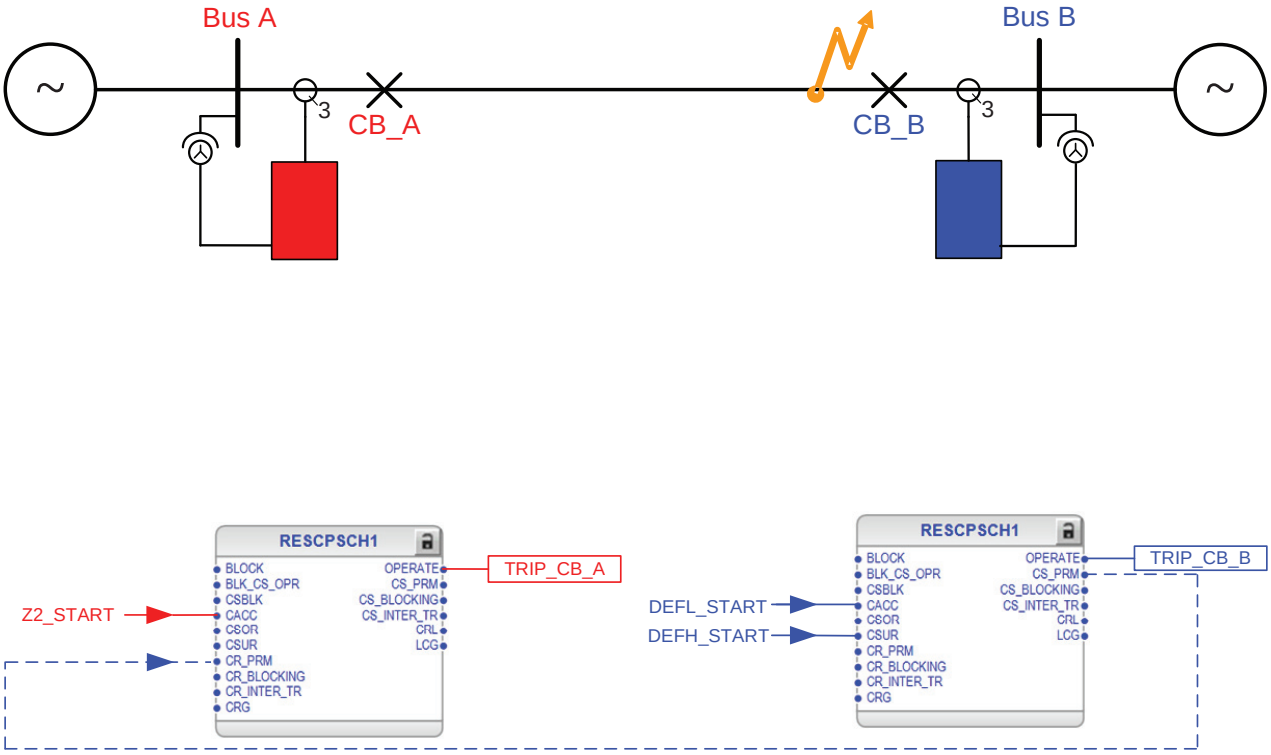



*Figure 712: Simplified functional diagram of the permissive underreach scheme*

**Permissive overrreaching transfer trip scheme POTT**

The permissive overreach scheme is enabled with *Scheme type* = "Permissive Overreach".

In this scheme, the START signal from the overreaching residual overcurrent function DEFLPDEF is connected to the CSOR input to create a CS_PRM signal. The CS_PRM signal can also be issued simultaneously from the underreaching residual overcurrent function DEFHPDEF. In this case, the start signal from the

underreaching function is connected to the CSUR input. The duration of the CSUR input signal can be prolonged by the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_PRM signal.

In case of parallel feeders, when the external current reversal logic (RCRWPSCH) is enabled, the CS_PRM signal is not prolonged and the value of *Carrier Min Dur* is set to zero to secure correct operation.

In the permissive overreach scheme, the received signal CR_PRM or CRL, if the unblocking function is enabled, is used to allow the overreaching residual overcurrent function DEFLPDEF to trip (activation of the OPERATE output) after the settable pick-up delay *Coordination time*. The start signal from the overreaching zone is connected to the CACC input.

The CS_PRM signal is also generated if the CR_PRM signal is received and the local carrier acceleration signal CACC is active.

Activating the BLOCK input totally blocks the permissive overreach scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

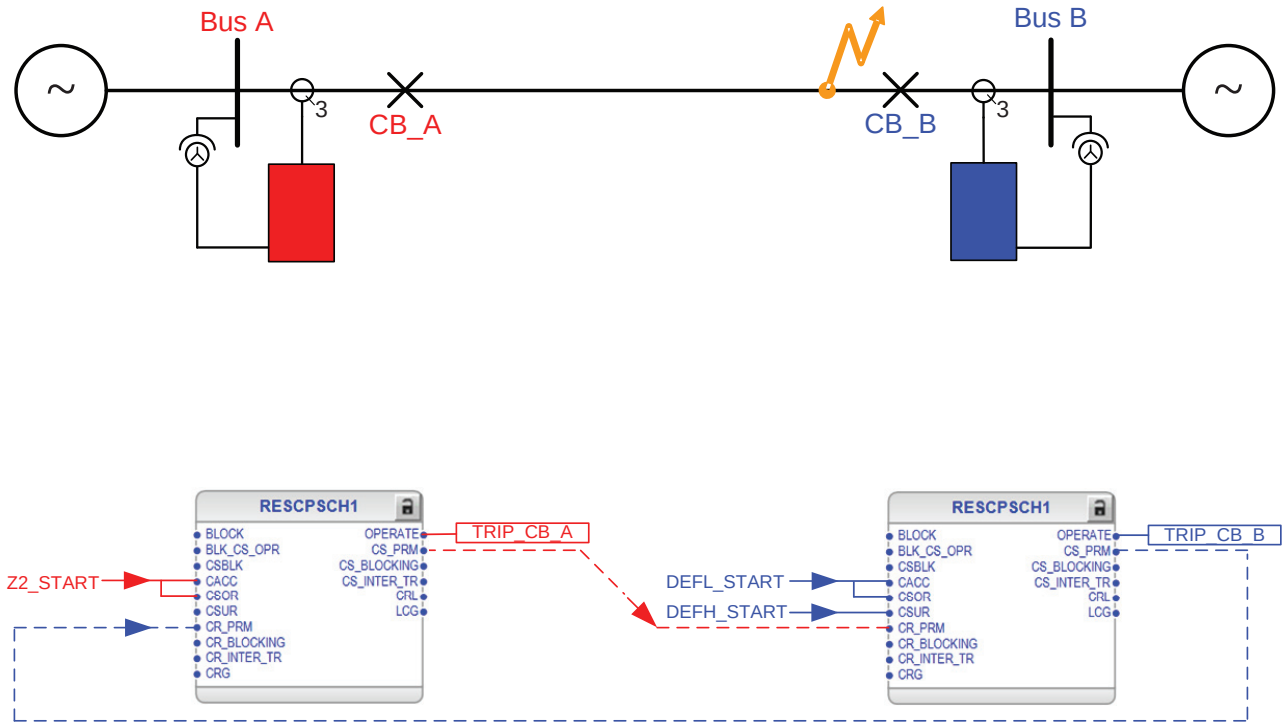



*Figure 713: Simplified functional diagram of the permissive overreach scheme*

**Directional comparison blocking scheme DCB**

The directional comparison blocking scheme is enabled with *Scheme type* = "Blocking".

In the blocking scheme, the START signal from the reverse-looking residual overcurrent function DEFLPDEF set to operate for the reverse direction earth fault, is connected to the CSBLK input to create a CS_BLOCKING signal. The starting of the reverse-looking function indicates that the fault is located outside the protected feeder. The duration of the CSBLK input signal can be prolonged with the *Carrier Min Dur* setting to ensure a sufficient duration of the CS_BLOCKING signal.

The blocking scheme is mainly used to allow the forward-looking overreaching residual overcurrent function to trip (activation of the OPERATE output) after the

settable *Coordination time*, and if no block signal is received from the remote terminal. To prevent a false trip in case of external faults, the CR_BLOCKING signal must be received before the *Coordination time* has elapsed. The start signal from the overreaching residual overcurrent function DEFLPDEF is connected to the CACC input.

The *Coordination time* setting in the blocking scheme depends, for example, on the communication system delay and on the terminal's response times in transmitting a CS_BLOCKING signal to the other feeder end. The *Coordination time* setting must not be zero.

Activating the BLOCK input totally blocks the directional comparison blocking scheme. The CS_PRM and OPERATE outputs can be blocked by the BLK_CS_OPR input.

In *Figure 714*, in case of internal faults, the CS_BLOCKING signal is not sent as the fault is not seen by the reverse-looking overreaching function.

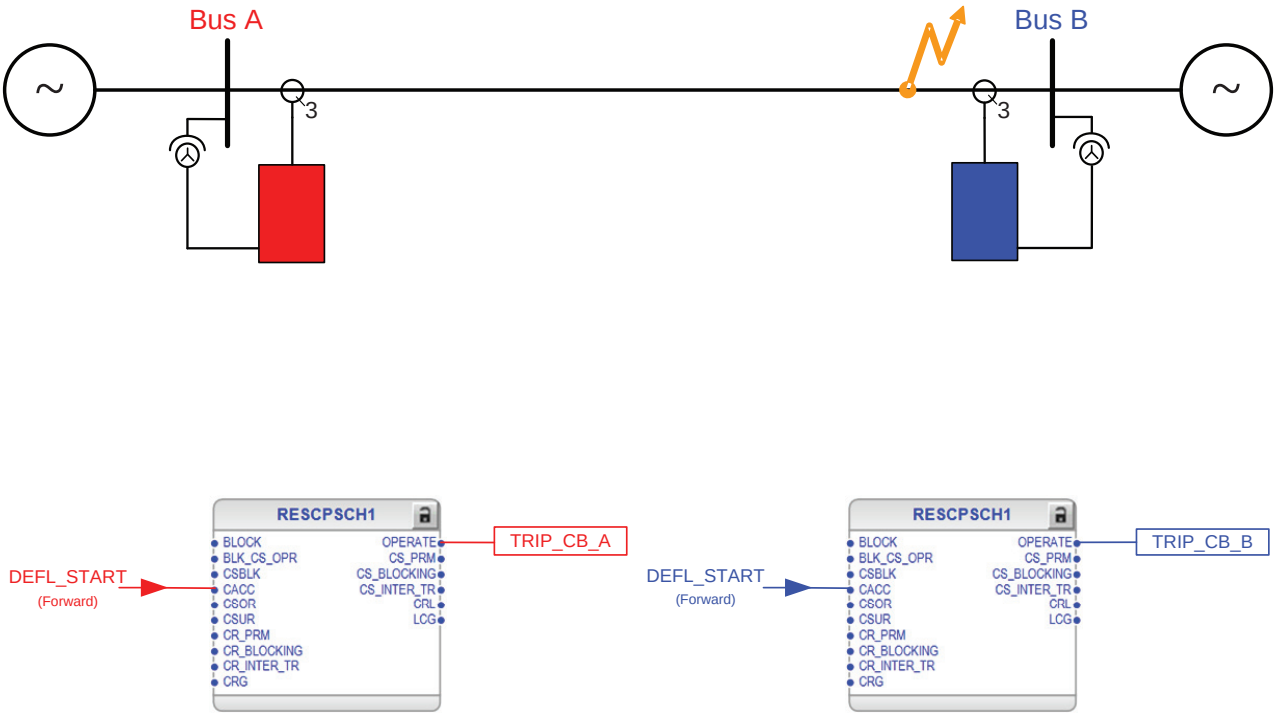



*Figure 714: Simplified functional diagram of the blocking scheme, internal fault*

In *Figure 715*, in case of external faults, the protection relay at bus B sees the fault in the reverse direction and sends a blocking signal CS_BLOCKING to the protection relay at bus A. There is no CB operation at either end.

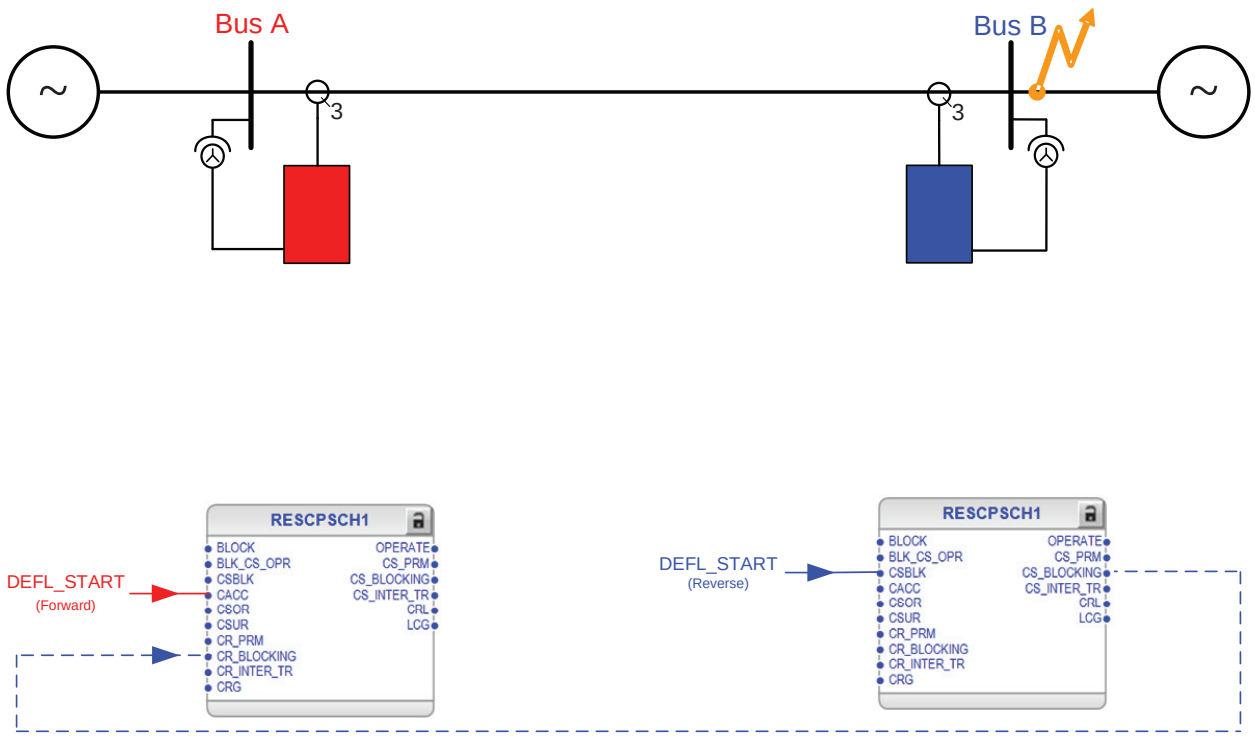



*Figure 715: Simplified functional diagram of the blocking scheme, external fault*

The unblocking function used with the blocking function provides a possibility to supervise the communication channel. In this case, the CRL output signal is used as a local blocking signal.

The operation mode *Unblock mode* = "Time window" is not recommended as the blocking is activated only for 150 ms after the guard signal disappears. This results in an unwanted operation of the protection.

**Directional comparison unblocking scheme DCUB**

The unblocking function is a complementary logic which can be used together with the permissive communication schemes. In the unblocking scheme, the dependability of the permissive schemes is improved by using the loss of guard signal from the communication equipment to create a CRL output signal locally. This enables the permissive scheme to operate even if the communication channel is interrupted or lost.

The unblocking function uses a carrier guard signal which must always be present. The absence of the CRG signal for a time longer than the value of the *Loss of carrier time* setting generates a logical CRL signal. A communication failure shorter than the value of the *Loss of carrier time* setting is always ignored.

The unblocking function is configured with the *Unblock mode* setting.

- *Unblock mode* = "Off": The unblocking function is disabled.
- *Unblock mode* = "Permanent": If the CRG signal disappears for a longer time than defined in the *Loss of carrier time* setting, the logical CRL signal is generated. The CRL output signal remains active until the CRG signal reappears. The communication failure is not signaled by the LCG output.

- *Unblock mode* = "Time window": If the CRG signal disappears for a longer time than defined in the *Loss of carrier time* setting, the CRL output signal is generated. The CRL output signal remains active for 150 ms, after which a communication failure is signaled by the LCG output. The LCG output is reset 200 ms after the CRG signal is present again. The purpose of this mode is to ensure tripping during a fixed delay of 150 ms after the loss of communication due to possible consequences of an internal fault. After this time, the accelerated tripping is allowed only if the CR_PRM signal is received again.

With operation modes *Unblock mode* = "Permanent" and *Unblock mode* = "Time window", the created CRL output signal is internally ORed with the CR_PRM input to allow the permissive scheme to operate even when the communication channel has been interrupted or lost. The values of CRL and LCG output signals are also available through the Monitored data view. Activating the BLOCK input blocks the CRL and LCG outputs.

## 5.11.5 Application

To achieve fast fault clearing on the part of the protected feeder not covered by the instantaneous step of the residual overcurrent protection, the directional residual overcurrent protection can be used with RESCPSCH.

Applying RESCPSCH requires a communication channel capable of transmitting an "On" or "Off" signal in each direction. To enable fast tripping, the most important requirement for communication is the communication speed.

The performance of RESCPSCH is directly related to the communication channel speed, and to the security against false or lost signals. Therefore, dedicated communication channels are recommended. With short distances of up to a few kilometers, a typical communication media is a simple pilot wire based on auxiliary power. With distances of up to 150 km, fibre-optic cables using digital data transmission can be used. To avoid false signals that could cause unwanted operation, the security of the communication channel should be emphasized. Also, the dependability of the communication channel should be considered to ensure that the signals are reliably transmitted during power system faults.

RESCPSCH supports five communication schemes.

- Direct underreaching transfer trip DUTT
- Permissive underreaching transfer trip PUTT
- Permissive overreaching transfer trip POTT
- Directional comparison blocking scheme DCB
- Directional comparison unblocking scheme DCUB

Depending on whether the communication channel is used for sending a block or a trip signal, the communication schemes can be divided into blocking schemes and permissive schemes.

In permissive schemes, the trip signals of the directional residual overcurrent protection are interchanged between the terminals to receive a permission to trip during an internal fault. The tripping of the local terminal depends on both the starting of its own forward-looking function and the received signal from the opposite terminal. In the underreaching scheme, no signals are sent during an external fault. A trip signal is sent to the opposite terminal during an external fault if the fault is seen in the forward direction and the overreaching scheme is used. However, in case of external faults, tripping is always blocked because either no signal is received as the opposite terminal sees a reverse fault or the signal

is received but locally the fault is seen in the reverse direction. In either case, the blocking is not dependent on the received signal so a lost communication channel does not result in false operation.

In the blocking scheme, a blocking signal is sent to the opposite terminal if the fault is locally seen in the reverse direction, that is, during an external fault. Thus, the blocking is dependent on the received signal, and there is typically a need to delay the tripping of the terminal receiving the blocking signal. This delay depends, for example, on the response times of the communication channel and terminals. During an internal fault, there is no signal transmission between the terminals, so the tripping does not depend on the received signal from the opposite terminal.

In conclusion, permissive schemes are inherently faster and have better security [1] against false tripping than a blocking scheme, since tripping in an external fault is not possible in case of a channel interruption. In a blocking scheme, a lost communication channel and a simultaneous external fault may lead to a false operation of the protection if the communication channel is not supervised. On the other hand, as the fast trip of the permissive scheme depends on a received signal, its dependability [2] is lower than that of the blocking scheme.

The unblocking scheme enhances the dependability of the permissive scheme. If the communication channel is interrupted and, simultaneously, a fault occurs in the forward direction, tripping is still possible either during a fixed time interval after the beginning of the interruption or as long as the communication channel is lost. This is achieved by connecting the supervision output of the implemented communication functionality to the dedicated carrier guard signal input of RESCPSCH. In general, the unblocking scheme provides better security than the blocking scheme because tripping in external faults is only possible if the fault occurs within the fixed time interval after the beginning of the channel interruption.

The direct transfer trip scheme uses the underreaching function to trip the local breaker and to transfer the trip signal to the remote terminal. The remote terminal operates immediately based on the received transfer trip signal, without any additional conditions. This scheme is very simple, but its security is low as a spurious signal results in false operation of the protection.

**Direct underreaching transfer trip DUTT**

In some applications, there is a need to trip the remote end breaker immediately because of fault detection by the local measurements. This applies, for example, when the transformers or reactors are connected to the system without circuit breakers, or for remote tripping following the operation of the local breaker failure protection (CBFP).

In the direct intertrip scheme (DUTT), the carrier send signal `CS_INTER_TR` is initiated by the underreaching or the tripping signal of an external protection relay, such as transformer or reactor protection. At the remote end, the received signal initiates the breaker trip immediately without any further local protection criteria. To limit the risk of an unwanted trip due to spurious sending of signals, the trip can be delayed by the *Coordination time* setting, which should be set to 10...30 ms, depending on the type of the communication channel. The communication channel operating in direct intertripping applications should be secure and dependable.

**Setting guidelines for the intertrip scheme DUTT**

- *Scheme type* = "Intertrip"

[1] The ability to block operation in case of an external fault.
[2] The ability to operate in case of an internal fault.

- *Coordination time* = "0.050" s (10 ms + maximal transmission time)
- *Carrier Min Dur* = "0.1" s

**Permissive underreaching transfer trip PUTT**

In the permissive underreach scheme, a permission to trip is obtained locally from the underreaching function and sent to the remote end. The received signal is then combined with the local fault indication from the overreaching function resulting in a trip command after a settable pick-up delay *Coordination time*.

The protection relay of either feeder end sends a permissive signal to trip the other end. The communication channel must be able to receive and transmit at the same time. In permissive schemes, the communication channel must be fast and secure, but also dependable. Inadequate security causes unwanted tripping for external faults. Inadequate speed or dependability causes delayed tripping for internal faults.

The CS_PRM signal is issued based on the underreaching residual overcurrent protection function.

The permissive scheme is not applicable on short feeder lengths because the residual overcurrent protection cannot easily distinguish between the internal and external faults in such cases.

The residual overcurrent function may start only at one end due to the system conditions such as weak zero-sequence source at one end, or high fault resistance. However, fast tripping from both ends can be achieved by connecting a general forward start signal to CACC. So, even if the local overreaching residual overcurrent function has not picked up, the local OPERATE output is activated. The function also generates a CS_PRM signal by combining the carrier received CR_PRM signal from a remote end and also the local activation of CACC, giving the permission to a remote function to trip instantaneously.

The CR_PRM signal must be received when the overreaching residual overcurrent protection is still active to achieve an instantaneous trip. In some cases, due to the fault current distribution, the overreaching protection can operate only after the fault has been cleared by the remote terminal. In this case, there is a risk that if the remote terminal is tripped directly by the instantaneous underreaching function, the CS_PRM signal that it issues resets before the overreaching function of the local end terminal is operated. To ensure a sufficient duration of the CR_PRM signal, the CS_PRM signal can be prolonged by time *Carrier Min Dur*. The recommended value of the *Carrier Min Dur* setting is "0.1" s.

The received communication signal is combined with the output from the local overreaching function. Therefore, there is less concern about a false signal causing an incorrect trip. Therefore, the timer *Coordination time* can be set to "0". A communication channel failure does not affect the selectivity, but delays the tripping at the other end for certain fault locations.

**Setting guidelines for the permissive underreach scheme PUTT**

- *Scheme type* = "Permissive Underreach"
- *Coordination time* = "0" s
- *Carrier Min Dur* = "0.1" s

**Permissive overreaching transfer trip POTT**

In the permissive overreach scheme, the permission to trip is obtained locally from an overreaching function and sent to the remote end. The received signal is then

combined with the local fault indication from the overreaching function, resulting in a trip command after a settable pick-up delay *Coordination time*.

The protection relay at either end of the feeder sends a permissive signal to trip the other end. Therefore the communication channel must be able to receive and transmit at the same time. A general requirement for the communication on permissive schemes is that it should be fast and secure.

In the permissive overreach scheme, the CS_PRM signal is issued based on the start of the overreaching residual overcurrent function.

The residual overcurrent function may start at one end due to the system conditions such as weak zero-sequence source at one end, or high fault resistance. However, fast tripping from both ends can be achieved by connecting a general forward start signal to CACC. So, even if the local overreaching residual overcurrent function has not picked up, the local OPERATE is activated. The function also generates a CS_PRM signal by combining the CR_PRM signal from a remote end and local activation of CACC, giving permission to the remote function to trip instantaneously.

The permissive overreach scheme can be used for all feeder types and lengths.

In the permissive overreach scheme, the communication channel is essential for obtaining fast tripping at both ends. Typically, a lost communication channel does not cause false tripping, but it delays the operation of the protection for the faults on the feeder.

The communication channel for a permissive overreach scheme must be fast and secure, but also dependable. Inadequate security can cause unwanted tripping for external faults. Inadequate speed or dependability can cause delayed tripping for internal faults.

In the permissive overreaching scheme, the CS_PRM signal can be issued in parallel both from the overreaching and underreaching functions. The CS_PRM signal from the overreaching function must not be prolonged, while the CS_PRM signal from the underreaching function must typically be prolonged. In parallel feeder applications, the scheme typically needs to be complemented by the current reversal logic. To ensure a correct operation in this case, the CS_PRM signal must not be prolonged (*Carrier Min Dur* = "0" s). There is no need to delay the tripping when receiving the carrier signal, so the time *Coordination time* is set to "0".

**Setting guidelines for the permissive overreaching transfer trip scheme POTT**

- *Scheme type* = "Permissive Overreach"
- *Coordination time* = "0" s
- *Carrier Min Dur* = "0.1" s
- *Carrier Min Dur* = "0" s (in case of parallel lines and current reversal logic)

**Directional comparison blocking scheme DCB**

In the blocking scheme, the reverse-looking residual overcurrent function is used for sending a block signal to the remote end to block the overreaching forward-looking residual overcurrent function.

The blocking scheme is very dependable because it operates for faults anywhere on the protected feeder, even if the communication channel is out of service. Conversely, it is less secure than a permissive scheme because it trips for the external faults within the reach of the overreaching local function if the communication channel is out of service and no block signal is received.

Inadequate speed or low dependability of the communication channel can cause spurious tripping for external faults.

To secure that the blocking signal arrives before the local overreaching function trips, the trip is delayed by the *Coordination time* setting. This setting must be set longer than the sum of the maximal transmission time of the channel and the start and response times of the protection relays sending and receiving the CS_PRM signal. A security margin of at least 10 ms should be considered. The time delay *Carrier Min Dur* for prolonging the CS_PRM signal is set to "0".

**Setting guidelines for the blocking scheme**

- *Scheme type* = "Blocking"
- *Coordination time* = "0.1" s (10 ms + maximal transmission time)
- *Carrier Min Dur* = "0" s

**Directional comparison unblocking scheme DCUB**

Metallic communication paths adversely affected by fault-generated noise or by other electrical phenomena, such as lightning, are not suitable for conventional permissive schemes that rely on signal transmission during a fault in the protected feeder. Principally, the communication media must be properly shielded or otherwise designed to provide an adequate performance during such conditions.

The unblocking scheme can be used to overcome the lower dependability of permissive schemes. The function is used in older, less reliable communication, where the signal has to be sent through the primary fault. The unblocking function uses a carrier guard signal CRG which must always be present, even when no CR_PRM signal is received. Due to the absence of the CRG signal during the security time, the *Loss of carrier time* setting is used as a CR_PRM signal. This also enables a permissive scheme to operate when the communication channel is temporarily lost during an internal fault.

**Setting guidelines for the unblocking scheme**

- *Unblock mode* = "Off": The unblocking function is disabled.
- *Unblock mode* = "Permanent": If the CRG signal disappears for a longer time period than defined in the Loss of carrier time setting, a logical carrier received signal CRL is generated. The CRL signal remains active until the CRG signal is present. The communication failure is not signalled by the LCG output. The *Loss of carrier time* setting is set to "35" ms.
- *Unblock mode* = "Time window": If the CRG signal disappears for a longer time period than the *Loss of carrier time* setting, a CRL signal is generated. The CRL signal remains active for 150 ms, after which a communication failure is signalled by the LCG output. The value of the LCG output is reset 200 ms after the CRG signal reappears. The *Loss of carrier time* setting is set to "35" ms.

## 5.11.6 Signals

### 5.11.6.1 RESCPSCH Input signals

**Table 1191: RESCPSCH Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_CS_OPR | BOOLEAN | 0=False | Signal for blocking CS and OPR in all schemes |
| CSBLK | BOOLEAN | 0=False | Reverse residual overcurrent signal for Carrier Send |
| CACC | BOOLEAN | 0=False | Signal to be used for tripping by Communication Scheme |
| CSOR | BOOLEAN | 0=False | Overreaching residual overcurrent signal for Carrier Send |
| CSUR | BOOLEAN | 0=False | Underreaching residual overcurrent signal for Carrier Send |
| CR_PRM | BOOLEAN | 0=False | Received teleprotection permissive from the other side |
| CR_BLOCKING | BOOLEAN | 0=False | Received teleprotection blocking from the other side |
| CR_INTER_TR | BOOLEAN | 0=False | Received direct trip from the other side |
| CRG | BOOLEAN | 0=False | Carrier guard signal received |

### 5.11.6.2 RESCPSCH Output signals

**Table 1192: RESCPSCH Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| CS_PRM | BOOLEAN | Permissive transmitted to the other side |
| CS_BLOCKING | BOOLEAN | Blocking transmitted to the other side |
| CS_INTER_TR | BOOLEAN | Direct trip transmitted to the other side |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| CRL | BOOLEAN | Carrier received after unblock logic |
| LCG | BOOLEAN | Loss of guard |

## 5.11.7 RESCPSCH Settings

**Table 1193: RESCPSCH Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Scheme type | 1=None<br>2=Intertrip<br>3=Permissive Underreach<br>4=Permissive Overreach<br>5=Blocking | | | 3=Permissive Underreach | Scheme type, mode of operation |
| Carrier Min Dur | 0...60000 | ms | 1 | 100 | Minimum duration of carrier send signal |
| Coordination time | 0...60000 | ms | 1 | 35 | Co-ordination timer for blocking scheme |

**Table 1194: RESCPSCH Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Unblock mode | 1=Off<br>2=Permanent<br>3=Time window | | | 1=Off | Unblock function mode for scheme type |
| Loss of carrier time | 0...60000 | ms | 1 | 35 | Pickup security timer on loss of carrier guard signal |

## 5.11.8 RESCPSCH Monitored data

**Table 1195: RESCPSCH Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| RESCPSCH | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 5.11.9 Technical data

**Table 1196: RESCPSCH Technical data**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |

## 5.12 Current reversal and weak-end infeed logic CRWPSCH (ANSI 85 21CREV,WEI)

### 5.12.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current reversal and weak-end infeed logic | CRWPSCH | CLCRW | 85 21CREV,WEI |

### 5.12.2 Function block

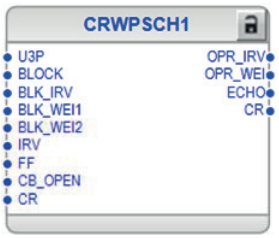



*Figure 716: Function block*

### 5.12.3 Functionality

The current reversal and weak-end infeed logic function CRWPSCH can be used when the scheme communication logic DSOCPSCH requires additional logics to operate correctly in all power system conditions.

In parallel feeder applications, the fault current direction on the healthy feeder can change when the circuit breaker on the faulty feeder opens to clear the fault. This can lead to an unwanted operation of the distance protection on the healthy parallel feeder when DSOCPSCH is used with the permissive overreach scheme. The main purpose of the current reversal logic is to prevent such unwanted operations.

The permissive communication schemes can operate only when the protection in the remote terminal can detect the fault. This detection requires sufficient minimum fault current. If such current is not available due to a too weak remote end source, the weak-end infeed logic can be used to overcome the situation and trip the remote end breaker.

## 5.12.4 Analog channel configuration

CRWPSCH has one analog group input which must be properly configured.

**Table 1197: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1198: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phases connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.12.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of CRWPSCH can be described with a module diagram. All the modules in the diagram are explained in the next sections.

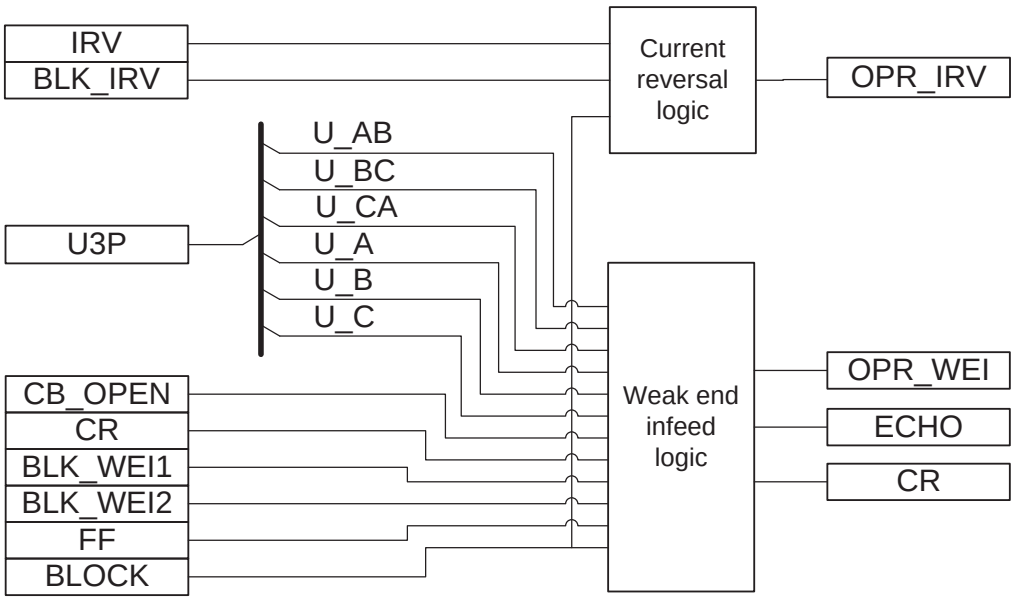



*Figure 717: Functional module diagram*

### Current reversal logic

Current reversal logic is enabled by changing the value of the *Reversal mode* setting to "On".

This logic uses the start signal of the reverse-looking zone (Z3) connected to the IRV input, which is used to recognize the fault in the reverse direction, that is, in the parallel feeder. When the reverse zone is activated after a start delay (the *Reversal time* setting), the logic is ready to issue an OPR_IRV output signal. The OPR_IRV signal is connected to the BLK_CS_OPR input of DSOCPSCH in order to block the sending of the carrier send signal (CS) and the activation of the OPERATE output of the communication logic. The OPR_IRV signal has a drop-off delay defined with the *Reversal reset time* setting.

An internal 10 ms drop-off timer enables the current reversal logic to be activated for the short-duration input signals even if the *Reversal reset time* setting is set to zero.

The BLK_IRV input is used to block the activation of the OPR_IRV output. The BLK_IRV input is typically connected to the forward-looking zone start signals within the terminal. General blocking is achieved by activating the BLOCK input.

### Weak-end infeed logic

Weak-end infeed logic is used to activate the distance protection function when the fault current infeed is too low due to, for example, high source impedance or fault current distribution between sources. When activated, the CR signal is logically combined with the local criteria to initiate the tripping of the weak-end breaker. The received signal is echoed back to accelerate the tripping in the opposite end with the stronger source.

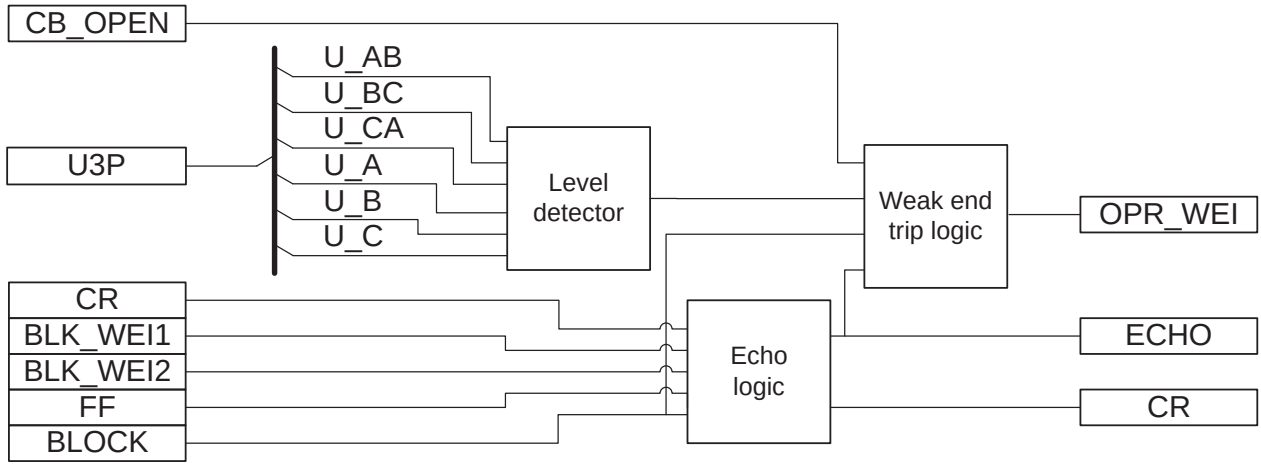



*Figure 718: Functional module diagram of weak-end infeed logic*

The WEI logic is enabled using the *Wei mode* setting.

- If *Wei mode*= "Off", the WEI logic is disabled.
- If *Wei mode*= "Echo", the WEI logic is enabled without Level detector.
- If *Wei mode*= "Echo and Operate", the WEI logic is enabled with Level detector.

**Level detector**

Both phase-to-earth and phase-to-phase voltages are monitored. The undervoltage criteria are applied to the phase-to-phase voltages with the *PPV level for Wei* setting and to the phase-to-earth voltages with the *PhV level for Wei*. Level detector sends an enable signal for a phase to Weak-end trip logic when one or more voltages are below the corresponding settings. Level detector blocks the enable signal if all three-phase voltages are above the set value more than 100 ms. This is to avoid sending an unnecessary operate signal if the breaker is already open.

**Echo logic**

Echo logic returns the received carrier signal with the ECHO output when it receives a CR signal if no fault has been detected by the forward- and reverse-looking zones and the duration of CR is longer than the coordination time delay (setting *Wei Crd time*). The received carrier receive signal is also given as the CR output.

When the WEI logic is enabled at both feeder ends, a spurious signal can be looped round by Echo logic. To avoid a continuous lockup of the system, the duration of the echoed signal is limited to 200 ms.

The ECHO and CR outputs can be blocked by activating the BLOCK input. The FF, BLK_WEI1 and BLK_WEI2 inputs can be used to block the ECHO output. The FF input is usually connected to the functional output of the fuse failure function, and the BLK_WEI1 input is typically connected to the start signals of the forward and reverse directional residual overcurrent functions within the terminal. The BLK_WEI2 signal has an in-built 200 ms drop-off delay. The BLK_WEI2 input is usually connected to all the fault detection functions within the terminal except the residual overvoltage function.

### Weak-end trip logic

Weak-end trip logic is activated if it receives an enable signal from Level detector and ECHO output of Echo logic is activated. Then a general trip signal OPR_WEI is activated. The activation of the CB_OPEN input blocks the tripping.

The OPR_WEI output can be blocked by activating the BLOCK input.

## 5.12.6 Application

### Current reversal logic

In parallel feeder applications, when the overreaching permissive communication schemes are used, unselective tripping may result due to the current reversal. Such a condition can occur in the healthy feeder when the fault is cleared in the faulty feeder. The tripping of the healthy parallel feeder may lead to losing the connection between the two buses. To avoid this situation, the current reversal logic (transient blocking logic) can be used.

Assume that Relay A1, Relay A2, Relay B1 and Relay B2 are equipped with DSOCPSCH and the permissive overreach scheme is enabled. A fault occurs at Feeder 1 close to bus B. Relay A2 at the healthy Feeder 2 recognizes the fault in the forward direction within the overreaching zone Z2 and sends a CS signal to Relay B2 according to the POTT scheme. Relay B2 does not recognize the fault in the forward direction and does not operate even though a permissive CR signal is received from Relay A2. Moreover, Relay B2 does not send a permissive signal to Relay A2.

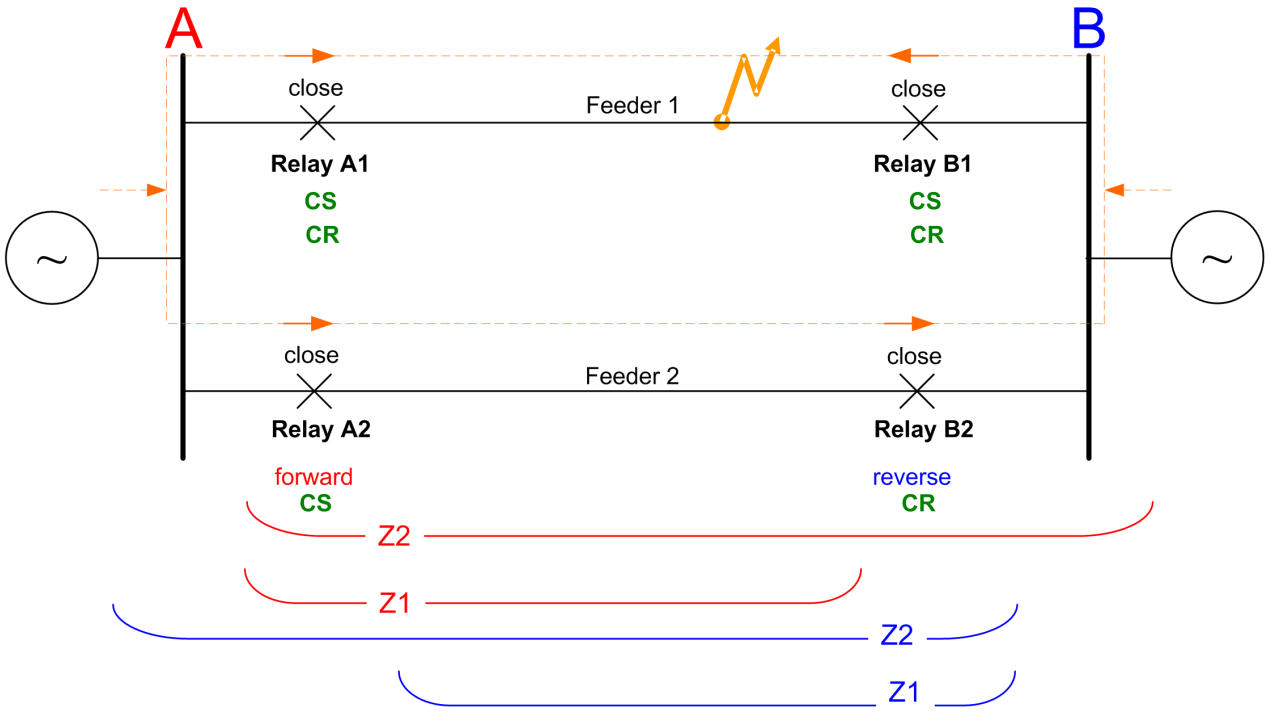



*Figure 719: The fault occurs at one of the parallel lines.*

The faulty feeder (Feeder 1) is not simultaneously tripped at both ends and it might occur that, for example, the circuit breaker closer to the fault at Relay B1 is tripped faster than the breaker at bus A due to the direct operation of the zone Z1 of Relay

B1. Thus, when the breaker at Relay B1 opens, the direction of the fault current at the healthy feeder (Feeder 2) is reversed.

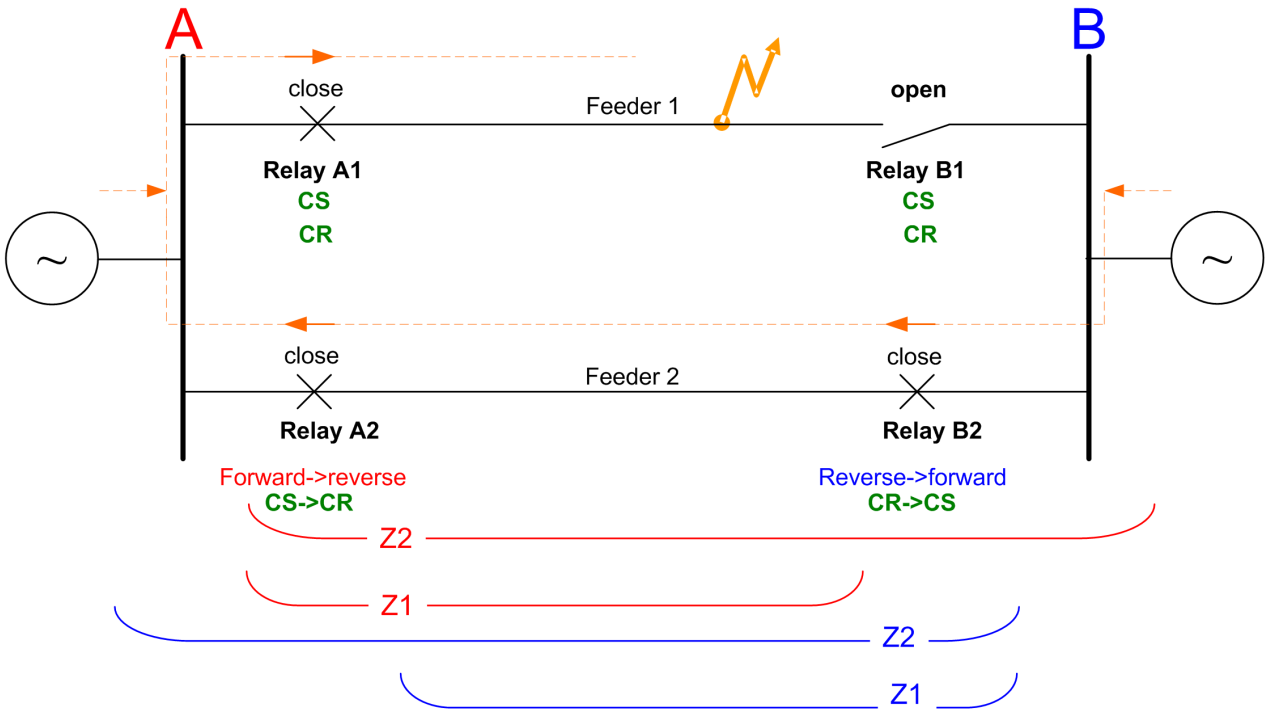



*Figure 720: The circuit breaker at Relay B1 opens and creates a current reversal condition*

Relay A2 is still sending the CS signal because of the reset time delay of the forward zone of Relay A2 when the overreaching zone of Relay B2 starts to recognize the fault in the forward direction. Relay B2 can malfunction and trip the breaker of the healthy feeder.

This problem can be solved by using the reverse-looking zone (Z3) to recognize the fault in reverse direction and temporarily block the operation of DSOCPSCH due to the current reversal condition. This is used in CRWPSCH.

### Weak-end infeed logic

Avoid using the WEI function at both feeder ends. It can only be enabled at the weak end.

The weak-end infeed logic should be used only in permissive schemes.

### Setting guidelines for current reversal logic

Setting *Reversal reset time*: Set the *Reversal reset time* setting to the maximum reset time of the communication channel. A minimum setting of 40 ms is recommended. A long *Reversal reset time* setting increases the security against unwanted tripping, but delays the fault clearing if the fault develops in one feeder and involves the other. However, the probability of this type of fault is small.

Setting *Reversal time*: Set the start delay *Reversal time* setting to less than 80 percent of the breaker operate time, but to a minimum of 20 ms.

**Setting guidelines for weak-end infeed logic**

The WEI function returns the received carrier signal with the ECHO output when it receives the carrier signal (CR) if no fault has been detected by forward- and reverselooking zones and the signal duration is longer than the *Wei Crd time* coordination time delay setting. Set the *Wei Crd time* = "0.010" s to avoid the spurious carrier received signals that activate the WEI logic and cause unwanted communication.

Set the voltage criteria *PPV level for Wei* and *PhV level for Wei* for the weak-end trip to 70 percent of the system's base voltage. The setting should be below the minimum operate voltage of the system but above the voltage that occurs for a fault on the protected feeder. The phase-to-phase elements must be verified not to operate for the phase-to-earth faults.

## 5.12.7 Signals

### 5.12.7.1 CRWPSCH Input signals

**Table 1199: CRWPSCH Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_IRV | BOOLEAN | 0=False | Block of current reversal function |
| BLK_WEI1 | BOOLEAN | 0=False | Block of WEI Logic |
| BLK_WEI2 | BOOLEAN | 0=False | Block of WEI logic due to operation of other protections |
| IRV | BOOLEAN | 0=False | Activation of current reversal logic |
| FF | BOOLEAN | 0=False | Block of trip from WEI logic through fuse-failure function |
| CB_OPEN | BOOLEAN | 0=False | Block of trip from WEI logic by an open breaker |
| CR | BOOLEAN | 0=False | POR Carrier receive for WEI logic |
| CR | BOOLEAN | 0=False | POR Carrier signal received from remote end |

### 5.12.7.2 CRWPSCH Output signals

**Table 1200: CRWPSCH Output signals**

| Name | Type | Description |
|---|---|---|
| OPR_IRV | BOOLEAN | Operation of WEI logic in phase B |
| OPR_WEI | BOOLEAN | Operation of WEI logic in phase C |
| ECHO | BOOLEAN | Carrier send by WEI logic |
| CR | BOOLEAN | POR Carrier signal received from remote end |

## 5.12.8 CRWPSCH Settings

**Table 1201: CRWPSCH Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Reversal mode | 1=Off<br>2=On | | | 1=Off | Operating mode of Current Reversal Logic |
| Wei mode | 1=Off<br>3=Echo<br>4=Echo and Operate | | | 1=Off | Operating mode of WEI logic |
| PhV level for Wei | 0.10...0.90 | xUn | 0.01 | 0.70 | Phase to Neutral voltage for detection of fault condition |
| PPV level for Wei | 0.10...0.90 | xUn | 0.01 | 0.70 | Phase to Phase voltage for detection of fault condition |
| Reversal time | 0...60000 | ms | 10 | 20 | Pickup time for current reversal logic |
| Reversal reset time | 0...60000 | ms | 10 | 60 | Time Delay to prevent Carrier send and local trip |
| Wei Crd time | 0...60000 | ms | 10 | 10 | Coordination time for the WEI logic |

## 5.12.9 CRWPSCH Monitored data

**Table 1202: CRWPSCH Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| CRWPSCH | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.12.10 Technical data

**Table 1203: CRWPSCH Technical data**

| Characteristic | Value |
|---|---|
| Operate accuracy | At the frequency f = $f_n$ |
| | ±1.5 % of the set value or ±0.002 × $U_n$ |
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |

# 5.13 Current reversal and weak-end infeed logic for residual overcurrent RCRWPSCH (ANSI 85 67G/N CREV,WEI)

## 5.13.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current reversal and weak-end infeed logic for residual overcurrent | RCRWPSCH | CLCRWN | 85 67G/N CREV,WEI |

## 5.13.2 Function block

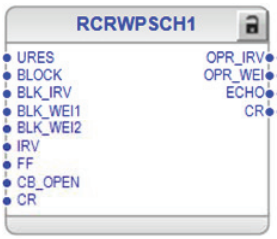



*Figure 721: Function block*

## 5.13.3 Functionality

The current reversal and weak-end infeed logic for residual overcurrent function RCRWPSCH can be used when the communication logic for residual overcurrent RESCPSCH requires additional logics to operate correctly in all power system conditions.

In parallel feeder applications, the direction of the fault current on the healthy feeder can change when the circuit breaker on the faulty feeder opens to clear the fault. This can lead to an unwanted operation of the residual overcurrent protection on the healthy parallel feeder when RESCPSCH with the permissive overreach scheme is used. The main purpose of the current reversal logic is to prevent such unwanted operations.

The permissive communication schemes can operate only when the protection in the remote terminal can detect the fault. This detection requires sufficient minimum fault current. If such current is not available due to too weak a remote end source, the WEI logic can be used to overcome the situation and trip the remote end breaker.

## 5.13.4 Analog channel configuration

RCRWPSCH has one analog group input which must be properly configured.

**Table 1204: Analog inputs**

| Input | Description |
|---|---|
| URES [1] | Residual voltage (measured or calculated), necessary when *Wei mode* is set to "Echo and Operate" |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

**Table 1205: Special conditions**

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected to calculate the residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.13.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of RCRWPSCH can be described with a module diagram. All the modules in the diagram are explained in the next sections.

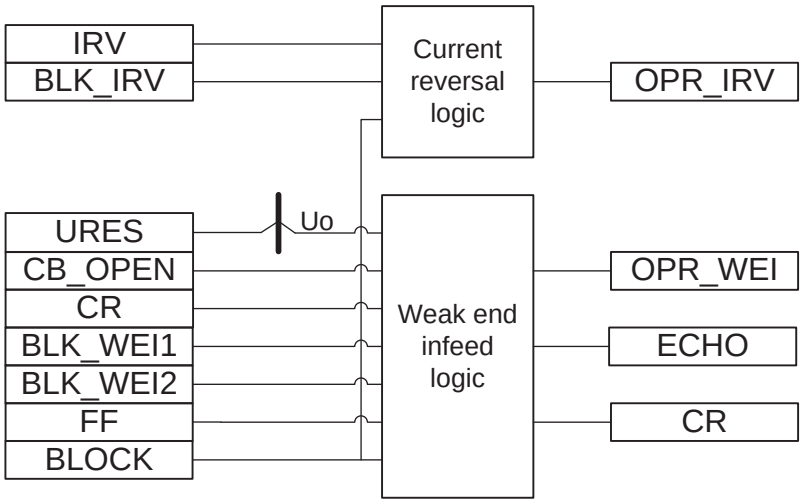



*Figure 722: Functional module diagram*

[1] Can be connected to GRPOFF if *Wei mode* is set to "Off" or "Echo".

### Current reversal logic

Current reversal logic is enabled by changing the value of the *Reversal mode* setting to "On".

Current reversal logic uses the start signal of the reverse directional residual overcurrent function connected to the IRV input, which is used to recognize the fault in the reverse direction, that is, in the parallel feeder. When the reverse directional residual overcurrent function is activated, the logic is ready to issue an OPR_IRV output signal after a start delay (setting *Reversal time*). The OPR_IRV signal is connected to the BLK_CS_OPR input of the scheme communication logic function to block the sending of the carrier send signal (CS) and the activation of the OPERATE output of the communication logic. The OPR_IRV signal has a drop-off delay defined with the *Reversal reset time* setting.

An internal 10 ms drop-off timer is provided which ensures the current reversal logic is activated for short-duration input signals, even if the *Reversal reset time* setting is set to zero.

The BLK_IRV input is used to block the activation of the OPR_IRV output. The BLK_IRV input is typically connected to the start signals of the forward-looking residual overcurrent function in the terminal. General blocking is achieved by activating the BLOCK input.

### Weak-end infeed (WEI) logic

The WEI logic is used to activate the residual overcurrent protection function when the fault current infeed is too low due to, for example, high source impedance or fault current distribution between sources. When activated, the carrier receive (CR) signal is logically combined with the local criteria to initiate the tripping of the weak-end breaker. The received signal is also echoed back to accelerate the tripping at the opposite end with the stronger source.

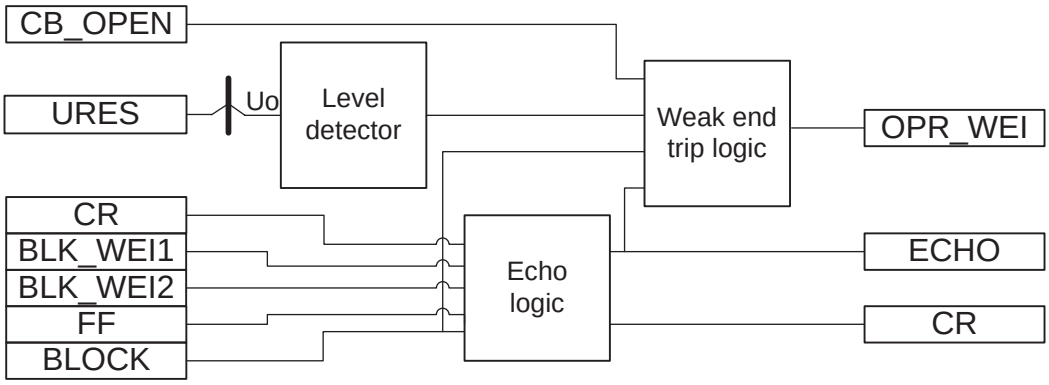



*Figure 723: Functional module diagram of Weak-end infeed logic*

The WEI logic is enabled using the *Wei mode* setting.

- If *Wei mode* = "Off", the WEI logic is disabled.
- If *Wei mode* = "Echo", the WEI logic is enabled without Level detector.
- If *Wei mode* = "Echo and Operate", the WEI logic is enabled with Level detector.

#### Level detector

Level detector sends an enabling signal to Weak-end trip logic when the residual voltage is above the *Residual voltage Val* setting.

#### Echo logic

Echo logic returns the received carrier signal with the ECHO output when it receives a carrier receive signal (CR) if no fault has been detected by the forward and reverse directional residual overcurrent functions and the duration of CR is longer than the coordination time delay (the setting *Wei Crd time*). The received carrier receive signal is also given as the CR output.

When the WEI logic is enabled at both feeder ends, a spurious signal can be looped round by Echo logic. To avoid a continuous lockup of the system, the duration of the echoed signal is limited to 200 ms.

The ECHO and CR outputs can be blocked by activating the BLOCK input. The FF, BLK_WEI1 and BLK_WEI2 inputs can be used to block the ECHO output. The FF input is usually connected to the functional output of the fuse failure function, and the BLK_WEI1 input is typically connected to the start signals of the forward and reverse directional residual overcurrent functions in the terminal. The BLK_WEI2 signal has an in-built 200 ms drop-off delay and is usually connected to all the fault detection functions in the terminal except the residual overvoltage function.

#### Weak-end trip logic

Weak-end trip logic is activated if it receives an enable signal from Level detector and ECHO output of Echo logic is activated. Then a general trip signal OPR_WEI is activated. The activation of the CB_OPEN input blocks the tripping.

The OPR_WEI output can be blocked by activating the BLOCK input.

## 5.13.6 Application

#### Current reversal logic

When the overreaching permissive communication schemes are used in parallel feeder applications, the current reversal can result in unselective tripping. Such a condition can occur in the healthy feeder when the fault is cleared in the faulty feeder. The tripping of the healthy parallel feeder can lead to losing the connection between the two buses. To avoid this situation, the current reversal logic (transient blocking logic) can be used.

In the current reversal condition, the relays Relay A1, Relay A2, Relay B1 and Relay B2 can be equipped with the scheme communication logic RESCPSCH and the permissive overreach scheme can be enabled.

A fault occurs at Feeder 1 close to bus B. Relay A2 at the healthy feeder 2 recognizes the fault in the forward direction and sends a CS signal to Relay B2 according to the PUTT scheme. Relay B2 does not recognize the fault in the forward direction and hence does not send a permissive signal to Relay A2.

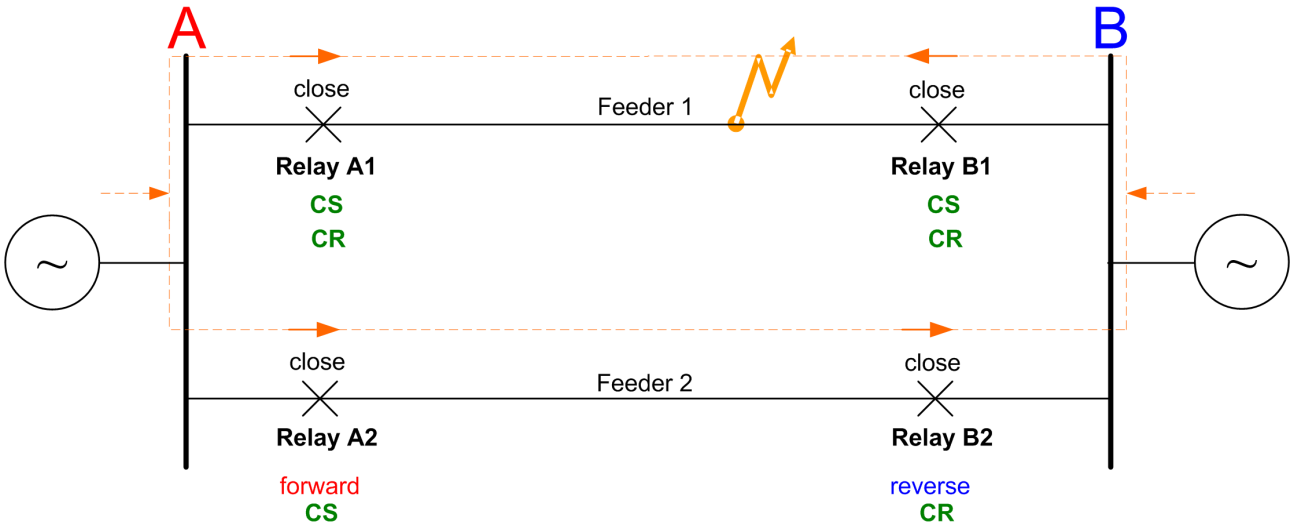



*Figure 724: Fault occurs at one of the parallel lines. CS=carrier signal sending, CR=carrier signal receiving*

The faulty feeder (Feeder 1) is not simultaneously tripped at both ends and, for example, the circuit breaker closer to the fault at Relay B1 may be tripped faster than the breaker at bus A. As a result, when the breaker at Relay B1 opens, the direction of the fault current at the healthy feeder (Feeder 2) is reversed.

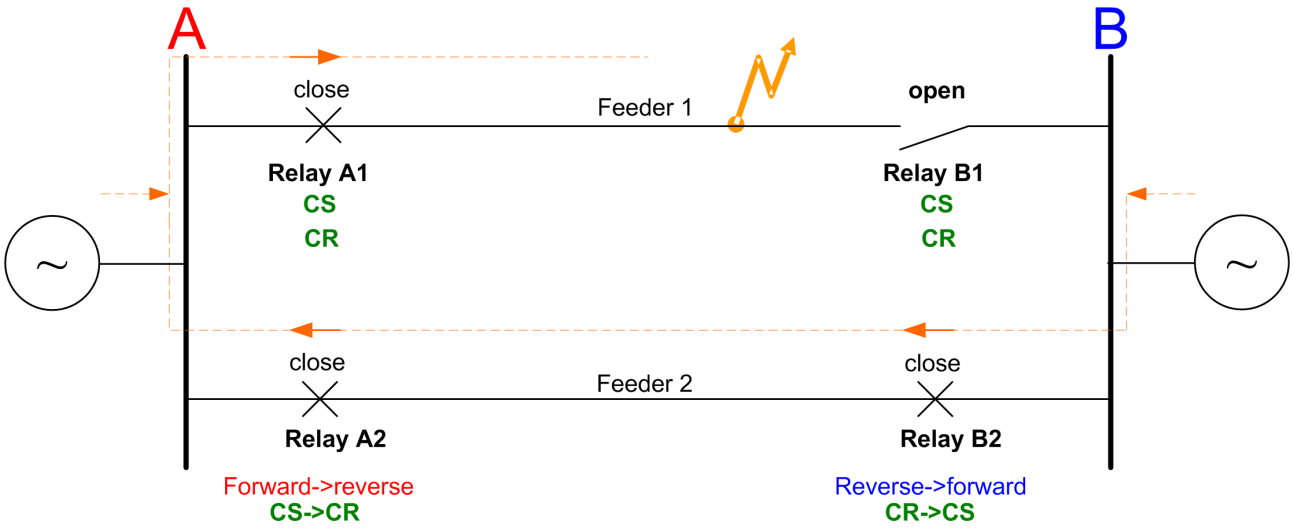



*Figure 725: Circuit breaker at Relay B1 opens and creates a current reversal condition. CS=carrier signal sending, CR=carrier signal receiving*

Relay A2 still sends the CS signal because of the reset time delay of the forward direction residual overcurrent function of Relay A2. When Relay B2 starts to recognize the fault in the forward direction, Relay B2 can malfunction and trip the breaker of the healthy feeder.

This problem can be solved using the reverse directional residual overcurrent function to recognize the fault in reverse direction and temporarily block the operation of the scheme communication logic due to the current reversal condition. This is used in RCRWPSCH.

#### Weak-end infeed (WEI) logic

Do not use the WEI function at both feeder ends. It can only be enabled at the weak end.

The WEI logic is recommended to be used only in the permissive schemes.

#### Setting guidelines for current reversal logic

*Reversal reset time*: This setting can be set to the maximum reset time of the communication channel. A minimum setting of 40 ms is recommended. A long *Reversal reset time* setting increases the security against unwanted tripping, but delays the fault clearing if the fault develops from one feeder to involve the other. However, the probability of this type of fault is small.

*Reversal time*: Set the start delay reversal time below 80 percent of the breaker operate time, but to a minimum of 20 ms.

#### Setting guidelines for Weak-end infeed (WEI) logic

The WEI logic returns the received carrier signal with the `ECHO` output when it receives the carrier signal (CR) if no fault has been detected by the forward and reverse directional measuring elements and the duration is longer than the *Wei Crd time* coordination time delay setting. To prevent the spurious carrier receive signals from activating the WEI logic and causing unwanted communication, the *Wei Crd time* setting can be set to "0.010 s".

## 5.13.7 Signals

### 5.13.7.1 RCRWPSCH Input signals

**Table 1206: RCRWPSCH Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| BLK_IRV | BOOLEAN | 0=False | Block of current reversal function |
| BLK_WEI1 | BOOLEAN | 0=False | Block of WEI Logic |
| BLK_WEI2 | BOOLEAN | 0=False | Block of WEI logic due to operation of other protections |
| IRV | BOOLEAN | 0=False | Activation of current reversal logic |
| FF | BOOLEAN | 0=False | Block of trip from WEI logic through fuse-failure function |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| CB_OPEN | BOOLEAN | 0=False | Block of trip from WEI logic by an open breaker |
| CR | BOOLEAN | 0=False | POR Carrier receive for WEI logic |
| CR | BOOLEAN | 0=False | POR Carrier signal received from remote end |

### 5.13.7.2 RCRWPSCH Output signals

**Table 1207: RCRWPSCH Output signals**

| Name | Type | Description |
|---|---|---|
| OPR_IRV | BOOLEAN | Operation of current reversal logic |
| OPR_WEI | BOOLEAN | Operation of WEI logic |
| ECHO | BOOLEAN | Carrier send by WEI logic |
| CR | BOOLEAN | POR Carrier signal received from remote end |

## 5.13.8 RCRWPSCH Settings

**Table 1208: RCRWPSCH Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Reversal mode | 1=Off<br>2=On | | | 1=Off | Operating mode of Current Reversal Logic |
| Wei mode | 1=Off<br>3=Echo<br>4=Echo and Operate | | | 1=Off | Operating mode of WEI logic |
| Residual voltage Val | 0.05...0.70 | xUn | 0.01 | 0.25 | Neutral voltage setting for fault conditions measurement |
| Reversal time | 0...60000 | ms | 10 | 20 | Pickup time for current reversal logic |
| Reversal reset time | 0...60000 | ms | 10 | 60 | Time Delay to prevent Carrier send and local trip |
| Wei Crd time | 0...60000 | ms | 10 | 0 | Coordination time for the WEI logic |

## 5.13.9 RCRWPSCH Monitored data

**Table 1209: RCRWPSCH Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| RCRWPSCH | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.13.10 Technical data

**Table 1210: RCRWPSCH Technical data**

| Characteristic | Value |
|---|---|
| Operate accuracy | At the frequency f = $f_n$ |
| | ±1.5 % of the set value or ±0.002 × $U_n$ |
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |

# 5.14 Three-phase power directional element DPSRDIR (ANSI 67P-TC)

## 5.14.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase power directional element | DPSRDIR | I1-> | 67P-TC |

## 5.14.2 Function block




*Figure 726: Function block*

## 5.14.3 Functionality

The three-phase power directional element function DPSRDIR is used to detect positive-sequence power direction. The output of the function is used for blocking or releasing other functions in protection scheme.

The directional positive-sequence power protection contains a blocking functionality which blocks function output and resets Timer.

DPSRDIR executes on the direction of positive-sequence power and not the value. If overpower or underpower is needed, refer to DOPPDPR and DUPPDPR. DPSRDIR is generally used for directional controls.

## 5.14.4 Analog channel configuration

DPSRDIR has two analog group inputs which must be properly configured.

**Table 1211: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1212: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.14.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DPSRDIR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

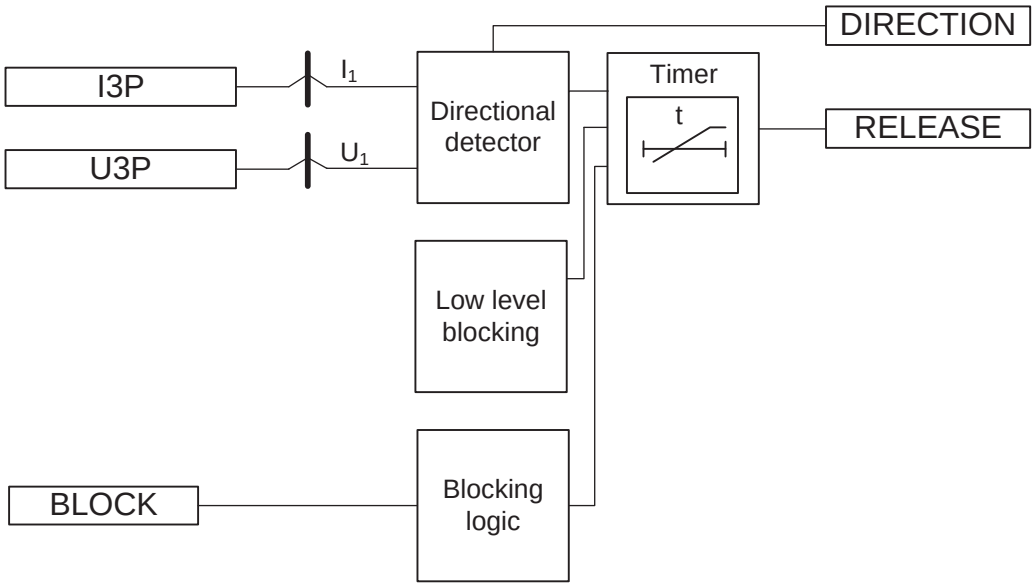



*Figure 727: Functional module diagram*

### Directional detector

The Directional detector module compares the angle of the positive-sequence current I1 to the angle of the positive-sequence voltage V1. Using the positive-sequence voltage angle as reference, the positive-sequence current angle is compared to the *Characteristic angle* setting. If the angular difference is within the operating sector selected with the *Directional mode* setting, the On signal is sent to Timer.

The operating sector is defined by the setting *Min forward angle*, *Max forward angle*, *Min reverse angle* and *Max reverse angle*. The options that can be selected for the *Directional mode* setting are “Forward” and “Reverse”.

The sector limits are always given as positive degree values.

The *Characteristic angle* setting is also known as Relay Characteristic Angle (RCA), Relay Base Angle or Maximum Torque Line.

### Low-level blocking

For a reliable operation, signal levels should be greater than the minimum level. If they are not greater than the minimum level, Timer is blocked. If the amplitude of the positive-sequence current is greater than the *Min trip current* value and the positive-sequence voltage amplitude is greater than the *Min trip voltage* value, the On signal is sent to Timer.

### Timer

Once activated, the internal operating timer is started. The Timer characteristic is according to definite time DT. When Timer has reached the value of *Release delay time*, the RELEASE output is activated. If a drop-off situation happens, that is, if the operating current moves outside the operating sector or signal amplitudes drop

below the minimum level before *Release delay time* is exceeded, the Timer reset state is activated. If the drop-off continues for more than *Reset delay time*, Timer is deactivated.

**Blocking logic**

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates the RELEASE output and resets Timer.

## 5.14.6 Application

The three-phase power directional element function DPSRDIR improves the possibility to obtain a selective function of the overcurrent protection in meshed networks. DPSRDIR is used to block or release other overcurrent protection functions.

## 5.14.7 Signals

### 5.14.7.1 DPSRDIR Input signals

**Table 1213: DPSRDIR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### 5.14.7.2 DPSRDIR Output signals

**Table 1214: DPSRDIR Output signals**

| Name | Type | Description |
|---|---|---|
| RELEASE | BOOLEAN | Release signal if direction criteria is satisified |
| DIRECTION | Enum | Direction information |

## 5.14.8 DPSRDIR Settings

**Table 1215: DPSRDIR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Release delay time | 0...1000 | ms | 1 | 10 | Release delay time |
| Characteristic angle | -179...180 | deg | 1 | 60 | Characteristic angle |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max forward angle | 0...90 | deg | 1 | 88 | Maximum phase angle in forward direction |
| Max reverse angle | 0...90 | deg | 1 | 88 | Maximum phase angle in reverse direction |
| Min forward angle | 0...90 | deg | 1 | 88 | Minimum phase angle in forward direction |
| Min reverse angle | 0...90 | deg | 1 | 88 | Minimum phase angle in reverse direction |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |

**Table 1216: DPSRDIR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 1217: DPSRDIR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Min operate current | 0.01...1.00 | xIn | 0.01 | 0.10 | Minimum operating current |
| Min operate voltage | 0.01...1.00 | xUn | 0.01 | 0.30 | Minimum operating voltage |

### 5.14.9 DPSRDIR Monitored data

**Table 1218: DPSRDIR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ANGLE_RCA | FLOAT32 | -180.00...180.00 | deg | Angle between operating angle and characteristic angle |
| DPSRDIR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.15 Neutral power directional element DNZSRDIR (ANSI 67N-TC)

## 5.15.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Neutral power directional element | DNZSRDIR | I2->, Io-> | 67N-TC |

## 5.15.2 Function block




*Figure 728: Function block*

## 5.15.3 Functionality

Neutral power directional element function DNZSRDIR is used to detect negative or residual power direction. The output of the function is used for blocking or releasing other functions in protection scheme.

In negative-sequence voltage selection, if the angle difference between negativesequence voltage and negative-sequence current is in a predefined direction (either in forward or reverse direction), DNZSRDIR gives a release signal after a definite time delay.

In residual voltage selection, if the angle difference between residual voltage and residual current is in a predefined direction (either in forward or reverse direction), DNZSRDIR gives release signal after a definite time delay.

This function contains a blocking functionality which blocks the function output and resets Timer.

DNZSRDIR executes on the direction of either negative-sequence or zero-sequence power and not the value. The function is generally used for directional controls.

## 5.15.4 Analog channel configuration

DNZSRDIR has four analog group inputs which must be properly configured.

**Table 1219: Analog inputs**

| Input | Description |
|---|---|
| I3P [1] | Three-phase currents, necessary when Pol quantity is "Neg. seq. volt." |
| IRES [2] | Residual current (measured or calculated), necessary when Pol quantity is "Zero seq. volt." |
| U3P [1] | Three-phase voltages, necessary when Pol quantity is "Neg. seq. volt." |
| URES [2] | Residual voltage (measured or calculated), necessary when Pol quantity is "Zero seq. volt." |

See the preprocessing function blocks in this document for the possible signal sources.The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

**Table 1220: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two phase voltage channels connected but it is recommended to connect all three voltage channels. |
| URES calculated | The function requires that all three voltage channels are connected to calculate residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.15.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of DNZSRDIR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

[1] Can be connected to GRPOFF if *Pol quantity* is set to "Zero seq. volt.".
[2] Can be connected to GRPOFF if *Pol quantity* is set to "Neg. seq. volt.".

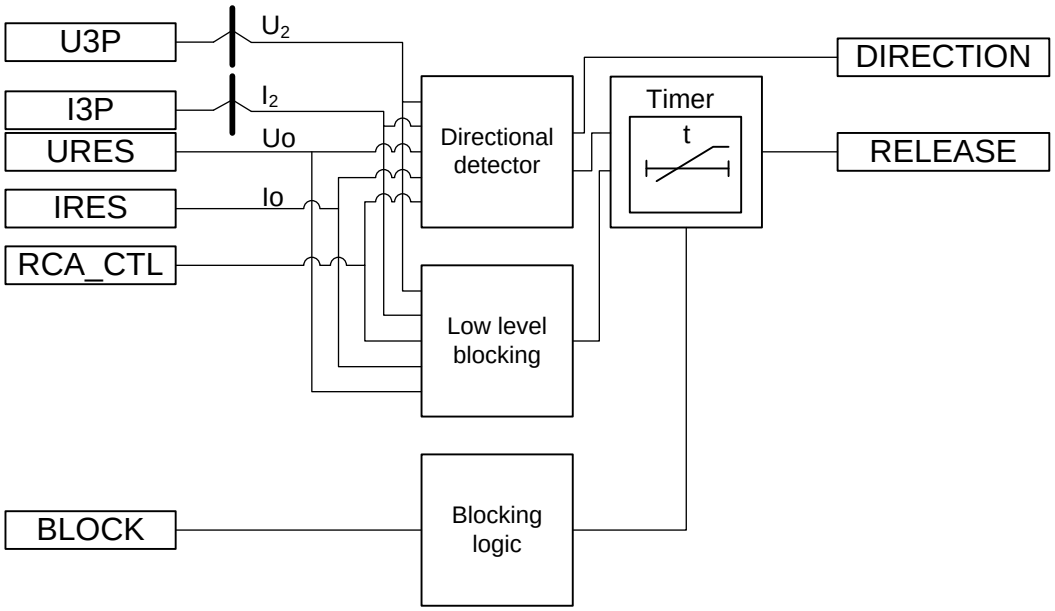



*Figure 729: Functional module diagram*

**Directional detector**

When "Neg. seq. volt." selection is made using the *Pol quantity* setting, the Directional detector module compares the angle of the negative-sequence current ($I_2$) to the negative-sequence voltage ($–U_2$). Using the negative-sequence voltage angle as the reference, the negative-sequence current angle is compared to the *Characteristic angle* setting. If the angle difference is within the operating sector selected by *Direction mode* setting, the Enable signal is sent to Timer.

The value of *Characteristic angle* should be chosen in such way that all the faults in the operating direction are seen in the operating zone and all the faults in the opposite direction are seen in the backward zone.

The operating sector is defined by the settings *Max forward angle*, *Max reverse angle*, *Min forward angle* and *Min reverse angle*. The options that can be selected for *Directional mode* settings are “Forward” and “Reverse”.

*Characteristic angle* is also known as Relay Characteristic Angle RCA, Relay Base Angle or Maximum Torque Line.

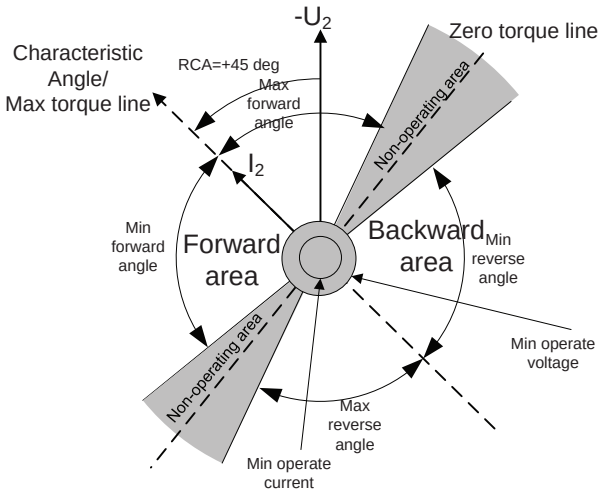



*Figure 730: Configurable directional setting when "Neg. seq. volt." selection is made using the Pol quantity setting*

When *Zero seq. volt.* voltage selection is made using *Pol quantity* setting, the directional detector module compares the angle of the residual current to the residual voltage. Using the residual voltage as reference, the residual current angle is compared to the *Characteristic angle* setting. If the angle difference is within the operating sector selected by the *Directional mode* setting, the Enable signal is sent to Timer.

The polarizing quantity (residual voltage) is inverted because of switched voltage measurement cables, the correction can be done by setting the *Pol reversal* setting to "True", which rotates the polarizing quantity by 180 degrees.

The directional characteristic for the measured or calculated residual power is same.

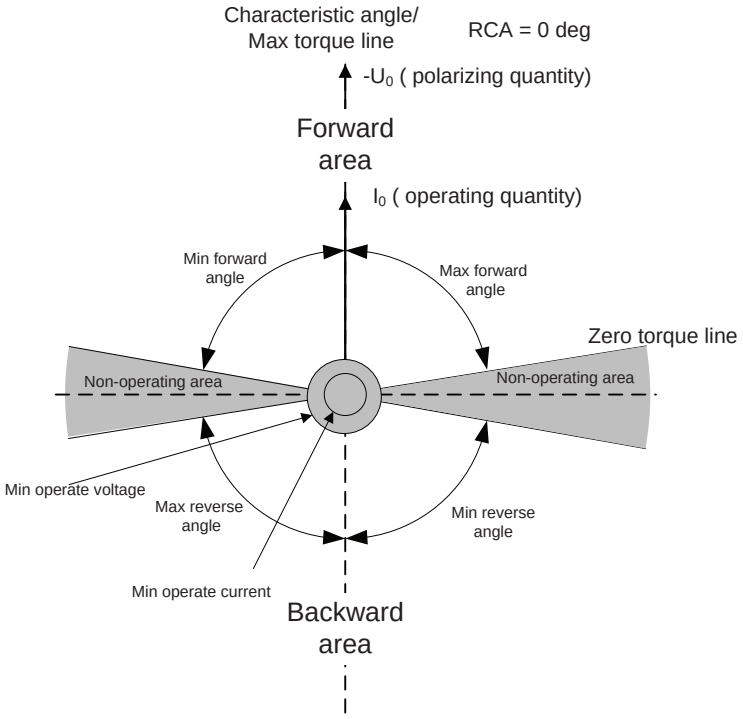



*Figure 731: Configurable directional setting for Zero seq. volt. (residual voltage) using the Pol quantity setting*

The *Characteristic angle* setting is done based on method of grounding employed in the network. For example, in case of an isolated network, *Characteristic angle* is set to –90°, and in case of a compensated network, *Characteristic angle* is set to 0° and 60° for solidly grounded systems. In general *Characteristic angle* is selected so that it matches close to the expected fault angle value, which results in maximum sensitivity. *Characteristic angle* can be set anywhere between –179° to +180°. The figures show examples of the operating area with RCA set to +60° and –90°, respectively.

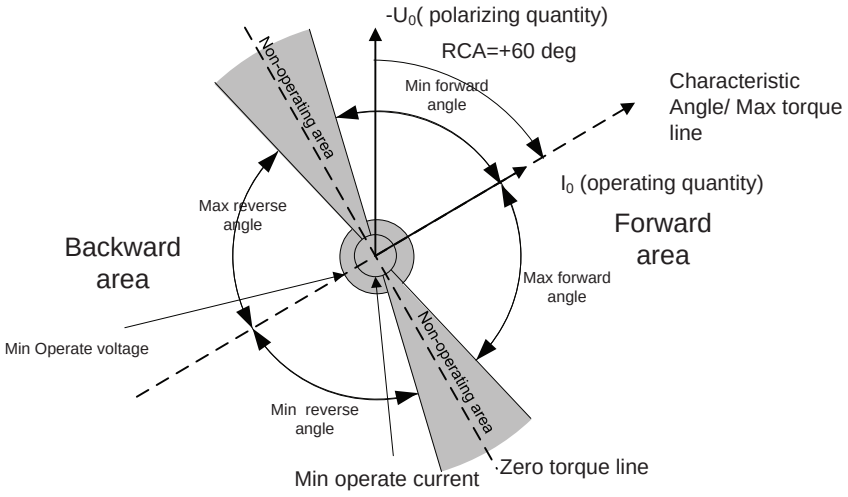



*Figure 732: Configurable directional characteristics (RCA =+60 ˚) for a solidly earthed network*

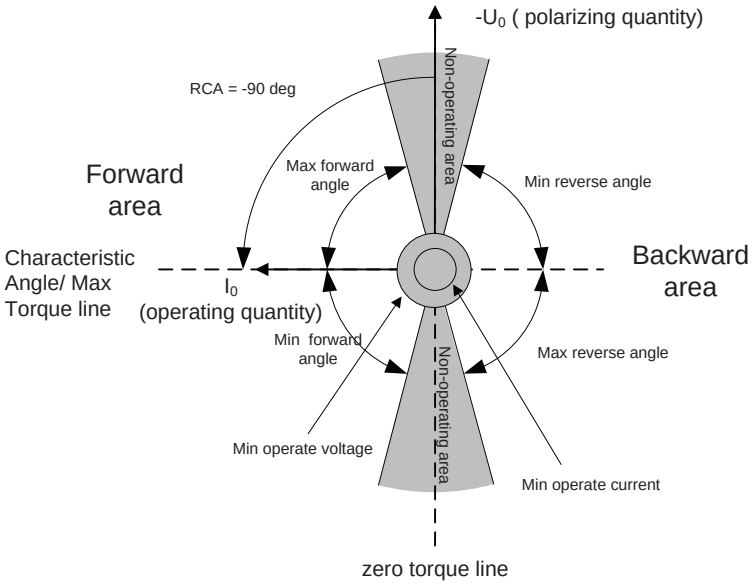



*Figure 733: Configurable directional characteristics (RCA = -90 ˚) for an isolated network*

*Characteristic angle* should be set to a positive value if the operating signal lags the polarizing quantity -VG or -VN, respectively, and a negative value if operating signal leads the polarizing quantity, respectively.

**Table 1221: Recommended Characteristic angle setting for different network**

| Type of network | Characteristic angle recommended |
|---|---|
| Compensated network | 0° |
| Solidly grounded network | +60° |
| Isolated network | –90° |

The *Characteristic angle* setting is adjusted to the operation according to the method of neutral-point grounding, so that in an isolated network *Characteristic angle* is –90° and in a compensated network 0°. In addition, *Characteristic angle* can be changed via the control signal RCA_CTL, in which case the alternatives are –90° and 0°. The operation of the `RCA_CTL` input depends on the *Characteristic angle* setting.

The Peterson coil or the grounding resistor may be temporarily out of operation. To keep the protection scheme selective, it is necessary to update the *Characteristic angle* settings accordingly. This is done with an auxiliary input in the relay which receives a signal from an auxiliary switch of the disconnector of the Peterson coil in compensated networks or of the grounding resistor in grounded network as a result the *Characteristic angle* is set automatically to suit the earthing method.

**Table 1222: Characteristic angle control for the RCA_CTL condition**

| Characteristic angle Setting | RCA_CTL=FALSE | RCA_CTL=TRUE |
|---|---|---|
| –90° | *Characteristic angle* = –90° | *Characteristic angle* = 0° |
| 0° | *Characteristic angle* = 0° | *Characteristic angle* = –90° |

When the phase angle criterion is used, the DIRECTION output indicates on which operating sector the negative or residual power is measured.

**Low-level blocking**

For a reliable operation, signal levels should be greater than the minimum level. If they are not greater than the minimum level, Timer is blocked.

In the "Neg. seq. volt." polarization selection using the *Pol quantity* setting, if the amplitude of the negative-sequence current is greater than the *Min operate current* value and the negative-sequence voltage amplitude is greater than the *Min operate voltage* value, the Enable signal is sent to Timer.

In the "Zero seq. volt." polarization selection using *Pol quantity*, if the amplitude of the residual current is greater than the *Min operate current* value and residual voltage amplitude is greater than the *Min operate voltage* value, the Enable signal is sent to Timer.

**Timer**

Once activated, the internal operating timer is started. The Timer characteristic is according to DT. When Timer has reached the value of *Release delay time*, the RELEASE output is activated. If a drop-off situation happens, that is, if the operating current moves out of the operating sector or signal amplitudes drop below the minimum levels, before *Release delay time* is exceeded, the Timer reset state is activated. If the drop-off continues for more than *Reset delay time*, Timer is deactivated.

**Blocking logic**

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates RELEASE output and resets Timer.

## 5.15.6 Application

The neutral power directional element function DNZSRDIR improves the possibility to obtain selective function of the overcurrent protection in meshed networks. DNZSRDIR is used to block or release other overcurrent protection functions.

## 5.15.7 Signals

### 5.15.7.1 DNZSRDIR Input signals

**Table 1223: DNZSRDIR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RCA_CTL | BOOLEAN | 0=False | Relay characteristic angle control |

### 5.15.7.2 DNZSRDIR Output signals

**Table 1224: DNZSRDIR Output signals**

| Name | Type | Description |
|---|---|---|
| RELEASE | BOOLEAN | Release signal if direction criteria is satisified |
| DIRECTION | Enum | Direction information |

## 5.15.8 DNZSRDIR Settings

**Table 1225: DNZSRDIR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Release delay time | 0...1000 | ms | 10 | 10 | Release delay time |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |
| Characteristic angle | -179...180 | deg | 1 | 60 | Characteristic angle |
| Max forward angle | 0...180 | deg | 1 | 88 | Maximum phase angle in forward direction |
| Min forward angle | 0...180 | deg | 1 | 88 | Minimum phase angle in forward direction |
| Max reverse angle | 0...180 | deg | 1 | 88 | Maximum phase angle in reverse direction |
| Min reverse angle | 0...180 | deg | 1 | 88 | Minimum phase angle in reverse direction |

**Table 1226: DNZSRDIR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Pol quantity | 3=Zero seq. volt.<br>4=Neg. seq. volt. | | | 3=Zero seq. volt. | Reference quantity used to determine fault direction |

**Table 1227: DNZSRDIR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |
| Min operate current | 1.0...100.0 | %In | 0.1 | 10.0 | Minimum operating current |
| Min operate voltage | 1.0...100.0 | %Un | 0.1 | 30.0 | Minimum operating voltage |
| Pol reversal | 0=False<br>1=True | | | 0=False | Rotate polarizing quantity |

## 5.15.9 DNZSRDIR Monitored data

**Table 1228: DNZSRDIR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ANGLE_RCA | FLOAT32 | -180.00...180.00 | deg | Angle between operating angle and characteristic angle |
| DNZSRDIR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

# 5.16 Load blinder LBRDOB (ANSI 21LB)

## 5.16.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE identification |
|---|---|---|---|
| Load blinder | LBRDOB | LB | 21LB |

## 5.16.2 Function block

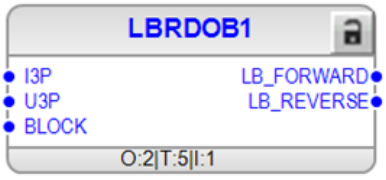



*Figure 734: Function block*

## 5.16.3 Functionality

Load blinder, or Load encroachment, function LBRDOB is used to block the directional overcurrent protection aiming at avoiding incorrect trip in case of heavy loading condition in network whose power factor close to 1.00.

Operation principle is based on calculated positive sequence impedance. Function provides blocking signal if positive sequence impedance is in load blinder forward or reverse area.

## 5.16.4 Analog channel configuration

LBRDOB has two analog group inputs which must be properly configured.

**Table 1229: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1230: Special conditions**

| Condition | Description |
|---|---|
| U3P connected real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 5.16.5 Operation principle

The *Operation* setting is used to enable or disable the function. When selected "On" the function is enabled and respectively "Off" means function is disabled.

The operation of Load blinder LBRDOB can be described by using a module diagram (see *Figure 735*). All the modules in the diagram are explained in the next sections.

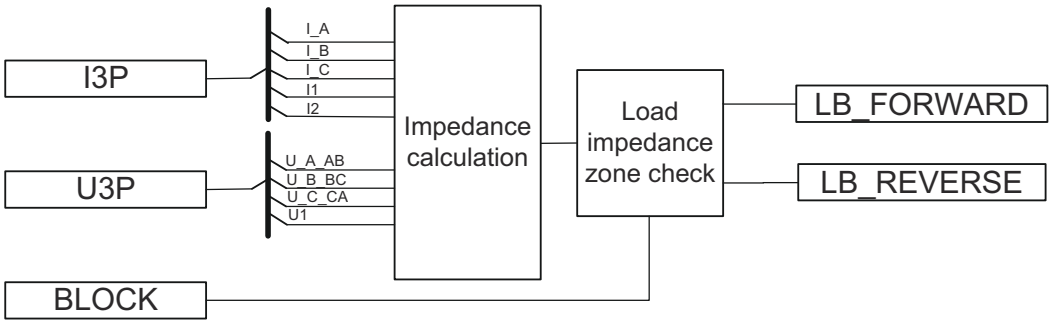



*Figure 735: Functional module diagram*

### Impedance calculation

The impedance calculation is enabled if the negative sequence current stays below the *Max Ng Seq current* setting and the positive sequence voltage stays above the *Min Ps Seq voltage* setting.

The positive sequence impedance phasor $\bar{Z}_1$ is calculated according to:

$$\bar{Z}_1 = \frac{\bar{U}_1}{\bar{I}_1}$$

(Equation 312)

where $\bar{U}_1$ is positive sequence voltage phasor and $\bar{I}_1$ is positive sequence current phasor.

The calculated positive sequence impedance amplitude *Z1_AMPL* (primary ohms) and angle *Z1_ANGLE* (degrees) are available in monitored data view.

The calculated impedance is converted to primary ohms as the operating characteristics are defined with settings in primary ohms.

### Load impedance zone check

The forward and reverse load blinder sectors are defined separately. The load blinder forward area, or load-out region, or load exporting is limited with the *Max impedance angle* and *Min impedance angle*. Similarly, these two setting parameters are also as limitations for the load blinder reverse area, or load-in region, or load importing. the *Resistive reach Fw* is maximum resistive load on forward load blinder area. *Resistive reach Rv* is maximum resistive load on reverse load blinder area. Characteristics are shown *Figure 736*.

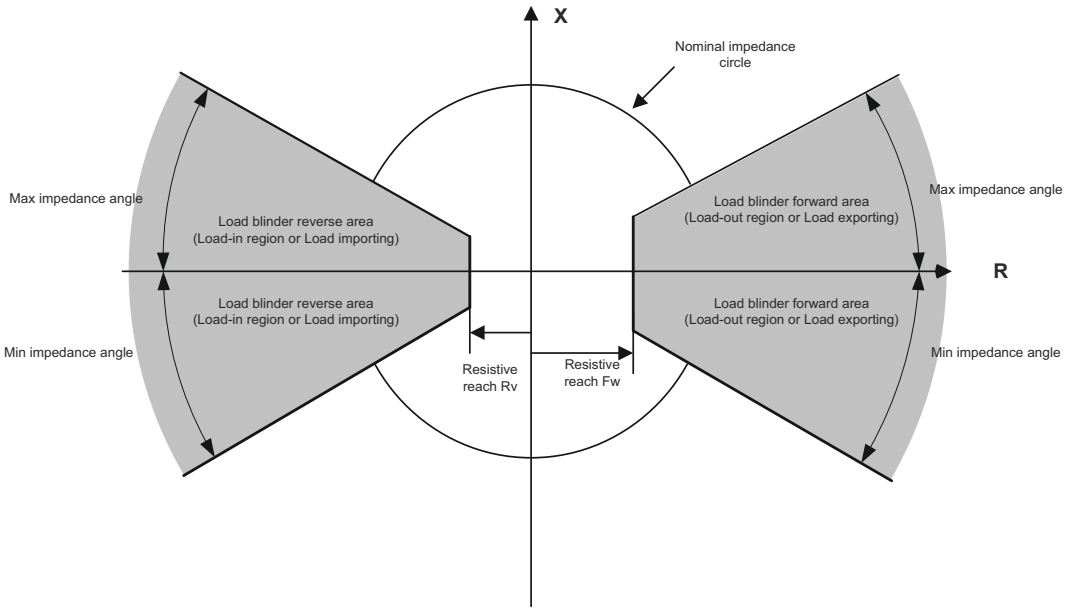



*Figure 736: Operating sectors for load blinder*

The blinder directional operation can be selected with the *Directional mode* setting. The alternatives are "Non-directional", "Forward" and "Reverse" operation.

Forward operation is allowed if *Directional mode* is set to “Forward”. If the resistive part value of positive sequence impedance is higher than *Resistive reach Fw* and the angle of positive sequence impedance stays in the range limited with the *Max impedance angle* and *Min impedance angle* on forward area, the function output LB_FORWARD is activated.

Reverse operation is allowed if *Directional mode* is set to “Reverse”. If the resistive part value of positive sequence impedance exceeds the limitation of *Resistive reach Rv* and the angle of positive sequence impedance stays in the range limited with the *Max impedance angle* and *Min impedance angle* on reverse area, the function output LB_REVERSE is activated.

In case *Directional mode* is set to “Non-directional”, operation is allowed both directions according to conditions described above.

Activation of the BLOCK input deactivates the function outputs.

## 5.16.6 Application

Load blinder or load encroachment, function LBRDOB is used to block the directional overcurrent protection aiming at avoiding incorrect trip in case of heavy loading condition in network. In general, the active power increases to the level leading to a high power factor, the network turns into heavy load status, and there exists risk of incorrect trip for the directional overcurrent protection because of high level of load current.

The suitability of *Resistive reach Fw* and *Resistive reach Rv* settings will influence the activation of load blinder function. If *Resistive reach Fw* and *Resistive reach Rv* are set beyond the network minimal resistive load, the function will not be activated in the case that the load impedance approaches the network minimal impedance load. Hence, the absolute values of *Resistive reach Fw* and *Resistive reach Rv* should be set less than that of the minimal resistive load.

The blinder in forward direction, *Resistive reach Fw*, can be calculated according to

$$Resistive\ reach\ Fw = K \cdot \frac{U_{expmin}^2}{P_{expmax}}$$

(Equation 313)

where:

| | |
|---|---|
| $P_{expmax}$ | is the maximum exporting active power |
| $U_{expmin}$ | is minimum phase-to-phase voltage when the exporting active power occurs |
| *K* | is a security factor to ensure that the setting of *Resistive reach Fw* less than minimal resistive load, with a recommended value 0.8. |

The resistive boundary *Resistive reach Rv* can be obtained in the same way as *Resistive reach Fw*, but replace the maximum exporting active power $P_{expmax}$ and the corresponding voltage $U_{expmin}$ with the maximum importing active power $P_{impmax}$ and the corresponding voltage $U_{impmin}$.

The *Max impedance angle* and *Min impedance angle* are symmetric in forward and reverse direction, these values are recommended to set the maximum possible load angle when load active power arrives at top. A value bigger than 20° must be used.

## 5.16.7 Signals

### 5.16.7.1 LBRDOB Input signals

**Table 1231: LBRDOB Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### 5.16.7.2 LBRDOB Output signals

**Table 1232: LBRDOB Output signals**

| Name | Type | Description |
|---|---|---|
| LB_FORWARD | BOOLEAN | Load discrimination active in forward direction |
| LB_REVERSE | BOOLEAN | Load discrimination active in reverse direction |

## 5.16.8 Settings

### 5.16.8.1 LBRDOB Settings

**Table 1233: LBRDOB Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Resistive reach Fw | 1.00...6000.00 | ohm | 0.01 | 150.00 | Resistive forward reach for load discrimination |
| Resistive reach Rv | 1.00...6000.00 | ohm | 0.01 | 150.00 | Resistive reverse reach for load discrimination |
| Max impedance angle | 5...85 | deg | 1 | 25 | Maximum angle for load area |
| Min impedance angle | -85...-5 | deg | 1 | -25 | Minimum angle for load area |
| Directional mode | 1=Non-directional<br>2=Forward<br>3=Reverse | | | 2=Forward | Directional mode |

**Table 1234: LBRDOB Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on | | | 1=on | Operation Off / On |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 5=off | | | | |

**Table 1235: LBRDOB Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min Ps Seq voltage | 0.1...1.0 | xUn | 0.1 | 0.1 | Minimum positive sequence voltage |
| Max Ng Seq current | 0.01...10.00 | xIn | 0.01 | 0.20 | Maximum negative sequence current |

## 5.16.9 Monitored data

### 5.16.9.1 LBRDOB Monitored data

**Table 1236: LBRDOB Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Z1_AMPL | FLOAT32 | 0.00...99999.00 | ohm | Positive sequence impedance amplitude |
| Z1_ANGLE | FLOAT32 | -180.00...180.00 | deg | Positive sequence impedance phase angle |
| LBRDOB | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 5.16.10 Technical data

**Table 1237: LBRDOB Technical Data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the current measured: $f_n$ |
| | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br><br>Impedance accuracy:<br>±3% of the set value<br>(In range load angle<75 deg)<br><br>±4.5% of the set value<br>(In range 75 deg<load angle<83 deg) |

*Table continues on the next page*

| Characteristic | Value |
|---|---|
| | ±8% of the set value<br>(In range load angle>83 deg)<br><br>Phase angle: ±2° |
| Reset ratio | Typically 0.96 |
| Operation time [1, 2] | Typically 30 ms |
| Reset time | Typically 25 ms |

[1] $f_n$= 50Hz, results based on statistical distribution of 1000 measurements
[2] Includes the delay of the signal output contact

# 6 Supervision functions

## 6.1 Trip circuit supervision TCSSCBR (ANSI TCM)

### 6.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Trip circuit supervision | TCSSCBR | TCS | TCM |

### 6.1.2 Function block




*Figure 737: Function block*

### 6.1.3 Functionality

The trip circuit supervision function TCSSCBR is designed to supervise the control circuit of the circuit breaker. The invalidity of a control circuit is detected by using a dedicated output contact that contains the supervision functionality. The failure of a circuit is reported to the corresponding function block in the relay configuration.

The function starts and operates when TCSSCBR detects a trip circuit failure. The operating time characteristic for the function is DT. The function operates after a predefined operating time and resets when the fault disappears.

The function contains a blocking functionality. Blocking deactivates the `ALARM` output and resets the timer.

### 6.1.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of TCSSCBR can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

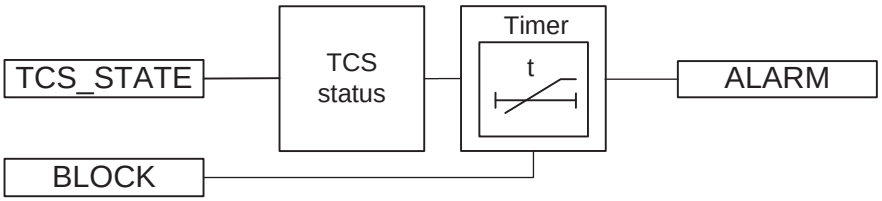



*Figure 738: Functional module diagram*

**TCS status**

This module receives the trip circuit status from the hardware. A detected failure in the trip circuit activates the timer.

**Timer**

Once activated, the timer runs until the set value of *Operate delay time* has elapsed. The time characteristic is according to DT. When the operation timer has reached the maximum time value, the `ALARM` output is activated. If a drop-off situation occurs during the operate time up counting, the fixed 0.5 s reset timer is activated. After that time, the operation timer is reset.

The `BLOCK` input can be controlled with a binary input, a horizontal communication input or an internal signal of the relay program. The activation of the `BLOCK` input prevents the `ALARM` output to be activated.

## 6.1.5 Application

TCSSCBR detects faults in the electrical control circuit of the circuit breaker. The function can supervise both open and closed coil circuits. This supervision is necessary to find out the vitality of the control circuits continuously.

*Figure 739* shows an application of the trip circuit supervision function use. Example of both mechanical (on the left) and static (on the right) outputs TCS connections are shown.

The mechanical outputs (PODPx) are used in both AC or DC circuits, and polarity is insignificant. The static outputs (SPOx) can be used in DC only and polarity must be correct.

The best solution is to connect an external $R_{ext}$ shunt resistor in parallel with the circuit breaker internal contact as shown with the dashed line. This way, although the circuit breaker auxiliary contact is open, TCS can see the trip circuit through $R_{ext}$. The $R_{ext}$ resistor should have such a resistance that the current through the circuit breaker coil remains small, that is, it does not harm or overload the circuit breaker's trip coil if the trip is latched/locked-out.

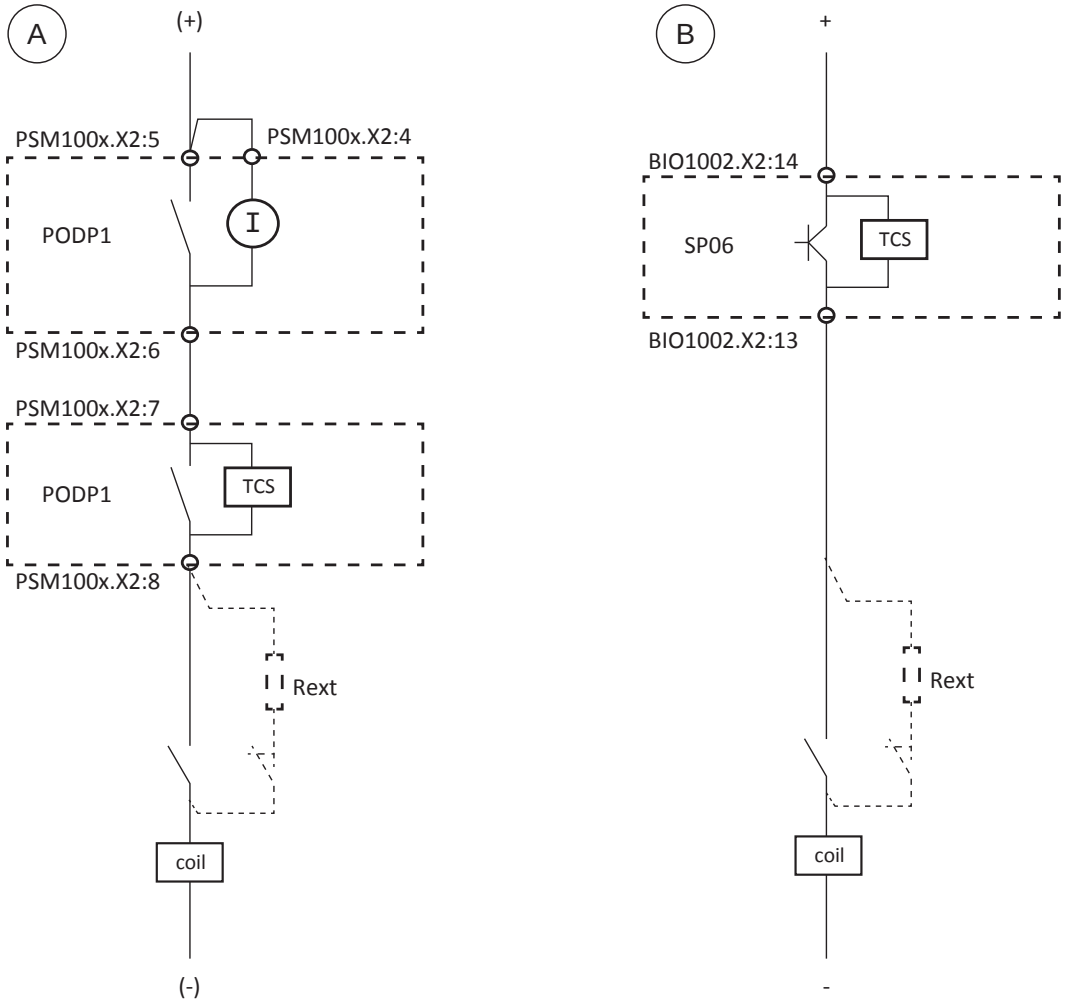



*Figure 739: Operating principle of the trip-circuit supervision, single-pole connection*

If TCS is required only in a closed position, the external shunt resistance can be omitted. When the circuit breaker is in the open position, TCS sees the situation as a faulty circuit. One way to avoid TCS operation in this situation is to block the supervision function whenever the circuit breaker is open.

It is also recommended to block the supervision function when the trip output is active. Otherwise, TCS issues an alarm if the trip remains active over the set TCS *Operate delay time*.

*Figure 740* shows a double-pole connection of the trip circuit supervision. For the static output, this requires using SPO5 or SPO6 output in series of the circuit.

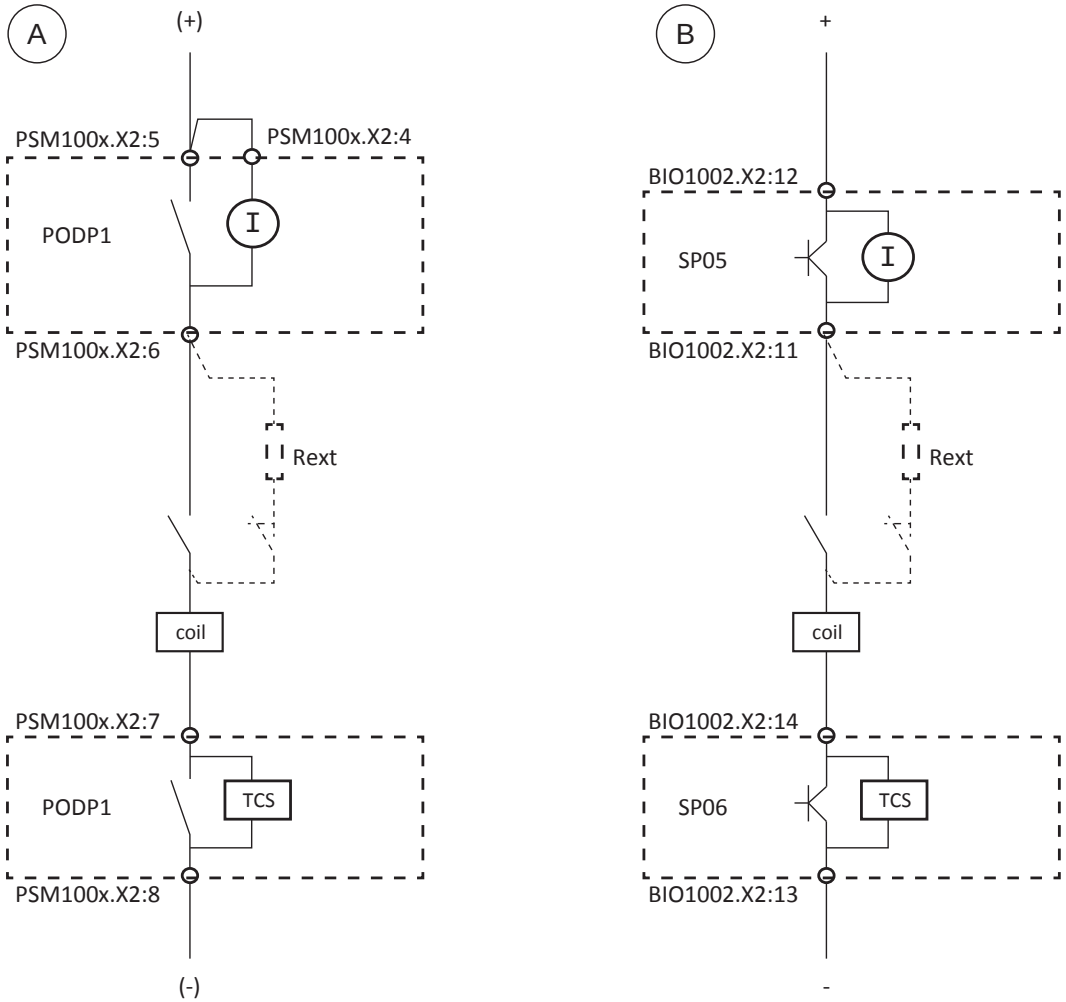



*Figure 740: Operating principle of the trip-circuit supervision, double-pole connection*

**Trip circuit supervision and other trip contacts**

It is typical that the trip circuit contains more than one trip contact in parallel, for example in transformer feeders where the trip of a Buchholz relay is connected in parallel with the feeder terminal and other relays involved. The supervising current cannot detect if one or all the other contacts connected in parallel are not connected properly.

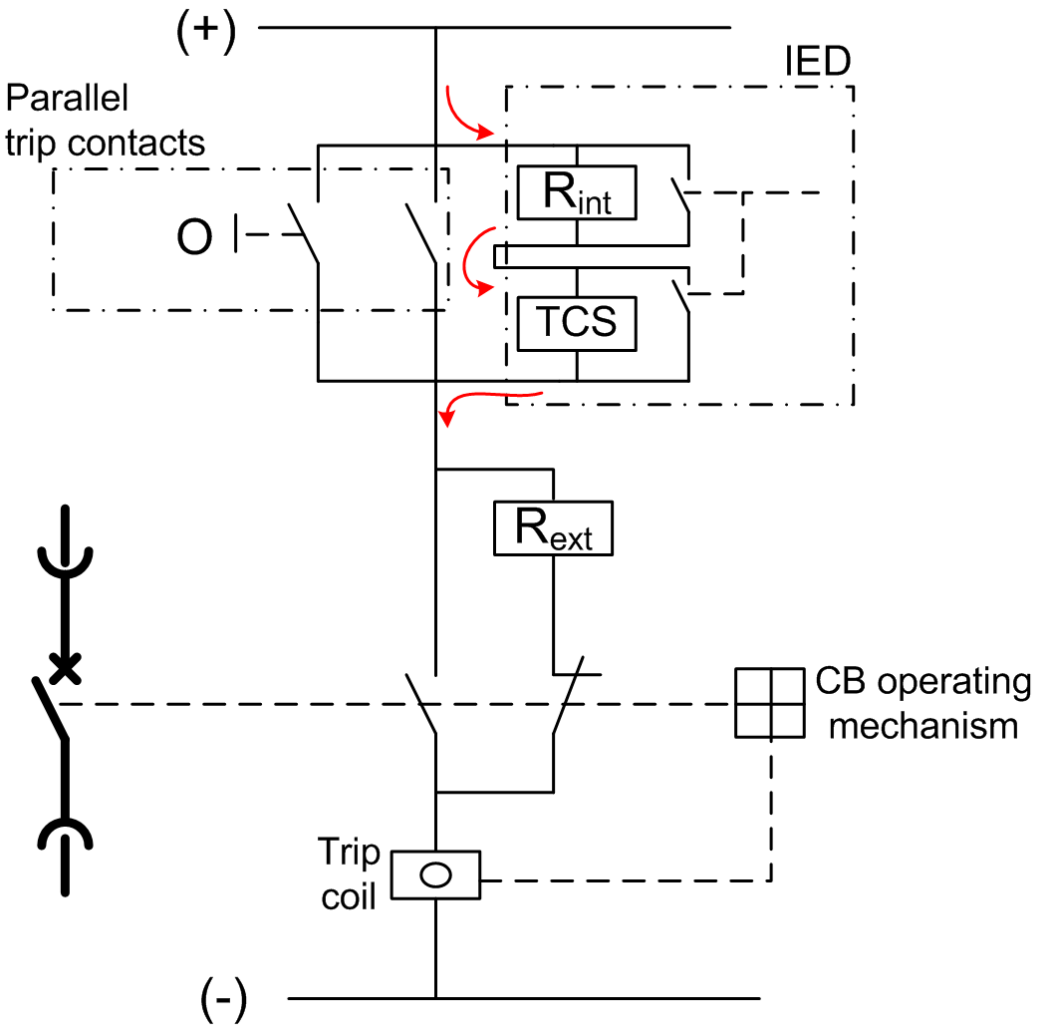



*Figure 741: Constant test current flow in parallel trip contacts and trip circuit supervision*

In case of parallel trip contacts, the recommended way to do the wiring is that the TCS test current flows through all wires and joints.

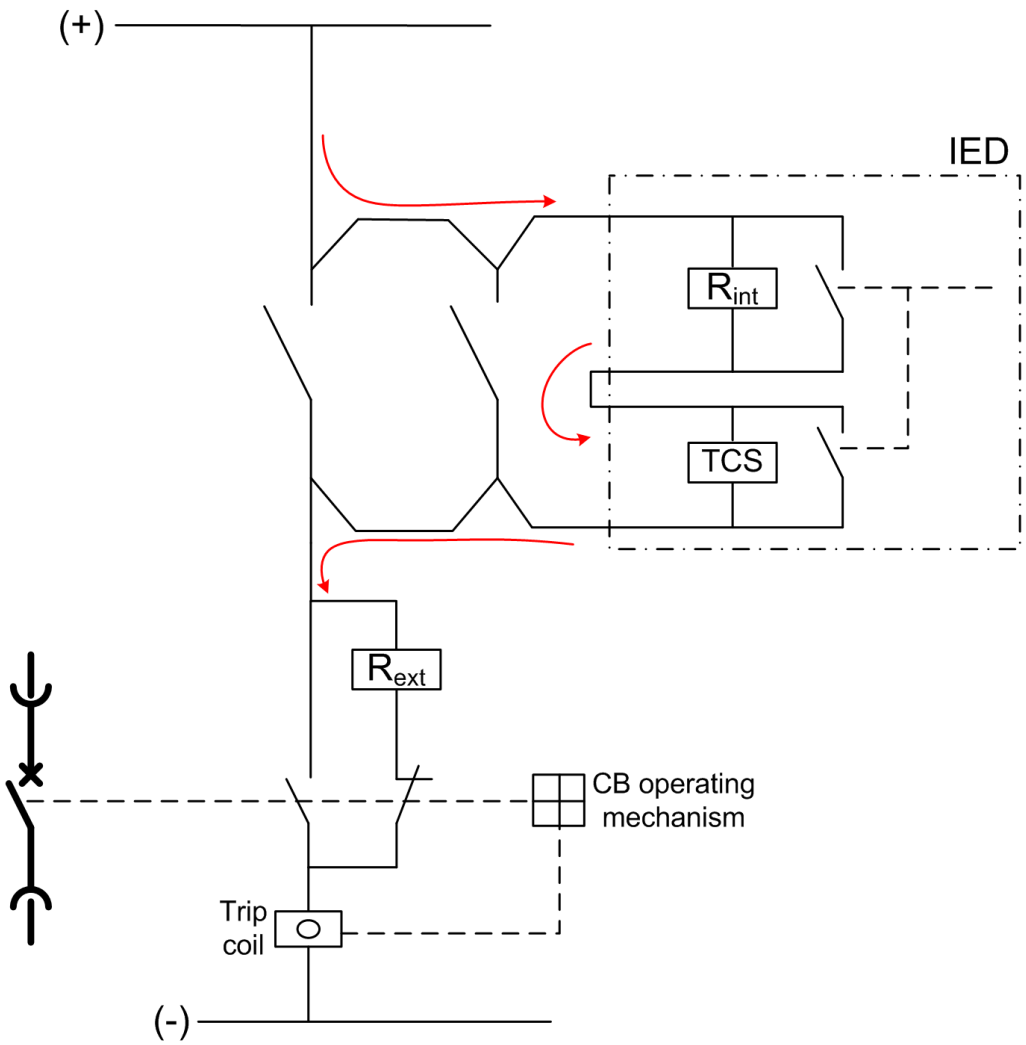



*Figure 742: Improved connection for parallel trip contacts where the test current flows through all wires and joints*

### Several trip circuit supervision functions parallel in circuit

Not only the trip circuit often have parallel trip contacts, it is also possible that the circuit has multiple TCS circuits in parallel. Each TCS circuit causes its own supervising current to flow through the monitored coil and the actual coil current is a sum of all TCS currents. This must be taken into consideration when determining the resistance of $R_{ext}$.

Setting the TCS function in a protection relay not-in-use does not typically affect the supervising current injection.

### Trip circuit supervision with auxiliary relays

Many retrofit projects are carried out partially, that is, the old electromechanical relays are replaced with new ones but the circuit breaker is not replaced. This creates a problem that the coil current of an old type circuit breaker can be too high for the protection relay trip contact to break.

The circuit breaker coil current is normally cut by an internal contact of the circuit breaker. In case of a circuit breaker failure, there is a risk that the protection relay trip contact is destroyed since the contact is obliged to disconnect high level of electromagnetic energy accumulated in the trip coil.

An auxiliary relay can be used between the protection relay trip contact and the circuit breaker coil. This way the breaking capacity question is solved, but the TCS circuit in the protection relay monitors the healthy auxiliary relay coil, not the circuit breaker coil. The separate trip circuit supervision relay is applicable for this to supervise the trip coil of the circuit breaker.

**Dimensioning of the external resistor**

Under normal operating conditions, the applied external voltage is divided between the relay's internal circuit and the external trip circuit so that at the minimum 20 V (15...20 V) remains over the relay's internal circuit. Should the external circuit's resistance be too high or the internal circuit's too low, for example due to welded relay contacts, a fault is detected.

Mathematically, the operation condition can be expressed as:

$$U_C - U_D - I_C \cdot (R_s + R_{ext}) \geq 20V \quad AC / DC$$

(Equation 314)

| | |
|---|---|
| $U_c$ | Operating voltage over the supervised trip circuit |
| $U_D$ | Voltage drop over internal 3 mA current drain, about 6.5 V |
| $I_c$ | Measuring current through the trip circuit, appr. 1.5 mA (0.99...1.72 mA) |
| $R_{ext}$ | External shunt resistance |
| $R_s$ | Trip coil resistance |

If the external shunt resistance is used, it has to be calculated not to interfere with the functionality of the supervision or the trip coil. Too high a resistance causes too high a voltage drop, jeopardizing the requirement of at least 20 V over the internal circuit, while a resistance too low can enable false operations of the trip coil.

**Table 1238: Values recommended for the external resistor R ext**

| Operating voltage $U_c$ | Shunt resistor $R_{ext}$ |
|---|---|
| 48 V AC/DC | 1.2 kΩ, 5 W |
| 60 V AC/DC | 5.6 kΩ, 5 W |
| 110...130 V AC/DC | 22 kΩ, 5 W |
| 220...250 V AC/DC | 33 kΩ, 5 W |

Due to the requirement that the voltage over the TCS contact must be 20 V or higher, the correct operation is not guaranteed with auxiliary operating voltages lower than 48 V DC because of the voltage drop in $U_D$ and $R_{ext}$ and the operating coil or even voltage drop of the feeding auxiliary voltage system which can cause too low voltage values over the TCS contact. In this case, erroneous alarming can occur.

At lower (<48 V DC) auxiliary circuit operating voltages, it is recommend either touse the static output and single-pole connection (as then there is no internal currentdrain and $U_D$ = 0 V), or not to use $R_{ext}$ and block TCS when the circuit breaker isopen.

**Using power output contacts without trip circuit supervision**

In case of mechanical outputs, if TCS is not used, the internal current drain (PSM100x.X2:4, PSM100x.X2:9 and PSM100x.X2:14 in PODP1, PODP2 and PODP2 outputs, respectively) can be left unconnected. The output can then be used as a normal power output.

**Incorrect connections and use of trip circuit supervision**

Although the TCS circuit in the PODP1, PODP2 and PODP2 outputs consists of two separate contacts, it must be noted that those are designed to be used as series connected to guarantee the breaking capacity given in the technical manual of the protection relay. *Figure 743* shows incorrect usage of a TCS circuit when only one of the contacts is used.

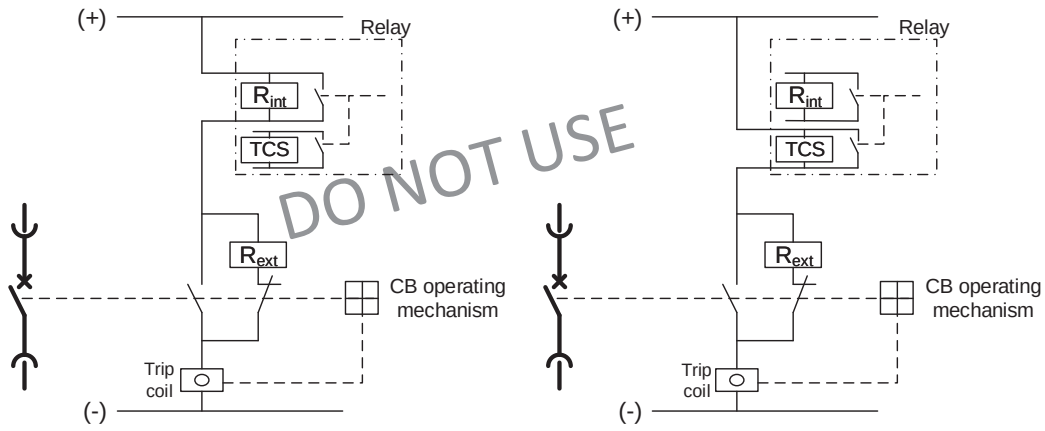



*Figure 743: Incorrect connection of trip-circuit supervision*

## 6.1.6 Signals

### 6.1.6.1 TCSSCBR Input signals

**Table 1239: TCSSCBR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| TCS_STATE | BOOLEAN | 0=False | Trip circuit supervision status |
| BLOCK | BOOLEAN | 0=False | Block input status |

### 6.1.6.2 TCSSCBR Output signals

**Table 1240: TCSSCBR Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm output |

### 6.1.7 TCSSCBR Settings

**Table 1241: TCSSCBR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operate delay time | 1000...300000 | ms | 1 | 3000 | Operate delay time |

**Table 1242: TCSSCBR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 20...60000 | ms | 1 | 1000 | Reset delay time |

### 6.1.8 TCSSCBR Monitored data

**Table 1243: TCSSCBR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| TCSSCBR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 6.2 Current circuit supervision CCSPVC (ANSI CCM)

### 6.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current circuit supervision | CCSPVC | MCS 3I | CCM |

### 6.2.2 Function block




*Figure 744: Function block*

## 6.2.3 Functionality

The current circuit supervision function CCSPVC is used for monitoring current transformer secondary circuits.

CCSPVC calculates internally the sum of phase currents (I_A, I_B and I_C) and compares the sum against the measured single reference current (I_REF). The reference current must originate from other three-phase CT cores than the phase currents (I_A, I_B and I_C) and it is to be externally summated, that is, outside the protection relay.

CCSPVC detects a fault in the measurement circuit and issues an alarm or blocks the protection functions to avoid unwanted tripping.

It must be remembered that the blocking of protection functions at an occurring open CT circuit means that the situation remains unchanged and extremely high voltages stress the secondary circuit.

## 6.2.4 Analog channel configuration

CCSPVC has two analog group inputs which must be properly configured.

**Table 1244: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| IRES | Residual current (measured) |



See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1245: Special conditions**

| Condition | Description |
|---|---|
| IRES measured | In case IRES needs to be derived, the function requires that all CT cores, except for the one used for phase current measurement, must be used and summed externally. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 6.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of CCSPVC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

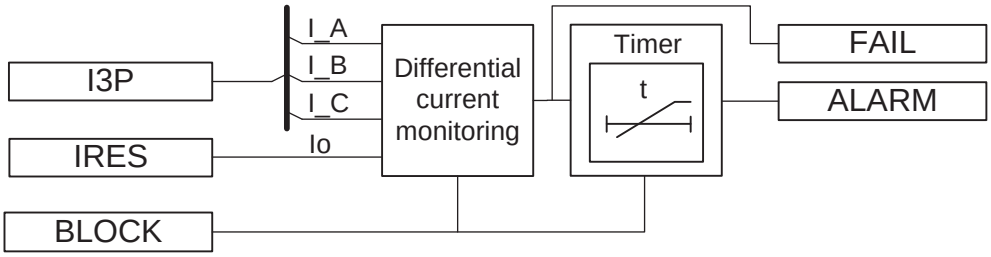



*Figure 745: Functional module diagram*

**Differential current monitoring**

Differential current monitoring supervises the difference between the summed phase currents I_A, I_B and I_C and the reference current I_REF.

The current operating characteristics can be selected with the *Start value* setting. When the highest phase current is less than 1.0 × In, the differential current limit is defined with *Start value*. When the highest phase current is more than 1.0 × In, the differential current limit is calculated with the equation.

$$MAX(I_A, I_B, I_C) \times Start\ value$$

(Equation 315)

The differential current is limited to 1.0 × In.

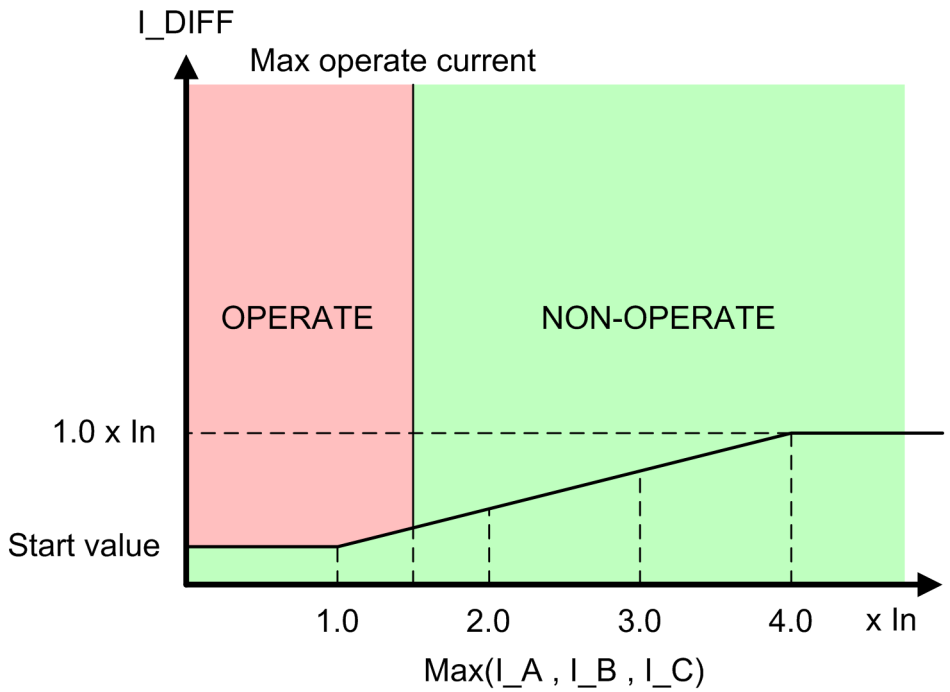



*Figure 746: CCSPVC operating characteristics*

When the differential current I_DIFF is in the operating region, the `FAIL` output is activated.

The function is internally blocked if any phase current is higher than the set *Max operate current*. When the internal blocking activates, the FAIL output is deactivated immediately. The internal blocking is used for avoiding false operation during a fault situation when the current transformers are saturated due to high fault currents.

The value of the differential current is available in the monitored data view on the LHMI or through other communication tools. The value is calculated with the equation.

$$I_DIFF = \left| \overline{I_A} + \overline{I_B} + \overline{I_C} \right| - \left| \overline{I_REF} \right|$$

(Equation 316)

The *Start value* setting is given in units of ×In of the phase current transformer. The possible difference in the phase and reference current transformer ratios is internally compensated by scaling I_REF with the value derived from the *Primary current* setting values. These setting parameters can be found in the Basic functions section.

The activation of the BLOCK input deactivates the FAIL output immediately.

**Timer**

The timer is activated with the FAIL signal. The ALARM output is activated after a fixed 200 ms delay. FAIL needs to be active during the delay.

When the internal blocking is activated, the FAIL output deactivates immediately. However, the ALARM output deactivates after a fixed delay of three seconds.

The function resets when the differential current is below the start value and the highest phase current is more than 5 percent of the nominal current (0.05 × In).

If the current falls to zero when the FAIL or ALARM outputs are active, the deactivation of these outputs is prevented.

The activation of the BLOCK input deactivates the ALARM output.

## 6.2.6 Application

Open or short-circuited current transformer cores can cause unwanted operation in many protection functions such as differential, earth-fault current and negative-sequence current functions. When currents from two independent three-phase sets of CTs or CT cores measuring the same primary currents are available, reliable current circuit supervision can be arranged by comparing the currents from the two sets. When an error in any CT circuit is detected, the protection functions concerned can be blocked and an alarm given.

In case of high currents, the unequal transient saturation of CT cores with a different remanence or saturation factor can result in differences in the secondary currents from the two CT cores. An unwanted blocking of protection functions during the transient stage must then be avoided.

The supervision function must be sensitive and have a short operation time to prevent unwanted tripping from fast-acting, sensitive numerical protections in case of faulty CT secondary circuits.

Open CT circuits create extremely high voltages in the circuits, which may damage the insulation and cause further problems. This must be taken into consideration especially when the protection functions are blocked.

When the reference current is not connected to the protection relay, the function should be turned off. Otherwise, the FAIL output is activated when unbalance occurs in the phase currents even if there was nothing wrong with the measurement circuit.

**Reference current measured with core-balanced current transformer**

CCSPVC compares the sum of phase currents to the current measured with the core-balanced CT.

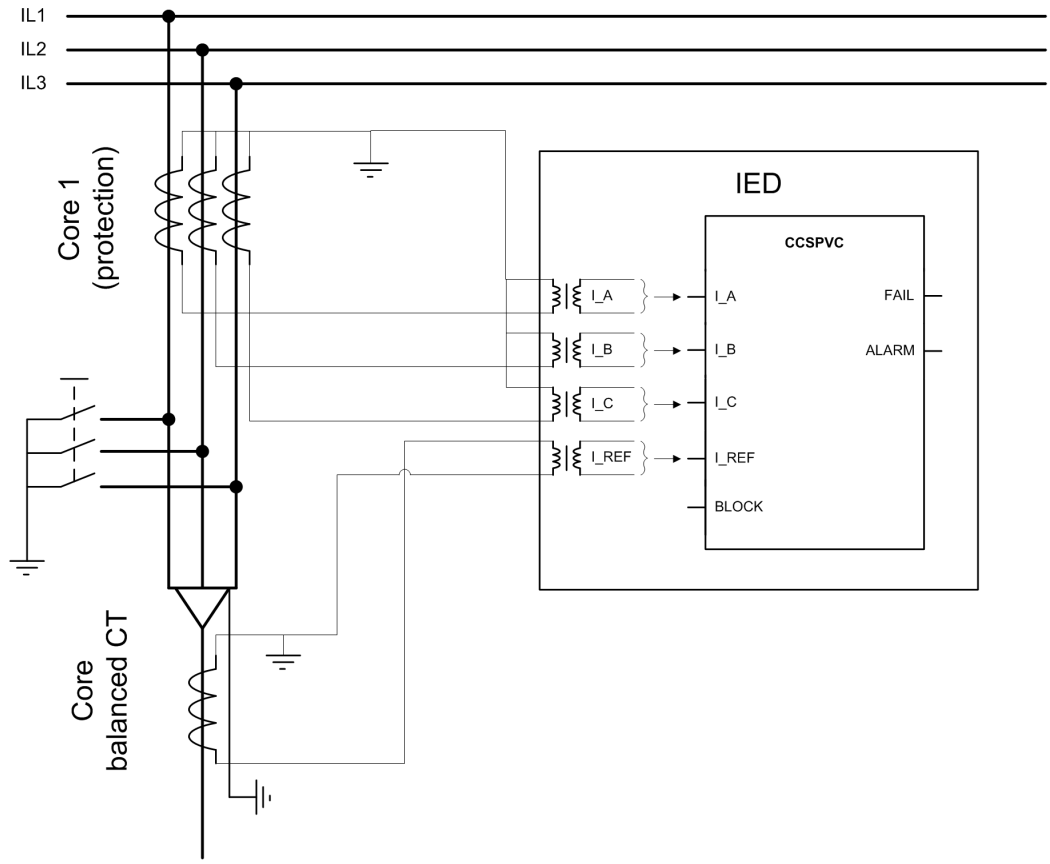



*Figure 747: Connection diagram for reference current measurement with core-balanced current transformer*

**Current measurement with two independent three-phase sets of CT cores**

*Figure 748* and *Figure 749* show diagrams of connections where the reference current is measured with two independent three-phase sets of CT cores.

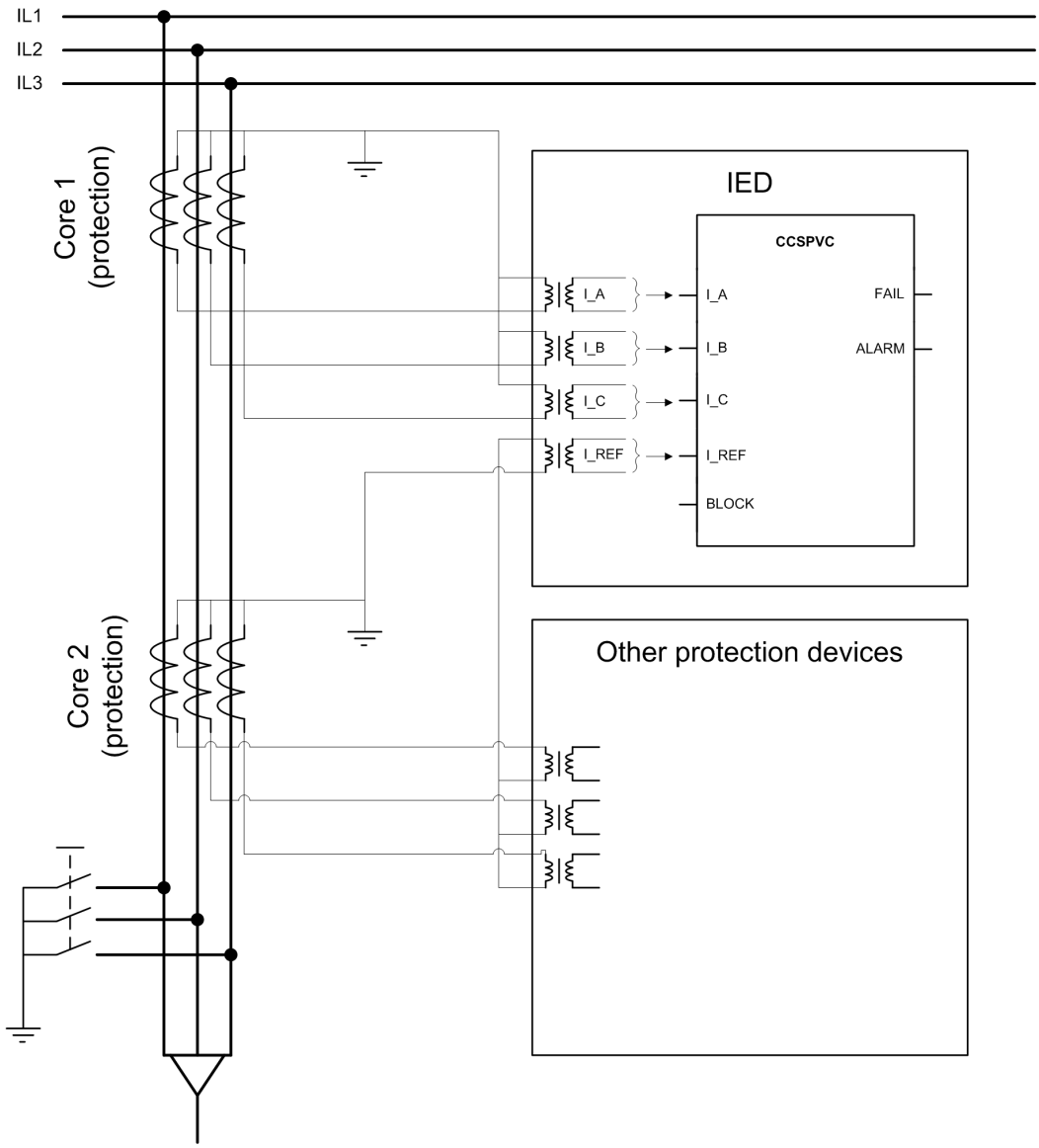



*Figure 748: Connection diagram for current circuit supervision with two sets of three-phase current transformer protection cores*

When using the measurement core for reference current measurement, it should be noted that the saturation level of the measurement core is much lower than with the protection core. This should be taken into account when setting the current circuit supervision function.

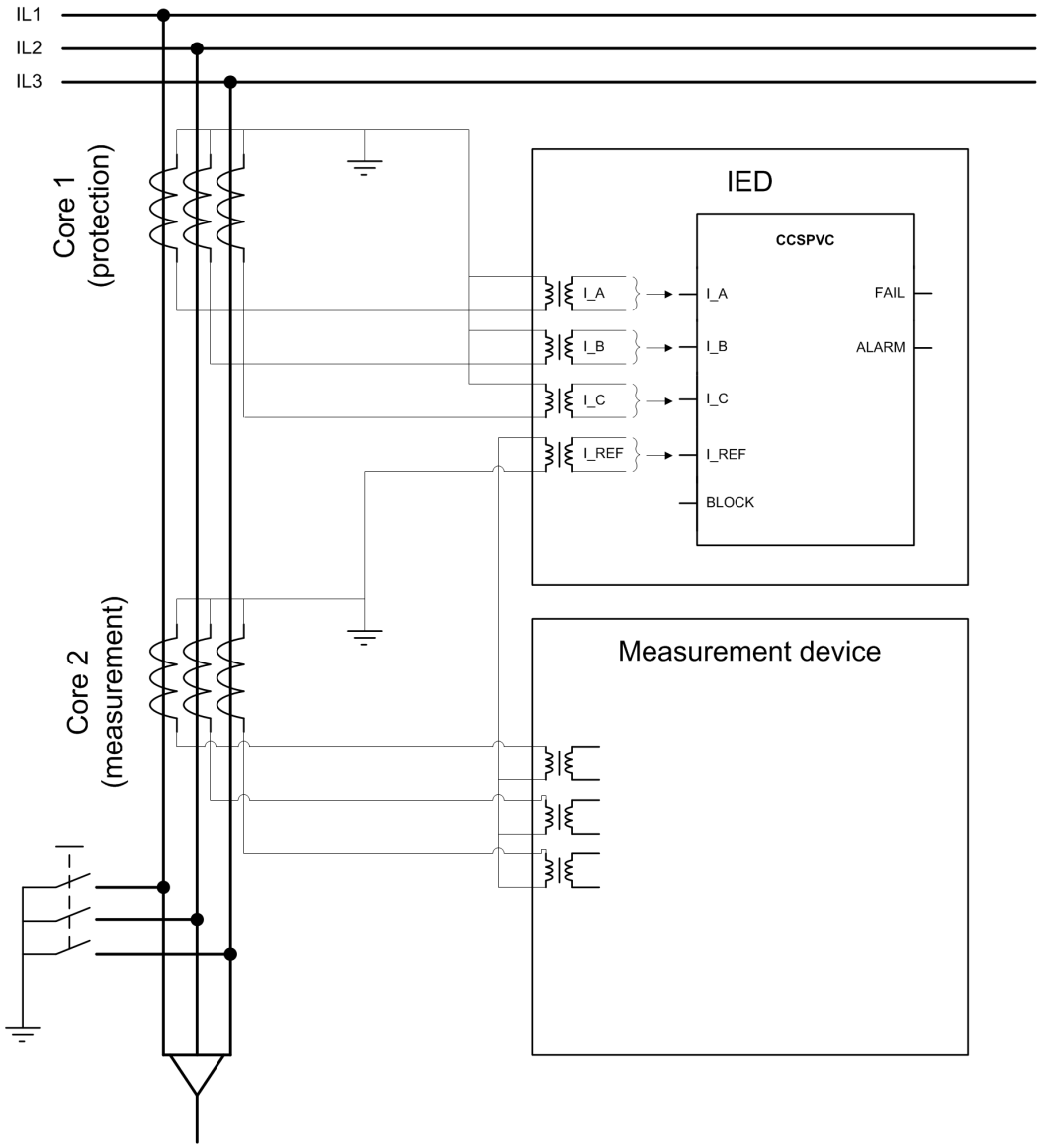



*Figure 749: Connection diagram for current circuit supervision with two sets of three-phase current transformer cores (protection and measurement)*

**Example of incorrect connection**

The currents must be measured with two independent cores, that is, the phase currents must be measured with a different core than the reference current. A connection diagram shows an example of a case where the phase currents and the reference currents are measured from the same core.

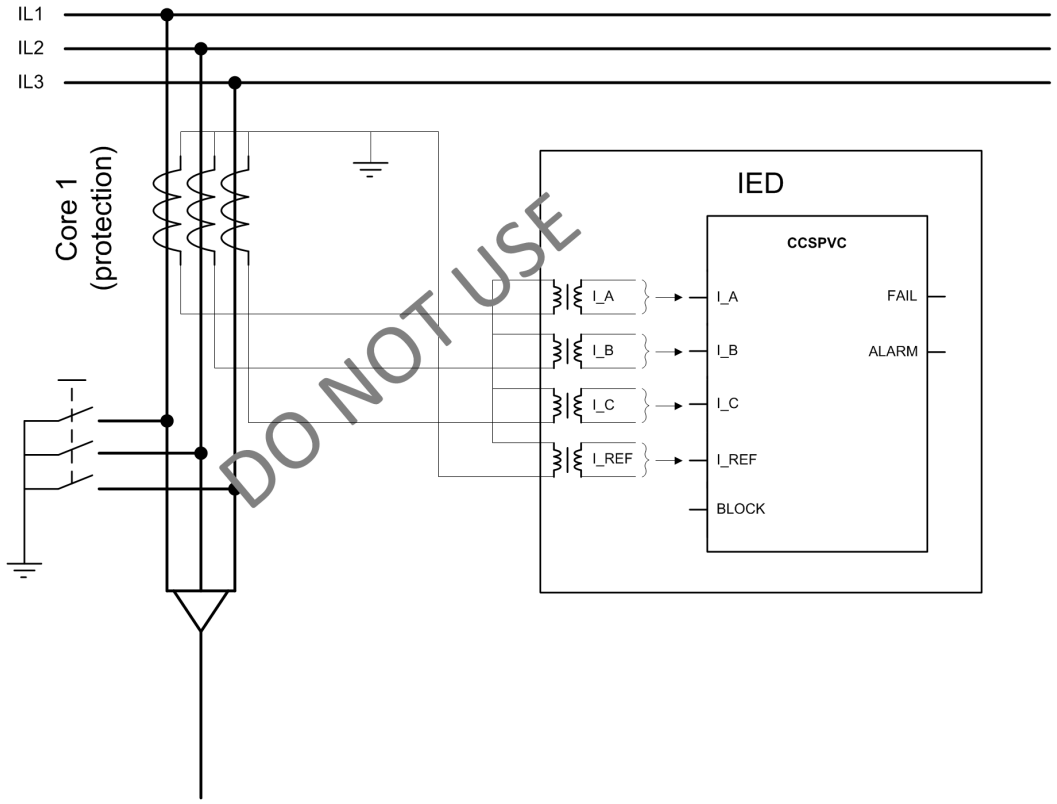



*Figure 750: Example of incorrect reference current connection*

## 6.2.7 Signals

### 6.2.7.1 CCSPVC Input signals

**Table 1246: CCSPVC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

### 6.2.7.2 CCSPVC Output signals

**Table 1247: CCSPVC Output signals**

| Name | Type | Description |
|---|---|---|
| FAIL | BOOLEAN | Fail output |
| ALARM | BOOLEAN | Alarm output |

## 6.2.8 CCSPVC Settings

**Table 1248: CCSPVC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation On / Off |
| Start value | 0.05...0.50 | xIn | 0.01 | 0.05 | Minimum operate current differential level |

**Table 1249: CCSPVC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max operate current | 1.00...5.00 | xIn | 0.01 | 1.50 | Block of the function at high phase current |

## 6.2.9 CCSPVC Monitored data

**Table 1250: CCSPVC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| IDIFF | FLOAT32 | 0.00...40.00 | xIn | Differential current |
| CCSPVC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 6.2.10 Technical data

**Table 1251: CCSPVC Technical data**

| Characteristic | Value |
|---|---|
| Operate time (including the delay of the output contact) | <30 ms |

## 6.2.11 Technical revision history

**Table 1252: CCSPVC Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | F | Setting *Start value* maximum extended to 0.50xIn. |

# 6.3 Current transformer supervision for high-impedance protection scheme HZCCxSPVC (ANSI CCM_A, CCM_B, CCM_C)

## 6.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current transformer supervision for high-impedance protection scheme for phase A | HZCCASPVC | MCS I_A | CCM_A |
| Current transformer supervision for high-impedance protection scheme for phase B | HZCCBSPVC | MCS I_B | CCM_B |
| Current transformer supervision for high-impedance protection scheme for phase C | HZCCCSPVC | MCS I_C | CCM_C |

## 6.3.2 Function block

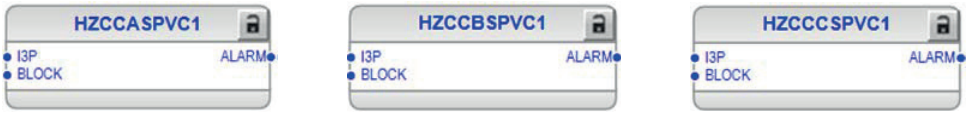



*Figure 751: Function block*

## 6.3.3 Functionality

The current transformer supervision for high-impedance protection scheme function HZCCxSPVC is a dedicated phase-segregated supervision function to be used along with the high-impedance differential protection for detecting the broken CT secondary wires. The differential current is taken as an input for the protection relay. During normal CT condition, the value of the differential current is zero. However, when the CT is broken, the secondary differential current starts flowing and it is used for generating alarms.

To avoid maloperation, HZCCxSPVC should have a sensitive setting, compared to the high-impedance differential protection. The function is likely to start under through-fault conditions. However, by incorporating a high time delay (3 s or more), the downstream protection clears the fault before an alarm is generated.

HZCCxSPVC generates an alarm when the differential current exceeds the set limit. The function operates within the DT characteristic.

HZCCxSPVC contains a blocking functionality. It is possible to block the function output, Timer or the whole function.

### 6.3.4 Analog channel configuration

HZCCxSPVC has one analog group input which must be properly configured.

**Table 1253: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 6.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of HZCCxSPVC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

The module diagram illustrates all the phases of the function. However, the functionality is described only for phase A. The functionality for phase B and C is identical.

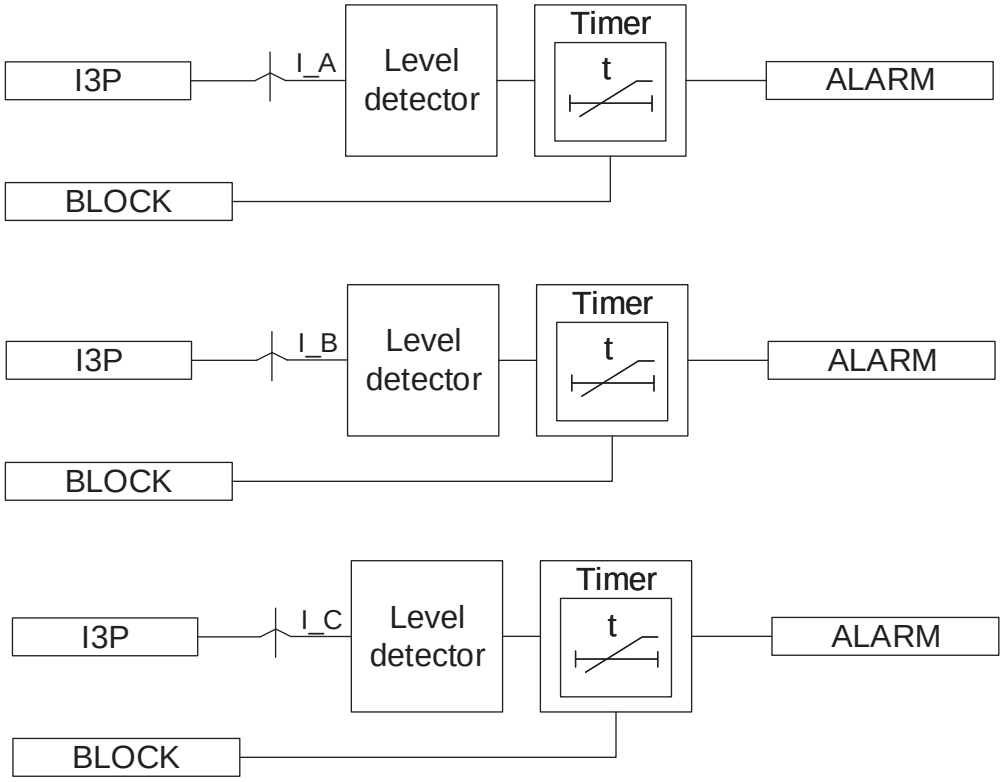



*Figure 752: Functional module diagram*

**Level detector**

This module compares the differential current `I_A` to the set *Start value*. The timer module is activated if the differential current exceeds the value set in the *Start value* setting.

**Timer**

The time characteristic is according to DT. When the alarm timer reaches the value set by *Alarm delay time*, the `ALARM` output is activated. If the fault disappears before the module generates an alarm signal, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the alarm timer resets. The activation of the `BLOCK` signal resets the Timer and deactivates the `ALARM` output.

**Lockout logic**

HZCCxSPVC is provided with the possibility to activate a lockout for the `ALARM` output depending on the *Alarm output mode* setting. In the "Lockout" mode, the `ALARM` must be reset manually from the LHMI Clear menu after checking the CT secondary circuit. In the "Non-latched" mode, the `ALARM` output functions normally, that is, it resets as soon as the fault is cleared.

## 6.3.6 Measuring modes

The function operates on two alternative measurement modes, DFT and Peak-to-Peak. The measurement mode is selected using the *Measurement mode* setting.

## 6.3.7 Application

HZCCxSPVC is a dedicated phase-segregated supervision function to be used along with the high-impedance differential protection for detecting the broken CT secondary wires. The operation principle of HZCCxSPVC is similar to the high-impedance differential protection function HIxPDIF. However, the current setting of HZCCxSPVC is set to be much more sensitive than HIxPDIF and it operates with a higher time delay. A typical example of the HZCCxSPVC *Start value* setting is 0.1 pu with an *Alarm delay time* of 3 s or more.

As the current setting of HZCCxSPVC is more sensitive than the actual differential stage, it can start internally under the through-fault conditions; however, a sufficient time delay prevents false alarm. If the bus wire is broken, differential current arises depending on the load of the feeder with the broken bus wire.

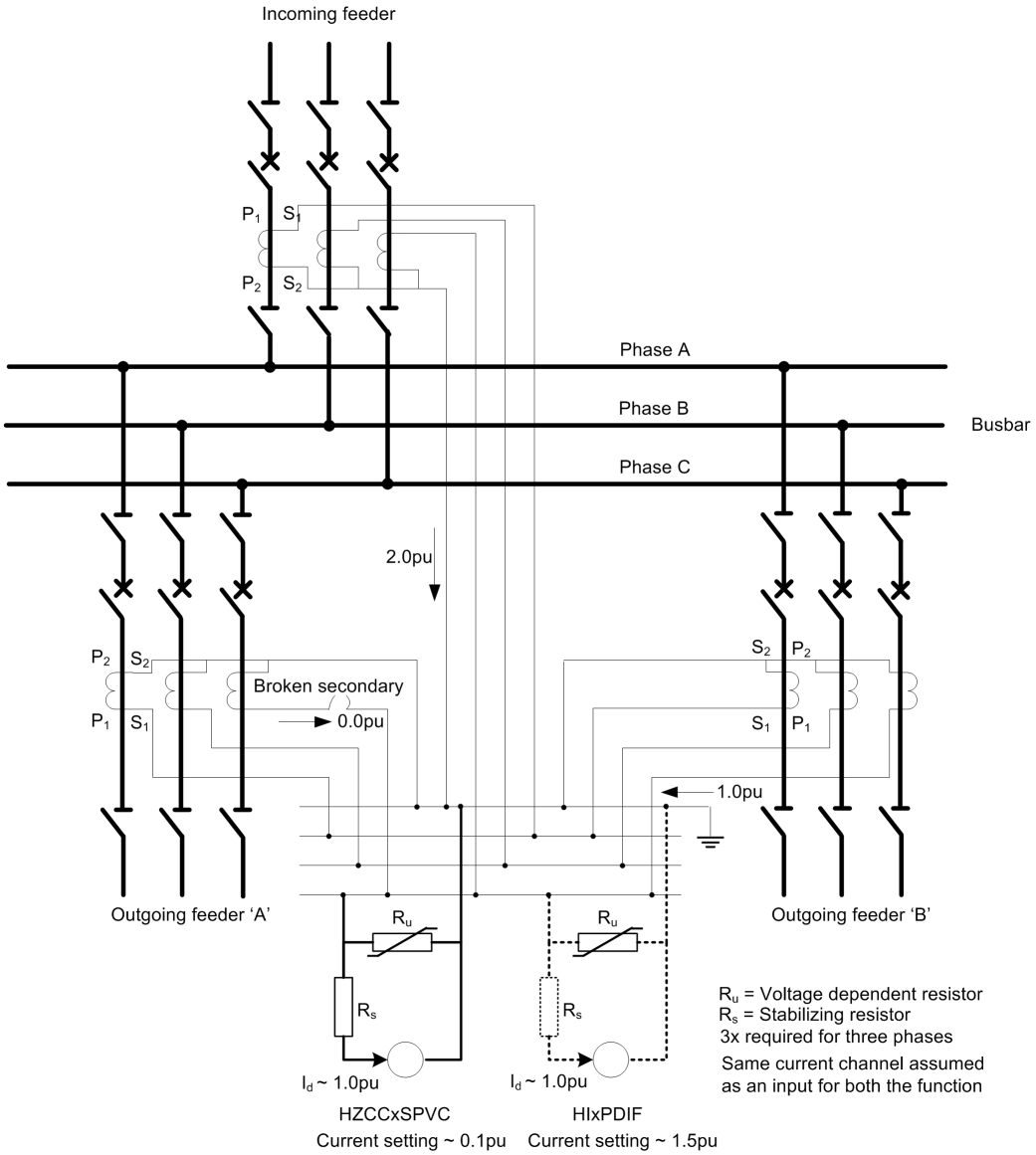



*Figure 753: Broken secondary detection by HZCCxSPVC*

In the example, the incoming feeder is carrying a load of 2.0 pu and both outgoing feeders carry an equal load of 1.0 pu However, both HIxPDIF and HZCCxSPVC consider the current as an increased differential or unbalance current because of the broken CT wire in phase C. Both HIxPDIF and HZCCxSPVC receive the differential current of approximately 1.0 pu The main differential protection HIxPDIF cannot operate because of the higher current setting.



All CTs must have the same ratio.

The ALARM output of the CT supervision function can be used to energize an auxiliary relay which can short-circuit the current CT wires, making the busbar differential protection inoperative. This arrangement does not prevent unwanted operation of HIxPDIF if the start setting is below the rated load. For example, if the start setting for HIxPDIF in the example is set as 0.8 pu HIxPDIF operate before HZCCxSPVC.

## 6.3.8 Signals

### 6.3.8.1 HZCCASPVC Input signals

**Table 1254: HZCCASPVC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating blocking mode |

### 6.3.8.2 HZCCBSPVC Input signals

**Table 1255: HZCCBSPVC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating blocking mode |

### 6.3.8.3 HZCCCSPVC Input signals

**Table 1256: HZCCCSPVC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for activating blocking mode |

### 6.3.8.4 HZCCASPVC Output signals

**Table 1257: HZCCASPVC Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm output |

### 6.3.8.5 HZCCBSPVC Output signals

**Table 1258: HZCCBSPVC Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm output |

### 6.3.8.6 HZCCCSPVC Output signals

**Table 1259: HZCCCSPVC Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm output |

## 6.3.9 Settings

### 6.3.9.1 HZCCASPVC Settings

**Table 1260: HZCCASPVC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Start value | 1.0...100.0 | %In | 0.1 | 10.0 | Start value, percentage of the nominal current |
| Alarm delay time | 100...300000 | ms | 10 | 3000 | Alarm delay time |
| Alarm output mode | 1=Non-latched<br>3=Lockout | | | 3=Lockout | Select the operation mode for alarm output |

**Table 1261: HZCCASPVC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |
| Measurement mode | 2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

### 6.3.9.2 HZCCBSPVC Settings

**Table 1262: HZCCBSPVC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Start value | 1.0...100.0 | %In | 0.1 | 10.0 | Start value, percentage of the nominal current |
| Alarm delay time | 100...300000 | ms | 10 | 3000 | Alarm delay time |
| Alarm output mode | 1=Non-latched<br>3=Lockout | | | 3=Lockout | Select the operation mode for alarm output |

**Table 1263: HZCCBSPVC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |
| Measurement mode | 2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

### 6.3.9.3 HZCCCSPVC Settings

**Table 1264: HZCCCSPVC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Start value | 1.0...100.0 | %In | 0.1 | 10.0 | Start value, percentage of the nominal current |
| Alarm delay time | 100...300000 | ms | 10 | 3000 | Alarm delay time |
| Alarm output mode | 1=Non-latched<br>3=Lockout | | | 3=Lockout | Select the operation mode for alarm output |

**Table 1265: HZCCCSPVC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 10 | 20 | Reset delay time |
| Measurement mode | 2=DFT<br>3=Peak-to-Peak | | | 2=DFT | Selects used measurement mode |

## 6.3.10 Monitored data

### 6.3.10.1 HZCCASPVC Monitored data

**Table 1266: HZCCASPVC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| HZCCASPVC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked | | Status |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 5=off | | |

### 6.3.10.2 HZCCBSPVC Monitored data

**Table 1267: HZCCBSPVC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| HZCCBSPVC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 6.3.10.3 HZCCCSPVC Monitored data

**Table 1268: HZCCCSPVC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| HZCCCSPVC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 6.3.11 Technical data

**Table 1269: HZCCxSPVC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the current measured: $f_n$ ±2 Hz |
| | ±1.5 % of the set value or ±0.002 × $I_n$ |
| Reset time | <40 ms |
| Reset ratio | Typically 0.96 |
| Retardation time | <35 ms |
| Operate time accuracy in definite time mode | ±1.0 % of the set value or ±20 ms |

# 6.4 Protection communication supervision PCSITPC (ANSI PCS)

## 6.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Protection communication supervision | PCSITPC | PCS | PCS |

## 6.4.2 Function block




*Figure 754: Function block*

## 6.4.3 Functionality

The protection communication supervision function PCSITPC monitors the protection communication channel. PCSITPC blocks the line differential protection functions when interference in the protection communication channel is detected. The blocking takes place automatically for the LNPLDF and BSTGAPC functions which are dependent on the continuous availability of the protection communication channel.

The protection communication channel is continuously monitored by PCSITPC. The function detects missing or delayed protection telegrams. Protection telegrams are used for transferring the sampled analog and other protection related data. Missing or delayed protection telegrams can jeopardize the demand operate speed of the differential protection.

When a short-term interference is detected in the protection communication channel, the function issues a warning and the line differential functions are automatically internally blocked. PCSITPC reacts fast for the protection communication interferences. The blocking takes place at the latest when a communication interruption lasting for two fundamental network periods is detected. When a severe and long lasting interference or total interruption in the protection communication channel is detected, an alarm is issued (after a five-second delay). The protection communication supervision quality status is exchanged continuously online by the local and remote PCSITPC instances. This ensures that both local and remote ends protection blocking is issued coordinately. This further enhances the security of the line differential protection by forcing both line end protection relays to the same blocking state during a protection communication interference, even in cases where the interference is detected with only one line end protection relay. There is also the *Reset delay time* settings parameter available which is used for changing the required interference-free time before releasing the line-differential protection back in operation after a blocking due to an interference in communication.

## 6.4.4 Operation principle

The operation of protection communication supervision can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

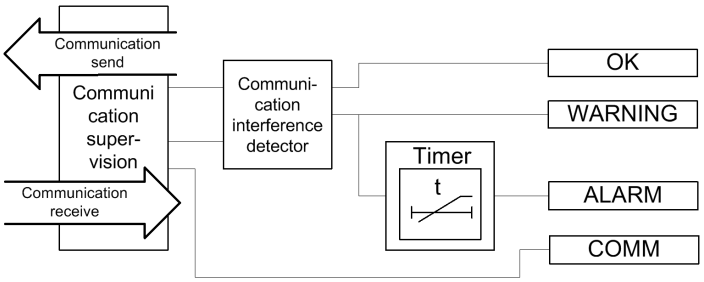



*Figure 755: Functional module diagram*

#### Communication supervision

The protection communication is supervised because the differential calculation is dependent on the refreshing of new analog phasor samples from the remote terminal within the protection telegram. The new protection telegram also updates the status of the binary signals sent by the remote terminal. The calculation of the differential current is based on comparing the remote and local terminal measured current samples. It is therefore essential that the protection communication telegrams are supervised and the result of the sample latency calculation can be used further in the differential current calculation. When the communication is able to receive telegrams correctly from the remote end via the communication media, the communication is assumed to be operating correctly and the COMM output is kept active.

#### Communication interference detector

The communication interference detector continuously measures and observes the sample latency of the protection telegrams. This value is also available as monitored data. The function provides three output signals of which only the corresponding one is active at a time depending on if the protection communication supervision is in OK, WARNING or ALARM. The OK state indicates the correct operation of the protection. The WARNING state indicates that the protection is internally blocked due to detected interference. The WARNING state is switched to ALARM if the interference lasts for a longer period. These output signals are set to the FALSE state until the first telegram is received over the communication link and supervision is started. The protection communication supervision can sometimes be in the WAITING state. This state indicates that the terminal is waiting for the communication to start or restart from the remote end terminal.

#### Timer

Once activated with the WARNING signal, the timer has a constant time delay value of five seconds. If the communication failure exists after the delay, the ALARM output is activated.

## 6.4.5 Application

### Communication principle

Analog samples, trip-, start- and user programmable signals are transferred in each protection telegram and the exchange of these protection telegrams is done eight times per power system cycle (every 2.5 ms when $F_n$ = 50 Hz).

Master-Master communication arrangement is used in the two-terminal line differential solution. Current samples are sent from both line ends and the protection algorithms are also executed on both line ends. The direct-intertrip, however, ensures that both ends are always operated simultaneously.

### Time synchronization

In numerical line differential protection, the current samples from the protections which are located geographically apart from each other must be time coordinated so that the current samples from both ends of the protected line can be compared without introducing irrelevant errors. The time coordination requires an extremely high accuracy.

As an example, an inaccuracy of 0.1 ms in a 50 Hz system gives a maximum amplitude error of approximately around 3 percent. An inaccuracy of 1 ms gives a maximum amplitude error of approximately 31 percent. The corresponding figures for a 60 Hz system are 4 and 38 percent respectively.

In the protection relay, the time coordination is done with an echo method. The protection relays create their own time reference between each other so that the system clocks do not need to synchronize.

The figure shows that in the time synchronization the transmission time to send a message from station B to station A, T1→T2, and the time to receive a message from A to B, T4→T5, are measured. The station A protection relay delay from the sampling to the start of send, T3→T4, and the local delay from receive to the station B protection relay sampling T5→T6 time, are also measured for the station B protection relay, and vice versa. This way the time alignment factor for the local and remote samples is achieved.

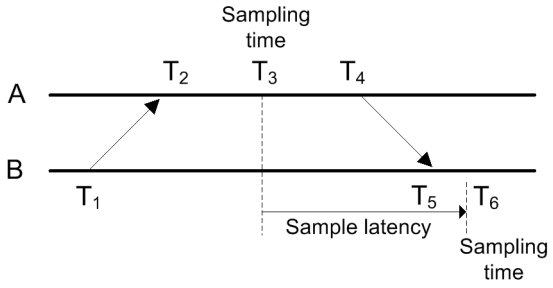



*Figure 756: Measuring sampling latency*

$$P_d = \frac{(T_2 - T_1) + (T_5 - T_4)}{2}$$

(Equation 317)

$$S_d = P_d + (T_4 - T_3) + (T_6 - T_5)$$

(Equation 318)

The sampling latency $S_d$ is calculated for each telegram on both ends. The algorithm assumes that the one-way propagation delay $P_d$ is equal for both directions.

The echo method without GPS can be used in telecommunication transmission networks as long as delay symmetry exists, that is, the sending and receiving delays are equal.

## 6.4.6 Signals

### 6.4.6.1 PCSITPC Output signals

**Table 1270: PCSITPC Output signals**

| Name | Type | Description |
|---|---|---|
| OK | BOOLEAN | Protection communication ok |
| WARNING | BOOLEAN | Protection communication warning |
| ALARM | BOOLEAN | Protection communication alarm |
| COMM | BOOLEAN | Communication detected, active when data is received |

## 6.4.7 PCSITPC Settings

**Table 1271: PCSITPC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 100...300000 | ms | 10 | 1000 | Reset delay time from alarm and warning into ok state |
| Alarm count | 0...99999 | | 1 | 0 | Set new alarm count value |
| Warning count | 0...99999 | | 1 | 0 | Set new warning count value |

## 6.4.8 PCSITPC Monitored data

**Table 1272: PCSITPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| HEALTH | Enum | 1=Ok<br>2=Warning<br>3=Alarm<br>-2=Waiting | | Communication link health |
| ALARM_CNT | INT32 | 0...99999 | | Number of alarms detected |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| WARN_CNT | INT32 | 0...99999 | | Number of warnings detected |
| SMPL_LATENCY | FLOAT32 | 0.000...99.999 | ms | Measured sample latency |
| PROPAGTN_DLY | FLOAT32 | 0.000...99.999 | ms | Measured propagation delay |
| RND_TRIP_DLY | FLOAT32 | 0.000...99.999 | ms | Measured round trip delay |
| T_ALARM_CNT | Timestamp | | | Time when alarm count was last changed |
| T_WARN_CNT | Timestamp | | | Time when warning count was last changed |

# 6.5 Fuse failure supervision SEQSPVC (ANSI VCM, 60)

## 6.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Fuse failure supervision | SEQSPVC | FUSEF | VCM, 60 |

## 6.5.2 Function block

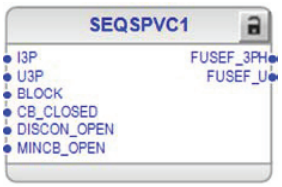



*Figure 757: Function block*

## 6.5.3 Functionality

The fuse failure supervision function SEQSPVC is used to block the voltage-measuring functions when failure occurs in the secondary circuits between the voltage transformer (or combi sensor or voltage sensor) and protection relay to avoid misoperations of the voltage protection functions.

SEQSPVC has two algorithms, a negative sequence-based algorithm and a delta current and delta voltage algorithm.

A criterion based on the delta current and the delta voltage measurements can be activated to detect three-phase fuse failures which usually are more associated with the voltage transformer switching during station operations.

## 6.5.4 Analog channel configuration

SEQSPVC has two analog group inputs which all must be properly configured.

**Table 1273: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |



See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1274: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 6.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of SEQSPVC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

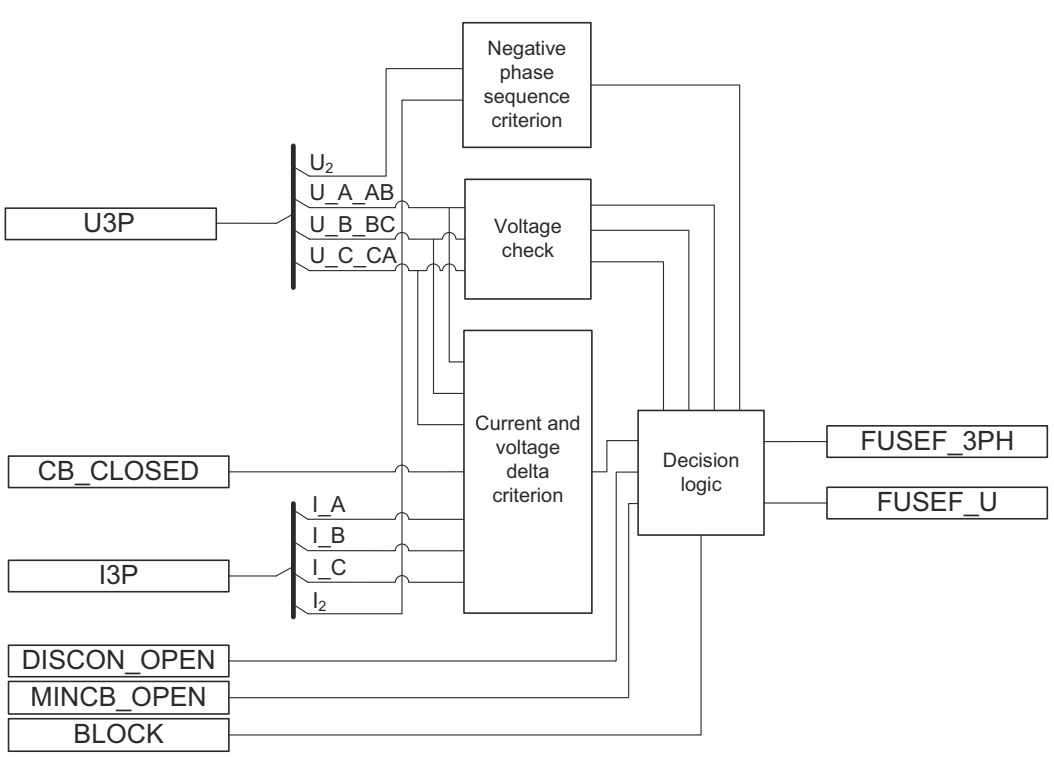



*Figure 758: Functional module diagram*

**Negative phase-sequence criterion**

A fuse failure based on the negative-sequence criterion is detected if the measured negative-sequence voltage exceeds the set *Neg Seq voltage Lev* value and the measured negative-sequence current is below the set *Neg Seq current Lev* value. The detected fuse failure is reported to the decision logic module.

**Voltage check**

The phase voltage magnitude is checked when deciding whether the fuse failure is a three, two or a single-phase fault.

The module makes a phase-specific comparison between each voltage input and the *Seal in voltage* setting. If the input voltage is lower than the setting, the corresponding phase is reported to the decision logic module.

**Current and voltage delta criterion**

The delta function can be activated by setting the *Change rate enable* parameter to "True". Once the function is activated, it operates in parallel with the negative sequence-based algorithm. The current and voltage are continuously measured in all three phases to calculate:

- Change of voltage dU/dt
- Change of current dI/dt

The calculated delta quantities are compared to the respective set values of the *Current change rate* and *Voltage change rate* settings.

The delta current and delta voltage algorithms detect a fuse failure if there is a sufficient negative change in the voltage amplitude without a sufficient change in

the current amplitude in each phase separately. This is performed when the circuit breaker is closed. Information about the circuit breaker position is connected to the CB_CLOSED input.

There are two conditions for activating the current and voltage delta function.

- The magnitude of dU/dt exceeds the corresponding value of the *Voltage change rate* setting and magnitude of dI/dt is below the value of the *Current change rate* setting in any phase at the same time due to the closure of the circuit breaker ( CB_CLOSED = TRUE).
- The magnitude of dU/dt exceeds the value of the *Voltage change rate* setting and the magnitude of dI/dt is below the *Current change rate* setting in any phase at the same time and the magnitude of the phase current in the same phase exceeds the *Min Op current delta* setting.

The first condition requires the delta criterion to be fulfilled in any phase at the same time as the circuit breaker is closed. Opening the circuit breaker at one end and energizing the line from the other end onto a fault could lead to an improper operation of SEQSPVC with an open breaker. If this is considered to be an important disadvantage, the CB_CLOSED input is to be connected to FALSE. In this way only the second criterion can activate the delta function.

The second condition requires the delta criterion to be fulfilled in one phase together with a high current for the same phase. The measured phase current is used to reduce the risk of a false fuse failure detection. If the current on the protected line is low, a voltage drop in the system (not caused by the fuse failure) is not followed by a current change and a false fuse failure can occur. To prevent this, the minimum phase current criterion is checked.

The fuse failure detection is active until the voltages return above the *Min Op voltage delta* setting. If a voltage in a phase is below the *Min Op voltage delta* setting, a new fuse failure detection for that phase is not possible until the voltage returns above the setting value.

### Decision logic

If voltages are Wye-connected, it is recommended to scale the default values of voltage-based settings with 1/sqrt(3) because the default setting values apply for Delta-connected settings.

The fuse failure detection outputs FUSEF_U and FUSEF_3PH are controlled according to the detection criteria or external signals.

**Table 1275: Fuse failure output control**

| Fuse failure detection criterion | Conditions and function response |
|---|---|
| Negative-sequence criterion | If a fuse failure is detected based on the negative sequence criterion, the FUSEF_U output is activated. |
| | If the fuse failure detection is active for more than five seconds and at the same time all the phase voltage values are below the set value of the *Seal in voltage* setting with *Enable seal in* turned to "True", the function activates the FUSE_3PH output signal. |

*Table continues on the next page*

| Fuse failure detection criterion | Conditions and function response |
|---|---|
| | The FUSEF_U output signal is also activated if all the phase voltages are above the *Seal in voltage* setting for more than 60 seconds and at the same time the negative sequence voltage is above *Neg Seq voltage Lev* for more than 5 seconds, all the phase currents are below the *Current dead Lin Val* setting and the circuit breaker is closed, that is, CB_CLOSED is TRUE. |
| Current and voltage delta function criterion | If the current and voltage delta criterion detects a fuse failure condition, but all the voltages are not below the *Seal in voltage* setting, only the FUSEF_U output is activated. |
| | If the fuse failure detection is active for more than five seconds and at the same time all the phase voltage values are below the set value of the *Seal in voltage* setting with *Enable seal in* turned to "True", the function activates the FUSE_3PH output signal. |
| External fuse failure detection | The MINCB_OPEN input signal is supposed to be connected through a protection relay binary input to the N.C. auxiliary contact of the miniature circuit breaker protecting the VT secondary circuit. The MINCB_OPEN signal sets the FUSEF_U output signal to block all the voltage-related functions when MCB is in the open state. |
| | The DISCON_OPEN input signal is supposed to be connected through a protection relay binary input to the N.C. auxiliary contact of the line disconnector. The DISCON_OPEN signal sets the FUSEF_U output signal to block the voltage-related functions when the line disconnector is in the open state. |

It is recommended to always set *Enable seal in* to "True". This secures that the blocked protection functions remain blocked until normal voltage conditions are restored if the fuse failure has been active for 5 seconds, that is, the fuse failure outputs are deactivated when the normal voltage conditions are restored.

The activation of the BLOCK input deactivates both FUSEF_U and FUSEF_3PH outputs.

## 6.5.6 Application

Some protection functions operate on the basis of the measured voltage value in the protection relay point. These functions can fail if there is a fault in the measuring circuits between the voltage transformer (or combi sensor or voltage sensor) and protection relay.

A fault in the voltage-measuring circuit is called a fuse failure. This term is misleading since a blown fuse is just one of the many possible reasons for a broken circuit. Since incorrectly measured voltage can result in a faulty operation of some of the protection functions, it is important to detect the fuse failures. A fast fuse failure detection is one of the means to block voltage-based functions before they operate.

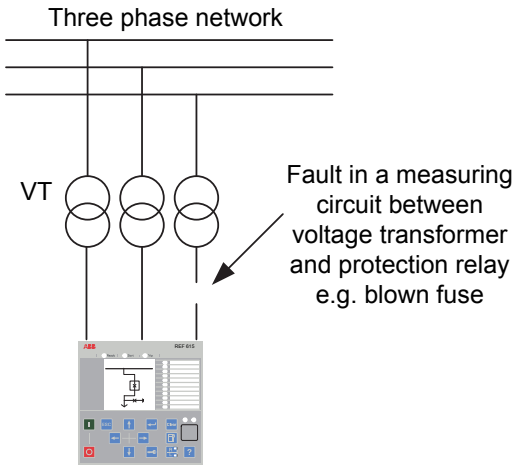



*Figure 759: Fault in a circuit from the voltage transformer to the protection relay*

A fuse failure occurs due to blown fuses, broken wires or intended substation operations. The negative sequence component-based function can be used to detect different types of single-phase or two-phase fuse failures. However, at least one of the three circuits from the voltage transformers must be intact. The supporting delta-based function can also detect a fuse failure due to three-phase interruptions.

In the negative sequence component-based part of the function, a fuse failure is detected by comparing the calculated value of the negative sequence component voltage to the negative sequence component current. The sequence entities are calculated from the measured current and voltage data for all three phases. The purpose of this function is to block voltage-dependent functions when a fuse failure is detected. Since the voltage dependence differs between these functions, SEQSPVC has two outputs for this purpose.

## 6.5.7 Signals

### 6.5.7.1 SEQSPVC Input signals

**Table 1276: SEQSPVC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block of function |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| CB_CLOSED | BOOLEAN | 0=False | Active when circuit breaker is closed |
| DISCON_OPEN | BOOLEAN | 0=False | Active when line disconnector is open |
| MINCB_OPEN | BOOLEAN | 0=False | Active when external MCB opens protected voltage circuit |

### 6.5.7.2 SEQSPVC Output signals

**Table 1277: SEQSPVC Output signals**

| Name | Type | Description |
|---|---|---|
| FUSEF_3PH | BOOLEAN | Three-phase start of function |
| FUSEF_U | BOOLEAN | General start of function |

## 6.5.8 SEQSPVC Settings

**Table 1278: SEQSPVC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

**Table 1279: SEQSPVC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Neg Seq current Lev | 0.03...0.20 | xIn | 0.01 | 0.03 | Operate level of neg seq undercurrent element |
| Neg Seq voltage Lev | 0.03...0.20 | xUn | 0.01 | 0.10 | Operate level of neg seq overvoltage element |
| Current change rate | 0.01...0.50 | xIn | 0.01 | 0.15 | Operate level of change in phase current |
| Voltage change rate | 0.25...0.90 | xUn | 0.01 | 0.40 | Operate level of change in phase voltage |
| Change rate enable | 0=False<br>1=True | | | 0=False | Enabling operation of change based function |
| Min Op voltage delta | 0.01...1.00 | xUn | 0.01 | 0.50 | Minimum operate level of phase voltage for delta calculation |
| Min Op current delta | 0.01...1.00 | xIn | 0.01 | 0.10 | Minimum operate level of phase current for delta calculation |
| Seal in voltage | 0.01...1.00 | xUn | 0.01 | 0.50 | Operate level of seal-in phase voltage |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Enable seal in | 0=False<br>1=True | | | 0=False | Enabling seal in functionality |
| Current dead Lin Val | 0.05...1.00 | xIn | 0.01 | 0.05 | Operate level for open phase current detection |

## 6.5.9 SEQSPVC Monitored data

**Table 1280: SEQSPVC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SEQSPVC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 6.5.10 Technical data

**Table 1281: SEQSPVC Technical data**

| Characteristic | | Value | |
|---|---|---|---|
| Operate time [1] | NPS function | $U_{Fault}$ = 1.1 × set *Neg Seq voltage Lev* | <33 ms |
| | | $U_{Fault}$ = 5.0 × set *Neg Seq voltage Lev* | <18 ms |
| | Delta function | ΔU = 1.1 × set *Voltage change rate* | <30 ms |
| | | ΔU = 2.0 × set *Voltage change rate* | <24 ms |

[1] Includes the delay of the signal output contact, $f_n$ = 50 Hz, fault voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements.

# 6.6 Runtime counter for machines and devices MDSOPT (ANSI OPTM)

## 6.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Runtime counter for machines and devices | MDSOPT | OPTS | OPTM |

## 6.6.2 Function block




*Figure 760: Function block*

## 6.6.3 Functionality

The runtime counter for machines and devices function MDSOPT calculates and presents the accumulated operation time of a machine or device as the output. The unit of time for accumulation is hour. The function generates a warning and an alarm when the accumulated operation time exceeds the set limits. It utilizes a binary input to indicate the active operation condition.

The accumulated operation time is one of the parameters for scheduling a service on the equipment like motors. It indicates the use of the machine and hence the mechanical wear and tear. Generally, the equipment manufacturers provide a maintenance schedule based on the number of hours of service.

## 6.6.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of MDSOPT can be described using a module diagram. All the modules in the diagram are explained in the next sections.

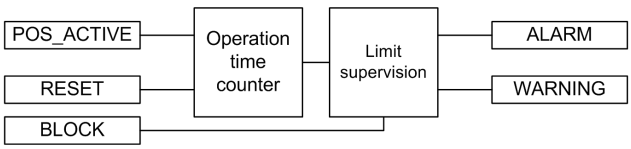



*Figure 761: Functional module diagram*

**Operation time counter**

This module counts the operation time. When POS_ACTIVE is active, the count is continuously added to the time duration until it is deactivated. At any time the OPR_TIME output is the total duration for which POS_ACTIVE is active. The unit of time duration count for OPR_TIME is hour. The value is available through the Monitored data view.

The OPR_TIME output is a continuously increasing value and it is stored in a non-volatile memory. When POS_ACTIVE is active, the OPR_TIME count starts increasing from the previous value. The count of OPR_TIME saturates at the final value of 299999, that is, no further increment is possible. The activation of RESET can reset the count to the *Initial value* setting.

**Limit supervision**

This module compares the motor run-time count to the set values of *Warning value* and *Alarm value* to generate the WARNING and ALARM outputs respectively when the counts exceed the levels.

The activation of the WARNING and ALARM outputs depends on the *Operating time mode* setting. Both WARNING and ALARM occur immediately after the conditions are met if *Operating time mode* is set to “Immediate”. If *Operating time mode* is set to “Timed Warn”, WARNING is activated within the next 24 hours at the time of the day set using the *Operating time hour* setting. If *Operating time mode* is set to “Timed Warn Alm”, the WARNING and ALARM outputs are activated at the time of day set using *Operating time hour*.

The *Operating time hour* setting is used to set the hour of day in Coordinated Universal Time (UTC). The setting has to be adjusted according to the local time and local daylight-saving time.

The function contains a blocking functionality. Activation of the BLOCK input blocks both WARNING and ALARM.

## 6.6.5 Application

The machine operating time since commissioning indicates the use of the machine. For example, the mechanical wear and lubrication requirement for the shaft bearing of the motors depend on the use hours.

If some motor is used for long duration runs, it might require frequent servicing, while for a motor that is not used regularly the maintenance and service are scheduled less frequently. The accumulated operating time of a motor together with the appropriate settings for warning can be utilized to trigger the condition based maintenance of the motor.

The operating time counter combined with the subsequent reset of the operating-time count can be used to monitor the motor's run time for a single run.

Both the long term accumulated operating time and the short term single run duration provide valuable information about the condition of the machine and device. The information can be co-related to other process data to provide diagnoses for the process where the machine or device is applied.

## 6.6.6 Signals

### 6.6.6.1 MDSOPT Input signals

**Table 1282: MDSOPT Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block input status |
| POS_ACTIVE | BOOLEAN | 0=False | When active indicates the equipment is running |
| RESET | BOOLEAN | 0=False | Resets the accumulated operation time to initial value |

### 6.6.6.2 MDSOPT Output signals

**Table 1283: MDSOPT Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm accumulated operation time exceeds Alarm value |
| WARNING | BOOLEAN | Warning accumulated operation time exceeds Warning value |

## 6.6.7 MDSOPT Settings

**Table 1284: MDSOPT Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Warning value | 0...299999 | h | 1 | 8000 | Warning value for operation time supervision |
| Alarm value | 0...299999 | h | 1 | 10000 | Alarm value for operation time supervision |

**Table 1285: MDSOPT Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Initial value | 0...299999 | h | 1 | 0 | Initial value for operation time supervision |
| Operating time hour | 0...23 | h | 1 | 0 | Time of day when alarm and warning will occur |
| Operating time mode | 1=Immediate<br>2=Timed Warn | | | 1=Immediate | Operating time mode for warning and alarm |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 3=Timed Warn Alm | | | | |

## 6.6.8 MDSOPT Monitored data

**Table 1286: MDSOPT Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| MDSOPT | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| OPR_TIME | INT32 | 0...299999 | h | Total operation time in hours |

## 6.6.9 Technical data

**Table 1287: MDSOPT Technical data**

| Description | Value |
|---|---|
| Motor runtime measurement accuracy [1] | ±0.5 % |

# 6.7 Motor start counter MSCPMRI (ANSI 66)

## 6.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Motor start counter | MSCPMRI | n< | 66 |

## 6.7.2 Function block




*Figure 762: Function block*

[1] Of the reading, for a stand-alone relay, without time synchronization

## 6.7.3 Functionality

The motor start counter function MSCPMRI counts the number of motor starts and distinguishes between cold and warm starts. The allowed number is generally provided by the motor manufacturer. The motor starting MOT_START output of the motor start-up supervision function is used to count the starts. The motor thermal level TEMP_RL calculated by the thermal overload protection is used to distinguish between a cold and warm start.

The function contains a blocking functionality. It is possible to block the function outputs or the function itself.

## 6.7.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of MSCPMRI can be described with a module diagram. All the modules in the diagram are explained in the next sections.

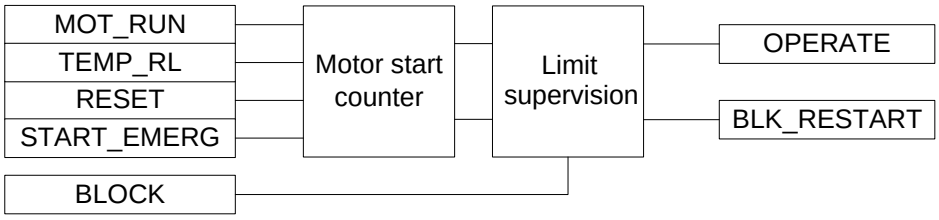



*Figure 763: Functional module diagram*

### Motor start counter

This module counts the number of motor starts. The value of the cold count COLD_COUNT and warm count WARM_COUNT is available in the Monitored data view. On the rising edge of MOT_RUN, the module increments the cold start counter. If the thermal content available at the TEMP_RL input is above the set *Warm start level* when the rising edge of the MOT_RUN input is received, both cold and warm start counter values are incremented.

If *Operation* of the thermal overload protection for motors function MPTTR is set as "Off", the TEMP_RL value is not available. In this case, the warm start counter does not increase.

The counter decrease timer also starts at the first increment of the cold start counter (that is the first time when the counter increases from zero). When *Cnt decrease time* elapses, both cold and warm start counters decrease by one and the counter decrease timer restarts. This is repeated until both cold and warm counters are zero.

When the motor is not in operation, that is, the motor is in stop condition, it takes more time to cool. During such condition *Cnt decrease time* is multiplied by a *Cnt Dec timer Mult* setting.

The motor start detection is available at the MOT_START output of the motor start-up supervision function STTPMSU. The MOT_START output of STTPMSU must be connected to the MOT_RUN input of this function in Application Configuration

in PCM600. Similarly, the TEMP_RL output of MPTTR must be connected to the TEMP_RL input of this function in Application Configuration in PCM600.

When the emergency start signal START_EMERG is set high and if the value of the cold or warm counter is above its start value setting, the value of the counter is set one count less than the respective maximum number of start value setting. This disables BLK_RESTART and OPERATE which makes the restart of motor possible.

The values can be reset by activating the RESET binary input. The activation of the RESET input also resets the counter decrease timer. The counter value can also be reset on the Clear menu.

**Limit supervision**

This module compares the motor cold and warm count to the set *Max Num cold start* and *Max Num warm start*, respectively. The BLK_RESTART output is activated when either the cold or the warm start counter reaches the set *Max Num cold start* or *Max Num warm start*, respectively. The OPERATE output is activated when either the cold or the warm start counter exceeds the set *Max Num cold start* or *Max Num warm start*, respectively.

When the BLK_RESTART output is active, T_RST_ENA shows the possible time for the next restart. The value of T_RST_ENA is calculated as the time left for both counters to decrease below their maximum number of starts.

Activation of the BLOCK input blocks both OPERATE and BLK_RESTART outputs.

## 6.7.5 Application

Repeated motor starts increase the temperature to a high value in the stator or rotor windings, or both, unless enough time is allowed for the heat to dissipate. To ensure a safe operation, it is necessary to provide a fixed-time interval between starts or limit the number of starts within a period of time. This is why the motor manufacturers have restrictions on how many starts are allowed in a defined time interval.

This function counts the number of cold and warm starts and provides a block restart signal when the number of starts reaches the permitted limit. The customer can use this signal for blocking a new start operation. An operate signal is also available which can be used to disconnect the motor when the number of starts exceeds the limit.

## 6.7.6 Signals

### 6.7.6.1 MSCPMRI Input signals

**Table 1288: MSCPMRI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| START_EMERG | BOOLEAN | 0=False | Signal to indicate the need of emergency start |
| RESET | BOOLEAN | 0=False | Reset cold and warm start counter value |
| MOT_RUN | BOOLEAN | 0=False | Signal to show that motor start up is in progress |
| TEMP_RL | FLOAT32 | 0.00 | Thermal level of the motor |

### 6.7.6.2 MSCPMRI Output signals

**Table 1289: MSCPMRI Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate signal |
| BLK_RESTART | BOOLEAN | Restart inhibited |

## 6.7.7 MSCPMRI Settings

**Table 1290: MSCPMRI Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Warm start level | 20.0...100.0 | % | 0.1 | 35.0 | Thermal threshold to define a warm start |
| Max Num cold start | 1...10 | | 1 | 2 | Maximum number of cold start allowed |
| Max Num warm start | 1...10 | | 1 | 1 | Maximum number of warm start allowed |
| Cnt decrease time | 1...180 | min | 1 | 60 | Counter decrease time |

**Table 1291: MSCPMRI Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Cnt Dec timer Mult | 1.00...10.00 | | 0.01 | 1.00 | Multiplier for counter decrease timer |

**Table 1292: MSCPMRI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |

### 6.7.8 MSCPMRI Monitored data

**Table 1293: MSCPMRI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| COLD_COUNT | INT32 | 0...100 | | Count value of cold start |
| WARM_COUNT | INT32 | 0...100 | | Count value of warm start |
| T_RST_ENA | INT32 | 0...180 | min | Time left for restart when lockstart is enabled in minutes |
| MSCPMRI | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 6.8 Three-phase remanent undervoltage supervision MSVPR (ANSI 27R)

### 6.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase remanent undervoltage supervision | MSVPR | 3U<R | 27R |

### 6.8.2 Function block




*Figure 764: Function block*

### 6.8.3 Functionality

The three-phase remanent undervoltage supervision function MSVPR is used to supervise the remanent voltage of the motor. The rotor with high inertia load may

continue to rotate after the primary supply voltage is switched off. Re-energizing the motor immediately can result in catastrophic failure.

MSVPR gives permissive output when the remanent voltage of the motor reaches a safe level to re-energize. Supervision can be selected for one-phase or for three-phase operation. MSVPR can also adapt to a frequency range of 10...70 Hz.

The function contains a blocking functionality. It is possible to block the function output, timer or the function itself.

## 6.8.4 Analog channel configuration

MSVPR has one analog group input which must be properly configured.

**Table 1294: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1295: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected when *Phase supervision* is set to "A or AB", "B or BC" or "C or CA". |
| | The function requires that all three voltage channels are connected if *Phase supervision* is set to "A&B&C or AB&BC&CA". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 6.8.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of MSVPR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

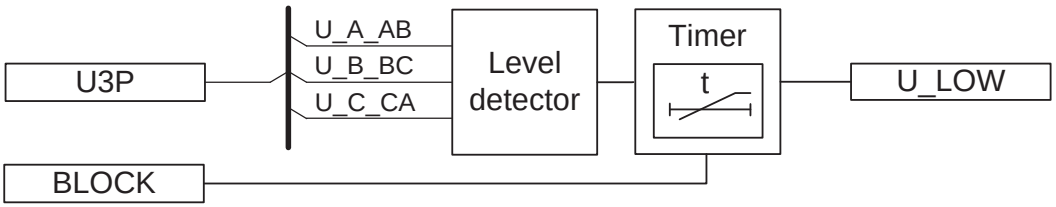



*Figure 765: Functional module diagram*

**Level detector**

The *Voltage selection* setting is used for selecting the phase-to-earth or phase-tophase voltages for supervision.

The voltage measurement can adapt the frequency to a range of 10...70 Hz.

Level detector supports one- or three-phase operation. Selection can be made with setting *Phase supervision*.

**Table 1296: Functionality depending on Phase supervision**

| Value of *Phase supervision* | Functionality |
|---|---|
| 1 = A or AB<br>2 = B or BC<br>4 = C or CA | This selection implements single-phase voltage supervision on the selected phase.<br>If the measured voltage of the supervised phase is lower than the set value of the *Start value* setting, Level detector enables the Timer module. |
| 7 = A&B&C or AB&BC&CA | This selection implements three-phase voltage supervision. The measured voltage of three supervised phases is compared against the *Start value* setting.<br>If the number of phases where the voltage is below the setting matches the Num of phases setting, Level detector enables the Timer module. |

**Timer**

Once activated, Timer runs until the value of *Operate delay time* has elapsed. The time characteristic is according to DT. When the operation timer has reached the value of *Operate delay time*, the U_LOW output is activated.

In a drop-off case, the remanent voltage returns to a value higher than the set value of *Start value* before *Operate delay time* is exceeded. Also, the timer reset state is activated. The reset timer runs until the *Reset delay time* value is exceeded. If the duration of the voltage drop-off exceeds the set Reset delay time, the operate timer is reset and the U_LOW output is deactivated.

The BLOCK input can be controlled with a binary input, a horizontal communication input or an internal signal of the relay program. The activation of the BLOCK input resets Timer and prevents the U_LOW output from being activated.

## 6.8.6 Application

Systems with critical motor applications provide a backup power source that can be switched in when the primary power source becomes faulty. When the power to a motor is suddenly lost, the motor terminal voltage does not immediately fall to zero because the rotating motor now acts as a generator producing its own voltage. Remanent voltage decays as the motor comes to a stop at a rate depending on the motor and load. Connecting the backup power source while the remanent voltage is at a high level can result in damage to the motor shaft and windings.

MSVPR is used to monitor the motor remanent voltage over a decaying frequency after power supply is lost, before allowing connection of backup power. It provides a permissive signal indicating when the backup power can be safely connected.

This application example describes the re-energization process. MSVPR is used to supervise the Bus1 remanent voltage. Control logic is used to detect the loss of primary power source and initiate the transfer to backup power. Normally, bus tie breaker CB5 is open and motor voltage power is supplied by incoming Feeder1 (see *Figure 766*).

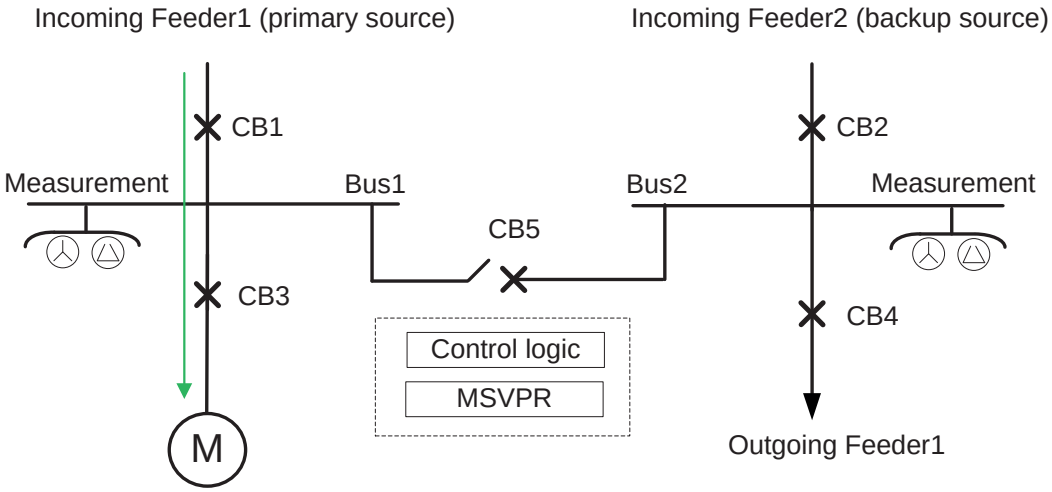



*Figure 766: Example of remanent voltage supervision before fault*

CB1 is tripped when a fault occurs on incoming Feeder1. MSVPR gives permission to control logic when the remanent voltage of the motor reaches a safe level on Bus1. Control logic closes the tie breaker CB5 if closing conditions are met. Finally, the motor is re-energized by incoming Feeder2 (see *Figure 767*).

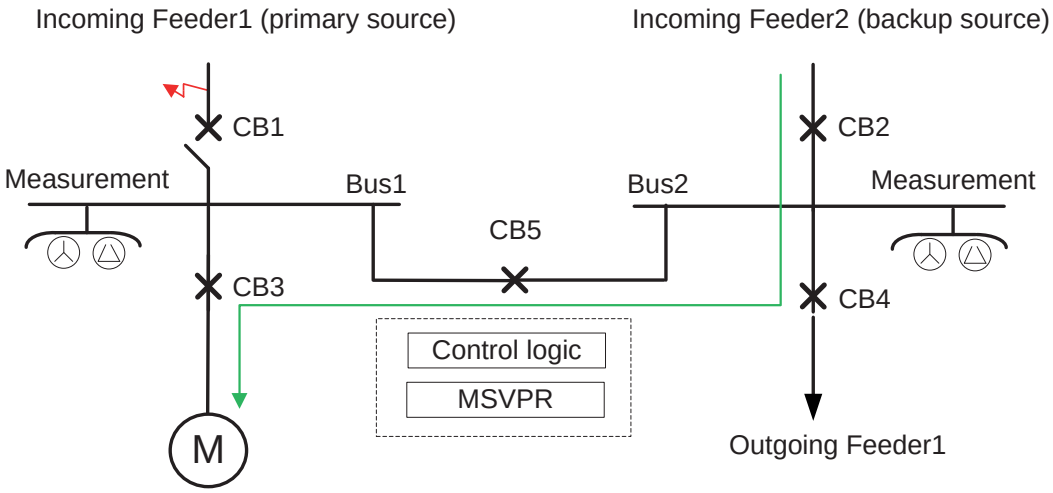



*Figure 767: Example of remanent voltage supervision after fault*

MSVPR runs in the range of 10...70 Hz. If the frequency is lower than 10 Hz, the motor terminal voltage is very low. The remanent voltage setting is typically set to 20...30 percent of the rated voltage.

## 6.8.7 Signals

### 6.8.7.1 MSVPR Input signals

**Table 1297: MSVPR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### 6.8.7.2 MSVPR Output signals

**Table 1298: MSVPR Output signals**

| Name | Type | Description |
|---|---|---|
| U_LOW | BOOLEAN | Low remanent voltage |

## 6.8.8 MSVPR Settings

**Table 1299: MSVPR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Start value | 0.05...1.20 | xUn | 0.01 | 0.25 | Start value |
| Operate delay time | 100...300000 | ms | 100 | 100 | Operate delay time |
| Voltage selection | 1=phase-to-earth<br>2=phase-to-phase | | | 2=phase-to-phase | Parameter to select phase or phase-to-phase voltages |
| Num of phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 3=3 out of 3 | Number of phases required for voltage supervision |
| Phase supervision | 1=A or AB<br>2=B or BC<br>4=C or CA<br>7=A&B&C or AB&BC&CA | | | 7=A&B&C or AB&BC&CA | Monitored voltage phase |

**Table 1300: MSVPR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reset delay time | 0...60000 | ms | 1 | 20 | Reset delay time |

## 6.8.9 MSVPR Monitored data

**Table 1301: MSVPR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U_AMPL_A | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase A |
| U_AMPL_B | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase B |
| U_AMPL_C | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase C |
| U_AMPL_AB | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase to phase AB |
| U_AMPL_BC | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase to phase BC |
| U_AMPL_CA | FLOAT32 | 0.00...5.00 | xUn | Remanent voltage of phase to phase CA |
| MSVPR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 6.8.10 Technical data

**Table 1302: MSVPR Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage: |
| | 20 Hz < f ≤ 70 Hz: ±1.5 % of the set value or ±0.002 × $U_n$ |
| | 10 Hz < f ≤ 20 Hz: ±4.0 % of the set value or ±0.002 × $U_n$ |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 1.04 |
| Operate time accuracy in definite time mode | ±1.0 % of the set value or ±20 ms |

## 6.9 Current circuit supervision for transformers CTSRCTF (ANSI CCM 3I,I2)

### 6.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current circuit supervision for transformers | CTSRCTF | MCS 3I,I2 | CCM 3I,I2 |

### 6.9.2 Function block

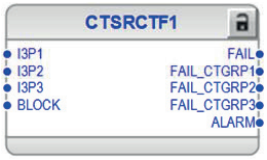



*Figure 768: Function block*

### 6.9.3 Functionality

The current circuit supervision for transformers function CTSRCTF is used for monitoring the current transformer secondary circuit where a separate reference current transformer input for comparison is not available or where a separate voltage channel for calculating or measuring the zero-sequence voltage is not available. CTSRCTF can be used for detecting the single-phase failure on the current transformer secondary for protection application involving two or three sets of the three-phase current transformers.

CTSRCTF detects a fault in the measurement circuit and issues an alarm which can be used for blocking the protection functions, for example, differential protection, to avoid unwanted tripping.

CTSRCTF is internally blocked in case of a transformer under no-load condition or if a current in any one phase exceeds the set maximum limit.

## 6.9.4 Analog channel configuration

CTSRCTF has three analog group inputs which must be properly configured.

**Table 1303: Analog inputs**

| Input | Description |
|---|---|
| I3P1 | Three-phase currents |
| I3P2 | Three-phase currents |
| I3P3 | Three-phase currents, can be connected to GRPOFF |



See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 6.9.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of CTSRCTF can be described with a module diagram. All the modules in the diagram are explained in the next sections.

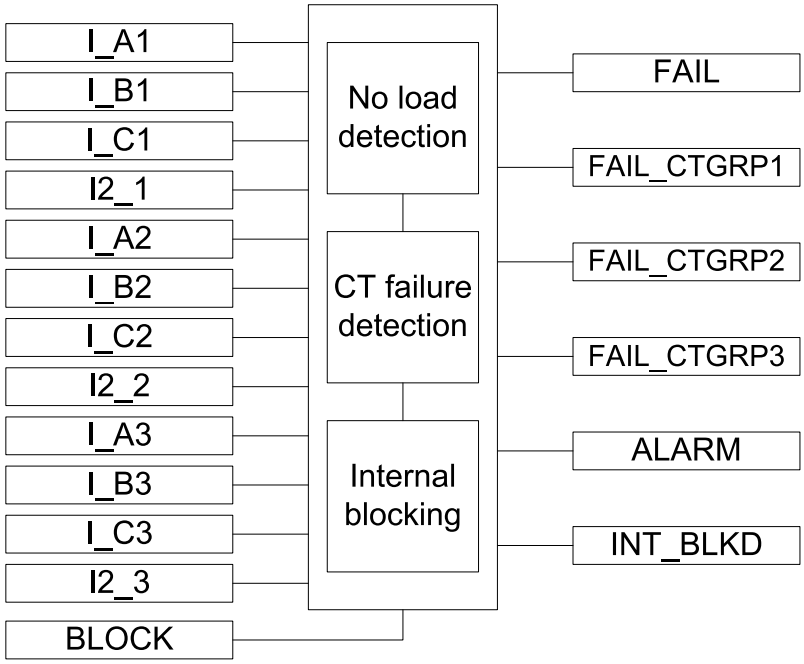



*Figure 769: Functional module diagram*

**No-load detection**

No-load detection module detects the loading condition. If all the three-phase currents of any two sets of current transformer are zero, the protected equipment is considered to be in the no-load condition and the function is internally blocked by activating the `INT_BLKD` output.

To avoid any false operation, the function is also internally blocked if any two-phase currents of any set of current transformers are below *Min operate current*. This activates `INT_BLKD`. The value of the Min operate current setting depends on the type of equipment to be protected. For example, in case of transformer protection, *Min operate current* depends on the no-load current rating. Typically, it can be set equal to the transformer no-load current rating.

**CT failure detection**

This module detects the CT secondary failure in any sets of current transformers. The module continuously scans the value of all the three-phase currents in all groups of current transformers to detect any sudden drop in the current value to zero. The detection of a zero current should not be the only criterion for considering a fault in the current transformer secondary. Two other criteria are evaluated to confirm the CT failure:

- A zero current due to the CT failure does not result in a negative-sequence current on healthy CT sets.

  On the detection of a zero current in any phase on either group of CT, the negative-sequence current $I_2$ is further evaluated. For a genuine CT secondary failure, the magnitude of $I_2$ changes only on the side where zero current has been detected. The change in the magnitude of $I_2$ ($\Delta I_2$) on the other sets of the current transformer (other than where zero current is detected) is calculated. If

the change is detected on the healthy sets of CT, it is an indication of system failure.

- A zero current due to the CT failure does not result in a phase angle difference between the healthy phases.

  If a system faults happens on the phase A, it results in a change in the phase angle difference between phase B and phase C. This change in the phase angle difference between the healthy phases is evaluated in all three sets of current transformer, and if the change is detected in any set of CT, it is an indication of the system failure.

If both conditions are satisfied at zero current, the FAIL output is activated immediately. The ALARM output is activated after a fixed 200 ms delay. FAIL needs to be active during the delay. The outputs FAIL, CTGRP1, FAIL_CTGRP2 and FAIL_CTGRP3 are activated according to the CT group where the secondary failure is detected.

Activation of the BLOCK input deactivates the FAIL and ALARM outputs.



It is not possible to detect the CT secondary failure happening simultaneously with the system faults or failures or two simultaneous failures in the secondary circuit. The function resets if the zero current does not exist longer than 200 ms.

**Internal blocking**

This module blocks the function internally under specific condition to avoid any false operation during a system fault situation. When any of the following condition is satisfied, the function is internally blocked and the FAIL output is deactivated immediately.

- Magnitude of any phase current for any group of current transformers exceeds the *Max operate current* setting. The magnitude of phase current is calculated from the peak-to-peak value.
- Magnitude of the negative-sequence current $I_2$ on the healthy set of current transformer exceeds the *Max Nq Seq current* setting.

The INT_BLKD output is activated when FAIL is deactivated if any of the above conditions is satisfied. The ALARM output is also deactivated after a fixed three-second delay after the FAIL output is deactivated.

## 6.9.6 Application

Open or short-circuited current transformer secondary can cause unwanted operation in many protection functions, such as earth-fault current and differential. The simplest method for detecting the current transformer secondary failure is by comparing currents from two independent three-phase sets of CTs or the CT cores measuring the same primary currents. Another widely used method is the detection of a zero-sequence current and zero-sequence voltage. The detection of a zero-sequence current in the absence of a zero-sequence voltage is an indication of the current transformer secondary failure. However, both methods have disadvantages as they require an additional set of current transformer, or a voltage channel is needed for detecting a zero-sequence voltage.

The methods may not be applicable where additional current channels or voltage channels are not available. This CT secondary circuit supervision presents an algorithm that can be used as an example for detecting the CT secondary failure

used for the unit protection of a two-winding or three-winding transformer. However, the function has a limitation that it cannot detect failure in case of equipment under protection in no-load condition or when two simultaneous secondary CT failures occur.

The detection of a zero current in any one phase is a partial indication of failure in the current transformer secondary. Furthermore, if this current zero is due to the failure in the current transformer secondary, it results in a change in the magnitude of the negative-sequence current in the group only where current zero has been detected. However, changes in the negative-sequence current in other groups of three-phase current transformers at the instance of zero-current detection is an indication of a system problem. Also, it may happen that after the detection of a failure in the current transformer secondary, a fault may occur in the system. During such condition, functions are internally blocked.

**Phase discontinuity**

A zero current detected due to the phase discontinuity results in an asymmetry in all the sets of the current transformer, which then results in a change in the negative-sequence current ($\Delta I_2$) in the healthy set. This change in the negative-sequence current on the healthy sides, that is, other than where a zero current has been detected, blocks the function.

In case of a lightly loaded transformer (up to 30 %) the change in the negative-sequence current may be very negligible. However, a phase discontinuity results in a change in the phase angle difference between two healthy phases in the set of CTs where a zero current has been detected as well as on the primary side of the transformer. This change in the value of the angle blocks the function internally.

**Overload / System short circuit condition**

It is required that any overload or short circuit conditions after a CT failure should block the function. During overload or short circuit condition, the phase current increases beyond its rated value; if any phase current on any set of current transformer exceeds the set limit, the function is blocked internally. Also in case of an unsymmetrical fault, the negative-sequence current increases. If the negative-sequence current increases beyond the set limit, the function is blocked internally. The overcurrent and negative-sequence current setting both can be set equal to the overcurrent and negative-sequence protection function start value.

The internal blocking is thus useful for avoiding false operation during a fault situation.

## 6.9.7 Signals

### 6.9.7.1 CTSRCTF Input signals

**Table 1304: CTSRCTF Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| I3P3 | SIGNAL | - | Three-phase currents 3 |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### 6.9.7.2 CTSRCTF Output signals

**Table 1305: CTSRCTF Output signals**

| Name | Type | Description |
|---|---|---|
| FAIL | BOOLEAN | CT secondary failure |
| FAIL_CTGRP1 | BOOLEAN | CT secondary failure group 1 |
| FAIL_CTGRP2 | BOOLEAN | CT secondary failure group 2 |
| FAIL_CTGRP3 | BOOLEAN | CT secondary failure group 3 |
| ALARM | BOOLEAN | Alarm |

## 6.9.8 CTSRCTF Settings

**Table 1306: CTSRCTF Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Min operate current | 0.01...0.50 | xIn | 0.01 | 0.02 | Minimum operate current |
| Max operate current | 1.00...5.00 | xIn | 0.01 | 1.30 | Maximum operate current |
| Max Ng Seq current | 0.01...1.00 | xIn | 0.01 | 0.10 | Maximum I2 current in healthy set |

## 6.9.9 CTSRCTF Monitored data

**Table 1307: CTSRCTF Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| INT_BLKD | BOOLEAN | 0=False | | Function blocked internally |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 1=True | | |
| CTSRCTF | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 6.9.10 Technical data

**Table 1308: CTSRCTF Technical data**

| Characteristic | Value |
|---|---|
| Operate time (including the delay of the output contact) | <30 ms |

# 7 Condition monitoring functions

## 7.1 Circuit-breaker condition monitoring SSCBR (ANSI 52CM)

### 7.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Circuit-breaker condition monitoring | SSCBR | CBCM | 52CM |

### 7.1.2 Function block

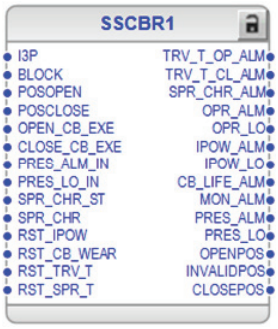



*Figure 770: Function block*

### 7.1.3 Functionality

The circuit-breaker condition monitoring function SSCBR is used to monitor different parameters of the circuit breaker. The breaker requires maintenance when the number of operations has reached a predefined value. The energy is calculated from the measured input currents as a sum of $I^{y}t$ values. Alarms are generated when the calculated values exceed the threshold settings.

The function contains a blocking functionality which can be used to block the function outputs.

### 7.1.4 Analog input configuration

SSCBR has one analog group input which must be properly configured.

**Table 1309: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |



See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 7.1.5 Operation principle

The circuit breaker condition monitoring function includes different metering and monitoring sub-functions. The functions can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”. The operation counters are cleared when *Operation* is set to “Off”.

The operation of SSCBR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

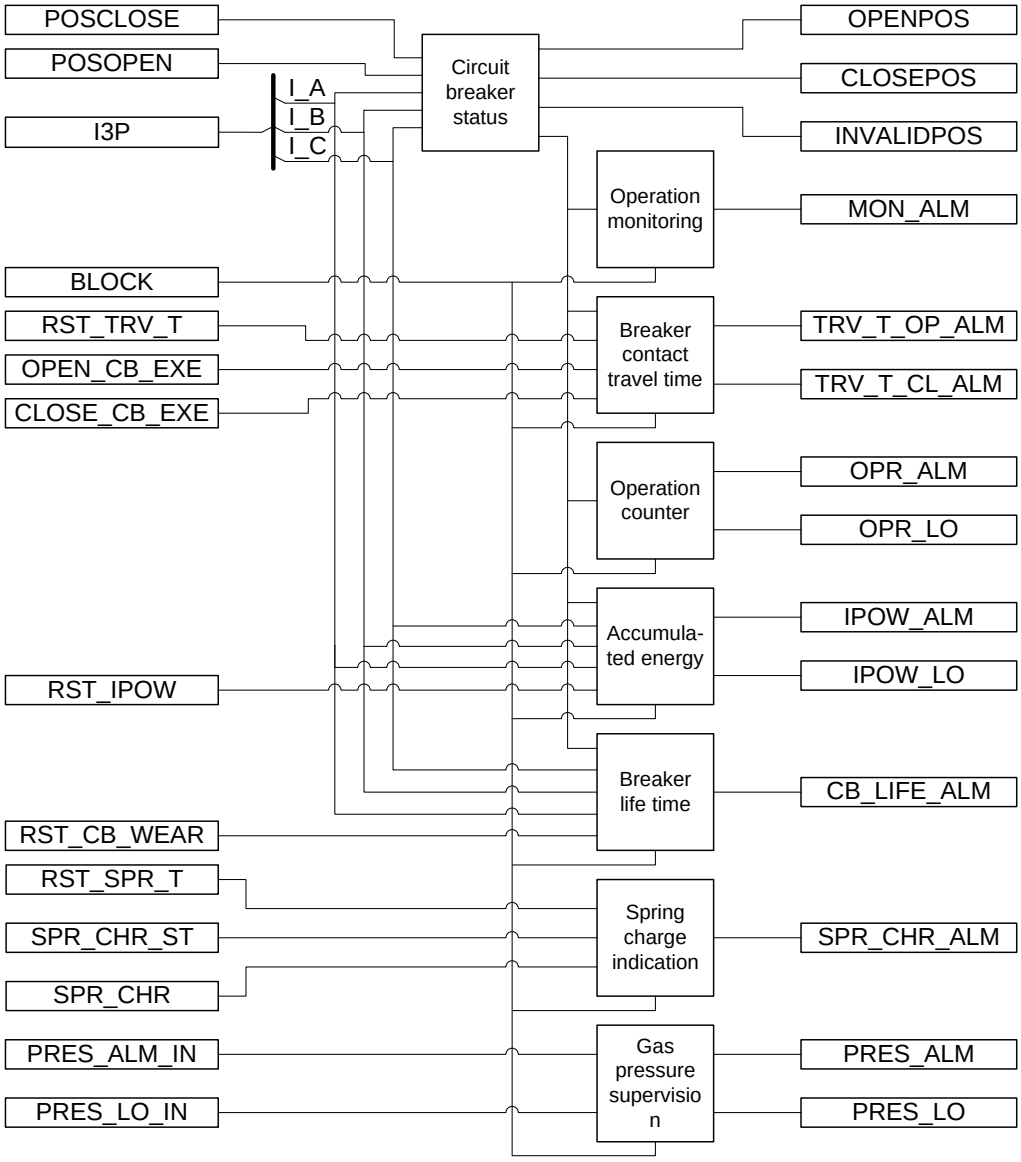



*Figure 771: Functional module diagram*

### 7.1.5.1 Circuit breaker status

The Circuit breaker status sub-function monitors the position of the circuit breaker, that is, whether the breaker is in open, closed or invalid position. The operation of the breaker status monitoring can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

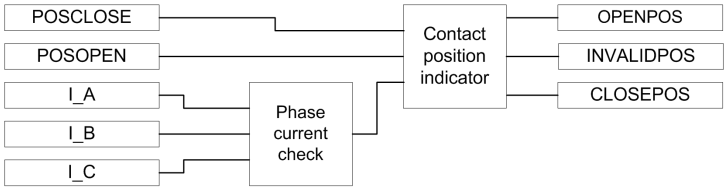



*Figure 772: Functional module diagram for monitoring circuit breaker status*

**Phase current check**

This module compares the three phase currents to the setting *Acc stop current*. If the current in a phase exceeds the set level, information about the phase is reported to the contact position indicator module.

**Contact position indicator**

The OPENPOS output is activated when the auxiliary input contact POSCLOSE is FALSE, the POSOPEN input is TRUE and all the phase currents are below the setting *Acc stop current*.

The CLOSEPOS output is activated when the auxiliary POSOPEN input is FALSE and the POSCLOSE input is TRUE.

The INVALIDPOS output is activated when both the auxiliary contacts have the same value, that is, both are in the same logical level, or if the auxiliary input contact POSCLOSE is FALSE and the POSOPEN input is TRUE and any of the phase currents exceed the setting Acc stop current.

The status of the breaker is indicated by the binary outputs OPENPOS, INVALIDPOS and CLOSEPOS for open, invalid and closed position respectively.

### 7.1.5.2 Circuit breaker operation monitoring

The purpose of the circuit breaker operation monitoring subfunction is to indicate if the circuit breaker has not been operated for a long time.

The operation of the circuit breaker operation monitoring can be described with a module diagram. All the modules in the diagram are explained in the next sections.

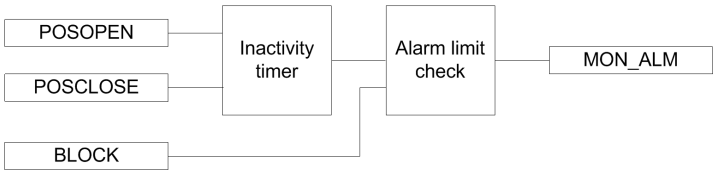



*Figure 773: Functional module diagram for calculating inactive days and alarm for circuit breaker operation monitoring*

**Inactivity timer**

The module calculates the number of days the circuit breaker has remained inactive, that is, has stayed in the same open or closed state. The calculation is done by monitoring the states of the POSOPEN and POSCLOSE auxiliary contacts.

The inactive days INA_DAYS is available in the monitored data view. It is also possible to set the initial inactive days with the *Ini inactive days* parameter.

#### Alarm limit check

When the inactive days exceed the limit value defined with the *Inactive Alm days* setting, the MON_ALM alarm is initiated. The time in hours at which this alarm is activated can be set with the *Inactive Alm hours* parameter as coordinates of UTC. The alarm signal MON_ALM can be blocked by activating the binary input BLOCK.

### 7.1.5.3 Breaker contact travel time

The Breaker contact travel time module calculates the breaker contact travel time for the closing and opening operation. The operation of the breaker contact travel time measurement can be described with a module diagram. All the modules in the diagram are explained in the next sections.

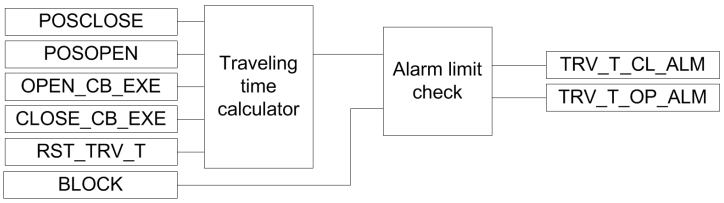



*Figure 774: Functional module diagram for breaker contact travel time*

#### Traveling time calculator

The travel time can be calculated using two different methods based on the setting *Travel time Clc mode*.

When the setting *Travel time Clc mode* is “From Pos to Pos”, the contact travel time of the breaker is calculated from the time between auxiliary contacts' state change. The opening travel time is measured between the opening of the POSCLOSE auxiliary contact and the closing of the POSOPEN auxiliary contact. The travel time is also measured between the opening of the POSOPEN auxiliary contact and the closing of the POSCLOSE auxiliary contact.

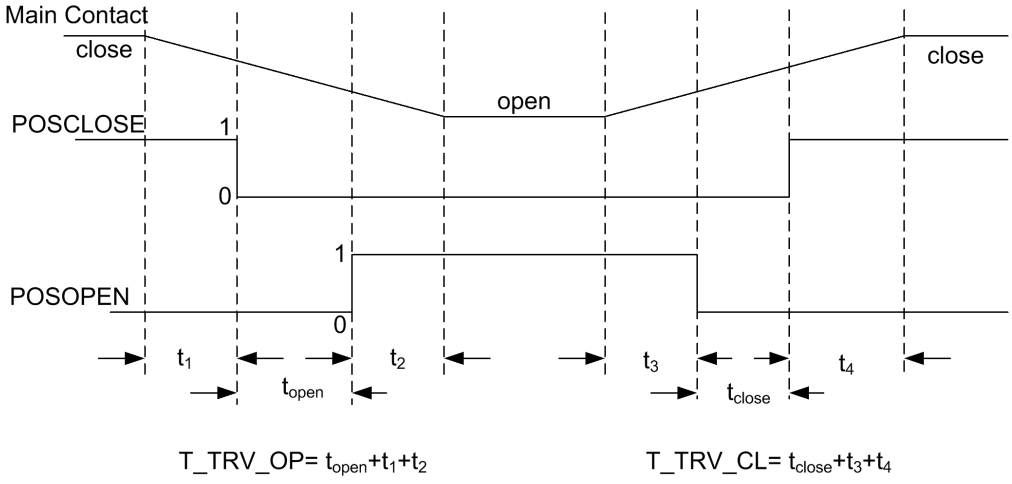



*Figure 775: Travel time calculation when Travel time Clc mode is “From Pos to Pos”*

There is a time difference $t_1$ between the start of the main contact opening and the opening of the POSCLOSE auxiliary contact. Similarly, there is a time gap $t_2$

between the time when the POSOPEN auxiliary contact opens and the main contact is completely open. To incorporate the time $t_1 + t_2$, a correction factor needs to be added with $t_{open}$ to get the actual opening time. This factor is added with the *Opening time Cor* (= $t_1 + t_2$) setting. The closing time is calculated by adding the value set with the *Closing time Cor* ($t_3 + t_4$) setting to the measured closing time.

When the setting *Travel time Clc mode* is “From Cmd to Pos”, the contact travel time of the breaker is calculated from the time between the circuit breaker opening or closing command and the auxiliary contacts’ state change. The opening travel time is measured between the rising edge of the OPEN_CB_EXE command and the POSOPEN auxiliary contact. The closing travel time is measured between the rising edge of the CLOSE_CB_EXEC command and the POSCLOSE auxiliary contact.

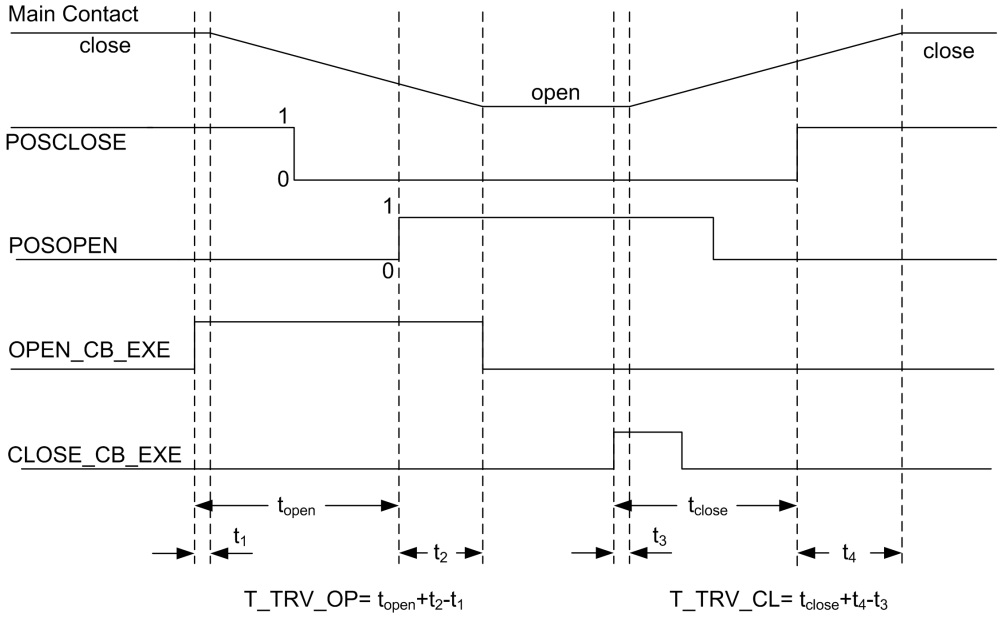



*Figure 776: Travel time calculation when Travel time Clc mode is “From Cmd to Pos”*

There is a time difference $t_1$ between the start of the main contact opening and the OPEN_CB_EXE command. Similarly, there is a time gap $t_2$ between the time when the POSOPEN auxiliary contact opens and the main contact is completely open. Therefore, to incorporate the times $t_1$ and $t_2$, a correction factor needs to be added with $t_{open}$ to get the actual opening time. This factor is added with the *Opening time Cor* (= $t_2 - t_1$) setting. The closing time is calculated by adding the value set with the *Closing time Cor*($t_4 - t_3$) setting to the measured closing time.

The last measured opening travel time T_TRV_OP and the closing travel time T_TRV_CL are available in the monitored data view on the LHMI or through tools via communications.

**Alarm limit check**

When the measured opening travel time is longer than the value set with the *Open alarm time* setting, the TRV_T_OP_ALM output is activated. Respectively, when the measured closing travel time is longer than the value set with the *Close alarm time* setting, the TRV_T_CL_ALM output is activated.

It is also possible to block the TRV_T_CL_ALM and TRV_T_OP_ALM alarm signals by activating the BLOCK input.

### 7.1.5.4 Operation counter

The operation counter subfunction calculates the number of breaker operation cycles. The opening and closing operations are both included in one operation cycle. The operation counter value is updated after each opening operation.

The operation of the subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

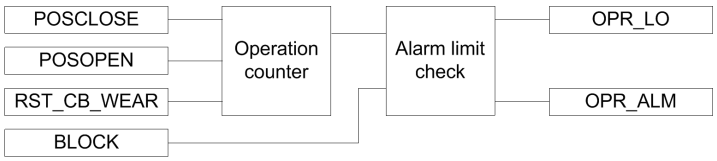



*Figure 777: Functional module diagram for counting circuit breaker operations*

#### Operation counter

The operation counter counts the number of operations based on the state change of the binary auxiliary contacts inputs POSCLOSE and POSOPEN.

The number of operations NO_OPR is available in the monitored data view on the LHMI or through tools via communications. The old circuit breaker operation counter value can be taken into use by writing the value to the *Counter initial Val* parameter and by setting the parameter *CB wear values* in the clear menu from WHMI or LHMI.

#### Alarm limit check

The OPR_ALM operation alarm is generated when the number of operations exceeds the value set with the *Alarm Op number* threshold setting. However, if the number of operations increases further and exceeds the limit value set with the *Lockout Op number* setting, the OPR_LO output is activated.

The binary outputs OPR_LO and OPR_ALM are deactivated when the BLOCK input is activated.

### 7.1.5.5 Accumulation of I y t

Accumulation of the $I^{y}t$ module calculates the accumulated energy.

The operation of the module can be described with a module diagram. All the modules in the diagram are explained in the next sections.

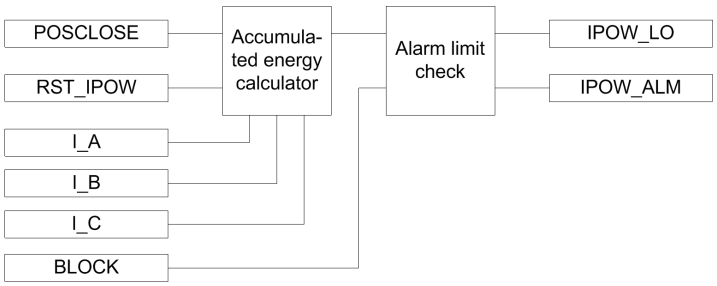



*Figure 778: Functional module diagram for calculating accumulative energy and alarm*

### Accumulated energy calculator

This module calculates the accumulated energy $I^y t$ [(kA)$^y$s]. The factor y is set with the *Current exponent* setting.

The calculation is initiated with the POSCLOSE input opening events. It ends when the RMS current becomes lower than the *Acc stop current* setting value.

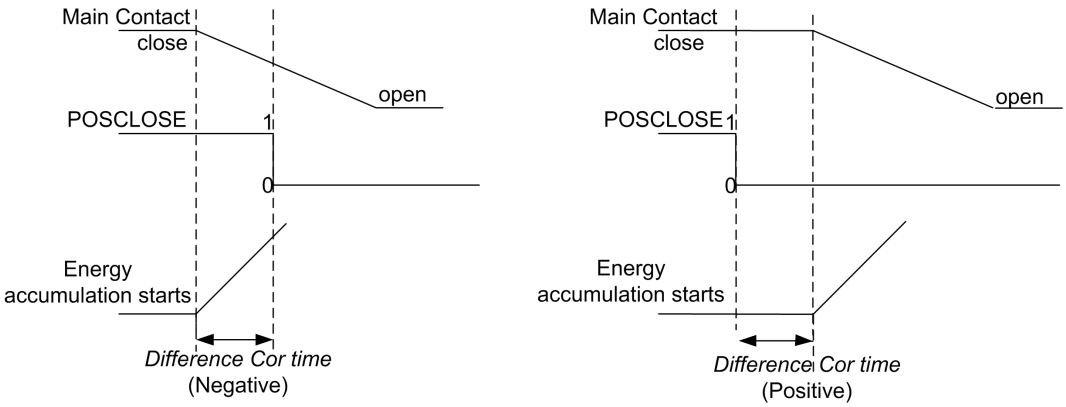



*Figure 779: Significance of the Difference Cor time setting*

The *Difference Cor time* setting is used instead of the auxiliary contact to accumulate the energy from the time the main contact opens. If the setting is positive, the calculation of energy starts after the auxiliary contact has opened and when the delay is equal to the value set with the *Difference Cor time* setting. When the setting is negative, the calculation starts in advance by the correction time before the auxiliary contact opens.

The accumulated energy outputs IPOW_A (_B, _C) are available in the monitored data view on the LHMI or through tools via communications. The values can be reset by setting the parameter *CB accum. currents power* setting to true in the clear menu from WHMI or LHMI.

### Alarm limit check

The IPOW_ALM alarm is activated when the accumulated energy exceeds the value set with the *Alm Acc currents Pwr* threshold setting. However, when the energy exceeds the limit value set with the *LO Acc currents Pwr* threshold setting, the IPOW_LO output is activated.

The IPOW_ALM and IPOW_LO outputs can be blocked by activating the binary input BLOCK.

### 7.1.5.6 Remaining life of circuit breaker

Every time the breaker operates, the life of the circuit breaker reduces due to wearing. The wearing in the breaker depends on the tripping current, and the remaining life of the breaker is estimated from the circuit breaker trip curve provided by the manufacturer. The remaining life is decremented at least with one when the circuit breaker is opened.

The operation of the remaining life of the circuit breaker subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

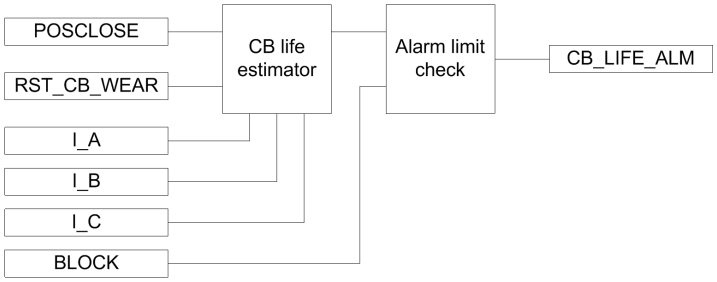



*Figure 780: Functional module diagram for estimating the life of the circuit breaker*

#### CB life estimator

CB life estimator module calculates the remaining life of the circuit breaker. The *Op number rated* and *Op number fault* parameters set the number of operations the breaker can perform at the rated current and at the rated fault current. If the tripping current is lower than the rated operating current set with the *Rated Op current* setting, the remaining operation of the breaker reduces by one operation. If the tripping current is higher than the rated fault current set with the *Rated fault current* setting, the remaining operation of the breaker reduces by *Op number rated* divided by *Op number fault*. The remaining life reduction of the tripping current in between these two values is calculated based on the trip curve given by the manufacturer.

$$Directional\ Coef = \frac{\log\left(\frac{Op\ number\ fault}{Op\ number\ rated}\right)}{\log\left(\frac{Rated\ fault\ current}{Rated\ Op\ current}\right)}$$

(Equation 319)

$$Remaining\ life\ reduction = \left(\frac{I_{fault}}{Rated\ Op\ current}\right)^{-Directional\ Coef}$$

(Equation 320)

The remaining life is calculated separately for all three phases and it is available as a monitored data value CB_LIFE_A (_B,_C). The values can be cleared by setting the parameter CB wear values in the clear menu from WHMI or LHMI.

Clearing *CB wear values* also resets the operation counter.

#### Alarm limit check

When the remaining life of any phase drops below the *Life alarm level* threshold setting, the corresponding circuit breaker life alarm CB_LIFE_ALM is activated.

It is possible to deactivate the CB_LIFE_ALM alarm signal by activating the binary input BLOCK. The old circuit breaker operation counter value can be taken into use by writing the value to the *Initial CB Rmn life* parameter and resetting the value via the clear menu from WHMI or LHMI.

### 7.1.5.7 Circuit breaker spring-charged indication

The circuit breaker spring-charged indication subfunction calculates the spring charging time.

The operation of the subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

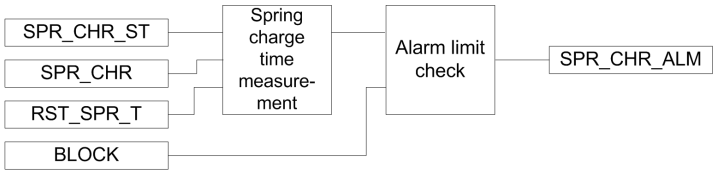



*Figure 781: Functional module diagram for circuit breaker spring-charged indication and alarm*

#### Spring charge time measurement

Two binary inputs, SPR_CHR_ST and SPR_CHR, indicate spring charging started and spring charged, respectively. The spring-charging time is calculated from the difference of these two signal timings.

The spring charging time T_SPR_CHR is available in the monitored data view on the LHMI or through tools via communications.

#### Alarm limit check

If the time taken by the spring to charge is more than the value set with the *Spring charge time* setting, the subfunction generates the SPR_CHR_ALM alarm.

It is possible to block the SPR_CHR_ALM alarm signal by activating the BLOCK binary input.

### 7.1.5.8 Gas pressure supervision

The gas pressure supervision subfunction monitors the gas pressure inside the arc chamber.

The operation of the subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

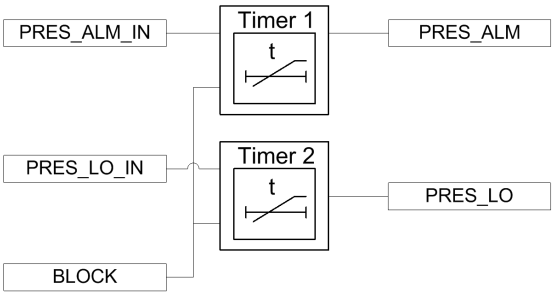



*Figure 782: Functional module diagram for circuit breaker gas pressure alarm*

The gas pressure is monitored through the binary input signals PRES_LO_IN and PRES_ALM_IN.

**Timer 1**

When the PRES_ALM_IN binary input is activated, the PRES_ALM alarm is activated after a time delay set with the *Pressure alarm time* setting. The PRES_ALM alarm can be blocked by activating the BLOCK input.

**Timer 2**

If the pressure drops further to a very low level, the PRES_LO_IN binary input becomes high, activating the lockout alarm PRES_LO after a time delay set with the *Pres lockout time* setting. The PRES_LO alarm can be blocked by activating the BLOCK input.

## 7.1.6 Application

SSCBR includes different metering and monitoring subfunctions.

**Circuit breaker status**

Circuit breaker status monitors the position of the circuit breaker, that is, whether the breaker is in an open, closed or intermediate position.

**Circuit breaker operation monitoring**

The purpose of the circuit breaker operation monitoring is to indicate that the circuit breaker has not been operated for a long time. The function calculates the number of days the circuit breaker has remained inactive, that is, has stayed in the same open or closed state. There is also the possibility to set an initial inactive day.

**Breaker contact travel time**

High traveling times indicate the need for the maintenance of the circuit breaker mechanism. Therefore, detecting excessive traveling time is needed. During the opening cycle operation, the main contact starts opening. The auxiliary contact A opens, the auxiliary contact B closes and the main contact reaches its opening position. During the closing cycle, the first main contact starts closing. The auxiliary contact B opens, the auxiliary contact A closes and the main contact reaches its

closed position. The travel times are calculated based on the state changes of the auxiliary contacts and the adding correction factor to consider the time difference of the main contact's and the auxiliary contact's position change.

**Operation counter**

Routine maintenance of the breaker, such as lubricating breaker mechanism, is generally based on a number of operations. A suitable threshold setting to raise an alarm when the number of operation cycle exceeds the set limit helps preventive maintenance. This can also be used to indicate the requirement for oil sampling for dielectric testing in case of an oil circuit breaker.

The change of state can be detected from the binary input of the auxiliary contact. There is a possibility to set an initial value for the counter which can be used to initialize this functionality after a period of operation or in case of refurbished primary equipment.

**Accumulation of I y t**

Accumulation of $I^{y}t$ calculates the accumulated energy $\Sigma I^{y}t$, where the factor y is known as the current exponent. The factor y depends on the type of the circuit breaker. For oil circuit breakers, the factor y is normally 2. In case of a high-voltage system, the factor y can be 1.4...1.5.

**Remaining life of the breaker**

Every time the breaker operates, the life of the circuit breaker reduces due to wearing. The wearing in the breaker depends on the tripping current, and the remaining life of the breaker is estimated from the circuit breaker trip curve provided by the manufacturer.

**Example for estimating the remaining life of a circuit breaker**

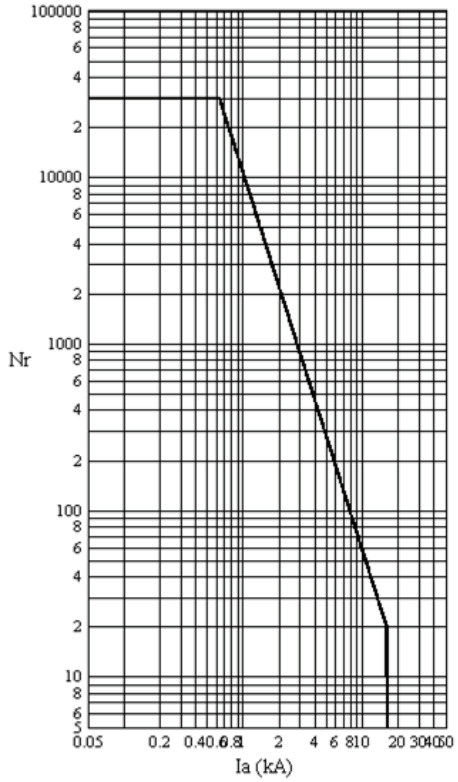



*Figure 783: Trip Curves for a typical 12 kV, 630 A, 16 kA vacuum interrupter*

| | |
|---|---|
| Nr | the number of closing-opening operations allowed for the circuit breaker |
| Ia | the current at the time of tripping of the circuit breaker |

**Calculation for estimating the remaining life**

*Figure 783* shows that there are 30,000 possible operations at the rated operating current of 630 A and 20 operations at the rated fault current 16 kA. Therefore, if the tripping current is 10 kA, one operation at 10 kA is equivalent to 30,000/60=500 operations at the rated current. It is also assumed that prior to this tripping, the remaining life of the circuit breaker is 15,000 operations. Therefore, after one operation of 10 kA, the remaining life of the circuit breaker is 15,000-500=14,500 at the rated operating current.

**Spring-charged indication**

For normal operation of the circuit breaker, the circuit breaker spring should be charged within a specified time. Therefore, detecting long spring-charging time indicates that it is time for the circuit breaker maintenance. The last value of the spring-charging time can be used as a service value.

**Gas pressure supervision**

The gas pressure supervision monitors the gas pressure inside the arc chamber. When the pressure becomes too low compared to the required value, the circuit breaker operations are locked. A binary input is available based on the pressure levels in the function, and alarms are generated based on these inputs.

## 7.1.7 Signals

### 7.1.7.1 SSCBR Input signals

**Table 1310: SSCBR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block input status |
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for closeposition of apparatus from I/O |
| OPEN_CB_EXE | BOOLEAN | 0=False | Signal for open command to coil |
| CLOSE_CB_EXE | BOOLEAN | 0=False | Signal for close command to coil |
| PRES_ALM_IN | BOOLEAN | 0=False | Binary pressure alarm input |
| PRES_LO_IN | BOOLEAN | 0=False | Binary pressure input for lockout indication |
| SPR_CHR_ST | BOOLEAN | 0=False | CB spring charging started input |
| SPR_CHR | BOOLEAN | 0=False | CB spring charged input |
| RST_IPOW | BOOLEAN | 0=False | Reset accumulation energy |
| RST_CB_WEAR | BOOLEAN | 0=False | Reset input for CB remaining life and operation counter |
| RST_TRV_T | BOOLEAN | 0=False | Reset input for CB closing and opening travel times |
| RST_SPR_T | BOOLEAN | 0=False | Reset input for the charging time of the CB spring |

### 7.1.7.2 SSCBR Output signals

**Table 1311: SSCBR Output signals**

| Name | Type | Description |
|---|---|---|
| TRV_T_OP_ALM | BOOLEAN | CB open travel time exceeded set value |
| TRV_T_CL_ALM | BOOLEAN | CB close travel time exceeded set value |
| SPR_CHR_ALM | BOOLEAN | Spring charging time has crossed the set value |
| OPR_ALM | BOOLEAN | Number of CB operations exceeds alarm limit |
| OPR_LO | BOOLEAN | Number of CB operations exceeds lockout limit |
| IPOW_ALM | BOOLEAN | Accumulated currents power (Iyt),exceeded alarm limit |
| IPOW_LO | BOOLEAN | Accumulated currents power (Iyt),exceeded lockout limit |
| CB_LIFE_ALM | BOOLEAN | Remaining life of CB exceeded alarm limit |
| MON_ALM | BOOLEAN | CB 'not operated for long time' alarm |
| PRES_ALM | BOOLEAN | Pressure below alarm level |
| PRES_LO | BOOLEAN | Pressure below lockout level |
| OPENPOS | BOOLEAN | CB is in open position |
| INVALIDPOS | BOOLEAN | CB is in invalid position (not positively open or closed) |
| CLOSEPOS | BOOLEAN | CB is in closed position |

## 7.1.8 SSCBR Settings

**Table 1312: SSCBR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Acc stop current | 5.00...500.00 | A | 0.01 | 10.00 | RMS current setting below which engy acm stops |
| Open alarm time | 0...200 | ms | 10 | 40 | Alarm level setting for open travel time in ms |
| Close alarm time | 0...200 | ms | 10 | 40 | Alarm level Setting for close travel time in ms |
| Spring charge time | 0...60 | s | 1 | 15 | Setting of alarm for spring charging time of CB in s |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Alarm Op number | 0...99999 | | 1 | 200 | Alarm limit for number of operations |
| Lockout Op number | 0...99999 | | 1 | 300 | Lock out limit for number of operations |
| Current exponent | 0.00...5.00 | | 0.01 | 2.00 | Current exponent setting for energy calculation |
| Difference Cor time | -10...10 | ms | 1 | 5 | Corr. factor for time dif in aux. and main contacts open time |
| Alm Acc currents Pwr | 0.00...20000.00 | | 0.01 | 2500.00 | Setting of alarm level for accumulated currents power |
| LO Acc currents Pwr | 0.00...20000.00 | | 0.01 | 2500.00 | Lockout limit setting for accumulated currents power |
| Initial CB Rmn life | 0...99999 | | 1 | 5000 | Initial value for the CB remaining life |
| Rated Op current | 100.00...6300.00 | A | 0.01 | 1000.00 | Rated operating current of the breaker |
| Rated fault current | 500.00...99999.00 | A | 0.01 | 5000.00 | Rated fault current of the breaker |
| Op number rated | 1...99999 | | 1 | 10000 | Number of operations possible at rated current |
| Op number fault | 1...10000 | | 1 | 1000 | Number of operations possible at rated fault current |
| Inactive Alm days | 0...9999 | | 1 | 2000 | Alarm limit value of the inactive days counter |
| Travel time Clc mode | 1=From Cmd to Pos<br>2=From Pos to Pos | | | 2=From Pos to Pos | Travel time calculation mode selection |

**Table 1313: SSCBR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Opening time Cor | -100...100 | ms | 1 | 10 | Correction factor for open travel time in ms |
| Closing time Cor | -100...100 | ms | 1 | 10 | Correction factor for CB close travel time in ms |
| Counter initial Val | 0...99999 | | 1 | 0 | The operation numbers counter initialization value |
| Ini Acc currents Pwr | 0.00...20000.00 | | 0.01 | 0.00 | Initial value for accumulation energy (Iyt) |
| Life alarm level | 0...99999 | | 1 | 500 | Alarm level for CB remaining life |
| Pressure alarm time | 0...60000 | ms | 1 | 10 | Time delay for gas pressure alarm in ms |
| Pres lockout time | 0...60000 | ms | 10 | 10 | Time delay for gas pressure lockout in ms |
| Ini inactive days | 0...9999 | | 1 | 0 | Initial value of the inactive days counter |
| Inactive Alm hours | 0...23 | h | 1 | 0 | Alarm time of the inactive days counter in hours |

## 7.1.9 SSCBR Monitored data

**Table 1314: SSCBR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| T_TRV_OP | FLOAT32 | 0...60000 | ms | Travel time of the CB during opening operation |
| T_TRV_CL | FLOAT32 | 0...60000 | ms | Travel time of the CB during closing operation |
| T_SPR_CHR | FLOAT32 | 0.00...99.99 | s | The charging time of the CB spring |
| NO_OPR | INT32 | 0...99999 | | Number of CB operation cycle |
| INA_DAYS | INT32 | 0...9999 | | The number of days CB has been inactive |
| CB_LIFE_A | INT32 | -99999...99999 | | CB Remaining life phase A |
| CB_LIFE_B | INT32 | -99999...99999 | | CB Remaining life phase B |
| CB_LIFE_C | INT32 | -99999...99999 | | CB Remaining life phase C |
| IPOW_A | FLOAT32 | 0.000...30000.000 | | Accumulated currents power (Iyt), phase A |
| IPOW_B | FLOAT32 | 0.000...30000.000 | | Accumulated currents power (Iyt), phase B |
| IPOW_C | FLOAT32 | 0.000...30000.000 | | Accumulated currents power (Iyt), phase C |
| SSCBR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 7.1.10 Technical data

**Table 1315: SSCBR Technical data**

| Characteristic | Value |
|---|---|
| Current measuring accuracy | ±1.5 % or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0 %<br>(at currents in the range of 10…40 × $I_n$) |
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |
| Travelling time measurement | +10 ms / -0 ms |

# 7.2 Motor controlled earthing switch and disconnector supervision ESDCSSWI (ANSI 29CM)

## 7.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Motor controlled earthing switch and disconnector supervision | ESDCSSWI | ESDCCM | 29CM |

## 7.2.2 Function block

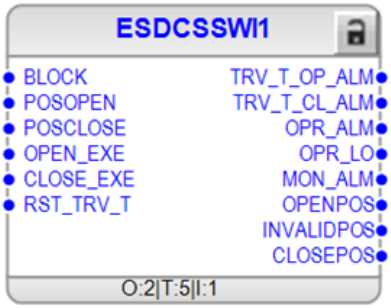



*Figure 784: Function block*

## 7.2.3 Functionality

The motor controlled earthing switch and disconnector supervision (ESDCSSWI) is used for monitoring switch status, inactivity, contact travel time and operation counter. Function can be used for condition monitoring and as indicator for maintenance need.

## 7.2.4 Operation principle

The *Operation* setting is used to enable or disable the function. When selected "On" the function is enabled and respectively "Off" means function is disabled.

The operation of ESDCSSWI is described by using a module diagram (see figure below). All the modules in the diagram are explained in the next sections.

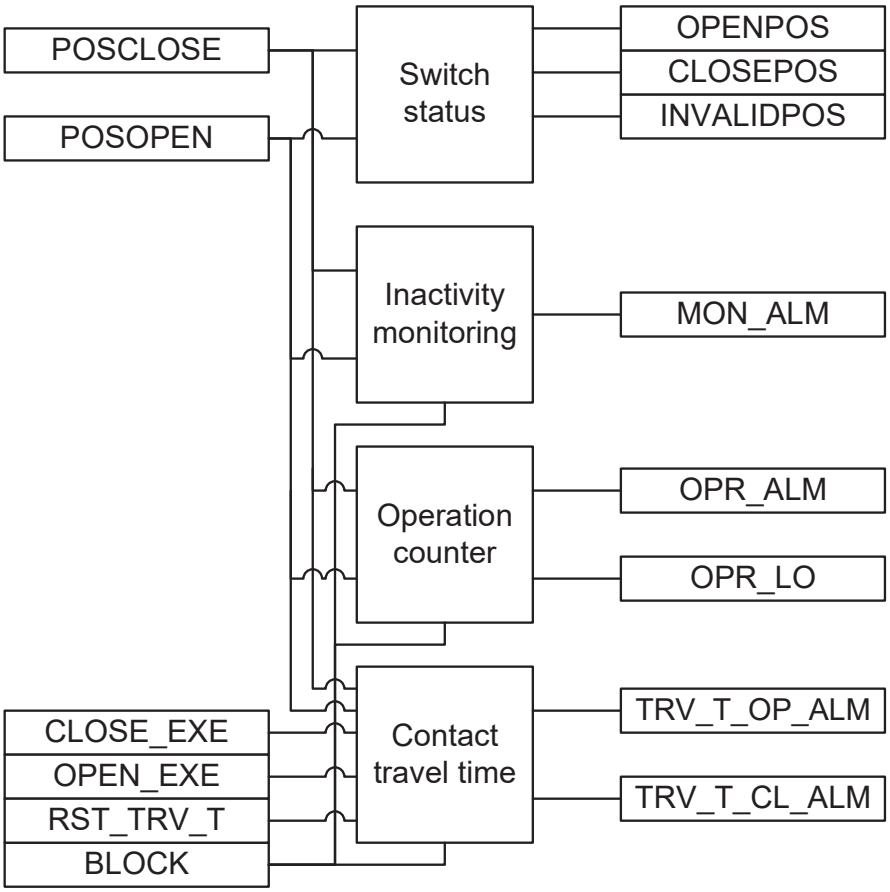



*Figure 785: Functional module diagram*

### 7.2.4.1 Switch status

This module monitors the position of the earthing switch or disconnector, that is, whether the switch is in an open, closed, intermediate or faulty position.

The OPENPOS output is activated when the auxiliary input contact POSCLOSE input is FALSE and the POSOPEN input is TRUE. The CLOSEPOS output is activated when the POSOPEN input is FALSE and the *POSCLOSE* input is TRUE.

The INVALIDPOS output is activated when both auxiliary contacts have the same value, that is, both are in the same logical level.

### 7.2.4.2 Inactivity monitoring

The purpose of the inactivity monitoring is to indicate if the earthing switch or disconnector has not been operated for a long time.

This module calculates the number of days the earthing switch or disconnector has remained inactive, that is, has stayed in the same open, closed and intermediate or faulty state. The calculation is done by monitoring the states of the POSOPEN, POSCLOSE auxiliary contacts. The inactive days INA_DAYS is available in the monitored data view. For relay retrofit installations, it is possible to initialize

INA_DAYS to certain value with *Ini inactive days* setting. The inactive days INA_DAYS will reset to zero when there is change in auxiliary contact.

When the INA_DAYS exceeds the limit value defined with the *Inactive Alm days* setting, the MON_AL alarm is activated. The time during the day when alarm is forwarded can be set with the *Inactive Alm hours* parameter. The warning signal MON_ALM can be blocked by activating the binary input BLOCK.

### 7.2.4.3 Operation counter

This module calculates the number of operation cycles which means the combination of opening and closing operation of switch. The operation counter is increased on each opening operation of the switch.

The number of operations NO_OPR is available in the monitored data view. The former operation counter value can be taken into use by writing the value to the *Counter initial Val* parameter setting and can be cleared by setting the parameter *Operation counter* in the clear menu from WHMI or LHMI.

The OPR_ALM operation warning is generated when the number of operations exceeds the value set with the *Alarm Op number* threshold setting. However, if the number of operations increases further and exceeds the limit value set with the Lockout Op number setting, the OPR_LO output is activated.

The binary outputs OPR_ALM and OPR_LO are deactivated when the BLOCK input is activated.

### 7.2.4.4 Contact travel time

This module calculates the contact travel time for the closing and opening operation. the travel time can be calculated in two different ways based on setting *Travel time Clc* mode.

When setting *Travel time Clc* mode is “From Pos to Pos”, the contact travel time of the earthing switch or disconnector is calculated from the time between auxiliary contacts’ state change. The opening travel time is measured between the opening of the POSCLOSE auxiliary contact and the closing of the POSOPEN auxiliary contact. The closing travel time is measured between the opening of the POSOPEN auxiliary contact and the closing of the POSCLOSE auxiliary contact.

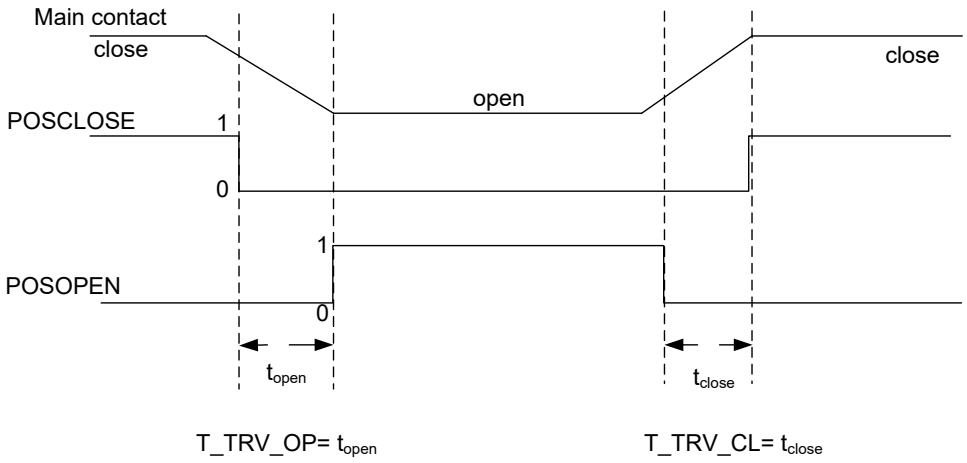



*Figure 786: Travel time calculation when Travel time Clc mode is "From Pos to Pos*

When setting *Travel time Clc* mode is "From Cmd to Pos", the contact travel time of the earthing switch or disconnector is calculated from the time between opening or closing command and auxiliary contacts' state change. The opening travel time is measured between rising edge of OPEN_EXE command and POSOPEN auxiliary contact. The closing travel time is measured between rising edge of the CLOSE_EXE command and POSCLOSE auxiliary contact.

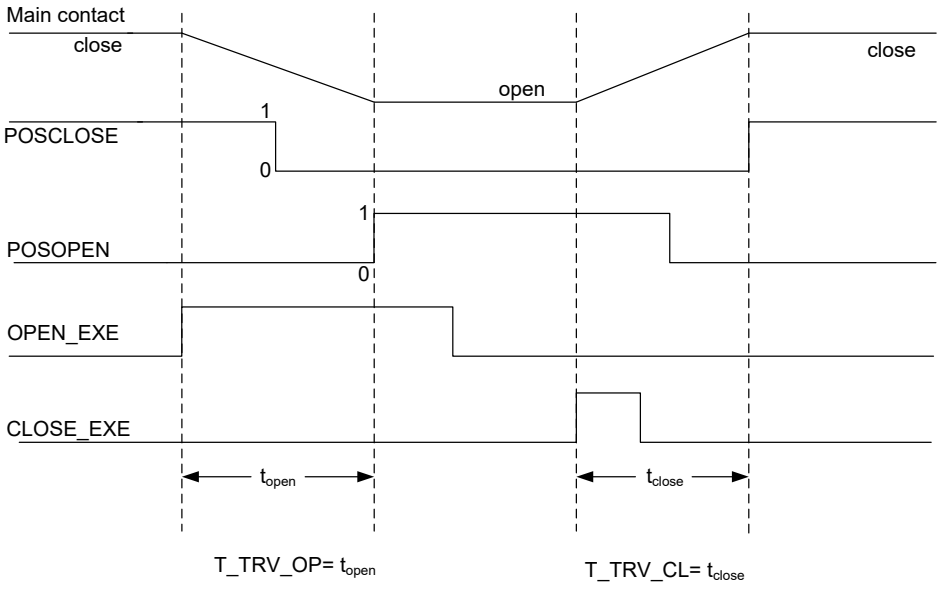



*Figure 787: Travel time calculation when Travel time Clc mode is "From Cmd to Pos"*

The last measured opening travel time T_TRV_OP and the closing travel time T_TRV_CL are available in the monitored data.

The maximum measured opening travel time T_TRV_MAX_OP and the maximum measured closing travel time T_TRV_MAX__CL are available in the monitored data.

The last measured and maximum travel time are stored in nonvolatile memory and these values are not cleared until the reset input (RST_TRV_ T) is set to TRUE or reset from the clear menu.

When the measured opening travel time is longer than the value set with the *Open alarm time* setting, the TRV_T_OP_ALM output is activated. Respectively, when the measured closing travel time is longer than the value set with the *Close alarm time* setting, the TRV_T_CL_ALM output is activated.

It is also possible to block the TRV_T_CL_ALM and TRV_T_OP_ALM alarm signals by activating the BLOCK input.

## 7.2.5 Application

Earthing switches or disconnectors are usually located either in metal- clad draw out switchgear or outside in switch yard or pole mounted pole mounted. These switches are operated on no load when circuit breaker is opened. Mechanical actuation is affected due to continued exposure of varying weather conditions. Supervision of following parameters helps understanding the mechanical condition and need for maintenance:

- Increasing contact travel time might be indication e.g., of mechanical wear or lubrication problem.
- Certain maintenance actions are dependent on operation counter value.
- Mechanism may be stuck if switch is in same position long period of time. Inactivity time measurement guides operator for periodic movement.

## 7.2.6 Signals

### 7.2.6.1 ESDCSSWI Input signals

**Table 1316: ESDCSSWI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block all the alarm and lockout indications |
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |
| OPEN_EXE | BOOLEAN | 0=False | Signal for open command to coil |
| CLOSE_EXE | BOOLEAN | 0=False | Signal for close command to coil |
| RST_TRV_T | BOOLEAN | 0=False | Reset input for switch closing and opening travel times |

### 7.2.6.2 ESDCSSWI Output signals

**Table 1317: ESDCSSWI Output signals**

| Name | Type | Description |
|---|---|---|
| TRV_T_OP_ALM | BOOLEAN | Switch open travel time exceeded set value |
| TRV_T_CL_ALM | BOOLEAN | Switch close travel time exceeded set value |
| OPR_ALM | BOOLEAN | Number of switch operations exceeds alarm limit |
| OPR_LO | BOOLEAN | Number of switch operations exceeds lockout limit |
| MON_ALM | BOOLEAN | Switch not operated for long time alarm |
| OPENPOS | BOOLEAN | Apparatus open position |
| INVALIDPOS | BOOLEAN | Apparatus position is invalid |
| CLOSEPOS | BOOLEAN | Apparatus closed position |

## 7.2.7 ESDCSSWI Settings

**Table 1318: ESDCSSWI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Open alarm time | 40...30000 | ms | 10 | 15000 | Alarm level setting for open travel time in ms |
| Close alarm time | 40...30000 | ms | 10 | 15000 | Alarm level setting for close travel time in ms |
| Alarm Op number | 0...99999 | | 1 | 200 | Alarm limit for number of operations |
| Inactive Alm days | 0...9999 | | 1 | 2000 | Alarm limit value of the inactive days counter |
| Travel time Clc mode | 1=From Cmd to Pos<br>2=From Pos to Pos | | | 2=From Pos to Pos | Travel time mode selection |
| Lockout Op number | 0...99999 | | 1 | 300 | Lock out limit for number of operations |

**Table 1319: ESDCSSWI Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Counter initial Val | 0...99999 | | 1 | 0 | Operation numbers counter initialization |
| Ini inactive days | 0...9999 | | 1 | 0 | Initial value of the inactive days counter |
| Inactive Alm hours | 0...23 | h | 1 | 0 | Alarm time of the inactive days counter in hours |

## 7.2.8 ESDCSSWI Monitored data

**Table 1320: ESDCSSWI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| T_TRV_OP | FLOAT32 | 0...60000 | ms | Travel time of the switch during opening operation |
| T_TRV_CL | FLOAT32 | 0...60000 | ms | Travel time of the switch during closing operation |
| T_TRV_MAX_OP | FLOAT32 | 0...60000 | ms | Maximum travel time during opening operation |
| T_TRV_MAX_CL | FLOAT32 | 0...60000 | ms | Maximum travel time during closing operation |
| NO_OPR | INT32 | 0...99999 | | Number of switch operation cycle |
| INA_DAYS | INT32 | 0...9999 | | The number of days switch has been inactive |
| ESDCSSWI | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 7.2.9 Technical data

**Table 1321: ESDCSSWI technical data**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |
| Travelling time measurement | +10 ms / -5 ms |

# 7.3 Hot-spot and insulation ageing rate monitoring for transformers HSARSPTR (ANSI 26/49HS)

## 7.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Hot-spot and insulation ageing rate monitoring for transformers | HSARSPTR | 3Ihp>T | 26/49HS |

## 7.3.2 Function block

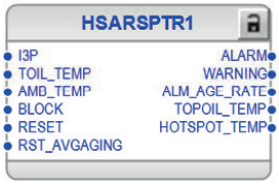



*Figure 788: Function block*

## 7.3.3 Functionality

The hot-spot and insulation ageing rate monitoring for transformers function HSARSPTR is used for online monitoring of transformers. The function monitors the hot-spot temperature of the transformer winding and the ageing rate of the insulation caused by thermal stress. The function can be applied for new transformers as well as for transformers already in service.

The hot-spot temperature and loss of life of transformer are calculated for one winding of the transformer from three phase currents and RTD inputs for top oil temperature and ambient temperature.

The hot-spot temperature and the momentary ageing rate are calculated based on the IEC 60076-7 or the IEEE C57.91-2011 standard, depending upon a user defined setting. The total ageing and loss of transformer insulation life is calculated in years.

The function generates `WARNING` and `ALARM` signals if the calculated hot-spot temperature exceeds the set value.

## 7.3.4 Analog channel configuration

HSARSPTR has one analog group input which must be properly configured.

**Table 1322: Analog signals**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings.

For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 7.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of HSARSPTR can be described with a module diagram. All modules in the diagram are explained in the next sections.

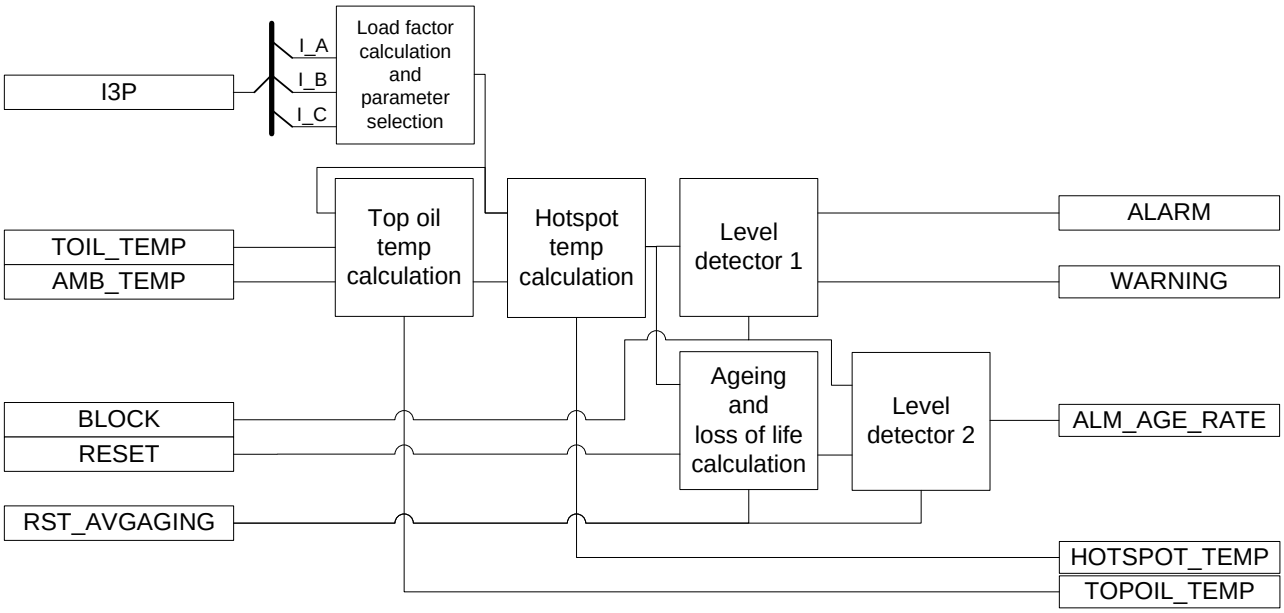



*Figure 789: Functional module diagram*

### 7.3.5.1 Load factor calculation and parameter selection

The transformer top oil and hot-spot temperatures are dependent on the load factor, the winding conductor properties and the cooling oil properties of the transformer. This module calculates the load factor based on the measured phase currents and selects the transformer parameters based on user defined settings.

#### Load factor calculation

Load factor is a ratio of the load current to the rated current. Since the thermal content of all the three phase currents influence the temperature inside the transformer, the load factor is calculated as a ratio of the root of sum of squared phase currents to three times the rated current.

$$K = \sqrt{\frac{I_A^2 + I_B^2 + I_C^2}{3 \cdot I_{rated}^2}}$$

(Equation 321)

Where

| | |
|---|---|
| K | Load factor |
| I_A, I_B and I_C | RMS value of input phase currents (Amperes) |
| $I_{rated}$ | Rated current (Amperes) |

If *Transformer type* is set to “Single phase”, the denominator consists only of $I^2_{rated}$ instead of $3\times I^2_{rated}$.

*Equation 321* assumes that voltage is constant and tap changer position is not considered.

For a star-delta transformer, it is recommended to use the function on the star winding, since the circulating zero sequence currents (in case of unbalance) cannot be measured on the delta winding of the transformer.

**Transformer parameter selection**

The transformer parameters are selected based on the *Parameter Sel method*, *Cooling mode*, *Transformer type*, and *Transformer rating* settings.

If the *Parameter Sel method* setting is set to "IEC", the transformer parameters' values are automatically selected as per the IEC 60076-7 guidelines based on *Table 1323*.

**Table 1323: Constants based IEC guidelines**

| | **Distribution Transformers** | **Medium and Large power transformers** | | | |
|---|---|---|---|---|---|
| **Cooling mode** | **ONAN** | **ONAN** | **ONAF** | **OFAF** | **ODAF** |
| Oil Exponent (x) | 0.8 | 0.8 | 0.8 | 1.0 | 1.0 |
| Winding Exponent (y) | 1.6 | 1.3 | 1.3 | 1.3 | 2.0 |
| Constant K11 ($k_{11}$) | 1.00 | 0.50 | 0.50 | 1.00 | 1.00 |
| Constant K21 ($k_{21}$) | 1.00 | 2.00 | 2.00 | 1.30 | 1.00 |
| Constant K22 ($k_{22}$) | 2.00 | 2.00 | 2.00 | 1.00 | 1.00 |
| Oil Time Constant ($\tau_0$) [minutes] | 180 | 210 | 150 | 90 | 90 |
| Winding Tm Constant ($\tau_w$) [minutes] | 4 | 10 | 7 | 7 | 7 |

If *Parameter Sel method* is set to "IEEE", the constants are selected as per the IEEE C57.91™-2011 standard based on *Table 1324*.

**Table 1324: Constants based on IEEE guidelines**

| | **Distribution Transformers** | **Medium and Large power transformers** | | | |
|---|---|---|---|---|---|
| **Cooling mode** | **ONAN** | **ONAN** | **ONAF** | **OFAF** | **ODAF** |
| Oil Exponent (x) | 0.8 | 0.8 | 0.8 | 0.8 | 1.0 |
| Winding Exponent (y) | 0.8 | 0.8 | 0.9 | 0.9 | 1.0 |
| Constant K11 ($k_{11}$) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

*Table continues on the next page*

| | Distribution Transformers | Medium and Large power transformers | | | |
|---|---|---|---|---|---|
| **Cooling mode** | **ONAN** | **ONAN** | **ONAF** | **OFAF** | **ODAF** |
| Constant K21 ($k_{21}$) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Constant K22 ($k_{22}$) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Oil Time Constant ($\tau_0$) [minutes] | 180 | 210 | 150 | 90 | 90 |
| Winding Tm Constant ($\tau_w$) [minutes] | 4 | 10 | 7 | 7 | 7 |

A transformer is a distribution transformer if the *Transformer rating* setting < 2.5 MVA and *Transformer type* is set to "Three phase" or if the *Transformer rating* setting < 0.833 MVA and *Transformer type* is set to "Single phase".

Transformer parameters vary with the material used for winding and insulating oil. The *Parameter Sel method* setting can be set to "Manual" and the constants can be set individually through the *Oil exponent*, *Winding exponent*, *Constant K11*, *Constant K21*, *Constant K22*, *Oil time constant* and *Winding Tm constant* settings.

If *Parameter Sel method* is set to "Manual", the *Cooling mode* setting has no effect on the transformer parameters.

Since there is no direct *Cooling mode* based time constants' selection mentioned in the IEEE Std C57.91™- 2011 standard, the oil time constant ($\tau_0$) and winding time constant ($\tau_w$) in *Table 1324* are kept same as in *Table 1323*.

For more accuracy, the values of the constants can be entered manually by setting *Parameter Sel method* to "Manual".

### 7.3.5.2 Top oil temp calculation

The function receives two sensor inputs for measuring top oil temperature and ambient temperature.

The top oil temperature of the tank is obtained through a sensor placed at the upper inner turn of the winding. If the top oil temperature sensor status `TOIL_SNSFLT` is FALSE, the top oil temperature is directly obtained from the `TOIL_TEMP` input.

If the status of `TOIL_SNSFLT` is TRUE, indicating that the sensor is faulty, the top oil temperature is calculated with the help of measured ambient temperature.

The status of the ambient temperature sensor is obtained through the `AMB_SNSFLT` binary input. If `AMB_SNSFLT` is FALSE, indicating the healthy status of the sensor, the ambient temperature is directly measured through the `AMB_TEMP` input. Else, if `AMB_SNSFLT` is TRUE, the ambient temperature is taken from the *Average ambient Tmp* setting.

The formula for calculating the top oil temperature from the measured or set ambient temperature is shown in *Equation 322*.

$$D\theta_{0(n)} = \frac{Dt}{(k_{11} \cdot \tau_o)} \cdot \left( \left[ \frac{1 + (K^2 \cdot R)}{1 + R} \right]^x \cdot \Delta\theta_{or} - \left[ \theta_{0(n-1)} - \theta_a \right] \right)$$

(Equation 322)

Where

| | |
|---|---|
| $\theta_{0(n)}$ | Top oil temperature in the tank at $n^{th}$ time step |
| $\theta_a$ | Ambient temperature [°C] |
| $\Delta\theta_{or}$ | Top oil temperature rise over ambient temperature at rated load, given by the setting *Top oil Tmp rise* |
| R | Ratio of losses at rated current to no load losses, given by the setting *Ratio of losses* |

$k_{11}$, $\tau_0$, K and x are as defined in the Parameter selection module in *Figure 789*.

The D operator implies a difference in the associated variable that corresponds to each time step Dt. At each time step, the $n^{th}$ value of $D\theta_{0(n)}$ is calculated from the $(n-1)^{th}$ value.

The initial conditions are calculated by setting the time derivative equal to zero in $D\theta_{0(n)}$ equation, resulting in the following equations.

$$\theta_{0(0)} = \left[ \frac{1 + (K^2 \cdot R)}{1 + R} \right]^x \cdot \Delta\theta_{or} + \theta_a$$

(Equation 323)

The top oil temperature at the $n^{th}$ time step is calculated as shown below.

$$TOPOIL_TEMP = \theta_{0(n-1)} + D\theta_{0(n)}$$

(Equation 324)

The measured/calculated top oil temperature TOPOIL_TEMP is available in the Monitored data view.

If the top oil temperature sensor is valid, the `TOPOIL_TEMP` output is equal to the measured top oil temperature `TOIL_TEMP` input.

### 7.3.5.3 Hot-spot temp calculation

Winding hot-spot temperature depends on the winding temperature rise due to the load factor and oil flow. These two factors act complimentary to each other in the influence of temperature rise.

The differential equations for hot-spot temperature rise above top oil temperature is solved as the sum of two differential equations.

$$\Delta\theta_{h(n)} = \Delta\theta_{h1(n)} - \Delta\theta_{h2(n)}$$

(Equation 325)

The two differential equations are shown in *Equation 326* and *Equation 327*.

$$D\Delta\theta_{h1(n)} = \frac{Dt}{(k_{22} \cdot \tau_w)} \cdot \left(k_{21} \cdot \Delta\theta_{hr} \cdot K^y - \Delta\theta_{h1(n-1)}\right)$$

(Equation 326)

$$D\Delta\theta_{h2(n)} = \frac{Dt}{\left(\left(\frac{1}{k_{22}}\right) \cdot \tau_o\right)} \cdot \left((k_{21} - 1) \cdot \Delta\theta_{hr} \cdot K^y - \Delta\theta_{h2(n-1)}\right)$$

(Equation 327)

Where

$\Delta\theta_{hr}$ Hot-spot-to-top-oil gradient at rated current [°C]

The constants $\tau_w$, $k_{21}$, $k_{22}$ and y are varying according to the *Cooling mode* setting and are obtained from the Load factor calculation and parameter selection module.

The rated hot-spot to top oil gradient, HS_TOIL_GRA ($\Delta\theta_{hr}$), is calculated using the formula as shown in *Equation 328*.

$$\Delta\theta_{hr} = \frac{Hotspot\ \ Tmp\ rise - Top\ oil\ \ Tmp\, rise}{\left(\frac{Current\, type\, test}{I_{rated}}\right)^y}$$

(Equation 328)

Where

| | |
|---|---|
| $I_{rated}$ | Rated current of the transformer |
| Hotspot Tmp rise | Hot-spot temperature rise over ambient at rated load |
| Top oil Tmp rise | Top oil temperature rise over ambient at rated load |
| Current type test | Current applied in type testing to reach rated hot-spot temperature |

At each time step, the $n^{th}$ value of $D\Delta\theta_{h1(n)}$ and $D\Delta\theta_{h2(n)}$ are calculated from the (n-1) value; the solutions of which are combined in accordance with the hot-spot temperature rise equation.

$$\Delta\theta_{h1(n)} = \Delta\theta_{h1(n-1)} + D\Delta\theta_{h1(n)}$$

(Equation 329)

$$\Delta\theta_{h2(n)} = \Delta\theta_{h2(n-1)} + D\Delta\theta_{h2(n)}$$

(Equation 330)

The initial conditions are calculated by setting the time derivative equal to zero in$D\Delta\theta_{h1(n)}$ and $D\Delta\theta_{h2(n)}$ equations, resulting in the following equations.

$$\Delta\theta_{h1(0)} = k_{21} \cdot \Delta\theta_{hr} \cdot K^{y}$$

(Equation 331)

$$\Delta\theta_{h2(0)} = (k_{21} - 1) \cdot \Delta\theta_{hr} \cdot K^{y}$$

(Equation 332)

The final hot-spot temperature is calculated as the sum of top oil temperature and the rise of hot-spot temperature over the top oil temperature.

The hot-spot temperature at the nth time step is calculated as shown in *Equation 333*.

$$HOTSPOT_TEMP = \theta_{o(n)} + \Delta\theta_{h(n)}$$

(Equation 333)

The calculated hot-spot temperature HOTSPOT_TEMP and rated hot-spot to top oil gradient, HS_TOIL_GRA are available in the Monitored data view.

### 7.3.5.4 Level detector 1

This module compares the calculated hot-spot temperature, HOTSPOT_TEMP value with the *Alarm level* and *Warning level* settings.

If HOTSPOT_TEMP is greater than the *Warning level*, the module activates the WARNING output after a settable *Warning delay time*.

If HOTSPOT_TEMP is greater than the *Alarm level*, the module activates the ALARM output after a settable *Alarm delay time*.

Assuming existing conditions, as long as the alarm/warning conditions are not reached, the module calculates the available load reserve in percentage to reach the alarm condition LD_RSV_ALM_PCT and to reach the warning condition, LD_RSV_WRN_PCT. These outputs can be obtained from the Monitored data view.

If the warning condition is reached, the LD_RSV_WRN_PCT output is forced to zero and if the alarm condition is reached, LD_RSV_ALM_PCT is forced to zero.

The load reserve outputs are only indicative and are calculated based on rated current, assuming the same ambient temperature and cooling modes. If, for any reason, the load reserve calculation is not feasible, the load reserve outputs are shown as zero.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates WARNING and ALARM outputs and resets the internal timers.

### 7.3.5.5 Ageing and loss of life calculation

This module calculates the rate at which transformer insulation ageing is accelerating compared with the ageing rate at rated hot-spot temperature and equivalent ageing over a time period.

If transformer insulation paper is not upgraded, that is, if setting *Insul paper type* is set to "Normal", the setting *Ageing rate method* selects between the IEC and IEEE

methods of calculation. If *Ageing rate method* is set to "IEC", the relative ageing rate is calculated as shown in *Equation 334*.

$$V_{IEC} = 2^{\frac{(\theta_h - 98)}{6}}$$

(Equation 334)

If the setting *Ageing rate method* is set to "IEEE", the ageing rate is calculated as shown in *Equation 335*.

$$V_{IEEE} = e^{\frac{15000}{110+273} - \frac{15000}{\theta_h + 273}}$$

(Equation 335)

Where

| | |
|---|---|
| $V_{IEC}$ | Momentary ageing rate as per IEC method |
| $V_{IEEE}$ | Momentary ageing rate as per IEEE method |
| $\theta_h$ | The calculated hot-spot temperature |

If the setting *Insul paper type* is set to "Upgraded", the IEEE method is used for calculating the ageing rate irrespective of the value of *Ageing rate method* setting.

The calculated value of the relative ageing rate, AGEING_RATE is given as an output in the Monitored data view.

The module also calculates the average ageing rate, AVG_AGE_RATE, over a specified time period given by the *Avg Age rate period* setting. The setting *Avg Age rate period* can be set to "DAY", "WEEK", "MONTH" or "YEAR".

For example, if the *Avg Age rate period* is set to "MONTH", the output AVG_AGE_RATE is updated every day with the average ageing rate since the day the calculation started. Once a month is completed, the AVG_AGE_RATE is calculated over the previous 30 days. That is, after the 31st day, the average ageing rate is calculated from day 2 to day 31 and so on.

If the *Avg Age rate period* is set to "DAY", "WEEK" or "MONTH", the calculated AVG_AGE_RATE is refreshed every day at 12:00 hours, but if it is set to "YEAR", the AVG_AGE_RATE is refreshed once in 30 days.

The calculated AVG_AGE_RATE is given as an output in the Monitored data view.

The function considers month as 30 days and correspondingly a year as 12 months or 360 days.

**Loss of life calculation**

The momentary loss of life can be calculated as the product of the momentary ageing rate and the time step over which the momentary ageing is calculated.

$$DL_n = V_n \cdot Dt$$

(Equation 336)

The total loss of life is the sum of the momentary loss of life and the total loss of life until time, n-1.

$$L_n = L_{n-1} + DL_n$$

(Equation 337)

The initial loss of life $L_0$, is taken from the setting *Initial loss of life*.

For new transformer installations, the *Initial loss of life* setting should be “0”. For previously installed transformers, the *Initial loss of life* can be set to the consumed transformer life in months.

The calculated value of the loss of life in years, LOSS_OF_LIFE, is given as an output in the Monitored data view.

The calculated value of LOSS_OF_LIFE can be reset through the input RESET.

#### 7.3.5.6 Level detector 2

This module compares the ALM_AGE_RATE output with the setting *Alarm level Age Rte*.

If the calculated AVG_AGE_RATE over the *Avg Age rate period* setting is greater than *Alarm level Age Rte*, the module activates the binary output ALM_AGE_RATE.

The binary input RST_AVGAGING can be used to reset the output ALM_AGE_RATE and also the calculated value of AVG_AGE_RATE.

Once the RST_AVGAGING input is active, the average ageing rate values stored over the *Avg Age rate period* setting is erased and the calculation of AVG_AGE_RATE is restarted.

If the *Avg Age rate period* is set to "YEAR", the output AVG_AGE_RATE is refreshed once in 30 days starting from the time the relay is installed or since the last activation of binary input RST_AVGAGING.

The activation of the BLOCK input deactivates the ALM_AGE_RATE output.

### 7.3.6 Application

The insulation used in transformer windings is paper oil insulation that can degrade over a period of time. The deterioration of insulation is a time function of temperature, moisture and oxygen content. With modern oil preservation systems, the moisture and oxygen contributions to insulation deterioration can be minimized, leaving insulation temperature as the controlling parameter.

Since, in most of the transformers the temperature distribution is not uniform, the part that is operating at the highest (hot-spot) temperature normally undergoes the greatest deterioration. Hot-spot temperature of winding needs to be monitored continuously in order to not exceed the flashover value of transformer insulation oil. The first step in monitoring the insulation age is the calculation of hot-spot temperature of the transformer.

A simplified representation of the variation of temperature inside the transformer is shown in *Figure 790* (IEC 60076-7).

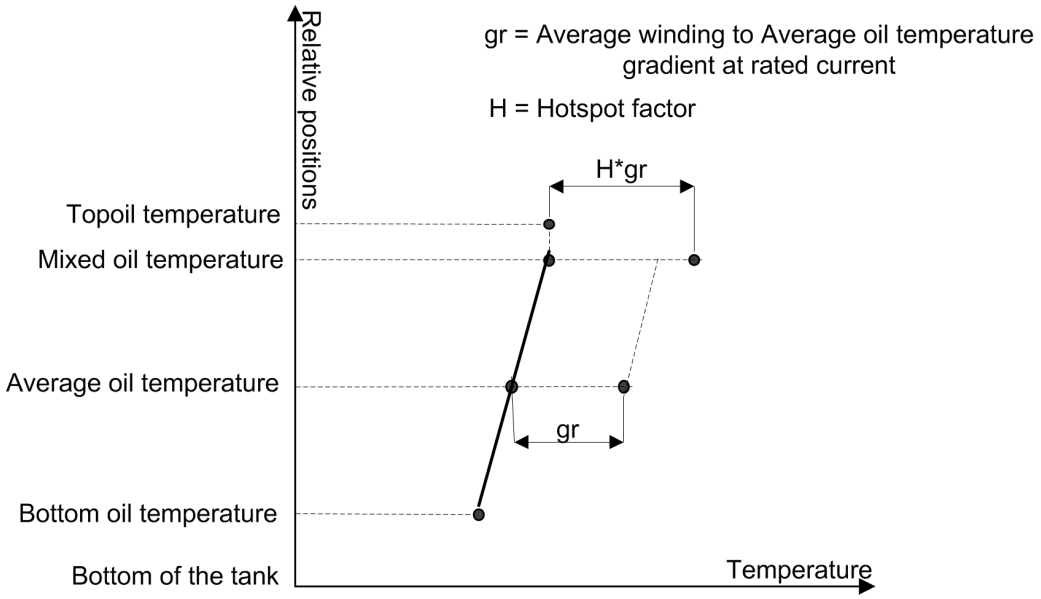



*Figure 790: Transformer thermal diagram*

The winding hot-spot temperature depends on the load losses, type of cooling and ambient temperature. Usually the conductors near the top of the winding experience the maximum leakage field and the highest surrounding oil temperature (due to convection effect). It is natural to consider that the top conductors contain the hottest spot. Measurements have shown that the hottest spot can also be moved to lower conductors.

Direct measurement of hot-spot temperature with fiber optic probes became available in mid 1980s. Experience has shown that there might be gradients of more than 10 °C between different locations at the top of a transformer winding. It is unlikely that the insertion of one to three sensors detect the real hot-spot. Direct measurement of hot-spot temperature is difficult and it is calculated using the empirical formulae.

The hot-spot temperature calculation is dependent upon the thermal properties of the winding material, cooling oil and the cooling mode of the transformer. The thermal model may also differ from IEC and IEEE markets, though the underlying principle of temperature calculation remains the same. The transformer constants are decided based on a user defined setting to select the preferred type of thermal model (IEC, IEEE or Manual).

For most transformers in service, the top oil temperature inside a winding is difficult to measure. On the other hand, the top oil temperature at the top of the tank is well known, either by measurement or by calculation. The winding hot-spot temperature rise above the top oil temperature is calculated. By adding this value to the measured or calculated top oil temperature, the winding hot-spot temperature is obtained. A pictorial representation of the location of top oil temperature sensor is shown in *Figure 791*.

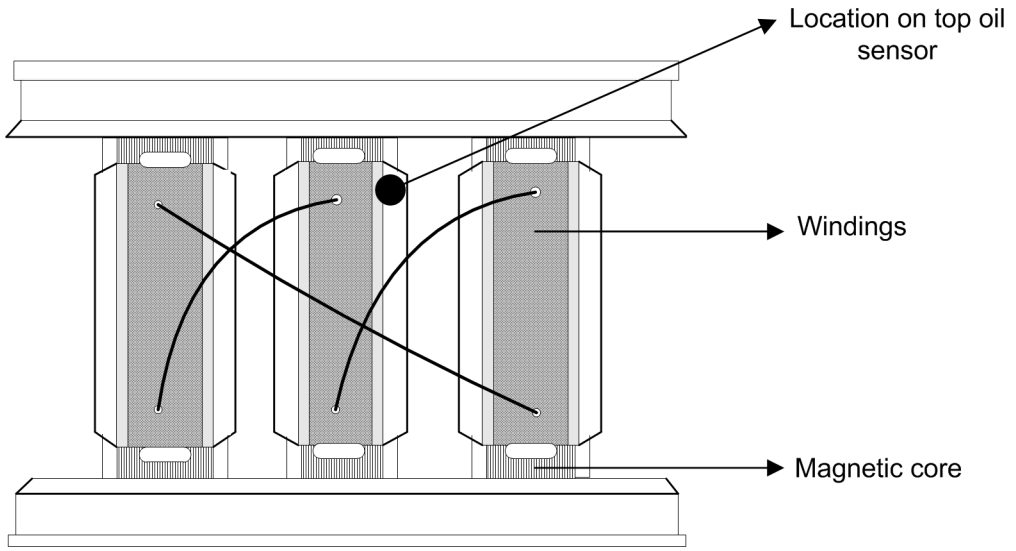



*Figure 791: Location of top oil sensor*

WARNING and ALARM signals are provided for the operator to take corrective actions to reduce the temperature inside the transformer. Corrective actions include switching on coolers, reducing the load on the transformers and so on.

Normally, warning level is set to indicate if the temperature is nearing the limiting value and alarm is generated when the limiting condition has reached. Hence, alarm level is set at a higher value than the warning level.

The function only calculates hot-spot temperature based on the load factor of the winding. This function does not calculate the rise in actual hot-spot temperature, which occurs due to oil flow blockage or malfunction of cooler groups. That said, the set oil and winding properties can be updated manually to indicate this change.

Based on the calculated hot-spot temperature, the function calculates the relative ageing, that is, the accelerated or decelerated ageing of the insulation at current load compared to its ageing at rated load. The variation of ageing acceleration factor with respect to the hot-spot temperature for a sample transformer is plotted in *Figure 792*. Here, 110 °C is taken as the rated hot-spot temperature at which point an ageing acceleration factor of 1.0 is achieved.

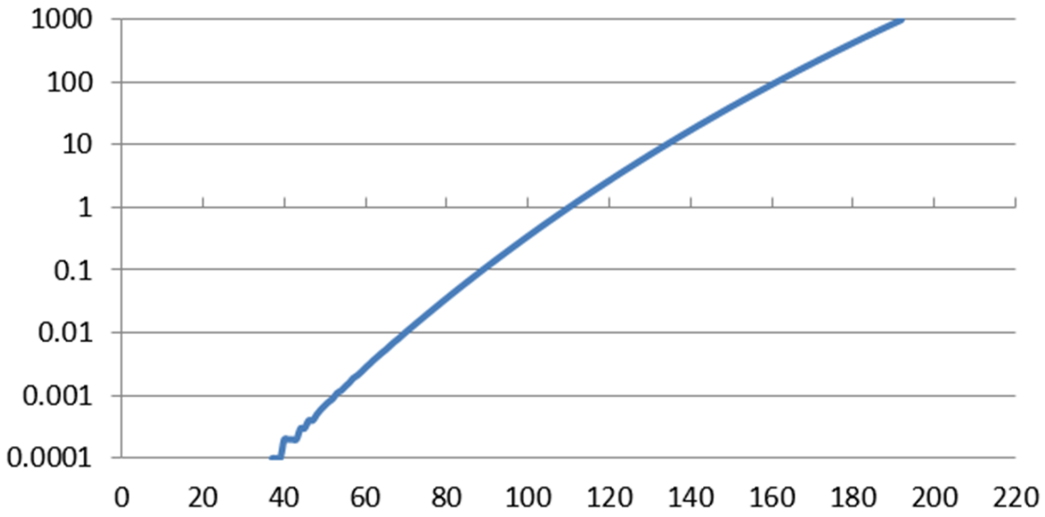



*Figure 792: Variation of insulation ageing factor with hot-spot temperature (Graph produced using values from Table 11 of IEEE Std. C57.91-1995)*

The variation of insulation life with respect to the hot-spot temperature depends upon the type of insulation paper used. Thermally upgraded insulation paper neutralizes the production of acids caused by the hydrolysis of the material over the lifetime of the transformer and slows down insulation ageing when compared to the normal insulation paper (IEC 60076-7). The proper selection of insulation paper type is needed for better accuracy of loss of life calculation.

In certain cases, it is necessary to monitor the loading of the transformer over a defined time period. For example, during a planned overloading of a transformer for a period of one month. In such cases it is important to know the ageing rate during that period of overload rather than the overall loss of life transformer. Hence, an additional output on average ageing rate over a settable average ageing period is provided in the function.

The function can be applied for new transformers and also for transformers already in service using the *Initial loss of life* setting.

## 7.3.7 Signals

### 7.3.7.1 HSARSPTR Input signals

**Table 1325: HSARSPTR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| TOIL_TEMP | FLOAT32 | 0 | Measured top oil temperature |
| AMB_TEMP | FLOAT32 | 0 | Measured ambient temperature |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| RESET | BOOLEAN | 0=False | Reset loss of life calculation |
| RST_AVGAGING | BOOLEAN | 0=False | Reset average ageing rate calculation |

### 7.3.7.2 HSARSPTR Output signals

**Table 1326: HSARSPTR Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Alarm signal |
| WARNING | BOOLEAN | Warning signal |
| ALM_AGE_RATE | BOOLEAN | Alarm signal for Avg ageing rate over set time period |
| TOPOIL_TEMP | FLOAT32 | Calculated value of top oil temperature |
| HOTSPOT_TEMP | FLOAT32 | Calculated value of hot spot temperature |

## 7.3.8 HSARSPTR Settings

**Table 1327: HSARSPTR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Cooling mode | 1=ONAN<br>2=ONAF<br>3=OFAF<br>4=ODAF | | | 1=ONAN | Transformer cooling method |
| Alarm level | 50.0...350.0 | °C | 0.1 | 120.0 | Alarm level for hotspot temperature |
| Warning level | 50.0...350.0 | °C | 0.1 | 100.0 | Warning level for hotspot temperature |
| Alarm delay time | 0...3600000 | ms | 10 | 10000 | Time delay for hotspot temperature alarm |
| Warning delay time | 0...3600000 | ms | 10 | 10000 | Time delay for hotspot temperature warning |
| Average ambient Tmp | -20.00...70.00 | °C | 0.01 | 20.00 | Average ambient temperature |

**Table 1328: HSARSPTR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on | | | 1=on | Operation Off / On |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 5=off | | | | |
| Transformer type | 1=Single phase<br>2=Three phase | | | 2=Three phase | Number of phases of the transformer |
| Parameter Sel method | 1=IEC<br>2=IEEE<br>3=Manual | | | 1=IEC | Transformer parameter selection method |
| Ageing rate method | 1=IEC<br>2=IEEE | | | 1=IEC | Ageing rate calculation method |
| Insul paper type | 1=Normal<br>2=Upgraded | | | 1=Normal | Type of transformer paper insulation |
| Transformer rating | 1.00...500.00 | MVA | 0.01 | 2.50 | Rating of the transformer |
| Initial loss of life | 0...1000 | | 1 | 0 | Initial value for winding insulation loss of life in months |
| Hotspot Tmp rise | 50.0...350.0 | °C | 0.1 | 80.0 | Hotspot temperature rise over ambient at rated load |
| Top oil Tmp rise | 50.0...350.0 | °C | 0.1 | 65.0 | Top oil temperature rise over ambient at rated load |
| Current type test | 0.01...2.00 | xIn | 0.01 | 1.00 | Current applied in type testing to reach rated hotspot Temp |
| Ratio of losses | 0.1...500000.0 | | 0.1 | 25.0 | Ratio of load losses at rated load to no-load losses |
| CT ratio correction | 0.200...5.000 | | 0.001 | 0.200 | Current transformer ratio correction factor |
| Oil exponent | 0.10...10.00 | | 0.01 | 0.10 | User defined value for oil exponent |
| Winding exponent | 0.10...10.00 | | 0.01 | 0.10 | User defined value for winding exponent |
| Constant K11 | 0.01...10.00 | | 0.01 | 1.00 | User defined value of thermal model constant K11 |
| Constant K21 | 0.01...10.00 | | 0.01 | 1.00 | User defined value of thermal model constant K21 |
| Constant K22 | 0.01...10.00 | | 0.01 | 2.00 | User defined value of thermal model constant K22 |
| Oil time constant | 1...20000 | s | 1 | 10800 | Oil time constant in seconds |
| Winding Tm constant | 1...20000 | s | 1 | 240 | Winding time constant in seconds |
| Alarm level Age Rte | 0.00...100.00 | | 0.01 | 1.00 | Alarm level for average ageing rate over set time period |

**Table 1329: HSARSPTR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Avg Age rate period | 4=DAY<br>5=WEEK | | | 6=MONTH | Time period over which average ageing rate is calculated |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 6=MONTH<br>7=YEAR | | | | |

## 7.3.9 HSARSPTR Monitored data

**Table 1330: HSARSPTR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| HS_TOIL_GRA | FLOAT32 | 0...1000 | | Rated hot spot to top oil temperature gradient |
| LD_RSV_WRN_PCT | FLOAT32 | 0.0...1000.0 | % | Percentage load reserve for reaching warning condition |
| LD_RSV_ALM_PCT | FLOAT32 | 0.0...1000.0 | % | Percentage load reserve for reaching alarm condition |
| AGEING_RATE | FLOAT32 | 0.00...50.00 | | Momentary relative ageing rate |
| LOSS_OF_LIFE | FLOAT32 | 0...100 | | Loss of life in years |
| AVG_AGE_RATE | FLOAT32 | 0...100 | | Average ageing rate over set time period |
| HSARSPTR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 7.3.10 Technical data

**Table 1331: HSARSPTR technical data**

| Characteristic | Value |
|---|---|
| Warning/alarm time accuracy | ±1.0 % of the set value or ±0.50 s |

# 7.4 Cable fault detection RCFD (ANSI CFD)

## 7.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Cable fault detection | RCFD | CFD | CFD |

## 7.4.2 Function block

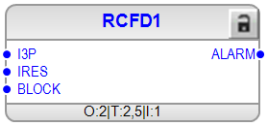



*Figure 793: Function block*

## 7.4.3 Functionality

The self-clearing fault detection function (RCFD) calculates half cycle DFT of the current signal for all the three phases and earth and uses it to detect a self-clearing fault pronounced primarily in cable networks.

The function provides individual counter values for number of times a self-clearing fault is observed in each phase and earth. The function determines the self-clearing fault is detected in all three phases or earth.

## 7.4.4 Analog input configuration

RCFD has two analog group inputs which must be properly configured.

**Table 1332: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents. |
| IRES | Measured residual current |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 7.4.5 Operation principle

The *Operation* setting is used to enable or disable the function. When selected "On" the function is enabled and respectively "Off" means function is disabled.

The operation of RCFD can be described by using a module diagram (see Figure *Figure 794* below). All the modules in the diagram are explained in the next sections.

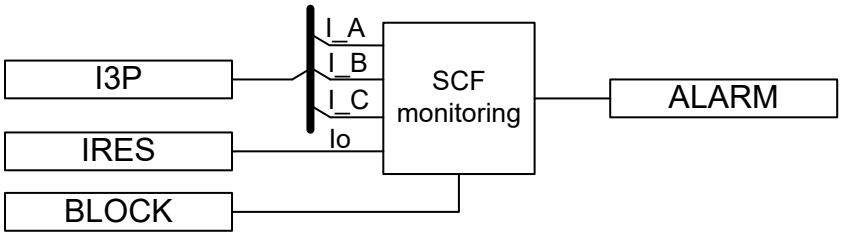



*Figure 794: Functional module diagram*

### 7.4.5.1 SCF monitoring

The SCF(Self Clearing Fault) monitoring module provides measurement channel specific monitoring for phase and residual currents. Following table lists the options for monitoring and available monitored data values.

**Table 1333: SCF monitoring options and data values**

| Measurement channel | Calculated ½ cycle DFT current | Start detection | SCF indication | SCF counter |
|---|---|---|---|---|
| Phase A current (I_A) | I_CLC_AMPL_A | STR_DET_A | SLFCLR_FLT_A | SLFCLR_CNT_A |
| Phase B current (I_B) | I_CLC_AMPL_B | STR_DET_B | SLFCLR_FLT_B | SLFCLR_CNT_B |
| Phase C current (I_C) | I_CLC_AMPL_C | STR_DET_C | SLFCLR_FLT_C | SLFCLR_CNT_C |
| Residual current (Io) | I_CLC_AMPL_N | STR_DET_N | SLFCLR_FLT_N | SLFCLR_CNT_N |

Half cycle DFT values are calculated for the SCF detection. Values are available in monitored data. If the calculated phase current (or residual current) exceeds above set *Phase start value* (or *Residual start value*), then the corresponding start

detection in monitored data is set to TRUE. Monitored data is set to FALSE once fault current has dropped below start value.

The module calculates the duration for currents continuously staying above the set *Phase start value* (or *Residual start value*). If the calculated duration is between ¼ cycles and cycles set by *Maximum fault cycle*, then it is regarded as the SCF and corresponding SCF indication in monitored data is set to TRUE. Simultaneously corresponding SCF counter in monitored data is increased.



The parameter settings *Residual start value*, *Residual current limit* are dimmed when *Ena selfclear Det EF* setting is set to “FALSE”. And also Monitoring for residual current (Io), can be disabled by setting *Ena selfclear Det EF* to “FALSE”.

If the setting *Adaptive Str Val Ena* is set to TRUE. the adaptive phase and residual start value are defined based on the one-minute phase and residual averages, the *Minimum load current* (for phase) and *Residual current limit* (for earth) setting.

At end of the every healthy state one-minute period, new one-minute phase and residual current averages are calculated. If it is greater than the *Minimum load current* (for phase) and *Residual current limit* (for earth) setting, then the adaptive start value will be updated as twice the calculated value.

If one-minute phase and ground averages are less than the *Minimum load current* and *Residual current limit*, then the adaptive start value are set to twice the *Minimum load current* and *Residual current limit*.

In case fault is detected, the adaptive start value will hold the last updated one-minute average of phase and residual current.

The adaptive start values of corresponding phases (or residual) are displayed in monitored data ADP_ST_VAL_A, ADP_ST_VAL_B, ADP_ST_VAL_C and ADP_ST_VAL_N.

If the SCF is detected in at least one phase or residual current channel, the ALARM output is set to TRUE. When one phase detects a fault, the algorithm waits for 1 cycle time and if during this period two other phases also detect fault, then the fault is considered as three phase SCF and the SLFCLR_3PH in monitored data is set to TRUE.

The counter type monitored data can be reset to their initial value along with the all the outputs in the monitored data via a control parameter RCFD1 reset that is located under the clear menu.

When BLOCK input is activated, the ALARM output is set to FALSE, and also the Boolean type monitored data are set to FALSE and ADP_ST_VAL_x (phase A,B and C) are defaulted to *Phase start value* setting (ADP_ST_VAL_N is defaulted to *Residual start value* setting), Counter type monitored data are not affected and will retain last SCF fault count.

## 7.4.6 Application

The self-clearing fault will not the damage the cable initially, but if the frequency of the self-clearing fault slowly increases and causes the cable insulation breakdown.

## 7.4.7 Signals

### 7.4.7.1 RCFD Input signals

**Table 1334: RCFD Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### 7.4.7.2 RCFD Output signals

**Table 1335: RCFD Output signals**

| Name | Type | Description |
|---|---|---|
| ALARM | BOOLEAN | Self clearing fault alarm |

## 7.4.8 RCFD Settings

**Table 1336: RCFD Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Phase start value | 0.10...40.00 | xIn | 0.01 | 0.10 | Fault current threshold |
| Maximum fault cycle | 1...20 | | 1 | 5 | Fault detect threshold parameter in fundamental cycles |
| Minimum load current | 0.00...1.00 | xIn | 0.10 | 0.10 | Absolute minimum loading on the feeder |
| Adaptive Str Val Ena | 0=False<br>1=True | | | 0=False | Adaptive threshold enable |
| Residual start value | 0.10...40.00 | xIn | 0.01 | 0.50 | Fault residual current threshold |
| Residual current limit | 0.00...1.00 | xIn | 0.10 | 0.10 | Absolute maximum residual current under normal condition |

**Table 1337: RCFD Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Ena selfclear Det EF | 0=False<br>1=True | | | 0=False | Self clearing fault on EF |

## 7.4.9 RCFD Monitored data

**Table 1338: RCFD Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SLFCLR_FLT | BOOLEAN | 0=False<br>1=True | | Self clearing fault detected |
| SLFCLR_3PH | BOOLEAN | 0=False<br>1=True | | Three phase self clearing fault detected |
| STR_DET_A | BOOLEAN | 0=False<br>1=True | | Detection started (phase A) |
| STR_DET_B | BOOLEAN | 0=False<br>1=True | | Detection started (phase B) |
| STR_DET_C | BOOLEAN | 0=False<br>1=True | | Detection started (phase C) |
| STR_DET_N | BOOLEAN | 0=False<br>1=True | | Detection started (residual) |
| SLFCLR_CNT_A | INT32 | 0...10000 | | Number of self clearing fault detected (phase A) |
| SLFCLR_CNT_B | INT32 | 0...10000 | | Number of self clearing fault detected (phase B) |
| SLFCLR_CNT_C | INT32 | 0...10000 | | Number of self clearing fault detected (phase C) |
| SLFCLR_CNT_N | INT32 | 0...10000 | | Self clearing fault detected (residual) |
| SLFCLR_FLT_A | BOOLEAN | 0=False<br>1=True | | Self clearing fault detected (phase A) |
| SLFCLR_FLT_B | BOOLEAN | 0=False<br>1=True | | Self clearing fault detected (phase B) |
| SLFCLR_FLT_C | BOOLEAN | 0=False<br>1=True | | Self clearing fault detected (phase C) |
| SLFCLR_FLT_N | BOOLEAN | 0=False<br>1=True | | Self clearing fault detected (residual) |
| ADP_ST_VAL_A | FLOAT32 | 0.00...40.00 | xIn | Used adaptive start value (phase A) |
| ADP_ST_VAL_B | FLOAT32 | 0.00...40.00 | xIn | Used adaptive start value (phase B) |
| ADP_ST_VAL_C | FLOAT32 | 0.00...40.00 | xIn | Used adaptive start value (phase C) |
| ADP_ST_VAL_N | FLOAT32 | 0.00...40.00 | xIn | Used adaptive start value (residual) |
| I_CLC_AMPL_A | FLOAT32 | 0.00...40.00 | xIn | Calculated current magnitude (phase A) |
| I_CLC_AMPL_B | FLOAT32 | 0.00...40.00 | xIn | Calculated current magnitude (phase B) |
| I_CLC_AMPL_C | FLOAT32 | 0.00...40.00 | xIn | Calculated current magnitude (phase C) |
| I_CLC_AMPL_N | FLOAT32 | 0.00...40.00 | xIn | Calculated current magnitude (residual) |
| RCFD | Enum | 1=on<br>2=blocked | | Status |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 3=test<br>4=test/blocked<br>5=off | | |

### 7.4.10 Technical data

**Table 1339: RCFD Technical data**

| Characteristic | Value | | |
|---|---|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | ±2.5% of the set value or 0.005 x$I_n$ | | |
| Alarm time[1, 2] | Minimum | Typical | Maximum |
| | 10 ms | 15 ms | 20 ms |

## 7.5 Diesel generator monitoring and protection DGMGAPC (ANSI 32/40G)

### 7.5.1 Identification

**Table 1340: Function identification**

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Diesel generator monitoring and protection function | DGMGAPC | P><, U/f >< | 32/40G |

[1] Results based on statistical distribution of 1000 measurements
[2] Measured with static signal output (SSO)

## 7.5.2 Function block

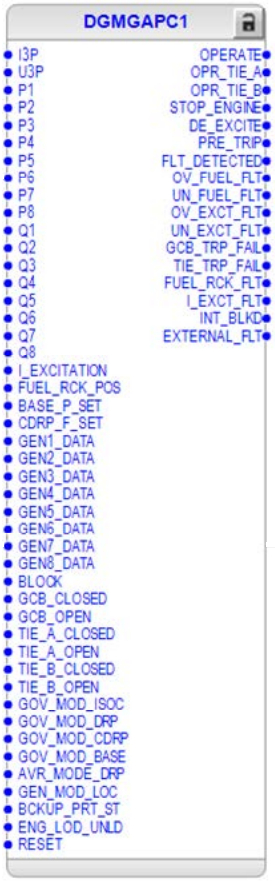



*Figure 795: Function block*

## 7.5.3 Functionality

The Diesel generator monitoring and protection DGMGAPC function protects industrial power plants and vessels from faults which are not easily detected by normal protection functions. The most important of such faults are the over/under fueling of diesel engines and over/under excitation of generators.

DGMGAPC protects the generators in isochronous load sharing, droop load sharing and base load modes. The function performs topology determination to identify the components connected in its own electrical network and exchanges relevant data with all other relays having DGMGAPC function and present in the same IEC61850 network.

The DGMGAPC identifies a fault in the generator by comparing its behavior to its current governor mode or with reference to other generators in the network. When a fault is detected, the function will signal the fault to the Power Management System (PMS). If the fault condition deteriorates, the function issues commands to stop the engine or to de-excite the generator. It then issues a trip command to the Generator Circuit Breaker (GCB).

## 7.5.4 Analog channel configuration

DGMGAPC has two analog group inputs which must be properly configured.

**Table 1341: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1342: Special conditions**

| Condition | Description |
|---|---|
| U3P connected real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 7.5.5 Operation principle

The *Operation* setting is used to enable or disable the function. When selected "on" the function is enabled and respectively "off" means function is disabled.

The operation of DGMGAPC can be described by using a module diagram (see *Figure 796*). All the modules in the diagram are explained in the next sections.

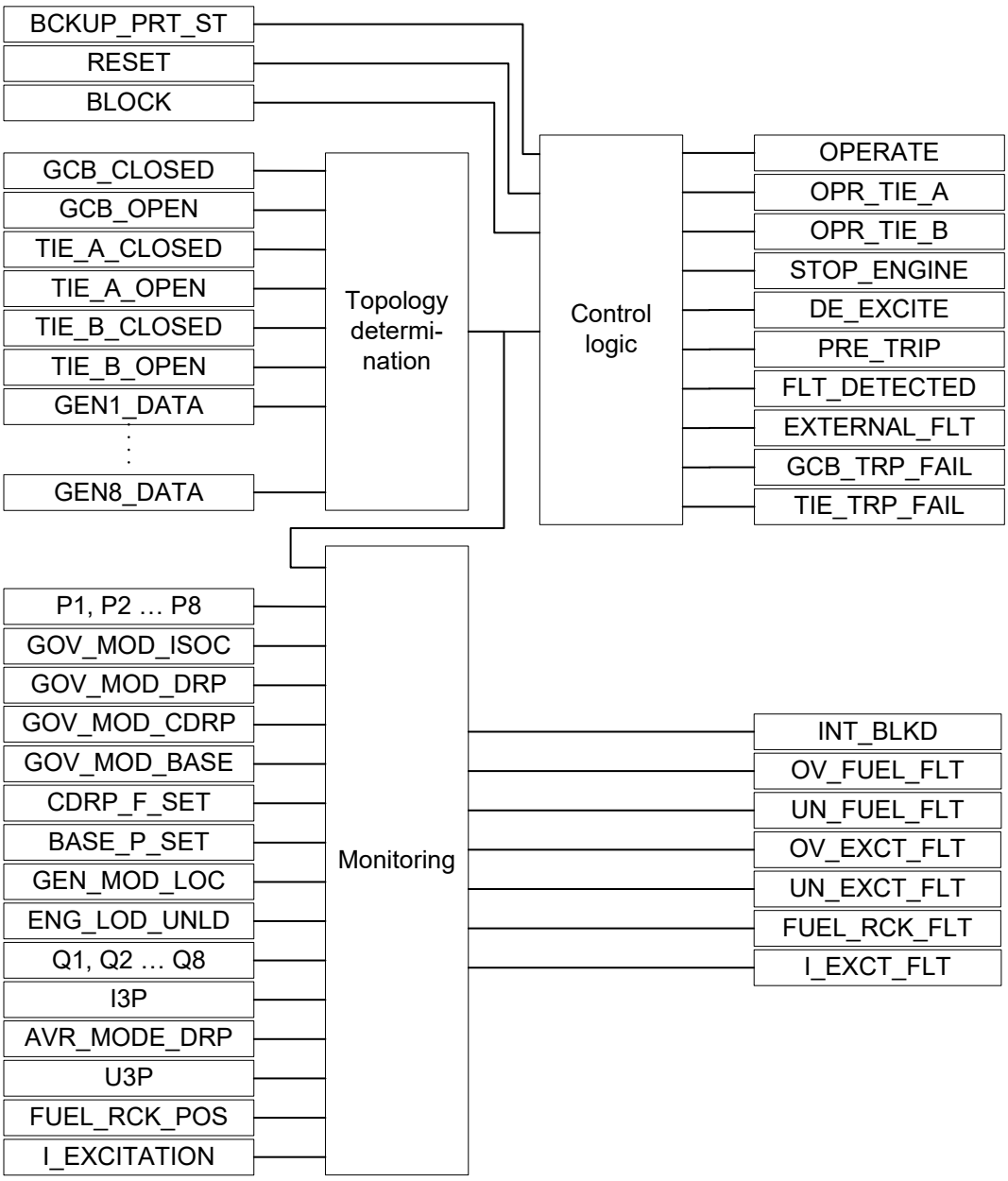



*Figure 796: Functional module diagram*

### 7.5.5.1 Topology determination

The Topology determination module identifies the group of busbar and generators that are electrically connected and calculates the subnetwork number for each group. The maximum network configuration considered is 8 generators, 8 GCBs and 8 tie breakers.

Some typical busbar arrangements in a Diesel Generator Monitoring and protection System (DGMS) are shown in *Figure 797* and *Figure 798*.

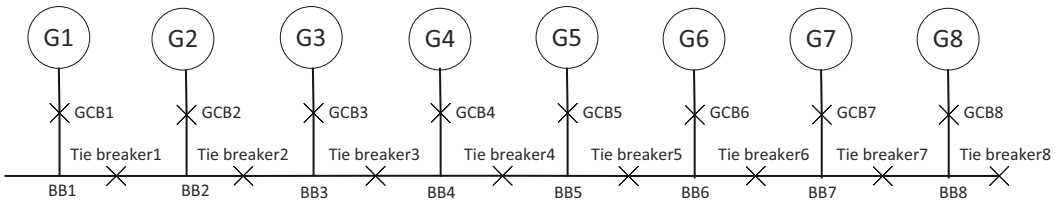



*Figure 797: Topology of a DGMS system with all generators in a single network*

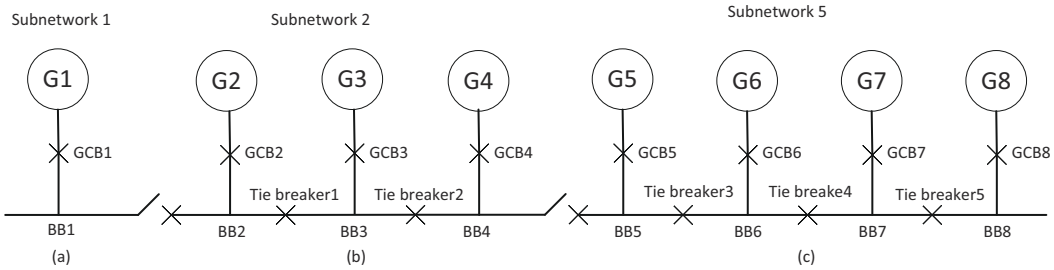



*Figure 798: Topology of a DGMS system with 3 subnetworks*

The connection of a generator to a particular busbar can be configured by using corresponding settings, *Gn 1 busbar Num* to *Gn 8 busbar Num*. Each of the settings can be set to values “Bus 1” to “Bus 8” or to “Not configured”.

For example, if generator 1 is connected to busbar1, then *Gn 1 busbar Num* is set to “Bus 1”. If suppose there are only four generators in the system, then settings *Gn 5 busbar Num* to *Gn 8 busbar Num* are set to “Not configured”.

The numbering of each GCB is assumed to be same as the number given to the generator it is connected to. That is, GCB1 assumed to be connected to generator 1, GCB2 to generator 2 and so on.

The tie breaker connects different busbar to form the different subnetwork groups. Each tie breaker connects two busbars and these are referred to as bus A and bus B. Hence, two settings are used to indicate the connection of a tie breaker to the two busbars.

For example: If tie breaker 1 connects busbar1 and busbar2, then setting *Tie 1 busbar A Num* is set to “Bus 1” and *Tie 1 busbar B Num* is set to “Bus 2”. If a tie breaker is not configured in the network, it is set to “Not configured”.

The entire network configuration can be modeled in a similar method using settings *Tie 2 busbar A Num, Tie 2 busbar B Num … Tie 8 busbar A Num and Tie 8 busbar B Num*.

Once the entire network has been defined using the settings as mentioned above, the module identifies the existing network topology through the status of GCBs and the tie breakers. The status of the local GCB is obtained through confirmed closed and open inputs `GCB_CLOSED` and `GCB_OPEN`, whereas the adjacent tie breaker statuses are received through inputs, `TIE_A_CLOSED`, `TIE_A_OPEN`, `TIE_B_CLOSED` and `TIE_B_OPEN`. The status of other GCBs and tie breakers are obtained from corresponding weighted integer inputs `GEN1_DATA … GEN8_DATA`.

The module expects that the tie breaker which connects to the lower numbered busbar is configured as tie breaker A and the tie breaker which connects to the higher numbered busbar as tie breaker B.

For example, if Generator 2 is connected to busbar2 and the busbar2 connects to busbars 1 and 3 through tie breakers 1 and 2 as shown in *Figure 796*. Then the status of tie breaker1 shall be received through inputs TIE_A_CLOSED and TIE_A_OPEN and the status of tie breaker 2 is shall be received as TIE_B_CLOSED and TIE_B_OPEN.

If one of the tie breakers of the generator under consideration is not configured or connects to a non-configured busbar, then the module expects the status of the other tie breaker through inputs TIE_B_CLOSED and TIE_B_OPEN.

The inputs GEN1_DATA to GEN8_DATA are received from other generators in the system. Each of these inputs contain information on the status of GCB, status of the adjacent tie breakers, governor and Automatic Voltage Regulator (AVR) modes, generator local mode status, backup protection status, fault status and tie breaker trip failure indication in the respective generators from where the information is being received.

The setting *Local generator Num* is used to set the local generator number. Based on this setting the local active/reactive power, circuit breaker statuses, governor and excitation system information are associated to the corresponding generator.

Though 8 inputs, GEN1_DATA ... GEN8_DATA, are provided to receive information from other generators, the input corresponding to the local generator need not be connected.

That is, if *Local generator Num* is set to "5", then GEN5_DATA needs to be left unconnected and any information connected to this input would not be used by the function.

Based on this information, the Topology determination module determines the different subnetwork groups. Each network group is assigned a network number which is the lowest busbar number in the sub group.

For example in *Figure 798* (c), the subnetwork group has busbar 5, 6, 7 and 8. Hence the subnetwork number of this group is 5.

If an element is not electrically connected to any busbar, then a zero subnetwork number is assigned. The DGMGAPC function will be disabled in those networks whose subnetwork number will be zero.

When the quality bit of local GCB status input indicates that the data is not reliable, then the corresponding breaker status is considered open and rest of the modules in the function are disabled. If the quality bits of the local tie breakers status indicate that data is not reliable, then that tie breaker is considered as open and the generators connected through that tie breaker are suspended from participating in the monitoring function.

In case the quality of the status of the adjacent tie breakers are not reliable, then the module may identify the status of the same tie breaker using the data received from the adjacent generator sharing the same tie breaker.

The subnetwork numbers of eight generators are available in monitored data SBNW_GEN1 to SBNW_GEN8. The subnetwork numbers of tie breakers are available in monitored data SBNW_TIE_CB1 to SBNW_TIE_CB8.

If the inputs GEN1_DATA ... GEN8_DATA indicate that a network generator is faulty, then it is indicated in the respective monitored data output FAULT_GEN1 ... FAULT_GEN8 and the data corresponding to those generators are not used in other modules of DGMGAPC.

### 7.5.5.2 Monitoring

Monitoring module consists of Fuel fault detection, Excitation fault detection, Fuel rack monitoring and Excitation current monitoring as shown in *Figure 799*.

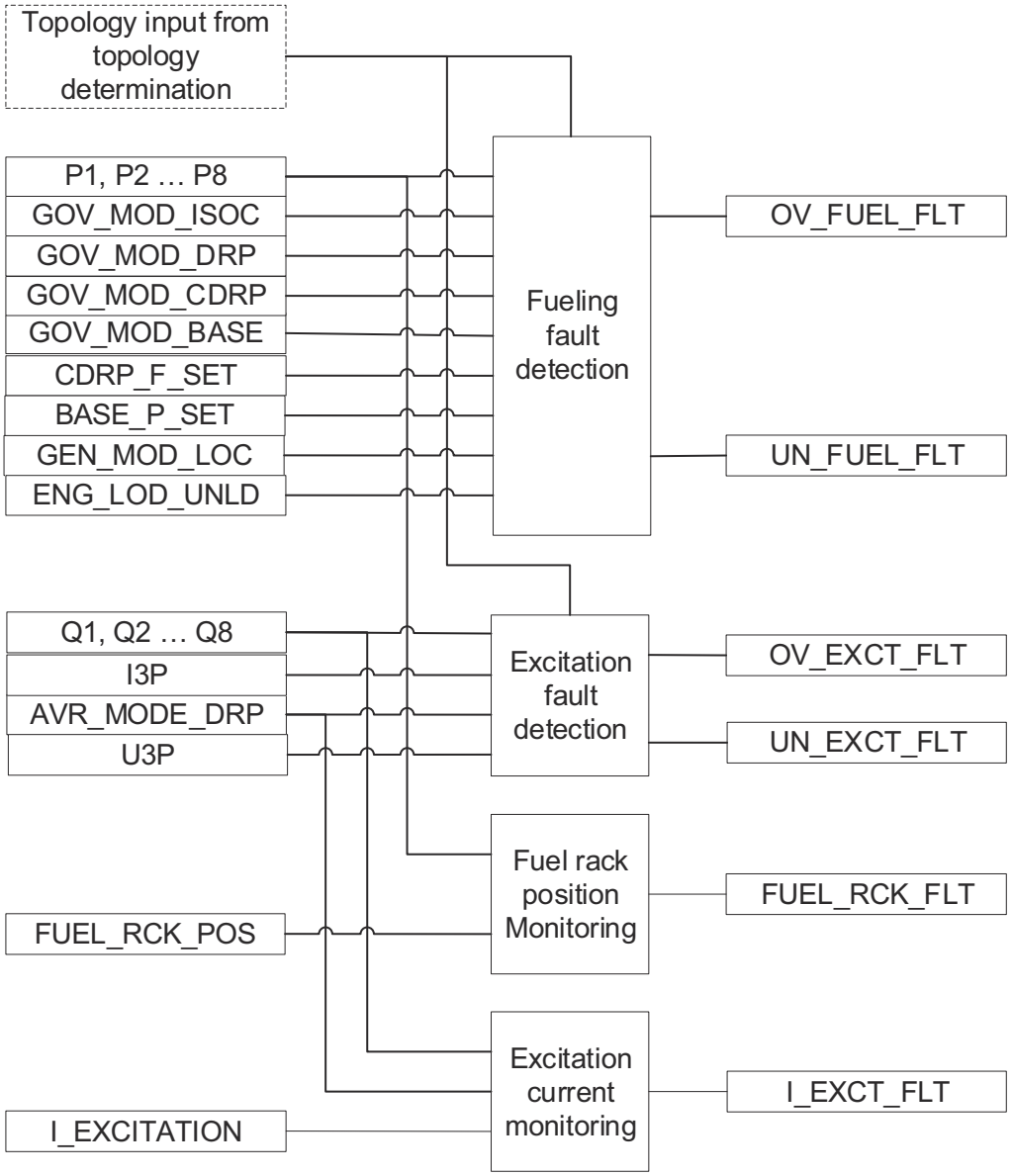



*Figure 799: Submodules of Monitoring*

#### Fueling fault detection

This module detects over/under fueling faults in the fuel system or engine governor, which result in the generator producing excessive active power (over fueling condition) or insufficient active power (under fueling condition).

Fueling faults are detected by two methods which are Correlation algorithm and Voting algorithm. The module activates `OV_FUEL_FLT` output in case of over fueling fault detection and `UN_FUEL_FLT` output in case of under fueling fault. Fueling faults are reported to Control logic module.

If the input GEN_MOD_LOC is 1, indicating that the generator is in local mode, then the Fueling fault detection module is disabled. If the quality status of the local active power input is faulty, then the module is disabled and INT_BLKD output is activated.

If one of the generators present in the same subnetwork is faulty, then that generator is removed from comparison in the Fueling fault detection module.

The input ENG_LOD_UNLD suggests whether the engine is in loading or unloading condition. When the engine is in loading condition (confirmed by GCB position change from open to close) the fueling fault detection is disabled until the generated power reaches 80% of the average loading of generators in the same subnetwork or until the elapsing of *Disable time*, whichever is faster. When the function is in unloading condition (i.e. GCB continues to remain in closed position), then the module is blocked until the elapsing of *Disable time*. As the GCB status change and ENG_LOD_UNLD input may not come together, by using settings (*Wait time signal status* - Wait time for Load/Unload signal and *Wait time status signal* - Wait time for GCB status and Load/Unload signal) the confirmation of loading/unloading of engine is done.

**Correlation algorithm:**

The Correlation algorithm compares the active power of the local generator, to its expected behavior in the current governor mode.

The algorithm can be disabled through the setting *Disable Fuel Crl*.

The function has 8 active power inputs, P1 ... P8. The input corresponding to the setting *Local generator Num*, would be considered as the local active power.

For example, if *Local generator Num* is set to “1”, then P1 is considered as the local generator active power output.

Correlation algorithm uses different criteria based on the governor mode.
The governor mode information is obtained through the four binary inputs GOV_MOD_ISOC, GOV_MOD_DRP, GOV_MOD_CDRP and GOV_MOD_BASE. The governor and AVR modes of other generators are obtained through inputs GEN1_DATA ... GEN8_DATA. In case any generator in the same subnetwork is communicated to be faulty, through the inputs GEN1_DATA ... GEN8_DATA, then that generator is not considered in the Correlation algorithm.

If the input GOV_MOD_ISOC is active, the function monitors the system frequency and active power of all generators in the same subnetwork and with the same governor mode. If the frequency of the network exceeds the set *Expected frequency* over and above the margin *Max Freq Dev Isoc*, and if the local active power is more than the rest of the generators by a margin *Max P Dev Crl*, then the generator is deemed faulty and OV_FUEL_FLT output is activated.

If the frequency of the network is below the set *Expected frequency* over and above the margin *Max Freq Dev Isoc*, and if the local active power is less than the rest of the generators by a margin *Max P Dev Crl*, then the generator is deemed faulty and UN_FUEL_FLT output is activated. The fueling fault detection algorithm in isochronous mode needs at least 2 generators in parallel and operating in same mode.

When the input GOV_MOD_DRP is active, the function compares the local active power and system frequency with the set droop curve. Deviation above or below this curve (for over and under fueling conditions respectively) by a margin greater than *Max Freq deviation*, indicates a failure of the governor or the fuel system. The

droop curve is set using the settings *F set point no load* and *Frequency droop*. A sample droop characteristics and the associated settings are shown in *Figure 800*.

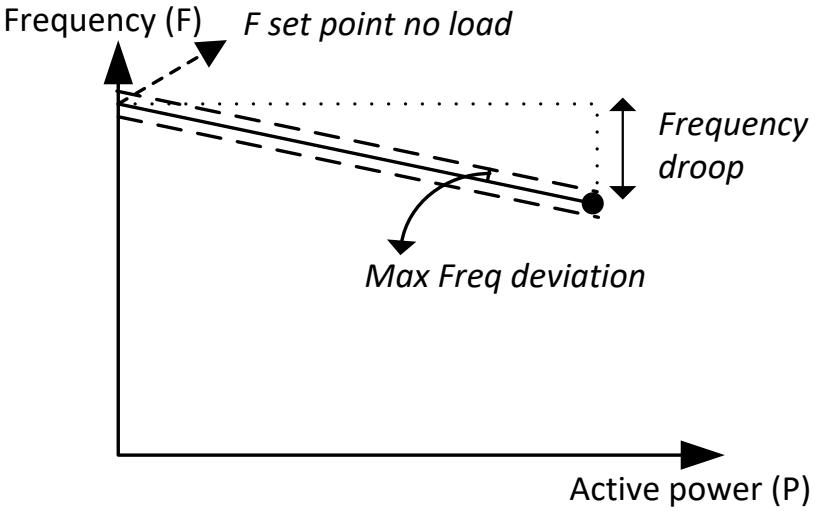



*Figure 800: Frequency vs. Active power droop characteristics*

When the input GOV_MOD_CDRP is active, then the central PMS shifts the droop curve parallel to the existing curve, through inputs CDRP_F_SET. The CDRP_F_SET input is a 0-20mA signal obtained through an RTD input, directly gives the no load set point frequency for the generator, using which the droop characteristic is generated. The calculated frequency limit at a particular load is displayed in monitored data F_CALC_LIMIT. If the network frequency value deviates over/under the F_CALC_LIMIT by a margin greater than set *Max Freq deviation*, the OV_FUEL_FLT or UN_FUEL_FLT outputs are activated. When the generator is in compensated droop mode and if the quality of the signal CDRP_F_SET is not reliable, the module is disabled and INT_BLKD output is activated.

When input GOV_MOD_BASE is active, the local active power is compared to the load set point received from PMS, BASE_P_SET. The BASE_P_SET input is a 0-20mA signal obtained through an RTD input. If the local active power deviates from this set point by a margin greater than the set *Max P Dev Crl*, it indicates an over/under fueling fault. In case the quality of the signal BASE_P_SET is not reliable when generator is in base mode, then the correlation module is disabled and INT_BLKD output is activated.

Any one among the binary inputs from governor, for example, GOV_MOD_ISOC, GOV_ MOD_DRP, GOV_MOD_CDRP and GOV_MOD_BASE can be active at a given time. If more than one of them is active or if none of them is active, then the output INT_BLKD is activated and the Correlation algorithm is stopped.

*Table 1343* indicates the method of detecting over/under fueling faults in a diesel generator system. For simplicity, the local active power will simply be called P in the tables below.

**Table 1343: Correlation algorithm for detecting fueling faults**

| Type of fault | Governor mode | Fault detection criteria | Output activation |
|---|---|---|---|
| Over fueling fault | GOV_MOD_ISOC = TRUE | F > (*Expected frequency* + *Max Freq Dev Isoc*)<br>AND<br>Local active power (P) > MAX(P1, P2, … P8) + *Max P Dev Crl*<br>Note: Only generators within the same subnetwork are considered for comparison. | OV_FUEL_FLT |
| | GOV_MOD_DRP = TRUE | F > *F set point no load* – ((*Frequency droop**0.01) * P) + *Max Freq deviation* | |
| | GOV_MOD_CDRP = TRUE | F > F_CALC_LIMIT + *Max Freq deviation* | |
| | GOV_MOD_BASE = TRUE | P > BASE_P_SET + *Max P Dev Crl* | |
| Under fueling fault | GOV_MOD_ISOC = TRUE | F < (*Expected frequency* - *Max Freq Dev Isoc*)<br>AND<br>P < MIN(P1, P2, … P8) - *Max P Dev Crl*<br>Note: Only generators within the same subnetwork are considered for comparison. | UN_FUEL_FLT |
| | GOV_MOD_DRP = TRUE | F < *F set point no load* - ((*Frequency droop**0.01) * P) - *Max Freq deviation* | |
| | GOV_MOD_CDRP = TRUE | F < F_CALC_LIMIT - *Max Freq deviation* | |
| | GOV_MOD_BASE = TRUE | P < BASE_P_SET - *Max P Dev Crl* | |

**Voting algorithm:**

Voting algorithm is applied to groups of generators running in parallel. Voting algorithm compares the behavior of the local generator with rest of the generators in the connected network and if the load on local generator deviates excessively from the others, it is identified as faulty.

The algorithm needs minimum three generators (including the local generator) running in parallel.

The algorithm can be disabled through the setting *Disable Fuel voting*. *Table 1344* shows the method of detecting fueling faults using the voting algorithm.

**Table 1344: Voting algorithm for detecting fueling faults**

| Type of fault | Fault detection criteria | Output activation |
|---|---|---|
| Over fueling fault | Number of generators in parallel with same governor mode >= 3<br>AND<br>MAX(P1, P2, … P8) – MIN(P1, P2 … P8) < *Max P Dev Vot*<br>(This check ensures that the network generators, **excluding local generator**, are operating with similar load)<br>AND<br>P > MAX (P1, P2… P8) + *Max P Dev Vot*<br>(This is to check if the local generator load (P) is deviating significantly from other generators in the same network) | OV_FUEL_FLT |
| Under fueling fault | Number of generators in parallel with same governor mode >= 3<br>AND<br>MAX(P1, P2, … P8) – MIN(P1, P2 … P8) < *Max P Dev Vot*<br>AND<br>P < MIN (P1, P2… P8) - *Max P Dev Vot* | UN_FUEL_FLT |

If the generator is identified as faulty by the Correlation algorithm, then the generator is removed from the Voting algorithm. Similarly if a network generator is communicated to be faulty via inputs GEN1_DATA … GEN8_DATA, or if the quality of any of the inputs GEN1_DATA … GEN8_DATA is unreliable, then that generator is also removed from the Voting algorithm. This prevents misdiagnosis by Voting algorithm in the event that several generators should suffer from a common mode failure.

### Excitation fault detection

This module detects problems with the generator excitation or AVR, which result in excessive reactive power (over excitation) or insufficient reactive power (under excitation) production by the generator.

As in Fueling fault detection block, the excitation faults are also detected by Correlation algorithm and Voting algorithm. The module activates OV_EXCT_FLT in case of over excitation fault detection and UN_EXCT_FLT output in case of under excitation fault. These two signals are available as outputs. Once an excitation fault is detected, the module initiates the Control logic module.

If the input AVR_MODE_DRP is FALSE, indicating that the automatic voltage regulator is not in droop mode, then the module is disabled. If the quality status of the local reactive power input is faulty, then the module is disabled and INT_BLKD output is activated. If generator present in the same subnetwork is faulty or if the quality status of reactive power of a generator is faulty, then that generator is removed from comparison in the Fueling fault detection module. INT_BLKD_STS

enumerated monitored data indicates the effect of signal loss (quality faulty) on all the four algorithms (i.e. Fueling Fault-Correlation, Fueling Fault-Voting, Excitation Fault-Correlation and Excitation Fault-Voting).

**Correlation algorithm:**

The generator excitation system normally follows the droop characteristic. Hence, the average generator phase-phase bus voltage (Uavg), derived from the three phase input `U3P`, and local generator reactive power are compared to the set droop curve. Deviation above/below this curve indicates over/under excitation condition.

The Correlation algorithm for excitation faults can be disabled through the setting *Disable Ext Crl*. The droop curve is set through the settings *U set point no load* and *Voltage droop*.

*Table 1345* shows the criteria for detecting excitation faults using Correlation algorithm.

**Table 1345: Correlation algorithm for identifying excitation faults**

| Type of fault | Fault detection criteria | Output activation |
|---|---|---|
| Over excitation fault | Uavg > *U set point no load* - ((*Voltage droop* *0.01) * Q) + *Max Volts deviation* | OV_EXCT_FLT |
| Under excitation fault | Uavg < *U set point no load* - ((*Voltage droop* * 0.01) * Q) - *Max Volts deviation* | UN_EXCT_FLT |

**Voting algorithm:**

As in Fueling fault detection block, the Voting algorithm for excitation faults is also applied when at least 3 generators (including the local generator) are running in parallel. Whenever necessary, the algorithm can be disabled through the setting *Disable Ext Voting*.

*Table 1346* shows the criteria for identifying excitation faults using Voting algorithm.

**Table 1346: Voting algorithm for identifying excitation faults**

| Type of fault | Fault detection criteria | Output activation |
|---|---|---|
| Over excitation fault | Number of generators in parallel with same governor mode >= 3<br>AND<br>MAX(Q1, Q2, … Q8) – MIN(Q1, Q2 … Q8) < *Max Q Dev Vot*<br>(Check to ensure that the network generators, **excluding local generator**, are operating with similar load)<br>AND<br>Q > MAX(Q1, Q2 … Q8) + *Max Q Dev Vot* | OV_EXCT_FLT |

*Table continues on the next page*

| Type of fault | Fault detection criteria | Output activation |
|---|---|---|
| | (Check if the local reactive power (**Q**) is deviating significantly from other generators in the same network) | |
| Under excitation fault | Number of generators in parallel with same governor mode >= 3<br><br>AND<br><br>MAX(Q1, Q2, … Q8) – MIN(Q1, Q2 … Q8) < *Max Q Dev Vot*<br><br>AND<br><br>Q < MIN(Q1, Q2 … Q8) - *Max Q Dev Vot* | UN_EXCT_FLT |

Among the 8 reactive power inputs, `Q1 … Q8`, the input corresponding to the setting *Local generator Num*, would be considered as the local reactive power. For example, if *Local generator Num* is set to "1", then `Q1` is considered as the local generator reactive power output.

### Fuel rack position monitoring

This module compares the position of the engine's fuel rack, obtained as input `FUEL_RCK_POS`, to the active power, P. The `FUEL_RCK_POS` input is a 0-20mA signal obtained through an `RTD` input. An offset linear relationship, refer *Figure 801*, is assumed between the fuel rack position and the generator active power.

The droop characteristics can be parameterized using the settings *Rack Pos no load* and *Rack Pos gain*. If the performance of the generator set deviates over/under the set droop curve, the fuel rack system is identified as faulty and the output `FUEL_RCK_FLT` is activated. The module can be disabled using the setting *Disable Fuel Rck Mon*.

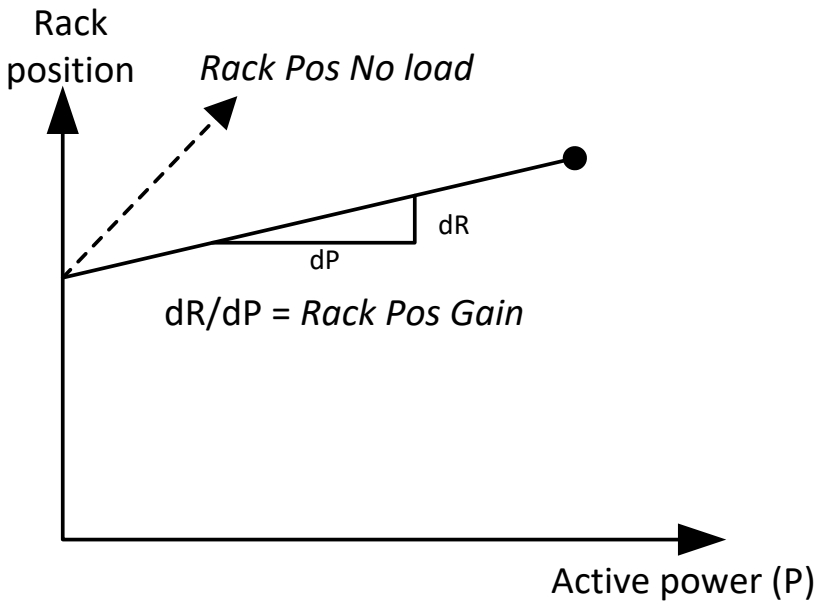



*Figure 801: Rack position vs. Active power output of the generator*

**Excitation current monitoring**

The excitation current, I_EXCITATION, produced by the AVR is compared to the reactive power output, Q, of the generator. A linear relationship is assumed between I_EXCITATION and Q. The I_EXCITATION input is a 0-20mA signal obtained through an RTD input and is in primary Amperes.

The droop characteristics can be parameterized using the settings *Ext current no load* and *Ext current gain*. If the performance of the generator deviates from this relationship, the module activates the output I_EXCT_FLT. The module can be disabled using the setting *Disable Ext Cur Mon*.

For both the Fuel rack position monitoring and the Excitation current monitoring modules, an internal delay of 100ms is assumed before activation of FUEL_RCK_FLT and I_EXCT_FLT outputs. This delay is to enable the generator mechanics to respond to the changes in fuel rack position and excitation current.

### 7.5.5.3 Control logic

Once activated by either the Fuel fault detection module or by the Excitation fault detection module, the Control logic module activates the FLT_DETECTED output. This output serves as an indication for the operator or the central PMS to start standby engines or alter the power sharing between healthy diesel generators.

If the network frequency and voltage deteriorate beyond control, the module activates the STOP_ENGINE (incase of fueling faults) and DE_EXCITE (incase of

excitation faults) to protect the system. The logic for the same has been shown in *Table 1347* and *Table 1348*.

The over/under fueling and over/under excitation logic will be checked only if the local active and reactive power are above 2% of nominal value respectively. When the local active and reactive power are less than 2%, the OPERATE output is issued instantaneously.

**Table 1347: Criteria for activation of STOP_ENGINE output**

| Fault type | Criteria | Output |
|---|---|---|
| Over fueling fault | MIN (P1 … P8) < *Min active power*<br>That is, One among the **network generators (excluding the local generator)** enter reverse power<br>OR<br>F > *Max Freq limit* + *Max Freq deviation* | STOP_ENGINE |
| Under fueling fault | (MAX (P1 … P8) > *Max active power*<br>That is, One among the **network generators** enter over power region<br>OR<br>F < *Min Freq limit* – *Max Freq deviation*)<br>AND<br>P < 0.0<br>That is, **local generator** enters reverse power zone. | |

**Table 1348: Criteria for activation of DE_EXCITE output**

| Fault type | Criteria | Output |
|---|---|---|
| Over excitation fault | MIN(Q1 … Q8) <*Min reactive power*<br>OR<br>Uavg > *Max voltage limit* + *Max Volts deviation* | DE_EXCITE |
| Under excitation fault | (Uavg < *Min voltage limit* – *Max Volts deviation*<br>OR<br>I_MAX > 100% of nominal value<br>I_MAX = Maximum of the three phase currents obtained from input I3P)<br>AND<br>Q < 0.0<br>That is, **local generator** enters reverse reactive power zone. | |

The activation of STOP_ENGINE or DE_EXCITE outputs, activates the PRE_TRIP output and initiates the operate delay timer. The timer characteristic is based on DT. Once the time set by *Operate delay time* elapses or when active power (for fueling

faults)/ reactive power (for excitation faults) falls below 2% of nominal value, the OPERATE output is activated to open the generator circuit breaker.

In case the active or reactive power does not fall below 2% of nominal value within the set *Operate delay time*, after the activation of STOP_ENGINE or DE_EXCITE outputs respectively, the EXTERNAL_FLT output is activated along with OPERATE output.

The *Min active power*, *Max active power*, *Min reactive power* and *Max reactive power* settings should be set such that the faulty generator is tripped by its own DGMGAPC function before a healthy generator is tripped on over/under power/excitation condition.

The opening of the generator circuit breaker is monitored through the inputs GCB_CLOSED and GCB_OPEN. If the confirmation of GCB opening is not obtained with in the set *Max CB trip delay*, from the instant of activating OPERATE output, the OPR_TIE_A and OPR_TIE_B outputs are activated to trip the tie breakers and GCB_TRP_FAIL output is activated.

If any of the inputs GEN1_DATA ... GEN8_DATA indicate that backup protection is triggered in one of the generators in its own subnetwork, then the module activates the outputs OPR_TIE_A and OPR_TIE_B after the set *Backup delay time*, to protect the local diesel generator from tripping due to faults in other network generators.

The module continues to monitor the tie breaker status through inputs TIE_A_CLOSED, TIE_A_OPEN, TIE_B_CLOSED and TIE_B_OPEN. If after another *Max CB trip delay*, the confirmed opening information of tie breakers is not obtained then the module activates TIE_TRP_FAIL output.

The information on tie A or tie B side breaker tripping failure is shared with other DGMGAPC functions in the network through output GEN_DATA to initiate tripping of tie breaker. If the DGMGAPC function receives tie breaker trip failure indication from a generator which shares a tie breaker with the local generator, then the module initiates tripping of that shared tie breaker through either or both outputs OPR_TIE_A and OPR_TIE_B to protect the local generator.

The activated binary outputs, OPERATE, OPR_TIE_A, OPR_TIE_B and EXTERNAL_FLT, will remain active unless the RESET input is activated either from LHMI or through communication.

The module combines the binary information, namely, the GCB status, adjacent tie breaker statuses, Governor Mode, AVR mode, Generator local mode information, backup protection activation (BCKUP_PRT_ST), fault status of the generator (PRE_TRIP activation), A or B side tie breaker trip failure indication into output GEN_DATA. This output is available in the monitored data and is communicated to other DGMGAPC functions in the network on GOOSE. The active and reactive power inputs of the local generator are also communicated over GOOSE for usage as inputs in other DGMGAPC functions.

The binary input BLOCK can be used to block the function, for example, during synchronization of switchboard sections and when the engine is placed in manual control. The activation of the BLOCK input deactivates all module binary outputs, binary monitored data and resets the internal timers.

## 7.5.6 Application

The function is intended towards a set of diesel generators with similar characteristics interconnected with busbar and tie-breakers.

The DGMGAPC function is mainly used to protect the diesel generator from the over/under fueling of the diesel engines and over/under excitation of the generators. These faults are not easily detected by the traditional protection relay algorithms, which can result in healthy generators behaving abnormally in an attempt to maintain the system voltage and frequency within acceptable limits. This can lead to a cascade fault in which all the healthy generators are disconnected, leaving only the faulty unit running. Without the healthy generators to maintain the frequency and voltage, the faulty generator will also be tripped, resulting in a complete blackout of that part of the industrial network.

The DGMGAPC function identifies the existing network topology and the generators are compared with the expected behavior corresponding to their operation mode or with other generators with in the network.

Two algorithms are used to detect fueling and excitation faults, namely, Correlation and Voting algorithms. The Correlation algorithm compares the generator behavior with the set operation mode of the governor. If the local generator is deviating significantly then it is identified as faulty. The Voting algorithm works on the assumption that, generators share the load similarly. Hence a generator is identified as faulty, if the local generation is moving significantly away from the rest of the generators in the network. Any generator identified as faulty will not be used in either of the algorithms.

Real and reactive power for the local generator is obtained from power measurement function PEMMXU and for the network generator over GOOSE. As an example, a part of application configuration with two generators is shown in *Figure 802*. Here, Generator1 is the local generator whose real and reactive power is obtained from PEMMXU and Generator2 is the network generator whose real and reactive power are obtained over GOOSE.

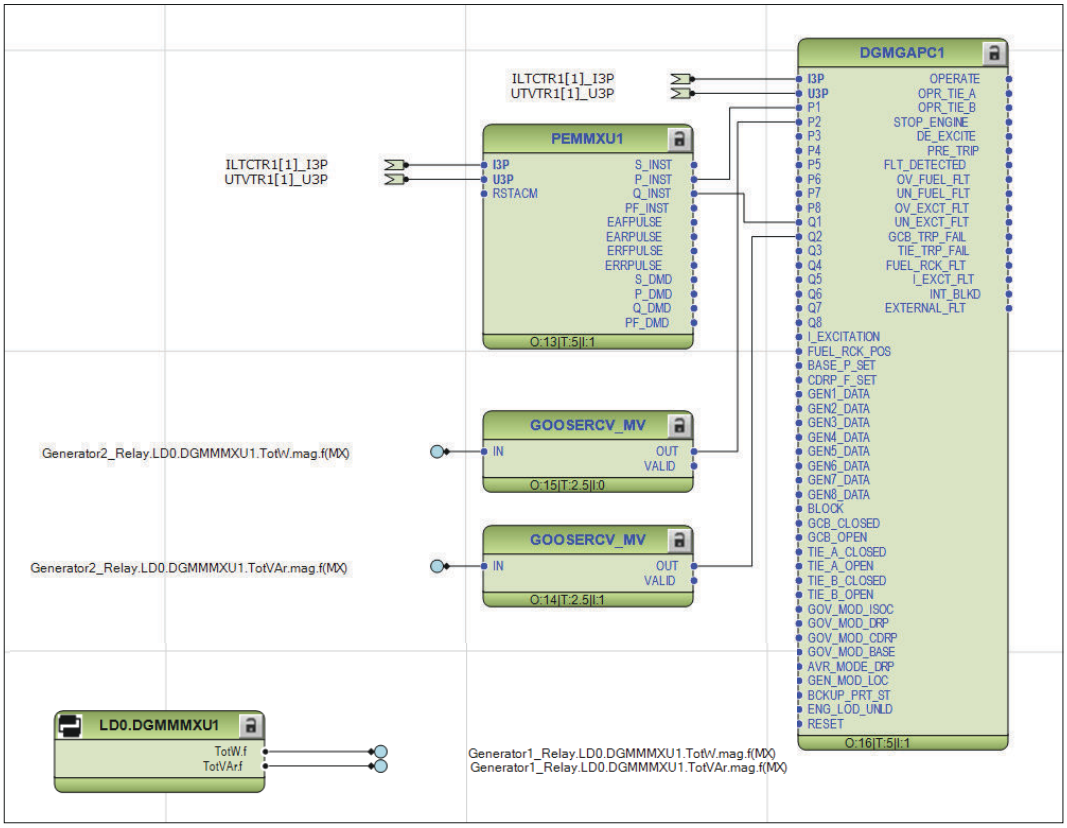



*Figure 802: Example application configuration for real and reactive power connection*

Once a generator is identified faulty an indication is sent to PMS for starting the backup generators, or to alter the power sharing between healthy generators, which would allow the faulty generator to be offloaded and tripped. But in case the system deteriorates, the function issues commands to shut down the engine or de-excite the generator. It then issues the command to open the GCB. In case the GCB tripping is unsuccessful, the function opens the neighboring tie breakers.

The network topology identification enables the function to locate a particular fault in the network and trip the neighboring tie breakers of healthy generators in case a network generator is faulty and is still not tripped.

The application configuration needs to ensure that in case any protection functions like, over speed protection or over voltage protection or if generator operates outside stability limit then a signal needs to be sent to shut down the diesel engine and open the GCB.

This needs to be configured outside the DGMGAPC function block.

The function monitors the fuel rack position and excitation current of the generator and rises an alarm in case they are deviating from the set operation mode.

## 7.5.7 Signals

### 7.5.7.1 DGMGAPC Input signals

**Table 1349: DGMGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| P1 | FLOAT32 | 0.0 | Active power of network generator 1 |
| P2 | FLOAT32 | 0.0 | Active power of network generator 2 |
| P3 | FLOAT32 | 0.0 | Active power of network generator 3 |
| P4 | FLOAT32 | 0.0 | Active power of network generator 4 |
| P5 | FLOAT32 | 0.0 | Active power of network generator 5 |
| P6 | FLOAT32 | 0.0 | Active power of network generator 6 |
| P7 | FLOAT32 | 0.0 | Active power of network generator 7 |
| P8 | FLOAT32 | 0.0 | Active power of network generator 8 |
| Q1 | FLOAT32 | 0.0 | Reactive power of network generator 1 |
| Q2 | FLOAT32 | 0.0 | Reactive power of network generator 2 |
| Q3 | FLOAT32 | 0.0 | Reactive power of network generator 3 |
| Q4 | FLOAT32 | 0.0 | Reactive power of network generator 4 |
| Q5 | FLOAT32 | 0.0 | Reactive power of network generator 5 |
| Q6 | FLOAT32 | 0.0 | Reactive power of network generator 6 |
| Q7 | FLOAT32 | 0.0 | Reactive power of network generator 7 |
| Q8 | FLOAT32 | 0.0 | Reactive power of network generator 8 |
| I_EXCITATION | FLOAT32 | 0.0 | Excitation current of the generator |
| FUEL_RCK_POS | FLOAT32 | 0.0 | Fuel rack position of the governor |
| BASE_P_SET | FLOAT32 | 0.0 | Set active power limit in generator base load mode |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| CDRP_F_SET | FLOAT32 | 0.0 | Compensated droop no load set point frequency from PMS |
| GEN1_DATA | INT32 | 0 | Data received from network generator 1 |
| GEN2_DATA | INT32 | 0 | Data received from network generator 2 |
| GEN3_DATA | INT32 | 0 | Data received from network generator 3 |
| GEN4_DATA | INT32 | 0 | Data received from network generator 4 |
| GEN5_DATA | INT32 | 0 | Data received from network generator 5 |
| GEN6_DATA | INT32 | 0 | Data received from network generator 6 |
| GEN7_DATA | INT32 | 0 | Data received from network generator 7 |
| GEN8_DATA | INT32 | 0 | Data received from network generator 8 |
| BLOCK | BOOLEAN | 0=False | Block input to block all binary outputs |
| GCB_CLOSED | BOOLEAN | 0=False | Local generator circuit breaker closed position status |
| GCB_OPEN | BOOLEAN | 0=False | Local generator circuit breaker open position status |
| TIE_A_CLOSED | BOOLEAN | 0=False | Adjacent tie breaker A closed position |
| TIE_A_OPEN | BOOLEAN | 0=False | Adjacent tie breaker A open position |
| TIE_B_CLOSED | BOOLEAN | 0=False | Adjacent tie breaker B closed position |
| TIE_B_OPEN | BOOLEAN | 0=False | Adjacent tie breaker B open position |
| GOV_MOD_ISOC | BOOLEAN | 0=False | Governor isochronous mode status |
| GOV_MOD_DRP | BOOLEAN | 0=False | Governor droop mode status |
| GOV_MOD_CDRP | BOOLEAN | 0=False | Governor compensated droop mode status |
| GOV_MOD_BASE | BOOLEAN | 0=False | Governor base load mode status |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| AVR_MODE_DRP | BOOLEAN | 0=False | Automatic voltage regulator mode |
| GEN_MOD_LOC | BOOLEAN | 0=False | Generator in local mode |
| BCKUP_PRT_ST | BOOLEAN | 0=False | Backup protection activated |
| ENG_LOD_UNLD | BOOLEAN | 0=False | Engine loading or unloading in progress |
| RESET | BOOLEAN | 0=False | Reset the correlation and voting algorithms and timer |

### 7.5.7.2 DGMGAPC Output signals

**Table 1350: DGMGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Operate |
| OPR_TIE_A | BOOLEAN | Operate tie breaker A |
| OPR_TIE_B | BOOLEAN | Operate tie breaker B |
| STOP_ENGINE | BOOLEAN | Stop fuel inflow to the engine |
| DE_EXCITE | BOOLEAN | De excite the generator |
| PRE_TRIP | BOOLEAN | Pre-trip signal indicating imminent trip of generator |
| FLT_DETECTED | BOOLEAN | Fault detected in the local generator |
| OV_FUEL_FLT | BOOLEAN | Over fueling fault detected |
| UN_FUEL_FLT | BOOLEAN | Under fueling fault detected |
| OV_EXCT_FLT | BOOLEAN | Over excitation fault detected |
| UN_EXCT_FLT | BOOLEAN | Under excitation fault detected |
| GCB_TRP_FAIL | BOOLEAN | Trip command to generator circuit breaker failed |
| TIE_TRP_FAIL | BOOLEAN | Trip command to tie breaker failed |
| FUEL_RCK_FLT | BOOLEAN | Fault in fuel rack of the governor |
| I_EXCT_FLT | BOOLEAN | Fault in excitation system of the generator |
| INT_BLKD | BOOLEAN | Internal block status |
| EXTERNAL_FLT | BOOLEAN | Gen P/Q not controlled due to fault in external system |

## 7.5.8 Settings

### 7.5.8.1 DGMGAPC Settings

**Table 1351: DGMGAPC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Disable Fuel Crl | 0=False<br>1=True | | | 0=False | Disable correlation algorithm for fueling faults |
| Disable Fuel voting | 0=False<br>1=True | | | 0=False | Disable voting algorithm for fueling faults |
| Disable Ext Crl | 0=False<br>1=True | | | 0=False | Disable correlation algorithm for excitation faults |
| Disable Ext voting | 0=False<br>1=True | | | 0=False | Disable voting algorithm for excitation faults |
| Disable Fuel Rck Mon | 0=False<br>1=True | | | 0=False | Disable fuel rack position monitoring |
| Disable Ext Cur Mon | 0=False<br>1=True | | | 0=False | Disable excitation current monitoring |
| Min Freq limit | 0.95...1.00 | xFn | 0.01 | 0.95 | Minimum Freq limit below which STOP_ENGINE is activated |
| Max Freq limit | 1.00...1.05 | xFn | 0.01 | 1.05 | Maximum Freq limit above which STOP_ENGINE is activated |
| Min voltage limit | 0.5...1.5 | xUn | 0.1 | 0.8 | Minimum voltage limit below which DE_EXCITE is activated |
| Max voltage limit | 0.5...1.5 | xUn | 0.1 | 1.2 | Maximum voltage limit above which DE_EXCITE is activated |
| Operate delay time | 10...300000 | ms | 10 | 600 | Operate delay time |
| Max CB trip delay | 10...300000 | ms | 10 | 600 | Maximum time delay for detection of CB status |
| Disable time | 10...3600000 | ms | 10 | 60000 | Function disable time during engine loading/unloading |
| Backup delay time | 10...300000 | ms | 10 | 100 | Operate delay time for backup protection |

**Table 1352: DGMGAPC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min active power | 0.01...1.00 | xSn | 0.01 | 0.05 | Active power limit below which STOP_ENGINE is activated |
| Max active power | 0.10...2.00 | xSn | 0.01 | 1.00 | Active power limit above which STOP_ENGINE is activated |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Min reactive power | 0.01...1.00 | xSn | 0.01 | 0.05 | Reactive power limit below which DE_EXCITE is activated |
| Max reactive power | 0.10...2.00 | xSn | 0.01 | 1.00 | Reactive power limit above which DE_EXCITE is activated |
| Expected frequency | 0.95...1.05 | xFn | 0.01 | 1.00 | Expected frequency of the network in isochronous mode |
| F set point no load | 0.10...2.00 | xFn | 0.01 | 1.00 | No load frequency of the generator for droop characteristics |
| Frequency droop | 0.00...100.00 | %Fn | 0.01 | 5.00 | Percentage frequency droop from no load to full load |
| U set point no load | 0.10...2.00 | xUn | 0.01 | 1.00 | No load voltage of the generator |
| Voltage droop | 0.00...100.00 | %Un | 0.01 | 10.00 | Percentage voltage droop from no load to full load |
| Rack Pos no load | 0.00...100.00 | % | 0.01 | 0.00 | Fuel rack position on no load |
| Rack Pos gain | 0.01...10.00 | | 0.01 | 1.00 | Rate of change of rack position from no load to full load |
| Ext current no load | 0.0010...1.0000 | xIn | 0.0005 | 0.0100 | Excitation current when generator is on no load |
| Ext current gain | 0.0100...10.0000 | | 0.0005 | 1.0000 | Rate of change of excitation Curr from no load to full load |

**Table 1353: DGMGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Total Num of Gn | 1...8 | | 1 | 8 | Total number of generators |
| Total Num of tie | 1...8 | | 1 | 8 | Total number of tie |
| Reset delay time | 20...15000 | ms | 10 | 100 | Reset delay time |

**Table 1354: DGMGAPC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max Freq deviation | 0.00...0.10 | xFn | 0.01 | 0.01 | Maximum allowed deviation in frequency |
| Max Freq Dev Isoc | 0.00...0.10 | xFn | 0.01 | 0.01 | Maximum allowed deviation in frequency for isochronous mode |
| Max Volts deviation | 0.00...0.10 | xUn | 0.01 | 0.01 | Maximum allowed deviation in voltage |
| Max P Dev Crl | 0.00...0.10 | xSn | 0.01 | 0.01 | Maximum allowed deviation in active power for correlation |
| Max P Dev Vot | 0.00...0.10 | xSn | 0.01 | 0.01 | Maximum allowed deviation in active power for voting |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max Q Dev Vot | 0.00...0.10 | xSn | 0.01 | 0.01 | Maximum allowed deviation in reactive power for voltng |
| Local generator Num | 1...8 | | 1 | 1 | Local generator number |
| Gn 1 busbar Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar number of generator 1 |
| Gn 2 busbar Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar number of generator 2 |
| Gn 3 busbar Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar number of generator 3 |
| Gn 4 busbar Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar number of generator 4 |
| Gn 5 busbar Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7 | | | 0=Not configured | Busbar number of generator 5 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 8=Bus8 | | | | |
| Gn 6 busbar Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar number of generator 6 |
| Gn 7 busbar Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar number of generator 7 |
| Gn 8 busbar Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar number of generator 8 |
| Tie 1 busbar A Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar A number of tie breaker 1 |
| Tie 1 busbar B Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar B number of tie breaker 1 |
| Tie 2 busbar A Num | 0=Not configured | | | 0=Not configured | Busbar A number of tie breaker 2 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | | |
| Tie 2 busbar B Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar B number of tie breaker 2 |
| Tie 3 busbar A Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar A number of tie breaker 3 |
| Tie 3 busbar B Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar B number of tie breaker 3 |
| Tie 4 busbar A Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar A number of tie breaker 4 |
| Tie 4 busbar B Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3 | | | 0=Not configured | Busbar B number of tie breaker 4 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | | |
| Tie 5 busbar A Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar A number of tie breaker 5 |
| Tie 5 busbar B Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar B number of tie breaker 5 |
| Tie 6 busbar A Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar A number of tie breaker 6 |
| Tie 6 busbar B Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar B number of tie breaker 6 |
| Tie 7 busbar A Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6 | | | 0=Not configured | Busbar A number of tie breaker 7 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 7=Bus7<br>8=Bus8 | | | | |
| Tie 7 busbar B Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar B number of tie breaker 7 |
| Tie 8 busbar A Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar A number of tie breaker 8 |
| Tie 8 busbar B Num | 0=Not configured<br>1=Bus1<br>2=Bus2<br>3=Bus3<br>4=Bus4<br>5=Bus5<br>6=Bus6<br>7=Bus7<br>8=Bus8 | | | 0=Not configured | Busbar B number of tie breaker 8 |
| Wait time signal status | 0...100 | ms | 1 | 50 | Wait time between Load/Unload signal and GCB status |
| Wait time status signal | 0...100 | ms | 1 | 50 | Wait time between GCB status and Load/Unload signal |

## 7.5.9 DGMGAPC Monitored data

**Table 1355: DGMGAPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_MAX | FLOAT32 | 0.00...5.00 | xIn | Maximum of the three phase input currents |
| F_CALC_LIMIT | FLOAT32 | 0.00...2.00 | xFn | Calculated Freq limit in governor compensated droop mode |
| GEN_DATA | INT32 | 0...8191 | | Generator data sent on GOOSE for usage in Ntw DGMGAPC |
| P_LOCAL | FLOAT32 | -499999.9...499999.9 | kW | Active power output of generator |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Q_LOCAL | FLOAT32 | -499999.9...499999.9 | kVAr | Reactive power output of generator |
| INT_BLKD_STS | Enum | 0=None<br>1=Fuel Crl<br>2=Fuel Vot<br>3=Fuel Crl Vot<br>4=Ext Crl<br>5=Fuel Ext Crl<br>6=Fuel Vot Ext Crl<br>7=Fuel Crl Vot Ext Crl<br>8=Ext Vot<br>9=Fuel Crl Ext Vot<br>10=Fuel Ext Vot<br>11=Fuel Crl Vot Ext Vot<br>12=Ext Crl Vot<br>13=Fuel Crl Ext Crl Vot<br>14=Fuel Vot Ext Crl Vot<br>15=Fuel Ext Crl Vot | | Internal block status |
| GEN_STATE | Enum | -1=Unknown<br>1=Stopped<br>3=Started<br>5=Disabled | | Current operating state |
| FAULT_GEN1 | BOOLEAN | 0=False<br>1=True | | Fault in network generator 1 |
| FAULT_GEN2 | BOOLEAN | 0=False<br>1=True | | Fault in network generator 2 |
| FAULT_GEN3 | BOOLEAN | 0=False<br>1=True | | Fault in network generator 3 |
| FAULT_GEN4 | BOOLEAN | 0=False<br>1=True | | Fault in network generator 4 |
| FAULT_GEN5 | BOOLEAN | 0=False<br>1=True | | Fault in network generator 5 |
| FAULT_GEN6 | BOOLEAN | 0=False<br>1=True | | Fault in network generator 6 |
| FAULT_GEN7 | BOOLEAN | 0=False<br>1=True | | Fault in network generator 7 |
| FAULT_GEN8 | BOOLEAN | 0=False<br>1=True | | Fault in network generator 8 |
| SBNW_GEN1 | INT32 | 0...8 | | Subnetwork number of generator 1 |
| SBNW_GEN2 | INT32 | 0...8 | | Subnetwork number of generator 2 |
| SBNW_GEN3 | INT32 | 0...8 | | Subnetwork number of generator 3 |
| SBNW_GEN4 | INT32 | 0...8 | | Subnetwork number of generator 4 |
| SBNW_GEN5 | INT32 | 0...8 | | Subnetwork number of generator 5 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SBNW_GEN6 | INT32 | 0...8 | | Subnetwork number of generator 6 |
| SBNW_GEN7 | INT32 | 0...8 | | Subnetwork number of generator 7 |
| SBNW_GEN8 | INT32 | 0...8 | | Subnetwork number of generator 8 |
| SBNW_TIE_CB1 | INT32 | 0...8 | | Subnetwork number of tie breaker 1 |
| SBNW_TIE_CB2 | INT32 | 0...8 | | Subnetwork number of tie breaker 2 |
| SBNW_TIE_CB3 | INT32 | 0...8 | | Subnetwork number of tie breaker 3 |
| SBNW_TIE_CB4 | INT32 | 0...8 | | Subnetwork number of tie breaker 4 |
| SBNW_TIE_CB5 | INT32 | 0...8 | | Subnetwork number of tie breaker 5 |
| SBNW_TIE_CB6 | INT32 | 0...8 | | Subnetwork number of tie breaker 6 |
| SBNW_TIE_CB7 | INT32 | 0...8 | | Subnetwork number of tie breaker 7 |
| SBNW_TIE_CB8 | INT32 | 0...8 | | Subnetwork number of tie breaker 8 |
| DGMGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 7.5.10 Technical data

**Table 1356: Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage and current: $f_n$ ±2 Hz |
| | Voltage:<br>±1.5% of the set value or 0.002 x$U_n$<br>Frequency:<br>±5 mHz<br>Active power:<br>±3% of the set value or 0.002 x$S_n$<br>Reactive power:<br>±3% of the set value or 0.002 x$S_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Reset ratio | Typically 0.96/1.04 |

# 8 Measurement functions

## 8.1 Basic measurements

### 8.1.1 Functions

The three-phase current measurement function CMMXU is used for monitoring and metering the phase currents of the power system.

The three-phase voltage measurement function VMMXU is used for monitoring and metering the phase-to-phase voltages of the power system. The phase-to-earth voltages are available in VPHMMXU.

Single-phase voltage measurement function VAMMXU is used for monitoring and metering the single-phase voltage of the power system.

The residual current measurement function RESCMMXU is used for monitoring and metering the residual current of the power system.

The residual voltage measurement function RESVMMXU is used for monitoring and metering the residual voltage of the power system.

The frequency measurement function FMMXU is used for monitoring and metering the frequency of the power system.

The sequence current measurement CSMSQI is used for monitoring and metering the phase sequence currents.

The sequence voltage measurement VSMSQI is used for monitoring and metering the phase sequence voltages.

The frequency measurement FMMXU is used for monitoring and metering the power system frequency.

The three-phase power and energy measurement PEMMXU is used for monitoring and metering the active power (P), reactive power (Q), apparent power (S) and power factor (PF) and for calculating the accumulated energy separately as forward active, reversed active, forward reactive and reversed reactive. PEMMXU calculates these quantities using the fundamental frequency phasors, that is, the DFT values of the measured phase current and phase voltage signals.

The information of the measured quantity is available for the operator both locally in LHMI or WHMI and remotely to a network control center with communication.



If the measured data in LHMI or WHMI is within parentheses, there are some problems to express the data.

## 8.1.2 Measurement functionality

The functions can be enabled or disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

Some of the measurement functions operate on two alternative measurement modes: "DFT" and "RMS". The measurement mode is selected with the *X Measurement mode* setting. Depending on the measuring function if the measurement mode cannot be selected, the measuring mode is "DFT".

### Demand value calculation

The demand values are calculated separately for each measurement function and per phase when applicable. The available measurement modes are "Linear" and "Logarithmic". The "Logarithmic" measurement mode is only effective for phase current and residual current demand value calculations. The demand value calculation mode is selected with the setting parameter **Configuration** > **Measurements** > **A demand Av mode**. The time interval for all demand value calculations is selected with the setting parameter **Configuration** > **Measurements** > **Demand interval**.

The demand time interval is synchronized to the real-time clock of the protection relay. When the demand time interval or calculation mode is changed, it initializes the demand value calculation. For the very first demand value calculation interval, the values are stated as invalid until the first refresh is available.

The "Linear" calculation mode uses the periodic sliding average calculation of the measured signal over the demand time interval. A new demand value is obtained once in a minute, indicating the analog signal demand over the demand time interval proceeding the update time. The actual rolling demand values are stored in the memory until the value is updated at the end of the next time interval.

The "Logarithmic" calculation mode uses the periodic calculation using a log10 function over the demand time interval to replicate thermal demand ammeters. The logarithmic demand calculates a snapshot of the analog signal every 1/15 x demand time interval.

Each measurement function has its own recorded data values. In protection relay, these are found in **Monitoring** > **Recorded data** > **Measurements**. In the technical manual these are listed in the monitored data section of each measurement function. These values are periodically updated with the maximum and minimum demand values. The time stamps are provided for both values.

*Reset of Recorded data* initializes a present demand value to the minimum and maximum demand values.

### Value reporting

The measurement functions are capable of reporting new values for network control center (SCADA system) based on various functions.

- Zero-point clamping
- Deadband supervision
- Limit value supervision



In the three-phase voltage measurement function VMMXU the supervision functions are based on the phase-to-phase voltages. However, the phase-to-earth voltage values are also reported with the phase-to-phase voltages.

GOOSE is an event based protocol service. Analog GOOSE uses the same event generation functions as vertical SCADA communication for updating the measurement values. Update interval of 500 ms is used for data that do not have zero-point clamping, deadband supervision or limit value supervision.

### Zero-point clamping

A measured value under the zero-point clamping limit is forced to zero. This allows the noise in the input signal to be ignored. The active clamping function forces both the actual measurement value and the angle value of the measured signal to zero. In the three-phase or sequence measuring functions, each phase or sequence component has a separate zero-point clamping function. The zero-value detection operates so that once the measured value exceeds or falls below the value of the zero-clamping limit, new values are reported.

**Table 1357: Zero-point clamping limits**

| Function | Zero-clamping limit |
|---|---|
| Three-phase current measurement (CMMXU) | 1 % of nominal (In) |
| Three-phase voltage measurement (VMMXU) | 1 % of nominal (Un) |
| Phase-to-earth voltage measurement (VPHMMXU) | 1 % of nominal (Un) |
| Residual current measurement (RESCMMXU) | 1 % of nominal (In) |
| Residual voltage measurement (RESVMMXU) | 1 % of nominal (Un) |
| Phase sequence current measurement (CSMSQI) | 1 % of the nominal (In) |
| Phase sequence voltage measurement (VSMSQI) | 1 % of the nominal (Un) |
| Three-phase power and energy measurement (PEMMXU) | 1.5 % of the nominal (Sn) |

When the frequency measurement function FMMXU is unable to measure the network frequency in the undervoltage situation, the measured values are set to the nominal and also the quality information of the data set accordingly. The undervoltage limit is fixed to 10 percent of the nominal for the frequency measurement.

### Limit value supervision

The limit value supervision function indicates whether the measured value of `X_INST` exceeds or falls below the set limits. The measured value has the corresponding range information `X_RANGE` and has a value in the range of 0 to 4:

- 0: "normal"
- 1: "high"
- 2: "low"
- 3: "high-high"
- 4: "low-low"

The range information changes and the new values are reported.

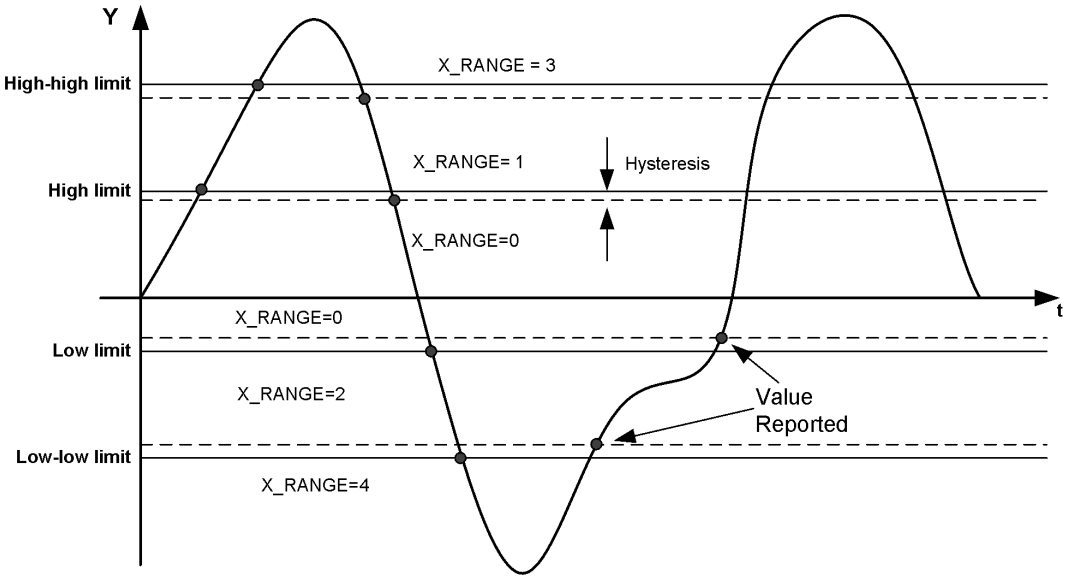



*Figure 803: Presentation of operating limits*

The range information can also be decoded into boolean output signals on some of the measuring functions and the number of phases required to exceed or undershoot the limit before activating the outputs and can be set with the *Num of phases* setting in the three-phase measurement functions CMMXU and VMMXU. The limit supervision boolean alarm and warning outputs can be blocked.

**Table 1358: Settings for limit value supervision**

| Function | Settings for limit value supervision | |
|---|---|---|
| Three-phase current measurement (CMMXU) | High limit | *A high limit* |
| | Low limit | *A low limit* |
| | High-high limit | *A high high limit* |
| | Low-low limit | *A low low limit* |
| Three-phase voltage measurement (VMMXU) | High limit | *V high limit* |
| | Low limit | *V low limit* |
| | High-high limit | *V high high limit* |
| | Low-low limit | *V low low limit* |
| Phase voltage measurement (VPHMMXU) | High limit | *V high limit* |
| | Low limit | *V low limit* |
| | High-high limit | *V high high limit* |
| | Low-low limit | *V low low limit* |
| Single-phase voltage measurement (VAMMXU) | High limit | *V high limit* |
| | Low limit | *V low limit* |
| | High-high limit | *V high high limit* |
| | Low-low limit | *V low low limit* |
| Residual current measurement (RESCMMXU) | High limit | *A high limit res* |

*Table continues on the next page*

| Function | Settings for limit value supervision | |
|---|---|---|
| | Low limit | – |
| | High-high limit | *A Hi high limit res* |
| | Low-low limit | – |
| Frequency measurement (FMMXU) | High limit | *F high limit* |
| | Low limit | *F low limit* |
| | High-high limit | *F high high limit* |
| | Low-low limit | *F low low limit* |
| Residual voltage measurement (RESVMMXU) | High limit | *V high limit res* |
| | Low limit | – |
| | High-high limit | *V Hi high limit res* |
| | Low-low limit | – |
| Phase sequence current measurement (CSMSQI) | High limit | *Ps Seq A high limit, Ng Seq A high limit, Zro A high limit* |
| | Low limit | *Ps Seq A low limit, Ng Seq A low limit, Zro A low limit* |
| | High-high limit | *Ps Seq A Hi high Lim, Ng Seq A Hi high Lim, Zro A Hi high Lim* |
| | Low-low limit | *Ps Seq A low low Lim, Ng Seq A low low Lim, Zro A low low Lim* |
| Phase sequence voltage measurement (VSMSQI) | High limit | *Ps Seq V high limit, Ng Seq V high limit, Zro V high limit* |
| | Low limit | *Ps Seq V low limit, Ng Seq V low limit, Zro V low limit* |
| | High-high limit | *Ps Seq V Hi high Lim, Ng Seq V Hi high Lim, Zro V Hi high Lim* |
| | Low-low limit | *Ps Seq V low low Lim, Ng Seq V low low Lim,* |
| Three-phase power and energy measurement (PEMMXU) | High limit | – |
| | Low limit | – |
| | High-high limit | – |
| | Low-low limit | – |

### Deadband supervision

The deadband supervision function reports the measured value according to integrated changes over a time period. In *Figure 804* the values are reported at points Y1, Y2, Y3 and Y4. There is no value report at the end of |A3 + A4 + A5 + A6 + A7| because the positive and negative areas counteract each other. The integrated changes, |A3 + A4 + A5 + A6 + A7|, equal approximately zero.

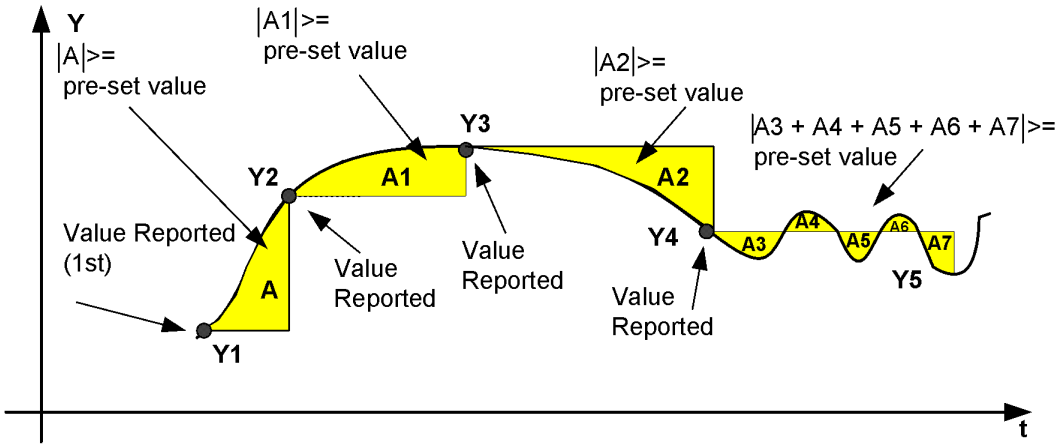



*Figure 804: Integral deadband supervision*

The deadband value used in the integral calculation is configured with the *X deadband* setting. The value represents the percentage of the difference between the maximum and minimum limit in the units of 0.001 percent x seconds.

The reporting delay of the integral algorithms in seconds is calculated with the formula:

$$t(s) = \frac{(\max - \min) \times deadband / 1000}{|\Delta Y| \times 100\%}$$

(Equation 338)

Example for CMMXU:

A deadband = 2500 (2.5 % of the total measuring range of 40)

`I_INST_A` = `I_DB_A` = 0.30

If `I_INST_A` changes to 0.40, the reporting delay is:

$$t(s) = \frac{(40 - 0) \times 2500 / 1000}{|0.40 - 0.30| \times 100\%} = 10s$$

**Table 1359: Parameters for deadband calculation**

| Function | Settings | Minimum/maximum |
|---|---|---|
| Three-phase current measurement (CMMXU) | *A deadband* | *0.04/40* |
| Three-phase voltage measurement (VMMXU) | *V deadband* | *0.004/4* |
| Phase voltage measurement (VMHMMXU) | *V deadband* | *0.004/4* |
| Single-phase voltage measurement (VAMMXU) | *V deadband* | *0.004/4* |
| Residual current measurement (RESCMMXU) | *A deadband res* | *0.04/40* |
| Residual voltage measurement (RESVMMXU) | *V deadband res* | *0.004/4* |
| Frequency measurement (FMMXU) | *F deadband* | *0.04/40* |

*Table continues on the next page*

| Function | Settings | Minimum/maximum |
|---|---|---|
| Phase sequence current measurement (CSMSQI) | *Ps Seq A deadband*, *Ng Seq A deadband*, *Zro A deadband* | *0.04/40* |
| Phase sequence voltage measurement (VSMSQI) | *Ps Seq V deadband*, *Ng Seq V deadband*, *Zro V deadband* | *0.004/4* |
| Three-phase power and energy measurement (PEMMXU) | *Power deadband* | *0.01/0.1* |

### Power and energy calculation

The three-phase power is calculated from the selected voltage and current measurements as described in *Table 1360*. The setting *Measurement mode* determines which voltage and current measurements are used.

It is also possible to use positive-sequence components for calculating the apparent power, which makes the determination of power insensitive to any asymmetry in currents or voltages.

**Table 1360: Measured apparent power**

| ***Measurement mode* setting values** | **Power calculation** |
|---|---|
| PhsA, PhsB, PhsC | $\overline{S} = \overline{U_A} \cdot \overline{I_A}^* + \overline{U_B} \cdot \overline{I_B}^* + \overline{U_C} \cdot \overline{I_C}^*$ (Equation 339) |
| Arone | $\overline{S} = \overline{U_{AB}} \cdot \overline{I_A}^* - \overline{U_{BC}} \cdot \overline{I_C}^*$ (Equation 340) |
| Pos Seq | $\overline{S} = 3 \cdot \overline{U_1} \cdot \overline{I_1}^*$ (Equation 341) |
| PhsAB | $\overline{S} = \overline{U_{AB}} \cdot \left( \overline{I_A}^* - \overline{I_B}^* \right)$ (Equation 342) |
| PhsBC | $\overline{S} = \overline{U_{BC}} \cdot \left( \overline{I_B}^* - \overline{I_C}^* \right)$ (Equation 343) |
| PhsCA | $\overline{S} = \overline{U_{CA}} \cdot \left( \overline{I_C}^* - \overline{I_A}^* \right)$ (Equation 344) |

*Table continues on the next page*

| *Measurement mode* setting values | Power calculation |
|---|---|
| PhsA | $\overline{S} = 3 \cdot \overline{U_A} \cdot \overline{I_A}^*$ (Equation 345) |
| PhsB | $\overline{S} = 3 \cdot \overline{U_B} \cdot \overline{I_B}^*$ (Equation 346) |
| PhsC | $\overline{S} = 3 \cdot \overline{U_C} \cdot \overline{I_C}^*$ (Equation 347) |

Depending upon the set *Measurement mode*, the Power and energy calculation module calculates active power, reactive power and apparent power values from the available set of measurements.

$$P = \mathrm{Re}(\overline{S})$$

(Equation 348)

$$Q = \mathrm{Im}(\overline{S})$$

(Equation 349)

$$S = \left|\overline{S}\right| = \sqrt{P^2 + Q^2}$$

(Equation 350)

$$Cos\varphi = \frac{P}{S}$$

(Equation 351)

The calculated powers are available as function outputs `S_INST`, `P_INST`, `Q_INST` and the power factor angle as `PF_INST`.

Depending on the unit multiplier selected with *Power unit Mult*, the calculated power values in the monitored data and measurement view are presented in units of kVA/kW/kVAr or in units of MVA/MW/MVAr.

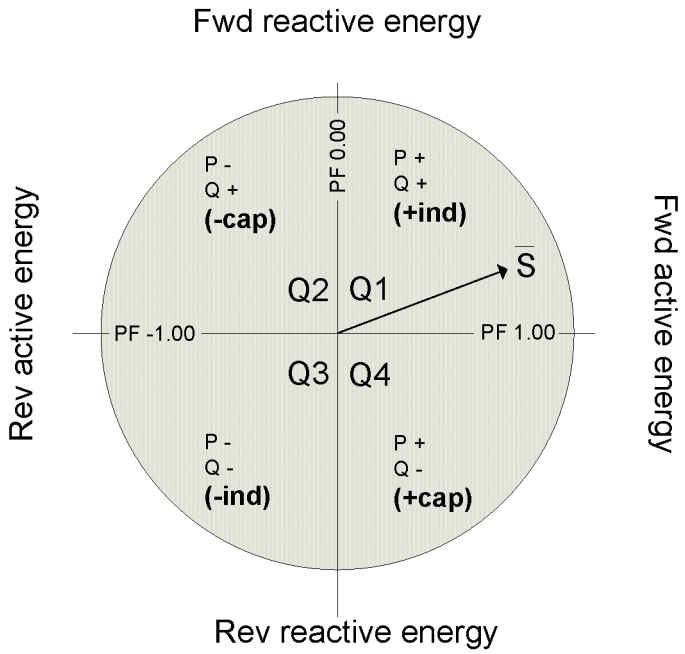



*Figure 805: Complex power and power quadrants*

**Table 1361: Power quadrants**

| Quadrant | Current | P | Q | PF | Power |
|---|---|---|---|---|---|
| Q1 | Lagging | + | + | 0...+1.00 | +ind |
| Q2 | Lagging | - | + | 0...-1.00 | -cap |
| Q3 | Leading | - | - | 0...-1.00 | -ind |
| Q4 | Leading | + | - | 0...+1.00 | +cap |

The active power P direction can be selected between forward and reverse with *Active power Dir* and correspondingly the reactive power Q direction can be selected with *Reactive power Dir*. This affects also the accumulated energy directions.

The accumulated energy is calculated separately as forward active ( EA_FWD_ACM), reverse active ( EA_RV_ACM), forward reactive ( ER_FWD_ACM) and reverse reactive ( ER_RV_ACM). Depending on the value of the unit multiplier selected with *Energy unit Mult*, the calculated power values are presented in units of kWh/kVArh or in units of MWh/MVArh.

When the energy counter reaches its defined maximum value, the counter value is reset and restarted from zero. Changing the value of the *Energy unit Mult* setting resets the accumulated energy values to the initial values, that is, EA_FWD_ACM to *Forward Wh Initial*, EA_RV_ACM to *Reverse Wh Initial*, ER_FWD_ACM to *Forward VArh Initial* and ER_RV_ACM to *Reverse VArh Initial*. It is also possible to reset the accumulated energy to initial values through a parameter or with the RSTACM input.

### Sequence components

The phase-sequence components are calculated using the phase currents and phase voltages. More information on calculating the phase-sequence components can be found in *Chapter 11.7 Calculated measurements* in this manual.

## 8.1.3 Measurement function applications

The measurement functions are used for power system measurement, supervision and reporting to LHMI, a monitoring tool within PCM600, or to the station level, for example, with IEC 61850. The possibility to continuously monitor the measured values of active power, reactive power, currents, voltages, power factors and so on, is vital for efficient production, transmission, and distribution of electrical energy. It provides a fast and easy overview of the present status of the power system to the system operator. Additionally, it can be used during testing and commissioning of protection and control protection relays to verify the proper operation and connection of instrument transformers, that is, the current transformers (CTs) and voltage transformers (VTs). The proper operation of the protection relay analog measurement chain can be verified during normal service by a periodic comparison of the measured value from the protection relay to other independent meters.

When the zero signal is measured, the noise in the input signal can still produce small measurement values. The zero point clamping function can be used to ignore the noise in the input signal and, hence, prevent the noise to be shown in the user display. The zero clamping is done for the measured analog signals and angle values.

The demand values are used to neglect sudden changes in the measured analog signals when monitoring long time values for the input signal. The demand values are linear average values of the measured signal over a settable demand interval. The demand values are calculated for the measured analog three-phase current signals.

The limit supervision indicates, if the measured signal exceeds or goes below the set limits. Depending on the measured signal type, up to two high limits and up to two low limits can be set for the limit supervision.

The deadband supervision reports a new measurement value if the input signal has gone out of the deadband state. The deadband supervision can be used in value reporting between the measurement point and operation control. When the deadband supervision is properly configured, it helps to keep the communication load to a minimum and yet measurement values are reported frequently enough.

The instantaneous measurement values of several measurement functions are available as primary values for further use in Application Configuration. The current values are in amperes while voltage values are in kilovolts and power values in kilovolt-amperes, watts or volt-amperes reactive.

## 8.1.4 Three-phase current measurement CMMXU (ANSI IA, IB, IC)

### 8.1.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase current measurement | CMMXU | 3I | IA, IB, IC |

### 8.1.4.2 Function block

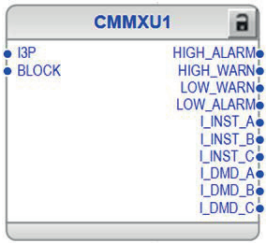



*Figure 806: Function block*

### 8.1.4.3 Functionality

The three-phase current measurement function CMMXU provides limit value supervision output (HIGH_ALARM, HIGH_WARN, LOW_WARN, LOW_ALARM). The delay of the activation and deactivation of these outputs can be controlled with setting parameters *On delay time* and *Off delay time*.

Instantaneous phase currents (I_INST_A, I_INST_B and I_INST_C) are provided as outputs in amperes. These can be used in the application configuration.

Phase current demand values (I_DMD_A, I_DMD_B and I_DMD_C) are provided as outputs in amperes. These outputs are dedicated for Load profile recorder (LDPRLRC).

### 8.1.4.4 Analog channel configuration

CMMXU has one analog group input which must be properly configured.

**Table 1362: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.4.5 Signals

**CMMXU Input signals**

**Table 1363: CMMXU Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

**CMMXU Output signals**

**Table 1364: CMMXU Output signals**

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | High alarm |
| HIGH_WARN | BOOLEAN | High warning |
| LOW_WARN | BOOLEAN | Low warning |
| LOW_ALARM | BOOLEAN | Low alarm |
| I_INST_A | FLOAT32 | Phase A current instantaneous value amplitude in amperes |
| I_INST_B | FLOAT32 | Phase B current instantaneous value amplitude in amperes |
| I_INST_C | FLOAT32 | Phase C current instantaneous value amplitude in amperes |
| I_DMD_A | FLOAT32 | Demand value of IL1 current |
| I_DMD_B | FLOAT32 | Demand value of IL2 current |
| I_DMD_C | FLOAT32 | Demand value of IL3 current |

### 8.1.4.6 CMMXU Non group settings

**Table 1365: CMMXU Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | | | | 1=on | Operation Off / On |
| Num of phases | | | | 1=1 out of 3 | Number of phases required by limit supervision |
| A high high limit | 0.00...40.00 | xIn | 0.01 | 1.40 | High alarm current limit |
| A high limit | 0.00...40.00 | xIn | 0.01 | 1.20 | High warning current limit |
| A low limit | 0.00...40.00 | xIn | 0.01 | 0.00 | Low warning current limit |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| A low low limit | 0.00...40.00 | xIn | 0.01 | 0.00 | Low alarm current limit |
| A deadband | 100...100000 | | 1 | 2500 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |

**Table 1366: CMMXU Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | | | | 2=DFT | Selects used measurement mode |
| On delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs |
| Off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs |

### 8.1.4.7 CMMXU Monitored data

**Table 1367: CMMXU Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| IL1-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured current amplitude phase A |
| IL2-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured current amplitude phase B |
| IL3-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured current amplitude phase C |
| Max demand IL1 | FLOAT32 | 0.00...40.00 | xIn | Maximum demand for Phase A |
| Max demand IL2 | FLOAT32 | 0.00...40.00 | xIn | Maximum demand for Phase B |
| Max demand IL3 | FLOAT32 | 0.00...40.00 | xIn | Maximum demand for Phase C |
| Min demand IL1 | FLOAT32 | 0.00...40.00 | xIn | Minimum demand for Phase A |
| Min demand IL2 | FLOAT32 | 0.00...40.00 | xIn | Minimum demand for Phase B |
| Min demand IL3 | FLOAT32 | 0.00...40.00 | xIn | Minimum demand for Phase C |
| Time max demand IL1 | Timestamp | | | Time of maximum demand phase A |
| Time max demand IL2 | Timestamp | | | Time of maximum demand phase B |
| Time max demand IL3 | Timestamp | | | Time of maximum demand phase C |
| Time min demand IL1 | Timestamp | | | Time of minimum demand phase A |
| Time min demand IL2 | Timestamp | | | Time of minimum demand phase B |
| Time min demand IL3 | Timestamp | | | Time of minimum demand phase C |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| BLOCK | BOOLEAN | 0=False<br>1=True | | Block signal for all binary outputs |
| HIGH_ALARM | BOOLEAN | 0=False<br>1=True | | High alarm |
| HIGH_WARN | BOOLEAN | 0=False<br>1=True | | High warning |
| LOW_WARN | BOOLEAN | 0=False<br>1=True | | Low warning |
| LOW_ALARM | BOOLEAN | 0=False<br>1=True | | Low alarm |
| I_INST_A | FLOAT32 | 0.00...40.00 | xIn | IL1 Amplitude, magnitude of instantaneous value |
| I_ANGL_A | FLOAT32 | -180.00...180.00 | deg | IL1 current angle |
| I_DB_A | FLOAT32 | 0.00...40.00 | xIn | IL1 Amplitude, magnitude of deadband value |
| I_DMD_A | FLOAT32 | 0.00...40.00 | xIn | Demand value of IL1 current |
| I_RANGE_A | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | IL1 Amplitude range |
| I_INST_B | FLOAT32 | 0.00...40.00 | xIn | IL2 Amplitude, magnitude of instantaneous value |
| I_ANGL_B | FLOAT32 | -180.00...180.00 | deg | IL2 current angle |
| I_DB_B | FLOAT32 | 0.00...40.00 | xIn | IL2 Amplitude, magnitude of deadband value |
| I_DMD_B | FLOAT32 | 0.00...40.00 | xIn | Demand value of IL2 current |
| I_RANGE_B | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | IL2 Amplitude range |
| I_INST_C | FLOAT32 | 0.00...40.00 | xIn | IL3 Amplitude, magnitude of instantaneous value |
| I_ANGL_C | FLOAT32 | -180.00...180.00 | deg | IL3 current angle |
| I_DB_C | FLOAT32 | 0.00...40.00 | xIn | IL3 Amplitude, magnitude of deadband value |
| I_DMD_C | FLOAT32 | 0.00...40.00 | xIn | Demand value of IL3 current |
| I_RANGE_C | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | IL3 Amplitude range |

#### 8.1.4.8 Technical data

**Table 1368: CMMXU Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±0.5 % or ±0.002 × $I_n$<br>(at currents in the range of 0.01...4.00 × $I_n$) |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,...<br>RMS: No suppression |

## 8.1.5 Three-phase voltage measurement VMMXU (ANSI VA, VB, VC)

### 8.1.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase voltage measurement | VMMXU | 3U | VA, VB, VC |

### 8.1.5.2 Function block

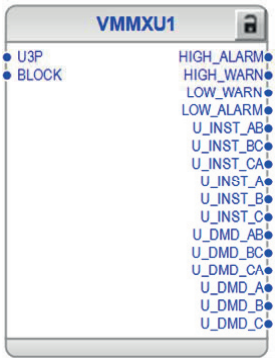



*Figure 807: Function block*

### 8.1.5.3 Functionality

The three-phase voltage measurement function VMMXU provides limit value supervision output (HIGH_ALARM, HIGH_WARN, LOW_WARN, LOW_ALARM). Setting parameters *On delay time* and *Off delay time* are used for controlling the activation and the deactivation of alarm and warning outputs.

Instantaneous phase-to-phase and phase-to-earth voltages in volts are available for application configurations through outputs U_INST_AB, U_INST_BC and U_INST_CA and U_INST_A, U_INST_B and U_INST_C, respectively.

Phase current demand values in volts are for connecting to Load profile recorder (LDPRLRC) through outputs I_DMD_A, I_DMD_B and I_DMD_C.

### 8.1.5.4 Analog channel configuration

VMMXU has one analog group input which must be properly configured.

**Table 1369: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1370: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that at least one voltage channel is connected if *Num of start phases* is set to "1 out of 3". |
| | The function requires that at least two voltage channels are connected if *Num of start phases* is set to "2 out of 3". |
| | The function requires that all three voltage channels are connected if *Num of start phases* is set to "3 out of 3". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.5.5 Signals

#### VMMXU Input signals

**Table 1371: VMMXU Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

**VMMXU Output signals**

**Table 1372: VMMXU Output signals**

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | High alarm |
| HIGH_WARN | BOOLEAN | High warning |
| LOW_WARN | BOOLEAN | Low warning |
| LOW_ALARM | BOOLEAN | Low alarm |
| U_INST_AB | FLOAT32 | Phase AB voltage instantaneous value amplitude in kV |
| U_INST_BC | FLOAT32 | Phase BC voltage instantaneous value amplitude in kV |
| U_INST_CA | FLOAT32 | Phase CA voltage instantaneous value amplitude in kV |
| U_INST_A | FLOAT32 | Phase A voltage instantaneous value amplitude in kV |
| U_INST_B | FLOAT32 | Phase B voltage instantaneous value amplitude in kV |
| U_INST_C | FLOAT32 | Phase C voltage instantaneous value amplitude in kV |
| U_DMD_AB | FLOAT32 | Demand value of U12 voltage |
| U_DMD_BC | FLOAT32 | Demand value of U23 voltage |
| U_DMD_CA | FLOAT32 | Demand value of U31 voltage |
| U_DMD_A | FLOAT32 | Demand value of UL1 voltage |
| U_DMD_B | FLOAT32 | Demand value of UL2 voltage |
| U_DMD_C | FLOAT32 | Demand value of UL3 voltage |

## 8.1.5.6 VMMXU Settings

**Table 1373: VMMXU Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required by limit supervision |
| V high high limit | 0.00...4.00 | xUn | 0.01 | 1.40 | High alarm voltage limit |
| V high limit | 0.00...4.00 | xUn | 0.01 | 1.20 | High warning voltage limit |
| V low limit | 0.00...4.00 | xUn | 0.01 | 0.00 | Low warning voltage limit |
| V low low limit | 0.00...4.00 | xUn | 0.01 | 0.00 | Low alarm voltage limit |
| V deadband | 100...100000 | | 1 | 10000 | Deadband configuration value for integral calculation. |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | | | | | (percentage of difference between min and max as 0,001 % s) |

**Table 1374: VMMXU Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT | | | 2=DFT | Selects used measurement mode |
| On delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs |
| Off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs |

### 8.1.5.7 VMMXU Monitored data

**Table 1375: VMMXU Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U12-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured phase to phase voltage amplitude phase AB |
| U23-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured phase to phase voltage amplitude phase BC |
| U31-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured phase to phase voltage amplitude phase CA |
| UL1-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to earth voltage amplitude phase A |
| UL2-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to earth voltage amplitude phase B |
| UL3-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to earth voltage amplitude phase C |
| BLOCK | BOOLEAN | 0=False<br>1=True | | Block signal for all binary outputs |
| HIGH_ALARM | BOOLEAN | 0=False<br>1=True | | High alarm |
| HIGH_WARN | BOOLEAN | 0=False<br>1=True | | High warning |
| LOW_WARN | BOOLEAN | 0=False<br>1=True | | Low warning |
| LOW_ALARM | BOOLEAN | 0=False<br>1=True | | Low alarm |
| U_INST_AB | FLOAT32 | 0.00...4.00 | xUn | U12 amplitude, magnitude of instantaneous value |
| U_ANGL_AB | FLOAT32 | -180.00...180.00 | deg | U12 angle |
| U_DB_AB | FLOAT32 | 0.00...4.00 | xUn | U12 amplitude, magnitude of deadband value |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U_DMD_AB | FLOAT32 | 0.00...4.00 | xUn | Demand value of U12 voltage |
| U_RANGE_AB | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | U12 amplitude range |
| U_INST_BC | FLOAT32 | 0.00...4.00 | xUn | U23 amplitude, magnitude of instantaneous value |
| U_ANGL_BC | FLOAT32 | -180.00...180.00 | deg | U23 angle |
| U_DB_BC | FLOAT32 | 0.00...4.00 | xUn | U23 amplitude, magnitude of deadband value |
| U_DMD_BC | FLOAT32 | 0.00...4.00 | xUn | Demand value of U23 voltage |
| U_RANGE_BC | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | U23 amplitude range |
| U_INST_CA | FLOAT32 | 0.00...4.00 | xUn | U31 amplitude, magnitude of instantaneous value |
| U_ANGL_CA | FLOAT32 | -180.00...180.00 | deg | U31 angle |
| U_DB_CA | FLOAT32 | 0.00...4.00 | xUn | U31 amplitude, magnitude of deadband value |
| U_DMD_CA | FLOAT32 | 0.00...4.00 | xUn | Demand value of U31 voltage |
| U_RANGE_CA | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | U31 amplitude range |
| U_INST_A | FLOAT32 | 0.00...5.00 | xUn | UL1 amplitude, magnitude of instantaneous value |
| U_ANGL_A | FLOAT32 | -180.00...180.00 | deg | UL1 angle |
| U_DMD_A | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL1 voltage |
| U_INST_B | FLOAT32 | 0.00...5.00 | xUn | UL2 amplitude, magnitude of instantaneous value |
| U_ANGL_B | FLOAT32 | -180.00...180.00 | deg | UL2 angle |
| U_DMD_B | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL2 voltage |
| U_INST_C | FLOAT32 | 0.00...5.00 | xUn | UL3 amplitude, magnitude of instantaneous value |
| U_ANGL_C | FLOAT32 | -180.00...180.00 | deg | UL3 angle |
| U_DMD_C | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL3 voltage |

### 8.1.5.8 Technical data

**Table 1376: VMMXU Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz<br>At voltages in range 0.01…1.15 × $U_n$ |
| | ±0.5 % or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

## 8.1.6 Phase voltage measurement VPHMMXU

### 8.1.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Phase voltage measurement | VPHMMXU | 3UL | VL |

### 8.1.6.2 Function block

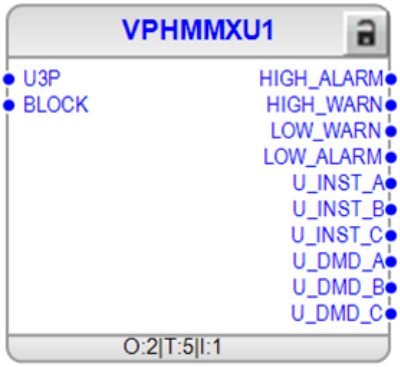



*Figure 808: Function block*

### 8.1.6.3 Functionality

The phase voltage measurement function VPHMMXU provides limit value supervision output (`HIGH_ALARM`, `HIGH_WARN`, `LOW_WARN` and `LOW_ALARM`). Instantaneous phase voltage in volt is available for application configurations through output `U_INST_A`, `U_INST_B` and `U_INST_C`. Phase voltage demand value in volt is for connecting to Load profile recorder (LDPRLRC) through output `U_DMD_A`, `U_DMD_B` and `U_DMD_C`.

### 8.1.6.4 Analog channel configuration

VPHMMXU has one analog group input which must be properly configured.

**Table 1377: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltage |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1378: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that at least one voltage channel is connected if *Num of start phases* is set to "1 out of 3". |
| | The function requires that at least two voltage channels are connected if *Num of start phases* is set to "2 out of 3". |
| | The function requires that at least three voltage channels are connected if *Num of start phases* is set to "3 out of 3". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the content of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.6.5 Signals

#### VPHMMXU Input signals

**Table 1379: VPHMMXU Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

#### VPHMMXU Output signals

**Table 1380: VPHMMXU Output signals**

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | High alarm |
| HIGH_WARN | BOOLEAN | High warning |
| LOW_WARN | BOOLEAN | Low warning |
| LOW_ALARM | BOOLEAN | Low alarm |
| U_INST_A | FLOAT32 | Phase A voltage instantaneous value amplitude in kV |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| U_INST_B | FLOAT32 | Phase B voltage instantaneous value amplitude in kV |
| U_INST_C | FLOAT32 | Phase C voltage instantaneous value amplitude in kV |
| U_DMD_A | FLOAT32 | Demand value of UL1 voltage |
| U_DMD_B | FLOAT32 | Demand value of UL2 voltage |
| U_DMD_C | FLOAT32 | Demand value of UL3 voltage |

### 8.1.6.6 VPHMMXU Settings

**Table 1381: VPHMMXU Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required by limit supervision |
| V high high limit | 0.00...5.00 | xUn | 0.01 | 1.40 | High alarm voltage limit |
| V high limit | 0.00...5.00 | xUn | 0.01 | 1.20 | High warning voltage limit |
| V low limit | 0.00...5.00 | xUn | 0.01 | 0.00 | Low warning voltage limit |
| V low low limit | 0.00...5.00 | xUn | 0.01 | 0.00 | Low alarm voltage limit |
| V deadband | 100...100000 | | 1 | 10000 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |

**Table 1382: VPHMMXU Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT | | | 2=DFT | Selects used measurement mode |
| On delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs |
| Off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs |

### 8.1.6.7 VPHMMXU Monitored data

**Table 1383: VPHMMXU Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| UL1-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to neutral voltage phase A |
| UL2-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to neutral voltage phase B |
| UL3-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to neutral voltage phase C |
| BLOCK | BOOLEAN | | | Block signal for all binary outputs |
| HIGH_ALARM | BOOLEAN | | | High alarm |
| HIGH_WARN | BOOLEAN | | | High warning |
| LOW_WARN | BOOLEAN | | | Low warning |
| LOW_ALARM | BOOLEAN | | | Low alarm |
| U_INST_A | FLOAT32 | 0.00...5.00 | xUn | UL1 amplitude, magnitude of instantaneous value |
| U_ANGL_A | FLOAT32 | -180.00...180.00 | deg | UL1 angle |
| U_DMD_A | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL1 voltage |
| U_RANGE_A | Enum | | | UL1 amplitude range |
| U_INST_B | FLOAT32 | 0.00...5.00 | xUn | UL2 amplitude, magnitude of instantaneous value |
| U_ANGL_B | FLOAT32 | -180.00...180.00 | deg | UL2 angle |
| U_DMD_B | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL2 voltage |
| U_RANGE_B | Enum | | | UL2 amplitude range |
| U_INST_C | FLOAT32 | 0.00...5.00 | xUn | UL3 amplitude, magnitude of instantaneous value |
| U_ANGL_C | FLOAT32 | -180.00...180.00 | deg | UL3 angle |
| U_DMD_C | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL3 voltage |
| U_RANGE_C | Enum | | | UL3 amplitude range |

## 8.1.6.8 Technical data

**Table 1384: VPHMMXU Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz |

*Table continues on the next page*

| Characteristic | Value |
|---|---|
| | At voltages in range 0.01…1.15 × $U_n$ |
| | ±0.5 % or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

## 8.1.7 Single-phase voltage measurement VAMMXU (ANSI V_A)

### 8.1.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Single-phase voltage measurement | VAMMXU | U_A | V_A |

### 8.1.7.2 Function block

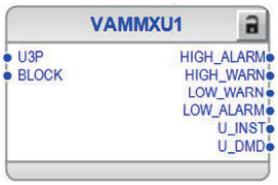



*Figure 809: Function block*

### 8.1.7.3 Functionality

The single-phase voltage measurement function VAMMXU provides limit value supervision output (HIGH_ALARM, HIGH_WARN, LOW_WARN, LOW_ALARM).

Instantaneous single-phase voltage in volt is available for application configurations through output U_INST. Phase voltage demand value in volt is for connecting to Load profile recorder (LDPRLRC) through output U_DMD.

### 8.1.7.4 Analog channel configuration

VAMMXU has one analog group input which must be properly configured.

**Table 1385: Analog inputs**

| Input | Description |
|---|---|
| U3P | Voltage group signal |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1386: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that the first phase voltage U_A or U_AB is connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.7.5 Signals

#### VMMXU Input signals

**Table 1387: VMMXU Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

#### VMMXU Output signals

**Table 1388: VMMXU Output signals**

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | High alarm |
| HIGH_WARN | BOOLEAN | High warning |
| LOW_WARN | BOOLEAN | Low warning |
| LOW_ALARM | BOOLEAN | Low alarm |
| U_INST_AB | FLOAT32 | Phase AB voltage instantaneous value amplitude in kV |
| U_INST_BC | FLOAT32 | Phase BC voltage instantaneous value amplitude in kV |
| U_INST_CA | FLOAT32 | Phase CA voltage instantaneous value amplitude in kV |
| U_INST_A | FLOAT32 | Phase A voltage instantaneous value amplitude in kV |
| U_INST_B | FLOAT32 | Phase B voltage instantaneous value amplitude in kV |
| U_INST_C | FLOAT32 | Phase C voltage instantaneous value amplitude in kV |
| U_DMD_AB | FLOAT32 | Demand value of U12 voltage |
| U_DMD_BC | FLOAT32 | Demand value of U23 voltage |
| U_DMD_CA | FLOAT32 | Demand value of U31 voltage |
| U_DMD_A | FLOAT32 | Demand value of UL1 voltage |
| U_DMD_B | FLOAT32 | Demand value of UL2 voltage |
| U_DMD_C | FLOAT32 | Demand value of UL3 voltage |

### 8.1.7.6 VMMXU Settings

**Table 1389: VMMXU Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Num of phases | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | | | 1=1 out of 3 | Number of phases required by limit supervision |
| V high high limit | 0.00...4.00 | xUn | 0.01 | 1.40 | High alarm voltage limit |
| V high limit | 0.00...4.00 | xUn | 0.01 | 1.20 | High warning voltage limit |
| V low limit | 0.00...4.00 | xUn | 0.01 | 0.00 | Low warning voltage limit |
| V low low limit | 0.00...4.00 | xUn | 0.01 | 0.00 | Low alarm voltage limit |
| V deadband | 100...100000 | | 1 | 10000 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |

**Table 1390: VMMXU Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT | | | 2=DFT | Selects used measurement mode |
| On delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs |
| Off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs |

### 8.1.7.7 VMMXU Monitored data

**Table 1391: VMMXU Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U12-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured phase to phase voltage amplitude phase AB |
| U23-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured phase to phase voltage amplitude phase BC |
| U31-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured phase to phase voltage amplitude phase CA |
| UL1-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to earth voltage amplitude phase A |
| UL2-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to earth voltage amplitude phase B |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| UL3-kV:1 | FLOAT32 | 0.00...5.00 | xUn | Measured phase to earth voltage amplitude phase C |
| BLOCK | BOOLEAN | 0=False<br>1=True | | Block signal for all binary outputs |
| HIGH_ALARM | BOOLEAN | 0=False<br>1=True | | High alarm |
| HIGH_WARN | BOOLEAN | 0=False<br>1=True | | High warning |
| LOW_WARN | BOOLEAN | 0=False<br>1=True | | Low warning |
| LOW_ALARM | BOOLEAN | 0=False<br>1=True | | Low alarm |
| U_INST_AB | FLOAT32 | 0.00...4.00 | xUn | U12 amplitude, magnitude of instantaneous value |
| U_ANGL_AB | FLOAT32 | -180.00...180.00 | deg | U12 angle |
| U_DB_AB | FLOAT32 | 0.00...4.00 | xUn | U12 amplitude, magnitude of deadband value |
| U_DMD_AB | FLOAT32 | 0.00...4.00 | xUn | Demand value of U12 voltage |
| U_RANGE_AB | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | U12 amplitude range |
| U_INST_BC | FLOAT32 | 0.00...4.00 | xUn | U23 amplitude, magnitude of instantaneous value |
| U_ANGL_BC | FLOAT32 | -180.00...180.00 | deg | U23 angle |
| U_DB_BC | FLOAT32 | 0.00...4.00 | xUn | U23 amplitude, magnitude of deadband value |
| U_DMD_BC | FLOAT32 | 0.00...4.00 | xUn | Demand value of U23 voltage |
| U_RANGE_BC | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | U23 amplitude range |
| U_INST_CA | FLOAT32 | 0.00...4.00 | xUn | U31 amplitude, magnitude of instantaneous value |
| U_ANGL_CA | FLOAT32 | -180.00...180.00 | deg | U31 angle |
| U_DB_CA | FLOAT32 | 0.00...4.00 | xUn | U31 amplitude, magnitude of deadband value |
| U_DMD_CA | FLOAT32 | 0.00...4.00 | xUn | Demand value of U31 voltage |
| U_RANGE_CA | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | U31 amplitude range |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U_INST_A | FLOAT32 | 0.00...5.00 | xUn | UL1 amplitude, magnitude of instantaneous value |
| U_ANGL_A | FLOAT32 | -180.00...180.00 | deg | UL1 angle |
| U_DMD_A | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL1 voltage |
| U_INST_B | FLOAT32 | 0.00...5.00 | xUn | UL2 amplitude, magnitude of instantaneous value |
| U_ANGL_B | FLOAT32 | -180.00...180.00 | deg | UL2 angle |
| U_DMD_B | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL2 voltage |
| U_INST_C | FLOAT32 | 0.00...5.00 | xUn | UL3 amplitude, magnitude of instantaneous value |
| U_ANGL_C | FLOAT32 | -180.00...180.00 | deg | UL3 angle |
| U_DMD_C | FLOAT32 | 0.00...5.00 | xUn | Demand value of UL3 voltage |

#### 8.1.7.8 Technical data

**Table 1392: VAMMXU Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz<br>At voltages in range 0.01…1.15 × $U_n$ |
| | ±0.5 % or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

## 8.1.8 Residual current measurement RESCMMXU (ANSI IG)

### 8.1.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Residual current measurement | RESCMMXU | Io | IG |

### 8.1.8.2 Function block

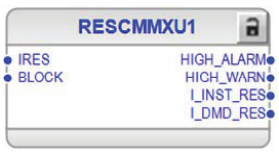



*Figure 810: Function block*

### 8.1.8.3 Functionality

The residual current measurement function RESCMMXU provides limit value supervision output (HIGH_ALARM, HIGH_WARN). Setting parameters *On delay time* and *Off delay time* are used for controlling the activation and, respectively, the deactivation of alarm and warning outputs.

Instantaneous residual current in amperes is available for application configurations through output I_INST_RES. The residual current demand value in amperes is for connecting to Load profile recorder (LDPRLRC) through output I_DMD_RES.

### 8.1.8.4 Analog channel configuration

RESCMMXU has one analog group input which must be properly configured.

**Table 1393: Analog inputs**

| Input | Description |
|---|---|
| IRES | Residual current (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.8.5 Signals

#### RESCMMXU Input signals

**Table 1394: RESCMMXU Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

#### RESCMMXU Output signals

**Table 1395: RESCMMXU Output signals**

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | High alarm |
| HIGH_WARN | BOOLEAN | High warning |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| I_INST_RES | FLOAT32 | Residual current instantaneous value amplitude in amperes |
| I_DMD_RES | FLOAT32 | Demand value of residual current |

### 8.1.8.6 RESCMMXU Settings

**Table 1396: RESCMMXU Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| A Hi high limit res | 0.00...40.00 | xIn | 0.01 | 0.20 | High alarm current limit |
| A high limit res | 0.00...40.00 | xIn | 0.01 | 0.05 | High warning current limit |
| A deadband res | 100...100000 | | 1 | 2500 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |

**Table 1397: RESCMMXU Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT | | | 2=DFT | Selects used measurement mode |
| On delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs |
| Off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs |

### 8.1.8.7 RESCMMXU Monitored data

**Table 1398: RESCMMXU Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Io-A:1 | FLOAT32 | 0.00...40.00 | xIn | Residual current |
| BLOCK | BOOLEAN | 0=False<br>1=True | | Block signal for all binary outputs |
| HIGH_ALARM | BOOLEAN | 0=False<br>1=True | | High alarm |
| HIGH_WARN | BOOLEAN | 0=False<br>1=True | | High warning |
| I_INST_RES | FLOAT32 | 0.00...40.00 | xIn | Residual current Amplitude, magnitude of instantaneous value |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I_ANGL_RES | FLOAT32 | -180.00...180.00 | deg | Residual current angle |
| I_DB_RES | FLOAT32 | 0.00...40.00 | xIn | Residual current Amplitude, magnitude of deadband value |
| I_DMD_RES | FLOAT32 | 0.00...40.00 | xIn | Demand value of residual current |
| I_RANGE_RES | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Residual current Amplitude range |
| Max demand Io | FLOAT32 | 0.00...40.00 | xIn | Maximum demand for residual current |
| Min demand Io | FLOAT32 | 0.00...40.00 | xIn | Minimum demand for residual current |
| Time max demand Io | Timestamp | | | Time of maximum demand residual current |
| Time min demand Io | Timestamp | | | Time of minimum demand residual current |

### 8.1.8.8 Technical data

**Table 1399: RESCMMXU Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | ±0.5 % or ±0.002 × $I_n$<br>(at currents in the range of 0.01...4.00 × $I_n$) |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

## 8.1.9 Residual voltage measurement RESVMMXU (ANSI VG/VN)

### 8.1.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Residual voltage measurement | RESVMMXU | Uo | VG/VN |

### 8.1.9.2 Function block

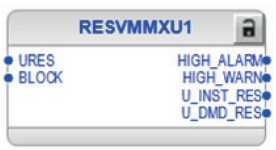



*Figure 811: Function block*

### 8.1.9.3 Functionality

The residual voltage measurement function RESVMMXU provides limit value supervision output (HIGH_ALARM, HIGH_WARN). Setting parameters *On delay time* and *Off delay time* are used for controlling the activation and, respectively, the deactivation of alarm and warning outputs.

Instantaneous residual voltage in volt is available for application configurations through output U_INST_RES. The residual voltage demand value in volt is for connecting to Load profile recorder (LDPRLRC) through output U_DMD_RES.

### 8.1.9.4 Analog channel configuration

RESVMMXU has one analog group input which must be properly configured.

**Table 1400: Analog inputs**

| Input | Description |
|---|---|
| URES | Residual voltage (measured or calculated) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1401: Special conditions**

| Condition | Description |
|---|---|
| URES calculated | The function requires that all three voltage channels are connected to calculate residual voltage. Setting *VT connection* must be "Wye" in that particular UTVTR. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.9.5 Signals

**RESVMMXU Input signals**

**Table 1402: RESVMMXU Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| URES | SIGNAL | - | Residual voltage |
| BLOCK | BOOLEAN | 0=False | Block signal for all binary outputs |

**RESVMMXU Output signals**

**Table 1403: RESVMMXU Output signals**

| Name | Type | Description |
|---|---|---|
| HIGH_ALARM | BOOLEAN | High alarm |
| HIGH_WARN | BOOLEAN | High warning |
| U_INST_RES | FLOAT32 | Residual voltage instantaneous value amplitude in kV |
| U_DMD_RES | FLOAT32 | Demand value of residual voltage |

## 8.1.9.6 RESVMMXU Settings

**Table 1404: RESVMMXU Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| V Hi high limit res | 0.00...4.00 | xUn | 0.01 | 0.20 | High alarm voltage limit |
| V high limit res | 0.00...4.00 | xUn | 0.01 | 0.05 | High warning voltage limit |
| V deadband res | 100...100000 | | 1 | 10000 | Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s) |

**Table 1405: RESVMMXU Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Measurement mode | 1=RMS<br>2=DFT | | | 2=DFT | Selects used measurement mode |
| On delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs |
| Off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs |

## 8.1.9.7 RESVMMXU Monitored data

**Table 1406: RESVMMXU Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Uo-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Residual voltage |
| BLOCK | BOOLEAN | 0=False<br>1=True | | Block signal for all binary outputs |
| HIGH_ALARM | BOOLEAN | 0=False<br>1=True | | High alarm |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| HIGH_WARN | BOOLEAN | 0=False<br>1=True | | High warning |
| U_INST_RES | FLOAT32 | 0.00...4.00 | xUn | Residual voltage Amplitude, magnitude of instantaneous value |
| U_ANGL_RES | FLOAT32 | -180.00...180.00 | deg | Residual voltage angle |
| U_DB_RES | FLOAT32 | 0.00...4.00 | xUn | Residual voltage Amplitude, magnitude of deadband value |
| U_DMD_RES | FLOAT32 | 0.00...4.00 | xUn | Demand value of residual voltage |
| U_RANGE_RES | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Residual voltage Amplitude range |

### 8.1.9.8 Technical data

**Table 1407: RESVMMXU Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage: $f/f_n$ = ±2 Hz |
| | ±0.5 % or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

## 8.1.10 Frequency measurement FMMXU (ANSI f)

### 8.1.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Frequency measurement | FMMXU | f | f |

### 8.1.10.2 Function block




*Figure 812: Function block*

### 8.1.10.3 Functionality

The frequency measurement range is 35...75 Hz. The measured frequencies outside the measurement range are considered to be out of range and the minimum and maximum values are then shown in parentheses.

There is an extended range of 10...75 Hz in a 50 Hz network and 12...75 Hz in a 60 Hz network. The measured frequencies outside 35...75 Hz are shown in parentheses.

When the frequencies cannot be measured, for example, due to too low voltage amplitude, the default value for frequency measurement can be selected with the *Def frequency Sel* setting parameter. In the “Nominal” mode the frequency is set to 50 Hz (or 60 Hz) and in “Zero” mode the frequency is set to zero and shown in parentheses.

FMMXU provides instantaneous frequency in hertz which is available for application configurations through output `F_INST`.

### 8.1.10.4 Signals

#### FMMXU Input signals

**Table 1408: FMMXU Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |

#### FMMXU Output signals

**Table 1409: FMMXU Output signals**

| Name | Type | Description |
|---|---|---|
| F_INST | FLOAT32 | Frequency, instantaneous value |

### 8.1.10.5 FMMXU Settings

**Table 1410: FMMXU Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| F high high limit | 35.00...75.00 | Hz | 0.01 | 60.00 | High alarm frequency limit |
| F high limit | 35.00...75.00 | Hz | 0.01 | 55.00 | High warning frequency limit |
| F low limit | 35.00...75.00 | Hz | 0.01 | 45.00 | Low warning frequency limit |
| F low low limit | 35.00...75.00 | Hz | 0.01 | 40.00 | Low alarm frequency limit |
| F deadband | 100...100000 | | 1 | 1000 | Deadband configuration value for integral calculation (percentage of difference between |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | | | | | min and max as 0,001 % s) |

**Table 1411: FMMXU Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Def frequency Sel | 1=Nominal<br>2=Zero | | | 1=Nominal | Default frequency selection |

### 8.1.10.6 FMMXU Monitored data

**Table 1412: FMMXU Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| f-Hz:1 | FLOAT32 | 35.00...75.00 | Hz | Measured frequency |
| F_INST | FLOAT32 | 35.00...75.00 | Hz | Frequency, instantaneous value |
| F_DB | FLOAT32 | 35.00...75.00 | Hz | Frequency, deadband value |
| F_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Measured frequency range |

### 8.1.10.7 Technical data

**Table 1413: FMMXU Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | ±5 mHz<br>(in measurement range 35...75 Hz) |

## 8.1.11 Sequence current measurement CSMSQI (ANSI I1, I2, I0)

### 8.1.11.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Sequence current measurement | CSMSQI | I1, I2, I0 | I1, I2, I0 |

### 8.1.11.2 Function block

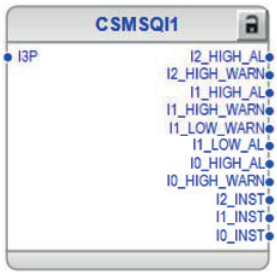



*Figure 813: Function block*

### 8.1.11.3 Functionality

The sequence current measurement function CSMSQI provides limit value supervision outputs (`I2_HIGH_AL`, `I2_HIGH_WARN`, `I1_HIGH_AL`, `I1_HIGH_WARN`, `I1_LOW_WRN`, `I1_LOW_AL`, `I0_HIGH_AL`, `I0_HIGH_WARN`). Setting parameters *Ps Seq A on delay time, Ps Seq A off delay time, Ng Seq A on delay time, Ng Seq A off delay time, Zro Seq A on delay time, Zro Seq A off delay time* are used for controlling the activation and the deactivation of alarm and warning outputs.

Instantaneous sequence currents in amperes are available for application configurations through outputs `I2_INST`, `I1_INST` and `I0_INST`.

### 8.1.11.4 Analog channel configuration

CSMSQI has one analog group input which must be properly configured.

**Table 1414: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.11.5 Signals

**CSMSQI Input signals**

**Table 1415: CSMSQI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |

**CSMSQI Output signals**

**Table 1416: CSMSQI Output signals**

| Name | Type | Description |
|---|---|---|
| I2_HIGH_AL | BOOLEAN | Negative sequence high alarm |
| I2_HIGH_WARN | BOOLEAN | Negative sequence high warning |
| I1_HIGH_AL | BOOLEAN | Positive sequence high alarm |
| I1_HIGH_WARN | BOOLEAN | Positive sequence high warning |
| I1_LOW_WARN | BOOLEAN | Positive sequence low warning |
| I1_LOW_AL | BOOLEAN | Positive sequence low alarm |
| I0_HIGH_AL | BOOLEAN | Zero sequence high alarm |
| I0_HIGH_WARN | BOOLEAN | Zero sequence high warning |
| I2_INST | FLOAT32 | Negative sequence current amplitude, instantaneous value (A) |
| I1_INST | FLOAT32 | Positive sequence current amplitude, instantaneous value (A) |
| I0_INST | FLOAT32 | Zero sequence current amplitude, instantaneous value (A) |

## 8.1.11.6 CSMSQI Settings

**Table 1417: CSMSQI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on | | | 1=on | Operation Off / On |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 5=off | | | | |
| Ps Seq A Hi high Lim | 0.00...40.00 | xIn | 0.01 | 1.40 | High alarm current limit for positive sequence current |
| Ps Seq A high limit | 0.00...40.00 | xIn | 0.01 | 1.20 | High warning current limit for positive sequence current |
| Ps Seq A low limit | 0.00...40.00 | xIn | 0.01 | 0.00 | Low warning current limit for positive sequence current |
| Ps Seq A low low Lim | 0.00...40.00 | xIn | 0.01 | 0.00 | Low alarm current limit for positive sequence current |
| Ps Seq A deadband | 100...100000 | | 1 | 2500 | Deadband configuration value for positive sequence current for integral calculation. (percentage of difference between min and max as 0,001 % s) |
| Ng Seq A Hi high Lim | 0.00...40.00 | xIn | 0.01 | 0.20 | High alarm current limit for negative sequence current |
| Ng Seq A High limit | 0.00...40.00 | xIn | 0.01 | 0.05 | High warning current limit for negative sequence current |
| Ng Seq A low limit | 0.00...40.00 | xIn | 0.01 | 0.00 | Low warning current limit for negative sequence current |
| Ng Seq A low low Lim | 0.00...40.00 | xIn | 0.01 | 0.00 | Low alarm current limit for negative sequence current |
| Ng Seq A deadband | 100...100000 | | 1 | 2500 | Deadband configuration value for negative sequence current for integral calculation. (percentage of difference between min and max as 0,001 % s) |
| Zro A Hi high Lim | 0.00...40.00 | xIn | 0.01 | 0.20 | High alarm current limit for zero sequence current |
| Zro A High limit | 0.00...40.00 | xIn | 0.01 | 0.05 | High warning current limit for zero sequence current |
| Zro A low limit | 0.00...40.00 | xIn | 0.01 | 0.00 | Low warning current limit for zero sequence current |
| Zro A low low Lim | 0.00...40.00 | xIn | 0.01 | 0.00 | Low alarm current limit for zero sequence current |
| Zro A deadband | 100...100000 | | 1 | 2500 | Deadband configuration value for zero sequence current for integral calculation. (percentage of difference between min and max as 0,001 % s) |

**Table 1418: CSMSQI Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Ps Seq A on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for positive sequence current |
| Ps Seq A off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for positive sequence current |
| Ng Seq A on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for negative sequence current |
| Ng Seq A off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for negative sequence current |
| Zro A on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for zero sequence current |
| Zro A off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for zero sequence current |

## 8.1.11.7 CSMSQI Monitored data

**Table 1419: CSMSQI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| NgSeq-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured negative sequence current |
| PsSeq-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured positive sequence current |
| ZrSeq-A:1 | FLOAT32 | 0.00...40.00 | xIn | Measured zero sequence current |
| I2_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Negative sequence high alarm |
| I2_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Negative sequence high warning |
| I1_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Positive sequence high alarm |
| I1_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Positive sequence high warning |
| I1_LOW_WARN | BOOLEAN | 0=False<br>1=True | | Positive sequence low warning |
| I1_LOW_AL | BOOLEAN | 0=False<br>1=True | | Positive sequence low alarm |
| I0_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Zero sequence high alarm |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| I0_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Zero sequence high warning |
| I2_INST | FLOAT32 | 0.00...40.00 | xIn | Negative sequence current amplitude, instantaneous value |
| I2_ANGL | FLOAT32 | -180.00...180.00 | deg | Negative sequence current angle |
| I2_DB | FLOAT32 | 0.00...40.00 | xIn | Negative sequence current amplitude, deadband value |
| I2_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Negative sequence current amplitude range |
| I1_INST | FLOAT32 | 0.00...40.00 | xIn | Positive sequence current amplitude, instantaneous value |
| I1_ANGL | FLOAT32 | -180.00...180.00 | deg | Positive sequence current angle |
| I1_DB | FLOAT32 | 0.00...40.00 | xIn | Positive sequence current amplitude, deadband value |
| I1_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Positive sequence current amplitude range |
| I0_INST | FLOAT32 | 0.00...40.00 | xIn | Zero sequence current amplitude, instantaneous value |
| I0_ANGL | FLOAT32 | -180.00...180.00 | deg | Zero sequence current angle |
| I0_DB | FLOAT32 | 0.00...40.00 | xIn | Zero sequence current amplitude, deadband value |
| I0_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Zero sequence current amplitude range |

## 8.1.11.8 Technical data

**Table 1420: CSMSQI Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f/f_n$ = ±2 Hz |
| | ±1.0 % or ±0.002 × $I_n$<br>at currents in the range of 0.01...4.00 × $I_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 8.1.12 Sequence voltage measurement VSMSQI (ANSI V1, V2, V0)

### 8.1.12.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Sequence voltage measurement | VSMSQI | U1, U2, U0 | V1, V2, V0 |

### 8.1.12.2 Function block

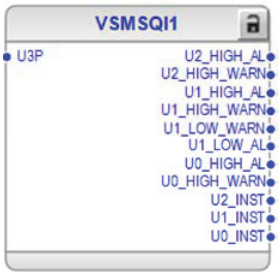



*Figure 814: Function block*

### 8.1.12.3 Functionality

The sequence voltage measurement function VSMSQI provides limit value supervision outputs (`U2_HIGH_AL`, `U2_HIGH_WARN`, `U1_HIGH_AL`, `U1_HIGH_WARN`, `U1_LOW_WRN`, `U1_LOW_AL`, `U0_HIGH_AL`, `U0_HIGH_WARN`). Setting parameters *Ps Seq V on delay time*, *Ps Seq V off delay time*, *Ng Seq V on delay time*, *Ng Seq V off delay time*, *Zro Seq V on delay time*, and *Zro Seq V off delay time* are used for controlling the activation and the deactivation of alarm and warning outputs.

Instantaneous sequence voltages in volt are available for application configurations through outputs `U2_INST`, `U1_INST` and `U0_INST`.

### 8.1.12.4 Analog channel configuration

VSMSQI has one analog group input which must be properly configured.

**Table 1421: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1422: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that any two voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.12.5 Signals

#### VSMSQI Input signals

**Table 1423: VSMSQI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |

#### VSMSQI Output signals

**Table 1424: VSMSQI Output signals**

| Name | Type | Description |
|---|---|---|
| U2_HIGH_AL | BOOLEAN | Negative sequence high alarm |
| U2_HIGH_WARN | BOOLEAN | Negative sequence high warning |
| U1_HIGH_AL | BOOLEAN | Positive sequence high alarm |
| U1_HIGH_WARN | BOOLEAN | Positive sequence high warning |
| U1_LOW_WARN | BOOLEAN | Positive sequence low warning |
| U1_LOW_AL | BOOLEAN | Positive sequence low alarm |
| U0_HIGH_AL | BOOLEAN | Zero sequence high alarm |
| U0_HIGH_WARN | BOOLEAN | Zero sequence high warning |
| U2_INST | FLOAT32 | Negative sequence voltage amplitude, instantaneous value (kV) |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| U1_INST | FLOAT32 | Positive sequence voltage amplitude, instantaneous value (kV) |
| U0_INST | FLOAT32 | Zero sequence voltage amplitude, instantaneous value (kV) |

### 8.1.12.6 VSMSQI Settings

**Table 1425: VSMSQI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Ps Seq V Hi high Lim | 0.00...4.00 | xUn | 0.01 | 1.40 | High alarm voltage limit for positive sequence voltage |
| Ps Seq V high limit | 0.00...4.00 | xUn | 0.01 | 1.20 | High warning voltage limit for positive sequence voltage |
| Ps Seq V low limit | 0.00...4.00 | xUn | 0.01 | 0.00 | Low warning voltage limit for positive sequence voltage |
| Ps Seq V low low Lim | 0.00...4.00 | xUn | 0.01 | 0.00 | Low alarm voltage limit for positive sequence voltage |
| Ps Seq V deadband | 100...100000 | | 1 | 10000 | Deadband configuration value for positive sequence voltage for integral calculation. (percentage of difference between min and max as 0,001 % s) |
| Ng Seq V Hi high Lim | 0.00...4.00 | xUn | 0.01 | 0.20 | High alarm voltage limit for negative sequence voltage |
| Ng Seq V High limit | 0.00...4.00 | xUn | 0.01 | 0.05 | High warning voltage limit for negative sequence voltage |
| Ng Seq V low limit | 0.00...4.00 | xUn | 0.01 | 0.00 | Low warning voltage limit for negative sequence voltage |
| Ng Seq V low low Lim | 0.00...4.00 | xUn | 0.01 | 0.00 | Low alarm voltage limit for negative sequence voltage |
| Ng Seq V deadband | 100...100000 | | 1 | 10000 | Deadband configuration value for negative sequence voltage for integral calculation. (percentage of difference between min and max as 0,001 % s) |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Zro V Hi high Lim | 0.00...4.00 | xUn | 0.01 | 0.20 | High alarm voltage limit for zero sequence voltage |
| Zro V High limit | 0.00...4.00 | xUn | 0.01 | 0.05 | High warning voltage limit for zero sequence voltage |
| Zro V low limit | 0.00...4.00 | xUn | 0.01 | 0.00 | Low warning voltage limit for zero sequence voltage |
| Zro V low low Lim | 0.00...4.00 | xUn | 0.01 | 0.00 | Low alarm voltage limit for zero sequence voltage |
| Zro V deadband | 100...100000 | | 1 | 10000 | Deadband configuration value for zero sequence voltage for integral calculation. (percentage of difference between min and max as 0,001 % s) |

**Table 1426: VSMSQI Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Ps Seq V on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for positive sequence voltage |
| Ps Seq V off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for positive sequence voltage |
| Ng Seq V on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for negative sequence voltage |
| Ng Seq V off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for negative sequence voltage |
| Zro V on delay time | 0...1800000 | ms | 100 | 0 | Delay the activation of the alarm and warning outputs for zero sequence voltage |
| Zro V off delay time | 0...1800000 | ms | 100 | 0 | Delay the deactivation of the alarm and warning outputs for zero sequence voltage |

## 8.1.12.7 VSMSQI Monitored data

**Table 1427: VSMSQI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| NgSeq-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured negative sequence voltage |
| PsSeq-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured positive sequence voltage |
| ZrSeq-kV:1 | FLOAT32 | 0.00...4.00 | xUn | Measured zero sequence voltage |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U2_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Negative sequence high alarm |
| U2_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Negative sequence high warning |
| U1_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Positive sequence high alarm |
| U1_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Positive sequence high warning |
| U1_LOW_WARN | BOOLEAN | 0=False<br>1=True | | Positive sequence low warning |
| U1_LOW_AL | BOOLEAN | 0=False<br>1=True | | Positive sequence low alarm |
| U0_HIGH_AL | BOOLEAN | 0=False<br>1=True | | Zero sequence high alarm |
| U0_HIGH_WARN | BOOLEAN | 0=False<br>1=True | | Zero sequence high warning |
| U2_INST | FLOAT32 | 0.00...4.00 | xUn | Negative sequence voltage amplitude, instantaneous value |
| U2_ANGL | FLOAT32 | -180.00...180.00 | deg | Negative sequence voltage angle |
| U2_DB | FLOAT32 | 0.00...4.00 | xUn | Negative sequence voltage amplitude, deadband value |
| U2_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Negative sequence voltage amplitude range |
| U1_INST | FLOAT32 | 0.00...4.00 | xUn | Positive sequence voltage amplitude, instantaneous value |
| U1_ANGL | FLOAT32 | -180.00...180.00 | deg | Positive sequence voltage angle |
| U1_DB | FLOAT32 | 0.00...4.00 | xUn | Positive sequence voltage amplitude, deadband value |
| U1_RANGE | Enum | 0=normal<br>1=high<br>2=low<br>3=high-high<br>4=low-low | | Positive sequence voltage amplitude range |
| U0_INST | FLOAT32 | 0.00...4.00 | xUn | Zero sequence voltage amplitude, instantaneous value |
| U0_ANGL | FLOAT32 | -180.00...180.00 | deg | Zero sequence voltage angle |
| U0_DB | FLOAT32 | 0.00...4.00 | xUn | Zero sequence voltage amplitude, deadband value |
| U0_RANGE | Enum | 0=normal<br>1=high | | Zero sequence voltage amplitude range |

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 2=low<br>3=high-high<br>4=low-low | | |

### 8.1.12.8 Technical data

**Table 1428: VSMSQI Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz<br>At voltages in range 0.01…1.15 × $U_n$ |
| | ±1.0 % or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

## 8.1.13 Three-phase power and energy measurement PEMMXU (ANSI P, E)

### 8.1.13.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-phase power and energy measurement | PEMMXU | P, E | P, E |

### 8.1.13.2 Function block

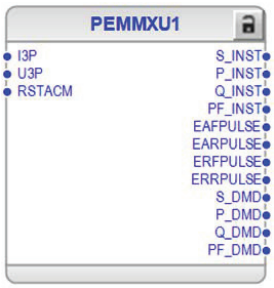



*Figure 815: Function block*

### 8.1.13.3 Functionality

The three-phase power and energy measurement function PEMMXU calculates energy and power from the available current and voltage inputs. The function stores the accumulated values of the real and reactive energy in both directions, and presents these values as numerical and pulse outputs.

PEMMXU provides pulse outputs EAFPULSE, EARPULSE, ERFPULSE and ERRPULSE which are activated based on the calculated values of forward and reverse, active and reactive accumulated energy. The activation of the pulse depends on the *Pulse quantity* setting. For example, if *Pulse quantity* is set as "10000" Wh, EAFPULSE is activated every time accumulated energy EA_FWD_ACM increases by 10000 Wh. The pulse-on and -off time duration can be set using the *Pulse on time* and *Pulse off time* settings.

Instantaneous three-phase power and power factor measurements are available for application configurations through output S_INST, P_INST, Q_INST and PF_INST.

Three-phase power and power factor demand values (S_DMD, P_DMD, Q_DMD and PF_DMD) are provided as outputs. These outputs are dedicated for Load profile recorder (LDPRLRC).

### 8.1.13.4 Analog channel configuration

PEMMXU has two analog group inputs which all must be properly configured.

**Table 1429: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1430: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with the corresponding one voltage channel connected if *Measurement mode* is set to "PhsAB", "PhsBC" or "PhsCA". |
| | The function can work with the corresponding two voltage channels connected if *Measurement mode* is set to "PhsA", "PhsB" or "PhsC". |
| | The function requires that all three voltage channels are connected for the other measurement modes. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 8.1.13.5 Signals

**PEMMXU Input signals**

**Table 1431: PEMMXU Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| RSTACM | BOOLEAN | 0=False | Reset of accumulated energy reading |

**PEMMXU Output signals**

**Table 1432: PEMMXU Output signals**

| Name | Type | Description |
|---|---|---|
| S_INST | FLOAT32 | Apparent power, magnitude of instantaneous value in kVA |
| P_INST | FLOAT32 | Active power, magnitude of instantaneous value in kW |
| Q_INST | FLOAT32 | Reactive power, magnitude of instantaneous value in kvar |
| PF_INST | FLOAT32 | Power factor, magnitude of instantaneous value |
| EAFPULSE | SIGNAL | Accumulated forward active energy pulse |
| EARPULSE | SIGNAL | Accumulated reverse active energy pulse |
| ERFPULSE | SIGNAL | Accumulated forward reactive energy pulse |
| ERRPULSE | SIGNAL | Accumulated reverse reactive energy pulse |
| S_DMD | FLOAT32 | Demand value of apparent power |
| P_DMD | FLOAT32 | Demand value of active power |
| Q_DMD | FLOAT32 | Demand value of reactive power |
| PF_DMD | FLOAT32 | Demand value of power factor |

### 8.1.13.6 PEMMXU Settings

**Table 1433: PEMMXU Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on | | | 1=on | Operation Off / On |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 5=off | | | | |
| Power unit Mult | 3=k<br>6=M | | | 3=k | Unit multiplier for presentation of the power related values |
| Energy unit Mult | 3=k<br>6=M | | | 3=k | Unit multiplier for presentation of the energy related values |
| Active power Dir | 1=Forward<br>2=Reverse | | | 1=Forward | Direction of active power flow: Forward, Reverse |
| Reactive power Dir | 1=Forward<br>2=Reverse | | | 1=Forward | Direction of reactive power flow: Forward, Reverse |
| Power deadband | 1000...10000 | | 1 | 10000 | Deadband configuration value for integral calculation. (percentage of Sn as 0,001 % s) |
| Pulse quantity | 1...10000000 | Wh/VArh | 1 | 100000 | Pulse quantity for the energy pulse outputs |

**Table 1434: PEMMXU Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Forward Wh Initial | 0...999999999 | | 1 | 0 | Preset Initial value for forward active energy |
| Reverse Wh Initial | 0...999999999 | | 1 | 0 | Preset Initial value for reverse active energy |
| Forward VArh Initial | 0...999999999 | | 1 | 0 | Preset Initial value for forward reactive energy |
| Reverse VArh Initial | 0...999999999 | | 1 | 0 | Preset Initial value for reverse reactive energy |
| Measurement mode | 1=PhsA, PhsB, PhsC<br>2=Arone<br>3=Pos Seq<br>4=PhsAB<br>5=PhsBC<br>6=PhsCA<br>7=PhsA<br>8=PhsB<br>9=PhsC | | | 1=PhsA, PhsB, PhsC | Selected measurement mode for power calculation |
| Pulse on time | 0.050...60.000 | s | 0.001 | 1.000 | Energy accumulated pulse ON time in secs |
| Pulse off time | 0.050...60.000 | s | 0.001 | 0.500 | Energy accumulated pulse OFF time in secs |

### 8.1.13.7 PEMMXU Monitored data

**Table 1435: PEMMXU Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| S-kVA:1 | FLOAT32 | -999999.9...999999.9 | kVA | Total Apparent Power |
| P-kW:1 | FLOAT32 | -999999.9...999999.9 | kW | Total Active Power |
| Q-kVAr:1 | FLOAT32 | -999999.9...999999.9 | kVAr | Total Reactive Power |
| PF:1 | FLOAT32 | -1.00...1.00 | | Average Power factor |
| RSTACM | BOOLEAN | 0=False<br>1=True | | Reset of accumulated energy reading |
| S_INST | FLOAT32 | -999999.9...999999.9 | kVA | Apparent power, magnitude of instantaneous value |
| S_DB | FLOAT32 | -999999.9...999999.9 | kVA | Apparent power, magnitude of deadband value |
| S_DMD | FLOAT32 | -999999.9...999999.9 | kVA | Demand value of apparent power |
| P_INST | FLOAT32 | -999999.9...999999.9 | kW | Active power, magnitude of instantaneous value |
| P_DB | FLOAT32 | -999999.9...999999.9 | kW | Active power, magnitude of deadband value |
| P_DMD | FLOAT32 | -999999.9...999999.9 | kW | Demand value of active power |
| Q_INST | FLOAT32 | -999999.9...999999.9 | kVAr | Reactive power, magnitude of instantaneous value |
| Q_DB | FLOAT32 | -999999.9...999999.9 | kVAr | Reactive power, magnitude of deadband value |
| Q_DMD | FLOAT32 | -999999.9...999999.9 | kVAr | Demand value of reactive power |
| PF_INST | FLOAT32 | -1.00...1.00 | | Power factor, magnitude of instantaneous value |
| PF_DB | FLOAT32 | -1.00...1.00 | | Power factor, magnitude of deadband value |
| PF_DMD | FLOAT32 | -1.00...1.00 | | Demand value of power factor |
| EA_RV_ACM | INT64 | 0...999999999 | kWh | Accumulated reverse active energy value |
| ER_RV_ACM | INT64 | 0...999999999 | kVArh | Accumulated reverse reactive energy value |
| EA_FWD_ACM | INT64 | 0...999999999 | kWh | Accumulated forward active energy value |
| ER_FWD_ACM | INT64 | 0...999999999 | kVArh | Accumulated forward reactive energy value |
| Max demand S | FLOAT32 | -999999.9...999999.9 | kVA | Maximum demand value of apparent power |
| Min demand S | FLOAT32 | -999999.9...999999.9 | kVA | Minimum demand value of apparent power |
| Max demand P | FLOAT32 | -999999.9...999999.9 | kW | Maximum demand value of active power |
| Min demand P | FLOAT32 | -999999.9...999999.9 | kW | Minimum demand value of active power |
| Max demand Q | FLOAT32 | -999999.9...999999.9 | kVAr | Maximum demand value of reactive power |
| Min demand Q | FLOAT32 | -999999.9...999999.9 | kVAr | Minimum demand value of reactive power |
| Time max dmd S | Timestamp | | | Time of maximum demand |
| Time min dmd S | Timestamp | | | Time of minimum demand |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Time max dmd P | Timestamp | | | Time of maximum demand |
| Time min dmd P | Timestamp | | | Time of minimum demand |
| Time max dmd Q | Timestamp | | | Time of maximum demand |
| Time min dmd Q | Timestamp | | | Time of minimum demand |

### 8.1.13.8 Technical data

**Table 1436: PEMMXU Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy [1] | At all three currents in range 0.10…1.20 × $I_n$<br>At all three voltages in range 0.50…1.15 × $U_n$<br>At the frequency $f_n$ ±1 Hz |
| | ±1.5 % for apparent power S<br>±1.5 % for active power P and active energy [2]<br>±1.5 % for reactive power Q and reactive energy [3]<br>±0.015 for power factor |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

# 8.2 Disturbance recorder, common functionality RDRE (ANSI DFR)

## 8.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Disturbance recorder, common functionality | RDRE | DR | DFR |

[1] *Measurement mode* = "Pos Seq" (default)
[2] |PF| >0.5 which equals |cosϕ| >0.5
[3] |PF| <0.86 which equals |sinϕ| >0.5

## 8.2.2 Function block




*Figure 816: Function block*

## 8.2.3 Functionality

The protection relay is provided with a disturbance recorder featuring up to 24 analog and 64 binary signal channels. The analog channels can be set to record either the waveform or the trend of the currents and voltages measured and they can trigger the recording function when the measured value falls below or exceeds the set values.

The binary signal channels can be set to start a recording either on the rising or the falling edge of the binary signal or on both. By default, the binary channels are set to record external or internal relay signals, for example, the start or trip signals of the relay stages, or external blocking or control signals. Binary relay signals, such as protection start and trip signals, or an external relay control signal via a binary input can be set to trigger the recording. Recorded information is stored in a nonvolatile memory and can be uploaded for subsequent fault analysis.

### 8.2.3.1 Recorded analog and binary inputs

The relay's analog and binary signals for disturbance recorder can be configured with Application Configuration in PCM600. In addition, each channel of the disturbance recorder can be enabled or disabled by setting the *Operation* parameter of the corresponding channel to "on" or "off".

All channels of the disturbance recorder that are enabled and have a valid signal connected are included in the recording.

### 8.2.3.2 Triggering alternatives

The recording can be triggered by any of the following alternatives.

- Triggering according to the state change of any of the binary channels of the disturbance recorder. The level sensitivity can be set with the *Level trigger mode* parameter of the corresponding binary channel.
- Triggering on limit violations of the analog channels of the disturbance recorder (high and low limit)
- Manual triggering via the *Trig recording* parameter (LHMI or communication)
- Periodic triggering

Regardless of the triggering type, each recording generates the Recording started and Recording made events. The Recording made event indicates that the recording has been stored to the nonvolatile memory. In addition, every analog channel and binary channel of the disturbance recorder has its own *Channel triggered* parameter. Manual trigger has the *Manual triggering* parameter and periodic trigger has the *Periodic triggering* parameter.

#### Triggering by binary channels

The input signals for the binary channels of the disturbance recorder can be formed from any of the digital signals that can be dynamically mapped. A change in the status of a monitored signal triggers the recorder according to the configuration and settings. Triggering on the rising edge of a digital input signal means that the recording sequence starts when the input signal is activated. Correspondingly, triggering on the falling edge means that the recording sequence starts when the active input signal resets. It is also possible to trigger from both edges. In addition, the monitored signal can be non-triggering. The trigger setting can be set individually for each binary channel of the disturbance recorder with the *Level trigger mode* parameter of the corresponding binary channel.

#### Triggering by analog channels

The trigger level can be set for triggering in a limit violation situation. The user can set the limit values with the *High trigger level* and *Low trigger level* parameters of the corresponding analog channel. Both high level and low level violation triggering can be active simultaneously for the same analog channel. If the duration of the limit violation condition exceeds the filter time of approximately 50 ms, the recorder triggers. In case of a low level limit violation, if the measured value falls below approximately 0.05 during the filter time, the situation is considered to be a circuit-breaker operation and therefore, the recorder does not trigger. This is useful especially in undervoltage situations. The filter time of approximately 50 ms is common to all the analog channel triggers of the disturbance recorder. The value used for triggering is the calculated peak-to-peak value. Either high or low analog channel trigger can be disabled by setting the corresponding trigger level parameter to zero.



Frequency cannot be used as a trigger to disturbance recorder.

#### Manual triggering

The recorder can be triggered manually via the LHMI or via communication by setting the *Trig recording* parameter to "Trig".

#### Periodic triggering

Periodic triggering means that the recorder automatically makes a recording at certain time intervals. The interval can be adjusted with the *Periodic trig time* parameter. If the value of the parameter is changed, the new setting takes effect when the next periodic triggering occurs. Setting the parameter to zero disables the triggering alternative and the setting becomes valid immediately. If a new non-zero setting needs to be valid immediately, the *Periodic trig time* parameter should first be set to zero and then to the new value. The time remaining to the next triggering can be monitored with the Time to trigger monitored data which counts downwards.

### 8.2.3.3 Length of recordings

The recording length can be defined with the *Record length* parameter. The length is given as the number of fundamental cycles.

According to the memory available and the number of analog channels used, the disturbance recorder automatically calculates the remaining number of recordings

that fit into the available recording memory. This information can be seen with the Rem. amount of rec. monitored data. The fixed memory size allocated to the recorder can fit in two recordings that are ten seconds long. The recordings contain data from all analog and binary channels of the disturbance recorder, at the sample rate of 32 samples per fundamental cycle.

The number of recordings in the memory can be viewed with the Number of recordings monitored data. The used memory space can be viewed with the Rec. memory used monitored data. It is shown as a percentage value.

The maximum number of recordings is 100.

### 8.2.3.4 Sampling frequencies

The sampling frequency of the disturbance recorder analog channels depends on the set rated frequency. One fundamental cycle always contains the number of samples set with the *Storage rate* parameter. Since the states of the binary channels are sampled once per task execution of the disturbance recorder, the sampling frequency of binary channels is 400 Hz at the rated frequency of 50 Hz and 480 Hz at the rated frequency of 60 Hz.

**Table 1437: Sampling frequencies of the disturbance recorder analog and binary channels**

| Storage rate (samples per fundamental cycle) | Recording length | Rated frequency = 50 Hz | | Rated frequency = 60 Hz | |
|---|---|---|---|---|---|
| | | Sampling frequency of analog channels | Sampling frequency of binary channels | Sampling frequency of analog channels | Sampling frequency of binary channels |
| 32 | 1 · Record length | 1600 Hz | 400 Hz | 1920 Hz | 480 Hz |
| 16 | 2 · Record length | 800 Hz | 400 Hz | 960 Hz | 480 Hz |
| 8 | 4 · Record length | 400 Hz | 400 Hz | 480 Hz | 480 Hz |

### 8.2.3.5 Uploading of recordings

The protection relay stores COMTRADE files to the `C:\COMTRADE` folder. The files can be uploaded with PCM600 or any appropriate computer software that can access the `C:\COMTRADE` folder.

One complete disturbance recording consists of two COMTRADE file types: the configuration file and the data file. The file name is the same for both file types. The configuration file has .CFG and the data file .DAT as the file extension.

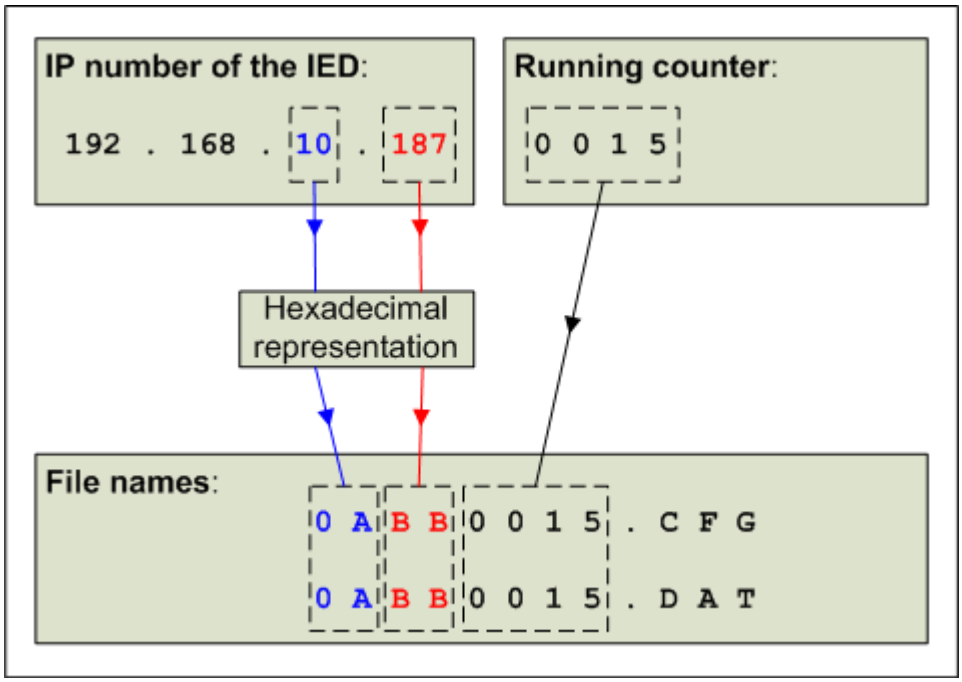



*Figure 817: Disturbance recorder file naming*

The naming convention of 8+3 characters is used in COMTRADE file naming. The file name is composed of the last two octets of the protection relay's IP number and a running counter, which has a range of 1...9999. A hexadecimal representation is used for the IP number octets. The appropriate file extension is added to the end of the file name.

### 8.2.3.6 Deletion of recordings

The recordings can be deleted individually or all at once.

Individual disturbance recordings can be deleted with PCM600 or any appropriate computer software, which can access the protection relay's `C:\COMTRADE` folder. The disturbance recording is not removed from the protection relay's memory until both of the corresponding COMTRADE files, .CFG and .DAT, are deleted. Both file types may need to be deleted separately, depending on the software used.

Deleting all disturbance recordings at once is done either with PCM600 or any appropriate computer software, or from the LHMI via the **Clear** > **Disturbance records** menu. Deleting all disturbance recordings at once also clears the pre-trigger recording in progress.

### 8.2.3.7 Storage mode

The disturbance recorder can capture data in two modes: waveform and trend mode. The storage mode can be set individually for each trigger source with the *Storage mode* parameter of the corresponding analog channel or binary channel, the *Stor. mode manual* parameter for manual trigger and the *Stor. mode periodic* parameter for periodic trigger.

In the waveform mode, the samples are captured according to the *Storage rate* and *Pre-trg length* parameters.

In the trend mode, one value is recorded for each enabled analog channel, once per fundamental cycle. The recorded values are RMS values, which are scaled to peak level. The binary channels of the disturbance recorder are also recorded once per fundamental cycle in the trend mode.



Only post-trigger data is captured in trend mode.

The trend mode enables recording times of 32 * *Record length*.

### 8.2.3.8 Pre-trigger and post-trigger data

The waveforms of the disturbance recorder analog channels and the states of the disturbance recorder binary channels are constantly recorded into the history memory of the recorder. The percentage of the data duration preceding the triggering, that is, the pre-trigger time, can be adjusted with the *Pre-trg length* parameter. The duration of the data following the triggering, that is, the post-trigger time, is the difference between the recording length and the pre-trigger time. Changing the pre-trigger time resets the history data and the current recording under collection.

### 8.2.3.9 Operation modes

The disturbance recorder has two operation modes: saturation and overwrite mode. The operation mode of the disturbance recorder can be changed with the *Operation mode* parameter.

#### Saturation mode

In saturation mode, the captured recordings cannot be overwritten with new recordings. Capturing the data is stopped when the recording memory is full, that is, when the maximum number of recordings is reached. In this case, the event is sent via the state change (TRUE) of the *Memory full* parameter. When there is memory available again, another event is generated via the state change (FALSE) of the *Memory full* parameter.

#### Overwrite mode

In the overwrite mode, if the recording memory is full, the oldest recording is overwritten with the pre-trigger data collected for the next recording. Each time a recording is overwritten, the event is generated via the state change of the *Overwrite of rec.* parameter.

The overwrite mode is recommended if it is important to have the latest recordings in the memory. The saturation mode is preferred when the oldest recordings are more important.

New triggerings are blocked in both modes until the previous recording is completed, but a new triggering can be accepted before all pre-trigger samples are collected for the new recording. In such a case, the recording is as much shorter as there are pre-trigger samples lacking.

### 8.2.3.10 Exclusion mode

Exclusion mode is on when the value of the *Exclusion time* parameter is higher than zero. During the exclusion mode, new triggerings are ignored if the triggering reason is the same as in the previous recording. The *Exclusion time* parameter controls how long the exclusion of triggerings of same type is active after a triggering. The exclusion mode applies only to the analog and binary channel triggerings, not to periodic and manual triggerings.

When the value set with the *Exclusion time* parameter is zero, the exclusion mode is disabled and there are no restrictions on the triggering types of the successive recordings.

The exclusion time setting is global for all inputs, but there is an individual counter for each analog and binary channel of the disturbance recorder, counting the remaining exclusion time. The remaining exclusion time can be monitored with the *Exclusion time rem* parameter (only visible via communication, IEC 61850 data ExclTmRmn) of the corresponding analog or binary channel. The *Exclusion time rem* parameter counts downwards.

## 8.2.4 Configuration

The disturbance recorder can be configured with PCM600 or any tool supporting the IEC 61850 standard.

RDRE1 should always be included in Application Configuration when the disturbance recorder is used.

The disturbance recorder can be enabled or disabled with the *Operation* parameter under the **Configuration** > **Disturbance recorder** > **General** menu.

One analog signal type of the protection relay can be mapped to each of the analog channels of the disturbance recorder. The mapping is done in Application Configuration in PCM600. The name of the analog channel is user-configurable. It can be modified by defining a new name to the *Channel id text* parameter of the corresponding analog channel. *Channel id text* can be edited in Application Configuration by selecting the input channel and defining a new *Instance Name* for the channel in the Object Properties window.

Any external or internal digital signal of the protection relay which can be dynamically mapped can be connected to the binary channels of the disturbance recorder. These signals can be, for example, the start and trip signals from protection function blocks or the external binary inputs of the protection relay. The connection is made with dynamic mapping to the binary channel of the disturbance recorder using, for example, Signal Matrix of PCM600. It is also possible to connect several digital signals to one binary channel of the disturbance recorder. In that case, the signals can be combined with logical functions, for example AND and OR. The name of the binary channel can be modified by defining a new name to the *Channel id text* parameter of the corresponding channel. *Channel id text* can be edited in Application Configuration by selecting the input channel and defining a new *Instance Name* for the channel in the Object Properties window.

The *Channel id text* parameter is used in COMTRADE configuration files as a channel identifier.

The recording always contains all binary channels of the disturbance recorder. If one of the binary channels is disabled, the recorded state of the channel is continuously FALSE and the state changes of the corresponding channel are not recorded. The corresponding channel name for disabled binary channels in the COMTRADE configuration file is Unused BI.

To enable or disable an analog or a binary channel of the disturbance recorder, the *Operation* parameter of the corresponding analog or binary channel is set to "on" or "off".

The states of manual triggering and periodic triggering are not included in the recording, but they create a state change to the *Periodic triggering* and *Manual triggering* status parameters, which in turn create events.

The TRIGGERED output can be used to control the indication LEDs of the protection relay. The triggering of the disturbance recorder sets the TRIGGERED output to TRUE. The output remains in this state until all the data for the corresponding recording has been recorded.

The IP number of the protection relay and the value of the *Bay name* parameter are both included in the COMTRADE configuration file for identification purposes.

## 8.2.5 Application

The disturbance recorder is used for post-fault analysis and for verifying the correct operation of protection relays and circuit breakers. It can record both analog and binary signal information. The analog inputs are recorded as instantaneous values and converted to primary peak value units when the protection relay converts the recordings to the COMTRADE format.

COMTRADE is the general standard format used for storing disturbance recordings.

The binary channels are sampled once per task execution of the disturbance recorder. The task execution interval for the disturbance recorder is the same as for the protection functions. During the COMTRADE conversion, the digital status values are repeated so that the sampling frequencies of the analog and binary channels correspond to each other. This is required by the COMTRADE standard.

The disturbance recorder follows the 1999 version of the COMTRADE standard and uses the binary data file format.

## 8.2.6 Signals

**Table 1438: RDRE Output signals**

| Name | Type | Description |
|---|---|---|
| TRIGGERED | BOOLEAN | Recording started |

## 8.2.7 Settings

**Table 1439: RDRE Non group general settings (basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | 1 | 1=on | Disturbance recorder on/off |
| Record length | 10...500 | fundamental cycles | 1 | 50 | Size of the recording in fundamental cycles |
| Pre-trg length | 0...100 | % | 1 | 50 | Length of the recording preceding the triggering |

**Table 1440: RDRE Non group general settings (advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation mode | 1=Saturation<br>2=Overwrite | | 1 | 1 | Operation mode of the recorder |
| Exclusion time | 0...1 000 000 | ms | 1 | 0 | The time during which triggerings of same type are ignored |
| Storage rate | 32, 16, 8 | samples per fundamental cycle | | 32 | Storage rate of the waveform recording |
| Periodic trig time | 0...604 800 | s | 10 | 0 | Time between periodic triggerings |
| Stor. mode periodic | 0=Waveform<br>1=Trend / cycle | | 1 | 0 | Storage mode for periodic triggering |
| Stor. mode manual | 0=Waveform<br>1=Trend / cycle | | 1 | 0 | Storage mode for manual triggering |

**Table 1441: RDRE Control data (basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Trig recording | 0=Cancel<br>1=Trig | | | 0=Cancel | Trigger the disturbance recording |
| Clear recordings | 0=Cancel<br>1=Trig | | | 0=Cancel | Clear all recordings currently in memory |

## 8.2.8 Monitored data

**Table 1442: RDRE Monitored data**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Number of recordings | 0...100 | | | | Number of recordings currently in memory |
| Rem. amount of rec. | 0...100 | | | | Remaining amount of recordings that |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | | | | | fit into the available recording memory, when current settings are used |
| Rec. memory used | 0...100 | % | | | Storage mode for the binary channel |
| Time to trigger | 0...604 800 | s | | | Time remaining to the next periodic triggering |

# 8.3 Disturbance recorder, analog channels 1...24 A1RADR and A2RADR

## 8.3.1 Function block




*Figure 818: Function block*

## 8.3.2 Signals

The input signal tables for A1RADR and A2RADR are similar except for the channel numbers.

- A1RADR, CH1...CH12
- A2RADR, CH13...CH24

**Table 1443: A1RADR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| CH1 | SIGNAL | | Signal for input 1 |

Values are the same for each input signal. The channel numbers are shown after the parameter name in the HMI and PCM600.

### 8.3.3 Settings

Setting tables for all A1RADR and A2RADR channels are similar except for the channel numbers.

**Table 1444: A1RADR Non group general settings (basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Analog channel on / off |
| Channel id text | | | | Analog ch 1 input | Channel identifier text |
| High trigger level | 0.00...60.00 | | 0.01 | 10 | Over limit |
| Low trigger level | 0.00...2.00 | | 0.01 | 0 | Under limit |

**Table 1445: A1RADR Non group general settings (advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Storage mode | 0=Waveform<br>1=Trend / cycle | | | 0 | Storage mode selection (waveform / trend) |

## 8.4 Disturbance recorder, binary channels 1...64 B1RBDR and B2RBDR

## 8.4.1 Function block

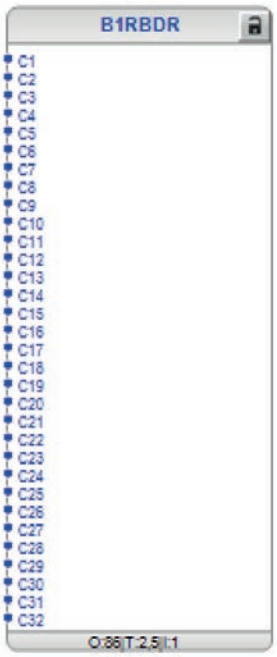



*Figure 819: Function block*

## 8.4.2 Signals

The input signal tables for B1RBDR and B2RBDR are similar except for the channel numbers.

- B1RBDR, C1...C32
- B2RBDR, C33...C64

**Table 1446: B1RBDR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| C1 | BOOLEAN | 0=False | Signal for input 1 |

Values are the same for each input signal. The channel numbers are shown after the parameter name in the HMI and PCM600.

## 8.4.3 Settings

Setting tables for all B1RBDR and B2RBDR channels are similar except for the channel numbers.

**Table 1447: B1RBDR Non group general settings (basic) Parameter Values (Range) Unit Step**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on | | | 5=off | Binary channel on / off |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 5=off | | | | |
| Level trigger mode | 1=Positive or Rising<br>2=Negative or Falling<br>3=Both<br>4=Level trigger off | | | 1=Positive or Rising | Rising / falling / both / trigger off |

**Table 1448: B1RBDR Non group general settings (advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Storage mode | 0=Waveform<br>1=Trend / cycle | | | 0=Waveform | Storage mode selection (waveform / trend) |
| Channel id text | | | | Binary ch 1 input | Channel identifier text |

# 8.5 Tap changer position indication TPOSYLTC (ANSI 84T)

## 8.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Tap changer position indication | TPOSYLTC | TPOSM | 84T |

## 8.5.2 Function block

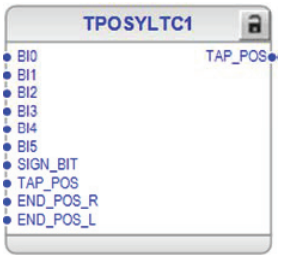



*Figure 820: Function block*

## 8.5.3 Functionality

The tap changer position indication function TPOSYLTC is used for transformer tap position supervision. The binary inputs can be used for converting a binary-coded tap changer position to a tap position status indication. The RTD module, available as an option, provides the RTD sensor information to be used and the versatile analog inputs enabling the tap position supervision through mA.

There are three user-selectable conversion modes available for the 7-bit binary inputs where MSB is used as the SIGN bit: the natural binary-coded boolean input to the signed integer output, binary coded decimal BCD input to the signed integer output and binary reflected GRAY coded input to the signed integer output.

## 8.5.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off". When the function is disabled, the tap position quality information is changed accordingly. When the tap position information is not available, it is recommended to disable this function with the *Operation* setting.

The operation of TPOSYLTC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

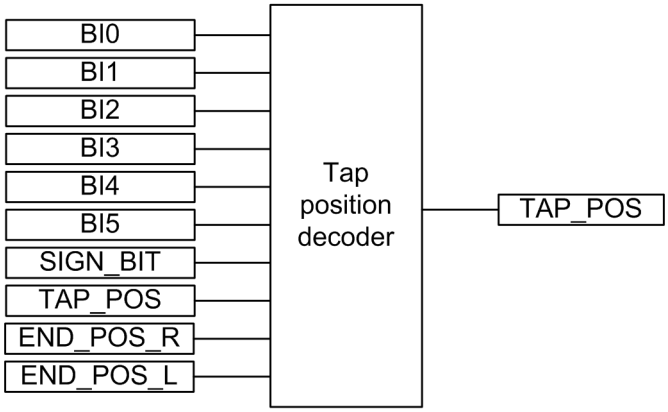



*Figure 821: Functional module diagram*

**Tap position decoder**

When there is a wired connection to the TAP_POS input connector, the corresponding tap changer position is decoded from the mA or RTD input. When there is no wired connection to the TAP_POS connector, the binary inputs are expected to be used for the tap changer position information. The tap changer position value and quality are internally shared to other functions. The value is available in the Monitored data view or as a TAP_POS output signal.

The function has three alternative user selectable operation modes: "NAT2INT", "BCD2INT" and "GRAY2INT". The operation mode is selected with the *Operation mode* setting. Each operation mode can be used to convert a maximum of 6–bit coded input to an 8–bit signed short integer output. For less than 6–bit input, for example 19 positions with 5 bits when the BCD coding is used, the rest of the bits can be set to FALSE (0).

The operation mode "NAT2INT" is selected when the natural binary coding is used for showing the position of the transformer tap changer. The basic principle of the natural binary coding is to calculate the sum of the bits set to TRUE (1). The LSB has the factor 1. Each following bit has the previous factor multiplied by 2. This is also called dual coding.

The operation mode "BCD2INT" is selected when the binary-coded decimal coding is used for showing the position of the transformer tap changer. The basic principle

with the binary-coded decimal coding is to calculate the sum of the bits set to TRUE (1). The four bits nibble (BI3...BI0) have a typical factor to the natural binary coding. The sum of the values should not be more than 9. If the nibble sum is greater than 9, the tap position output validity is regarded as bad.

The operation mode “GRAY2INT” is selected when the binary-reflected Gray coding is used for showing the position of the transformer tap changer. The basic principle of the Gray coding is that only one actual bit changes value with consecutive positions. This function is based on the common binary-reflected Gray code which is used with some tap changers. Changing the bit closest to the right side bit gives a new pattern.

An additional separate input, SIGN_BIT, can be used for negative values. If the values are positive, the input is set to FALSE (0). If the SIGN_BIT is set to TRUE (1) making the number negative, the remaining bits are identical to those of the coded positive number.

The tap position validity is set to good in all valid cases. The quality is set to bad in invalid combinations in the binary inputs. For example, when the “BCD2INT” mode is selected and the input binary combination is “0001101”, the quality is set to bad. For negative values, when the SIGN_BIT is set to TRUE (1) and the input binary combination is “1011011”, the quality is set to bad.

If the tap changer has auxiliary contacts for indicating the extreme positions of the tap changer, their status can be connected to END_POS_R and END_POS_L inputs. The END_POS_R (End position raise or highest allowed tap position reached) status refers to the extreme position that results in the highest number of the taps in the tap changer. Similarly, END_POS_L (End position lower or lowest allowed tap position reached) status refers to the extreme position that results in the lowest number of the taps in the tap changer. TAP_POS output is dedicated for transferring the validated tap position for the functions that need tap position information, for example OL5ATCC and TRxPTDF. It includes both the actual position information and the status of reached end positions, assuming that inputs END_POS_R and END_POS_L are connected.

**Table 1449: Truth table of the decoding modes**

| **Inputs** | | | | | | | **TAP_POS outputs** | | |
|---|---|---|---|---|---|---|---|---|---|
| SIGN_BIT | BI5 | BI4 | BI3 | BI2 | BI1 | BI0 | NAT2INT | BCD2INT | GRAY2INT |
| ... | | ... | | ... | | ... | ... | ... | ... |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | -3 | -3 | -2 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | -2 | -2 | -3 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | -1 | -1 | -1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 3 |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 3 | 2 |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 4 | 7 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | 5 | 5 | 6 |
| 0 | 0 | 0 | 0 | 1 | 1 | 0 | 6 | 6 | 4 |

*Table continues on the next page*

| Inputs | | | | | | | TAP_POS outputs | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 7 | 7 | 5 |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 8 | 8 | 15 |
| 0 | 0 | 0 | 1 | 0 | 0 | 1 | 9 | 9 | 14 |
| 0 | 0 | 0 | 1 | 0 | 1 | 0 | 10 | 9 | 12 |
| 0 | 0 | 0 | 1 | 0 | 1 | 1 | 11 | 9 | 13 |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 | 12 | 9 | 8 |
| 0 | 0 | 0 | 1 | 1 | 0 | 1 | 13 | 9 | 9 |
| 0 | 0 | 0 | 1 | 1 | 1 | 0 | 14 | 9 | 11 |
| 0 | 0 | 0 | 1 | 1 | 1 | 1 | 15 | 9 | 10 |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 16 | 10 | 31 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 17 | 11 | 30 |
| 0 | 0 | 1 | 0 | 0 | 1 | 0 | 18 | 12 | 28 |
| 0 | 0 | 1 | 0 | 0 | 1 | 1 | 19 | 13 | 29 |
| 0 | 0 | 1 | 0 | 1 | 0 | 0 | 20 | 14 | 24 |
| 0 | 0 | 1 | 0 | 1 | 0 | 1 | 21 | 15 | 25 |
| 0 | 0 | 1 | 0 | 1 | 1 | 0 | 22 | 16 | 27 |
| 0 | 0 | 1 | 0 | 1 | 1 | 1 | 23 | 17 | 26 |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | 24 | 18 | 16 |
| 0 | 0 | 1 | 1 | 0 | 0 | 1 | 25 | 19 | 17 |
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 26 | 19 | 19 |
| 0 | 0 | 1 | 1 | 0 | 1 | 1 | 27 | 19 | 18 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 28 | 19 | 23 |
| 0 | 0 | 1 | 1 | 1 | 0 | 1 | 29 | 19 | 22 |
| 0 | 0 | 1 | 1 | 1 | 1 | 0 | 30 | 19 | 20 |
| 0 | 0 | 1 | 1 | 1 | 1 | 1 | 31 | 19 | 21 |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 32 | 20 | 63 |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 33 | 21 | 62 |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 34 | 22 | 60 |
| 0 | 1 | 0 | 0 | 0 | 1 | 1 | 35 | 23 | 61 |
| 0 | 1 | 0 | 0 | 1 | 0 | 0 | 36 | 24 | 56 |
| ... | | ... | | ... | | ... | ... | ... | ... |

## 8.5.5 Application

TPOSYLTC provides tap position information for other functions as a signed integer value that can be fed to the tap position input.

The position information of the tap changer can be coded in various methods for many applications, for example, the differential protection algorithms. In this function, the binary inputs in the transformer terminal connector are used as inputs to the function. The coding method can be chosen by setting the mode parameter. The available coding methods are BCD, Gray and Natural binary coding. Since the

number of binary inputs are limited to seven, the coding functions are limited to seven bits including the sign bit and thus the six bits are used in the coding functions. The position limits for the tap positions at BCD, Gray and Natural binary coding are ±39, ±63 and ±63 respectively.

In this example, the transformer tap changer position indication is wired as a mA signal from the corresponding measuring transducer. The position indication is connected to input 1 (AI_VAL1) of the (RTD) module. The tap changer operating range from the minimum to maximum turns of the tap and a corresponding mA signal for the tap position are set in the RTD module. Since the values of the RTD module outputs are floating point numbers, the float to integer (T_R_TO_I8) conversion is needed before the tap position information can be fed to TPOSYLTC. When there is a wired connection to the TAP_POS connector, the validated tap changer position is presented in the TAP_POS output that is connected to other functions, for example, OL5ATCC1. When there is no wired connection to the TAP_POS connector, the binary inputs are expected to be used for the tap changer position information.




*Figure 822: RTD/analog input configuration example*

## 8.5.6 Signals

### 8.5.6.1 TPOSYLTC Input signals

**Table 1450: TPOSYLTC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BI0 | BOOLEAN | 0=False | Binary input 1 |
| BI1 | BOOLEAN | 0=False | Binary input 2 |
| BI2 | BOOLEAN | 0=False | Binary input 3 |
| BI3 | BOOLEAN | 0=False | Binary input 4 |
| BI4 | BOOLEAN | 0=False | Binary input 5 |
| BI5 | BOOLEAN | 0=False | Binary input 6 |
| SIGN_BIT | BOOLEAN | 0=False | Binary input sign bit |
| END_POS_R | BOOLEAN | 0=False | End position raise or highest allowed tap position reached |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| END_POS_L | BOOLEAN | 0=False | End position lower or lowest allowed tap position reached |
| TAP_POS | INT8 | 0 | Tap position indication |

### 8.5.6.2 TPOSYLTC Output signals

**Table 1451: TPOSYLTC Output signals**

| Name | Type | Description |
|---|---|---|
| TAP_POS | INT8-TAPPOS | Tap position indication |

## 8.5.7 TPOSYLTC Settings

**Table 1452: TPOSYLTC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=NAT2INT<br>2=BCD2INT<br>3=GRAY2INT | | | 2=BCD2INT | Operation mode selection |

## 8.5.8 TPOSYLTC Monitored data

**Table 1453: TPOSYLTC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| BI0 | BOOLEAN | 0=False<br>1=True | | Binary input 1 |
| BI1 | BOOLEAN | 0=False<br>1=True | | Binary input 2 |
| BI2 | BOOLEAN | 0=False<br>1=True | | Binary input 3 |
| BI3 | BOOLEAN | 0=False<br>1=True | | Binary input 4 |
| BI4 | BOOLEAN | 0=False<br>1=True | | Binary input 5 |
| BI5 | BOOLEAN | 0=False<br>1=True | | Binary input 6 |
| SIGN_BIT | BOOLEAN | 0=False<br>1=True | | Binary input sign bit |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| END_POS_R | BOOLEAN | 0=False<br>1=True | | End position raise or highest allowed tap position reached |
| END_POS_L | BOOLEAN | 0=False<br>1=True | | End position lower or lowest allowed tap position reached |
| TAP_POS | INT8 | -63...63 | | Tap position indication |

## 8.5.9 Technical data

**Table 1454: TPOSYLTC Technical data**

| Description | Value |
|---|---|
| Response time for binary inputs | Typical 100 ms |

# 9 Control functions

## 9.1 Circuit breaker control CBXCBR, Disconnector control DCXSWI and Earthing switch control ESXSWI (ANSI 52, 29DS, 29GS)

### 9.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Circuit breaker control | CBXCBR | I<->O CB | 52 |
| Disconnector control | DCXSWI | I<->O DCC | 29DS |
| Earthing switch control | ESXSWI | I<->O ESC | 29GS |

### 9.1.2 Function block

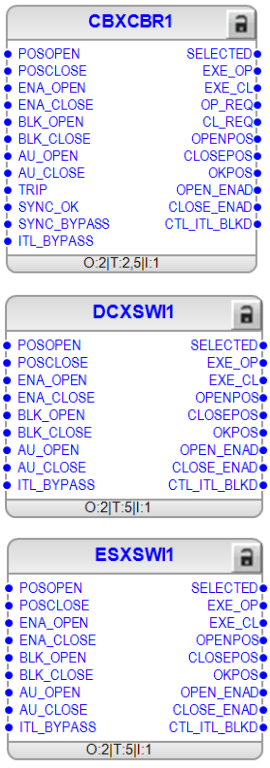



*Figure 823: Function block*

## 9.1.3 Functionality

CBXCBR, DCXSWI and ESXSWI are intended for circuit breaker, disconnector and earthing switch control and status information purposes. These functions execute commands and evaluate block conditions and different time supervision conditions. The functions perform an execution command only if all conditions indicate that a switch operation is allowed. If erroneous conditions occur, the functions indicate an appropriate cause value. The functions are designed according to the IEC 61850-7-4 standard with logical nodes CILO, CSWI and XSWI/XCBR.

The circuit breaker, disconnector and earthing switch control functions have an operation counter for closing and opening cycles. The counter value can be read and written remotely from the place of operation or via LHMI.

## 9.1.4 Operation principle

### Status indication and validity check

The object state is defined by two digital inputs, POSOPEN and POSCLOSE, which are also available as outputs OPENPOS and CLOSEPOS together with the OKPOS according to *Table 1455*. The debouncing and short disturbances in an input are eliminated by filtering. The binary input filtering time can be adjusted separately for each digital input used by the function block. The validity of the digital inputs that indicate the object state is used as additional information in indications and event logging. The reporting of faulty or intermediate position of the apparatus occurs after the *Event delay* setting, assuming that the circuit breaker is still in a corresponding state.

**Table 1455: Status indication**

| Input | | Status | Output | | |
|---|---|---|---|---|---|
| **POSOPEN** | **POSCLOSE** | **POSITION (Monitored data)** | **OKPOS** | **OPENPOS** | **CLOSEPOS** |
| 1=True | 0=False | 1=Open | 1=True | 1=True | 0=False |
| 0=False | 1=True | 2=Closed | 1=True | 0=False | 1=True |
| 1=True | 1=True | 3=Faulty/Bad (11) | 0=False | 0=False | 0=False |
| 0=False | 0=False | 0=Intermediate (00) | 0=False | 0=False | 0=False |

### Enabling and blocking

CBXCBR, DCXSWI and ESXSWI have an enabling and blocking functionality for interlocking and synchrocheck purposes.

### Circuit breaker control CBXCBR

Normally, the CB closing is enabled (that is, CLOSE_ENAD signal is TRUE) by activating both ENA_CLOSE and SYNC_OK inputs. Typically, the ENA_CLOSE comes from the interlocking, and SYNC_OK comes from the synchronism and energizing

check. The input ITL_BYPASS can be used for bypassing ENA_CLOSE input, while the SYNC_BYPASS can be used for bypassing SYNC_OK input. However, the BLK_CLOSE input always blocks the CLOSE_ENAD output. The CB opening (OPEN_ENAD) logic is the same as CB closing logic, except that SYNC_OK and SYNC_BYPASS are used only in closing.

The CB opening ( OPEN_ENAD) logic is the same as CB closing logic, except that SYNC_OK is used only in closing. The SYNC_ITL_BYP input is used in both CLOSE_ENAD and OPEN_ENAD logics.

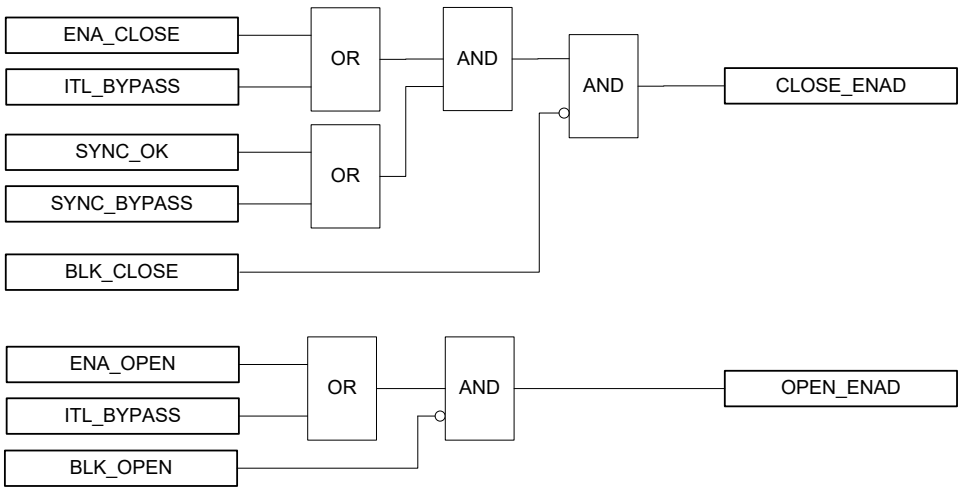



*Figure 824: Enabling and blocking logic for CLOSE_ENAD and OPEN_ENAD signals*

**Disconnector control DCXSWI and earthing switch control ESXSWI**

Normally, the switch closing is enabled (that is, the CLOSE_ENAD signal is TRUE) by activating the ENA_CLOSE input. The input ITL_BYPASS can be used for bypassing this control. The ITL_BYPASS input can be used to activate the CLOSE_ENAD discarding the ENA_CLOSE input state. However, the BLK_CLOSE input always blocks the CLOSE_ENAD output.

The CB opening ( OPEN_ENAD) logic is identical to CB closing logic. The ITL_BYPASS input is used in both CLOSE_ENAD and OPEN_ENAD logics.

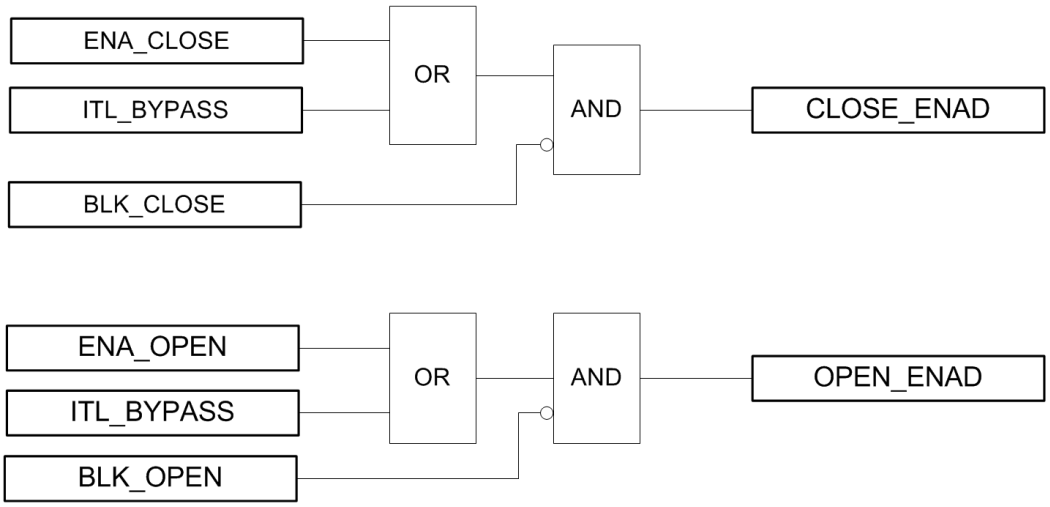



*Figure 825: Enabling and blocking logic for CLOSE_ENAD and OPEN_ENAD signals*

**Opening and closing operations**

The opening and closing operations are available via communication, binary inputs or LHMI commands. As a prerequisite for control commands, there are enabling and blocking functionalities for both opening and closing commands ( CLOSE_ENAD and OPEN_ENAD signals). If the control command is executed against the blocking or if the enabling of the corresponding command is not valid, CBXCBR, DCXSWI and ESXSWI generate an error message. If the control is inhibited due to interlocking conditions the pulse output CTL_ITL_BLKD is activated. The length of the pulse is defined by the *Interlocking Pls Len* setting.

When close command is given from communication, via LHMI or activating the AU_CLOSE input, it is carried out (the EXE_CL output) only if CLOSE_ENAD is TRUE.

If the SECRSYN function is used in “Command” mode, the CL_REQ output can be used in CBXCBR. Initially, the SYNC_OK input is FALSE. When the close command given, it activates the CL_REQ output, which should be routed to SECRSYN. The close command is then processed only after SYNC_OK is received from SECRSYN.

When using SECRSYN in the “Command” mode, the CBXCBR setting *Operation timeout* should be set longer than SECRSYN setting *Maximum Syn time*.

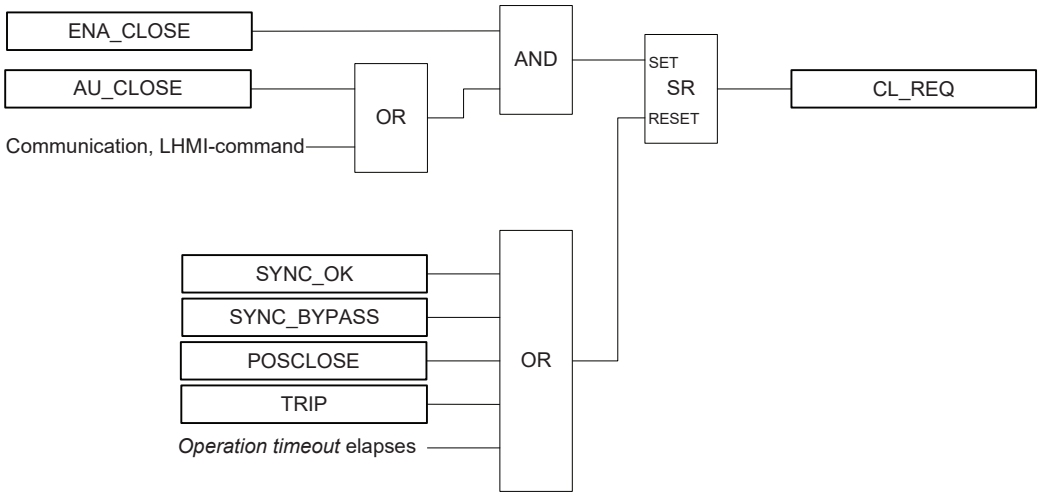



*Figure 826: Condition for enabling the close request (CL_REQ) for CBXCBR*

When the open command is given from communication, via LHMI or activating the AU_OPEN input, it is processed only if OPEN_ENAD is TRUE. OP_REQ output is also available.

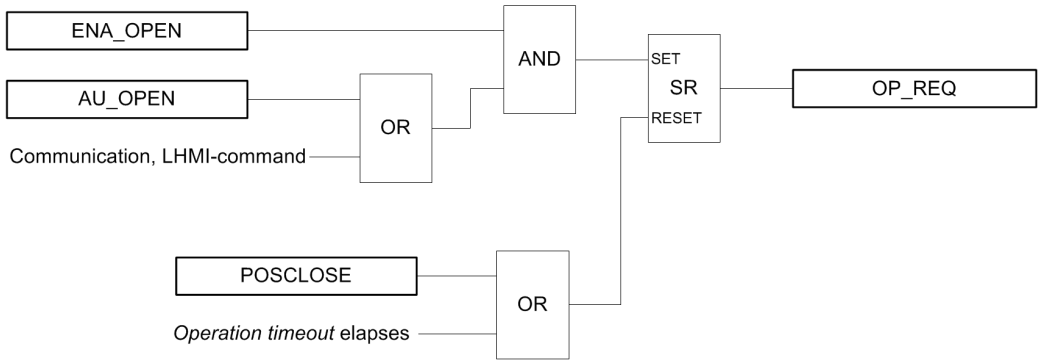



*Figure 827: Condition for enabling the open request (OP_REQ) for CBXCBR*

**OPEN and CLOSE outputs**

The EXE_OP output is activated when the open command is given ( AU_OPEN, via communication or from LHMI) and OPEN_ENAD signal is TRUE. In addition, the protection trip commands can be routed through the CBXCBR function by using the TRIP input. When the TRIP input is TRUE, the EXE_OP output is activated immediately and bypassing all enabling or blocking conditions.

The EXE_CL output is activated when the close command is given ( AU_CLOSE, via communication or from LHMI) and CLOSE_ENAD signal is TRUE. When the TRIP input is “TRUE”, CB closing is not allowed.

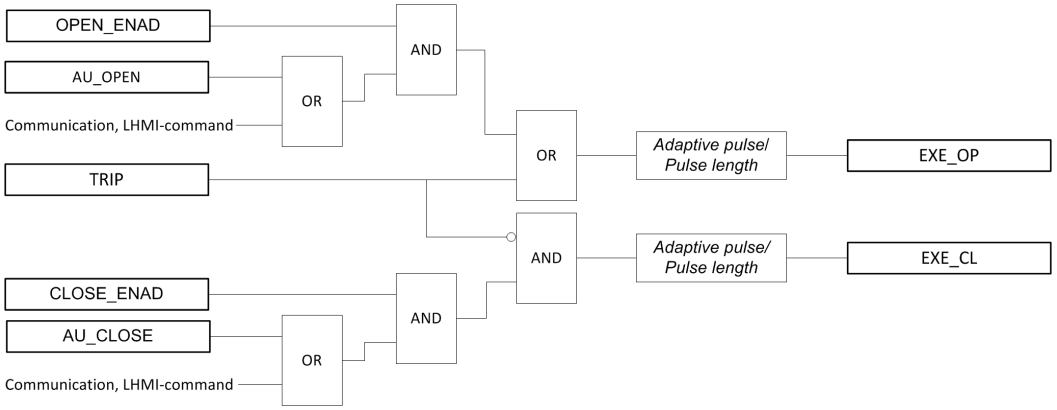



*Figure 828: OPEN and CLOSE outputs logic for CBXCBR*

### Opening and closing pulse widths

The pulse width type can be defined with the *Adaptive pulse* setting. The function provides two modes to characterize the opening and closing pulse widths. When the *Adaptive pulse* is set to “TRUE”, it causes a variable pulse width, which means that the output pulse is deactivated if the object state shows that the apparatus has entered the correct state before the pulse time has elapsed. The pulse will not be extended beyond the maximum pulse width. If apparatus fails to enter the correct state, the output pulse is deactivated after the set *Operation timeout* setting, and an error message is displayed. When the *Adaptive pulse* is set to “FALSE”, the functions always use the maximum pulse width, defined by the user-configurable *Pulse length* setting. The *Pulse length* setting is the same for both the opening and closing commands. When the apparatus already is in the right position, the maximum pulse length is given.

*Pulse length* setting does not affect the length of the opening pulse when `EXE_OP` is activated via `TRIP` input. `EXE_OP` will remain active as long as `TRIP` input is active.

### Control methods

The command execution mode can be set with the *Control model* setting. The alternatives for command execution are direct control and secured object control, which can be used to secure controlling.

The secured object control SBO is an important feature of the communication protocols that support horizontal communication, because the command reservation and interlocking signals can be transferred with a bus. All secured control operations require two-step commands: a selection step and an execution step. The secured object control is responsible for the several tasks.

- Command authority: ensures that the command source is authorized to operate the object
- Mutual exclusion: ensures that only one command source at a time can control the object
- Interlocking: allows only safe commands
- Execution: supervises the command execution
- Command canceling: cancels the controlling of a selected object.

In direct operation, a single message is used to initiate the control action of a physical device. The direct operation method uses less communication network capacity and bandwidth than the SBO method, because the procedure needs fewer messages for accurate operation.

The “status-only” mode means that control is not possible (non-controllable) via communication or from LHMI. However, it is possible to control a disconnector (DCXSWI) from AU_OPEN and AU_CLOSE inputs.

AU_OPEN and AU_CLOSE control the object directly regardless of the set *Control model*. These inputs can be used when control is wanted to be implemented purely based on ACT logic and no additional exception handling is needed. However, in case of simultaneous open and close control, the open control is always prioritized.

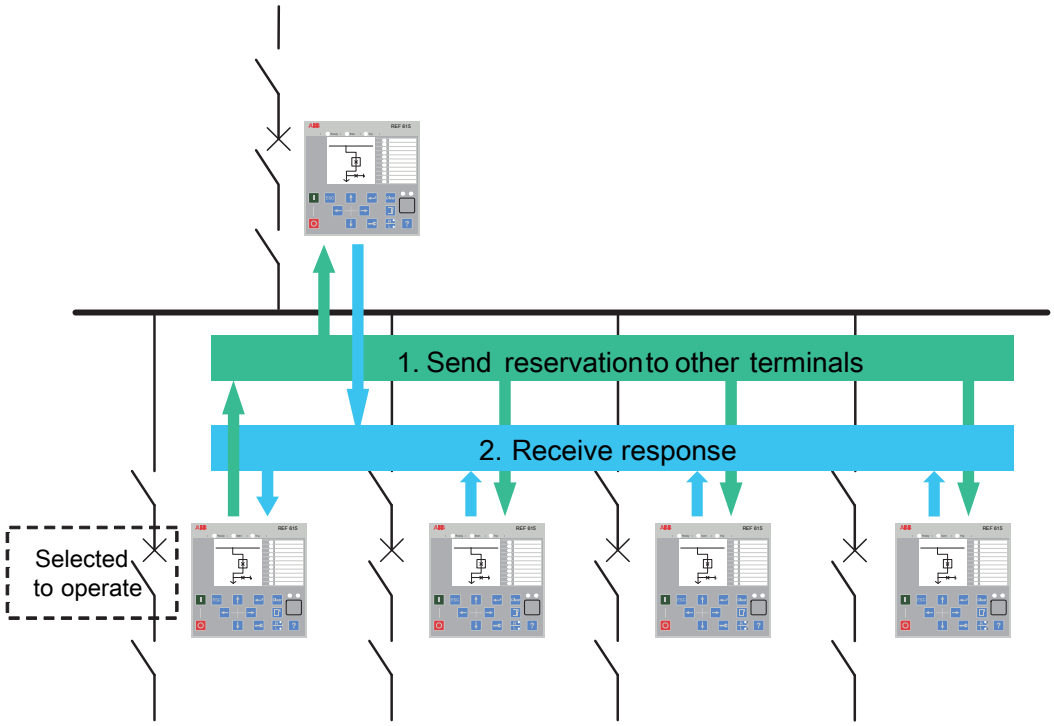



*Figure 829: Control procedure in the SBO method*

**Local/Remote operations**

The local/remote selection affects CBXCBR, DCXSWI and ESXSWI.

- Local: the opening and closing via communication is disabled.
- Remote: the opening and closing via LHMI is disabled.
- AU_OPEN and AU_CLOSE inputs function regardless of the local/remote selection.

## 9.1.5 Application

In the field of distribution and sub-transmission automation, reliable control and status indication of primary switching components both locally and remotely is in a significant role. They are needed especially in modern remotely controlled substations.

Control and status indication facilities are implemented in the same package with CBXCBR, DCXSWI and ESXSWI. When primary components are controlled in the energizing phase, for example, the correct execution sequence of the control commands must be ensured. This can be achieved, for example, with interlocking based on the status indication of the related primary components. The interlocking on substation level can be applied using the IEC 61850 GOOSE messages between feeders.

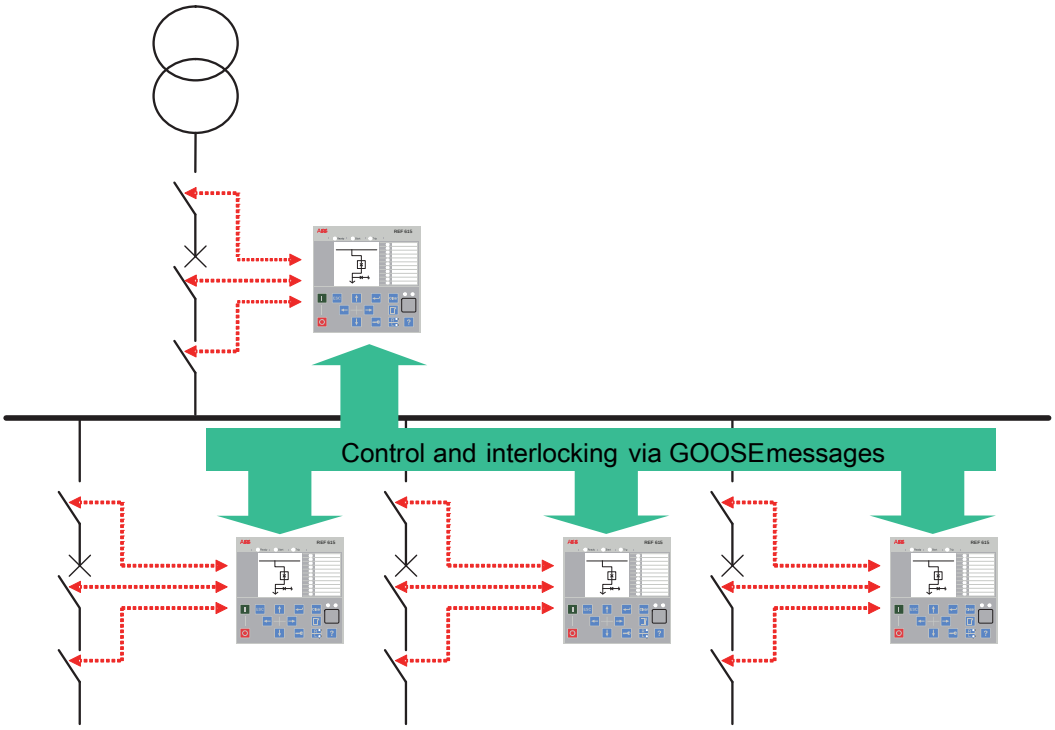



*Figure 830: Status indication-based interlocking via the GOOSE messaging*

## 9.1.6 Signals

### 9.1.6.1 CBXCBR Input signals

**Table 1456: CBXCBR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |
| ENA_OPEN | BOOLEAN | 1=True | Enables opening |
| ENA_CLOSE | BOOLEAN | 1=True | Enables closing |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| BLK_OPEN | BOOLEAN | 0=False | Blocks opening |
| BLK_CLOSE | BOOLEAN | 0=False | Blocks closing |
| AU_OPEN | BOOLEAN | 0=False | Auxiliary open |
| AU_CLOSE | BOOLEAN | 0=False | Auxiliary close |
| TRIP | BOOLEAN | 0=False | Trip signal |
| SYNC_OK | BOOLEAN | 1=True | Synchronism-check OK |
| SYNC_BYPASS | BOOLEAN | 0=False | Discards SYNC_OK interlocking when TRUE |
| ITL_BYPASS | BOOLEAN | 0=False | Discards ENA_OPEN and ENA_CLOSE interlocking when TRUE |

### 9.1.6.2 DCXSWI Input signals

**Table 1457: DCXSWI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |
| ENA_OPEN | BOOLEAN | 1=True | Enables opening |
| ENA_CLOSE | BOOLEAN | 1=True | Enables closing |
| BLK_OPEN | BOOLEAN | 0=False | Blocks opening |
| BLK_CLOSE | BOOLEAN | 0=False | Blocks closing |
| AU_OPEN | BOOLEAN | 0=False | Auxiliary open |
| AU_CLOSE | BOOLEAN | 0=False | Auxiliary close |
| ITL_BYPASS | BOOLEAN | 0=False | Discards ENA_OPEN and ENA_CLOSE interlocking when TRUE |

### 9.1.6.3 ESXSWI Input signals

**Table 1458: ESXSWI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |
| ENA_OPEN | BOOLEAN | 1=True | Enables opening |
| ENA_CLOSE | BOOLEAN | 1=True | Enables closing |
| BLK_OPEN | BOOLEAN | 0=False | Blocks opening |
| BLK_CLOSE | BOOLEAN | 0=False | Blocks closing |
| AU_OPEN | BOOLEAN | 0=False | Auxiliary open |
| AU_CLOSE | BOOLEAN | 0=False | Auxiliary close |
| ITL_BYPASS | BOOLEAN | 0=False | Discards ENA_OPEN and ENA_CLOSE interlocking when TRUE |

### 9.1.6.4 CBXCBR Output signals

**Table 1459: CBXCBR Output signals**

| Name | Type | Description |
|---|---|---|
| SELECTED | BOOLEAN | Object selected |
| EXE_OP | BOOLEAN | Executes the command for open direction |
| EXE_CL | BOOLEAN | Executes the command for close direction |
| OP_REQ | BOOLEAN | Open request |
| CL_REQ | BOOLEAN | Close request |
| OPENPOS | BOOLEAN | Apparatus open position |
| CLOSEPOS | BOOLEAN | Apparatus closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |
| OPEN_ENAD | BOOLEAN | Opening is enabled based on the input status |
| CLOSE_ENAD | BOOLEAN | Closing is enabled based on the input status |
| CTL_ITL_BLKD | BOOLEAN | Control is blocked due to interlocking |

### 9.1.6.5 DCXSWI Output signals

**Table 1460: DCXSWI Output signals**

| Name | Type | Description |
|---|---|---|
| SELECTED | BOOLEAN | Object selected |
| EXE_OP | BOOLEAN | Executes the command for open direction |
| EXE_CL | BOOLEAN | Executes the command for close direction |
| OPENPOS | BOOLEAN | Apparatus open position |
| CLOSEPOS | BOOLEAN | Apparatus closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |
| OPEN_ENAD | BOOLEAN | Opening is enabled based on the input status |
| CLOSE_ENAD | BOOLEAN | Closing is enabled based on the input status |
| CTL_ITL_BLKD | BOOLEAN | Control is blocked due to interlocking |

### 9.1.6.6 ESXSWI Output signals

**Table 1461: ESXSWI Output signals**

| Name | Type | Description |
|---|---|---|
| SELECTED | BOOLEAN | Object selected |
| EXE_OP | BOOLEAN | Executes the command for open direction |
| EXE_CL | BOOLEAN | Executes the command for close direction |
| OPENPOS | BOOLEAN | Apparatus open position |
| CLOSEPOS | BOOLEAN | Apparatus closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |
| OPEN_ENAD | BOOLEAN | Opening is enabled based on the input status |
| CLOSE_ENAD | BOOLEAN | Closing is enabled based on the input status |
| CTL_ITL_BLKD | BOOLEAN | Control is blocked due to interlocking |

## 9.1.7 Settings

### 9.1.7.1 CBXCBR Settings

**Table 1462: CBXCBR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation mode on/off |
| Select timeout | 10000...300000 | ms | 10000 | 30000 | Select timeout in ms |
| Pulse length | 10...60000 | ms | 1 | 200 | Open and close pulse length |
| Control model | 0=status-only<br>1=direct-with-normal-security<br>4=sbo-with-enhanced-security | | | 4=sbo-with-enhanced-security | Select control model |
| Operation timeout | 10...6000000 | ms | 1 | 500 | Timeout for negative termination |
| Identification | | | | CBXCBR1 switch position | Control Object identification |

**Table 1463: CBXCBR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation counter | 0...99999 | | 1 | 0 | Nr of opening operations |
| Adaptive pulse | 0=False<br>1=True | | | 1=True | Deactivate control pulse when apparatus has reached correct position |
| Event delay | 0...10000 | ms | 1 | 200 | Event delay of the intermediate and faulty position |
| Interlocking Pls Len | 1...10 | s | 1 | 2 | Pulse length for interlocking violation signal |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

### 9.1.7.2 DCXSWI Settings

**Table 1464: DCXSWI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation mode on/off |
| Select timeout | 10000...300000 | ms | 10000 | 30000 | Select timeout in ms |
| Pulse length | 10...60000 | ms | 1 | 100 | Open and close pulse length |
| Control model | 0=status-only<br>1=direct-with-normal-security<br>4=sbo-with-enhanced-security | | | 4=sbo-with-enhanced-security | Select control model |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation timeout | 10...60000 | ms | 1 | 30000 | Timeout for negative termination |
| Identification | | | | DCXSWI1 switch position | Control Object identification |

**Table 1465: DCXSWI Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation counter | 0...10000 | | 1 | 0 | Nr of opening operations |
| Adaptive pulse | 0=False<br>1=True | | | 1=True | Deactivate control pulse when apparatus has reached correct position |
| Event delay | 0...60000 | ms | 1 | 10000 | Event delay of the intermediate and faulty position |
| Interlocking Pls Len | 1...10 | s | 1 | 2 | Pulse length for interlocking violation signal |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

### 9.1.7.3 ESXSWI Settings

**Table 1466: ESXSWI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation mode on/off |
| Select timeout | 10000...300000 | ms | 10000 | 30000 | Select timeout in ms |
| Pulse length | 10...60000 | ms | 1 | 100 | Open and close pulse length |
| Control model | 0=status-only<br>1=direct-with-normal-security<br>4=sbo-with-enhanced-security | | | 4=sbo-with-enhanced-security | Select control model |
| Operation timeout | 10...60000 | ms | 1 | 30000 | Timeout for negative termination |
| Identification | | | | ESXSWI1 switch position | Control Object identification |

**Table 1467: ESXSWI Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation counter | 0...10000 | | 1 | 0 | Nr of opening operations |
| Adaptive pulse | 0=False<br>1=True | | | 1=True | Deactivate control pulse when apparatus has reached correct position |
| Event delay | 0...60000 | ms | 1 | 10000 | Event delay of the intermediate and faulty position |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Interlocking Pls Len | 1...10 | s | 1 | 2 | Pulse length for interlocking violation signal |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

## 9.1.8 Monitored data

### 9.1.8.1 CBXCBR Monitored data

**Table 1468: CBXCBR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Apparatus position indication |

### 9.1.8.2 DCXSWI Monitored data

**Table 1469: DCXSWI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Apparatus position indication |

### 9.1.8.3 ESXSWI Monitored data

**Table 1470: ESXSWI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Apparatus position indication |

## 9.1.9 Technical revision history

### 9.1.9.1 Technical revision history

**Table 1471: CBXCBR Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | G | Input SYN_ITL_BYPS is devided into two inputs SYN_BYPASS and ITL_BYPASS. New output CTL_ITL_BLKD and pulse timer setting *Interlocking Pls Len* added. |

### 9.1.9.2 Technical revision history

**Table 1472: DCXSWI Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | E | New output CTL_ITL_BLKD and pulse timer setting *Interlocking Pls Len* added. |

### 9.1.9.3 Technical revision history

**Table 1473: ESXSWI Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | E | New output CTL_ITL_BLKD and pulse timer setting *Interlocking Pls Len* added. |

# 9.2 Three-state disconnector control P3SXSWI (ANSI 29DS/GS)

## 9.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-state disconnector control | P3SXSWI | I<->O P3S | 29DS/GS |

## 9.2.2 Function block




*Figure 831: Function block*

## 9.2.3 Functionality

The three-state disconnector control function P3SXSWI is used to control a three-state switch (disconnector closed, both open, earthing switch closed) and to provide status information on the MV air-insulated switchgear (AIS) and gas-insulated switchgear (GIS). P3SXSWI executes commands to RIO600 SCM or directly drives the switchgear motor by direct control of the protection relay's H-bridge (if available). The function evaluates blocking conditions and different supervision conditions and it performs an execution command only if all conditions are fulfilled. If erroneous conditions occur, the function indicates an appropriate cause value. The function is designed according to the IEC 61850-7-4 standard including logical nodes CILO, CSWI and XSWI.

P3SXSWI has operation counters for disconnector operation and earthing switch operation. The counter values can be read and written remotely from the place of operation or via LHMI.

The function can also be configured to handle only two-position switches (earthing switch or disconnector).

## 9.2.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The switch type is determined depending on the connected inputs in Application Configuration.

- If inputs DCPOSOPEN, DCPOSCLOSE, ESPOSOPEN and ESPOSCLOSE are connected, the switch type is three-position switch.
- When only inputs DCPOSOPEN and DCPOSCLOSE are connected, the switch type is disconnector.
- When only inputs ESPOSOPEN and ESPOSCLOSE are connected, the switch type is earthing switch.

Any other connection leads to a configuration error.

The motor control application of the three-position switch can be selected with parameter setting *Control mode*. If "With RIO600 SCM" is selected, the motor control is handled externally by the RIO600 SCM module; the protection relay only supervises the switch position and interlocking but provides commands to RIO600. If "Direct control" is selected, the motor control is handled by the protection relay's H-bridge and no external RIO600 SCM device is needed.

### 9.2.4.1 Position indication and validity check

Depending on the switch type connection, a three-position switch, disconnector or earthing switch can be configured.



Be aware of the physical switch type and corresponding connections in Application Configuration, both for P3SXSWI and in RIO600 SCM, if used. A wrong connection according to the physical switch type can cause misleading position indication.

In certain three-position switches an additional reed contact is available to indicate safe earthing. The contact is TRUE only when the earthing switch is in closed position. The reed contact is given a short time window to confirm closed earthing switch position, in case of vibrations. If the earthing switch has closed but the reed contact does not close within the time window, faulty position is reported.

**Table 1474: Reed contact detection**

| Control mode | Reed contact detection |
|---|---|
| Direct control | The availability of the reed contact needs to be set through the *Reed contact* setting by setting it as "Available". The reed contact signal is connected at input REED. |
| With RIO600 SCM | Reed detection is handled externally by the module. The input ESPOSCLOSE is not indicated TRUE by RIO600 if reed contact closing is not detected. Therefore, unsecure earthing is reported to input REED_ERR so that P3SXSWI can indicate faulty position in this control mode. |

The state of the switch is indicated at outputs DCCLOSE_POS, DCOPEN_POS, ESCLOSE_POS and ESOPEN_POS together with the OKPOS information.

Debouncing and short disturbances in an input are eliminated by filtering. The binary input filtering timer can be adjusted separately for each digital input used by the function block. The reporting of faulty or intermediate position of the apparatus occurs after the *Event delay* setting.

**Table 1475: Status indication for a three-position switch with auxiliary contacts in direct control mode**

| Status | Inputs | | | | | Outputs | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **POSITION** | **DCPOSCLOSE** | **DCPOSOPEN** | **ESPOSCLOSE** | **ESPOSOPEN** | **REED** | **DCCLOSE_POS** | **DCOPEN_POS** | **ESCLOSE_POS** | **ESOPEN_POS** | **OKPOS** |
| Disconnector closed | 1 | 0 | 0 | 1 | x | 1 | 0 | 0 | 1 | 1 |
| Disconnector intermediate | 0 | 0 | 0 | 1 | x | 0 | 0 | 0 | 1 | 0 |
| Both open | 0 | 1 | 0 | 1 | x | 0 | 1 | 0 | 1 | 1 |
| Earthing switch intermediate | 0 | 1 | 0 | 0 | x | 0 | 1 | 0 | 0 | 0 |
| Earthing switch closed | 0 | 1 | 1 | 0 | 1[1] | 0 | 1 | 1 | 0 | 1 |
| Faulty | 0 | 1 | 1 | 0 | 0[2] | 0 | 1 | 0 | 0 | 0 |
| Faulty | 0 | 1 | 1 | 1 | x | 0 | 1 | 0 | 0 | 0 |
| Faulty | 1 | 1 | 0 | 1 | x | 0 | 0 | 0 | 1 | 0 |
| Faulty | 1 | x | 1 | x | x | 0 | 0 | 0 | 0 | 0 |
| Faulty | x | 0 | x | 0 | x | 0 | 0 | 0 | 0 | 0 |
| x = no difference | | | | | | | | | | |

The REED input is only supervised during a short time window when earthing switch has closed and if *Reed contact* setting is set as "Available" in direct control mode.

When a two-position switch type is used, only the corresponding outputs are enabled. For example, if the switch type is disconnector, the status of the two-position switch is based only on the connected inputs DCPOSOPEN and DCPOSCLOSE. Furthermore, the outputs ESOPEN_POS and ESCLOSE_POS are disabled.

Common three-position status is indicated at variable POSITION, regardless of the switch type. For example, if only a disconnector is available, and the disconnector is in open state, the open indication equals “both open”.

[1] REED input has been detected as closed within time-out and earthing switch is indicated as closed.

[2] REED input has not been detected as closed within time-out and faulty position is indicated.

**Table 1476: Position indication values based on switch type**

| Status | Switch type | | |
|---|---|---|---|
| **POSITION** | **Three-position switch** | **Disconnector** | **Earthing switch** |
| Earthing switch closed | Earthing switch closed and disconnector open | N/A | Earthing switch closed |
| Earthing switch intermediate | Earthing switch intermediate and disconnector open | N/A | Earthing switch intermediate |
| Both open | Earthing switch open and disconnector open | Disconnector open | Earthing switch open |
| Disconnector intermediate | Earthing switch open and disconnector intermediate | Disconnector intermediate | N/A |
| Disconnector closed | Earthing switch open and disconnector closed | Disconnector closed | N/A |
| Faulty | Earthing switch faulty or disconnector faulty (or incorrect combination) | Faulty | Faulty |

When controlling P3SXSWI with RIO600 SCM, the switch's position information should be made available to the function in the protection relay via GOOSE or binary inputs from RIO600 to reflect correct position and status information.

### 9.2.4.2 Control of a three-position switch

There are three possible end positions in a three-position switch: earthing switch closed, both open, and disconnector closed. Additionally, there are two intermediate states: earthing switch intermediate and disconnector intermediate. The function follows the command order in cyclic order as shown in *Figure 832*. For example, at disconnector close state only disconnector open command can be executed. Similarly, when the state is both open, both disconnector close and earth close commands can be executed. When the switch indicates earthing switch or disconnector intermediate position (for example, the motor has stopped due to timeout), a specified open command is allowed only.

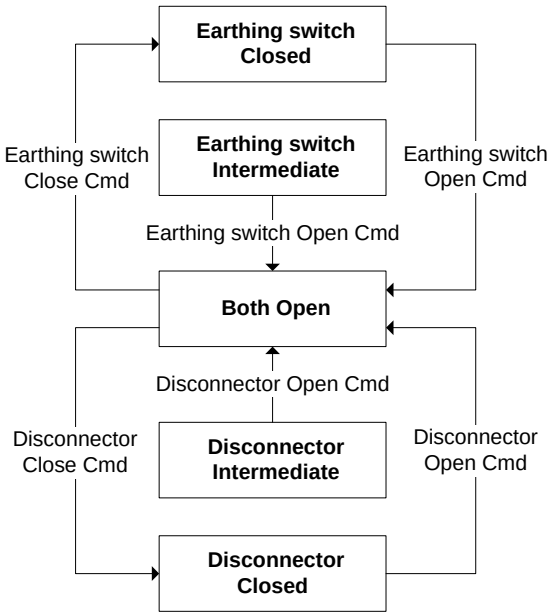



*Figure 832: Control of a three-position switch by commands*

### 9.2.4.3 Blocking

The function has a blocking functionality to prevent human errors that can cause injuries to the operator and damages to the system components.

The control operations are allowed if the interlocking signals for the operations are TRUE. These signals are ENA_DCOPEN, ENA_DCCLOSE, ENA_ESOPEN and ENA_ESCLOSE.

In addition, the function provides a general interlocking bypass input ITL_BYPASS. When ITL_BYPASS is TRUE, the apparatus can be controlled by discarding the ENA_DCOPEN, ENA_DCCLOSE, ENA_ESOPEN and ENA_ESCLOSE input states.

However, the BLK_DCOPEN, BLK_DCCLOSE, BLK_ESOPEN and BLK_ESCLOSE input signals are not bypassed with the interlocking bypass functionality since they always have higher priority.

In *Table 1477* the interlocking condition is switch-specific by row.

**Table 1477: Interlocking conditions for enabling the closing/opening command**

| Inputs | | | Outputs |
|---|---|---|---|
| **ITL_BYPASS** | **ENA_DCCLOSE** | **BLK_DCCLOSE** | **DCCLOSE_ENAD** |
| | **ENA_DCOPEN** | **BLK_DCOPEN** | **DCOPEN_ENAD** |
| | **ENA_ESCLOSE** | **BLK_ESCLOSE** | **ESCLOSE_ENAD** |
| | **ENA_ESOPEN** | **BLK_ESOPEN** | **ESOPEN_ENAD** |
| 0 = False | 0 = False | 0 = False | 0 = False |
| 0 = False | 0 = False | 1 = True | 0 = False |
| 0 = False | 1 = True | 0 = False | 1 = True |

*Table continues on the next page*

| Inputs | | | Outputs |
|---|---|---|---|
| **ITL_BYPASS** | **ENA_DCCLOSE** | **BLK_DCCLOSE** | **DCCLOSE_ENAD** |
| | **ENA_DCOPEN** | **BLK_DCOPEN** | **DCOPEN_ENAD** |
| | **ENA_ESCLOSE** | **BLK_ESCLOSE** | **ESCLOSE_ENAD** |
| | **ENA_ESOPEN** | **BLK_ESOPEN** | **ESOPEN_ENAD** |
| 0 = False | 1 = True | 1 = True | 0 = False |
| 1 = True | 0 = False | 0 = False | 1 = True |
| 1 = True | 0 = False | 1 = True | 0 = False |
| 1 = True | 1 = True | 0 = False | 1 = True |
| 1 = True | 1 = True | 1 = True | 0 = False |

However, the enabled outputs also depend on the actual position of the switch, according to *Figure 832* and if any motor operation is ongoing. Internal blocking based on switch position or motor in progress always overrides the enabled output regardless of the status of enable, block and interlock bypass inputs.

For two-position switches, the enabling outputs of the opposite switch type are disabled regardless of the input status. For example, if the switch type is earthing switch, DCCLOSE_ENAD and DCOPEN_ENAD are forced to FALSE.

Operation of the three-position switch is permitted only when the circuit breaker is in open position. The closed circuit breaker information can be connected to the BLK inputs in Application Configuration.

### 9.2.4.4 Various operations

The required operation command is available via communication, binary inputs or LHMI. As a prerequisite for control commands, there are enabling and blocking functionalities for all the operations. If the control command is executed against the blocking or if the enabling of the corresponding command is not valid, the function generates an error message. If the control is inhibited due to interlocking conditions the pulse output CTL_ITL_BLKD is activated. The length of the pulse is defined by the *Interlocking Pls Len* setting. The command operations are requested through binary inputs AU_DCOPEN, AU_DCCLOSE, AU_ESOPEN and AU_ESCLOSE. The requested operation is possible provided the apparatus is not blocked by the interlocking logic and no other previous request is active.

When the function block is selected for performing any of the operations locally from the HMI, the output SELECTED is activated. Once the function is selected, the command for execution of operation should be issued before *Select timeout* time lapses.

The function contains two operation counters: disconnector counter *Operation counter DC* and earthing switch counter *Operation counter ES*. The first one indicates each disconnector opening state and the latter one indicates each earthing switch opening state. The counter values are resettable and writable and stored in a nonvolatile memory.

Output INPRO indicates any active motor operation, including braking and pause operation.

### 9.2.4.5 Control of three-position switch using RIO600 smart control module

When using RIO600 smart control module (SCM) for controlling a three-position switch, the setting *Control mode* should be set as "With RIO600 SCM".

SCM is available with RIO600 to be able to drive a three-position switch. The motor of the three-position switch is directly driven by the RIO600 SCM. RIO600 sends the status information to the protection relay by GOOSE communication, and the switch position is indicated on the HMI on the protection relay. When a three-position switch operation is requested and enabled by the protection relay, it generates commands via EXE_DCOPEN, EXE_DCCLOSE, EXE_ESOPEN or EXE_ESCLOSE, which are transmitted to RIO600 over GOOSE communication. Though the command handling is pre-checked by P3SXSWI, RIO600 SCM further checks for command priority and if the requested command is allowed. The commands are always checked on rising edge by the RIO600 SCM.

In RIO600 SCM control mode, the operation timeouts in P3SXSWI are not available due to external motor handling by the SCM module. Status feedback from the module is returned to the protection relay via GOOSE. The inputs for P3SXSWI shown in *Figure 833* must be connected by GOOSE status signals from SCM. Input REED remains unconnected in this control mode.

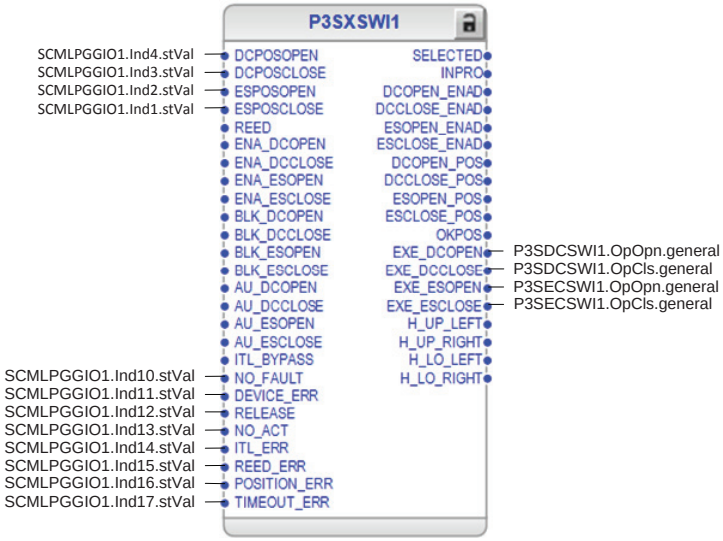



*Figure 833: Connections in P3SXSWI when using RIO600 SCM for a threeposition switch*

See the RIO600 and SCM manual when using RIO600 SCM for threeposition switch motor control. All the signals from RIO600 must be connected to the P3SXSWI function block as in *Figure 833*.

### 9.2.4.6 Control of three-position switch using H-bridge with static outputs of the protection relay

When using the protection relay for direct motor control of the three-position switch, the setting *Control mode* must be set as "Direct control".

If the protection relay is equipped with static power outputs, the three-position switch's driving motor can be controlled with an H-bridge. The function has four outputs for motor control.

- H-bridge upper-left: `H_UP_LEFT`
- H-bridge upper-right: `H_UP_RIGHT`
- H-bridge lower-left: `H_LO_LEFT`
- H-bridge lower-right: `H_LO_RIGHT`

These outputs must be connected to the static outputs of the protection relay. With the H-bridge functionality it is possible to drive the motor to left or to right, and brake the motor. The auxiliary voltage ($U_{aux}$) connected to the H-bridge has to match the voltage of the motor.

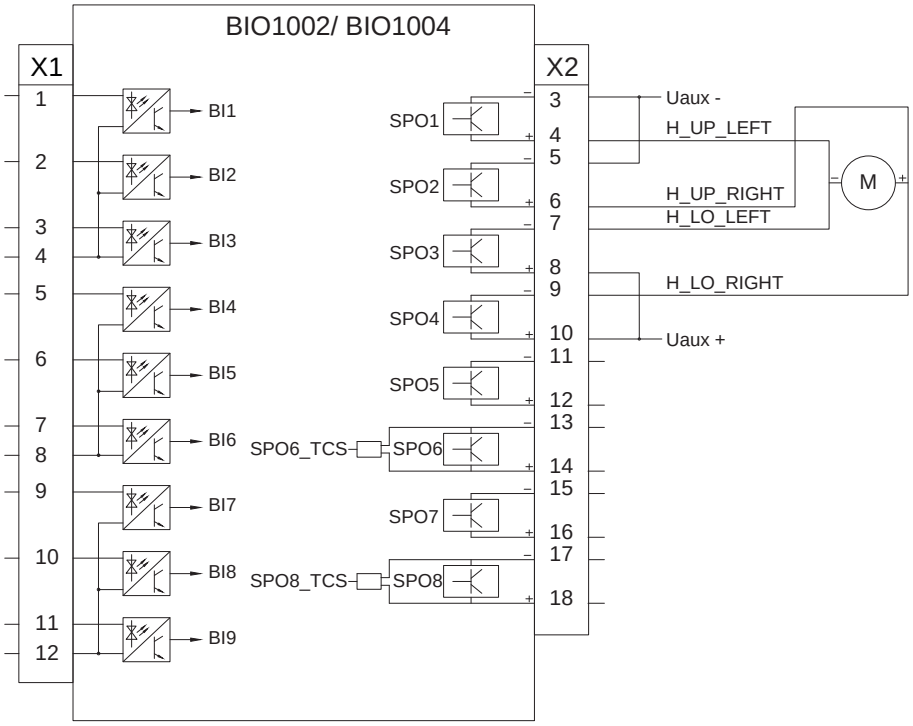



*Figure 834: H-bridge motor control for a protection relay equipped with BIO1002 module*

**Table 1478: H-bridge motor operation depending on active outputs**

| Motor direction | Static outputs | | | |
|---|---|---|---|---|
| | H_UP_LEFT | H_UP_RIGHT | H_LO_LEFT | H_LO_RIGHT |
| Motor right | 1 | 0 | 0 | 1 |
| Motor left | 0 | 1 | 1 | 0 |
| Motor brake | 1 | 1 | 0 | 0 |
| Motor brake | 0 | 0 | 1 | 1 |
| Motor free | 0 | 0 | 0 | 0 |

Be aware of the motor polarity so that a correct connection between the motor and the H-bridge is established. The H-bridge needs to be properly connected to the static outputs of the protection relay in Application Configuration. Wrong connections affect the motor functionality and may cause personal injury or damage to the equipment.

**Motor logic and parameters**

To prevent damage to the motor, the motor is protected by several settable timeouts. With setting parameter *Motor start timeout*, the maximum start time for the motor to recognize a position indication change is defined. If a position indication change is not recognized during this time, the motor is stopped. If *Motor start timeout* is set to zero, the motor start timeout is disabled.

With timeout *Operation timeout DC*, the maximum time for the disconnector to go from one state to another is defined.

With timeout *Operation timeout ES*, the maximum time for the earthing switch to go from one state to another is defined. If a state change is not fulfilled within this time, the motor is stopped.

If an unexpected position is detected based on the requested command, in other words the motor is running in the wrong direction, or if faulty position of the switch is detected, the motor is immediately stopped. Additionally, an activated block input that corresponds to the active command stops the running motor immediately.

If any of the cases above occur, the specific event is displayed on the HMI or reported via communication.

When the motor operates and reaches the final destination, the motor brakes if the *Motor braking* setting is selected as "True". The braking time of the motor is selectable with the *Motor brake time* parameter. After the motor has braked and stopped, the motor is in a free state, meaning that the switch is mechanically operable by hand-crank. A successful operation is also displayed on the HMI or reported via communication.

After each operation the motor is paused for one second before any new control command can pass through.

### 9.2.4.7 Control methods

The command execution mode can be set with the *Control model* setting. The alternatives for command execution are direct control and secured object control, which can be used to secure controlling.

The secured object control SBO is an important feature of the communication protocols that support horizontal communication, because the command reservation and interlocking signals can be transferred with a bus. All secured control operations require two-step commands: a selection step and an execution step. The secured object control is responsible for several tasks.

- Command authority: ensures that the command source is authorized to operate the object.
- Mutual exclusion: ensures that only one command source at a time can control the object.
- Interlocking: allows only safe commands.
- Execution: supervises the command execution.
- Command canceling: cancels the controlling of a selected object.

In direct operation, a single message is used to initiate the control action of a physical device. The direct operation method uses less communication network capacity and bandwidth than the SBO method, because the procedure needs fewer messages for accurate operation.

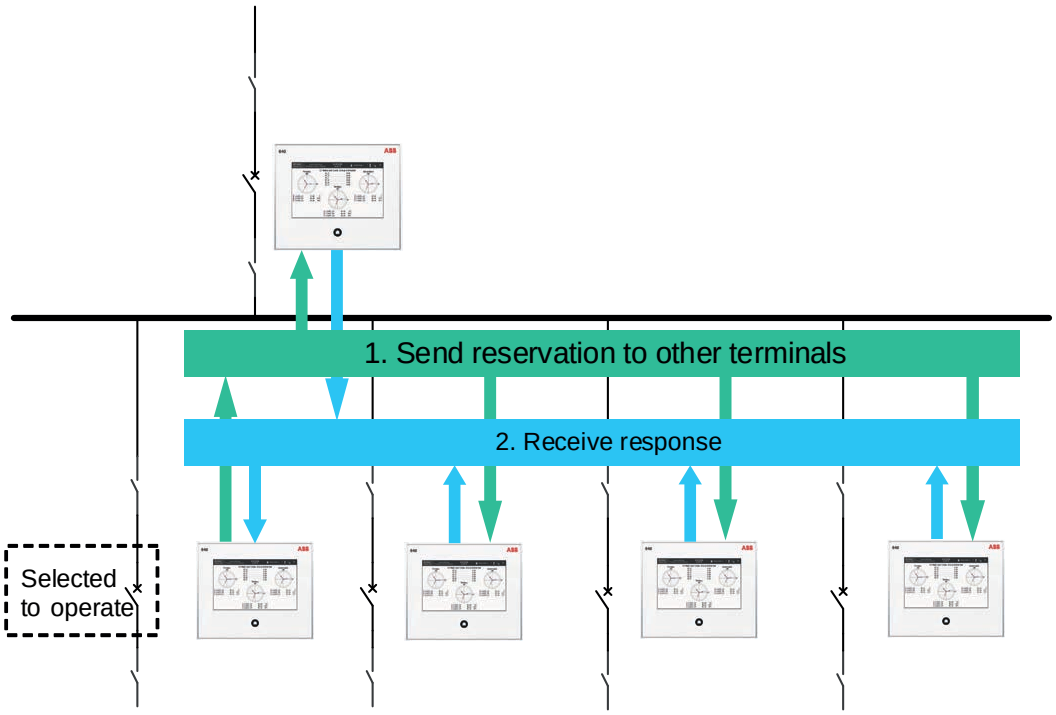



*Figure 835: Control procedure in the SBO method*

## 9.2.5 Application

In the field of distribution and sub-transmission, automatic, reliable control and status indication of primary switching components, both locally and remotely, are of significant importance. They are needed especially in modern remotely controlled substations.

P3SXSWI is designed to be used for the control of two- (open, closed) and three-state (earthing switch closed, disconnector closed and both open) switches. The function also handles user-defined interlocking logics and provides commands.

Control and status indication facilities are implemented in the same package with P3SXSWI. When primary components are controlled in the energizing phase, for example, the correct execution sequence of the control command must be ensured. This can be achieved, for example, with interlocking based on the status indication of the related primary components.

The interlocking on the substation level can be applied using the IEC 61850 GOOSE message between feeders.

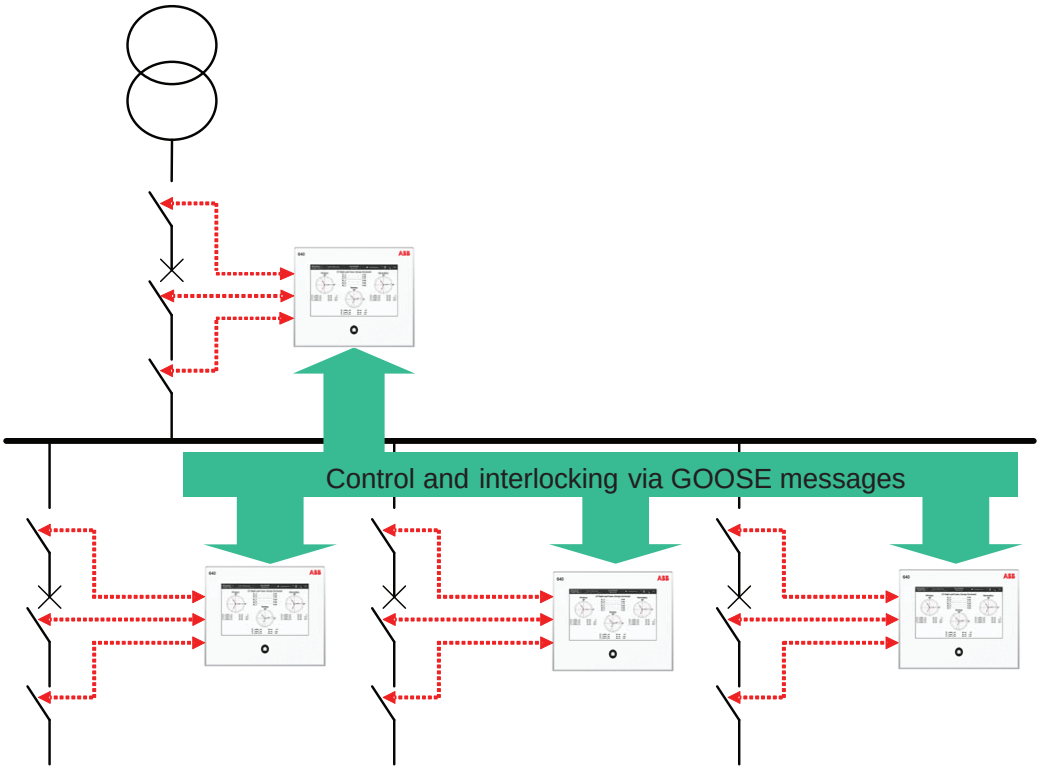



*Figure 836: Status indication-based interlocking via the GOOSE messaging*

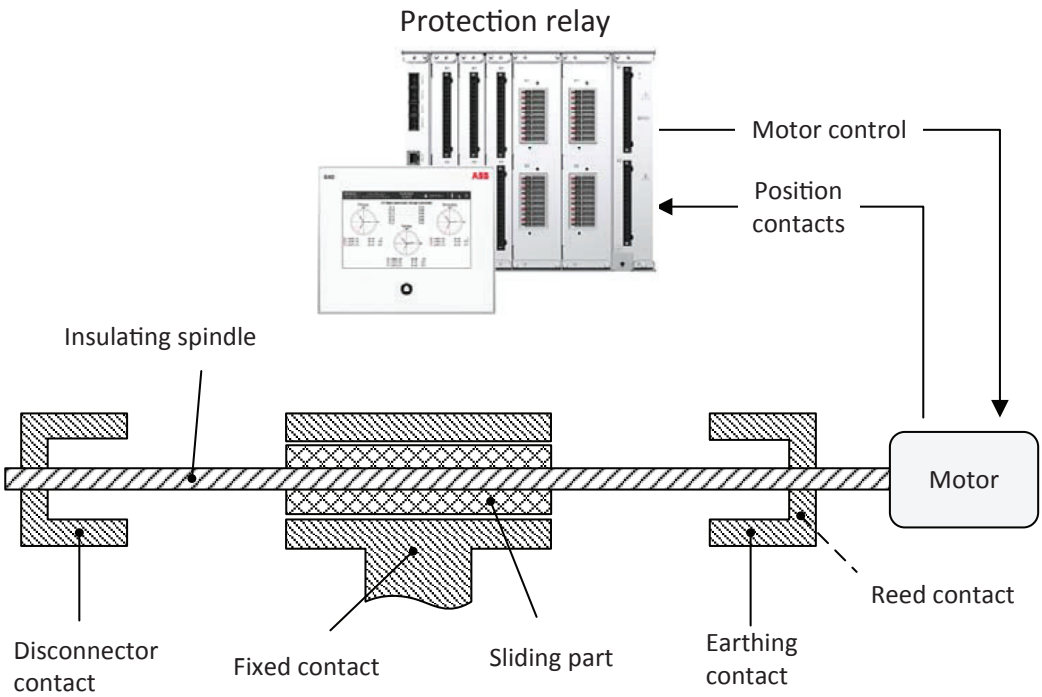



*Figure 837: Connection diagram for direct control of a three-position switchgear motor*

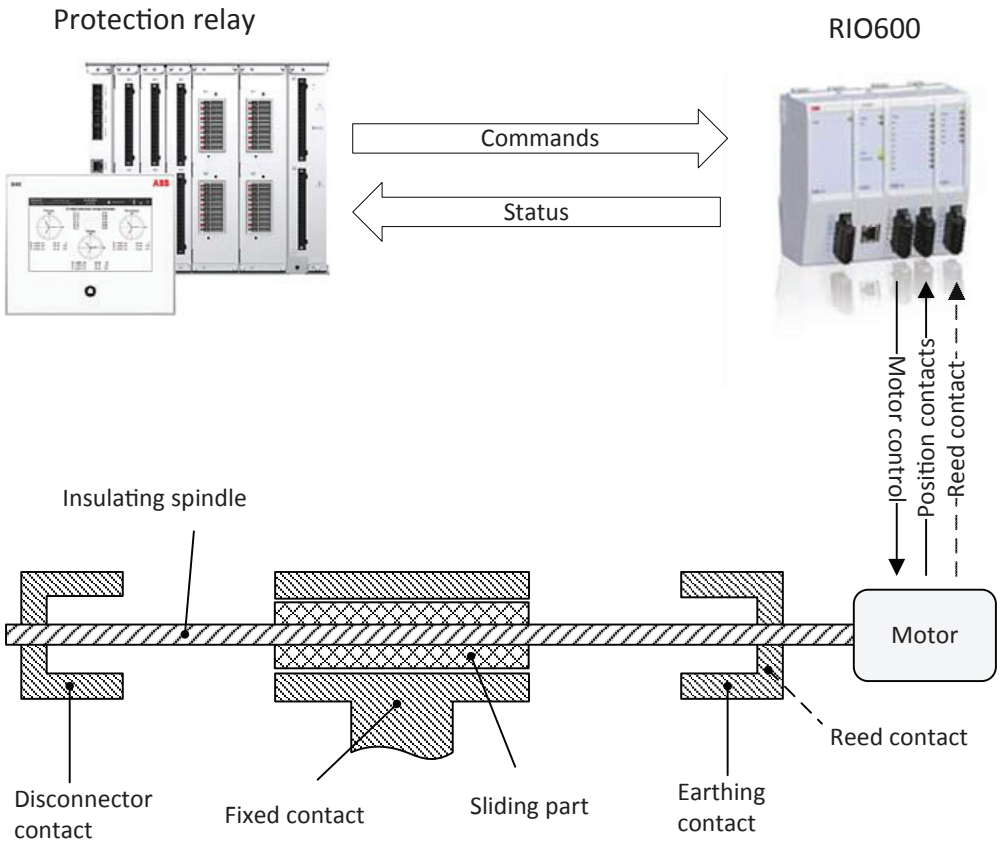



*Figure 838: Connection diagram for RIO600 control of a three-position switchgear motor*

When the RIO600 SCM module is selected as control mode, outputs `EXE_DCCLOSE`, `EXE_DCOPEN`, `EXE_ESCLOSE` and `EXE_ESOPEN` are connected in Application Configuration. When direct motor control is selected as control mode, static outputs `H_UP_LEFT`, `H_UP_RIGHT`, `H_LO_LEFT` and `H_LO_RIGHT` are connected in Application Configuration.

## 9.2.6 Signals

### 9.2.6.1 P3SXSWI Input signals

**Table 1479: P3SXSWI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| DCPOSOPEN | BOOLEAN | 0=False | Signal for open position of disconnector |
| DCPOSCLOSE | BOOLEAN | 0=False | Signal for close position of disconnector |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| ESPOSOPEN | BOOLEAN | 0=False | Signal for open position of earthing switch |
| ESPOSCLOSE | BOOLEAN | 0=False | Signal for close position of earthing switch |
| REED | BOOLEAN | 0=False | Signal for close position of reed contact |
| ENA_DCOPEN | BOOLEAN | 1=True | Enables opening command for disconnector |
| ENA_DCCLOSE | BOOLEAN | 1=True | Enables closing command for disconnector |
| ENA_ESOPEN | BOOLEAN | 1=True | Enables opening command for earthing switch |
| ENA_ESCLOSE | BOOLEAN | 1=True | Enables closing command for earthing switch |
| BLK_DCOPEN | BOOLEAN | 0=False | Blocks opening of disconnector |
| BLK_DCCLOSE | BOOLEAN | 0=False | Blocks closing of disconnector |
| BLK_ESOPEN | BOOLEAN | 0=False | Blocks opening of earthing switch |
| BLK_ESCLOSE | BOOLEAN | 0=False | Blocks closing of earthing switch |
| AU_DCOPEN | BOOLEAN | 0=False | Auxiliary open disconnector |
| AU_DCCLOSE | BOOLEAN | 0=False | Auxiliary close disconnector |
| AU_ESOPEN | BOOLEAN | 0=False | Auxiliary open earthing switch |
| AU_ESCLOSE | BOOLEAN | 0=False | Auxiliary close earthing switch |
| ITL_BYPASS | BOOLEAN | 0=False | Discards enable interlocking when TRUE |
| NO_FAULT | BOOLEAN | 1=True | RIO600 SCM no fault |
| DEVICE_ERR | BOOLEAN | 0=False | RIO600 SCM device error |
| RELEASE | BOOLEAN | 0=False | RIO600 SCM release information |
| NO_ACT | BOOLEAN | 1=True | RIO600 SCM no motor action |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| ITL_ERR | BOOLEAN | 0=False | RIO600 SCM interlocking error |
| REED_ERR | BOOLEAN | 0=False | RIO600 SCM reed error |
| POSITION_ERR | BOOLEAN | 0=False | RIO600 SCM position error |
| TIMEOUT_ERR | BOOLEAN | 0=False | RIO600 SCM timeout error |

### 9.2.6.2 P3SXSWI Output signals

**Table 1480: P3SXSWI Output signals**

| Name | Type | Description |
|---|---|---|
| SELECTED | BOOLEAN | Obejct selected |
| INPRO | BOOLEAN | Motor operation in progress |
| DCOPEN_ENAD | BOOLEAN | Disconnector opening is enabled |
| DCCLOSE_ENAD | BOOLEAN | Disconnector closing is enabled |
| ESOPEN_ENAD | BOOLEAN | Earthing switch opening is enabled |
| ESCLOSE_ENAD | BOOLEAN | Earthing switch closing is enabled |
| DCOPEN_POS | BOOLEAN | Disconnector in open position |
| DCCLOSE_POS | BOOLEAN | Disconnector in closed position |
| ESOPEN_POS | BOOLEAN | Earthing switch in open position |
| ESCLOSE_POS | BOOLEAN | Earthing switch in closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |
| EXE_DCOPEN | BOOLEAN | Command to RIO600 SCM for opening disconnector |
| EXE_DCCLOSE | BOOLEAN | Command to RIO600 SCM for closing disconnector |
| EXE_ESOPEN | BOOLEAN | Command to RIO600 SCM for opening earthing switch |
| EXE_ESCLOSE | BOOLEAN | Command to RIO600 SCM for closing earthing switch |
| H_UP_LEFT | BOOLEAN | H-bridge output upper left |
| H_UP_RIGHT | BOOLEAN | H-bridge output upper right |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| H_LO_LEFT | BOOLEAN | H-bridge output lower left |
| H_LO_RIGHT | BOOLEAN | H-bridge output lower right |
| CTL_ITL_BLKD | BOOLEAN | Control is blocked due to interlocking |

## 9.2.7 P3SXSWI Settings

**Table 1481: P3SXSWI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Control mode | 1=Direct control<br>2=With RIO600 SCM | | | 1=Direct control | Direct control or RIO600 SCM control |
| Reed contact | 0=Not available<br>1=Available | | | 0=Not available | Availability of reed contact |
| Select timeout | 10000...300000 | ms | 10000 | 30000 | Select timeout in ms |
| Control model | 0=status-only<br>1=direct-with-normal-security<br>4=sbo-with-enhanced-security | | | 4=sbo-with-enhanced-security | Select control model |
| Operation timeout DC | 10...60000 | ms | 1 | 30000 | Timeout for negative termination for disconnector |
| Operation timeout ES | 10...60000 | ms | 1 | 30000 | Timeout for negative termination for earthing switch |
| Motor braking | 0=False<br>1=True | | | 1=True | Motor braking on/off selection |
| Identification | | | | P3SXSWI1 switch position | Control object identification |

**Table 1482: P3SXSWI Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation counter DC | 0...10000 | | 1 | 0 | Disconnector operation cycles |
| Operation counter ES | 0...10000 | | 1 | 0 | Earthing switch operation cycles |
| Event delay | 0...60000 | ms | 1 | 10000 | Event delay of intermediate or faulty position |
| Motor start timeout | 0...32000 | ms | 100 | 0 | Timeout for motor to start |
| Motor brake time | 10...500 | ms | 1 | 100 | Motor brake time |
| Interlocking Pls Len | 1...10 | s | 1 | 2 | Pulse length for interlocking violation signal |
| Vendor | | | | 0 | External equipment vendor |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

## 9.2.8 P3SXSWI Monitored data

**Table 1483: P3SXSWI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Enum | 0=earthing switch closed<br>1=earthing switch intermediate<br>2=both open<br>3=disconnector intermediate<br>4=disconnector closed<br>5=faulty | | 3-position switch position |
| POSITION_DC | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Disconnector position |
| POSITION_ES | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Earthing switch position |
| SWTYPE | Enum | 1=3-position switch<br>2=Disconnector<br>3=Earthing switch<br>4=Unknown | | Switch type |

## 9.2.9 Technical revision history

**Table 1484: P3SXSWI Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | B | New output `CTL_ITL_BLKD` and pulse timer setting *Interlocking Pls Len* added. |

# 9.3 Three-state disconnector position indication P3SSXSWI (ANSI 29DS/GS)

## 9.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Three-state disconnector position indication | P3SSXSWI | I<->O P3SS | 29DS/GS |

## 9.3.2 Function block

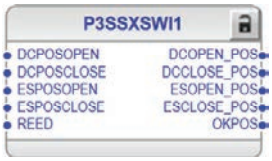



*Figure 839: Function block*

## 9.3.3 Functionality

The three-state disconnector position indication function P3SSXSWI provides status information on three-state switches: MV air-insulated switchgear (AIS) and gas-insulated switchgear (GIS). The function is designed according to the IEC 61850-7-4 standard including logical nodes CSWI and XSWI.

## 9.3.4 Operation principle

**Position indication**

In certain three-position switches an additional reed contact is available to indicate safe earthing. The contact is TRUE only when the earthing switch is in closed position. The reed contact is given a short time window to confirm closed earthing switch position, in case of vibrations. If the earthing switch has closed but the reed contact does not close within the time window, faulty position is reported. The availability of the reed contact needs to be set through *Reed contact* setting by setting it as "Available". The reed contact signal is connected at input `REED` in this control mode.

The state of the switch is indicated at outputs `DCCLOSE_POS`, `DCOPEN_POS`, `ESCLOSE_POS` and `ESOPEN_POS` together with the `OKPOS` information.

Debouncing and short disturbances in an input are eliminated by filtering. The binary input filtering timer can be adjusted separately for each digital input used by the function block. The reporting of faulty or intermediate position of the apparatus

occurs after the *Event delay* setting. A common three-position status is indicated at variable POSITION.

**Table 1485: Status indication for a three-position switch based on auxiliary contacts**

| Status | Inputs | | | | | Outputs | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| POSITION | DCPOSCLOSE | DCPOSOPEN | ESPOSCLOSE | ESPOSOPEN | REED | DCCLOSE_POS | DCOPEN_POS | ESCLOSE_POS | ESOPEN_POS | OKPOS |
| Disconnector closed | 1 | 0 | 0 | 1 | x | 1 | 0 | 0 | 1 | 1 |
| Disconnector intermediate | 0 | 0 | 0 | 1 | x | 0 | 0 | 0 | 1 | 0 |
| Both open | 0 | 1 | 0 | 1 | x | 0 | 1 | 0 | 1 | 1 |
| Earthing switch intermediate | 0 | 1 | 0 | 0 | x | 0 | 1 | 0 | 0 | 0 |
| Earthing switch closed | 0 | 1 | 1 | 0 | 1[1] | 0 | 1 | 1 | 0 | 1 |
| Faulty | 0 | 1 | 1 | 0 | 0[2] | 0 | 1 | 0 | 0 | 0 |
| Faulty | 0 | 1 | 1 | 1 | x | 0 | 1 | 0 | 0 | 0 |
| Faulty | 1 | 1 | 0 | 1 | x | 0 | 0 | 0 | 1 | 0 |
| Faulty | 1 | x | 1 | x | x | 0 | 0 | 0 | 0 | 0 |
| Faulty | x | 0 | x | 0 | x | 0 | 0 | 0 | 0 | 0 |
| x = no difference | | | | | | | | | | |

The REED input is only supervised during a short time window when earthing switch has closed and if *Reed contact* setting is set as "Available".

## 9.3.5 Application

In the field of distribution and sub-transmission automatic, reliable control and status indication of primary switching components both locally and remotely is of significant importance. They are needed especially in modern remotely controlled substations.

P3SSXSWI is designed to be used for status indication of a three-state (earthing switch closed, disconnector closed and both open) switch.

## 9.3.6 Signals

[1] REED input has been detected as closed within time-out and earthing switch is indicated as closed.

[2] REED input has not been detected as closed within time-out and faulty position is indicated.

### 9.3.6.1 P3SSXSWI Input signals

**Table 1486: P3SSXSWI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| DCPOSOPEN | BOOLEAN | 0=False | Signal for open position of disconnector |
| DCPOSCLOSE | BOOLEAN | 0=False | Signal for close position of disconnector |
| ESPOSOPEN | BOOLEAN | 0=False | Signal for open position of earthing switch |
| ESPOSCLOSE | BOOLEAN | 0=False | Signal for close position of earthing switch |
| REED | BOOLEAN | 0=False | Signal for close position of reed contact |

### 9.3.6.2 P3SSXSWI Output signals

**Table 1487: P3SSXSWI Output signals**

| Name | Type | Description |
|---|---|---|
| DCOPEN_POS | BOOLEAN | Disconnector in open position |
| DCCLOSE_POS | BOOLEAN | Disconnector in closed position |
| ESOPEN_POS | BOOLEAN | Earthing switch in open position |
| ESCLOSE_POS | BOOLEAN | Earthing switch in closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |

## 9.3.7 P3SSXSWI Settings

**Table 1488: P3SSXSWI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reed contact | 0=Not available<br>1=Available | | | 0=Not available | Availability of reed contact |
| Identification | | | | P3SSXSWI1 switch position | Control object identification |

**Table 1489: P3SSXSWI Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Event delay | 0...60000 | ms | 1 | 10000 | Event delay of intermediate or faulty position |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

### 9.3.8 P3SSXSWI Monitored data

**Table 1490: P3SSXSWI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Enum | 0=earthing switch closed<br>1=earthing switch intermediate<br>2=both open<br>3=disconnector intermediate<br>4=disconnector closed<br>5=faulty | | 3-position switch position |
| POSITION_DC | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Disconnector position |
| POSITION_ES | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Earthing switch position |

## 9.4 Disconnector position indicator DCSXSWI and Earthing switch position indication ESSXSWI (ANSI 29DS, 29GS)

### 9.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Disconnector position indication | DCSXSWI | I<->O DC | 29DS |
| Earthing switch indication | ESSXSWI | I<->O ES | 29GS |

## 9.4.2 Function block




*Figure 840: Function block*

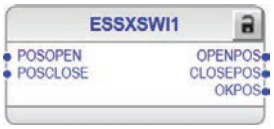



*Figure 841: Function block*

## 9.4.3 Functionality

The functions DCSXSWI and ESSXSWI indicate remotely and locally the open, close and undefined states of the disconnector and earthing switch. The functionality of both is identical, but each one is allocated for a specific purpose visible in the function names. For example, the status indication of disconnectors or circuit breaker truck can be monitored with the DCSXSWI function.

The functions are designed according to the IEC 61850-7-4 standard with the logical node XSWI.

## 9.4.4 Operation principle

### Status indication and validity check

The object state is defined by the two digital inputs POSOPEN and POSCLOSE, which are also available as outputs OPENPOS and CLOSEPOS together with the OKPOS according to *Table 1491*. The debounces and short disturbances in an input are eliminated by filtering. The binary input filtering time can be adjusted separately for each digital input used by the function block. The validity of digital inputs that indicate the object state is used as additional information in indications and event logging.

**Table 1491: Status indication**

| Input | | Status | Output | | |
|---|---|---|---|---|---|
| **POSOPEN** | **POSCLOSE** | **POSITION (Monitored data)** | **OKPOS** | **OPENPOS** | **CLOSEPOS** |
| 1=True | 0=False | 1=Open | 1=True | 1=True | 0=False |
| 0=False | 1=True | 2=Closed | 1=True | 0=False | 1=True |
| 1=True | 1=True | 3=Faulty/Bad (11) | 0=False | 0=False | 0=False |
| 0=False | 0=False | 0=Intermediate (00) | 0=False | 0=False | 0=False |

## 9.4.5 Application

In the field of distribution and sub-transmission automation, the reliable control and status indication of primary switching components both locally and remotely is in a significant role. These features are needed especially in modern remote controlled substations. The application area of DCSXSWI and ESSXSWI functions covers remote and local status indication of, for example, disconnectors, air-break switches and earthing switches, which represent the lowest level of power switching devices without short-circuit breaking capability.

## 9.4.6 Signals

### 9.4.6.1 DCSXSWI Input signals

**Table 1492: DCSXSWI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |

### 9.4.6.2 ESSXSWI Input signals

**Table 1493: ESSXSWI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| POSOPEN | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLOSE | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |

### 9.4.6.3 DCSXSWI Output signals

**Table 1494: DCSXSWI Output signals**

| Name | Type | Description |
|---|---|---|
| OPENPOS | BOOLEAN | Apparatus open position |
| CLOSEPOS | BOOLEAN | Apparatus closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |

#### 9.4.6.4 ESSXSWI Output signals

**Table 1495: ESSXSWI Output signals**

| Name | Type | Description |
|---|---|---|
| OPENPOS | BOOLEAN | Apparatus open position |
| CLOSEPOS | BOOLEAN | Apparatus closed position |
| OKPOS | BOOLEAN | Apparatus position is ok |

## 9.4.7 Settings

### 9.4.7.1 DCSXSWI Settings

**Table 1496: DCSXSWI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Identification | | | | DCSXSWI1 switch position | Control Object identification |

**Table 1497: DCSXSWI Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Event delay | 0...60000 | ms | 1 | 30000 | Event delay of the intermediate and faulty position |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

### 9.4.7.2 ESSXSWI Settings

**Table 1498: ESSXSWI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Identification | | | | ESSXSWI1 switch position | Control Object identification |

**Table 1499: ESSXSWI Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Event delay | 0...60000 | ms | 1 | 30000 | Event delay of the intermediate and faulty position |
| Vendor | | | | 0 | External equipment vendor |
| Serial number | | | | 0 | External equipment serial number |
| Model | | | | 0 | External equipment model |

### 9.4.8 Monitored data

#### 9.4.8.1 DCSXSWI Monitored data

**Table 1500: DCSXSWI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Apparatus position indication |

#### 9.4.8.2 ESSXSWI Monitored data

**Table 1501: ESSXSWI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| POSITION | Dbpos | 0=intermediate<br>1=open<br>2=closed<br>3=faulty | | Apparatus position indication |

## 9.5 Synchronism and energizing check SECRSYN (ANSI 25)

### 9.5.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Synchronism and energizing check | SECRSYN | SYNC | 25 |

### 9.5.2 Function block

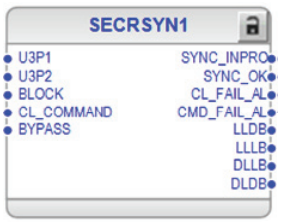



*Figure 842: Function block*

## 9.5.3 Functionality

The synchronism and energizing check function SECRSYN checks the condition across the circuit breaker from separate power system parts and gives the permission to close the circuit breaker. SECRSYN includes the functionality of synchrocheck and energizing check.

Asynchronous operation mode is provided for asynchronously running systems. The main purpose of the asynchronous operation mode is to provide a controlled closing of circuit breakers when two asynchronous systems are connected.

The synchrocheck operation mode checks that the voltages on both sides of the circuit breaker are perfectly synchronized. It is used to perform a controlled reconnection of two systems which are divided after islanding and it is also used to perform a controlled reconnection of the system after reclosing.

The energizing check function checks that at least one side is dead to ensure that closing can be done safely.

The function contains a blocking functionality. It is possible to block function outputs and timers.

## 9.5.4 Analog channel configuration

SECRSYN has two analog group inputs which must be properly configured.

**Table 1502: Analog inputs**

| Input | Description |
|---|---|
| U3P1 | Three-phase voltages (bus side) |
| U3P2 | Three-phase voltages (line side) |



See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1503: Special conditions**

| Condition | Description |
|---|---|
| U3P1 connected to real measurements | The function requires that at least two voltage channels from the bus side are connected. |
| U3P2 connected to real measurements | The function requires that one voltage channel from the line side is connected to channel 1 or any two voltage channels from the line side. |

When a single voltage channel is connected on the line side, the *VT connection* setting of the U3P2 source UTVTR defines whether ph-to-earth or ph-to-ph voltages are used from both sides in checking the conditions. If at least two voltage channels are connected on line side, ph-to-ph voltages are used from both sides in checking the conditions regardless of the *VT connection* settings of the source UTVTRs.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings.

For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 9.5.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

SECRSYN has two parallel functionalities, the synchro check and energizing check functionality. The operation of SECRSYN can be described using a module diagram. All the modules in the diagram are explained in the next sections.

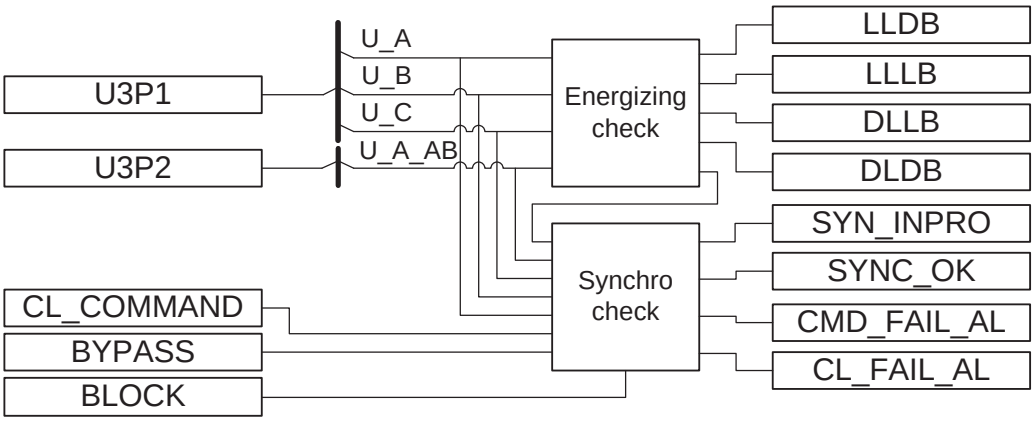



*Figure 843: Functional module diagram*

If Energizing check is passed, no further conditions need to be fulfilled to permit closing. Otherwise, Synchro check function can operate either with the U_AB or U_A voltages. The selection of used voltages is defined with the *VT connection* setting of the line voltage general parameters.

By default, voltages U_BUS and U_LINE are connected as presented in *Figure 852*. If necessary, connections can be switched by setting *Voltage source switch* to “True”.

### Energizing check

The Energizing check function checks the energizing direction. Energizing is defined as a situation where a dead network part is connected to an energized section of the network. The conditions of the network sections to be controlled by the circuit breaker, that is, which side has to be live and which side dead, are determined by the setting. A situation where both sides are dead is possible as well. The actual value for defining the dead line or bus is given with the *Dead bus value* and *Dead line value* settings. Similarly, the actual values of live line or bus are defined with the *Live bus value* and *Live line value* settings.

**Table 1504: *Live dead mode* of operation under which switching can be carried out**

| Live dead mode | Description |
|---|---|
| Both Dead | Both line and bus de-energized |
| Live L, Dead B | Bus de-energized and line energized |
| Dead L, Live B | Line de-energized and bus energized |
| Dead Bus, L Any | Both line and bus de-energized or bus de-energized and line energized |
| Dead L, Bus Any | Both line and bus de-energized or line de-energized and bus energized |
| One Live, Dead | Bus de-energized and line energized or line de-energized and bus energized |
| Not Both Live | Both line and bus de-energized or bus de-energized and line energized or line de-energized and bus energized |

When the energizing direction corresponds to the settings, the situation has to be constant for a time set with the *Energizing time* setting before the circuit breaker closing is permitted. The purpose of this time delay is to ensure that the dead side remains de-energized and also that the situation is not caused by a temporary interference. If the conditions do not persist for a specified operation time, the timer is reset and the procedure is restarted when the conditions allow. The circuit breaker closing is not permitted if the measured voltage on the live side is greater than the set value of *Max energizing V*.

The measured energized state is available as a monitored data value ENERG_STATE and as four function outputs `LLDB` (live line / dead bus), `LLLB` (live line / live bus), `DLLB` (dead line / live bus) and `DLDB` (dead line / dead bus), of which only one can be active at a time. It is also possible that the measured energized state indicates “Unknown” if at least one of the measured voltages is between the limits set with the dead and live setting parameters.

### Synchro check

The Synchro check function measures the difference between the line voltage and bus voltage. The function permits the closing of the circuit breaker when certain conditions are simultaneously fulfilled.

- The measured line and bus voltages are higher than the set values of *Live bus value* and *Live line value* (ENERG_STATE equals to "Both Live").
- The measured bus and line frequency are both within the range of 95 to 105 percent of the value of $f_n$.
- The measured voltages for the line and bus are less than the set value of *Max energizing V*.

In case *Syncro check mode* is set to "Syncronous", the additional conditions must be fulfilled.

- In the synchronous mode, the closing is attempted so that the phase difference at closing is close to zero.
- The synchronous mode is only possible when the frequency slip is below 0.1 percent of the value of $f_n$.
- The voltage difference must not exceed the 1 percent of the value of $U_n$.

In case *Syncro check mode* is set to “Asyncronous”, the additional conditions must be fulfilled.

- The measured difference of the voltages is less than the set value of *Difference voltage*.
- The measured difference of the phase angles is less than the set value of *Difference angle*.
- The measured difference in frequency is less than the set value of *Frequency difference*.
- The estimated breaker closing angle is decided to be less than the set value of *Difference angle*.

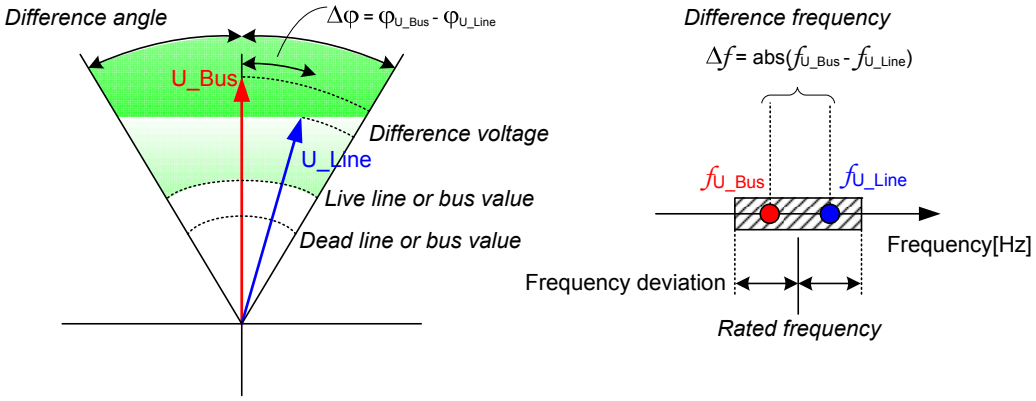



*Figure 844: Conditions to be fulfilled when detecting synchronism between systems*

When the frequency, phase angle and voltage conditions are fulfilled, the duration of the synchronism conditions is checked so as to ensure that they are still met when the condition is determined on the basis of the measured frequency and phase difference. Depending on the circuit breaker and the closing system, the delay from the moment the closing signal is given until the circuit breaker finally closes is about 50...250 ms. The selected *Closing time of CB* informs the function how long the conditions have to persist. The Synchro check function compensates for the measured slip frequency and the circuit breaker closing delay. The phase angle advance is calculated continuously with the formula.

$$Closing\ angle = \left|\left(\angle U_{Bus} - \angle U_{Line}\right)° + \left(\left(f_{Bus} - f_{line}\right) \times \left(T_{CB} + T_{PL}\right) \times 360°\right)\right|$$

(Equation 352)

| | |
|---|---|
| $\angle U_{Bus}$ | Measured bus voltage phase angle |
| $\angle U_{Line}$ | Measured line voltage phase angle |
| $f_{Bus}$ | Measured bus frequency |
| $f_{line}$ | Measured line frequency |
| $T_{CB}$ | Total circuit breaker closing delay, including the delay of the protection relay output contacts defined with the *Closing time of CB* setting parameter value |
| $T_{PL}$ | Output type dependent delay according to *Table 1505* |

**Table 1505: Typical delays for different output types**

| Output type | Recommended value for $T_{PL}$ |
|---|---|
| Semiconductor output (HSO, SPO) | 0 ms |
| Mechanical relay output (POSP, PODP, PO) | 6 ms |

The closing angle is the estimated angle difference after the breaker closing delay.

The *Minimum Syn time* setting time can be set, if required, to demand the minimum time within which conditions must be simultaneously fulfilled before the SYNC_OK output is activated.

The measured voltage, frequency and phase angle difference values between the two sides of the circuit breaker are available as monitored data values U_DIFF_MEAS, FR_DIFF_MEAS and PH_DIFF_MEAS. Also, the indications of the conditions that are not fulfilled and thus preventing the breaker closing permission are available as monitored data values U_DIFF_SYNC, PH_DIF_SYNC and FR_DIFF_SYNC. These monitored data values are updated only when the Synchro check is enabled with the *Synchro check mode* setting and the measured ENERG_STATE is "Both Live".

**Continuous mode**

The continuous mode is activated by setting the parameter *Control mode* to "Continuous". In the continuous control mode, Synchro check is continuously checking the synchronism. When synchronism is detected (according to the settings), the SYNC_OK output is set to TRUE (logic '1') and it stays TRUE as long as the conditions are fulfilled. The command input is ignored in the continuous control mode.

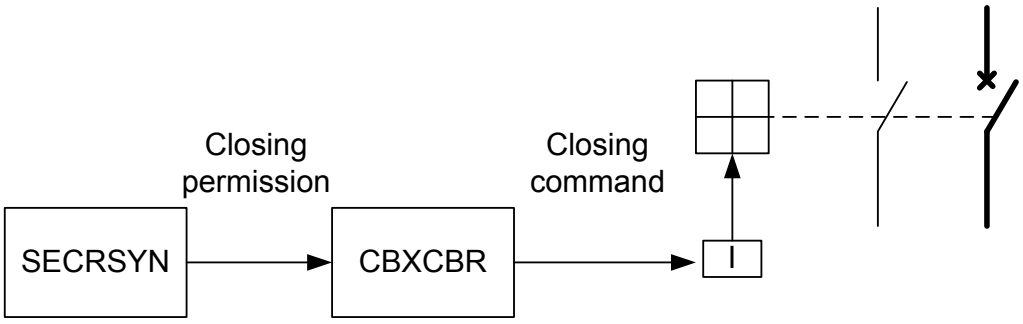



*Figure 845: A simplified block diagram of the Synchro check function in the continuous mode operation*

**Command mode**

If *Control mode* is set to "Command", the purpose of the Synchro check functionality in the command mode is to find the instant when the voltages on both sides of the circuit breaker are in synchronism. The conditions for synchronism are met when the voltages on both sides of the circuit breaker have the same frequency and are in phase with a magnitude that makes the concerned busbars or lines such that they can be regarded as live.

In the command mode operation, an external command signal CL_COMMAND (initiated by the breaker function CBXCBR output CL_REQ), in addition to the normal closing conditions, is needed for delivering the SYNC_OK signal for the breaker function input SYNC_OK. If the closing conditions are fulfilled during a permitted check time set with *Maximum Syn time*, the Synchro check function delivers a SYNC_OK signal to the circuit breaker function after the command signal is delivered for closing.

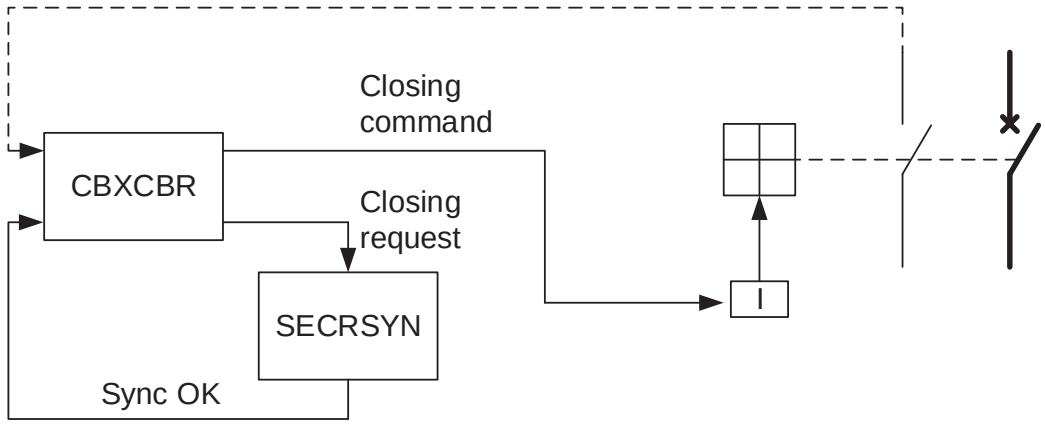



*Figure 846: A simplified block diagram of SECRSYN in the command mode operation*

The SYNC_OK signal is delivered only once for each activated external closing command signal. The pulse length of the delivered SYNC_OK is set with the *Close pulse* setting.

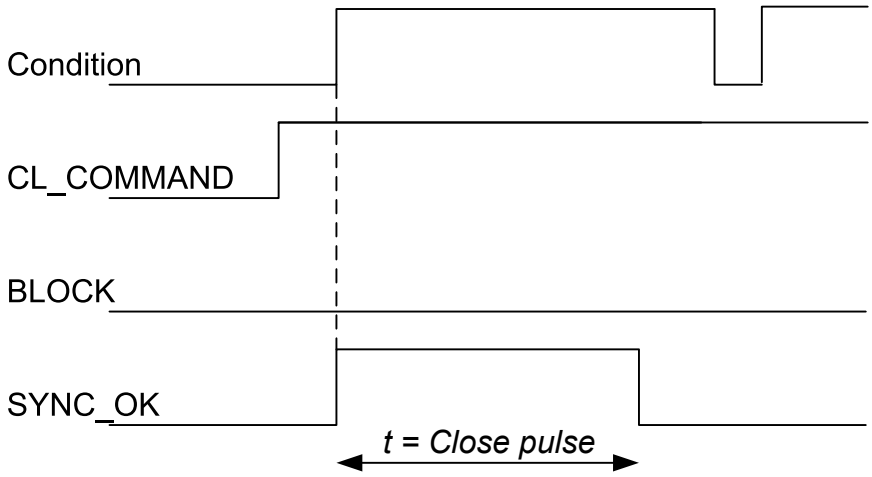



*Figure 847: Determination of the pulse length of the closing signal*

In the command control mode operation, there are alarms for a failed closing attempt ( CL_FAIL_AL) and for a command signal that remains active too long ( CMD_FAIL_AL).

If the conditions for closing are not fulfilled within the set time of *Maximum Syn time*, a failed closing attempt alarm is given. The CL_FAIL_AL alarm output signal is pulse-shaped and the pulse length is 500 ms. If the external command signal is removed too early, that is, before conditions are fulfilled and the closing pulse is given, the alarm timer is reset.

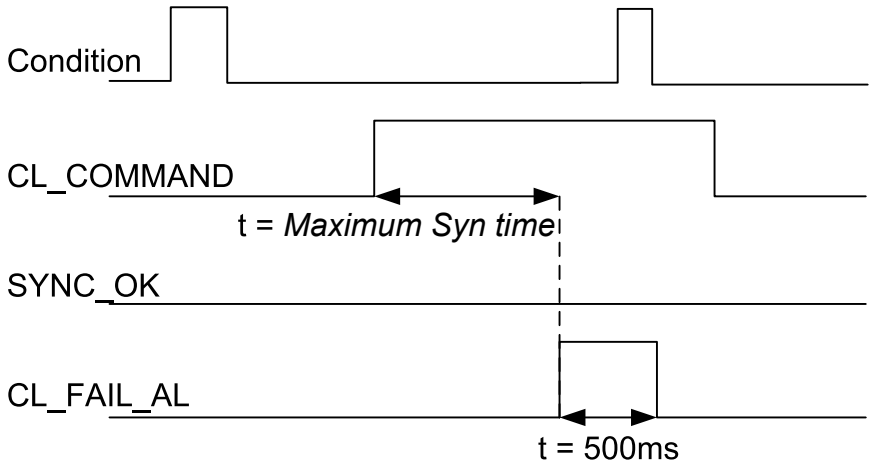



*Figure 848: Determination of the checking time for closing*

CBXCBR receives information about the circuit breaker status and thus is able to adjust the command signal to be delivered to the Synchro check function. If the external command signal CL_COMMAND is kept active longer than necessary, the CMD_FAIL_AL alarm output is activated. The alarm indicates that the control module has not removed the external command signal after the closing operation. To avoid unnecessary alarms, the duration of the command signal should be set in such a way that the maximum length of the signal is always below *Maximum Syn time* + 5s.

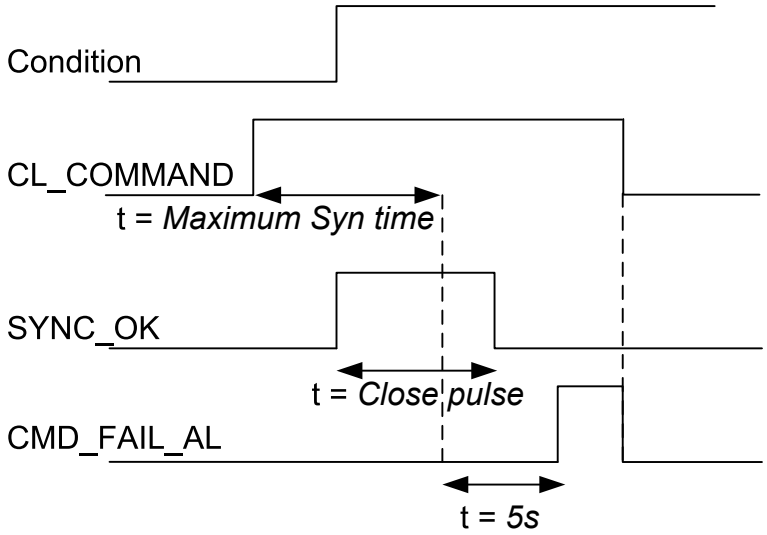



*Figure 849: Determination of the alarm limit for a still-active command signal*

Closing is permitted during *Maximum Syn time*, starting from the moment the external command signal CL_COMMAND is activated. The CL_COMMAND input must be kept active for the whole time that the closing conditions are waited to be fulfilled. Otherwise, the procedure is cancelled. If the closing-command conditions are fulfilled during *Maximum Syn time*, a SYNC_OK pulse is delivered to the circuit breaker function. If the closing conditions are not fulfilled during the checking time, the alarm CL_FAIL_AL is activated as an indication of a failed closing attempt. The SYNC_OK pulse is not delivered if the closing conditions become valid after *Maximum Syn time* has elapsed. The closing pulse is delivered only once for

each activated external command signal, and a new closing-command sequence cannot be started until the external command signal is reset and reactivated. The SYNC_INPRO output is active when the closing-command sequence is in progress and it is reset when the CL_COMMAND input is reset or *Maximum Syn time* has elapsed.

### Bypass mode

SECRSYN can be set to the bypass mode by setting the parameters *Synchrocheck mode* and *Live dead mode* to "Off" or alternatively by activating the BYPASS input.

In the bypass mode, the closing conditions are always considered to be fulfilled by SECRSYN. Otherwise, the operation is similar to the normal mode.

### Voltage angle difference adjustment

In application where the power transformer is located between the voltage measurement and the vector group connection gives phase difference to the voltages between the high- and low-voltage sides, the angle adjustment can be used to meet synchronism.

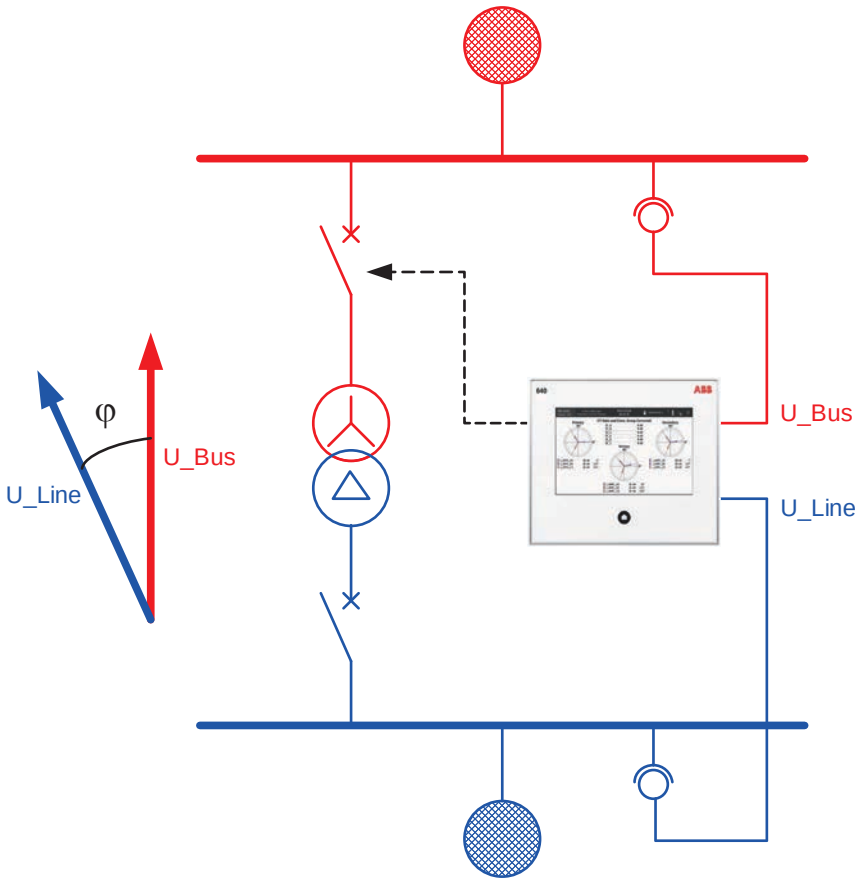



*Figure 850: Angle difference when power transformer is in sychrocheck zone*

The vector group of the power transformer is defined with clock numbers, where the value of the hour pointer defines the low-voltage-side phasor and the high-voltage-side phasor is always fixed to the clock number 12, which is same as zero. The angle between clock numbers is 30 degrees. When comparing phase angles, the U_BUS input is always the reference. This means that when the Yd11 power transformer is used, the low-voltage-side voltage phasor leads by 30 degrees or

lags by 330 degrees the high-voltage-side phasor. The rotation of the phasors is counterclockwise.

The generic rule is that a low-voltage-side phasor lags the high-voltage-side phasor by clock number * 30º. This is called angle difference adjustment and can be set for SECRSYN with the *Phase shift* setting.

## 9.5.6 Application

The main purpose of the synchrocheck function is to provide control over the closing of the circuit breakers in power networks to prevent the closing if the conditions for synchronism are not detected. This function is also used to prevent the reconnection of two systems which are divided after islanding and a three-pole reclosing.

The Synchro check function block includes both the synchronism check function and the energizing function to allow closing when one side of the breaker is dead.

Network and the generator running in parallel with the network are connected through the line AB. When a fault occurs between A and B, the protection relay protection opens the circuit breakers A and B, thus isolating the faulty section from the network and making the arc that caused the fault extinguish. The first attempt to recover is a delayed autoreclosure made a few seconds later. Then, the autoreclose function DARREC gives a command signal to the synchrocheck function to close the circuit breaker A. SECRSYN performs an energizing check, as the line AB is de-energized ( `U_BUS`> *Live bus value*, `U_LINE`< *Dead line value*) . After verifying the line AB is dead and the energizing direction is correct, the protection relay energizes the line ( `U_BUS` -> `U_LINE`) by closing the circuit breaker A. The PLC of the power plant discovers that the line has been energized and sends a signal to the other synchrocheck function to close the circuit breaker B. Since both sides of the circuit breaker B are live ( `U_BUS` > *Live bus value*, `U_LINE` > *Live bus value*), the synchrocheck function controlling the circuit breaker B performs a synchrocheck and, if the network and the generator are in synchronism, closes the circuit breaker.

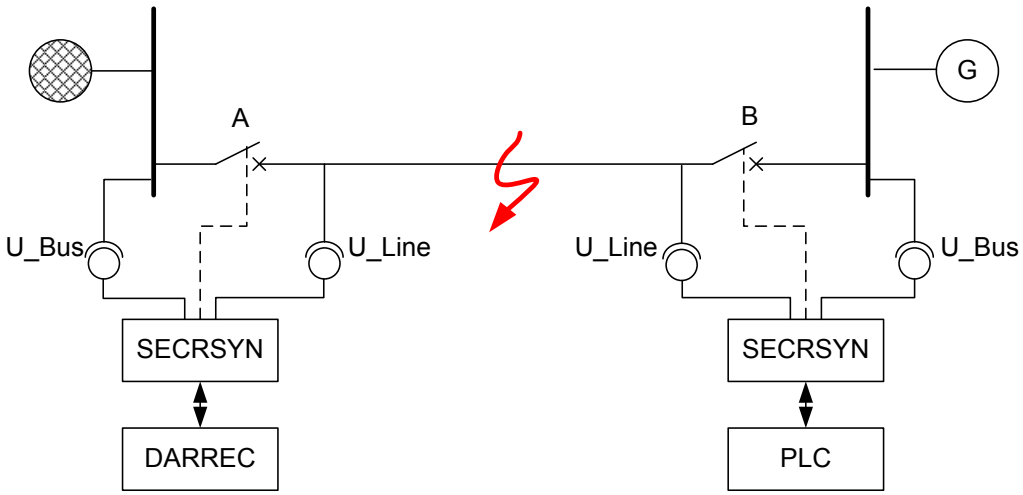



*Figure 851: Synchrocheck function SECRSYN checking energizing conditions and synchronism*

### Connections

A special attention is paid to the connection of the protection relay. Furthermore it is checked that the primary side wiring is correct.

A faulty wiring of the voltage inputs of the protection relay causes a malfunction in the synchrocheck function. If the wires of an energizing input have changed places, the polarity of the input voltage is reversed (180°). In this case, the protection relay permits the circuit breaker closing in a situation where the voltages are in opposite phases. This can damage the electrical devices in the primary circuit. Therefore, it is extremely important that the wiring from the voltage transformers to the terminals on the rear of the protection relay is consistent regarding the energizing inputs U_BUS (bus voltage) and U_LINE (line voltage).

The wiring should be verified by checking the reading of the phase difference measured between the U_BUS and U_LINE voltages. The phase difference measured by the protection relay has to be close to zero within the permitted accuracy tolerances. The measured phase differences are indicated in the LHMI. At the same time, it is recommended to check the voltage difference and the frequency differences presented in the monitored data view. These values should be within the permitted tolerances, that is, close to zero.

*Figure 852* shows an example where the synchrocheck is used for the circuit breaker closing between a busbar and a line. The phase-to-phase voltages are measured from the busbar and also one phase-to-phase voltage from the line is measured.

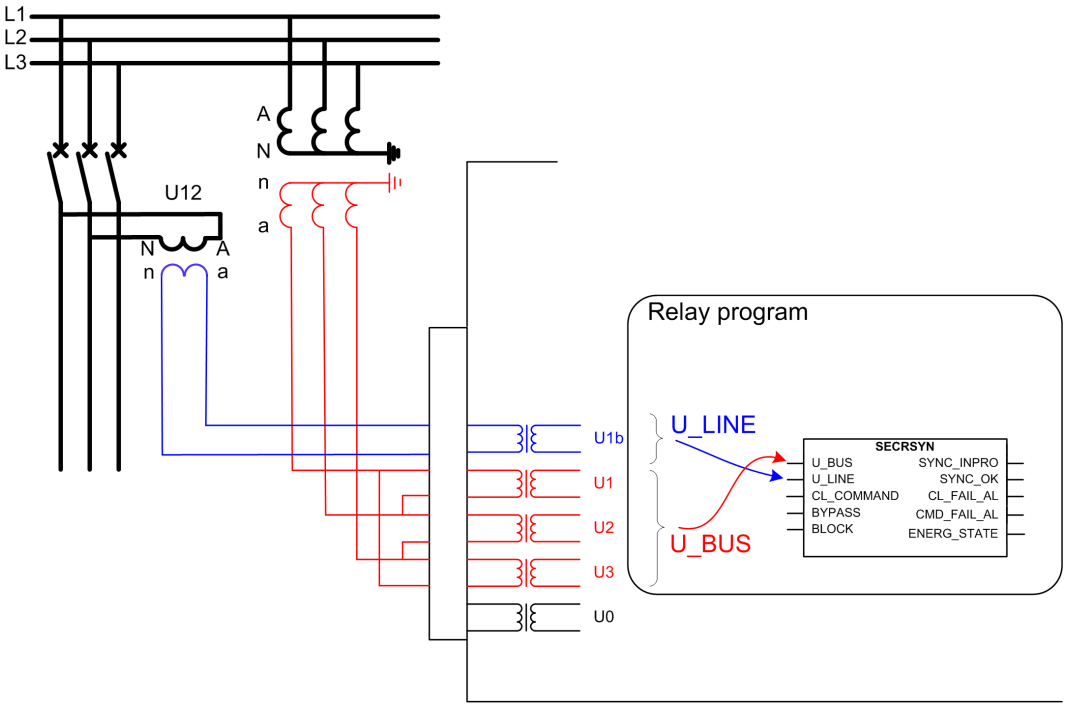



*Figure 852: Connection of voltages for the protection relay and signals used in synchrocheck*

## 9.5.7 Signals

### 9.5.7.1 SECRSYN Input signals

**Table 1506: SECRSYN Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P1 | SIGNAL | - | Three-phase voltages 1 |
| U3P2 | SIGNAL | - | Three-phase voltages 2 |
| BLOCK | BOOLEAN | 0=False | Blocking signal of the synchro check and voltage check function |
| CL_COMMAND | BOOLEAN | 0=False | External closing request |
| BYPASS | BOOLEAN | 0=False | Request to bypass synchronism check and voltage check |

### 9.5.7.2 SECRSYN Output signals

**Table 1507: SECRSYN Output signals**

| Name | Type | Description |
|---|---|---|
| SYNC_INPRO | BOOLEAN | Synchronizing in progress |
| SYNC_OK | BOOLEAN | Systems in synchronism |
| CL_FAIL_AL | BOOLEAN | CB closing failed |
| CMD_FAIL_AL | BOOLEAN | CB closing request failed |
| LLDB | BOOLEAN | Live Line, Dead Bus |
| LLLB | BOOLEAN | Live Line, Live Bus |
| DLLB | BOOLEAN | Dead Line, Live Bus |
| DLDB | BOOLEAN | Dead Line, Dead Bus |

## 9.5.8 SECRSYN Settings

**Table 1508: SECRSYN Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Live dead mode | -1=Off<br>1=Both Dead<br>2=Live L, Dead B<br>3=Dead L, Live B<br>4=Dead Bus, L Any<br>5=Dead L, Bus Any<br>6=One Live, Dead | | | 1=Both Dead | Energizing check mode |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 7=Not Both Live | | | | |
| Difference voltage | 0.01...0.50 | xUn | 0.01 | 0.05 | Maximum voltage difference limit |
| Difference frequency | 0.0002...0.1000 | xFn | 0.0001 | 0.0010 | Maximum frequency difference limit |
| Difference angle | 5...90 | deg | 1 | 5 | Maximum angle difference limit |

**Table 1509: SECRSYN Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Synchro check mode | 1=Off<br>2=Synchronous<br>3=Asynchronous | | | 3=Asynchronous | Synchro check operation mode |
| Dead line value | 0.1...0.8 | xUn | 0.1 | 0.2 | Voltage low limit line for energizing check |
| Live line value | 0.2...1.0 | xUn | 0.1 | 0.8 | Voltage high limit line for energizing check |
| Dead bus value | 0.1...0.8 | xUn | 0.1 | 0.2 | Voltage low limit bus for energizing check |
| Live bus value | 0.2...1.0 | xUn | 0.1 | 0.5 | Voltage high limit bus for energizing check |
| Max energizing V | 0.50...1.15 | xUn | 0.01 | 1.05 | Maximum voltage for energizing |

**Table 1510: SECRSYN Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Control mode | 1=Continuous<br>2=Command | | | 1=Continuous | Selection of synchro check command or Continuous control mode |
| Close pulse | 200...60000 | ms | 10 | 200 | Breaker closing pulse duration |
| Phase shift | -180...180 | deg | 1 | 0 | Correction of phase difference between measured U_BUS and U_LINE |
| Minimum Syn time | 0...60000 | ms | 10 | 0 | Minimum time to accept synchronizing |
| Maximum Syn time | 100...6000000 | ms | 10 | 2000 | Maximum time to accept synchronizing |
| Energizing time | 100...60000 | ms | 10 | 100 | Time delay for energizing check |
| Closing time of CB | 40...250 | ms | 10 | 60 | Closing time of the breaker |
| Voltage source switch | 0=False<br>1=True | | | 0=False | Voltage source switch |

## 9.5.9 SECRSYN Monitored data

**Table 1511: SECRSYN Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ENERG_STATE | Enum | 0=Unknown<br>1=Both Live<br>2=Live L, Dead B<br>3=Dead L, Live B<br>4=Both Dead | | Energization state of Line and Bus |
| U_DIFF_MEAS | FLOAT32 | -3.00...3.00 | xUn | Calculated voltage amplitude difference |
| FR_DIFF_MEAS | FLOAT32 | -1.500...1.500 | xFn | Calculated voltage frequency difference |
| PH_DIFF_MEAS | FLOAT32 | -180.00...180.00 | deg | Calculated voltage phase angle difference |
| U_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Voltage difference out of limit for synchronizing |
| PH_DIF_SYNC | BOOLEAN | 0=False<br>1=True | | Phase angle difference out of limit for synchronizing |
| FR_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Frequency difference out of limit for synchronizing |
| SECRSYN | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 9.5.10 Technical data

**Table 1512: SECRSYN Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±1 Hz |
| | Voltage:<br>±3.0 % of the set value or ±0.01 × $U_n$<br>Frequency:<br>±10 mHz<br>Phase angle:<br>±3° |
| Reset time | <50 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0 % of the set value or ±20 ms |

# 9.6 Autosynchronizer for generator breaker ASGCSYN (ANSI 25AUTOSYNCG)

## 9.6.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Autosynchronizer for generator breaker | ASGCSYN | AUTOSYNCG | 25AUTOSYNCG |

## 9.6.2 Function block

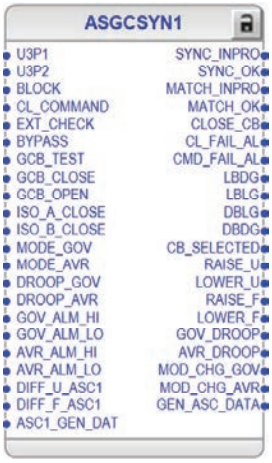



*Figure 853: Function block*

## 9.6.3 Functionality

The autosynchronizer for generator breaker function ASGCSYN checks the conditions across the circuit breaker from generator and bus side and issues the pulse commands to the automatic voltage regulator (AVR) and prime mover governor to match the voltage and frequency conditions if required. Once the synchronization check and close CB conditions are fulfilled, the function gives permission to close the circuit breaker. ASGCSYN includes the functionality of energizing check, synchronization check and voltage and frequency matching.

The energizing check function checks that bus side is dead to ensure that breaker closing can be done safely. The synchronization check function checks that the voltages and frequency on both sides of the circuit breaker are within the predefined setting. It is used to perform a controlled reconnection of two systems.

Depending on the selected control mode, the synchronization process is fully automatic or it requires operator action for breaker closing and voltage and frequency matching. In all of the modes, the synchronization check prevents breaker closing if the set limit values are not met.

The voltage and frequency matching function issues raise or lower pulse commands to AVR and the governor to match the voltage and frequency, based on the

calculated voltage and frequency difference across the circuit breaker to be synchronized. ASGCSYN also participates in voltage and frequency matching for network breaker synchronization.

## 9.6.4 Analog channel configuration

ASGCSYN has two analog group inputs which must be properly configured.

**Table 1513: Analog inputs**

| Input | Description |
|---|---|
| U3P1 | Three-phase voltages (generator side) |
| U3P2 | Three-phase voltages (bus side) |



See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1514: Special conditions**

| Condition | Description |
|---|---|
| U3P1 and U3P2 connected to real measurements | When one voltage channel from the generator side is connected to channel 1 of U3P1 and one voltage channel from the bus side is connected to channel 1 of U3P2, the function can only work if UTVTR's *VT connection* settings on the generator and bus sides are similar. |
| | The function can work if one voltage channel from the generator side is connected to channel 1 of U3P1 and three voltage channels from the bus side are connected to U3P2. |
| | The function can work if one voltage channel from the generator side is connected to channel 1 of U3P1 and two voltage channels along with the residual voltage from the bus side are connected to U3P2. |
| | The function can work if three voltage channels from the generator side are connected to U3P1 and one voltage channel from the bus side is connected to channel 1 of U3P2. |
| | The function can work if two voltage channels and the residual voltage from the generator side are connected to U3P1 and one voltage channel from the bus side is connected to channel 1 of U3P2. |
| Dissimilar VT connection settings for UTVTR on the generator and bus sides | The function requires that all three voltage channels or two voltage channels and the residual voltage are connected to either U3P1 or U3P2. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 9.6.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of ASGCSYN can be described with a module diagram. All the modules in the diagram are explained in the next sections.

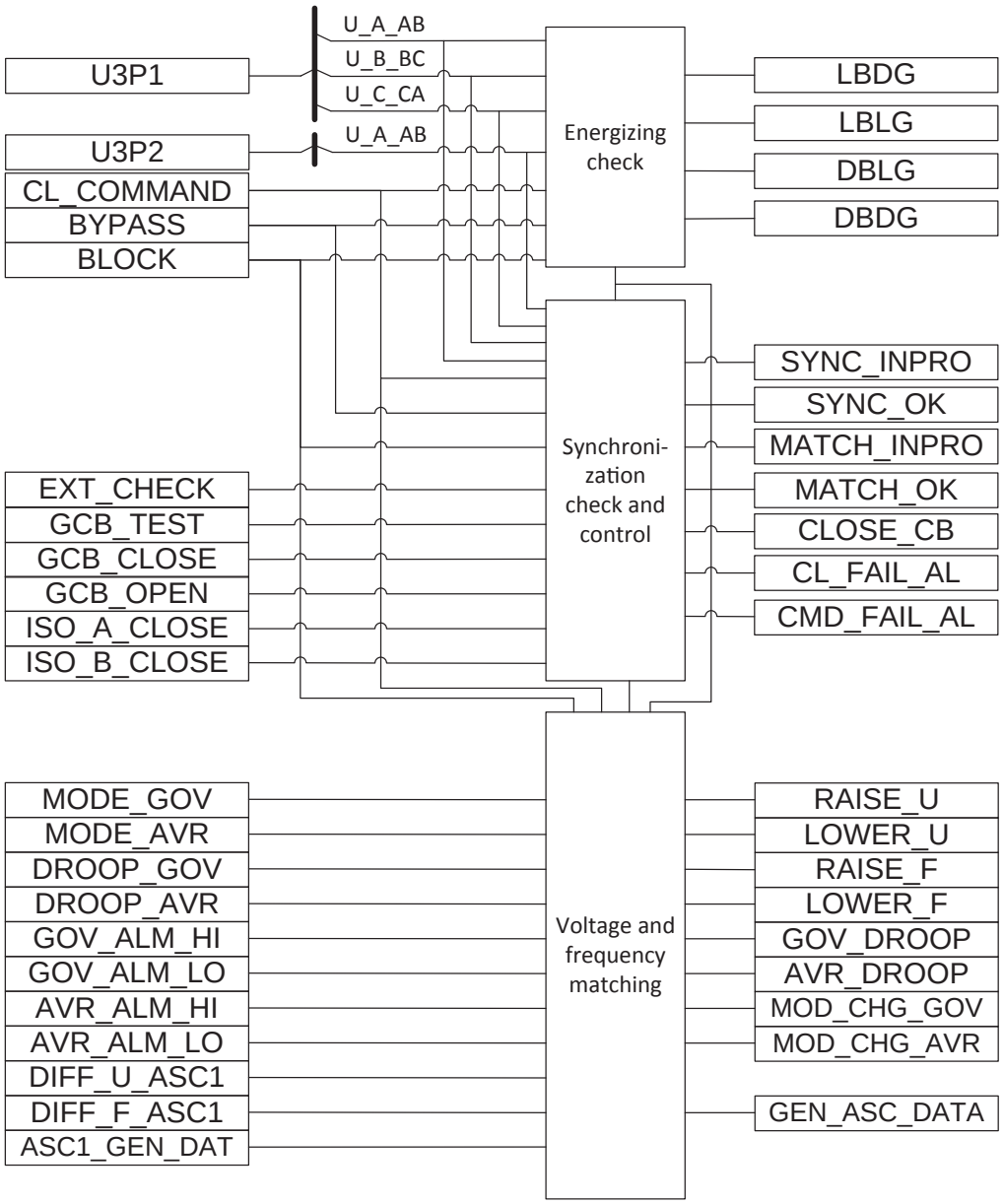



*Figure 854: Functional module diagram*

ASGCSYN can operate either with the U_AB or U_A voltages. The selection of used voltages is defined with the *VT connection* setting of the voltage measurement parameters.

### 9.6.5.1 Energizing check

The Energizing check module checks the energizing direction. Energizing is the situation where a dead network part is connected to an energized section of the network. The conditions of the network sections to be controlled by the circuit breaker, that is, which side has to be live and which side dead, are determined by the setting *Live dead mode*.

*Live dead mode* can be set in two ways: either through settings or through the command control.

If the *Live dead mode* parameter under the Setting menu is set as "Command", then *Live dead mode Ctl* parameter under the Control menu can be used to select the values in *Table 1515*. Otherwise, the *Live dead mode* parameter under the Setting menu is used to select the values in *Table 1515*.

**Table 1515: Live dead mode of operation when switching can be carried out**

| Live dead mode | Description |
|---|---|
| Off | Live dead mode setting is in off status |
| Both Dead | Both bus and generator de-energized |
| Live G, Dead B | Bus de-energized and generator energized |
| Dead B, G Any | Bus de-energized and generator energized or de-energized |

The actual value for defining the dead bus or generator is given with the *Dead voltage value* setting. Similarly, the actual values of live bus or generator are defined with the *Live voltage value* setting.

When the energizing direction corresponds to the settings, the situation has to be constant for a time set with the *Energizing time* setting before the circuit breaker closing is permitted. This time delay ensures that the dead side remains de-energized and that the situation is not caused by a temporary interference. If the conditions do not persist for a specified operate time, the timer is reset and the procedure is restarted when the conditions allow it. The circuit breaker does not close if the measured voltage on the live side is greater than the set value of *Maximum voltage*.

The measured energized state is available as a monitored data value ENERG_STATE and as four function outputs `LBLG` (“Both Live”), `LBDG` (“Live B, Dead G”), `DBLG` (“Dead B, Live G”) and `DBDG` (“Both Dead”), of which only one can be active at a time. The measured energized state indicates “Unknown” if at least one of the measured voltages is between the limits set with the dead and live setting parameters.

### 9.6.5.2 Synchronization check and control

The operation of Synchronization check and control modes can be described with a module diagram.

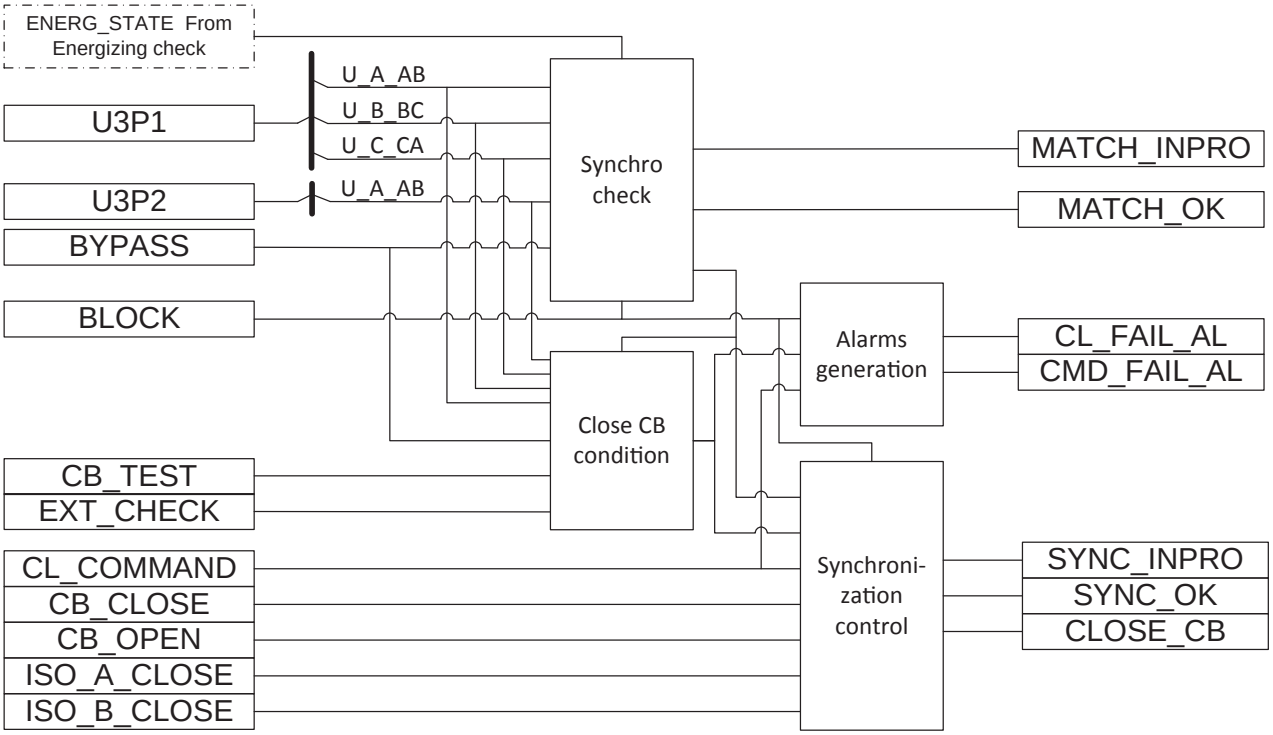



*Figure 855: Module diagram for Synchronization check and control*

**Synchro check**

The function measures the voltage difference U_DIFF_MEAS, frequency difference FR_DIFF_MEAS and phase angle difference PH_DIFF_MEAS between the bus voltage and generator voltage. In the calculation of PH_DIFF_MEAS, setting *Phase shift* is used to compensate the angle shift caused if a power transformer is located between the voltage measurements. Offset correction due to different channel measurements (for voltage and frequency values) can be done using *Voltage offset* and *Frequency offset*. The user can select the direction of generator synchronization using the setting *Synchronization Dir*.

$$U_DIFF_MEAS = U_{Gen} - U_{Bus} - Voltage\ offset$$

(Equation 353)

| | |
|---|---|
| $U_{Bus}$ | Measured bus side voltage |
| $U_{Gen}$ | Measured generator side voltage |
| Voltage off-set | Setting *Voltage offset* |

$$FR_DIFF_MEAS = f_{Gen} - f_{Bus} - Frequency\ offset$$

(Equation 354)

| | |
|---|---|
| $f_{Bus}$ | Measured bus side frequency |
| $f_{Gen}$ | Measured generator side frequency |
| Frequency offset | Setting *Frequency offset* |

$$PH_DIFF_MEAS = \angle U_{Gen} - \angle U_{Bus} - Phase\ shift$$

(Equation 355)

| | |
|---|---|
| $\angle U_{Bus}$ | Measured bus side voltage phase angle |
| $\angle U_{Gen}$ | Measured generator side voltage phase angle |
| Phase shift | Setting *Phase shift* |

The synchronism conditions are checked according to several criteria.

- The measured bus and generator voltages are higher than the set value of *Live voltage value* (ENERG_STATE equals “Both Live”).
- The measured bus and generator frequencies are both within the range of 95...105 percent of the nominal frequency (fn).
- The measured bus and generator voltages are lower than the set value of *Maximum voltage*.

If the *Synchrocheck mode* parameter under the Setting menu is set as "Command", then the *SynchroChk Mod Ctl* parameter under the Control menu is used to set values "OFF/Asynchronous". Otherwise, the *Synchrocheck mode* parameter under the Setting menu is used to set the values "Off/Asynchronous".

Some additional conditions must also be fulfilled as per the set *Synchrocheck mode*.

**Table 1516: Additional conditions for the Synchro check**

| Measurements | Synchrocheck mode “Asynchronous” |
|---|---|
| U_DIFF_MEAS | < Voltage Diff Ov Ex and > -Voltage Diff Un Ex |
| PH_DIFF_MEAS | < Angle Diff positive and > - Angle Diff negative |
| FR_DIFF_MEAS | < Freq Diff OV Synch and > -Freq Diff sub Synch |
| Closing angle | < Angle Diff positive and >- Angle Diff negative |

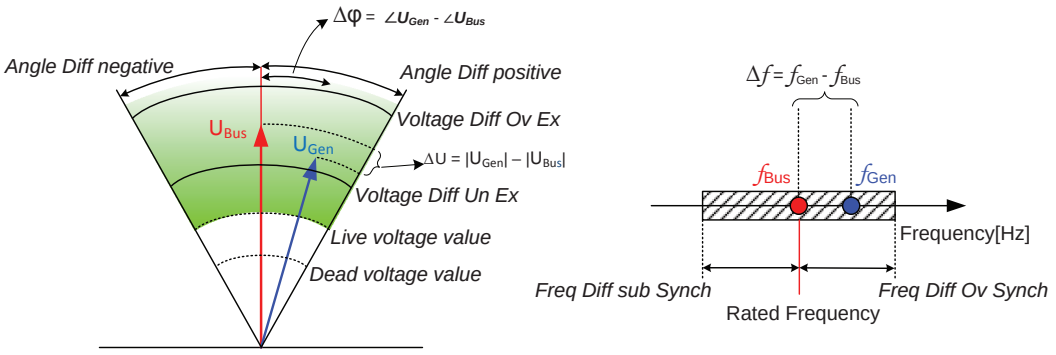



*Figure 856: Conditions to be fulfilled when detecting synchronism between systems*

When the measured differences in voltage and frequency are within the synchro check limits, the output MATCH_OK is activated. The output MATCH_INPRO is active while the voltage and frequency matching is in progress.

When the frequency, phase angle and voltage conditions are fulfilled, the duration of the synchronism conditions is checked to ensure that they are still met when the condition is determined on the basis of the measured frequency and phase difference. Depending on the circuit breaker and the closing system, the delay between the closing signal and the circuit breaker closing is about 50...250 ms. The selected *Closing time of CB* informs the function how long the conditions have to persist. The value covers both circuit breaker closing delay and output type dependent delay. The synchro check function compensates for the measured slip frequency and the circuit breaker closing delay. The closing angle advance is calculated continuously:

$$Closing\ angle = \left| (\angle U_{Gen} - \angle U_{Bus})° + \left( (f_{Gen} - f_{Bus}) \cdot \left( \frac{TCB}{1000} \right) \cdot 360° \right) \right|$$

(Equation 356)

| | |
|---|---|
| $\angle U_{Bus}$ | Measured generator voltage phase angle |
| $\angle U_{Gen}$ | Measured bus voltage phase angle |
| TCB | Parameter *Closing time of CB* to be set as in *Equation 357* |

$$TCB = t_{CB} + T_{PL} + x$$

(Equation 357)

| | |
|---|---|
| $t_{CB}$ | Circuit breaker closing delay in ms |
| $T_{PL}$ | Output type dependent delay in ms (see *Table 1517*) |
| x | Hardware delays between the protection relay and CB in ms; delays due to, for example, auxiliary relays and contactors, if used |

**Table 1517: Typical delays for different output types**

| Output type | Recommended value for $T_{PL}$ | |
|---|---|---|
| | **Generator voltage measurement: Non-Adaptive**<br>**Bus voltage measurement: Non-Adaptive** | **Generator voltage measurement: Adaptive**<br>**Bus voltage measurement: Non-Adaptive** |
| Semiconductor output (SPO) | 16 ms | 7 ms |
| Mechanical relay output (POSP, PODP) | 23 ms | 13 ms |

The *Minimum Syn time* setting defines the minimum time for which synchro check conditions must be simultaneously fulfilled.

ASGCSYN can be set to the bypass mode by setting the parameters *Synchrocheck mode* and *Live dead mode* to "Off" or, alternatively, by activating the BYPASS input. In the bypass mode, the synchro check conditions are always fulfilled. Otherwise, the operation is similar to the normal mode.

The frequency slip acceleration (ds/dt) FR_SLIP_ACCL is the average value of frequency slip difference (Δs) calculated over a time period of 0.5 s.

$$Frequency\ slip(s) = \frac{(f_{Gen} - f_{Bus})}{f_{Bus}}$$

(Equation 358)

The measured bus voltage ($U_{Bus}$), bus frequency ($f_{Bus}$), generator voltage ($U_{Gen}$), generator frequency ($f_{Gen}$) and phase angle difference values between the two sides of the circuit breaker are available as monitored data values U_BUS_MEAS, FR_BUS_MEAS, U_GEN_MEAS, FR_GEN_MEAS, U_DIFF_MEAS, FR_DIFF_MEAS and PH_DIFF_MEAS. The calculated frequency slip acceleration (ds/dt) is available as monitored data value FR_SLIP_ACCL. Also, the indications of the conditions that are not fulfilled and thus preventing the breaker closing permission are available as monitored data values U_DIFF_SYNC, PH_DIF_SYNC and FR_DIFF_SYNC. These monitored data values are updated only when the setting *Synchrocheck mode* is set to "Asynchronous" and the measured ENERG_STATE is "Both Live".

The measured voltage, frequency are updated in the monitored data irrespective of any condition.

**Close CB condition**

When *Synchrocheck mode* is set to "Asynchronous", the close CB condition is generated as explained below.

From the frequency slip s, the acceleration ds/dt, the bus frequency FR_BUS_MEAS ($f_{Bus}$) and the set *Closing time of CB*, the function calculates the necessary lead angle ($\alpha_{Lead}$) by which the close CB command is shifted forward in time so that the main contacts close on phase coincidence.

$$\alpha_{Lead} = \left( 360 \cdot f_{Bus} \cdot \left( s + \frac{\frac{TCB}{2} \cdot \frac{ds}{dt}}{1000} \right) \cdot \frac{TCB}{1000} \right)$$

(Equation 359)

| | |
|---|---|
| $f_{Bus}$ | Bus side frequency |
| s | Frequency slip |
| ds/dt | Frequency slip acceleration |
| TCB | Setting *Closing time of CB* |

ASGCSYN can be set to the bypass mode by setting the parameters *Synchrocheck mode* and *Live dead mode* to "Off" or, alternatively, by activating the BYPASS input. In the bypass mode, the close CB conditions are always fulfilled. Otherwise, the operation is similar to the normal mode.

If the parameter *Synchronization Dir* is “Both directions”, function issues CLOSE_CB output direct-ly when the measured frequency difference is zero and the measured phase difference is less than 5 degrees for duration set by *Minimum Syn time*.

If the parameter *Synchronization Dir* is “Always over-synchronous”, closing signal is blocked when the measured frequency difference is between 0 and 1/3* *Freq Diff Ov Synch*.

The monitored data CB_CL_BLKD depends on the inputs GCB_TEST and EXT_CHECK, and also on IED test mode as described in *Table 1518*. CB_CL_BLKD is available in the Monitored data view.

**Table 1518: Monitored data CB_CL_BLKD activation based on the inputs**

| IED test mode | Inputs | | Monitored data |
|---|---|---|---|
| | GCB_TEST | EXT_CHECK | CB_CL_BLKD |
| TRUE | TRUE | TRUE | 1 (“Unblocked”) |
| FALSE | FALSE | | |
| TRUE | TRUE | FALSE | 2 (“Ext Check Fail”) |
| FALSE | FALSE | | |
| TRUE | FALSE | N/A | 3 (“IED Test CB Service”) |
| FALSE | TRUE | N/A | 4 (“IED Service CB Test”) |

The close CB condition is blocked if the CB_CL_BLKD status is 2(“Ext Check Fail”), 3(“IED Test CB Service”) or 4(“IED Service CB Test”).

In case for BYPASS input activation,

- If GCB_TEST is activated, CLOSE_CB is activated.
- If GCB_TEST is deactivated, and the bus and generator terminal voltages are both live or one side live, CLOSE_CB is not activated.

### Synchronization control

The general bus bar arrangement for a generator bus is shown in *Figure 857*. The bus to which the generator is connected is determined based on the circuit breaker and isolator position inputs (GCB_OPEN, GCB_CLOSE, ISO_A_CLOSE and ISO_B_CLOSE). The generator's bus connection status is shared with the autosynchronizer co-ordinator function ASCGAPC as part of the GEN_ASC_DATA output.

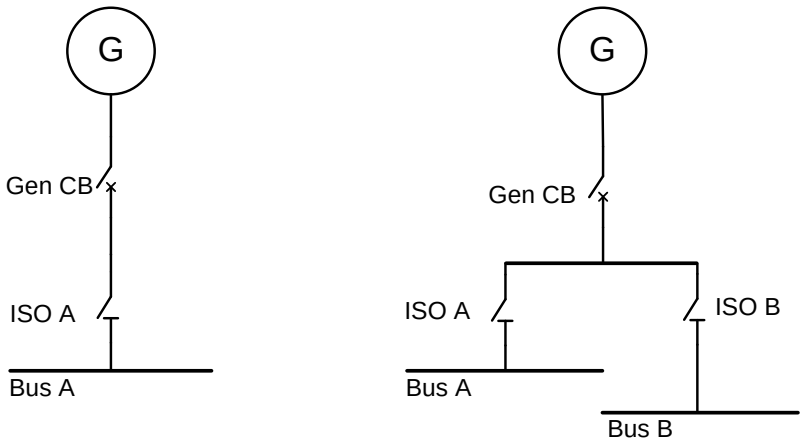



*Figure 857: Different bus bar arrangements for a generator bus*

**Auto synchronization mode**

In this mode, the closing signal is delivered if either the command *Synchronize CB* or the input CL_COMMAND is set to TRUE. The relay should be in the local mode if synchronization is initiated with the Synchronize CB command.

If the setting *Auto Syn mode* is set as "Manual mode" or "Semi-automatic synchronising mode", the additional command Manual CB release should be active for the closing signal CLOSE_CB to be activated. If the setting *Auto Syn mode* is set as "Automatic synchronising mode", no additional command is required to activate the closing signal CLOSE_CB.

In this auto synchronization mode, once all the closing conditions are satisfied within the set *Maximum Syn time*, the outputs SYNC_OK and CLOSE_CB become TRUE and remain active as long as the closing conditions are fulfilled. If *Multiple command* is set to "Off", then only CLOSE_CB outputs are delivered once for each activated input signal as shown in *Figure 858*. If *Multiple command* is set to "On", then CLOSE_CB outputs are delivered each time the conditions are satisfied as shown in *Figure 859*.

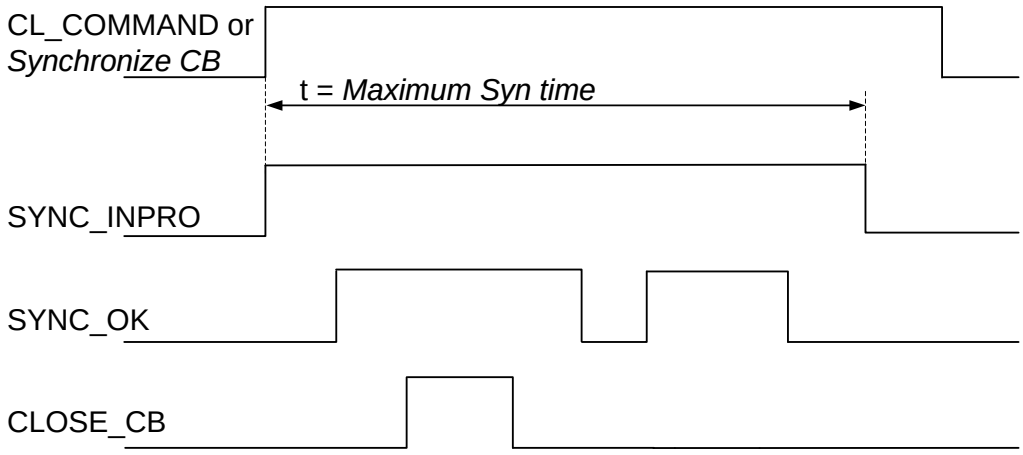



*Figure 858: Determination of closing signal CLOSE_CB when Multiple command is set to "Off"*

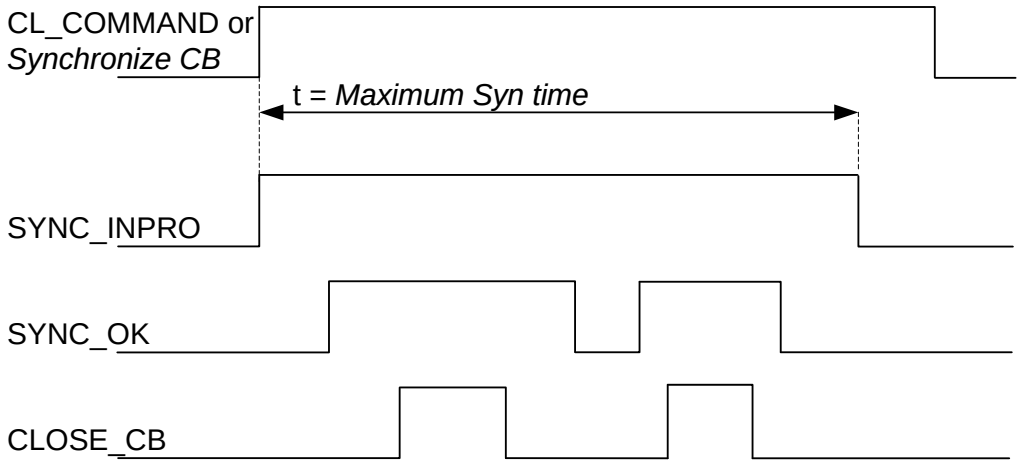



*Figure 859: Determination of closing signal CLOSE_CB when Multiple command is set to "On"*

The SYNC_INPRO output is active when the close command (CL_COMMAND or *Synchronize CB*) is in progress and it is reset when the close command is reset or *Maximum Syn time* has elapsed.

If the closing conditions are fulfilled during a permitted check time set with *Maximum Syn time*, ASGCSYN gives synchro check permission to the breaker control function block after the closing command signal is delivered. The simplified configuration block diagram of ASGCSYN with CLOSE_CB to the breaker control function block is shown in *Figure 860*.

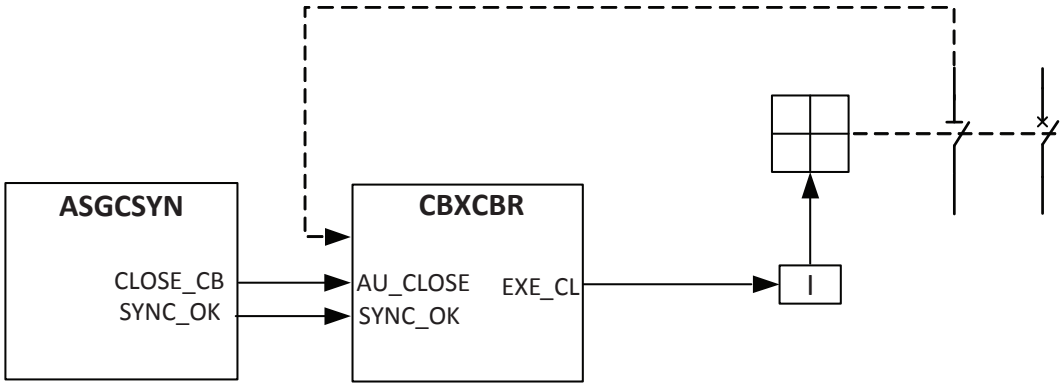



*Figure 860: Simplified configuration block diagram of ASGCSYN in auto synchronization mode operation*

**Alarms generation**

In the synchro check command and auto synchronization control mode operation, there are alarms for failed closing attempt (CL_FAIL_AL) and for a command signal that remains active too long (CMD_FAIL_AL).

In the auto synchronization control mode, the closing command generation is activated either by the command input CL_COMMAND or by the command parameter *Synchronize CB*.

From the closing command activation, if the conditions for closing CB are not fulfilled within the set time of *Maximum Syn time*, a failed closing attempt alarm is given. The CL_FAIL_AL alarm output signal is pulse-shaped and the pulse length is 500 ms.

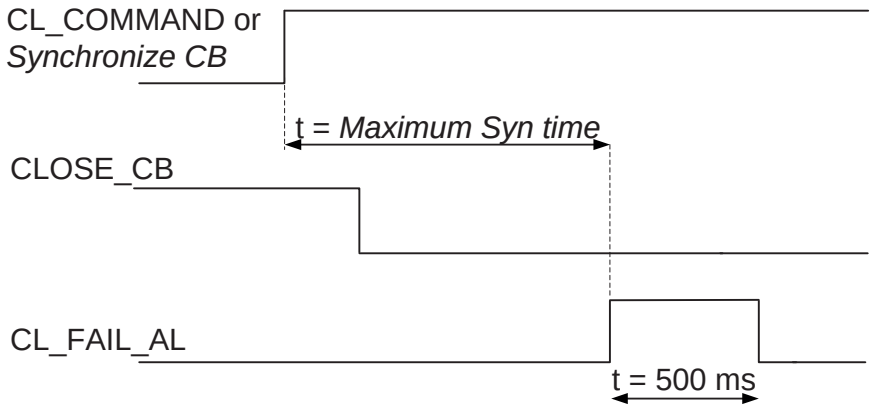



*Figure 861: Determination of checking time for closing*

CB closing is permitted during *Maximum Syn time*, starting from the moment the close command is activated. The close command must be active while the closing conditions are fulfilled, otherwise the procedure is cancelled. If the closing conditions are fulfilled during *Maximum Syn time*, a closing pulse output is delivered to the circuit breaker. If the closing conditions are not fulfilled during the checking time, the alarm CL_FAIL_AL is activated as an indication of a failed closing attempt. The closing pulse is not delivered if the closing conditions become valid after *Maximum Syn time* has elapsed. The closing pulse is delivered only once for each activated close command, and a new closing command sequence cannot be started until the close command is reset and reactivated.

The circuit breaker control function block receives information about the circuit breaker status and thus is able to adjust the command signal to be delivered to ASGCSYN. If the closing command is active longer than necessary, the CMD_FAIL_AL alarm output is activated. To avoid unnecessary alarms, the maximum length of the closing command signal should be below *Maximum Syn time* + 5 s.

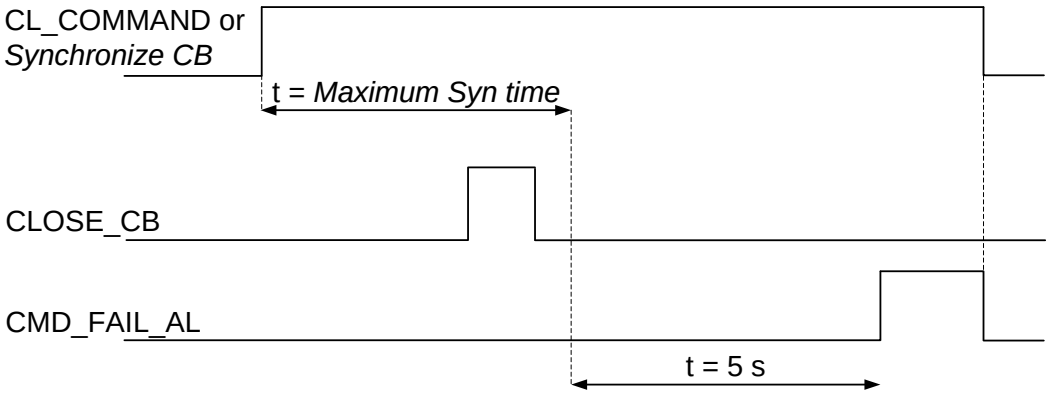



*Figure 862: Determination of the alarm limit for a still-active command signal*

### 9.6.5.3 Voltage and frequency matching

The operation of the Voltage and frequency matching module can be described with a module diagram. All the modules in the diagram are explained in the next sections.

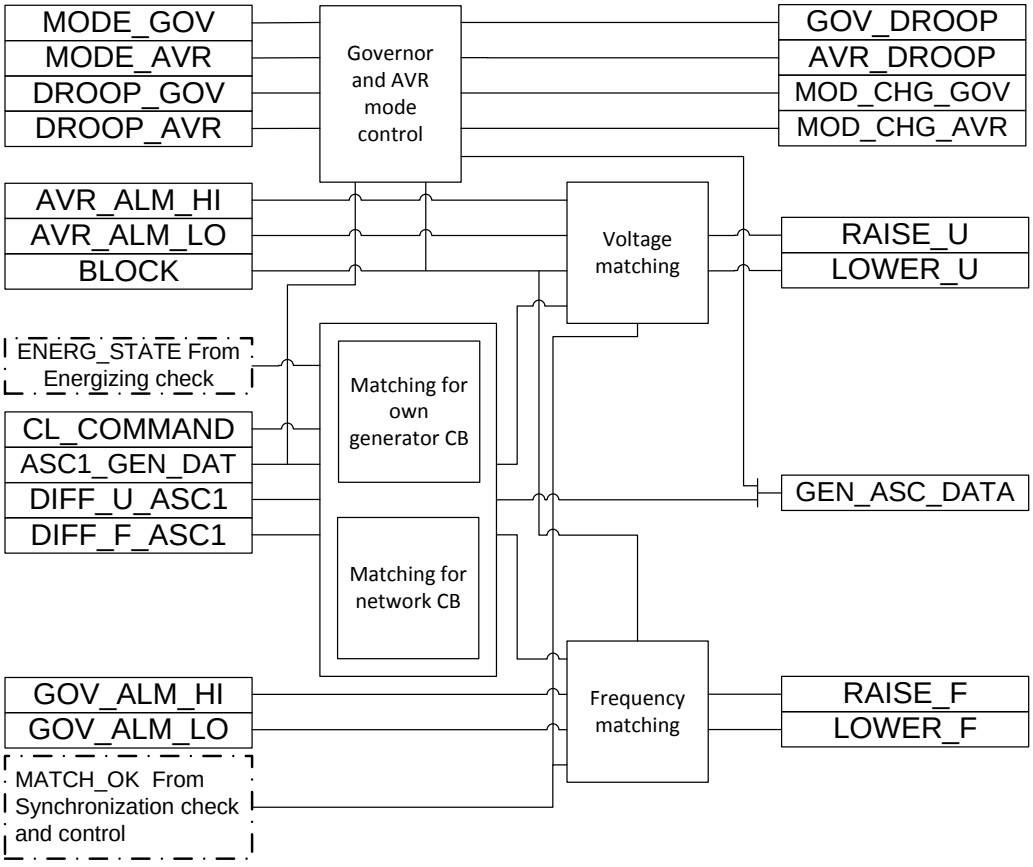



*Figure 863: Module diagram for Voltage and frequency matching*

The voltage and frequency matching is activated automatically during the “Autosynchronization” mode.

#### Governor and AVR mode control

If the setting *Central PMS present* is set to "Yes", then the governor and AVR mode is decided based on the inputs MODE_GOV and MODE_AVR, respectively. If the setting *Central PMS present* is set to "No", then the governor and AVR mode is decided based on the inputs DROOP_GOV and DROOP_AVR, respectively.

For the matching of frequency and voltage, the governor or AVR mode must be 1(“Droop”) or 2(“Fixed MW’). Otherwise, the MOD_CHG_GOV or MOD_CHG_AVR output is used for the mode change request.

When the setting *Central PMS present* is set to "Yes" and the Governor or AVR mode is not 1(“Droop”) or 2(“Fixed MW’), then the function sets MOD_CHG_GOV or MOD_CHG_AVR output to (“Droop”) or (“Fixed MW’). Otherwise, the function sets MOD_CHG_GOV or MOD_CHG_AVR output to “No change”.

When the setting *Central PMS present* is set to "No" and the Governor or AVR mode is not Droop mode, then the function activates the binary output GOV_DROOP or AVR_DROOP by using the input DROOP_GOV or DROOP_AVR.

The governor and AVR modes can also be changed through the command parameters *Gov mode change* and *AVR mode change*, respectively. If the command parameter *Gov mode change* is set to "Droop" or "Fixed MW", the function activates the binary output GOV_DROOP and sets integer output MOD_CHG_GOV to 1(“Droop”) or 2(“Fixed MW’), respectively. If the command parameter *AVR mode change* is set to "Droop" or "Fixed MVAr", the function activates the binary output AVR_DROOP and sets integer output MOD_CHG_AVR to 9(“Droop”) or 11(“Fixed MVAr”), respectively.

**Matching for own generator CB**

If the command ‘Synchronize CB’ is set to “TRUE” or input CL_COMMAND is TRUE, the generator CB is selected for synchronizing. For the voltage and frequency matching to start, the generator CB should be in open position and *Synchrocheck mode* should be set to "Asynchronous".

The measured voltage difference U_DIFF_MEAS is used for generating AVR raise or lower pulses to match the voltages across the CB. The measured frequency difference FR_DIFF_MEAS is used for generating governor raise or lower pulses to match the frequencies across the CB. The voltage and frequency matching starts only when the ENERG_STATE is “Both Live”.

Voltage difference (ΔU) = U_DIFF_MEAS

Frequency difference (ΔF) = FR_DIFF_MEAS

**Matching for network CB**

The generator is ready for network CB matching only when the generator CB is closed, the protection relay is in remote mode and the generator is requested for matching from non-source function.

After receiving the acknowledgement from ASGCSYN, the autosynchronizer coordinator function ASCGAPC gives permission to participate in the voltage and frequency matching across the CB to be synchronized in the network. ASCGAPC also shares the information about how many generators participate in the voltage matching (NgV) and frequency matching (NgF). Depending on the number of participating generators, the voltage and frequency difference is divided among the generators.

The voltage and frequency difference calculated for generating raise or lower pulses for AVR and governor are

Voltage difference (ΔU) = DIFF_U_ASC1 / NgV

Frequency difference (ΔF) = DIFF_F_ASC1 / NgF

The sign bit for voltage difference and frequency difference is decided based on the data received from ASCGAPC. The calculated voltage difference and frequency difference are available in the Monitored data view U_DIFF_NTW and FR_DIFF_NTW, respectively.

### Voltage matching

#### Working range of the voltage matcher

If the bus voltage U_BUS is between settings *Minimum voltage* and *Maximum voltage* and the generator voltage U_GEN is greater than the setting *Dead voltage value*, the adjusting commands are released. The direction of the adjusting commands depends on the polarity of ΔU. As an additional condition, both frequencies must be in the range $f_n$ ±5 Hz.

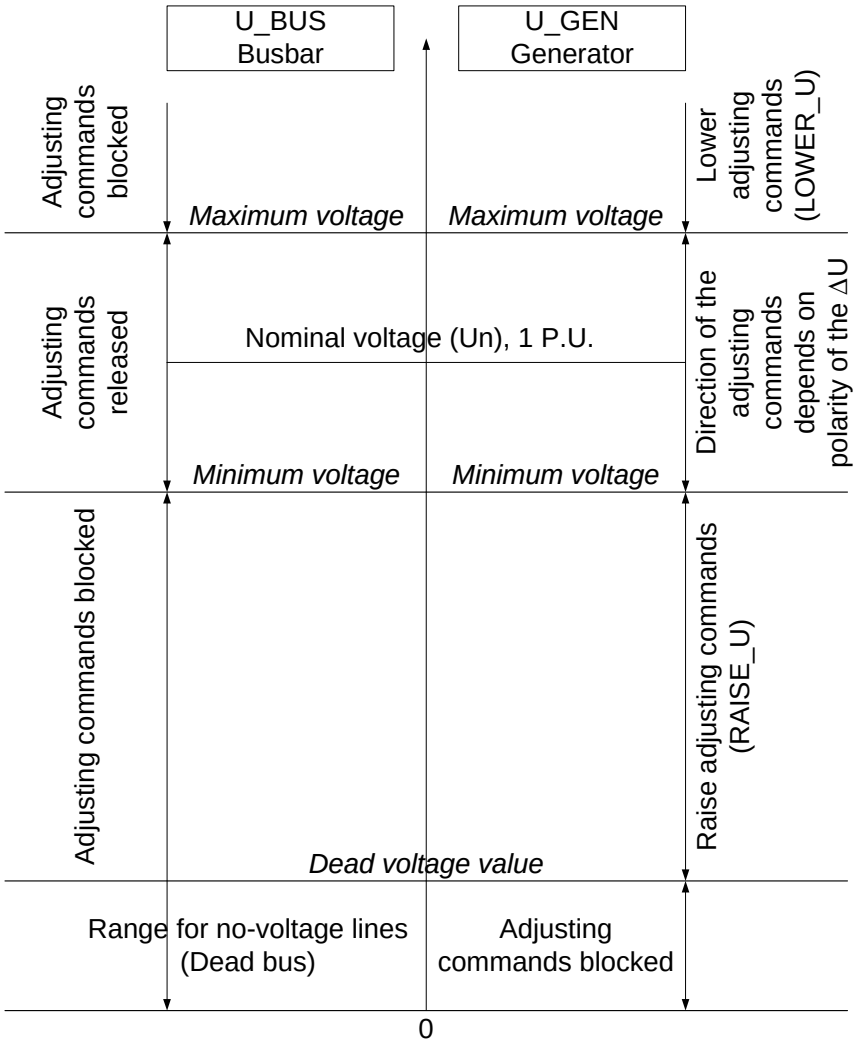



*Figure 864: Working range of the voltage matcher*

If *Auto Syn mode* is set to either "Semi-automatic synchronizing mode" or "Automatic synchronizing mode", the voltage raise or lower command pulses are generated from the function based on the voltage difference across the breaker and AVR response characteristics. If the voltage difference (ΔU) is negative, it means the reference side voltage is greater than the running side voltage. So the voltage matching generates the voltage raise command pulse `RAISE_U`. If the voltage difference (ΔU) is positive, it means the reference side voltage is lower than the running side voltage. So the voltage matching generates the voltage lower command pulse `LOWER_U`.

The length of the voltage raise and lower command pulse (tpU) and the pulse off interval (tsU) are calculated based on the setting *Voltage match mode*.

**Voltage matching in manual mode**

If *Auto Syn mode* is set to "Manual mode", the voltage raise or lower command pulses are generated manually from the function's user commands.

If the command *AVR voltage raise* is set to "RAISE", the function activates the voltage raise command pulse `RAISE_U`. If the command *AVR voltage lower* is set to "LOWER", the function activates the voltage lower command pulse `LOWER_U`.

The lengths of these generated pulses tpU and pulse off interval tsU are based on the settings as: tpU = *Volt pulse Min Dur*; tsU = *Volt pulse off Intv*.

**Voltage matching with variable command pulse lengths**

When the setting *Voltage match mode* is set to "Variable Pulse", the voltage matching is done with variable command pulse lengths.

The voltage matcher issues a command with a length proportional to the voltage difference. The proportionality factor setting *Volt rate of change* (dU/dt) can be adapted to the voltage regulator. The voltage matcher aims at a value in the middle of the set tolerance band.

The adjusting voltage command pulse length tpU is calculated as

$$tpU = \frac{\Delta U - \left( \frac{+\Delta U\max - \left| -\Delta U\max \right|}{2} \right)}{\frac{dU}{dt}}$$

(Equation 360)

| | |
|---|---|
| ΔU | Measured voltage difference across the CB to be synchronized |
| +ΔUmax | Setting *Voltage Diff Ov Ex* |
| -ΔUmax | Setting *Voltage Diff Un Ex* |
| dU/dt | Setting *Volt rate of change* |

The adjusting pulse is discontinued as soon as the voltage difference exceeds the target value. The command length does not fall below a settable minimum value *Volt pulse Min Dur*. After an adjusting command, the system waits for the set *Volt pulse off Intv* (tsU) so that the actual values can stabilize to the new set point.

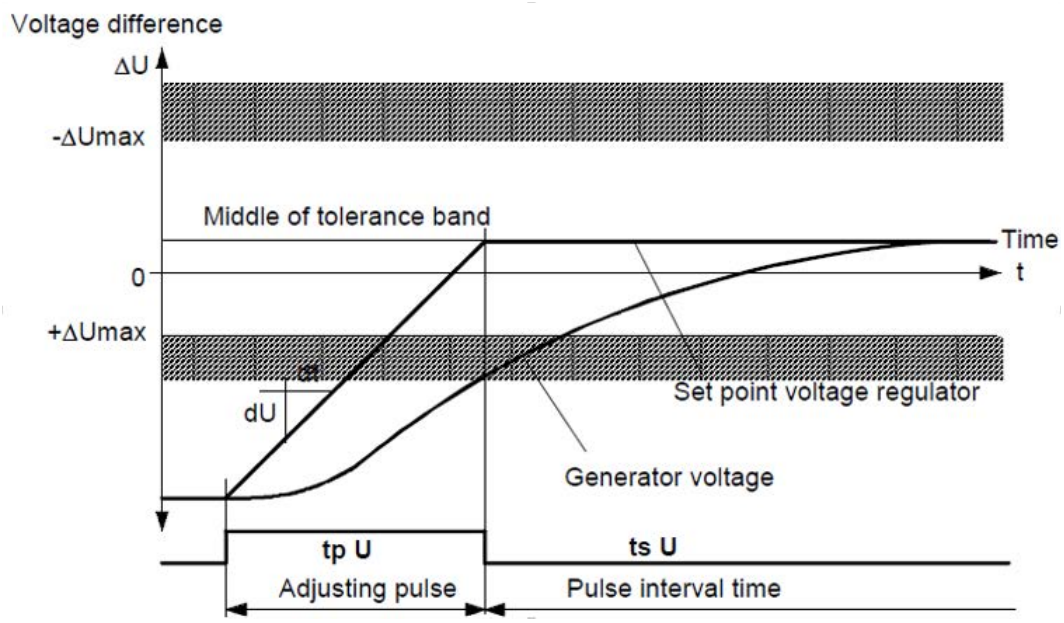



*Figure 865: Voltage matching pulse generation with variable command pulse length*

**Voltage matching with variable command pulse off intervals**

When the setting *Voltage match mode* is set to "Variable Interval", the voltage matching is done with variable command pulse off intervals.

The voltage match command pulses are now the same length, but the intervals are inversely proportional to the voltage difference.

Pulse length (tpU): adjustable with the setting *Volt pulse Min Dur* (tpUmin)

Pulse off interval (tsU): adjustable with the setting *Volt pulse off Intv*, and also dependent on settings *Voltage Diff Ov Ex* and *Voltage Diff Un Ex* as per *Equation 361*.

$$tsU = Volt\ pulse\ off\ Intv \cdot \left( 1 - 0.325 \cdot \left( \Delta U - \frac{\left( +\Delta U\max + \left| -\Delta U\max \right| \right)}{2} \right) \right) \geq 0$$

(Equation 361)

| | |
|---|---|
| ΔU | Measured voltage difference across the CB to be synchronized |
| +ΔUmax | Setting *Voltage Diff Ov Ex* |
| -ΔUmax | Setting *Voltage Diff Un Ex* |

**Reset of voltage raise and lower command pulses**

The generated voltage raise and lower command pulses RAISE_U and LOWER_U are immediately reset if any of the following conditions is met.

- During matching of its own CB synchronization
  - If AVR lower limit alarm AVR_ALM_LO is TRUE, it resets the voltage lower command LOWER_U. If AVR high limit alarm AVR_ALM_HI is TRUE, it resets the voltage raise command RAISE_U.
  - If the output MATCH_OK is TRUE, the raise and lower commands are reset.

- If the voltage difference reaches the target value with a hysteresis band that is in the middle of the tolerance band specified by the settings *Voltage Diff Ov Ex* and *Voltage Diff Un Ex*, the raise and lower commands are reset.

- During matching of network CB synchronization
  - If either of the AVR limit alarms AVR_ALM_LO and AVR_ALM_HI is TRUE, it resets the voltage raise and lower commands.
  - When the generator is selected for fine tuning, if the voltage difference is within the limits of tolerance band specified by the settings *Voltage Diff Ov Ex* and *Voltage Diff Un Ex*, the raise and lower commands are reset.
  - When the generator is selected for coarse tuning, if the voltage difference reaches within the limits of *Coarse Volt Diff Ov* and *Coarse Volt Diff Un*, the raise and lower commands are reset.

**Voltage rate of change tuning**

When the control command parameter *Tune V and F match* is set to "Volt match rate", the function calculates the generator voltage matching rate (dU/dt). The calculated voltage matching rate is stored to the nonvolatile memory output VOLT_CHG_RTE and is available in the Monitored data view. Once stored, the value from the output VOLT_CHG_RTE can be used to set the setting *Volt rate of change*.

This tuned voltage matching rate proceeds as follows:

1. The generator voltage is adjusted until it lies in the range of 95...97 % of the line voltage, then the adjusting pulse is discontinued.
2. Ten seconds after the first adjusting pulse, the voltage difference ΔU0 is measured, then a voltage raise command RAISE_U lasting 5 s is given. Ten seconds after the end of the pulse, the voltage difference ΔU is measured and dU/ dt calculated according to the following formula:

$$\frac{dU}{dt} = \frac{\Delta U - \Delta U_0}{5}$$

(Equation 362)

3. With this dU/dt value, the generator voltage is brought back to approximately 96 %.

Ten seconds later, the generator voltage is brought to approximately 100 % with the same dU/dt value. After ten seconds, dU/dt is calculated again and shown as monitored data output VOLT_CHG_RTE.

**Frequency matching**

**Working range of the frequency matcher**

No adjustment takes place between 1/3 and 2/3 of smax. The adjusting pulse is discontinued as soon as the slip passes through zero. The command length does not fall below a settable *Freq pulse Min Dur*. After an adjusting command, the system waits for the set *Freq pulse off Intv* so that the actual values can stabilize to the new set point.

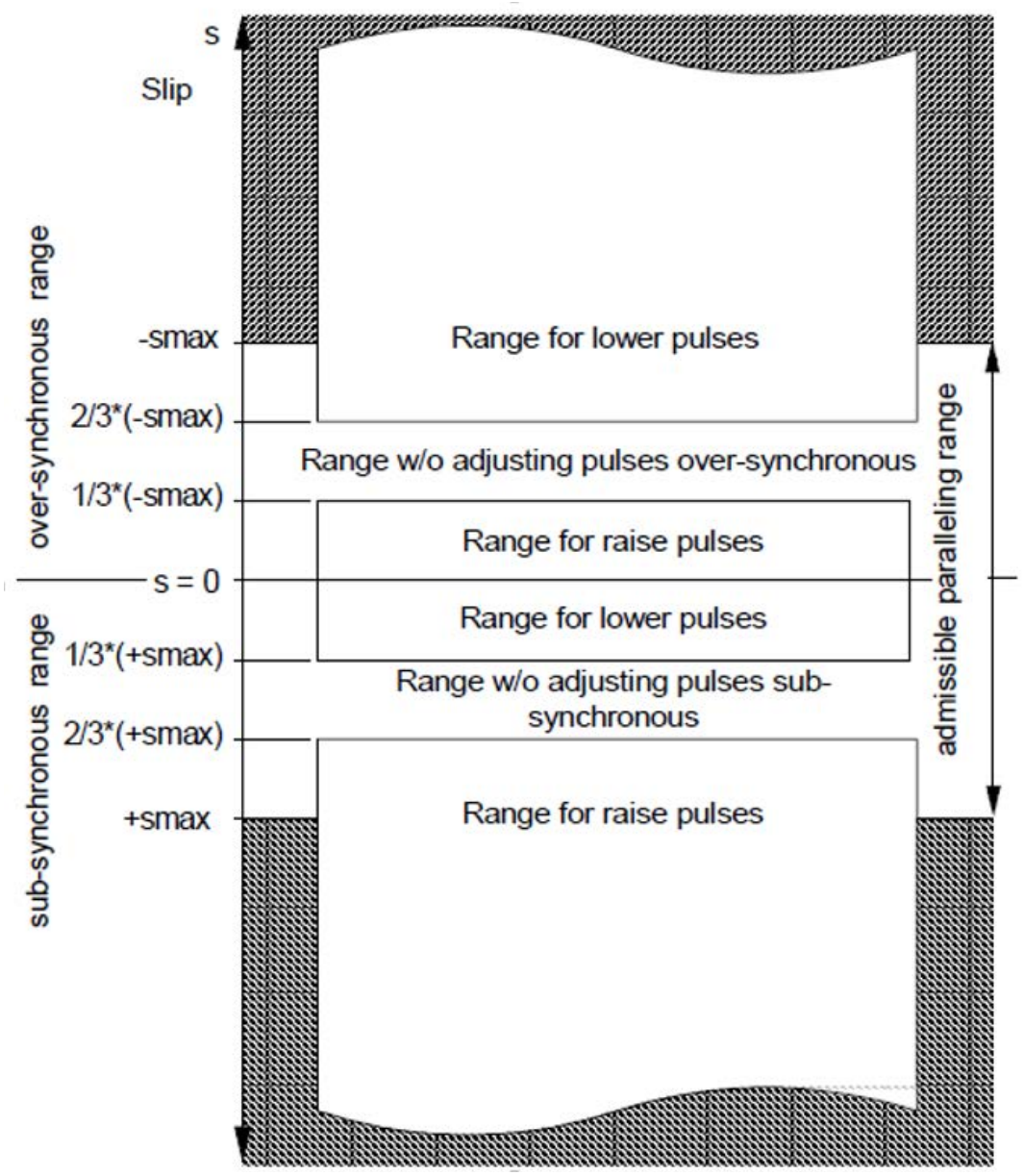



*Figure 866: Working range of the frequency matcher*

If *Auto Syn mode* is set to either "Semi-automatic synchronizing mode" or "Automatic synchronizing mode", the frequency raise or lower command pulses are generated from the function based on the frequency difference across the CB and governor response characteristics.

If the frequency difference (DF) is negative, the reference side frequency is greater than the running side frequency. So the frequency matching generates frequency raise command pulse `RAISE_F`.

If the frequency difference (DF) is positive, it means the reference side frequency is lower than the running side frequency. So the frequency matching generates frequency lower command pulse `LOWER_F`.

The length of the frequency raise and lower command pulses (tpf) and pulse off interval (tsf) are calculated based on the setting *Frequency match mode*.

**Frequency matching in manual mode**

If *Auto Syn mode* is set to "Manual mode", the frequency raise or lower command pulses are generated manually from the function's user commands.

If the command Gov frequency raise is set to “RAISE”, the function activates the frequency raise command pulse `RAISE_F`. If the command Gov frequency lower is set to “LOWER”, the function activates the frequency lower command pulse `LOWER_F`.

The length of these generated pulses tpf and pulse off interval tsf are based on the settings as: tpf = *Freq pulse Min Dur*; tsf = *Freq pulse off Intv*.

**Frequency matching with variable command pulse lengths**

When the setting *Frequency match mode* is set to "Variable Pulse", the frequency matching is done with variable command pulse lengths.

The frequency matcher issues a command with a length proportional to the current slip. The proportionality factor df/dt can be adapted to the governor. The frequency matcher aims at a value midway between the nearer slip limit and zero.

The adjusting frequency command pulse length tpf is calculated as

$$tpf = \frac{|\pm s| - \frac{|\pm s\max|}{2}}{\frac{df}{dt}}$$

(Equation 363)

| | |
|---|---|
| s | Measured frequency difference across the CB to be synchronized |
| +smax | Setting *Freq Diff Ov Synch* |
| -smax | Setting *Freq Diff sub Synch* |
| df/dt | Setting *Freq rate of change* |

The command length does not fall below a settable minimum value *Freq pulse Min Dur*. After an adjusting command, the system waits for the set *Freq pulse off Intv* (tsf) so that the actual values can stabilize to the new set point.

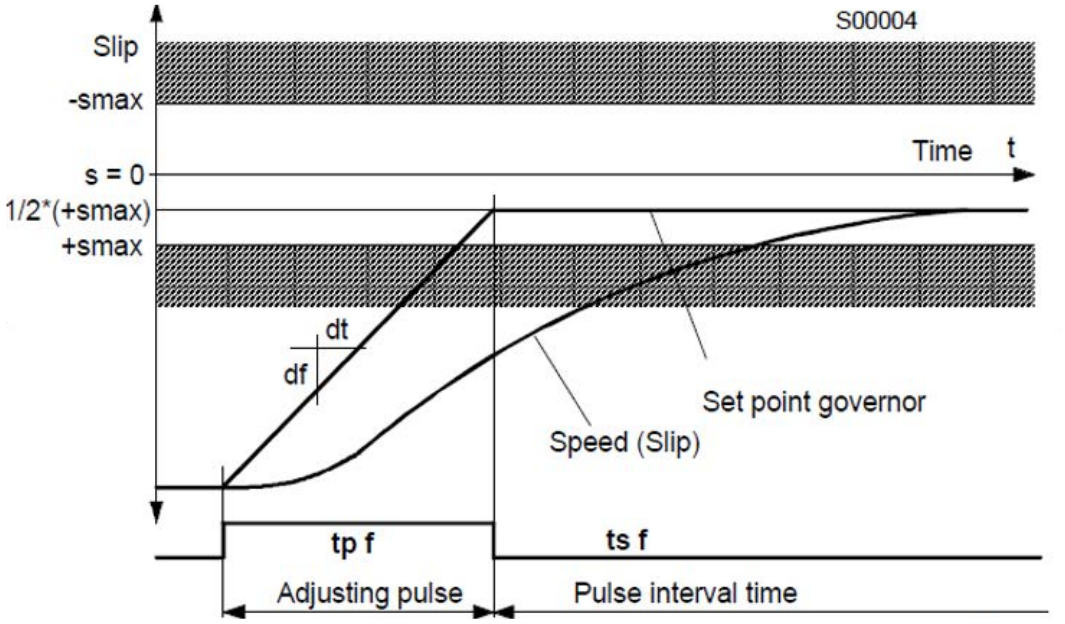



*Figure 867: Frequency matching pulses generation with variable command pulse length*

**Frequency matching with variable command pulse off intervals**

When the setting *Frequency match mode* is set to "Variable Interval", the frequency matching is done with variable command pulse off intervals.

The voltage match command pulses are now the same length, but the intervals are inversely proportional to the frequency slip.

Pulse length (tpf): adjustable with the setting *Freq pulse Min Dur* (tpfmin)

Pulse off interval (tsf): calculated as

$$tsf = \frac{1}{f_{Gen} - f_{Bus}} = \frac{1}{f_{Gen}|s|} \leq 30\ [Sec]$$

(Equation 364)

| | |
|---|---|
| s | Measured frequency slip across the CB to be synchronized |
| $f_{Gen}$ | Measured generator side frequency |
| $f_{Bus}$ | Measured bus side frequency |

**Reset of frequency raise and lower command pulses**

The generated frequency raise and lower command pulses RAISE_F and LOWER_F are immediately reset if any of the following conditions is met.

- During matching of its own CB synchronization
  - If governor lower limit alarm GOV_ALM_LO is TRUE, it resets the frequency lower command LOWER_F. If governor high limit alarm GOV_ALM_HI is TRUE, it resets the frequency raise command RAISE_F.
  - If the output MATCH_OK is TRUE, the raise and lower commands are reset.

- If the frequency difference reaches the target value "± Smax/2" with the hysteresis band specified by the settings *Freq Diff Ov Synch* and *Freq Diff sub Synch*, the raise and lower commands are reset.

- During matching of network CB synchronization
  - If any of the governor limit alarms GOV_ALM_HI or GOV_ALM_LO is TRUE, the raise and lower commands are reset.
  - When the generator is selected for fine tuning, if the frequency difference reaches to target value "± Smax/2" with the hysteresis band specified by the settings *Freq Diff Ov Synch* and *Freq Diff sub Synch*, the raise and lower commands are reset.
  - When the generator is selected for coarse tuning, if the frequency difference reaches within the limits of *Coarse Freq Diff Ov* and *Coarse Freq Diff sub*, the raise and lower commands are reset.

When the matching is done for its own CB synchronization, the output MATCH_OK is activated if the measured voltage and frequency differences are within the set synchro check limits. The MATCH_INPRO output is active while the matching is in progress.

When the matching is done for network CB synchronization, the monitored data NTWMATCH_OK is activated if the network breaker voltage and frequency differences are within the set match limits. NTWMATCH_PRO is active while the matching is in progress. NTWMATCH_OK and NTWMATCH_PRO are available in the Monitored data view.

**Frequency rate of change tuning**

When the control command parameter *Tune V and F match* is set to "Freq match rate", the function calculates the generator frequency matching rate (dF/dt). The calculated frequency matching rate is stored to the nonvolatile memory output FREQ_CHG_RTE and is available in the Monitored data view. Once stored, the value from FREQ_CHG_RTE can be used to set the setting *Freq rate of change*.

This tune frequency matching rate proceeds as follows:

1. The slip is adjusted until this lies in the range of +1...+3 %, then the adjusting pulse is discontinued.
2. Ten seconds after the first adjusting pulse, the slip s0 is measured, then a frequency raise command RAISE_F lasting 3 s is given. Ten seconds after the end of the pulse, the slip s is measured and df/dt is calculated according to the formula

$$\frac{df}{dt} = \frac{s - s0}{3}$$

(Equation 365)

3. With this df/dt value, the slip is brought back to approximately +2 %.

Ten seconds later, the slip is brought to 0 % with the same df/dt value. After ten seconds, df/dt is calculated again and shown as monitored data output FREQ_CHG_RTE.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all binary outputs, binary monitored data and resets the internal timers.

## 9.6.6 Application

A circuit breaker is used to connect two different power networks. It is essential to ensure that these power networks are synchronized before closing the circuit breaker, otherwise it may lead to disturbances in the power system, causing stress and damage to the connected equipment.

ASGCSYN controls the closing of the generator circuit breakers in power networks; it enables the closing after matching the voltage and frequency conditions to achieve synchronism. ASGCSYN also participates in matching voltage and frequency conditions for the network breaker synchronization.

ASGCSYN includes both the synchronization check function and the energizing function to allow closing when one side of the breaker is dead.

The participation of ASGCSYN in matching of voltage and frequency conditions for the network breaker synchronization is described via one of the typical application example as shown in *Figure 868*.

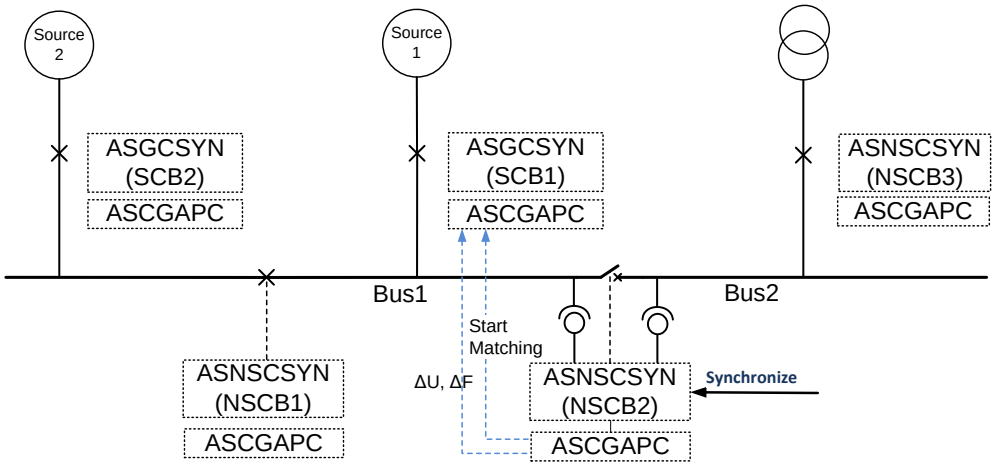



*Figure 868: ASGCSYN participation in matching of V, F during network breaker synchronization*

In this application example, breaker NSCB2 must be closed, so the synchronizing conditions between the Bus1 and Bus2 power systems are checked by the autosynchronizer for network breaker function ASNSCSYN. If the synchro check conditions are not met, then ASNSCSYN sends the auto synchronization request and voltage and frequency difference (ΔU, ΔF) between Bus1 and Bus2 to the autosynchronizer co-ordinator function ASCGAPC.

ASCGAPC transfers the voltage and frequency difference sent by ASNSCSYN to the ASCGAPC of the generator1 ASGCSYN function. It also sends permission to the generator to start matching the voltage and frequency. The generator's ASGCSYN function gives the raise or lower pulses to AVR and governor to raise or lower their voltage and frequency on Bus2. The matching process is carried out so that the voltage and frequency difference between Bus1 and Bus2 measured by ASNSCSYN reduces and comes within the synchro check limits. This satisfies the synchro check conditions for breaker NSCB2 which can then be synchronized by ASNSCSYN.

#### Voltage angle difference adjustment

In applications where the power transformer is located between the voltage measurement and the generator circuit breaker, the vector group connection gives

phase difference to the voltages between the high- and low-voltage sides. The angle adjustment can be used to meet synchronism.

The vector group of the power transformer is defined with clock numbers, where the value of the hour pointer defines the low-voltage side phasor and the high-voltage side phasor is always fixed to the clock number 12, which is the same as zero. The angle between clock numbers is 30º. When comparing phase angles, the U_BUS input is always the reference. This means that when the Yd11 power transformer is used, the low-voltage side voltage phasor leads the high-voltage side phasor by 30º or lags by 330º. The rotation of the phasors is counterclockwise.

The generic rule is that a low-voltage side phasor lags the high-voltage side phasor by clock number · 30º. This is called angle difference adjustment and can be set for ASGCSYN with the *Phase shift* setting.

## 9.6.7 Signals

### 9.6.7.1 ASGCSYN Input signals

**Table 1519: ASGCSYN Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P1 | SIGNAL | - | Three-phase voltages (generator side) |
| U3P2 | SIGNAL | - | Three-phase voltages (bus side) |
| BLOCK | BOOLEAN | 0=False | Blocking signal of the auto synchronization function |
| CL_COMMAND | BOOLEAN | 0=False | External closing request |
| EXT_CHECK | BOOLEAN | 0=False | External permissive check for CB close |
| BYPASS | BOOLEAN | 0=False | Request to bypass synchronism check and voltage check |
| GCB_TEST | BOOLEAN | 0=False | Circuit breaker test position status |
| GCB_CLOSE | BOOLEAN | 0=False | Circuit breaker close status |
| GCB_OPEN | BOOLEAN | 0=False | Circuit breaker open status |
| ISO_A_CLOSE | BOOLEAN | 0=False | Isolator A close status |
| ISO_B_CLOSE | BOOLEAN | 0=False | Isolator B close status |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| MODE_GOV | Enum | 1=Droop | Governor working mode |
| MODE_AVR | Enum | 9=Droop | AVR working mode |
| DROOP_GOV | BOOLEAN | 0=False | Governor droop mode status |
| DROOP_AVR | BOOLEAN | 0=False | AVR droop mode status |
| GOV_ALM_HI | BOOLEAN | 0=False | Governor alarm due to high limits |
| GOV_ALM_LO | BOOLEAN | 0=False | Governor alarm due to low limits |
| AVR_ALM_HI | BOOLEAN | 0=False | AVR alarm due to high limits |
| AVR_ALM_LO | BOOLEAN | 0=False | AVR alarm due to low limits |
| DIFF_U_ASC1 | FLOAT32 | 0.00 | Network breaker voltage difference from ASCGAPC1 |
| DIFF_F_ASC1 | FLOAT32 | 0.000 | Network breaker frequency difference from ASCGAPC1 |
| ASC1_GEN_DAT | INT32 | 0 | Integer weighted input data from ASCGAPC1 |

### 9.6.7.2 ASGCSYN Output signals

**Table 1520: ASGCSYN Output signals**

| Name | Type | Description |
|---|---|---|
| SYNC_INPRO | BOOLEAN | Auto synchronization in progress |
| SYNC_OK | BOOLEAN | Systems in synchronism |
| MATCH_INPRO | BOOLEAN | Voltage and frequency matching in progress |
| MATCH_OK | BOOLEAN | Voltage and frequency of the systems matched |
| CLOSE_CB | BOOLEAN | CB close signal |
| CL_FAIL_AL | BOOLEAN | CB closing failed |
| CMD_FAIL_AL | BOOLEAN | CB closing request failed |
| LBDG | BOOLEAN | Live bus, dead generator |
| LBLG | BOOLEAN | Live bus, live generator |
| DBLG | BOOLEAN | Dead bus, live generator |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| DBDG | BOOLEAN | Dead bus, dead generator |
| CB_SELECTED | BOOLEAN | CB selected for synchronization |
| RAISE_U | BOOLEAN | Raise voltage pulse |
| LOWER_U | BOOLEAN | Lower voltage pulse |
| RAISE_F | BOOLEAN | Raise frequency pulse |
| LOWER_F | BOOLEAN | Lower frequency pulse |
| GOV_DROOP | BOOLEAN | Command for governor mode change to droop |
| AVR_DROOP | BOOLEAN | Command for AVR mode change to droop |
| MOD_CHG_GOV | Enum | MOD_CHG_GOV |
| MOD_CHG_AVR | Enum | MOD_CHG_AVR |
| GEN_ASC_DATA | INT32 | Integer weighted output data to ASCGAPC |

## 9.6.8 ASGCSYN Settings

**Table 1521: ASGCSYN Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Live dead mode | -1=Off<br>-2=Command<br>1=Both Dead<br>4=Dead B, G Any<br>2=Live G, Dead B | | | -1=Off | Live dead mode |
| Freq Diff Ov Synch | 0.000...0.060 | xFn | 0.001 | 0.004 | Over synchronous limit for admissible paralleling range |
| Freq Diff sub Synch | 0.000...0.060 | xFn | 0.001 | 0.004 | Sub synchronous limit for admissible paralleling range |
| Coarse Freq Diff Ov | 0.000...0.060 | xFn | 0.001 | 0.005 | Over synchronous limit during generator coarse matching |
| Coarse Freq Diff sub | 0.000...0.060 | xFn | 0.001 | 0.005 | Sub synchronous limit during generator coarse matching |
| Voltage Diff Ov Ex | 0.00...0.40 | xUn | 0.01 | 0.03 | Maximum voltage difference limit allowed during matching |
| Voltage Diff Un Ex | 0.00...0.40 | xUn | 0.01 | 0.03 | Maximum voltage difference limit allowed during matching |
| Coarse Volt Diff Ov | 0.00...0.40 | xUn | 0.01 | 0.03 | Maximum voltage difference limit allowed during matching |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Coarse Volt Diff Un | 0.00...0.40 | xUn | 0.01 | 0.03 | Maximum voltage difference limit allowed during matching |
| Angle Diff positive | 5...90 | deg | 1 | 5 | Maximum angle difference limit |
| Angle Diff negative | 5...90 | deg | 1 | 5 | Maximum angle difference limit |
| Volt rate of change | 0.001...0.050 | xUn/s | 0.001 | 0.003 | dU/dt adapted to AVR for voltage matching pulses |
| Freq rate of change | 0.001...0.050 | xFn/s | 0.001 | 0.002 | dF/dt adapted to governor for frequency matching pulses |

**Table 1522: ASGCSYN Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase shift | -180...180 | deg | 1 | 0 | Correction of phase difference between measured voltages |
| Closing time of CB | 40...250 | ms | 1 | 60 | Closing time of the breaker |
| Multiple command | 0=Off<br>1=On | | | 0=Off | Multiple command generation |
| Synchronization Dir | 1=Always over synchronous<br>2=Both direction | | | 2=Both direction | Synchronization direction |
| Voltage offset | -0.100...0.100 | xUn | 0.001 | 0.000 | Voltage offset |
| Frequency offset | -0.010...0.010 | xFn | 0.001 | 0.000 | Frequency offset |

**Table 1523: ASGCSYN Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Synchrocheck mode | 1=Off<br>3=Asynchronous<br>4=Command | | | 3=Asynchronous | Synchrocheck operation mode |
| Dead voltage value | 0.10...0.80 | xUn | 0.10 | 0.20 | Voltage low limit for energizing check |
| Live voltage value | 0.20...1.00 | xUn | 0.10 | 0.50 | Voltage high limit for energizing check |
| Maximum voltage | 0.50...1.30 | xUn | 0.01 | 1.05 | Maximum voltage above which no paralleling takes place |
| Minimum voltage | 0.50...0.95 | xUn | 0.01 | 0.80 | Minimum voltage below which no paralleling takes place |
| Voltage match mode | 1=Off<br>2=Variable Pulse<br>3=Variable Interval | | | 2=Variable Pulse | Voltage matcher mode |
| Frequency match mode | 1=Off | | | 2=Variable Pulse | Frequency matcher mode |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=Variable Pulse<br>3=Variable Interval | | | | |
| Auto Syn mode | -1=Semi-automatic synchronising mode<br>1=Automatic synchronising mode<br>3=Manual mode | | | 3=Manual mode | Auto synchronization operation mode |

**Table 1524: ASGCSYN Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Minimum Syn time | 0...60000 | ms | 10 | 0 | Minimum time to accept synchronizing |
| Maximum Syn time | 100...6000000 | ms | 10 | 60000 | Maximum time to accept synchronizing |
| Energizing time | 100...60000 | ms | 10 | 100 | Time delay for energizing check |
| Central PMS present | 1=No<br>2=Yes | | | 1=No | Centralized Power Management System present |
| Volt pulse off Intv | 1000...20000 | ms | 10 | 2000 | Set voltage pulse off interval time |
| Volt pulse Min Dur | 50...2000 | ms | 10 | 50 | Set voltage pulse minimum duration |
| Freq pulse off Intv | 1000...120000 | ms | 10 | 20000 | Set frequency pulse off interval time |
| Freq pulse Min Dur | 50...2000 | ms | 10 | 50 | Set frequency pulse minimum duration |

## 9.6.9 ASGCSYN Monitored data

**Table 1525: ASGCSYN Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ENERG_STATE | Enum | 0=Unknown<br>1=Both Live<br>2=Live G, Dead B<br>3=Dead G, Live B<br>4=Both Dead | | Energization state of bus and generator |
| U_DIFF_MEAS | FLOAT32 | -3.00...3.00 | xUn | Calculated voltage amplitude difference |
| FR_DIFF_MEAS | FLOAT32 | -1.500...1.500 | xFn | Calculated voltage frequency difference |
| PH_DIFF_MEAS | FLOAT32 | -180.00...180.00 | deg | Calculated voltage phase angle difference |
| U_BUS_MEAS | FLOAT32 | 0.00...5.00 | xUn | Calculated bus voltage amplitude |
| U_GEN_MEAS | FLOAT32 | 0.00...5.00 | xUn | Calculated generator voltage amplitude |
| FR_BUS_MEAS | FLOAT32 | 35.00...75.00 | Hz | Calculated bus frequency |
| FR_GEN_MEAS | FLOAT32 | 35.00...75.00 | Hz | Calculated generator frequency |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| FR_SLIP_ACCL | FLOAT32 | 0.000...5.000 | xFn/s | Calculated rate of change of frequency slip |
| U_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Voltage difference out of limit for synchronizing |
| FR_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Frequency difference out of limit for synchronizing |
| PH_DIF_SYNC | BOOLEAN | 0=False<br>1=True | | Phase angle difference out of limit for synchronizing |
| CB_CL_BLKD | Enum | 1=Unblocked<br>2=Ext Check Fail<br>3=IED Test CB Service<br>4=IED Service CB Test | | CB close blocked status |
| VOLT_CHG_RTE | FLOAT32 | 0.000...0.050 | xUn/s | Calculated generator matching voltage rate of change |
| FREQ_CHG_RTE | FLOAT32 | 0.000...0.050 | xFn/s | Calculated generator matching frequency rate of change |
| U_DIFF_NTW | FLOAT32 | -3.00...3.00 | xUn | Voltage amplitude difference of the network breaker |
| FR_DIFF_NTW | FLOAT32 | -1.500...1.500 | xFn | Voltage frequency difference of the network breaker |
| NTWMATCH_PRO | BOOLEAN | 0=False<br>1=True | | Matching in progress for network breaker synchronization |
| NTWMATCH_OK | BOOLEAN | 0=False<br>1=True | | Voltage, frequency across the network breaker systems matched |
| SYNCCHK_STS | Enum | 1=Off<br>3=Asynchronous | | Synchro check mode status |
| LIVEDEAD_STS | Enum | -1=Off<br>1=Both Dead<br>2=Live G, Dead B<br>4=Dead B, G Any | | Live dead mode status |
| ASGCSYN | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 9.6.10 Technical data

**Table 1526: ASGCSYN Technical data**

| Characteristic | Value |
|---|---|
| Measurement accuracy | At the frequency f = $f_n$ |
| | Voltage difference: ±1.0 % or ±0.004 × $U_n$<br>Frequency difference: ±10 mHz<br>Phase angle difference: ±1° (±2.5° when f = $f_n$ ±2 Hz) |
| Operation accuracy | MATCH_OK for voltage: ±0.001 × $U_n$<br>MATCH_OK for frequency: ±10 mHz |
| Operation time accuracy | Raise/Lower output pulse width:<br>±1.0 % of the set value or ±20 ms<br>*Energizing time* for dead-bus closing:<br>±1.0 % of the set value or ±35 ms<br>*Minimum Syn time* for SYNC_OK:<br>±1.0 % of the set value or ±60 ms |
| Reset time | Typically 20 ms |
| Closing angle accuracy | ±1° |

## 9.7 Autosynchronizer for network breaker ASNSCSYN (ANSI 25AUTOSYNCBT/T)

### 9.7.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Autosynchronizer for network breaker | ASNSCSYN | AUTOSYNCBT/T | 25AUTO-SYNCBT/T |

## 9.7.2 Function block




*Figure 869: Function block*

## 9.7.3 Functionality

The autosynchronizer function for network breaker ASNSCSYN can be used for synchronized closing of a non-generator circuit breaker such as a bus sectionalizer, a bus coupler or an incoming feeder. ASNSCSYN includes functionalities for autosynchronization, synchrocheck and energizing check.

ASNSCSYN checks the power system conditions between both networks across the circuit breaker. The energizing check is used to check that at least one side is dead to ensure that closing can be done safely.

In case of a synchronous system, the closing command is issued after considering the function modes, essential checks, CB closing time and the paralleling conditions. In case of asynchronous systems, the function initiates the matching of voltage and frequency with the help of available generators through Autosynchronizer co-ordinator ASCGAPC.

The function contains a blocking functionality. It is possible to block function outputs.

## 9.7.4 Analog input configuration

ASNSCSYN has two analog group inputs which must be properly configured.

**Table 1527: Analog inputs**

| Input | Description |
|---|---|
| U3P1 | Three-phase voltages (Bus B side) |
| U3P2 | Three-phase voltages (Bus A side) |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1528: Special conditions**

| Condition | Description |
|---|---|
| U3P1 and U3P2 connected to real measurements | When one voltage channel from the Bus B side is connected to channel 1 of U3P1 and one voltage channel from the Bus A side is connected to channel 1 of U3P2, the function can only work if UTVTR's VT connection settings on the Bus A and Bus B sides are similar. |
| | The function can work if one voltage channel from the Bus B side is connected to channel 1 of U3P1 and three voltage channels from the Bus A side are connected to U3P2. |
| | The function can work if one voltage channel from the Bus B side is connected to channel 1 of U3P1 and two voltage channels along with the residual voltage from the Bus A side are connected to U3P2. |
| | The function can work if three voltage channels from the Bus B side are connected to U3P1 and one voltage channel from the Bus A side is connected to channel 1 of U3P2. |
| | The function can work if two voltage channels along with the residual voltage from the Bus B side are connected to U3P1 and one voltage channel from the Bus A side is connected to channel 1 of U3P2. |
| Dissimilar VT connection settings for UTVTR on the Bus A and Bus B sides | The function requires that all three voltage channels or two voltage channels along with the residual voltage are connected to either U3P1 or U3P2. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 9.7.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of ASNSCSYN can be described with a module diagram. All the modules in the diagram are explained in the next sections.

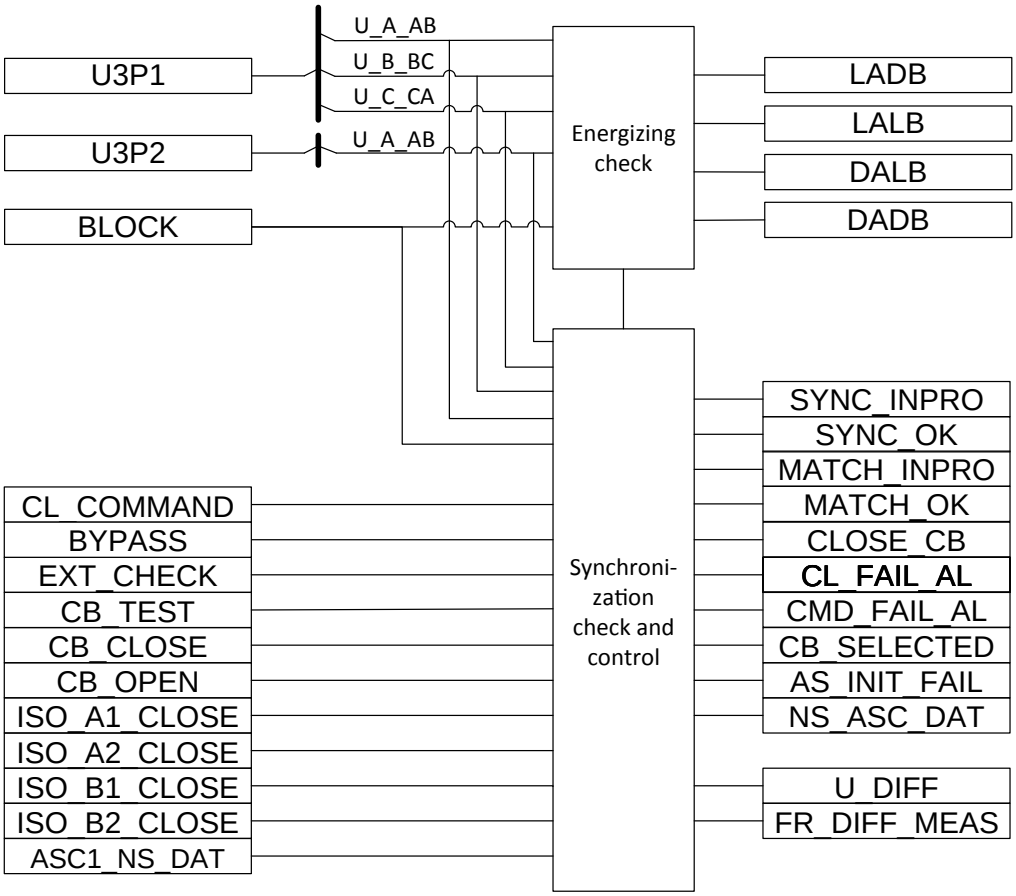



*Figure 870: Functional module diagram*

This function can operate either with the U_AB or U_A voltages. The selection of used voltages is defined with the *VT connection* of the line voltage general parameters.

### 9.7.5.1 Energizing check

The Energizing check module checks the energizing direction. Energizing is the situation where a dead network part is connected to an energized section of the network. The *Live dead mode* setting is used to set the energized condition of the bus section across the CB, that is, whether the bus section across the CB is live or dead..

When the *Live dead mode* setting parameter is set to "Command", then then the energized condition (see *Table 1529*) of bus sections across the CB can be set using the *Live dead mode Ctl* control command only. If the *Live dead mode* setting parameter is not set to "Command", then the *Live dead mode* setting parameter is used to set the energized condition (see *Table 1529*) of the bus section across the CB.

**Table 1529: Live dead mode of operation when switching can be carried out**

| Live dead mode | Description |
|---|---|
| Command | The *Live dead mode* setting uses *Live dead mode Ctl* control command. |
| Off | *Live dead mode* is set to "Off". |
| Both Dead | Both Bus A and Bus B de-energized |
| Live B, Dead A | Bus B energized and Bus A de-energized |
| Dead B, Live A | Bus B de-energized and Bus A energized |
| Dead A , B Any | Bus A de-energized and Bus B energized or deenergized |
| Dead B, A Any | Bus B de-energized and Bus A energized or deenergized |
| One Live, Dead | Bus A de-energized and Bus B energized or Bus B de-energized and Bus A energized |
| Not Both Live | Both Bus A and B de-energized or Bus A deenergized and Bus B energized or Bus B deenergized and Bus A energized |

When the energizing direction corresponds to the settings, the situation has to be constant for a time set with the *Energizing time* setting before the CB closing is permitted. This time delay ensures that the dead side remains de-energized and that the situation is not caused by a temporary interference. If the conditions do not persist for a specified operation time, the timer is reset and the procedure is restarted when the conditions allow it. The CB does not close if the measured voltage on the live side is greater than the set value of *Max energizing V*.

The measured energized state is available as a monitored data value ENERG_STATE and as four function outputs `LADB` (live bus A and dead bus B), `LALB` (live bus A and live bus B), `DALB` (dead bus A and live bus B) and `DADB` (dead bus A and dead bus B), of which only one can be active at a time. The measured energized state indicates “Unknown” if at least one of the measured voltages is between the limits set with the dead and live setting parameters.

### 9.7.5.2 Synchronization check and control

The operation of Synchronization check and control can be described with a module diagram. All the modules in the diagram are explained in the next sections.

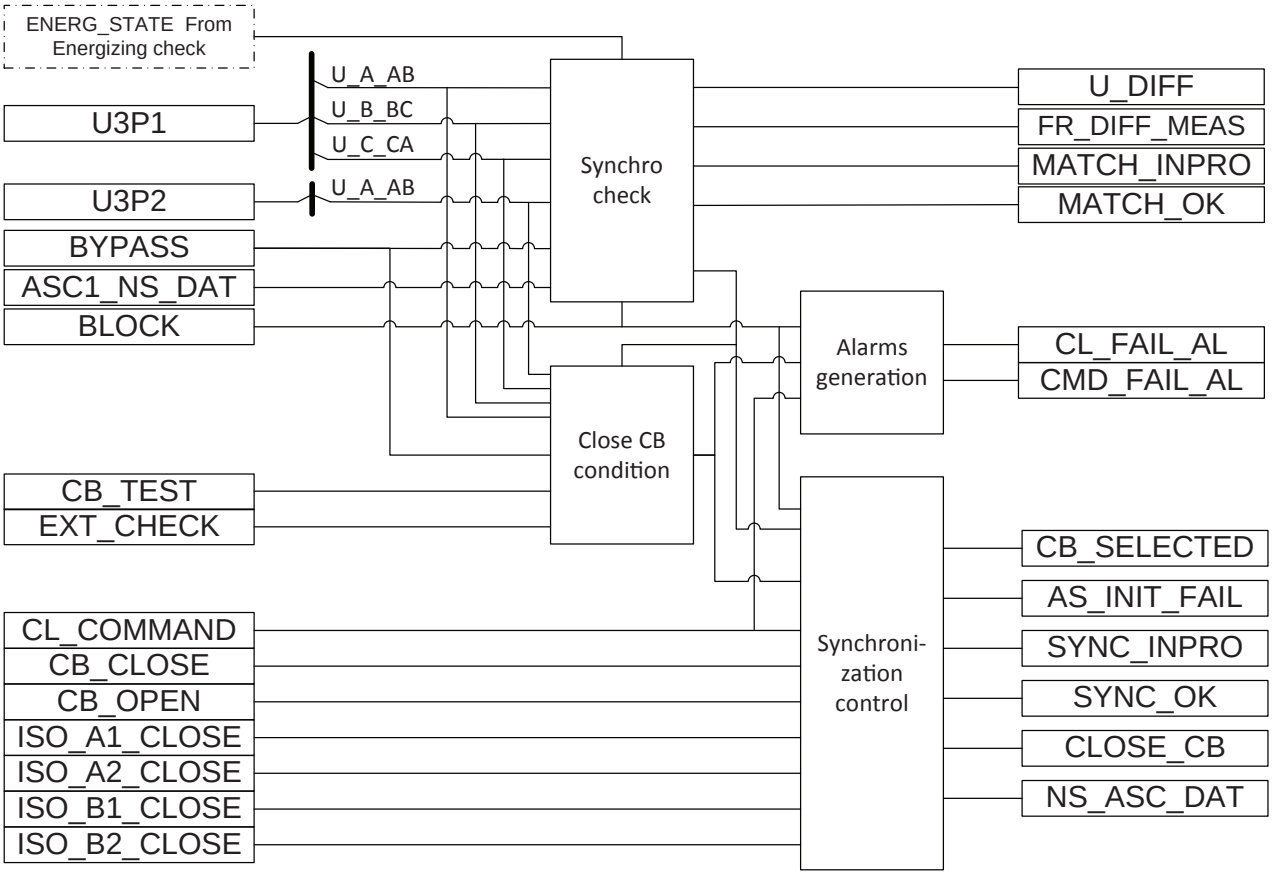



*Figure 871: Module diagram for Synchronization check and control*

**Synchro check**

The function measures the voltage difference U_DIFF_MEAS, frequency difference FR_DIFF_MEAS and phase angle difference PH_DIFF_MEAS between the two bus sides.

$$U_DIFF_MEAS = U_{BusA} - U_{BusB} + Voltage\ offset$$

(Equation 366)

| | |
|---|---|
| $U_{BusA}$ | Measured bus A side voltage |
| $U_{BusB}$ | Measured bus B side voltage |
| Voltage off-set | Setting *Voltage offset* |

$$FR_DIFF_MEAS = f_{BusA} - f_{BusB} + Frequency\ offset$$

(Equation 367)

| | |
|---|---|
| $f_{BusA}$ | Measured bus A side frequency |
| $f_{BusB}$ | Measured bus B side frequency |
| Frequency offset | Setting *Frequency offset* |

$$PH_DIFF_MEAS = \angle U_{BusA} - \angle U_{BusB} + Phase\ shift$$

(Equation 368)

| | |
|---|---|
| $\angle U_{BusA}$ | Measured bus A side voltage phase angle |
| $\angle U_{BusB}$ | Measured bus B side voltage phase angle |
| Phase shift | Setting *Phase shift* |

The calculated voltage and phase angle difference values between these voltages are available as monitored data U_DIFF_MEAS and PH_DIFF_MEAS. The setting *Phase shift* is used to compensate the angle shift caused if a power transformer is located between the voltage measurements.

The synchronism condition and CB closing instance are checked according to several criteria.

- The measured bus A and bus B voltages are higher than the set value of *Live bus voltage* (ENERG_STATE equals “Both Live”).
- The measured bus A and bus B frequencies are both within the range of 95...105 % of the value of the nominal frequency ($f_n$).
- The measured bus A and bus B voltages are lower than the set value of *Max energizing V*.

When the *Synchrocheck mode* setting parameter is set to "Command", then the “Synchronous”, “Asynchronous” or “Off” condition of the network across the CB can be set using the *SynchroChk Mod Ctl* control command only. If the *Synchrocheck mode* setting parameter is not set to "Command", then the *Synchrocheck mode* setting parameter is used to set the “Synchronous”, “Asynchronous” or “Off” condition of the network across the CB.

Some additional conditions must be fulfilled according to the set *Synchrocheck mode*.

**Table 1530: Additional conditions for the synchro check**

| Measurements | Synchrocheck mode | |
|---|---|---|
| | “Synchronous” | “Asynchronous” |
| U_DIFF_MEAS | < 0.01 x Nominal voltage ($U_n$) | < Difference voltage |
| PH_DIFF_MEAS | < 5 degree | < Difference angle |
| FR_DIFF_MEAS | < 0.001 x Nominal frequency ($f_n$) | < Frequency difference |
| Estimated closing angle | N/A | < Difference angle |

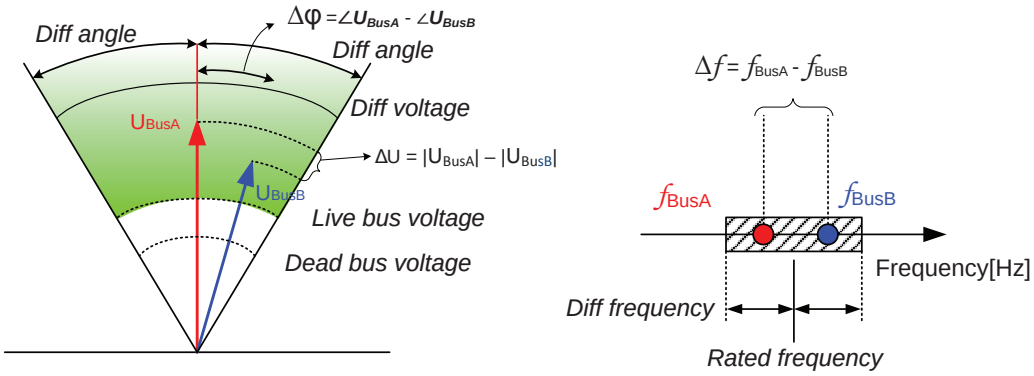



*Figure 872: Conditions to be fulfilled when detecting synchronism between systems*

When the measured difference of voltages (U_DIFF_MEAS) and measured difference in frequency (FR_DIFF_MEAS) are within the synchro check limits given in *Table 1530*, the output MATCH_OK is activated. The output MATCH_INPRO is activated when the voltage and frequency matching is in progress. The matching status input is received via ASC1_NS_DAT signal from ASCGAPC.

When the frequency, phase angle and voltage conditions are fulfilled, the duration of the synchronism conditions is checked to ensure that they are still met when the condition is determined on the basis of the measured frequency and phase difference. Depending on the CB and the closing system, the delay between the closing signal and the CB closing is about 50...250 ms. The selected *Closing time of CB* informs the function how long the conditions have to persist. The value covers both the CB closing delay and the output type dependent delay. The synchro check function compensates for the measured slip frequency and the CB closing delay.

The closing angle advance is calculated continuously:

$$Closing\ angle = \left| \left( \angle U_{BusA} - \angle U_{BusB} \right)° + \left( \left( f_{BusA} - f_{BusB} \right) \cdot \left( \frac{TCB}{1000} \right) \cdot 360° \right) \right|$$

(Equation 369)

| | |
|---|---|
| $\angle U_{BusA}$ | Measured bus A voltage phase angle |
| $\angle U_{BusB}$ | Measured bus B voltage phase angle |
| TCB | Parameter *Closing time of CB* to be set as in *Equation 370* |

$$TCB = t_{CB} + T_{PL} + x$$

(Equation 370)

| | |
|---|---|
| $t_{CB}$ | CB closing delay in ms |
| $T_{PL}$ | Output type dependent delay in ms (see *Table 1531*) |
| x | Hardware delays between the protection relay and CB in ms; delays due to, for example, auxiliary relays and contactors, if used |

**Table 1531: Typical delays for different output types**

| Output type | Recommended value for $T_{PL}$ | |
|---|---|---|
| | **Both Bus side voltage measurements: Non-Adaptive or**<br>**Both Bus side voltage measurements: Adaptive** | **Any one of the Bus side voltage measurement: Adaptive,**<br>**The other Bus side voltage measurement: Non Adaptive** |
| Semiconductor output (SPO) | 16 ms | 7 ms |
| Mechanical relay output (POSP, PODP) | 23 ms | 13 ms |

The *Minimum Syn time* setting defines the minimum time for which synchro check conditions must be simultaneously fulfilled.

The frequency slip acceleration (ds/dt) SLIP_ACCL is the average value of frequency slip difference (Δs) calculated over a time period of 0.5 s.

$$Frequency\ slip(s) = \frac{\left(f_{BusA} - f_{BusB}\right)}{f_{BusA}}$$

(Equation 371)

The measured bus A voltage ($U_{BusA}$), bus A frequency ($f_{BusA}$), measured bus B voltage ($U_{BusB}$), bus B frequency ($f_{BusB}$) and phase angle difference (PH_DIFF_MEAS) values between the two sides of the CB are available as monitored data values.

If the measured U_DIFF_MEAS does not fulfill the condition given in *Table 1530* and thus synchronism is prevented, the monitored data U_DIFF_SYNC is activated. Similarly PH_DIF_SYNC and FR_DIFF_SYNC are activated based on the measurements PH_DIFF_MEAS and FR_DIFF_MEAS, respectively. These monitored data values are updated only when the setting *Synchrocheck mode* is set to either "Synchronous" or "Asynchronous" and the measured ENERG_STATE is "Both Live". The outputs `U_DIFF` and `FR_DIFF_MEAS` give the calculated phaseto- phase voltage difference and the frequency difference values, respectively. These `U_DIFF` and `FR_DIFF_MEAS` outputs are sent to ASCGAPC.

The monitored data ACT_ASC_CB indicates the ASCGAPC CB number. The CB number of the protection relay's ASCGAPC is received via `ASC1_NS_DAT` signal.

### Close CB condition

If *Synchrocheck mode* is set to "Asynchronous", the CB close command is generated as explained below.

From the frequency slip s, the acceleration ds/dt, the bus frequency FR_BUS_MEAS ($f_{Bus}$) and the set *Closing time of CB*, the function calculates the necessary lead angle ($\alpha_{Lead}$) by which the close CB command is shifted forward in time so that the main contacts close on phase coincidence.

$$\alpha_{Lead} = \left( 360 \cdot f_{BusA} \cdot \left( s + \frac{\frac{TCB}{2} \cdot \frac{ds}{dt}}{1000} \right) \cdot \frac{TCB}{1000} \right)$$

(Equation 372)

| | |
|---|---|
| $f_{BusA}$ | Bus A side frequency |
| s | Frequency slip |
| ds/dt | Frequency slip acceleration |
| TCB | Setting *Closing time of CB* |

The breaker closes only when the measured phase-angle difference across the breaker (PH_DIFF_MEAS) equals the calculated lead angle ($\alpha_{Lead}$) and all synchronization check conditions are fulfilled.

If *Synchrocheck mode* is set to "Synchronous", a zero-passage of the phase-angle difference is not necessary and CB closing is permitted as soon as all the synchrocheck conditions are fulfilled. Similarly for dead bus synchronization, CB closing is possible when the energizing check permits.

The CB closing signal can be blocked based on the inputs CB_TEST and EXT_CHECK and IED test mode as described in *Table 1532*. This blocking status is available in the monitored data CB_CL_BLKD.

**Table 1532: CB_CL_BLKD status based on the inputs**

| IED test mode | Inputs | | Monitored data |
|---|---|---|---|
| | CB_TEST | EXT_CHECK | CB_CL_BLKD |
| TRUE | TRUE | TRUE | 1 (“Unblocked”) |
| FALSE | FALSE | | |
| TRUE | TRUE | FALSE | 2 (“Ext Check Fail”) |
| FALSE | FALSE | | |
| TRUE | FALSE | N/A | 3 (“IED Test CB Service”) |
| FALSE | TRUE | N/A | 4 (“IED Service CB Test”) |

ASNSCSYN can be set to the bypass mode by setting the parameters *Synchrocheck mode* and *Live dead mode* to "Off" or, alternatively, by activating the BYPASS input. In the bypass mode, the closing conditions are always considered to be fulfilled by ASNSCSYN.

### Synchronization control

The general bus bar arrangement for a non-source CB bus is shown in *Figure 873*. The bus to which the generator is connected is determined based on the circuit breaker and isolator position inputs (CB_OPEN, CB_CLOSE, ISO_A1_CLOSE, ISO_A2_CLOSE, ISO_B1_CLOSE and ISO_B2_CLOSE). The generator's bus connection status is shared with ASCGAPCs as part of the NS_ASC_DATA output.

The equipment which is capable of voltage and frequency adjustment, that is, the generator, is referred to as source and the rest as nonsource. Hence the generator's CB is referred to as source CB and the bus coupler or tie feeder CB as non-source CB. The non-source CB is not directly related to a generator although its closing has to be handled using synchronization.

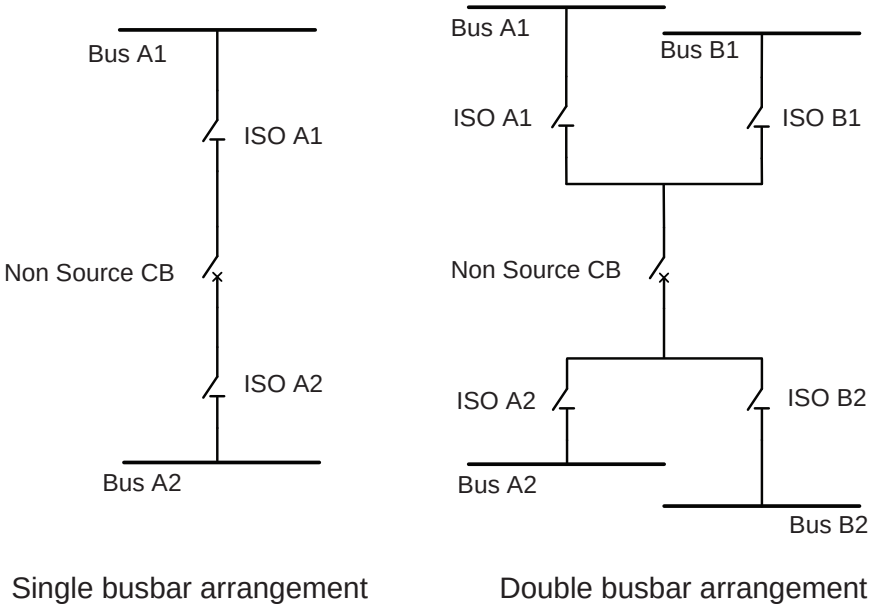



*Figure 873: Different busbar arrangement for a non-source CB*

**Auto synchronization mode**

In this mode, the closing signal is delivered if either the command *Synchronize CB* or the input CL_COMMAND is set to TRUE. The device should be in local mode if synchronization is initiated with the *Synchronize CB* command.

If the setting *Auto Syn mode* is set as "Manual mode" or "Semi-automatic synchronising mode", the additional command Manual CB release should be active for the closing signal CLOSE_CB to be activated. If the setting *Auto Syn mode* is set as "Automatic synchronising mode", no additional command is required to activate the closing signal CLOSE_CB.

In this auto synchronization mode, once all the closing conditions are satisfied within the set *Maximum Syn time*, the outputs SYNC_OK and CLOSE_CB become TRUE and remain active as long as the closing conditions are fulfilled. If *Multiple command* is set to "Off", then only CLOSE_CB outputs are delivered once for each activated input signal as shown in *Figure 874*. If *Multiple command* is set to "On", then CLOSE_CB outputs are delivered each time the conditions are satisfied as shown in *Figure 875*. In this auto synchronization mode, once all the closing conditions are satisfied within the set *Maximum Syn time*, the outputs SYNC_OK and CLOSE_CB become TRUE. These outputs remain active as long as the respective conditions are fulfilled. If *Multiple command* is set to "Off", then only CLOSE_CB outputs are delivered only once for each activated input signal as shown in *Figure 874*. If *Multiple command* is set to "On", then CLOSE_CB outputs are delivered each time the conditions are satisfied as shown in *Figure 875*.

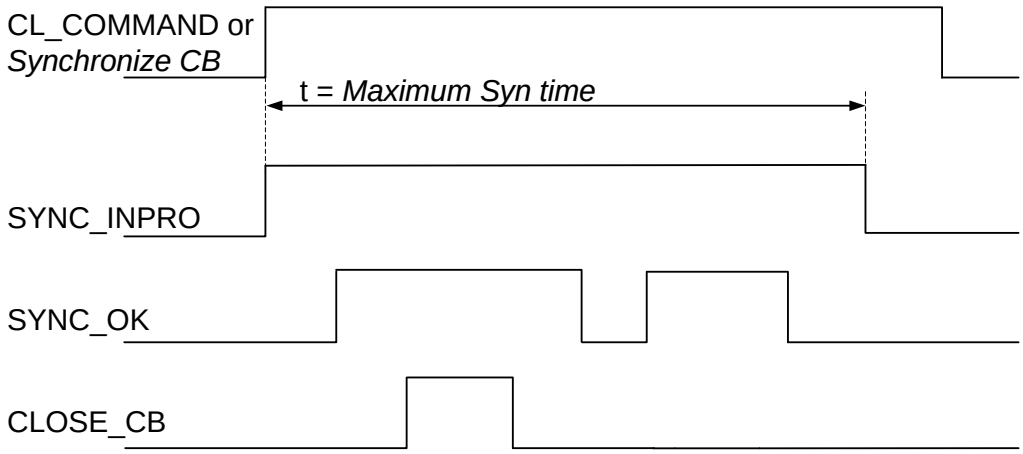



*Figure 874: Determination of closing signal CLOSE_CB when Multiple command is set to "Off"*

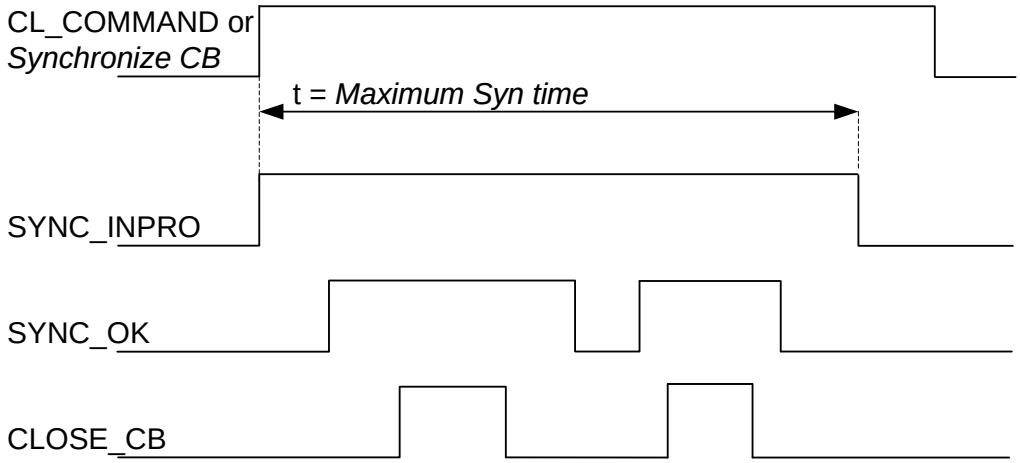



*Figure 875: Determination of closing signal CLOSE_CB when Multiple command is set to "On"*

The SYNC_INPRO output is active when the close command (CL_COMMAND or *Synchronize CB*) is in progress and it is reset when the close command is reset or *Maximum Syn time* has elapsed. In this automatic mode the closing signal CLOSE_CB is activated automatically once all the closing conditions are satisfied.

If the closing conditions are fulfilled during a permitted check time set with *Maximum Syn time*, ASNSCSYN gives synchro check permission to the circuit-breaker control CBXCBR after the closing command signal is delivered. The simplified configuration block diagram of ASNSCSYN with CLOSE_CB to CBXCBR is shown in *Figure 876*.

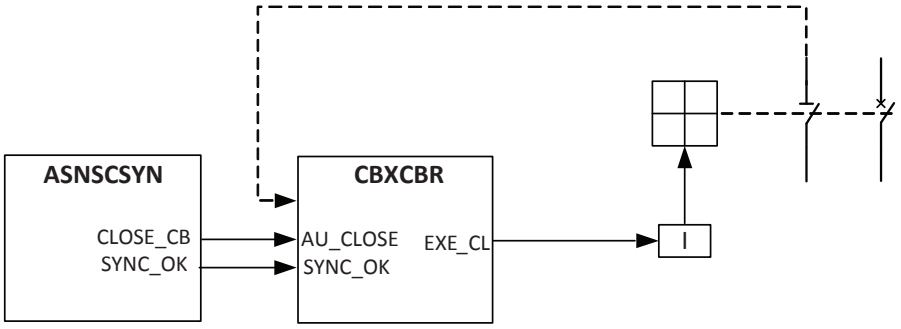



*Figure 876: Simplified configuration block diagram of ASNSCSYN in auto synchronization mode operation*

**Alarms generation**

In auto synchronization control mode, the closing command generation is activated either by the command input CL_COMMAND or by command parameter *Synchronize CB*.

After the closing command activation, if the conditions for closing CB are not fulfilled within the set time of *Maximum Syn time*, a failed closing attempt alarm is given. The CL_FAIL_AL alarm output signal is pulse-shaped and the pulse length is 500 ms.

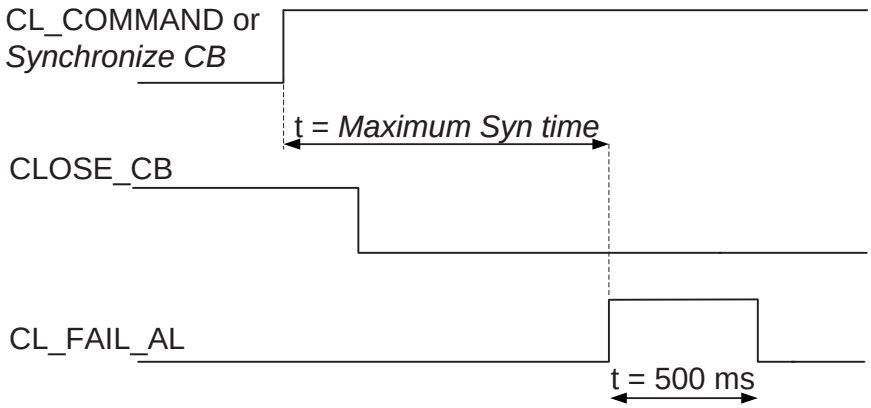



*Figure 877: Determination of checking time for closing*

CB closing is permitted during *Maximum Syn time*, starting from the moment the close command is activated. The close command must be active while the closing conditions are fulfilled, otherwise the procedure is cancelled. If the closing conditions are fulfilled during *Maximum Syn time*, a closing pulse output is delivered to the CB. If the closing conditions are not fulfilled during the checking time, the alarm CL_FAIL_AL is activated as an indication of a failed closing attempt. The closing pulse is not delivered if the closing conditions become valid after *Maximum Syn time* has elapsed. The closing pulse is delivered only once for each activated close command, and a new closing command sequence cannot be started until the close command is reset and reactivated.

CBXCBR receives information about the CB status and thus is able to adjust the command signal to be delivered to ASNSCSYN. If the closing command is

active longer than necessary, the CMD_FAIL_AL alarm output is activated. To avoid unnecessary alarms, the maximum length of the closing command signal should be below *Maximum Syn time* + 5 s.

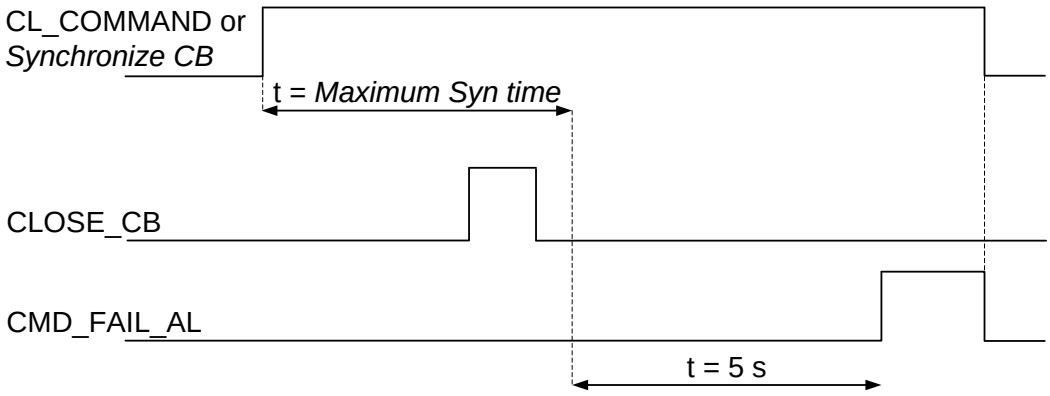



*Figure 878: Determination of the alarm limit for a still-active command signal*

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all binary outputs and resets the internal timers.

## 9.7.6 Application

A circuit breaker is used to connect two different power networks. It is essential to ensure that these power networks are synchronized before closing the CB, otherwise it may lead to disturbances in the power system, causing stress and damage to the connected equipment.

ASNSCSYN can be used for the synchronized closing of a non-generator circuit breaker such as a bus sectionalizer, a bus coupler or an incoming feeder. It checks for the synchronization conditions across the CB and releases the CB closing command. If these conditions are not fulfilled, the sources in the power network connected across this bus coupler or tie feeder CB have to change their operating points to meet the requirements. This is achieved with Autosynchronizer co-ordinator ASCGAPC available with the source (ASGCSYN) function and non-source (ASNSCSYN) function.

ASCGAPC assists in the participating sources selection based on the network topology and interacts with the sources to initiate the voltage and frequency matching for the bus coupler or tie feeder CB to be synchronized. When any non-source circuit breaker (NSCB) is selected for synchronization, a synchronization procedure is started. ASCGAPC located in the NSCB relay starts communicating with ASCGAPCs of possible source circuit breaker (SCB) relays for matching the voltage and frequency difference. Both ASCGAPCs pass the required information to the participating sources. A non-source CB synchronization is described with one typical example in *Figure 879*.

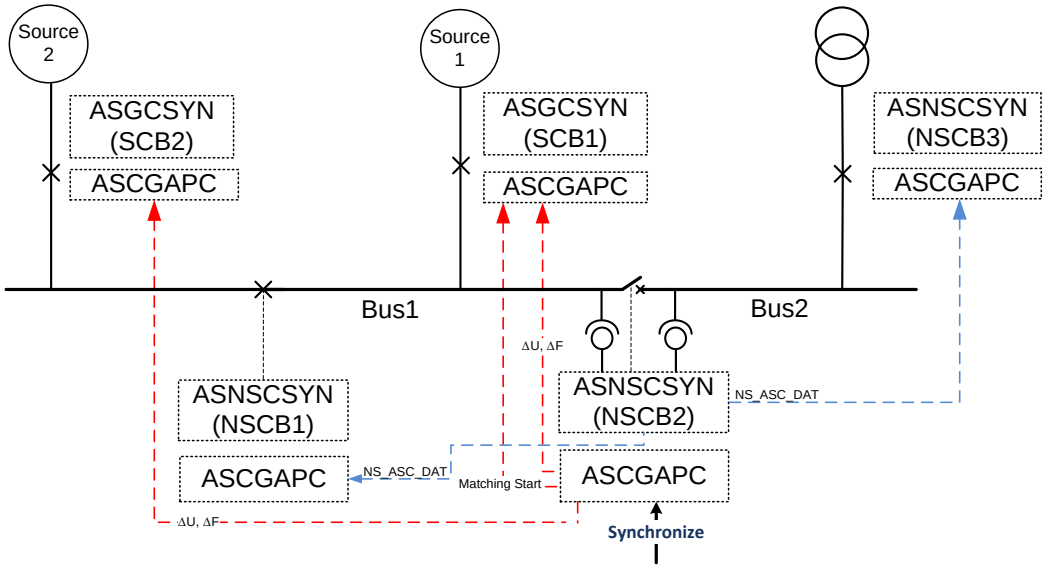



*Figure 879: NSCB2 synchronization*

In this application example, breaker NSCB2 must be closed. So the synchronizing conditions between Bus1 and Bus2 are checked by ASNSCSYN. ASNSCSYN sends the auto synchronization request and the voltage and frequency difference (ΔU, ΔF) between Bus1 and Bus2 to ASCGAPC.

ASCGAPC transfers the voltage and frequency difference sent by ASNSCSYN to the selected ASCGAPC function of source 1 ASGCSYN function. It also sends the permission to the source to start matching the voltage and frequency. The matching process is carried out so that the voltage and frequency difference between Bus1 and Bus2 measured by ASNSCSYN reduces and comes within the synchro check limits. This satisfies the synchro check conditions for breaker NSCB2 which can then be synchronized by ASNSCSYN. Similarly, the synchronization of NSCB1 and NSCB3 having ASCGAPC is done as shown in *Figure 880* and *Figure 881*.

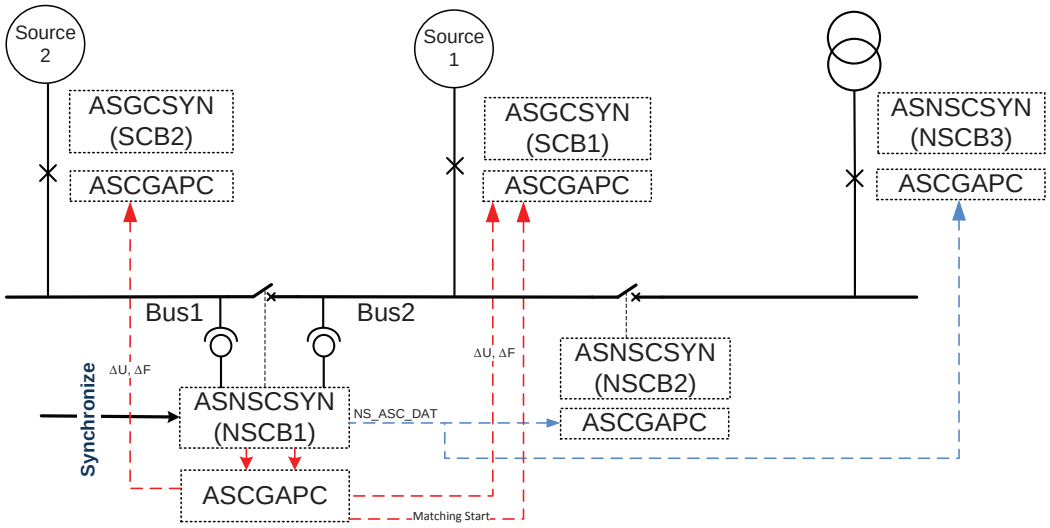



*Figure 880: NSCB1 synchronization*

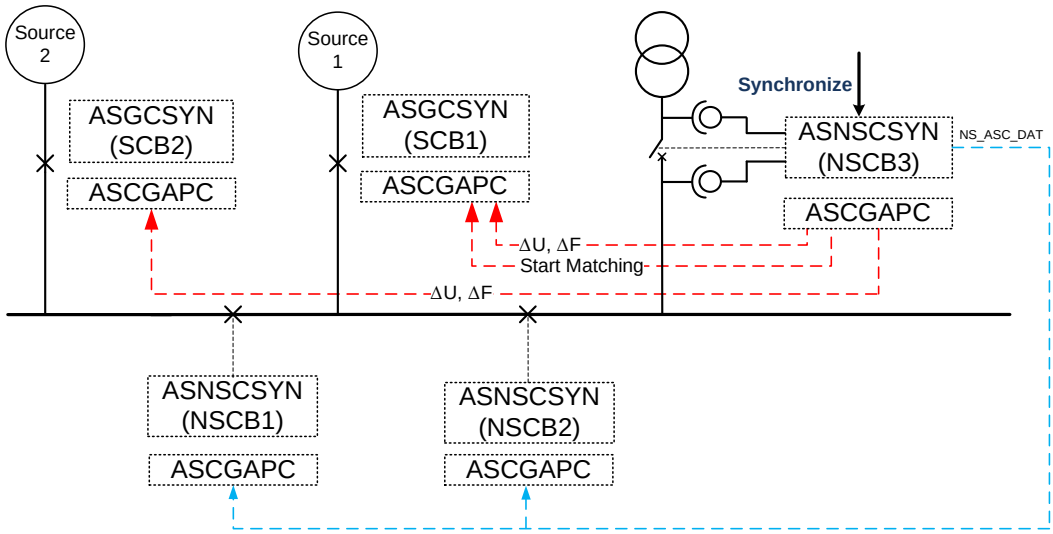



*Figure 881: NSCB3 synchronization*

This function supports manual, semi-automatic and automatic synchronizing, which adds flexibility in the user operation. In the manual synchronization, the matching is done manually and the closing command is released from the function on user request. In the semi-automatic synchronization, the matching is done automatically with coordination from ASCGAPC and the closing command is released from the function on user request. In the automatic synchronization, the matching is done automatically with coordination from ASCGAPC and the subsequent closing command is released from the function without user intervention.

This function output can be used to block the other functions in the power network to ensure that only one CB is synchronized at a time. This logic has to be developed outside the function block.

**Voltage angle difference adjustment**

In applications where the power transformer is located between the voltage measurement and the CB, the vector group connection gives phase difference to the voltages between the high- and low-voltage sides. The angle adjustment can be used to meet synchronism.

The vector group of the power transformer is defined with clock numbers, where the value of the hour pointer defines the low-voltage-side phasor and the high-voltage-side phasor is always fixed to the clock number 12, which is the same as zero. The angle between clock numbers is 30°. When comparing phase angles, the U_BUS_A input is always the reference. This means that when the Yd11 power transformer is used, the low-voltage-side voltage phasor leads the high-voltage-side phasor by 30º or lags by 330º. The rotation of the phasors is counterclockwise.

The generic rule is that a low-voltage-side phasor lags the high-voltage-side phasor by clock number · 30º. This is called angle difference adjustment and can be set for ASNSCSYN with the *Phase shift* setting.

## 9.7.7 Signals

### 9.7.7.1 ASNSCSYN Input signals

**Table 1533: ASNSCSYN Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P1 | SIGNAL | - | Three-phase voltages (Bus B side) |
| U3P2 | SIGNAL | - | Three-phase voltages (Bus A side) |
| BLOCK | BOOLEAN | 0=False | Blocking signal of the auto synchronization function |
| BYPASS | BOOLEAN | 0=False | Bypass for synchronization and closing conditions check |
| CL_COMMAND | BOOLEAN | 0=False | External closing request |
| EXT_CHECK | BOOLEAN | 0=False | External permissive check for CB close |
| CB_TEST | BOOLEAN | 0=False | Circuit breaker test position status |
| CB_OPEN | BOOLEAN | 0=False | Circuit breaker open status |
| CB_CLOSE | BOOLEAN | 0=False | Circuit breaker close status |
| ISO_A1_CLOSE | BOOLEAN | 0=False | Isolator A1 close status |
| ISO_B1_CLOSE | BOOLEAN | 0=False | Isolator B1 close status |
| ISO_A2_CLOSE | BOOLEAN | 0=False | Isolator A2 close status |
| ISO_B2_CLOSE | BOOLEAN | 0=False | Isolator B2 close status |
| ASC1_NS_DAT | INT32 | 0 | Coded integer data from ASCGAPC1 |

### 9.7.7.2 ASNSCSYN Output signals

**Table 1534: ASNSCSYN Output signals**

| Name | Type | Description |
|---|---|---|
| CL_FAIL_AL | BOOLEAN | CB closing failed |
| CMD_FAIL_AL | BOOLEAN | CB closing request failed |
| AS_INIT_FAIL | BOOLEAN | Synchronization not initiated |
| CLOSE_CB | BOOLEAN | CB close signal |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| SYNC_OK | BOOLEAN | Systems in synchronism |
| MATCH_OK | BOOLEAN | Voltage and frequency of the systems matched |
| MATCH_INPRO | BOOLEAN | Voltage and frequency matching in progress |
| SYNC_INPRO | BOOLEAN | Synchronization in progress |
| LADB | BOOLEAN | Live bus A, dead bus B |
| LALB | BOOLEAN | Live bus A, live bus B |
| DALB | BOOLEAN | Dead bus A, live bus B |
| DADB | BOOLEAN | Dead bus A, dead bus B |
| U_DIFF | FLOAT32 | Line voltage difference across synchronizing CB |
| FR_DIFF_MEAS | FLOAT32 | Calculated voltage frequency difference |
| CB_SELECTED | BOOLEAN | CB selected for synchronization |
| NS_ASC_DAT | INT32 | Integer weighted output data to ASCGAPC |

## 9.7.8 ASNSCSYN Settings

**Table 1535: ASNSCSYN Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Live dead mode | -2=Command<br>-1=Off<br>1=Both Dead<br>2=Live B, Dead A<br>3=Dead B, Live A<br>4=Dead A, B Any<br>5=Dead B, A Any<br>6=One Live, Dead<br>7=Not Both Live | | | 1=Both Dead | Live dead mode |
| Diff voltage | 0.01...0.50 | xUn | 0.01 | 0.05 | Maximum voltage difference limit |
| Diff frequency | 0.001...0.060 | xFn | 0.001 | 0.001 | Maximum frequency difference limit |
| Diff angle | 5...90 | deg | 1 | 5 | Maximum angle difference limit |

**Table 1536: ASNSCSYN Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Multiple command | 0=Off<br>1=On | | | 0=Off | Multiple command to the circuit breaker |
| Voltage offset | -0.100...0.100 | xUn | 0.001 | 0.000 | Voltage offset |
| Frequency offset | -0.010...0.010 | xFn | 0.001 | 0.000 | Frequency offset |

**Table 1537: ASNSCSYN Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Synchrocheck mode | 1=Off<br>2=Synchronous<br>3=Asynchronous<br>4=Command | | | 3=Asynchronous | Synchrocheck operation mode |
| Dead bus voltage | 0.1...0.8 | xUn | 0.1 | 0.2 | Voltage low limit for energizing check |
| Live bus voltage | 0.2...1.0 | xUn | 0.1 | 0.5 | Voltage high limit for energizing check |
| Max energizing V | 0.50...1.30 | xUn | 0.01 | 1.05 | Maximum voltage above which no paralleling takes place |
| Auto Syn mode | -1=Semi-automatic synchronising mode<br>1=Automatic synchronising mode<br>3=Manual mode | | | 3=Manual mode | Autosynchronization operation mode |

**Table 1538: ASNSCSYN Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase shift | -180...180 | deg | 1 | 0 | Phase difference correction between bus A and bus B voltages |
| Minimum Syn time | 0...60000 | ms | 10 | 0 | Minimum time to accept synchronizing |
| Maximum Syn time | 100...6000000 | ms | 10 | 60000 | Maximum time to accept synchronizing |
| Energizing time | 100...60000 | ms | 10 | 100 | Time delay for energizing check |
| Closing time of CB | 40...250 | ms | 1 | 60 | Closing time of the breaker |

## 9.7.9 ASNSCSYN Monitored data

**Table 1539: ASNSCSYN Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ENERG_STATE | Enum | 0=Unknown<br>1=Both Live<br>2=Live Bus B, Dead Bus A<br>3=Dead Bus B, Live Bus A<br>4=Both Dead | | Energization state of bus A and bus B |
| U_DIFF_MEAS | FLOAT32 | -3.00...3.00 | xUn | Calculated voltage amplitude difference |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| PH_DIFF_MEAS | FLOAT32 | -180.00...180.00 | deg | Calculated voltage phase angle difference |
| U_BUSA_MEAS | FLOAT32 | 0.00...5.00 | xUn | Calculated bus A voltage amplitude |
| U_BUSB_MEAS | FLOAT32 | 0.00...5.00 | xUn | Calculated bus B voltage amplitude |
| FR_BUSA_MEAS | FLOAT32 | 35.00...75.00 | Hz | Calculated bus A frequency |
| FR_BUSB_MEAS | FLOAT32 | 35.00...75.00 | Hz | Calculated bus B frequency |
| U_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Voltage difference out of limit for synchronizing |
| FR_DIFF_SYNC | BOOLEAN | 0=False<br>1=True | | Frequency difference out of limit for synchronizing |
| PH_DIF_SYNC | BOOLEAN | 0=False<br>1=True | | Phase angle difference out of limit for synchronizing |
| SLIP_ACCL | FLOAT32 | 0.000...5.000 | xFn/s | Calculated rate of change of frequency slip |
| ACT_ASC_CB | INT32 | 0...2147483647 | | Active ASCGAPC host circuit breaker number |
| CB_CL_BLKD | Enum | 1=Unblocked<br>2=Ext Check Fail<br>3=IED Test CB Service<br>4=IED Service CB Test | | CB close blocked status |
| SYNCCHK_STS | Enum | 1=Off<br>2=Synchronous<br>3=Asynchronous | | Synchro check mode status |
| LIVEDEAD_STS | Enum | -1=Off<br>1=Both Dead<br>2=Live B, Dead A<br>3=Dead B, Live A<br>4=Dead A, B Any<br>5=Dead B, A Any<br>6=One Live, Dead<br>7=Not Both Live | | Live dead mode status |
| ASNSCSYN | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 9.7.10 Technical data

**Table 1540: ASNSCSYN Technical data**

| Characteristic | Value |
|---|---|
| Measurement accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz |
| | Voltage difference: ±1.0 % or ±0.004 × $U_n$<br>Frequency difference: ±10 mHz Phase angle difference: ±1° |
| Operation accuracy | MATCH_OK for voltage: ±0.001 × $U_n$<br>MATCH_OK for frequency: ±10 mHz |
| Operation time accuracy | *Energizing time* for dead-bus closing:<br>±1.0 % of the set value or ±35 ms<br>*Minimum Syn time* for SYNC_OK:<br>±1.0 % of the set value or ±60 ms |
| Reset time | Typically 20 ms |
| Closing angle accuracy | ±1° |

# 9.8 Autosynchronizer co-ordinator ASCGAPC (ANSI 25AUTOSYNC)

## 9.8.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Autosynchronizer co-ordinator | ASCGAPC | AUTOSYNC | 25AUTOSYNC |

## 9.8.2 Function block

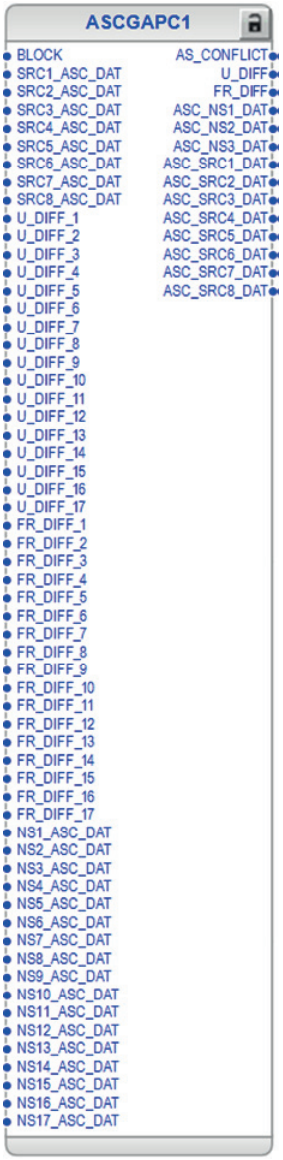



*Figure 882: Function block*

## 9.8.3 Functionality

The autosynchronizer co-ordinator function ASCGAPC can be used as a coordinator for the synchronization of any bus coupler or grid transformer incomer breakers in the power network. ASCGAPC must be present on the relay configuration together with the bus coupler or grid transformer autosynchronization functions (ASNSCSYN) as well as in generator autosynchronization functions (ASGCSYN).

ASCGAPC performs the network topology determination to identify the subnetworks within the whole network. It routes the voltage and frequency difference values from the synchronizing CB to all the generator sources. It also identifies the sources which are eligible to participate in matching the voltage and

frequency difference. ASCGAPC allows to select sources for synchronization and gives permission for matching to the selected sources after essential checks.

ASCGAPC allows autosynchronization of only one non-source circuit breaker at a time. It also provides the voltage and frequency matching status for the synchronization in progress.

## 9.8.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off".

The operation of ASCGAPC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

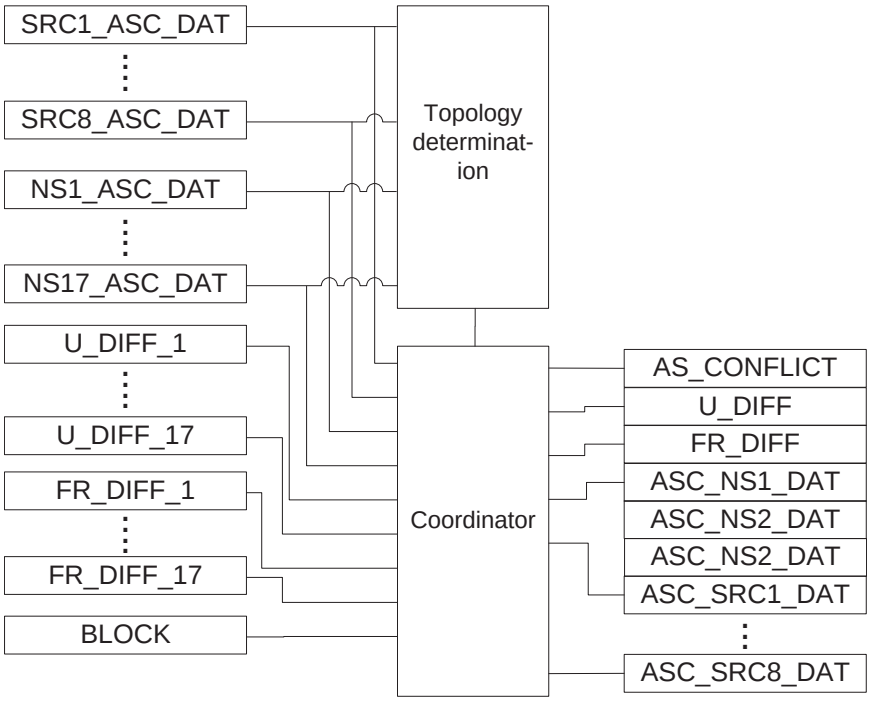



*Figure 883: Functional module diagram*

### 9.8.4.1 Topology determination

This module identifies the group of busbars, power sources and network circuit breakers electrically connected together and calculates the subnetwork number for each group. It also identifies the sources and buses which are electrically connected to the external network. The maximum network configuration considered is 8 sources, 8 source CBs (SCB), 15 busbars and 17 non-source CBs (NSCB).

The equipment which is capable of voltage and frequency adjustment, that is, the generator, is referred to as source and the rest as non-source. Hence the generator CB is referred to as source CB and the bus coupler or tie feeder CB as non-source CB. Also, any bus or system, external to this network is referred to as grid.

The general busbar arrangement across any NSCB is shown in *Figure 884*. For each NSCB, the numbers for Bus A1, Bus A2, Bus B1 and Bus B2 must be set. These bus numbers for non-source CB 1 are set in *NonSrc1 bus A1 Num*, *NonSrc1 bus A2 Num*, *NonSrc1 bus B1 Num* and *NonSrc1 bus B2 Num*, respectively. Each of these settings can be set to values "Bus 1"..."Bus 15" or to "Not Configured".

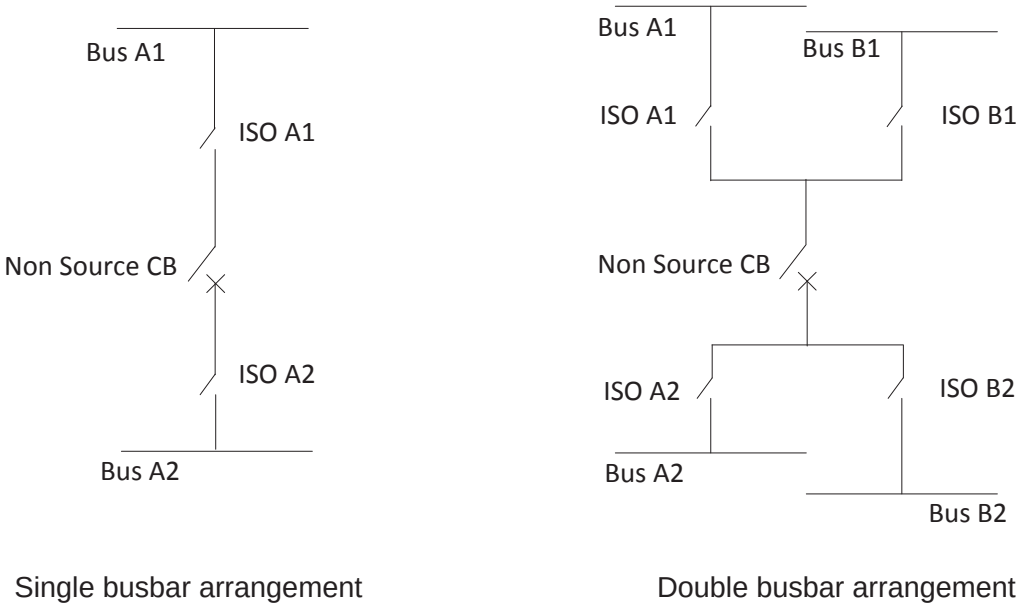



*Figure 884: Different busbar arrangement across any non-source CB*

The general busbar arrangement across any SCB is shown in *Figure 885*. For each source CB, the Bus A and Bus B numbers are to be set. These bus numbers for source CB 1 are set in *Src1 bus A Num* and *Src1 bus B Num*, respectively. Each of these settings can be set to values "Bus 1"..."Bus 15" or to "Not Configured".

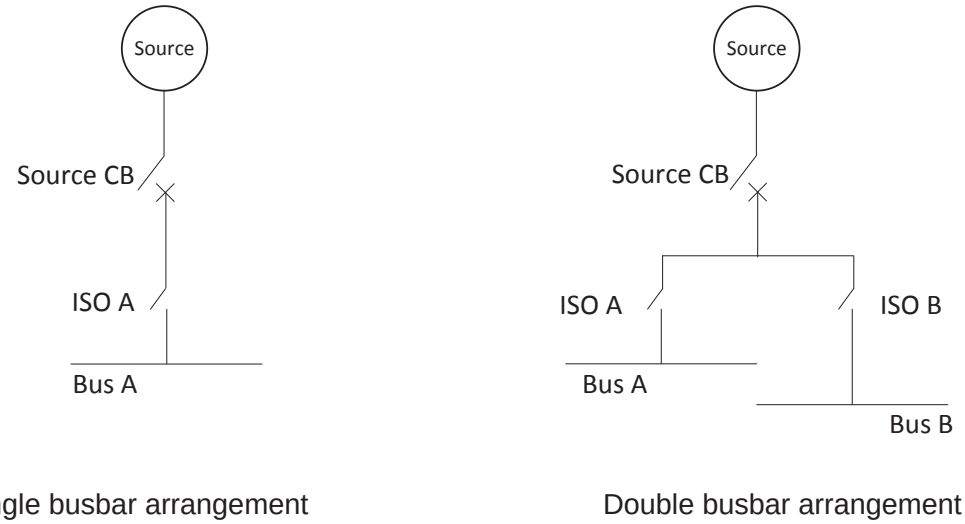



*Figure 885: Different busbar arrangement for any source CB*

The subnetwork group identification is based on the set busbar arrangement across each CB and the connection status input received from the corresponding

ASGCSYN via SRC1_ASC_DAT...SRC8_ASC_DAT or from the corresponding ASNSCSYN via signals NS1_ASC_DAT...NS17_ASC_DAT.

An example of the subnetwork group identification is shown in *Figure 886*. Since NSCB 2 connects bus bar 1 and bus bar 2, then setting *NonSrc2 bus A1 Num* is set to "Bus 1" and *NonSrc2 bus A2 Num* is set as "Bus 2". Based on the bus connection status received via the input NS2_ASC_DAT, this module determines that Bus 1, Bus 2 and NSCB 2 are electrically connected. Similarly for SCB 2, *Src2 bus A Num* is set as "Bus 2" and the source CB closed status input is received via SRC1_ASC_DAT. So SCB 2 is electrically connected to Bus 2. Hence it is determined that SCB 2, Bus 2, Bus 1 and NSCB 2 are electrically connected to each other.

Two subnetworks are identified in *Figure 886*. The first comprises Bus 1, Bus 2, NSCB 1, NSCB 2, SCB 2 and source 2. The second comprises Bus 3, Bus 4, NSCB 4, SCB 3 and source 3. Each network group is assigned a subnetwork number which is the lowest bus bar number in the subgroup. Hence the first group is assigned subnetwork number 1 and the second group is assigned subnetwork number 3.

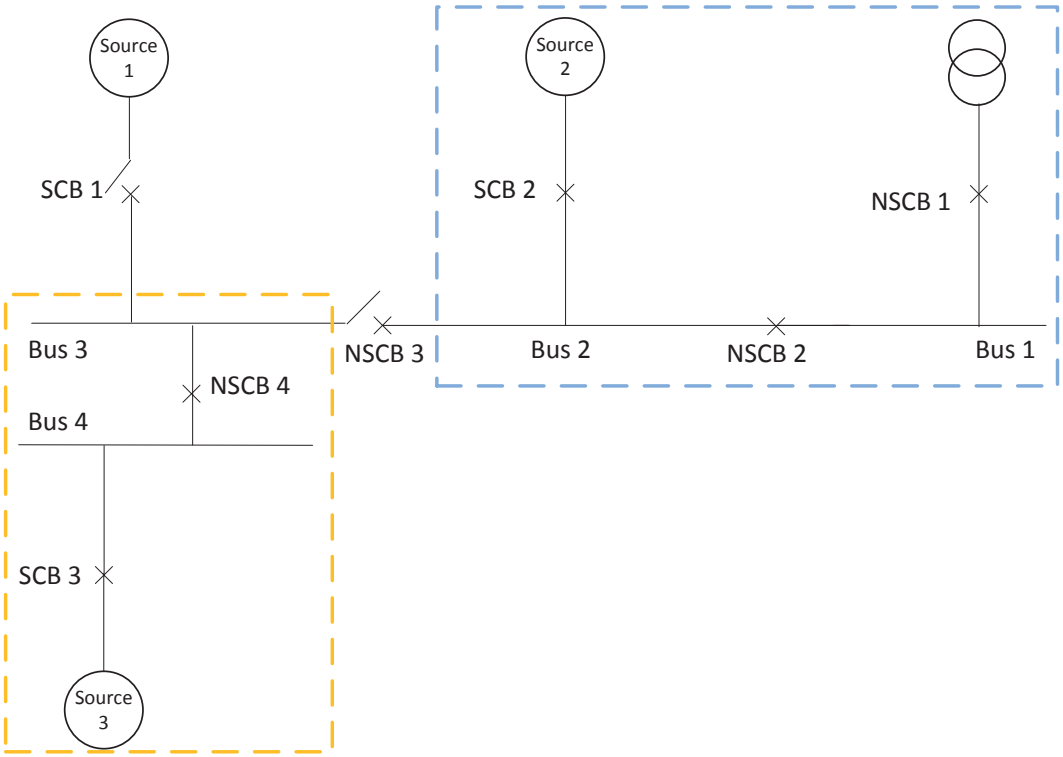



*Figure 886: An example of subnetwork group identification*

**Table 1541: ASCGAPC settings of NSCB1 for given example**

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Non source CB 1 | ASC1 host circuit breaker number 1 |
| Number of sources | 3 | Total number of sources present in the system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |
| Src1 bus A Num | Bus 3 | Source1 CB connected bus A number |

*Table continues on the next page*

| Settings | Suggested values | Description |
|---|---|---|
| Src2 bus A Num | Bus 2 | Source1 CB connected bus A number |
| Src3 bus A Num | Bus 4 | Source1 CB connected bus A number |
| NonSrc1 bus A1 Num | Bus 1 | Non-source CB1 connected bus A1 number |
| NonSrc1 bus A2 Num | Grid | Non-source CB1 connected bus A2 number |
| NonSrc2 bus A1 Num | Bus 1 | Non-source CB2 connected bus A1 number |
| NonSrc2 bus A2 Num | Bus 2 | Non-source CB2 connected bus A2 number |
| NonSrc3 bus A1 Num | Bus 3 | Non-source CB3 connected bus A1 number |

**Table 1542: Settings of ASCGAPC of NSCB2 for given example**

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Non source CB 2 | ASC1 host circuit breaker number 2 |
| Number of sources | 3 | Total number of sources present in the system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |
| Src1 bus A Num | Bus 3 | Source1 CB connected bus A number |
| Src2 bus A Num | Bus 2 | Source1 CB connected bus A number |
| Src3 bus A Num | Bus 4 | Source1 CB connected bus A number |
| NonSrc1 bus A1 Num | Bus 1 | Non-source CB1 connected bus A1 number |
| NonSrc1 bus A2 Num | Grid | Non-source CB1 connected bus A2 number |
| NonSrc2 bus A1 Num | Bus 1 | Non-source CB2 connected bus A1 number |
| NonSrc2 bus A2 Num | Bus 2 | Non-source CB2 connected bus A2 number |
| NonSrc3 bus A1 Num | Bus 2 | Non-source CB3 connected bus A1 number |

**Table 1543: Settings of ASCGAPC of NSCB3 for given example**

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Non source CB 3 | ASC1 host circuit breaker number 3 |
| Number of sources | 3 | Total number of sources present in the system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |
| Src1 bus A Num | Bus 3 | Source1 CB connected bus A number |
| Src2 bus A Num | Bus 2 | Source1 CB connected bus A number |
| Src3 bus A Num | Bus 4 | Source1 CB connected bus A number |
| NonSrc1 bus A1 Num | Bus 1 | Non-source CB1 connected bus A1 number |
| NonSrc1 bus A2 Num | Grid | Non-source CB1 connected bus A2 number |
| NonSrc2 bus A1 Num | Bus 1 | Non-source CB2 connected bus A1 number |
| NonSrc2 bus A2 Num | Bus 2 | Non-source CB2 connected bus A2 number |
| NonSrc3 bus A1 Num | Bus 2 | Non-source CB3 connected bus A1 number |

**Table 1544: Settings of ASCGAPC of NSCB4 for given example**

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Non source CB 4 | ASC1 host circuit breaker number 4 |
| Number of sources | 3 | Total number of sources present in the system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |
| Src1 bus A Num | Bus 3 | Source1 CB connected bus A number |
| Src2 bus A Num | Bus 2 | Source1 CB connected bus A number |
| Src3 bus A Num | Bus 4 | Source1 CB connected bus A number |
| NonSrc1 bus A1 Num | Bus 1 | Non-source CB1 connected bus A1 number |
| NonSrc1 bus A2 Num | Grid | Non-source CB1 connected bus A2 number |
| NonSrc2 bus A1 Num | Bus 1 | Non-source CB2 connected bus A1 number |
| NonSrc2 bus A2 Num | Bus 2 | Non-source CB2 connected bus A2 number |
| NonSrc3 bus A1 Num | Bus 2 | Non-source CB3 connected bus A1 number |
| NonSrc3 bus A2 Num | Bus 3 | Non-source CB3 connected bus A2 number |
| NonSrc4 bus A1 Num | Bus 3 | Non-source CB4 connected bus A1 number |
| NonSrc4 bus A2 Num | Bus 4 | Non-source CB4 connected bus A2 number |

**Table 1545: Settings of ASCGAPC of SCB1 for given example**

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Source CB 1 | ASC1 host circuit breaker number 1 |
| Number of sources | 3 | Total number of sources present in system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |

**Table 1546: Settings of ASCGAPC of SCB2 for given example**

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Source CB 2 | ASC1 host circuit breaker number 2 |
| Number of sources | 3 | Total number of sources present in system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |

**Table 1547: Settings of ASCGAPC of SCB3 for given example**

| Settings | Suggested values | Description |
|---|---|---|
| ASC CB Num1 | Source CB 3 | ASC1 host circuit breaker number 3 |
| Number of sources | 3 | Total number of sources present in system |
| Number of NonSrc CB | 4 | Number of bus coupler or grid transformer CB in the system |

The subnetwork numbers of eight power sources are available in monitored data SBNW_SRC1...SBNW_SRC8. The subnetwork numbers of NSCBs are available in

monitored data SBNW_NSCB1...SBNW_NSCB17. The subnetwork numbers of busbars are available in monitored data SBNW_BB1...SBNW_BB15.

The monitored data SRC1_GRI_CON...SRC8_GRI_CON give the grid connection status of source 1...source 8. In *Figure 886*, source 2 is electrically connected to the grid, so the monitored data SRC2_GRI_CON is TRUE. Also, zero subnetwork number is assigned to all the open CBs. Hence SCB 1 and NSCB3 are assigned zero as subnetwork number.

The CB status is assumed uncertain in abnormal conditions (communication failure, bad quality of the data received from any ASGCSYN or ASNSCSYN) or when the CB status inhibit input is received via `SRC1_ASC_DAT...SRC8_ASC_DAT` or `NS1_ASC_DAT...NS17_ASC_DAT` signal. When the status of the CB is uncertain, the group including this CB or the groups connected across this CB are assigned zero as the subnetwork number. For example, if the SCB1 status is uncertain, then source 1, source 3, SCB1, SCB3, NSCB4, Bus 3 and Bus 4 are assigned zero as subnetwork number.



All subnetwork numbers are displayed as zero when ASC CB Num1 = "Sourcex", x= 1...8.

### 9.8.4.2 Coordinator

Three instances of ASNSCSYN can be configured for the synchronization of three NSCBs in a single relay. The CB number can be set using settings *ASC CB Num1*, *ASC CB Num2* and *ASC CB Num3*. The function allows only NSCBs to be synchronized at a time. If synchronization is initiated for one of the three breakers, Coordinator sends the synchronized status to all the sources via `ASC_SRC1_DAT...ASC_SRC8_DAT` signal and to all the non-sources via `ASC_NS_DAT` signal. The rest of the operation is explained in *Figure 887*.

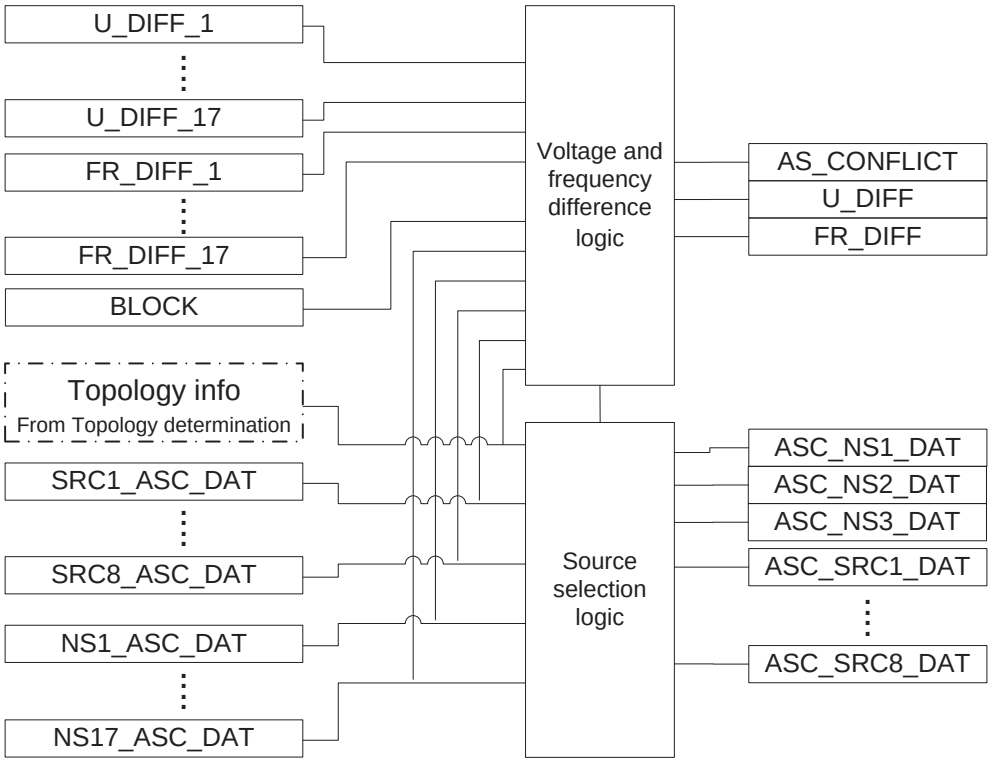



*Figure 887: Module diagram of Coordinator*

### Voltage and frequency difference logic

This module sends the voltage and frequency difference values received from the NSCB to be synchronized to all the sources with appropriate sign according to the topology.

Of the two busbars connected across any NSCB, the voltage transformer (VT) from the lower-number busbar should be connected to bus A voltage channel (U_BUS_A) and the other to bus B voltage channel (U_BUS_B).

If these VT connections are interchanged physically, then the correction can be done in function using *NonSrc1 VT Conn*...*NonSrc17 VT Conn* for NSCB 1...NSCB 17. When the coordinator is active and NSCB 1 is selected for synchronization, the corresponding voltage and frequency difference inputs `U_DIFF_1` and `FR_DIFF_1` are available as outputs `U_DIFF` and `FR_DIFF`, respectively, with their sign adjusted according to the setting *NonSrc1 VT Conn*. If set as "No Change", the sign of `U_DIFF` and `FR_DIFF` remains the same. If set as "Reverse", the sign is reversed. Similarly, when any of the NSCB 2...NSCB 17 is selected for synchronization, the corresponding inputs `U_DIFF_2`...`U_DIFF_17` and `FR_DIFF_2`...`FR_DIFF_17` are passed as the outputs `U_DIFF` and `FR_DIFF`, respectively.

The output `AS_CONFLICT` is active in any of the following conditions:

- If more than one NSCB are selected for synchronization at the same time.
- If a NSCB is selected for synchronization while source synchronization is in progress.
- If more than one source are in synchronization.

When `AS_CONFLICT` is TRUE, then the Coordinator module stops the ongoing coordination activities till a new synchronization request is received from any NSCB.

This conflict status is available in the monitored data CONFL_STATUS as given in *Table 1548*.

**Table 1548: States of CONFL_STATUS**

| Monitored data | Value |
|---|---|
| CONFL_STATUS | 1 (“No conflict”) |
| | 2 (“Multiple NSCB sync”) |
| | 3 (“Multiple SCB sync”) |
| | 4 (“NSCB and SCB sync”) |

### Source selection logic

Source selection logic is responsible for the selection and coordination of the sources for the voltage and frequency matching. It is enabled only when the autosynchronization function of the selected NSCB is in “Semiautomatic” or “Automatic” mode.

A source is available for participation in the voltage and frequency matching if the corresponding autosynchronization function is in “Semi-automatic” or “Automatic” mode and the host protection relay is in remote mode. This information is received from the corresponding source via input signals `SRC1_ASC_DAT`...`SRC8_ASC_DAT`.

All the sources in the network can be divided into nine participation groups based on topology and their availability for participation.

**Table 1549: Groups for source participation (monitored data SRC1_PTC_GRP...SRC8_PTC_GRP)**

| Source participation group | Description |
|---|---|
| Group 1 | All the sources which are unavailable for participation, are electrically connected to the grid or are not part of either subnetwork which must be synchronized by the selected CB. |
| Group 2 | The sources which do not belong to Group 1 and are part of the subnetwork which includes the lower-number busbar of the two busbars connected across the selected CB. |
| Group 3 | The sources which do not belong to Group 1 and are part of the other subnetwork, which includes the higher-number busbar. |
| Group 4 | The sources in Group 2 which are not ready for participation in matching. |
| Group 5 | The sources which are part of Group 3, but not ready for participation in matching. |
| Group 6 | The sources which are part of Group 2 or Group 3, but the network is internally connected and setting *Synchrocheck mode* in ASNSCSYN is "Synchronous" |
| Group 7 | The sources which are part of Group 2 or Group 3, but the network is internally connected and the setting *Synchrocheck mode* in ASNSCSYN is "Asynchronous". |
| Group 8 | The sources which are part of Group 2 or Group 3, but the network is internally asynchronous and setting *Synchrocheck mode* in ASNSCSYN is "Synchronous". |
| Group 9 | The sources which are part of Group 2 or Group 3, but setting *Synchrocheck mode* in ASNSCSYN is "Off". |

The participation group number for source 1...source 9 is available in the monitored output SRC1_PTC_GRP...SRC8_PTC_GRP.

Any source can be nominated for participation in voltage and frequency matching from the command parameter *Source1 selected*...*Source8 selected*. This selection is confirmed from the command parameter *Confirm source Sel*. The selected participation group information is available in monitored data SELECTED_GRP.

ASCGAPC allows multiple sources to participate in the voltage and frequency matching simultaneously, but all the sources nominated for matching should belong to either participation Group 2 or participation Group 3.

One of the participating sources (set with *Tuning source*) is used for the fine tuning of voltage and frequency. This information is sent to the corresponding source via the respective output signal ASC_SRC1_DAT...ASC_SRC8_DAT.

**Table 1550: States of MATCH STATUS**

| Value | Description |
|---|---|
| 1 (“No request”) | No NSCB is selected for synchronization. |
| 2 (“Request received”) | Synchronization request is received. |
| 3 (“No source selection”) | The request is received and the command parameter *Confirm source Sel* is "FALSE". |
| 4 (“Correct Src selection”) | The synchronization request is received, the command parameter *Confirm source Sel* is "TRUE", and the nominated sources belong to either Group 2 or Group 3. |
| 5 (“Wrong source selection”) | The synchronization request is received, the command parameter *Confirm source Sel* is "FALSE", and the nominated sources do not belong to Group 2 or all belong to Group 3. |
| 6 (“Wrong tuning Src Sel”) | The source selected for fine tuning is not among the nominated sources. |
| 8 (“Source ready”) | Any of the selected sources are ready for matching. |
| 9 (“GOV-AVR modes not OK”) | Any source is selected for matching and the governor and AVR of all the participating sources are not in droop mode and non-participating sources are not in “Fixed MW” and “Fixed MVAr” mode.<br>The governor and Automatic Voltage Regulator (AVR) modes corresponding to each source are received via the corresponding input signal SRC1_ASC_DAT...SRC8_ASC_DAT. If modes are different, then mode change request is sent to the sources via the corresponding output signal ASC_SRC1_DAT...ASC_SRC8_DAT. |
| 10 (“GOV-AVR modes OK”) | Any source is selected for matching, and its governor and AVR are in droop mode and nonparticipating sources are in “Fixed MW” and “Fixed MVAr” mode. |
| 11 (“Matching in progress”) | All the selected sources are issued the permission for matching. |
| 12 (“Matching done”) | Matching is complete according to the NSCB under synchronization. |
| 13 (“Matching not done”) | Matching is not done within the set *Max matching time*. |
| 14 (“Int Connect,set Sync”) | The network is internally connected and setting *Synchrocheck mode* in ASNSCSYN is "Synchronous". |

*Table continues on the next page*

| Value | Description |
|---|---|
| 15 (“Int Connect,set Async”) | The network is internally connected and setting *Synchro-check mode* in ASNSCSYN is "Asynchronous". |
| 16 (“Externally connected”) | The network is externally connected. |
| 17 (“Int Async,set Sync”) | The network is internally asynchronous and setting *Synchro-check mode* in ASNSCSYN is "Synchronous". |

**Internally connected**

A network where Bus1 is connected to Bus3, Bus2 is connected to Bus4 and CB1 is closed is seen as an internally connected network by CB2.

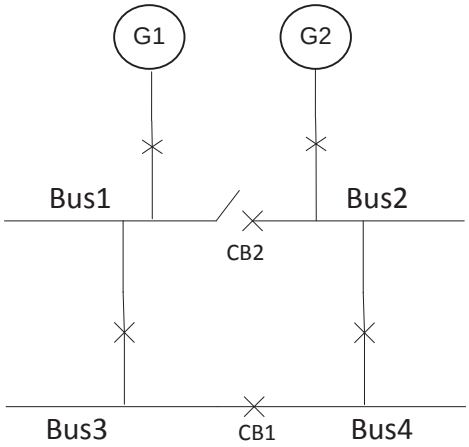



*Figure 888: Example of an internally connected network*

**Externally connected**

A network where both Bus3 and Bus4 are connected to the grid across CB1 is considered an externally connected network.

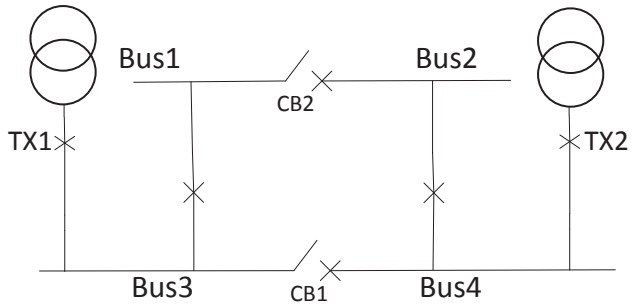



*Figure 889: Example of an externally connected network*

The number of sources active in the voltage and frequency matching is shared to sources via the corresponding output signal ASC_SRC1_DAT...ASC_SRC8_DAT.

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates all binary outputs and resets the internal timers.

## 9.8.5 Application

A circuit breaker is used to connect two different power networks. It is essential to ensure that these power networks are synchronized before closing the CB, otherwise it may lead to disturbances in the power system, causing stress and damage to the connected equipment.

The synchronization of any bus coupler or tie feeder is not feasible if the voltage and frequency differences across the circuit breaker are not within the allowed limits. In this case, the sources which are part of the power network connected across this bus coupler or tie feeder CB have to adjust their voltage and frequency. ASCGAPC can be used as coordinator for selection and coordination with the sources, during the synchronization of any bus coupler or tie feeder circuit breaker. The function allows the synchronization of only one circuit breaker at a time. In case of any conflict, the synchronization process is stopped.

As a coordinator the function assists in the participating sources selection based on the network topology and interacts with the sources to initiate the voltage and frequency matching for the bus coupler or tie feeder CB to be synchronized.

When selected for synchronization, any NSCB communicates with ASCGAPC for matching of voltage and frequency difference. ASCGAPC passes the required information to the participating sources along with their active status. An NSCB synchronization is described with one typical example in *Figure 890*.

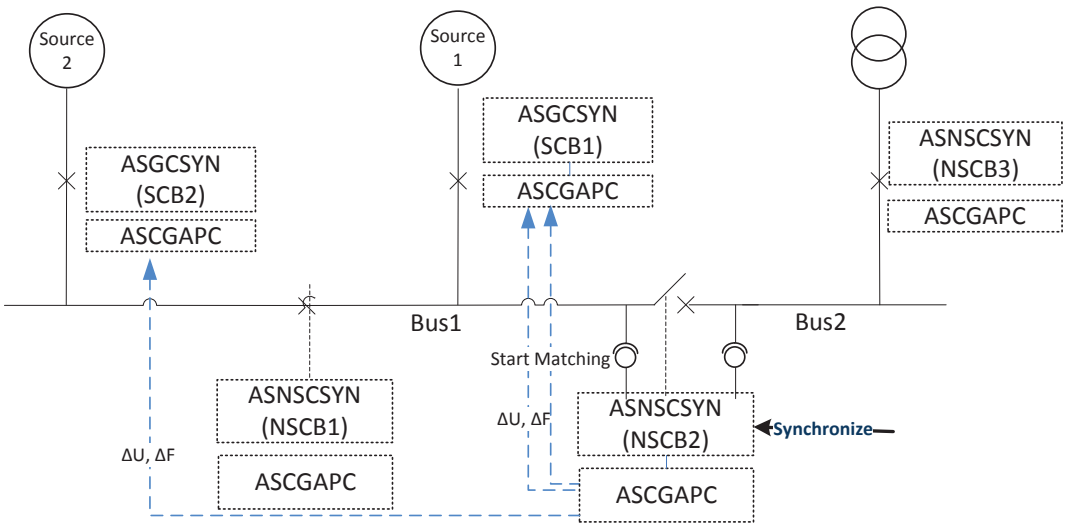



*Figure 890: NSCB2 synchronization*

In this application example, breaker NSCB2 must be closed so the synchronizing conditions between Bus1 and Bus2 are checked by ASNSCSYN. ASNSCSYN sends the autosynchronization request and voltage and frequency difference (ΔU, ΔF) between the Bus1 and Bus2 to the Autosynchronization coordinator functions ASCGAPC.

ASCGAPC transfers the voltage and frequency difference sent by ASNSCSYN to the ASCGAPC of source 1 ASGCSYN function as well as to the ASCGAPC of source 2 ASGCSYN function. It also sends the permission to the source to start matching the voltage and frequency. The matching process is carried out so that the voltage and frequency difference between Bus1 and Bus2 measured by ASNSCSYN reduces and comes within the synchrocheck limits. This satisfies the synchrocheck conditions for breaker NSCB2 which can then be synchronized by ASNSCSYN.

## 9.8.6 Signals

### 9.8.6.1 ASCGAPC Input signals

**Table 1551: ASCGAPC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| BLOCK | BOOLEAN | 0=False | Blocking output signal of the function |
| SRC1_ASC_DAT | INT32 | 0 | Input data from source number 1 |
| SRC2_ASC_DAT | INT32 | 0 | Input data from source number 2 |
| SRC3_ASC_DAT | INT32 | 0 | Input data from source number 3 |
| SRC4_ASC_DAT | INT32 | 0 | Input data from source number 4 |
| SRC5_ASC_DAT | INT32 | 0 | Input data from source number 5 |
| SRC6_ASC_DAT | INT32 | 0 | Input data from source number 6 |
| SRC7_ASC_DAT | INT32 | 0 | Input data from source number 7 |
| SRC8_ASC_DAT | INT32 | 0 | Input data from source number 8 |
| NS1_ASC_DAT | INT32 | 0 | Input data from non-source CB number 1 |
| NS2_ASC_DAT | INT32 | 0 | Input data from non-source CB number 2 |
| NS3_ASC_DAT | INT32 | 0 | Input data from non-source CB number 3 |
| NS4_ASC_DAT | INT32 | 0 | Input data from non-source CB number 4 |
| NS5_ASC_DAT | INT32 | 0 | Input data from non-source CB number 5 |
| NS6_ASC_DAT | INT32 | 0 | Input data from non-source CB number 6 |
| NS7_ASC_DAT | INT32 | 0 | Input data from non-source CB number 7 |
| NS8_ASC_DAT | INT32 | 0 | Input data from non-source CB number 8 |
| NS9_ASC_DAT | INT32 | 0 | Input data from non-source CB number 9 |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| NS10_ASC_DAT | INT32 | 0 | Input data from non-source CB number 10 |
| NS11_ASC_DAT | INT32 | 0 | Input data from non-source CB number 11 |
| NS12_ASC_DAT | INT32 | 0 | Input data from non-source CB number 12 |
| NS13_ASC_DAT | INT32 | 0 | Input data from non-source CB number 13 |
| NS14_ASC_DAT | INT32 | 0 | Input data from non-source CB number 14 |
| NS15_ASC_DAT | INT32 | 0 | Input data from non-source CB number 15 |
| NS16_ASC_DAT | INT32 | 0 | Input data from non-source CB number 16 |
| NS17_ASC_DAT | INT32 | 0 | Input data from non-source CB number 17 |
| U_DIFF_1 | FLOAT32 | 0.00 | Voltage difference from non-source CB 1 |
| U_DIFF_2 | FLOAT32 | 0.00 | Voltage difference from non-source CB 2 |
| U_DIFF_3 | FLOAT32 | 0.00 | Voltage difference from non-source CB 3 |
| U_DIFF_4 | FLOAT32 | 0.00 | Voltage difference from non-source CB 4 |
| U_DIFF_5 | FLOAT32 | 0.00 | Voltage difference from non-source CB 5 |
| U_DIFF_6 | FLOAT32 | 0.00 | Voltage difference from non-source CB 6 |
| U_DIFF_7 | FLOAT32 | 0.00 | Voltage difference from non-source CB 7 |
| U_DIFF_8 | FLOAT32 | 0.00 | Voltage difference from non-source CB 8 |
| U_DIFF_9 | FLOAT32 | 0.00 | Voltage difference from non-source CB 9 |
| U_DIFF_10 | FLOAT32 | 0.00 | Voltage difference from non-source CB 10 |
| U_DIFF_11 | FLOAT32 | 0.00 | Voltage difference from non-source CB 11 |
| U_DIFF_12 | FLOAT32 | 0.00 | Voltage difference from non-source CB 12 |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| U_DIFF_13 | FLOAT32 | 0.00 | Voltage difference from non-source CB 13 |
| U_DIFF_14 | FLOAT32 | 0.00 | Voltage difference from non-source CB 14 |
| U_DIFF_15 | FLOAT32 | 0.00 | Voltage difference from non-source CB 15 |
| U_DIFF_16 | FLOAT32 | 0.00 | Voltage difference from non-source CB 16 |
| U_DIFF_17 | FLOAT32 | 0.00 | Voltage difference from non-source CB 17 |
| FR_DIFF_1 | FLOAT32 | 0.000 | Frequency difference from non-source CB 1 |
| FR_DIFF_2 | FLOAT32 | 0.000 | Frequency difference from non-source CB 2 |
| FR_DIFF_3 | FLOAT32 | 0.000 | Frequency difference from non-source CB 3 |
| FR_DIFF_4 | FLOAT32 | 0.000 | Frequency difference from non-source CB 4 |
| FR_DIFF_5 | FLOAT32 | 0.000 | Frequency difference from non-source CB 5 |
| FR_DIFF_6 | FLOAT32 | 0.000 | Frequency difference from non-source CB 6 |
| FR_DIFF_7 | FLOAT32 | 0.000 | Frequency difference from non-source CB 7 |
| FR_DIFF_8 | FLOAT32 | 0.000 | Frequency difference from non-source CB 8 |
| FR_DIFF_9 | FLOAT32 | 0.000 | Frequency difference from non-source CB 9 |
| FR_DIFF_10 | FLOAT32 | 0.000 | Frequency difference from non-source CB 10 |
| FR_DIFF_11 | FLOAT32 | 0.000 | Frequency difference from non-source CB 11 |
| FR_DIFF_12 | FLOAT32 | 0.000 | Frequency difference from non-source CB 12 |
| FR_DIFF_13 | FLOAT32 | 0.000 | Frequency difference from non-source CB 13 |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| FR_DIFF_14 | FLOAT32 | 0.000 | Frequency difference from non-source CB 14 |
| FR_DIFF_15 | FLOAT32 | 0.000 | Frequency difference from non-source CB 15 |
| FR_DIFF_16 | FLOAT32 | 0.000 | Frequency difference from non-source CB 16 |
| FR_DIFF_17 | FLOAT32 | 0.000 | Frequency difference from non-source CB 17 |

### 9.8.6.2 ASCGAPC Output signals

**Table 1552: ASCGAPC Output signals**

| Name | Type | Description |
|---|---|---|
| AS_CONFLICT | BOOLEAN | Auto synchronization conflict |
| U_DIFF | FLOAT32 | Voltage difference across the synchronizing CB |
| FR_DIFF | FLOAT32 | Frequency difference across the synchronizing CB |
| ASC_NS1_DAT | INT32 | Output data to non-source CB 1 |
| ASC_NS2_DAT | INT32 | Output data to non-source CB 2 |
| ASC_NS3_DAT | INT32 | Output data to non-source CB 3 |
| ASC_SRC1_DAT | INT32 | Output data to source number 1 |
| ASC_SRC2_DAT | INT32 | Output data to source number 2 |
| ASC_SRC3_DAT | INT32 | Output data to source number 3 |
| ASC_SRC4_DAT | INT32 | Output data to source number 4 |
| ASC_SRC5_DAT | INT32 | Output data to source number 5 |
| ASC_SRC6_DAT | INT32 | Output data to source number 6 |
| ASC_SRC7_DAT | INT32 | Output data to source number 7 |
| ASC_SRC8_DAT | INT32 | Output data to source number 8 |

## 9.8.7 ASCGAPC Settings

**Table 1553: ASCGAPC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Number of sources | 1...8 | | 1 | 8 | Total number of sources present in the system |
| Number of NonSrc CB | 1...17 | | 1 | 17 | Number of bus coupler or grid transformer CB in the system |

**Table 1554: ASCGAPC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Src1 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 1 CB connected bus A number |
| Src1 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 1 CB connected bus B number |
| Src2 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3 | | | 0=Not Configured | Source 2 CB connected bus A number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | | |
| Src2 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 2 CB connected bus B number |
| Src3 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 3 CB connected bus A number |
| Src3 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4 | | | 0=Not Configured | Source 3 CB connected bus B number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | | |
| Src4 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 4 CB connected bus A number |
| Src4 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 4 CB connected bus B number |
| Src5 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5 | | | 0=Not Configured | Source 5 CB connected bus A number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | | |
| Src5 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 5 CB connected bus B number |
| Src6 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 6 CB connected bus A number |
| Src6 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6 | | | 0=Not Configured | Source 6 CB connected bus B number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | | |
| Src7 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 7 CB connected bus A number |
| Src7 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 7 CB connected bus B number |
| Src8 bus A Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7 | | | 0=Not Configured | Source 8 CB connected bus A number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | | |
| Src8 bus B Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15 | | | 0=Not Configured | Source 8 CB connected bus B number |
| NonSrc1 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB1 connected bus A1 number |
| NonSrc1 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7 | | | 0=Not Configured | Non-source CB1 connected bus A2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc1 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB1 connected bus B1 number |
| NonSrc1 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB1 connected bus B2 number |
| NonSrc2 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5 | | | 0=Not Configured | Non-source CB2 connected bus A1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc2 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB2 connected bus A2 number |
| NonSrc2 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB2 connected bus B1 number |
| NonSrc2 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3 | | | 0=Not Configured | Non-source CB2 connected bus B2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc3 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB3 connected bus A1 number |
| NonSrc3 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB3 connected bus A2 number |
| NonSrc3 bus B1 Num | 0=Not Configured<br>1=Bus 1 | | | 0=Not Configured | Non-source CB3 connected bus B1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc3 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB3 connected bus B2 number |
| NonSrc4 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB4 connected bus A1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc4 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB4 connected bus A2 number |
| NonSrc4 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB4 connected bus B1 number |
| NonSrc4 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14 | | | 0=Not Configured | Non-source CB4 connected bus B2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 15=Bus 15<br>21=Grid | | | | |
| NonSrc5 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB5 connected bus A1 number |
| NonSrc5 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB5 connected bus A2 number |
| NonSrc5 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12 | | | 0=Not Configured | Non-source CB5 connected bus B1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc5 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB5 connected bus B2 number |
| NonSrc6 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB6 connected bus A1 number |
| NonSrc6 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10 | | | 0=Not Configured | Non-source CB6 connected bus A2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc6 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB6 connected bus B1 number |
| NonSrc6 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB6 connected bus B2 number |
| NonSrc7 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8 | | | 0=Not Configured | Non-source CB7 connected bus A1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc7 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB7 connected bus A2 number |
| NonSrc7 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB7 connected bus B1 number |
| NonSrc7 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6 | | | 0=Not Configured | Non-source CB7 connected bus B2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc8 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB8 connected bus A1 number |
| NonSrc8 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB8 connected bus A2 number |
| NonSrc8 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4 | | | 0=Not Configured | Non-source CB8 connected bus B1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc8 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB8 connected bus B2 number |
| NonSrc9 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB9 connected bus A1 number |
| NonSrc9 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2 | | | 0=Not Configured | Non-source CB9 connected bus A2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc9 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB9 connected bus B1 number |
| NonSrc9 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB9 connected bus B2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc10 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB10 connected bus A1 number |
| NonSrc10 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB10 connected bus A2 number |
| NonSrc10 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14 | | | 0=Not Configured | Non-source CB10 connected bus B1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 15=Bus 15<br>21=Grid | | | | |
| NonSrc10 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB10 connected bus B2 number |
| NonSrc11 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB11 connected bus A1 number |
| NonSrc11 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12 | | | 0=Not Configured | Non-source CB11 connected bus A2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc11 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB11 connected bus B1 number |
| NonSrc11 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB11 connected bus B2 number |
| NonSrc12 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10 | | | 0=Not Configured | Non-source CB12 connected bus A1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc12 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB12 connected bus A2 number |
| NonSrc12 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB12 connected bus B1 number |
| NonSrc12 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8 | | | 0=Not Configured | Non-source CB12 connected bus B2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc13 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB13 connected bus A1 number |
| NonSrc13 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB13 connected bus A2 number |
| NonSrc13 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6 | | | 0=Not Configured | Non-source CB13 connected bus B1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc13 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB13 connected bus B2 number |
| NonSrc14 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB14 connected bus A1 number |
| NonSrc14 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4 | | | 0=Not Configured | Non-source CB14 connected bus A2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc14 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB14 connected bus B1 number |
| NonSrc14 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB14 connected bus B2 number |
| NonSrc15 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2 | | | 0=Not Configured | Non-source CB15 connected bus A1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc15 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB15 connected bus A2 number |
| NonSrc15 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB15 connected bus B1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| NonSrc15 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB15 connected bus B2 number |
| NonSrc16 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB16 connected bus A1 number |
| NonSrc16 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14 | | | 0=Not Configured | Non-source CB16 connected bus A2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 15=Bus 15<br>21=Grid | | | | |
| NonSrc16 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB16 connected bus B1 number |
| NonSrc16 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB16 connected bus B2 number |
| NonSrc17 bus A1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12 | | | 0=Not Configured | Non-source CB17 connected bus A1 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc17 bus A2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB17 connected bus A2 number |
| NonSrc17 bus B1 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10<br>11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | 0=Not Configured | Non-source CB17 connected bus B1 number |
| NonSrc17 bus B2 Num | 0=Not Configured<br>1=Bus 1<br>2=Bus 2<br>3=Bus 3<br>4=Bus 4<br>5=Bus 5<br>6=Bus 6<br>7=Bus 7<br>8=Bus 8<br>9=Bus 9<br>10=Bus 10 | | | 0=Not Configured | Non-source CB17 connected bus B2 number |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 11=Bus 11<br>12=Bus 12<br>13=Bus 13<br>14=Bus 14<br>15=Bus 15<br>21=Grid | | | | |
| NonSrc1 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB1 |
| NonSrc2 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB2 |
| NonSrc3 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB3 |
| NonSrc4 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB4 |
| NonSrc5 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB5 |
| NonSrc6 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB6 |
| NonSrc7 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB7 |
| NonSrc8 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB8 |
| NonSrc9 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB9 |
| NonSrc10 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB10 |
| NonSrc11 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB11 |
| NonSrc12 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB12 |
| NonSrc13 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB13 |
| NonSrc14 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB14 |
| NonSrc15 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB15 |
| NonSrc16 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB16 |
| NonSrc17 VT Conn | 2=No Change<br>3=Reverse | | | 2=No Change | Voltage transformer connection type for non-source CB17 |

**Table 1555: ASCGAPC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| ASC CB Num1 | 1=Non source CB 1<br>2=Non source CB 2<br>3=Non source CB 3<br>4=Non source CB 4<br>5=Non source CB 5<br>6=Non source CB 6<br>7=Non source CB 7<br>8=Non source CB 8<br>9=Non source CB 9<br>10=Non source CB 10<br>11=Non source CB 11<br>12=Non source CB 12<br>13=Non source CB 13<br>14=Non source CB 14<br>15=Non source CB 15<br>16=Non source CB 16<br>17=Non source CB 17<br>18=Source CB 1<br>19=Source CB 2<br>20=Source CB 3<br>21=Source CB 4<br>22=Source CB 5<br>23=Source CB 6<br>24=Source CB 7<br>25=Source CB 8 | | | 1=Non source CB 1 | ASC host circuit breaker number 1 |
| ASC CB Num2 | 0=Not Configured<br>1=Non source CB 1<br>2=Non source CB 2<br>3=Non source CB 3<br>4=Non source CB 4<br>5=Non source CB 5<br>6=Non source CB 6<br>7=Non source CB 7<br>8=Non source CB 8<br>9=Non source CB 9<br>10=Non source CB 10<br>11=Non source CB 11<br>12=Non source CB 12 | | | 0=Not Configured | ASC host circuit breaker number 2 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 13=Non source CB 13<br>14=Non source CB 14<br>15=Non source CB 15<br>16=Non source CB 16<br>17=Non source CB 17 | | | | |
| ASC CB Num3 | 0=Not Configured<br>1=Non source CB 1<br>2=Non source CB 2<br>3=Non source CB 3<br>4=Non source CB 4<br>5=Non source CB 5<br>6=Non source CB 6<br>7=Non source CB 7<br>8=Non source CB 8<br>9=Non source CB 9<br>10=Non source CB 10<br>11=Non source CB 11<br>12=Non source CB 12<br>13=Non source CB 13<br>14=Non source CB 14<br>15=Non source CB 15<br>16=Non source CB 16<br>17=Non source CB 17 | | | 0=Not Configured | ASC host circuit breaker number 3 |

**Table 1556: ASCGAPC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max matching time | 100...6000000 | ms | 1 | 60000 | Maximum time to complete the voltage and frequency matching |
| Central PMS present | 1=No<br>2=Yes | | | 1=No | Centralized power management system present |
| Double busbar | 0=False<br>1=True | | | 0=False | Double busbar present in the system |

## 9.8.8 ASCGAPC Monitored data

**Table 1557: ASCGAPC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SBNW_SRC1 | INT32 | 0...99 | | Source 1 subnetwork number |
| SBNW_SRC2 | INT32 | 0...99 | | Source 2 subnetwork number |
| SBNW_SRC3 | INT32 | 0...99 | | Source 3 subnetwork number |
| SBNW_SRC4 | INT32 | 0...99 | | Source 4 subnetwork number |
| SBNW_SRC5 | INT32 | 0...99 | | Source 5 subnetwork number |
| SBNW_SRC6 | INT32 | 0...99 | | Source 6 subnetwork number |
| SBNW_SRC7 | INT32 | 0...99 | | Source 7 subnetwork number |
| SBNW_SRC8 | INT32 | 0...99 | | Source 8 subnetwork number |
| SBNW_NSCB1 | INT32 | 0...99 | | Non-source CB 1 subnetwork number |
| SBNW_NSCB2 | INT32 | 0...99 | | Non-source CB 2 subnetwork number |
| SBNW_NSCB3 | INT32 | 0...99 | | Non-source CB 3 subnetwork number |
| SBNW_NSCB4 | INT32 | 0...99 | | Non-source CB 4 subnetwork number |
| SBNW_NSCB5 | INT32 | 0...99 | | Non-source CB 5 subnetwork number |
| SBNW_NSCB6 | INT32 | 0...99 | | Non-source CB 6 subnetwork number |
| SBNW_NSCB7 | INT32 | 0...99 | | Non-source CB 7 subnetwork number |
| SBNW_NSCB8 | INT32 | 0...99 | | Non-source CB 8 subnetwork number |
| SBNW_NSCB9 | INT32 | 0...99 | | Non-source CB 9 subnetwork number |
| SBNW_NSCB10 | INT32 | 0...99 | | Non-source CB 10 subnetwork number |
| SBNW_NSCB11 | INT32 | 0...99 | | Non-source CB 11 subnetwork number |
| SBNW_NSCB12 | INT32 | 0...99 | | Non-source CB 12 subnetwork number |
| SBNW_NSCB13 | INT32 | 0...99 | | Non-source CB 13 subnetwork number |
| SBNW_NSCB14 | INT32 | 0...99 | | Non-source CB 14 subnetwork number |
| SBNW_NSCB15 | INT32 | 0...99 | | Non-source CB 15 subnetwork number |
| SBNW_NSCB16 | INT32 | 0...99 | | Non-source CB 16 subnetwork number |
| SBNW_NSCB17 | INT32 | 0...99 | | Non-source CB 17 subnetwork number |
| SBNW_BB1 | INT32 | 0...99 | | Bus 1 subnetwork number |
| SBNW_BB2 | INT32 | 0...99 | | Bus 2 subnetwork number |
| SBNW_BB3 | INT32 | 0...99 | | Bus 3 subnetwork number |
| SBNW_BB4 | INT32 | 0...99 | | Bus 4 subnetwork number |
| SBNW_BB5 | INT32 | 0...99 | | Bus 5 subnetwork number |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SBNW_BB6 | INT32 | 0...99 | | Bus 6 subnetwork number |
| SBNW_BB7 | INT32 | 0...99 | | Bus 7 subnetwork number |
| SBNW_BB8 | INT32 | 0...99 | | Bus 8 subnetwork number |
| SBNW_BB9 | INT32 | 0...99 | | Bus 9 subnetwork number |
| SBNW_BB10 | INT32 | 0...99 | | Bus 10 subnetwork number |
| SBNW_BB11 | INT32 | 0...99 | | Bus 11 subnetwork number |
| SBNW_BB12 | INT32 | 0...99 | | Bus 12 subnetwork number |
| SBNW_BB13 | INT32 | 0...99 | | Bus 13 subnetwork number |
| SBNW_BB14 | INT32 | 0...99 | | Bus 14 subnetwork number |
| SBNW_BB15 | INT32 | 0...99 | | Bus 15 subnetwork number |
| SRC1_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 1 grid connection status |
| SRC2_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 2 grid connection status |
| SRC3_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 3 grid connection status |
| SRC4_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 4 grid connection status |
| SRC5_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 5 grid connection status |
| SRC6_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 6 grid connection status |
| SRC7_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 7 grid connection status |
| SRC8_GRI_CON | BOOLEAN | 0=False<br>1=True | | Source 8 grid connection status |
| ASC ACTIVE | BOOLEAN | 0=False<br>1=True | | ASC active status |
| MATCH STATUS | Enum | 1=No request<br>2=Request received<br>3=No source selection<br>4=Correct Src selection<br>5=Wrong source selection<br>6=Wrong tuning Src Sel<br>8=Source ready<br>9=GOV-AVR modes not OK<br>10=GOV-AVR modes OK<br>11=Matching in progress | | Matching status |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 12=Matching done<br>13=Matching not done<br>14=Int Connect,set Sync<br>15=Int Connect,set Async<br>16=Externally connected<br>17=Int Async,set Sync | | |
| SRC1_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 1 participation group |
| SRC2_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 2 participation group |
| SRC3_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 3 participation group |
| SRC4_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 4 participation group |
| SRC5_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4 | | Source 5 participation group |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | |
| SRC6_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 6 participation group |
| SRC7_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 7 participation group |
| SRC8_PTC_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3<br>4=Group 4<br>5=Group 5<br>6=Group 6<br>7=Group 7<br>8=Group 8<br>9=Group 9 | | Source 8 participation group |
| SELECTED_GRP | Enum | 1=Group 1<br>2=Group 2<br>3=Group 3 | | Selected source participation group |
| CONFL_STATUS | Enum | 1=No conflict<br>2=Multiple NSCB sync<br>3=Multiple SCB sync<br>4=NSCB and SCB sync | | Autosynchronization conflict status |
| NSCB_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Operation mode of non-source CB undergoing synchronization |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| SRC1_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 1 |
| SRC2_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 2 |
| SRC3_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 3 |
| SRC4_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 4 |
| SRC5_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 5 |
| SRC6_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 6 |
| SRC7_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem | | Synchronization operation mode of source 7 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | |
| SRC8_SYN_MOD | Enum | 0=Invalid<br>1=AS Man Relay Loc<br>2=AS Man Relay Rem<br>3=AS Semi Relay Loc<br>4=AS Semi Relay Rem<br>5=AS Auto Relay Loc<br>6=AS Auto Relay Rem | | Synchronization operation mode of source 8 |
| NSCB_UND_SYN | INT32 | 0...99 | | Non-source CB undergoing synchronization |
| SRC1_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 1 participation status |
| SRC2_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 2 participation status |
| SRC3_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 3 participation status |
| SRC4_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 4 participation status |
| SRC5_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 5 participation status |
| SRC6_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 6 participation status |
| SRC7_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 7 participation status |
| SRC8_PTC_ST | BOOLEAN | 0=False<br>1=True | | Source 8 participation status |
| ASCGAPC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

# 9.9 Autoreclosing DARREC (ANSI 79)

## 9.9.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Autoreclosing | DARREC | O -> I | 79 |

## 9.9.2 Function block

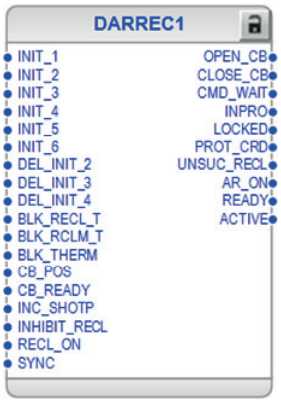



*Figure 891: Function block*

## 9.9.3 Functionality

About 80 to 85 percent of faults in the MV overhead lines are transient and automatically cleared with a momentary de-energization of the line. The rest of the faults, 15 to 20 percent, can be cleared by longer interruptions. The de-energization of the fault location for a selected time period is implemented through automatic reclosing, during which most of the faults can be cleared.

In case of a permanent fault, the automatic reclosing is followed by final tripping. A permanent fault must be located and cleared before the fault location can be re-energized.

The autoreclosing function DARREC can be used with any circuit breaker suitable for autoreclosing. The function provides five programmable autoreclosing shots which can perform one to five successive autoreclosings of desired type and duration, for instance one high-speed and one delayed autoreclosing.

When the reclosing is initiated with starting of the protection function, the autoreclosing function can execute the final trip of the circuit breaker in a short operate time, provided that the fault still persists when the last selected reclosing has been carried out.

### 9.9.3.1 Protection signal definition

The *Control line* setting defines which of the initiation signals are protection start and trip signals and which are not. With this setting, the user can distinguish the blocking signals from the protection signals. The *Control line* setting is a bit mask, that is, the lowest bit controls the `INIT_1` line and the highest bit the `INIT_6` line. Some example combinations of the *Control line* setting are as follows:

**Table 1558: Control line setting definition**

| *Control line* setting | INIT_1 | INIT_2 DEL_INIT _2 | INIT_3 DEL_INIT _3 | INIT_4 DEL_INIT _4 | INIT_5 | INIT_6 |
|---|---|---|---|---|---|---|
| 0 | other | other | other | other | other | other |
| 1 | prot | other | other | other | other | other |
| 2 | other | prot | other | other | other | other |
| 3 | prot | prot | other | other | other | other |
| 4 | other | other | prot | other | other | other |
| 5 | prot | other | prot | other | other | other |
| ...63 | prot | prot | prot | prot | prot | prot |

prot = protection signal
other = non-protection signal

When the corresponding bit or bits in both the *Control line* setting and the INIT_X line are TRUE:

- The CLOSE_CB output is blocked until the protection is reset
- If the INIT_X line defined as the protection signal is activated during the discrimination time, the AR function goes to lockout
- If the INIT_X line defined as the protection signal stays active longer than the time set by the *Max trip time* setting, the AR function goes to lockout (long trip)
- The UNSUC_RECL output is activated after a pre-defined two minutes (alarming earth-fault).

### 9.9.3.2 Zone coordination

Zone coordination is used in the zone sequence between local protection units and downstream devices. At the falling edge of the INC_SHOTP line, the value of the shot pointer is increased by one, unless a shot is in progress or the shot pointer already has the maximum value.

The falling edge of the INC_SHOTP line is not accepted if any of the shots are in progress.

### 9.9.3.3 Master and slave scheme

With the cooperation between the AR units in the same protection relay or between protection relays, sequential reclosings of two breakers at a line end in a 1½-breaker, double breaker or ring-bus arrangement can be achieved. One unit is defined as a master and it executes the reclosing first. If the reclosing is successful and no trip takes place, the second unit, that is the slave, is released to complete the reclose shot. With persistent faults, the breaker reclosing is limited to the first breaker.

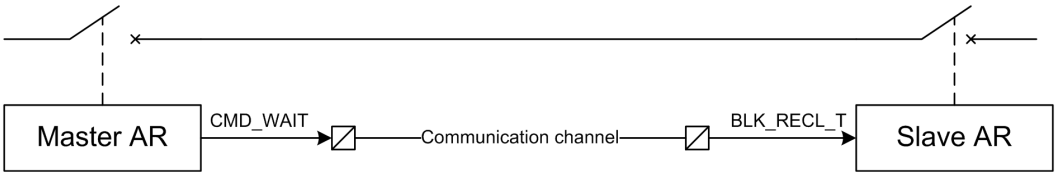



*Figure 892: Master and slave scheme*

If the AR unit is defined as a master by setting its terminal priority to high:

- The unit activates the CMD_WAIT output to the low priority slave unit whenever a shot is in progress, a reclosing is unsuccessful or the BLK_RCLM_T input is active
- The CMD_WAIT output is reset one second after the reclose command is given or if the sequence is unsuccessful when the reclaim time elapses.

If the AR unit is defined as a slave by setting its terminal priority to low:

- The unit waits until the master releases the BLK_RECL_T input (the CMD_WAIT output in the master). Only after this signal has been deactivated, the reclose time for the slave unit can be started.
- The slave unit is set to a lockout state if the BLK_RECL_T input is not released within the time defined by the *Max wait time* setting , which follows the initiation of an autoreclosing shot.

If the terminal priority of the AR unit is set to "none", the AR unit skips all these actions.

### 9.9.3.4 Thermal overload blocking

An alarm or start signal from the thermal overload protection (T1PTTR) can be routed to the input BLK_THERM to block and hold the reclose sequence. The BLK_THERM signal does not affect the starting of the sequence. When the reclose time has elapsed and the BLK_THERM input is active, the shot is not ready until the BLK_THERM input deactivates. Should the BLK_THERM input remain active longer than the time set by the setting *Max Thm block time*, the AR function goes to lockout.

If the BLK_THERM input is activated when the auto wait timer is running, the auto wait timer is reset and the timer restarted when the BLK_THERM input deactivates.

## 9.9.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off". Setting *Operation* to "Off" resets non-volatile counters.

The reclosing operation can be enabled and disabled with the *Reclosing operation* setting. This setting does not disable the function, only the reclosing functionality. The setting has three parameter values: “On”, “External Ctl” and ”Off”. The setting value “On” enables the reclosing operation and “Off” disables it. When the setting value “External Ctl” is selected, the reclosing operation is controlled with the RECL_ON input. AR_ON is activated when reclosing operation is enabled.

The operation of DARREC can be described using a module diagram. All the modules in the diagram are explained in the next sections.

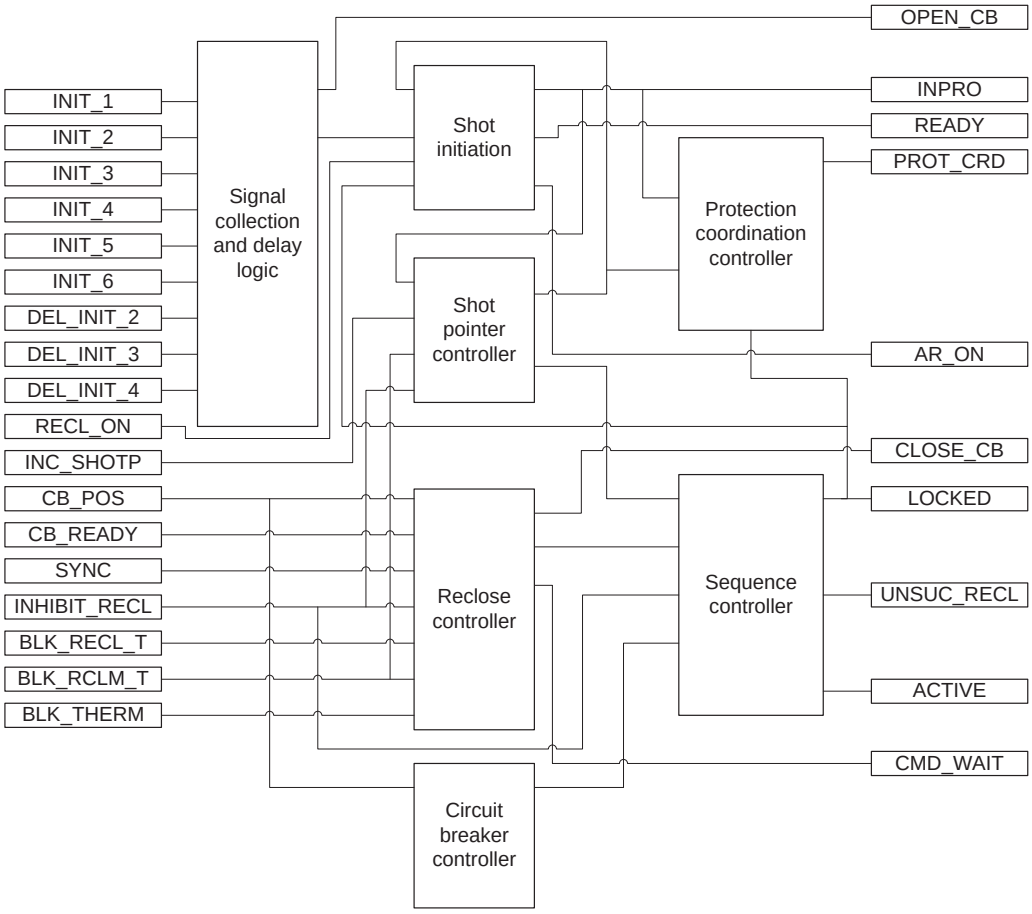



*Figure 893: Functional module diagram*

### 9.9.4.1 Signal collection and delay logic

When the protection trips, the initiation of autoreclosing shots is in most applications executed with the `INIT_1...6` inputs. The `DEL_INIT2...4` inputs are not used. In some countries, starting the protection stage is also used for the shot initiation. This is the only time when the `DEL_INIT` inputs are used.

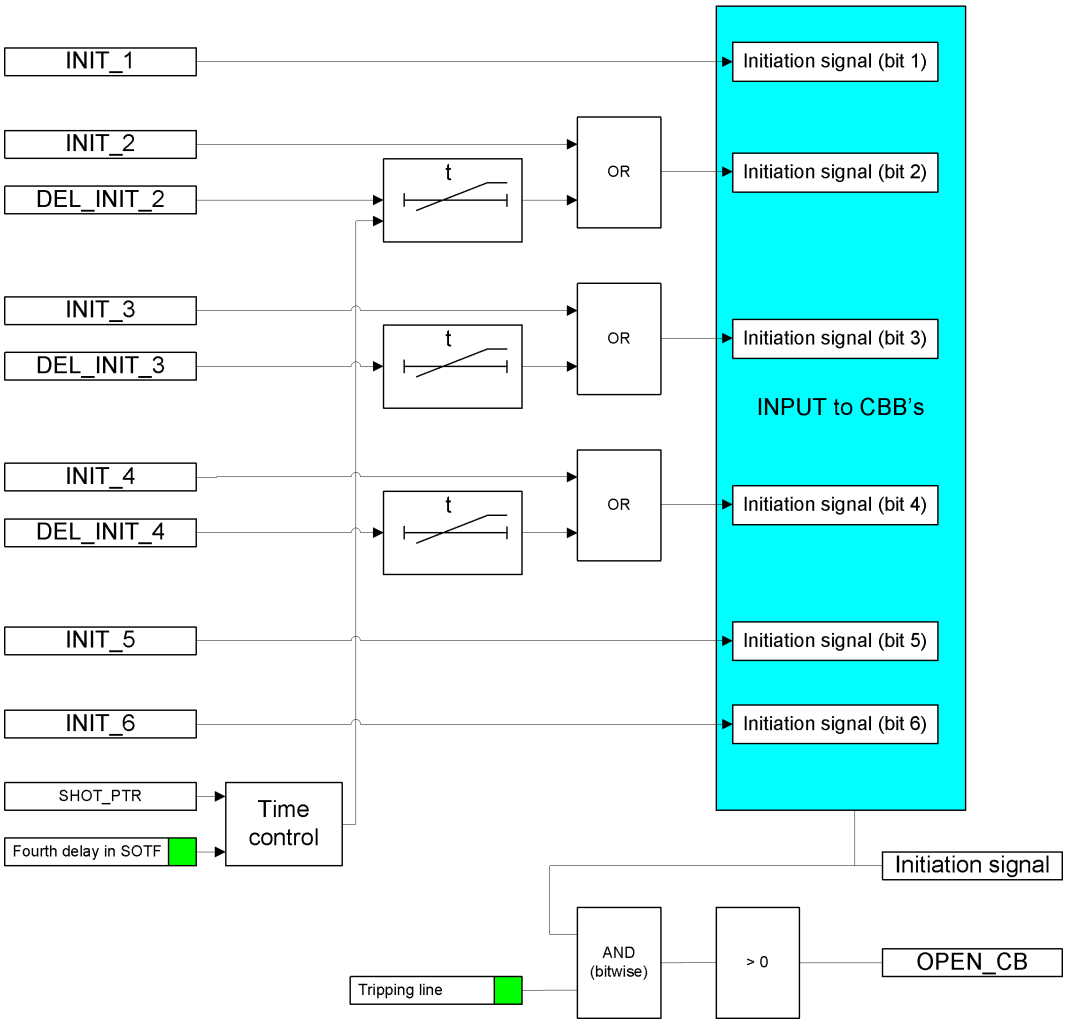



*Figure 894: Schematic diagram of delayed initiation input signals*

In total, the AR function contains six separate initiation lines used for the initiation or blocking of the autoreclosing shots. These lines are divided into two types of channels. In three of these channels, the signal to the AR function can be delayed, whereas the other three channels do not have any delaying capability.

Each channel that is capable of delaying a start signal has four time delays. The time delay is selected based on the shot pointer in the AR function. For the first reclose attempt, the first time delay is selected; for the second attempt, the second time delay and so on. For the fourth and fifth attempts, the time delays are the same.

Time delay settings for the `DEL_INIT_2` signal

- *Str 2 delay shot 1*
- *Str 2 delay shot 2*
- *Str 2 delay shot 3*
- *Str 2 delay shot 4*

Time delay settings for the `DEL_INIT_3` signal

- *Str 3 delay shot 1*
- *Str 3 delay shot 2*
- *Str 3 delay shot 3*

- *Str 3 delay shot 4*

Time delay settings for the DEL_INIT_4 signal

- *Str 4 delay shot 1*
- *Str 4 delay shot 2*
- *Str 4 delay shot 3*
- *Str 4 delay shot 4*

Normally, only two or three reclosing attempts are made. The third and fourth attempts are used to provide the so-called fast final trip to lockout.

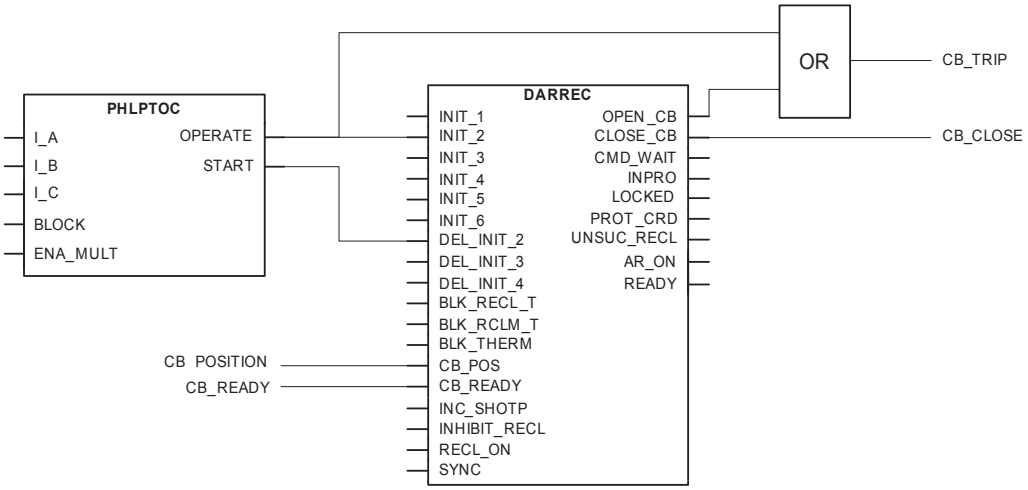



*Figure 895: Autoreclosing configuration example*

Delayed DEL_INIT_2...4 signals are used only when the autoreclosing shot is initiated with the start signal of a protection stage. After a start delay, the AR function opens the circuit breaker and an autoreclosing shot is initiated. When the shot is initiated with the trip signal of the protection, the protection function trips the circuit breaker and simultaneously initiates the autoreclosing shot.

If the circuit breaker is manually closed against the fault, that is, if SOTF is used, the fourth time delay can automatically be taken into use. This is controlled with the internal logic of the AR function and the *Fourth delay in SOTF* parameter.

A typical autoreclose situation is where one autoreclosing shot has been performed after the fault was detected. There are two types of such cases: operation initiated with protection start signal and operation initiated with protection trip signal. In both cases, the autoreclosing sequence is successful: the reclaim time elapses and no new sequence is started.

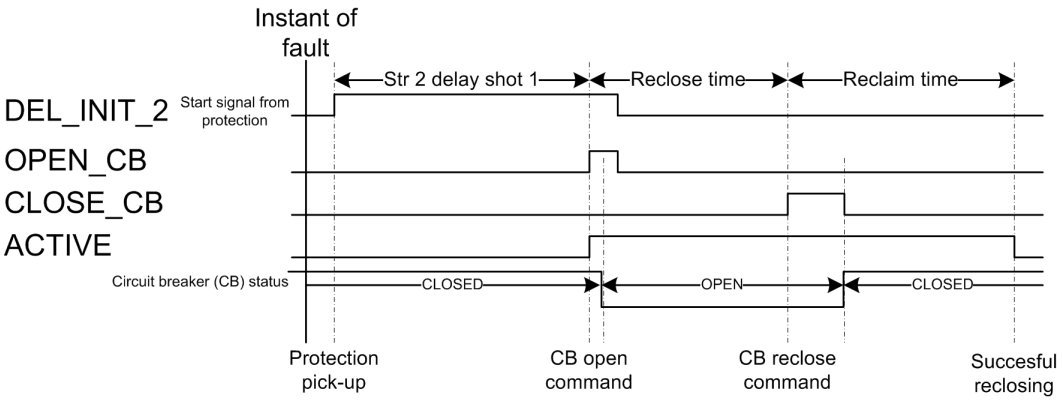



*Figure 896: Signal scheme of autoreclosing operation initiated with protection start signal*

The autoreclosing shot is initiated with a start signal of the protection function after the start delay time has elapsed. The autoreclosing starts when the *Str 2 delay shot 1* setting elapses.

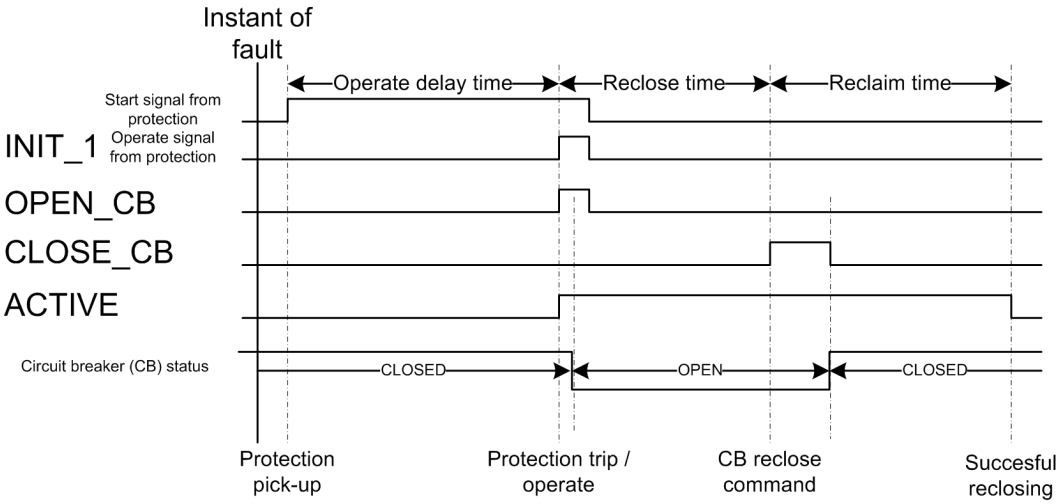



*Figure 897: Signal scheme of autoreclosing operation initiated with protection operate signal*

The autoreclosing shot is initiated with a trip signal of the protection function. The autoreclosing starts when the protection operate delay time elapses.

Normally, all trip and start signals are used to initiate an autoreclosing shot and trip the circuit breaker. `ACTIVE` output indicates reclosing sequence in progress. If any of the input signals `INIT_X` or `DEL_INIT_X` are used for blocking, the corresponding bit in the *Tripping line* setting must be FALSE. This is to ensure that the circuit breaker does not trip from that signal, that is, the signal does not activate the `OPEN_CB` output. The default value for the setting is "63", which means that all initiation signals activate the `OPEN_CB` output. The lowest bit in the *Tripping line* setting corresponds to the `INIT_1` input, the highest bit to the `INIT_6` line.

### 9.9.4.2 Shot initiation

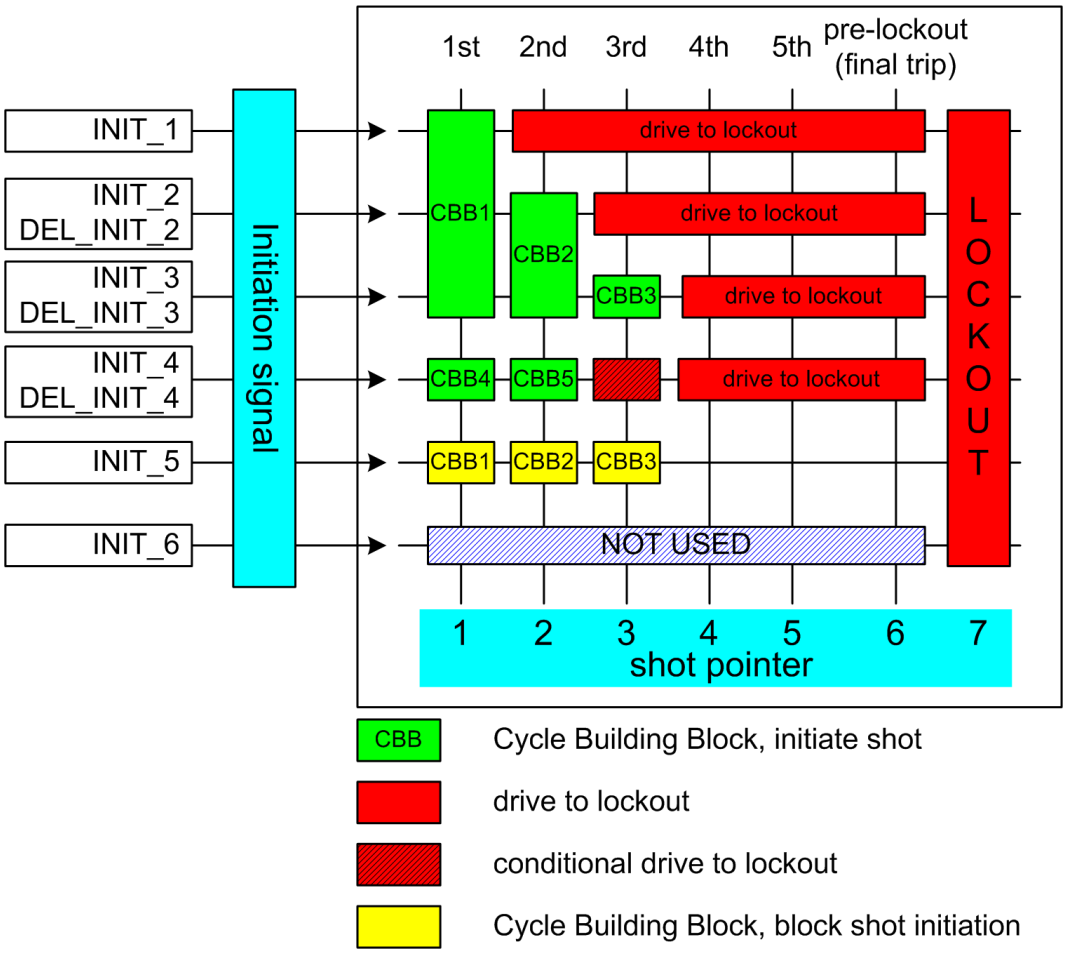



*Figure 898: Example of an autoreclosing program with a reclose scheme matrix*

In the AR function, each shot can be programmed to locate anywhere in the reclose scheme matrix. The shots are like building blocks used to design the reclose program. The building blocks are called CBBs. All blocks are alike and have settings which give the attempt number (columns in the matrix), the initiation or blocking signals (rows in the matrix) and the reclose time of the shot.

The settings related to CBB configuration are:

- *First...Seventh reclose time*
- *Init signals CBB1...CBB7*
- *Blk signals CBB1...CBB7*
- *Shot number CBB1...CBB7*

The reclose time defines the open and dead times, that is, the time between the `OPEN_CB` and the `CLOSE_CB` commands. The *Init signals CBBx* setting defines the initiation signals. The *Blk signals CBBx* setting defines the blocking signals that are related to the CBB (rows in the matrix). The *Shot number CBB1...CBB7* setting defines which shot is related to the CBB (columns in the matrix). For example, CBB1 settings are:

- *First reclose time* = 1.0s
- *Init signals CBB1* = 7 (three lowest bits: 111000 = 7)
- *Blk signals CBB1* = 16 (the fifth bit: 000010 = 16)

- *Shot number CBB1* = 1

CBB2 settings are:

- *Second reclose time* = 10s
- *Init signals CBB2* = 6 (the second and third bits: 011000 = 6)
- *Blk signals CBB2* = 16 (the fifth bit: 000010 = 16)
- *Shot number CBB2* = 2

CBB3 settings are:

- *Third reclose time* = 30s
- *Init signals CBB3* = 4 (the third bit: 001000 = 4)
- *Blk signals CBB3* = 16 (the fifth bit: 000010 = 16)
- *Shot number CBB3* = 3

CBB4 settings are:

- *Fourth reclose time* = 0.5s
- *Init signals CBB4* = 8 (the fourth bit: 000100 = 8)
- *Blk signals CBB4* = 0 (no blocking signals related to this CBB)
- *Shot number CBB4* = 1

If a shot is initiated from the INIT_1 line, only one shot is allowed before lockout. If a shot is initiated from the INIT_3 line, three shots are allowed before lockout.

A sequence initiation from the INIT_4 line leads to a lockout after two shots. In a situation where the initiation is made from both the INIT_3 and INIT_4 lines, a third shot is allowed, that is, CBB3 is allowed to start. This is called conditional lockout. If the initiation is made from the INIT_2 and INIT_3 lines, an immediate lockout occurs.

The INIT_5 line is used for blocking purposes. If the INIT_5 line is active during a sequence start, the reclose attempt is blocked and the AR function goes to lockout.

If more than one CBBs are started with the shot pointer, the CBB with the smallest individual number is always selected. For example, if the INIT_2 and INIT_4 lines are active for the second shot, that is, the shot pointer is 2, CBB2 is started instead of CBB5.

Even if the initiation signals are not received from the protection functions, the AR function can be set to continue from the second to the fifth reclose shot. The AR function can, for example, be requested to automatically continue with the sequence when the circuit breaker fails to close when requested. In such a case, the AR function issues a CLOSE_CB command. When the wait close time elapses, that is, the closing of the circuit breaker fails, the next shot is automatically started. Another example is the embedded generation on the power line, which can make the synchronism check fail and prevent the reclosing. If the autoreclose sequence is continued to the second shot, a successful synchronous reclosing is more likely than with the first shot, since the second shot lasts longer than the first one.

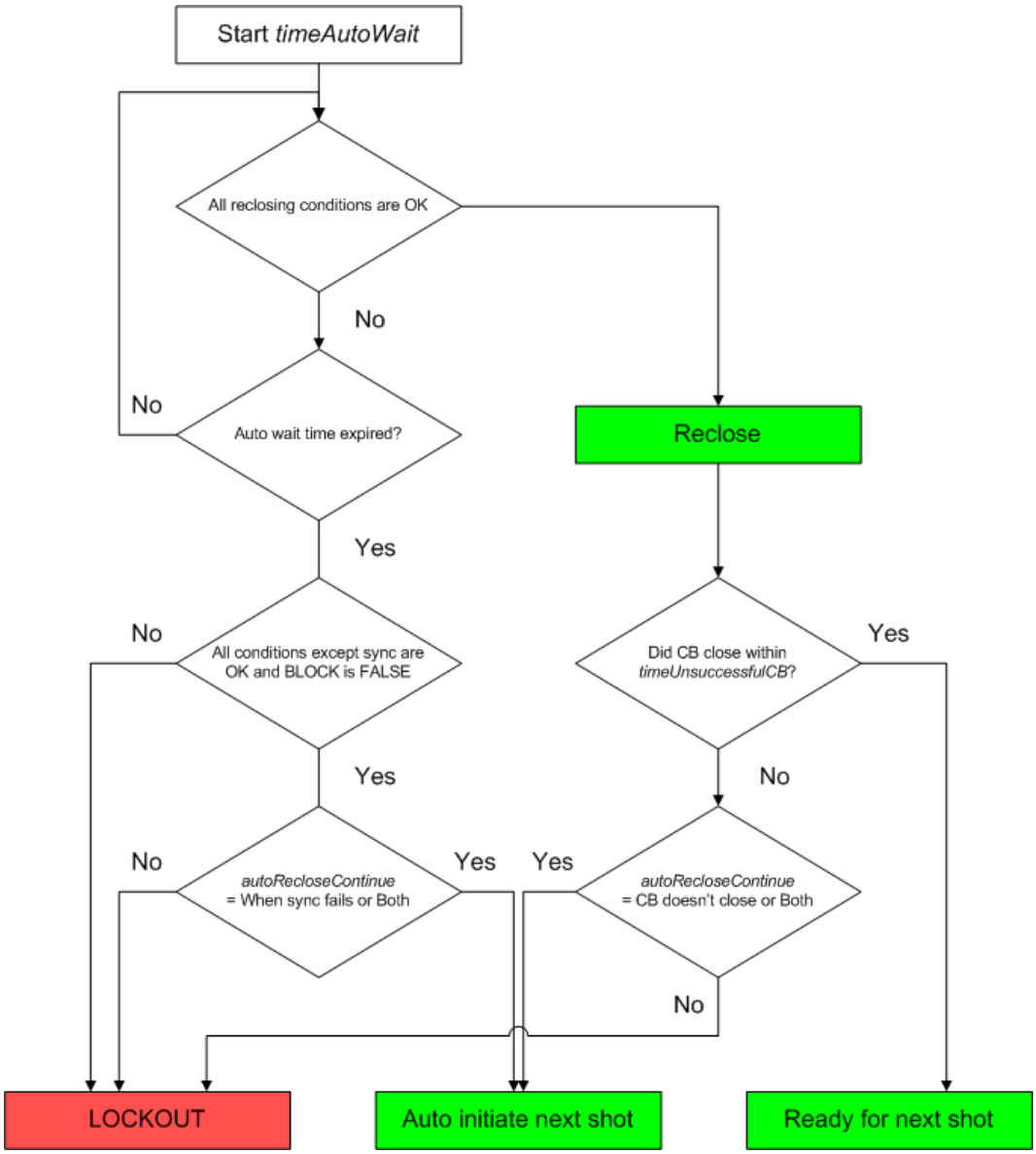



*Figure 899: Logic diagram of auto-initiation sequence detection*

Automatic initiation can be selected with the *Auto initiation Cnd* setting to be the following:

- Not allowed: no automatic initiation is allowed
- When the synchronization fails, the automatic initiation is carried out when the auto wait time elapses and the reclosing is prevented due to a failure during the synchronism check
- When the circuit breaker does not close, the automatic initiation is carried out if the circuit breaker does not close within the wait close time after issuing the reclose command
- Both: the automatic initiation is allowed when synchronization fails or the circuit breaker does not close.

The *Auto init* parameter defines which `INIT_X` lines are activated in the auto-initiation. The default value for this parameter is "0", which means that no auto-initiation is selected.

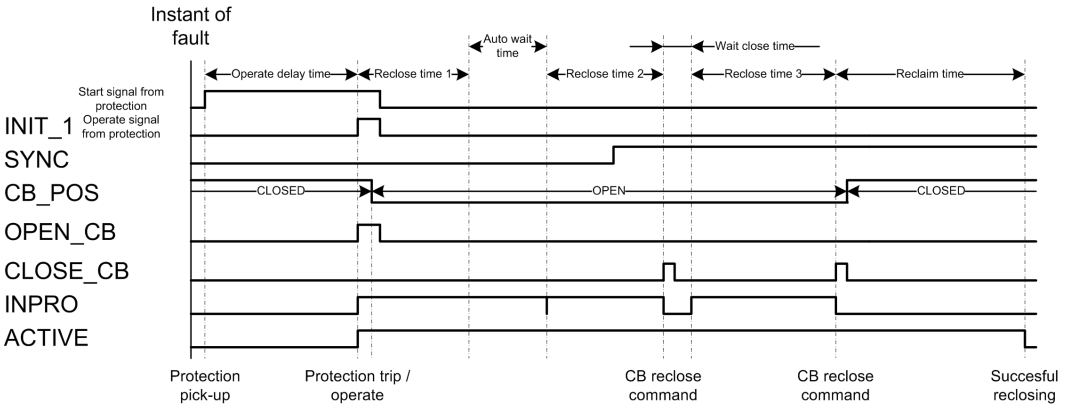



*Figure 900: Example of an auto-initiation sequence with synchronization failure in the first shot and circuit breaker closing failure in the second shot*

In the first shot, the synchronization condition is not fulfilled ( SYNC is FALSE). When the auto wait timer elapses, the sequence continues to the second shot. During the second reclosing, the synchronization condition is fulfilled and the close command is given to the circuit breaker after the second reclose time has elapsed.

After the second shot, the circuit breaker fails to close when the wait close time has elapsed. The third shot is started and a new close command is given after the third reclose time has elapsed. The circuit breaker closes normally and the reclaim time starts. When the reclaim time has elapsed, the sequence is concluded successful.

### 9.9.4.3 Shot pointer controller

The execution of a reclose sequence is controlled by a shot pointer. It can be adjusted with the SHOT_PTR monitored data.

The shot pointer starts from an initial value "1" and determines according to the settings whether or not a certain shot is allowed to be initiated. After every shot, the shot pointer value increases. This is carried out until a successful reclosing or lockout takes place after a complete shot sequence containing a total of five shots.

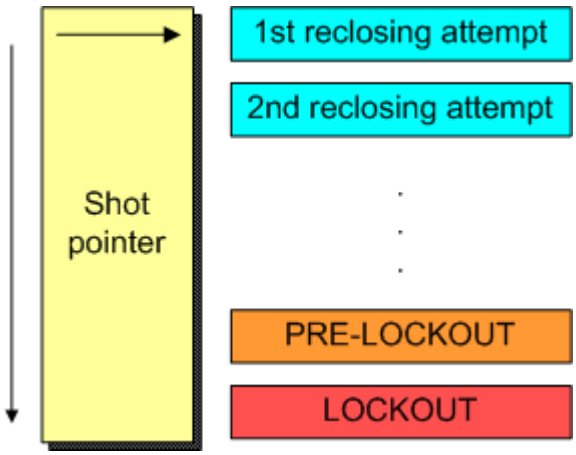



*Figure 901: Shot pointer function*

Every time the shot pointer increases, the reclaim time starts. When the reclaim time ends, the shot pointer sets to its initial value, unless no new shot is initiated.

The shot pointer increases when the reclose time elapses or at the falling edge of the INC_SHOTP signal.

When SHOT_PTR has the value six, the AR function is in a so called pre-lockout state. If a new initiation occurs during the pre-lockout state, the AR function goes to lockout. Therefore, a new sequence initiation during the pre-lockout state is not possible.

The AR function goes to the pre-lockout state in the following cases:

- During SOTF
- When the AR function is active, it stays in a pre-lockout state for the time defined by the reclaim time
- When all five shots have been executed
- When the frequent operation counter limit is reached. A new sequence initiation forces the AR function to lockout.

### 9.9.4.4 Reclose controller

The reclose controller calculates the reclose, discrimination and reclaim times. The reclose time is started when the INPRO signal is activated, that is, when the sequence starts and the activated CBB defines the reclose time.

When the reclose time has elapsed, the CLOSE_CB output is not activated until the following conditions are fulfilled:

- The SYNC input must be TRUE if the particular CBB requires information about the synchronism
- All AR initiation inputs that are defined protection lines (using the *Control line* setting) are inactive
- The circuit breaker is open
- The circuit breaker is ready for the close command, that is, the CB_READY input is TRUE. This is indicated by active READY output.

If at least one of the conditions is not fulfilled within the time set with the *Auto wait time* parameter, the autoreclose sequence is locked.

The synchronism requirement for the CBBs can be defined with the *Synchronisation set* setting, which is a bit mask. The lowest bit in the *Synchronisation set* setting is related to CBB1 and the highest bit to CBB7. For example, if the setting is set to "1", only CBB1 requires synchronism. If the setting is it set to "7", CBB1, CBB2 and CBB3 require the SYNC input to be TRUE before the reclosing command can be given.

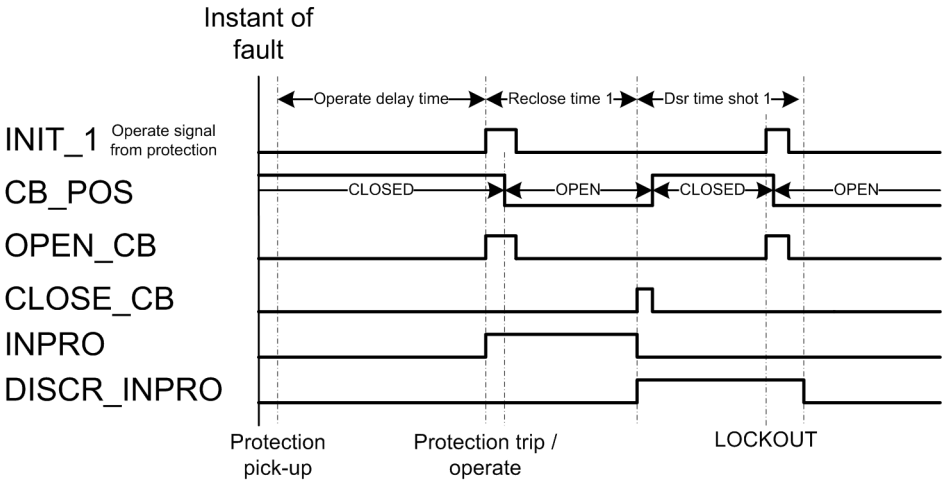



*Figure 902: Initiation during discrimination time - AR function goes to lockout*

The discrimination time starts when the close command CLOSE_CB has been given. If a start input is activated before the discrimination time has elapsed, the AR function goes to lockout. The default value for each discrimination time is zero. The discrimination time can be adjusted with the *Dsr time shot 1...4* parameter.

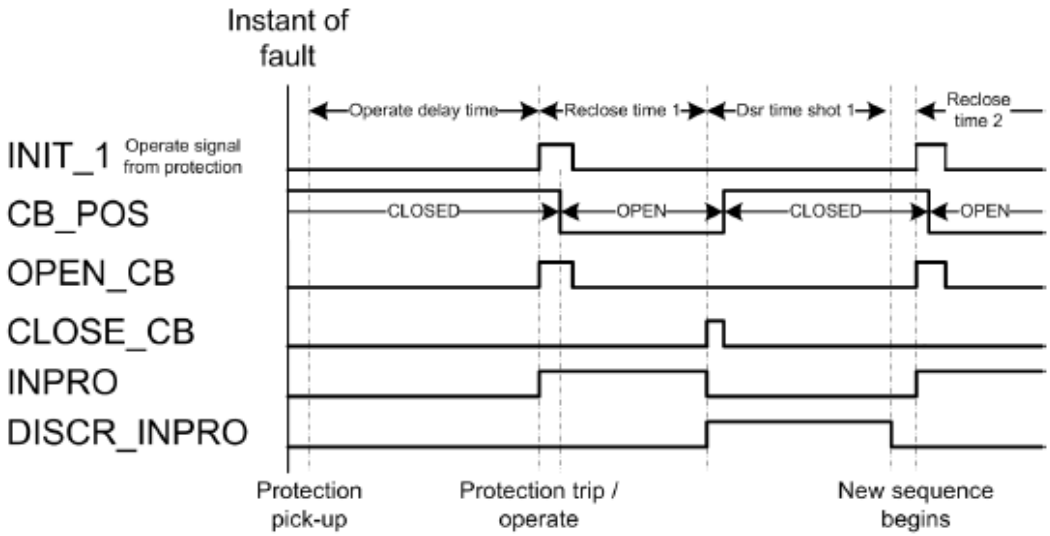



*Figure 903: Initiation after elapsed discrimination time - new shot begins*

### 9.9.4.5 Sequence controller

When the LOCKED output is active, the AR function is in lockout. This means that new sequences cannot be initialized, because AR is insensitive to initiation commands. It can be released from the lockout state in the following ways.

- The function is reset through communication with the *RecRs* parameter. The same functionality can also be found in the Clear menu (DARREC1 reset).
- The lockout is automatically reset after the reclaim time, if the *Auto lockout reset* setting is in use.

If the *Auto lockout reset* setting is not in use, the lockout can be released only with the *RecRs* parameter.

The AR function can go to lockout for many reasons.

- The INHIBIT_RECL input is active.
- All shots have been executed and a new initiation is made (final trip).
- The time set with the *Auto wait time* parameter expires and the automatic sequence initiation is not allowed because of a synchronization failure.
- The time set with the *Wait close time* parameter expires, that is, the circuit breaker does not close or the automatic sequence initiation is not allowed due to a closing failure of the circuit breaker.
- A new shot is initiated during the discrimination time.
- The time set with the *Max wait time* parameter expires, that is, the master unit does not release the slave unit.
- The frequent operation counter limit is reached and new sequence is initiated. The lockout is released when the recovery timer elapses.
- The protection trip signal has been active longer than the time set with the *Max wait time* parameter since the shot initiation.
- The circuit breaker is closed manually during an autoreclosing sequence and the manual close mode is FALSE.

### 9.9.4.6 Protection coordination controller

The PROT_CRD output is used for controlling the protection functions. In several applications, such as fuse-saving applications involving down-stream fuses, tripping and initiation of shot 1 should be fast (instantaneous or short-time delayed). The tripping and initiation of shots 2, 3 and definite tripping time should be delayed.

In this example, two overcurrent elements PHLPTOC and PHIPTOC are used. PHIPTOC is given an instantaneous characteristic and PHLPTOC is given a time delay.

The PROT_CRD output is activated, if the SHOT_PTR value is the same or higher than the value defined with the *Protection crd limit* setting and all initialization signals have been reset. The PROT_CRD output is reset under the following conditions:

- If the cut-out time elapses
- If the reclaim time elapses and the AR function is ready for a new sequence
- If the AR function is in lockout or disabled, that is, if the value of the *Protection crd mode* setting is "AR inoperative" or "AR inop, CB man".

The PROT_CRD output can also be controlled with the *Protection crd mode* setting. The setting has the following modes:

- "no condition": the PROT_CRD output is controlled only with the *Protection crd limit* setting
- "AR inoperative": the PROT_CRD output is active, if the AR function is disabled or in the lockout state, or if the INHIBIT_RECL input is active
- "CB close manual": the PROT_CRD output is active for the reclaim time if the circuit breaker has been manually closed, that is, the AR function has not issued a close command
- "AR inop, CB man": both the modes "AR inoperative" and "CB close manual" are effective

- "always": the PROT_CRD output is constantly active

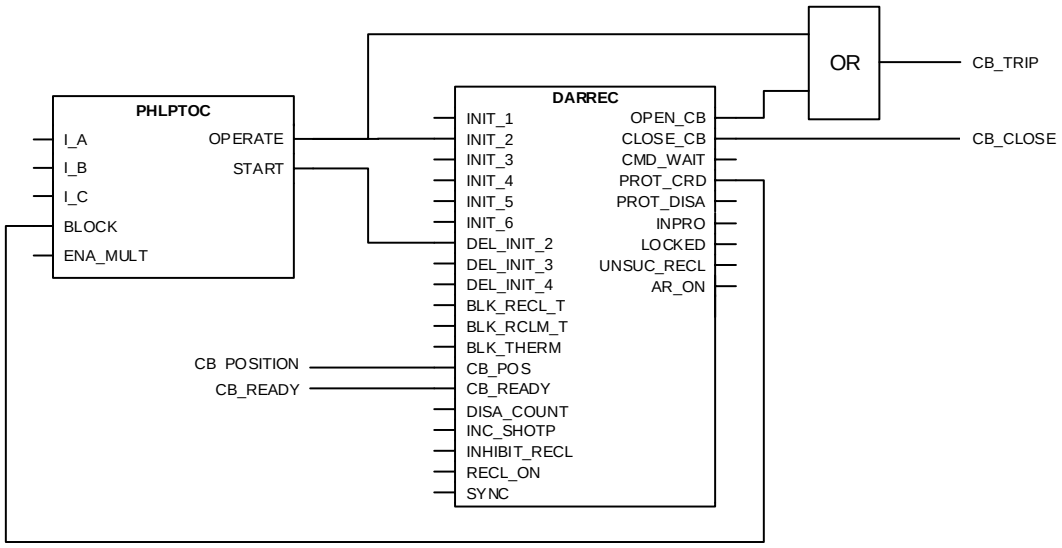



*Figure 904: Configuration example of using the PROT_CRD output for protection blocking*

If the *Protection crd limit* setting has the value "1", the instantaneous three-phase overcurrent protection function PHIPTOC is disabled or blocked after the first shot.

### 9.9.4.7 Circuit breaker controller

Circuit breaker controller contains two features: SOTF and frequent-operation counter. SOTF protects the AR function in permanent faults.

The circuit breaker position information is controlled with the *CB closed Pos status* setting. The setting value "TRUE" means that when the circuit breaker is closed, the CB_POS input is TRUE. When the setting value is "FALSE", the CB_POS input is FALSE, provided that the circuit breaker is closed. The reclose command pulse time can be controlled with the *Close pulse time* setting: the CLOSE_CB output is active for the time set with the *Close pulse time* setting. The CLOSE_CB output is deactivated also when the circuit breaker is detected to be closed, that is, when the CB_POS input changes from open state to closed state. The *Wait close time* setting defines the time after the CLOSE_CB command activation, during which the circuit breaker should be closed. If the closing of circuit breaker does not happen during this time, the autoreclosing function is driven to lockout or, if allowed, an auto-initiation is activated.

The main motivation for autoreclosing to begin with is the assumption that the fault is temporary by nature, and that a momentary de-energizing of the power line and an automatic reclosing restores the power supply. However, when the power line is manually energized and an immediate protection trip is detected, it is very likely that the fault is of a permanent type. A permanent fault is, for example, energizing a power line into a forgotten earthing after a maintenance work along the power line. In such cases, SOTF is activated, but only for the reclaim time after energizing the power line and only when the circuit breaker is closed manually and not by the AR function.

SOTF disables any initiation of an autoreclosing shot. The energizing of the power line is detected from the CB_POS information.

SOTF is activated when the AR function is enabled or when the AR function is started and the SOTF should remain active for the reclaim time.

When SOTF is detected, the parameter *SOTF* is active.

If the *Manual close mode* setting is set to FALSE and the circuit breaker has been manually closed during an autoreclosing shot, the AR unit goes to an immediate lockout.

If the *Manual close mode* setting is set to TRUE and the circuit breaker has been manually closed during an autoreclosing shot (the INPRO is active), the shot is considered as completed.

When SOTF starts, reclaim time is restarted, provided that it is running.

The frequent-operation counter is intended for blocking the autoreclosing function in cases where the fault causes repetitive autoreclosing sequences during a short period of time. For instance, if a tree causes a short circuit and, as a result, there are autoreclosing shots within a few minutes interval during a stormy night. These types of faults can easily damage the circuit breaker if the AR function is not locked by a frequent-operation counter.

The frequent-operation counter has three settings:

- *Frq Op counter limit*
- *Frq Op counter time*
- *Frq Op recovery time*

The *Frq Op counter limit* setting defines the number of reclose attempts that are allowed during the time defined with the *Frq Op counter time* setting. If the set value is reached within a pre-defined period defined with the *Frq Op counter time* setting, the AR function goes to lockout when a new shot begins, provided that the counter is still above the set limit. The lockout is released after the recovery time has elapsed. The recovery time can be defined with the *Frq Op recovery time* setting .

If the circuit breaker is manually closed during the recovery time, the reclaim time is activated after the recovery timer has elapsed.

### 9.9.5 Counters

The AR function contains six counters. Their values are stored in a semi-retain memory. The counters are increased at the rising edge of the reclosing command. The counters count the following situations.

- COUNTER: counts every reclosing command activation
- CNT_SHOT1: counts reclosing commands that are executed from shot 1
- CNT_SHOT2: counts reclosing commands that are executed from shot 2
- CNT_SHOT3: counts reclosing commands that are executed from shot 3
- CNT_SHOT4: counts reclosing commands that are executed from shot 4
- CNT_SHOT5: counts reclosing commands that are executed from shot 5

The counters are disabled through communication with the *DsaCnt* parameter. When the counters are disabled, the values are not updated.

The counters are reset through communication with the *CntRs* parameter. The same functionality can also be found in the clear menu (DARREC1 counters).

## 9.9.6 Application

Modern electric power systems can deliver energy to users very reliably. However, different kind of faults can occur. Protection relays play an important role in detecting failures or abnormalities in the system. They detect faults and give commands for corresponding circuit breakers to isolate the defective element before excessive damage or a possible power system collapse occurs. A fast isolation also limits the disturbances caused for the healthy parts of the power system.

The faults can be transient, semi-transient or permanent. Permanent fault, for example in power cables, means that there is a physical damage in the fault location that must first be located and repaired before the network voltage can be restored.

In overhead lines, the insulating material between phase conductors is air. The majority of the faults are flash-over arcing faults caused by lightning, for example. Only a short interruption is needed for extinguishing the arc. These faults are transient by nature.

A semi-transient fault can be caused for example by a bird or a tree branch falling on the overhead line. The fault disappears on its own if the fault current burns the branch or the wind blows it away.

Transient and semi-transient faults can be cleared by momentarily de-energizing the power line. Using the auto-reclose function minimizes interruptions in the power system service and brings the power back on-line quickly and effortlessly.

The basic idea of the auto-reclose function is simple. In overhead lines, where the possibility of self-clearing faults is high, the auto-reclose function tries to restore the power by reclosing the breaker. This is a method to get the power system back into normal operation by removing the transient or semi-transient faults. Several trials, that is, autoreclose shots are allowed. If none of the trials is successful and the fault persists, definite final tripping follows.

The auto-reclose function can be used with every circuit breaker that has the ability for a reclosing sequence. In DARREC auto-reclose function the implementing method of auto-reclose sequences is patented by ABB.

**Table 1559: Important definitions related to auto-reclosing**

| | |
|---|---|
| Autoreclose shot | An operation where after a preset time the breaker is closed from the breaker tripping caused by protection. |
| Autoreclose sequence | A predefined method to do reclose attempts (shots) to restore the power system. |
| SOTF | If the protection detects a fault immediately after an open circuit breaker has been closed, it indicates that the fault was already there. It can be, for example, a forgotten earthing after maintenance work. Such closing of the circuit breaker is known as switch on to fault. Autoreclosing in such conditions is prohibited. |
| Final trip | Occurs in case of a permanent fault, when the circuit breaker is opened for the last time after all programmed autoreclose operations. Since no auto-reclosing follows, the circuit breaker remains open. This is called final trip or definite trip. |

### 9.9.6.1 Shot initiation

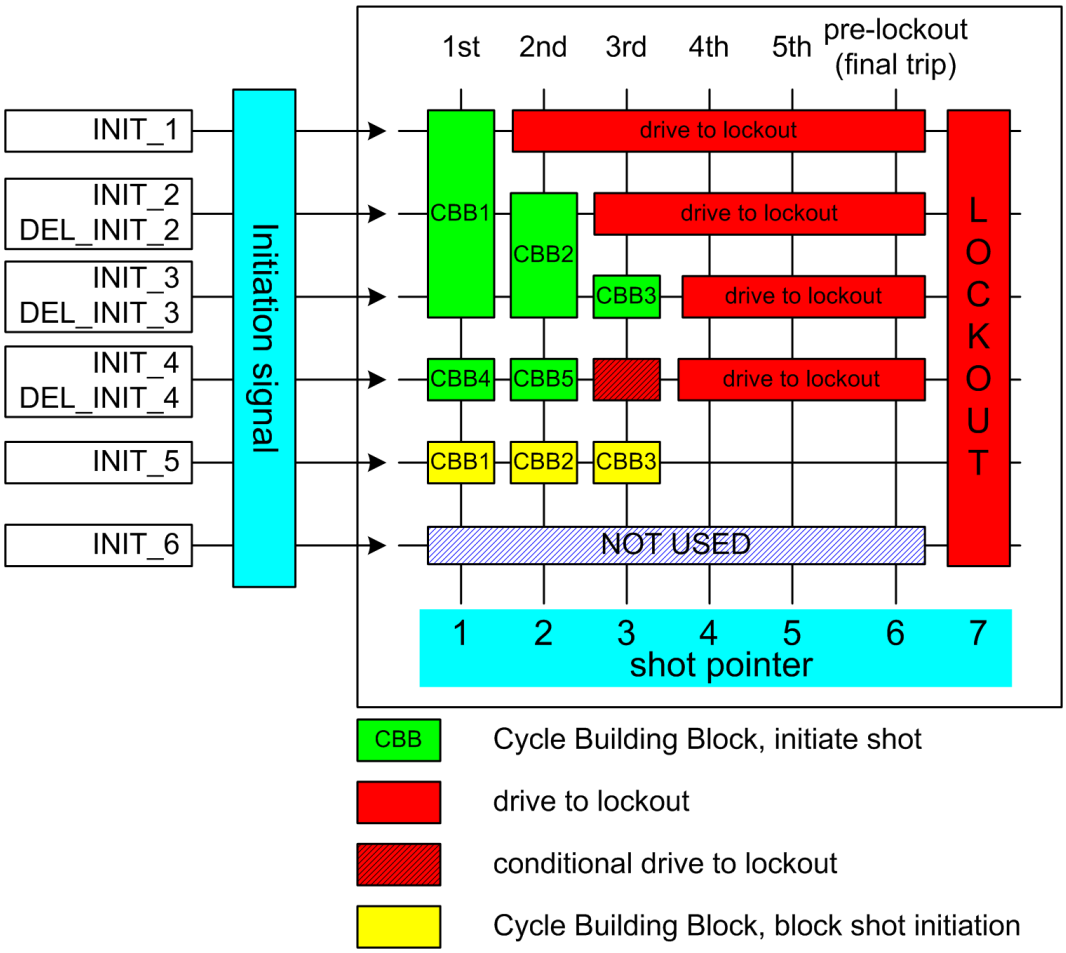



*Figure 905: Example of an autoreclosing program with a reclose scheme matrix*

In the AR function, each shot can be programmed to locate anywhere in the reclose scheme matrix. The shots are like building blocks used to design the reclose program. The building blocks are called CBBs. All blocks are alike and have settings which give the attempt number (columns in the matrix), the initiation or blocking signals (rows in the matrix) and the reclose time of the shot.

The settings related to CBB configuration are:

- *First...Seventh reclose time*
- *Init signals CBB1...CBB7*
- *Blk signals CBB1...CBB7*
- *Shot number CBB1...CBB7*

The reclose time defines the open and dead times, that is, the time between the `OPEN_CB` and the `CLOSE_CB` commands. The *Init signals CBBx* setting defines the initiation signals. The *Blk signals CBBx* setting defines the blocking signals that are related to the CBB (rows in the matrix). The *Shot number CBB1...CBB7* setting defines which shot is related to the CBB (columns in the matrix). For example, CBB1 settings are:

- *First reclose time* = 1.0s
- *Init signals CBB1* = 7 (three lowest bits: 111000 = 7)

- *Blk signals CBB1* = 16 (the fifth bit: 000010 = 16)
- *Shot number CBB1* = 1

CBB2 settings are:

- *Second reclose time* = 10s
- *Init signals CBB2* = 6 (the second and third bits: 011000 = 6)
- *Blk signals CBB2* = 16 (the fifth bit: 000010 = 16)
- *Shot number CBB2* = 2

CBB3 settings are:

- *Third reclose time* = 30s
- *Init signals CBB3* = 4 (the third bit: 001000 = 4)
- *Blk signals CBB3* = 16 (the fifth bit: 000010 = 16)
- *Shot number CBB3* = 3

CBB4 settings are:

- *Fourth reclose time* = 0.5s
- *Init signals CBB4* = 8 (the fourth bit: 000100 = 8)
- *Blk signals CBB4* = 0 (no blocking signals related to this CBB)
- *Shot number CBB4* = 1

If a shot is initiated from the INIT_1 line, only one shot is allowed before lockout. If a shot is initiated from the INIT_3 line, three shots are allowed before lockout.

A sequence initiation from the INIT_4 line leads to a lockout after two shots. In a situation where the initiation is made from both the INIT_3 and INIT_4 lines, a third shot is allowed, that is, CBB3 is allowed to start. This is called conditional lockout. If the initiation is made from the INIT_2 and INIT_3 lines, an immediate lockout occurs.

The INIT_5 line is used for blocking purposes. If the INIT_5 line is active during a sequence start, the reclose attempt is blocked and the AR function goes to lockout.



If more than one CBBs are started with the shot pointer, the CBB with the smallest individual number is always selected. For example, if the INIT_2 and INIT_4 lines are active for the second shot, that is, the shot pointer is 2, CBB2 is started instead of CBB5.

Even if the initiation signals are not received from the protection functions, the AR function can be set to continue from the second to the fifth reclose shot. The AR function can, for example, be requested to automatically continue with the sequence when the circuit breaker fails to close when requested. In such a case, the AR function issues a CLOSE_CB command. When the wait close time elapses, that is, the closing of the circuit breaker fails, the next shot is automatically started. Another example is the embedded generation on the power line, which can make the synchronism check fail and prevent the reclosing. If the auto-reclose sequence is continued to the second shot, a successful synchronous reclosing is more likely than with the first shot, since the second shot lasts longer than the first one.

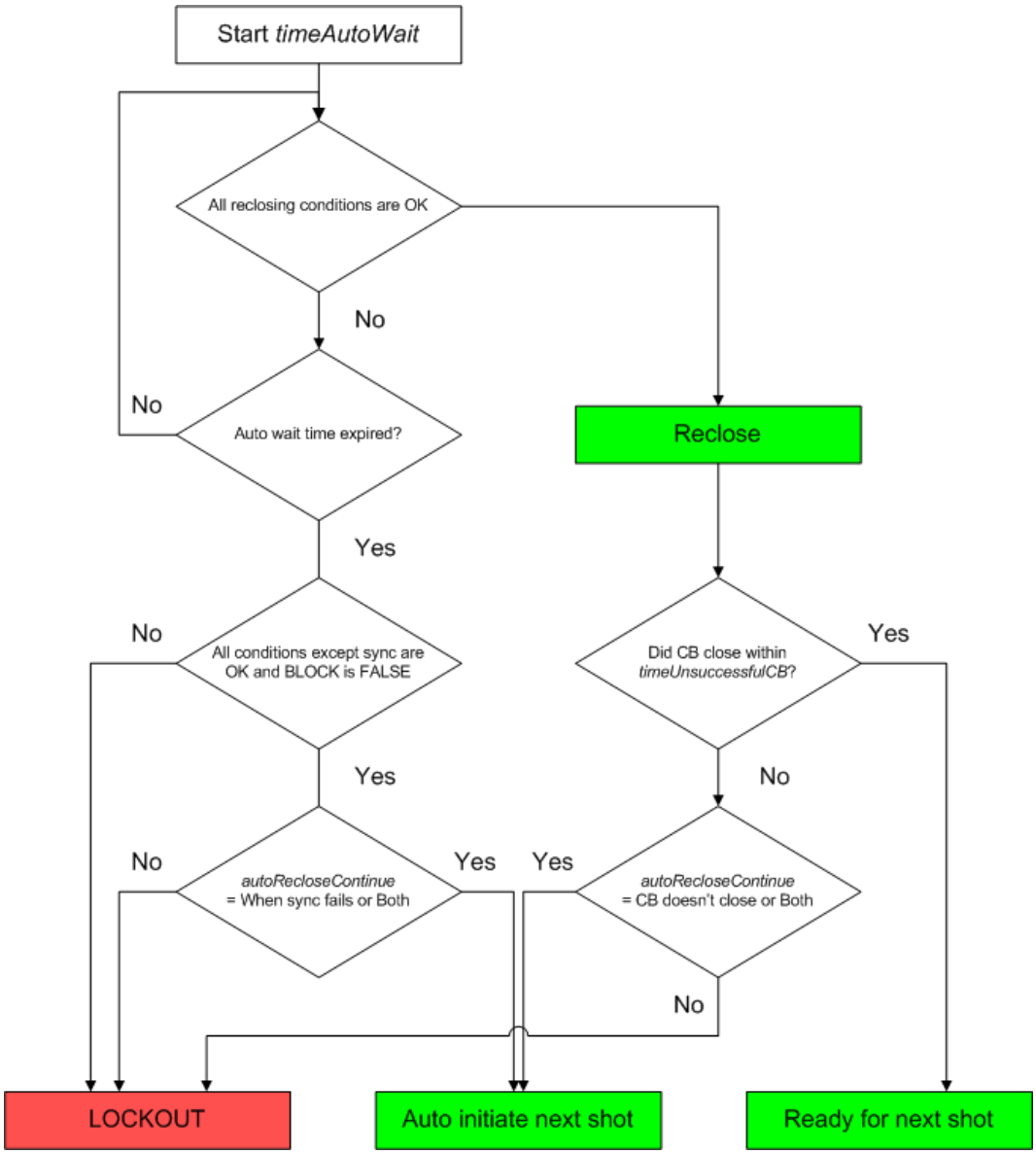



*Figure 906: Logic diagram of auto-initiation sequence detection*

Automatic initiation can be selected with the *Auto initiation Cnd* setting to be the following:

- Not allowed: no automatic initiation is allowed
- When the synchronization fails, the automatic initiation is carried out when the auto wait time elapses and the reclosing is prevented due to a failure during the synchronism check
- When the circuit breaker does not close, the automatic initiation is carried out if the circuit breaker does not close within the wait close time after issuing the reclose command
- Both: the automatic initiation is allowed when synchronization fails or the circuit breaker does not close.

The *Auto init* parameter defines which `INIT_X` lines are activated in the auto-initiation. The default value for this parameter is "0", which means that no auto-initiation is selected.

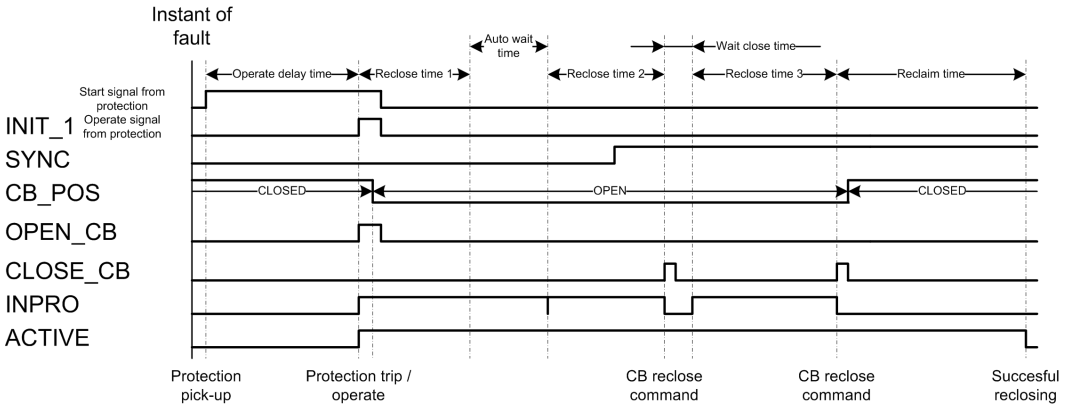



*Figure 907: Example of an auto-initiation sequence with synchronization failure in the first shot and circuit breaker closing failure in the second shot*

In the first shot, the synchronization condition is not fulfilled ( SYNC is FALSE). When the auto wait timer elapses, the sequence continues to the second shot. During the second reclosing, the synchronization condition is fulfilled and the close command is given to the circuit breaker after the second reclose time has elapsed.

After the second shot, the circuit breaker fails to close when the wait close time has elapsed. The third shot is started and a new close command is given after the third reclose time has elapsed. The circuit breaker closes normally and the reclaim time starts. When the reclaim time has elapsed, the sequence is concluded successful.

### 9.9.6.2 Sequence

The auto reclose sequence is implemented by using CBBs. The highest possible amount of CBBs is seven. If the user wants to have, for example, a sequence of three shots, only the first three CBBs are needed. Using building blocks instead of fixed shots gives enhanced flexibility, allowing multiple and adaptive sequences.

Each CBB is identical. The *Shot number CBB_* setting defines at which point in the auto-reclose sequence the CBB should be performed, that is, whether the particular CBB is going to be the first, second, third, fourth or fifth shot.

During the initiation of a CBB, the conditions of initiation and blocking are checked. This is done for all CBBs simultaneously. Each CBB that fulfils the initiation conditions requests an execution.

The function also keeps track of shots already performed, that is, at which point the auto-reclose sequence is from shot 1 to lockout. For example, if shots 1 and 2 have already been performed, only shots 3 to 5 are allowed.

Additionally, the *Enable shot jump* setting gives two possibilities:

- Only such CBBs that are set for the next shot in the sequence can be accepted for execution. For example, if the next shot in the sequence should be shot 2, a request from CBB set for shot 3 is rejected.
- Any CBB that is set for the next shot or any of the following shots can be accepted for execution. For example, if the next shot in the sequence should be shot 2, also CBBs that are set for shots 3, 4 and 5 are accepted. In other words, shot 2 can be ignored.

In case there are multiple CBBs allowed for execution, the CBB with the smallest number is chosen. For example, if CBB2 and CBB4 request an execution, CBB2 is allowed to execute the shot.

The auto-reclose function can perform up to five auto-reclose shots or cycles.

### 9.9.6.3 Configuration examples

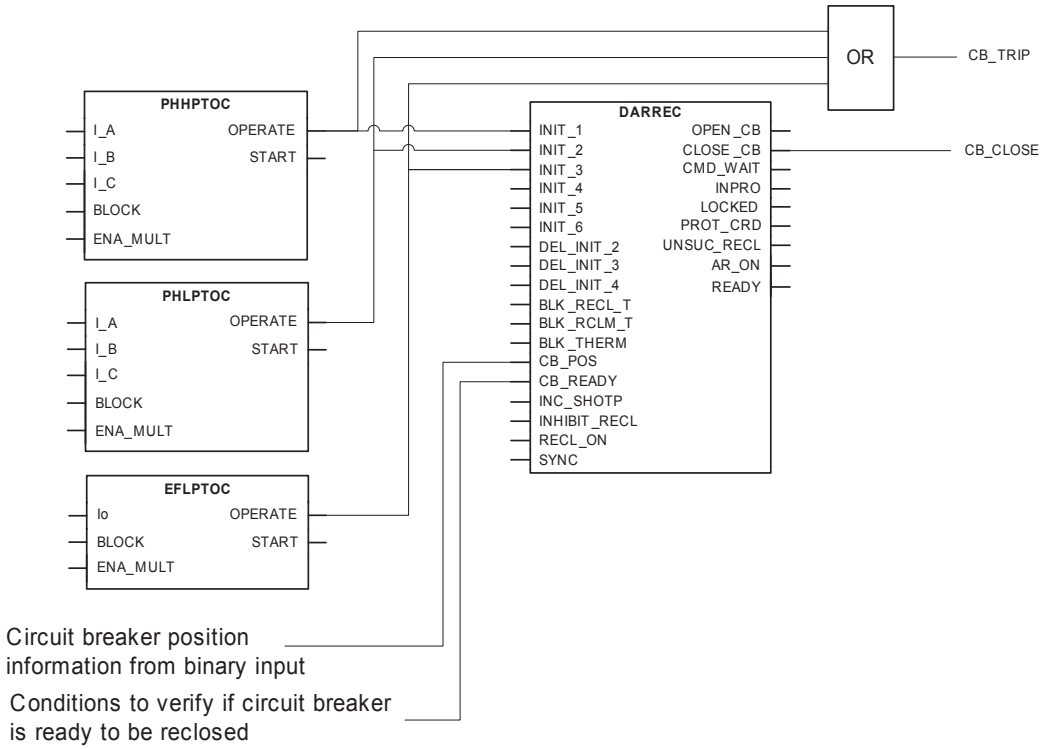



*Figure 908: Example connection between protection and autoreclosing functions in protection relay configuration*

It is possible to create several sequences for a configuration.

Autoreclose sequences for overcurrent and non-directional earth-fault protection applications where high speed and delayed autoreclosings are needed can be as follows:

**Example 1**

The sequence is implemented by two shots which have the same reclosing time for all protection functions, namely I>>, I> and Io>. The initiation of the shots is done by activating the operating signals of the protection functions.

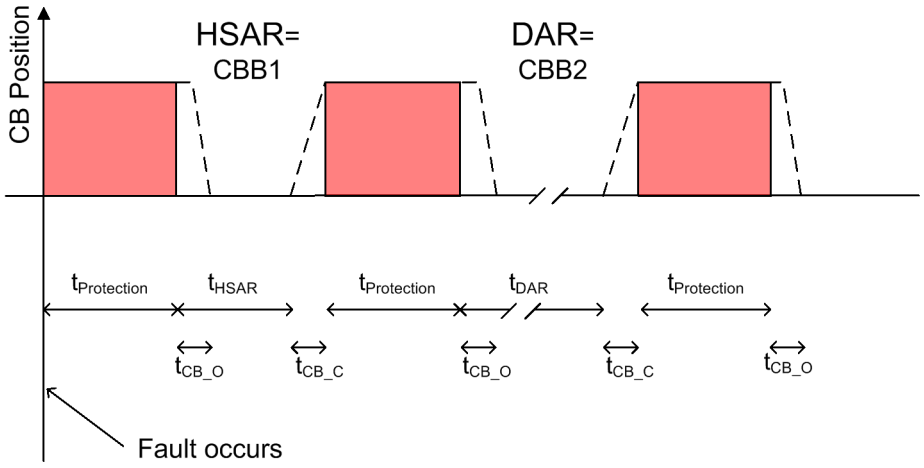



*Figure 909: Autoreclosing sequence with two shots*

| | |
|---|---|
| $t_{HSAR}$ | Time delay of high-speed autoreclosing, here: *First reclose time* |
| $t_{DAR}$ | Time delay of delayed autoreclosing, here: *Second reclose time* |
| $t_{Protection}$ | Operating time for the protection stage to clear the fault |
| $t_{CB_O}$ | Operating time for opening the circuit breaker |
| $t_{CB_C}$ | Operating time for closing the circuit breaker |

In this case, the sequence needs two CBBs. The reclosing times for shot 1 and shot 2 are different, but each protection function initiates the same sequence. The CBB sequence is described in *Table 1560* as follows:

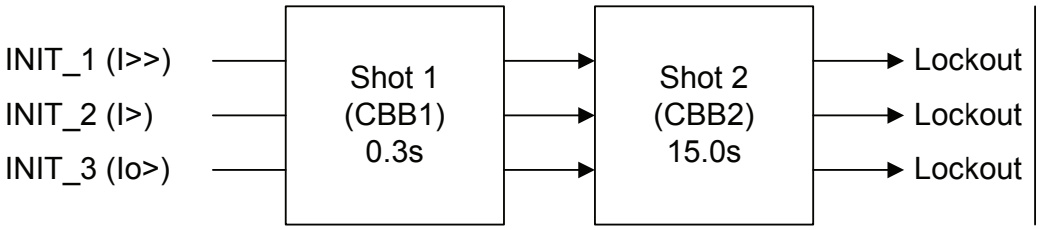



*Figure 910: Two shots with three initiation lines*

**Table 1560: Settings for configuration example 1**

| Setting name | Setting value |
|---|---|
| Shot number CBB1 | 1 |
| Init signals CBB1 | 7 (lines 1, 2 and 3 = 1+2+4 = 7) |
| First reclose time | 0.3s (an example) |
| Shot number CBB2 | 2 |
| Init signals CBB2 | 7 (lines 1, 2 and 3 = 1+2+4 = 7) |
| Second reclose time | 15.0s (an example) |

**Example 2**

There are two separate sequences implemented with three shots. Shot 1 is implemented by CBB1 and it is initiated with the high stage of the overcurrent protection (I>>). Shot 1 is set as a high-speed autoreclosing with a short time delay. Shot 2 is implemented with CBB2 and meant to be the first shot of the autoreclose sequence initiated by the low stage of the overcurrent protection (I>) and the low stage of the non-directional earth-fault protection (Io>). It has the same reclosing time in both situations. It is set as a high-speed autoreclosing for corresponding faults. The third shot, which is the second shot in the autoreclose sequence initiated by I> or Io>, is set as a delayed autoreclosing and executed after an unsuccessful high-speed autoreclosing of a corresponding sequence.

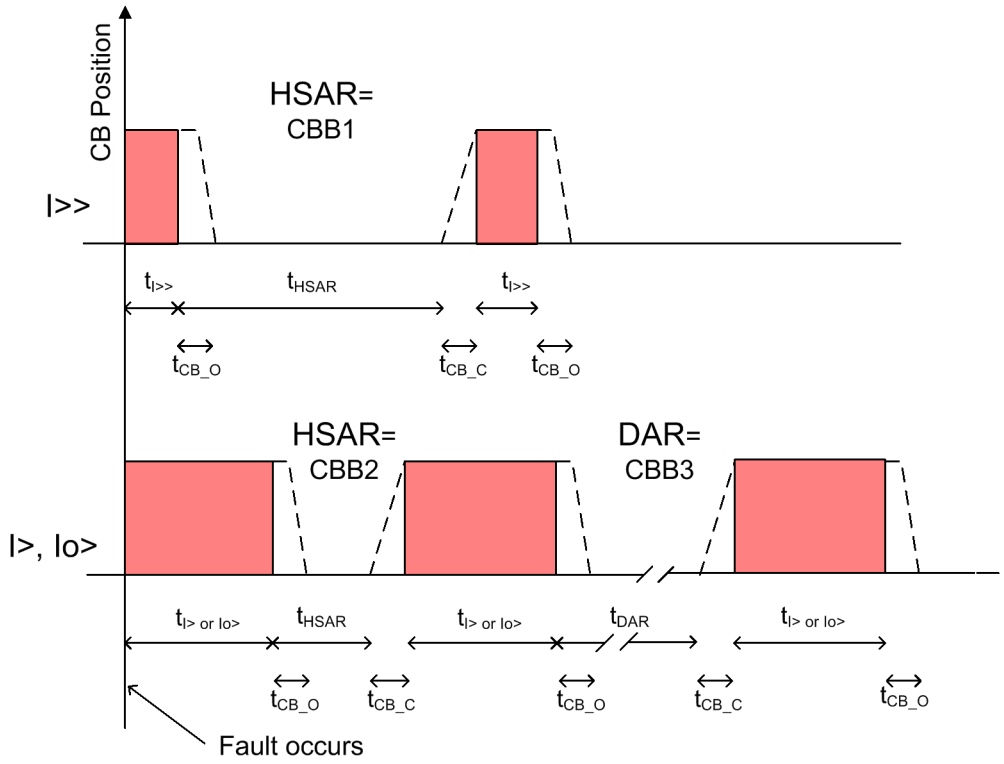



*Figure 911: Autoreclosing sequence with two shots with different shot settings according to initiation signal*

| | |
|---|---|
| $t_{HSAR}$ | Time delay of high-speed autoreclosing, here: *First reclose time* |
| $t_{DAR}$ | Time delay of delayed autoreclosing, here: *Second reclose time* |
| $t_{I>>}$ | Operating time for the I>> protection stage to clear the fault |
| $t_{I>}$ or $_{Io>}$ | Operating time for the I> or Io> protection stage to clear the fault |
| $t_{CB_O}$ | Operating time for opening the circuit breaker |
| $t_{CB_C}$ | Operating time for closing the circuit breaker |

In this case, the number of needed CBBs is three, that is, the first shot's reclosing time depends on the initiation signal.

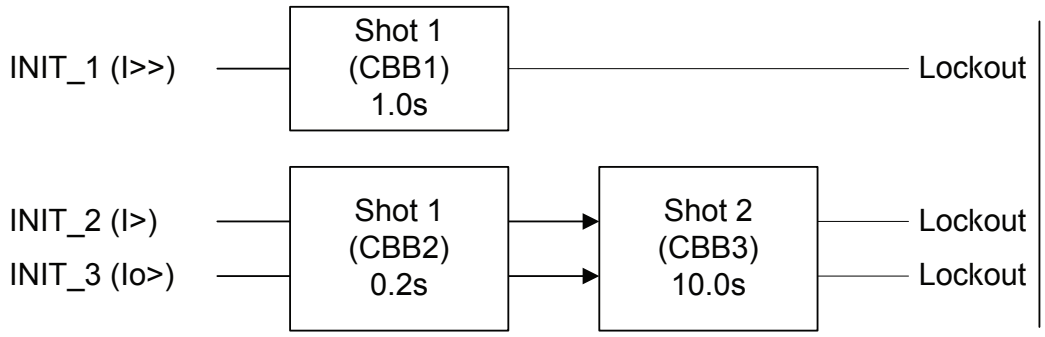



*Figure 912: Three shots with three initiation lines*

If the sequence is initiated from the INIT_1 line, that is, the overcurrent protection high stage, the sequence is one shot long. If the sequence is initiated from the INIT_2 or INIT_3 lines, the sequence is two shots long.

**Table 1561: Settings for configuration example 2**

| Setting name | Setting value |
|---|---|
| Shot number CBB1 | 1 |
| Init signals CBB1 | 1 (line 1) |
| First reclose time | 0.0s (an example) |
| Shot number CBB2 | 1 |
| Init signals CBB2 | 6 (lines 2 and 3 = 2+4 = 6) |
| Second reclose time | 0.2s (an example) |
| Shot number CBB3 | 2 |
| Init signals CBB3 | 6 (lines 2 and 3 = 2+4 = 6) |
| Third reclose time | 10.0s |

### 9.9.6.4 Delayed initiation lines

The auto-reclose function consists of six individual auto-reclose initiation lines INIT_1...INIT_6 and three delayed initiation lines:

- DEL_INIT_2
- DEL_INIT_3
- DEL_INIT_4

DEL_INIT_2 and INIT_2 are connected together with an OR-gate, as are inputs 3 and 4. Inputs 1, 5 and 6 do not have any delayed input. From the auto-reclosing point of view, it does not matter whether INIT_x or DEL_INIT_x line is used for shot initiation or blocking.

The auto-reclose function can also open the circuit breaker from any of the initiation lines. It is selected with the *Tripping line* setting. As a default, all initiation lines activate the OPEN_CB output.

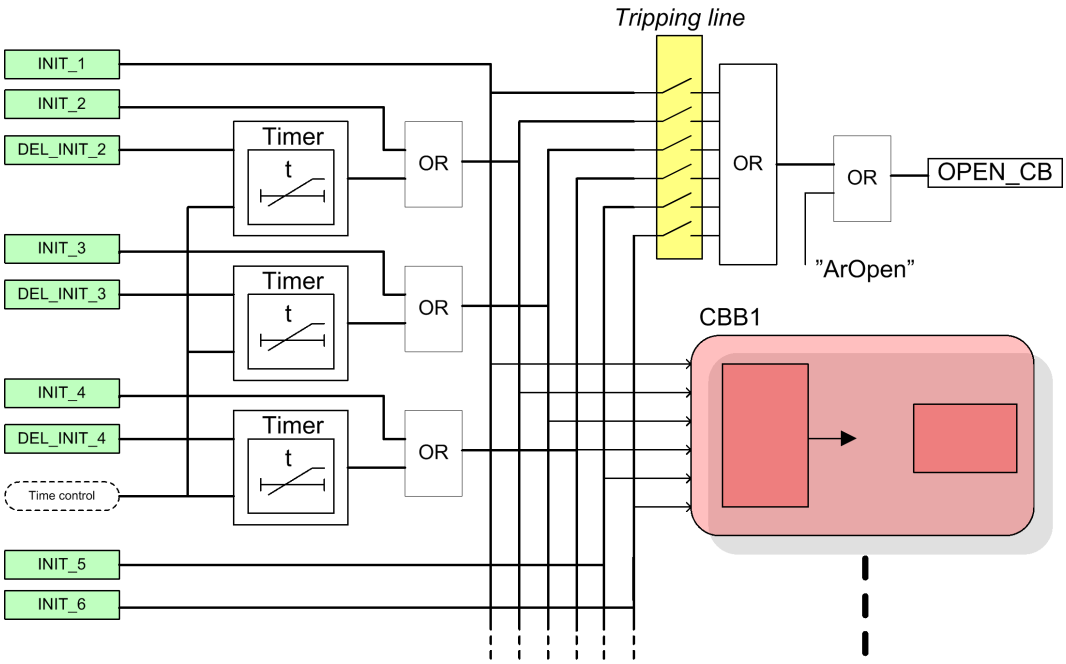



*Figure 913: Simplified logic diagram of initiation lines*

Each delayed initiation line has four different time settings:

**Table 1562: Settings for delayed initiation lines**

| Setting name | Description and purpose |
|---|---|
| *Str x delay shot 1* | Time delay for the DEL_INIT_x line, where x is the number of the line 2, 3 or 4. Used for shot 1. |
| *Str x delay shot 2* | Time delay for the DEL_INIT_x line, used for shot 2. |
| *Str x delay shot 3* | Time delay for the DEL_INIT_x line, used for shot 3. |
| *Str x delay shot 4* | Time delay for the DEL_INIT_x line, used for shots 4 and 5. Optionally, can also be used with SOTF. |

### 9.9.6.5 Shot initiation from protection start signal

In it simplest, all auto-reclose shots are initiated by protection trips. As a result, all trip times in the sequence are the same. This is why using protection trips may not be the optimal solution. Using protection start signals instead of protection trips for initiating shots shortens the trip times.

**Example 1**

When a two-shot-sequence is used, the start information from the protection function is routed to the DEL_INIT 2 input and the operate information to the INIT_2 input. The following conditions have to apply:

- protection operate time = 0.5s
- *Str 2 delay shot 1* = 0.05s

- *Str 2 delay shot 2* = 60s
- *Str 2 delay shot 3* = 60s

Operation in a permanent fault:

1. Protection starts and activates the DEL_INIT 2 input.
2. After 0.05 seconds, the first autoreclose shot is initiated. The function opens the circuit breaker: the OPEN_CB output activates. The total trip time is the protection start delay + 0.05 seconds + the time it takes to open the circuit breaker.
3. After the first shot, the circuit breaker is reclosed and the protection starts again.
4. Because the delay of the second shot is 60 seconds, the protection is faster and trips after the set operation time, activating the INIT 2 input. The second shot is initiated.
5. After the second shot, the circuit breaker is reclosed and the protection starts again.
6. Because the delay of the second shot is 60 seconds, the protection is faster and trips after the set operation time. No further shots are programmed after the final trip. The function is in lockout and the sequence is considered unsuccessful.

**Example 2**

The delays can be used also for fast final trip. The conditions are the same as in Example 1, with the exception of *Str 2 delay shot 3* = 0.10 seconds.

The operation in a permanent fault is the same as in Example 1, except that after the second shot when the protection starts again, *Str 2 delay shot 3* elapses before the protection operate time and the final trip follows. The total trip time is the protection start delay + 0.10 seconds + the time it takes to open the circuit breaker.

### 9.9.6.6 Fast trip in Switch on to fault

The *Str _ delay shot 4* parameter delays can also be used to achieve a fast and accelerated trip with SOTF. This is done by setting the *Fourth delay in SOTF* parameter to "1" and connecting the protection start information to the corresponding DEL_INIT_ input.

When the function detects a closing of the circuit breaker, that is, any other closing except the reclosing done by the function itself, it always prohibits shot initiation for the time set with the *Reclaim time* parameter. Furthermore, if the *Fourth delay in SOTF* parameter is "1", the *Str _ delay shot 4* parameter delays are also activated.

**Example 1**

The protection operation time is 0.5 seconds, the *Fourth delay in SOTF* parameter is set to "1" and the *Str 2 delay shot 4* parameter is 0.05 seconds. The protection start signal is connected to the DEL_INIT_2 input.

If the protection starts after the circuit breaker closes, the fast trip follows after the set 0.05 seconds. The total trip time is the protection start delay + 0.05 seconds + the time it takes to open the circuit breaker.

## 9.9.7 Signals

### 9.9.7.1 DARREC Input signals

**Table 1563: DARREC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| INIT_1 | BOOLEAN | 0=False | AR initialization / blocking signal 1 |
| INIT_2 | BOOLEAN | 0=False | AR initialization / blocking signal 2 |
| INIT_3 | BOOLEAN | 0=False | AR initialization / blocking signal 3 |
| INIT_4 | BOOLEAN | 0=False | AR initialization / blocking signal 4 |
| INIT_5 | BOOLEAN | 0=False | AR initialization / blocking signal 5 |
| INIT_6 | BOOLEAN | 0=False | AR initialization / blocking signal 6 |
| DEL_INIT_2 | BOOLEAN | 0=False | Delayed AR initialization / blocking signal 2 |
| DEL_INIT_3 | BOOLEAN | 0=False | Delayed AR initialization / blocking signal 3 |
| DEL_INIT_4 | BOOLEAN | 0=False | Delayed AR initialization / blocking signal 4 |
| BLK_RECL_T | BOOLEAN | 0=False | Blocks and resets reclose time |
| BLK_RCLM_T | BOOLEAN | 0=False | Blocks and resets reclaim time |
| BLK_THERM | BOOLEAN | 0=False | Blocks and holds the reclose shot from the thermal overload |
| CB_POS | BOOLEAN | 0=False | Circuit breaker position input |
| CB_READY | BOOLEAN | 1=True | Circuit breaker status signal |
| INC_SHOTP | BOOLEAN | 0=False | A zone sequence coordination signal |
| INHIBIT_RECL | BOOLEAN | 0=False | Interrupts and inhibits reclosing sequence |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| RECL_ON | BOOLEAN | 0=False | Level sensitive signal for allowing (high) / not allowing (low) reclosing |
| SYNC | BOOLEAN | 0=False | Synchronizing check fulfilled |

### 9.9.7.2 DARREC Output signals

**Table 1564: DARREC Output signals**

| Name | Type | Description |
|---|---|---|
| OPEN_CB | BOOLEAN | Open command for circuit breaker |
| CLOSE_CB | BOOLEAN | Close (reclose) command for circuit breaker |
| CMD_WAIT | BOOLEAN | Wait for master command |
| INPRO | BOOLEAN | Reclosing shot in progress, activated during dead time |
| LOCKED | BOOLEAN | Signal indicating that AR is locked out |
| PROT_CRD | BOOLEAN | A signal for coordination between the AR and the protection |
| UNSUC_RECL | BOOLEAN | Indicates an unsuccessful reclosing sequence |
| AR_ON | BOOLEAN | Autoreclosing allowed |
| READY | BOOLEAN | Indicates that the AR is ready for a new sequence, i.e. the CB_READY input equals TRUE |
| ACTIVE | BOOLEAN | Reclosing sequence is in progress |

## 9.9.8 DARREC Settings

**Table 1565: DARREC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off/On |
| Reclosing operation | 1=Off<br>2=External Ctl<br>3=On | | | 1=Off | Reclosing operation (Off, External Ctl / On) |
| Close pulse time | 10...10000 | ms | 10 | 200 | CB close pulse time |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reclaim time | 100...1800000 | ms | 100 | 10000 | Reclaim time |
| Terminal priority | 1=None<br>2=Low (follower)<br>3=High (master) | | | 1=None | Terminal priority |
| Synchronisation set | 0...127 | | 1 | 0 | Selection for synchronizing requirement for reclosing |
| Auto initiation cnd | 1=Not allowed<br>2=When sync fails<br>3=CB doesn't close<br>4=Both | | | 2=When sync fails | Auto initiation condition |
| Tripping line | 0...63 | | 1 | 0 | Tripping line, defines INIT inputs which cause OPEN_CB activation |
| Fourth delay in SOTF | 0=False<br>1=True | | | 0=False | Sets 4th delay into use for all DEL_INIT signals during SOTF |
| First reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB1 |
| Second reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB2 |
| Third reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB3 |
| Fourth reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB4 |
| Fifth reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB5 |
| Sixth reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB6 |
| Seventh reclose time | 0...300000 | ms | 10 | 5000 | Dead time for CBB7 |
| Init signals CBB1 | 0...63 | | 1 | 0 | Initiation lines for CBB1 |
| Init signals CBB2 | 0...63 | | 1 | 0 | Initiation lines for CBB2 |
| Init signals CBB3 | 0...63 | | 1 | 0 | Initiation lines for CBB3 |
| Init signals CBB4 | 0...63 | | 1 | 0 | Initiation lines for CBB4 |
| Init signals CBB5 | 0...63 | | 1 | 0 | Initiation lines for CBB5 |
| Init signals CBB6 | 0...63 | | 1 | 0 | Initiation lines for CBB6 |
| Init signals CBB7 | 0...63 | | 1 | 0 | Initiation lines for CBB7 |
| Shot number CBB1 | 0...5 | | 1 | 0 | Shot number for CBB1 |
| Shot number CBB2 | 0...5 | | 1 | 0 | Shot number for CBB2 |
| Shot number CBB3 | 0...5 | | 1 | 0 | Shot number for CBB3 |
| Shot number CBB4 | 0...5 | | 1 | 0 | Shot number for CBB4 |
| Shot number CBB5 | 0...5 | | 1 | 0 | Shot number for CBB5 |
| Shot number CBB6 | 0...5 | | 1 | 0 | Shot number for CBB6 |
| Shot number CBB7 | 0...5 | | 1 | 0 | Shot number for CBB7 |
| Frq Op counter limit | 0...250 | | 1 | 0 | Frequent operation counter lockout limit |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Frq Op counter time | 1...250 | min | 1 | 1 | Frequent operation counter time |
| Frq Op recovery time | 1...250 | min | 1 | 1 | Frequent operation counter recovery time |
| Auto init | 0...63 | | 1 | 0 | Defines INIT lines that are activated at auto initiation |

**Table 1566: DARREC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Manual close mode | 0=False<br>1=True | | | 0=False | Manual close mode |
| Wait close time | 50...10000 | ms | 50 | 250 | Allowed CB closing time after reclose command |
| Max wait time | 100...1800000 | ms | 100 | 10000 | Maximum wait time for BLK_RECL_T release |
| Max trip time | 100...10000 | ms | 100 | 10000 | Maximum wait time for deactivation of protection signals |
| Max Thm block time | 100...1800000 | ms | 100 | 10000 | Maximum wait time for thermal blocking signal deactivation |
| Cut-out time | 0...1800000 | ms | 100 | 10000 | Cutout time for protection coordination |
| Dsr time shot 1 | 0...10000 | ms | 100 | 0 | Discrimination time for first reclosing |
| Dsr time shot 2 | 0...10000 | ms | 100 | 0 | Discrimination time for second reclosing |
| Dsr time shot 3 | 0...10000 | ms | 100 | 0 | Discrimination time for third reclosing |
| Dsr time shot 4 | 0...10000 | ms | 100 | 0 | Discrimination time for fourth reclosing |
| Auto wait time | 0...60000 | ms | 10 | 2000 | Wait time for reclosing condition fullfilling |
| Auto lockout reset | 0=False<br>1=True | | | 1=True | Automatic lockout reset |
| Protection crd limit | 1...5 | | 1 | 1 | Protection coordination shot limit |
| Protection crd mode | 1=No condition<br>2=AR inoperative<br>3=CB close manual<br>4=AR inop, CB man<br>5=Always | | | 4=AR inop, CB man | Protection coordination mode |
| Control line | 0...63 | | 1 | 63 | Control line, defines INIT inputs which are protection signals |
| Enable shot jump | 0=False<br>1=True | | | 1=True | Enable shot jumping |
| CB closed Pos status | 0=False<br>1=True | | | 0=False | Circuit breaker closed position status |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Blk signals CBB1 | 0...63 | | 1 | 0 | Blocking lines for CBB1 |
| Blk signals CBB2 | 0...63 | | 1 | 0 | Blocking lines for CBB2 |
| Blk signals CBB3 | 0...63 | | 1 | 0 | Blocking lines for CBB3 |
| Blk signals CBB4 | 0...63 | | 1 | 0 | Blocking lines for CBB4 |
| Blk signals CBB5 | 0...63 | | 1 | 0 | Blocking lines for CBB5 |
| Blk signals CBB6 | 0...63 | | 1 | 0 | Blocking lines for CBB6 |
| Blk signals CBB7 | 0...63 | | 1 | 0 | Blocking lines for CBB7 |
| Str 2 delay shot 1 | 0...300000 | ms | 10 | 0 | Delay time for start2, 1st reclose |
| Str 2 delay shot 2 | 0...300000 | ms | 10 | 0 | Delay time for start2 2nd reclose |
| Str 2 delay shot 3 | 0...300000 | ms | 10 | 0 | Delay time for start2 3rd reclose |
| Str 2 delay shot 4 | 0...300000 | ms | 10 | 0 | Delay time for start2, 4th reclose |
| Str 3 delay shot 1 | 0...300000 | ms | 10 | 0 | Delay time for start3, 1st reclose |
| Str 3 delay shot 2 | 0...300000 | ms | 10 | 0 | Delay time for start3 2nd reclose |
| Str 3 delay shot 3 | 0...300000 | ms | 10 | 0 | Delay time for start3 3rd reclose |
| Str 3 delay shot 4 | 0...300000 | ms | 10 | 0 | Delay time for start3, 4th reclose |
| Str 4 delay shot 1 | 0...300000 | ms | 10 | 0 | Delay time for start4, 1st reclose |
| Str 4 delay shot 2 | 0...300000 | ms | 10 | 0 | Delay time for start4 2nd reclose |
| Str 4 delay shot 3 | 0...300000 | ms | 10 | 0 | Delay time for start4 3rd reclose |
| Str 4 delay shot 4 | 0...300000 | ms | 10 | 0 | Delay time for start4, 4th reclose |

## 9.9.9 DARREC Monitored data

**Table 1567: DARREC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| DISA_COUNT | BOOLEAN | 0=False<br>1=True | | Signal for counter disabling |
| FRQ_OPR_CNT | INT32 | 0...2147483647 | | Frequent operation counter |
| FRQ_OPR_AL | BOOLEAN | 0=False<br>1=True | | Frequent operation counter alarm |
| STATUS | Enum | -1=Not defined<br>1=Ready<br>2=InProgress<br>3=Successful<br>4=WaitingForTrip<br>5=TripFromProtection | | AR status signal for IEC61850 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 6=FaultDisappeared<br>7=WaitToComplete<br>8=CBclosed<br>9=CycleUnsuccessful<br>10=Unsuccessful<br>11=Aborted | | |
| INPRO_1 | BOOLEAN | 0=False<br>1=True | | Reclosing shot in progress, shot 1 |
| INPRO_2 | BOOLEAN | 0=False<br>1=True | | Reclosing shot in progress, shot 2 |
| INPRO_3 | BOOLEAN | 0=False<br>1=True | | Reclosing shot in progress, shot 3 |
| INPRO_4 | BOOLEAN | 0=False<br>1=True | | Reclosing shot in progress, shot 4 |
| INPRO_5 | BOOLEAN | 0=False<br>1=True | | Reclosing shot in progress, shot 5 |
| DISCR_INPRO | BOOLEAN | 0=False<br>1=True | | Signal indicating that discrimination time is in progress |
| CUTOUT_INPRO | BOOLEAN | 0=False<br>1=True | | Signal indicating that cut-out time is in progress |
| SUC_RECL | BOOLEAN | 0=False<br>1=True | | Indicates a successful reclosing sequence |
| UNSUC_CB | BOOLEAN | 0=False<br>1=True | | Indicates an unsuccessful CB closing |
| CNT_SHOT1 | INT32 | 0...2147483647 | | Resetable operation counter, shot 1 |
| CNT_SHOT2 | INT32 | 0...2147483647 | | Resetable operation counter, shot 2 |
| CNT_SHOT3 | INT32 | 0...2147483647 | | Resetable operation counter, shot 3 |
| CNT_SHOT4 | INT32 | 0...2147483647 | | Resetable operation counter, shot 4 |
| CNT_SHOT5 | INT32 | 0...2147483647 | | Resetable operation counter, shot 5 |
| COUNTER | INT32 | 0...2147483647 | | Resetable operation counter, all shots |
| SHOT_PTR | INT32 | 1...7 | | Shot pointer value |
| MAN_CB_CL | BOOLEAN | 0=False<br>1=True | | Indicates CB manual closing during reclosing sequence |
| SOTF | BOOLEAN | 0=False<br>1=True | | Switch-onto-fault |
| DARREC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

### 9.9.10 Technical data

**Table 1568: DARREC Technical data**

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0 % of the set value or ±20 ms |

## 9.10 Tap changer control with voltage regulator OL5ATCC (ANSI 90V)

### 9.10.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Tap changer control with voltage regulator | OL5ATCC | COLTC | 90V |

### 9.10.2 Function block




*Figure 914: Function block symbol*

### 9.10.3 Functionality

The tap changer control with voltage regulator function OL5ATCC (on-load tap changer controller) regulates the voltage of power transformers with on-load tap changers in distribution substations. OL5ATCC provides manual or automatic voltage control of the power transformer by using the raising or lowering signals to the on-load tap changer.

The automatic voltage regulation can be used in single or parallel transformer applications. The parallel operation can be based on the Master/Follower principle (M/F), Negative Reactance Principle (NRP) or Minimizing Circulating Current (MCC).

OL5ATCC includes the line drop compensation (LDC) functionality, and the load decrease is possible with a dynamic voltage reduction. Further, OL5ATCC can manage voltage regulation in case of reverse power flow.

Either definite time characteristic ( DT) or inverse time characteristic ( IDMT) is selectable for delays between the raising and lowering operations.

The function contains a blocking functionality. It is possible to block the voltage control operations with an external signal or with the supervision functionality of the function.

## 9.10.4 Analog channel configuration

Function block OL5ATCC has four analog group inputs which all must be properly configured. The table below presents inputs and their purpose.

**Table 1569: Analog inputs**

| Input | Purpose |
|---|---|
| I3P1 | Three-phase currents from transformer secondary side. |
| U3P1 | Three-phase voltages from transformer secondary side. |
| I3P2[1] | Three-phase currents from transformer primary side. |
| U3P2[1] | Three-phase voltages from transformer primary side. |

Please refer to Preprocessing function block section in this manual for possible signal sources.

There are few special conditions which must be noted with configuration. See *Table 1570*.

**Table 1570: Special conditions**

| Condition | Note |
|---|---|
| U3P1 or U3P2 connected to real measurements | Function can work with one voltage connected to channel 1 or with two voltages connected to channels 2 and 3 or with all three voltage channels connected. |

Improper analog channel configuration causes validation error in Application configuration tool. In such a case analog channels and certain settings are not matching. For troubleshooting, check the given material in this chapter. Configuration can be written to relay once the mismatch is corrected.

## 9.10.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of OL5ATCC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

[1] Should be connected to GRPOFF if HV side measurements are not available when “Regulation mode” is “Forward” or “Bi-dir(calc)”

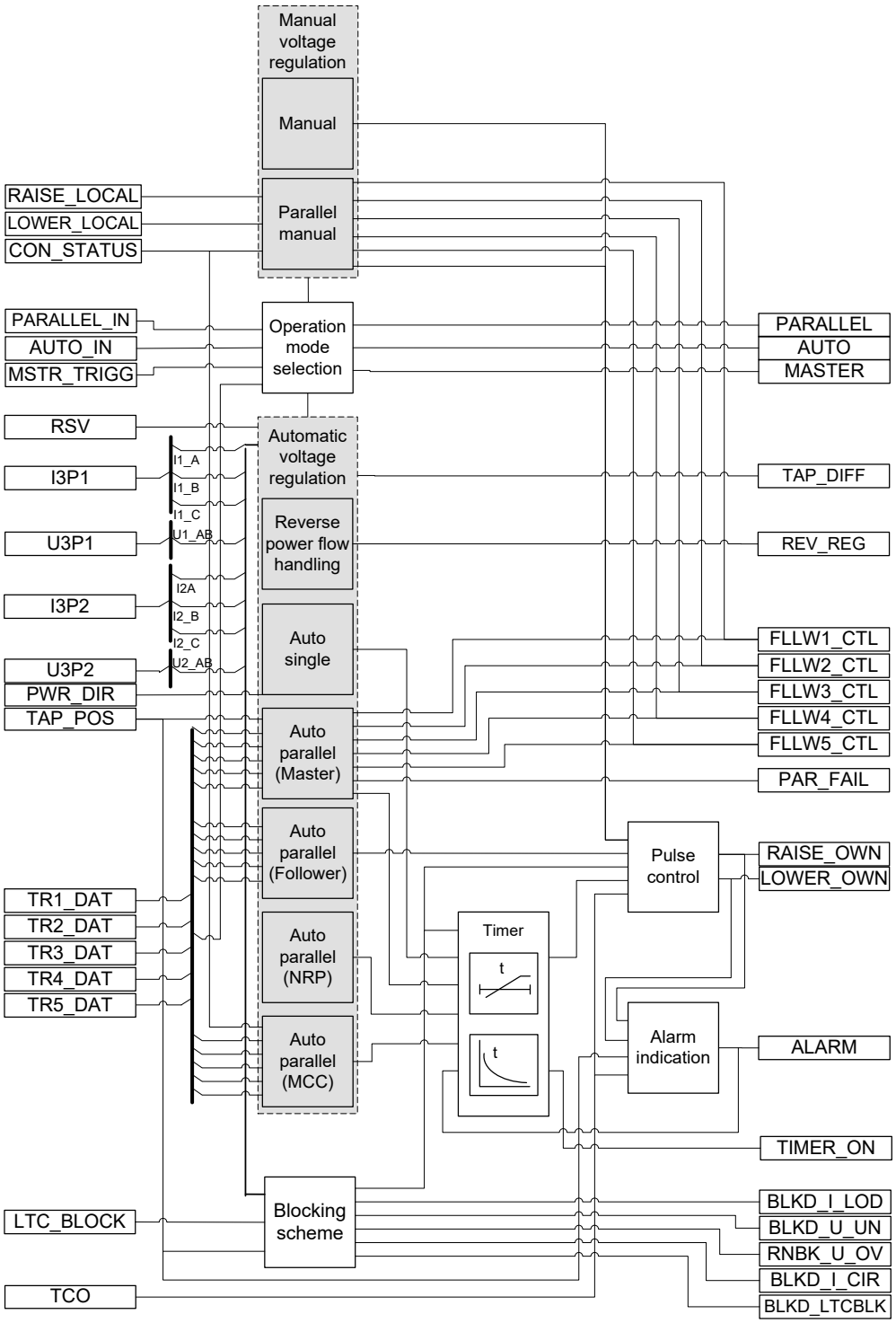



*Figure 915: Functional module diagram*

### 9.10.5.1 Voltage and current measurements

The measured voltage must be a phase-to-phase voltage from the regulated side. Typically, it is the phase-to-phase voltage U_AB from the secondary side

of the power transformer. If the phase voltages are measured, the voltage U_AB is calculated internally in the protection relay. In case bi-directional regulation is expected, then voltage measurement from primary side is also required. If not available, calculated values can be used under certain conditions.

The currents from the secondary side of the power transformer (I_x, where x is A, B or C) have several uses.

- The highest phase current value is used for overcurrent blocking.
- The currents from the secondary side of the power transformer are used for LDC (average of the connected inputs).
- The currents from the secondary side of the power transformer are used for calculating the circulating current in the NRP and MCC operation modes.

When reverse regulation takes place, primary side current measurements are expected and is used in a similar way.

Both voltage U_AB and the phase currents are always measured using the value of the filtered fundamental frequency component (DFT). Hence, the harmonics are always suppressed. Moreover, the measured voltage value is continuously average-filtered with the eight-value-long sliding window. The phase-compensated voltage U_A is always used in calculations, although it is not connected. This averaged value, the parameter $U_m$ in *Equation 384*, is used for control, and its magnitude can be read from the monitored data U_MEAS.

Similarly, the magnitude of the phase current of the own transformer, I_x, and the phase angle difference between the internally phase-compensated voltage U_A and phase current I_x (the angle difference used in *Equation 376* and *Equation 378*) are also average-filtered by the same fixed-length window. The phase angle value can be read from the monitored data ANGL_UA_IA. These currents and phase angle differences are used solely in circulating current calculations.

There are minimum limits for the voltage and current magnitudes, so the magnitude and phase angle difference values diverge from zero. The voltage magnitude must exceed three percent of $U_n$ and the current I_A must exceed two percent of $I_n$.

### 9.10.5.2 Tap changer position inputs

The position value of the tap changer can be brought to OL5ATCC as a resistance value, a mA signal or as a binary-coded signal. More information on how the resistance value, the mA signal or a binary-coded interface are implemented can be found in TPOSYLTC in this manual.

The indicated tap changer position of the own transformer is internally connected to the `TAP_POS` input, and the tap changer positions of the parallel transformers are fed to inputs `TRx_DAT` via data combiner function blocks OLGAPC. This also defines the connection identity so that follower 1 is connected to `TR1_DAT`, follower 2 is connected to `TR2_DAT` and follower 3 is connected to `TR3_DAT`. The own transformer position can be read from the input `TAP_POS`. The follower tap changer positions can be read from the input data `TR_TAP_POS` of OLGAPCx.

The tap changer position value is given in parentheses. For example, (0) indicates that there is no tap changer position connected or the quality of the tap changer position value is bad. Typically, if no tap changer position is connected, all the TPOSYLTC binary inputs are FALSE by default and the value shown is (0). A value other than zero indicates bad quality. OL5ATCC treats a bad-quality tap changer position as unconnected tap position information.

### 9.10.5.3 Operation mode selection

OL5ATCC has the *Operation mode* and *Parallel mode* settings for selecting the desired operation mode. The *Operation mode* setting can have any of the following values: "Manual", "Auto single", "Parallel manual", "Auto parallel", "Input control" and “Command”. If the *Operation mode* setting is set to "Input control", the active operation mode is determined by the inputs PARALLEL and AUTO.

The PARALLEL input defines if the transformer (voltage regulator) is in parallel or single mode. The AUTO input defines if the operation is in auto or manual mode. The PARALLEL and AUTO outputs represent acting “Parallel or single operation” and “Auto/Manual indication”, respectively.

When the *Operation mode* setting is set to "Command", the active operation mode is determined by the IEC 61850 command data points Auto and ParOp.

Furthermore, if the operation mode has been set to any parallel mode, that is "Parallel manual" or "Auto parallel" via the *Operation mode* setting, binary inputs or commands, the parallel mode is selected by the setting *Parallel mode*.

The *Parallel mode* setting can have any of following values: "Master", "Follower", "NRP", "MCC", "Input control" or "Command".

If the *Parallel mode* setting is set to "Input control", the active operation mode is determined by the input MSTR_TRIGG.

When the *Parallel mode* setting is set to "Command", the active operation mode is determined by the IEC 61850 command data point MstrOp.

MSTR_TRIGG is a rising edge input, that is, the master role is kept even though the MSTR_TRIGG input changes from “true” to “false”. This functionality is used because another parallel transformer must be able to assume the master role even though the MSTR_TRIGG input has remained in “true” state. Switching between operation mode states resets the internal master set. However, switching between Auto master mode and Parallel manual mode keeps the master role.

**Table 1571: Active operation mode when Operation mode setting is "Manual", "Auto single", "Parallel manual" or "Auto parallel"**

| Operation mode | Parallel mode | MSTR_TRIGG | OPR_MODE_STS |
|---|---|---|---|
| Manual | – | – | Manual |
| Auto single | – | – | Auto single |
| Parallel manual | Master | – | Parallel manual |
| Parallel manual | Input control Command | 0 [1] | Manual |
| Parallel manual | Input control Command | 1 [1] | Parallel manual |
| Auto parallel | Master | – | Auto master |
| Auto parallel | Follower | – | Auto follower |
| Auto parallel | MCC | – | MCC |
| Auto parallel | NRP | – | NRP |

*Table continues on the next page*

[1] The master role is set on rising edge and internally kept until another parallel transformer assumes the master role, or the operation mode is changed.

| Operation mode | Parallel mode | MSTR_TRIGG | OPR_MODE_STS |
|---|---|---|---|
| Auto parallel | Input control Command | 0 [1] | Auto follower |
| Auto parallel | Input control Command | 1 [1] | Auto master |

**Table 1572: Active operation mode when Operation mode setting is "Input control" or "Command"**

| PARALLEL | AUTO | Parallel mode | MSTR_TRIGG | OPR_MODE_STS |
|---|---|---|---|---|
| 0 | 0 | – | – | Manual |
| 0 | 1 | – | – | Auto single |
| 1 | 0 | Master | – | Parallel manual |
| 1 | 0 | Follower | – | Manual |
| 1 | 0 | MCC | – | Manual |
| 1 | 0 | NRP | – | Manual |
| 1 | 0 | Input control Command | 0 [1] | Manual |
| 1 | 0 | Input control Command | 1 [1] | Parallel manual |
| 1 | 1 | Master | – | Auto master |
| 1 | 1 | Follower | – | Auto follower |
| 1 | 1 | MCC | – | MCC |
| 1 | 1 | NRP | – | NRP |
| 1 | 1 | Input control Command | 0 [1] | Auto follower |
| 1 | 1 | Input control Command | 1 [1] | Auto master |

The active operation mode can be read from the monitored data OPR_MODE_STS.

**Command exclusion**

An active operation mode change using three inputs (PARALLEL, AUTO, MSTR_TRIGG and setting group change either by input or via menu) is needed when the active operation mode must be changed automatically, that is, there is a logic which drives these three inputs based on the status information from the circuit breakers.

The common Local/Remote (L/R) exclusion concerns the manual raise and lower commands of OL5ATCC, that is, it internally provides the exclusion mechanism to prevent remote commands (from SCADA) when the protection relay is in local mode and vice versa.

### 9.10.5.4 Manual voltage regulation

The manual raising and lowering commands can be given via the configuration inputs LOWER_LOCAL and RAISE_LOCAL, via the HMI of the protection relay or via

[1] The master role is set on rising edge and internally kept until another parallel transformer assumes the master role, or the operation mode is changed.

remote commands. The active operation mode of OL5ATCC must be set to "Manual" or "Parallel manual" and the Local/Remote control LR state monitored data of the protection relay has to be "Local" to execute the control commands manually from HMI or via configuration inputs. If OL5ATCC is set to "Manual" or “Parallel manual” but the LR state is set to "OFF" or "Remote", no manual control commands can be given.

For remote commands, the active operation mode of OL5ATCC must also be set to "Manual" or “Parallel manual” and the LR state monitored data has to be "Remote".

The manual raising or lowering commands can be given locally either via the *Manual control* parameter ("Cancel"/"Lower"/"Raise") located in the HMI menu **Control** > **OL5ATCC1** or via the configuration inputs LOWER_LOCAL or RAISE_LOCAL.

A raising command is given by selecting the enumeration value "Raise" and the lowering command is given by selecting the enumeration value "Lower". An accepted manual raising or lowering command activates the corresponding output RAISE_OWN or LOWER_OWN to control the voltage of the own transformer.

**Parallel manual voltage regulation**

While in single manual mode the voltage regulator acts independently, in parallel manual mode the voltage regulator set to “Parallel manual” acts as master and the others follow.

The parallel manual mode is intended for maintenance work and has no permanent settings. When the mode is set again to automatic, the voltage is stepped back to the set value.

Followers not responding to parallel manual command are indicated at output PAR_FAIL and the number of failed followers at monitored data FAIL_FLLW.

In parallel manual mode, the TR_STATUS monitored data indicates “Master” status to the other parallel transformers.

**Voltage control vs. tap changer moving direction**

OL5ATCC has the control settings *Lower block tap* and *Raise block tap* which give the tap changer position that results in the lowest and highest controlled voltage value (usually at the LV side of the transformer). *Raise block tap* can be set higher than *Lower block tap* and *Lower block tap* can be set higher than *Raise block tap*.

When the value of *Raise block tap* exceeds the *Lower block tap* value, the raise control activates the RAISE_OWN output. This results in raising the tap changer position, and the measured voltage rises. Furthermore, the RAISE_OWN output value is TRUE. If the own tap changer position is connected (that is, the own tap changer's quality is good), the tap changer alarm is activated if the tap changer does not move upwards within *Cmd error delay time* after the pulse activation. As a result, ALARM_REAS in the monitored data contains a command error value. The default value of the *Cmd error delay time* setting is 20 seconds.

The lowering control works in a similar way, as shown in *Figure 916*. In the output data, the LOWER_OWN output value is TRUE. An alarm is generated if the tap changer does not move downwards in *Cmd error delay time* after the pulse activation, assuming that the own tap changer position is connected.

In the second case, the parameters are set so that the value of Lower block tap exceeds the value of Raise block tap. The raising control activates the RAISE_OWN output. The result should be that the tap changer lowers its position and the measured voltage rises. Furthermore, the RAISE_OWN output value is TRUE in the

output data. If the own tap changer position is connected, the tap changer alarm is activated if the tap changer does not move downwards in *Cmd error delay time* after the pulse activation. As a result, ALARM_REAS in the monitored data contains a command error value.

The lowering control works in a similar way, as shown in *Figure 916*. In the output data, the LOWER_OWN output value is TRUE. An alarm is generated if the tap changer does not move upwards in *Cmd error delay time* after the pulse activation, assuming that the own tap changer position is connected. When doing HV side regulation, the *Lower block tap* and *Raise block tap* are internally reversed to achieve regulation of the primary side voltage of the transformer.

### 9.10.5.5 Automatic voltage regulation of single transformers (Auto single)

OL5ATCC is intended to control the power transformers with a motor-driven on-load tap changer. The function regulates the voltage at the secondary side (or primary side during HV side regulation) of the power transformer. The control method is based on a step-by-step principle, which means that one control pulse at a time is issued to the tap changer mechanism to move it exactly one position upwards or downwards. However, when intermediate steps are not indicated for the tap changer, it does not cause alarm if more than one step change is met.

The purpose of the regulator is to maintain a stable voltage on the regulated side of the power transformer. The basis for this operation is the *Band center voltage* setting. By increasing or decreasing various compensation factors, the regulator calculates a control voltage from the band center voltage as shown in *Equation 373*. Hence, the control voltage is the desired transformer regulated side voltage to be maintained by the regulator. The control voltage is compared to the measured voltage and the difference between the two forms the regulating process error.

Since the tap changer changes the voltage in steps, a certain error has to be allowed. The error, called *Band width voltage*, is also set by the user. A recommended setting for *Band width voltage* should be close to twice the step voltage of the transformer $\Delta U_{step}$ and never below it as a minimum. For example, *Band width voltage* is twice the value of $\Delta U_{step}$ in *Figure 916*.

If the measured voltage fluctuates within the control voltage ± half the *Band width voltage* setting, the regulator is inactive. If the measured voltage is outside the half-bandwidth voltage limits, an adjustable delay T1 ( *Control delay time 1* ) starts, as shown in *Figure 916*, where the lowering function is an example. The delay T1 remains active as long as the measured voltage is outside the hysteresis limits of half the value of *Band width voltage*. The factory setting for the hysteresis is 10 percent of the set *Band width voltage*.

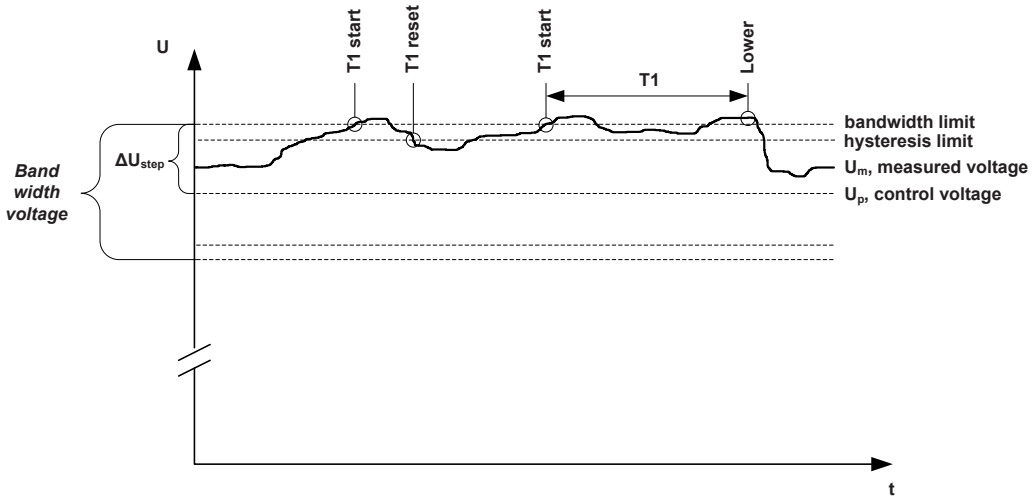



*Figure 916: Voltage-regulating function. A control pulse to lower the voltage is issued after the elapsed T1.*

If the measured voltage is outside the hysteresis when the delay counter T1 reaches its setting value, the raising or lowering output relay is activated. This activates either output pulse RAISE_OWN or LOWER_OWN, and the motor drive of the tap changer operates. The status of these outputs can be read from the output data RAISE_OWN or LOWER_OWN.

If the measured voltage falls or rises within the hysteresis limits during the operating time, the delay counter is reset.

The pulse length can be defined with the *LTC pulse time* setting. The default value is 1.5 seconds.

A short delay, same as the typical tap changer operating time, is active before the start of the next operating timer. For OL5ATCC, the delay is set to 6 seconds. If one tap changer operation is not enough to regulate the transformer voltage within the hysteresis limits, a second adjustable delay T2 (*Control delay time 2*), usually with a shorter time setting than T1, starts. This delay is used for the control commands within the same sequence until the recovery of voltage occurs. The delays T1 and T2 can be selected either with definite or inverse time characteristics. In the inverse time mode, the operate time depends on the difference between the control voltage and the measured voltage as shown in *Equation 384*. The bigger the difference in the voltage, the shorter the operating time. More information on the inverse time operation can be found in the *Chapter 9.10.5.8 Timer characteristics*.

**Regulation equation**

The simple regulating principle is often complemented by additional features to take the voltage drop of lines into account (line drop compensation), coordinate the regulation of parallel transformers and change the voltage level according to the loading state of the network. The control voltage $U_p$ is calculated according to the equation

$$U_p = U_s + U_z + U_{ci} - U_{rsv}$$

(Equation 373)

| | |
|---|---|
| $U_p$ | Control voltage |
| $U_s$ | Set voltage level *Band center voltage* |
| $U_z$ | Line drop compensation term |
| $U_{ci}$ | Circulating current compensation term |
| $U_{rsv}$ | Voltage reduction parameter |

$U_p$ can be directly read in the monitored data U_CTL.

The circulating current compensation term is calculated only in the parallel acting operation modes "NRP" and "MCC".

**Line Drop Compensation (LDC)**

The LDC feature is used to compensate the voltage drop along a line or network fed by the transformer. The compensation setting parameters can be either calculated if the resistance and reactance of the line are known or measured from the line drop.

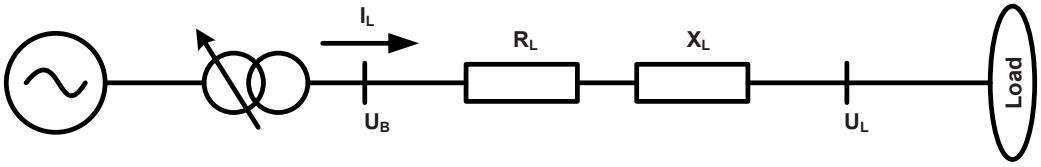



*Figure 917: Equivalent electrical circuit for calculating the LDC term*

The compensation parameters *Line drop V Ris* ($U_r$) and *Line drop V React* ($U_x$), are percentage values of $U_n$ according to the equations.

$$Line\ drop\ V\ Ris = U_r[\%] = \frac{\sqrt{3} \cdot I_{CT_n1} \cdot R}{U_{VT_n1}} \cdot 100 \quad [\%U_n]$$

$$Line\ drop\ V\ React = U_x[\%] = \frac{\sqrt{3} \cdot I_{CT_n1} \cdot X}{U_{VT_n1}} \cdot 100 \quad [\%U_n]$$

(Equation 374)

| | |
|---|---|
| $I_{CT_n1}$ | Nominal primary current of the CT |
| $U_{VT_n1}$ | Nominal primary voltage of the VT (phase-to-phase voltage) |
| R | Resistance of the line, Ω/phase |
| X | Reactance of the line, Ω/phase |

The general LDC equation can be calculated.

$$U_z = \frac{I_L}{I_{CT_n1}} \cdot \frac{\left(U_r[\%]\cos\varphi + U_x[\%]\sin\varphi\right)}{100} \quad [xU_n]$$

(Equation 375)

| | |
|---|---|
| $I_L$ | Average of the currents I_A, I_B and I_C |
| $I_{CT_n1}$ | Nominal primary current of the CT |
| $U_r$ | Setting *Line drop V Ris* |

*Table continues on the next page*

| | |
|---|---|
| $U_x$ | Setting *Line drop V React* |
| ϕ | Phase angle between U_A and I_A (ANGL_UA_IA) |

By default, LDC is not active, but it can be activated by setting *LDC enable* to "True". To keep the LDC term within acceptable limits in all situations, OL5ATCC has a setting parameter *LDC limit*, which has a default value of 0.10 $xU_n$. This gives the maximum value for $U_z$ in *Equation 373*.

If more than one line is connected to the LV busbar, the equivalent impedance is calculated and given as a parameter setting as shown in *Figure 917* for the equivalent electrical circuit for calculating LDC. For example, if there are N number of identical lines with identical loads in the substation, the R- and X-values needed for the settings *Line drop V React* and *Line drop V Ris* are obtained by dividing the resistance and the reactance of one line by N. Because the voltage drop is different in lines with different impedances and load currents, it is necessary to make a compromise when setting the *Line drop V React* and *Line drop V Ris* settings. Raising the voltage in the point of lowest voltage must not lead to overvoltage elsewhere.

By default, LDC is effective only on the normal active power flow direction. If the active power flow in the transformer turns opposite, that is, from the regulated side towards the system in the upper level, the LDC term is ignored, that is, set to zero. In such a case, it is assumed that the feeding units at the regulated side of the transformers maintain proper voltage levels. This can cause a conflict if the transformer tries to reduce the voltage at the substation. Additionally, it is difficult to predict the actual voltage levels in the feeder lines in such a case, and lowering the voltage at the substation can have harmful effects in the far end of the network. However, the *Rv Pwr flow allowed* setting allows also negative LDC terms to be taken into equation.

The topology changes in the network can cause changes to the equivalent impedance value of the network. If the change is substantial, the setting groups can be used to switch between different setting values for *Line drop V React* and *Line drop V Ris*. This means that the boolean-type information from the topology change is connected to the active setting group change.

The use of the LDC equation in the case of parallel transformers is described in *Chapter 9.10.5.6 Automatic voltage regulation of parallel transformers (Auto parallel)*.

**Reduce Set Voltage (RSV) input**

The system frequency decreases when the active power production in the network is smaller than its consumption. Either the power supply has to be increased or some loads have to be shed to restore the power balance.

The simplest way to decrease the load is to reduce the voltage level by giving a lower band center voltage value to the regulators. For this purpose, OL5ATCC has the setting group parameter *Band reduction*. The RSV input activation results in reduction. If this input is set to TRUE, a set target voltage value is decreased by *Band reduction*. If more than one RSV reduction steps are desired, the setting group change has to be used where different *Band reduction* values are supported. The decreased value is kept as a target value as long as the RSV input is TRUE.

Because the decrease of frequency indicates a need to reduce the load, it is practical to connect the start signal of an underfrequency function block to the RSV digital input.

It depends on the load characteristics how much the load is reduced as the voltage drops. For instance, purely resistive loads are proportional to the square of the voltage, whereas motor drives based on frequency controllers may draw constant power despite small voltage changes.

The status of the RSV input can be read from the RSV input data.

### 9.10.5.6 Automatic voltage regulation of parallel transformers (Auto parallel)

A circulating current may occur between transformers if two or more transformers with slightly different ratios are energized in parallel. This is due to the unbalanced short circuit impedances of the parallel transformers. To avoid such currents, the tap changers of the transformers should be adjusted to achieve equilibrium. If the transformers are assumed identical, the tap (voltage) steps and tap positions should also match. In this case, the Master/Follower principle can be used. However, unequally rated transformers with different tap steps can be connected in parallel and these configurations can also be managed by the tap changer control function. For these configurations, the Minimizing Circulating Current (MCC) or Negative Reactance Principle (NRP) should be used. MCC and NRP are also suitable for identical transformers.

The circulating current, which is almost purely inductive, is defined as negative if it flows towards the transformer. $U_{ci}$ in *Equation 373* is positive and the control voltage $U_p$ rises as a result to the RAISE_OWN output signal activation if the circulating current level is sufficient ( *Equation 377* and *Equation 379*) and the other parameters remain the same. As a result, the voltage rise should diminish the circulating current.

#### LDC equation and parallel connection

The additional challenge in the parallel connection regarding LDC is to know the total current which flows through the parallel transformers.

In the Master/Follower mode, it is easier to know the total current than in other parallel modes since the transformers are assumed to have identical ratings, that is, the total current ($I_L$ in *Equation 375*) is obtained by multiplying the measured load current (the average of the currents I_A, I_B and I_C of the connected own transformer) by the number of parallel transformers. OL5ATCC can internally conclude the number of parallel transformers from the connected tap changer position inputs. However, if there is no connected position information from the other parallel transformers, the correct number of the parallel transformers, excluding the own transformer, needs to be set with the *Parallel trafos* setting.

In the MCC mode, the horizontal communication transfers the information from the measured load currents between the regulators so that the total current needed in the line drop compensation can be summed accurately. Here, $I_L$ is defined to be the phasor sum of all the parallel power transformer currents. The currents from other transformers must be fed via the TR_I_AMPL and TR_I_ANGL inputs of the OLGAPC function.

In the NRP mode, the parallel transformers have different ratings and there is no communication between the regulators. Therefore, when setting *Line drop V React* and *Line drop V Ris*, the $I_{CT_n1}$ used in the equation should be the sum of the rated currents of all the transformers operating in parallel. Here, $I_L$ is also defined as the average of the currents (I_A, I_B and I_C). The calculated line drop compensation value can be read from the monitored data LDC.

### Master/Follower principle M/F

The M/F operation principle is suitable for power transformers with identical ratings and step voltages. One voltage regulator (master) measures and controls and the other regulators (followers) follow the master, that is, all the tap changers connected in parallel are synchronized. This parallel operation is obtained by connecting the FLLWx_CTL output of the master to the corresponding OLGAPC function input TR_TAP_FLLW of the followers via horizontal GOOSE communication.

The values for the FLLWx_CTL command are 1=Lower follower x and 2=Raise follower x. Consequently, the values for OLGAPC function TR_TAP_FLLW command are 1=Lower and 2=Raise.

If several regulators act as masters (one at a time), their outputs also have to be routed to the inputs of the other regulators. To start the parallel operation, the master regulator is set to the "Auto master" mode and the followers to the "Auto follower" mode. A regulator acting as a follower can be set to master in three ways.

- Activating input MSTR_TRIGG if *Parallel mode* is set to "Input control"
- Activating MstrOp via communication if *Parallel mode* is set to "Command"
- Activating the Master Trig button in the LHMI control dialog for OL5ATCC if *Parallel mode* is set to "Command"

The regulator indicates its master status (“Independent”, “Master” or “Follower”) by the TR_STATUS monitored data. A parallel regulator, previously acting as master, receives this signal via the TR_STATUS input of OLGAPC and changes its status to follower.



Connect the TR_STATUS input to the OLGAPC of the parallel transformer and route the TR_DAT output from OLGAPC to OL5ATCC TRx_DAT for proper M/F functionality. If TR_STATUS is left unconnected, that particular parallel transformer is assumed to not be participating even though receiving valid tap position information.

To keep all the tap changers in the same position, the master needs to know the tap positions of the followers. This way, the circulating current is kept at its minimum. The position values of the followers can be brought to the master either via horizontal GOOSE communication or TPOSYLTC.

If it is not possible to use horizontal communication between the protection relays and the position information cannot be wired from the parallel transformers, the M/F principle can still be used to regulate two or an unlimited number of transformers in parallel. Since the master cannot detect the tap positions of parallel transformers, it just activates the lowering and raising outputs for all the followers when it controls its own tap changer. This is called blind control. In this case, a number of parallel transformers are regulated as one unit.

The combined data inputs TRx_DAT must be left unconnected for the master to know that the tap positions of the followers are unknown. The time delay between successive commands can be set by the *Follower delay time* setting. The default value is 6 seconds.

When a disconnected transformer is taken into use and the tap position is unknown, it is recommended that the follower should be manually controlled to the same position as the master. In the M/F mode, the master gives its own transformer a control command which is echoed to the followers (the follower's tap positions must be connected). Thereafter, successive control commands to the followers take place until the master and followers have the same tap positions.

To indicate if a follower is on a different tap position compared to the active master, TAP_DIFF output is set to TRUE at that specific follower. Even though the follower transformer is not yet included in parallel connection, that is, its TR_STATUS is “Independent”, tap difference to master can be indicated. To enable TAP_DIFF output usage, valid tap position TR_TAP_POS and M/F status TR_STATUS from master must be routed through OLGAPC to the follower. The TAP_DIFF output can be used as an alarm or to block the closing of the circuit breaker of the follower transformer.

**Out-of-step function**

The out-of-step means that the master detects a difference of at least one step between the tap changer positions in the follower and in the master. The out-of-step function is usually used in the M/F mode only. The out-of-step function means that the master is able to detect the position values of the followers and control them to the same position as the master's. In this case, the master assumes that the followers also have either *Raise block tap* higher than *Lower block tap* or *Lower block tap* higher than *Raise block tap* because this defines what is the given command pulse for a follower. If the master has *Raise block tap* higher than *Lower block tap* and the follower has *Lower block tap* higher than *Raise block tap*, the corresponding tap changer follow included control signals should be connected crosswise. This requires extra logic where dual point command bits have to be converted, that is, 0=>0, [01]=1=>[10]=2 and [10]=2=>[01]=1.

M/F is the only parallel mode which has an out-of-step functionality. In the MCC and NRP operation modes, the circulating current is minimized, which often means different tap positions in the parallel transformers. Moreover, these modes allow different ratings and step voltages for the parallel transformers. Therefore, it is reasonable to apply the out-of-step function only to the M/F operation mode.

In an out-of-step situation at startup, follower commands take place only after the master has given its own control command, which is echoed to the followers. This is followed by special raise or lower commands to the diverging follower.

By setting the parameter *Inst out of step Cor* to "TRUE", an out-of-step situation at startup sends special raise or lower commands to the diverging follower after *Follower delay time*. *Inst out of step Cor* is by default set to "FALSE".

If two consecutive commands fail to change the position of the follower to the right direction, the master activates the PAR_FAIL output, that is, PAR_FAIL is set to TRUE, and stops the special recovery efforts. However, every time the master controls its own tap changer later, it sends a controlling pulse to the diverging follower too. Furthermore, if the master notices a correct position change after a sent pulse, it restarts the attempts to drive the follower to the same position and deactivates the PAR_FAIL output, that is, PAR_FAIL is set to FALSE. However, if there still are diverging followers, the reset is not indicated. It is indicated only when no diverging followers exist. Monitoring, and hence the indication of a paralleling failure, is not possible in blind control.

The followers with a parallel failure can be read from the monitored data FAIL_FLLW. For example, if only follower 3 is in the parallel failure state, FAIL_FLLW has the value "T3". If both followers 1 and 2 are in the parallel failure state, FAIL_FLLW has the value "T1+T2". By default, when no failed followers exist, the value is "No failed followers".

**Negative Reactance Principle NRP**

This parallel control scheme is suitable for power transformers with different ratings and step voltages. Since no communication between the regulators is needed, this principle can be applied even when the parallel transformers are located at different substations. To start the parallel operation, the active operation mode has to be set to "NRP" for all the regulators of the connection. The active operation mode can be changed via function block inputs or by setting it either locally or remotely.

When applying this principle, each regulator has a phase angle setting $\phi_{Load}$ (setting parameter *Load phase angle*) towards which it tries to regulate the current. The setting value is chosen according to the expected power factor of the load (positive setting value equals inductive load). When the actual phase angle of the load current is the same as the setting and the transformers and their tap changer positions are identical, the currents of the transformers are in the same phase as the total load current. If the tap changer positions are different, the circulating current flows and the currents of different transformers either lag or lead the load current. *Figure 918* shows that the circulating current is the reactive component which separates the measured current vector from the expected angle value.

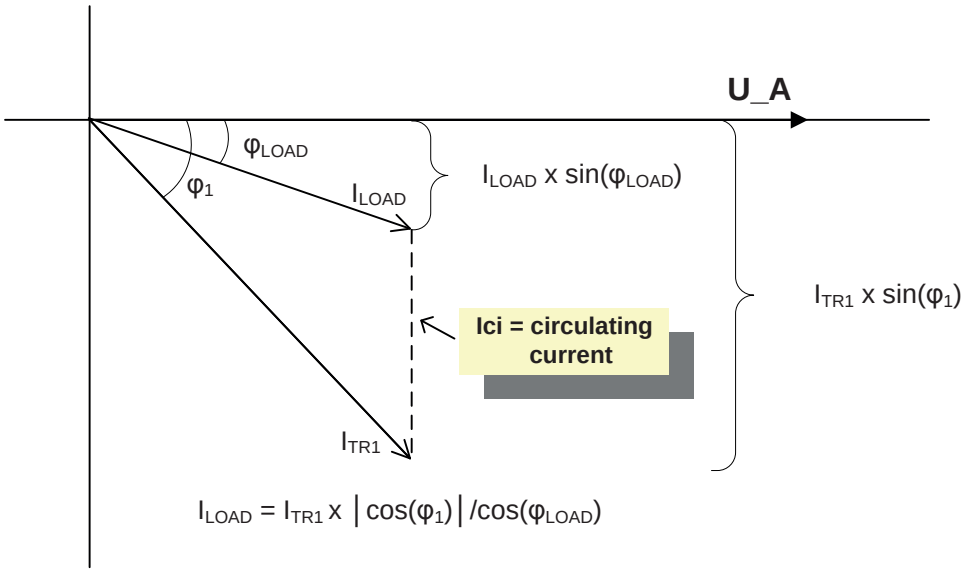



*Figure 918: The expected phase angle of the load supplied by the transformers operating in parallel is entered as a setting value ϕLoad*

The regulators calculate the circulating current with the equation

$$I_{ci} = (\sin\varphi_1 - \tan\varphi_{Load} \cdot |\cos\varphi_1|) \cdot I_{TR1}$$

(Equation 376)

| | |
|---|---|
| $I_{TR1}$ | Average of the currents I_A, I_B and I_C |
| $\phi_1$ | Phase angle between U_A and I_A |
| $\phi_{Load}$ | Set *Load phase angle* of the load current |

In the negative reactance method, the circulating current is minimized by changing the control voltage according to the measured circulating current. The regulator

calculates the circulating current compensation term $U_{ci}$ ( *Equation 373*) as in the MCC.

$$U_{ci} = \frac{-I_{ci}}{I_n} \cdot \frac{Stability\ factor}{100} \cdot U_n$$

(Equation 377)

| | |
|---|---|
| $I_{ci}$ | Circulating current |
| *Stability factor* | Stability setting (the recommended value depends on the loop impedance) |

If the transformers operating in parallel have different rated currents, the value of the *Stability factor* setting of the regulator should be proportional to the rated currents, that is, the higher the rated current, the higher the *Stability factor* setting value.

It is possible to find out if the circulating current has been minimized by comparing the reactive components of the currents measured by the different regulators. The circulating current is minimized when the reactive components are equal.

The negative reactance method gives satisfactory results only if the phase angle of the load current is known relatively accurately. If the actual phase angle deviates from the phase angle setting, a regulating error occurs. However, if there is an occasional stepwise change in the phase angle of the load, the regulating error can be suppressed with the logic. This kind of stepwise change can occur, for example, when a capacitor bank is switched on to compensate a reactive power flow. Another possibility is to use an automatic setting group change between setting groups in different loading situations. The setting groups then have different set values for the load phase angle.

**Minimizing Circulating Current MCC**

The MCC principle is an optimal solution for controlling parallel transformers of different ratings or step voltages in substations with varying reactive loads. Since this control scheme allows the exchange of data between regulators, the circulating current can be calculated more accurately than with other schemes. However, a maximum of six regulators can be connected in parallel. To start the parallel operation, the active operation mode parameter has to be set to "MCC" for all the regulators of the connection. Furthermore, the signal `CON_STATUS` must indicate that the transformers are connected to the network. A unit that minimizes the circulating current must have the active operation mode set to "MCC". Units that have the active operation mode set to "Manual" do not perform any circulating current minimization operations themselves.

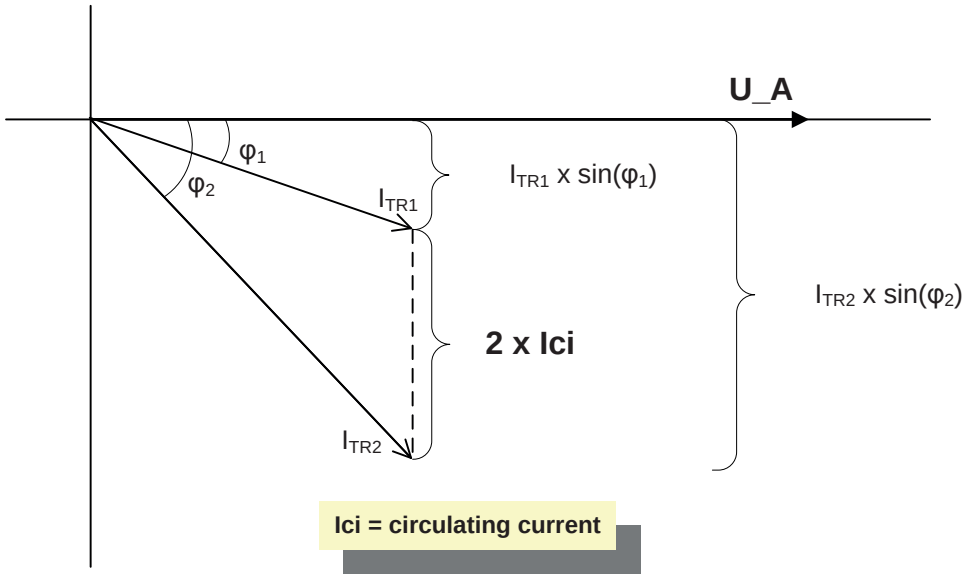



*Figure 919: The circulating current between two parallel transformers*

In this case, the circulating current can be calculated with the equation

$$I_{ci} = \frac{(\sin\phi_1 \cdot I_{TR1} - \sin\phi_2 \cdot I_{TR2})}{2}$$

(Equation 378)

| | |
|---|---|
| $I_{TR1}$ | Current magnitude of regulator 1 |
| $I_{TR2}$ | Current magnitude of regulator 2 |
| $\phi_1$ | Phase angle between U_A and I_A in regulator 1 |
| $\phi_2$ | Phase angle between U_A and I_A in regulator 2 |

The circulating current can be read from the monitored data I_CIR.

Using the circulating current, the compensation term $U_{ci}$ can be calculated with the equation

$$U_{ci} = \frac{-I_{ci}}{I_{CT_n1}} \cdot \frac{Stability\ factor}{100} \cdot U_n$$

(Equation 379)

| | |
|---|---|
| $I_{ci}$ | Circulating current |
| $I_{CT_n1}$ | Nominal primary current of the CT |
| *Stability factor* | Stability setting (the recommended value depends on the loop impedance) |

The value of $U_{ci}$, which can be positive or negative, is added to the *Band center voltage Us* ( *Equation 373*). According to *Figure 919* and *Equation 378*, the phasor information from the other protection relays is needed.

#### Parallel unit detection and the MCC mode

The network connection status information is essential for the MCC operation mode. The status FALSE needs to be connected to the CON_STATUS input to ensure a proper operation of the MCC calculation if the transformer is disconnected but OL5ATCC remains in the MCC mode. This way the disconnected transformer is excluded from the circulating current calculations.

The CON_STATUS input is used to identify if a transformer controller can send the current information to other transformer controllers for circulating current minimization purposes. As a result, this input has effect only in the MCC or Manual active operation modes. In these modes, if CON_STATUS is TRUE, the information transmission is started. The circulating current information receiving is allowed only in the MCC active operation mode when CON_STATUS is TRUE. PAR_UNIT_MCC can be seen in the Monitored data view.

#### Communication and the MCC mode

The phasor information from the other parallel protection relays is needed for the circulating current calculation. Therefore, horizontal GOOSE communication is needed between protection relays when the MCC principle is used.

The transferred current phasor information contains a primary value of the measured current. The magnitude and angle of the current phasor can be read from the OLGAPC function input data TR_I_AMPL and TR_I_ANGL, respectively.

The sent phasor information always represents the difference between the voltage phasor *U_A* and current phasor *I_A*. The information about the current phasor can be read from the monitored data TR0_I_AMPL and TR0_I_ANGL. The allowed active operation modes for sending data are MCC or Manual, both with the input CON_STATUS activated. The communication is active when the sent and received phasor magnitude is not clamped to zero. The communication phasor magnitude is zero due to a rejected active operation mode or too low signal magnitudes (see *Chapter 9.10.5.1 Voltage and current measurements*). Active CON_STATUS indicates that the corresponding transformer is connected to the network and its current affects the circulating current of other transformers even when it is in the manual operating mode.

### 9.10.5.7 Reverse power flow handling

Power flowing through the transformer can be bi-directional under certain circumstances. Traditionally, power flows from high voltage (HV) side to medium voltage (MV) side. In this case the target is to keep the MV side voltage constant despite of load current and HV side voltage variations. This is achieved by monitoring the MV side voltage and controlling tap changer position accordingly. Increasing the HV winding turns will lower the MV side voltage and vice versa.

But when power flow direction changes from the MV side to the HV side, the relay has to adapt to this situation based on the *Regulation Mode* setting.



The direction of power flow in all the parallel connected transformers should be same at any given point of time.

If the *Regulation Mode* is set as “Forward”, normal regulation of MV side voltage takes place irrespective of the power flow direction, If the setting is kept as “Bi-dir(meas)” or “Bi-dir(calc)”, when power flow direction reverses, the target is to keep

the HV side voltage constant despite of variations in the load current and the MV side voltage. This is achieved by monitoring the HV side voltage.

"Bi-dir(meas)" or "Bi-dir(calc)" set values should be used only when it is clear that the source of reverse power flow is a strong source.

If HV side measurements are directly available, "Bi-dir(meas)" mode can be used. If it is not available, "Bi-dir(calc)" can be set and HV side values are calculated (after power reversal) from MV side measurements with the help of settings *Step of tap*, *Tap nominal* and *Impedance voltage* as given below.

If *Raise block tap* > *Lower block tap*, then HV side voltage and current are calculated as

$$U_{HV} = \{1 + (TAP_POS - TAP_NOM) * \Delta U_{step}\} * \{U_{MV} - I_{MV} * ZV\}$$

(Equation 380)

$$I_{HV} = \frac{I_{MV}}{\{1 + (TAP_POS - TAP_NOM) * \Delta U_{step}\}}$$

(Equation 381)

If *Raise block tap* < *Lower block tap*, then HV side voltage and current are calculated as

$$U_{HV} = \{1 + (TAP_NOM - TAP_POS) * \Delta U_{step}\} * \{U_{MV} - I_{MV} * ZV\}$$

(Equation 382)

$$I_{HV} = \frac{I_{MV}}{\{1 + (TAP_NOM - TAP_POS) * \Delta U_{step}\}}$$

(Equation 383)

| | |
|---|---|
| $U_{HV}$ | HV side voltage which will be compared with control voltage $U_p$ for HV side regulation |
| $I_{HV}$ | HV side current |
| $U_{MV}$ | MV side measured voltage |
| $I_{MV}$ | MV side measured current |
| TAP_NOM | *Tap nominal* |
| TAP_POS | Own tap position |
| $\Delta U_{step}$ | *Step of Tap* |
| ZV | Impedance voltage referred to MV side |

When "Bi-dir(calc)" set value is used, it is mandatory that own tap position information should be connected.

Since it is not always possible to know the source strengths on either side of the transformer, an additional setting option "Auto select" is also provided. If the *Regulation mode* is set as "Auto select", the direction of regulation will be automatically selected by OL5ATCC function as below. A power ratio factor (PRF) is calculated by the OL5ATCC function utilizing HV and MV side voltage and current

measurements. If this factor is less than 1, it implies that the source on MV side is comparatively weak and hence forward regulation will be carried out. Here, if *LDC enable* is set as TRUE, then *Rv pwr flow allowed* must be internally set as TRUE if not already so.

If PRF > 1, it implies that the source on MV side is stronger and then HV side regulation will take place. It should be noted that in HV side regulation, increasing the HV winding turns will increase the HV side voltage and vice versa. The commands issued will be opposite of that issued for forward regulation. The output REV_REG is activated during HV side regulation, which can be used to select the setting group which gives the line parameters on HV side for LDC.

If *Regulation mode* is set as “Auto select”, measurements from both HV and MV side should be available for the accuracy of PRF calculation.

### 9.10.5.8 Timer characteristics

#### Operation timer functionality

The delay times can be set to follow either the definite time characteristic or the inverse time characteristic with the *Delay characteristic* setting. By default, the "Definite time" mode is selected. The timer mode cannot be changed between cycles T1 and T2, only either before T1 has started or after T2 has elapsed.

**Table 1573: Different timer mode delays**

| Timer mode | Setting | Description |
|---|---|---|
| T1 | *Control delay time 1* | First delay when the measured voltage exceeds or falls below the limit value. |
| T2 | *Control delay time 2* | Second delay when the first control did not bring the measured voltage to a desired level. |

The delay after the command pulse activation and the restart of the timer is six seconds. The delay is assumed to be the tap changer operating delay. The timer status can also be read from the monitoring data TIMER_STS, where T1 active gives a value "Lower timer1 on" or "Raise timer1 on" while T2 active gives a value "Lower timer2 on" or "Raise timer2 on". Furthermore, the "Fast lower T on" value indicates that the fast lowering control functionality is active (*Chapter 9.10.5.10 Blocking scheme*).

Activation of operation timer also activates the `TIMER_ON` output.

#### IDMT type operation

The IDMT timer can be selected by setting *Delay characteristic* to "Inverse time". The minimum time at the inverse time characteristic is limited to 1.0 second. However, the minimum recommended setting of the control delay times T1 and T2 is 10 seconds when the definite time delay is used and 25 seconds when the inverse time delay is used.

The inverse time function is defined by the equations:

$$B = \frac{U_d}{(U_{BW} / 2)}$$

(Equation 384)

| | |
|---|---|
| $U_d$ | $\lvert U_m - U_p \rvert$, differential voltage |
| $U_{BW}$ | Setting parameter *Band width voltage* |

$$t = \frac{T}{2^{(B-1)}}$$

(Equation 385)

| | |
|---|---|
| T | T1 or T2 |

The monitored data UD_CTL shows the differential voltage value $U_m - U_p$. If the value exceeds half of the *Band width voltage* setting and has a negative sign, a raising pulse is issued. The UD_CTL monitored data can also be seen in the DT timer mode.

The hysteresis approach is presented in *Figure 916*.

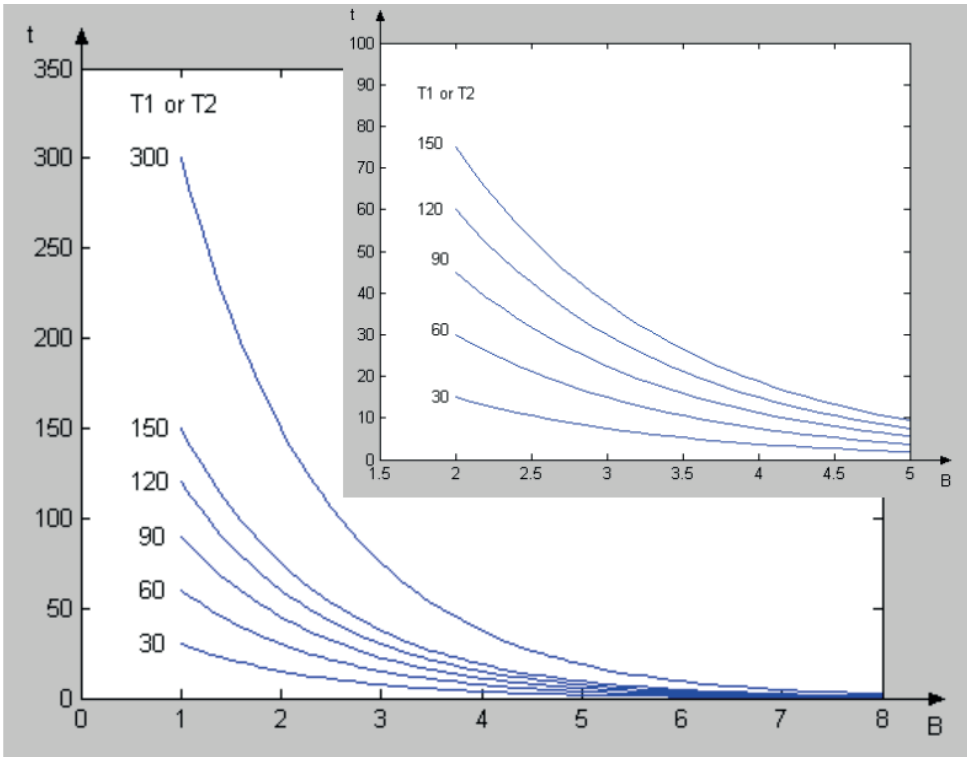



*Figure 920: Inverse time characteristic for different values on T1 or T2 (The smaller figure is a zoom-in of the larger one)*

## 9.10.5.9 Pulse control

The tap changer generates an active operating signal when the tap-changing process is active. This signal is used for alarming purposes and must be connected

to the TCO input. If the signal is active (=TRUE) for more than 15 seconds after the control pulse has been deactivated, an alarm is generated (*Chapter 9.10.5.11 Alarm indication*). If the TCO input is not connected, no alarm is generated.

The control operation is disabled when the TCO input signal is active, unless no tap changer stuck is detected (*Chapter 9.10.5.11 Alarm indication*). Thus, the controller cannot send new pulses to the tap changer when this is already operating because tap changers are typically immune to new pulses when they operate. Furthermore, because the pulses are omitted, the tap changer pulse counter of the controller is not incremented.

The commands are not tolerated during an active pulse. Therefore the command pulse length (setting *LTC pulse time*) has to be carefully selected, although an active TCO input is used internally to prevent new commands from reaching the tap changer.

To be more certain that no new pulses are sent when the tap changer is in operation, the tap changer operating signal can be connected to the LTC_BLOCK input. In this case, external blocking is achieved when an automatic pulse is sent to the operating tap changer. By default, the external LTC_BLOCK has no effect when the active operation mode is set to "Manual" or "Parallel manual".

The status of the TCO input can be read from the TCO input data.

### 9.10.5.10 Blocking scheme

The operation of the voltage regulator can be blocked for several reasons. The purpose of blocking is to prevent the tap changer from operating under conditions that can damage the tap changer or exceed other power system limits. The BLK_STATUS monitored data does not imply actual blocking but reveals if the coming command pulse is issued or not. The blocking itself happens when the corresponding bit in the signal BLK_STATUS is active and the command pulse is started due to a timer elapse or a local command. This is to avoid unnecessary event sending.

The BLK_STATUS monitored data is also packed. It contains information about the blocking status as bit-coded output. The block status output does not indicate the actual blocking but indicates if the coming command is successful. The actual blocking is indicated by the corresponding output (BLKD_I_LOD, BLKD_U_UN, RNBK_U_OV, BLKD_LTCBLK, BLKD_I_CIR, BLK_RAISE and BLK_LOWER) values. *Table 1574* illustrates the meaning of different monitored data values. For example, block status value 9 indicates that there are conditional circulating current and load current blockings (8 + 1 = 9) indicated. By default, the status is “0”.

**Table 1574: Bit-coded block status and the meaning of different bits**

| Bit | Active value | Blocking reason |
|---|---|---|
| 6 (msb) | 64 | Lowest position reached |
| 5 | 32 | Highest position reached |
| 4 | 16 | External LTC_BLOCK |
| 3 | 8 | High circuit current |
| 2 | 4 | Overvoltage - Runback raise voltage |
| 1 | 2 | Undervoltage - Block lower voltage |
| 0 (lsb) | 1 | Overcurrent - Load current |

The cross (X) in the table defines when the operation is blocked (if the corresponding bit is active in BLK_STATUS). For example, an overvoltage (runback raising voltage) results in blocking only when the active operation mode is "Manual" and the manual raising command is given.

**Table 1575: Default blocking schema in OL5ATCC**

| Active operation mode | Command | Load current | Block lower voltage | Runback raise voltage | High circulating current | External block | Extreme positions |
|---|---|---|---|---|---|---|---|
| Manual, Parallel manual | Raise | X | | X | | | X |
| | Lower | X | | | | | X |
| Auto follower | Raise | X | X | | | X | X |
| | Lower | X | X | | | X | X |
| Auto single, Auto master, NRP, MCC | Raise | X | X | | X [1] | X | X [2] |
| | Lower | X | X | | X [1] | X | X [2] |

In addition to the default blocking, the *Custom Man blocking* setting has been added due to different operation practices of the manual command blocking. The setting can be used to adapt blockings considering the manual overcurrent, undervoltage or external blocking. (The blockings are in *Table 1575* in columns Load current, Block lower voltage and External block for the manual operating mode.) The default value for the parameter is "OC". This means that the default blocking schema explained in *Table 1575* operates as such. However, there are other alternatives that cause different operations.

**Table 1576: Customized manual blocking schema**

| Manual blocking type | Enumeration | Description |
|---|---|---|
| 1 | Custom disabled | No load current, block lower (under) voltage, external blocking has no effect in the manual operation modes |
| 2 | OC | Load current blocking has an effect in the manual operation mode |
| 3 | UV | Block lowering (under) voltage blocking has an effect in the manual operation mode |
| 4 | OC, UV | Conditions 2 and 3 together: Load current and block lowering (under) voltage blocking have effect in the manual operation mode |

*Table continues on the next page*

[1] Because the circulating current is calculated only in the NRP and MCC modes, it can have a blocking effect only in these modes.

[2] In these cases the automatic operation notices that the extreme position has already been reached and there is no need to activate the signal for data set event sending. The automatic follower case can here be compared to a manual case and an event can be sent, that is, the corresponding output is activated.

| Manual blocking type | Enumeration | Description |
|---|---|---|
| 5 | EXT | External blocking has an effect in the manual operation mode |
| 6 | OC, EXT | Conditions 2 and 5 together: Load current and external blocking have effect in the manual operation mode |
| 7 | UV, EXT | Conditions 3 and 5 together: Block lowering (under) voltage and external blocking have effect in the manual operation mode |
| 8 | OC, UV, EXT | All conditions 2, 3 and 5 together: Load current and block lowering (under) voltage and external blocking have effect in the manual operation mode |

If the *Custom Man blocking* setting is "Custom disabled", the blocking schema regarding the acting operation mode "Manual" or “Parallel manual” is as given in *Table 1577*. Other operation modes follow the default schema.

**Table 1577: Blocking schema for selection "Custom disabled"**

| Active operation mode | Command | Load current | Block lower voltage | Runback raise voltage | High circulating current | External block | Extreme positions |
|---|---|---|---|---|---|---|---|
| Manual, Parallel manual | Raise | | | x | | | x |
| | Lower | | | | | | x |

**Table 1578: Blocking schema for selection "OC, UV, EXT"**

| Active operation mode | Command | Load current | Block lower voltage | Runback raise voltage | High circulating current | External block | Extreme positions |
|---|---|---|---|---|---|---|---|
| Manual, Parallel manual | Raise | x | x | x | | x | x |
| | Lower | x | x | | | x | x |

**Table 1579: Blocking schema for selection “UV, EXT”**

| Active operation mode | Command | Load current | Block lower voltage | Runback raise voltage | High circulating current | External block | Extreme positions |
|---|---|---|---|---|---|---|---|
| Manual, Parallel manual | Raise | | x | x | | x | x |
| | Lower | | x | | | x | x |

### Load current

The load current blocking is mainly used for preventing the tap changer from operating in an overcurrent situation. For example, if the current is not high enough to activate the protection relay of the substation, it can still be fatal for the diverter switch of the tap changer. This operation can be adjusted with the setting

parameter *Load current limit*. The maximum of measurements from the current phases is used for blocking. By default, both the automatic operation and the manual operation are blocked ( *Table 1575* ) when the set limit is exceeded.

The blocking status can be read from the output BLKD_I_LOD.

**Block lowering voltage**

The block lowering voltage feature blocks both raise and lower voltage commands if the measured voltage is too low to be corrected by operating the tap changer. Such a situation can occur due to a faulty measuring circuit, an earth fault or an overcurrent situation. By default, only the automatic (also automatic follower) operation is blocked when the undervoltage condition is met ( *Table 1575* ). This operation can be adjusted with the setting parameter *Block lower voltage*.

The blocking status can be read from the output BLKD_U_UN.

However, there is no minimum limit for the undervoltage blocking. The blocking is allowed even if the measured voltage is not connected or it temporarily has a very low value. There is a minimum limit for the phase angle calculation based on the voltage phasor magnitude.

**Runback raising voltage**

The manual raising command is blocked if the overvoltage limit is exceeded ( *Table 1575*). However, in the automatic operation mode, the overvoltage situation triggers the fast lowering feature. More information can be found in *Chapter 9.10.5.4 Manual voltage regulation* . This operation can be adjusted with the setting parameter *Runback raise V*.

The blocking status can be read from the output RNBK_U_OV.

**High Circulating Current**

The circulating current value is calculated in the operation modes Negative Reactance Principle (NRP) and Minimizing Circulating Current (MCC). Only the automatic operation in these modes is blocked when the high circulating current is measured ( *Table 1575*). This operation can be adjusted with the setting parameter *Cir current limit*.

The blocking status can be read from the output BLKD_I_CIR.

**LTC_BLOCK – external block input**

With the PCM600 tool configuration possibilities, a desired blocking condition can be built by connecting an outcome to this input. The blocking status can be read from the output BLKD_LTCBLK. When activated, this input blocks only the automatic operation of the regulator by default ( *Table 1575* ). For the fully automatic modes, the signal activation resets the timer, and the monitored data BLKD_LTCBLK is not activated.

**Extreme positions**

This blocking function supervises the extreme positions of the tap changer. These extreme positions can be adjusted with the setting parameters *Raise block tap* and *Lower block tap*. When the tap changer reaches one of these two positions, the commands in the corresponding direction are blocked ( *Table 1575* ). It depends on the comparison between the *Raise block tap* and *Lower block tap* settings, which

direction is blocked ( *AAVoltage control vs. tap changer moving direction*). This blocking affects both the automatic and manual operation modes.

However, as shown in *Table 1575*, no blocking indication is generated in the fully automatic modes. Here "Auto follower" is not a fully automatic mode. The unconnected position information does not cause the total block of OL5ATCC, only the extreme position blocking does not work.

The blocking status can be seen in the generated events.

#### Fast lowering control

OL5ATCC provides the fast lowering control in the automatic operation modes. When the set *Runback raise V* is exceeded, the regulator gives fast lowering control pulses until the voltage drops below the specified limit. This fast lowering control can be seen with the monitoring data TIMER_STS, where the value "Fast lower T on" indicates this functionality to be active.

To allow the fast lowering operation, *Runback raise V* has to be set always to a value higher than the control voltage (U_CTL) plus half of *Band width voltage*.

Typically, the blockings are reset when the corresponding limit with the hysteresis is undershoot or exceeded. Although blocking is reset after undershooting the above-mentioned limit, the fast lowering control operation continues until the measured voltage signal difference undershoots half the *Band width voltage* hysteresis limit ( *Figure 916* ). As a result, normal automatic operation mode is not possible before this happens.

Fast lowering control causes successive `LOWER_OWN` pulses to be activated. The time between consecutive pulses is the pulse length plus 1.5 seconds.

- There is no tap changer operating delay (otherwise 6 seconds) taken into account in this cycle meaning that some command pulses are ineffective due to tap changer operation, as described in the *Chapter 9.10.5.9 Pulse control*.
- Timer mode set by *Delay characteristic* has no effect here (always the DT timer-type operation). Because the minimum pulse length (the *LTC pulse time* setting) is 0.5 seconds, the shortest interval between successive pulses can be two seconds.

In the automatic follower mode, the fast lowering is not triggered. In this way, the awkward dispersion of position values in different units can be avoided. The master always decides on the fast lowering on behalf of the follower units. Moreover, master and follower should measure an equal voltage level and have similar setting values for the overvoltage blocking limit.

### 9.10.5.11 Alarm indication

#### Tap changer monitoring

OL5ATCC supervises the operation of the tap changer and generates alarms if the alarm condition is detected. An alarm activation means that the `ALARM` output is activated and the alarm reason can be read from the monitored data ALARM_REAS. Alarms are in use by default but they can be disabled by setting *Alarms enabled* to "False". Three different alarm conditions and their combinations can be detected by OL5ATCC.

#### Command error

OL5ATCC supervises the tap changer position information of the own transformer when a control pulse is given. If the correct position change (direction depends on the comparison of the settings *Raise block tap* and *Lower block tap*) is not seen by OL5ATCC in *Cmd error delay time* after the pulse start, the alarm is issued.

If the position information is not connected, no alarm is generated. The alarm is reset when the correct change in position value is detected after a given pulse or if a new command pulse is given.

The monitored data ALARM_REAS is set during an alarm. This means that if the alarm reason is active, ALARM_REAS has the value "Cmd error".

#### TCO signal fails

If the tap changer operating signal TCO stays active for more than 15 seconds after the output pulse deactivation, OL5ATCC sees this as an abnormal condition and assumes that the tap changer is stuck. The alarm is reset when the TCO input signal deactivates. The monitored data ALARM_REAS is set during the alarm. This means that only if the alarm reason is active, ALARM_REAS has the value "TCO error".

If the TCO input signal is not connected (indicated by bad quality), this type of alarm is not possible.

#### Regulator pumping

Faulty settings may cause the regulator to give control pulses too frequently. For example, too low a setting for the *Band width voltage* ( *Figure 916*) can result in a pumping condition where the regulator has problems to bring the regulated voltage to a desired level. To detect this, OL5ATCC has a setting *Max operations in 1h*, which defines the allowed number of lowering and raising commands during a one-hour sliding time window. The detection is active both in the manual and automatic operation modes. The alarm is reset after the counted number of the operations during the one-hour time window is less than the set value. The number of executed operations per last one hour can be read from the monitored data OP_TM_NUM_H. However, this parameter is updated only in three-minute intervals. Again, the monitored data ALARM_REAS is set during an alarm. This means that only if alarm reason is active, ALARM_REAS has the value "Pump error".

The operation of OL5ATCC is not blocked during an alarm situation, but all the alarms mentioned above cause the automatic operation to be delayed, which means that the set delay times T1 and T2 are doubled.

In addition to the alarm detections, OL5ATCC provides a nonvolatile operation counter parameter (monitored data OPR_CNT) for determining the service intervals of the tap changer. The counter gives the total number of raising and lowering commands given in the manual and automatic modes. All commands, even those that are omitted by the tap changer due to its operation sequence, are calculated in a cumulative counter. This data parameter can be reset via the parameter *OL5ATCC counter* on the Clear menu.

## 9.10.6 Application

See the application manual for more information.

## 9.10.7 Signals

### 9.10.7.1 OL5ATCC Input signals

**Table 1580: OL5ATCC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| U3P1 | SIGNAL | - | Three-phase voltages 1 |
| U3P2 | SIGNAL | - | Three-phase voltages 2 |
| TAP_POS | INT8 | 0 | Integer value representing tap changer position of own transformer |
| RAISE_LOCAL | BOOLEAN | 0=False | Raise command input from configuration |
| LOWER_LOCAL | BOOLEAN | 0=False | Lower command input from configuration |
| CON_STATUS | BOOLEAN | 0=False | Network connection status of the (own) transformer |
| LTC_BLOCK | BOOLEAN | 0=False | External signal for blocking |
| TCO | BOOLEAN | 0=False | Tap changer operating input |
| RSV | BOOLEAN | 0=False | Reduce set voltage active |
| PWR_DIR | Enum | 1=forward | Power flow direction |

### 9.10.7.2 OL5ATCC Output signals

**Table 1581: OL5ATCC Output signals**

| Name | Type | Description |
|---|---|---|
| RAISE_OWN | BOOLEAN | Raise command for own transformer |
| LOWER_OWN | BOOLEAN | Lower command for own transformer |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| FLLW1_CTL | INT32 | Lower/Raise command for follower transformer 1 in the Master/Follower operation mode |
| FLLW2_CTL | INT32 | Lower/Raise command for follower transformer 2 in the Master/Follower operation mode |
| FLLW3_CTL | INT32 | Lower/Raise command for follower transformer 3 in the Master/Follower operation mode |
| FLLW4_CTL | INT32 | Lower/Raise command for follower transformer 4 in the Master/Follower operation mode |
| FLLW5_CTL | INT32 | Lower/Raise command for follower transformer 5 in the Master/Follower operation mode |
| BLKD_I_LOD | BOOLEAN | Indication of over current blocking |
| BLKD_U_UN | BOOLEAN | Indication of under voltage blocking |
| RNBK_U_OV | BOOLEAN | Indication of raise voltage runback |
| BLKD_I_CIR | BOOLEAN | Indication of high circulating current blocking |
| BLKD_LTCBLK | BOOLEAN | Indication of external blocking |
| ALARM | BOOLEAN | Alarm status |
| PAR_FAIL | BOOLEAN | Parallel failure detected |
| PARALLEL | BOOLEAN | Parallel or single operation |
| AUTO | BOOLEAN | Auto/Manual indication |
| MASTER | BOOLEAN | Master indication |
| TAP_DIFF | BOOLEAN | Tap difference between follower and master |
| REV_REG | BOOLEAN | Reverse regulation |

## 9.10.8 OL5ATCC Settings

**Table 1582: OL5ATCC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| LDC limit | 0.00...2.00 | xUn | 0.01 | 0.10 | Maximum limit for line drop compensation term |
| Lower block tap | -36...36 | | 1 | 0 | Tap changer limit position which gives lowest voltage on the regulated side |
| Raise block tap | -36...36 | | 1 | 17 | Tap changer limit position which gives highest voltage on the regulated side |
| LDC enable | 0=False<br>1=True | | | 1=True | Selection for line drop compensation |
| Parallel mode | 2=Master<br>3=Follower<br>5=NRP<br>7=MCC<br>-1=Input control<br>-2=Command | | | 2=Master | Parallel mode selection |
| Band center voltage | 0.000...2.000 | xUn | 0.001 | 1.000 | Band center voltage Us |
| Line drop V Ris | 0.0...25.0 | % | 0.1 | 0.0 | Resistive line-drop compensation factor |
| Line drop V React | 0.0...25.0 | % | 0.1 | 0.0 | Reactive line-drop compensation factor |
| Band reduction | 0.00...9.00 | %Un | 0.01 | 0.00 | Step size for reduce set voltage (RSV) |
| Stability factor | 0.0...70.0 | % | 0.1 | 0.0 | Stability factor in parallel operation |
| Load phase angle | -89...89 | deg | 1 | 0 | Load phase-shift, used only with the negative reactance principle |
| Control delay time 1 | 1000...300000 | ms | 100 | 60000 | Control delay time for the first control pulse |
| Control delay time 2 | 1000...300000 | ms | 100 | 30000 | Control delay time for the following control pulses |

**Table 1583: OL5ATCC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Rv Pwr flow allowed | 0=False<br>1=True | | | 0=False | Reverse power flow allowed |

**Table 1584: OL5ATCC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Operation mode | 1=Manual<br>2=Auto single | | | 6=Command | The operation mode |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 3=Parallel manual<br>4=Auto parallel<br>5=Input control<br>6=Command | | | | |
| Custom Man blocking | 1=Custom disabled<br>2=OC<br>3=UV<br>4=OC, UV<br>5=EXT<br>6=OC, EXT<br>7=UV, EXT<br>8=OC, UV, EXT | | | 2=OC | Customized manual blocking |
| Parallel trafos | 0...10 | | 1 | 0 | Number of parallel transformers in addition to own transformer |
| Delay characteristic | 0=Inverse time<br>1=Definite time | | | 1=Definite time | Selection of delay characteristic |
| Band width voltage | 1.00...18.00 | %Un | 0.01 | 3.00 | Allowed deviation of the control voltage |
| Load current limit | 0.10...5.00 | xIn | 0.01 | 2.00 | Load current blocking limit |
| Block lower voltage | 0.10...1.20 | xUn | 0.01 | 0.70 | Voltage limit, where further voltage lowering commands are blocked |
| Runback raise V | 0.80...2.40 | xUn | 0.01 | 1.25 | Voltage limit, where fast lower commands takes place |
| Cir current limit | 0.10...5.00 | xIn | 0.01 | 0.15 | Blocking limit for high circulating current |
| LTC pulse time | 500...10000 | ms | 100 | 1500 | Output pulse duration, common for raise and lower pulses |
| Regulation mode | 1=Forward<br>2=Bi-dir(meas)<br>3=Bi-dir(calc)<br>4=Auto select | | | 1=Forward | Regulation mode |

**Table 1585: OL5ATCC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Max operations in 1h | 0...10000 | | 1 | 100 | Allowed number of controls per one hour sliding window |
| Cmd error delay time | 10...50 | s | 1 | 20 | Time delay before command error will be activated |
| Follower delay time | 6...20 | s | 1 | 6 | Time delay between successive follower commands by a master |
| Alarms enabled | 0=False<br>1=True | | | 1=True | Alarm selection |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Inst out of step Cor | 0=False<br>1=True | | | 0=False | Enable instant out of step correction in M/F mode |
| Step of tap | 0.60...9.00 | % | 0.01 | 1.50 | The percentage change in voltage corresponding one step of the tap changer |
| Tap nominal | -36...36 | | 1 | 8 | The nominal position of the tap changer resulting the default transformation ratio of the transformer (as if there was no tap changer) |
| Impedance voltage | 0.00...100.00 | % | 0.01 | 5.00 | The percentage impedance voltage at rated current referred to MV side |

## 9.10.9 OL5ATCC Monitored data

**Table 1586: OL5ATCC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| U_MEAS | FLOAT32 | 0.00...5.00 | xUn | Phase-to-phase voltage, average filtered |
| ANGL_UA_IA | FLOAT32 | -180...180 | deg | Measured angle value between phase A voltage and current |
| TIMER_STS | Enum | 0=Timer off<br>1=Lower timer1 on<br>2=Raise timer1 on<br>3=Lower timer2 on<br>4=Raise timer2 on<br>5=Fast lower T on | | Timer T1, T2 or fast lower timer active |
| OPR_MODE_STS | Enum | 0=Not in use<br>1=Manual<br>2=Auto single<br>3=Parallel manual<br>4=Auto master<br>5=Auto follower<br>6=MCC<br>7=NRP | | The acting operation mode of the function block |
| U_CTL | FLOAT32 | 0.000...3.000 | xUn | Control voltage, Up, target voltage level |
| UD_CTL | FLOAT32 | -2.000...2.000 | xUn | Voltage difference between Measured voltage - Control Voltage: Um - Up |
| I_CIR | FLOAT32 | -10.00...10.00 | xIn | Calculated circulating current - calculated in operation modes NRP and MCC |
| LDC | FLOAT32 | -2.00...2.00 | xUn | Calculated line drop compensation |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| BLK_STATUS | INT32 | 0...127 | | Bit-coded output showing the blocking status for the next operation |
| ALARM_REAS | Enum | 0=No alarm<br>1=Cmd error<br>2=TCO error<br>3=Cmd + TCO err<br>4=Pump error<br>5=Pump + cmd err<br>6=Pump + TCO err<br>7=Pmp+TCO+cmd err | | Status and reason for alarm |
| OP_TM_NUM_H | INT32 | 0...2147483647 | | Number of controls for own tap changer during last hour |
| FAIL_FLLW | Enum | 0=No failed followers<br>1=T1<br>2=T2<br>3=T1+T2<br>4=T3<br>5=T1+T3<br>6=T2+T3<br>7=T1+T2+T3<br>8=T4<br>9=T1+T4<br>10=T2+T4<br>11=T1+T2+T4<br>12=T3+T4<br>13=T1+T3+T4<br>14=T2+T3+T4<br>15=T1+T2+T3+T4<br>16=T5<br>17=T1+T5<br>18=T2+T5<br>19=T1+T2+T5<br>20=T3+T5<br>21=T1+T3+T5<br>22=T2+T3+T5<br>23=T1+T2+T3+T5<br>24=T4+T5<br>25=T1+T4+T5<br>26=T2+T4+T5<br>27=T1+T2+T4+T5<br>28=T3+T4+T5<br>29=T1+T3+T4+T5<br>30=T2+T3+T4+T5<br>31=T1+T2+T3+T4+T5 | | Failed followers |
| PAR_UNIT_MCC | Enum | 0=No parallel units<br>1=T1<br>2=T2<br>3=T1+T2 | | Parallel units included in MCC calculation |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 4=T3<br>5=T1+T3<br>6=T2+T3<br>7=T1+T2+T3<br>8=T4<br>9=T1+T4<br>10=T2+T4<br>11=T1+T2+T4<br>12=T3+T4<br>13=T1+T3+T4<br>14=T2+T3+T4<br>15=T1+T2+T3+T4<br>16=T5<br>17=T1+T5<br>18=T2+T5<br>19=T1+T2+T5<br>20=T3+T5<br>21=T1+T3+T5<br>22=T2+T3+T5<br>23=T1+T2+T3+T5<br>24=T4+T5<br>25=T1+T4+T5<br>26=T2+T4+T5<br>27=T1+T2+T4+T5<br>28=T3+T4+T5<br>29=T1+T3+T4+T5<br>30=T2+T3+T4+T5<br>31=T1+T2+T3+T4+T5 | | |
| OPR_CNT | INT32 | 0...2147483647 | | Total number of raise and lower commands given in the manual and automatic modes |
| TR0_I_AMPL | FLOAT32 | 0.00...15000.00 | A | Transmitted current magnitude |
| TR0_I_ANGL | FLOAT32 | -180.00...180.00 | deg | Transmitted current angle |
| TR_STATUS | Enum | 0=Independent<br>1=Master<br>2=Follower | | Transformer status information |
| OL5ATCC | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 9.10.10 Technical data

**Table 1587: OL5ATCC Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy [1] | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Differential voltage $U_d$ = ±0.5% of the measured value or ±0.005 × $U_n$ (in measured voltages <2.0 × $U_n$)<br>Operation value = ±1.5 % of the $U_d$ for Us = 1.0 × $U_n$ |
| Operate time accuracy in definite time mode [2] | +4.0 %/-0 % of the set value |
| Operate time accuracy in inverse time mode [2] | +8.5 %/-0 % of the set value<br>(at theoretical B in range of 1.1…5.0)<br>Also note fixed minimum operate time (IDMT) 1 s. |
| Reset ratio for control operation | Typically 0.80 (1.20) |
| Reset ratio for analog based blockings (except run back raise voltage blocking) | Typically 0.96 (1.04) |

## 9.10.11 Technical revision history

**Table 1588: OL5ATCC Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL2 | B | Added new output `TAP_DIFF` for indicating the difference in tap position between master and follower<br>Changed the *Band width voltage* minimum value to "1.00"<br>Added setting *Inst out of step Cor* for enabling triggering of instant out-of-step sequence in M/F mode |
| PCL4 | C | Added new inputs I3P2, U3P2, PWR_DIR. Added new output REV_REG. Added new settings *Regulation mode*, *Step of Tap*, *Tap nominal* and *Impedance voltage*. Updated the implementation to handle HV side regulation during reverse power flow from stronger sources. |

[1] Default setting values used.
[2] Voltage before deviation = set *Band center voltage*.

# 9.11 Petersen coil controller PASANCR (ANSI 90)

## 9.11.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Petersen coil controller | PASANCR | ANCR | 90 |

## 9.11.2 Function block

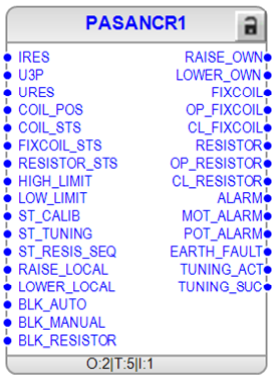



*Figure 921: Function block*

## 9.11.3 Functionality

The Petersen coil controller function PASANCR is a numerical automatic controller for the stepless adjustment of the arc suppression coil (ASC or Petersen coil) and the control of the parallel resistor of the coil. It can be applied to compensated networks for arc suppression coils with or without parallel resistor to increase the resistive earth-fault current. The controller can also manage an additional parallel fixed coil control.

PASANCR is intended for controlling arc suppression coils in networks with natural ground capacitance asymmetry, for example, mixed overhead line and cable networks. The main features of the function are:

- Operation based on forced change in zero-sequence voltage
- Arc suppression coil tuning to the desired position
- Network parameter calculation and displaying of the resonance curve and the fault current estimate curve of the network
- Control of the parallel resistor
- Clear numerical value of the resonance point steady-state zero-sequence voltage, for example, for earth-fault protection purposes

## 9.11.4 Analog channel configuration

PASANCR has three analog group inputs which must be properly configured.

**Table 1589: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |
| IRES [1] | Residual current (measured or calculated) |
| URES | Residual voltage (measured) |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 9.11.5 Controller connections

### Voltages

PASANCR supports zero-sequence voltage measurement from busbar or from coil. Busbar measurement is, for example, an open-delta connection of phase-to-earth voltage transformers. Coil measurement uses the coil's own secondary measurement winding. *Voltage measurement setting* is used to select the active measurement. Available options are "Busbar" and "Coil".

Phase-to-phase voltage AB must be connected to the controller. If only the phase voltages are measured, the voltage U_AB is calculated internally in the protection relay.

### Coil position

The controller supports two possibilities for the coil position measurement. *Position Meas mode* setting is used to select the active coil position measurement. Available options are:

- "Pos. indication": Using only the RTD input module to measure the resistance value from the arc suppression coil potentiometer with `COIL_POS` input and to convert it into corresponding coil position according to the linearization table.
- "Pos. ind. and meas.": Using both `COIL_POS` and `IRES` signals. `IRES` is arc suppression coil current measurement using conventional CTs or sensors. Special attention should be paid to the accuracy of the current signals at low amplitudes. Additionally, high accuracy can be ensured by applying measurement class CTs and sensors. Accurate current measurement improves controller speed and

[1] The possible connection options are measured IRES from the coil/main transformer neutral point, calculated IRES from the phase CTs of earthing transformer, or GRPOFF. If GRPOFF is connected to IRES, the *Position Meas mode* is restricted to "Pos. indication" only.

accuracy. The recommendation for the CT is a primary current equivalent to the coil's maximum current and accuracy class 0.5S or better. The IRES signal is not sufficient for the controller as it does not allow manual control of the coil if it is disconnected from the network.

All voltage and current signals are measured using the value of the filtered fundamental frequency component (DFT). Hence, the harmonics are always suppressed.

**Status information**

The connection status (COIL_STS) information from the adjustable arc suppression coil disconnector or circuit breaker should be wired to the controller. Also, fixed parallel coil status (FIXCOIL_STS) and the parallel resistor status (RESISTOR_STS) should be wired to the controller if they are present in the system. Inactive status information signal means that the device is not connected and active status information signal means that the device is connected.

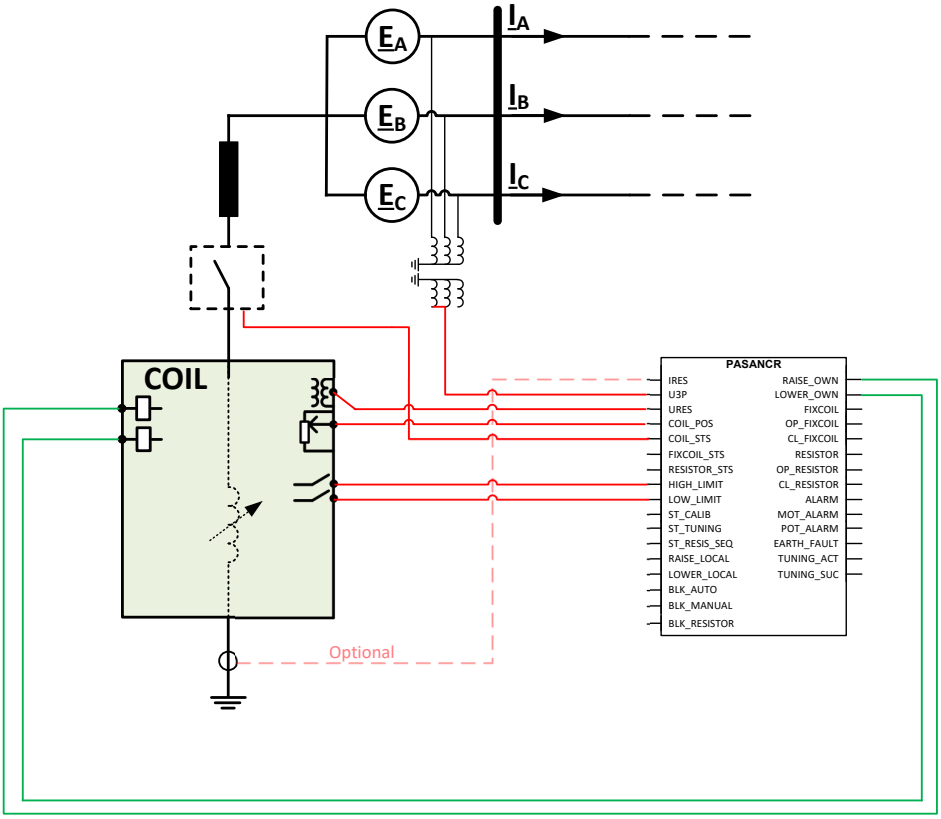
**Outputs**

The following outputs should be considered in order to ensure correct operation of the controller if a fixed parallel coil or parallel resistor is installed in the network:

- FIXCOIL, OP_FIXCOIL and CL_FIXCOIL: Status signal and corresponding open and close command signals, with 100 ms fixed pulse length for controlling the circuit breaker or disconnector of the fixed parallel coil. These signals are applied if a fixed parallel coil is installed in the system.
- RESISTOR, OP_RESISTOR and CL_RESISTOR: Status signal and corresponding open and close command signals, with 100 ms fixed pulse length for controlling the contactor, circuit breaker or disconnector of the parallel resistor. These signals are applied if a parallel resistor is installed in the system.

An example configuration of the connections is shown in *Figure 922*. Controller inputs are indicated with red lines and outputs with green lines. This example shows a simple, one-controller setup without the parallel resistor of the coil.

*Figure 922: Example configuration of the controller connections*




## 9.11.6 Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "on" and "off".

The operation of PASANCR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

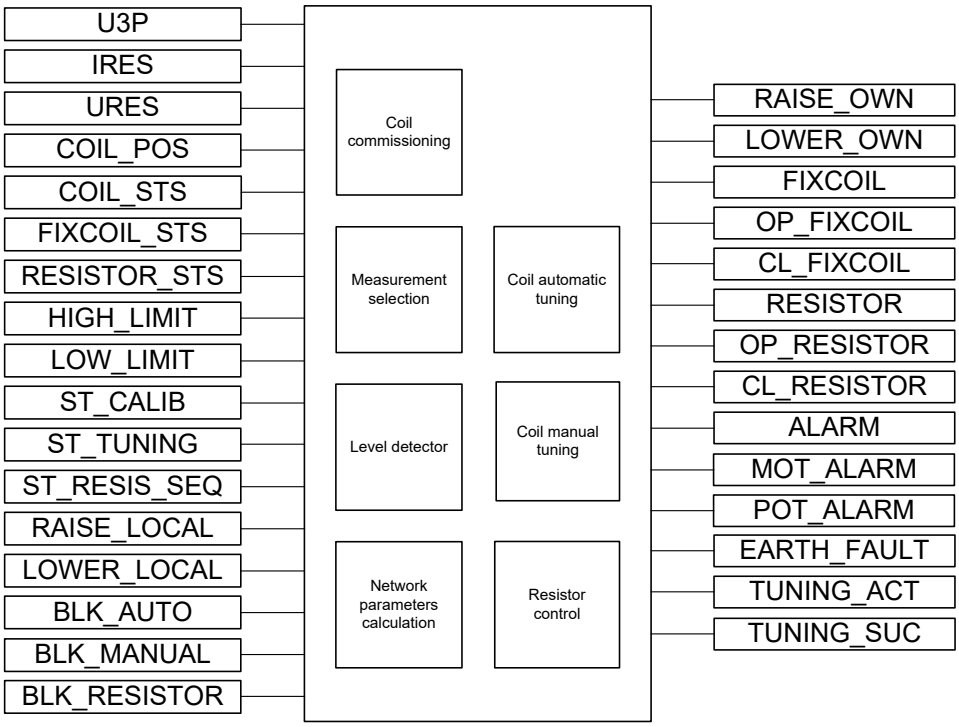



*Figure 923: Functional module diagram*

### 9.11.6.1 Measurement selection

PASANCR supports two possibilities for zero-sequence voltage and coil position measurement.

*Voltage measurement* setting is used to define the location of voltage measurement: from busbar or from coil. Busbar measurement is usually an open-delta connection of phase-to-earth voltage transformers. Coil measurement is available from the arc suppression coil's measurement winding.

*Position Meas mode* setting is used to select the measurement between coil position indication and coil position indication with a CT or sensor. "Pos. indication" option uses the potentiometer-based `COIL_POS` information only. If "Pos. ind. and meas." option is selected, the measured `IRES` is used for the control algorithm. In this case, the `COIL_POS` signal works as a backup and is switched automatically into use if the coil is disconnected from the network.

### 9.11.6.2 Level detector

*Level detector op* setting is used to enable or disable the Level detector module. "Enable" means that the Level detector module is enabled and can be used to start the tuning procedure.

When "Disable" is selected, the automatic coil tuning procedure can be started with input `ST_TUNING`.

Level detector's main task is to release the coil automatic tuning procedure in case of network switching operation. After every successful tuning procedure, the measured zero-sequence voltage is stored as a new reference voltage $U_{ref}$. Also, the calculated network admittances are stored as new reference admittances $Y_{symm_ref}$ and $Y_{asymm_ref}$ (for more information, see *Chapter 9.11.6.3 Network parameter calculation*).

If the change in the measured zero-sequence voltage exceeds the setting *V Res change level* with respect to $U_{ref}$, then a new coil tuning procedure is released. The measured zero-sequence voltage must exceed the threshold at least by the time defined with *Tuning delay* setting, otherwise the start of the tuning procedure is canceled.

Zero-sequence voltage change can be determined considering the voltage amplitude only or a phasor value. Setting *V Res Meas mode* is used to select between these two modes. The available options are "Amplitude" and "Phasor". The phasor triggering mode is explained in *Figure 924*. Monitored data output TUNING_TRIGG indicates the relation between present zero-sequence voltage and the reference voltage. When TUNING_TRIGG value is below 100%, the controller is at stand-by. When TUNING_TRIGG value is above 100%, that is, Uo vector in *Figure 924* enters the red area, the tuning delay is started.

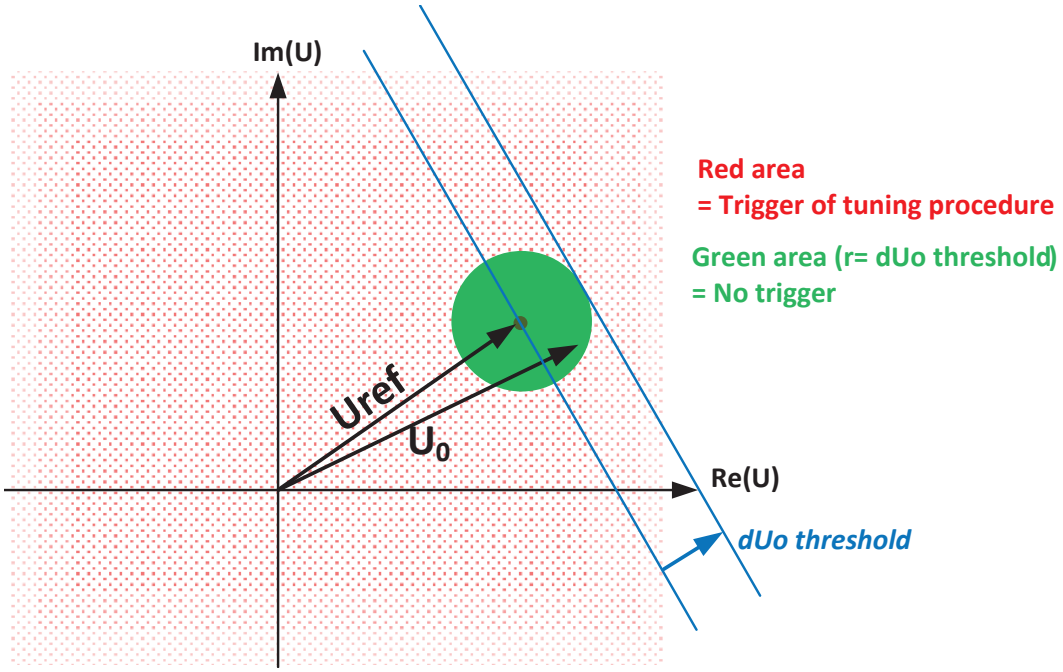



*Figure 924: Phasor triggering mode*

Level detector also includes a threshold-based earth-fault detection functionality. The detection is based on *V Res EF level* voltage threshold setting. If the measured zero-sequence voltage exceeds the threshold at least by the time defined in *Transient time EF* setting, the earth fault is indicated by activating the EARTH_FAULT output and the controller proceeds as described in *Chapter 9.11.6.4.1 Operation during earth faults*.

The delay defined in *Tuning delay* can be bypassed by activating ST_TUNING input, for example, via HMI application. When the rising edge of the signal is detected, the controller skips the tuning delay and proceeds immediately with the coil automatic tuning procedure. The automatic tuning procedure can be started with ST_TUNING input even without the zero-sequence voltage trigger. The automatic

tuning procedure is also released when the *Controller mode* is switched from "Manual" to "Automatic".

PASANCR has an adaptive $U_{ref}$ feature. The *V Ref adaptive mode* setting is used to enable or disable the functionality. The functionality allows slow changes in measured zero-sequence voltage and therefore reduces unnecessary tuning operations. If the measured zero-sequence voltage does not exceed the *V Res change level* setting during the time defined in *V Ref adaptive delay* setting, the existing measured zero-sequence voltage is stored as a new reference voltage $U_{ref}$ at the end of the adaptive period. The operation principle of the adaptive $U_{ref}$ feature is explained in *Figure 925*.

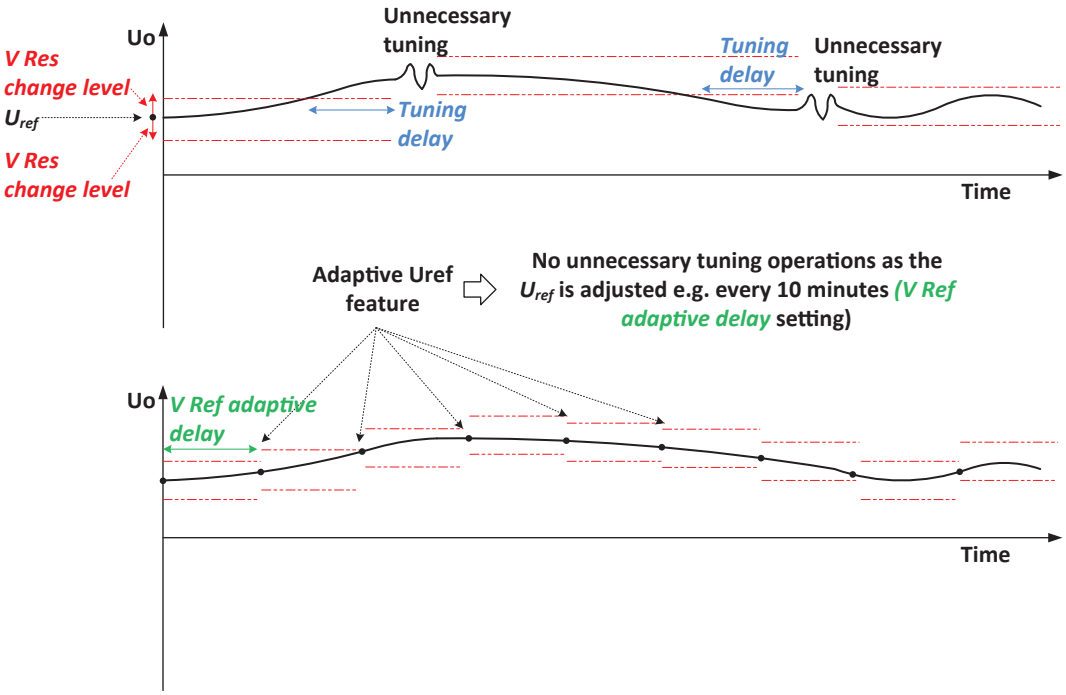



*Figure 925: Example of Uo fluctuation with and without adaptive Uref feature (amplitude triggering mode)*

### 9.11.6.3 Network parameter calculation

To explain the controller, the simplified equivalent circuit of a three-phase distribution network illustrated in *Figure 926* is used. The controller assumes that:

- The real network is presented with its shunt admittances neglecting line series impedances as their values are very small compared with the shunt admittances.
- The individual phase admittances of the network are presented with symmetrical phase admittances whose sum equals

$$\underline{Y}_{symm} = G_{symm} + j \cdot B_{symm}$$

(Equation 386)

(one third connected in each phase)

- The natural asymmetry in a real network is due to differences in individual phase admittances and it is presented with an asymmetry admittance concentrated into phase A and presented with admittance

$$\underline{Y}_{asymm} = G_{asymm} + j \cdot B_{asymm}$$

(Equation 387)

(only connected in phase A)

- The single-phase earth fault in the network is presented with admittance $\underline{Y}_f = G_f + j \cdot B_f$. Fault impedance can be assumed to be purely resistive (fault resistance $R_f$) which is connected between phase A, B or C and earth depending on the faulted phase.
- The zero-sequence impedance of the earthing (or main) transformer with the neutral point connected to the coil is represented with impedance $\underline{Z}_{oTr}$ (in the three-phase equivalent scheme one third must be applied).

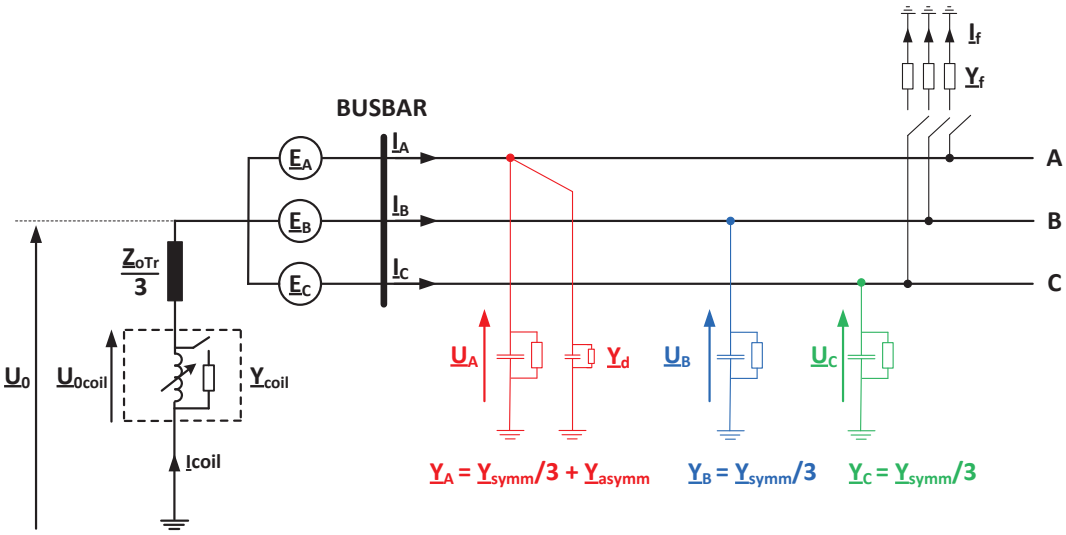



*Figure 926: Simplified three-phase equivalent circuit of a compensated distribution network*

| | |
|---|---|
| $\underline{E}_A$ | Phase A to earth voltage of the source |
| $\underline{E}_B$ | Phase B to earth voltage of the source |
| $\underline{E}_C$ | Phase C to earth voltage of the source |
| $\underline{U}_A$ | Phase A to earth voltage at busbar (= $\underline{E}_A + \underline{U}_o$) |
| $\underline{U}_B$ | Phase B to earth voltage at busbar (= $\underline{E}_B + \underline{U}_o$) |
| $\underline{U}_C$ | Phase C to earth voltage at busbar (= $\underline{E}_C + \underline{U}_o$) |
| $\underline{U}_0$ | Zero-sequence voltage = ($\underline{U}_A + \underline{U}_B + \underline{U}_C$)/3 |
| $\underline{U}_{0coil}$ | Zero-sequence voltage measured at coil |
| $\underline{I}_A$ | Phase A current at the source |
| $\underline{I}_B$ | Phase B current at the source |
| $\underline{I}_C$ | Phase C current at the source |
| $\underline{I}_{coil}$ | Current through the central compensation coil |
| $\underline{Y}_A$ | Phase A to earth admittance of the network |
| $\underline{Y}_B$ | Phase B to earth admittance of the network |
| $\underline{Y}_C$ | Phase C to earth admittance of the network |
| $\underline{Y}_{coil}$ | Admittance of central compensation coil including the parallel resistor |
| $\underline{Z}_{oTr}$ | Zero-sequence impedance of the earthing transformer or the main transformer through which the coil is connected to the network. Settings *R0Transformer* |

and *X0Transformer* are used to input the zero-sequence impedance of the earthing / main transformer. If the settings are applied, the controller can consider the transformer when calculating network parameters.

Using this network model, the controller determines network parameters $G_{symm}$, $B_{symm}$, $G_{asymm}$, $B_{asymm}$, $G_{coil}$ and $B_{coil}$.

| | |
|---|---|
| $G_{symm}$ | Real part of symmetrical part of the total network admittance. The sign is positive and it represents the shunt losses of the network (excluding the losses of the central coil and the parallel resistor). If there are distributed compensation coils in the network, their shunt losses are included in this value. |
| $B_{symm}$ | Imaginary part of symmetrical part of the total network admittance. The sign is positive (capacitive) and it represents the capacitive uncompensated earth-fault current of the network. If there are distributed compensation coils in the network, their effect is included in this value. |
| $G_{asymm}$ | Real part of asymmetry admittance. The sign may be positive or negative depending on the actual level of asymmetry. |
| $B_{asymm}$ | Imaginary part of asymmetry admittance. The sign may be positive or negative depending on the actual level of asymmetry. |
| $G_{coil}$ | Real part of the coil admittance. The sign is positive and it represents the resistive losses of the central coil including the parallel resistor. |
| $B_{coil}$ | Imaginary part of the coil admittance. The sign is negative and it represents the inductive current of the central coil, which defines the compensation degree of the network. |

All previous admittance terms can be easily converted into equivalent current values by multiplying them by the system nominal phase-to-earth voltage $U_n$.

| | |
|---|---|
| $I_{ef_network} = (B_{symm} + B_{asymm}) \cdot U_n$ | Uncompensated earth-fault current |
| $I_{loss_network} = (G_{symm} + G_{asymm}) \cdot U_n$ | Network shunt losses |
| $I_{coil} = B_{coil} \cdot U_n$ | Coil inductive current |
| $I_{loss_coil} = G_{coil} \cdot U_n$ | Coil loss current |

Network parameter calculation is based on the forced change in network zero-sequence voltage. This is achieved by changing the coil position or by changing the connection state of the parallel resistor of the coil. All the Monitored data values expressed in Amperes are scaled with reference to $U_0$ primary voltage.

### 9.11.6.4 Coil automatic tuning

Coil automatic tuning mode is enabled with setting *Controller mode* = "Automatic". In this mode, the TUNING_ACT binary output is activated. The coil automatic tuning procedure consists of two parts. First, sufficient zero-sequence voltage variation is obtained using coil movement or resistor switching. Secondly, network parameters are calculated.

The automatic tuning procedure requires a sufficient change to be detected in the measured zero-sequence voltage. This can be achieved by coil movement or switching the parallel resistor of the coil. The mode is selected with *Tuning mode* setting. The available options are "Coil movement" and "Resistor switching".

In the coil movement mode, the controller first moves the coil a little towards the coil's default position and determines the direction of raising Uo voltage. Then the controller moves the coil preferably to the direction of raising zero-sequence voltage until the measured zero-sequence voltage is changed by the amount defined with *V Res variation* setting. *V Res maximum* setting defines the maximum

zero-sequence voltage that the controller does not exceed when obtaining the required Uo variation. If the zero-sequence voltage reaches the value defined in *V Res maximum* setting, the controller seeks the required Uo variation from the direction of decreasing zero-sequence voltage.

The measured zero-sequence voltage level must exceed setting *V Res minimum* during the whole tuning process. If the measured zero-sequence voltage is initially below the *V Res minimum* setting, the controller extends the search range in order to achieve this minimum level. If the minimum required level of zero-sequence voltage cannot be reached, the controller cancels the tuning. If the required zero-sequence voltage variation cannot be reached, the controller moves the coil to *Error position*.

The most accurate tuning is possible when *Pass resonance* setting is enabled: the controller moves the coil over the network resonance point and collects additional measurement points resulting in the most accurate estimate of the network parameters. Particularly passing the resonance point improves the estimate of network losses. Setting *V Res maximum* can deny the resonance point passing functionality.



*V Res EF level* setting should be set to a higher value than *V Res maximum*.

If the coil is equipped with a parallel resistor, the resistor switching mode offers a fast alternative to obtain the change in measured zero-sequence voltage. In the resistor switching mode, the controller changes the connection status of the parallel resistor for three seconds and then switches the resistor back to its original position. If the change in the measured zero-sequence voltage exceeds the *V Res variation* setting, the controller can proceed immediately to network parameters calculation. If the change defined in *V Res variation* setting cannot be obtained using resistor switching, the controller automatically uses the coil movement method.



In the case of resistor switching, the setting *V Res maximum* is ineffective.

After sufficient change in the measured zero-sequence voltage is obtained using coil movement or resistor switching, the controller calculates new network parameters and compares them to the reference values. If the network's capacitive earth-fault current has changed, the controller moves the coil to maintain the set compensation level. The active compensation mode is selected with *Compensation mode* setting. The available options are "Absolute" (tuning level selected with *Detuning level* setting) and "Relative" (tuning level selected with *Detuning level Rl* setting). The controller monitors the actual coil current while moving it to the desired tuning position. Taking into account the after-running of the coil motor, it is stopped just before reaching the desired tuning point. If the zero-sequence voltage reaches the voltage level set with *V Res maximum* setting, the controller stops the coil movement.

If the parallel resistor is installed in the system (setting *Parallel resistor* = "True"), PASANCR includes a feature to temporarily connect the parallel resistor into the system while moving the coil to the desired tuning position if the resistor is initially disconnected. The temporary connection of the parallel resistor should lower the zero-sequence voltage and therefore the movement of the coil to the desired tuning position could be possible. The feature can be enabled with *Temporary damping* setting. The available options are "True" and "False".

An example of the feature is shown in *Figure 927* where the initial coil position is at 60 A, the parallel resistor is disconnected and the target position is at 110 A. Before the controller starts moving the coil, it estimates if the zero-sequence voltage at target position is below the *V Res maximum* setting and if the movement is allowed. If the conditions allow, the controller starts moving the coil towards the higher current. While the movement stops at *V Res maximum* (set to 3.5 percent of the system's nominal phase-to-earth voltage in this example), the controller automatically connects the parallel resistor and moves the coil to the desired inductive current position (that is, 110 A). After the coil has reached the target position, the controller automatically disconnects the resistor, that is, returns it to its original connection state while simultaneously obtaining the target position of 110 A with the parallel resistor disconnected.

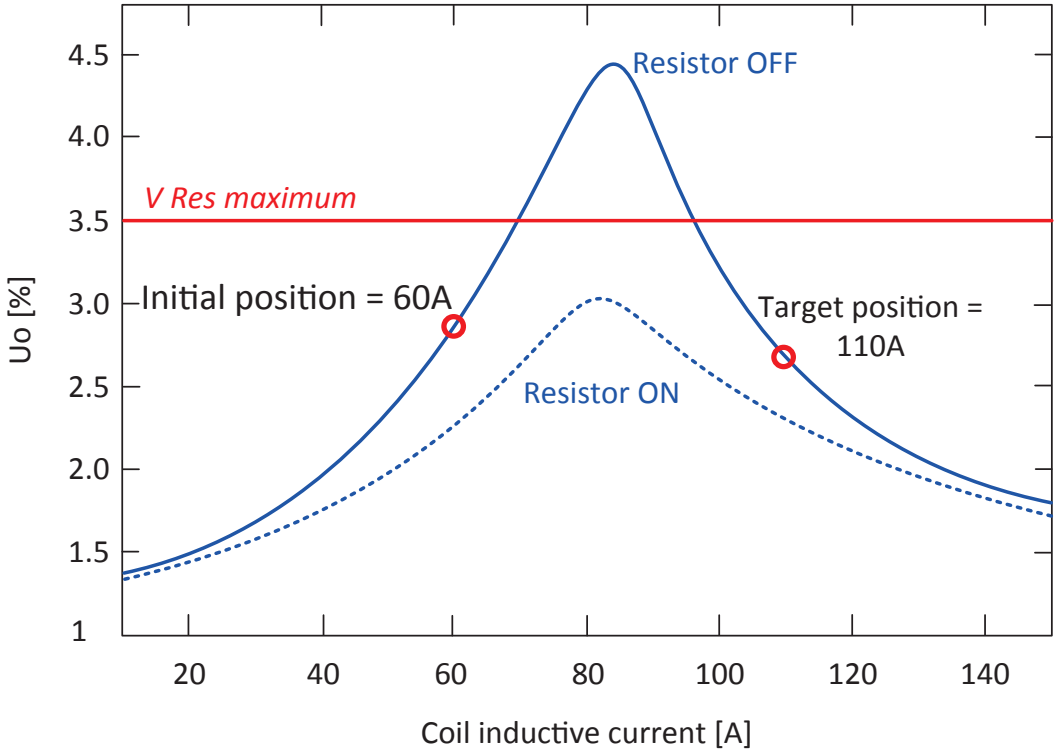



*Figure 927: Damping of the resonance curve by using the parallel resistor*

The number of maximum tuning cycles can be limited with *Tuning cycles* setting. The delay between consecutive tuning cycles is controllable by setting *Tuning cycles delay*. After the maximum number of tuning cycles is reached, the tuning procedure can be started by activating the ST_TUNING input, for example, via HMI application. The counter for maximum tuning cycles is reset after a successful tuning operation.

The ALARM output is a general problem indication during the tuning process. Usually, it is an indication of not obtaining a required minimum level or change of zero-sequence voltage during the coil movement. The reason for this might be, for example, a very symmetrical network. Other reasons for the ALARM indication are coil movement into wrong direction, maximum number of tuning sequences exceeded or simultaneous indication from both end switches of the coil. There is a dedicated MOT_ALARM output indicating no detected coil movement after activating RAISE_OWN or LOWER_OWN outputs.

After ALARM indication with ALARM_STS “Umin not reached” or “Cannot obtain minimum Uo variation” the coil is moved to a position which is defined with *Error*

*position* setting. The same procedure is executed after CLC_SEQ_WRN indication. The options are to move the coil to the position from where the tuning procedure was started, leave it to its present position or to move the coil to the default position which is settable by the user.

The active tuning range of the arc suppression coil can be limited with *Minimum current* and *Maximum current* settings. Once the operating limits are activated, the controller does not leave the selected range during the tuning procedure. If the operating limits are applied, the limited range of the coil is indicated on the HMI resonance curve view.

**Operation during earth faults**

The controller supports three modes for operation during earth fault. The active mode can be selected with *EF mode* setting. The available modes are "Blocked during EF", "Resonance" and "Tuning during EF".

- Blocked during EF: No coil movement when the earth fault is detected.
- Resonance: Coil is moved to the resonance point which is determined during the healthy-state operation of the network.
- Tuning during EF: The controller determines the network parameters during a sustained earth fault and maintains the set compensation level. The controller can also detect network switching operations and tune the ASC correspondingly (for example, disconnecting feeders to isolate the earth fault). Tuning during EF can be performed when the measured zero-sequence voltage is below 80 percent of the system's nominal phase-to-earth voltage. If the measured zero-sequence voltage is over 80 percent of the system's nominal phase-to-earth voltage, the “Blocked during EF” mode is automatically switched into use.

**Fixed parallel coil control**

PASANCR supports the control of the fixed parallel coil. The ampere value and the nominal voltage of the coil can be set with *Fix coil value* and *Fix coil V Nom* settings. The treatment of the fixed parallel coil is selected with *Fix coil type* setting. By applying “OFF” or “ON”, the controller cannot automatically switch the connection status of the fixed parallel coil. If “Automatic” is selected, the controller can change the connection status of the fixed parallel coil to reach the desired compensation level. During the automatic operation, the controller tunes the adjustable ASC first. If the desired compensation level cannot be reached, the fixed parallel coil can be switched on or off. The presence of the fixed parallel coil in the system has effect on correct tuning when the compensation mode is relative.

Absolute detuning current can be calculated:

$$I_v = I_{coil} + I_{fix} - I_{reson}$$

(Equation 388)

The corresponding relative detuning is calculated as:

$$v = \frac{I_{coil} + I_{fix} - I_{reson}}{I_{reson}} \cdot 100\%$$

(Equation 389)

| | |
|---|---|
| $I_{coil}$ | Current of the adjustable ASC |
| $I_{fix}$ | Value of the fixed parallel coil |
| $I_{reson}$ | Current at resonance point |

If a fixed parallel coil is introduced in the network (“ON” or “Automatic”), the x axis title of the resonance curve displayed on the HMI can be selected with the *Resonance curve Cur* setting. Available options are:

- Icoil: Only the current of adjustable ASC
- Icoil + Ifix: Total current of adjustable ASC and fixed parallel coil

### Statistics

The controller supports displaying resettable statistics. The statistics can be reset via settings menu using *Clear counters* command.

**Table 1590: Displayed statistics**

| Type | Statistics | Description |
|---|---|---|
| General | Operation time | Controller time in operation |
| | Tuning procedures | Number of started tuning procedures |
| | Tuned | Number of successful tuning operations |
| | Canceled tunings | Number of the canceled tuning procedures, that is, *Tuning delay* has not elapsed |
| | Tuned at Uo max | Number of tuning cases when coil movement has stopped to *V Res maximum* position |
| | Tuned at low limit | Number of cases when coil final position is limited either by low end position indication of the coil or the limited operating range *Minimum current* |
| | Tuned at high limit | Number of cases when coil final position is limited either by high end position indication of the coil or the limited operating range *Maximum current* |
| Earth faults | Transient earth-faults | Number of transient earth faults (that is, fault time shorter than time defined in *Transient time EF* setting) |
| | Permanent earth-faults | Number of permanent earth faults (that is, fault time longer than time defined in *Transient time EF* setting) |
| Resistor control | Switch parallel resistor (auto) | Number of parallel resistor switch operations. For example, if the resistor is initially off, then it is switched on and after a defined delay, it is again switched off, this increases the counter by two. |
| | Switch parallel resistor (manual) | Number of manual switch operations for parallel resistor |
| Other | Motor running time | Sum time of `RAISE_OWN` and `LOWER_OWN` outputs activated |

### 9.11.6.5 Coil manual tuning

PASANCR supports manual coil tuning when *Controller mode* setting is "Manual". Manual control is achieved by activating RAISE_LOCAL and LOWER_LOCAL inputs which activate the corresponding RAISE_OWN and LOWER_OWN outputs. The manual mode and the corresponding inputs can be activated, for example, via HMI application. Moreover, the manual control of the coil can be achieved via communication by using the *Coil Target Pos* setting. Once the setting is committed, the controller moves to the desired position. Also the activated operating limits can restrict the coil movement. The MOT_ALARM output is activated during manual control if the coil position is not changed due to activated RAISE_OWN and LOWER_OWN commands. The ALARM output is activated when the movement of the coil is in wrong direction or both end switches indicate simultaneously enabled signaling.

Coil manual movement is possible only after calibration.

During the manual control mode the network resonance curve is not updated automatically. The previous automatically detected resonance curve is displayed on the HMI view.

It is possible to manually control the connection status of the fixed parallel coil with *Fix coil type* setting by selecting "ON" or "OFF". The setting can be changed via the settings menu or HMI application.

### 9.11.6.6 Resistor control

Zero-sequence currents in compensated networks are usually very low, making it difficult to select the faulty line. To avoid sensitivity problems, the parallel resistor of the ASC is often used to increase the zero-sequence current allowing a simple earth-fault protection to locate the faulty line. PASANCR contains a functionality to switch the resistor on and off automatically or on user input.

First, the resistor installation status is set with *Parallel resistor* setting. The available options are "True" and "False". If the parallel resistor is installed in the system, the value is selected with *Resistor Nom value* setting. Second, the nominal voltage level of the power auxiliary winding is selected with *Auxiliary Wnd V Nom* setting.

The *Resistor control* setting is used to enable the automatic control sequence or to connect or disconnect the resistor. The automatic control sequence is released if the functionality is enabled (*Resistor control* = "Automatic") and the EARTH_FAULT output is active. The resistor control sequence after the earth-fault indication depends on the resistor connection status during the healthy state. The healthy-state status is selected with the *Resistor healthy St* setting. The available options are "On" and "Off". The settings affecting the control sequence are explained in *Figure 928*.

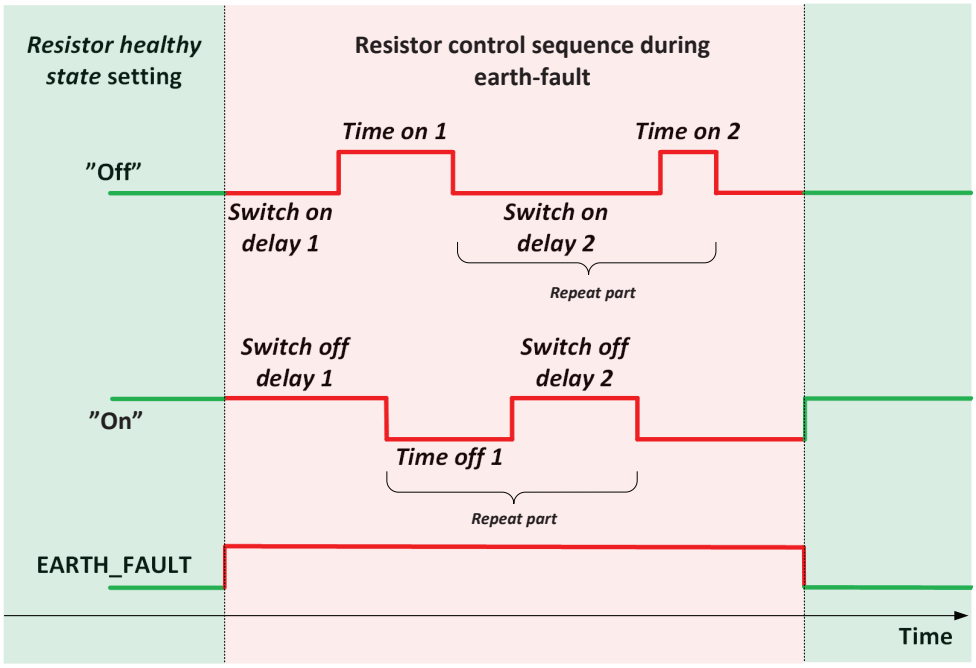



*Figure 928: Resistor control sequence*

When the earth-fault indication becomes inactive, any active single sequence or repeat sequence is cancelled, and the resistor is switched back to its initial state.

The resistor control sequence contains a repeat part which can be repeated after the whole sequence is executed once. The number of repetitions can be selected with *Resistor repeats* setting. Additionally, the pause between the consecutive repeats can be selected with *Resistor pause* setting. If the resistor status is the opposite to the *Resistor healthy state* when the earth-fault recovers, the resistor is restored to healthy state at latest after one second from the last resistor change. If the resistor already is in its healthy state when the earth-fault recovers, the status remains.

It is also possible to manually trigger the resistor control sequence with `ST_RESIS_SEQ` binary input.

### 9.11.6.7 Blocking

The `BLK_AUTO` input blocks the automatic operation of the function. PASANCR's automatic operation is blocked internally if the ASC is disconnected at the substation, that is, `COIL_STS` signal is low. The `BLK_MANUAL` input blocks the manual control of the coil. The `BLK_RESISTOR` input disconnects the parallel resistor and blocks its switching on, for example, due to resistor overheating.

## 9.11.7 Application

PASANCR is a numerical automatic controller for arc suppression coil (Petersen coil) and the parallel resistor. It can be applied to compensated networks where a switched parallel resistor is optionally connected in parallel with the arc-

suppression coil. An efficient protecting method against earth faults occurring in a medium-voltage compensated network is the earth-fault compensation. It is carried out by inserting an inductive coil (arc suppression coil or Petersen coil) between the transformer's star point and the earth in order to compensate the zero-sequence capacitive current of the network. It increases the probability of the arc extinction in case of a temporary earth fault. The arc extinction coil is effective only if its value is tuned to the zero-sequence capacity of the network so they are in resonance state and as a consequence the earth-fault current is very low.

### 9.11.8 Commissioning

During the coil setup process, it is not yet needed to connect the ASC to the network. The coil setup consists of two parts:

- Calibration of coil
- Evaluation of coil linearity

The coil calibration procedure is started by activating `ST_CALIB` input which can be done via local HMI application. Before starting the procedure, it must be checked that coil end switches (`HIGH_LIMIT` and `LOW_LIMIT`) are connected to the controller. If end switches are not available, end positions are detected during the calibration process if there was no coil movement for more than 20 s.

First, in the coil calibration procedure the coil is moved automatically from the lower-end switch to the upper-end switch. In both locations, the corresponding potentiometer values are recorded for further use. Also, the coil movement speed is determined during the calibration procedure. Secondly, the coil is moved to its middle position and the after-running and mechanical play of the coil are determined. Finally, the potentiometer gaps are determined. All results from coil calibration (running speed, after running, mechanical play and potentiometer gap locations) are visible in the Monitored data view.

After the calibration, the coil linearity is evaluated. The automatic coil calibration determined the potentiometer ohmic end-switch values. These values are displayed on the HMI and can be entered into the linearization table. The corresponding coil position values (that is, inductive current of the coil) might be entered, for example, from the coil routine test report delivered by the coil manufacturer. The values are entered at coil nominal voltage level which is defined with *Coil V Nom* setting. Moreover, if the potentiometer/coil position relationship is nonlinear, additional eight interpolation points, or part of them, might be applied. This is done by entering the potentiometer and corresponding coil position values into the linearization table. Values which are left to default value of 0.0 are discarded from the actual linearization curve. Both end values of the linearization table are displayed on the HMI view of the resonance curve. An example of the linearization table is given in *Table 1591* and the corresponding linearization curve is plotted in *Figure 929*.

The values put in ascending order are automatically adjusted so they are in the neighboring positions of the array, irrespective of the position in the linearization table.

**Table 1591: Example of a linearization table**

| Potentiometer value (setting Pot value x, x = 1...10) | Coil position (setting Coil current x, x = 1...10) |
|---|---|
| 100 | 10 |
| 150 | 20 |
| 200 | 30 |
| 250 | 37 |
| 300 | 43 |
| 350 | 48 |
| 400 | 53 |
| 450 | 57 |
| 600 | 68 |
| 1000 | 90 |

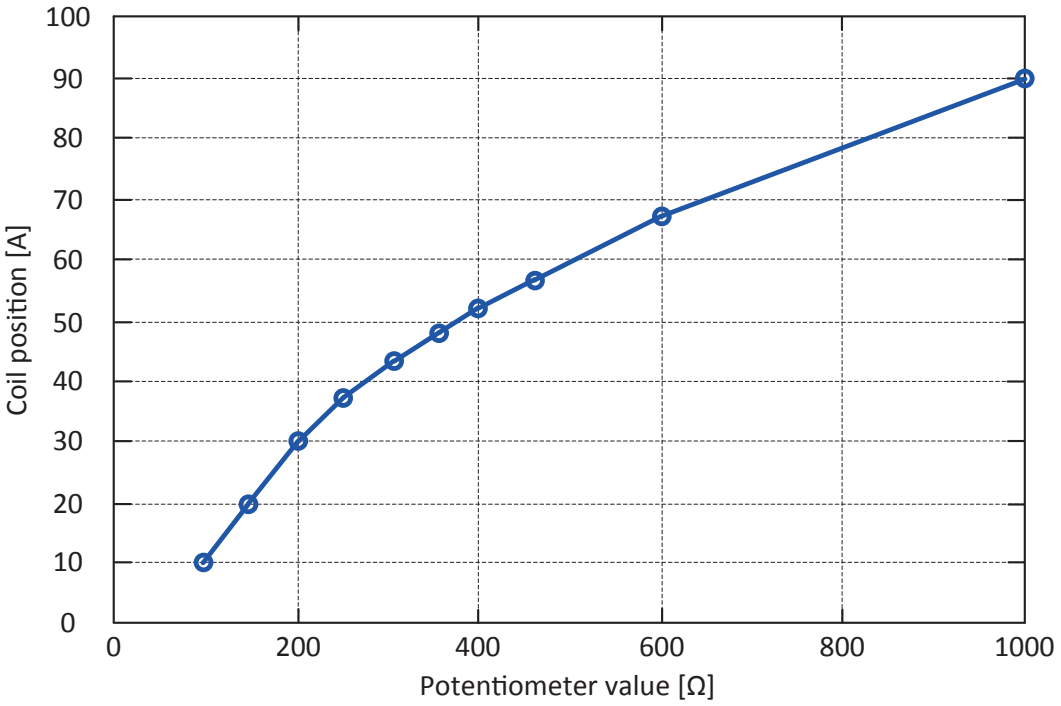



*Figure 929: Example of a linearization curve*

Aged ASCs can suffer from wearing of the position-indicating potentiometer. The potentiometer gaps are identified during the calibration and the number of the gaps is displayed on the HMI after the calibration. Actual gap locations GAP_LO_VAL_x and GAP_HI_VAL_x (x = 1…5, which corresponds to the gap identification number) are visible in the Monitored data view. If the maximum number of five gap locations is exceeded, the first pair is overwritten.

The coil position should be known and the controller operation should be guaranteed even if no new calibration is done. When potentiometer gaps are present in either both ends or in the middle of the potentiometer range, the potentiometer should be replaced. These are the three critical points of the calibration where ohmic measurements must be precise.

The maximum percentage length of the potentiometer gap can be set with setting *Pot Max gap*. The controller determines a gap length by measuring the distance between both ends of a gap in ohms. A gap is indicated when the ohmic position exceeds 2000 Ω.

If the coil potentiometer enters a gap during the normal operation, the controller estimates the coil position based on its previous known position and coil movement speed. If the actual gap length exceeds the setting *Pot Max gap* or a new gap appears during daily operation, `POT_ALARM` output is activated. Moreover, TUNING_STS monitored data indicates the reason of alarm. High values of the *Pot Max gap* setting introduce inaccuracy to the coil movement as the coil position is based on a calculated estimate. The purpose of the gap detection functionality is to enable the controller operation even if the potentiometer is worn out during the normal operation. The potentiometer should be replaced during the next service break in order to guarantee accurate operation of the controller. The gap detection functionality can be disabled by setting the *Pot Max gap* value to 0. Potentiometer gaps are illustrated in *Figure 930*.

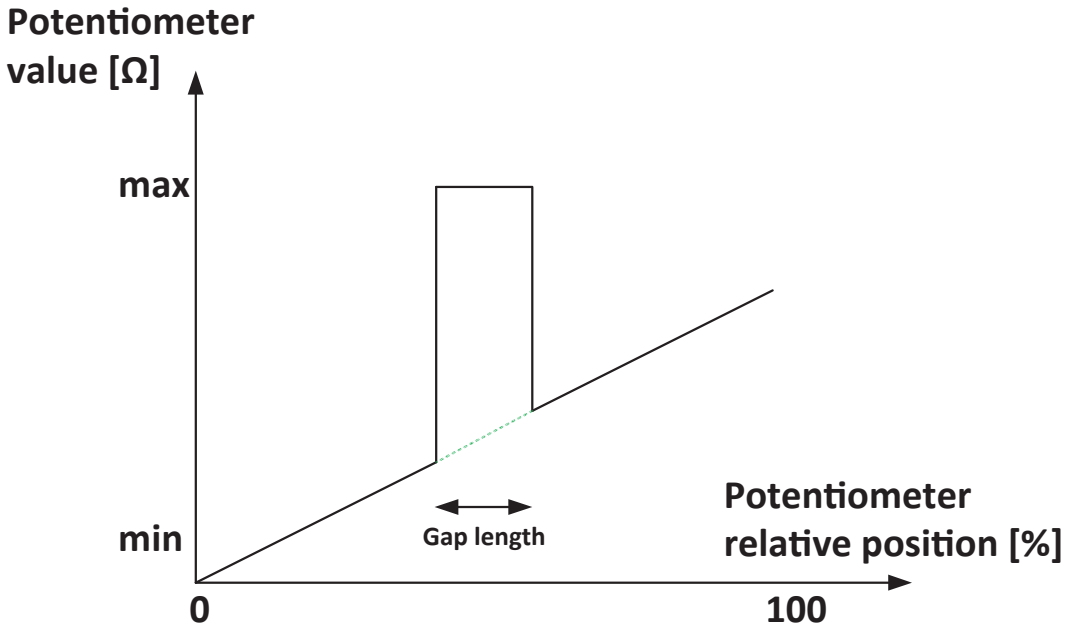



*Figure 930: Potentiometer gaps*

## 9.11.9 Signals

### 9.11.9.1 PASANCR Input signals

**Table 1592: PASANCR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| IRES | SIGNAL | - | Residual current |
| U3P | SIGNAL | - | Three-phase voltages |
| URES | SIGNAL | - | Residual voltage |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| COIL_STS | BOOLEAN | 0=False | Connection status of the variable arc suppression coil |
| FIXCOIL_STS | BOOLEAN | 0=False | Connection status of the fixed coil |
| RESISTOR_STS | BOOLEAN | 0=False | Connection status of the parallel current raising resistor |
| HIGH_LIMIT | BOOLEAN | 0=False | High end position reached |
| LOW_LIMIT | BOOLEAN | 0=False | Low end position reached |
| ST_CALIB | BOOLEAN | 0=False | Rising edge of this signal triggers the calibration procedure of the coil |
| ST_TUNING | BOOLEAN | 0=False | Rising edge of this signal triggers the automatic tuning procedure |
| ST_RESIS_SEQ | BOOLEAN | 0=False | Rising edge of this signal triggers the resistor control sequence |
| RAISE_LOCAL | BOOLEAN | 0=False | Increase arc suppression coil current |
| LOWER_LOCAL | BOOLEAN | 0=False | Decrease arc suppression coil current |
| PARALLEL | BOOLEAN | 0=False | Parallel controller has coil movement in progress |
| BLK_AUTO | BOOLEAN | 0=False | Blocking the coil automatic tuning |
| BLK_MANUAL | BOOLEAN | 0=False | Blocking the coil manual operation |
| BLK_RESISTOR | BOOLEAN | 0=False | Disconnect and block switching on the parallel resistor |
| HIGH_LIMIT | BOOLEAN | 0=False | High coil position |
| LOW_LIMIT | BOOLEAN | 0=False | Low coil position |

### 9.11.9.2 PASANCR Output signals

**Table 1593: PASANCR Output signals**

| Name | Type | Description |
|---|---|---|
| RAISE_OWN | BOOLEAN | Increase coil current |
| LOWER_OWN | BOOLEAN | Decrease coil current |
| FIXCOIL | BOOLEAN | Status information to control fixed coil on/off |
| OP_FIXCOIL | BOOLEAN | Command to disconnect fix coil |
| CL_FIXCOIL | BOOLEAN | Command to connect fix coil |
| RESISTOR | BOOLEAN | Status information to control parallel current rising resistor on/off |
| OP_RESISTOR | BOOLEAN | Command to disconnect parallel current rising resistor |
| CL_RESISTOR | BOOLEAN | Command to connect parallel current rising resistor |
| ALARM | BOOLEAN | General alarm indication |
| MOT_ALARM | BOOLEAN | Motor alarm: no detected coil movement |
| POT_ALARM | BOOLEAN | Potentiometer alarm |
| EARTH_FAULT | BOOLEAN | Earth-fault indication |
| HIF | BOOLEAN | High impedance fault indication |
| TUNING_ACT | BOOLEAN | Automatic tuning procedure ongoing |
| TUNING_SUC | BOOLEAN | Tuning successful |

## 9.11.10 PASANCR Settings

**Table 1594: PASANCR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Compensation mode | 1=Absolute<br>2=Relative | | | 1=Absolute | Compensation degree in absolute amperes or relative to the resonance point |
| Detuning level | -100...100 | A | 1 | 0 | Detuning level in amperes |
| Detuning level Rl | -100.0...100.0 | % | 0.1 | 0.0 | Detuning level in percent |
| V Res change level | 0.0...1000.0 | %Uref | 0.1 | 10.0 | Zero-sequence voltage change threshold as percent of reference voltage |
| V Res Meas mode | 1=Amplitude | | | 2=Phasor | Uo trigger based on amplitude or |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=Phasor | | | | phasor measurement |
| Tuning delay | 0...3600 | s | 1 | 60 | Zero-sequence voltage trigger delay to start control procedure |
| V Res variation | 0.10...100.00 | %Un | 0.01 | 2.00 | Req. change in Uo that calc. of net. param. can be executed |
| Tuning mode | 1=Coil movement<br>2=Resistor switching | | | 1=Coil movement | Method for obtaining Uo variation |
| V Ref adaptive mode | 0=Disable<br>1=Enable | | | 1=Enable | Uref adaptive mode |
| V Ref adaptive delay | 0...1000 | min | 1 | 20 | Uref adaptive delay |
| V Res EF level | 0.00...100.00 | %Un | 0.01 | 15.00 | Uo level for detection of earth fault in the network |
| Default position | 0...1000 | A | 1 | 50 | Coil default position |
| V Res minimum | 0.00...20.00 | %Un | 0.01 | 0.10 | Minimum level for zero-sequence voltage to allow coil automatic tuning |
| V Res maximum | 0.00...150.00 | %Un | 0.01 | 10.00 | Maximum level for zero-sequence voltage allowed during automatic tuning process |
| Temporary damping | 0=False<br>1=True | | | 0=False | Resistor switching on/off allowed during the automatic tuning procedure |
| Minimum current | 0...100 | A | 1 | 0 | Minimum current of arc-suppression coil (low operating limit) |
| Maximum current | 0...10000 | A | 1 | 10000 | Maximum current of arc-suppression coil (high operating limit) |
| Error position | 1=Current<br>2=Previous<br>3=Default | | | 2=Previous | Coil position in the case error occurred during the automatic tuning process |
| Pass resonance | 0=False<br>1=True | | | 0=False | Pass resonance enabled / disabled |
| Transient time EF | 0...1000000 | ms | 1 | 5 | Transient earth-fault duration threshold |
| EF mode | 1=Blocked during EF<br>2=Resonance<br>3=Tuning during EF | | | 1=Blocked during EF | Operation mode during earth-fault (alarming earth-fault) |
| Resistor healthy St | 0=Off<br>1=On | | | 0=Off | Resistor connection status during healthy state operation |
| Resistor repeats | 0...100 | | 1 | 0 | Number of resistor control sequence repeats |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Resistor pause | 0...100000000 | ms | 1 | 5 | Time between consecutive resistor control sequence repeats |
| Resonance curve Cur | 1=Icoil<br>2=Icoil + Ifix | | | 2=Icoil + Ifix | Resonance curve x-axis title on HMI |
| Switch on delay 1 | 0...300000 | ms | 1 | 1000 | Resistor switch-on delay time |
| Time on 1 | 0...300000 | ms | 1 | 1000 | Resistor switch on time |
| Switch on delay 2 | 0...300000 | ms | 1 | 1000 | Resistor repetition switch-on delay time |
| Time on 2 | 0...300000 | ms | 1 | 1000 | Resistor repetition switch-on time |
| Switch off delay 1 | 0...300000 | ms | 1 | 1000 | Resistor switch-off delay time |
| Time off 1 | 0...300000 | ms | 1 | 1000 | Resistor switch-off time |
| Switch off delay 2 | 0...300000 | ms | 1 | 1000 | Resistor repetition switch-off delay time |

**Table 1595: PASANCR Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Tuning cycles | 1...100 | | 1 | 5 | Maximum number of tuning cycles |
| Tuning cycle delay | 0...86400 | s | 1 | 300 | Delay between consecutive tuning cycles |

**Table 1596: PASANCR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Coil V Nom | 0...400000 | V | 1 | 10000 | Adjustable arc suppression coil nominal voltage |
| Fix coil V Nom | 0...400000 | V | 1 | 10000 | Fixed arc suppression coil nominal voltage |
| Auxiliary Wnd V Nom | 0...10000 | V | 1 | 500 | Power auxiliary winding nominal voltage |
| Controller mode | 0=Manual<br>1=Automatic | | | 0=Manual | Coil controller operating in automatic or manual mode |
| Parallel resistor | 0=False<br>1=True | | | 0=False | Parallel resistor installation status |
| R0Transformer | 0...100 | ohm | 1 | 0 | Zero-sequence resistance of the earthing/main transformer |
| X0Transformer | 0...100 | ohm | 1 | 0 | Zero-sequence reactance of the earthing/main transformer |
| Voltage measurement | 1=Busbar<br>2=Coil | | | 2=Coil | Residual voltage measurement from busbar or from coil |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Position Meas mode | 1=Pos. indication<br>2=Pos. ind. and meas. | | | 1=Pos. indication | Coil position measurement mode |
| Resistor control | 1=OFF<br>2=ON<br>3=Automatic | | | 1=OFF | Resistor control mode |
| Resistor Nom value | 0.00...100.00 | ohm | 0.01 | 5.00 | Nominal resistance of the parallel resistor at power auxiliary winding secondary voltage level |
| Coil losses | 0.00...20.00 | % | 0.01 | 2.00 | Coil losses |
| Fix coil value | 0...10000 | A | 1 | 0 | Inductive current produced by fixed coil at fixed coil nominal voltage level |
| Fix coil losses | 0.00...20.00 | % | 0.01 | 2.00 | Fix coil losses |
| Pot Max gap | 0...100 | % | 1 | 5 | Potentiometer maximum gap length |
| Fix coil type | 1=OFF<br>2=ON<br>3=Automatic | | | 1=OFF | Fix coil type |
| Level detector op | 0=Disable<br>1=Enable | | | 1=Enable | Enable / disable level detector module |
| Pot value 1 | 0...3000 | ohm | 1 | 0 | Potentiometer value 1 |
| Coil current 1 | 0...10000 | A | 1 | 0 | Coil current 1 |
| Pot value 2 | 0...3000 | ohm | 1 | 0 | Potentiometer value 2 |
| Coil current 2 | 0...10000 | A | 1 | 0 | Coil current 2 |
| Pot value 3 | 0...3000 | ohm | 1 | 0 | Potentiometer value 3 |
| Coil current 3 | 0...10000 | A | 1 | 0 | Coil current 3 |
| Pot value 4 | 0...3000 | ohm | 1 | 0 | Potentiometer value 4 |
| Coil current 4 | 0...10000 | A | 1 | 0 | Coil current 4 |
| Pot value 5 | 0...3000 | ohm | 1 | 0 | Potentiometer value 5 |
| Coil current 5 | 0...10000 | A | 1 | 0 | Coil current 5 |
| Pot value 6 | 0...3000 | ohm | 1 | 0 | Potentiometer value 6 |
| Coil current 6 | 0...10000 | A | 1 | 0 | Coil current 6 |
| Pot value 7 | 0...3000 | ohm | 1 | 0 | Potentiometer value 7 |
| Coil current 7 | 0...10000 | A | 1 | 0 | Coil current 7 |
| Pot value 8 | 0...3000 | ohm | 1 | 0 | Potentiometer value 8 |
| Coil current 8 | 0...10000 | A | 1 | 0 | Coil current 8 |
| Pot value 9 | 0...3000 | ohm | 1 | 0 | Potentiometer value 9 |
| Coil current 9 | 0...10000 | A | 1 | 0 | Coil current 9 |
| Pot value 10 | 0...3000 | ohm | 1 | 0 | Potentiometer value 10 |
| Coil current 10 | 0...10000 | A | 1 | 0 | Coil current 10 |
| Reset delay time EF | 0...1000000 | ms | 1 | 500 | Reset delay time for earth-fault |

## 9.11.11 PASANCR Monitored data

**Table 1597: PASANCR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| COIL_MV_SPD | FLOAT32 | 0.00...100.00 | A/s | Coil movement speed detected during calibration |
| I_AFTER_RUN | FLOAT32 | 0.00...100.00 | A | Coil after-running current |
| I_MCH_PLAY | FLOAT32 | 0.00...100.00 | A | Mechanical play of the coil |
| I_COIL_TOT | FLOAT32 | 0.00...10000.00 | A | Total inductive current of adjustable and fixed arc suppression coil |
| OHM_COIL | FLOAT32 | 0...3000 | ohm | Coil position indicating potentiometer value |
| I_DAMPING | FLOAT32 | 0.00...10000.00 | A | Wattmetric part of the residual current at the fault location |
| I_C_NETWORK | FLOAT32 | 0.00...10000.00 | A | Uncompensated earth-fault current of the network |
| I_EF | FLOAT32 | 0.00...10000.00 | A | Earth-fault current at present operate point |
| I_RESONANCE | FLOAT32 | 0.00...10000.00 | A | Current at the resonance point |
| DAMPING | FLOAT32 | 0.00...100.00 | | Damping of the network |
| I_DETUNING | FLOAT32 | -100.00...100.00 | A | Petersen coil detuning in amperes |
| DETUNING_REL | FLOAT32 | -100.00...100.00 | % | Petersen coil detuning in percent |
| UREF_AMPL | FLOAT32 | 0.00...100.00 | xUn | Reference voltage amplitude |
| UREF_ANG | FLOAT32 | -180.00...180.00 | deg | Reference voltage angle |
| URESO_AMPL | FLOAT32 | 0...100000 | V | Resonance point voltage amplitude without the parallel resistor |
| URESO_REL | FLOAT32 | 0.0...100.0 | % | Resonance point voltage in percent without the parallel resistor |
| URESO_AMPL_R | FLOAT32 | 0...100000 | V | Resonance point voltage amplitude with the parallel resistor connected |
| URESO_REL_R | FLOAT32 | 0.0...100.0 | % | Resonance point voltage in percent with the parallel resistor connected |
| TUNING_TRIGG | FLOAT32 | 0...100 | % | Percentage value indicating present deviation in zero-sequence voltage with respect to reference voltage |
| GAP_LO_VAL_1 | FLOAT32 | 0...3000 | ohm | Potentiometer 1st gap low value |
| GAP_HI_VAL_1 | FLOAT32 | 0...3000 | ohm | Potentiometer 1st gap high value |
| GAP_LO_VAL_2 | FLOAT32 | 0...3000 | ohm | Potentiometer 2nd gap low value |
| GAP_HI_VAL_2 | FLOAT32 | 0...3000 | ohm | Potentiometer 2nd gap high value |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| GAP_LO_VAL_3 | FLOAT32 | 0...3000 | ohm | Potentiometer 3rd gap low value |
| GAP_HI_VAL_3 | FLOAT32 | 0...3000 | ohm | Potentiometer 3rd gap high value |
| GAP_LO_VAL_4 | FLOAT32 | 0...3000 | ohm | Potentiometer 4th gap low value |
| GAP_HI_VAL_4 | FLOAT32 | 0...3000 | ohm | Potentiometer 4th gap high value |
| GAP_LO_VAL_5 | FLOAT32 | 0...3000 | ohm | Potentiometer 5th gap low value |
| GAP_HI_VAL_5 | FLOAT32 | 0...3000 | ohm | Potentiometer 5th gap high value |
| CLC_SEQ_WRN | BOOLEAN | 0=False<br>1=True | | Maximum number of tuning cycles is reached |
| DEFAULT_POS | BOOLEAN | 0=False<br>1=True | | Coil has been moved to its default position |
| ERROR_POS | BOOLEAN | 0=False<br>1=True | | Coil has been moved to its error position |
| UMAX_RES_STS | BOOLEAN | 0=False<br>1=True | | Zero-sequence voltage has reached U0 max level |
| UMIN_RES_STS | BOOLEAN | 0=False<br>1=True | | Zero-sequence voltage has reached Uo min level |
| TUNING_DL_ON | BOOLEAN | 0=False<br>1=True | | Tuning delay ongoing |
| TUNING_ST_DELAY | INT32 | 0...3600 | s | Remaining delay time in seconds to start automatic tuning procedure |
| OPR_TIME | INT32 | 0...999999 | h | Controller time in operation (hours) |
| CNT_TUNINGS | INT32 | 0...999999 | | Counter of started tuning procedures |
| CNT_TUNED | INT32 | 0...999999 | | Counter of successful tuning procedures |
| CNT_CNL_TUN | INT32 | 0...999999 | | Counter of cancelled tuning procedures |
| CNT_TUN_UMAX | INT32 | 0...999999 | | Counter of coil final tuning position at Uo max |
| CNT_TUN_HIGH | INT32 | 0...999999 | | Counter of cases when coil final tuning position is at high limit (high end switch or high operating limit) |
| CNT_TUN_LOW | INT32 | 0...999999 | | Counter of cases when coil final tuning position is at low limit (low end switch or low operating limit) |
| CNT_TRNS_EF | INT32 | 0...999999 | | Counter of transient earth-faults |
| CNT_EF | INT32 | 0...999999 | | Counter of earth-faults |
| CNT_RES_SW_A | INT32 | 0...999999 | | Counter of parallel resistor automatic switching operations |
| CNT_RES_SW_M | INT32 | 0...999999 | | Counter of parallel resistor manual switching operations |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| MOT_RUN_TIME | INT32 | 0...999999 | h | Total arc suppression coil motor run time (hours) |
| CALIB_RSL | Enum | 1=Calibration successful<br>2=Calibration ongoing<br>3=Calibration failed<br>4=Not calibrated | | Calibration result |
| CALIB_STS | Enum | 1=Detect end switches<br>2=Move to middle position<br>3=Detect mechanical play<br>4=Detect after running<br>5=Detect potentiometer gaps<br>6=Calibration not ongoing | | Calibration status |
| ALARM_STS | Enum | 1=No alarm<br>2=No movement detected<br>3=Movement into wrong direction<br>4=Simultaneously indication from both end-switches<br>5=Potentiometer maximum gap length exceeded<br>6=Potentiometer new gap appeared<br>7=Maximum number of potentiometer gaps exceeded<br>8=Check measurements<br>9=Umin not reached<br>10=Cannot obtain minimum Uo variation | | Alarm status |
| TUNING_STS | Enum | 1=Tuned successfully<br>2=Not tuned<br>3=Tuned at Umax<br>4=Tuned at low limit (low end switch or low operating limit)<br>5=Tuned at high limit (high end switch or high operating limit)<br>6=Tuning delay ongoing<br>7=Move to Ures min<br>8=Direction determination<br>9=Pick up 1st point<br>10=Pick up 2nd point<br>11=Pick up 3rd point<br>12=Calculate parameters | | Tuning status |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 13=Move to detuning point | | |
| BSYMM | FLOAT32 | -1000.000...1000.000 | mS | Symmetrical susceptance of network |
| GSYMM | FLOAT32 | -1000.000...1000.000 | mS | Symmetrical conductance of network |
| BASYMM | FLOAT32 | -1000.000...1000.000 | mS | Asymmetrical susceptance of network |
| GASYMM | FLOAT32 | -1000.000...1000.000 | mS | Asymmetrical conductance of network |
| BSYMM_REF | FLOAT32 | -1000.000...1000.000 | mS | Reference value of symmetrical susceptance of network |
| GSYMM_REF | FLOAT32 | -1000.000...1000.000 | mS | Reference value of symmetrical conductance of network |
| BASYMM_REF | FLOAT32 | -1000.000...1000.000 | mS | Reference value of asymmetrical susceptance of network |
| GASYMM_REF | FLOAT32 | -1000.000...1000.000 | mS | Reference value of asymmetrical conductance of network |
| BCOIL | FLOAT32 | -1000.000...1000.000 | mS | Coil susceptance |
| GCOIL | FLOAT32 | -1000.000...1000.000 | mS | Coil conductance |
| BFIXCOIL | FLOAT32 | -1000.000...1000.000 | mS | Fixed parallel coil susceptance |
| GFIXCOIL | FLOAT32 | -1000.000...1000.000 | mS | Fixed parallel coil conductance |
| GPARALLEL | FLOAT32 | -1000.000...1000.000 | mS | Parallel resistor conductance |
| I_COIL_HMI | FLOAT32 | 0.00...10000.00 | A | Coil current value dedicated for HMI purposes (depends on Resonance curve Cur setting) |
| I_COIL | FLOAT32 | 0.00...10000.00 | A | Adjustable arc suppression coil value |
| CALIB_O_MIN | FLOAT32 | 0...3000 | ohm | Low end switch position of the coil (ohms) |
| CALIB_O_MAX | FLOAT32 | 0...3000 | ohm | High end switch position of the coil (ohms) |
| B_RATIO | FLOAT32 | 0.000...100.000 | | Susceptance ratio |
| PASANCR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 9.11.12 Technical data

**Table 1598: PASANCR Technical data**

| Characteristic | Value |
|---|---|
| Measuring accuracy | Resistance:<br>±2% or ±1 Ω |
| Operation accuracy [1] | I_C_NETWORK: |

| Characteristic | Value |
|---|---|
| | Typically ±5% |

## 9.11.13 Technical revision history

**Table 1599: PASANCR Technical revision history**

| Product connectivity level | Technical revision | Change |
|---|---|---|
| PCL4 | B | More accurate operation of controller with low residual voltage magnitudes. Parallel resistor automatic control sequence is reset if earth-fault indication becomes inactive. New output TUNING_SUC ("Tuned successfully"). New monitored data B_RATIO. Network capacitive current I_C_NETWORK is scaled with respect to residual voltage channel setting *Primary voltage*. IRES input allows connection from GRPOFF function block. Outputs OP_RESISTOR, CL_RESISTOR, OP_FIXCOIL and CL_FIXCOIL are fixed to 100 ms pulses. TUNING_STS enumerator has new elements. |

[1] Network resonance point voltage must be at least 0.005 × $U_n$, where $U_n$ = nominal phase-to-earth voltage

# 9.12 High speed bus transfer HSABTC (ANSI I<->O BT)

## 9.12.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE identification |
|---|---|---|---|
| High speed bus transfer | HSABTC | I<->O BT | I<->O BT |

## 9.12.2 Function block

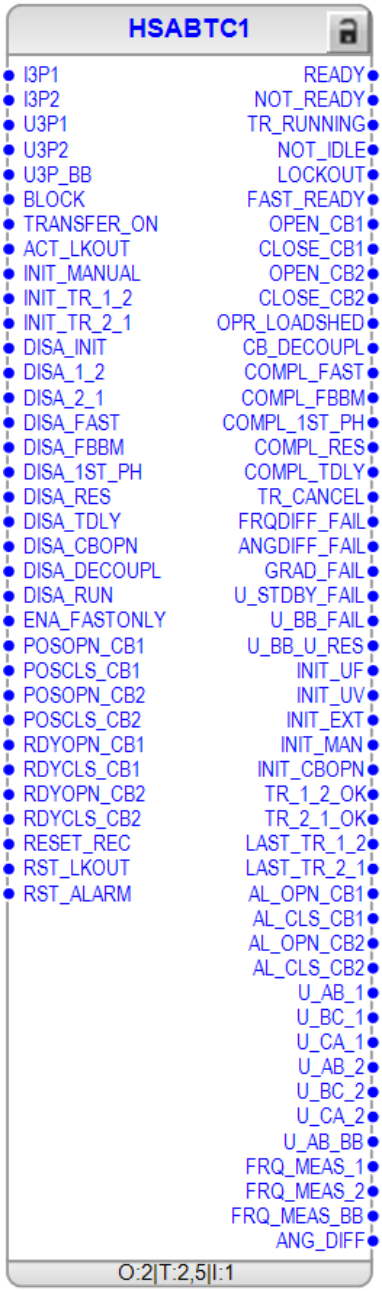



*Figure 931: Function block*

## 9.12.3 Functionality

The high speed bus transfer function HSABTC is used for securing alternative (standby) supply for loads connected to a busbar, thus minimizing disturbances for the primary process.

Electrical power supply stability and availability is most essential for many industrial processes. Interruptions in the power supply can cause considerable production

losses or even dangerous operation conditions for the process itself. Solution is to connect a standby power supply for the installation.

The HSABTC function monitors the voltage and frequency of the available supply feeders and the busbar. Function continuously keeps track on the allowed transfer direction and the standby incomer(s) readiness for transfer. Bus transfer can be initiated internally by the function, based on drop on voltage or frequency. Alternatively external initiation can be used. Once transfer is initiated, sequence for busbar transfer is executed according to the allowed and enabled transfer modes. HSABTC also provides support for load shedding as a part of the transfer sequence.

## 9.12.4 Analog channel configuration

HSABTC has five analog group inputs which must be properly configured.

**Table 1600: Analog inputs**

| Input | Description |
|---|---|
| U3P1 | Voltage from feeder 1 |
| U3P2 | Voltage from feeder 2 |
| U3P_BB | Voltage from busbar |
| I3P1 | Current from feeder 1 |
| I3P2 | Current from feeder 2 |

Recommended number of measured voltages is following:

- U3P1: all three phases, can be phase-to-phase or phase-to-ground voltages
- U3P2: all three phases, can be phase-to-phase or phase-to-ground voltages
- U3P_BB: one phase-to-phase voltage

Minimum requirement is to have one voltage connected to each voltage group. In this case all measurements must be made with the same connection type, meaning all measurements must be either phase-to-ground or phase-to-phase voltages. Mixing between different connections types in this case is not allowed. Measurements must also be made from same phase (phase A or phase AB), mixing between phases is not allowed.

*Table 1601* shows supported voltage connections.

**Table 1601: Supported voltage connections**

| U3P1 | U3P2 | U3P_BB | Note |
|---|---|---|---|
| 3 phase-to-phase | 3 phase-to-phase | 1 phase-to-phase | Recommended |
| 3 phase-to-ground | 3 phase-to-ground | 1 phase-to-phase | Recommended |
| 3 phase-to-phase | 3 phase-to-phase | 1 phase-to-ground | Not recommended |

*Table continues on the next page*

| U3P1 | U3P2 | U3P_BB | Note |
|---|---|---|---|
| | | | Allowed only if Uo is also measured from U3P1 and U3P2 |
| 3 phase-to-ground | 3 phase-to-ground | 1 phase-to-ground | Supported |
| 1 phase-to-phase | 1 phase-to-phase | 1 phase-to-phase | Limited functionality |
| 1 phase-to-ground | 1 phase-to-ground | 1 phase-to-ground | Limited functionality |

Limited functionality due to limited voltage connections is related to under-voltage triggering. In case only one voltage is connected, function is blind to unconnected phases. In this case external triggering is recommended.

Phase currents can be left unconnected but then circuit breaker monitoring has limited functionality available. Recommendation is to connect full three phase current triplet to both I3P inputs.

**Table 1602: Supported current connections**

| I3P1 | I3P2 | Note |
|---|---|---|
| All three phases connected | All three phases connected | Recommended |
| Not connected | Not connected | Limited functionality |

## 9.12.5 Operation principle

The *Operation* setting is used to enable or disable the function. When selected "On" the function is enabled and respectively "Off" means function is disabled. Function state can be controlled also with level sensitive TRANSFER_ON input. If input is TRUE, function is “On” and if input is FALSE, function is “Off”. If TRANSFER_ON input is not connected in relay configuration tool, then status is “On”. The operation of HSABTC is described by a module diagram presented in *Figure 932*. All the modules in the diagram are explained in the next sections.

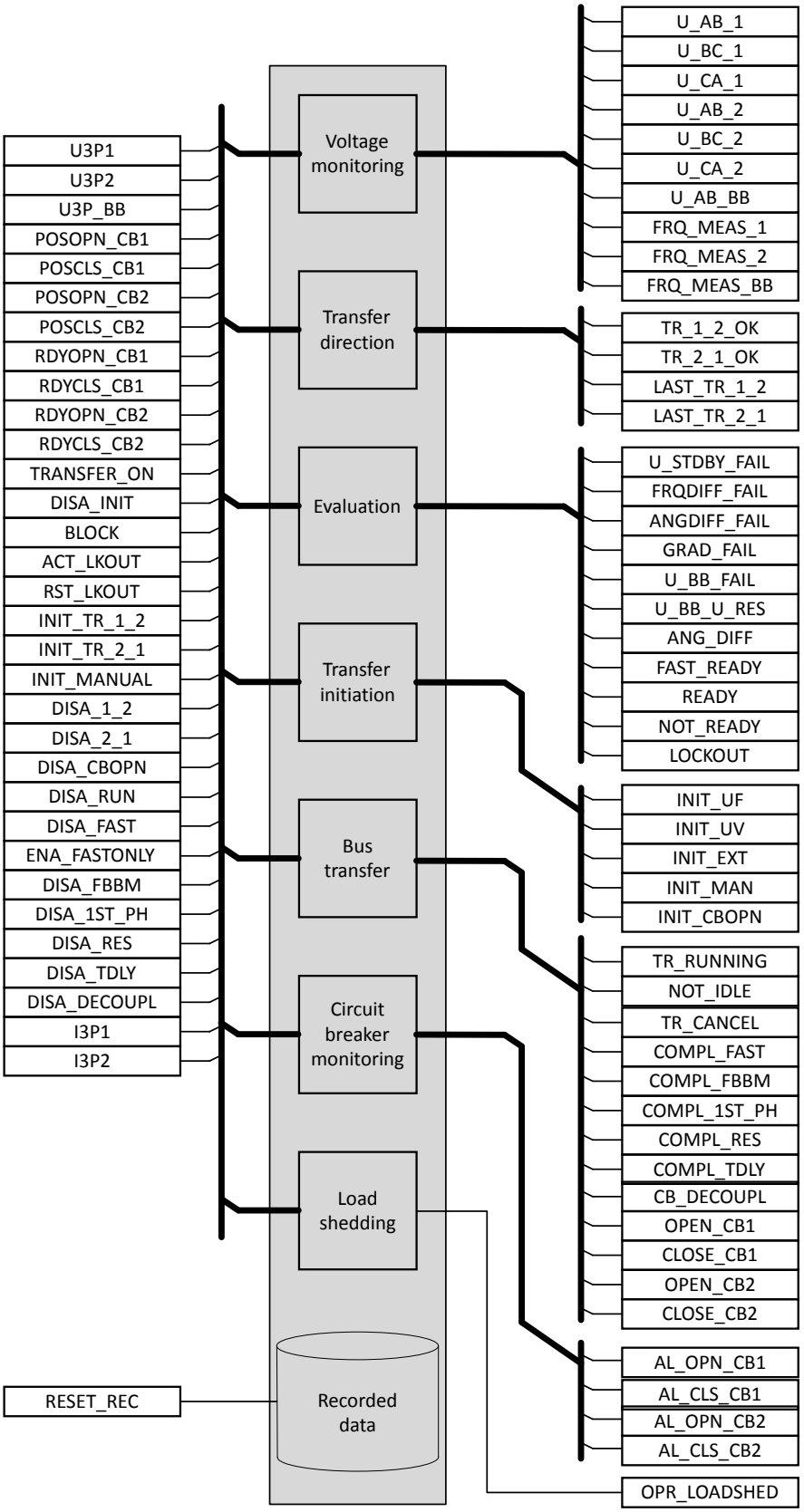



*Figure 932: Functional module diagram. Grey area in figure presents internal signalling between modules. All signals are presented later in module specific description.*

### 9.12.5.1 Voltage monitoring

Voltage monitoring module calculates measurement values necessary in HSABTC internal operation. Functionally module can be split to submodules presented in *Figure 933*. Each module is explained later below.

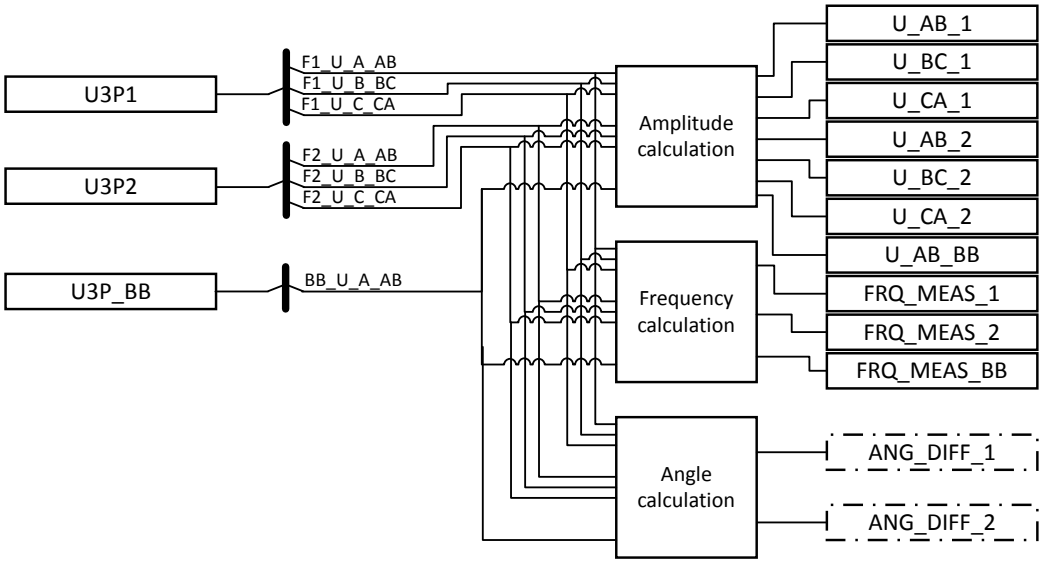



*Figure 933: Voltage monitoring module diagram.*

#### Amplitude calculation

Amplitude calculation reports phase-to-phase voltages from busbar (U_AB_BB), feeder 1 (U_AB_1, U_BC_1, U_CA_1) and feeder 2 (U_AB_2, U_BC_2, U_CA_2).

#### Frequency calculation

This module calculates the frequencies of feeder 1, feeder 2 and busbar. The calculated frequencies for feeder 1, feeder 2 and busbar, FRQ_MEAS_1, FRQ_MEAS_2 and FRQ_MEAS_BB respectively, are available as function outputs.

#### Angle calculation

This module calculates phase angle difference between feeder 1 and busbar (ANG_DIFF_1), and between feeder 2 and busbar (ANG_DIFF_2). Values are available in monitored data view.

### 9.12.5.2 Transfer direction

The module checks the present transfer direction and stores the valid saved transfer direction from the breaker's auxiliary contact states. Functionally module can be split to submodules presented in *Figure 934*. Each module is explained later below.

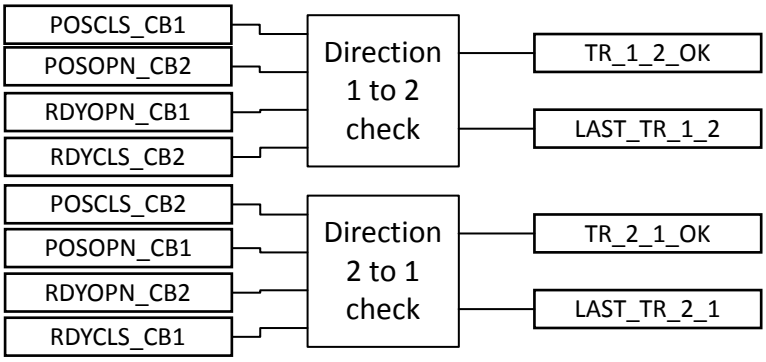



*Figure 934: Module diagram for Transfer direction*

**Direction 1 to 2 check**

Breaker position information for feeder 1 is obtained from POSOPN_CB1 and POSCLS_CB1 inputs. Circuit breaker readiness to open and close are defined with inputs RDYOPN_CB1 and RDYCLS_CB2.

If the CB1 is closed and CB2 is open, CB1 is ready to open and CB2 is ready close, then TR_1_2_OK is TRUE, meaning transfer from feeder 1 to feeder 2 is allowed ( *Figure 935*, left side).

All other combinations of CB status will set TR_1_2_OK FALSE.

TR_1_2_OK – TRUE when present direction of transfer is from feeder 1 to feeder 2 and stand-by feeder is feeder 2.

LAST_TR_1_2 output shows if the last valid transfer has been from feeder 1 to feeder 2.

**Direction 2 to 1 check**

Breaker position information for feeder 2 is obtained from POSOPN_CB2 and POSCLS_CB2 inputs. Circuit breaker readiness to open and close are defined with inputs RDYCLS_CB1 and RDYOPN_CB2.

If the CB2 is closed and CB1 is open, CB2 is ready to open and CB1 is ready to close, then TR_2_1_OK is TRUE, meaning transfer from feeder 2 to feeder 1 is allowed ( *Figure 935*, right side).

All other combinations of CB status will set TR_2_1_OK to FALSE.

TR_2_1_OK – TRUE when present direction of transfer is from feeder 2 to feeder 1 and stand-by feeder is feeder 1.

LAST_TR_2_1 output shows if the last valid transfer has been from feeder 2 to feeder 1.

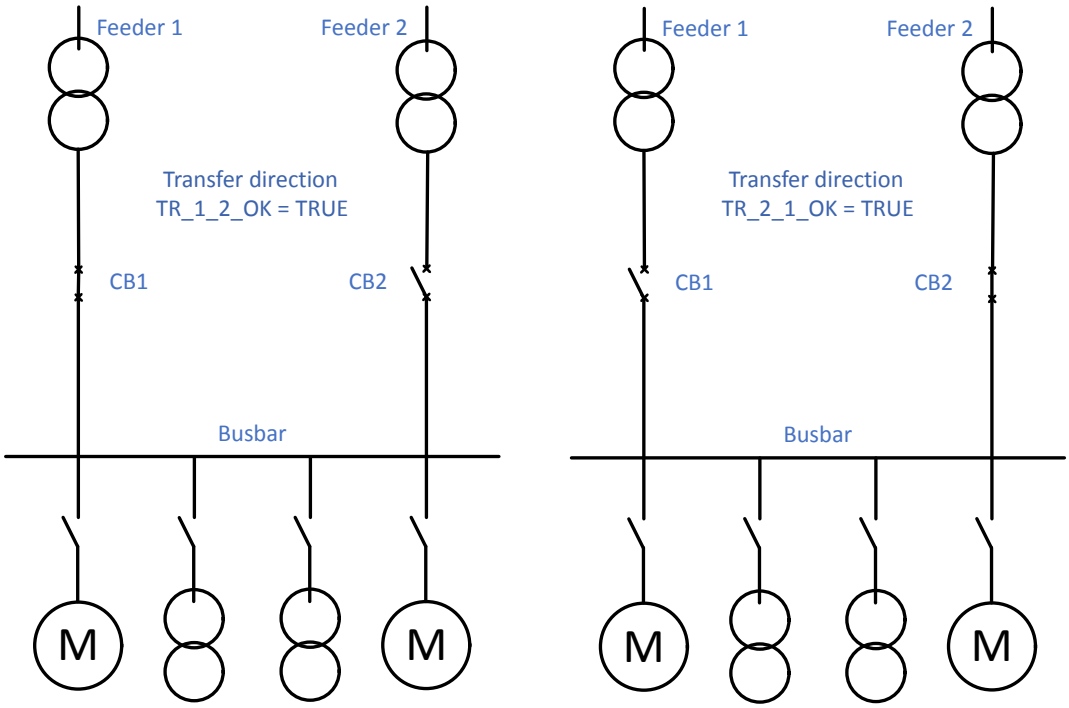



*Figure 935: Example figure of breaker configuration*

### 9.12.5.3 Evaluation

Functionally module can be split to submodules presented in *Figure 936*. Each module is explained later below.

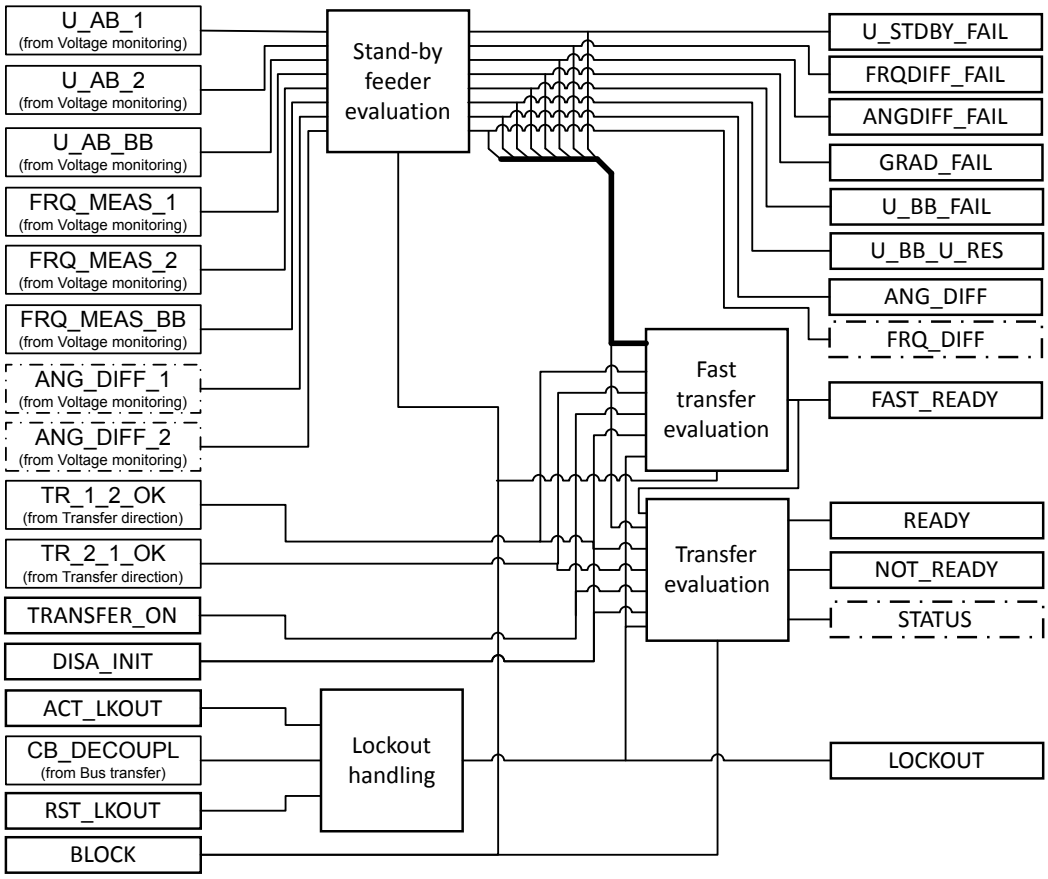



*Figure 936: Transfer readiness evaluation module diagram.*

**Stand-by feeder evaluation**

The phase angle difference is determined between the voltage of busbar and the voltage of the standby feeder. If phase angle difference is outside sector defined by *Maximum phase lead* and *Maximum phase lag*, output `ANG_DIFF_FAIL` is activated. The measured angle difference between stand-by feeder and busbar (ANG_DIFF) is available as function output.

Same way frequency difference is determined between the voltage of busbar and the voltage of the stand-by feeder. If frequency difference is greater than setting *Max frequency Diff*, output `FRQ_DIFF_FAIL` is activated. The measured frequency difference (FRQ_DIFF) is shown in monitored data.

Busbar frequency gradient is also monitored and if frequency gradient is larger than setting *Maximum DfDt*, output `GRAD_FAIL` is activated.

Stand-by feeder voltage must be higher than setting *Min standby voltage*. If stand-by feeder voltage falls below the setting value, U_STDBY_FAIL is activated. If U_STDBY_FAIL is active, then all transfers are prohibited.

Busbar voltage must be higher that setting *Min busbar voltage*. If busbar voltage falls below the setting value, U_BB_FAIL is activated. If U_BB_FAIL is active, then fast transfer is not allowed.

If busbar voltage falls below *Res voltage limit* setting, U_BB_U_RES output is activated. This allows transfer based on residual voltage transfer.

BLOCK input activation resets all outputs.

**Lockout handling**

Function can be set to lockout state by activation of ACT_LKOUT input. When function is in lockout, this is shown with LOCKOUT output. Lockout state can be reset with RST_LKOUT input or via clear menu parameter *HSABTC reset lockout*. Lockout state can be activated also when circuit breaker decoupling, CB_DECOUPL, activates.

**Fast transfer evaluation**

This module evaluates fast transfer readiness. Fast transfer is allowed if following conditions are met:

- U_STDBY_FAIL is FALSE

  Stand-by feeder voltage is greater than setting *Min standby voltage*
- U_BB_FAIL is FALSE

  Busbar voltage is greater than setting *Min busbar voltage*
- FRQ_DIFF_FAIL is FALSE

  Frequency difference between standby feeder and busbar is less than setting *Max frequency Diff*
- ANG_DIFF_FAIL is FALSE

  Phase angle difference is inside sector defined by *Maximum phase lead* and *Maximum phase lag*
- GRAD_FAIL is FALSE

  Frequency rate of change in busbar is less than setting *Max DfDt*
- BLOCK input is FALSE
- TRANSFER_ON input is TRUE
- DISA_INIT input is FALSE
- LOCKOUT is FALSE (Function is not in lockout)
- Transfer is allowed to one direction, i.e. TR_1_2_OK or TR_2_1_OK is true

If all conditions are met, then the information is signaled to Bus transfer with FAST_READY signal.

**Transfer evaluation**

This module evaluates the transfer enable signal. The READY output is active if following conditions are fulfilled:

- U_STDBY_FAIL is FALSE

  Stand-by feeder voltage is greater than setting *Min standby voltage*
- BLOCK input is FALSE
- TRANSFER_ON input is TRUE
- DISA_INIT input is FALSE
- LOCKOUT is FALSE
- Transfer is allowed to one direction, i.e. TR_1_2_OK or TR_2_1_OK is true

When function is ready for transfer, this is shown with output READY. If transfer initiation is not possible, then NOT_READY output is activated.

Monitored data STATUS is updated based on the function state. STATUS output can have following values:

- Ready – sync
  - Function is ready for transfer, i.e. READY output is TRUE
  - FAST_READY is TRUE (Fast transfer conditions are met)
- Ready – not sync: function is ready
  - Function is ready for transfer, i.e. READY output is TRUE
  - FAST_READY is FALSE (Fast transfer conditions are not met)
- Not ready – sync
  - Function is not ready for transfer, i.e. READY output is FALSE
  - FAST_READY is TRUE (Fast transfer conditions are met)
- Not ready – not sync
  - Function is not ready for transfer, i.e. READY output is FALSE
  - Function is set “off” or TRANSFER_ON is FALSE.
- Off
  - Function is set “off” or TRANSFER_ON is FALSE.

### 9.12.5.4 Transfer initiation

Functionally module can be split to submodules presented in *Figure 937*. Each module is explained later below.

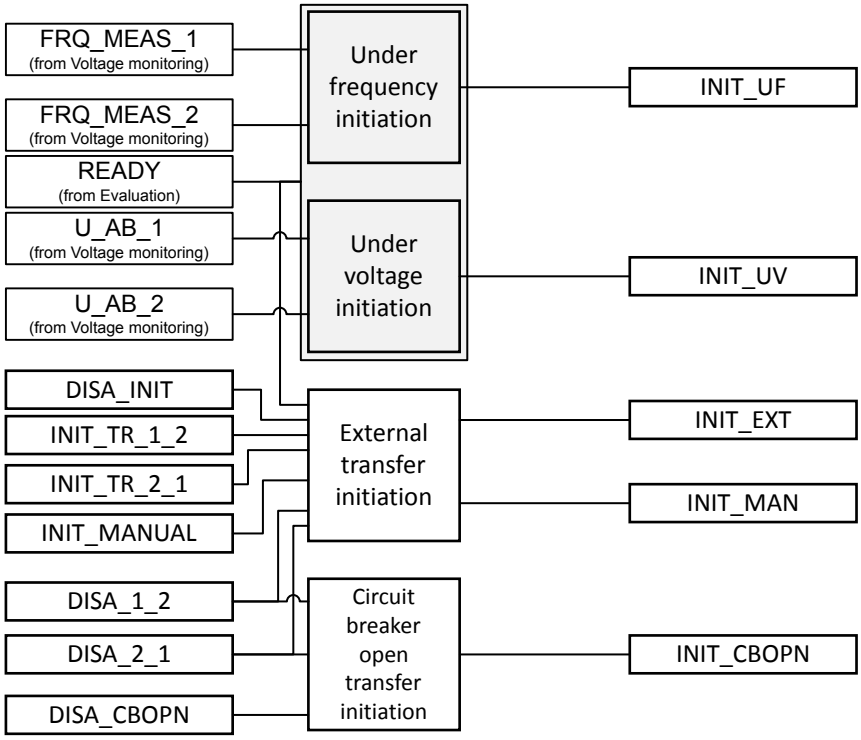



*Figure 937: Transfer initiation module diagram*

**Under frequency initiation**

Function monitors the active supply feeder frequency. If under frequency initiation is enabled, then transfer is initiated if the supply feeder frequency falls below the set value. The threshold can be set with a setting *Start Val frequency*. Under frequency initiation is enabled if *Operation mode* setting is “Freq<” or “Freq< or U<”.

Under frequency transfer initiation can be delayed with a setting *Under frequency time*.

Output INIT_UF is activated if transfer is initiated by internal under frequency initiation. Output INIT_UF can be activated only if function is ready for transfer, i.e. READY output is active.

**Under voltage initiation**

Function monitors the active supply feeder voltage. If under voltage initiation is enabled, then transfer is initiated if any the connected supply feeder voltages fall below the set value. The threshold can be set with a setting *Start Val voltage*. Under voltage initiation is enabled if *Operation mode* setting is “U<“ or “Freq< or U<”.

Under voltage-based transfer initiation can be delayed with a setting *Under voltage time*.

Output INIT_UV is activated if transfer is initiated by internal under voltage initiation. Output INIT_UV can be activated only if function is ready for transfer, i.e. READY output is active.

**External transfer initiation**

The bus transfer action can be initiated externally by different inputs:

- INIT_TR_1_2 – Initiates any enabled transfer from feeder 1 to feeder 2
- INIT_TR_2_1 – Initiates any enabled transfer from feeder 2 to feeder 1
- INIT_MANUAL – Initiates manual transfer, transfer direction depends on which direction is enabled in transfer direction block

Bus transfer initiation can be disabled with different inputs:

- DISA_INIT – Disables all transfers
- DISA_1_2 – Disables all transfers from feeder 1 to feeder 2
- DISA_2_1 – Disables all transfers from feeder 2 to feeder 1

If transfer initiation is signaled to direction that is allowed, transfer initiation is signaled to Bus transfer module (transfer initiation).

Output INIT_EXT is activated if transfer is initiated by external initiation. Output INIT_EXT can be activated only if function is ready for transfer, i.e. READY signal (from Evaluation module) is active.

When function is ready for transfer, this is shown with output READY. If transfer initiation is not possible, then NOT_READY output is activated.

Output INIT_MAN is activated if transfer is initiated manually. Output INIT_MAN is activated only if function is ready for transfer, i.e. READY signal (from Evaluation module) is active. Manual initiation is controlled by *Manual transfer* setting as explained in *Table 1603*.

**Table 1603: Manual transfer setting description**

| Manual transfer setting values | Description |
|---|---|
| “Off” | Manual transfer is disabled |
| “On” | Manual transfer is enabled |
| “Fast MBB” | Manual transfer is enabled. With this selection fast transfer is always made as fast sequential make before break transfer. |

**Circuit-breaker open transfer initiation**

In case the circuit breaker of the active feeder is opened without reason (no transfer initiation, breaker opened manually or directly by external triggering), function initiates transfer in case transfer conditions are fulfilled. Circuit breaker open transfer can be enabled with setting *Ena CB open transfer*. Transfer can be enabled to one direction only or to both directions:

- Setting value “1>2” enables transfer from feeder 1 to feeder 2.
- Setting value “2>1” enables transfer from feeder 2 to feeder 1.
- Setting value “both” enables transfer to both directions.
- Setting value “Off” disables the transfer initiation based on circuit breaker opening.

Activation based on CB open transfer can be also disabled via input `DISA_CBOPN`.

Output `INIT_CBOPN` is activated if transfer is initiated by CB open transfer.

Transfer initiation signal combines all initiation signals.

### 9.12.5.5 Bus transfer

Functionally module can be split to submodules presented in *Figure 938*. Each module is explained later below.

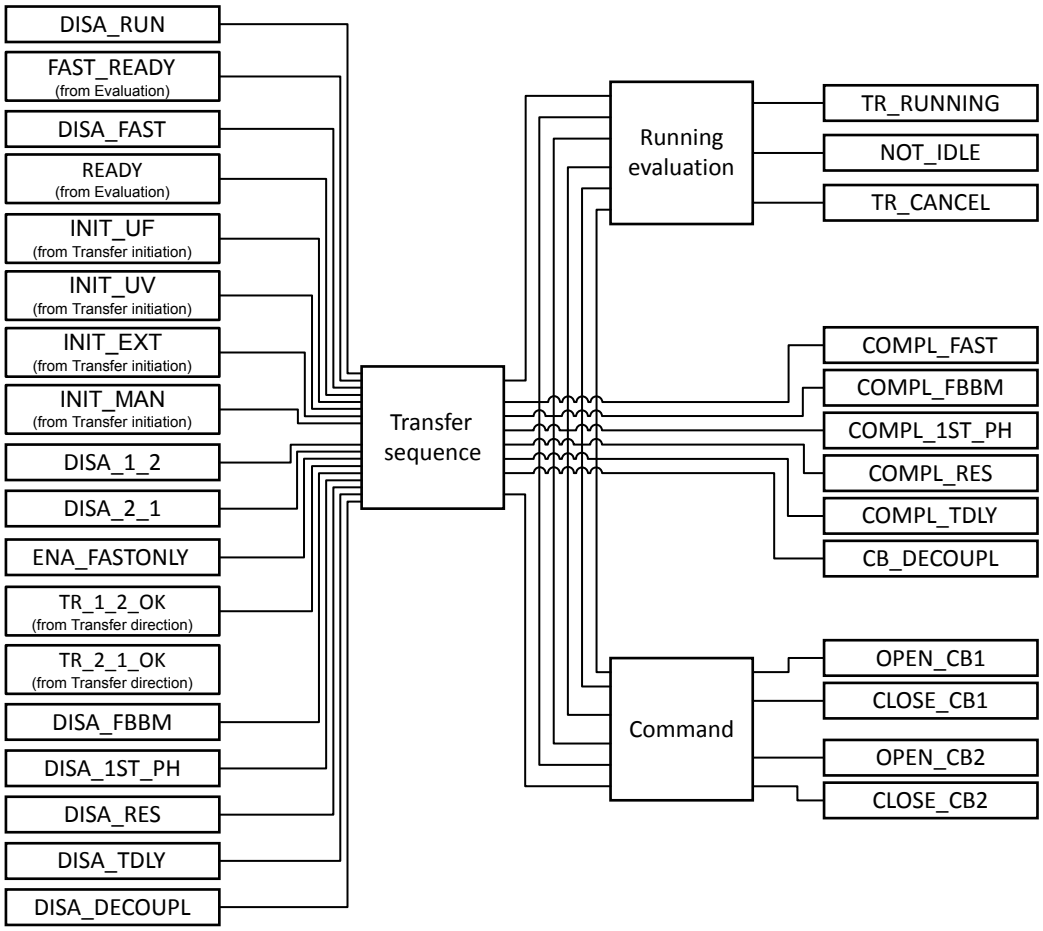



*Figure 938: Bus transfer module diagram*

Function supports following transfer modes:

- Fast transfer
  - simultaneous control of both involved circuit breakers (fastest mode)
  - sequential control of both involved circuit breakers
- Transfer at the 1st phase coincidence
- Residual voltage transfer
- Time-delayed transfer

Both fast transfer modes, simultaneous and sequential, are optimum transfer modes for ensuring only a minimum interruption of the voltage supply in case of faults in external network. If the network status does not permit fast transfer, slower transfer modes are selected.

*Figure 939* shows the typical decay characteristic (voltage and frequency) of a disconnected busbar and the possible closing moments.

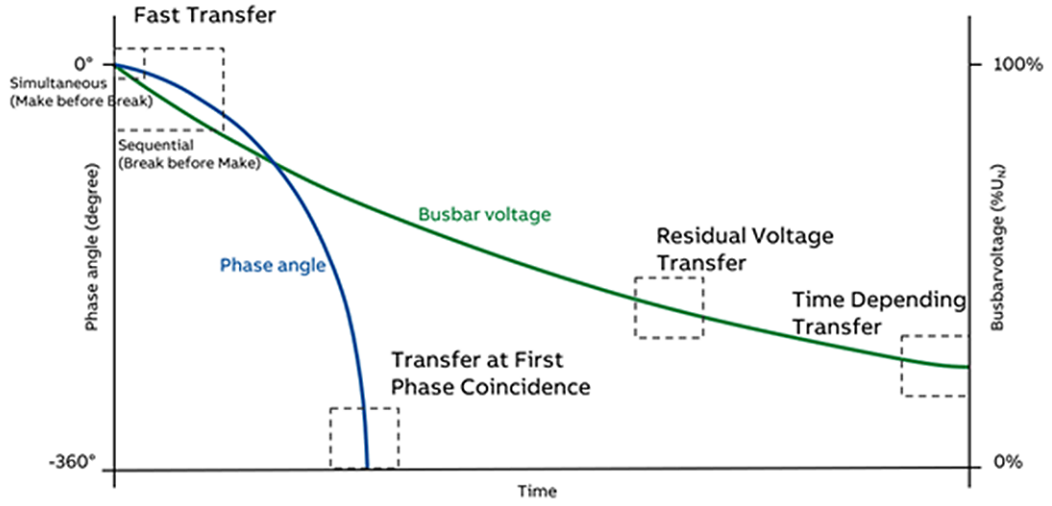



*Figure 939: Transfer mode overview*

### Running evaluation

The transfer in progress is indicated by TR_RUNNING output. If any of the transfer mode(s) is/are in progress, the TR_RUNNING output is TRUE. This output remains TRUE until reset by any of the following conditions:

- The COMPL_FAST, COMPL_1ST_PH, COMPL_FBBM, COMPL_RES or COMPL_TDLY output is TRUE
- The TR_RUNNING signal is active for more than *Max Trn run time* setting

NOT_IDLE output is TRUE when transfer is running or when transfer wait timer is running. Transfer wait time is set with *Transfer wait time* setting. Transfer wait time indicates minimum time between successive transfers.

All transfer mode(s) are reset if TR_RUNNING output changes from TRUE to FALSE.

If transfer is not successful and transfer is interrupted, this is indicated with TR_CANCEL output.

The transfer modes are explained in next chapters.

### Transfer sequence

Bus transfer follows always certain sequence presented in *Figure 940*. Simultaneous fast transfer (if enabled) is attempted first. If disabled or not successful, next step is sequential fast transfer (if enabled). If disabled or not successful, function attempts to perform 1st phase transfer. If not successful, residual voltage transfer is attempted. If not successful, function attempts to execute time delayed transfer (if enabled). If all previous transfer attempts are unsuccessful, finally function allows busbar to be decoupled.

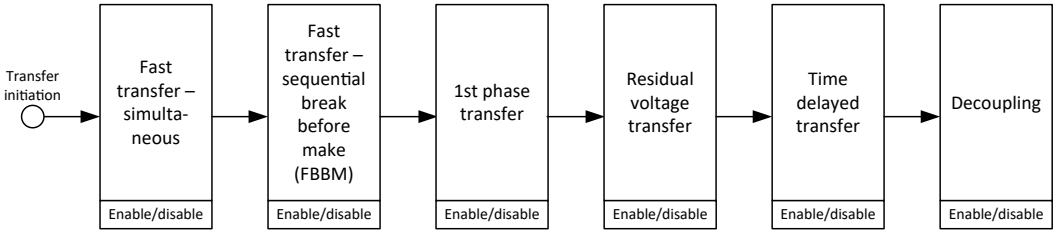



*Figure 940: Transfer sequence steps*

*Fast transfer – simultaneous*

A fast transfer takes place when both the main and the stand-by feeders are within specified limit values at the moment of initiation, e.g. frequency slip and phase angle difference are limited between the networks and the stand-by voltage lies above a minimum value.

Fast transfer can be enabled with the setting *Enable fast transfer*. If *Enable fast transfer* setting is set to “1>2”, then fast transfer is allowed to the direction from feeder 1 to feeder 2. If *Enable fast transfer* setting is set to “2>1”, then fast transfer is allowed to the direction from feeder 2 to feeder 1. Setting value “Both” allows fast transfer to both directions. Fast transfer can be disabled by setting *Enable fast transfer* to “Off”.

If *Enable FBBM* setting is set to “false”, then function executes simultaneous fast transfer. In case *Enable FBBM* is set to “true”, then function executes sequential transfer.

In simultaneous fast transfer circuit breaker open and close commands are issued at the same time (see *Figure 941*)

For uninterrupted transfer, the HSABTC function carries out a fast transfer, under the condition that busbar and stand-by feeder are synchronous and other criteria as described below are satisfied. For this the circuit breaker open and close signals are issued simultaneously to the respective circuit breakers of main feeder and standby feeder.

The fast transfer occurs in the direction of feeder 1 to feeder 2, if following conditions are fulfilled simultaneously:

- The FAST_READY (from Evaluation module) is TRUE
- The READY (from Evaluation module) is TRUE
- `DISA_FAST` input is FALSE
- `DISA_1_2` input is FALSE
- Setting *Enable fast transfer* is “1 > 2” or “Both”
- Transfer is activated as described in transfer initiation

The simultaneous fast transfer minimizes the dead time without current flow. *Figure 941* shows fast transfer with current free transfer time (dead time) of about 20ms. The dead time depends on the used circuit breakers and settings and this can be optimized.

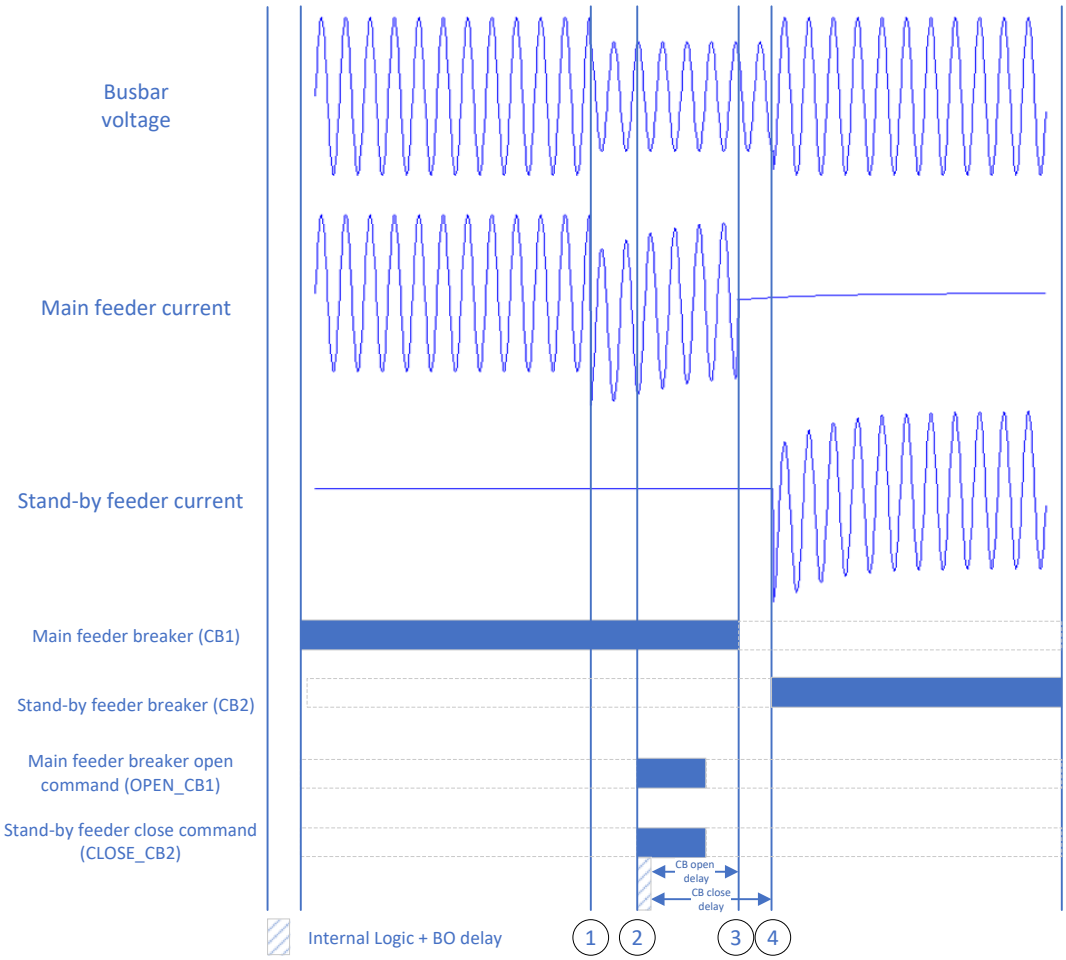



*Figure 941: Signal diagram of a fast simultaneous transfer (Fast) (For simplicity reasons only one voltage is presented in the figure)*

**1** External fault begins

**2** Main feeder breaker open command (OPEN_CB1) and stand-by feeder close command (CLOSE_CB2), both are HSABTC function outputs

**3** Main feeder breaker opens

**4** Stand-by feeder breaker closes

If DISA_RUN input is active, transfer is not allowed to complete until input is deactivated.

When fast transfer is completed, this is indicated with COMPL_FAST output.

*Fast transfer – sequential break before make (FBBM)*

Fast Sequential break before make transfer is activated if fast transfer has been enabled with *Enable fast transfer* (defined in the previous chapter) and *Enable FBBM* is “True”. If fast sequential transfer is enabled, then simultaneous transfer is not enabled, i.e. only one can be active at the same time.

In the sequential fast transfer mode (FBBM) the transfer function waits for the OPEN position indication of the feeding circuit breaker before issuing the close command to the circuit breaker of the stand-by feeder. The dead time without

current flow in the sequential transfer mode is therefore longer in sequential transfer mode than in simultaneous. Once open information from feeding circuit breaker is received, transfer conditions are evaluated once more before close command is given to the standby feeder. If conditions are not met, fast transfer is canceled. Function will switch to next available transfer mode. Conditions to be fulfilled before close command can be given are:

- READY (from Evaluation module) is TRUE
- Busbar voltage phase angle compared to standby feeder is still within angle defined by *Max angle Diff FBBM* setting. Phase angle evaluation includes circuit breaker closing time and frequency and frequency gradient of busbar voltage.

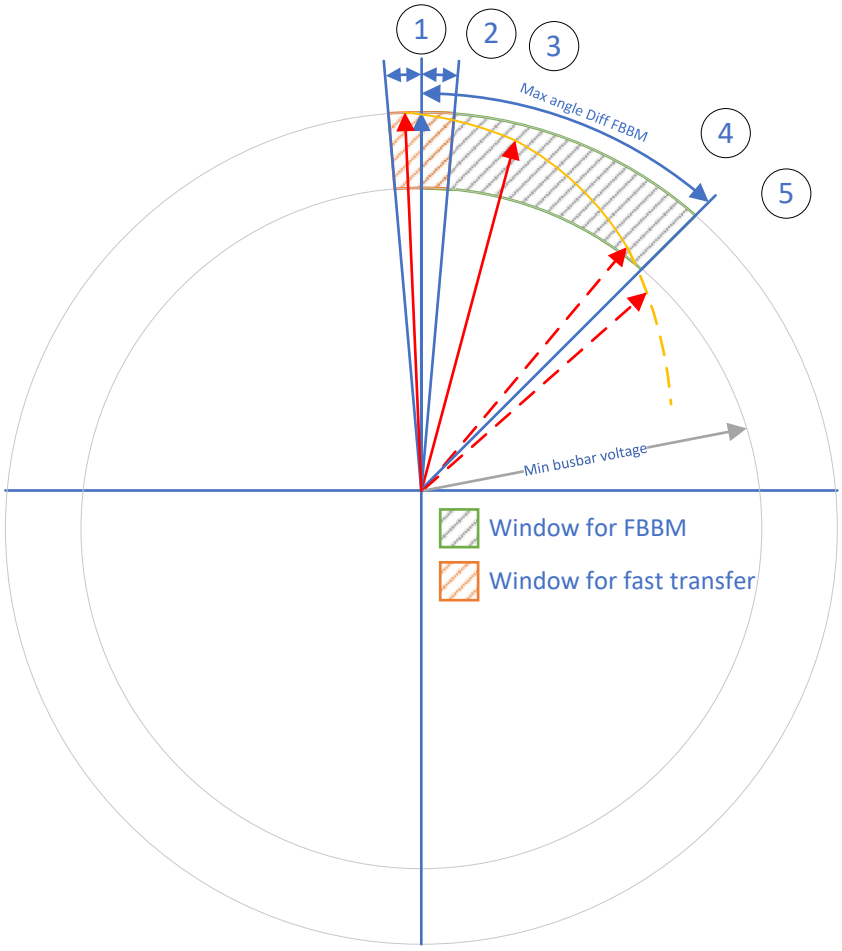



*Figure 942: Phase angle trajectory during fast sequential transfer (FBBM)*

**1** Synchronous conditions, transfer initiation

**2** Circuit breaker opening

**3** Circuit breaker opening detected, transfer conditions are evaluated before close command is activated

**4** Evaluated phase angle and amplitude of busbar voltage that would allow close command

**5** Evaluated phase angle and amplitude of busbar voltage that would not allow close command, amplitude too low (Min busbar voltage) or phase angle outside (Max angle Diff FBBM)

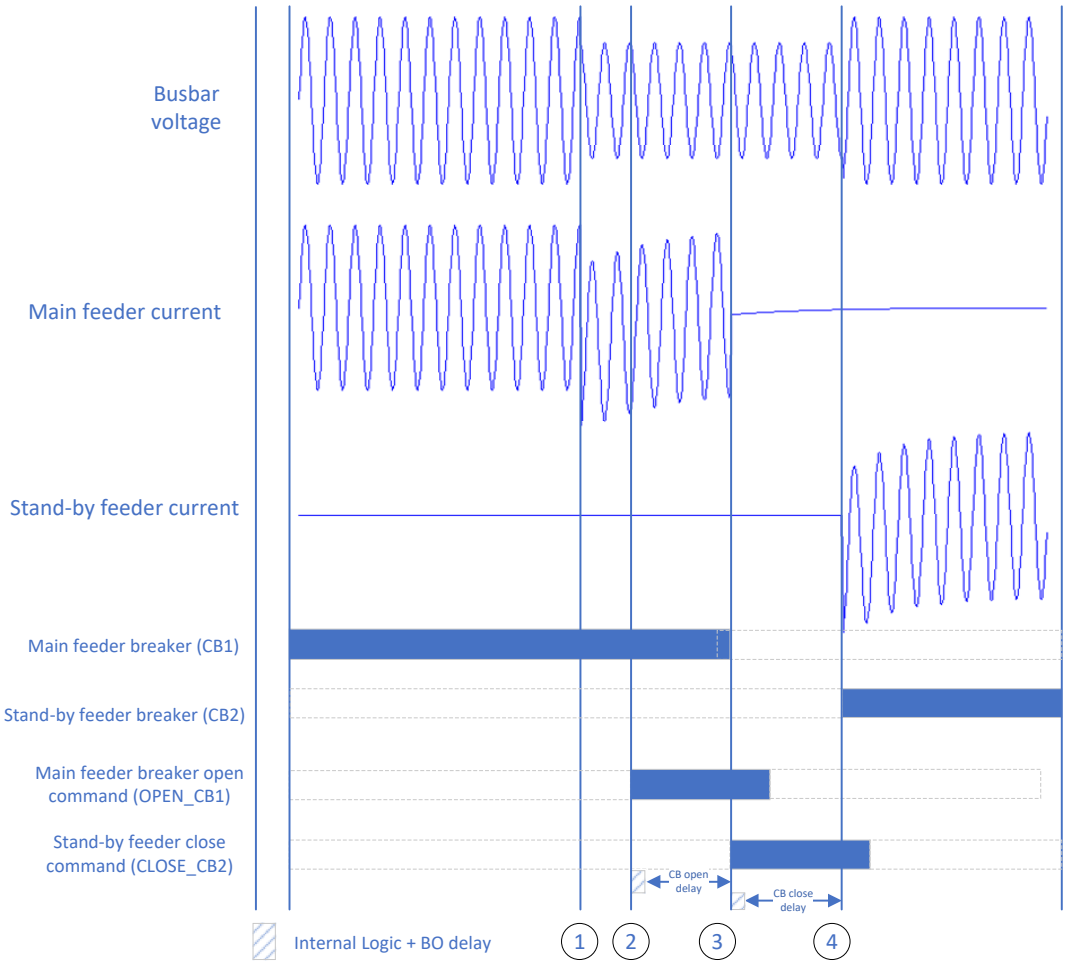



*Figure 943: Signal diagram of a fast sequential transfer (FBBM) (For simplicity reasons only one voltage is presented in the figure)*

**1** External fault begins

**2** Main feeder breaker open command (OPEN_CB1)

**3** Main feeder breaker opens, stand-by feeder close command (CLOSE_CB2)

**4** Stand-by feeder breaker closes

If `DISA_RUN` input is active, transfer is not allowed to complete until input is deactivated.

When fast sequential transfer is completed, this is indicated with `COMPL_FBBM` output.

*1st phase transfer*

The transfer at the 1$^{st}$st phase coincidence is executed when there are no synchronized conditions present at the moment of the transfer initiation, so that no fast transfer can be carried our due to physical reasons.

Initial conditions required for 1$^{st}$ phase transfer initiation are (transfer from feeder 1 to feeder 2):

- DISA_1ST_PH is FALSE

- DISA_1_2 is FALSE
- GRAD_FAIL is FALSE
- Setting Ena 1st Ph transfer is “1>2” or “both”
- READY (from Evaluation module) is TRUE
- If transfer is initiated manually, then ENA_FASTONLY must be FALSE

First the main supply feeder will be opened without delay. Once the supply feeder breaker opens, the connected busbar is without power supply and will run down in accordance with its specific characteristic curve.

For the connection of the stand-by feeder, variety of points in time are possible at which circuit breaker closing is possible with minimal stress to the system. Closing of the circuit breaker is timed is such way that at the closing time of the breaker, phase angle difference between stand-by feeder and busbar is close to zero.

The HSABTC determines the course of the difference voltage and the point in time of the 1st phase coincidence through anticipatory computation. In order to compensate for the installation-specific processing time (system response time, circuit breaker operating time), the close command is issued accordingly before the actual first minimum of the difference voltage occurs within a previously defined connection window.

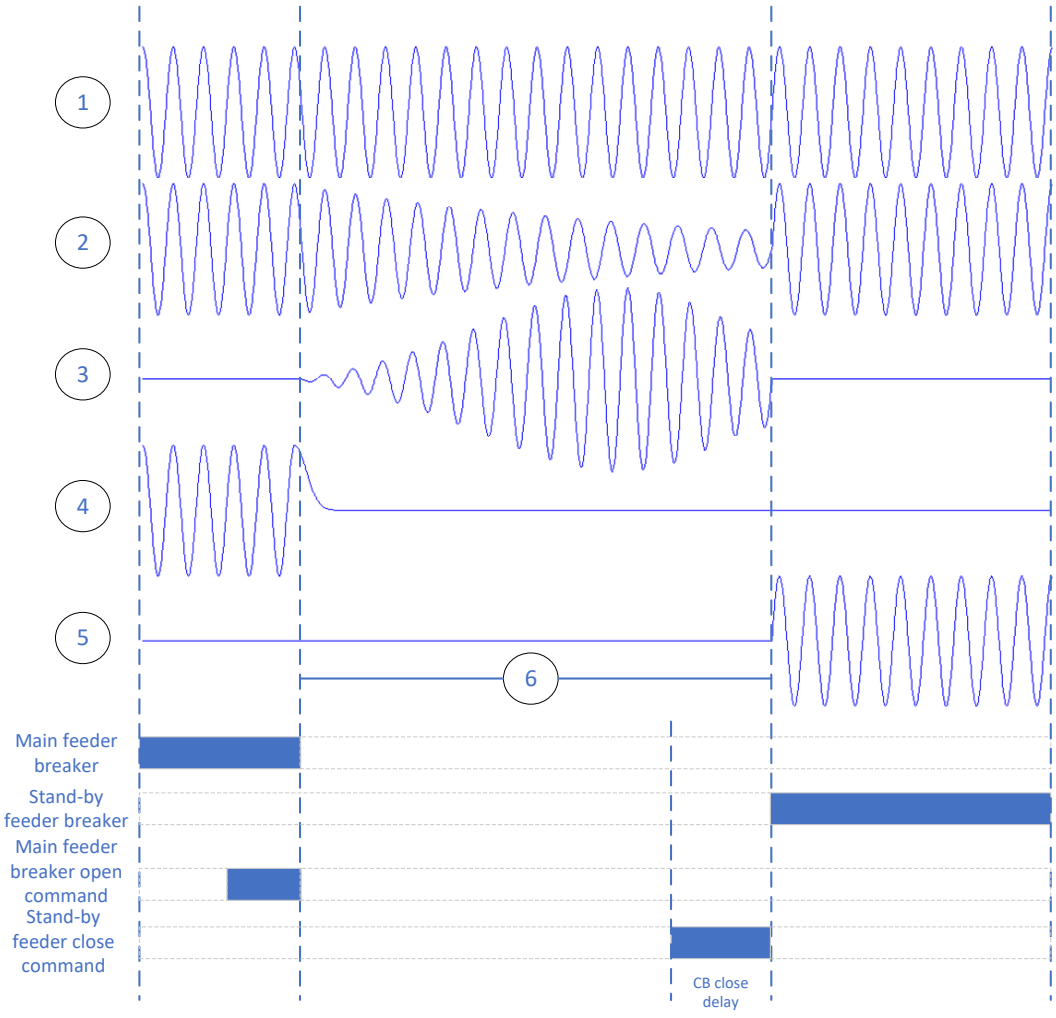



*Figure 944: Signal diagram of 1st phase transfer*

1 Stand-by feeder voltage
2 Busbar voltage
3 Voltage difference between stand-by and busbar voltage
4 Main feeder current
5 Stand-by feeder current
6 Transfer duration

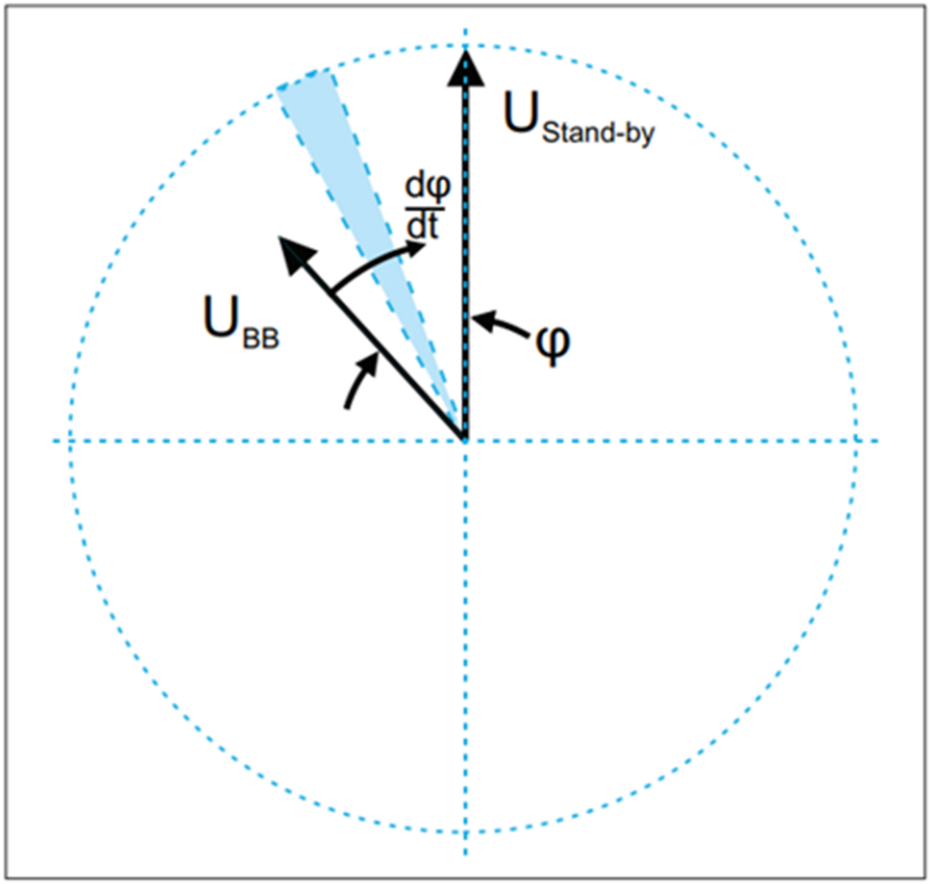



*Figure 945: Vector diagram of a transfer at the 1st phase coincidence*

| | |
|---|---|
| $U_{Stand-by}$ | Stand-by feeder voltage |
| $U_{Busbar}$ | Busbar voltage |
| ϕ | Angle between stand-by voltage and busbar voltage |
| dϕ/dt | Angle speed between stand-by voltage and busbar voltage |
| Blue area | Connection window (dependent upon breaker closing time and dϕ/dt |

If `DISA_RUN` input is active, transfer is not allowed to complete until input is deactivated.

When 1st phase transfer is completed, this is indicated with `COMPL_1ST_PH` output.

*Residual voltage transfer*

The residual voltage transfer is utilized when a connection in the 1st phase coincidence is not possible. Following conditions must be met for residual voltage transfer:

- transfer is running
- both breakers are open
- DISA_RES is FALSE
- setting *Ena Res V transfer* allows transfer
- if transfer is initiated manually, then ENA_FASTONLY must be FALSE

The connection of the stand-by feeder takes place when the voltage of the busbar has subsided to a preset, permissible value. The threshold value for the busbar voltage for residual voltage transfer is set with setting *Residual voltage limit*. Residual voltage transfer is enabled with setting *Ena Res V transfer*.

The connection takes place without assessment of the angle or of the difference frequency, thus in unsynchronized fashion. Because the voltage of the busbars has however reached a sufficiently low residual voltage value, the transient effects of the connection are manageable (momentary jolt, current needed for users to run up again, voltage reduction).

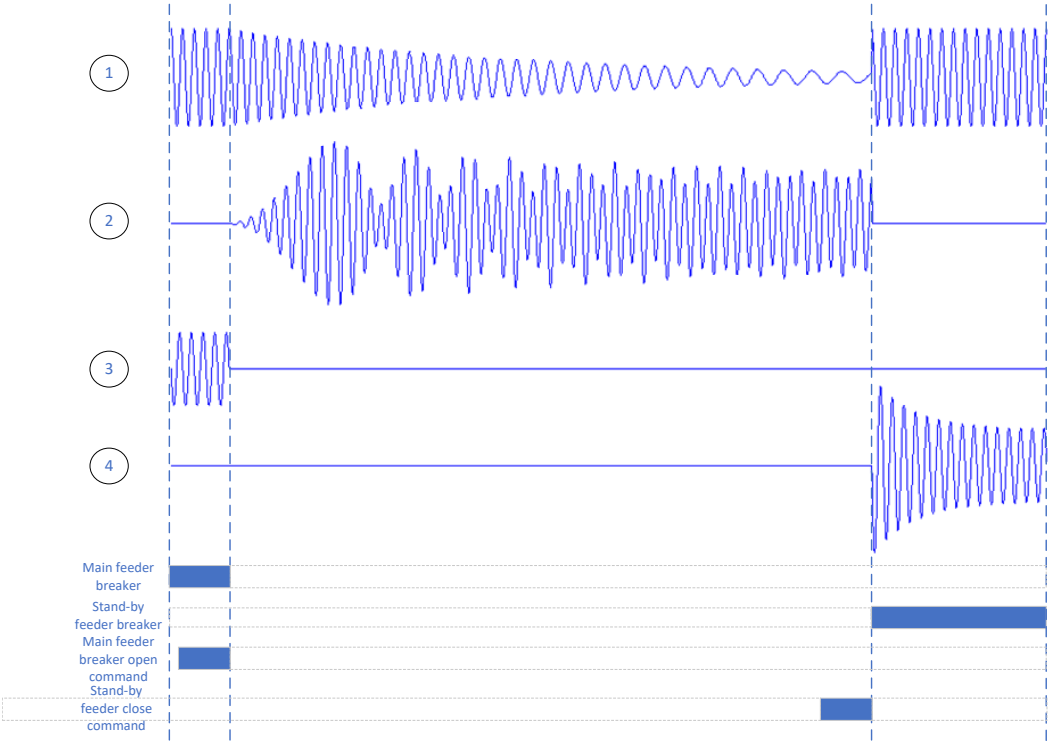



*Figure 946: Signal diagram of residual voltage transfer*

**1** Busbar voltage

**2** Voltage difference between stand-by and busbar voltage

**3** Main feeder current

**4** Stand-by feeder current

If DISA_RUN input is active, transfer is not allowed to complete until input is deactivated.

When residual voltage transfer is completed, this is indicated with COMPL_RES output.

Residual voltage transfer can be disabled with DISA_RES input.

*Time delayed transfer*

The time delayed transfer takes place when *Transfer delay time* elapses. Following conditions must be met for time delayed transfer:

- transfer is running
- both breakers are open
- DISA_TDLY is FALSE
- setting *Ena Time delay transfer* allows transfer
- if transfer is initiated manually, then ENA_FASTONLY must be FALSE

If DISA_RUN input is active, transfer is not allowed to complete until input is deactivated.

Time delayed transfer can be enabled with a setting *Ena Time delay transfer*. When time delayed transfer is completed, this is indicated with COMPL_TDLY output.

Time delayed transfer can be disabled with DISA_TDLY input.

*Decoupling*

Decoupling is a configurable safety feature. In case during transfer both controllable breakers end up closed or breaker position is unknown after transfer, last closed breaker can be set to be reopened. Opening time can be configured with *Decoupling delay* setting. If decoupling is activated, this is indicated with CB_DECOUPL output. Decoupling functionality can be enabled with setting *Enable decoupling*.

*Enable decoupling* has following modes:

- “Off”, decoupling functionality disabled
- “CB man close”, decoupling is done when both connected breakers closed. Note that this mode does not require active transfer for the decoupling.
- “Transfer based”, decoupling is done during transfer incase both controllable breakers end up closed after transfer
- “Both”, both operation modes are in use

Decoupling functionality can be disabled with DISA_DECOUPL input.

If decoupling is activated, function is set to lockout state and this is indicated with LOCKOUT output. Lockout state can be reset via RST_LKOUT input.

**Command**

Circuit breaker opening and closing is handled by this module based on the inputs from transfer modes.

If feeder 2 is the standby feeder, then OPEN_CB1 is activated if:

- transfer is allowed from feeder 1 to feeder 2
- transfer is not started by CB open transfer
- transfer is running, i.e. one of more transfers are active

CLOSE_CB2 is activated if:

- transfer is allowed from feeder 1 to feeder 2
- transfer is completed, this is indicated with following signals:

- COMPL_FAST
- COMPL_FBBM
- COMPL_1ST_PH
- COMPL_RES
- COMPL_TDLY

If feeder 1 is the standby feeder, then OPEN_CB2 is activated if:

- transfer is allowed from feeder 2 to feeder 1
- transfer is not started by CB open transfer
- transfer is running, i.e. one or more transfers are active

CLOSE_CB1 is activated if:

- transfer is allowed from feeder 2 to feeder 1
- transfer is completed, this is indicated with following signals:
  - COMPL_FAST
  - COMPL_FBBM
  - COMPL_1ST_PH
  - COMPL_RES
  - COMPL_TDLY

### 9.12.5.6 Load shedding

The load-shedding action can be performed based on various load shedding modes during transfer action.

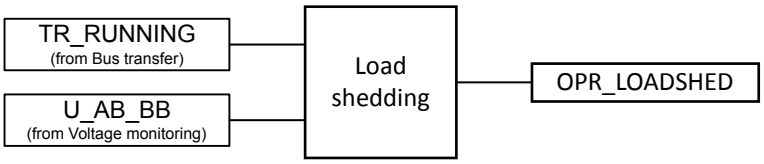



*Figure 947: Load shedding module diagram*

The OPR_LOADSHED output is TRUE if any of the following conditions are satisfied:

- Instantaneous: If the transfer is active (TR_RUNNING is TRUE), and *Load shedding mode* setting is “Instantaneous”, the OPR_LOADSHED will be TRUE.

  Load shedding is not activated during fast transfer.

- Voltage based: If the TR_RUNNING signal is TRUE, and *Load shedding mode* setting is “Voltage based” and busbar voltage is less than *Loadshed V limit*.
- Time based: If the TR_RUNNING signal is TRUE, and *Load shedding mode* setting is “Time based” and the fast transfer is not active (FAST_READY is FALSE), the OPR_LOADSHED is TRUE after *Loadshed time delay* setting parameter value.

If *Load shedding mode* setting is “None”, the OPR_LOADSHED output remains FALSE.

### 9.12.5.7 Circuit breaker monitoring

Breaker closing time is essential information for the function, especially the 1st phase transfer needs accurate information of the circuit breaker closing time in

order to schedule the close command properly. Function monitors both circuit breaker opening and closing times and issues alarm in case opening or closing time is too long. Added to this the closing time difference is also monitored and an alarm is given incase circuit breaker closing time differs too much between closings.

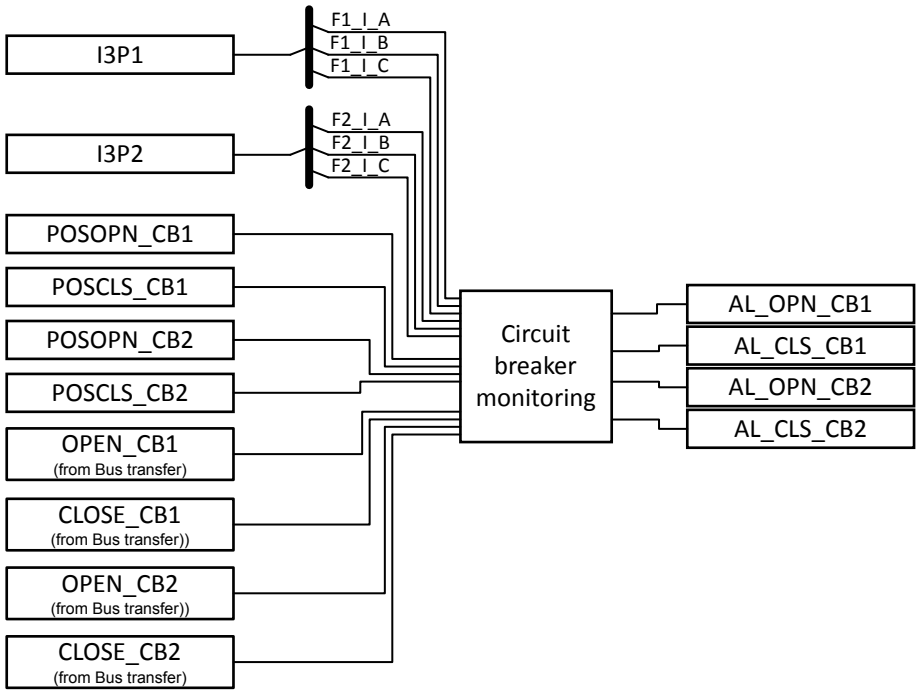



*Figure 948: Circuit breaker monitoring module diagram*

Circuit breaker monitoring can operate in several modes. Operation mode is set with setting *Travel time Clc mode*. Supported calculation modes are shown in *Table 1604*.

**Table 1604: Supported traveling time measurement modes**

| Setting values | Description |
|---|---|
| From Cmd to Pos | Traveling time is measured from command to position change |
| From Pos to Pos | Traveling time is measured from position change to position change |
| From Cmd to Curr | Traveling time is measured from command till current is measured to flow through circuit breaker |
| From Pos to Curr | Traveling time is measured from position change till current is measured to flow through circuit breaker |

Circuit breaker opening and closing times are defined with following settings: *Closing time CB1*, *Closing time CB2*, *Opening time CB1* and *Opening time CB2*. Measured closing and opening times can be taken into use via control menu by activating parameter Set travel times.

Reset travel times set the travelling times back to set values.

Measured circuit breaker opening and closing times are shown in the monitored data with outputs CB_OPN_T_CB1, CB_OPN_T_CB2, CB_CLS_T_CB1 and CB_CLS_T_CB2.

An alarm is issued in case circuit breaker opening or closing time exceeds the set limits. Opening time alarm limit is set with setting *CB open alarm time* and closing time alarm limit is set with setting *CB close alarm time*.

An alarm is also issued in case closing time between consecutive closings varies more than set by setting *CB closing time Dif*.

Alarm outputs are AL_OPN_CB1 and AL_CLS_CB1 for circuit breaker 1 and AL_OPN_CB2 and AL_CLS_CB2 for circuit breaker 2.

**Circuit breaker closing time measurement, “From Cmd to Pos”**

“From Cmd to Pos” mode measures the closing time from binary output activation till position change has been indicated by auxiliary contacts.

*Figure 949* shows an example of CB closing time measurement in “From Cmd to Pos” mode.

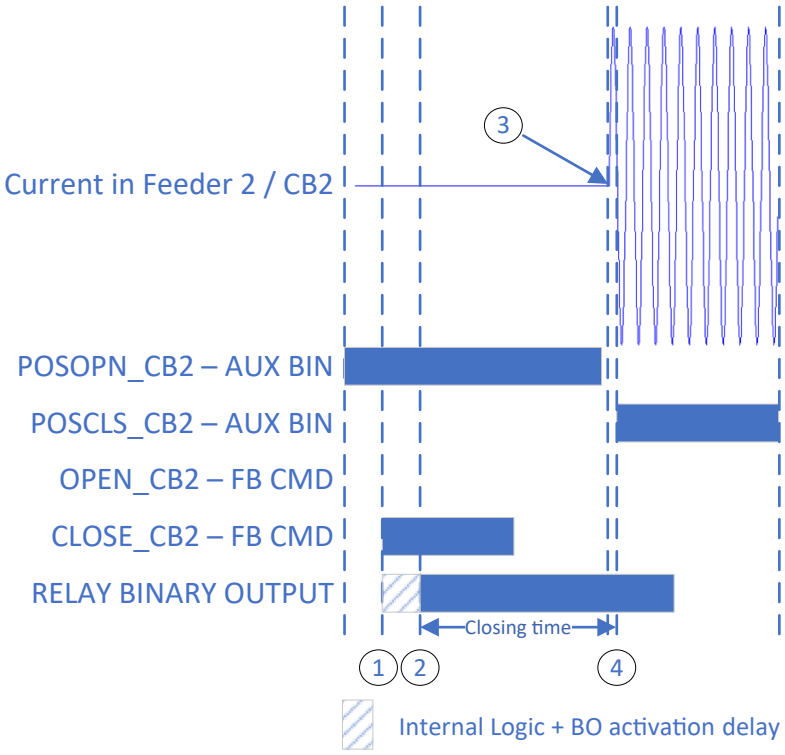



*Figure 949: Circuit breaker closing time measurement (“From Cmd to Pos”)*

**1** HSABTC function activates CLOSE_CB2 output

**2** Relay binary output activates – closing time measurement starts from this point

**3** Circuit breaker main contacts close

**4** Close position indicated to relay with auxiliary contacts

Closing time is time from 2 to 4

**Circuit breaker closing time measurement, “From Pos to Pos”**

“From Pos to Pos” measures the closing time from auxiliary contacts. This will not represent the actual closing time but it can be used to check that circuit breaker reaches end state and that it will not hang to intermediate state (POSOPN and POS CLS are both False).

This mode is recommended only for supervision purposes to alarm incase breaker doesn’t close properly, not to measure actual travelling time .

**Circuit breaker closing time measurement, “From Cmd to Curr”**

“From Cmd to Curr” measures the closing time from binary output activation till current is flowing in the primary circuit. This operation mode requires that current signal is connected to I3P1 and I3P2 inputs.

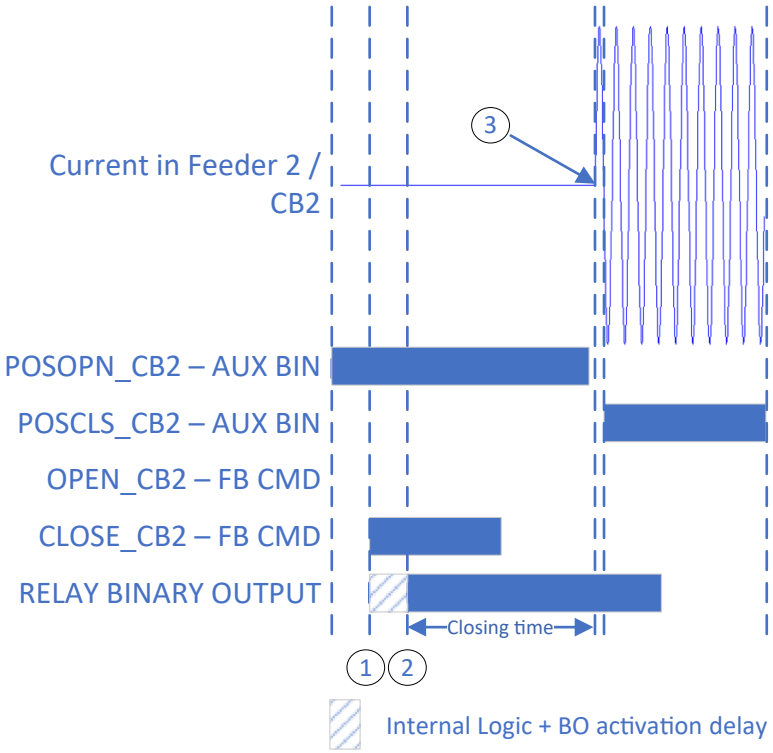



*Figure 950: Circuit breaker closing time measurement (“From Cmd to Curr”)*

**1** HSABTC function activates `CLOSE_CB2` output

**2** Relay binary output activates – closing time measurement starts from this point

**3** Circuit breaker main contacts close and current flows

Recommended operation mode

**Circuit breaker closing time measurement, “From Pos to Curr”**

“From Pos to Curr” measures the closing time from position change indicated by auxiliary contacts till current is flowing in the primary circuit.



This operation mode requires that current signal is connected to I3P1 and I3P2 inputs. This mode is recommended only for supervision purposes to alarm incase breaker doesn’t close properly, not to measure actual travelling time.

**Circuit breaker opening time measurement**

From the function operation point of view the opening time measurement is not as important as closing time. Hence the opening time is always measured in “From Cmd to Pos” mode which would provide accurate enough information.

### 9.12.5.8 Recorded data

The transfer related information is stored when the Recorded data module is triggered. This happens when *Decoupling delay* time is elapsed after TR_RUNNING signal goes from TRUE to FALSE. Three sets of recorded data are available in total for each of the measurement. The sets are saved in data banks 1-3.

The data bank 1 of the respective measurement holds the most recent recorded data. Older data are moved to the subsequent banks (1→2 and 2→3). When all three banks have data of a respective measurement and there is a new transfer complete operation, the latest data set is placed into bank 1 and the data in bank 3 is overwritten by the data from bank 2.

The recorded data can be reset with the RESET_REC binary input, from Clear menu or via communication.

**Table 1605: Recorded data**

| Parameter | Type | Description |
|---|---|---|
| Transfer mode | ENUM | Transfer mode |
| Transfer direction | ENUM | Transfer direction |
| Transfer cause | ENUM | Cause of transfer |
| Transfer failure | ENUM | Transfer failure cause |
| Transfer time | TimeStamp | The time at which the close command is issued for transfer |
| Transfer Dur | INT | Time between transfer initiation and CB close command |
| Busbar Max dv/dt | REAL | Maximum rate of change of busbar voltage |
| Busbar Max df/dt | REAL | Maximum rate of change of frequency of busbar voltage |

*Table continues on the next page*

| Parameter | Type | Description |
|---|---|---|
| Busbar voltage | REAL | Busbar voltage at the time of CB close command |
| Busbar frequency | REAL | Busbar frequency at the time of CB close command |
| Phase Diff | REAL | Busbar and standby feeder phase diff at CB close command |
| CB decoupled | ENUM | CB decoupling happened during the transfer |
| Loadshed operated | ENUM | Load shedding operated during transfer |

**Table 1606: Enumeration values for the recorded values parameters**

| Parameter name | Enum name | Value |
|---|---|---|
| Transfer mode | None | 0 |
| Transfer mode | Fast | 1 |
| Transfer mode | FBBM | 2 |
| Transfer mode | Phase coincidence | 3 |
| Transfer mode | Res Voltage | 4 |
| Transfer mode | Time delay | 5 |
| Transfer direction | Unknown | 0 |
| Transfer direction | Feeder 1 to Feeder 2 | 1 |
| Transfer direction | Feeder 2 to Feeder 1 | 2 |
| Transfer cause | None | 0 |
| Transfer cause | External | 1 |
| Transfer cause | External under voltage | 2 |
| Transfer cause | Internal under frequency | 3 |
| Transfer cause | Internal under voltage | 4 |
| Transfer cause | Circuit breaker open | 5 |
| Transfer cause | Manual | 6 |
| CB decoupled | TRUE | 0 |
| CB decoupled | FALSE | 1 |

*Table continues on the next page*

| Parameter name | Enum name | Value |
|---|---|---|
| Load shed mode | None | 0 |
| Load shed mode | Instantaneous | 1 |
| Load shed mode | Voltage base | 2 |
| Load shed mode | Time base | 3 |

The active transfer mode that carries out the transfer action is provided by Transfer mode output. *Table 1607* shows the calculation for Transfer mode recorded data parameter and priority order in case multiple modes are active for bus transfer.

**Table 1607: Transfer mode output calculation**

| Priority order | Cause of Transfer | Transfer mode output |
|---|---|---|
| 1 | Fast transfer completed & Transfer cause > 0 | 1=Fast transfer |
| 2 | FBBM transfer completed & Transfer cause > 0 | 2=FBBM |
| 3 | 1st phase coincidence transfer completed & Transfer cause > 0 | 3=Phase coincidence |
| 4 | Residual voltage transfer completed & Transfer cause > 0 | 4=Res Voltage transfer |
| 5 | Time delay transfer completed & Transfer cause > 0 | 5=Time delay transfer |
| 6 | None | 0=None |

The transfer direction from feeder 1 to feeder 2 or vice – versa is recorded by Transfer direction recorded data parameter.

The maximum rate of change of busbar voltage, the maximum rate of change of frequency and frequency difference between stand-by feeder and busbar, busbar frequency, busbar voltage, phase angle difference between stand-by feeder and busbar are provided by Max dv/dt, Max df/dt, Bus frequency, Bus voltage, Phase Diff recorded data parameters respectively at the instance transfer complete is activated.

## 9.12.6 Application

The High speed transfer device is utilized where the availability of a safe voltage supply is important and where a breakdown of the electrical energy supply would mean an interruption in production and thus lead to costs and/or damages as a result.

The usual areas of installation include, for example:

1. Auxiliary distributions in power stations, for example

- Steam power stations
- Combined cycle power plants
- Nuclear power stations

2. Environmental technology installations
   - Flue gas purification
   - Refuse incineration installations
3. Voltage supply to continuous industrial processes
   - Chemical plants
   - Industrial facilities with high degrees of automation
   - Fiber manufacturing
   - Petrochemical processes

A typical switchgear configuration with two circuit breakers is shown in *Figure 951*. One of the two feeders is connected to the busbar. One of the two feeder's circuit breaker is closed, the other is open. A parallel operation of both feeders is not intended. If an error leads to an interruption of the feeder currently in operation say feeder 1, the transfer device switches the load over to the second feeder 2 in the shortest possible time. Following successful transfer, the busbar is then supplied by the second feeder 2. Once the main feeder 1 is again in operation, a manually-initiated transfer back can take place and the normal status can be restored once again. A protection-initiated transfer can be executed from either of feeder 1 or feeder 2.

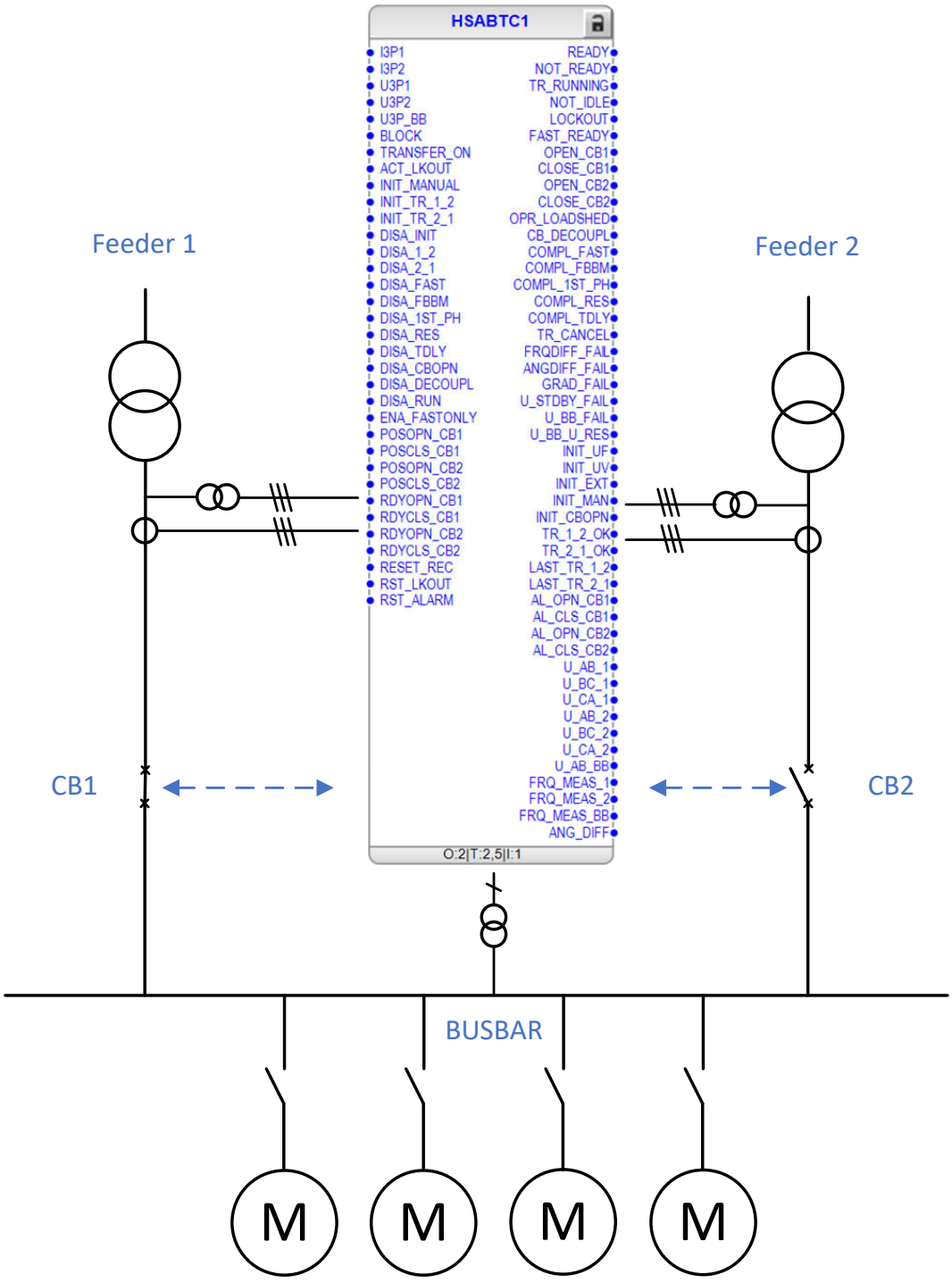



*Figure 951: Busbar with two feeders*

This function is intended to perform the core responsibility of the High speed transfer device, i.e., to transfer the busbar load from one feeder to another upon initiation in the shortest possible time, safely. The primary functional mode of this function is the execution of fast transfer. In this, the commands are issued simultaneously to the respective circuit breakers which is to be opened or closed, on condition that the feeders be synchronous with one another. In the event of non-synchronous feeders or break before make arrangements, it offers a number

of other mechanisms such as FBBM transfer, first phase transfer, residual voltage transfer and time delayed transfer.

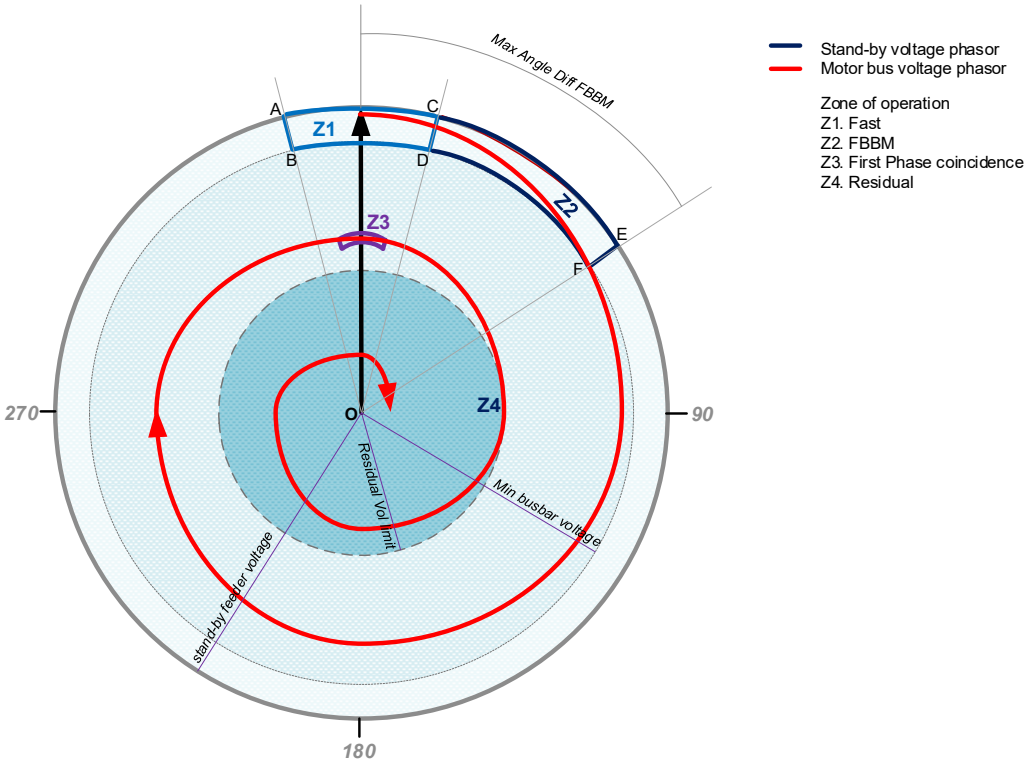



*Figure 952: Busbar phasor and zones of operation for different transfer modes*

The *Figure 952* provides an insight into the movement of busbar voltage phasor w.r.t stand-by feeder voltage phasor after the circuit breaker of the main supply feeder is opened. The busbar voltage phasor starts to move away from the stand-by feeder phasor. The rate of this movement is guided by the frequency difference and rate of change of frequency difference between the stand-by feeder and busbar voltage phasors. The rate of this movement depends upon the moment of inertia of the motors and the loads connected to the busbar.

The radius of the outermost circle in the *Figure 952* represent the voltage magnitude of the stand-by feeder. The radius of inner circle represents the setting, *Min busbar voltage* magnitude used for Fast and FBBM transfer. The radius of innermost circle represents the setting, *Res voltage limit*.

Fast transfer can occur if the busbar phasor lies in the zone Z1, defined by the area under curve ACDB, after transfer initiation is active. This area reflects the criterion for the fast transfer to occur i.e., the phase angle difference, frequency difference between stand-by feeder and busbar voltage phasor must within specified limits and busbar voltage phasor magnitude must be above the specified limit defined by minimum busbar voltage setting.

FBBM mode attempts to transfer such that the phase angle difference between stand-by voltage and busbar voltage phasor lies within a defined limit, represented by Max Angle Diff FBBM, after the stand-by feeder is completely closed. It estimates this advance phase angle difference ahead of CB closing time based on the prevailing frequency difference and rate of change of frequency difference between the stand-by and busbar voltage. Fast break before make, FBBM, transfer can occur

if the estimated busbar phasor, after advance angle adjustment, lies in the zone Z2, defined by the area under the curve AEFB.

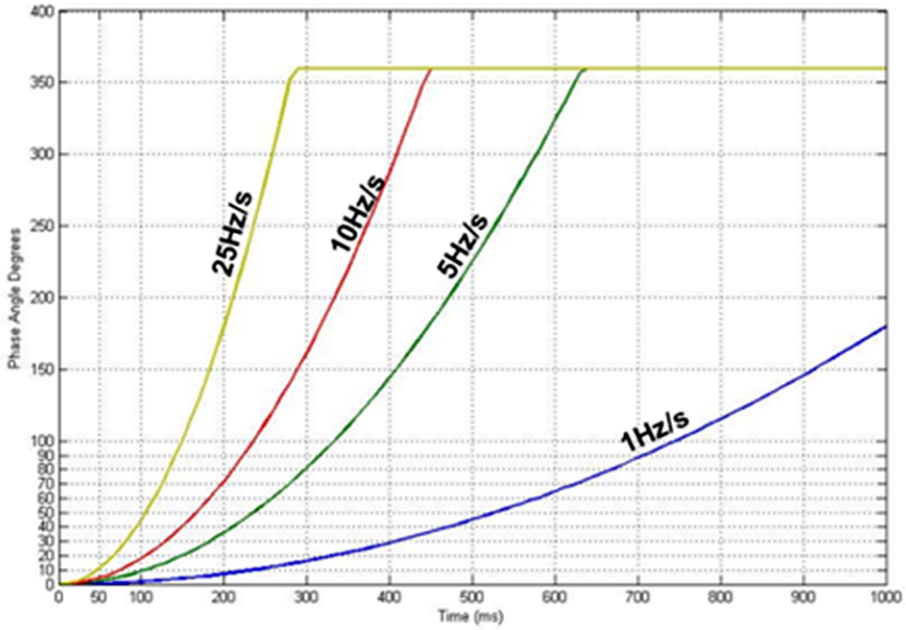



*Figure 953: Trajectory of phase-angle in relation to time*

*Figure 953* shows the trajectory of phase angle between stand-by feeder and busbar and voltages and time after main supply feeder opening. It is shown for various linear rates of frequency difference between the stand-by feeder and busbar, assuming main supply feeder and stand-by feeders were in synch and the frequency difference is zero prior to circuit breaker opening for main supply feeder. FBBM transfer mode is suitable for setups having low frequency difference and rate of change of frequency difference between the stand-by and busbar voltage.

First phase coincidence mode attempts to transfer at the 1st phase coincidence, differential voltage minimum, between the stand-by feeder and busbar voltages through anticipatory computation. It estimates the phase angle difference between the stand-by feeder and busbar voltage ahead of CB closing time keeping into account the prevailing frequency difference and rate of change of frequency difference between the stand-by and busbar voltage. It attempts to transfer such that phase angle difference is zero (ideally zero, practically near zero) after stand-by feeder is completely closed. First phase coincidence transfer can occur if the estimated busbar phasor, after anticipatory calculation, lies in the zone Z3.

Residual mode attempts to transfer if busbar voltage magnitude drops below predefined setting, *Res voltage limit*. Residual transfer can occur if the busbar phasor lies in the zone Z4, represented by the area under the inner most circle with radius *Res voltage limit*.

### Application variants

The following different variants, depending on various circuit breaker configurations, can be realized with the instances of this function.

### Application package APP51

The following different variants, depending on various circuit breaker configurations, can be realized with the instances of this function.

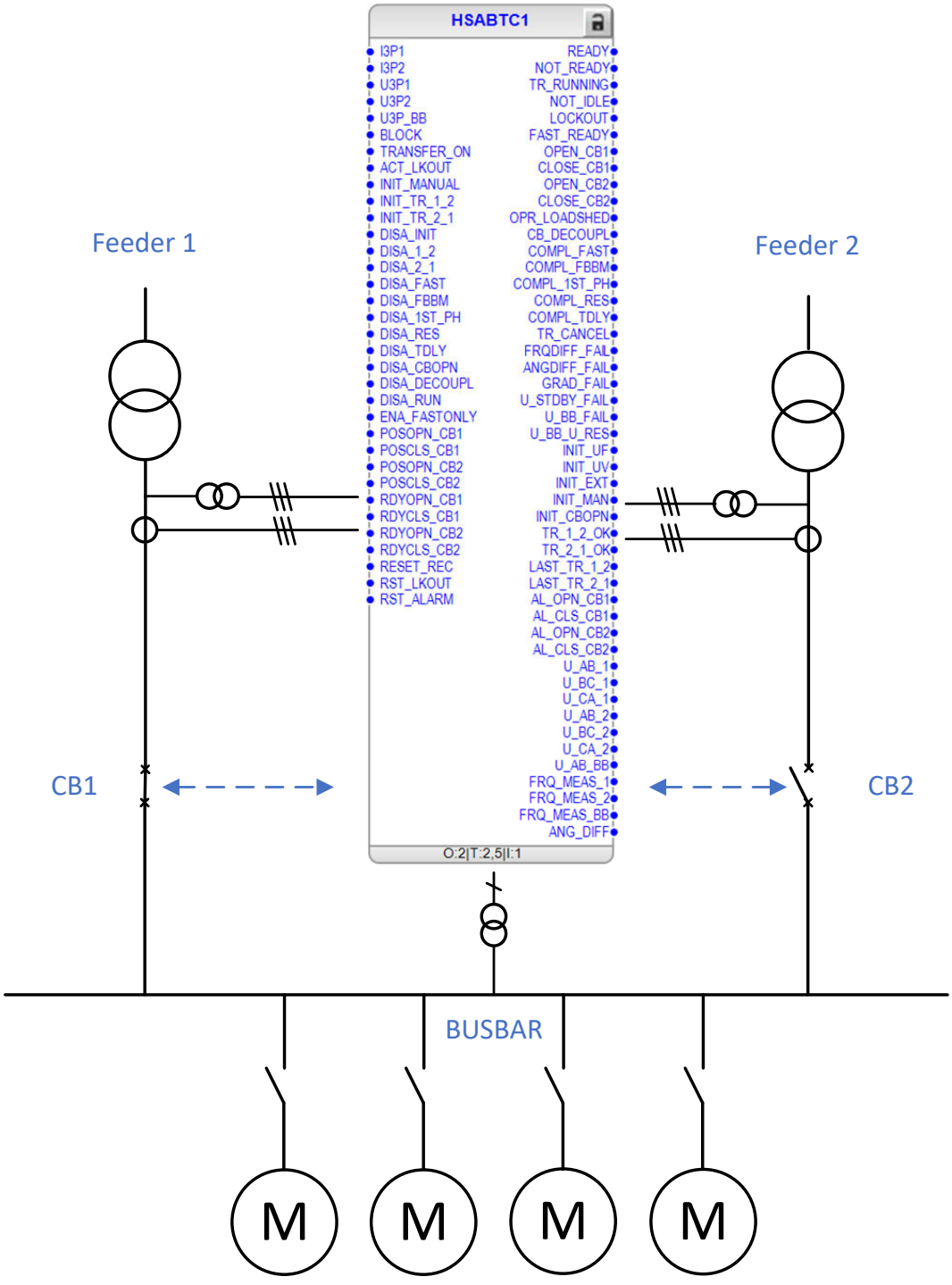



*Figure 954: Application package APP51*

2-Circuit-breaker configuration

- One busbar
- Transfer takes place between the two feeders

- One instance of HSABTC function can perform the transfer operation between feeder 1 and feeder 2.

**Application package APP52**

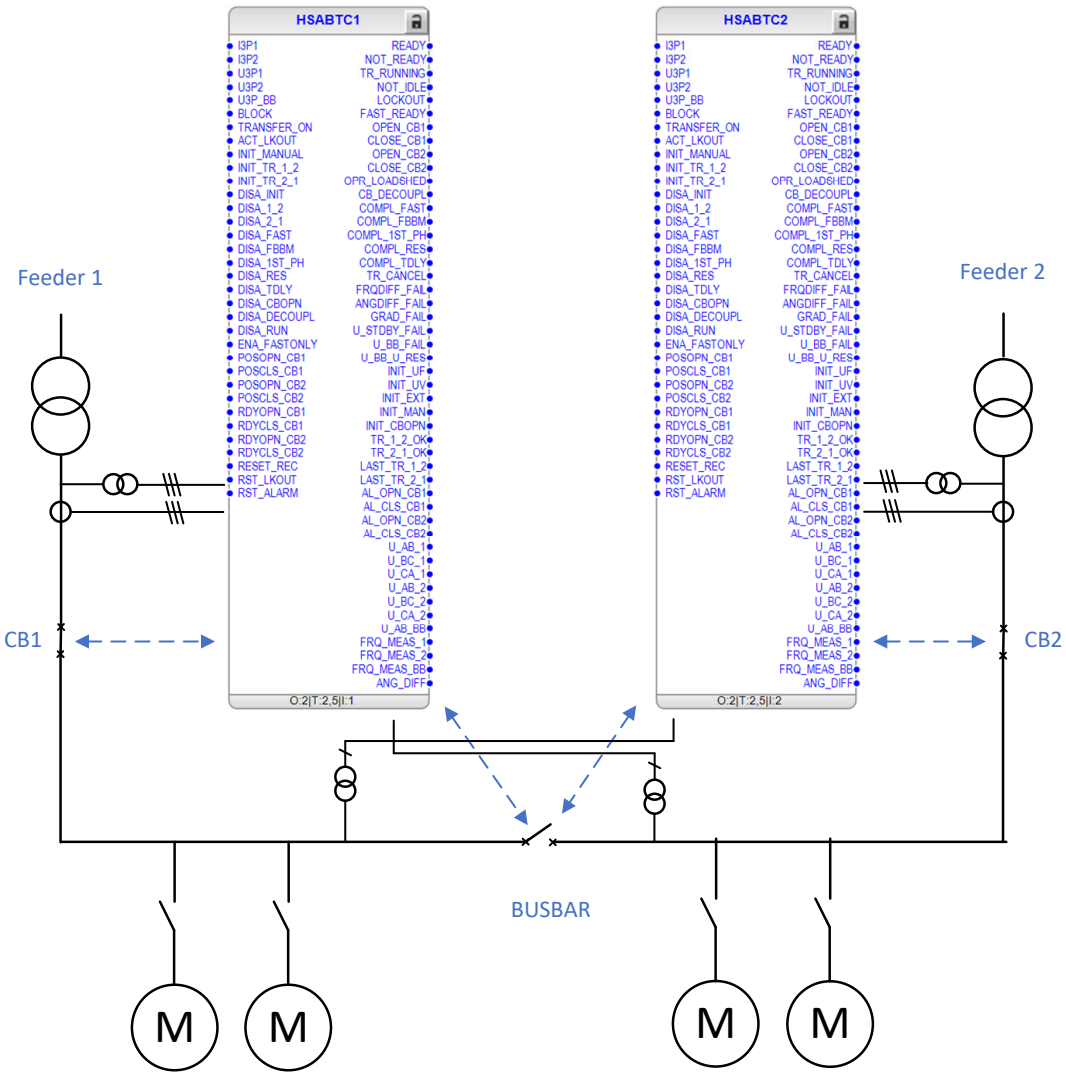



*Figure 955: Application package APP52*

3-Circuit-breaker configuration

- Two busbar sections, Busbar coupling breaker
- Transfer between each feeder and bus coupling breaker
- Two instances of HSABTC function are required for this variant. The first instance performs the transfer operation between feeder 1 and bus coupling breaker. The second instance performs the transfer operation between feeder 2 and bus coupling breaker.

**Application package APP52**

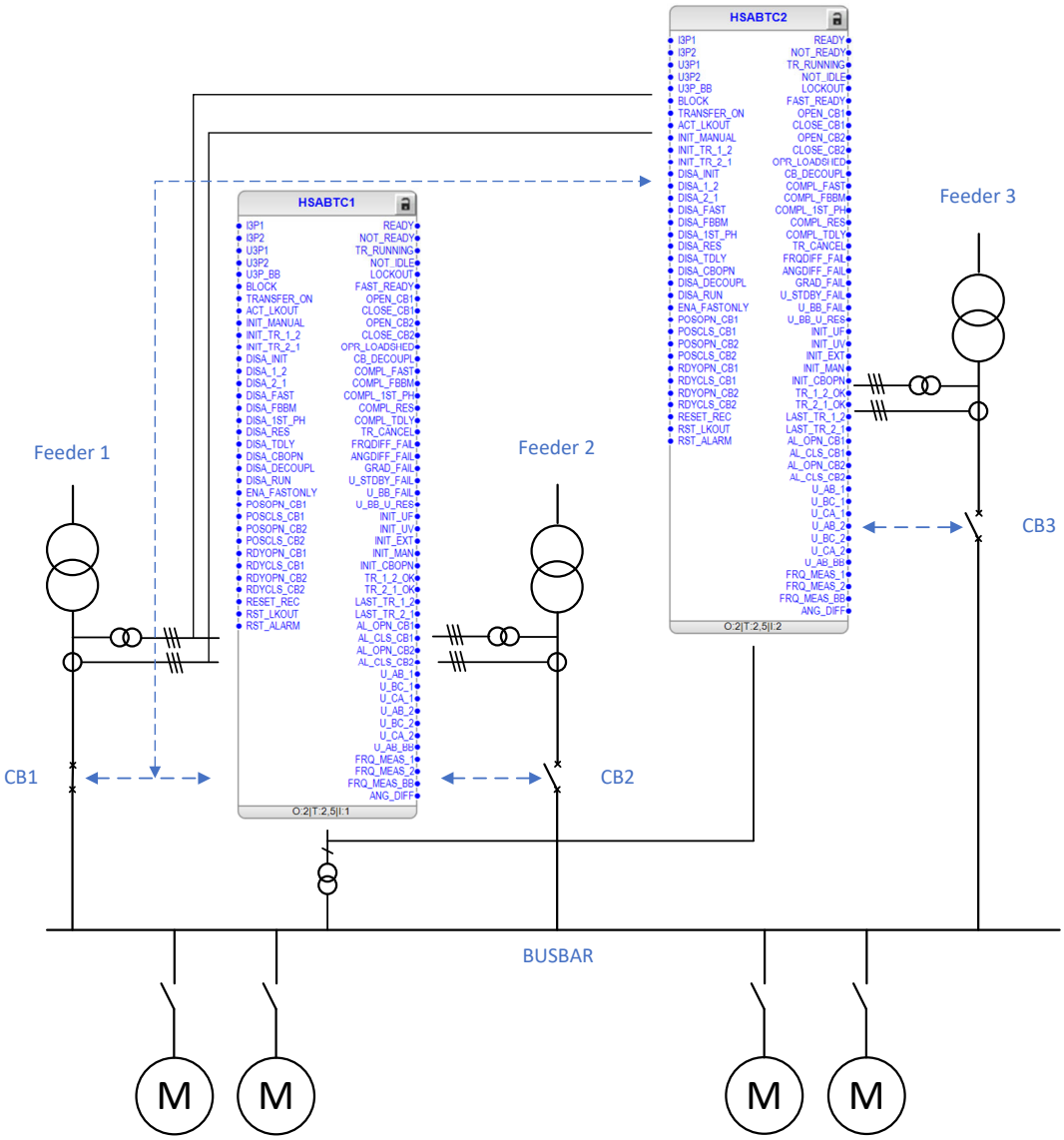



*Figure 956: Application package APP52*

3-Circuit-breaker configuration with pre-selection

- One busbar
- 2 out of 3 selection
- Two instances of HSABTC function are required for this variant. The first instance performs the transfer operation between feeder 1 and feeder 2. The second instance performs the transfer operation between feeder 1 and feeder 3.

**Application package APP53**

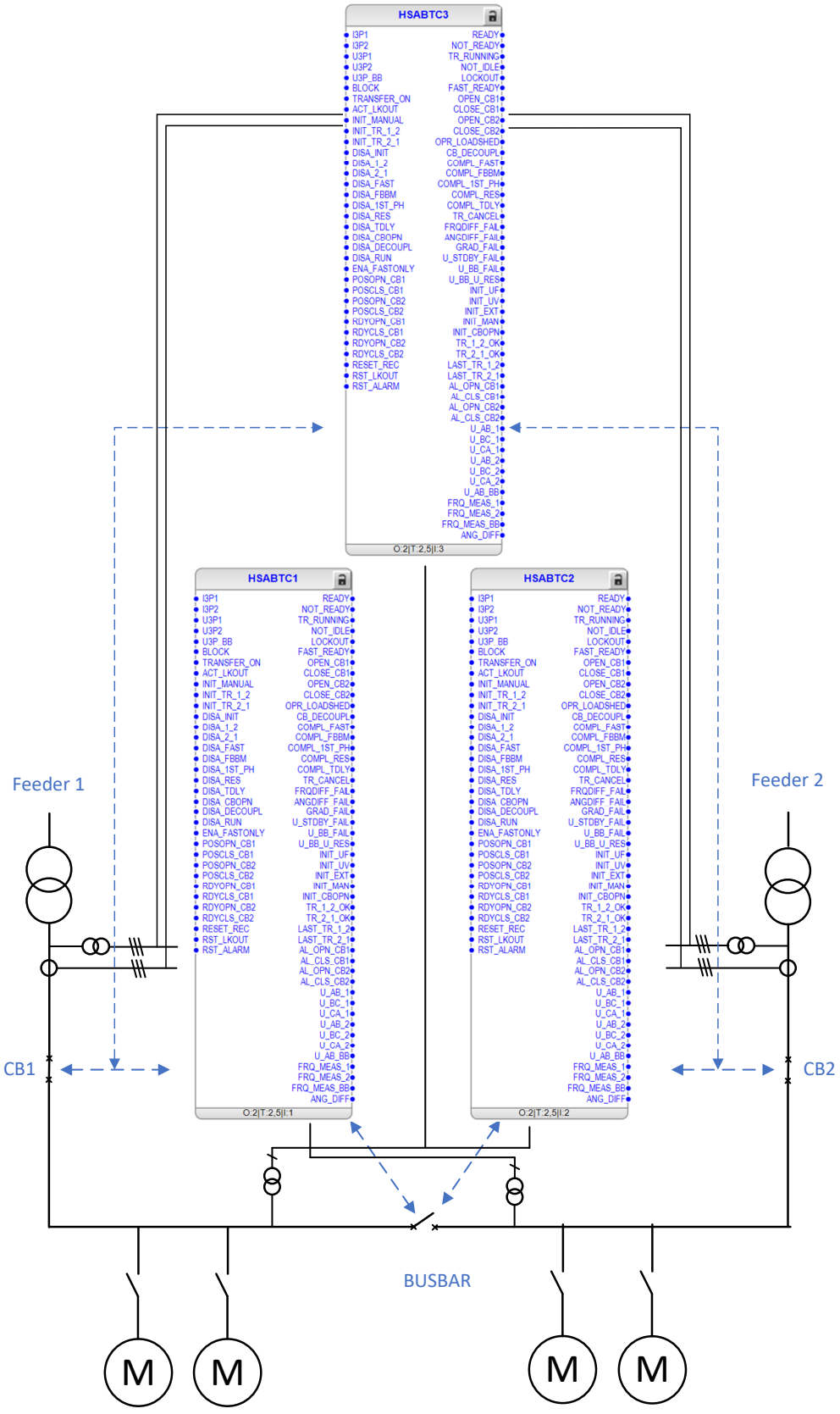



*Figure 957: Application package APP53*

3-Circuit-breaker configuration

- 2 busbar sections, Busbar coupling breaker
- Transfer takes place between the two feeders and bus coupling breaker and feeder 1 and feeder 2 when bus coupler breaker is closed.
- Three instances of HSABTC function are required for this variant. The first instance performs the transfer operation between feeder 1 and bus coupling breaker. The second instance performs the transfer operation between feeder 2 and bus coupling breaker. The third instance performs the transfer operation between feeder 1 and feeder 2.

**Application package APP53**

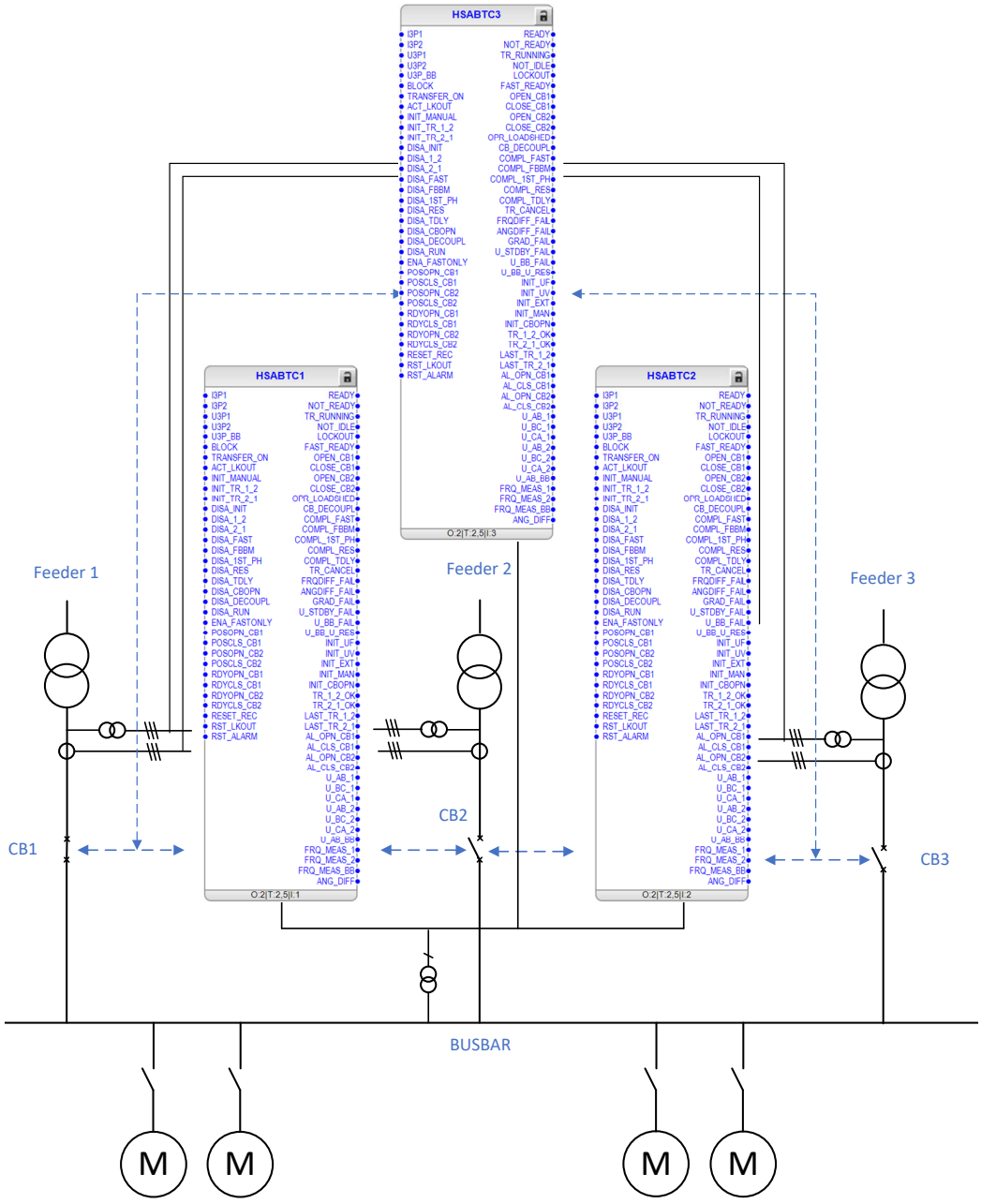



*Figure 958: Application package APP53*

3-Circuit-breaker configuration with pre-selection

- One busbar
- Transfer takes place between each feeder
- Three instances of HSABTC function are required for this variant. The first instance performs the transfer operation between feeder 1 and feeder 2. The second instance performs the transfer operation between feeder 1 and feeder 3. The third instance performs the transfer operation between feeder 2 and feeder 3.

## 9.12.7 Signals

### 9.12.7.1 HSABTC Input signals

**Table 1608: HSABTC Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P1 | SIGNAL | - | Three-phase currents 1 |
| I3P2 | SIGNAL | - | Three-phase currents 2 |
| U3P1 | SIGNAL | - | Three-phase voltages (Bus B side) |
| U3P2 | SIGNAL | - | Three-phase voltages (Bus A side) |
| U3P_BB | SIGNAL | - | Analog input |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |
| TRANSFER_ON | BOOLEAN | 0=False | Level sensitive signal for enabling transfer |
| ACT_LKOUT | BOOLEAN | 0=False | Activate transfer lockout until function is reset |
| INIT_MANUAL | BOOLEAN | 0=False | Manual transfer initiation |
| INIT_TR_1_2 | BOOLEAN | 0=False | Transfer initiation from feeder 1 to feeder 2 |
| INIT_TR_2_1 | BOOLEAN | 0=False | Transfer initiation from feeder 2 to feeder 1 |
| DISA_INIT | BOOLEAN | 0=False | Disable transfer initiation |
| DISA_1_2 | BOOLEAN | 0=False | Disable transfer from feeder 1 to feeder 2 |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| DISA_2_1 | BOOLEAN | 0=False | Disable transfer from feeder 2 to feeder 1 |
| DISA_FAST | BOOLEAN | 0=False | Disable transfer based on fast transfer |
| DISA_FBBM | BOOLEAN | 0=False | Disable transfer based on fast break before make |
| DISA_1ST_PH | BOOLEAN | 0=False | Disable transfer based on first phase coincidence |
| DISA_RES | BOOLEAN | 0=False | Disable transfer based on residual voltage |
| DISA_TDLY | BOOLEAN | 0=False | Disable transfer based on time delay |
| DISA_CBOPN | BOOLEAN | 0=False | Disable transfer initiation based on CB open transfer |
| DISA_DECOUPL | BOOLEAN | 0=False | Disable decoupling |
| DISA_RUN | BOOLEAN | 0=False | Disable transfer completion when active |
| ENA_FASTONLY | BOOLEAN | 0=False | Enable fast transfer only |
| POSOPN_CB1 | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLS_CB1 | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |
| POSOPN_CB2 | BOOLEAN | 0=False | Signal for open position of apparatus from I/O |
| POSCLS_CB2 | BOOLEAN | 0=False | Signal for close position of apparatus from I/O |
| RDYOPN_CB1 | BOOLEAN | 0=False | Circuit breaker ready to open feeder 1 |
| RDYCLS_CB1 | BOOLEAN | 0=False | Circuit breaker ready to close feeder 1 |
| RDYOPN_CB2 | BOOLEAN | 0=False | Circuit breaker ready to open feeder 2 |
| RDYCLS_CB2 | BOOLEAN | 0=False | Circuit breaker ready to close feeder 2 |
| RESET_REC | BOOLEAN | 0=False | Reset recorded data |

*Table continues on the next page*

| Name | Type | Default | Description |
|---|---|---|---|
| RST_LKOUT | BOOLEAN | 0=False | Reset lockout |
| RST_ALARM | BOOLEAN | 0=False | Reset traveling time alarms |

### 9.12.7.2 HSABTC Output signals

**Table 1609: HSABTC Output signals**

| Name | Type | Description |
|---|---|---|
| READY | BOOLEAN | Ready for transfer |
| NOT_READY | BOOLEAN | Not ready for transfer |
| TR_RUNNING | BOOLEAN | Transfer is in running state |
| NOT_IDLE | BOOLEAN | Transfer is not in idle state |
| LOCKOUT | BOOLEAN | Transfer lockout status |
| FAST_READY | BOOLEAN | Ready for fast transfer |
| OPEN_CB1 | BOOLEAN | Open command for feeder 1 breaker |
| CLOSE_CB1 | BOOLEAN | Close command for feeder 1 breaker |
| OPEN_CB2 | BOOLEAN | Open command for feeder 2 breaker |
| CLOSE_CB2 | BOOLEAN | Close command for feeder 2 breaker |
| OPR_LOADSHED | BOOLEAN | Activate load shedding |
| CB_DECOUPL | BOOLEAN | CB decoupling activated |
| COMPL_FAST | BOOLEAN | Fast transfer complete |
| COMPL_FBBM | BOOLEAN | Fast break before make transfer complete |
| COMPL_1ST_PH | BOOLEAN | First phase coincidence transfer complete |
| COMPL_RES | BOOLEAN | Residual voltage based transfer complete |
| COMPL_TDLY | BOOLEAN | Time delayed based transfer complete |
| TR_CANCEL | BOOLEAN | Transfer cancelled |
| FRQDIFF_FAIL | BOOLEAN | Frequency difference is not in range for fast transfer |
| ANGDIFF_FAIL | BOOLEAN | Phase angle difference is not in range for fast transfer |
| GRAD_FAIL | BOOLEAN | Frequency gradient over permissible for 1st phase transfer |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| U_STDBY_FAIL | BOOLEAN | Standby voltage below permissible limit for transfer |
| U_BB_FAIL | BOOLEAN | Busbar voltage below permissible limit for fast transfer |
| U_BB_U_RES | BOOLEAN | Busbar voltage below residual voltage limit |
| INIT_UF | BOOLEAN | Transfer is initiated by under frequency initiation |
| INIT_UV | BOOLEAN | Transfer is initiated by under voltage initiation |
| INIT_EXT | BOOLEAN | Transfer is initiated by external initiation |
| INIT_MAN | BOOLEAN | Transfer is initiated by manual initiation |
| INIT_CBOPN | BOOLEAN | Transfer initiated by CB open initiation |
| TR_1_2_OK | BOOLEAN | Transfer is allowed from feeder 1 to feeder 2 |
| TR_2_1_OK | BOOLEAN | Transfer is allowed from feeder 2 to feeder 1 |
| LAST_TR_1_2 | BOOLEAN | Last valid transfer has been from feeder 1 to feeder 2 |
| LAST_TR_2_1 | BOOLEAN | Last valid transfer has been from feeder 2 to feeder 1 |
| AL_OPN_CB1 | BOOLEAN | Circuit breaker 1 opening time alarm |
| AL_CLS_CB1 | BOOLEAN | Circuit breaker 1 closing time alarm |
| AL_OPN_CB2 | BOOLEAN | Circuit breaker 2 opening time alarm |
| AL_CLS_CB2 | BOOLEAN | Circuit breaker 2 closing time alarm |
| U_AB_1 | FLOAT32 | Analog output |
| U_BC_1 | FLOAT32 | Analog output |
| U_CA_1 | FLOAT32 | Analog output |
| U_AB_2 | FLOAT32 | Analog output |
| U_BC_2 | FLOAT32 | Analog output |
| U_CA_2 | FLOAT32 | Analog output |
| U_AB_BB | FLOAT32 | Analog output |
| FRQ_MEAS_1 | FLOAT32 | Analog output |
| FRQ_MEAS_2 | FLOAT32 | Analog output |
| FRQ_MEAS_BB | FLOAT32 | Analog output |
| ANG_DIFF | FLOAT32 | Analog output |

## 9.12.8 HSABTC Settings

**Table 1610: HSABTC Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Start Val frequency | 0.900...1.100 | xFn | 0.001 | 0.980 | Under frequency limit for internal transfer initiation |
| Start Val voltage | 0.50...1.20 | xUn | 0.01 | 0.70 | Under voltage limit for internal transfer initiation |
| Under frequency time | 10...1000 | ms | 1 | 100 | Under frequency initiation delay |
| Under voltage time | 10...1000 | ms | 1 | 100 | Under voltage initiation delay |
| Min standby voltage | 0.05...1.20 | xUn | 0.01 | 0.70 | Minimum standby feeder voltage |
| Min busbar voltage | 0.05...1.20 | xUn | 0.01 | 0.70 | Minimum busbar voltage |
| Residual voltage limit | 0.01...1.00 | xUn | 0.01 | 0.10 | Residual voltage limit for residual transfer |

**Table 1611: HSABTC Group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Loadshed V limit | 0.05...1.00 | | 0.01 | 0.50 | Busbar voltage limit in load shedding |
| Loadshed V time delay | 0...200000 | ms | 10 | 0 | Voltage based load shedding time delay |
| Loadshed time delay | 100...200000 | ms | 10 | 100 | Load shedding time delay |

**Table 1612: HSABTC Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation mode on/off |
| Operation mode | 1=Only ext<br>2=Freq<<br>3=U<<br>4=Both | | | 1=Only ext | Operation mode for transfer initiation |
| Enable fast transfer | 1=1>2<br>2=2>1<br>3=Both<br>4=Off | | | 3=Both | Enable fast transfer |
| Enable FBBM | 0=False<br>1=True | | | 0=False | Enable Fast break before make transfer |
| Ena 1st Ph transfer | 1=1>2<br>2=2>1<br>3=Both<br>4=Off | | | 4=Off | Ena 1st phase transfer |
| Ena Res V transfer | 1=1>2<br>2=2>1 | | | 3=Both | Enable residual voltage transfer |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 3=Both<br>4=Off | | | | |
| Ena Time delay transfer | 1=1>2<br>2=2>1<br>3=Both<br>4=Off | | | 3=Both | Enable Time delay transfer |
| Ena CB open transfer | 1=1>2<br>2=2>1<br>3=Both<br>4=Off | | | 4=Off | Enable transfer based on CB opening |
| Manual transfer | 1=Off<br>2=On<br>3=Fast MBB | | | 1=Off | Enable manual transfer |
| Max frequency Diff | 0.05...2.50 | Hz | 0.01 | 1.00 | Maximum frequency difference limit for fast transfer |
| Maximum phase lead | 5...50 | deg | 1 | 20 | Maximum phase lead limit for fast transfer |
| Maximum phase lag | 5...50 | deg | 1 | 20 | Maximum phase lag limit for fast transfer |
| Max angle Diff FBBM | 5...90 | deg | 1 | 45 | Max phase angle allowed for fast break before make transfer |
| Maximum DfDt | 5...40 | | 1 | 40 | Maximum DfDt limit for transfer |
| Transfer delay time | 100...200000 | ms | 1 | 2000 | Time delayed transfer activation time |
| Max Trn run time | 100...200000 | ms | 1 | 5000 | Maximum transfer running time |
| Travel time Clc mode | 1=From Cmd to Pos<br>2=From Pos to Pos<br>3=From Cmd to Curr<br>4=From Pos to Curr | | | 1=From Cmd to Pos | Travel time calculation mode selection |
| CB open alarm time | 0...1000 | ms | 1 | 60 | Alarm level setting for open travel time in ms |
| CB close alarm time | 0...1000 | ms | 1 | 80 | Alarm level setting for close travel time in ms |
| CB closing time Dif | 0...1000 | ms | 1 | 10 | Allowed closing time difference for alarm activation in ms |

**Table 1613: HSABTC Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Transfer wait time | 100...200000 | ms | 10 | 5000 | Transfer wait time until new transfer is allowed |
| Closing time of CB1 | 0...200 | ms | 1 | 60 | Closing time of the breaker feeder1 |
| Closing time of CB2 | 0...200 | ms | 1 | 60 | Closing time of the breaker feeder2 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Opening time of CB1 | 0...200 | ms | 1 | 40 | Opening time of the breaker feeder1 |
| Opening time of CB2 | 0...200 | ms | 1 | 40 | Opening time of the breaker feeder2 |
| Close cmd delay time | 0...200 | ms | 1 | 0 | Breaker close command delay time |
| Load shedding mode | 1=None<br>2=Instantaneous<br>3=Voltage based<br>4=Time based | | | 1=None | Load shedding operation mode |
| Enable decoupling | 1=Off<br>2=Transfer based<br>3=CB man close<br>4=Both | | | 1=Off | Enable circuit breaker decoupling |
| Decoupling delay | 50...200000 | ms | 1 | 1000 | Circuit breaker decoupling delay |

## 9.12.9 HSABTC Monitored data

**Table 1614: HSABTC Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| STATUS | Enum | 0=Off<br>1=Ready - sync<br>2=Ready - no sync<br>3=Not ready - sync<br>4=Not ready - no sync<br>5=Transfer running<br>6=Not defined | | Transfer status |
| FRQ_DIFF | FLOAT32 | -30.00...30.00 | Hz | Frequency difference between standby feeder and busbar |
| ANG_DIFF_1 | FLOAT32 | -180.0...180.0 | deg | Angle difference between feeder 1 and busbar |
| ANG_DIFF_2 | FLOAT32 | -180.0...180.0 | deg | Angle difference between feeder 2 and busbar |
| CLS_T_CB1 | FLOAT32 | 0.0...10000.0 | ms | Measured close time for circuit breaker of feeder 1 |
| CLS_T_CB2 | FLOAT32 | 0.0...10000.0 | ms | Measured close time for circuit breaker of feeder 2 |
| OPN_T_CB1 | FLOAT32 | 0.0...10000.0 | ms | Measured open time for circuit breaker of feeder 1 |
| OPN_T_CB2 | FLOAT32 | 0.0...10000.0 | ms | Measured open time for circuit breaker of feeder 2 |
| ACT_CLS_T_CB1 | FLOAT32 | 0.0...10000.0 | ms | Active close time for circuit breaker of feeder 1 |
| ACT_CLS_T_CB2 | FLOAT32 | 0.0...10000.0 | ms | Active close time for circuit breaker of feeder 2 |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ACT_OPN_T_CB1 | FLOAT32 | 0.0...10000.0 | ms | Active open time for circuit breaker of feeder 1 |
| ACT_OPN_T_CB2 | FLOAT32 | 0.0...10000.0 | ms | Active open time for circuit breaker of feeder 2 |
| HSABTC1 | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| Triggering time | Timestamp | | | Triggering time |
| Transfer mode | Enum | 0=None<br>1=Fast<br>2=FBBM<br>3=Ph coincidence<br>4=Res Voltage<br>5=Time delay | | Transfer mode |
| Transfer reason | Enum | 0=None<br>1=External<br>2=External UV<br>3=Internal UF<br>4=Internal UV<br>5=CB open<br>6=Manual | | Transfer reason |
| Transfer direction | Enum | 0=Unknown<br>1=1>2<br>2=2>1 | | Transfer direction |
| Transfer duration | FLOAT32 | 0.0...200000.0 | ms | Time between transfer initiation and CB close command |
| Busbar Max dv/dt | FLOAT32 | -100.00...100.00 | | Maximum rate of change of busbar voltage |
| Busbar Max df/dt | FLOAT32 | -100.00...100.00 | | Maximum rate of change of frequency of busbar voltage |
| Busbar voltage | FLOAT32 | 0.0...10.0 | | Busbar voltage at the time of CB close command |
| Busbar frequency | FLOAT32 | 35.00...75.00 | Hz | Busbar frequency at the time of CB close command |
| Phase difference | FLOAT32 | -180.0...180.0 | deg | Busbar and standby feeder phase diff at CB close command |
| CB decoupled | BOOLEAN | 0=False<br>1=True | | CB decoupling happened during the transfer |
| Loadshed operated | BOOLEAN | 0=False<br>1=True | | Load shedding operated during transfer |
| Triggering time | Timestamp | | | Triggering time |
| Transfer mode | Enum | 0=None<br>1=Fast<br>2=FBBM<br>3=Ph coincidence | | Transfer mode |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| | | 4=Res Voltage<br>5=Time delay | | |
| Transfer reason | Enum | 0=None<br>1=External<br>2=External UV<br>3=Internal UF<br>4=Internal UV<br>5=CB open<br>6=Manual | | Transfer reason |
| Transfer direction | Enum | 0=Unknown<br>1=1>2<br>2=2>1 | | Transfer direction |
| Transfer duration | FLOAT32 | 0.0...200000.0 | ms | Time between transfer initiation and CB close command |
| Busbar Max dv/dt | FLOAT32 | -100.00...100.00 | | Maximum rate of change of busbar voltage |
| Busbar Max df/dt | FLOAT32 | -100.00...100.00 | | Maximum rate of change of frequency of busbar voltage |
| Busbar voltage | FLOAT32 | 0.0...10.0 | | Busbar voltage at the time of CB close command |
| Busbar frequency | FLOAT32 | 35.00...75.00 | Hz | Busbar frequency at the time of CB close command |
| Phase difference | FLOAT32 | -180.0...180.0 | deg | Busbar and standby feeder phase diff at CB close command |
| CB decoupled | BOOLEAN | 0=False<br>1=True | | CB decoupling happened during the transfer |
| Loadshed operated | BOOLEAN | 0=False<br>1=True | | Load shedding operated during transfer |
| Triggering time | Timestamp | | | Triggering time |
| Transfer mode | Enum | 0=None<br>1=Fast<br>2=FBBM<br>3=Ph coincidence<br>4=Res Voltage<br>5=Time delay | | Transfer mode |
| Transfer reason | Enum | 0=None<br>1=External<br>2=External UV<br>3=Internal UF<br>4=Internal UV<br>5=CB open<br>6=Manual | | Transfer reason |
| Transfer direction | Enum | 0=Unknown<br>1=1>2<br>2=2>1 | | Transfer direction |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Transfer duration | FLOAT32 | 0.0...200000.0 | ms | Time between transfer initiation and CB close command |
| Busbar Max dv/dt | FLOAT32 | -100.00...100.00 | | Maximum rate of change of busbar voltage |
| Busbar Max df/dt | FLOAT32 | -100.00...100.00 | | Maximum rate of change of frequency of busbar voltage |
| Busbar voltage | FLOAT32 | 0.0...10.0 | | Busbar voltage at the time of CB close command |
| Busbar frequency | FLOAT32 | 35.00...75.00 | Hz | Busbar frequency at the time of CB close command |
| Phase difference | FLOAT32 | -180.0...180.0 | deg | Busbar and standby feeder phase diff at CB close command |
| CB decoupled | BOOLEAN | 0=False<br>1=True | | CB decoupling happened during the transfer |
| Loadshed operated | BOOLEAN | 0=False<br>1=True | | Load shedding operated during transfer |

## 9.12.10 Technical data

**Table 1615: HSABTC Technical data**

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | Voltage | ±1.5% of the set value or ±0.002 × Un, frequency range ±10Hz | | |
| | Frequency | ±25mHz of the set value | | |
| Initiation time | | Minimum | Typical | Maximum |
| | Under voltage[1, 2, 3] | 14 ms | 18 ms | 21 ms |
| | Under frequency[2, 3, 4] | 47 ms | 49 ms | 50 ms |
| | External (binary input)[2, 3, 5] | 9 ms | 10 ms | 12 ms |
| Initiation time accuracy | | ±20 ms of the set value | | |
| Operate time accuracy | | ±1.0% of the set value or ±20 ms | | |

1 *Start val Voltage* = 0.95 × Un, voltage before fault = 1.0 × Un, fault voltage = 0.9 × set *Start val Voltage*, undervoltage in one phase-to-phase voltage with nominal frequency injected from random phase angle
2 Measured with static power output (SPO)
3 Results based on statistical distribution of 1000 measurements
4 Applies to continuous frequency change. If frequency change ≥ 0.5Hz (disturbance in network or due to test setup), then initiation time is increased with 100ms to prevent false reaction.
5 Excluding the delay of the external triggering device

# 10 Power quality measurement functions

## 10.1 Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics CHMHAI (ANSI PQM ITHD,IDC)

### 10.1.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics | CHMHAI | PQM3IH | PQM ITHD,IDC |

### 10.1.2 Function block

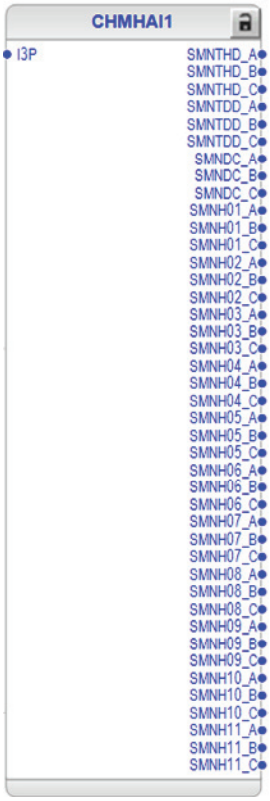



*Figure 959: Function block*

### 10.1.3 Functionality

Harmonic current values are available as measurements for each harmonic, THD and TDD. There are also direct current component and fundamental frequency values. The values of three phases are calculated separately.

There are short-time sliding measurement mean values (3 seconds, 1 minute or 5 minutes). In the configuration tool these values can be connected to other logics. Blocks can be used as limiters, timers and multipurpose analog protection, and alarms can be created when needed.

Non-sliding 10-minute measured mean values are available via communication to substation monitoring products such as COM600S. Only the main function part with an analog signal input must be connected in relay configuration. Data can be collected and stored with the substation monitoring system to the historian database.

These mean values can also be found in the LHMI menus of the protection relay and WHMI.

The applicable power quality standards include EN 50160:2010, IEEE 519-2014, IEC 61000-4-7:2002+A1:2008 and IEC 61000-4-30:2015.

### 10.1.4 Analog channel configuration

CHMHAI has one analog group input which must be properly configured.

**Table 1616: Analog inputs**

| Input | Description |
|---|---|
| I3P | Three-phase currents |

See the preprocessing function blocks in this document for the possible signal sources.

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

### 10.1.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off". Changes will result to reset the function internal data.

The operation of CHMHAI can be described with a module diagram. All the modules in the diagram are explained in the next sections.

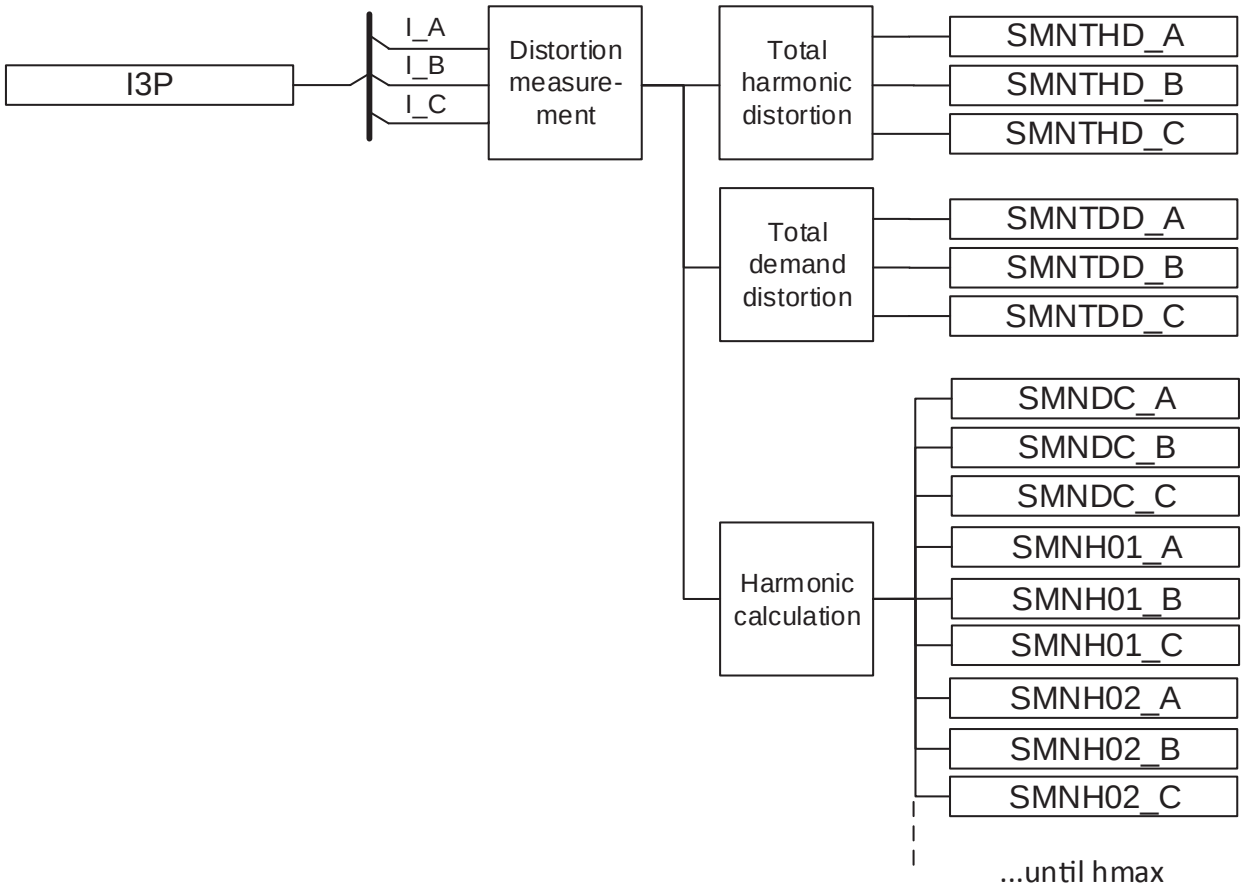



*Figure 960: Functional module diagram*

### 10.1.5.1 Distortion measurement

The Distortion measurement module measures harmonics up to the 11$^{th}$ harmonic.

The filter used for harmonics includes a spectrum of frequencies near each harmonic frequency. FFT for one period is used. The resulting frequency spectrum is wider than in a harmonic subgroup. An anti-aliasing filter is used.

### 10.1.5.2 Total harmonic distortion

The total harmonic distortion THD is calculated from the measured harmonic components with the formula

$$THD = \sqrt{\sum_{h=2}^{n}\left(\frac{I_h}{I_1}\right)^2}$$

(Equation 390)

| | |
|---|---|
| $I_h$ | h$^{th}$ harmonic component |
| $I_1$ | Fundamental frequency current (1$^{st}$ harmonic) |
| n | Number of harmonics |

THD sliding mean value outputs are SMNTHD_A, SMNTHD_B and SMNTHD_C. Non-sliding 10-minute mean values LMNTHD_A, LMNTHD_B and LMNTHD_C are seen in the monitored data. These values are always shown as percentage of the fundamental frequency current mean value. The 10-minute mean values follow 10 min ticks. See also *Figure 961* and the description for sliding values.

### 10.1.5.3 Total demand distortion

The total demand distortion TDD is calculated from the measured harmonic components with the formula

$$TDD = \sqrt{\sum_{h=2}^{n}\left(\frac{I_h}{I_L}\right)^2}$$

(Equation 391)

| | |
|---|---|
| $I_h$ | $h^{th}$ harmonic component |
| $I_L$ | Maximum demand load current set with *Demand current setting* |
| n | Number of harmonics |

The used reference current is the absolute value of the *Demand current* setting. It is typically set according to the maximum load current of the feeder. The TDD value is calculated separately for each phase.

TDD sliding mean value outputs are SMNTDD_A, SMNTDD_B and SMNTDD_C. Non-sliding 10-minute mean values LMNTDD_A, LMNTDD_B and LMNTDD_C are seen in the monitored data. These values are always shown as percentage of the setting *Demand current*. The 10-minute mean values follow 10 min ticks. See also *Figure 961* and the description for sliding values.

### 10.1.5.4 Harmonic calculation

Harmonic mean values are calculated for each phase. Also, the mean values of the nominal frequency (fundamental) and direct current component are calculated. The fundamental frequency mean values are shown as percentage of the nominal phase current.

The actual harmonic mean values are shown as percentage of the reference current. By default, the fundamental frequency current is used as reference. This can be selected by setting *Reference Cur Sel* to "fundamental". When amplitude of fundamental frequency current is very low, below 0.02 xIn, calculation is blocked internally. As a result, value zero is used in the mean value calculation. Extremely high harmonic values are limited to 2.0 xIn. This is also used for fundamental mean value, but not for reference.

The value of Demand current setting can be used as reference by setting *Reference Cur Sel* to "absolute". Typically, it is set according to the maximum demand load current. That is more typically used when TDD is preferred, but might also be found useful when THD is monitored.

Settings *Reference Cur Sel* and *Demand current* have no effect in THD calculation, but setting *Demand current* is used in TDD calculation.

The calculation window length is set with the *Sliding interval* setting. It has three window lengths ("3 seconds", "1 minute" or "5 minutes") for sliding mean value outputs. Output values can also be seen in monitoring.

The window type used for configuration tool output values is always sliding. Output values are updated once every 0.1 seconds.

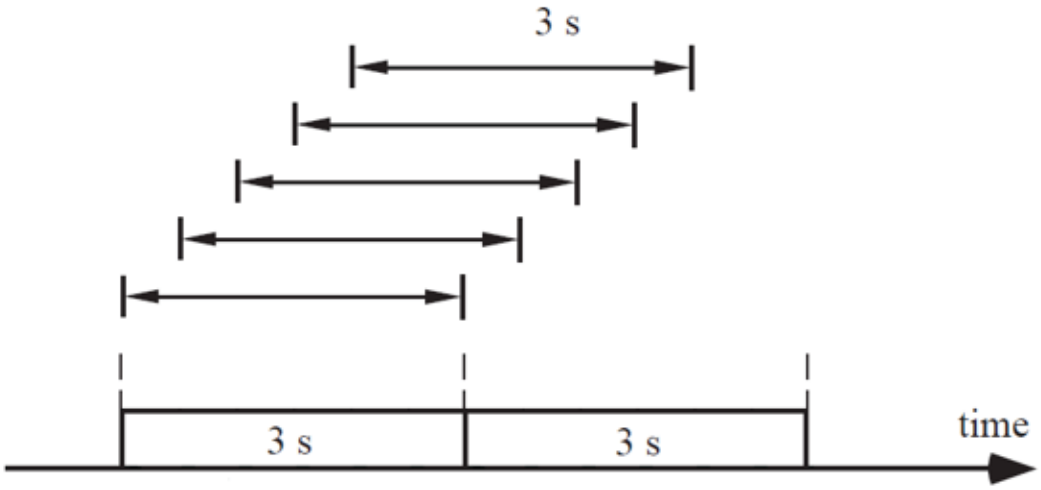



*Figure 961: Sliding 3 seconds value calculation in principle*

The sliding mean values of the fundamental of each phase are SMNH01_A, SMNH01_B and SMNH01_C. Actual harmonics are seen with their number, for example, phase A for second harmonic is SMNH02_A and phase C for 9th harmonic is SMNH09_C. Direct current component outputs are SMNDC_A, SMNDC_B and SMNDC_C.

Intervals that are longer than 3 seconds are calculated using free running 3-second mean values.

The longer 10-minute mean values of the fundamental of each phase are seen in monitored data as LMNH01_A, LMNH01_B and LMNH01_C. Actual harmonics are seen with their number. Direct current components are LMNDC_A, LMNDC_B and LMNDC_C.

Time stamps for ready 10-minute mean value calculation can be seen in the monitored data L time stamp.

The window type used for the 10-minute mean value calculation is always non-sliding. The 10-minute value calculation begins based on the protection relay's internal clock 10 minutes time (for example,11:00, 11:10, 11:20, 11:30, 11:40, 11:50, 12:00…). This is called 10 min tick.

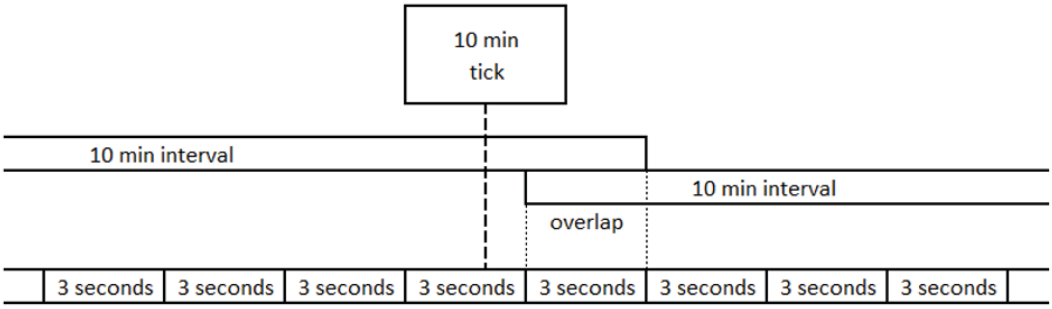



*Figure 962: The 10-minute interval with time synchronization and free running 3 seconds*

The 10-minute mean value is shown in the monitored data until the next 10-minute mean value has been cumulated. Another 10-minute calculation might be started when time synchronization is used to change the protection relay's internal clock. The first calculation continues for 10 minutes and is then seen in the monitored data with a time stamp. An event is sent every time a 10-minute value calculation is ready in the monitored data.

See the Time synchronization chapter in this document.

When the protection relay is powered on, the shown value is zero until the first 10- minute mean value has been cumulated. During this time, the 10-minute output quality is marked questionable in the IEC 61850 data.

When the settings *Reference Cur Sel* or *Demand current* are changed, older data is not cleared. Although older data is calculated based on different setting values, those can still be used as they are used to calculate mean values. The influence might be seen in mean values. These are considered as minor adjustments to the reference current, similar to varying fundamental current.

Changing setting *Sliding interval* has influence on the seen mean values. Sliding values change slowly towards the input value during the time interval. When mean values have not been calculated for a full interval, quality is marked questionable in the IEC 61850 data. Questionable quality is also indicated for a full interval if the protection relay is reset.

## 10.1.6 Application

Typically, the measured short-time 3-second mean values are used with a suitable logic to give alarms. If a more stabilized value is needed, a 1-minute or 5-minute mean value should be selected.

One example of using short-time mean values is to compare the level of THD and some harmonics, for example, $5^{th}$ and $7^{th}$. The values to be compared to the same limit can be combined with MAX3R, and MAPGAPC can be used to test if the settable limit value is exceeded. Outputs of MAPGAPC can be connected to the needed logic and, for example, an event can be sent with MVGAPC.

The 10-minute mean values can be collected to an external substation monitoring system. Collected data can be used in weekly reporting. If longer mean values are needed, the collected 10-minute mean values can be used to calculate, for example, two-hour mean values.

Typically, 10-minute THD or TDD mean values are collected from all three phases. Individual harmonics and the fundamental frequency component can also be collected.

## 10.1.7 Signals

**Table 1617: CHMHAI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | – | Three-phase currents |

**Table 1618: CHMHAI Output signals**

| Name | Type | Description |
|---|---|---|
| SMNTHD_A | FLOAT32 | Mean THD for phase A in 3 s, 1 min or 5 min mean (%) |
| SMNTHD_B | FLOAT32 | Mean THD for phase B in 3 s, 1 min or 5 min mean (%) |
| SMNTHD_C | FLOAT32 | Mean THD for phase C in 3 s, 1 min or 5 min mean (%) |
| SMNTDD_A | FLOAT32 | Mean TDD for phase A in 3 s, 1 min or 5 min mean (%) |
| SMNTDD_B | FLOAT32 | Mean TDD for phase B in 3 s, 1 min or 5 min mean (%) |
| SMNTDD_C | FLOAT32 | Mean TDD for phase C in 3 s, 1 min or 5 min mean (%) |
| SMNDC_A | FLOAT32 | Shorter mean value of DC component for Phase A (%) |
| SMNDC_B | FLOAT32 | Shorter mean value of DC component for Phase B (%) |
| SMNDC_C | FLOAT32 | Shorter mean value of DC component for Phase C (%) |
| SMNH01_A | FLOAT32 | Shorter mean value of basic freq. for Phase A (%) |
| SMNH01_B | FLOAT32 | Shorter mean value of basic freq. for Phase B (%) |
| SMNH01_C | FLOAT32 | Shorter mean value of basic freq. for Phase C (%) |
| SMNH02_A | FLOAT32 | Shorter mean value of 2nd harmonic for Phase A (%) |
| SMNH02_B | FLOAT32 | Shorter mean value of 2nd harmonic for Phase B (%) |
| SMNH02_C | FLOAT32 | Shorter mean value of 2nd harmonic for Phase C (%) |
| SMNH03_A | FLOAT32 | Shorter mean value of 3rd harmonic for Phase A (%) |
| SMNH03_B | FLOAT32 | Shorter mean value of 3rd harmonic for Phase B (%) |
| SMNH03_C | FLOAT32 | Shorter mean value of 3rd harmonic for Phase C (%) |
| SMNH04_A | FLOAT32 | Shorter mean value of 4th harmonic for Phase A (%) |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| SMNH04_B | FLOAT32 | Shorter mean value of 4th harmonic for Phase B (%) |
| SMNH04_C | FLOAT32 | Shorter mean value of 4th harmonic for Phase C (%) |
| SMNH05_A | FLOAT32 | Shorter mean value of 5th harmonic for Phase A (%) |
| SMNH05_B | FLOAT32 | Shorter mean value of 5th harmonic for Phase B (%) |
| SMNH05_C | FLOAT32 | Shorter mean value of 5th harmonic for Phase C (%) |
| SMNH06_A | FLOAT32 | Shorter mean value of 6th harmonic for Phase A (%) |
| SMNH06_B | FLOAT32 | Shorter mean value of 6th harmonic for Phase B (%) |
| SMNH06_C | FLOAT32 | Shorter mean value of 6th harmonic for Phase C (%) |
| SMNH07_A | FLOAT32 | Shorter mean value of 7th harmonic for Phase A (%) |
| SMNH07_B | FLOAT32 | Shorter mean value of 7th harmonic for Phase B (%) |
| SMNH07_C | FLOAT32 | Shorter mean value of 7th harmonic for Phase C (%) |
| SMNH08_A | FLOAT32 | Shorter mean value of 8th harmonic for Phase A (%) |
| SMNH08_B | FLOAT32 | Shorter mean value of 8th harmonic for Phase B (%) |
| SMNH08_C | FLOAT32 | Shorter mean value of 8th harmonic for Phase C (%) |
| SMNH09_A | FLOAT32 | Shorter mean value of 9th harmonic for Phase A (%) |
| SMNH09_B | FLOAT32 | Shorter mean value of 9th harmonic for Phase B (%) |
| SMNH09_C | FLOAT32 | Shorter mean value of 9th harmonic for Phase C (%) |
| SMNH10_A | FLOAT32 | Shorter mean value of 10th harmonic for Phase A (%) |
| SMNH10_B | FLOAT32 | Shorter mean value of 10th harmonic for Phase B (%) |
| SMNH10_C | FLOAT32 | Shorter mean value of 10th harmonic for Phase C (%) |
| SMNH11_A | FLOAT32 | Shorter mean value of 11th harmonic for Phase A (%) |
| SMNH11_B | FLOAT32 | Shorter mean value of 11th harmonic for Phase B (%) |
| SMNH11_C | FLOAT32 | Shorter mean value of 11th harmonic for Phase C (%) |

## 10.1.8 Settings

**Table 1619: CHMHAI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Sliding interval | 1=3 seconds<br>2=1 minute<br>3=5 minutes | | | 1=3 seconds | Time interval for demand calculation |

**Table 1620: CHMHAI Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reference Cur Sel | 0=fundamental<br>2=absolute | | | 0=fundamental | Selection of reference current used with individual harmonics |
| Demand current | 0.10...1.00 | xIn | 0.01 | 1.00 | Reference current for harmonic demand calculation |

## 10.1.9 Monitored data

**Table 1621: CHMHAI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNTHD_A | FLOAT32 | 0.00...500.00 | % | Mean THD for phase A in 10 min non-sliding mean in % |
| LMNTHD_B | FLOAT32 | 0.00...500.00 | % | Mean THD for phase B in 10 min non-sliding mean in % |
| LMNTHD_C | FLOAT32 | 0.00...500.00 | % | Mean THD for phase C in 10 min non-sliding mean in % |
| LMNTDD_A | FLOAT32 | 0.00...500.00 | % | Mean TDD for phase A in 10 min non-sliding mean in % |
| LMNTDD_B | FLOAT32 | 0.00...500.00 | % | Mean TDD for phase B in 10 min non-sliding mean in % |
| LMNTDD_C | FLOAT32 | 0.00...500.00 | % | Mean TDD for phase C in 10 min non-sliding mean in % |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNDC_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase A in % |
| LMNDC_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase B in % |
| LMNDC_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase C in % |
| LMNH01_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase A in % |
| LMNH01_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase B in % |
| LMNH01_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase C in % |
| LMNH02_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase A in % |
| LMNH02_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase B in % |
| LMNH02_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase C in % |
| LMNH03_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase A in % |
| LMNH03_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase B in % |
| LMNH03_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase C in % |
| LMNH04_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase A in % |
| LMNH04_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase B in % |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNH04_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase C in % |
| LMNH05_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase A in % |
| LMNH05_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase B in % |
| LMNH05_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase C in % |
| LMNH06_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase A in % |
| LMNH06_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase B in % |
| LMNH06_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase C in % |
| LMNH07_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase A in % |
| LMNH07_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase B in % |
| LMNH07_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase C in % |
| LMNH08_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase A in % |
| LMNH08_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase B in % |
| LMNH08_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase C in % |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNH09_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase A in % |
| LMNH09_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase B in % |
| LMNH09_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase C in % |
| LMNH10_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase A in % |
| LMNH10_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase B in % |
| LMNH10_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase C in % |
| LMNH11_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase A in % |
| LMNH11_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase B in % |
| LMNH11_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase C in % |
| L time stamp | Timestamp | | | Time stamp of end of 10 min mean values |

## 10.1.10 Technical data

**Table 1622: CHMHAI Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy<br>Nominal frequency 50 Hz. Harmonics in the range 0…0.21 × fundamental amplitude | ±3.0 % or ±0.2 |

# 10.2 Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics VHMHAI (ANSI PQM VTHD,VDC)

## 10.2.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics | VHMHAI | PQM3VH | PQM VTHD,VDC |

## 10.2.2 Function block

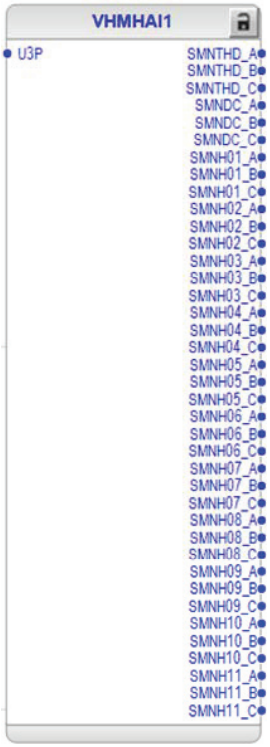



*Figure 963: Function block*

## 10.2.3 Functionality

Harmonic voltage values are available as measurements for each harmonic and THD. There are also direct current component and fundamental frequency values. The values of three phases are calculated separately.

There are short-time sliding measurement mean values (3 seconds, 1 minute or 5 minutes) which can be connected to other logics in the configuration tool. Blocks, such as limiters, timers and multipurpose analog protection, can be used and alarms can be created when needed.

Non-sliding 10-minute measured mean values are available via communication to substation monitoring products such as COM600S. Only the main function part with an analog signal input must be connected in relay configuration. Data can be collected and stored with the substation monitoring system to the historian database.

These mean values can also be found in the LHMI menus of the protection relay and WHMI.

The applicable power quality standards include EN 50160:2010, IEEE 519-2014, IEC 61000-4-7:2002+A1:2008 and IEC 61000-4-30:2015.

## 10.2.4 Analog channel configuration

VHMHAI has one analog group input which must be properly configured.

**Table 1623: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages for voltage harmonic measurement function VHMHAI |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1624: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function requires that all three voltage channels are connected. |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 10.2.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "on" and "off". Changes will result to reset the function internal data.

The operation of VHMHAI can be described with a module diagram. All the modules in the diagram are explained in the next sections.

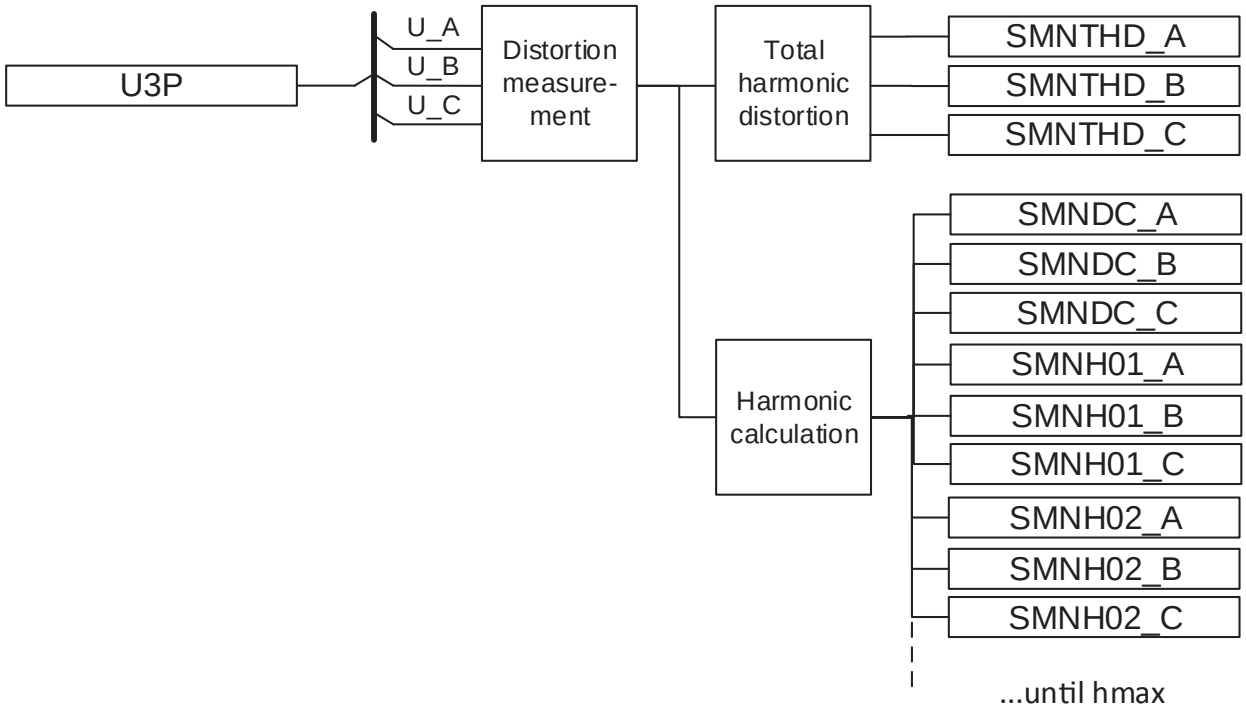



*Figure 964: Functional module diagram*

### 10.2.5.1 Distortion measurement

The Distortion measurement module measures harmonics up to the 11$^{th}$ harmonic.

The filter used for harmonics includes a spectrum of frequencies near each harmonic frequency. FFT for one period is used. The resulting frequency spectrum is wider than in a harmonic subgroup. An anti-aliasing filter is used.

### 10.2.5.2 Total harmonic distortion

The total harmonic distortion THD is calculated from the measured harmonic components with the formula

$$THD = \sqrt{\sum_{h=2}^{n}\left(\frac{I_h}{I_1}\right)^2}$$

(Equation 392)

| | |
|---|---|
| $I_h$ | h$^{th}$ harmonic component |
| $I_1$ | Fundamental voltage (1$^{st}$ harmonic) |
| n | Number of harmonics |

THD shorter mean value outputs are SMNTHD_A, SMNTHD_B and SMNTHD_C. These and also the 10-minute mean values LMNTHD_A, LMNTHD_B and LMNTHD_C are seen in the monitored data. These values are always shown as percentage of the fundamental frequency's phase-to-earth voltage 3-second mean value. The 10-minute mean values also follow 10 min ticks. See also *Figure 965* and the description for sliding values.

### 10.2.5.3 Harmonic calculation

Harmonic mean values are calculated for each phase. Also, the mean values of the nominal frequency (fundamental) and direct current component are calculated. The fundamental frequency mean values are shown as percentage of the nominal phase-to-earth voltage.

The actual harmonic mean values are shown as percentage of the fundamental voltage. When the reference voltage (the fundamental voltage) is extremely low (below 0.02 xUn), the calculation is blocked internally. As a result, value zero is used in the mean value calculation of individual harmonics. Extremely high harmonic values are limited to 2.0 xUn.

The calculation window length is set with the *Sliding interval* setting. It has three window lengths ("3 seconds", "1 minute" or "5 minutes") for shorter mean value outputs. Output values can also be seen in the monitored data.

The window type used for configuration tool output values is always sliding. Output values are updated once every 0.1 seconds.

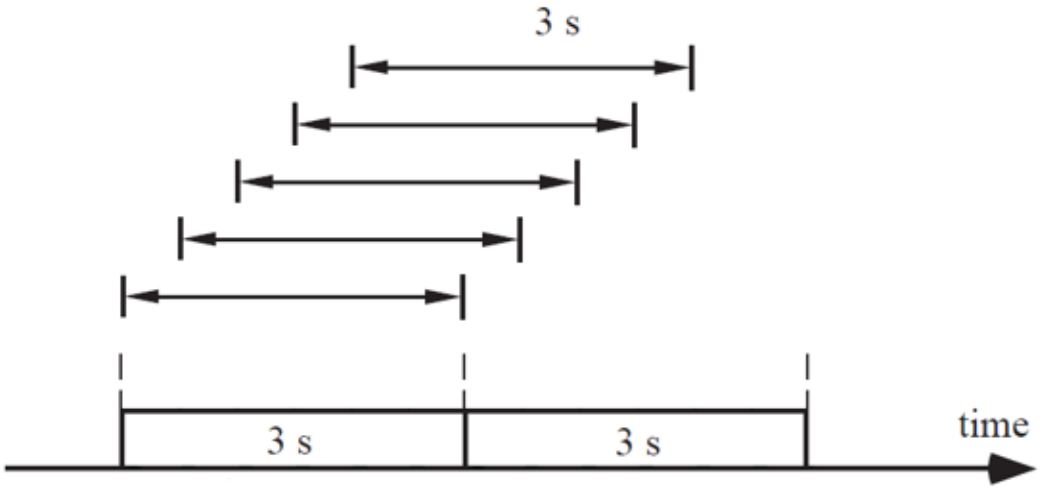



*Figure 965: Sliding 3 seconds value calculation in principle*

The shorter mean values of the fundamental of each phase are SMNH01_A, SMNH01_B and SMNH01_C. Actual harmonics are seen with their number, for example, phase A for second harmonic is SMNH02_A and phase C for 9th harmonic is SMNH09_C. Direct current component outputs are SMNDC_A, SMNDC_B and SMNDC_C.

Intervals that are longer than 3 seconds are calculated using free running 3-second mean values.

The longer 10-minute mean values of the fundamental of each phase are seen in monitored data as LMNH01_A, LMNH01_B and LMNH01_C. Actual harmonics are seen with their number. Direct current components are LMNDC_A, LMNDC_B and LMNDC_C.

The time stamp for the ready 10-minute mean value calculation can be seen in monitored data L time stamp.

The window type used for the 10-minute mean value calculation is always non-sliding. The 10-minute value calculation begins based on the protection relay's internal clock 10 minutes time (for example,11:00, 11:10, 11:20, 11:30, 11:40, 11:50, 12:00...). This is called 10 min tick.

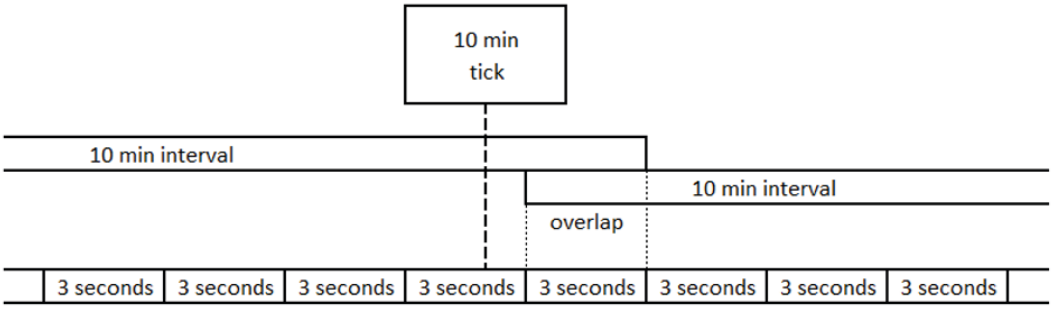



*Figure 966: The 10-minute interval with time synchronization and free running 3 seconds*

The 10-minute mean value is shown in monitored data until the next 10-minute mean value has been cumulated. Another 10-minute calculation can be started when time synchronization is used to change the protection relay's internal clock. The first calculation continues for 10 minutes and is then seen in the monitored data with a time stamp. An event is sent every time a 10-minute value calculation is ready in the monitored data.

See also the Time synchronization chapter in this document.

When the protection relay is powered on, the shown value is zero until the first 10-minute mean value has been cumulated. During this time, the 10-minute output quality is marked as bad in the IEC 61850 data.

Changing setting *Sliding interval* has influence on the seen mean values. Sliding values change slowly towards the input value during the time interval. When mean values have not been calculated for a full interval, quality is marked as bad in the IEC 61850 data. Bad quality is also indicated after the protection relay has been reset.

## 10.2.6 Application

Typically, the measured short-time 3-second mean values are used with a suitable logic to give alarms. If a more stabilized value is needed, a 1-minute or 5-minute mean value should be selected.

One example of using short-time mean values is to compare the level of THD and some harmonics, for example, $5^{th}$ and $7^{th}$. The values to be compared to the same limit can be combined with MAX3R, and MAPGAPC can be used to test if the settable limit value is exceeded. Outputs of MAPGAPC can be connected to the needed logic and, for example, an event can be sent with MVGAPC.

The 10-minute mean values can be collected to an external substation monitoring system. Collected data can be used in weekly reporting. If longer mean values are needed, the collected 10-minute mean values can be used to calculate, for example, two-hour mean values.

Typically, 10-minute THD or TDD mean values are collected from all three phases. Individual harmonics and the fundamental frequency component can also be collected.

## 10.2.7 Signals

**Table 1625: VHMHAI Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | – | Three-phase voltages |

**Table 1626: VHMHAI Output signals**

| Name | Type | Description |
|---|---|---|
| SMNTHD_A | FLOAT32 | Mean THD for phase A in 3 s, 1 min or 5 min mean (%) |
| SMNTHD_B | FLOAT32 | Mean THD for phase B in 3 s, 1 min or 5 min mean (%) |
| SMNTHD_C | FLOAT32 | Mean THD for phase C in 3 s, 1 min or 5 min mean (%) |
| SMNDC_A | FLOAT32 | Shorter mean value of DC component for Phase A (%) |
| SMNDC_B | FLOAT32 | Shorter mean value of DC component for Phase B (%) |
| SMNDC_C | FLOAT32 | Shorter mean value of DC component for Phase C (%) |
| SMNH01_A | FLOAT32 | Shorter mean value of basic freq. for Phase A (%) |
| SMNH01_B | FLOAT32 | Shorter mean value of basic freq. for Phase B (%) |
| SMNH01_C | FLOAT32 | Shorter mean value of basic freq. for Phase C (%) |
| SMNH02_A | FLOAT32 | Shorter mean value of 2nd harmonic for Phase A (%) |
| SMNH02_B | FLOAT32 | Shorter mean value of 2nd harmonic for Phase B (%) |
| SMNH02_C | FLOAT32 | Shorter mean value of 2nd harmonic for Phase C (%) |
| SMNH03_A | FLOAT32 | Shorter mean value of 3rd harmonic for Phase A (%) |
| SMNH03_B | FLOAT32 | Shorter mean value of 3rd harmonic for Phase B (%) |
| SMNH03_C | FLOAT32 | Shorter mean value of 3rd harmonic for Phase C (%) |
| SMNH04_A | FLOAT32 | Shorter mean value of 4th harmonic for Phase A (%) |
| SMNH04_B | FLOAT32 | Shorter mean value of 4th harmonic for Phase B (%) |
| SMNH04_C | FLOAT32 | Shorter mean value of 4th harmonic for Phase C (%) |
| SMNH05_A | FLOAT32 | Shorter mean value of 5th harmonic for Phase A (%) |

*Table continues on the next page*

| Name | Type | Description |
|---|---|---|
| SMNH05_B | FLOAT32 | Shorter mean value of 5th harmonic for Phase B (%) |
| SMNH05_C | FLOAT32 | Shorter mean value of 5th harmonic for Phase C (%) |
| SMNH06_A | FLOAT32 | Shorter mean value of 6th harmonic for Phase A (%) |
| SMNH06_B | FLOAT32 | Shorter mean value of 6th harmonic for Phase B (%) |
| SMNH06_C | FLOAT32 | Shorter mean value of 6th harmonic for Phase C (%) |
| SMNH07_A | FLOAT32 | Shorter mean value of 7th harmonic for Phase A (%) |
| SMNH07_B | FLOAT32 | Shorter mean value of 7th harmonic for Phase B (%) |
| SMNH07_C | FLOAT32 | Shorter mean value of 7th harmonic for Phase C (%) |
| SMNH08_A | FLOAT32 | Shorter mean value of 8th harmonic for Phase A (%) |
| SMNH08_B | FLOAT32 | Shorter mean value of 8th harmonic for Phase B (%) |
| SMNH08_C | FLOAT32 | Shorter mean value of 8th harmonic for Phase C (%) |
| SMNH09_A | FLOAT32 | Shorter mean value of 9th harmonic for Phase A (%) |
| SMNH09_B | FLOAT32 | Shorter mean value of 9th harmonic for Phase B (%) |
| SMNH09_C | FLOAT32 | Shorter mean value of 9th harmonic for Phase C (%) |
| SMNH10_A | FLOAT32 | Shorter mean value of 10th harmonic for Phase A (%) |
| SMNH10_B | FLOAT32 | Shorter mean value of 10th harmonic for Phase B (%) |
| SMNH10_C | FLOAT32 | Shorter mean value of 10th harmonic for Phase C (%) |
| SMNH11_A | FLOAT32 | Shorter mean value of 11th harmonic for Phase A (%) |
| SMNH11_B | FLOAT32 | Shorter mean value of 11th harmonic for Phase B (%) |
| SMNH11_C | FLOAT32 | Shorter mean value of 11th harmonic for Phase C (%) |

## 10.2.8 Settings

**Table 1627: VHMHAI Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Sliding interval | 1=3 seconds<br>2=1 minute<br>3=5 minutes | | | 1=3 seconds | Time interval for demand calculation |

## 10.2.9 Monitored data

**Table 1628: VHMHAI Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNTHD_A | FLOAT32 | 0.00...500.00 | % | Mean THD for phase A in 10 min non-sliding mean in % |
| LMNTHD_B | FLOAT32 | 0.00...500.00 | % | Mean THD for phase B in 10 min non-sliding mean in % |
| LMNTHD_C | FLOAT32 | 0.00...500.00 | % | Mean THD for phase C in 10 min non-sliding mean in % |
| LMNDC_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase A in % |
| LMNDC_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase B in % |
| LMNDC_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of DC component for Phase C in % |
| LMNH01_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase A in % |
| LMNH01_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase B in % |
| LMNH01_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of basic freq. for Phase C in % |
| LMNH02_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase A in % |
| LMNH02_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase B in % |
| LMNH02_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 2nd harmonic for Phase C in % |
| LMNH03_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase A in % |
| LMNH03_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase B in % |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNH03_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 3rd harmonic for Phase C in % |
| LMNH04_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase A in % |
| LMNH04_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase B in % |
| LMNH04_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 4th harmonic for Phase C in % |
| LMNH05_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase A in % |
| LMNH05_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase B in % |
| LMNH05_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 5th harmonic for Phase C in % |
| LMNH06_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase A in % |
| LMNH06_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase B in % |
| LMNH06_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 6th harmonic for Phase C in % |
| LMNH07_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase A in % |
| LMNH07_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase B in % |
| LMNH07_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 7th harmonic for Phase C in % |
| LMNH08_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase A in % |
| LMNH08_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase B in % |
| LMNH08_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 8th harmonic for Phase C in % |
| LMNH09_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase A in % |
| LMNH09_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase B in % |
| LMNH09_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 9th harmonic for Phase C in % |
| LMNH10_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase A in % |
| LMNH10_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase B in % |
| LMNH10_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 10th harmonic for Phase C in % |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| LMNH11_A | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase A in % |
| LMNH11_B | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase B in % |
| LMNH11_C | FLOAT32 | 0.00...500.00 | % | Longer mean value of 11th harmonic for Phase C in % |
| L time stamp | Timestamp | | | Time stamp of end of 10 min mean values |

### 10.2.10 Technical data

**Table 1629: VHMHAI Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy<br>Nominal frequency 50 Hz. Harmonics in the range 0...0.21 × fundamental amplitude | ±3.0 % or ±0.2 |

## 10.3 Voltage variation PHQVVR (ANSI PQMV SWE,SAG,INT)

### 10.3.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Voltage variation | PHQVVR | PQMU | PQMV SWE,SAG,INT |

### 10.3.2 Function block

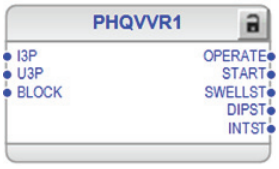



*Figure 967: Function block*

### 10.3.3 Functionality

The voltage variation function PHQVVR is used for measuring the short-duration voltage variations in distribution networks.

Power quality in the voltage waveform is evaluated by measuring voltage swells, dips and interruptions. PHQVVR includes single-phase and three-phase voltage variation modes.

Typically, short-duration voltage variations are defined to last more than half of the nominal frequency period and less than one minute. The maximum magnitude (in the case of a voltage swell) or depth (in the case of a voltage dip or interruption) and the duration of the variation can be obtained by measuring the RMS value of the voltage for each phase. International standard 61000-4-30 defines the voltage variation to be implemented using the RMS value of the voltage. IEEE standard 1159-1995 provides recommendations for monitoring the electric power quality of the single-phase and polyphase ac power systems.

PHQVVR contains a blocking functionality. It is possible to block a set of function outputs or the function itself.

## 10.3.4 Analog channel configuration

PHQVVR has two analog group inputs which must be properly configured.

**Table 1630: Analog inputs**

| Input | Description |
|---|---|
| I3P [1] | Three-phase currents |
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources. The GRPOFF signal is available in the function block called Protection.

There are a few special conditions which must be noted with the configuration.

**Table 1631: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with one voltage channel connected (A, B or C depending on the *Phase supervision* setting "Ph A", "Ph B" or "Ph C") if *Phase mode* is set to "Single Phase". |
| | The function can work with two voltage channel connected (A-B, B-C or C-A depending on the *Phase supervision* setting "Ph A+B", "Ph B+C" or "Ph A+C") if *Phase mode* is set to "Three Phase". |
| | The function requires that all three voltage channels are connected if *Phase supervision* is set to "Ph A+B+C" and *Phase mode* setting is set to "Three Phase". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

[1] Can be connected to GRPOFF

## 10.3.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of PHQVVR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

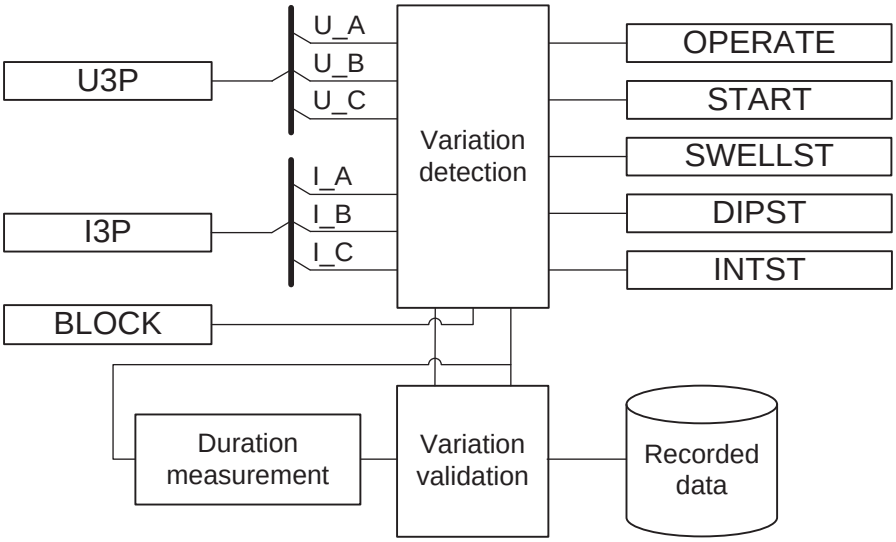



*Figure 968: Functional module diagram*

### 10.3.5.1 Phase mode setting

PHQVVR is designed for both single-phase and polyphase ac power systems, and selection can be made with the *Phase mode* setting, which can be set either to the "Single Phase" or "Three Phase" mode. The default setting is "Single Phase".

The basic difference between these alternatives depends on how many phases are needed to have the voltage variation activated. When the *Phase mode* setting is "Single Phase", the activation is straightforward. There is no dependence between the phases for variation start. The START output and the corresponding phase start are activated when the limit is exceeded or undershot. The corresponding phase start deactivation takes place when the limit (includes small hysteresis) is undershot or exceeded. The START output is deactivated when there are no more active phases.

However, when *Phase mode* is "Three Phase", all the monitored phase signal magnitudes, defined with *Phase supervision*, have to fall below or rise above the limit setting to activate the START output and the corresponding phase output, that is, all the monitored phases have to be activated. Accordingly, the deactivation occurs when the activation requirement is not fulfilled, that is, one or more monitored phase signal magnitudes return beyond their limits. Phases do not need to be activated by the same variation type to activate the START output. Another consequence is that if only one or two phases are monitored, it is sufficient that these monitored phases activate the START output.

### 10.3.5.2 Variation detection

The module compares the measured voltage against the limit settings. If there is a permanent undervoltage or overvoltage, the *Reference voltage* setting can be set to this voltage level to avoid the undesired voltage dip or swell indications. This is accomplished by converting the variation limits with the *Reference voltage* setting in the variation detection module, that is, when there is a voltage different from the nominal voltage, the *Reference voltage* setting is set to this voltage.

The *Variation enable* setting is used for enabling or disabling the variation types. By default, the setting value is "Swell+dip+Int" and all the alternative variation types are indicated. For example, for setting "Swell+dip", the interruption detection is not active and only swell or dip events are indicated.

In a case where *Phase mode* is "Single Phase" and the dip functionality is available, the output DIPST is activated when the measured TRMS value drops below the *Voltage dip set 3* setting in one phase and also remains above the *Voltage Int set* setting. If the voltage drops below the *Voltage Int set* setting, the output INTST is activated. INTST is deactivated when the voltage value rises above the setting *Voltage Int set*. When the same measured TRMS magnitude rises above the setting *Voltage swell set 3*, the SWELLST output is activated.

There are three setting value limits for dip ( *Voltage dip set 1..3*) and swell activation ( *Voltage swell set 1..3*) and one setting value limit for interruption.

If *Phase mode* is "Three Phase", the DIPST and INTST outputs are activated when the voltage levels of all monitored phases, defined with the parameter *Phase supervision*, drop below the *Voltage Int set* setting value. An example for the detection principle of voltage interruption for "Three Phase" when *Phase supervision* is "Ph A + B + C", and also the corresponding start signals when *Phase mode* is "Single Phase", are as shown in the example for the detection of a three-phase interruption.

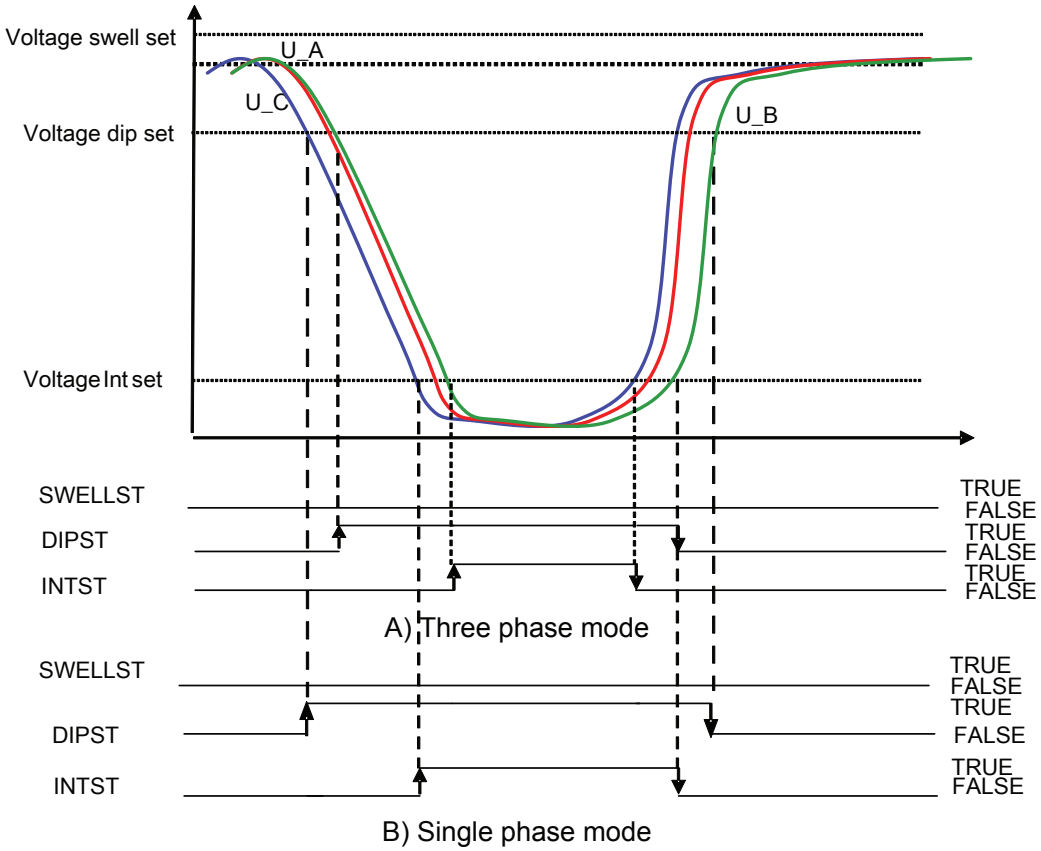



*Figure 969: Detection of three-phase voltage interruption*

The module measures voltage variation magnitude on each phase separately, that is, there are phase-segregated outputs `ST_A`, `ST_B` and `ST_C` for voltage variation indication. The configuration parameter *Phase supervision* defines which voltage phase or phases are monitored. If a voltage phase is selected to be monitored, the function assumes it to be connected to a voltage measurement channel. In other words, if an unconnected phase is monitored, the function falsely detects a voltage interruption in that phase.

The maximum magnitude and depth are defined as percentage values calculated from the difference between the reference and the measured voltage. For example, a dip to 70 percent means that the minimum voltage dip magnitude variation is 70 percent of the reference voltage amplitude.

The activation of the `BLOCK` input resets the function and outputs.

### 10.3.5.3 Variation validation

The validation criterion for voltage variation is that the measured total variation duration is between the set minimum and maximum durations (Either one of *VVa dip time 1*, *VVa swell time 1* or *VVa Int time 1*, depending on the variation type, and *VVa Dur Max*). The maximum variation duration setting is the same for all variation types.

*Figure 970* shows voltage dip operational regions. In *Figure 969*, only one voltage dip/swell/Int set is drawn, whereas in this figure there are three sub-limits for the dip operation. When *Voltage dip set 3* is undershot, the corresponding `ST_x` and

also the DIPST outputs are activated. When the TRMS voltage magnitude remains between *Voltage dip set 2* and *Voltage dip set 1* for a period longer than *VVa dip time 2* (shorter time than *VVa dip time 3*), a momentary dip event is detected. Furthermore, if the signal magnitude stays between the limits longer than *VVa dip time 3* (shorter time than *VVa Dur max*), a temporary dip event is detected. If the voltage remains below *Voltage dip set 1* for a period longer than *VVa dip time 1* but a shorter time than *VVa dip time 2*, an instantaneous dip event is detected.

For an event detection, the OPERATE output is always activated for one task cycle. The corresponding counter and only one of them (INSTDIPCNT, MOMDIPCNT or TEMPDIPCNT) is increased by one. If the dip limit undershooting duration is shorter than *VVa dip time 1*, *VVa swell time 1* or *VVa Int time 1*, the event is not detected at all, and if the duration is longer than *VVa Dur Max*, MAXDURDIPCNT is increased by one but no event detection resulting in the activation of the OPERATE output and recording data update takes place. These counters are available through the monitored data view on the LHMI or through tools via communications. There are no phase-segregated counters but all the variation detections are registered to a common time/magnitude-classified counter type. Consequently, a simultaneous multiphase event, that is, the variation-type event detection time moment is exactly the same for two or more phases, is counted only once also for single-phase power systems.

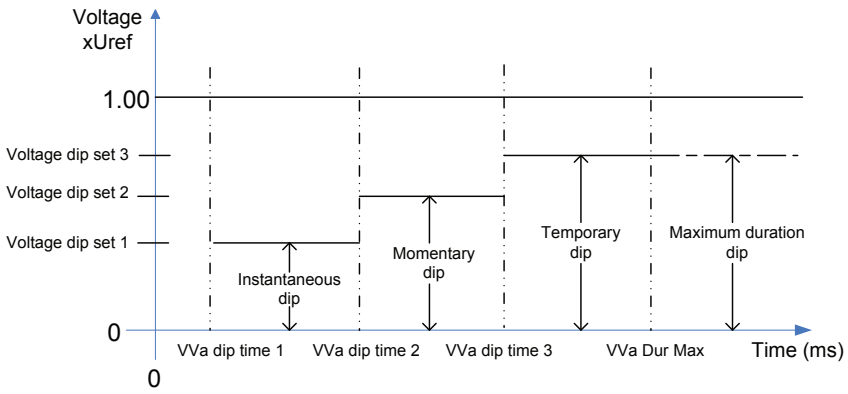



*Figure 970: Voltage dip operational regions*

In *Figure 971*, the corresponding limits regarding the swell operation are provided with the inherent magnitude limit order difference. The swell functionality principle is the same as for dips, but the different limits for the signal magnitude and times and the inherent operating zone change (here, *Voltage swell set x* > 1.0 xUn) are applied.

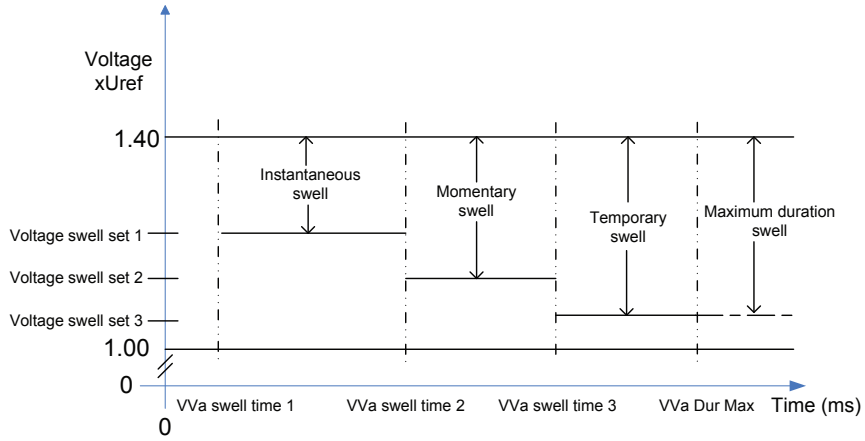



*Figure 971: Voltage swell operational regions*

For interruption, as shown in *Figure 972*, there is only one magnitude limit but four duration limits for interruption classification. Now the event and counter type depends only on variation duration time.

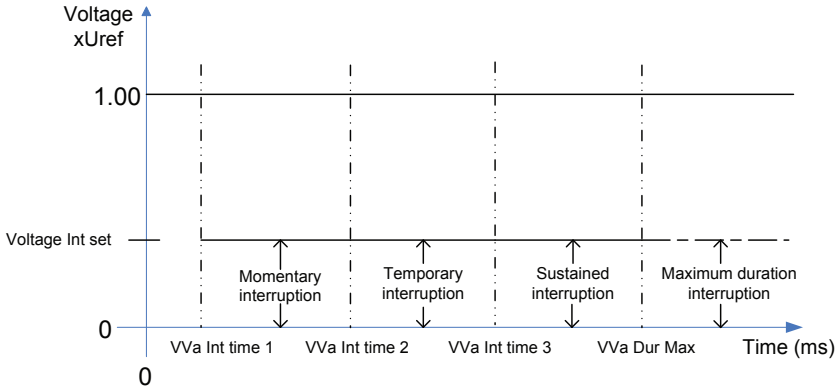



*Figure 972: Interruption operating regions*

Generally, no event detection is done if both the magnitude and duration requirements are not fulfilled. For example, the dip event does not indicate if the TRMS voltage magnitude remains between *Voltage dip set 3* and *Voltage dip set 2* for a period shorter than *VVa dip time 3* before rising back above *Voltage dip set 3*.

The event indication ends and possible detection is done when the TRMS voltage returns above (for dip and interruption) or below (for swell) the activation-starting limit. For example, after an instantaneous dip, the event indication when the voltage magnitude exceeds *Voltage dip set 1* is not detected (and recorded) immediately but only if no longer dip indication for the same dip variation takes place and maximum duration time for dip variation does not exceed before the signal magnitude rises above *Voltage dip set 3*. There is a small hysteresis for all these limits to avoid the oscillation of the output activation. No drop-off approach is applied here due to the hysteresis.

Consequently, only one event detection and recording of the same variation type can take place for one voltage variation, so the longest indicated variation of each variation type is detected. Furthermore, it is possible that another instantaneous dip event replaces the one already indicated if the magnitude again undershoots *Voltage dip set 1* for the set time after the first detection and the signal magnitude

or time requirement is again fulfilled. Another possibility is that if the time condition is not fulfilled for an instantaneous dip detection but the signal rises above *Voltage dip set 1*, the already elapsed time is included in the momentary dip timer. Especially the interruption time is included in the dip time. If the signal does not exceed *Voltage dip set 2* before the timer *VVa dip time 2* has elapsed when the momentary dip timer is also started after the magnitude undershooting *Voltage dip set 2*, the momentary dip event instead is detected. Consequently, the same dip occurrence with a changing variation depth can result in several dip event indications but only one detection. For example, if the magnitude has undershot *Voltage dip set 1* but remained above *Voltage Intr set* for a shorter time than the value of *VVa dip time 1* but the signal rises between *Voltage dip set 1* and *Voltage dip set 2* so that the total duration of the dip activation is longer than *VVa dip time 2* and the maximum time is not overshot, this is detected as a momentary dip even though a short instantaneous dip period has been included. In text, the terms "deeper" and "higher" are used for referring to dip or interruption.

Although examples are given for dip events, the same rules can be applied to the swell and interruption functionality too. For swell indication, "deeper" means that the signal rises even more and "higher" means that the signal magnitude becomes lower respectively.

The adjustable voltage thresholds adhere to the relationships:

*VVa dip time 1* ≤ *VVa dip time 2* ≤ *VVa dip time 3*.

*VVa swell time 1* ≤ *VVa swell time 2* ≤ *VVa swell time 3*.

*VVa Int time 1* ≤ *VVa Int time 2* ≤ *VVa Int time 3*.

There is a validation functionality built-in function that checks the relationship adherence so that if *VVa x time 1* is set higher than *VVa x time 2* or *VVa x time 3*, *VVa x time 2* and *VVa x time 3* are set equal to the new *VVa x time 1*. If *VVa x time 2* is set higher than *VVa x time 3*, *VVa x time 3* is set to the new *VVa x time 2*. If *VVa x time 2* is set lower than *VVa x time 1*, the entered *VVa x time 2* is rejected. If *VVa x time 3* is set lower than *VVa x time 2*, the entered *VVa x time 3* is rejected.

### 10.3.5.4 Duration measurement

The duration of each voltage phase corresponds to the period during which the measured TRMS values remain above (swell) or below (dip, interruption) the corresponding limit.

Besides the three limit settings for the variation types dip and swell, there is also a specific duration setting for each limit setting. For interruption, there is only one limit setting common for the three duration settings. The maximum duration setting is common for all variation types.

The duration measurement module measures the voltage variation duration of each phase voltage separately when the *Phase mode* setting is "Single Phase". The phase variation durations are independent. However, when the *Phase mode* setting is "Three Phase", voltage variation may start only when all the monitored phases are active. An example of variation duration when *Phase mode* is "Single Phase" can be seen in *Figure 973*. The voltage variation in the example is detected as an interruption for the phase B and a dip for the phase A, and also the variation durations are interpreted as independent `U_B` and `U_A` durations. In case of single-phase interruption, the `DIPST` output is active when either `ST_A` or `ST_B` is active. The measured variation durations are the times measured between the activation of the `ST_A` or `ST_B` outputs and deactivation of the `ST_A` or `ST_B` outputs. When

the *Phase mode* setting is "Three Phase", the example case does not result in any activation.

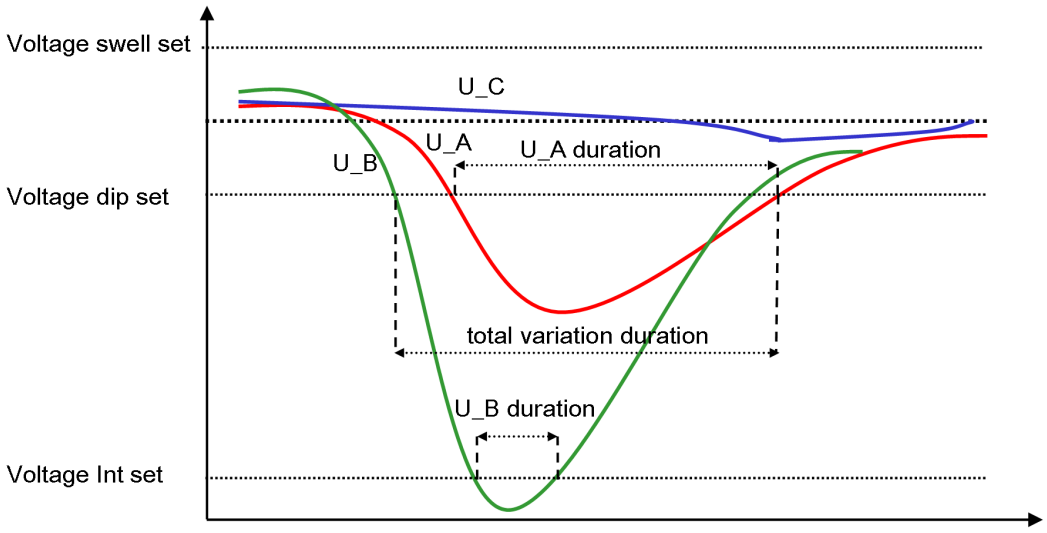



*Figure 973: Single-phase interruption for the Phase mode value "Single Phase"*

### 10.3.5.5 Three/single-phase selection variation examples

The provided rules always apply for single-phase ( *Phase mode* is "Single Phase") power systems. However, for three-phase power systems (where *Phase mode* is "Three Phase"), it is required that all the phases have to be activated before the activation of the START output. Interruption event indication requires all three phases to undershoot *Voltage Int set* simultaneously, as shown in *Figure 969*. When the requirement for interruption for "Three Phase" is no longer fulfilled, variation is indicated as a dip as long as all phases are active.

In case of a single-phase interruption of *Chapter 10.3.5.4 Duration measurement*, when there is a dip indicated in another phase but the third phase is not active, there is no variation indication start when *Phase mode* is "Three Phase". In this case, only the *Phase Mode* value "Single Phase" results in the ST_B interruption and the ST_A dip.

It is also possible that there are simultaneously a dip in one phase and a swell in other phases. The functionality of the corresponding event indication with one inactive phase is shown in *Figure 974*. Here, the "Swell + dip" variation type of *Phase mode* is "Single Phase". For the selection "Three Phase" of *Phase mode*, no event indication or any activation takes place due to a non-active phase.

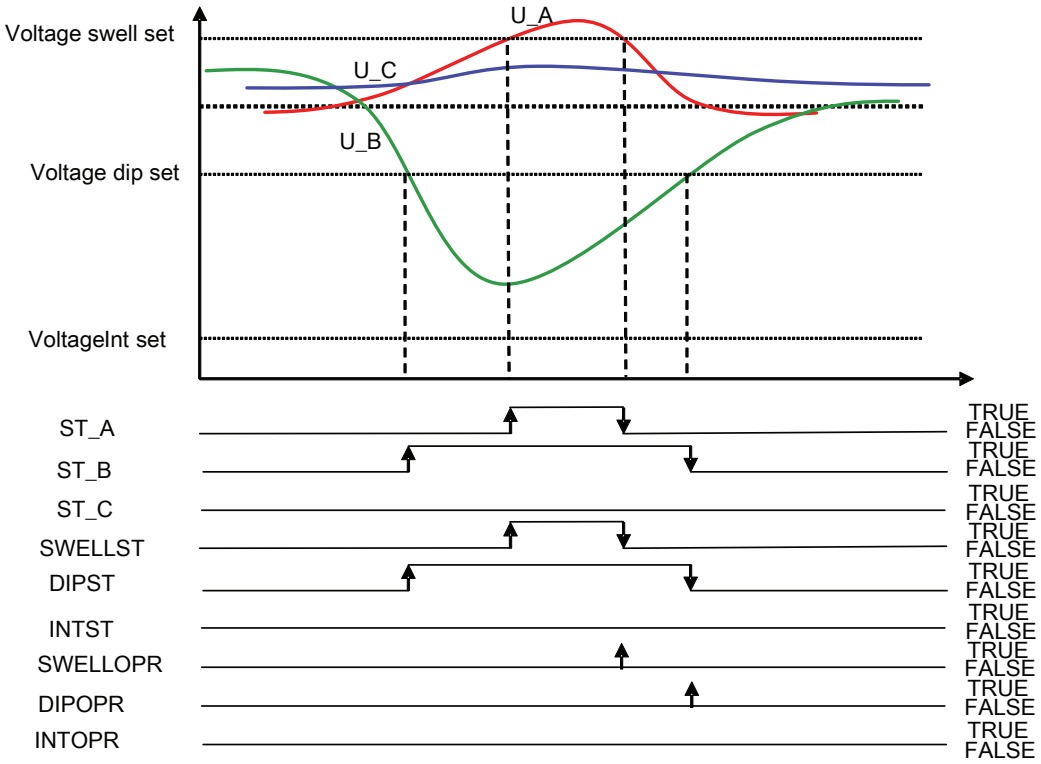



*Figure 974: Concurrent dip and swell when Phase mode is "Single Phase"*

In *Figure 975*, one phase is in dip and two phases have a swell indication. For the *Phase mode* value "Three Phase", the activation occurs only when all the phases are active. Furthermore, both swell and dip variation event detections take place simultaneously. In case of a concurrent voltage dip and voltage swell, both SWELLCNT and DIPCNT are incremented by one.

Also *Figure 975* shows that for the *Phase mode* value "Three Phase", two different time moment variation event swell detections take place and, consequently, DIPCNT is incremented by one but SWELLCNT is totally incremented by two. Both in *Figure 974* and *Figure 975* it is assumed that variation durations are sufficient for detections to take place.

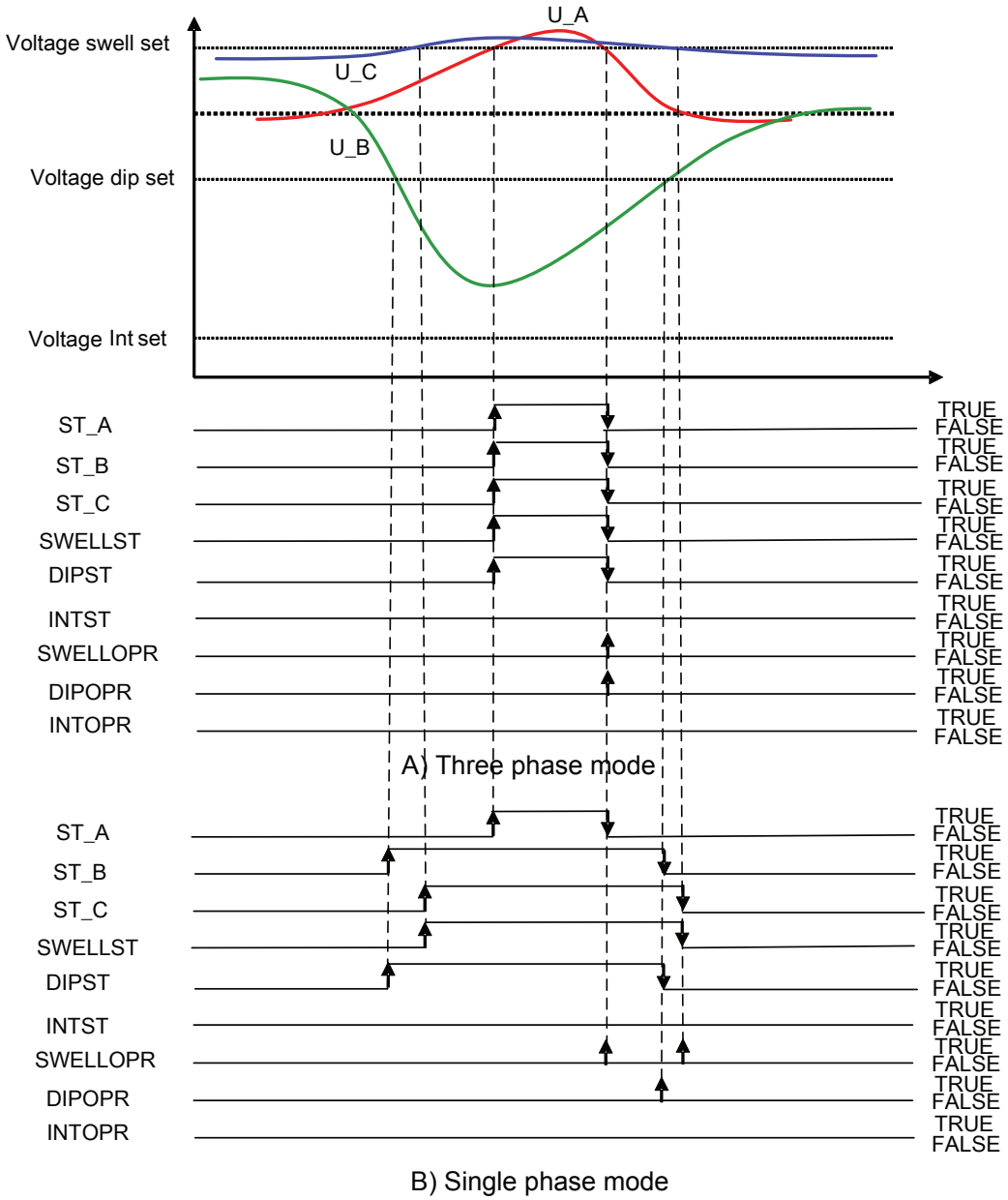



*Figure 975: Concurrent dip and two-phase swell*

## 10.3.6 Recorded data

Besides counter increments, the information required for a later fault analysis is stored after a valid voltage variation is detected.

### Recorded data information

When voltage variation starts, the phase current magnitudes preceding the activation moment are stored. Also, the initial voltage magnitudes are temporarily stored at the variation starting moment. If the variation is, for example, a two-phase voltage dip, the voltage magnitude of the non-active phase is stored from this same moment, as shown in *Figure 976*. The function tracks each variation-active

voltage phase, and the minimum or maximum magnitude corresponding to swell or dip/ interruption during variation is temporarily stored. If the minimum or maximum is found in tracking and a new magnitude is stored, also the inactive phase voltages are stored at the same moment, that is, the inactive phases are not magnitudetracked. The time instant (time stamp) at which the minimum or maximum magnitude is measured is also temporarily stored for each voltage phase where variation is active. Finally, variation detection triggers the recorded data update when the variation activation ends and the maximum duration time is not exceeded.

The data objects to be recorded for PHQVVR are given in *Table 1632*. There are totally three data banks, and the information given in the table refers to one data bank content.

The three sets of recorded data available are saved in data banks 1-3. The data bank 1 holds always the most recent recorded data, and the older data sets are moved to the next banks (1→2 and 2→3) when a valid voltage variation is detected. When all three banks have data and a new variation is detected, the newest data are placed into bank 1 and the data in bank 3 are overwritten by the data from bank 2.

*Figure 976* shows a valid recorded voltage interruption and two dips for the *Phase mode* value "Single Phase". The first dip event duration is based on the `U_A` duration, while the second dip is based on the time difference between the dip stop and start times. The first detected event is an interruption based on the `U_B` duration given in *Figure 976*. It is shown also with dotted arrows how voltage time stamps are taken before the final time stamp for recording, which is shown as a solid arrow. Here, the `U_B` timestamp is not taken when the `U_A` activation starts.

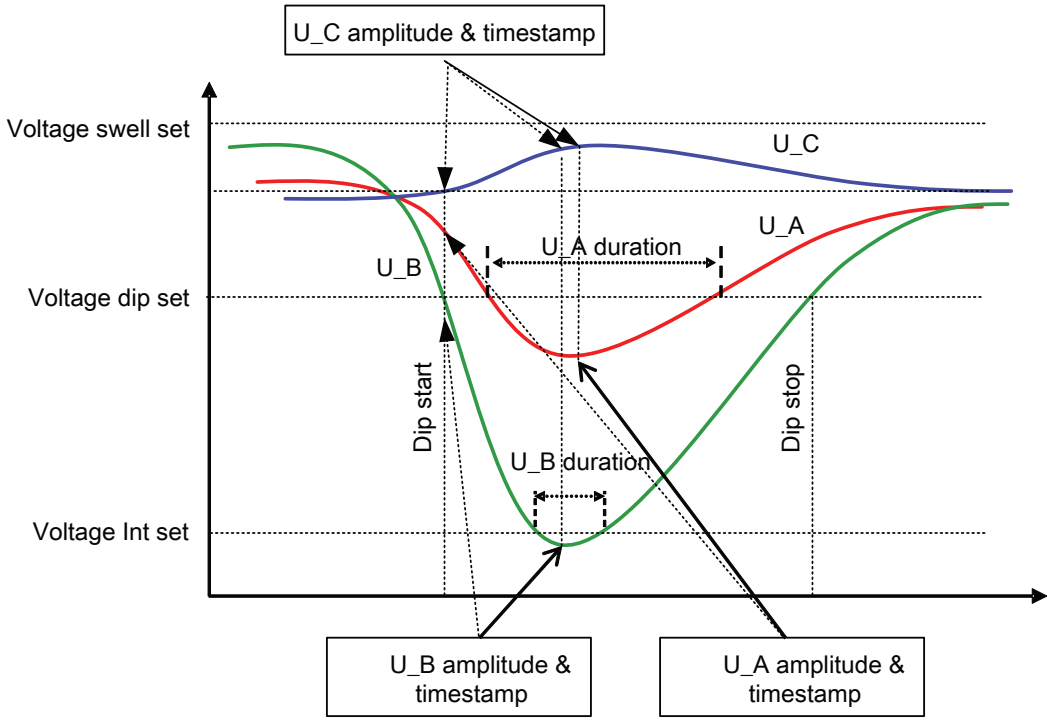



*Figure 976: Valid recorded voltage interruption and two dips*

**Table 1632: PHQVVR recording data bank parameters**

| Parameter description | Parameter name |
|---|---|
| Event detection triggering time stamp | Time |
| Variation type | Variation type |
| Variation magnitude Ph A | Variation Ph A |
| Variation magnitude Ph A time stamp (maximum/minimum magnitude measuring time moment during variation) | Var Ph A rec time |
| Variation magnitude Ph B | Variation Ph B |
| Variation magnitude Ph B time stamp (maximum/minimum magnitude measuring time moment during variation) | Var Ph B rec time |
| Variation magnitude Ph C | Variation Ph C |
| Variation magnitude Ph C time stamp (maximum/minimum magnitude measuring time moment during variation) | Var Ph C rec time |
| Variation duration Ph A | Variation Dur Ph A |
| Variation Ph A start time stamp (phase A variation start time moment) | Var Dur Ph A time |
| Variation duration Ph B | Variation Dur Ph B |
| Variation Ph B start time stamp (phase B variation start time moment) | Var Dur Ph B time |
| Variation duration Ph C | Variation Dur Ph C |
| Variation Ph C start time stamp (phase C variation start time moment) | Var Dur Ph C time |
| Current magnitude Ph A preceding variation | Var current Ph A |
| Current magnitude Ph B preceding variation | Var current Ph B |
| Current magnitude Ph C preceding variation | Var current Ph C |

**Table 1633: Enumeration values for the recorded data parameters**

| Setting name | Enum name | Value |
|---|---|---|
| Variation type | Swell | 1 |
| Variation type | Dip | 2 |
| Variation type | Swell + dip | 3 |
| Variation type | Interruption | 4 |
| Variation type | Swell + Int | 5 |
| Variation type | Dip + Int | 6 |
| Variation type | Swell+dip+Int | 7 |

## 10.3.7 Application

Voltage variations are the most typical power quality variations on the public electric network. Typically, short-duration voltage variations are defined to last

more than half of the nominal frequency period and less than one minute (European Standard EN 50160 and IEEE Std 1159-1995).

These short-duration voltage variations are almost always caused by a fault condition. Depending on where the fault is located, it can cause either a temporary voltage rise (swell) or voltage drop (dip). A special case of voltage drop is the complete loss of voltage (interruption).

PHQVVR is used for measuring short-duration voltage variations in distribution networks. The power quality is evaluated in the voltage waveform by measuring the voltage swells, dips and interruptions.

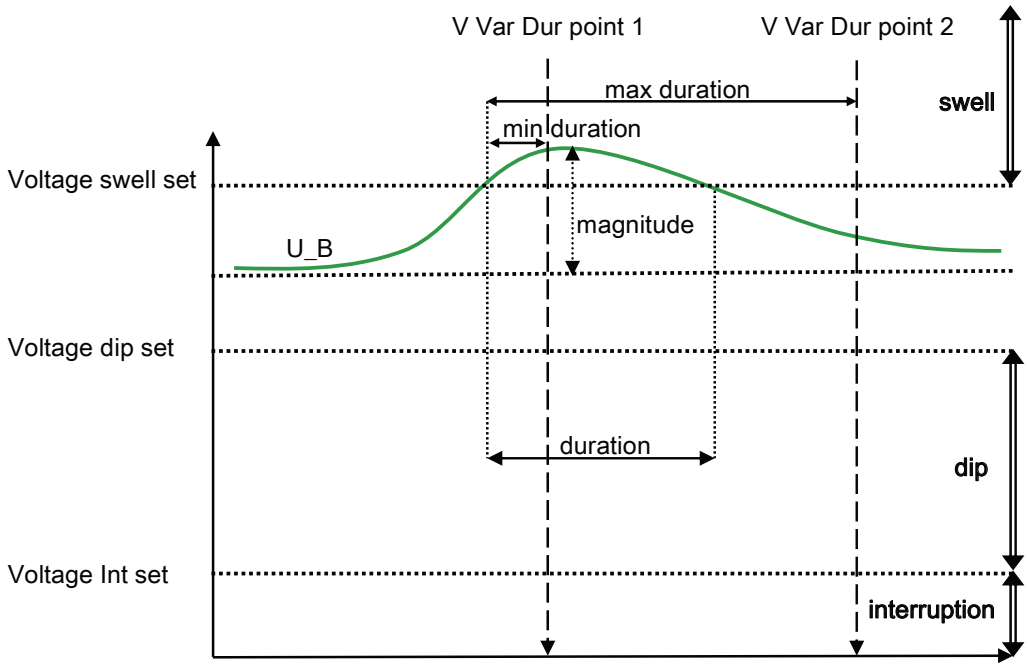



*Figure 977: Duration and voltage magnitude limits for swell, dip and interruption measurement*

Voltage dips disturb the sensitive equipment such as computers connected to the power system and may result in the failure of the equipment. Voltage dips are typically caused by faults occurring in the power distribution system. Typical reasons for the faults are lightning strikes and tree contacts. In addition to fault situations, the switching of heavy loads and starting of large motors also cause dips.

Voltage swells cause extra stress for the network components and the devices connected to the power system. Voltage swells are typically caused by the earth faults that occur in the power distribution system.

Voltage interruptions are typically associated with the switchgear operation related to the occurrence and termination of short circuits. The operation of a circuit breaker disconnects a part of the system from the source of energy. In the case of overhead networks, automatic reclosing sequences are often applied to the circuit breakers that interrupt fault currents. All these actions result in a sudden reduction of voltages on all voltage phases.

Due to the nature of voltage variations, the power quality standards do not specify any acceptance limits. There are only indicative values for, for example, voltage dips

in the European standard EN 50160. However, the power quality standards like the international standard IEC 61000-4-30 specify that the voltage variation event is characterized by its duration and magnitude. Furthermore, IEEE Std 1159-1995 gives the recommended practice for monitoring the electric power quality.

Voltage variation measurement can be done to the phase-to-earth and phase-to-phase voltages. The power quality standards do not specify whether the measurement should be done to phase or phase-to-phase voltages. However, in some cases it is preferable to use phase-to-earth voltages for measurement. The measurement mode is always TRMS.

## 10.3.8 Signals

### 10.3.8.1 PHQVVR Input signals

**Table 1634: PHQVVR Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| I3P | SIGNAL | - | Three-phase currents |
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block signal for activating the blocking mode |

### 10.3.8.2 PHQVVR Output signals

**Table 1635: PHQVVR Output signals**

| Name | Type | Description |
|---|---|---|
| OPERATE | BOOLEAN | Voltage variation detected |
| START | BOOLEAN | Voltage variation present |
| SWELLST | BOOLEAN | Voltage swell active |
| DIPST | BOOLEAN | Voltage dip active |
| INTST | BOOLEAN | Voltage interruption active |

## 10.3.9 PHQVVR Settings

**Table 1636: PHQVVR Group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Reference voltage | 10.0...200.0 | %Un | 0.1 | 57.7 | Reference supply voltage in % |
| Voltage dip set 1 | 10.0...100.0 | % | 0.1 | 80.0 | Dip limit 1 in % of reference voltage |
| VVa dip time 1 | 0.5...54.0 | cycles | 0.1 | 3.0 | Voltage variation dip duration 1 |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Voltage dip set 2 | 10.0...100.0 | % | 0.1 | 80.0 | Dip limit 2 in % of reference voltage |
| VVa dip time 2 | 10.0...180.0 | cycles | 0.1 | 30.0 | Voltage variation dip duration 2 |
| Voltage dip set 3 | 10.0...100.0 | % | 0.1 | 80.0 | Dip limit 3 in % of reference voltage |
| VVa dip time 3 | 2000...60000 | ms | 10 | 3000 | Voltage variation dip duration 3 |
| Voltage swell set 1 | 100.0...140.0 | % | 0.1 | 120.0 | Swell limit 1 in % of reference voltage |
| VVa swell time 1 | 0.5...54.0 | cycles | 0.1 | 0.5 | Voltage variation swell duration 1 |
| Voltage swell set 2 | 100.0...140.0 | % | 0.1 | 120.0 | Swell limit 2 in % of reference voltage |
| VVa swell time 2 | 10.0...80.0 | cycles | 0.1 | 10.0 | Voltage variation swell duration 2 |
| Voltage swell set 3 | 100.0...140.0 | % | 0.1 | 120.0 | Swell limit 3 in % of reference voltage |
| VVa swell time 3 | 2000...60000 | ms | 10 | 2000 | Voltage variation swell duration 3 |
| Voltage Int set | 0.0...100.0 | % | 0.1 | 10.0 | Interruption limit in % of reference voltage |
| VVa Int time 1 | 0.5...30.0 | cycles | 0.1 | 3.0 | Voltage variation Int duration 1 |
| VVa Int time 2 | 10.0...180.0 | cycles | 0.1 | 30.0 | Voltage variation Int duration 2 |
| VVa Int time 3 | 2000...60000 | ms | 10 | 3000 | Voltage variation interruption duration 3 |
| VVa Dur Max | 100...3600000 | ms | 100 | 60000 | Maximum voltage variation duration |

**Table 1637: PHQVVR Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation Off / On |
| Variation enable | 1=Swell<br>2=Dip<br>3=Swell + dip<br>4=Interruption<br>5=Swell + Int<br>6=Dip + Int<br>7=Swell+dip+Int | | | 7=Swell+dip+Int | Enable variation type |

**Table 1638: PHQVVR Non group settings (Advanced)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Phase supervision | 1=Ph A<br>2=Ph B<br>3=Ph A + B<br>4=Ph C<br>5=Ph A + C<br>6=Ph B + C<br>7=Ph A + B + C | | | 7=Ph A + B + C | Monitored voltage phase |
| Phase mode | 1=Three Phase | | | 2=Single Phase | Three/Single phase mode |

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| | 2=Single Phase | | | | |

## 10.3.10 PHQVVR Monitored data

**Table 1639: PHQVVR Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| ST_A | BOOLEAN | 0=False<br>1=True | | Start Phase A (Voltage Variation Event in progress) |
| ST_B | BOOLEAN | 0=False<br>1=True | | Start Phase B (Voltage Variation Event in progress) |
| ST_C | BOOLEAN | 0=False<br>1=True | | Start Phase C (Voltage Variation Event in progress) |
| INSTSWELLCNT | INT32 | 0...2147483647 | | Instantaneous swell operation counter |
| MOMSWELLCNT | INT32 | 0...2147483647 | | Momentary swell operation counter |
| TEMPSWELLCNT | INT32 | 0...2147483647 | | Temporary swell operation counter |
| MAXDURSWELLCNT | INT32 | 0...2147483647 | | Maximum duration swell operation counter |
| INSTDIPCNT | INT32 | 0...2147483647 | | Instantaneous dip operation counter |
| MOMDIPCNT | INT32 | 0...2147483647 | | Momentary dip operation counter |
| TEMPDIPCNT | INT32 | 0...2147483647 | | Temporary dip operation counter |
| MAXDURDIPCNT | INT32 | 0...2147483647 | | Maximum duration dip operation counter |
| MOMINTCNT | INT32 | 0...2147483647 | | Momentary interruption operation counter |
| TEMPINTCNT | INT32 | 0...2147483647 | | Temporary interruption operation counter |
| SUSTINTCNT | INT32 | 0...2147483647 | | Sustained interruption operation counter |
| MAXDURINTCNT | INT32 | 0...2147483647 | | Maximum duration interruption operation counter |
| PHQVVR | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |
| Time | Timestamp | | | Time |
| Variation type | Enum | 0=No variation<br>1=Swell<br>2=Dip<br>3=Swell + dip<br>4=Interruption<br>5=Swell + Int<br>6=Dip + Int<br>7=Swell+dip+Int | | Variation type |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Variation Ph A | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase A |
| Var Ph A rec time | Timestamp | | | Variation magnitude Phase A time stamp |
| Variation Ph B | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase B |
| Var Ph B rec time | Timestamp | | | Variation magnitude Phase B time stamp |
| Variation Ph C | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase C |
| Var Ph C rec time | Timestamp | | | Variation magnitude Phase C time stamp |
| Variation Dur Ph A | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase A |
| Var Dur Ph A time | Timestamp | | | Variation Ph A start time stamp |
| Variation Dur Ph B | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase B |
| Var Dur Ph B time | Timestamp | | | Variation Ph B start time stamp |
| Variation Dur Ph C | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase C |
| Var Dur Ph C time | Timestamp | | | Variation Ph C start time stamp |
| Var current Ph A | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase A preceding variation |
| Var current Ph B | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase B preceding variation |
| Var current Ph C | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase C preceding variation |
| Time | Timestamp | | | Time |
| Variation type | Enum | 0=No variation<br>1=Swell<br>2=Dip<br>3=Swell + dip<br>4=Interruption<br>5=Swell + Int<br>6=Dip + Int<br>7=Swell+dip+Int | | Variation type |
| Variation Ph A | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase A |
| Var Ph A rec time | Timestamp | | | Variation magnitude Phase A time stamp |
| Variation Ph B | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase B |
| Var Ph B rec time | Timestamp | | | Variation magnitude Phase B time stamp |
| Variation Ph C | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase C |
| Var Ph C rec time | Timestamp | | | Variation magnitude Phase C time stamp |
| Variation Dur Ph A | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase A |
| Var Dur Ph A time | Timestamp | | | Variation Ph A start time stamp |
| Variation Dur Ph B | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase B |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Var Dur Ph B time | Timestamp | | | Variation Ph B start time stamp |
| Variation Dur Ph C | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase C |
| Var Dur Ph C time | Timestamp | | | Variation Ph C start time stamp |
| Var current Ph A | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase A preceding variation |
| Var current Ph B | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase B preceding variation |
| Var current Ph C | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase C preceding variation |
| Time | Timestamp | | | Time |
| Variation type | Enum | 0=No variation<br>1=Swell<br>2=Dip<br>3=Swell + dip<br>4=Interruption<br>5=Swell + Int<br>6=Dip + Int<br>7=Swell+dip+Int | | Variation type |
| Variation Ph A | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase A |
| Var Ph A rec time | Timestamp | | | Variation magnitude Phase A time stamp |
| Variation Ph B | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase B |
| Var Ph B rec time | Timestamp | | | Variation magnitude Phase B time stamp |
| Variation Ph C | FLOAT32 | 0.00...5.00 | xUref | Variation magnitude Phase C |
| Var Ph C rec time | Timestamp | | | Variation magnitude Phase C time stamp |
| Variation Dur Ph A | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase A |
| Var Dur Ph A time | Timestamp | | | Variation Ph A start time stamp |
| Variation Dur Ph B | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase B |
| Var Dur Ph B time | Timestamp | | | Variation Ph B start time stamp |
| Variation Dur Ph C | FLOAT32 | 0.000...3600.000 | s | Variation duration Phase C |
| Var Dur Ph C time | Timestamp | | | Variation Ph C start time stamp |
| Var current Ph A | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase A preceding variation |
| Var current Ph B | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase B preceding variation |
| Var current Ph C | FLOAT32 | 0.00...60.00 | xIn | Current magnitude Phase C preceding variation |

### 10.3.11 Technical data

**Table 1640: PHQVVR Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.5 % of the set value or ±0.2 % of reference voltage |
| Reset ratio | Typically 0.96 (Swell), 1.04 (Dip, Interruption) |

## 10.4 Voltage unbalance VSQVUB (ANSI PQMV UB)

### 10.4.1 Identification

| Function description | IEC 61850 identification | IEC 60617 identification | ANSI/IEEE C37.2 device number |
|---|---|---|---|
| Voltage unbalance | VSQVUB | PQUUB | PQVUB |

### 10.4.2 Function block

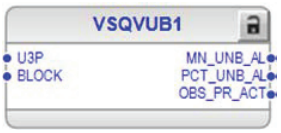



*Figure 978: Function block*

### 10.4.3 Functionality

The voltage unbalance function VSQVUB monitors voltage unbalance conditions in power transmission and distribution networks. It can be applied to identify a network and load unbalance that can cause sustained voltage unbalance. VSQVUB is also used to monitor the commitment of the power supply utility of providing a high-quality, that is, a balanced voltage supply on a continuous basis.

VSQVUB uses five different methods for calculating voltage unbalance. The methods are the negative-sequence voltage magnitude, zero-sequence voltage magnitude, ratio of the negative-sequence voltage magnitude to the positive-sequence voltage magnitude, ratio of the zero-sequence voltage magnitude to the positive-sequence voltage magnitude and ratio of maximum phase voltage magnitude deviation from the mean voltage magnitude to the mean of the phase voltage magnitude.

VSQVUB provides statistics which can be used to verify the compliance of the power quality with the European standard EN 50160 (2000). The statistics over selected period include a freely selectable percentile for unbalance. VSQVUB also includes an alarm functionality providing a maximum unbalance value and the date and time of occurrence.

VSQVUB contains a blocking functionality. It is possible to block a set of function outputs or the function itself.

## 10.4.4 Analog channel configuration

VSQVUB has one analog group input which must be properly configured.

**Table 1641: Analog inputs**

| Input | Description |
|---|---|
| U3P | Three-phase voltages |

See the preprocessing function blocks in this document for the possible signal sources.

There are a few special conditions which must be noted with the configuration.

**Table 1642: Special conditions**

| Condition | Description |
|---|---|
| U3P connected to real measurements | The function can work with any two voltage channels connected but it is recommended to connect all three voltage channels. |
| | Further, if *VT connection* is "Delta" in that particular UTVTR, the *Unb detection method* cannot be set to "Zero Seq" or "Zero to Pos Seq". |

Improper analog channel configuration causes a validation error if the analog channels are not completely configured or they do not match with certain settings. For troubleshooting, check the contents of this chapter and also the preprocessing blocks in this document. The configuration can be written to the protection relay once the mismatch is corrected.

## 10.4.5 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of VSQVUB can be described with a module diagram. All the modules in the diagram are explained in the next sections.

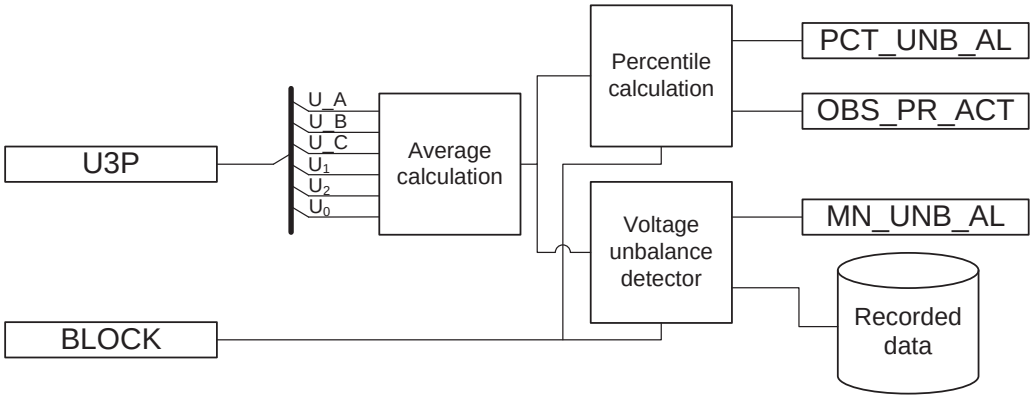



*Figure 979: Functional module diagram*

### 10.4.5.1 Average calculation

VSQVUB calculates two sets of measured voltage unbalance values, a three-second and a ten-minute non-sliding average value. The three-second average value is used for continuous monitoring. The ten-minute average is used for percentile calculation for a longer period.

The Average calculation module uses five different methods for the average calculation. The required method can be selected with the *Unb detection method* parameter.

When the "Neg Seq" mode is selected with *Unb detection method*, the voltage unbalance is calculated based on the negative-sequence voltage magnitude. Similarly, when the "Zero Seq" mode is selected, the voltage unbalance is calculated based on the zero-sequence voltage magnitude. When the "Neg to Pos Seq" mode is selected, the voltage unbalance is calculated based on the ratio of the negative-sequence voltage magnitude to the positive-sequence magnitude. When the "Zero to Pos Seq" mode is selected, the voltage unbalance is calculated based on the ratio of the zero-sequence voltage magnitude to the positive-sequence magnitude. When the "Ph vectors Comp" mode is selected, the ratio of the maximum phase voltage magnitude deviation from the mean voltage magnitude to the mean of the phase voltage magnitude is used for voltage unbalance calculation.

The calculated three-second value and ten-minute value are available in the Monitored data view through the outputs `3S_MN_UNB` and `10MN_MN_UNB`.

3S_MN_UNB values are updated every three seconds and 10MIN_MN_UNB is updated every minute.

For VT connection = "Delta", the calculated zero-sequence voltage is always zero, hence, the setting *Unb detection method* = "Zero Seq" is not applicable in this VT configuration.

### 10.4.5.2 Voltage unbalance detector

The three-second average value is calculated and compared to the set value *Unbalance start val*. If the voltage unbalance exceeds this limit, the `MN_UNB_AL` output is activated.

The activation of the BLOCK input blocks MN_UNB_AL output.

### 10.4.5.3 Percentile calculation

The Percentile calculation module performs the statistics calculation for the level of voltage unbalance value for a settable duration. The operation of the Percentile calculation module can be described with a module diagram.

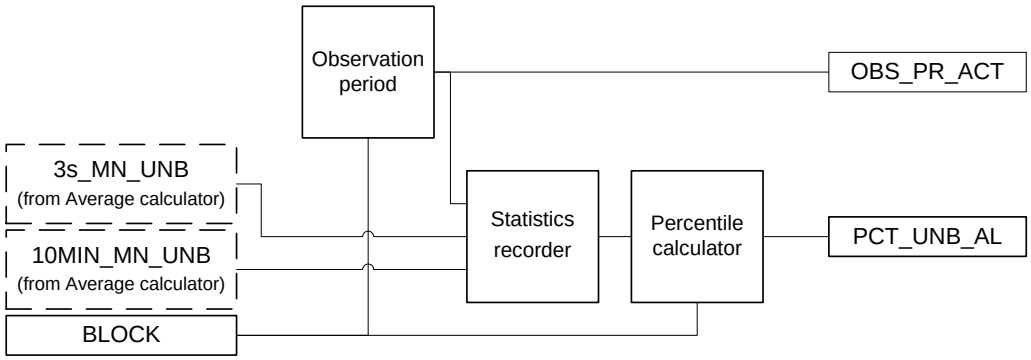



*Figure 980: Percentile calculation*

### 10.4.5.4 Observation period

The Observation period module calculates the length of the observation time for the Statistics recorder sub-module as well as determines the possible start of a new one. A new period can be started by timed activation using calendar time settings *Obs period Str year*, *Obs period Str month*, *Obs period Str day* and *Obs period Str hour*.

The observation period start time settings *Obs period Str year*, *Obs period Str month*, *Obs period Str day* and *Obs period Str hour* are used to set the calendar time in UTC. These settings have to be adjusted according to the local time and local daylight saving time.

A preferable way of continuous statistics recordings can be selected over a longer period (months, years). With the *Trigger mode* setting, the way the next possible observation time is activated after the former one has finished can be selected.

**Table 1643: Trigger mode observation times**

| Trigger mode | Observation time |
|---|---|
| Single | Only one period of observation time is activated. |
| Periodic | The time gap between the two trigger signals is seven days. |
| Continuous | The next period starts right after the previous observation period is completed. |

The length of the period is determined by the settings *Obs period selection* and *User Def Obs period*. The OBS_PR_ACT output is an indication signal which exhibits rising edge (TRUE) when the observation period starts and falling edge (FALSE) when the observation period ends.

If the *Percentile unbalance*, *Trigger mode* or *Obs period duration* settings change when OBS_PR_ACT is active, OBS_PR_ACT deactivates immediately.

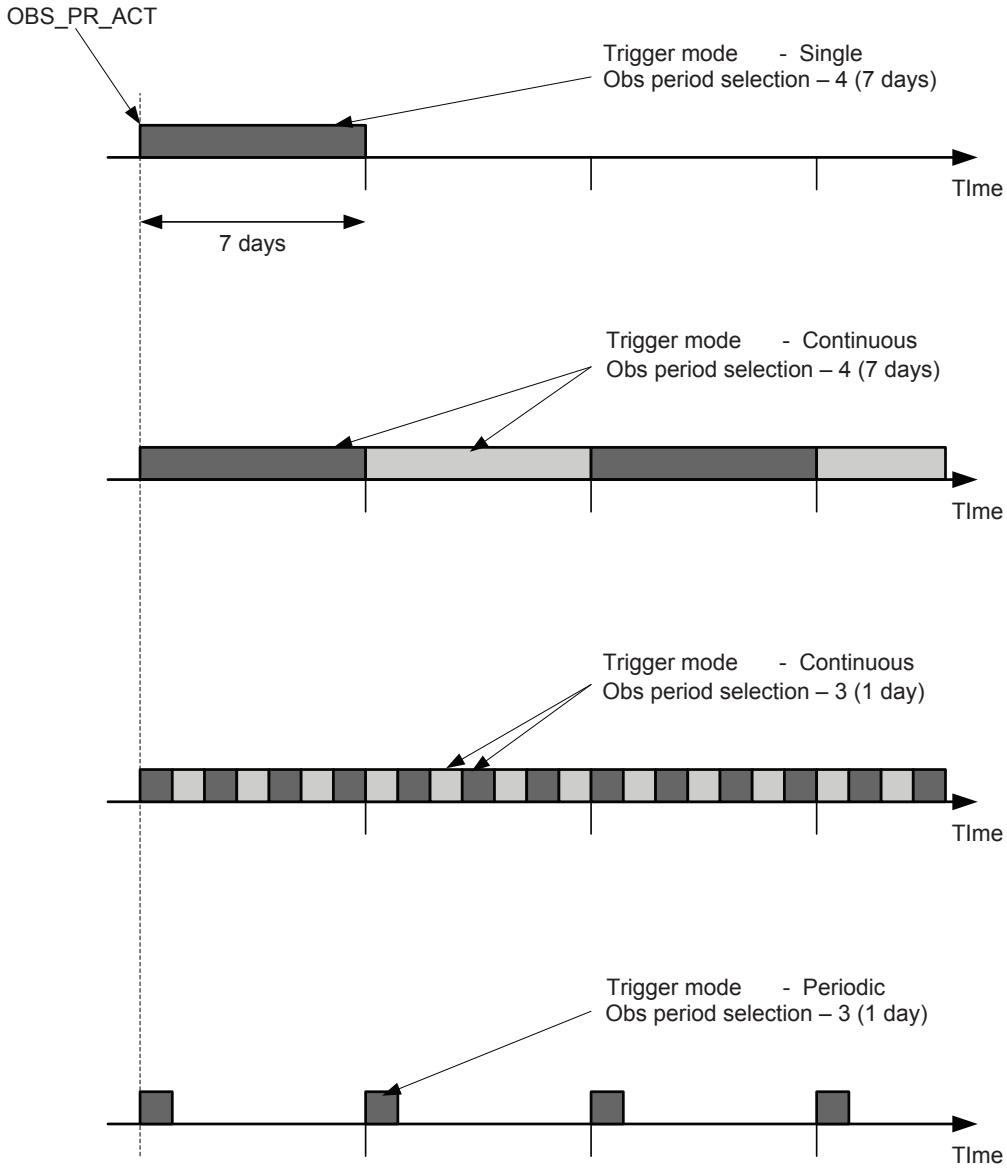



*Figure 981: Periods for statistics recorder with different trigger modes and period settings*

The BLOCK input blocks the OBS_PR_ACT output, which then disables the maximum value calculation of the Statistics recorder module. If the trigger mode is selected "Periodic" or "Continuous" and the blocking is deactivated before the next observation period is due to start, the scheduled period starts normally.

### 10.4.5.5 Statistics recorder

The Statistics recorder module provides readily calculated three-second or ten-minute values of the selected phase to the percentile calculator module based on the length of the active observation period. If the observation period is less than

one day, the three-second average values are used. If the observation period is one day or longer, the ten-minute average values are used.

The maximum three-second or ten-minute mean voltage unbalance is recorded during the active observation period. The observation period start time *PR_STR_TIME*, observation period end time *PR_END_TIME*, maximum voltage unbalance value during observation period active, *MAX_UNB_VAL* and time of occurrence *MAX_UNB_TIME* are available through the Monitored data view. These outputs are updated once OBS_PR_ACT deactivates.

### 10.4.5.6 Percentile calculator

The purpose of the Percentile calculator module is to find the voltage unbalance level so that during the observation time 95 percent (default value of the *Percentile unbalance* setting) of all the measured voltage unbalance amplitudes are less than or equal to the calculated percentile.

The computed output value PCT_UNB_VAL, below which the percentile of the values lies, is available in the Monitored data view. The PCT_UNB_VAL output value is updated at the end of the observation period.

If the output PCT_UNB_VAL is higher than the defined setting *Unbalance start val* at the end of the observation period, an alarm output PCT_UNB_AL is activated. The PCT_UNB_AL output remains active for the whole period before the next period completes.

The BLOCK input blocks the output PCT_UNB_VAL.

### 10.4.5.7 Recorded data

The information required for a later fault analysis is stored when the Recorded data module is triggered. This happens when a voltage unbalance is detected by the Voltage unbalance detector module.

Three sets of recorded data are available in total. The sets are saved in data banks 1...3. The data bank 1 holds the most recent recorded data. Older data are moved to the subsequent banks (1 to 2 and 2 to 3) when a voltage unbalance is detected. When all three banks have data and a new variation is detected, the latest data set is placed into bank 1 and the data in bank 3 is overwritten by the data from bank 2.

The recorded data can be reset with the RESET binary input signal by navigating to the HMI reset ( **Main menu** > **Clear** > **Reset recorded data** > **VSQVUBx**) or through tools via communications.

When a voltage unbalance is detected in the system, VSQVUB responds with the MN_UNB_AL alarm signal. During the alarm situation, VSQVUB stores the maximum magnitude and the time of occurrence and the duration of alarm MN_UNB_AL. The recorded data is stored when MN_UNB_AL is deactivated.

**Table 1644: Recorded data**

| Parameter | Description |
|---|---|
| Alarm high mean Dur | Time duration for alarm high mean unbalance |
| Max unbalance Volt | Maximum three-second voltage |
| Time Max Unb Volt | Time stamp of voltage unbalance |

## 10.4.6 Application

Voltage unbalance is one of the basic power quality parameters.

Ideally, in a three-phase or multiphase power system, the frequency and voltage magnitude of all the phases are equal and the phase displacement between any two consecutive phases is also equal. This is called a balanced source. Apart from the balanced source, usually the power system network and loads are also balanced, implying that network impedance and load impedance in each phase are equal. In some cases, the condition of a balance network and load is not met completely, which leads to a current and voltage unbalance in the system. Providing unbalanced supply voltage has a detrimental effect on load operation. For example, a small magnitude of a negative-sequence voltage applied to an induction motor results in a significant heating of the motor.

A balanced supply, balanced network and balanced load lead to a better power quality. When one of these conditions is disturbed, the power quality is deteriorated. VSQVUB monitors voltage unbalance conditions in power transmission and distribution networks. VSQVUB calculates two sets of measured values, a three-second and a ten-minute non-sliding average value. The three-second average value is used for continuous monitoring while the ten-minute average value is used for percentile calculation for a longer period of time. It can be applied to identify the network and load unbalance that may cause sustained voltage unbalance. A single-phase or phase-to-phase fault in the network or load side can create voltage unbalance but, as faults are usually isolated in a short period of time, the voltage unbalance is not a sustained one. Therefore, the voltage unbalance may not be covered by VSQVUB.

Another major application is the long-term power quality monitoring. This can be used to confirm a compliance to the standard power supply quality norms. The function provides a voltage unbalance level which corresponds to the 95 $^{th}$ percentile of the ten minutes' average values of voltage unbalance recorded over a period of up to one week. It means that for 95 percent of time during the observation period the voltage unbalance was less than or equal to the calculated percentile. An alarm can be obtained if this value exceeds the value that can be set.

The function uses five different methods for calculating voltage unbalance.

- Negative-sequence voltage magnitude
- Zero-sequence voltage magnitude
- Ratio of negative-sequence to positive-sequence voltage magnitude
- Ratio of zero-sequence to positive-sequence voltage magnitude
- Ratio of maximum phase voltage magnitude deviation from the mean voltage magnitude to the mean of phase voltage magnitude.

Usually, the ratio of the negative-sequence voltage magnitude to the positive-sequence voltage magnitude is selected for monitoring the voltage unbalance. However, other methods may also be used if required.

## 10.4.7 Signals

### 10.4.7.1 VSQVUB Input signals

**Table 1645: VSQVUB Input signals**

| Name | Type | Default | Description |
|---|---|---|---|
| U3P | SIGNAL | - | Three-phase voltages |
| BLOCK | BOOLEAN | 0=False | Block all outputs except measured values |

### 10.4.7.2 VSQVUB Output signals

**Table 1646: VSQVUB Output signals**

| Name | Type | Description |
|---|---|---|
| MN_UNB_AL | BOOLEAN | Alarm active when 3 sec voltage unbalance exceeds the limit |
| PCT_UNB_AL | BOOLEAN | Alarm active when percentile unbalance exceeds the limit |
| OBS_PR_ACT | BOOLEAN | Observation period is active |

## 10.4.8 VSQVUB Settings

**Table 1647: VSQVUB Non group settings (Basic)**

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Operation | 1=on<br>5=off | | | 1=on | Operation On/Off |
| Unb detection method | 1=Neg Seq<br>2=Zero Seq<br>3=Neg to Pos Seq<br>4=Zero to Pos Seq<br>5=Ph vectors Comp | | | 3=Neg to Pos Seq | Set the operation mode for voltage unbalance calculation |
| Unbalance start Val | 1...100 | % | 1 | 1 | Voltage unbalance start value |
| Trigger mode | 1=Single<br>2=Periodic<br>3=Continuous | | | 3=Continuous | Specifies the observation period triggering mode |
| Percentile unbalance | 1...100 | % | 1 | 95 | The percent to which percentile value PCT_UNB_VAL is calculated |
| Obs period selection | 1=1 Hour<br>2=12 Hours<br>3=1 Day<br>4=7 Days<br>5=User defined | | | 5=User defined | Observation period for unbalance calculation |

*Table continues on the next page*

| Parameter | Values (Range) | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| User Def Obs period | 1...168 | h | 1 | 168 | User define observation period for statistic calculation |
| Obs period Str year | 2008...2076 | | | 2011 | Calendar time for observation period start year in YYYY |
| Obs period Str month | 0=reserved<br>1=January<br>2=February<br>3=March<br>4=April<br>5=May<br>6=June<br>7=July<br>8=August<br>9=September<br>10=October<br>11=November<br>12=December | | | 1=January | Calendar time for observation period start month |
| Obs period Str day | 1...31 | | | 1 | Calendar time for observation period start day |
| Obs period Str hour | 0...23 | h | | 0 | Calendar time for observation period start hour |

## 10.4.9 VSQVUB Monitored data

**Table 1648: VSQVUB Monitored data**

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| 3S_MN_UNB | FLOAT32 | 0.00...150.00 | % | Non sliding 3 second mean value of voltage unbalance |
| 10MIN_MN_UNB | FLOAT32 | 0.00...150.00 | % | Sliding 10 minutes mean value of voltage unbalance |
| PCT_UNB_VAL | FLOAT32 | 0.00...150.00 | % | Limit below which percentile unbalance of the values lie |
| MAX_UNB_VAL | FLOAT32 | 0.00...150.00 | % | Maximum voltage unbalance measured in the observation period |
| MAX_UNB_TIME | Timestamp | | | Time stamp at which maximum voltage unbalance measured in the observation period |
| PR_STR_TIME | Timestamp | | | Time stamp of starting of the previous observation period |
| PR_END_TIME | Timestamp | | | Time stamp of end of previous observation period |
| Alarm high mean Dur | FLOAT32 | 0.000...3600.000 | s | Time duration for alarm high mean unbalance |
| Max unbalance Volt | FLOAT32 | 0.00...150.00 | % | Maximum 3 seconds unbalance voltage |
| Time Max Unb Volt | Timestamp | | | Time stamp of maximum voltage unbalance |

*Table continues on the next page*

| Name | Type | Values (Range) | Unit | Description |
|---|---|---|---|---|
| Alarm high mean Dur | FLOAT32 | 0.000...3600.000 | s | Time duration for alarm high mean unbalance |
| Max unbalance Volt | FLOAT32 | 0.00...150.00 | % | Maximum 3 seconds unbalance voltage |
| Time Max Unb Volt | Timestamp | | | Time stamp of maximum voltage unbalance |
| Alarm high mean Dur | FLOAT32 | 0.000...3600.000 | s | Time duration for alarm high mean unbalance |
| Max unbalance Volt | FLOAT32 | 0.00...150.00 | % | Maximum 3 seconds unbalance voltage |
| Time Max Unb Volt | Timestamp | | | Time stamp of maximum voltage unbalance |
| VSQVUB | Enum | 1=on<br>2=blocked<br>3=test<br>4=test/blocked<br>5=off | | Status |

## 10.4.10 Technical data

**Table 1649: VSQVUB Technical data**

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.5 % of the set value or ±0.002 × $U_n$ |
| Reset ratio | Typically 0.96 |

# 11 General function block features

## 11.1 Definite time characteristics

### 11.1.1 Definite time operation

The DT mode is enabled when the *Operating curve type* setting is selected either as "ANSI Def. Time" or "IEC Def. Time". In the DT mode, the OPERATE output of the function is activated when the time calculation exceeds the set *Operate delay time* .

The user can determine the reset in the DT mode with the *Reset delay time* setting, which provides the delayed reset property when needed.



The *Type of reset curve* setting has no effect on the reset method when the DT mode is selected, but the reset is determined solely with the *Reset delay time* setting.

The purpose of the delayed reset is to enable fast clearance of intermittent faults, for example self-sealing insulation faults, and severe faults which may produce high asymmetrical fault currents that partially saturate the current transformers. It is typical for an intermittent fault that the fault current contains so called drop-off periods, during which the fault current falls below the set start current, including hysteresis. Without the delayed reset function, the operate timer would reset when the current drops off. In the same way, an apparent drop-off period of the secondary current of the saturated current transformer can also reset the operate timer.

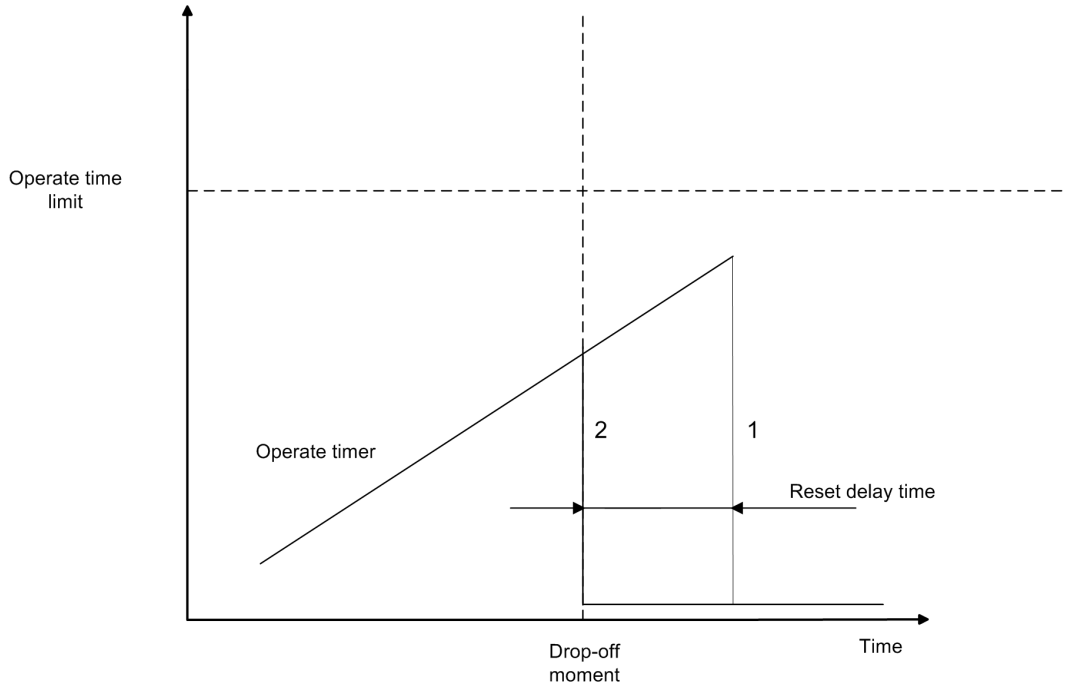



*Figure 982: Operation of the counter in drop-off*

In case 1, the reset is delayed with the *Reset delay time* setting and in case 2, the counter is reset immediately, because the *Reset delay time* setting is set to zero.

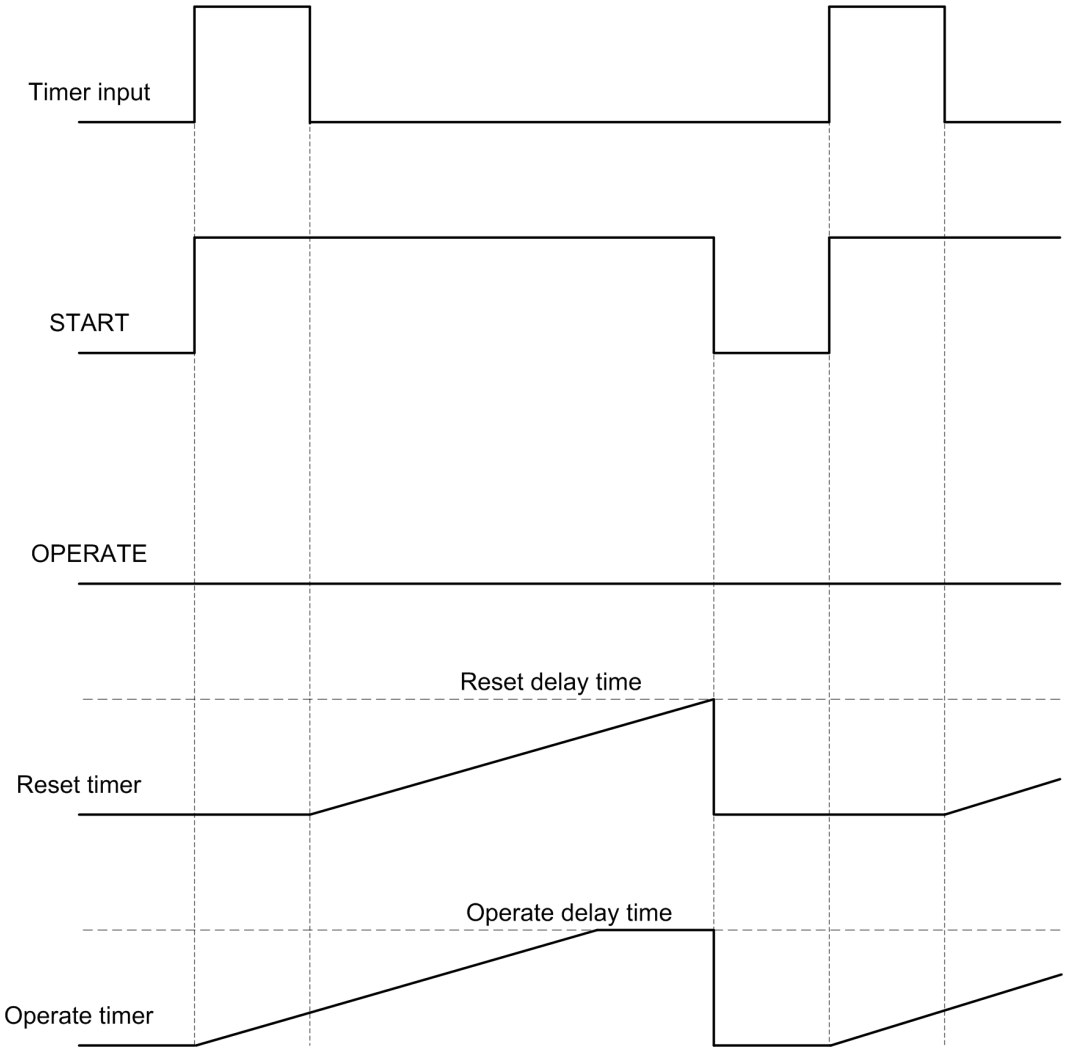



*Figure 983: Drop-off period is longer than the set Reset delay time*

When the drop-off period is longer than the set *Reset delay time*, as described in *Figure 983*, the input signal for the definite timer (here: timer input) is active, provided that the current is above the set *Start value*. The input signal is inactive when the current is below the set *Start value* and the set hysteresis region. The timer input rises when a fault current is detected. The definite timer activates the START output and the operate timer starts elapsing. The reset (drop-off) timer starts when the timer input falls, that is, the fault disappears. When the reset (drop-off) timer elapses, the operate timer is reset. Since this happens before another start occurs, the OPERATE output is not activated.

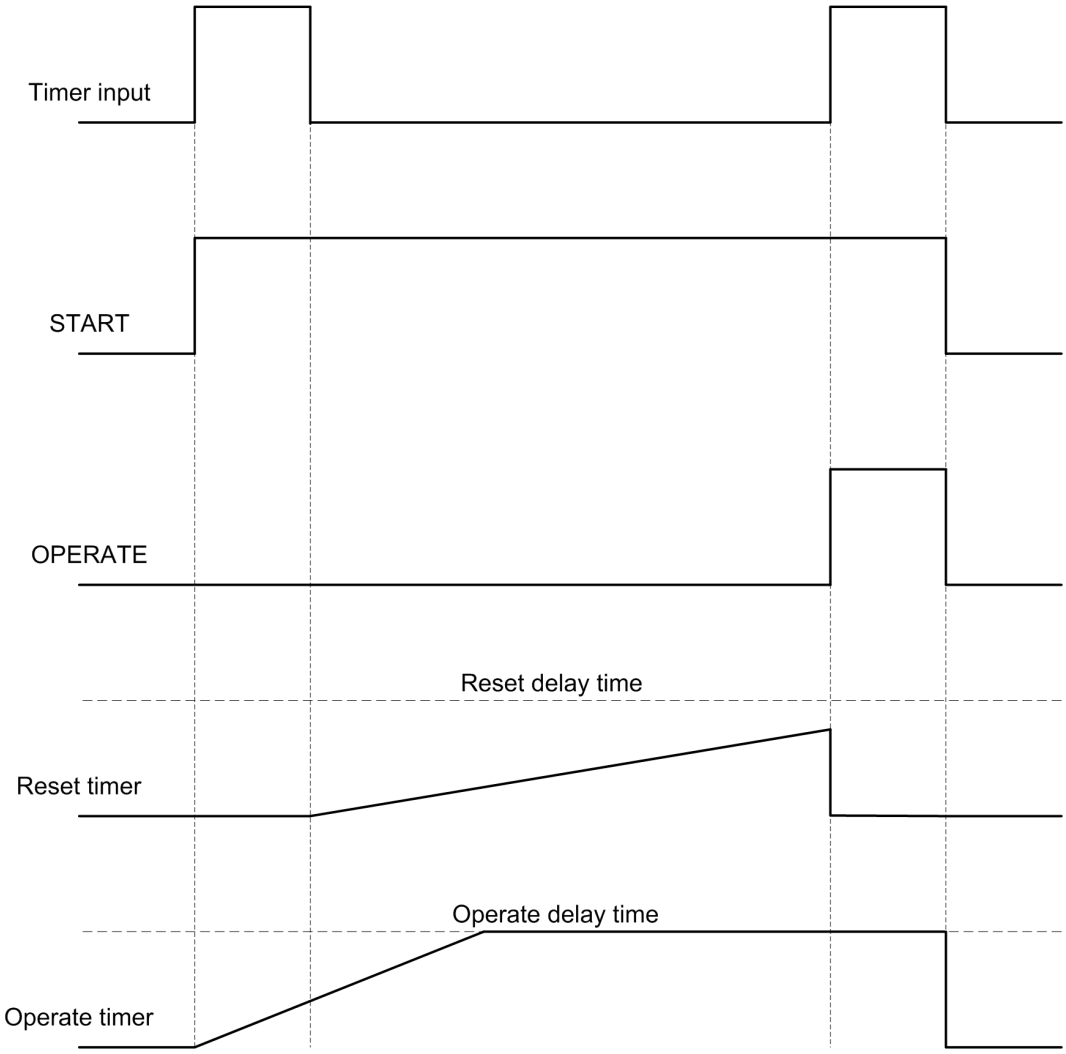



*Figure 984: Drop-off period is shorter than the set Reset delay time*

When the drop-off period is shorter than the set *Reset delay time*, as described in *Figure 984*, the input signal for the definite timer (here: timer input) is active, provided that the current is above the set *Start value*. The input signal is inactive when the current is below the set *Start value* and the set hysteresis region. The timer input rises when a fault current is detected. The definite timer activates the START output and the operate timer starts elapsing. The Reset (drop-off) timer starts when the timer input falls, that is, the fault disappears. Another fault situation occurs before the reset (drop-off) timer has elapsed. This causes the activation of the OPERATE output, since the operate timer already has elapsed.

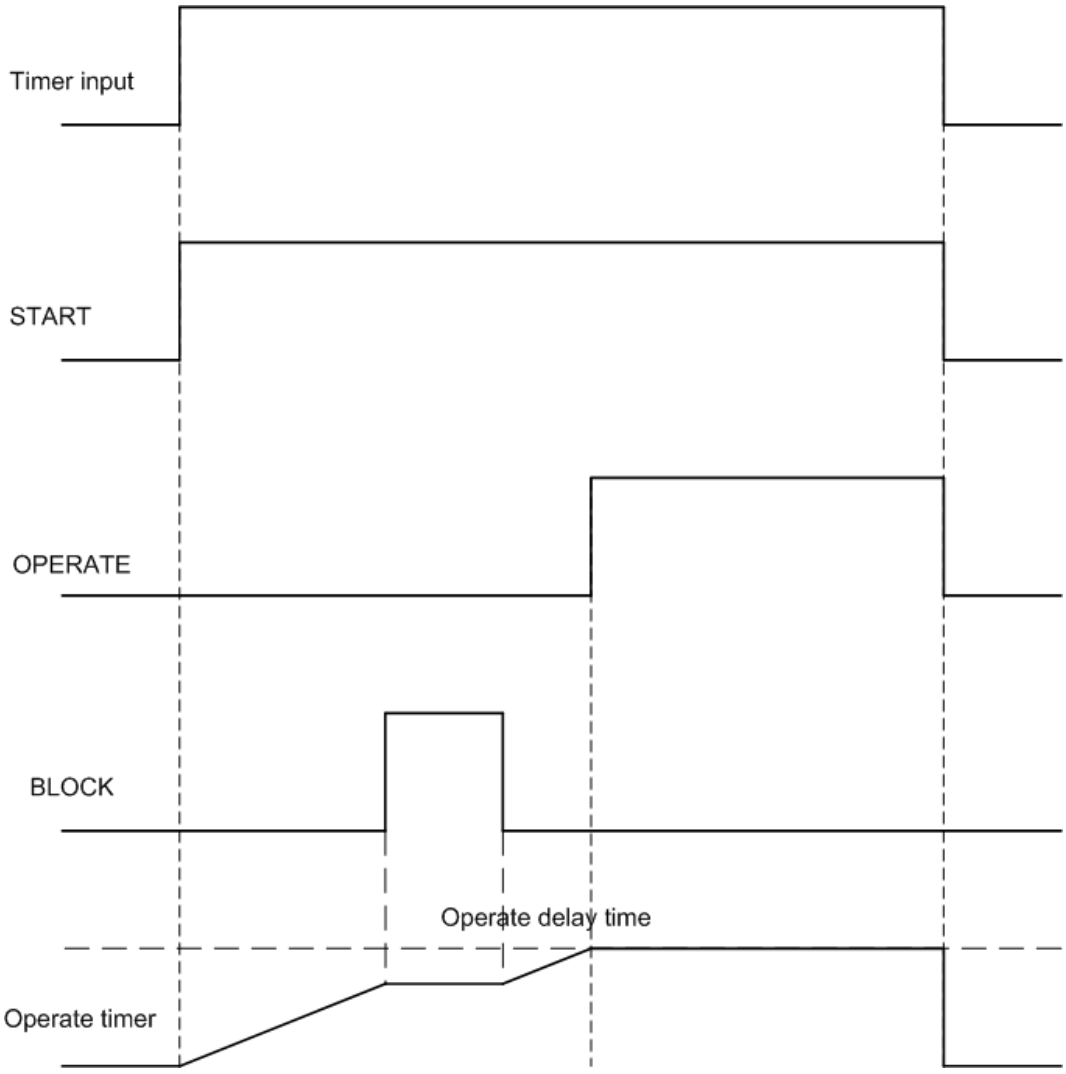



*Figure 985: Operating effect of the BLOCK input when the selected blocking mode is "Freeze timer"*

If the BLOCK input is activated when the operate timer is running, as described in *Figure 985*, the timer is frozen during the time BLOCK remains active. If the timer input is not active longer than specified by the *Reset delay time* setting, the operate timer is reset in the same way as described in *Figure 983*, regardless of the BLOCK input .

The selected blocking mode is "Freeze timer".

## 11.2 Current based inverse definite minimum time characteristics

### 11.2.1 IDMT curves for overcurrent protection

In inverse-time modes, the operation time depends on the momentary value of the current: the higher the current, the faster the operation time. The operation time calculation or integration starts immediately when the current exceeds the set *Start value* and the START output is activated.

The OPERATE output of the component is activated when the cumulative sum of the integrator calculating the overcurrent situation exceeds the value set by the inverse-time mode. The set value depends on the selected curve type and the setting values used. The curve scaling is determined with the *Time multiplier* setting.

There are two methods to level out the inverse-time characteristic.

- The *Minimum operate time* setting defines the minimum operating time for the IDMT curve, that is, the operation time is always at least the *Minimum operate time* setting.
- Alternatively, the *IDMT Sat point* is used for giving the leveling-out point as a multiple of the *Start value* setting. (Global setting: **Configuration** > **System** > ***IDMT Sat point***). The default parameter value is 50. This setting affects only the overcurrent and earth-fault IDMT timers.



IDMT operation time at currents over 50 x In is not guaranteed.



See *Chapter 3.12 Sensor inputs for currents and voltages* for Rogowski channel saturation details. Rogowski sensors do not saturate, but protection relay input does not have infinite range. 50 x In saturation is not achievable with some of the higher primary current settings.

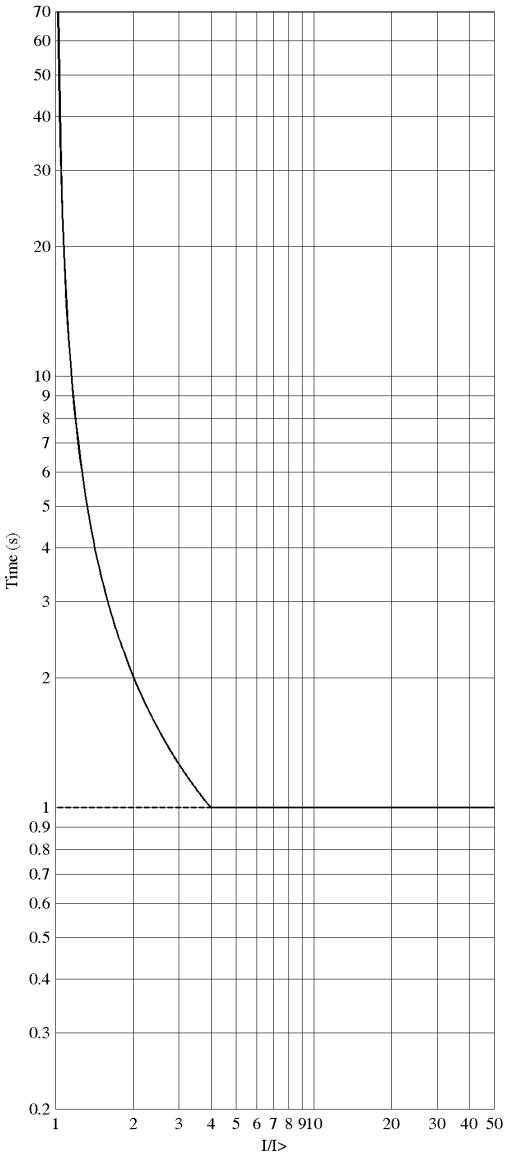



*Figure 986: Operation time curve based on the IDMT characteristic leveled out with the Minimum operate time setting is set to 1000 milliseconds ( the IDMT Sat point setting is set to maximum).*

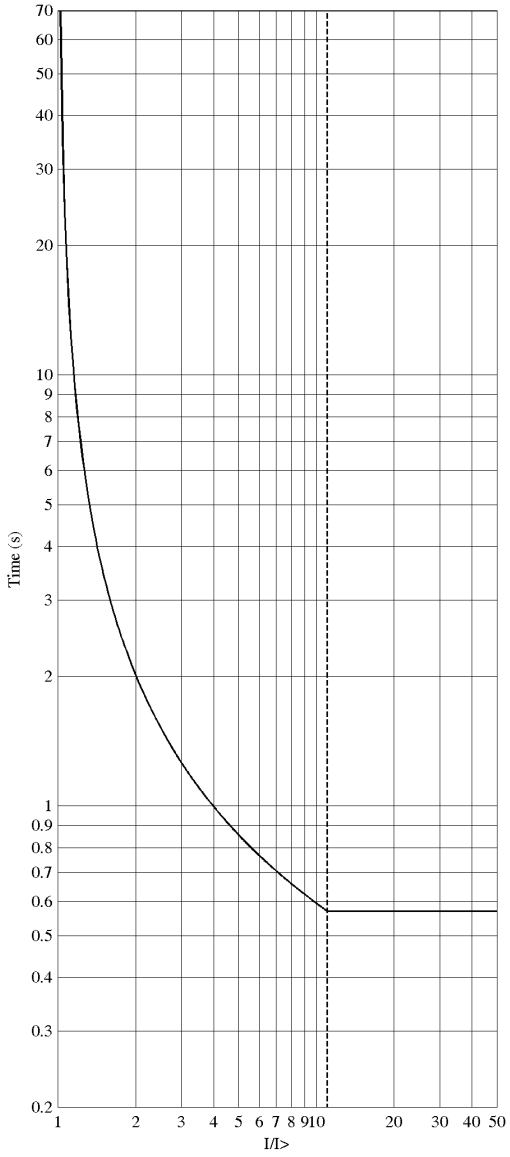



*Figure 987: Operation time curve based on the IDMT characteristic leveled out with IDMT Sat point setting value "11" (the Minimum operate time setting is set to minimum).*

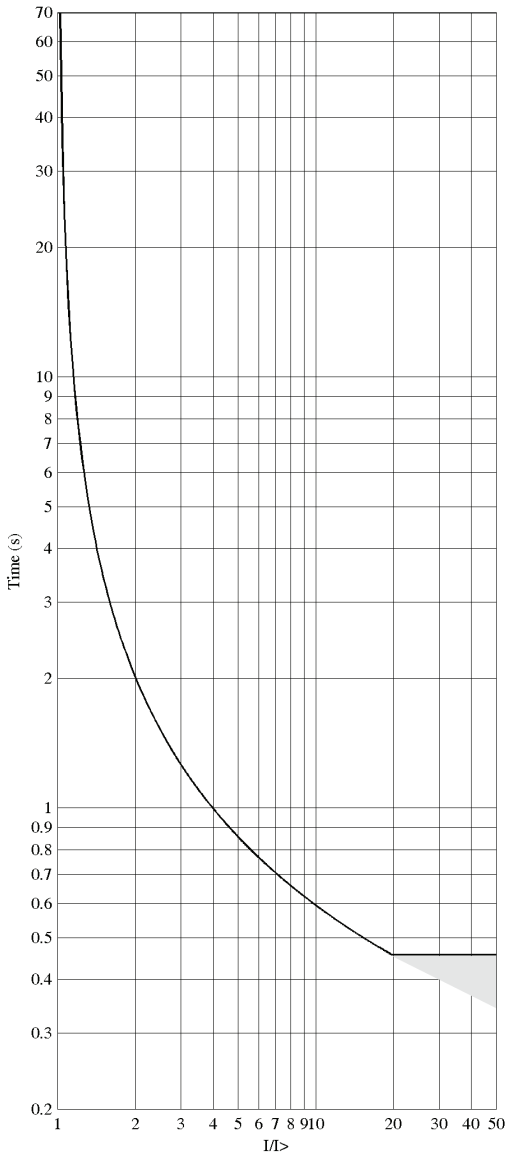



*Figure 988: Example of how the inverse time characteristic is leveled out with currents over 50 x In and the Setting Start value setting "2.5 x In". (the IDMT Sat point setting is set to maximum and the Minimum operate time setting is set to minimum).*

The grey zone in *Figure 988* shows the behavior of the curve in case the measured current is outside the guaranteed measuring range. Also, the maximum measured current of 50 x In gives the leveling-out point 50/2.5 = 20 x I/I>.

### 11.2.1.1 Standard inverse-time characteristics

For inverse-time operation, both IEC and ANSI/IEEE standardized inverse-time characteristics are supported.

The operate times for the ANSI and IEC IDMT curves are defined with the coefficients A, B and C.

The values of the coefficients can be calculated according to the formula:

$$t[s] = \left( \frac{A}{\left( \frac{I}{I>} \right)^{c} - 1} + B \right) \cdot k$$

(Equation 393)

| | |
|---|---|
| t[s] | Operate time in seconds |
| I | Measured current |
| I> | Set *Start value* |
| k | Set *Time multiplier* |

**Table 1650: Curve parameters for ANSI and IEC IDMT curves**

| Curve name | A | B | C |
|---|---|---|---|
| (1) ANSI Extremely Inverse | 28.2 | 0.1217 | 2.0 |
| (2) ANSI Very Inverse | 19.61 | 0.491 | 2.0 |
| (3) ANSI Normal Inverse | 0.0086 | 0.0185 | 0.02 |
| (4) ANSI Moderately Inverse | 0.0515 | 0.1140 | 0.02 |
| (6) Long Time Extremely Inverse | 64.07 | 0.250 | 2.0 |
| (7) Long Time Very Inverse | 28.55 | 0.712 | 2.0 |
| (8) Long Time Inverse | 0.086 | 0.185 | 0.02 |
| (9) IEC Normal Inverse | 0.14 | 0.0 | 0.02 |
| (10) IEC Very Inverse | 13.5 | 0.0 | 1.0 |
| (11) IEC Inverse | 0.14 | 0.0 | 0.02 |
| (12) IEC Extremely Inverse | 80.0 | 0.0 | 2.0 |
| (13) IEC Short Time Inverse | 0.05 | 0.0 | 0.04 |
| (14) IEC Long Time Inverse | 120 | 0.0 | 1.0 |

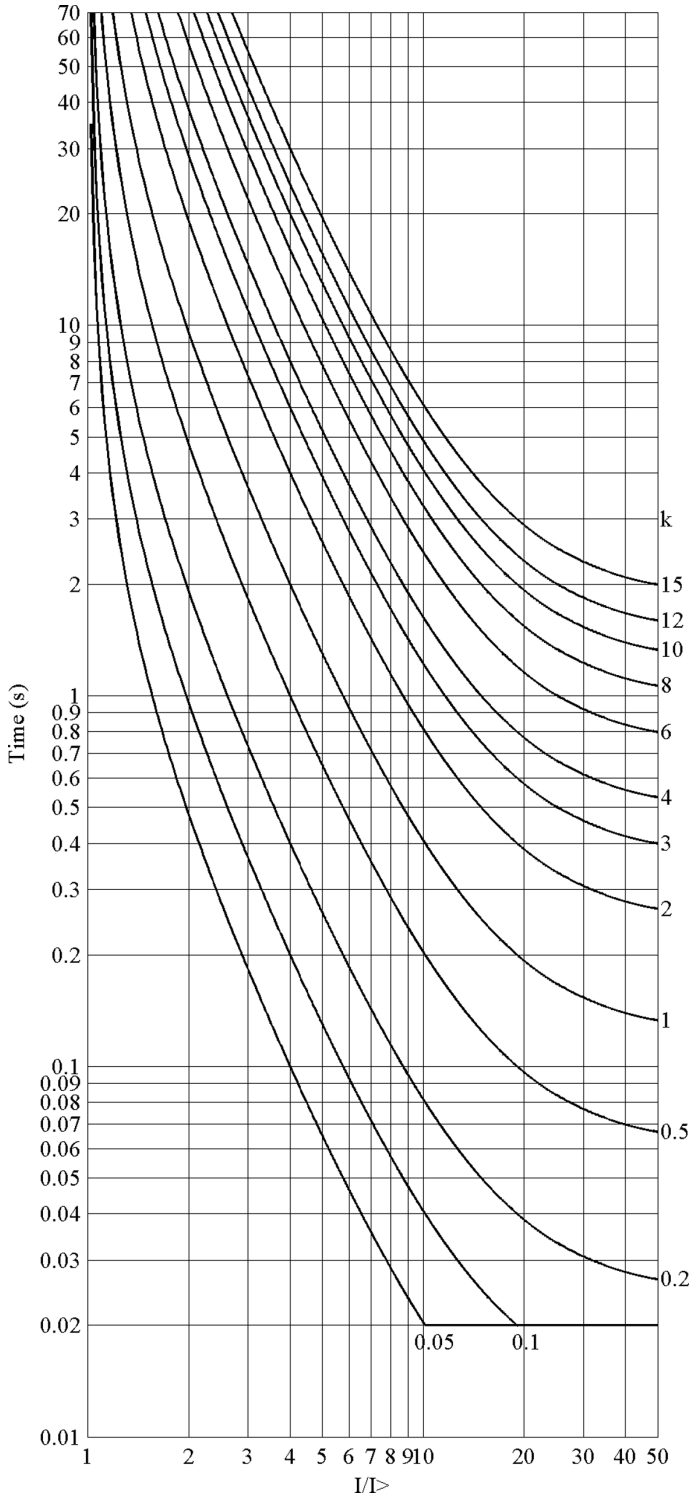



*Figure 989: ANSI extremely inverse-time characteristics*

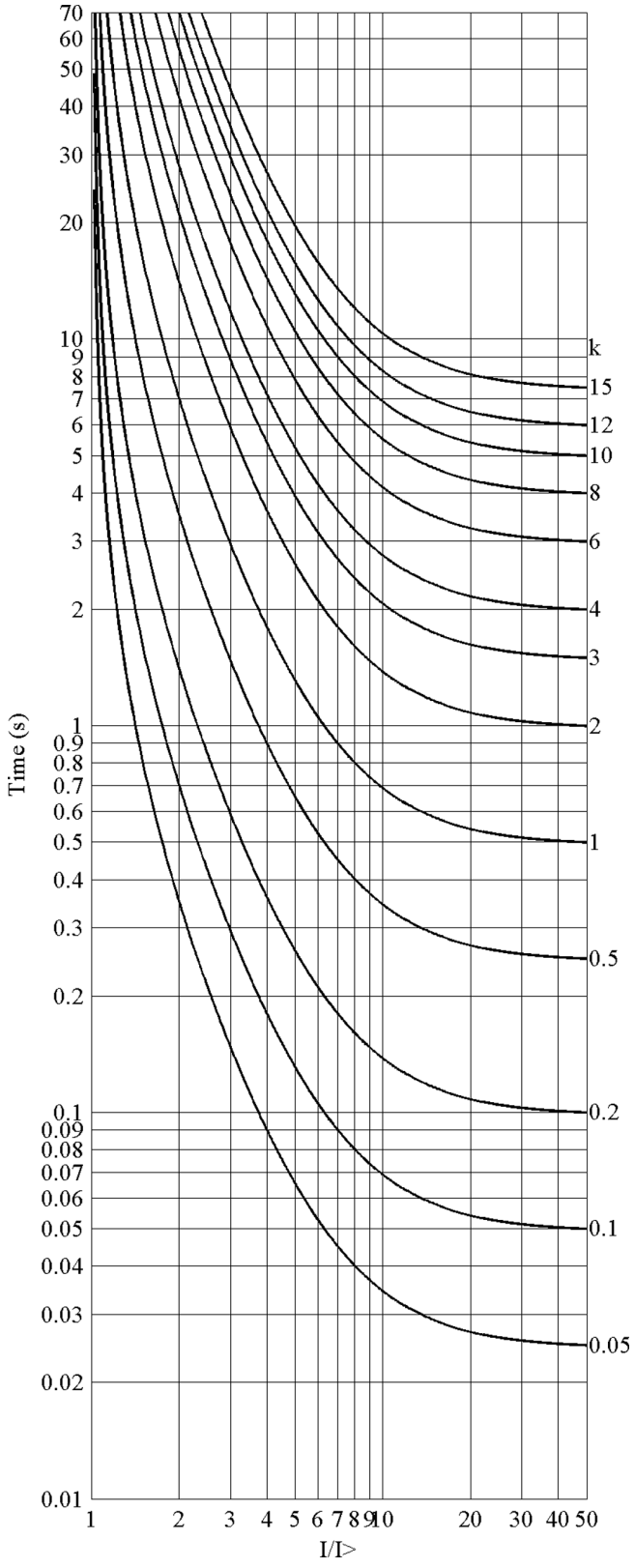



*Figure 990: ANSI very inverse-time characteristics*

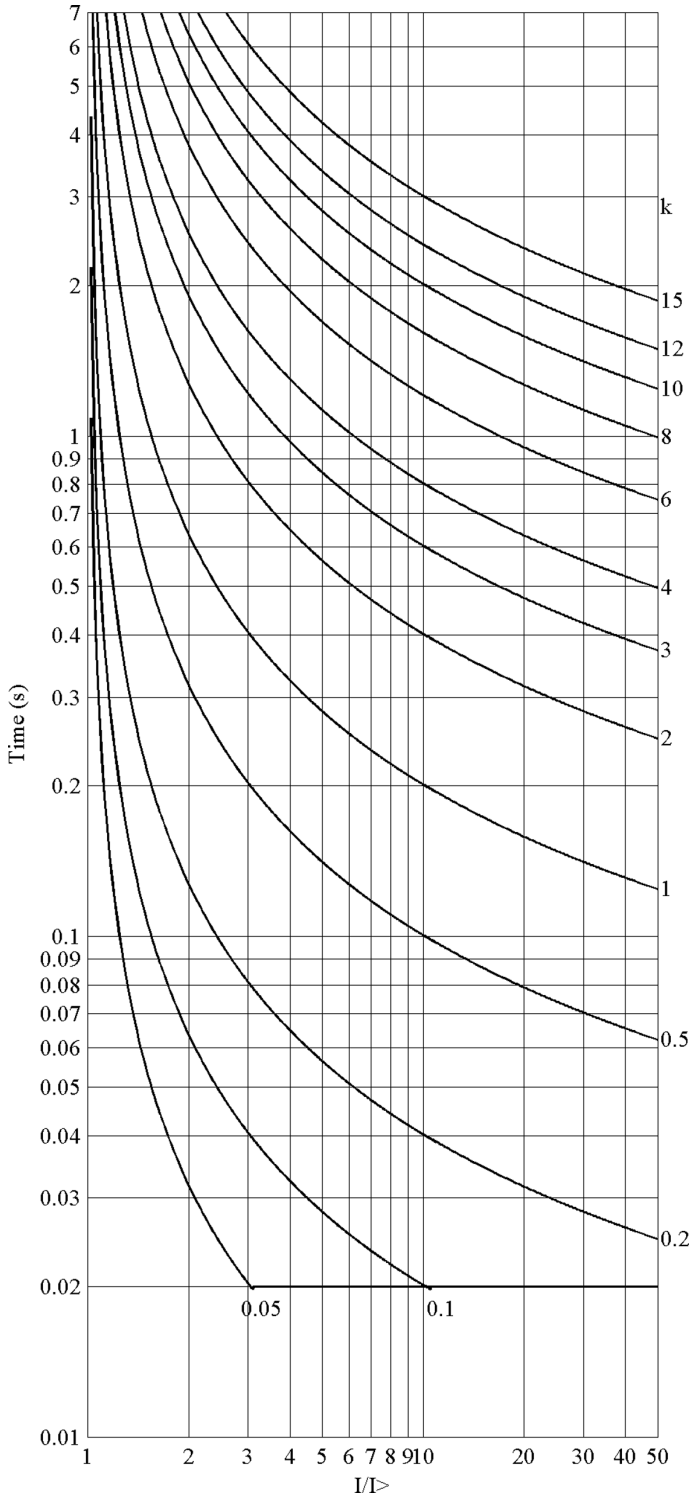



*Figure 991: ANSI normal inverse-time characteristics*

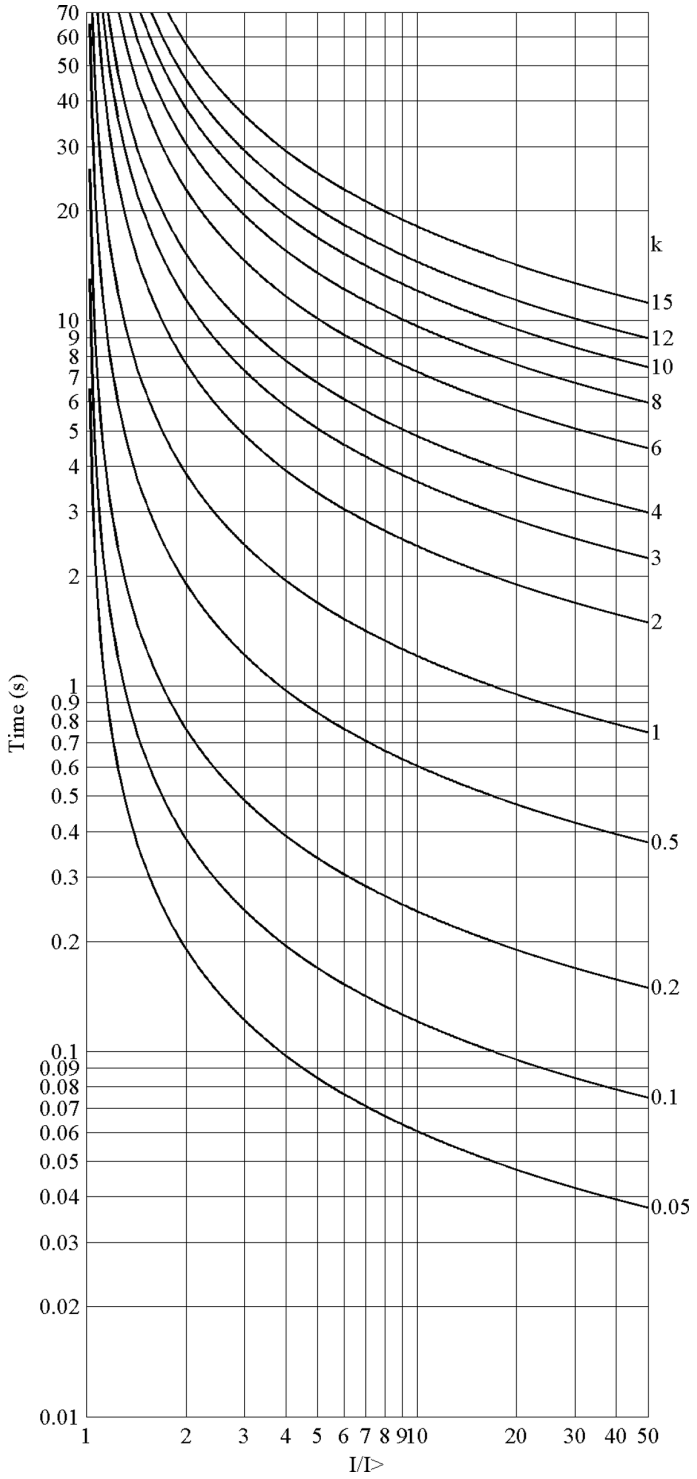



*Figure 992: ANSI moderately inverse-time characteristics*

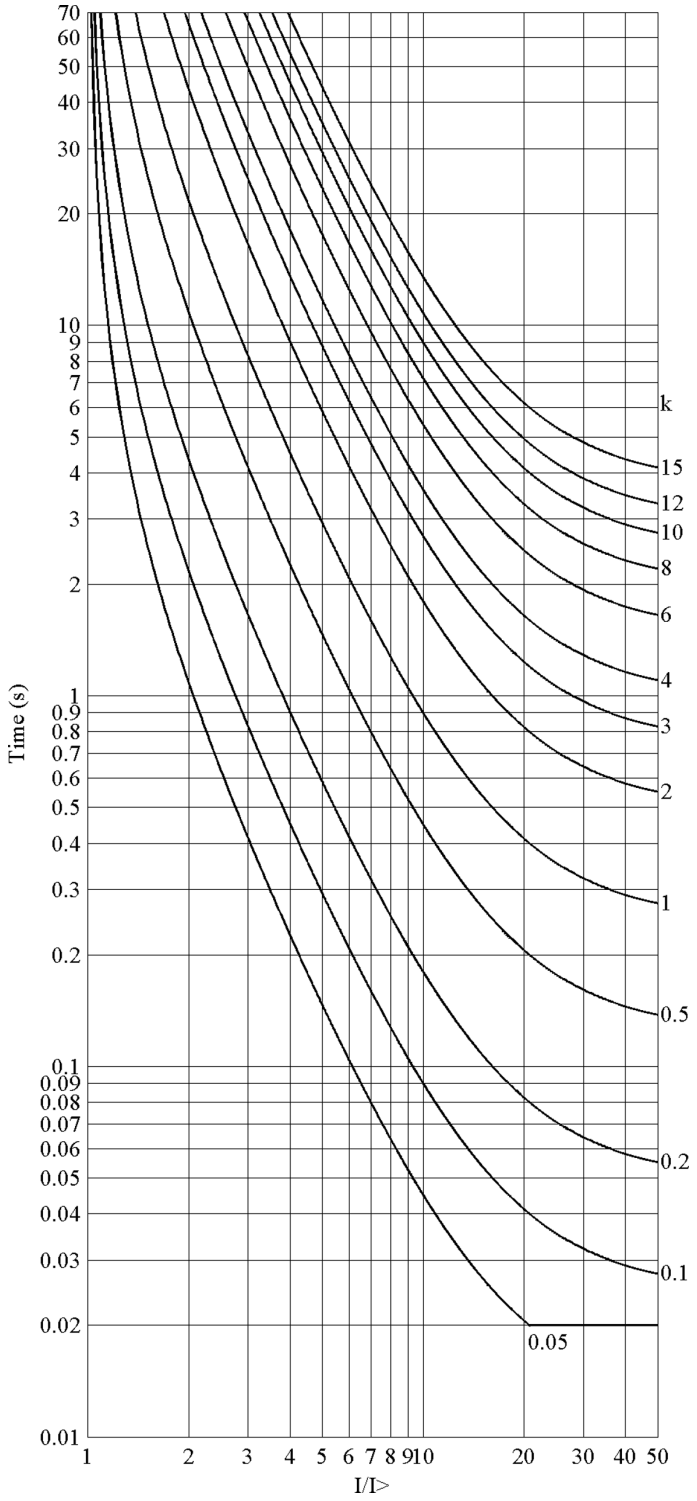



*Figure 993: ANSI long-time extremely inverse-time characteristics*

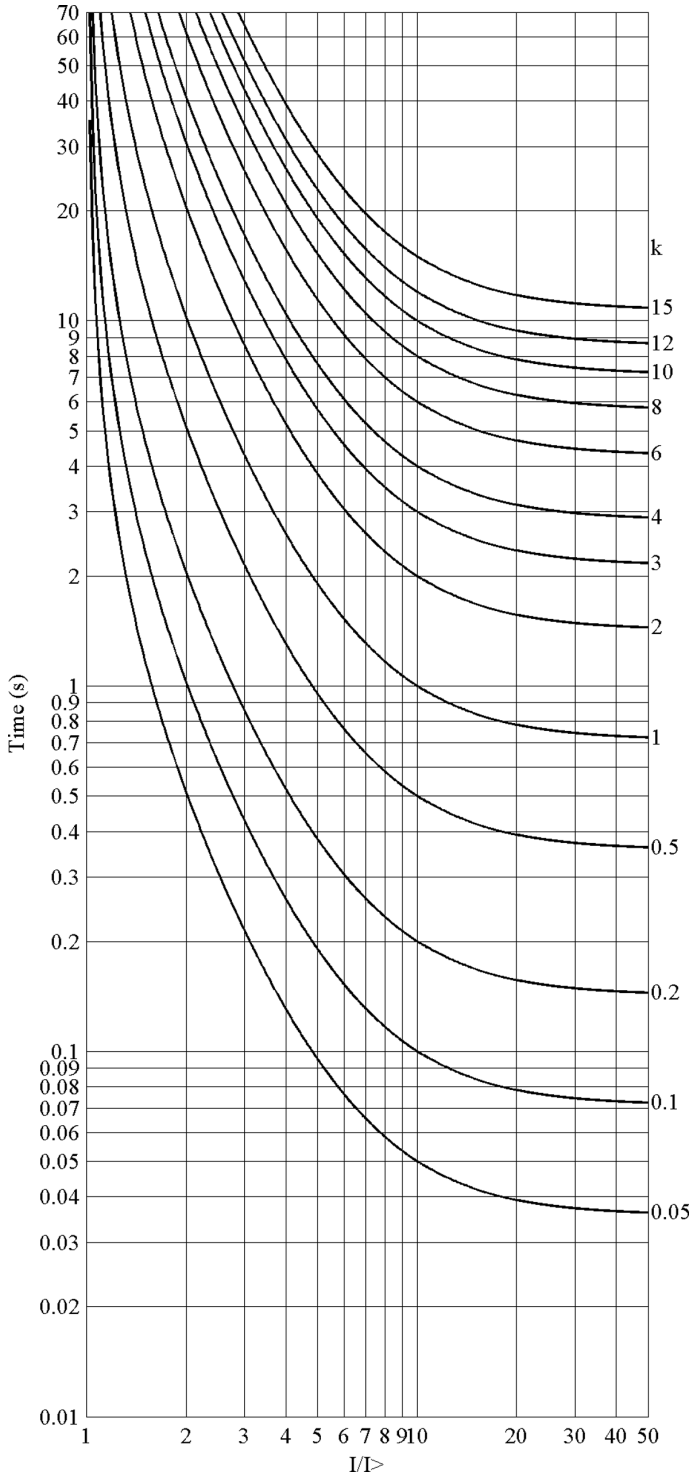



*Figure 994: ANSI long-time very inverse-time characteristics*

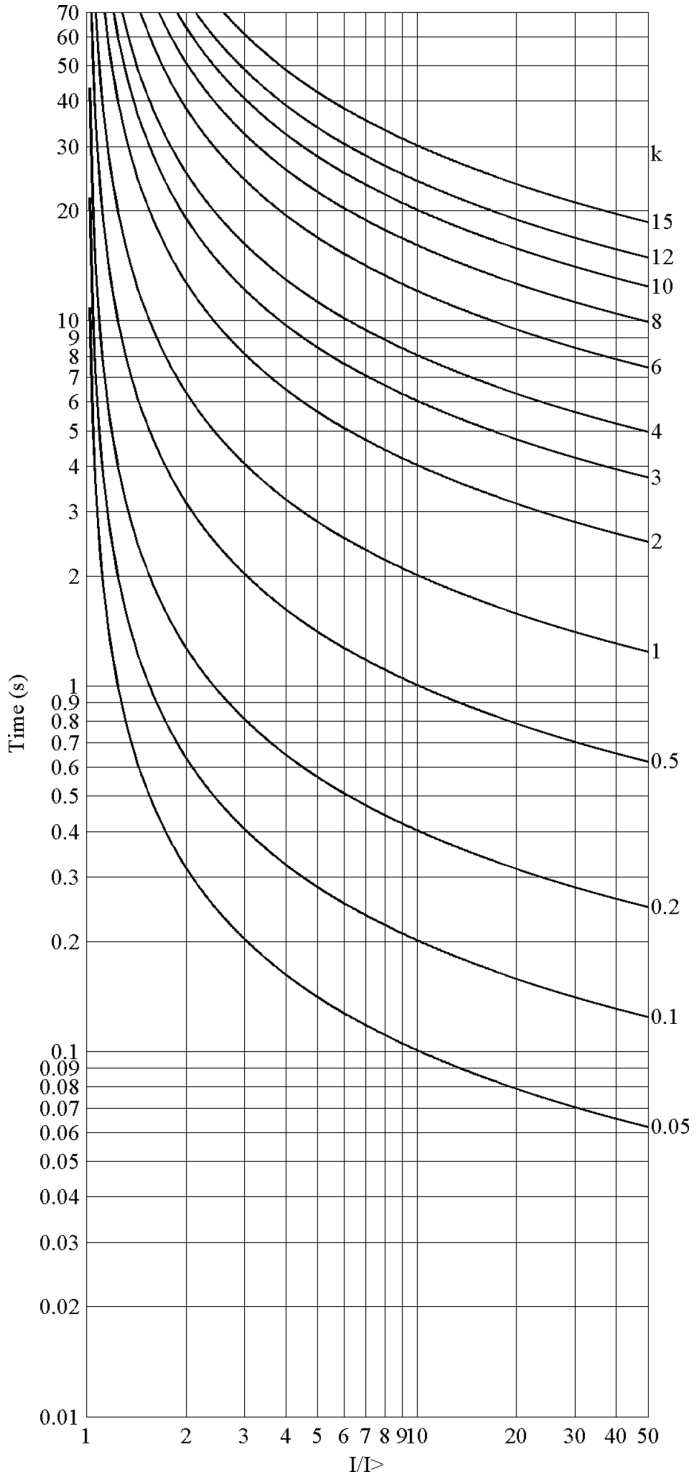



*Figure 995: ANSI long-time inverse-time characteristics*

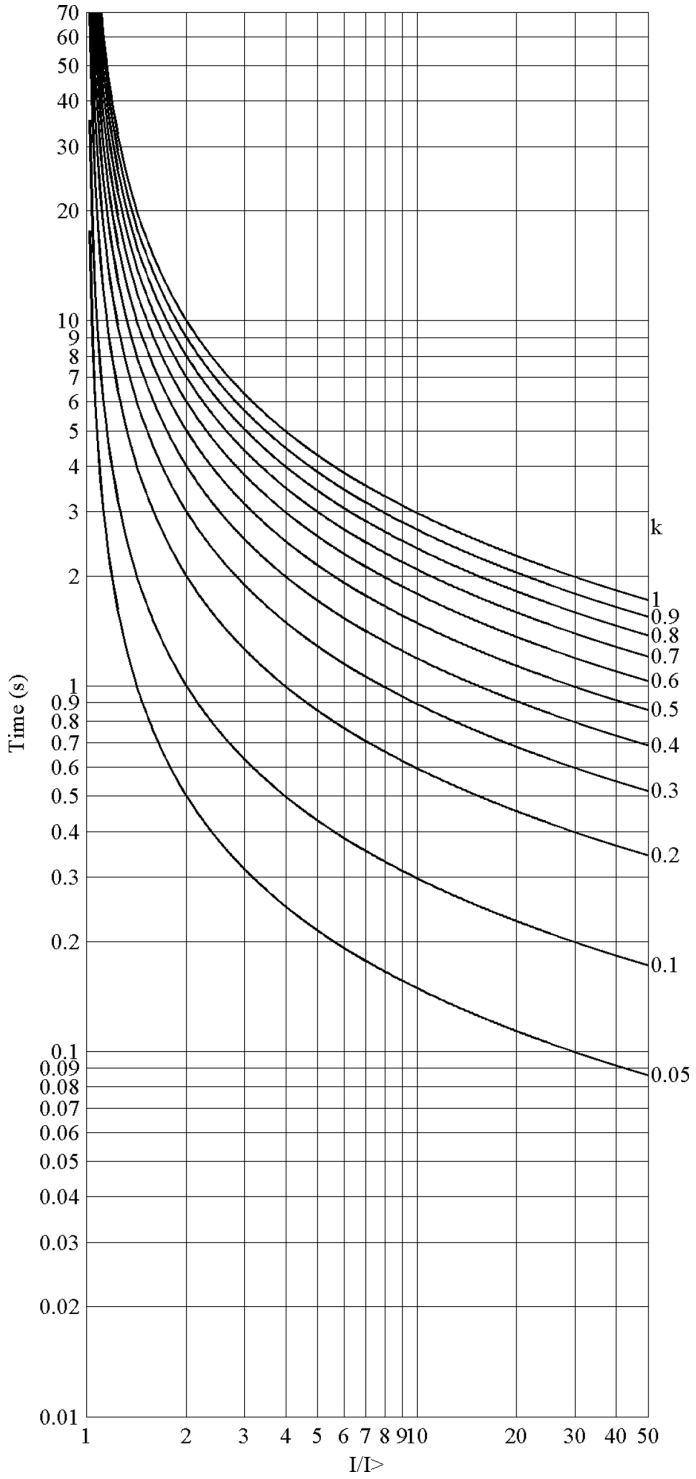



*Figure 996: IEC normal inverse-time characteristics*

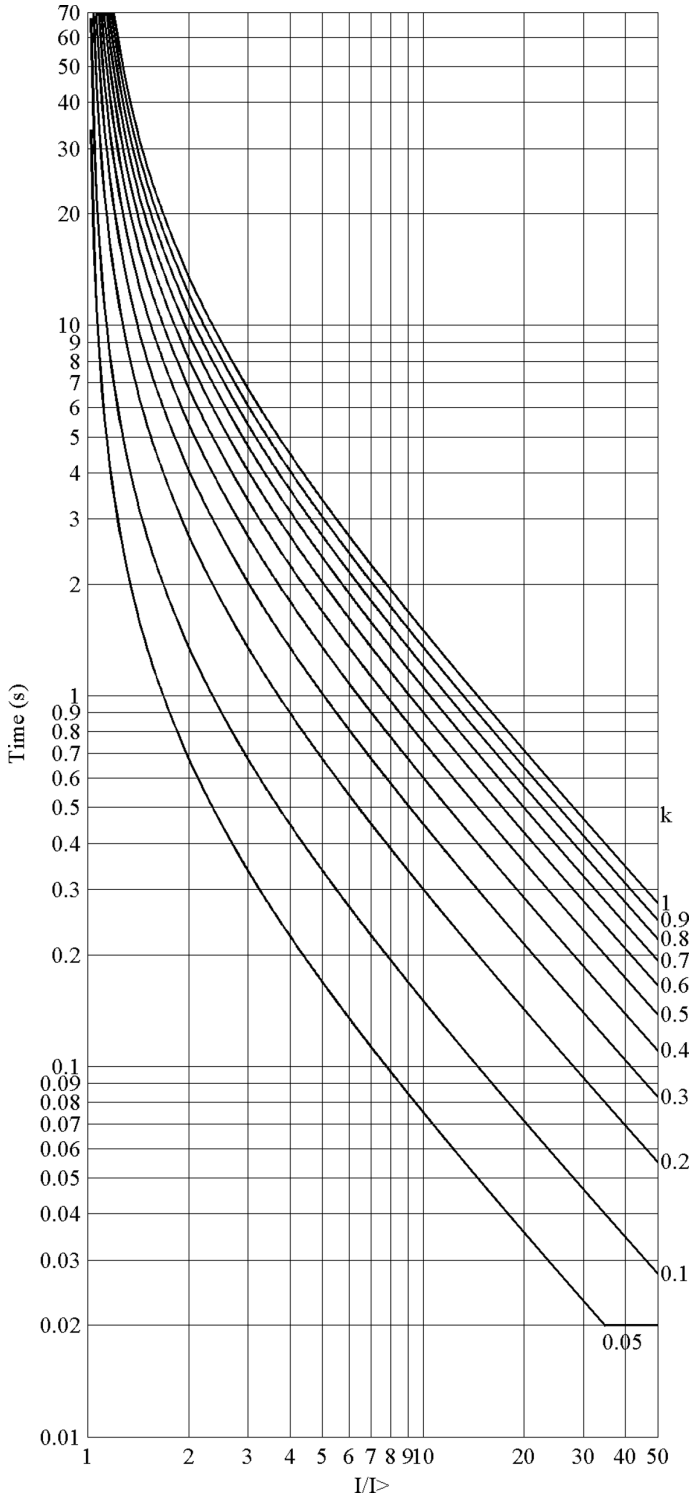



*Figure 997: IEC very inverse-time characteristics*

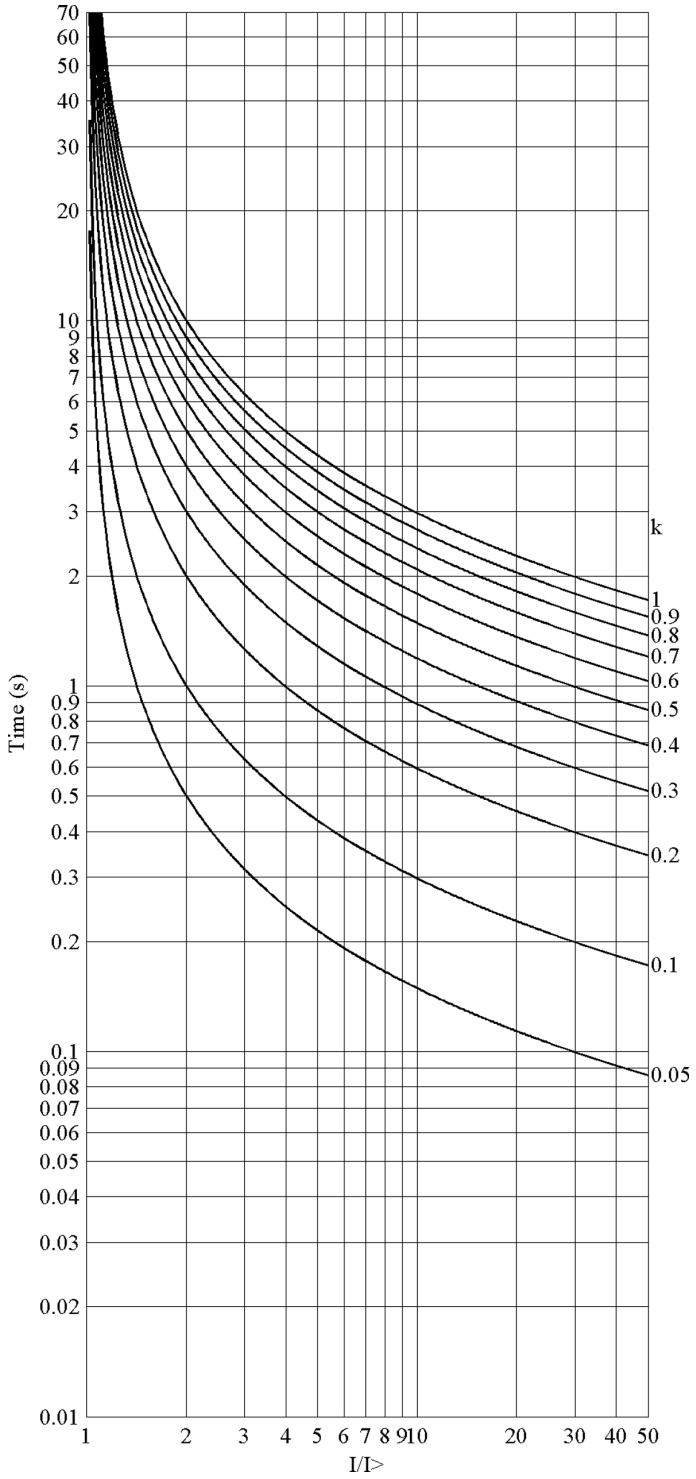



*Figure 998: IEC inverse-time characteristics*

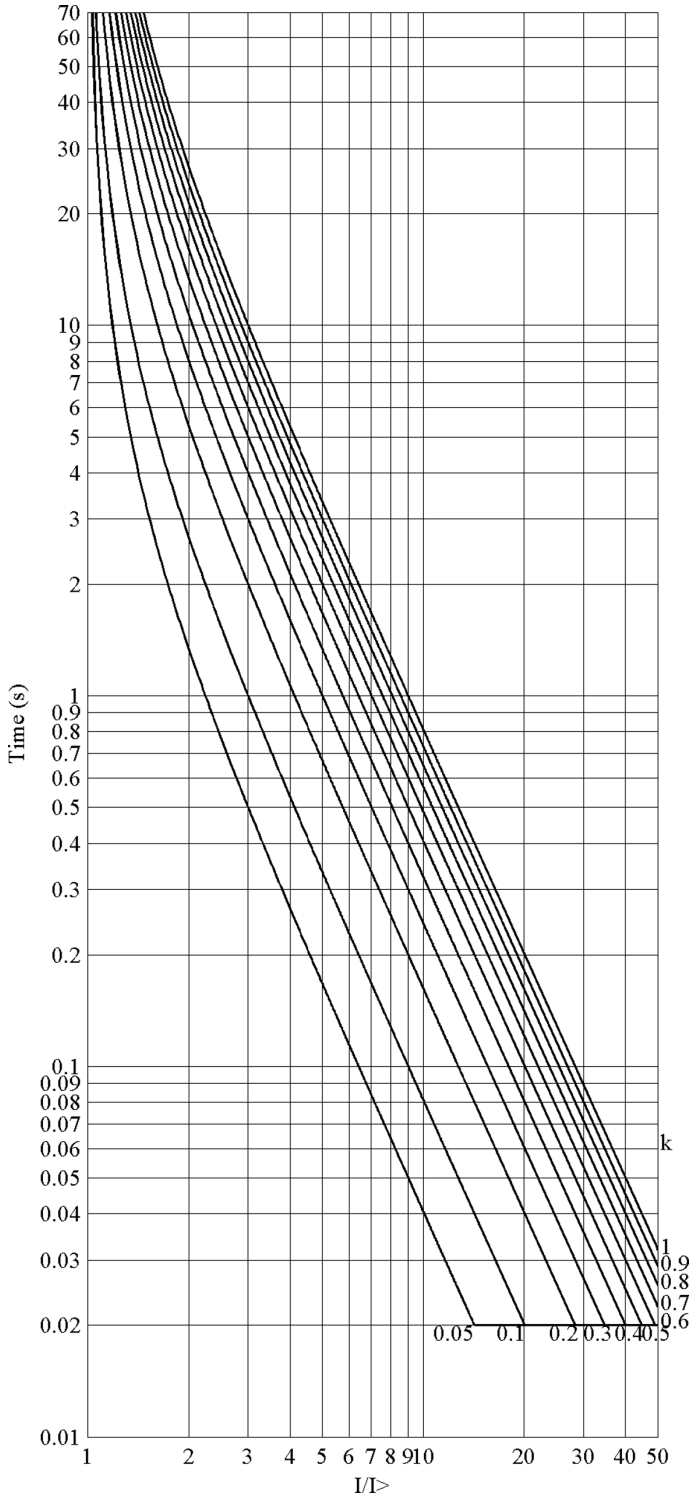



*Figure 999: IEC extremely inverse-time characteristics*

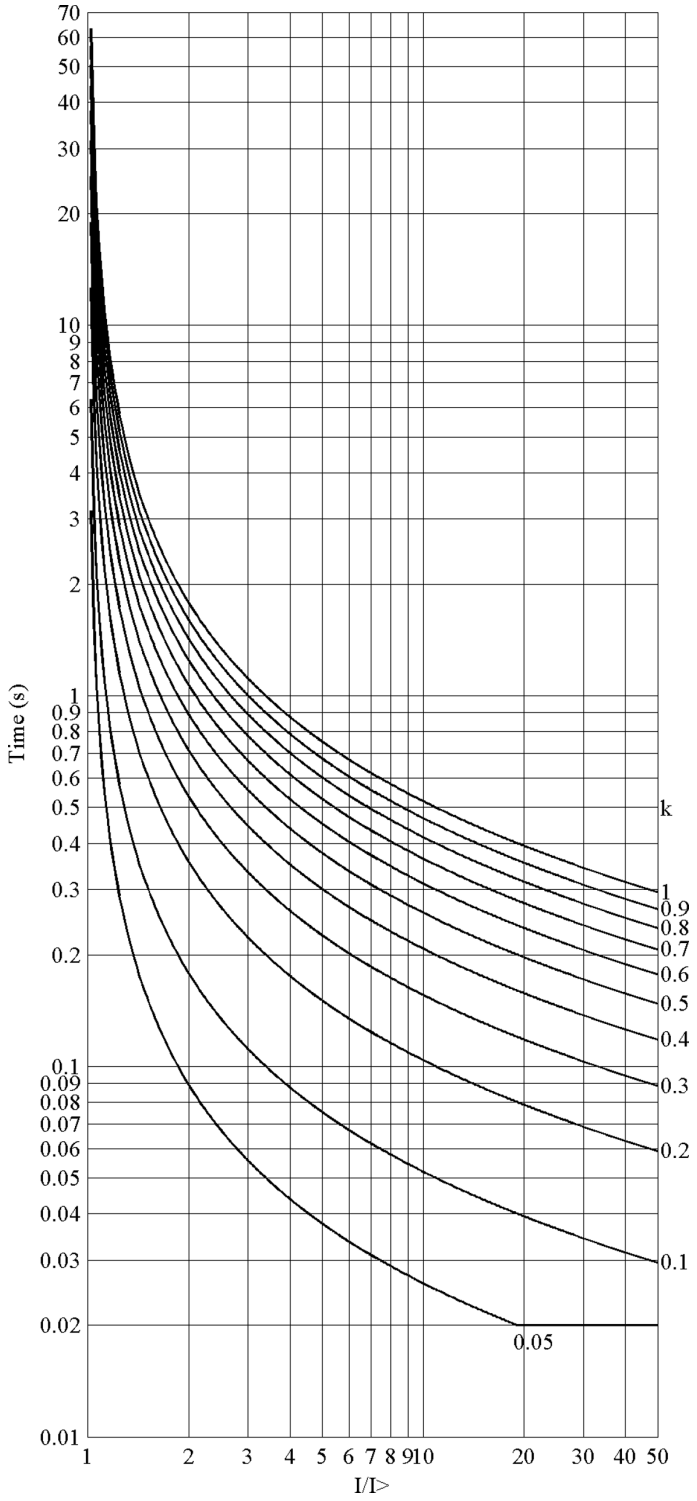



*Figure 1000: IEC short-time inverse-time characteristics*

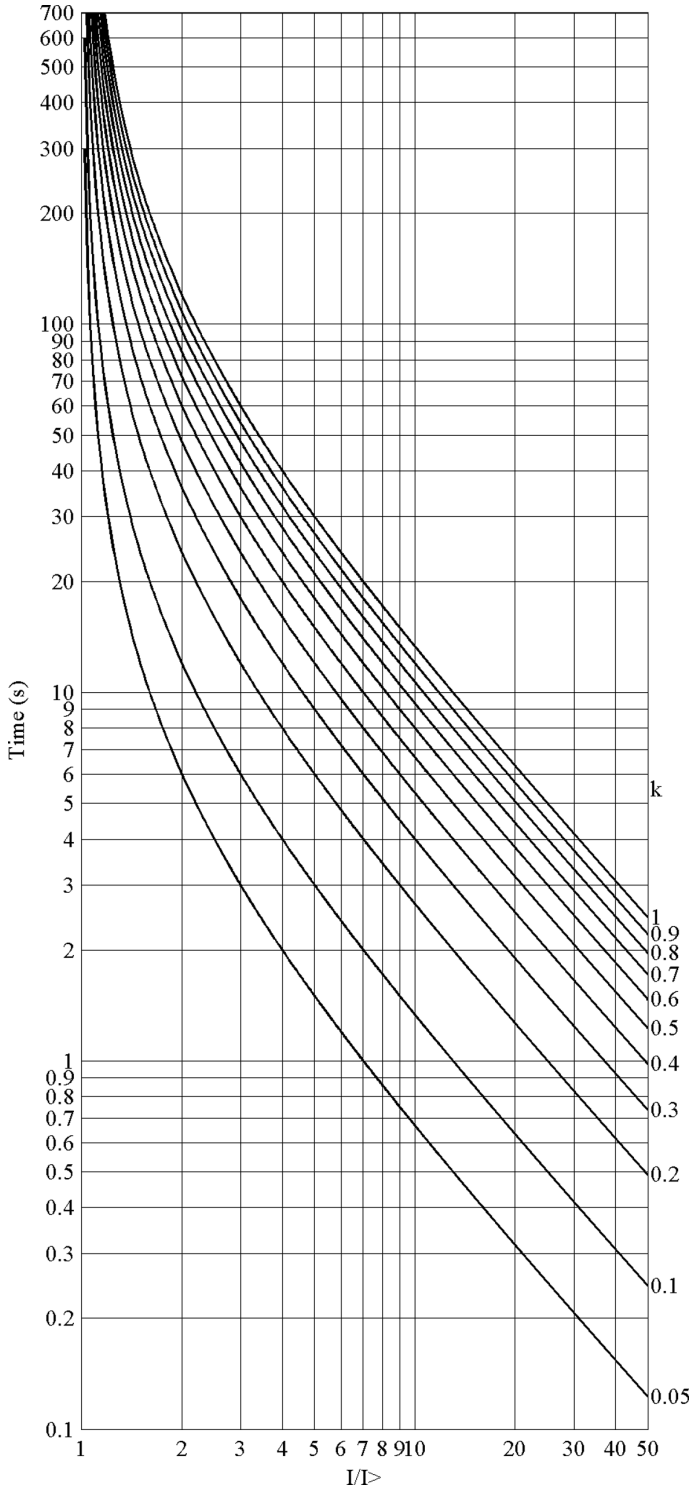



*Figure 1001: IEC long-time inverse-time characteristics*

### 11.2.1.2 User-programmable inverse-time characteristics

The user can define curves by entering parameters into the following standard formula:

$$t[s] = \left( \frac{A}{\left( \frac{I}{I>} \right)^{c} - E} + B \right) \cdot k$$

(Equation 394)

| | |
|---|---|
| t[s] | Operate time (in seconds) |
| A | Set *Curve parameter A* |
| B | Set *Curve parameter B* |
| C | Set *Curve parameter C* |
| E | Set *Curve parameter E* |
| I | Measured current |
| I> | Set *Start value* |
| k | Set *Time multiplier* |

### 11.2.1.3 RI and RD-type inverse-time characteristics

The RI-type simulates the behavior of electromechanical relays. The RD-type is an earth-fault specific characteristic.

The RI-type is calculated using the formula

$$t[s] = \left( \frac{k}{0.339 - 0.236 \times \frac{I>}{I}} \right)$$

(Equation 395)

The RD-type is calculated using the formula

$$t[s] = 5.8 - 1.35 \times \ln\left( \frac{I}{k \times I>} \right)$$

(Equation 396)

| | |
|---|---|
| t[s] | Operate time (in seconds) |
| k | Set *Time multiplier* |
| I | Measured current |
| I> | Set *Start value* |

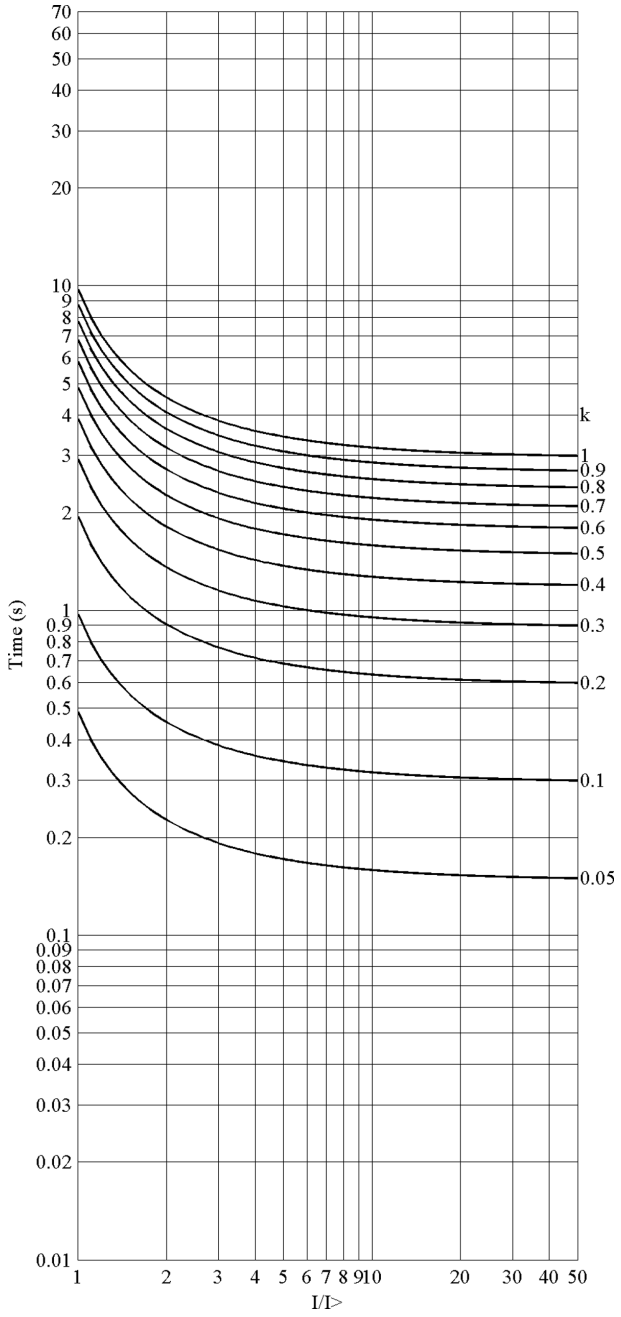



*Figure 1002: RI-type inverse-time characteristics*

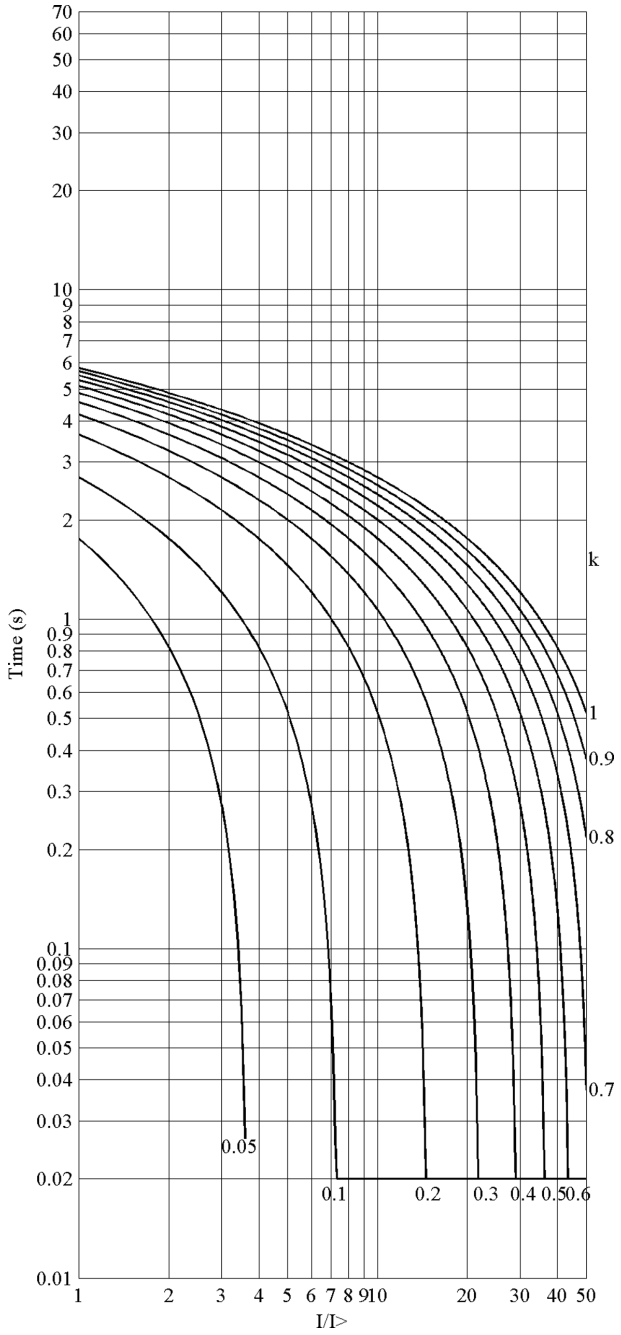



*Figure 1003: RD-type inverse-time characteristics*

### 11.2.1.4 UK rectifier inverse-time characteristic

The UK rectifier type simulates the rectifier bridge.

The operate times are defined with the coefficients A, B and C.

The values of the coefficients can be calculated according to the formula

$$t[s] = \left( \frac{A}{\left( \frac{I}{I>} \right)^{c} - 1} + B \right) \cdot k$$

t[s] Operate time in seconds

I Measured current

I> Set *Start value*

k Set *Time multiplier*

**Table 1651: Curve parameters for UK rectifier**

| Operating curve type | A | B | C |
|---|---|---|---|
| (20) UK rectifier | 45900 | 0 | 5.6 |

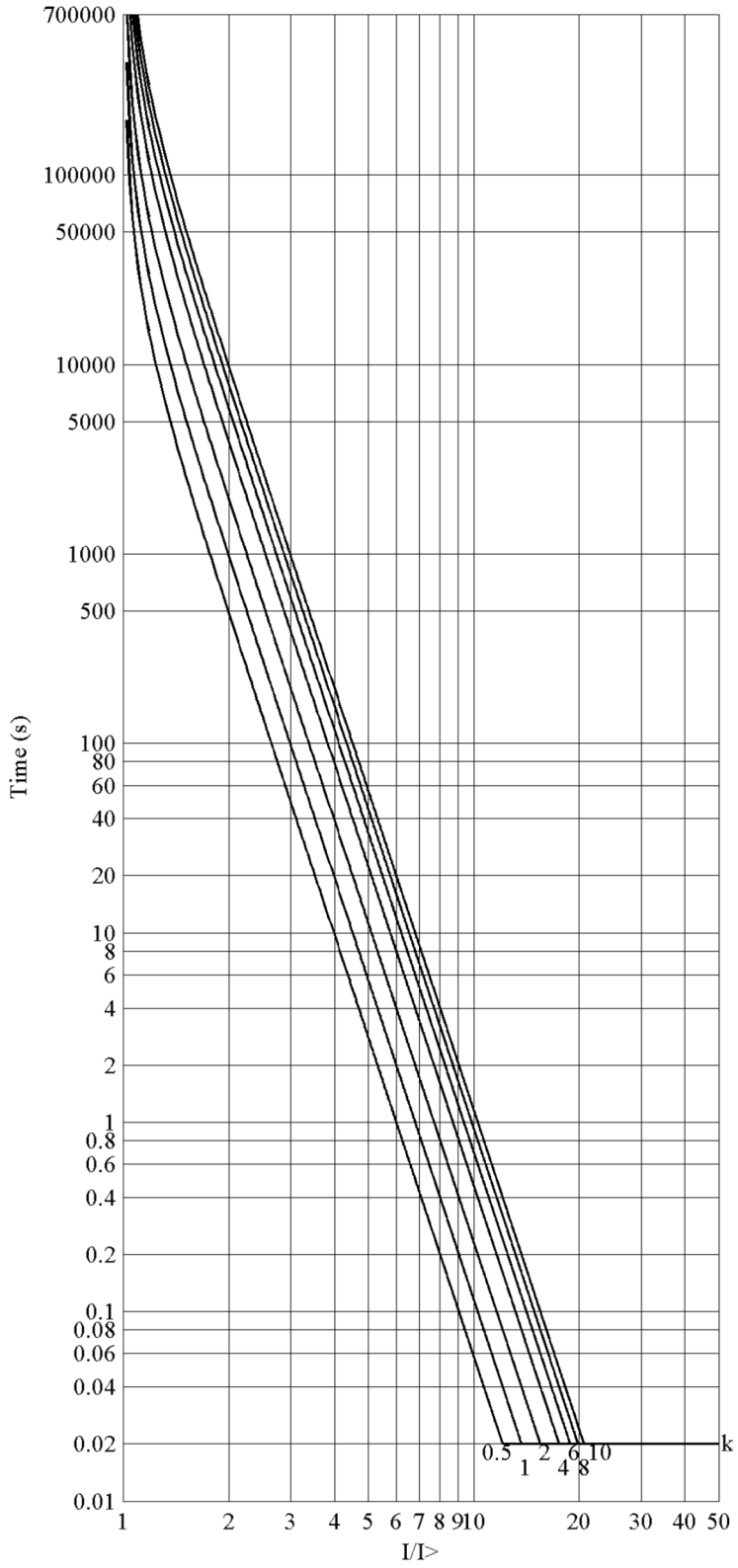



*Figure 1004: UK rectifier inverse-time characteristic*

## 11.2.2 Reset in inverse-time modes

The user can select the reset characteristics by using the *Type of reset curve* setting.

**Table 1652: Values for reset mode**

| Setting name | Possible values |
|---|---|
| *Type of reset curve* | 1=Immediate<br>2=Def time reset<br>3=Inverse reset |

### Immediate reset

If the *Type of reset curve* setting in a drop-off case is selected as "Immediate", the inverse timer resets immediately.

### Definite time reset

The definite type of reset in the inverse-time mode can be achieved by setting the *Type of reset curve* parameter to “Def time reset”. As a result, the operate inverse-time counter is frozen for the time determined with the *Reset delay time* setting after the current drops below the set *Start value*, including hysteresis. The integral sum of the inverse-time counter is reset, if another start does not occur during the reset delay.

If the *Type of reset curve* setting is selected as “Def time reset”, the current level has no influence on the reset characteristic.

### Inverse reset

Inverse reset curves are available only for ANSI and user-programmable curves. If you use other curve types, immediate reset occurs.

### Standard delayed inverse reset

The reset characteristic required in ANSI (IEEE) inverse-time modes is provided by setting the *Type of reset curve* parameter to “Inverse reset”. In this mode, the time delay for reset is given with the following formula using the coefficient D, which has its values defined in the table below.

$$t[s] = \left| \frac{D}{\left(\frac{I}{I>}\right)^2 - 1} \right| \cdot k$$

(Equation 397)

| | |
|---|---|
| t[s] | Reset time (in seconds) |
| k | Set *Time multiplier* |

*Table continues on the next page*

I Measured current

I> Set *Start value*

**Table 1653: Coefficients for ANSI delayed inverse reset curves**

| Curve name | D |
|---|---|
| (1) ANSI Extremely Inverse | 29.1 |
| (2) ANSI Very Inverse | 21.6 |
| (3) ANSI Normal Inverse | 0.46 |
| (4) ANSI Moderately Inverse | 4.85 |
| (6) Long Time Extremely Inverse | 30 |
| (7) Long Time Very Inverse | 13.46 |
| (8) Long Time Inverse | 4.6 |

The delayed inverse reset time depends also on the protection function's start duration value START_DUR. The reset time on the drop-off moment can be calculated by multiplying t[s] with START_DUR.

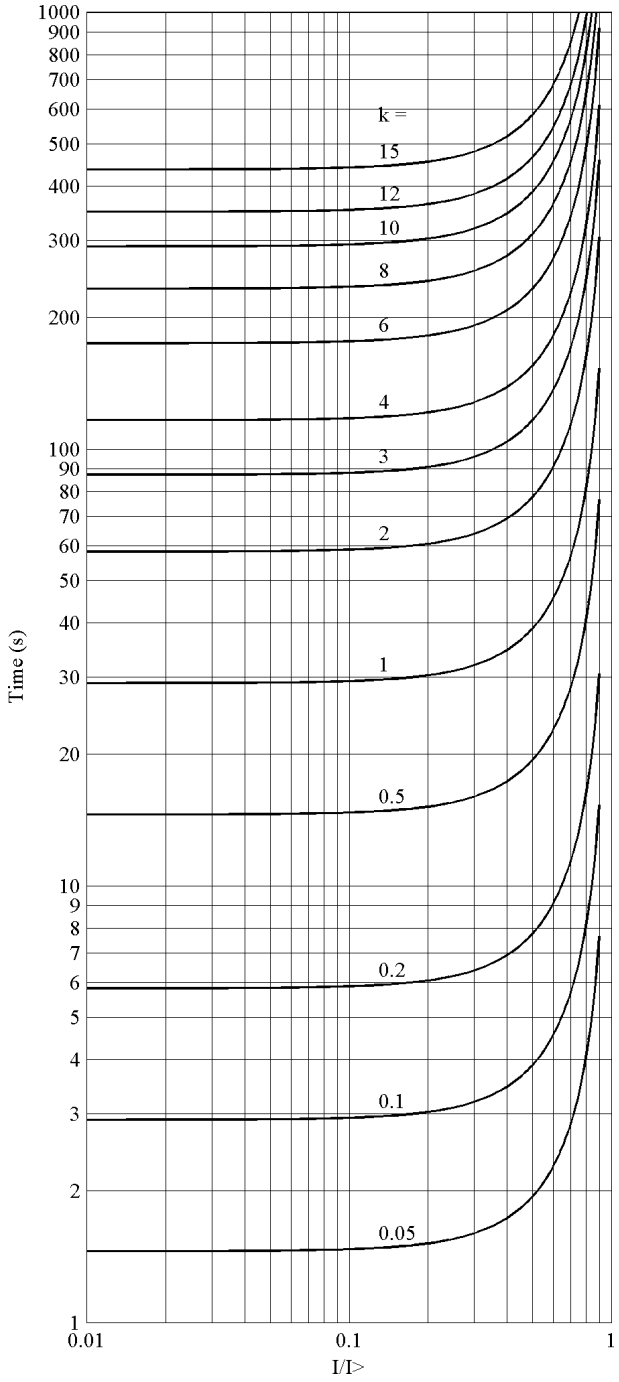



*Figure 1005: ANSI extremely inverse reset time characteristics*

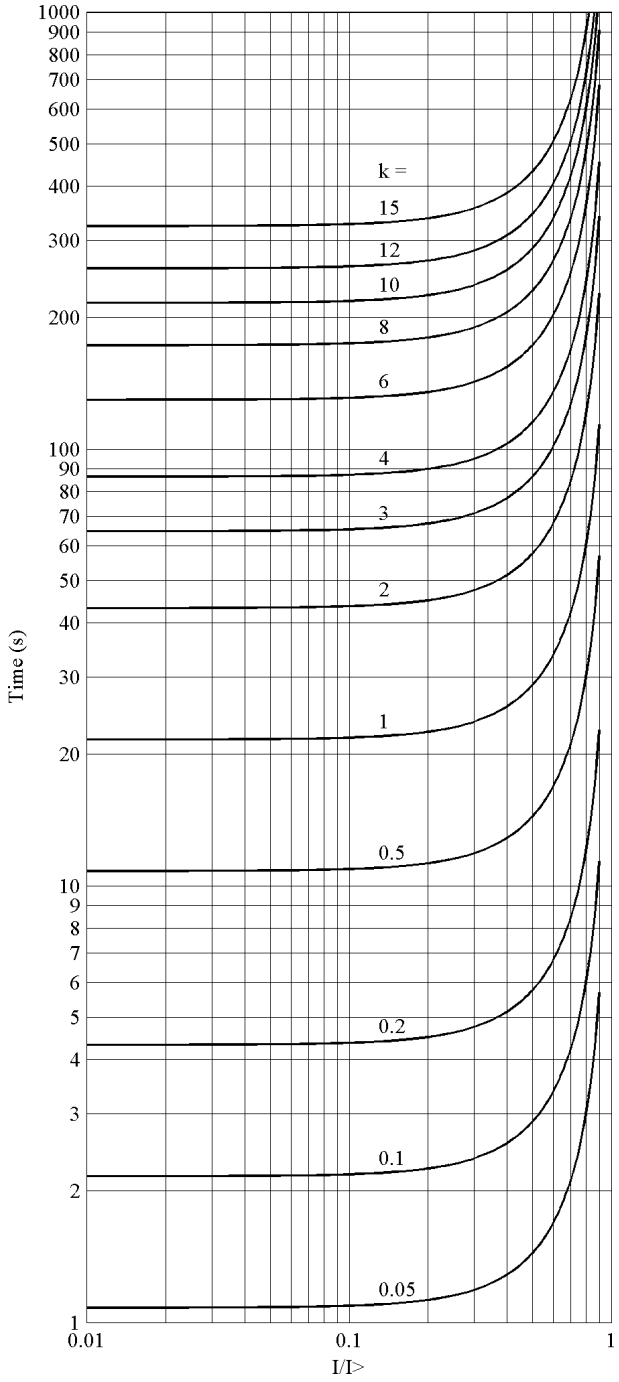



*Figure 1006: ANSI very inverse reset time characteristics*

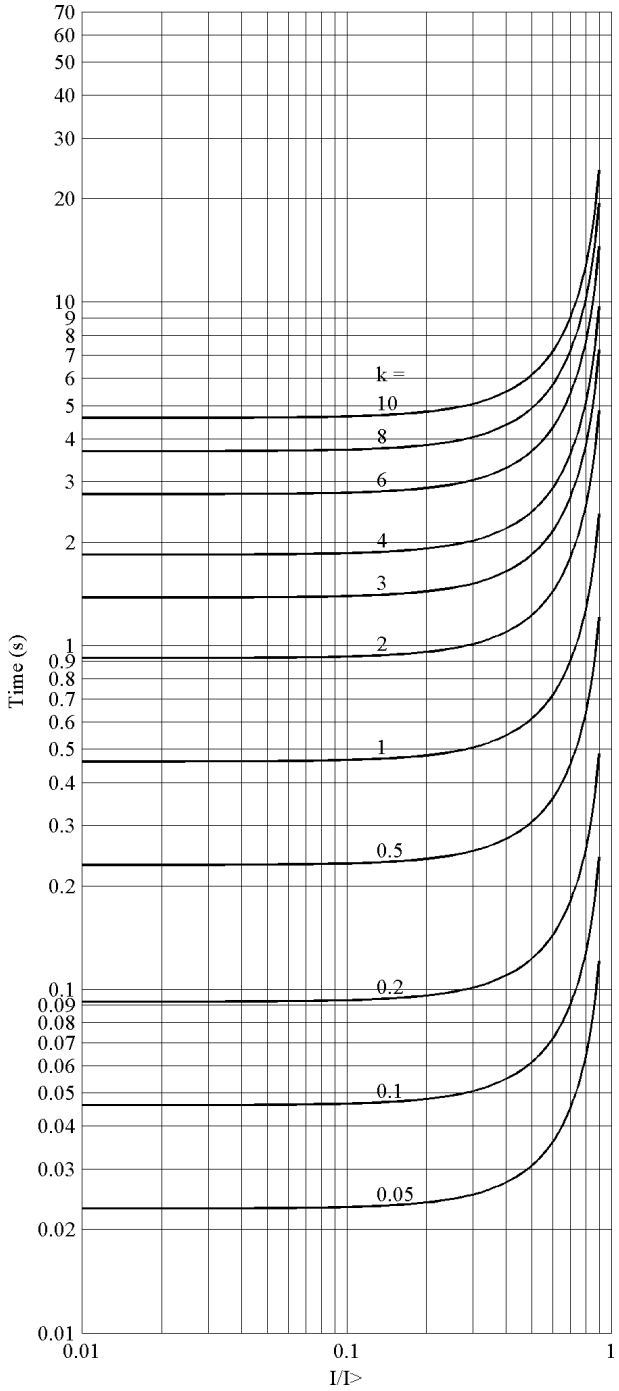



*Figure 1007: ANSI normal inverse reset time characteristics*

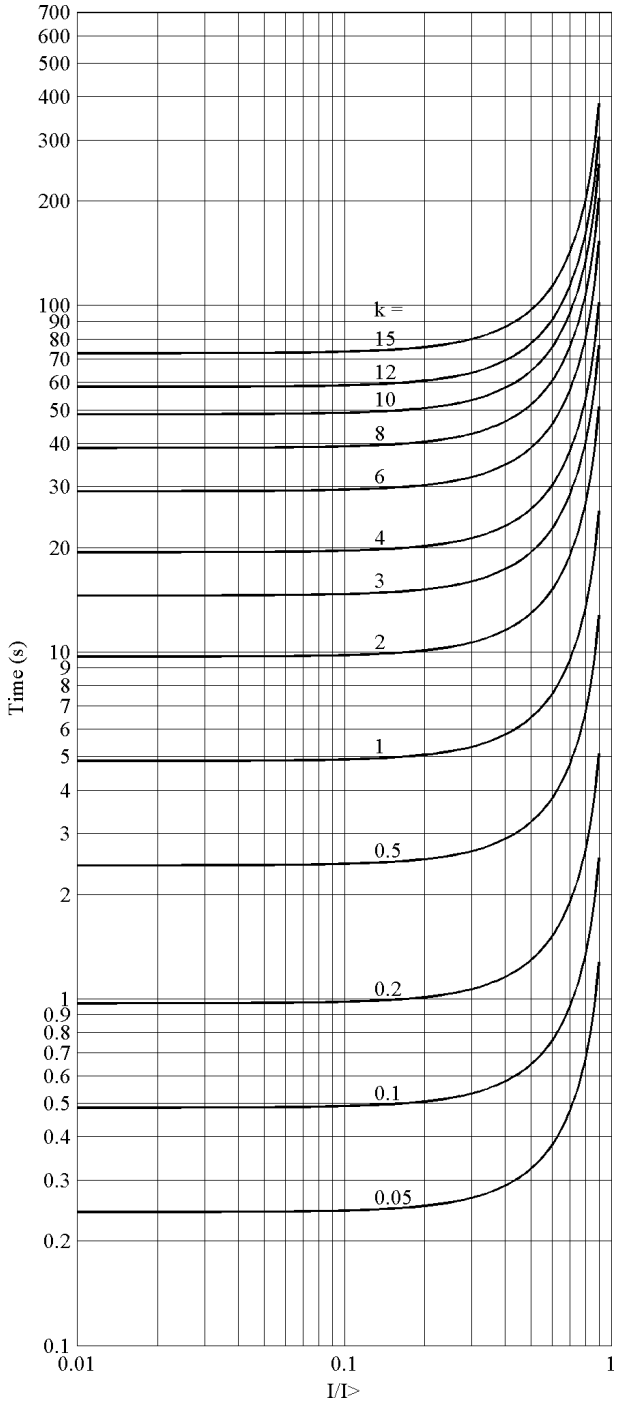



*Figure 1008: ANSI moderately inverse reset time characteristics*

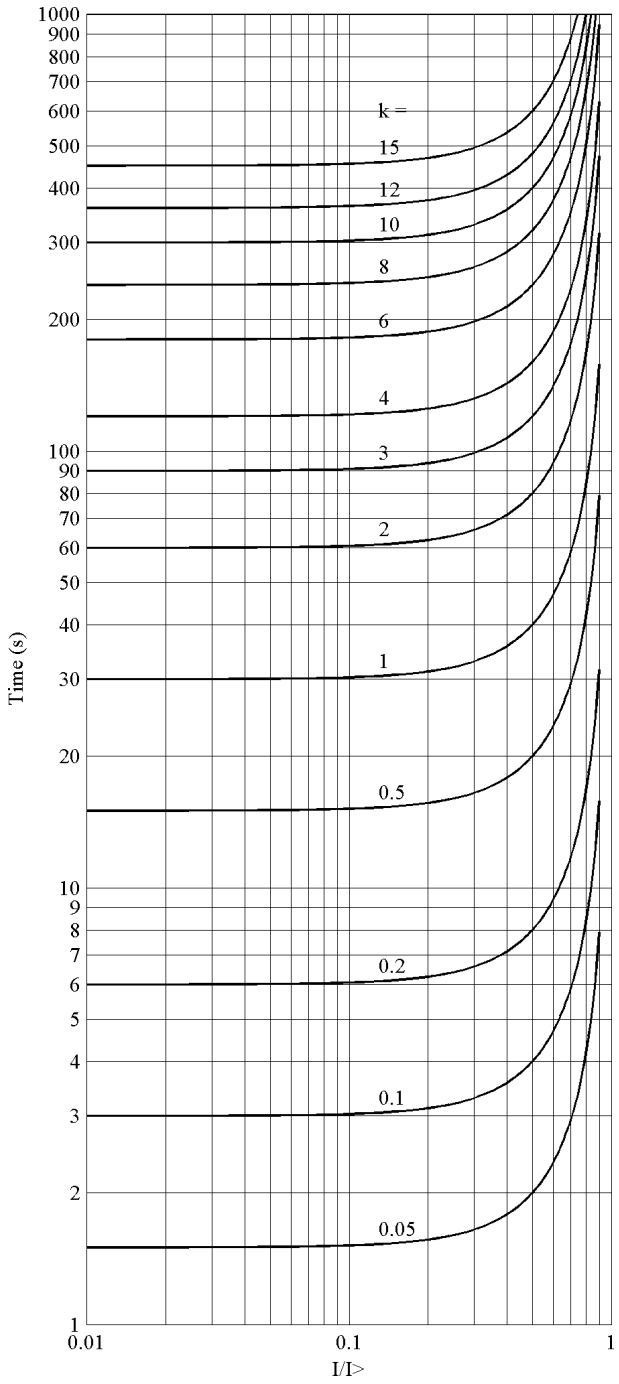



*Figure 1009: ANSI long-time extremely inverse reset time characteristics*

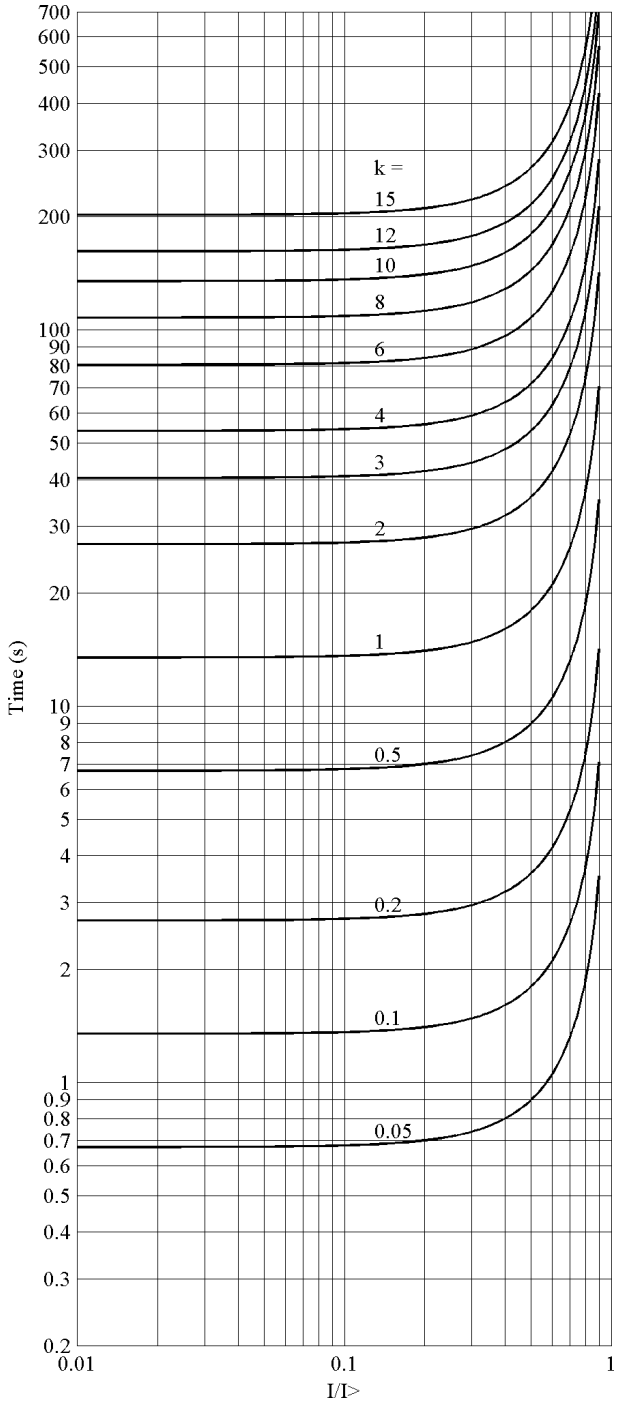



*Figure 1010: ANSI long-time very inverse reset time characteristics*

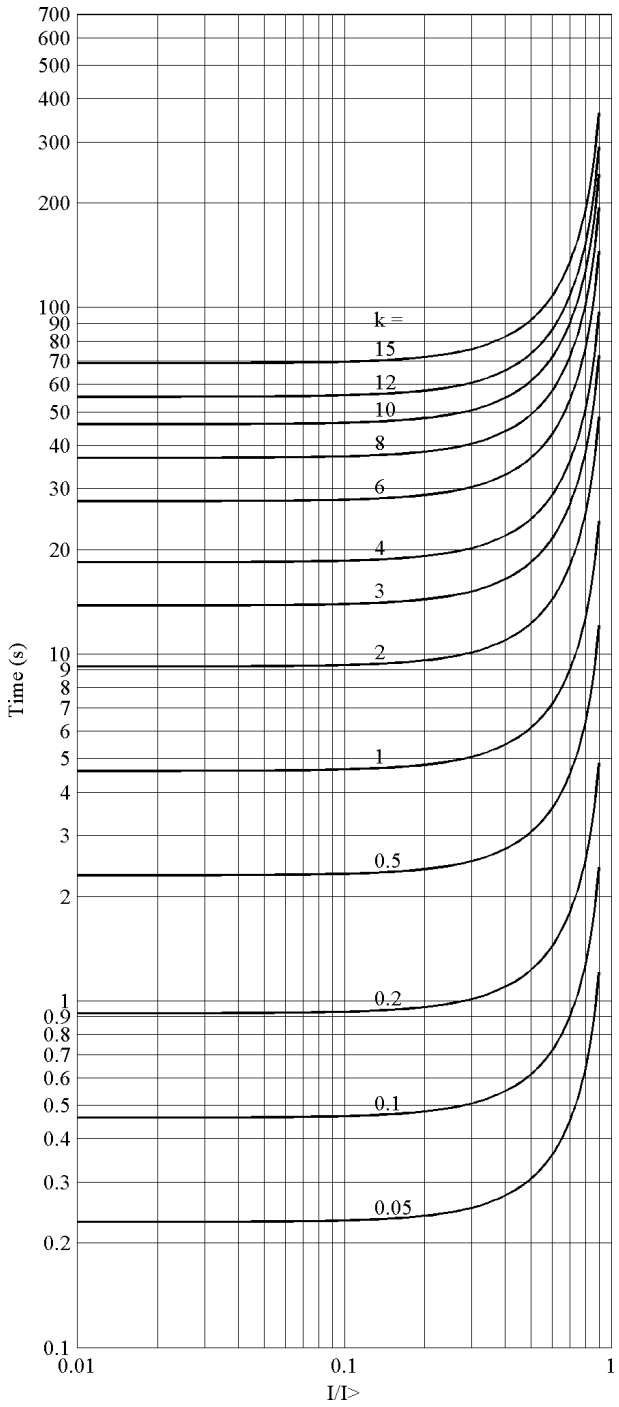



*Figure 1011: ANSI long-time inverse reset time characteristics*

The delayed inverse-time reset is not available for IEC-type inverse time curves.

**User-programmable delayed inverse reset**

The user can define the delayed inverse reset time characteristics with the following formula using the set *Curve parameter D*.

$$t[s] = \left| \frac{D}{\left(\frac{I}{I>}\right)^2 - 1} \right| \cdot k$$

(Equation 398)

The delayed inverse reset time depends also on the protection function's start duration value START_DUR. The reset time on the drop-off moment can be calculated by multiplying t[s] with START_DUR.

| | |
|---|---|
| t[s] | Reset time (in seconds) |
| k | Set *Time multiplier* |
| D | Set *Curve parameter D* |
| I | Measured current |
| I> | Set *Start value* |

### 11.2.3 Inverse-timer freezing

When the BLOCK input is active, the internal value of the time counter is frozen at the value of the moment just before the freezing. Freezing of the counter value is chosen when the user does not wish the counter value to count upwards or to be reset. This may be the case, for example, when the inverse-time function of a protection relay needs to be blocked to enable the definite-time operation of another protection relay for selectivity reasons, especially if different relaying techniques (old and modern relays) are applied.

The selected blocking mode is "Freeze timer".

The activation of the BLOCK input also lengthens the minimum delay value of the timer.

Activating the BLOCK input alone does not affect the operation of the START output. It still becomes active when the current exceeds the set *Start value*, and inactive when the current falls below the set *Start value* and the set *Reset delay time* has expired.

## 11.3 Voltage based inverse definite minimum time characteristics

### 11.3.1 IDMT curves for overvoltage protection

In inverse-time modes, the operate time depends on the momentary value of the voltage, the higher the voltage, the faster the operate time. The operate time calculation or integration starts immediately when the voltage exceeds the set value of the *Start value* setting and the START output is activated.

The OPERATE output of the component is activated when the cumulative sum of the integrator calculating the overvoltage situation exceeds the value set by the inverse time mode. The set value depends on the selected curve type and the setting values used. The user determines the curve scaling with the *Time multiplier* setting.

The *Minimum operate time* setting defines the minimum operate time for the IDMT mode, that is, it is possible to limit the IDMT based operate time for not becoming too short. For example:

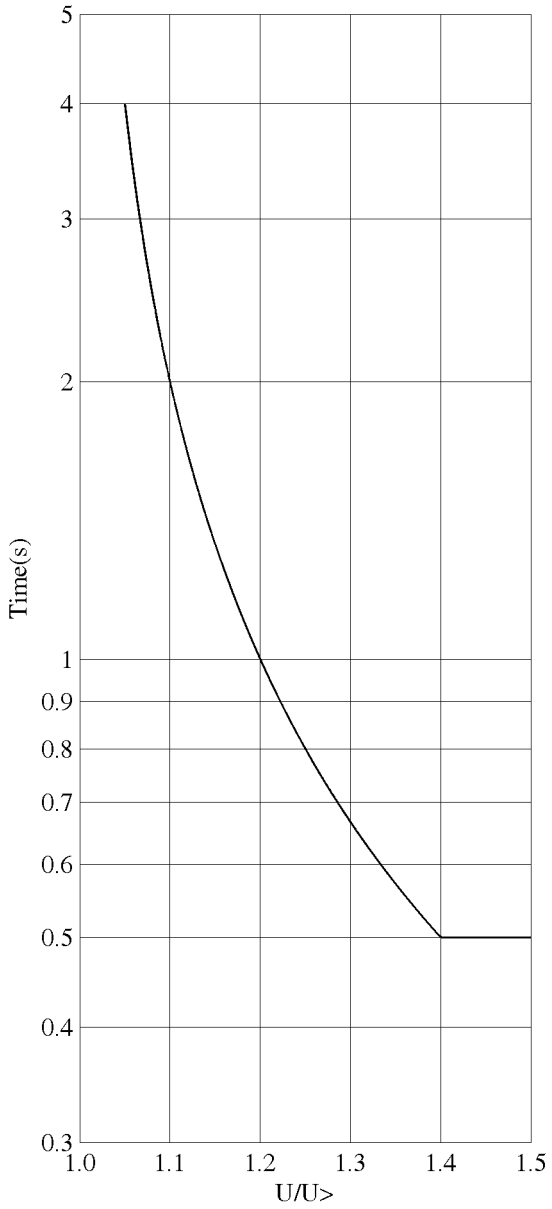



*Figure 1012: Operate time curve based on IDMT characteristic with Minimum operate time set to 0.5 second*

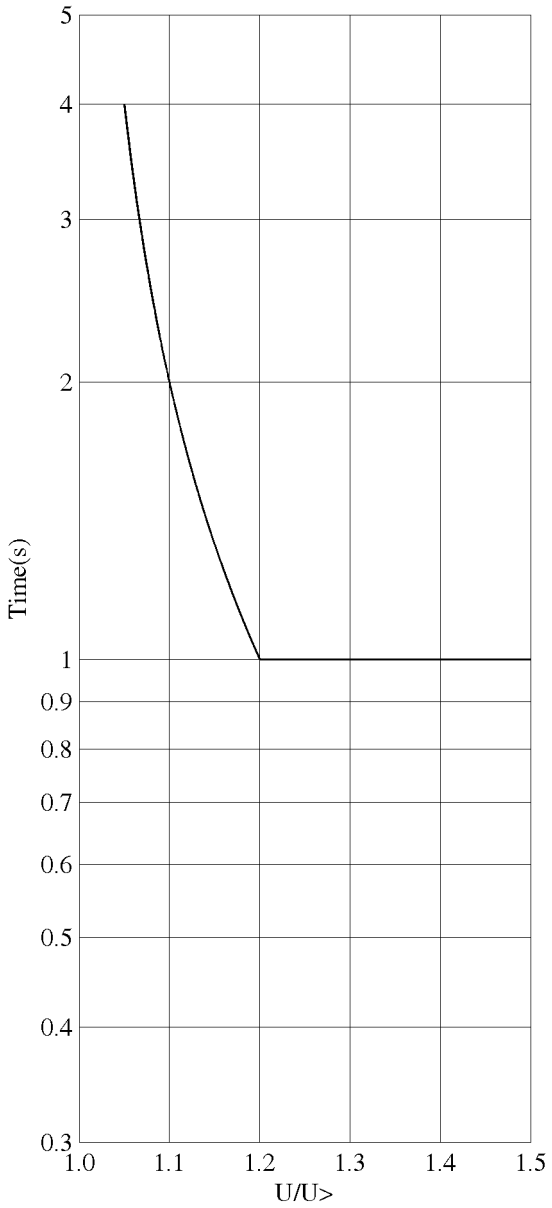



*Figure 1013: Operate time curve based on IDMT characteristic with Minimum operate time set to 1 second*

### 11.3.1.1 Standard inverse-time characteristics for overvoltage protection

The operate times for the standard overvoltage IDMT curves are defined with the coefficients A, B, C, D and E.

The inverse operate time can be calculated with the formula:

$$t\left[s\right] = \frac{k \cdot A}{\left(B \times \frac{U - U>}{U>} - C\right)^{E}} + D$$

(Equation 399)

t [s] Operate time in seconds
U Measured voltage
U> Set value of *Start value*
k Set value of *Time multiplier*

**Table 1654: Curve coefficients for the standard overvoltage IDMT curves**

| Curve name | A | B | C | D | E |
|---|---|---|---|---|---|
| (17) Inverse Curve A | 1 | 1 | 0 | 0 | 1 |
| (18) Inverse Curve B | 480 | 32 | 0.5 | 0.035 | 2 |
| (19) Inverse Curve C | 480 | 32 | 0.5 | 0.035 | 3 |

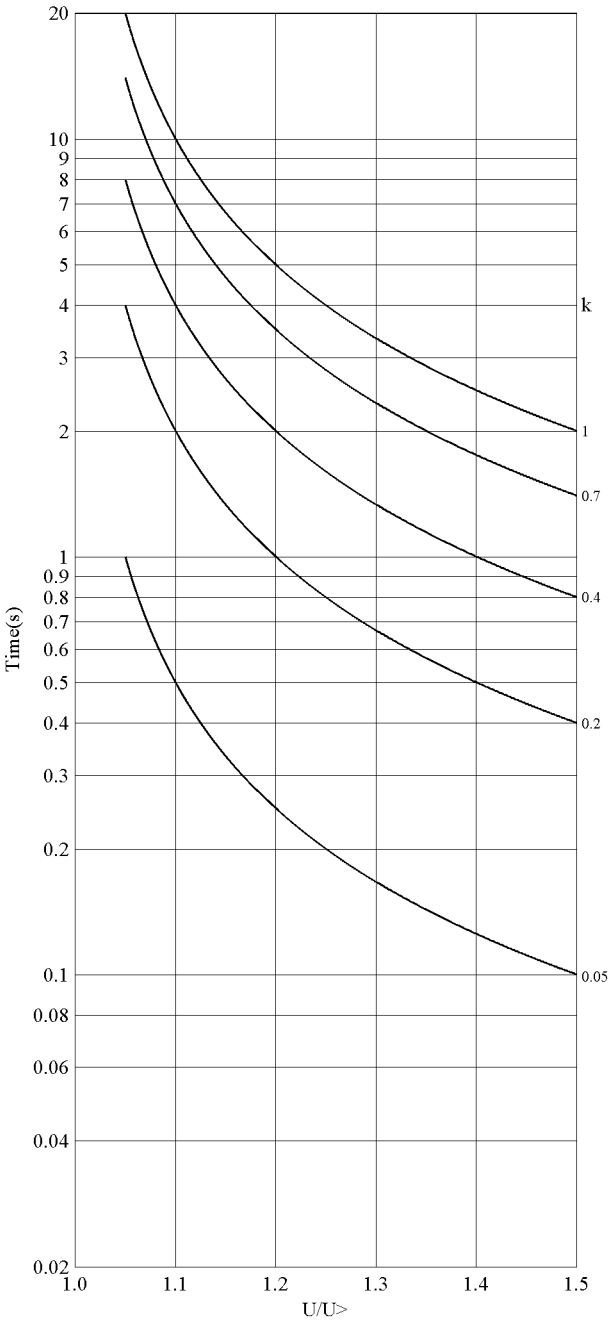



*Figure 1014: Inverse curve A characteristic of overvoltage protection*

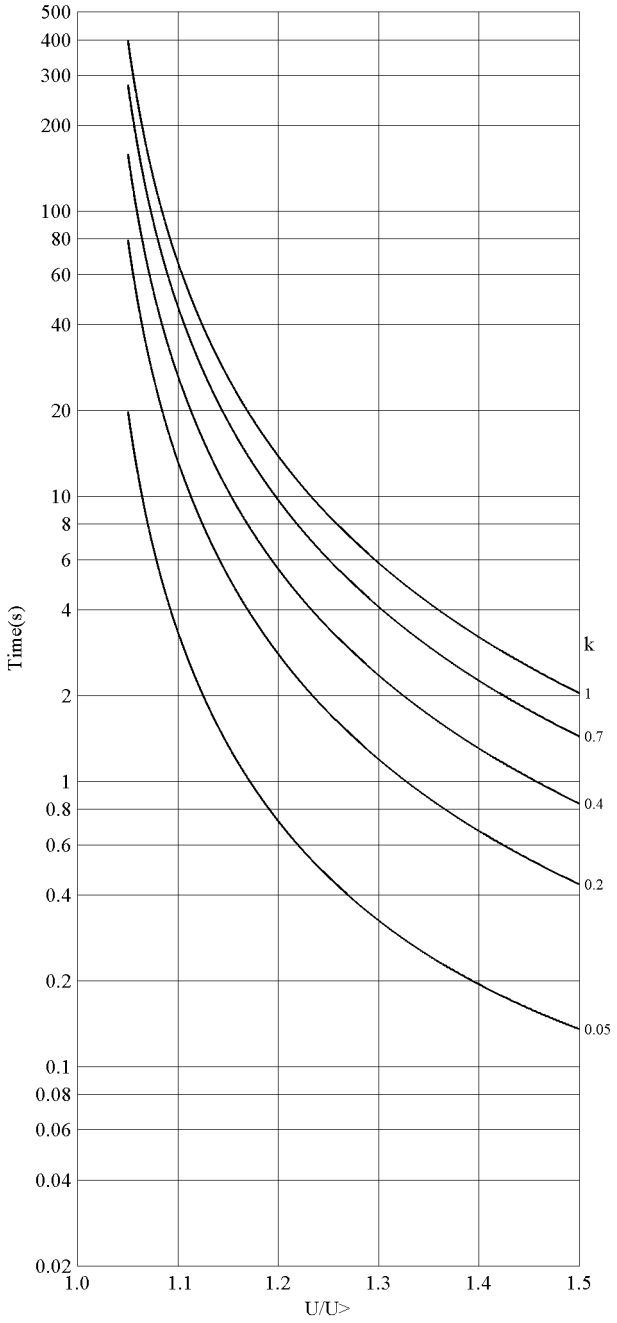



*Figure 1015: Inverse curve B characteristic of overvoltage protection*

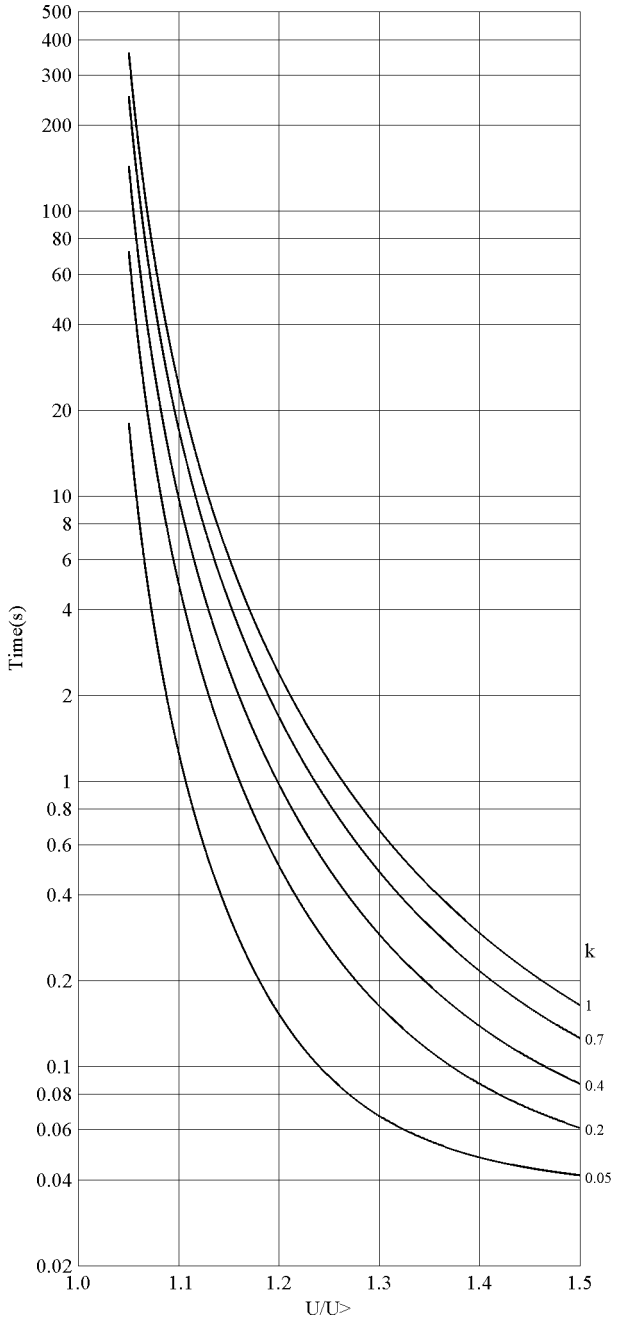



*Figure 1016: Inverse curve C characteristic of overvoltage protection*

### 11.3.1.2 User programmable inverse-time characteristics for overvoltage protection

The user can define the curves by entering the parameters using the standard formula:

$$t\left[s\right] = \frac{k \cdot A}{\left(B \times \frac{U - U>}{U>} - C\right)^{E}} + D$$

(Equation 400)

| | |
|---|---|
| t[s] | Operate time in seconds |
| A | Set value of *Curve parameter A* |
| B | Set value of *Curve parameter B* |
| C | Set value of *Curve parameter C* |
| D | Set value of *Curve parameter D* |
| E | Set value of *Curve parameter E* |
| U | Measured voltage |
| U> | Set value of *Start value* |
| k | Set value of *Time multiplier* |

#### 11.3.1.3 IDMT curve saturation of overvoltage protection

For the overvoltage IDMT mode of operation, the integration of the operate time does not start until the voltage exceeds the value of *Start value*. To cope with discontinuity characteristics of the curve, a specific parameter for saturating the equation to a fixed value is created. The *Curve Sat Relative* setting is the parameter and it is given in percents compared to *Start value*. For example, due to the curve equation B and C, the characteristics equation output is saturated in such a way that when the input voltages are in the range of *Start value* to *Curve Sat Relative* in percent over *Start value*, the equation uses *Start value* * (1.0 + *Curve Sat Relative* / 100 ) for the measured voltage. Although, the curve A has no discontinuities when the ratio U/U> exceeds the unity, *Curve Sat Relative* is also set for it. The *Curve Sat Relative* setting for curves A, B and C is 2.0 percent. However, it should be noted that the user must carefully calculate the curve characteristics concerning the discontinuities in the curve when the programmable curve equation is used. Thus, the *Curve Sat Relative* parameter gives another degree of freedom to move the inverse curve on the voltage ratio axis and it effectively sets the maximum operate time for the IDMT curve because for the voltage ratio values affecting by this setting, the operation time is fixed, that is, the definite time, depending on the parameters but no longer the voltage.

### 11.3.2 IDMT curves for undervoltage protection

In the inverse-time modes, the operate time depends on the momentary value of the voltage, the lower the voltage, the faster the operate time. The operate time calculation or integration starts immediately when the voltage goes below the set value of the *Start value* setting and the START output is activated.

The OPERATE output of the component is activated when the cumulative sum of the integrator calculating the undervoltage situation exceeds the value set by the inverse-time mode. The set value depends on the selected curve type and the setting values used. The user determines the curve scaling with the *Time multiplier* setting.

The *Minimum operate time* setting defines the minimum operate time possible for the IDMT mode. For setting a value for this parameter, the user should carefully study the particular IDMT curve.

### 11.3.2.1 Standard inverse-time characteristics for undervoltage protection

The operate times for the standard undervoltage IDMT curves are defined with the coefficients A, B, C, D and E.

The inverse operate time can be calculated with the formula:

$$t\left[s\right] = \frac{k \cdot A}{\left(B \times \frac{U < -U}{U <} - C\right)^{E}} + D$$

(Equation 401)

| | |
|---|---|
| t [s] | Operate time in seconds |
| U | Measured voltage |
| U< | Set value of the *Start value* setting |
| k | Set value of the *Time multiplier* setting |

**Table 1655: Curve coefficients for standard undervoltage IDMT curves**

| Curve name | A | B | C | D | E |
|---|---|---|---|---|---|
| (21) Inverse Curve A | 1 | 1 | 0 | 0 | 1 |
| (22) Inverse Curve B | 480 | 32 | 0.5 | 0.055 | 2 |

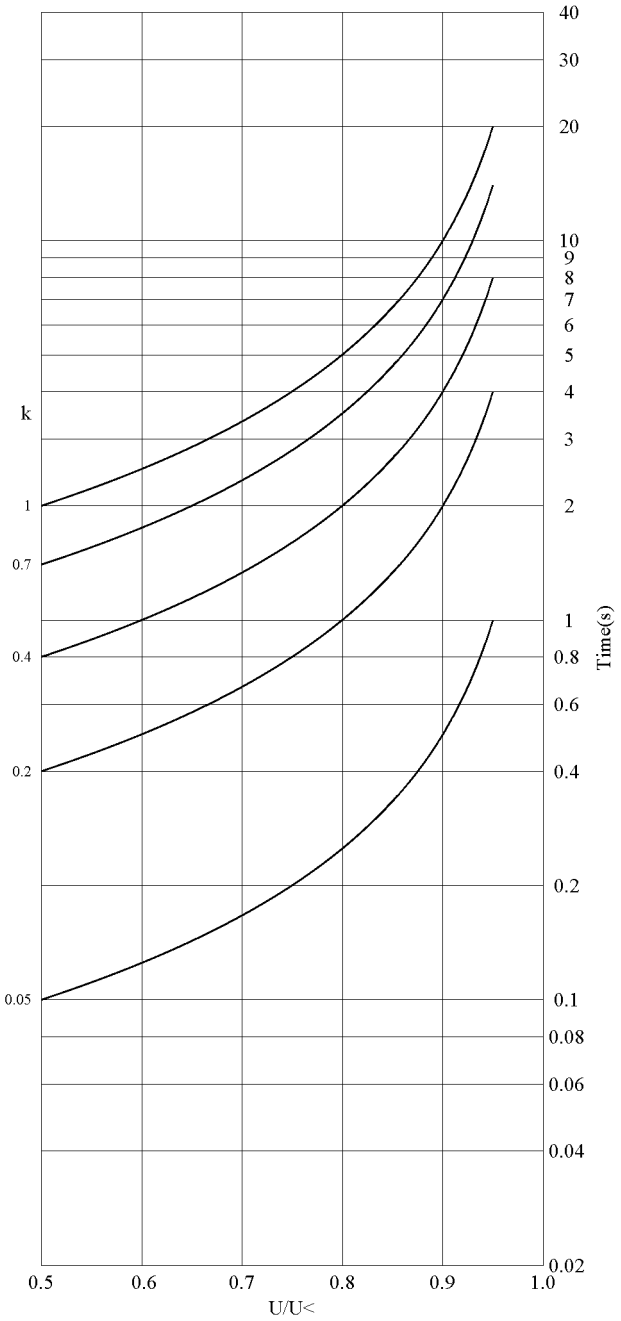



*Figure 1017: : Inverse curve A characteristic of undervoltage protection*

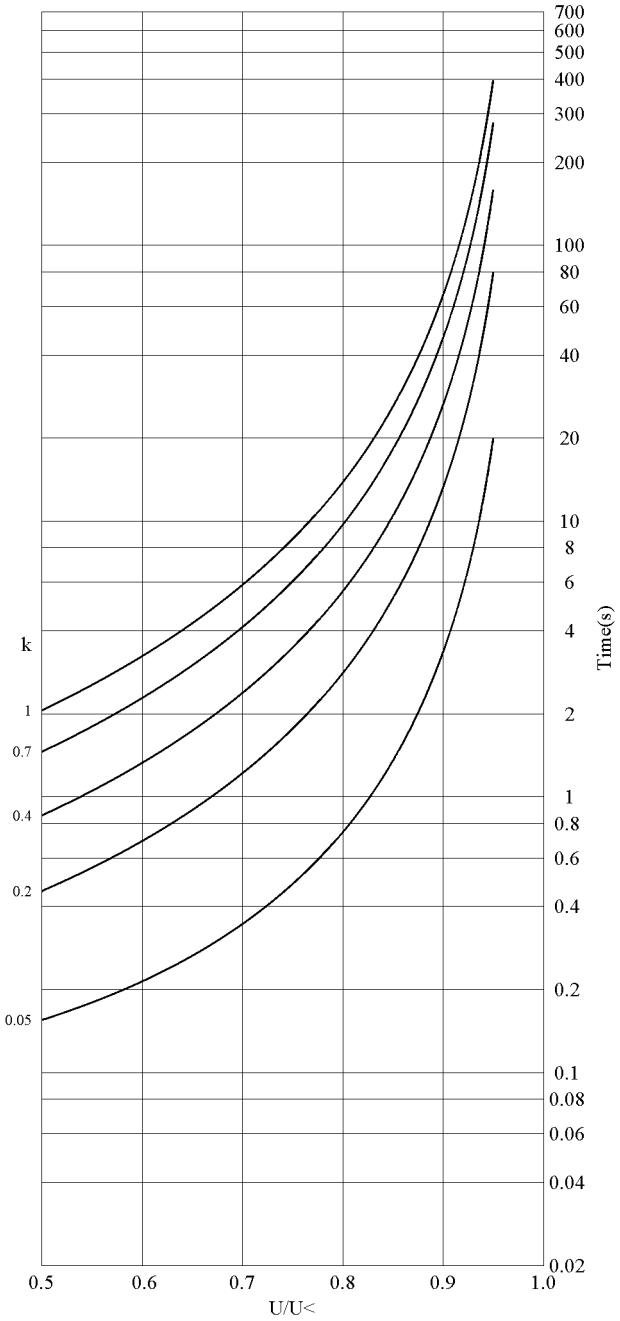



*Figure 1018: Inverse curve B characteristic of undervoltage protection*

### 11.3.2.2 User-programmable inverse-time characteristics for undervoltage protection

The user can define curves by entering parameters into the standard formula:

$$t\left[s\right] = \frac{k \cdot A}{\left(B \times \frac{U < -U}{U <} - C\right)^{E}} + D$$

(Equation 402)

| | |
|---|---|
| t[s] | Operate time in seconds |
| A | Set value of *Curve parameter A* |
| B | Set value of *Curve parameter B* |
| C | Set value of *Curve parameter C* |
| D | Set value of *Curve parameter D* |
| E | Set value of *Curve parameter E* |
| U | Measured voltage |
| U< | Set value of *Start value* |
| k | Set value of *Time multiplier* |

### 11.3.2.3 IDMT curve saturation of undervoltage protection

For the undervoltage IDMT mode of operation, the integration of the operate time does not start until the voltage falls below the value of *Start value*. To cope with discontinuity characteristics of the curve, a specific parameter for saturating the equation to a fixed value is created. The *Curve Sat Relative* setting is the parameter and it is given in percents compared with *Start value*. For example, due to the curve equation B, the characteristics equation output is saturated in such a way that when input voltages are in the range from *Start value* to *Curve Sat Relative* in percents under *Start value*, the equation uses *Start value* * (1.0 - *Curve Sat Relative*/ 100 ) for the measured voltage. Although, the curve A has no discontinuities when the ratio U/U> exceeds the unity, *Curve Sat Relative* is set for it as well. The *Curve Sat Relative* setting for curves A, B and C is 2.0 percent. However, it should be noted that the user must carefully calculate the curve characteristics concerning also discontinuities in the curve when the programmable curve equation is used. Thus, the *Curve Sat Relative* parameter gives another degree of freedom to move the inverse curve on the voltage ratio axis and it effectively sets the maximum operate time for the IDMT curve because for the voltage ratio values affecting by this setting, the operation time is fixed, that is, the definite time, depending on the parameters but no longer the voltage.

## 11.4 Frequency measurement and protection

All the function blocks that use frequency quantity as their input signal share the common features related to the frequency measurement algorithm. The frequency estimation is done from one phase (phase-to-phase or phase voltage) or from the positive phase sequence ( PPS). The voltage groups with three-phase inputs use PPS as the source. The frequency measurement range is 0.6...1.5 × $F_n$. (For REG615 the range is 0.2...1.4 × $F_n$ when *Frequency adaptivity* is enabled.) The df/dt measurement range always starts from 0.6 × $F_n$. When the frequency exceeds these limits, it is regarded as out of range and a minimum or maximum value is held as the measured value respectively with appropriate quality information. The frequency estimation requires 160 ms to stabilize after a bad quality signal. Therefore, a delay

of 160 ms is added to the transition from the bad quality. The bad quality of the signal can be due to restrictions like:

- The source voltage is below 0.02 × $U_n$ at $F_n$.
- The source voltage waveform is discontinuous.
- The source voltage frequency rate of change exceeds 15 Hz/s (including stepwise frequency changes).

When the bad signal quality is obtained, the nominal or zero (depending on the *Def frequency Sel* setting) frequency value is shown with appropriate quality information in the measurement view. The frequency protection functions are blocked when the quality is bad, thus the timers and the function outputs are reset. When the frequency is out of the function block's setting range but within the measurement range, the protection blocks are running. However, the `OPERATE` outputs are blocked until the frequency restores to a valid range.

## 11.5 Frequency adaptivity and generator start-up protection

Frequency adaptivity enables sensitive and selective protection during the start-up and shutdown phase of the generator when low frequency and low voltage amplitude exist at the same time. Sensitive protection is necessary because, for example, the fault current level in generator internal fault during start-up or shutdown (when field excitation is not present) may not exceed even the nominal current level.

Frequency adaptivity can be enabled by setting *Frequency adaptivity* and setting one UTVTR *Frequency adaptivity* to "Main frequency source". One additional UTVTR or ILTCTR can be set to "Backup frequency source". For main or backup frequency source, all three-phases must be connected. Each TxTR block that is set to Frequency adaptivity mode enable outputs measurements adapted to either main or backup source frequency depending on their availability.



See the Preprocessing blocks chapter for more information.



Harmonics calculation is limited to 2nd, 3rd and 5th harmonic when frequency adaptivity is enabled.

The frequency adaptivity uses the positive-sequence voltage in the frequency tracking and adapts the DFT, RMS, peak-to-peak and peak measurement accuracies of the current and voltage inputs by using the tracked frequency in the operation range of 0.2...1.5 xFn. Frequency adaptation starts when the generator terminal positive-sequence voltage level exceeds 0.04 xUn (minimum level). If frequency adaptivity backup source is currents their positive sequence must exceed 0.07 xIn to be usable as backup source. Backup source threshold limit is valid at nominal frequency and threshold increases when frequency deviates from nominal (up to 0.35 xIn or 0.2 xUn at 0.2 xFn or 0.11 xIn or 0.06 xUn at 1.5 xFn). As the Synchronism and energizing check (SECRSYN) bus voltage U12b voltage input always expects *Rated frequency*, the frequency adaptivity does not apply for this input.

If the generator terminal positive-sequence voltage is below the minimum level, the relay is not able to maintain frequency adaptation. The non-adaptive situation is

indicated by function Protection output FRQ_ADP_FAIL. When frequency adaptivity uses backup frequency source, the FRQ_ADP_BU output is activated. The tracked frequency is retained for 3 seconds until the FRQ_ADP_FAIL output is activated and Rated frequency is expected. Outputs FRQ_ADP_FAIL, FRQ_ADP_BU and FRQ_ADP_WARN can be used in the application configuration, if necessary.



See function block Protection for more information.

The operation accuracy of the protection functions in the range of 0.2...1.5 xFn can be assumed to be according to the technical data given separately for each function. Slight deviations in operation accuracy are possible outside the frequency range specified in technical data. Operate time accuracy and reset times given in technical data are only valid in the frequency range specified for each function.

The specified operate times are expected to increase at lower frequency due to longer network cycles.

Frequency adaptivity depends on the availability of voltages or currents. The generator start-up protection can be also extended by using wide peak-to-peak measurement mode (operational from 2 Hz upward) with designated start-up overcurrent protection function (PHLPTOC). Before the generator is connected with the rest of the network by closing the circuit breaker, the designated start-up overcurrent function should be either blocked or its start value increased, as the *Start value* setting is typically lower than the nominal current.

## 11.6 Measurement modes

In many current or voltage dependent function blocks, there are various alternative measuring principles.

- RMS
- DFT which is a numerically calculated fundamental component of the signal
- Peak-to-peak
- Peak-to-peak with peak backup
- Wide peak-to-peak

Consequently, the measurement mode can be selected according to the application.

In extreme cases, for example with high overcurrent or harmonic content, the measurement modes function in a slightly different way. The operation accuracy is defined with the frequency range of f/fn=0.95...1.05. In peak-to-peak and RMS measurement modes, the harmonics of the phase currents are not suppressed, whereas in the fundamental frequency measurement the suppression of harmonics is at least -50 dB at the frequency range of f= n x fn, where n = 2, 3, 4, 5,...

### RMS

The RMS measurement principle is selected with the *Measurement mode* setting using the value "RMS". RMS consists of both AC and DC components. The AC component is the effective mean value of the positive and negative peak values. RMS is used in applications where the effect of the DC component must be taken into account.

RMS is calculated according to the formula:

$$I_{RMS} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} I_i^2}$$

(Equation 403)

| | |
|---|---|
| n | Number of samples in a calculation cycle |
| $I_i$ | Current sample value |

**DFT**

The DFT measurement principle is selected with the *Measurement mode* setting using the value "DFT". In the DFT mode, the fundamental frequency component of the measured signal is numerically calculated from the samples. In some applications, for example, it can be difficult to accomplish sufficiently sensitive settings and accurate operation of the low stage, which may be due to a considerable amount of harmonics on the primary side currents. In such a case, the operation can be based solely on the fundamental frequency component of the current. In addition, the DFT mode has slightly higher CT requirements than the peak-to-peak mode, if used with high and instantaneous stages.

**Peak-to-peak**

The peak-to-peak measurement principle is selected with the *Measurement mode* setting using the value "Peak-to-Peak". It is the fastest measurement mode, in which the measurement quantity is made by calculating the average from the positive and negative peak values. The DC component is not included. The retardation time is short. The damping of the harmonics is quite low and practically determined by the characteristics of the anti-aliasing filter of the protection relay inputs. Consequently, this mode is usually used in conjunction with high and instantaneous stages, where the suppression of harmonics is not so important. In addition, the peak-to-peak mode allows considerable CT saturation without impairing the performance of the operation.

**Peak-to-peak with peak backup**

The peak-to-peak with peak backup measurement principle is selected with the *Measurement mode* setting using the value "P-to-P+backup". It is similar to the peak-to-peak mode, with the exception that it has been enhanced with the peak backup. In the peak-to-peak with peak backup mode, the function starts with two conditions: the peak-to-peak value is above the set start current or the peak value is above two times the set *Start value*. The peak backup is enabled only when the function is used in the DT mode in high and instantaneous stages for faster operation.

**Wide peak-to-peak**

The wide peak-to-peak measurement principle is available in products where it is necessary for overcurrent protection to operate already starting from as low frequency as 2 Hz during the generator start-up or shutdown phase. The wide peakto-peak measurement principle is selected with the *Measurement mode* setting "Wide P-to-P".

The measurement mode calculates the average from the positive and negative peak values over the 500 ms wide measurement window, independently of the *Frequency adaptivity* setting value. Retardation and reset times are longer due to the length

of the measurement window. The frequency of the fault current affects the operate time. The damping of the harmonics is quite low and practically determined by the characteristics of the anti-aliasing filter of the protection relay current inputs.

When using measurement mode “Wide P-to-P”, the protection relay accepts only *Operate delay time* setting value 800 ms or longer and *Operating curve type* 5=”ANSI Def. Time” or 15=”IEC Def. Time”.

Operation accuracy in the frequency range 2...85 Hz is ±1.5% or ±0.003 × $I_n$. Operate time accuracy in definite time mode is ±1.0% of the set value or ±60 ms when $I_{Fault}$ = 2 × set *Start value* and the fault current frequency is 10...85 Hz.

## 11.7 Calculated measurements

### Calculated residual current and voltage

The residual current is calculated from the phase currents according to equation:

$$\overline{Io} = -(\bar{I}_A + \bar{I}_B + \bar{I}_C)$$

(Equation 404)

The residual voltage is calculated from the phase-to-earth voltages when the VT connection is selected as “Wye” with the equation:

$$\overline{Uo} = (\overline{U}_A + \overline{U}_B + \overline{U}_C)/3$$

(Equation 405)

### Sequence components

The phase-sequence current components are calculated from the phase currents according to:

$$\bar{I}_0 = (\bar{I}_A + \bar{I}_B + \bar{I}_C)/3$$

(Equation 406)

$$\bar{I}_1 = (\bar{I}_A + a \cdot \bar{I}_B + a^2 \cdot \bar{I}_C)/3$$

(Equation 407)

$$\bar{I}_2 = (\bar{I}_A + a^2 \cdot \bar{I}_B + a \cdot \bar{I}_C)/3$$

(Equation 408)

The phase-sequence voltage components are calculated from the phase-to-earth voltages when *VT connection* is selected as “Wye” with the equations:

$$\overline{U}_0 = (\overline{U}_A + \overline{U}_B + \overline{U}_C)/3$$

(Equation 409)

$$\overline{U}_1 = (\overline{U}_A + a \cdot \overline{U}_B + a^2 \cdot \overline{U}_C)/3$$

(Equation 410)

$$\overline{U}_2 = (\overline{U}_A + a^2 \cdot \overline{U}_B + a \cdot \overline{U}_C)/3$$

(Equation 411)

When *VT connection* is selected as “Delta”, the positive and negative phase sequence voltage components are calculated from the phase-to-phase voltages according to the equations:

$$\overline{U}_1 = (\overline{U}_{AB} - a^2 \cdot \overline{U}_{BC})/3$$

(Equation 412)

$$\overline{U}_2 = (\overline{U}_{AB} - a \cdot \overline{U}_{BC})/3$$

(Equation 413)

The phase-to-earth voltages are calculated from the phase-to-phase voltages when *VT connection* is selected as "Delta" according to the equations.

$$\overline{U}_A = \overline{U}_0 + \left(\overline{U}_{AB} - \overline{U}_{CA}\right)/3$$

(Equation 414)

$$\overline{U}_B = \overline{U}_0 + \left(\overline{U}_{BC} - \overline{U}_{AB}\right)/3$$

(Equation 415)

$$\overline{U}_C = \overline{U}_0 + \left(\overline{U}_{CA} - \overline{U}_{BC}\right)/3$$

(Equation 416)

If the $\overline{U}_0$ channel is not valid, it is assumed to be zero.

The phase-to-phase voltages are calculated from the phase-to-earth voltages when *VT connection* is selected as "Wye" according to the equations.

$$\overline{U}_{AB} = \overline{U}_A - \overline{U}_B$$

(Equation 417)

$$\overline{U}_{BC} = \overline{U}_B - \overline{U}_C$$

(Equation 418)

$$\overline{U}_{CA} = \overline{U}_C - \overline{U}_A$$

(Equation 419)

# 11.8 Test mode

## 11.8.1 Functionality

The mode of all the logical nodes in the relay's IEC 61850 data model can be set with *Test mode*. *Test mode* activation method can be changed via parameter **Configuration** > **System** > **Test mode selection**. Available activation methods are "Local", "Local+remote, maintenance", "Local+Remote, all levels" and "Binary input". By default, *Test mode* activation method is "Local" which means the test mode can be activated only via LHMI through parameter **Tests** > **IED test** > **Test mode**. The remote activation method via binary input or via IEC 61850 communication is possible (LD0.LLN0.Mod). When the binary input is selected as the test mode activation method, the behavior can be configured with the application configuration.

**Table 1656: Test mode**

| Test mode | Description | Protection BEH_BLK | Protection BEH_TST |
|---|---|---|---|
| Normal mode | Normal operation | FALSE | FALSE |
| IED blocked | Protection working as in “Normal mode” but ACT configuration can be used to block physical outputs to process. Control function commands blocked. | TRUE | FALSE |
| IED test | Protection works as in “Normal mode” but protection functions work in parallel with test parameters | FALSE | TRUE |
| IED test and blocked | Protection works as in “Normal mode” but protection functions work in parallel with the test parameter. The ACT configuration can be used to block physical outputs to process. The control function command is blocked. | TRUE | TRUE |



See function block Protection for more details.



The behavior data objects in all logical nodes follow LD0.LLN0.Mod value. If "Normal mode" is selected, the behavior data objects follow the mode (.Mod) data object of the corresponding logical device.



Vertical and horizontal communication is not blocked by the “IED blocked” or “IED test and blocked” modes.

## 11.8.2 Application configuration and Test mode

The breaker and disconnector outputs from control commands to process are blocked with ”IED blocked” and “IED test and blocked” modes. If physical outputs

need to be blocked from the protection, the application configuration must be used to block these signals. The blocking scheme needs to use BEH_BLK output of PROTECTION function block.

BEH_BLK signal can be used to

- Connect to TRPPTRC BLOCK input. This is the best option when all protection signaling goes through the master trip function.
- Connect to necessary protection function BLOCK inputs.
- Create logic condition for physical outputs to block state changes when BEH_BLK is active.

## 11.8.3 Control mode

The mode of all logical nodes located under CTRL logical device can be set with *Control mode*. The *Control mode* parameter is available via the HMI or PCM600 path **Configuration** > **Control** > **General**. By default, *Control mode* can only be set locally through LHMI. *Control mode* inherits its value from *Test mode* but *Control mode* "On", "Blocked" and "Off" can also be set independently. *Control mode* is also available via IEC 61850 communication (CTRL.LLN0.Mod).

**Table 1657: Control mode**

| Control mode | Description | Control BEH_BLK |
|---|---|---|
| On | Normal operation | FALSE |
| Blocked | Control function commands blocked | TRUE |
| Off | Control functions disabled | FALSE |

See function block Control for more details.

The behavior data objects under CTRL logical device follow CTRL.LLN0.Mod value. If "On" is selected, behavior data objects follow the mode of the corresponding logical device.

## 11.8.4 Application configuration and Control mode

The physical outputs from commands to process are blocked with "Blocked" mode. If physical outputs need to be blocked totally, meaning also commands from the binary inputs, the application configuration must be used to block these signals. Blocking scheme uses BEH_BLK output of CONTROL function block.

## 11.8.5 Authorization

By default, *Test mode* and *Control mode* can only be changed from LHMI. It is possible to write test mode by remote client if it is needed in configuration. This is done via LHMI by setting parameter *Test mode selection* via **Configuration** > **System**. Remote operation is possible only when the relay's control position is in remote position. Local and remote control can be selected with R/L button or via Control function block in application configuration.

When using the Signal Monitoring tool to force online values, the following conditions need to be met.

- *Remote force* is set to “All levels”
- *Test mode* is enabled
- The relay's control position is in remote position.

**Table 1658: Test mode selection**

| Test mode selection | LHMI | 61850-8-1-MMS | WHMI | Binary input |
|---|---|---|---|---|
| Local | Yes | No access | No access | No access |
| Local+Remote, Maintenance | Yes | Command originator category maintenance | No access | No access |
| Local+Remote, All levels | Yes | All originator categories | Yes | No access |
| Binary input | No access | No access | No access | Yes |

## 11.8.6 LHMI indications

The Home button flashes green with low frequency indicating that one of the test mode options, that is, “IED blocked”, “IED test and blocked” or "IED test", is activated.

# 12 Requirements for measurement transformers

## 12.1 Current transformers

### 12.1.1 Current transformer requirements for overcurrent protection

For reliable and correct operation of the overcurrent protection, the CT has to be chosen carefully. The distortion of the secondary current of a saturated CT may endanger the operation, selectivity, and co-ordination of protection. However, when the CT is correctly selected, a fast and reliable short circuit protection can be enabled.

The selection of a CT depends not only on the CT specifications but also on the network fault current magnitude, desired protection objectives, and the actual CT burden. The protection settings of the protection relay should be defined in accordance with the CT performance as well as other factors.

#### 12.1.1.1 Current transformer accuracy class and accuracy limit factor

The rated accuracy limit factor ($F_n$) is the ratio of the rated accuracy limit primary current to the rated primary current. For example, a protective current transformer of type 5P10 has the accuracy class 5P and the accuracy limit factor 10. For protective current transformers, the accuracy class is designed by the highest permissible percentage composite error at the rated accuracy limit primary current prescribed for the accuracy class concerned, followed by the letter "P" (meaning protection).

**Table 1659: Limits of errors according to IEC 60044-1 for protective current transformers**

| Accuracy class | Current error at rated primary current (%) | Phase displacement at rated primary current | | Composite error at rated accuracy limit primary current (%) |
|---|---|---|---|---|
| | | minutes | centiradians | |
| 5P | ±1 | ±60 | ±1.8 | 5 |
| 10P | ±3 | – | – | 10 |

The accuracy classes 5P and 10P are both suitable for non-directional overcurrent protection. The 5P class provides a better accuracy. This should be noted also if there are accuracy requirements for the metering functions (current metering, power metering, and so on) of the protection relay.

The CT accuracy primary limit current describes the highest fault current magnitude at which the CT fulfils the specified accuracy. Beyond this level, the secondary current of the CT is distorted and it might have severe effects on the performance of the protection relay.

In practise, the actual accuracy limit factor ($F_a$) differs from the rated accuracy limit factor ($F_n$) and is proportional to the ratio of the rated CT burden and the actual CT burden.

The actual accuracy limit factor is calculated using the formula:

$$F_a \approx F_n \times \frac{|S_{in} + S_n|}{|S_{in} + S|}$$

| | |
|---|---|
| $F_n$ | the accuracy limit factor with the nominal external burden $S_n$ |
| $S_{in}$ | the internal secondary burden of the CT |
| S | the actual external burden |

### 12.1.1.2 Non-directional overcurrent protection

#### Current transformer selection

Non-directional overcurrent protection does not set high requirements on the accuracy class or on the actual accuracy limit factor ($F_a$) of the CTs. It is, however, recommended to select a CT with $F_a$ of at least 20.

The nominal primary current $I_{1n}$ should be chosen in such a way that the thermal and dynamic strength of the current measuring input of the protection relay is not exceeded. This is always fulfilled when

$I_{1n} > I_{kmax} / 100$,

$I_{kmax}$ is the highest fault current.

The saturation of the CT protects the measuring circuit and the current input of the protection relay. For that reason, in practice, even a few times smaller nominal primary current can be used than given by the formula.

#### Recommended start current settings

If $I_{kmin}$ is the lowest primary current at which the highest set overcurrent stage is to operate, the start current should be set using the formula:

*Current start value* < 0.7 × ($I_{kmin}$ / $I_{1n}$)

$I_{1n}$ is the nominal primary current of the CT.

The factor 0.7 takes into account the protection relay inaccuracy, current transformer errors, and imperfections of the short circuit calculations.

The adequate performance of the CT should be checked when the setting of the high set stage overcurrent protection is defined. The operate time delay caused by the CT saturation is typically small enough when the overcurrent setting is noticeably lower than $F_a$.

When defining the setting values for the low set stages, the saturation of the CT does not need to be taken into account and the start current setting is simply according to the formula.

**Delay in operation caused by saturation of current transformers**

The saturation of CT may cause a delayed protection relay operation. To ensure the time selectivity, the delay must be taken into account when setting the operate times of successive protection relays.

With definite time mode of operation, the saturation of CT may cause a delay that is as long as the time constant of the DC component of the fault current, when the current is only slightly higher than the starting current. This depends on the accuracy limit factor of the CT, on the remanence flux of the core of the CT, and on the operate time setting.

With inverse time mode of operation, the delay should always be considered as being as long as the time constant of the DC component.

With inverse time mode of operation and when the high-set stages are not used, the AC component of the fault current should not saturate the CT less than 20 times the starting current. Otherwise, the inverse operation time can be further prolonged. Therefore, the accuracy limit factor $F_a$ should be chosen using the formula:

$F_a > 20 \times$ *Current start value* / $I_{1n}$

The *Current start value* is the primary start current setting of the protection relay.

### 12.1.1.3 Example for non-directional overcurrent protection

The following figure describes a typical medium voltage feeder. The protection is implemented as three-stage definite time non-directional overcurrent protection.

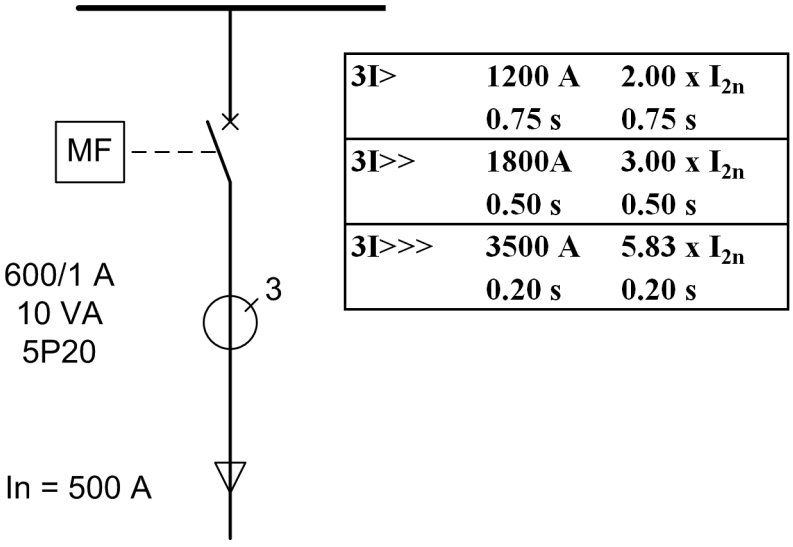



*Figure 1019: Example of three-stage overcurrent protection*

The maximum three-phase fault current is 41.7 kA and the minimum three-phase short circuit current is 22.8 kA. The actual accuracy limit factor of the CT is calculated to be 59.

The start current setting for low-set stage (3I>) is selected to be about twice the nominal current of the cable. The operate time is selected so that it is selective with the next protection relay (not visible in *Figure 1019*). The settings for the high-set stage and instantaneous stage are defined also so that grading is ensured with the downstream protection. In addition, the start current settings have to be defined so that the protection relay operates with the minimum fault current and it does not

operate with the maximum load current. The settings for all three stages are as in *Figure 1019*.

For the application point of view, the suitable setting for instantaneous stage (I>>>) in this example is 3 500 A (5.83 × $I_{2n}$). $I_{2n}$ is the 1.2 multiple with nominal primary current of the CT. For the CT characteristics point of view, the criteria given by the current transformer selection formula is fulfilled and also the protection relay setting is considerably below the $F_a$. In this application, the CT rated burden could have been selected much lower than 10 VA for economical reasons.

## 12.1.2 Current transformer requirements for transformer differential protection

The more important the object to be protected, the more attention has to be paid to the current transformers. It is not normally possible to dimension the current transformer so that they repeat the currents with high DC components without saturating when the residual flux of the current transformer is high. TR2PTDF and TR3PTDF operate reliably even though the current transformers are partially saturated.

The accuracy class recommended for current transformers to be used with TR2PTDF and TR3PTDF is 5P or X-type. In the 5P type, the limit of the current error at the rated primary current is 1 percent and the limit of the phase displacement is 60 minutes. The limit of the composite error at the rated accuracy limit primary current is 5 percent.

The approximate value of the accuracy limit factor $F_a$ corresponding to the actual current transformer burden can be calculated on the basis of the rated accuracy limit factor $F_n$ at the rated burden, the rated burden $S_n$, the internal burden $S_{in}$and the actual burden $S_a$ of the current transformer.

$$F_a = F_n \times \frac{S_{in} + S_n}{S_{in} + S_a}$$

(Equation 420)

| | |
|---|---|
| $F_a$ | The approximate value of the accuracy limit factor ( ALF) corresponding to the actual CT burden |
| $F_n$ | The rated accuracy limit factor at the rated burden of the current transformer |
| $S_n$ | The rated burden of the current transformer |
| $S_{in}$ | The internal burden of the current transformer |
| $S_a$ | The actual burden of the current transformer |

Class X defines the CT knee-point voltage $U_{kn}$ as a sinusoidal voltage applied to the CT secondary (primary open) which, when increased by 10 %, causes the CT magnetizing current to increase by 50 %. The relationship between the actual accuracy limit factor $F_a$ and the CT knee-point voltage, assuming resistive burden, is $U_{kn} = k * F_a * I_n * (R_{in} + R_a)$ where $I_n$ = CT rated secondary current, $R_{in}$ = CT internal resistance and $R_a$ = CT's actual burden in ohms. Factor k depends on the CT magnetizing curve. The value k = 1.0 is used in IEC 61869-2:2012.

**Example 1**

The rated burden $S_n$ of the current transformer 5P20 is 10 VA, the secondary rated current is 5A, the internal resistance $R_{in}$= 0.07 Ω and the accuracy limit factor $F_n$ corresponding to the rated burden is 20 (5P20). Thus the internal burden of the current transformer is $S_{in}$= $(5A)^2$ * 0.07 Ω = 1.75 VA. The input impedance of the protection relay at a rated current of 5A is < 20 mΩ. If the measurement conductors have a resistance of 0.113 Ω, the actual burden of the current transformer is $S_a$=$(5A)^2$ * (0.113 + 0.020) Ω = 3.33 VA. Thus the accuracy limit factor $F_a$ corresponding to the actual burden is approximately 46.

The CT burden can grow considerably at the rated current 5A. The actual burden of the current transformer decreases at the rated current of 1A while the repeatability simultaneously improves.

At faults occurring in the protected area, the currents may be very high compared to the rated currents of the current transformers. Due to the instantaneous stage of the differential function block, it is sufficient that the current transformers are capable of repeating the current required for instantaneous tripping during the first cycle.

Thus the current transformers usually are able to reproduce the asymmetric fault current without saturating within the next 10 ms after the occurrence of the fault to secure that the operate times of the protection relay comply with the retardation time.

The accuracy limit factors corresponding to the actual burden of the phase current transformer to be used in differential protection fulfill the requirement.

$$F_a > K_r \times Ik_{\max} \times (T_{dc} \times \omega \times (1 - e^{-T_m/T_{dc}}) + 1)$$

(Equation 421)

| | |
|---|---|
| $Ik_{max}$ | The maximum through-going fault current (in $I_r$) at which the protection is not allowed to operate |
| $T_{dc}$ | The primary DC time constant related to $Ik_{max}$ |
| ω | The angular frequency, that is, 2*π*fn |
| $T_m$ | The time-to-saturate, that is, the duration of the saturation free transformation |
| $K_r$ | The remanence factor 1/(1-r), where r is the maximum remanence flux in p.u. from saturation flux |

The accuracy limit factors corresponding to the actual burden of the phase current transformer is used in differential protection.

The parameter *r* is the maximum remanence flux density in the CT core in p.u. from saturation flux density. The value of the parameter *r* depends on the magnetic material used and on the construction of the CT. For instance, if the value of *r* = 0.4, the remanence flux density can be 40 percent of the saturation flux density. The manufacturer of the CT has to be contacted when an accurate value for the parameter *r* is needed. The value *r* = 0.4 is recommended to be used when an accurate value is not available.

The required minimum time-to-saturate $T_m$ in TR2PTDF and TR3PTDF is half fundamental cycle period (10 ms when fn = 50Hz).

Two typical cases are considered for the determination of the sufficient accuracy limit factor ($F_a$):

1. A fault occurring at the substation bus:

   The protection must be stable at a fault arising during a normal operating situation. Re-energizing the transformer against a bus fault leads to very high fault currents and thermal stress and therefore re-energizing is not preferred in this case. Thus, the remanence can be neglected.

   The maximum through-going fault current $Ik_{max}$ is typically 10 $I_r$ for a substation main transformer. At a short circuit fault close to the supply transformer, the DC time constant ($T_{dc}$) of the fault current is almost the same as that of the transformer, the typical value being 100 ms.

   | | |
   |---|---|
   | $Ik_{max}$ | 10 $I_r$ |
   | $T_{dc}$ | 100 ms |
   | ω | 100π Hz |
   | $T_m$ | 10 ms |
   | $K_r$ | 1 |

   When the values are substituted in *Equation 421*, the result is:

   $$F_a > K_r \times Ik_{\max} \times (T_{dc} \times \omega \times (1 - e^{-T_m / T_{dc}}) + 1) \approx 40$$

2. Re-energizing against a fault occurring further down in the network:

   The protection must be stable also during re-energization against a fault on the line. In this case, the existence of remanence is very probable. It is assumed to be 40 percent here.

   On the other hand, the fault current is now smaller and since the ratio of the resistance and reactance is greater in this location, having a full DC offset is not possible. Furthermore, the DC time constant ($T_{dc}$) of the fault current is now smaller, assumed to be 50 ms here.

   Assuming a maximum fault current being 30 percent lower than in the bus fault and a DC offset 90 percent of the maximum.

   | | |
   |---|---|
   | $Ik_{max}$ | 0.7* 10 = 7 ( $I_r$ ) |
   | $T_{dc}$ | 50 ms |
   | ω | 100π Hz |
   | $T_m$ | 10 ms |
   | $K_r$ | 1/(1-0.4) = 1.6667 |

   When the values are substituted in the equation, the result is:

   $$F_a > K_r \times Ik_{\max} \times 0.9 \times (T_{dc} \times \omega \times (1 - e^{-T_m / T_{dc}}) + 1) \approx 40$$

   If the actual burden of the current transformer ($S_a$) in *Equation 420* cannot be reduced low enough to provide a sufficient value for $F_a$, there are two alternatives to deal with the situation:

   - a CT with a higher rated burden $S_n$ can be chosen (which also means a higher rated accuracy limit $F_n$)

- a CT with a higher nominal primary current $I_{1n}$ (but the same rated burden) can be chosen

**Example 2**

Assuming that the actions according to alternative two above are taken in order to improve the actual accuracy limit factor:

$$F_a = \frac{IrCT}{IrTR} \times F_n$$

(Equation 422)

| | |
|---|---|
| IrTR | 1000 A (rated secondary side current of the power transformer) |
| IrCT | 1500 A (rated primary current of the CT on the transformer secondary side) |
| $F_n$ | 30 (rated accuracy limit factor of the CT) |
| $F_a$ | (IrCT / IrTR) * Fn (actual accuracy limit factor due to oversizing the CT) = (1500/1000) * 30 = 45 |

In TR2PTDF and TR3PTDF, it is important that the accuracy limit factors $F_a$ of the phase current transformers at both sides correspond with each other, that is, the burdens of the current transformers on both sides are to be as equal as possible. If high inrush or start currents with high DC components pass through the protected object when it is connected to the network, special attention is required for the performance and the burdens of the current transformers and for the settings of the function block.

# 13 Protection relay's physical connections

## 13.1 Module diagrams

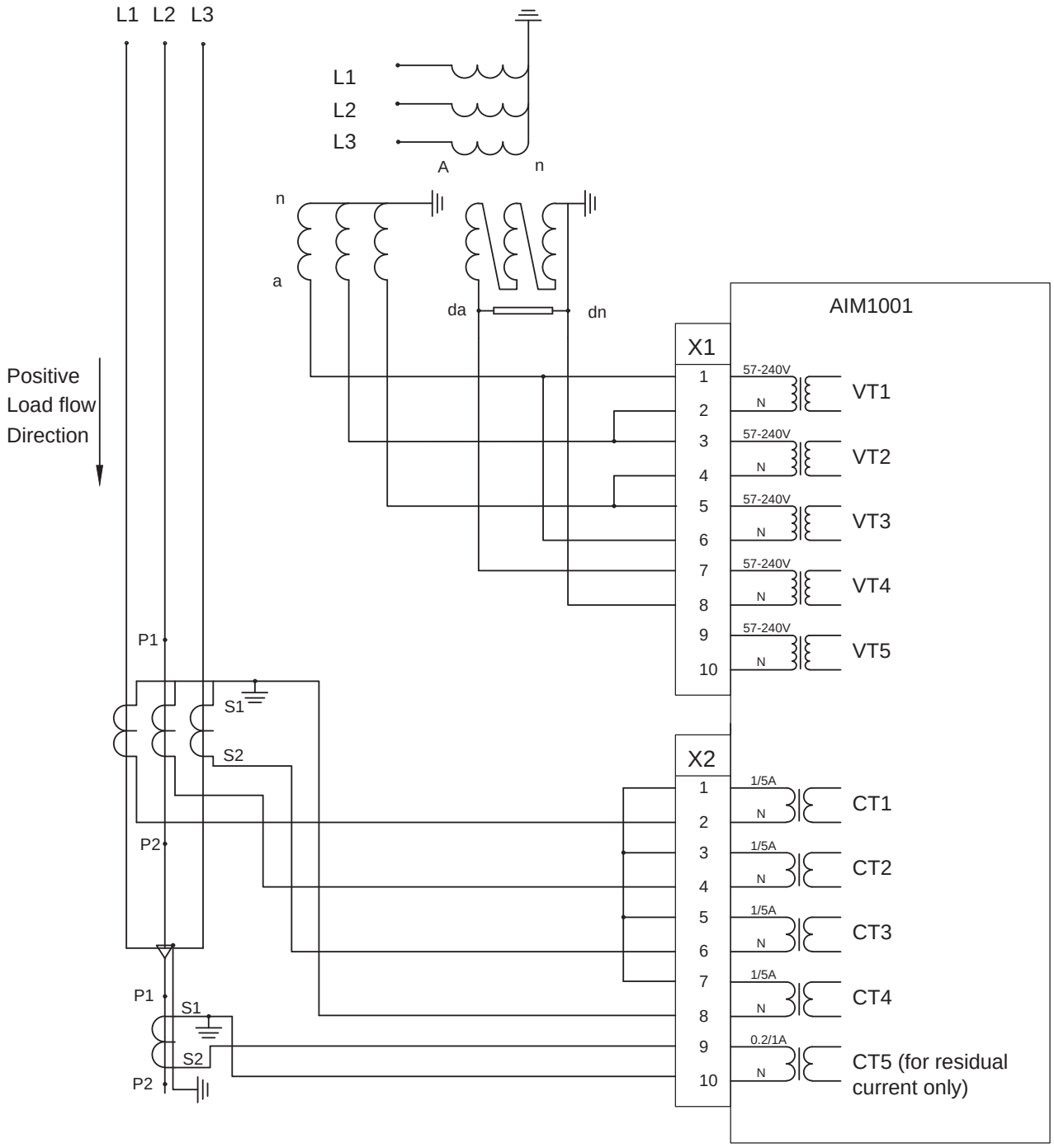



*Figure 1020: AIM1001 module*

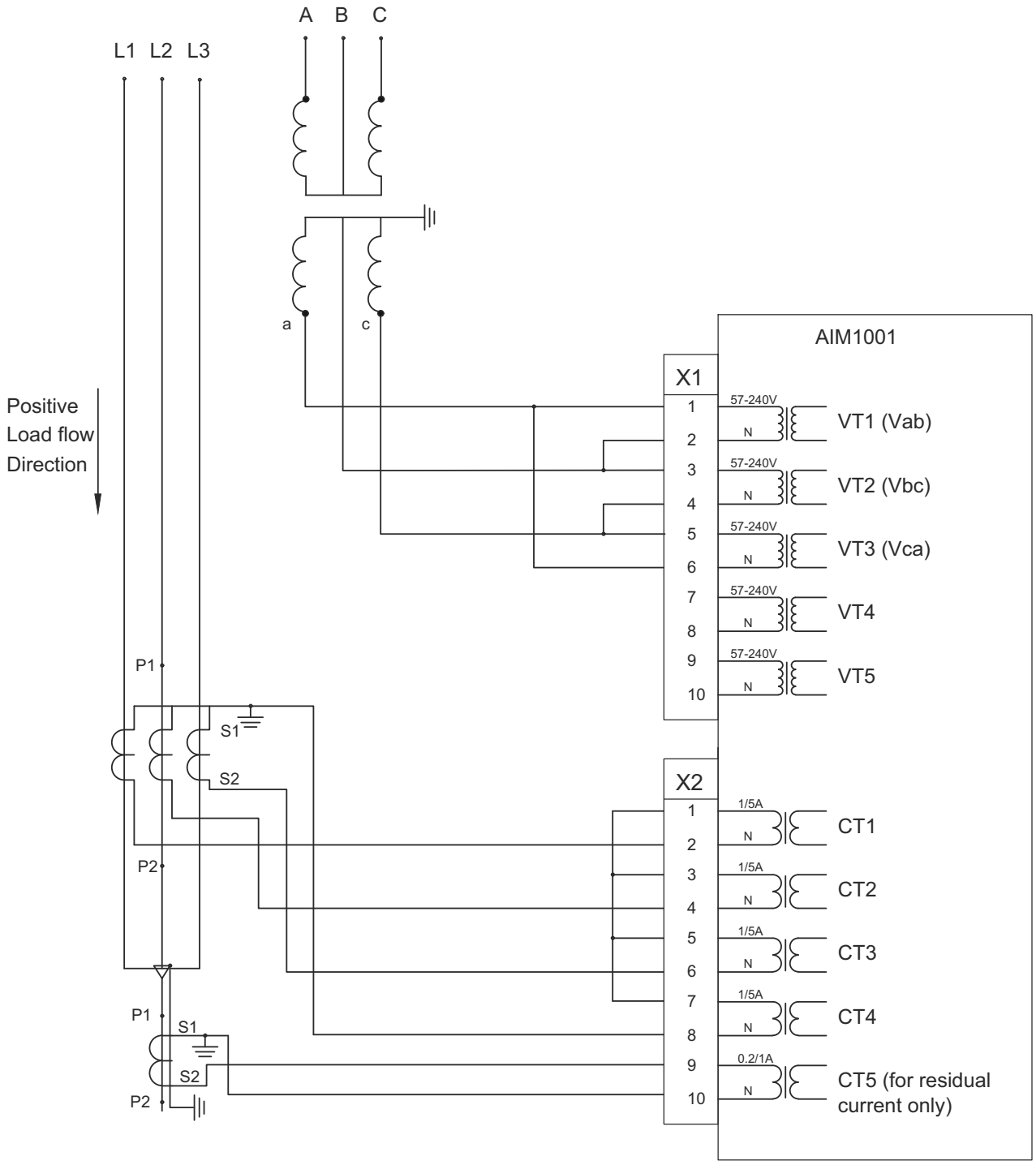



*Figure 1021: AIM1001 module (two phase-to-phase VTs)*

The two phase-to-phase VT connection is often referred as “open delta” (ANSI) or as “V” (IEC) connection. The relay measures all three phase-to-phase voltages using only two primary VTs. The relay will calculate the phase-to-ground voltages internally, with the assumption that the three-phase system is balanced, i.e. residual voltage is zero.

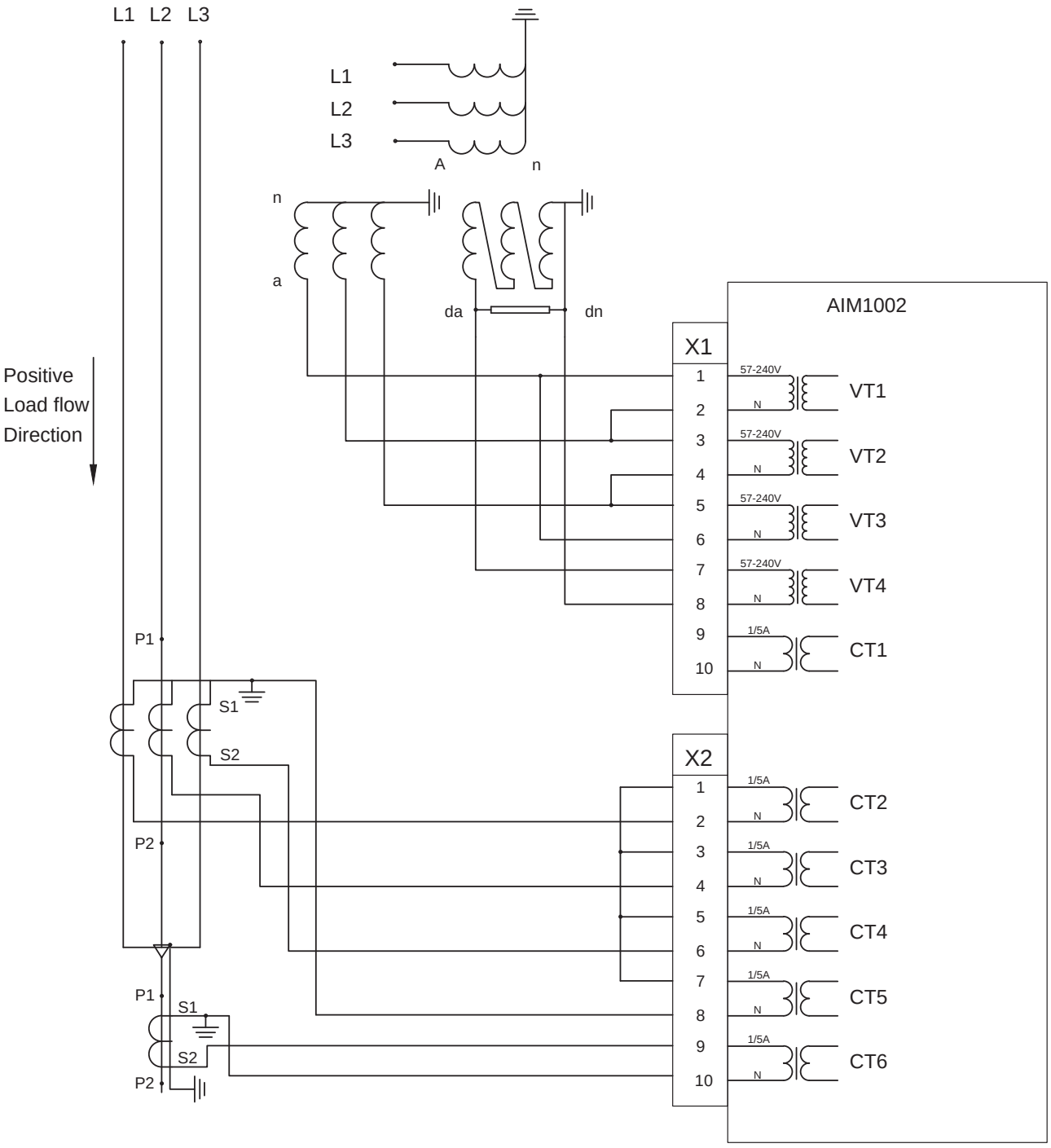



*Figure 1022: AIM1002 module*

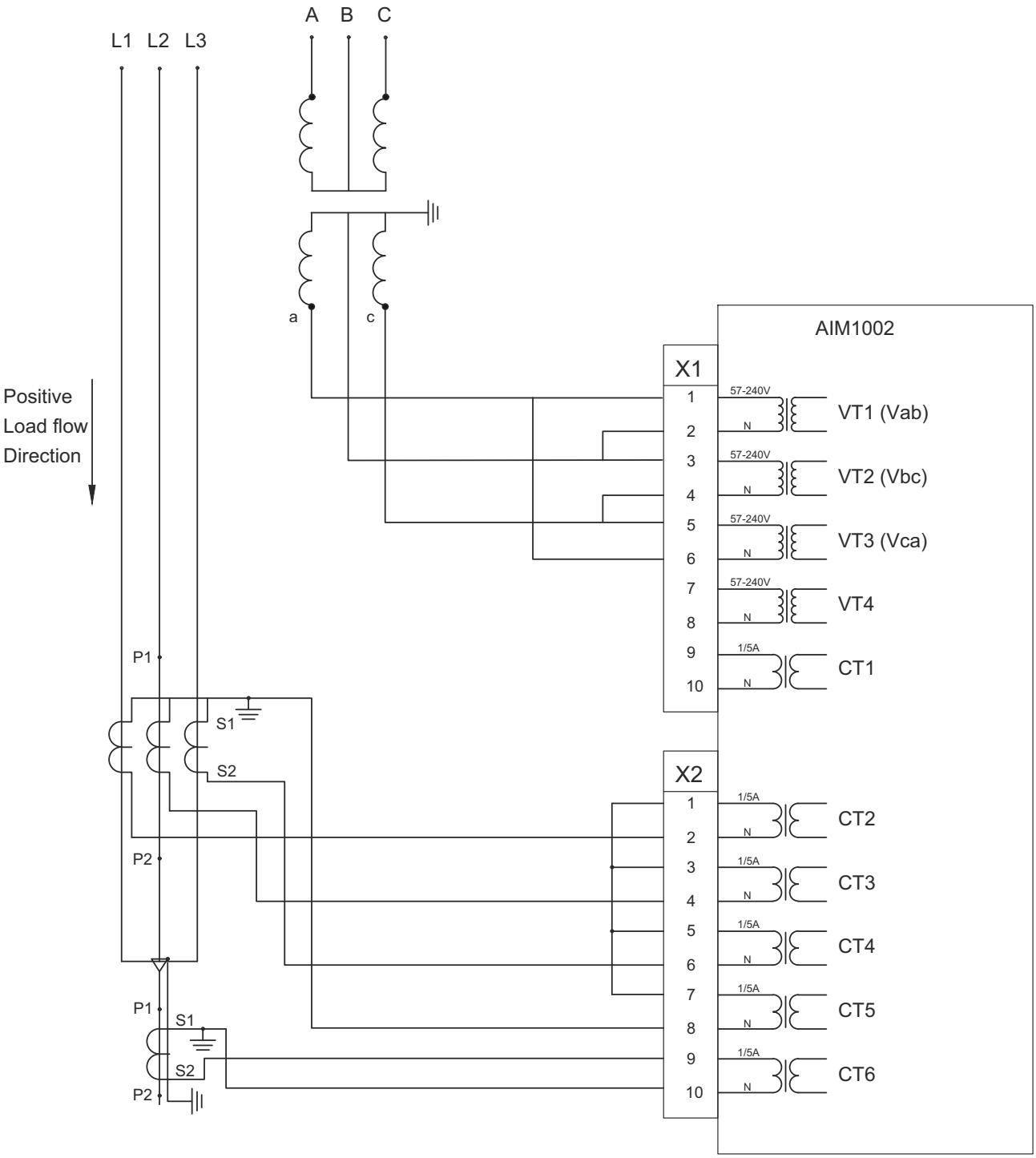



*Figure 1023: AIM1002 module (two phase-to-phase VTs)*

The two phase-to-phase VT connection is often referred as “open delta” (ANSI) or as “V” (IEC) connection. The relay measures all three phase-to-phase voltages using only two primary VTs. The relay will calculate the phase-to-ground voltages internally, with the assumption that the three-phase system is balanced, i.e. residual voltage is zero.

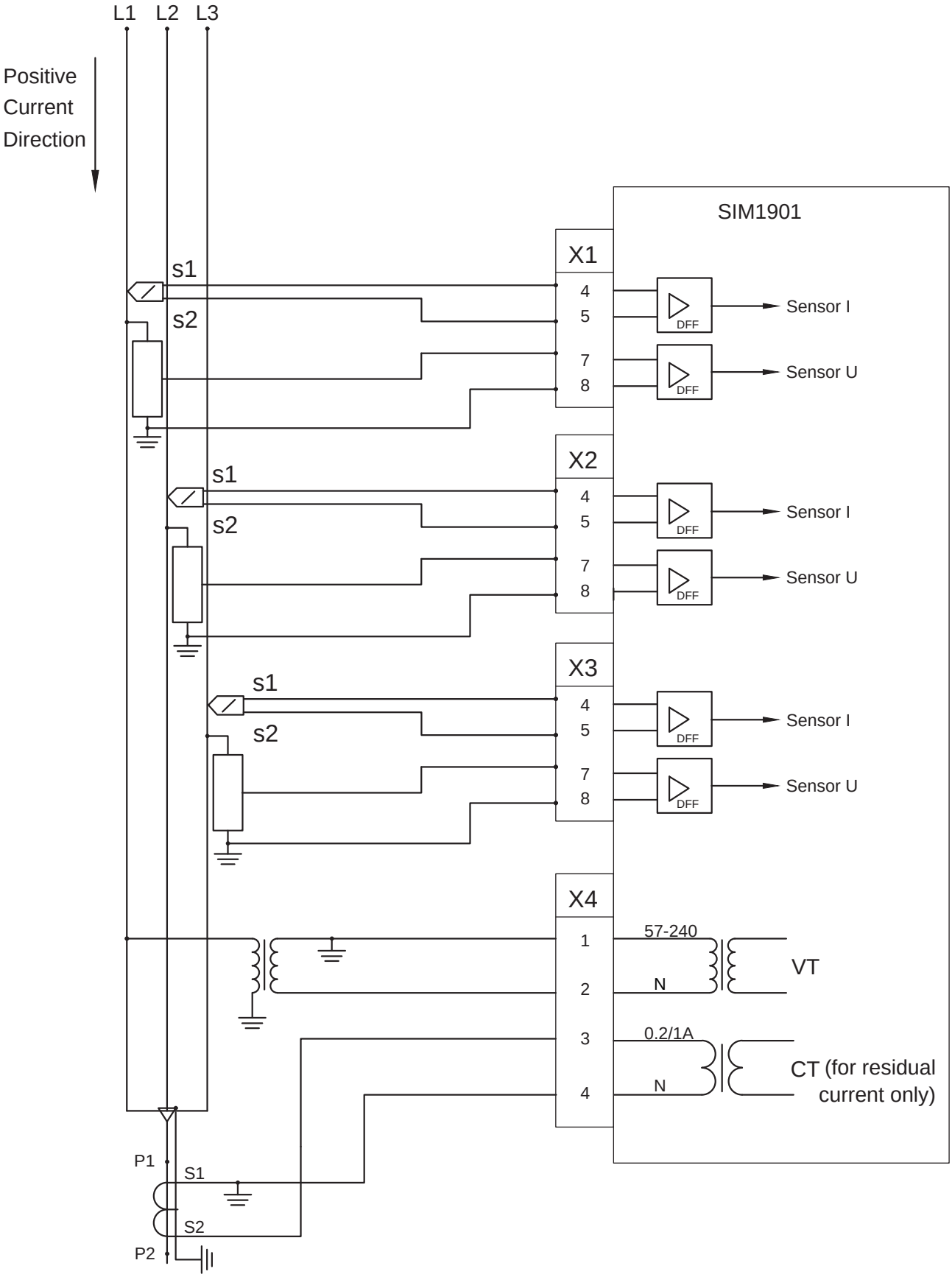



*Figure 1024: SIM1901 module (VT primary connection phase-to-earth)*

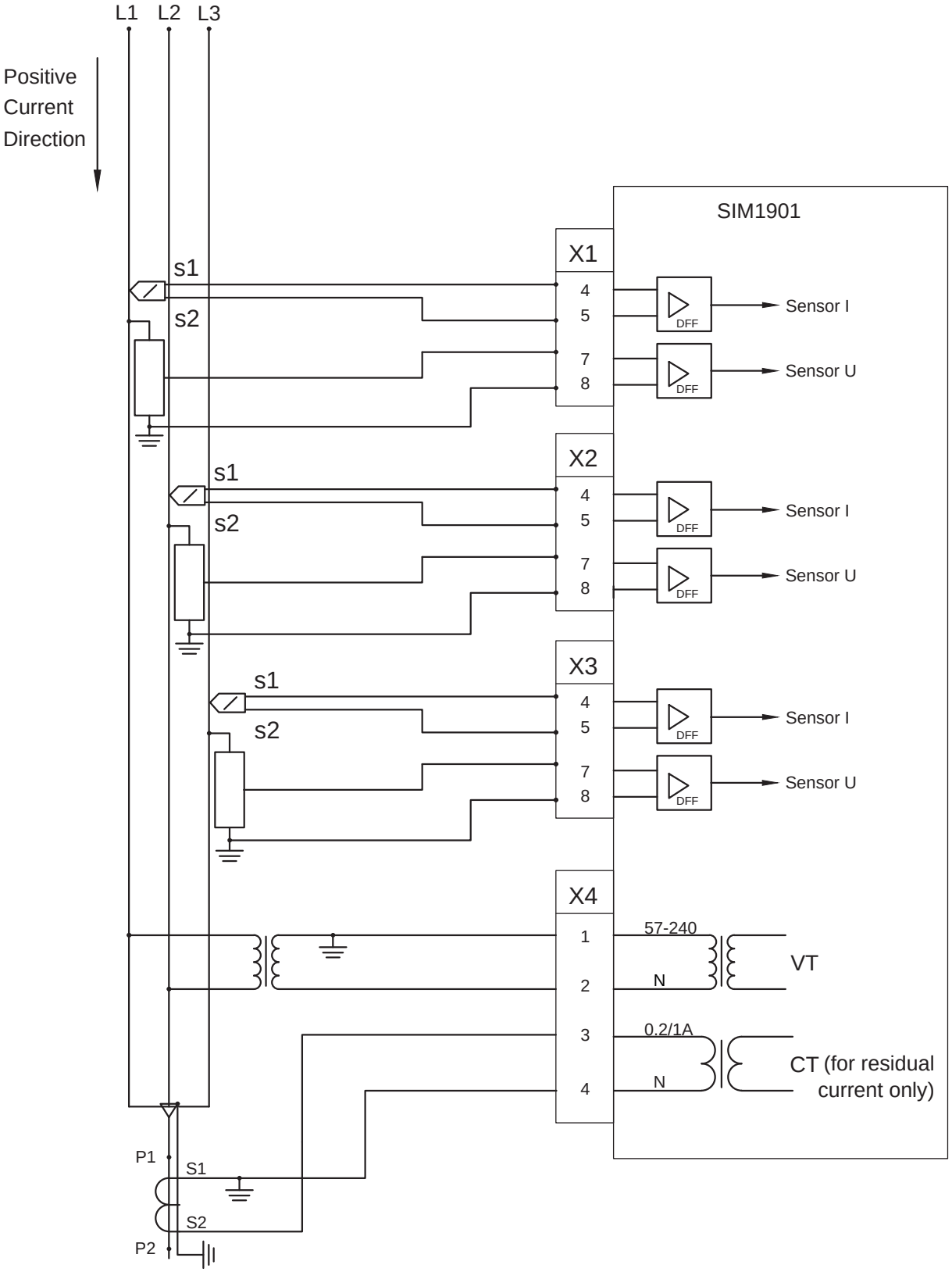



*Figure 1025: SIM1901 module (VT primary connection phase-to-phase)*

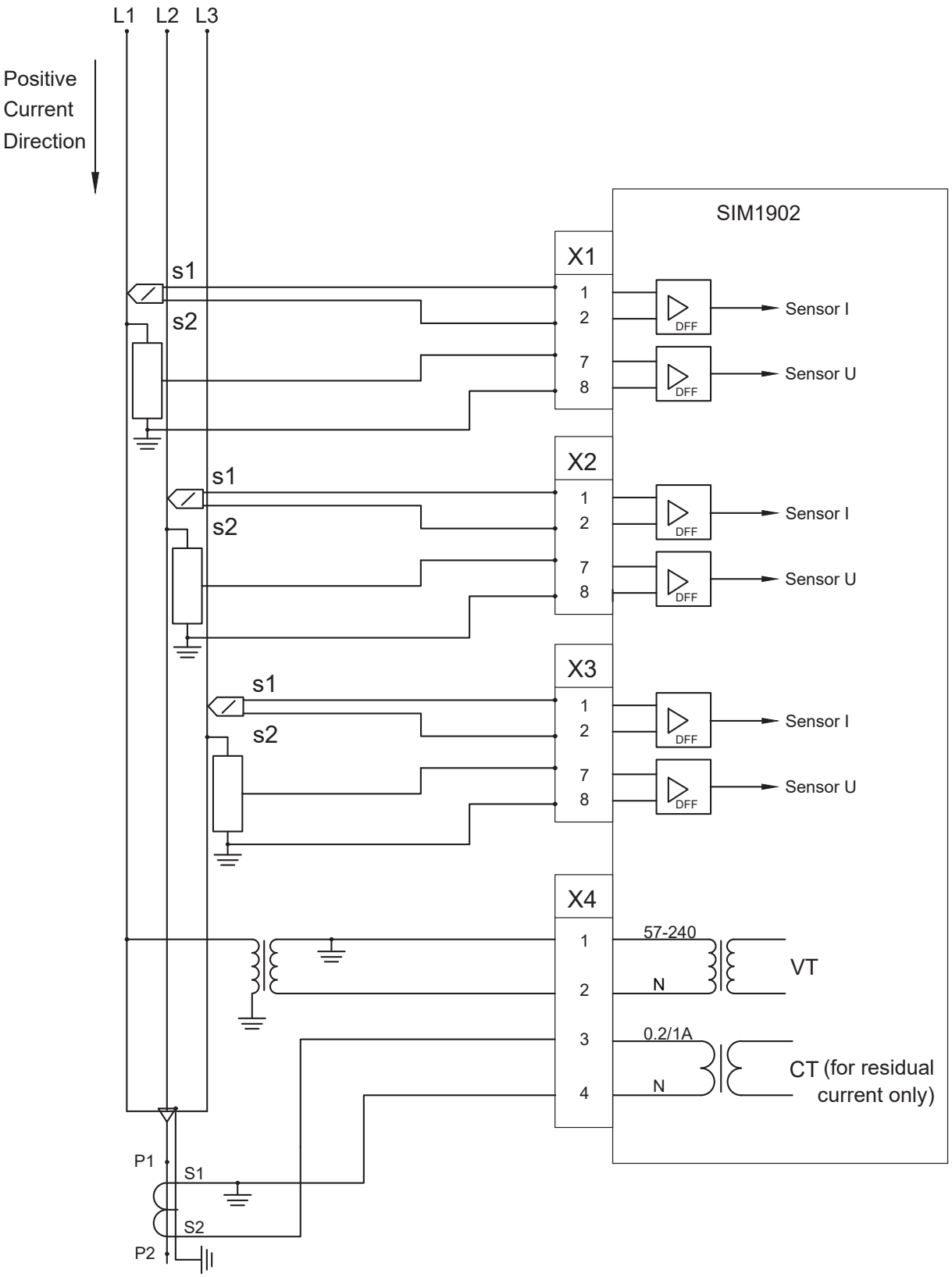



*Figure 1026: SIM1902 module (VT primary connection phase-to-earth)*

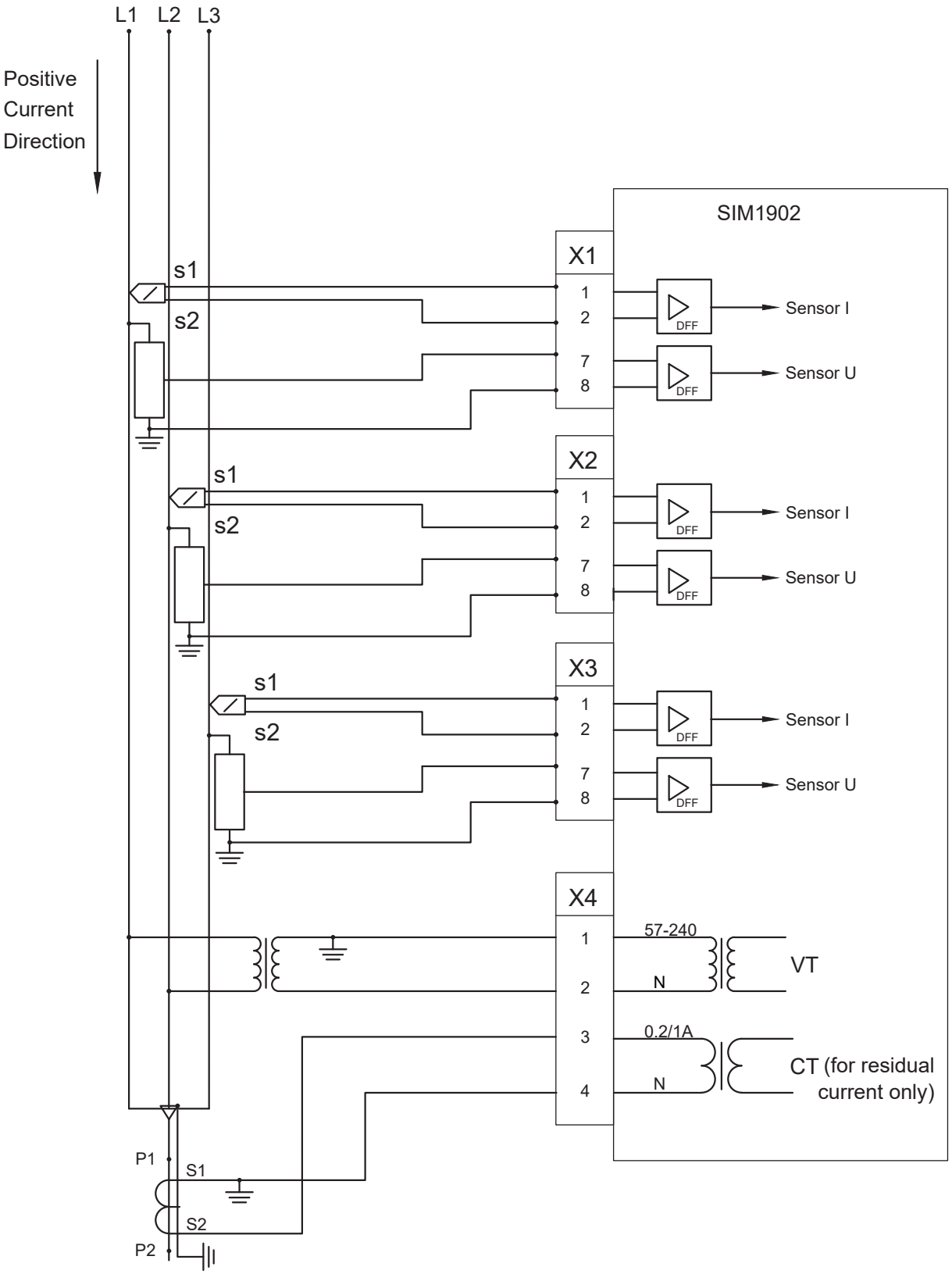



*Figure 1027: SIM1902 module (VT primary connection phase-to-phase)*

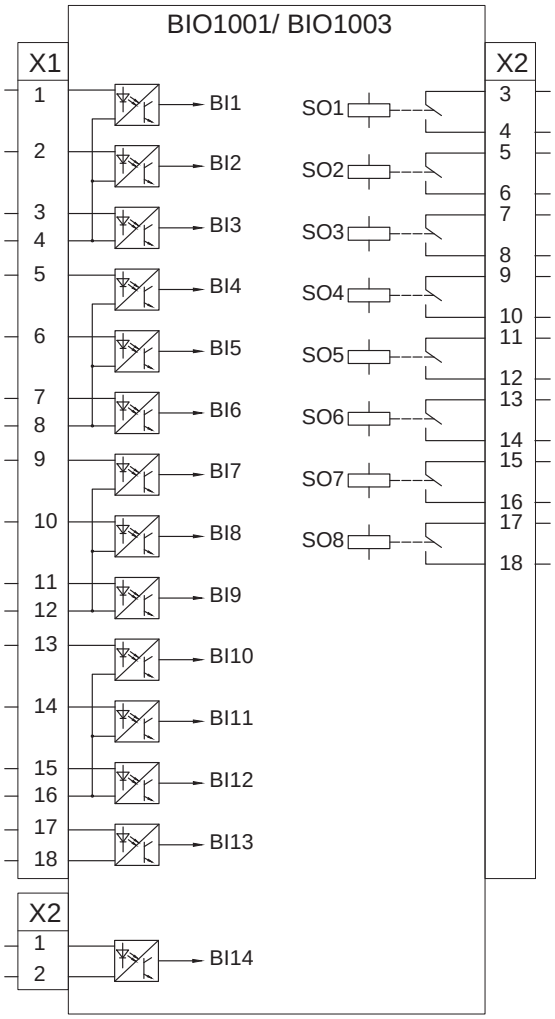



*Figure 1028: BIO1001/BIO1003 modules*

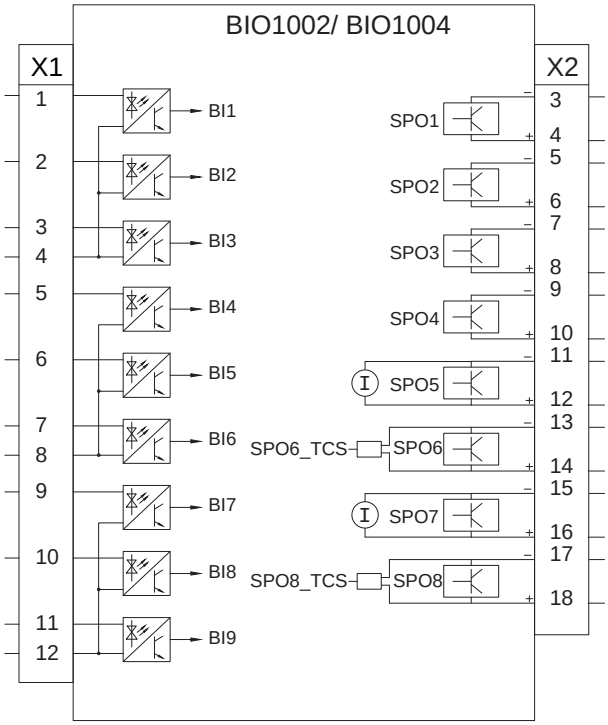



*Figure 1029: BIO1002/BIO1004 modules*

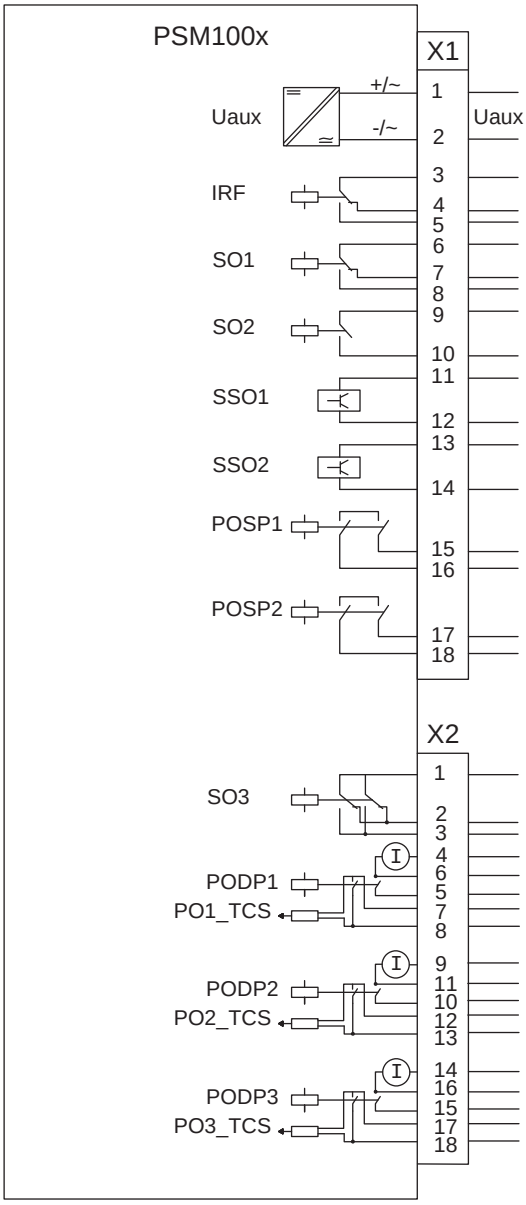



*Figure 1030: PSM100x module*

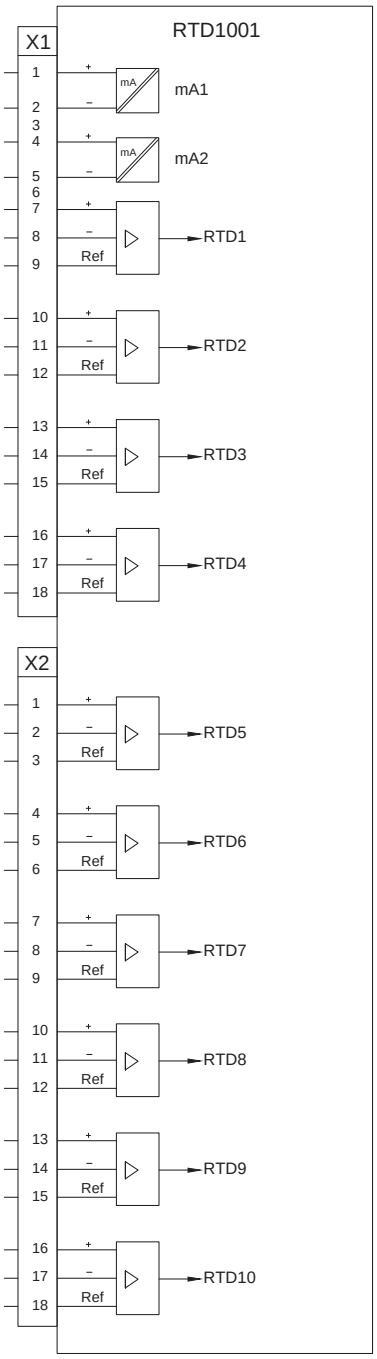



*Figure 1031: RTD1001 module*

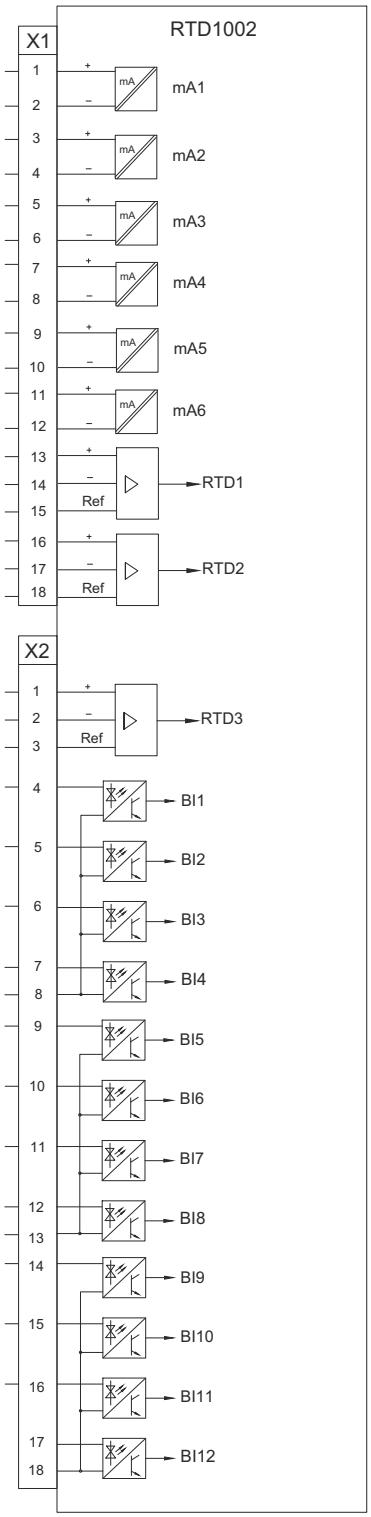



*Figure 1032: RTD1002 module*

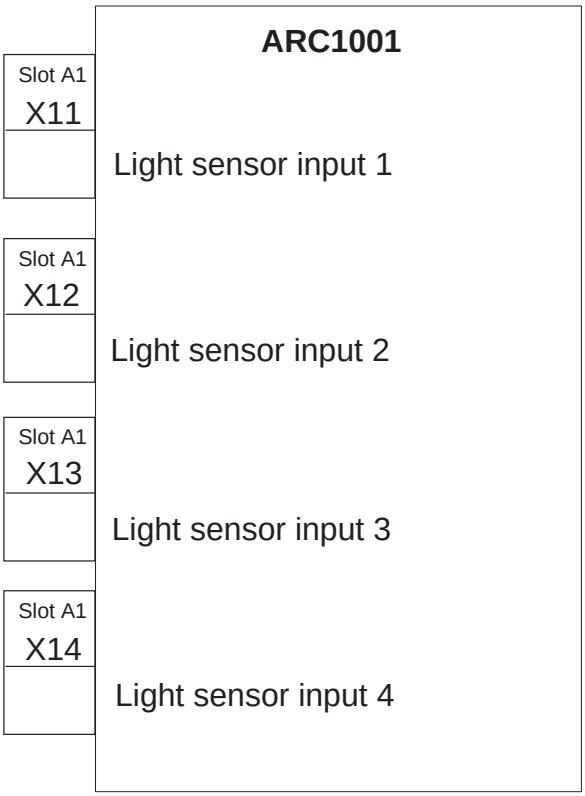



*Figure 1033: Arc module*

## 13.2 Communication modules

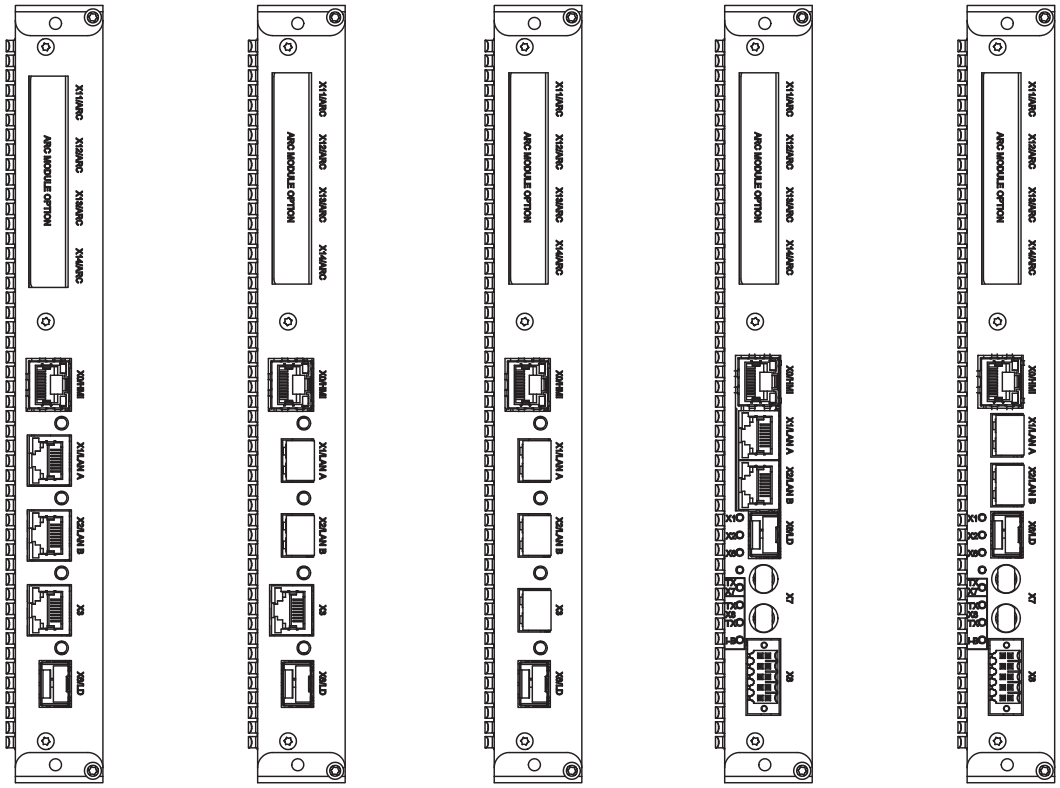



*Figure 1034: Communication module options*

The Ethernet ports marked with LAN A and LAN B are used with redundant Ethernet protocols HSR and PRP. The third station bus Ethernet port without the LAN A or LAN B label is an interlink port which is used to connect a device to the common redundant Ethernet channel.

**Table 1660: Ports in communication modules**

| Port | Type | Description |
|---|---|---|
| X0 | RJ-45 | HMI |
| X1 | RJ-45 or LC | Ethernet (LAN A) |
| X2 | RJ-45 or LC | Ethernet (LAN B) |
| X3 | RJ-45 or LC | Ethernet (Interlink) |
| X6 | SFP - LC | Protection communication [1] |
| X7 | FO - ST | Serial communication |
| X8 | TP [2] | Serial communication/IRIG-B |

[1] If a galvanic pilot wire is used as the protection communication link, the pilot wire modem RPW600 is required. A single-mode SFP transceiver and corresponding fiber-optic cable is used to connect REX640 with the RPW600 modem. The recommended minimum length of this cable is 3 m.

[2] 2- or 4-wire twisted pair

**Table 1661: Station bus communication interfaces included in communication modules**

| Module ID | RJ-45 | LC | EIA_485 | ST |
|---|---|---|---|---|
| COM1001 | 3 | – | – | – |
| COM1002 | 1 | 2 | – | – |
| COM1003 | – | 3 | – | – |
| COM1004 | 2 | – | 1 | 1 |
| COM1005 | – | 2 | 1 | 1 |

## 13.3 Arc sensor interface

Light sensor input connections for the arc protection are available on the optional hardware module in Slot A1. The module supports connection of up to four sensors. The sensors can be lens or loop types or a free mixture.

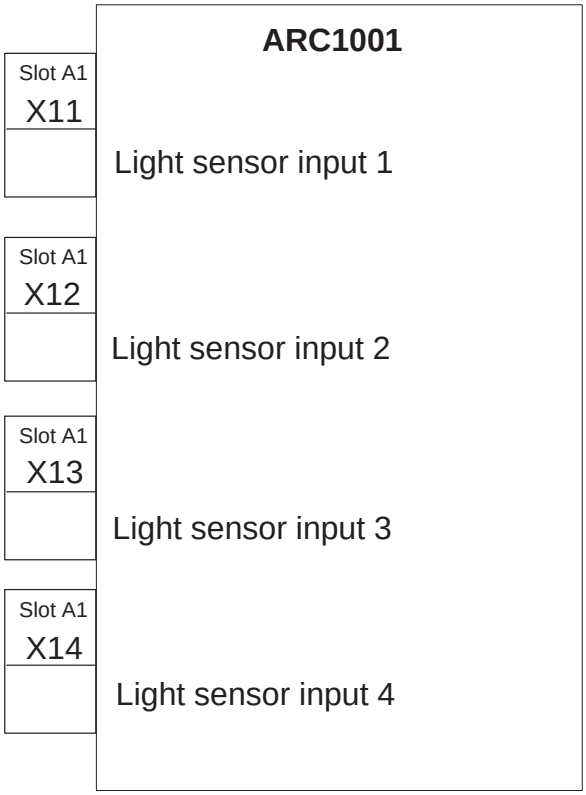



*Figure 1035: ARC module*

The ARCSARC function must be instantiated in the application configuration to enable the sensor inputs.

**Table 1662: ARCSARC instances and arc sensor inputs**

| Instance | Sensor input activation |
|---|---|
| ARCSARC1 | Light sensor input 1 |
| ARCSARC2 | Light sensor input 2 |
| ARCSARC3 | Light sensor input 3 |
| ARCSARC4 | Light sensor input 4 |

# 14 Technical data

**Table 1663: Dimensions of the relay**

| Description | | Value |
|---|---|---|
| Width | | 304.0 mm (11.9685 in) |
| Height | | 264.8 mm (10.4252 in) |
| Depth | With compression type CT/VT connectors | 242.2 mm (9.5354 in) |
| | With ring lug type CT/VT connectors | 254.1 mm (10.0039 in) |
| | With grounding bar | 274.0 mm (10.7874 in) |
| Weight box | | 6.9...8.8 kg (15.2...19.4 lb) |

**Table 1664: Dimensions of the HMI**

| Description | Value |
|---|---|
| Width | 212.5 mm (8.3661 in) |
| Height | 177.5 mm (6.9882 in) |
| Depth | 57.6 mm (2.2677 in) |
| Weight | 1.6 kg (3.5 lb) |
| Display element size | Seven inches |
| Display element resolution[1] | 800 x 480 pixels |

**Table 1665: Power supply for the relay**

| Description | PSM1001 | PSM1002 | PSM1003 |
|---|---|---|---|
| Nominal auxiliary voltage $U_n$ | 24, 30, 48, 60 V DC | 100, 110, 120, 220, 240 V AC, 50 and 60 Hz | 110, 125 V DC |
| | | 48, 60, 110, 125, 220, 250 V DC | |
| Maximum interruption time in the auxiliary DC voltage without resetting the relay | 50 ms at $U_n$ | | |
| Auxiliary voltage variation | 50...120 % of $U_n$ (12...72 V DC) | 38...110 % of $U_n$ (38...264 V AC) | 70...120 % of $U_n$ (77...150 V DC) |

*Table continues on the next page*

[1] The HMI display element can contain dark and/or bright dots up to five pieces in random locations, or up to two adjacent dots in two different locations. Also slight imperfections like scratches and dust particles on the display element surface can appear. These are not affecting the usability of the HMI and are within the normal display element manufacturing tolerances.

| Description | PSM1001 | PSM1002 | PSM1003 |
|---|---|---|---|
| | | 80...120 % of $U_n$ (38.4...300 V DC) | |
| Start-up threshold | 16 V DC (24 V DC × 67%) | | 77 V DC (110 V DC × 70 %) |
| Burden of auxiliary voltage supply under quiescent ($P_q$)/ operating condition | DC <18.0 W (nominal)/ <25.0 W (max.) | DC <20.0 W (nominal)/ <25.0 W (max.)<br>AC <20.0 W (nominal)/ <25.0 W (max.) | DC <17.0 W (nominal)/ <25.0 W (max.) |
| Ripple in the DC auxiliary voltage | Max 15 % of the DC value (at frequency of 100 Hz) | | |
| Fuse type | T8A/250 V | T4A/250 V | |
| Permissible frequency band | 50/60Hz +-10% | | |

**Table 1666: Power supply for the LHMI**

| Description | Value |
|---|---|
| Nominal auxiliary voltage $U_n$ | 100, 110, 120, 220, 240 V AC, 50 and 60 Hz |
| | 24, 48, 60, 110, 125, 220, 250 V DC |
| Auxiliary voltage variation | 38...110 % of $U_n$ (38...264 V AC) |
| | 80...120 % of $U_n$ (19.2...300 V DC) |
| Start-up threshold | 19.2 V DC (24 V DC × 80 %) |
| Burden of auxiliary voltage supply under quiescent ($P_q$)/operating condition | DC <6.0 W (nominal)/<14.0 W (max.)<br>AC <7.0 W (nominal)/<12.0 W (max.) |
| Ripple in the DC auxiliary voltage | Max 15 % of the DC value (at frequency of 100 Hz) |
| Fuse type | T3.15A/250V |

**Table 1667: Energizing inputs**

| Description | | Value | |
|---|---|---|---|
| Rated frequency | | 50/60 Hz | |
| Current inputs | Rated current, $I_n$ | 0.2/1 A | 1/5 A[2] |
| | Thermal withstand capability:<br>• Continuously<br>• For 1 s | 4 A<br>100 A | 20 A<br>500 A |
| | Dynamic current withstand:<br>• Half-wave value | 250 A | 1250 A |
| | Input impedance | <100 mΩ | <20 mΩ |

*Table continues on the next page*

[2] Residual current and/or phase current.

| Description | | Value |
|---|---|---|
| Voltage inputs | Rated voltage | 57...240 V AC |
| | Voltage withstand:<br>• Continuous<br>• For 10 s | <br>288 V AC<br>360 V AC |
| | Burden at rated voltage | <0.05 VA |

**Table 1668: Table 9: Energizing Inputs (SIM1901)**

| Description | | Value |
|---|---|---|
| Current sensor input | Rated current voltage | 75 mV ... 9000 mV [3] |
| | Continuous voltage withstand | 125 V |
| | Input impedance at 50/60Hz | 2...3 MΩ [4] |
| Voltage sensor input | Rated secondary voltage | 346 mV...1733 mV [5] |
| | Continuous voltage withstand | 50 V |
| | Input impedance at 50/60Hz | 3 MΩ |

**Table 1669: Energizing Inputs (SIM1902)**

| Description | | Value |
|---|---|---|
| Current sensor input | Rated current voltage | 75 mV ... 9000 mV [6] |
| | Continuous voltage withstand | 125 V |
| | Input impedance at 50/60Hz | 2 MΩ |
| Voltage sensor input | Rated secondary voltage | 346 mV...2339 mV [7] |
| | Continuous voltage withstand | 50 V |
| | Input impedance at 50/60Hz | 2 MΩ |

**Table 1670: Binary inputs**

| Description | Value |
|---|---|
| Operating range | ±20 % of the rated voltage |
| Rated voltage | 24...250 V DC |
| Current drain | 1.6...1.9 mA |
| Power consumption | 31.0...570.0 mW |

*Table continues on the next page*

[3] Equals the current range of 40 … 4000 A with 80A, 3mV/Hz Rogowski
[4] Depending on the used nominal current (hardware gain)
[5] Covers 6 kV … 30 kV sensors with division ratio of 10 000:1. Secondary voltages 600mV/√3 … 3 V / √3. Range up to 2 x Rated.
[6] Equals the current range of 40 … 4000 A with 80A, 3mV/Hz Rogowski
[7] Covers 6 kV … 40.5 kV sensors with division ratio of 10 000:1. Secondary voltages 600mV/√3 … 4.05V / √3. Range up to 2 x Rated.

| Description | Value |
|---|---|
| Threshold voltage | 16...176 V DC |
| Ripple in the DC auxiliary voltage | Max 15 % of the DC value (at frequency of 100 Hz) |
| Wetting current | 220 mA, impulse period 5ms<br>0...120 mA[10], impulse period 8ms |

Adjust the binary input threshold voltage correctly. It is recommended to set the threshold voltage to 70 % of the nominal auxiliary voltage. The factory default is 16 V to ensure the binary inputs' operation regardless of the auxiliary voltage used (24, 48, 60, 110, 125, 220 or 250 V DC). However, the default value is not optimal for the higher auxiliary voltages. The binary input threshold voltage should be set as high as possible to prevent any inadvertent activation of the binary inputs due to possible external disturbances. At the same time, the threshold should be set so that the correct operation is not jeopardized in case of undervoltage of the auxiliary voltage.

**Table 1671: RTD/mA inputs and mA outputs**

| Description | | Value | |
|---|---|---|---|
| RTD inputs | Supported RTD sensors | 100 Ω platinum<br>250 Ω platinum<br>100 Ω nickel<br>120 Ω nickel<br>250 Ω nickel | TCR 0.00385 (DIN 43760)<br>TCR 0.00385<br>TCR 0.00618 (DIN 43760)<br>TCR 0.00618<br>TCR 0.00618 |
| | Supported resistance range | 0...4 kΩ | |
| | Maximum lead resistance (three-wire measurement) | 100 Ω per lead | |
| | Isolation | 2 kV (inputs to protective earth) | |
| | Response time | <1 s | |
| | RTD/resistance sensing current | <1 mA rms | |
| | Operation accuracy | Resistance | Temperature |
| | | ± 2.0 % or ±1 Ω | ±1°C |
| mA inputs | Supported current range | ±0...20 mA | |
| | Current input impedance | 44 Ω ±0.1 % | |
| | Operation accuracy | ±0.5 % or ±0.01 mA | |
| mA outputs | Supported current range | ±0...20 mA | |

*Table continues on the next page*

[10] Adjustable only in RTD1002 module

| Description | | Value |
|---|---|---|
| | Maximum loop impedance | 700 Ω |
| | Operation accuracy | ±0.1 mA |

**Table 1672: Signal outputs and IRF output**

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 1250 VA |
| Continuous contact carry | 5 A |
| Make and carry for 3.0 s | 10 A |
| Make and carry 0.5 s | 15 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC | 1 A/0.25 A/0.15 A |
| Minimum contact load | 10 mA at 5 V AC/DC |

**Table 1673: Single-pole power output relays**

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 2000 VA |
| Continuous contact carry | 8 A |
| Make and carry for 3.0 s | 15 A |
| Make and carry for 0.5 s | 30 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC | 5 A/3 A/1 A |
| Minimum contact load | 100 mA at 24 V AC/DC |

**Table 1674: Static signal output (SSO) relays**

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 250 VA |
| Continuous contact carry | 1 A |
| Make and carry for 3.0 s | 5 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 110 V DC | 0.25 A |
| Minimum load current | 1 mA |
| Maximum operation frequency at 50% duty cycle | 10 Hz |

**Table 1675: Double-pole power output relays with TCS function**

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Maximum continuous burden (resistive load, AC) | 2000 VA |
| Continuous contact carry | 8 A |
| Make and carry for 3.0 s | 15 A |
| Make and carry for 0.5 s | 30 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC (two contacts connected in series) | 5 A/3 A/1 A |
| Minimum contact load | 100 mA at 24 V AC/DC |
| Trip-circuit supervision (TCS):<br>• Control voltage range<br>• Current drain through the supervision circuit<br>• Minimum voltage over the TCS contact | <br>20...250 V AC/DC<br>~1.5 mA<br>20 V AC/DC (15...20 V) |

**Table 1676: Static power output (SPO) relays**

| Description | Value |
|---|---|
| Rated voltage | 250 V DC |
| Maximum continuous burden (resistive load, DC) | 2000 VA |
| Continuous contact carry | 5 A, 60 s<br>5 A continuous (one output active at a time per module)<br>1 A continuous (multiple outputs simultaneously active in the same module) |
| Make and carry for 0.2 s | 30 A |
| Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC two contacts connected in series | 16 A/6 A/3 A |
| Minimum load current | 1 mA |
| Trip-circuit supervision (TCS) SP06 and SP08:<br>• Control voltage range<br>• Current drain through the supervision circuit<br>• Minimum voltage over the TCS contact | <br>20...250 V DC<br>~1.5 mA<br>20 V DC |
| SP05 and SP07: Current drain through the circuit | ~3 mA |

**Table 1677: Serial interface**

| Type | Connector |
|---|---|
| Screw terminal X8 | 10-pin 2-row connector |
| Serial port X7 | Optical ST-connector |

**Table 1678: USB interface, HMI**

| Type | Description |
|---|---|
| USB | Hi-Speed USB Type A |

**Table 1679: Ethernet interfaces (connectors X0, X1, X2 and X3)**

| Connector | Media | Reach[1] | Rate | Wavelength | Permitted path attenuation[2] |
|---|---|---|---|---|---|
| RJ-45 | CAT 6 S/FTP | 100 m | 100 mbits/s | – | – |
| LC | MM 62.5/125 or 50/125 µm glass fiber core | 2 km | 100 mbits/s | 1300 nm | <8 dB |

**Table 1680: Maximum processing delay time**

| SMVSENDER internal processing time (us) | 50 Hz nominal frequency | 60 Hz nominal frequency |
|---|---|---|
| Average processing delay time | 1800 | 1520 |
| Maximum processing delay time | 2000 | 1720 |

**Table 1681: Protection communication link (connector X6)**

| Connector | Part number[3] | Fiber type | Reach[1] | Wavelength | Permitted path attenuation[2] |
|---|---|---|---|---|---|
| LC (SFP) | 2RCA045621 | MM 62.5/125 or 50/125 µm | 2 km | 1310 nm | <8 dB |
| LC (SFP) | 2RCA045622 | SM 9/125 µm | 20 km | 1310 nm | <13 dB |
| LC (SFP) | 2RCA045623 | SM 9/125 µm | 50 km | 1310 nm | <26 dB |

[1] Maximum length depends on the cable attenuation and quality, the amount of splices and connectors in the path.
[2] Maximum allowed attenuation caused by connectors and cable together.
[3] Only these ABB verified SFP modules are supported in the protection communication link (port X6 in the communication module).

**Table 1682: IRIG-B (connector X8)**

| Description | Value |
|---|---|
| IRIG time code format | B004, B005[4] |
| Isolation | 500V 1 min |
| Modulation | Unmodulated |
| Logic level | 5 V TTL |
| Current consumption | <1.0 mA |
| Power consumption | <0.5 W |

**Table 1683: Lens sensor and optical fiber for arc protection**

| Description | Value |
|---|---|
| Normal service temperature range of the lens | –40...+100°C |
| Maximum service temperature range of the lens, max 1 h | +140°C |
| Minimum permissible bending radius of the connection fiber | 100 mm |
| Arc sensor loop maximum attenuation | 25dB |

**Table 1684: Degree of protection of the protection relay**

| Description | Value |
|---|---|
| Front/connector side | IP 20 (with ring-lug signal connectors IP 00 or IP 10 depending on wiring) |
| Top and bottom | IP 30 |
| Rear | IP 40 |

**Table 1685: Degree of protection of the HMI**

| Description | Value |
|---|---|
| Front | IP 54 |
| Other sides | IP 20 |

**Table 1686: Environmental conditions**

| Description | Value |
|---|---|
| Operating temperature range | –25...+55ºC (continuous) |
| Short-time service temperature range | –40...+85ºC (<16 h)[5, 6] |
| Relative humidity | <93 %, non-condensing |
| Atmospheric pressure | 86...106 kPa |

*Table continues on the next page*

[4] According to the 200-04 IRIG standard
[5] Degradation in MTBF and HMI performance outside the temperature range of –25...+55 ºC.
[6] For relays with an LC communication interface the maximum operating temperature is +70 ºC.

| Description | Value |
|---|---|
| Altitude | Up to 2000 m |
| Transport and storage temperature range | –40...+85ºC |

# 15 Protection relay and functionality tests

**Table 1687: Electromagnetic compatibility tests**

| Description | Type test value | Reference |
|---|---|---|
| 1 MHz/100 kHz burst disturbance test<br>• Common mode<br>• Differential mode | 2.5 kV<br>2.5 kV | IEC 61000-4-18<br>IEC 60255-26, class III<br>IEEE C37.90.1-2012 |
| 3 MHz, 10 MHz and 30 MHz burst disturbance test<br>• Common mode | 2.5 kV | IEC 61000-4-18<br>IEC 60255-26, class III |
| Electrostatic discharge test<br>• Contact discharge<br>• Air discharge | 8 kV<br>15 kV | IEC 61000-4-2<br>IEC 60255-26<br>IEEE C37.90.3-2001 |
| Radio frequency interference test | 10 V (rms)<br>f = 150 kHz...80 MHz<br>10 V/m (rms)<br>f = 80...2700 MHz<br>10 V/m<br>f = 900 MHz<br>20 V/m (rms)<br>f = 80...1000 MHz | IEC 61000-4-6<br>IEC 60255-26, class III<br>IEC 61000-4-3<br>IEC 60255-26, class III<br>ENV 50204<br>IEC 60255-26, class III<br>IEEE C37.90.2-2004 |
| Fast transient disturbance test<br>• Communication<br>• Other ports | 2 kV<br>4 kV | IEC 61000-4-4<br>IEC 60255-26<br>IEEE C37.90.1-2012 |
| Surge immunity test<br>• Communication<br>• Other ports | 1 kV, line-to-earth<br>4 kV, line-to-earth<br>2 kV, line-to-line | IEC 61000-4-5<br>IEC 60255-26 |
| Power frequency (50 Hz) magnetic field immunity test<br>• Continuous<br>• 1...3 s | 300 A/m<br>1000 A/m | IEC 61000-4-8<br>IEC 60255-26 |
| Pulse magnetic field immunity test | 1000 A/m<br>6.4/16 µs | IEC 61000-4-9 |

*Table continues on the next page*

| Description | Type test value | Reference |
|---|---|---|
| Damped oscillatory magnetic field immunity test<br>• 2 s<br>• 1 MHz | 100 A/m<br>400 transients/s | IEC 61000-4-10 |
| Voltage dips and short interruptions | 0%/50 ms Criterion A<br>40%/200 ms Criterion C<br>70%/500 ms Criterion C<br>0%/5000 ms Criterion C | IEC 61000-4-11<br>IEC 61000-4-29<br>IEC 60255-26 |
| Power frequency immunity test<br>• Common mode<br>• Differential mode | Binary inputs only 300 V rms<br>150 V rms | IEC 61000-4-16<br>IEC 60255-26, class A |
| Emission tests<br>• Conducted<br>0.15. 0.50 MHz<br>0.5...30 MHz<br>• Radiated<br>30...230 MHz<br>230...1000 MHz<br>1…3 GHz<br>3…6 GHz | <br><79 dB (µV) quasi peak<br><66 dB (µV) average<br><73 dB (µV) quasi peak<br><60 dB (µV) average<br><br><40 dB (µV/m) quasi peak, measured at 10 m distance<br><47 dB (µV/m) quasi peak, measured at 10 m distance<br><76 dB (µV/m) peak<br><56 dB (µV/m) average, measured at 3 m distance<br><80 dB (µV/m) peak<br><60 dB (µV/m) average, measured at 3 m distance | EN 55011, class A<br>IEC 60255-26<br>CISPR 11<br>CISPR 12 |

**Table 1688: Safety-related tests**

| Description | Type test value | Reference |
|---|---|---|
| Overvoltage category | III | IEC 60255-27 |
| Pollution degree | 2 | IEC 60255-27 |
| Insulation class | Class I | IEC 60255-27 |
| Dielectric tests | 500 V, 50 Hz, 1 min, RS-485 and IRIG-B<br>1 kV, 50 Hz, 1 min, across open contacts<br>1.5 kV, 50 Hz, 1 min, Ethernet RJ-45 | IEC 60255-27 |

*Table continues on the next page*

| Description | Type test value | Reference |
|---|---|---|
| | 2 kV, 50 Hz, 1 min, all other circuits | |
| Impulse voltage test | 1 kV, 1.2/50 µs, 0.5 J, RS-485 and IRIG-B<br>2.4 kV, 1.2/50 µs, 0.5 J, Ethernet RJ-45<br>5 kV, 1.2/50 µs, 0.5 J, all other circuits | IEC 60255-27 |
| Insulation resistance measurements | >100 MΩ, 500 V DC | IEC 60255-27 |
| Protective bonding resistance | <0.1 Ω, 4 A, 60 s | IEC 60255-27 |
| Maximum temperature of parts and materials | Tested | IEC 60255-27 |
| Flammability of insulating materials, components and fire enclosures | Evaluated / Tested | IEC 60255-27 |
| Single-fault condition | Tested | IEC 60255-27 |

**Table 1689: Mechanical tests**

| Description | Requirement | Reference |
|---|---|---|
| Vibration tests (sinusoidal) | Class 2 | IEC 60068-2-6 (test Fc)<br>IEC 60255-21-1 |
| Shock and bump test | Class 2 | IEC 60068-2-27 (test Ea shock)<br>IEC 60068-2-29 (test Eb bump)<br>IEC 60255-21-2 |

**Table 1690: Environmental tests**

| Description | Type test value | Reference |
|---|---|---|
| Dry heat test | 96 h at +55°C<br>16 h at +85°C [1] | IEC 60068-2-2 |
| Dry cold test | 96 h at –25°C<br>16 h at –40°C | IEC 60068-2-1 |
| Damp heat test | 6 cycles (12 h + 12 h) at +25…+55°C, humidity >93% | IEC 60068-2-30 |
| Change of temperature test | 5 cycles (3 h + 3 h) at -25...+55°C | IEC60068-2-14 |
| Storage test | 96 h at –40°C | IEC 60068-2-1 |

[1] For relays with an LC communication interface the maximum operating temperature is +70°C.

| Description | Type test value | Reference |
|---|---|---|
| | 96 h at +85°C | IEC 60068-2-2 |

**Table 1691: Product safety**

| Description | Reference |
|---|---|
| LV directive | 2006/95/EC |
| Standard | EN 60255-27 (2014)<br>EN 60255-1 (2009) |

**Table 1692: EMC compliance**

| Description | Reference |
|---|---|
| EMC directive | 2014/30/EU |
| Standard | EN 60255-26 (2013) |

**Table 1693: RoHS compliance**

| Description |
|---|
| Complies with RoHS Directive 2011/65/EU |

# 16 Applicable standards and regulations

EN 60255-1
EN 60255-26
EN 60255-27
EMC council directive 2004/108/EC
EU directive 2002/96/EC/175
IEC 60255
Low-voltage directive 2006/95/EC
IEC 61850
BS EN 60255-26: 2013
BS EN 61000-6-2: 2005
BS EN 61000-6-4: 2019
BS EN 60255-1: 2010
BS EN 60255-27: 2014

# 17 Glossary

| | |
|---|---|
| 100BASE-FX | A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses fiber optic cabling |
| 100BASE-TX | A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses twisted-pair cabling category 5 or higher with RJ-45 connectors |
| ACT | 1. Application Configuration tool in PCM600<br>2. Trip status in IEC 61850 |
| AD | Active directory |
| AIM | Analog input module |
| AIS | Air-insulated switchgear |
| AR | Autoreclosing |
| ASC | Arc suppression coil |
| AVR | Automatic voltage regulator |
| BCD | Binary coded decimal |
| CAT 6 | Cable standard for gigabit Ethernet and other network protocols that is backward compatible with CAT 5/5e and CAT 3 cable standards |
| CB | Circuit breaker |
| CBB | Cycle building block |
| CBCT | Core balance current transformer |
| CBFP | Circuit breaker failure protection |
| COM600S | Substation Management Unit. An all-in-one communication gateway, automation platform and user interface solution for utility and industrial distribution substations. |
| COMTRADE | Common format for transient data exchange for power systems. Defined by the IEEE Standard. |
| CR | Carrier receive signal |
| CS | Carrier send signal |
| CT | Current transformer |
| DAN | Doubly attached node |
| DC | 1. Direct current<br>2. Disconnector<br>3. Double command |
| DCB | Directional comparison blocking scheme |
| DCS | Distributed control system |
| DCUB | Directional comparison unblocking scheme |
| DFT | Discrete fourier transform |
| DG | Distributed generation |

| | |
|---|---|
| DHCP | Dynamic host configuration protocol |
| DIP switch | A set of on-off switches arranged in a standard dual inline package |
| DNP3 | A distributed network protocol originally developed by Westronic. The DNP3 Users Group has the ownership of the protocol and assumes responsibility for its evolution. |
| DO | Data object (IEC61850) |
| DST | Daylight-saving time |
| DT | Definite time |
| DUTT | Direct underreach transfer trip |
| EEPROM | Electrically erasable programmable read-only memory |
| EMC | Electromagnetic compatibility |
| Ethernet | A standard for connecting a family of frame-based computer networking technologies into a LAN |
| FLC | Full load current |
| FPGA | Field-programmable gate array |
| FPN | Flexible product naming |
| FTP | File transfer protocol |
| FTPS | FTP Secure |
| GCB | Generator circuit breaker |
| GFC | General fault criteria |
| GIS | 1. Gas-insulated switchgear<br>2. Geoinformation systems |
| GND | Ground/earth |
| GNSS | Global navigation satellite systems |
| GOOSE | Generic object-oriented substation event |
| GPS | Global positioning system |
| HF | High frequency |
| HMI | Human machine interface |
| HSR | High-availability seamless redundancy |
| HTTPS | Hypertext transfer protocol secure |
| HV | High voltage |
| IDMT | Inverse definite minimum time |
| IEC | International electrotechnical commission |
| IEC 60870-5-101 | Companion standard for basic telecontrol tasks |
| IEC 60870-5-103 | 1. Communication standard for protective equipment<br>2. A serial master/slave protocol for point-to-point communication |
| IEC 60870-5-104 | Network access for IEC 60870-5-101 |
| IEC 61850 | International standard for substation communication and modeling |
| IEC 61850-8-1 | A communication protocol based on the IEC 61850 standard series |
| IEC 61850-9-2 | A communication protocol based on the IEC 61850 standard series |

| | |
|---|---|
| IEC 61850-9-2 LE | Lite Edition of IEC 61850-9-2 offering process bus interface |
| IED | Intelligent electronic device |
| IEEE 1588 | Standard for a Precision Clock Synchronization Protocol for networked measurement and control systems |
| IRF | 1. Internal fault<br>2. Internal relay fault |
| IRIG-B | Inter-Range Instrumentation Group's time code format B |
| L/R | Local/Remote |
| LAN | Local area network |
| LC | Connector type for glass fiber cable, IEC 61754-20 |
| LD | Logical device |
| LDC | Line drop compensation |
| LE | Light edition |
| LED | Light-emitting diode |
| LF | Low frequency |
| LHMI | Local human machine interface |
| LN | Logical node (IEC61850) |
| LOG | Loss of grid |
| LOM | Loss of mains |
| LV | Low voltage |
| M/F | Master/Follower |
| MAC | Media access control |
| MCB | Miniature circuit breaker |
| MCC | Minimizing circulating current |
| MM | 1. Multimode<br>2. Multimode optical fiber |
| MMS | 1. Manufacturing message specification<br>2. Metering management system |
| Modbus | A serial communication protocol developed by the Modicon company in 1979. Originally used for communication in PLCs and RTU devices. |
| Modbus ASCII | Link mode using 7-bit ASCII characters |
| Modbus RTU | Link mode using 8-bit binary characters |
| MSB | Most significant bit |
| MV | Medium voltage |
| NC | Normally closed |
| NPS | Negative phase sequence |
| NRP | Negative reactance principle |
| NSCB | Non-source circuit breaker |
| OSB | Out of step blocking |

| | |
|---|---|
| P2P | peer-to-peer |
| PC | 1. Personal computer<br>2. Polycarbonate |
| PCM600 | Protection and control IED manager |
| Peak-to-peak | 1. The amplitude of a waveform between its maximum positive value and its maximum negative value<br>2. A measurement principle where the measurement quantity is made by calculating the average from the positive and negative peak values without including the DC component. The peak-to-peak mode allows considerable CT saturation without impairing the performance of the operation. |
| Peak-to-peak with peak back-up | A measurement principle similar to the peak-to-peak mode but with the function starting on two conditions: the peak-to-peak value is above the set start current or the peak value is above two times the set start value |
| PGU | Power generating unit |
| PLC | Programmable logic controller |
| PMS | Power management system |
| PO | Power output |
| PODP | Power output, double pole |
| POSP | Power output, single pole |
| POTT | Permissive overreach transfer trip |
| PPS | Pulse per second |
| PRP | Parallel redundancy protocol |
| PST | Parameter setting tool |
| PTP | Precision time protocol |
| PUTT | Permissive underreach transfer trip |
| RAM | Random access memory |
| RCA | Also known as MTA or base angle. Characteristic angle. |
| RIO600 | Remote I/O unit |
| RJ-45 | Galvanic connector type |
| RMS | Root-mean-square (value) |
| ROM | Read-only memory |
| RS-485 | Serial link according to EIA standard RS485 |
| RSTP | Rapid spanning tree protocol |
| RTC | Real-time clock |
| RTD | Resistance temperature detector |
| Rx | Receive/Received |
| SA | Substation automation |
| SAN | Single attached node |
| SBO | Select-before-operate |
| SCADA | Supervision, control and data acquisition |

| | |
|---|---|
| SCB | 1. Shunt capacitor bank<br>2. Source circuit breaker |
| SCL | XML-based system configuration description language defined by IEC 61850 |
| SCM | Smart control module |
| SHMI | Switchgear HMI |
| SI | Sensor input |
| SIM | Sensor input module |
| SLD | Single-line diagram |
| SM | 1. Single mode<br>2. Single-mode optical fiber |
| SMT | Signal matrix tool in PCM600 |
| SMV | Sampled measured values |
| SNTP | Simple network time protocol |
| SOTF | Switch onto fault |
| SPO | Static power output |
| SSO | Static signal output |
| ST | Connector type for glass fiber cable |
| TCP | Transmission control protocol |
| TCS | Trip-circuit supervision |
| TP | Disturbance data recorded with or without trip bit |
| Tx | Transmit/Transmitted |
| UART | Universal asynchronous receiver-transmitter |
| UDP | User datagram protocol |
| USB | Universal serial bus |
| UTC | Coordinated universal time |
| VDR | Voltage-depended resistor |
| VT | Voltage transformer |
| WAN | Wide area network |
| WEI | Weak-end infeed logic |
| WHMI | Web human-machine interface |

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2.9.3.Transformers

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# MEDIUM VOLTAGE INSTRUMENT TRANSFORMERS

## OUTDOOR / INDOOR



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In July 2021 **ESITAS company** has been added to Arteche`s project, a company with **over 35 years' experience** in the sector and in the instrumentation and measuring market.

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# M.V. CURRENT TRANSFORMERS





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## General Definitions

General definitions have been given according to International Standarts IEC 61869

## Instrument Transformer

A transformer intended to supply measuring instruments meters, protection relays and other similiar apparatus.

## Applicable Standards

Our transformers comply with applicable national and international standards.

## Current Transformers

An instrument transformer in which the secondary current, in normal conditions of use, is substantially proportional to the primary current and differs in phase from it by angle which is approximately zero for an appropriate direction of the connections. It isolates the instrument and protection circuit from the primary side and protect the devices against overload according to the overcurrent characteristics of the transformer. Current transformers can have several secondary windings with cores of identical of different characteristics completely isolated from each other.

## Measuring Current Transformer

A current transformer intended to supply indicating instruments, integrating meters and similiar apparatus.

## Protective Current Transformer

A current transformer intended to supply protective relays.

## Primary Winding

The winding through which flows the current to be transformed.

## Secondary Winding

The winding, which supplies the current circuits of measuring instruments, meters, relays or similiar devices.

## Secondary Circuit

The external circuit supplied by the secondary winding of a transformer.

## Rated Primary Current

The value of the primary current on which the performance of the transformer is based.

## Rated Secondary Current

The value of the secondary current on which the performance of the transformer is based.

## Rated Transformation Ratio

The ratio of rated primary current to the rated secondary current (I1N/I2N-i.e. 100/5A)

## Current Error (Ratio Error)

The error which a transformer introduces into the measurement of a current and which arises from the fact that the actual transformation ratio is not equal to the rated transformation ratio.
The current error expressed in per cent is given by formula:

$$\text{Current Error}\% = \frac{Kn\ Is - Ip}{Ip} \times 100$$

Where

Kn is the rated transformation ratio;
Ip is the actual primary current
Is is the actual secondary current when Ip is flowing, under the conditions of measurements.

## Accuracy Class

A designation assigned to a current transformer errors of which remain within specified limits under prescribed conditions of use.

## Burden

The impedance of the secondary circuit in ohms and power-factor. The burden is usually expressed as the apparent power in voltamperes absorbed at a specified power-factor and at the rated secondary current.

## Rated Burden

The value of the burden on which the accuracy requirements are based on.

## Rated Output

The value of the apparent power (in voltamperes at a specified power-factor) which the transformer is intended to supply to the secondary circuit at the rated secondary current and with rated burden connected to it.

## Rated Insulation Level

The combination of voltage values which characterizes the insulation of a transformer with regard to its capability to whitstand dielectric stresses.

## Rated Frequency

This is the frequency for which the transformer is designed and given in Hz on the rating plate.

## Rated Short-Time Thermal Current (Ith)

The r.m.s. value of the primary current which a transformer will withstand for one second without suffering harmful effects, the secondary winding being short-circuited.

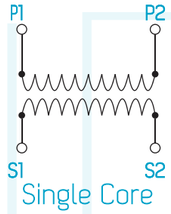
## Rated Dynamic Current (Idyn)

The peak value of the primary current which a transformer will withstand, without being damaged electrically or mechanically by the resulting electromagnetic forces, the secondary winding being short-circuited.

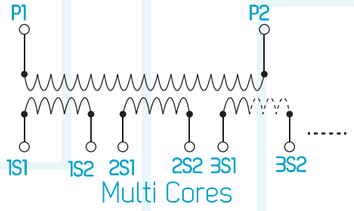
## Rated Continuous Thermal Current

The value of the current which can be permitted to flow continuously in the primary winding, the secondary winding being connected to the rated burden, without temperature rise exceeding the values specified.

## CONNECTION DIAGRAMS
### Single Ratio Current Transformers



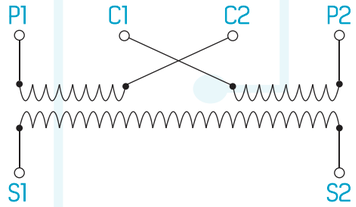
Single Core



Multi Cores

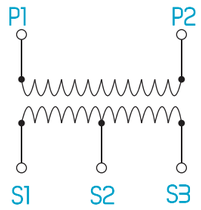
### Reconnection of Current Transformer
In case of changeable ratios, it is possible to design the transformer with primary reconnection or secondary tapping;

### Primary Reconnection
Changeover will be done at the primary side by using joint bars.
Can be used only for primary currents up to 2 x 600A




C1 -C2 short circuited: low rated current
P1 - C1 and P2 - C2 short circuited: high rated current

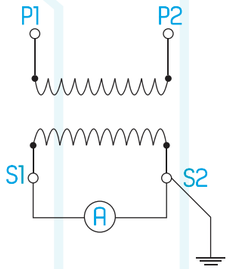
### Secondary Tapping
Changeover will be done at the secondary side.




S1 -S2 low rated current
S1 - S3 high rated current

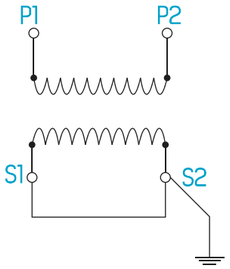
### Safety Operation Conditions for Current Transformers
- When the secondary terminals are connected to the measuring or protection devices, one of the terminals should be earthed for safety, as seen in Diagram-1.

Diagram-1



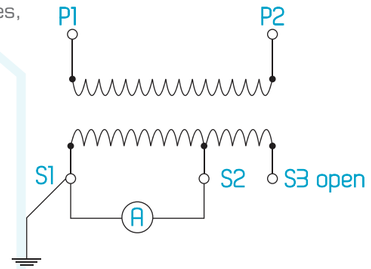

- The secondary circuit of a current transformer must not be operated with an open - circuit.
- The secondary winding of a current transformer which will not be used must be short - circuited and earthed as seen in Diagram-2

Diagram-2



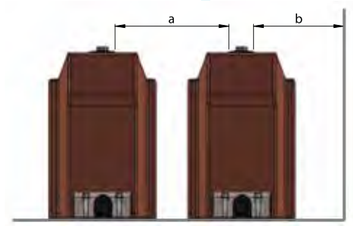

- For the transformer with reconnectable and - or tapped secondaries, unused terminals must be left open as seen in Diagram-3.

Diagram-3




- The current transformers which have capacitive divider tap (Ck) must be connected to the indicator, if the tap will not be used then it must be earthed.

## M.V. CURRENT TRANSFORMERS CONNECTION CLEARENCES




| INSULATION LEVEL | a minimum | b minimum |
|---|---|---|
| 12kV | 100mm | 110mm |
| 24kV | 190mm | 210mm |
| 36kV | 305mm | 325mm |



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV ..... 17,5kV BLOCK TYPES)

### Types:

ATB 10-B
ATB 10-B3
ATB 10-2

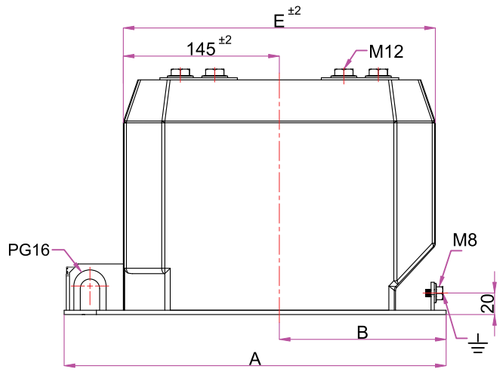
- Up to 3 cores*
- On request with capacitive layer.
- On request with barrier.

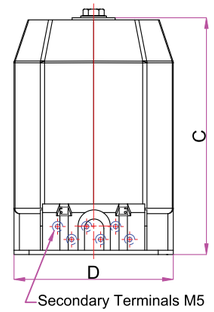
| Technical Data | Produced only in Indonesia Factory | | |
|---|---|---|---|
| Types | ATB 10-B | ATB 10-B3 | ATB 10-2 |
| Operating voltage, Um (kV) | 3,6 7,2 12 17,5 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 20 28 38 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 60 75 95 | | |
| Rated frequency (Hz) | 50-60 | | |
| Primary rated current (A) | 5 - 2500 (On request 3000A 1.0xIn / Cont. & Insulation class B) | | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | | |
| Secondary rated current (A) | 1 - 5 | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | | |
| Rated short-time thermal current (Ith) (1s) (kA) | Max. 60 kA or 1000 x In | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | |
| Short-time load (mechanical) (N) | 5000 | | |
| Insulation class | E | | |
| Ambient temperature (°C) | -25 ..... +40** | | |
| Altitude (m) | 1000 | | |
| Standard | According to the customer requirements | | |
| Weight (approx.) (kg) | 20 - 25 | 25 - 33 | 28 - 33 |

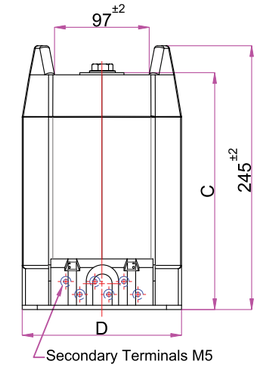
*On request operating voltage of 17,5 kV is available.*
* *For more cores please contact with ARTECHE for feasibility.*
** *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

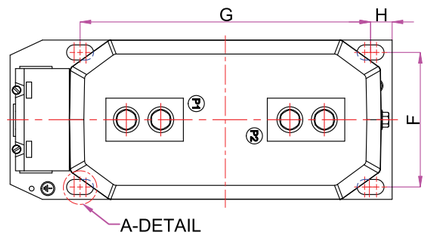
(Um=3,6kV ..... 17,5kV BLOCK TYPES)

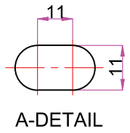


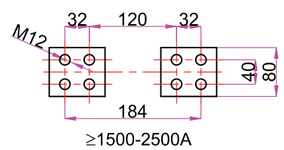




With barrier

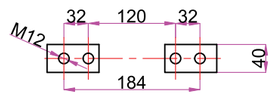


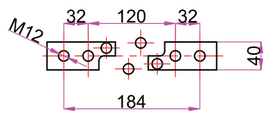

Primary Connection Bars




≥1500-2500A




<1500A




≤ 2x600A

| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATB 10-B | 355 | 155 | 220 | 148 | 290 | 125 | 270 | 20 |
| ATB 10-B3 | 455 | 255 | 220 | 148 | 390 | 125 | 370 | 20 |
| ATB 10-2 | 385 | 170 | 220 | 175 | 290 | 150 | 300 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV ..... 17,5kV NEW BLOCK TYPES)

### Types:

ATB 10-BS (With barrier ATB 10-BSB)
ATB 10-BS2 (With barrier ATB 10-BS2B)
ATB 10-B3 (With barrier ATB 10-B3B)
ATB 10-B4 (With barrier ATB 10-B4B)

- Up to 3 cores*
- On request with capacitive layer.
- On request with barrier.

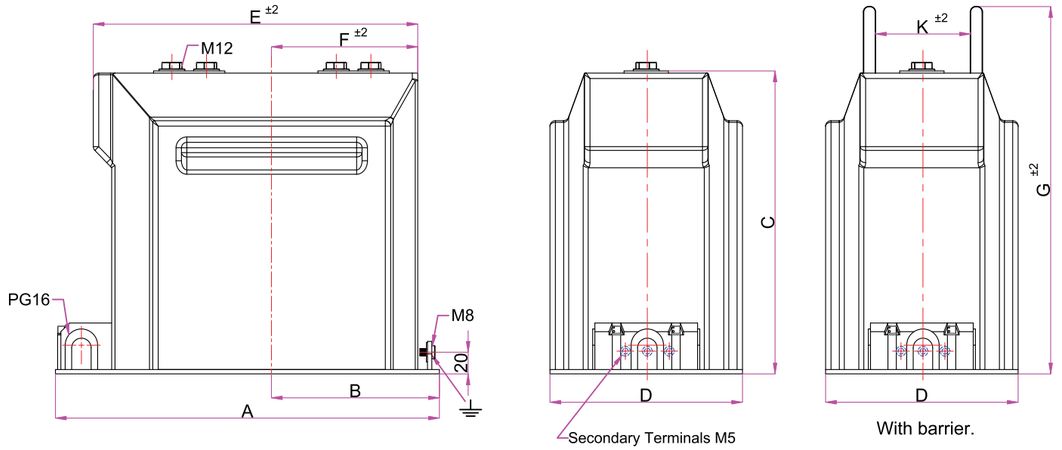
### Technical Data

| Types | ATB 10-BS | ATB 10-BS2 | ATB 10-B3 | ATB 10-B4 |
|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 7,2 | 12 17,5 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 20 | 28 38 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 60 | 75 95 | | |
| Rated frequency (Hz) | 50-60 | | | |
| Primary rated current (A) | 5 - 2500 (On request 3000A 1.0xIn / Cont. & Insulation class B) | | | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | | | |
| Secondary rated current (A) | 1 - 5 | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | | |
| Short-time load (mechanical) (N) | 5000 | | | |
| Insulation class | E | | | |
| Ambient temperature (°C) | -25 ..... +40** | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 20 - 25 | 25 - 33 | 28 - 33 | |

* *For more cores please contact with ARTECHE for feasibility.*
** *It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.*

## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV ..... 17,5kV NEW BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ATB 10-BS | 355 | 155 | 220 | 148 | 299 | 135 | 245 | 125 | 270 | 20 | 88 |
| ATB 10-BS2 | 355 | 155 | 220 | 175 | 300 | 135 | 245 | 150 | 270 | 20 | 115 |
| ATB 10-B3 | 455 | 255 | 220 | 148 | 390 | 245 | 245 | 125 | 370 | 20 | 88 |
| ATB 10-B4 | 355 | 160 | 220 | 184 | 300 | 135 | 280 | 160 | 270 | 25 | 110 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=17,5 ..... 24kV NEW BLOCK TYPES)

### Types:

ATB 20-BS (With barrier ATB 20-BSB)
ATB 20-BS2 (With barrier ATB 20-BS2B)

- Up to 3 cores*
- On request with capacitive layer.
- On request with barrier.

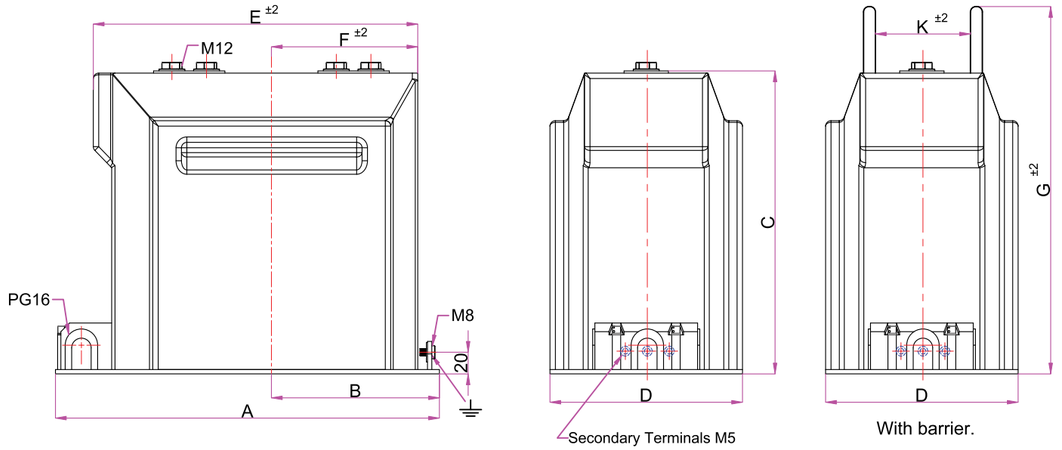
### Technical Data

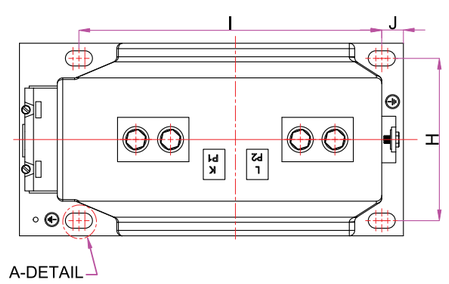
| Types | ATB 20-BS | ATB 20-BS2 |
|---|---|---|
| Operating voltage, Um (kV) | 17,5 | 24*** |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | 125 |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5 - 2500 (On request 3000A 1.0xIn / Cont. & Insulation class B) | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | |
| Short-time load (mechanical) (N) | 5000 | |
| Insulation class | E | |
| Ambient temperature (°C) | -25 ..... +40** | |
| Altitude (m) | 1000 | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 30 | |

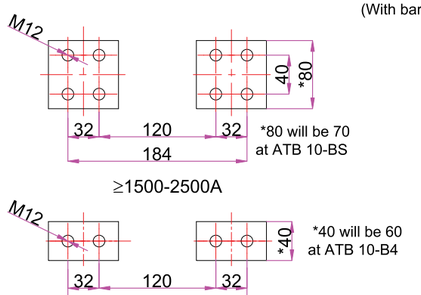
* For more cores please contact with ARTECHE for feasibility.
** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.
*** For more kV, please contact with ARTECHE for feasibility.

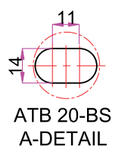
## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

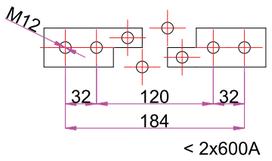
(Um=17,5 ..... 24kV NEW BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ATB 20-BS | 355 | 155 | 280 | 178 | 300 | 135 | 340 | 150 | 280 | 20 | 88 |
| ATB 20-BS2 | 355 | 155 | 280 | 250 | 300 | 135 | 340 | 150 | 280 | 20 | 88 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV ..... 12kV NARROW BLOCK TYPES)

Types:
ATB 10-10
ATB 10-15

- ATB 10-10, up to 1 core*
- ATB 10-15, up to 2 cores.*

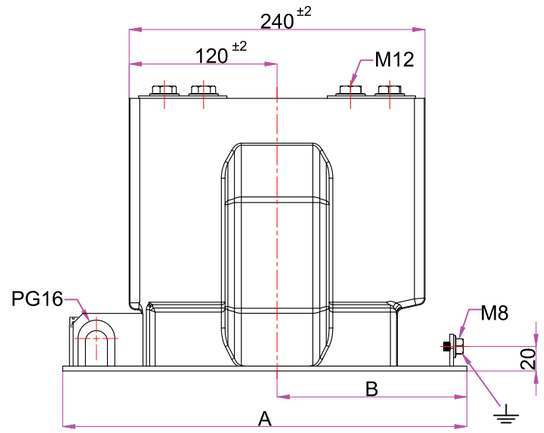
### Technical Data

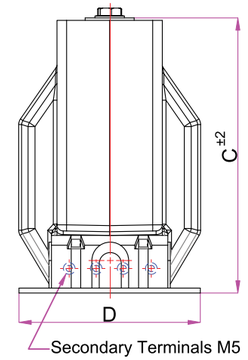
| Types | ATB 10-10 | ATB 10-15 |
|---|---|---|
| Operating voltage, Um (kV) | 3,6 7,2 12 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 20 28 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 60 75 | |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5-up to 1250 | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; Cl:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | (max. 200 x In) ** | |
| Rated dynamic current (Idyn) (kA) | (2,5 x Ith) | |
| Short-time load (mechanical) (N) | 5000 | |
| Insulation class | E | |
| Ambient temperature (°C) | -25 ..... +40 *** | |
| Altitude (m) | 1000 | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 12 | 17 |

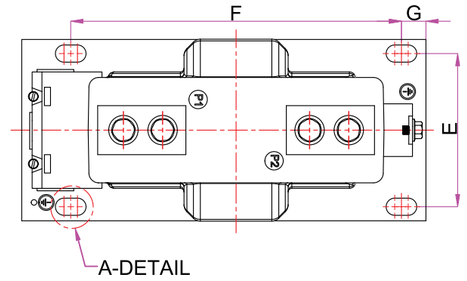
*On request operating voltage of 17,5 kV is available.*
* *For more cores please contact with ARTECHE for feasibility.*
** *May vary according to requested primary current and core values.*
*** *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

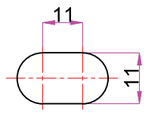
## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV ..... 12kV NARROW BLOCK TYPES)

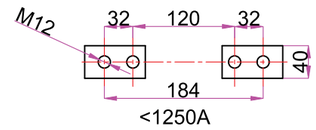


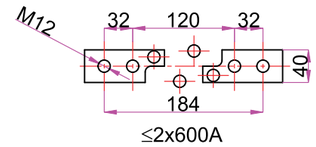




Primary Connection Bars




| Types | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| ATB 10-10 | 330 | 155 | 220 | 148 | 125 | 270 | 20 |
| ATB 10-15 | 330 | 155 | 220 | 148 | 125 | 270 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=17,5kV ..... 24kV BLOCK TYPES)

### Types:

ATB 20-B (With barrier ATB 20-BR)
ATB 20-B2
ATB 20-3
ATB 20-3B

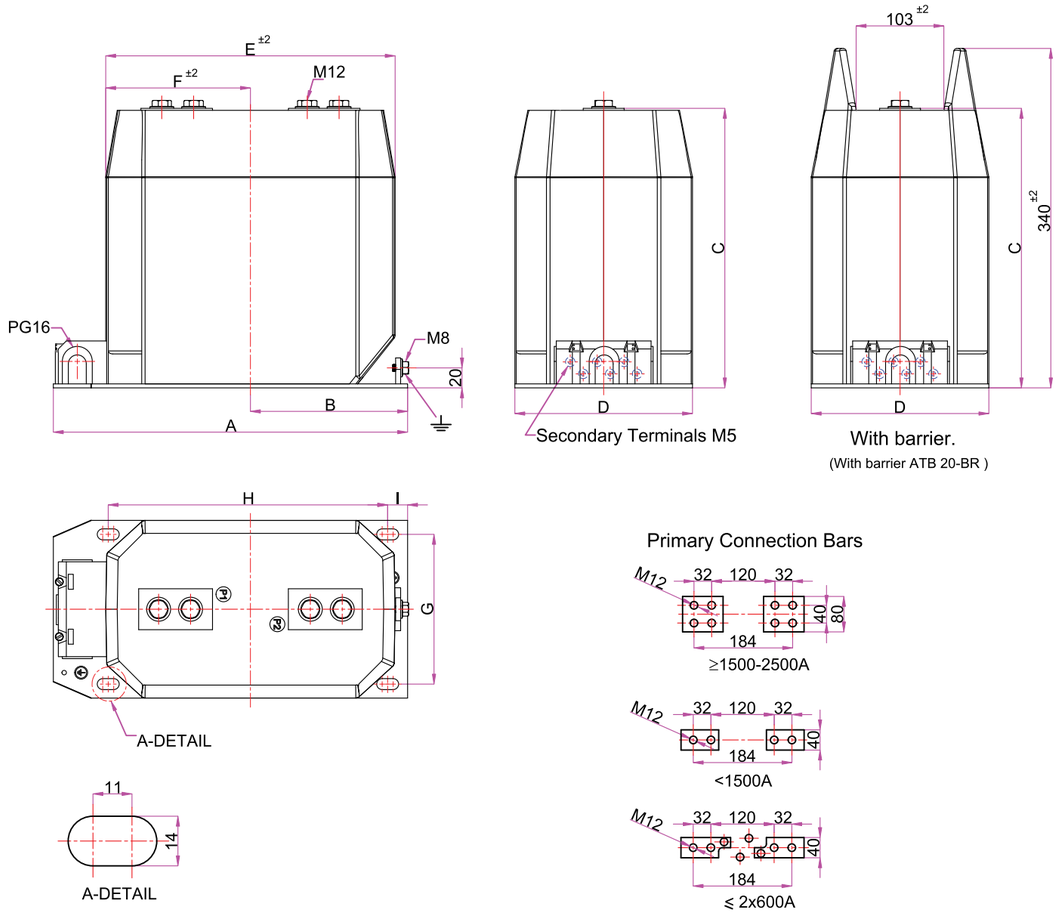
- Up to 3 cores.*
- On request with capacitive layer.
- On request with barrier.

| Technical Data | Produced only in Indonesia Factory | | | |
|---|---|---|---|---|
| Types | ATB 20-B | ATB 20-B2 | ATB 20-3 | ATB 20-3B |
| Operating voltage, Um (kV) | 17,5 | | 24 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | | 50 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | | 125 | |
| Rated frequency (Hz) | 50-60 | | | |
| Primary rated current (A) | 5 - 2500 (On request 3000A 1.0xIn / Cont. & Insulation class B) | | | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | | | |
| Secondary rated current (A) | 1 - 5 | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | Max. 60 kA or 1000 x In | | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | | |
| Short-time load (mechanical) (N) | 5000 | | | |
| Insulation class | E | | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 30 | 42 | 44 | 55 |

* For more cores please contact with ARTECHE for feasibility.
** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.

## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=17,5kV ..... 24kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| ATB 20-B | 355 | 155 | 280 | 178 | 290 | 145 | 150 | 280 | 20 |
| ATB 20-B2 | 355 | 155 | 280 | 205 | 290 | 145 | 180 | 280 | 17 |
| ATB 20-3 | 455 | 197 | 280 | 178 | 390 | 195 | 150 | 300 | 22 |
| ATB 20-3B | 455 | 197 | 280 | 205 | 390 | 195 | 180 | 375 | 22 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=17,5kV ..... 24kV NEW BLOCK TYPES)

### Types:

ATB 20-3A (With barrier ATB 20-3AB)
ATB 20-3B (With barrier ATB 20-3BB)

- Up to 3 cores.*
- On request with capacitive layer.
- On request with barrier.

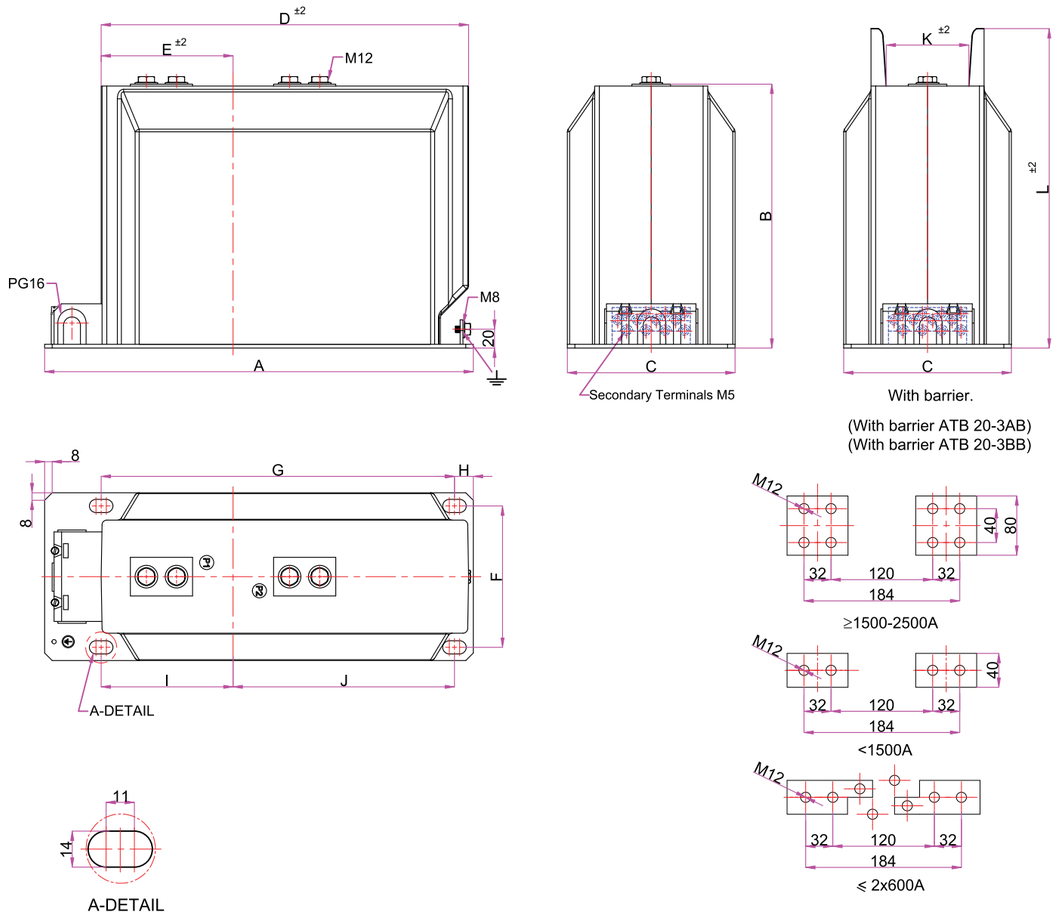
### Technical Data

| Types | ATB 20-3A | ATB 20-3B |
|---|---|---|
| Operating voltage, Um (kV) | 17,5 | 24*** |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | 125 |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5 - 2500 (On request 3000A 1.0xIn / Cont. & Insulation class B) | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | |
| Short-time load (mechanical) (N) | 5000 | |
| Insulation class | E | |
| Ambient temperature (°C) | -25 ..... +40 ** | |
| Altitude (m) | 1000 | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 44 | 55 |

* For more cores please contact with ARTECHE for feasibility.
** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.
*** For more kV, please contact with ARTECHE for feasibility.

## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=17,5kV ..... 24kV NEW BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ATB 20-3A | 455 | 280 | 178 | 390 | 140 | 150 | 375 | 20 | 140 | 235 | - | - |
| ATB 20-3B | 455 | 280 | 205 | 390 | 140 | 180 | 375 | 20 | 140 | 235 | 88 | 340 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*




## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=17,5kV ..... 24kV NARROW BLOCK TYPES)

### Types:

ATB 20-10
ATB 20-15

- ATB 20-10, up to 1 core*
- ATB 20-15, up to 2 cores.*

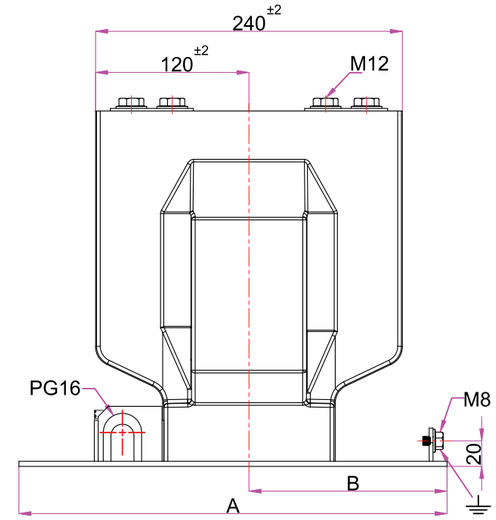
### Technical Data

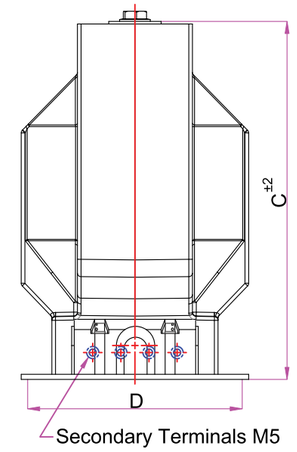
| Types | ATB 20-10 | ATB 20-15 |
|---|---|---|
| Operating voltage, Um (kV) | 17,5 | 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | 125 |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5 up to 1250 | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | (max. 300 x In) ** | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | |
| Short-time load (mechanical) (N) | 5000 | |
| Insulation class | E | |
| Ambient temperature (°C) | -25 ..... +40 *** | |
| Altitude (m) | 1000 | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 20 | 25 |

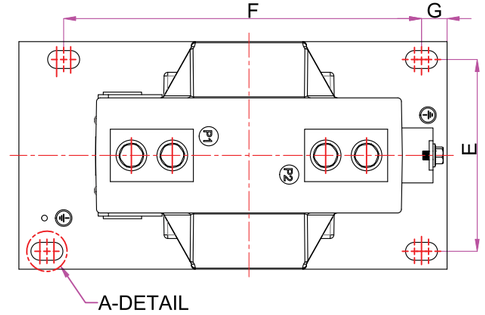
* *For more cores please contact with ARTECHE for feasibility.*
** *May vary according to requested primary current and core values.*
*** *It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.*

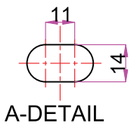
## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

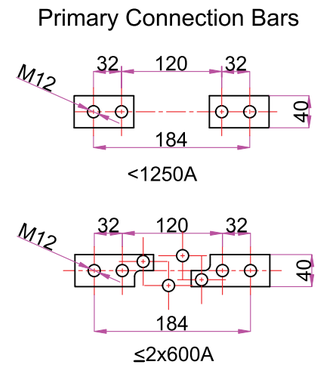
(Um=17,5kV ..... 24kV NARROW BLOCK TYPES)




| Types | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| ATB 20-10 | 335 | 155 | 280 | 178 | 150 | 280 | 20 |
| ATB 20-15 | 335 | 155 | 280 | 178 | 150 | 280 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=36kV BLOCK TYPES)

### Types:

ATB 30-S1 (With barrier ATB 30-S1B)
ATB 30-1
ATB 30-2 (With barrier ATB 30-2B)
ATB 30-3 (With barrier ATB 30-3B)

- Up to 3 cores.*
- On request with capacitive layer.
- On request with barrier.
- On request height: 390 mm as ATB 30-S1H
  ATB 30-2H
  ATB 30-3H

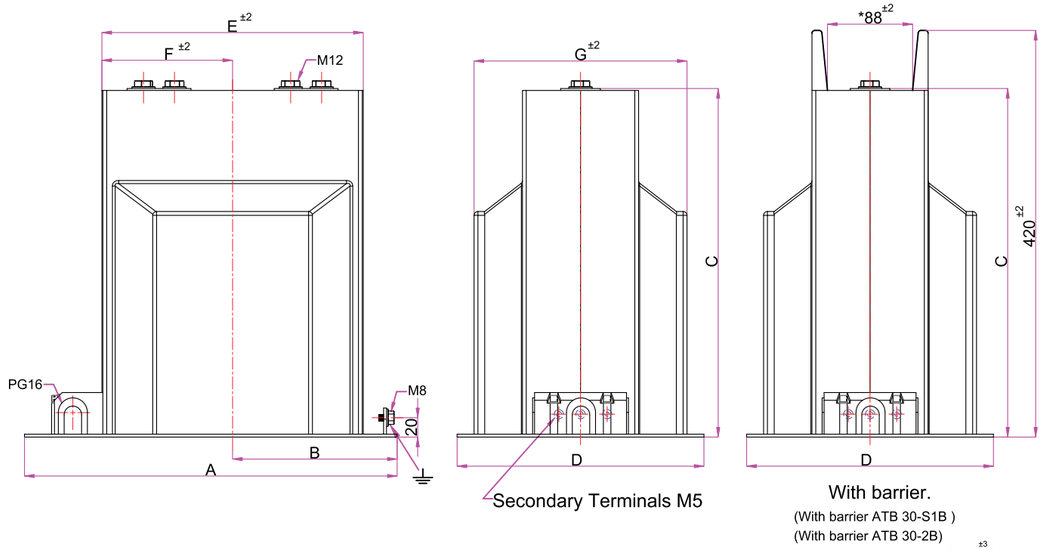
### Technical Data

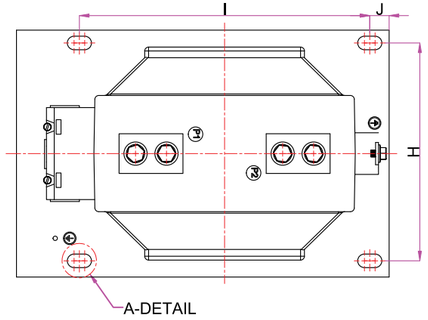
| Types | ATB 30-S1 | ATB 30-1 | ATB 30-2 | ATB 30-3 |
|---|---|---|---|---|
| Operating voltage, Um (kV) | 36*** | | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | | | |
| Rated frequency (Hz) | 50-60 | | | |
| Primary rated current (A) | 5 - 2500 (On request 3150A 1.0xIn / Cont. & Insulation class B ) | | | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | | | |
| Secondary rated current (A) | 1 - 5 | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | | |
| Short-time load (mechanical) (N) | 5000 | | | |
| Insulation class | E | | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 38-48 | 45-50 | 50-55 | 65 |

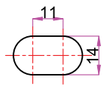
* For more cores please contact with ARTECHE for feasibility.
** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.
*** For more kV, please contact with ARTECHE for feasibility.

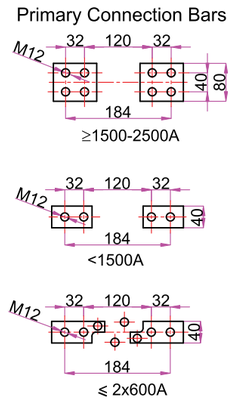
## INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=36kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| ATB 30-S1 | 385 | 170 | 360(390 ATB 30-S1H) | 255 | 270 | 135 | 220 | 225 | 300 | 20 |
| ATB 30-1 | 385 | 170 | 360 | 255 | 270 | 135 | 220 | 225 | 300 | 20 |
| ATB 30-2 | 385 | 170 | 360(390 ATB 30-2H) | 255 | 310 | 155 | 240 | 225 | 300 | 20 |
| ATB 30-3 | 455 | 210 | 360(390 ATB 30-3H) | 255 | 389 | 195 | 249 | 225 | 375 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Tolerances are according to DIN 7168-g when not specified.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



# INDOOR SUPPORT TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=36kV NARROW BLOCK TYPES)

## Types:

ATB 30-5
ATB 30-10 (With barrier ATB 30-10B)
ATB 30-15 (With barrier ATB 30-15B)

- ATB 30-5, 30-10 up to 1 core.*
- ATB 30-15, up to 2 cores.**
- ATB 30-10 & ATB 30-15 with barrier on request.
- On request height: 390 mm as ATB 30-10H
  ATB 30-15H

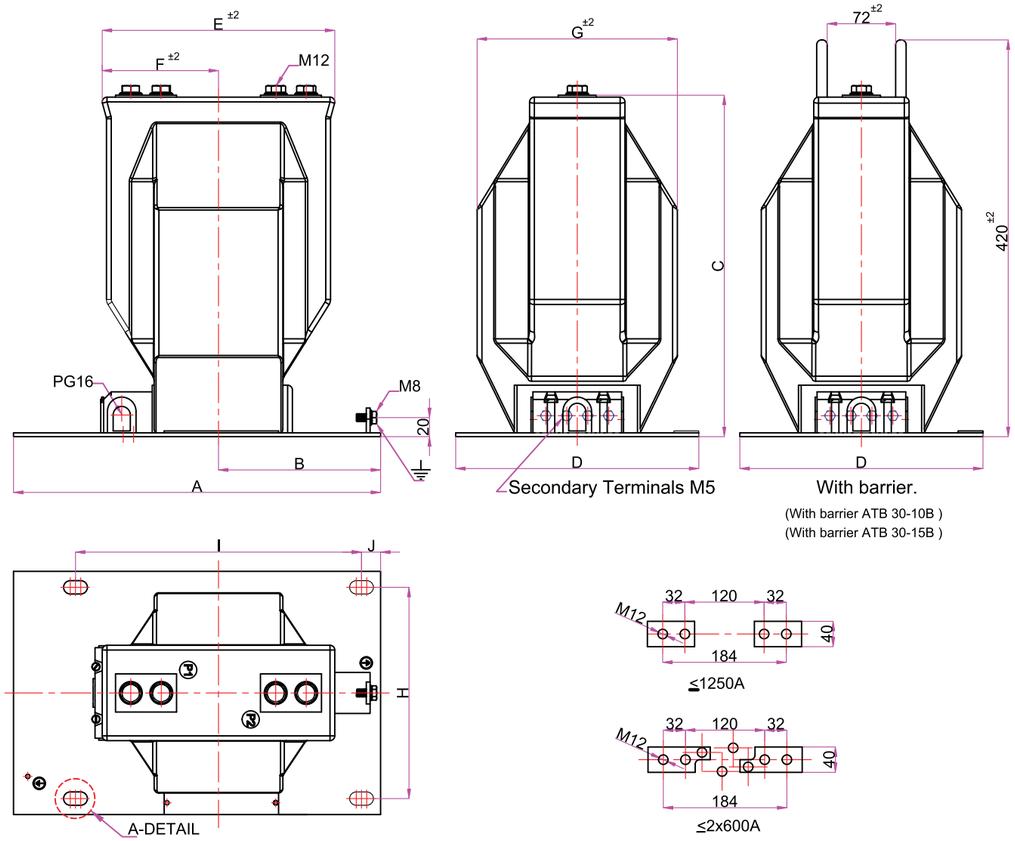
## Technical Data

| Types | ATB 30-5 | ATB 30-10 | ATB 30-15 |
|---|---|---|---|
| Operating voltage, Um (kV) | 36 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | | |
| Rated frequency (Hz) | 50-60 | | |
| Primary rated current (A) | 5 - 1250 | | |
| Primary reconnection (A) | 2x5 - 2x600 | | |
| Secondary rated current (A) | 1 - 5 | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 400xIn ** (for 1 measurement core) | max. 800xIn ** (for 1 measurement core) | max. 300xIn ** (for 2 core) |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | |
| Short-time load (mechanical) (N) | 5000 | | |
| Insulation class | E | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | |
| Altitude (m) | 1000 | | |
| Standard | According to the customer requirements | | |
| Weight (approx.) (kg) | 22 | 30-35 | 35-40 |

* For more cores please contact with ARTECHE for feasibility.
** May vary according to requested primary current and core values.
*** It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.

# INDOOR SUPPORT TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=36kV NARROW BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| ATB 30-5 | 385 | 170 | 360 | 255 | 250 | 125 | 210 | 225 | 300 | 20 |
| ATB 30-10 | 385 | 170 | 360(390 ATB 30-10H) | 255 | 250 | 125 | 210 | 225 | 300 | 20 |
| ATB 30-15 | 385 | 170 | 360(390 ATB 30-15H) | 255 | 250 | 125 | 210 | 225 | 300 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

- *All dimensions are in mm.*
- *Tolerances are according to DIN 7168-g when not specified.*
- *Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
- *Customer designed products are also available.*



## INDOOR SUPPORT TYPE CAST RESIN INSULATED NARROW TYPE CURRENT TRANSFORMERS

(Um=7,2kV ..... 24kV BLOCK TYPES)

**Types:**
ATU 24

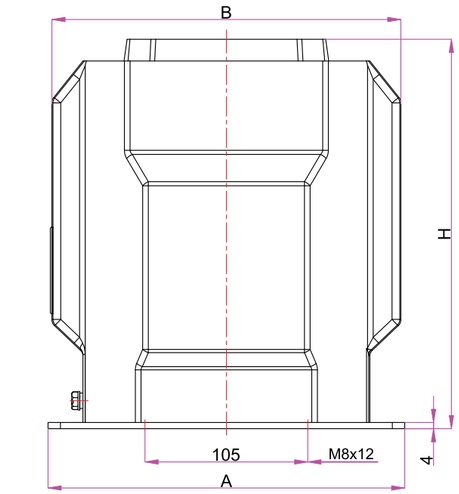
- Up to 2 cores.

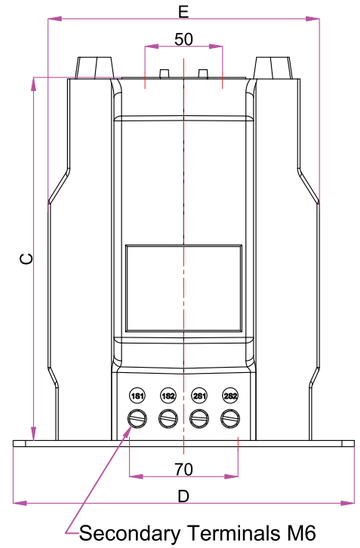
| Technical Data | Produced only in Indonesia Factory |
|---|---|
| Types | ATU 24 |
| Operating voltage, Um (kV) | 7,2 / 12 / 17,5 / 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 20 / 28 / 38 / 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 60 / 75 / 95 / 125 |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 10 - 800 |
| Primary reconnection (A) | 2x10 - 2x400 |
| Secondary rated current (A) | 1 - 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | 100 x In* |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith |
| Short-time load (mechanical) (N) | 5000 |
| Insulation class | E |
| Ambient temperature (°C) | -25 ..... +40 ** |
| Altitude (m) | 1000 |
| Standard | According to the customer requirements |
| Weight (approx.) (kg) | 24 |

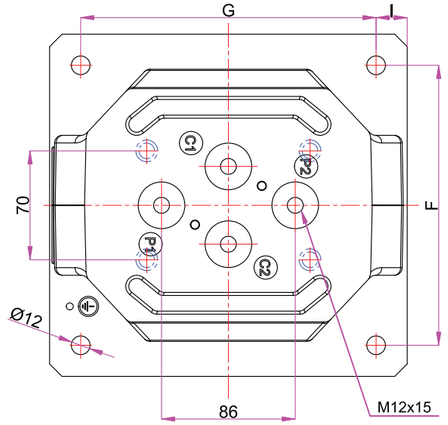
* *May vary according to requested primary current and core values.*
** *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

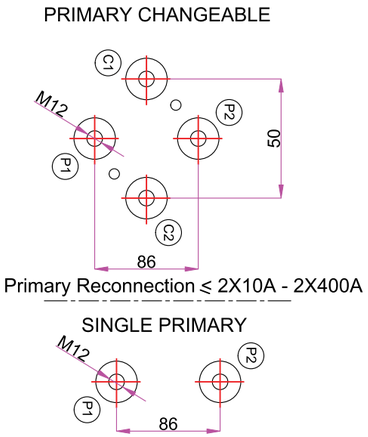
## INDOOR SUPPORT TYPE CAST RESIN INSULATED NARROW TYPE C.T.'S TECHNICAL DRAWING

(Um=7,2kV ..... 24kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| ATU 24 | 230 | 225 | 234 | 220 | 175 | 180 | 190 | 247 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



# INDOOR SUPPORT TYPE CAST RESIN INSULATED SPECIAL TYPE CURRENT TRANSFORMERS

(Um=7,2kV ..... 24kV BLOCK TYPES)

## Types:

ES 24 C3-B

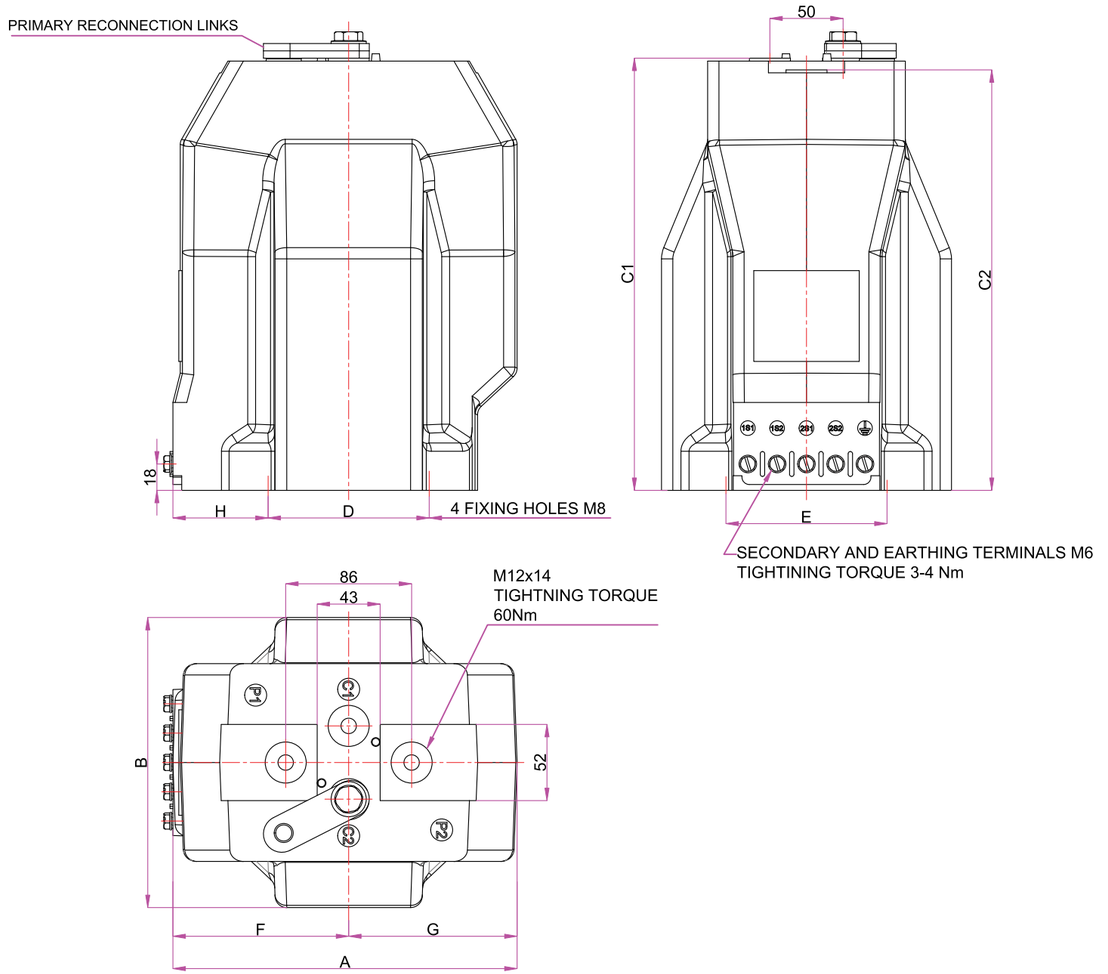
- Up to 2 cores.

| Technical Data | Produced only in Indonesia Factory | | | |
|---|---|---|---|---|
| Types | ES 24 C3-B | | | |
| Operating voltage, Um (kV) | 7,2 | 12 | 17,5 | 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 20 | 28 | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 60 | 75 | 95 | 125 |
| Rated frequency (Hz) | 50-60 | | | |
| Primary rated current (A) | 10 - 800 | | | |
| Primary reconnection (A) | 2 x 10 - 2 x 400 | | | |
| Secondary rated current (A) | 1 - 5 | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | |
| Protection classes | 5P-10P-PX Acc. to IEC 61869-1&2 | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | Up to 60kA* | | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | | |
| Short-time load (mechanical) (N) | 5000 | | | |
| Insulation class | E | | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 25 | | | |

* *May vary according to requested primary current and core values.*
** *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

# INDOOR SUPPORT TYPE CAST RESIN INSULATED SPECIAL TYPE C.T.'S TECHNICAL DRAWING

(Um=7,2kV ..... 24kV BLOCK TYPES)




| Types | A | B | C1 | C2 | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|
| ES 24 C3-B | 235 | 198 | 295 | 287 | 110 | 110 | 120 | 115 | 65 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV .....24kV)

### Types:

ATD 10
ATD 20

- Up to 2 cores.

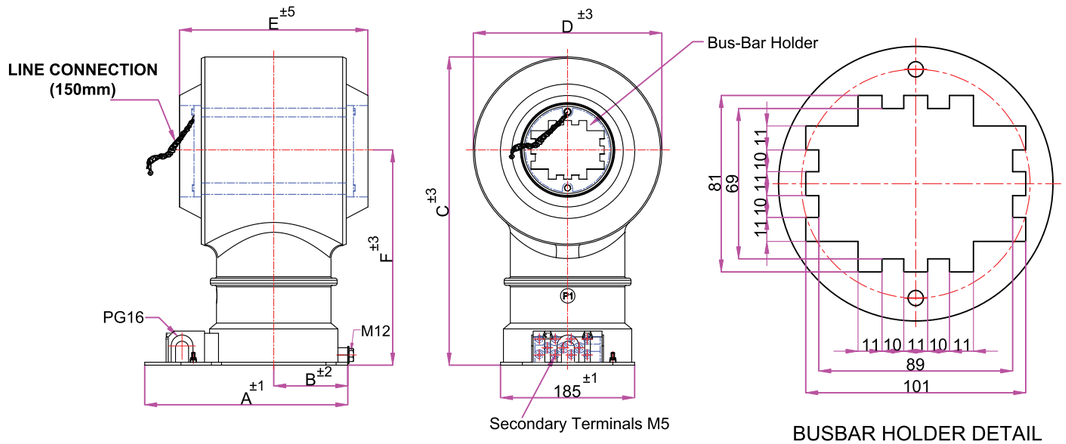
## Technical Data

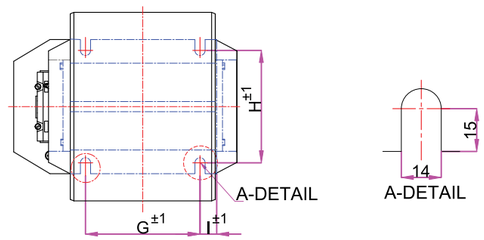
| Types | ATD 10 | | | ATD 20 | |
|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 |
| Rated frequency (Hz) | 50-60 | | | | |
| Primary rated current (A) | 800-3000 | | | 800-4000 | |
| Primary reconnection (A) | 2 x 10 - 2 x 400 | | | | |
| Secondary rated current (A) | 1 - 5 | | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 100 | | | | |
| Rated dynamic current (Idyn) (kA) | Practically Unlimited | | | | |
| Short-time load (mechanical) (N) | 3000 | | | | |
| Insulation class | E | | | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | | | |
| Altitude (m) | 1000 | | | | |
| Standard | According to the customer requirements | | | | |
| Weight (approx.) (kg) | 19 | | | 34 | |

* *For more cores please contact with ARTECHE for feasibility.*
** *It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.*

## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV .....24kV)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| ATD 10 | 280 | 102 | 342 | 214 | 215 | 235 | 158 | 155 | 23 |
| ATD 20 | 280 | 102 | 427 | 260 | 260 | 295 | 158 | 155 | 23 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

*- All dimensions are in mm.*
*- Tolerance is DIN 7168-g .*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*




## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV.....17,5kV)

Types:
ATN 17-1
ATN 17-2
ESO 17 C
ATN 18
ATN 19
AR 01a
AR 03

- Up to 3 cores.*

## Technical Data

| Types | ATN 17-1 | ATN 17-2 | ATN 17 C | ATN 18 | ATN 19 | AR01a / AR 03 |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | | 7,2 | 12 | 17,5 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | | 20 | 28 | 38 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | | 60 | 75 | 95 | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Primary rated current (A) | 800-4000 | | | | | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | | | | | |
| Secondary rated current (A) | 1 - 5 | | | | | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | | | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | | | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 100 | | | | | |
| Rated dynamic current (Idyn) (kA) | Practically Unlimited | | | | | |
| Short-time load (mechanical) (N) | 3000 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40 ** | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 35 | 30 | 40 | | | 38 |

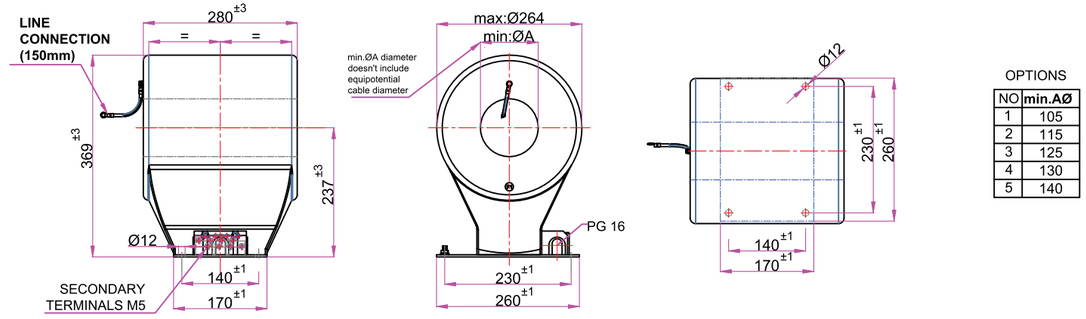
* *For more cores please contact with ARTECHE for feasibility.*
** *It can be produced according to customer's specified ambient temperature.Please contact with ARTECHE for feasibility.*



## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV.....17,5kV)

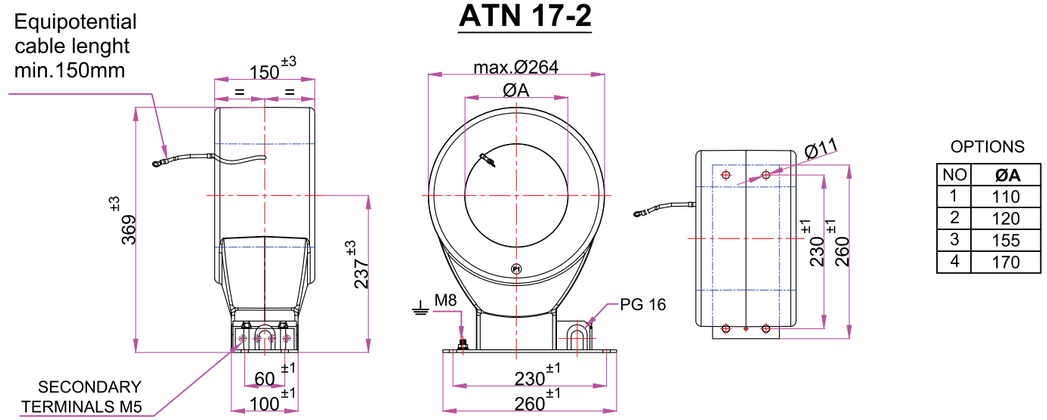
### ATN 17-1




OPTIONS

| NO | min.AØ |
|---|---|
| 1 | 105 |
| 2 | 115 |
| 3 | 125 |
| 4 | 130 |
| 5 | 140 |

### ATN 17-2




OPTIONS

| NO | ØA |
|---|---|
| 1 | 110 |
| 2 | 120 |
| 3 | 155 |
| 4 | 170 |

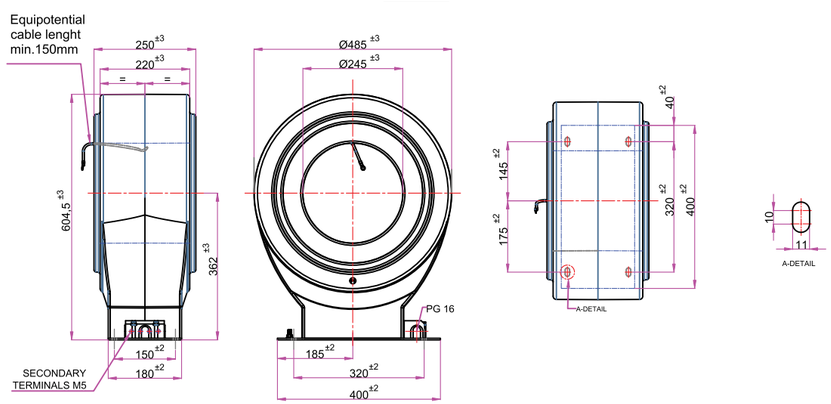
| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

*- All dimensions are in mm.*
*- Tolerance is DIN 7168-g.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*

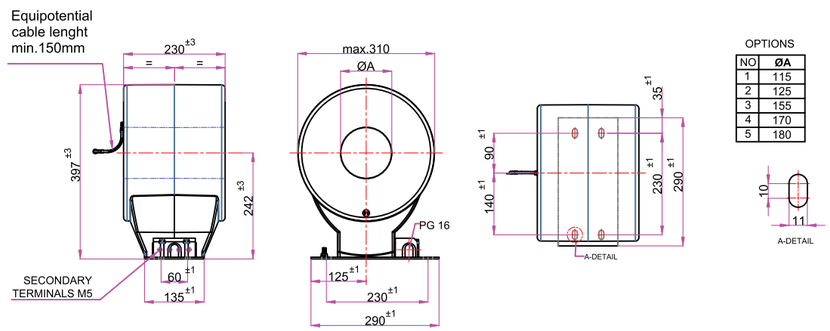
# INDOOR POST BUSBAR TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV.....17,5kV)

## ATN 18




## ATN 19




OPTIONS

| NO | ØA |
|---|---|
| 1 | 115 |
| 2 | 125 |
| 3 | 155 |
| 4 | 170 |
| 5 | 180 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

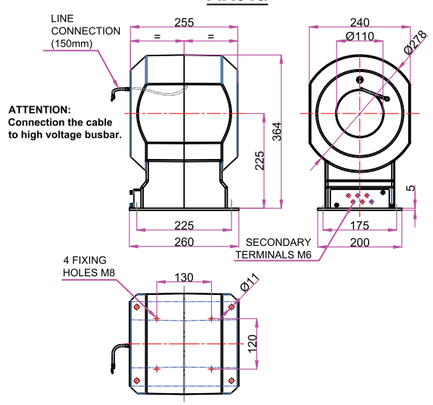
*- All dimensions are in mm.*
*- Tolerance is DIN 7168-g.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



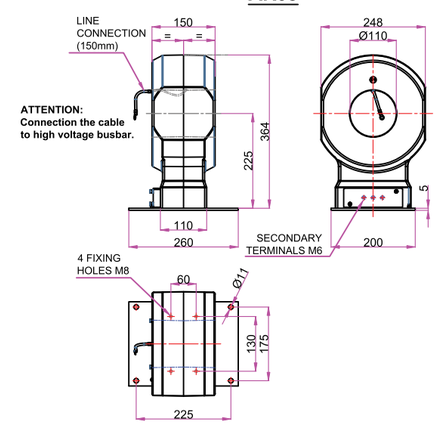
INDOOR POST BUSBAR TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV.....17,5kV)

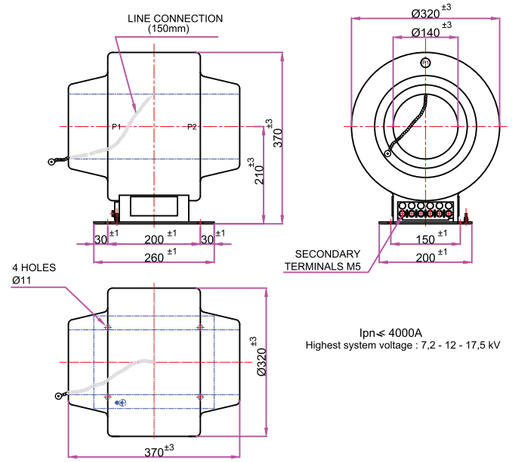
## AR01a




## AR03




## ESO 17 C




Ipn≤ 4000A
Highest system voltage : 7,2 - 12 - 17,5 kV

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M6 (Primary Terminal) | 3 | 5 |

*- All dimensions are in mm.*
*- Tolerance is DIN 7168-g.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SUPPORT TYPE CAST RESIN INSULATED SPECIAL TYPE CURRENT TRANSFORMERS

(Um= 3.6kV ..... 24kV BLOCK TYPES)

### Types:

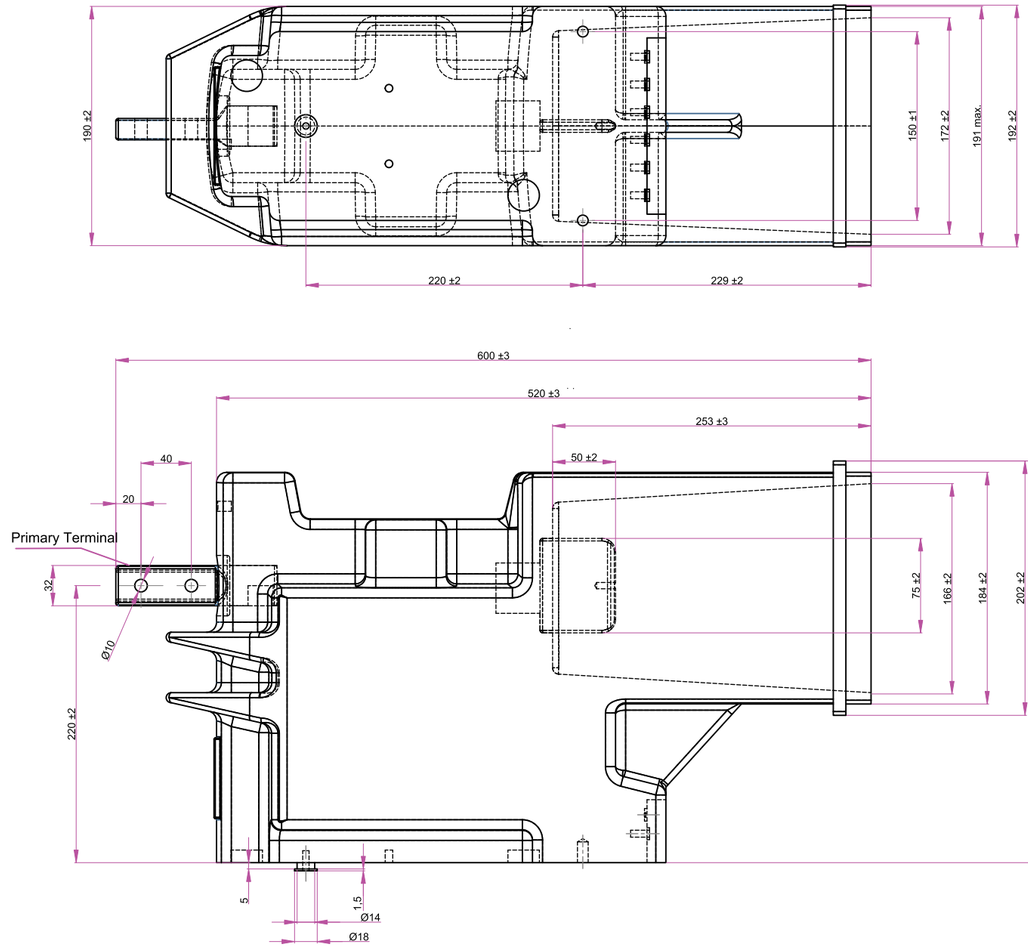
ATSI 24

| Technical Data | Produced only in Indonesia Factory |
|---|---|
| Types | ATSI 24 |
| Operating voltage, Um (kV) | 3,6 7,2 12 17,5 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 20 28 38 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 60 75 95 125 |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 300-600 or 400-800 |
| Secondary reconnection (A) | 300-600/5 or 400-800/5 |
| Secondary rated current (A) | 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P-10P- to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | Up to 60kA* |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith |
| Short-time load (mechanical) (N) | 5000 |
| Insulation class | E |
| Ambient temperature (°C) | -25 ..... +40 ** |
| Altitude (m) | 1000 |
| Standard | According to the customer requirements |
| Weight (approx.) (kg) | 25 |

* *May vary according to requested primary current and core values.*
** *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR SUPPORT TYPE CAST RESIN INSULATED SPECIAL TYPE C.T.'S TECHNICAL DRAWING

(Um= 3.6kV ..... 24kV BLOCK TYPES)




*- All dimensions are in mm.*
*- Tolerance is DIN 7168-g.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*




## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV.....24kV)

### Types:

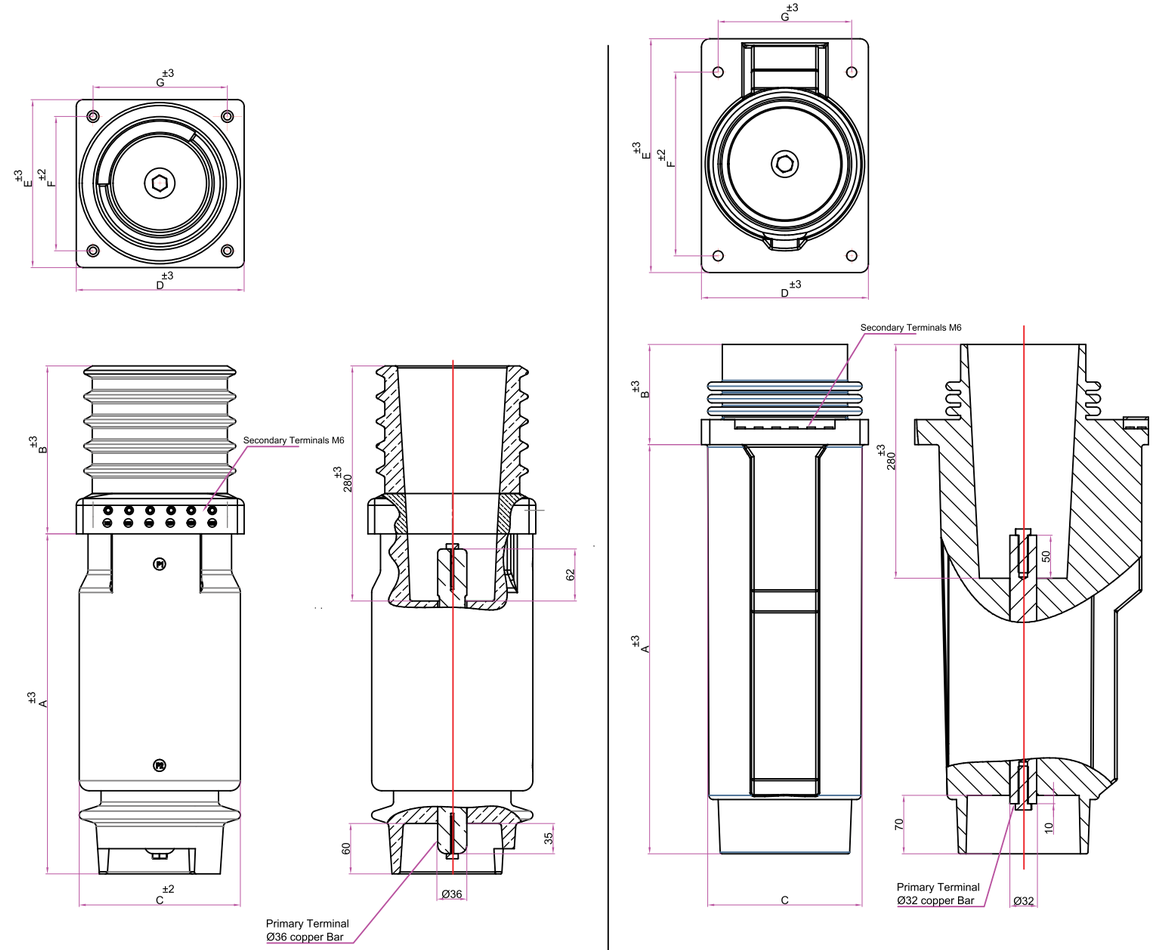
ATGI 24
ATGI 24-2

| Technical Data | Produced only in Indonesia Factory |
|---|---|
| Types | ATGI 24 |
| Operating voltage, Um (kV) | 3,6 7,2 12 17,5 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 20 28 38 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 60 75 95 125 |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 300-600 or 400-800 |
| Primary reconnection (A) | 300-600/5 or 400-800/5 |
| Secondary rated current (A) | 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P-10P- to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | Up to 60kA* |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith |
| Short-time load (mechanical) (N) | 5000 |
| Insulation class | E |
| Ambient temperature (°C) | -25 ..... +40 ** |
| Altitude (m) | 1000 |
| Standard | According to the customer requirements |
| Weight (approx.) (kg) | 25 |

* *May vary according to requested primary current and core values.*
** *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR POST BUSBAR TYPE CAST RESIN INSULATED SPECIAL TYPE C.T.'S TECHNICAL DRAWING

(Um=3,6kV.....24kV)




| Types | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| ATGI 24 | 405 | 200 | Ø190 | 200 | 200 | 160 | 160 |
| ATGI 24-2 | 490 | 120 | Ø185 | 200 | 280 | 220 | 160 |

*- All dimensions are in mm.*
*- Tolerance is DIN 7168-g.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=3,6kV .....24kV)

### Types:

ATH 20-S
ATH 21
ATH 21-2
ATH 22-N

- ATH 20-S up to 1 core.*
- ATH 21, ATH 21-2 up to 2 cores.*
- ATH 22-N up to 3 cores.*



For the connection of aluminium conductors steel reinforced

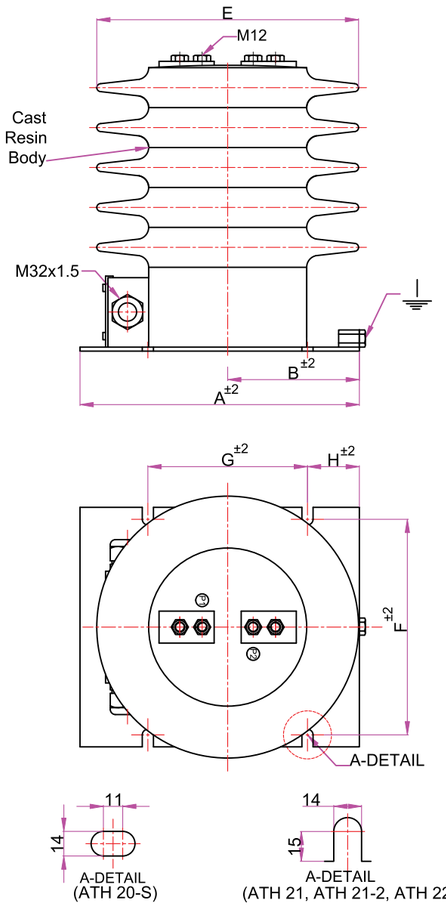
### Technical Data

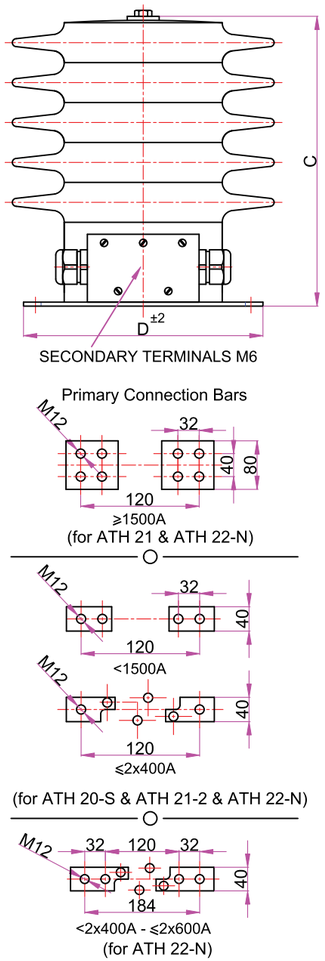
| Types | ATH 20-S | ATH 21 | ATH 21-2 | ATH 22-N |
|---|---|---|---|---|
| Operating voltage, Um (kV) | | 3,6 7,2 12 17,5 24** | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | | 10 20 28 38 50 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | | 40 60 75 95 125 | | |
| Rated frequency (Hz) | | 50-60 | | |
| Primary rated current (A) | 5-1250 | 5-2500 | | |
| Primary reconnection (A) | | 2x5 - 2x400 | | 2x5 - 2x600 |
| Secondary rated current (A) | | 1 - 5 | | |
| Metering classes | | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | |
| Protection classes | | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | | |
| Rated short-time thermal current (Ith) (1s) (kA) | | max. 1000 x In | | |
| Rated dynamic current (Idyn) (kA) | | 2,5 x Ith | | |
| Short-time load (mechanical) (N) | | 2400 | | |
| Insulation class | | E | | |
| Min. creepage distance (mm) | 560 | 825 | | 770 |
| Altitude (m) | | According to the customer requirements | | |
| Standard | | According to the customer requirements | | |
| Weight (approx.) (kg) | 24 | 35 | 38 | 78 |

* For more cores please contact with ARTECHE for feasibility.
** For more kV, please contact with ARTECHE for feasibility.

## OUTDOOR DRY TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=3,6kV .....24kV)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATH 20-S | 245 | 105 | max. 350 | 220 | max. ⌀225 | 178 | 175 | 20 |
| ATH 21 | 350 | 165 | max. 370 | 300 | max. ⌀340 | 270 | 200 | 65 |
| ATH 21-2 | 350 | 165 | max. 370 | 300 | max. ⌀340 | 270 | 200 | 65 |
| ATH 22-N | 400 | 195 | max. 380 | 370 | max. ⌀415 | 340 | 250 | 70 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary Terminal) | 60 | 70 |

- All dimensions are in mm.
- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.
- Customer designed products are also available.



## OUTDOOR DRY TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=36kV)

### Types:

ATH 32

- ATH 32 up to 3 cores.*



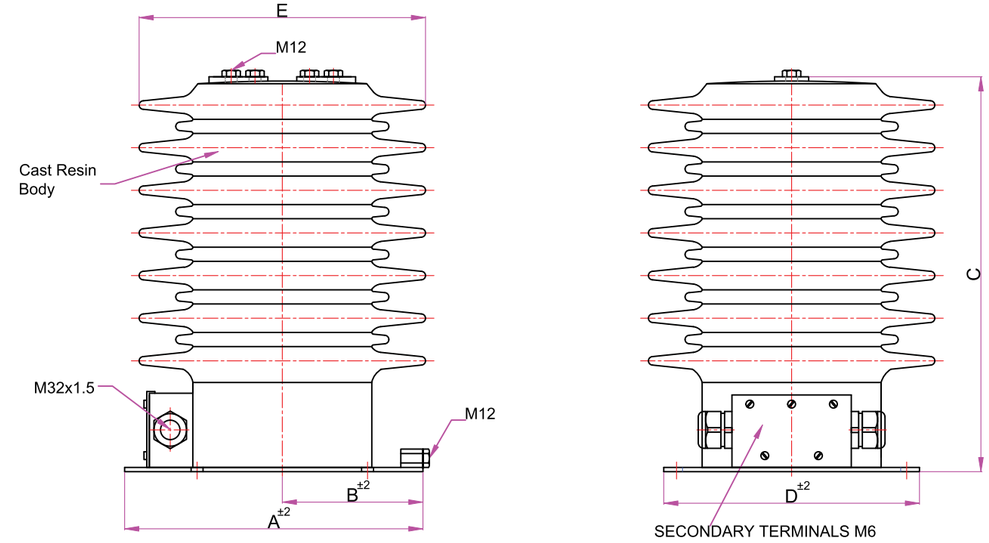
For the connection of aluminium conductors steel reinforced

| Technical Data | Produced only in Indonesia Factory | |
|---|---|---|
| Types | ATH 32 | |
| Operating voltage, Um (kV) | 36 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5-2500 | |
| Primary reconnection (A) | 2x5 - 2x600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | |
| Short-time load (mechanical) (N) | 2500 | |
| Insulation class | E | |
| Min. creepage distance (mm) | 1140 | |
| Altitude (m) | According to the customer requirements | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 47 | 85 |

* *For more cores please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=36kV)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATH 32 | 390 | 190 | max. 477 | 350 | max. ø403 | 320 | 250 | 65 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=36 kV)

### Types:

ATH 30-N
ATH 32-N

- ATH 30-N up to 2 cores.*
- ATH 32-N up to 3 cores.*



For the connection of aluminium conductors steel reinforced

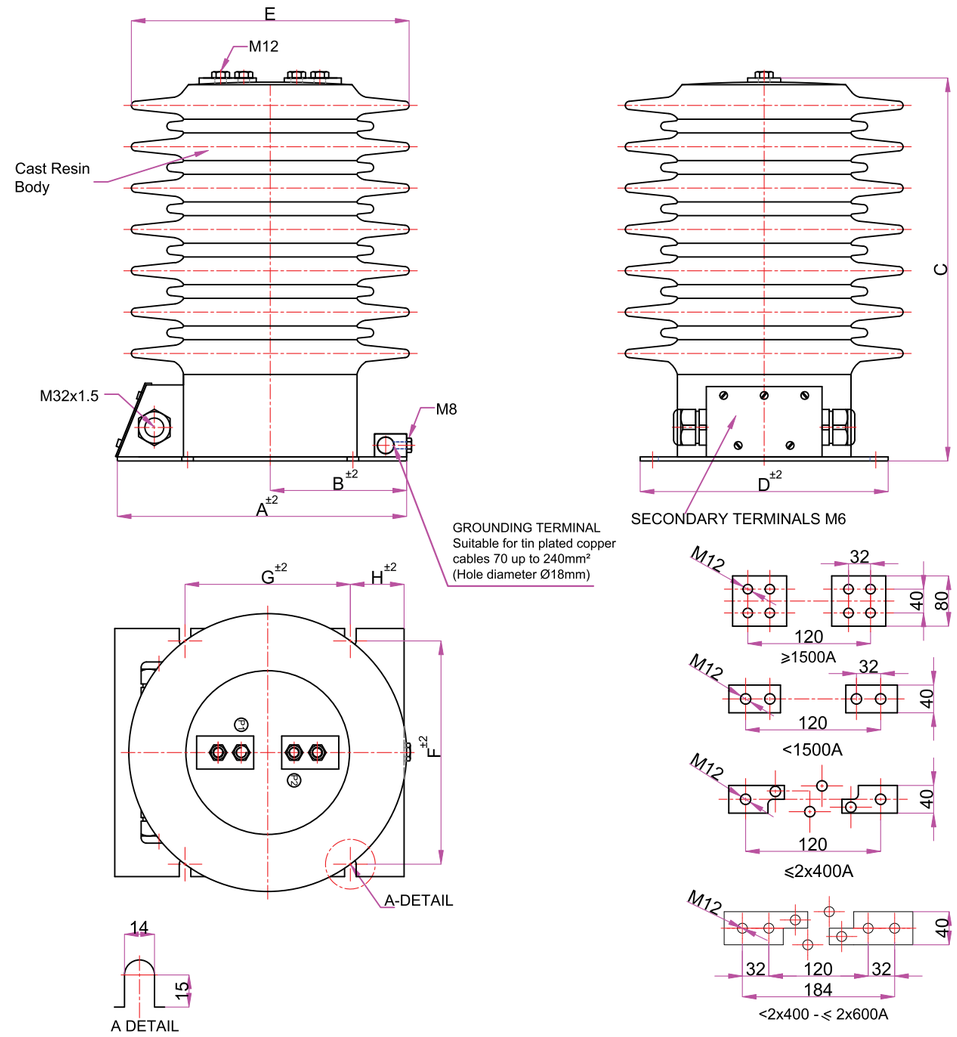
## Technical Data

| Types | ATH 30-N | ATH 32-N |
|---|---|---|
| Operating voltage, Um (kV) | 36** | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | |
| Rated frequency (Hz) | 50-60 | |
| Primary rated current (A) | 5 - 2500 | |
| Primary reconnection (A) | 2 x 5 - 2 x 600 | |
| Secondary rated current (A) | 1 - 5 | |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | |
| Short-time load (mechanical) (N) | 2500 | |
| Insulation class | E | |
| Min. creepage distance (mm) | 1140 | |
| Altitude (m) | According to the customer requirements | |
| Standard | According to the customer requirements | |
| Weight (approx.) (kg) | 47 | 85 |

* *For more cores please contact with ARTECHE for feasibility*
** *For more kV, please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=36kV)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATH 30-N | 350 | 165 | max. 465 | 300 | max. Ø340 | 270 | 200 | 65 |
| ATH 32-N | 390 | 173 | max. 474 | 350 | max. Ø400 | 320 | 250 | 65 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M8 (Ground Terminal) | 15 | 20 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=52kV)

### Types:
ATH 52

- Up to 2 cores.*



For the connection of aluminium conductors steel reinforced

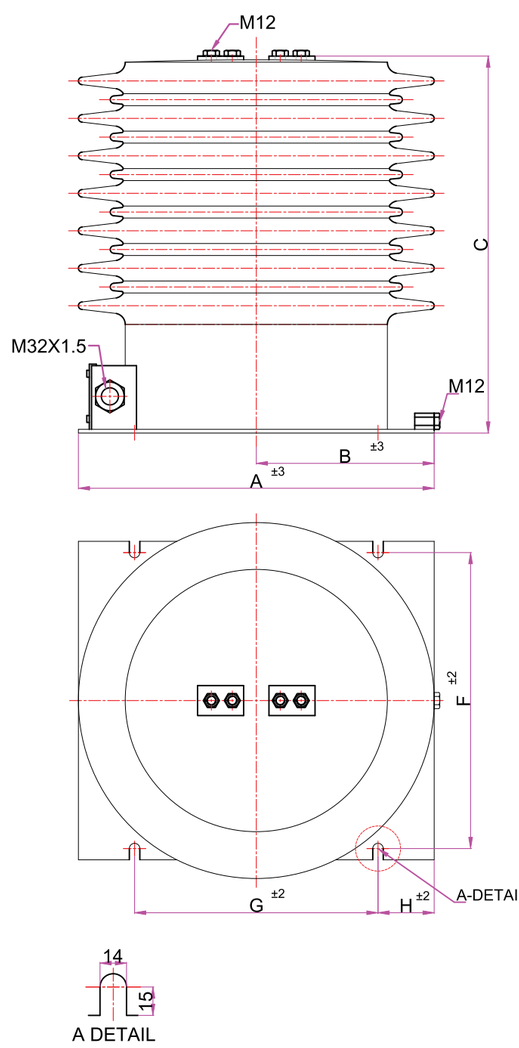
## Technical Data

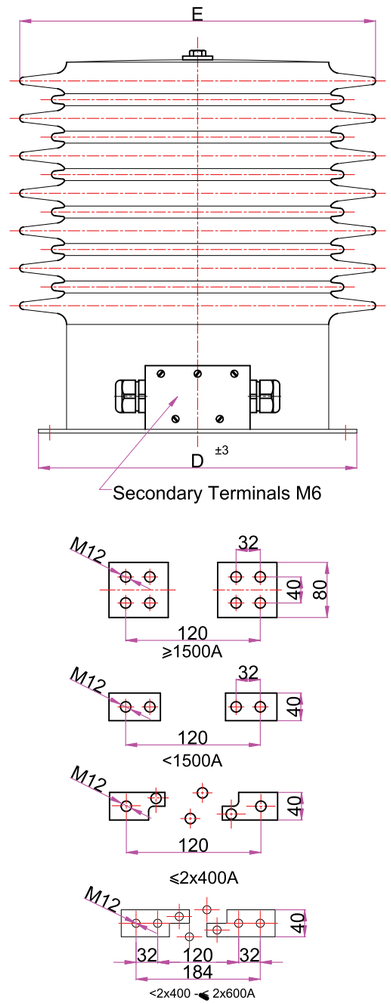
| Types | ATH 52 |
|---|---|
| Operating voltage, Um (kV) | 52 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 95 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 250 |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 5 - 2500 |
| Primary reconnection (A) | 2 x 5 - 2 x 600 |
| Secondary rated current (A) | 1 - 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith |
| Short-time load (mechanical) (N) | 2500 |
| Insulation class | E |
| Min. creepage distance (mm) | 1615 |
| Altitude (m) | According to the customer requirements |
| Standard | According to the customer requirements |
| Weight (approx.) (kg) | 140 |

* *For more cores please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=52kV )




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATH 52 | 475 | 237,5 | max 510 | 425 | max ø480 | 395 | 325 | 75 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE CAST RESIN INSULATED CURRENT TRANSFORMERS

(Um=72,5kV)

### Types:

ATH 72-N

### Technical Data

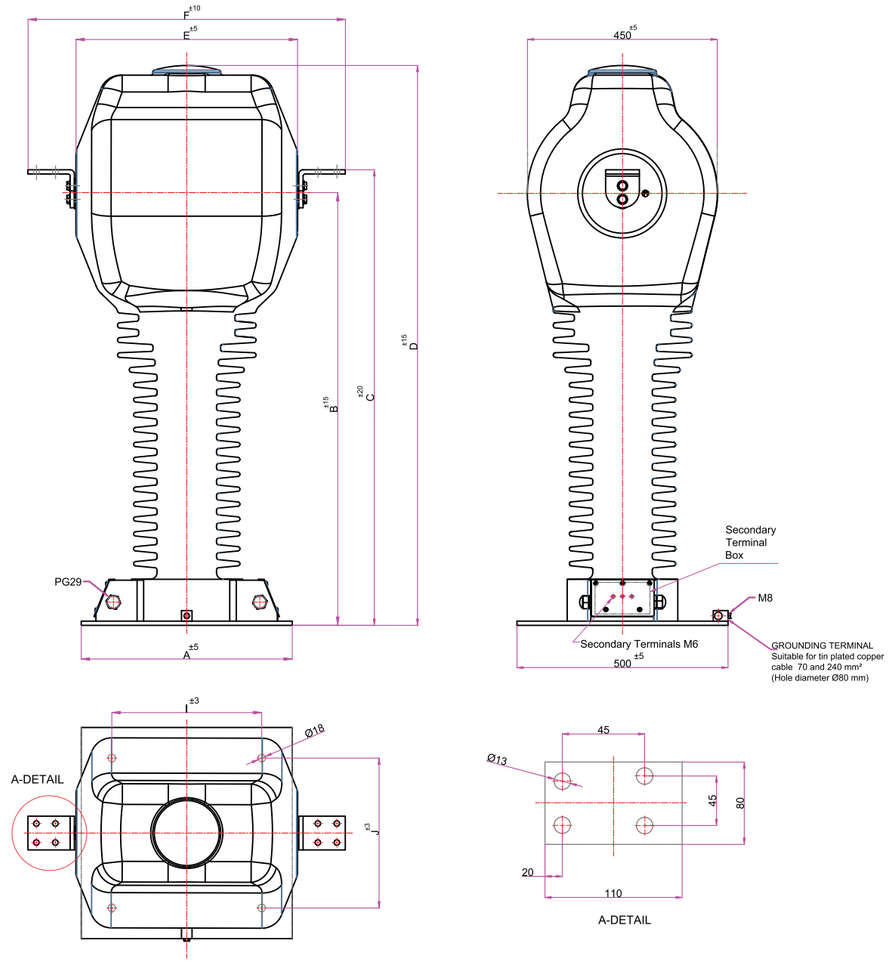
| Types | ATH 72-N |
|---|---|
| Operating voltage, Um (kV) | 72,5 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 140 |
| Rated impulse test voltage (1.2/50 μs) full wave (kV) | 325 |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 5 - 2000 |
| Secondary rated current (A) | 1 - 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P- 10P; CI:PX Acc. to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 1000 x In |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith |
| Short-time load (mechanical) (N) | 2500 |
| Insulation class | E |
| Min. creepage distance (mm) | 2400 |
| Altitude (m) | According to the customer requirements |
| Standard | According to the customer requirements |
| Weight (approx.) (kg) | 300 |

* *For more cores please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE CAST RESIN INSULATED C.T.'S TECHNICAL DRAWING

(Um=72,5 kV)

**ATH 72-N**




| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| ATH 72-N | 500 | 1025 | 1080 | 1325 | 525 | 755 | 500 | 450 | 355 | 355 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



# OUTDOOR DRY TYPE CAST RESIN INSULATED COMBINED TRANSFORMERS (CURRENT & VOLTAGE)

(Um=12kV ..... 36kV)

## Types:

ATH 32-C

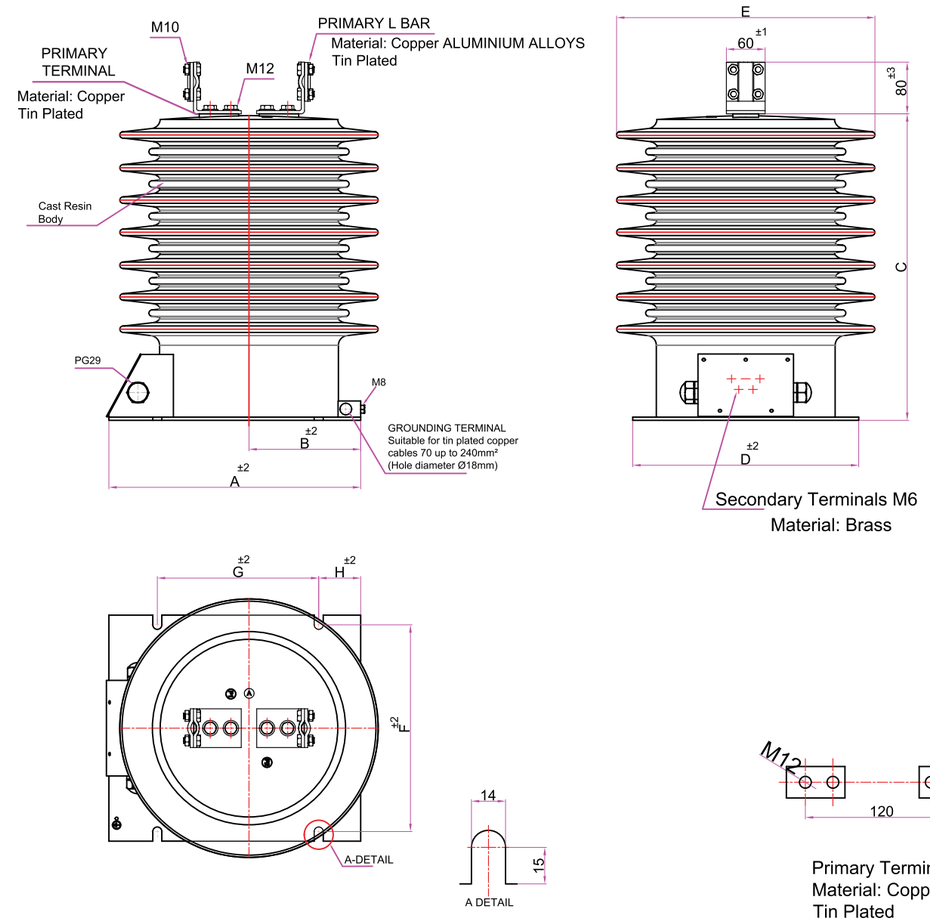
## Technical Data

| Types | ATH 32-C | | | |
|---|---|---|---|---|
| Operating voltage, Um (kV) | 12 | 17,5 | 24 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 28 | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 75 | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | |
| Primary rated current (A) - Rated primary voltage (max)(kv) | 20A-1250A | | 100/√3 110/√3 120/√3 | |
| Secondary rated current (A) - Secondary voltage (V) | 1 - 5 | | | |
| Metering classeses for C.T. | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 | | | |
| Raten burden (max) in class 0,2 (VA) For V.T. | 15 | | | |
| Raten burden (max) in class 0,5 (VA) For V.T. | 25 | | | |
| Raten burden (max) in class 1 (VA) For V.T. | 50 | | | |
| Rated voltage factor (30 sec. or 8h) (Un) (1s) For C.T. (kA) | 1,9 | | | |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 200 x In (25kA) | | | |
| Rated dynamic current (Idyn) (kA) | 2,5 x Ith | | | |
| Short-time load (mechanical) (N) | 2500 | | | |
| Insulation class | E | | | |
| Min. creepage distance (mm) | 1140 | | | |
| Altitude (m) | According to the customer requirements | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 85 | | | |

* *For more cores please contact with ARTECHE for feasibility.*

# OUTDOOR DRY TYPE CAST RESIN INSULATED COMBINED TRANSFORMERS C.T.'S & V.T.'S TECHNICAL DRAWING

(Um=12kV ..... 36kV)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ATH 32-C | 390 | 173 | max 474 | 350 | Ø400 | 320 | 250 | 65 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*

# L.V. CURRENT TRANSFORMERS





arteche



# INDOOR KAP TYPE (CABLE TYPE) CAST RESIN INSULATED AND ENCLOSED BY PLASTIC COVER CURRENT TRANSFORMERS

(Um=0,72kV)

Types:
KAP

- Width 35, 55mm up to 1 core.*
- Width 95, 115mm up to 2 cores.*

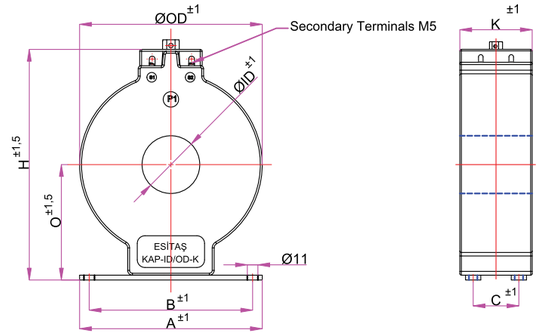
## Technical Data

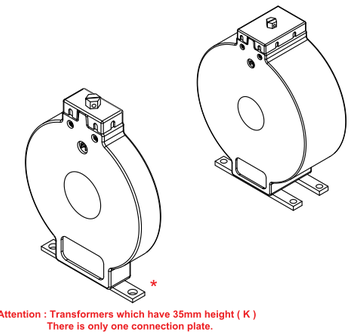
| Types | KAP |
|---|---|
| Operating voltage, Um (kV) | 0,72 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 3 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | - |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 40 ..... 3000 |
| Secondary rated current (A) | 1 - 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P- 10P; Acc. to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 100 |
| Rated dynamic current (Idyn) (kA) | Practically unlimited |
| Insulation class | E |
| Ambient temperature (°C) | -25.....+40** |
| Altitude (m) | 1000 |
| Standard | According to the customer requirements |

* *For more cores, please contact with ARTECHE for feasibility.*
** *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

# INDOOR KAP TYPE (CABLE TYPE) CAST RESIN INSULATED AND ENCLOSED BY PLASTIC COVER C.T.'S TECHNICAL DRAWING

(Um=0,72kV)



* Attention : Transformers which have 35mm height ( K )
There is only one connection plate.

## KAP TYPE ( With Horizontal Mounted Plates) CURRENT TRANSFORMER

As can be seen In the below tables there are various dimensions of KAP Types. Please contact with ARTECHE for feasibility of required transformer's which have different ratio, class, burden and dimensions.

| NO | TYPE | ID | OD | H | K | O | A | B | C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | KAP-40/190-35 | 40 | 190 | 241 | 35 | 119 | 150 | 130 | - |
| 2 | KAP-40/190-55 | 40 | 190 | 241 | 55 | 119 | 150 | 130 | 25 |
| 3 | KAP-40/190-95 | 40 | 190 | 241 | 95 | 119 | 150 | 130 | 40 |
| 4 | KAP-40/190-115 | 40 | 190 | 241 | 115 | 119 | 170 | 150 | 40 |
| 5 | KAP-60/190-35 | 60 | 190 | 241 | 35 | 119 | 150 | 130 | - |
| 6 | KAP-60/190-55 | 60 | 190 | 241 | 55 | 119 | 150 | 130 | 25 |
| 7 | KAP-60/190-95 | 60 | 190 | 241 | 95 | 119 | 150 | 130 | 40 |
| 8 | KAP-60/190-115 | 60 | 190 | 241 | 115 | 119 | 170 | 150 | 40 |
| 9 | KAP-80/190-35 | 80 | 190 | 241 | 35 | 119 | 150 | 130 | - |
| 10 | KAP-80/190-55 | 80 | 190 | 241 | 55 | 119 | 150 | 130 | 25 |
| 11 | KAP-80/190-95 | 80 | 190 | 241 | 95 | 119 | 150 | 130 | 40 |
| 12 | KAP-80/190-115 | 80 | 190 | 241 | 115 | 119 | 170 | 150 | 40 |
| 47 | KAP-100/190-55 | 100 | 190 | 241 | 55 | 119 | 150 | 130 | 25 |
| 48 | KAP-100/190-95 | 100 | 190 | 241 | 95 | 119 | 150 | 130 | 40 |
| 49 | KAP-100/190-115 | 100 | 190 | 241 | 115 | 119 | 170 | 150 | 40 |

| NO | TYPE | ID | OD | H | K | O | A | B | C |
|---|---|---|---|---|---|---|---|---|---|
| 13 | KAP-40/210-35 | 40 | 210 | 261 | 35 | 129 | 150 | 130 | - |
| 14 | KAP-40/210-55 | 40 | 210 | 261 | 55 | 129 | 150 | 130 | 25 |
| 15 | KAP-40/210-95 | 40 | 210 | 261 | 95 | 129 | 150 | 130 | 40 |
| 16 | KAP-40/210-115 | 40 | 210 | 261 | 115 | 129 | 170 | 150 | 40 |
| 17 | KAP-60/210-35 | 60 | 210 | 261 | 35 | 129 | 150 | 130 | - |
| 18 | KAP-60/210-55 | 60 | 210 | 261 | 55 | 129 | 150 | 130 | 25 |
| 19 | KAP-60/210-95 | 60 | 210 | 261 | 95 | 129 | 150 | 130 | 40 |
| 20 | KAP-60/210-115 | 60 | 210 | 261 | 115 | 129 | 170 | 150 | 40 |
| 21 | KAP-80/210-35 | 80 | 210 | 261 | 35 | 129 | 150 | 130 | - |
| 22 | KAP-80/210-55 | 80 | 210 | 261 | 55 | 129 | 150 | 130 | 25 |
| 23 | KAP-80/210-95 | 80 | 210 | 261 | 95 | 129 | 150 | 130 | 40 |
| 24 | KAP-80/210-115 | 80 | 210 | 261 | 115 | 129 | 170 | 150 | 40 |

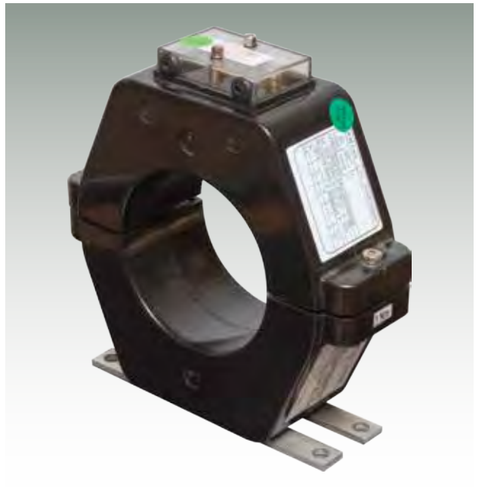
| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

* *All dimensions are in mm.*

| NO | TYPE | ID | OD | H | K | O | A | B | C |
|---|---|---|---|---|---|---|---|---|---|
| 25 | KAP-40/250-35 | 40 | 250 | 301 | 35 | 149 | 150 | 130 | - |
| 26 | KAP-40/250-55 | 40 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 27 | KAP-40/250-95 | 40 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 28 | KAP-40/250-115 | 40 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |
| 29 | KAP-60/250-35 | 60 | 250 | 301 | 35 | 149 | 150 | 130 | - |
| 30 | KAP-60/250-55 | 60 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 31 | KAP-60/250-95 | 60 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 32 | KAP-60/250-115 | 60 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |
| 33 | KAP-80/250-35 | 80 | 250 | 301 | 35 | 149 | 150 | 130 | - |
| 34 | KAP-80/250-55 | 80 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 35 | KAP-80/250-95 | 80 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 36 | KAP-80/250-115 | 80 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |

| NO | TYPE | ID | OD | H | K | O | A | B | C |
|---|---|---|---|---|---|---|---|---|---|
| 37 | KAP-100/250-35 | 100 | 250 | 301 | 35 | 149 | 150 | 130 | - |
| 38 | KAP-100/250-55 | 100 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 39 | KAP-100/250-95 | 100 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 40 | KAP-100/250-115 | 100 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |
| 41 | KAP-120/250-55 | 120 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 42 | KAP-120/250-95 | 120 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 43 | KAP-120/250-115 | 120 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |
| 44 | KAP-150/250-55 | 150 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 45 | KAP-150/250-95 | 150 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 46 | KAP-150/250-115 | 150 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |

| NO | TYPE | ID | OD | H | K | O | A | B | C |
|---|---|---|---|---|---|---|---|---|---|
| 50 | KAP-170/250-55 | 170 | 250 | 301 | 55 | 149 | 150 | 130 | 25 |
| 51 | KAP-170/250-95 | 170 | 250 | 301 | 95 | 149 | 150 | 130 | 40 |
| 52 | KAP-170/250-115 | 170 | 250 | 301 | 115 | 149 | 170 | 150 | 40 |



## INDOOR A-KAP TYPE (SPLIT TYPE) CAST RESIN INSULATED AND ENCLOSED BY PLASTIC COVER CURRENT TRANSFORMERS

(Um=0,72kV)

Types:
A-KAP

- Inside Diameters: Ø80 / Ø100 / Ø120

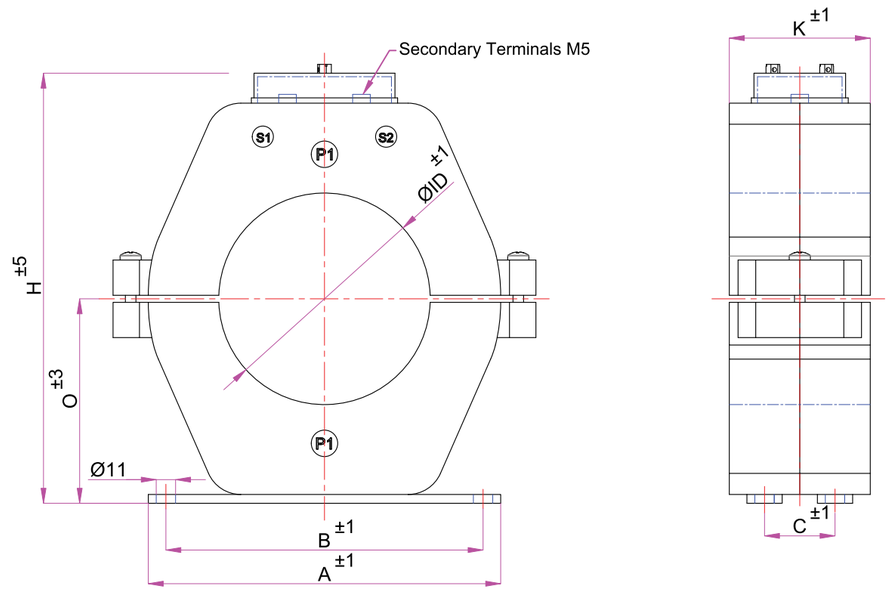
### Technical Data

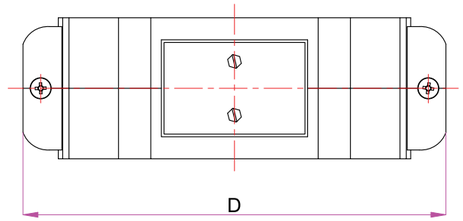
| Types | A- KAP |
|---|---|
| Operating voltage, Um (kV) | 0,72 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 3 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | - |
| Rated frequency (Hz) | 50-60 |
| Primary rated current (A) | 50 ..... 2000 |
| Secondary rated current (A) | 1 - 5 |
| Metering classes | 0,2 - 0,2S - 0,5 - 0,5S - 1 - 3 - 5 Acc. to IEC 61869-1&2 |
| Protection classes | 5P- 10P; Acc. to IEC 61869-1&2 |
| Rated short-time thermal current (Ith) (1s) (kA) | max. 100 |
| Rated dynamic current (Idyn) (kA) | Practically unlimited |
| Insulation class | E |
| Ambient temperature (°C) | -25.....+40** |
| Altitude (m) | 1000 |
| Standard | According to the customer requirements |

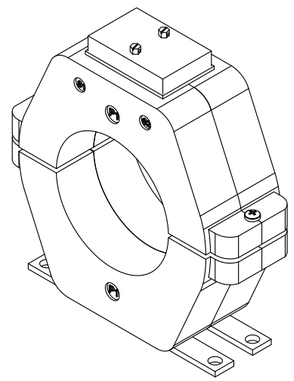
*** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR A-KAP TYPE (SPLIT TYPE) CAST RESIN INSULATED AND ENCLOSED BY PLASTIC COVER C.T.'S TECHNICAL DRAWING

(Um=0,72kV)



| Types | ØID | H | K | O | A | B | C | D |
|---|---|---|---|---|---|---|---|---|
| A-KAP | 80/100/120 | 245 | 80 | 116 | 200 | 180 | 40 | max.240 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

** All dimensions are in mm.*

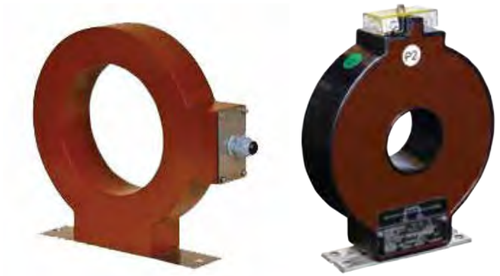
## RING TYPE CURRENT TRANSFORMERS

(Um=0,72kV)

### INDOOR RING TYPES



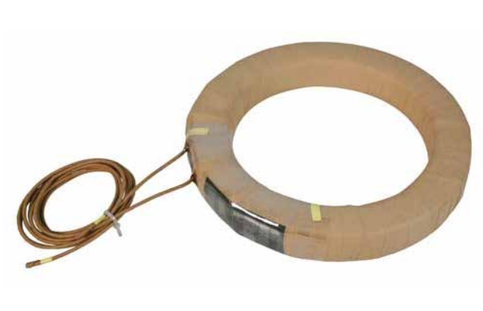
### OUTDOOR RING TYPES



- Cable type.
- Insulated by cast resin.
- Applicable for measurement and protection purposes.

### BUSHING TYPES



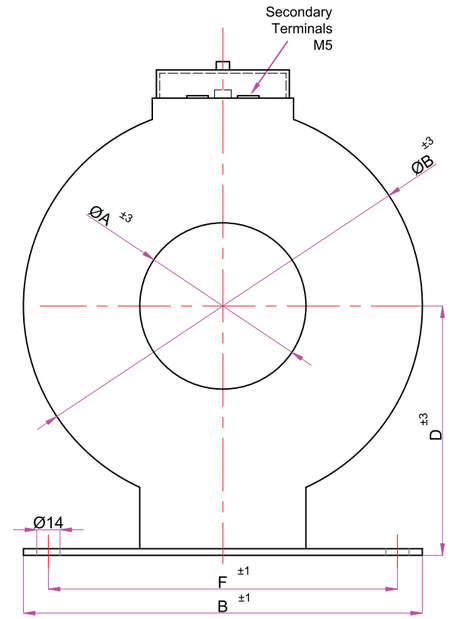


- For power transformers.
- Suitable for operation under oil continuous 130°C.
- Insulated by Insulation paper or Polyester tape.
- Applicable for measurement and protection purposes.



*- Dimensions : According to the customer requirements.*
*- Standards : According to the customer requirements.*
*- Please contact with ARTECHE for feasibility of required transformer's which have different ratio, class, burden and dimensions.*

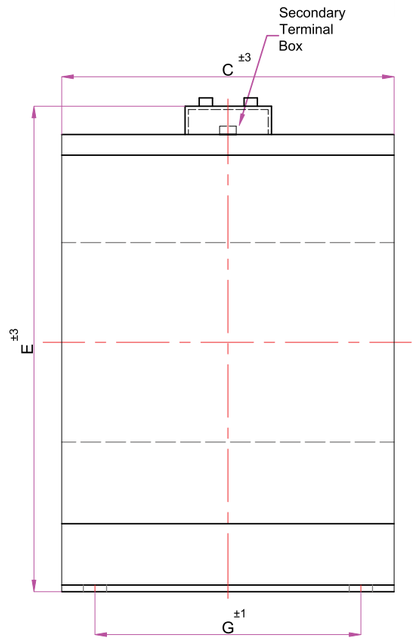
## C.T.'S TECHNICAL DRAWING












** All dimensions are in mm.*

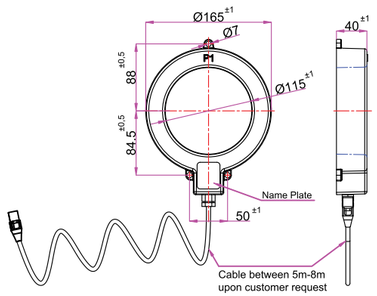


## INDOOR TYPE LPCT
### (Low Power Current Transformer) (Cable Type)

(Um=0, 72kV)

### Types:
LPCT-115

- LPCT-115 is defining low power current transformer with voltage output in compliance with IEC 60044-8.
- It is designed for measuring nominal currents of 5A to 1250 A with ratio 100A / 22,5mV. Thus it should be used with a digital relay which have 100A / 22,5mV input with LPCT.
- Esitas LPCT Set is composed of three LPCT and one digital relay. In case of preffered set without relay, Esitas has to be informed about the relay that will be used.
- The sensor is delivered with cable which is between 5m - 8m upon customer request.




### Advantages :
-Same transformer is usable for nominal currents of 5A to 1250A.
- Accurracy warranty throughout the range :
  • Protection : 5A-40kA ; class 5P
  • Measuring: 100A-1250A; class 0,5 (class 0,75 for 20A, class 1,5 for 5A).

### Simple Assembly :
- Ready for connection secondary cables.
- Simple connection with insulated cable for all types cubicles.

### Safety Operation :
- Openable secondary circuit under load.

**Technical Data**

| Types | LPCT - 115 |
|---|---|
| Standard | IEC 60044-8 |
| Minimum primary curent (A) | 5 |
| Rated primary current (A) | 100 |
| Rated secondary voltage (mV) | 22,5 |
| Rated maximum primary current (A) | 1250 |
| Class of protection | 0,5 (100A - 1250A), 0,75 (20A), 1,5 (5A) |
| Class of measuring | 5P |
| Accuracy limit factor (Kalf) | 150 |
| Rated short - time current (kA / 1s) | 40 |
| Insulation level (kV) | 0,72 / 3 / - |
| Frequency (Hz) | 50 - 60 |
| Burden (Rbr) (kΩ) | 2 |

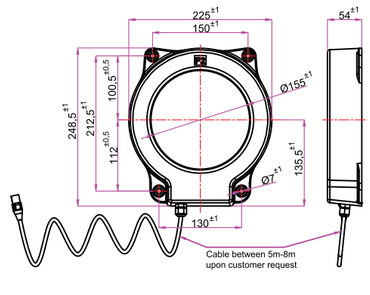


## INDOOR TYPE LPCT
### (Low Power Current Transformer) (Cable Type)

(Um=0, 72kV)

### Types:
LPCT-160

- LPCT-160 is defining low power current transformer with voltage output in compliance with IEC 60044-8.
- It is designed for measuring nominal currents of 5A to 2000 A with ratio 100A / 22,5mV. Thus it should be used with a digital relay which have 100A / 22,5mV input with LPCT.
- Esitas LPCT Set is composed of three LPCT and one digital relay. In case of preffered set without relay, Esitas has to be informed about the relay that will be used.
- The sensor is delivered with cable which is between 5m - 8m upon customer request.




### Advantages :
-Same transformer is usable for nominal currents of 5A to 2000A.
- Accurracy warranty throughout the range :
  • Protection : 5A-40kA ; class 5P
  • Measuring: 100A-2000A; class 0,5 (class 0,75 for 20A, class 1,5 for 5A).

### Simple Assembly :
- Ready for connection secondary cables.
- Simple connection with insulated cable for all types cubicles.

### Safety Operation :
- Openable secondary circuit under load.

**Technical Data**

| Types | LPCT - 160 |
|---|---|
| Standard | 60044-8 |
| Minimum primary curent (A) | 5 |
| Rated primary current (A) | 100 |
| Rated secondary voltage (mV) | 22,5 |
| Rated maximum primary current (A) | 2000 |
| Class of protection | 0,5 (100A - 2000A), 0,75 (20A), 1,5 (5A) |
| Class of measuring | 5P |
| Accuracy limit factor (Kalf) | 400 |
| Rated short - time current (kA / 1s) | 40 |
| Insulation level (kV) | 0,72 / 3 / - |
| Frequency (Hz) | 50 - 60 |
| Burden (Rbr) (kΩ) | 2 |

# M.V. VOLTAGE TRANSFORMERS



arteche

## Voltage Transformers

An instrument transformer in which the secondary voltage, in normal conditions of use, is substantially proportional to the primary voltage and differs in phase from it by an angle which is approximately zero for an appropriate direction of the connections.

It isolates the primary side rated voltage from the connected instruments and protection circuits and convert the primary voltage into a measurable secondary voltage, which is true in magnitude and phase.

## Primary Winding

The winding to which the voltage to be transformed is applied.

## Secondary Winding

The winding, which supplies the voltage circuits of measuring instruments, meters, relays or similar apparatus.

## Rated Primary Voltage

The value of the primary voltage, which appears in the designation of the transformer and on which its performance is based.

## Rated Secondary Voltage

The value of the secondary voltage, which appears in the designation of the transformer and on which its performance is based.

## Rated Transformation Ratio

The ratio of the rated primary to the rated secondary voltage.

## Voltage Error (Ratio Error)

The error which a transformer introduces into the measurement of a voltage and which arises when the actual transformation ratio is not equal to the transformation ratio.
The voltage error, expressed in per cent, is given by the formula:

$$\text{Voltage Error } \% = \frac{Kn\ Us - Up}{Up} \times 100$$

Where
Kn is the rated transformation ratio;
Up is the actual primary voltage;
Us is the actual secondary voltage when Up is applied under the conditions of measurement.

## Accuracy Class

A designation assigned to a voltage transformer, the errors of which remain within specified limits under prescribed conditions of use.

## Burden

The admittance of the secondary circuit expressed in siemens and power factor (lagging or leading)

## Rated Burden

The value of the burden on which the accuracy requirements are based on.

## Rated Output

The value of apparent power (in voltamperes at a specified power - factor), which the transformer is intended to supply to the secondary circuit at the rated secondary voltage and with rated burden, connected to it.

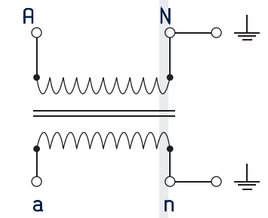
## Rated Insulation Level

The combination of voltage values which characterizes the isolation of a transformer with regard to its capability to withstand dielectric stresses.

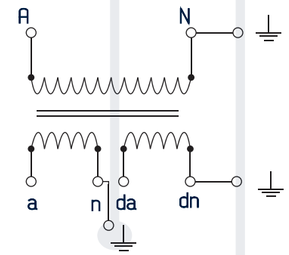
## Rated Voltage Factor

The multiplying factor to be applied to the rated primary voltage to determine the maximum voltage at which a transformer must comply with the relevant thermal requirements for a specified time and with the relevant accuracy requirements.

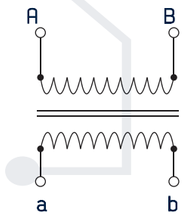
## CONNECTION DIAGRAMS




Single Pole insulated
voltage transformer
(e.g. 11000/√3: 100/√3V)



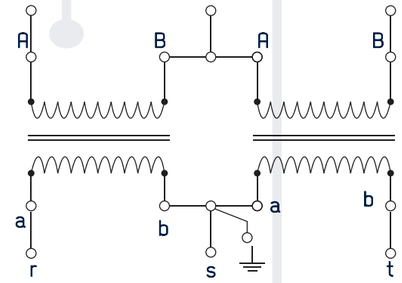

Single Pole insulated
voltage transformer
with an open delta winding
(e.g. 11000/√3: 100/√3V - 100/3V)




Double pole insulated
voltage transformer
(e.g. 11000: 100V)

It can be required for multi secondary winding and changeable ratios.

## V-Connection of Two Double Pole Insulated Voltage Transformers




## Safety Operation Conditions for Voltage Transformers

-When the Secondary terminals are connected to the measuring or protection devices, one of the terminals should be earthed for safety as seen in Diagram-1.hh

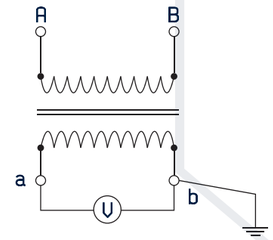
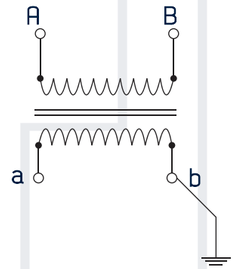



Diagram-1

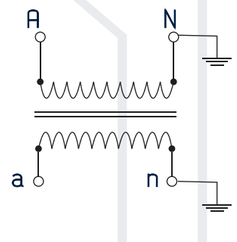
- The base plate must be earthed
- The secondary circuits must not be short-circuited during operation. Otherwise the voltage transformers will be thermally destroyed.
- If any of the secondary windings of a voltage transformer will not be used, then it must be left open with one of the terminals connected to the earth as seen in Diagram-2.

Diagram-2




- For the single phase transformers, the neutral terminal of the primary "N" must be earthed in the earthed (neutral) systems as seen in Diagram-3.

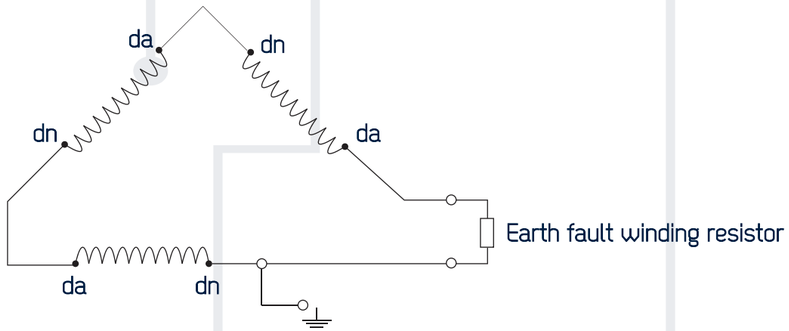
Diagram-3




## Other Important Points and Notes

When using single pole insulated inductive voltage transformers it is very important to understand that, when a circuit is being closed or during the decaying period of an earth fault ferroresonance may occur. Ferroresonance can lead to the overheating and thermal destruction of the voltage transformer or high levels of voltages may be induced. In general, ferroresonance can be eliminated by the use of an appropriate resistor placed as a burden in open-delta circuit formed by three voltage transformers open-delta windings. The open-delta circuit must always be earthed only at one point as seen in Diagram-4. The open-delta connection can also be used for earth-fault monitoring with appropriate devices.

Diagram-4

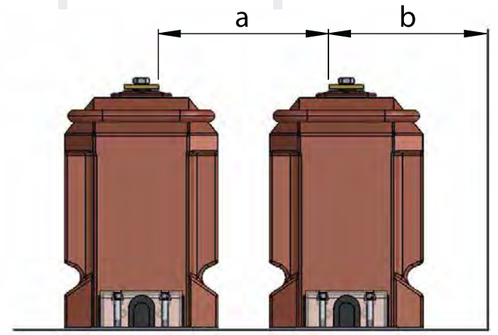



As the number of cable systems is increasing in the energy distribution systems, the protection of voltage transformers have become very important for the uninterrupted operation of the system without any failure and/or down time. For that reason, ARTECHE is always recommending the use of open-delta windings in single phase inductive voltage transformers.



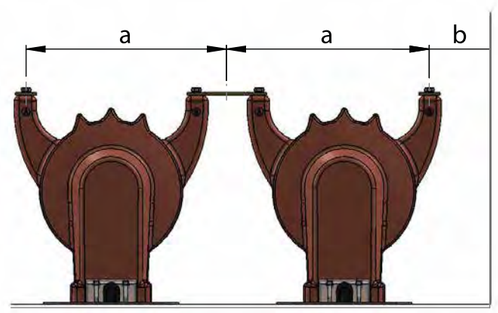
## M.V. VOLTAGE TRANSFORMERS CONNECTION CLEARENCES

### SINGLE PHASE VOLTAGE TRANSFORMERS




| INSULATION LEVEL | a minimum | b minimum |
|---|---|---|
| 12kV | 100mm | 110mm |
| 24kV | 190mm | 210mm |
| 36kV | 305mm | 325mm |

### PHASE TO PHASE VOLTAGE TRANSFORMERS




| INSULATION LEVEL | a minimum | b minimum |
|---|---|---|
| 12kV | 185mm | 120mm |
| 24kV | 240mm | 220mm |
| 36kV | 340mm | 325mm |



## INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....24kV BLOCK TYPES)

Types:
VTB 10-S
VTB 10-K
VTB 20
VTB 20-K

## Technical Data

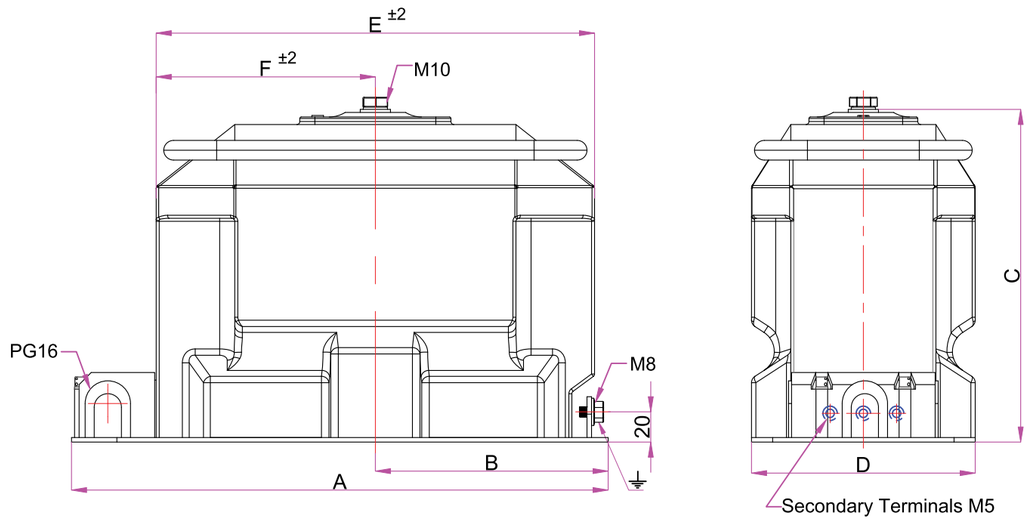
| Types | VTB 10-S | | VTB 10-K | | VTB 20 | | VTB 20-K |
|---|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 17,5 | | 24** |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 38 | | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 95 | | 125 |
| Rated frequency (Hz) | 50-60 | | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | | 24/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | 50 | | |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | 120 | | |
| Rated burden (max.) in class 1 (VA) | 200 | | | | 250 | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | | |
| Insulation class | E | | | | | | |
| Ambient temperature (°C) | -25.....+40* | | | | | | |
| Altitude (m) | 1000 | | | | | | |
| Standard | According to the customer requirements | | | | | | |
| Weight (approx.) (kg) | 27 | | | | 37 | | |

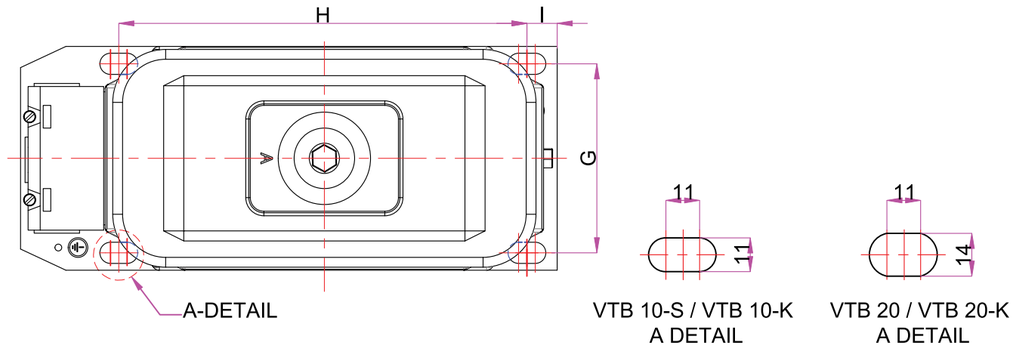
* *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*
** *For more kV, please contact with ARTECHE for feasibility.*



## INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....24kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| VTB 10-S | 355 | 155 | 220 | 148 | 290 | 145 | 125 | 270 | 20 |
| VTB 10-K | 355 | 155 | 220 | 148 | 290 | 145 | 125 | 270 | 20 |
| VTB 20 | 355 | 155 | 280 | 178 | 290 | 145 | 150 | 280 | 20 |
| VTB 20-K | 355 | 155 | 280 | 178 | 290 | 145 | 150 | 280 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



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# INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=36kV Block Types)

Types:
VTB 30-K

## Technical Data

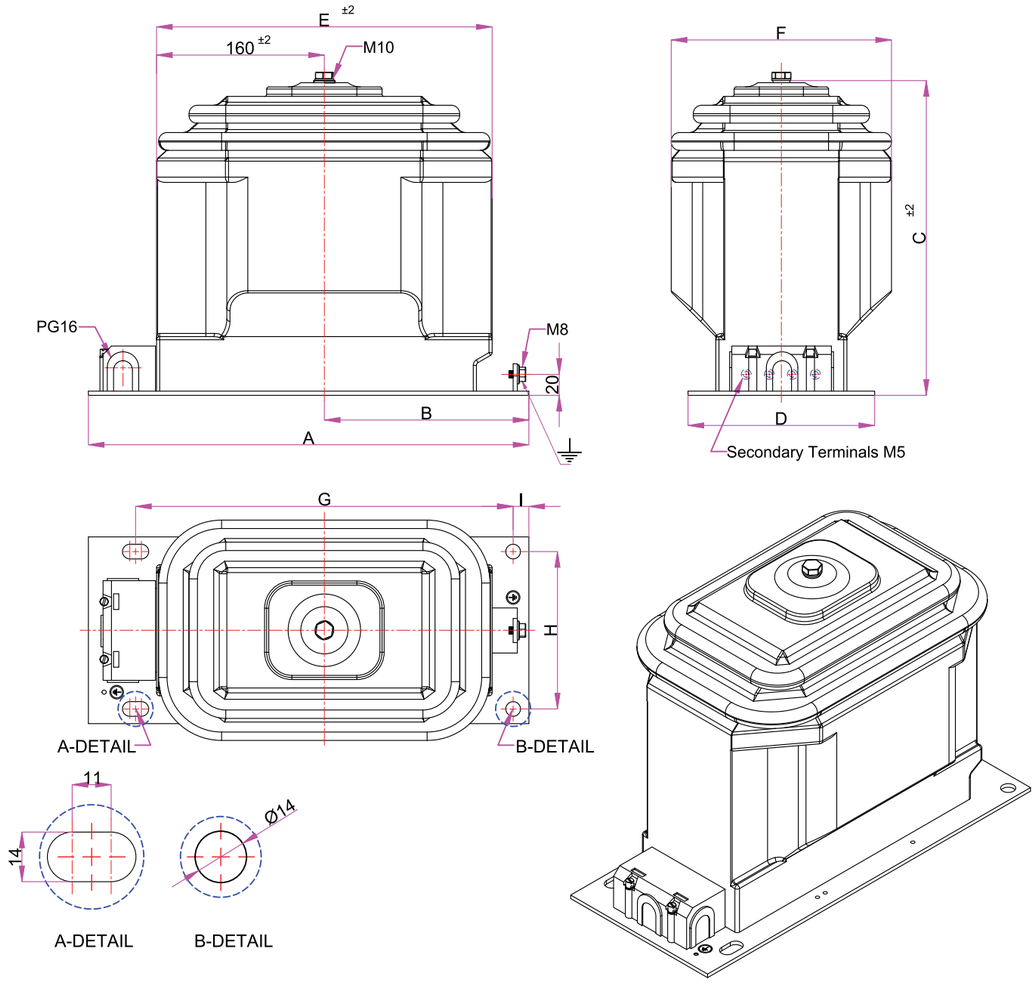
| Types | VTB 30-K | | | | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 36** | | | | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | | | | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | | | | | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 36/√3 | | | | | |
| Secondary voltage (V) | 100/√3 | 100/3 | 110/√3 | 110/3 | 120/√3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 50 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 120 | | | | | |
| Rated burden (max.) in class 1 (VA) | 250 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25.....+40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 46 | | | | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*
*** For more kV, please contact with ARTECHE for feasibility.*



# INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=36kV Block Types)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| VTB 30-K | 420 | 195 | 300 | 178 | 320 | 210 | 360 | 150 | 15 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=17.5kV ..... 36kV)

**Types:**
VT 20-B
VTB 30
VTB 30-1
VTB 30-200

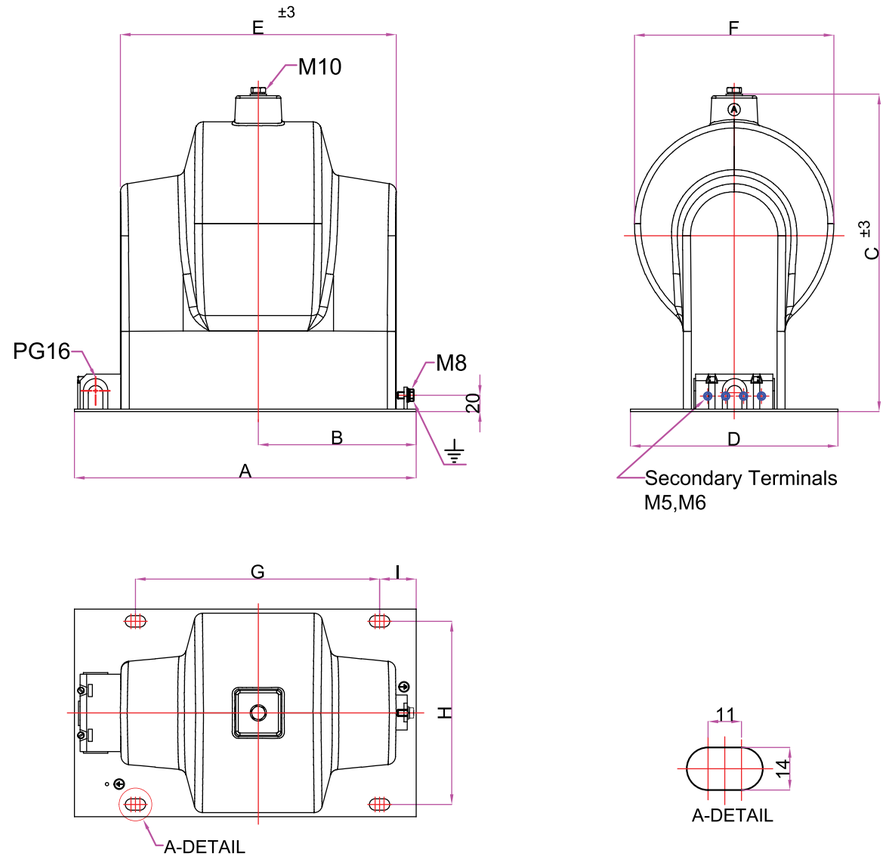
## Technical Data

| Types | VT 20-B | | VTB 30 | VTB 30-1 | VTB 30-200 |
|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 17,5 | 24 | 36 | | 36** |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | 50 | 70 | | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | 125 | 170 | | 200 |
| Rated frequency (Hz) | 50-60 | | | | |
| Rated primary voltage (max.) (kV) | 17,5/√3 | 24/√3 | 36/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 & Suitable for 220V winding | | |
| Rated burden (max.) in class 0,2 (VA) | 50 | | | | |
| Rated burden (max.) in class 0,5 (VA) | 150 | | | | |
| Rated burden (max.) in class 1 (VA) | 300 | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | |
| Rated burden for 220V winding (VA) | 800 | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | |
| Insulation class | E | | | | |
| Ambient temperature (°C) | -25.....+40* | | | | |
| Altitude (m) | 1000 | | | | |
| Standard | According to the customer requirements | | | | |
| Weight (approx.) (kg) | 45 | | 50-60 | | 62 |

* *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*
** *For more kV, please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=17.5kV ..... 36kV)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| VTB 30 | 420 | 195 | 390 | 255 | 338 | - | 300 | 225 | 45 |
| VTB 30-1 | 420 | 195 | 390 | 255 | 338 | - | 300 | 225 | 45 |
| VT 20-B | 440 | 205 | 300 | 200 | 360 | 215 | 270 | 170 | 70 |
| VTB 30-200 | 420 | 195 | 445 | 255 | - | - | 300 | 225 | 45 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



# INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....17,5kV)

Types:
ES 17 V3

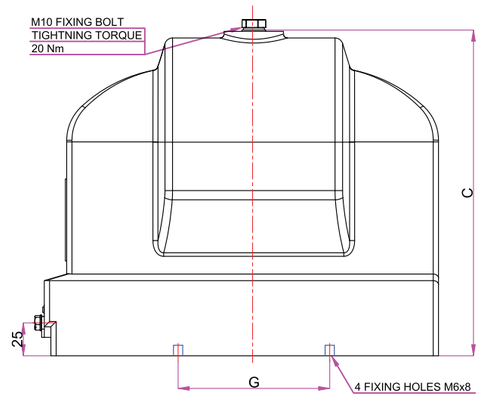
## Technical Data

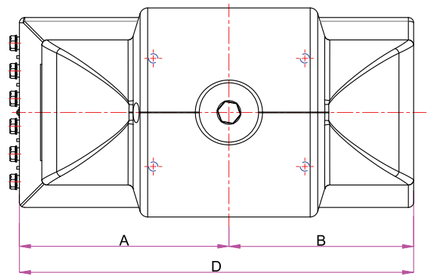
| Types | ES 17 V3 | | | | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 3,6/√3 | 7,2/√3 | | 12/√3 | | 17/√3 |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | 20 |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | | 60 |
| Rated burden (max.) in class 1 (VA) | 200 | | | | | 120 |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 22 | | | | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

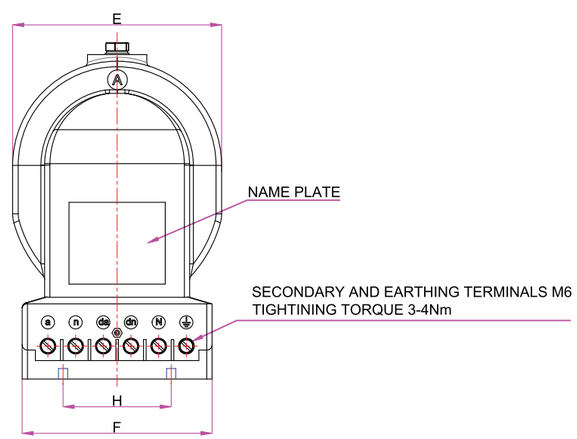
# INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....17,5kV)




Highest system voltage : 7,2-12-17,5kV




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ES 17 V3 | 158 | 139 | 455 | 297 | 158 | 144 | 115 | 82 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



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## INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS

(Um=7,2kV..... 24kV)

Types:
ES 24 V2-B

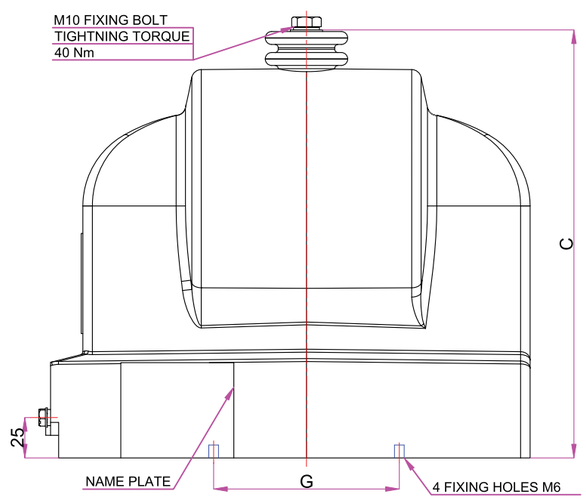
## Technical Data — Produced only in Indonesia Factory

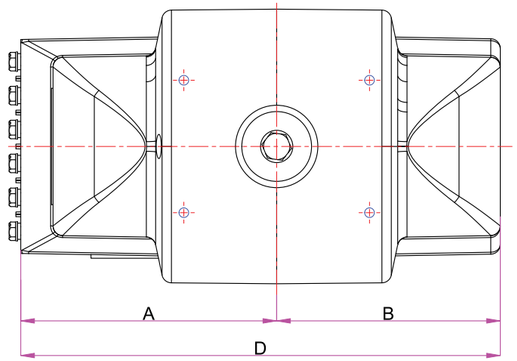
| Types | ES 24 V2-B | | | | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 7,2 | 12 | 17,5 | 24 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 20 | 28 | 38 | 50 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 60 | 75 | 95 | 125 | | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 7,2/√3 | 12/√3 | 17,5/√3 | 24/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 75 | | | | | |
| Rated burden (max.) in class 1 (VA) | 150 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 26 | | | | | |

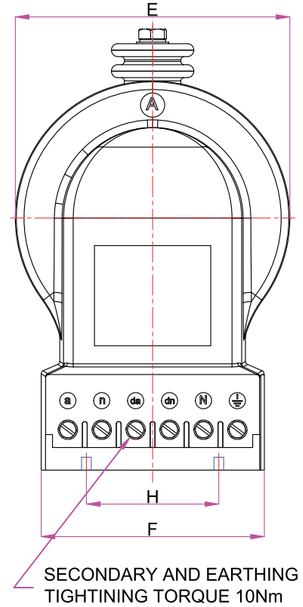
** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=7,2kV..... 24kV)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ES 24 V2-B | 158,5 | 138,5 | 265 | 297 | 170 | 138 | 115 | 82 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*




## INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS

(Um=24kV)

**Types:**
ES 24 V1

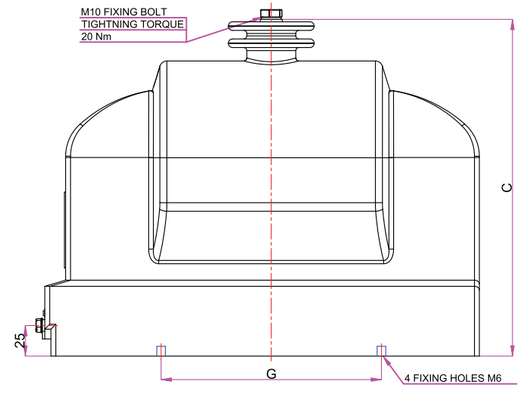
### Technical Data

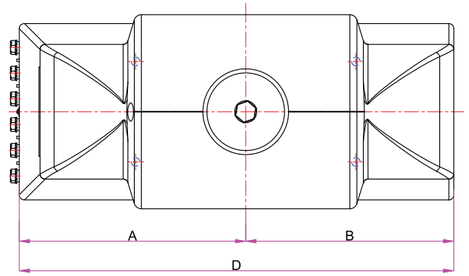
| Types | ES 24 V1 | | | | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 24 | | | | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 50 | | | | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 125 | | | | | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 24/√3 | | | | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | | |
| Rated burden (max.) in class 1 (VA) | 200 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 30 | | | | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

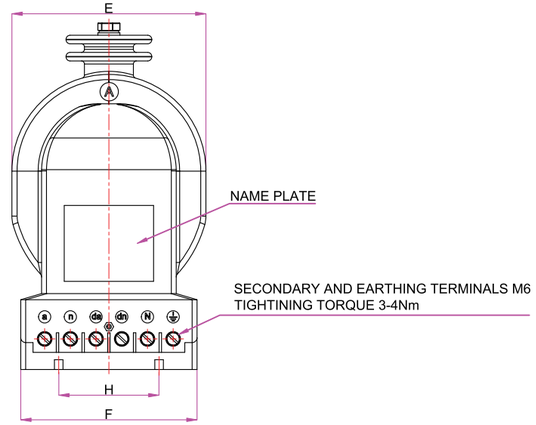
## INDOOR SINGLE PHASE CAST RESIN INSULATED SPECIAL TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=24kV)




Highest system voltage : 24kV




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| ES 24 V1 | 185 | 170 | 275 | 355 | 158 | 144 | 180 | 82 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SINGLE PHASE CAST RESIN INSULATED NARROW TYPE VOLTAGE TRANSFORMERS

(Um=7,2kV.....24kV)

**Types:**
VTU-24

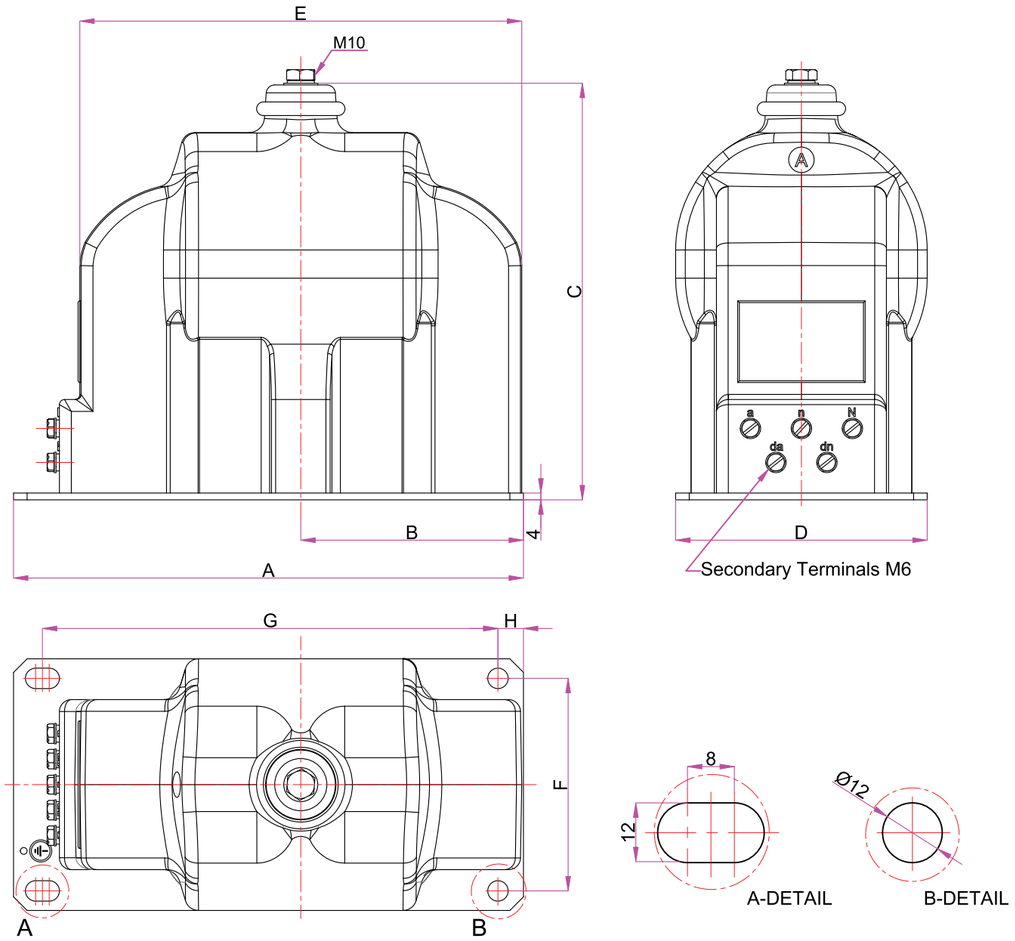
### Technical Data

| Types | VTU-24 | | | | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 7,2 | | 12 | 17,5 | 24 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 20 | | 28 | 38 | 50 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 60 | | 75 | 95 | 125 | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 7,2/√3 | | 12/√3 | 17,5/√3 | 24/√3 | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 75 | | | | | |
| Rated burden (max.) in class 1 (VA) | 150 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 28 | | | | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE CAST RESIN INSULATED NARROW TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=7,2kV.....24kV)




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| VTU-24 | 300 | 131 | 241 | 148 | 260 | 125 | 268 | 15 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 4 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*




## INDOOR PHASE TO PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....24kV BLOCK TYPES)

Types:
2VTB 10
2VTB 20

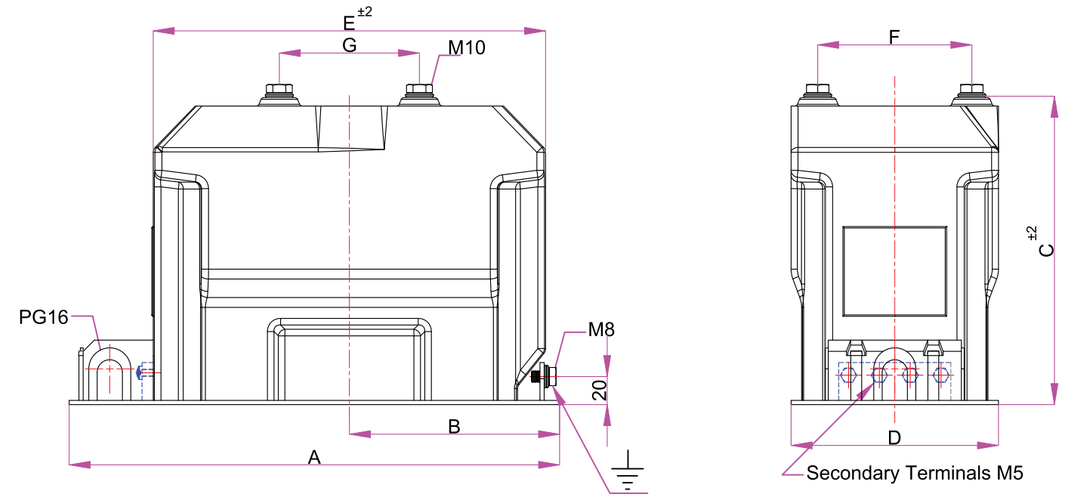
## Technical Data

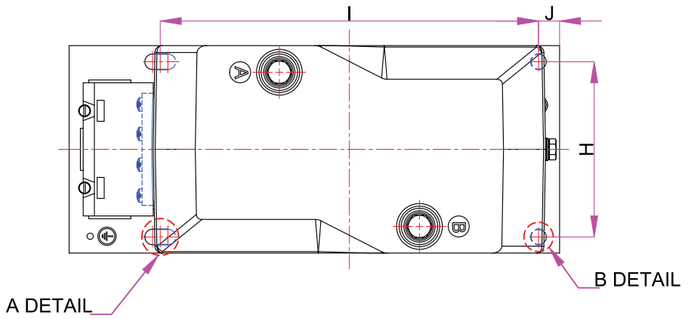
| Types | 2VTB 10 | | | 2VTB 20 | |
|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 |
| Rated frequency (Hz) | 50-60 | | | | |
| Rated primary voltage (max.) (kV) | 12 | | | 24 | |
| Secondary voltage (V) | 100 | 110 | | 120 | |
| Rated burden (max.) in class 0,2 (VA) | 15 | | | | |
| Rated burden (max.) in class 0,5 (VA) | 60 | | | | |
| Rated burden (max.) in class 1 (VA) | 100 | | | | |
| Rated voltage factor (Cont.) (Un) | 1,2 | | | | |
| Insulation class | E | | | | |
| Ambient temperature (°C) | -25.....+40* | | | | |
| Altitude (m) | 1000 | | | | |
| Standard | According to the customer requirements | | | | |
| Weight (approx.) (kg) | 28 | | | 37 | |

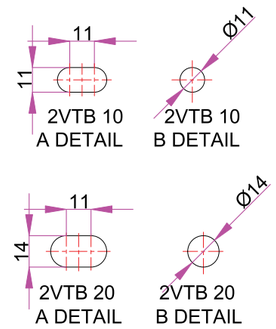
** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR PHASE TO PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....24kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 2VTB 10 | 350 | 150 | 220 | 148 | 280 | 110 | 100 | 125 | 270 | 15 |
| 2VTB 20 | 355 | 155 | 280 | 178 | 290 | 130 | 165 | 150 | 280 | 15 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



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## INDOOR PHASE TO PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=17.5kV ..... 36kV LARGE TYPES)

Types:
2VT 20-B
2VTB 30
2VT 40-200

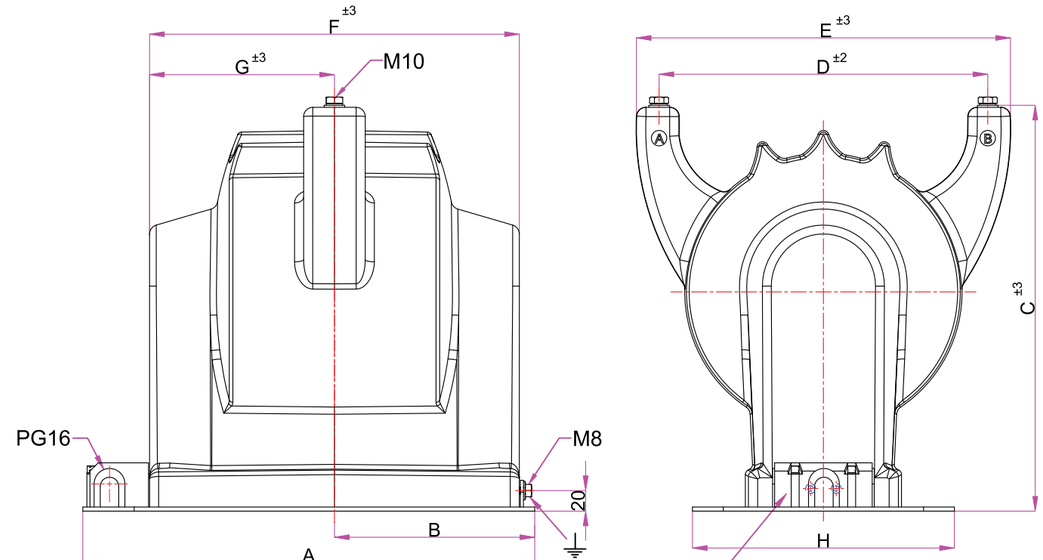
## Technical Data

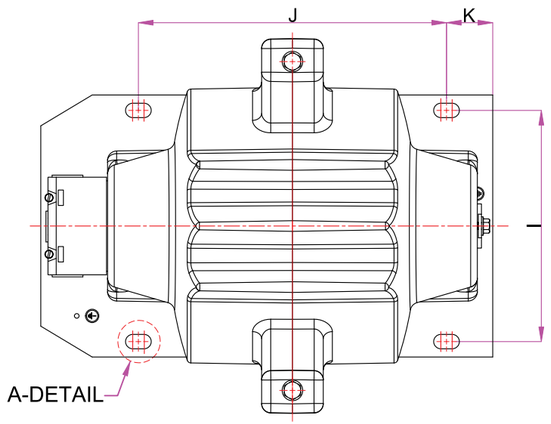
| Types | 2VT 20-B | | 2VTB 30 | 2VT 40-200 |
|---|---|---|---|---|
| Operating voltage, Um (kV) | 17,5 | 24 | 36 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 38 | 50 | 70 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 95 | 125 | 170 | 200 |
| Rated frequency (Hz) | 50-60 | | | |
| Rated primary voltage (max.) (kV) | | 24 | 36 | 36 |
| Secondary voltage (V) | 100 - 110 - 120 & Suitable for 220V winding | | | |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | |
| Rated burden (max.) in class 0,5 (VA) | 120 | | | |
| Rated burden (max.) in class 1 (VA) | 200 | | | |
| Rated burden for 220V winding (VA) | 800 | | | |
| Rated voltage factor (Cont.) (Un) | 1,2 | | | |
| Insulation class | E | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | | 48 | 65 | 73 |

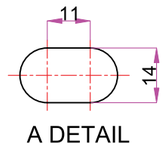
** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR PHASE TO PHASE SUPPORT TYPE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=17.5kV ..... 36kV LARGE TYPES)




| Types | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2VT 20-B | 440 | 205 | 300 | 210 | 250 | 360 | 180 | 200 | 170 | 270 | 70 |
| 2VTB 30 | 440 | 195 | 395 | 320 | 363 | 360 | 180 | 255 | 225 | 300 | 45 |
| 2VT 40-200 | 480 | 220 | 445 | 350 | 390 | 370 | 185 | 255 | 225 | 300 | 70 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



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# INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV BLOCK TYPES)

**Types:**
VTB 10-KF1
VTB 20-KF1
VTB 30-KF1

## Technical Data

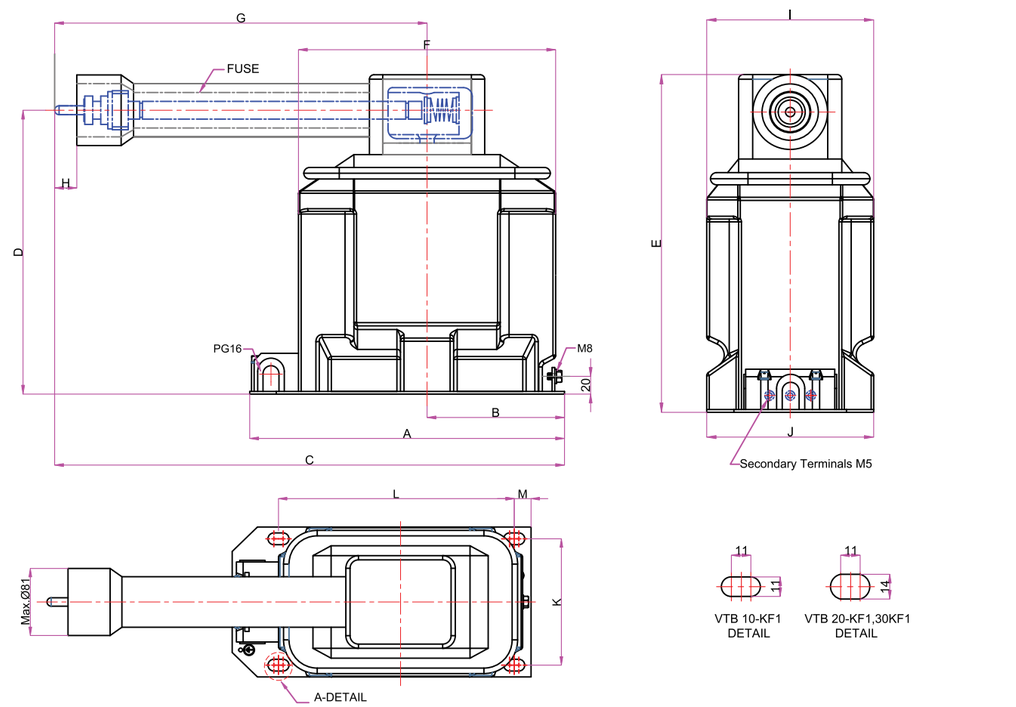
| Types | VTB 10-KF1 | | | | VTB 20-KF1 | | VTB 30-KF1 | |
|---|---|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 17,5 | 24** | 36** | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 38 | 50 | 70 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 95 | 125 | 170 | |
| Rated frequency (Hz) | 50-60 | | | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | | 24/√3 | | 36/√3 | |
| Secondary voltage (V) | 100/√3 | | 110/√3 | | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | 50 | | 50 | |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | 120 | | 120 | |
| Rated burden (max.) in class 1 (VA) | 200 | | | | 250 | | 250 | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | | | |
| Rated voltage factor (30 sec. or 8 h) (Un) | 1,9 | | | | | | | |
| Insulation class | E | | | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | | | |
| Altitude (m) | 1000 | | | | | | | |
| Standard | According to the customer requirements | | | | | | | |
| Weight (approx.) (kg) | 30 | | | | 40 | | 55 | |

* *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*
** *For more kV, please contact with ARTECHE for feasibility.*



# INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....36kV BLOCK TYPES)

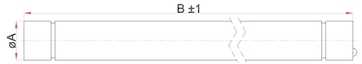



| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |

| Types | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VTB 10-KF1 | 355 | 155 | 492 | 260 | 299 | 290 | 336 | 25 | 148 | 148 | 125 | 270 | 20 |
| VTB 20-KF1 | 355 | 155 | 575 | 318 | 361 | 290 | 420 | 25 | 178 | 178 | 150 | 280 | 20 |
| VTB 30-KF1 | 395 | 175 | 688 | 364 | 421,5 | 320 | 513 | 75 | 210 | 210 | 180 | 300 | 15 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*

Protection Fuses For Voltage Transformer




| NO | V.T. Types | Rated Currents (A) | Rated Voltage (Un) | Ø A | B (mm) |
|---|---|---|---|---|---|
| 1 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 7,2 kV | 20 | 190 |
| 2 | | 1 Amper | | | |
| 3 | | 2 Amper | | | |
| 4 | | 3,15 Amper | | | |
| 5 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 12 kV | | 254 |
| 6 | | 1 Amper | | | |
| 7 | | 2 Amper | | | |
| 8 | | 3,15 Amper | | | |
| 9 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 15,5 kV | | |
| 10 | | 1 Amper | | | |
| 11 | | 2 Amper | | | |
| 12 | | 3,15 Amper | | | |
| 13 | VTB 20-KF1 or KF2<br>VTB 30-KF1 or KF2 | 0,5 Amper | 25,5 kV | | 340 |
| 14 | | 1 Amper | | | |
| 15 | | 2 Amper | | | |
| 16 | VTB 30-KF1 or KF2 | 1 Amper | 36 kV | 36 | 400 |
| 17 | | 2 Amper | | | |



## INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV BLOCK TYPES)

Types:
VTB 10-KF2
VTB 10-KFA2
VTB 20-KF2
VTB 30-KF2

## Technical Data

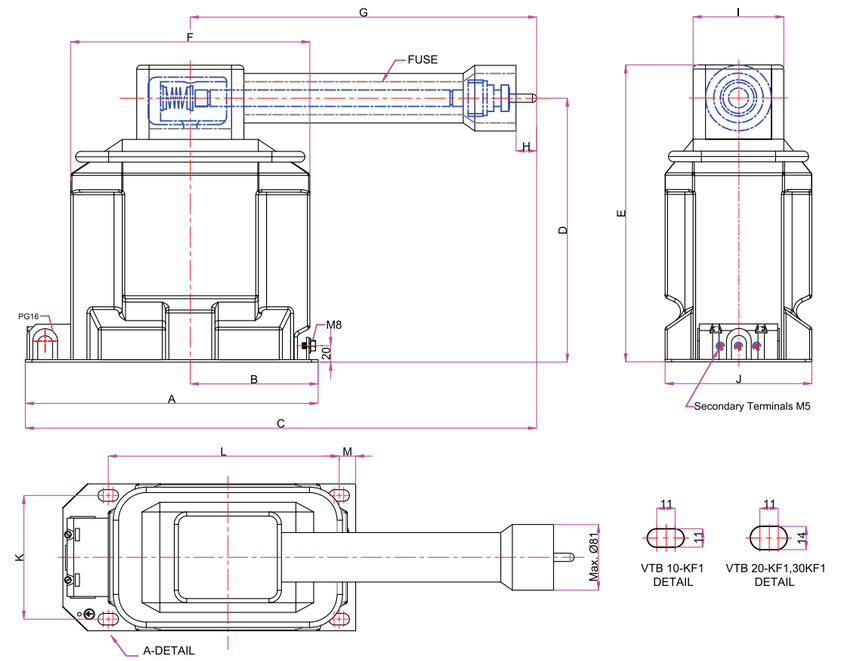
| Types | VTB 10-KF2 / KFA2 | | | | VTB 20-KF2 | | VTB 30-KF2 | |
|---|---|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 17,5 | 24** | 36** | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 38 | 50 | 70 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 95 | 125 | 170 | |
| Rated frequency (Hz) | 50-60 | | | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | | 24/√3 | | 36/√3 | |
| Secondary voltage (V) | 100/√3 | | 110/√3 | | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | 50 | | 50 | |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | 120 | | 120 | |
| Rated burden (max.) in class 1 (VA) | 200 | | | | 250 | | 250 | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | | | |
| Rated voltage factor (30 sec. or 8 h) (Un) | 1,9 | | | | | | | |
| Insulation class | E | | | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | | | |
| Altitude (m) | 1000 | | | | | | | |
| Standard | According to the customer requirements | | | | | | | |
| Weight (approx.) (kg) | 30 | | | | 40 | | 55 | |

* *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*
** *For more kV, please contact with ARTECHE for feasibility.*



## INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....36kV BLOCK TYPES)

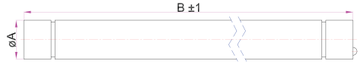



| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |

| Types | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VTB 10-KFA2 | 350 | 160 | 520 | 285 | 315 | - | - | 25 | - | 160 | 120 | 270 | - |
| VTB 10-KF2 | 355 | 155 | 536 | 260 | 299 | 290 | 336 | 25 | 148 | 148 | 125 | 270 | 20 |
| VTB 20-KF2 | 355 | 155 | 575 | 318 | 361 | 290 | 420 | 25 | 178 | 178 | 150 | 280 | 20 |
| VTB 30-KF2 | 395 | 175 | 733 | 364 | 421,5 | 320 | 513 | 75 | 210 | 210 | 180 | 300 | 15 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*

Protection Fuses For Voltage Transformer




| NO | V.T. Types | Rated Currents (A) | Rated Voltage (Un) | ØA | B (mm) |
|---|---|---|---|---|---|
| 1 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 7,2 kV | 20 | 190 |
| 2 | | 1 Amper | | | |
| 3 | | 2 Amper | | | |
| 4 | | 3,15 Amper | | | |
| 5 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 12 kV | | 254 |
| 6 | | 1 Amper | | | |
| 7 | | 2 Amper | | | |
| 8 | | 3,15 Amper | | | |
| 9 | VTB 10-KF1 or KF2<br>VTB 20-KF1 or KF2 | 0,63 Amper | 15,5 kV | | |
| 10 | | 1 Amper | | | |
| 11 | | 2 Amper | | | |
| 12 | | 3,15 Amper | | | |
| 13 | VTB 20-KF1 or KF2<br>VTB 30-KF1 or KF2 | 0,5 Amper | 25,5 kV | | 340 |
| 14 | | 1 Amper | | | |
| 15 | | 2 Amper | | | |
| 16 | VTB 30-KF1 or KF2 | 1 Amper | 36 kV | 36 | 400 |
| 17 | | 2 Amper | | | |



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# INDOOR SINGLE PHASE CAST RESIN INSULATED WITH STRIKER PIN SIGNALLING BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....24kV BLOCK TYPES)

Types:
VTB 10-KFP
VTB 20-KFP

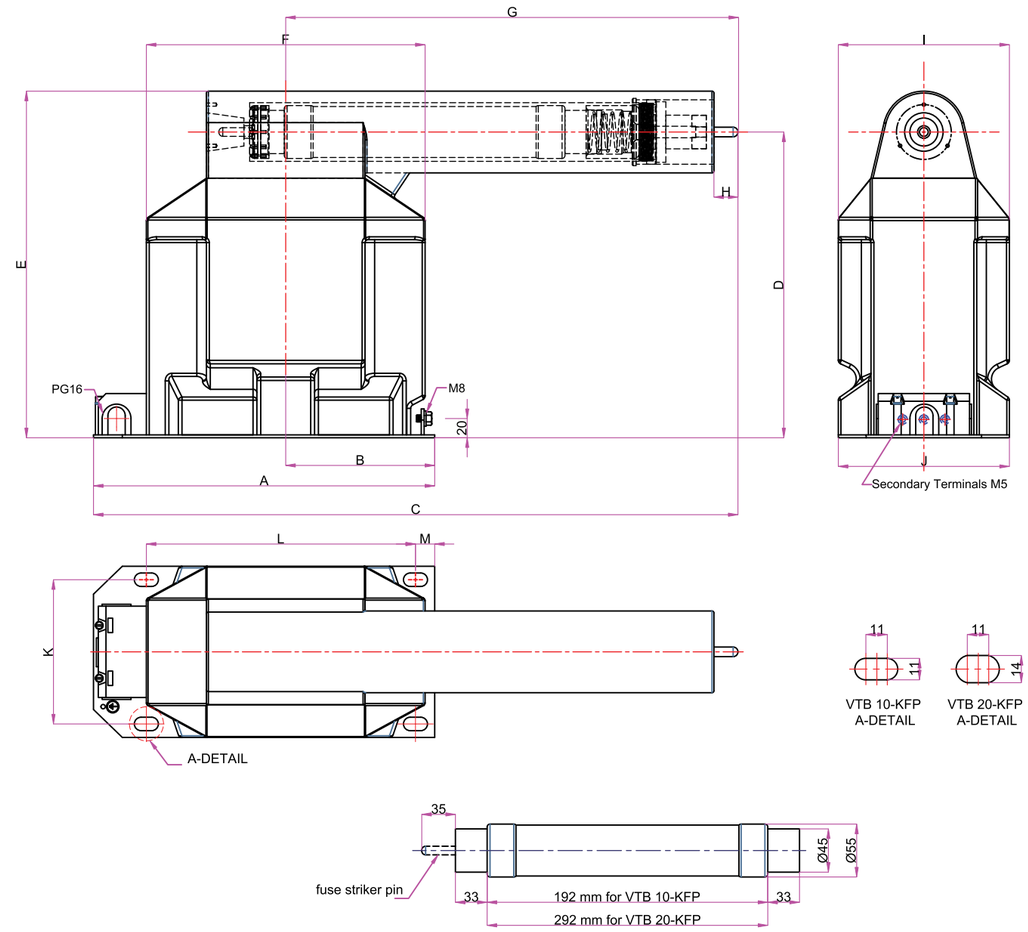
## Technical Data

| Types | VTB 10-KFP | | | VTB 20-KFP | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | 24/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | 50 | | |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | 120 | | |
| Rated burden (max.) in class 1 (VA) | 200 | | | 250 | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8 h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 32 | | | 42 | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

# INDOOR SINGLE PHASE CAST RESIN INSULATED WITH STRIKER PIN SIGNALLING BUILT IN FUSE WITHDRAWABLE TYPE V.T.'S TECHNICAL DRAWING

(Um=3,6kV .....24kV BLOCK TYPES)




| Types | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VTB 10-KFP | 355 | 155 | 560 | 260 | 302 | 290 | 360 | 25 | 148 | 148 | 125 | 270 | 20 |
| VTB 20-KFP | 355 | 155 | 671 | 318 | 361 | 290 | 471 | 25 | 178 | 178 | 150 | 270 | 20 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



# INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE SPECIAL TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....24kV BLOCK TYPES)

Types:
ES 12 VR-F
ES 24 V2-F

## Technical Data — Produced only in Indonesia Factory

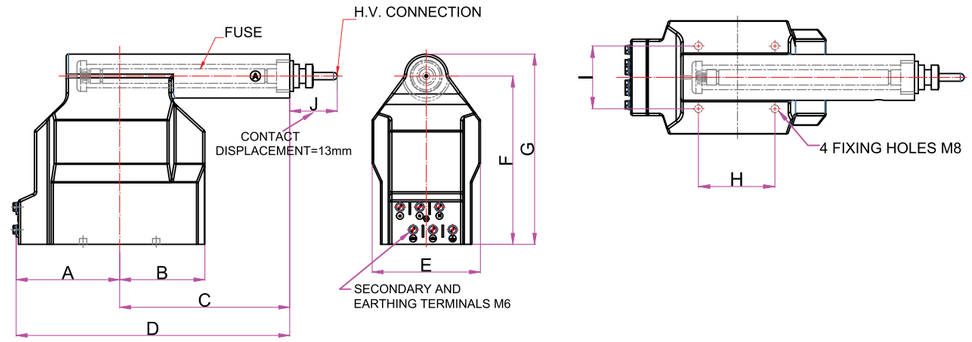
| Types | ES 12 VR-F | | | ES 24 V2-F | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17.5 | 24 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | 24/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 20 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 60 | | | | | |
| Rated burden (max.) in class 1 (VA) | 120 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 60 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 21 | | | 29 | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

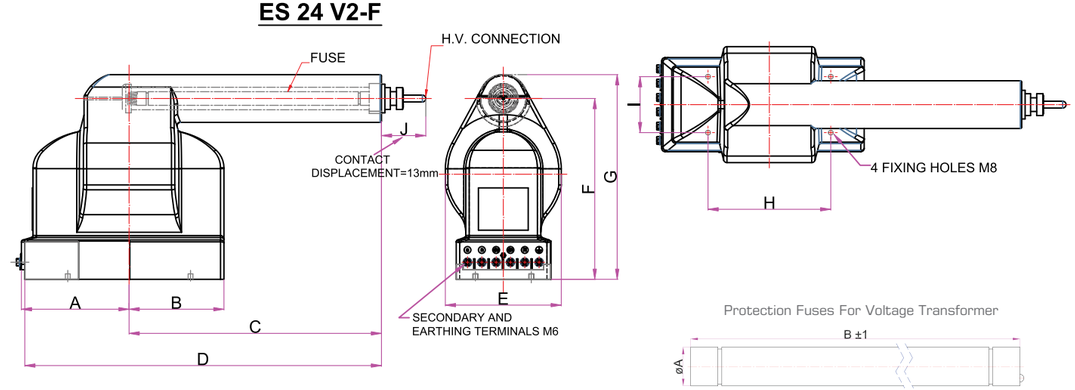
# INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE SPECIAL TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....24kV BLOCK TYPES)

## ES 12 VR-F




## ES 24 V2-F




| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 4 |

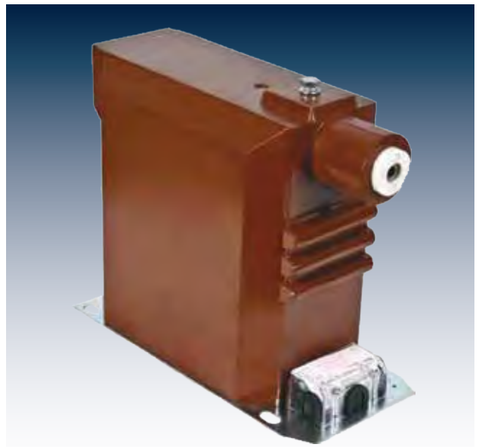
| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| ES 12 VR-F | 141,5 | 116,5 | 232,5 | 374 | 148 | 230 | 260 | 100 | 82 | 65 |
| ES 24 V2-F | 158 | 139 | 370 | 528 | 170 | 265 | 300 | 180 | 82 | 65 |

Protection Fuses For Voltage Transformer




| NO | V.T. Types | Rated Currents (A) | Rated Voltage (Un) | ØA | B (mm) |
|---|---|---|---|---|---|
| 1 | ES 12 VR-F ES 24 V2-F | 0,63 Amper | 7,2 kV | 20 | 190 |
| 2 | | 1 Amper | | | |
| 3 | | 2 Amper | | | |
| 4 | | 3,15 Amper | | | |
| 5 | ES 12 VR-F ES 24 V2-F | 0,63 Amper | 12 kV | | 254 |
| 6 | | 1 Amper | | | |
| 7 | | 2 Amper | | | |
| 8 | | 3,15 Amper | | | |
| 9 | ES 12 VR-F ES 24 V2-F | 0,63 Amper | 15,5 - 17,5 kV | | |
| 10 | | 1 Amper | | | |
| 11 | | 2 Amper | | | |
| 12 | | 3,15 Amper | | | |
| 13 | ES 24 V2-F | 0,5 Amper | 24-25.5 kV | | 340 |
| 14 | | 1 Amper | | | |
| 15 | | 2 Amper | | | |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



# INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE FIXED TYPE VOLTAGE TRANSFORMERS

(Um=3,6kV.....24kV)

**Types:**
VTB 10-SF
VTB 20-F2

## Technical Data — Produced only in Indonesia Factory

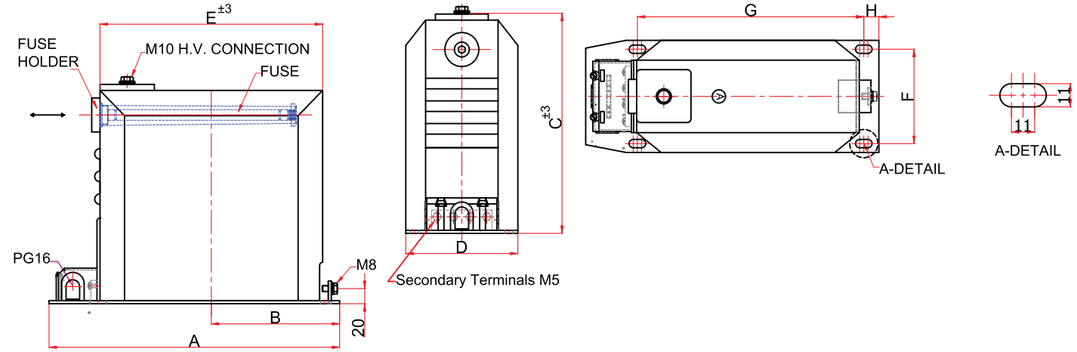
| Types | VTB 10-SF | | | VTB 20-F2 | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17.5 | 24 | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | 24/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | 60 | | 50 |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | 180 | | 120 |
| Rated burden (max.) in class 1 (VA) | 200 | | | 300 | | 250 |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 34 | | | 45 | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

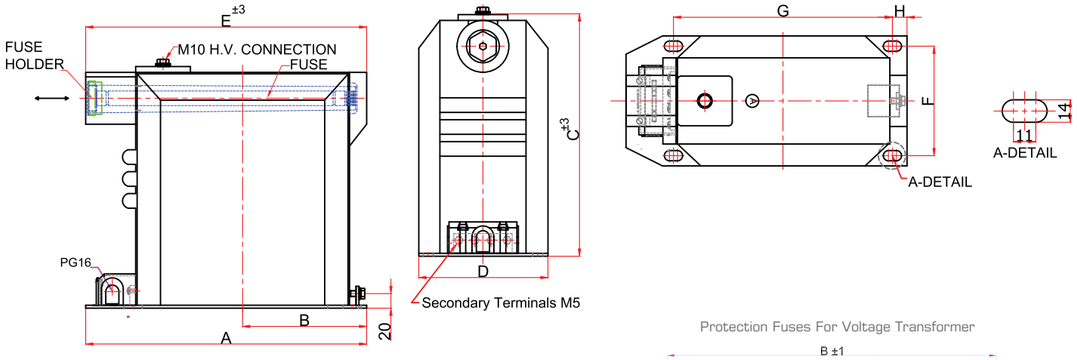
# INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE FIXED TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....24kV)

**VTB 10-SF**



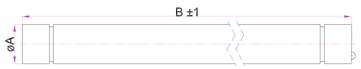

**VTB 20-F2**




| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |
| M10 (Primary Terminal) | 30 | 40 |

| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| VTB 10-SF | 385 | 170 | 290 | 148 | 291 | 125 | 300 | 20 |
| VTB 20-F2 | 385 | 170 | 365 | 178 | 385 | 150 | 300 | 20 |

Protection Fuses For Voltage Transformer




| NO | V.T. Types | Rated Currents (A) | Rated Voltage (Un) | ØA | B (mm) |
|---|---|---|---|---|---|
| 1 | VTB 10-SF VTB 20-F2 | 0,63 Amper | 7,2 kV | 20 | 190 |
| 2 | | 1 Amper | | | |
| 3 | | 2 Amper | | | |
| 4 | | 3,15 Amper | | | |
| 5 | VTB 10-SF VTB 20-F2 | 0,63 Amper | 12 kV | | 254 |
| 6 | | 1 Amper | | | |
| 7 | | 2 Amper | | | |
| 8 | | 3,15 Amper | | | |
| 9 | VTB 10-SF VTB 20-F2 | 0,63 Amper | 15,5- 17,5 kV | | |
| 10 | | 1 Amper | | | |
| 11 | | 2 Amper | | | |
| 12 | | 3,15 Amper | | | |
| 13 | VTB 20-F2 | 0,5 Amper | 24-25,5 kV | | 340 |
| 14 | | 1 Amper | | | |
| 15 | | 2 Amper | | | |

*- All dimensions are in mm.*
*- Tolerances are according to DIN 7168-g when not specified.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



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# INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS

(Um=36 kV)

Types:
VTB 30-F1
VTB 30-F1B

## Technical Data

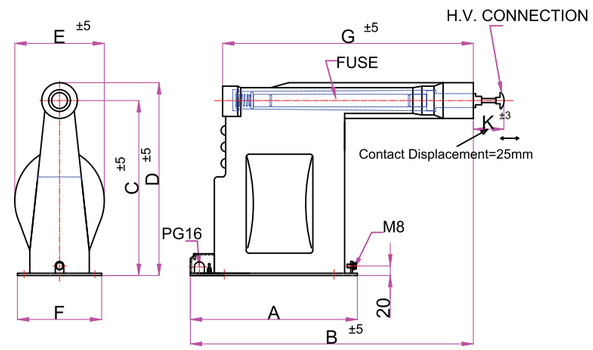
| Types | VTB 30-F1 | | | VTB 30-F1B | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 36** | | | | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 70 | | | | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 170 | | | | | |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 36/√3 | | | | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | |
| Rated burden (max.) in class 0,5 (VA) | 150 | | | | | |
| Rated burden (max.) in class 1 (VA) | 250 | | | | | |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated voltage factor (30 sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation class | E | | | | | |
| Ambient temperature (°C) | -25 ..... +40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 70 | | | | | |

* *It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*
** *For more kV, please contact with ARTECHE for feasibility.*

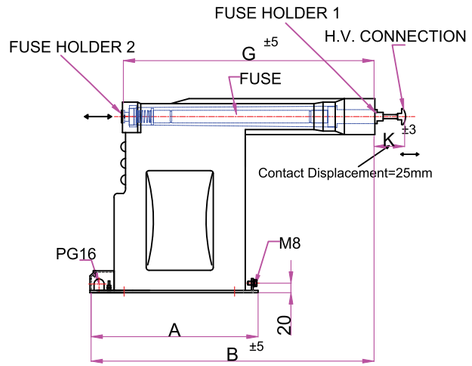
# INDOOR SINGLE PHASE CAST RESIN INSULATED BUILT IN FUSE WITHDRAWABLE TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

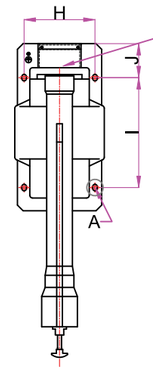
(Um=36kV)

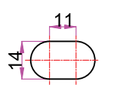
**VTB 30-F1**



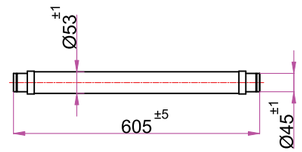

**VTB 30-F1B**




PROTECTION FUSES FOR VOLTAGE TRANSFORMER




Rated Voltage = 36kV
Rated Current = 2A

| Types | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VTB 30-F1 | 450 | 890 | 455 | 510 | 240 | 220 | 805 | 190 | 240 | 90 | 75 |
| VTB 30-F1B | 450 | 890 | 455 | 510 | 240 | 220 | 805 | 190 | 240 | 90 | 75 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2,5 | 3,5 |
| M8 (Ground Terminal) | 15 | 20 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV)

Types:
VTH 20
VTH 30



Clamp type terminal
for high voltage connection.

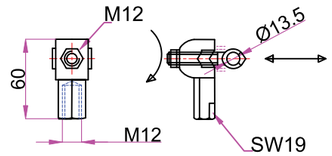
### Technical Data

| Types | VTH 20 | | | | | VTH 30 |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24* | 36* |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 24/√3 | | | | | 36/√3 |
| Secondary voltage (V) | | 100/√3 | 110/√3 | | 120/√3 | & suitable for 220V winding. |
| Rated burden (max.) in class 0,2 (VA) | 40 | | | | | 50 |
| Rated burden (max.) in class 0,5 (VA) | 120 | | | | | 150 |
| Rated burden (max.) in class 1 (VA) | 250 | | | | | 250 |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated burden for 220V winding (VA) | 800 | | | | | |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 | | | | | |
| Short time load (mechanical) (N) | 3750 | | | | | |
| Insulation Class | E | | | | | |
| Min. creepage distance (mm) | 820 | | | | | 1220 |
| Altitude (m) | According to the customer requirements | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 50 | | | | | 65 |

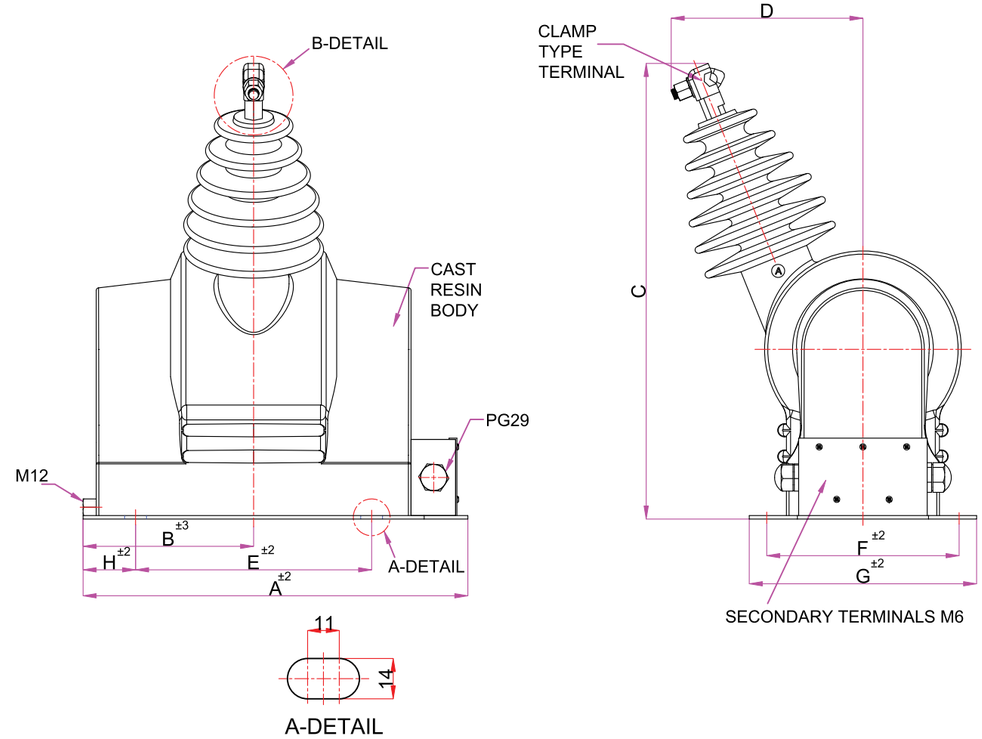
** For more kV, please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....36kV)




B-DETAIL CLAMP TYPE TERMINAL




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| VTH 20 | 440 | 195 | 535 ±5 | 235 ±5 | 270 | 220 | 260 | 60 |
| VTH 30 | 450 | 200 | max.625 | max.295 | 270 | 190 | 220 | 70 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary&Ground Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV)

Types:
VTH 20-N
VTH 30-N



Clamp type terminal
for high voltage connection.

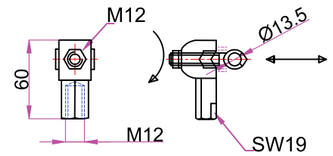
### Technical Data

| Types | VTH 20-N | | | | | VTH 30-N |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24* | 36* |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 24/√3 | | | | | 36/√3 |
| Secondary voltage (V) | 100/√3 | | 110/√3 | | 120/√3 | & suitable for 220V winding. |
| Rated burden (max.) in class 0,2 (VA) | 40 | | | | | 50 |
| Rated burden (max.) in class 0,5 (VA) | 120 | | | | | 150 |
| Rated burden (max.) in class 1 (VA) | 250 | | | | | 250 |
| Rated burden for protection purpose in class 3P (VA) | 100 | | | | | |
| Rated burden for 220V winding (VA) | 800 | | | | | |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 | | | | | |
| Short time load (mechanical) (N) | 3750 | | | | | |
| Insulation Class | E | | | | | |
| Min. creepage distance (mm) | 820 | | | | | 1220 |
| Altitude (m) | According to the customer requirements | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 55 | | | | | 65 |

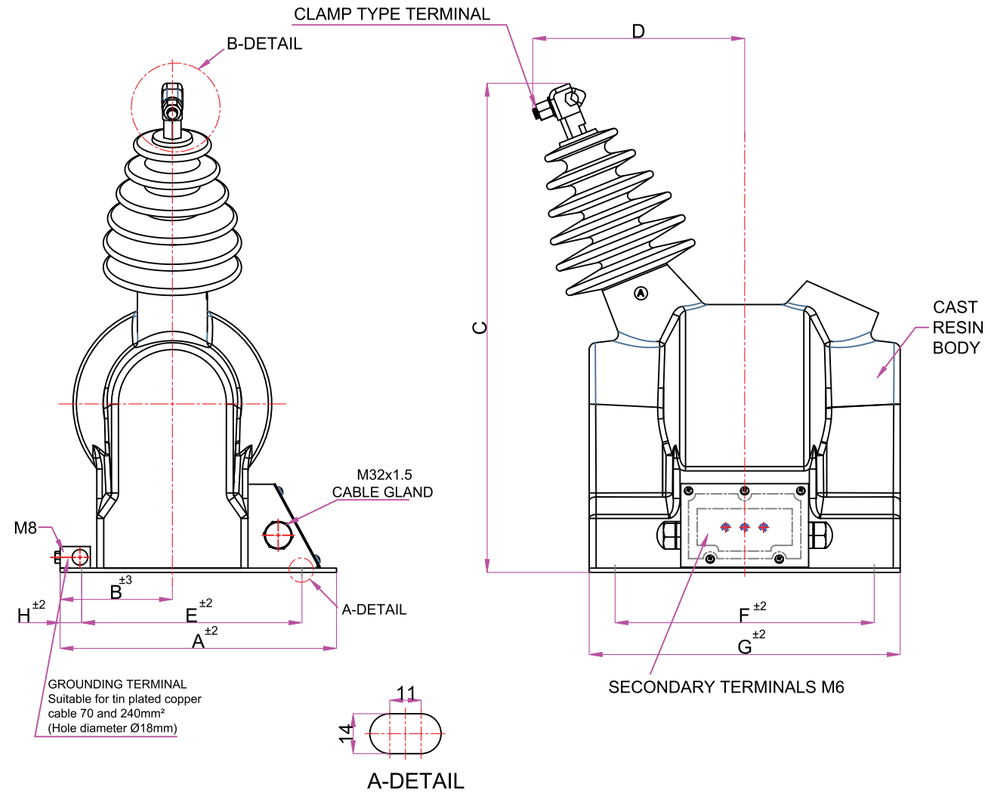
* *For more kV, please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....36kV)




B-DETAIL CLAMP TYPE TERMINAL




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| VTH 20-N | 320 | 130 | max.585 | max.255 | 255 | 300 | 360 | 20 |
| VTH 30-N | 315 | 135 | max.660 | max.275 | 255 | 300 | 360 | 30 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*





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## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=52kV)

Types:
VTH 52-N



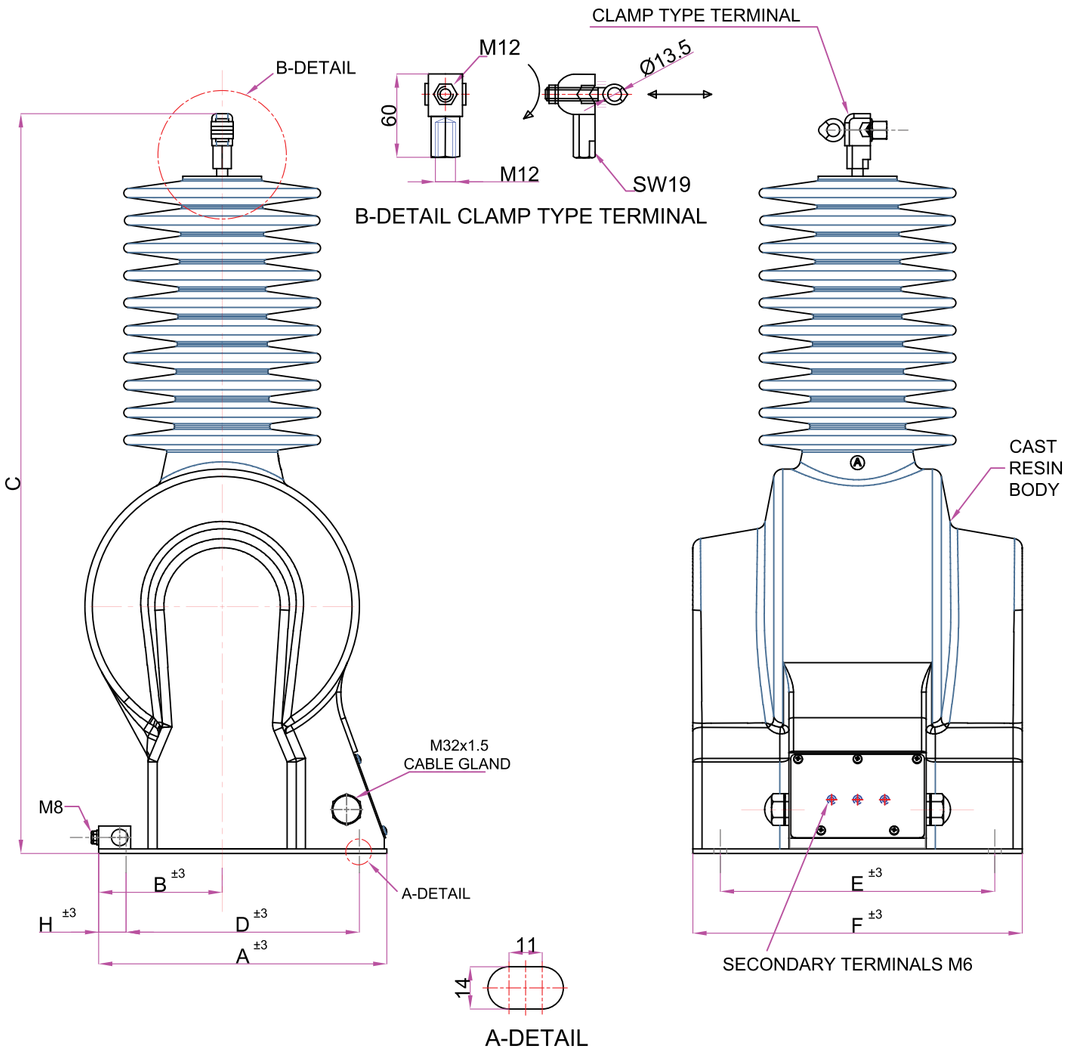
Clamp type terminal
for high voltage connection.

### Technical Data

| Types | VTH 52-N |
|---|---|
| Operating voltage, Um (kV) | 52 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 95 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 250 |
| Rated frequency (Hz) | 50-60 |
| Rated primary voltage (max.) (kV) | 46/√3 |
| Secondary voltage (V) | 100/√3 110/√3 120/√3 & suitable for 220V winding. |
| Rated burden (max.) in class 0,2 (VA) | 50 |
| Rated burden (max.) in class 0,5 (VA) | 150 |
| Rated burden (max.) in class 1 (VA) | 250 |
| Rated burden for protection purpose in class 3P (VA) | 100 |
| Rated burden for 220V winding (VA) | 800 |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 |
| Short time load (mechanical) (N) | 3750 |
| Insulation Class | E |
| Min. creepage distance (mm) | 1650 |
| Altitude (m) | According to the customer requirements |
| Standard | According to the customer requirements |
| Weight (approx.) (kg) | 90 |

## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=52kV)




| Types | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| VTH 20-N | 315 | 135 | max.820 | 255 | 300 | 360 | 30 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE PHASE TO PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV)

Types:
2VTH 20
2VTH 30

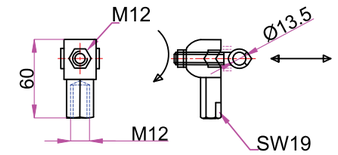


Clamp type terminal
for high voltage connection.

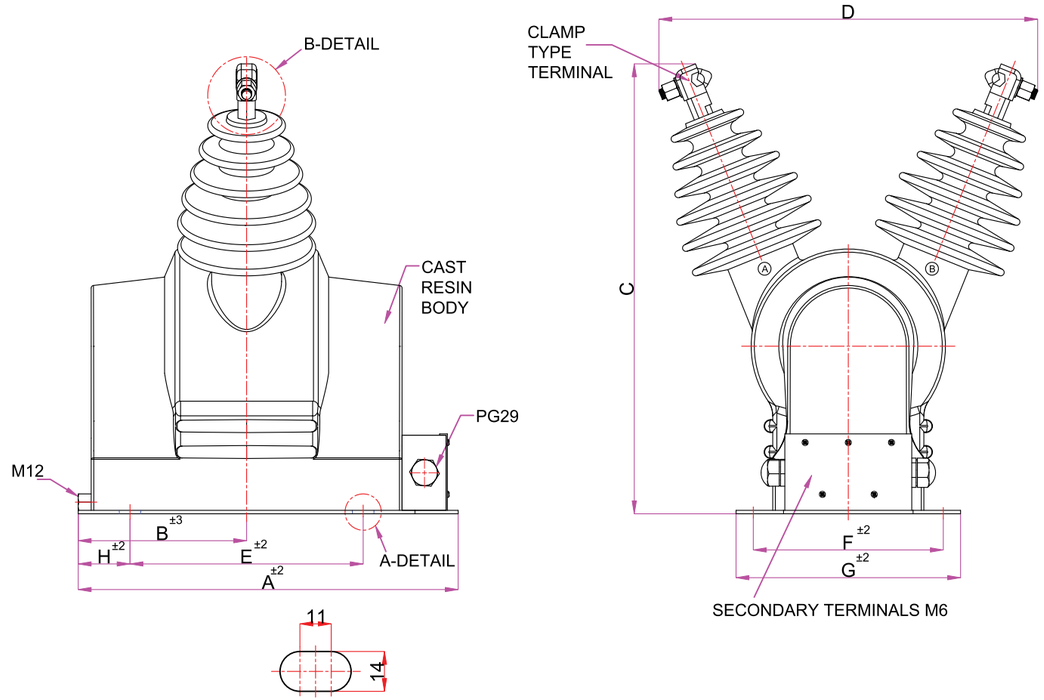
| Technical Data | | | | | | Produced only in Indonesia Factory |
|---|---|---|---|---|---|---|
| Types | 2VTH 20 | | | | | 2VTH 30 |
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 24 | | | | | 36 |
| Secondary voltage (V) | 100, 110, 120 & suitable for 220V winding. | | | | | |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | 40 |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | | 120 |
| Rated burden (max.) in class 1 (VA) | 200 | | | | | 200 |
| Rated burden for 220V winding (VA) | 800 | | | | | |
| Rated voltage factor (30sec. or 8h) (Un) | 1,2 | | | | | |
| Short time load (mechanical) (N) | 3750 | | | | | |
| Min. creepage distance (mm) | 820 | | | | | 1220 |
| Altitude (m) | According to the customer requirements | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 60 | | | | | 70 |

## OUTDOOR DRY TYPE PHASE TO PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....36kV)




B-DETAIL CLAMP TYPE TERMINAL




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 2VTH 20 | 440 | 195 | 535 ±5 | 460 ±5 | 270 | 20 | 260 | 60 |
| 2VTH 30 | 450 | 200 | max.625 | max.580 | 270 | 190 | 220 | 70 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary and Ground Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## OUTDOOR DRY TYPE PHASE TO PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=3,6kV.....36kV)

Types:
2VTH 20-N
2VTH 30-N



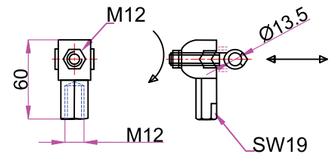
Clamp type terminal
for high voltage connection.

## Technical Data

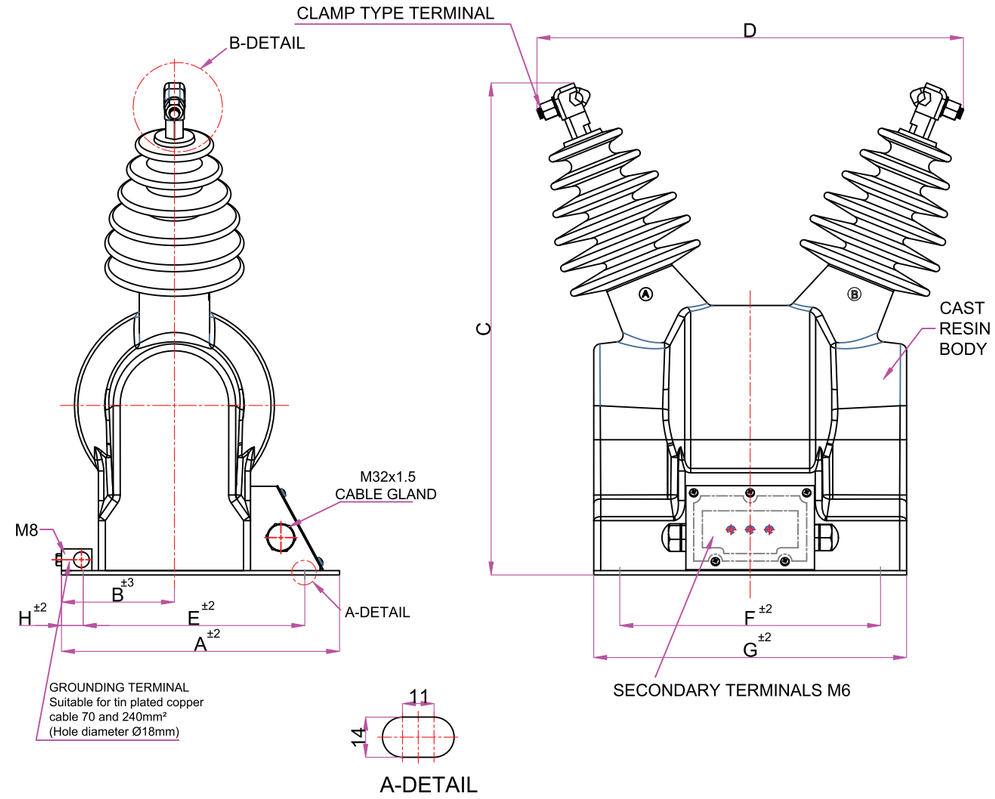
| Types | 2VTH 20-N | | | | | 2VTH 30-N |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 3,6 | 7,2 | 12 | 17,5 | 24 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 10 | 20 | 28 | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 40 | 60 | 75 | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 24 | | | | | 36 |
| Secondary voltage (V) | 100, 110, 120 & suitable for 220V winding. | | | | | |
| Rated burden (max.) in class 0,2 (VA) | 30 | | | | | 40 |
| Rated burden (max.) in class 0,5 (VA) | 100 | | | | | 120 |
| Rated burden (max.) in class 1 (VA) | 200 | | | | | 200 |
| Rated burden for 220V winding (VA) | 800 | | | | | |
| Rated voltage factor (30sec. or 8h) (Un) | 1,2 | | | | | |
| Short time load (mechanical) (N) | 3750 | | | | | |
| Insulation Class | E | | | | | |
| Min. creepage distance (mm) | 820 | | | | | 1220 |
| Altitude (m) | According to the customer requirements | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 67 | | | | | 86 |

## OUTDOOR DRY TYPE PHASE TO PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=3,6kV.....36kV)




B-DETAIL CLAMP TYPE TERMINAL

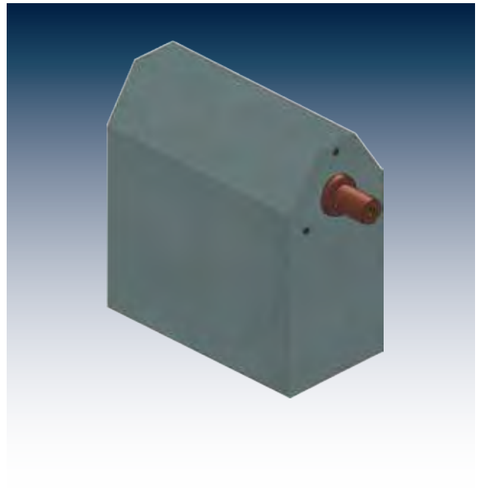



A-DETAIL

| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 2VTH 20-N | 320 | 130 | max.585 | max.510 | 255 | 300 | 360 | 20 |
| 2VTH 30-N | 315 | 135 | max.660 | max.550 | 255 | 300 | 360 | 30 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*



## INDOOR SINGLE PHASE METAL HOUSING BUSHING TYPE VOLTAGE TRANSFORMERS

(Um=12kV ..... 36kV)

V VMVT 10B
MVT 30B

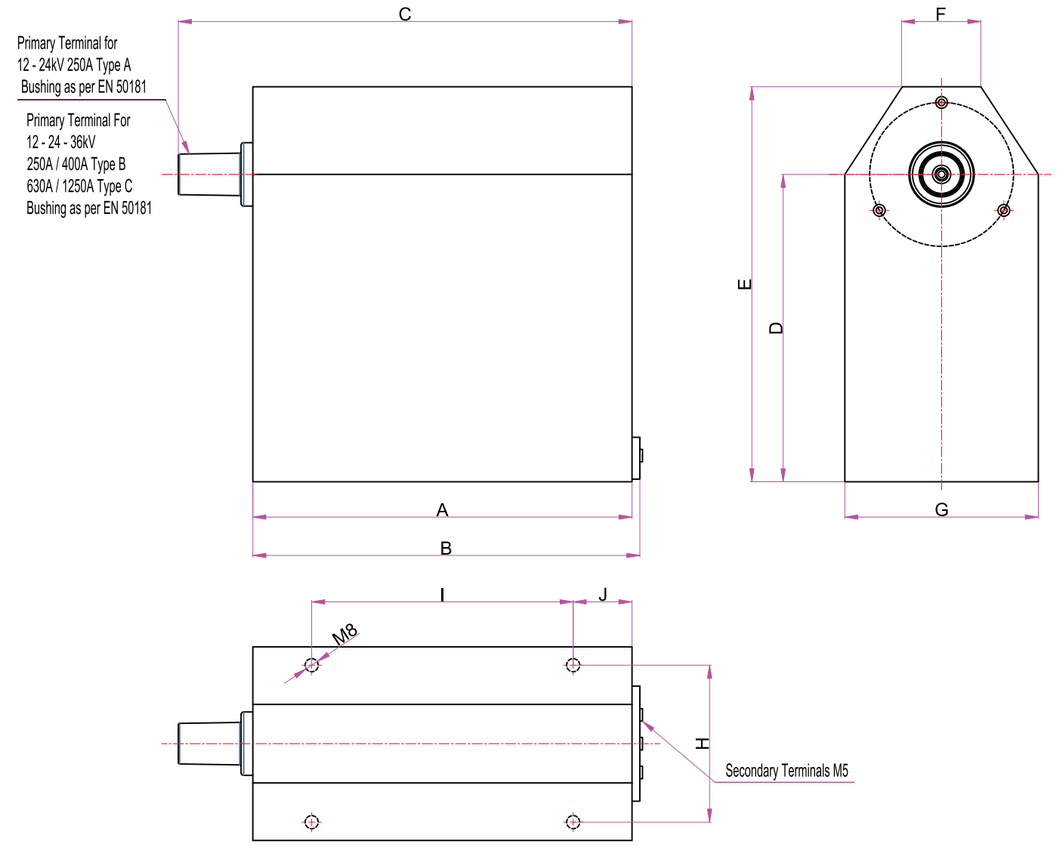
### Technical Data

| Types | MVT 10B | | | MVT 30B | | |
|---|---|---|---|---|---|---|
| Operating voltage, Um (kV) | 12 | | | 17,5 | 24 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 28 | | | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 75 | | | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | | | 36/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 10 | | | 10 | 10 | 10 |
| Rated burden (max.) in class 0,5 (VA) | 30 | | | 30 | 30 | 30 |
| Rated burden (max.) in class 1 (VA) | 60 | | | 60 | 60 | 60 |
| Rated burden for 220V winding (VA) | 50(Ith 2A) | | | 50 | 50 | 50(Ith 4A) |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 | | | | | |
| Insulation Class | E | | | | | |
| Min. creepage distance (mm) | -25.....+40* | | | | | |
| Altitude (m) | 1000 | | | | | |
| Standard | According to the customer requirements | | | | | |
| Weight (approx.) (kg) | 30 | | | 45 | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE METAL HOUSING BUSHING TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=12kV ..... 36kV)




| Types | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| MVT 10B | 290 | 296 | 347 | 235 | 302 | 60 | 148 | 120 | 200 | 45 |
| MVT 30B | 370 | 376 | 482 | - | 306,5 | 95 | 185 | 150 | 250 | 60 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
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## INDOOR SINGLE PHASE METALISED BUSHING TYPE VOLTAGE TRANSFORMERS

(Um=12kV ..... 36kV)

Types:
MVT 10
MVT 30

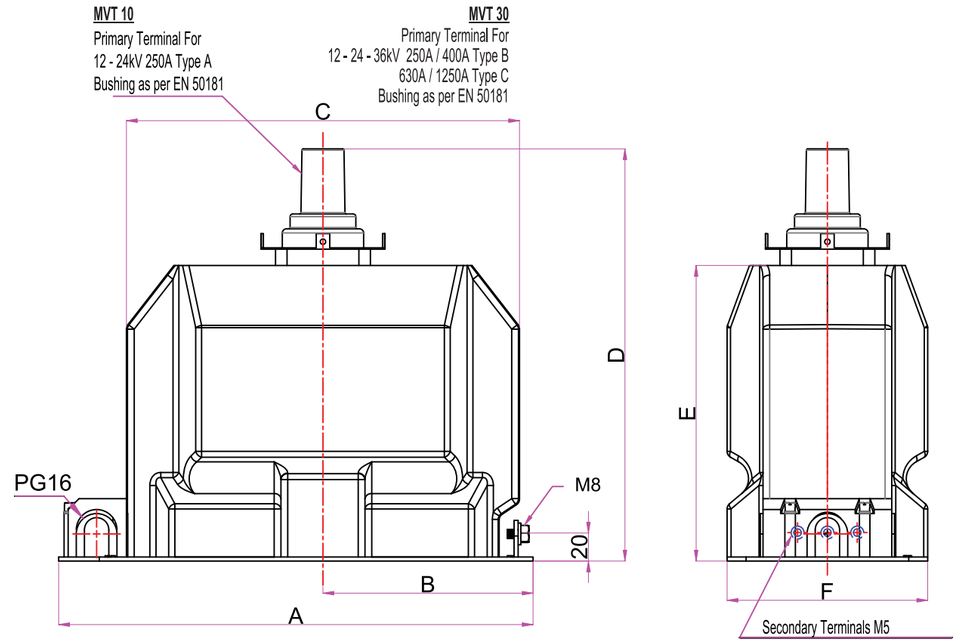
### Technical Data

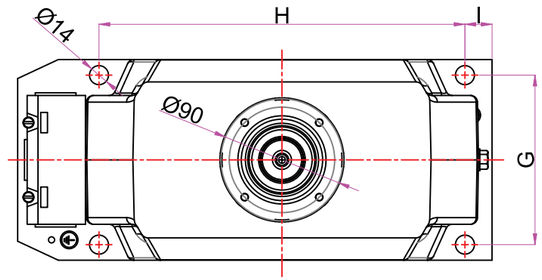
| Types | MVT 10 | MVT 30 | | |
|---|---|---|---|---|
| Operating voltage, Um (kV) | 12 | 17,5 | 24 | 36 |
| Rated power-frequency withstand voltage (1 minute) (kV) | 28 | 38 | 50 | 70 |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 75 | 95 | 125 | 170 |
| Rated frequency (Hz) | 50-60 | | | |
| Rated primary voltage (max.) (kV) | 12/√3 | 36/√3 | | |
| Secondary voltage (V) | 100/√3 110/√3 120/√3 | 100/3 | 110/3 | 120/3 |
| Rated burden (max.) in class 0,2 (VA) | 10 | 10 | 10 | 10 |
| Rated burden (max.) in class 0,5 (VA) | 30 | 30 | 30 | 30 |
| Rated burden (max.) in class 1 (VA) | 60 | 60 | 60 | 60 |
| Rated burden for 220V winding (VA) | 50( Ith 2A) | 50 | 50 | 50(Ith 4A) |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 | | | |
| Insulation Class | E | | | |
| Min. creepage distance (mm) | -25.....+40* | | | |
| Altitude (m) | 1000 | | | |
| Standard | According to the customer requirements | | | |
| Weight (approx.) (kg) | 30 | 45 | | |

** It can be produced according to customer's specified ambient temperature. Please contact with ARTECHE for feasibility.*

## INDOOR SINGLE PHASE METALISED BUSHING TYPE VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um=12kV ..... 36kV)




| Types | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| MVT 10 | 350 | 155 | 290 | 304 | 218 | 148 | 125 | 270 | 20 |
| MVT 30 | 430 | 195 | 370 | 429 | 290 | 185 | 150 | 300 | 45 |

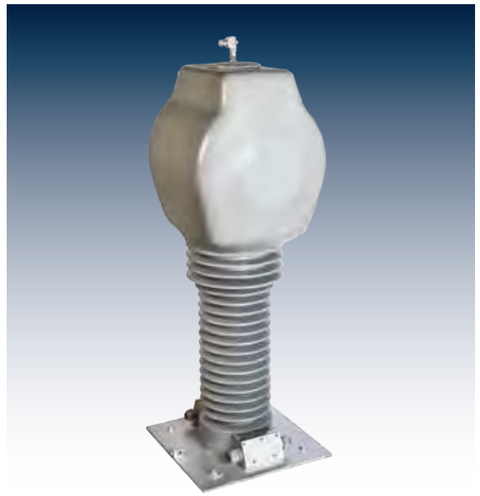
| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M5 (Secondary Terminal) | 2.5 | 3.5 |
| M8 ( Ground Terminal) | 15 | 20 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*





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## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS

(Um=72,5kV)

Types:
VTH 72-N

### Technical Data

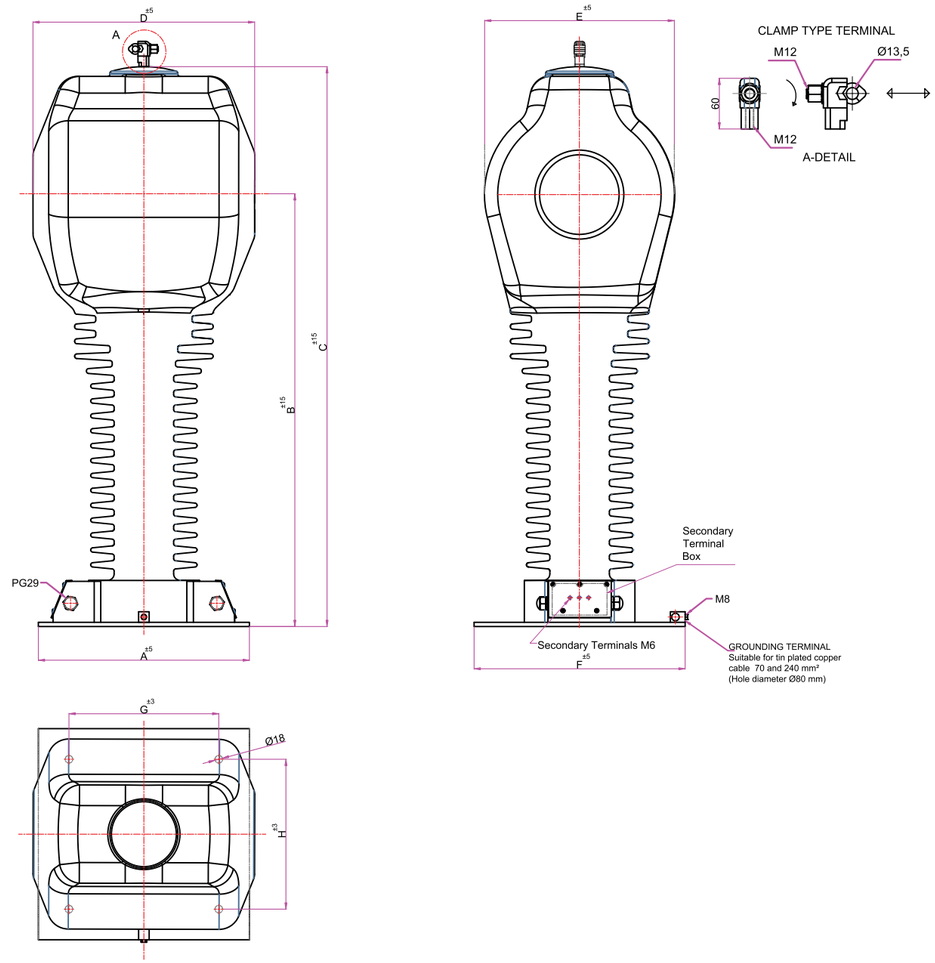
| Types | VTH 72-N | | |
|---|---|---|---|
| Operating voltage, Um (kV) | 72,5 | | |
| Rated power-frequency withstand voltage (1 minute) (kV) | 140 | | |
| Rated impulse test voltage (1.2/50 µs) full wave (kV) | 325 | | |
| Rated frequency (Hz) | 50-60 | | |
| Rated primary voltage (max.) (kV) | 66/√3 | | |
| Secondary voltage (V) | 100/√3 | 110/√3 | 120/√3 |
| Rated burden (max.) in class 0,2 (VA) | 50 | | |
| Rated burden (max.) in class 0,5 (VA) | 150 | | |
| Rated burden (max.) in class 1 (VA) | 300 | | |
| Rated burden for protection purpose in class 3p (VA) | 100 | | |
| Rated voltage factor (30sec. or 8h) (Un) | 1,9 | | |
| Insulation Class | E | | |
| Min. creepage distance (mm) | 2500 | | |
| Altitude (m) | According to the customer requirements | | |
| Standard | According to the customer requirements | | |
| Weight (approx.) (kg) | 300 | | |

** For more cores please contact with ARTECHE for feasibility.*

## OUTDOOR DRY TYPE SINGLE PHASE CAST RESIN INSULATED VOLTAGE TRANSFORMERS TECHNICAL DRAWING

(Um= 72,5kV)

**VTH 72-N**




| Types | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| VTH 72-N | 500 | 1025 | 1325 | 525 | 450 | 500 | 355 | 355 |

| TIGHTENING TORQUE (Nm) | min. | max. |
|---|---|---|
| M6 (Secondary Terminal) | 3 | 5 |
| M12 (Primary and Ground Terminal) | 60 | 70 |

*- All dimensions are in mm.*
*- Arteche reserves the right to change the specifications and the dimensions of the goods. Please ask for updated information.*
*- Customer designed products are also available.*

# INSULATORS



arteche

# INSULATORS

Insulators are insulating and supporting components of the power transmission lines and busbars (distribution centers, switchgears) where they are fixed.

Insulators are intended to be used for 2 reason:
-Separating conductors from the earth in regards to electricity
-Supporting the weight of conductors and additional loads

Arteche Insulators are epoxy cast resin insulated with internal metal fittings.

The insulators are particularly suitable to be used as single support or voltage control.

Arteche MV Insulators are designed for indoor-indoor and outdoor-indoor applications (from 3,6kV to 36kV):

- Bushing Insulators
- Post Insulators
- Capacitive Insulators(voltage divider)

## Post insulators for indoor installation

### General characteristics
Epoxy resin post insulators, for indoor application, with internal metal fitting.
These insulators are particularly suitable to be used as single supports for conductors, for fuses and for other equipment (as switchgears).

### Application
For indoor installation with working condition at T° max. 85 °C.

### Service voltage
Up to 36 kV (40,5 kV available on request)

### Routine Tests
Visual inspection
Testing of conductive connection of fixing inserts for post insulators
Dry power-frequency withstand voltage
Partial discharge extinction voltage test

### Standards
IEC 60273 (CEI 36/12) - CENELEC HD 578 S1
IEC 60660

### General characteristics
Epoxy resin post insulators with capacitive divider for the reading of the voltage.
Manufactured with internal metal fitting, they can be equipped with couplings and low voltage light signal box.
These insulators are mainly suitable to be used as insulated supports of equipment, bus bar or fuses.

### Application
Max working temperature of 85 °C.

### Routine Tests
Visual inspection
Testing of conductive connection of fixing inserts for post insulators
Dry power-frequency withstand voltage
Partial discharge extinction voltage test (connected to the voltage indicator)

### Service voltage
Up to 36 kV (40,5 available on request)

### Standards
IEC 60660

## Bushing Insulators for indoor-indoor / outdoor-indoor

### General characteristics
12 - 36 kV epoxy resin bushing insulators. The insulators can be fitted with copper bars designed from 250 up to 1250 A.
They are equipped with internal metal fittings for installation on the relevant frame and with brass nuts and washers for fastening of phase connectors.

### Application
Indoor/outdoor installation at max working temperature of 85 ºC.

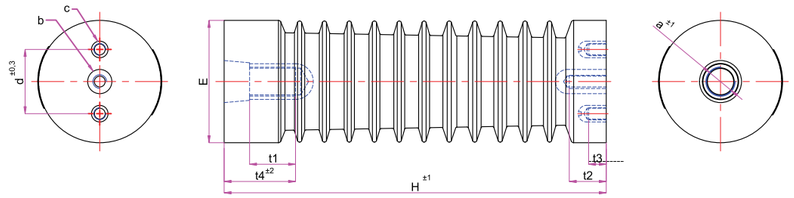
### Service voltage
Up to 36 kV.

### Routine Tests
Visual inspection
Dry power-frequency withstand voltage
Measurement of partial discharge quantity

### Standards
IEC 60137

## INDOOR POST INSULATORS UP TO 36kV






Material Type: Epoxy Resin

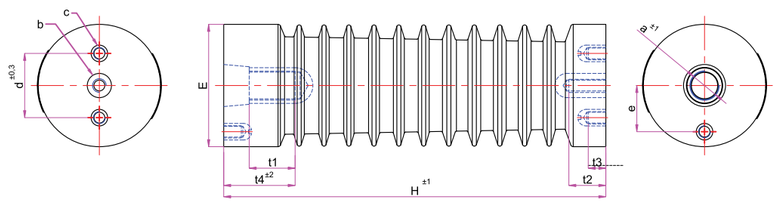
According to IEC 60273 (1990), IEC 60660 (1999)

| TYPES | Um (kV) | Power-frequency withstand voltage, dry (kV) | Falling load bending (N) | Weight app. (kg) | Dimensions (mm) | | | | | | | | | | Min. Creepage Distance (mm) | Number of ribs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | a | b | c | d | E | H | t1 | t2 | t3 | t4 | | |
| J04-75 (10N500) | 12 | 38 | 4000 | 0,60 | M16 | M12 | M6 | 36 | Ø61 | 130 | 25 | 18 | 10 | 37 | 170 | 5 |
| J010-125 (20N1000) | 12/24 | 38/50 | 10000 | 0,97 | M20 | M16 | M10 | 46 | Ø86 | 210 | 27 | 24 | 12 | 42 | 210 | 8 |
| J010-125 (20N1000 EGY) | 24 | 50 | 8000 | 1,80 | M16 | M10 | M6 | 36 | Ø90 | 210 | 45 | 40 | 16 | 63 | 440 | 9 |
| J010-75 (10N1000) | 12 | 38 | 10000 | 0,85 | M20 | M16 | M10 | 46 | Ø72 | 130 | 27 | 24 | 12 | 42 | 190 | 5 |
| J010-75 (10N1000 EGY) | 12 | 38 | 5000 | 0,75 | M16 | M10 | M6 | 36 | Ø71 | 130 | 40 | 20 | 10 | 50 | 240 | 7 |
| J04-95 (15N500) | 17,5 | 50 | 4000 | 0,95 | M16 | M12 | M6 | 36 | Ø70 | 175 | 25 | 18 | 10 | 40 | 250 | 6 |
| J010-95(15N1000) | 17,5 | 50 | 10000 | 1,7 | M20 | M16 | M10 | 46 | Ø90 | 175 | 27 | 24 | 12 | 42 | 270 | 6 |
| J04-125 (20N500) | 24 | 50 | 4000 | 1,30 | M16 | M12 | M6 | 36 | Ø75 | 210 | 25 | 18 | 10 | 40 | 320 | 8 |
| J010-125 (B20N1000) | 24 | 50 | 7500 | 1,6 | M16 | M12 | - | - | Ø85 | 225 | 40 | 32 | - | 60 | 425 | 13 |
| J04-170 (30N500) | 36 | 70 | 4000 | 1,9 | M16 | M12 | M6 | 36 | Ø80 | 300 | 25 | 26 | 12 | 48 | 510 | 11 |
| J010-170 (30N1000) | 36 | 70 | 10000 | 3,00 | M24 | M16 | M10 | 46 | Ø96 | 300 | 38 | 28 | 12 | 56 | 460 | 11 |
| J010-170 (30N1000 ABB) | 36 | 70 | 10000 | 3,9 | M24 | - | M12 | 32 | Ø96 | 390 | 38 | - | 18 | 56 | 550 | 11 |

Tolerance ∓ (Dimensions x 0,01 + 0,2) mm

## INDOOR CAPACITIVE POST INSULATORS UP TO 36kV





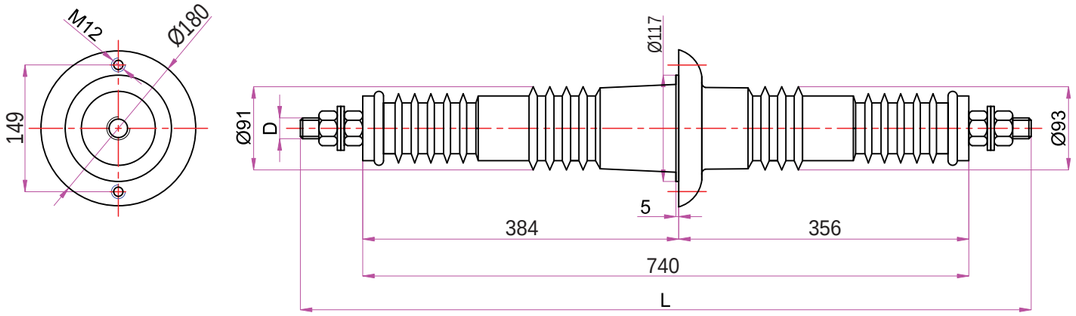

| TYPES | Um (kV) | Power-frequency withstand voltage, dry (kV) | Falling load bending (N) | Weight app. (kg) | Dimensions (mm) | | | | | | | | | | Min. Creepage Distance (mm) | Number of ribs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | a | b | c | d | e | E | H | t1 | t2 | t3 | | |
| 10N1000K | 12 | 38 | 10000 | 0,95 | M20 | M16 | M10 | 46 | 30 | ø 77 | 130 | 27 | 24 | 12 | 190 | 5 |
| 15N1000K | 17,5 | 50 | 10000 | 1,70 | M20 | M16 | M10 | 46 | 30 | ø 90 | 175 | 27 | 24 | 12 | 270 | 6 |
| 20N500K | 24 | 50 | 4000 | 1,30 | M16 | M12 | M6 | 36 | 30 | ø 75 | 210 | 25 | 18 | 10 | 320 | 8 |
| 20N1000K | 24 | 50 | 10000 | 1,90 | M20 | M16 | M10 | 46 | 30 | ø 85 | 210 | 27 | 24 | 12 | 330 | 8 |
| 30N500K | 36 | 70 | 4000 | 2,00 | M16 | M12 | M6 | 36 | 30 | ø 80 | 300 | 25 | 26 | 12 | 510 | 11 |
| 30N1000K | 36 | 70 | 10000 | 3,10 | M24 | M16 | M10 | 46 | 34 | ø 96 | 300 | 38 | 28 | 12 | 460 | 11 |
| 6 KN | 12 | 38 | 6000 | 0,95 | M16 | M4 | M8 | 36 | 20 | ø 75 | 154 | 30 | 5 | 12 | 255 | 7 |
| 4 KN | 36 | 70 | 4000 | 2,50 | M12 | M10 | M6 | - | - | - | 349 | - | - | - | 640 | 13 |

Tolerance ∓ (Dimensions x 0,01 + 0,2) mm



## M.V. INDOOR - INDOOR BOLT BUSHING UP TO 1250A

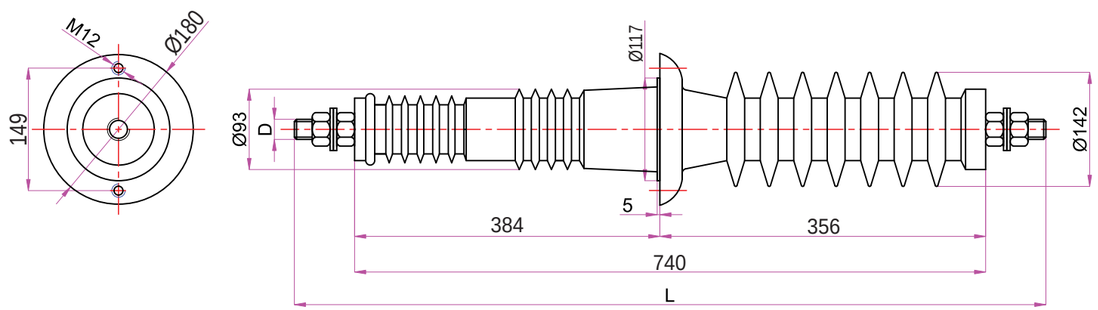
| TYPES | Um (kV) | Falling load bending (N) | In (A) | D | L | Weight (kg) |
|---|---|---|---|---|---|---|
| EDD-36 | 36 | 3750 | 400 | M16 | 840 | 8,6 |
| | | | 630 | M20 | 860 | 9,8 |
| | | | 800 | M24 | 880 | 11,7 |
| | | | 1250 | M30 | 920 | 14,9 |





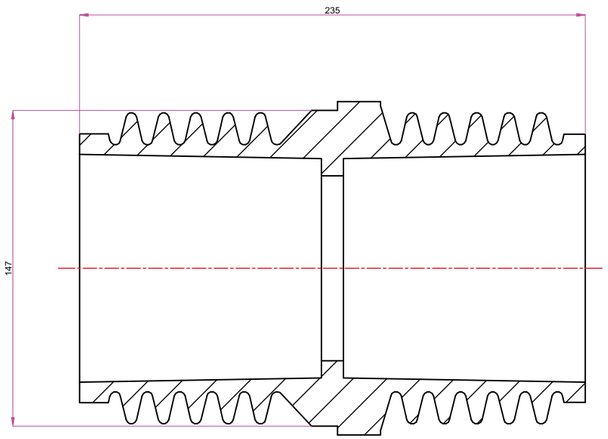

## M.V. OUTDOOR - INDOOR BOLT BUSHING UP TO 1250A

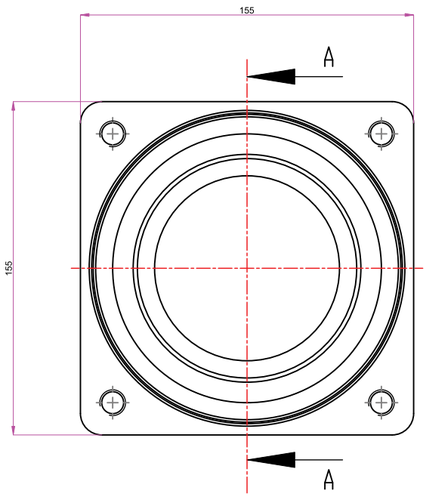
| TYPES | Um (kV) | Falling load bending (N) | In (A) | D | L | Weight (kg) |
|---|---|---|---|---|---|---|
| EDH-36 | 36 | 3750 | 400 | M16 | 840 | 10,8 |
| | | | 630 | M20 | 860 | 12,0 |
| | | | 800 | M24 | 880 | 14,2 |
| | | | 1250 | M30 | 920 | 19,4 |



## SPECIAL PRODUCT - I

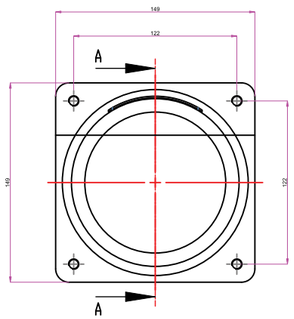


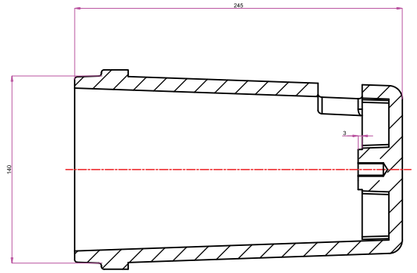


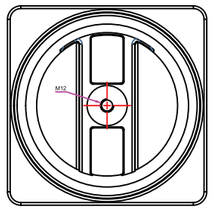



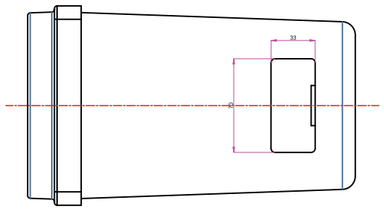

## SPECIAL PRODUCT - II





## SPECIAL PRODUCTS UPON CUSTOMER REQUEST



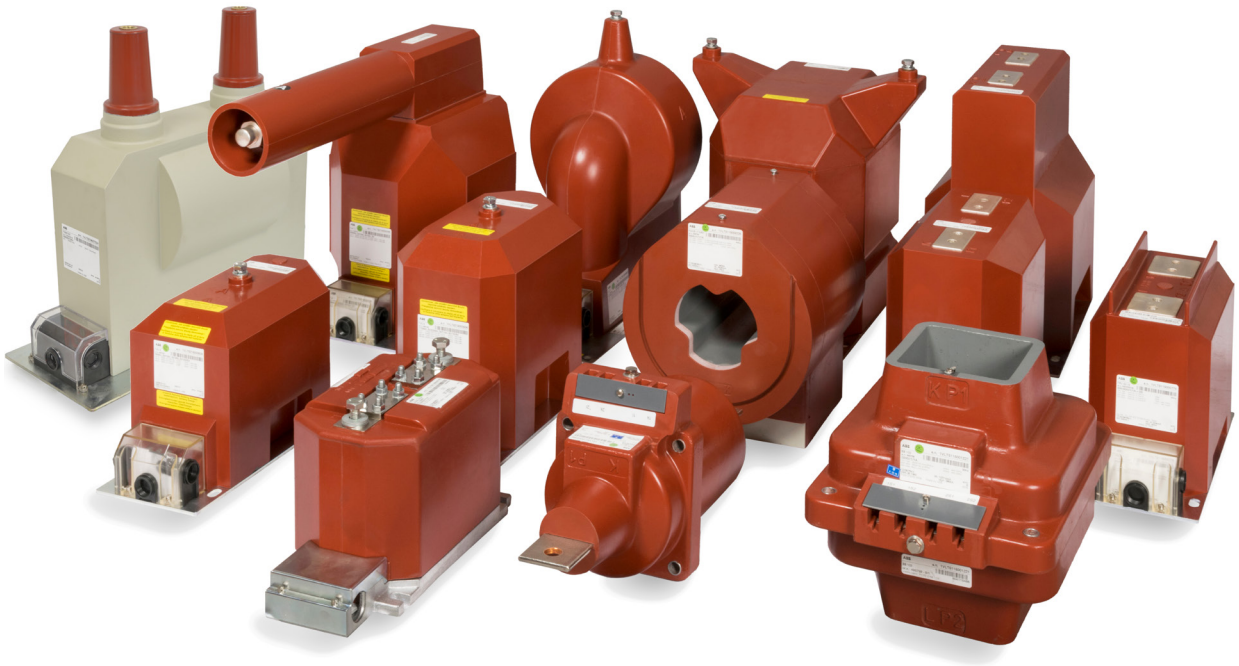
## NOTES

NOTES

MEDIUM VOLTAGE PRODUCTS

# Current and Voltage Instrument Transformers

## Instruction for Installation, Use and Maintenance



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| | |
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# Instructions for Installation, Use and Maintenance for Current and Voltage Transformers

This installation, use and maintenance guide is valid for current and voltage transformers operating in indoor conditions.

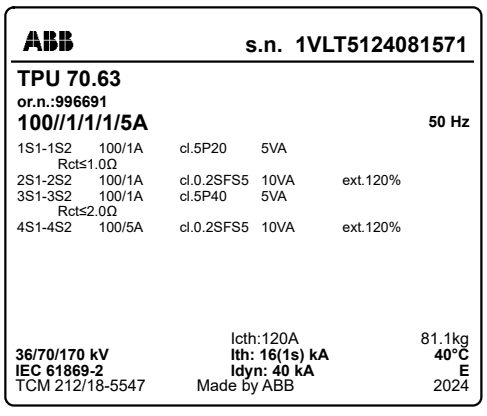
**These instructions are valid for**
Current transformer type:
TPU; TPE; TTR; BB; BBO; KOKS; KOFA; IHBF
Voltage transformers types:
TJE; TJCL; TJC; TJCH; TDC; TJP; TJPH; TDP; KGUG; KGUGI; TJMC, TJMP, TDMC

## 1. Service conditions

The transformers should be mounted in dry indoor conditions where the ambient air is not significantly polluted by dust, smoke, corrosive gases, vapours or salt.
The transformers are designed for standard ambient temperature between –5°C and +40°C. The altitude for use should be lower than 1000 m above the sea level. The transformers may be used also in higher or lower ambient temperatures and higher altitudes when agreed between the manufacturer and purchaser.

## 2. Technical details

The technical details for each individual transformer are mentioned on the rating plate fastened on the transformer. Values mentioned on the rating plate must not be exceeded. Markings used on the rating plate are as follows:

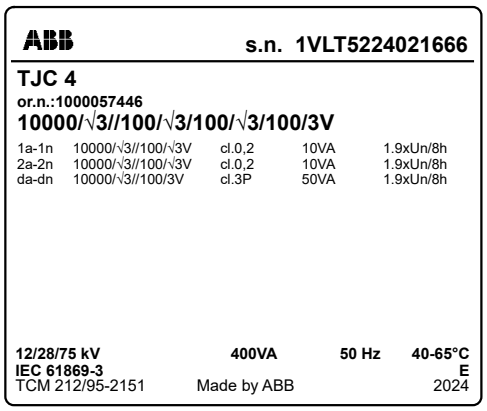



01 Example of current transformer label

**Where:**

| 1VLT5124081571 | serial number |
|---|---|
| TPU 70.63 | transformer type code |
| or.n. 996691 | order number |
| 100//1/1/1/5A | rated transformer ratio |
| 50 Hz | rated frequency |
| 1S1-1S2 | terminal marking for core number 1 |
| 2S1-2S2 | terminal marking for core number 2 |
| 3S1-3S2 | terminal marking for core number 3 |
| 4S1-4S2 | terminal marking for core number 4 |
| 0.2SFS5; 5P20; 5P40 | accuracy classes |
| 5; 10 VA | rated output |
| ext | extension |
| $I_{cth}$ | rated thermal current |
| 81.1 kg | weight |
| 36/70/170 kV | highest voltage for equipment / power-frequency withstand voltage / rated lightning-impulse voltage |
| Ith | rated short time thermal current (thermal time) |
| 40°C | ambient temperature |
| IEC 61869-2 | referred standard(s) |
| Idyn | rated dynamic current |
| E | temperature class |
| 2024 | year of production |

—
02 Example of voltage transformer label




—
02

**Where:**

| 1VLT5224021666 | serial number |
|---|---|
| TJC 4 | transformer type code |
| 10000/√3//100/ √3/100/√3/100/3V | rated voltage ratio |
| 1a-1n | terminal marking for first measuring secondary winding |
| 2a-2n | terminal marking for second measuring secondary winding |
| da-dn | terminal marking for residual (open-delta) winding |
| 0.2; 3P | accuracy classes |
| 10; 50 VA | rated output |
| 1.9xUn/8h | overvoltage factor |
| 12/28/75 kV | highest voltage for equipment / power-frequency withstand voltage / rated lightning-impulse voltage |
| 400 VA | rated output |
| 50 Hz | rated frequency |
| 40-65 °C | ambient temperature |
| IEC 61869-3 | referred standard |
| E | temperature class |
| 2024 | year of production |

## 3. Instructions for installation

**General informations**

Instrument transformer is an electrical equipment and the electrical installation shall be done by skilled person only. National legislation can set down the minimum age and the criteria for competence of skilled persons working on, with, or near an electrical installation.

Where is not the national legislation requirements for competence, the criteria shall be used at least according to EN 50110-1.

**Safety instructions**

1. Always consider transformer as a part of the circuit to which it is connected, and do not touch the leads and terminals or other parts of the transformer unless they are known to be grounded.
2. Always ground the metallic bases of instrument transformer.
3. Always ground one secondary terminal of the transformer, except if the windings of voltage transformer are connected to open delta. Residual voltage windings connected to open delta must have dn terminal earthed only on one of three transformers (earthing screws at dn terminals of others two transformers have to be removed). When the secondary of transformer is interconnected, there should be only one grounded point to prevent accidental paralleling with system grounding wire. In case of disconnection from the ground, the grounding screw has to be removed from the secondary terminal. Connection between secondary terminal and base plate (ground) is shown on the picture “Cross section of double line terminal box“.
4. Always short-circuit the secondary of the current transformer, which is not currently in use to prevent secondary voltages which may be hazardous to personnel or damaging to the transformer’s secondary. The secondary like this must be additionally grounded.
5. Never short-circuit the secondary terminal of a voltage transformer even this is not in use. A secondary short-circuit will cause the unit to overheat and fail in a very short period of time.
6. Protection of single pole insulated voltage transformers against ferroresonance phenomena is stated in Appendix 3. – Damping of the ferroresonance in Voltage transformers type range TJx.
7. In case of the current transformer with voltage indication (coupling electrode included) is secondary terminal box equipped with PE terminal, which is connected with earthing screw to the base plate, which must be generally earthed. Connection between secondary terminal and base plate is shown on the picture “Cross section of single line terminal box“.

**Attention: Terminal PE must be always earthed, this is hold generally, even if the base plate is removed. In case of disassembling the base plate, producer is not warranting the earthing. Coupling electrode terminals Ck and PE are always delivered interconnected. Remove this connection before installation of indication system. Leave the connection if Ck-PE terminals are not**

—
03 Low ratio
—
04 High ratio
—
05 KOKS 12, KOKS 17.5 shielding connection

**in use.**

8. All current and voltage transformers are, for safety reasons, shipped with earthed secondary windings. Earthing of the terminals are shown in Appendix 1. Before putting into operation always check whether it corresponds to the earthing scheme involved in the application and remove earthing screws accordingly (simple examples of network connection are in Appendix 2 ).

**Attention: Manufacturer is not responsible for damage, loss and injuries caused by wrong connection of transformers.**

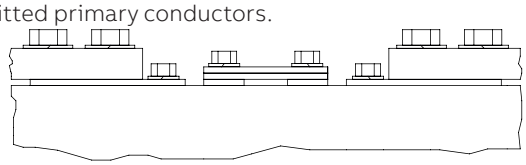
**Mounting**

Following informations are general and some details can differentiate according to type and variants of transformers. It is necessary to combine it with other technical and marketing specifications like catalogues, dimensional drawings and rating plate for specific transformer type.

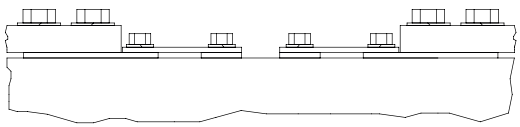
The mounting position of the indoor transformer can be freely chosen. The transformer is fixed using the mounting base with four screws M10 and washers. Fastening must be done on a smooth surface. There is a M8 screw for earthing the transformer on the base plate.

**Primary connection**

Primary terminals of the current transformer are made of copper and they are silver or tin plated. There are M12 (CT) and M10 (VT) screws used for fastening of primary conductor to the terminal. For primary reconnectable transformers the ratio can be reconnected by changing position of the links fixed by M8 screws without removing already fitted primary conductors.



—
03



—
04

| Screw | Max. torque [Nm] | Min. torque [Nm] |
|---|---|---|
| M5 | 3.5 | 2.8 |
| M6 | 4 | 3 |
| M8 | 20 | 16 |
| M10 | 20 | 16 |
| M12 | 70 | 56 |

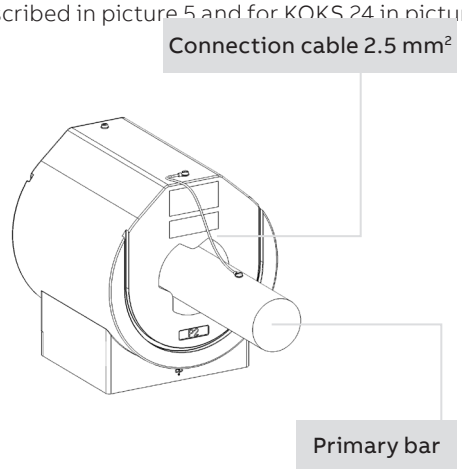
Tab. 1. Maximum allowed torques for screw connections of current transformers

Maximum allowed torque for screw connection of voltage transformer is 20 Nm.

Maximum allowed cantilever strength is:
Voltage transformers 2000 N.
Current transformers 5000 N.

Primary connectors of metal coated transformers (TJMC, TDMC) should be cleaned by pressured air to eliminate all undesired impurities created from unpacking and manipulation. An alcohol can be used in case of any additional pollution caused by manipulation after unpacking.

In case of Bus CT, there must be always connected CT shielding to the primary bar. Connection must be done on one side of the CT.
Shielding connection example of KOKS 12, 17.5 described in picture 5 and for KOKS 24 in picture 6.



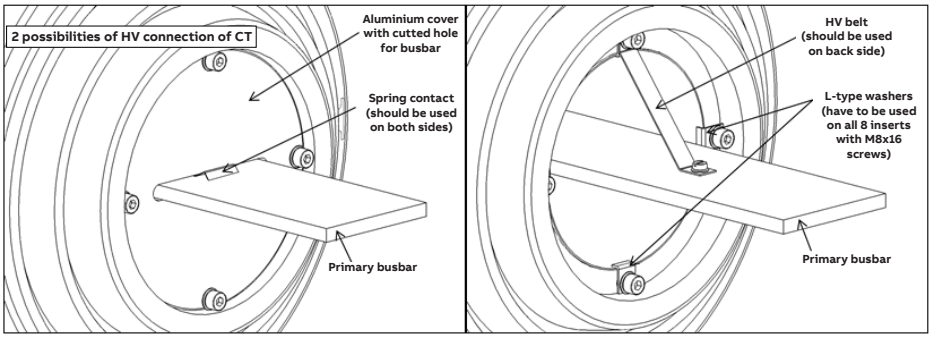

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05

06 KOKS 24 shielding connection

07 Example of current transformer terminal box

08 Example of voltage transformer terminal box

09 Cross section of double line secondary terminal box




06

## Secondary connections

The terminals, screws, nuts and washers are made of stainless steel. Secondary grounding screws and secondary terminal fastening screws are made of nickel-plated brass.

The secondary terminal cover box used for most types is made from the plastic and provided with three detachable threaded inserts. (Instruction how to provide removing of cable grommet on a secondary terminal cover – please see appendix 5). The terminals are provided with M5 screws for secondary wiring connection and with through going holes for direct earthing of the secondary circuit by M5 screws. The terminal cover is sealable.

## Degrees of IP protection

Indoor transformers: IP40 or IP30 for transformers TTR, BB, KOKS

| | Max. Tightening torque (Nm) | Min. Tightening torque (Nm) |
|---|---|---|
| M5 | 3.5 | 2.8 |
| M6 | 4 | 3 |

Tab. 2. The maximum permissible tightening torques for secondary screw connections

Max. diameter of the cable or wire connected to one terminal of the secondary is: 2x Ø 2.5 mm.

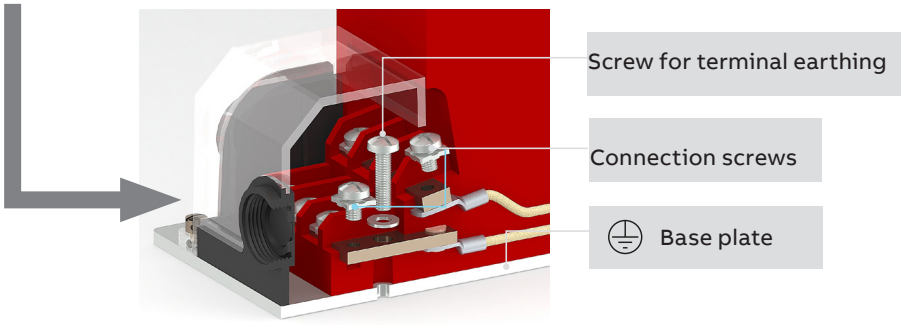
For terminal marking see Appendix 1.




07




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09

—
10 Delivered VT with fixation

—
11 Fixation removing

**Capacitive voltage indicator (divider)**
The transformer can be supplied with the capacitive voltage indicator on the request. Integrated voltage detection system is corresponding to Separable Voltage Detection System according to IEC 61234-5. It is integrated coupling electrode connected to secondary terminal (terminal Ck). **Electrode acts as a capacitor between electrode and primary winding (C1), or electrode and ground (C2).** If the electrode is connected to an indication device (not part of delivery – it is part of switchgear) it works as indication of voltage presence – more in IEC 61234-5.

| Ub (kV) | C1 (pF) > | C2 (pF) > |
|---|---|---|
| 3 – 5.4 | 30 | 20 |
| 5.5 – 7.2 | 25 | 20 |
| 10 – 13.5 | 20 | 20 |
| 13.8 – 17.5 | 15 | 20 |
| 20 – 40 | 10 | 20 |

**Tab. 3. CE capacity according to nominal voltage**

**Note: Recommended min. capacities for nominal voltage.**

**Fuses**
The fuse can be a part of a supply of voltage transformers with a fuse. We can supply following fuses:

| Rated current (A) | Rated voltage (kV) | Length (mm) | Striker pin |
|---|---|---|---|
| 0.5 – 6.3 | 12/17.5 | 192 | YES*/NO |
| 0.5 – 6.3 | 24 | 292 | YES*/NO |
| 2 or 4 | 36 | 440 | NO |
| 0.3 or 0.6 | 12/24 | 255 | NO |

(*) Available only for certain types

Tab. 4. List of offered fuses

**Warning: The majority of VT types TJP/TJPH have a fuse contact equipped with a fixation for transportation. If this fixation is present, it must be removed before VT's installation. See pictures Fig. 9. and Fig. 10**

For safety fuse replacement see Instructions for installation, use and maintenance for voltage (potential) transformers fuse replacement (1VLM000614).



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11

**External fuse holder**
No special tools are needed for the installation of the external fuse holder and It can be installed in any direction. All the necessary mounting accessories are a part of delivery and shall be used for fixing the fuse holder on the top of the VT. Maximum allowed torque for screw connection is 20 Nm.

## 4. Instructions for use

Current and voltage instrument transformers are used:
- to convert large currents or voltage in the primary circuit to an appropriate level for secondary circuit equipment (relays and meters);
- to insulate primary and secondary circuit from each other to protect the secondary equipment from the harmful effects of large current or voltage appearing during the operation (short circuits).

The use of current or voltage transformer for other purpose than described above is forbidden if not agreed with the producer.

**Routine test report**
Together with instrument transformer are delivered:
- routine test report;
- two rating plates (one plastered on the transformer and one free).

The following information can be included on the request. These are free of charge:
- theoretical current/voltage errors and phase displacement values;
- theoretical excitation curves.

There are additional extra paid reports which can be supplied on request:
- accuracy test report;
- magnetizing curve (for current transformers);
- additional labels (if more than 2);
- verification tests.

## 5. Instructions for maintenance

Visible surface pollution shall be cleaned off the transformer. Polluted transformer can be cleaned by alcohol. In case of surface contamination please contact the manufacturer.

## 6. Transport and storage

Temperature for transport and storage the indoor transformers is from -25°C to +70°C. During transportation and storage the transformers must be protected from direct sunlight.
The transformers are shipped in wooden boxes or mounted on the pallets. Other temperature must be agreed by the manufacturer.

## 7. Disposal

Materials used in instrument transformers are considered as materials without dangerous environmental impact and materials are not toxic. Disposal of instrument transformers is controlled by national legislation of communal waste.

## 8. Handling with the transformers

Handling with the transformer is described in the Appendix 4.

## 9. Normative references

| | |
|---|---|
| IEC 61869-1 | Instrument transformers – general requirement |
| IEC 61869-2 | Instrument transformers – additional requirements for current transformers |
| IEC 61869-3 | Instrument transformers – additional requirements for voltage transformers |
| IEC 61243-5 | Voltage detectors – Voltage detecting systems (VDS) |
| IEC 60529 | Degrees of protection provided by enclosures (IP Code) |
| ISO 12100 | Safety of machinery — Basic concepts, general principles for design |
| EN 50110-1 | Operation of electrical installa tions |

Current and Voltage transformers are designed, tested and produced according to international or national standards required by customers and agreed by producer. Specific standard is always mentioned on the Rating plate of transformer.

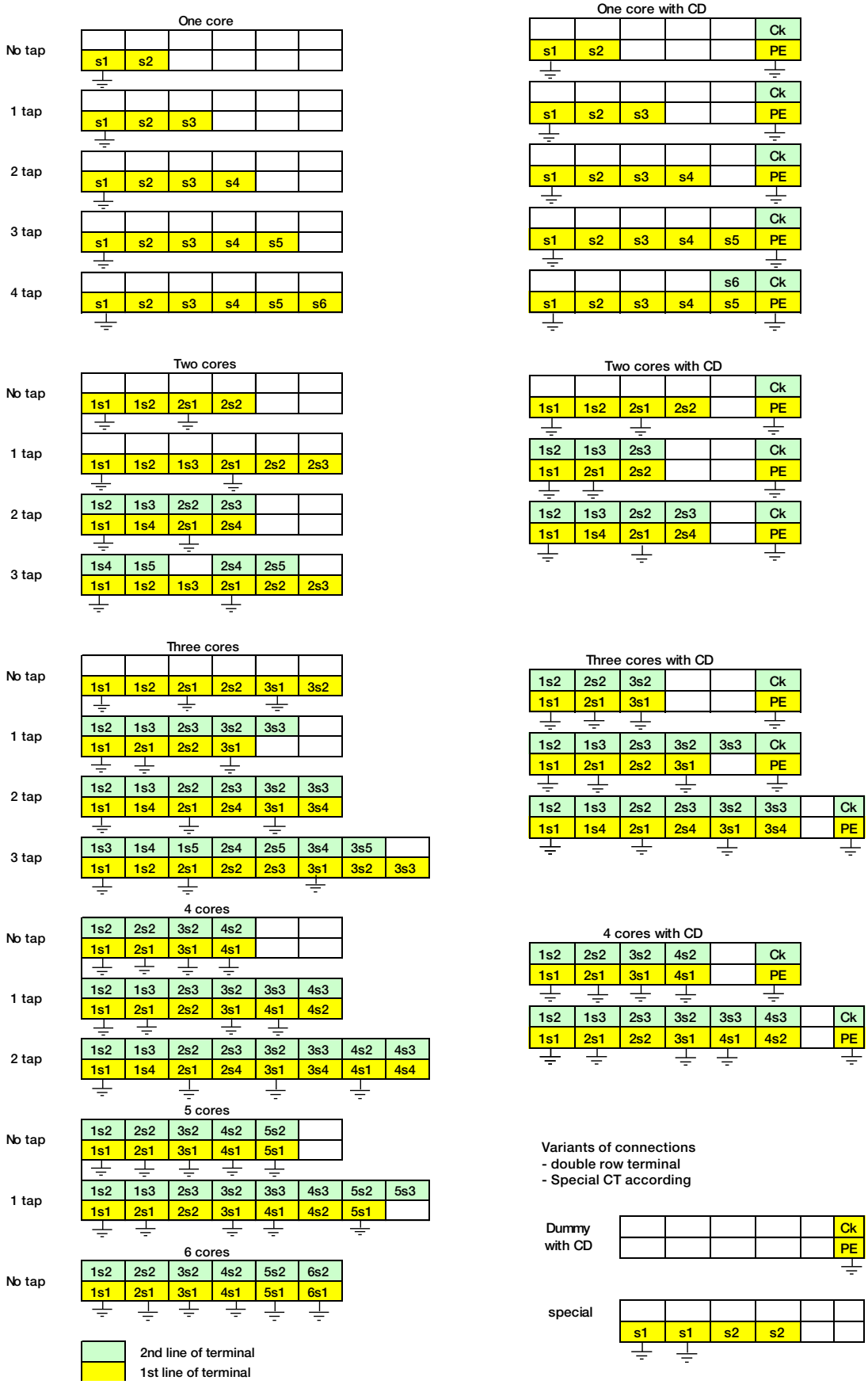
For example these standards:
IEC 60044-1; IEC 60044-2; IEC 60044-6; IEC 61869-1, IEC 61869-2; IEC 61869-3
AS 60044-1; AS 60044-2
AS 1243-1982; AS 1675-1986
ČSN 351301; ČSN 351302; ČSN 351361
ČSN EN 61896-1; ČSN EN 61896-2; ČSN EN 61896-6
IEEE Std C57.13.6
CSA Std CAN3-C13-M83
GOST 1516.3-96; GOST 7746-2001
BS 3939:1973; BS EN 61869-2

If it is agreed between customer and producer it is possible to deliver also other standard or standards which are mentioned above with different revision.

# Appendix 1
# Examples of secondary terminal marking for cast terminal box

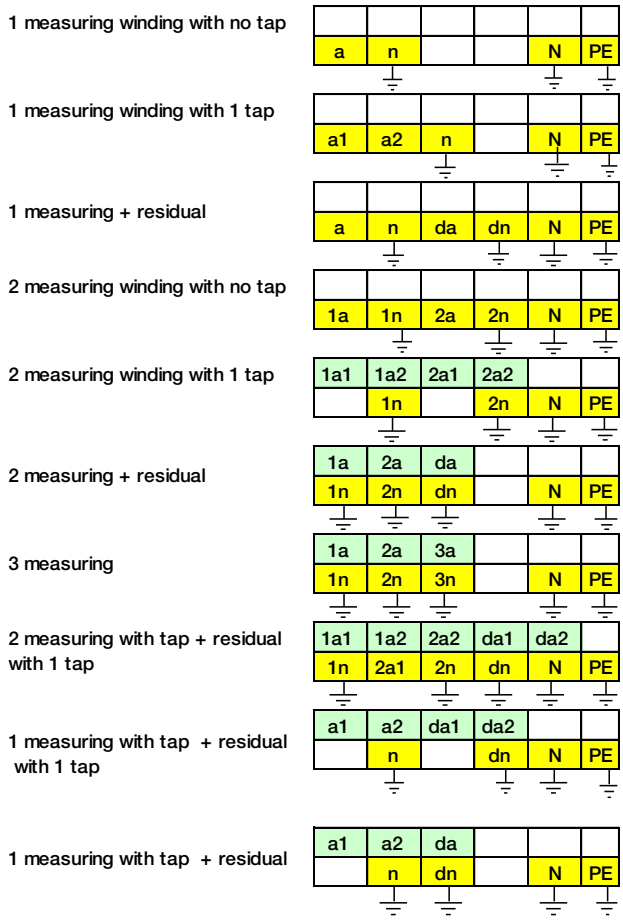
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## Current transformers according to IEC

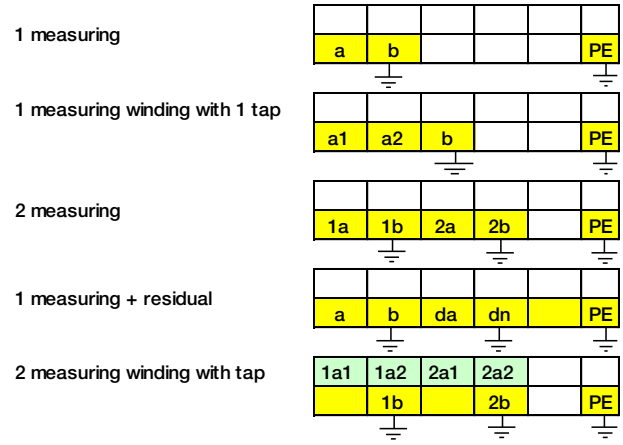


# Voltage transformers according to IEC

Variants of connections of double row terminal - One pole VT according to IEC

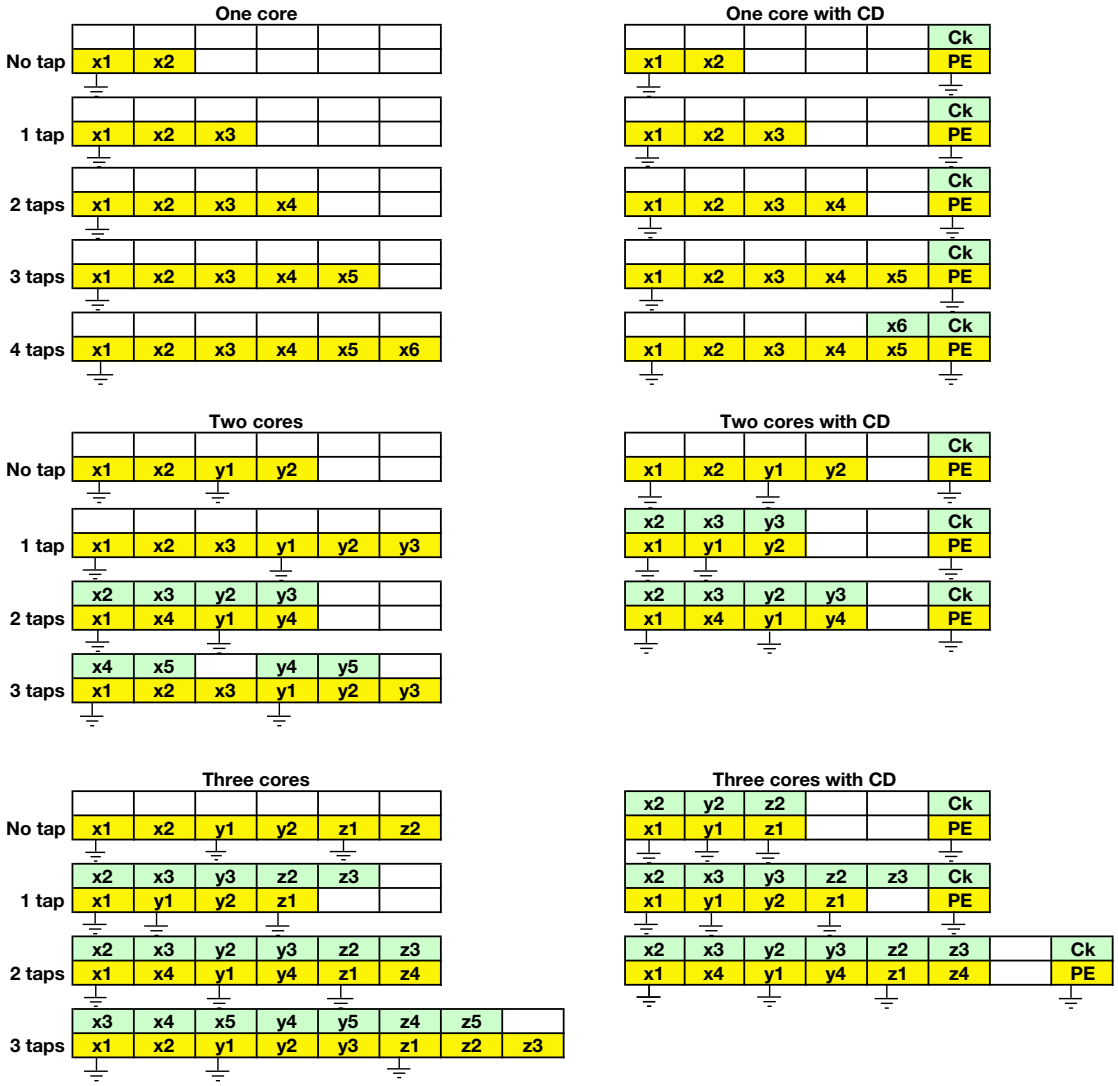



Variants of connections of double row terminal - Double pole VT according to IEC



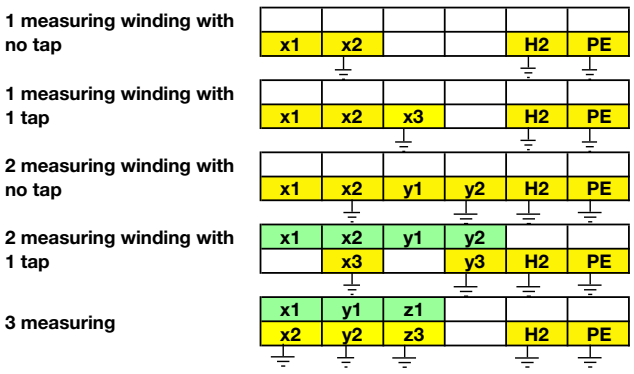

**Residual voltage windings connected to open delta must have dn terminal earthed only on one of three transformers (earthing screws at dn terminals of others two transformers have to be removed).**

# Current transformers according to IEEE

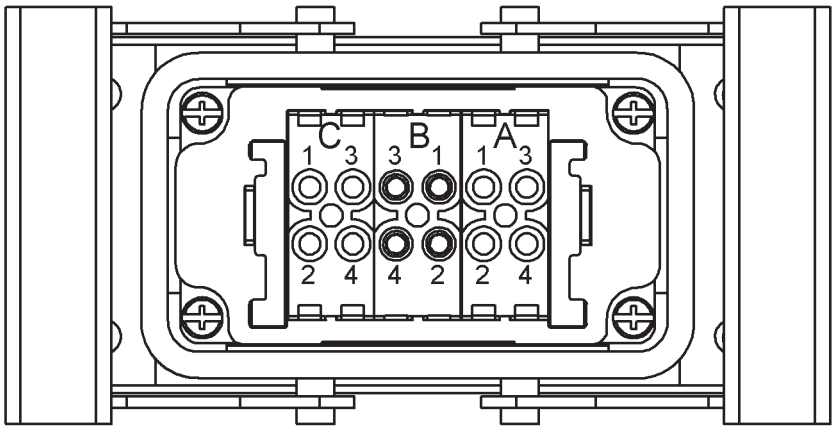


## Voltage transformers according to IEEE

**Variants of connections of double row terminal**




## Voltage transformers according to IEC TJMC 7.2 W and TJMC 7.0 W plug in connection

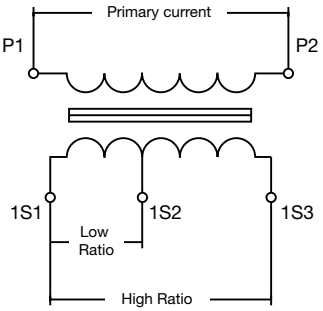


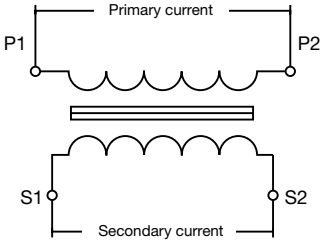

| Connection | Female connector | | | | Male connector | | | | Female connector | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A1 | A2 | A3 | A4 | B1 | B2 | B3 | B4 | C1 | C2 | C3 | C4 |
| 1 winding (star) | a | | | n | B4 | | | B1 | | | | |
| 2 windings (star / open delta) | a | | | n | B4 | | | B1 | da | | | dn |
| 2 windings (star / star) | 1a | 2a | | 1n | B4 | | | B1 | | | 2n | |
| 3 windings (2x star / open delta) | 1a | 2a | | 1n | B4 | | | B1 | da | | 2n | dn |
| 3 windings (3x star) | 1a | 2a | | 1n | B4 | | | B1 | 3a | | 2n | 3n |
| 1 winding with tap (star) | a1 | a2 | | n | B4 | | | B1 | | | | |
| 2 windings with tap (star / open delta) | a1 | a2 | | n | B4 | | | B1 | da1 | | da2 | dn |
| 2 windings with tap (2x star) | 1a1 | 2a1 | | 1n | B4 | | | B1 | 1a2 | | 2n | 2a2 |

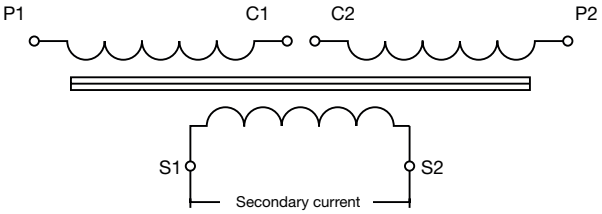
B1-B4 connection bridge inside connector

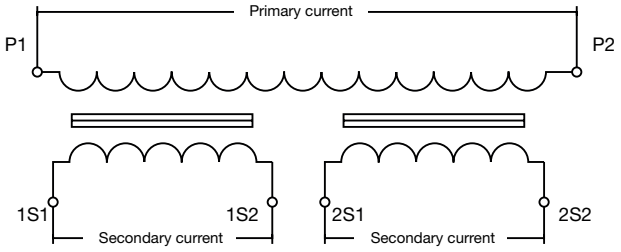
# Appendix 2
# Wiring diagram examples

**Current transformers:**

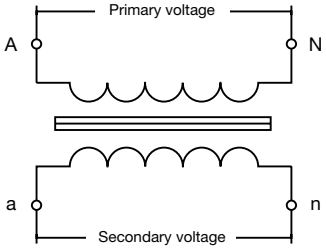


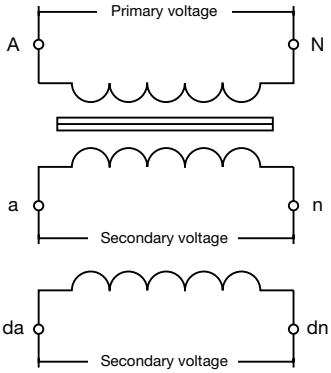



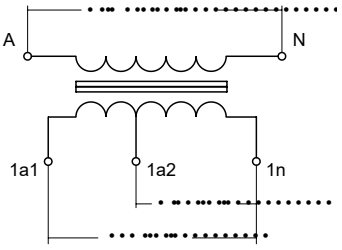



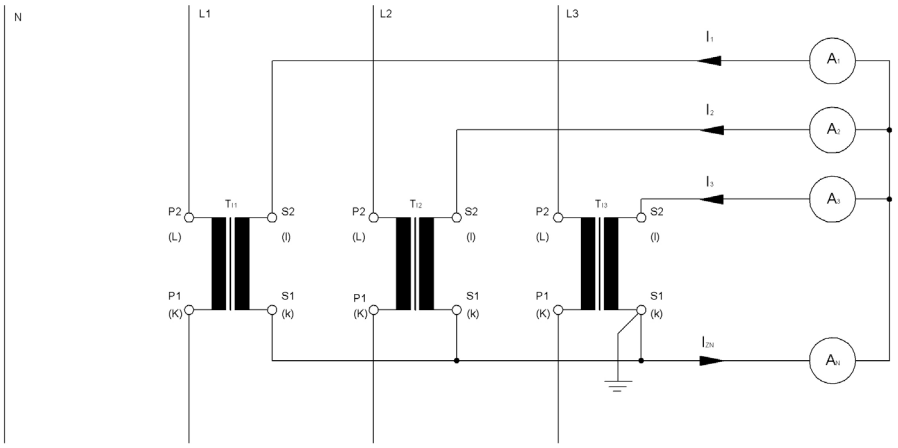

**Voltage transformers:**

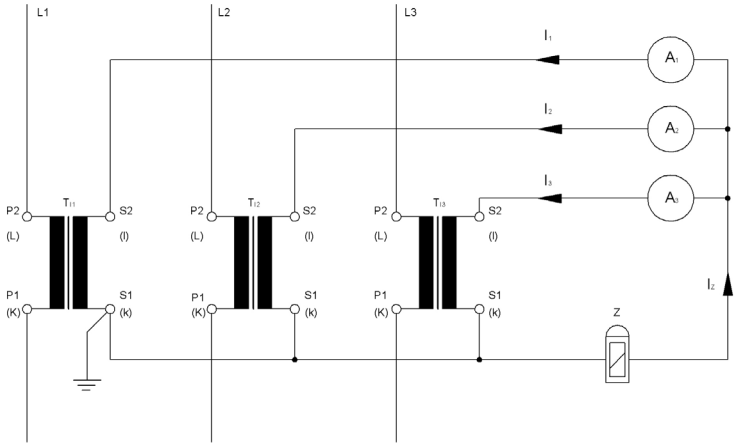


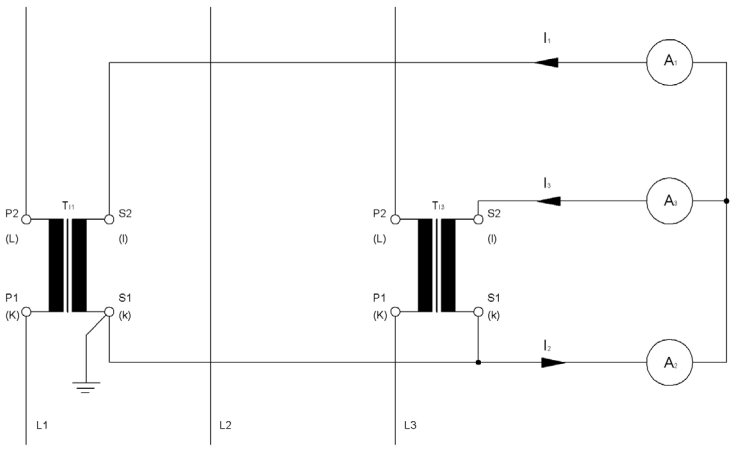



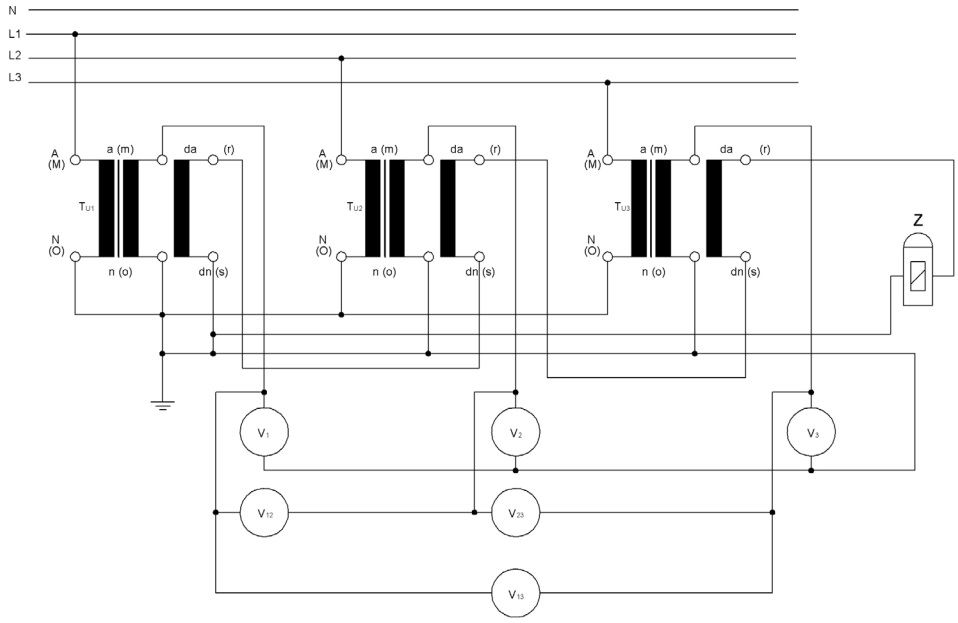
## Examples of current transformers connection

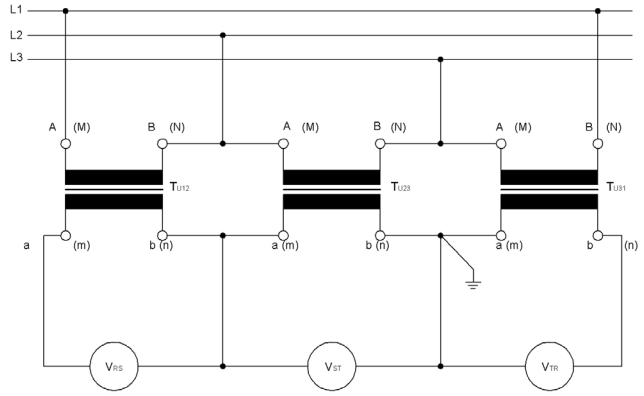


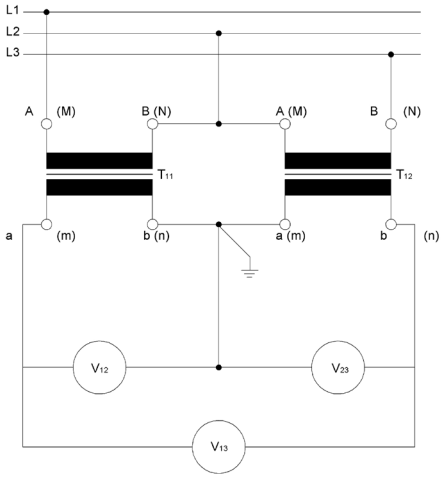



## Examples of voltage transformers connection



# Appendix 3
# Ferroresonance damping for single-pole voltage transformers

**Technical background**

Ferroresonance is a phenomenon usually characterized by over-voltages and very irregular wave shapes and is associated with the excitation of one or more saturable inductors through capacitance in parallel with nonlinear inductor. The saturable inductor is usually present in the form of an instrument transformer, power transformer or reactor which utilizes an iron core.

Ferroresonance of single-pole insulated transformers in unearthed network is one of the most common ferroresonance cases. Depending on the supply voltage, capacitance and inductance the oscillation can be either periodic (over- or sub-harmonic or with fundamental frequency) or aperiodic. Using damping resistor or VT Guard Pro / VT Guard Pro-D in the residual voltage secondary, shown in figure below, can considerably reduce the risk for ferroresonance.

VT Guard Pro is an advanced security device which protects MV inductive voltage transformers (VTs) against ferroresonance oscillations. It is designed to be used in the open-delta connection of three single-phase VTs. There exist two versions of VT Guard Pro:

a) VT Guard Pro
b) VT Guard Pro-D

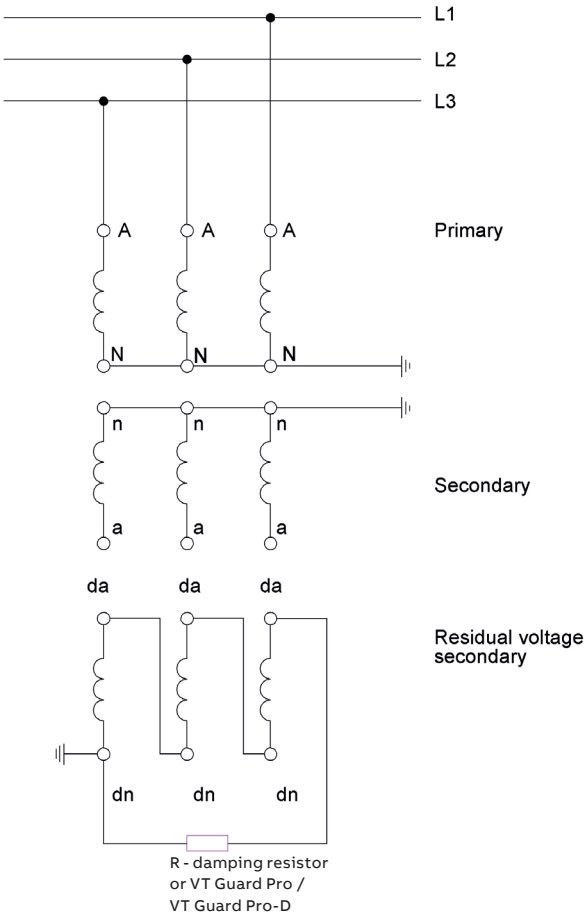
Both versions are identical from functionality point of view (dumping ability), but the VT Guard Pro–D has extended functions which allows self-diagnostic. This diagnostic feature allows the device to check itself (functionality of its circuits) and is able to send information about its state into a superior system. In case of use of the VT Guard Pro / Pro-D for protection of the VTs against ferroresonance please follow the latest Instructions for installation, use and maintenance for the VT Guard Pro / VT Guard Pro-D (document 1VLM000657).

There is an additional factor that can in some cases reduce or totally eliminate the risk for ferroresonance and it is over-voltage factor. According to IEC standard is the rated over-voltage factor 1.9xUn/ 8h. Higher rated over-voltage factor shifts the operating point towards lower flux values of voltage transformer. It results in smaller sensitivity of transformer. Some kind of transients usually initiates ferroresonance.

**Recommendation**
Rated voltage factor: We recommend using the voltage transformers with the over-voltage factor in the range (2.5-3) xUn/8h. We cannot guarantee the value of the over-voltage factor if the requirements for the secondary winding are too high.

| Voltage of residual winding | Value of Rdamp | Power Dissipation |
|---|---|---|
| 100:3 V | 22 Ω | 450 W |
| 110:3 V | 27 Ω | 450 W |

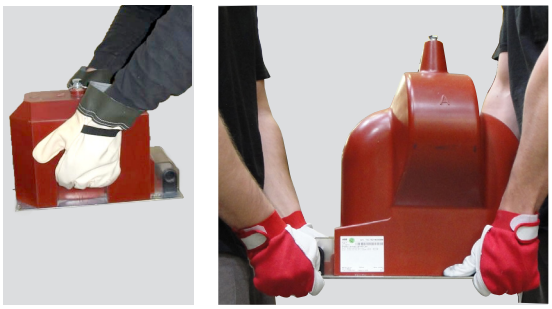
Tab. 5. Recommended values of damping resistor



# Appendix 4
# Handling with transformers

There are few possibilities of handling:

**1) Manual handling**
Transformers can be handled by hands in case the weight of the transformer is not higher than 25 kg.
Always use glows during the manual handling. For grasp of the transformers always use handling grip (see the picture), or the base of the transformer.

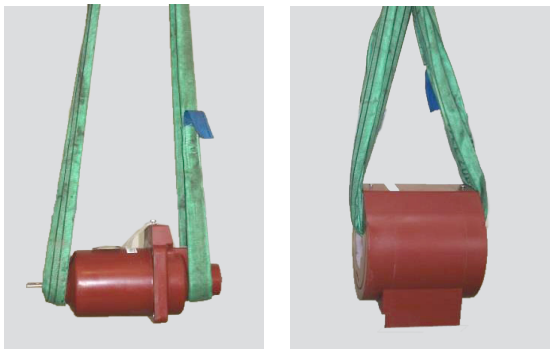


11 Manual handling

**Note. This system is recommended for metal coated instrument transformers TJMC, TJMP or TDMC. Types TJP, TDP, never handle by gripping the fuse holder – risk of break.**

Transformers heavier than 25 kg can be handled by hands in case the transformer is equipped with baseplate. In this case the transformer must be carried by at least two persons using the baseplate. It is necessary to follow all safety instructions during the manipulation.

**2) Handling by belts**
For safety reasons transformers can be handled by hanging on belts when it is possible. Then the handling can be done by hanging of the transformer on the crane.



12 Transformer hanging on belts

**Note. This system is recommended for types: TTR, TSR, BB(O), KOKS. Hanging systems for those types are visualized on pictures.**

**Safety warning! Lifting capacity of the belts and the crane has to be at least 200 kg. Always make sure that the belts hold safely on the crane and on the transformer.**

—
13 Self locking hooks attached on the handling grips
—
14 Self-locking hooks attached under primary screws

**3) Handling by the self-locking hooks**
It is possible to handle transformers by self-locking hooks hanging on the crane, if the transformer is equipped with handling grips. When the transformer has no handling grips, is it possible to grip the hooks under the base of the transformer.

**Note. This system is recommended for types: TPU, TPE, TJC, TJCL, TJCH, TJP, TJPH, TDP, TDC, KGUG, KGUGI. This handling system is visualized on the pictures.**

**Safety warning! Lifting capacity of the hooks and the crane has to be 200 kg at least. Always make sure that the hooks hold safely on the crane and on the transformer.**



—
13

**4) Handling by the self-locking hooks under primary screws**
In case of indoor current transformers, which are equipped with primary terminal screws M12, it is possible to hang the transformer on self-locking hooks holding under the primary screws. The handling can be done by hanging of the hooks on the crane.

**Note. This system is recommended for types: TPU, TPE, IHBF, KOFA. This handling system is visualized on the picture.**

**Safety warning! Lifting capacity of the hooks and the crane has to be 200 kg at least. Always make sure that the hooks hold safely on the crane and on the transformer.**



—
14

**SAFETY WARNING: During the manipulation with transformer it is necessary to follow safety work instructions. Never stand under the freight. Always make sure that the freight is safely locked on the crane and make sure that there is no risk of unexpected release or turnover of the freight.**

**Note. Holding jigs, described in these chapters, are not a part of delivery.**

# Appendix 5
# Removing of cable grommet on a secondary terminal cover

**1) Step drill procedure**
In case of use of a step drill, it is necessary to dismount a secondary terminal cover to prevent a damage of a transformer body. Maximal drill bit size is 20 mm.





A drilled plastic part shall be fully fixed to avoid any injuries. The pictures are for illustration purpose only.
It is recommended to clear the edges of all new holes immediately after drilling these holes. For these purposes, a rasper or a knife can be used. Cleaned secondary terminal cover can be mounted back to a body of transformer.

**2) Screwdriver procedure**
It is recommended to use a screwdriver to puncture a hole in a secondary terminal cover.
A screwdriver shall be placed to a weakened place close to a pre-perforated ring. Two dimensions of hole can be punctured.



1/ an inner diameter



2/ an outer diameter

If necessary, a plastic mallet can be used. The plastic mallet shall be used with ease.
It is recommended to clear the edges of all new holes immediately after puncturing these holes. For these purposes, a rasper or a knife can be used.

**Note: Whole procedure must be realized with all caution, to avoid damage of a secondary terminal.**

# Appendix 6
# Repair kit for metal coated voltage transformers

**The repair kit contains material for 10 individual repairs. It is intended for ABB products only.**

**The repair kit includes:**
Paint roller brush
10 pieces of roller covers wide 5 cm
Brush
Thinner S6300
Zinc spray ZINCOSIL 400 ml
Hempadur 15570 light grey coating
Hardener 95570
Fine filling putty for sealing 200 g POLYKAR Super Plus
Sandpaper 230x280 mm, grit 150



Repairing according to next steps:

1) Clean the damaged area with sandpaper, the surface must be as smooth as possible.

2) Mix both components of the filling putty in the ratio given by the manufacturer on the packaging.

3) Apply the prepared sealant to the damaged area and let it harden for 25-30 minutes.

4) Remove excess sealant with sandpaper. The surface must be smooth after sanding, without any noticeable transition.

5) Shake the zinc spray thoroughly, then apply it to the damaged area.

6) Always apply the spray from a distance of approx. 25 cm to achieve an even layer.

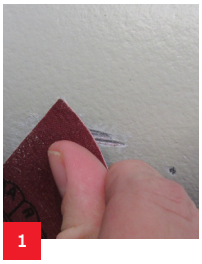
7) Prepare a mixture of Hempadur and hardener in the ratio:
- Hempadur 15570 - 3 parts
- Hardener 95570 - 1 part

8) Mix both components thoroughly and then apply with a roller to the damaged area. Apply the mixture around the damaged area until proper color transition is achieved.

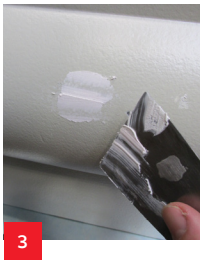
9) Apply the first layer of coating, allow to dry and then apply the second layer of coating. Apply the layers until the repaired area has the same shade as the undamaged surface of the transformer.

10) Clean all used tools with S6300 thinner.

**Note:**
**This kit can be used to repair minor surface damages at your own risk and responsibility.**
**In case of major damage, contact the supplier.**


1


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# Appendix 7
# Assemble the PT Sheet

**Clean VT cones with the duster (ideally with Staubfix super, 80x50cm which does not leave its parts on the surface of the cones) and grease them (1) with insulating vaseline/paste (3, 4, 5). The surface must be clean. Use a brush (2) to apply the insulating vaseline/paste.**




1



2




3

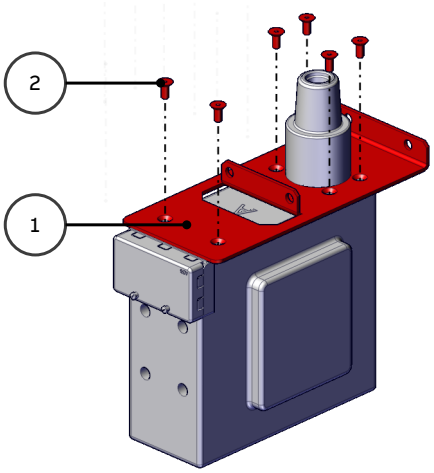



4




5

**The example of mounting on a board for mounting in the switchboard panel.**

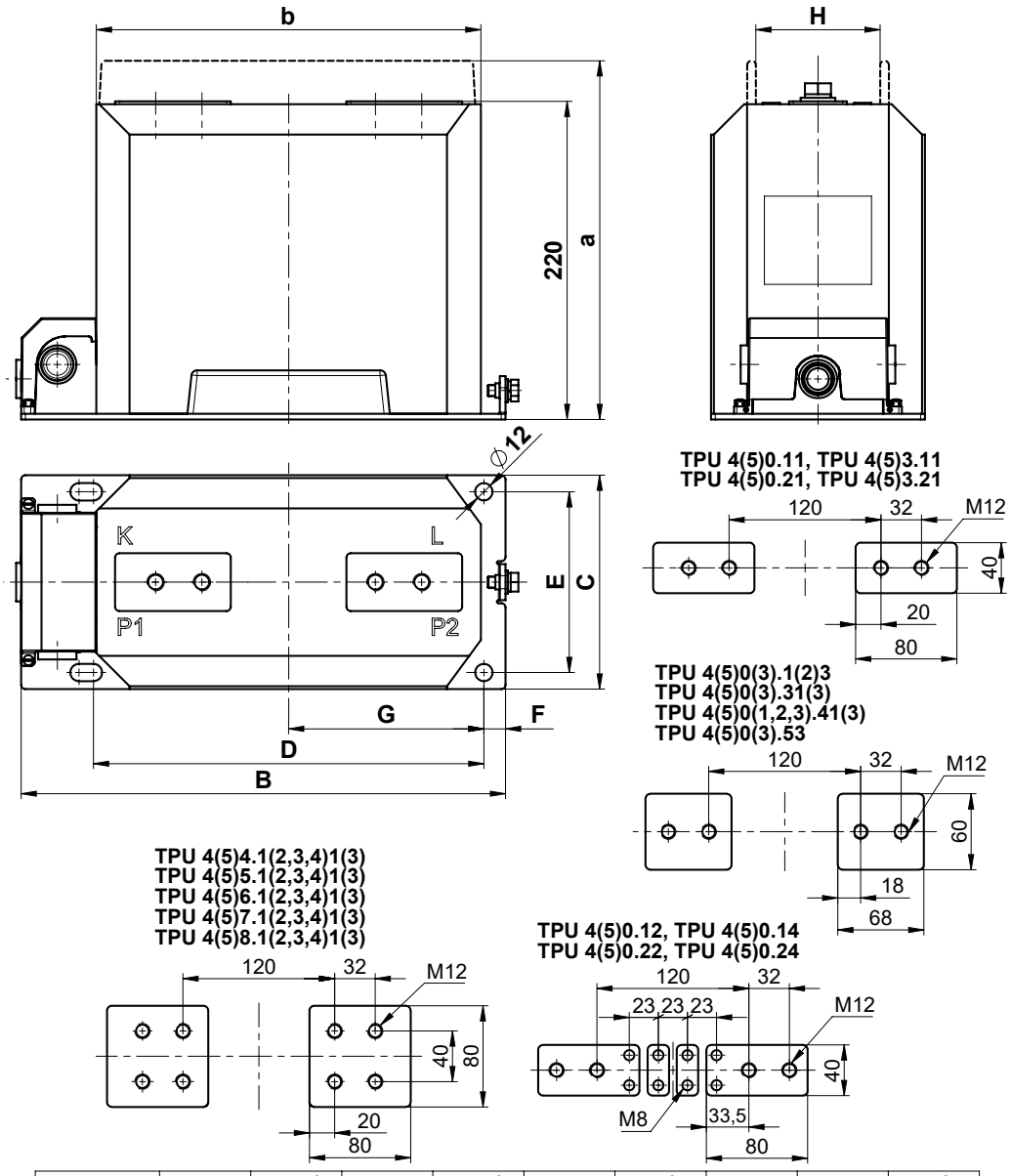



| Components from 2R... | | |
|---|---|---|
| **Name** | **Nr.** | **Amt.** |
| PT Sheet | 2RJA024422P0001 | **1** |
| SCR-CTSK_ISO10642_ M8X20-10.9 | 9ABA450064P4206 | 6 |

The screw tightening torque is defined 12 Nm.

## TPU 4x.xx and TPU 5x.xx

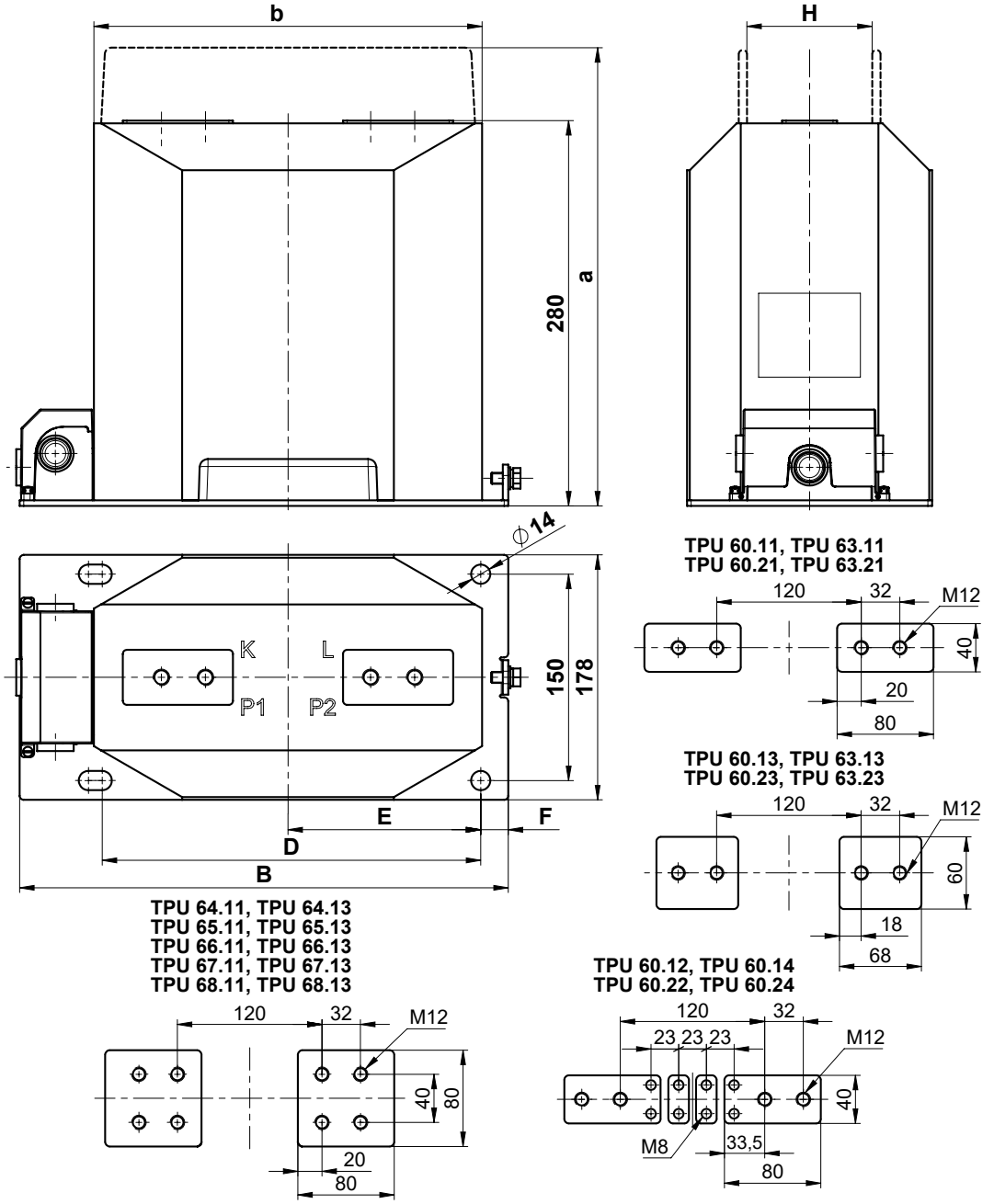
Dimensional Drawing




| | TPU 4(5)0(3).11<br>TPU 4(5)0.12<br>TPU 4(5)4(5,6,7,8).11 | TPU 4(5)0(3).13<br>TPU 4(5)0.14<br>TPU 4(5)4(5,6,7,8).13 | TPU 4(5)0(3).21<br>TPU 4(5)0.22<br>TPU 4(5)4(5,6,7,8).21 | TPU 4(5)0(3).23<br>TPU 4(5)0.24<br>TPU 4(5)4(5,6,7,8).23 | TPU 4(5)0(3).31<br>TPU 4(5)4(5,6,7,8).31 | TPU 4(5)0(3).33<br>TPU 4(5)4(5,6,7,8).33 | TPU 4(5)0.53 | TPU 4(5)0(1,3).41<br>TPU 4(5)4(5,6,7,8).41 | TPU 4(5)0(1,3).43<br>TPU 4(5)4(5,6,7,8).43 |
|---|---|---|---|---|---|---|---|---|---|
| a [mm] | - | 340 | - | 248 | - | 280 | 248 | - | 280 |
| B [mm] | 355 | 355 | 455 | 455 | 355 | 355 | 335 | 465 | 465 |
| b [mm] | 266 | 266 | 386 | 386 | 285 | 285 | 283 | 395 | 395 |
| C [mm] | 148 | 148 | 148 | 148 | 184 | 184 | 148 | 184 | 184 |
| D [mm] | 270 | 270 | 390 | 390 | 270 | 270 | 270 | 390 | 390 |
| E [mm] | 125 | 125 | 125 | 125 | 160 | 160 | 125 | 160 | 160 |
| F [mm] | 15 | 15 | 15 | 15 | 25 | 25 | 15 | 15 | 15 |
| G [mm] | 135 | 135 | 255 | 255 | 135 | 135 | 135 | 255 | 255 |
| H [mm] | - | 86 | - | 86 | - | 110 | 86 | - | 110 |

## TPU 6x.xx

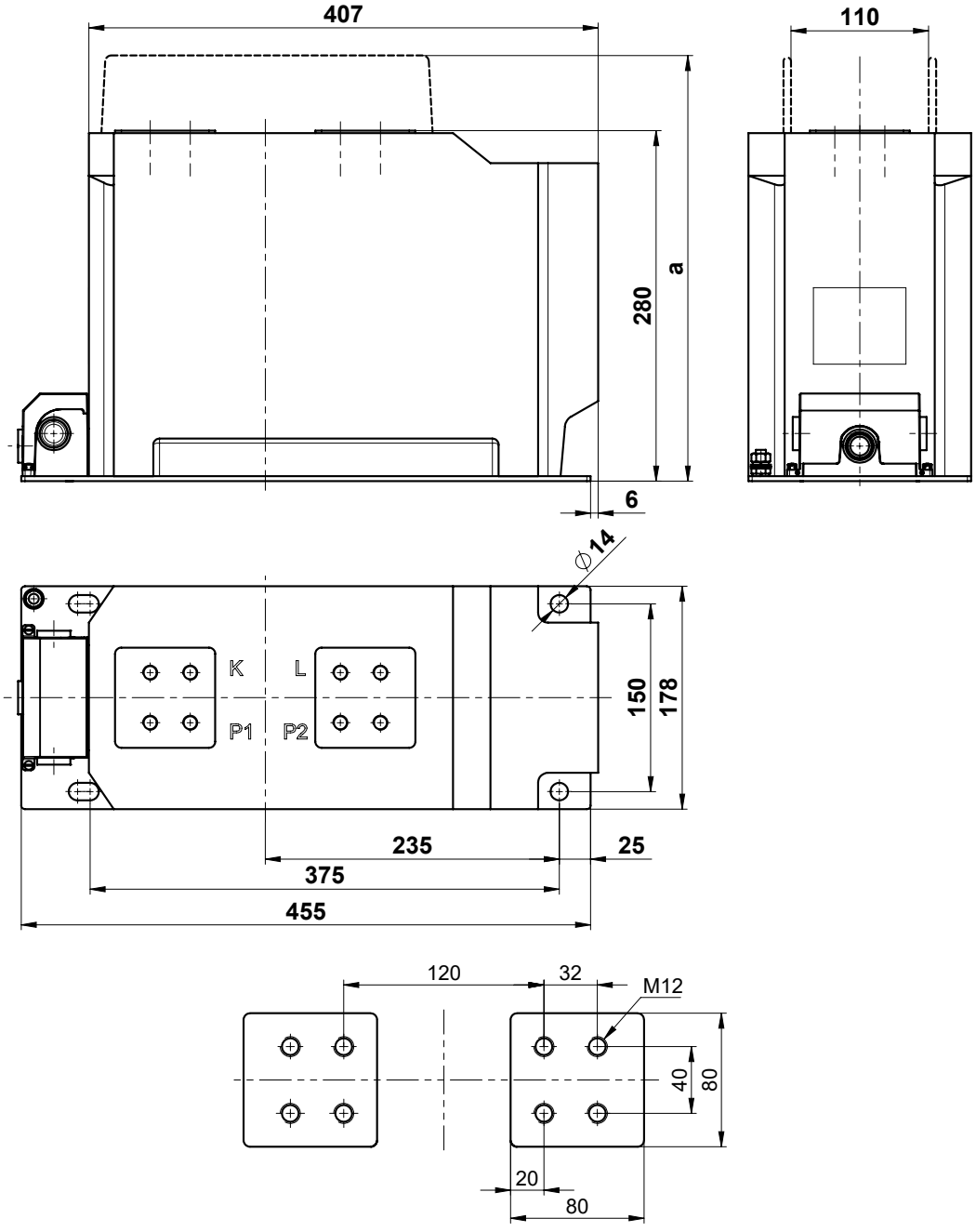
Dimensional Drawing




| | TPU 60(3).11, TPU 60.12<br>TPU 64(5,6,7,8).11 | TPU 60(3).13, TPU 60.14<br>TPU 64(5,6,7,8).13 | TPU 60(3).21<br>TPU 60.22 | TPU 60(3).23<br>TPU 60.24 |
|---|---|---|---|---|
| a [mm] | - | 340 | - | 340 |
| B [mm] | 355 | 355 | 455 | 455 |
| b [mm] | 282 | 282 | 382 | 382 |
| D [mm] | 275 | 275 | 375 | 375 |
| E [mm] | 140 | 140 | 235 | 235 |
| F [mm] | 20 | 20 | 25 | 25 |

## TPU 6x.xx

Dimensional Drawing

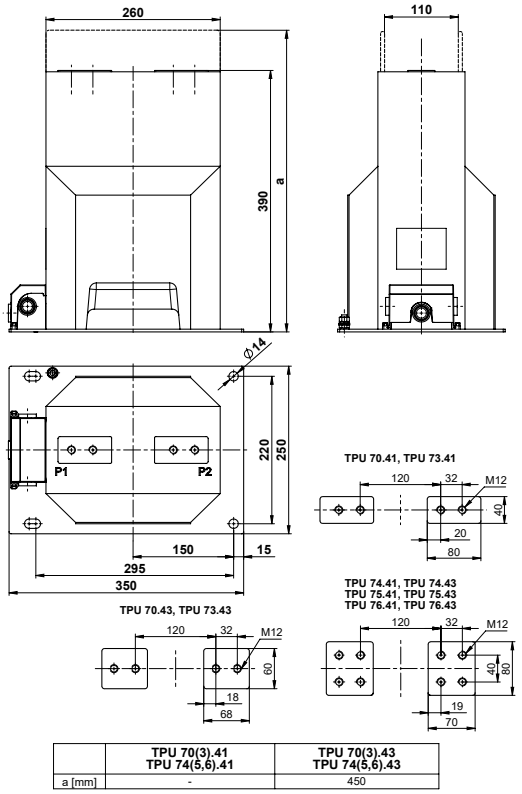



| | TPU 64-68.21 | TPU 64-68.23 |
|---|---|---|
| a [mm] | - | 340 |

# TPU 7x.xx

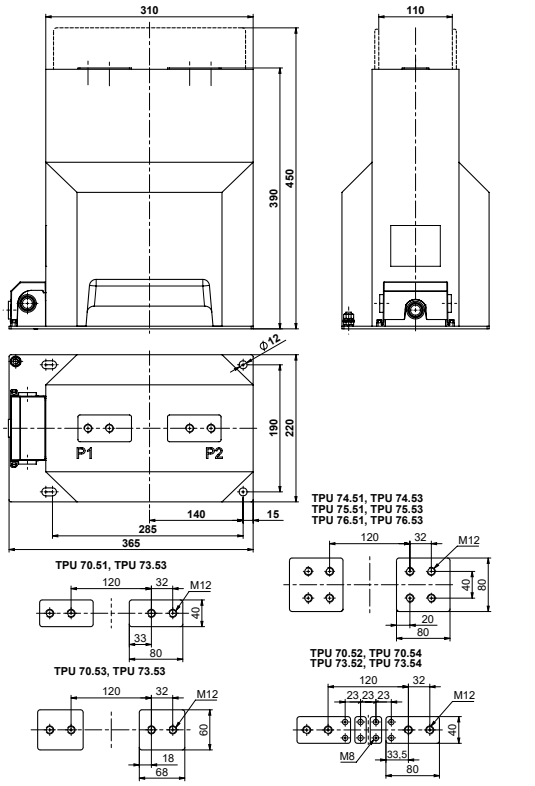
## Dimensional Drawing

### TPU 7x.4x

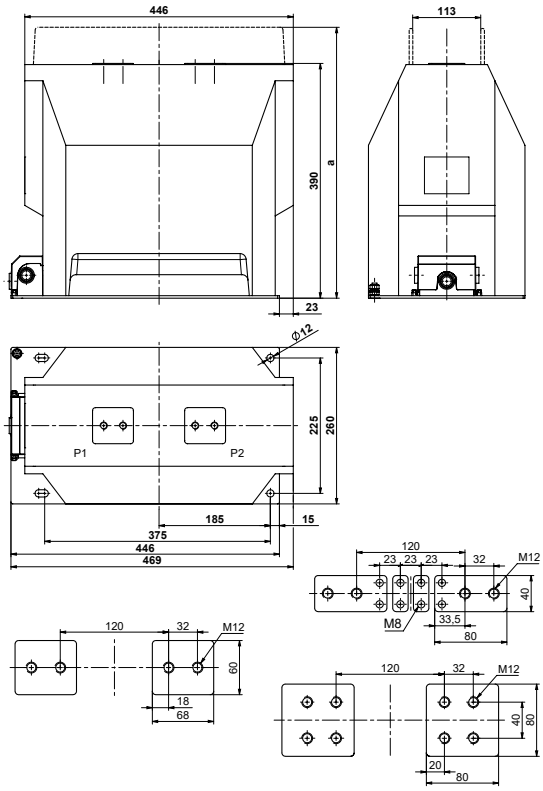



| | TPU 70(3).41<br>TPU 74(5,6).41 | TPU 70(3).43<br>TPU 74(5,6).43 |
|---|---|---|
| a [mm] | - | 450 |

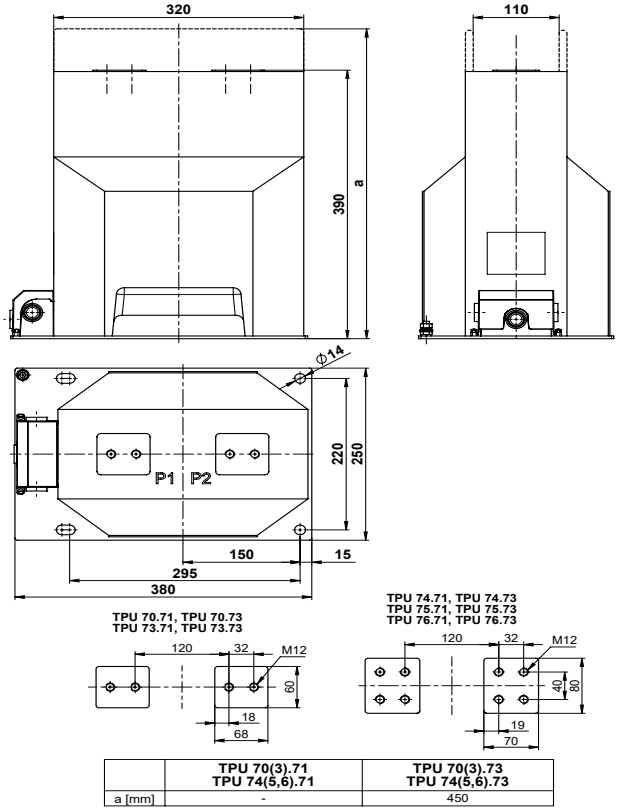
### TPU 7x.5x




### TPU 7x.6x

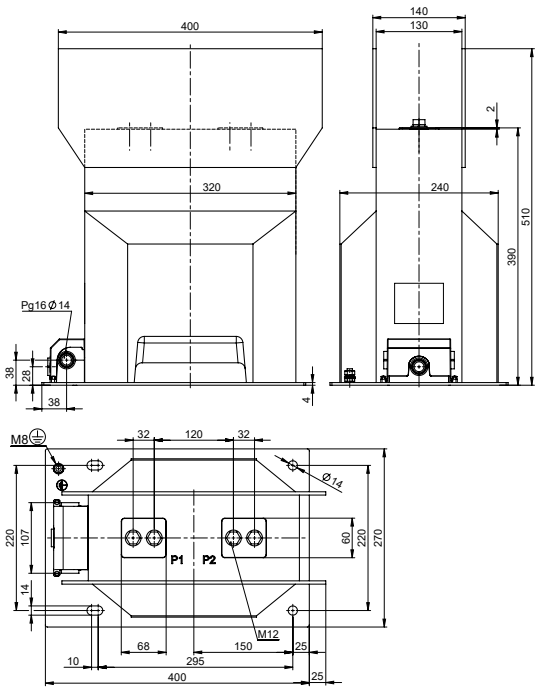



### TPU 7x.7x

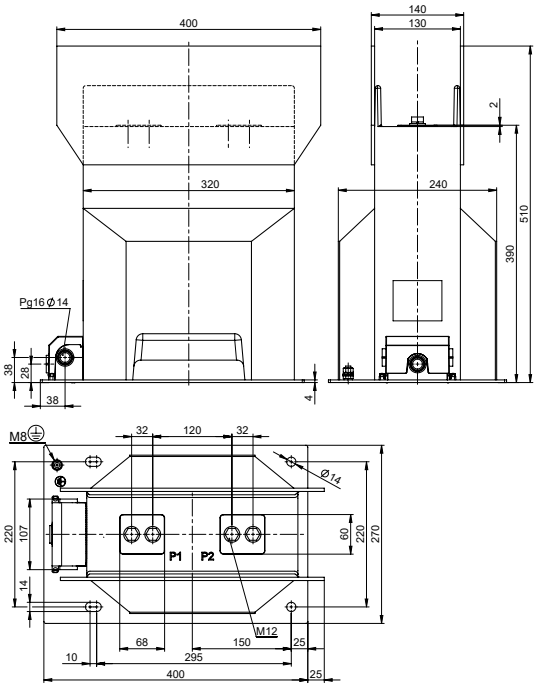



| | TPU 70(3).71<br>TPU 74(5,6).71 | TPU 70(3).73<br>TPU 74(5,6).73 |
|---|---|---|
| a [mm] | - | 450 |

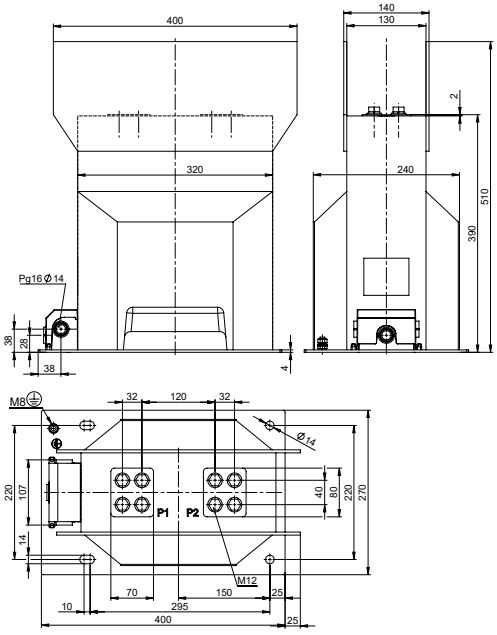
**TPU 70(3).71** Weight: 56 kg
Incresed ribs Creepage distance: 410 mm



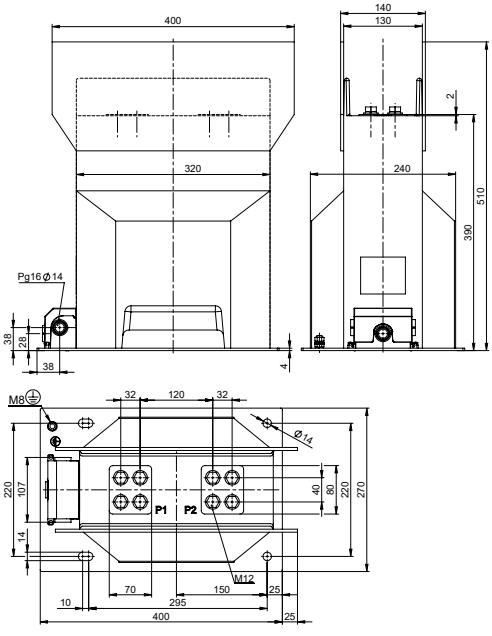

**TPU 70(3).73** Weight: 57 kg
Incresed ribs Creepage distance: 410 mm




**TPU 74(6).71** Weight: 58 kg
Incresed ribs Creepage distance: 410 mm

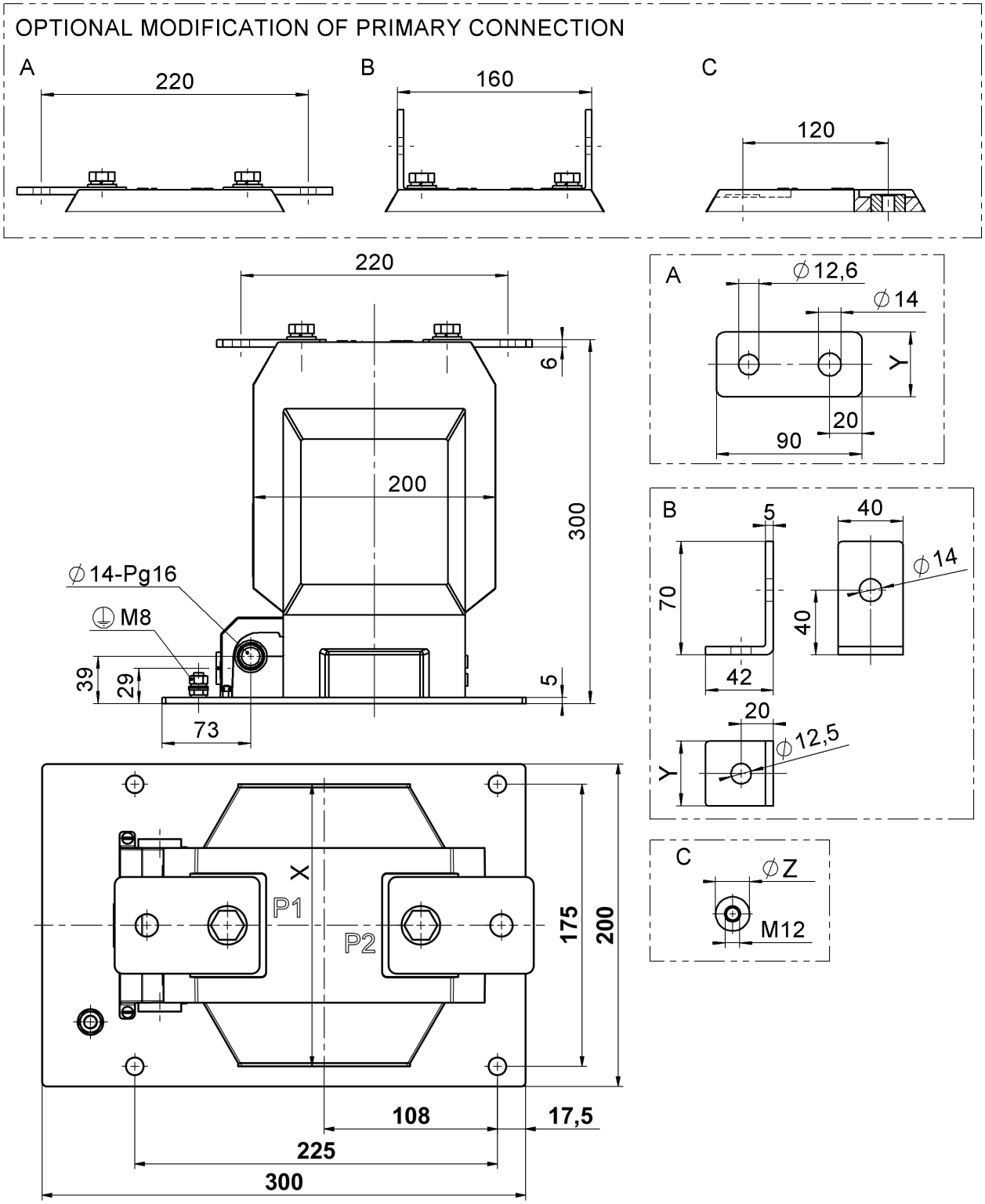



**TPU 74(6).73** Weight: 58 kg
Incresed ribs Creepage distance: 410 mm



## TPE

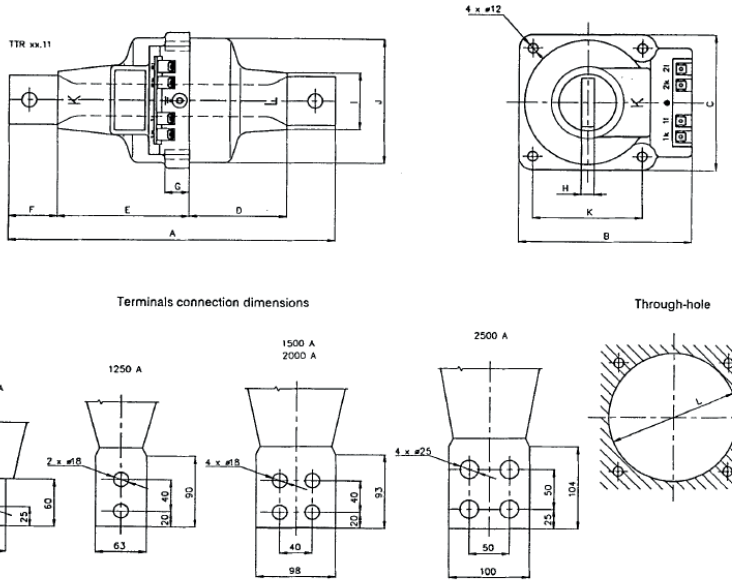
Dimensional Drawing




| | TPE 60.11 | TPE 60.31 | TPE 63.31 |
|---|---|---|---|
| X [mm] | 150 | 175 | 175 |
| Y [mm] | 40 | 40 | 60 |
| Z [mm] | 28 | 28 | 40 |

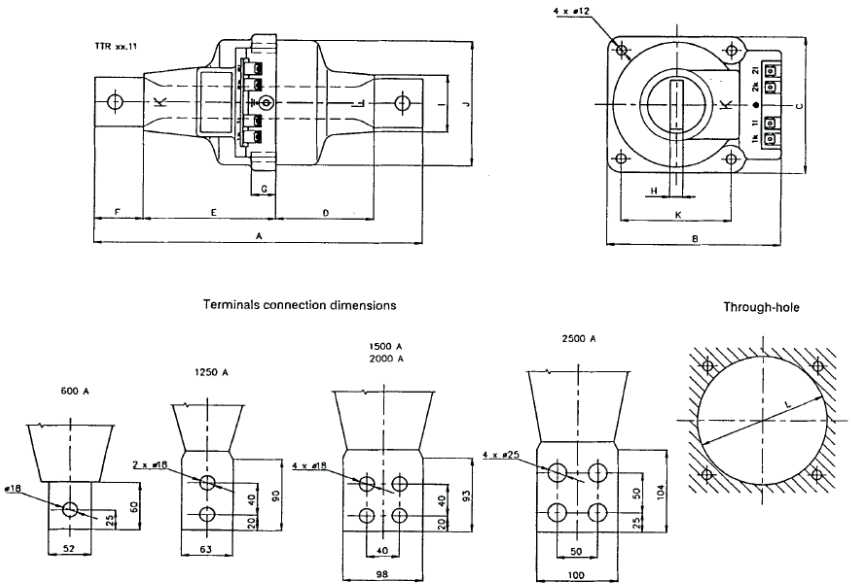
# TTR
## Dimensional Drawing

### TTR 4x.xx




| Insulation voltage [kV] | Type | Rated current [A] | Dimensions | | | | | | | | | | | | | Weight [kg] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F | G | H | H∞ | øI | øJ | K | øL | |
| 12 | TTR 41.11 | to 600 | 402 | 214 | 170 | 120 | 162 | 60 | 30 | 16 | 6 | 71 | 156 | 136 | 160 | 10.0 |
| | TTR 42.11 | to 300 | 500 | 214 | 170 | 220 | 162 | 60 | 30 | 16 | 6 | 71 | 156 | 136 | 160 | 17.0 |
| | TTR 43.11 | 750-1250 | 472 | 214 | 170 | 120 | 162 | 95 | 30 | 20 | 10 | 71 | 156 | 136 | 160 | 11.0 |
| | TTR 44.11 | 1500 | 482 | 252 | 208 | 120 | 162 | 100 | 30 | 16 | 20 | 110 | 192 | 174 | 196 | 15.0 |
| | TTR 45.11 | 2000 | 482 | 252 | 208 | 120 | 162 | 100 | 30 | 20 | 20 | 110 | 192 | 174 | 196 | 21.0 |
| | TTR 46.11 | 2500 | 502 | 252 | 208 | 120 | 162 | 110 | 30 | 20 | 20 | 110 | 192 | 174 | 196 | 24.0 |

### TTR 6x.xx

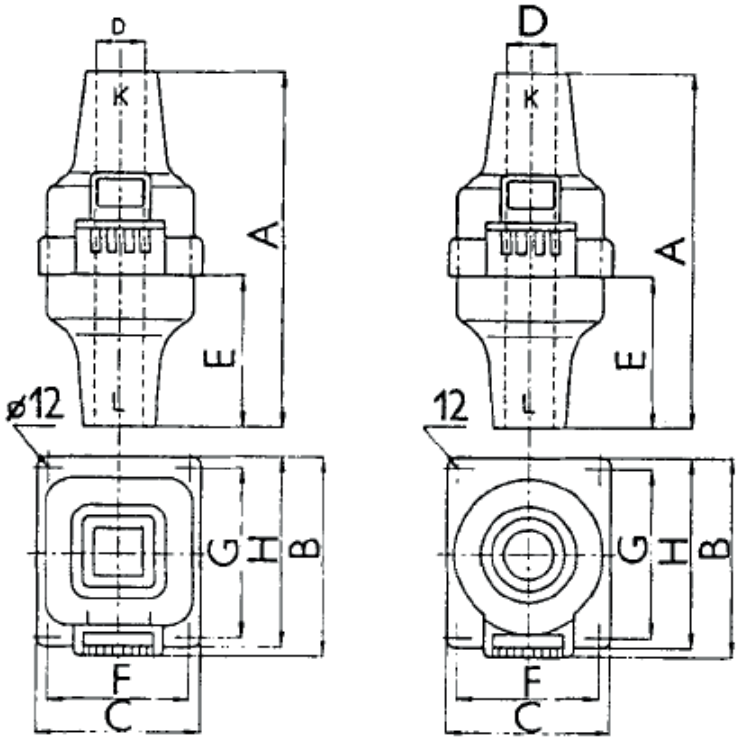



| Insulation voltage [kV] | Type | Rated current [A] | Dimensions | | | | | | | | | | | | | Weight [kg] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F | G | H | H∞ | øI | øJ | K | øL | |
| 25 | TTR 61.11 | to 600 | 620 | 224 | 180 | 238 | 262 | 60 | 30 | 16 | 6 | 71 | 166 | 146 | 170 | 14.0 |
| | TTR 62.11 | to 300 | 680 | 224 | 180 | 298 | 262 | 60 | 30 | 16 | 6 | 71 | 166 | 146 | 170 | 21.0 |
| | TTR 63.11 | 750-1250 | 690 | 224 | 180 | 238 | 262 | 95 | 30 | 20 | 10 | 71 | 166 | 146 | 170 | 15.0 |
| | TTR 64.11 | 1500 | 700 | 274 | 230 | 238 | 262 | 100 | 30 | 16 | 20 | 110 | 216 | 190 | 220 | 23.0 |
| | TTR 65.11 | 2000 | 700 | 274 | 230 | 238 | 262 | 100 | 30 | 20 | 20 | 110 | 216 | 190 | 220 | 32.0 |
| | TTR 66.11 | 2500 | 720 | 274 | 230 | 238 | 262 | 110 | 30 | 20 | 20 | 110 | 216 | 190 | 220 | 35.0 |

## BB

Dimensional Drawing

**BB 103**
**BB 104**
**BB 223**



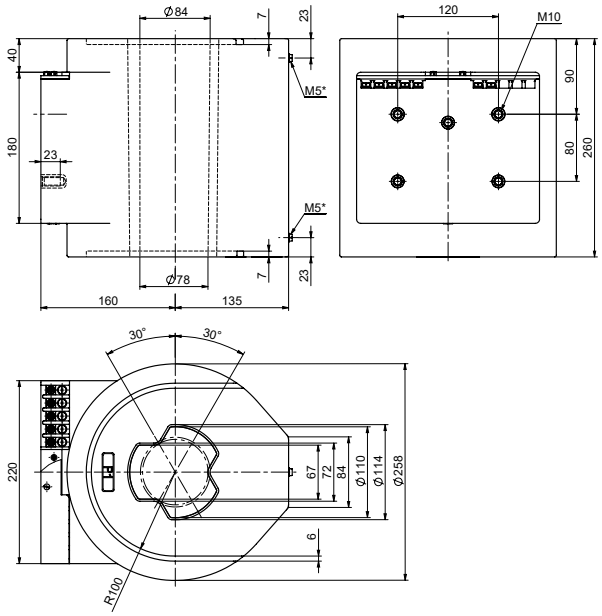

| Type | Dimension | | | | | | | | Weight kg |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | |
| BB 103 | 280 | 341 | 262 | □ 116 x116 | 132 | 212 | 278 | 328 | 22,0 |
| BB 104 | 465 | 389 | 322 | o 132 | 216 | 276 | 300 | 346 | 45.0 |
| BB 223 | 500 | 351 | 274 | □ 116 x116 | 238 | 224 | 290 | 340 | 28.0 |

# KOKS xx A xx

## Dimensional Drawing

**KOKS 17.5 A 31**
**KOKS 12 A 31**

Weight: 35 kg

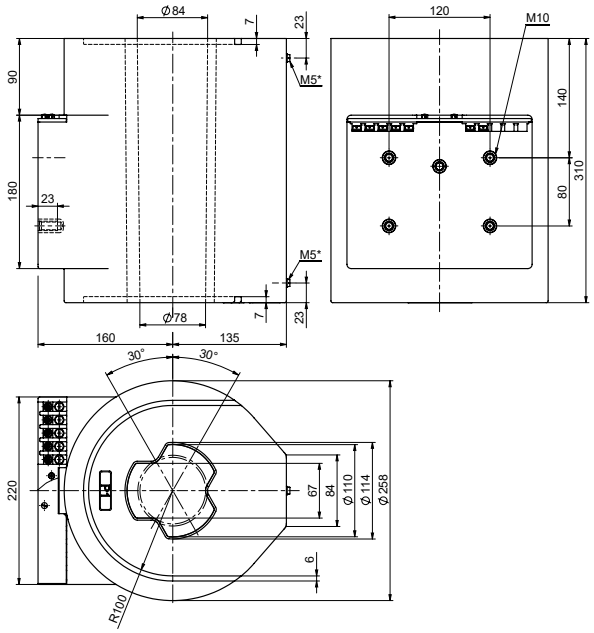



* M5 TERMINAL MUST BE CONNECTED TO THE PRIMARY BAR

| Drawing n. | Polarity |
|---|---|
| 44402520 | P1 to secondary terminal |
| 44402530 | P2 to secondary terminal |

**KOKS 17.5 A 41**
**KOKS 12 A 41**

Weight: 42 kg

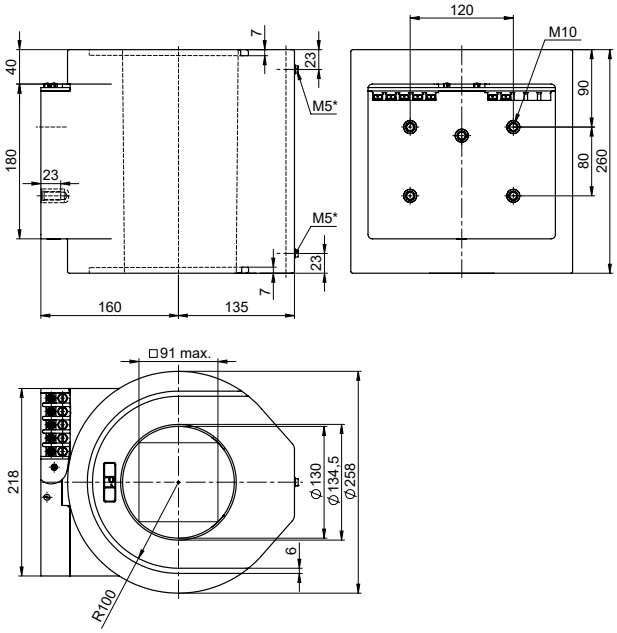



* M5 TERMINAL MUST BE CONNECTED TO THE PRIMARY BAR

| Drawing n. | Polarity |
|---|---|
| 44402540 | P1 to secondary terminal |
| 44402550 | P2 to secondary terminal |

**KOKS 17.5 C 31**
**KOKS 12 C 31**

Weight: 34 kg



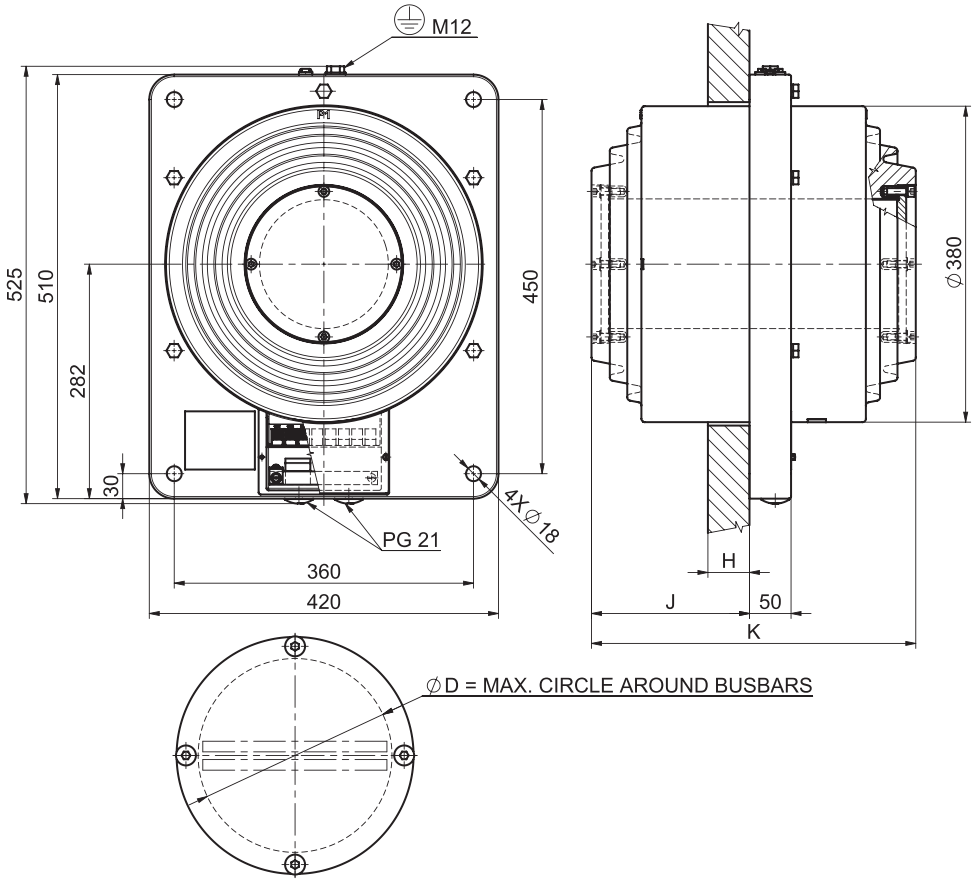

* M5 TERMINAL MUST BE CONNECTED TO THE PRIMARY BAR

| Drawing n. | Polarity |
|---|---|
| 1VL4400076R0101 | P1 to secondary terminal |
| 1VL4400076R0102 | P2 to secondary terminal |

# KOKS 24

Dimensional Drawing

**KOKS 24**



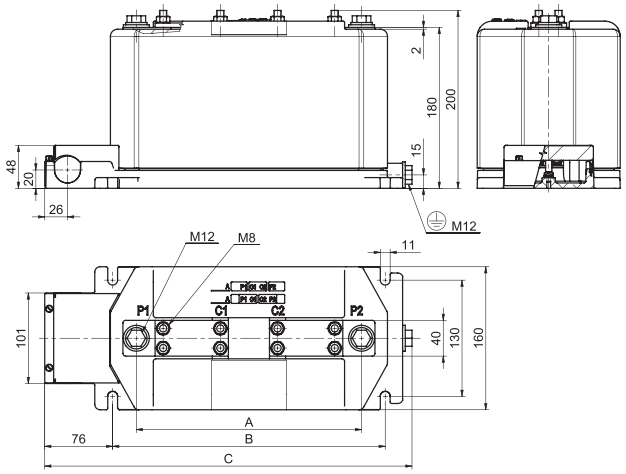

| Drawing n. | Type | D [mm] | H [mm] | J [mm] | K [mm] | Weight [kg] |
|---|---|---|---|---|---|---|
| 1VL4600900R0101 | KOKS 24 D 11 | 150 | 35 | 190 | 390 | 80 |
| 1VL4600900R0102 | KOKS 24 D 21 | 150 | 75 | 245 | 500 | 115 |
| 1VL4600900R0103 | KOKS 24 F 11 | 205 | 35 | 195 | 400 | 65 |
| 1VL4600900R0104 | KOKS 24 F 21 | 205 | 75 | 250 | 510 | 90 |

# KOFA

## Dimensional Drawing

**KOFA 12 B1, D1**
**KOFA 12 B2, D2, F2**
**KOFA 12 B3, D3, F3**

Weight: appr. 18 kg
Creepage distance: 160 mm
Arcing distance 150 mm




| Drawing n. | Transformer type | A [mm] | B [mm] | C [mm] | Weight [kg] |
|---|---|---|---|---|---|
| 1VL4600866R0101 | KOFA 12 B1 | 132 | 185 | 292 | 13 |
| 1VL4600866R0102 | KOFA 12 D1 | 132 | 185 | 292 | 13 |
| 1VL4600866R0103 | KOFA 12 B2 | 192 | 245 | 352 | 17 |
| 1VL4600866R0104 | KOFA 12 D2 | 192 | 245 | 352 | 17 |
| 1VL4600866R0105 | KOFA 12 F2 | 192 | 245 | 352 | 17 |
| 1VL4600866R0106 | KOFA 12 B3 | 252 | 305 | 412 | 24 |
| 1VL4600866R0107 | KOFA 12 D3 | 252 | 305 | 412 | 24 |
| 1VL4600866R0108 | KOFA 12 F3 | 252 | 305 | 412 | 24 |

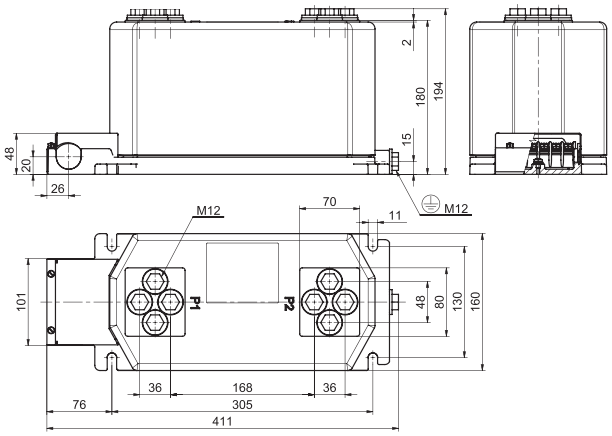
Terminal markings




E.g. 2 cores

**KOFA 12 A3**
**KOFA 12 C3**
**KOFA 12 E3**

Weight: appr. 20 kg
Creepage distance: 165 mm
Arcing distance 150 mm




Terminal markings when secondary reconnectable for two primary currents:




Connect between S1 and S2 for the lower primary current.
Connect between S1 and S3 for the higher primary current.

Terminal markings

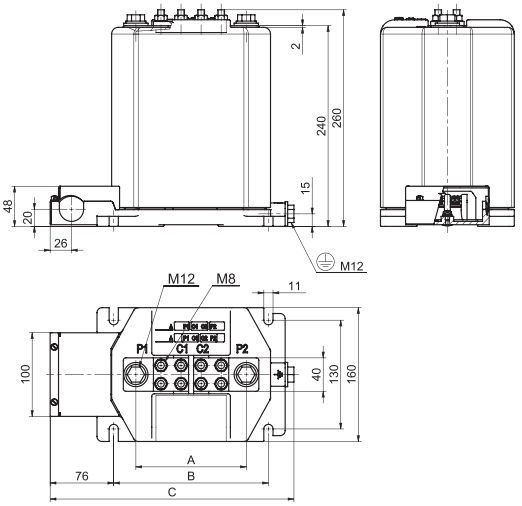



E.g. 3 cores

| Drawing n. | Transformer type | Weight [kg] |
|---|---|---|
| 1VL4600868R0101 | KOFA 12 A3 | 23 |
| 1VL4600868R0102 | KOFA 12 C3 | 23 |
| 1VL4600868R0103 | KOFA 12 E3 | 23 |

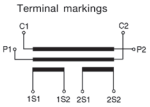
**KOFA 24 B1, D1**
**KOFA 24 B2, D2, F2**
**KOFA 24 B3, D3, F3**

Weight: appr. 18 kg
Creepage distance: 220 mm
Arcing distance 210 mm




| Drawing n. | Transformer type | A [mm] | B [mm] | C [mm] | Weight [kg] |
|---|---|---|---|---|---|
| 1VL4600867R0101 | KOFA 24 B1 | 132 | 185 | 292 | 17 |
| 1VL4600867R0102 | KOFA 24 D1 | 132 | 185 | 292 | 17 |
| 1VL4600867R0103 | KOFA 24 B2 | 192 | 245 | 352 | 20 |
| 1VL4600867R0104 | KOFA 24 D2 | 192 | 245 | 352 | 20 |
| 1VL4600867R0105 | KOFA 24 F2 | 192 | 245 | 352 | 20 |
| 1VL4600867R0106 | KOFA 24 B3 | 252 | 305 | 412 | 23 |
| 1VL4600867R0107 | KOFA 24 D3 | 252 | 305 | 412 | 23 |
| 1VL4600867R0108 | KOFA 24 F3 | 252 | 305 | 412 | 23 |

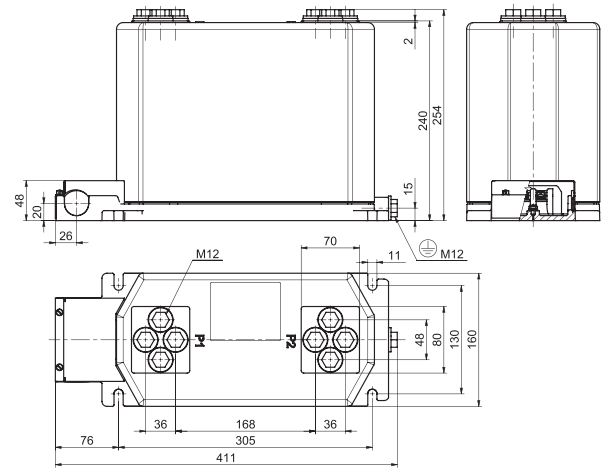
Terminal markings




E.g. 2 cores

**KOFA 24 A3**
**KOFA 24 C3**
**KOFA 24 E3**

Weight: appr. 24 kg
Creepage distance: 225 mm
Arcing distance 210 mm




Terminal markings when secondary reconnectable for two primary currents:




Connect between S1 and S2 for the lower primary current.
Connect between S1 and S3 for the higher primary current.

Terminal markings




E.g. 3 cores

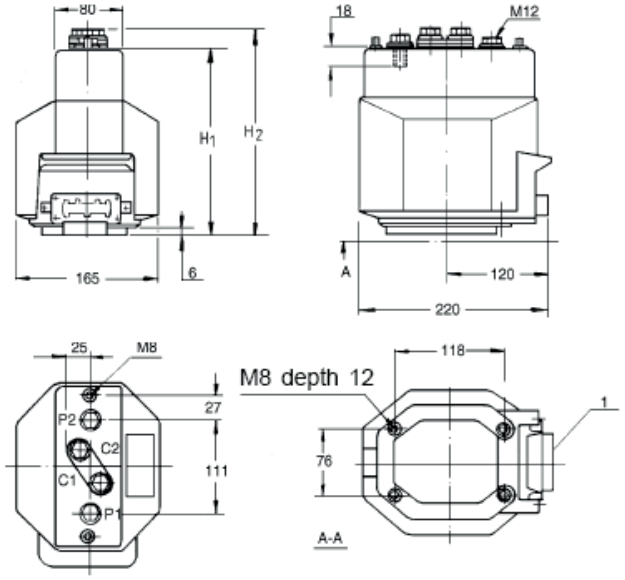
| Drawing n. | Transformer type | Weight [kg] |
|---|---|---|
| 1VL4600869R0101 | KOFA 24 A3 | 27 |
| 1VL4600869R0102 | KOFA 24 C3 | 27 |
| 1VL4600869R0103 | KOFA 24 E3 | 27 |

# IHBF

## Dimensional Drawing

**IHBF 12 A**
**IHBF 17 A**
**IHBF 24 C**

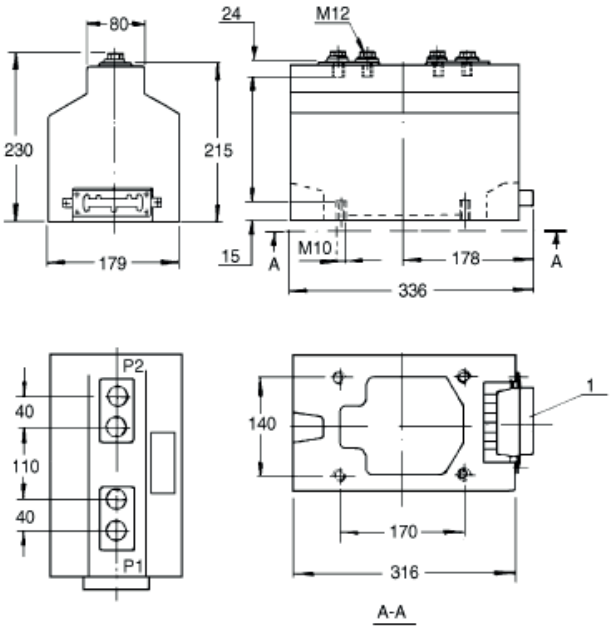
Weight: appr. 19 kg




IHBF 12 A, 17 A $H_1$ = 212 $H_2$ = 242
24 C $H_1$ = 292 $H_2$ = 322

**IHBF 12 B**
**IHBF 17 B**

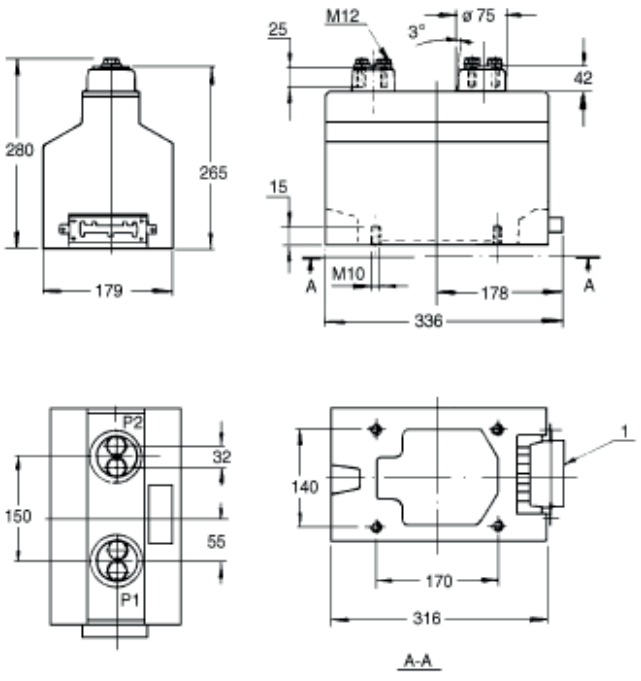
Weight: appr. 27 kg




1. Plug-in contact

**IHBF 24 B**

Weight: appr. 14 kg




1. Plug-in contact

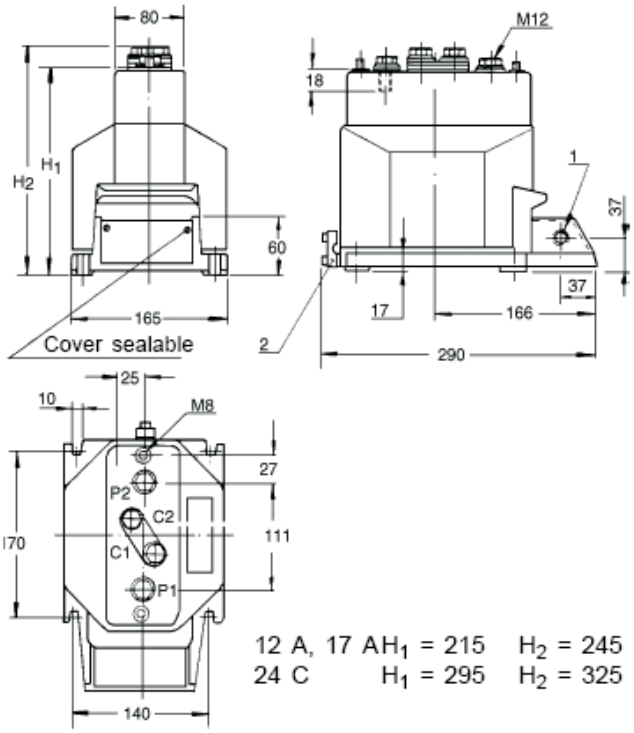
# IHBF

## Dimensional Drawing

## Transformers with base plate, clamp type secondary terminals

**IHBF 12 A**
**IHBF 17 A**
**IHBF 24 C**

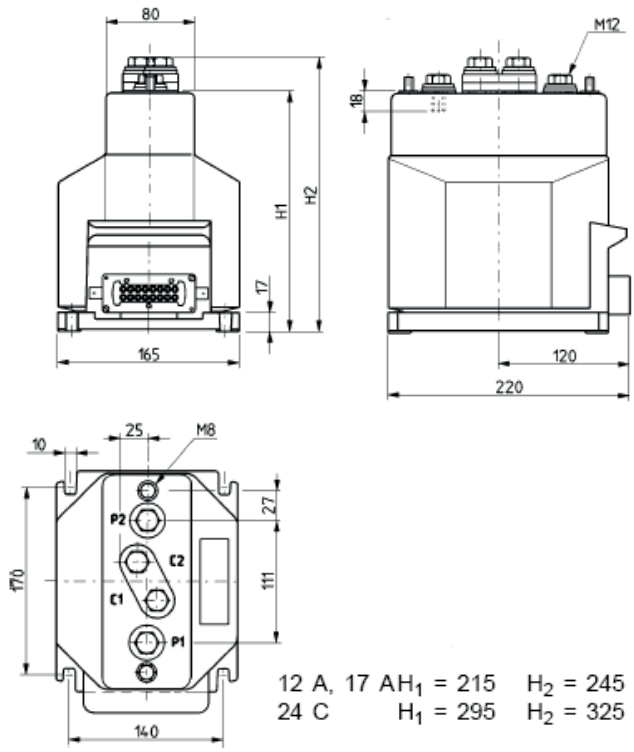
Weight: appr. 14 kg




12 A, 17 A $H_1$ = 215 $H_2$ = 245
24 C $H_1$ = 295 $H_2$ = 325

**IHBF 12 A**
**IHBF 17 A**
**IHBF 24 C**

Weight: appr. 14 kg

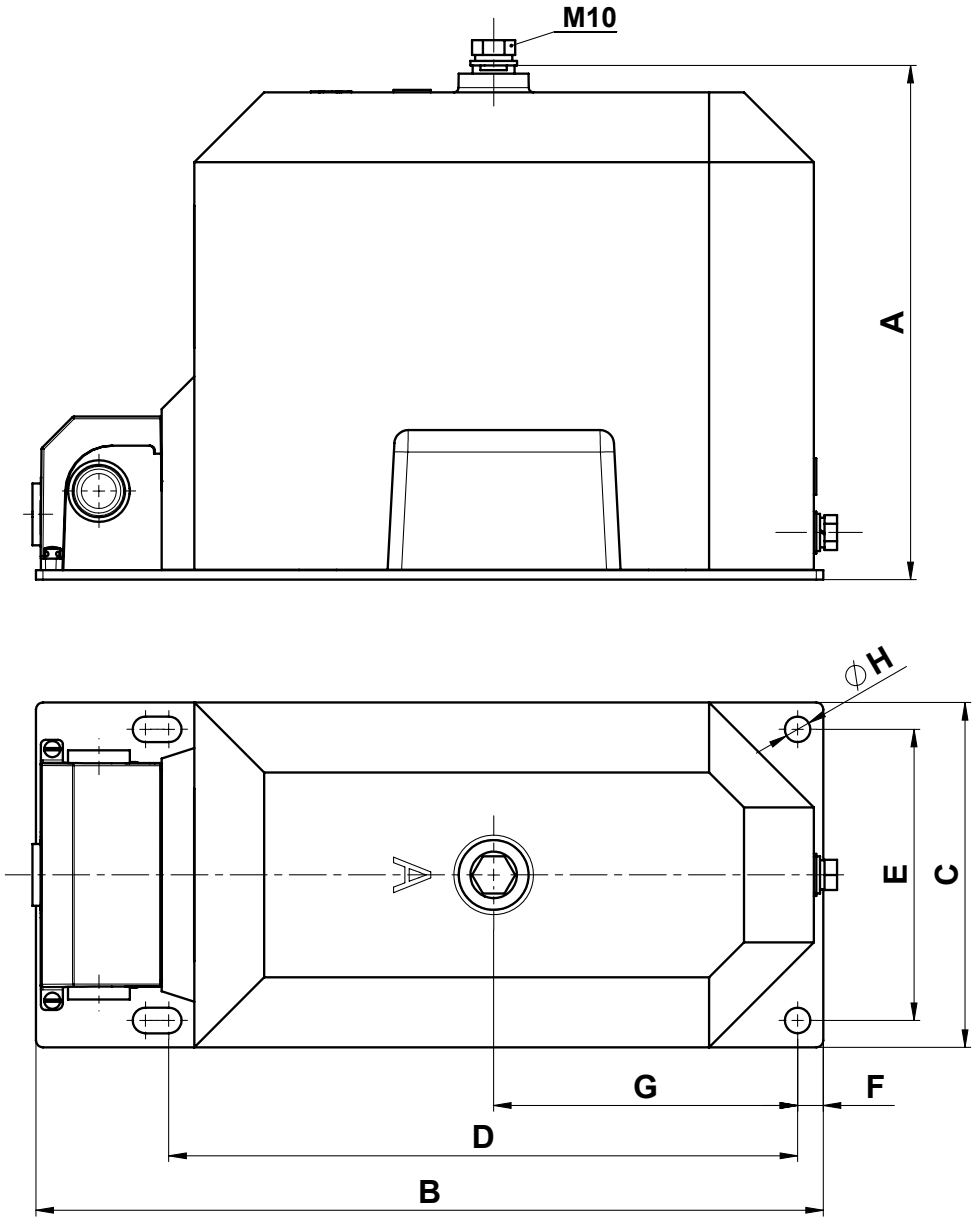



12 A, 17 A $H_1$ = 215 $H_2$ = 245
24 C $H_1$ = 295 $H_2$ = 325

# TJC

## Dimensional Drawing

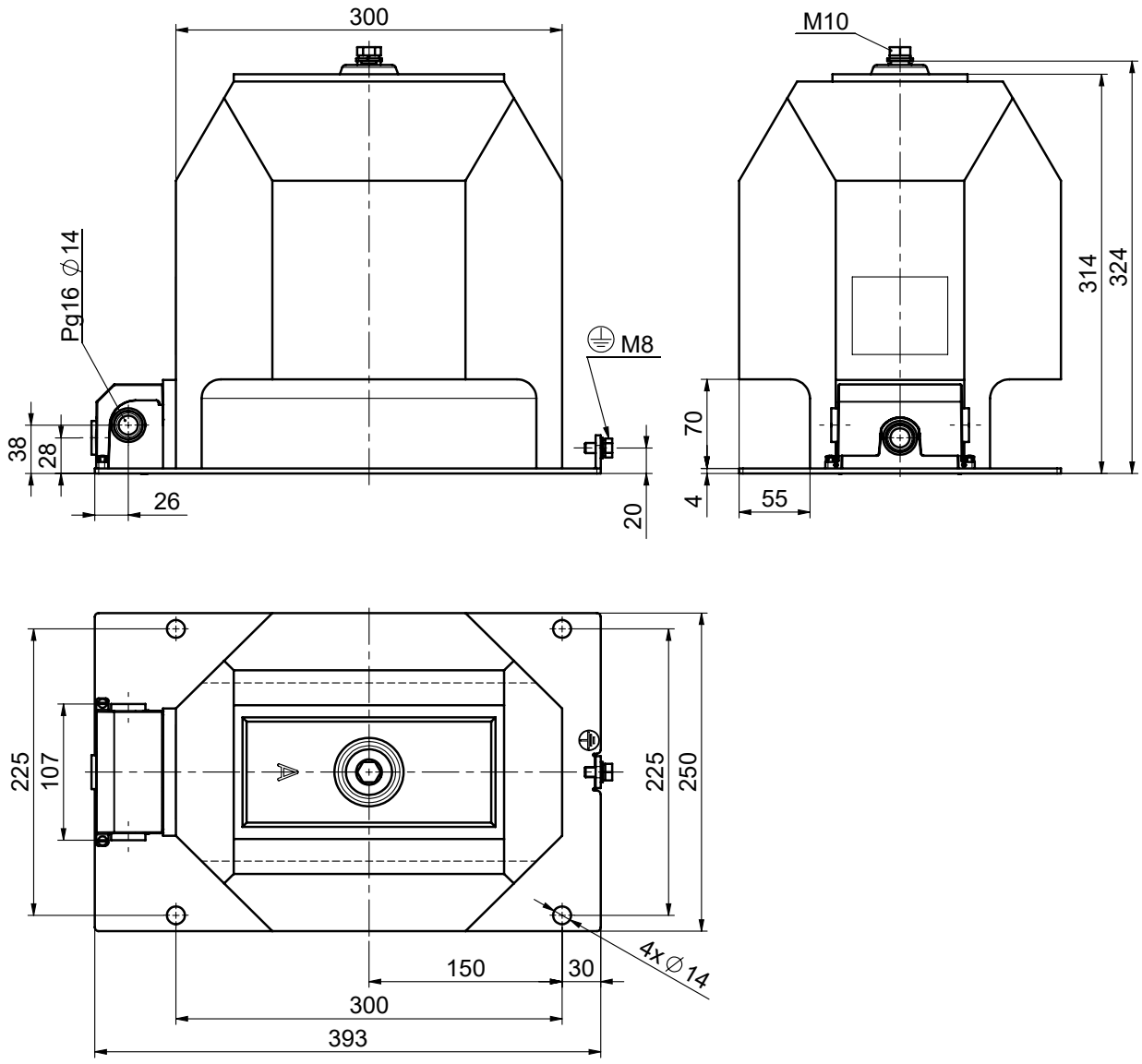
**TJC(H) 4(5,6,7)**




| | TJC 4(5), TJCH 4(5) | TJC 6 | TJC 7.1 |
|---|---|---|---|
| A [mm] | 220 | 282 | 324 |
| B [mm] | 338 | 352 | 393 |
| C [mm] | 148 | 178 | 250 |
| D [mm] | 270 | 275 | 300 |
| E [mm] | 125 | 150 | 225 |
| F [mm] | 11 | 11 | 30 |
| G [mm] | 130 | 143 | 150 |
| H [mm] | 11 | 14 | 14 |

—
**TJC 7.1**

Weight:48 kg
Creepage distance: 398 mm



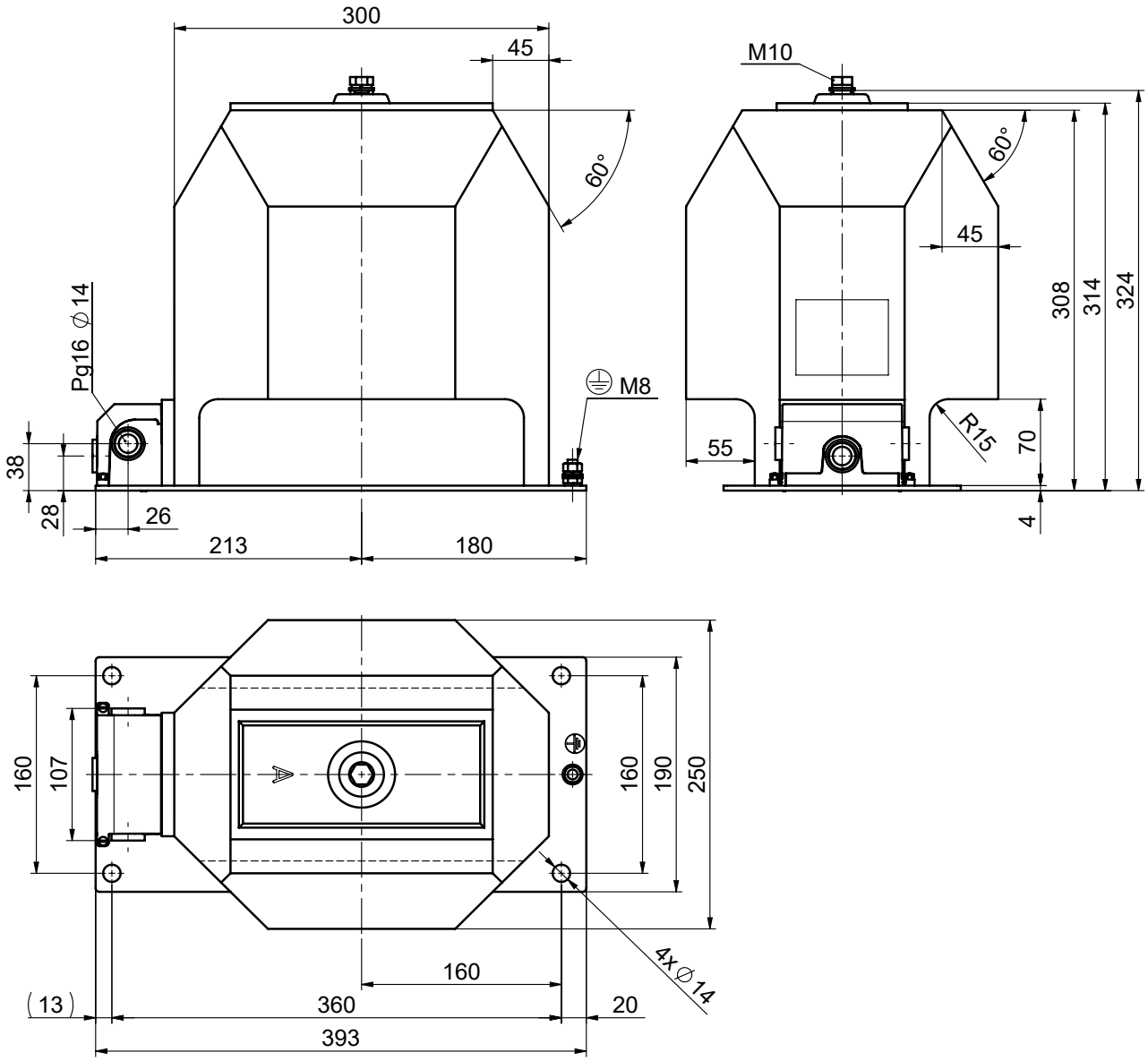

| Drawing n. |
| --- |
| 44204010 |

# TJC

## Dimensional Drawing

**TJC 7.1**
**medium baseplate**

Weight:47 kg
Creepage distance: 398 mm

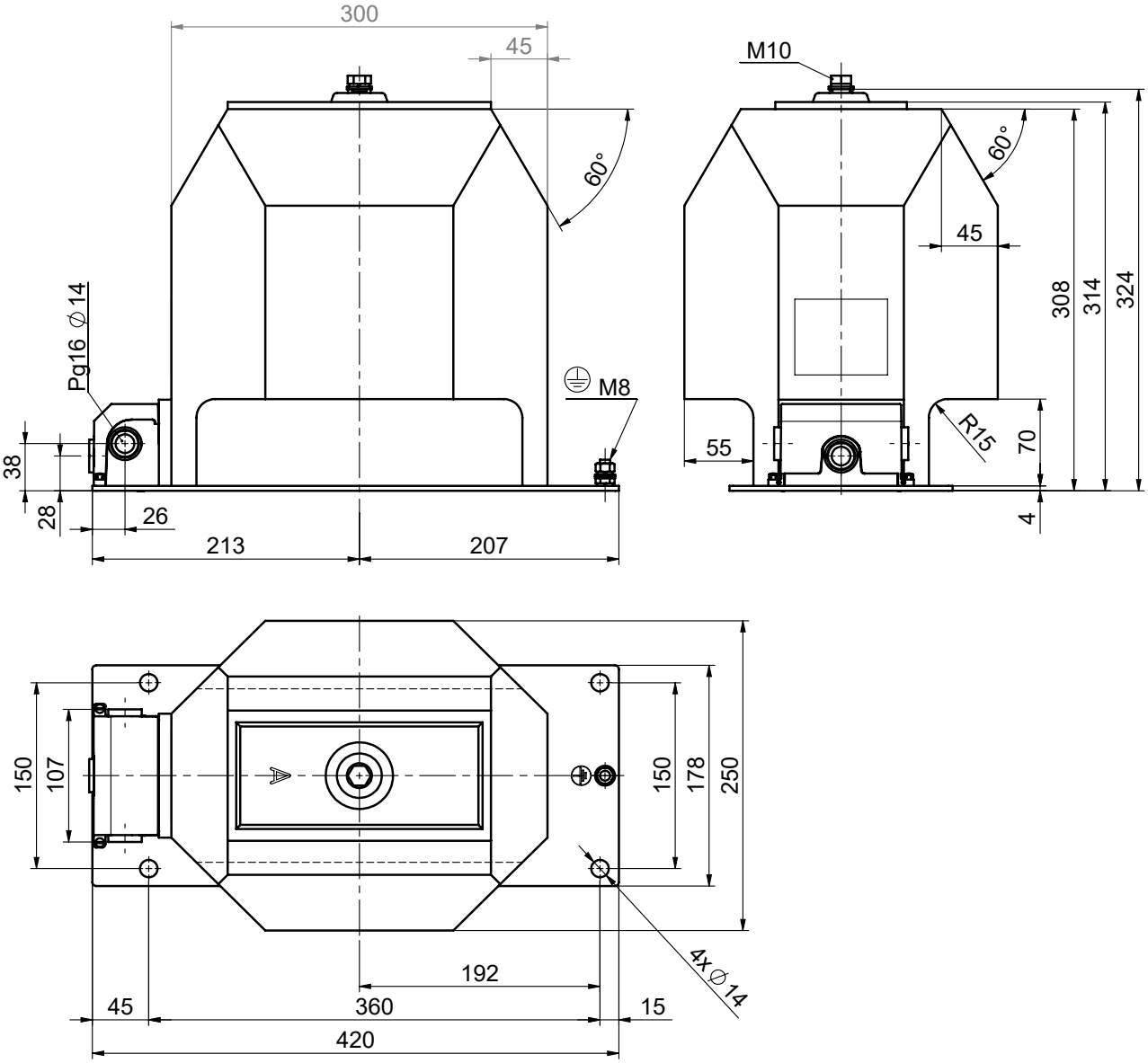



| Drawing n. |
| --- |
| 1VL4200541R0101 |

—

**TJC 7.1**
**narrow baseplate**

Weight:48 kg
Creepage distance: 398 mm



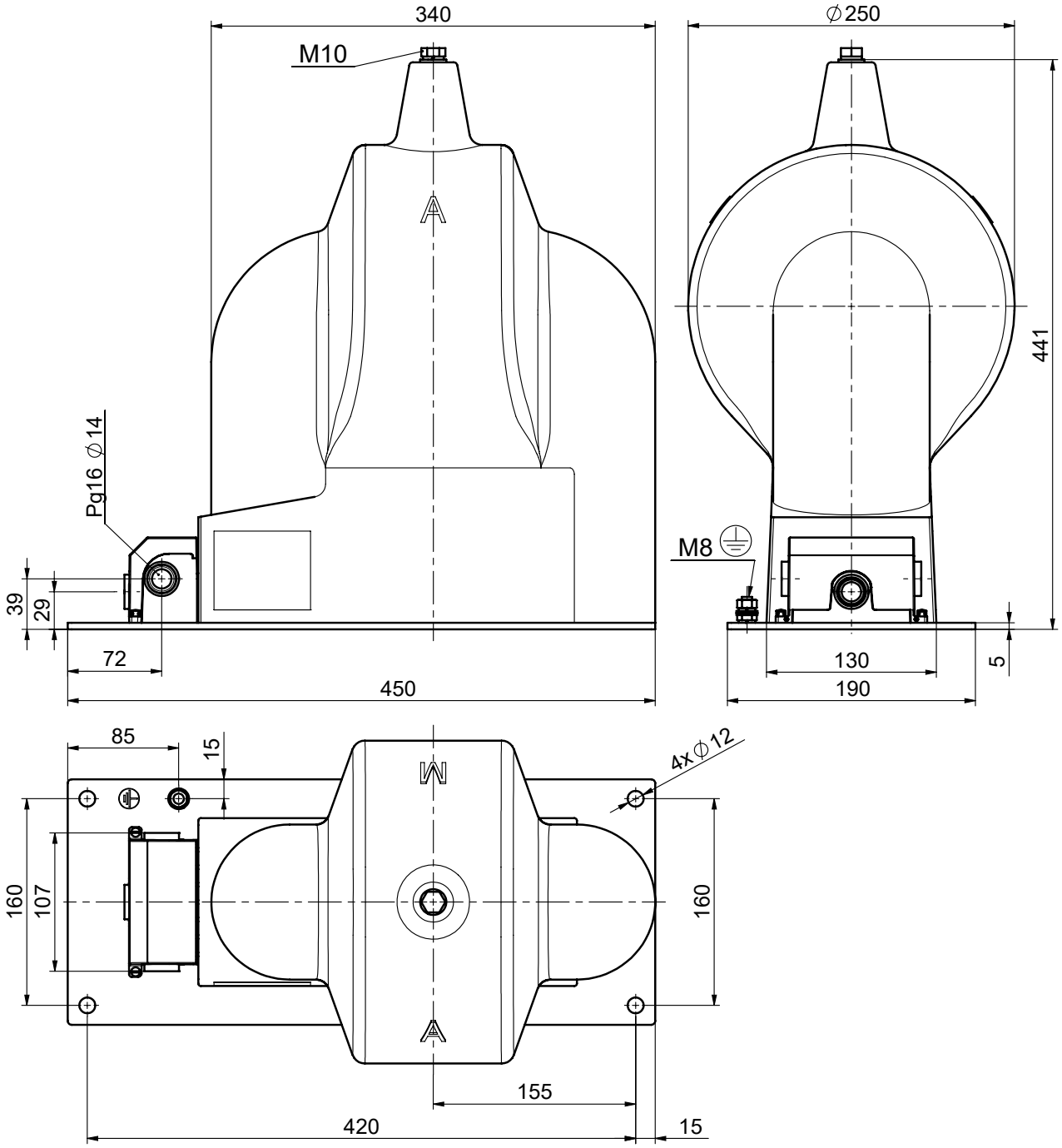

| Drawing n. |
| --- |
| 1VL4200515R0101 |

# TJC

## Dimensional Drawing

**TJC 7**

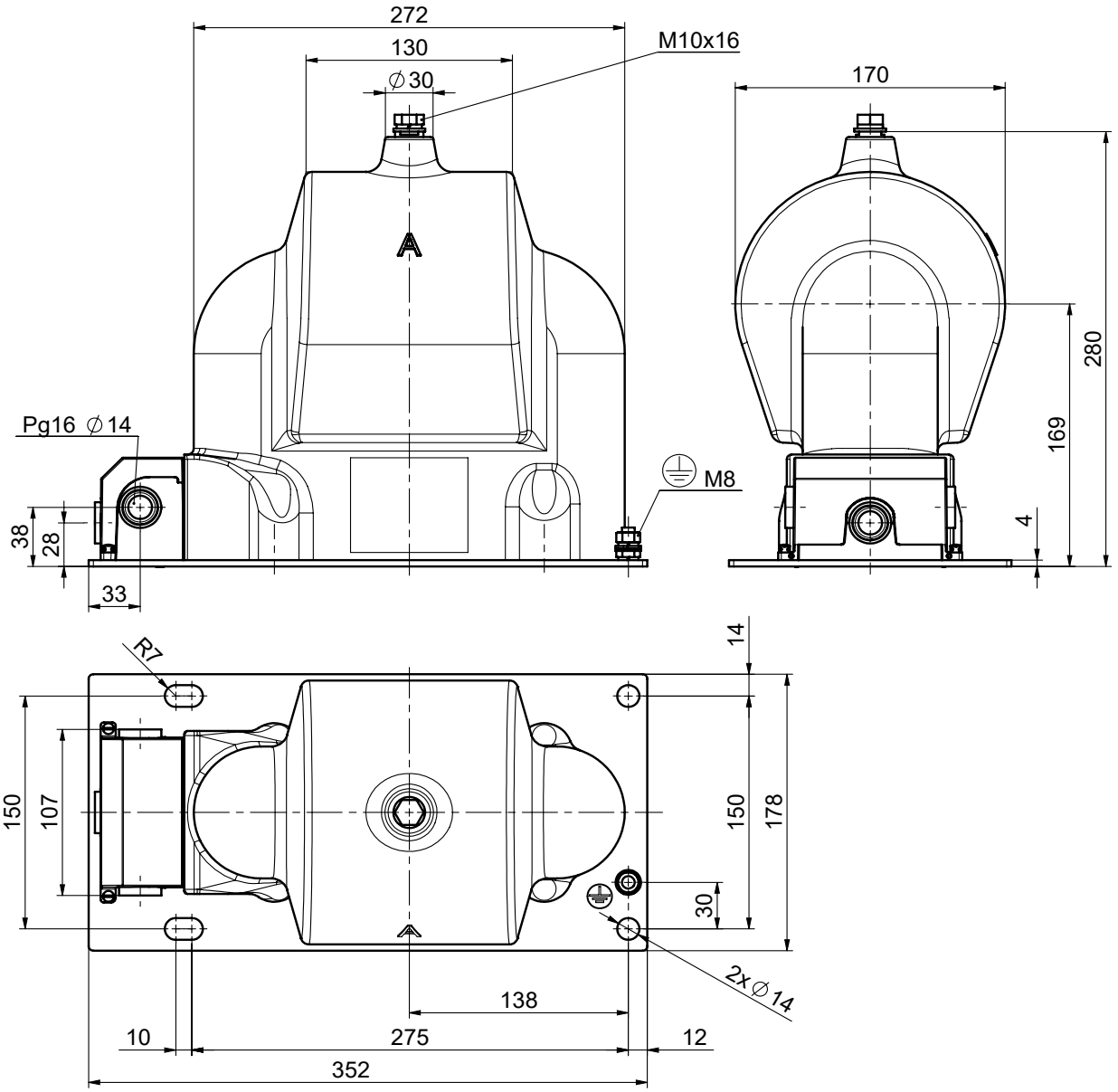
Weight:50 kg
Creepage distance: 480 mm




| Drawing n. |
| --- |
| 44203800 |

**TJCL 6**

Weight: appr. 25 kg
Creepage distance: 326 mm

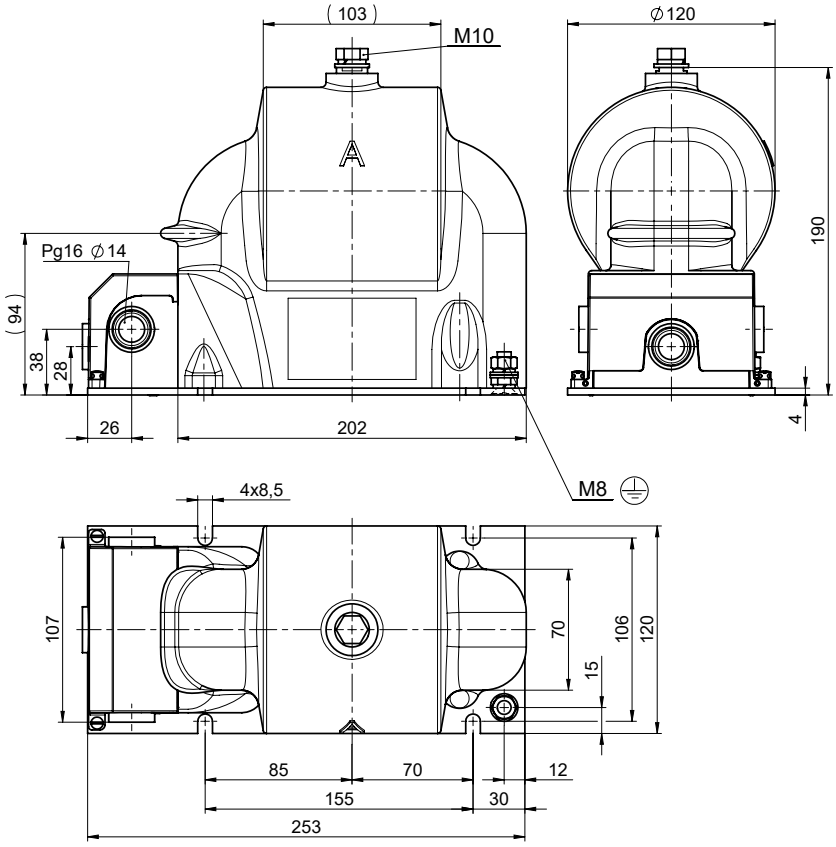



| Drawing n. |
| --- |
| 1VL4200396R0101 |

# TJE

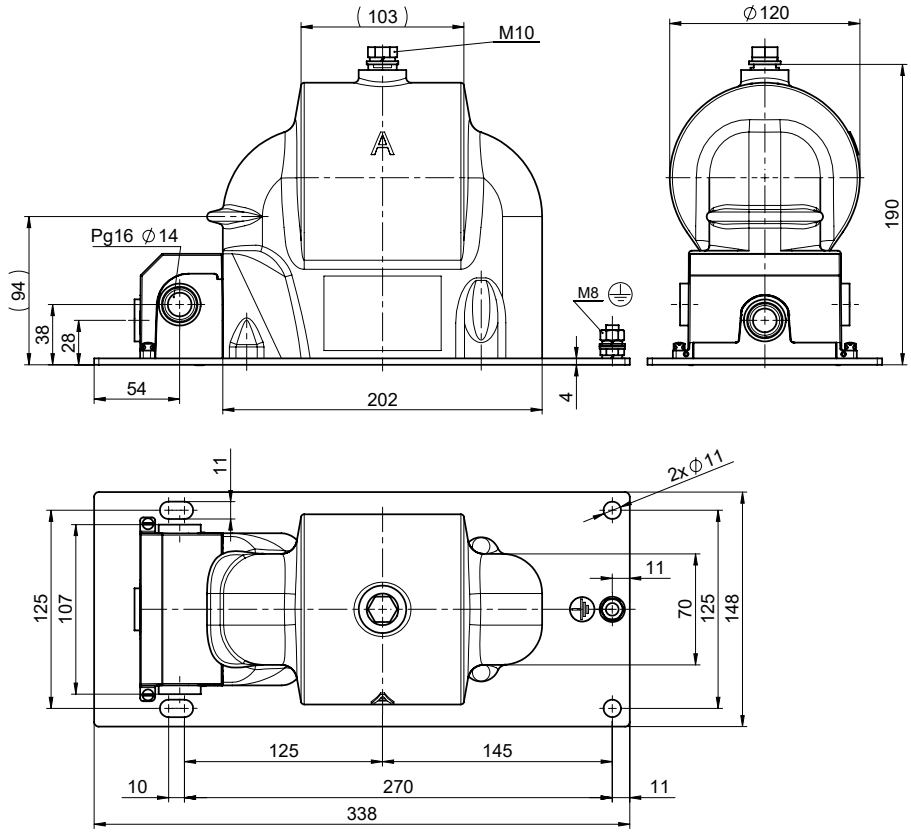
## Dimensional Drawing

**TJE 3**




Weight: 10 kg
Creepage distance: 245 mm

**TJE 3.1**



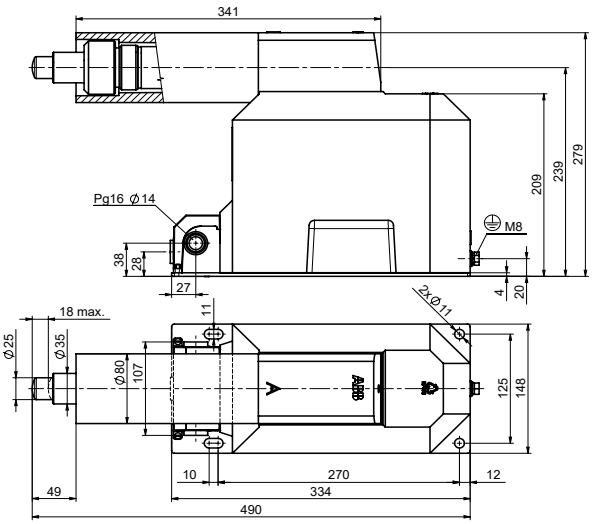

Weight: 11,5 kg
Creepage distance: 245 mm

# TJP

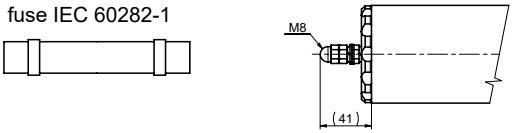
## Dimensional Drawing

**TJP 4.0, TJPH 4.0**
**TJP 5.0, TJPH 5.0**
**fuse IEC 60282-1**

Weight: 24 kg
Creepage distance: 400 mm




OPTIONAL FOR CABLE CONNECTION
CREEPAGE DISTANCE: 418mm

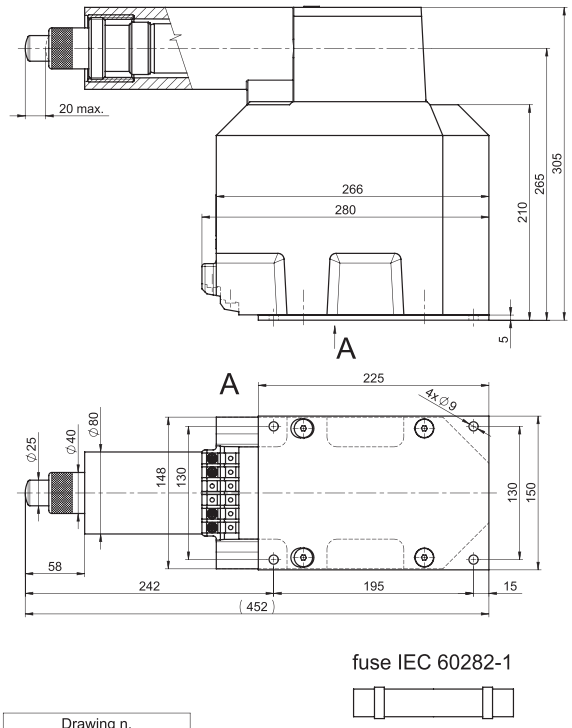



| Drawing n. |
|---|
| 44204060 |

| Drawing n. |
|---|
| 1VL4200418R0101 |

**TJP 4.3**
**TJP 5.3**

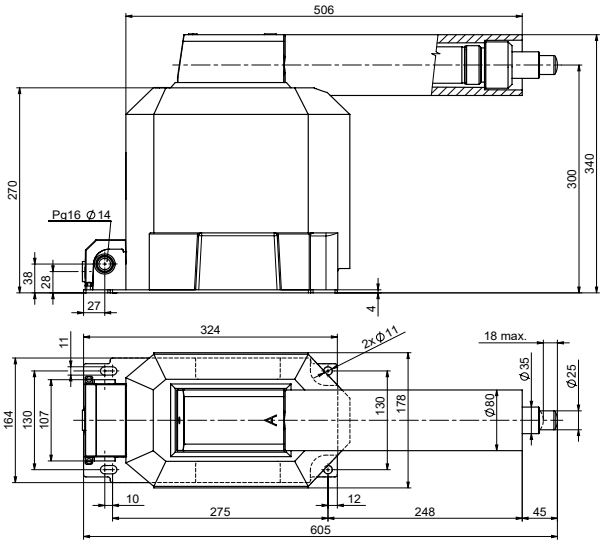
Weight: appr. 28 kg
Creepage distance: 385 mm



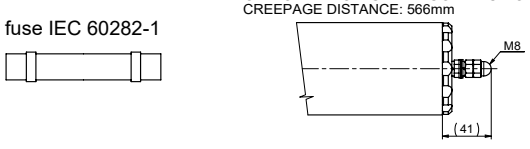

| Drawing n. |
|---|
| 1VL4200314R0101 |

**TJP 6.0**

Weight: 42 kg
Creepage distance: 548 mm




OPTIONAL FOR CABLE CONNECTION
CREEPAGE DISTANCE: 566mm

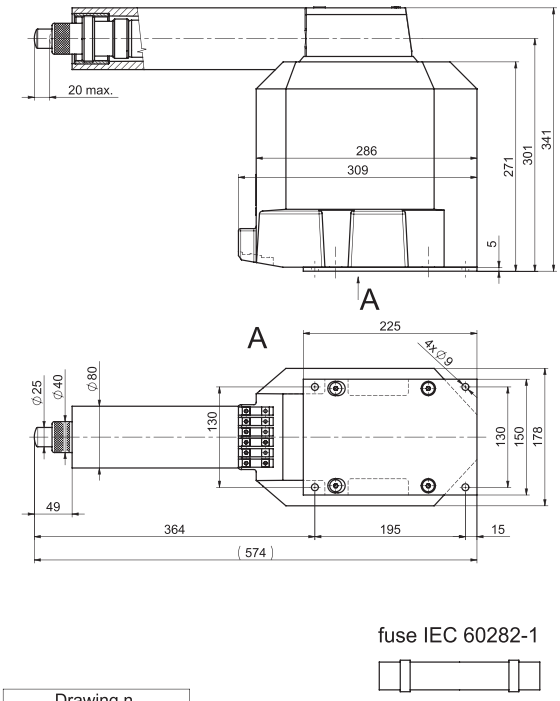



| Drawing n. |
|---|
| 44204070 |

| Drawing n. |
|---|
| 1VL4200419R0101 |

**TJP 6.3**

Weight: 42 kg
Creepage distance: 547 mm

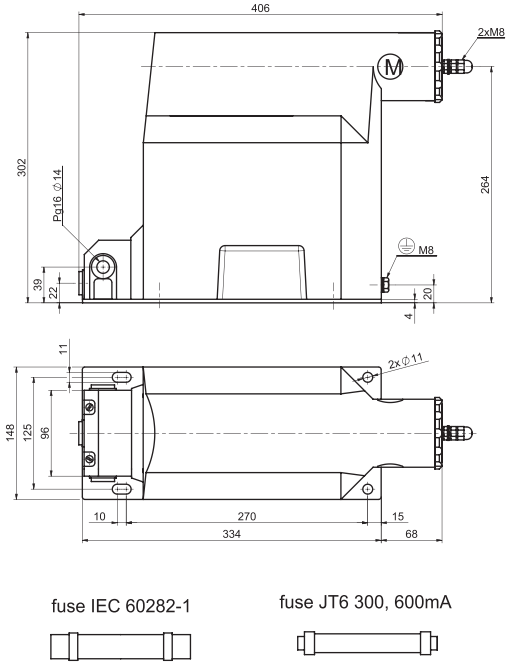



| Drawing n. |
|---|
| 1VL4200315R0101 |

**TJP 4.1**
**TJP 5.1**
**fuse JT6 300 mA**
**fuse JT6 600 mA**

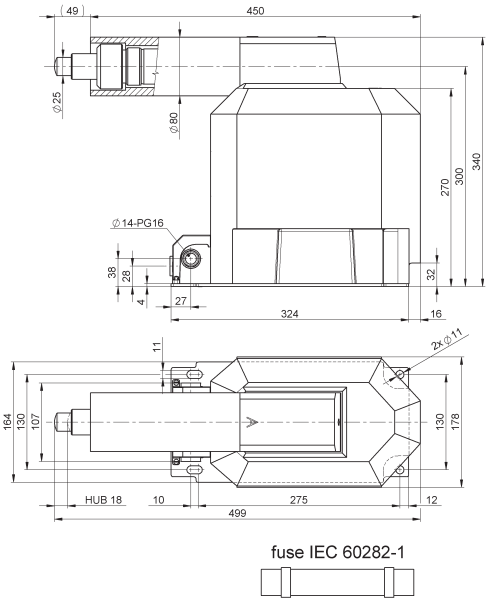
**TJP 4.2**
**TJP 5.2**
**fuse IEC 60282-1**

Weight: 24 kg
Creepage distance: 296 mm



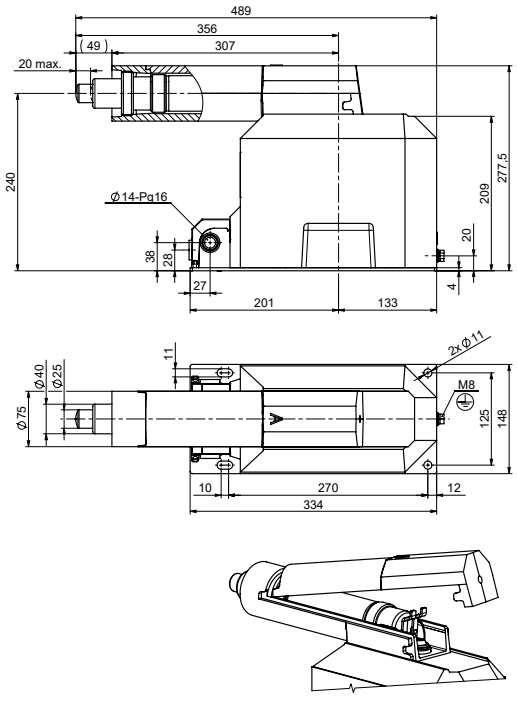

**TJP 4.4**
**TJP 5.4**

Weight: 41 kg
Creepage distance: 453 mm




**TJP 4.0-F**
**TJP 5.0-F**
**fuse IEC 60282-1**

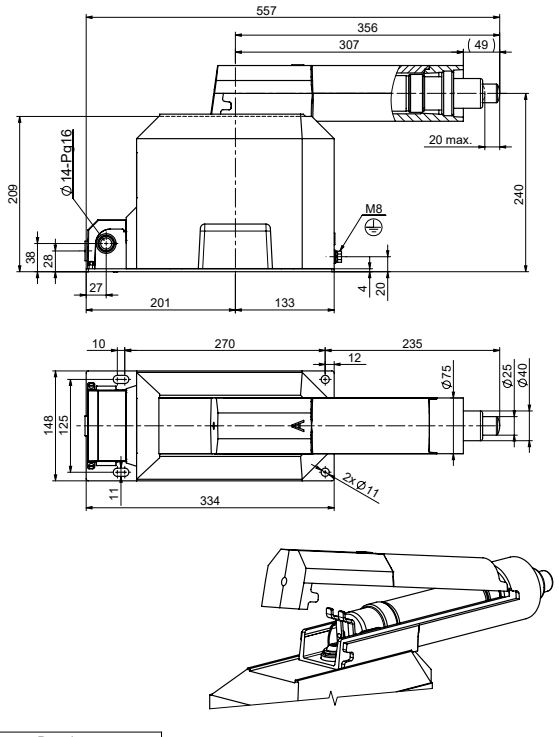
Weight: 24 kg
Creepage distance: 403 mm




| Drawing n. |
|---|
| 1VL4200251R0101 |

**TJP 4.0-F**
**TJP 5.0-F**
**fuse IEC 60282-1**

Weight: 24 kg
Creepage distance: 403 mm

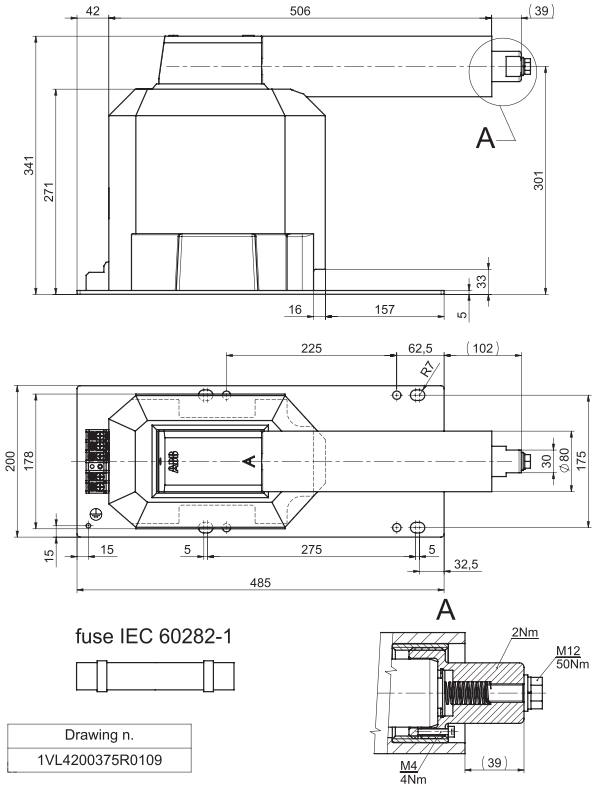



| Drawing n. |
|---|
| 1VL4200300R0101 |

—

**TJP 6.0-G**
**with long baseplate**

Weight: 43 kg
Creepage distance: 536 mm

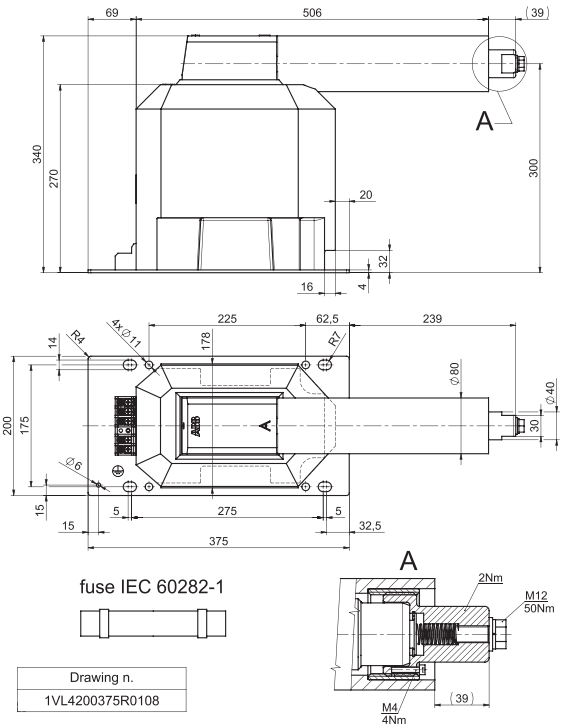



| Drawing n. |
|---|
| 1VL4200375R0109 |

—

**TJP 6.0-G**

Weight: appr. 42 kg
Creepage distance: 536 mm



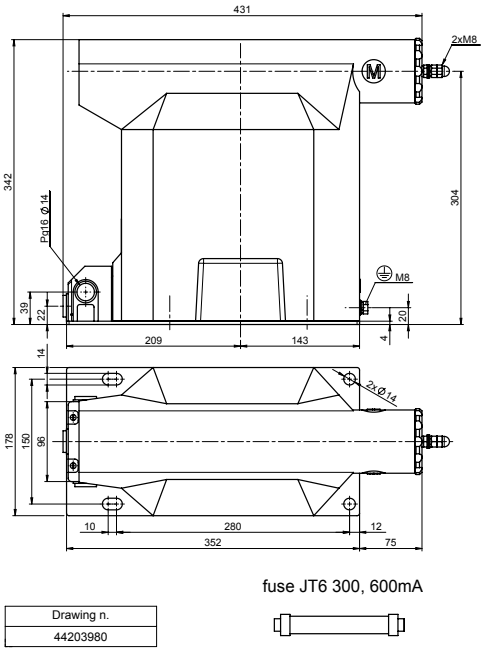

| Drawing n. |
|---|
| 1VL4200375R0108 |

—

**TJP 6.1**
**fuse JT6 300 mA**
**fuse JT6 600 mA**

**TJP 6.2**
**fuse IEC 60282-1**

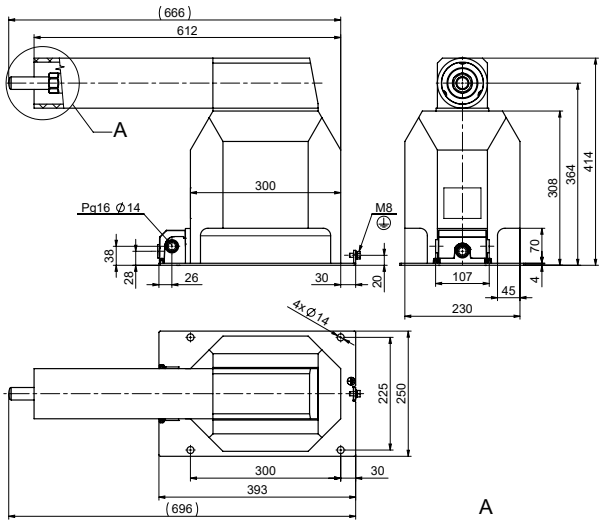
Weight: 42 kg
Creepage distance: 342 mm



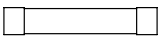

| Drawing n. |
|---|
| 44203980 |

**TJP 7.0**

Weight: appr. 53 kg
Creepage distance: 745 mm



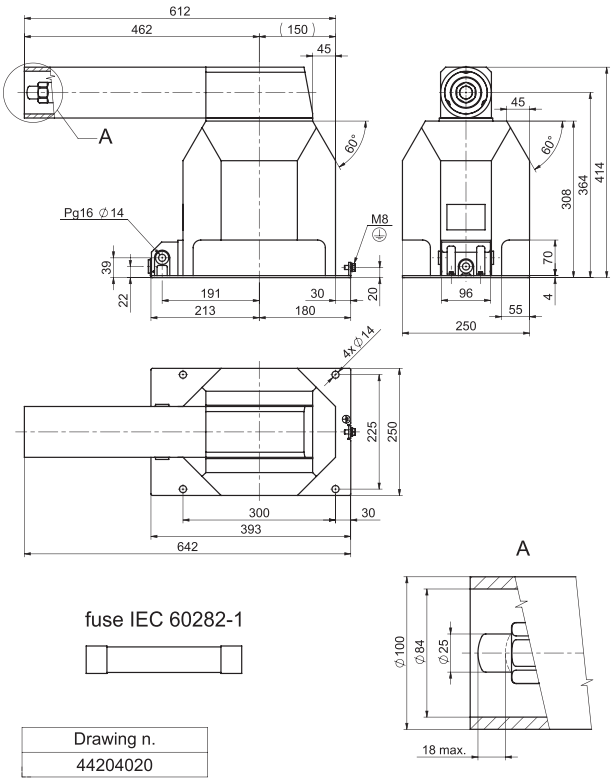

fuse IEC 60282-1



| Drawing n. |
|---|
| 1VL4200508R0101 |

**TJP 7.1**

Weight: appr. 54 kg
Creepage distance: 745 mm



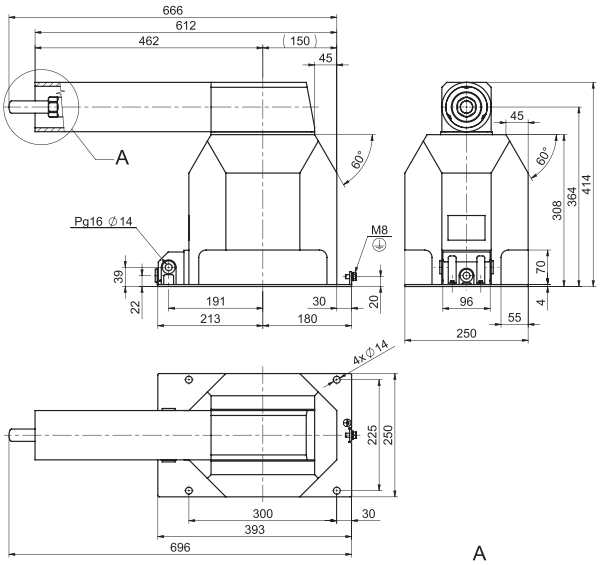

fuse IEC 60282-1



| Drawing n. |
|---|
| 44204020 |

**TJP 7.2**

Weight: appr. 54 kg
Creepage distance: 745 mm



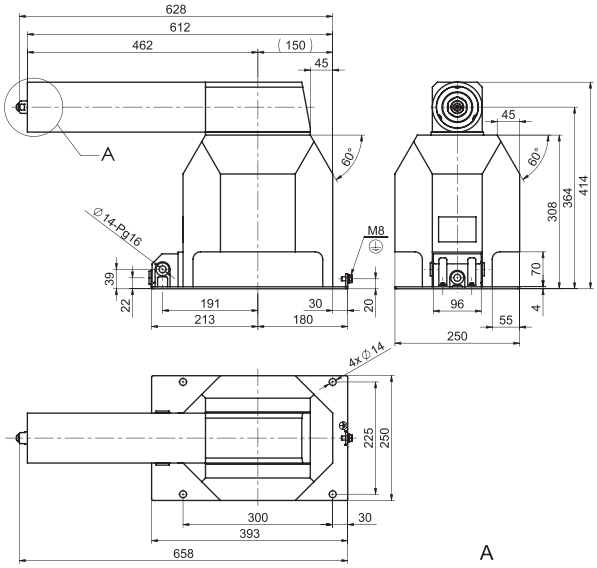

fuse IEC 60282-1



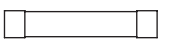
| Drawing n. |
|---|
| 44204030 |

**TJP 7.3**

Weight: appr. 54 kg
Creepage distance: 745 mm



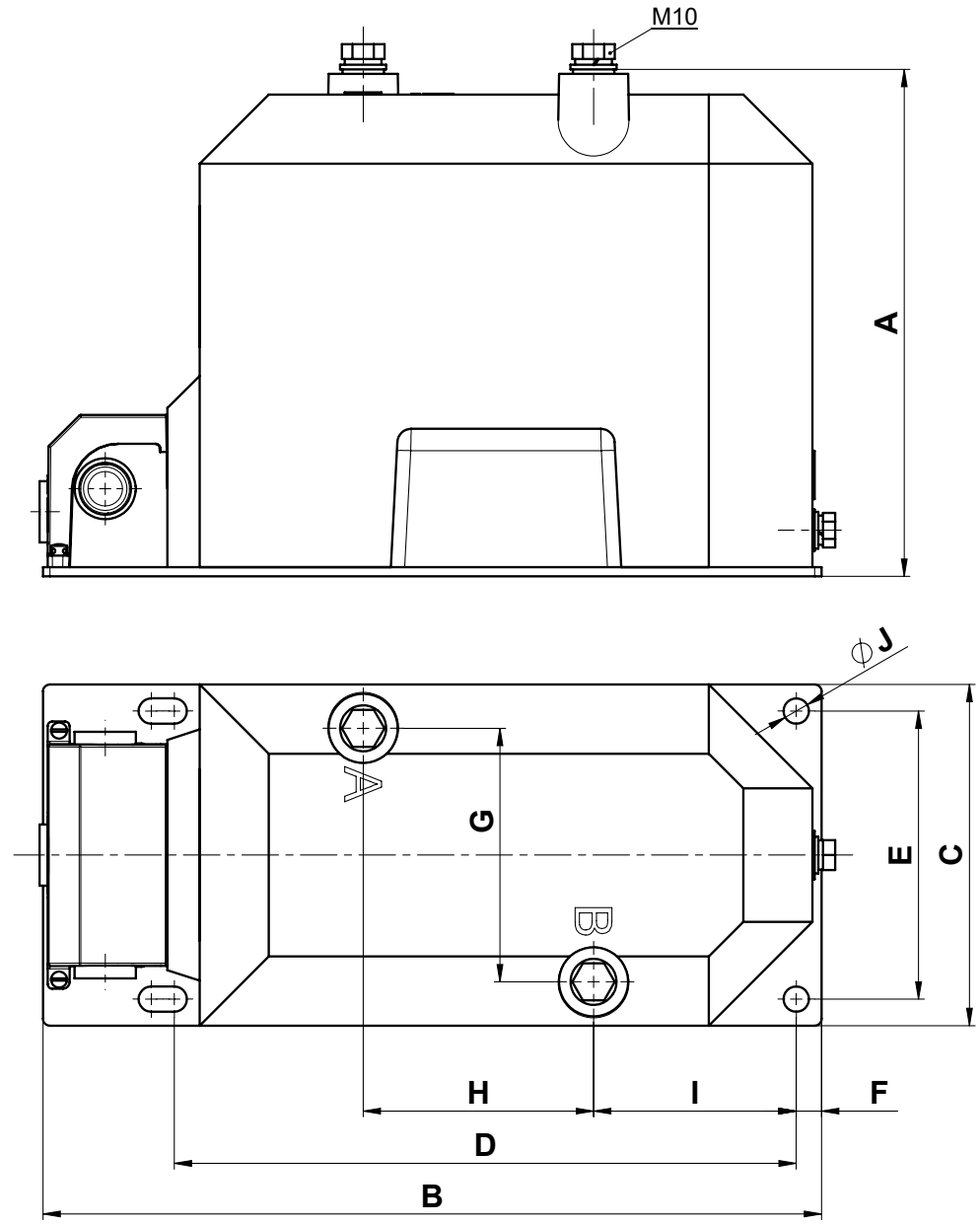

fuse IEC 60282-1



| Drawing n. |
|---|
| 44204170 |

# TDC
## Dimensional Drawing

**TDC 4(5,6)**

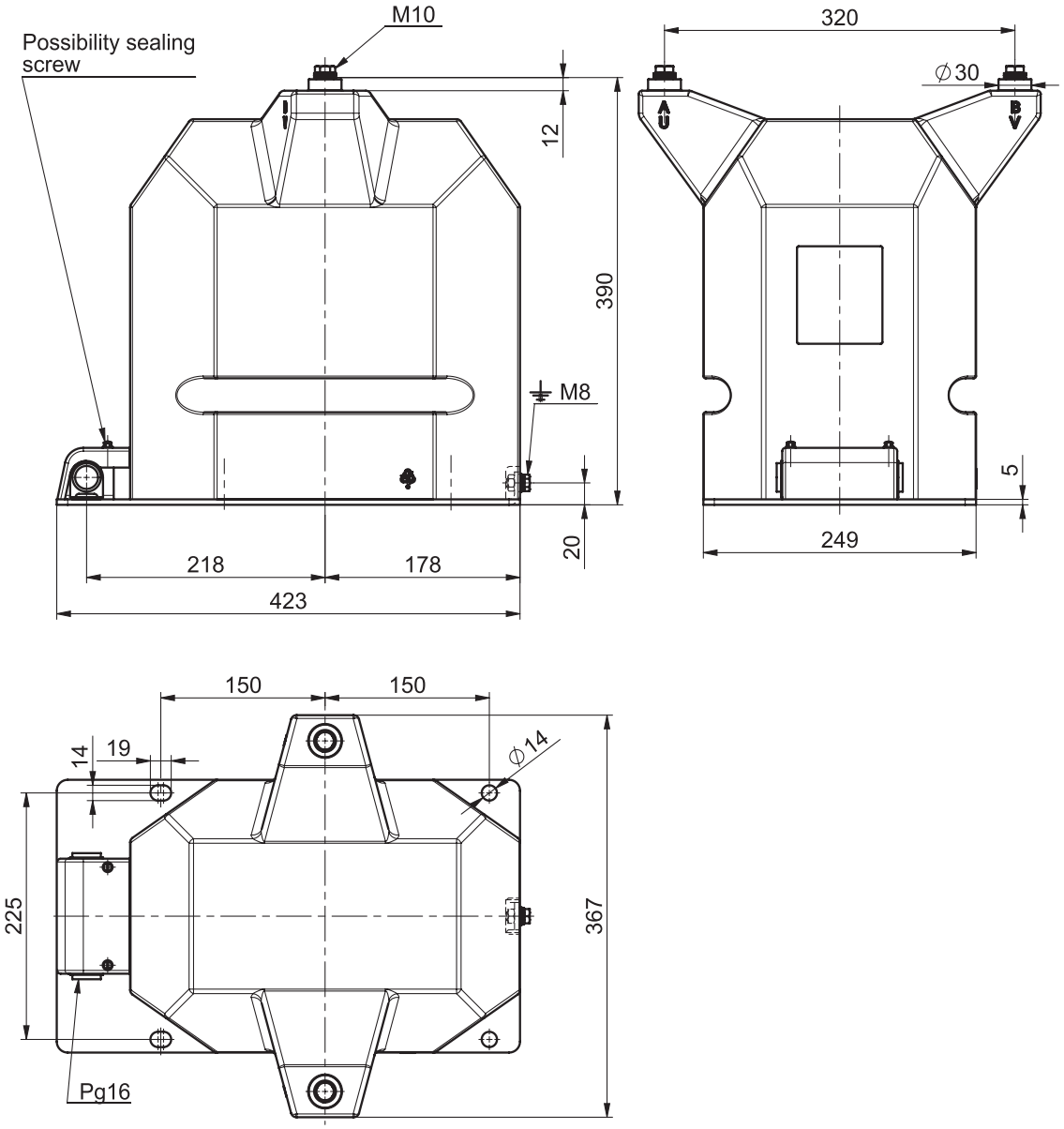



| | TDC 4(5) | TDC 6 |
|---|---|---|
| A [mm] | 220 | 280 |
| B [mm] | 338 | 352 |
| C [mm] | 148 | 178 |
| D [mm] | 270 | 275 |
| E [mm] | 125 | 150 |
| F [mm] | 11 | 11 |
| G [mm] | 110 | 130 |
| H [mm] | 100 | 165 |
| I [mm] | 88 | 60 |
| J [mm] | 11 | 14 |

—

**TDC 7**

Weight: 72 kg
Creepage distance: 334 mm



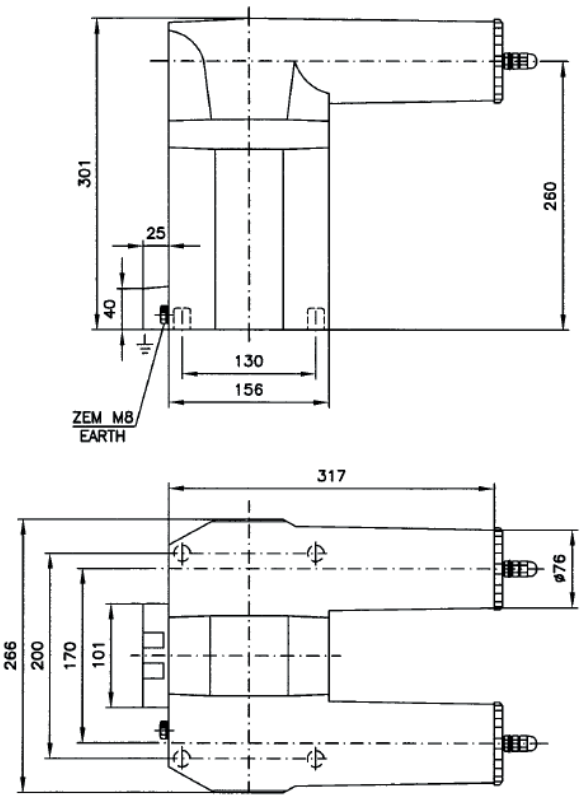

| Drawing n. |
| --- |
| 44616400 |

# TDP

## Dimensional Drawing

**TDP 4.1**
**fuse JT6 300 mA**
**fuse JT6 600 mA**

Weight: 29 kg

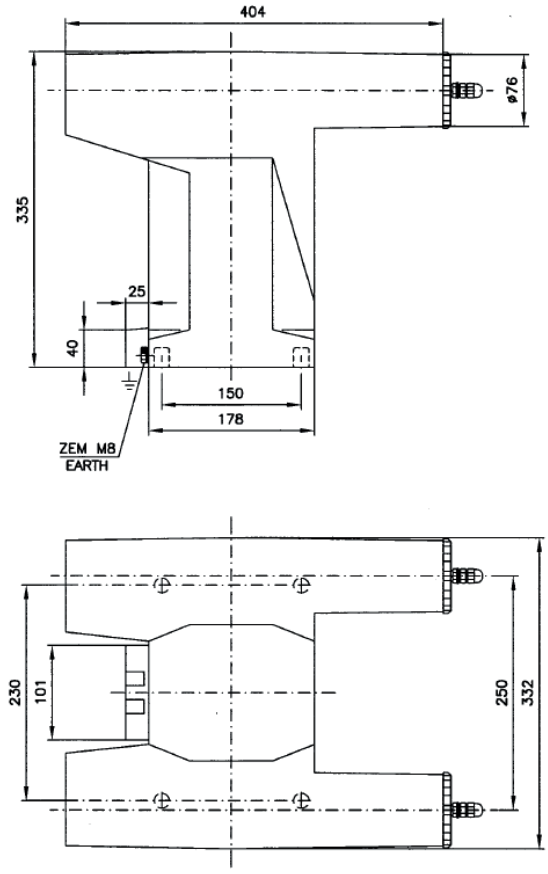



**TDP 4.2**
**fuse IEC 600282-1**

Weight: 29 kg

**TDP 6.1**
**fuse JT6 300 mA**
**fuse JT6 600 mA**

Weight: 38 kg




**TDP 6.2**
**fuse IEC 600282-1**

Weight: 38 kg

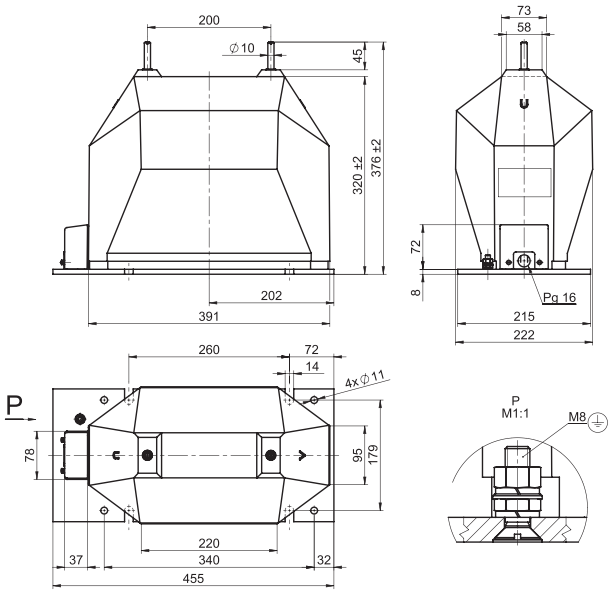
# KUGI and KGUG

## Dimensional Drawing

**KGUG 24**
**KGUG 36**

### KGUG 24

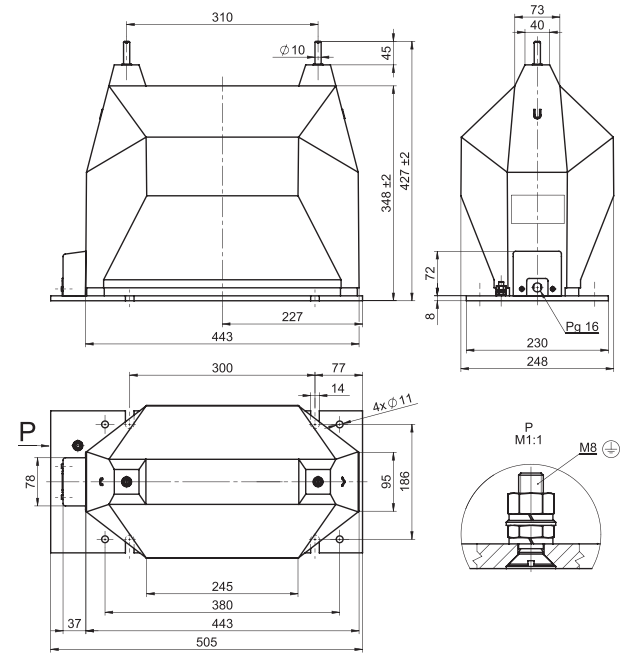
WEIGHT: 60kg




| Drawing n. |
|---|
| 1VL4200393R0101 |

### KGUG 36

WEIGHT: 80kg

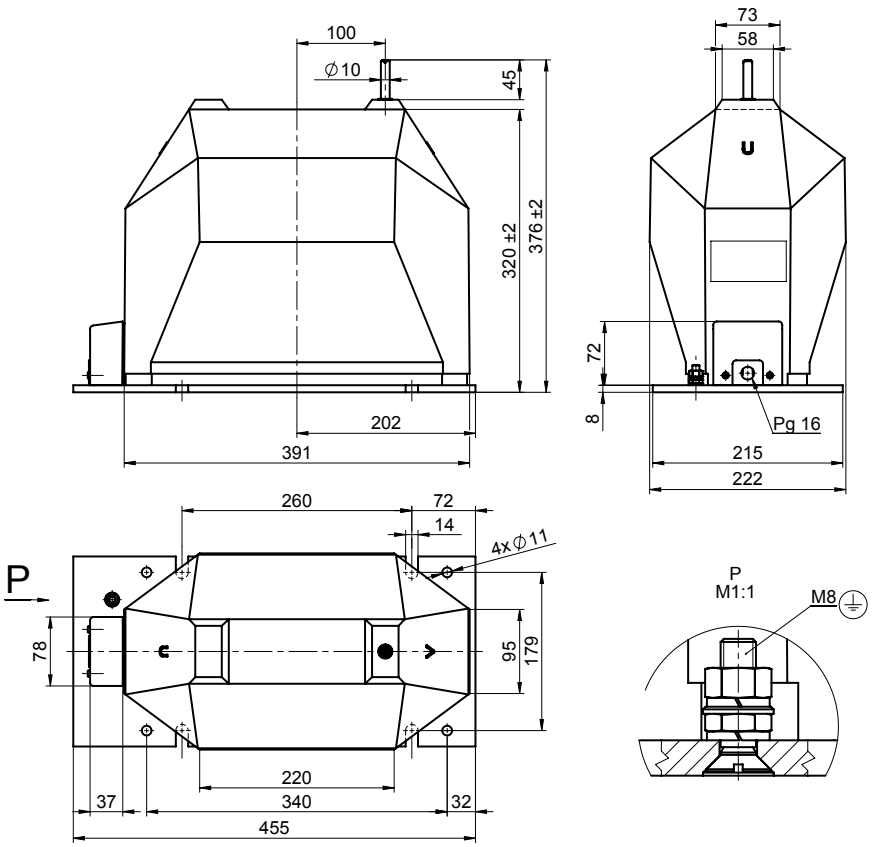



| Drawing n. |
|---|
| 1VL4200395R0101 |

| Type | A | B | C | D | E | F | G | H | J | K | L | m/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **KGUG 24** | 391 | 202 | 455 | 376 | 320 | 200 | 222 | 215 | 260 | 179 | 72 | approx. 60 |
| **KGUG 36** | 443 | 227 | 505 | 427 | 348 | 310 | 248 | 230 | 300 | 186 | 72 | approx. 80 |

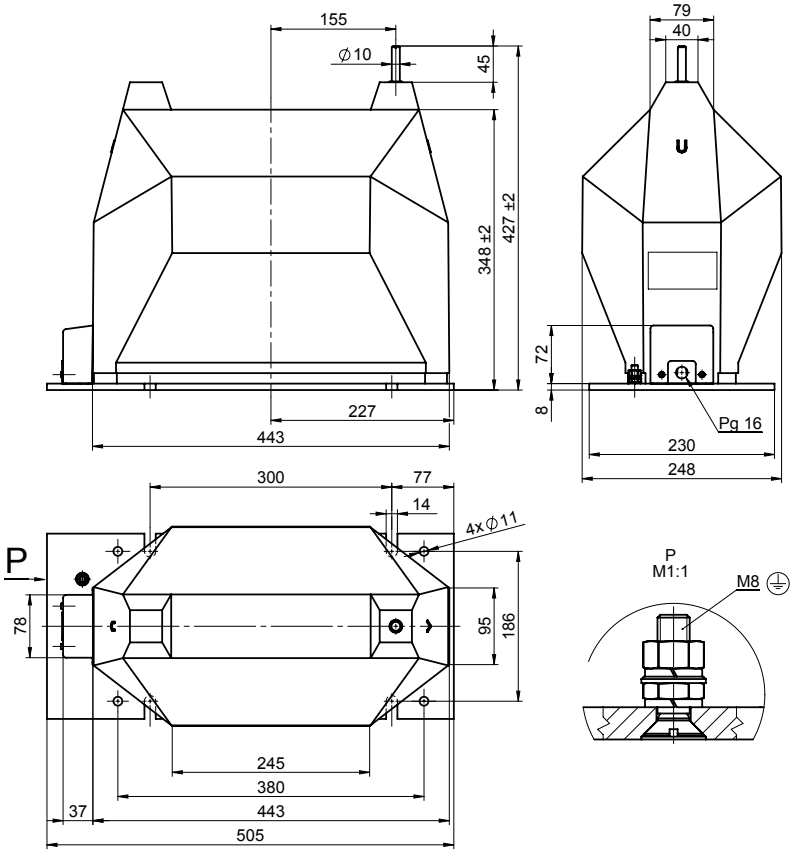
**KGUGI 24**

Weight: 60 kg

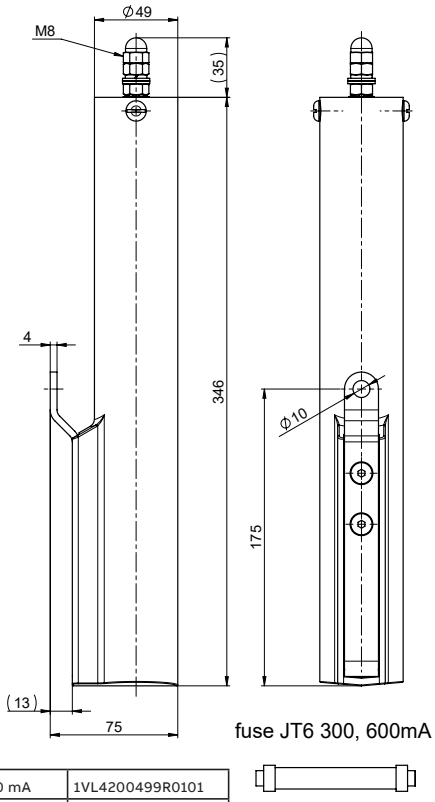



**KGUGI 36**

Weight: 80 kg



**External fuse holder up to 17.5 kV**

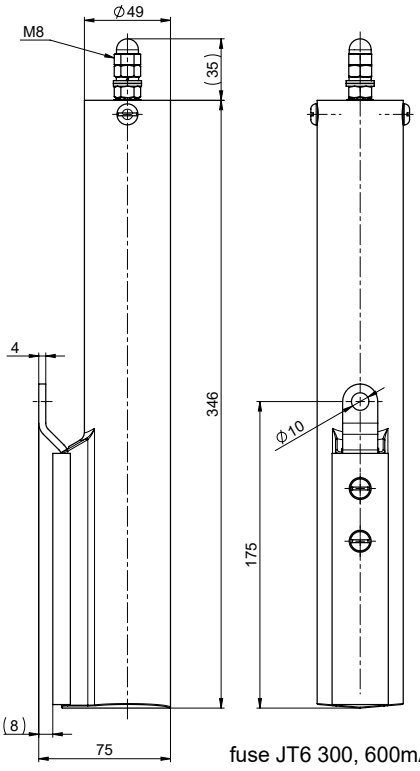



fuse JT6 300, 600mA

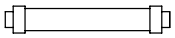


| | |
|---|---|
| fuse JT6 300 mA | 1VL4200499R0101 |
| fuse JT6 600 mA | 1VL4200499R0102 |

**External fuse holder up to 25 kV**




fuse JT6 300, 600mA



| | |
|---|---|
| fuse JT6 300 mA | 1VL4200499R0201 |
| fuse JT6 600 mA | 1VL4200499R0202 |

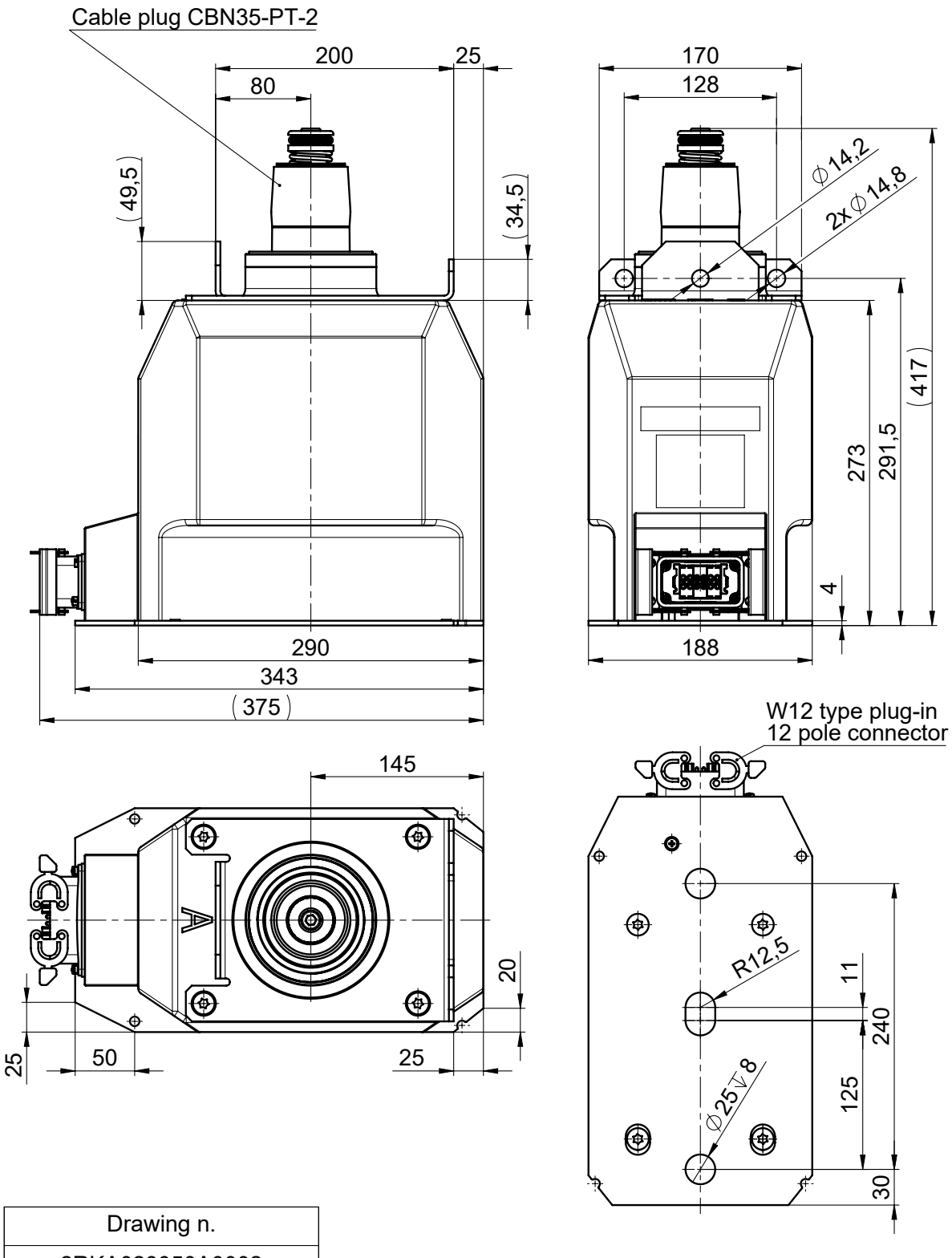
## Metal Coated Types

Dimensional Drawing

**TJMC 7.0 W**

Plug-in secondary terminal

Weight: 41 kg

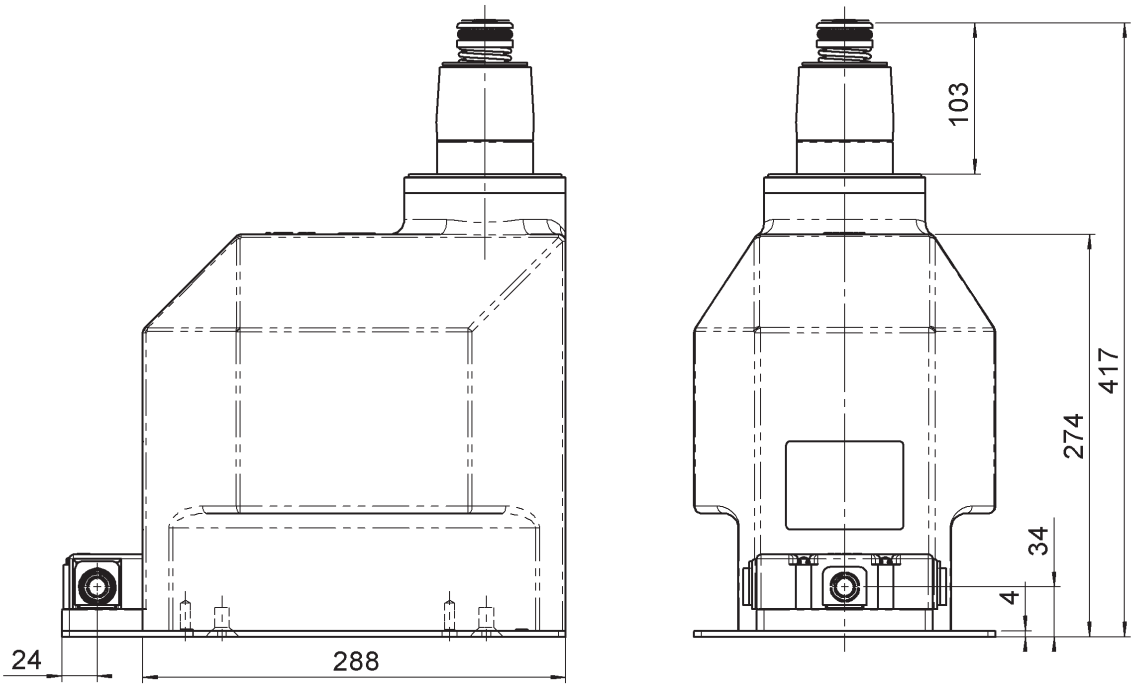


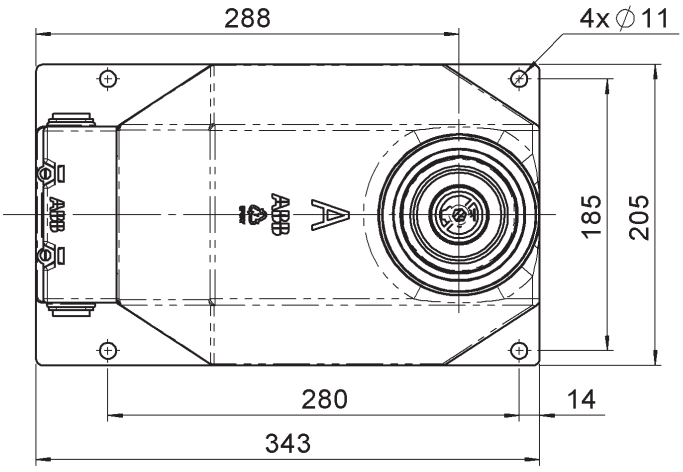

| Drawing n. |
| --- |
| 2RKA023050A0002 |

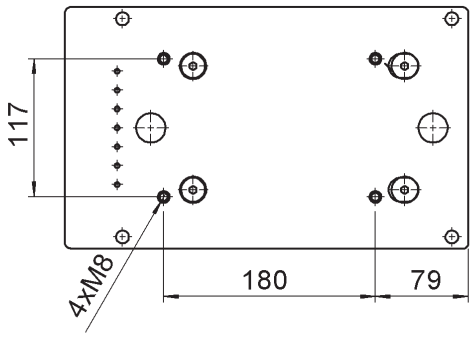
—

**TJMC 7.1**

Weight: appr. 40 kg



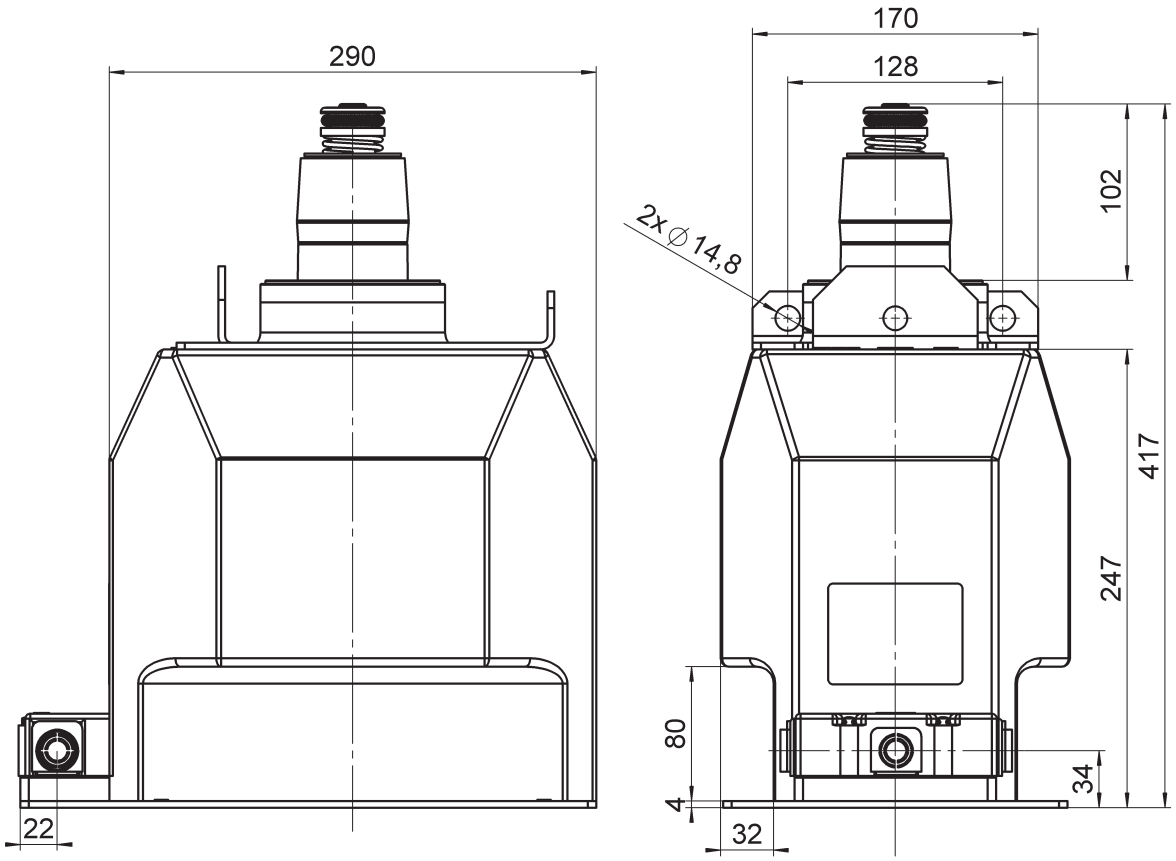



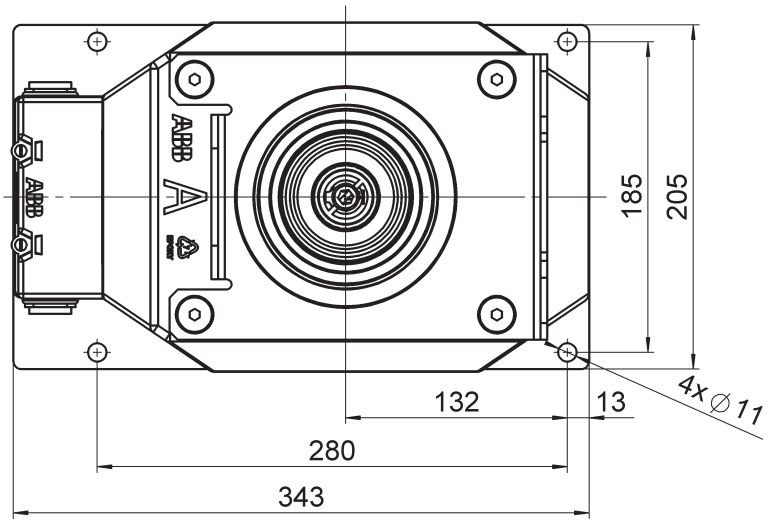



—

**TJMC 7.2**

Weight: appr. 41 kg



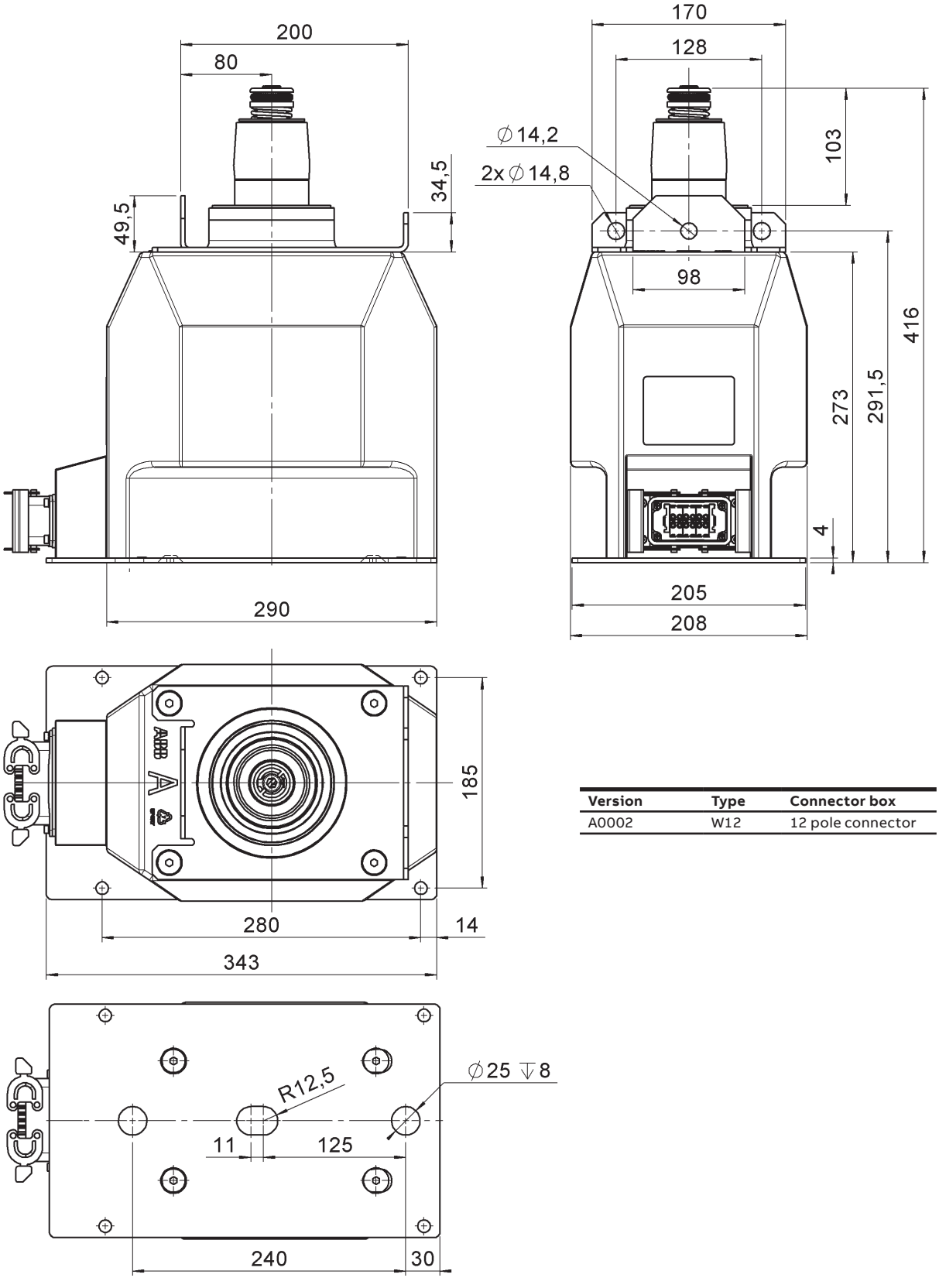

| Drawing n. |
| --- |
| 2RKA023050A0001 |

—

**TJMC 7.2 W**

Plug-in secondary terminal

Weight: appr. 41 kg

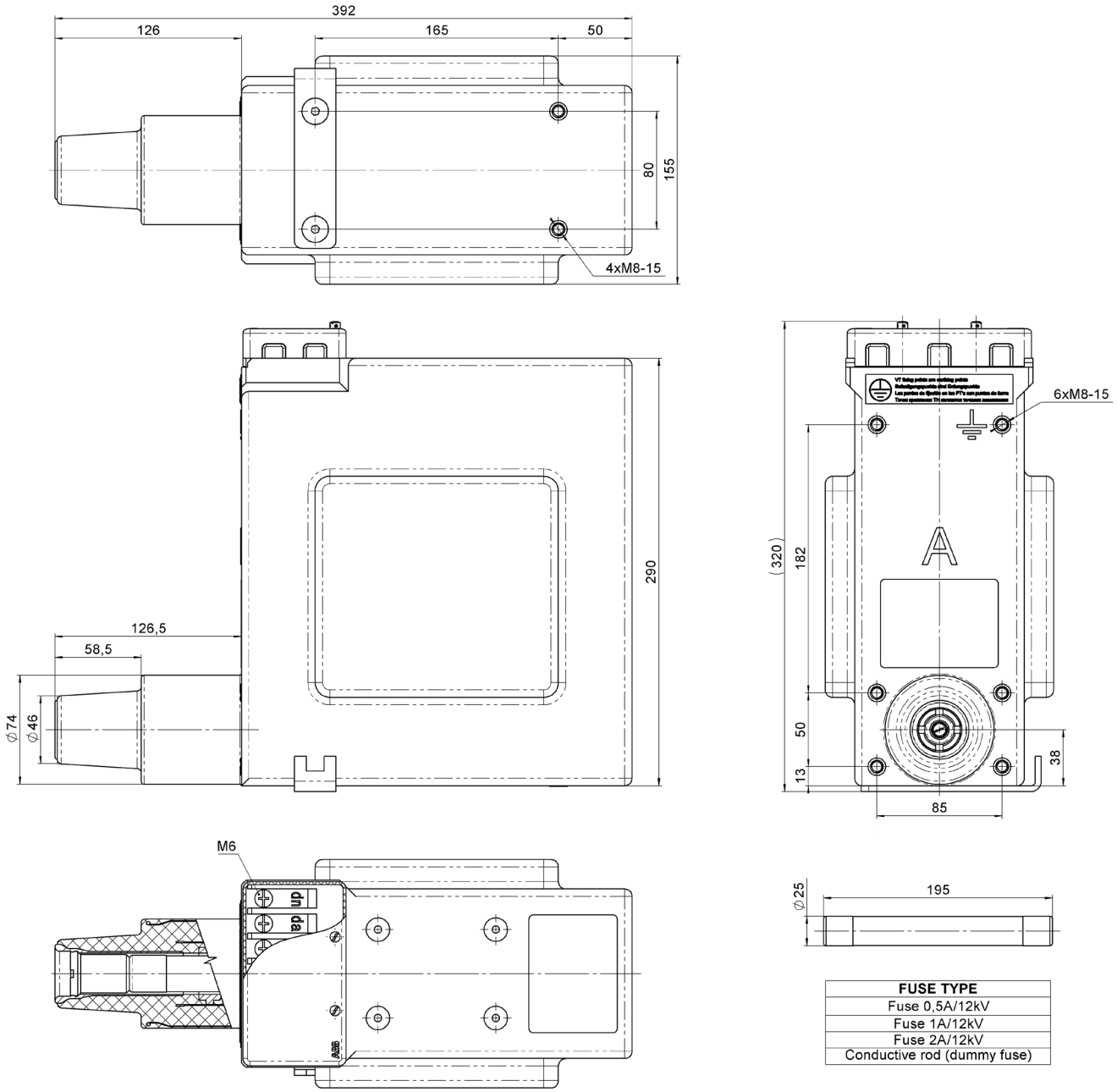



| Version | Type | Connector box |
|---|---|---|
| A0002 | W12 | 12 pole connector |

—

**TJMP 4.1**
Plug-in secondary terminal

Weight: appr. 28 kg
Primary connection: INTERFACE ½ C cone

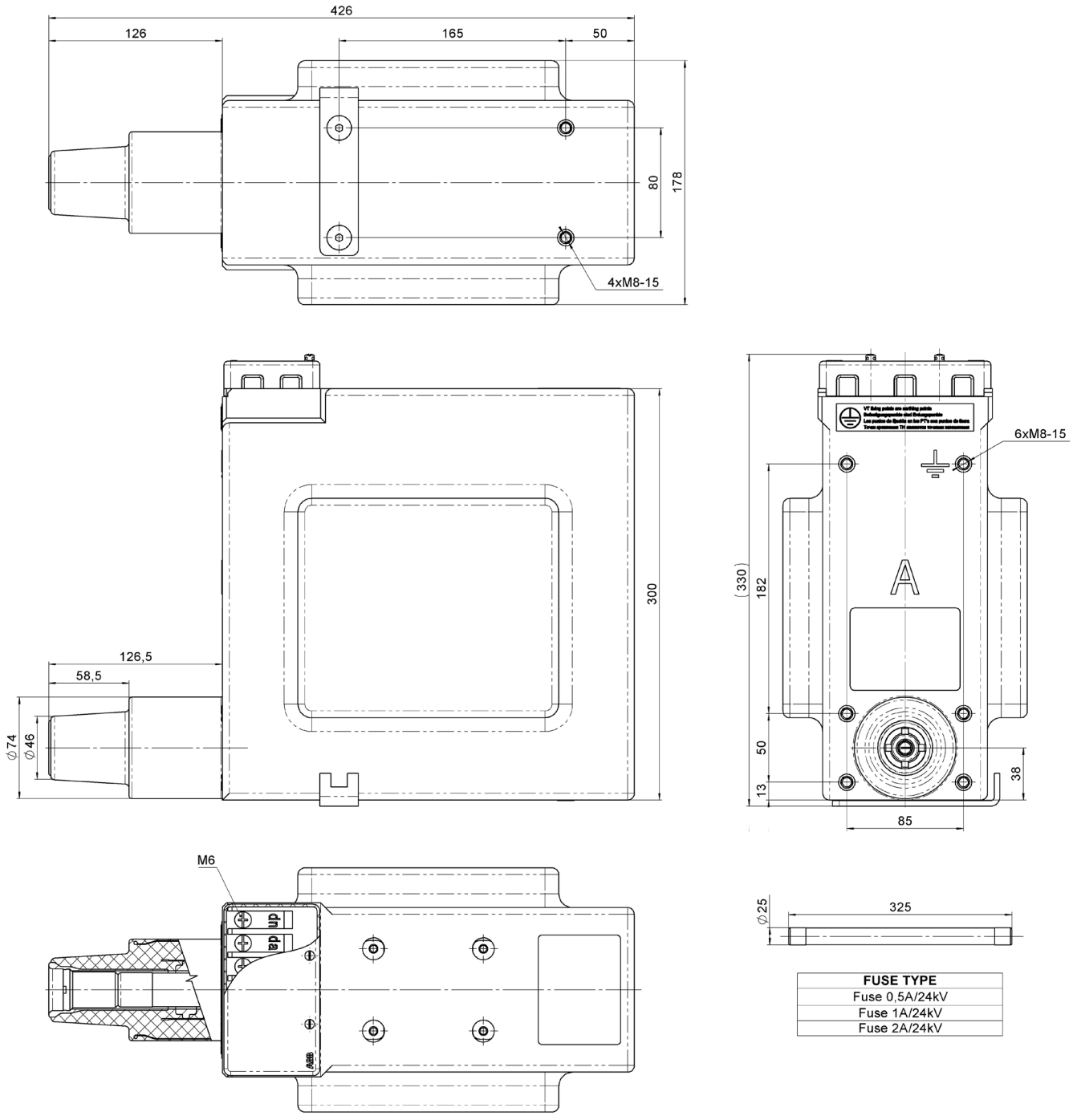



| FUSE TYPE |
|---|
| Fuse 0,5A/12kV |
| Fuse 1A/12kV |
| Fuse 2A/12kV |
| Conductive rod (dummy fuse) |

—

**TJMP 6.1**
Plug-in secondary terminal

Weight: appr. 40 kg
Primary connection: INTERFACE ½ C cone

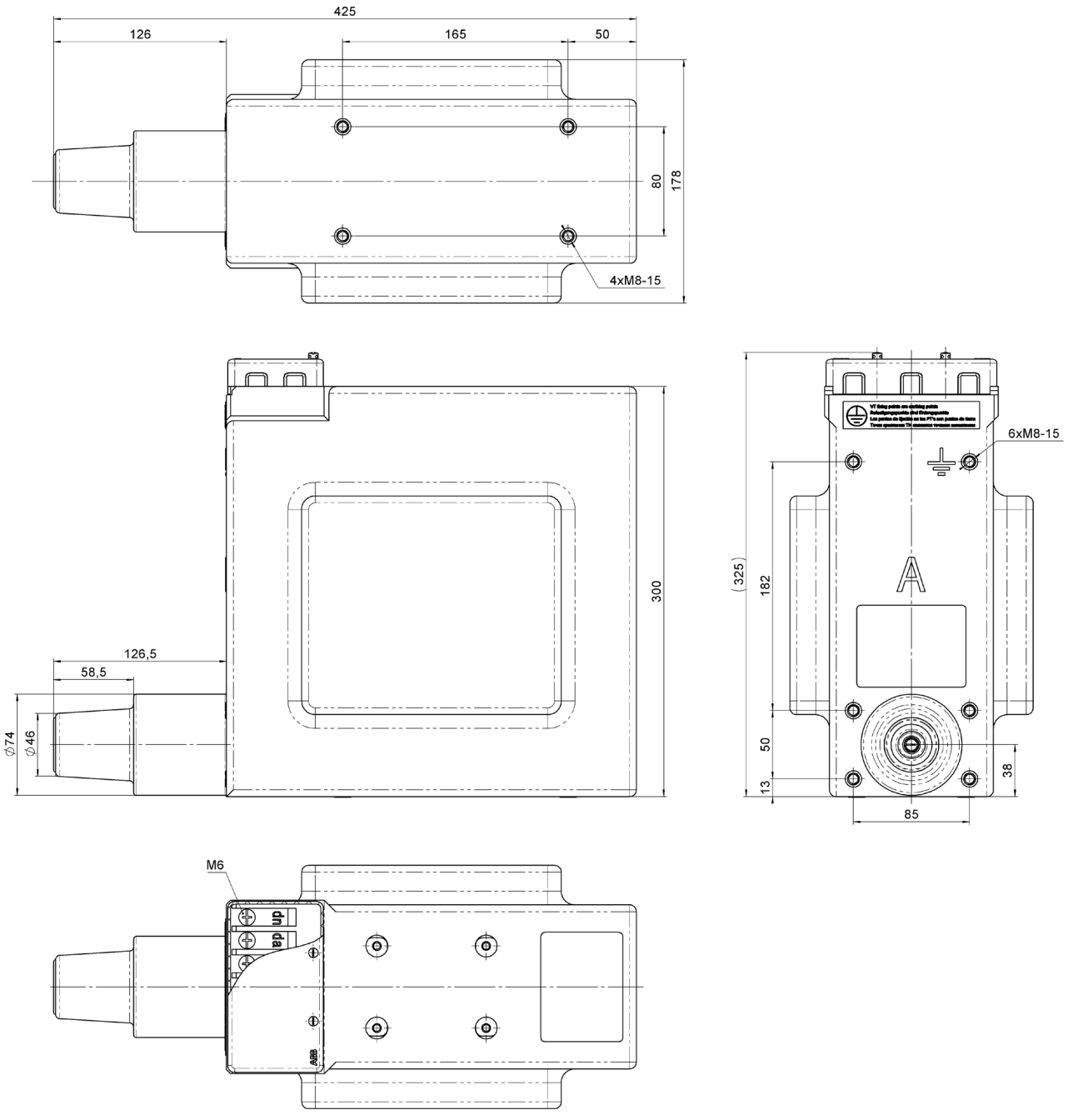



| FUSE TYPE |
|---|
| Fuse 0,5A/24kV |
| Fuse 1A/24kV |
| Fuse 2A/24kV |

—

**TJMC 6.1**
Plug-in secondary terminal

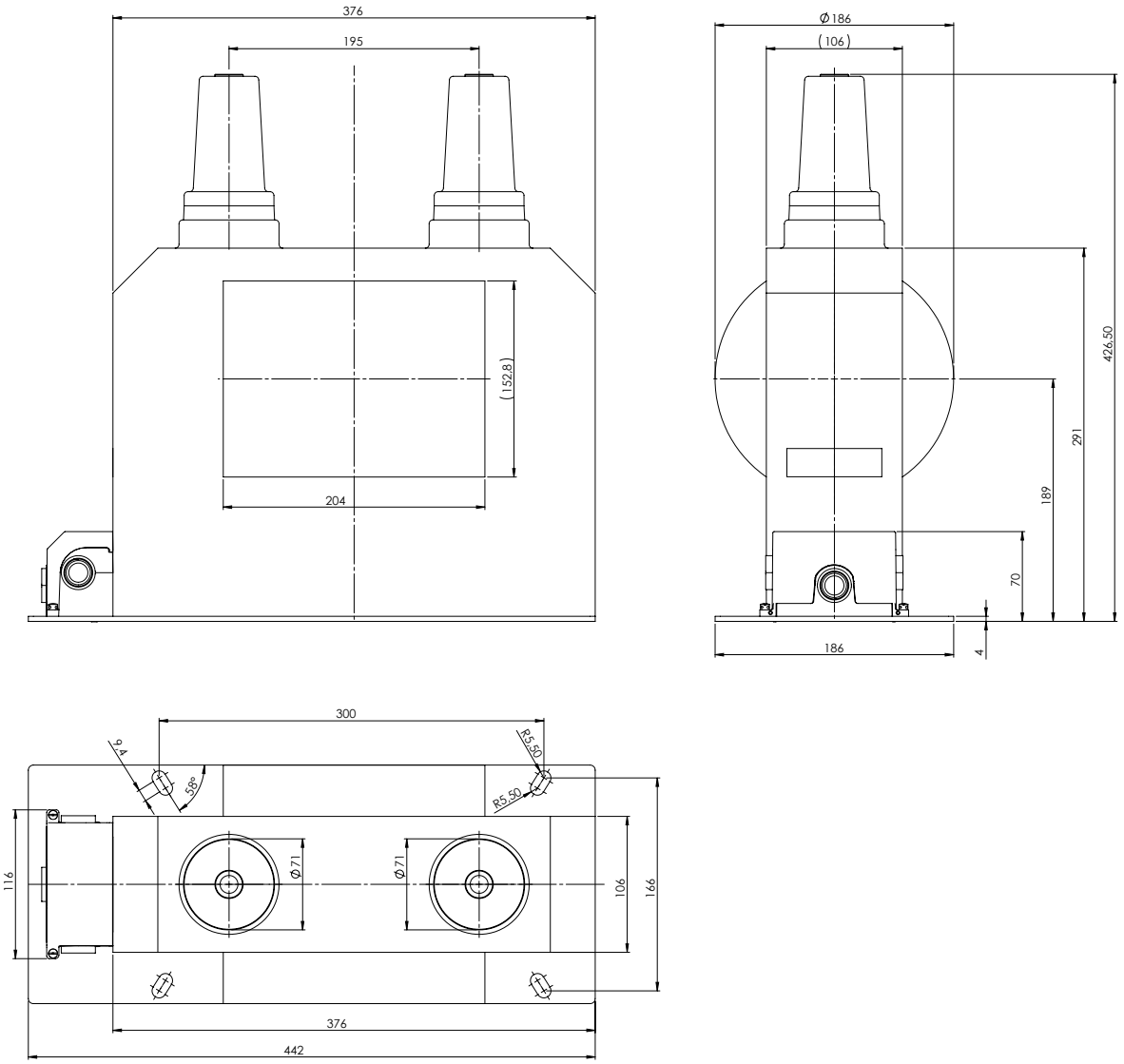
Weight: appr. 40 kg
Primary connection: INTERFACE ½ C cone



—

**TDMC 6.0 C**

Weight: appr. 38 kg
Creepage Distance A-B: 210 mm
Creepage Distance A(B)-⏚: 285mm
Primary connection acc. to EN 50181:2010 - interface ½ C cone




| Drawing n.: |
| --- |
| 026554 |

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1VLM000610 Rev.27, en 2024.10.17

MEDIUM VOLTAGE PRODUCT

# TJP 4.3, TJP 5.3, TJP 6.3

## Indoor Voltage Transformers



| Parameters | Units |
|---|---|
| Highest voltage for equipment | 3.6 - 24(25) kV |
| Power frequency test voltage, 1 min. | 10 - 50 kV |
| Lightning impulse test voltage | 40 - 125 kV |
| Fuses | 0.5 - 6.3 A (IEC) |
| Max. rated burden, classes | up to 50/0.2 - 150/0.5 - 200/1 VA/cl |
| Residual winding | 50 - 200/6P VA/cl |

**Description**
TJP 4.3, TJP 5.3 , TJP 6.3 epoxy insulated voltage transformers are cast in epoxy resin and designed mostly for insulation voltages of

- 3.6 kV to 12 kV TJP 4.3 type
- 17.5 kV TJP 5.3 type
- 24 (25)kV TJP 6.3 type

Trasformers are suitable for ABB UNISAFE panel or PowerCube type PB.

If no a different value is required, the transformers are manufactured with a overvoltage factor of 1.9 x Un/8 hrs. One outlet of the primary winding, including the respective terminal is insulated from the earth to a level which corresponds to the rated insulation value.

Other outlet of primary winding with its terminal is earthed during the operation.

Most of the transformers are equipped with two secondary windings, the first one for either measuring or protection purposes, other for being connected into an open-delta connection in a three-phase system. One terminal of each secondary winding and one of the open delta connected terminals have to be earthed during the transformer operation.

The secondary windings are lead out into a cast-type secondary terminal board. The transformer can be mounted in any position. Transformer body is fixed by four screws.

The TJP 4.3; TJP 5.3; TJP 6.3 transformers are equipped with a fuses conformably to IEC standard. Fuse can be delivered with or without striker pin.

**Note. In case of a request for a fuse with a striker pin, it must be clearly requested in the offer request or in the purchase order.**

**Rated primary voltages**
3/√3 kV; 3.3/√3 kV; 6/√3 kV; 6.6/√3 kV; 10/√3 kV; 11/√3 kV; 13.8/√3 kV; 15/√3 kV; 20/√3 kV; 22/√3 kV
Other primary voltages can also be supplied on request.

**Rated secondary voltages**
100/√3 V; 110/√3 V – accuracy classes 0.2; 0.5; 1 (measuring winding) or 3P; 6P (protection winding). Other secondary voltages can also be supplied on request.

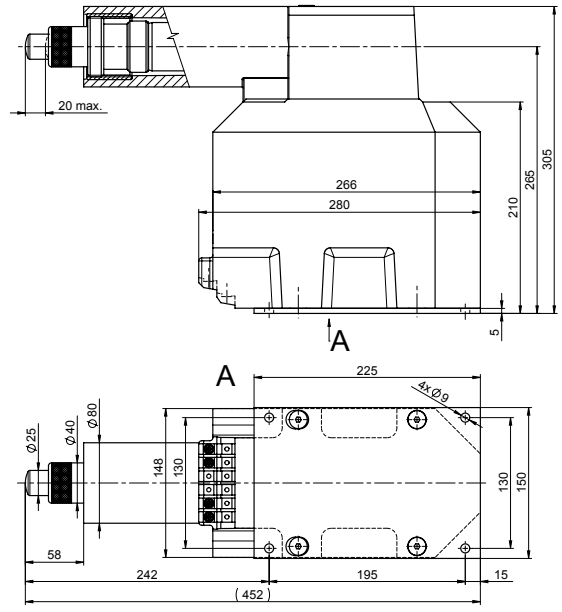
**Rated voltages for open-delta connection**
100/3 V; 110/3 V - class 6P.
Other voltages for open-delta connection can also be supplied based on customer requirement.

**Rated frequency**
50 Hz; 60 Hz.
Based on a discussion with the manufacturer the transformer can also be provided with primary winding designed for two different primary voltages (with secondary side changeover).

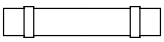
The transformers are manufactured conformably to the requirements and recommendations of the following standards and regulations: IEC, VDE, ANSI, BS, GOST and CSN.

# Dimensional Drawings

**TJP 4.3** Weight: appr. 28 kg
**TJP 5.3** Creepage Distance: 385 mm

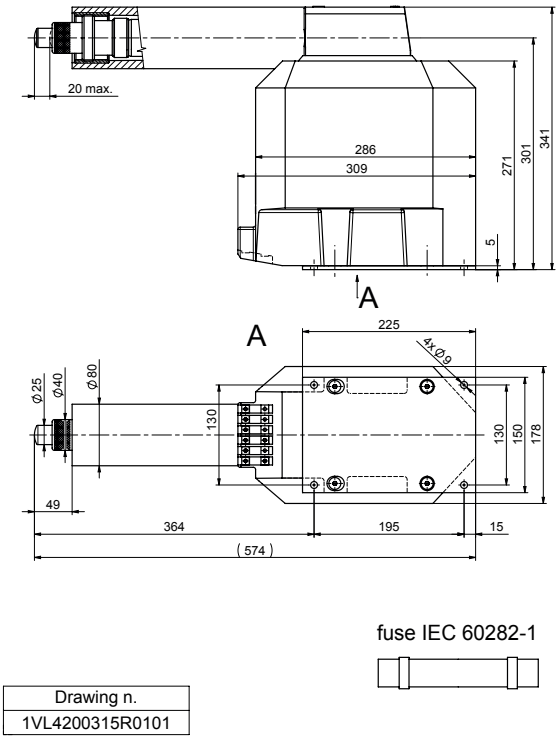



fuse IEC 60282-1



| Drawing n. |
|---|
| 1VL4200314R0101 |

**TJP 6.3** Weight: appr. 42 kg
**TJP 5.3** Creepage Distance: 547 mm

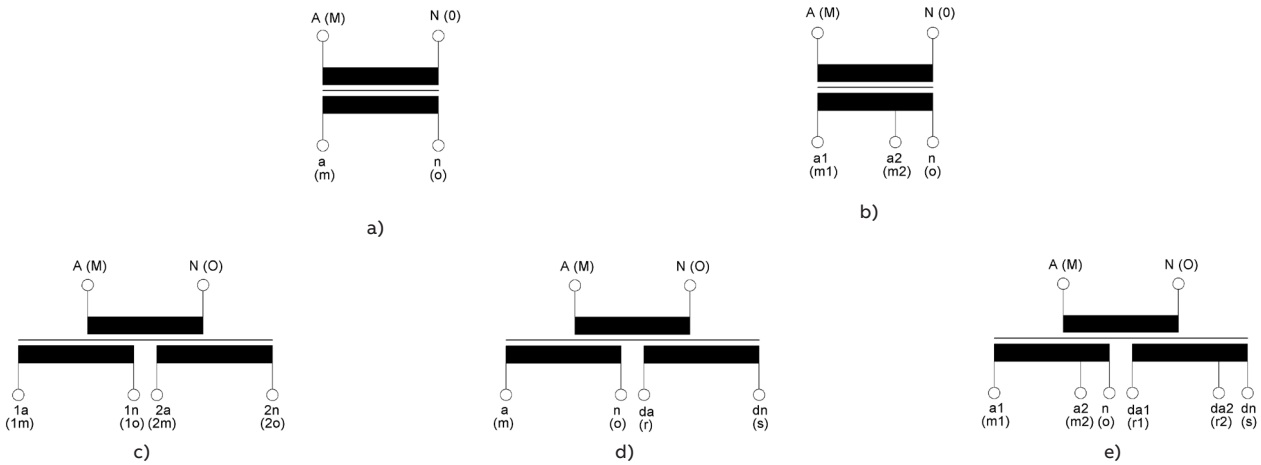



fuse IEC 60282-1



| Drawing n. |
|---|
| 1VL4200315R0101 |

**Marking of the voltage transformer outlets**




a) Single-pole insulated transformer
b) Single-pole insulated transformer with a tap
c) Single-pole insulated transformer with two secondary windings
d) Single-pole insulated transformer with two secondary windings, with one of which being the auxiliary (residual) winding
e) Single-pole insulated transformer with two secondary, tapped windings, with one which being the auxiliary (residual) winding.

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